NAMMCO

Annual Report
2012

North Atlantic Marine Mammal Commission

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COMMITTEES AND OFFICE BEARERS

Members of the Commission		**Councillors**
Faroe Islands	(F)	Ms Hanna í Horni
Greenland	(G)	Ms Amalie Jessen
Iceland	(I)	Ms Ásta Einarsdóttir
Norway	(N)	Mr Ole-David Stenseth

Council

Chairs –	*1992-1995*	Mr Kjartan Høydal (F)
	1995-1997	Mr Halvard P. Johansen (N)
	1997-1999	Mr Arnór Halldórsson (I)
	1999-2004	Ms Amalie Jessen (G)
	2004-2008	Ms Kate Sanderson (F)
	2008-2009	Mr Halvard P. Johansen (N)
	2009-2012	Mr Ole-David Stenseth (N)
	2012.	Ms Ásta Einarsdóttir (I)

Committee on Hunting Methods

Chairs –	*1994-1998*	Ms Amalie Jessen (G)
	1998-2005	Mr Jústines Olsen (F)
	2005-2012	Dr Egil Ole Øen (N)
	2012.	Mr Eyþór Björnsson (I)

Committee on Inspection and Observation

Chairs –	*1993-1995*	Mr Einar Lemche (G)
	1995-2005	Dr Egil Ole Øen (N)
	2005-2011	Mr Ole Heinrich (G)
	2011-2012.	Mr Eigil Tofte Bjørvik (G)
	2012.	Ms Nette Leverman (G)

Finance and Administration Committee

Chairs –	*1999-2000*	Mr Øyvind Rasmussen (N)
	2000-2005	Mr Einar Lemche (G)
	2005-2009	Ms Ásta Einarsdóttir (I)
	2009-2012	Ms Kate Sanderson (F)
	2012.	Mr Einar Tallaksen (N)

Management Committee (as of 2008 divided into MC for Cetaceans and MC for Seals and Walruses)

Chairs –	*1993-1994*	Mr Kjartan Høydal (F) interim
	1994-1998	Mr Einar Lemche (G)
	1998-2004	Mr Kaj P. Mortensen (F)
	2004-2008	Mr Halvard P. Johansen (N)

Management Committee for Cetaceans

Chairs -	*2008-2012*	Ms Ásta Einarsdóttir (I)
	2012.	Ms Ulla Wang (F)

Management Committee for Seals and Walruses

Chairs –	*2007-2011*	Ms Amalie Jessen (G)
	2011.	Ms Hild Ynnesdal (N)

Scientific Committee

Chairs –	*1993-1995*	Dr Jóhann Sigurjónsson (I)
	1995-1997	Prof. Tore Haug (N)
	1997-2000	Dr Mads Peter Heide-Jørgensen (G)
	2000-2004	Mr Gísli A. Víkingsson (I)
	2004-2005	Prof. Lars Walløe (N)
	2005-2009	Dr Geneviève Desportes (F)
	2009-2012	Dr Lars Witting (G)
	2012.	Dr Þórvaldur Gunnlaugsson (I)

Secretariat

General Secretary	Dr Christina Lockyer
Scientific Secretary	Dr Mario Acquarone
Deputy Secretary	Ms Charlotte Winsnes

SECTION 1 - COUNCIL

1.1
REPORT OF THE TWENTY FIRST MEETING OF THE COUNCIL
11 - 13 September 2012, Svolvær, Norway

1. OPENING PROCEDURES

1.1 Welcome address
The meeting was opened with a welcoming address by the honourable mayor of Vågen, Eivind Holst who drew attention to the history of and current activity in the Lofoten area in relation to fisheries and whaling and also shipyards and marine industry.

Following this, the Chair of Council, Ole-David Stenseth (Norway), welcomed participants (Address Section 5.1) and summarised the history and development of NAMMCO on this occasion of its 20th anniversary. He conveyed apologies from the Norwegian Minister of Fisheries and Coastal Affairs, Lisbeth Berg Hansen, who was unable to be present.

1.2 Admission of Observers
The Chair welcomed all observers, noting representatives from Canada, Denmark, Japan, the Russian Federation, and in addition representatives from intergovernmental organisations: the International Council for the Exploration of the Sea (ICES), Arctic Council, International Whaling Commission (IWC), Northwest Atlantic Fisheries Organisation (NAFO), North East Atlantic Fisheries Commission (NEAFC) and the South East Atlantic Fisheries Organisation (SEAFO). In addition a special welcome was extended to special guests invited on the occasion of the 20th celebration, and the invited speaker. A number of regrets had been received, including the EU (both EC-DG Maritime Affairs and Fisheries and EC-DG Environment), North Atlantic Salmon Commission (NASCO), Agreement on Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), UN Food and Agriculture Organization (FAO – RSN division), Nunavut Tunngavik Incorporated (NTI), Association of Traditional Marine Mammal Hunters of Chukotka (ATTMHC), European Bureau for Conservation and Management (EBCD) and the Inuit Circumpolar Conference (ICC).

1.3 Opening statements
Opening statements were presented by member nations of the Faroes, Greenland, Norway and Iceland; Canada also made an opening statement, and a written statement was received from Japan. All statements are contained in Appendix 3.

1.4 Adoption of agenda
The agenda was adopted without amendments (Appendix 1). Documents relating to the agenda points are listed in Appendix 2.

1.5 Meeting arrangements
The General Secretary, Christina Lockyer, welcomed everyone on behalf of the Secretariat, and explained a number of housekeeping matters, Secretariat support available, the schedule of the meeting programme and arrangements for a number of

social events, including a reception hosted by the Råfisklag and a banquet hosted by the Norwegian Ministry of Fisheries and Coastal Affairs.

1.6 Invited speaker presentation
The Chair welcomed Professor Richard Caddell, Swansea University School of Law, UK, who presented a talk entitled: *Marine Mammal Management in the North Atlantic: Future Challenges and Opportunities for NAMMCO.* This was very well received, and a summary is presented in Appendix 5. A number of questions followed.

2. FINANCE AND ADMINISTRATION

2.1 Report of the Finance and Administration Committee (FAC)
The chair of the FAC, Einar Talakksen (Norway), presented the report of meetings held on 6 June 2012 in Copenhagen and also 10 September 2012. He highlighted the main items requiring a decision by the Council. He explained that some items regarding finance were still open until after the conclusion of the meetings of the Management Committees and their recommendations and requests were available.

2.2 Audited accounts 2011
The accounts (NAMMCO/20/4.1; Appendix 4) were approved and **adopted** by Council.

2.3 Draft Budget 2013 and Forecast Budget 2014
The Chair of the FAC indicated that these (NAMMCO/21/4.2) would not be finalised until later in the meeting, but he highlighted possible changes in the light of new needs of 200 000 NOK for Information and Printing (SC publications and website upgrading); of 125 000 NOK for the proposed Hunting Committee manual on hunting to reflect the NAMMCO contribution in a total budget of 350 000 NOK for which external funding would need to be sought; and of 220 000 NOK for T-NASS.

After examining the draft budget for 2013 and also the forecast budget for 2014, amendments were made to accommodate the above requirements. On the advice of the FAC, Council adopted the draft budget 2013 and the forecast budget 2014 (NAMMCO/21/4.2 revised).

2.4 Adoption of Staff Rules for the Secretariat

These revised Staff Rules (NAMMCO/21/5) were **adopted**. It was also noted that in adopting these rules, Council were approving the annual incremental increase in salaries for staff on 1 January. This endorsed the back-dating of increases to 1 January 2012, in recognition of satisfactory staff assessments held during the last year.

2.5 Other business
A new Chair was elected, Einar Talakksen (Norway) and Vice-Chair, Ásta Einarsdottír (Iceland).

3. SCIENTIFIC COMMITTEE

3.1 Report of the Scientific Committee

The Chair of the Scientific Committee, Lars Witting (Greenland) presented the report (NAMMCO/21/6; Section 3). Apart from the main report and the Executive Summary, there were 4 Annexes containing reports from the Working Groups (WG) of the JWG of the NAMMCO/JCNB (ANNEX 1), Planning of the Second T-NASS (ANNEX 2), Workshop on Age Estimation in Monodontids (ANNEX 3), Workshop on Beluga Age Estimation (ANNEX 4).

The Chair of the Scientific Committee (SC) gave a brief summary presentation of the SC report, noting that detailed advice on specific stocks and other relevant issues would be presented in the two Management Committees. The SC Chair commenced with a summary of the work of the working groups:

- WG JWG of the NAMMCO/JCNB – here there were several requests - R-3.4.11: Update of research, assessments & recommendations on sustainable takes (West and East Greenland); R-3.4.13: Seasonal and temporal restrictions on beluga hunt in West Greenland; and R-3.4.9: How to proceed with human disturbance (ANNEX 1).
- WG Second T-NASS planning – Here there was a review of current survey plans with the optimal year for countries and parties for a coordinated survey was 2015; the seasonal whale occurrence around Iceland; a review of survey methodology; and how to proceed with a large-scale survey (ANNEX 2).
- Workshop on Age Estimation in Monodontids – following a recommendation from the JWG of the NAMMCO/JCNB (ANNEX 3).
- Workshop on Beluga Age Estimation – following a recommendation from the JWG of the NAMMCO/JCNB (ANNEX 4).

In addition the SC Chair referred to the ICES/NAFO WG on harp and hooded seals that took place in August 2011, and also a background paper on Norwegian by-catch of harbour porpoises.

3.2 T-NASS 2015

The Scientific Committee Chair noted that at the January 2012 Working Group meeting and based on past experience, the Scientific Committee agreed on the following specifications for the proposed T-NASS. The optimum year of the survey was 2015.

- Coverage, to the extent possible, to include the potential range of target species:
    - Target species are pilot whale, minke whale, fin whale, humpback whale and sei whale.
- Designed to capture shifts in distribution and abundance;
    - Avoid the mistakes of the survey off Iceland 2007: large coastal minke whale decline; critical northern areas not being surveyed;
    - Include all previously survey areas and previously non-surveyed areas if potentially important.
- Fully corrected estimates developed for all areas:

  - Double platform design to be used on all survey vessels and aircrafts.
- Include Canada and Russia and neighboring countries in early planning.

In addition to the traditional national geographical areas the following had been recommended

- East Greenland from Kap Farvel to about 80^{o}N
  - Significant numbers have been seen by opportunistic surveys;
- Offshore areas between Labrador and West Greenland
  - Not surveyed in the past
- Area between Iceland and Jan Mayen, if not covered by Norway
  - Important for minke whales
- South of Irminger Sea down to 55^{o}N (for sei whale and pilot whale)
- North of 70^{o}N in West Greenland (because of recent catches of minke whales)
- Areas between east Iceland and Norway, depending upon Norwegian survey
- Areas in northeast Barents Sea and Pechora Sea
  - Russian surveys have indicated an increased presence of cetaceans.

Matters regarding the budget for T-NASS 2015 are referred to below in point 3.3 on Terms of Reference for the Survey Planning Steering Committee
.

3.3 Priorities and Work plan of the Scientific Committee in 2012-2013

The Scientific Committee suggested two working groups (WG):

Harbour Porpoise WG: February/March 2013?

- Assessment for Greenland; Initiate Norway assessment (review by-catch estimate);
- 2nd meeting: by-catch and assessments for Norway and Iceland (and Faroes).

Walrus WG: Winter/spring 2012/13?

- Small WG for updating the Greenlandic estimates and assessments.

In addition the following were proposed to be held later than the 2013 SC meeting:

- Narwhal catch allocation meeting (2013/14).
- 2014 symposium on seismic exploration and shipping effects on narwhals and beluga, ensuring coordination with similar symposia and avoiding duplication of work with special reference to an apparent planned WG by the IWC.
- Grey and harbour seal: second WG 2013/14.
- Large whale assessment and Pilot whale working groups – pending.

T-NASS

There was also a schedule proposed for the orderly planning of the T-NASS 2015. This required a T-NASS-15 Survey Planning Steering Committee to be approved by Council. The Terms of Reference for this Steering Committee and its membership are outlined as follows:

- One Scientific Committee member for each country and the Secretariat. The committee will appoint its own chair.
- Plan T-NASS-15 on a scale as large as possible in consultations with Finance and Administration Committee (FAC) and the Scientific Committee (SC) to
    - Work inter-sessionally and report back to the FAC for decision making as soon as possible (no later than next year's SC meeting);
    - To be in charge of the SC T-NASS budget in consultation with the SC Chair and the Secretariat.
- Work by "Skype", as well as up to two face-to-face meetings before next SC;
- Plan extended coverage including detailed budgets (including contacts to non-NAMMCO country participants);
- Investigate and list expected national resources (integrating planned surveys);
- Discuss, investigate and seek funding possibilities in consultation with FAC;
- Define the needs for, and Terms of Reference for, a potential survey coordinator;
- Decide on meetings of the Survey Planning Working Group (one potential meeting before next SC).

Council, heeding the budgetary advice from the FAC, **endorsed** these proposals, both for the Working Groups in 2013 and Planning Steering Committee for T-NASS-15, and encouraged the establishment of the T-NASS planning committee as soon as possible and then to proceed with its work.

3.4 Other business

There was no other business

4. NATIONAL PROGRESS REPORTS

All National Progress Reports (NPR) had been received from member countries (Section 4) and also from observer countries Canada, Japan, and the Russian Federation, all of whom were thanked for their contributions. The General Secretary reminded members that it had previously been decided to submit catch statistics separately from the NPR – perhaps as an Appendix, so that the data can easily be extracted and compiled in a catch database accessible to members. In response, Greenland requested that the format of the existing NPR be reviewed, and that a new format could be designed that would help standardise all information submitted. The Secretariat agreed to liaise with Greenland (and others) regarding a revision of the NPR format.

5. MANAGEMENT COMMITTEE FOR CETACEANS

5.1 Report of the Management Committee for Cetaceans

The adopted report of the CMC was presented by the Chair, Ásta Einarsdottir (Iceland) (NAMMCO/21/7; Section 2.1). No new recommendations for Proposals for Conservation and Management and no new requests for the Scientific Committee. The Council noted the report and recommendations to member countries.

Council noted the election of the new Chair Ulla Svarrer Wang (Faroe Islands) and the Vice Chair, Nette Levermann (Greenland).

5.2 Recommendations for requests for advice
There were no new requests.

5.3 Other business
There was no other business.

6. MANAGEMENT COMMITTEE FOR SEALS AND WALRUSES

6.1 Report of the Management Committee for Seals and Walrus
The adopted report of the SMC was presented by the interim chair, Arne Bjørge (Norway) (NAMMCO/21/8; Section 2.2). No new recommendations for Proposals for Conservation and Management were presented. The Council noted the report and recommendations to member countries.

6.2 Recommendations for requests for advice
There was one new request relating to walruses. Walrus quotas in Greenland presently follow the scientific advice and the quota level has a probability of sustainability of 70 % or more until 2014. The present quota block covers the years 2010-2012. The Management Committee **requested** the Scientific Committee to investigate the possibility to include a carryover for quotas in order to include this possibility in the next hearing for the new quota block period.

This request was **endorsed** by Council.

6.3 Any other business
There was no other business.

7. HUNTING METHODS

7.1 Report of the Committee on Hunting Methods
The Chair of the Hunting Committee, Egil Ole Øen (Norway), presented the report NAMMCO/21/9 (Section 1.2). There was much to report in 2011-12. The annual meeting in Copenhagen was in March 2012. The Faroe Islands had changed regulations relating to interference in the pilot whale hunt. Greenland had new regulations for beluga and narwhal, netting of animals, ammunitions control and collection of data. Iceland reported no changes in the hunting regulations and laws. In Norway there were also no new regulations for sealing or whaling. There have been several working groups in recent years, and the committee chose to trace all recommendations and check if they had been followed up in the countries. The relevant working groups and workshops included the Expert Group Report on Best Practices in Sealing and the Expert Group Meeting on Assessment of Whale Killing Data. Iceland has collected whale data on these and will submit them to NAMMCO. The next meeting is scheduled for January-February 2013.

7.2 Report of the Expert Group on Assessment of Hunting Methods in Small Cetaceans

The Expert Group met in November 2011 and the meeting was initiated by a request from Japan. Japan delivered a paper on small whale killing and requested a review. Council endorsed the Expert Group on small whale killing and provided Terms of Reference. The meeting started with presentations on anatomy and ballistics as a background before discussions proceeded with the data on time to death (TTD). Different hunts and methods in participating countries were compared and assessed.

Faroes – killing methods were reviewed for the drive hunt of pilot whales and dolphins. Methods have changed very little over the years. The whale is secured with an iron whaling hook or a ball-pointed blowhole hook. The whaling knife (in Faroese “grindaknívur”) is used to kill the animals. Trials have been carried out with a new spinal lance to kill the animals and the TTD has been reduced significantly.

As an update, the Faroe Islands informed that they are now producing a manual for using the new spinal lance. The spinal lance will be approved as a killing tool.

Japan – killing methods were reviewed for the dolphin drive fisheries. Up until 2009, TTD was up to 5 min; however, the spinal lance used recently produced TTD similar to the Faroes. The Japanese spinal lance is similar to that used in the Faroese pilot whale drive fishery. However, the lance should not be used rocky beaches but preferably on sand. The results now show an improvement in TTD and although the spinal lance is similar to the Faroese variety it is not as efficient and there has been a recommendation to modify it. Blood-letting has been stopped during the kill by using plugs to prevent blood leaching into the seawater and turning it red, for esthetic reasons. However this process may delay death (and is not good for the meat quality).

Japan expressed gratitude to NAMMCO for organising this Expert Group meeting, and would like to continue to participate in such groups in the future and to submit data to NAMMCO for review.

Greenland – firstly, the use of rifles in open water from small boats was discussed for porpoise. Small calibre rifles are used. Both white-sided and white-beaked dolphins are hunted in a similar manner to porpoise by using higher calibre rifles. High calibre rifles with full metal jacket ammunition are used for pilot and killer whales. Regulations on hunting equipment and methods should be made, “struck and loss” rates (S&L) and data on TTD should be collected. Small motor boats are used in open water for narwhal and belugas when full metal jacket high calibre rifles are employed. Floats are used in the capture. Kayak harpoon hunting is conducted near the ice edge. Safety measures require the cooperation of at least two hunters. The whale is secured by harpoon before shooting. Technological improvements have been made in the form of a metal (iron) harpoon which makes the harpoon heavier and results in better penetration into the animal.

Greenland reported as an update, that there had been discussion on “struck and loss” rates during the recent JCNB meeting in Iqaluit when recommendations were made.

Canada (Nunavut) – the hunt focused on narwhal and belugas. The data on TTD were supplied by Nunavut Tungavik Incorporated and not by the Canadian government. Three different types of conditions were reported – open water form using small boats, shooting from the ice edge, and hunting along cracks in the ice. The target area of hit and the animal reaction were described. Floats and harpoon strike (usually one) are used during the kill to facilitate carcase recovery. The TTD is 2-4 min. as in Greenland, the harpoon rod is now metal.

There was a session on hunting and training of hunters. Greenland commented that training in hunting methods is crucial and the work done so far is of great interest, and recommendations are increasing. Greenland proposes that at the next meeting of the Committee on Hunting Methods, there is a discussion on detailed short and long term goals and actions. The "struck and loss" issues are very important and require cooperation with hunters and the Committee on Hunting Methods. It was debated whether or not a new workshop is needed now.

Council noted the recommendations and recognitions made in the Expert Group meeting report, and **endorsed all recommendations** for improvement on killing methods. These included developing a manual for the Faroese pilot whale hunt and developing a training manual for hunters.

7.3 Manual on Hunting of Marine Mammals

In 2010 Council approved the go-ahead for a manual on hunting. However, in planning the content and budget in 2012, it was decided that killing using penthrite grenades would be the topic for a pilot study (NAMMCO/21/11). Regarding costs, 350 000 NOK is the total estimated cost of production. The Finance and Administration Committee which is considering the budget informed that 125 000 NOK of this budget would be supplied by NAMMCO, with the remaining 225 000 NOK to be sought externally.

The Finance and Administration Committee Chair advised that the NAMMCO support for this could be found within the NAMMCO budget in 2013, and that this will also enable the project to commence seeking external funding. Council acknowledged this and had approved the budget including this amount under Item 2.3.

7.4 Other business

There was no other business.

8. THE JOINT NAMMCO CONTROL SCHEME

8.1 Report of the Committee on Inspection and Observation

The chair of the Committee on Inspection and Observation, Nette Levermann (Greenland), presented the report (NAMMCO/21/12; Section 1.3). The committee had a meeting in March 2012 in Copenhagen. There were two reports from observers; one from minke and seal hunts in Greenland, and the other on minke whaling in Iceland. No violations were reported. The Faroe Islands are the observation target during 2012.

The training course previously approved by Council and which should have taken place in 2011 has been delayed. Nominations for candidates for the training course are required.

Regarding the Terms of Reference (TOR) for this committee, there had been a desire to formalise annual meetings but the TOR gave no guidance. Rules of Procedure (ROP) should be developed, similar in format to the ROP for other committees. This matter was however, referred to the Finance and Administration Committee meeting for guidance.

After consideration of the request, the Finance and Administration Committee advised Council which approved the proposed amendment to the Terms of Reference for annual meetings, and recommended that the Committee should prepare draft Rules of Procedure at the next meeting in 2013 and get them adopted by Council at NAMMCO 22.

8.2 Other business

There was no other business.

9. ENVIRONMENTAL QUESTIONS

Greenland informed that following the Ministerial meeting immediately prior to NAMMCO 21, there was a proposal for a working group to look at food security in the future via a international conference in 2014 focusing on marine mammals. NAMMCO has the capacity to advise on the amount of marine mammal tonnage that is available in the N.Atlantic ecosystem and available as potential food. Iceland and the Faroe Islands support this idea. Norway requested more details before approving the go-ahead. However, it was noted that it is only the Working Group that is proposed at this stage to investigate possibilities and funding. It was also noted by Norway that the value of consuming food from marine mammal origin could be an additional part of such a conference. Draft Terms of Reference are required.

As a follow-up to this discussion, Greenland proposed to form a Working Group to look at the possibilities of convening an international event in 2014 where the use of marine mammal meat and other products will be examined in the context of global food security.

The Council approved that the Working Group should come up with a proposal on Terms of Reference, the format of the conference, the main target audiences, the expected outcome, time frame and budgetary aspects to the Heads of Delegations, which will be dealt with inter-sessionally at the latest in the beginning of November 2012.

10. EXTERNAL RELATIONS

10.1 Cooperation with international organisations

The General Secretary presented NAMMCO/21/13 which contained NAMMCO observer reports from annual meetings held within the last 12 months of the international organisations IWC, NAFO, NASCO, NEAFC, the Arctic Council's working group PAME and the Arctic Council's Senior Arctic Officials (SAO), ASCOBANS Advisory Committee, and the FAO FIRMS organisation. Council encouraged continued participation as observer at such meetings, and with respect to FIRMS, advised continued observership is desirable until such time that partnership might be considered. Both the Faroes and Iceland consider strengthening relations with FAO via FIRMS is valuable. ICES reported that it has been a member of FIRMS for a long while. ICES respectfully suggested that it might be a timely step for NAMMCO to join FIRMS and make open its activities which are not as widely known or recognised as they could and perhaps should be.

ASCOBANS

The invitation to observe at the 7th Meeting of Parties of ASCOBANS – also celebrating 20 years of existence, should be followed up. The value of cooperating with these organisations is seen as a positive action, and in the case of ASCOBANS, sharing information on species and stocks of mutual interest as well as collaboration in survey planning is good cooperation.

SEAFO

Norway, as observer for NAMMCO, reported verbally on the South East Atlantic Fisheries Organisation (SEAFO) meetings held last winter. The SEAFO held its 8th Annual Commission Meeting 10-14 October 2011 in Windhoek, Namibia.

NAMMCO had the previous year applied for observer status at SEAFO meetings on a reciprocal basis. SEAFO had expressed appreciation for the exchange of observers, and had hence appointed Norway to be its observer at the NAMMCO Council Meeting.

The 8th Annual meeting focused on strengthening its fisheries management regime and to protect vulnerable marine ecosystems. The Commission has adopted a comprehensive fishing footprint to regulate bottom fishing in the Convention area. Two new conservation measures were adopted by the Commission dealing with port state control and bottom fishing activities. With regard to compliance, SEAFO adopted a new Port State Measure fully in line with the FAO Port State Control Agreement. Other main issues addressed by the Meeting were fishery regulations including catch limits.

The Meeting reaffirmed its appreciation of the good working relations that SEAFO has established with other members of the wider RFMO family as well as with other relevant international and regional bodies, and the organisation remains committed to continued fruitful and mutually beneficial cooperation.

The next (9th) Annual meeting of the SEAFO Commission will be held 3-7 December 2012 in Busan, Korea.

ICES

It was informed that the Scientific Secretary would be attending the ICES Annual Scientific Conference in Bergen next week (week 38).

Conferences

Greenland reported verbally on the conference, *Hunting and Protecting of Marine Mammals - a Clash of Cultures?* held in Torshavn, Faroe Islands in June 2012. The theme addressed why hunting and protection of marine mammals have become an ethical dilemma. For the Nordic countries in the North Atlantic region, whale and seal meat together with blubber have been an important part of their nutrition for centuries. Nevertheless there are clashes between hunting communities and conservation managers and politicians. The questions raised were if this is a clash of cultures between traditional and modern society today, is it possible to achieve a better mutual understanding of these challenges? If this is the case, what improvements are possible and what can be done by NGOs, hunters and politicians? Participation was limited to Nordic countries. The report from the meeting is not yet finalised.

JCNB

Greenland also reported verbally on the JCNB Commissioners' meeting held in late August in Iqaluit. Questions had been put to the JWG NAMMCO/JCNB and the meeting considered research priorities for stocks. In addition the draft Rules of Procedure (ROP) for the JWG NAMMCO/JCNB were considered and were approved in principle with additional modifications. These must now be considered by the JWG before adoption by the JCNB and NAMMCO. In due course, any final ROP draft should be considered by the FAC. The report from the JCNB has not yet been finalised.

CITES

Greenland continued with a notice regarding the proposed CITES uplisting of species (narwhal). The deadline for comment was 4. October. The 16th Meeting of Parties is scheduled for March 2013 when listing of walrus on CITES Appendix 2 will be considered. Canada reported that together with the US they propose a listing of walrus under CITES Appendix 3 which will allow trade. Canada has recently revised its domestic management of narwhal in view of CITES proposals on listings. Canada will keep the Secretariat of NAMMCO informed on updates on this matter.

10.2 Other business

Norway informed that the IWC Scientific Committee is proposing a global review of narwhal and beluga to include stock structure, assessment, *etc.* NAMMCO and NAMMCO member countries will be invited to participate. It is hoped that that such a review will avoid duplication of work.

11. INFORMATION

The General Secretary presented NAMMCO/21/14 which reported on two main scientific conferences – the European Cetacean Society (ECS) annual conference in March 2012 and the biennial conference on the Biology of Marine Mammals in

December 2011. It was emphasised by the Secretariat that such meetings were very important for the maintenance of scientific networks, for keeping abreast of new research and also to make NAMMCO visible. Norway noted that such conferences were good venues / arenas to get visibility by displaying publications during the conference.

11.1 Scientific Publications

The Scientific Secretary provided an update on the new planned publication on walrus for which 10 papers have been received. Following this volume, a new publication on Age Estimation in Monodontids, as approved in principle by Council last year, would be the next volume. This was already well into the planning stage and for which there were already two papers and many more offered. Finally, a recently published Japanese book on whales and whaling is likely to be translated into English in the future. On this occasion, NAMMCO might like to revisit this matter in the future in order to decide whether the English version might be published by NAMMCO.

Norway enquired what had happened to the proposed online publication of scientific volumes and papers. The reply was that currently there had to be major upgrades to the existing website in order to enable this. Presently there were investigations ongoing regarding development of the website and its capacity, and that funding was being looked at in the Finance and Administration Committee.

11.2 Progress on Stock Status list

The General Secretary reported that actual progress was only in contracting GDNatur to continue the work of the stock status listings. Unfortunately, the time taken to reach this point had taken longer than anticipated, and the capacity of the GDNatur was such that the work could not begin until the autumn of 2012. However, the contract had a specific schedule, and it was expected that this would now proceed as planned.

12. ANY OTHER BUSINESS

Timing of Council and associated meetings

The Council **approved** a proposal to revert to former timings of the Council and Scientific Committee meetings that prevailed up to 2007. Council meetings and associated Management Committee meetings will now be held at the beginning of the year in late January – February, and the Scientific Committee will be held in the late autumn. There were several advantages in this shift in timing which avoided the long vacation period in summer immediately before the Council meeting and also permitted easier participation of scientists at meetings.

Scientific Secretary

The Chair, on behalf of Council, expressed sadness at the resignation of Mario Acquarone, Scientific Secretary. His contribution to NAMMCO since April 2007 was greatly appreciated, and all good wishes were given for his future. He was applauded and presented with flowers.

13. CLOSING ARRANGEMENTS

A draft press release was distributed to all delegates and approved. The statement (Appendix 6) was sent to the press after the meeting.

13.1 Election of Chair

The existing but outgoing Chair Ole-David Stenseth was thanked by Iceland on behalf of the Council for his able chairing of NAMMCO, and Ásta Einarsdottir, Iceland, was elected as the new Chair. The new vice-Chair is Amalie Jessen (Greenland).

13.2 Next meeting

Following the adoption of the new timing of Council meetings, the next meeting will be held in the period January-February 2014. According to tradition, the Secretariat will host the next meeting, but the venue has not yet been decided. The next Scientific Committee will be held in the latter part of 2013, possibly November.

Finally the Chair thanked all delegates for a productive meeting.

Appendix 1

AGENDA

1. OPENING PROCEDURES

1.1 Welcome address
1.2 Admission of Observers
1.3 Opening statements
1.4 Adoption of agenda
1.5 Meeting arrangements
1.6 Invited speaker presentation – Professor Richard Caddell, Swansea University School of Law, Swansea, Wales, UK. Title: *Marine Mammal Management in the North Atlantic: Future Challenges and Opportunities for NAMMCO*

2. FINANCE AND ADMINISTRATION

2.1 Report of the Finance and Administration Committee
2.2 Audited accounts 2011
2.3 Draft Budget 2013 and Forecast Budget 2014
2.4 Adoption of Staff Rules for the Secretariat
2.5 Other business

3. SCIENTIFIC COMMITTEE

3.1 Report of the Scientific Committee
3.2 T-NASS 2015
3.3 Priorities and Work plan of the Scientific Committee in 2012-2013
3.4 Other business

4. NATIONAL PROGRESS REPORTS

5. MANAGEMENT COMMITTEE FOR CETACEANS

5.1 Report of the Management Committee for Cetaceans
5.2 Recommendations for requests for advice
5.3 Other business

6. MANAGEMENT COMMITTEE FOR SEALS AND WALRUSES

6.1 Report of the Management Committee for Seals and Walrus
6.2 Recommendations for requests for advice
6.3 Any other business

7. HUNTING METHODS

7.1 Report of the Committee on Hunting Methods

7.2 Report of the Expert Group on Assessment of Hunting Methods in Small Cetaceans
7.3 Manual on Hunting of Marine Mammals
7.4 Other business

8. THE JOINT NAMMCO CONTROL SCHEME

8.1 Report of the Committee on Inspection and Observation
8.2 Other business

9. ENVIRONMENTAL QUESTIONS

10. EXTERNAL RELATIONS

10.1 Cooperation with international organisations
10.2 Other business

11. INFORMATION

11.1 Scientific Publications
11.2 Progress on Stock Status list - website

12. ANY OTHER BUSINESS

13. CLOSING ARRANGEMENTS

13.1 Election of Chair
13.2 Next meeting.

Appendix 2

LIST OF DOCUMENTS

NAMMCO/21/1	List of Participants
NAMMCO/21/2	Agenda
NAMMCO/21/3	List of Documents
NAMMCO/21/4	Report of the Finance and Administration Committee
NAMMCO/21/4.1	Audited accounts 2011
NAMMCO/21/4.2	Commission Draft Budget 2013 and Forecast Budget 2014
NAMMCO/21/5	Revised Staff Rules for the Secretariat
NAMMCO/21/6	Report of the Scientific Committee
NAMMCO/21/7	Report of the Management Committee for Cetaceans
NAMMCO/21/8	Report of the Management Committee for Seals and Walrus
NAMMCO/21/9	Report of the Committee on Hunting Methods
NAMMCO/21/10	Report of the Expert Group on Assessment of Hunting Methods for Small Cetaceans
NAMMCO/21/11	Manual on Hunting of Marine Mammals
NAMMCO/21/12	Report of the Committee on Inspection and Observation
NAMMCO/21/13	External Relations
NAMMCO/21/14	Information
NAMMCO/21/NPR-F	National Progress Report Faroe Islands
NAMMCO/21/NPR-G	National Progress Report Greenland
NAMMCO/21/NPR-I	National Progress Report Iceland
NAMMCO/21/NPR-N	National Progress Report Norway
NAMMCO/21/NPR-C	National Progress Report Canada
NAMMCO/21/NPR-J large	National Progress Report Japan large cetaceans
NAMMCO/21/NPR-J small	National Progress Report Japan small cetaceans
NAMMCO/21/NPR-R	National Progress Report Russian Federation

Appendix 3

OPENING STATEMENTS BY
MEMBER DELEGATIONS AND OBSERVER GOVERNMENTS

FAROE ISLANDS – OPENING STATEMENT

Mr Chairman, Delegates, Observers, Ladies and Gentlemen,

The Faroese delegation is very pleased to be back in Norway for this Twenty-first Meeting of the Council of NAMMCO – 20 years since the signing of the NAMMCO Agreement on April 9th 1992 in Nuuk. We are particularly pleased about the meeting being held here in Svolvær because it is a privilege to be at a meeting and enjoying such a stunning view at the same time in the heart of Norway's whaling communities.

As our Minister, Johan Dahl pointed out yesterday at the Ministerial Meeting, the Faroe Islands have always been convinced that regional cooperation is the best approach to managing all marine resources – fish as well as seals and whales. These are not resources that migrate around the globe - they should be managed where they occur and where they are used. And not least, they should be managed **by** those countries which have an active stake in these resources for commerce and trade in food and other products.

For the Faroes, these years of cooperation through NAMMCO have had great significance for us as a nation with a long and unbroken history of utilising marine mammals. Through our membership of NAMMCO we are a Party to an internationally recognised organisation for cooperation on the management and conservation of marine mammals. NAMMCO's assessments and management advice on the sustainability of our pilot whale hunt have not only provided us with guidance for our own management, but have also shown the relevance of regional cooperation based on a pragmatic and rational approach to marine mammal management.

We have benefited and continue to benefit from our participation in NAMMCO in many areas, not least through the valuable work in the Scientific Committee, the technical cooperation on hunting methods, the international transparency provided through NAMMCO's observation scheme and the useful exchange and promotion of information on marine mammal management and utilisation across the North Atlantic.

We always have something new to learn from the different approaches and perspectives of our North Atlantic neighbours, and we appreciate being able to contribute our own views and expertise in this process. This appreciation is also extended to the governments of Canada, Denmark, Japan and the Russian Federation and their continued efforts to follow and contribute to our work within NAMMCO.

Mr Chairman, the Faroese delegation will do its utmost to help ensure that this meeting will be as constructive and productive as the meetings of the past 20 years have been.

Last, but not least, congratulations to us all on this 20th anniversary - we look forward to many more years of strengthened cooperation in meeting future challenges in the management of marine mammals.

GREENLAND – OPENING STATEMENT

Mr Chair, Ladies and Gentlemen,

Greenland would like to congratulate NAMMCO, its member countries, observers and the Secretariat for the 20 years' Anniversary of NAMMCO.

Greenland called for the Ministerial Meeting with the focus to discuss further strengthening of science and capacity building in other main areas for which NAMMCO has responsibilities as a regional management organization.

Greenland was very satisfied with the outcome of the Ministerial Meeting and hopes and expects that there will be follow up annually on the issue of capacity building of the organization.

Sustainable and responsible management of Whaling and Sealing

Whaling and sealing in the North Atlantic are culturally and socio-economically important activities. They are conducted in accordance with a sustainable and precautionary principle under appropriate management measures and with the use of effective killing techniques and methods. For Greenland, categorization of whaling to certain boxes like "commercial whaling" or "aboriginal subsistence whaling" is not a favourable option. The most important point is that any type of whaling is conducted in a sustainable and responsible way.

For all NAMMCO countries, an increase in the use of all living resources in our national waters, based on sound biological advice, is of major importance. For this, a strong management body is vital. A regional organisation as NAMMCO will never lose its importance. It is also clear point that we as NAMMCO countries should secure responsible management of marine mammals, whether it is by a regional or international management organization. The question of when "enough is enough", and "going with the wind" is not satisfactory.

Ecosystem based management of wildlife

Greenland finds that ecosystem-based management of all living resources is the way forward. The increase in numbers of whales and seals in the North Atlantic waters represent big competitors to our fishermen and hunters. This conflict is increasing, and in some areas, due to political decisions in industrialized countries.

In order to implement this type of management, more information than we currently have together of our waters and its environment, are required, and with financial solutions to support such modelling work. We should assess if the Scientific Committee has sufficient competence to perform these tasks if the tasks for the committee are increased in the future.

By a higher level of utilization and increased manufacturing of our own resources, we will also reduce and limit modern life style diseases that are occurring more often in Greenland.

Greenland has, with regret, observed the current development in Europe and other industrialized countries which are in the process of destroying the possibility of the IWC to live up to its convention. These initiatives have and will have severe negative consequences for our hunters, their families and their livelihood.

From the very beginning, we have noticed that some groups of people's attitude on marine mammals are based on emotions and misinformation, and not on facts. It is therefore crucial that we coordinate and have ongoing dialogue on the issue of information.

We have realized that there is very little or no public and administrative knowledge about the EU trade ban and especially the Inuit exemption. This is another categorization we are not happy with, and which has left us in an undesirable situation.

A stronger and more constructive NAMMCO as a regional management body requires a united North Atlantic – together we are stronger!

ICELAND – OPENING STATEMENT

Minister, Mr Chair, Delegates, Observers and Guests,

On behalf of the Icelandic delegation I would like to extend our appreciation to Norway for hosting the 20 years' Anniversary Meeting of NAMMCO here in Svolvær.

At this point in time we need to look back and we need to look forward. Why did we found NAMMCO? How has it been functioning and what do we want to do with it?

Why was NAMMCO established?
Twenty years ago, the IWC was not functioning - rather as it is today. The organization had ceased to act in accordance with its primary obligations according to its own convention, namely to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.

Therefore, the Government of Iceland decided early in 1992 to withdraw from the IWC with the aim of establishing a new regional commission for the conservation and management of marine mammals in the North Atlantic. The NAMMCO Agreement, on cooperation in research, conservation and management of marine mammals in the North Atlantic, was signed by the Ministers of Fisheries of the Faroe Islands, Greenland, Iceland and Norway in April 1992. This Agreement was based on the conviction that regional bodies in the North Atlantic could ensure effective conservation and sustainable marine resource utilization and development, with due regard to the interests of coastal communities and indigenous people. It was clearly understood by the participating governments that this goal could be achieved because, unlike the IWC, the new North Atlantic Marine Mammal Commission (NAMMCO) would comprise only those countries that had **genuine interest** in the responsible management of the marine mammal stocks of the region.

True cooperation among the participating governments in NAMMCO has been achieved because all decisions have been taken unanimously. This system of decision-making has ensured that each member of the Commission has given the fullest and fairest consideration to the issue at hand. Important management issues have therefore not been trivialized by the existence of an automatic majority committed in advance to a particular outcome. This is what fundamentally distinguishes NAMMCO from the IWC.

As I mentioned before, the IWC is no longer functioning in its prime role in the management and conservation of whale stocks. This has been clear for some time and this year's event underlined this fact even more when the IWC explicitly deprived Greenland of all their aboriginal whaling quotas, contrary to the recommendations by the Scientific Committee. The moratorium on commercial whaling imposed by the IWC in 1986 and originally scheduled to last 4 years is still maintained on political grounds and there are no signs of breaks in that deadlock.

NAMMCO's function for Iceland
Iceland's membership in NAMMCO has been of great importance because international cooperation regarding management of marine mammals is imperative to us. Contrary to the IWC's global moratorium, a regional approach to management based on science at the population level lies at the heart of NAMMCO. This is the approach generally taken for fish stocks and other marine resources. In Iceland's view the same principles should apply for marine mammals. In particular, I would like to mention the valuable scientific work that has been conducted by the Scientific Committee both in terms of increasing general knowledge of marine mammals and as direct scientific advice for management. In this context, I would like to stress the fact that assessments by the NAMMCO Scientific Committee have formed the main basis for management decisions taken by Icelandic authorities concerning fin and minke whales.

Dear friends: let me give you an example of the importance of having a regional organization like NAMMCO. The IUCN classifies *Fin Whale* as endangered on its red list because of its poor state in the Southern Hemisphere – totally ignoring the fact that the independent North Atlantic stocks are in a good and healthy state. This classification of course is completely misleading and has led to powerful States sanctioning Iceland for their extremely limited Fin whaling. We have many other examples of such misinterpretation of data by various organizations. Therefore we need to keep up the good work that has been carried out within NAMMCO for the sustainable utilisation, conservation and study of marine mammals in the North Atlantic.

NAMMCO has placed a large emphasis on animal welfare issues by the important work conducted by the Committee on Hunting Methods. The Committee on Inspection and Observation monitors the implementation of the NAMMCO Joint Control Scheme for the Hunting of Marine Mammals, thereby ensuring international inspection of the hunt.

In conclusion

The existence and proper functioning of NAMMCO is therefore crucial to its member countries if they are at all to continue whaling, and in fact such cooperation is also crucial for the conservation of the marine mammals in the North Atlantic.

The science from NAMMCO of course is fundamental, but the implementation of the science and the political processes are also crucial. Therefore, discussions and recommendations within the Management Committee of NAMMCO on the management of whale stock are so important to us because there we stand jointly together for the principle of conservation and sustainable utilization, and withstand political pressure from the outside.

Last but not least, Iceland’s cooperation within NAMMCO is also important because we are thereby able to fulfil the requirements of international law regarding the duty to cooperate within the appropriate international organisation regarding the conservation and management of whales stocks. Furthermore, recent development within the IWC, with increased polarization, does not raise hopes that the IWC will become functional as a management body in the near future.

NORWAY – OPENING STATEMENT

Chair, Delegates, Observers and Guests - Dear Friends,

Welcome to Svolvær! to Lofoten, and the hub of Norway's whaling operations.

It is 20 years ago that the Agreement on cooperation in research, conservation and management of marine mammals in the North Atlantic was signed in Nuuk.

As the Chair pointed out, NAMMCO meetings have always been meetings among friends; friends not only in the proper sense of the word, but in the sense of like-minded, supporting the right to utilize living marine resources, as long as – it goes without saying – it is done sustainably.

However, the hunting of sea mammals does not meet with general acceptance. There is much talk about the principle of sustainable use of marine resources, but somehow, that seems not to apply to all. How should we, the members of NAMMCO, deal with this?

The Ministerial Meeting yesterday provided us with some guidance in that respect. Increase the emphasis on the unused potential of marine mammals in global food supply.

For 20 years now, NAMMCO has served us well. We must, however, keep looking ahead and ask ourselves if the scope and quality of our organization are tailored to our future needs, to a changing environment, so as best to enable us to strengthen both the understanding and acceptance of our way of life in the international community.

Dear friends - our meeting this week gives us the opportunity to discuss these and other questions in a frank and open manner, thereby providing us with the platform we need to secure a NAMMCO that is relevant, and attractive to all responsible harvesters of marine mammals.

CANADA – OPENING STATEMENT

Canada is pleased to participate as an Observer in this 21st Meeting of the NAMMCO Council. We would like to take this opportunity to thank our Norwegian colleagues for hosting this meeting in such a beautiful venue, and we look forward to productive discussions over the next three days.

This, of course, is a particularly important year for NAMMCO, celebrating 20 years since its creation. Over the past two decades, NAMMCO has grown into an organization well-known for providing strong and impartial science advice on marine mammals. While other organizations have struggled with reaching consensus decisions, NAMMCO has embraced its responsibilities and shown a dedication to the sustainable management of marine mammals.

Canada is committed to promoting the sustainable use of living marine resources, including marine mammals. We have subsistence harvests of bowhead whales, beluga and narwhal which take place in communities in Northern Quebec, Nunavut and the Northwest Territories. Seal harvesting for both commercial and subsistence purposes remains an important way of life in many communities in Atlantic Canada, and the central and eastern Canadian Arctic. Whether for subsistence or commercial purposes, Canada works to ensure harvests of marine mammals are based on the best available scientific and traditional information in order to provide long-term social and economic benefit to the small communities throughout these regions. And it is for these reasons that we continue to recognize the strong value which this organization provides to the conservation of these species.

As Canada shares many of these valued marine mammals populations with other countries, we recognize the importance of collaborating with our international partners in both the science and management of these species and maintaining our close relationship with NAMMCO participants to ensure a coordinated approach to research and conservation. Canada remains committed to actively participating in the Commission's work and looks forward to continued bilateral engagement with NAMMCO members within other organizations as well, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the Canada – Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga.

In particular, Canada remains focused on a number of key goals, including collaboration on the development of an internationally recognized standard for the humane harvesting of seals. Significant research has already been conducted on this issue, and we want to continue to build on this existing knowledge. We feel this work, coupled with parallel research on the humane harvesting of cetaceans, is important to clearly demonstrate to the international community that harvesting of marine mammals is both sustainable and humane, and to dispel any arguments to the contrary.

We hope to explore further opportunities for collaboration during this meeting and are looking forward to positive discussions over the next few days.

JAPAN – OPENING STATEMENT

The Delegation of Japan wishes to express its appreciation to NAMMCO for the invitation to attend its 21st Annual Meeting. Our appreciation is heightened by the fact that this meeting marks 20 years since the NAMMCO Agreement was signed and entered into force.

The 20th Anniversary of NAMMCO provides an opportunity to review its notable achievements and all who have been involved in the work of NAMMCO over these past 20 years should be proud of such accomplishment. The Ministerial Meeting held in advance of the meeting of the Council is an attestation of the achievements of NAMMCO. NAMMCO has become a model of international cooperation related to the sustainable utilization of marine living resources based on science, in conformity with international law and with respect for the needs of coastal communities and indigenous people. Japan fully supports and shares the objectives of NAMMCO member countries in this regard.

NAMMCO was born from dissatisfaction with the IWC (International Whaling Commission). While NAMMCO has made very considerable progress as a marine resource management organization, it is regrettable that the IWC on the other hand has only further entrenched its bipolar and dysfunctional nature over the same period. Unfortunately, the people from Japan’s small type coastal whaling communities have remained the victims of the IWC. Their legitimate requests for a quota have continued to be denied. In addition, Japan’s research vessels conducting valuable research in the Antarctic under Article VIII of the ICRW (International Convention for the Regulation of Whaling) continue to be illegally attacked by the Sea Shepherd Conservation Society, and some IWC member countries have continuously been the flag States for their vessels and allowed their access to the ports of those countries.

For these reasons, the delegation of Japan fully concurs with the statement made by the keynote speaker at the 20th Annual Meeting of NAMMCO, Ambassador Karsten Klepsvik from the Norwegian Ministry of Foreign Affairs when he said that recent international developments indicated that NAMMCO would have even more significance in the future for the conservation and management advice with regard to whales. In this regard, it is our pleasure that we have made contributions to increasing and strengthening the cooperation between NAMMCO and Japan, including Japan’s submission of whale killing data and National Progress Reports. We would like to continue to make a similar contribution in the future.

Once again, we would like to extend our appreciation to NAMMCO on the occasion of its 20th Anniversary. We would also like to thank the NAMMCO Secretariat for the meeting arrangements and the Government of Norway for its warm hospitality. We wish all delegates a successful meeting.

Appendix 4

AUDITED ACCOUNTS FOR 2011

PROFIT AND LOSS ACCOUNT (NOK)

	2011	*2010*
Income		
Contributions	3 605 303	*3 605 303*
Interest received (net)	51 063	*33 177*
Book sale	1 304	*1 912*
Employers Tax	234 205	*237 831*
Employees	931 215	*662 090*
Total Income	**4 823 090**	***4 540 313***
Expenditure		
Secretariat costs	3 824 742	*3 802 452*
Meetings	163 368	*129 129*
Observation Scheme	109 028	*56 816*
Scientific Committee	185 129	*180 048*
Conference	76 696	*67 303*
Total operating costs	**5 276 603**	***4 235 748***
Operating result	**-453 513**	***304 565***

BALANCE SHEET

Current assets		
Bank deposits	1 359 724	*1 229 503*
Outstanding claims	299 062	*301 025*
Total assets	**1 658 786**	***1 530 528***
Current liabilities		
Employers tax	97 973	*106 461*
Creditors	880 784	*8 198*
Other	183 451	*465 778*
Total liabilities	**1 162 208**	***580 437***
EQUITY		
Distributable equity (General Reserve)	496 578	*950 091*
Total equity	**496 578**	***950 091***
Total liabilities and equity	**1 658 786**	***1 530 528***

Appendix 5

MARINE MAMMAL MANAGEMENT IN THE NORTH ATLANTIC: CHALLENGES AND OPPORTUNITIES FOR NAMMCO

Dr Richard Caddell
Institute of International Shipping and
Trade Law, Swansea University, Swansea, United Kingdom

NAMMCO is a unique institution; there is no direct regional equivalent for comparison. However, a considerable number of organisations address some of the species covered by NAMMCO. The main global body for large cetaceans is the International Whaling Commisison (IWC), although a number of other treaties have an application to marine mammal management and consumption: The Bonn Convention on Migratory Species (CMS), Convention on Biodiversity (CBD), Convention on International Trade of Endangered Species (CITES).

Commitments towards marine mammals were established in the UN Convention on the Law of the Sea 1982, and particularly relevant are Articles 64 and 65. Both provisions are rather vague and unclear, and seemingly require states to develop management procedures through multilateral bodies and international cooperation. However, the precise legal obligations within these provisions are subject to considerable debate and controversy.

The Articles 64 states:
"The coastal State and other States whose nationals fish in the region for the highly migratory species listed in Annex I shall cooperate directly or through appropriate international organizations with a view to ensuring conservation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the exclusive economic zone. In regions for which no appropriate international organization exists, the coastal State and other States whose nationals harvest these species in the region shall cooperate to establish such an organization and participate in its work."

Broadly speaking, obligations arise for a relatively limited of species, primarily fish, but also apply to an extensive range of cetaceans, including those species that are harvested or prospectively harvested in the NAMMCO area. However, the Article does not apply to pinnipeds.

The Article 65 states:
"Nothing in this Part restricts the right of a coastal State or the competence of an international organization, as appropriate, to prohibit, limit or regulate the exploitation of marine mammals more strictly than provided for in this Part. States shall cooperate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management and study."

Article 65 addresses all species of marine mammals, but reserves particular obligations for cetaceans. The obligations are controversial and there is little objective guidance as to their precise meaning. The Article appears to be weighted towards conservation of the species instead of Maximum Sustainable Yield (MSY) principles – although this does not *per se* require a ban on exploitation. Provision also applies to the high seas (Article 120).

The formation and evolution of NAMMCO came about because of the IWC moratorium and the politics of whaling. In addition there was disillusionment among whaling nations with IWC management of whale stocks and application of scientific advice. There was also a need to regulate pinniped stocks in the High North – not then covered. A promotion of regional management and sustainable utilisation of marine living resources was seen as necessary.

Initially politics of whaling ensured that international response to NAMMCO was highly negative. There were concerns over fragmentation of whaling management and proliferation of other bodies. Because of the relatively limited legal literature, most authors initially viewed NAMMCO as not an “appropriate organisation” for whale management, and the role of the agreement in pinniped management was ignored.

In fact there is little guidance provided by international institutions on an “appropriate organisation” – and where guidance is given, there has been little explanation of how and why international bodies qualify as “appropriate”. Even if a body is “appropriate” the wider obligations associated with Article 65 are also unclear. At this time the following organisations were endorsed as “appropriate”:

- IWC.
- UN Food and Agriculture Organisation and the UN Environment Programme (UN Office of Legal Affairs Declaration 1996).
- International Maritime Organization (in respect of ship-strikes).
- *Agenda 21* lists IWC, IATTC and ASCOBANS.
- Likely also to include CMS, CITES, ACCOBAMS and NAMMCO.

The criteria for assessing organisations as “appropriate” are unclear and not objective. Suggested factors may include:

- The engagement of states and entities affected by the decision-making processes within the area of jurisdiction of the organisation in question.
- Technical capacity to generate sufficient and accurate information upon which to inform the decision-making process.

The decision-making process is in fact informed by clear, verifiable and impartial technical findings.

- The decision-making process is transparent, accessible and accountable.
- The institutional framework is capable of engaging with other bodies and organisations that are relevant to the issues under consideration.
- The organisation has sufficient resources to facilitate and sustain the operation of these processes.

With respect to NAMMCO, the following are offered:

- A designated forum for the discussion of marine mammal management, engaging major stakeholders.
- A body to consolidate and advance scientific knowledge of marine mammal issues in the North Atlantic.
- A body that addresses marine mammals from a sustainable use perspective.
- A body that is close-knit and with similar viewpoints.

The main successes of NAMMCO are to date:

- Establishment of numerous specialist working groups and specialist fora.
- Trans-North Atlantic Sightings Survey (T-NASS) and significant scientific findings.
- Observer and inspection scheme.
- Advancements in killing techniques.
- Seal and walrus forum which provides a rare management forum for under-regulated species.

The key challenges for NAMMCO are now:

- Strategic direction and vision for the next 20 years.
- Scepticism from other bodies and states in anti-hunting regions.
- General ignorance of High North realities and traditions.
- Engagement with other management bodies.
- Financial and budgetary pressures.
- Change management.

There are however, key opportunities which include

- Expansion of the scientific and knowledge base.
- Possibilities to work more closely with the IWC on emerging conservation problems.
- Further and wider recognition of NAMMCO as a meaningful component in the international system.

In conclusion, NAMMCO has quietly overcome a considerable amount of early cynicism about its formation and can be considered "appropriate". A number of key projects and initiatives has been developed – many of which would struggle to be advanced in alternative bodies. There has been strong and meaningful scientific contribution and advancement of the knowledge base. However, key challenges are financial and in outlining precise goals for NAMMCO in the mid- to long-term future.

Appendix 6

PRESS RELEASE
13 September 2012

20 YEARS OF NAMMCO AND THE FUTURE

The North Atlantic Marine Mammal Commission held its 21st Annual Council Meeting from 11-13 September 2012, in Svolvær, Lofoten Islands, Norway. The member countries of NAMMCO, the Faroe Islands, Greenland, Iceland and Norway again confirmed their commitment to ensuring the sustainable utilisation of marine mammals through active regional cooperation and science-based management decisions.

The Governments of Canada, Denmark, Japan and the Russian Federation are represented by observers at meetings of NAMMCO, as well as other international governmental organizations within the fields of fisheries and whaling.

For the first time, a Ministerial Meeting was held immediately prior to the Council meeting on 10th September to discuss the future of NAMMCO after 20 years of existence. In the light of the discussions taking place at the meeting it was decided by the NAMMCO Council to form a working group to look at the possibilities of organising an international event in 2014 where the use of marine mammal products will be examined in the context of global food security. The Ministers concluded that NAMMCO is a fully fledged international organisation well prepared for future challenges.

The keynote speaker at the Council meeting, Professor Richard Caddell of the Department of Law, Swansea University in Wales, United Kingdom, addressed the future challenges and opportunities for NAMMCO, and through his intervention confirmed the status of NAMMCO as an appropriate body for the management of marine mammals.

Key events and conclusions from the meeting included the following:

1. T-NASS 2015

Planning for another comprehensive Trans-North Atlantic survey for whales and dolphins in 2015 is in progress, involving cooperation with countries outside of NAMMCO, including Canada, the Russian Federation, the US and the EU countries. Periodic surveys form the corner stone of assessment of stocks, their distribution, sustainability and management.

2. Manual on Hunting of Marine Mammals

In 2010 Council approved the go-ahead for a manual on hunting. It will be the first comprehensive manual for hunters that details weaponry and ballistics information with a focus on safety.

3. Expert Group report on Assessment of Hunting Methods in Small Cetaceans

An international Expert Group on killing methods in small cetaceans met in November 2011. NAMMCO continues to be considered as an appropriate international forum for scientific advice for hunting methods. Significant reductions in killing times have been recorded in recent years in Faroe Islands, Greenland, Japan and Nunavut Canada, due to development of new equipment and practices. Several recommendations were made regarding further improvement in killing methods, safety and training of hunters. The report can be found at http://www.nammco.no/webcronize/images/Nammco/970.pdf

4. Advice for long-finned pilot whale and small cetaceans

NAMMCO concluded, following advice from the Scientific Committee, that an abundance of pilot whales in the range of 50 000 – 80 000 will sustain the annual Faroese drive hunt. The most recent scientific estimate of abundance for the pilot whale stock is 128,000 in the Iceland-Faroese survey area. This estimate is based on data from the latest T-NASS in 2007, coordinated by NAMMCO, meaning that the annual Faroese catch of pilot whales is well within sustainable limits.

In addition, the Scientific Committee provided advice for the first time on sustainable catch levels for long-finned pilot whale and white-beaked dolphin in Greenland.

5. Marine mammal – fisheries interactions

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

6. Council chairmanship

The Present Council Chair Ole-David Stenseth, Norway, was thanked for his term of able chairmanship, and the new Chair Ásta Einarsdottir, Iceland, was welcomed.

1.2
REPORT OF THE COMMITTEE ON HUNTING METHODS

The Committee on Hunting Methods (Section 5.5) met on 7 and 8 March 2012 at the Faroese representation in Copenhagen. Present were Egil Ole Øen, chair, Kathrine Ryeng and Hild Ynnesdal (Norway), Jústines Olsen, (Faroe Islands), Kristjan Loftsson and Eyþór Björnsson (Iceland), Amalie Jessen and Nette Levermann (Greenland), and Christina Lockyer and Charlotte Winsnes from the Secretariat. Jessen did not attend 8 March.

1. INTRODUCTORY REMARKS, ADOPTION OF AGENDA AND APPOINTMENT OF RAPPORTEUR

The Chair of the Committee, Egil Ole Øen, welcomed the Committee members to the meeting. Ryeng was introduced and welcomed as a new committee member from Norway. The draft agenda was adopted and Charlotte Winsnes acted as rapporteur.

2. UPDATES ON HUNTING METHODS IN MEMBER COUNTRIES

The lists of references on hunting methods (NAMMCO/HM-March 2012-2), and laws and regulations in member countries (NAMMCO/HM-March 2012-3) were updated (see Appendices 1 and 2 of this report).

Faroe Islands

Olsen (Faroe Islands) reported that there had been a revision of the regulations on pilot whale hunting. The update has no bearing on the hunting methods but relate to the authorities legal right to prohibit people's access to participate in the hunt. Interference of any sort, be it on land, in the air or at sea, with the aim of hindering a drive hunt, is not permitted.

Greenland

Levermann (Greenland) reported on the following:

A revision of the Executive Order regulating the hunt on beluga and narwhal (No. 7 dated 29 March 2011) is finalized. Changes entail among other things regulation of the quota for leisure hunters to be limited to a total of 10% of the overall quota, the protection on the taking of calves has been lifted, specifications related to the hunt by netting and requirements on weapons and ammunition and on the reporting and collection of data.

Work is ongoing on a revision of the two Executive Orders on the hunting and protection of large whales, and the Committee will be notified when the revision is finalized.

Greenland had submitted data to the IWC Working Group on Whale Killing Methods and Associated Welfare Issues (IWC Document IWC/63/WKM&AWI9) at last year's meeting.

Iceland
Björnsson (Iceland) reported that there had been no new regulations for the hunting of fin and minke whales the last year.

Norway
Ynnesdal (Norway) reported that there had been no new regulations with respect to hunting of whales or seals the last year.

3. EXPERT GROUP MEETING TO ASSESS THE HUNTING METHODS FOR SMALL CETACEANS

The Expert Group (EG) met in Copenhagen 15 - 17 November 2011 under the chairmanship of Egil Ole Øen. ANNEX 1 (Document NAMMCO/21/10) contains the report from the meeting.

The Council at its 19th annual meeting in September 2010 tasked the Committee on Hunting Methods with organising an Expert Group to assess the hunting methods for small cetaceans. The EG was given the following terms of reference:

1. *Review and assess current hunting and killing methods for small cetaceans*
2. *Review and assess information on recent and ongoing research on improvements and technical innovations in hunting methods and gear used for hunting of small cetaceans*
3. *Review and assess time to death (TTD) data on the killing of small cetaceans*
4. *Give recommendations with respect to possible improvements.*

The aim of the EG was to assess the presented data on hunting methods and give recommendations with respect to possible improvements. In addition to data from the NAMMCO member countries Greenland and the Faroe Islands, Canada and Japan presented data and information on their hunts of small whales.

All members of the EG were invited in a personal capacity as experts in fields such as veterinary medicine, statistics, physiology and biology specifically related to the killing of small cetaceans and animal welfare. The EG also consisted of hunters from Greenland, Canada and Faroe Islands, in addition to members of the Hunting Committee. The conclusions and recommendations from the EG were agreed upon by consensus before the end of the meeting.

The Committee on Hunting Methods agreed that the EG meeting had been very successful with in-depth and informed discussions. Special acknowledgment was given to the participating hunters for their valuable and very informative inputs on the practical aspects of hunting. The Committee had always recognised and emphasised the importance of including both the theoretical and practical sides when discussing hunting methods and possible improvements. This EG meeting once again confirmed the value and necessity of this viewpoint.

The Committee acknowledged the significant work done by Justines Olsen in cooperation with the Faroese hunters in developing the spinal lance and the new blowhole hook used in the pilot whale hunt in the Faroe Islands. These improvements represent a significant progress through reducing TTD in the pilot whale drive hunt, and it recommended the use of this method in other drive hunts. It was noted that Japanese hunters already are trying out similar methods in their dolphin drive hunts.

The Committee endorsed the recommendation made by the EG on developing a manual for the Faroese pilot whale hunt.

The Committee noted with appreciation that Greenland has commenced work to improve data collection on struck and lost and TTD in beluga and narwhal hunting and encourage the continuation of this work.

The Committee endorsed all recommendation made by the EG, and especially appreciated the emphasis put on the importance of training. The development of a training manual for hunters is strongly recommended.

4. NAMMCO HANDBOOK

The Council at its meeting in 2010 agreed in principal to produce a hunters' manual, and asked the Committee to further develop the idea and also present a more detailed budget for the total production of the manual.

The Committee discussed the development of the manual in is meeting in 2011. Target hunts were identified and the Committee agreed to make killing by Whale grenade-99 (penthrite grenade) a "pilot case". The pilot case together with a skeleton of the total contents of the handbook and the budget would be presented to Council at its next meeting.

Due to other commitments the work on the manual had been put on hold in 2011. The Committee revisited the issue at this meeting and reiterated what had been agreed in 2011. It was again underlined that the manual should to be very concise and concrete, with text held to a minimum and supplemented with drawings or photographic illustrations of good quality. The guiding principle should be to make everything as simple as possible without losing essential information. Furthermore the division of work was upheld – Egil Ole Øen and the Secretariat should produce a first draft of the pilot case for the consideration of the Committee before 1 June, and Greenland would supply the necessary illustrations.

The Committee agreed that the pilot case should be in Norwegian.

5. REVIEW OF EXPERT GROUP MEETINGS

An overview of all conclusions and recommendations arising from the three expert group meetings organised by the Committee was given in document NAMMCO/HM-March/2012-7. Member countries were asked to comment on and inform the

Committee of possible follow ups of those conclusions and recommendations that pertained to hunts in their region. The recommendations from the Expert Group meeting on small cetaceans would not be dealt with in this meeting given that the report had just been finalised.

In the following where recommendations are quoted directly from the respective reports, the text is in cursive.

Expert Group on the best practices in the hunting and killing of seals held 2009
<u>Recommendations:</u>

Firearms
Firearms and ammunition used should have the capacity to achieve the intended effect.
Noting that new types of ammunition have been developed for hunting, the Expert Group recommends further studies on the use of ammunition for hunting seals of different species and age groups in order to determine their capacity to achieve the intended effect.

Hakapik
Different types of hakapiks and clubs are used and known to be effective tools to stun young seals. Factual information is required to explain the effectiveness of hakapiks and clubs as stunning tools, through evaluation of the force delivered in relation to the damage produced and the relative solidity of the skull, which may vary among species.

Bleeding out
The Expert Group recognizes the value of determining the duration (average and range) of bleeding in seals when axillary (brachial) blood vessels on both sides are cut, which represents the bleeding method currently and commonly used. This information should be available for different species as differences may exist. Other bleeding methods (e.g. carotid arteries and jugular veins) could also be investigated.

<u>Comments:</u>
Norway reported that no action had taken with respect to the recommendations, but that they are hoping to initiate studies on the use of ammunition and hakapik in the Norwegian seal hunt in the course of 2012. Greenland reiterated that the Executive Order on the hunting of seals that came in 2010 had incorporated requirements and recommendations evolving from this Expert group meeting.

The Committee reiterated the recommendations and encouraged Norway to follow up with studies in particular of ammunition and calibres used for seals.

Expert Group meeting to assess killing of large whales held in 2010
<u>Recommendations</u>

Norway

The Expert Group (EG) recommended a sampling of Time to Death (TTD) in the same way as was done in previous years so that the data are comparable – either on all boats or in a random sample of boats.

Comment:
Norway started the sampling process in 2011 and plan to conclude its sampling in 2012. The Committee acknowledged what had been done in 2011 and encouraged Norway to finalise the study in 2012.

Greenland

Minke whale - Harpoon hunt
The EG recommended Greenland to present the data and analyses in a statistically more informative way than is being done now.

It was furthermore recommended the organization of a practical training course for gunners. There should, as stated by the hunters, be a debriefing at the end of the season in order to exchange information and experiences from the season.

Minke whale - Rifle hunt
The EG recommended that experienced hunters should meet with less experienced hunters to exchange information. It is especially important to focus on where to aim the first shot and the aiming of the shot that kills the whale after the floats have been attached.

More data are needed with reference to the body position where the whale is hit and TTD. Norwegian anatomical figures of the position of the brain of minke whales can be used for training purposes and be handed out to the hunters.

Comments harpoon hunt and rifle hunt minke whale
The impression is that the information exchange between experienced and less experienced hunters takes place and the Committee encourages the continuation of this very important aspect. Greenland has held courses on the use and maintenance of the harpoon canon, but have not organised practical training courses for gunners.

Bowhead
The EG recommended that shooting trials are set up to study the trajectory of the harpoon through the water and on this basis give advice on how to approach and where to aim at the whale.

Fin whale and bowhead
The EG agreed with Greenland's recommendation to increase the current penthrite charge for the fin and bowhead hunts and also to investigate a potential increase in the propellant charge.

Fin, humpback and bowhead
The EG recommended that the same modified penthrite grenade be used for the three

large species – in fin, humpback and bowhead whale hunts.

It was furthermore recommended that hunters be trained to measure and report on strike location, detonation location and distance between the two.

Comment fin, humpback and bowhead

Greenland informed the Committee that shooting trials had been set up and that the hunters had been advised on how to approach the whales and where to aim at the whale. The Committee further noted that based on the experience gained in the last couple of years of using grenades with different penthrite charges in Greenland and Iceland, the increased penthrite charge (45 g of penthrite) for the humpback and bowhead hunts in Greenland is an improvement. The Committee also took note of the new standard detonation depth of 110 cm.

In Greenland the hunters use 50 mm Henriksen Harpoon canons and the following 4 types of Whale grenade-99 exist:

Minke whale: 30 g penthrite-70 cm detonation depth - line 42 cm
Fin whale: 30 g - line 110 cm, 130 detonation depth

Following recommendations from the Expert group meeting a new grenade with 45 g of penthrite was introduced for the hunt of fin, bowhead and humpback whales in Greenland. Simultaneously the trigger rope was reduced from 110 cm to 90 cm which detonate the grenade at a depth of 110 cm.

Grenades are expensive and represent a substantial element in the overall economy of the hunt. In an interim period – until all the "old" grenades are used, the hunters of fin, bowhead and humpback whales will use what they have available. It will therefore take some years before all hunters use the new grenade.

6. NEXT MEETING

The next ordinary meeting in the Committee will be January/February 2013. In the intervening interval the Secretariat in cooperation with the Chair will call for telephone meetings when necessary, and if a face-to-face meeting is needed this will be organised just prior to NAMMCO 21 in September 2012.

7. ANY OTHER BUSINESS

Workshop on strandings

Greenland informed the Committee that they had organised a very successful workshop on stranded animals in January 2012 in connection with the annual meeting of the hunting and wildlife inspectors in Greenland. Dr Joseph Geraci had been invited and he gave both a series of lectures and also undertook practical training on dead seals.

Iceland informed the Committee that in 2005 Egil Ole Øen had been commissioned to produce a manual on handling and killing of stranded live whales. This manual which is in Icelandic can be found on http://www.mast.is/flytileidir/dyraheilbrigdi/dyravernd/hvalreki.

Definition of harpoongrenade

The Committee discussed various possible definitions of harpoongrenade without reaching a definite wording. The issue was raised by Øen who thanked the Committee for valuable input.

Workshop on data collection and statistics

The Expert Group on hunting methods for small cetaceans recommended that data be collected in a standardised manner so that it will be possible to make comparisons between hunts and development over time. Greenland noted that in order to accomplish this it would be necessary to educate personnel on how to collect data and how to produce the statistics. The Committee on Hunting Methods emphasised the importance of this issue and encouraged member countries to cooperate on organising such a dedicated workshop.

8. APPROVAL OF THE REPORT

The report was approved by correspondence on 10 April 2012.

Appendix 1

LIST OF LAWS AND REGULATIONS IN NAMMCO MEMBER COUNTRIES

FAROE ISLANDS

Parliamentary Act	No 57 of 5 June 1984 on whale hunting
	No 54 of 20 May 1996 amending Parliamentary Act on whale hunting
	No 9 of 14 March 1985 on the protection of animals, as last amended by Parliamentary Act No 60 of 30 May 1990
	No 43 of 22 May 1969 on weapons etc. as amended by Parliamentary Act No 54 of 12 May 1980
	No 128 of 25 October 1988 on hare hunting
Executive order	No 57 of 12 September 1969 on weapons etc.
	No 19 of 1 March 1996 on exemption from protection of whales
	No 126 of 23 June 1997 on protection of whales
	No 46 of 8 April 1998 on pilot whaling
	No 107 of 21 November 1989 on authorisation of whaling bays, as amended by executive order No 64 of 11 May 1992, executive order No 127 of 27 August 1992, executive order No 141 of 23 June 1993, executive order No 34 of 24 March 1994 and executive order No 94 of 31 May 2001
	No 166 of 27 August 1993 on provisional authorisation of whaling bays
	No 118 of 23 October1996 on provisional authorisation of whaling bays
	No 72 of 17 May 2000 on provisional authorisation of whaling bays
	No. 87 of 20 September 2007 on protections of whales
	No 72 of 6 June 2011 on amendment of executive order No 46 of 8 April 1998 on pilot whaling

GREENLAND

Greenland Home Rule Act	No 12 of 29 October 1999 on hunting
	No 11 of 12 November 2001 on revisions to Greenland Home Rule Act No 12 of 29 October 1999 on hunting
	No 9 of 15 April 2003 on revisions to Greenland Home Rule Act No 12 of 29 October 1999 on hunting
	No 1 of 16 Mai 2008 on revisions to Greenland Home Rule Act No 12 of 29 October 1999 on hunting
	No 25 of 18 December 2003 on animal welfare
	No 29 of 18 December 2003 on nature protection

Executive Order	No 26 of 24 October 1997 on extraordinary check and approval of harpoon canons No 22 of 19 August 2002 on trophy-hunting and fishing No 20 of 27 November 2003 on hunting licenses for full time hunters No 21 of 28 November 2003 on hunting licenses for part-time and/or sport hunters No 7 of 29 March 2011 on protection and hunting of beluga and narwhal No 21 of 22 September 2005 on protection and hunt of polar bears No 20 of 27 October 2006 on protection and hunting of walrus No 11 of 16 July 2010 on protection and hunting of large whales (*Under revision, expected approval April 2012*) No 12 of 16 July 2010 on reporting from hunting and strike of large whales (*Under revision, expected approval April 2012*) No 16 of 12 November 2010 on protection and hunting of seals

Catch registration form (1993-present) "*Piniarneq"*

ICELAND

Law	No 26, May 3, 1949 on whaling No 40, June 1, 1979 on amendments to Law No 26/1949 on whaling No 23, April 17, 1991 on amendments to Law No 26/1949 on whaling (cf. Law No 40/1979) No 92, July 1, 1991 on amendments to Law 26/1949 on whaling (cf. Law No 40/1979 and 23/1991)
Regulation	No 163, May 30, 1973 on whaling No 304, May 9, 1983 on amendments to Regulation No 163 of May 30, 1973 on whaling No 239, May 10, 1984 on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983) No 862, October 17, 2006 on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983 and 239/1984) No 822, September 14, 2007, on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983, 239/1984 and 862/2006)

	No 456, May 19, 2008, on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983, 239/1984, 862/2006 and 822/2007) No 58, January 27, 2009, on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983, 239/1984, 862/2006, 822/2007 and 456/2008) No 263, Mars 9, 2009 on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983, 239/1984, 862/2006, 822/2007, 456/2008 and 58/2009) No 359, April 6, 2009 on amendments to Regulation No 163 of May 30, 1973 on whaling (cf. Regulation No 304/1983, 239/1984, 862/2006, 822/2007, 456/2008 58/2009 and 263/2009) No 414, April 29, 2009 on the ban on whale hunting in specific areas.
Minke whaling licenses	Rules in the licenses for minke whaling.

NORWAY

Act of 29 May 1981 No 38	Relating to Wildlife and Wildlife Habitats (the Wildlife act)
Act of 27 March 1999 No 15	Relating to the Right to Participate in Fisheries and Hunting
Act of 6 June 2008 No 37	The Marine Resources Act
Act of 19 June 2009 No 97	Animal Welfare

Executive Orders from the Department of Fisheries and Coastal Affairs:

31 March 2000	Regulation of the practice of hunting minke whales.
11 March 2003	Regulation of the practice of hunting seals in the West Ice and the East Ice

The Ministry of Fisheries and Coastal Affairs and the Directorate of Fisheries issues each year executive orders relating to the participation and governing of the hunt of Whales and Seals.

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ANNEX 1

REPORT OF
THE NAMMCO EXPERT GROUP MEETING TO ASSESS THE HUNTING METHODS FOR SMALL CETACEANS
Copenhagen, Denmark
15 – 17 November 2011

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INTRODUCTION

Coastal people's right to hunt and utilise marine mammals has always been a firmly established principle in the North Atlantic Marine Mammal Commission – NAMMCO. However, embedded in this right is also the obligation for hunters and the competent authorities, to conduct the hunt in a sustainable way and in such a manner that it minimises animal suffering associated with the hunting and killing methods, and take into account hunters safety.

The Committee on Hunting Methods was formally established in 1994 to facilitate NAMMCO's work in this field and to give advice on hunting methods to the Council and the member countries. Advice given should be based on the best available scientific findings, technological developments and users' knowledge, and with due consideration to safety requirements / hunters safety and the efficient use of the resources.

The Committee on Hunting Methods has organised much of its work through the convening of international workshops. Valuable dialogues have been fostered by bringing together hunters, managers, technical experts and scientists to exchange ideas and viewpoints on hunting matters in an atmosphere of mutual respect and cooperation. The workshops have all generated recommendations at both general and specific levels. Over the years the Committee has also organised several Expert Group Meetings to address specific issues related to hunting of marine mammal (Appendix 3).

At its 19th annual meeting in September 2010 the NAMMCO Council tasked its Committee on Hunting Methods to organise an Expert Group to assess hunting methods for small whales.

Terms of reference for the Expert Group as provided by the NAMMCO Council were:

1. Review and assess current hunting and killing methods for small cetaceans
2. Review and assess information on recent and ongoing research on improvements and technical innovations in hunting methods and gear used for hunting of small cetaceans
3. Review and assess time to death (TTD) data on the killing of small cetaceans
4. Give recommendations with respect to possible improvements.

In setting up the Expert Group, the Committee on Hunting Methods identified a small group of qualified scientists and other persons with extended experience and knowledge of marine mammal hunting in general and in particular small cetaceans/or marine mammal specific biology, physiology, anatomy, pathology and statistics. All members of the Expert Group were invited in a personal capacity as experts in fields related to the issue of killing mammals. Also members of the Committee on Hunting Methods participated in the Expert Group. The Expert Group met under the chairmanship of Egil Ole Øen on 15 – 17 November 2011 in Copenhagen, Denmark.

The Expert Group was presented with data on hunting methods and killing of small cetaceans from Canada, Greenland, the Faroe Islands and Japan. The participating regions had been presented with a suggestion of what kind of data would be of interest for the Expert Group to assess prior to the meeting (Appendix 4).

At the beginning of the meeting the programme (Appendix 1) was presented and a small drafting committee (Bjørge, Geraci, Iwasaki, Levermann, Olsen, Williams and Øen) was established with the responsibility to formulate conclusions and recommendations. Based on the discussions and deliberations of the meeting they formulated and presented draft recommendations on the last day. These recommendations were discussed in plenary together with extracts of the report where fundamental views, statement or opinions of the members of the Expert Group had been expressed, and adopted by consensus. The finalising of the full report was completed by correspondence in February 2012.

The present report summarises the discussions of the Expert Group and gives the conclusions and recommendations.

The Expert Group (Appendix 2):
Dr Egil Ole Øen: *Wildlife Management Service, Norway/Sweden, chair of Expert Group**
Dr Arne Bjørge, *Institute of Marine Research, Norway*
Head of Section Eigil Bjørvik, *Department of Fisheries, Hunting and Agriculture, Greenland**
Director Eyþór Björnsson, *Directorate of Fisheries, Iceland**
Hunter Jens Danielsen, *KNAPK (Fishermen and Hunters Organisation), Greenland*
Prof Pierre-Yves Daoust, *University of Prince Edward Island, Canada*
Prof Lars Folkow, *Department of Arctic and Marine Biology, University of Tromsø, Norway*
Prof Joseph Geraci, *USA*
Hunter Svend Heilmann, *KNAPK (Fishermen and Hunters Organisation), Greenland*
Hunter Charlie Inuarak, *Nunavut Tunngavik Inc., Canada*
Dr. Toshihide Iwasaki, *National Research Institute of Far Seas Fisheries, Japan*
Hunter Erneeraq Jeremiassen, *KNAPK (Fishermen and Hunters Organisation), Greenland*
Hunter Regin Jespersen, *Grindamannafelagið (Hunters Union), Faroe Islands*
Head of Office Amalie Jessen, *Department of Fisheries, Hunting and Agriculture, Greenland*
Hunter Noah Kadlak, *Nunavut Tunngavik Inc., Canada*
Head of Section Nette Levermann, *Department of Fisheries, Hunting and Agriculture, Greenland**
Senior Veterinarian Jústines Olsen, *Veterinary Service, Faroe Islands**
Prof Lars Walløe, *Department of Physiology, University of Oslo, Norway*
Mr Glenn Williams, *Nunavut Tunngavik Inc., Canada*
Senior Advisor Hild Ynnesdal, *Norwegian Directorate of Fisheries**

*Member of the NAMMCO Committee on Hunting Methods

The NAMMCO Secretariat was represented by General Secretary Dr Christina Lockyer and Deputy Secretary Ms Charlotte Winsnes. Winsnes acted as rapporteur.

BACKGROUND

Hunting of small cetaceans takes place in many different regions of the world. A variety of weapons and methods are used often depending on several factors such as species hunted, size of the animal, hunting habitat and environmental conditions, cultural traditions, commercial availability of gear, national legislation, hunter's economy, personal experiences and preferences, and animal welfare considerations.

For animal welfare reasons it is important to achieve rapid insensibility to avoid unnecessary pain and reduce the risk of losing the animal. Thus the ideal weapon from an animal welfare point of view should render the animal instantly and irreversibly unconscious and insensible to pain, until death.

Anatomical features including Ballistics with relevance to the Killing of Small Cetaceans

A brief overview of anatomical features including ballistics with relevance to the killing of small cetaceans was given. It was emphasised that whales in general are difficult to approach and get close to in open water. With the exception of the drive hunts, the stunning and killing device must therefore be applied to the animal from some distance.

The fact that whales live in and dive under water and in the Arctic regions occasionally dive under the ice may make it difficult to observe the whale after the killing device has been launched. For the hunter it will therefore sometimes be difficult to judge if the whale is dead or not and how successful or rapid the killing attempt has been. In addition most of the species are in a negative state of buoyancy in water and will sink when they are dead.

Equipment used for whaling (whale crafts) are therefore often of a design with a multipurpose use. It should serve the purposes to stun/kill and secure the whale in order to retrieve it, in one and the same operation. To successfully achieve this effect it must inflict so much damage to organs vital for conscious life, that the whale is rendered unconscious and dies instantly or very fast.

An overview of the anatomical position of vital organs like the brain and the spinal cord in the neck, the circulatory system with the heart, main blood vessels in thorax, neck and spinal cord together with the lungs and its main vessels and main vessels in abdomen, was given. For the hunter the knowledge of exactly where these organs are situated in the whale's body and how they can be reached and wounded/damaged by different weapons is essential for a successful kill (Figs 1 and 2).

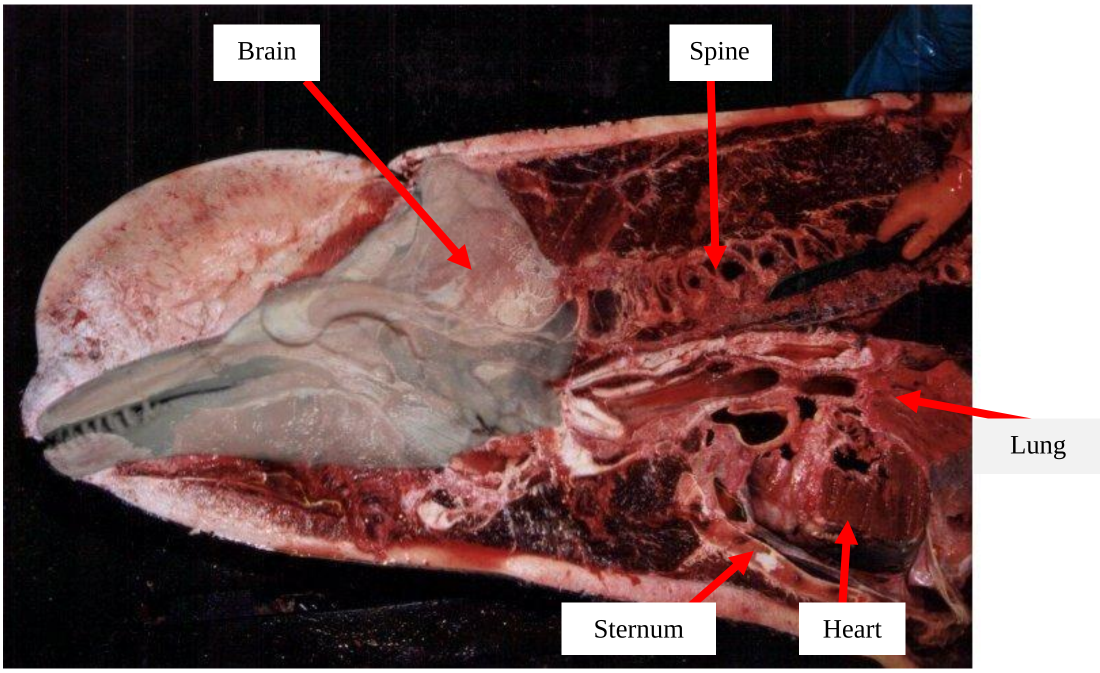

Figure 1. Longitudinal section showing anatomical positions of vital organs in head, neck and thorax of pilot whale *(Globicephala melas)*. Photo: B. Hanusson, J. Olsen

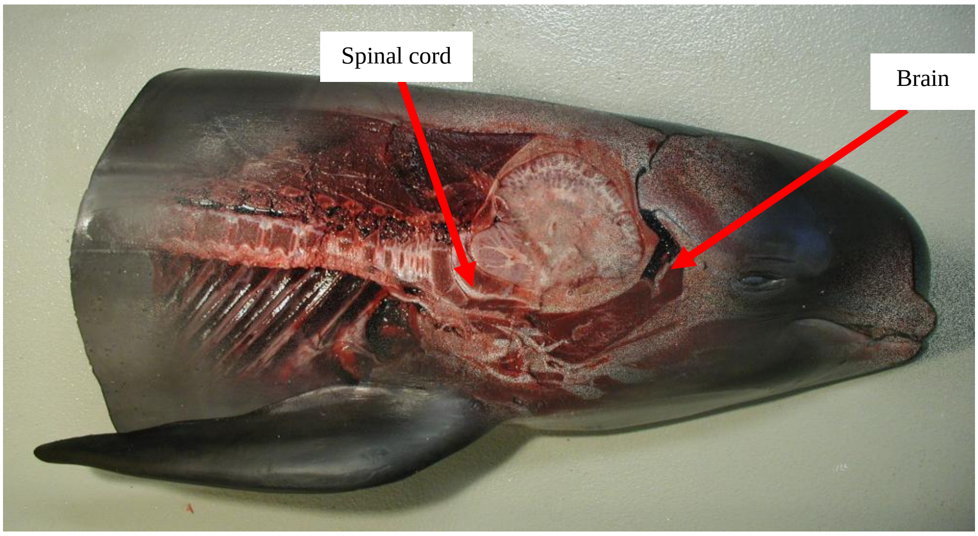

Figure 2. Pilot whale head and torso. Longitudinal section showing location of brain and spinal cord in neck and thorax. Photo: B. Hanusson, J. Olsen

Hunting and killing weapons used for whales (alone or in combination) are

- Harpoons delivered by harpoon gun or by hand
- Explosive grenades delivered by harpoon gun or darting gun (only large cetaceans)
- Firearms – rifles and different types of ammunition
- Lances - spears
- Knives
- Nets

Factors that may influence the choice of weapons and hunting methods are

- Whale species
- Traditions
- Environmental conditions
- Availability of equipment and weapons
- Economy
- Others

The hunting methods and equipment used for the hunting of small cetaceans may vary considerably. The whales may be

- Harpooned and killed with lances or firearms from the ice edge or from small skiffs
- Shot with a firearm and harpooned/hooked afterwards
- In drive hunts the whales are herded ashore using boats and rendered unconscious and killed using knife and/or spinal lance.

Criteria of Death – Voluntary versus Reflex Movements

A brief review of current criteria for insensibility and death in various mammals was given largely based on a review by Knudsen (2005). For humans, criteria exist for systemic death (irreversible cessation of cardio-respiratory function) and for brain death (irreversible cessation of all functions of the entire brain, brainstem included), according to the "Harvard criteria"[1] and the "NINDS criteria"[2]. For domestic animals in slaughterhouse practice, no official death criteria exist, but animals are classified as

[1] **Harvard criteria**

Criteria for brain death delineated by "Ad Hoc Committee of the Harvard Medical School to Examine the Definition of Brain Death". They require the absence of all of the following: cerebral responsiveness, induced or spontaneous movement, spontaneous respiration, brainstem and deep tendon reflexes. The committee also recommended the presence of a flat electroencephalogram (EEG) and tests over a period of 24 h to reveal the persistence of the condition. In addition, the following must be present: body temperature ≥32º C, absence of CNS depressants (Anon., 1968. A definition of irreversible coma. Report of the ad hoc committee of the Harvard Medical School to examine the definition of brain death. Journal of the American Medical Association 205, 337–340.)

[2] **NINDS (National Institute of Neurological Disorders and Stroke, USA) criteria**

These criteria of cerebral death require: coma with cerebral unresponsitivity, apnoea, dilated fixed pupils, absent cephalic reflexes and electrocerebral silence which should be present for 30 min at least six hours after the onset of the state (Anon., 1977. An appraisal of the criteria of cerebral death – a summary of statement: a collaborative study. Journal of the American Medical Association 237, 982–986.)

dead when cardio-respiratory function has ceased and/or the animal has been bled. Killing by bleeding is always preceded by stunning, which should cause immediate loss of consciousness which lasts until death. Stunning is typically achieved with electrical current, captive bolt or CO_2, each of which produces fairly distinctive responses in the animals. Such responses are used to assess stunning efficiency. In big game hunt, animals are mostly shot in the thorax without prior stunning and lose consciousness due to massive damages to heart/lung that compromise brain blood flow and oxygen supply. For large whales, the International Whaling Commission has defined specific death criteria: slackened lower jaw, no flipper movements, cessation of all movements with the animal rolling over (IWC, 1980). In whale hunts using penthrite grenades or rifle shot to the head/upper cervical spine, animals may be stunned as part of the killing process, while use of the harpoon or lance as a first weapon, or rifle shot to other body regions, includes no stunning prior to killing. The methods specific to hunts for small cetaceans are detailed under separate headings in this report.

For all species, reflex movements that originate from spinal cord or brain stem circuits may be displayed for several minutes after loss of consciousness or even death. Reflex movements are sometimes violent and may also persist for particularly long durations in diving mammals due to their higher tolerance to hypoxia. Determination of the state of consciousness/sensibility can be difficult, since these movements may be mistaken for signs of animal awareness. Thus, a whale may have been killed during a hunt (as judged from post mortem examinations) without fulfilment of all the IWC death criteria. Due to the lack of conclusive insensibility/death signs for various hunting techniques, it may be concluded that, as a general rule, methods that rapidly cause either blast- or rifle induced severe traumatic brain injury or damages to the heart/major blood vessels and/or the lungs that compromise blood and oxygen delivery to the brain, are likely to lead to rapid and irreversible loss of consciousness and death. If doubt exists as to the state of the animal, the killing procedures employed should be repeated.

Comments and discussion
Several comments were given after the presentation.

Brain - blood supply
It was emphasised that the use of weapons that cause massive damages to the lungs, the heart and large central vessels, or to the main vessels supplying blood to the brain, leads to rapid loss of consciousness, and ultimately death, because of the high sensitivity to hypoxia that is characteristic of nervous tissue. Haemorrhages in the brain, and in particular in the base of the brain (brain stem) from explosives or by high energy rifle bullets, cause instant and irreversible loss of brain function and instant death.

Diving mammals typically display a higher tolerance to hypoxia than most non-diving species, which allows their tissues to remain functional under more severe hypoxic conditions than tissues of most non-diving species could tolerate. This also concerns their nervous tissue. However, in this context it is important to make a distinction between hypoxic conditions (low availability of oxygen, such as towards the end of a long breath-hold dive) and anoxic conditions (no oxygen available, such as if brain blood perfusion has been stopped), since, although diving mammal neural tissue has an anaerobic capacity that is somewhat higher than in most non-diving mammals, its normal function is completely dependent on aerobic metabolism as well as on a steady supply of glucoses. This means that diving mammals should be expected to lose consciousness almost as quickly as do other mammals, if the blood supply to their brain has been stopped.

The Expert Group concluded that even if the brain of marine mammals has a somewhat higher tolerance to hypoxia than the brain of terrestrial mammals, the corresponding increase in time to unconsciousness and subsequently death following cessation of blood flow to the brain is in the order of seconds.

The Expert Group further emphasised the fact that dolphins and whales that are in the process of dying and even those that have recently died may show strong reflex movements, in particular up-and-down thrashing of the flukes or tail that can last several minutes. The thrashing can be severe and is dangerous to anyone close enough to be struck by the tail. There are insufficient data on whether these reflex movements are influenced by the hunting method. The Expert group, therefore, recommends the same precautions be taken regardless of the killing technique.

Time to Death – Principles for Collection and Processing of Data
Why do we want to record TTD?
Time to death (TTD) is internationally accepted as a measurement when discussing animal welfare issues in respect to killing of animals. TTD quantifies the time it takes for an animal to die and in doing so gives an indication of whether or not a killing method is acceptable from an animal welfare point of view. TTD may also be instrumental in discovering potential ways in which one may improve killing methods and recording of TTD may be a tool to monitor improvements and developments in killing methods over time.

How should TTD be recorded?
The best method to record TTD is to use a stopwatch and calculate the time from the first shot of the rifle or harpoon, until the animal is dead according to the accepted death criteria (mouth open, flippers slackened, all movements ceased). The next best method is to estimate TTD using an ordinary watch.

Ideally TTD should be measured or estimated by one person who has this as his or her main task during this phase of the hunt. At the same time or later, relevant other variables should be recorded ('explanatory variables'), e.g. distance to the animal, swimming angle in relation to the hunter and where the animal is hit, state of the sea and weather conditions. If the animal is still living after some time and a secondary (backup) weapon or killing method is used (e.g. harpoon first and then the rifle), the time used to change weapon/method should be recorded and subsequently used in the statistical treatment of the data.

Which and how many killings should be recorded?

The perfect and ultimate situation would be to record TTD for all animals killed. However it is scientifically sufficient to record TTD for a random (in the statistical sense) sample of the killings (or boats or hunters).

If random sampling is not possible, even non-random samples may provide valuable information, especially if ‘explanatory variables’ as mentioned earlier are recorded. In non-random sampling it is important to try to include all possible types of boats or hunters, and also to try to include the same boats or hunters (or similar boats and hunters) in the following years.

As a general rule a very small sample (~10 animals) is better than no sample at all. The results should be analysed with methods from “survival analysis” with “Cox regression” (and “logistic regression” for instantaneously dead animals).

Comments and discussion

The Expert Group emphasised that TTD data collection will benefit hunters in helping to make improvements to the hunt and to make the hunt more efficient. The Expert Group also agreed that time to death (TTD) is calculated from the moment the animal is first struck by an implement or projectile intended to secure or kill it, to the death of the animal. The Expert Group’s position was that every effort should be made to achieve the shortest possible TTD, and it was underlined that a small random sample is better and preferable to a larger non-random sample

Ballistics Training

Bullets are designed to have specific “terminal ballistic characteristics”. Lead tipped, hollow point, or round nosed bullets have different characteristics. Rifle used for hunting have bullets from a diameter of .224” (5.56 mm) up to .458” (11.6 mm) and weights from 45 grains (2,9 gram) to 700 grains (45,4 gram). Each type of bullet has different sized casings. Such variations allow the best match between the many bullet designs and their intended terminal ballistic characteristics.

Death is caused by “circulatory disruption” or “neural disruption”. Marine mammal hunting utilises neural disruption as the preferred method of killing, as the animals are taken in a marine environment while at the surface, to immobilise the animal and prevent sinking or losing the animal.

In 2006 in Nunavut six experienced narwhal, beluga and walrus hunters carried out a field test using .338 Winchester magnum and .375 H&H caliber rifles with solid and full metal jacket round nose bullets (FMJ RN). They reported (unpublished) significant penetration abilities and improved TTD when using this equipment. Controlled terminal ballistic tests done by the NAMMCO Committee on Hunting Methods in 2004 showed similar results (Appendix 3, Doc 5).

Examples of different wound channels in the tissues were demonstrated. Cavity and channel wounds were shown as well as a wound channel from FMJ military ammunition (pointed nose) (Figs 3 and 4). Depth of penetration of different bullet types and calibers were also presented.

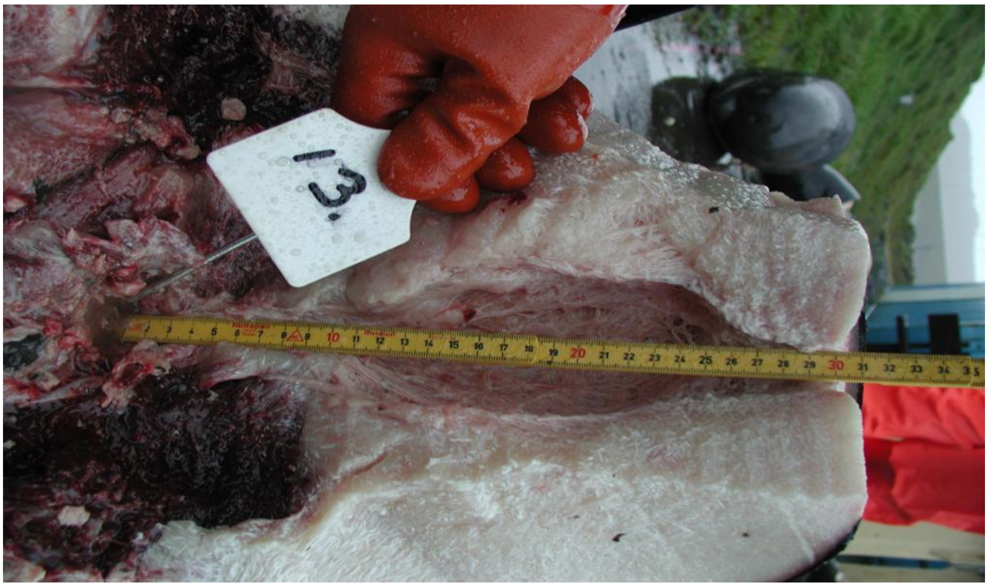

Figure 3. Cavity wound channel caused by an expanding bullet.

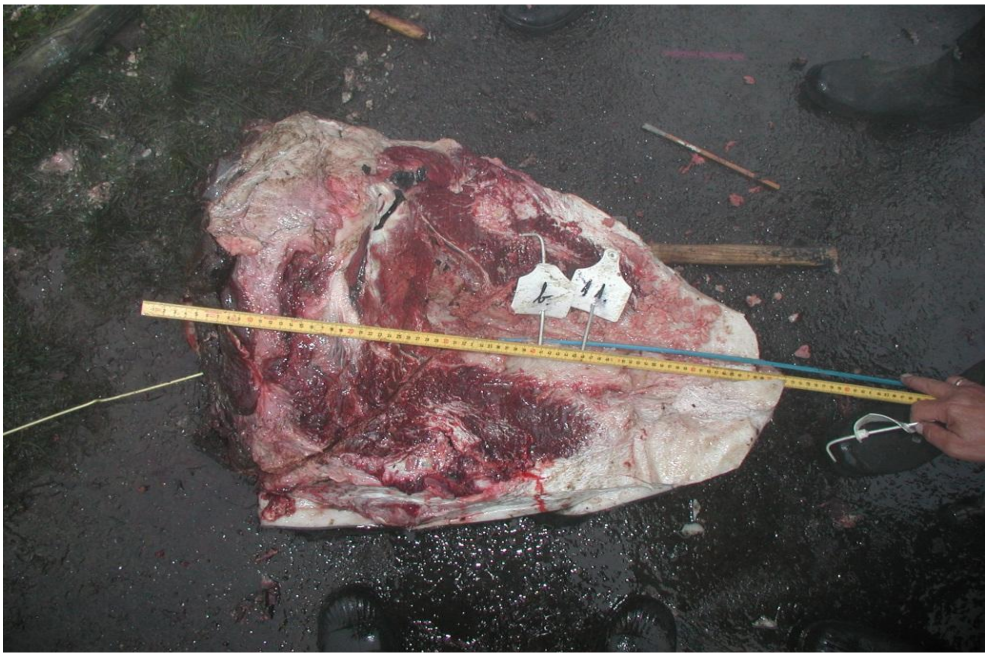

Figure 4 . The labels 11(b) and the blue probe show a channel wound caused by a .338 Win, 250 grain RN Solid bullet in the head of a beluga *(Delphinapterus leucas)*.

Comments and discussion

The caliber, the type of jacket and the bullet tip affect the size and nature of the wounding. The bullet path made by a FMJ RN bullet is often channel-like with minor cavity-formation along the path (Fig. 4). This is contrary to soft point /expanding bullets which make large cavities in the tissues they pass (Fig. 3).

Military surplus ammunitions (FMJ with pointed nose) which often rotate (tumble) in soft tissue after entry, do not penetrate as well as the round nose solid or full metal jacket bullets that do not tumble in soft tissue. For larger whales like minke whales *(Balaenoptera acutorostrata)*, high caliber FMJ RN bullets are recommended.

In hunting marine mammals, neural disruption is desirable for efficient killing as opposed to terrestrial mammals where circulatory disruption is the norm. The Expert Group agreed that for killing marine mammals, the preferred method of death is neural disruption. The most efficient wound type for neural disruption in most cetaceans is a channel wound which gives the greatest depth of penetration. Therefore the most suitable bullet types for cetaceans are; Solid round nose, FMJ RN, and Solid expanding. It also appears from the shooting trials on pilot whale (*Globicephala melas)* heads (Appendix 3, doc 5) that among the large calibers tested (.270, .308, .338, .375) in these trials the bullet type was more important than the caliber.

With respect to ammunition and weaponry, it was noted that also the skill of the hunter is very important when deciding on suitable caliber. Choice depends on the target site and the type of damage that is desired to kill the animal. It was also pointed out that high calibers give rise to greater impact and energy transformation that result in greater shock effect. However, the recoil caused by high caliber weapons might influence the accuracy of the shooting.

DESCRIPTION OF KILLING METHODS IN USE AND/OR UNDER DEVELOPMENT, SAMPLING AND REVIEW OF TTD DATA

Drive Hunts

<u>Faroe Islands</u>

The drive hunt in the Faroe Islands includes the following species: Long-finned pilot whale (*Globicephala melas)*, Bottlenose dolphin (*Tursiops truncatus)*, White-beaked dolphin (*Lagenorhyncus albirostris)* and White-sided dolphin (*Lagenorhynchus acutus).*

The Faroe Islands is divided into six districts with 23 authorised whaling bays. The most important criterion for a whaling bay is that the sea bed slopes gradually up to the shore line, and that the bay is spacious enough for the killing to take place. Whaling bays which do not fulfil these criterions are either abandoned or improved.

When a school of pilot whales is sighted (either from land, sea or air), the district administrator, the foremen or all have to decide into which whaling bay the school shall be driven. Once the decision on location is made, the boats form in a semi-circle behind the whales and stones are thrown into the water to make air bubbles, which help herd the whales in the desired direction. Upon approaching the whaling bay the boats are arranged by size, the smallest boats which can get closest to the beach, are in the front row, while the larger boats are kept behind. In this manner the school is beached or driven so close to the beach that people are able to wade out to the whales to secure them for the killing.

The actual killing method has changed very little throughout history. The whale is secured with a traditional iron whaling hook or a ball-pointed blowhole hook, after which the whale is cut across the back of the neck one hand's breadth behind the blowhole. The cut severs both the main blood supply to the brain as well as the spinal cord followed by severing the jugular veins and the carotid arteries. Once the cut is made, the whale lies completely paralyzed and unconscious[3]. The whaling knife – (in Faroese *grindaknívur)*, is used for the cutting. There are no specific formal requirements with respect to the whaling knife, but usually the length of the blade is between 16 cm and 19 cm (Fig. 5).

Figure 5. Traditional Faroese whaling knife, Photo H. Joensen

[3] International Whaling Commission: Document IWC/47/18. Report of the workshop on whale killing methods, Dublin 23-25 June 1995, p 25:
Blackmore stated that based on previous experiments on domestic stock and anatomical studies of arterial blood supply to the brain of pilot whales, the following conclusions could be logical:
1. severing the spinal cord itself will cause pain and will have no effect on loss of sensibility;
2. by severing the cord at this site, the rete of blood vessels supplying the brain will be severed, resulting in a total loss of cerebral circulation. This will result in permanent insensibility within approximately 5-10s.

In 1995 the ball-pointed blunt hook was introduced as an alternative to the iron hook. It is inserted in either of the vestibular air sacs of the blowhole. The rationale behind the new hook was to minimise the possibilities of wounding the whale before the final cut and thus reducing the total killing time. In addition the hook makes it much easier to guide the whales towards the beach. Today both the iron hook and the ball-pointed hook are permitted for securing the whales. However it has been suggested to only permit the use of the ball-pointed hook with the stipulation that the iron hook may be used given permission from the district administrator or whaling foremen in circumstances where the ball-pointed hook cannot be used for instance when the water is too deep for the whalers to reach the animal in order to insert the ball-pointed hook.

Starting in 1998 trials have been carried out with a new spinal lance (Fig. 6) to replace the whaling knife. The spinal lance makes a much more directed and swift cut and trials have shown that TTD are reduced significantly.

The killing method with the spinal lance consists of first securing the whale with the ball pointed blowhole hook. When secured the spinal lance is positioned in the midline between the blowhole and the dorsal fin at one hand's breadth behind the blowhole and directed at an angle approximately 10 degrees backward. With a single thrust followed by sideways movements the spinal cord and the surrounding blood vessels are severed, directly followed by severing the jugulars and the carotids with a whaling knife so that the whale can be bled properly.

Figure 6. The Faroese spinal lance, Photo: B. Hanusson

Systematic recordings of TTD have been carried out in the Faroe Islands, and the killing of the pilot whale has been divided in two phases. The first phase is the time from which the whale is secured with the iron hook or the newer blunt hook. The second phase is the actual severing of the spinal cord and the surrounding blood vessels. When estimating TTD using the iron hook both phases are included in the estimate, while only the second phase counts when the blunt hook is used, the assumption being that the hook does not wound the whale.

The average TTD estimate found when using the traditional whaling knife was 65.4 s (range 8.0 - 290 s), of which securing the whale on average took 29.3 s (range 0 - 132 s) while cutting the spine took 36.1 s (range 3,5 - 195 s). When using the blunt blowhole hook the average securing time was 20.1 s (range 6 - 211 s).

The average cutting time with the new spinal lance and the blunt blowhole hook was approximately 1-2 s. Consequently the total time from the insertion of the blowhole hook until the animal was dead was on average around 22 s.

Monitoring the killing time for the spinal lance by using a stop watch has been considered. However due to the very short TTD (1 – 2 s) quantification of the exact time is difficult, as the killing time using the spinal lance is the time from the start of the thrust of the lance until the spinal cord and the surrounding vessels are cut.

Comments and discussion

The Expert Group acknowledged that considerable progress had been made in improving the hunting methods in the Faroese pilot whale drive hunt with the introduction of the blunt hook and the spinal lance.

One of the explanations of the reduced securing and cutting times (TTD) is most probably that the hook is positioned in the blowhole and therefore does not interfere with the process of cutting the spinal cord and the main blood vessels to the brain. Also the blunt hook significantly decreases the time used to drag the whale onto the beach, because the whale moves in a straight line versus the side to side movements often observed when using the traditional gaff. Consequently, the total time used to secure and kill a whale is shorter using the blunt hook rather than the traditional hook.

Comments were made with respect to the presented statistics, and the underlying assumption that the blunt hook is not painful for the animal. The Expert Group could not accept this assumption as the blowhole like nostrils in terrestrial mammals probably are sensitive to stretching and strain. The general opinion of the Expert Group was that TTD should be recorded from the time the blunt hook is inserted into the blowhole, as is the case with the iron gaff until further investigations (i.e. gross post mortem and histological examination of affected tissues in the blowhole) have been undertaken and shown the opposite. TTD calculated from hooking to the time that the animal is dead still shows great improvements (65.4 s versus 22 s).

The traditional knife normally requires several cuts in order to sever the spinal cord and the blood vessels. With the spinal lance one stab is generally sufficient. The

Expert Group therefore recognised the improvements made with the introduction of the spinal lance. A critical success factor is the angle with which the lance is thrust into the neck of the whale. However, the shape and wider tip of the latest version of the lance conforms with the anatomical shape of the skull of a pilot whale and ensures that the target area is hit.

The possibility of using captive bolts for stunning in the Faroese hunt was considered. However, captive bolts are primarily designed for stunning of ruminants and the bolt will be too short to effectively destroy the brain functions and stun a pilot whale. The Expert Group therefore concluded that this method would not be an option. This is supported by former trials in the Faroese hunt which have shown that the use of the captive bolt provokes very strong movements with violent trashing of the tail, making it dangerous for the hunter to approach the whale and cut its neck.

Japan

In the Japanese drive hunt of dolphins up until 1999 the hunters drove the dolphin schools to a small bay and closed the entrance of the bay with a net after which the hunters, standing in small boats, threw lances aiming at the neck region of the dolphins. The lances were approximately 3 m long. Using a wrist watch, it was observed that it took approximately 5 min from the first strike to a striped dolphin *(Stenella coeruleoalba)* until death (disappearance of any movements).

In 2000/2001, trials were undertaken on the beach with a spinal lance of similar design as the prototype tested in the Faroese Island drive hunt of pilot whales. The hunters applied the spinal cut to 9 Risso's *(Grampus griseus),* 4 striped and 2 spotted *(Stenella attenuata*) dolphins and one southern form short-finned pilot whale *(Globicephala macrocephalus).*

In the case of the Risso's dolphins, it was easy to drag and beach the dolphins with ropes attached to the tail. Hunters considered the lack/disappearance of movement/breath to indicate that the animal was dead. The TTD of the Risso's dolphins ranged between 5 s and 40 s (n=9).

In the case of the striped dolphins, it was impossible to restrain the animals because they struggled before beaching or stranded on a rocky part of the beach (it should be done on sandy a beach). Therefore the hunters used the traditional lances to weaken the dolphins after which it was easy to cut the spine. Killing times after spinal cutting ranged between 5 s and 30 s (n=4). One whale was killed using the traditional method and TTD was recorded at approximately 5 min.

In the case of the spotted dolphins, the situation was similar to that of the striped dolphins. Spinal cut was applied for two spotted dolphins after having been hit by the lance. Killing time after spinal cut were 8 s and 10 s respectively (n=2).

In the case of a pilot whale, it was easy to simply apply a spinal cut. TTD was 25 s.

In 2008, the hunters covered the rocky part of the beach with a vinyl sheet (3 m in depth and 25 m in length) thus preventing access to this part, and drove the dolphins to the sandy beach. This attempt was successful as the dolphins in the net could be guided towards the beach without using lances and could be rapidly killed using a spinal cut.

Comments and discussion

The Expert Group welcomed the information on hunting methods from the Japanese dolphin hunt which clearly shows improvements over the recent years.

The Japanese spinal lance is different from the Faroese spinal lance with respect to length and design of the tip. The Japanese lance is thinner and more pointed than the current (latest version) Faroese lance which is wider and longer. The Expert Group underlined that this difference in shape may prolong the TTD as compared to the Faroese hunt and favoured a modification of the lance similar to the Faroese lance. The width and the double edged tip of the Faeroes lance especially ensure that the cut hits /destroys the targeted spinal cord and blood vessels to the brain with one stab.

The blood spill in the water from the exsanguinations has been used by anti-whaling groups to negatively focus on the killing of whales. In 2009, the hunters in Taiji made some attempts to prevent the blood from spilling into the sea to avoid such criticism. A modified knife with a small blade (almost similar to a shaft of 13 mm in diameters) was made to minimise the area of the wound and through that prevent the blood spill into water. Immediately after cutting the spine, the hunters inserted a wooden plug into the wound, after which the dolphins were taken to a offshore “dissection” boat for further processing.

The Expert Group discussed at length the purpose of inserting the plug into the wound of the whale to reduce the flow of blood into the sea. The Expert Group emphasised that the process of bleeding out animals is part of the killing process and that it is a widely accepted principle both from an animal welfare point of view and from the point of view of meat quality.

Whether this plugging procedure might actually prolong time to death was discussed. If the consequence is that this stops or hinders the blood draining from the brain, it might keep the brain active for a longer time period than necessary. Concerns were also raised that preventing the bleeding with the plug would reduce the quality of the meat.

Hunting using Harpoon or Firearms or Combinations of Harpoon/Firearms
<u>Greenland</u>

Harbour porpoise *(Phocoena phocoena)*

The hunt takes place in ice-free, off-shore areas using rifles from small, open boats with powerful engines. There are often several boats participating in each hunt, but there will not be any appointed leader. This collective hunt requires extreme caution from the hunters, both in order to avoid ricochet and also in order to not disturb each other's hunts.

When the whales are spotted, the hunters will approach parallel to the animals. If the weather is sunny, they will position themselves so that they have the sun in their back. This makes it easier to spot the whales when they are diving. The aim is to deliver a broadside shot into the thorax region (Fig. 7), which will kill the whale rapidly by hitting the heart, lungs or vertebrae. Typical shot ranges vary from 5 – 30 m. After a successful shot, the hunter must rush to the animal and secure it with a long shafted (4-7 m) gaff hook, called *nissik* in Greenlandic, before it sinks. Head shots are avoided, because the whale will usually sink fast and easily be lost if not reached with the *nissik*.

The minimum caliber that the experienced hunters recommend is .222 with a full metal jacket bullet. Due to the fast swimming speed, and the relatively short shooting ranges, open sights are preferred. 12 or 16 gauge shotguns were used earlier, but are no longer preferred due to an increased TTD.

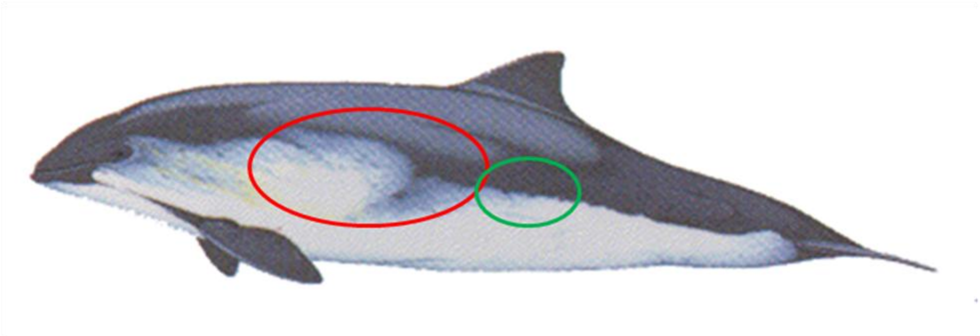

Figure 7. The red ring indicates the hunters preferred rifle target area in harbour porpoise. A hit within the green ring, is not necessarily instantly lethal, but the animal will be immobilized and can easily be retrieved. Head shots are instantly lethal, but are avoided due to the high risk of losing the whale.

White-sided and white-beaked dolphins *(Lagenorhynchus acutus* and *L.albirostris)*

White-sided and white-beaked dolphins are relatively new species to be hunted by the Greenlandic hunters. Dolphin hunting is very similar to the harbour porpoise hunt with respect to hunting technique, target area and equipment. Due to the larger body-size, more powerful rifles are preferred. The hunters recommend a caliber .30-06 rifle with full metal jacket bullets as a minimum.

The hunters have experienced that head-shots may induce violent reflex movements, and this can be dangerous to the hunters and damage the boat - and result in a higher chance of struck and loss. Hence, the hunters will try to hit the thorax region (Fig. 8).

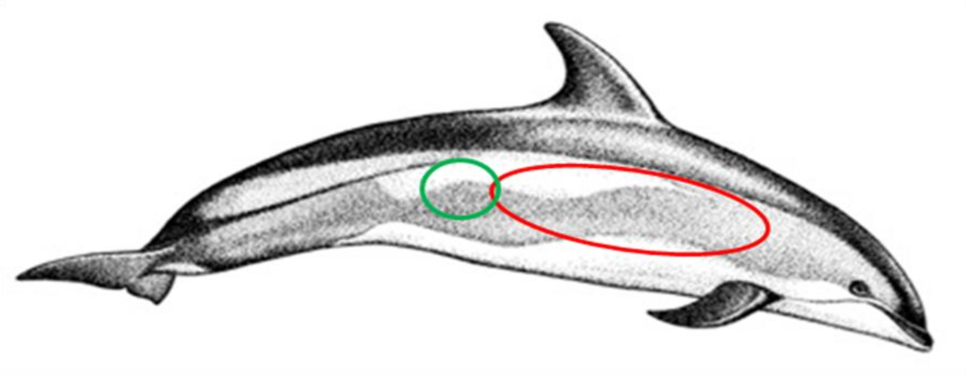

Figure 8. The red ring indicates the hunters preferred rifle target area of white beaked and white sided dolphins. A hit within the green ring, is not necessarily instantly lethal, but the animal will be immobilized and can easily be retrieved. Head shots are instantly lethal, but are avoided due to the high risk of violent reflex movements in the whale.

Long-finned pilot whale *(Globicephala melas)*

The first catches of pilot whales in Greenland were reported in 1998. The pilot whale (Fig. 9) hunt is usually performed as a collective hunt, and remains very similar to the harbour porpoise and dolphin hunts. The strong schooling behaviour of pilot whales makes the hunt relatively easy, compared to the above mentioned species. When a school is discovered, the hunters only take the number of animals that they need. The hunters recommend a caliber .30-06 rifle with full metal jacket bullets as a minimum for pilot whales.

Figure 9. The red ring indicates the hunters preferred rifle target area of a pilot whale.

Killer whale *(Orcinus orca)*

Only a few killer whales (Fig. 10) are taken in Greenland, and the hunt is usually performed as a collective hunt with small boats. Rifles, with a minimum caliber of .30-06 and full metal jacket bullets, are used as the primary weapon.

Figure 10. The red ring indicates the hunters preferred rifle target area of a killer whale.

Comments and discussion on harbour porpoise, white-beaked, white-sided, long-finned pilot whale and killer whale hunting in Greenland

The Expert Group discussed the observation reported by hunters that if the bullet hits the head the animal nearly always sinks immediately, whereas if hit in the thorax area, it floats for a while. There might be different explanations for this observed reaction, although all are hypothetical. According to one explanation proposed by the Expert Group and based on the fast swimming pattern of porpoises, an animal shot in the head might carry its momentum downward into the water, and rapid compression of the body by water pressure could quickly reduce its buoyancy; trauma to the head could also cause some loss of air from the lungs. Conversely, a shot in the thorax might break the body's streamlined downward movement, particularly if the animal is not killed instantly or if its spinal cord is damaged.

The Expert Group noted that the collective hunt makes it important to know exactly where one's fellow hunters are and also to know how ammunition deflects on water.

The Expert Group was informed that the hunters' assessment of the struck and lost rate in the collective hunts was from 5% up to 10%. It was also noted that hunters observe animals with scars indicating that they have been struck by rifle shots earlier. If a harbour porpoise is lost the hunters will look for accumulation of birds as the occurrence of birds within five minutes sometimes indicates where the animal is located.

It was reported that in Canada the .223. is now replacing the .222. because of easy access to .223 ammunition. In Greenland one can get both ammunition types but the

.223 is usually the preferred ammunition. In the NAMMCO Workshop in 1999 it was reported that there were problems getting all recommended types of ammunition for small cetacean hunting in Greenland. However, Greenland responded that this was no longer a problem.

Narwhal and Beluga *(Monodon monoceros* and *Delphinapterus leucas)*
Traditionally and culturally the beluga and narwhal are key hunting species in Greenland. Both species are hunted in North Greenland and on the West coast whereas only narwhal is hunted on the East coast.

Narwhal (Fig. 11) and beluga (Fig. 12) are hunted by harpoon from qayaqs and with rifles from small boats (skiffs). In a few places in northern and eastern Greenland the whales are also captured with nets. All types of hunting require that the hunters have licenses and are governed by regulations. There are differences in surfacing behaviour between belugas and narwhals, the latter surfacing less frequently due to their longer dives. Sea transport has increased markedly off coastal Greenland, and the hunters believe that noise may disturb the whales and their movements.

Often Greenlandic hunters combine traditional hunting methods with the restrictions of contemporary regulations. For instance, the municipalities of Qaanaaq, Upernavik and Uummannaq have developed regulations stipulating that the hunters may only use qayaqs and harpoons, thereby limiting the number of animals taken. It is prohibited to hunt whales by surrounding, trapping or blocking them against land or the ice edge.

Rifle hunt from small motor boats
The hunt takes place in open water and ice cracks. The whale is first harpooned with floats attached and then shot with a rifle of caliber 30.06/.375. full metal jacket, pointed bullets. The number of participants varies depending on the ice situation – the more ice the fewer places to move. At the start of the hunt and as it proceeds new hunters may join, but as soon as a whale is wounded usually no new hunters will be allowed to join the hunt. .

The whale is targeted at an angle from the side (Figs 13 and 14). The brain is the desired target, but the neck and heart are also regarded as good targets. The hunters may also aim for the vertebrae in the back to slow the animal and harpoon it in order to secure and kill it. The criteria of death are air bubbles rising to the surface, slackened flippers and jaw. If the whale is not hit in vital areas it dives and is killed on resurfacing. This may take up to 15 min. When the brain is hit there may be thrashing behaviour, making it risky for the hunter. TTD after hit in the brain and neck is usually instantaneous, and 1-2 minutes after hits in heart/lungs. When the animal is dead it is secured by binding a rope around the tail.

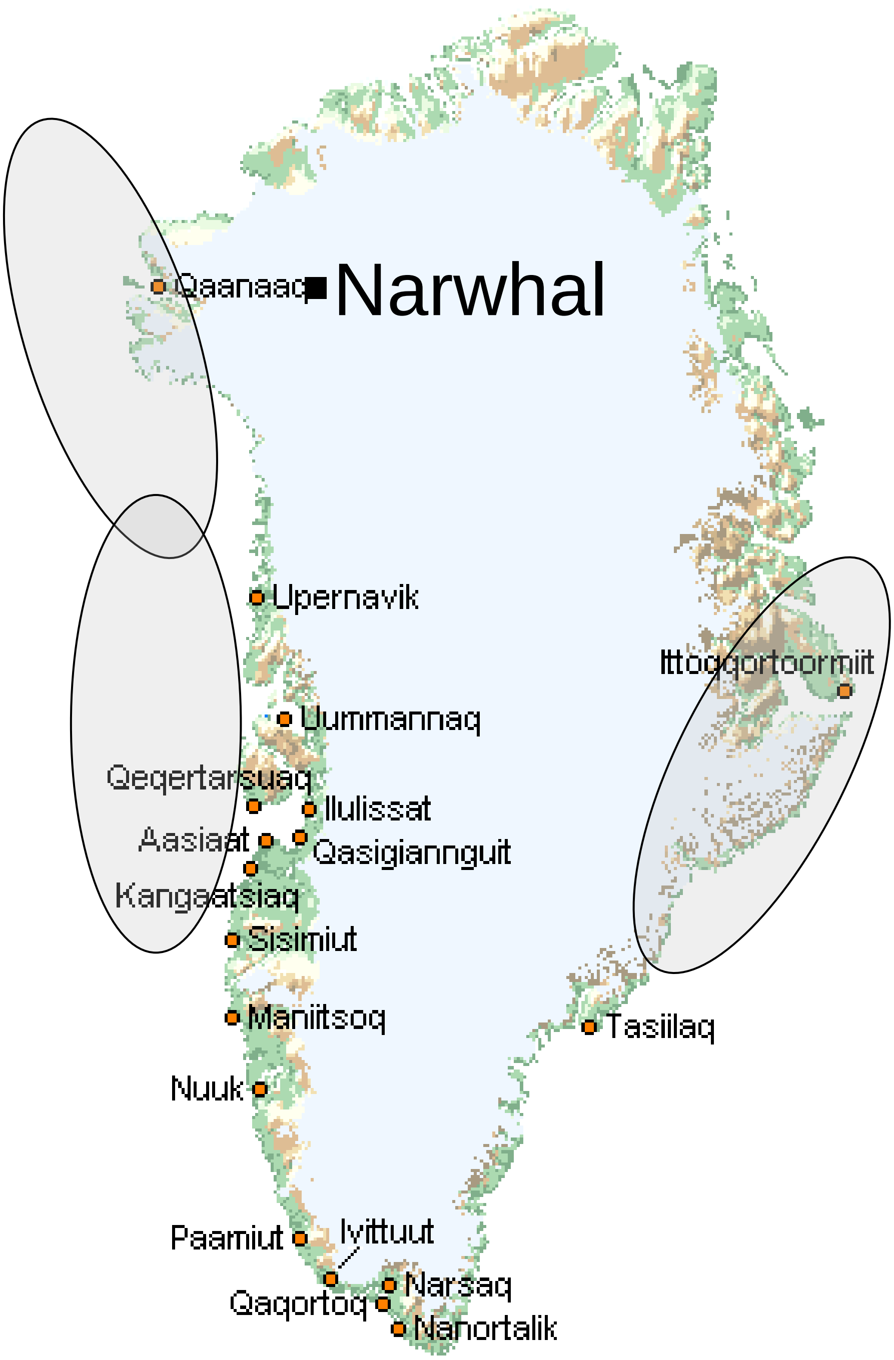

Figure 11. Narwhal hunting areas in Greenland

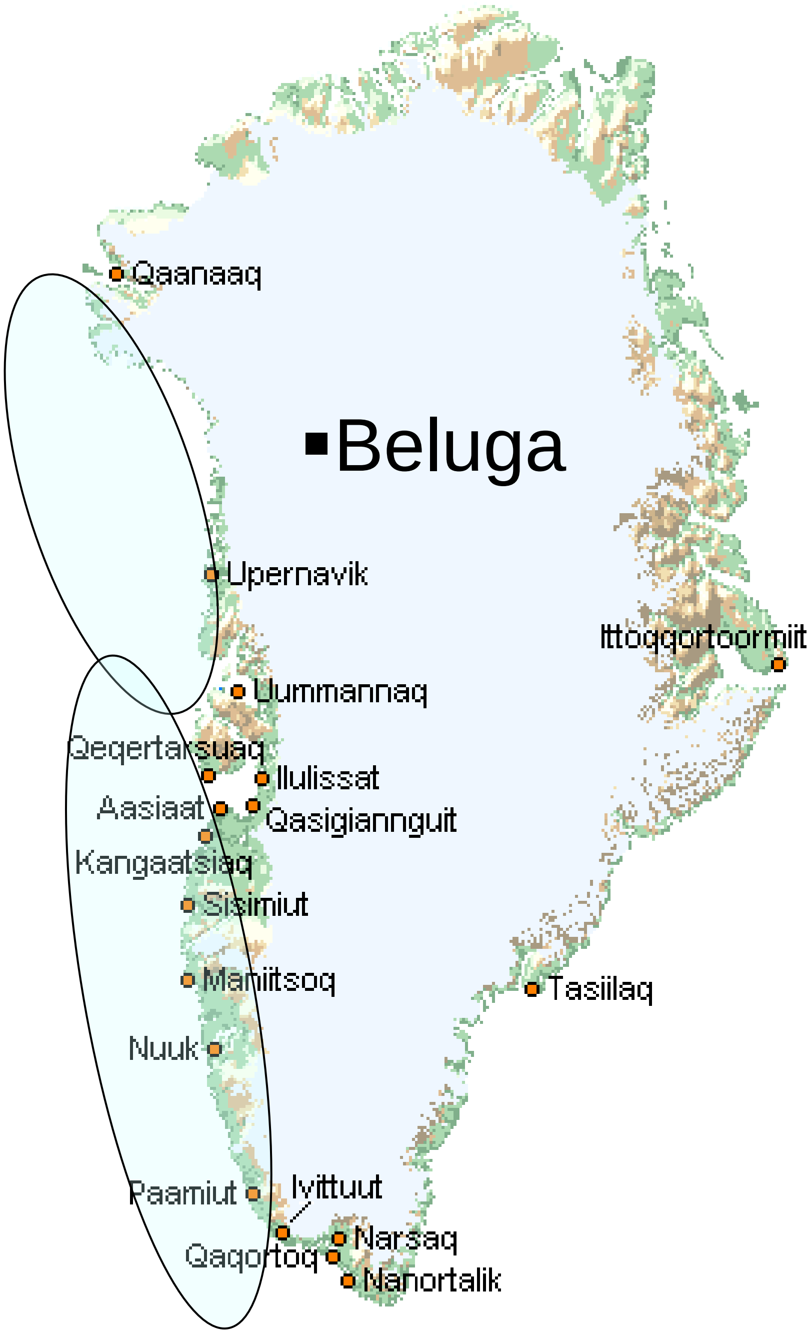

Figure 12. Beluga hunting areas in Greenland

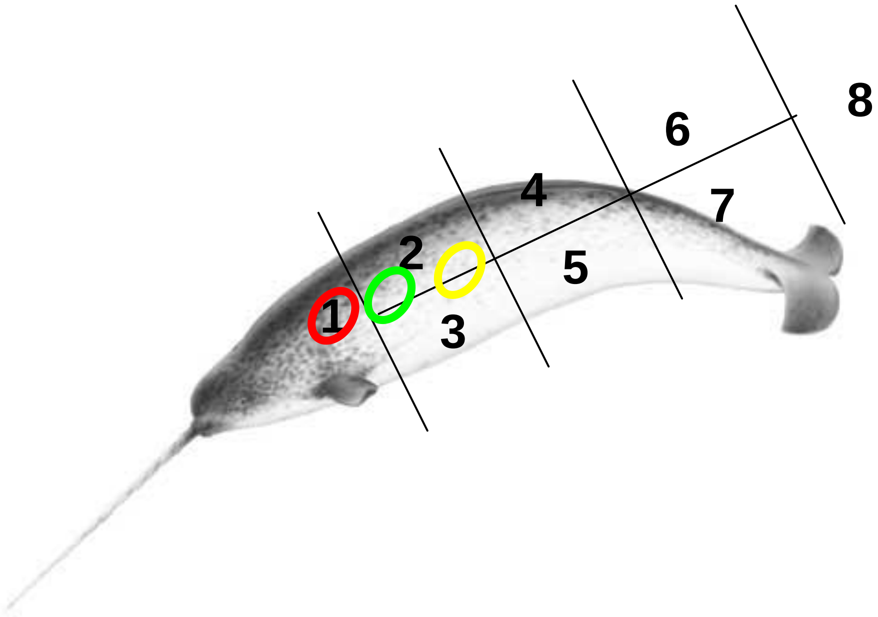

Figure 13. Narwhal hunters preferred rifle target areas. Red circle indicates position of brain, green circle indicates position of neck and yellow circle indicates thorax and the upper abdominal area.

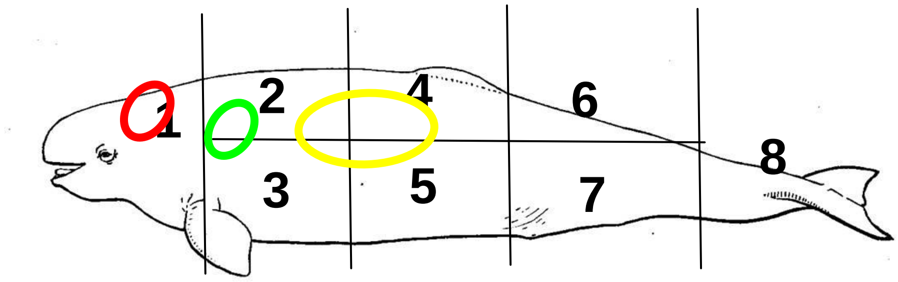

Figure 14. Beluga hunters preferred rifle target areas. Red circle indicates position of brain, green circle indicates position of neck and yellow circle indicates thorax and the upper abdominal area.

The harpoon hunt from qayaqs

This type of hunt takes place from close to the ice edge in North Greenland when there is daylight from mid-May to mid-September. Typically for safety reasons two hunters will cooperate as it is potentially dangerous to go out in a qayaq alone. Silence and stealth are important in this hunt in order not to spook the animals. The hunters will observe the whale(s) from shore and very quietly embark the qayaqs The hunter uses a hand-held harpoon in a thrower to gain extra throwing distance. The harpoon shaft (Fig. 15) is made of wood and the harpoon point is made of stainless steel and tusk from walrus. Attached to the harpoon is a buoy of skin/cloth tied to a wooden frame on a line of 15-16 m.

The whale will first be secured with the harpoon and then shot using rifle caliber 30.06 or .375 with full metal jacket pointed ammunition when it re-surfaces. The target points/areas for the rifle shot are the brain, neck or heart. The total time from the first harpoon strike to the time that the whale is dead is usually 20-25 min. When it is dead the animal is hauled to a beach or ice edge for flensing and further processing.

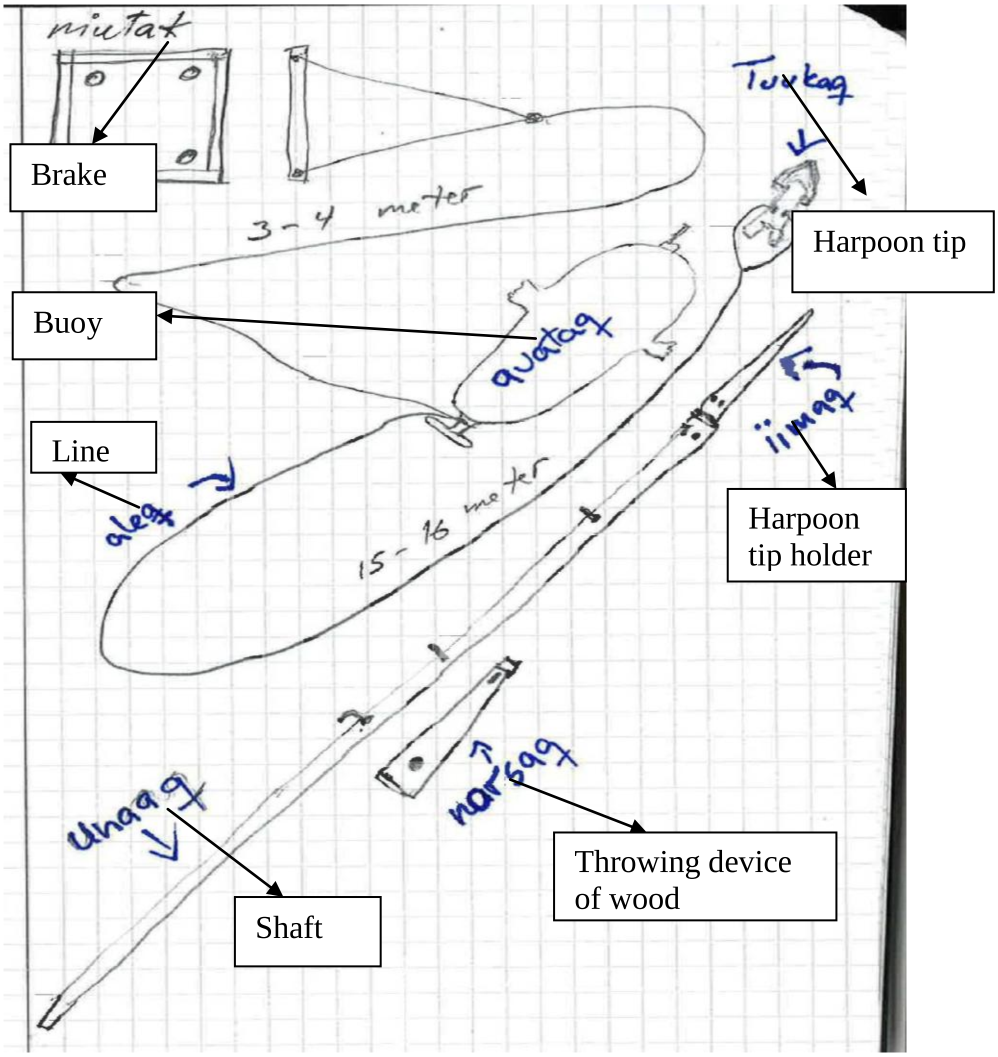

Figure 15. Hunter's drawing of harpoon and equipment used for small cetacean hunting from qayaqs in Greenland

Net hunting

This traditional method targeting narwhal is used only by Municipality Executive Order in East and North Greenland during dark periods of the year when there is no daylight and during very ice-filled conditions under the sea-ice. Approximately 20 animals are taken on an annual basis.

The net is set in open water or under the sea-ice. The net is 10 meters high and 30 – 40 m long with a 380 mm mesh-size. The net is anchored to land or ice by a wire or chain and held upright by intervals of floats attached by an arm's length of rope to the headline. The base of the net is not secured but is weighted at intervals by hanging stones. Another netting method is free floating nets anchored underwater at one end. Stones are not used for weighting the foot line, but sink lines.

All nets are checked daily for captures, and live animals will be shot.

Improvements of small cetacean hunting gears

Technological improvements in Greenland have entailed the use of hand-held harpoons made
of iron, the harpoon shafts as well as the spearing point. This makes the harpoon heavier which results in better penetration into the animal. In addition this harpoon can be used to pull up whales that have sunk. In the anticipation of possible new species being hunted the hunters have started talking about how to exchange knowledge and know-how in order to ensure that appropriate killing methods are used, while also taking the safety of hunters into consideration.

Other improvements have consisted of a better supply of ammunition, new rifles, use of stronger ropes, better boats and GPS. The GPS is used for directing hunters to the area of the last successful hunting place and is also used for timing the diving behaviour of the whales in order to predict when or where to expect the next surfacing.

Comments and discussion on Narwhal and Beluga hunting in Greenland

The Expert Group welcomed the information on narwhal and beluga hunting in Greenland.

The Expert Group noted that the hunters' experience of violent thrashing of the tail after hits in the brain with rifle bullets was common both in Canada and Greenland. The preferred target areas (brain, neck and heart) were similar. But there was a difference in preference of the target areas between Nunavut and Greenlandic hunters. The Nunavut hunters preferred the neck to the brain, while the Greenlandic hunters often targeted the brain. This might be due to the fact that the Canadian hunt described was conducted from solid ice whereas the Greenlandic hunt was on the water from small boats.

The Expert Group was of the opinion that netting is likely to cause stress for the animals associated with the capture and the possible prolonged time to death. The Expert Group noted that netting is prohibited in Greenland with the exception of East Greenland and Qaanaaq in wintertime due to the lack of visibility in the dark period making it impossible to use firearms or other more effective methods of killing

The Expert Group noted Greenland's comment that most of the work on improving its hunting methods had been done in close collaboration with NAMMCO, weapon experts and veterinarians.

Time to Death Data

Some preliminary data on TTD using different hunting methods on beluga and narwhal were presented by Greenland. These data had been sampled by hunters according to the suggested data collection set up by the chair of the Expert Group and circulated prior to the hunting season (Appendix 4).

The Expert Group very much welcomed the presented material. However the data presented were too preliminary, although very promising, to be discussed or concluded upon during the meeting. The Expert Group encouraged Greenland to continue the data sampling and to further process the data already gathered for presentation to the NAMMCO Committee on Hunting Methods at a later stage.

The Expert Group also noted that the Greenlandic hunters saw the use of GPS as beneficial for the success of the hunt, and that they expressed an interest in more organized training for hunters.

Canada

Narwhal and Beluga *(Monodon monoceros* and *Delphinapterus leucas)*

It was emphasized that the information presented was provided by Nunavut Tunngavik Inc. – an Inuit Organization, and not by the Canadian Government. The information relates to the areas of Pond Inlet, Coral Harbor, and Iqaluit in South Baffin, and describes two populations of narwhal – one wintering in Baffin Bay and another in Hudson Strait. The presentation on belugas described the summer aggregations around Somerset and in areas where freshwater outlets entered the sea. The largest group is in West Hudson Bay, which migrates to Hudson Strait in winter.

Narwhal

Three different types of hunt were presented:

1. Floe edge hunt.

   The floe edge hunt is conducted from May-June from the edge of fast sea ice near open water in Pond Inlet and Arctic Bay. Here the animals are shot from the fast ice. The animals are observed for some time before action is taken. Thereafter the animals are shot in the base of the neck area targeted from the side. The animal is retrieved with a thrown hook on a weighted line and secured to the ice. The carcass is then heaved up onto the ice by rope and tackle. It was noted that by aiming at the neck region, the animal relaxes, is immobilised and will roll to one side (trapping the air in the lungs), rather than going into spasm and thrashing. The shot is only taken when the narwhal takes a final, large breath just prior to diving beneath the ice. This also has the advantage that the animal is as close as possible to the hunter and the narwhal is struck and killed when the lungs are fully inflated thus assisting flotation of the carcass.

2. Crack ice hunt

   This hunt is carried out where cracks (leads) exist in the sea ice. As the sea ice deteriorates in the spring, cracks (leads) form giving narwhal access to new feeding areas with cracks (leads) that can be only 1.5 meters wide. The animals are again shot from the side in order to target the neck area. This hunting technique requires patience and often necessitates camping on the ice nearby for some days awaiting the narwhals' arrival. Rifles used are center-fire .338 Winchester Magnum, or .375 H&H Magnum. The original choice was the .303 British issued because it was generally available to the militia (Arctic Rangers) along with full metal jacket ammunition. These are no longer available. Guns are used with open sights but the ammunition used is generally dictated by what is available and this is generally now soft-point round nose bullets.

3. Open water hunt,

   The open water hunt is conducted from boats. This method is most generally used today because of changing ice conditions. Again the target area is the neck region and the animal is shot after it has been driven by the hunters towards the shore and shallow water.

In the spring, with its constant daylight, the hunters need to ensure they are not overly tired and have adequate rest during the hunt

Target area of the body

Narwhals will stay at the surface breathing and resting for long periods. In preparation for a dive, the narwhal will swim towards the ice edge and as it takes the last large breath before diving it will expose the vital area at the base of the skull. The hunter must be ready for this moment and shoot from the side. If the animal is alarmed or disturbed, a shot must not be taken as it may dive deeply and for a long while.

Anatomical markers are used such as the blowhole and the back of the skull to target the right shooting area in the neck region. Hits in this region damage the spine in the cervical area and shatter the base of the skull resulting in neural trauma. If the animal is shot in the lungs, it will swim rapidly away and may be lost.

The choice of gun is related to a hunter's preference and different guns may be preferred for different hunts and quarries. Generally, the strongest gun the hunter has is selected for narwhal.

The hunter will check the eye of the narwhal and if the eye is closed or if the heart is beating while the whale is hauled in the animal is not considered to be dead. Another shot will be taken – again in the neck and not the head. A shot to the head frequently results in thrashing which may be dangerous to the hunter (especially in a boat), or it may dive for up to 30 min and it may be lost. Although thrashing does not always occur when the head is shot, targeting the neck avoids this problem.

Beluga

A report was presented for the area of Coral Harbor, on Southampton Island, where the belugas are present from August – September, and later migrate south for the winter. There are four settlements in this area on the mainland where beluga hunting takes place using boats. The animal is generally chased / driven towards the beach where the water is shallower and the carcass can be seen even if it sinks.

Historically a handmade wooden harpoon was used in the hunt together with an attached line and float, thrown from the boat. Now a steel rod has replaced the harpoon shaft (weighing about 4.5 kg) which is more efficient as the extra weight permits deeper penetration and it may reach to the heart when this is aimed at the right angle from the side in the heart and lung region. The harpoon is a cold-rolled steel rod (5/8” in diameter) fashioned to a length that correlates with the height of the hunter. The handle has a rope binding (for a hand grip) at one end, while the harpoon head has a line that links it to the handle and shaft, and a long line for securing the animal. The majority of belugas (>50%) are killed using only one harpoon strike.

The animal dives after being struck and it may take 2-5 min before the animal is dead. If the strike is efficient, no further action is required. However, if necessary, the animal can be shot in the neck. This usually results in no flurrying or thrashing. When opened up, the chest and organs will be full of blood.

Comments and discussion on Narwhal and Beluga hunting in Canada

The Expert Group welcomed the information on narwhal and beluga hunting in Canada.

Commenting on the TTD it was noted that when hitting the heart the animal will die fast and when hitting the lungs it might take up to some minutes. The Expert Group noted that data on TTD would be desirable.

In a Workshop held by NAMMCO in 2001 (Appendix 3) it had been reported that many animals bear bullet scars from previous hunting encounters. The Expert Group noted that the hunter’s impression now was that this was observed less frequently than previously, and that this was perhaps because of more efficient and appropriate weaponry.

The Expert Group noted that in spring, snow and ice melt contributes to lowering the salinity at the sea surface. For this reason whales are less buoyant and more likely to sink at this time.

With respect to equipment it was reported that in the narwhal hunt a 3-pronged hook was preferred to a 4-prong hook was preferred to a 4-prong in securing the line to the ice and that a .338 rifle with expanding bullets worked well in this hunt. It was also noted that expanding bullets do not penetrate into water as well as round nosed solid bullets do.

The Expert Group recognised that the hand held harpoon is a primary weapon and is recognised as an important/essential tool to secure the animal in some forms of marine mammal hunts. The aspects of the hunter's safety and the retrieval of the animal have therefore to be balanced against the animal welfare issue.

TRAINING OF HUNTERS, MONITORING AND COLLECTION OF DATA

Hunters training

In the Faroe Islands the Pilot Whalers Association holds annual meetings to discuss experiences from the last season and potential new and better killing methods. In Greenland there was an expressed wish for more training of inexperienced hunters. However, a school for educating hunters and fishermen started in 2009 in Uummannaq where the teaching is divided between theory and practical exercises.

The Expert Group noted that in general for all types of hunts presented and discussed in this meeting training of hunters is not mandatory. Hunting knowledge is thus passed on from generation to generation and between hunters through direct observation and participation in the hunt. The Expert Group emphasised that the incentives to train new and younger hunters and also to improve killing methods are to improve and ensure hunter safety, to minimize animal suffering and to increase the efficiency of the hunt.

Monitoring and collection of data

Monitoring and systematic reporting of the hunt takes place in the Faroe Islands through the district administrators report to the Ministry of Fisheries. In the Faroe Islands each drive hunt reports data such as when and where the hunt occurred, total killing time for the school, number of whales, size and sex, number of participating boats, number of hunters on shore and in boat and any breaches of the regulations governing the hunt.

In Greenland the hunt is monitored by the local authorities and by fisheries and hunting inspectors or wildlife officers. The Ministry of Fisheries and Hunting gathers information and follows the development of the hunt through a self reporting catch system. There is one executive order (latest revision March 2011) that directly affects the taking of narwhal and beluga by controlling the hunt, the reporting and selling of edible products. Licences and hunting certificates are required for the killing of narwhal and beluga. The product of a catch cannot be sold before the municipal authorities have registered the hunt and stamped the licence. The catch report was designed to collect information on date and position of capture, hunting method and gear, sex and age, and for the 2011 hunt also on the number of rifle shots fired, the times the harpoon was used and the time to death.

In Japan and Canada (Nunavut) no formal control or monitoring mechanisms exist, and there is no formal collection of data. In Nunavut the hunt is self-reported by the hunters.

GENERAL COMMENTS AND RECOMMENDATIONS

General comments

NAMMCO's focus is on ensuring that hunters make every effort to reduce unnecessary suffering by hunted animals, by minimizing killing times to the extent feasible. We recognize that this goal must be balanced by considerations of the safety of the hunter, and the risk of losing the animal.

The Expert Group acknowledges the significant advances that have been made in achieving the goals of hunting efficiency thus reducing TTD and S&L, and that this is largely due to the growing cooperation and trust among managers, scientists and especially the hunters nationally and internationally. In this context the group is impressed by the adaptability of the hunters and their willingness to effect changes.

It is inherently difficult to compare hunting efficiencies from one method or country to another. The Expert Group recognises that technology and methodology differ from species to species, region to region, and country to country. The goal is not to unify methods and techniques but to ensure that, by open dialogue that transfers information, each hunt is conducted within the circumstances that define its methodology in a manner that maximizes hunter safety, and reduces TTD and S&L, while achieving the intended goal.

Specific comments and recommendations

The Expert Group expressed its appreciation and congratulated the hunting communities with the progress made to improve the animal welfare aspects of the drive hunts for small cetaceans.

Drive hunt - Faroe Islands

The Expert Group noted that the introduction of the spinal lance has entailed significant improvements in the TTD for the Faroese pilot whale hunt. The Expert Group also noted the extensive advances that had been made in the development of the lance.

The Expert Group recommends:

- An illustrated manual is developed to document the technique, gear and bays certified for drive hunts. A manual could add credibility to the science behind the improvements, facilitate uniform practice among bays and also assist in exporting the knowledge to other hunting communities.
- The spinal lance has proven efficient in reducing the TTD and reducing the number of cuts, and therefore the standardized lance should be made mandatory for use in the Faroese drive hunt.
- Adopting this lance as a standard should not preclude further improvements of the lance.
- Any damages from the use of the newly designed blunt tipped hook should be further explored.
- TTD should be measured from the first use of the blunt hook.

Drive hunt - Japan

The Expert Group noted that a spinal lance has been introduced in the Taiji drive hunt and is expected to have improved the efficiency of the hunt in relation to TTD. The Expert Group recommends that this effect be documented with an appropriate sample size for the involved species.

The Expert Group noted the difference between the Faroese and Japanese spinal lance and blowhole hook and recommends Japan to adapt the design of the Faroese spinal lance and perhaps the blowhole hook.

Finally the Expert Group recommends a study to document the effects of plugging the bleeding wound on the efficacy of killing and the quality of the meat product.

Hunting of pilot whales, dolphins and porpoises - Greenland

The Expert Group recommends that regulations on equipment and hunting methods are developed for harbour porpoises, white-sided and white-beaked dolphins, pilot whales and killer whales and that efficiency, struck and lost rate and TTD are documented for the involved species. It is recommended that data are gathered in a standardized manner making comparison between hunts and development over time possible.

Hunting of beluga and narwhal - Greenland

The Expert Group appreciates Greenland's effort to improve the data collection on struck and lost and to initiate data collection on TTD. It is recommended that data are gathered in a standardized manner making comparison between hunts and development over time possible.

Netting - Greenland

The Expert Group noted that netting of beluga and narwhal is prohibited in most areas in Greenland, but is allowed in East Greenland and one location in North West Greenland. This method is used when there is no other available option. The Expert Group noted that netting is likely to cause stress for the animals associated with the capture and the prolonged time to death and recommends that every attempt should be made to develop alternative catching methods.

Hunting of beluga and narwhal - Canada

The Expert Group noted the information on hunting provided by the Inuit hunters of Nunavut. The Expert Group encourages management agencies to engage with NAMMCO in its commitment to

- Continue to improve standards of hunting methods;
- Training of hunters;
- Assuring the funding of programmes to document TTD.

It is recommended that data on TTD and S&L are gathered in a standardized manner making comparison between hunts and development over time possible.

Hunter training

The Expert Group recommended that hunters should be trained in both the theoretical and practical aspects of hunting, and that training materials and programmes should be appropriate to local conditions.

The Expert Group recommends the development of a training manual for hunters, to include such topics as hunters' safety, anatomy of the relevant species with emphasis on target sites likely to minimise TTD and S&L, required equipment, such as weapons, ammunition and secondary equipment, approaches to efficient utilisation of carcasses, and other topics to be identified. The Expert Group recommends a small working group be identified to explore the feasibility of developing such a manual, fully identify its components and develop a plan of human and other resources needed to produce it.

"STRUCK AND LOST" IN SMALL CETACEAN HUNTING

The issue of S&L was not on the agenda for the meeting but was raised at the beginning of the meeting. It was agreed to discuss the issue if time permitted. However due to lack of time the Expert Group recommended that Greenland and Canada in cooperation discuss the issue. The following statement was submitted for inclusion in this report from Greenland and Canada:

- It was noted that Canada did not present new or recent information on rates of S&L for small cetaceans.
- It was noted that Greenland reports a loss rate of 0 on a reported catch of 179 narwhals and 86 belugas.
- Canada and Greenland delegates agree that an exchange of information and experience on the collection of S&L rates in the harvesting of marine mammals would be beneficial to both the resource harvesters and the management decision process.

Appendix 1

PROGRAMME

TUESDAY 15 NOVEMBER

0900 – 1045 INTRODUCTORY SESSION – agenda items 1, 2, 3, and 4

1. INTRODUCTION – Terms of reference, review of documents, meeting procedure
2. ANATOMICAL FEATURES INCLUDING BALLISTICS WITH RELEVANCE TO THE KILLING OF SMALL CETACEANS
3. CRITERIA OF DEATH **-** VOLUNTARY VERSUS REFLEX MOVEMENTS
4. TIME TO DEATH – PRINCIPLES FOR COLLECTION AND PROCESSING OF DATA

1045 – 1100 Coffee break
1100 – 1700 MAIN SESSION - agenda item 5
1300 – 1345 Lunch
1515 – 1530 Coffee break

5. DESCRIPTION OF KILLING METHODS IN USE AND/OR UNDER DEVELOPMENT,
   SAMPLING AND REVIEW OF TTD DATA
   - 5.1 Drive Hunt **-** Pilot whales, Dolphins and Harbour porpoise
     - 5.1.1 Faroe Islands
     - 5.1.2 Japan
     - Review of TTD
     - Assessment and comparison of methods and efficacy
     - Recommendations

WEDNESDAY 16 NOVEMBER

0900 – 1700 MAIN SESSION - agenda item 5 continued

5. DESCRIPTION OF KILLING METHODS IN USE AND/OR UNDER DEVELOPMENT,
   SAMPLING AND REVIEW OF TTD DATA
   - 5.2 Hunting using harpoon or firearms or combinations of harpoon/firearms
     - 5.2.1 Pilot whales, Dolphins and Harbour porpoise
       - 5.2.1.1 Greenland
       - 5.2.1.2 Canada
     - Review of TTD
     - Assessment and comparison of methods and efficacy
     - Recommendations

     - 5.2.2 Beluga and Narwhal
       - 5.2.2.1 Greenland

5.2.2.2 Canada
Review of TTD
Assessment and comparison of methods and efficacy
Recommendations

THURSDAY 17 NOVEMBER

0900 – 1700 MAIN SESSION AND CLOSING OF MEETING
6. CONCLUSIONS AND RECOMMENDATIONS
7. OTHER MATTERS
8. ADOPTION OF REPORT

Appendix 2

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Appendix 3

LIST OF DOCUMENTS AND REFERENCES

NAMMCO/EG/Doc 1	Programme
NAMMCO/EG/Doc 2	List of Documents
NAMMCO/EG/Doc 3	List of Participants
NAMMCO/EG/Doc 4	Terms of Reference
NAMMCO/EG/Doc 5	Olsen and Øen: Shooting trials on heads of dead pilot whales – guidelines to test the efficiency of rifle ammunition used for hunting and euthanasia of small whales (2004)
NAMMCO/EG/Doc 6	Olsen: Killing methods and equipment in the Faroese pilot whale hunt.
NAMMCO/EG/Doc 7	Olsen: Information from the Faroe Islands to the NAMMCO Expert Group meeting on small whale killing, Copenhagen Nov. 15th to Nov. 17th
NAMMCO/EG/Doc 8	Toshihide Iwasaki: Brief report on improvement of slaughtering method in dolphin drive fisheries in Taiji, Japan during the years between 2000 and 2010
NAMMCO/EG/Doc 9	Roberge and Dunn: Assessment of the subsistence harvest and biology of narwhal (*monodo monoceros L.)* from Admiralty Inlet, Baffin Island N.T.W. 1983 and 1986-89.
NAMMCO/EG/Doc 10	Øen: Data collection in preparation for the Expert Group meeting on assessing hunting and whale killing data for small cetaceans 15 - 17 November 2011

References and additional documents:

Anon. 1968. A definition of irreversible coma. Report of the ad hoc committee of the Harvard Medical School to examine the definition of brain death. *Journal of the American Medical Association* 205: 337–340.

Anon. 1977. An appraisal of the criteria of cerebral death – a summary of statement: a collaborative study. *Journal of the American Medical Association* 237: 982–986.

IWC 1995. International Whaling Commission. Report of the workshop on whale killing methods. *Report of the International Whaling Commission* IWC/47/18: 25.

IWC 1980. International Whaling Commission. Report of the Workshop on Humane Killing Techniques for Whales. *Report of the International Whaling Commission* IWC/30/15.

Knudsen S.K. 2005. A review of the criteria used to assess insensibility and death in hunted whales compared to other species. *The Veterinary Journal* 169: 42-59

NAMMCO 1999. Report from the NAMMCO Workshop on hunting methods. *NAMMCO Annual Report* 1999 265: 61-82.

NAMMCO 2001. Report from the NAMMCO Workshop on marine mammals: weapons, ammunition and ballistics. *NAMMCO Annual Report* 2001 335: 71-93.

NAMMCO 2006. NAMMCO Conference on User Knowledge and Scientific Knowledge in Management Decision-Making. Reykjavik, Iceland 2003.

NAMMCO 2006. Report of the NAMMCO Workshop to address the problems of "struck and lost" in seal, walrus and whale hunting. *NAMMCO Annual Report 2006* – Volume 1 277: 69-144

NAMMCO 2010. Report from the NAMMCO Expert Group meeting on assessment of large whale killing data. Copenhagen, Denmark, 2010.

Appendix 4

DATA COLLECTION IN PREPARATION FOR THE EXPERT GROUP MEETING ON ASSESSING HUNTING AND WHALE KILLING DATA FOR SMALL CETACEANS 15 - 17 NOVEMBER 2011

Background: To facilitate that the expert group on small cetaceans will have the essential and necessary data to do an assessment of the killing methods it is suggested that the listed data may be collected in the coming season.

It is a prerequisite that the hunters are informed that all information they give will be treated with confidentiality.

> NB! A practical method is to define death as the moment the mouth is slackened or open, the flippers are slackened/lie along the sides and/or all movements have ceased.

For any given species the following data would be of interest:

1. Weapons, ammunition and equipment/gear used or combinations of weapons/gears for the different species or in the different hunts
2. Number of animals that are struck with harpoons/rifle shots/combination of harpoon and rifle shots/gaffed (pilot whales) and retrieved
3. Number of animals that are struck with harpoons/rifle shots/combination of harpoon and rifle shots/gaffed (pilot whales) and lost 1) dead or 2) alive
4. If whales were lost, the most probable reasons for losses
5. If harpooned and shot ; Where the animal was hit with harpoon and rifle shot(s) (Please, mark as exactly as possible on a figure)
6. How many shots and/or harpoons were used before the animal died
7. If available measured Time to Death (TTD) (**using watch**): Time measured from the first harpoon/shot/gaff to the animal is perceived as dead
8. In the absence of measured TTD (point 7) report estimated TTD, (**without using watch**): Estimated time from the first struck of harpoon /shot/gaff to the animal is perceived as dead

In addition the following information would be acknowledged:

- Is training of hunters mandatory?

  If YES what kind of training and how is it transmitted/given to the hunters
- If there are control mechanisms, to describe these
- How are data reported

1.3
REPORT OF THE COMMITTEE ON INSPECTION AND OBSERVATION

The Committee on Inspection and Observation met at the Faroese Representation in Copenhagen on 8 March. Present were Nette Levermann Chair (Greenland), Eyþór Björnsson (Iceland), Egil Ole Øen and Hild Ynnesdal (Norway), Jústines Olsen (Faroe Islands), and Christina Lockyer and Charlotte Winsnes from the Secretariat. Ulla Svarre Wang (Faroe Islands) participated by phone.

1. OPENING PROCEDURE

The acting Chair of the Committee, Nette Levermann, welcomed the Committee members to the meeting. The draft agenda was adopted and Charlotte Winsnes acted as rapporteur.

2. THE 2011 SEASON

Documents NAMMCO/I&O-March 2012-2 containing the report from the Secretariat of the Observation Scheme for 2011 and NAMMCO/I&O-March 2012-3 containing the confidential reports from the two observers active in 2011 were presented to the meeting.

Minke whale hunt in Iceland and whale and seal hunting in Greenland had been the focus of the observation scheme in 2011. Two observers were contracted, one in each region, and no violations had been observed.

The observer arrived in Greenland 15 August and returned on 8 September. During this period observations were made in Illulissat, Qeqerarsuaq, Aasiaat and Aknnaaq. The observer participated and observed at two seal hunts, three minke whale hunts (two harpoon hunts and one communal rifle hunt involving 10 boats), and the flensing site. He made observations at the local markets and on one occasion observed the delivery from a boat that had been out hunting. In total 6 seals were hunted of which 2 were struck and lost and 3 minke whales of which 1 was struck and lost.

The observer arrived in Iceland 15 July and returned on 18 July. In this period he went out on one hunting trip with a minke whale boat and observed the taking of two minke whales.

The Committee took note of the reports, and also that whaling in the Faroe Islands will be the scope for the 2012 season.

3. TRAINING COURSE FOR OBSERVER CANDIDATES

Document NAMMCO/I&O-March/2012-4 presented the programme for the training course for observer candidates that was agreed upon last year. Document NAMMCO/I&O-March/2012-5 gave the list of the 13 approved observer candidates for 2012.

The Council had approved the idea of organising a training course for observer candidates at its last meeting in September 2011, and the Secretariat in cooperation with the Committee had been tasked with the implementation. Initially the plan was to hold the course in the winter 2012, but due to various reasons (availability in terms of time of instructors and candidates) the course had been postponed and it will now take place in the beginning of 2013.

The Committee had no further comments to the draft programme, and the Secretariat was urged to set a date for the course well in advance to secure that both the candidates and the presenters would be able to participate.

4. ANY OTHER BUSINESS

The Committee underlined the importance of its work and function, and noted that the Committee now reports directly to the Council. Its function is two folded; to be a standing review body to monitor the implementation of the Control Scheme and provide recommendations for improvements when necessary and provide advice to the Secretariat when needed.

The Committee therefore requested that annual meetings be held in order to meet its obligations and recommends that the ToR be amended with a new paragraph IV. as follows:

TERMS OF REFERENCE FOR
THE COMMITTEE ON INSPECTION AND OBSERVATION

I. The Committee shall function as a standing review body to monitor the implementation of the Observation Scheme under the Joint NAMMCO Control Scheme and provide recommendations for improvements.
II. The Committee shall upon request from the Secretariat provide advice on the Observation Scheme.
III. The Committee shall report to Council.
IV. The Committee shall meet once a year, preferably prior to the annual meeting of the Council, unless otherwise decided by the Council. Additional meetings may be held when judged necessary by the Committee and approved by the Chairman of the Council.
V. The Financial aspects of the Observation Scheme shall be dealt with by the NAMMCO Finance and Administration Committee.

5. ADOPTION OF THE REPORT

The final report of the meeting was approved by correspondence on 24 August 2012.

SECTION 2 – MANAGEMENT COMMITTEES

2.1
REPORT OF THE MEETING OF THE MANAGEMENT COMMITTEE FOR CETACEANS

12 September 2012, Svolvær, Norway

1. CHAIRPERSON'S OPENING REMARKS

The Chair, Ásta Einarsdóttir (Iceland), opened the meeting and welcomed all participants (Address Section 5.3).

2. ADOPTION OF AGENDA

The agenda (Appendix 1) was adopted.

3. APPOINTMENT OF RAPPORTEUR

The Secretariat was appointed as rapporteur.

4. CONSERVATION AND MANAGEMENT MEASURES FOR WHALE STOCKS

The Chair summarised past proposals for conservation and management and responses with reference to document NAMMCO/21/MC/3 (Section 2.2 Annex 1) and past requests to the Scientific Committee and responses with reference to document NAMMCO/21/MC/4 (Section 2.2 Annex 2), and NAMMCO/21/MC/5 (NAMMCO Annual report 2011, Section 2.1, Appendix 3) – recommendations to member countries in 2011. All new recommendations to member countries on scientific research arising and approved by the Management Committee for Cetaceans are contained in Appendix 2.

The Chair of the Scientific Committee, Lars Witting, presented the information on whale stocks from the Scientific Committee report (NAMMCO/21/6, Section 3.1).

4.1. Fin whales

Status of past proposals for Conservation and Management

In 2011 the Management Committee reiterated its endorsement from 2010 that an annual take of up to 154 fin whales from the West Iceland (WI) Sub area is sustainable for the next 5 years.

Requests from Council for advice from the Scientific Committee

There was one ongoing request to the Scientific Committee:

R-3.1.7 – NAMMCO/17-2008: to complete an assessment of fin whales in the North Atlantic and also to include an estimation of sustainable catch levels in the Central North Atlantic.

At **NAMMCO/19-2010** the Management Committee recommended that Iceland carry out the simulation trials required to check if catch levels for 60% tuning are sustainable in the long term as soon as possible. It was further recommended that studies should be carried out to help distinguish between alternative stock structure hypotheses, using several different approaches such as genetics, satellite telemetry and photo-identification.

Update from the Scientific Committee

The planned Icelandic rerunning of the trials with 60% tuning of the RMP has yet to be completed. Iceland included a stock structure hypothesis testing in its research proposal to the IWC in June 2012 but this was not finalised at the time of the NAMMCO SC meeting.

Iceland reported that there had been no fin whale hunt in Iceland the last 2 years and that it is anticipated that hunting will take place in 2013.

Conclusions by the Management Committee

The Management Committee **noted** the report and **reiterated its recommendations** from 2010.

The Management Committee further **noted** that there had been no catches of fin whales in Iceland in 2011 and 2012.

4.2. Humpback whales

Requests by Council for advice from the Scientific Committee

There was one pending request to the Scientific Committee:

R-3.2.4 - NAMMCO/15-2006: to conduct a formal assessment following the completion of the T-NASS. Furthermore to investigate the relationship between the humpback whales summering in West Greenland and other areas and incorporate this knowledge into the estimate of sustainable yields of West Greenland humpback whales.

At **NAMMCO/19-2010** the Management Committee recommended to run detailed simulation testing of the AWMP-C procedure. The development and simulation testing of management procedures for humpback whales in West Greenland is ongoing in the IWC, and it was recommended that NAMMCO relies on this work to avoid duplication.

Update from the Scientific Committee

The recommended analyses (see NAMMCO Annual report 2011, Section 2.1) to detect responsive movements to survey vessels in humpback whales will not be performed by Iceland.

It had been noted that humpback whales are present in areas off East Greenland that have not previously been surveyed, in agreement with information provided by observers on seismic surveys.

Conclusions by the Management Committee

The Management Committee **noted** the report.

4.3. Sei whales

Requests from Council for advice from the Scientific Committee

There was one pending request to the Scientific Committee:

R-3.5.3 amended NAMMCO/19-2010: to assess the status of sei whales in West Greenland waters and the Central North Atlantic, and provide minimum estimates of sustainable yield.

At NAMMCO/20-2011 the Management Committee noted that the response from the Scientific Committee implies that although an assessment of sei whales can in theory be conducted it is not likely to result in a realistic estimate of sustainable yield. This is primary due to the lack of recent abundance estimates that cover more than a fraction of the distribution area for this stock. Therefore the Management Committee recommended that the Scientific Committee monitors the development and proceeds with an assessment as soon as sufficient data become available.

Update from the Scientific Committee

Sei whales are not a priority species for the coming surveys for Greenland, Norway, and the Faroes, and Iceland have not yet decided on the matter.

Iceland informed the meeting that sei whales might be one of the target species depending on the how the next surveys are designed.

Conclusions by the Management Committee

The Management Committee **noted** the report, and **reiterated its recommendation** from last year that the Scientific Committee monitors the development and proceeds with an assessment if and when sufficient data become available.

4.4. Minke whales

Status of past proposals for Conservation and Management

In 2011, based on new abundance estimates, the Management Committee agreed that annual removals of 229 minke whales from the CIC (Central Iceland Coastal) area are sustainable and precautionary at least for the period 2011 – 2016.

Requests from Council for advice from the Scientific Committee

There was one ongoing request to the Scientific Committee:

R-3.3.4 - NAMMCO/17-2008: to conduct a full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic once results from the 2009 survey become available.

Update from the Scientific Committee

At **NAMMCO/19 2010** the Management Committee for Cetaceans recommended calculating, as soon as possible, catch limits based on running the RMP on the Central North Atlantic medium area, with catch cascade allocation of catches to small areas.

However no progress has been made partially because the Icelandic quotas have not been fully utilised.

It was reported that the logistics and specifications of the Norwegian Minke Whale DNA Register have now been reviewed. The register gives information on:

- Data for 98.6% of the whales landed from 1997 to 2010
- Probability of match between two whales from 0.0006 to 0.00000003 (5 *vs* 8 *loci*)
- Allows for verification of traded whale products *via* matches to the register
- Application of similar registers to other species has been evaluated
- Iceland has established a similar register for fin and minke whales.

Norway informed the meeting that, in addition to being a data base to monitor whale products, the register has proven very useful in giving information on minke whale biology and behaviour that are relevant for management. Norway did not conduct sighting surveys (with minke whales as prime target species) in 2012, but intend to do so in 2013 to complete the current 6-year cycle.

Conclusions by the Management Committee
The Management Committee **noted** the report from the Scientific Committee

4.5 Narwhal – West Greenland

Requests for advice from the Scientific Committee
There were four ongoing requests to the Scientific Committee:

R-3.4.10 - NAMMCO/14-2005: future surveys for beluga and narwhal should be planned using the international expertise available through the Scientific Committee, and with input from hunters at the planning stage. In addition, if and when new survey methods are applied, they should be calibrated against previously used methods so that the validity of the survey series for determining trends in abundance is ensured.

R-3.4.9 - NAMMCO/15-2005: to provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland. In 2009 (NAMMCO/18) it was further specified that there was no need for a broad assessment for all marine mammals, and that focus would be on walrus, narwhal and beluga (ongoing).

R-3.4.11 – NAMMCO/17-2008: to update the assessment of both narwhal and beluga when new data are available.

R-3.4.12 - NAMMCO/19-2010: to provide advice on sustainable takes for narwhal from the Kane Basin in spring, summer and fall.

Advice from the Scientific Committee

West Greenland

The SC agreed on the metapopulation structure for narwhals in Baffin Bay, Hudson Bay, and adjacent waters as a useful approach for identifying summer aggregations as management units in narwhals. The model includes seasonal movements with relationships between stocks and hunting localities and satellite tracking of whales that return to summering grounds the following year suggest inter-annual site fidelity, with summer aggregations to some extent being demographically-independent subpopulations with minimal or no exchange of animals.

Narwhals in Canada constitute 5 separate stocks with some limited exchange between 3 of the stocks. Coastal summer aggregations in Greenland constitute 2 stocks in addition to 2 fall-winter aggregations supplied by narwhals from several summering stocks. Several of the narwhal stocks are mixing on the wintering areas in Baffin Bay-Davis Strait, but mating most likely occur after the initiation of migration towards summering areas.

The Scientific Committee recommends that a small Working Group (WG) fully explore the allocation of harvest to summer aggregations before the next NAMMCO/JCNB JWG meeting.

Aerial surveys conducted in the North Water in May resulted in new fully corrected abundance estimates of 10,677 (95% CI: 6,120-18,620) narwhals in 2009 and 4,775 (95% CI: 2,417-9,430) in 2010.

New data on age structure were reviewed by the Scientific Committee and these data from hunts were found to be useful for assessment models by providing better estimates of population growth.

The assessments of West Greenland narwhals were updated with age-structured data, recent abundance estimates, and catches. Several scenarios of stock delineations and harvest allocations were explored, and the Scientific Committee agreed that the current quotas are sustainable. A new and updated advice is expected from the next NAMMCO/JCNB JWG meeting based on a metapopulation model.

Area	Current quotas
Inglefield Bredning	85
Melville Bay	81
Uummannaq	85
Disko Bay	59
Total	310

East Greenland

Satellite tracking shows that narwhals in East Greenland have a yearly migration where they leave the fjords and move off the coast in winter. Whales from the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland, and the Scientific Committee agreed that narwhals in Scoresby Sound (Ittoqqortoormiit) and Kangerlussuaq-Sermilik (Tasiilaq) should be treated as 2 separate stocks.

Abundance estimates from 2008 are

- Scoresby Sound: 3,900 (95%CI:13,100-1,160)
- Kangerlussuaq-Sermilik: 1,520 (95%CI:5,540-417)

Age-structure data from Ittoqqortoormiit were applied to assessments of both East Greenland areas, and the harvest was found to select for older animals. It was estimated that narwhals in the Ittoqqortoormiit area have increased slightly, while narwhals in the Tasiilaq/Kangerlussuaq area might be stable. The current growth rate in the absence of harvest was estimated between 1.2% (95% CI:0–3.5) and 3.7% (95% CI:1.6–5.9), depending upon model and area.

The Scientific Committee agreed on the following new advice with a 70% probability of increase:

- Scoresby Sound: total removal per year 70
- Kangerlussuaq-Sermilik: total removal per year 18

The Scientific Committee recommended continued work on survey correction factors, collection of age-data for improved assessments, studies for the estimation of struck and loss rates, and further development of assessment models.

R. 3-4-9

Little information is available on the response of marine mammal populations to changing Arctic conditions including sea ice, climate, prey species and increasing human development (seismic, shipping, drilling). It is recommended to organize an international symposium on the effects of seismic and other development activities on Arctic marine mammals with a focus on beluga and narwhal.

Greenland informed the meeting that it is following the scientific advice given by NAMMCO and has set a quota level with a 70% probability of continued growth.

Greenland noted that the USA is planning a workshop on the anthropogenic impact on cetaceans with a more general focus than the Scientific Committee is planning. It was emphasised that efforts should be made not to duplicate work.

Age Estimation Workshops for narwhal and beluga

Two workshops were held in December 2011 and concluded that counting of tooth growth layers can only be used for belugas and not routinely in narwhal tusk. Furthermore, contrary to what has been the assumption before, the now accepted standard is one annual growth layer group (GLG). The Scientific Committee recommends standardization among laboratories. For narwhal, the aspartic acid racemization technique has proven promising and the Scientific Committee recommends it for beluga for calibration and also as an alternative method. A final growth layer reading exercise in beluga is planned for later in 2012.

Conclusions by the Management Committee

The Management Committee **noted** the report and the new advice of total removals from Scoresby Sound and Kangerlussuaq-Sermilik.

The Management Committee further **endorsed the Scientific Committee recommendation** to fully explore the allocation of harvest to summer aggregations of narwhals in West Greenland before the next NAMMCO/JCNB JWG meeting, and also its recommendations to continue its work in line with work on survey correction factors, collection of age-data for improved assessments, studies for the estimation of struck and loss rates, and further development of assessment models.

The Management Committee **encouraged** the Scientific Committee to further plan an international symposium on the effects of seismic and other development activities with focus on narwhal and beluga. The Management Committee **noted** that two age estimation workshops had been held and that a final growth layer reading exercise would take place later in 2012.

4.6 Beluga - West Greenland

Requests by Council for advice from the Scientific Committee

There were four ongoing requests to the Scientific Committee:

R-3.4.9 - NAMMCO/15-2005: to provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland. In 2009 (NAMMCO/18) it was further specified that there was no need for a broad assessment for all marine mammals, and that focus would be on walrus, narwhal and beluga (ongoing).

R-3.4.10 - NAMMCO/15–2005: future surveys for beluga and narwhal should be planned using the international expertise available through the Scientific Committee of NAMMCO, and with input from hunters at the planning stage. In addition, if and when new survey methods are applied, they should be calibrated against previously used methods so that the validity of the survey series for determining trends in abundance is ensured (ongoing).

R-3.4.11 – NAMMCO/17-2008: to update the assessment of both narwhal and beluga when new data are available.

R-3.4.13 - NAMMCO/19–2010: to reconsider the temporal and geographical restrictions on the takes of beluga from West Greenland within the framework of the NAMMCO/JCNB JWG in view of recent dynamic changes in the environment.

Advice from the Scientific Committee

R-3.4-11

The Somerset Island stock supplies the belugas overwintering off West Greenland and in the North Water (Qaanaaq), where the majority of the removals take place. Although there are not enough data to quantify the influx of belugas from Cumberland Sound to West Greenland, it is unlikely that these animals contribute significantly to the exploited winter aggregation in Greenland.

Catches in West Greenland declined during 1979-2011 from about 1,300 in the early 1980s to levels below 300 whales per year after 2004. There are no research plans for quantification of struck and lost rates in belugas.

There are no new survey estimates from West Greenland (next 2012).

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

The assessments of West Greenland beluga were updated with age-structured data, recent abundance estimates, and catches. Results from different scenarios provided annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated to 44% (95% CI: 16%–88%), with a yearly replacement of 510 (95% CI:170–780) individuals.

The Scientific Committee agreed that the revised assessment confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it is concluded that a total annual removal of 310 belugas in West Greenland is sustainable (excluding Qaanaaq). A new updated advice is expected at the next meeting based on a new abundance estimates from the spring survey in 2012, and the Scientific Committee noted that new abundance estimates for assessments should be available at least every 10th year.

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

R-3.4.13
The Scientific Committee reiterated the recommendations for seasonal closures to allow for the possible reestablishment of local aggregations of belugas:

- Northern area (Uummannaq, Upernavik and Qaanaaq): June through August
- Central area (Disko Bay): June through October
- Southern area (south of Disko Bay to 65°N): May through October.
- The area south of 65°N: closed for hunting.

The purpose of these is to allow for the possibility of reestablishment of local aggregations of belugas in Greenland.

Greenland informed the meeting that it has set a quota of 310 animals with a 70% probability which includes Qaanaaq even though the NAMMCO advice is currently excluding Qaanaaq. Greenland is therefore looking forward to a new advice for the Qaanaaq area.

Hunters have reported observations of beluga in East Greenland but there are so far no confirmed observations in East Greenland and the assumption is that the observed animals may be from the Spitsbergen stock.

The Faroese commended Greenland for implementing its multi-year management plans.

Greenland reported that hunters are obliged to report struck and lost (S/L) animals but very few reports are received. In Greenland the reported S/L are deducted from the quota which probably does not increase the hunters' motivation for reporting. One of the conclusions from the NAMMCO/JCNB JWG was to increase the effort to collect S/L data both in Canada and Greenland.

Greenland acknowledged the recommendations on seasonal closure and informed the meeting that it will discuss the implementation of this advice nationally.

Conclusions by the Management Committee
The Management Committee **noted** the report and that the total annual removal of 310 belugas in West Greenland is sustainable and **endorsed the recommendations** on seasonal closures.

4.7 Northern bottlenose whales

Update from the Scientific Committee
The Faroese T-NASS 2007 data have been analysed together with data from CODA for a model-based estimate of abundance.

The Faroe Islands informed that at the next meeting in the WG on Abundance estimates, the feasibility of generating an abundance estimate of northern bottlenose whales will be explored.

Conclusion by the Management Committee
The Management Committee **noted** the report.

4.8 Killer whales

Requests by Council for advice from the Scientific Committee
There is one pending request:

R-3.7.2-NAMMCO/13-2004: to review the knowledge on the abundance, stock structure, migration and feeding ecology of killer whales in the North Atlantic, and to provide advice on research needs to improve this knowledge. Priority should be given to killer whales in the West Greenland – Eastern Canada area.

Update from the Scientific Committee

Studies of the genetic differentiation of north Atlantic killer whales and acoustic signals produced by killer whales were conducted in Icelandic waters in 2011.

Conclusions by the Management Committee

The Management Committee **noted** the update.

4.9 Long-finned pilot whales

Requests by Council for advice from the Scientific Committee

There were two ongoing requests for advice from the Scientific Committee:

R-3.8.5 - NAMMCO/19–2010: to assess the status of long-finned pilot whales in West Greenland waters and provide minimum estimates of sustainable yield.

R-3.8.6 – NAMMCO/20-2011 to continue work to complete a full assessment of pilot whales in the North Atlantic and provide advice on the sustainability of catches, as soon as necessary further information becomes available, with particular emphasis on the Faroese area and East and West Greenland. In the short term, the Scientific Committee was requested to provide a general indication of the level of abundance of pilot whales required to sustain an annual catch equivalent to the annual average of the Faroese catch in the years since 1997.

Advice from the Scientific Committee

R-3.8.6: A full assessment of pilot whale around the Faroe Islands is unlikely to be conducted in the near future due to lack of necessary information. For the short term advice both the AWMP-C procedure (which has been used for preliminary advice for baleen whales in West Greenland by NAMMCO and the IWC), as well as the PBR approach, could be used to reflect precautionary estimates of the minimum abundance estimates required to sustain the Faroese hunt.

The annual average catch in the Faroes since 1997 is 678 animals . The AWMP-C procedure needs an abundance estimate of 50,000, and the PBR approach an abundance estimate of 80,000, to conclude that the Faroese hunt is sustainable. However, the geographical range of the stock(s) that supply the Faroese hunt is unknown, and it is unresolved how the calculated estimates compare with the accepted estimate of 128,000 (95% CI: 75,700-217,000) pilot whales from the Icelandic and Faroe Islands area of T-NASS.

The Scientific Committee reiterated its previous recommendations which were endorsed by the Management Committee for Cetaceans at NAMMCO/20-2011 for further research to improve the basis for providing more robust estimates of pilot whale abundance, which include:

- tracking animals from as many schools as possible
- additional work on trends, abundance, and stock structure
- timely implementation of a long-term monitoring programme.

The Faroe Islands welcomed the new precautionary estimates by the Scientific Committee of the minimum abundance estimates required to sustain the Faroese hunt. The Faroe Islands informed that satellite tracking will continue to explore the geographical range of the animals recruiting to the Faroese catches; data necessary for performing a full assessment. It was suggested that the Scientific Committee look at alternative work to solve and speed up the stock structure issue. A new trend analysis has been finalised, no significant trend was detected in abundance estimates between the survey years 1989, 1995 and 2007. The long term sampling programme is in the planning stage.

R-3.8.5: The average annual catch in West Greenland during 1993-2007 was 126 whales. An aerial survey conducted in 2007 gave an estimate of 7,440 animals (95% CI 3,014-18,367). Applying a PBR approach estimates a sustainable harvest level of around 50 whales per year, while the AWMP-C procedure gives an annual take of 70 whales. However, the survey did not cover the entire range of pilot whales in West Greenland. The summer aggregation in West Greenland cannot be considered an isolated stock, as it is likely connected to pilot whales along Labrador and at Newfoundland, and the occurrence and abundance in West Greenland is probably influenced by the sea temperature regimes in the area although the extent of this is not known.

Greenland welcomed the advice and informed the meeting that this will be included in the upcoming Executive Order on hunting and protection of small cetaceans.

Conclusions by the Management Committee

The Management Committee **noted** that it is unlikely that a full assessment of the pilot whales in the North Atlantic can be conducted in the near future.

For the West Greenland hunt it is difficult to reach any conclusion on sustainability because there is too little information on the inter-relation between animals in Labrador and Newfoundland. Never the less the advice from the Scientific Committee provides a minimum estimate of sustainable yield.

The Management Committee concluded that the minimum level of abundance of pilot whales required to sustain an annual catch equivalent to the annual average of the Faroese drive hunt is estimated to be in the range of 50,000 to 80,000 animals.

4.10 White-beaked, white-sided and bottlenose dolphins

Requests from Council for advice from the Scientific Committee

There was one pending request to the Scientific Committee:

R-3.9.6 - NAMMCO/13-2004: to carry out assessments of these species when sufficient information was available on stock delineation, distribution, abundance and biological parameters to initiate the work.

Advice from the Scientific Committee

The average annual catch of white-beaked dolphins in West Greenland during 1993-

2007 was 30 dolphins. In 2007 an aerial survey estimated an abundance of 11,801 animals (95% CI 7,562-18,416). Applying a PBR approach suggests that the sustainable harvest level of white-beaked dolphins taken from this abundance would be around 125 whales per year.

In 2011 the first stranding of a bottlenose dolphin in Iceland was recorded, which is also the first confirmed record of the presence of bottlenose dolphins in Icelandic territorial waters.

The Faroe Islands has collected samples from the drive hunt of white-sided dolphins in 2001-2009 and the analyses will be finalised within the next couple of years.

Greenland welcomed the new advise which will be included in the before mentioned new Executive Order on small cetaceans.

Conclusions by the Management Committee
The Management Committee **noted** the report and that the annual catch of white-beaked dolphins in West Greenland is sustainable.

4.11 Harbour porpoise

Requests for advice from the Scientific Committee
There is one ongoing request to the Scientific Committee:

R-3.10.1 - NAMMCO/7-1997: to conduct a comprehensive assessment of the harbour porpoise throughout its North Atlantic range.

Advice from the Scientific Committee
Norway's total annual by-catch estimate of 6,900 harbour porpoises raises concerns that the by-catch of harbour porpoises in Norway may not be sustainable. It is therefore recommended to initiate an assessment of harbour porpoises in Norway that include *i)* reviewing the by-catch estimates *ii)* examining the relevant abundance estimates *iii)* assessing the need for coastal surveys of harbour porpoises in Norway *iv)* investigating the use of satellite tracking for stock delineation, and *v)* evaluating the use of acoustic deterrents (pingers) in the gillnet fishery in order to reduce the by-catch.

Greenland now has sufficient data for an assessment of harbour porpoises in West Greenland and both Iceland and the Faroe Islands have abundance estimates as well as some estimates of by-catch in Iceland.

It is therefore suggested that assessments of harbour porpoise be attempted for all areas. This will require at least two meetings, with the first meeting providing a full assessment for West Greenland, and initiating the process for Norway, including a review of the method used for obtaining total by-catch estimates. The second meeting should focus on by-catch in Norway and Iceland, attempt to finalize assessments for Norway, Iceland and the Faroes, and could, if feasible, evaluate methods for reducing by-catch.

Greenland welcome the proposed work and urges it to take place as soon as possible as harbour porpoises is by far the most hunted small cetacean in Greenland.

Norway supported the suggested plan to undertake an assessment. Today Norway does not have very good abundance estimates for harbour porpoises, and it is anticipated that in order to assess the sustainability of the by-catch of harbour porpoises substantial work remains to be done.

Conclusions by the Management Committee

The Management Committee **noted** the report and endorsed the plans to undertake an assessment of harbour porpoises for all areas.

4.12 Bowhead whale

Update by the Scientific Committee

A genetic mark-recapture estimate in West Greenland revealed an abundance in 2009 of 1410 bowhead whales (95% CI: 783-2038) confirming an increase of observed animals in previous aerial surveys. A new abundance estimate based on aerial surveys and genetic mark-recapture will be available later in 2012.

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

Given the increase in sightings it is suggested that abundance trends are monitored for the East Greenland - Svalbard population. Norway will continue the passive acoustic monitoring with two extra devices in the northern Fram strait and north of Svalbard.

Conclusions by the Management Committee

The Management Committee **noted** the report.

4.13 Sperm whale

Past proposals for Conservation and Management

In 2011 the Management Committee recommended the re-processing of the T-NASS 2007 survey acoustic data from Iceland.

Update by the Scientific Committee:

The Icelandic and Faroese data may be reanalysed at end of 2012 (paid for by NAMMCO), and data will then be available for the development of abundance estimates by Iceland and the Faroe Islands.

Conclusions by the Management Committee

The Management Committee **noted** the report.

5. T-NASS 2015 and Survey Planning

The most optimal year for a large scale coordinated survey is 2015. The survey plans for the different countries are generally similar to those of the last T-NASS survey, with some exceptions described in the main report.

Based on the Working Group report and with reference to Council's decision that a new large-scale T-NASS survey of cetaceans in the North Atlantic is desirable within the near future, the SC discussed how best to approach such a large scale survey effort.

Based on experience from past surveys agreement was reached on the following specifications for a proper survey that could inform and improve management decisions:

- The survey should to the extent possible cover the potential range of the target species to provide robust abundance estimates useful for management;
- The following species were identified as being targets: long-finned pilot whales, humpback whales, fin whales, sei whales and minke whales;
- The survey should include all previously surveyed areas and it should be designed so that shifts in occurrence can be detected and that previously non-surveyed areas are covered if they are considered potentially important for abundance estimation;
- Fully corrected abundance estimates should be developed for all the areas and this will include double-platform design of survey vessels and aircrafts;
- Early in the planning stage it should be attempted to include Canada and Russia and neighboring countries in surveying parts of the Atlantic to ensure that all important areas are covered intensively;
- The survey should be planned for 2015 to ensure sufficient time for preparations and because other areas of the Atlantic likely will be covered by surveys conducted by the US and by EU. Seasonal timing will be agreed upon at a later meeting.

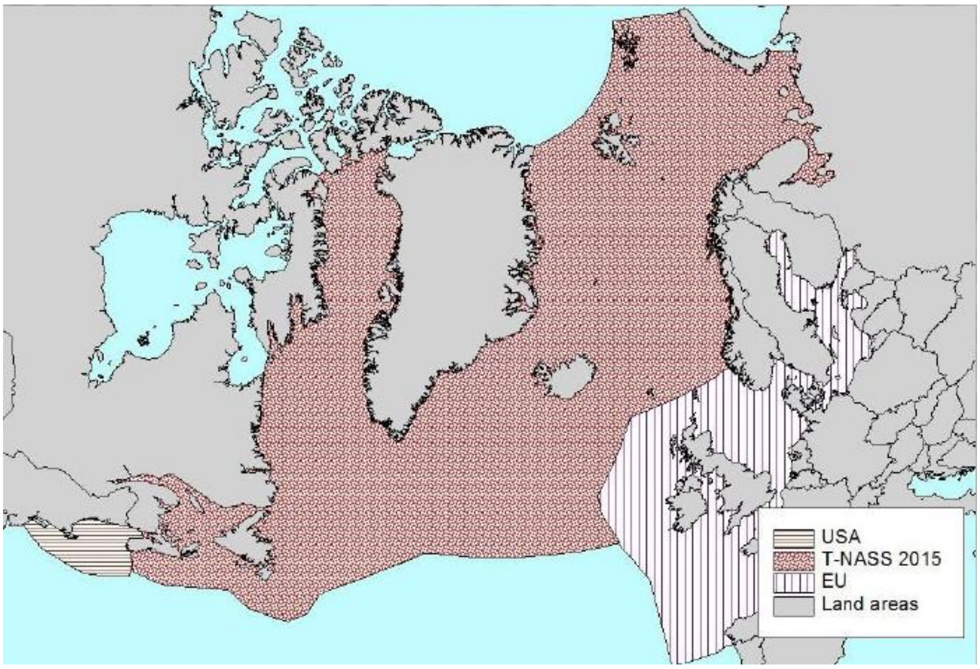

Figure 1. Proposed extent of the 2015 Trans-North Atlantic Sightings Survey (T-NASS-15).

The geographical extent of the survey is shown in Figure 1 above. In addition to areas covered in the past the following new areas were considered critically important to include in a TNASS-15 survey:

- The East Greenland shelf from Kap Farvel to about 80^{o}N where significant numbers have been detected by platforms of opportunity in recent years;
- The offshore areas between the Labrador coast and the shelf areas of West Greenland that has not been surveyed in the past;
- The areas between Iceland and Jan Mayen should be surveyed in case it is not included in the Norwegian mosaic surveys, which is important for minke whales;
- Areas south of the Irminger Sea and generally south of 55^{o}N where sei whales and pilot whales occur;
- Areas north of 70^{o}N in West Greenland where recent catches of minke whales have been taken;
- Areas between east Iceland and Norway depending on the Norwegian mosaic survey effort;
- Areas in the northeast Barents Sea, Pechora Sea where Russian surveys have indicated increased presence of cetaceans.

Based on experience from past surveys the SC has estimated the costs for a large scale to be in the magnitude of 50mill NOK. In comparison the total cost of the T-NASS-07 survey was 30mill NOK, when corrected for inflation to 2012. Partial funding of the survey could cause gaps in coverage that will leave areas without data that cannot be included in the abundance estimates and will also reduce the options for detecting shift in abundance between areas and will hamper the assessment of whale stocks.

Aside from already planned national survey activities there are also plans for surveys of cetaceans funded by oil companies in areas where oil exploration is planned and there are also expected participations from Russia, Canada and other countries. However, the expenses for a large scale TNASS-15 cannot solely be covered by current national budgets or by NAMMCO funding. It is unlikely that funding for such an effort can be secured from scientific funding agencies and SC seeks the advice from the Council on if it is desired that SC continues its planning of a large scale TNASS-15 and on possible avenues for ensuring proper funding of the survey.

Conclusion from the Management Committee
The Management Committee emphasised that sighting surveys are of the outmost importance in order to be able to make abundance estimates and make informed management decisions with respect to hunting. The MC therefore requests the SC to continue their planning of T-NASS.

The economical aspects of T-NASS will be dealt with in FAC and the final discussions and deliberations was forwarded to Council.

10. Elections of officers
Ulla Svarrer Wang (Faroe Islands) was elected chair and Nette Levermann (Greenland) was elected vice-chair for the period 2012 – 2014.

Appendix 1

AGENDA

1. CHAIRMAN'S OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEUR
4. CONSERVATION AND MANAGEMENT MEASURES FOR WHALE STOCKS

4.1 Fin whales

East-Greenland –Iceland stock
West Greenland
Faroe Islands

- Updates

4.2 Humpback whales

Greenland

- Update

4.3 Sei whales

- Update

4.4 Minke whales

Central North Atlantic
West Greenland

- Updates

4.5 Narwhal

West Greenland
East Greenland

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.6 Beluga

West Greenland

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.7 Northern bottlenose whales

- Update

4.8 Killer whales

- Update

4.9 Long-finned pilot whales

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.10 White-beaked, white-sided and bottlenose dolphins
- Update
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.11 Harbour porpoise
- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.12 Sperm whale
- Update

4.13 Bowhead whale

East Greenland - Svalbard
West Greenland
- Update
- New proposals and recommendations for scientific research
- Proposals for conservation and management

5. T-NASS 2015 AND SURVEY PLANNING
6. PROCEDURES FOR DECISION-MAKING ON CONSERVATION AND MANAGEMENT MEASURES
7. ECOSYSTEM-BASED MANAGEMENT
8. USER KNOWLEDGE IN MANAGEMENT DECISION-MAKING
9. RELATED MANAGEMENT ISSUES[4]
   - 9.1 Marine mammal - fisheries interactions[5]
   - 9.2 Environmental questions
   - 9.3 By-catch data and monitoring
   - 9.4 Other topics
10. ELECTIONS
11. ANY OTHER BUSINESS

[4] **Agenda Item 9**: These items have been placed separately from the individual species, because they overlap to varying extents with the work of other committees; items 9.1 – 9.3 incl. overlap with the Management Committee for Seals and Walruses, and will be discussed in a joint meeting of the two Management Committees; item 9.2 is also listed on the Council agenda.

[5] **Agenda Item 9.1:** This item also includes Economic aspects of marine mammal – fisheries interactions and Multi-species approaches to management

Appendix 2

LIST OF DOCUMENTS

Document no	**Title**	**Agenda item**
NAMMCO/21/MC/1	List of Documents	
NAMMCO/21/MC/2	Agenda	2.
NAMMCO/21/MC/3	Status of Past Proposals for Conservation and Management	4.
NAMMCO/21/MC/4	Summary of Requests by NAMMCO Council to the Scientific Committee, and Responses by the Scientific Committee	4.
NAMMCO/21/MC/5	Recommendations to member countries 2010	4.
NAMMCO/20/6 and ANNEXES	Report of the Eighteenth Meeting of the Scientific Committee	4., 5., 6., 7., 8. and 9.

Appendix 3

RECOMMENDATIONS TO MEMBER COUNTRIES 2012

Fin whales
Iceland:
The Management Committee for Cetaceans **reiterated previous recommendations to** carry out the simulation trials required to check if catch levels for 60% tuning are sustainable in the long term as soon as possible. It was further recommended that studies should be carried out to help distinguish between alternative stock structure hypotheses, using several different approaches such as genetics, satellite telemetry and photo-identification.

Narwhal
Greenland:
The Management Committee for Cetaceans **recommended** continued work on survey correction factors, collection of age-data for improved assessments, studies for the estimation of struck and loss rates, and further development of assessment models for the East Greenland narwhal.

The Management Committee for Cetaceans further **endorsed the recommendation** to fully explore the allocation of harvest to summer aggregations of narwhals in West Greenland before the next JWG meeting.

Beluga
Greenland:
The Management Committee for Cetaceans **reiterated previous recommendations** for seasonal closures to allow for the possible reestablishment of local aggregations of belugas:

1. Northern area (Uummannaq, Upernavik and Qaanaaq): June through August
2. Central area (Disko Bay): June through October
3. Southern area (south of Disko Bay to 65°N): May through October.
4. The area south of 65°N, closed for hunting.

Harbour porpoise
All countries:
The Management Committee for Cetaceans **recommended** that assessments of harbour porpoise be attempted for all areas. This will require at least two meetings, with the first meeting providing a full assessment for West Greenland, and initiating the process for Norway, including a review of the method used for obtaining total by-catch estimates. The second meeting should focus on by-catch in Norway and Iceland, attempt to finalize assessments for Norway, Iceland and the Faroes, and could, if feasible, evaluate methods for reducing by-catch.

2.2
REPORT OF THE MEETING OF THE MANAGEMENT COMMITTEE FOR SEALS AND WALRUS

12 September 2012, Svolvær, Norway

1. CHAIRPERSON'S OPENING REMARKS

The Chair, Arne Bjørge (Norway), was appointed to stand in for Hild Ynnesdal (Norway) who could not participate to the meeting. Bjørge welcomed the delegates (members listed in Address Section 5.3) and the observers to the Management Committee for Seals and Walruses.

2. ADOPTION OF AGENDA

The agenda was adopted (Appendix 1). The Chair reminded the Committee that agenda items 5. to 8. would be dealt with jointly together with the Management Committee for Cetaceans.

3. APPOINTMENT OF RAPPORTEUR

The Secretariat was appointed as rapporteur.

4. CONSERVATION AND MANAGEMENT MEASURES FOR SEAL STOCKS

Documents to the meeting were compiled in Appendix 2. Status of Past Proposals for Conservation and Management and Responses with reference to document NAMMCO/21/MC/3 (Section 2.2, ANNEX 1) and summary of Requests by Council to the Scientific Committee and Responses with reference to document NAMMCO/21/MC/4 (Section 2.2, ANNEX 2) were summarised. The list of past recommendations to member countries was presented for information in document NAMMCO/21/MC/5 (NAMMCO Annual report 2011, Section 2.1, Appendix 3). All new recommendations to member countries agreed below are listed in Appendix 3.

The Chair of the Scientific Committee, Lars Witting, presented the information on seal and walrus stocks from the Scientific Committee report (NAMMCO/21/6) under each species.

4.1 Harp Seals

Requests by Council for advice from the Scientific Committee

R-2.1.4 - NAMMCO/12-2003 (standing): To regularly update the stock status of North Atlantic harp and hooded seals as new information becomes available.

R-2.1.10 – NAMMCO/17-2008 (standing): To provide advice on Total Allowable Catches for the management of harp seals and the establishment of a quota system for the common stocks between Norway and the Russian Federation, leaving full freedom to the Committee to decide on the best methods to determine this parameter based on an ecosystem approach.

R-2.1.11 - NAMMCO/18-2009 (pending): To evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.

<u>Advice from the Scientific Committee</u>

The Scientific Committee examined the information provided by the ICES/NAFO Working Group (WG) on Harp and Hooded Seals (WGHARP) which had met during August 2011.

For the White Sea/Barents Sea **(R-2.1.4)** a modified population model with time-varying fecundity estimated 1,364,700 (95% C.I. 1,230,384 – 1,498,916) animals in 2011, with the sustainable catch (**R-2.1.10**) being 15,827 1+ animals (or an equivalent number of pups, where one 1+ seal is balanced by 2 pups).

The Greenland Sea population (**R-2.1.4)** seems to be data rich and the population model estimates indicate a substantial increase from 1970 to 650,000 (95% CI: 379,000-920,000) in 2011. A sustainable catch (**R-2.1.10**) will have to approximate 16,737 animals of the 1+ age class or 33,474 pups. Alternatively, given that the latest estimate is the largest, the 80% probability of less than 30% declined gives a sustainable catch of 25,000 animals of class 1+ if adequate monitoring is put in place.

Regarding **R-2.1.11** the Scientific Committee reported that abundance estimates from West Greenland need to be developed to discriminate between actual and perceived changes in abundance. The population is believed to approach carrying capacity and this is normally associated with new factors becoming important for a continued growth of the population. It is therefore uncertain whether the distribution of the seals in the years to come is predictable based on hind-cast analysis. Such analyses will, however, be important to describe how distribution patterns change as the population and the environment change. Historically the abundance of seals in Greenland waters was positively associated with increases in the harp seal population. Since 2000, it appears that ecological and hydrographical changes have changed the relationship, and possibly led to decreases in harp seals. However, there are insufficient data available to adequately analyse the latter.

<u>Recommendations to member countries</u>

The Management Committee for Seals and Walruses **endorsed** the Scientific Committee recommendations to limit the catches for the common stock between Norway and Russia (**R-2.1.10)** for the White Sea/Barents Sea to 15,827 1+ animals (or an equivalent number of pups, where one 1+ seal is balanced by 2 pups) and for the Greenland Sea to 16,737 animals of the 1+ age class or 33,474 pups; as an alternative 25,000 animals of class 1+ if adequate monitoring is put in place.

<u>Any other business</u>

Norway reported that WGHARP has recently developed a population model which includes fecundity data. This model is more realistic than the previous one, but the figures for population abundance and therefore the allowable catches are lower. Norway also commented on the poor ice conditions in recent years which probably will have a great influence on the population.

Greenland expressed appreciation for the response from the ICES/NAFO WGHARP and their consideration at their last meeting of request **R-2.1.11**. It is understandable that this is not a simple question that can be answered based on available data, but one which will require new abundance estimates with several surveys at various times of the year for some years. Greenland expressed the intention to establish a dialogue with the Institute of Natural Resources and the Hunters and Fishermen Association (KNAPK) in order to define consider our further approach.

Greenland has in 2012, as in previous years, given Norway permission to carry out scientific work on seals and to take harp seals within the Greenland EEZ.

Canada reported that the surveys in 2012 have been completed and the results will be communicated as soon as the peer review is passed. The harvest has been very low also due to poor ice conditions, and it has not fully utilised the Total Allowable Catch.

4.2 Hooded Seals

Requests by Council for advice from the Scientific Committee

R-2.1.4 - NAMMCO/12-2003 (standing): To regularly update the stock status of North Atlantic harp and hooded seals as new information becomes available. The Management Committee for Seals and Walruses noted the likely impact of increasing abundance of these species on fish stocks.

Advice from the Scientific Committee

In response to request **R-2.1.4**, the Scientific Committee reported that the ICES-NAFO WG meeting on Harp and Hooded Seals in August 2011 had reviewed the status of hooded seals in the Greenland Sea (NAMMCO/21/6). The 2007 abundance estimate is of 16,140 pups, which is considerably lower than in 1997. The population model estimate for 2011 was 85,000 to 106,000. This is well below the limit of 173,000 (30% of the maximum estimate of 575,000) animals, where WGHARP recommends that catches shall not occur. Therefore, no catches of hooded seals should be taken from the Greenland Sea, except for local catches in East Greenland.

Recommendations to member countries

The Management Committee for Seals and Walruses **welcomed** the information provided by the Scientific Committee jointly with the ICES/NAFO WGHARP and the 2012 harp and hooded seal surveys.

The Management Committee **reviewed** the recommendations of the ICES-NAFO WG on Harp and Hooded Seals and continued to **support** the recommendations for the Greenland Sea.

Any other business

The 1956 -2006 data from the Northwest Atlantic showed that the age at birth increased from 4.4 (1956-78) to 6.1 (1989-95). Pregnancy rates declined from 91-98% to 7.4-7.9%

Norwegian survey in 2012 in the Greenland Sea also identified patches of hooded seals even if it was designed for harp seals and this data might yield a new abundance estimate. The analysis of data from the 2010 scientific sampling programme to investigate the reasons for the significantly lower abundance of this species compared to earlier years will be performed in the next years.

Greenland has in 2012, as in previous years, given Norway permission to carry out scientific work on seals and to take hooded seals within the Greenland Exclusive Economic Zone (EEZ).

All models runs indicated a decrease in the Greenland Sea Hooded Seal population from the late 1940s and up to the early 1980s. The population has remained at this low level up to this date despite reduced hunting pressure. Although difficult ice conditions may have contributed, the low population level of hooded seals is far from fully understood. Samples have, however, been collected for use in studies for potential factors such as reduced fecundity, diseases, predation by polar bears and food shortage. The collected material is presently being analysed.

4.3 Ringed Seals

Requests by Council for advice from the Scientific Committee

R-2.3.1- NAMMCO/5-1995 (standing): To advise on stock identity of ringed seals (*Phoca hispida*) for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (*i.e.* disturbance, pollution) and changes in the food supply, and interactions with other marine living resources.

R-2.3.2 - NAMMCO/7-1997 (standing): To advise on what scientific studies need to be completed to evaluate the effects of changed levels of removals of ringed seals in West and East Greenland.

Recommendations for scientific research

The Management Committee for Seals and Walruses welcomed the deployment of satellite tags and **reiterated its recommendation** from the previous year to perform abundance estimates on sea ice in offshore areas but also including that updated information on fjord area occupancy is also needed.

Any other business

The Scientific Committee reported on the increased effort in research on this species towards gathering of data on movement, dive behaviour and environmental preferences of ringed seals with the use of satellite tracking devices both in Svalbard and in Greenland both in 2011 and 2012.

Norway noted that fjord ice, on which this species depends, is diminishing at a time of the year critical for survival and that data is needed to evaluate the extent of this phenomenon.

4.4 Grey Seals

Requests by Council for advice from the Scientific Committee

R-2.4.2 - NAMMCO/11-2002 (standing): The Scientific Committee had previously provided advice in response to a request to review and assess abundance and stock levels of grey seals in the North Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematode infestations in fish in particular (NAMMCO 1995). Given the apparent stock decline in Iceland, an apparent increase in Southwest Norway and in the United Kingdom, and the fact that this species interacts with fisheries in three NAMMCO member countries, the Management Committee **recommended** that the Scientific Committee provide a new assessment of grey seal stocks throughout the North Atlantic.

Advice from the Scientific Committee

The Scientific Committee recommends convening a WG meeting to finalise **R-2.4.2** in 2014 when the current studies on this species are expected to have produced results.

Recommendations

The Management Committee for Seals and Walruses **endorsed** the recommendation to prepare for an assessment, and **recommended** that the Scientific Committee proceeds with it.

Other information

The Scientific Committee reported on increased efforts in seal by-catch reporting in Iceland, but warned of the frequency of unidentified seals in the reports. A survey is expected for the summer/autumn 2012.

Norway reported on progress in the new assessment for this species and oriented the Management Committee that data on stock structure from the whole north Atlantic has been analysed and the results will be available in the next months. Norway and Russia are planning a joint research programme in the Barents Sea.

Grey seals have been protected in Greenland since 2010 according to an Executive Order.

Iceland communicated that new surveys and a catch reporting system are planned for the near future and that efforts towards the identification of the reasons behind and the quantification of the increase in pup production during the late decade.

In the Faroe Islands, studies have included the collection of samples for stock delineation. Results are expected during 2013. The mandatory reporting system for grey seal removals in aquaculture farms has been in place since 2011 and some adjustments have been implemented to improve the reporting. Abundance surveys are planned for the coming years. Due to difficulties in estimating the abundance of this species in the Faroe Islands various assessment approaches probably need to be used.

4.5 Harbour Seals

Requests by Council for advice from the Scientific Committee

R-2.5.2 - NAMMCO/16-2007 modified **NAMMCO/19-2010** (pending): To conduct a formal assessment of the status of harbour seals for all areas as soon as feasible.

<u>Advice from the Scientific Committee</u>
The Scientific Committee **recommended** convening a WG meeting to finalise **R-2.4.2** in 2014 when the current studies on this species are expected to have produced results.

<u>Recommendations:</u>
The Management Committee **reiterated its recommendation** to obtain updated information on abundance and struck and lost figures. In the case of struck and lost data it **recommended** that a struck and lost factor be developed.

<u>Any other business</u>
The Scientific Committee reported about the Norwegian aerial surveys for this species in 2011-2013. These are meant to update the earlier surveys from the years 2003-2006.

An abundance estimate of 11,000 (95% CI:8,000-16,000) was produced for Iceland and the figures are similar to the estimates from 2003 and 2006.

Tagging in South Greenland showed local movements and a coastwise breeding migration along the east coast in the period mid-June to mid-July. There are plans for installing monitoring cameras for the small groups present on the west coast.

In Norway, seals are hunted at sea and struck and lost data are important for assessment. The monitoring in place in Norway includes self-reporting for struck and lost, but there is no evaluation of the system.

Harbour seals have been protected in Greenland since 2010 according to an Executive Order.

Icelandic catches have not increased in the recent years and are low. Information on this species will be updated after an aerial survey during summer 2013.

4.6 Walrus

<u>Requests by Council for advice from the Scientific Committee</u>
R-2.6.3 - NAMMCO/15-2006 (ongoing): The Scientific Committee should provide advice on the effects of human disturbance, including fishing and shipping activities, in particular scallop fishing, on the distribution, behaviour and conservation status of walrus in West Greenland.

<u>Advice from the Scientific Committee</u>
Owing to a lack of explicit studies, the Scientific Committee is not in a strong position to provide advice on the effects of human disturbance on walrus.

The Scientific Committee **recommended** convening a Working Group meeting in the winter/spring 2012/2013 to reassess this species.

<u>Recommendations for Scientific Research</u>
Walrus quotas in Greenland presently follow the scientific advice and the quota level

has probability of sustainability of 70 % or more until 2014. The present quota block covers the years 2010-2012.

In a new request (**R-2.6.6**), the Management Committee **requested** the Scientific Committee to investigate the possibility to include a carryover for quotas in order to include this possibility in the next hearing for the new quota block period.

Any other business

A survey in 2011 estimates the Pechora Sea population at a minimum of 3,900 (95% CI:3,750-4,290) and a special monitoring programme related to oil exploration was initiated in 2010.

Norway reported on the continuation of the monitoring programme for potential impact of tourist activities on the haulouts.

Greenland recently produced new abundance estimates¸ using the associated tagging data for bias correction, for the North Water surveys of 2010.

A hunter interview on walrus has been performed by the Greenland Institute of Natural Resources and the results will be presented as soon as they are available.

4.7 Bearded seal

The Scientific Committee communicated that some limited satellite tracking of bearded seals is ongoing and continuing in Svalbard and Greenland. The Committee noted that this species, as in the case of ringed seals, faces ice-related challenges due to global change.

The Management Committee **welcomed** this progress and **reiterated its recommendation** that efforts be renewed towards gathering information on biology, abundance and stock status with the view to an assessment.

JOINT SESSION OF BOTH MANAGEMENT COMMITTEES

5. PROCEDURES FOR DECISION-MAKING ON CONSERVATION AND MANAGEMENT MEASURES

No issues were raised under this agenda item.

6. ECOSYSTEM BASED MANAGEMENT

Norway reported that two integrated management plans are already in place, for the Barents Sea and Norwegian Sea respectively, and that a third one for the North Sea is being prepared. Information on these is available upon request or on the web.

Canada reported that it is undertaking a process to revise its management plan for walrus, with the implementation of a new Integrated Fisheries Management Plan for walrus expected in 2013. This new plan will, to a large extent, make use of spatial planning to set harvest limits.

The 3rd Arctic Council Ecosystem-Based Management Experts Group Meeting will take place 3-5 October in Tromsø and NAMMCO has been invited to observe.

7. USER KNOWLEDGE IN MANAGEMENT DECISION-MAKING

The Management Committee **charged** Arne Bjørge (Norway) to observe at the presentation at the University of Tromsø of a project involving Traditional Ecological Knowledge.

Greenland oriented the Management Committees that a pilot project in three areas in North Greenland, working with local documentation and local management of living resources has been running since 2010. The final visit to the settlements will take place at end of September 2012 and an evaluation of the project will be presented at NAMMCO 22. Furthermore, there is continuing collaboration between the Hunters and Fishermen Association (KNAPK) and Greenland Institute of Natural Resources, based on a written agreement.

The Chair of the Committee on Hunting Methods informed that hunters' knowledge is an important and acknowledged part of the Committee's discussion of hunting methods and its recommendations to the Council. He also pointed at other activities where hunters' knowledge is important for a successful outcome, like sighting surveys for whales.

8. RELATED MANAGEMENT ISSUES

8.1 Marine-mammal – fisheries interaction

The Scientific Committee was informed about applications to NORA and the EU for financing the project on testing different modelling approaches. There were positive reviews from NORA but no funding obtained. The Committees **recommend** seeking national funding for this project.

In Norway, a project in Porsanger fjord investigates the ecological role of harbour seals using GSM tags, diet studies and estimates of fish resources. In the Barents Sea, using data from the Ecosystem Surveys, a study examines habitat use and prey of white-beaked dolphins and another investigates habitat use of baleen whales in relation to fish, krill and copepods.

The Icelandic minke whale programme is up for review in the IWC with a deadline in winter 2012/13. Efforts are being made to complete the studies and they will be presented to the Scientific Committee at its 2013 meeting. An Icelandic project is underway on salmon fisheries-seal interactions in Northwest Iceland.

8.2 Environmental questions

The Management Committee **underlined** the serious situation for ice-breeding seals when the extent and quality of sea ice is rapidly changing under the current climate change.

8.3 By-catch data and monitoring

Monitoring of Norwegian gillnetters for monkfish and cod (2006-8) has yielded a by-catch estimate of 6,900 harbour porpoises. This by-catch would require a population of at least 400,000 to be sustainable. However the abundance along the Norwegian coast is unknown and the North Sea estimate of around a third of a million is not necessarily relevant. Norway has an unknown, but potentially high by-catch of harbour and grey seals.

The by-catch numbers of harbour porpoises, grey seals, and harbour seals could also be high in Iceland, based on preliminary information presented to the NAMMCO-ICES workshop in 2010. Reporting is often of unidentified seals, making it difficult to estimate by-catch for species. The Scientific Committee **reiterated its recommendation** to obtain updated information on abundance and struck and lost figures. In the case of struck and lost data it **recommended** that a struck and lost factor be developed.

The Management Committee **endorsed the Scientific Committee recommendation** that total by-catch estimates be attempted for all species (*e.g.* harbour porpoises, grey seals, and harbour seals) and that assessments of sustainability proceed through the relevant WGs.

By-catch in the Faroe Islands and Greenland is likely a small problem due to the absence of gillnets used in fisheries.

A small revision of the Greenlandic reporting system for catch, by-catch and struck and lost is underway and a process of digitalization of the hunting license system and catch reporting system will incorporate these issues in a more standard way. Greenland also reminded the Committee that a report on struck and lost rates based on a questionnaire study had been published in 2006 and it can be diffused to any interested parties.

The Scientific Committee **recommended** that:

- By-catch estimates are attempted where lacking
- By-catch estimates are validated in WGs
- Appropriate are the Harbour porpoise WG and Grey and harbour seal WG
- The sustainability of by-catch is assessed by WGs
- By-catches be reduced as much as possible, irrespectively of sustainability.

The Management Committee **endorsed** the recommendations from the Scientific Committee and **noted** the updates from member countries.

8.4 Other Topics

None were noted.

9. TRADE ISSUES AND THE EU BAN ON IMPORT OF SEALSKIN

In relation to the 2010 EU ban, Greenland has worked intensively through the Danish embassies, on informing on the negative effects the ban gives, and that the Inuit exemption has not helped on the trade of sealskin resulting in about 250.000 skins in storage. Greenland had reported during a public hearing in Brussels February 7th, 2012 on the consequences of the ban, including a revised “White Paper on Seal Management in Greenland”. Greenland also informed that it has received information that Russia recently has introduced exemptions for sealskin produced by Inuit people.

The Government of Greenland has produced a white paper on the Management and Utilisation of Seals in Greenland available at:
http://www.nanoq.gl/emner/landsstyre/departementer/departement_for_fiskeri/~/media/7F9AFE61E16845F7A92AA52563437165.ashx

Several collaboration information projects with the Hunters and Fishermen Association (KNAPK) and an external media company have been initiated.

Norway and Canada oriented on the status of the World Trade Organisation (WTO) case. The panel selection has not yet been started, but it should happen this month. A realistic timeline sees the production of a final report by the middle of 2013.

10. ANY OTHER BUSINESS

A proposal to streamline the agenda of the Management Committees was submitted by Greenland, and will be further developed by the Chairs of the Committees.

Appendix 1

AGENDA

1. **CHAIRMAN'S OPENING REMARKS**
2. **ADOPTION OF AGENDA**
3. **APPOINTMENT OF RAPPORTEUR**
4. **CONSERVATION AND MANAGEMENT MEASURES FOR SEAL STOCKS**

4.1 Harp Seals

White / Barents seas
Greenland Sea
Northwest Atlantic

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.2 Hooded Seals

Greenland Sea
Norhwest Atlantic

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.3 Ringed Seals

Greenland
Others?

- Updates

4.4 Grey Seals

Greenland
Norway
Faroe Islands
Iceland

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.5 Harbour Seals

Greenland
Norway

Iceland

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.6 Walrus

Greenland

- Status of past proposals
- Requests by Council for advice from the Scientific Committee
- Responses by the Scientific Committee
- New proposals and recommendations for scientific research
- Proposals for conservation and management

4.7 Bearded seal

Greenland

Norway

- Updates

5. PROCEDURES FOR DECISION-MAKING ON CONSERVATION AND MANAGEMENT MEASURES

6. ECOSYSTEM-BASED MANAGEMENT

7. USER KNOWLEDGE IN MANAGEMENT DECISION-MAKING

8. RELATED MANAGEMENT ISSUES[6]

8.1 Marine mammal - fisheries interactions[7]

8.2 Environmental questions

8.3 By-catch data and monitoring

8.4 Other topics

9. TRADE ISSUES AND THE EU BAN OF IMPORT OF SEALSKIN

10. ANY OTHER BUSINESS

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[6] **Agenda Item 8**: These items have been placed separately from the individual species, because they overlap to varying extents with the work of other committees; items 8.1 – 8.3 incl. overlap with the Management Committee for Cetaceans, and will be discussed in a joint meeting of the two Management Committees; item 8.2 is also listed on the Council agenda.

[7] **Agenda Item 8.1:** This item also includes Economic aspects of marine mammal – fisheries interactions and Multi-species approaches to management.

Appendix 2

LIST OF DOCUMENTS

Document no	Title	Agenda item
NAMMCO/20/SMC/1	List of Documents	
NAMMCO/20/SMC/2	Agenda	2.
NAMMCO/20/MC/3	Status of Past Proposals for Conservation and Management	4.
NAMMCO/20/MC/4	Summary of Requests by NAMMCO Council to the Scientific Committee, and Responses by the Scientific Committee	4.
NAMMCO/20/SMC/5	Recommendations to member countries 2010	4.
NAMMCO/20/6 and ANNEXES	Report of the Eighteenth Meeting of the Scientific Committee	4., 5., 6., 7., 8. and 9.

Appendix 3

RECOMMENDATIONS TO MEMBER COUNTRIES 2012

Harp seals

Norway, Greenland:

The Management Committee for Seals and Walruses **endorsed** the Scientific Committee recommendations to limit the catches for the common stock between Norway and Russia (**R-2.1.10)** for the White Sea/Barents Sea to 15,827 1+ animals (or an equivalent number of pups, where one 1+ seal is balanced by 2 pups) and for the Greenland Sea to 16,737 animals of the 1+ age class or 33,474 pups; as an alternative 25,000 animals of class 1+ if adequate monitoring is put in place.

Hooded seals

Norway, Greenland:

The Management Committee for Seals and Walruses **reviewed** the recommendations of the ICES-NAFO WG on Harp and Hooded Seals and continued to **support** the recommendations for no catches of hooded seals to be taken from the Greenland Sea, except for local catches in East Greenland.

Ringed seals

Greenland:

The Management Committee for Seals and Walruses **reiterated its recommendation** from the previous year to perform abundance estimates on sea ice in offshore areas but also included that updated information on fjord area occupancy is also needed.

Harbour seals

All countries:

The Management Committee for Seals and Walruses **reiterated its recommendation** to obtain updated information on abundance and struck and lost figures. In the case of struck and lost data it **recommended** that a struck and lost factor be developed.

Bearded seals

Norway, Greenland:

The Management Committee for Seals and Walruses **reiterated its recommendation** that efforts be renewed towards gathering information on biology, abundance and stock status with the view to an assessment.

By-catch

Iceland, Norway:

The Management Committee for Seals and Walruses **endorsed the SC recommendation** that total by-catch estimates be attempted for all species (*e.g.* harbour porpoises, grey seals, and harbour seals) and that assessments of sustainability proceed through the relevant WGs.

All countries:

The Management Committee for Seals and Walruses **recommended** that:

- By-catch estimates are attempted where lacking

- By-catch estimates are validated in WGs
- Appropriate are the Harbour porpoise WG and Grey and harbour seal WG
- The sustainability of by-catch is assessed by WGs
- By-catches be reduced as much as possible, irrespectively of sustainability.

ANNEX 1: STATUS OF PAST PROPOSALS FOR CONSERVATION AND MANAGEMENT

This table provides a summary of all proposals for conservation and management made by the Management Committees, and the responses of member countries to these proposals as stated at later meetings. This document will be continually updated to serve as a resource for both the Council and the Management Committees. See List of References for sources of meeting documents. Codes beginning with: 1 – relevant to all Management Committees; 2 – relevant to seals; 3 – relevant to whales.

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
1.1.0	**Incorporation of the users' knowledge in the deliberations of the Scientific Committee**	
1.1.1	The Management Committee endorsed the proposals and viewpoints contained in section 6 in the Scientific Committee report, and suggested that the "Draft Minke Whale Stock Status Report" (NAMMCO/9/7) could usefully serve as a pilot project for cooperation with the hunters. (NAMMCO/9).	Status Reports under development.
1.1.2	The Management Committee had previously asked the Secretariat to proceed with a proposal by the Scientific Committee to use stock status reports as a starting point for discussions with resource users to incorporate their knowledge in advice to Council, and to use the stock status report on minke whales as a pilot project. However, in 2000 the Management Committee recommended that a proposal for a conference on incorporating user knowledge and scientific knowledge into management advice should proceed, and asked the Conference Advisory Group to plan this conference to evaluate whether and how the previous proposal for incorporating user knowledge into the Scientific Committee's deliberations could be	Greenland informed the Committee that a person had been hired at the Greenland Institute of Natural Resources to deal with these issues, and that this employee is also on the Advisory Board of the Conference. (NAMMCO/11)

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
	incorporated into the Conference (NAMMCO/11).	
1.1.3	The Management Committee re-established the Working Group on User Knowledge in Management and provided new Terms of Reference for the Group (NAMMCO/15). However, in 2006 the Committee had not met and no progress has been made. The Management Committee reaffirmed the importance of this issue, and considered that the process might be facilitated by focussing on a few key species at first. The Management Committee therefore **recommended** that the Working Group focus narwhal and beluga in the near term. It was also noted that this Working Group will report to the Council henceforth (NAMMCO/16). The Management Committee agreed that the issue of user knowledge in management decision-making, while also being a general item on the Council agenda, should be included on future agendas of the Committee to allow for the presentation of relevant new information from member countries and discussion in relation to the management of specific species and stocks. Council agreed to this recommendation from the MC and as a result agreed to dispense with the associated Working Group, noting that any further dedicated treatment of this issue would be decided in relation to deliberations in the respective MC's at future meetings (NAMMCO 17).	
1.2.0	**Marine mammal – fisheries interactions**	

<table>
<tr><th>CODE</th><th>PROPOSAL FOR CONSERVATION AND MANAGEMENT</th><th>MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES</th></tr>
<tr><td>1.2.1</td><td>The Management Committee noted (NAMMCO/16) the long-standing requests to the Scientific Committee in this area, and the conclusion of the Scientific Committee that no further progress was likely unless more resources were dedicated to modelling efforts already begun in Iceland and Norway, and to gathering the data necessary as model input previously identified by the Scientific Committee. In this respect it was noted that the Icelandic Research Program, which will provide required data on the feeding ecology of minke whales, will be completed by 2007. The Management Committee therefore agreed to recommend that the Scientific Committee review the results of the Icelandic program on the feeding ecology of minke whales and multispecies modelling as soon as these become available (NAMMCO/16).</td><td>The Management Committees expressed a general support for the modelling exercise proposed and recommended the Secretariat and the Scientific Committee to continue the planning. The four modelling approaches proposed are:
1. Minimal realistic model implemented using GADGET
2. Ecopath with Ecosim
3. Time series regression
4. A simple biomass-based model such as one recently applied in eastern Canada.
Potential candidates have been identified to undertake the work.

The exercise should be carried out preferably for two areas. Likely candidates include the Barents Sea and the region around Iceland. The projected investigation would require a funded multi-year project. Once funding is obtained, selection of appropriate area(s) should, if necessary, be decided by a working group of experts knowledgeable in the data requirements and availability.

The tentative schedule provided for the work was articulated around 4 key-step meetings with a 2-year</td></tr>
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CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
		period as a realistic time-span for the whole process (NAMMCO 18).
1.3.0	**By-catch**	
1.3.1	*Norway*: The Management Committee supported the recommendation of the Working Group on by-catch that Norway provide the report of the March 2007 evaluation meeting to the NAMMCO Scientific Committee at their next meeting, and provide estimates of by-catch from fisheries to NAMMCO as soon as they become available (NAMMCO/16). *Faroes:* The WG supported the Faroes plan of conducting a questionnaire of fishermen to gather information about the magnitude of marine mammal by-catch as a useful first step (NAMMCO/16). *Iceland:* The Management Committee supported the advice of Working Group on by-catch that recommendations for improving the Icelandic monitoring program be accepted and implemented by Iceland in a timely fashion (NAMMCO/16). The Management Committee agreed in 2007 that the design of monitoring programs that will provide accurate and precise	Norway reported that it has a reference fleet as a trial for by-catch reporting. It is hoped that data will be available and analysed at the end of 2009. The findings should be available for reporting next year (NAMMCO 18). Efforts are being made to include mandatory reporting of marine mammal by-catch in all fishing vessel logbooks in the Faroe Islands. It should be noted that logbooks are already mandatory on all vessels over 15 tonnes (NAMMCO 18). In Iceland there had been progress in monitoring but no results as yet (NAMMCO 18). There was still uncertainty whether by-catch in

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
	estimates of by-catch is in the main a scientific issue, and that such advice could therefore be provided by the Scientific Committee. The Management Committee agreed therefore to disband the standing Working Group on By-catch, as its role would now be fulfilled by the Scientific Committee (NAMMCO/16). The Management Committee agreed to the need for further guidance from Council in relation to priority of requests and workload of the Scientific Committee, before endorsing a review of by-catch systems (NAMMCO 17).	Greenland was reported as such or as catch (NAMMCO 18). The Management Committees **noted** the work undertaken by the Scientific Committee for organising a joint workshop with ICES, focussing on by-catch monitoring systems and reviewing the advantages and disadvantages of existing observation schemes for marine mammals, and **recommended** moving forward on this matter (NAMMCO 18). A Workshop on By-Catch Monitoring of marine mammals and seabirds, co-convened by NAMMCO and ICES was held successfully in Copenhagen in July 2010, and guidelines for best practices in monitoring by-catch are being developed and will be published (NAMMCO 19). Iceland reported new information on by-catch monitoring from 2009 (porpoise, harbour seal, bearded seal, grey seal and harp seal). Efforts are ongoing to improve reporting systems (NAMMCO 19). The Faroe Islands reported that a new electronic logbook system for vessels larger than 15 BRT is being developed and should be implemented in 2011

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
		when reporting of marine mammal by-catch will become mandatory. (Conventional logbooks are already mandatory on vessels larger than 15 BRT.) (NAMMCO 19). Greenland reported that by-catches are reported as catches but a revised reporting system allowing discrimination of origin is underway (NAMMCO 19).
1.4.0	**Joint NAMMCO control scheme**	
1.4.1	The Management Committee agreed that the provisions of the Scheme should be amended to integrate requirements for observer training to ensure observer safety onboard vessels, and to take account of recent technological developments in automated monitoring. In addition the provisions should be modified to support it reporting to the Council rather than the Management Committee. (NAMMCO/16).	The revision of the provisions were finalised and adopted at NAMMCO 18.
1.5.0	**Enhancing ecosystem-based management**	
1.5.1	The Management Committee recommended that the Working Group on Enhancing ecosystem-based management meet in 2007, and noted that it will be reporting to the Council henceforth. Nevertheless this item is of course of interest in a management context, and will remain on the agenda of the Management Committees. (NAMMCO/16).	

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
	Noting the conclusion of the Scientific Committee that no further progress was likely in this area unless more resources were dedicated to modelling efforts already begun in Iceland and Norway, and to gathering the data necessary as model input, the Management Committee recommended that these activities be a priority for member countries (NAMMCO/16). Development of ecosystem models for use in management is a time-consuming process,. However enough progress has been made recently to warrant new consideration and a broader terms of reference in the Scientific Committee Working Group on marine mammal-fisheries interactions. Council therefore decided to discontinue the *ad hoc* Working Group on ecosystem-based management. Discussions of a general nature on the management level in recent years had been useful, and the efforts of the members of the *ad hoc* Working Group were appreciated. However, the continued scientific and management focus on these issues was more appropriate for detailed discussion in the respective Management Committees. It was however also agreed to keep this item on the Council agenda as an opportunity to follow developments in more general terms and to review how other relevant international bodies are addressing both the concepts and the practicalities of ecosystem-based management (NAMMCO 17).	
2.1.0	**Harp seals**	

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
2.1.1	The Management Committee requests that the Scientific Committee annually discusses the scientific information available on harp and hooded seals and advice on catch quotas for these species given by the ICES/NAFO Working Group on Harp and Hooded Seals. The advice by the Scientific Committee on catch quotas should not only be given as advice on replacement yields, but also levels of harvest that would be helpful in light of ecosystem management requirements For the Barents/White Sea and Greenland Sea stocks, in addition to the advice on replacement yields, advice should be provided on the levels of harvest that would result in varying degrees of stock reduction over a 10 year period (NAMMCO/13).	Greenland informed that a new executive order on seals will come into force in 2010 (NAMMCO 18).
2.1.2	*Northwest Atlantic* The Management Committee noted that a new abundance estimate for Northwest Atlantic harps seals of 4.8 million was available, based on a pup production estimate for 1994 of 702,900. The Management Committee also noted the conclusion that the Northwest Atlantic population of harp seals has been growing at a rate of 5% per year since 1990, and that the 1996 population was estimated to be 5.1 million, with a calculated replacement yield of 287,000. The Management Committee <u>concluded</u> that catch levels of harp	Canada brought to the attention of the Committee the recently completed Report of the Eminent Panel on Seal Management, which contains a full review of research and management of seals in Canada, with a primary focus on Northwest Atlantic harp and hooded seals. The Report is available at the following web site: http://www.dfo-mpo.gc.ca/seal-phoque/reports/index.htm. Canada also noted that an abundance survey of the Northwest Atlantic harp seals had been completed in 1999, and that published results were now available. (NAMMCO/11).

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	seals in Greenland and Canada from 1990 to 1995 were well below the calculated replacement yields in this period (NAMMCO/6). The Management Committee noted that combined estimated catches of harp seals in Canada and Greenland are in the order of 300,000 and that these catches are near, or at, the established replacement yields (NAMMCO/8*)*. Noting that Canada has instituted a multi-year management plan with a 3- year allowable catch of harp seals totalling 975,000 (not including the catch by Greenland), the Management Committee requested the Scientific Committee to provide advice on the likely impact on stock size, age composition, and catches in West Greenland and Canada under the conditions of this plan (NAMMCO/13). The Management Committee noted that the request from advice from NAMMCO/14 "Evaluate how a projected decrease in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland" was still open. The SC gave partial answer and had recommended again the request to be addressed to the ICES-NAFO WG. The Management Committee recommended that Greenland take the initiative of forwarding this request to ICES. (NAMMCO/16).	Greenland commented that sustainable catches may be obtained at other catch levels than those that provide replacement yields. (NAMMCO/11). The Observer for Canada presented information on a multi-year management plan for the Atlantic seal hunt, which was announced in February 2003. For harp seals total allowable catch is set at 975,000 over a 3-year period. If the full quota were taken and Greenlandic harvests were as forecast, the total take should result in a slight population reduction over the period, while still maintaining the population well above the conservation reference points adopted (NAMMCO/12). Greenland informed the Management Committee that bilateral discussions with Canada on the Canadian Management Plan had taken place over the past year (NAMMCO/13). Greenland noted that there had still been no bilateral

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		consultations with Canada on management of this stock, which is shared between the two countries. The Observer for Canada informed the Committee that a new multi-year management plan is in preparation, and that consultations with Greenland would be arranged in the near future (NAMMCO/15).
2.1.3	*North Atlantic, White/Barents Sea* The Management Committee noted the stock status and catch options presented by the Scientific Committee, and concluded that the catch level in 1998 was well below the calculated replacement yield. Catches at the same level in the future may result in population increase. From a resource management point of view, future quota levels approaching the replacement yield are advised. (NAMMCO/9).	Norway informed the Committee that measures were being considered to improve the efficiency of the seal harvest in this area. The possibility of introducing smaller vessels into the seal hunt is being pursued. The long-term goal will be to reduce the need for subsidising the hunt and increase the take of seals from this stock (NAMMCO/13, NAMMCO/14, NAMMCO/15).
2.1.4	*Greenland Sea* The Management Committee noted the stock status and catch options presented by the Scientific Committee, and concluded that the catch level in 1998 was well below the calculated replacement yield. Catches at the same level in the future may result in population increase. From a resource management point of view, future quota levels approaching the replacement yield are advised. (NAMMCO/6).	Norway informed the Committee that, similar to the situation for the White/Barents Sea stock, efforts are being made to improve the efficiency of harvesting. Recent harvests have been a small fraction of available quotas. Again the long-term goal will be to reduce the need for subsidising the hunt and increase the take of seals from this stock (NAMMCO/13).

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		Norway reported that quotas for this stock have been roughly doubled since 2005, based on advice from NAMMCO and ICES. However at present there is insufficient capacity to take higher quotas, so catches are expected to be much lower than the quotas (NAMMCO/15).
2.1.5	The Management Committee noted the conclusion of the Scientific Committee that the framework for the management of these species proposed by the ICES/NAFO Working Group would not be useful for NAMMCO for technical reasons and because the management objectives inherent in the framework were inflexible. In the case of harp and hooded seals, where management goals may in the future be defined in relation to ecosystem based objectives, more flexibility will be required than is allowed in this framework (NAMMCO/15). As suggested by the Scientific Committee in 2004, the Management Committee recommended that NAMMCO explore the possibility with ICES and NAFO of assuming a formal joint role in the Working Group on Harp and Hooded Seals. The Secretariat should contact ICES and NAFO in this regard. As a starting point, the Working Group, jointly with the NAMMCO Scientific Committee, should be asked to provide advice on outstanding requests (see NAMMCO Annual Report 2004, p. 27) (NAMMCO/15).	
2.1.6	The Management Committee also **endorsed** the WGHARP	

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	recommendation to implement the four-tiered management strategy which aligns with the Norwegian management strategy for Greenland Sea harp seals, once the population becomes data rich NAMMCO 18).	
2.2.0	**Hooded seals**	
2.2.1	*Northwest Atlantic* Noting the Scientific Committee's review of available analyses of hooded seal pup production, which recognised that calculations are dependent on the particular rate of pup mortality used, as well as the harvest regimes, the Management Committee <u>concluded</u> that present catches of hooded seals in the Northwest Atlantic (1990-1995) were below the estimated replacement yields of 22,900 calculated for a harvest of pups only, and 11,800 calculated for a harvest of 1-year and older animals only (NAMMCO/6).	
2.2.2	*Northwest Atlantic* The Management Committee <u>noted</u> that the total catch of hooded seals in the Northwest Atlantic in 1996 slightly exceeded the replacement yield while in 1997 the total number of seals taken was much lower (NAMMCO/8).	Greenland noted that this stock was shared with Canada and that the two countries hold regular bilateral discussions on management of this stock, including an exchange of information on harvest statistics, utilisation and stock assessment. (NAMMCO/11).
2.2.3	*Greenland Sea* The Management Committee noted the stock status and catch options presented by the Scientific Committee, and concluded that	While supporting the past conclusion of the Management Committee that catch levels for this stock

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	the catch level in 1998 was well below the calculated replacement yield. Catches at the same level in the future may result in population increase. From a resource management point of view, future quota levels approaching the replacement yield are advised (NAMMCO/9).	are below replacement yield, Norway noted that the abundance estimate for this stock is dated and that it hoped that new information should soon be available from surveys planned for 2002. (NAMMCO/11). Norway informed the Committee that quotas in this area have been reduced on the advice of the ICES/NAFO Working Group on Harp and Hooded Seals, mainly because there is no recent abundance estimate for the stock. Consequently it is expected that the quota may be fully utilised this year (NAMMCO/13). Norway informed the Committee that a hooded seal survey covering all stocks will be carried out jointly with Canada and Greenland in 2005 (NAMMCO/14). A survey covering all stocks was carried out in 2005. Norway reported that, based on preliminary results from these surveys, quotas have been reduced for the Greenland Sea stock. A new survey will be carried out in the near future. Greenland noted that it had given Norway permission to take seals within the Greenland EEZ in 2006 (NAMMCO/15).
2.3.0	**Ringed seals**	

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2.3.1	The Management Committee noted the conclusions of the Scientific Committee on the assessment of ringed seals in the North Atlantic, which had been carried out through the Scientific Committee Working Group on Ringed Seals. In particular, the Management Committee noted that three geographical areas had been identified for assessing the status of ringed seals, and that abundance estimates were only available for Area 1 (defined by Baffin Bay, Davis Strait, eastern Hudson Strait, Labrador Sea, Lancaster, Jones and Smith sounds (NAMMCO/6).	
2.3.2	While recognising the necessity for further monitoring of ringed seal removals in Area 1, the Management Committee endorsed the Scientific Committee's conclusions that present removals of ringed seals in Area 1 can be considered sustainable (NAMMCO/6).	The Greenland government is presently undertaking a regulatory initiative which will deal with hunting of all seals in Greenland, rather than just harbour seals as at present (NAMMCO/11).
2.4.0	**Grey seals**	
2.4.1	The Management Committee noted the concern expressed by the Scientific Committee with regard to the observed decline in the grey seal stock around Iceland, where harvesting has been above sustainable levels for more than 10 years, with the apparent objective of reducing the size of the stock. The Management Committee agreed to recommend that Iceland should define clear management objectives for this stock. The Management Committee noted the conclusion of the Scientific	Iceland reported that the management objective for grey seals would be to maintain the stock size close to the current level, and that protective measures would be taken should further declines continue. A precondition to this objective will be careful monitoring of the stock size. Norway reported that a management plan for grey seals is presently under development. Recent catches have

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	Committee that the new quota levels implemented for Norwegian grey seals would, if filled, almost certainly lead to a rapid reduction in population in the area. The Management Committee agreed to recommend that Norway should define clear management objectives for this stock. For the Faroe Islands, the Management Committee supported the recommendation of the Scientific Committee to obtain better information on the level of catch (NAMMCO/13).	been lower than the quota levels in most areas (NAMMCO/14). Norway reported that a management plan for grey seals is still under development. Recent catches have been lower than the quota levels in most areas. In response to a query from Greenland, Norway informed the Committee that grey seals are not managed in cooperation with other jurisdictions as there is believed to be little exchange among stocks (NAMMCO/15). The Faroe Islands noted that a drastic decline in salmon aquaculture had likely led to a decline in killing of grey seals that were a nuisance to the industry (NAMMCO/15). The Faroes reported that there would be a satellite tracking programme for grey seals starting in the spring of 2007 with a view to further studies on feeding ecology and abundance. This information was welcomed by the Committee (NAMMCO/16). Norway informed that a quota of 25% of the population has been established taking into consideration the estimated by-catch levels. A new

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	The Management Committee recommended Greenland to protect grey seals from hunting given the likely isolation of the small stock in southeast Greenland (NAMMCO 19).	population estimate for the period 2006-8 will soon be available, and a management plan, complemented by a genetic study, will be presented to the next Scientific Committee meeting in 2009 (NAMMCO 17). Norway reported that national management plans are presently ready to be fully implemented for both grey and harbour seals (NAMMCO 19). Greenland reported that the recommendation of a total ban on hunting of grey seals has already been incorporated in a new Executive Order (NAMMCO 19).
2.4.2	With regards to the present estimate of a harvest up til 40% of the population annually, the Scientific Committee **urged** the Faroe Islands to estimate their present removals and abundance off their coast. The Scientific Committee **strongly recommended** that all efforts be made in providing a proper estimate of population size and catch at its next meeting (NAMMCO 18). The Scientific Committee also **recommended** that the Faroe	The Faroese reported that efforts were being undertaken to obtain better information on population, removals and breeding sites for this species, and that satellite tagging of grey seals has been attempted and is in progress. Private companies possess data on this and other species With regards to the present estimate of a harvest up til 40% of the population annually, the Scientific Committee **urged** the Faroe Islands to

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	Islands define clear management objectives for grey seals, and that the reporting of grey seal catches in the Faroe Islands be made mandatory and enforced (NAMMCO 18). The Management Committee for Seals and Walruses **noted** the considerations and all suggestions by the Scientific Committee and **recommended** the convening of a WG on Coastal Seals to review the Norwegian Management plan in view of an assessment. The Management Committee for Seals and Walruses also **supported** the recommendations concerning the compilation and reporting of Faroese removal and abundance data, and the Icelandic research data (NAMMCO 18). The Management Committee urged the Faroe Islands to estimate removals and abundance of grey seals around their coast, and to provide proper estimates of population size snd catches for 2011 (NAMMCO 19).	estimate their present removals and abundance off their coast. The Scientific Committee **strongly recommended** that all efforts be made in providing a proper estimate of population size and catch at its next meeting (NAMMCO 18). The Scientific Committee also **recommended** that the Faroe Islands define clear management objectives for grey seals, and that the reporting of grey seal catches in the Faroe Islands be made mandatory and enforced (NAMMCO 18). The Management Committee for Seals and Walruses **noted** the considerations and all suggestions by the Scientific Committee and **recommended** the convening of a WG on Coastal Seals to review the Norwegian Management plan in view of an assessment. The Management Committee for Seals and Walruses also **supported** the recommendations concerning the compilation and reporting of Faroese removal and abundance data, and the Icelandic research data (NAMMCO 18). (NAMMCO 17). Iceland reported that the management objective is to maintain the grey seal stock at the 2004 level of 4,100

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		animals. The latest estimate is 6,200 animals and well above the management objective (NAMMCO 19).
2.5.0	**Harbour seals**	
2.5.1	The Committee noted a request from NAMMCO 16: to define management objectives for harbour seals in Norway, Iceland and Greenland (NAMMCO 17). A total ban on hunting for this species in Greenland is **recommended**, and a formal assessment of the stocks in all areas and the establishment of clear management objectives should be undertaken (NAMMCO 18). The Management Committee **reiterated a recommendation** for a formal assessment of the Icelandic stock and the establishment of clear management objectives (NAMMCO 18). Concerning the new Norwegian Management plan, the Management Committee **recommended**, as for the grey seal management plan, that a better way of taking uncertainties into consideration be developed and that an expert working group make an in depth evaluation of the plan, including a comparison with existing management models for e.g. harp and hooded seals (NAMMCO 18).	Norway is currently working on a management plan for harbour seals (NAMMCO/16). The Faroe Islands took note of the SC report and recommendations but have no priority for a specific management plan at this time because the species no longer occurs in the Faroes (NAMMCO/16). Greenland is working on management plans for a number of species, including harbour seal. Until now work has focused on polar bears, walrus, narwhal and beluga. However, the next priority will be given to harbour seals. Reported catches have been very high, probably due to misreporting. Greenland has moved harbour seal to a different place on the list used to report catches, and only a catch of 24 was reported for 2006 (NAMMCO/16).

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		In Iceland, new abundance estimates are available, but there is still insufficient information on by-catch. Norway implemented a system for assessment of the two coastal seal species that secures updated information about abundance approximately every 5 yr. This system has provided two abundance estimates after 1996. As a third point estimate is needed for an assessment for harbour seals another survey is needed and will probably be performed by 2010 (NAMMCO 17). Greenland informed that a draft of an executive order on protection and hunting of seals in Greenland is under construction and in this a ban on hunting of harbour seal is included (NAMMCO 17). Iceland reported that management objectives for harbour seals had been set to maintain the stock close to the 2006 level (NAMMCO 19). Norway reported that national management plans are presently ready to be fully implemented for both grey and harbor seals (NAMMCO 19).
2.6.0	**Atlantic walruses**	
2.6.1	The Management Committee examined the advice of the Scientific Committee on Atlantic Walrus and noted the apparent decline	Greenland provided the Management Committee with information on further measures recently implemented

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	which the Scientific Committee identified in respect to "functional" stocks of walrus of Central West Greenland and Baffin Bay. While recognising the over all priority of further work to clarify and confirm the delineation and abundance of walrus stocks in the North Atlantic area, the Management Committee recommends that Greenland take appropriate steps to arrest the decline of walrus along its west coast. Taking into account the views of the Scientific Committee that the Baffin Bay walrus stock is jointly shared with Canada and that the West Greenland stock might be shared, the Management Committee encourages Canada to consider working co-operatively with Greenland to assist in the achievement of these objectives (*NAMMCO Annual Report 1995*: 49).	through legislation by the Greenland authorities for the conservation of the West Greenland stock. These regulations include: the restriction of walrus hunting to people with valid professional hunting licences only; a year-round ban on walrus hunting south of 66° N; limitations on the means of transport used in connection with walrus hunting to dog sleds and vessels of 19.99 GRT/31.99 GT or less; and the sale of walrus products limited to direct sales at open markets or for personal use only. Municipal authorities now also have the possibility of implementing further restrictions if circumstances require. (NAMMCO/8). Greenland noted that in addition to the regulatory measures that were taken in 1999, it had been decided to introduce quotas on walrus. A new regulatory proposal has been drafted and public hearings will be held in the near future. The final regulatory proposal will take these hearings into account. (NAMMCO/11). Greenland informed the Committee that the regulatory initiative to introduce quotas and other hunting regulations for this species had been delayed, and comprehensive public hearings have been conducted.

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		The draft regulations have now been submitted to the Council of Hunters. It is expected that a final decision on the initiative will be taken later in 2003 (NAMMCO/12). Greenland informed the Committee that a regulatory initiative that will restrict walrus hunting to those holding valid hunting licences, and allow the introduction quotas and other hunting regulations for this species was now in progress, and that public hearings were being conducted. The regulation will go to the Greenlandic government for approval this year (NAMMCO/13). Greenland announced that they plan introducing quotas for walrus, possibly in 2005. Greenland is awaiting the findings of the Scientific Committee in their assessment of walrus. (NAMMCO/14). Greenland noted that the planned regulatory initiative had been delayed but was expected to be introduced in 2006 (NAMMCO/15).
2.7.2	The Management Committee noted that there was an ongoing request for advice for an assessment of this stock. Present removals were likely not sustainable for the North Water and West Greenland	Greenland had made considerable progress in this area of assessment through implementation of hunting regulations and the Greenland Institute for Natural

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	stocks, and it was recommended that new assessments for these stocks be completed as soon as identified research recommendations were fulfilled (survey reanalysis, new surveys, stock structure, and complete corrected catch series) (NAMMCO/16).	Resources (GINR) developing a Research Plan for 2007-10 (NAMMCO/16). Greenland informed that quotas and other regulations had been introduced under a new Executive Order, finalised in 2006. Thereafter, the government introduced 3-year quotas for the period 2007 – 2009. The approved 3-year quotas are designed to allow for a gradual reduction of catches that by 2009 will result in removals that will be within the sustainable levels recommended by the Greenland Institute of Natural Resources (NAMMCO/16).
	The Management Committee agreed that the relationship between JCNB and NAMMCO regarding walrus would be revisited next year. (NAMMCO/16).	Greenland explained that the JCNB dealt originally with narwhal and beluga, and deals now also with walrus. NAMMCO has agreed that JCNB gives management advice for stocks of narwhal and beluga in West Greenland. A similar agreement could be reached about walrus. However, the interaction between JCNB and NAMMCO regarding management advice for walrus should be addressed. (NAMMCO/16).
	The Management Committee agreed that total removals for all areas	

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	should be set under consideration of a probability of sustainability that is higher than or equal to 70% (NAMMCO 19). The Management Committee also agreed that managers should consider establishing a more robust system for monitoring the sex and age composition of the catch (NAMMCO 19). The Management Committee agreed that a common management regime should be established between Greenland and Canada on shared stocks of walruses (NAMMCO 19).	
2.8.0	**Bearded seal**	
	The Management Committee **recommended** that the status of this species be assessed (NAMMCO 18).	
3.1.0	**North Atlantic fin whales**	
3.1.1	*East Greenland-Iceland Stock* The Management Committee accepted that for fin whales in the East Greenland – Iceland (EGI) stock area, removals of 200 animals per year would be unlikely to bring the population down below 70% of its pre-exploitation level in the next 10 years, even under the least optimistic scenarios. However, catches at this level should be spread throughout the EGI stock area, roughly in proportion to the abundance of fin whales observed in the NASS surveys. Furthermore, the Management Committee stressed that the utilization of this stock should be followed by regular monitoring of	

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	the trend in the stock size. The Management Committee also noted the conservative nature of the advice from the Scientific Committee on which the conclusion of the Management Committee was based (NAMMCO/9).	
3.1.2	*East Greenland-Iceland Stock* The Management Committee noted the conclusion of the Scientific Committee that projections under constant catch levels suggest that the inshore substock will maintain its present abundance (which is above MSY level) under an annual catch of about 150 whales. It is important to note that this result is based upon the assumption that catches are confined to the "inshore" substock, *i.e.* to the grounds from which fin whales have been taken traditionally. If catches were spread more widely, so that the "offshore" substock was also harvested, the level of overall sustainable annual catch possible would be higher than 150 whales. (NAMMCO/13). In 2007 The Management Committee noted the conclusion of the Scientific Committee that there was no reason to change their previous conclusion that a catch of 150 whales from the West Iceland sub-stock would be sustainable, and considered that this should conclude the SC's work on the EGI stock until new information becomes available (NAMMCO/16).	

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	The Management Committee noted that it had previously asked that the Scientific Committee continue with its assessments of fin whale stocks in the areas of interest to NAMMCO countries with existing and new information on abundance and stock delineation as it becomes available, and endorsed the plan of the Scientific Committee to complete an assessment for the Northeast Atlantic stocks as a next step in this process (NAMMCO/16). The Management Committee noted the assessment performed by the SC and concluded that an annual strike of up to 154 fin whales from the WI Sub area is sustainable at least for the immediate 5 year period. (NAMMCO/19).	
3.1.3	*Faroe Islands* The Management Committee noted that the conclusion of the Scientific Committee had not changed from the previous assessment, that the uncertainties about stock identity are so great as to preclude carrying out a reliable assessment of the status of fin whales in Faroese waters, and thus the Scientific Committee was not in a position to provide advice on the effects of various catches. It may also be necessary to obtain clearer guidance on the management objectives for harvesting from what is likely to be a recovering stock before specific advice can be given (NAMMCO/13).	
3.2.0	**Minke Whales - Central North Atlantic**	

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3.2.1	The Management Committee accepted that for the Central Stock Area the minke whales are close to their carrying capacity and that removals and catches of 292 animals per year (corresponding to a mean of the catches between 1980-1984) are sustainable. The Management Committee noted the conservative nature of the advice from the Scientific Committee (NAMMCO/8).	
3.2.2	The Management Committee took note of the conclusions of the Scientific Committee with regard to the Central Atlantic Stock, that, under all scenarios considered, a catch of 200 minke whales per year would maintain the mature component of the population above 80% of its pre-exploitation level over that period. Similarly, a catch of 400 per year would maintain the population above 70% of this level. This constitutes precautionary advice, as these results hold even for the most pessimistic combination of the lowest MSYR and current abundance, and the highest extent of past catches considered plausible. The advice applies to either the CIC Small Area (coastal Iceland), or to the Central Stock as a whole (NAMMCO/13). Noting that a full assessment, including the 2009 estimate, will be conducted at the next meeting of the Large Whale Assessment WG in January 2010, the Management Committee for Cetaceans recommends that 200 minke whales per year be considered as the	

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	largest short-term catch that should be contemplated over the short-term, 2-5 years. This catch level refers to total removals from the CIC or CMA, both Icelandic and others (NAMMCO 18). The Management Committee agreed that annual removals of 216 minke whales from the CIC area are sustainable and precautionary and that annual removals of 121 minke whales from the CM area are sustainable and precautionary. Furthermore it was agreed that this management advice should apply for the next 5 years unless the Scientific Committee considers that new scientific evidence is likely to change the basis of the advice (NAMMCO 19).	
	- West Greenland	
3.2.3		Greenland reported that a quota of 178 minke whales in West Greenland had been implemented from 2010 in response to the advice of the Scientific Committee of the IWC (NAMMCO 19).
3.3.0	**Narwhal - West Greenland**	
3.3.1	*Avanersuaq* The Management Committee noted that the present exploitation level in Avanersuaq of 150/yr seems to be sustainable, assuming that the same whales are not harvested in other areas *Melville Bay – Upernavik* The Management Committee noted that the Scientific Committee	As for beluga, harvest quotas will be introduced for West Greenland narwhal in the near future (NAMMCO/11). Greenland informed the Committee that the regulatory initiative to introduce quotas and other hunting

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	could give no status for the Melville Bay – Upernavik summering stock. *Uummannaq* The Management Committee noted that the substantial catches (several hundreds) in some years do cause concern for the status of this aggregation. The Management Committee further noted that the abundance of narwhal in this area should be estimated. *Disko Bay* The Management Committee noted that present catches in this area are probably sustainable. *Catch Statistics* The Management Committee noted that for both narwhal and beluga it is mandatory for future management that more reliable catch statistics (including loss rates) are collected from Canada and Greenland (NAMMCO/9).	regulations for this species had been delayed, and comprehensive public hearings have been conducted. The draft regulations have now been submitted to the Council of Hunters. It is expected that a final decision on the initiative will be taken later in 2003 (NAMMCO/12).
3.3.2	The Management Committee accepted that the JCNB would provide management advice for this stock, which is shared by Canada and Greenland. The Management Committee therefore recommended that closer links be developed with the JCNB on this and other issues of mutual concern. (NAMMCO/10).	Greenland informed the Committee that the new regulations mentioned under 5.8 for beluga will also apply to narwhal, and that quotas will be introduced in July 2004 (NAMMCO/13).
3.3.3	The Management Committee noted the conclusions of the Scientific	Greenland informed the Committee that quotas of 200

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	Committee, that the West Greenland narwhal have been depleted, and that a substantial reduction in harvest levels will be required to reverse the declining trend. These are preliminary conclusions, and more research and assessment work will be required. Nevertheless the Management Committee expressed its grave concern over the status of the West Greenland narwhal, and noted that the JCNB, which provides management advice for this stock, would be considering this information in the near future. The Management Committee also noted that it will be important for NAMMCO to monitor the situation closely and update the assessment as soon as more information is available (NAMMCO/13).	in West Greenland and 100 in Qaanaaq had been introduced in 2004. After implementation the catch was lower than the quota level (NAMMCO/14). Greenland noted that a quota system for narwhal had been introduced in 2004, and the quota for 1 July 2004 to 30 June 2005 of 300 had been nearly fully taken. The quota for 2005/2006 of 260 had been raised to 310 during the hunting season, mainly because hunter observations suggested that narwhal numbers were larger than expected and because the original quota levels were exceeded (NAMMCO/15).
3.3.4	In 2005 the Scientific Committee provided similar advice to that given in 2004, that the total removal of narwhals in West Greenland should be reduced to no more than 135 individuals. This advice was provided with even greater emphasis due to the fact that all models reviewed suggested total annual removals even lower than this. This conclusion was reached in a joint meeting with the JCNB Scientific Working Group, using the best scientific advice available. It is apparent that there continues to be considerable disagreement between scientists and hunters on narwhal stock structure, life history, and especially abundance and trends. While recognising the existence of this disagreement, the Management Committee concluded that it is nevertheless necessary to manage narwhals in a	

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	precautionary manner in the face of uncertainty and apparently contradictory evidence. In this regard it was noted that the 2004/2005 quota was 300 and that the quota for 2005/2006 of 260 was raised to 310. These quotas are more than two times the level recommended by the Scientific Committee. While commending Greenland for the recent introduction of quotas and reduction in the harvest, the Management Committee expressed serious concern that present takes of narwhal in West Greenland, according to the advice of both the NAMMCO Scientific Committee and the JCNB Scientific Working Group, are not sustainable and will lead to further depletion of the stock. In 2000 NAMMCO accepted that the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) would provide management advice for this stock. The Management Committee therefore strongly urged the JCNB and the Government of Greenland to take action to bring the removals of narwhals in West Greenland to sustainable levels (NAMMCO/15). In 2007, Norway, Iceland and the Faroes shared the concern expressed by the Scientific Committee, that the narwhal quota for West Greenland remained well above the recommended level of	

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	135 and that the quota had increased since it was introduced in 2004. It was also noted in this respect that the JCNB in 2006 had expressed grave concern at the status of this stock, and recommended the development of a work plan with a time frame for the reduction in total removals of narwhal to the recommended level (NAMMCO/16). The Management Committee welcomed the development of a monitoring plan but reiterated the serious concern expressed in previous years that present takes of narwhal in West Greenland, according to the advice of both the NAMMCO Scientific Committee and the JCNB Scientific Working Group, are not sustainable and will lead to further depletion of the stock. While accepting that there remains considerable disagreement between scientists and hunters with regard to the status of the stocks, it was nevertheless considered advisable to manage in a precautionary manner in the face of such uncertainty. The Management Committee therefore once again strongly urged the JCNB and the Government of Greenland to take action to bring the removals of narwhals in West Greenland to sustainable levels as quickly as possible. (NAMMCO/16).	In 2007, the Minister of Fisheries for Greenland responded that decisions regarding catch limitations are taken with consideration of the views of scientists and hunters, and that in this case the two groups have a very different perception of the status of the stock. Narwhal are seasonally abundant in some areas and it has proven difficult up to now to reach a consensus between scientists and hunters on stock status. Hunting is very important to the culture and economy of Greenland. The minister also stated that belugas and narwhals consume Greenland halibut and disturb the fisheries. Jessen added that, in order to avoid inflicting undue hardship on hunting families, Greenland has opted for a gradual reduction of quotas, with the aim of reaching recommended sustainable levels. Greenland has also developed a monitoring and survey plan to obtain better information on the status of beluga, narwhal and walrus, for which funding is being sought. In addition Greenland is developing a multi-year management plan for narwhal (NAMMCO/16).
3.3.5	The Management Committee for Cetaceans **noted** that the quotas given for the period July 2008 - June 2009 of 260 narwhals in West Greenland (WG) and 130 narwhals in Melville Bay (MB), gave a	The Management Committee **noted** that NAMMCO is the competent body to advise on East Greenland, and that Greenland has followed the advice of the

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	lower probability of population increase than the 70% recommended for West Greenland narwhals (70% chance of increase corresponds to a total take of 229 and 81 narwhals in WG and MB) (NAMMCO 18). The Management Committee for Cetaceans, based on advice from the Scientific Committee, **recommended** that catches be set so that there is at least a 70% probability that management objectives will be met for West and East Greenland narwhals, i.e. maximum **total removals** of 310 and 85 narwhals in West and East Greenland respectively (NAMMCO 18).	NAMMCO Scientific Committee, which is now endorsed. The Management Committee welcomed the fact that Greenland has followed the NAMMCO advice (NAMMCO 18). Greenland stated that it will continue with its multi-year management plan for narwhals using 70% probability of increase – total 310 for W.Greenland and 85 narwhals for East Greenland. Greenland commented that collaboration between managers, hunters and scientists has improved (NAMMCO 18).
3.3.6	The Management Committee strongly **recommends** that "struck and lost" data be collected from all areas and types of hunt and that all "struck and lost" animals be included in the advice (NAMMCO 19).	
3.4.0	**Beluga - West Greenland**	
3.4.1	*Maniitsoq – Disko* The Management Committee noted that a series of surveys conducted since 1981 indicate a decline of more than 60% in abundance in the area Maniitsoq to Disko. It further noted that with the present harvest levels (estimated at 400/yr) the aggregation of belugas in this area is likely declining due to overexploitation.	Greenland stated that this issue again will be thoroughly discussed with the hunters, and that the Greenland Government does share the concerns expressed. (NAMMCO/10). Greenland informed the Committee that in November

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	Avanersuaq – Upernavik The present harvest in the area Avanersuaq - Upernavik is estimated to be more than 100/yr. The Management Committee noted that since this beluga occurrence must be considered part of those wintering in the area from Maniitsoq to Disko, it is considered to be declining due to overexploitation. Finally the Management Committee noted the conclusion by the Scientific Committee that with the observed decline a reduction in harvesting in both areas seems necessary to halt or reverse the trend (NAMMCO/9).	2000 the government made a decision to introduce harvest quotas for beluga and narwhal. Public hearings on a draft regulatory proposal were held in spring 2001. The results of these hearings are being taken into account in the drafting of a revised regulatory proposal, and a final set of regulations is expected to be introduced sometime in 2002 (NAMMCO/11). Greenland informed the Committee that the regulatory initiative to introduce quotas and other hunting regulations for this species had been delayed, and comprehensive public hearings have been conducted. The draft regulations have now been submitted to the Council of Hunters. It is expected that a final decision on the initiative will be taken later in 2003 (NAMMCO/12).
3.4.2	It was accepted that the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) would provide management advice for this stock, which is shared by Canada and Greenland. The Management Committee therefore <u>recommended</u> that closer links be developed between NAMMCO and the JCNB on this and other issues of mutual concern. (NAMMCO/10).	
3.4.3	In 2000 the Management Committee accepted that the JCNB would provide management advice for this stock, which is shared by	Greenland informed the Committee that a regulatory framework allowing the government to set quotas and

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	Canada and Greenland. The Management Committee noted with pleasure that a joint meeting of the NAMMCO Scientific Working Group on the Population Status of North Atlantic Narwhal and Beluga and the JCNB Scientific Working Group had been held in May 2001, and recommended that this co-operation at the scientific level should continue. The Management Committee also reiterated its recommendation that closer links be developed between NAMMCO and the JCNB on this and other issues of mutual concern. (NAMMCO/11).	other limitations on hunting has now been passed. The new regulations provide protection for calves and females with calves and limit the size of vessels that are involved in beluga and narwhal hunting as well as hunting methods. The Municipalities will have the power to limit or prohibit the use of nets for narwhal/beluga harvesting. It is expected that quotas will be introduced for beluga and narwhal by July 2004. The municipalities will be involved in the allocation of the quotas (NAMMCO/13). Greenland informed the Committee that a quota of 320 had been introduced in West Greenland and Qaanaaq year-round from 1st July 2004. After implementation the catch was lower than the quota level, mainly due to poor weather conditions (NAMMCO/14). Greenland noted that a quota system for beluga had been introduced in 2004, and the quota for 1 July 2004 to 30 June 2005 of 320 had not been fully harvested due mainly to poor weather conditions. The quota for 2005/2006 is 220 (NAMMCO/15).
3.4.4	In 2005 the Scientific Committee provided similar advice to that given previously, that reducing catches to 100 per year will have an 80% chance of halting the decline in beluga numbers by 2010.	

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	Maintaining higher catches reduces the probability of halting the decline. This conclusion was reached in a joint meeting with the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) Scientific Working Group, using the best scientific advice available. Similar advice was first provided in 2000 and has been confirmed and reiterated in meetings held in 2003 and 2004. It is apparent that there continues to be considerable disagreement between scientists and hunters on beluga stock structure, life history, and especially abundance and trends. While recognising the existence of this disagreement, the Management Committee concluded that it is nevertheless necessary to manage beluga in a precautionary manner in the face of uncertainty and apparently contradictory evidence. In this regard it was noted that the present quota of 200 was twice that recommended by the Scientific Committee. While commending Greenland for the recent introduction of quotas and reduction in the harvest, and recognising that the actual catch in 2004/2005 was within the level recommended, the Management Committee expressed serious concern that present quotas for beluga in West Greenland, according to the advice of both the NAMMCO Scientific Committee and the JCNB Scientific Working Group, are not sustainable and will lead to further reduction of the stock.	

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	In 2000 NAMMCO accepted that the JCNB would provide management advice for this stock. The Management Committee therefore strongly urged the JCNB and the Government of Greenland to take action to bring the removal of belugas in West Greenland to sustainable levels (NAMMCO/15). In 2007 the Management Committee noted the concern of the Scientific Committee that the quota for West Greenland beluga remained above the recommended level of 100, at 140 annually. In this respect the conclusion of the JCNB from their meeting in 2006, that the population is depleted and that further action is required to halt the decline, was also noted. However it was also noted that the quota has been reduced since its introduction in 2004. The Management Committee therefore commended Greenland for their management efforts to improve the conservation status of beluga in this area, and strongly urged Greenland to continue their efforts to bring the catch to sustainable levels. The Management Committee also welcomed the development of the monitoring plan mentioned above for narwhal which also applies to beluga (NAMMCO/16).	The Management Committee for Cetaceans welcomed the multi-annual catch quotas recently introduced by Greenland for beluga stocks and based on advice of the Scientific Committee that an annual take of 310 belugas over 5 years up to 2014 was sustainable, and **noted** that these are intended to rebuild the level of the stocks in coming years and therefore ensure the long-term sustainability of catches (NAMMCO 18).
3.5.0	**Northern bottlenose whales**	
3.5.1	The Management Committee discussed the advice of the Scientific Committee on the status of the northern bottlenose whale and noted that this was the first conclusive analysis on which management of	

CODE	PROPOSAL FOR CONSERVATION AND MANAGEMENT	MANAGEMENT MEASURES/RESPONSE BY MEMBER COUNTRIES
	the northern bottlenose whale could be based. The Management Committee accepted that the population trajectories indicated that the traditional coastal drive hunt in the Faroe Islands did not have any noticeable effect on the stock and that removals of fewer than 300 whales a year were not likely to lead to a decline in the stock (NAMMCO/5).	
3.6.0	**Long-finned pilot whales**	
3.6.1	The Management Committee noted the findings and conclusions of the Scientific Committee, through its review of the ICES Study Group Report and the analysis of data from NASS-95 with respect to the status of long-finned pilot whales in the North Atlantic (Section 3.1, item 3.1), which also confirmed that the best available abundance estimate of pilot whales in the Central and Northeast Atlantic is 778,000. With respect to stock identity it was noted that there is more than one stock throughout the entire North Atlantic, while the two extreme hypotheses of i) a single stock across the entire North Atlantic stock, and ii) a discrete, localised stock restricted to Faroese waters, had been ruled out. The Management Committee further noted the conclusions of the Scientific Committee that the effects of the drive hunt of pilot whales in the Faroe Islands have had a negligible effect on the population, and that an annual catch of 2,000 individuals in the eastern Atlantic corresponds to an exploitation rate of 0.26%.	In 1997 the Management Committee concluded that the Faroese drive hunt of pilot whales is sustainable. There have been no changes in annual take, new abundance estimates or other information that warrant any change in this conclusion. (NAMMCO/11). The Faroe Islands reported that plans are underway to implement a monitoring programme, the aim of which is to update the existing comprehensive biological data on pilot whales that was provided by the dedicated international research programme in the Faroe Islands in 1986-1988 (NAMMCO 18).

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	Based on the comprehensive advice which had now been provided by the Scientific Committee to requests forwarded from the Council, the Management Committee concluded that the drive hunt of pilot whales in the Faroe Islands is sustainable (NAMMCO/7). In 2007, noting the comprehensive international scientific research sampling of all pilot whales caught in the Faroes from 1986 to 1988, the Management Committee underlined the value of building on and updating this valuable information by ensuring ongoing sampling of pilot whales in the Faroes (NAMMCO/16).	
3.7.0	**Humpback whales**	
3.7.1	In 2006 new abundance estimates for West Greenland were available from surveys conducted in 2005. The Management Committee accepted the conclusion of the Scientific Committee that a removal (including by-catch) of up to 10 animals per year in West Greenland would not harm the stock in the short or medium term. The Management Committee therefore proposed that Greenland limit annual removals of humpback whales, including by-caught and struck and lost whales, to 10 off West Greenland. (NAMMCO/16). The Management Committee **noted** that in 2008, the Scientific Committee reconsidered its interim advice from 2006 for West	

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	Greenland humpbacks on the basis of the estimate of the survey conducted in 2007, noting that the abundance estimate was higher than that of the 2005 survey, on which the 2006 interim advice was based. The Management Committee **recommended** that the total quota of humpbacks in West Greenland in 2009, including by-catches, should not exceed 10 animals (NAMMCO 17; NAMMCO 18). The Management Committee **recommended** that a total removal of up to 20 humpback whales per year 2010-2015 would be sustainable (NAMMCO/19).	
3.8.0	**Harbour porpoises**	
3.8.1	The Management Committee noted in 2007 there was not a sufficient information base to provide advice on sustainable removals for this species for any of the NAMMCO member countries. Noting this, the Management Committee recommended that member countries conduct surveys to produce reliable estimates of abundance for harbour porpoises in their areas. In addition the Management Committee recommended that member countries provide reliable estimates of total removals, including by-catch, for this species. Once this information is available for any area, the sustainability of removals can be assessed by the Scientific Committee. This was considered particularly urgent for Greenland, where directed catches are in the low thousands annually	The Management Committee **endorsed** the Scientific Committee recommendations that Iceland and Greenland co-ordinate their analyses of the 2007 data with regard to this species, that any survey undertaken in the Faroe Islands should be designed to be compatible with the SCANS surveys, and that there should be adequate monitoring of by-catches in all areas. Iceland underlined that harbour porpoises were included in the 2007 survey and analyses will be presented to the next Scientific Committee meeting in

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	(NAMMCO/16).	2009. This will provide the first reliable abundance estimate in the Icelandic coastal area. Greenland informed the Management Committee that a new executive government order on small cetaceans is being prepared that will include harbour porpoises, pilot whales and dolphins. Norway reported that porpoise by-catch data will be available after validation of their by-catch monitoring programme (NAMMCO 17).
3.9.0	**T-NASS**	
3.9.1	While recognizing national priorities, the Management Committee recommended that NAMMCO countries make every effort possible to ensure the coordination of the survey in terms of timing and coverage (spatial contiguity). The Management Committee also recommended that member countries assist the Committee in obtaining additional funding to support the T-NASS Extension and Acoustic subprojects. (NAMMCO/16). The Management Committee endorsed the Scientific Committee's recommendations for the next survey would be within the 2013-2015 time frame, and that a working group for planning of future surveys be set up as soon as possible, along with negotiations with	Estimates from T-NASS 2007 surveys had allowed for the first time estimates of abundance for the following species in the whole North Atlantic: 50,000 fin whales 15,000 humpback whales 150,000 minke whales (NAMMCO 19).

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	all potential partners, and a consideration of extending the survey areas (NAMMCO 19).	
4.0.0	**General Models**	
4.0.1	The Management Committee **endorsed** the Scientific Committee recommendation to use an "RMP implementation simulation process (IST)-like approach – as modified by Norway" as a general model for conservation and management of baleen whales in NAMMCO (NAMMCO 18).	

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ANNEX 2: SUMMARY OF REQUESTS BY NAMMCO COUNCIL TO THE SCIENTIFIC COMMITTEE, AND RESPONSES BY THE SCIENTIFIC COMMITTEE

This table provides a summary of all active requests by the NAMMCO Council to the Scientific Committee, and notes the response of the Scientific Committee (SC) to these requests. This document will be continually updated to serve as a resource for both the Council and the Scientific Committee. See List of References for sources of meeting documents. Codes beginning with: 1 – relevant to all Management Committees; 2 – relevant to seals; 3 – relevant to whales.

Code	**Meeting**	**Request**	**Response of the Scientific Committee**	**Status**
1.1.0	**MARINE MAMMAL – FISHERIES INTERACTIONS**:			
1.1.1	NAMMCO/1 1992	To provide an overview of the current state of knowledge of the dependence of marine mammals on the fish and shrimp stocks and the interrelations between these compartments.		Ongoing
1.1.2	NAMMCO/1 1992	In the multispecies context ... to address specific questions related to the Davis Strait ecosystem such as: - the apparent increase in harp seal stocks; - its influence on the economically important shrimp and cod stocks; - the impact of the fisheries on marine mammals, particularly harp seals; - the southward shift of minke whale distribution in recent years, and	Questions related to harp and hooded seals were forwarded to the ICES/NAFO Joint Working Group on Harp and Hooded Seals (SC/2). Specific questions related to the Davis Strait ecosystem were not addressed.	Ongoing

Code	**Meeting**	**Request**	**Response of the Scientific Committee**	**Status**
		- observed changes in oceanographical conditions after the 1970s; - and to the East Greenland-Iceland-Jan Mayen area interactions between capelin stocks, fishery and marine mammals.		
1.1.3	NAMMCO/2 1993	To assess the impact of marine mammals on the marine ecosystem, with special emphasis on the availability of economically important fish species.		Ongoing
1.1.4	NAMMCO/6 05-1996	The Scientific Committee was requested to focus its attention on the food consumption of three predators in the North Atlantic: the minke whale, the harp seal and the hooded seal, with a particular emphasis on the study of the potential implications for commercially important fish stocks.	The Scientific Committee established a Working Group on the Role of Minke Whales, Harp Seals and Hooded Seals in the North Atlantic. The Scientific Committee used the report of this Working Group to provide advice to Council, and to recommend further research. (SC/5) Many of the papers presented have been published in Volume 2 of NAMMCO Scientific Publications. (SC/7).	Completed
1.1.5	NAMMCO/7 05-1997	The Council encourages scientific work that leads to a better understanding of interactions between marine mammals and commercially exploited marine resources, and requested the Scientific Committee to periodically review and update available knowledge in this field.		*Ongoing*

Code	Meeting	Request	Response of the Scientific Committee	Status
1.1.6	NAMMCO/16 02-2007	The Commission requested the Scientific Committee to review the results of the Icelandic programme on the feeding ecology of minke whales and multi-species modelling as soon as these become available.	The SC considered that new development in ecosystem modelling warranted a new meeting of the WG on Marine Mammal Fishery Interactions. The WG would then be in charge of reviewing the results from the Icelandic Programme and advances in Ecosystem Modelling. The SC **recommended** that the WG expands its terms of reference to include all areas under NAMMCO jurisdiction and investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses. (SC/15). The SC forwarded this task to the WG on Marine Mammal Fisheries Interaction (MMFI) convened in 2009 Only preliminary results were presented and it was still too early to undertake a general review of the results. (SC/16).	Ongoing
1.1.7	NAMMCO/16 02-2007	The Committee requested the Scientific Committee to take into consideration the drafted text (NAMMCO/16/6) provided by the former By-catch WG in formulating how to handle by-catch issues in the future.	The SC **recommended** the organization of a workshop to review the use and applicability of the by-catch monitoring systems in use in different organizations. and suggested to seek contact with other organizations dealing with by-catch monitoring in view of initiating	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			collaboration on this matter. (SC/15). Steps were taken towards the organisation of the workshop. (SC/16).	
1.1.8	NAMMCO/17 09-2008	In addressing the standing requests on ecosystem modelling and marine mammal fisheries interaction, the SC is requested to extend the focus to include all areas under NAMMCO jurisdiction. In the light of the distributional shifts seen under T-NASS 2007, the SC should investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses. See also 1.1.6 and 1.4.6.	The SC convened in 2009 the WG on Marine Mammal Fisheries Interaction (MMFI) because it judged at its last meeting that the developments in modelling and other progress which had occurred in Norway, Canada and Japan warranted their review. SC has reviewed progress made in all areas and for all species. (SC/16).	Ongoing
1.2.0	**MULTISPECIES APPROACHES TO MANAGEMENT:**			
1.2.1	NAMMCO/1 1992	To consider whether multispecies models for management purposes can be established for the North Atlantic ecosystems and whether such models could include the marine mammals compartment. If such models and the required data are not available then identify the knowledge lacking for such an enterprise to be beneficial to proper scientific management and suggest scientific projects which would be required for		Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
		obtaining this knowledge.		
1.2.2	NAMMCO/5 02-1995	In relation to the importance of the further development of multispecies approaches to the management of marine resources, the Scientific Committee was requested to monitor stock levels and trends in stocks of all marine mammals in the North Atlantic.	It was clarified that the purpose of this request was to ensure that data on marine mammals was available for input into multi-species models for management. The Committee agreed that updated information on abundance and indications of trends in abundance of stocks of marine mammals in the North Atlantic should be clearly described in a new document for the internal reference of the Council, to replace the List of Priority Species. This document would be entitled Status of Marine Mammals in the North Atlantic and should include those cetacean and pinniped species already contained in the List of Priority Species, as well as other common cetacean species in the NAMMCO area for which distribution and abundance data is also available (fin, sei, humpback, blue, and sperm whales). (SC/5).	Ongoing
1.3.0	**SEALWORM INFESTATION**:			
1.3.1	NAMMCO/6 05-1996	Aware that the population dynamics of the sealworm (*Pseudoterranova decipiens*) may be influenced by sea temperature, bathymetry,	The Scientific Committee established a Working Group on Sealworm Infection to address this question. The Scientific Committee	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		invertebrate and fish fauna, the Scientific Committee was requested to review the current state of knowledge with respect to sealworm infestation and to consider the need for comparative studies in the western, central and eastern North Atlantic coastal areas, taking into account the priority topics recommended by the Scientific Committee and its *ad hoc* Working Group on grey seals.	used their report as the basis for providing advice to Council, and developing recommendations for further research. (SC/5) Many of the papers considered by the Working Group are published in *NAMMCO Scientific Publications* Vol. 3, *Sealworms in the North Atlantic: Ecology and population dynamics* (SC/7).	
1.4.0	**ECONOMIC ASPECTS OF MARINE MAMMAL-FISHERIES INTERACTIONS:**			
1.4.1	NAMMCO/7 05-1997	The Council requested that special attention be paid to studies related to competition and the economic aspects of marine mammal-fisheries interactions.	The Scientific Committee established a Working Group on Economic Aspects of Marine Mammal-Fisheries Interactions. The Scientific Committee concluded that inclusion of economic considerations is a valuable addition to multispecies models of interactions between marine mammals and fisheries. The work presented at the Working Group was considered the first step towards more complete analyses of these interactions and it was recommended, in light of the economic impacts, that more complete models should be developed and presented. The Scientific Committee showed a continued interest in the development	*Ongoing*

Code	Meeting	Request	Response of the Scientific Committee	Status
			of the models and it was decided to maintain the Working Group and seek further guidance from the Council on matters of particular interest. (SC/6).	
1.4.2	NAMMCO/8 09-1998	The Scientific Committee is requested to investigate the following economic aspects of marine mammal – fisheries interactions: – to identify the most important sources of uncertainty and gaps in knowledge with respect to the economic evaluation of harvesting marine mammals in the different areas; – to advise on research required to fill such gaps both in terms of refinement of ecological and economical models and collection of basic biological and economical data required as input parameters for the models; – to discuss specific cases where the state of knowledge may allow quantification of the economic aspects of marine mammal – fisheries interactions: a) what could be the economic consequences of a total stop in harp seal exploitation versus different levels of continued	The Working Group On The Economic Aspects Of Marine Mammal - Fisheries Interactions was reactivated to meet this request. It was agreed to separate the request into two sections. At the first Working Group meeting the first two items in the request were addressed. The Working Group used available information to derive estimates of consumption of cod, herring, capelin and shrimp by harp seals, minke whales and *Lagenorhynchus* spp. and bottlenose dolphins in some areas. Multispecies models presently in use or under development in Norway and Iceland offer a means of assessing the impact of marine mammal predation on fish stocks. The Scientific Committee therefore **recommended** that the next logical step in addressing the request should be for NAMMCO to lead or assist in the development of a	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
		sustainable harvest? b) what could be the economic consequences of different levels of sustainable harvest vs. no exploitation of minke whales?	multispecies-economic model for a candidate area. However, the Scientific Committee reiterated that the estimation and model uncertainties are such that definitive quantification of the economic aspects of marine mammal-fisheries interactions in candidate areas cannot be expected in the near term. (SC/8). See under 1.1.6. (SC/15).	
1.4.3	NAMMCO/10 09-2000	Noting the requests for advice from the Council at its Eighth meeting in Oslo 1998 (see Annual Report 1998 page 23), the Management Committee **recommended** that the Scientific Committee continue the assessment of the economic aspects of fishery - marine mammal interactions in the two areas (Barents Sea and Iceland) and with the two species (minke whales and harp seals) that have been identified as feasible for this assessment.	The Scientific Committee convened a workshop, under the theme "Marine mammals: From feeding behaviour or stomach contents to annual consumption – what are the main uncertainties?", to further investigate the methodological and analytical problems in estimating consumption by marine mammals. (SC/9).	Ongoing
1.4.5	NAMMCO/11 02-2002	The Management Committee noted the conclusion of the Scientific Committee that the estimation and model uncertainties are such that the economic aspects of marine mammal-fishery	The Scientific Committee convened a workshop, under the theme "Modelling Marine Mammal – Fisheries Interactions in the North Atlantic", to investigate how presently available	Ongoing

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		interactions in candidate areas cannot be quantified without further work. The Management Committee therefore **recommended** that the Scientific Committee should hold a workshop on ecosystem models aiming for a better understanding of the ecological role of minke whales and harp and hooded seals in the North Atlantic, as proposed in the Scientific Committee report.	ecosystem models can be adapted for quantifying marine mammal - fishery interactions. (SC/10). See under 1.1.6. (SC/15).	
1.4.6	NAMMCO/12 03-2003	The Management Committee agreed that the Scientific Committee should monitor progress made in multispecies modelling and in the collection of input data and decide when enough progress has been made to warrant further efforts in this area. Future meetings should focus on assessing modelling results from the Scenario Barents Sea model and possibly the GADGET-based template models for other areas, if they are developed. The Scientific Committee should also consider the feasibility of connecting the multi-species models with simple economic models at that time.	The SC convened in 2009 the WG on Marine Mammal Fisheries Interaction (MMFI) because it judged at its last meeting that the developments in modelling and other progress which had occurred in Norway, Canada and Japan warranted their review. The degree of progress in the quantitative description of marine mammal diets is in general not extensive and a considerable amount of work still remains. Some new approaches to estimating diet appear promising but still required verification. Multi-species modelling is a valid approach for	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			a better understanding of the ecological relations between species. However, the multi-species modelling required in order to address management questions is quite complex and the current multi-species models are not, at this time, sufficient to provide quantitative management advice, which is presently provided by single species management. Additional research is required in order to develop ecosystem models to a point where it may become possible, although with no guarantee, to use them to provide quantitative management advice. Therefore the SC **recommends**, as the best way forward, carrying out the modelling exercise suggested by the WG on MMFI for comparing the results of different models on the same ecosystem(s) using a common dataset. (SC/16).	
1.5.0	**ENVIRONMENTAL ISSUES:**			
1.5.1	NAMMCO/1 1992	To describe the possible pathways of radioactive material from blowouts and leakage in existing	Forwarded to ICES.	Pending

Code	Meeting	Request	Response of the Scientific Committee	Status
		nuclear power plants, leakage from dumped material and possible accidents in planned recycling plants in the northern part of Scotland into the food web of the North Atlantic and hence into the top predators like marine mammals.		
1.5.2	NAMMCO/1 1992	To review the contaminant burden (especially organochlorines) in marine mammals in the North Atlantic and evaluate the possible sources of these contaminants.	No response from the Scientific Committee. In 1995, NAMMCO hosted the International Conference on Marine Mammals and the Marine Environment. The Conference covered the following themes: Marine mammals and the marine environment-impacts and management approaches; Contaminants in marine mammals – sources, levels and effects; Coastal communities and marine pollution – social, economic and health considerations; Addressing the questions – problems and future needs. The proceedings were published as a special issue of *The Science of the Total Environment* (186, 1, 2).	Completed
1.6.0	**MANAGEMENT PROCEDURES:**			

Code	Meeting	Request	Response of the Scientific Committee	Status
1.6.1	NAMMCO/2 1993	To review the basis for, and develop assessments necessary to provide the scientific foundation for conservation and management of the stocks relevant for management under NAMMCO.	A Working Group on Management Procedures was established to consider this matter. The Scientific Committee noted that there were many different management needs requiring different management procedures. It was agreed that there was need for more guidance on management objectives before any concrete work can be started on developing appropriate management procedures, and in turn this was likely to be case- (species and/or area) specific. Related to this it was also noted that NAMMCO may prefer to assume an advisory and evaluative role in developing its management. (SC/2).	Completed
1.6.2	NAMMCO/4 1994	Further development of RMP-like procedures.	The Scientific Committee decided to develop management procedures on a case-by-case basis: "a more pragmatic approach on an area and species/case-specific basis would be desirable for the development of specific management procedures. It was therefore decided to suggest that requests for advice from the Council be accompanied by specific objectives defined for the case in question" (SC/3)	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
1.6.3	NAMMCO/17 09-2008	The Scientific Committee is requested to study general models for conservation and management of baleen whales, *inter alia* based on Norwegian studies presented to the Scientific Committee of the IWC (in 2008).	The SC **strongly recommends** using an "RMP implementation simulation process (IST)-like approach" as a general model for conservation and management of baleen whales in NAMMCO, but advising that implementation will have cost implications. (SC/16).	Completed
1.7.0	**MONITORING MARINE MAMMAL STOCK LEVELS AND TRENDS IN STOCKS /NORTH ATLANTIC SIGHTINGS SURVEYS (NASS)*:***			
1.7.1	NAMMCO/3 1993	To plan joint cetacean sighting surveys in the North Atlantic by co-ordinating national research programmes.	The Scientific Committee agreed to establish a Working Group to plan the sighting survey for the summer of 1995. (SC/2).	Completed
1.7.2	NAMMCO/5 02-1995	The 1995 North Atlantic Sightings Survey (NASS-95) would provide updated abundance estimates for a number of whale species in the North Atlantic, and the Scientific Committee was requested to review results in the light of recent assessments of North Atlantic whale stocks.	The Scientific Committee agreed to establish a Working Group on Abundance Estimates. The task of the Working Group would be to review analyses and where relevant also analyse data from NASS-95 to ensure its compatibility, both between NASS-95 survey areas, as well as with data from other sightings surveys, in order to provide a basis for calculating abundance estimates for the relevant cetacean stocks in the North Atlantic. (SC/4).	Completed
1.7.3	NAMMCO/6 05-1996	The Management Committee noted the successful completion of the North Atlantic Sightings	To address this request, a Working Group on Abundance Estimates had been established with	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		Survey in 1995, and commended the process initiated by the Scientific Committee to conclude the analysis of NASS-95 data. It was expected that the results on abundance will be dealt with by the newly established Scientific Committee Working Group on Abundance Estimates and will be presented at the next annual meeting. It was noted that the Working Group would at least to some extent address last year's request from the Council regarding monitoring of stock levels and trends in stocks. However, it was also noted that one outstanding matter from last year is the request to the Scientific Committee to review results of NASS-95 in the light of recent assessments of North Atlantic whale stocks. The Council agreed to the suggestion from the Management Committee that this be drawn to the attention of the Scientific Committee to secure a follow-up to last year's request.	the task of reviewing the analyses, and where relevant, also to analyse data from NASS-95 to provide a basis for calculating abundance estimates for the relevant cetacean stocks in the North Atlantic. The Working Group had focused on describing synoptic distributions of the cetacean species encountered during NASS-95, and abundance estimates for minke, fin, sei and pilot whales, which were the target species of the survey. The Scientific Committee concluded that the updated abundance estimates for the target species as reviewed by the Working Group on Abundance Estimates represented the best available estimates for the stocks concerned, and used them as a basis to provide advice to Council. The Scientific Committee also **recommended** that the results of NASS-95 be compiled to a future volume of *NAMMCO Scientific Publications*. (SC/5).	
1.7.4	NAMMCO/7 05-1997	The Scientific Committee was requested to continue its work to monitor stock levels and trends in all stocks of marine mammals in the North Atlantic in accordance with previous		Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		recommendations (see *NAMMCO Annual Report 1996*:131-132). In this context the Scientific Committee was encouraged to prioritise calculation of the abundance of species covered by NASS-95, in particular those species presently harvested and species considered to be important with respect to interactions with fisheries.		
1.7.5	NAMMCO/9 10-1999	The Management Committee noted particularly that abundance estimates from NASS-95 have not been completed for some species. The Management Committee therefore **recommended** that the Scientific Committee complete abundance estimates for all species, as part of its efforts to monitor the abundance of all species in the North Atlantic.	The Scientific Committee noted that abundance estimates for the main target species of NASS-95 (minke whale, fin whale, sei whale, pilot whale) had been completed and accepted by them, however most had not yet been published in the primary scientific literature. The Scientific Committee agreed that further analyses of the abundance of non-target species from the NASS-95 survey should be conducted if they are warranted. However, as the survey was not optimised for these species, it was recognised that the design and conduct of the survey would make this possible to a varying degree, depending on both the species and area in question. In some cases, a general description of the spatial distribution of sightings may be the only analysis warranted. The Scientific	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
			Committee agreed to pursue these analyses in the coming year. (SC/8) The Scientific Committee considered new information on the NASS-95 Icelandic aerial and shipboard surveys for minke whales, and a new abundance estimate for humpback whales from the NASS-95 Icelandic shipboard survey. (SC/9).	
1.7.6	NAMMCO/9 10-1999	The Management Committee **recommended** that the Scientific Committee continue its efforts to coordinate future sightings surveys and analyses of the results from such surveys in the North Atlantic. Priority species should be minke whales and fin whales, and the Management Committee **recommended** that that the survey design be optimized for these species. The survey should also be optimized to cover those areas where abundance estimates are most urgently required.	The Working Group on Abundance Estimates met in November 2000 to plan for NASS-2001. The survey was conducted in June/July 2001. (SC/9).	Completed
1.7.7	NAMMCO/11 02-2002	The Management Committee **recommended** that remaining abundance estimates from the NASS-95 and new estimates from the NASS-2001 surveys should be developed as soon as feasible, with the target species of the surveys being of	The Working Group on Abundance Estimates met in March 2002 and developed preliminary abundance estimates for fin whales, minke whales, humpback whales, sperm whales and dolphins. In addition a full evaluation of the	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		highest priority. The Management Committee emphasised that this work should be published in a timely manner.	2001 survey was conducted, and recommendations for future surveys were made. (SC/10) The Scientific Committee has now completed estimates for most species for which estimates are feasible. A new volume of NAMMCO Scientific Publications is presently in progress which will integrate results from all NASS. (SC/11).	
1.7.8	NAMMCO/13 03-2004	The Management Committee therefore requested that the Scientific Committee co-ordinate the efforts of member countries in planning and conducting a large-scale sightings survey in 2006. In order to ensure as broad a coverage as possible, this should include co-ordination with planned surveys by non-member countries, and inviting other jurisdictions, particularly in the Western Atlantic, to participate in the surveys.	After consultations with various other jurisdictions, the SC **recommended** that 2007 would be the optimal year to carry out the next NASS (SC/12). See under 1.7.10. (SC/15).	Completed
1.7.9	NAMMCO/14 03-2005	For various reasons, 2007 will be the optimal year to carry out the next NASS, rather than 2006 as originally planned. Efforts of the Scientific Committee to expand the NASS to include involvement from countries in the Western and	The SC concluded that there is a perhaps unique opportunity to conduct a very wide ranging synoptic cetacean survey, covering areas of the eastern and western Atlantic that have never been covered simultaneously in	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		Eastern Atlantic should be continued.	previous surveys. The Committee **strongly recommended** that the Council and individual member countries encourage other jurisdictions to become involved in the NASS project for 2007. To take advantage of this opportunity, it was decided to establish a steering group to begin planning NASS and its coordination with other surveys. It is anticipated that a planning meeting, involving participation from all relevant jurisdictions, should be held sometime in 2006 (SC/13). Two meetings were held in 2006 to plan the Trans NASS (TNASS), including its coordination with US and European surveys and the use of platforms of opportunity in adjacent areas (SC/14) See under 1.7.10. (SC/15).	
1.7.10	NAMMCO/16 02-2007	The Committee requested the Scientific Committee to continue their diligent planning of T-NASS, taking care to ensure that the coverage	The SC convened 3 meetings of the Working Group on T-NASS to insure a smooth planning of the meeting (April 2007) and a general	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		of the survey and the methodology would be adequate for obtaining reliable data for the main target species - fin, minke and pilot whales - while accommodating at the same time the need for estimates for the harbour porpoise, especially in Icelandic waters.	evaluation of the survey (Nov. 2007 and April 2008). The SC concluded that coordination of surveys under the T-NASS banner had been successful and productive and will allowed reliable estimate for the target species. (SC/15). The modifications implemented in the Icelandic coastal aerial survey for encompassing harbour porpoises had been successful and will lead to the first reliable harbour porpoise abundance in this area. (SC/15).	
1.7.11	NAMMCO/16 02-2007	Once the survey has been completed, the Committee requested the Scientific Committee to develop estimates of abundance and trends as soon as possible, with the primary target species (fin, minke and pilot whales) as a first priority, and secondary target species as a second priority.	This request is being addressed with the near completion of most of the analyses of T-NASS minke whale survey data. Abundance estimates for fin whales have been finalized (Icelandic-Faroese shipboard and Greenland aerial T-NASS surveys) or are on their way (Norway shipboard T-NASS survey). Some progress has been made in the analyses of pilot whale data, although further analyses are warranted, which will be presented to the next AE WG in October 2009. (SC/16). Estimates of abundance for some key species	Ongoing

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			are available and referred to in the SC report (SC/17).	
1.8.0	**OTHER:**			
1.8.1	NAMMCO/8 09-1998	Greenland noted the need for greater input from hunters and users in the work of the Scientific Committee. While noting the need for scientists to be able to conduct their work on their own scientific terms in the context of their Committee meetings, it was suggested that scientists and users of marine mammal resources which are the subject of examination by the Scientific Committee could, for example, meet prior to meetings of the Scientific Committee in order to exchange information relevant to the work planned by the Scientific Committee. With these ideas in mind, Greenland recommended that concrete steps should be taken to provide for a more active dialogue between scientists and resource users. This recommendation was **endorsed** by Council.	The Scientific Committee agreed to a proposal put forward by the Secretariat, to use the "Status of Marine Mammals in the North Atlantic" stock status reports as a means of incorporating the knowledge of marine mammal users. This proposal was presented to NAMMCO Council for approval. (SC/7). The Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic met jointly with the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) in May 2001. Prior to the main meeting, the Joint Working Group met with hunters from Greenland and Canada, and Canadian hunters participated throughout the meeting. (SC/9).	Ongoing
1.8.2	NAMMCO/9	With respect to the language used in the Report of the Scientific Committee, Greenland suggested	No response.	Ongoing

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	10-1999	that it must be kept precise and simple. The Management Committee agreed to convey this as a suggestion to the Scientific Committee.		
2.1.0	**HARP AND HOODED SEALS**			
2.1.1	NAMMCO/2 1993	- to assess the stock size, distribution and pup production of harp seals in the Barents Sea and White Sea, and of harp and hooded seals in the Greenland Sea and the Northwest Atlantic; - to assess sustainable yields at present stock sizes and in the long term under varying options of age composition in the catch; - to provide advice on catch options in the White Sea/Barents Sea/Greenland Sea and NAFO areas; - to assess effects of recent environmental changes or changes in the food supply and possible interaction with other living marine resources in the areas.	These requests forwarded to Joint ICES/NAFO Working Group on Harp and Hooded Seals. A partial assessment was completed, but more work was required. (SC/2). The Scientific Committee considered the report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals which had met in Dartmouth, Canada, 5-9 June 1995. The Scientific Committee endorsed the recommendations in the report and identified further research needs. However the required assessments had not yet been completed. (SC/4). The Scientific Committee considered the report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals which had met in Copenhagen in 1997. The Scientific Committee	Completed

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			used this report as the basis for its advice to Council, while noting that catch options had not been completed for Greenland Sea harp and hooded seals, and White Sea and Barents Sea harp seals. (SC/6). The Joint ICES/NAFO Working Group on Harp and Hooded Seals met in 1998 to complete the assessments for Greenland Sea harp and hooded seals, and White Sea and Barents Sea harp seals. The Scientific Committee used their report as the basis of its advice to Council, and noted that the required assessments had now been completed. Assessment of the effects of recent environmental changes or changes in the food supply and possible interaction with other living marine resources in the areas is ongoing. (SC/7).	
2.1.2	NAMMCO/8 09-1998	The Scientific Committee is requested to co-ordinate joint feeding studies of harp and hooded seals in the Nordic Seas (Iceland, Greenland and Norwegian Seas) and off West Greenland.	The Scientific Committee noted that preparations to coordinate such studies between member countries were already under way, outside of the NAMMCO Scientific Committee. The Scientific Committee therefore emphasized its support for such joint studies and urged	Completed

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			member countries to participate. (SC/7).	
2.1.3	NAMMCO/11 02-2002	The Management Committee **recommended** that the Scientific Committee regularly update the stock status of North Atlantic harp and hooded seal stocks as new information becomes available.	Ongoing as new information becomes available.	Replaced by 2.1.4
2.1.4	NAMMCO/12 03-2003	The Management Committee noted that new information recently had become available on the abundance of harp seals in the Greenland Sea and the Northwest Atlantic. In addition new information is available on movements and stock delineation of harp seals in the Greenland, Barents and White seas. The Management Committee therefore reiterated its previous request to the Scientific Committee to regularly update the stock status of North Atlantic harp and hooded seals as new information becomes available. The Management Committee noted the likely impact of increasing abundance of these species on fish stocks. For harp seals in the Northwest Atlantic, the immediate management objective is to maintain the stocks at their present levels of abundance.	An update of the stock status of North Atlantic hooded seals had been made by the WGHARP at its 2008 meeting, which in turn had been endorsed by the Committee. The SC notes that this is a standing request that will be taken up again when new data become available. Considering that the population in the Greenland Sea in 2007 is still well below N_{lim}, and the results of the 2007 survey were similar to those in 2005, the SC reiterates its recommendation from SC 14 that the catches in the Greenland Sea be restricted to necessary scientific catches and to satisfy local needs at roughly current levels. (SC/16).	Standing
2.1.5	NAMMCO/13	The Management Committee requests that the	With regard to the Canadian Management Plan,	Completed

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	03-2004	Scientific Committee annually discusses the scientific information available on harp and hooded seals and advice on catch quotas for these species given by the ICES/NAFO Working Group on Harp and Hooded Seals. The advice by the Scientific Committee on catch quotas should not only be given as advice on replacement yields, but also levels of harvest that would be helpful in light of ecosystem management requirements. For the Barents/White Sea and Greenland Sea stocks, in addition to the advice on replacement yields, advice should be provided on the levels of harvest that would result in varying degrees of stock reduction over a 10 year period. Noting that Canada has instituted a multi-year management plan with a 3- year allowable catch of harp seals totalling 975,000 (not including the catch by Greenland), the Management Committee requested the Scientific Committee to provide advice on the likely impact on stock size, age composition, and catches in West Greenland and Canada under the conditions of this plan.	the SC concluded that the likely effect of the harvest levels outlined in Plan was a slight drop in total abundance in the short term (3-5 years), and an accelerating decline if these harvest levels are maintained over a longer period (*ca*. 10 years), and that the availability of seals to Greenlandic hunters would likely decrease as the total population decreased. (SC/12). The SC **recommended** that catches of hooded seals in the Greenland Sea be restricted to necessary scientific catches and to satisfy local needs at roughly current levels. This should be accompanied by a careful monitoring (SC/14).	

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2.1.6	NAMMCO/14 03-2005	The Management Committee **recommended** that the Scientific Committee evaluate how a projected decrease in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.	With regard to this request, the SC notes that it had recommended several times (SC 13, 14, 15) that this question be referred to the ICES-NAFO Working Group. However, since this has not been done by Greenland, the SC tasked the MMFI WG to deal with the request. The conclusion of the WG is reported in document SC/16/08. The SC concludes that there were clear positive correlations between catches of harp seals off northwest and southwest Greenland and abundance estimates of these seals off Canada. Hence a decrease in the numbers of seals in Canada is likely to cause a decrease of the catches in Greenland. This relationship might not be linear, but is difficult to quantify. As suggested by the WG, one way to proceed would be to attempt multi-linear regression analysis, which takes account of any information available on annual hunting effort and periods for which the seals stay off Greenland, as well as the Canadian abundance	Ongoing

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			estimates. This would also allow the calculation of confidence limits associated with any estimate of a decrease in catch. (SC/16).	
2.1.7	NAMMCO/14 03-2005	The Management Committee requested the Scientific Committee to specify harvest levels for these 2 stocks that would result in a population reduction of 20% over a period of 20 years.	New modelling results were considered which provided target catch levels for both the Barents/White Sea and Greenland Sea stocks (SC/14).	Completed
2.1.8	NAMMCO/15 03-2006	As suggested by the Scientific Committee in 2004, the Management Committee recommended that NAMMCO explore the possibility with ICES and NAFO of assuming a formal joint role in the Working Group on Harp and Hooded Seals. The Secretariat should contact ICES and NAFO in this regard. As a starting point, the Working Group, jointly with the NAMMCO Scientific Committee, should be asked to provide advice on outstanding requests (MC/4, 4.9.6 and 4.9.7, also NAMMCO 2005 p. 25). Greenland specifically stressed the importance of these outstanding requests, and indicated that they would expect a more complete *discussion next year.*	Not successful in assuming joint role in the Working Group.	Completed
2.1.9	NAMMCO/16	The commission requested the SC to- investigate	This request was forwarded to the ICES-NAFO	Ongoing

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	02-2007	possible reasons for the apparent decline of Greenland Sea stock of hooded seals; and assess the status of the stock on basis of the results from the planned survey in 2007.	WG, which dealt with this request at its meeting in Tromsø in 2008. (SC/15). On the basis of the conclusion of this group, the SC concludes that the reasons for the decline of the stock are still not understood. A reduction in extent and concentration of drift ice has occurred in the Greenland Sea between Greenland and the Jan Mayen Island. These changes must have resulted in substantial changes in breeding habitat for the Greenland Sea populations of harp and hooded seals. Could these changes in ice-conditions have triggered behavioural changes of such a magnitude as a relocation of breeding for at least parts of the populations? Recent low pup production in hooded seals, and new (2007 and 2008) discoveries of breeding harp seals in areas outside those used historically by the species could both be indicative of such changes. Work conducted in Norway (including new assessment of biological parameters) will help	

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			in addressing the questions of the maintained low pup production of hooded seals in the Greenland Sea. The SC appreciates the efforts made by Norwegian and cooperating scientists to address the questions related to the apparent decline of hooded seals in the Greenland Sea. It **strongly recommends** that these activities are given high priority in the coming years. (SC/16).	
2.1.10	NAMMCO/17 09-2008	The SC is requested to provide advice on Total Allowable Catches for the management of harp seals and the establishment of a quota system for the common stocks between Norway and the Russian Federation, leaving full freedom to the Committee to decide on the best methods to determine this parameter based on an ecosystem approach.	The Committee notes that in October 2008, ICES provided advice that was used to set the 2009 quotas for northeast Atlantic harp seals by the Joint Norwegian Russian Fisheries Commission. The SC endorses at its present meeting the advice provided. The committee also notes that WGHARP will meet in August 2009 to review the research activities that are currently in progress, including but not limited to, new pup surveys in the White Sea and collection of new reproduction data during the current hunt in the Greenland Sea. Once these data are available, it will be possible to provide updated advice for the two populations for 2010 and following years. This advice will provide	Standing

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			information on the level of total removals that can be sustained. Dividing the total removals for each population into national allocations is traditionally carried out through bilateral negotiations in the Joint Norwegian Russian Fisheries Commission. Therefore the SC feels it needs clarification from the Council on the request of the establishment of a quota system. The SC also wishes a clarification from Council about the definition of "ecosystem approach" in the establishment of a quota system as stated in the request R-2.1.10. (SC/16).	
2.1.11	NAMMCO/ 18 09-2009	The Scientific Committee is requested to evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.	As the NAMMCO SC has no tradition of establishing WGs on harp seals, the SC recommended that Greenland forward the request to ICES/NAFO so that it can be considered by the WGHARP. The request has been forwarded to ICES by Greenland and is on the agenda of the ICES NAFO WG on harps and hoods meeting in August 2011.	Pending

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			(WGHARP 2011) New estimates of abundance need to be developed to discriminate between actual and perceived changes in abundance. The population is believed to approach carrying capacity and this is normally associated with new factors becoming important for a continued growth of the population. It is therefore uncertain whether the distribution of the seals in the years to come is predictable based on hind-cast analysis. Such analyses will, however, be important to describe how distribution patterns change as the population and the environment change. Historically the abundance of seals in Greenland waters was positively associated with increases in the harp seal population. Since 2000, it appears that ecological and hydrographical changes have changed the relationship, and possibly led to decreases in harp seals. However, there are insufficient data available to adequately analyse the latter. (SC/19)	
2.3.0	**RINGED SEALS**:			

Code	Meeting	Request	Response of the Scientific Committee	Status
2.3.1	NAMMCO/5 02-1995	To advise on stock identity of ringed seals (*Phoca hispida*) for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (i.e. disturbance, pollution) and changes in the food supply, and interactions with other marine living resources. The Management Committee endorsed again this request as a standing request. (NAMMCO 19)	The Scientific Committee established a Working Group on Ringed Seals. The Scientific Committee considered the report of the Working Group and provided advice to Council. They also provided recommendations for future research. (SC/5). Papers considered by the Working Group as well as other papers were published in the first volume of NAMMCO Scientific Publications, *Ringed Seals in the North Atlantic*.	Standing
2.3.2	NAMMCO/7 05-1997	The Scientific Committee was requested to advise on what scientific studies need to be completed to evaluate the effects of changed levels of removals of ringed seals in West and East Greenland. The Management Committee endorsed again this request as a standing request. (NAMMCO 19)	It was noted that the exploitation level of ringed seals in Greenland has shown considerable variability over decades in this century. The Scientific Committee chose to focus on scenarios where exploitation is raised by more than twice the level reported in recent years. The Scientific Committee then identified the main gaps in knowledge, and **recommended** research required to address them. (SC/6).	Standing
2.4.0	**GREY SEALS**:			
2.4.1	NAMMCO/5 02-1995	To review and assess abundance and stock levels of grey seals (*Halichoerus grypus*) in the North	The Scientific Committee established a Working Group on Grey Seals. The Scientific	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematodal infestations in fish in particular.	Committee considered the report of the Working Group and provided advice to Council, including recommendations for further research. (SC/4).	
2.4.2	NAMMCO/11 02-2002	The Management Committee noted that there has been a decline in the numbers of grey seals around Iceland, possibly due to harvesting at rates that are not sustainable. The Scientific Committee had previously provided advice in response to a request to review and assess abundance and stock levels of grey seals in the North Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematodal infestations in fish in particular (NAMMCO 1995). Given the apparent stock decline in Iceland, an apparent increase in Southwest Norway and in the United Kingdom, and the fact that this species interact with fisheries in three NAMMCO member countries, the Management Committee **recommended** that the Scientific Committee provide a new assessment of grey seal stocks throughout the North Atlantic.	The Working Group on Grey Seals met in April 2003 and completed an initial assessment of stocks around Norway, Iceland, Great Britain and the Baltic. (SC/11). The SC recommends: • Establishment and/or continuation of standardised and regular monitoring programmes for seal abundance in all countries, including the development of appropriate survey methods. • Securing catch records and associated data from hunted seals. • Quantification and standardisation of methods to estimate struck and lost and by-catch. • Population assessment of both species in *Russia.* • Survey of harbour seals along the coast of *Iceland.*	Standing

Code	Meeting	Request	Response of the Scientific Committee	Status
			• Studies to identify the population structure of *Norwegian* harbour seals. • Exploration of the south-eastern *Greenland* coast for the presence of harbour and grey seals. • Estimation of the stock identity, size, distribution and structure of the *Faroese* population of grey seals. • Completion of the ongoing genetic analyses of grey seal population structures for the north Atlantic including new samples from the *Faroe Islands.* The SC furthermore recommends • Development of common sampling protocols for all areas in the North Atlantic in preparation for epidemic disease outbreaks, including establishment of blood serum stores for seals sampled. • Compilation of a database of samples stored in the NAMMCO countries. (SC/18)	

Code	Meeting	Request	Response of the Scientific Committee	Status
			The SC recommended that the Grey and Harbour Seals WG meet in 2014, reflecting the recommendations to finalise the **request 2.4.2**. (SC/19)	
2.5.0	**HARBOUR SEAL**			
2.5.1	NAMMCO/14 03-2005	Harbour seal abundance has fluctuated in the Northeast Atlantic in recent years due to local outbreaks of viral distemper. Usually these outbreaks have been followed by rapid recoveries, and harbour seal abundance may have increased in many areas. In some areas, harbour seals are harvested and/or taken incidentally by fisheries and aquaculture operations (*e.g.* Greenland, Norway and Iceland). They also have significant direct and indirect interactions with fisheries in many areas. For these reasons, the Scientific Committee is requested to: - Review and assess the status of harbour seals throughout the North Atlantic; - Review and evaluate the applied survey methods; - Assess stock delineation using available data on genetics, spatial and temporal distribution and other sources;	A Working Group on Harbour Seals was convened in October 2006 to deal with this request. The WG completed assessments of harbour seals in all areas of the North Atlantic and the Baltic.	Completed.

Code	Meeting	Request	Response of the Scientific Committee	Status
		- Review available information about harbour seal ecology; - Identify interactions with fisheries and aquaculture.		
2.5.2	NAMMCO/16 02-2007	The commission requested the Scientific Committee to conduct a formal assessment of the status of harbour seals around Iceland and Norway as soon as feasible.	At its meeting 2007 (SC/15), the SC **recommended** that an assessment be conducted in 2010 after the third Norwegian survey, leaving Iceland time for developing a management plan. However, the Norwegian survey will take place in mid-summer 2010, and the results of the survey will probably not be available before early 2011, therefore the SC **recommends** that an assessment be conducted early 2011. Data on removals are still needed both for Iceland and Norway. (SC/16). The SC reiterated the recommendation that a formal assessment of harbour seals in all areas be carried out by a WG meeting on coastal seals in 2011. SC **recommended** that a WG on coastal seals be held to review the ***Norwegian*** management plan for grey and harbour seals, to perform assessments for grey and harbour seals	Pending

Code	Meeting	Request	Response of the Scientific Committee	Status
		The Management Committee agreed to change the geographical focus of this request to entail ALL areas. (NAMMCO 19)	in all areas, and to develop a common management model for both species in all areas. The WG should also consider whether the age data from the catch of grey and harbour seals in ***Iceland*** would improve the assessment. If a meeting is planned for early 2011, another meeting is likely required to fulfill the task. (SC/17) The SC recommends: • Establishment and/or continuation of standardised and regular monitoring programmes for seal abundance in all countries, including the development of appropriate survey methods. • Securing catch records and associated data from hunted seals. • Quantification and standardisation of methods to estimate struck and lost and by-catch. • Population assessment of both species in *Russia.* • Survey of harbour seals along the coast of *Iceland.*	

Code	Meeting	Request	Response of the Scientific Committee	Status
			• Studies to identify the population structure of *Norwegian* harbour seals. • Exploration of the south-eastern *Greenland* coast for the presence of harbour and grey seals. • Estimation of the stock identity, size, distribution and structure of the *Faroese* population of grey seals. • Completion of the ongoing genetic analyses of grey seal population structures for the north Atlantic including new samples from the *Faroe Islands*. The SC furthermore recommends • Development of common sampling protocols for all areas in the North Atlantic in preparation for epidemic disease outbreaks, including establishment of blood serum stores for seals sampled. • Compilation of a database of samples stored in the NAMMCO countries. (SC/18) The SC recommended that the Grey and	

Code	Meeting	Request	Response of the Scientific Committee	Status
			Harbour Seals WG meet in 2014, reflecting the recommendations to finalise the **request 2.5.2**. (SC/19)	
2.6.0	**ATLANTIC WALRUS**:			
2.6.1	NAMMCO/2 1993	To advise on stock identity for management purposes; to assess abundance in each stock area; to assess long-term effects on stocks by present removals in each stock area; to assess effects of recent environmental changes (i.e. disturbance, pollution) and changes in the food supply.	The assessment was postponed pending report of Walrus International Technical and Scientific Committee (WITS). (SC/2) It was decided in late 1994 to request Erik Born of the Greenland Fisheries Research Institute in Copenhagen to coordinate the compilation of a status report on the Atlantic walrus in time for the Scientific Committee meeting. The result of this collaboration was the report, E.W. Born, I. Gjertz and R.R. Reeves, "Population assessment of Atlantic walrus (*Odobenus rosmarus rosmarus*)" This report was used by the Scientific Committee as the basis of its management and research recommendations to Council. (SC/3).	Completed
2.6.2	NAMMCO/13 03-2004	The Management Committee noted that the Scientific Committee had last provided an assessment of walrus in 1994. Noting that considerable new information has become	The SC provided assessment advice for East Greenland, West Greenland and North Water stocks of walrus, but noted that the assessments were incomplete due to insufficient information	Replaced by 2.6.5

Code	Meeting	Request	Response of the Scientific Committee	Status
		available since then, the Management committee therefore requested the Scientific Committee to provide an updated assessment of walrus, to include stock delineation, abundance, harvest, stock status and priorities for research.	on stock delineation and abundance. It was anticipated that the assessment for West Greenland could be completed within the next 2 years (SC/13). The SC considered that sufficient new information would be available to provide new assessments for the West Greenland and North Water stocks in 2008 (SC/14).	
2.6.3	NAMMCO/15 03-2006	The Scientific Committee should provide advice on the effects of human disturbance, including fishing and shipping activities, in particular scallop fishing, on the distribution, behaviour and conservation status of walrus in West Greenland.	With the current actual state of knowledge, the SC is unable to answer this question. The walrus disturbance study on Svalbard will help only in answering the problem of disturbance by tourists. The SC referred, however, to the answer to request 3.4.9. (SC/16). Owing to a lack of explicit studies, the SC is not in a strong position to provide advice on the effects of human disturbance on walrus. (SC/17)	Ongoing
2.6.4	NAMMCO/16 02-2007	The Commission requested the Scientific Committee to provide a formal assessment of the Davis Strait stock as soon as finalization of the catch series is complete and the results from the	See item 2.6.5 (SC/16). A full assessment of all walrus stocks in this request was carried out and presented at SC/17.	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		planned 2007 survey are available. The Scientific Committee is then requested to provide estimate of sustainable yields of the North Water and West Greenland stocks of walrus.		
2.6.5	NAMMCO/17 09-2008	The Management Committee requested the SC to provide a full assessment of North Water, West Greenland-Eastern Baffin Island and East Greenland stocks.	Pending the walrus assessment WG meeting in November 2009. The SC reiterates its recommendation that Greenland makes progress on the old catch series, as well as provides the results of the 2009 surveys and tagging experiments, before the next assessment meeting in November 2009. (SC/16). A full assessment of all walrus stocks in this request was carried out and presented at SC/17.	Completed
2.6.6	NAMMCO/21 09-2012	The Management Committee requested the SC to investigate the possibility to include a carryover for quotas in order to include this possibility in the next hearing for the new quota block period.		New request
3.1.0	**FIN WHALE:**			
3.1.1	NAMMCO/8	The Scientific Committee is requested to	The Scientific Committee established a	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
	09-1998	undertake an assessment of the status of fin whales in the North Atlantic based on all available data. (This request was later elaborated as follows: "Acknowledging the large amount of work involved in such a comprehensive assessment of all possible fin whale stocks in the North Atlantic, the Council requests the Scientific Committee, when conducting such comprehensive assessment, particularly to i. assess the stock structure of fin whales in the whole North Atlantic. ii. assess the long-term effects of annual removal of 50, 100 and 200 fin whales in the stock area traditionally assumed to have a main concentration off East Greenland and Iceland (EGI stock area), iii. identify MSY exploitation levels for that stock area."	Working Group on Fin Whales to deal with this request. The Working Group met in April 1999. Their report dealt with the stock structure of fin whales throughout the North Atlantic, and with assessment of the EGI stock. The Scientific Committee used the report of the Working Group to formulate advice and research recommendations to NAMMCO Council. Detailed assessment of other fin whale stocks was not carried out, but will be if further requests from Council are forthcoming.	
3.1.2	NAMMCO/9 10-1999	The Management Committee **recommended** that the Scientific Committee continue its assessment of fin whale stocks in the North Atlantic, focussing in the near term on the status of fin whales in Faroese territorial waters. The	The Scientific Committee reactivated the Working Group on North Atlantic Fin Whales and used their report as the basis for their advice to the Council. The results of the assessments indicated that fin whales in the area	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		Scientific Committee should focus particularly on the following issues: i. Assess the long-term effects of annual removals of 5, 10 and 20 fin whales in Faroese waters; ii. Information gaps that may need to be filled in order to complete a full assessment in this area.	have likely been substantially depleted by past harvests, but there was great uncertainty in the results. The Scientific Committee noted that in attempting to respond to the Council's request for advice on the long-term effect of various catch levels in the Faroese area, it had immediately become apparent that there is insufficient information on stock identity to carry out a reliable assessment of the status of fin whales in Faroese waters, and thus provide reliable advice on the effects of various catches. The Scientific Committee therefore **recommended** a research program primarily geared to understanding the stock relationships of fin whales around the Faroes.	
3.1.3	NAMMCO/10 09-2000	The Management Committee noted that the requested assessment (4.31) had not been fully completed and awaited in particular the provision of more information on stock delineation. The Management Committee therefore **recommended** that the Scientific Committee continue its assessment, as new data become available.	To be addressed as new information becomes available.	Replaced by 3.1.4

Code	**Meeting**	**Request**	**Response of the Scientific Committee**	**Status**
3.1.4	NAMMCO/11 02-2002	The Management Committee clarified its previous request for advice on fin whales, asking that the Scientific Committee continue with its assessments of fin whale stocks in the areas of interest to NAMMCO countries with existing and new information on abundance and stock delineation as it becomes available.	The Scientific Committee completed assessments on EGI and Faroese fin whales based on new abundance data. Future effort will be concentrated on Northeast Atlantic fin whales. (SC/11). The SC convened a Working Group on Fin Whales in October 2005 to update information relating to stock delineation, abundance and catch in all areas of the North Atlantic (SC/13). The Scientific Committees of the IWC and NAMMCO convened a Joint Working Group on the Catch History, Stock Structure and Abundance of North Atlantic Fin Whales in March 2006 (SC/14).	Replaced by 3.1.5
3.1.5	NAMMCO/13 03-2004	The Management Committee noted that it had previously asked that the Scientific Committee continue with its assessments of fin whale stocks in the areas of interest to NAMMCO countries with existing and new information on abundance and stock delineation as it becomes available, and endorsed the plan of the Scientific Committee to complete an assessment for the Northeast Atlantic	The SC convened a Working Group on Fin Whales in October 2005 to update information relating to stock delineation, abundance and catch in all areas of the North Atlantic (SC/13). The Scientific Committees of the IWC and NAMMCO convened a Joint Working Group on the Catch History, Stock Structure and	Replaced by 3.1.6

Code	Meeting	Request	Response of the Scientific Committee	Status
		stocks and update assessments for other areas, probably in 2005.	Abundance of North Atlantic Fin Whales in March 2006 (SC/14).	
3.1.6	NAMMCO/16 02-2007	The Commission requested the Scientific Committee to complete an assessment for the Northeast Atlantic stocks as a next step in the process of assessing fin whale stocks in the areas of interest to NAMMCO countries.	An assessment can be initiated for the North east Atlantic Stocks when the estimate for the 2007 estimate will be made available. This could be made in conjunction with a new assessment of the central stock subsequent to the new 2007 abundance estimate. The SC **recommended** that this be done before the next SC meeting. (SC/15).	Replaced by 3.1.7
3.1.7	NAMMCO 17 09-2008	The SC is requested to complete an assessment of fin whales in the North Atlantic and also to include an estimation of sustainable catch levels in the Central North Atlantic. This work should be initiated as soon as all estimates become available and before the meeting of the SC in 2009.	The fin whale assessment has been postponed to after the completion of the RMP Implementation Assessment of North Atlantic fin whales scheduled for June 2009. The WG on Large Whale Assessment is scheduled to meet 26-28 January 2010 in Copenhagen with fin whales on its agenda. (SC/16). The SC completed an assessment of North Atlantic fin whales at its 2010 meeting (SC/17). The SC considers that an annual strike of up to 154 fin whales from the WI sub-area is sustainable at least for the immediate 5-year period. It noted that the RMP-variant with a	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			60% tuning level has yet to be simulation-tested for trials involving stock structure uncertainty in the long term, thus it recommends that simulation trials be carried out as soon as possible and the long-term sustainability of the advice be reconsidered in the light of these results.	
3.2.0	**HUMPBACK WHALE:**			
3.2.1	NAMMCO/11 02-2002	The Management Committee noted the conclusions of the Scientific Committee that there was evidence of a rapidly increasing abundance of humpback whales around Iceland, and **recommended** that the Scientific Committee complete abundance estimates for this species as a high priority. The Scientific Committee should also consider the results of the "Years of the North Atlantic Humpback" (YoNAH) project as it pertains to member countries in providing advice for this species.	The Scientific Committee has noted previously (SC/9) that abundance estimates from the NASS-95 survey appear to conflict with the results of the YoNAH project, and comparison with the estimates from NASS-2001 should be of great interest. (SC/10). The Scientific Committee concluded that the discrepancy between the NASS and YoNAH estimates suggests that the North Atlantic population of humpback whales is likely considerably larger than estimated in the YoNAH study. Further studies are needed to resolve these differences more fully. (SC/11).	Completed
3.2.2	NAMMCO/13	The Management Committee noted the	Mainly because of a lack of current information	Replaced by

Code	Meeting	Request	Response of the Scientific Committee	Status
	03-2004	conclusion of the Scientific Committee that there is evidence from the NASS of a rapidly increasing abundance of humpback whales in the Central North Atlantic. The Scientific Committee was requested to assess the sustainable yield levels for humpback whales, particularly those feeding in West Greenlandic waters. The management objective in this case would be to maintain the stock at a stable level.	on abundance, the Scientific Committee was unable to complete the Assessment for West Greenland. The Scientific Committee noted that they would be able to estimate sustainable yield levels for humpback whales in the Northeast Atlantic. (SC/12).	3.2.3.
3.2.3	NAMMCO/14 04-2005	The Scientific Committee is requested to continue its assessment of humpback whale stocks in the North Atlantic. For West Greenland, the Scientific Committee should assess the long-term effects of annual removals of 0, 2, 5, 10 and 20 whales. For the Northeast Atlantic the Scientific Committee should provide estimates of sustainable yield for the stocks. In all cases the management objective would be to maintain the stocks at a stable level. The Scientific Committee should identify information gaps that must be filled in order to complete the assessments.	The Committee decided to postpone the provision of advice for West Greenland until a new abundance estimate is available, probably in 2006. Sufficient information on historical catch, abundance and stock structure is available at present to conduct assessments for the Icelandic and Norwegian stocks. However, given other priorities, the Committee considered it advisable to delay this assessment until after the completion of the NASS-2007 survey, when an additional estimate of abundance should become available (SC/13). The SC reviewed new information on the abundance of humpback whales off West	Replaced by 3.2.5.

Code	Meeting	Request	Response of the Scientific Committee	Status
			Greenland from surveys conducted in 2005, and provided interim advice on safe removal levels for the area. Further information will be available after the TNASS in 2007 to complete assessments in all areas (SC/14).	
3.2.4	NAMMCO/15 03-2006	The Commission requested the Scientific Committee to conduct a formal assessment following the completion of the T-NASS. In addition the Scientific Committee is requested to investigate the relationship between the humpback whales summering in West Greenland and other areas and incorporate this knowledge into their estimate of sustainable yields of West Greenland humpback whales.	The SC **recommended** that the preliminary work to conclude such assessment be made in connection with the fin whale assessment meeting and that abundance estimate from all the surveys be made available to that meeting. (SC/15).	Pending
3.2.5[8]	NAMMCO/18 09-2009	The SC is requested to assess the sustainability of yearly catches of 5, 10, 20 humpback whales off West Greenland.	The SC **found** that the AWMP-C procedure (Witting 2008; IWC 2009) would be appropriate for providing management advice for West Greenland humpback whales. For a need of up to 20 humpback whales, this procedure sets the yearly strike limit for a five	Completed

[8] R.3.2.5 as from NAMMCO/17 was replaced by the present abridged version at NAMMCO/18 (see NAMMCO Annual Report 2009 pp:101-102).

Code	Meeting	Request	Response of the Scientific Committee	Status
			year period equal to 2% of the lower 5th percentile of the most recent abundance estimate. Using the fully corrected 2007 estimate of 3,270 (CV 0.50) humpback whales off West Greenland, the SC concluded that strikes of up to 20 humpback whales per year from 2010 to 2015 would be safe. This number is not to be compared directly with the lower 90% credibility estimate of the replacement yield (72-96 whales per year). The estimate of replacement yield is based not only on the current abundance but also on the estimated increase in abundance, while the AWMP-C procedure was constructed to ensure safe long-term catches for humpback whales given a need of up to 20 humpback whales per year. The SC noted that the assessment conclude that the probability that humpback whales off West Greenland will continue to increase is larger than 0.99, even with a total annual removal of 20 whales over a 5-year period. (SC/17)	
3.3.0	**MINKE WHALE:**			
3.3.1	NAMMCO/7	In the light of the new survey abundance results	The Scientific Committee agreed to assign the	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
	05-1997	the Scientific Committee is requested to undertake an assessment of the status of the Central North Atlantic minke whale stock, including to evaluate the long term effects of past and present removal levels on the stock.	task of assessing the status of the stock to the Working Group on Management Procedures. The Council had requested the Scientific Committee to provide its advice on this matter prior to the next meeting of the Council, however it was the general view of the Committee that it was unlikely that this work could be completed within this time frame. (SC/5). The Scientific Committee used the report of the Working Group on Management Procedures as the basis for providing advice and research recommendations to Council. The Committee agreed that catches of 292 per year (the mean of the catch between 1980-84) are sustainable for the Central stock, and that catches of 185 whales per year are sustainable for the Coastal Icelandic Area. (SC/6).	
3.3.2	NAMMCO/8 09-1998	In order to ascertain the stock structure of minke whales in the North Atlantic, the Scientific Committee is requested to investigate the possibility of supplementing present sampling with existing older material from NAMMCO	It was noted that such exchanges of samples are ongoing between Norway and Greenland. Samples collected in the past from Iceland and Norway have already been analyzed concurrently, and there are no recent samples	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		countries and other countries in joint genetic analyses. If possible, such analyses should be undertaken.	from Iceland. The Scientific Committee concluded that available samples are being utilized effectively. (SC/7).	
3.3.3	NAMMCO/11 02-2002	The Management Committee **recommended** that the Scientific Committee should complete an assessment of Central Atlantic minke whales once new abundance estimates from NASS-2001 become available.	The Scientific Committee completed the assessment and provided advice on sustainable catches to the Council. (SC/11).	Completed
3.3.4	NAMMCO/17 09-2008	The SC is requested to conduct a full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic once results from the 2009 survey become available. In the meantime the SC is requested to assess the short-term (2-5 year) effects of the following total annual catches: 0, 100, 200 and 400.	The Assessment WG was convened to help answer with temporary advice. The SC **recommends** that 200 minke whales per year be considered as the largest short-term catch that should be contemplated over the short-term, 2-5 years. This catch level refers to total removals from the CIC or Central Medium areas, both Icelandic and others. A full assessment, including the 2009 estimate, will be conducted at the next meeting of the Assessment WG in January 2010. (SC/16). The SC considered that annual removals of up	Ongoing

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			to 216 minke whales from the CIC area are safe and precautionary. The advice is conservative in the sense that it is based on the uncorrected, downward biased 2009 abundance estimate as well as the lower of the two accepted abundance estimates from 2007. Similarly, an annual removal of 121 minke whales from the CM area is a safe and precautionary management advice. (SC/17)	
3.4.0	**NARWHAL AND BELUGA:**			
3.4.1	NAMMCO/7 05-1997	The Scientific Committee was requested to examine the population status of narwhal and beluga (white whales) throughout the North Atlantic.	The Scientific Committee established a Working Group on the Population Status of Narwhal and Beluga in the North Atlantic, which met in March 1999. The Scientific Committee used the report of the Working Group to evaluate the stock status of the various narwhal and beluga aggregations, and provided recommendations to Council. (SC/7).	Completed
3.4.2	NAMMCO/8 09-1998	The Management Committee requested advice from the Scientific Committee on the level of sustainable utilization of West Greenland beluga in different areas and under different management	The Scientific Committee reactivated the Working Group on the Population Status of Narwhal and Beluga and used its report as the basis of its recommendations to the Council.	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		objectives. For narwhal, the Management Committee requested that the Scientific Committee identify the information which is lacking in order to answer the same question proposed in respect to beluga.	The Scientific Committee concluded that the stock is substantially depleted and that present harvests are several times the sustainable yield, and, if continued, will likely lead to stock extinction within 20 years. The Committee assessed a range of harvest options with the overall objective of arresting the decline of West Greenland Beluga, and provided prioritized research recommendations. (SC/8). The Scientific Committee noted that developing recommendations on the sustainable harvest of narwhal in Greenland will require significant additional research and cannot be done at present. To this end, the Scientific Committee provided research recommendations to answer questions about catch statistics, stock identity and abundance. (SC/8).	
3.4.3	NAMMCO/10 09-2000	The Management Committee **recommended** that the Scientific Committee continue its assessment of West Greenland beluga with reference to the short-term research goals identified. It is anticipated that a joint meeting of the Scientific Working Group of the JCNB and the NAMMCO	The Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic met jointly with the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) to	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
		Scientific Working Group on the Population Status of Narwhal and Beluga in the North Atlantic can be held in spring 2001.	deal with these requests. The Scientific Committee used their report to provide catch options for West Greenland Beluga and research recommendations for West Greenland beluga and narwhal. (SC/9).	
3.4.4	NAMMCO/10 09-2000	The Management Committee **recommended** that the Scientific Committee complete an assessment of narwhal in West Greenland when the necessary data are available. Specifically, the Scientific Committee is requested to evaluate the extent of movements of narwhal between Canada and Greenland.	The Scientific Committee used evidence from genetic and contaminant analysis, satellite tagging and hunter knowledge to evaluate the extent of movement between Greenland and Canada. (SC/9).	Replaced by 3.4.11.
3.4.5	NAMMCO/11 02-2002	The Management Committee **recommended** that the Scientific Committee should concentrate its assessment efforts on the West Greenland narwhal in the near term.	For the Inglefield Bredning, Uummannaq, and Disko Bay areas most stock scenarios examined indicate that an annual removal of 135 narwhals for the entire area should result in a probability of 0.7 for some increase within ten years. The SC also recommended a cessation of narwhal hunting in the Melville Bay area. (SC/12). The SC considered that there were enough data to warrant an update on the assessment of	Completed

Code	Meeting	Request	Response of the Scientific Committee	Status
			belugas and narwhal and recommended that the JCNB/NAMMCO Joint WG meet before March 2009. (SC/15).	
3.4.6	NAMMCO/12 03-2003	The Management Committee noted that a new survey of West Greenland beluga will be conducted in 2004. The Scientific Committee was therefore requested to update the assessment of West Greenland Beluga in light of the new survey results and any other new information. The main management objective is to halt the decline of this stock.	The SC considered that there were enough data to warrant an update on the assessment of belugas and narwhal and **recommended** that the JCNB/NAMMCO Joint WG meet before March 2009. (SC/15).	Replaced by 3.4.7
3.4.7	NAMMCO/13 03-2004	The Committee noted that a new survey will be carried out in the over-wintering area of the West Greenland beluga in March 2004. If the survey is successful, it will provide an abundance estimate with which to update the assessment of this stock. The Management Committee therefore endorsed the plan of the Scientific Committee to update this assessment in 2005, jointly with the Scientific Working Group of the JCNB.	The survey was not successful in 2004, and may be attempted again in 2005. The SC agreed that the recommendation provided in 2004, that the total removal in West Greenland should be reduced to no more than 135 individuals, should be provided again and with greater emphasis (SC/13).	Completed
3.4.8	NAMMCO/14 03-2005	The Management Committee requested that the Scientific Committee carry out an assessment of East Greenland narwhal, and provide an estimate	Given that almost nothing is known about the stock structure and seasonal migrations of East Greenland narwhal, and that the abundance	Replaced by 3.4.11

Code	Meeting	Request	Response of the Scientific Committee	Status
		of sustainable yield for the stock. The management objective in this case is to maintain the stock at a stable level. If the assessment cannot be completed with available information, the Scientific Committee should provide a list of research that would be required to complete the assessment.	estimate for Scoresbysund is more than 20 years old, a reliable assessment is not possible without new information. Research recommendations are provided (SC/13). The SC considered that there were enough data to warrant an update on the assessment of belugas and narwhal and recommended that the JCNB/NAMMCO Joint WG meet before March 2009. (SC/15).	
3.4.9	NAMMCO/14 03-2005	The Scientific Committee should provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland.	The SC conveyed this request to the JCNB/NAMMCO Joint Working Group to consider at their next meeting, probably in late 2007 or 2008 (SC/14). The SC recommended that this item be on the agenda of the meeting of the JCNB/NAMMCO Joint WG, recommended to meet before March 2009. (SC/15). The SC is not in the position to progress on this issue at this point and **recommends** that habitat-related concerns becomes a standing	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			item on the JCNB/NAMMCO JWG agenda. It may be difficult, if not impossible, to answer the specific request for beluga for several years to come. The SC notes that many of the habitat concerns apply to other marine mammals besides beluga and therefore it may be appropriate to treat all species together in addressing this topic. As a way forward, the SC **recommends** that the Council consider extending the scope for a more general request with the SC establishing a WG on the impacts of human activities other than hunting on marine mammals in the North Atlantic. Ugarte is suggested as Chair. Terms of Reference for the first meeting would be the evaluation of impact of seismic, shipping and tourist activities on the distribution, behaviour and conservation of marine mammals. (SC/16). The JWG and the SC (SC/19) recommended holding an international symposium on the effect of seismic and other development activities on arctic marine mammals with a focus on beluga and narwhal.	

Code	**Meeting**	**Request**	**Response of the Scientific Committee**	**Status**
3.4.10	NAMMCO/14 03-2005	Surveys for estimating abundance and trends are an essential component of the assessment of the conservation status of all marine mammals. The Management Committee recognizes that the planning, conduct and interpretation of surveys is a very contentious issue between hunters, managers and scientists in Greenland. Such surveys must be planned using the best available expertise, including input from hunters, so that all will have confidence in their results. The Committee therefore **recommends** that future surveys for beluga and narwhal should be planned using the international expertise available through the Scientific Committee of NAMMCO, and with input from hunters at the planning stage. In addition, if and when new survey methods are applied, they should be calibrated against previously used methods so that the validity of the survey series for determining trends in abundance is insured.	The SC noted that that the survey carried out in 2006 had been planned with consideration of the recommendations of the Committee and with extensive consultations with local hunters. The SC recommended that the plans for the survey of Inglefield Bredning/Melville Bay scheduled for August 2007 be reviewed by the T-NASS Planning Committee at their next meeting (SC/14). The plans for the 2007 narwhal and beluga surveys were not presented to the T-NASS committee and therefore not reviewed by this committee. (SC/15). Advice from hunters was sought for organising the 2006 and 2007 aerial survey off West Greenland. However the SC regrets that the survey plans had never been submitted to the Abundance Estimates WG as indicated. (SC/16). An aerial survey of narwhals was conducted in the North Water in May 2009 and 2010 with the	Ongoing.

Code	Meeting	Request	Response of the Scientific Committee	Status
			purpose of developing a fully corrected abundance estimate. The resulting abundance estimates were 10,677 narwhal (6,120-18,620) in 2009 and 4,775 narwhals (2,417-9,430) in 2010. The JWG and the SC (SC/19) approved that these abundance estimates can be used for assessment purposes of the Inglefield Bredning stock. (SC/19) Aerial surveys of belugas were conducted in the North Water in May 2009 and 2010 with the purpose of developing fully corrected abundance estimates. The resulting abundance estimates were 2,008 beluga (95% CI 1,050-3,850) in 2009 and 2,482 beluga (95% CI 1,439-4,282) in 2010. (SC/19)	
3.4.11	NAMMCO/17 09-2008	The Scientific Committee is requested to update the assessment of both narwhal and beluga, noting that new data warrant such an exercise.	The SC endorses the assessment performed by the JWG. Narwhal: noted that the conclusion reached differed from those reached in 2005. It **recommends** that catches be set so that there is at least a 70% probability that management objectives (population increase) will be met for	Standing

Code	Meeting	Request	Response of the Scientific Committee	Status
			West and East Greenland narwhals, i.e. maximum total removals of 310 and 85 narwhals in West and East Greenland respectively. Narwhal update: The JWG and the SC (SC/19) agreed that narwhals in Scoresby Sound (Ittoqqortormiit) and Kangerlussuaq-Sermilik (Tasiilaq) should be treated as two separate stocks. The age structure from animals collected between 2007 and 2010 in Ittoqqortormiit was applied to both areas, and the harvest was found to select older animals. It was estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasiilaq/Kangerlussuaq area might be stable. The current growth rate in the absence of harvest was estimated to lie between 1.2% (95% CI:0–3.5) and 3.7% (95% CI:1.6–5.9), depending upon model and area. Proposed quotas ranged from 17-70% (Ittoqqortormiit) with probability of 95-70% increase in population and 0-18 (Tasiilaq) with probability of 95-70% increase.	

Code	Meeting	Request	Response of the Scientific Committee	Status
			Beluga: the catch of belugas in West Greenland has been reduced in response to previous advice. These reduced takes already seem to be having a positive effect on population size. The modelling for belugas rests on a more solid background than that of narwhals because of simpler stock structure, however since there is still uncertainty in the assessment, the SC **strongly recommends** that future catches be set according to the probability of population increase of at least 70%. Annual takes between 180 to 310 individuals over the next 5 years will leave the population an 70% to 95% probability of a continued increase until 2014. (SC/16). Beluga update: The JWG considered, and SC agreed (SC/19), that the revised assessment models, which incorporate the age structure data but no new abundance estimate, confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it is concluded that a total annual removal of 310 beluga in West Greenland (excluding Qaanaaq)	

Code	Meeting	Request	Response of the Scientific Committee	Status
			is sustainable. A new and updated advice is expected at the next meeting based on a new abundance estimates from the spring survey in 2012, and the SC noted that new abundance estimates for assessments should be available at least every 10th year. No specific advice was given on the North Water (Qaanaaq), since the current removals remain at a low level relative to the population size. No advice was given for the harvest in Canada. Results from different scenarios of the age structured population dynamic model were presented, providing annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated to 44% (95% CI: 16%–88%), with a yearly replacement of 510 (95% CI:170–780) individuals. (SC/19)	
3.4.12	NAMMCO/19 09 2010	The Scientific Committee is requested to provide advice on sustainable takes of narwhal from the Kane Basin in spring, summer and fall.	The request is part of the ToR for the NAMMCO/JCNB JWG meeting scheduled for 12 – 18 February 2012. (SC/18)	Ongoing
3.4.13	NAMMCO/19	In view of recent dynamic changes in the	The request is part of the ToR for the	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
	09 2010	environment the Scientific Committee is requested to reconsider the temporal and geographical restrictions on the takes of beluga from West Greenland within the framework of the NAMMCO/JCNB JWG	NAMMCO/JCNB JWG meeting scheduled for 12 – 18 February 2012. (SC/18) Beluga: The JWG and the SC (SC/19) reiterated the recommendations for seasonal closures: • Northern area (Uummannaq, Upernavik and Qaanaaq): June through August • Central area (Disko Bay): June through October • Southern area (south of Disko Bay to 65°N): May through October. • The area south of 65°N, closed for hunting. The purpose of these closures is to allow for the possibility of reestablishment of local aggregations of belugas in Greenland.	
3.5.0	**SEI WHALES**:			
3.5.1	NAMMCO/16 02-2007	The Commission requested the Scientific Committee to investigate the status of sei whales in East and West Greenland waters, and provide estimates of sustainable yield.	The SC **recommended** that the assessment working group for fin and humpback whales should make a state of the art investigation about the possibility of providing a status for sei whales in East and West Greenland waters. (SC/15). See item 3.5.2.	Replaced by 3.5.3
3.5.2	NAMMCO/17	The Scientific Committee is requested to review	The SC **reiterates its recommendation** that the	Replaced by

Code	Meeting	Request	Response of the Scientific Committee	Status
	09-2008	the new data from T-NASS and associated surveys and report on the status of sei whales through the Fin Whale assessment WG.	WG on Large Whale Assessment makes a state of the art investigation about the possibility of providing a status assessment for sei whales in East and West Greenlandic waters. (SC/16).	3.5.3
3.5.3	NAMMCO/ 18 09/2009	The Scientific committee is requested to make a state of the art investigation about the possibility of providing a status assessment for sei whales in East and West Greenlandic waters and in waters West of Iceland.	Abundance estimates are available from the NASS surveys in the Central North Atlantic (1989 and 1995) and one more could be produced from the 2007 surveys. In addition, estimates for East and West Greenland area are available from the 2005 survey. These estimates are incomplete in temporal and spatial coverage and cannot be used for a formal assessment of the stock's maximum sustainable yield. The estimates, however, could be used as minimum estimates. The SC concluded that assessments with minimum estimate of sustainable yield rates should be feasible once a minimum abundance estimate from the 2007 surveys has been produced. (SC/17)	Completed
3.5.3 amended	NAMMCO/19 09-2010	The Scientific Committee is requested to assess the status of sei whales in West Greenland waters and the Central North Atlantic and provide minimum estimates of sustainable yield	The Scientific Committee notes that the RMP could be applied using existing data. The resulting catch limits would consequently be lower than the stock could sustain. A prerequisite for initial assessment work is the	Ongoing

Code	**Meeting**	**Request**	**Response of the Scientific Committee**	**Status**
			recalculation (including considerations of extrapolation) of abundance estimates for a comparable area and assessing the extent of negative bias for the reasons mentioned above. Advice based on an RMP approach would require an initial assessment and likely the development of implementation trials. (SC/18)	
3.6.0	**NORTHERN BOTTLENOSE WHALES**:			
3.6.1	NAMMCO/2 1993	To undertake an assessment of the status of the northern bottlenose whale (*Hyperoodon ampullatus*) stock in the North Atlantic.	A Working Group on Northern Bottlenose and Killer Whales established, and provided a preliminary assessment which was used as the basis of advice and recommendations for further research given by the Scientific Committee. (SC/2).	Completed
3.6.2	NAMMCO/4 1994	To undertake the necessary modelling of the species as suggested under ... items 9.2. and 10.2.2 of ...[the Report of the Third Meeting of the Scientific Committee, 1993].	A joint session was held of the Working Group on Northern Bottlenose Whales and the Working Group on Management Procedures in order to consider the request from the Council to undertake the necessary modelling of the population using catch series and abundance estimates. Their report was used as the basis for advice and research recommendations conveyed by the Scientific Committee. (SC/3).	Completed

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3.7.0	**KILLER WHALES**:			
3.7.1	NAMMCO/2 1993	To advise on stock identity for management purposes; to assess abundance in each stock area; to assess effects of recent environmental changes, changes in the food supply and interactions with other marine living resources in each stock area.	A Working Group on Northern Bottlenose and Killer Whales established by the Scientific Committee, and provided a preliminary assessment. This provided the basis for advice and research recommendations given by the Scientific Committee. (SC/2). The Chairman noted that it had not yet been possible to complete a full assessment of the killer whale as requested by the Council. Few new data were available, other than recent sightings data from NASS-95 which had not been analysed. (SC/5).	Completed
3.7.2	NAMMCO/13 03-2004	The Management Committee requested the Scientific Committee to review the knowledge on the abundance, stock structure, migration and feeding ecology of killer whales in the North Atlantic, and to provide advice on research needs to improve this knowledge. Priority should be given to killer whales in the West Greenland – Eastern Canada area.	The Scientific Committee concluded that there was not enough information to carry out the assessment at this time, particularly for the West Greenland area. The Scientific Committee will review new information on killer whales annually with the aim of completing the assessment once sufficient information becomes available for a particular area.	Ongoing

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			Not enough information still. (SC/15). Situation unchanged (SC/16).	
3.8.0	**LONG-FINNED PILOT WHALES**:			
3.8.1	NAMMCO/1 1992	To provide an assessment of the state of the pilot whale stock in the north eastern Atlantic, based on the information sampled from the Faroese drive fishery and the NASS sighting surveys.	The Scientific Committee decided to base its advice on the report of the ICES Study Group on Long-Finned Pilot whales. They concluded that an evaluation of status could not be provided without further work. (SC/2).	Completed
3.8.2	NAMMCO/2 1993	To analyse the effects of the pilot whale drive hunt in the Faroe Islands on North Atlantic pilot whales (*Globicephala melas*), especially whether the numbers taken are consistent with sustainable utilisation.	This matter was addressed by the Scientific Committee, based on the findings of the ICES Study Group and the review of the results of NASS-95. The Scientific Committee agreed to endorse the list of future research requirements listed by the ICES Study Group in its report, and provided advice on the sustainability of the Faroese catch. (SC/5).	Completed
3.8.3	NAMMCO/16 02-2007	The Management Committee noted that it had been over 10 years since the SC concluded its assessment of pilot whales. It was recommended then that a monitoring programme for pilot whales caught in the Faroes drive hunt be	The SC convened a WG for developing such a proposal, under the chairmanship of C. Lockyer. The monitoring programme is under development. (SC/15). In 2008, the SC presented a detailed plan with	Standing

Code	Meeting	Request	Response of the Scientific Committee	Status
		implemented. The Commission requested therefore the Scientific Committee to develop a proposal for the details of a cost-effective scientific monitoring programme for pilot whales in the Faroes.	options for different scales of monitoring relative to costs. In particular, the SC noted that it needed an intensive short–term catch sampling programme of sex and age distribution over a 3-year period to be implemented in order to assess the variability within- and between years and compare with the 1986-88 sampling programme, before it could identify a cost effective long-term monitoring plan. Such a short-term programme has not been implemented yet, so the SC has not considered this issue again for 2009. (SC/16).	
3.8.4	NAMMCO/16 02-2007	Bearing in mind that T-NASS in 2007 was expected to provide a better basis for an updated abundance estimate for pilot whales in the North Atlantic, the Commission requested the SC to make sure that both the methodology and the coverage of T-NASS take into account the need for reliable estimates for pilot whales. In addition, priority should be given to the analysis of data on pilot whales after the completion of T-NASS.	The T-NASS committee took pilot whale into consideration when designing the survey. The WG on Abundance Estimate reviewed the data collected and gave advice for analysis and recommended that these be initiated immediately. The Faroes took the lead in this. (SC/15). See item 1.7.11 (SC/16).	Ongoing
3.8.5	NAMMCO/19	The Scientific Committee is requested to assess	The **SC recommends** that a pilot whale WG	Ongoing

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	09 2010	the status of long-finned pilot whales in West Greenland waters and provide minimum estimates of sustainable yield.	meeting be held to perform assessments and aim at providing advice on sustainable removals for pilot whales around the Faroes Islands and West Greenland. This meeting awaits progress on abundance estimates and stock structure from the Faroes.(SC/18) Update: The average annual catch of long-finned pilot whales in West Greenland during 1993-2007 was 126 whales. An aerial survey conducted in 2007 with partial coverage of the potential pilot whale habitat (Figure 4, above) revealed an abundance of 7,440 animals (95% CI 3,014-18,367) which has been approved by the NAMMCO SC. Applying a PBR approach (rmax of 3% and recovery factor of 1), it is suggested that a sustainable harvest level of pilot whales taken from this abundance would be around 50 whales per year. An estimate based on the AWMPc procedure, suggests that an annual take 70 whale is sustainable. However, the survey did not cover the entire range of pilot whales in West Greenland and the summer aggregation in West Greenland cannot be considered an isolated stock. Instead, it is	

Code	Meeting	Request	Response of the Scientific Committee	Status
			likely connected to pilot whales along Labrador and at Newfoundland, and the occurrence and abundance in West Greenland is probably influenced by the sea temperature regimes in the area (Fullard *et al*. 2000), although the extent of this is not known. (SC/19)	
3.8.6	NAMMCO 20 09 2011	The Scientific Committee is **requested** to continue work to complete a full assessment of pilot whales in the North Atlantic and provide advice on the sustainability of catches, as soon as necessary further information becomes available, with particular emphasis on the Faroese area and East and West Greenland. In the short term, the Scientific Committee was requested to provide a general indication of the level of abundance of pilot whales required to sustain an annual catch equivalent to the annual average of the Faroese catch in the years since 1997.	The SC (SC/19) agreed that it was unlikely that a full assessment could be attempted in the near future. Regarding a short term advice, the SC noted that both the AWMPc procedure (which has been used for preliminary advice for baleen whales in West Greenland by NAMMCO and the IWC), as well as the PBR approach, could be used for an inverse advice calculation of the minimum abundance required to sustain the average take by the Faroese. With the average annual catch by the Faroese since 1997 being 678, and the CV of the latest abundance estimate being 0.27, the AWMPc procedure estimates that an abundance estimate around 50,000 pilot whales and a similar precision is required to sustain the catch. In	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			comparison, the PBR approach (rmax of 3% and recovery factor of 1) calculates an abundance estimate around 80,000 whales. These calculations reflect precautionary estimates of the minimum abundance estimates required to sustain the Faroese hunt. However, the geographical range of the stock(s) that supply the Faroese hunt is unknown, and it is unresolved how the calculated estimates compare with the accepted estimate of 128,000 (95% CI: 75,700-217,000) pilot whales from the Icelandic and Faroe Islands area of T-NASS.	
3.9.0	**DOLPHIN SPECIES *(Tursiops* and *Lagenoryhncus spp.):***			
3.9.1	NAMMCO/7 05-1997	The Council **recommended** that NAMMCO member countries study the ecological interaction between dolphin species (e.g., *Lagenorhynchus spp.*) and fisheries, with the view to future assessments of such interactions.	Not addressed due to insufficient information.	Replaced by 3.9.6
3.9.2	NAMMCO/8 09-1998	Noting that ecological interactions between dolphin species of the *Lagenorhynchus* genus and fisheries have caused concern in NAMMCO countries, the Scientific Committee is requested to perform an assessment of distribution, stock	The Scientific Committee noted that the IWC Scientific Committee had dealt with these species in 1996. Generally, it was considered that there is insufficient information on stock structure, abundance and feeding ecology to	Replaced by 3.9.6

Code	Meeting	Request	Response of the Scientific Committee	Status
		identity, abundance and ecological interactions of white-beaked and white-sided dolphins in the North Atlantic area.	carry out a meaningful assessment of these species at this time. Some new information on abundance may become available from the NASS-95 survey, but these data have not yet been analyzed. The Scientific Committee agreed to begin compiling available information on these species in member countries, with the objective of identifying knowledge gaps and creating a basis for assessment in the longer term. (SC/7).	
3.9.3	NAMMCO/9 10-1999	At its Eighth Meeting in 1998, the Council agreed to the recommendation of the Management Committee to request the Scientific Committee to perform an assessment of distribution, stock identity, abundance and ecological interactions of white-beaked and white-sided dolphins in the North Atlantic area. The Management Committee noted the conclusion of the Scientific Committee that there is insufficient information on stock structure, abundance and feeding ecology to carry out a meaningful assessment of these species at this	The Scientific Committee noted that the NASS surveys were optimised for species other than dolphins, and that in some cases, it was not possible to identify dolphins to species. In these cases, mapping of sightings may be the only analysis warranted. Further analyses may be feasible from the Faroese and Icelandic survey areas, and the Scientific Committee made preparations to begin these analyses. (SC/8). These species are harvested sporadically in drive hunts in the Faroe Islands, and there is some by-catch in Iceland. They are rarely taken in Norway or Greenland. Scientific papers on	Replaced by 3.9.6

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		time. The Management Committee further noted that, in addition to the focus of the Management Committee's former request for advice on these species in relation to their ecological interactions with fisheries, these dolphin species are harvested in significant numbers in the Faroe Islands. The Management Committee therefore agreed to **recommend** that the Scientific Committee be requested to facilitate the requested assessment of these species, with an emphasis on the following: - to analyse results from NASS 95 and other sightings surveys as a basis for establishing abundance estimates for the stocks; - to coordinate the efforts of member countries to conduct research to fill the noted information gaps, taking advantage in particular of the sampling opportunities provided by the Faroese catch, as well as dedicated samples in other areas.	feeding ecology and life history in Icelandic waters are expected to be published soon. The Scientific Committee **recommended** that a sampling program be initiated in the Faroe Islands for white-sided, white-beaked and bottlenose dolphins, primarily to collect information on feeding ecology, life history and stock delineation. They also **recommended** that sampling should continue in Iceland and Norway on an opportunistic basis. (SC/8).	
3.9.4	NAMMCO/9	The Management Committee noted that		Replaced

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	10-1999	bottlenosed dolphins, like white-sided and white-beaked dolphins, are also harvested in the coastal drive fishery in the Faroe Islands. The Management Committee agreed to **recommend** that, in connection with the updated request for advice from the Scientific Committee on white-sided and white-beaked dolphins, that bottlenosed dolphins also be included in this assessment.		by 3.9.6
3.9.5	NAMMCO/10 09-2000	The Management Committee noted that the requested assessments for these species could not at present be completed because of a lack of information on stock identity, distribution, abundance and biology. The Management Committee therefore **recommended** that the Scientific Committee monitors developments in this area and continues its assessments, as new data become available.	The Committee noted that considerable progress has been made in the Faroes in describing the ecology and life history of white sided dolphins, but that some analytical work remains to be completed and sampling will continue. At this point the Scientific Committee considered that there was still insufficient information on abundance, stock relationships, life history and feeding ecology to go forward with the requested assessments for these species. This may become feasible by 2007. (SC/11).	Replaced by 3.9.6

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3.9.6	NAMMCO/13 03-2004	The Management Committee has asked the Scientific Committee to carry out assessments of these species, but to date insufficient information has been available on stock delineation, distribution, abundance and biological parameters to initiate the work. The Committee was pleased to note that considerable progress has been made in the Faroes in describing the ecology and life history of white-sided dolphins and that information on white-beaked dolphins should be available from Iceland and Norway in about 2 years time. Abundance estimates are lacking in all areas except Icelandic coastal waters, and no information on stock delineation or pod structure is yet available. The SCANS survey planned for 2005/6 and coastal surveys planned for Norway (see 9.3) should provide information on distribution and abundance in some areas. The Committee endorsed the plan of the Scientific Committee to proceed with the assessments once the above-mentioned studies have been completed, probably by 2007.	There is still insufficient data on these species to conduct an assessment, but the SC **recommended** that abundance be estimated for white-sided and white-beaked dolphins from the 2007 T-NASS survey as soon as possible. An assessment of the species could be attempted in 2009 at the earliest. (SC/15). The Committee notes that there are still not enough data (life history and abundance) for any of the three species to complete an assessment. The Faroes have samples for diet and life history parameters from 350 white-sided dolphins, but the analysis is not completed yet. (SC/16). The SC **noted** that the data on life history and abundance for any of the three species is still not sufficient for an assessment and **recommended** that Faroese samples for diet and life history parameters from 350 white-sided dolphins be finalised and at the same time that an abundance estimate from the 2007 survey be attempted. (SC/17)	Pending.

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3.10.0	**HARBOUR PORPOISES**:			
3.10.1	NAMMCO/7 05-1997	The Council noted that the harbour porpoise is common to all NAMMCO member countries, and that the extent of current research activities and expertise in member countries and elsewhere across the North Atlantic would provide an excellent basis for undertaking a comprehensive assessment of the species throughout its range. The Council therefore requested the Scientific Committee to perform such an assessment, which might include distribution and abundance, stock identity, biological parameters, ecological interaction, pollutants, removals and sustainability of removals.	The Scientific Committee decided that the matter could best be dealt with by convening an international workshop / symposium on harbour porpoises, which would involve experts working on this species throughout its North Atlantic range. The agenda would include the following themes: distribution, abundance and stock identity; biological parameters; ecological interactions; pollutants; removals and sustainability of removals. (SC/6). The Scientific Committee utilised the report of the Symposium to develop its own assessment advice to the Council. Recent abundance estimates are available for only a few places in the North Atlantic. Directed harvesting occurs in some areas, but most removals are through by-catch. In some areas, present removals are not sustainable. The Scientific Committee developed research recommendations to address some of the information needs for management	Ongoing

Code	Meeting	Request	Response of the Scientific Committee	Status
			of this species. (SC/8). The SC considered that formal assessments for this species were warranted for Greenland, Iceland and Norway, but that there was insufficient information on abundance in all areas and removals in Iceland and Norway to conduct assessment at this time. (SC/ 14). Estimates of abundance and removals are still needed in all areas. The T-NASS survey will provide an estimate for the coastal area around Iceland, and maybe Greenland but will not do so for other areas. (SC/15). Information was still lacking on abundance in all areas and removals in Faroes, Iceland and Norway in order to conduct an assessment. Such an assessment can be performed when the ongoing analyses cited above are completed, maybe end of 2010 or early 2011, providing that data on total removals are also available. (SC/16). The SC recommended that an assessment	

Code	Meeting	Request	Response of the Scientific Committee	Status
		The Management Committee recommends that total removal estimates are made for all areas, and that abundance estimates from the 2007 survey in Iceland and the 2010 survey in the Faroe Islands are available before a WG meeting. (NAMMCO 19).	meeting for harbour porpoises in all areas be held during the winter 2011/12. The SC recommended that the Faroese authorities make sure that obligatory reporting of takes of harbour porpoises is effective. Total removal estimates should be obtained for all areas before the planned WG meeting. It also recommended that abundance estimates from the 2007 survey in Iceland and the 2010 survey in the Faroe Islands become available before the meeting. (SC/18) Update: A total annual by-catch estimate of 6,900 harbour porpoises in Norway was reported. This estimate is substantial, and it raises concerns that the by-catch of harbour porpoises in Norway may not be sustainable. Therefore the SC recommended initiating an assessment of harbour porpoises in Norway. This process should include *i)* reviewing the by-catch estimates *ii)* examining the relevant abundance estimates *iii)* assessing the need for coastal surveys of harbour porpoises in Norway *iv)* investigating the use of satellite tracking for	

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			stock delineation, and *v)* evaluating the use of acoustic deterrents (pingers) in the gillnet fishery in order to reduce the by-catch. Greenland reported that they had sufficient data for an assessment of harbour porpoises in West Greenland. A catch history is available, a recent abundance estimate, as well as two samples of the age structure (from 1995 and 2010). The SC also noted the existence of abundance estimates from both Iceland and the Faroe Islands, as well as some estimates of by-catch in Iceland. (SC/19)	

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SECTION 3 – SCIENTIFIC COMMITTEE

3.1
REPORT OF THE NINETEENTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

EXECUTIVE SUMMARY

The 19th meeting of Scientific Committee (SC) was held in Tasiilaq, East Greenland, 19 – 22 April 2012. The SC had reports from two NAMMCO SC Working Groups (WG): the NAMMCO JCNB JWG on Narwhal and Beluga in the North Atlantic (Annex 1) and the WG on Survey Planning (Annex 2). It had also the Report from the Age Estimation Workshop, Tampa, Florida (Annex 3) and the Summary of the Report from the Age Estimation Workshop, Beaufort, North Carolina (Annex 4). Additionally there were reports from the ICES/NAFO WG on Harp and Hooded Seals and from several other meetings and workshops.

THE ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

Last year the SC reiterated its determination to the project on modelling of marine mammals in the ecosystem, and urges that financing bodies be identified and applications submitted. The SC was informed that applications had been submitted to NORA and the EU 7FP. Reviews from NORA were very positive, but no funding has been obtained.

An ongoing Norwegian project (EPIGRAPH) uses satellite tags, diet studies and estimates of fish resources to evaluate the ecological role of harbour seals in Porsangerfjord, North Norway.

A joint Norwegian-Russian Ecosystem Survey had been used to examine habitat use and prey associations of white-beaked dolphins in late summer. Dolphins used the southern Atlantic water and the Polar Front area farther north, with a general overlap with most prey species, and positively association with blue whiting in the southern habitat. The Polar Front may offer predictable prey aggregations that are more beneficial for foraging than non-front patches with higher densities.

The Icelandic minke whale programme is coming up for review in IWC, with deadline in the winter 2012/13. This marks the end of the programme and the results will be available for examination by the NAMMCO SC at its next meeting.

BY-CATCH OF MARINE MAMMALS

Catch and by-catch data from 2006-2008 from a monitored segment of the Norwegian fleet of coastal gillnetters targeting monkfish and cod were used to estimate by-catch rates of harbour porpoises in Norway. Landings statistics were used to extrapolate to the entire fishery, estimating a total annual by-catch of 6,900 porpoises by the two fisheries. According to the criteria advised by ASCOBANS, that by-catches should not exceed 1.7% of the best population estimate, a population in excess of 400,000 is required to sustain the annual by-catch. One third of the Norwegian coast is bordering the North Sea where the abundance of porpoises is estimated at approximately 1/3 million. The abundance in the North Sea, however, is not necessarily related to the majority of the Norwegian by-catch, and the abundance along the Norwegian coast is unknown.

Considering the large number of by-caught harbour porpoises in Norway, the **SC recommends** that the sustainability is assessed by the WG on Harbour Porpoises, including a validation of the by-catch estimate itself. The SC also noted the potentially high by-catch of grey, and especially harbour seals, in Norway, and referred this to the WG on Harbour and Grey Seals.

The by-catch numbers of harbour porpoises, grey seals, and harbour seals could also be high in Iceland, based on preliminary information presented to the NAMMCO-ICES workshop in 2010. Reporting is often of unidentified seals, making it difficult to estimate by-catch for species. The **SC recommends** that total by-catch estimates be attempted, and that assessments of sustainability proceed through the relevant WGs.

By-catch of marine mammals around the Faroese is likely of a smaller magnitude due to the absence of gillnets in coastal waters, and by-catch in Greenland is generally reported as direct catch, although the SC is still missing estimates of the extent to which by-catch is reported as direct catch. Irrespectively of sustainability, the SC also recommends that by-catch be reduced as much as possible.

SEALS AND WALRUSES

Harp Seal

White Sea / Barents Sea

A Russian survey in March 2010 estimated 163,032 (95% C.I. 97,682 – 228,382) pups. The ICES WGHARP discussed several hypotheses to explain the reduced pup production since 2004. Given lack of evidence for a significant adult mortality event, the most parsimonious explanation is a decline in fecundity. A modified population model with time-varying fecundity estimated 1,364,700 (95% C.I. 1,230,384 – 1,498,916) animals in 2011, with the sustainable catch for the White Sea/Barents Sea being 15,827 *1+*animals (or an equivalent number of pups, where one *1+* seal is balanced by 2 pups).

Greenland Sea

The WGHARP considered the stock data rich, and used population modelling to estimate abundance and catch options. This indicated a substantial abundance increase from the 1970s to 649,570 (95% CI: 379,031 – 920,101) animals in 2011, with the sustainable catch for the Greenland Sea being 16,737 *1+* animals, or an equivalent number of pups.

Given that the most recent estimate of total population size is the largest observed to date, ICES suggests that the harvest level can be set to ensure an 80% probability that the population does not decline by more than 30% over a 10 year period. This estimates a catch level of 25,000 *1+* animals, or an equivalent number of pups. Any allowable catch should be contingent on an adequate monitoring scheme to detect adverse impacts before it is too late for them to be reversed, particularly if the Total Allowable Catch (TAC) is set at a level where a decline is expected.

An aerial survey to assess harp seal pup production was conducted by Norway in the Greenland Sea in 2012.

Northwest Atlantic

NAMMCO **Request R-2.1.11** had been forwarded to WGHARP, to examine how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.

There are no abundance data for West Greenland, but catch statistics is strongly correlated with population size until 2000, suggesting that an increasing number of the seals migrated to West Greenland as the population increased. The relationship fails after 2000 when catches dropped, despite a continued increase in population.

Fairly precise predictions of catch numbers in Greenland can only be calculated for the years up to 2000. New estimates of abundance need to be developed with seals being surveyed in West Greenland at various times a year for a number of years. Alternatively, a proxy of relative seal abundance might be found by selecting catch data from settlements where changes in hunting effort are likely to have been relatively small. However, it would still be uncertain whether the distribution of the seals in years to come could be predicted.

An aerial survey to assess harp seal pup production was conducted in the Northwest Atlantic in March 2012.

Hooded seal

Greenland Sea

Population modelling at WGHARP indicates a decline in abundance from the late 1940s and up to the early 1980s, and gave point estimates of the 2011 abundance between 85,000 and 106,000 animals. This is well below the limit of 173,000 (30% of the maximum estimate of 575,000) animals, where WGHARP recommends that catches shall not occur. Therefore, no catches of hooded seals should be taken from the Greenland Sea, except for local catches in East Greenland.
The aerial survey for harp seal pups in 2012 was successful in obtaining data also on the pup production of hooded seals.

Other species

Experience from the first season with mandatory reporting from the protective hunt of grey seals at aquaculture farms in the Faroes demonstrates that the reporting system needs further adjustments.

An aerial survey in Iceland for harbour seal estimated 11,000 (95% CI 8,000-16,000) animals in 2011, which is similar to estimates from 2003 and 2006.

Extensive oil exploration, development and production are currently taking place in the Pechora Sea, where a joint Russian-Norwegian survey estimated 3,906 (95% CI, 3,571-4,285) walruses in 2011. No females with calves were found during the survey implying that the population that uses the Pechora Sea during summer has a larger distributional area. Risks associated with these activities to walruses and their food base should be assessed, and the delineations of the population clarified.

The **SC recommends** that a small WG update the advice for West Greenland walrus before the next SC meeting.

CETACEANS

Narwhal

West Greenland / Canada

The SC agreed on the metapopulation structure for narwhals in Baffin Bay, Hudson Bay, and adjacent waters as a useful approach for identifying summer aggregations as management units in narwhals. The model includes seasonal movements with relationships between stocks and hunting localities (Figure 2), and satellite tracking of whales that return to summering grounds the following year suggest inter-annual site fidelity, with summer aggregations to some extent being demographically-independent sub-populations with minimal or no exchange of animals.

Narwhals in Canada constitute five separate stocks with some limited exchange between three of the stocks. Coastal summer aggregations in Greenland constitute two stocks in addition to two fall-winter aggregations supplied by narwhals from several summering stocks. Several of the narwhal stocks are mixing on the wintering areas in Baffin Bay-Davis Strait, but mating most likely occur after the initiation of migration towards summering areas.

The **SC recommends** that a small WG fully explore the allocation of harvest to summer aggregations before next JWG meeting.

There has been an overall increase in West Greenland narwhal catches during the 20th century which is especially pronounced after 1950. However since 1993 a significant decline in overall catches has been observed; most pronounced in Uummannaq and Disko Bay, with no decline detected in Qaanaaq and Upernavik. Catches in East Greenland seem to have peaked during 1999-2006, with a declined thereafter. No new data was presented on the struck and lost rates in Canada or Greenland.

Aerial surveys conducted in the North Water in May resulted in fully corrected abundance estimates of 10,677 (95% CI: 6,120-18,620) narwhals in 2009 and 4,775 (95% CI: 2,417-9,430) in 2010.

Age estimation by racemization estimated biological parameters of narwhals, including a maximal lifespan expectancy of ~100 years of age. These data are useful for estimating exponential growth, and a full assessment, with estimates of abundance and population growth, can, for example, be provided from a catch history, a single abundance estimate, and a single sample of the age structure.

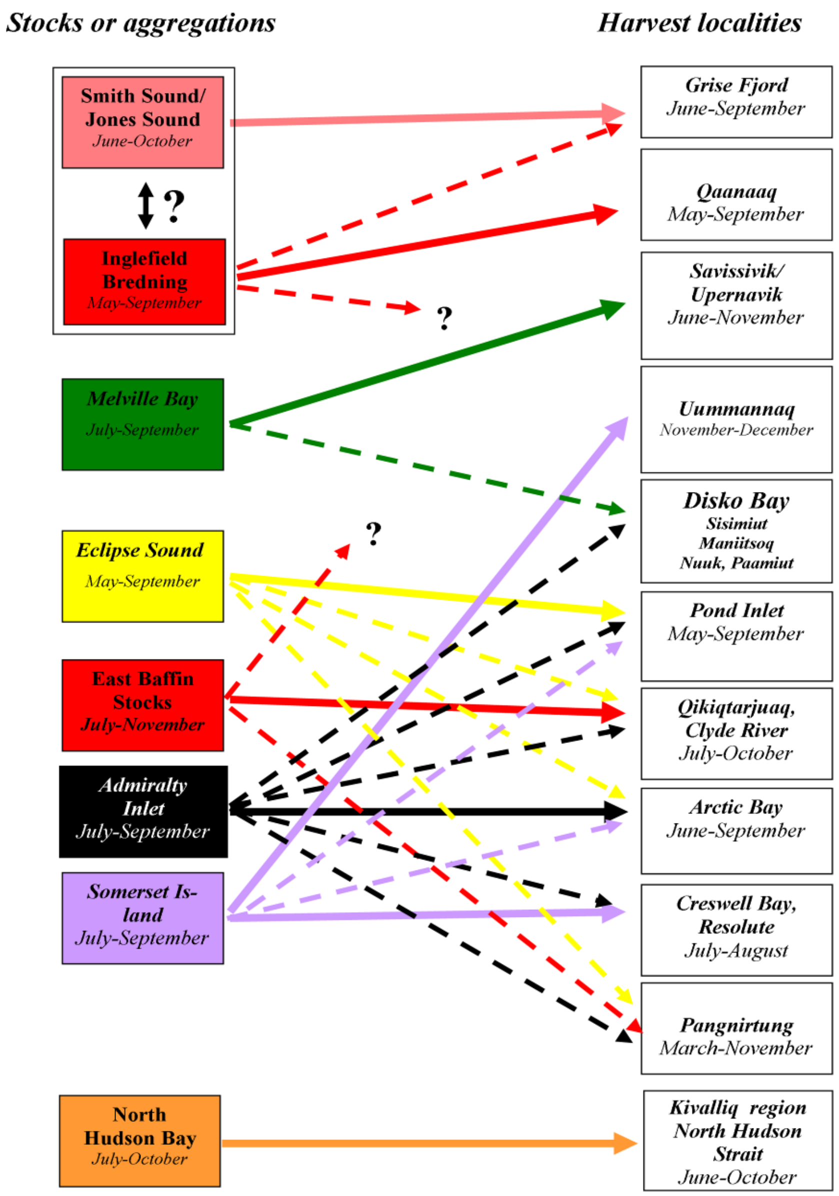

Figure 1. Diagram relating summer stocks and aggregations to hunt locations. Solid lines are verified by tagging studies, dashed lines are based on geography and inference from other sources.

The assessments of West Greenland narwhals was updated with age-structured data, recent abundance estimates, and catches. Several scenarios of stock delineations and harvest allocations were explored, and the SC agreed that the current quotas (Table 1) are sustainable. A new and updated advice is expected from the next JWG meeting, based on the allocation method to be developed at the proposed intercessional meeting. No advice on management was developed for any of the Canadian stocks.

Area	Current quotas
Inglefield Bredning	85
Melville Bay	81
Uummannaq	85
Disko Bay	59
Total	310

Table 1. Current quotas in West Greenland.

East Greenland

Satellite tracking shows that narwhals in East Greenland have a yearly migration where they leave the fjords and move off the coast in winter. Whales from the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland, and the SC agreed that narwhals in Scoresby Sound (Ittoqqortormiit) and Kangerlussuaq-Sermilik (Tasiilaq) should be treated as two separate stocks.

Age-structure data from Ittoqqortormiit was applied to assessments of both East Greenland areas, and the harvest was found to select for older animals. It was estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasiilaq/Kangerlussuaq area might be stable. The current growth rate in the absence of harvest was estimated between 1.2% (95% CI:0–3.5) and 3.7% (95% CI:1.6–5.9), depending upon model and area.

Narwhal	**Ittoqqortormiit**	**Kangerlussuaq**
Probability of increase	**Total removals**	**Total removals**
95 %	17	0
90 %	35	1
85 %	45	6
80 %	50	9
75 %	60	13
70 %	70	18

Table 2. The probability that total annual removals from 2012 to 2016 will ensure an increase in the two exploited stocks of narwhal in East Greenland.

The probability that total annual removals from 2012 to 2016 will ensure an increasing stock for the two stocks in East Greenland was estimated (Table 2).

In discussions on management advice it was noted that there is little information on the predicted response of marine mammal populations to changing arctic conditions including changes in sea ice, climate and prey species as well as increased human development activity as seismic, shipping, and drilling. The **SC recommends** holding an international symposium on the effect of seismic and other development activities on arctic marine mammals with a focus on beluga and narwhal.

Beluga

The Somerset Island stock supplies the belugas overwintering in the North Water and off West Greenland, where the majority of the removals take place. Although there are not enough data to quantify the influx of belugas from Cumberland Sound to West Greenland, it is unlikely that these animals contribute significantly to the exploited winter aggregation in Greenland.

Catches of beluga in West Greenland declined during 1979-2011 from about 1,300 in the early 1980s to levels below 300 whales per year after 2004. There are no research plans for quantification of struck and lost rates in belugas.

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

The assessments of West Greenland beluga was updated with age-structured data, recent abundance estimates, and catches. Results from different scenarios provided annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated to 44% (95% CI: 16%–88%), with a yearly replacement of 510 (95% CI:170–780) individuals. The SC agreed that the revised assessment confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it is concluded that a total annual removal of 310 belugas in West Greenland is sustainable (excluding Qaanaaq). A new updated advice is expected at the next meeting based on a new abundance estimates from the spring survey in 2012, and the SC noted that new abundance estimates for assessments should be available at least every 10th year.

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

Relating to **Request-3.4.13**, the SC reiterated the recommendations for seasonal closures:

- Northern area (Uummannaq, Upernavik and Qaanaaq): June through August.
- Central area (Disko Bay): June through October.
- Southern area (south of Disko Bay to 65°N): May through October.

- The area south of 65°N, closed for hunting.

The purpose of these is to allow for the possibility of reestablishment of local aggregations of belugas in Greenland.

Age-determination workshops

Recognizing that there are a number of problems with age determination for beluga and narwhal, three age determination workshops were organised. The first in Tampa (FL, USA) examined the state of the art of general ageing techniques; the second in Beaufort (NC, USA) focussed on age estimation of belugas using teeth; and the third in Copenhagen focussed on the use of tusks for age estimation in narwhals.

There are several aging methods which are or may be applicable to narwhal and belugas, including potential new methods which, depending on the type of tissue required for analysis, may be applicable both to living and dead animals. Tooth GLG are only useable in belugas, and the Aspartic Acid Racemization is very promising in narwhals. A further method that is accurate and can be used for calibration is that of bomb radiocarbon, ^{14}C. However, this requires animals that were born after the fallout commenced, *i.e.*, post-1958.

The SC agreed that an annual deposition rate of tooth GLG was to be the accepted standard in belugas, and it recommends that Aspartic Acid Racemization is applied to belugas, to included known history/age animals in the analyses in order to calibrate the technique and provide an alternative ageing method. Relating to beluga age estimation from teeth, there should be standardisation of readings among laboratories with inter-laboratory calibrations.

Pilot whale

Relating to **Request-3.8.6** the SC agreed that it was unlikely that a full assessment could be attempted in the near future. Regarding a short term advice, the SC noted that both the AWMPc procedure (which has been used for preliminary advice for baleen whales in West Greenland by NAMMCO and the IWC), as well as the PBR approach, could be used for an inverse advice calculation of the minimum abundance required to sustain the average take by the Faroese.

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

The average annual catch of long-finned pilot whales in West Greenland during 1993-2007 was 126 whales, and an aerial survey estimated 7,440 (95% CI 3,014-18,367) animals in 2007. Applying a PBR approach, it is suggested that a sustainable harvest level of pilot whales taken from this abundance would be around 50 whales per year. An estimate based on the AWMPc procedure, suggests that an annual take 70 whale is sustainable. However, the survey did not cover the entire range of pilot whales in West Greenland and the summer aggregation cannot be considered an isolated stock. Instead, it is likely connected to pilot whales along Labrador and at Newfoundland, and the occurrence and abundance in West Greenland is probably influenced by the sea temperature regimes in the area (Fullard *et al*. 2000), although the extent of this is not known.

Other species

The rerunning of fin whale trials with 60% tuning of the RMP remains to be completed, and a testing of stock structure hypotheses for Central North Atlantic fin whales will be submitted by Iceland to the 64th meeting of IWC SC. Despite the allocation of quotas for 2011 and 2012, there was no catch of fin whales in Iceland in 2011 and, as yet, no decision on catches for 2012.

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

For minke whales the MC recommended in 2010 the calculation of catch limits based on running the RMP on the Central North Atlantic medium area, with catch cascade allocation of catches to small areas. No progress on this has been made, partially because the quota set for Iceland coastal area alone has not been fully utilised. Catches in 2011 were 58 minke whales, well below the sustainable catch levels of 229 animals recommended by the NAMMCO SC.

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

The **SC recommends** that assessments of harbour porpoise be attempted for all areas by the WG on Harbor Porpoise. This will require at least two meetings. The first meeting could provide a full assessment for West Greenland, and initiate the process for Norway, including a review of the method used for obtaining total by-catch estimates. The second meeting should focus on by-catch in Norway and Iceland, attempt to finalize assessments for Norway, Iceland and the Faroes, and could, if feasible, evaluate methods for reducing by-catch.

A genetic mark-recapture estimate of bowhead whales in West Greenland revealed a 2009 abundance of 1410 (95% CI: 783-2038) animals, which confirm the increase observed in previous aerial surveys. A new estimate based on aerial surveys and genetic mark-recapture will be available later in 2012.

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

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

SURVEY PLANNING

The most optimal year for a large scale coordinated survey is 2015. The survey plans for the different countries are generally similar to those of the last T-NASS survey, with some exceptions described in the main report.

The state of the art in aerial survey for cetaceans was reviewed. Aerial surveys were used for all types and sizes of cetaceans, except deep divers such as sperm and beaked whales. It was emphasized that a double-platform configuration was essential to quantify perception bias for all species. It was recognized that additional and more detailed data on dive profiles of target species were required from all areas to facilitate the application of corrections for availability bias. The **SC recommends** that efforts be made to obtain these data in Iceland, Greenland, and Canada.

A review of the implementation of the double-platform mode in shipboard surveys was conducted. Biases in distance data introduce bias in abundance estimates, and the SC considered that the measurement of distance by precision instruments represent a considerable progress that should be pursued.

Two Technical Working Groups, one for aerial and one for shipboard surveys, were established to seek a wide cooperation on the joint development of protocols, techniques and equipment. Initial reports were received by the SC, which recommends that member countries relate to the recommendations, with reports being considered in detail at the next meeting of the WG on Survey Planning.

Based on the WG report and with reference to Council's decision that a new large-scale T-NASS survey of cetaceans in the North Atlantic is desirable within the near future, the SC discussed how best to approach such a large scale survey effort.

Based on experience from past surveys agreement was reached on the following specifications for a proper survey that could inform and improve management decisions:

- The survey should to the extent possible cover the potential range of the target species to provide robust abundance estimates useful for management

- The following species were identified as being targets: long-finned pilot whales, humpback whales, fin whales, sei whales and minke whales
- The survey should include all previously surveyed areas and it should be designed so that shifts in occurrence can be detected and that previously unsurveyed areas are covered if they are considered potentially important for abundance estimation
- Fully corrected abundance estimates should be developed for all the areas and this will include double-platform design of survey vessels and aircrafts
- It should early in the planning stage be attempted to include Canada and Russia and neighboring countries in surveying parts of the Atlantic to ensure that all important areas are covered intensively
- The survey should be planned for 2015 to ensure sufficient time for preparations and because other areas of the Atlantic likely will be covered by surveys conducted by the US and by EU. Seasonal timing will be agreed upon at a later meeting.

The geographical extent of the survey is shown in Figure 1. In addition to areas covered in the past the following new areas were considered critically important to include in a TNASS-15 survey:

- The East Greenland shelf from Kap Farvel to about 80^{o}N where significant numbers have been detected by platforms of opportunity in recent years.
- The offshore areas between the Labrador coast and the shelf areas of West Greenland that has not been surveyed in the past
- The areas between Iceland and Jan Mayen should be surveyed in case it is not included in the Norwegian mosaic surveys, which is important for minke whales
- Areas south of the Irminger Sea and generally south of 55^{o}N where sei whales and pilot whales occur
- Areas north of 70^{o}N in West Greenland where recent catches of minke whales have been taken
- Areas between east Iceland and Norway depending on the Norwegian mosaic survey effort
- Areas in the northeast Barents Sea, Pechora Sea where Russian surveys have indicated increased presence of cetaceans.

Proper coverage of all areas of importance will ensure that unbiased estimates are obtained. The use of double-platforms will further reduce the bias of the estimates. Both approaches are critical for achieving a survey that will be of long-term value for the management of whales in this area. Such a large-scale survey will also be able to detect major shifts in abundance caused by ongoing climatic perturbations in the North Atlantic. Finally the survey will provide critically important information of several of non-target species and provide abundance estimates for some of those.

An example of how the results of this planned survey will be fundamental to the interpretation of observed changes in abundance is the minke whales around Iceland. A significant decline in abundance in coastal areas of Iceland was detected in the T-

NASS-07 survey compared with previous surveys. However, critical areas north of Iceland and the East Greenland coast were not included in the survey effort in T-NASS-07. It is therefore impossible to say if the decline represents a catastrophic drop in population abundance or if it constitutes a shift in occurrence, perhaps in response to oceanographic changes. In the survey planned for 2015 all areas will be covered and major shifts in abundance should be detectable.

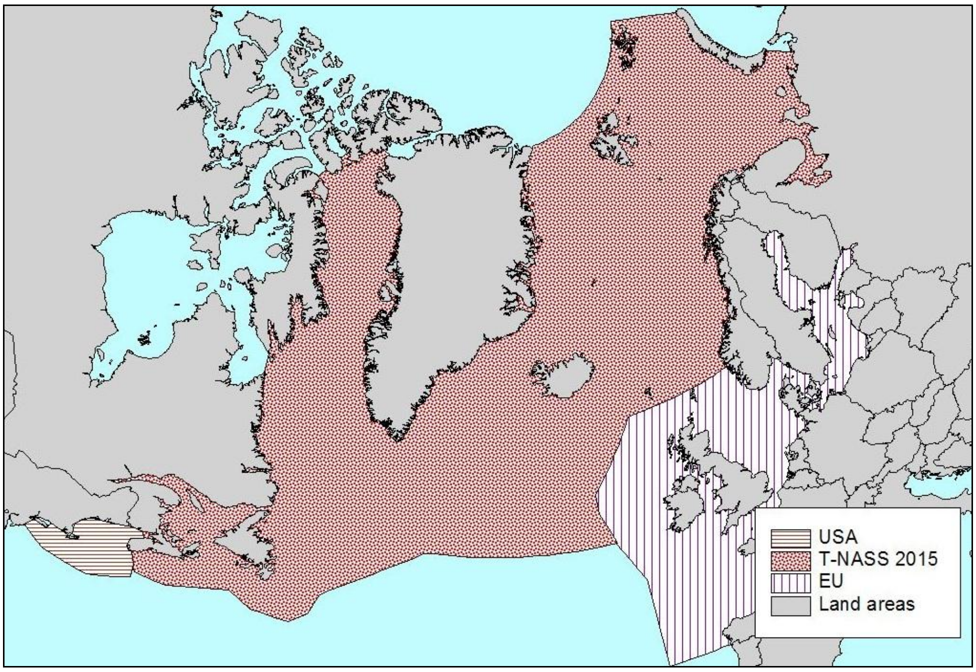

Figure 1. Extension of the proposed T-NASS 2015 and associated surveys.

Based on experience from past surveys the SC has estimated the costs for a large scale to be in the magnitude of 50mill NOK. In comparison the total cost of the T-NASS-07 survey was 30mill NOK, when corrected for inflation to 2012. Partial funding of the survey could cause gaps in coverage that will leave areas without data that cannot be included in the abundance estimates and will also reduce the options for detecting shift in abundance between areas and will hamper the assessment of whale stocks.

Aside from already planned national survey activities there are also plans for surveys of cetaceans funded by oil companies in areas where oil exploration is planned and there are also expected participations from Russia, Canada and other countries. However, the expenses for a large scale TNASS-15 cannot solely be covered by current national budgets or by NAMMCO funding. It is unlikely that funding for such an effort can be secured from scientific funding agencies and SC seeks the advice from the Council on if it is desired that SC continues its planning of a large scale TNASS-15 and on possible avenues for ensuring proper funding of the survey.

MAIN REPORT

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

The Scientific Committee (SC) Chair Witting opened the 19th meeting of the NAMMCO SC. He welcomed all the NAMMCO participants (Section 5.4) to the Hotel Ammassalik in Tasiilaq as well as the observer from Japan and the Russian Federation.

2. ADOPTION OF AGENDA

The Draft Agenda (Appendix 1) was adopted with minor amendments.

3. APPOINTMENT OF RAPPORTEUR

Acquarone (Scientific Secretary) was appointed Rapporteur with the help of the Secretariat and meeting participants as needed.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The documents available to the meeting are listed in Appendix 2.

4.1 National Progress Reports

National Progress Reports for 2011 from the Faroes, Iceland and Norway were received by the Committee. In addition the SC was pleased to receive progress reports from Canada, the Russian Federation and Japan. No report from Greenland was submitted by the time of the meeting.

4.2 Working Group Reports

Reports from four NAMMCO WG meetings / workshops were available at the meeting:

- NAMMCO-JCNB Joint WG on Narwhal and Beluga (Annex 1),
- WG on Survey Planning (Annex 2),
- Age-estimation Workshops (Annexes 3 and 4).

4.3 Other reports and documents

Several other reports and documents were presented to the meeting and were examined under the relevant agenda items.

5. COOPERATION WITH OTHER ORGANISATIONS

Observer reports from meetings of other organisations were available for consideration and are summarized below.

5.1 IWC

The 63rd meeting of the SC of the International Whaling Commission was held in Tromsø, Norway, 30 May -11 June 2011 and Acquarone and Lockyer attended as observers for the NAMMCO SC.

Lars Walløe presented a summary of the 17th meeting of the NAMMCO Scientific Committee and Tore Haug presented the work of the joint NAMMCO/ICES Workshop on observation schemes for by-catch of mammals and birds (WKOSBOMB) which met at the ICES HQ in Copenhagen, Denmark, 28 June-1 July 2010.

NAMMCO informed of progress in the modelling exercise initiated by the NAMMCO Scientific Committee under the Marine Mammal and Fisheries Interactions Working Group. An expression of continued interest from the IWC Environmental Modelling sub-committee was recorded which will be followed by an invitation to report on progress on occasion of the next meeting of the IWC Scientific Committee.

Arne Bjørge summarised the work on planning a proposed global review of monodontids (involving, at a minimum, IWC, NAMMCO and JCMB - the Canada-Greenland Joint Commission on Narwhal and Beluga). The United States, Russia and Norway have expressed interest in participating. Additional preparatory work is needed and a proposal is being developed for consideration by the IWC Scientific Committee for a workshop to be held in the autumn of 2013.

The IWC Scientific Committee noted that NAMMCO is convening three workshops addressing monodontid age estimation at the request of the Joint Scientific Working Group (JWG) of NAMMCO and the JCMB.

The IWC Scientific Committee examined a report by Bjørge *et al* which estimate a total annual by-catch of 6,900 harbour porpoises in Norway in the anglerfish and cod fisheries combined.

Lars Walløe was appointed as the IWC representative at the next NAMMCO SC meeting.

The NAMMCO SC appointed Iceland as observer for the NAMMCO SC to the IWC SC 64.

5.2 ASCOBANS

The 19th meeting of the ASCOBANS Advisory Committee was held in Galway, Ireland, March 20-22, 2012, and attended by the Scientific Secretary. On the programme NAMMCO was mentioned in relation to questions on the hunt of Risso's dolphins in the Faroe Islands in 2009 and 2010. The ASCOBANS Secretariat had written to the Faroese authorities and had contacted NAMMCO as the competent international forum.

Also in the programme was that ASCOBANS had noted that there seemed to be sufficient indication of an overlap between the stock of pilot whales utilized in the Faroes and the animals occurring in the ASCOBANS area. They remarked that there were "no reliable data" on trends in abundance and that pilot whale population structure in the North East Atlantic remained unclear. According to ASCOBANS Resolution 3.3 a total anthropogenic removal of much less than 1.7 % as an "unacceptable interaction" would be applicable in this case, exacerbated by the fact that the available data did not allow a reliable estimation of total anthropogenic removal, which would have to take into account all threats to the population, not just the deliberate take.

Mario Acquarone explained that in the latest approved abundance estimate based on the 2007 surveys NAMMCO used conventional sampling methodology and questioned the doubts raised in the ASCOBANS documentation about the "reliability" of this population estimate. He underlined that the population estimates lay within a range of 70,000 to 200,000, and therefore the Faroese hunts which took on average 600 animals (between 0.4 and 0.8 per cent of the total) were considered sustainable and lay within ASCOBANS standards for acceptable anthropogenic removals. Acquarone pointed out that new survey work was planned for 2014 or 2015 in conjunction with the Russian Federation, Canada, the USA and the EU. ASCOBANS should positively welcome such studies. ASCOBANS recognised that it was neither competent nor in a position to set and police quotas, and that it would attempt at securing the cooperation of the Faroese through persuasion.

The Advisory Committee decided that:

- They would write to the Faroese authorities welcoming the detailed information regarding the small cetacean hunts
- That they would maintain dialogue with NAMMCO and
- That further research into species abundance, such as NAMMCO's T-NASS II and further CODA and SCANS surveys, should be encouraged and supported.

5.3 ICES AND NAFO

Haug reviewed the 2011 activities in ICES which have some relevance to the work in NAMMCO SC. This included work in the ICES Working Group on Marine Mammal Ecology (WGMME), the Working Group on By-catch of Protected Species, and the Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP). The ICES Annual Science Conference generally include sessions with marine mammals included as an integral part, occasionally also sessions entirely devoted to marine mammals.
Preparations for the upcoming T-NASS survey and the advantages of a synoptic survey coordinated with parallel initiatives such as SCANS/CODA survey were mentioned in the March 2012 meeting report of the WGMME.

5.4 JCNB

A meeting of the NAMMCO-JCNB JWG took place in February 2012 (SC/19/14). The JCNB is scheduled to hold a meeting later in 2012.

6. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

6.1 Update

Acquarone reported about funding applications (SC/19/O/07; O/09; O/10; O/11) developed in collaboration with Matís (Iceland) and submitted to NORA (North Atlantic Cooperation, www.nora.fo) and the EU 7th Framework Programme (7FP, http://cordis.europa.eu/fp7) for the "Modelling Exercise" project. Vikingsson underlined that the applications to NORA and to the 7FP differ fundamentally in magnitude and that the feedback received from NORA SC/19/O/08 has been very positive, hence the recent resubmission by 5 March 2012.

Haug and Zabavnikov reported that a high priority part of the planned Joint Norwegian-Russian Research Program on Harp Seal Ecology is to deploy satellite transmitters on harp seals in the White Sea. In all the years 2007-2011 it was planned to do this in a joint Russian-Norwegian effort just after the moulting period (in late May), or, alternatively, in late March – early April if ice conditions turns out to be unfavourable in early May. Unfortunately, the Federal Technical Committee (FTC) did not permit satellite tagging using non-Russian tags in Russian waters in all years. In 2012, however, permission to tag harp seals in the White Sea was given by the Russian Authorities, but now a lack of funding prevented tagging of seals. In 2013 the Russian colleagues in PINRO will renew their attempt at obtaining funding for and carrying out both aerial surveys and satellite tagging in the White Sea – if only one of the projects proves feasible, tagging will be given priority over the aerial surveys. During the tagging experiment, PINRO will provide the necessary logistics required for helicopter- or boat-based live catch of seals in April-May 2013. The Institute for Marine Research (IMR), Norway, will, as before, be responsible for the satellite tags, including providing all necessary technical details, as well as for providing experienced personnel and equipment for anaesthetizing seals and tag deployment. For proper planning and budgeting on both institutes, PINRO scientist must obtain the necessary permissions from Russian authorities before December 2012. The permission from Russian authorities is not dependent on the origin of the transmitters; both US and Russian transmitters can be used. The transmitters cannot collect georeferenced temperature and salinity data. After the 2013 tagging season future seal tagging will be decided upon following an evaluation of both the tagging methods and the obtained seal movement data set. Due to low pregnancy rates and decline in pup production it will be important to focus on harp seal ecology and demographics in the coming years.

Haug further informed about the ecological Norwegian EPIGRAPH project, which includes a study on the ecological role of harbour seals in the Porsangerfjord, Finnmark, and North Norway. In September-October 2009 and 2010, 6 harbour seals each year were equipped with GPS phone tags. Harbour seal scat samples were collected in autumn 2009 and 2010, and are in course of analysis. Data from the seal tags, diet studies and estimates of fish resources carried out in the project will be used to evaluate the ecological role of harbour seals in the area. Preliminary results from the analysis of individual movements showed that harbour seals habitat usage in the Porsangerfjord is limited to a restricted area, the inner part of the fjord, with very few registered trips to the outer areas. Preliminary analysis of the scat contents showed the presence of otoliths of a large number of fish species, particularly from the families *Gadidae*, *Cottidae* and *Stichaeidae*, but also with representatives from *Pleuronectidae*, *Cyclopteridae* and *Zoarcidae*.

Haug also reported that Norwegian scientists have used data from the Norwegian-Russian Joint Ecosystem Survey to examine habitat use and prey associations of white-beaked dolphins in late summer. Data was available for one period with low (2003-2006) and one with high (2007-2009) capelin abundance, and these periods were examined separately in order to assess the importance of this key species. Since associations may be scale dependent, associations between dolphins, prey and habitat (temperature, fronts, depth and slope) were analysed at two spatial scales: 1) at habitat scale, by analysing spatial associations between averaged distributions across years in a Principal Component Analysis, and 2) at mesoscale, by analysing spatial associations within 50 km grid cells in a Generalised Additive Model. Dolphins used two different habitats; the southern warm Atlantic water, and the Polar Front area farther north. The habitat scale suggested a general overlap with most prey species but did not reveal any specific associations, while at mesoscale, dolphins associated positively with blue whiting in the southern habitat. No clear prey associations could be identified in the frontal habitat, although capelin is likely of some importance as prey. The authors suggest that the Polar Front offers predictable prey aggregations that are more beneficial for the dolphins to forage on than the highest density prey patches, thus resulting in non-linear relationships between dolphin and prey densities.

6.2 Future work

Vikingsson reported that the minke whale programme is coming up for review in the IWC. The deadline for results in the IWC is the coming winter. This marks the end of the programme and the results will as well be available for examination by the NAMMCO SC at its next meeting.

7. BY-CATCH OF MARINE MAMMALS

7.1 Update

Haug reported from an estimation of by-catch of harbour porpoise in Norway (SC/19/O/02). Based on catch and by-catch data from 2006-2008 from a monitored segment of the fleet of coastal gillnetters targeting monkfish and cod, general additive models were used to model by-catch rates, where number of harbour porpoises entered as the response variable, and catch by the fisheries was entered as offset. Landings statistics of target species were used to extrapolate to entire fisheries. The two best models predicted the total number of porpoise by-catch to 20,719 and 20,989 porpoises, with CVs 36.05% and 27.33%, respectively. Thus, the models predict annual total by-catch of about 6,900 porpoises in the two fisheries. The minimum fishing depths ranged from 5-200 m for cod and 20-400 m for monkfish nets. In cod nets porpoise by-catch rate decreased rapidly with increasing depth from 5m to 50m and then levelled off. The by-catch rate decreased linearly with increasing depth throughout the depth range for monkfish nets. According to the criteria advised by ASCOBANS (by-catches should not exceed 1.7% of the best population estimate), a population in excess of 400,000 is required to sustain an annual by-catch of 6,900 porpoises. One third of the Norwegian coast is bordering the North Sea where the abundance of porpoises is estimated at approximately 1/3 million. The abundance in the North Sea, however, is not necessarily related to the majority of the Norwegian by-catch, and the abundance along the Norwegian coast is unknown.

This information had previously been requested in advance of the joint NAMMCO-ICES workshop held in July 2010 on by-catch monitoring, but has not been available to the SC before now. With NAMMCO being the international management authority of small cetaceans for Norway, it was noted that the information was received as a for-information paper from the June 2011 meeting the IWC SC.

Considering the large number of by-caught harbour porpoises in Norway, the **SC recommends** that the sustainability of the by-catch is assessed. Therefore the **SC recommends** that both the validation of the by-catch estimation procedure and the sustainability of the by-catch be assessed through the WG on Harbour Porpoises (*see point 9.11*). The SC also noted the potentially high by-catch of grey, and especially harbour seals, in Norway (NAMMCO 2011), and referred this work to the WG on Harbour and Grey Seals.

The by-catch numbers of harbour porpoises, grey seals, and harbour seals could also be high in Iceland, based on preliminary information presented to the NAMMCO-ICES workshop in 2010. The **SC recommends** that total by-catch estimates be attempted, and that assessments of sustainability proceed through the relevant WGs.

By-catch of marine mammals around the Faroes is likely of a smaller magnitude due to the absence of gillnets in coastal waters, and by-catch in Greenland is generally reported as direct catch, although the SC is still missing estimates of the extent to which by-catch is reported as direct catch.

The SC reiterated that by-catch are equally important as direct catch as removals. It therefore reiterated the importance to ensure that reliable by-catch reporting and estimate occur for all species in all areas. Irrespectively of sustainability, the SC also recommends that by-catch be reduced as much as possible.

From Russian side, PINRO initiated monitoring of marine mammals by catch in the Barents Sea in 2012. Tables of marine mammals by catch are filled out by captains of small vessels that fish in the Barents Sea and White Sea coastal zone. For vessels that fish in the Barents Sea open water, PINRO observers would record the by-catch of all marine mammals. Initial results are obtained in 2012, and can be presented at the next SC meeting.

8. SEALS AND WALRUSES STOCKS - STATUS AND ADVICE TO THE COUNCIL

8.1 Harp Seal

<u>8.1.1 Update</u>

Haug reported from the ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) that met during 15-19 August 2011 in St. Andrews, Scotland, to consider recent research and to provide catch advice on the White Sea / Barents Sea and Greenland Sea stocks of harp seals in response to a September 2010 request from Norway. WGHARP also responded to a request from NAFO to consider the impacts of the increasing northwest Atlantic harp seals on the number of seals near Greenland and reviewed some new information about this stock.

White Sea / Barents Sea

A Russian survey was carried out during 20-23 March 2010, and resulted in an estimate of 163,032 pups (95% C.I. 97 682 – 228 382). WGHARP concluded that the survey appeared to have been carried out very well, and discussed several hypotheses to explain the reduced pup production since 2004, including unobserved mortality of adults around 2004, high mortality of neonates prior to the aerial surveys, or declines in fecundity (*i.e.* pup production). Given the lack of evidence for a significant adult mortality event, the most parsimonious explanation for the continued low count of pups in surveys in both good and bad ice years appears to be a decline in fecundity. The existing population model could not account for the decline in pup production after 2003 with a fixed fecundity and maturity. A revised model with time-varying maturity and condition varying fecundity (i.e., as animal conditions improves, fecundity improves) provided a good fit to the observed pup counts. However, the model was considered preliminary and not ready to be applied. A modified version of the existing model with time-varying maturity and fecundity provided a transitional model form, and was considered to be an appropriate temporary analytic tool. This model provided a 2011 total population estimate of 1,364,700 (95% C.I. 1,230,384 – 1,498,916), and it is estimated that the sustainable catch for the White Sea/Barents Sea harp seal stock should be 15,827 *1+* animals or an equivalent number of pups (where one *1+* seal is balanced by 2 pups). In 2011 and 2012 PINRO performed ice condition monitoring in the White Sea/Barents Sea.

Greenland Sea

No new data have been collected since 2009, but the recent series of catch and reproductive data lead the WGHARP to still consider the stock to be data rich. Therefore, it is appropriate to use a population model to estimate abundance and evaluate catch options. All model runs seem to indicate a substantial increase in the population abundance from the 1970s to the present. Using the modified population model with time varying reproductive parameters, the total 2011 abundance of harp seals in the Greenland Sea is estimated to 649,570 (379,031 – 920,101). The estimate provided by the modified model is lower, but presumably more realistic, than estimates provided by the original, unmodified model. WGARP estimated sustainable catches of 16,737 *1+* animals or an equivalent number of pups (where one *1+* seal is balanced by 2 pups).

Since Greenland Sea harp seals are classified as data rich, ICES now find the Precautionary Approach framework developed for the management of harp and hooded seals appropriate for the population. Given that the most recent estimate of total population size is the largest observed to date, ICES suggest that the harvest level can be set to ensure a 80% probability that the population does not decline by more than 30% over a 10 year period. This approach estimates a catch level of 25,000 *1+* animals, or an equivalent number of pups (where one *1+* seal is balanced by 2 pups). Any allowable catch should be contingent on an adequate monitoring scheme to detect adverse impacts before it is too late for them to be reversed, particularly if the TAC is set at a level where a decline is expected.

2012 survey

New aerial surveys to assess harp seal pup production were conducted in the Greenland Sea in 2012. Reconnaissance surveys were flown by helicopter (18 March – 1 April) and two fixed-wing aircrafts (22 March – 1 April) in an area along the eastern ice edge between 67°55'N and 74°10'N. The reconnaissance surveys detected two patches of harp seal breeding. The general drift of the two patches were in a south westerly direction. Due to more scattered and loose drift ice in the northernmost patch, this patch drifted faster than the more southern patch. Thus, on 28 March the two patches had merged, yielding one large patch which was photographed by the two aircrafts. A total of 27 photo transects, spacing 3 nmi, were flown using both aircrafts in the area between 70º43'N/18º31'-18º15'W and 72º01'N/17º29'-17º29'W. The survey covered the entire area of the merged patches, and all transects were flown with cameras operated to ensure about 80-90 % coverage of the area along each transect line.

Northwest Atlantic

Request R-2.1.11 had been forwarded to the ICES/NAFO working group, that examined how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.

There are no abundance data on harp seal from west Greenland. Catch statistics from an unrestricted seal hunt, was show a very strong correlation with population size through 2000 that explain more than 90% of the variation in the catch numbers. The correlation suggests that an increasingly larger number of the seals migrated to Greenland as the population increased. This relationship failed after 2000 when catches dropped, despite a continued increase in the population. The hunting effort has probably dropped somewhat in certain parts of Greenland since 2000, but it is also the general belief among hunters, that the number of harp seals has dropped considerably in South-west Greenland (south of 67^{o}N). This change in abundance coincide with a significant decrease in sea ice extend in the area between Canada and Greenland. Decreasing sea ice may affect the migratory pattern and seasonal abundance of harp seals in certain areas.

The data show that fairly precise predictions of seal abundance (catch numbers in Greenland) could have been calculated from the population size alone in the years up to 2000. After 2000, however, additional variables (*e.g.* changed sea ice extent) may have changed the distribution and local abundance of harps in Greenland waters. However, it is possible that changes in hunting effort during the latest decade may have contributed to the appearance of decline in abundance.

New estimates of abundance need to be developed to discriminate between actual and perceived changes in abundance. A time-series of surveys on seal abundance in Greenland waters would be a possibility. Seals will have to be surveyed at various times a year for a number of years. Such a model will, however, not be reliable before the time-series with the new variables is longer and include years with changing trends. Furthermore, it is possible that new variables become important as the population grow. The population is believed to approach carrying capacity and this is normally associated with new factors becoming important for a continued growth of the population. It is therefore uncertain whether the distribution of the seals in the years to come is predictable based on hind-cast analysis. Such analyses will, however, be important to describe how distribution patterns change as the population and the environment change.

Alternatively, a proxy of relative seal abundance (does abundance increase or decrease) might be found by selecting catch data from settlements where changes in hunting effort are likely to have been relatively small.

In conclusion, historically the abundance of seals in Greenland waters was positively associated with increases in the harp seal population. Since 2000, it appears that ecological and hydrographical changes have changed the relationship, and possibly led to decreases in harp seals. However, there are insufficient data available to adequately analyze the latter.

Poor sea ice conditions

WGHARP was informed that the total extent of ice suitable for whelping Northwest Atlantic harp seals in the Gulf of St. Lawrence and of the coast of southern Newfoundland during 2010 and 2011 were at, or near, the lowest since 1969. Upon examination on how harp seals responded to these poor ice conditions, it has been observed that seals used unsuitable ice, moved to other areas, extending the whelping period and pupping outside of historical areas. There was no evidence to indicate that harp seals whelped on land even in areas where ice was absent. Young seals that did drift to shore had high levels of abandonment and mortality. The specific responses of whelping seals to poor ice conditions were influenced by the amount and timing of ice development in the different whelping areas. It is likely that mortality of young was high in both years, but likely greater in 2010 and 2011.

Fecundity

Obtaining accurate estimates of fecundity are critical for estimating the population dynamics of a species. Annual estimates of late term pregnancy rates, fecundity and mean age of sexual maturity of Northwest Atlantic harp seals were obtained from samples collected off the coast of Newfoundland and Labrador between 1954 and 2008. Annual fecundity rates are highly variable. Although they remained high (>85%) until the late 1970s, they subsequently declined and remained low. WGHARP noted that the proportion of mature females that were pregnant was particularly low (<40%) in 2004, which was a survey year. Reproductive rates increased to approximately 70% in 2008, another survey year, which may account for the rapid increase in pup production, observed between these two surveys. Preliminary data from 2009 through 2011 indicate that fecundity rates have declined and may be in the order of 30% during the last two years.

An aerial survey to assess harp seal pup production had been conducted in the Northwest Atlantic in March 2012.

8.1.2 Future work

The WGHARP will meet again in August 2013, presumably in Murmansk, Russia, to review the status and assess the catch potential of harp seals in the Northeast Atlantic.

8.2 Hooded seal

8.2.1 Update

At their 2011 meeting, the WGHARP considered recent research and provided catch advice on the Greenland Sea stock of hooded seals in response to a September 2010 request from Norway. Some additional information about the northwest Atlantic hooded seal stock was reviewed.

Greenland Sea

The March-April 2007 Norwegian survey estimated 16,140 pups (SE = 2,140). This estimate is not significantly different from the estimate obtained with comparable methodology in 2005, but is considerably lower than the 1997 estimate. The model developed for the 2011 assessment is similar to the model assessing the abundance of the Barents Sea/White Sea harp seal population, modified to incorporate historical maturity curves and historical pregnancy rates. The available historical data on pregnancy rates were considered unreliable. Hence, the model was run for a range of pregnancy rates, in addition to a run using the original model assuming constant reproductive data. All model runs indicate a decrease in population abundance from the late 1940s and up to the early 1980s, and gave point estimates for the total population ranging between 85,000 and 106,000 animals, *i.e.*, a population currently well below the N_{lim} of 172,577 (30% of the N_{max} estimate of 575,257). Following the Precautionary harvest strategy previously developed by WGHARP, catches shall not occur for populations below N_{30}. Therefore, no catches should be taken from the Greenland Sea hooded seal stock (except for local catches in East Greenland).

2012 survey

During the aerial surveys conducted in the Greenland Sea in 2012, harp seal was the prime target species for the surveys since this population is still hunted. Hooded seals have been protected since 2007 due to the low pup production numbers – to assess the effect of protection on the pup production, more than 5 years are needed due to the usually 4-5 years age at maturity observed in the species. If possible, however, it was a secondary goal to obtain also a new abundance estimate for hooded seals in the area during the same survey. Evidently, given the available logistical resources and the priority of harp seals, the possibilities to obtain a hooded seal pup production estimate would require that hooded seal breeding occurred within the same main areas as the harp seal breeding. During the course of the survey, it proved possible to obtain data on the pup production of both harp and hooded seals which were both included in the photo transects run on 28 March.

Northwest Atlantic
WGHARP reviewed results from joint analyses of Norwegian and Canadian reproductive data (more than 2500 ovaries) from Northwest Atlantic hooded seal females collected between 1956 and 2006 (Frie *et al.* 2012). Estimate of mean age at first birth was observed to have increased from 4.2-4.5 years in 1956-78 to 6.1 years in 1989-95. Simultaneously, pregnancy rates showed a significant drop from 91-98 % in 1967-87 to 79-74% in 1989. Thus, not all mature hooded seal females produce offspring each year, and this seems to apply to all age groups. From the 1990s, further declining adult pregnancy rates are suggested.

8.2.2 Future work

At their planned 2013 meeting, WGHARP will review the status and assess the catch potential of hooded seals in the Northeast Atlantic.

8.3 Ringed seal

8.3.1 Update

In September 2011, 12 ringed seals (10 adults and 2 juveniles) were live-captured in Melville Bay, Northwest Greenland, and equipped with satellite-linked transmitters.
Lydersen reported of the deployment of 11 CTD-fluoro SRDL tags in Svalbard and these tags provide data on dive behaviour as well as hydrographic data (salinity and temperature) and information on primary production. During the life of the tags most of the animals were sedentary and stayed close of to a glacier front.

8.3.2 Future work

A new pilot project using ringed seals as collectors of environmental data by the use of CTD-SRDL's will be initiated in Greenland close to two large outlet glaciers in Jacobshavn Isfjord (near Ilulissat) and the Heilheim Glacier (near Tasiilaq).

8.4 Grey seal

8.4.1 Update

In reviewing the status of grey seals in the NAMMCO area in 2011, the SC observed that a model had been developed for estimation of total population size for Norwegian grey seals and projection of future population trajectories under various catch options. The model includes total pup production estimates in 2006-2008, estimated by-catch mortality rates and catch statistics, while age specific pregnancy rates were derived from a large study on Canadian grey seals. Haug informed that the model, which indicated an increase in abundance of the total Norwegian grey seal population during the last 30-years and suggested a total of a little over 8,000 animals (including pups) in 2010, is now accepted for publication in the ICES Journal of Marine Science.

Report of by-catch is mandatory in Iceland, but the data are often reported as unidentified seals, which makes it difficult to determine the exact level of by-catch for each species.

Samples from 30 grey seals collected in the Faroe Islands have been included in a holistic examination on stock delineations based on genetics. The final outcome is awaited in 2013. The year 2011 was the first season with mandatory reporting from the protective hunt of grey seals at aquaculture farms. The experiences from this first year demonstrate that the system needs some further adjustments. It has also turned difficult to get samples from the hunted animals, since they are usually not retrieved from the water.

8.4.2 Future work

A grey seal survey is scheduled in Iceland in the summer/autumn of 2012. Estimating the abundance of Faroese grey seals will be attempted in the coming future; it is expected that it will require more than one year of field work to generate a robust estimate. Norway and Russia plan a joint survey of grey seals in the Southern Barents Sea.

The SC **recommended** that the Grey and Harbour Seals WG meet in 2014, reflecting the recommendations to finalise the **Requests 2.4.2 and 2.5.2**.

8.5 Harbour seal

8.5.1 Update

The most recent abundance estimate of harbour seals in Norway is based on data obtained in 2003-2006. Aerial surveys aimed to obtain a new abundance estimate for the species in Norway were started in August 2011. The area of operation was the southern coast of Norway up to Trøndelag. The rest of the Norwegian coast will be covered in 2012-2013.

Eight harbour seals were equipped with satellite linked transmitters in 2009 and six in 2010 in South Greenland. Some of the transmitters were glued on the fur (these transmitters give position and measure depth, temperature and haul out periods) and some very small transmitters could be put on the flipper in a similar way as ear-tags on sheep and cattle. Some of these small tags (that only give position and haulout periods) are still transmitting.

The seals have stayed near a small group of islands near Cape Farwell for the most of the year, but adult seals swim about 250 km up the east coast and stay there in the breeding period (around mid June-mid July). This small group of harbour seals has been estimated to count around 40 seals.

An aerial harbour seal survey conducted in Iceland in the summer of 2011 gave an average haulout count of 4512 harbour seals and resulted in an estimate of 11,000 animals (95% CI 8,000-16,000). This is similar to the estimates that were made in 2003 and 2006 with comparable methodology. These results will be submitted to the NAMMCO WG on grey and harbour seals.

The results of the fifth comprehensive seal count in Vatnsnes peninsula, NW Iceland, on 25th of July resulted in a count of 1,033 harbour seals in 2011, marginally fewer than in 2010 when the result was 1,057 seals.

8.5.2 Future work

A few small groups of harbour seals have also been located up along the Greenland west coast. Cameras taking several pictures every day throughout the summer will be put up to monitor some of these locations. The plan is to move these cameras around so that known haulout localities will be monitored at least once every fifth year.

8.6 Bearded seal

8.6.1 Update

Two bearded seals; an adult or near adult male and an adult or near adult female were equipped with satellite-linked transmitters in Melville Bay, Northwest Greenland in September 2011. The transmitters on both seals are still transmitting.

Newly developed CTD-GPS-SRDL tags were attached to 5 adult bearded seals in Svalbard. Preliminary results are promising.

8.6.2 Future work

In May 2012 six transmitters are planned to be put on bearded seals in the pack ice in Baffin Bay, Northwest Greenland.
Five more CTD-GPS-SRDLs will be deployed in summer 2012 in Svalbard.

8.7 Walrus

8.7.1 Update

A joint Russian-Norwegian survey of the coastlines of the Pechora Sea and adjacent waters for walruses was conducted during August 2011. A total of 2,563 km of coastline was inspected using a combination of infrared techniques and visual observations. Hauled out walruses were found at three sites, one group on Vaygach Island and two separate haulout groups on Matveyev Island, with a total of 958 animals counted on the aerial photographs from these two sites. All three haulouts were occupied by only males. Measurements of dorsal curvilinear lengths, show that in addition to many adult males 14.5 % of the animals were shorter than 225 cm indicating good recruitment of younger age classes into this population. Using a correction factor developed for male walruses in Svalbard to account for animals that were at sea during the survey, according to date in August and weather conditions at the time of the surveys, the estimate of the number of walruses occupying this area is 3,906 (95% CI, 3,571-4,285). No females with calves were found during this survey implying that the population (or subpopulation) that uses the Pechora Sea during summer has a larger distributional area than encompassed by the survey. Extensive oil exploration, development and production are currently taking place in the Pechora Sea. Risks associated with these activities to walruses and their food base should be assessed, and the delineations of the population clarified.

Zabavnikov reported that the WWF, Russian Ministry of Natural Resources and Russian Council of Marine Mammals special Program on walrus monitoring in the Pechora Sea was initiated in 2010. The main purpose the Program is walrus status monitoring before and during oil raw materials exploitation in the Pechora Sea.

Heide-Jørgensen reported about recent walrus surveys performed in the North Water and about the satellite tagging programme designed to provide data for bias corrections.

Norway continued the camera monitoring of selected haulout sites of walrus haulout behaviour and potential impact of tourist activities.

8.7.2 Future work

GPS-Solar Cell tags for tusk mounting are under development by the company Sirtrack for the Norwegian Polar Institute and will be tested in Svalbard as soon as available.

The SC suggested performing a stock assessment of west Greenland walrus in 2013.

9. CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL

9.1 Fin whale

9.1.1 Update

Vikingsson reported that the process of rerunning the trials with 60% tuning of the RMP remains to be completed. A stock structure hypothesis testing will be included in the research proposal that Iceland will submit to the 64th meeting of the SC of the IWC in June 2012. The SC took note that progress is expected on these matters.

Despite the allocation of quotas, in 2011 and 2012 there was no catch of fin whales in Iceland in 2011 and, as yet, no decision on catches for 2012 has been made.

9.2 Humpback whale

9.2.1 Update

The SC noted that the recommended analyses to detect responsive movements to survey vessels in humpback whales will not be performed by Iceland.

The SC noted that Joiris (2011) documented that humpback whales are present in previously unsurveyed areas off East Greenland, in agreement with information provided by observers on seismic surveys.

9.3 Sei whale

9.3.1 Update

It was noted that sei whales are not a priority species for the coming surveys for Greenland, Norway, and the Faroes, and that Iceland has not yet decided on the matter.

9.4 Minke whale

9.4.1 Update

In 2010 the MC recommended calculating, as soon as possible, catch limits based on running the RMP on the Central North Atlantic medium area, with catch cascade allocation of catches to small areas. No progress on this has been made, partially because the quota set for Iceland coastal area alone has not been fully utilised. Catches in 2011 were 58 minke whales, well below the sustainable catch levels of 229 animals recommended by the NAMMCO SC.

Haug reported that in abundance estimation of minke whales, Norway intend to follow the RMP requirements. This implies sighting surveys conducted over 6-year cycles (2006-2013, 2014-2019) to cover the entire area. In the current period (2008-2013), subarea ES was covered in 2008 (good coverage), subarea EN was covered in 2009 (insufficient coverage), subarea CM was covered in 2010 (insufficient coverage) and subarea EW was covered in 2011 with good coverage. Due to changes in resource allocation there will not be a Norwegian sighting survey in 2012. To complete the current 6-year cycle, subarea EB will, therefore, have to be covered in 2013. It may also be necessary to resurvey some of the subareas with insufficient coverage in 2013.

The Norwegian Minke Whale DNA Register (NMDR) is a data base monitoring commercial harvest and trade of whale products. Haug reported the register's logistics and specifications have now been reviewed, and the potential to apply similar registers to control the exploitation of other marine species has been evaluated (Glover *et al*. 2011). The application of genetics for the management of natural resources is expanding, and within this field, DNA registers will play an increasing role. The NMDR, established in 1996, was designed primarily as a control system to detect any attempts at illegal trade of products derived from other stocks of minke whale, or other whale species, under cover of the legal Norwegian harvest originating from the Northeast Atlantic. The register contains genetic data for 7,644 of 7,751 whales landed in the period 1997–2010. Profiles are established from sequencing part of the mtDNA control region, analysis of 10 STRs and a sex determining marker. Probabilities of genotypes matching between two randomly selected whales are 6.0^{-04} and 3.0^{-08} for five and eight of the STR loci, respectively. This allows verification of traded whale products via match to the register. The NMDR possibly represents the only fully operational DNA register implemented to monitor the commercial exploitation of a marine species, at the individual sample level. The close interaction of the NMDR, regulatory authorities, and the whalers themselves provides an example of how a highly regulated marine harvest can be conducted, in addition to how an individual based DNA register can be implemented to monitor and control the sustainable harvest of marine resources. While not without operational and logistical challenges (a few whales not sampled which may lead to unregistered meat on the marked), the experiences gained through operation of the NMDR clearly illustrate that DNA registers to track individual samples are viable. The register has also been used in a number of *ad hoc* scientific studies resulting through the accumulation of genetic, demographic and biological data.

Lydersen reported that the Norwegian minke whale DNA register had been used successfully to trace the origin of minke whale blubber discards found in the stomachs of Greenland sharks.

Vikingsson reported that a similar DNA register for minke and fin whales has been established in Iceland.

9.5 Narwhal

9.5.1 WG report

A joint meeting of the NAMMCO Scientific Committee Working Group on the population status of narwhal and beluga in the North Atlantic and the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga Scientific Working Group was held in Copenhagen on 13-17 February 2012 under the chairmanships of Rod Hobbs for NAMMCO and Steve Ferguson for JCBN.

The report from the meeting provides advice on the status of shared stocks of beluga and narwhal as well as for narwhals in East Greenland. The advice is based on estimates of current population size and trends, stock definition, biological parameters, current and historical harvest and other impacts. Advice on research and monitoring needs is also presented.

Genetic evidence of stock structure

Population structure in narwhals as inferred from mitochondrial DNA suggest that East Greenland is distinct from West Greenland and that West Greenland samples from Uummannaq appear different from samples collected in the Melville Bay and the Disko Bay. These two latter areas appear to be part of the same population, whereas samples from the North Water (Qaanaaq) appear to be separate. Genetic divergences were also detected among years in areas with large samples sizes (such as Qaanaaq) rendering the interpretation of the result somehow uncertain. Furthermore samples from Northern Hudson Bay seem to be distinct from samples from East Greenland and from a collection of localities in Baffin Bay. Narwhals from Jones Sound and the Somerset Island summering stock are differentiated, although this may be influenced by low sample numbers from especially Somerset Island.

The low genetic divergence among geographic areas does not imply high rates of gene flow/migration but could be due to historically high migration rates and/or common ancestry. If more contemporary estimates of gene flow/migration are required then another genetic approach will be required, such as kinship-based analyses.

Satellite tracking evidence of stock structure

Baffin Bay

Satellite tracking of narwhals from Admiralty Inlet (2009) and Eclipse Sound (2010-2011) revealed a similar timing of migration (in late autumn/early winter) to the Davis Strait and a similar home range as previously defined. One whale from Admiralty Inlet spent winter in northern Foxe Basin rather than the Davis Strait, as is typical for narwhals from this stock. This indicates a connection between the regions but not the stocks in Hudson Bay and Lancaster Sound since tracking studies have shown the stocks are geographically separated during the autumn-winter period. Thus there is no evidence of linkages of animals from these stocks. None of the other whales showed any indication of going to other wintering grounds than the known areas in Davis Strait.

East Greenland

Animals in East Greenland seem to have a yearly migratory schedule where they leave the fjords and move off the coast in winter. The whales in the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland. These apparent distinctions indicate that the East Greenland narwhals for management purposes should be separated into different stocks.

Other evidence on stock structure

Skin tissues collected from narwhals stocks in Canada and West Greenland were analyzed for stable isotopes to determine if chemical signatures can be used as another tool for defining narwhals to specific stocks. Stable isotopes varied among most narwhal stocks assessed, suggesting the technique may be useful for stock delineation. The location of the food ingested is what translates into the isotopic signature and if the origin of the food varies (migratory food species or feeding along a migration) the discrimination into stock units would be impaired. Also, the time lag for the appearance of a signal could have a strong influence on the results of the analysis. Overall, stable isotope analysis is a cost effective technique and in combination with satellite tracking and genetic techniques, may enhance our understanding of narwhal stock structure.

Management units

Baffin Bay

The JWG and the SC agreed to continue to use the metapopulation model of narwhals in Baffin Bay, Hudson Bay, and adjacent waters as a useful approach for identifying stocks/management units and aggregations of narwhals. The model also includes knowledge of seasonal movements and the relation between the stocks and the hunting localities (Figure 2). The model is based on data collected from two decades of satellite telemetry studies of narwhals tracked from six coastal aggregations in the eastern Canadian high Arctic, Hudson Bay and West Greenland, and on information on seasonal catches of narwhals in 11 Inuit communities. The tracking data suggest that disjunct summer aggregations of narwhals to some extent are demographically-independent sub-populations with minimal or no exchange with other summering aggregations and that these, for management purposes, should be considered separate stocks. Tracking results of whales that return to the summering grounds the following year suggest inter-annual site fidelity in narwhals. It is proposed that the narwhals in Canada constitute five separate stocks with some limited exchange between three of the stocks. Coastal summer aggregations in Greenland constitute two stocks in addition to two fall-winter aggregations supplied by narwhals from several summering stocks. Several of the narwhal stocks will be mixing on the wintering areas in Baffin Bay-Davis Strait but the metapopulation structure is maintained through a combination of life history traits and migratory routes, where mating most likely occur after the initiation of the return migration towards summering areas.

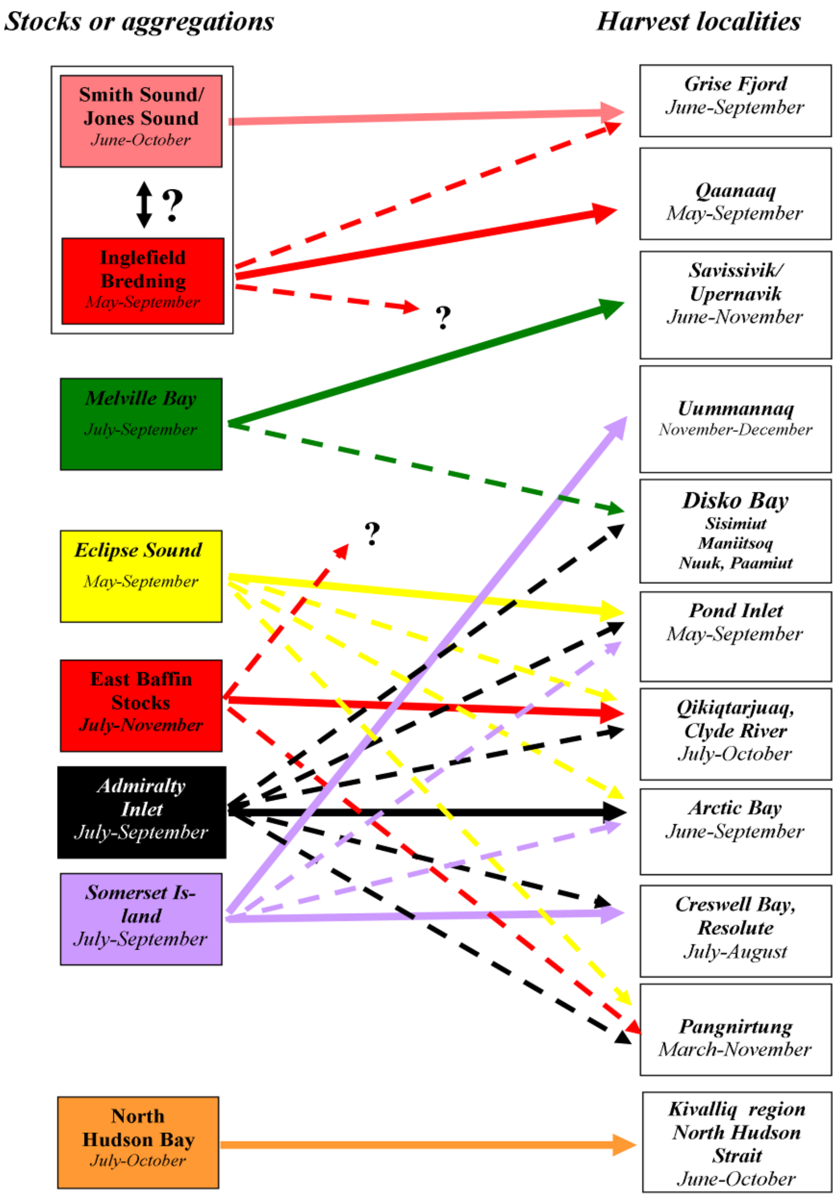

Figure 2. Diagram relating summer stocks and aggregations to hunt locations based on the metapopulation model. Solid lines have been verified by tagging studies, dashed lines are based on geography and inference from TEK and other sources.

East Greenland

The JWG and the SC agreed that management advice should be provided separately for narwhals in the Scoresby Sound (Ittoqqortormiit) and Kangerlussuaq-Sermilik (Tasiilaq) areas.

Meeting on procedures for the allocation of the harvest to the summering stock
It was not possible at the JWG to fully explore the allocation of harvest in the context of the metapopulation model and it was therefore recommended to establish a sub-group to i) review information on distribution, movements and harvest locations; ii) Develop an allocation model that will provide a mechanism for assigning harvested animals to stocks based on existing data; iii) Specify and quantify exchange rates between aggregations and stocks, and iv) Identify and quantify uncertainty in the allocation model and determine implications for management. This sub-group should meet before next JWG meeting.

Age estimation, biological parameters and population dynamics
A new racemization rate for narwhals have been estimated by regressing aspartic acid D/L ratios in eye lens nuclei against growth layer groups in tusks (n = 9) and the results were used in a large-scale study of age estimation of narwhals and estimation of life history parameters. Age at sexual maturity based on data from reproductive organs was estimated to be 8 years for females and 17 years for males. Age at first parturition was estimated to 9 yrs of age. Pregnancy rates for East and West Greenland were 0.42 and 0.38, respectively. Oldest pregnant female was 68 yrs of age. Maximum lifespan expectancy for narwhals was found to be ~100 years of age.

It was shown that age structure data are useful for estimating the exponential growth of both narwhals and belugas. A full assessment, with estimates of abundance and population growth, could, for example, be provided from a single abundance estimate and a single sample of the age structure. Furthermore, these models were developed so that they included estimates of the age-structured selectivity of the hunt. Similarly a model with life history traits based on age structure and fertility estimates and historical catch data from East and West Greenland can be used to estimate the minimum viable starting population in both areas in 1969 that would be required to endure the historical catch and still match current estimates of population size.

Catch statistics
Information on catches of narwhals is available from Greenland since 1862 although detailed statistics split by hunting grounds are missing for most of the years. There has been an overall increase in catches in West Greenland during the 20th century which is especially pronounced after 1950. However since 1993 a significant decline in overall catches has been observed. The decline was most pronounced in Uummannaq and Disko Bay and could not be detected in the other areas (Qaanaaq, Upernavik). Catches in East Greenland seem to have peaked during 1999-2006 but have declined after 2006. No new data was presented on the struck and lost rates in Canada or Greenland. No working paper on catches in Canada was presented but data were presented at the meeting and are included in the report. It was recommended that Canadian narwhal catches should be compiled with historic catch estimates for the different stocks to provide an updated catch history.

Abundance
An aerial survey of narwhals was conducted in the North Water in May 2009 and 2010 with the purpose of developing a fully corrected abundance estimate. The

resulting abundance estimates were 10,677 narwhal (6,120-18,620) in 2009 and 4,775 narwhals (2,417-9,430) in 2010. The JWG and the SC approved that these abundance estimates can be used for assessment purposes of the Inglefield Bredning stock.

A study in Northern Hudson Bay found that narwhals spent approximately 32% of their time at the surface where they would be available to be seen by an aerial survey. When this correction factor was applied to the 2000 photographic aerial survey estimate of 1,778 (95% CI 1,688-2,015), an estimate of 5,627 narwhals (95% CI: 3,543 – 8,935) narwhals was attained.

Update of assessment for West Greenland

An age- and sex-structured population model with exponential or density regulated growth including recent abundance estimates, age structure data and catch history was used to update the assessments of narwhals in West Greenland. Several scenarios of stock delineations and harvest allocations were explored. While the age-structured models are the preferred assessment models for Greenland the models presented require further refinement especially in relation to stock structure and the allocation of catches not taken during summer. Some further testing of assumptions regarding the prior distributions of growth rate, birth rate and survival rate, and consideration of the inclusion of stochastic elements, are also required.

Recommendations

The **SC recommended**:

- continued work on survey correction factors,
- continued collection of age-data for improved assessments,
- studies for the estimation of struck and loss rates, and
- further development of the assessment model

Advice for West Greenland

The JWG and the SC agreed that the models explored at the current meeting, incorporating recent abundance estimates, updated age distribution data and new movement information from satellite tracking, confirmed that the current quotas in Greenland, for each stock area (Table 1), are sustainable:

Area	**Current quotas**
Inglefield Bredning	85
Melville Bay	81
Uummannaq	85
Disko Bay	59
Total	310

Table 1. Current quotas in Greenland for each stock area.

A new and updated advice is expected from the next JWG meeting, based on the allocation method to be developed at the proposed intercessional meeting. No advice on management was developed for any of the Canadian stocks.

Update of assessment for East Greenland

The JWG and the SC agreed that narwhals in Scoresby Sound (Ittoqqortormiit) and Kangerlussuaq-Sermilik (Tasiilaq) should be treated as two separate stocks. The age structure from animals collected between 2007 and 2010 in Ittoqqortormiit was applied to both areas, and the harvest was found to select older animals. It was estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasiilaq/Kangerlussuaq area might be stable. The current growth rate in the absence of harvest was estimated to lie between 1.2% (95% CI:0–3.5) and 3.7% (95% CI:1.6–5.9), depending upon model and area.

<u>Advice for East Greenland</u>

The probability that total annual removals from 2012 to 2016 will ensure an increasing stock for the two stocks in East Greenland (Table 2) was estimated:

Narwhal	**Ittoqqortormiit**	**Kangerlussuaq**
Probability of increase	***Total removals***	***Total removals***
95 %	17	0
90 %	35	1
85 %	45	6
80 %	50	9
75 %	60	13
70 %	70	18

Table 2. The probability that total annual removals from 2012 to 2016 will ensure an increasing stock for the two stocks in East Greenland.

Impact of human made noise

In discussions on management advice it was noted that there is little information on the predicted response of marine mammal populations to changing arctic conditions including changes in sea ice, climate and forage species as well as increased human development activity in the arctic including seismic, shipping, drilling, and shore based development. The **JWG and the SC recommended** holding an international symposium on the effect of seismic and other development activities on arctic marine mammals with a focus on beluga and narwhal.

9.6 Beluga

<u>9.6.1 Working Group Report</u>

Stock structure

The Somerset Island stock supply the belugas overwintering in the North Water and off West Greenland, where the majority of the removals take place (Figure 3).

Although there are not enough data to quantify the influx of belugas from Cumberland Sound to West Greenland, it is unlikely that these animals contribute significantly to the exploited winter aggregation in Greenland.

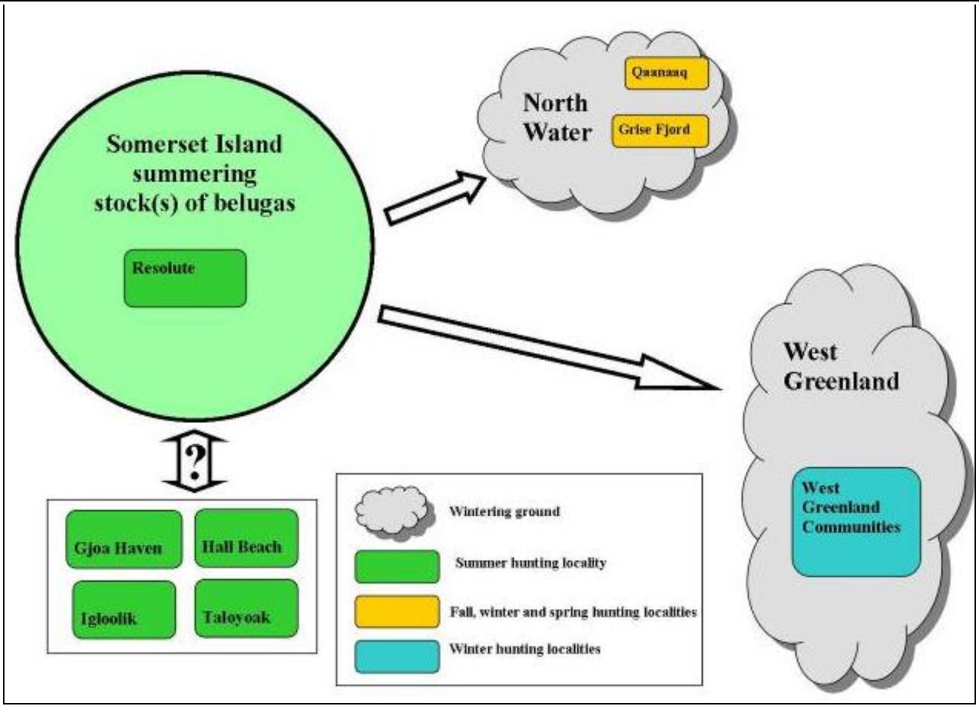

Figure 3. Beluga stock relation hypothesis. Summering stock around Somerset Island is known to travel to North Water and West Greenland based on satellite tracking data. The four Canadian communities (boxes) are thought to derive their harvest from the Somerset Island summering stock.

Age estimation, biological parameters and predation

JWG recommended at its 2009 meeting that separate workshop(s) were needed to address the problems with age determination of monodontids (9.6.2). No new biological parameters were presented for belugas, but it was agreed to apply an annual deposition rate of 1 growth layer group in tooth dentine for age estimations.

Polar bear predation on belugas was considered important as well as predation by killer whales. It was noted that receding sea ice caused an increase in the presence of belugas in shallow coastal areas. As a consequence the availability of belugas for polar bear predation also increases which warrants further investigation.

Catch statistics

Statistics on catches of belugas in West Greenland are available from 1862 to 2011. Catches declined during 1979-2011 from about 1,300 in the early 1980s to levels below 300 whales per year after 2004. Reported catches in East Greenland are considered erroneous. No working paper on catches in Canada was presented but data were presented at the meeting and are included in the report. It was recommended that

Canadian beluga catches should be compiled with historic catch estimates for the different stocks to provide an updated catch history.

There are no research plans for the quantification of struck and lost whales of belugas.

Abundance
Aerial surveys of belugas were conducted in the North Water in May 2009 and 2010 with the purpose of developing fully corrected abundance estimates. The resulting abundance estimates were 2,008 beluga (95% CI 1,050-3,850) in 2009, and 2,482 beluga (95% CI 1,439-4,282) in 2010. A low correction factor for availability bias may introduce a negative bias on the abundance estimate and it is suggested that specific correction factors for the Greenland beluga surveys are developed. The surveys might also be negatively biased because the surveys probably did not capture the entire population of belugas that winter in the North Water, since some of the whales would, by the time of the survey, have moved out of the North Water towards Lancaster Sound. The estimates were approved by the JWG and SC for assessment purposes.

Assessment for West Greenland
An age structured population dynamic model was used to assess the current status of beluga wintering in West Greenland. The analysis combined the historical catches from 1862, with the winter counts from 1981 to 2006, and age structure of the individuals in the catches from 1984 to 1997. Results from different scenarios of the model were presented, providing annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated to 44% (95% CI: 16%–88%), with a yearly replacement of 510 (95% CI:170–780) individuals.

It was agreed that while the age structure data improved the estimates annual survival and growth rates, there were no data on birth or juvenile survival rates for this population. The JWG did not come to a consensus on the preferred modelling approach but discussed analysis alternatives including the use of birth and survival data from other beluga populations to inform prior distributions for this population.

<u>Recommendations</u>
The SC recommended:

- the collection of new age-data for improved assessments,
- studies for the estimation of struck and loss rates, and
- further development of the assessment model in relation to prior distributions

<u>Advice</u>
Relating to **Request-3.4.11**, on updated advice when new data is available, the JWG considered, and SC agreed, that the revised assessment models, which incorporate the age structure data but no new abundance estimate, confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it is concluded that a total annual removal of 310 beluga in West Greenland (excluding Qaanaaq), is sustainable. A new and updated advice is expected at the next meeting based on a new abundance estimates from the spring survey in 2012, and the

SC noted that new abundance estimates for assessments should be available at least every 10th year.

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

Relating to **Request-3.4.13**, the JWG and the SC reiterated the recommendations for seasonal closures:

- Northern area (Uummannaq, Upernavik and Qaanaaq): June through August
- Central area (Disko Bay): June through October
- Southern area (south of Disko Bay to 65°N): May through October.
- The area south of 65°N, closed for hunting.

The purpose of these closures is to allow for the possibility of reestablishment of local aggregations of belugas in Greenland.

9.6.2 Other updates

NAMMCO Monodontid Age Workshops

Recognizing that there are a number of problems with age determination for both beluga and narwhal, three age determination workshops were organised. The first in Tampa (Florida, USA) examined the state of the art of general aging techniques for marine mammals and other species; the second in Beaufort (North Carolina, USA) focussed on age estimation of belugas using teeth; the third in Copenhagen focussed on the use of tusks for age estimation in narwhals.

Workshop 1 in Tampa, Florida

The report (Annex 3) made it clear that the breadth and depth of the workshop presentations indicated that most issues concerning monodontid age estimation are not unique. Many researchers investigating many taxa have considered a diversity of methods and a diversity of tissues to reveal biological records of age. Aside from the biological materials, accuracy and precision of the counts or metric, have been considered, as well as their interpretation.

The workshop members agreed on several aging methods which are or may be applicable to monodontids, including potential new methods which, depending on the type of tissue required for analysis, may be applicable both to living and dead animals. Presently, tooth Growth Layer Groups (GLG) are only useable in belugas, and the Aspartic Acid Racemization (AAR) technique is very promising in narwhals. More work needs to be undertaken on embedded tusks of young animals to help tune the AAR rate for narwhals. The AAR method should also be applied to beluga eye lenses to provide a correlation with beluga tooth GLG. Such a study might provide more reliability on the narwhal AAR work presently done.

A further method that is accurate and can be used for calibration is that of bomb radiocarbon, ^{14}C. However, the main limitation is that the teeth or hard tissues must come from animals that were born after the fallout commenced, *i.e.*, post-1958.

Currently, the workshop agreed that an annual deposition rate of tooth GLG was to be the accepted standard in belugas.

The proceedings from the workshop are scheduled to be published in a volume of the NAMMCO Scientific Publication Series, entitled *Age estimation in marine mammals with a focus on monodontids*. The approval for the proposed volume had already been taken in NAMMCO, and the likely publication date would be in 2013.

Workshop 2 in Beaufort, North Carolina

The second workshop comprised 3 parts. The first part consisted in the reading of 60 images circulated to the workshop participants. The images originated from different stocks and were prepared using various techniques corresponding to the typical practices of the contributing laboratories. The participants were asked to estimate the age of each individual represented by the tooth image and provide an assessment of relative quality and readability. These estimates were used as input data for a statistical analysis of the discrepancies and errors in reading. The second part included readers from several laboratories. Based on the findings during the laboratory sessions and subsequent discussion the group recommended best practices for tooth and section preparation, reading, imaging and documenting the counts. Document SC/19/18, Annex 4 to this report, presents a summary of the main results, conclusions and recommendations from this exercise.

The third part, which will take place later in 2012, is a second reading exercise by the whole group, based on a standardised set of scanned images, representing a selection of features and levels of reading difficulty.

A third, shorter, workshop was held in Copenhagen, Denmark, in conjunction with the JWG meeting and concentrated on the preparation techniques and reading of narwhal tusks.

The **SC recommends** the AAR technique to be applied to belugas, to included known history/age animals in the analyses in order to calibrate the technique and provide an alternative aging method for beluga. Furthermore, it was recommended that with respect to beluga age estimation from teeth GLGs, there should be standardisation of GLG readings among laboratories with inter-laboratory calibrations, and the setting up of reference collections ideally accessible to all for standardisation of age estimation.
The final report from workshop 2 will be published in the NAMMCO Scientific Publications Series.

9.7 Bottlenose whale

9.7.1 Update

The Faroese T-NASS 2007 data have been analysed together with data from CODA for a model based estimate of abundance.

9.8 Killer whale

9.8.1 Update

Studies into the genetic differentiation of north Atlantic killer whales and acoustic signals produced by killer whales were conducted in Icelandic waters in 2011 (Foote *et al* 2010, Samarra 2012).

9.9 Pilot whale

R-3.8.5 – 2010: The Scientific Committee is requested to assess the status of long-finned pilot whales in West Greenland waters and provide minimum estimates of sustainable yield.

R-3.8.6 – 2011 (new): The Scientific Committee is **requested** to continue work to complete a full assessment of pilot whales in the North Atlantic and provide advice on the sustainability of catches, as soon as necessary further information becomes available, with particular emphasis on the Faroese area and East and West Greenland. In the short term, the Scientific Committee was requested to provide a general indication of the level of abundance of pilot whales required to sustain an annual catch equivalent to the annual average of the Faroese catch in the years since 1997.

9.9.1 Update

Mikkelsen reported about a tracking study carried out in the Faroe Islands, where 8 animals in a pod of 40 were tagged in late May 2011. The longest-lasting tag lasted only 14 days, over which the animal had moved SW for 400 nmi to Rockall. This reveals a different pattern from earlier tracking, where animals have moved north into the Norwegian Sea.

The SC appreciated the effort by the Faroe Islands and encouraged the continuation and the improvement of the tagging. The SC discussed that it is preferable to tag animals from intact pods but that tagging animals from a partially exploited pod could be an alternative, especially if the first option is not available.

Relating to **R-3.8.6** the SC agreed that it was unlikely that a full assessment could be attempted in the near future. Regarding a short term advice, the SC noted that both the AWMPc procedure (which has been used for preliminary advice for baleen whales in West Greenland by NAMMCO and the IWC), as well as the PBR approach, could be used for an inverse advice calculation of the minimum abundance required to sustain the average take by the Faroese.

With the average annual catch by the Faroese since 1997 being 678, and the CV of the latest abundance estimate being 0.27, the AWMPc procedure estimates that an abundance estimate around 50,000 pilot whales and a similar precision is required to sustain the catch. In comparison, the PBR approach (r_{max} of 3% & recovery factor of 1) calculates an abundance estimate around 80,000 whales. These calculations reflect precautionary estimates of the minimum abundance estimates required to sustain the Faroese hunt. However, the geographical range of the stock(s) that supply the Faroese hunt is unknown, and it is unresolved how the calculated estimates compare with the accepted estimate of 128,000 (95% CI: 75,700-217,000) pilot whales from the

Icelandic and Faroe Islands area of T-NASS.

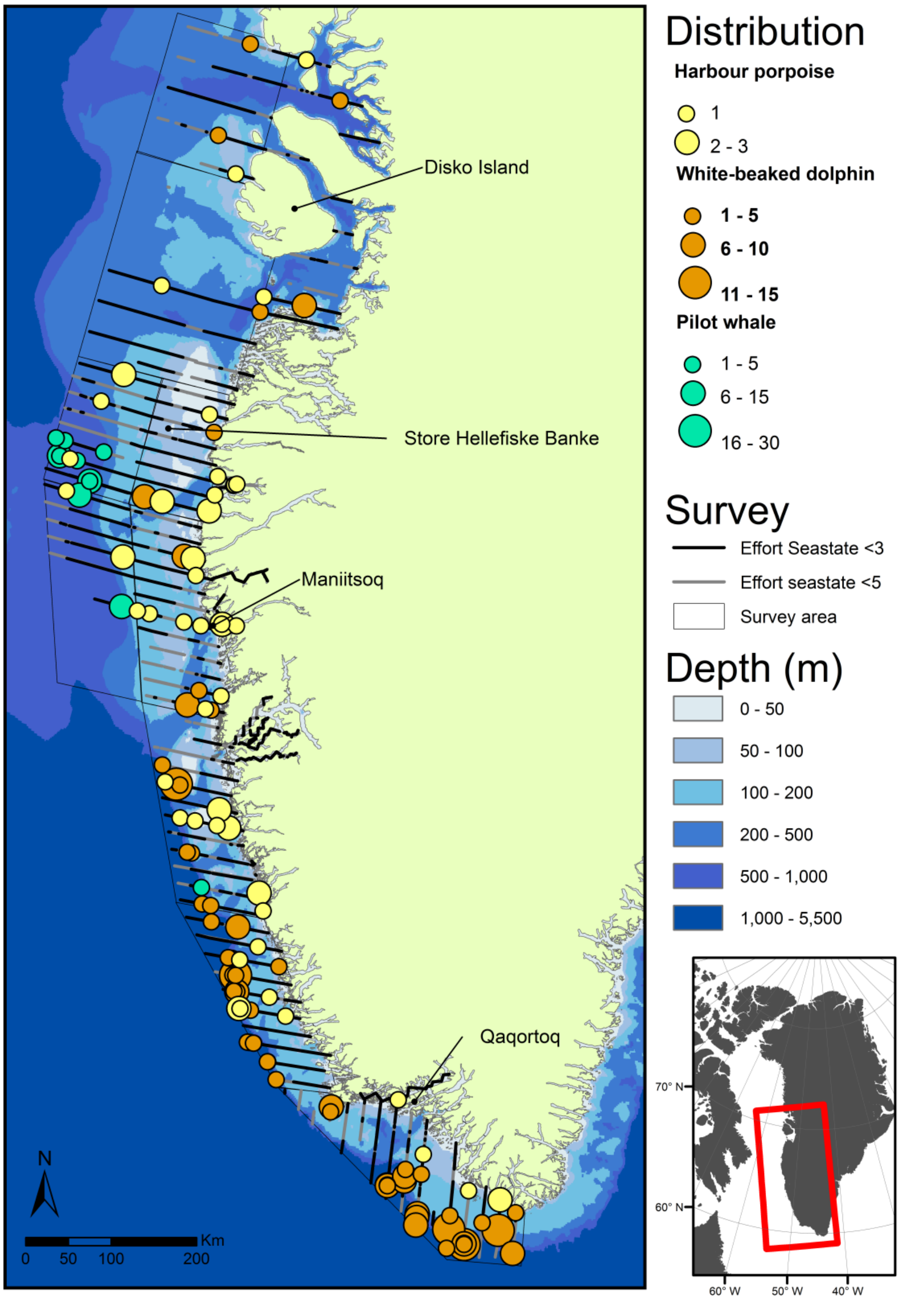

Figure 4. Realised survey effort from the 2007-survey in West Greenland. Lines flown in Beaufort sea state less than 5 are indicated in grey and sea state less than 3 in black. Distribution of pilot whales, white-beaked dolphins and harbour porpoises are shown in relation to depth.

The average annual catch of long-finned pilot whales in West Greenland during 1993-2007 was 126 whales. An aerial survey conducted in 2007 with partial coverage of the potential pilot whale habitat (Figure 4, above) revealed an abundance of 7,440 animals (95% CI 3,014-18,367) which has been approved by the NAMMCO SC. Applying a PBR approach (r_{max} of 3% & recovery factor of 1), it is suggested that a sustainable harvest level of pilot whales taken from this abundance would be around 50 whales per year. An estimate based on the AWMPc procedure, suggests that an annual take 70 whale is sustainable. However, the survey did not cover the entire range of pilot whales in West Greenland and the summer aggregation in West Greenland cannot be considered an isolated stock. Instead, it is likely connected to pilot whales along Labrador and at Newfoundland, and the occurrence and abundance in West Greenland is probably influenced by the sea temperature regimes in the area (Fullard *et al*. 2000), although the extent of this is not known.

9.9.2 Future work

Mikkelsen reported that efforts have been done to improve tag design, especially with regards to antennas, and that more trackings will be attempted in the future.

The SC was informed that the monitoring of the catch recommended by the SC over a 3-year period, which is needed for the definition of a long term monitoring programme, had not been implemented yet, although a small *ad hoc* sampling was performed from some of the landed schools. The SC reiterated its recommendation to timely implement this monitoring and underlined that an *ad hoc* sampling of the catch as performed so far would not fulfil the requirements of the recommendation.

Regarding trends in abundance, the SC reiterated its recommendation that survey estimates from 1989, 1995 and 2007 (including CODA), *i.e.,* only from the three widest surveys, are divided into comparable blocks so that recent estimates and trends can be investigated on a larger area than what has been done so far and for the areas close to the Faroese.

9.10 Dolphins

9.10.1 Update

The average annual catch of white-beaked dolphins in West Greenland during 1993-2007 was 30 dolphins (Hansen 2010). An aerial survey conducted in 2007 revealed an abundance of 11,801 animals (95% CI 7,562-18,416) which has been approved by the NAMMCO SC. Applying a PBR approach (r_{max} of 3% & recovery factor of 1) suggests that the sustainable harvest level of white-beaked dolphins taken from this abundance would be around 125 whales per year.

In 2011 the first stranding of a bottlenose dolphin in Iceland was recorded, which is also the first confirmed record of the presence of bottlenose dolphins in Icelandic territorial waters.

9.10.2 Future work

In the Faroe Islands samples were collected from the drive fisheries in 2001-2009 and the analyses will be finalised within the next couple of years.

9.11 Harbour porpoise
There is an open request (**R-3.10.1)** for the assessment of the harbour porpoises throughout its North Atlantic range.

9.11.1 Update
A total annual by-catch estimate of 6,900 harbour porpoises in Norway was reported. This estimate is substantial, and it raises concerns that the by-catch of harbour porpoises in Norway may not be sustainable. Therefore the SC recommended initiating an assessment of harbour porpoises in Norway. This process should include *i)* reviewing the by-catch estimates *ii)* examining the relevant abundance estimates *iii)* assessing the need for coastal surveys of harbour porpoises in Norway *iv)* investigating the use of satellite tracking for stock delineation, and *v)* evaluating the use of acoustic deterrents ("pingers") in the gillnet fishery in order to reduce the by-catch.

Greenland reported that they had sufficient data for an assessment of harbour porpoises in West Greenland. A catch history is available, a recent abundance estimate, as well as two samples of the age structure (from 1995 and 2010). The SC also noted the existence of abundance estimates from both Iceland and the Faroe Islands, as well as some estimates of by-catch in Iceland.

9.11.2 Future work
The SC **recommended** that assessments of harbour porpoise be attempted for all areas by the WG on Harbor Porpoise. This will require at least two meetings. The first meeting could provide a full assessment for West Greenland, and initiate the process for Norway, including a review of the method used for obtaining total by-catch estimates. The second meeting should focus on by-catch in Norway and Iceland, attempt to finalize assessments for Norway, Iceland and the Faroes, and could, if feasible, evaluate methods for reducing by-catch.

9.12 Sperm whale
9.12.2 Update
Acquarone reported on the financial and temporal need in relation to a reanalysis of the acoustics data from the 2007 T-NASS survey (SC/19/O/06). The data could be reanalysed at end of 2012. These will then be available for abundance estimation. With the production of the data being paid for by NAMMCO it is expected that abundance estimates will be derived by Iceland and the Faroe Islands in a timely manner.

9.13 Bowhead whale
9.13.1 Update
The Spitsbergen stock of bowhead whales has been considered severely depleted for centuries, but there are currently signs of low levels of sightings in the area especially along the East Greenland coast. One whale tagged west of Svalbard in April 2010 moved south towards an area off Liverpool Land in East Greenland where it stayed during the summer (Lydersen *et al*. 2012). This area was known by the bowhead whalers as the Southern Whaling Ground. Winter positions were obtained in

November-December and then the whale was back in the area west of Svalbard, known by the whalers as the Northern Whaling Ground. The tracks of this whale confirm that the historical movement patterns of bowhead whales are maintained in the Greenland Sea. Passive acoustic monitoring reveals that bowhead whales are present in the Fram Strait year-round, and the amount of vocalizations may suggest that the population may be larger than what the levels of sightings indicate (Moore *et al.* 2012).

One dead bowhead whale washed ashore at Kong Oscars Fjord in East Greenland in 2009 or 2010.

In West Greenland a genetic mark-recapture estimate revealed an abundance in 2009 of 1,410 bowhead whales (95% CI: 783−2,038) (Wiig *et al.* 2011) which confirm the increase observed in previous aerial surveys (Heide-Jørgensen *et al.* 2007). One male tagged in Disko Bay in May 2010 moved into the Northwest Passage where it spend a couple weeks in September 2010 in close proximity of a bowhead whale tagged in Alaska in spring the same year (Heide-Jørgensen *et al*. 2011). Both returned to their normal seasonal range, but the excursions suggest that bowhead whales from the Pacific and the Atlantic occasionally may be connected in years with little sea ice in the Northwest Passage.

One bowhead whale entangled in wires from a crab trap was found dead in Disko Bay in April 2011.

9.13.2 Future work

Based on an increase in sightings the **SC recommends** monitoring of abundance trends for the East Greenland - Svalbard population. Norway will continue the passive acoustic monitoring with two extra devices in the northern Fram Strait and north of Svalbard.

A new abundance estimate for west Greenland based on aerial surveys and genetic mark-recapture will be available later in 2012.

10. GENERAL MODELS FOR MANAGEMENT

No progress was made in this field.

11. SURVEY PLANNING

11.1 WG report

The Survey Planning WG met in Reykjavik, 10-12 January 2012. Scientists from all the member countries and the UK and Canada were present, and the US and IWC head of science by skype.

The SC had identified 3 tasks to be completed before and considered during this meeting:

TASK 1	Spatial analysis of all previous NASS for use in survey planning. Funds had not been available for such contract work.
TASK 2	Information on the seasonal occurrence of cetaceans in all survey areas. One new paper addressed this issue in coastal Icelandic waters based on aerial surveys. Earlier reference papers had considered shipboard surveys.
TASK 3	Documents describing advantages and disadvantages of different survey methodologies for aerial and for shipboard surveys. The Secretariat contracted papers to be prepared (titled *reviews of methodologies from earlier surveys*) and these were available before or at the meeting.

The WG reiterated the importance for management of continued periodic survey conducted in a single year in July-September covering the maximum possible area and coordinated at least at the level of the 2007 T-NASS, while recognizing differing national priorities.

Coordination should ensure that national survey areas are contiguous, and every effort made to cover any gaps, from the shores of Europe across the North Atlantic to Greenland and North America. This should minimize the confounding effect of migrations and variations in the seasonal distribution of animals on observed changes in distribution, abundance estimates, detection of trends and ecosystem monitoring. Practical advantages of coordination include the joint development of methodological protocols and equipment, centralized purchasing, which can result in cost savings, and more efficient joint data compilation, analysis, and dissemination. It was noted that T-NASS should co-ordinate with activities in the US, SCANS-III, the ACCOBAMS-Mediterranean area, and the Saint-Pierre and Miquelon area.

Current survey plans

The most optimal year for a large scale coordinated survey is 2015. The survey plans for the different countries were generally similar to those of the last T-NASS survey, except the following considerations:

Iceland and Faroes may consider surveying later in the summer. Although this would exclude the possibility of using a redfish survey platform, it would increase the chances of gathering high-quality data on sei and pilot whales, especially if an extension of the survey area to the south were included in the design. Biopsy collection from fin whales and tagging will be considered during the surveys. The plan is not to repeat the modifications of the 2007 aerial survey for including harbour porpoises as target species.

Greenland is planning an aerial line transect with a Twin Otter, double-platform and camera, ideally for August-September 2015. Coverage is planned to include the traditional survey area in West and Southwest Greenland, with a possible extension of the area farthest north because of recent catches of minke whales in Siorapaluk. This survey would not extend to include areas for other species (*e.g.,* westwards for pilot whales). Satellite telemetry is applied to reduce the variance of the abundance estimate by obtaining a new correction factor for time not at surface.

Canada is currently planning that a survey from the northern tip of Labrador to the U.S. border would be conducted after 2015, but will consider the possibility of moving the survey to 2015. Platforms include one Twin Otter in the north and another Otter and/or Partenavia P-68 Observer in the south, with double-platform and video camera coverage of the trackline. The eastern Arctic portion of Canadian waters may also be surveyed given the large-scale industrial developments proposed recently for northern Canada.

As for the previous T-NASS, the Russian Federation plan for one or two observers on a Russian Redfish survey vessel and two additional observers being available. The inclusion of an Antonov AN-26 survey aircraft is a possibility. Marine mammal sightings will be recorded during the Ecosystem surveys in the Barents Sea.

The possibility of a "*SCANS*-III" survey of European Atlantic waters is in the early planning phase. The requirements are driven primarily by the demands of the Habitats Directive. Results will also inform management issues related to the rapidly increasing deployment of wind, tidal, and wave energy developments. The ideal year is considered to be 2015, but it is currently unclear whether or not shelf and offshore waters can be surveyed in the same year.

A complete survey of the whole Mediterranean Sea and Black Sea is being planned within ACCOBAMS. It is the plan that most of the effort will be covered by aerial survey. Small vessels will use towed acoustics to survey for sperm whales. The dates have not been defined yet but the indicative period is around 2015.

The WG also took note of the multi-year extensive French aerial survey programme both in the mainland and overseas territories.

USA non-summer surveys are of high priority with secured funding for aerial surveys in March-April 2012 and Oct-Nov 2012. Aerial surveys are planned during Jan-Feb 2013, March-April 2014, and Oct-Nov 2014. A shipboard and aerial survey in June-Aug 2013 may be pushed back a year or so. Passive and active acoustic equipment are used during shipboard surveys.

Review of methodology from previous surveys

The state of the art in aerial survey for cetaceans was reviewed from 48 surveys. Aerial surveys were used for all types and sizes of cetaceans, except deep divers such as sperm and beaked whales. The majority of surveys used a single-platform configuration with one observer on each side; the remainder used either a full or partial double-platform. Most surveys used visual line transect methodology, and only a small proportion used cue counting or data on time in view during the survey with data on availability based on surfacing frequency and dive profiles from external studies to correct for availability bias. The correction of perception bias requires either a double-platform configuration or the circleback technique. In the latter, the correction combines perception and availability bias. Improvements in declination and bearing measurement methodology, as well as increased precision and automation of data acquisition, are important. Still or video photographic methods have great potential as camera and data storage technology has improved greatly in recent years. The potential of using photography as a second platform on smaller aircraft is particularly promising. Finally, unmanned aerial vehicles are undergoing rapid development and becoming commercially viable.

In discussion it was emphasized that a double-platform configuration was essential to quantify perception bias for all species. For this a photographic platform might also be feasible. It was recognized that additional and more detailed data on dive profiles of target species were required from all areas to facilitate the application of corrections for availability bias. The WG and **SC recommends** that efforts be made to obtain these data in Iceland, Greenland, and Canada.

Recognizing the difficulties in training observers for species identification on aerial survey, the WG recommended the compilation of a photographic identification guide for observers. The SC discussed that observer experience was essential, and that photos may be useful only for some species, while videos of cues would be required for other species like minke whale. Collaboration on a compilation of photos and videos to be used for observer training was recommended.

A review of the implementation of the double-platform mode in shipboard surveys was conducted from more than 50 surveys. The currently most-used methods are the Independent Observer configuration (IO mode), with two-way independence between symmetrical teams of primary observers, and the Trial Observer configuration (BT mode), with one-way independence of the tracker team from a primary team. Identification of duplicate sightings based on timing and position may be done *in situ*, requiring an observer dedicated to the task, or later.

Biases in distance data introduce bias in abundance estimates, and the WG and SC considered that the measurement of distance by precision instruments represent a considerable progress that should be pursued. The technical logistical requirements underlying shipboard sighting surveys have become increasingly complex. Planning must include increased and thorough testing of the equipment both on land and *in situ*, and a thorough training regime for the both the cruise leaders and the observers.

Two Technical Working Groups, one for aerial and one for shipboard surveys, were established to seek a wide cooperation on the joint development of protocols, techniques and equipment, with specific terms of reference compiled from the general recommendations provided in the review. Initial reports were received by the SC, which recommends that member countries relate to the recommendations. The reports will be considered in detail at the next meeting of the planning WG.

Seasonal occurrence

Information on seasonal distribution of cetaceans around Iceland was examined. Large variation in minke whale presence between years and an apparent northward shift in distribution observed in the midsummer surveys (June-July) complicates comparison, but a peak later than July but before September cannot be ruled out. For fin and pilot whales a somewhat later peak is also possible and for sei whales a later survey could be needed.

Recommendations

Based on the WG report with reference to the Council's decision that a new large-scale T-NASS survey of cetaceans in the North Atlantic is desirable within the near future, the SC discussed how best to approach such a large scale survey effort.

Based on experience from past surveys agreement was reached on the following specifications for a proper survey that could inform and improve management decisions:

- The survey should to the extent possible cover the potential range of the target species to provide robust abundance estimates useful for management
- The following species were identified as being targets: long-finned pilot whales, humpback whales, fin whales, sei whales and minke whales
- The survey should include all previously surveyed areas and it should be designed so that shifts in occurrence can be detected and that previously unsurveyed areas are covered if they are considered potentially important for abundance estimation
- Fully corrected abundance estimates should be developed for all the areas and this will include double-platform design of survey vessels and aircrafts
- It should early in the planning stage be attempted to include Canada and Russia and neighbouring countries in surveying parts of the Atlantic to ensure that all important areas are covered intensively
- The survey should be planned for 2015 to ensure sufficient time for preparations and because other areas of the Atlantic likely will be covered by surveys conducted by the US and by EU. Seasonal timing will be agreed upon at a later meeting.

The geographical extent of the survey is depicted on the map below (Figure 5). In addition to areas covered in the past the following new areas were considered critically important to include in a TNASS-15 survey:

- The East Greenland shelf from Kap Farvel to the about 80^{o}N where significant numbers have been detected by platforms of opportunity in recent years.
- The offshore areas between the Labrador coast and the shelf areas of West Greenland that has not been surveyed in the past
- The areas between Iceland and Jan Mayen (CM) should be surveyed in case it is not included in the Norwegian mosaic surveys, which is important for minke whales
- Areas south of the Irminger Sea and generally south of 55^{o}N where sei whales and pilot whales occur

- Areas north of 70°N in West Greenland where recent catches of minke whales have been taken
- Areas between east Iceland and Norway depending on the Norwegian mosaic survey effort
- Areas in the northeast Barents Sea, Pechora Sea where Russian surveys have indicated increased presence of cetaceans.

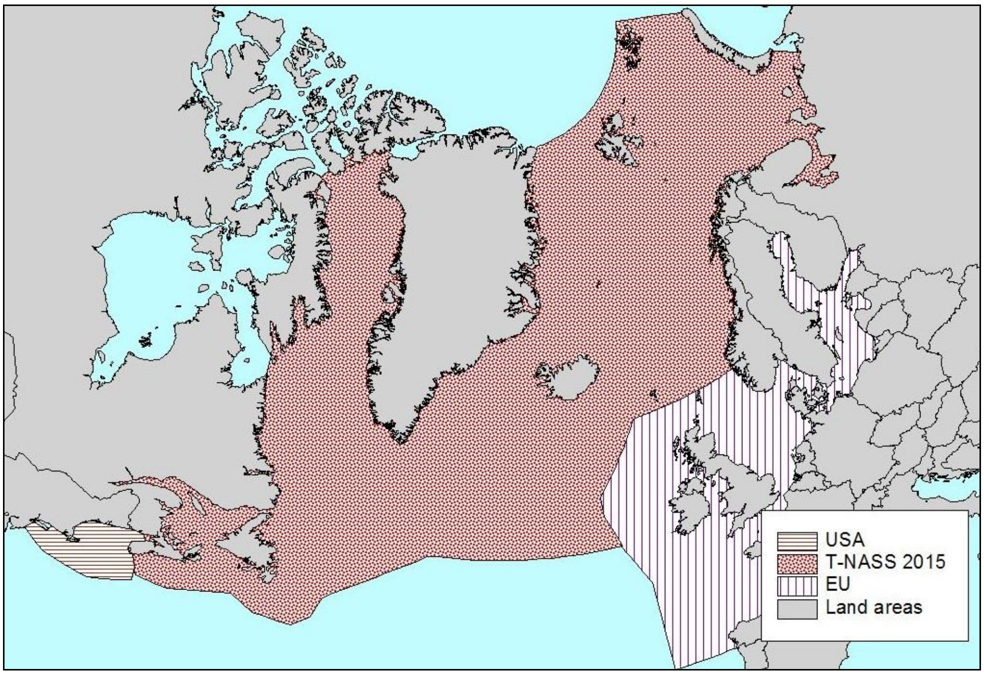

Figure 5. Extension of the proposed T-NASS 2015 and associated surveys.

Proper coverage of all areas of importance will ensure that unbiased estimates are obtained. The use of double-platforms will further reduce the bias of the estimates and provide a more accurate abundance estimates. Both approaches are critical for achieving a survey that will be of long-term value for the management of whales in this area. Such a large-scale survey will also be able to detect major shifts in abundance caused by ongoing climatic perturbations in the North Atlantic. Trends in important areas with time-series will be examined and if necessary calibrations will be conducted to ensure compatibility with past surveys. Finally the survey will provide critically important information of several of non-target species and provide abundance estimates for some of those.

An example of how the results of this planned survey will be fundamental to the interpretation of observed changes in abundance is the minke whales around Iceland. A significant decline in abundance in coastal areas of Iceland was detected in the TNASS-07 survey compared with previous surveys. However, critical areas north of Iceland and the East Greenland coast were not included in the survey effort in TNASS-07. It is therefore impossible to say if the decline represents a catastrophic drop in population abundance or if it constitutes a shift in occurrence, perhaps in response to oceanographic changes. In the survey planned for 2015 all areas will be covered and major shifts in abundance should be detectable. This is just an example, but it illustrates that regional or local surveys anywhere in the North Atlantic may give rise to questions about shifts in abundance that cannot be answered unless survey coverage is improved.

The cost of the coordination of such a large survey was also discussed. Desportes, who had been asked to act as temporary coordinator of TNASS-2 at the last SC meeting, presented a budget for the coordination effort up to the survey and beyond. There was disagreement within the committee about the necessity of such coordination and the level of work required. To avoid any conflicts of interests she was asked by the Chair to leave the room during the following discussion of the budget-proposal for T-NASS-2015.[9]

Based on experience from past surveys the SC has estimated the costs for a large scale to be in the magnitude of 50mill NOK. In comparison the total cost of the T-NASS-07 survey was 30mill NOK, when corrected for inflation to 2012. Partial funding of the survey could cause gaps in coverage that will leave areas without data that cannot be included in the abundance estimates and will also reduce the options for detecting shift in abundance between areas and will hamper the assessment of whale stocks.

Aside from already planned national survey activities there are also plans for surveys of cetaceans funded by oil companies in areas where oil exploration is planned and there are also expected participations from Russia, Canada and other countries. However, the expenses for a large scale TNASS-15 cannot solely be covered by current national budgets or by NAMMCO funding. It is unlikely that funding for such an effort can be secured from scientific funding agencies and SC seeks the advice from the Council on if it is desired that SC continues its planning of a large scale TNASS-15 and on possible avenues for ensuring proper funding of the survey.
The SC recommended a meeting of the Survey Planning WG in 2013.

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[9] _Comment received from Desportes on May 10 at the acceptance of this report:_ Desportes noted that, based on the recommendation from previous T-NASS WG and SC meetings, and the approval by Council, the budget she presented for the coordination was for a large synoptic survey coordinated at least at the level of T-NASS, as she explained during the meeting. This means coordinated internally and also coordinated with other American and European dedicated cetacean surveys, as well as other non-dedicated surveys simultaneously occurring in the area. The budget she prepared was based on the level of coordination effort carried out for T-NASS and the experience gained from that survey as agreed upon in the following WG and SC meetings. She further noted that the much lower coordination budget subsequently agreed upon by the Scientific Committee in Desportes' absence (presented under point 16.2) was unrealistic to achieve the so far recommended level of coordination - at least at the level of T-NASS, for an even larger survey. She regretted that the principle discussion and scientific arguments sustaining that approach of a less coordinated survey were not reflected in the SC report, as it is essential to specify which kind of project the SC is supporting and thereby continuing the coordination work, whatever its level.

12. NAMMCO SCIENTIFIC PUBLICATIONS

Acquarone reported on progress in the publication of walrus volume. In the proposed publication plan there are 21 chapters of which 10 have been received by the editors. The submitted articles are presently being sent for review and the editorial team has decided to go ahead with the online publication of the single chapters as soon as possible without waiting for all the planned chapters to be available.

Documents from the Age Determination Workshops (see item 9.6.1) are planned to be published in a new NAMMCO Scientific Publication Series (SPS) volume, and Lawson has been charged to coordinate the publication of unpublished 2007 T-NASS work.

The SC discussed improvements to the publication system with the objectives of speeding up publication time so that it would become more attractive for scientists to publish in NAMMCO SPS. The **SC recommends** supplementing the existing system with fast online publication in annual volumes that are not topic specific. Such a system could accept any submission of relevance, including working papers from WG meetings, with papers being published shortly after acceptance. The SC does not think it necessary that these annual volumes are published as paper volumes. This will only increase costs, while most scientists will be using the online version only. It is recommended that the possibility of special topic volumes within the SPS series is maintained, and these volumes could be published in paper format if Council wishes.

13. DATABASES ON ABUNDANCE AND CATCHES

13.1 Abundance

The SC agreed that the large whale abundance survey data can best be kept within the IWC system and encouraged the member Countries to submit all the data that might still not have been submitted. Regarding small cetaceans survey data, some NAMMCO Countries communicated that they will not be able to follow the same route, because of their non-recognition of the IWC as the management authority for small cetaceans.

The SC reiterated its recommendation to submit, collate and preserve at the Secretariat approved abundance estimates (Appendix 3), including the necessary metadata (such as the coverage area).

13.2 Catches

The SC reiterated its recommendation that catch data submitted through the progress reports are presented in a format suitable for direct use in the planned Stock Status list website.

14. WORK PROCEDURES IN THE SC

The SC encouraged its members to submit to the Secretariat for circulation within the Committee the details of upcoming meetings, conferences and symposia of interest.

The SC agreed that presentations at the SC meeting can be enhanced by PowerPoint, and the use of audiovisual systems for presentations is encouraged.

15. FUTURE WORK PLANS

15.1 Review of Active Request

The active requests were examined and reported under the relevant items.

15.2 Scientific Committee

Iceland is in turn for the next SC meeting, with a suggested period being 15-28 April 2013.

15.3 Working groups

The SC **recommended** that the following Working Groups meet before its next meeting, noting that other meetings may be held depending on new requests received from the Council:

<u>Harbour Porpoise Working Group</u>

The SC **recommended** a first assessment meeting for harbour porpoise to provide a full assessment for West Greenland and to initiate the process for Norway, including a review of the method used for obtaining total by-catch estimates. The meeting could be held in February/March 2013, most likely in Norway. *Chair: Bjarni Mikkelsen*

<u>Working Group on Walrus Assessment</u>

The **SC recommends** that a small WG meeting be held to update the advice for walrus in West and Northwest Greenland. Time: Winter 2012/13, Location: Copenhagen or Norway. *Convenor: Lars Witting; Chair: Øystein Wiig*

<u>Working Group for Planning Future Surveys</u>

The **SC recommends** that the Survey Planning WG meets in 2013, either before or after the next SC meeting. ToR would be to plan the possibility of extended coverage, including funding possibilities, and to continue the work on technical details of both the aerial and ship-board platforms. *Chair: Þorvaldur Gunnlaugsson/Geneviève Desportes*

WG meetings recommended to be held later than the 2013 SC meeting include:

<u>Narwhal and Beluga Catch Allocation Meeting</u>

The **SC recommends** that a small WG is held in 2013/14, before the next JWG meeting, to provide a framework for the catch allocation within the multi-stock model for Canadian and West Greenland narwhals. The Terms of Reference of this group should be:

- Review information on distribution, movements and harvest locations.
- Develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data.
- Specify and quantify exchange rates between aggregations and stocks.

- Identify and quantify uncertainty in the allocation model and determine implications for management.
- Recommend future work to resolve uncertainties within the model structure.

This group should ensure a useful catch allocation model given the current knowledge and data, and it would report back to the JWG at its next meeting. The location is likely to be Copenhagen. *Convenor: Mads Peter Heide-Jørgensen; Chair: Rod Hobbs.*

Narwhal and Beluga Symposium

To address **R-3.4.9** (see below) the Scientific Committee recommends that an international symposium on the effects of seismic exploration and shipping activity on narwhals and belugas is being organized by NAMMCO in 2014. Among other things, the symposium should relate to the increasing pressure from the oil industry in Greenland, and it could include studies on other species where information is missing on narwhals and belugas. Funding should be sought from industry and stakeholders.

The *Steering Committee* would include *Mads-Peter Heide-Jørgensen (NAMMCO SC)* and *Randall Reeves (Chair).* Other relevant scientists for the Steering Committee include Malene Simon, Anders Mosbech, Susanna Blackwell, and Kate Stafford, but the final decision on members is left for Mads-Peter and the Chair to decide.

R.3.4.9 NAMMCO/15-2005 (ongoing) **-** NAMMCO asked its Scientific Committee to provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland. In 2009 (NAMMCO/18) it was further specified that there was no need for a broad assessment for all marine mammals, and that focus would be on walrus, narwhal and beluga.

Grey and Harbour Seal Working Group

The SMC recommended in 2010 that the WG on coastal seals perform assessment for grey and harbour seals in all areas and develop a common management model for both species in all areas. A second meeting, which could be held in 2013/14, is needed in order to finalize assessments and to agree on a common management model for all areas. *Convenor: Tore Haug; Chair: Kjell Tormod Nilssen.*

Working Group on Large Whale Assessment

Remaining items of on the agenda for this WG include fin whale simulation trials for the Central North Atlantic applying the 60% tuning of the RMP, as well as further studies on the stock structure hypotheses for North Atlantic fin whales. It includes also a recommended catch calculation with catch cascading for minke whales in the Central North Atlantic medium area. This work is currently not prioritized by Iceland for the coming year, and a next meeting of the assessment WG thus currently not scheduled. *Convenor: Gísli Víkingsson; Chair: Lars Walløe.*

Pilot Whale Working Group

The SC recommend that a pilot whale WG meeting be held to perform assessments and aim at providing advice on sustainable removals for pilot whales around the

Faroes Islands and West Greenland, as relating to **R.3.8.1, R.3.8.2** and **R.3.8.5**. This meeting awaits progress on abundance estimates and stock structure from the Faroes (see recommendations under agenda item 9.9).

15.4 Other matters

Zabavnikov and Lydersen informed the SC about the seventh Marine Mammals in the Holarctic Conference to be held in Suzdal, Russia http://mmh2012.2mn.org 24-28 September 2012.

16. BUDGET

16.1 Spending in 2011/12

The SC examined the spending for the 2011 and 2012 presented by the Secretariat and noted that there are about 50,000 NOK left on the budget until the end of 2012.

16.2 Budget for 2012/13 and T-NASS-15 budget up to 2016

A budget for the rest of 2012 and 2013 was prepared and approved. In order to clarify the financial implications of a T-NASS in 2015 the SC prepared a general budget spanning from the present to 2016, the year after the proposed survey effort.

17. ANY OTHER BUSINESS

17.4 Election of officers

The SC thanks Witting (Greenland) for serving as Chair and welcomes Gunnlaugsson (Iceland) as Chair and Haug (Norway) as Vice-Chair.

17.5 NAMMCO Stock Status List Update

No progress.

18. MEETING CLOSURE

18.1 Acceptance of report

This report was approved in a preliminary form at end of the meeting and was accepted by correspondence on 10 May 2012.

18.2 Closing remarks

The Chair thanked the Participants, the Observers and the Secretariat for an efficient meeting. Everybody joined the Secretariat in thanking Witting for his term in office as SC Chair and welcome the Chair-elect Gunnlaugsson.

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Appendix 1

AGENDA

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

2. ADOPTION OF AGENDA

3. APPOINTMENT OF RAPPORTEUR

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS
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   4.2 Working Group Reports
   4.3 Other reports and documents

5. COOPERATION WITH OTHER ORGANISATIONS
   5.1 IWC
   5.2 ASCOBANS
   5.3 ICES & NAFO
   5.4 JCNB
   5.5 Others

6. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM
   6.1 Update
   6.2 Future work

7. BY CATCH OF MARINE MAMMALS
   7.1 Update
   7.2 Future work

8. SEALS AND WALRUSES STOCKS - STATUS AND ADVICE TO THE COUNCIL
   8.1 Harp Seal
      8.1.1 Update
      8.1.2 Future work
   8.2 Hooded seal
      8.2.1 Update
      8.2.2 Future work
   8.3 Ringed seal
      8.3.1 Update
      8.3.2 Future work
   8.4 Grey seal
      8.4.1 Update
      8.4.2 Future work
   8.5 Harbour seal
      8.5.1 Update
      8.5.2 Future work
   8.6 Bearded seal

8.6.1 Update
8.6.2 Future work
8.7 Walrus
8.7.1 Update
8.7.2 Future work

9. CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL
9.1 Fin whale
9.1.1 Update
9.2 Humpback whale
9.2.1 Update
9.3 Sei whale
9.3.1 Update
9.4 Minke whale
9.4.1 Update
9.5 Narwhal
9.5.1 WG report
9.6 Beluga
9.6.1 WG report
9.6.2 Other updates
9.7 Bottlenose whale
9.7.1 Update
9.8 Killer whale
9.8.1 Update
9.9 Pilot whale
9.9.1 Update
9.9.2 Future work
9.10 Dolphins
9.10.1 Update
9.10.2 Future work
9.11 Harbour porpoise
9.11.1 Update
9.11.2 Future work
9.12 Sperm whale
9.12.2 Update
9.13 Bowhead whale
9.13.1 Update
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10. GENERAL MODELS FOR MANAGEMENT
11.1 Update
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18. MEETING CLOSURE
    18.1 Acceptance of report
    18.2 Closing remarks.

Appendix 2

LIST OF DOCUMENTS

Document no	**Title**
SC/19/01	Draft List of Participants
SC/19/02	Provisional Annotated Agenda
SC/19/03	Draft List of Documents
SC/19/NPR-F	National Progress Report – Faroe Islands
SC/19/NPR-G	*National Progress Report – Greenland (Not received)*
SC/19/NPR-I	National Progress Report – Iceland
SC/19/NPR-N	National Progress Report – Norway
SC/19/NPR-C	National Progress Report – Canada
SC/19/NPR-J-1	National Progress Report – Japan – Large cetaceans
SC/19/NPR-J-2	National Progress Report – Japan – Small cetaceans
SC/19/NPR-R	National Progress Report – Russian Federation
SC/19/04	Observer's report on activities in ICES
SC/19/05	Report of the Working Group on Harp and Hooded Seals (WGHARP) - 15 - 19 August 2011, St. Andrews, Scotland, UK
SC/19/06	Report of the stakeholders meeting of the TXOTX (FP7) project, Bilbao, 12-13 May 2011
SC/19/07	Observer's report: 63nd meeting of the IWC Scientific Committee
SC/19/08	Report of the NAMMCO Working Group on Survey Planning, January 2012
SC/19/09	NAMMCO Scientific Committee Expenses 2011/12 and Budget 2012/13 and beyond
SC/19/10	Summary of requests by NAMMCO Council to the Scientific Committee, and responses by the Scientific Committee, Annual Report 2010
SC/19/11	Observer's Report from the 26th Conference of the European Cetacean Society, Galway March 2012
SC/19/12	Observer's Report of the ASCOBANS AC19 meeting, Galway March 2012
SC/19/13	NAMMCO Scientific Publications Series: progress report
SC/19/14	Report of the Joint Scientific Working Group of the Canada-Greenland Joint Committee and NAMMCO Scientific Working Group on narwhal and beluga - February 2012.
SC/19/15	Report on progress in the Modelling Exercise under the Marine Mammals and Fisheries Interactions Working Group
SC/19/16	Report on progress in the NAMMCO Stock Status List
SC/19/17	Report of the NAMMCO Age Estimation Workshop 1 – Tampa, FL, USA.
SC/19/18	Report of the NAMMCO Age Estimation Workshop 2 – Beaufort, NC, USA. A summary.
SC/19/19	Observer's Report from the 19th Biennial Conference of the Society for Marine Mammalogy, Tampa, December 2011
SC/19/20	Report of the Technical Working Group on Aerial Surveys

SC/19/21	Summary of the Report of the Technical Working Group on Aerial Surveys
SC/19/22	Summary of the Report of the NAMMCO Working Group on Survey Planning, January 2012
SC/19/23	Report of the Technical Working Group on Shipboard Surveys

BACKGROUND DOCUMENTS

Document no	**Title**
SC/19/O/01	Excerpt from IWC 63 SC report – Annex L (Small Cetaceans): 8.2 Harbour porpoise.
SC/19/O/02	Bjørge, A., Godøy, H. and Skern-Mauritzen, M. 2011. Estimated by-catch of harbour porpoise *Phocoena phocoena* in two coastal gillnet fisheries in Norway. Working paper SM18 for the IWC 63 SC meeting, Tromsø.
SC/19/O/03	Frie, A.K., Stenson, G.B. and Haug, T. 2012. Long-term trends in reproductive and demographic parameters of female Northwest Atlantic hooded seals (*Cystophora cristata*): population responses to ecosystem change? *Can. J. Zool.* 90:376-392.
SC/19/O/04	Glover, K.A., Haug, T., Øien, N., Walløe, L., Lindblom, L., Seliussen, B.B. and Skaug, H.J. 2011. The Norwegian minke whale DNA register: a data base monitoring commercial harvest and trade of whale products. *Fish Fish.* DOI: 10.1111/j.1467-2979.2011.00447.x.
SC/19/O/05	Joiris, C.R. 2011. A major feeding ground for cetaceans and seabirds in the south-western Greenland Sea. *Polar Biol.* 34:1597-1607.
SC/19/O/06	Email correspondence with René Swift on the reanalysis of T-NASS 2007 acoustics data.
SC/19/O/07	Proposal for NORA 2011: MarEcoModelling – Ecosystem monitoring tool for sustainable management of marine resources.
SC/19/O/08	Outcome from NORA 2011 application SC/19/O/07.
SC/19/O/09	Proposal for NORA 2012: MarEcoModelling – Ecosystem monitoring tool for sustainable management of marine resources.
SC/19/O/10	Proposal for FP7 2011: MarEcoModelling – Ecosystem Monitoring Toolbox for Sustainable Management of Marine Resources.
SC/19/O/11	Outcome from FP7 2011 application SC/19/O/10
SC/19/O/12	MarEcoModelling Final Report to Nordic Council of Ministers (AG-Fisk)
SC/19/O/13	AWMPc
SC/19/O/14	Report of the 18th meeting of the NAMMCO Scientific Committee meeting, Gjøgv, Faroe Islands, 2-5 May 2011.
SC/19/O/15	MacNeil *et al.* 2012. Biology of the Greenland shark *Somniosus microcephalus*. *J. Fish Biol.* 80:991–1018.

Appendix 3

Abundance estimate from T-NASS (2007) endorsed by NAMMCO (updated 2012)

Survey Areas	West Greenland	Iceland Coastal **(Faroese coastal)**	Iceland-Faroes	Canada GSS	Canada NL	Norwegian mosaic 2002-7
Species / Survey	Aerial	Aerial	Shipboard	Aerial	Aerial	Shipboard
Fin whale	4,359 n,j (1,879-10,114)	-	20,613 n,j (14,819-25,466) 26,117 pj (17,401-39,199)	462 n,j (270-791)	1254 p,j (765-2,059)	To be done
Minke whale	16,609 pa[1] ,j (7,172-38,461) 22,952 pa[2]j (7,815-67,403)	14,638[3] pa, l (7,381-24,919) 20,834[4] pa, l (9,808-37,042)	10,782 n,k (4,733- 19,262)	1,927 j (1,196-2,799)	3,748 pj (2,214- 6,345)	IWC 108,140 (69,299-168,752)
Minke whale 2009		9,588 pa, l (5,274-14,420)				
Humpback whale	3,272 pa,j (1.230-8.710)	1,242 p,j (632-2,445)	11,572 n,j (4,502-23,807)	653 j (385-1,032)	3,712 p,j (2,536-5,428)	To be done
Pilot whale	**2,976 n,j (1,178-7,515)**	-	**Not accepted**	6,134 n,j (2,774-10,573)	-	To be done
Sperm whale	-	-	To be done	-	-	To be done
Bottlenose whale	-	-	To be done	-	-	To be done
Harbour porpoise	**33,271 pa,j (15,939-69,450)**	**43,179 pa, l (31,755-161,899)**	-	3,667 n,j (1,565-6,566)	958 n,j (470-1,954)	To be done
Harbour porpoise		**5,175 pa, l**				

Faroes 2010		**(3,457-17,637)**				
White-beaked dolphins	**9,827 p,j (6,723-14,365)**	To be done	To be done	-	-	To be done
White-sided dolphin	-	-	To be done	4,289 n,j (cv = 0.210)	3,086 p,j (1,781-5,357)	To be done
Common dolphin	-	-	-	53,049 n,j (34,865-80,717)	613 p,j (278-1,355)	-

Estimates in bold are first estimates for the species in the area. Estimates in blue have been endorsed at the 18th SC meeting, estimates in black have been endorsed at previous meetings. For details about the remaining or recommended supplementary analyses see NAMMCO (2011), pp. 307-8, Appendix 4.

n, uncorrected for bias; p, corrected for perception bias; a, corrected for availability bias.

[1] Availability bias is adjusted using aerial photographic images taken in Iceland.

[2] Availability bias is adjusted using satellite tagging data from three different areas.

[3] Using both primary observers

[4] Using only the most effective primary observer (much higher sighting rate)

i, Endorsed at the NAMMCO WG on Abundance Estimate, Copenhagen, April 2008, and subsequent SC Meeting (NAMMCO, 2009)

j, Endorsed at the NAMMCO WG on Abundance Estimate, Quebec, October 2009, and subsequent SC Meeting (NAMMCO, 2011)

k, Endorsed at the NAMMCO WG on Assessment, Copenhagen, March 2010, and subsequent SC Meeting (NAMMCO, 2011)

l, Endorsed at the NAMMCO WG on Abundance Estimate, Copenhagen, March 2011.

ANNEX 1

JOINT MEETING OF THE

NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF NARWHAL AND BELUGA IN THE NORTH ATLANTIC

AND THE

CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP

17-21 February 2012 in Copenhagen, Denmark

REPORT

Chairs
Rod Hobbs for NAMMCO and Steve Ferguson for JCBN

EXECUTIVE SUMMARY

The Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga met 17-21 February 2012 in Copenhagen, Denmark. The meeting was held jointly with the NAMMCO Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic. The group, referred to as the Joint Working Group (JWG), reviewed 19 working papers on stock structure, catches, movements, behaviour, abundance, and population dynamics of narwhal and beluga in the greater Baffin Bay region. General population trends of both beluga and narwhal in the region have shown positive demographic signs of population growth over the past decade.

The Terms of Reference adopted outlined as objectives for the meeting to update the stock assessment for narwhal and beluga from recent years and to review and evaluate results of recent research in order to improve our understanding of narwhal and beluga populations in Canada and Greenland.

BELUGAS

The JWG agreed to a stock structure model for Baffin Bay beluga that describes a summering aggregation in the Somerset Island area and two wintering aggregations in the North Water and in east Baffin Bay. Although no new genetic studies of Baffin Bay beluga have been conducted, the JWG reviewed alternative approaches to defining beluga population structure which could assist in allocating proportions of beluga harvests in various communities to source summer stocks. No new information on beluga biological parameters and reproductive rates was available for review from the region; however recent information from Alaska provided estimates of population

growth rates (4%), age of female sexual maturity (9 y), interbirth interval (3 y), and calf age of independence (2 y). Future research planned for other regions that will inform beluga knowledge of demographic rates include hormone work to understand female reproductive cycles and estimates of survival rates and fecundity. Recent acoustic research on beluga is providing knowledge of feeding events that will assist in determining interactions with emerging fisheries. The JWG welcomed this study and suggested using satellite tagging to retrieve detailed information on the migration routes of the animals; developing quantitative methods to estimate feeding using acoustics and behaviour; including other species in this investigation; and documenting the noise level of the area.

Updates were provided on a recent series of NAMMCO workshops to examine aging techniques for marine mammals with particular interest in beluga and narwhal ageing methods. Techniques such as genetic telomere length, aspartic acid racemisation, endogenous fatty acid ratios, and historic hunting artifacts were reviewed. The preferred method, where applicable, was using hard structures, such as teeth or ear plugs that provide regular episodic growth layers. Precision, accuracy, and quality control were considered essential for development of an appropriate aging programme. The workshop participants agreed that the annual deposition of tooth GLGs was the accepted standard approach to be used for belugas. Proceedings of the workshop, entitled *Age estimation in marine mammals with a focus on monodontids,* are under compilation.

Mortality of beluga included a discussion of predation impacts by killer whales and polar bears. Recent catch statistics from Greenland and Canada were reviewed and a recommendation that catch statistics be made available one month prior to the next meeting would assist with the assessment process. Catches in West Greenland have remained below 300 belugas per year since 2004, whereas in Canada catches have remained below 200 belugas per year. For East Greenland, reported beluga catches may be erroneous and should perhaps be added to the narwhal catches. The JWG recommended studies by both countries to better quantify struck and lost rates for both beluga and narwhal. For future assessments, the JWG recommends separating catches from the North Water from those off West Greenland.

Recent abundance estimates included two aerial surveys of beluga (and narwhal) in the North Water in May 2009 and 2010 that provided corrected estimates of 2,008 and 2,482 respectively.

The assessment for West Greenland used an age structured population dynamic model that included historical catches from 1862, with winter aerial survey results from 1981 to 2006. Model results indicate an historic population size of 26,000 in 1862, to a minimum of 9,300 in 2004, to a projected abundance of 13,000 in 2017. No new data were available to update advice provided in 2009 and the JWG determined that the revised assessment models that incorporated age structure data did not require new advice on current removals of belugas from West Greenland. A survey is planned for 2012 and an updated population assessment will be prepared for the next meeting. The JWG reiterated the previous advice to seasonally close the northern area in June through August, the central area in June through October, the Southern area in May through October, and the area south of 65oN remained closed to protect the few animals that may form a summer aggregation in West Greenland.

NARWHALS

Genetic stock structure findings from mtDNA and nuclear DNA have provided a consistent pattern of genetic separation among three narwhal populations (East Greenland, Baffin Bay, and Northern Hudson Bay) with a suggestion of differences between the North Water narwhal from other Baffin Bay stocks. In contrast to other cetaceans, narwhals are characterized by very low genetic diversity that dates back 50,000 years which may limit the usefulness of genetics as a tool to understand population sub-structure and provide information required to allocate catches to summer aggregations. Recommendations were to decide on a quantitative definition of a stock and to use new emerging genotyping technologies with biomarker data, such as fatty acid, isotope, and contaminant data to improve assignment testing. Last, use of genetic information to better understand relatedness would provide knowledge of pod structure and social inferences.

Recent satellite tracking studies in Canada (Admiralty Inlet in 2009 and Eclipse Sound in 2010 and 2011) and Greenland (Scoresby Sound in 2010 and 2011) provided evidence of stock structure as well as more information on discreteness of summer aggregations. For example: one whale tagged in Admiralty Inlet spent winter in northern Foxe Basin rather than Davis Strait; many narwhals tagged in Eclipse Sound made use of Admiralty Inlet; and whales of Scoresby Sound seem to belong to a stock separate from other narwhal aggregations in East Greenland. Recent tracking results were used to update the metapopulation structure model (now referred to as stock aggregation model) that indicates disjunct summer aggregation areas of narwhal representing somewhat demographically-independent sub-populations for management purposes (*i.e.* minimal or no exchange of animals among other summer aggregations and year-to-year site fidelity). For management purposes the JWG recommends subdividing the Baffin Bay population into six separate summering aggregations: four in Canada (Somerset Island, Admiralty Inlet, East Baffin, and Eclipse Sound) and two in Greenland (Melville Bay and Inglefield Bredning with the latter having a currently unspecified linkage to Smith Sound/Jones Sound). Winter hunting only occurs in Greenland with autumn-winter aggregations occurring in two areas in Baffin Bay-Davis Strait that provide narwhals from a number of summer aggregations. Mating occurs in late winter-early spring in these areas and population sub-structure is maintained through a combination of life history traits and migratory routes of narwhal to various summer aggregations. Inuit hunting of narwhal occurs both along these migration routes and at the summer aggregations depending on different seasonal hunting areas. It is important to identify which narwhal stocks contribute to which subsistence hunts in order to assess the sustainability of those hunts to individual summer aggregations.

The JWG makes the following recommendations:

- a continuation of tagging studies to elucidate the location of the summering grounds for the animals belonging to the stock harvested in the Uummannaq area;
- tagging studies to understand where the animals summering in East Baffin, Jones/ Smith Sound spend the winter and are possibly hunted;
- develop alternative tagging options that are less costly and less intrusive;
- investigate the possibility of using alternative markers (*e.g.* ectoparasites, tusk phytoplankton;
- investigate the use of photo-id, (*e.g.* aerial or vessel platform);
- develop a glossary of definitions to assist discussions of management stocks and summer/winter aggregations.

The JWG recommends a meeting be convened to develop common procedures for the allocation of the harvest to all six summering stocks of the Baffin Bay population, tentatively in early March 2013, and to include a group of less than 10 participants (*e.g.* Heide-Jørgensen, Ferguson, Hobbs, Witting, Richard, successor to Richard, Hansen, Lee, Laidre). The suggested location is Copenhagen. The Terms of Reference of this group are to

- review information on distribution, movements and harvest locations of narwhal;
- develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data;
- specify and quantify exchange rates between aggregations and stocks;
- identify and quantify uncertainty in the allocation model and determine implications for management; and
- recommend future work to resolve uncertainties within the model structure.

This group would report back to the JWG at its next meeting.

The aging of narwhal using eye lenses was reviewed. A species-specific racemization rate for narwhals has been updated and more sampling of tusks and matching eyes are needed to improve the estimated values. Updated life-history parameters included asymptotic body lengths, age at asymptotic body lengths, asymptotic tusk length and age at asymptotic tusk length for East and West Greenland narwhals. Also, updated are reproductive (age at sexual maturity, age at first parturition, and pregnancy rate) and longevity estimates for the species.

A Bayesian assessment model was developed to estimate the exponential growth rate of a whale population based on a single abundance estimate and a single sample of the age structure. Results illustrated the usefulness of the Bayesian assessment approach based on age-structured data to inform precautionary management advice.

A population life history matrix (*i.e.* Leslie matrices) model was developed to estimate population age or class structure. Using an individually tested stochastic model with life history and historical catch data from East and West Greenland improved estimates of the starting population of narwhal in both areas in 1969 that would account for the historical catch and match current estimates of population size. Unusual mortality such as ice entrapments will be added. The JWG considers this model to improve the relation between the original population sizes and future projections and noted the similarity of results to the Bayesian model currently used for stock assessment.

In order to understand diving behaviour of the Northern Hudson Bay narwhal, nine whales were tagged with satellite tracking devices in the Repulse Bay area in August of 2006 and 2007 that provided time at depth of 0 to 2 meters of water. Narwhals spent approximately 32% of their time at the surface where they would be available to be seen by an aerial survey and this correction for availability bias was applied to the estimate from the photographic aerial survey in 2000. The JWG noted that dive behaviour has both species characteristics and characteristics dependent on location, season, behaviour and available prey and encouraged continued collection of these data with emphasis on dive interval and time-at-surface data in areas to be surveyed at the time of the survey.

Canadian and Greenland catch statistics were presented although catch statistics for Canada represent landed animals and did not include "struck and lost" estimates. The JWG encourages Canada to build a time series of catch statistics using the historical catch estimates that could be used in assessment models. Information and trade statistics on catches of narwhals in Greenland since 1862 provided a time series of somewhat realistic catch levels. There has been an overall increase in catches in West Greenland during the 20th century which is especially pronounced after 1950. During the period since adoption of the hunting reporting system (Piniarneq) a significant decline in overall catches has been observed. Catches in East Greenland peaked during 1999-2006 but have declined after 2006. The JWG requests that Greenland data include the sex of the landed animals when available and that both countries complete studies to determine "struck-and-lost" rates with various hunting methods and circumstances. Overall, for the Baffin Bay population that is shared by Canada and Greenland the average annual take for the past 5 years has been 335 narwhal by Greenland and 422 by Canada.

In November 2008, an ice entrapment event occurred off the coast of Bylot Island, Nunavut near the community of Pond Inlet that resulted in a collection of 250 skin and blubber samples from over 600 harvested whales. Dietary differences by sex or age did not occur; however, distinct feeding groups were evident, work is underway to determine the relatedness of these groups. Emaciation was evident and not thought to be the result of the entrapment period. While the later arrival of the freeze up is well documented, the relation to and mechanism of entrapment remain unclear. The JWG recommended monitoring ice entrapments and freeze-up along migration paths to understand the environmental mechanisms leading to entrapments.

An aerial survey of narwhals, conducted in the North Water in May 2009 and 2010 and accounting for both perception bias of the observers and the availability of animals to be observed, estimated 10,677 (0.29) and 4,775 (0.36), respectively. Two aerial surveys were completed in August 2010 to assess the summering stock of narwhals in Admiralty Inlet. Combining the estimates from the two surveys using an effort weighted mean of estimates yielded a population estimate of 18,049 (CV=0.23, 95% C.I.=11,613-28,053) and a new recommended Total Allowable Landed Catch (TALC) for the Admiralty Inlet narwhal stock of 233 animals. The JWG recommended ensuring that at least one of the authors of key documents such as these is present at the meetings.

Planned aerial surveys include (1) an aerial survey off West Greenland from 26 March to 15 April 2012 that includes a systematic survey design that samples using east-west transects from glaciers to the fast ice across the open water area; (2) an aerial survey in Melville Bay is planned for 30 July-6 August, 27 August-4 September, 20-28 September before, during and after seismic activities in the Kanumas West area using a systematic sampling with transects from glaciers to the fast ice across the open water area; (3) tentative Canadian plans for the next 5 years include Cumberland Sound for beluga, and Jones Sound, Somerset Island, East Baffin Island for narwhal. The Canadian delegation reported evidence of narwhal range extension into the western Canadian Arctic and were hunted in 2011 in areas where hunting of narwhals is unusual (Cambridge Bay).

The JWG reviewed assessments of narwhals in West Greenland and Uummannaq which used a Bayesian model that incorporated recent abundance estimates, historical catches , age-structure data , and an age- and sex-structured population model with exponential or density regulated growth. While the JWG indicated that the approach had merit but deferred assessment until the assessment models could be revised according to the summer aggregation model for West Greenland. This implied separate models of the two summer aggregations (Inglefield Bredning and Melville Bay), as well as models of the fall hunt in Uummannaq and the winter hunt in Disko Bay.

Inglefield Bredning was modelled as an isolated summer aggregation model and assumed that these animals are not hunted elsewhere. It applied the summer estimates from the area, the spring count from 2009, and the 2007 age structure for West Greenland as a whole. It estimated a rather stable Inglefield Bredning aggregation since the 1960s, with an average abundance around 10,000 individuals, and a current exponential growth rate of about 1.2% in the absence of removals.

The JWG determined that Melville Bay should be modelled as a distinct summer aggregation that is distributed south along the west coast of Greenland during other seasons. The model assumed that all of the catches from Melville Bay, plus 14% of the catches were from fall and winter in Disko Bay, and 12% of the catches were from winter in Uummannaq are considered to be taken from the Melville Bay aggregation. These proportions were calculated on the assumption that Admiralty Inlet, Eclipse Sound and Melville Bay supply the hunt in Disko Bay in proportion to their respective stock sizes. Similarly Uummannaq is presumed to be supplied by whales from Somerset Island and Melville bay. Besides the catch history, the model was based on the 2007 abundance estimate (6,200; cv: 0.85), and the 2007 age structure for West Greenland. Based on the information in the age structure, the narwhal abundance in

Melville Bay was estimated to have increased slightly since the 1960s, with an exponential growth rate of 1-2%/y in the absence of removals.

The model for Uummannaq relates to the hunt on stock components that arrive in the area during fall and likely overwinter in the Baffin Bay outside Uummannaq. This component was estimated at 6,070 (cv: 0.37) individuals in 2006, the model includes the age structure from animals caught in the area in 1993, and the Uummannaq catch history. This model estimated a rather stable population until the 1990s, where the numbers declined due to high catches, and a subsequent stable or increasing population thereafter. The growth rate with no catches was estimated to approximate 2% per year.

The model for the Disko Bay area relates to the hunt on the stock components that overwinter in the area. The model is based on the series of winter surveys in the area, the Disko Bay catch history, and the 2007 age structure for West Greenland as a whole. It is assumed that 14% of the Disko Bay catches are taken from the Melville Bay stock, and that the rest are taken from Canadian stocks, primarily from Eclipse Sound and Admiralty Inlet. Unlike the other areas, no absolute abundance estimates were available for this area, and it was not possible to construct a successful model.By allocating catches from the fall and wintering grounds of Uummannaq and Disko Bay to the Melville Bay stock and Canadian summer stocks, it should be possible to use this model framework for advice on sustainable catches of narwhals in all areas in West Greenland and Canada.

The JWG agreed that age-structured models are the preferred assessment models for Greenland narwhal and beluga because they provide information on the survival and growth rates of the population and in some cases on abundance. However, the models presented require further refinement especially in relation to stock structure, the allocation of catches not taken during summer and assumptions regarding the prior distributions of growth rate, birth rate and survival rate, and the inclusion of stochastic elements.

The JWG reiterated its previous advice for West Greenland (Inglefield=85, Melville=8, Uummannaq=85, Disko=59) since the new assessment models required further development. The models explored at the current meeting, incorporating recent abundance estimates, updated age distribution data and new movement information from satellite tracking, confirmed that the current quotas in Greenland, for each stock area, are still sustainable.

The JWG considered allocating the hunt in Canada and Greenland following the concept of a summer aggregation (metapopulation) model and inclusion of age structures. However, the JWG concluded that further work is required before these elements can be incorporated in the modelling approach and recommended a meeting of a subgroup of the JWG be convened as described above. For Inglefield Bredning, a new assessment should include new information on abundance from the recent survey of Smith Sound and the possibility that the stock may be shared with Jones Sound.

For East Greenland, the dynamics of narwhals at the two hunting areas, *i.e.* the Ittoqqortormiit and Tasiilaq/Kangerlussuaq areas, the Bayesian assessment model used the 2008 age structure from Ittoqqortormiit. Results indicate that the harvest was selective against the take of animals younger than 20 years of age. It was estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasiilaq/Kangerlussuaq area are likely stable. The current growth rate in the absence of harvest was estimated to lie between 1.2 and 3.7%, depending upon model and area. A more conservative result was chosen for Tasiilaq because of the general lack of data for the area and the uncertainty on the growth of the population. Recommended total removals of narwhals from East Greenland Ittoqqortormiit remain the same as the previous assessment (95% confidence of an increasing stock=17; 90%=35; 85%=45; 80%=50; 75%=60; 70%=70) and for narwhal from East Greenland Tasiilaq/Kangerlussuaq area (95% confidence of an increasing stock=0; 90%=1; 85%=6; 80%=9; 75%=13; 70%=18).

The JWG recommends:

- Regular monitoring of population sizes (at least every 5-10 years) for each summer aggregation, and
- Satellite tracking that includes dive behaviour of 20-50 animals per aggregation every 5 years are key to developing the allocation model and providing accurate advice on allowable removals.
- Development and testing of an allocation model for shared narwhal stocks between Canada and Greenland, and
- Further development and testing of the assessment models using simulations where necessary to determine the impact of assumptions and identify potential biases.

Canada continues to assess Total Allowable Harvest Levels based on the Precautionary Approach that requires using Potential Biological Removals since the five summer aggregations/stocks are considered Data Poor (*i.e.* limited time series of abundance surveys and limited age/sex structure and reproduction information).

OTHER ADVICE

The JWG notes that measurement of noise effects of seismic, drilling, shipping and other human activities on arctic marine mammals and the implications for population dynamics are not well understood for cetaceans in general and suggests that NAMMCO include this as a topic in an international symposium on human impacts. The inclusion of other species (*i.e.* walrus or bowhead) to the work of the JWG was discussed but it was not deemed desirable.

MAIN REPORT

1. OPENING REMARKS

Chairmen Steve Ferguson (JCNB) and Rod Hobbs (NAMMCO) welcomed the participants (Section 5.6) to the fifth joint meeting of the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) Scientific Working Group and the North Atlantic Marine Mammal Commission (NAMMCO) Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic (hereafter referred to as the Joint Working Group or JWG).

Section 2 of the Memorandum of Understanding between the Department of Fisheries and Oceans of the Government of Canada and the Ministry of Fisheries and Industry of the Greenland Home Rule Government on the Conservation and Management of Narwhal and Beluga signed in 7 December 1989 states that:

"The Joint Commission will be entrusted with the following functions:

- To establish terms of reference for the scientific working group;
- To be responsible for the exchange of data and information and the coordination of such research project as the Parties have agreed to carry out jointly;
- To submit to the Parties proposals concerning scientific research to be undertaken jointly or separately;
- To submit to the Parties recommendations respecting the conservation and management of stocks.

The scientific working group will be responsible for the provision of scientific advice as requested by the Joint Commission and will coordinate the exchange of data and assessment of research results."

The Scientific Working Group of the *Joint Commission on the Conservation and Management of Narwhal and Beluga* has met 13-17 February, 2012, in Copenhagen, Denmark. The meeting has been held jointly with the *North Atlantic Marine Mammal Commission Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic*. These two Scientific Working Groups, known collectively as the Joint Working Group (JWG) have reviewed several working papers that address scientific questions relevant to shared stocks of narwhal and beluga in the greater Baffin Bay region.

This Report provides advice on the status of shared stocks of beluga and narwhal, including estimates of current population size and trends, stock definition, current and historical harvest and other impacts. Advice on research and monitoring needs is also presented. The advice formulated by the Joint Working Group in this report will be presented to the next meeting of the *Joint Commission on the Conservation and Management of Narwhal and Beluga*, whose role is to provide management recommendations to both parties in respect of research, conservation and management.

The Objectives for the meeting of the JWG were to:

- Update the stock assessment for narwhal and beluga from recent years;
- Review and evaluate results of recent research in order to improve our understanding of narwhal and beluga populations in Canada and Greenland;
- Review several working papers prepared in response to questions arising from the last Joint Commission on the Conservation and Management of Narwhal and Beluga meeting in Nuuk, Greenland, in May 2009 and include:
    - Impacts of killer whales on behaviour and survival of narwhal and beluga.
    - Impacts of fish removal and fishing activity on beluga and narwhal.
    - Impacts of feeding by beluga and narwhal on commercial fishing.
    - Identify calving areas and further document stock identification and stock structure of narwhal and beluga.
    - Determine reproductive parameters of narwhal and beluga populations.
    - Impacts of changing sea ice conditions on beluga and narwhal.
    - Determine "struck-and-lost" rates with various hunting methods and circumstances.
    - Recommend collection of information on effect of noise pollution and other human activity on populations.

This Report will be prepared and presented at the Twelfth meeting of the *Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga* to be held in Iqaluit, Nunavut in 2012. At that time, the Commission will review the JWG Final Report and provide management recommendation to both Parties.

2. ADOPTION OF JOINT AGENDA

The Agenda (Appendix 1) was adopted.

3. APPOINTMENT OF RAPPORTEURS

Mario Acquarone was appointed as rapporteur for NAMMCO. Participants from the Canadian delegation shared the task of rapporteuring for JCNB. Other members assisted as required.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents that were available for the meeting are listed in Appendix 2.

5. BELUGA

5.1 Stock structure

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/03 presented an update of the most recent knowledge on stock structure for belugas in Nunavut. The aggregation previously called the Baffin Bay stock, identified as summer aggregation B in the document, is supposed to be the origin of most of the belugas overwintering in the North Water and off West Greenland, where the majority of the removals take place. Although there are not enough data to quantify the influx of belugas from Cumberland Sound to West Greenland, it is unlikely that these animals contribute significantly to the exploited winter aggregation in Greenland (Figure 6, below). Therefore, for management purposes, the JWG considered it sufficient to base the calculation of removals on the winter and spring abundance estimates from Greenland.

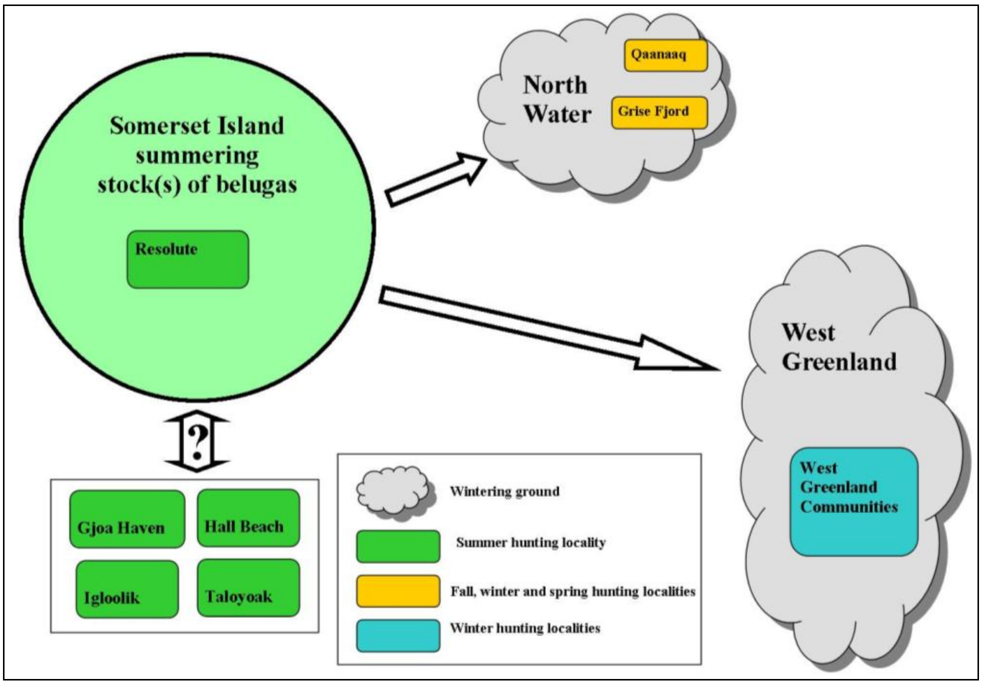

Figure 6. Beluga stock relation hypothesis. Summering stock around Somerset Island is known to travel to North Water and West Greenland based on satellite tracking data. The four Canadian communities (boxes) are thought to derive their harvest from the Somerset Island summering stock.

__Recommendations__

The JWG recommends performing further tagging, in new sites, in Canada to investigate the origin, within the summer aggregations, of the animals present on the winter grounds off Greenland.

Genetics

Analysis using the BEAST analysis software (Drummond and Rambaut 2007, BMC Evolutionary Biology) which includes a spatial and temporal framework incorporating both contemporary and ancient DNA to reconstruct population history, indicated that beluga showed high levels of genetic diversity and geographic structuring. Data from Greenland, Canada, Svalbard, the North Sea and the Barents Sea indicate that the beluga has lost genetically diverse lineages, present in the North Sea during the Late Pleistocene, which could be attributed to genetic replacement through drift, or population loss.

A recently published paper (Turgeon *et al*. 2012) presents an approach to allocate proportions of beluga harvests in various communities to source summer stocks. There is potential to expand this method to other beluga stocks, specifically in the Canadian High Arctic and West Greenland. However, this method will not be suitable for narwhal as the genetic diversity is too low and we have less understanding of social structure and behaviour in narwhal as compared to beluga.

5.2 Biological parameters

- NAMMCO: Identify calving areas and further document stock identification and stock structure of beluga.

No new information was presented and the JWG did not advance any research proposals.

5.2.1 Age estimation

- NAMMCO: Age estimation workshop on belugas

Recognizing that there are a number of problems with age determination for both beluga and narwhal and that these need to be studied in more detail, at its 2009 meeting the JWG recommended that a steering group (chaired by Lockyer and including Hobbs, Hohn and Stewart) work by e-mail to scope the problems and produce draft terms of reference for one or more workshops. The steering committee was set up as recommended and it organized three workshops: the first one in Tampa (FL, USA), in conjunction with the Biennial Conference of the Society for Marine Mammalogy, to examine the state of the art of general aging techniques for marine mammals and other species; the second in Beaufort (NC, USA) focussed on age estimation of belugas using teeth; the third one in Copenhagen, in conjunction with the meeting of the JWG, focussing on the use of tusks for age determination in narwhals.

Workshop 1 in Tampa, Florida

The **first workshop** was a 2-day event organised immediately before the biennial conference in Tampa. NAMMCO funding enabled participation of 4 invited experts and also supported the organization and logistics associated with the workshop. The breadth and depth of the workshop presentations made it clear that most issues concerning monodontid age estimation are not unique. Many researchers investigating many taxa have considered a diversity of methods and a diversity of tissues to reveal biological records of age. Aside from the biological materials, accuracy and precision of the counts or metric, have been considered, as well as their interpretation.

Relative age can be estimated using biological or chemical changes if the rate of change is known. Attempts to use **genetic telomere length** to estimate age show telomere lengths provide a measure of individual body fitness and condition rather than age, as environment, migration, health and reproduction affect telomere length. The method has potential but is still under investigation. Reviews of **aspartic acid racemisation (AAR) aging techniques** on harp seals, fin whales, harbour porpoises and bowhead whales indicated potential but warned that the presence of cataracts in the eye lens could seriously bias the age estimation and give falsely old ages. In narwhal, tusk GLG (Growth Layer Groups) correlated well with AAR age. The AAR method is potentially relatively accurate, but species-specific racemisation rates are essential for accurate age estimation. Age models using **endogenous fatty acid (FA) ratios** have been successfully derived for killer whales and also humpback whales and preliminary results using a single fatty acid ratio for Cook Inlet belugas correlated with age from tooth GLG for physically immature animals. Future work using two FA ratios in belugas is expected to provide more precision in age. It may be possible to use bone density as a proxy for age in beluga and narwhal flippers. The method would need to be calibrated with reference to beluga teeth GLG and AAR ages in narwhal. The recording of **historic hunting artifacts** recovered in bowhead whales in Alaska has presented an opportunistic and remarkable insight into longevity of this species which exceeds 100 yr. Micro-CT scanning of teeth demonstrated great potential for investigating internal structure of tooth and other hard tissue specimens that are difficult or not possible to section, because there is no destruction of the specimen and 3-D viewing is possible.

Counts of presumed annual markers can provide a more accurate (absolute) estimate of age than other tissues which show gradual changes with age. Hard structures that show **regular episodic growth** are the most commonly used tissues to investigate for records of age that can be estimated from **growth layer groups (GLG).** These can include bones, otoliths, claws, and ear plugs although teeth are most widely used. **Ear plugs in baleen whales** provide a permanent record of total age from GLG therein, as long as there is no damage. Apart from longevity, life history parameters of age at sexual maturity and possibly physical maturity can be identified form the GLG patterns. Such patterns might exist in some teeth, and should be investigated. Ear plug extraction from carcasses of minke whales is facilitated by a new method which increases the possibility of extracting whole and undamaged ear plugs. This method should be tried in bowhead whales for which ear plugs are very soft and fragile.

Teeth GLG are commonly used to age carnivorous mammals, including marine mammals. Techniques for preparing teeth vary. All are directed to obtaining the most complete record of clear laminae and it is important that the quality of tooth section preparations includes correct orientation providing a central section through crown and root when dentine is examined. A review of aging in sirenians indicated there are many internal similarities between dugong tusks and beluga teeth, and also perhaps narwhal tusks. GLG deposition rate in dugongs is annual. The most suitable method of age estimation in belugas is thin untreated sections (ca 150-200 micron). GLG patterns in sperm whales and belugas are very similar.

In belugas, counts of **GLG in dentine** as seen in medial longitudinal sections of teeth are the standard method and completely consistent with methods used in other taxa.

Discussion on the use of **cemental GLG** for estimating age, which was not so usual for cetaceans, might, in the case of belugas where cement is thick, be used to help estimate age when the dentine is worn down at the crown.

The most direct age estimation technique is following recognizable individuals through time. **Long-term photo-ID monitoring** and surveys of the Gulf of St Lawrence belugas resulted in a mass of reliable data on life history, age, reproduction, growth and colour change. Necropsies on recovered known-age and -history animals on death, have provided teeth for verifying age and validating GLG deposition rate. Several other studies confirmed the value of long-term monitoring of known animals for validation of age.

Precision and accuracy are essential in age estimation from GLG counts. The repeatability of the GLG counts and validating age are not the same as precision. **Quality control** is essential for both in the age estimation of aquatic animals, and there must be regular monitoring of an aging programme. The best measures of age precision are coefficient of variation (CV), average percent error (APE) and index of dispersion (D); the least reliable is percent agreement among readers which is usually the most commonly used. A permanent reference collection of aging materials *e.g.* known-age beluga teeth, is the key to effective quality control. In an investigation of precision and bias in aging on belugas with reference to tooth age data, it was concluded that errors in estimation of parameters can arise from errors in aging with both negative and positive bias and varying degrees of variance. In turn these translate to errors in estimation of growth rates. Efforts should be made to quantify bias and precision.

One of the most persistent debates in age estimation of a monodontid, the beluga, has been about the accurate translation of GLG counts into time units (years). The **measurement of radiocarbon, ^{14}C,** in laminated hard structures of animals has been a precise and successful method for validating age in many species, including **belugas where GLG deposition rate is unquestionably annual.** Necropsies on recovered known-age and -history belugas on death, have provided teeth which have verified age and also support an annual GLG deposition rate. Investigation of the age from teeth of known-history captive belugas, together with data on **tetracycline time-marking of teeth** generally also supported an annual deposition rate of GLGs. However, GLG definition was unclear in some specimens, particularly in the juvenile phase.

Information claimed in support of 2 GLG per year deposition rate through examination of growth and reproduction in Cumberland Sound belugas was criticized on a number of counts and did not agree with other evidence presented at the workshop based on GLG calibration using radiocarbon techniques and photo-ID studies of known-age and -history belugas for which teeth were available.

Future research was identified in several areas to fine tune our understanding. One potential technique for estimating total age from worn beluga teeth using **the angle of the boundary layers at the dentin-cement junction relative to the pulp cavity edge** appeared very promising, and should be followed up. Of a broader nature is the potential to understand the ecological correlates to lamina formation. **Laser ablation (ICPMS) for trace elements** in beluga tooth GLG indicated some elements show periodic oscillations. Investigation of **stable isotope ratios** ^{13}C and ^{15}N in beluga teeth were also promising. The point of weaning can be identified from the ^{15}N depletion up to this point. Oscillations of elements in the teeth may be linked to ecology and movements associated with feeding and migration, although these may not be annual, and thus cannot be used as an age proxy presently.

A number of **specific recommendations for monodontids** were made at the workshop, including inter-method comparisons of alternative aging methods free-living known-age animals. The number of samples of known age captive beluga from which teeth can be collected should be augmented and comprehensive sampling of other materials useful for age determination. A focus on the on the immature phase of growth in teeth in beluga with reference to captive animals to determine GLG patterns is desirable. Reference collections (hard parts) should be established, and digital image exchange for calibration and training among labs be considered. Quality control routines should be established in counting. Periodic exchanges among labs and inter-laboratory calibration for all aging techniques are essential. Comparison of tooth preparation methodologies among labs is desirable. A new study to estimate crown wear from angles of boundary layers at the dentin-cement junction relative to the pulp cavity edge in beluga teeth in order to determine the maximum number of GLG that have disappeared should be initiated. Chemical time-marking for age calibration of hard parts and bomb radiocarbon validation of hard parts and eye lenses should be encouraged. A comparison of GLG structure among stocks (free-living and captive) is desirable.

In conclusion, the workshop members agreed on several aging methods which are or may be applicable to monodontids, including potential new methods which, depending on the type of tissue required for analysis, may be applicable both to living and dead animals.

Overall, tooth GLGs are judged to be the best and most precise method. Presently, tooth GLG are only useable in belugas, but the AAR technique is very promising in narwhals. More work needs to be undertaken on embedded tusks of young animals to help tune the AAR rate for narwhals. The AAR method should also be applied to beluga eye lenses to provide a correlation with beluga tooth GLGs. Such a study might provide more reliability on the narwhal AAR work presently done.

A further method that is accurate and can be used for calibration is that of **bomb radiocarbon.** However, the main limitation is that the teeth or hard tissues must come from animals that were born before the fallout commenced, *i.e.* pre-1958.

Currently, **the workshop agreed that an annual deposition rate of tooth GLGs was to be the accepted standard in belugas.**

Finally, it was agreed to publish the proceedings from the workshop in a volume of the NAMMCO Scientific Publication Series, entitled *Age estimation in marine mammals* *with a focus on monodontids*. The approval for the proposed volume had already been taken in NAMMCO, and the likely publication date would be in 2013. The editors would comprise the members of the Steering Committee for the workshop in addition to the technical editor, Mario Acquarone.

Workshop 2 in Beaufort, North Carolina

The second workshop comprised 3 parts. The first part consisted in the reading of 60 images circulated to the workshop participants. The images originated from different stocks and were prepared using various techniques corresponding to the typical practices of the contributing laboratories. All images were considered to be usable for the purpose of estimating age. The participants were asked to estimate the age of each individual represented by the tooth image and provide an assessment of relative quality and readability. These estimates were used as input data for a statistical analysis of the discrepancies and errors in reading. The second part was held at the NOAA Laboratory in Beaufort (NC, USA) December 5-9, 2011. Participants included: 2 readers from DFO Canada, 2 readers from the Wildlife board of Nunavik in northern Quebec, 1 experienced reader and 3 inexperienced from NMFS Alaska Fisheries Science Center, an experienced reader from the North Slope Borough (AK, USA), 1 experienced and 1 inexperienced readers from NAMMCO and an experienced reader at the Beaufort Laboratory. In-kind support was provided by the Beaufort lab in the form of laboratory space and equipment, a laboratory technician and logistical support. General financial support was provided by NAMMCO. Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/20 presents a summary of the main results, conclusions and recommendations from this exercise. The third part will be completed in the first half of 2012 and consists of a second reading exercise by the whole group, based on a standardised set of scanned images, representing a selection of features and levels of reading difficulty. The results will be analysed in a similar way to the pre-workshop reading exercise and will assess the efficacy of the standardisation of the preparation and reading methods agreed upon during the workshop. The results of this last part of the workshop will be presented at the next meeting of the JWG.

A third, shorter, workshop has been held (Wednesday, 15 February 2012) in Copenhagen (Denmark) in conjunction with the JWG meeting and concentrated on the preparation techniques and reading of narwhal tusks.

<u>Discussion</u>

It was noted that a challenge in correct age determination is posed by the wear of the crown of middle to old age animals. Brodie suggested during Workshop 1, to use GLG angles at the midline of the tooth sections to estimate the number of missing GLGs, as these increase with age. Stewart reported that he had tried this and did not appear to be applicable because of the challenges of standardisation and calibration; however the JWG recommended re-examining this possibility.

It was suggested to employ the Aspartic Acid Racemization (AAR) technique to belugas as this would give better estimates for old animals where only minimum age estimates are possible due to crown wear. Additionally it was observed that, as opposed to narwhals, calibration of the AAR technique for belugas would be cheaper and feasible as these animals are more accessible and the biological material needed for the calibration does not have a high commercial value as in the case of narwhal tusks. Additionally it might be possible to obtain eye lenses of belugas from known history animals from the St. Lawrence (ref. Robert Michaud), from wild animals in Greenland and in Alaska (ref. Robert Suydam).

Recommendations

Considering that age distribution data from removals at this meeting were found informative for the assessment the JWG recommended applying the AAR technique to belugas, to included known history/age animals in the analyses in order to calibrate the technique and provide an alternative aging method for beluga.

Furthermore, it was recommended that with respect to beluga age estimation from teeth GLG, there should be standardisation of GLG readings among laboratories with inter-laboratory calibrations, and the setting up of reference collections ideally accessible to all for standardisation of age estimation.

5.2.2 Reproductive rates

- **NAMMCO:** Determine reproductive parameters beluga populations.

The JWG noted that there is no new information on reproductive rates and that standard values are used in the modelling:

- Population growth rates: 4% (from aerial counts in Bristol Bay);
- Mean age at sexual maturity: 9.25 yr (Suydam 2009);
- Inter-birth interval: 3 yr (several sources);
- Mother-calf association: about 2 years (from aerial photographs, Suydam 2009).

Future research

A study is in course in the St Lawrence estuary where biopsies of blubber will be analysed for hormones to detect pregnancy. Additionally a photo-id study which will detect survival rates and estimate fecundity is in progress in Cook Inlet.

5.2.3 Other information

- **NAMMCO:** Impacts of killer whales on behaviour and survival of beluga.

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/20 presented a model-based estimate of killer whale predation on monodontids and other marine mammals in Hudson Bay. Although predation on monodontids seems important in Canada, it is also recognized that the mixed foraging strategy used by killer whales includes seasonal predator specialization. Killer whale predation may not be constrained by a regulatory functional response.

Recommendations

The JWG discussed polar bear predation on belugas and suggested that it might be important as well as that performed by killer whales. It also noted that receding sea ice caused an increase in the presence of belugas in shallow coastal areas. As a consequence the availability of belugas for polar bear predation also increases which warrants further investigation. Since polar bears have also been observed to take belugas from breathing holes in the ice, changes in coverage and thickness of ice may impact predation of this type as well.

5.3 Recent catch statistics

- **NAMMCO:** Determine "struck-and-lost" rates with various hunting methods and circumstances.

Information and statistics including trade statistics on catches of white whales or belugas in West Greenland since 1862 are presented in document NAMMCO/SC/19-JCNB/SWG/2012-JWG/14. The period before 1952 was dominated by large catches south of 66°N that peaked with 1,380 reported kills in 1922. Catch levels in the past five decades are evaluated on the basis of official catch statistics, trade in mattak (whale skin), sampling of jaws and reports from local residents and other observers. Options are given for corrections of catch statistics based upon auxiliary statistics on trade of mattak, catches in previous decades for areas without reporting and on likely levels of loss rates in different hunting operations. The fractions of the reported catches that are caused by ice entrapments of whales are estimated. During 1954-1999 total reported catches ranged from 216 to 1874 and they peaked around 1970. Correcting for underreporting and killed-but-lost whales increases the catch reports by 42% on average for 1954-1998. If the whales killed in ice entrapments are removed then the corrected catch estimate is on average 28% larger than the reported catches. Catches declined during 1979-2011 from about 1,300 in the early 1980s to levels below 300 whales per year after 2004. Reported catches in East Greenland are considered erroneous and should perhaps be added to the narwhal catches.

Regarding the quantification of "struck and lost", the JWG noted that there are no research plans for this subject, but that it should probably fall under the jurisdiction of the Administration authorities, to attempt at quantifying the phenomenon. It also noted that a narwhal "struck and lost" study has been ongoing in Canada since 2007, however there has not been any programme specifically aimed at belugas.

Recommendations

The JWG requests that recent Canadian beluga catches be compiled with historic catch estimates for the different stocks to provide an updated catch history.

The JWG recommends the separation of the North Water catches from those off West Greenland and that the results be used in the assessments. Likewise the JWG recommended providing two separate advices for removals for the two areas.

The JWG recommends gathering information on "struck and lost" for all areas in Canada and Greenland and to evaluate the compliance to the self-reporting system.

The JWG recommends that a deadline of at least 1 month prior to the JWG meeting be established for removals and "struck and lost" data to ensure proper review and assessment analyses. Data on catches and "struck and lost" from the Greenland Home Rule were presented very late for the purpose of this meeting. Because of time constraints there was no time to validate and verify these data. Also, Canadian catch data had not been made available to the Group prior to the meeting, but arrived during the meeting. As data on catches are necessary to the assessment they have to be made available for calculations at least one month ahead of the meeting.

5.4 Abundance

5.4.1 Recent and future estimates

Aerial surveys of belugas were conducted in the North Water in May 2009 and 2010 with the purpose of developing fully corrected abundance estimates (NAMMCO/SC/19-JCNB/SWG/2012-JWG/16). The region of interest covered an area of 54,840 km^2 in 2009 and 51,223 km^2 in 2010. The abundance estimators took into account both the perception bias of the observers and the availability of animals to be observed. The resulting abundance estimates were 2,008 beluga (cv=34%) in 2009 and 2,482 belugas (cv=28%) in 2010. The combined estimate of the two surveys (Table 3) was 2,245 (cv=11%, 95% CI 1,811-2,783). The impact of the analysis decisions and bias factors on these abundance estimates was investigated. A relatively low factor for correction for availability of 0.43 (cv=9%) developed from satellite tracking of belugas tagged in northern Canada, was used. This low correction factor may introduce a negative bias on the abundance estimate and it is suggested that specific correction factors for the Greenland beluga surveys are developed. The surveys might also be negatively biased because the surveys probably did not capture the entire population of belugas that winter in the North Water, since some of the whales would, by the time of the survey, have moved out of the North Water towards Lancaster Sound.

BELUGA	2009	2010	Combined 2009+2010
Abundance	2,008 (34%)	2,482 (28%)	2,245 (11%)
CI	1,050-3,850	1,439-4,282	1,811-2,783

Table 3. Abundance estimates (cv's shown in parenthesis) and corresponding 95% confidence intervals (CI) corrected for perception bias and availability bias.

Discussion

Some concerns were expressed regarding the efficiency of multi-species surveys at providing accurate estimates of abundance for each species. However, the double platform design should account for this bias.

Measures of time-in-view for beluga are available both for Greenland and Cook Inlet beluga. However there are no data on time-at-surface or dive interval for many areas. The lack of these data resulted in an analysis approach that may introduce a small positive bias.

The JWG approved these abundance estimates for assessment purposes.

Future research
The JWG recommends investigating time-at-surface and dive intervals for the areas and the time of the year of future surveys and the range of this population during the survey period using satellite linked location and dive recorders.

5.5 Assessment update

5.5.1 West Greenland

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/13 used age-structured population dynamic modelling to assess the current status of beluga wintering in West Greenland. The analysis combined the historical catches from 1862, with the winter counts from 1981 to 2006, and five data sets over the age structure of the individuals in the catches from 1984 to 1997. The catch was found to be age-selective, perhaps because hunters prefer larger whales when a choice is available. From 1984 to 1993 there was a clear selection against individuals younger than approximately 10 to 20 years of age. Then, starting in 1994 and continuing through 1997, there was an apparent shift towards even older animals (a shift that may have other causes than hunter selection). A short-term model of exponential growth, that included the age-structured data, estimated a 2012 growth rate of 5% (95% CI:4.1–6.9) or 3.5% (95% CI:2.6–6.1), depending upon whether the average adult survival of the prior was assumed as 0.98 or 0.97. A density-regulated model with no age-structured data, estimated an abundance that declined from a population dynamic equilibrium with 26,000 (95% CI:17,000–48,000) individuals in 1862 to a maximal depletion of 9,300 (95% CI:5, 800–18,000) in 2004. It is expected that the population will increase to a projected abundance of 13,000 (95% CI:6,100–23,000) individuals in 2017 (assuming yearly post-2011 catches of 204). This model estimated a 2012 depletion ratio of 0.44 (95% CI: 0.16–0.88) and a yearly replacement of 510 (95% CI:170–780) individuals.

Discussion
It was discussed that the models may be overly optimistic in the birth rate prior, and perhaps also on the survival prior. It was noted that while the age structures provided information on the survival rates, there were no data on birth rates or neonate survival rates for this population. Some members of the JWG stated that it was important that the priors of population models were constrained within the limits of the known biology observed in other beluga populations, while the author indicated that an artificial bias would be introduced into the analysis unless the prior distributions for birth rates and survival rates were symmetrical around their expected parameter values. The author conducted new analysis runs of the assessment model that addressed this problem which were presented in the extension to JWG/13. These showed, that the estimated current growth rate declined (from a point estimate of 4.2% to 3.2%) when an upper prior limit of 33% on the maximal birth rate was imposed. A uniform prior on the maximal growth rate from 1 to 7% (and no explicit prior on the birth rate) gave essentially the same estimate as the original model with a uniform prior from 0.21 to 0.45 on the maximal growth rate, and no explicit prior on the growth rate. While it was clear that constraining the priors for birth rate did affect the outcome of the analysis, the JWG did not come to a consensus on the preferred modelling approach but discussed analysis alternatives including the use of birth and

survival data from other beluga populations to inform prior distributions for this population.

Recommendations

No new data were available to provide updated advice and the JWG considered that the revised assessment models incorporating age structure data show that the current removals based on the 2009 advice are set at a sustainable level (Table 4). New updated advice is expected at the next meeting based on new abundance estimates resulting from a survey later in 2012 and an updated population structure (Figure 6 above).

Probability of increase	Total Catch
95%	180
90%	210
80%	265
70%	310
60%	355
50%	400

Table 4. Advice on current removals of beluga for West Greenland.

The JWG recommends further investigation of the impact of choice of prior distributions on the outcomes of assessment models for future advice so that the JWG can resolve the issue of choice of these critical distributions.

The JWG reiterates the previous advice from 2005 about seasonal closures. The following seasonal closures are recommended:

- Northern: June through August
- Central: June through October
- Southern: May through October.
- For the area south of 65°N, it is recommended that no harvesting of beluga be allowed at any time.

The function of these closures is to protect the few animals that may remain from earlier summer aggregations in Greenland, and to allow for the possibility of reestablishment of the aggregations.

No specific advice was given on the North Water, presupposing that the removals remain at a low level relative to the population size derived from the 2009-2010 surveys in the North Water and around Somerset Island in 1996.

5.5.2 Other stocks

No new information.

5.6 Other information (see items 7-10 below)

6 NARWHALS

6.1 Stock structure

6.1.1 Genetic information

Information on narwhal genetics including ancient mtDNA and recent findings on nuclear DNA was presented to the JWG.

The assumed population structure in narwhals off West Greenland is inferred from mitochondrial DNA and is based upon the works of Palsbøll *et al.* (1997) and NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/19. The East Greenland population is highly distinct. Within West Greenland fall samples collected in the Uummannaq district appear different from samples collected in the Melville Bay (during the summer) and the Disko Bay (winter/spring samples) areas. These two latter areas appear to be part of the same population, whereas samples from the North Water (Avannaarsua district) appear separate. Genetic divergences were also detected among years in areas with large samples sizes (such as Avannaarsua).

In contrast to other cetaceans, narwhals harbour remarkably low levels of genetic diversity based on mtDNA (Palsbøll *et al.* 1997), which may date back 50,000 years (Garde *et al.* in press). No evidence was found of a bottleneck in the recent history of the species, through BEAST analysis (Drummond and Rambaut 2007, BMC Evolutionary Biology): a spatial and temporal framework incorporating both contemporary and ancient DNA to reconstruct population history. Further analysis with more biologically realistic methods (Approximate Bayesian Computation - ABC analysis, Cornuet *et al*. 2008 Bioinformatics) is pending.

Postma presented on behalf of Petersen a work on the population structure of narwhal based on genetics (NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/04). To identify stock structure, narwhals from the Canada-Greenland range were genetically profiled using 12 microsatellite markers in the nuclear DNA. Bayesian analysis to determine the number of genetic clusters without sampling location data was unable to resolve population structure at any level. This was in spite of significant genetic differentiation among the Baffin Bay, Northern Hudson Bay, and East Greenland populations (F_{ST} values between 0.011 and 0.028). These results support the population divisions previously established by mitochondrial sequences, contaminant analysis, and satellite telemetry. Within Baffin Bay, partial support was found for the existing stock designations using multivariate analysis to differentiate groups. The analysis suggests that narwhals from Jones Sound and the Somerset Island summering stock are differentiated, although the Somerset Island finding may be influenced by low sample numbers. Increased sampling of most stocks is suggested in order to increase the understanding of how stocks are related and at what rate migration among stocks may occur.

Discussion (Comments on genetic studies by Palsbøll and Olsen)

Bottlenecks probably happened throughout the history and the population size has probably been low. The problem of the current analytical methods is that they cannot handle this kind of model. The number of breeding females influences the effects of the population size when looking at the low mtDNA diversity.

Novel mutations accumulate slowly and hence the low genetic diversity through 50,000 years may be due to a bottleneck preceding the oldest samples analysed by Garde *et al.*(in press). The possible alternate explanation, of repeated population bottlenecks during the last 50,000 years could result in the observed wide geographical of the same mtDNA haplotypes if there was/is gene flow among areas. It was also suggested that the wide geographical distribution of a few closely related mtDNA haplotypes could be due to selection for a specific maternal lineage. The genetic effect of such a selective sweep is in essence the same as a severe demographic bottleneck. In both cases the current (during the last 50,000 years) matrilines descend from a small ancestral female population (genetically and/or demographically).

The low genetic divergence among geographic areas does not necessarily imply high rates of gene flow/migration but could be due to historically high migration rates and/or common ancestry (*i.e.* current populations descend from the same ancestral population). If more contemporary estimates of gene flow/migration are required then another genetic approach will be needed, such as kinship-based analyses (Palsbøll 1999, Waples and Yokota 2007, Peery *et al.* 2008, Okland *et al.* 2010, Palsbøll *et al.* 2010).

<u>Use of genetic data</u>

Stock structure

In order to use genetic data for stock delineation a quantitative definition of a stock is required (Waples and Gaggiotti 2006, Palsbøll *et al.* 2007); in particular, at which migration rate(s) areas are to be viewed as a different/same stock. Once such parameters are defined, then population genetic simulations can be undertaken to assess the amount of samples and genetic data that need to be collected to infer stock structure at the desired levels of migration (Hoban *et al.* 2012).

The potential for matrilineal herd/pod structure should be assessed in order to avoid (or estimate the degree of) bias in the estimation of stock structure (Palsbøll *et al.* 2002).

Assignment of non-summer area catches to summer areas

One desirable use of genetic (and other biomarkers) data is to assign harvested individuals to summer areas (Paetkau *et al.* 1995; Pritchard *et al.* 2000). The current amount of data (12 microsatellite loci) is insufficient to conduct such individual assignments, even at the highest levels of population structure (eastern Canadian Arctic, Baffin Bay and East Greenland). With the new emerging genotyping technologies it is feasible to type thousands of single nucleotide polymorphisms (SNPs) in each individual sample, which may provide sufficient statistical power to assign harvested individuals to summer areas. Current estimates of genetic divergence may be utilized as a basis to simulate such large data sets with the observed degree of divergence and thereby assess if indeed such large SNP data sets are likely to yield the desired level of rigour in individual assignments of harvested individuals (Hoban *et al.* 2012).

Individual multi-locus genotypes may also be combined with other biomarker data, such as fatty acid data, isotope and pollutant data, to augment individual assignments. The time scale of the different classes of biomarkers need be assessed in order to ensure that all data used in such a combined assignment reflect summer area origin.

Recommendations (by Palsbøll and Olsen)

- Combining a suite of different markers (Stable Isotopes, Fatty Acids, contaminants, and genetics) to see if this leads to a stronger method for assigning summer aggregations to harvested wintering stocks to identify the most effective markers in relation to the desired signal.
- Use the existing genetics, microsatellite data in simulation runs to test if it is possible to discriminate between the summering stocks and if yes how many markers would be necessary. If successful then biopsy sampling to develop genetic profiles of the stocks.
- Evaluate pod structure to highlight kinship within the pod, the social structure of the pods, using relatedness analysis as these factors may bias population genetics inferences of stock structure if unaccounted for.

6.1.2 Satellite tracking

West Greenland-Canada

Watt presented NAMMCO/SC/19-JCNB/SWG/2012-JWG/21 on satellite tracking of narwhals from Admiralty Inlet (2009) and Eclipse Sound (2010-2011). Narwhals are annually hunted in Greenland and Canada and are an important component of Inuit diet. Narwhal populations are divided into stocks based on their summer distribution in order to set hunting quotas for sustainable management. Satellite tracking of narwhals has been particularly useful for defining narwhal stocks. From this data, researchers have defined at least nine independent narwhal summering aggregations and three shared overwintering grounds. Although this data has been invaluable, only a small number of narwhals from some aggregations and none from others have been satellite tracked. This study tagged and tracked 19 narwhals in 2009-2011 from the Admiralty Inlet and Eclipse Sound narwhal stocks, in order to gain a better understanding of narwhal movements. Tracks revealed a similar timing of migration (in late autumn/early winter) to the Davis Strait and a similar home range as previously defined. Summer range of narwhals from Eclipse Sound was larger and more variable than previously identified, with many narwhals travelling into Admiralty Inlet. One whale from Admiralty Inlet spent winter in northern Foxe Basin rather than the Davis Strait, as is typical for narwhals from this stock. Overall, narwhal may have a more diverse summer range than previously identified; however, the sample size is small and continued monitoring of narwhal movements is required before making any definitive conclusions on these narwhal stocks.

Discussion

The one tagged animal which swam westward and went on to enter Foxe Basin indicates a connection between the regions but not the stocks in Hudson Bay and

Lancaster Sound since tracking studies have shown the stocks are geographically separated during the autumn-winter period. Thus there is no evidence of linkages of removals of the animals from these stocks. None of the other whales showed any indication of going to other wintering grounds than the known areas in Davis Strait and the fall migration visits more of the fjords of Baffin Island. It was noted that the Eclipse Sound tagging programme is ongoing.

East Greenland

In NAMMCO/SC/19-JCNB/SWG/2012-JWG/18 fourteen narwhals were captured in set nets and tagged with mk10A backpack satellite transmitters at Hjørnedal in the Scoresby Sound fjord in East Greenland. Live captures and instrumentations followed methods used in similar studies in Canada and West Greenland. The tags were programmed to transmit every other day in order to extend battery life. Daily average positions were calculated from all good quality positions (NQ>0). If no good quality positions were available low quality positions were used. Distance travelled per hour was estimated based on the daily average positions and the 48hrs elapsed between positions. The narwhals used the entire fjord complex during the open water season and they visited most of the side-fjords during that period. Several of the whales circumnavigated Milne Island during the period they were inside Scoresby Sound. The whales apparently preferred the deeper parts of the fjord and when moving out of the fjord system they used the southern part where water depths range between 500 and 1,000 m. All the whales left the fjord in the first week of November (2010) or the last weeks of October (2011) and they went straight to the wintering ground south of 69°N off the Blosseville Coast. All narwhals wintered in the same general area on the Greenland shelf along the slope that over short distance increases from 500 to 1,500 m. Within Scoresby Sound the maximum depths of dives during 24 hr (for every other day) was usually less than 900 m and often less than 500 m. After the wintering area was reached and usually after December when sea ice forced the whales further offshore, the maximum depth of dives increased to 1,500 m. One whale provided at-surface time data useful for correcting visual aerial sighting surveys and it spent 34.96% (cv=0.06) at depths <2 m during August and during the time period from 12:00 to 24:00 GMT (corresponding to 10:00-22:00 local time).

<u>Discussion</u>

Animals in East Greenland seem to have a yearly migratory schedule and generally move slowly (1 km/hr). The whales in the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland. These apparent distinctions indicate that the different narwhal aggregations along the East coast of Greenland should be divided into separate management units (stocks).

Recommendation

The JWG recommends that the East Greenland narwhals for management purposes be separated into different stocks according to satellite tracking data and that the corresponding discrete abundance estimates in the areas where narwhals are hunted be obtained for stock assessment purposes.

6.1.3 Other information

Watt presented NAMMCO/SC/19-JCNB/SWG/2012-JWG/08. An understanding of narwhal populations for assigning narwhals to specific stocks is essential for providing management advice to ensure hunting quotas for northern communities meet subsistent goals. These stocks are principally defined based on satellite tracking results; however only a small proportion of possible subunits of this large population (approximately 80,000 individuals) have been studied using satellite tracking. Carbon and nitrogen have naturally occurring stable isotopes and the ratio of the heavy to light isotopic forms can provide detailed information regarding the integrated dietary and geographic information of a species. Nitrogen ratios are often used as indicators of the relative trophic position of an organism, while carbon ratios are used to evaluate the source of carbon (*i.e.* benthic versus pelagic or inshore versus offshore). These isotopes are commonly used in dietary reconstruction, but can also be used as spatial markers. If specific summering areas that distinct narwhal stocks use vary in their isotopic signature, or if different narwhal aggregations incorporate different prey species or proportions of these prey in their diet, isotope analysis may be another tool for delineating narwhal stocks. Skin tissues collected by Inuit hunters from narwhals defined as independent stocks in Canada and Greenland waters, were analysed for stable isotopes to determine if these chemical signatures can be used as another tool for assigning narwhals to specific stocks. Stable isotopes varied among most narwhal stocks assessed, suggesting the technique may be useful for stock delineation. Overall, stable isotope analysis is a cost effective technique and in combination with satellite tracking and genetic techniques, may enhance our understanding of narwhal stock structure.

Discussion

It was recognized that the method is promising and in the future might even allow discrimination of the origin of individuals taken around the same mixing ground; however, there could be bias in assigning animals to a group when samples were collected in different seasons (ice edge migration versus summer aggregations). The discriminating factors used in this study are standard factors and can be improved by performing a feeding experiment, which is not likely to happen. Discrimination among stocks is likely dependent on different prey choice and geographical origin of the narwhals. The time lag for the appearance of a signal could have a strong influence on the results of the analysis when samples are collected over different seasons. Studies on other animal models indicate a turnover rate the order of magnitude of a year, which could have strong implications for the interpretation of the analyses reported in this study.

It was mentioned that care should be taken when considering stable isotopes for stock delineation as the location of origin of the food ingested is what translates into the isotopic signature. If the origin of the food ingested is varied (migratory food species or feeding along a migration) the discrimination into stock units would be impaired. Similarly, given the same caveats, trace elements could help in discrimination.

Recommendations

It was suggested that the investigator consider restricting the time period for the choice of West Greenland samples and possibly to include in the study samples from Inglefield Bredning to improve the reliability of the approach. This approach could be a useful addition to a multi-dimension discrimination analysis for stock identity.

6.1.4 Management units

- NAMMCO: Identify calving areas and further document stock identification and stock structure of narwhal.

A model of the metapopulation structure of narwhals in Baffin Bay, Hudson Bay, and adjacent waters is proposed based on data collected from two decades of satellite telemetry studies of narwhals tracked from six coastal aggregations in the eastern Canadian high Arctic, Hudson Bay and West Greenland (NAMMCO/SC/19-JCNB/SWG/2012-JWG/17). In addition, information on seasonal catches of narwhals in 11 Inuit communities provides information on the occurrence of narwhals in these areas. The tracking data suggest that disjunct summer aggregations of narwhals to some extent are demographically-independent sub-populations with minimal or no exchange with other summering aggregations and that these, for management purposes, should be considered separate stocks. Tracking results of tagged whales that return to the summering grounds the following year suggest inter-annual site fidelity in narwhals. It is proposed that the narwhals in Canada constitute five separate stocks with some limited exchange between three of the stocks. Coastal summer aggregations in Greenland constitute two stocks in addition to two fall-winter aggregations supplied by narwhals from several summering areas. Several of the narwhal stocks will be mixing on the wintering areas in Baffin Bay-Davis Strait but the metapopulation structure is maintained through a combination of life history traits and migratory routes, where mating most likely occurs after the initiation of the return migration towards summering areas. A metapopulation structure in Baffin Bay narwhals will be impacted differentially by Inuit hunting, depending on the migratory schedule of narwhals and dates at which whales occur in different seasonal hunting areas. It is therefore important to identify which narwhal stocks contribute to which subsistence hunts in order to assess the sustainability of those hunts. This paper proposes a preliminary stock model for this purpose.

Discussion

The JWG agree to continue using the metapopulation model (now referred to as the stock aggregation model) as a useful approach for identifying stocks/management units and aggregations of narwhals in this area as well as indicating current knowledge of seasonal movements related to the areas where they are hunted (Figure 7). The JWG acknowledged that the model should be refined by additional research and that it was not possible to quantify the exchange rates at this meeting.

Recommendations

There is still uncertainty on the location of the summering grounds for the animals belonging to the stock harvested in the Uummannaq area. The JWG recommends a continuation of the tagging studies to elucidate this question. Similarly it is unclear where the animals summering in East Baffin, Jones and Smith Sound spend the winter and are possibly hunted. The JWG encourages effort to increase information on this question but recognizes that this is logistically challenging.

Future research efforts

- Tagging in Uummannaq, Jones Sound, Admiralty Inlet, Eclipse Sound, Somerset Island and East Baffin.
- Develop alternative tagging options for Canada: less costly and less intrusive.
- Investigate the possibility of using alternative markers such as ectoparasites and fouling phytoplankton on narwhal tusks.
- Investigate the use of photo-id, (*e.g.* from an aerial or vessel platform).

The JWG recommends that an acceptable glossary of definitions be developed to assist in maintaining acceptable discussions. For example, there is a need to define differences between management stocks and summer/winter aggregations.

Meeting on procedures for the allocation of the harvest to the summering stock

Before the next JWG meeting and tentatively in early March 2013, it is recommended to convene a group of up to 6 participants (Heide-Jørgensen, Ferguson, Hobbs, Witting, Richard, successor to Richard, Hansen, Lee, Laidre, and possibly others). The suggested location is Copenhagen.

The Terms of Reference of this group are:

- Review information on distribution, movements and harvest locations;
- Develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data;
- Specify and quantify exchange rates between aggregations and stocks.
- Identify and quantify uncertainty in the allocation model and determine implications for management.
- Recommend future work to resolve uncertainties within the model structure.

This group would report back to the JWG at its next meeting.

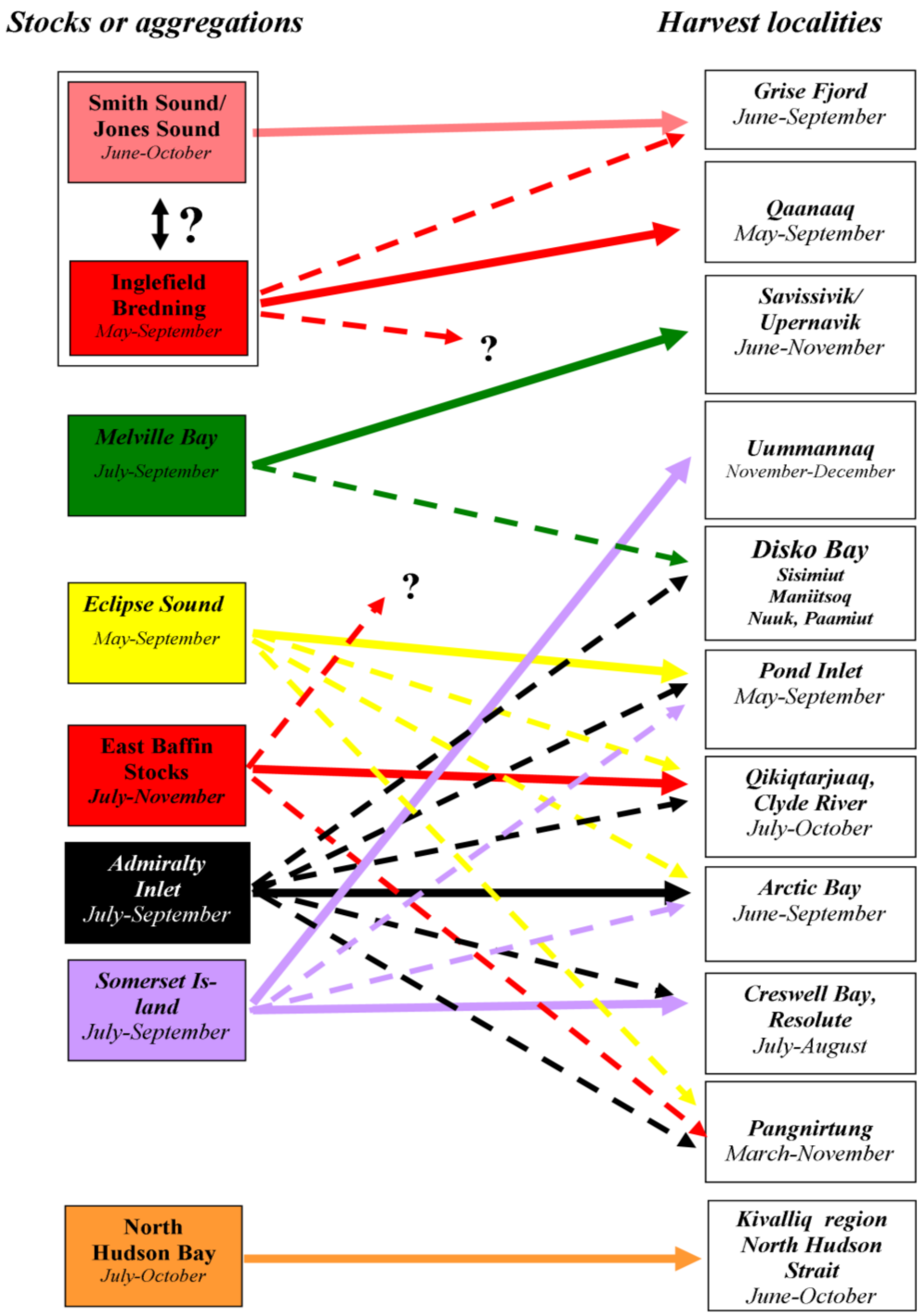

Figure 7. Diagram relating summer stocks and aggregations to hunt locations. Solid lines have been verified by tagging studies, dashed lines are based on geography and inference from traditional ecological knowledge and other sources.

6.2 Biological parameters

6.2.1 Age estimation

A new species-specific racemization rate for narwhals has been estimated by regressing aspartic acid D/L ratios in eye lens nuclei against growth layer groups (GLG) in tusks (n = 9). The racemization rate was estimated based on a bootstrap study, taking into account the uncertainty in the age estimation (r^2 was in all cases between 0.88 and 0.98). The $2k_{Asp}$ value from the bootstrap study was found to be 0.00229 +/- 0.000089 SE, which corresponds to a racemization rate of 0.00114^{-yr} +/- 0.000044 SE. The intercept of 0.0580 +/- 0.00185 SE corresponds to twice the $(D/L)_0$ value, which is then 0.0290 +/- 0.00093 SE. The previous estimated racemization rate for narwhals, based on data from narwhals and fin whales, was 0.001045^{-yr} +/- 0.000069 SE (Garde *et al.* 2007).

		Female		Male	
		EGl	WGl	EGl	WGl
Growth	Asymp. body length	405	399	462	456
	Age at asymp. body length	22	25	42	28
	Asymp. tusk length	-	-	162	186
	Age at asymp. tusk length	-	-	50	53
Reproduction	Est. age at sexual maturity	8	8	17	17
	Length at sexual maturity	~ 340	~ 340	≥ 400	≥ 400
	Est. age at first parturition	9	9	-	-
	Oldest pregnant female	39.5	67.9	-	-
	Pregnancy rate	0.42	0.38	-	-
Longevity*	Age	83.7	101	79.7	94.9

Table 5. Life history parameters for narwhals (Garde *et al.* unpublished data). Ages were estimated using the aspartic acid racemization (AAR) technique. Age at sexual maturity and first parturition as well as the pregnancy rate were estimated based on analysis of length, weight and number of corpora scars of ovaries and length and weight of testes as well as from data on fetuses. *Longevity is interpreted as the oldest individuals in the sample. Abbreviations: East Greenland (EGl); West Greenland (WGl).

The above values were used in a large-scale study of age estimation of narwhals using the aspartic acid racemization technique. The obtained ages were used to construct age distribution and estimate life history parameters. Eyes and reproductive organs were collected from 280 narwhals in East and West Greenland in 1993, 2004, and 2007 – 2010. Measures of body length, fluke width, tusk length and lengths of fetuses were obtained. Asymptotic body length was estimated to be 405 cm for females and 462 cm for males from East Greenland, and 399 cm for females and 456 cm for males from West Greenland. Age at sexual maturity, based on data from the reproductive organs, was estimated to be 8 years for females and 17 years for males. Age at first parturition was estimated to 9 years of age. Previously, Garde *et al.* (2007) estimated age at sexual maturity for females and males to be 6-7 yrs and 9 yrs of age, respectively based on growth curves and Laws (1956) who found that cetaceans attain sexual maturity at about 85% of their physical maturity. Pregnancy rates estimated in this study for East and West Greenland were 0.42 and 0.38, respectively. Oldest pregnant female was 68 yrs of age. Maximum lifespan expectancy for narwhals was found to be ~100 years of age (Table 5 above).

Discussion

This study has provided a calibration of AAR to tooth GLG providing a consistent means to age narwhal landed in the hunt. It also demonstrated a strong similarity between the growth characteristics of the narwhal on the east and west coasts of Greenland, with the difference between the longevity explainable by greater hunting pressure on the west Greenland stocks.

Recommendations

The JWG encouraged the continuation of this work, to increase the sample size of paired tusk/eye specimens (from the same animal) to improve the calibration of AAR and test for stock differences. In particular it would be important to obtain samples with tusks of different sizes and especially large tusks, making sure that tusks are whole from tip to base, to investigate a method to estimate the missing GLGs from the taper of the broken tusk and also collect right-side embedded tusks where possible to develop a method for males with a broken tusk or that can be applied to female narwhal.

Bayesian assessment

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/09 analyses the possibility of estimating the exponential growth rate of a population from a Bayesian assessment that is based on a single abundance estimate and a single sample of the age structure. Applying a whale-like life-history, it is shown that the Bayesian assessment provides unbiased estimates of the exponential growth rate, when given a uniform survival prior that is symmetrical around the true survival rate. If the survival prior is biased low, the estimated growth rate will be negatively biased, and it will be positively biased if the survival prior is biased towards values that are larger than the true survival rate. It is also shown that unbiased estimates are obtained independently of a bias in a uniform growth rate prior, and independently of a bias in a uniform prior on first year survival. This illustrates that Bayesian assessments based on age-structured data can be applied for precautionary management advice when the average value of a uniform prior on adult survival is smaller than or equal to the true survival rate.

Comments

While presented under the narwhal section this result applies to any long lived multiparous population with similar data limitations. The author noted that results are sensitive to the prior distribution of survival rate, consequently an estimate of survival rates derived from other stocks or species is necessary to inform the prior. A review of published and unpublished survival rate estimates in seven species of baleen whales and killer whale found an average point estimate 0.981 (1x0.96; 1x0.97; 2x0.98; 4x0.99).

Recommendation
Investigate the impact of various priors on management advice and develop a conservative method for selecting the priors when little information is available.

6.2.2 Reproductive rates
See Table 5 above.

Recommendation
The JWG noting the similarity between the east and west Greenland population age parameters suggests combining reproductive information from Greenland and Canada to estimate species wide reproductive parameters of narwhals, especially from samples around the age of sexual maturity and then test for stock differences.

6.2.3 Population Dynamics
Harding showed how population life history matrixes (*i.e.* Leslie matrixes) can be used to estimate population age or class structure and how it could help establishing if an event is age-independent or not. For example, the Phocine Distemper Virus infecting the harbour seals in Northern Europe in 1988 and 2002 was age dependent, infecting juvenile individuals at a lower than expected ratio. She also presented a model that predicts the future of the ringed seal in the Baltic based on estimated climate changes with declines in reproductive habitat due to temperature increases.

By using an individually tested stochastic model with life history traits based on age structure and fertility estimates from Garde's work and historical catch data from East and West Greenland it is possible to estimate the minimum viable starting population in both areas in 1969 that would be required to endure the historical catch and still match current estimates of population size. Since ice entrapment mortality is not yet included in the model, these starting populations (~2,600 in EGL, ~17,500 in WGL) are probably rather significantly underestimated, but this could be remedied with refinement of the model in the near future.

Discussion
The input data to the model have been taken from Garde 2012 (submitted). Natural mortality such as ice entrapments has yet to be added as an external factor, for example as a random mortality or as a part of the natural mortality. Alternatively it could be included as an increase in variance of the natural mortality or a density dependent factor.

The JWG appreciated the model presented and its potential for the understanding the relation between the original population sizes and future projections. On the other hand it noted the sensitivity of such a model to the input data.

6.2.4 Diving behaviour
Some information is presented in Westdal (NAMMCO/SC/19-JCNB/SWG/2012-JWG/07) on Availability bias in population survey of Northern Hudson Bay narwhal.

Population estimates are important for development of management plans of harvested species and thereby ultimately important for species sustainability. Aerial surveys are one method used in preparing population estimates. For marine mammals, aerial population surveys require that animal biology is understood in order to account for availability bias. Availability bias in this case derives from animals that are invisible to the survey due to diving behavior. In order to understand diving behavior of the Northern Hudson Bay narwhal, nine whales were tagged with satellite tracking devices in the Repulse Bay area in August of 2006 (n=5) and 2007 (n=4). Seventeen interviews with hunters and elders in the community of Repulse Bay were also conducted in order to gather local knowledge of the Northern Hudson Bay narwhal as it relates to this topic. Of specific interest was time at depth of 0 to 2 meters of water, the depth at which Richard *et al*. (1994) discovered that whales could be distinguished at the species level during an aerial survey. The proportion of time spent in 0 to 2 meters of water was then used to correct the population estimate from aerial survey. This research found that narwhals spent approximately 32% of their time at the surface where they would be available to be seen by an aerial survey. When this correction factor was applied to the 2000 photographic aerial survey estimate of 1778 (95% CI 1688-2015), an estimate of 5627 narwhals with 95% confidence limits of 3543 to 8935 narwhals and 90% confidence limits of 3817 to 8295 is attained. Data gathered from local hunters and elders suggests that timing of aerial surveys with regards to the narwhal hunt and presence of killer whales in the area can affect surface times as well as push narwhal distribution outside of the survey area.

Recommendations
The JWG noted that dive behaviour has both species characteristics and characteristics dependent on location, season, behaviour and available prey and encouraged continued collection of these data with emphasis on dive interval and time-at-surface data in areas to be surveyed at the time of the survey.

6.2.5 Other information
No new information at this meeting.

6.3 Catch statistics
6.3.1 Canadian and Greenland catch statistics
Canadian catch statistics were presented in document NAMMCO/SC/19-JCNB/SWG/2012-JWG/23 (Appendix 3). Catch statistics for Canada represent landed animals and do not include "struck and lost".

Information and statistics including some trade statistics on catches of narwhals in Greenland since 1862 are reviewed in document NAMMCO/SC/19-JCNB/SWG/2012-JWG/15. Detailed statistics split by hunting grounds are missing for most of the years. For the northernmost area, the municipality of Qaanaaq, only sporadic reporting exists. Based on statistics from the most recent three decades a time series is constructed for West Greenland with catches split into hunting grounds and corrected for under-reporting detected from purchases of mattak (low option), for periods without catch records (medium option) and from rates of killed-but-lost whales (high option). This reveals a time series 25 of somewhat realistic catch levels from 1862 through 2011. There has been an overall increase in catches in West

Greenland during the 20th century which is especially pronounced after 1950. During the period with the new hunting reporting system (Piniarneq) a significant decline in overall catches has been observed (p=0.0001). The decline was most pronounced in Uummannaq (p=0.0001) and Disko Bay (p=0.001) and could not be detected in the other areas (Qaanaaq p=0.172, Upernavik p=0.29). Catches in East Greenland seem to have peaked during 1999-2006 but have declined after 2006.

Recommendations
The JWG requests that Greenland data include the sex of the landed animals when available.

6.3.1 Struck and lost

- NAMMCO: Determine "struck and lost" rates with various hunting methods and circumstances.

No new data were presented on the "struck and lost" rates in Canada or Greenland.

Recommendations
The JWG recommends gathering information on "struck and lost" for all areas in Canada and Greenland and to evaluate the compliance to the self-reporting system.

6.3.2 Ice entrapments

In November 2008, an ice entrapment event occurred off the coast of Bylot Island, Nunavut near the community of Pond Inlet (NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/05). Hundreds of narwhals attempted to travel outside of the inlets and fjords in the area before becoming entrapped by thickening ice. As a result, a humane Inuit harvest of animals occurred before the whales drowned. In total, 250 skin and blubber samples were collected from over 600 harvested whales. The entrapment event provided a unique sample because the individuals were likely closely related and many were females trapped with their young, whereas typically samples obtained from Inuit subsistence hunts are biased towards males. A dietary study was initiated to determine if diet differed among age classes and between sexes, and to determine if diet could be utilized to elucidate social structure in narwhals. Skin samples were analysed for stable isotopes of carbon and nitrogen, which provides information on foraging location and trophic level, and dietary fatty acids in blubber were used to identify primary prey items. Non-parametric statistics identified differences in isotopic signatures among age classes of narwhals, but no difference between sexes. Principal component analysis of fatty acids resulting from dietary intake qualitatively assessed the feeding ecology of these narwhals and determined that there were no dietary differences between sexes or among age classes; however, distinct feeding groups were evident and genetic work is underway to determine the relatedness among these groupings. Emaciation appeared to have no significant impact on the fatty acid or isotopic signatures of samples from the entrapment event compared to published results, although more work is required to validate these conclusions.

Discussion
It was surprising to notice how the animals in this entrapment presented some symptoms of emaciation according to a necropsy conducted by a veterinarian. While

the entrapment continued over several weeks prior to the harvest, the JWG could not agree that the entrapment period was long enough for the animals to starve had they been in optimal body conditions.

Freeze up conditions

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/10 shows that the date of the 50% freeze-up occurred later and later in recent years. The authors postulate that if narwhals stay longer in the summering grounds they might be more likely to get caught up when the freeze-up.

Discussion

While the later arrival of the freeze up is well documented the relation to and mechanism of entrapment remains unclear. However speculation by the JWG suggested that a number of factors may be acting, including the novel freeze-up time in the experience of the whales, a change in the sequence of freeze-up so that the narwhals are blocked in by an area that according to prior experience would have remained open, or the general suddenness of a later freeze-up.

Recommendations

Monitor ice entrapments and freeze-up of migration paths to understand the environmental mechanisms leading to entrapments and how they relate to the speed and sequence of freeze-ups.

6.4 Abundance

6.4.1 Recent estimates

An aerial survey of narwhals was conducted in the North Water in May 2009 and 2010 with the purpose of developing a fully corrected abundance estimate (NAMMCO/SC/19-JCNB/SWG/2012-JWG/16). The region of interest covered an area of 54,840 km^2 in 2009 and 51,223 km^2 in 2010. The abundance estimators took into account both the perception bias of the observers (mark-recapture techniques) and the availability of animals to be observed (obtained from satellite-linked time-depth recorders). This is the first fully corrected abundance estimate from the North Water (Table 6) and it demonstrates the importance of this high latitude open water area to narwhals.

NARWHAL	2009	2010	Combined 2009+2010
Abundance	10,677 (0.29)	4,775 (0.36)	7,726 (0.38)
CI	6,120-18,620	2,417-9,430	2,032-8,572

Table 6. Abundance estimates (CVs shown in parenthesis) and corresponding 95% confidence intervals (CI) corrected for perception bias and availability bias

Discussion

There was a discussion on the advantages and disadvantages of combining the estimates for the two years. The opinions diverged and it was recommended to keep all three estimates: each year separately and the two years combined. Also, there was concern that the complete range of this stock was not surveyed so that an unknown portion of the population was missed.

As with beluga, some concerns were expressed regarding the efficiency of multi-species surveys at providing accurate estimates of abundance for each species. However, the double platform design should account for this bias.

Measures of time-in-view, time-at-surface or dive interval are not available for this area. The lack of these data resulted in an analysis approach that may introduce a small positive bias.

The JWG approved these abundance estimates for assessment purposes.

Future research
The JWG recommends investigating time-at-surface and dive intervals for the areas and the time of the year of future surveys and the range of this population during the survey period using satellite linked location and dive recorders.

Comments
The JWG noted that document NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/01 presenting the results from the latest aerial surveys in Admiralty Inlet was submitted as a "for information" document. This document presented a new abundance estimate, and is the report of the survey that provided the results above. This placed the JWG in a difficult position of accepting abundance estimates and providing advice, without actually having had the opportunity to review the survey from which they were derived.

Recommendations
The JWG recognized the challenge and the importance of obtaining reliable information to translate into availability bias corrections. Unfortunately drift in instrument readings could add up with circadian differences in the diving habits and blur the correction factors. Because availability is the largest contributor/scaling factor for the abundance estimates the JWG recommended that this problem be tackled as a priority. In association with the populations being surveyed it is suggested to use time-depth recorders (TDR) to provide better dive profile data and obtain data on both time at depth and time at surface.

The JWG acknowledges the need for national governments to complete internal reviews of research necessary to management advice, however consistent and independent review and advice from the JWG requires that the JWG be provided the opportunity to review the key research results as well. Abundance estimates and their surveys and analysis should be provided as working papers, not as papers for information.

The JWG recommended ensuring that at least one of the authors of key documents such as these is present at the meetings.

Two aerial surveys were completed in August 2010 to assess the summering stock of narwhals in Admiralty Inlet. The surveys used an adaptive sampling plan which combined visual line-transect sampling of the entire inlet and aerial photography of aggregations of more than 50 animals. The two surveys yielded estimates of 24,398 (CV=0.25) and 13,729 (CV=0.40) narwhals. The differences between the two survey estimates are likely due to sampling variation related to survey coverage, sea state and animal movement. Combining the estimates from the two surveys using an effort weighted mean yielded a final Admiralty Inlet narwhal estimate of 18,049 (CV=0.23, 95% C.I.=11,613-28,053). This estimate was used to calculate a new recommended Total Allowable Landed Catch (TALC) for the Admiralty Inlet narwhal stock of 233 animals.

Discussion

This document included a new population estimate, significantly higher than the previous one, and a corresponding increase of the catch advice (the original TALC from 2008 based on the 2005 survey estimate was 28).

6.4.2 Estimates by management units

The surveys at the North Water (NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/07 and NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/11) provided abundance estimates of the Inglefield Bredning management unit (see above) and these were approved for assessment purposes.

Methods for estimating other management units will be addressed by the allocation working group.

6.4.3 Future survey plans

An aerial survey off West Greenland (Figure 8 below) will take place from 26 March to 15 April 2012 and will cover 242,000 km^2 with almost 12,000 kilometres planned effort. Aerial surveys have been conducted in the Disko Bay area since 1981 but this survey will be the first attempt to survey the Melville Bay in winter and spring as well as the offshore areas in Baffin Bay. The survey design will be a systematic sampling with east-west going transects crossing density gradients from glaciers to the fast ice across the open water area.

The platform will be a twin otter aeroplane with bubble windows with a double platform design with no visual or audio contact between observers. Continuous photographs of the trackline will serve as quantification of sea ice and as control for observations on or close to the trackline.

An aerial survey in Melville Bay (Figure 9 below) will take place on 30 July-6 August, 27 August-4 September, 20-28 September before, during and after seismic activities in the Kanumas West area (blue area in Figure 8) using the same setup as described above. The survey design will be a systematic sampling with transects crossing density gradients from glaciers to the fast ice across the open water area.

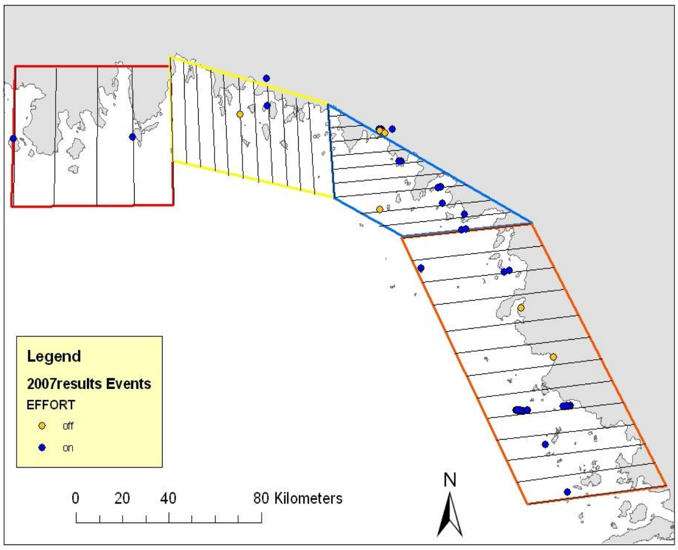

Figure 8. Planned aerial survey off West Greenland 26 March-15 April 2012.

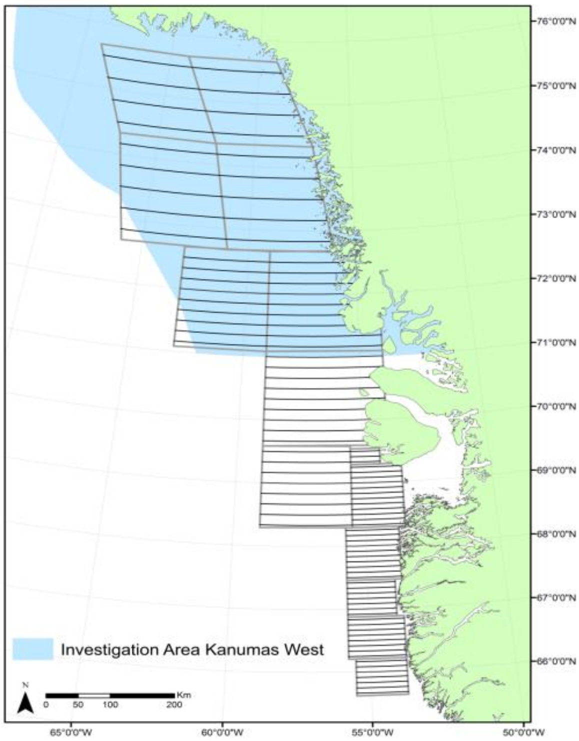

Figure 9. Planned aerial survey in Melville Bay 30 July-6 August 2012.

Ferguson reported on the requests of surveys to be carried out within the next 5 years: Cumberland Sound for beluga (most probably in 2012), and Jones Sound, Somerset Island, East Baffin Island for narwhal.

6.4.5 Recent changes in distribution in Canada

The Canadian delegation reported evidence of range extension towards the west and were hunted in 2011 in areas where hunting of narwhals is unusual (Cambridge Bay).

6.5 Assessment

6.5.1 Update of West Greenland assessment

Assessment West Greenland

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/10 used recent abundance estimates, historical catches starting from 1862, age-structure data from 2004 to 2010, and an age- and sex-structured population model with exponential or density regulated growth to perform Bayesian assessments of narwhals in West Greenland. The assessment included all areas in West Greenland except Uummannaq, and it was estimated that the catch selected against the take of animals younger than approximately 20 to 30 years of age (hunters likely prefer larger animals when possible). All applied models estimated a rather stable population which may have shown a small historical decline that, with the recent decline in the catch, proceeds into a stable or slightly increasing trend. The estimate of the current growth rate was rather stable, ranging from 1.4% (95% CI: 0.0–3.0) to 1.9% (95% CI: 0.3–3.2) across the seven different models. These were based on an average adult survival of 0.98 or 0.97, and included models that applied and did not apply the age structured data, as well as the winter surveys from the Disko Bay area.

Discussion

It was discussed that environmental variability was not included in the model, and that it did not assume a negative, or positive, effect of climate change on narwhal populations. The inclusion of such parameters could provide a worst case scenario and more conservative advice. However, it is unclear how a realistic level of environmental variability in life history parameters can be estimated from the available data, and the effect of climate change on narwhal populations are also largely unknown. The current approach, with feed-back from continuous population monitoring in assessments that look only 5 years ahead, is a pragmatic approach that, at least to some degree, incorporate major stochastic events and climate induced trends implicitly by re-estimating the dynamics on a regular basis. It was also discussed that some of the prior distributions might be overly optimistic, but no better alternatives were provided.

Assessment Uummannaq

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/11 used an age-structure from the 1993 catch of narwhals in Uummannaq to estimate the exponential growth rate of the stock that supplies this hunt. Contrary to the catch in other areas, there was no evidence that this catch selected against the take of smaller/younger individuals. The exponential growth rate in the absence of harvest was estimated to 1.3% (95% CI: −0.4–3.1%), if we assume an average adult survival of 0.98 in the prior, and the estimate declined to 0.4% (95% CI: −2.2–3.0%) with an assumed survival of 0.97. These estimates are comparable to the growth rate estimate for the other areas in West Greenland, suggesting that the growth of these stocks may be correlated, at least to some extent. The estimate was independent of assumptions on the abundance of the stock.

General discussion

The assessment models of NAMMCO/SC/19-JCNB/SWG/2012-JWG/10 and /2012-JWG/11 were restructured to a summer aggregation model for West Greenland. This implied separate models of the two summer aggregations (Inglefield Bredning and Melville Bay), as well as models of the fall hunt in Uummannaq and the winter hunt in Disko Bay.

The model for Inglefield Bredning was an isolated summer aggregation model assuming that these animals are not hunted elsewhere. It applied the summer estimates from the area, the spring count from 2009, and the 2007 age structure for West Greenland as a whole. It estimated a rather stable Inglefield Bredning aggregation since the 1960s, with an average abundance around 10,000 individuals, and a current exponential growth rate of about 1.2% in the absence of removals.

The JWG decided to model Melville Bay as a distinct summer aggregation that is distributed south along the west coast of Greenland during other seasons. The model assumed that of all the catches from Melville Bay, 14% of the catches were from fall and winter in Disko Bay (DB), and 12% of the catches were from winter in Uummannaq (Uu) and together are considered to be taken from the Melville Bay aggregation. These proportions were calculated on the assumption that Admiralty Inlet, Eclipse Sound and Melville Bay supply the hunt in Disko Bay in proportion to the stock sizes. Similarly Uummannaq is presumed to be supplied by whales from Somerset Island and Melville bay. Besides the catch history, the model was based on the 2007 abundance estimate (6,200; cv:0.85), and the 2007 age structure for West Greenland. Based on the information in the age structure, the narwhal abundance in Melville Bay was estimated to have increased slightly since the 1960s, with an exponential growth rate of one to two percent per year in the absence of removals.

The model for Uummannaq relates to the hunt on stock components that arrive in the area during fall and likely over winter in the Baffin Bay outside Uummannaq. This component was counted to 6,070 (cv: 0.37) individuals in 2006, and besides from this estimate the model includes also the age structure from animals caught in the area in 1993, and the Uummannaq catch history (of which 14% are allocated to the Melville Bay stock, with the rest assumed to be taken from Canadian stocks, primarily Somerset Island). This model estimates a rather stable population until the 1990s, where there were some decline due to very high catches, and a stabilisation into a stable or increasing population thereafter. The growth rate with no catches was estimated to approximately 2% per year.

The model for the Disko Bay area relates to the hunt on the stock components that over winter in the area. The model is based on the series of winter surveys in the area, the Disko Bay catch history, and the 2007 age structure for West Greenland as a whole. It is assumed that 14% of the Disko Bay catches are taken from the Melville Bay stock, and that the rest are taken from Canadian stocks, primarily from Eclipse Sound and Admiralty Inlet. Unlike the other areas, no absolute abundance estimates were available for this area, and it was not possible to construct a successful model.

By allocating catches from the fall and wintering grounds of Uummannaq and Disko Bay to the Melville Bay stock, it should be possible to use this model framework for advice on sustainable catches of narwhals in all areas in West Greenland and Canada.

Recommendations

The JWG agreed that age-structured models are the preferred assessment models for Greenland narwhal and beluga because they provide information on the survival and growth rate of the population and in some cases maybe even on abundance. However, the models presented require further refinement especially in relation to stock structure and the allocation of catches not taken during summer. Some further testing of assumptions regarding the prior distributions of growth rate, birth rate and survival rate, and consideration on the inclusion of stochastic elements, are also required.

West Greenland and Canada

The JWG agreed to reiterate its previous advice (Table 7 - ref. report from 2009 meeting). While the new assessment models look promising, and have the potential to better match the population structure as we understand it, the underlying data were considered inadequately explored at this meeting. In particular, the model for the allocation of summer, fall, winter, and spring hunts in Canada and Greenland to summering aggregations requires further development. The models explored at the current meeting, incorporating recent abundance estimates, updated age distribution data and new movement information from satellite tracking, confirmed that the current quotas in Greenland, for each stock area, are still sustainable.

Area	Current situation
Inglefield	85
Melville	81
Uummannaq	85
Disko	59
Total	**310**

Table 7. Current quotas for the take of narwhal in West Greenland

The JWG considered allocating the hunt in Canada and Greenland following the concept of a summer aggregation *(metapopulation)* model and inclusion of age structures. However, the JWG concluded that further work is required before these elements can be incorporated in the modelling approach for generating advice on sustainable removals in Canada and Greenland.

For the purpose of assessment the distribution of narwhals in West Greenland includes:

- two summer stocks (aggregations in footnote for Canada) in Inglefield Bredning and Melville Bay,
- fall and winter aggregations off Uummannaq,
- winter aggregations in and off the Disko Bay area.

Satellite tracking shows that these two fall and winter aggregations contain animals of Canadian origin, especially from Somerset Island, Admiralty Inlet and Eclipse Sound, as well as from Melville Bay.

Inglefield Bredning

A new assessment should include new information on abundance from a survey of Smith Sound and the possibility that the stock may be shared with Jones Sound. An exploratory Bayesian Analysis Model (BAM) including this new information resulted in a range of sustainable removals.

Melville Bay

The JWG acknowledged that, based on tagging data, the summering stock is also harvested in Disko Bay and Uummannaq during the winter. The wintering ground is also shared with stocks from Somerset Island, Admiralty Inlet and Eclipse Sound. Consequently the harvest from Disko Bay and Uummannaq was allocated on a preliminary basis from the proportional fraction of population sizes of the stocks and the tracking results between the stocks that share these wintering grounds. Tagging data from Admiralty Inlet and Eclipse Sound suggest that they contribute to the harvest in Disko Bay. Similarly, tagging data also suggest that animals from Somerset Island contribute to the harvest in Uummannaq. The fractions of Disko Bay and Uummannaq harvests assigned to the Melville Bay summer aggregation will be based on analyses of satellite tracking data.

The BAM would account for the fractions from these two other areas, Melville Bay and Uummannaq in the harvest data used in the model.

Uummannaq

The JWG acknowledged that the removals in Uummannaq are supplied by the fall and winter mixture of stocks wintering in Baffin Bay of which only a fraction periodically occurs inside Uummannaq and in winter remains near shore. Consequently the surveys executed in 2006 provided the basis for the population size estimates for this area as was done previously. The BAM should account for the fractions of different stocks in the model.

Disko Bay

The JWG acknowledged that removals in Disko Bay are supplied by a mixture of stocks wintering in Baffin Bay/Davis Strait of which only a fraction remains near shore. Consequently the surveys executed in 2006 provide the basis for the population size estimates for this area as was done previously. The BAM should account for the fractions from different stocks in the model.

6.5.2 Canadian summer stocks

Recommend the joint allocation model account for Canadian summer stocks as well.

6.5.3 East Greenland

Document NAMMCO/SC/19-JCNB/SWG/2012-JWG/12 analysed the dynamics of narwhals at the two hunting areas in East Greenland separately, *i.e.* the Ittoqqortormiit and Tasilaq/Kangerlussuaq areas. The 2008 age structure from Ittoqqortormiit was applied to both areas, and the harvest was found to be age selective, selecting against the take of animals younger than approximately 20 years of age. Assuming an average natural adult survival of either 0.97 or 0.98 in the prior, it is estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasilaq/Kangerlussuaq area might be stable (increasing slightly with 0.98 survival, decreasing slightly with 0.97 survival). The current growth rate in the absence of harvest was estimated to lie between 1.2% (95% CI:0–3.5) and 3.7% (95% CI:1.6–5.9), depending upon model and area.

Based on the previous discussions (above) the JWG agreed that narwhals in Scoresby Sound (Ittoqqortormiit) and Kangerlussuaq-Sermilik (Tasiilaq) should be treated as two separate stocks. The age structure from animals collected between 2007 and 2010 in Ittoqqortormiit was applied to both areas, and the harvest was found to select older animals (Table 8). The BAM accounts for the fractions from these areas in the harvest data used in the model. A more conservative result was chosen for Tasiilaq because of the general lack of data for the area and the uncertainty on the growth of the population (Table 9).

P	Total Removals
95	17
90	35
85	45
80	50
75	60
70	70

Table 8. Narwhal East Greenland Ittoqqortormiit. The probability that total yearly removals from 2012 to 2016 will ensure an increasing stock. The estimates are average values between an exponential (with low survival) and a density regulated (with high survival) assessment model.

P	Total Removals
95	0
90	1
85	6
80	9
75	13
70	18

Table 9. Narwhal East Greenland TasiIlaq/Kangerlussuaq area. The probability that total yearly removals from 2012 to 2016 will ensure an increasing stock. The estimates are based on an exponential model with a low survival prior.

6.6 Future research requirements

Regular monitoring of population sizes (at least every 5-10 years) and further satellite tracking and dive behaviour work on the summering aggregations (20-50 animals per aggregation every 5 years) are key to developing the allocation model and providing accurate advice on allowable removals.

Development and testing of an allocation model for shared narwhal stocks and further development and testing of the assessment models using simulations where necessary to determine the impact of assumptions and identify potential biases.

7 IMPLEMENTATION OF EARLIER ADVICE

7.1 Beluga

At its last meeting this group presented a trade off table of risk factors and associated removals. The Scientific Committee of NAMMCO suggested choosing a factor of 70% or higher (corresponding to 310 removals for the total of West Greenland including the North Water). The NAMMCO Council adopted this advice and the quotas for 2011 were set to 290 removals for West Greenland, 20 for the North Water.

Canada

At its last meeting the Scientific Committee of JCNB suggested choosing a factor of 80% (corresponding to 265 removals for the total of West Greenland including the North Water). The NAMMCO Council adopted the 70% probability advice and the quotas for 2011 were set to 290 removals for West Greenland, 20 for the North Water.

7.2 Narwhal

East Greenland: Followed recommendations.

West Greenland: Followed recommendations.

Canada: Canada continues to assess Total Allowable Harvest Levels (TAHL) based on the Precautionary Approach that requires using Potential Biological Removals (PBR) since the five summer aggregations/stocks are considered Data Poor (*i.e.* limited time series of abundance surveys and limited age/sex structure and reproduction information).

8 TRADITIONAL KNOWLEDGE

8.1 Beluga

No new information.

8.2 Narwhal

Some information in the discussion above in NAMMCO/SC/19-JCNB/SWG /2012-JWG/07

9 IMPACT OF HUMAN-MADE-NOISE

9.1 Beluga

A recent paper demonstrated the reduction in stress hormones in the North Atlantic right whale during the hiatus in shipping through the Gulf of Maine during the week following September 11, 2001 (Rolland *et al.* 2012).

The US National Marine Mammal Laboratory plans to collect audiograms on belugas captured for tagging and health assessment in Bristol Bay. Audiograms will be collected with ambient background and with playback of typical anthropogenic noise to estimate the threshold shift resulting from noise exposure. Marcoux presented a study of passive acoustic monitoring of beluga presence and feeding in Cumberland Sound (NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/21). In this study it was noted that passive acoustic methods are being increasingly used to monitor cetaceans because they are relatively inexpensive, operate under poor weather conditions as well as year round. Cumberland Sound is a diverse Arctic ecosystem and is home to a threatened population of belugas. Emerging fisheries for turbot and char, two potential prey species for belugas, are expanding in the Sound. There is a need for research examining the usage of Cumberland Sound by belugas and their relationship with turbot and char. Using passive acoustic methods, the authors attempted to detect the presence of belugas as well as their feeding events. They used a combination of a digital recorder (AURAL) and a click detector (C-POD) over 31 days in Clearwater Fjord, within Cumberland Sound, August 2010 and 2011. Belugas emit echolocation trains of clicks to navigate and locate their prey. They produce buzzes, a rapid train of clicks with inter-click intervals smaller than 20 ms that are believed to correspond to closing on a prey. The authors quantified the temporal pattern of click trains and buzzes as detected by the C-POD throughout the study period. Almost all the click trains detected by the C-POD were associated with beluga calls on the AURAL audio files (98% of random sample of 50 click trains). From the click series, belugas preferably visited the fjord at noon and at high tide. Future steps for this project include the validation of the C-POD as beluga click detector, assessment of false alarm rates, determination of the detection range of the instrument, and deployment of a network of C-PODs year-round in Cumberland Sound to monitor beluga time-space habitat usage pattern.

Discussion:
The JWG welcomed this study and suggested:

- Using satellite tagging to retrieve detailed information on the migration routes of the animals;
- Developing quantitative methods to estimate feeding from acoustics behaviour;
- Including other species in this investigation;
- Documenting the noise level of the area.

9.2 Narwhal

No new information on noise impact on narwhal.

The JWG notes that measurement of noise effects of seismic, drilling, shipping and other human activities on arctic marine mammals and the implications for population dynamics are not well understood for cetaceans in general and suggests that NAMMCO include this as a topic in an international symposium (see below item 10.3) on human impacts for all species of interest to NAMMCO.

10 OTHER BUSINESS

10.1 Implications of the inclusion of other species (*e.g.*walrus) in the work of the JWG

The inclusion of other species to the work of the JWG was discussed but it was not deemed desirable. For bowhead whales Greenland receives harvest quota advice from the IWC. Providing advice on other species would require additional expertise and increase the size of the present group to the point of jeopardizing efficiency. An alternative would be to convene a separate JWG to review pinniped science that would meet prior to or following the beluga and narwhal meeting to take advantage of the shared expertise while keeping the individual meetings manageable.

10.2 NAMMCO question regarding Ageing workshop

10.2.1 Beluga

Discussed above under item 5.2.1.

10.2.2 Narwhal

Discussed above under item 5.2.1.

10.3 Human Impact on habitat (NAMMCO request)

- Impacts of fish removal and fishing activity on beluga and narwhal.
- Impacts of changing sea ice conditions on beluga and narwhal.
- Impacts of feeding by beluga and narwhal on commercial fishing.

Discussion

The JWG discussed this topic briefly but noted that little new information was presented. However, in discussions on management advice it was noted that there is little information on the predicted response of marine mammal populations to changing arctic conditions including changes in sea ice, climate and forage species as well as increased human development activity in the arctic including seismic, shipping, drilling, and shore based development. Impacts may include changes in timing and distribution of prey and increased competition with fisheries, timing and distribution of sea ice, ensonification of the habitat, changes and increase of intensity and number of storms, and increased risk of toxic spills, all of which increase the uncertainty in the distribution and abundance of marine mammals of the arctic.

Recommendation

The JWG recommended holding an international symposium on the effect of seismic, drilling, shipping, increased fishing and other development activities on arctic marine mammals with a focus on beluga and narwhal.

10.4 Review of Rules of Procedure (ROP)

Regrettably the JWG did not have the time to examine the working proposal for a set of Rules of Procedure compiled by the NAMMCO Secretariat (NAMMCO/SC/19-JCNB/SWG/2012-JWG/05). However it was noted that for the future:

- Primary papers should be presented as working papers as opposed to published papers, and submitted in due time.

- New information should be reviewed.
- Abundance estimates and assessments should be rejected or adopted.

A small correspondence group will continue working on the matter.

11 ADOPTION OF REPORT

Approved in a preliminary form at the end of the meeting and by correspondence on 11 April 2012.

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Appendix 1

AGENDA

1. OPENING REMARKS

2. ADOPTION OF JOINT AGENDA

3. APPOINTMENT OF RAPPORTEURS

4. REVIEW OF AVAILABLE DOCUMENTS

5. BELUGA
   - 5.1 Stock structure
   - 5.2 Biological parameters
     - 5.2.1 Age estimation
     - 5.2.2 Reproductive rates
     - 5.2.3 Other information
   - 5.3 Recent catch statistics
   - 5.4 Abundance
     - 5.4.1 Recent and future estimates
   - 5.5 Assessment update
     - 5.5.1 West Greenland
     - 5.5.2 Other stocks
   - 5.6 Other information

6. NARWHALS
   - 6.1 Stock structure
     - 6.1.1 Genetic information
     - 6.1.2 Satellite tracking
     - 6.1.3 Other information
     - 6.1.4 Management units
   - 6.2 Biological parameters
     - 6.2.1 Age estimation
     - 6.2.2 Reproductive rates
     - 6.2.3 Population Dynamics
     - 6.2.4 Diving behavior
     - 6.2.5 Other information.
   - 6.3 Catch statistics
     - 6.3.1 Canadian and Greenlandic catch statistics
     - 6.3.1 Struck and lost
     - 6.3.2 Ice entrapments
   - 6.4 Abundance
     - 6.4.1 Recent estimates
     - 6.4.2 Estimates by management units
     - 6.4.3 Future survey plans
     - 6.4.5 Recent changes in distribution in Canada
   - 6.5 Assessment

6.5.1 Update of West Greenland assessment
6.5.2 Canadian summer stocks
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6.6 Future research requirements

7. IMPLEMENTATION OF EARLIER ADVICE
7.1 Beluga
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8. TRADITIONAL KNOWLEDGE
8.1 Beluga
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9. IMPACT OF HUMAN-MADE-NOISE
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10. OTHER BUSINESS
10.1 Implications of the inclusion of other species (e.g.walrus) in the work of the JWG.
10.2 NAMMCO question regarding Ageing workshop
10.2.1 Beluga
10.2.2 Narwhal
10.3 Human Impact on habitat (NAMMCO request):
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11. ADOPTION OF REPORT

Appendix 2

LIST OF DOCUMENTS

Document no	Title
NAMMCO/SC/19-JCNB/SWG/2012-JWG/01	List of participants.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/02	Agenda.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/03	List of documents.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/04	Terms of Reference for this meeting
NAMMCO/SC/19-JCNB/SWG/2012-JWG/05	Draft Rules of Procedure for the Joint Working Group
NAMMCO/SC/19-JCNB/SWG/2012-JWG/06	Presentation Schedule
NAMMCO/SC/19-JCNB/SWG/2012-JWG/07	Westdal, K.H., Richard, P.R. and J.R. Orr. Availability bias in population survey of Northern Hudson Bay narwhal (*Monodon monoceros*)
NAMMCO/SC/19-JCNB/SWG/2012-JWG/08	Watt, C.A., Ferguson, S.H., Fisk, A. and M.P. Heide-Jørgensen. Using stable isotope analysis as a tool for narwhal (*Monodon monoceros*) stock delineation
NAMMCO/SC/19-JCNB/SWG/2012-JWG/09	Witting, L. Growth rate estimates from Bayesian assessments with age structured data.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/10	Witting, L. and Heide-Jørgensen, M. P. Assessment of West Greenland narwhals.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/11	Witting, L. and Heide-Jørgensen, M. P. Estimation of dynamics for narwhals in Uummannaq, West Greenland.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/12	Witting, L. and Heide-Jørgensen, M. P. Assessment of East Greenland narwhals.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/13	Witting, L. and Heide-Jørgensen, M. P. Assessment of West Greenland beluga.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/14	Heide-Jørgensen, M.P. and Hansen, R.G. Catch statistics for belugas in Greenland 1862 to 2011.

NAMMCO/SC/19-JCNB/SWG/2012-JWG/15	Heide-Jørgensen, M.P. and Hansen, R.G. Reconstructing catch statistics for narwhal in Greenland 1862 to 2011.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/16	Heide-Jørgensen, M.P., Hansen, R.G., Nielsen, R.H., Burt, M.L. Surveys of belugas and narwhals in the North Water 2009 and 2010.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/17	Heide-Jørgensen, M.P., Richard, R.R., Dietz, R., Laidre. K.L. A metapopulation model of narwhals.
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NAMMCO/SC/19-JCNB/SWG/2012-JWG/22	Hansén, J. and Harding, K.C. Some investigations on the minimum initial population size and possible growth rates of Narwhals in Greenland
NAMMCO/SC/19-JCNB/SWG/2012-JWG/23	Catch Statistics for narwhal and beluga in selected communities in Nunavut, Canada (2006-2010)

DOCUMENTS FOR INFORMATION

Document no	**Title**
NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/01	Asselin, N.C. and P.R. Richard. 2011. Results of narwhal (*Monodon monoceros*) aerial surveys in Admiralty Inlet, August 2010.
NAMMCO/SC/19-JCNB/SWG/2012-JWG/O/02	Richard, P.R. 2011. Allocation model for landed catches from Baffin Bay narwhal stocks.
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Appendix 3

Catch Statistics for narwhal and beluga in selected communities in Nunavut, Canada (2006-2010).

Introduction

Canadian narwhal and beluga fisheries are regulated by the Fisheries Act (R.S., 1985, c. F-14) and regulations made pursuant to it, including the *Fishery (General) Regulations* and the *Marine Mammal Regulations*. In the Nunavut Settlement Area, these fisheries are co-managed by Fisheries and Oceans Canada (DFO), the Nunavut Wildlife Management Board (NWMB), Regional Wildlife Organizations (RWOs), and Hunter and Trapper Organizations (HTOs), and Nunavut Tunngavik Inc. (NTI) in accordance with the Nunavut Land Claims Agreement (NLCA), and the Fisheries Act. Where an inconsistency exists between federal statutes and the NLCA, the Agreement shall prevail to the extent of the inconsistency. The NWMB is the main instrument of wildlife management in the Nunavut Settlement Area; however the DFO Minister retains ultimate responsibility for wildlife management.

This document presents updated landed catch information for subsistence narwhal and beluga fisheries in selected Nunavut communities for the period 2006–2010. Some communities have yet to report their narwhal and beluga catches for 2011. Preliminary information is included where available, but the values are subject to change.

For narwhal, regulatory quotas and harvest limits[10] are administered using numbered Marine Mammal Tags (MMT, or ‘tag’), which are issued only to Inuit. DFO Fishery Officers monitor narwhal hunting activities when possible, to ensure compliance with the Marine Mammal Regulations. In some Nunavut communities, established narwhal hunting by-laws govern local hunting practices.

The harvest year extends from 01 April to 31 March. At the beginning of the harvest year, DFO distributes a set of MMTs to each Hunters and Trappers Organization equal to the community’s quota or harvest limit. The HTO distributes these MMTs amongst its members, who report the outcome of their hunts to the HTO. Hunters are required to complete and attach a numbered MMT to each landed narwhal, *i.e.* to the tusk if present or to the carcass if not. Detachable tag returns are completed and returned to the HTO. At the close of the hunting season, each HTO returns its harvest summary to DFO, together with any unused MMTs and the completed tag returns from harvested narwhal. DFO compiles annual catch summaries using information from completed MMT returns and local summaries provided by individual HTOs.

Table 1 presents landed catches of narwhal in High Arctic communities from 2006-2010. Marine Mammal Tag returns for these years have recently been re-assessed; in some cases previously reported catches are slightly changed. The cumulative landed catch in these communities slightly exceeded 500 narwhals in 2006. In 2007-2009 landed catches stabilized at just under 400 narwhals (387-391), and then rose to 435

[10] Under Community Based Management, NWMB harvest limits replaced the original regulatory quotas in the participating communities.

narwhals in 2010. The average landed catch for this period was 422 narwhals, equivalent to the 2003-2007 average of 423 reported for these communities by Baker (2009). A breakdown of catches by seasons by years is provided in the original document (NAMMCO/SC/19-JCNB/SWG/2012-JWG/23).

Tables 2-4 summarize the seasonal distribution of narwhal harvests by community, using cut-off dates developed by Romberg and Richard (2005). Spring (floe edge/ice crack) hunts occurred on/before calendar day 205, summer (open water) hunts occurred between calendar days 205 and 274, and fall hunts occurred on/after calendar day 275. Igloolik and Hall Beach hunters have access to both the Somerset and Northern Hudson Bay stocks; the ratio of each stock present in the landed catch from these communities is not known.

Table 5 excludes narwhal catches that originated within the summer range of the Northern Hudson Bay population and provides information on seasonal proportions and the overall catch composition of community harvests for 2006-2010. Intervals are coded by calendar day (see Romberg and Richard 2005), where spring (ice-edge) hunts occurred before day 205, summer (open water) hunts occurred between days 205 and 274, and fall hunts occurred after day 274.

Table 6 provides data on landed catches of belugas in selected Nunavut communities from 2006 – 2010. Catch information for 2011 has not been received from some locations. Preliminary reports are included where available, but these values may be subject to change.

Literature Cited

Romberg, S. and Richard, P. 2005. Seasonal distribution and sex ratio of narwhal catches in the Baffin region of Nunavut Territory, Canada. JCNB/NAMMCO JWG meeting (Nuuk, Oct 2005) Working paper NAMMCO/SC/13-JCNB/SWG/2005-JWG/9: 16 p.

Table 1. Narwhal landed catches reported from selected communities in Nunavut, Canada from 2006 – 2010. For each year, the aggregate catch is compared to the quota available to these communities. Catch information from 2011 has not been received from some communities. Preliminary information is included where available, but the values are subject to change.

Community	2006		2007		2008		2009		2010		Cumulative (5-yrs)		*2011 Preliminary*	
	Quota / Harvest Limit	Landed Catch	Quota / Harvest Limit	Landed Catch	Quota / Harvest Limit	Landed Catch	Quota / Harvest Limit	Landed Catch	Quota / Harvest Limit	Landed Catch	Total Catch	Average Catch	Quota / Harvest Limit	*Landed Catch*
Arctic Bay [CBM]	130	130	130	124	130	132	130	129	130	128	643	129	130	*130*
Cambridge Bay	NRQ	-	NRQ	-	2 [1]	0	NRQ	-	NRQ	-	0	0	NRQ	*10*
Clyde River	50	43	50	42	50	17	50	13	50	50	165	33	50	*36*
Gjoa Haven	10 Ŧ	0	10 Ŧ	1	8 Ŧ	0	10 Ŧ	1	10 Ŧ	1	3	1	10 Ŧ	*pending*
Grise Fiord	20	21	20	20	20	23*	20	5	20	21 BA	90	18	20	*pending*
Hall Beach	10	1	10	0	10	0	10	0	10	2 [NHB]	1	0	10	*pending*
Igloolik	25	25	25	1	25	0	25	1	25	0	27	5	25	*pending*
Kugaaruk [CBM]	25 Ŧ	48 [2]	25 Ŧ	40	25 Ŧ	35	25 Ŧ	42	25 Ŧ	45	210	42	25 Ŧ	*50*
Pangnirtung	40	1	40	1	40	21	40	41	40	28	92	18	40	*pending*
Pond Inlet [CBM]	130	88	130	65	130	73 [3]	130	44	130	62	332	66	130	*112*
Qikiqtarjuaq [CBM]	90	85	90	88	90	80	90	90	90	89	432	86	90	*90*
Resolute Bay & Creswell Bay	32	28	32	9	32	10	32	16	32	9	72	14	32	*pending*

Taloyoak	10 Ŧ	34 *	10 Ŧ	0	10 Ŧ	3	10 Ŧ	5	10 Ŧ	2	44	9	10 Ŧ	*1*
Total	572	504	572	391	572	394	572	387	572	435	2111	422	572	*pending*
Harvest/Quota		0.88		0.68		0.69		0.68		0.76		0.74		

CBM Community Based Management harvest limit
NRQ No Regulatory Quota
BA Borrowed Against the following year's quota to reconcile overharvest, approved by NWMB & DFO
* Overharvest was reconciled with a transfer/borrowing of tags from another community
Ŧ In 2006, a combined harvest of 75 narwhals was approved for Gjoa Haven, Kugaaruk and Taloyoak. Of these, 45 are community specific and 30 are held in reserve by the Kitikmeot Regional Wildlife Board.
1 Cambridge Bay acquired 2 Marine Mammal Tags from Gjoa Haven, these were unused and returned
2 Allocation from Kitikmeot Regional Wildlife Board, plus 3 tags carried over from 2005.
3 An additional authorized harvest of 624 narwhals entrapped by ice is considered natural mortality and not included in the yearly total.
4 Catch is attributed to the Northern Hudson Bay population and not included in the yearly total.

Table 2. Catch composition of seasonal narwhal harvests in selected Nunavut communities in 2006-2007. For each community and year, darkened cells indicate seasons where no narwhals were landed.

Community	Quota / Limit	2006										2007									
		Number Landed	Spring			Summer			Fall			Number Landed	Spring			Summer			Fall		
			F	M	U	F	M	U	F	M	U		F	M	U	F	M	U	F	M	U
Arctic Bay CBM	130	130	30	96	0	3	1	0	0	0	0	124	15	53	0	3	53	0	0	0	0
			23.8%	76.2%	--	75.0%	25.0%	--	--	--	--		22.1%	77.9%	--	5.4%	94.6%	--	--	--	--
Clyde River	50	43	1	2	0	18	12	0	2	8	0	42	5	3	0	11	11	0	10	2	
			33.3%	66.7%	--	60.0%	40.0%	--	20.0%	80.0%	--		62.5%	37.5%	--	50.0%	50.0%	--	83.3%	16.7%	--
Gjoa Haven	10 Ŧ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
			--	--	--	--	--	--	--	--	--		--	--	--	100%	--	--	--	--	--
Grise Fiord	20	21	0	0	0	0	21	0	0	0	0	20	1	15	0	2	9	0	0	0	0
			--	--	--	--	100.0%	--	--	--	--		6.3%	93.8%	--	18.2%	81.8%	--	--	--	--
Hall Beach	10	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			--	--	--	100.0%	--	--	--	--	--		--	--	--	--	--	--	--	--	--

Igloolik	25	25	0	0	0	10	15	0	0	0	0	1	0	0	0	0	1	0	0	0	0
			--	--	--	40.0 %	60.0 %	--	--	--	--		--	--	--	0.0 %	100.0 %	--	--	--	--
Kugaaruk CBM	25 Ŧ	48 [2]	0	0	0	9	39	0	0	0	0	40	0	0	0	4	36	0	0	0	0
			--	--	--	18.8 %	81.3 %	--	--	--	--		--	--	--	10.0 %	90.0 %	--	--	--	--
Pangnirtung	40	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
			--	--	--	--	--	--	--	100.0%	--			100.0 %							
Pond Inlet CBM	130	88	10	12	0	19	43	0	1	1	0	65	3	3	0	25	32	0	0	2	0
			45.5 %	54.5 %	--	30.6 %	69.4 %	--	50.0 %	50.0 %	--		50.0 %	50.0 %	--	43.9 %	56.1 %	--	--	100.0%	--
Qikiqtarjuaq CBM	90	85	26	0	0	0	58	0	1	0	0	88	0	0	0	25	54		1	8	0
			100.0%	--	--	0.0%	100.0%	--	100.0%	--	--		--	--	--	31.6 %	68.4 %	--	11.1 %	88.9 %	--
Resolute Bay & Creswell Bay	32	28	1	0	0	3	24	0	0	0	0	9	0	0	0	3	6	0	0	0	0
			100.0%	--	--	11.1 %	88.9 %	--	--	--	--		--	--	--	33.3 %	66.7 %	--	--	--	--
Taloyoak	10 Ŧ	34 *	0	0	0	7	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			--	--	--	20.6 %	79.4 %	--	--	--	--		--	--	--	--	--	--	--	--	--

Table 3. Catch composition of seasonal narwhal harvests in selected Nunavut communities in 2008-2009. For each community and year, darkened cells indicate seasons where no narwhals were landed**.**

Community	Quota / Limit	2008											2009										
		Number Landed	Sprin			Summer			Fall				Number Landed	Spring			Summer			Fall		
			F	M	U	F	M	U	F	M	U			F	M	U	F	M	U	F	M	U
Arctic Bay CBM	130	132	29	19	0	9	75	0	0	0	0		129	8	9	0	7	10 5	0	0	0	0
			60.4 %	39.6 %	--	10. 7%	89.3 %	--	--	--	--			47.1 %	52. 9%	--	6.3 %	93. 8%	--	--	--	--
Clyde River	50	17	0	2	0	6	6	0	0	3	0		13	1	6	0	0	1	0	1	4	0
			0.0%	100.0 %	--	50. 0%	50.0 %	--	--	--	--			14.3 %	85. 7%	--	--	10 0.0 %	--	20. 0 %	80. 0%	--
Gjoa Haven	10 Ŧ	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	0	0	0	0	0
			--	--	--	--	--	--	--	--	--			--	--	--	10 0.0 %	0	0	--	--	--
Grise Fiord	20	23*	0	0	0	3	20	0	0				5	1	3	0	0	1	0	0	0	0
			--	--	--	13. 0%	87.0 %	--	--	--	--			25.0 %	75. 0%	--	--	10 0.0	--	--	--	--

																	%				
Hall Beach	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Igloolik	25	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
			--	--	--	--	--	--	--	--	--		--	100%	--	--	--	--	--	--	--
Kugaaruk CBM	25 Ŧ	35	0	0	0	5	30	0	0	0	0	42	0	0	0	16	26	0	0	0	0
			--	--	--	14.3%	85.7%	--	--				--	--	--	38.1%	61.9%	--	--	--	--
Pangnirtung	40	21	0	0	0	4	17	0	0	0	0	41	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
			--	--	--	19.0%	81.0%	--	--												
Pond Inlet CBM	130	73 [3]	10	4	1	23	34	0	1	0	0	44	11	10	0	12	8	0	1	2	0
			66.7%	26.7%	6.7%	40.4%	59.6%	--	100.0%	--	--		52.4%	47.6%	--	60.0%	40.0%	--	33.3%	66.7%	--
Qikiqtarjuaq CBM	90	80	0	0	0	5	28	0	8	39	0	90	0	0	0	3	77	0	6	4	0
			--	--	--	15.2%	84.8%	--	--	83.0%	--		--	--	--	3.8%	96.3%	--	60.0%	40.0%	--
Resolute	32	10	0	0	0	3	7	0	0	0	0	16	0	1	0	0	15	0	0	0	0

Bay &																					
Creswell Bay			--	--	--	30.0%	70.0%	--	--	--	--		--	100.0%	--	--	100.0%	--	--	--	--
Taloyoak	10 Ŧ	3	0	0	0	0	0	3	0	0	0	5	0	0	0	4	0	1	0	0	0
			--	--	--	--	--	100.0%	--	--	--		--	--	--	80.0%	0.0%	20.0%	--	--	--

Table 4. Catch composition of seasonal narwhal harvests in selected Nunavut communities in 2010. For each community and year, darkened cells indicate seasons where no narwhals were landed.

Community	Quota / Harvest Limit	2010									
		Number Landed	Spring			Summer			Fall		
			F	M	U	F	M	U	F	M	U
Arctic Bay [CBM]	130	128	10	28	0	10	80	0	0	0	0
			26.3%	73.7%	--	11.1%	88.9%	--	--	--	--
Clyde River	50	50	4	10	0	9	27	0	0	0	0
			28.6%	71.4%	--	25.0%	75.0%	--	--	--	--
Gjoa Haven	10 Ŧ	1	0	0	0	0	1	0	0	0	0
			--	--	--		100.0%		--	--	--
Grise Fiord	20	21 [BA]	5	3	0	5	7	1	0	0	0
			62.5%	37.5%	--	38.5%	53.8%	7.7%	--	--	--
Hall Beach	10	2 [NHB]	1 [NHB]	0	0	1 [NHB]	0	0	0	0	0
				--	--		--	--	--	--	--
Igloolik	25	0	0	0	0	0	0	0	0	0	0
			--	--	--	--	--	--	--	--	--
Kugaaruk [CBM]	25 Ŧ	45	0	1	0	0	44	0	0	0	0
			--	100.0%	--		100.0%		--	--	--
Pangnirtung	40	28	6	5	0	1	0	0	4	12	0
			54.5%	83.3%	--	100.0%	--	--	25.0%	75.0%	--

Pond Inlet [CBM]	130	62	8	9	0	16	20	0	6	2	0
			47.1%	36.0%	--	44.4%	55.6%	--	75.0%	25.0%	--
Qikiqtarjuaq [CBM]	90	89	0	0	0	18	52	1	3	15	0
			--	--	--	25.7%	73.2%	1.4%	16.7%	83.3%	--
Resolute Bay &	32	9	0	0	0	1	8	0	0	0	0
Creswell Bay			--	--	--	11.1%	88.9%	--	--	--	--
Taloyoak	10 Ŧ	2	0	0	0	0	1	1	0	0	0
			--	--	--	0.0%	50.0%	50.0%	--	--	--

Table 5. Catch distribution of narwhal harvests by community for 2006-2010. For each community, the total reported landed catch and seasonal proportions are followed by the overall catch composition and the proportion of the total catch taken in each of the spring, summer and fall hunting seasons. Seasons are coded by calendar day (Romberg & Richard 2005), where spring (ice-edge) hunts occurred before day 205 (July 23rd), summer (open water) hunts occurred between days 205 and 274 (July 24th-Sept 31st), and fall hunts occurred after day 274 (Oct 1st).

Community	Quota/ Harvest Limit	Landed (F:M:U)	2006				2007				2008				2009				2010		
			Spring	Summer	Fall	Landed (F:M:U)	Spring	Summer	Fall	Landed (F:M:U)	Spring	Summer	Fall	Landed (F:M:U)	Spring	Summer	Fall	Landed (F:M:U)	Spring	Summer	Fall
Arctic Bay CBM	130	130	126	4	0	124	69	55	0	132	48	84	0	129	17	112	0	128	38	90	0
		(33:97:0)	0.97	0.03	--	(18:106:0)	0.55	0.45	--	(38:94:0)	0.36	0.64	--	(15:114:0)	0.13	0.87	0	(19:109:0)	0.30	0.70	--
Clyde River	50	43	4	29	11	42	8	22	12	17	2	12	3	13	7	1	5	50	14	36	0
		(21:22:0)	0.093	0.67	0.22	(26:16:0)	0.19	0.52	0.29	(6:11:0)	0.12	0.71	0.18	(2:11:0)	0.54	0.08	0.38	(13:36:0)	0.29	0.73	--
Gjoa Haven	10 Ŧ	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0	1	0
		(0:0:0)	--	--	--	(1:0:0)	--	1	--	(0:0:0)	--	--	--	(1:0:0)	--	1	--	(0:1:0)	--	1.00	--
Grise Fiord	20	21	0	21	0	20	3	17	0	23*	0	23	0	5	4	1	0	21 [BA]	8	13	0
		(0:21:0)	--	1.00	--	(3:17:0)	0.15	0.85	--	(3:20:0)	--	1	--	(1:4:0)	0.8	0.2	--	(10:10:1)	0.38	0.57	--

Hall Beach	10	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2 NHB	1 NHB	1 NHB	0
		(1:0:0)	--	1.00	--	(0:0:0)	--	--	--	(0:0:0)	--	--	--	(0:0:0)	--	--	--	(1:1:0)	--	--	--
Igloolik	25	25	0	25	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0
		(10:15:0)	--	1	--	(0:1:0)	0	1	--	(0:0:0)	--	--	--	(0:1:0)	1	0	--	(0:0:0)	--	--	--
Kugaaruk CBM	25 Ŧ	48 [2]	0	48	0	40	0	40	0	35	0	35	0	42	0	42	0	45	1	44	0
		(9:39:0)	--	1	--	(4:36:0)	0	1	--	(5:30:0)	--	1	--	(16:26:0)	--	1	--	(1:44:0)	0.02	0.98	--
Pangnirtung	40	1	0	0	1	1	1	0	0	21	0	21	0	41	--	--	--	28	11	1	20
		(0:1:0)	--	--	1.00	(0:1:0)	1	0	--	(4:17:0)	--	0.9	--	(0:0:41)	--	--	--	(11:17:0)	0.39	0.04	0.57
Pond Inlet CBM	130	88	22	64	2	65	7	56	2	73 [3]	14	58	1	44	21	20	3	62	17	37	8
		(30:56:0)	--	0.73	0.02	(28:37:0)	0.11	0.86	0.03	(34:38:0)	0.19	0.79	0.01	(24:20:0)	0.48	0.45	0.07	(30:32:0)	0.27	0.60	0.13
Qikiqtarjuaq CBM	90	85	0	85	0	88	0	79	9	80	0	33	47	90	0	82	8	89	0	71	49
		(27:58:0)	--	0.99	0.01	(26:62:0)	0	0.9	0.1	(13:67:0)	--	0.41	0.59	(9:81:0)	--	0.92	0.08	(21:67:1)	--	0.80	0.20
Resolute Bay &	32	28	1	27	0	9	0	9	0	10	0	10	0	16	2	14	0	9	0	9	5

Creswell Bay																					
		(4:24:0)	0.04	0.96	--	(3:6:0)	0	1	--	(3:7:0)	--	1.00	--	(0:16:0)	0.125	0.88	--	(1:8:0)	--	1.00	0.00
Taloyoak	10 Ŧ	34 *	0	34	0	0	0	0	0	3	0	1	2	5	0	5	0	2	0	2	0
		(7:27:0)	--	1.00	--	(0:0:0)	--	--	--	(0:0:3)	--	1.00	0.00	(4:0:1)	--	1	--	(0:1:1)	--	1.00	--

Table 6. Landed catch of beluga in selected Nunavut communities from 2006 – 2010. Catch information for 2011 has not been received from some locations. Preliminary reports are included where available, but these values may be subject to change.

Community	Landed Catch						
	Quota	2006	2007	2008	2009	2010	2011 (preliminary)
Arctic Bay	NRQ	5	14	0	0	0	0
Clyde River	NRQ	0	0	0	0	0	0
Gjoa Haven	NRQ	26	6	0		nr	10
Grise Fiord	NRQ	6	2	10	1	1	*pending*
Hall Beach	NRQ	0	10	3		15 [1]	*pending*
Igloolik	NRQ	27	18	17	18	74	*pending*
Kugaaruk	NRQ	0	0	0		nr	0
Kugluktuk	NRQ	0	0	0	0	0	21
Pond Inlet	NRQ	2	0	0		0	0
Qikiqtarjuaq	NRQ	0	0	0		2	0
Resolute Bay	NRQ	31	5		6	6	*pending*
Taloyoak	NRQ	30	100	0		45	0
Total		127	155	30	25	146	*pending*

NRQ No Regulatory Quota
nr no record received
1 Hall Beach subsistence harvest in 2010 was originally reported as a range (15-20), the value was replaced with an average (15)

ANNEX 2

**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP
ON PLANNING THE SECOND
TRANS NORTH ATLANTIC SIGHTINGS SURVEY**

Marine Research Institute, Reykjavík, 10-12 January 2012

REPORT

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

Chair Gunnlaugsson welcomed the participants (Section 5.7) to the meeting, the purpose of which was to plan the next large-scale, internationally coordinated cetacean survey in the North Atlantic. The Group likewise welcomed the newly-appointed Chair Gunnlaugsson and T-NASS Co-ordinator Desportes. Documents submitted for use in this meeting are listed in Appendix 1.

2. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 2.

3. APPOINTMENT OF RAPPORTEURS

Acquarone was appointed as rapporteur, with the help of the participants, where needed.

4. BACKGROUND FOR AND RATIONALE BEHIND A NEW T-NASS

Due to national and international requirements, management decisions on cetacean harvests necessitate scientific advice based on updated abundance estimates. For this reason a series of national, management-oriented surveys are planned in the North Atlantic for the years 2013-2017.

At previous meetings, this Group (*e.g.* NAMMCO 2008, 2011) agreed that a better basis for the management of cetacean species in the area would be obtained through effort coordination aiming at a synoptic and contiguous survey across the whole North Atlantic. In particular it had noted that:

- coordination at least at the level of the 2007 T-NASS was desirable and should be pursued for the next round of surveys.
- the surveys should be coordinated to the maximum extent possible, while recognising differing national priorities.

The coordination of what would otherwise be ongoing national and international (European) survey efforts into a single coordinated survey conducted in July-September in the same year, using compatible methodology and covering the maximum possible area will provide a much better view of the overall distribution of cetaceans in the North Atlantic, compared to that realized with uncoordinated surveys.

This is particularly important in light of changes in distribution that have been observed for several species in the more recent surveys (SC/19/TNASS2/06, SC/18/AESP/07, SC/18/AESP/05, SC/17/AE/4, SC/19/TNASS2/O/07).

The data gathered in such coordinated surveys could permit the detection of trends in distribution and abundance of species for ecosystem monitoring. This requires a very large survey area and a series of surveys spread over time to be successful. This is an important added value that can only be realized with the continuation of a coordinated survey.

A coordinated planning of the survey will ensure that national survey areas are contiguous, and every effort will be made to cover any gaps with additional effort to form a contiguous survey area from the shores of Europe across the North Atlantic to Greenland and North America.

Such an enlargement of the coverage would reduce the probability of missing significant cetacean aggregations - thus countering a potentially negative effect of migrations and unpredictable variations in the seasonal distribution of animals on the precision of the abundance estimates. Additional objectives of the surveys will be updated distribution maps and associated basic environmental data to enhance our understanding of the relationships between animals and their environment.

Other practical advantages of a coordinated approach include the joint development of methodological protocols and equipment that can be used in future surveys, sharing of vessels and equipment, centralized purchasing which can result in cost savings, and more efficient joint data compilation, analysis, and dissemination.

5. OVERVIEW OF PLANS AND AVAILABLE RESOURCES BY JURISDICTION

5.1 Canada

Timing: An aerial line transect census of cetaceans in eastern Canada in the late summer, from the northern tip of Labrador to the U.S. border, is planned to be conducted after 2015 (ideally 2017); with one Twin Otter in the north and another Otter and/or Partenavia P-68 Observer in the south, double-platform, and video camera coverage of the trackline.

Target species: Cetaceans, sea turtles, basking sharks, sunfish.

Coverage: The area covered will be the same as in the 2007 T-NASS (but see below).

Funding: Department of Fisheries and Oceans (DFO) funding has been identified (900K CAD) for this scale of survey on a 10-yr rotation (hence the next DFO cetacean survey in the Atlantic is expected to occur in 2017); however there may be some flexibility in this schedule if an international survey is planned for an earlier period, although the 2015 time frame coincides with the fiscal support of the planned Atlantic harp seal survey.

Other issues: Funding is an issue that needs to be resolved well ahead of planning for a new survey. The eastern Arctic portion of Canadian waters may also be surveyed given the large-scale industrial developments proposed recently for northern Canada.

5.2 Greenland

Timing: An aerial line transect with a Twin Otter, double-platform and camera ideally for 2015; probably late August-September for weather reasons.

Target species: Primarily minke whales, but including all other species of marine mammals.

Coverage: Traditional west and southwest Greenland survey area with a possible extension of the area farthest north because of recent catches of minke whales in Siorapaluk. The survey will not extend to include areas for other species (e.g., westwards for pilot whales).

Funding: National

Other issues: Relatively large numbers of humpback whales and fin whales, in feeding grounds outside of Ammassalik/Tasiilaq have been sighted in August and the area has not been covered by the previous NASS. There is no hunting of these species in the area and the administration is not willing to fund surveys in that area as the management requirements for the minke whales harvest in East Greenland is covered by the abundance estimates from Iceland and Norway. Research in progress aims at providing measures for reducing the abundance CV and obtaining a new bias correction factor (surface time correction factor by satellite telemetry).

5.3 Iceland

Timing: A shipboard line transect survey in offshore waters and an aerial line transect survey in coastal waters around Iceland is expected to be conducted between 2013 and 2015. Iceland’s policy is to conduct surveys every six years to meet the requirements of the RMP.

Target species: Fin, minke, sei, and sperm whales.

Timing: Not earlier than 20 June. Although surveying later in the summer would exclude the possibility of using a redfish survey platform, it would increase the chances of gathering high-quality data on sei and pilot whales, especially if an extension of the survey area to the south were included in the design.

Platforms: One aircraft, 2-3 dedicated vessels.

Coverage: The area covered in the aerial survey will be the same as in previous years, with a consideration to extend/shift coverage north/northwest to the ice edge. Shipboard survey area will be within the area covered in earlier surveys. The primary area will

	be Icelandic waters (200 nmi EEZ), with extensions to East Greenland and south to 55°N.
Funding:	No funding has been allocated for the survey. There are no indications of a change in the general policy of large scale surveys approximately every six years, although Iceland will be flexible on the timing, if this facilitates a coordinated survey.
Other issues:	Acoustic equipment is available. Biopsy collection from fin whales and tagging might be considered during the survey. It is not planned to repeat the modifications of the 2007 aerial survey for including harbour porpoises as target species.

5.4 Faroes

Timing:	A shipboard line transect survey in inshore and offshore waters is to be conducted between 2013 and 2015.
Target species:	Pilot whales (seasonal and spatial issue).
Timing:	Late June, but flexible for a later start if the pilot whale is the overall target species (seasonal and spatial issues).
Platforms:	One dedicated vessel.
Coverage:	Primarily Faroese EEZ, with potential extension to adjacent waters.
Funding:	National funding.
Other issues:	Acoustic equipment is available. Biopsy collection and tagging during the survey might be considered.

5.5 Norway

Timing:	Intention is to follow the RMP requirements for minke whales. This implies 6-year cycles (2008-2013, 2014-2019). Due to changes in resource allocation there is not going to be a survey in 2012. There are indications that survey effort in the future will be lower.
Target species:	Minke whales.
Season:	July.
Methods:	Two platforms, two dedicated vessels.

5.6 EU Waters

<u>North Atlantic and North Sea</u>

Timing:	A "SCANS-III" survey of European Atlantic waters is in the very early planning phase for centrally coordinated synoptic estimation of abundance and distribution mapping of cetaceans. The requirements are driven primarily by the demands of the Habitats Directive. Timing is considered an approximately decadal scale, meaning that the next survey should be between 2014 and 2017. The ideal year is considered to be 2015. It is currently unclear whether or not shelf and offshore waters can be surveyed in the same year.
Target species:	All cetacean species. Minke whales, common and bottlenose dolphins occur widely on and off the shelf.

Other: EU member states seem to be receptive to the idea of a new survey. Results will also inform management issues related to the rapidly increasing deployment of wind, tidal, and wave energy developments.

Mediterranean: A whole-basin survey with coverage of the whole Mediterranean Sea and Black Sea is being planned. The current plan is for most of the effort to be carried out by aerial survey. Small vessels will use towed acoustics to survey sperm whales.

The Group also took note of the French programmes submitted as documents SC/19/TNASS2/O/05 and SC/19/TNASS2/O/06.

5.7 Russian Federation

The availability of Russian resources for the next survey will be the same as for the previous T-NASS (one observer on a Russian Redfish survey vessel and two additional observers), with the possible inclusion of an Antonov AN-26 survey aircraft.

5.8 USA

Timing: At the time of writing the planned activities with secured funding are: aerial surveys (with Twin Otter) in March-April 2012 and Oct-Nov 2012. Other planned activities requiring funding are an aerial survey during Jan-Feb 2013, a shipboard and aerial survey in June-Aug 2013, an aerial survey in March-April 2014, and an aerial survey in Oct-Nov 2014. The 2013 summer shipboard and aerial survey may be pushed back a year or so, the non-summer surveys are of higher priority since the US has almost no survey effort in non-summer seasons.

Target: For all surveys, the target species are cetaceans, seals, sea turtles, basking sharks, and sunfish. Seabirds are also a target species during the shipboard surveys.

Coverage: All of the aerial surveys will cover "coastal" waters (from the coastline to about the 1000 m depth contour) from Florida to Bay of Fundy and the US and Canadian parts of the Gulf of Maine. The summer shipboard survey cover waters from the offshore edge of where the plane survey covers to the 4,000 m depth contour (which is usually near or beyond the US EEZ).

Funding: See timing.

Other issues: On the shipboard surveys passive and active acoustic equipment are also used. Funding has not been confirmed for 2013 and beyond. Depending on when the NAMMCO surveys are, the US might be able to also conduct a summer shipboard and aerial survey at the same time and not do the tentatively proposed 2013 summer shipboard and aerial surveys.

6. REVIEW OF METHODOLOGY FROM PREVIOUS SURVEYS

6.1 Aerial surveys

Pike presented (Appendix 3 – SC/19/TNASS2/04) a review of the recent (2001 and later) literature pertaining to aerial surveys for cetaceans, compiling a database of 48 surveys, including factors relating to survey type, target species, survey design, field methods, equipment, photography and/or video, and analyses. This was used to assess the present state of the art in aerial survey, and to provide examples that might be applicable in the T-NASS study area and situation. Most surveys used visual line transect methodology, and only a small proportion used cue counting or incorporated still and/or video photography. Aerial survey was used for all types and sizes of cetaceans, except deep divers such as sperm and beaked whales. Survey designs used in the 2007 T-NASS were generally adequate but the trackline layout in the Icelandic inner strata did not have an even coverage distribution. The majority of surveys (58%) used a single-platform configuration with one observer on each side; the remainder used either a full or partial double-platform. The correction of perception bias requires either a double-platform configuration or the circleback technique. In the latter, portions of a transect where animals have been sighted are re-flown some minutes later, and sightings from the first and second segment are then used to estimate the value of *g*(0), incorporating both perception and availability biases. Circleback is applicable for species which have relatively short diving intervals and do not form large groups. In other surveys, availability bias is corrected using either cue counting or by incorporating data on time in view during the survey with data on availability based on surfacing frequency and dive profiles from external studies. For the latter method it is important to explicitly gather data on time in view during the survey. Improvements in declination and bearing measurement methodology, as well as increased precision and automation of data acquisition, are required. While few surveys use still or video photographic methods, this has great potential as camera and data storage technology has improved greatly in recent years. The potential of using photography as a second platform on smaller aircraft is particularly promising. Finally, unmanned aerial vehicles (UAVs) are undergoing rapid development and becoming commercially viable, but are presently either unsuitable for marine surveys or too expensive for most potential users. It is likely that this technology will become important for aerial surveys in the near future.

Some general recommendations were provided and endorsed by the Group:

Survey design

1. The stratification of the Icelandic aerial survey is generally effective for minke whales. However distribution does change between surveys and an adaptive approach, wherein the survey area is first covered at low effort and then additional effort is applied to areas of high density, should be considered.
2. A systematic design using parallel equally-spaced transects is best for most surveys as it always results in even coverage. Zig-zag designs may be preferable for very large, low-coverage strata where ferrying time is an issue, or rectangular strata.
3. The transect layout used in the Icelandic aerial survey resulted in uneven coverage in the inner strata, although this has not been quantified. Modification of this design will depend on the competing priorities of survey comparability and unbiased abundance estimation.

4. The designs of the Canadian T-NASS and Faroese 2009 surveys are adequate. Future changes in stratification could be based on observed animal density or changes in funded effort.

Platforms

1. Visual platforms should use bubble windows.
2. The secondary platform used in the Icelandic aerial surveys does not give a good view close to the aircraft. A larger aircraft and/or the use of a photographic secondary platform (see below) should be considered.
3. The circle-back method is successful for harbour porpoise surveys but has not been adequately tested for other species.

Data acquisition

1. Vocal recordings are the most efficient and reliable means of recording observer observations, and should be used on all surveys, even in cases where a dedicated data recorder is employed.
2. A system to record declination measurements immediately, perhaps using an electronic inclinometer, should be developed.
3. A means of more accurately determining when a sighting comes abeam of the aircraft should be developed.
4. The recording system used in the Icelandic aerial survey is dated, becoming unreliable, and must be improved.

Video and still photography

1. HD video and/or still photographic equipment is of moderate cost and excellent quality and should be considered for all surveys. Video might be particularly useful as a second platform on smaller aircraft.

Bias correction

1. Perception bias cannot be corrected without double-platform data; to accomplish this, double platforms would be required on all surveys (except those using circle-back).
2. Forward sighting distance and time in view (TIV) is required for the correction of availability bias using dive cycle information. Therefore TIV should be collected for every sighting. This again requires the use of observer recordings and accurate timing of observations.
3. The possibility of analyzing Icelandic survey data using a correction for availability based on TIV and dive cycle data, for comparison with estimates based on cue counts, should be investigated.
4. Ideally dive cycle information, including cue rates, should be collected from the survey area at the same time of year the survey is carried out.

Unmanned Aerial Vehicles (UAVs)

1. Civilian UAVs suitable for marine aerial survey are currently too costly and/or not adequately tested, and it is difficult to obtain operational permits in some survey areas. The use of HD video and/or still photograph in conjunction with

visual aerial surveys will facilitate the transition to UAVs should they become available.

In discussion it was emphasized that a double-platform configuration was essential to quantify perception bias for all species. This usually takes the form of two independent teams of observers, but photographic platforms might also be feasible and should be developed further. It was recognized that additional and more detailed data on dive profiles of target species were required from all areas to facilitate the application of corrections for availability bias. These detailed data could feasibly be collected using satellite-linked tags, but more appropriately using short-term recoverable tag applications. The Group strongly recommended that efforts be made to obtain these data in Iceland, Greenland, and Canada.

Recognizing the difficulties in training observers for species identification on aerial survey, the Group recommended the compilation of a photographic identification guide for observers.

The Group was informed that a large scale aerial survey was being planned in the Mediterranean (with *Caterina Fortuna (Chair), Greg Donovan, Ana Cañadas and Alexei Birkunin (Chair of the ACCOBAMS Scientific Committee) constituting the Steering Group).* This presents an important opportunity for cooperation on the joint development of equipment and techniques. In addition a workshop on aerial surveys at the upcoming European Cetacean Society Conference might provide a venue for collaboration.

The Group charged the T-NASS coordinator, Desportes, with establishing a Technical Working Group, led by Pike and proposed to include Lawson, Heide-Jørgensen, Donovan, Palka, and Gilles, to develop further the protocols and equipment requirements for aerial surveys, with specific terms of reference compiled from the recommendations above. The Technical WG will provide this Group with an initial progress report including a timeline and budgetary implications in time for the 2012 meeting of the NAMMCO SC in April.

6.2 Ship surveys

A double-platform mode, allowing for the correction of biases inherent to the collection of data for distance sampling in cetacean sightings surveys, has been used in the T-NASS shipboard survey and has been recommended by the WG to be used again in future surveys. Desportes presented a review (Appendix 4 – SC/19/TNASS2/07) of the logistic implementation of double-platform mode in shipboard sighting surveys based on a review of the over 50 surveys which have used such a mode. She also reviewed data recording methods and the recent improvements that have been implemented in data collection. The current most-used methods are (1) the Independent Observer configuration (IO mode), with two-way independence between symmetrical teams of primary observers, and (2) the Trial Observer configuration (BT mode), with one-way independence between a primary team and a tracker team. Both methods rely on the identification of duplicate sightings, based on timing and position, between the two platforms, which can be done *in situ*, requiring an observer dedicated to the task, or later during the analysis.

The complexity of the overall field logistics is a combination of the mode itself, data logging and data collection operations. Distance data (distance and bearing to sightings) are key data items in distance sampling. Bias in these has the potential to introduce large bias in abundance estimates and therefore they need to be recorded with the greatest accuracy possible. In recent vessel-based surveys (SCANS-II; NMFS), devices have been introduced for trackers using binoculars for achieving greater accuracy in the measurement of distance data. These are the photogrammetric methods first implemented in SCANS-II as well as the use of electronic range finders implemented in the NEFSC surveys. The tendency has been towards real-time data entry and automatic data logging, with the introduction in SCANS-II of an integrated data collection system, enabling observers to validate and cross check data collected during the cruise. In the context of the T-NASS (Iceland and Faroes) target species mix of fin, minke, and pilot whale, the BT method (correcting both for $g(0)<1$ and potential responsive movement) seems the most appropriate (the Group did not exclude the possibility of improvements or employment of alternative methods).. The *in situ* identification of duplicate sightings, which requires a dedicated person and very good communication system between platforms, is resource intensive, but adds unique knowledge of the situation which can provide an independent check for errors in the sighting information recorded by the observers (*e.g.*, in the distance estimate to sightings). The successful use of Big Eye binoculars by the trackers is very ship-, platform-, and observer-dependent and therefore they are not recommended *a priori*.
The measurement of distance data using precision instruments was considered to represent considerable progress for this type of platform, and should be pursued, although the way this was implemented in the field should be improved and simplified, taking into account the newest software and hardware developments. The technical logistical requirements underlying shipboard sighting surveys have become increasingly complex. Such planning must include increased and thorough testing of the equipment both on land and *in situ*, and a thorough training regime for the both the cruise leaders and the observers.

Some general recommendations were provided and endorsed by the Group:

1. The use of the BT method, which allows correction both for $g(0)<1$ and responsive movement, seems the most appropriate in the context of the T-NASS mix of target species.
2. A good separation of the search areas and the requirement of detecting the animals before they have reacted to the vessels imply using binoculars which are more powerful than 7×50 binoculars. However, because the successful use of Big Eye binoculars is very ship/platform/observer dependent, the use of mid-range binoculars (which require less room and should be easier to use on less stable platforms) should be investigated.
3. The measurement of distance data with more accurate tools than traditional reticule binoculars and angle boards was considered a significant advance and should definitely be implemented in future surveys.

   a. The way this was implemented for the tracker in SCANS-II, CODA and T-NASS should be improved and simplified, taking into account the newest software and hardware developments. Photogrammetric methods as implemented in SCANS-II require that both the horizon and the sighting are visible on the pictures taken, which is not always the case for several reasons including the occasional presence of fog. The use of electronic range finders, which do not require the horizon in the field of view, should be investigated and developed further.
   b. Distance and angle measurement methods should also be developed for primary observers searching with unaided vision.
4. The use of real-time data entry and automatic data logging, with the introduction of an integrated data collection system offers potentially valuable possibilities for *in situ* data validation and for checking whether sightings procedures and protocols are followed by the observers. Their utilization should be pursued. The data collection system as implemented in SCANS-II should be improved and made more user-friendly and more robust, taking into account the latest hardware and software developments.
5. The logistics of shipboard surveys, including preparation, have become increasingly complex and time-consuming. At the same time, their successful implementation requires intensive and dedicated training of both cruise leaders and observers. Both should be taken into account when planning future T-NASS surveys.
6. Measurement by the Tracker of distances to the Primary's sightings should be implemented to improve the accuracy of Primary estimates of distance.

The proposed SCANS-III survey presents an important opportunity for cooperation on the joint development of equipment and techniques.

The Group charged the T-NASS coordinator, Desportes, of establishing a Technical Working Group, under her leadership and proposed to include Gunnlaugsson, Hammond, Gillespie, Leaper, and Palka to develop further the protocols and equipment requirements for shipboard surveys, with specific terms of reference compiled from the recommendations above. The Technical WG will provide this Group with an initial progress report including a timeline and budgetary implications in time for the 2012 meeting of the NAMMCO SC in April.

6.3 Acoustic surveys

T-NASS 2007 acoustic data have not yet been fully analysed because of technical problems. Considering both the interest in the potential abundance estimates of sperm whales and the investment already made in acquiring the acoustic data (including purchasing the equipment), the WG and the SC had recommended at their last meetings that the analysis of these data be carried out again and the abundance estimate finalised. They urged NAMMCO Secretariat to find a suitable agreement with the Sea Mammal Research Unit (SMRU), so the analysis could be redone in a timely manner. Contact with the relevant person at SMRU has been made during this meeting and an initial agreement has been reached.

The work needed to progress with the analyses comprises one day for resetting the hydrophone separation parameters (by Swift). This will be completed before April 2012. Additionally, approximately one month is needed to analyse the data and the budget for this work should be presented to the SC meeting in April 2012.
There are four sets of acoustic equipment from the 2007 T-NASS currently stored in Iceland and the Faroe Islands. The Group recommends employing these in the context of the next T-NASS.

7. COORDINATION ISSUES

7.1 Timing

The year 2015 seemed to fit best with the national constraints as outlined in 5.1-5.8. Furthermore choosing 2015 as the survey year would allow:

1) Sufficient preparation time,
2) Highest chance of having all the national surveys happening concurrently,
3) Concurrency with ICES redfish surveys for Iceland and Russia (likely with possibility of having observers on board the vessels as in T-NASS 2007),
4) Concurrent with the likely year of the proposed SCANS-III survey,
5) Good overlap within the Norwegian survey cycle.

The group acknowledged that a large-scale harp seal survey is planned in Canada for the DFO fiscal year 2015-2016. The magnitude of the funding for the harp seal and T-NASS surveys make it unlikely that both will be funded in the same fiscal year. Lawson will investigate the possibility to hold the Canadian component of T-NASS in 2015.

Gunnlaugsson presented document IWC-SC/56/O5 where systemic information on seasonal distribution of cetaceans around Iceland, and in some instances over to Greenland, was collected by placing one or in most cases two observers on platforms of opportunity in some spring (May) and autumn (August) surveys in the period 1980-1995, and analyzed accordingly. Sighting rates of all main species are considerably lower during the spring. Sighting rates are higher during the mid-summer NASS surveys, but effort in these surveys was higher. In addition the NASS 1989 survey was a fortnight later than the other surveys. Sei whale densities were highest in 1989 at the southern survey area boundary 52°N during the latter half of the survey and are also relatively highest during the autumn surveys as also indicated from the catch information. For fin whales the catches have indicated a peak in June-July on the grounds west of Iceland, but the survey data can not preclude a later peak for the area in general. The same applies to minke and pilot whales. Partial aerial surveys in coastal Icelandic waters were conducted during 2003-2005 in the spring (April-May) and autumn (September), and are compared to the midsummer surveys in document SC/19/TNASS2/06 and IWC-SC/57/O8. Large variation between years and an apparent northward shift in distribution observed in the midsummer surveys (June-July) complicate the comparison, but a peak in minke whale presence later than July but before September can not be ruled out.

In general seasonal timing will be agreed upon at a later meeting. The general agreement was that surveys should be conducted as close as possible in time to avoid problems associated with any systematic directional movement of animals. In the meantime, the Group recommended that a series of short aerial surveys be conducted in Icelandic waters in July-August to investigate seasonal distribution in the coming years to identify the optimal seasonal timing for a survey. This could also be investigated through satellite tag applications but this seemed to have less prospect of success at present. The possibility of using existing data from bottom moored acoustic recorders should also be investigated.

7.2 Coverage

Aggregations of humpback and fin whales have been observed off East Greenland as far as 74°N (Heide-Jørgensen *pers. comm.*). This indicates that these species are found close to the coast and much further north than previous surveys have covered. Most previous surveys do not approach the East Greenland coast because of ice and fog. The Group considered that an aerial survey covering the East Greenland shelf from Kap Farvel to Northeast Greenland could be effective in this area. Due to recent catches of minke whales in Siorapaluk the west and southwest Greenland, the T-NASS survey area should be extended further north to Kane Basin. The Group highlighted the importance of ensuring the largest possible contiguous survey area. In this context the Group recommended that:

- The Norwegian planning group take this principle into account when allocating which area to survey in the year of the next T-NASS.
- The allocation of supplementary survey effort be considered in the coastal areas of eastern Baffin Island, Davis Strait, and southwest Greenland, given the possibility of impact and/or displacement of cetacean populations by proposed industrial activities (ice-breaking, shipping, seismic oil exploration) in Arctic Canada, and data indicating that cetaceans utilize these areas.
- The coastal area of East Greenland be included in the aerial effort.

7.3 Coordination with associated surveys

7.3.1 USA

Palka is a member of this Working Group which will enhance co-ordination with the dedicated US cetacean abundance surveys.

More information should be gathered on platforms of opportunity such as any north Atlantic research cruises of the Woods Hole Oceanographic Institute and other North American research institutions.

7.3.2 Other (SCANS-III, Mediterranean, SPM)

It was noted that T-NASS should co-ordinate the development of the project with activities in the SCANS-III, the ACCOBAMS-Mediterranean, and Saint-Pierre and Miquelon areas.

7.3.3. Coordination with "opportunistic" shipboard surveys (*ICES Redfish, Ecosystem Surveys, Others*)

In general opportunistic platforms could help in covering areas that would otherwise not be surveyed (Figure 10). However, experience from the 2007 T-NASS suggests that further care needs to be taken in collection of these data, particularly with regard to selection of observers and adherence to observer protocols. At least two observers should be present on the same platform, and must cooperate in collecting data. It cannot be expected that such surveys will produce unbiased estimates of abundance; they are however useful in determining cetacean distribution and relative abundance outside of the core survey area.

The value of such data is enhanced by the associated detailed environmental data often gathered by these surveys. Therefore, given the above conditions are met, the use of opportunistic platforms for the collection of both marine mammal and other data is encouraged concurrently to the next T-NASS. The areas covered by these platforms should be located in such a way (peripheral) so that the coverage of the core survey area would not be compromised if the data collected by the opportunistic platforms should not meet the quality requirements of the dedicated survey.

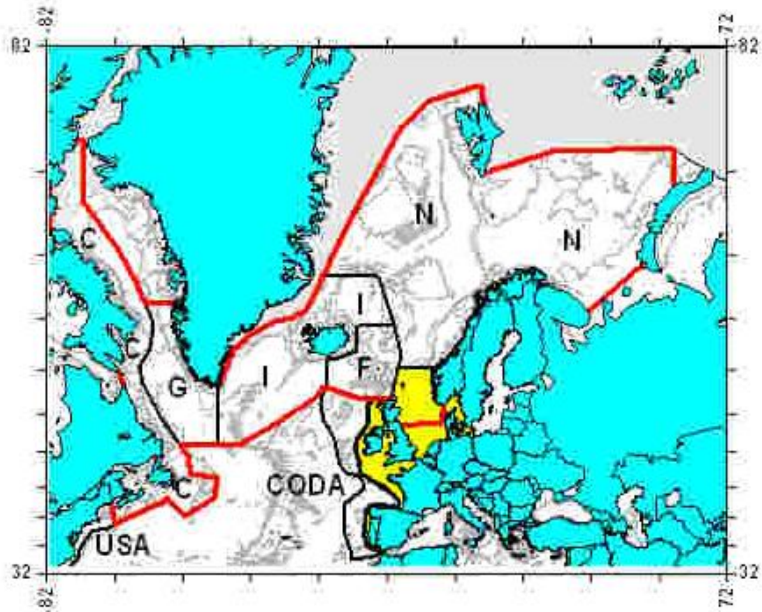


Figure 10. NAMMCO National Surveys with black boundaries and additional areas from additional synoptic surveys with red boundaries as in T-NASS 2007.

8. BUDGET

Nation	Area	Presumably covered by existing funding	Extra Funding required
Canada		Uncertain funding for 2015	
Greenland	West Greenland shelf	×	
	East Greenland shelf		×
	Southern Davis strait		×
	East Greenland north of Scoresby Sound		×
Iceland-Faroes	Irminger sea down to 55°N	×	
	Irminger sea south of 55°N		×
	South of Iceland-Faroe Islands to 55°N	×	
	South of 55°N		× (sei and pilot whales)
	East Iceland to Norway		× (important for pilot whales)
	Icelandic continental shelf	× (aerial)	
	Southern Norwegian Sea	×	
Norway	Jan Mayen block	Covered by Norway?	× probably
	Norwegian Sea (62-73°N)	most probable area Norway	
	Northern Greenland sea		× (could be possible)
	Spitsbergen/Barents		×

8.1 Integrated budget

The total budget for the 2007 T-NASS was 24,300 kDKK, including all expenses (also staff salaries) for preparation of the survey and the survey as such, but excluding data analysis. With an annual inflation at 3%, a similar level funding for the next T-NASS gives a budget of over 30,000 kDKK. The table above reflects the prospective budgetary commitment of the member countries and highlights the yet unfunded components. In addition there is a need for further funding for protocol development, equipment improvement and development and inclusion of platforms of opportunity. The Technical groups formed at this meeting will provide the necessary information.

8.2 External funding proposals

A project description and a proposal for funding should be developed by the T-NASS coordinator.

9. TASKS TO BE COMPLETED

9.1 Practical recommendations:

Under the leadership of the T-NASS Coordinator:

- Technical Working Group Aerial (6.1),
- Technical Working Group Shipboard (6.2),
- Project description to use for proposals.

Under the leadership of the NAMMCO secretariat (6.3):

- Feasibility of acoustic analyses from T-NASS 2007 data.

9.2 Publications/Deliverables

At its last meeting the AEWG considered necessary to appoint someone to take charge of coordinating this effort, and the Group recommended that this be done by Scientific Committee in cooperation with the NAMMCO Secretariat. In the absence of an appointment by the SC to date, this Group proposed Lawson as the Editorial Coordinator.

The following table, adapted from the report of the previous AEWG meeting, lists prospective items from T-NASS and earlier surveys to be prepared for a coordinated publication. The identified "Lead" is responsible for ensuring that all deadlines are met in completing the papers.

SUBJECT	SURVEY	LEAD
Introduction, general distribution	All	Lawson
Fin, sei, hump, blue	Ship+air	Víkingsson
Minke	Ship+air	Víkingsson
Pilot whales, Trends	Retrospective ship	Mikkelsen
Small toothed whales	Ship+air	Mikkelsen
Baleen whales	Can-air	Lawson
Harbour porpoises	Can-air	Lawson
Belugas	Can-air	Gosselin
Circleback/Correction factors (contact Palka)	SNESSA	Palka
Sperm whales	Ship acoustic	Gunnlaugsson
Baleen	Nils surveys 2002-7	Øien
Odontocetes	Nils surveys 2002-7	Øien
Large whales retrospective	Ship+air	Víkingsson

10. NEXT MEETING

This Group did not envisage the need to have a meeting before 2013.

11. ADOPTION OF REPORT

The report was adopted in a preliminary form at the end of the meeting. The final report was adopted by correspondence 10 March 2012.

Appendix 1

LIST OF DOCUMENTS

Document no	Title
SC/19/TNASS2/00	Practical Information
SC/19/TNASS2/01	List of Participants
SC/19/TNASS2/02	Draft Agenda
SC/19/TNASS2/03	List of Documents (this document)
SC/19/TNASS2/04	Daniel Pike, Aerial survey: state of the art and recommendations for the next T-NASS.
SC/19/TNASS2/05	Plans by jurisdiction
SC/19/TNASS2/06	Thorvaldur Gunnlaugsson. Aerial surveys off Iceland and minke whale distribution changes by season and over time.
SC/19/TNASS2/07	Desportes, Review of double platform implementation in shipboard sightings surveys.

BACKGROUND DOCUMENTS

Document no	Title
NAMMCO SC/18/07	NAMMCO Scientific Committee Working Group on Survey Planning (SPWG). Trans? North Atlantic Sighting Survey 2, First Planning Meeting. March 09-11, 2011 – Copenhagen
SC/18/AESP/05	Pike, Desportes, Gunnlaugsson, Mikkelsen and Bloch. Estimates of the relative abundance of pilot whales (*Globicephala melas*) from North Atlantic Sightings Surveys, 1987 to 2007.
SC/18/AESP/07	Pike, Gunnlaugsson, Vikingsson and Mikkelsen. Estimates of the abundance of sei whales (*Balaenoptera borealis*) from the NASS Icelandic and Faroese.
SC/17/AE /04	Pike et al. Estimates of the abundance of humpback whales (*Megaptera novaengliae*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007
IWC-SC/56/O5	T. Gunnlaugsson, G. A. Víkingsson and D.G. Pike. Comparison of sighting rates from NASS and other dedicated cetacean vessel effort around Iceland during 1982 to 2003
SC/19/TNASS2/O/01	C.R. Joiris. 2011. A major feeding ground for cetaceans and seabirds in the south-western Greenland Sea. *Polar Biol.* 34:1590-1607.
SC/19/TNASS2/O/02	Gillespie *et al.* 2010. An integrated data collection system for line transect surveys.
SC/19/TNASS2/O/03	Leaper *et al.* 2010. Comparisons of measured and estimated distances and angles from sightings surveys
SC/19/TNASS2/O/04	SCANS-II Shipboard Estimation Method Review
SC/19/TNASS2/O/05	Aerial surveys for observation of seabirds and marine mammals within the maritime domain of mainland France and its adjacent

	waters.
SC/19/TNASS2/O/06	Projets oiseaux et mammiferes marins en france metropolitaine
SC/19/TNASS2/O/07	Víkingsson, G., Pike, D., Lawson, J.W., Heide-Jørgensen, M.-P., Øien, N., Desportes, G., Gunnlaugsson, T., Gosselin, J.-F., Mikkelsen, B., Hansen, R., Wtting, L., Zabavnikov, V., and Acquarone, M. 2011. Changes in distribution and abundance of cetaceans detected using 20 years of North Atlantic Sightings Surveys. ESSAS Open Science Meeting, Seattle, WA.
IWC-SC/57/O8	T. Gunnlaugsson. Density by season in aerial sightings surveys around Iceland in 2003 and 2004. Preliminary report.

Appendix 2

AGENDA

1. CHAIRMAN'S WELCOME AND OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEURS
4. BACKGROUND FOR AND RATIONALE BEHIND A NEW NASS
5. OVERVIEW OF PLANS AND AVAILABLE RESOURCES BY JURISDICTION
   - 5.1 Canada
   - 5.2 Greenland
   - 5.3 Iceland
   - 5.4 Faroes
   - 5.5 Norway
   - 5.6 EU Waters
   - 5.7 Russian Federation
   - 5.8 USA
6. REVIEW OF METHODOLOGY FROM PREVIOUS SURVEYS
   - 6.1 Aerial surveys
   - 6.2 Ship surveys
   - 6.3 Acoustic surveys?
7. COORDINATION ISSUES
   - 7.1 Timing
   - 7.2 Coverage
   - 7.3 Coordination with associated surveys
     - *7.3.1 USA*
     - *7.3.2 Other (SCANS-III, Mediterranean, SPM)*
   - 7.4 Coordination with "opportunistic" shipboard surveys (*ICES Redfish, Ecosystem Surveys, Others*)
8. BUDGET
   - 8.1 Integrated budget
   - 8.2 External funding proposals
9. TASKS TO BE COMPLETED
10. NEXT MEETING
11. ADOPTION OF REPORT

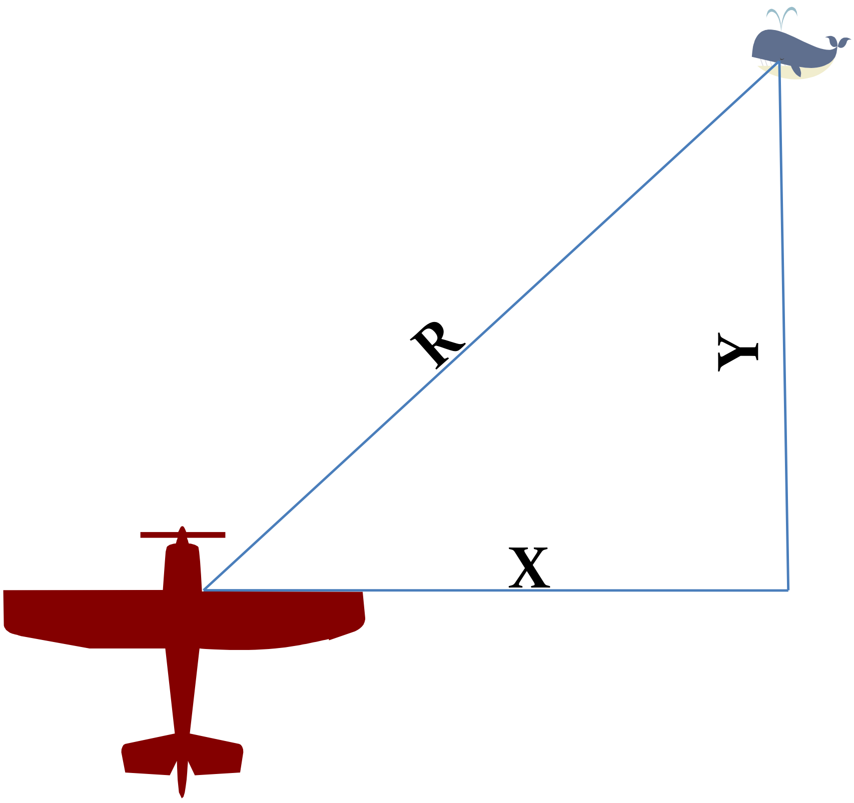
Appendix 3

AERIAL SURVEY:

STATE OF THE ART AND RECOMMENDATIONS FOR THE NEXT T-NASS

by

Daniel Pike



AERIAL SURVEY: STATE OF THE ART AND RECOMMENDATIONS FOR THE NEXT T-NASS

by

Daniel Pike, ESOX Associates, Ontario, Canada

INTRODUCTION

Aerial survey has been used in the NASS and T-NASS surveys since the first one carried out in 1987 (Pike *et al.* 2009, Hiby *et al.* 1989), primarily in coastal Icelandic and West Greenland waters. More recently the T-NASS 2007 survey included a large scale aerial survey off Atlantic Canada (Lawson and Gosselin 2008). In addition aerial survey is used off the US east coast (Palka 2005) and was used in a recent survey around the Faroe Islands (Gilles *et al.* 2011).

Aircraft can cover a large area in a short time. Aerial surveys are therefore generally preferred under one or more of the following circumstances: 1) areas with very geographically complex coastlines; 2) areas with short windows of acceptable weather; and 3) during animal migrations when the survey must be completed quickly. In addition, the altitude of the viewing platform allows simple and accurate measurement of distances using declination angles. Finally, aerial surveys are usually less expensive to conduct than ship surveys, as aircraft are less expensive to charter.

Most survey aircraft lack the range and speed to operate in the far offshore. In addition their relatively high speed means that a sometimes large proportion of whales are submerged during the passage of the aircraft, which can bias abundance estimates. Finally, there are significant safety issues with using aircraft offshore, although this is certainly true of ships as well.

Field methods, especially in the Icelandic aerial survey, have changed little since the survey was initiated in 1987. In 2011, the NAMMCO Scientific Committee Working Group on Survey Planning decided to commission a study to compare and contrast survey methodologies presently in use, and consider their advantages and disadvantages for use with the NASS species mix. I decided to approach this task by first reviewing the recent literature on aerial surveys to determine the state of the art, then using this information to provide recommendations for the improvement of aerial surveys in the NAMMCO area of interest.

MATERIALS AND METHODS

A non-exhaustive review of the recent (2001 and later) literature pertaining to aerial surveys for cetaceans was conducted. Searches were carried out using the *ProQuest* system searching the *Biological Sciences* database, primarily using the search terms "aerial survey", "cetaceans" and "whales or dolphins or porpoises" (("aerial survey") AND (cetaceans OR whales OR dolphins OR porpoises)). As this sources primarily the published literature, additional searches were carried out on IWC documents (http://iwcoffice.org/publications/doclist.htm), and lists of unpublished documents held by DFO (http://www.meds-sdmm.dfo-mpo.gc.ca/csas-sccs/applications/publications/index-eng.asp) and NOAA (http://www.lib.noaa.gov/noaainfo/pubsource.html). The search was selective and only those documents that explicitly described surveys conducted in the past 10 years were chosen.

A database of surveys conducted in the past 10 years was compiled, including factors relating to survey type, target species, survey design, field methods, equipment, photography and/or video, and analysis. This database was used to assess the present state of the art in aerial survey, and to provide examples that might be applicable in the NASS study area and situation.

RESULTS AND DISCUSSION

A database including 48 surveys, most but not all conducted since 2001, was compiled (Appendix 1). The surveys were concentrated in the northern and western hemispheres, and appeared to be most common in the far north (Fig. 1). All surveys were conducted in nearshore (<100 nmi from shore), with the exception of a single-flight survey conducted in mid-Baffin Bay (Laidre and Heide-Jørgensen 2011).

Survey type

Surveys were classified into 4 general types. The majority (75%) were visual line transect surveys. Cue counting surveys accounted for 13% of the total, and these were carried out by only 2 groups with the author involved in both groups. Cue counting was applied to minke whales (common and Antarctic) only. Two surveys (4%) used a combination of line transect methodology and still photography to census large concentrations of whales; this methodology was applied to narwhal and beluga only. Finally 4 surveys (8%) used still photo strip sampling methods. Three of these were for beluga in Canada while one had minke whales as the target species (Witting and Kingsley 2005). No surveys used video exclusively and only one survey (Heide-Jørgensen and Acquarone 2002) used video to count animals.

Target species

In cases where target species were given, they were divided into 3 categories: Small, including small dolphins and porpoises; Medium, including large dolphins (narwhal, beluga and killer whales) and minke whales; and Large, including whales larger than minke whales. Large and medium sized whales were the targets of a similar proportion of the surveys (29% and 35%), while small whales were explicitly targeted in 23%. Twelve percent of the surveys targeted a mixture of species and sizes. These results suggest that aerial survey is suitable for nearly all types of whales, with the possible exception of deep-diving species such as sperm and beaked whales, which were not targeted by any surveys.

Stratification

The main purpose of stratification is to improve the precision of abundance estimates by concentrating survey effort in areas where high density is expected. Almost all of the surveys used some form of stratification, some based on prior knowledge of animal distribution, and some based on operational factors such as coastline shape.

Clearly stratification is advisable in cases where distribution is predictably concentrated in certain parts of the survey area.

The stratification of the Icelandic aerial survey was based on the observed distribution from a previous survey (Donovan and Gunnlaugsson 1989). This stratification appears to be rather effective, based on the observed number of sightings relative to survey effort (Fig. 2). However minke whale distribution has changed substantially since 2001. For example Block 8, which up to 2001 had high densities of minke whales, had low density in 2007 and 2009 and is therefore oversampled in these surveys. Such changes in distribution are not readily predictable and may reverse, so it is debatable whether the survey stratification should be changed to accommodate them.

Transect layout

Two types of transect layout were used in aerial surveys: Parallel lines, equal spaced (P-ES) accounted for 54% of the sample, while Zig-Zag, equal spaced (Z-ES) accounted for 29%. A further 15% used a mixture of both types. In almost all cases the transects were oriented across the prevailing depth gradient, generally from shore out to sea.

The P-ES layout is often preferred because it by definition results in equal coverage probability across the stratum, no matter how the stratum is shaped. However it does require ferrying between transects which can increase off-effort flying time. The Z-ES layout produces even coverage probability only for rectangular strata, although this issue can be reduced by stratifying complex areas and designing the transects using a convex hull or bounding rectangle (Thomas *et al.* 2010). Ferrying between transects is reduced but not eliminated altogether as the use of a convex hull or bounding rectangle to design the transects results in the transect ends being cut off in strata with concavities.

Other designs are at least potentially suitable for some circumstances. Randomly spaced parallel lines could work in circumstances where a systematic design might result in bias. An equal angle zig-zag (Z-EA) design has features similar to the Z-ES design. An adjusted angle zig-zag is also available in Distance (Thomas *et al.* 2010), but it does not appear to have been implemented in practice.

Ferrying time is not usually as large an issue for aerial surveys as it is for ship surveys. Unless coverage is low and transect spacing is very large, ferrying lasts only a few minutes and provides a welcome rest between transects for the observers. As equal coverage probability is an assumption for design-based analyses, the P-ES design should be preferred under most circumstances. Exceptions might include very large strata with low coverage, or rectangular strata in which the Z-ES or Z-EA designs will result in even coverage.

The Icelandic aerial survey appears to use a type of Z-ES design although a convex hull or bounding rectangle was apparently not used to define the transects as all transects intersect. Essentially the same design, with very minor modifications, has been used in every survey since the first in 1987 (Pike *et al.* 2009). Since the design was developed before survey simulation software was available (*e.g*. Distance), the coverage probability distribution of this design has not been assessed. Certainly the outer strata are not problematic as they are rectangular. However the Icelandic coast is highly indented in some areas so it is likely that coverage density is not evenly distributed in some inner strata; visual inspection suggests this is true. This could potentially bias abundance estimation if coverage density is correlated with animal density. If estimating absolute abundance is the main goal of the survey, the characteristics of this design should be assessed or changed to a P-ES design. However, if assessing trends in abundance is a major goal, maintaining the same design, as has been done over 6 surveys since 1987, is advantageous as any bias inherent in the design is maintained over surveys.

The Canadian T-NASS survey used P-ES in the Gulf of St Lawrence and Southern Nova Scotia areas, and Z-ES in the Newfoundland and Labrador area. The latter portions of the survey were designed and tested using Distance software and found to produce acceptable coverage distribution. The Faroese aerial survey conducted in 2009 used a P-ES design (Gilles *et al.* 2011), as did the 2007 Greenlandic survey (Heide-Jørgensen *et al.* 2010).

Platforms

All visual aerial surveys but one (98%) used fixed high-wing aircraft. One visual survey used a helicopter. Only photo surveys without observers used low-wing aircraft. The most common aircraft used was the Cessna 337 Skymaster followed by the Partenavia P-68 Observer. Both of these aircraft are among the smallest twin engine aircraft available. Twin engine aircraft are considered safer for offshore surveys. However neither of these aircraft is large enough to accommodate a full double platform configuration (see below), for which a larger plane such as a DeHavilland Twin Otter or Aerocommander is required.

Operating altitude varied from 500 to 1500 ft for visual surveys, and was most commonly (61%) between 500 and 750 feet. Surveys conducted at higher altitudes tended to be for large whales and, surprisingly, beluga whales. An altitude of 600 ft is standard for harbour porpoise surveys.

The majority of surveys (58%) used a single platform configuration with 1 observer on each side. A further 21% used a full double platform configuration (2 platforms, 2 observers per platform) while 16% used a partial double platform configuration (2 platforms, one of which has only one observer). However the frequency of the latter 2 categories is somewhat misleading as most cases were by a single survey group. In all cases where double platforms were used, the platforms were visually and acoustically isolated from one another. Single platform surveys can use smaller aircraft and require fewer observers and are therefore less costly than other configurations. However assessing perception bias, which is substantial for some target species, is impossible using a single platform configuration unless specialized methodologies, such as “circle-back” (see below), are used.

Of the single platform surveys, 80 % used bubble windows 47% of the double platform surveys used bubble windows on both platforms while 35% used a flat window on the secondary platform. A further 18% used flat windows on both platforms. Bubble windows are clearly advantageous because they allow a better view of the trackline and forward of the aircraft. However they are expensive and are not available for all aircraft types. The effective use of a bubble window also requires a seating position that is fatiguing for observers.

Circle-back

The circle-back or "racetrack" type of survey provides an alternative to double platforms that can be implemented in a small aircraft (Hiby 1998, Hiby and Lovell 1998). In brief, a suitable sighting triggers a protocol wherein the aircraft breaks off transect, circles and rejoins the transect some distance back from the sighting that initiated the circle-back. This segment is then re-surveyed. The second coverage of a portion of the transect ("trailing leg") can be seen as a second platform. The entire process before the location of the initial sighting is re-surveyed must take longer than the average dive cycle length of the target species, but not so long that the initially sighted pod would be likely to have moved off. For harbour porpoise surveys a single circle-back takes about 3 minutes. Sightings from the first and second segment are assigned a duplicate probability based on an objective model. These data are then used to estimate the value of $g(0)$, in this case incorporating both perception and availability biases.

This method was used by 4 (8%) of the surveys, and only for harbour porpoises (but see Palka 2005). Presumably the duplicate probability model would have to be modified for other species, and larger circles would be required for species with longer dive cycles. A longer circle-back would make it less probable that a pod would be available for resighting (*i.e.* it could move away from the trackline). Therefore this method appears to be most useful for slow-moving species with a short dive cycle, such as the harbour porpoise or perhaps the minke whale, and less so for faster species with longer dive cycles, such as the fin whale.

The main advantages of the methodology are: 1) no necessity for double platforms, thus enabling the use of a smaller aircraft and fewer observers; and 2) estimation of $g(0)$ incorporating both perception and availability biases (although these cannot be discriminated by the method). The main disadvantage would be the extra flying time required to perform the circle-backs, which can be considerable to obtain acceptable precision (Palka 2005, Scheidat *et al.* 2005, Berggren *et al.* 2004). Exact timing of sightings, careful flying and precise navigation are critical to making the method work. It has also proven best to gather data outside of high-density areas, as additional sightings on the resighting leg make it difficult to assign duplicates (Scheidat *et al.* 2005).

<u>Evaluation</u>

At present the "gold standard" configuration is a 2+2 double platform, both platforms with bubble windows. Using this configuration perception bias can be estimated through sight-resight methods (Laake and Borchers 2004). A double platform on only one side of the plane is also acceptable if sufficient sightings and sight-resight trials

Can be generated in this way. The circle-back method appears to be successful for harbour porpoise surveys but has not been proven for other species.

The Icelandic aerial survey has used a double platform with the "secondary" platform surveying on one side only. However the secondary platform does not have a bubble window and therefore does not have a clear view of the trackline beneath the aircraft. In practice this means the secondary observer almost never has sightings closer than 150 m from the aircraft. As $g(0)$ is the proportion of sightings that are detected at distance 0, nearby sightings are the most important for its estimation, and if there are no trials at very low distance its estimation depends on extrapolation (*e.g.* Borchers *et al.* 2009). Clearly a second bubble window platform would be preferable but is not possible using the Partenavia P-68. A second video or photographic platform might be an alternative (see below).

The Canadian component of T-NASS 2007 used two platform types: a single platform configuration with bubble windows in the Gulf and Southern Nova Scotia areas, and a double platform on one side, with bubble windows at all stations in the Newfoundland and Labrador areas (Lawson and Gosselin 2008). The latter configuration allows estimation of perception bias while the former does not. The Faroese survey conducted in 2009 used a single platform (Gilles *et al.* 2011). However this survey had harbour porpoise as a target species and the observers were well-characterized in previous surveys which used the circle-back method. Therefore a $g(0)$ correction from previous surveys was applied.

Data acquisition

All visual surveys recorded radial distances using a hand-held, mechanical inclinometer. Electronic inclinometers are available but the ones I have investigated are difficult or impossible to use quickly. This would appear to be an area ripe for technological innovation. Many mobile phones and game controllers have accelerometers and it would certainly be possible to devise a system that would record angle measurements in real time.

Almost all visual surveys recorded radial distance when the sighting was directly abeam of the aircraft. Only some cue-counting surveys recorded lateral angles before the sighting came abeam, using a simple angle board. No studies reported specifically how the observers determined when the sighting was abeam: this is usually left to the judgement of the observer.

Data recording systems came in two basic types: those with a dedicated data recorder (DR), and those in which observers recorded their own observations (OR). DR-type surveys, in which one crew member acted as a dedicated data recorder, comprised 40% of the visual surveys. The data recorder is in constant contact with the observers and usually uses a data entry program and laptop. A popular data recording software package for this purpose, VOR (Hammond *et al.* 1995), records and maps navigational output from the GPS while allowing the data recorder/navigator to record sightings and environmental information in real time. Other surveys used other data entry programs or even pen-and-paper to record data. Minimal requirements for such a system are: 1) a record of time and location, generally provided by the GPS data stream, and 2) a time stamp with every observation, which can be related to location.

In the remainder of the visual surveys (60%), the observers recorded their own observations, generally through time-stamped vocal recordings. These recordings can be georeferenced through merging with the GPS data stream. Such systems can be very simple, with observers simply recording their observations into digital voice recorders. Other systems integrate the GPS data stream directly with the voice recordings. Of course a separate recording channel is required for each observer.

DR systems have the advantage that data are entered in the "field", eliminating post-flight data transcription. This enables the survey leader to keep close track of observer performance in real time and correct any problems as they arise. A DR system is required for a circle-back type survey as circle-backs are triggered by observations in real time and careful navigation is required. An additional advantage is that the observers can rotate between the observation and data recording positions, allowing them some rest. A major disadvantage can be that one space on a very expensive platform is used for a task that could be done on the ground. However this is not an issue if the space used by the data recorder could not be otherwise utilized. It is possible that the data recorder can become overwhelmed in areas with a high density of sightings. For this reason a DR system is not usually feasible for double platform configurations, when multiple observations coincident in time can be expected. Finally, there is often a slight time lag between making an observation and having it recorded. While this is not necessarily an issue for conventional line transect surveys, it is for cue-counting and circle-back surveys which rely an accurate timing to estimate radial distances and duplicate probability respectively.

All surveys using a double platform configuration used an OR system, as did 38% of those using a single platform. The advantages of the system mainly reflect the disadvantages of a DR system: possible better utilization of aircraft space, more accurate timing and the creation of a permanent record that can be analyzed repeatedly. The main disadvantage is the necessity for post-flight transcription. This latter issue can be serious if there is no opportunity for data transcription during the survey, because observers should be monitored consistently. In a worst case this can lead to data loss through an undetected malfunction, as happened in the 2009 Icelandic aerial survey (Pike *et al.* 2009).

Evaluation

The Icelandic aerial survey has used an OR system since its inception. As mentioned an OR system with accurate and identical timing on all channels is an absolute requirement for cue counting. In this survey the flight leader recorded environmental conditions navigational information in addition to his own sightings. This information was transcribed post-flight, in 2009 with the assistance of ground personnel. The recording system is now somewhat dated technically and recommendations for its improvement are provided in Appendix 1.

The Canadian component of T-NASS used a modified DR system in which observers recorded the time of their observations using a keyboard and were then queried by the data recorder for the details of the sighting. This latter innovation improves the accuracy of sighting times which are important for duplicate matching. In addition each observer was equipped with a notepad to record details of sightings in cases where the data recorder was engaged. The data recorder used VOR software to record sightings and environmental conditions. The reliability of this system might be improved if the observers recorded their observations vocally instead of using notepads, as memory can be faulty and note taking diverts observer attention.

The Faroese 2009 survey used a DR system with VOR software. The survey was modelled after harbour porpoise surveys conducted using circle-back in Germany and elsewhere (Gilles *et al.* 2011), even though the survey itself did not use circle-back.

There are advantages to recording observations vocally, especially accurate timing of observations and creation of a permanent record. Some observers (including me) have difficulty remembering the details (*e.g.* angles and headings) of a sighting within moments of making it. Therefore, I recommend that observers record their observations vocally even in cases where a data recorder is used. In addition an OR system is probably essential for any double platform configuration.

Some form of DR, wherein the data recorder also acts as navigator, is probably essential for a circle-back survey, as adaptive decision making and careful navigation are required for this survey type. Even in surveys of this type, however, recording observations vocally is recommended for the reasons noted above.

Video and still photography

Of the 48 surveys assessed, 4 (8%) were classified as primarily photographic. Three of these targeted beluga and/or narwhal. The remaining one (Witting and Kingsley 2005) had minke, fin and humpback whales as the primary target species. This latter survey is generally considered to have been unsuccessful because so few whales were detected on the photos and abundance estimates were hence much lower than comparable visual surveys in the same area (West Greenland).

Of the 44 visual surveys, 6 incorporated video, 11 used still photography and 5 used both. Of the latter 4 were done by the same survey group (Heide-Jørgensen *et al.*).

Although 6 surveys used video, only 1 (Heide-Jørgensen *et al.* 2002) actually used the system to count whales. In this West Greenland survey a single video camera was used to monitor the trackline. Video monitoring was essentially used as a second platform and video detections were used as trials for the visual observers in a sight-resight analysis. The remainder of the surveys that used video used it for habitat monitoring, mainly for ice cover (Heide-Jørgensen *et al.* 2002, 2007, 2009, 2010, Laidre *et al.* 2011). Other surveys did not report any use of the collected video.

Only 2 of the primarily visual surveys that incorporated still photography used it for counting whales. One narwhal survey (Asselin *et al.* 2011) used an adaptive survey design wherein a photographic strip survey was triggered when large concentrations of narwhal were encountered. Similarly Richard (2005) reported a beluga survey that used photo-strip methodology to census estuarian concentrations. Others used photography for habitat classification, confirmation of group sizes, photogrammetry and adult/calf classification but these results were generally not reported in detail and were secondary to the visual survey results.

Evaluation

The use of video and still photography in aerial surveys is now much less expensive due to the progress made in digital photography and especially data storage. The latter used to be a significant barrier as hours of video or thousands of photographs required a substantial amount of space; however very large capacity hard drives are now inexpensive, compact and readily available.

The use of still photography as a census method has been largely limited to highly visible species that aggregate in large numbers, most often narwhal and especially beluga. It has been less successful for more cryptic species that do not aggregate, such as minke and fin whales. In the latter case the main barrier is certainly detecting whales on the photos, when the vast majority of sometimes 10’s of thousands of photos will not contain whales. This can be very difficult as a surfacing whale, photographed instantaneously, can be very difficult to distinguish from a wave or other disturbance. Even if it does appear to be a cetacean it may be impossible to identify to species from a single photo. So far, software to detect whales on vertical photographs has not been developed.

Video may offer an advantage here as the human eye more readily detects movement against a background. My own experience with the use of video in Antarctica (Kelly *et al.* 2010) suggests that medium size species such as killer and minke whales can be readily detected, however these data have not been formally analyzed (N. Kelly pers. comm.). Mellor and Maher (2008) found that marine birds were readily detected and identified to species using an HD video system flown at 600 m, which would certainly imply that cetaceans could be detected as well.

Both types of photography provide a permanent record of the survey that can be analyzed post-survey. For surveys that use both visual observers and photography, the camera is clearly independent from the observers and can provide a second “platform” for estimating perception bias through mark-recapture. Even if not used for this purpose, the photographic or video record can be used as an adjunct to the visual observations to more accurately estimate perpendicular distances, confirm species identity and group size and composition, measure animal size and perhaps individually identify animals.

The Greenlandic aerial survey portion of T-NASS 2007 used both video and still photographic surveillance of the trackline. Neither was used in any subsequent data analysis (Heide-Jørgensen *et al.* 2010). The Greenlandic system is interesting however as it is a fully integrated data collection system for spatially related video, still photos and multichannel observer recordings. Video and photos collected using the same system have been used for habitat classification in other analyses (Heide-Jørgensen *et* *al.* 2002, 2007, 2009, Laidre *et al.* 2011). No other T-NASS aerial survey used video or still photography.

The cost of a video and/or still camera system is moderate, especially when compared to other costs (such as aircraft time) of a survey. The systems are lightweight, compact and generally do not take up space that could be otherwise used. Therefore such a system can be used even with a small aircraft such as a Partenavia. In fact a video system would seem particularly valuable in small aircraft that do not have space for 2 sets of observers. Even if the collected data is not immediately used in estimating abundance, it can be stored and analyzed at any time in the future. Therefore there seems little reason not to include a camera system in future aerial surveys.

Analysis type

While data analysis is not a primary focus of this review, I present it briefly here because the type of analysis that is possible is generally dictated by the type of data that is collected. Classified broadly by analysis type, 35% used mark-recapture distance sampling (MRDS). Of these 10% were cue counting surveys while the remainder used line transect methodology. All of these by necessity used a double platform configuration to generate the sight-resight data required for this technique.

Conventional distance sampling (CDS) techniques were used by 19% of the surveys, while 10% used multiple covariates distance sampling (MCDS). The remainder of the surveys used more specialized techniques such as CDS combined with circle-back (6%) and encounter rate mapping (21%). Photographic surveys used a strip transect approach (8%).

Bias correction

Estimation of the proportion of visible pods that are missed by observers (perception bias) requires sight-resight data generated by a double platform configuration, either within a single aircraft or through the circle-back technique. Perception bias was estimated and corrected in 46% of the surveys; of these 35% used MRDS while the remainder used circle-back. The remainder (54%) of the surveys did not estimate this bias.

The proportion of whale pods that are submerged during the passage of the aircraft and therefore not available to be seen (availability bias) presents a different problem for aerial surveys as it usually cannot be estimated using data from the survey alone. An exception here is the circle-back technique, used in 8% of the surveys, which provides data to estimate perception and availability bias simultaneously; however the two biases cannot be discriminated in this type of analysis (Hiby 1998, Hiby and Lovell 1998). The cue-counting technique, used by 10% of the surveys, estimates the density of whale behaviours or cues, usually dives or blows, in the survey area. The rate at which the animals cue must be estimated separately outside of the actual survey, generally through observational studies and/or tagging experiments. The combination of cue rate and cue density provides an estimate of abundance that is not biased by availability (Hiby and Hammond 1989). The remainder of the surveys that did correct for availability bias (33%) incorporated an estimate of near-surface availability, generated from observational or tagging studies, to estimate the bias.

In the latter methodology the proportion of whales at or near the surface is used as a multiplier to correct for availability bias. The depth range at which whales are considered visible depends on water clarity and other factors, and is sometimes assessed using artificial targets (*e.g.* Heide-Jørgensen *et al.* 2009, 2010). For example, if half of all whales are, on average, within the visible depth range, the survey estimate might be doubled. However, as this is an "instantaneous" rate or proportion, this is only true if the sighting process is also instantaneous, as for example is a photograph. If the instantaneous availability proportion is used to correct a survey in which the sighting process is not instantaneous, the estimate may be "overcorrected" and therefore positively biased. The length of time that a sighting is potentially in view of an observer (Time in View, TIV) depends on the observer's field of view and the speed of the aircraft. If TIV is known or can be estimated, this can be combined with information on the dive cycle of the target species to estimate availability bias (McClaren 1961, Laake *et al.* 1997).

Unfortunately, few aerial surveys actually record the exact time at which an animal is sighted: most only record the time at which the sighting passes abeam of the aircraft. Both times must be recorded to estimate the length of time the sighting was in view of the observer. Perhaps as a result, 27% of the surveys, or 81% of those that used this method of estimating availability, applied the instantaneous availability proportion without accounting for TIV. Only 3 surveys (6%) explicitly incorporated TIV in estimating availability bias, and one of these (Lawson and Gosselin 2011) did not record TIV but estimated it from platform speed, altitude and sighting distances.

The TIV depends on a number of factors including aircraft speed and altitude, observer searching pattern, the availability of bubble windows, and the visibility of the target. The latter depends on target size and cue type, as well as environmental conditions. Generally speaking TIV will be longer for large conspicuous species such as humpback whales and shorter for small cryptic species such as harbour porpoises. Heide-Jørgensen *et al.* (2010) estimated that minke whales were in view of observers for an average of 2.6 seconds (CV 0.29) during an aerial survey off West Greenland. This can be very dependent on the searching pattern of the observers: the mean TIV for minke whales from a cue counting survey around Iceland in 2009 was 8.3 seconds (CV 0.90) (D. Pike unpublished data).

Evaluation

The Icelandic cue counting surveys should theoretically provide unbiased estimates of minke whale abundance because they incorporate a double platform configuration to estimate perception bias and cue counting is not biased by availability (see above). The double platform configuration used is however not fully satisfactory as the secondary platform has a poor view below the aircraft. Perception bias may therefore be poorly estimated in some cases. The incorporation of a video and/or photographic platform, or the use of a larger aircraft with 2 sets of bubble windows, should be seriously considered for this survey.

The collection of radial distances to cues forms the basis of cue counting. Unlike in some line transect surveys, forward detection distances, and therefore TIV's, are collected for every sighting. To provide an alternative estimate of abundance, these data could be analyzed as a line transect using MRDS methods, then corrected for availability using the TIV distribution and available data on minke whale dive cycles (summarized by Lawson and Gosselin 2011). Such an analysis would be useful for comparison with the extant cue counting estimates and is strongly recommended.

The Canadian component of T-NASS 2007 used MRDS to estimate perception bias for the Newfoundland and Labrador portions of the survey (Lawson and Gosselin 2011). The Southern Nova Scotia and Gulf of St Lawrence did not incorporate a double platform. As perception bias nearly always exists and can be very substantial, the use of a double platform configuration in all areas is strongly recommended.

Lawson and Gosselin (2011) used published dive cycle information and estimated TIV to provide a correction for availability bias for some species. TIV was estimated using the largest perpendicular distance for a given species and assuming that observers searched in a semi-circular pattern. Forward distances and therefore TIV's were estimated trigonometrically. This rests on assumptions about observer behaviour, so the direct recording of forward distances would provide a more certain estimate of TIV. This is not feasible using the data collection system as was implemented in 2007 (Lawson and Gosselin 2008), so the development of a system that would facilitate this is recommended.

All surveys that use dive cycle information and TIV to estimate availability bias are of course dependent on the quality of the dive cycle information available. As diving behaviour may change with location, season or time of day, ideally the dive cycle data should come from the survey area, coincident in time with the survey. However, these are rarely achieved; (but see Innes *et al.* 2002).

The Faroese survey conducted in 2009 used MCDS analysis combined with an availability/perception bias correction derived from other surveys using the circle-back technique (Gilles *et al.* 2011). While the methodology and observers used in the survey were the same as those for which the availability/perception correction was derived, a survey-specific estimate would clearly be better. If this survey is conducted again, circle-back or other techniques to estimate availability and perception bias should be incorporated.

Use of unmanned aerial vehicles (UAV)

Unmanned aerial vehicles (UAV) are pilotless aircraft that are either remotely controlled from the ground, autonomous to some degree, or both. The most highly developed UAVs are available for military applications but civilian UAVs are also available. In fact the development of UAVs is a burgeoning field: Koski *et al.* (2010) estimated that more than 200 UAVs available or under development in the USA alone.

Koski *et al.* (2010) provide a thorough evaluation of the available UAVs and their application to surveys of marine mammals, and I will not replicate that here. Koski *et* *al.* (2010) concluded that most available civilian systems did not meet the minimum requirements for a marine aerial survey, but that several candidate systems might do so in the near future. Regulatory hurdles that preclude the operation of UAVs without special dispensation remain a serious issue in some jurisdictions. The best UAVs are presently too costly for most survey groups, but costs will likely come down as UAVs are further developed.

As UAVs applied to whale surveys will use HD video and/or still photography, the adoption of these technologies in manned survey platforms will simplify the transition to UAVs when they become more readily available.

CONCLUSIONS AND RECOMMENDATIONS

A review of aerial surveys conducted over the past 10 years suggests a general lack of innovation in field methodologies. Most surveys used 2 observers only and either did not correct for any biases, or did so using a simple (and erroneously applied) instantaneous availability rate. All observers continue to use mechanical inclinometers designed for forestry to measure angles, in a time when the simplest mobile phone or game controller incorporates a GPS and accelerometer. That said, the review provided several ideas for improvement of the T-NASS aerial surveys, especially in the areas of data acquisition, bias correction and the use of video or still photography.

Certainly the most exciting areas of development in aerial survey are in the use of photography, especially HD Video. The advantages of having a permanent record of a survey, rather than relying solely on inherently unreliable human observers, are obvious. Another area of rapid development is in the use of UAVs, but these are not yet ready for wide application to marine surveys. Certainly we can expect rapid development of aerial survey techniques in the next decade.

General recommendations are outlined below.

Survey design

1. The stratification of the Icelandic aerial survey is generally effective for minke whales. However distribution does change between surveys and an adaptive approach, wherein the survey area is first covered at low effort and then additional effort is applied to areas of high density, should be considered.
2. A systematic design using parallel equally spaced transects is best for most surveys as it always results in even coverage. Zig-zag designs may be preferable for very large, low coverage strata where ferrying time is an issue, or rectangular strata.
3. The transect layout used in the Icelandic aerial survey results in uneven coverage in the inner strata, although this has not been quantified. Modification of this design will depend on the competing priorities of survey comparability and unbiased abundance estimation
4. The designs of the Canadian T-NASS and Faroese 2009 surveys are adequate. Future changes in stratification could be based on observed animal density.

Platforms

1. All surveys should use double platforms, both platforms with bubble windows
2. The secondary platform used in the Icelandic aerial surveys is inadequate as it does give a good view close to the aircraft. A larger aircraft and/or the use of a photographic secondary platform (see below) should be considered.
3. One of the aircraft used in the Canadian T-NASS did not have a double platform configuration. Future surveys should have double platforms on all aircraft.
4. The circle-back method appears to be successful for harbour porpoise surveys but has not been adequately tested for other species.

Data acquisition

1. Vocal recordings are the most efficient and reliable means of recording observer observations, and should be used on all surveys, even in cases where a dedicated data recorder is employed.
2. A system to record angle measurements directly, perhaps using an electronic inclinometer, should be developed.
3. A means of more accurately determining when a sighting comes abeam of the aircraft should be developed.
4. The recording system used in the Icelandic aerial survey is dated, becoming unreliable and must be improved.

Video and still photography

1. HD video and/or still photographic equipment is of moderate cost and excellent quality and should be considered for all surveys.
2. The use of HD video as a secondary platform for the Icelandic aerial survey should be considered.

Bias correction

1. Perception bias cannot be corrected without double platform data; therefore double platforms are required on all surveys (except those using circle-back).
2. Forward sighting distance and time in view (TIV) is required for the correction of availability bias using dive cycle information. Therefore TIV should be collected for every sighting. This again requires the use of observer recordings and accurate timing of observations.
3. Cue counting requires the collection of TIV data. The Icelandic survey data should be analyzed using a correction for availability based on TIV and dive cycle data, for comparison with estimates based on cue counts.
4. Ideally dive cycle information, including cue rates, should be collected from the survey area at the same time of year the survey is carried out.

UAVs

1. Civilian UAVs suitable for marine aerial survey are currently too costly and/or not adequately tested. The use of HD Video and/or still photograph in conjunction with visual aerial surveys will facilitate the transition to UAVs should they become available.

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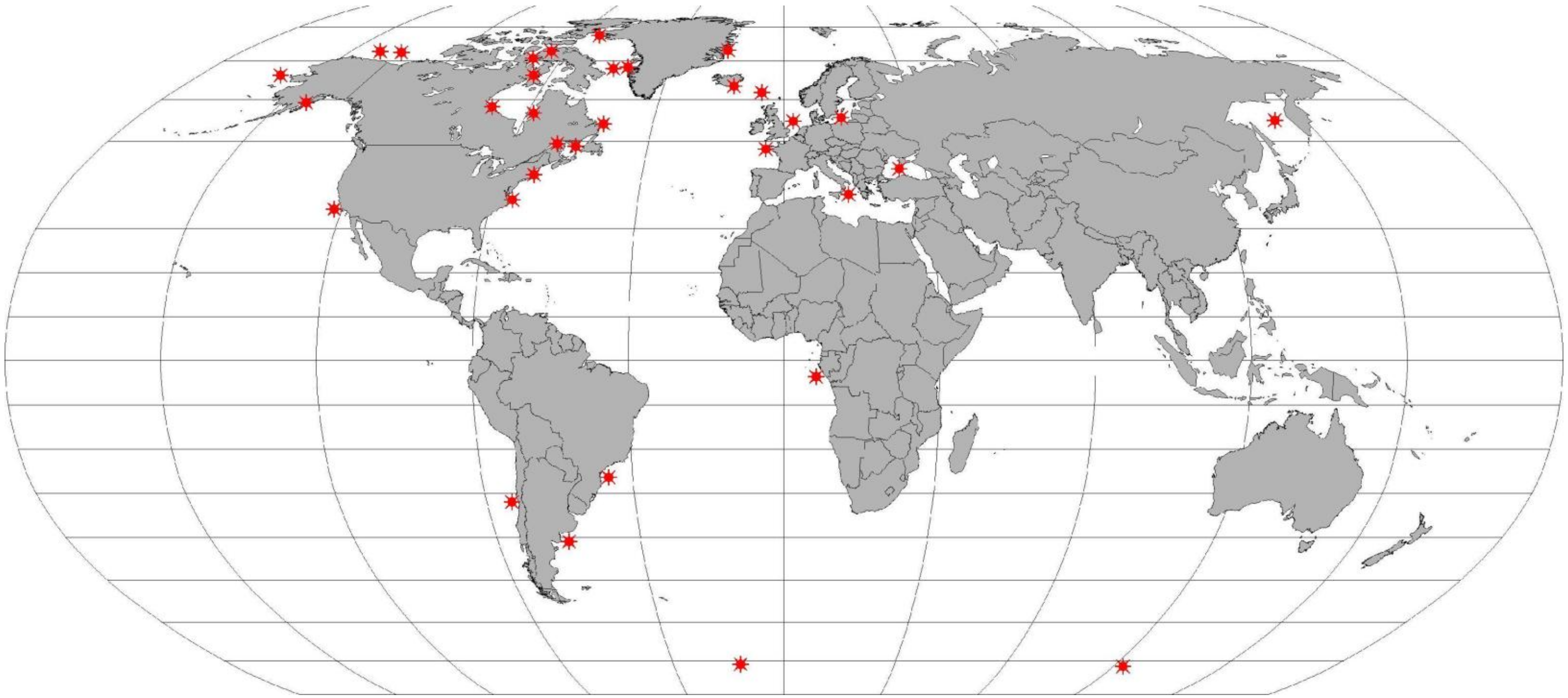


Figure 1. Locations of aerial surveys used in the assessment.

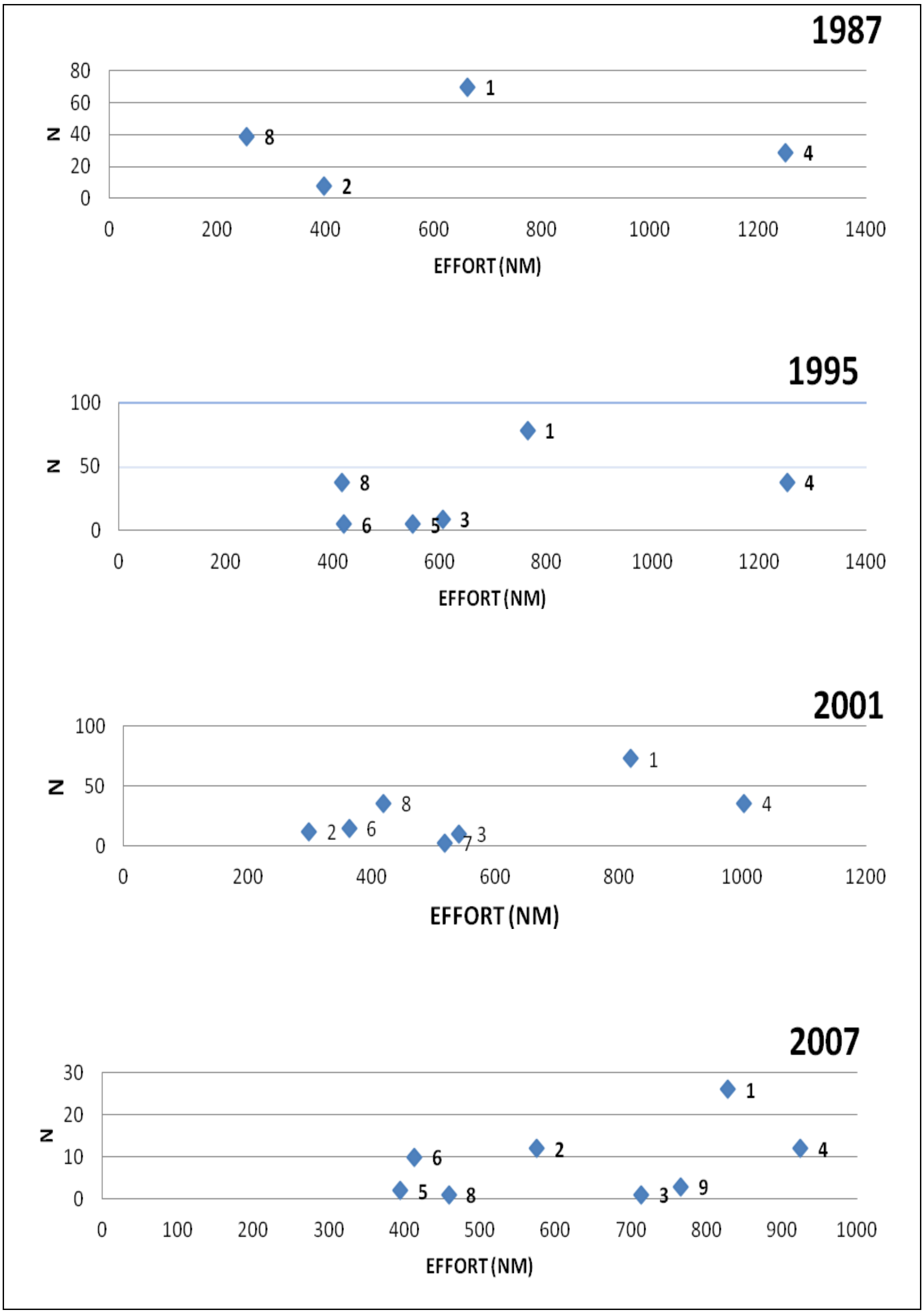


Figure 2. Numbers of sightings (N) by stratum in Icelandic aerial surveys. Strata labelled in the graphs.

Appendix 1

List of surveys assessed

V/P – visual or photographic; SUR – Survey type, LT=line transect, CC=cue counting, P=photo, A=adaptive; PER_B – Perception Bias correction, MR=mark recapture, CB=circle back, N=none; AVA_B – Availability Bias Correction, SD=surfacing data, CB=circle back, CC=cue counting, N=none; DES – Design, P-ES=parallel equal spaced, Z-ES=Zigzag equal spaced; TARG – Target species; Size – target species size; Aircraft – Aircraft type, FH=fixed high wing; FL=fixed low wing; RH=rotary; P/S – Platforms/Stations; WIN_P/S – Windows, Primary/Secondary, B=bubble, F=flat; DREC – Data recording, OR=observer recordings, DR=data recorder; VID – Video, Y or N; STIL – Still photography, Y or N; ANLYS – Analysis Type, MRDS=Mark Recapture Distance Sampling, CDS=Conventional Distance Sampling, MCDS=Multiple Covariates Distance Sampling, CB=Circle back, CC=cue counting, ER=encounter rate; AVAIL – Availability bias correction methodology, TIV=Time in view, CB=circle back, CC=cue count, I=instantaneous, N=none.

REF	**V/P**	**SUR**	**PER_B**	**AVA_B**	**DES**	**TARG**	**SIZE**	**AIRC**	**P/S**	**WIN_ P/S**	**DREC**	**VID**	**STIL**	**ANALYS**	**AVAIL**	**SOFTW**
Asselin and Richard 2011	V	LT-P-A	MR	SD	P-ES, Z-ES	MM	S	FH	2/4	B/B	OR	N	Y	MRDS	TIV-FR	D
Berggren et al. 2004	V	LT	CB	CB	Z-ES	PP	S	FH	1/2	B/	DR	N	N	CDS-CB	CB	PR
Birkun et al. 2003	V	LT	N	N	P-ES	PP, TT	S	FH	1/2	B/	OR	N	N	CDS	N	D
Blokhin et al.2004	V	LT	N	N	P-ES	ER	L	FH	1/2	F/	OR	N	N	ER	N	PR
Borchers et al. 2009	V	CC	MR	CC	Z-ES	BA	M	FH	2/3	B/F	OR	N	N	MRDS-CC	CC	D
Burt et al. 2008	V	LT	CB	CB	Z-ES	PP	S	FH	1/2	B/	DR	N	N	CDS-CB	CB	PR
Clarke et al.	V	LT	N	N	VAR	Bmy	L	FH	1/2	B/	DR	N	N	ER	N	NA

REF	**V/P**	**SUR**	**PER_B**	**AVA_B**	**DES**	**TARG**	**SIZE**	**AIRC**	**P/S**	**WIN_ P/S**	**DREC**	**VID**	**STIL**	**ANALYS**	**AVAIL**	**SOFTW**
2010																
Clarke and Ferguson 2010	V	LT	N	N	P-ES	EG	L	FH	1/2	B/	DR	N	Y	ER	N	NA
Cosens et al. 2006	V	LT	MR	SD	P-ES	BMy	L	FH	2/4	F/F	OR	N	N	MRDS	I	D
Crespo et al.2004	V	LT	N	SD	Z-ES	PB	S	FH	1/2	F/	DR	N	N	MCDS	TIV-ALT	D
Gilles et al. 2011	V	LT	CB	CB	P-ES, Z-ES	PP	S	FH	1/2	B/	DR	N	N	MCDS	CB	D
Gosselin 2005	V	LT	N	N	P-ES	DL	M	FH	1/2	B/	OR	N	N	CDS	N	D
Gosselin et al. 2007	V	LT	N	N	P-ES	DL	M	FH	1/2	B/	OR	N	N	CDS	N	PR
Gosselin et al. 2007	V	LT	N	SD	P-ES	DL	M	FH	1/2	B/	OR	N	N	CDS	I	D
Gosselin et al. 2009	P	P	N	SD	P-ES	DL	M	FL	1/2	NA	P	N	Y	S	I	PR
Gosselin et al. 2001	V	LT	N	N	P-ES	DL	M	FH	1/2	B/	OR	N	N	CDS	N	D
Gosselin et al.2002	P	p	N	SD	P-ES	DL	M	FL	1/2	NA	P	N	Y	S	I	PR
Hammond et al. 2002	V	LT	CB	CB	Z-ES	PP	S	FH	1/2	B/	OR	N	N	CDS-CB	CB	PR
Heide-Jorgensen and Acquarone	V	LT	MR	SD	P-ES	DL, MM, Bmy	M,L	FH	1/2	B/	OR	Y	N	MRDS	I	D

REF	V/P	SUR	PER_B	AVA_B	DES	TARG	SIZE	AIRC	P/S	WIN_ P/S	DREC	VID	STIL	ANALYS	AVAIL	SOFTW
2002																
Heide-Jorgensen et al 2007	V	CC	MR	CC	P-ES	BA, BP, MN	M,L	FH	2/3	B/F	OR	N	N	MRDS	CC	D
Heide-Jorgensen et al 2009	V	LT	MR	SD	P-ES	BMy	L	FH	2/4	B/B	OR	N	N	MRDS	I	D
Heide-Jorgensen et al 2007	V	LT	MR	SD	P-ES	DL	M	FH	2/4	B/B	OR	Y	Y	MRDS	I	D
Heide-Jorgensen et al. 2010a	V	LT	MR	SD	P-ES, Z-ES	MM	M	FH	2/4	B/B	OR	Y	Y	MRDS	I	D
Heide-Jorgensen et al. 2010b	V	LT	MR	SD	P-ES	BA, BP, MN	M,L	FH	2/4	B/B	OR	Y	Y	MRDS	TIV-AVG	D
Hobbs et al. 2010	V	LT	MR	SD	Z-ES	PP	S	FH	2/3	B/Belly	DR	N	N	MRDS	I	D
Innes et al.2002	V	LT	MR	SD	P-ES	DL, MM	M	FH	2/4	F/F	OR	N	Y	MRDS	I	D
Jung et al. 2009	V	LT	N	N	Z-ES	PP	S	FH	1/2	B/	DR	N	N	ER	N	NA
Kelly et al. 2010	V	CC	MR	N	P-ES, Z-ES	BB	M	FH	2/4	F/F	OR	Y	Y	MRDS-CC	N	D
Laidre and Heide-	V	LT	MR	SD	Z-ES	MM	M	FH	2/4	B/B	OR	Y	Y	MRDS	I	D

REF	V/P	SUR	PER_B	AVA_B	DES	TARG	SIZE	AIRC	P/S	WIN_ P/S	DREC	VID	STIL	ANALYS	AVAIL	SOFTW
Jorgensen 2011																
Lauriano et al. 2011	V	LT	N	N	P-ES	BP, SC, TT	S,L	FH	1/2	B/	DR	N	N	MCDS	N	D
Lawson and Gosselin 2008	V	LT	MR	N	Z-ES	UW	S,M,L	FH	2/3	B/B	DR	N	N	MRDS	N	D
Martins et al.2004	V	LT	N	N	P-ES, Z-ES	MN	L	FH	1/2	B/	DR	N	N	ER	N	NA
Moore et al.2010	V	LT	N	N	P-ES, Z-ES	ER	L	FH	1/1	na	DR	N	N	ER	N	NA
Moore et al.2003	V	LT	N	N	P-ES	BMy	L	FH	1/2	B/	NA	N	Y	ER	N	NA
Pike and Gunnlaugsson 2008	V	CC	MR	CC	Z-ES	BA	M	FH	2/3	B/F	OR	N	N	MRDS-CC	CC	D
Pike 2009	V	CC	MR	CC	Z-ES	BA	M	FH	2/3	B/F	OR	N	N	MRDS-CC	CC	D
Pike et al. 2011	V	CC	MR	CC	Z-ES	BA	M	FH	2/3	B/F	OR	N	N	MRDS-CC	CC	D
Richard 2005	V	LT-P	N	SD	P-ES	DL	M	FH	2/3	B/F	OR	N	Y	CDS	I	D
Richard 2010	P	P	N	N	P-ES	MM	M	NA	1/1	NA	P	N	Y	S	N	PR
Rosenbaum et al.2004	V	LT	N	N	Z-ES	MN	L	FH	1/2	F/	DR	N	N	CDS	N	NA
Scheidat et al. 2007	V	LT	N	N	P-ES	UW	L	RH	1/2	B/	ORDR	N	Y	ER	N	NA
Shelden and	V	LT	N	N	P-ES	ER	L	FH	1/2	B/	DR	N	N	ER	N	NA

REF	V/P	SUR	PER_B	AVA_B	DES	TARG	SIZE	AIRC	P/S	WIN_ P/S	DREC	VID	STIL	ANALYS	AVAIL	SOFTW
Laake 2002																
Torres et al.2005	V	LT	N	N	P-ES	TT	S	FH	1/2	B/	DR	N	N	ER	N	NA
Vernazzani et al. 2009	V	LT	N	N	Z-ES	BM	L	FH	1/2	F/	OR	N	N	CDS	N	D
Wedekin et al.2010	V	LT	N	N	P-ES, Z-ES	MN	L	FH	1/2	B/	DR	N	N	MCDS	N	D
Witting and Kingsley 2005	P	P	N	SD	P-ES	BA,BP	M,L	FL	1/2	NA	P	N	Y	S	I	PR
Yazvenko et al. 2006	V	LT	N	N	P-ES	ER	L	FH	1/2	F/	DR	N	N	CDS	N	D
Zerbini et al. 2011	V	LT	ALT	N	P-ES	PB	S	FH	2/4	B/F	OR	N	N	MCDS	N	D

Appendix 2

Recommendations for improvement of the recording system used in Icelandic aerial surveys, compiled after the 2009 survey.

Problems

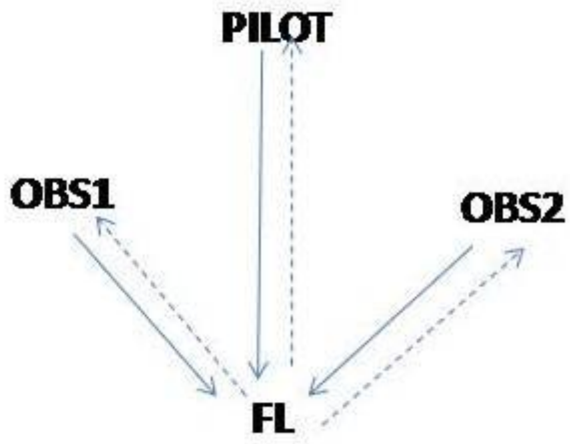
1. The software “HVAL2004” is intended for ship surveys and records time with at 1 second intervals. While this is adequate for a slow moving ship it is not for a plane, which moves over 50 m in 1 second. In addition the software can be adjusted to record positions at a minimum of 1 minute intervals, which is not precise enough for an aerial survey.
2. There is a slight (fraction of a second) time delay between pressing the microphone button and when the recording begins. Thus the first word of many records (usually “Dive”) is often missed.
3. The present system requires 3 laptop PCs to be running at all times. They are difficult to secure adequately in the airplane and take up most of the cargo space. They are also doing nearly nothing, and 1 computer should be more than sufficient for the monitoring needs.
4. Use of the handheld microphone to make recordings is extremely cumbersome for the primary observers particularly, as they must use both hands to make observations in the rather small bubble windows.

Recommendations

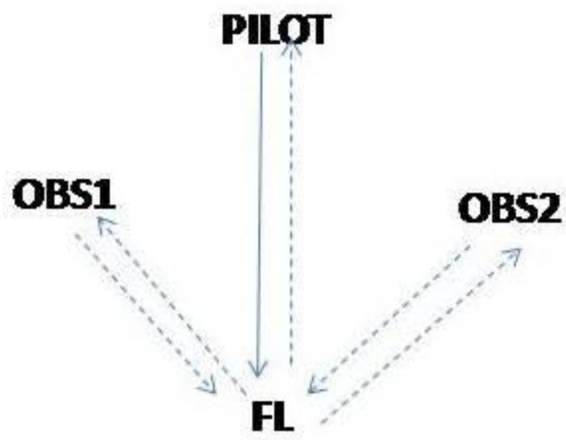
The system used is nearly 10 years old and was developed at a time when computer memory was much more expensive and bulky than it is now. Hence it was reasonable to have a system that minimized the consumption of memory by recording observations only. Now computer memory is inexpensive and compact, and there is no technical reason why vocal records of entire flights should not be recorded. This would free the observers from having to manually press a button and hold a microphone to make recordings. Instead the observer would use the headset microphone to make recordings.

The system envisioned would have to work in 3 operational modes. In the diagrams below the solid lines are open lines of communication, while the dashed lines require a manual switch (*e.g.* a button press):

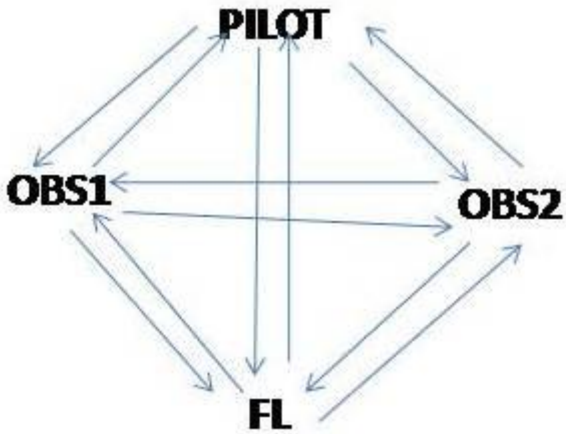
1. **Mode 1.** When FL is a non-independent observer. This would likely be used during training flights.



2. **Mode 2.** When FL is an independent observer.



3. **Mode 3.** (Chat mode) In non survey mode, *i.e.* ferrying or closing on a sighting.



System requirements

1. A recording channel for each observer. This could record onto a flash-memory card or to a computer hard-drive and would have a capacity of at least 10 hrs of continuous recording. The recordings would have a time signal from the computer, which would be synchronized to the GPS.
2. A switching device for each observer and the flight leader, to switch between modes.
3. A GPS that produces a log data file with date, time, lat and long, altitude, speed, etc., recorded at 1 second intervals throughout the flight.

There are likely many potential designs for such a system, and a technical expert should be consulted at the outset. But a very simple and inexpensive way of achieving this operational capability would be as follows:

1. All observers would record constantly through an open headset microphone to a single laptop computer equipped with a multi-channel sound card (minimum 3 channel) and the appropriate jacks. An alternative design would use individual voice recording devices at each station, but these should record onto a flash card or be easily down-loadable.
2. An adapter jack with an on/off switch or button and a splitter before the switch (i.e. the split would not be controlled by the switch) would plug into the aircraft intercom microphone jack, and the microphone jack from the headset would plug into this. The split would lead to the recording computer or dictaphone. Thus each station could easily shut down transmissions to the aircraft intercom system, but all voice at each station would be always recorded.
3. The survey modes would be controlled by switching on or off the intercom microphone switch. In Mode 1, the observer switch would be on, while the

FL switch would be off unless he/she wanted to speak to the observer. In Mode 2, the usual survey mode, all switches would be off. The FL could speak to the observers by switching on his/her microphone, and the observers could speak to the FL by doing the same. In Mode 3, all switches would be on.

The data output for each flight would be a single recording for each observer and the FL, and the GPS output. After the audio data are entered they can be easily merged by date and time with the GPS data. Data entry from single long recordings may seem daunting, but it is actually very simple using freely available software such as Audacity, as the voice records are easily found visually in the files.

Appendix 4

REVIEW OF DOUBLE PLATFORM IMPLEMENTATION IN SHIPBOARD SIGHTINGS SURVEYS.

by

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INTRODUCTION

Shipboard surveys have widely been used in the NASS and T-NASS surveys by all the countries involved since the first one was carried out in 1987 (Víkingsson *et al.* 2009), principally in offshore areas but also in coastal areas. They are, at present, the only platforms that can operate in the far offshore, where aerial surveys lack the range to operate.

Besides the design of representative and efficient surveys, there are several practical difficulties in meeting the key assumptions (*e.g.* Buckland et al. 1993, 2001) of conventional line-transect sampling when conducting shipboard cetacean surveys. Conventional line-transect methods for estimating abundance assume in particular that

1) all animals on the trackline line are detected with certainty (*g(0)*=1)
2) perpendicular sighting distances (*i.e.* radial distances and angles to animals) are measured without bias and error.
3) all animals are stationary, *i.e.*, they are detected before they may move in response to the survey platform.

Also school size should be estimated without error.

On most cetacean surveys, the assumption that *g(0)*=1 is questionable or known to be false (*e.g.* Hammond *et al.* 2002). Animals on the track line may be unavailable for detection a) because they are underwater (availability bias), or b) observers may fail to detect them even though they are available (perception bias). Responsive movement of animals to survey ships before they are detected may also lead to severe bias in line transect estimates of abundance - negative if animals avoid ships and positive if animals are attracted to ships. The most problematic bias in terms of conservation is the positive bias caused by strong attraction, such as has been demonstrated for example for common dolphins (Cañadas *et al.* 2004, Deboer *et al.* 2008).

Since the first NASS survey was conducted in 1987, there have been several key developments in field methods and analysis for shipboard surveys, in the hope of meeting the given assumptions or for allowing the estimation of the biases. For the latter, a variety of methods combining mark-recapture and distance sampling (MRDS) methods have been developed (see Laake and Borchers, 2004, for an overview), requiring double platform (DP) configurations to generate duplicate sightings data from which *g(0)* can be estimated. Hammond *et al.* (2006, appendix A2.1) reviewed data collection and analysis methods for shipboard data to inform the development of methods to be used in SCANS II 2005.

Two main configurations have been used, an independent observer configuration (IO mode, two independent but symmetrical teams of observer, which survey the same area of the sea) and a trial-observer configuration (BT mode, a "Tracker" team search ahead of the area searched by an independent "Primary" team).

The IO method typically allows abundance estimates to be corrected for perception bias and double platform track line conditional independence procedures may be used for estimating abundance (*e.g.*, Palka 1995; Borchers *et al.* 2007).

The BT method (Buckland and Turnock, 1992), allows abundance estimates to be corrected both for animals missed on the transect line and for movement of animals in response to the survey ship.

Palka and Hammond (2001) developed a method for accounting for responsive movement using data recorded in any mode. They look whether responsive movement is occurring by using the recorded initial swim direction. If it does, they apply a modified BT two-team analysis method where the sighting data are post-stratified into regions "close" to the ship (between the ship and a critical radial distance) and "far" from the ship (beyond that distance) instead of the original BT stratification by observation team. The PH method simultaneously estimates *g(0)* and accounts for responsive movement, and cannot separate out the effect of responsive movement from the effect of *g(0).*

Laake (1997) describes methods for correcting abundance estimate for availability bias.

Both SCANS surveys (1995 and 2005) used DP shipboard surveys with a trial-observer configuration (Hammond *et al.* 1995, 2006). The logistic/technical implementation of the method was very much developed under/for SCANS II, the development focusing on achieving an automated data logging method and improving methods to measure distance and angle to sightings (Hammond et al. 2006, Gillespie et al. 2010). The SCANS II method was later implemented in the concurrent CODA and T-NASS surveys in 2007, with only few modifications.

The NAMMCO Working Group and Scientific Committee recommended the use of a DP configuration in the shipboard component of future NASS surveys (NAMMCO 2011ab), because it provided important data with which to correct biases. While these biases tended to be more important for smaller, cryptic species such as minke whales than for larger species such as fin whales, analyses have demonstrated that they exist even for the latter.

However, recognizing that there had been problems with the implementation of the BT method in 2007 in both surveys and particularly on the T-NASS vessels, and that other types of double platform survey methodology, such as I/O as used by Norway, or different ways of implementing the BT method, e.g. with post-survey duplicate identification as used in SNESSA, were available, the NAMMCO Scientific Committee decided to recommend a study "to consider and compare the advantages and disadvantages of these approaches in the context of the target species mix and other circumstances expected in the next NASS".

Limited time was allocated to the review (40 hrs), which concentrated on reviewing the field implementation of the different DP methodologies and their technical and logistic requirements. In addition it looked how the problem with error in distance and angle estimation was tackled in both single platform and DP surveys.

MATERIALS AND METHODS

1) A non-exhaustive review of the recent literature (2000 and later) pertaining to shipboard surveys for cetaceans was conducted, as well as a wider specific search for shipboard surveys using a double platform methodology (since 1988). The focus was not on the analysis side but on the logistic implementation. Searches were carried out using the *ProQuest* system searching the *Biological Sciences* database, primarily using the search sentence (survey AND ship*) AND (whales* OR cetaceans* OR dolphins* OR porpoise*). Additional searches were carried out on the IWC documents (http://iwcoffice.org/documents/publications/SCSMWSDocs1970plus.pdf), the lists of unpublished documents held by NOAA (http://www.lib.noaa.gov/noaainfo/pubsource.html) and DFO (http://www.meds-sdmm.dfo-mpo.gc.ca/csas-sccs/applications/publications/index-eng.asp), the CREEM list of distance sampling related references (http://www.ruwpa.st-and.ac.uk/distancesamplingreferences/) and list of publications (http://www.ruwpa.st-and.ac.uk/Publications/index.htm). The logistic implementation of the method used is often not very detailed in the published literature, and we also had access to a number of survey guidelines, and cruise and survey reports.

2) A database of shipboard surveys using DP methodology, mostly conducted in the past 15 years, was compiled, including factors relating to survey type, target species, field methods, equipment, logging software, number of observers required and technical requirements.

3) Going beyond the strict scope of a review of double platform implementation, a review of the newest technical implementations for improving data recording (especially distance and angle estimate) and logging was also conducted.

4) Review of debriefing reports and CR from SCANS II, T-NASS and CODA to review problems encountered in the implementation of the BT method described in Gillespie et al (2010).

RESULTS AND DISCUSSION

1. REVIEW OF SURVEYS USING DP METHODOLOGY

A database including over 50 DP surveys conducted since 1984 was compiled (Appendix 1). Surveys performed by the same institute and using similar methodology and logistic implementation are grouped. Groups/institutes often keep to the same methodology, though developing methods for improving data collection.

Three types of double platforms mode have been used, with variants.

1.1 CIO mode, Conditionally Independent Observer mode: direct account of perception bias

A standard line transect is conducted but *occasionally* a "conditionally independent observer" search the same area as the primary observers and only announces sightings after they have passed abeam and have been clearly missed by the primary observation team (Barlow 1995)

- All cetaceans, several SWFSC surveys (Barlow 1995, Appler *et al.* 2004, Barlow *et al.* 2004, Calambokidis and Barlow 2004, Barlow and Forney 2007)
- Harbour porpoises, California 1995 (Caretta *et al.* 2000)
- All ceatceans, Gulf of Alaska AFSC surveys (GOALS), (Rone *et al.* 2010)

1.2 IO mode, Independent Observer mode: direct account of perception bias

Two independent (audibly and visually isolated) and symmetrical platforms search the same body of water. The two platforms act as two (independent) primary platforms, both providing a sighting rate. Three variants have been used.

1.2.1 IO Mode – one-way independence or trial independence*:*

A modified IO mode, where both platforms search the same body of water, but only one platform is independent for logistic reasons.

- Harbour porpoises, bottlenose dolphins and grey seals; Cardigan Bay (Reay 2005)

1.2.2 IO Mode with cetacean schools as sighting unit:

To facilitate the identification of duplicate sightings, some resightings are recorded, but no systematic tracking is performed.

- Harbour porpoises; California, Oregon and Washington 84-86 (Barlow 1988)
- Minke whales; Antarctic; IWC/IDCR-SOWER surveys (*e.g.* Butterworth and Borchers 1988, Matsuoka *et al.* 2003, Matsuoka *et al.* 2011);
- Minke whales and harbour porpoises; North Sea 90 (Øien 1992)
- Harbour porpoises; Gulf of Maine-Bay of Fundy 91 (Palka 1995)
- All cetaceans; Gulf of Maine-Bay of Fundy 98, 99, 04, AMAPPS-NE 11 (Palka 2005ab, 2006, AMAPPS 2011ab)
- White sided dolphins, fin & sei whales; Northwest Scotland 98 (MacLeod 2004, MacLeod *et al.* 2006)
- Minke whales; Western North Pacific (Miyashita 2006, 2007, 2008a,b, Miyashita and An 2010)

1.2.3 IO Mode with tracks of cues as sighting unit:

Specific tracking procedures are required for the target species: the observers shall concentrate on tracking the whale and report positional data (time, radial distance, angle) of all detected surfacings until the whale pass, or is assumed to have passed, behind abeam. The method is a *cue counting* variant. Analysis of these data requires estimate of cueing patterns or surfacing rates and generates abundance estimate corrected both for perception and availability biases.

- Minke whales; Northeast Atlantic; **NILS 1995-2011** (Øien 1995, Schweder *et al.* 1997, Skaug *et al.* 2004, NILS 2007, Øien and Bothun 2008, Bothun *et al.* 2009).

1.3 BT Mode, Buckland and Turnock mode: accounting for responsive movement, perception bias and some (a.o. species dependent) availability bias

Two asymmetrical platforms, where the higher, "tracker" platform search ahead of the area where the independent "primary" platform searches. The primary platform is independent of the tracker platform, but the reverse is not necessary. The primary platform (PP) provides the sighting rate, while the tracker platform generates trial for the PP.

- Small cetaceans; North Sea and adjacent waters – **SCANS 94** (Hammond *et al.* 1996, 2002, 2006, SCANS II, 2005a,b)
- Pilot and minke whales, dolphins; Northeast Atlantic; **Faroese NASS 95** (Desportes *et al.* 1996, Borchers *et al.* 1996, Burt and Borchers 1997, Cañadas *et al.* 2004, 2009)
- Common dolphins; Western approaches of the English Channel, WDCS 2005 (De Boer 2008)
- Minke whales and dolphins; Northeast Atlantic, **NASS 01** (Víkingsson *et al.* 2009)
- Small cetaceans in the North Sea and European Atlantic continental shelf waters – **SCANS II 05** (SCANS 2005, SCANS II 2006, MacLeod *et al.* 2009, Hammond *et al.* 2011)
- All cetaceans, European Atlantic offshore waters – **CODA 07** (CODA 2007, CODA 2009, MacLeod *et al.* 2009, Hammond *et al.* 2011)
- Fin, minke and pilot whales in the Northern North Atlantic – **TNASS 07** (TNASS 2007, Desportes 2011)
- Marine mammal and turtles, Gulf of Maine, **SNESSA 07** (Palka 2008)
- Minke whales, Antarctic **- SOWER experiment** (Burt and Borchers 2008)

2. LOGISTIC IMPLEMENTATION OF DOUBLE PLATFORMS ON SELECTED SURVEYS

We choose here to describe in more detailed the logistic of only the most recent surveys.

2.1 IO mode: 2 independent and symmetrical sighting platforms

Survey in IO mode are usually conducted in passing mode, although a delayed closure can be used as help to species identification and school size estimation.

The identification of duplicate sightings can be done on-line (real-time) or off-line (post survey).

Since both observer platforms must be independent, the on-line identification of duplicates requires that the duplicate identifier (DI) be placed on a separate platform, still allowing a good view over the search area and the sightings. A third "sighting" platform is therefore required. This 3-platform configuration is for example used in the IDCR/SOWER surveys (Butteworth and Borchers 1988, Matsuoka *et al.* 2003, Matsuoka *et al.* 2011) and some Japanese surveys Miyashita 2006, 2007, 2008a,b, Miyashita and An 2010). When this 3-platform configuration seams unlikely to happen in the framework of a T-NASS, we decided to not present further this type of configuration.

2.1.1 Schools as sighting unit

This methodology is used by the North West Atlantic NEFSC surveys, under the leadership of D. Palka. These surveys have a similar data collection methodology, although according to the target species the observers may be searching with naked eye (Palka 1995, 2000, 2006) or using Big Eyes (Palka 2005a,b, 2006, AMAPPS 2011a,b). Naked eye observers record their own data, while Big Eyes observers have a data recorder.

Example: AMAPPS 2011 (AMAPPS 2011a,b)

Target species: all marine mammals and turtles
Survey mode: delayed closing (abeam & <2nmi)
Identification of duplicate: off-line, using an automatic routine
Platform and observer configuration:

- Each team: 1 rest station and 3 work stations - a port big eye binocular (25x150 powered, BE), center observer/recorder (DR) (naked eye), and a starboard big eye binocular.
- Each BE search from 90º on side to about 10º on the other side.
- The recorder search (when not recording data) the entire area and should concentrate on distances close to the ship (from 30º port to 30º starboard and near the ship, from 0 to 1000m from the ship, where the high powered binoculars cannot see).
- **Periodic recording of resightings, but no systematic tracking**
- Each platform records its own data on its own independent ToughBook computer (+GPS).

Angles and radial distances.

- Angle: Angle ring at the base of each BE and mounted angle boards for the recorder.
- Distance: Reticle in the eye piece of the BE and E-Ranger (see under 4.4.1), naked eye or measuring stick estimation for the recorder.

Requirement in observers: 8 (2*3+1, with 2*2 dedicated observers)
Communication between platforms: no inter-platform communication needed
Data logging:

- Automatic data logging: date, time and position of ships, after sighting-input from data recorder
- No automatic sighting data transfer. All sighting data have to be announced to the recorder, incl. distance data from the E-Ranger.

Technical requirements:

- No communication system between platforms or between platforms and bridge.
- No cables connection between observer post and recorder computer.

2.1.2 Cues as sighting unit

This methodology has been used by the North East Atlantic NILS surveys, under the leadership of N. Øïen since 1995. The basic methodology is the same as that established in 1995 (Øïen 1995), but there has been much development in the technical logistics for data logging during the survey (*e.g.*, NILS 2007).
There is a single target species, the minke whale.

Example: NILS 2007 (NILS 2007, Bøthun *et al*. 2009)

Target species: minke whales
Survey mode: passing mode
Identification of duplicate: off-line, using an automatic routine
Platform and observer configuration:

- Each team consists of 2 on-effort observers searching using unaided eye and 2 off-effort observers. Observers rotate among the two positions within platform, but do not rotate between teams and platforms.
- 2 team leader alternate as data recorder in the bridge (as a back up to the audio recording).
- Search within 45° to 0° each on their side and within 1500 from vessel.
- **Specific tracking procedures for minke whales: the observers shall follow the whale and report the positional data (radial distance, angle) of all its surfacings until it passes, or is assumed to have passed, behind abeam.**
- Sightings data report is recorded as audio file directly to disc (central computer situated in the bridge) through a microphone with a push button. All microphones and buttons are connected to a central computer equipped with a GPS unit. Time delay due to software and hardware is expected to be less than one second for initial sightings and for resightings there is no time delay.
- Voice reporting to bridge through “intercom” of initial (minimal) sighting data after end of minke whale track or sighting of harbour porpoises and large whales.

Angles and radial distances.

- Mounted angle boards for the each observer
- Distance estimation by eye.

Requirement in observers: 10 (4 * 2 + 2)
Communication between platforms:

- No inter-platform communication needed, minimal reporting to bridge as a back up.

Data logging:

- Automatic data logging of vessel position and time, but not of sighting data.
- All sightings and resightings received a time and position stamp from the GPS unit in the audio files.

- Audio files translated to data form during the course of the survey when in off-effort mode.

Technical requirements:
- No communication system between observation platforms
- Each observation post is connected to bridge through communication cable to the DR and sound cable to central computer logging the voice files.

Remark
The method is very demanding and can only generate good data for one species at a time, the target species (in the Norwegian survey, the minke whale). Sightings of other species are recorded with lowest priority and in a normal way, as single sighting. The method is therefore not appropriate in multispecies target survey.

2.2 BT mode: 2 asymmetrical platforms with at least the primary platform independent

A BT mode implementation was first used in the SCANS 94 survey under the leadership of P. Hammond (Hammond *et al.* 1995). It was further developed for the SCANS II survey (SCANS II 2006), then used with little modification in the CODA (CODA 2007, 2009) and T-NASS (T-NASS 2007, Desportes 2011) surveys. The American NEFSC SNESSA survey used a simpler variant of the SCANS II implementation (Palka 2008).

The identification of duplicate sightings can be done on-line (real-time) or off-line (post survey).

2.2.1 Two independent platforms and off-line identification of duplicates

Example: SNESSA 2007 (Palka 2008)

Target species: all marine mammals and turtles
Survey mode: passing mode
Platform and observer configuration:
- Primary team (lower platform): 3 on-effort observers searching using naked eye + 2 off-effort observers. Search from 90° starboard to 90° port.
- Tracker team (upper platform): 4 on-effort observer, 2 searching with BE with each his own DR + 2 off-effort observers.
- The primary team determines the sighting rate of each species, i.e., record as many groups as possible, recording some resightings but no systematic tracking.
- The tracker team, both using BE, search from 60° starboard to 60° port, with an emphasis on the area 30° on either side of the track line, concentrate on tracking groups of animals from as far from the ship as possible to the time the group is abeam of the ship.
- Observers do not rotate between platforms.
- Systematic tracking by trackers: track groups of animals from as far from the ship as possible to the time the group was abeam of the ship.

- On either team, data logging of information on a computerized data entry device ("PingleNet"):

Angles and radial distances:

- Angle: Angle ring at the base of each big eye and mounted angle boards for the recorders and PO.
- Distance: Reticle in the eye piece of the BE, naked eye or measuring stick estimation for the recorder and PO.

Requirement in observers: 11 (3ne+2 // 2be+2dr+2)
Communication between platforms: no inter-platform communication needed
Data logging:

- Three separate data logging, one for each tracker, and one for the primary team.
- Automatic data logging: date, time and position, after input from data recorder.
- No automatic sighting data transfer. Sighting data have to be announced to the recorder.

Technical requirements

- No communication system between platforms or between platform and bridge.
- No cable connection between observer post and recorder computer.

2.2.2 On-line identification of duplicates, one independent platform

Example: SCANS II 2005 (SCANS II 2006), CODA 2007, T-NASS 2007

Target species: varies between the 3 surveys, from small to large cetaceans
Survey mode: passing mode
Platform and observer configuration:

- Primary platform (PP, lower platform) houses the independent observer team (PP), unaware of the activity and observations made on the other platform.
- Tracker platform (TP, upper platform) houses the trackers, the duplicate identifier (DI) and the data recorder (DR), all receiving all observation data and cooperating in assessing duplicates.
- PP: 2 on-effort observers searching with naked eye + 1 on-effort on TP as duplicate identifier (DI) or DR + 1 off-effort observer.
- TP: 2 on-effort observers tracking one with BE, the other with 7*50 binoculars, 1 on-effort observer serving as DI or DR + 1 off-effort observer.
- The primary team searched waters from 90° starboard to 90° port close to the ship (500m): determine the sighting rate of each species, i.e., record as many groups as possible.
- The tracker team searched beyond 500m, the BI from 60° starboard to 60° port, and the BE from 40° starboard to 40° port: concentrate on tracking groups of animals from as far from the ship as possible to the time the group was abeam of the ship or they have been assessed as duplicate of a primary sighting.

Angles and radial distances:

- PO and DI use mounted angle boards for recording bearing and estimate distance by eye or using a measuring stick.
- The tracker use angle ring (BE), angle board (7*50) and reticles to measure angles and distances, but these are also measured by photogrammetry (using two cameras attached to both binoculars)

Requirement in observers: 8 (2ne+1 // 2(be+bi)+1di+1dr+1)
Communication between platforms: very good inter-platform communication needed
Data logging:

- Common data logging on DR computer
- Automatic data logging: date, time and position, sighting number (and form) and for the tracker webcam image (angle) and video footage (distance) after touch of any sighting/resighting button.
- Integrated data collection system.

Technical requirements:

- Good communication system between platforms.
- Connection cables between all observer post, both primary and tracker, to the recorder computer.
- Connection between tracker post to video storage devices to DR computer.

Main problems encountered in SCANS II, CODA and T-NASS

In T-NASS, there were numerous technical problems with the audio and video equipment and the survey software that in some cases were never resolved. A particular problem was incompatible/ malfunctioning external sound cards which prevented the recording of audio. In addition communication between the platforms was very poor, which is problematic for the implementation of the BT method as planned. The media (external hard drives) meant to record the videos for distance estimate did not worked properly on any vessels.

Gillespie *et al.* (2010) review the problems encountered with the integrated data collection system used in the SCANS II and CODA. They note: “The data collection system worked effectively on all seven vessels taking part in the SCANS II survey, although the complexity of the system and the large number of interconnected components working in a harsh environment required a certain level of enthusiastic vigilance on the part of the operators to keep it running. The most commonly encountered problems were with the video capture system”.

It is interesting to note that less problems were encountered during the very well prepared SCANS II survey, where all cruise leaders had participated to 2-week pilot survey, than in CODA and T-NASS, where many things were only ready at the last minutes and several additions/transformations/changes made since SCANS II had not been fully tested. During the debriefing meetings of both CODA and T-NASS, it was recognized that a pilot survey/a period for testing/learning equipment would have been beneficial. Problems experienced at sea with the data collection system could have been minimised by rigorous testing in real condition before hand (CODA 2007b, NAMMCO 2008).

It was also clear from the SCANS survey, that the vessel experiencing the least technical problems were those having a "system technician" onboard or those where the integrated data collection system had been set-up and tested in survey condition by a "system technician".

Clearly the combination of a more complex survey procedure with the complexity of an integrated data collection system requires a thorough preparation of the cruise leaders and observers, and not the least the equipment, which was not achieved for T-NASS and CODA for various and different reasons (CODA 2007b, NAMMCO 2008)

Shipboard surveys are becoming increasingly technical and the time needed for a thorough preparation has consequently increased, this needs to be acknowledged and kept in mind for future surveys.

3. GENERAL PROBLEMS ENCOUNTERED IN DATA COLLECTION

Gillespie *et al.* (2010) underline that the majority of surveys still rely entirely on human observers for *estimating* and collect key data items, with limited scope for identifying or rectifying errors, while in other fields of science and engineering the use of calibrated instruments to take and record measurements is considered the norm.

3.1 Distance data

A fundamental assumption underlying distance sampling is that the relative locations of animals can be determined without error (*e.g.*, Chen 1998, Buckland *et al.* 2001, Palka and Hammond 2001). Distance data are therefore critical data, although they rely on estimates from observers, which often are *occasional* observers lacking routine and training. They may be subject to considerable errors, which has been confirmed experimentally (*e.g.* Williams *et al.* 2007), thus having the potential to introduce large bias in abundance from transect sightings surveys (Williams *et al.* 2007). Measurements errors are widely considered to be a problem to most surveys (*e.g.*, Schweder 1997, Leaper *et al.* 1997, Williams *et al.* 2007). Leaper *et al.* (2010) found a consistent pattern of over-estimation of small radial distances and under-estimation of larger ones. The potential effects of measurement error on abundance estimation are reviewed by Leaper et al. (2010).

Measurement errors on distance data are difficult to evaluate, and thus accounted/corrected for, because the distance experiments using fixed buoys, usually intended to examine these errors are unlikely to yield much information about the errors that occur under real conditions (Williams *et al.* 2007, Leaper *et al.* 2010), see under 3.2 for further discussions.

The introduction of photogrammetric measurements of distance and angle allowed investigating estimation errors made in the course of the real sighting process and for sightings of surfacing cetaceans. For the trackers, the difference between estimated and measured angles and distances could be directly compared for the same sighting event, while angles and distances estimated by the naked eye observers could be compared to photogrammetric measurements from the TO for the simultaneous surfacing events (Leaper *et al.* 2010).

3.1.1 Distance to sightings

The introduction of reticles reading improved distance estimation, but do not remove the "human estimate" with the observer having to extrapolate between reticle lines. This is particularly difficult for larger distances, with a tendency of rounding to certain reticle values (Leaper *et al.* 2010). The ability in estimating distances varies according e.g. to sea state, with reticle estimate of distances being more precise in good sea state (Kinzey and Gerodette 2003).

Leaper *et al.* (2010) compared measured distance and distance estimated by reticle (both Big Eye and 7*50) and by naked eye for sightings of surfacing cetaceans in SCANS II, CODA and SOWER. The magnitude of the errors indicated by the CV_{RMSE} varied between 0.19 for the CODA Big Eyes to 0.33 for the SCANS II Big Eyes and was 0.39 for the naked eye. They found an evidence of a non-linear relationship between error in distance and distance, with a consistent pattern of over-estimation of small radial distances and under-estimation of larger ones. Same pattern was observed by Williams *et al.* (2007) By contrast, there was no evidence of a similar pattern in the errors to fixed buoy in distance experiments performed with the same observers.

3.1.2 Angle to sighting

Leaper *et al*. (2010) compared measured and estimated angles using the data collected during SCANS II and CODA. For the 7 × 50 binoculars, this resulted in 651 initial sightings where both estimated and measured bearings were available. Of these, 5% (34 sightings) showed gross errors of more than 20º which could not be resolved (by listening to commentaries) and were assumed to be either observer error or related to angle pointers becoming mis-aligned. For the remaining sightings, the root-mean-square error was 7.1º for SCANS II and 7.2º for CODA. For the Big Eyes there were 355 sightings with both estimated and measured bearings of which 6% of sightings showing errors of more than 20º. Excluding these sightings with large errors gave a RMS error of 6.0º for SCANS II and 5.7º for CODA. For the simultaneous sightings from naked eye observers during SCANS II where there was also a measured angle from the tracker, the RMS error was 5.9 º. However, this value may be influenced by the selection criteria used for simultaneous sightings; angles needed to be within +/– 10 º and hence, sightings with larger angle errors were eliminated before the comparison.

Errors in angle measurements appear less likely to cause bias than errors in distances, but will affect the variance of estimates. Although there was little evidence of angle error causing overall bias, the contribution to the variance will be dependent on the distribution of angles to sightings (Leaper *et al.* 2010).

3.2 Distance and angle experiment

Most shipboard sightings surveys devote/are supposed to devote substantial time to training observers in distance estimation, but also in testing them in distance and angle estimation, with the hope of yielding sufficient data for assessing variance and correcting for distance errors. Fixed artificial visual target are used as cetacean proxy, generally fixed buoys, although the last harbour porpoise surveys have been using a porpoise model (NEFSC surveys, SCANS II).

Williams *et al.* (2007) results suggested that an observer differed in the ability to judge distance to fixed, continuously-visible cues and ephemeral, cetacean cues, which calls into the question the common practice of using fixed cues like marker buoys as cetacean proxies in distance-estimation experiments. Leaper *et al.* (2010) showed from the SOWER data that, although it would be expected that estimated distances to a stationary object that remains at the surface are more accurate than those to whales, the extent of the difference was surprisingly large. Based on this and the pattern of distance errors found, Leaper *et al.* (2010) concluded that distance errors are difficult to predict or correct from typical distance experiments using fixed targets and ultimately there appears no substitute for measuring these at sea.

Also these experiments are usually conducted under relatively good weather conditions (a.o. for safety reasons) which may not represent the overall condition of the survey.

When also considering how time consuming these “experiments” are, that the time taken is usually from over average good survey conditions and that they easily develop in a logistical nightmare, it would be worth reconsidering their utility in future surveys.

This comment however does not concern the usefulness of *training* observers in distance estimation, which is certainly worth pursuing, especially in the case of observers not regularly participating in surveys.

If someone should anyway attempt a distance and angle experiment, Norway has introduced GPS recording as a standard tool for the distance experiments, using a GPS (***Garmin Fortrex 201)*** device mounted on the buoy.

3.3 Observer experience

Mori *et al.* (2003) estimated that the sighting rate for minke whale schools by Beginners observers (0-4 surveys previously) was 42% lower (95% CI = 22%-56%) than that by Expert observers (>4 surveys previously), from looking at the IWC/IDCR-SOWER surveys from 1993/94 to 1998/99. Motivation and aptitude of the observers was likely also an important factor that influences sighting abilities. They concluded that “The estimated abundance of minke whales has decreased by some 50% between the second circumpolar set of surveys and the third, according to the analysis of Branch and Butterworth (2001). It seems reasonable to postulate that the introduction of Beginner observers during the third set may be responsible for part of this decrease.”

The difference among individual observers was one of two significant factors influencing perpendicular sighting distances for shipboard surveys in the Pacific in 1986-1996 (Barlow *et al.* 2001). Individual differences reflected visual acuity, experience, training, concentration, and state of rest/fatigue. Barlow *et al*. (2006)

found observer experience (grouped as first-time observers, observers with at least four months experience, observers with at least 12 months experience) to be a highly significant factor explaining differences in sighting rates for beaked whales off the coast of California, with sighting rates for experienced observers being approximately twice that of inexperienced observers.

Observer experience is particularly crucial in the case of cryptic species, including minke whales and porpoises as well as beaked whales.

4. ADVANTAGES AND DISADVANTAGES OF THE DIFFERENT METHODOLOGIES AND LOGISTIC IMPLEMENTATIONS

The need to use BT or IO as opposed to simpler methods, such as a single platform survey, is depending on the target species. The choice is more difficult in the case of a target species mix, as in T-NASS, and the specific biases that might be expected (response to the presence of the survey vessel, surfacing pattern, "detectability", etc). For fin whales, for example, preliminary estimates of *g(0)* have been close to 1 and responsive movement is not expected. Therefore a single platform mode would be adequate for this species and more efficient in terms of use of observers. In the NILS surveys 1995-2001, Øïen and Bøthun (2006) found *g(0)* estimates ranging for the single primary platform from 0.71 (1995) and 0.74-0.75 (1996-2001) and for the combined platform 0.91-0.92 (1995) and 0.93-0.94 (1996-2001). Pike *et al.* (2001, 2008) report *g(0)* values of 0.81 for the 2001 survey and 0.87 for the 2007 survey, both conducted in BT mode. For species such as minke and pilot whales, *g(0)* is low and responsive movement is expected. Therefore a BT type mode is required if absolute abundance estimates are desired for these species.

The table below presents data on responsive movement for the target species of T-NASS 2 shipboard survey. Responsive movement could be a problem for several of the species and a methodology which will allow investigation of whether it is present or not will be an advantage.

TNASS 2	avoidance	attraction	neutral	NA	Reference
Target species					
Fin whale					
Sei whale					
Minke whale	+				Hammond *et al.* 1995, 2002, 2011, Palka & Hammond 2001, Hammond *et al.* Submitted
Pilot whale		+			Palka 2006

Non target species					
Humpback whale				0	
Bottlenose whale	+				
White sided dolphin	+				Palka & Hammond 2001
White beaked dolphin		+			Hammond *et al*. 1995, 2002; Palka & Hammond 2001
Lagenorhynchus sp		+			Hammond *et al.* 1995, 2002
Common dolphin		+			Cañadas *et al*., 2004, 2009, de Boer *et al.* 2008 Hammond *et al.* Submitted
Harbour porpoise	+		+		Barlow 1988, Hammond *et al*. 1995, 2002, Palka & Hammond 2001, Hammond *et al.* Submitted
Stenella	+				Au and Perryman 1982
Risso dolphin	+				Palka 2006

4.1 Logistic limitation

The most adequate method is also dependent, although it should ideally not be, on the available platform. Palka describes in the following way, why she chose back the IO method in 2011 after having been using the BT method in 2007:

"I changed back to the IO method for 2 reasons. Primarily the BT method did not work that well on the ship we were using. This is probably because the primary team was using naked eye (where the primary target species was harbor porpoises) on a platform that was plenty high (11m) but it was far from the bow and the naked eye observers had a difficult time seeing the harbor porpoises. Their sighting rate was lower than I expected. The tracker team had big eyes and so being so far from the bow did not affect them and their sighting rate was very high even with the tracking task added on. The harbor porpoise estimate was not horrible, but the level of uncertainty was very high. I have not published these data because I was not sure I liked the fact that the tracker sighting rate of harbor porpoises was higher than the primary team. Note the observers on the primary team were good and so that is not why the sighting rate was low".

4.2 On- *vs* off-line identification of duplicates

All double platform methods rely on the identification of duplicate sightings/cues. In method CIO and IO- trial independence the duplicates are, by definition, identified on-line. For the other IO variants and BT mode, the identification of duplicate can/has been done both on-line (requiring good communication between platforms) and off-line (no communication between platform required) later during the analysis. In all cases identification of duplicate is based on timing, bearing and distances of cues.

Identifying duplicate on-line requires a person dedicated to the task (duplicate identifier, DI), especially in medium and high whales densities. It may prove very difficult to keep the pace in high density areas. In more normal situation, because the DI is looking at the sightings and can follow the tracks in the BT method, he can compensate for error in distance estimates from the primary. But the judgment is some times very subjective. Post survey identification of duplicate, using an automatic routine, is by definition a more objective process.

The on-line identification of duplicates creates the need for very good communication between platforms, especially if the density of sightings is high and there is no time for a repetition of data and discussion between observer and DI, which has proved to be a problem in many surveys.

In IO mode, because of the independency of the two platforms, the DI must be positioned on a third platform, which has logistical implications. Among the surveys reviewed, this was only done on the large Japanese research vessels (*e.g.* IDCR/SOWER and Japanese cruises). In BT mode, only the primary platform needs to be independent and the DI can be positioned with the trackers and cooperate with them to identify duplicate.

A reliable identification of duplicates, and particularly off-line, requires that angles and radial distances are estimated or measured as accurately as possible and not rounded. It is also important to obtain exact times of sightings and re-sightings and record swim direction.

4.3 Possibility for improving data collection

To be able to collect good quality data, especially when tracking of animals is involved, the observers should be able to concentrate on the sighting and not on recording, worse writing down data. On the other hands all the data required should be recorded, without missing data and without errors. Filling in paper forms takes the attention of observers away from their sightings and prevent the use of automatic time stamp. Clearly automatic data logging of data such as time of the sighting, distance and angle, position of the vessel is a big advantage.

<u>4.3.1 Time of sightings</u>

Sighting and resighting time are important in determining the relative location of the animal, but are especially important in identifying duplicate sightings, and particularly off-line. This is best achieved by an automatic logging of the time as a response to the observer pressing a sighting/resighting button.

4.3.2 Distance to sightings

Photogrametric methods

In SCANS II, the introduction of a photogrammetric method based on the method of Leaper and Gordon (2001) permitted to "measure" the distances to tracker sighting (Gillespie *et al*. 2010), besides the reticle estimation. The method was later used, practically unmodified in CODA and - with less success - in TNASS, as well as on an experimental basis in the last SOWER surveys (Leaper 2007, Gillespie *et al*. 2010, Leaper *et al*. 2010). One of the main challenges to the system is capturing an image of the first surfacing reported by the observer of sufficient quality to allow measurements to be made.

Gillespie *et al.* (2010) evaluate as follows the use of the system: "Success rates for the 7 × 50 and 25 × 100 binoculars were similar but varied considerably among vessels as a result of different conditions experienced and some technical problems. The overall success rate for the CODA survey (66%) was higher than that for SCANS II (37%). This was probably due to the use of high definition video cameras that resulted in much better image quality meaning that fewer surfacings were missed due to camera resolution and the fact that harbour porpoises, which made up the vast majority of sightings during SCANS II but were absent on CODA, were particularly challenging subjects. The most common problems encountered were with control of the Firestore hard-disc recording units."

Electronic range finders

Palka (2011) experimented in the 2011 AMAP survey with electronic range finders (E-Ranger) that are mounted on top of the big eyes for estimating radial distances. In the AMAPPS-Information for NE Shipboard Observers the following explanations are given.

> "This device consists of the E-Ranger box that is mounted on top of the big eyes, a cable attached to an LCD display which hangs from the big eye stand, and a cable to a START/STOP hand held switch. The E-Ranger box has an electronic inclinometer which, when given the height the big eyes are above the water, will display on the LCD display the distance between the big eyes and the spot on the water. "

In the AMAP survey, the LCD display was not connected to the recorder computer, so there was no automatic logging of the distance and the observer/recorder had to read and record the distance himself. As it is, because of their size, volume and weight, E-rangers can only be used on big eyes.

Once the E-ranger is calibrated, it is not needed to have a clear horizon to get a distance estimate. The difficulty resides in keeping the center cross hairs on the spot of the water, where the whale appeared, while the chip constantly records the distance, a mean distance being recorded on the display.

Figure B1 from AMAPPS (2011): The E-ranger mounted on the big eyes. Palka (pers. commn.) evaluation of the system at this point is: "The E-rangers need a bit more work, particularly the battery. Also Folks are so used to doing with reticles, some were reluctant to use the E-ranger. But they basically worked fine. The next version should be better, I would not suggest anyone uses the current version."

4.3.2 Bearing to sightings

Estimated angles are presently usually obtained using angle boards. For the observer, using unaided eye or loose binoculars, the angle board is usually attached on the ship rail in front of each observer. In some case, however, a single angle board is used for a whole platform. Clearly every single observer position should be equipped with its own angle board and a single angle board per platform is not considered as adequate.

In SCANS II (CODA and T-NASS) photogrammetric measurements of bearing were introduced (Gillespie *et al.* 2010). It used a downward pointing camera (webcam) taking a still image of reference marks on the deck of the vessel.

On the SCANS II survey (Gillespie *et al.* 2010), the bearing cameras generally worked well, with an overall 94% success rate. On CODA (and T-NASS) there were more problems due to hardware conflicts related to the number of USB devices connected to the computer resulting in a lower success rate of 85%. Achieving a high success rate of bearing measurement using webcams should be possible, however recent developments in other angle measurement devices (e.g. magnetic sensors) may ultimately give better results (Gillespie *et al.* 2010).

4.4 Real-time data entry and possibility for on-board validation of the data

Automatic logging of data liberates for posterior data entry and minimizes the need of exchange of data and communication between data recorder and observers.

Real-time data entry into a computer by definition minimises off-line data entry, liberating time for a validation of the data, supported by data validation algorithms, while details of the sightings are still fresh. It also allows for an automatic check for missing key data items.

The validation software developed for SCANS II allowed cruise leaders to examine the type of error made during data acquisition for identifying problems such as rounding in estimated value, discrepancy in measured and estimated distance, scanning of an inappropriate angle sector, problems which might be corrected during the course of the survey.

4.5 Comparing methods

More problems were encountered in implementing BT in T-NASS and CODA than in SCANS II, which is primarily due to equipment problems, of which many would have been solved with better preparation and testing. Others were likely due to insufficient training and experience of both cruise leader and observers, particularly in T-NASS. The problems of implementing the method could be overcome in future surveys through improvements in equipment and better observer training.

Methods where duplicate identification is done during the analysis, *e.g.*, the BT method as implemented in SNESSA or the IO method implemented in AMAPPS with *a posteriori* identification of duplicate, are less technically complex and equipment dependant than an implementation like the SCANS II, with duplicate identification in real time and a centralised computerised data entry.

SNESSA implemented a BT setup without communication between the primary and tracker platforms, with duplicate determined *a posteriori*, thus requiring much simpler equipment. The two trackers each had their own data recorder (a Fujitsu Stylistic Tablet PC), which recorded data on a hand-held computerized data sheet (*in house* NMFS software) that used both touch pull-down menus and hand-writing recognition fields. The three primary observers recorded their data on the same type of computer. The procedure performed very well, with no technical problems.

The proper use of the Big-Eyes seemed to depend on the stability of the platform and the willingness and determination of the trackers to persevere in using them, besides the quality of the equipment as such. If Big-Eyes are to be used in future surveys, special attention should be given to the stability of the vessels and platforms.

On the other hand searching with naked eyes might be problem if it leads to very many unidentified whales or dolphins. Palka (pers. comm.) switched back to the IO mode in the 2011 survey, after having conducted the 2007 survey in BT mode, because it was conducted outside of harbor porpoise habitat, unlike the 2007 survey. She notes "Using naked eye to identify all the different species of dolphins and whales would have been very difficult and so resulted in lots of unidentified dolphins and whales, which would not have been very useful. So in 2011 we had two teams using big eyes searching independently."

CONCLUSION AND RECOMMENDATION FOR FUTURE SURVEYS

The level of bias observed in the collection of distance data clearly points to the need for close attention to the measurement of these and the need of some form of more precise distance and angle measurements system, than reticle and angle board reading. Latest technical (*e.g.* high definition cameras) and software development has permitted the development of such systems and their use should be strongly considered. Williams et al. (2007) recommended that even if measurement could not be made to/obtained for all sightings, it was important to generate a sufficient and representative sample size to assess error distributions, examine evidence for non-linearity, and to consider inter-observer differences. As Leaper *et al.* (2010) point out, there still remain technological challenges in operating complex electronic systems at sea to measure distances and bearings, but compared to increase ship time, investment in these methods should be a cost effective way of reducing bias and improving precision of cetacean abundance estimates. Also Gillespie *et al.* (2010) note "As computer hardware capabilities develop it is likely that the optimum means of implementing a system like this may change more fundamentally. For example, some of the rather cumbersome cabled connections used here might be replaced by wireless links."

The SCANS II system attempted to precisely measure data wherever possible and to record data in ways that allowed errors to be identified (*e.g.*, cross validation). This effort should be pursued in future surveys.
The validation system also allowed the cruise leaders to control in the course of the survey the way each observer was collected the data, in turn allowing for improvement if necessary.

From experience gained in the NASS and T-NASS surveys and other regular surveys (Palka, pers. comm.), compared to occasional surveys such as SCANS and CODA, it has become evident that it is not always easy to implement new methodologies and that observers (and cruise leaders) can be very reluctant in using new techniques. They will do so, however, more easily if they have a good knowledge and understanding of the new methodology and if they have been prepared to use it, i.e., trained to use it, so they feel confident in using it.

This takes us back to the absolute necessity in prioritizing first the training of the cruise leaders, second that of the observers. Also, and particularly in the case of the implementation of a new methodology requiring new equipment, it is fundamental that this equipment has been tested *in situ* and works smoothly. Therefore it is critical that a technical backup is available in case of problems, so the problems can be solve before the training of observers id carried out and before departure.

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Appendix 1

List of double platform surveys reviewed

Survey year	Area	Target	Method	Duplicate Id	PO	TP/IOP	FB	DI	DR	Tot	Specification	Reference
1986	California, Oregon, Washington	HP	IO	off	3-5bi	3bi						Barlow 1988
1986/87 -now	Antarctica	MW	IO	on	2bi	1bi	2bi		3-4			Butterworth & Borchers 1988, Matsuoka *et al.* 2003; Matsuoka 2011
1990	North Sea	MW, HP	IO?	?	?	?			?			Øien 1992
1991, -93, -96, 2001, 2005	U.S. west coast.	all	CIO	on (IO)	2be	1bi			1ne			Barlow 1995, Appler *et al.* 2004, Calambokidis & Barlow 2004, Barlow & Forney 2007
1991	Gulf of Maine	HP	IO	off	3ne	3ne				8	Short tracking for Dup ID	Palka 1995
1994	**SCANS, North Sea and adjacent waters**	HP, MW, dol	BT	on (DI+Tracker)	3ne	2bi		1		8		Hammond *et al.* 1995, 2002
1995	NASS Faroes, NEA	PW, MW, BW, CD, WSD	BT (SCANS)	on (DI+Tracker)	2ne	2bi		1		10	WINCRUZ	Desportes *et al.* 1996, Cañadas *et al.* 2004, 2007, Víkingsson *et*

												al. 2007
1995	NILS 95, NEA	MW	IO cues	off	2ne	2ne	x			9/12	Tracking of MW, Tape recorder	Øïen 95, Schweder *et al.* 1997
1995	California	HP	CIO	on (IO)	4bi	1			1	9	PPCRUISE	Caretta *et al.* 2000
1996-2001	NILS, NEA	MW	IO cues	off	2ne	2ne			?	8	HVAL2000, Tracking of MW,	Skaug *et al.* 2004
1998	NW Scotland	Fin and sei, wsd	IO (Palka 95)	off	3ne	3ne				8	LOGGER, reticle reading	Macleod 2004, Macleod *et al.* 2006
1998, 2004	NW Atlantic	all (low density)	IO	off	2be	2be			2ne	8	Short tracking for Dup ID, hand-held data entry computers	Palka 2005a,b, 2006
1999	NW Atlantic	all (high density)	IO	off	3ne	3ne				8	*same as above*	Palka 2000, 2006
2000-2002	Antarctica	FW, HW, MW	BT exp.	on (DR)	1	2bi			1			Williams *et al.* 2006
2000-2009	W N Pacific (Japan, Korea)	MW	IO / DC	on	2ne	2ne	x			?		Miyashita & An 2010

2001	NASS, NEA	FW, HW, MW	BT	on	2ne	2bi		1		10	WINCRUZ	Víkingsson *et al.* 2007
2002	Hawaii	all	CIO	on (IO)	2be	1bi			1bi			Barlow *et al.* 2004
2002-2007	NILS, NEA	MW	IO cues	off	2ne	2ne	x			8	Hval2000, Hval 2004.	Øien 2007, Bøthun *et al.* 2009
2003-2005	Cardigan Bay	HP, BD, GS	IO trial	on(IO)	2ne	1ne				4-7		Reay 2005
2005	W.A. English Channel (winter)	CD	BT	off	2ne+1 DR	1bi					LOGGER, digital voice recorder, camera measuring angle	WDCS 2005, De Boer *et al.* 2008
2005	**SCANS- II, North Sea**	HP, BD, DD	BT	on (DI + Tracker)	2ne	2bi+be		1	1	8	LOGGER, reticles, camera for angle & distance	SCANS-II 2006, MacLeod *et al.* 2009, N37Hammond *et al.* 2011
2005/06 - 2008/09	Antarctica	MW	BT2	on (FB)	2ne	2bi	2		3-4			Burt & Borchers 2008, IWC 2008, Russel *et al.* 2011
2006	Northern Sea of Japan	MW	IO	on	2ne	2ne		2		?	Voice recording system	Miyashita 2007
2007	CODA/T-NASS North	diverse	BT (SCANS II)	on	2ne	2bi+be		1	1	8	LOGGER, camera for angle &	T-NASS 2007, CODA 2007, CODA 2009, MacLeod *et al.* 2009,

	Atlantic										distance	Desportes 2011, Hammond *et al.* 2011
2007	SNESSA	all	BT	off	3ne	2be			2ne	11	PingleNet computers	Palka, 2008
2008-2013	NILS, NEA	MW	IO cues	off	2ne	2ne	x			8	Hval 2004, audio files	Øien & Bøthun 2008
2009	Gulf of Alaska	all	CIO	on (IO)	2be	1bi			1bi		wincruz	Rone *et al.* 2010
2011	AMAPPS	all	IO	off	2be	2be			2* 1ne	8	ToughBook, VisSurv_NE	AMAPPS 2011ab

ANNEX 3

WORKSHOP ON AGE ESTIMATION IN MONODONTIDS
26-27 November 2011, Tampa Convention Center, Florida, USA

EXECUTIVE SUMMARY

The workshop was a 2-day event organised immediately before the Society for Marine Mammalogy biennial conference in Tampa. NAMMCO funding enabled participation of 4 invited experts and also supported the organization and logistics associated with the workshop. The breadth and depth of the workshop presentations made it clear that most issues concerning monodontid age estimation are not unique. Many researchers investigating many taxa have considered a diversity of methods and tissues to reveal biological records of age. Aside from the biological materials, accuracy and precision of the counts or metric have been considered, as well as their interpretation.

Relative age can be estimated using biological or chemical changes if the rate of change is known. Attempts to use **genetic telomere length** to estimate relative age show telomere lengths provide a measure of individual body fitness and condition rather than age, as environment, migration, health and reproduction affect telomere length. The method has potential but is still under investigation. Reviews of **aspartic acid racemization (AAR) aging techniques** on eye lenses from harp seals, *Pagophilus groenlandicus*, fin whales, *Balaenoptera physalus*, harbour porpoises, *Phocoena phocoena*, and bowhead whales, *Balaena mysticetus*, indicated potential for producing relative ages but warned that the presence of cataracts in the eye lens could seriously bias the age estimation upward. In narwhal, *Monodon monoceros*, tusk growth layer groups (GLG) correlated well with AAR age. The AAR method is relatively accurate, but species-specific racemization rates are essential for accurate age estimation. Age models using **endogenous fatty acid (FA) ratios** have been successfully derived for killer whales, *Orcinus orca*, and humpback whales, *Megaptera novaeangliae*. Preliminary results using a single FA ratio for Cook Inlet belugas, *Delphinapterus leaucas*, correlated with age from tooth GLG for physically immature animals. Future work using two FA ratios in belugas is expected to provide more precision in relative age. It may be possible to use bone density as an indicator of relative age in beluga and narwhal flippers. The method would need to be calibrated with reference to GLG in beluga teeth and validated AAR ages in narwhal.

The recording of **historic hunting artifacts** recovered in bowhead whales in Alaska has presented an opportunistic and potentially remarkable insight into longevity of this species (which may exceed 100 yr if the interpretation of the artefact is correct).

Micro-CT scanning demonstrated potential for investigating internal structure of teeth and other hard tissue specimens. Because there is no destruction of the specimen and 3-D viewing is possible, this technique could be applied to specimens that are difficult to interpret from thin sections or rare, and therefore, not possible to section.
Counts of presumed annual markers provide a more accurate (absolute) estimate of age than other tissues which show gradual changes with age. Hard structures that show **regular episodic growth** are the most commonly used tissues to investigate for

records of age that can be estimated from **GLG.** Tissues include bones, otoliths, claws, and ear plugs although teeth are most widely used. Undamaged e**ar plugs in baleen whales** provide a permanent record of total age from GLG therein. Apart from longevity, life-history parameters of age at sexual maturation and possibly physical maturation can be identified from the GLG patterns. Such patterns might exist in some teeth, and should be investigated. Ear plug extraction from carcasses of minke whales, *Balaenoptera acutorostrata,* is facilitated by a new method of **using injected gelatin** which increases the possibility of extracting whole and undamaged ear plugs. This method should be evaluated for bowhead whales in which ear plugs are soft and fragile.

Teeth GLG are commonly used to age carnivorous mammals, including marine mammals. Techniques for preparing teeth vary. All are directed at obtaining the most complete record of clear laminae, key to which are tooth sections with correct orientation to display all the laminae. A review of aging in sirenians indicated there are many internal similarities between dugong, *Dugong dugon*, tusks and beluga teeth, and also perhaps narwhal tusks. The GLG deposition rate in dugong tusks is annual.
In belugas, counting **GLG in dentine,** as seen in medial longitudinal sections of teeth, is the standard method and consistent with methods used in other taxa. The most suitable material is a thin untreated section (ca 150-200 micron). Counting **GLG in cement**, using the same medial sections, may be useful for belugas where cement is thick and especially when the dentine is worn down at the tooth crown. Cement is not useful for most cetaceans. GLG patterns in sperm whales and belugas are very similar.

Precision and accuracy are essential in age estimation from GLG counts. The repeatability of the GLG counts (precision) and accuracy (whether or not the GLG counts indicate the correct age) are not the same. **Quality control** is essential for both and there must be regular monitoring of an aging programme. The best measures of age precision are coefficient of variation (CV), average percent error (APE) and index of dispersion (D), while the least reliable is percent agreement among readers which is usually the most commonly used assessment. A permanent reference collection of aging materials, *e.g.*, known-age beluga teeth, is the key to effective quality control. In an investigation of precision and bias in beluga tooth age data, it was concluded that errors arising in estimation of biological parameters can be both negatively and positively biassed with varying degrees of variance. In turn these translate to errors in estimation of growth rates. Efforts should be made to quantify bias and precision.
One of the most persistent debates in age estimation of the beluga has been about the accurate translation of GLG counts into time units (years). The **measurement of radiocarbon, ^{14}C,** in laminated hard structures of animals has been a precise and successful method for validating age in many species, including **belugas where GLG deposition rate was found to be unquestionably annual.** The most direct age estimation technique is that of following recognizable individuals through time. **Long-term photo-ID monitoring** and surveys of the Gulf of St Lawrence belugas resulted in an abundance of reliable data on life history, age, reproduction, growth and colour change. Teeth collected during necropsies on recovered known-age and known-history belugas have validated GLG deposition rate.

Investigation of the age from teeth of known-history captive belugas, together with data on **tetracycline time-marking of teeth** generally also supported an annual deposition rate of GLG. However, GLG definition was unclear in some specimens, particularly in the juvenile phase. Several other studies confirmed the value of long-term monitoring of known animals for validation of age. **Information on growth and reproduction** of Cumberland Sound belugas that was presented in support of a deposition rate of 2 GLG per year was criticized on a number of counts and was not accepted by participants.

Future research was identified in several areas to fine tune our understanding. One potential technique for estimating total age from worn beluga teeth using **the angle of the boundary layers relative to the pulp cavity edge** appeared promising and should be followed up. Of a broader nature is the potential to understand the ecological correlates to lamina formation. **Laser ablation (ICPMS) for trace elements** in beluga tooth GLG indicated some elements show periodic oscillations. Investigation of **stable isotope ratios** ^{13}C and ^{15}N in beluga teeth were also promising. The point of weaning can be identified from the ^{15}N depletion up to this point. Oscillations of elements in the teeth may be linked to ecology and movements associated with feeding and migration, although these may not be annual, and thus cannot be used as an age proxy presently.

A number of **specific recommendations for monodontids** were made at the workshop, including inter-method comparisons of alternative aging methods using data and samples from free-living known-age animals. The number of samples of known age captive beluga from which teeth can be collected should be augmented with comprehensive sampling of other materials useful for age estimation. A focus on the immature phase of growth in teeth in beluga with reference to captive animals to determine GLG patterns is desirable. Reference collections (hard parts) should be established and digital image exchange for calibration and training among labs be considered. Quality control routines should be established and should include periodic exchanges among laboratories and inter-laboratory calibration for all aging techniques. Comparison of tooth preparation methods among labs is desirable. A new study to estimate crown wear from angles of boundary layers into the dentin-cement junction in beluga teeth to estimate the maximum number of GLG that have disappeared should be initiated. Chemical time-marking for age calibration of hard parts and bomb radiocarbon validation of hard parts and eye lenses is encouraged. A study comparing GLG in teeth to GLG in ear bones for beluga, and if successful, evaluating ear bones as a method for obtaining direct estimates of age in narwhals is encouraged. A comparison of GLG structure among stocks (free-living and captive) is desirable.

In conclusion, the workshop members agreed on several aging methods which are or may be applicable to monodontids, including potential new methods which, depending on the type of tissue required for analysis, may be applicable both to living and dead animals.

Overall, tooth GLG are judged to be the best and most precise method. Presently, tooth GLG are only useable in belugas, but the AAR technique is very promising in narwhals. More work needs to be undertaken on embedded tusks of young narwhal to help calibrate the AAR rate in narwhals. GLG in ear bones should be compared to results from the other methods. The AAR method should also be applied to beluga eye lenses to provide a correlation with beluga tooth GLG. Such a study might provide more reliability on the narwhal AAR work presently done.

Currently, **bomb radiocarbon** is the method that is most accurate and that can be used for calibration of alternative aging methods**.** However, the main limitation is that at least some of the teeth or hard tissues must come from animals that were born before the fallout commenced, *i.e.*, pre-1958.

The workshop agreed that an annual deposition rate of tooth GLG was to be the accepted standard in belugas.

Finally, it was agreed to publish the proceedings from the workshop in a volume of the NAMMCO Scientific Publication Series, entitled *Age estimation in marine mammals with a focus on monodontids*. NAMMCO has approved the proposed volume with a probable publication date in 2013. The editors would comprise the members of the Steering Committee for this workshop in addition to the technical editor, Mario Acquarone.

MAIN REPORT

1. OPENING, WELCOME AND INTRODUCTION

The workshop opened with a welcome by Christina Lockyer, General Secretary of NAMMCO, who presented the other members of the steering committee responsible for planning and convening the workshop. The steering committee, appointed by the Joint Scientific Working Group (JWG) of the NAMMCO-JCNB (Joint Canada Greenland Commission on Narwhal and Beluga), was Aleta Hohn (NOAA, Beaufort, North Carolina, USA), Roderick Hobbs (NOAA, Seattle, Washington, USA), and Robert Stewart (DFO, Winnipeg, Manitoba, Canada) in addition to Christina Lockyer. Mario Acquarone, Scientific Secretary of NAMMCO, was appointed general rapporteur for the meeting.

Lockyer stated that the focus of the workshop was on monodontids although contributions on all marine mammals, and even other organisms, that had possible relevance to methods applicable for monodontids would be welcomed. Many contributions had already been offered and registered, and a booklet of abstracts of most presentations was available to participants at the workshop.

2. WORKSHOP BACKGROUND, BASIS AND OBJECTIVES

Approval for the workshop came from the JWG of the NAMMCO-JCNB, and subsequently was approved a budget by NAMMCO Council under the work of its Scientific Committee.

Initial publications on age estimation in odontocetes used tooth growth layer groups (GLG) which were codified and defined by Klevezal (1980) and Perrin and Myrick (1980). A GLG is a group of incremental layers which may be recognised by virtue of cyclical repetition. Spacing of GLG is usually constant or changes in a regular, systematic manner, usually diminishing with age, and a GLG must involve at least one change between light and dark incremental layers. Hohn (2009) provides a good overview of aging in marine mammals.

From a historical perspective, publications on age estimation in belugas, *Delphinapterus leucas*, date from the pre-1970s (Sergeant 1959, Brodie 1982) when 2 GLG per year were anticipated by comparison with the then supposed deposition rate in sperm whales, *Physeter macrocephalus*, (Gambell and Grzegorzewska 1967). When this assumption for sperm whales was subsequently amended to an annual deposition rate (IWC 1969; 1980; Best 1970; Gambell 1977), a more general assumption was made for all odontocetes, except for belugas (Heide-Jørgensen *et al.* 1994). The assumption of an annual GLG deposition rate in odontocetes was also supported by other publications on a variety species for which validation of age estimation was possible;, *e.g.*, Myrick *et al.(*1984, 1988), Hohn *et al.* (1989), and Lockyer (1993).

The question of GLG deposition rate was raised again for belugas at the 51st IWC SC (IWC 2000) by Hohn and Lockyer (1999) referring to the examination of two captive known-age, known-history belugas with tetracycline time-marking of teeth. Although no conclusions were reached at this time, there was sufficient evidence to sow doubt on the interpretation of 2 GLG per yr in belugas.

Subsequently, a workshop, supported by NAMMCO and the NOAA laboratory in Beaufort, USA, focusing on interpreting age from teeth of 10 known-age and known-history belugas was held in 2001 (Lockyer *et al*. 2007). Recommendations included further monitoring of known-age captive belugas, trials of other aging methods, *e.g.*, aspartic acid racemization (AAR), and, not least, - standardization of GLG counting among researchers.

At the meeting of the JWG held February 2009 in Winnipeg, Canada, participants expressed broad support for a workshop to address age estimation in monodontids (beluga and narwhal). They noted, for example, the value of cross-laboratory calibration, standardization of methods, and the use of AAR of eye lenses relative to growth layers in small, embedded tusks of narwhal. It was suggested that consideration should be given to how the insights on age estimation developed at the workshop(s) will be incorporated into model input. Better life-history data based on known-age animals will improve the reliability of population assessments. Finally, interest was expressed in having new methods of age estimation (*e.g.*, fatty acids) explored in a workshop context.

NAMMCO indicated a willingness to convene and organize the workshop(s) and that selection of the venue(s) would be critical. For the practical components, it would be necessary to hold the workshop(s) in an appropriately and adequately equipped laboratory.

Recognizing that there are a number of problems with age estimation for both the monodontid species, and that these need to be studied in more detail, the JWG recommended that a steering group (chaired by Lockyer and including Hobbs, Hohn, and Stewart) work inter-sessionally by e-mail to scope the problems and produce draft terms of reference for one or more workshops.

Terms of Reference (TOR) were developed by the steering group, and subsequently approved by NAMMCO, which also approved a budget for the workshop(s). The two TOR provide the following guidance:

1. To standardize tooth GLG reading methods for age estimation in beluga and narwhal where feasible, and calibrate against other techniques such as using AAR, and produce a manual as a guide to tooth reading in the above species.
2. To draw together traditional and new techniques for determining age in marine mammals, where these methods may be applicable to belugas and narwhals, by holding a workshop of experts in this field, and produce a report.

At this stage it became clear that there should be two different workshops: one where new ideas and techniques could be presented and discussed (TOR 2), and another which focused purely on laboratory preparation, examination, interpretation and validation of teeth, (TOR 1). Two workshops were planned in association with the biennial Society for Marine Mammalogy (SMM) conference in 2011 when there would be the opportunity to bring as many experts together as possible. TOR1 was addressed at a laboratory workshop at the NOAA Beaufort laboratory following the SMM Conference and results will be reported in a separate document.

For the current workshop, held in Tampa, the following TOR were derived from TOR 2 (above):

1. Review current methods of age estimation in marine mammals with a focus on monodontids.
2. Recommend the method(s) most suitable for monodontids; and trials of any new techniques that are as yet untried in monodontids.
3. Compile previously unpublished papers submitted to the workshop and relevant to age estimation in monodontids in a publication volume entitled "Age estimation in marine mammals" of the NAMMCO Scientific Publication Series.

Invited participants (Appendix 1) discussed a diversity of studies as noted in the workshop agenda (Appendix 2). The following sections present each author's abstract, a summary of the presentation materials, and discussions that followed each presentation.

PRESENTATIONS

3. Age estimation methods applicable in mammals with special emphasis on marine mammals and especially monodontids – Fiona L. Read

ABSTRACT: *Accurate age estimates are fundamental for understanding and interpreting many aspects of mammalogy. Age has traditionally been used to understand the biology of a species at an individual and population level and further study the dynamics of the population and the need for accurate and precise ages has increased over time due to changes in research interests. Age estimation can be defined as absolute and relative age. Absolute ages are achieved by counting growth layer groups (GLG) in hard structures such as teeth, ear plugs, baleen, bones and claws. Relative age can be obtained by methods such as aspartic acid racemization of the eye lens, telomere length, bone mineral density, fatty acid signatures etc. The present work provides a review of methods for age estimation in marine mammals, including the pros and cons and accuracy of each method. Methods for validating age estimations will be discussed. Furthermore, the unresolved discrepancies of aging monodontids (narwhals and belugas) (mainly 1 or 2 GLG per annum) with special emphasis on recommendations for overcoming these problems and the application of newer methods,, e.g., telomere length, with be discussed. Finally, concluding with the main objectives that future age estimation studies should focus on.*

The presentation covered a variety of materials (Fig. 1) and methods used for estimating age in marine mammals, with an appraisal of each type. During her presentation the difference was noted between absolute and relative ages. The concept of a Growth Layer Group (GLG) was also explained as a repeating pattern that equates to a period of time. The structure of teeth was discussed in relation to the dentine originating from the pulp cavity and external cementum originating from the gum tissue, as well as the significance of the neonatal line at birth.

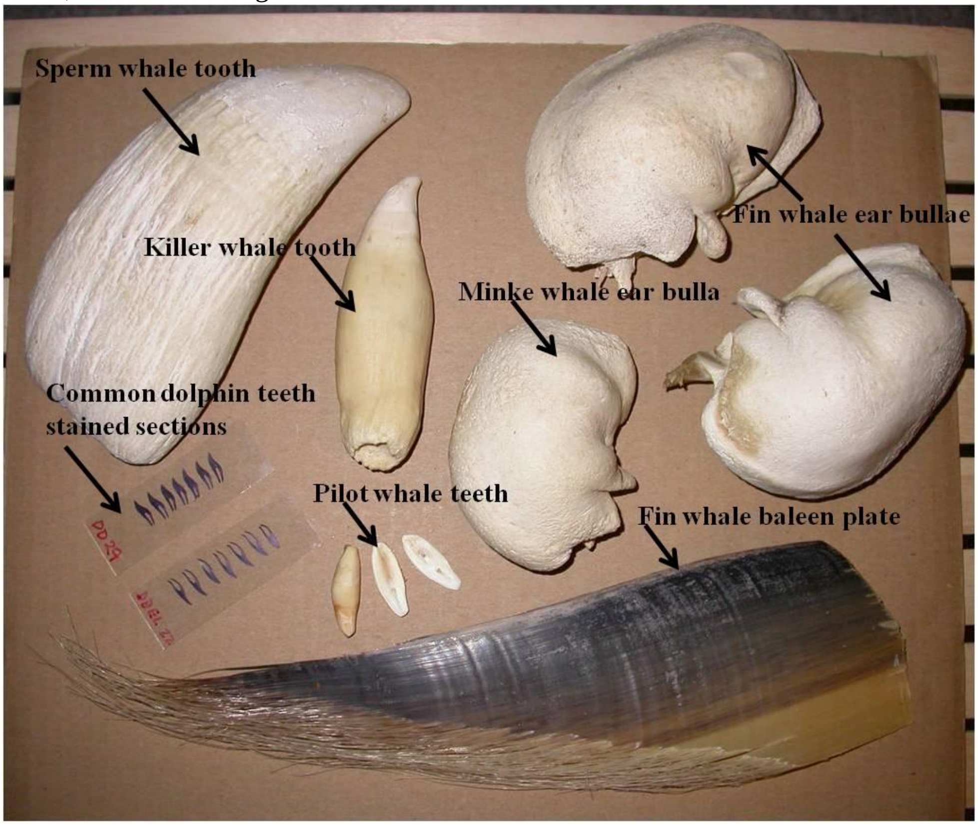

Figure 1. Hard parts including teeth, ear bones and baleen plates that can be used for age estimation (Photo: Christina Lockyer, Age Dynamics, Denmark.).

<u>Preparation methods:</u>

Direct methods

In summary, for teeth:

- Untreated sections: are often best for dentine, depending on species, and can be used for cementum. The method is time and cost effective. The method is less reliable for some species as GLG are not prominent and the pulp cavity becomes occluded with age.
- Stained sections: are best for small teeth, and are successful for several species but are time consuming to prepare and require additional specialized equipment.
- Acid etching of half teeth: is a simple and inexpensive method, but is not very satisfactory for teeth from small animals.
- Scanning electron microscopy (SEM): produces a 3D image with high clarity, which is very readable, but is not good for small species and is very expensive in time and resources.

- Microradiography: is a method that is non-destructive, unlike many others mentioned. For determining older GLG, high precision is needed.

Other materials than teeth employed for aging include:

- Claws: a method useable for seals, which is quick, easy and inexpensive. The method is only applicable for young animals with less worn claws.
- Baleen plates: this method is useable for baleen whales, but as with claws, only in young animals with unworn baleen.
- Ear plugs: this is a method useable in baleen whales. Total age and age at sexual maturity can be estimated, but the ear plugs are challenging to collect.
- Ear bones (tympanic bullae): thin untreated sections provide GLG counts lower than ear plugs, perhaps because of bone resorption with age. The method is limited to a few mysticete species.
- Periotic bones: this method is used in manatees where teeth (molars) are changed throughout life and cannot be used, but maybe be useful for other species, as well. Sections are decalcified and stained.
- Tusks: found in narwhals and walruses, as well as male dugongs, are often worn down and provide an incomplete age.
- Other bones, mainly mandibles and ribs, are sometimes useable but the methods are very species-specific, and to be used as a last resort when other means fail.

Mineralization anomalies in teeth can be used to identify environmental variations or unusual events (El Niño, life-history events – Manzanilla 1989). Presence of anomalies can be a source of potential misinterpretation of age. Misinterpretation of the GLG and poor preparation of the sections can lead to inaccuracy in counting. These issues may be overcome by some standard routines. There are also differences in GLG between young and old animals, which may lead to age inaccuracies. The former have accessory lines, while old animals may have tightly packed GLG that are hard to differentiate.

Indirect methods

Such methods provide relative age and are mostly unpublished and/or are unsuccessful.

- Bone density: a non-invasive, fast and relatively inexpensive method. However it requires basic age data for the model and specialized equipment. The method can be used from live to badly decomposed animals, all sexes.
- Genetic telomere: a method based on measurement of the average telomere length. Only two studies on marine mammals are currently published and are not unequivocally promising. Validation and calibration are necessary and the results may only produce age class information.
- Aspartic acid racemization (AAR): a method based on the D/L ratios of enantiomers, requiring stable temperatures. The method is better for old animals and species for which other methods are difficult, sensitive, and complicated, but it needs species-specific data for calibration and more precision.

- Fatty acid signatures (FA): the method can use the FA composition of the outer blubber layer. It has been successful with some species and is minimally invasive as biopsies can be taken. Presently the method can not to be used for estimating longevity and is not comparable across labs. The underlying biological factors are unclear.
- Ovarian corpora: a method that is easy and inexpensive, but requires dead animals and applies only to females. To calibrate age, life history data are needed to provide age at first parturition.
- Baleen plates in baleen whales can be analysed for isotopic patterns due to seasonal dietary changes. The method has been successful in bowhead whales (Schell and Saupe 1993, Lubetkin *et al*. 2008) but may only be useful in younger animals when other methods are more reliable.
- Dental colour: this method requires a standard colour reference guide for interpretation.
- Morphometrics: a method that is fast, consistent and cheap, *e.g.*, body length, but is not precise either for young animals, which may grow at variable rates, or older animals, which may achieve different ultimate sizes. Over-all growth may be too sensitive to energy intake to precisely measure age.

Validation:

Validation is essential to aging methods but has rarely been done in marine mammals. Validation can be effected through

- Known age, known-history animals. Photo-ID may help in tracking such free-living animals.
- Captive animals born in captivity or of known age when captured. GLG might not be as well defined as in wild animals
- Biomarkers, ideally administered on the animal's birthday and at set intervals,, *e.g.*, lead acetate or tetracycline antibiotics that leave a time-mark in hard tissues.
- Bomb radiocarbon isotope fallout (a natural biomarker), based on ^{14}C from nuclear experiments in the 1950s and 1960s. The method requires samples from before and after 1958. This is high technology and needs expensive equipment.
- Artifacts found in animals. These may include tags of natural or artificial origin, *e.g.*, "Discovery" tags, harpoon heads found in whales. It lacks precision due to the time span in which the technology was used and the life span of the animal before being 'tagged.'

General conclusions:

- Hard tissues, *e.g.*, teeth and bones, are good materials for aging but are species-specific.
- More than one method may be accurate for a species but time and funding constraints often preclude the use of more than one.
- There is a need for standardization among research labs for both method and reading GLG.
- All methods should be validated.

- The aging method chosen should reflect the purpose for which ages are required. Sometimes precise ages are not necessary.
- Combining complementary methods might be required for 'tricky' species.
- Often the ages estimated are only minimum ages.

Monodontids:

Beluga and narwhal are problematic species with respect to aging. To date, there are still discrepancies among methods and further work on validation is required. However, advances have been made for narwhal with the application of AAR techniques to eye lenses, although teeth (embedded or tusks) are not generally useable except in males. For belugas, teeth are potentially the most useful method of aging. There is a need for standardization of GLG counting, and especially for stating the number of GLG in addition to the age estimated. There is not yet full agreement on a deposition rate of GLG for beluga, although one per year is now favoured. Once GLG deposition rate is certain, all previous age data should be revised. Until agreement on GLG deposition rate is reached, management should be cautious about age parameters.

Focusing on belugas, a summary of methods for estimating age is provided in Table 1 where suitability, cost, source reference, and other factors are noted.

Discussion

Read was thanked for her comprehensive review. Steve Campana queried whether new imaging technology can reveal previously invisible structures in teeth of marine mammals. Imaging technology is relatively accessible. However, it is difficult to standardize the enhancements to the point where one does not see structures which do not relate to age. The possibility of enhancement by chelation by EDTA was raised. Care should be taken to interpret age artifacts which may be either opportunistic or experimental. It is important for animals tagged or marked at birth be followed throughout life for validating age methods.

Table 1. Different methods of age estimation in belugas with an appraisal of relative cost and efficacy. Green cells indicate preferred methods; yellow indicates some merit and areas for possible development; and red indicates little merit for routine aging.

BELUGA WHALE		**Relative cost**	**Time required**	**Precision**	**Accuracy (where tested)**	**Pros**	**Cons**	**Reference**
Teeth	**Untreated-dentine**	low	Short	medium	high	Clearer than cemental GLG. Does not close	Severe wear of the tip; some stocks show less distinct GLG	Perrin and Myrick 1980
	Untreated-cementum	low	Short	medium	medium		Cemental GLG form too closely to read; often the cemental GLG count is less than the dentinal GLG	Lockyer *et al.* 1999, Stewart *et al.* 2006
	Stained-dentine	medium	Long	high				
	Stained-cementum	medium	Long	high	high			

	Acid etching	low	Medium	low	low	GLG visible	Did not improve readability	Perrin and Myrick 1980, Pierce and Kajimura 1980
	Scanning Electron Microscope	high	Medium	high	low		GLG visible but not countable	Goren *et al.*1987
	Microradiography	medium	Short	low	n/a			
Mandible	**Untreated**	low	Short	medium	medium			
	Stained	medium	Long	high	medium			
Others	**Bone density**	medium	Medium	high	n/a			
	Genetic telomere	high	Long	medium	n/a			
Validation	**Aspartic acid racemization**	high	Long	high	n/a			
	Fatty acid signatures	high	Long	high	n/a			

	Relative age from ovarian *corpora*	low	Short	low	low		Accessory *corpora lutea*	Suydam 2009
	Known-age / history (incl. wild)	low	Long	high	medium/high	photo-id project has started		Hohn and Lockyer 1999, Lockyer *et al.* 2007
	Tetracycline	low	Long	high	medium			Brodie 1982, Hohn and Lockyer 1999, Lockyer *et al.* 2007
	Captive	low	Long	high	high			Brodie1982, Hohn and Lockyer 1999
	Bomb Radiocarbon	high	Long	high	high		Requires animals pre- and post 1958	Stewart *et al.* 2006
	Artifacts	low	Short	medium	n/a			George and Bockstoce 2008

4. Direct aging in dolphins, including belugas – Aleta Hohn

ABSTRACT: *Early studies suggested the possibility that teeth in dolphins (and pinnipeds) contained growth layers that served as an indicator of age. Since that time, most of the emphasis of direct age estimation in dolphins and porpoises has focused on validation of deposition rates, improved methods of preparing teeth for optimal resolution of growth layers, and standardizing protocols for counting growth layers. A workshop in 1978 discussed the complexity of growth layer patterns and the term "growth layer group" (GLG) was agreed to best represent that annual layers included smaller incremental growth layers. These incremental layers have been referred to in various ways, with particularly distinct incremental layers appearing as accessory layers that confuse readings of annual GLG or as marker lines, that represent life-history events. Despite remaining questions, with the exception of long-terms studies of known individuals, counts of GLG still serve as the best means of estimating age in dolphins.*

Hohn discussed the advantages of using teeth for age estimation and some caveats. Tooth structure reflects the animal's physiology at the time of deposition, which is a bonus for life history and stock information. The anatomy of teeth with specific examples was presented. The disadvantages of using teeth included sub-annual incremental growth laminae, which confuse age estimation, and crown wear, which erodes layers. It is critical that the orientation of the section is in the midline from crown to root apex. In some species GLG become compressed with age, so that layers are missed towards the root apex in old animals. There can be variations in tooth ultrastructure within species according to stock and region. The use of teeth for aging is relatively easy and inexpensive leading many "non experts" to use it without training, producing erroneous, non-standard ages. Accurate age estimation is important, as it is important to be aware that there are biases associated with the techniques (Hohn and Fernandez 1999).

Discussion

The possibility that dentinal-cemental layers might not be consistent was raised, but this seems to be a species-specific question. The cemental GLG counts can help in cases where the young dentinal layers are missing, depending on the species and how the cementum is formed. With reference to harbour porpoise, the cement can be used to determine where the first year layer is placed.

With respect to potential differences between captive-held and free-living animals, it was stated that there are no differences in tooth GLG in *Tursiops* in captivity or in the wild.

5. Investigating the deposition of growth layer groups in dentine tissue of captive common dolphins - Sinéad Murphy, Matthew Perrott, Jill McVee, Wendi Roe and Karen Stockin.

ABSTRACT: *Knowledge of age structure and longevity (maximum age) are essential for modelling marine mammal population dynamics. Estimation of age in common*

dolphins (Delphinus sp.) *is primarily based on counting Growth Layer Groups (GLG) in thin sections of decalcified and stained hard dental tissues. The incremental deposition rate was validated for* Delphinus sp. *30 years ago through the use of tetracycline, an antibiotic that was employed as a fluorescent vital marker in teeth of captive dolphins. Although an annual GLG deposition rate was identified, it is not known if the pulp cavity becomes occluded in older individuals or if GLG continue to be deposited in dentine tissue. To date, the oldest wild common dolphin has been aged at 30 yrs. To investigate the deposition of GLG in dentine tissue, tooth? samples were obtained during the necropsies of two New Zealand common dolphins that were held in captivity for 31 and 34 years. Individuals were captured together in Hawkes Bay, and classified as juveniles based on physical appearance. Teeth were processed in two aging laboratories, using four different bone decalcifiers, two sectioning techniques incorporating the use of both a freezing microtome (-20°C) and paraffin microtome, and two different stains. Time required for decalcification was determined by manual assessment of pliability, calcium oxalate precipitation end point tests or radiography. A maximum age was estimated for one of the dolphins, in line with that proposed based on estimated age at capture and period in captivity. However, a hypermineralised area was observed in the dentine tissue close to the pulp cavity of the second individual, preventing estimation of maximum age. The presence and structure of this anomaly is explored further within the study.*

A general introduction was given on common dolphin from different regions of the world with estimates of longevity from teeth up to *ca.* 30 yr. However, this presentation focused on the species around New Zealand, where two common dolphins, *Delphinus sp.*, captured young, were held in captivity for more than three decades before death. Shona died in 2006 at 206 cm length, after 31.3 yrs in captivity, suggesting an age of 4 yr from body length at time of capture (Kastelein *et al.* 2000); Kelly died in 2008 at 204.5 cm length after being held captive for 33.75 yr, suggesting an age of 3 yr from length at time of capture (Kastelein *et al.* 2000). Two preparation methods were applied to the teeth although both fixed the teeth in 10% neutral buffered formalin initially. Wax embedding, sectioning at 5 micron, and haematoxylin staining were employed in St Andrews University, Scotland, and frozen sectioning at 18-25 micron with toluidine blue staining at Massey University, NZ. Before sectioning, different decalcification methods were tried and compared, using whole teeth from each animal:

St Andrews:

- RDO - up to 3 days
- Formical-4 - more than 6 months

Massey:

- 10% Formic Acid - up to 6 weeks
- 10% EDTA - up to 6 weeks

Different endpoint tests (radiology or ammonium oxalate) were found for all chemicals. In some instances, the period for decalcification extended into months, and the chemicals were not completely effective. RDO was the most effective. Estimated ages for Shona were up to 27-36 yr, while for Kelly were up to 19 yr, far less than anticipated due to area of hypomineralisation around the pulp cavity. Both captive dolphins had lighter skulls than wild dolphins of a similar skull length found stranded along the New Zealand coastline.

Discussion

There was a suggestion that the teeth be pared down so that only the central part of thickness of about 2-3 mm is decalcified. This method would facilitate and hasten the decalcification process because of better permeation of the decalcifying agent.

6. Age estimation in seals - Fiona L.Read

ABSTRACT: *Accurate age estimates provide valuable information about the age structure, age at sexual maturity, and longevity of a population and are fundamental for understanding and interpreting the dynamics of a population. Age estimation in seals is particularly important due to the large numbers harvested in management systems and their large fluctuations in population size resulting from viral epidemics, e.g., the harbour seal* Phoca vitulina *phocine distemper epidemics in northern Europe in 1988 and 2002. Traditionally in seals age is determined by counting growth layer groups GLG in the dentine and/or cementum of teeth and, less frequently, in claws. In recent years, more novel approaches of age estimation have also been attempted with varying degrees of success, e.g., telomere length and aspartic acid racemization. The following presentation will review the methods used to establish age estimates in seals, the pros and cons of each method, the best tooth for age estimation and how the methods have been validated and calibrated, e.g., known age animals and multi-reader experiments. The presentation will conclude with how our present knowledge for obtaining age estimates in seals can be applied to age estimation of monodontids (narwhals and belugas).*

Direct methods of aging include tagging, freeze-branding and photo-ID. For indirect methods, claws and teeth are used. The presentation covered the following species: grey seals *(Halichoerus grypus)*, harbour seals *(Phoca vitulina)*, harp seals *(Phoca groenlandica)*, and ringed seals *(Pusa hispida)*, although other species were mentioned (Table 2 below). The best tooth for aging is the canine, although others have been used, and tooth selection largely depends on whether the animal is alive or dead. Mineralisation anomalies such as pulp stones were discussed. Their presence complicates the counting of GLG. Other methods tried for aging were mentioned, *e.g.*, AAR, genetic telomere length, radiography and X-ray of bone density and teeth. However, teeth remain the best method for seals, although AAR and telomere length are promising.

Discussion

The possibility of scaling the weight of teeth with body size/age to obtain an approximate age was discussed.

Table 2. Tooth preparation and age estimation in seal species.

Seal Species	Section	Untreated / Stained	Stain	Cementum / Dentine	Vali-dated	Reference
Baikal	Longitudinal	Stained	Haema-toxylin	Cementum	-	Amano *et al.* 2000
Bearded	Transverse	Untreated	-	Cementum	With claws	Benjaminsen 1973
Grey	Longitudinal	Untreated	-	Cementum	Known -age	Hewer 1964; Mansfield 1991
Harbour	Longitudinal	Stained	Tolui-dine Blue	Cementum	Known -age	Dietz *et al.* 1991; Lockyer *et al.* 2010
Harp	Transverse	Untreated	-	Dentine	Known -age	Bowen *et al.* 1983; Frie *et al.* 2011
Monk	Longitudinal / Transverse	Untreated	-	Cementum	-	Murphy *et al.* 2012
Ringed	Longitudinal	Stained	Haema-toxylin	Cementum	-	Stewart *et al.* 1996

7. A brief review of age estimation in sirenians, focusing on dugong tusks - Christina Lockyer

ABSTRACT: *The different evolutionary origins of sirenians, with links to elephants, means that teeth in this Order cannot generally be used for age estimation. The specialised molars in manatees, erupt at different times and wear down and move forward so that they are replaced (Marsh 1980) – as in elephants. Dugongs however have molars and premolars, which wear down, and a pair of incisors. These incisors erupt in males and continue growing throughout life to become tusks. Internally their structure shows a regular annual incremental GLG pattern (Mitchell 1976, 1978). Longevity can exceed 60 yr. Tusks generally do not erupt in females, so other*

techniques must be employed for aging,, e.g., dry eye lens weight. In manatees, ear bones can be used for aging, but this topic is not discussed. The similarities between internal GLG patterning in dugong tusk and both sperm whale and beluga whale teeth are reported.

Lockyer emphasised the longevity of sirenians and the very similar GLG patterning in teeth of monodontids. In some respects the dugong tusk in males has similarities to the tusks of male narwhals.

8. **Prospects for genetic age estimation of cetaceans - Morten T. Olsen**, Martine Bérubé, Jooke Robbins and Per J.Palsbøll

ABSTRACT: *Although the proliferation of tools available to cetologists has increased our understanding of whale ecology and evolution, there are questions of a temporal nature that will remain unanswered until a reliable and accurate method of age estimation is developed for free-ranging Cetaceans. Telomeres are DNA sequences situated at the end of chromosomes and tend to shorten with age, suggesting that telomeres may be used as a marker for age estimation. Here we report on the relationship between telomere length and age in the humpback whale (*Megaptera novaeangliae*). We used four different qPCR methods to estimate the rate of telomere shortening both across samples and* in vivo *in individual humpback whales for which multiple skin samples were available. The overall correlation between telomere length and age was weak, and highly variable among individuals of similar age, suggesting that telomere length measured by the qPCR method is an imprecise predictor of chronological age in humpback whales. We discuss the potential factors responsible for the observed patterns as well as the prospects for age estimation of cetaceans by use of the above and alternative methods for telomeres length measurement, such as TRF analysis and the novel dot blot method.*

Olsen's presentation indicated genetic material had been isolated from skin biopsies of 56 humpback whales using quantitative PCR analysis. A ratio between T/S was made using a known reference gene (Cawthon 2002, 2009). Telomere length was not precise for determining the absolute age, however, it might be used for characterizing the age classes of a population. Presently there are inherently large experimental errors. The method was nevertheless promising for relative age and for use in aging live animals. Telomeres can express biological age and are thus reflect external factors that may affect health and growth such as oxidative stress, *e.g.*, pollution, metabolism and diving hypoxia, reproduction and general health, which may affect the length of telomeres.

Comparing methods, TRF (telomere restriction fragmentation) has been found to be a precise and more accurate, while relatively expensive, technique for aging. The Dot Blot method (Kimura and Aviv 2011) requires less refined DNA and is relatively quick and inexpensive, and is useful for standard applications.

Species-specific calibration is required for aging. For humpback whales, additional older known-age animals are required for calibration and a cross-lab calibration is needed. The rate of telomere shortening is generally low although there is large individual variation. At best, telomeres may be proxies of life-history trade-offs.

Discussion

The study was accepted as preliminary but with interesting results. Although it is perhaps unlikely that this method may be useable for precise aging in any marine mammal, the technique has promise for defining broad age classes – useful in live populations, and may reflect life history of individuals.

9. Age estimation from teeth in large odontocetes - Christina Lockyer

ABSTRACT: *This presentation introduces the use of teeth from large whales to estimate age. The concept of counting Growth Layer Groups (GLG) that form throughout life is discussed with reference to its validity, and the assumption of an annual incremental rate of GLG. The species used as examples include sperm whales, killer whales, bottlenose whales, and beaked whales. The method of halving the tooth from crown through root for sperm whales,* Physeter macrocephalus*, and etching the smooth cut surface with 10% formic acid to throw the GLG into relief is satisfactory. However, methods of thin sectioning at 100-200 micron, as well as decalcification, thin-sectioning at 25 micron and subsequent staining, are discussed for smaller species such as beaked whales, e.g.,* Mesoplodon sp. *In sperm and killer whales, problems of wear at the crown of the tooth lead to under-estimation of age in old animals. The presentation concludes with comments on the relevance of the methods of tooth preparation to beluga, and finds similarities in sperm whale teeth GLG patterns as well as crown wear and possible longevity to belugas*

Methods described included acid-etching half-teeth with 10% formic acid or other agents (Gambell and Grzegorzewska 1967, Evans *et al.* 2002), thin sectioning, and decalcification methods with stained thin sectioning. For large teeth such as sperm whales, the best method is the simple acid-etching of half teeth. Special problems arise with teeth from some beaked whales (*Ziphiidae*) in which teeth are curved and difficult to cut/section. In conclusion, the size of the tooth dictates the method, but untreated sections work for small sperm whales, killer whales, beaked whales, and bottlenose whale, *Hyperoodon ampullatus*, teeth. The estimation of total age can be problematic when the crown is worn down and GLG are missing. The relevance to monodontids includes superficial similarities between beluga and sperm whale teeth; the untreated section method is good for both and crown wear is often severe and leads to underestimation of age. It is helpful to have body size data to compare with GLG age.

Validation of age has been feasible for known-history killer whales, some also with tetracycline antibiotic time-marking of teeth, but requires subsequent retrieval of teeth (Myrick *et al*. 1988). Bomb fallout radiocarbon isotope analysis may be possible in animals of all species born pre-1958.

10. Age estimation in mysticetes with a focus on ear plugs - Christina Lockyer

ABSTRACT: *The different methods that have been employed to age Mysticetes are briefly noted with comment on their applicability. The focus is on ear plugs as being the best method in Mysticetes. The ear plug (paired) which is of epidermal origin and is found in the external auditory meatus, grows continuously throughout life and thus holds a complete record of age. The incremental rate of deposition of GLG is annual and the ways this has been validated are reported. The ear plug anatomy, its collection, and the method of preparation for GLG counting are described and as are the internal GLG pattern that changes with age to permit estimation of age at sexual maturity at the transition phase. The ear plug is generally used successfully in fin, sei and minke whales, and also can be used in blue, Bryde and humpback whales. The total age and the transition phase enable life history parameters to be determined retrospectively. A comparison is made with beluga tooth GLG patterning, noting the occurrence of accessory lines which are primarily a juvenile feature in Mysticetes, and the compacting of GLG in old beluga teeth.*

Age estimation has been done using ear bones, jaw bones and tissues of epidermal origin (ear plugs and baleen plates) which contain GLG. Other methods relying on physical or chemical analysis include eye lens weight and opacity, AAR of eye lens, and isotopes in baleen plates. However, these latter require calibration using more precise methods that have GLG as a reference point.
The ear plug anatomy (Purves 1955) was described as was the method of extraction from carcasses. Ear plugs have been used for age estimation in several species of baleen whales (Ichihara 1964, Ohsumi 1964). The easiest approach for extraction is from the back of the skull when severed from the vertebral column so exposing the occipital condyles. However, this approach may require major flensing. Once the tympanic bullae are located the ear plugs can be found and extruded via the external auditory meatus. The ear plug is suitable for age estimation in balaenopterid whales, especially blue whales (*Balaenoptera musculus*), fin whales, humpback whales, sei whales (*Balaenoptera borealis*), and Bryde's whales (*Balaenoptera brydei*). Minke whales also have useable ear plugs but there are big problems in aging those from certain populations, *e.g.*, North Atlantic. Also, minke whale GLG are not as clear as in other balaenopterid species, and readability of the GLG can be variable (Kato 1984, Kato *et al.* 1991). Ear plugs from balaenid whales are problematic but ear plugs have been used in gray whales, *Eschrichtius robustus* (Rice and Wolman 1971).

The ear plug requires fixation and preservation in neutral buffered 10% formalin. The paired ear plugs are "shaved" down lengthways to the core centre using an old-fashioned straight hand razor, exposing the neonatal line and GLG above the "glove finger." Once exposed, the GLG can be counted using low-power magnification. A complete record of age is recorded as well as life-history stages from GLG growth pattern changes, *e.g.*, age at sexual maturity (transition phase) and even physical maturity (Lockyer 1972, 1974, 1984), providing parameters that can be used at a population level. Roe (1968) provided validation of annual GLG deposition in fin whales.

The relevance to monodontids is indirect. Ear plugs are very different structures to teeth and are not generally applicable in odontocetes. However, ear plugs and teeth have continued growth and potential for total age records; both have accessory lines that may confuse age estimation. The transition phase in ear plugs might be something to look for in teeth GLG patterns.

11. Feasibility study on the incorporation of the gelatinized collection method and the freeze-section technique of the ear plug in age estimation in common minke whales - Hikari Maeda, Tadafumi Kawamoto and Hidehiro Kato

ABSTRACT: *Because of its soft structure, ear plugs of common minke whales (*Balaenoptera acutorostrata*) are easily damaged during their collection from the external auditory meatus, especially among younger animals. In addition, there are still problems existing for ear plugs with unclear lamination on the bisected surface of the core. The present study tried to solve these two problems in age estimation of the common minke whales, by examining the feasibility of new techniques incorporating the gelatinized collection method and a histological approach by the freeze-sectioning of the core in ear plugs.*

For the first problem, we have tried a new ear plug collection method as follows; i) filling the space in the external auditory meatus with gelatin, ii) hardening the gelatin encasing the ear plug and any fragments by spraying a cooling gas, iii) removing the gelatinised ear plug from the meatus. Using a total of 214 trials on the minke whales at the scientific permit survey platform (JARPN II coastal program) in 2007 to 2009, it was revealed that embedding ear plugs with gelatin material minimized the proportion of breakages at the neonatal region, especially among ear plugs in younger animals. This obviously leads to an increased proportion of readable ear plugs and identifies high utility of the present gelatinized collection method. For the second problem, so as to have clearer core surface images of growth layers, we examined histological sections (thickness 5-10μm) sliced by the Kawamoto specialized frozen sectioning techniques (Kawamoto 2003), with staining by three different agents: Sudan III, Haematoxylin – Eosin, and Alizarin red. Through a total of 8 experiments, the histological section with Alizarin red gave the clearest growth laminations where we easily identified both dark and pale laminations, suggesting a close relation to the seasonal changes in intake of calcium through feeding. The present frozen section is also useful for investigating further detailed structure of ear plugs.

This presentation concluded that using the gelatinized technique for collection of ear plugs with the injection of liquid gelatin around the ear plug and the solidification, improves ease of extraction and, by maintaining the integrity of the ear plug, also improves the subsequent readability of GLG. The histological experiments indicated that the frozen sectioning technique and staining with Alizarin red helps clarify the GLG.

Discussion

The point was raised that probably the gelatin extraction technique could be used on the bowhead whale in which the ear plug is generally very soft and disintegrates easily. In general, the gelatin technique seems to be improving the extraction of ear plugs.

Kato noted that the correlation of GLG between ear plug and tympanic bullae in minke whales was good and that such a correlation might be sought for GLG in teeth and tympanic bullae in odontocetes, *e.g.*, belugas, especially for predicting real age when wear was present in the tooth crown. The ear bones are common to all whales.

12. Age estimation with age validation from eye lens of fin whales and harbour porpoises - Nynne Hjort-Nielsen

ABSTRACT: *The aspartic acid racemization (AAR) method is based on the fact that the amino acids in nearly all living tissue, consists solely of L-isomers, but once the life process has ceased, the L-isomer amino acids undergo racemization to its D-isomer. This racemization occurs at a constant rate and it is thus theoretically possible to calculate the time that has elapsed once the racemization rate (k) and the ratio of D and L at birth ((D/L)0) are known. However, k is highly temperature-dependent and it is thus of great importance to keep this in mind when handling the samples. The AAR method was originally developed for dating marine sediments (Bada* et al. *1970) and fossils (Bada 1972; Bada and Protsch 1973) but later it has been applied in forensic science on human tooth enamel and dentine (for a review, see Meissner and Ritz-Timme 2010) and on human eye lens nuclei (Masters* et al. *1977, 1978). Studies of known-age humans (Ohtani* et al. *1995) and zoo animals (Eva Garde pers. comm.) found conclusive agreement between AAR age estimates and actual ages. This study estimated the age of 121 fin whales (*Balaenoptera physalus*) and 83 harbour porpoises (*Phocoena phocoena*) by the AAR method and by counting the growth layer groups (GLG) in teeth (harbour porpoises) and ear plug (fin whales) respectively. The aspartic racemization rate (k_{Asp}) for fin whales was established from 15 foetuses classified to age, based on body length, and 15 adult whales age estimated by counting the GLG in the ear plugs. The k_{Asp} for harbour porpoises was derived from thirteen 1+ yr old porpoises age-estimated by counting GLG in the teeth and four neonate porpoises classified to age based on length. The k_{Asp} values were determined by regression of GLG against aspartic acid D/L ratios. For the fin whales k_{Asp} of 1.10 x 10-3 yr-1 (SE ± 0.00005) and a D/L ratio at birth ((D/L)0) of 0.028 (SE ± 0.0012) were determined. For the harbour porpoises a k_{Asp} of 3.10 x 10-3 yr-1 (SE ± 0.0004) and a (D/L)0 value of 0.023 (SE ± 0.0018) were determined. The fin whale k_{Asp} is in agreement with rates for other baleen whales, whereas the rate for harbour porpoise is considerably higher. Correlation between age estimates from AAR and GLG counts (individuals not included in the estimation of k_{Asp}) indicated that AAR might be a suitable method for determining age in marine mammals.*

The theory and history of the AAR method were presented. Details of the method used in marine mammals were described, specifically for fin whales (n = 121) and harbour porpoises (n = 83) for which a known method of age estimation (GLG in ear plugs and teeth respectively) was available for calibration. The art of extracting the nucleus from the eye lens, which is surrounded by layers like an onion, is in rolling the lens until the nucleus is exposed and then peeling off the outer layers. Sources of error in the analysis can come from contamination and also cataracts in the lens. Calibration of the AAR age was by GLG in ear plugs for fin whales and GLG in teeth for porpoises. There were large variations in D/L ratios in young animals and a high racemization rate, k_{Asp}, in harbour porpoises for which this was the first study.

One surprising finding was an AAR estimated age of 120 yr for an old stranded fin whale off coastal Denmark in 2010. This is the oldest estimated age for this species hitherto.

Validation of the AAR ages still requires reference to known-age animals.

13. Comparison of aging techniques, estimation of racemization rates and validation - Eva Garde

13.1 Background, the harp seal study and the known age animals study

ABSTRACT: *This talk will focus on the aspartic acid racemization (AAR) technique and the AAR results from two different studies. One study (Garde* et al. *2010) compares age estimates of harp seals (*Pagophilus groenlandicus*) obtained by 3 different methods, the traditional technique of counting growth layer groups (GLG) in teeth and 2 novel approaches, aspartic acid racemization (AAR) in eye lens nuclei and telomere sequence analyses as a proxy for telomere length. The other (Garde* et al. *submitted) uses animals of known age or ages estimated by another aging method to determine species-specific racemization rates and to examine the effect of body temperature on the rate of racemization. Both studies address the question of the AAR technique as a valid method for age estimation of mammals.*

*Lower jaws (containing the teeth), eyes, and skin samples were collected from harp seals (*Pagophilus groenlandicus*) in the southeastern Barents Sea for the purpose of comparing age estimates obtained by 3 different methods, the traditional technique of counting growth layer groups (GLG) in teeth and 2 novel approaches, AAR in eye lens nuclei and telomere sequence analyses as a proxy for telomere length. A significant correlation between age estimates obtained using GLG and AAR was found, whereas no correlation was found between GLG and telomere length. An AAR rate (k_{Asp}) of 0.00130/yr ± 0.00005 SE and a D-enantiomer to L-enantiomer ratio at birth (D/L_0 value) of 0.01933 ± 0.00048 SE were estimated by regression of D/L ratios against GLG ages from 25 animals (12 selected teeth that had high readability and 13 known-aged animals). AAR could prove to be useful, particularly for aging older animals in species such as harp seals where difficulties in counting GLG tend to increase with age. Age estimation by telomere length did not show any correlation with GLG ages and is not recommended for aging harp seals.*

The AAR technique has been applied for age estimation of humans and other animals over the past three decades. In this study, eyeballs from mammals (n =124; 25 species) of known age or age estimated by another aging method were used to determine species-specific racemization rates and to examine the effect of body

temperature on the rate of racemization. Strong correlations (range: r = 0.93-0.99) were found by regression of D/L ratios against known/estimated ages for 7 mammal species. Racemization rates (as $2k_{Asp}$ values) were well correlated (r = 0.91) with average core temperatures (°C), and a linear relationship was found between rate and temperature.

The presentation demonstrated that the AAR method is valid for several mammal species for which age is known, showing a strong correlation of D/L ratio with actual age. A total of 124 animals from 3 groups of species were examined. In pygmy goats the known age was similar to the AAR age. Racemization rates were different among species and racemization rates correlated well with core temperatures. When applied specifically to harp seals (n=113), there was also a strong correlation between tooth GLG and D/L ratio. AAR and GLG ages were similar but the AAR method appeared more accurate for old animals. The eye lens in narwhal was soft and clear in young animals but became hard and yellow in old animals. Some fine tuning and further calibration are still needed for harp seals. However, there was no correlation with telomere length which was deemed as an unsuitable method of aging in harp seals.

13.2 Narwhal age from eye lens and age validation

ABSTRACT: *This talk will focus on the AAR technique in age estimation of narwhals (*Monodon monoceros*). I will present the results from two studies. One (Garde* et al. *submitted 2) estimate a species-specific racemization rate for narwhals by regressing aspartic acid D/L ratios in eye lens nuclei against growth layer groups in tusks. The other (Garde* et al. *ms) is a large-scale study of age estimation in narwhals using the AAR technique, followed by construction of age distributions and estimation of life history parameters. The obtained parameters were subsequently used in a population dynamic analysis.*

Ages of marine mammals have traditionally been estimated by counting of dentinal growth layers in teeth. This method is, however, difficult to use on narwhals because of their special tooth structures. Alternative methods are therefore needed. The AAR technique has been used in age estimation studies of cetaceans, including narwhals (Garde et al. *2007). The purpose of this study was to estimate a species-specific racemization rate for narwhals by regressing aspartic acid D/L ratios in eye lens nuclei against growth layer groups in tusks. Two racemization rates were estimated: one by linear regression (r^2 = 0.98) based on the assumption that age was known without error, and one based on a bootstrap study, taking into account the uncertainty in the age estimation (r^2 between 0.88 and 0.98). The two estimated $2k_{Asp}$ values were identical to two significant digits. The $2k_{Asp}$ value from the bootstrap study was found to be 0.00229 ± 0.000089 SE, which corresponds to a racemization rate of 0.00114-yr ± 0.000044 SE. The intercept of 0.0580 ± 0.00185 SE corresponds to twice the $(D/L)_0$ value, which is then 0.0290± 0.00093 SE. We recommend that this species-specific racemization rate and $(D/L)_0$ value be used in future AAR aging studies of narwhals.*

Eyes, reproductive organs and body length measures were collected from 280 narwhalsin East and West Greenland in 1993, 2004, and 2007 – 2010. The purpose

was a large-scale study of age estimation using the AAR technique, followed by construction of age distributions and estimation of life history parameters. The obtained parameters were subsequently used in a population dynamic analysis. Age estimates were based on the racemization of L-aspartic acid to D-aspartic acid in the nucleus of the eye lens. The ratio of D- and L-enantiomers was measured using high-performance liquid chromatography (HPLC). The age equation used was determined from data from Garde et al. *(ms). Asymptotic body length was estimated to be 405 cm for females and 462 cm for males from East Greenland, and 399 cm for females and 456 cm for males from West Greenland. Age at sexual maturity based on data from reproductive organs was estimated to be 8 yr.s for females and 17 yr.s for males. Pregnancy rates for East and West Greenland were 0.42 and 0.38, respectively. Maximum lifespan expectancy for narwhals was found to be ~100 yr.s of age. A population projection matrix was parameterized with narwhal data on age structure and fertility rates. Under the assumption of stable age structure it is calculated that narwhals in East Greenland have a potential annual growth rate of 3.8% while narwhals in West Greenland have a potential growth at about 2.6%.*

Narwhal tusks were sectioned using a jig saw so that the cut surface of a half tusk was prepared. The surface was acid-etched with acetic acid by immersing the tusks in specially built tanks for many hours. The etched tusks were subsequently rinsed in water and then dried so that the GLG were thrown into relief and could be counted. The surface was also rubbed with soft pencil lead to emphasise the GLG. Deposition rate of GLG in narwhal is not known but inter-GLG spacing is very thick (ca 3 mm) and thus likely represents annual growth. A species-specific racemization rate was estimated for narwhals by using the tusk age as a calibration.

Discussion

This method showed great promise for a species where age is largely unknown. The possibility of using embedded tusks in young animals was suggested, as these are relatively easy and inexpensive to acquire. It was recommended that comparisons be made in future studies of narwhal population dynamics, age distribution and life-history parameters between samples from east and west Greenland using reproductive status and AAR techniques.

14. **Aging beluga (white) whales from measurements of specific fatty acids present in their outer-blubber biopsy tissues -** David P. Herman, Roderick C. Hobbs, Barbara A. Mahoney and **Gina M. Ylitalo**

ABSTRACT: *Age estimation of individual cetaceans and estimation of the age distribution of entire whale populations is fundamental to assessments of status and long-term viability. Until recently, there was no reliable benign method to determine the specific ages of live animals for remote populations where long-term longitudinal sighting studies were not practical. In two recent studies involving populations of eastern North Pacific (ENP) killer whales and humpback whales from both the ENP and western North Atlantic, we described a new method by which age could be estimated with good precision from measurements of specific endogenous fatty acids (FAs) and FA ratios present in the outer blubber layers obtained by remote dart*

biopsy techniques. Although the precisions (±σ) of the FA-age models derived for these populations of whales were somewhat variable (ranging between ±3.1 and ±5.3 yr), the results indicated that it should be possible to estimate the age of an individual whale from any population of these two species with better than decadal resolution using this approach. In this presentation, we provide some new preliminary data suggesting that it should be possible to age individual Cook Inlet beluga (white) whales following this approach based on FA results obtained from a combination of capture and release (biopsy) and stranded (necropsy) samples acquired between 2001 and 2007. Unlike the two previous studies in which exact or minimum known-ages were known and thus served as calibration standards to derive empirical FA-age models, ages of the Cook Inlet belugas described in this study were initially estimated from the von Bertalanffy allometric relationship between body length and teeth growth layer groups (hence age, assuming 1 GLG/yr) derived for this population of belugas in the 1990s from a large number of stranded animals, (Vos 2003). Whereas body lengths may only be used to derive crude age estimates for juvenile and sub-adult whales not yet having achieved maximum physical maturity (size), the proposed FA ratio – age model described in this presentation seemingly should enable the ages of physically mature adult whales of both sexes to be estimated following this approach.

The paper reviewed studies employing this method using specific endogenous fatty acids (FAs) and FA ratios (Herman *et al.* 2008, 2009). The method is robust and generally viable for age estimation, and is a non-lethal method that can use biopsies of blubber. Focusing on N.E. Pacific killer whales, despite some differences in blubber FAs in residents and transients, an empirical killer whale age-FA model was developed using this technique, which can predict ages with a precision of ±3.9 yr.

In humpback whale FA studies (endogenous and dietary in origin), where there has been a comparison with Photo-ID aging (S.E. Alaska vs Gulf of Maine), a robust model could predict ages within ±5.3 yr regardless of stock, sex and dietary preference. A generic species model is not optimal for precise age. The humpback whale studies highlighted the need to develop individual stock-based models. This may in part be due to different dietary habits affecting the FA composition. However, the underlying biological mechanism is not well understood. The outliers appear mainly to be very young and suckling animals. When the two stocks were analysed separately, a greater precision of ±3.1 yr for Gulf of Maine and ±4.5 yr for S.E. Alaska was obtained.

When FA techniques were applied to Cook Inlet belugas, body lengths and ages from teeth (Vos 2003) were compared with FA ratio-derived ages for 11 males and 11 females, using outer blubber. Analysis was based on the ratio of a single pair of blubber FA: C16:1n9/iso-C16:0. Preliminary results indicated that such a model can be used to predict ages within ±5.8 yr for juvenile/sub-adult belugas and appears to be independent of sex. Results appear to be contiguous thus enabling the ages of physically mature adult belugas to also be estimated. It is anticipated that age prediction uncertainties will be substantially reduced when biopsy samples from animals of exact known age are acquired and their blubber FA compositions fit to a linear combination of two FA ratios, similar to the killer whale and humpback whale models. However, as in humpbacks, there is no clear understanding of the underlying biological mechanisms responsible for the beluga age/FA relationship.

Discussion

One issue with using FAs, especially from remote biopsy sampling, is that small differences in the sampling of blubber might be significant. The sample would be affected by the angle of penetration of the biopsy tip or the selection of blubber analysed. The beluga work is in progress and, although the age precision is not as high as for killer whales, the technique is promising and should be investigated further. In time, the technique may be applicable to narwhal if there is an independent method for aging available.

15. Growth and maturity of belugas in Cumberland Sound compared to those raised in captivity - Paul Brodie, K. Ramirez and M. Haulena

ABSTRACT: *The beluga* (Delphinapterus leucas) *is one of the few odontocetes to adapt, year-round, to a polar environment, one of the most challenging marine habitats in the world, with shallow estuaries, high turbidity, shifting pack-ice and extreme tidal ranges. Adaptation is attributed in part, to year-round herd integrity and synchrony, occupying a sequence of restricted seasonal habitats and calving sites, which are reflected in tooth laminae. Newborn and the first four year-classes are recognizable by comparing length, body colour and morphology. Assessment of body colour is highly subjective in the field and provides a crude index of maturity. Field research, 1966-1969, led to the conclusion that females are sexually mature at 5.75 yr and males are at 8.75 yr, gestation is 15-16 months, and the reproductive cycle is 3 yr, with a lifespan of 30-35 yr. The 2- year nursing period results in rapid growth of the calf, coincident with a training period to acquire social, feeding and crucial navigational skills. The population in Cumberland Sound had been reduced through exploitation, thus it is unlikely that the present numbers are food limited, reflecting maximum rate of increase for a wild stock. We examine similar growth indices for captive belugas, some captured as calves, as well as first and second generations born in captivity, to compare known-age animals. Growth to onset of sexual maturity of males and females is similar to findings for the Cumberland Sound population, which was based on two growth layer groups per year in the teeth, or GLG/2. We analyse studies where previous oral doses of tetracycline, as well as bomb ^{14}C were used to argue for single annual GLG. Dedicated field studies, using appropriate dosage of intramuscular tetracycline, provide evidence for GLG/2. The ^{14}C study appears to have been compromised by preparation technique, and burdens sampled in the 1990s are probably of maternal origin, transferred during foetal growth and lactation. Direct observations and cross-referenced parameters fail to substantiate GLG/1, which requires halving the somatic growth rate, thus doubling the age of sexual and physical maturity as well as lifespan, resulting in a 40% reduction in the intrinsic rate of natural increase.*

This presentation gathers together diverse information regarding age, reproductive history and growth rate for the Cumberland Sound belugas during the pre-1970 period, and a comparison with biological parameters from known-history captive belugas primarily from Churchill, western Hudson Bay, the source of most captive beluga. Based on younger, known-age belugas from Churchill, the conclusions are that the deposition rate of tooth GLG is two per year. The ages at capture of two belugas in Hohn and Lockyer (1999) and later included in Lockyer *et al* (2007) were assessed as wrongly estimated and GLG counts based on realistic ages at capture (Robeck *et al* 2005) were more consistent with GLG/2 for

- Churchill (male) at total age 12.7yr (4.9 yr wild+7.83yr captive) = an expected 25.4 GLG, the average count of five readers being 27.8 (SD 3.63, range 24-32), while for
- SW-DL-7903 (female) at total age 10.75 yr (2.75 yr wild+ 8 yr captive) = an expected 21.5 GLG, the average count of five readers being 18.20 (SD 2.17, range 16-21) – neither consistent with GLG/1 nor GLG/2. (However, with reference to Lockyer *et al* (2007), this animal had a tetracycline mark which clearly established a GLG/1 rate at least in the adult phase – see Fig. 5 later under presentation 26. by Hohn and Lockyer.)

When appropriate ages at capture, and estimated GLG loss, were applied to the other captive belugas examined in Lockyer *et al* (2007), they were all (sample of 10) assessed as not conforming with GLG/1. Examples were:

- Aurora, a 246 cm female, possibly as old as 3.2 yr, plus 15.2 yr captivity = 18.3yr, thus 36.6 GLG. The average count in Lockyer *et al* (2007) Table 4, is 35 (SD 3.32, range 27-35).
- No-See-Um, a 257 cm male was a maximum of 3.2 yr at capture in August, plus 21.7 yr captivity = 24.9 yr, thus 49.8 GLG. The maximum count in Lockyer *et al* (2007) Table 4, is 46+, the "+" indicating lack of neonatal line and possible tooth wear. The average count was 42.8 (SD 4.66, range 35-46).

Discussion

There was much discussion, particularly with respect to the apparently circular arguments pertaining to GLG deposition rates, used in the presentation. The full arguments on interpretation of all GLG counts are discussed in Lockyer *et al* (2007), and different scenarios were tested based on both minimum and maximum GLG counts estimated, which clearly diminishes the strength of an argument for GLG/2 based on using the average count alone.

While body length can be taken as an indicator of age, especially in juvenile animals, growth rates and parameters vary among both stocks and individuals. It is important to compare like with like. With reference to the phasing of colour from grey to white, Brodie (1971) stated: "Whitening of female beluga in Cumberland Sound occurs after 6 yr, and of males after 7 yr. The white colour can be used in the field to establish at least a minimum age and to indicate that the animal is near physically mature size…" Light grey beluga females of 6 + yr of age have been observed to be pregnant both in Cumberland Sound and in Hudson Bay. Body colour which can change from grey to white in adult belugas, is not a knife-edge transition, and there are many documented cases of so-called "juveniles" of grey colouration that have produced a few young before becoming white (see presentation 20. by Michaud below; also Stewart, pers. comm., who reports dissecting foetuses from grey female belugas). Colour can therefore not be used reliably to assess maturity. In terms of allometric life-history, it seemed odd that belugas alone would live only half as long as pilot whales (*Globicephala sp.*), for example, which are about the same size, and be the only species of mammal that has a different tooth GLG deposition rate.

Convincing evidence for the one GLG per yr hypothesis requires appropriate numbers of productive females within a population, either pregnant and/or lactating, whose ages can be verified at 30-60 yr. Moby, a female, appears to be one of the oldest known history belugas, dying after 30 yr in captivity. According to Lockyer *et al.* (2007), among 5 readers, at least 30-43 GLG were observed in the tooth dentine which was worn at the crown. According to length, she was a juvenile on capture.

On balance the workshop members supported the current interpretation of annual GLG deposition rate. There were now many other studies (see Michaud presentation 20) that confirmed an annual deposition rate.

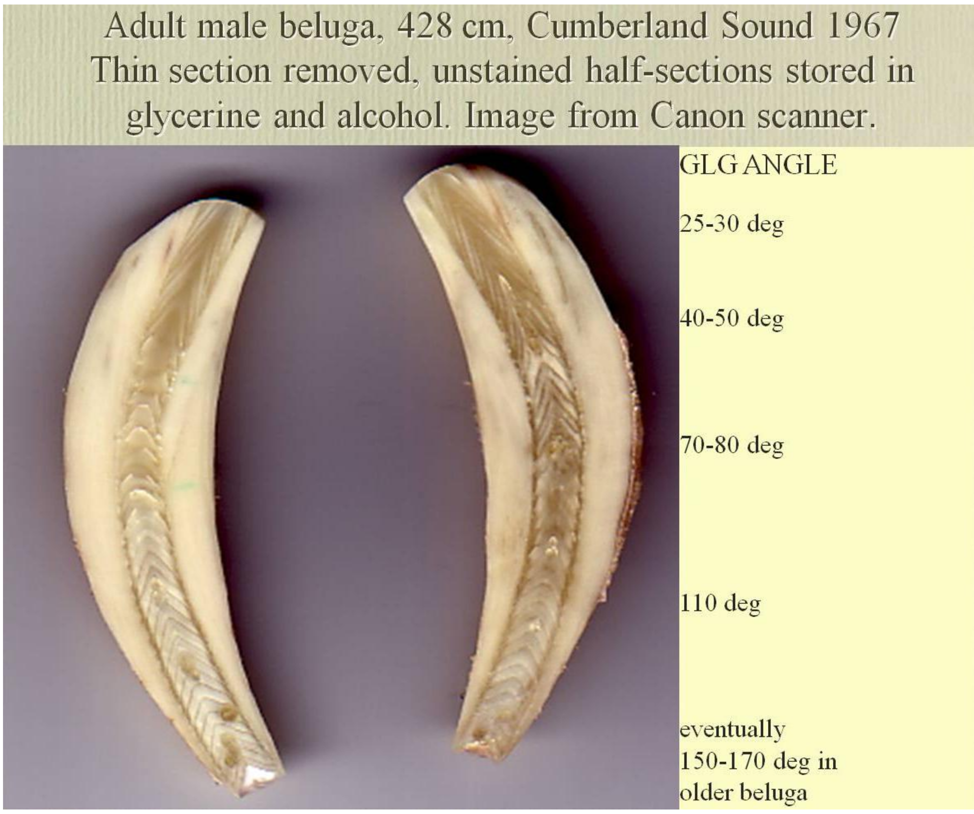

Figure 2. Beluga tooth sections showing the change in total angle of the GLG at the pulp cavity with age. Picture by courtesy of Paul Brodie, Balaena Dynamics Ltd, Halifax, Canada.

One detail from the presentation that the workshop found promising was a simple technique, whereby GLG lost to erosion could be estimated. As additional GLG are added to the pre-natal tooth, the total angle at the dentine interface with the root tissue expands in increments of 1-2 degrees, beginning at 25-30 deg, 40-50 deg after approx.12 GLG, 70-80 deg after approx 18 GLG; ultimately to 150-170 deg (see Fig. 2 above). Examining this matter in detail, perhaps through a special study specific to the population, could help identify cases where crown wear results in lost GLG and help to estimate the number of GLG worn away.

16. Use of micro-computed tomography for dental studies - Carolina Loch, Donald Schwass, Jules A. Kieser and R. Ewan Fordyce

ABSTRACT: *Teeth are important elements in studies of modern and fossil cetaceans, providing information on feeding habits, estimations of age, and phylogenetic relationships. The growth layer groups (GLG) recorded in dentine have demonstrated application for aging studies, but also have the potential to elucidate life history phenomena such as metabolic or physiologic events. Micro-Computed Tomography (Micro-CT) is a non-invasive and non-destructive technique that allows 3-dimensional study of mineralized tissues and their physical properties. It has mostly been used for qualitative dental studies in humans. Teeth from extant dolphins (*Globicephala *sp. and* Sotalia guianensis*) and an unnamed Oligocene fossil dolphin (OU 22108) were scanned in a Skyscan 1172 Micro-CT desktop system. X-rays were generated at 100 kV and 100 µA for extant samples and at 80kV and 124 µA for the fossil tooth. Aluminum and copper filters, 0.5 mm thick, were used in the beam. Reconstructed images were finely resolved for the fossil, showing the enamel, internal layers of dentine, and the pulp cavity. The enamel layer was well defined in both extant species throughout the images, but the dentinal layers were less resolved. We are refining the use of Micro-CT for dental studies in cetaceans, to allow resolution of internal structure and potential application in non-destructive aging techniques. Imaging software should elucidate greyscale values observed in the dentinal region of extant specimens and their relation to GLG. Future Micro-CT analysis will involve paired scans of teeth alongside resin-hydroxyapatite calibration standards of known densities to quantify mineral density of dental tissues in odontocetes.*

This technique, Micro-CT, is a non-destructive alternative for looking into hard structures such as bones and teeth of fossil and living animals to investigate internal structures. This may be very helpful for examining teeth that are difficult to cut / section because of shape or fragility. The examples shown demonstrated internal layering, and thus may have potential use in age estimation from tooth GLG. The technique is promising albeit still being developed. A significant limitation on application is that the actual size of the teeth that can be scanned is limited because of the dimensions of the investigative chamber.

17. Ear bones for aging manatees - Amber Howell

This presentation was a spontaneous review of the age estimation in manatees. The method entails thin sectioning of periotic bone which shows GLG (Marmontel *et al.* 1996). The sections are stained and examined in transmitted light. Fig. 3 shows GLG in a stained ear bone section of a 10 yr old manatee.

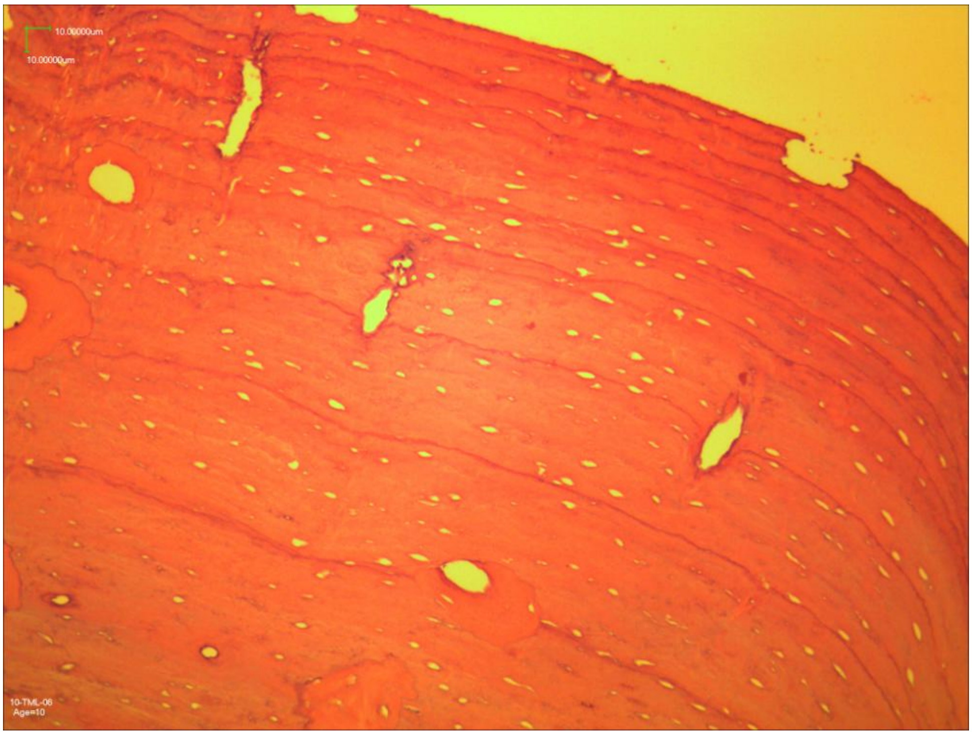

Figure 3. Stained section of ear bone of a 10 yr old manatee. Courtesy of Katherine Brill.

There is some degree of blurring of the layering above 12 GLG, and despite possible resorption, the oldest recorded age using this method is nearly 60 GLG (O'Shea *et al.* 1995). There are difficulties in interpreting GLG because of double laminae and merging of laminae. However, these problems are common to other methods of aging using layered hard tissues.

18. Informal progress report on *trace element profiles* in beluga teeth - Cory Matthews

This informal presentation reported the interim progress on an ongoing pilot study. Matthews reported on stable isotope ratios for diet and ecological determination of beluga, killer *(Orcinus orca)* and bowhead whales *(Balaena mysticetus)*. The teeth of belugas were micro-milled in the light and dark bands of the dentinal GLG and analysed for nitrogen ($^{15}N/^{14}N$) and carbon ($^{13}C/^{12}C$) isotope ratios, which varied among GLG. Dark bands seem enriched in both ^{15}N and ^{13}C. It may be feasible to cross-date at the population level using these chemical signals in teeth GLG. In addition, it appears possible to assess the weaning age using ^{15}N in early GLG in killer whales, and this may be similar in belugas.

Trace elements measured using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) show regular oscillations in the GLG, but this is not consistent for all teeth. However, if changes in element concentration can be linked to environment, such as oscillations caused by seasonal movements between summer and winter distributions, the method could be used to calibrate tooth structure. The method might be useful to look at the structure of the teeth to learn more about life history at both the population and the individual levels.

Discussion

It was pointed out that as of yet replicates of the same animals have not been made, so that the results must be treated with caution. It was suggested that the element ^{18}O could also be useful. There was encouragement that this work should continue.

19. Applications of Aspartic Acid Racemization for Aging Bowhead Whales - Craig George

ABSTRACT: *The Aspartic Acid Racemization (AAR) technique has been applied to estimating the age of several mammals. For bowhead whales, the technique has been applied in several publications on cetacean age, growth, animal health, and management advice (Bada 1972, Bada* et al.*1970, 1980, 1983, Rosa* et al. *2004, Rosa* et al. in press*, George* et al. *2011, Garde* et al. *2007).*

While age estimates for bowheads have high SEs there has been no indication of bias (George et al. *1999, Rosa* et al. in press*). For sub-adult bowheads (<15 yr), the CV of the AAR estimates exceeds 100% and should be applied cautiously. For young animals, the "baleen aging" technique (stable carbon cycles in baleen) is recommended as it is more accurate.*

With regard to the question of accuracy and bias, the age estimates for bowheads have been verified independently by several different approaches. These are reviewed below:

1. *The "baleen aging" technique suggested age at sexual maturity (ASM) for bowheads in their early 20 yr (Lubetkin* et al. *2008 , Schell and Saupe 1993) corroborating the AAR estimates of* ca *25 yr. (Rosa* et al. in press*).*
2. *Growth rate data from photogrammetry estimated ASM to be late 20 yr (Koski* et al.*2004). In their approach, they estimated growth rates using inter-year photographs and calculated the number of years to reach 13-14;, i.e., the well-documented length at sexual maturity.*
3. *Recovery of stone weapons in harvested bowhead whales indirectly confirms that bowhead whales live in excess of 100 yr, also corroborating the AAR maximum longevity estimates.*
4. *The recovery of a Yankee whaling projectile patented in 1879 in a recently harvested bowhead whale also corroborated the longevity estimates (George and Bockstoce 2008).*
5. *Population dynamics models for bowhead whales suggest that low values for ASM are unlikely and favour over 20 yr (Givens* et al.*1995).*

In view of the above, the AAR technique appears useful for long-lived cetaceans and possibly other vertebrates; however, its applications to species with shorter life spans (<30 yr) must be approached cautiously.

Samples of eyes of bowhead whales hunted in the traditional hunt were collected for analysis using AAR (George *et al.* 1999). For females, ovarian *corpora* were used as an age proxy for calibration. Investigating carbon isotopes in baleen plates of younger animals indicated an age at sexual maturation of 17-20 yr from the regular annual oscillations associated with feeding migration (Schell *et al*. 1989a, b). These data, together with the knowledge of potential longevity from artifacts, and relative age from body length, could be used to calibrate age derived from the AAR method. Improvement of the AAR method (Wetzel and Reynolds 2011) and testing of the consistency of k_{Asp} with calibration using known rates for humans and fin whales has allowed more reliable estimation of age. Results of investigating racemization rate k_{Asp} indicated a possible age at sexual maturation of >20 yr in females and a longevity of *ca* 120 yr in males.

In summary, the AAR technique was found useful for long-lived species as bowhead whales, for which other techniques are unavailable. There is no evidence of bias but there is a high variance, especially for young animals. Baleen plates are recommended for age estimation in young animals, *i.e.*, <20 yr. To get reliable results using AAR, repeated measures/samples are required, together with a good lab procedure and corroborative age estimates.

<u>Discussion</u>

Details were provided on age estimation using the ovarian *corpora* counts. The estimates of age at sexual maturity must necessarily be added to *corpora* age to obtain total age and are not totally independent from AAR ages. There is thus some circular dependency of the data. However, the AAR technique demonstrates reliably that bowheads are long-lived. In this respect, the apparent old ages estimated using AAR for narwhal (Garde presentation 13.2 above) must be seriously considered feasible.

20. Individual identification and life history of the St. Lawrence beluga - Robert Michaud

This presentation was offered and accepted during the workshop. The ongoing work started in 1989 (Michaud 1989, 1993, http://bed2.gremm.org/eng/pag.php?PagRef=Nws&NwsId=4569). To date there have been about 60 surveys per year in which belugas were photographed for reliable marks, identified and classified into 3 classes of re-sightability (RI). Common marks are nicks on the dorsal ridge and small scars including round indentations that were likely bullet wounds. The beluga population is about 1,000 animals, and a photo-identification catalogue holds files of 341 individuals (RI $\geq$ 1) identified from both sides, 265 first identified as white and 76 first identified as grey animals. Biopsies were taken during surveys and these used for sexing and genetic profiling. A genetic profile is known for 95 males and 38 females. Males have more scars than females. Between 1983 and 2011, over 350 beluga carcasses were recovered for detailed necropsy and identification. Teeth for aging and reproductive material were collected for determining life-history parameters. Histories of individuals first identified alive and recovered dead provided information on first age at parturition, longevity, calving interval, and a validation for tooth GLG deposition rate at one per year.

- Atomic – DL006, female, was first sighted in 1986, presumably born in 1984, first seen with a calf in 1992, She subsequently had calves in 1994 and 1996, (while she was still light grey), 2000 (when she turned white), 2002, and 2004. She was last sighted in 2007.
- Ligne ligne – DL225, male, first sighted as big grey in 1991, turned light grey in 1993, white in 1997 and died in 2007 at 21 yr old assuming 1 GLG per year deposition in the teeth. Assuming 2 GLG a year, Dl225 would have been white at its birth!
- Dl172 – female, first sighted in 1980 as a large white died in 2008 at 46 yr old assuming 1 GLG per year deposition in the teeth. Assuming 2 GLG per year, Dl172 would have been seen as a white whale before its birth!

Discussion

This study, apart from monitoring the distribution and social movements of the individuals, has been able to make valuable observations on age, growth and reproductive history. The recovery of biological samples after death provides a means to verify age from teeth and calving history based on reproductive tissues. The limitation of this work has been that there are fewer marked animals now since the end of the hunt (1979) when struck but escaped animals bore scars. In addition, it is not yet possible to quickly access beach-cast carcasses to recover fresh eyes for possible AAR analysis. The workshop welcomed this long-term work which potentially may provide a wealth of life history data and a means for absolute age validation using tooth GLG.

21. Value of long-term studies of humpback whales for determining population parameters and ground-truthing new age estimation methods - Christine M. Gabriele

ABSTRACT: *Photo-identification of individual animals has become an important source of information on humpback whale behaviour and population parameters via long-term studies occurring at several sites worldwide. Through photo-identification, researchers have determined age at first calving, reproductive rates and calf mortality for this species. The sheer length of sighting histories in long-term studies is also shedding light on the lifespan of humpbacks, in that many whales have sighting histories approaching 40 yr, although this species was earlier thought to have a 30 yr lifespan. Tissue samples from known-age humpback whales are also contributing to development of techniques for determining the age of unidentified individuals (i.e. stranded animals or those without a sighting history) from blubber fatty acids, chromosome telomeres, and eye lens aspartic acid racemization.*

This method of direct observation of free-living animals demonstrates the value of long-term monitoring for assessing age and life history. Since 1974, 626 animals have been identified using marks on tail flukes and supplemental marks on dorsal fins. Recently, validation of ear plug GLG deposition rate (one per year) was possible for a known-history female # 68 from Glacier Bay, Alaska, which was first sighted in 1975 as an adult with a calf and washed up dead 25+ yr later after a ship strike in July 2001. Her estimated age from the ear plugs was 44 yr with a likely age at sexual maturation (from the transition phase) of 7 yr (Gabriele *et al.* 2010). From sighting histories it is possible to get a minimum age estimation and age at first calving. Biopsy analysis has enabled comparative age studies to be undertaken on this population, including telomere length analysis (Olsen presentation 8 above) and endogenous FA ratios (Ylitalo presentation 14 above), which have also correlated with an annual GLG deposition rate in known-age animals. The AAR technique is now being applied to eye lenses from recovered dead animals.

Discussion

The Glacier Bay photo-ID sightings database has been used to validate several other aging techniques such as FA ratios, eye lens extraction for AAR, and genetic telomere length analysis. The previous presentation on photo-ID in belugas, also indicates the potential of this kind of study, although it is labour intensive and will probably never cover all members of a population. Humpbacks are coastal and migratory but generally return to their mother's feeding range, so that resighting is feasible. The oldest known-age whale so far recorded is 37 yr (first sighted in 1974). The importance of collection of ear plugs from stranded known animals was stressed.

22. Validation of growth layer deposition rates from known history and photo-ID (dolphins) - Aleta A.Hohn

ABSTRACT: *Long-term field studies have provided the opportunity to know the age or the approximate age of free-ranging studies. These studies are valuable for validating growth layers because the alternative generally is use of captive animals, for which it is possible that captivity, itself, has affected growth layer deposition patterns or rates. The best study, to date, that has provided and continues to provide teeth from free-ranging animals occurs in the Sarasota Bay region of Florida (Hohn* et al. *1989). From that study, teeth have been extracted from live animals during temporary catching and holding of animals. Additional teeth have been available when known dolphins died. In some cases, teeth available after death represent a second opportunity to examine a tooth from the same individual. These studies will be limited due to the nature of conducting such studies, but what has been learned is invaluable.*

The Sarasota Bay Photo-ID project on *Tursiops truncatus* has now run for at least 5 generations of dolphins and has provided a mass of life-history data for known individuals. The oldest known-age female, Nicklo, is 61 yr old and produced her last known calf at age 48 yr, but several females of age >40 yr have produced up to 8 calves during the monitoring programme. Although this study is a special case in that animals have been regularly captured and released to monitor individual health, growth, and development, aspects may be applicable to belugas. By extracting teeth from live animals, it has been possible to validate aging methods by comparing actual known age to the numbers of tooth GLG counted blind without reference to any data. Again, the value of long-term studies was underlined.

23. Bio markers and tetracycline antibiotic time marking - Aleta A.Hohn

ABSTRACT: *Examining teeth from known-age animals does not, in itself, calibrate*

growth-layer deposition. That is, a count of growth layer groups (GLG) in teeth that corresponds to a known or approximately-known age could match but that does not allow for the actual GLG boundaries to be known. Actual calibration would be required to be certain when an annual layering pattern starts and ends. A means to obtain this information is using a bio-marker. The most common biomarker for cetaceans has been oxytetracycline. This compound is incorporated into actively mineralized teeth. When those teeth are sectioned (not decalcified) and viewed under reflected UV light, the incorporated tetracycline fluoresces. This technique has been used across a spectrum of mammals (terrestrial and marine).

The most commonly used bio-marker for marking teeth is tetracycline which can be administered orally or intra-muscularly. The former method is perhaps better as the drug, which may be required in a relatively large quantity, is absorbed and circulated in the body quickly without potential damage to muscle tissue. The dosage must be calculated according to the body weight and can be administered once or in lower dosages over a few days. A typical dosage is between 10-50 mg/kg body weight and the intensity of the mark appears to increase with dosage. Circumstances will dictate which is practicable. The tetracycline binds with calcium during new growth of the tissue. The method is reliable for time-marking (Myrick *et al.* 1984), but it is important to recognize that the drug can also be transferred via milk during lactation and that, rarely, undocumented marks in teeth may be the result of food or prey ingested. Other problems that may affect the correct interpretation in teeth are the effect of captivity on GLG deposition and autofluorescence, an edge effect, including that due to cracks in the tooth. When teeth so-marked are extracted for age estimation, it is important not to fix in formalin or decalcify as these processes leach out the chemical. Exposure to light will also degrade the mark in teeth.

24. Bomb dating and age validation: conclusive results in a fuzzy world - Steve Campana

ABSTRACT: *Atmospheric testing of atomic bombs in the late 1950s resulted in an abrupt increase in atmospheric radiocarbon which was soon incorporated into all organisms that were growing at the time. Thus the period is analogous to a large-scale chemical tagging experiment, wherein all body hard parts formed before 1958 contain relatively little ^{14}C and all those formed after 1968 contain elevated levels. For fish and aquatic organisms born between 1958 and 1968, bomb radiocarbon in growth increments can be used to confirm the accuracy of more traditional aging approaches with an accuracy of $\pm$ 1-3 yr. This approach has proven to be effective in validating the age of fish, bivalves, sharks and belugas, and would be expected to be effective in many other organisms.*

The method is based on identifying and quantifying nuclear fallout elements from atomic testing, namely ^{14}C. The increase in concentration of radiocarbon first started in 1958 in surface marine waters around the world. The ^{14}C concentration curve reached a peak and plateau in the late 1960s, and is now slowly declining although still strong. Hard tissues bearing GLG were micro-milled for internal sampling of individual GLG. About 2 mg of material is sufficient for testing. The analysis is expensive – *ca* 1,000 – 1,500 USD per sample, but only 5 samples are needed for pre-1958 born animals. During the presentation, examples of the technique were given for halibut, *Hippoglossus sp.*, and yellowtail flounder, *Limanda ferruginea*, otoliths. There is a difference between freshwater and marine environments and an offset for surface or deep animals. Other examples included porbeagle shark, *Lamna nasus*, mako shark, *Isurus sp.*, and dogfish, *Squalus acanthias*, for which radiocarbon was used to calibrate ages.

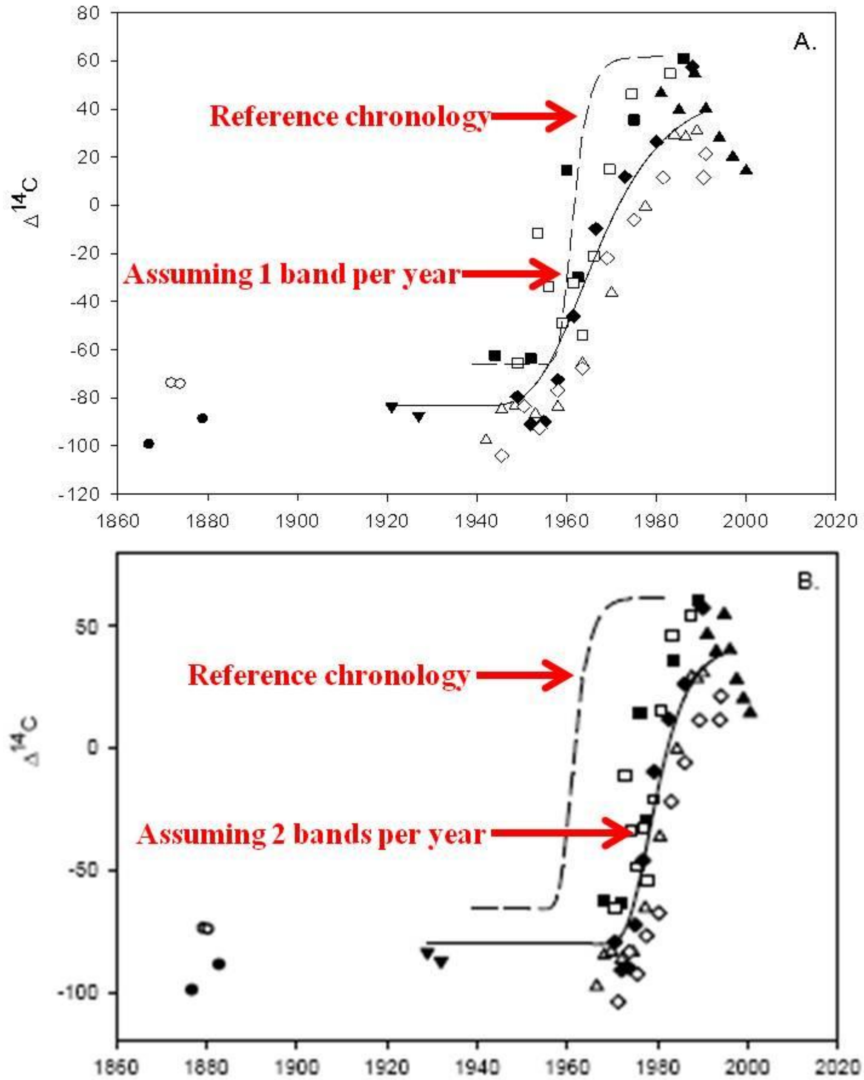

Figure 4. The radiocarbon ^{14}C signatures for belugas pre- and post atomic bomb fallout. The reference graph is shown in both A and B. The graphs overlap only for the assumption of one GLG per year in A. (After Stewart *et al.* 2006).

The method is suitable for all hard tissues, including beluga teeth and narwhal tusks, and also investigating individual GLG. In the study of beluga teeth (Stewart *et al.*

2006), the radiocarbon method was robust enough to validate age from GLG. A comparison of results making assumptions of deposition rate of one or two GLG per year had a strong offset (Fig. 4). Concluding, bomb radiocarbon is an excellent age validation method for long lived animals; the age of individual animals can be validated; and marine mammals, especially monodontids, are good study subjects.

Discussion

Earlier, Paul Brodie (presentation 15), had raised criticism to the findings of the bomb radiocarbon method. Brodie mentioned that the study by Stewart *et al* (2006) using bomb radiocarbon had been examined by B. Buchholz, senior research physicist, Center for AMS Livermore, California, who provided the following assessment:

> *"My problems with the paper are the incomplete methods and corrections they used to remove large amounts of dead carbon from the embedded samples. None of the samples embedded in epoxy are suitable for these measurement. The corrections seem arbitrary, and can be used to obtain whatever answer you want. You can make GLG/1 fit the late 1950s rise with a suitable correction. Ignoring all data after 1982 is not justified. If the corrections are accurate, they should work for the entire curve, not just a segment. Hence the data have significant problems." (Pers. comm. to P. Brodie; see also Brodie* et al. *in press.)*

Brodie also commented that an additional complication is that the radiocarbon burdens in the belugas may not have originated during their lifetime and were actually transferred during gestation and two years of intensive nursing. Campana responded that there is no difference in ^{14}C signature for animals feeding directly or lactating. The ^{14}C signal comes through milk or diet to calves, but the signal is the same. Even if gross resorption took place in the mother's skeleton, this would not have an appreciable effect on ^{14}C content and transfer. Thus maternal transfer to sucklings should not be a confounding factor in the deposition rate controversy.

25. Artifacts - Craig George

This presentation (no abstract available) traced the start of the investigations that were triggered by the discovery of a historic slate end-blade in the mattak of a bowhead whale caught recently in Alaska. Since then there has been a recovery of many stone weapons indicating a possible age of up to 117 yr, and also Former Yankee whaling bomb lance fragments (George and Bockstoce 2008), indicating a possible age of up to 129 yr. However, with respect to the stone weapons, some may still be employed today in some areas, so that the certainty that these were placed historically is in doubt. Nevertheless, such artifacts indicate a relative age of the animals in which they are found and indicate great longevity in bowhead whales. In summary, recording artifacts is a useful technique for long-lived species where other techniques are unavailable.

Discussion

There was an extended discussion about interpreting the finding of an artifact. An artifact such as a Yankee harpoon head clearly could not be placed in a whale before it was invented but it could be placed anytime after it was invented. The presence of a harpoon that was introduced in 1879 tells us that the whale was struck after 1879 but it could have been struck in 1979 if the artifact had been held and deployed later in time. One needs to be aware of such possible biases. The possibility of recovery of historic artifacts from monodontids is a possibility, but longevity is far less than in bowheads.

26. Age validation through known history captive studies in belugas – Aleta A. Hohn and **Christina Lockyer**

ABSTRACT: *This presentation is a recap of the now published work on examination of known-history captive beluga teeth (Lockyer* et al*. 2007). A sample of teeth from 10 beluga specimens was examined for total age. Data on sex, capture date, length at capture, history of tetracycline antibiotic medication, general health, and date of death were available. The results of agreed GLG counts for the sample teeth were compared to the life history, including time in captivity (ranging 4 – 30 yr), of each animal under two hypotheses: one and two GLG deposited annually. Resulting counts were more consistent with the hypothesis of one GLG per year. In five of the seven animals for which the neonatal line was present, given the length of the animal at capture and time in captivity before death, under the assumption of two GLG per year, the animals were younger than would be possible. The number of GLG between the tetracycline mark and death also corresponded to a deposition rate of one GLG per year. We believe the evidence supports that beluga whales deposit GLG at the same rate (one GLG per year) as other cetaceans for which this has been calibrated. Additional support for this conclusion is drawn from reference to other techniques that indicate an annual deposition rate.*

The tooth samples were from 10 animals all captured near Churchill, Manitoba, Canada. Details of tooth preparation were presented for thin untreated sections and thin stained sections. The untreated sections were examined under magnification using reflected UV light which makes tetracycline marks fluoresce. The belugas had been captive for 4-30 yr and, although none was of known age, all were captured when very young. Problems of crown wear in some animals meant that only minimum age could be estimated but many had an intact neonatal line. Although the evidence was not clear for some animals, from actual time in captivity and GLG age, at least 3 supported an annual GLG deposition rate, while a further 5 neither supported nor refuted an annual GLG deposition. There were however, another 2 specimens that supported an annual rate from tetracycline marking (see Fig. 5). On balance, the annual GLG deposition was accepted.

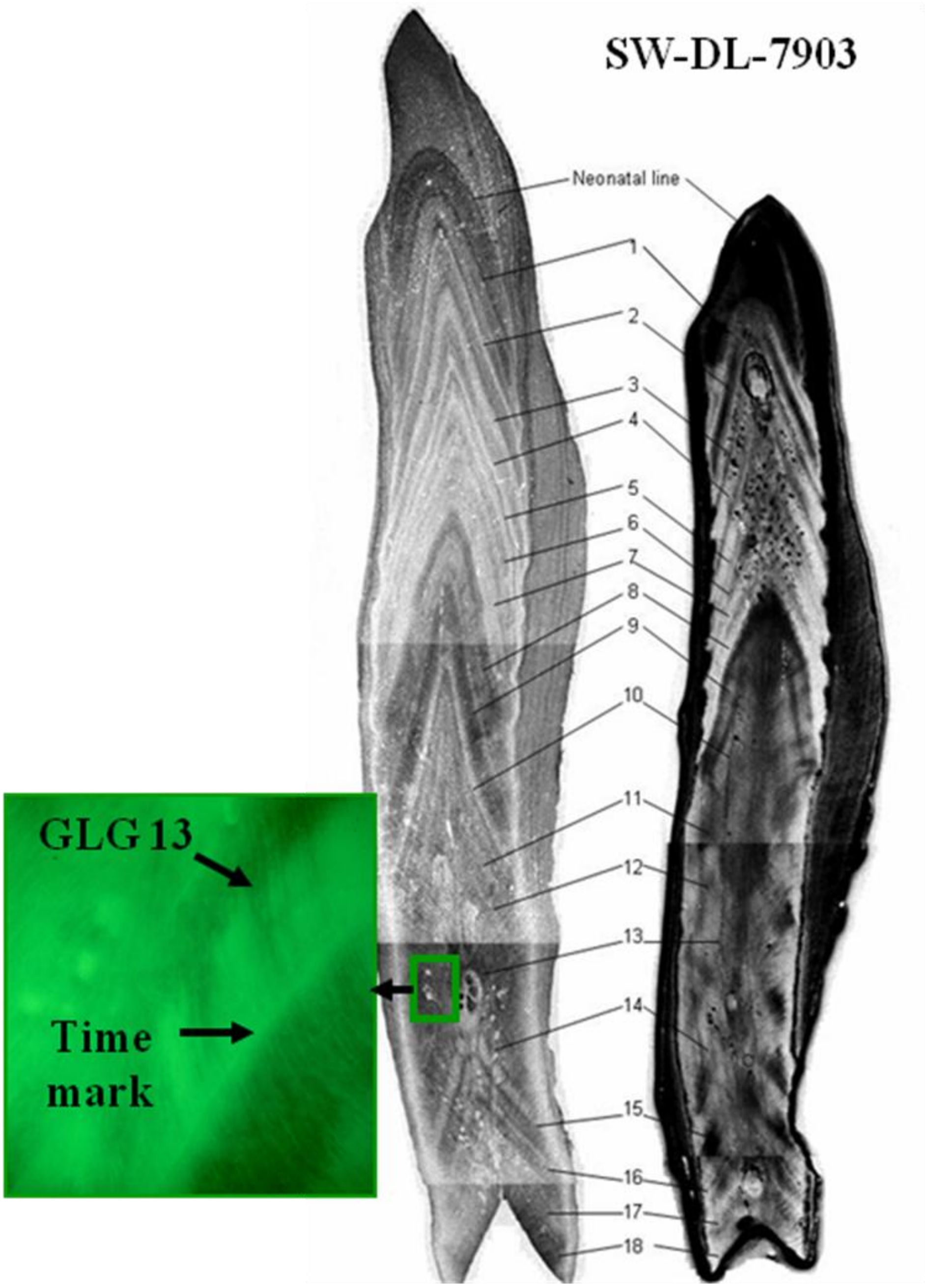

Figure 5. To the left is the decalcified and stained section of the tooth of SW-DL-7903, and to the right is the untreated section from the same tooth. There are 18 GLG marked up in the dentine, and the neonatal line is intact. This animal was in captivity almost 8 yr. Presence of a fluorescent time mark in the dentine around GLG 14 originates from a tetracycline treatment 4 yr and

2 mo before death. The conclusion is that a one GLG per year deposition rate is validated for this animal.

Discussion

Brodie queried the authors' conclusions and offered an alternative conclusion for possible evidence of two GLG deposition rate instead, based on his experience with size and growth of free-living animals. He drew attention to specific examples used by Hohn and Lockyer in his earlier presentation 15, and he believed that all the animals presented could be interpreted this way based on body lengths at capture. Suydam raised the issue of potential problems in growth, especially tooth growth, with the change from wild to captive status. For other species, *e.g., Tursiops*, there has not been evidence of a change in tooth structure due to captivity. Lockyer noted that geographical variations in ultrastructure occur in teeth (Lockyer 1999) and that probably climatic events also leave traces in the teeth (Manzanilla 1989). Possibly some animals taken into captivity also show such events in tooth ultrastructure. The events of capture (when often an animal fails to eat for a while), ill health, and reproductive events (births) can change the GLG pattern in short-finned pilot whales, *Globicephala macrocephalus* (Lockyer 1993) but these do not eliminate any GLG. Hohn noted that in dusky dolphins, *Lagenorhynchus obscurus*, the difference is in mineral density of GLG deposited during El Niño years. However, the changes were not deposition rate or thickness of the GLG. Clearly response to captivity is likely species-specific.

Stewart argued that there seemed to be no physiological rationale for 2 GLG per year in comparison with other species in which one per year is normal. Brodie persisted that the length at birth of two of the animals mentioned by Lockyer, plus the time in captivity, matches the two GLG per year hypothesis. For example, one beluga (Moby, captive 30 yr, and age > 43yr) should be consistent with two GLG per year if extra GLG are added for crown wear and the age at first capture was as a calf. Lockyer concluded that the juvenile phase in the teeth is the controversial item where most GLG identification problems exist and effort should be put there into assessing deposition rates and patterns and how to identify a GLG in the juvenile period.

27. The sensitivity of age structured population dynamics models to bias and precision in ages - Roderick C. Hobbs

There was no abstract provided for this talk. Published and sourced data on age parameters for belugas were presented as the basis of the talk. The sources of errors were listed as:

1. Ambiguous aging material
    a. Poor or interrupted growth layer groups (GLG) in teeth
        i. Estimation bias and variance increase with age
        ii. GLG formation may be correlated temporally by environmental events
    b. Worn or broken structures (crown, root, etc.) in teeth
        i. Minimum age only. If wear rate is > 1 GLG per yr, minimum age declines with age

2. Interpretation of material
    a. Deposition rate of GLG in teeth
        i. Was thought to be 2 per yr now 1 per yr.
        ii. Do older animals continue to add GLG's?
    b. Racemization rate (AAR method)
        i. Initial value may vary among individuals
        ii. May vary by population and species.

In investigating age structured models, the following were assumed for belugas:

1. Leslie Matrix
    a. Maximum age (80 yr)
    b. Age at first reproduction (11 yr)
    c. Survival rate (.95/yr)
    d. Birth rate (0.3/yr)
2. 100 individuals were drawn from a stable age distribution for the analyses.

For the analyses, the following were derived sequentially:

1. Age at first reproduction and survival rate estimated from age data.
2. Bias and variation drawn for each individual to simulate aging error.
3. Age at first reproduction and survival rate estimated from simulated aging data.
4. Intrinsic growth rates estimated for each data set for comparison.

In conclusion, errors in estimation of parameters can arise from errors in aging with both negative and positive bias and varying degrees of variance. In turn, these translate to errors in estimation of growth rates. Efforts should be made to quantify bias and precision.

28. Accuracy, precision and quality control in the age estimation of aquatic animals - Steve Campana

ABSTRACT: *Many calcified structures produce periodic growth increments useful for age estimation at the annual scale. However, age estimation is invariably accompanied by various sources of error, some of which can have a serious effect on age-structured calculations. This review highlights the best available methods for insuring aging accuracy and quantifying aging precision, whether in support of large-scale production aging or a small-scale research project. Through use of quality control monitoring, aging errors can be readily detected and quantified; reference collections are the key to both quality control and reduction of costs.*

Aging is a very important aspect of living resource management. Some examples of precisely wrong ages in different species were presented, which were only identified when known ages became available. Age validation methods are essential and age corroboration using different methods provides support for the ultimate age. In producing a successful aging programme a method must first be developed. This must be followed by validation of the method. Preparation of a reference collection, ideally of known-age hard parts or, at least, hard parts aged by international experts is necessary. The reference collection is best for monitoring aging consistency through time, in the training of new age readers, and for testing consistency among readers.

Quality control must also exist with regular monitoring and preparation of age bias graphs for readers and CVs. The best measures of precision were coefficient of variation (CV), average percent error (APE) and index of dispersion (D); the least reliable was percent agreement among readers (Campana 2001).

In conclusion, accuracy is not equal to consistency and age validation methods are not all created equal. Chemical mark-recapture and bomb radiocarbon are the most reliable age validation methods. A reference collection is the key to effective quality control.

<u>Discussion</u>

There was much discussion about the desirability of reference collections and also the usefulness of internationally available digital and accessible images. This would facilitate standardization and training in methods among diverse labs and workers, and obviate the need to exchange actual material when CITES permitting was problematic.

29. Summary of the main findings of the workshop with specific reference to monodontids – Christina Lockyer

The breadth and depth of the presentations made it clear that most issues concerning monodontid age estimation are not unique. Many researchers investigating many taxa have considered a diversity of methods and tissues to establish biological records of age. Aside from the biological materials, they have pondered accuracy and precision of the counts or metric, as well as their interpretation.

Relative age can be estimated using biological or chemical changes if the rate of change is known. Attempts to use **telomere length** to estimate age (Olsen presentation 8) show telomere lengths provide a measure of individual body fitness and condition rather than age, as environment, migration, health, and reproduction affect telomere length. The method has potential but is still under investigation; problems include locating long-lived known-age humpback whales for calibration. A review of **AAR** techniques on fin whale and harbour porpoise (Hjort-Nielsen presentation 12) warned that the presence of cataracts in the eye lens could seriously bias the age estimation and give falsely old ages. Longer-lived animals may be better candidates for the AAR technique, although neither fin whales nor porpoises had a good correlation of ear plug GLG and tooth GLG with AAR age respectively. There is an underestimation of age by AAR in harp seals, as in most animals (Garde presentation 13.1) although in narwhal (Garde presentation 13.2) tusk GLG correlated well with AAR age. The AAR technique using eye lens in bowhead whale (George presentation 19) showed good correlation with other age estimation methods, *e.g.*, known-age (from photo-ID), baleen plates, and ovarian *corpora* counts. Recent modifications to the hydrolysis technique and heating process at the Mote Marine Lab, Florida, had allowed refinement of the k_{Asp} rate (L_D/L_L) ratio which was found constant over time. Age models using endogenous **fatty acid** (FA) ratios have been successfully derived for killer whales and humpback whales (Ylitalo presentation 14), and preliminary results using a single fatty acid ratio for Cook Inlet belugas correlated with age from tooth GLG for physically immature animals. The maximum age from fatty acid ratio was *ca*

76 yr using C16:ln9/iso-C16:0. Future work plans to get two FA ratios is expected to provide more precision in age. It may be possible to use **bone density** as a proxy for age in beluga and narwhal flippers (Read presentation 3). The method would need to be calibrated with reference to beluga tooth GLG and AAR ages in narwhal. The recording of historic hunting **artifacts** recovered in bowhead whales (George presentation 25) in Alaska has presented an opportunistic and remarkable insight into longevity of this species which exceeds 100 yr. Other evidence of age from AAR aging technique would support this.

One technique shows promise for bridging relative ages from bone density and counting changes in density. Micro-CT scanning of teeth (Loch presentation 16) demonstrated great potential for investigating internal structure of teeth and other hard tissue specimens that are difficult or impossible to section, as there is no destruction of the specimen and it can be viewed in 3-dimensionally. It is also suitable for tympanic bones. The resolution from the technique was 5-50 micron. The main limitation is the small size of the experimental chamber, the height of which is 7-8 cm.

Counts of presumed annual markers can provide a more accurate (absolute) estimate of age than other tissues which show gradual changes with age. Among taxa, hard structures that show regular episodic growth are the most commonly used tissues to investigate for records of age. These can include bones, otoliths, claws, and ear plugs (Read presentations 3 and 6) although teeth are most widely used. **Ear plugs** in baleen whales provide a permanent record of total age from GLG, as long as there is no damage (Lockyer presentation 10). Apart from longevity, life-history parameters of age at sexual maturity and possibly physical maturity can be identified form the GLG patterns. Such patterns might exist in some teeth and should be investigated. Ear plug extraction from carcasses of minke whales (Maeda presentation 11) is facilitated by a new method involving injection of molten gelatin into the surrounding ear canal. Upon cooling, the gelatin supports the fragile ear plug structure, so increasing the possibility of extracting whole and undamaged ear plugs. This method should be tried in bowhead whales in which ear plugs are soft and fragile. The histological study of frozen thin sections of ear plug stained with Alizarin Red was successful in clarifying GLG in minke whale ear plugs.

Manatee periotic **bones** are suitable for age estimation in manatees (Howell presentation 17) where a thin section is cut from the middle of the periotic bone rostral lobe, decalcified, sectioned again to 5 micron, stained with Haematoxylin and Eosin, and examined with transmitted light under a microscope. Although some bone resorption occurs after age 15 yr, maximum ages up to 59 yr have been recorded.

Teeth are commonly used to age carnivorous mammals, including marine mammals. The seal age estimation review (Read presentation 6) indicated that canines are the optimal choice for aging, but that other teeth can be selected, especially in live animals. Techniques for preparing teeth vary. All are directed to obtaining the most complete record of clear lines. The dolphin age estimation review (Hohn presentation 4) noted the importance of quality tooth section preparations that included correct orientation providing a central section through crown and root when dentine was examined. The discussions following the dolphin tooth histology and preparation presentation (Murphy presentation 5) recommended that teeth prepared for decalcification should be wafered and sectioned thick initially at *ca* 2.5 mm to facilitate permeation of the decalcifying agent. A review of aging in sirenians (Lockyer presentation 7) indicated that dugong tusks had many internal similarities with beluga teeth and also perhaps narwhal tusks. GLG deposition rate in dugongs is annual. The most suitable method of age estimation in large odontocetes (Lockyer presentation 9) is using acid-etched half teeth in a crown to root-apex orientation, *e.g.*, in sperm whales, although thin untreated sections (*ca* 150-200 micron) are successful for smaller odontocetes, *e.g.*, killer whales and some beaked whales. Although the former method is unsuitable for belugas, the latter method is suitable. GLG patterns in sperm whales and belugas are very similar.

In beluga, counts of GLG in dentine as seen in medial longitudinal sections of teeth is the standard method and completely consistent with methods used in other taxa. Discussion on the use of cemental GLG for estimating age, which was not so usual for cetaceans, might, in the case of belugas where cement is thick, be used to help estimate age when the dentine is worn down at the crown.

The most direct age estimation technique is the ‘birth certificate’ method whereby known and recognizable individuals are followed though time. This approach is not applicable to many species and but is important in providing calibration animals for other techniques. **Long-term photo-ID** monitoring and surveys of the Gulf of St Lawrence belugas (Michaud presentation 20) resulted in a mass of reliable data on life history, age, reproduction, growth, and colour change. Necropsies on recovered known-age and known-history animals have provided teeth for verifying age. A photo-ID study of Alaskan humpback whales (Gabriele presentation 21) has also demonstrated the value of long-term monitoring of individuals. Calving intervals and reproductive history are known for several animals and many have been monitored since birth. Validation of an annual GLG deposition rate in humpback whale ear plugs was possible because of the recovery of samples and data from a stranded known-history female in Glacier Bay, Alaska. A long-term monitoring study of bottlenose dolphins in Sarasota Bay (Hohn presentation 22), involving capture and release, has enabled 5 generations to be monitored for life history. Extraction of teeth from live animals has permitted validation of the tooth GLG age technique for known-age animals, and knowledge of life-history parameters.

Once GLG are identified and counted, the next universal issue in age estimation is assessing the repeatability of the counts and validating their relationship to time. The first is precision; the second is accuracy and it is not the same as precision. Quality control is essential for both (Campana presentation 28). For quality control, there must be regular monitoring of an aging programme. The best measures of age precision are coefficient of variation (CV), average percent error (APE), and index of dispersion (D); the least reliable is percent agreement among readers which is usually the most commonly used. A permanent reference collection of aging materials, *e.g.*, known-age beluga teeth, is the key to effective quality control. An investigation of precision and bias in aging, focused on belugas with reference to tooth age data (Hobbs presentation

27). In conclusion, errors in estimation of parameters can arise from errors in aging with both negative and positive bias and varying degrees of variance. In turn these translate to errors in estimation of growth rates. Efforts should be made to quantify bias and precision.

One of the most persistent debates pertaining to age estimation in the beluga, has been about the accurate translation of GLG counts into time units (years). The measurement of radiocarbon, ^{14}C, in laminated hard structures of animals (Campana presentation 24) has been a precise and successful method for validating age in many species, including belugas where GLG deposition rate was found to be unquestionably annual. Necropsies on recovered known-age and -history animals have provided teeth for verifying age. Several examples support a GLG deposition rate of one per year in beluga teeth (Michaud presentation 20). Investigation of the age from teeth of known-history captive belugas, together with data on tetracycline time-marking of teeth (Hohn and Lockyer presentation 26), generally supported an annual deposition rate of GLG. However, GLG definition was unclear in some specimens, particularly in the juvenile phase. The use of tetracycline drugs for time-marking of hard tissues (Hohn presentation 23) has been proven to be a valuable method of validating age in teeth GLG. Oral administration to both captive and free-living (Sarasota Bay study) animals has enabled precise information on GLG deposition rate and is recommended as the bio-marker of choice.

Claims in support of 2 GLG per year deposition rate based on examination of growth and reproduction in Cumberland Sound belugas (Brodie presentation 15) were criticized on a number of counts. The information did not agree with other evidence presented at the workshop where 1 GLG per year deposition rates were verified by using radiocarbon techniques and photo-ID studies of known-age and -history belugas for which teeth were available.

Future research was identified in several areas to fine tune our understanding. One potential technique for estimating total age from worn beluga teeth by using the angle of the boundary layers relative to the pulp cavity edge appeared promising and should be pursued.. Of a broader nature is the potential to understand the ecological correlates to line formation. Laser ablation (ICPMS) for trace elements showing periodic oscillations in beluga tooth GLG (Matthews presentation 18) may be promising, and stable isotope ratios focusing on ^{13}C and ^{15}N. The point of weaning can be identified from the N depletion up to this point. Chemical oscillations in the teeth may be linked to ecology and movements associated with feeding and migration, although these may not be annual and thus cannot be used as an age proxy presently. The method offered great potential, and should be investigated further, especially looking at O_2.

30. Recommendations of the Workshop

The following recommendations for further studies on monodontids were agreed upon by participants:

1. Inter-method comparisons of alternative aging methods using wild, known-age animals (*e.g.* Sable Island grey seals, St Lawrence belugas).

2. Augmenting the number of samples of known age captive beluga from which teeth can be collected and comprehensive sampling of other materials useful for age estimation.
3. Examination of the immature phase of growth in teeth in beluga with reference to captive animals to determine GLG patterns.
4. Establishment of reference collections (hard parts) and consideration of a digital image exchange for calibration and training among labs.
5. Establishment of quality control routines.
6. Periodic exchanges among labs and inter-laboratory calibration for all aging techniques.
7. Comparison of tooth preparation methodologies among labs.
8. Estimation of crown wear from the angle of the boundary layers relative to the pulp cavity edge in beluga teeth, perhaps leading to estimation of the number of GLG that have disappeared.
9. Chemical time-marking for age calibration of hard parts.
10. Bomb radiocarbon validation of hard parts and eye lenses.
11. Comparison of GLG structure among stocks (wild and captive).
12. Compare GLG in teeth to growth layers in ear bones from belugas to determine if ear bones might have value for aging belugas and also narwhals.

31. Conclusions of the Workshop on aging methods applicable to monodontids

The workshop members agreed on the methods which are or may be applicable to monodontids, presented in Table 3. The methods are graded according to relative accuracy, feasibility, validity and assumptions made. New methods not yet applied to monodontids are also listed. The limitations of each technique are also given. Some methods, depending on the type of tissue required for analysis, may be applicable both to living and dead animals.

Overall, tooth GLG are judged to be the best and most precise method. Presently, tooth GLG are only useable in belugas, but AAR is promising in narwhals. More work needs to be undertaken on embedded tusks of young narwhals to help establish the AAR rate. The AAR method should also be applied to beluga eye lenses to provide a correlation with beluga tooth GLG. Such a study might provide more reliability on the narwhal AAR work presently done.

Other than known-age animals, the method that provides the most accurate ages and can be used for calibration is that of bomb radiocarbon. However, the main limitation is that at least some of the teeth or hard tissues must come from animals that were born before the fallout commenced, *i.e.*, pre-1958.

Currently, the workshop members agreed that an annual deposition rate of tooth GLG was to be the accepted standard. New evidence from known-age and -history belugas in the Gulf of St Lawrence, combining photo-ID, tooth GLG and known age, also supported this tenet. Any doubts regarding interpretation of GLG would be taken up in detail at the forthcoming workshop at the NOAA lab in Beaufort, North Carolina, where aging experts would examine beluga tooth ultrastructure and define a standard protocol for tooth preparation and GLG counting method.

32. Publication of the Proceedings from the Workshop

Acquarone presented the NAMMCO Scientific Publication Series to participants of the workshop, explaining that papers submitted to the workshop would be welcomed as submissions to a volume addressing *Age estimation in marine mammals with a focus on monodontids*. Presenters at the workshop and potential other authors would be contacted in early 2012 regarding an invitation to contribute a paper to the volume. The approval for the proposed volume had already been taken in NAMMCO, and the likely publication date would be in 2013. The editors would comprise the members of the Steering Committee, in addition to the technical editor, Mario Acquarone.

Table 3. Age estimation methods that are or may be applicable to monodontids with an appraisal.

Methods/ Techniques of Aging	**Absolute/ Relative age**	**New to monodontids ?**	**Validated method?**	**Correl-ational support?**	**Precision for age at sexual maturation**	**Alive or dead source**	**Assumptions**	**Comments**
Eye lens Aspartic Acid Racemization (AAR) with matching tooth-based age estimates	Relative	No -narwhals, yes - belugas	Not in marine mammals	Yes	Not sufficient	Dead	Lens metabolically stable. Racemization rate is constant.	Find surrogate species for testing. Encourage animal facilities to collect samples from known-age animals. Sample storage needs are specific.
Erupted tusks in narwhal	Absolute	No	No	No	Yes if accurate age	Dead	Interpret annual deposition correctly	Relatively difficult to obtain large specimen.
Embedded tusk studies in narwhal	Absolute	Hay (1980), Barner Neve (1995)	No	Pending	Unknown	Dead		Good for the first decades of life. Compare embedded to erupted tooth.
Trace element studies (in teeth and hard tissues)	Relative; unless there are periodic cycles	Yes (other models)	No	Unknown	Unknown	Dead mainly	Trace elements in the diet are cyclically incorporated in the teeth..	Could corroborate direct reading.Work in progress, encourage continuation.

Bone density of flippers	Relative	Yes	No	No	Unknown	Dead mainly	Requires that age and length are correlated	Samples available from some locations. .
Telomeres	Relative	Yes	No	?	Probably low	Alive mainly		Requires high quality DNA.
Photo-ID and known age studies in free living animals	Absolute	No	Yes	Not applicable	Yes	Alive	Existing marks do not change over time or can identify changes. Calves accurately identified.	Frequent and continuous sampling is essential. Can be an ideal validation method.
Bomb radiocarbon	Absolute	No for beluga, Yes for narwhal	Yes	Not applicable	Yes	Dead	Some of the animals have to have been born before 1958	On teeth, the core of the eye-lens (and in the ear plug).
Teeth (GLG in dentine/cementum)	Absolute	No	Yes for beluga	Not applicable	Yes	Dead mainly	Interpreting annual deposition correctly	
Ear bones (tympanic bullae)	Absolute	Yes	Not applicable		Yes - potentially	Dead	Interpreting annual deposition correctly. There is no significant resorption.	

MicroCT scanning	Absolute	Yes			Probably	Dead	Mineralized differences can be found in modern teeth.	
Artifacts (found in hunted animals, *e.g.*, harpoon heads, bullets)	Relative	No	No	?	?	Dead	Artifact used close to manufacture date. Correct identification of that date.	Rare, opportunistic. Dead animals only.
Scar accumulation on the body	Relative	Yes	No		No	Both	Can determine scarring rate and permanency.	Crude ages.
Fatty Acid (FA) analysis	Relative	In progress for beluga (2011)	No		No	Dead or biopsy samples	FA are changing consistently from year to year and with age.	Requires analyses specific to the population / stock. Investigate sensitivity to ambient temperature.
Stable isotope ratios	Relative	In progress for beluga (2011)	No	To be done	To be done	Dead mainly	Preliminary studies of ^{13}C and ^{15}N are promising. .	Could corroborate direct reading. Work in progress, encourage continuation.

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Appendix 1

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Appendix 2

SCHEDULE FOR THE
AGE ESTIMATION WORKSHOP

26-27 November 2011 -- Venue Room #19, Tampa Convention Center, Tampa, Florida

PROGRAMME

Terms of Reference (TOR)

1. Review current methods of age estimation in marine mammals with a focus on monodontids.
2. Recommend the method(s) most suitable for monodontids; and trials of any new techniques that are as yet untried in monodontids.
3. Compile papers submitted to the workshop and relevant to age estimation in monodontids in a publication volume entitled "Age estimation in marine mammals" of the NAMMCO Scientific Publication Series.

Day 1: 26 November

08:30 hr	**Registration**	
Opening, Welcome and Introduction		
09:00 hr	Background and the basis for the workshop and its aims (TOR)	Christina Lockyer
Review – Chair: Christina Lockyer		
09:15 hr	Age estimation methods applicable in mammals with special emphasis on marine mammals and especially monodontids	Fiona Read
09:55 hr	**Discussion and questions – led by Chair of session**	
10:15 hr	**Refreshments (30 min)**	

Direct methods of aging - Chair: Aleta Hohn

10:45 hr	Aging in dolphins including belugas	Aleta Hohn
11:00 hr	Investigating the deposition of growth layer groups in dentine tissue of captive common dolphins *Delphinus sp.*	Sinead Murphy
11:20 hr	Age estimation in seals	Fiona Read
11:35 hr	Age estimation from teeth in large odontocetes	Christina Lockyer
11:50 hr	A brief review of age estimation in sirenians focusing on dugong tusks	Christina Lockyer
12:00 hr	**Discussion - led by Chair of session**	
12:15 hr	**Lunch (1 hr 15 min)**	
13:30 hr	Age estimation in mysticetes with a focus on ear plugs	Christina Lockyer
13:50hr	Feasibility study on the incorporation of the gelatinized collection method and the freeze-section technique of the ear plug in age estimation in common minke whales	Hikari Maeda
14:10 hr	**Discussion – led by Chair of session**	

Indirect methods of aging – Chair: Rob Stewart

14:30 hr	Porpoise / fin whale age from eye lens and age validation	Nynne Hjort-Nielsen
14:45 hr	Background, the harp seal study and the known age animals study	Eva Garde
15:00 hr	Narwhal age from eye lens and age validation	Eva Garde
15:25 hr	Aging beluga (white) whales from measurements of specific fatty acids present in their outer-blubber biopsy tissues	Gina Ylitalo
15:45 hr	**Refreshments (30 min)**	
16.15 hr	Prospects for genetic age estimation of cetaceans	Morten Tang Olsen
16.35 hr	Growth and maturity of belugas (*Delphinapterus leucas*) in Cumberland Sound, Canada, compared to those raised in captivity	Paul Brodie

17:05 hr	**Discussion led by Chair of session**	
17:25 hr	Summing up for Day 1	Christina Lockyer
17:30 hr	**BREAK FOR DAY 1**	

DAY 2: 27 November

New techniques – Chair: Rod Hobbs

08:30 hr	Use of micro-computed tomography for dental studies	Carolina Loch
08:50 hr	Ear bones used for aging of manatees	Amber Howell
09:10 hr	Informal progress report on *Trace element profiles in beluga teeth*	Cory Matthews
09:20 hr	An overview on aspartic acid aging-strengths and weaknesses	Craig George
09:40 hr	Individual identification and life history of the St. Lawrence beluga	Robert Michaud
10:00 hr	**Discussion - led by Chair of session**	

Validation techniques – Chair: Rod Hobbs

10:15 hr	Long-term studies with respect to humpbacks photo-ID, age and reproduction	Chris Gabriele
10:25 hr	Known history and photo-ID (dolphins)	Aleta Hohn
10:35 hr	Bio-markers and tetracycline antibiotic time-marking	Aleta Hohn
10:50 hr	**Refreshments (10 min)**	
11:00 hr	Bomb dating and age validation: conclusive results in a fuzzy world	Steve Campana
11:20 hr	Artifacts (e.g. historic whaling weapon recovery from carcasses)	Craig George
11:35 hr	Age validation through known history captive studies in belugas	Christina Lockyer
11:50 hr	**Discussion - led by Chair of session**	

Application of age data – Chair: Christina Lockyer

12:00 hr	Sensitivity of age structured population dynamics models to bias and precision in ages	Rod Hobbs
12:20 hr	Accuracy, precision and quality control in the age estimation of aquatic animals	Steve Campana
12:40 hr	**Discussion - led by Chair of session**	
13:00 hr	**Lunch (1 hr 30 min)**	
Concluding the workshop - Chair: Christina Lockyer		
14:30 hr	Summing up of Days 1 and 2	Christina Lockyer
14:45 hr	Draft recommendations: • *Accepted methods for monodontids* • *Unsuitable methods for monodontids* • *New methods for trial with monodontids* • *Validation methods for monodontids* • *Conclusions on validation of GLG in teeth* • *Conclusions on quality control and any actions arising (e.g. standardisation)*	
15:30 hr	**Refreshments (30 min)**	
16:00 hr	Draft recommendations for the report – on screen Deadline for completion and circulation of the workshop report.	Mario Acquarone
16:30 hr	Contributions to the ***NAMMCO Scientific Publications***: who will contribute, deadlines for submissions, and editors. Author guidelines and planned publication date.	Mario Acquarone, Christina Lockyer
17:00 hr	**CONCLUSION OF WORKSHOP**	

ANNEX 4

PROGRESS REPORT ON BELUGA AGE-ESTIMATION WORKSHOP

Beaufort North Carolina, USA, 5-9 December 2011

(JCNB/NAMMCO cooperative project)

SUMMARY

INTRODUCTION

The Beluga Age-estimationWorkshop organized by the JCNB and NAMMCO was conducted with the following Terms of Reference:

1. Provide a guide as to acceptable levels of accuracy and precision for age reading that will enable ages to be used in population models.
2. Conduct an inter-reader/laboratory comparison for calibration and standardization of age readings from Growth Layer Groups (GLG) in teeth among all readers/laboratories.
3. Provide information on validation that will enable GLG to be translated to real age.
4. Produce a manual of guidelines for the preparation and reading of GLG in beluga teeth.

The workshop was comprised of three parts: 1) a pre-meeting reading of images by several participants to assess the existing level of agreement among readers and identify areas of discrepancy; 2) the meeting itself at which methods, images and sections were discussed; and 3) a post-meeting reading of images by the participants. Part 1 was completed during October and November of 2011. The meeting, Part 2, was held at the Beaufort Laboratory of the US National Oceanographic and Atmospheric Administration in Beaufort, North Carolina, from 5-9 December, 2011. It consisted of general discussions with short presentations, lab-work to examine images of tooth sections and and physical specimens, and further discussion about what had been learned during the lab session. A report on Parts 1 and 2 and a set of example images developed following the guidelines determined during the meeting are in preparation. Part 3[11] will be completed during spring 2012 when the report from Part 2 is available for guidance and the new set of images is developed.

HISTORY

At its meeting in February 2009, the Joint Scientific Working Group on Narwhal and Beluga (JWG) of the North Atlantic Marine Mammal Commission (NAMMCO) and Joint Commission on Narwhal and Beluga (JCNB) supported the initiative of a workshop to produce a report and a manual for the guidance of researchers on age determination from teeth in belugas and narwhals. The JWG also recommended that a steering Committee (SC, chaired by Lockyer and including Hobbs, Hohn and Stewart)

[11] This process has been delayed and will be completed during 2013.

work inter-sessionally to scope the problems and produce draft terms of reference for one or more workshops.

In 2010, NAMMCO noted the need to standardize ages using growth layers with new methods involving aspartic acid racemisation (AAR) and recommended that a workshop on age estimation be held to review age estimation methods, and discuss of how to standardize ages using growth layers with new methods. NAMMCO encouraged the SC to proceed with the workshop's organisation following the direction provided by the NAMMCO/JCNB JWG. The steering committee determined that two separate workshops were required: 1) A workshop on Marine mammal aging generally; focusing on mondontid age estimation which was held during the workshop sessions of the 19th biennial meeting of the Society for Marine Mammalogy in Tampa, Florida in the US, to be reported in a special volume of the NAMMCO publications; and 2) A focussed workshop to address the specific issue of beluga age estimation based on teeth; this report documents those proceedings.

While interest continued in tooth aging of narwhal, the steering committee acknowledged that there was limited available material for aging, and great difficulty and expense involved in bringing it to a workshop in the USA, and currently only one lab was working on this approach. Consequently the narwhal tooth (tusk) aging workshop was separated and conducted as a presentation during the meeting of the JWG in Copenhagen in February of 2012.

The workshop was provided with a background document developed under a contract by DFO CANADA Central and Arctic Region (Stewart 2012), which described the basic biology of tooth development and growth of beluga teeth. The document and its accompanying glossary were accepted by the workshop group as the basic reference on tooth development and an excerpted version is included in the workshop report.

WORKSHOP

Part 1: Pre-workshop Readings

In October 2011 a set of 60 images was circulated to the workshop participants (Appendix 1). The images were from different stocks and were made by various means following typical practices of the contributing laboratories. All images were considered to be usable for the purpose of estimating age. The participants were asked to estimate the age of each individual represented by the tooth image and provide an assessment of relative quality and readability.

All of the experienced readers attending the workshop provided readings for Part 1, and statistical analysis of these readings was presented during day the first day of the workshop at the Beaufort lab.

Part 2: Meeting at Beaufort Laboratory

The Workshop in Beaufort was conducted December 5-9, 2011. Participants included 2 readers from the Dept of Fisheries and Oceans (DFO) Canada, 2 readers from the Wildlife board of Nunavik in northern Quebec, 1 experienced reader and 3 inexperienced from National Marine Fisheries Service (NMFS) Alaska Fisheries Science Center, an experienced reader from the North Slope Borough in Alaska, 1 experienced and 1 inexperienced readers from NAMMCO and an experienced reader at the Beaufort Lab. In-kind support was provided by the Beaufort lab in the form of laboratory space and equipment, a laboratory technician and logistical support. General support was provided by NAMMCO.

Presentations

The meeting began with presentations by participants from labs currently engaged in aging belugas as a brief oral summary of their protocols which are included in more detail in the full workshop report. In general techniques were similar, and when possible, most participants choose one or more large straight teeth, usually from the mid-posterior area, and most used one side of the jaw routinely. Two labs used milling machines, the other a low speed saw but all used circular diamond wafering blades. Only Alaskan labs routinely used a 2-blade gang to cut a section in a single pass. Most labs chose the optimal line through recurved teeth although in one lab, highly curved teeth were bisected and the two parts each sectioned along its own optimal line. Most sections were stored wet and all were viewed, wet, using a dissection microscope. Transmitted light was used commonly while reflected or polarized light was used for added clarity of problematic sections. In most labs, the sections are read multiple times, sometime by multiple readers. One lab routinely prepared stained sections and another used this technique when required.

Rob Stewart presented a brief analysis of the efficacy of 3 or 5 blind readings and initial results of an inter-lab comparison of images and physical specimens. In general, 3 readings were sufficient to determine if the tooth would provide a reliable GLG count but up to 5 readings were necessary to provide a reliable median for teeth where counts did not result in a useable mode. Counts beyond 5 were considered to be of diminishing value. Comparison between the DFO Lab in Winnipeg and in Quebec showed that there was no consistent bias in counts between the two regions but that considerable variation could occur on the reading of individual teeth.

Results from the Part 1 pre-workshop readings were presented and had been analyzed for consistency and bias, by reader, image preparation method and estimated age. Estimated age was a strong predictor of precision comparability among readers in that for the most part when the tooth was properly prepared and a good quality image was obtained then animals less than 30 years old could be consistently aged to within 1-3 years. After age 30 yr, even very good images often resulted in wide discrepancies of 5-10 years. Following the statistical review the group then reviewed some example images and then formulated the plan for the laboratory analysis.

Laboratory Sessions

Specific issues addressed during the laboratory sessions included: 1) Direct comparisons of preparation method, thin sections (0.1-0.3mm), half tooth and stained sections. 2) Comparison of images with the actual sections. 3) Methods for interpreting the initial growth layers, the final growth layer, initial layers in teeth with missing or worn neonatal cap, and teeth where the pulp chamber has completely filled and the subsequent GLG are compressed and distorted. 4) Age determination of known-age individuals.

Based on the findings during the laboratory sessions and subsequent discussion, the group recommended best practices for tooth and section preparation, reading, imaging and documenting the counts. The draft workshop report is not yet complete and some of the findings remain to be articulated. However the following conclusions will be included in the final version.

CONCLUSIONS FROM THE BEAUFORT WORKSHOP

With respect to the objectives in the Terms of Reference:

1. Accuracy and precision (objective 2 is a specific action item aimed at addressing objective 1)
   a. A comparative study was initiated and quantification of differences presented here. The resulting training process for calibration and standardization is underway.
   b. Precision of experienced readers was better than that reported in the literature for sperm whale (Evans *et al.* 2002) and spotted dolphin (Reilly *et al.* 1983) age estimation.
   c. Efforts to continue to improve precision should be tempered by the need for better precision in the application of age data (example applications are analyses of: harvest age structure, age at maturation, body growth, age-structured population models.
   d. Good thin sections that are not stained generally allowed the greatest agreement among readers (precision).

2. Translate GLG into ages
   a. Workshop 1 (Tampa 26-27 November 2011) concluded that the evidence for interpreting one GLG as an annual record irrefutable.
   b. Teeth from captive beluga were particularly problematic both as untreated sections and stained sections and did not inform the reading of wild beluga teeth.

3. Guidelines = Best Practices
   a. ROUTINE AGE ESTIMATION: The working group recommends using thin medial sections from teeth known to yield, on average, the most complete GLG record, viewed wet on a dissecting microscope with transmitted light. Detailed data should be recorded on a standardized form which will include an annotated image. End-users should be provided with all the data but the default reduction would be the mode of at least 3 readings or median of at least 5 readings.
   b. IMAGING: The working group recommends using a high-resolution slide scanner to make images of thin sections of teeth known. Images should be stored in RAW format or TIFF format which retain the entire image, protected from changes and securely archived with complete metadata. Processing that allows hidden layers of data is preferred.

Other General conclusions:

1. Sections, stained with haematoxylin, allow examination of microstructure better than untreated sections.
2. Reading half-tooth sections was more difficult than thin sections for counts of 30 or more. These sections were also more labour intensive than thin sections because the surface must be polished every time it is examined.
3. Images were generally less satisfactory than the physical specimen.

RECOMMENDATIONS

1. For presenting age estimates to the two Commissions (JCNB and NAMMCO), authors should adopt the relevant Best Practice outlines here or provide a detailed rationale for deviating from it.
2. Continue to explore new methods and technologies to clarify or enhance GLG to increase precision.
3. New approaches should use, as the "control", the Best Practices for section preparation and reading to quantitatively calibrate the new method.
4. A reference collection of thin sections with high quality digital images should be prepared for training new readers, for refreshing experienced readers and for use in inter-lab comparison studies and standardization.
5. Reports should present GLG counts as well as their estimated age.
6. Inter-lab comparisons of precision are necessary when data are to be combined or results compared.

Recommended research topics

1. Accuracy would be improved by a better understanding of why GLG lines form. Examination of life-history correlates associated with GLG and accessory lines, the season of light and dark band formation, isotopic changes from wild to captive conditions, and known-age (or bio-marked) free-living whales could all contribute.
2. Accuracy may improve with a better understanding of how many lines are lost through occlusional wear.
3. Variation exists among stocks and a comparison of readability among stocks could guide the development of stock-specific methods. Topics could include characterization of the GLG, tooth growth and selection, and differences in seasonality.
4. Identifying GLG in juvenile belugas remains a challenge and further research on the life-history correlates, the season of formation, isotopic changes associated with weaning, and known-age free-living whales would be useful. Specifically, the influence of the protracted season of birth on the relative width and general characteristics of the early formed GLG would assist in their interpretation.
5. Investigation of cementum lines, and develop techniques. In some teeth the cementum lines are very clear and as detailed as the dentinal lines. Comparison of counts in both tissues would be useful to verify the comparability when cementum counts are used in place of dentine in difficult to read teeth.
6. Maximize use of teeth from captive animals including: tetracycline-marked, or diet studies.

7. Dental ontogeny and physiology of beluga: formation and resorption of deciduous dentition; developmental sequences of cementum and dentine growth layer deposits in permanent dentition, fetal cementum-postnatal cementum interface characteristics, eruption dynamics – embedded, partial eruption or full eruption relative to GLG count.
8. Categorization of the typical progression of occlusional wear *i.e.*, shape of cusp and tissues present, may provide a numerical approach for relative age analysis.
9. Categorization of the change in pulp cavity/root tip shape may provide a numerical approach for relative age analysis.
10. Stock differences: relative and absolute thickness of cementum *vs.* dentine; occlusional wear characteristics; quantity and type of inclusions, *etc.*
11. Measurement of the angle of GLG boundary lines at the dentin-cement junction to identify possible worn and lost GLGs.

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SECTION 4 - NATIONAL PROGRESS REPORTS

4.1
FAROE ISLANDS - PROGRESS REPORT ON MARINE MAMMALS IN 2011

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1. INTRODUCTION

This report summarises research on cetaceans and seals conducted in the Faroe Islands in 2011. The research has been conducted by the Zoological Department at the Museum of Natural History, the Environment Agency and the Veterinary Service.

2. RESEARCH 2011

2.1 Species/Stocks studied

- Pilot whale (*Globicephala melas*) – landed and tagged animals
- White-sided dolphin (*Lagenorhynchus acutus*) – landed animals
- Bottlenose whale (*Hyperoodon ampullatus*) – stranded animals
- Sowerby’s beaked whale (*Mesoplodon bidens*) – stranded animals
- Cuvier’s beaked whale (*Ziphius cavirostris*) – stranded animals
- Risso’s dolphin (*Grampus griseus*) – landed animals
- Grey seal (*Halichoerus grypus*) – stranded animal

2.2 Field work

A “full sample” refers to recordings and samplings of total length, weight (when possible), sex, teeth (lower jaw), ovaries/testes and stomach as well as muscle, blubber, kidney and liver tissues. Foetuses are sampled when present.

In 2011, a total of 85 full samples were collected from **pilot whales** by the Natural History Museum, from eight drives -Vestmanna on February 9 (15 samples), Vestmanna on April 8 (10), Gøta on Mai 28 (10), Vestmanna on September 2 (10), Hvannasund on September 8 (10), Funningsfjørður on November 13 (10), Sandavágur on November 18 (10) and Tórshavn on November 22 (10). This is part of a small-scale opportunistic sampling programme the Museum has initiated. The future plan is to complement this with a comprehensive monitoring programme, with the aim of updating the extensive 1986-1988 pilot whale study, in order to assess the sustainability of the Faroese catch; a programme recommended by NAMMCO.

On May 25, the Museum tagged eight **pilot whales** with satellite transmitters. A pod comprising about 40 whales was spotted 2 nmi from shore in the northern part of the archipelago and was driven to the bay of Hvannasund. The pod was forced gently towards the shore of the authorized whaling beach in the bay, where about half the group stranded. Eight whales were fitted with fin-tags during the tagging operation lasting about one hour. Thereafter, all animals reunited and the pod swam to sea again. This is the third time pilot whales have been tagged in a dedicated tracking programme. The objective is to study movements and distributions of pilot whales recruiting to the hunt in the Faroe Islands.

The Environment Agency took samples of muscle and blubber from 31 **pilot whales** from the Vestmanna 9 February 2011 drive, in addition to samples of liver tissue from 15 of these. At the drive kill also in Vestmanna, on September 2nd 2011, samples were taken of blood, liver, muscle, blubber, kidney as well as teeth and gonads (the latter by the Museum of Natural History) from 16 to 20 whales; blood samples were taken from 20 whales during the kill, while other samples were taken at the quay. Not all 20 whales were found at the quay so complete samples were taken of 16 only. Together with samples taken in the drive on 23 July 2010, these samples form the basis for a PhD study in which possible negative impacts of persistent organic pollutants will be analysed as well as the associated metabolism.

Heads from **pilot whales** were collected from a drive in Gøtu on 28 May (10 samples) and from a drive in Funningsfjørður on 13 November (10). The brain was dissected from the skulls and subsequently frozen and shipped to Denmark for examinations. The aim of the study is to track potential effects of pollution and contaminants on the neurodevelopment in the brain. This is in cooperation with the Department of Bioscience, Aarhus University, Denmark.

Trials with a spinal lance as new hunting equipment in the **pilot whale** drive hunt have been performed for many years. The spinal lance is now ready to be adopted in the Executive Order on pilot whaling as legal equipment. Reference is made to information submitted by the Faroe Islands to the NAMMCO Committee on Hunting Methods.

On 18 April, a **Cuvier's beaked whale** drifted up on the sandy beach at Leynar. This is the first record of this species from the Faroes. The animal had been dead for about a month and was fairly decomposed. The Museum took samples and secured the skeleton.

A **Sowerby's beaked whale** drifted up on the sandy beach at Sandur on 28 April. This is the fourth record over the last 15 years. The animal had been dead for about 14 days. The Museum secured necropsies and the skeleton.

On 25 April a **Bottlenose whale** calf, 300 cm and 315 kg, and thus virtually newborn, beached alive on the shore of the village Eiði. The animal died before it could be rescued. The Museum performed post-mortem and secured full samples.

A **Grey seal** washed up on the shore in Fuglafjørður on 15 August. The animal had been dead for at least a week. The Museum secured samples.

2.3 Laboratory work

The biological material collected from **pilot whales** in 2011 has been prepared ready for finalizing the age, diet and reproduction examinations.

When possible, the Environment Agency performs tissue sampling for contaminant analyses from two **pilot whale** drives a year. The samples taken are primarily blubber and muscle and from a smaller selection of animals, mainly the older/larger ones, also kidney and liver. The samples are stored in the Environmental Specimen Bank at -20°C until analysis. Muscle samples are analysed for mercury, and blubber samples for persistent organic pollutants such as PCB and "legacy" pesticides like DDT. Kidney and liver samples are analysed for mercury, cadmium and selenium. The focus of the monitoring of muscle and blubber is to elucidate possible changes in concentrations over time in the exposure of the human population utilizing pilot whale blubber and meat for food. The focus of the monitoring of heavy metals in kidney and liver tissues is to follow the possible risk to the pilot whale imposed by elevated tissue metal concentrations. Since 2008, the monitoring data established in the AMAP run by the Environment Agency, with support from the Ministry of Environment and Environmental Protection Agency DK, has been available online at www.us.fo, under the heading ENVOFAR. ENVOFAR is a cooperation of Faroese institutions that work actively to describe and study the environment in the AMAP and CAFF working groups under the Arctic Council (see also www.envofar.fo).

In late 2011, a large study with retrospective analyses of "new" contaminants in a number of marine mammals from the Northeast Atlantic was published (Dam *et al.* 2011). In the study, analyses on brominated flame retardants, polychlorinated naphthalenes, perfluorinated alkylated substances of the PFOS family and even in some samples also brominated dioxines, were done on samples from ringed seal, hooded seal, harbour porpoise, white-sided dolphins, pilot whale, minke whale and fin whale from specimen banks. The aim of the study was to provide insight into how the concentration of these pollutants had changed through time. Samples as old as from the early 1980s were retrieved from a few species, as were recent samples. The study was done as a Nordic cooperation, with support from the Nordic Council of Ministers. The results have been/will be presented in scientific journals and have provided scientific work which was rewarded with a PhD in biology at the University in Ørebro in September 2011(Rotander *et al.* 2012; 2012a; 2012b; 2012c). The samples provided from the Faroes to the project were **pilot whales** and **white-side dolphins**. Samples dating back to 1986/87 and 1997 were provided for these two species respectively.

2.4 Other studies

In the Faroe Islands **grey seals** are only killed at salmon farms, when interfering with the installations. In 2010 the Fisheries Ministry instructed all fish farm operators to keep observations and logbooks of seals culled and to deliver statistics once a year. The experience from this first year is that more time is needed for this new logbook system to function properly. Moreover, it is important to obtain an abundance estimation of grey seals in the Faroese in the near future, in order to be able to address the sustainability of the seal culls.

2.5 Research results

The satellite tags mounted on **pilot whales** on 25 May only transmitted for up to 14 days. Since the tagging, signals have regularly been received, but without sufficient quality to provide a position of the animals. The reason for this short tracking duration is believed to be caused by direct interactions from other animals in the pod upon the tags, destroying the external protruded antenna, resulting in a malfunction of the tag. The tracked pod moved in a south-west direction, along the shallow banks, Faroe Bank, Bill Bailey Bank and Lousy Bank, and the animals were lost when located 50nmi west of Rockall. During this period the pod moved a total of 400nmi, all the time seemingly as an intact group.

A conventional distance sampling analysis of **pilot whale** abundance was performed on the 2007 T-NASS sightings data, with an estimate for the total 2007 area, using the combined platform sightings from the dedicated vessels only, amounting to128,093 pilot whales (CI 75,682; 216, 802, not corrected for availability nor perception biases) (Pike *et al.*, 2011). This estimate was presented to the NAMMCO Working Group on Abundance Estimate which met in Copenhagen in March 2011 and endorsed for use in assessment.

The NAMMCO Scientific Committee recommended, latest in 2010, that an index of relative abundance of **pilot whales** be developed and applied to the area that is common to all surveys (1987, 1989, 1995, 2001, 2007), with the aim of determining trends in abundance over the full period of the NASS. An analysis of trends in abundance over the NASS series was presented to the NAMMCO Working Group on Abundance Estimate which met in Copenhagen in March 2011 (Pike *et al.*, 2011). No significant trend in the abundance of pilot whales between the years was found.

The analysis of the biological material sampled from the hunt of 24 Risso's dolphins in 2009 and 2010 is finalised and a manuscript has been accepted for publication in Aquatic Mammals.

In a study of the feeding ecology of bottlenose whales, the analytical part is now finalised and a manuscript is being prepared.

3. ONGOING (CURRENT) RESEARCH

The Museum of Natural History is planning to track more pods of **pilot whales** by satellite telemetry, in order to assess the overall distribution area of the pilot whales recruiting to the Faroese harvest. In 2012 the Museum can, given the opportunity, tag animals from another two pods.

4. CATCH DATA

Contained in Appendix 1.

5. BY-CATCH DATA

Reporting of by-catch of marine mammals has until now not been mandatory. But a new electronic logbook system for all fishing vessels is to be implemented, where also by-catch reporting of marine mammals is mandatory. By-catches of large whales have traditionally been reported directly to the Museum. No by-catch of large whales was reported in 2011.

6. ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

None.

7. PUBLICATIONS AND DOCUMENTS

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Appendix 1

Catch data for 2011.

Day	**Whaling location**	**Number**	**Skinn value**	**Species**
9. February	Vestmanna	41	283	*Globicephala melas*
7. Apríl	Vestmanna	58	376	*Globicephala melas*
28. May	Gøta	204	1240	*Globicephala melas*
2. September	Vestmanna	75	454	*Globicephala melas*
8. September	Hvannasund	28	234	*Globicephala melas*
13. November	Funningsfjørður	169	972	*Globicephala melas*
18. November	Sandavágur	49	243¾	*Globicephala melas*
20. November	Trongisvágur	21	194	*Globicephala melas*
22. November	Tórshavn	81	686	*Globicephala melas*

4.2
GREENLAND - PROGRESS REPORT ON MARINE MAMMALS IN 2011

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(Catch statistics provided by the Department of Fisheries, Hunting and Agriculture)

1. INTRODUCTION

This report summarizes the research on pinnipeds and cetaceans done in Greenland in 2011 by The Greenland Institute of Natural Resources (GINR), in collaboration with several organizations, including: Greenland Fisheries License Control (GFLK, Greenland), Marine Research Institute (Iceland), Norwegian Polar Institute (Tromsø), Swansea University (Wales), University of Iceland, Danish Centre for Environment and Energy (DCE, former NERI), Polar Science Center at the Applied Physics Laboratory (University of Washington), Natural History Museum of Denmark, University of Copenhagen, Natural History Museum at the University of Oslo**,** Research Unit for Wildlife Population Assessment at the University of St Andrews, Department of Fisheries and Oceans (Canada), University of Aarhus and Wood Hole's Oceanographic Institution (USA).

2. RESEARCH

2.1 Species and stocks studied

Pinnipeds

- Walrus *Odobenus rosmarus* – Northern Baffin Bay
- Hooded seals *Cystophora cristata* – South Greenland (Western Atlantic)
- Harbour seal *Phoca vitulina* – Central West and South Greenland
- Bearded seal *Erignathus barbatu* – Baffin Bay and South Greenland
- Ringed seal *Pusa hispida*– Baffin Bay and South Greenland
- Harp seal *Pagophilus groenlandicus* – South Greenland

Cetaceans

- Bowhead Whale *Balaena mysticetus* –West Greenland
- Narwhal *Monodon monoceros* **-** West and East Greenland
- Humpback whale *Megaptera novaeangliae* **-** West Greenland
- Fin Whale *Balaenoptera physalus* – West Greenland
- Minke Whale *Balaenoptera acutorostrata* – West Greenland.

2.2 Field work

Walrus

To correct for availability bias (*i.e.* animals not seen because they were submerged) in aerial surveys carried out in 2009 and 2010, hunters from Qaanaaq tagged 7 walruses with satellite senders.

Seals

The harbour seal is classified as “Critically Endangered” in the Greenland Red List, and its conservation requires immediate action. Despite reports of sporadic observations, no stable colonies have been identified in recent years north of Cape Farewell. Based on information gathered from catch reports and interviews with locals in several parts of West Greenland, a haulout site for harbour seals was identified south from Nuuk, in the municipality of Sermersooq in 2010. The place was monitored in the summer 2011 to determine whether this is a stable colony or a temporary gathering.

As part of a series of environmental studies for hydrocarbon development, in collaboration with DCE and hunters from Upernavik, GINR tagged 12 ringed seals and two bearded seals in Melville Bay.

Collection of stomach samples and other tissues from the seal harvest in Appilartoq, Cape Farewell continued throughout 2011. The project’s aim is to identify the diet of seals in the area. The location was chosen partly because all the 5 species of seals common in Greenland are harvested there. All the practical aspects of this project are run by locals.

<u>Cetaceans</u>

With the aim of mapping migration routes and understanding stock structure, GINR attempted to tag narwhals and belugas in Northwest Greenland (Qaanaaq and Uummannaq) and narwhals in East Greenland (Scoresby Sund). In East Greenland, the research team and local hunters caught and tagged 7 narwhals. Tagging of narwhals and belugas in Northwest Greenland was unsuccessful in 2011.

As part of a comprehensive series of studies on the ecology and stock structure of bowhead whales, carried out by GINR in cooperation with other institutions, hunters from Qeqertarsuaq collected biopsies from bowhead whales in Disko Bay between March and May. The samples are being used for sex determination, genetic identification and stock identity. In addition, as in previous years, bowhead whales from Disko Bay were instrumented with satellite transmitters.

Bowhead whales were hunted in Disko Bay for the third consecutive year after a 70 years long ban. As during 2009 and 2010, biological samples were collected from one the bowhead whale that was taken in 2011, to study prey choice, age and reproduction. To obtain dive data for calibration of aerial surveys, hunters from Qeqertarsuaq, attached one satellite transmitter to a minke whale in Disko Bay during summer. No data were received from the transmitter.

As in previous years, the occurrence and site fidelity of humpback whales in Nuuk fjord was investigated using photo-identification. Efforts in 2011 were expanded to include pictures of humpback whale flukes and dorsal fins provided by the public and tour operators in Nuuk and Disko Bay. In addition, biopsy samples were collected in the area around Nuuk.

In cooperation with tour operators, a set of guidelines for mitigating the effect of whale watching on the behaviour of humpback whales were tested in Nuuk. 2011 was the second and last year of this study.

The seasonal acoustic activity of large whales and bearded seals is being monitored by an array of recorders moored to the seabed at six locations in the Davis Strait and Baffin Bay. The moorings were deployed in October 2011 and will be redeployed in September 2012.

Stomach samples, body measurements and a variety of tissue samples were collected from 3 out of the 8 humpback whale that were caught in 2011.

As part of the requirements for obtaining a whaling licence, hunters from West Greenland provided GINR with tissue samples from 1 bowhead whale, 3 humpback whales and >45 minke whales.

Independently of GINR, the University of Copenhagen collected sound recordings and biopsies of bowhead whales in Disko Bay (Outi Tervo).

DCE maintains a database with observations of cetaceans and birds collected by marine mammal and bird observers on board vessels carrying out seismic surveys under licences provided by the Bureau of Minerals and Petroleum. In 2011 there were surveys in Northwest, West, Southwest and East Greenland.

2.2 Laboratory work

As in previous years, narwhal samples were analysed for genetic diversity, reproductive status and age estimation by aspartic acid racemization of eye lenses and dentine tooth layers. This study was part of a PhD at the University of Copenhagen and GINR (Eva Garde). The laboratory work for this PhD finished in 2011.

Age of harbour porpoises was estimated by aspartic acid racemization of eye lenses and dentine tooth layers as part of an MSc study at the University of Copenhagen and GINR (Nynne H. Nielsen).

2.4 Research results

Walrus

The data from the walrus studies from 2011 are being analysed and incorporated into abundance estimates for walruses in the North Water Polynia.

Seals

Results from the seal tagging in Baffin Bay will be available in 2013.

Analysis of the stomach samples and other data from the seal harvest in South Greenland is a work in progress.

Harbour seals were present at the haulout site in the municipality of Sermersooq, although in much smaller numbers that in 2010. It is therefore still unclear whether the location contains a stable colony or not.

Cetaceans
The majority of research results from the fieldwork of 2011 is not available yet.

A PhD on the acoustics and kinematics of large whales in West Greenland was defended in January at the University of Aarhus in January by Malene Simon (Supervisor: Peter Teglberg Madsen).

At the University of Copenhagen, Nynne Hjort Nielsen completed her Master's Degree on age determination and survival rates of fin whales and harbour porpoises in May. The study was carried out with external supervision and data from GINR (Mads Peter Heide Jørgensen).

A PhD on age determination, population dynamics and stock structure of narwhals was delivered by Eva Garde to the University of Copenhagen in December. External Supervisor was Mads Peter Heide Jørgensen, GINR.

Outi Tervo finished a PhD at the University of Copenhagen on the acoustic behaviour of bowhead whales in Disko Bay. The study was done independently of GINR.

3. ONGOING (CURRENT) RESEARCH

As in previous years, GINR focuses on identifying important areas for harbour seals in order to implement monitoring programs. In relation with hydrocarbon exploration in Baffin Bay, the satellite-tagging program on ringed seals and bearded seals that started in 2011 continued in 2012. Tagging of ringed seals in the vicinity of Ilulissat for obtaining oceanographic data (temperature at depth) with the help of seals will be attempted in 2012. A similar study started in Southeast Greenland in 2012.

In order to understand the stock delineation and to obtain complementary data for abundance estimates, GINR runs a series of satellite telemetry studies on walrus, narwhals and belugas (and polar bears) in West Greenland, as well as narwhals in East Greenland. There is an oceanographic component in the tagging of narwhals, since some of the tags used for these animals are equipped with depth and temperature sensors. Stomach sounds to document feeding events of narwhals are to be tested in 2012.

A winter survey for narwhal, beluga, walrus and bowhead whales off West Greenland scheduled for the spring 2012 was carried out as planned.

As one of three studies aimed at better understanding the effects of sound from seismic air guns in Baffin Bay, an array of bottom-mounted and drifting instruments was used to record seismic sounds at the bottom, middle and shallow layers of the water column in Baffin Bay. A second study consisted of a series of aerial surveys for estimating abundance and distribution of narwhals in Melville Bay before, during and after seismic surveys. Surveys were scheduled for July, August and September 2012.

A third and last study commissioned by the Bureau of Minerals and Petroleum in relation to seismic activities in 2012 was aimed at gathering information about the narwhal hunt and the way hunters perceive effects of seismic activities.

There is a series of ongoing projects on the foraging behavior, prey availability, migration and population structure of bowhead whales in Disko Bay and humpback whales in West Greenland.

Passive acoustic monitoring (PAM) of large whales and bearded seals in Davis Strait and Baffin Bay will continue until 2013. PAM off Southeast Greenland will start in the fall 2012. These studies are aimed at gathering information for environmental impact assessments and studying the relationship between sea ice and marine mammals.

4. CATCH DATA

Since 1993, catches of the most common game species, including pinnipeds and small whales, are reported through a form that hunters have to fill in order to renew their hunting permit. This form contains information about monthly catches from October to September the following year. The information is stored in the Pininarneq database. In 2012, catch statistics for full years from Piniarneq are only available for 2010 and before.

Catches of quoted species are reported also in separated and more detailed special forms, which are delivered to the government shortly after a catch and used to keep control over the number of licenses issued and the status of the quota for each particular region. In these special forms, hunters deliver data on time and location of each catch, as well as sex, reproductive state, size and other parameters. Animals struck but lost should also be reported.

Catch statistics for narwhal, beluga, walrus and polar bear are thus kept in two types of database: Piniarneq and the databases for special forms. All datasets are kept by the Department of Fisheries, Hunting and Agriculture. Catch statistic of large whales are kept only in a database based on the special forms and reports from the local authorities.

Catch statistics are shown in Appendix 1 for species that are not regulated by quotas and on Appendix 2 for quoted species.

5. BY-CATCH DATA

One bowhead whale was found floating dead near Qeqertarsuaq, entangled in fishing gear for crabs in May 2011. One bowhead whale was found floating dead near Qeqertarsuaq entangled in fishing gear for crabs in June 2011. One humpback whale male was found dead near Paamiut (with a length of 7-8 m), entangled in a pound net for cod in June 2011 (reported by the Department of Fisheries, Hunting and Agriculture to the IWC).

6. STRANDINGS

There were unusually high numbers of reports of stranded or floating carcasses in 2011. Seven events were recorded in West Greenland by the Department of Fisheries, Hunting and Agriculture and GINR. A cluster of 7-8 carcasses of unidentified species, probably sperm whales, was observed in March near Attu (*ca.* 68° N). Single floating sperm whales carcasses were reported in March near Itilleq (*ca.* 66.5 ° N), and in June near Nuuk (*ca.* 64 ° N) and near Sisimiut (*ca.* 66.5 ° N). The sperm whale from Sisimiut in June was alive but dying when first observed. A group of 5-12 sperm whale carcasses was observed adrift between Sisimiut and Maniitsoq (*ca.* 65.5 ° N) in June. The sperm whale carcase found adrift near Nuuk was towed to a nearby island and necropsied. It was an adult male. Lung infection was identified as likely cause of death by a veterinarian, but due to the advanced state of decomposition it was not possible to draw definitive conclusions. The cause of death of the other events is unknown.

A single humpback whale was seen at the end of March in South Greenland. A single pilot whale stranded in Nuuk in July. The pilot whale had holes in its body that resembled bullet wounds and a broken rope tied to its tailstock, so it was most likely an animal struck and lost during transport.

7. ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

In 2011, quotas and catches followed the biological advice given by NAMMCO and/or the International Whaling Commission for all the cetacean and pinniped species whose catch is regulated by quotas. This situation was new for Greenland, and the last species for which the quota followed the advice was the walrus. In March, GINR, as the scientific authority for CITES issued a positive Non Detriment Finding document (NDF) for Atlantic Walrus in Greenland. This replaced a negative NDF from 2007. Currently, GINR has issued positive NDFs for narwhal, beluga and walrus, and a negative one for polar bear. The positive NDF for narwhal is from 2009 and replaced a negative one from 2005. As a consequence of the NDF reports, the government of Greenland has banned the export of products derived from narwhals and polar bears.

In February 2010, GINR reminded the Department of Fisheries, Hunting and Agriculture that in 2000 NAMMCO recommended that the catch of belugas south of 65°N should be banned, in order to allow for the reestablishment of belugas in areas where they were abundant before the 1930s. The issue was taken up at the NAMMCO Council meeting in 2010 and the Management Committee for Cetaceans requested the Scientific Committee to reconsider the temporal and geographical restrictions on the takes of beluga from West Greenland within the framework of the NAMMCO/JCNB JWG. This scientific working group met in 2012, and their advice falls out of the time scope of this report.

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Appendix 1.

Reported catches of seals and small cetaceans that are not managed by quota systems

Source: Piniarneq/Jagtsystem Database, Department of Fisheries, Hunting and Agriculture.

Table 1.1 Catches of seals 2007-2010

	2007	2008	2009	2010
Ringed seal				
East Greenland	10,786	8,703	8,062	6,457
West Greenland	60,483	61,833	57,614	55,060
Hooded seal[(12)]				
East Atlantic	7	2	1	6
West Atlantic	3,287	2,603	1,985	2,119
Harp seal[(13)]				
Greenland Sea adult	325	190	130	121
Greenland Sea juvenile	1,112	1,534	1,403	870
West Atlantic adult	26,541	25,965	23,121	22,031
West Atlantic juvenile	56,299	54,498	48,777	67,724
Harbour seals				
East Greenland	33	40	5	2
Cape Farewell[14]	22	19	8	11
West Greenland	32	22	20	13
Bearded Seals				
East Greenland	394	277	264	220
West Greenland	1,174	1,160	994	1,183

[12] For hooded seals, East Atlantic includes only Ittoqqortoormiit, while West Atlantic includes West Greenland and Ammassalik

[13] For harp seals, Greenland Sea includes all catches reported from Ittoqqortoormiit and 50 % of the catches of Ammassalik. West Atlantic includes all catches from West Greenland and 50% of the catches from Ammassalik.

[14] From Ivittuut to Nanortalik

Table 1.2 Catches of small cetaceans that are not regulated by quotas 2007-2010

	2007	2008	2009	2010
Harbour porpoise				
East Greenland	0	1	0	10
West Greenland	2,910	1,758	2,029	2,067
White sided / white beaked dolphins				
East Greenland	1	2	5	18
West Greenland	38	106	87	243
Pilot whale				
East Greenland	20	0	1	0
West Greenland	268	182	237	337
Killer whale				
East Greenland	0	0	5	1
West Greenland	3	26	9	14
Bottlenose whale				
East Greenland	0	0	0	0
West Greenland	9	21	1	27

Appendix 2.

Catch statistics for pinnipeds and cetaceans managed by quota systems

Source: Department of Fisheries, Hunting and Agriculture, Government of Greenland

Table 2.1. Quotas and reported catches of walrus 2007-2012. Since 2010, the advice for NAMMCO has been that removals should allow for a 70% probability of population growth: East Greenland, 21 walrus per year; West Greenland (David Strait/Hudson Bay) 89 walrus per year; Northern Baffin Bay, 68 walrus per year. The advice includes catches, animals struck but lost and, in the case of West Greenland and Baffin Bay, the combined removals of Greenland and Canada.

Walrus	**2007**		**2008**		**2009**		**2010**		**2011**		**2012**
	Quota	***Catch***	Quota	***Catch***	Quota	***Catch***	Quota	***Catch***	Quota	***Catch***	Quota
East Greenland	30	***10***	30	***9***	23	***4***	18	***7***	18	***5***	18
West Greenland	71	***43***	65	***28***	38	***33***	61	***40***	60(15)	***50***	59(16)
Baffin Bay	99	***80***	80	***66***	75	***90***	48(17)	***60***	52(18)	***42***	64

[15] Quota of 61 and one subtracted from overharvest in 2010
[16] Quota of 61 and two subtracted from local overharvest in Upernavik and Sisimiut
[17] Quota of 64 and 16 subtracted from overharvest in 2009
[18] Quota of 64 and 12 subtracted from overharvest in 2010

Table 2.2 Quotas and reported catches of narwhal and beluga 2007-2012. Since 2009, the advice for NAMMCO has been that removals should allow for a 70% probability of population growth: East Greenland, 85 narwhals per year; West Greenland 310 narwhals per year and 310 belugas per year. There are no belugas in East Greenland.

	July 2007 – June 2008		**July 2008 – June 2009**		**July 2009 – June 2010**		**July 2010 – June 2011**		**2011**		**2012**
	Quota	***Catch***	Quota	***Catch***	Quota	***Catch***	Quota	***Catch***[19]	Quota	***Catch***	Quota
Narwhal Qaanaaq[20]	85	***81***	85	***97***	85	***55***	85	***89***	85	***55***	85
Melville Bay[21]	-	***125***	-	***129***	81	***95***	66[22]	***53***	81	***79***	83[23]
Rest Of West Gl.	-	***126***	-	***156***	144	***137***	144	***88***	144	***117***	171[24]
Total West Greenland	319	***332***	384	***382***	310	***287***	295[25]	***230***	310	***251***	339

19 Catch is only from July to December 2010. Quotas from 2011 and onwards follow the calendar year
20 Qaanaaq minus Savissivik (i.e. Inglefield Bredning and Smith Sound) has a technical quota of 425 narwhals for a 5 year period, or an average of 85 narwhals per year
21 Upernavik and Savissivik
22 Quota of 81 and 15 subtracted from overharvest in 2009-2010
23 Quota of 81 and 2 carried over from 2011
24 Quota of 144 and 27 carried over from 2011
25 Quota of 310 and 15 subtracted from overharvest in 2009-10

Narwhal East Greenland	None	***13***	None	***76***	85	***12***	85	***30***	85	***45***	85
Beluga Qaanaaq[26]	82	***6***	20	***50***	20	***16***	20	***1***	20	***7***	20
West Greenland	138	***127***	240	***250***	250	***225***	290	***103***	290	***131***	310
Total beluga	220	***133***	260	***300***	270	***241***	310	***104***	310	***138***	330

[26] Qaanaaq, including Savissivik has a quota of 100 belugas for a 5 year period, or an average of 20 belugas per year

Table 2.3. Quotas and catches of large whales 2007-2012, including reported struck and lost. Quotas for humpback whale and minke whale are as set by the International Whaling Commission (IWC). Quotas for bowhead whales and, since 2010 also fin whales are lower than the IWC quota.

Large whales	**2007**		**2008**		**2009**		**2010**		**2011**		**2012**
	Quota	***Strikes***	Quota	***Strikes***	Quota	***Strikes***	Quota	***Str.***	Quota	***Str.***	Quota
West											
Fin whale	19	***12***	19	***14***	19	***10***	10	***6***	10	***5***	10
Bowhead	0	***0***	2	***0***	4[27]	***3***	3[28]	***3***	2	***1***	3[29]
Humpback	0	***0***	0	***0***	0	***0***	9	***9***	9	***8***	10[30]
Minke	175	***167***	200	***151***	200	***164***	193[31]	***187***	185[32]	***179***	183[33]
East											
Minke	14	***2***	14	***1***	14	***4***	14	***9***	15	***10***	15

[27] Quota of 2 and 2 carried over from the 2008 quota
[28] Quota of 2 and one carried over from the 2009 quota
[29] Quota of 2 and one carried over from the 2011 quota
[30] Quota of 9 and one carried over from the 2011 quota
[31] Quota of 178 and 15 carried over from the 2009 quota
[32] Quota of 178 and 7 carried over from the 2010 quota
[33] Quota of 178 and 5 carried over from the 2011 quota

4.3
ICELAND - PROGRESS REPORT ON MARINE MAMMALS IN 2011

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1. INTRODUCTION

The following reports on studies on marine mammals in Icelandic and adjacent waters in 2011. While most of the studies were conducted by the Marine Research Institute (MRI) and it's various research partners, queries for information on research were sent to all offices or individuals known to have been involved in marine mammal research or data collection during the period. These include BioPol ehf. a Marine Biotechnology Science Hotel in Skagaströnd; Húsavík Research Centre (HRC), Húsavík Whale Museum (HWM); Faxaflói Cetacean Research project (FCR), Innovation Centre, Iceland (ICI); Institute of Freshwater fisheries (IFF); Keldur, Institute for Experimental Pathology (KIEP); Rannsjá; The Icelandic Seal Centre (ISC); The Institute of Natural History (INH); University of Iceland (UI) as well as data collection from private commercial platforms such as whaling and whale watching companies.

As in previous years research efforts on marine mammals at the MRI in 2011 were largely devoted to the wide ranging research programme on common minke whales initiated in 2003 and the results of recent sightings surveys. Progress of the programme is reported under respective headings according to the guidelines for national progress reports submitted to NAMMCO. Laboratory work continued in a comprehensive biological sampling programme from the commercial catch of fin whales initiated in 2009, but no catches were taken in 2011.

The INH is responsible for collection and preservation of museum specimens of marine mammals in Iceland. The institute also works on historical stranding records and conducts biological investigations on an opportunistic basis.

In recent years increasing number of scientists have conducted research on marine mammals from platforms of opportunity such as those offered by the rapidly expanding commercial whale watching operations. The geographical scale of these studies is generally small, but the frequency of observation is high during the summer and some companies operate throughout the year. Studies on cetaceans conducted under the auspices of the University of Iceland have mainly focused on acoustics, photo-id, behaviour and distribution in near-shore areas.

2. RESEARCH 2011

2.1 Species/stocks studied

<u>Pinnipeds</u>

- Grey seal (*Halichoerus grypus*)
- Harbour seal (*Phoca vitulina*)
- Harp seal (*Pagophilus groenlandica*)
- Hooded seal (*Cystophora cristata*)
- Bearded seal (*Erignahtus barbatus*)
- Walrus (*Odobenus rosmarus*)

<u>Cetaceans</u>

- Blue whale (*Balaenoptera musculus*)
- Fin whale (*Balaenoptera physalus*)
- Common minke whale (*Balaenoptera acutorostrata*)
- Humpback whale (*Megaptera novaeangliae*)
- Sperm whales (*Physeter macrocephalus*)
- Northern bottlenose whale (*Hyperoodon ampullatus*)
- Long-finned pilot whale (*Globicephala melas*)
- Killer whale (*Orcinus orca*)
- White-beaked dolphins (*Lagenorhyncus albirostris*)
- White-sided dolphins (*Lagenorhyncus acutus*)
- Striped dolphin (*Stenella coeruleoalba*)
- Common bottlenose dolphin (*Tursiops truncatus*)
- Harbour porpoise (*Phocoena phocoena*)

2.2 Field Work

<u>Pinnipeds</u>

An aerial harbour seal count was conducted in the summer of 2011 by the ISC, Rannsjá, IFF, BioPol ehf and the MRI. Harbour seals were counted 2-3 times in all known haul out sites along the cost of Iceland. This is the 10th time that aerial harbour seal counting surveys have been conducted in Iceland. However, previous to this year, surveys have consisted of only one count at each location.

A comprehensive seal count was carried out for the fifth year in a row in Húnaflói bay. The seal count was conducted by the Icelandic Seal center. Counting was carried out by several volunteers on 25th of July 2011 during 3 hours around low tide. All seals on the costline of Vatnsnes and Heggstaðanes peninsulas in Húnaflói bay were counted (100km). The number of seals in Vatnsnes will be monitored by repeating the count annually.

In a special sampling effort initiated in 2007 and continued to date by BioPol ehf., Skagaströnd, NW Iceland, seals have been collected for studies on the life history parameters, diet, body condition, genetics and pollutant burden. The animals came from direct hunt and as bycatch from the artisan gillnet lumpsucker fishery.

A study organized by the ISC and IFF, on the potential effects of increasing tourism on the haul-out behaviour of seals was initiated in the summer of 2008 at the seal watching location in Illugastaðir on Vatnsnes peninsula North west-Iceland. The effect of tourism on seals at seal watching sites is investigated by studying changes in behaviour and abundance of the seals. Between 2008 and 2011, the seals have been counted in the biggest haul-out areas on Vatnsnes peninsula regularly during the whole year and therefore the abundance has been monitored. The main haul out areas are at Svalbard, Illugastaðir, Hindisvík and Ósar. The study is a part of a larger project, called "The Wild North" (http://www.thewildnorth.org/) including research on cetacean behaviour by the HRC. The last year of the project was 2011, but the outcome has been good and partners have now decided to carry on with the next step of The Wild North for the next 3-5 years.

A study on the effect of seals on salmonids was initiated in 2009. The project is a co-operation between ISC and IFF and will continue for 4 years. The main goal is to determine feeding habits of seals in river mouth, especially in regards of the effect of seals on salmonids. The field work includes radio-tagging seals in river mouths to monitor their presence there during the summer, counting the seals there at different times of the years and collecting samples for feeding analyses.

Five harbour seals were tagged in 2010, and 11 in 2011.

Cetaceans

Strandings

Information on stranded cetaceans in Iceland is compiled by the MRI in cooperation with the INH and other relevant institutions (Table 1). According to an arrangement formally adopted in 2005 the Marine Research Institute is the central authority concerning science and research while other aspects of strandings such as euthanasia/rescue, disposal of carcasses and preservation of museum specimens fall under the responsibilities of the Chief Veterinary Office, the Environment Agency of Iceland and INH respectively.

Table 1. Cetacean strandings in 2011.

Species	Animals
Northern bottlenose whale	1
Sperm whale	5
Killer whale	1
Humpback whale	1
White-beaked dolphin	2
Common minke whale	1
Long-finned pilot whale	1
Striped dolphin	2
Common bottlenose dolphin	1
Unidentified whale	2
Total	**18**

In 2011, 18 incidents of cetacean strandings were recorded by the MRI, all single animals. These include the first stranding record of common bottlenose dolphins in Icelandic waters. None of these were known to have stranded alive. This is similar to

2009 and 2010, but considerably less than in 2008 when the number of reported strandings was record high. In 2011, the most commonly stranded cetacean species was the sperm whale, 5 strandings with no apparent pattern.

Depending on the condition of the stranded animals, samples are taken for studies on diet (stomach), life history (teeth, ear plugs, gonads), genetics (skin, muscle), energetics (muscle, blubber) and for morbillivirus antigen screening (blood). Various tissue samples for pollution studies have been routinely collected during dissections of stranded or by-caught cetaceans in recent years. These are stored frozen at the MRI.

Data from commercial catch

Sampling and measurements of common minke whales was conducted for the MRI by whalers onboard the vessels.

Sightings data

Monitoring of sightings during whale watching operations was conducted in two bays, Faxaflói and Skjálfandi. Sighting and effort data is stored at each whale watching company and data from Skjálfandi is also stored and analysed at the HWM.

The data collection in Faxaflói available (2007 to 2011) so far includes weather parameters (collected every 15min), effort, sighting, group size, calculation of no. photoID taken per day, per tour per month and per year, photo-ID images, behaviour (mainly focusing on feeding with emphasis on entrapment and engulfment manoeuvres), associated seabird species (mainly during feeding bouts). Data analysis by the FRC includes aims to assess minimum population size, site fidelity, distribution and occurrence of cutaneous disorders and epizoa mainly in minke whales and white-beaked dolphins. Peducle scarrings were studied in humpback whales and compared with the Skjalfandi Bay area too.

Telemetry data

The MRI's satellite tracking programme continued, resulting in tracking of a single humpback whales between 4^{th} and 17^{th} November 2011 (http://www.hafro.is/hvalamerki/93120.html). No signals were received from a single tagged minke whale.

Biopsy sampling

Skin biopsies were collected by the MRI from 18 humpback whales, 6 blue whales and a single common minke whales in 2011 in satellite tracking cruises. These have i.a. been used to determine the gender of the tracked animals.

Natural marking

Catalogues of individuals based on natural marking data are held at the MRI for blue, humpback and killer whales. Photographs are obtained in special cruises as well as from opportunistic platforms. In 2011 photos og humpback and blue whales were collected in nearshore North Icelandic waters and killer whale photos were obtained from Breiðafjörður, W-Iceland in cooperation with Filipa Samarra, University of St. Andrews, U.K. The MRI cooperates with various scientific bodies for matching photos from Iceland with photos from other areas within the North Atlantic.

In 2011 the FCR photo-identified 418 common minke whales, 337 white-beaked dolphins, 52 humpback whales and 8 killer whales.

The HWM has collected photo id pictures obtained in whale watching operations in Skjálfandi Bay since 2001. In 2011, data was collected from mid May to mid September.

Behaviour
A project to study the effects of the whale watching boats on the distribution of whales was continued at the HRC. This project is a part of the "Wild North project" including study on the potential disturbance of tourism on seal haul out behaviour (see above) (http://www.thewildnorth.org/).

Ecological Acoustic Recorders (EAR) have been deployed in two locations in Skjálfandi Bay since September 2008, as cooperation between the University of Hawaii, UI and HRC. EARs were deployed in Skjálfandi bay during January-March 2011 (humback whale project) and in July 2011 (blue whale project).The data from these two deployments are being analysed.

2.3 Laboratory work

Pinnipeds
Food studies and age determination
The diet of grey seals was studied by analysing stomach contents by BioPol, Skagaströnd, N.W. Iceland. Nematode and acanthocephalan infestation in the digestive tract and diseases in the intestines were also assessed.

The diet of harbour seals that haul out in river mouths in the north west of Iceland is being investigated in a study made by the IFF and the ISC. A special effort is put on investigating the effect of seals on salmonids.

Cetaceans
During 2003-2007 a wide ranging research programme concerning common minke whales was conducted in Icelandic waters including sampling of 200 minke whales (for details see MRI 2003). Progress has been reported to the Scientific Committees of NAMMCO and the IWC (see *e.g.* Víkingsson *et al.* 2009, NAMMCO 2009). A formal review of the results from the programme under the auspicies of the Scientific committee of the IWC is scheduled during the winter 2012/2013. The status of different sub-projects of the programme to date is discussed under the representative sections below.

Feeding and energetics
Diet composition
Preliminary results on diet composition of minke whales were presented in 2011

(Víkingsson and Elvarsson 2011) and final statistical analysis is nearly complete.

Analysis of diet based on stable isotopes and fatty acids is at a final stage.

Energetics
Laboratory analysis on the energy density of various tissues (muscle, blubber, visceral fat liver and kidneys) is completed. Energetic model to estimate seasonal fattening has been developed (Christensen *et al.* 2012, submitted).

Multi-species modelling
A multi-species model including minke whales is under construction as a PhD project at the University of Iceland and the MRI.

Environmental contaminants
Laboratory work on organic and inorganic contaminants in various tissues collected as a part of the minke whale research programme is completed and some preliminary results have been published (Dam *et al.*, Rotander *et al.* 2011, Auðunsson and Víkingsson 2012).

Analyses of abundance and trends
Data collection and evaluation on the distribution of cetacean species in Skjálfandi Bay in relation to environmental variables was continued at HWM.

Genetics
A DNA registry research program was initiated at the MRI in 2010. This includes the development of a tissue bank in which all genetic samples collected from cetaceans (commercial hunting, stranding and biopsy) will be registered with a unique ID number, and a DNA database in which all samples genotyped with genetic markers are recorded. The establishment of the tissue bank is expected to be completed by the end of 2012.

Life history parameters
Age reading of fin whales from the commercial hunt using laminated layers in ear plugs (MRI) and the asparctic acid racemisation method for eye lenses (MS project at the University of Copenhagen) was continued in 2011. The results of the different methods will be compared for estimating their reliability.

Analyses of ovaries and testes from the commercial hunt in 2009 and 2010 are completed.

Natural marking
Analysis of all available photo-id material on humpback whales in Icelandic waters (archived at the MRI) is at a final stage. In 2011 new material on humpback, killer and blue whales was added to the catalogue. A special database for cetacean photos and associated data has been created at the MRI. This database will serve as a central archive for photo-id material from Icelandic waters and should facilitate comparisons

with photo-id collections from other areas.

Studies conducted from commercial whale watching vessels included photo-id studies on common minke whales and white-beaked dolphins in Faxaflói Bay.

The HWM has collected data and photo id pictures obtained in whale watching operations in Skjálfandi Bay since 2001. The museum will continue data collection during the summer months.

2.4 Other studies

A collaborative study between MRI scientists and colleagues from Norway and Scotland on stock structure and movements on killer whales in the Northeastern Atlantic was continued in 2011 (Foote *et al.* 2010, 2011).

The Institute of Natural History archives mammal skeletons and bone remains discovered from soil including marine mammals. The archive now includes about 200 specimens, mostly from walruses. Information on occurrences of Walruses found in Iceland has been collected over many years. This includes live and dead animals, historical and recent. Included are also skeletal remains from the natural environment and archaeological material from middens. Cleaning and preservation of a blue whale skeleton from a stranding event in 2010 is at a final stage.

Whale strandings database project: Information on strandings of whales found in Icelandic waters has been collected over many years. This includes dead whales, ice-locked live animals and live animals driven ashore, historical and recent. Skeletal remains from the natural environment and archaeological material from middens is also included.

2.5 Research results

Pinnipeds

An aerial harbour seal survey cunducted in the summer of 2011 gave an average haul-out count of 4,512 harbour seals ("Trimmed Mean"= 4,982) and resulted in an estimate of 11,000 animals (95% CI: 8,000-16,000). This is similar to the estimates that were made in 2003 and 2006 with comparable methodology (Hauksson and Einarsson 2010).

The results of the fifth comprehensive seal count in Vatnsnes peninsula on 25th of July resulted in a count of 1,033 harbour seals in 2011, mariginally fewer than in 2010 when the result was 1,057 seals.

Cetaceans

New abundance estimates were presented at the NAMMCO AEWG March 2011 Copenhagen meeting. The first estimate of porpoises that is perception bias corrected (Gilles *et al.* 2011) for Icelandic coastal waters was based on the 2007 aerial survey where the harbour porpoise was a target species and gave 43,179 animals (CV=0.45; 95% CI: 31,755-161,899). The NASS 2007 shipboard survey gave a CDS estimate for sei whales (Pike *et al.* 2011c) of 4,924 (95% CI: 1,224-10,591). Migratory behaviour of sei whales can vary greatly from year to year and sei whales would have been present south and west of the survey area during the time of the survey. The WG concluded that for a better estimate of sei whale abundance, surveys will have to extend farther to the south and/or be conducted later in the season than has been the norm for NASS. Corrected abundance estimates for minke whales from the aerial surveys in 2007 and 2009 were also presented (Pike *et al.* 2011a) and an uncorrected estimate for the Iceland-Faroese shipboard survey area in 2007 outside the aerial block (Pike *et al.* 2011d). The AEWG concluded that the previous assumption that the most important component of the Central Atlantic stock is found within Icelandic coastal waters in summer is not valid every year – there can be considerable annual variation as shown by the 2007, 2008 and 2009 aerial survey results. Paxton *et al.* (2011) presented an estimate of pilot whale abundance based on density surface fitting to the NASS 2007 shipboard data. The AEWG concluded that additional work was required on this estimate. Pike *et al.* (2011e) presented relative abundnce estimates of pilot whales based on all NASS shipboard surveys. The Working Group agreed with the authors that no firm conclusions about trends in pilot whale abundance could be inferred from this work.

MRI's satellite tracking program resulted in tracking of four humpback whales. The movements of the whales were published in near-real time at MRI's website (http://www.hafro.is/undir.php?ID=210&REF=2).

A fin whale mother-foetus pair match to a father was detected in a relatedness analysis (Pampoulie *et al.* 2011) of the 2009 and 2010 fin whale catches.

Results from the study of the feeding ecology of minke whales were presented to the ICES Annual Science Conference in 2011 (Víkingsson and Elvarsson 2011).

Preliminary analysis of biological parameters of minke whales, including estimation of age and reproductive parameters was presented to the IWC SC in 2011 (Hauksson *et al.* 2011).

Research into sustainable catch levels of common minke whales in Icelandic waters was presented to the NAMMCO WG on assessments (Víkingsson *et al.* 2011a).

Preliminary results from sound recordings of blue and humpback whales were presented in 2011 (Rasmussen and Akamatsu 2011, Iversen 2011, Magnúsdóttir *et al.* 2011a).

Preliminary results from two studies on the effects of whaling and whale watching on the behaviour and energetics of minke whales in Iceland is were presented in 2011. An ongoing PhD project at the University of Aberdeen on the effects of whale watching on feeding behaviour and energetics of minke whales in Faxaflói was presented to the Scientific Committee of the IWC (Christiansen *et al*. 2011a). A study of potential impact of whale watching on the behaviour of minke whales in Skjálfandi Bay was introduced at the ECS annual conference (Cummings *et al.* 2011) and the Icelandic Society of Mammalogy (Magnúsdóttir *et al.* 2011b).

3. ONGOING (CURRENT) RESEARCH

Pinnipeds
The ISC has applied for funds for an aerial survey of grey seals in 2012. The last survey was in 2009 (Hauksson 2010).

The diet of harbour seals that hauls out in river mouths in the north west of Iceland is being investigated in a study made by the IFF and the ISC. A special effort will be put on investigating the effect of seals on salmonids.

The results from the investigation of the effect on tourism on harbour seals are being analysed. An assessment of whale watching activities on Skjálfandi bay with reference to generally accepted guidelines was undertaken as a MS thesis at the University of Akureyri (Martin 2012).

The INH currently works on age determination of walrus bones archived at the Museum.

Cetaceans
The analysis of acoustic data from the TNASS shipboard survey has been delayed due to technical difficulties. A re-analysis of the data has been initiated by an agreement between the NAMMCO Secretariat and the University of St Andrews.

Starting in 2012 skin samples for genetic analysis will be collected from all marine mammals bycaught in fisheries surveys.

In 2012 the MRI will submit a comprehensive research programme on fin whale stock structure as a part of the RMP implementation process within the IWC.

A study on the persistence of Lamprey marks on killer whales is ongoing (Samarra 2012).

4. CATCH DATA

Reported direct catches of cetaceans in 2011 and direct as well as indirect catches of pinnipeds in Icelandic waters in 2011 and updated for 2010 are given in Appendix 1, Tables 1-3. As in recent years, Icelandic authorities issued permits to Norwegian sealers to take harp seals within the Icelandic EEZ in 2011. These catches are not included here, but appear in the Norwegian sealing statistics.

5. BY-CATCH DATA

Reported by-catches of marine mammals by the Icelandic fishing fleet in 2010 and

2011 are given in Appendix I, Tables 1, 4 and 5. In 2011, information on marine mammal by-catch was obtained from all research surveys, the Fishery Directorate's observer programme (April - December) and logbooks from commercial fisheries. Finally, information on by-catch events were received on occasional basis from anecdotal sources, skin trading reports and lists of collected research samples.

The MRI has initiated efforts to estimate and improve reporting of bycatch in Icelandic waters. An overview of the situation was given by Ólafsdóttir (2010). Monitoring bycatch of pinnipeds is now the responsibility of the ISC where preparations are being made to improve the reporting system.

6. ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

Pinnipeds

Advice given for harbour seal in 2011 was in accordance with advice given in recent years. Based on the most recent surveys of harbour seals from August 2003 and 2006 respectively the MRI concluded that due to uncertainties in the number of net entangled animals it is not possible to predict whether the observed decline in abundance in the past will continue, although recent hunt rates are much reduced. The MRI therefore reiterated the importance of better by-catch recording and that the stock was monitored, including aerial surveys at two or three year intervals in the next years. Management objectives for the stock of harbour seals in Iceland were set by Icelandic authorities in 2010.

Advice given for grey seal in 2011 was identical to advice given in 2008 and 2009. The management objectives set for the grey seal stock in 2005 calls for action if the stock is further reduced below the estimated level in 2004 of 4100 animals. Based on the survey in 2005 this was considered very unlikely to be the case. The MRI stressed the importance of regular monitoring.

Cetaceans

Based on assessments conducted by the Scientific Committees of NAMMCO and the IWC, the MRI recommended that annual catches in 2011-2012 do not exceed 154 fin whales and 216 common minke whales on the traditional whaling grounds west of Iceland (West Iceland Small Area) and in the Icelandic continental shelf (CIC) area, respectively.

No fin whales were taken as commercial catch in 2011.

A total of 58 common minke whales were taken as commercial catch in 2011.

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Appendix 1

Table 1. Reported catch statistics for pinnipeds in Icelandic waters in 2010 – Revised data including both direct catches and by-catch.

Species	**Year**	**Stock area**	**Catch pups**	**Catch adults**	**Catch total**[34]
Grey seal	2010	Coastal Iceland	98	0	147
Harbour seal	2010	Coastal Iceland	66	1	190
Harp seal	2010	Coastal Iceland			35
Hooded seal	2010	Coastal Iceland			1
Bearded seal	2010	Coastal Iceland			1
Unidentified	2010	Coastal Iceland			7

Table 2. Reported catch statistics for pinnipeds in Icelandic waters in 2011 – Direct catches.

Species	**Year**	**Stock area**	**Catch pups**	**Catch adults**	**Catch total**
Grey seal	2011	Coastal Iceland	104		104
Harbour seal	2011	Coastal Iceland	50	18	68

Table 3. Catch statistics for cetaceans in Icelandic waters in 2011 – Direct catches.

Species	**Year**	**Stock area**	**Catch total**
Common minke whales	2011	Sub-area CIC - Iceland Continental shelf	58

[34] Including animals of unknown age

Table 4. Reported by-catch of pinnipeds in Icelandic waters in 2011.

Species	**Year**	**Stock area**	**Fishery gear**	**Catch pups**	**Catch adults**	**Catch total**[35]
Grey seal	2011	Coastal Iceland	Lumpsucker net			6
Harbour seal	2011	Coastal Iceland	Lumpsucker net			15
Bearded seal	2011	Coastal Iceland	Lumpsucker net			1
Unknown species	2011	Coastal Iceland	Lumpsucker net			188

Table 5. Reported by-catch of cetaceans in Icelandic waters in 2010 and 2011.

Species	**Year**	**Stock area**	**Fishery gear**	**Catch**	**Notes**
Harbour porpoise	2010	Coastal Iceland	Gillnet	50	MRI survey
Harbour porpoise	2010	Coastal Iceland	Gillnet	4	Log books
Harbour porpoise	2010	Coastal Iceland	Lumpsucker net	65	Log books
Harbour porpoise	**2010**	**Total**		**119**	
Harbour porpoise	2011	Coastal Iceland	Gillnet	28	MRI survey
Harbour porpoise	2011	Coastal Iceland	Gillnet	6	Log books
Harbour porpoise	2011	Coastal Iceland	Lumpsucker net	142	Log books
Harbour porpoise	2011	Coastal Iceland	Anglerfish net	1	Log books
Harbour porpoise	**2011**	**Total**		**177**	

[35] Including animals of unknown age

4.4
NORWAY - PROGRESS REPORT ON MARINE MAMMALS 2011

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1. INTRODUCTION

This report summarises the Norwegian research on pinnipeds and ceatceans conducted in 2011. The research was conducted at, or by representatives and associated groups of, the Institute of Marine Research (IMR), the Norwegian Polar Institute (NP), the University of Oslo/Natural History Museum (NHM), Laboratory for Environmental Toxicology, the Norwegian School of Veterinary Science/National Veterinary Institute (NVH/VI), the Norwegian Defence Research Establishment (FFI), the University of Tromsø/ Department of Arctic and Marine Biology (UIT-AMB), the Norwegian School of Veterinary Science/ Section of Arctic Veterinary Medicine (NVH-SAV), the University of Oslo/Centre for Ecological and Evolutionary Synthesis (CEES), the National Institute of Nutrition and Seafood Research (NIFES).

2. RESEARCH 2011

2.1 Species/Stocks studied

Pinnipeds

- Harp seals *Phoca groenlandica* **-** Greenland and Barents Seas
- Hooded seals *Cystophora cristata* **-** Greenland Sea
- Harbour seals *Phoca vitulina* **-** Norwegian coastal waters
- Grey seals *Halichoerus grypus* – Norwegian coastal waters
- Ringed seal *Phoca hispida* – Svalbard
- Bearded seal *Erignathus barbatus* – Greenland Sea
- Walruses *Odobenus rosmarus* – Svalbard
- Ross seals *Ommatophoca rossii* – Weddell Sea, Antarctica
- Antarctic fur seal *Arctocephalus gazella* – Bird and Bouvet Island, Antarctica
- Crabeater seals *Lobodon carcinophagus* – Weddell Sea, Antarctica
- Southern elephant seals *Mirounga leonine* – South Georgia and Macquarie Island, Antarctica
- Weddell seals *Leptonychotes weddellii* – Weddell Sea, Antarctica

Cetaceans

- Minke whales *Balaenoptera acutorostrata* **-** Northeast Atlantic
- Fin whale *Balaenoptera physalus* – North Atlantic
- Sei whale *Balaenoptera borealis* – North Atlantic
- Bowhead whales *Balaena mysticetus* – North Atlantic
- Beluga whale *Delphinapterus leucas* – Svalbard
- Narwhal *Monodon monoceras* – North Atlantic

- Killer whales *Orcinus orca* – North Atlantic
- Sperm whales *Physeter macrocephalus* – North Atlantic
- Long-finned pilot whales *Globicephala melas* – North Atlantic
- Harbour porpoise *Phocoena phocoena* – West Greenland, Maniistoq.

2.2 Field Work

Pinnipeds

Biological material to establish health, reproductive and nutritive status was collected from **harp seals** in the southeastern Barents Sea (collected on board a Norwegian sealer) (IMR).

Abundance estimation using aerial photographic surveys was performed for **harbour seals** in southern and western Norway in August (*i.e.*, the moulting period, methodology based on total counts) (IMR).

Ecological studies of **harbour and grey seals** were carried out in Finnmark, North Norway, in September (IMR).

Material to assess demographic parameters (teeth, measurements) and population structures (tissues for genetic analyses) were collected from the Norwegian **grey** and **harbour seal** hunt (IMR).

Ringed seals (N=11) were equipped with newly developed satellite tags that measure oceanographic data in addition to chlorophyll levels to study space use by these seals in northern parts of Svalbard with special emphasis on use of sea ice outside the breeding season (NP).

Five adult **bearded seals** were equipped with prototypes of satellite tags that measure oceanographic data and report GPS positions via the Argos system in a new study of space use by adult individuals of this species (NP).

Digital cameras taking pictures hourly were deployed on 5 different **walrus** haul-out sites during the period late June- early October to study haul-out behaviour and potential impact of visiting tourists to these sites. In addition an attempt was made to survey the whole Svalbard archipelago for walruses for an updated population estimate. This effort was however cancelled due to poor weather conditions (NP).

Studies of **hooded seals** and **harp seals** from the Greenland Sea stock were conducted during a research cruise with R/V “Jan Mayen” in the Greenland Sea between 19 March and 4 April 2011. Four adult female and 5 newborn hooded seals were culled for collection of brain tissue samples, for continued studies of the mechanisms underlying neuronal tolerance to lack of oxygen (hypoxia) and exposure to reactive oxygen species (ROS) in diving mammals (collaboration with Dr. T. Burmester and Dr. N Czech, Zoologisches Institut und Museum, Universität Hamburg, Germany). A few harp and hooded seal pups were also culled and sampled for a collaborative study concerning thermoregulation in newborn arctic phocid seals, with University of Alaska, Anchorage

(Dr. J.M. Burns). In addition, samples and data were collected for other scientific projects at other Norwegian institutes that report separately (UIT-AMB).

Four weanling **hooded seals** were live-captured and brought to the animal research facilities at Department of Arctic and Marine Biology (AMB) for studies concerning the early development of physiological adaptations to diving (changes in liver iron content in relation to changes in muscle myoglobin levels) (UIT-AMB).

The described field research was combined with teaching of 20 students that participated on the cruise, which represents a mandatory part of the course "Arctic Biology" (BIO-2310) at the University of Tromsø (UIT-AMB).

Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2011 70 pinniped observations were recorded. Of these 49 observations were of **harp seal** groups, 1 **hooded seal** group, 2 **bearded seals**, and 15 **walrus** groups (IMR).

Cetaceans

Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2011 a total of 1422 cetacean observation incidents have been reported. The most frequently observed species were **minke whales** (337 groups), **Lagenorhynchus dolphins** (273), **fin whales** (215), **humpback whales** (199), **killer whales** (73), **harbour porpoises** (45 groups), **blue whales** (38), **sperm whales** (35), **northern bottlenose whales** (22), **long-finned pilot whales** (15), **bottlenose dolphins** (13), **sei whales** (8), **common dolphins** (8 groups) and **white whales** (2) (IMR).

During the traditional whaling season (April-October), body condition data and tissue materials for studies of DNA identity were collected from all **minke whales** taken by vessels participating in the Norwegian small type whaling (IMR).

Biological material to establish nutritive status by analyses of stomach contents and fatty acid composition in blubber profiles, were taken from **minke whales** taken on one of the vessels participating in whaling operations in the Barents Sea and along the coast of Norway in May-June (IMR).

One acoustic recorder listening for **bowhead whales** was deployed autumn 2010 and retrieved autumn 2011 in the Fram Strait. Data will be analyzed for seasonal presence of bowhead whales and also other vocalizing marine mammals (NP, NHM).

During the periods 28 June to 18 July and 26 July to 16 August, sighting surveys were conducted with the chartered vessel M/S *Båragutt* and the institute vessel R/V *Johan Hjort* in the Norwegian Sea from 62°N-73°N between the Jan Mayen area and the Norwegian coast. The area which was covered is the IWC *Small Area EW* which is part of the Medium Management Area E which comprises waters in the northeast Atlantic. This was the fourth year of the six-year program 2008-2013 to cover the northeast

Atlantic to provide a new abundance estimate of **minke whales** every sixth year as part of the management scheme established for this species. A total of 2,822 nautical miles was surveyed with independent double platforms on primary effort and an additional 827 nautical miles with single platform activity in suboptimal conditions. During primary search effort, the number of observations from the primary platform was 69 sightings of **minke whales**. The sighting rate for **minke whales**, which was about 60 % of the 2002 value, was the lowest ever for this area over the surveys conducted since 1995. Sightings of other cetacean species include **sperm whales** (47 primary sightings), **fin whales** (28 primary sightings), **killer whales** (25 primary sightings), **Lagenorhynchus dolphins** (17 primary sightings), **harbour porpoises** (10 primary sightings), **long-finned pilot whales** (6 sightings) and **Northern bottlenose whale** (1 sighting) (IMR).

During 2011 photo IDs have been collected from about 104 **humpback whales** during field work and from incidental sources (IMR). In addition, biopsy samples have been collected from 19 of these whales.

During a cruise with the coastguard vessel K/V *Barentshav* in the period 26 August to 6 September six satellite tags were applied to humpback whales in the Barents Sea. Four of the tags provided position data.

During the period 25 August to 5 October 2011 mapping of whale distributions was conducted in connection with the annual ecosystem surveys in the Barents Sea. Data were collected by dedicated marine mammal observers following a line transect protocol on board the research vessels M/S *Christina E* and R/V *Johan Hjort* (IMR).

2.3 Laboratory work

Pinnipeds

Data on age and body condition and stomach samples from **grey seals** taken for scientific purposes in North Norway are being analysed (IMR, NFH-UIT).

Tissues sampled for stock identity studies of **grey seals** have been analysed using DNA techniques (IMR).

Demographic and reproduction data from **harp seals** taken in commercial catches, and **hooded seals** taken in dedicated surveys, are being analysed (IMR).

Immunohistochemical, biochemical and electrophysiological studies of antioxidant mechanisms and brain energy metabolism were conducted using brain tissue from **hooded seals**, as part of ongoing collaborative studies on the tolerance to hypoxia and to reactive oxygen species in the brain of diving mammals (collaboration between Dr. T. Burmester and Dr. Nicole Czech, Zoologisches Institut und Museum, Universität Hamburg, Germany, and Prof. Lars Folkow at UIT-AMB) (UIT-AMB).

Hooded seal pups are born with mature blood haemoglobin levels (i.e. similar to those of adults), but have much lower levels of myoglobin in their skeletal muscles, compared to adults. However, during their first year of living, muscle myoglobin levels approach those of the adult animals. We have continued to study the dynamics of the early development of muscle myoglobin stores by repeated biopsy sampling on captive hooded seal pups during their first year of living. We have, moreover, investigated whether hypoxic exposure or muscular activity is more important for the early development of myoglobin. Finally, we now also look into the iron metabolism of young animals, to investigate whether the size of bodily iron stores represents a limiting/controlling factor for the production of myoglobin/haemoglobin in early age (UIT-AMB).

We have conducted further studies to assess the ability of **hooded seals** to employ seawater as a source for body water. We have quantified the amount of seawater drunk as a result of a controlled experimental dehydration, and monitored the endocrine responses to dehydration and seawater drinking in five subadult hooded seals. Following 24 hrs of fasting the animals were dehydrated using the diuretic mannitol. They were then given *ad lib* access to seawater for 48 hrs. For the duration of the experiment total body water and the turnover rates of water were estimated by tritiated water injections and subsequently isotope dilution. Plasma parameters such as Na^+, Cl^- were monitored. The amount of seawater drunk by the seals was calculated as the difference between total influx and water influx from respiration and endogenous reserves (UIT-AMB).

It has previously been shown that reindeer extend their visual range into ultraviolet (UV) wavelengths. We have investigated whether this ability also concerns other arctic mammals, and have therefore studied photoreception in the UV-range in **hooded seals**. The study was conducted by illuminating the eyes of five anaesthetized hooded seals with light of various intensities and wavelengths, including UV, while recording the retinal neural responses using electroretinography. This study is a collaboration between the University College of London and UIT-AMB (UIT-AMB).

Hooded seal serum samples have been analysed for the presence of anti-*Brucella* antibodies using an indirect ELISA (iELISA) and several other serological tests for validation of the iELISA. The same iELISA has been used to evaluate the presence of anti-*Brucella* antibodies in **Antarctic fur seal**, **crabeater seals**, **southern elephant seals** and **Weddell seals** (NVH-SAV).

The pathogenicity of *Brucella pinnipedialis* from **hooded seal** has been studied in a large experimental infection of BALB/c mice. The study design allowed exposure of selected groups to PCB 153 in order to evaluate the effect of this persistent organic pollutant on the development of the infection (NVH-SAV).

In vitro infection of different macrophage cell lines with *B. pinnipedialis* from hooded seal has been performed. The ability of the marine *Brucella* spp to enter and multiply intracellulary in murine and human macrophages is evaluated by the use of a gentamicin protection assay. By killing the extracellular bacteria with gentamicin prior to harvesting the cells we are able to determine the number of surviving intracellular *brucellae* at fixed time points by plating serial dilutions of the cell lysate (NVH-SAV).

Validation of the Brucellergene as a diagnostic tool in seals is performed. The Brucellergene is a commercially available allergen used in live animals for the diagnosis of brucellosis. It is recommended by the World Organisation for Animal Health as an official diagnostic test in these animals. The allergen is injected in the skin or in the conjunctiva. In case of exposure to *Brucella* a swelling due to a local allergic reaction would occur at the injection site. The reason for performing this test in seals is that the brucellosis serological tests lack specificity. In order to validate the Brucellergene for seals three **hooded seals** housed at Arctic Biology, University of Tromsø, were injected with killed *B. pinnipedialis* intra-muscularly while two served as non-infected control animals. A month later the Brucellergene was injected both in the hind flippers and in the conjunctiva while the animals were sedated (NVH-SAV).

A direct agglutination test kit (Toxo-Screen DA bioMerieux S.A., Marcy-l'Etoile, France) has been used to evaluate the presence of anti-*Toxoplasma gondii* antibodies in **Antarctic fur seals**, **Weddell seals** and **southern elephant seals** (NVH-SAV)**.**

<u>Cetaceans</u>

Blubber profiles (fatty acids) of **minke whales** taken in the commercial hunt are being analysed and compared with potential prey animals (IMR, UIT).

Tissues sampled for stock identity studies of **minke whales** have been archived and analysed using DNA techniques (IMR).

Databases containing incidental observations of marine mammals have been updated. **Minke whale** catch data for the 2011 season have been computerised and evaluated. The work with cataloguing identification photos of **humpback whales** collected on incidental occasions and during our own surveys in Norwegian and adjacent waters are continuing (IMR).

Biopsy samples of **bowhead whales** from western Greenland are being analyzed using DNA techniques. The findings were partly reported to IWC and partly published in Endangered Species Research (NHM, GINR, DFO).

Biopsy samples from **beluga whales** from Svalbard are being analysed using DNA techniques in order to study population structure (NP, NHM).

A craniometrical study of population structure of **narwhals** in eastern Canada and Greenland has been finished and published in 2012 (NHM, UWash., OKAPI WA, GNI, UCopenh.).

Data from a passive acoustic recorder attached to an NP mooring in the Fram Strait during the period September 2008-September 2009 have been analysed. Preliminary results show that winter whales (bowheads, narwhals and beluga) and summer whales (including **blue** and **fin whales**) were recorded. Of particular interest was the detection of **bowhead whale** song in the Fram Strait throughout much of the winter. Results partly published 2012 (NHM, NP, UWash., NOAA, DFO, ERDC).

Samples from **minke whale**, **fin whale** and **sei whale** have been analysed for the presence of anti-*Brucella* antibodies using an iELISA (NVH-SAV).

2.4 Other studies

Pinnipeds

Data on **harp seal** consumption are being used in multispecies modelling (*e.g.*, GADGET) of the Barents Sea ecosystem (IMR).

Cetaceans

Data on **minke whale** consumption are being used in multispecies modelling (*e.g.*, GADGET) of the Barents Sea ecosystem (IMR).

2.5 Research results

Pinnipeds

In a Norwegian sampling program conducted during April/May in 1992-2011onboard Norwegian sealers operating in the southeastern Barents Sea (the East Ice), body condition data were collected from a large number of juvenile and adult **harp seals**. The data were analyzed to determine if there are some year-to-year variations, in particular if there are some changes after 2003 when the possible decline in recruitment to the stock could have occurred. Also, the functional relationship between harp seals body condition and the biomass of major harp seal prey (krill, capelin, herring, polar cod and cod) have been analyzed using general additive models (GAM). Resource abundance data were taken from published literature or stock assessment reports. Results from the GAM analysis suggest that the body condition of juvenile and adult harp seals varied significantly between years, increasing from 1992 until 2001 and later decreasing towards the lowest body condition in 2011. A significant year effect on pups' body condition was found. Also, there was no difference in body condition between genders. Using available abundance estimates (biomasses) of krill, capelin, polar cod and cod the previous year as predictors suggests significant predator-prey relationships. The body condition of juvenile harp seals was significantly affected by the available biomasses of polar cod, juvenile herring and cod. Herring and cod had a linear negative impact on the body condition, i.e., the body condition declined linearly with increasing biomass of herring and cod, whereas the relationship between polar cod biomass and seal condition was positive until the biomass of polar cod reached a certain level after which the effect was negative. The predator-prey relationship for adult seals differed from that of the juveniles; increasing biomass of capelin, polar cod, and cod had a significant negative impact on the body condition of adult seals, whereas krill had a positive impact on the body condition. The condition declined and increased linearly with increasing biomass of polar cod and krill, respectively, whereas for cod and capelin the decline flattened out beyond a certain biomass threshold. Also, the functional relationship between the body condition of adult females and pups was analyzed and the results indicate a positive relationship, i.e., poor body condition of pregnant females result in poor body condition of pups (IMR).

Historical Norwegian, Russian and Canadian data which describe the trends in fertility rate and maturity at average age (MAM) for **hooded seals** in the Greenland Sea as well as in the Northwest Atlantic have recently been subjected to joint analyses. For Northwest Atlantic hooded seals, estimates of mean age at primiparity (*i.e*., first birth) was observed to have increased from 4.2-4.5 years in 1956-78 to 6.1 years in 1989-95. Simultaneously, pregnancy rates showed a significant drop from 91-98 % in 1967-87 to 79-74% in 1989. Thus, not all mature hooded seal females produce offspring each year, and this seems to apply to all age groups. There is no evidence neither of absence nor reduction in the fertility of older females. For the Greenland Sea stock of hooded seals, data on fertility rate and maturity are from 1958-2010. Based on new reproductive samples collected in moulting patches off Northeast Greenland in July 2008 and July 2010, mean age at maturity was estimated at 3.7 (CI=0.4) years, which is considerably lower than the previous estimate of 4.6 years based on Russian moulting patch samples for the period 1990-94 used in previous models. In contrast, proportion based estimates of mean age at primiparity (MAP(P)) were similar for the 2008-10 and the 1991-94 data sets (5.5 years and 5.8 years, respectively) and a common MAP(P) of 5.7 years could be fitted. There were also no indications of consistent trends in frequency based estimates of mean age at primiparity based on both moulting and breeding patch data collected over the period 1958-2010. The most recent estimate of MAM(P) is based on samples collected in July and it is likely that the low estimate of MAM(P) is due to late ovulations in nulliparous females. A similar pattern has been found for Northwest Atlantic hooded seals, which also indicate that these late ovulations do not appear to result in successful pregnancies. Therefore, parity curves may be more appropriate for modeling of hooded seal population dynamics than maturity curves (IMR).

Grey seal pup production was surveyed along the Norwegian coast in 2006-2008 and resulted in a total minimum estimate of about 1,270 grey seal pups. Total population estimates of approximately 5,100-6,000 one year and older (1+) grey seals were derived from the recorded number of pups born by estimating a range of multipliers (4.0-4.7). The results show an increase in the pup production from the Lofoten area and north to Finnmark county but a reduction in the number of pups born in Sør-Trøndelag county. Results from grey seal populations modeling based on pup production estimates and information on life history parameters show that the highest multiplier (4.7) fits well with the modeled population size. The total modeled population (including pups) was 7,875 (6,628 – 9,121) animals in 2010. Overall the total number of grey seals in Norwegian waters has increased by approximately 6.5% annually before 2005, since then the annual increase has been 3.2% (IMR).

Harbour seals have been counted along Norwegian coast during moult (August) in 1996-1999 and 2003-2006. Almost all known moulting areas from Finnmark to Vestfold counties were covered by aerial photo surveys during low tide (± 2 hours). In some sub-areas, two or three independent surveys were conducted. Additionally, visual counts from small boats and islands were carried out in some selected areas. The surveys revealed a total minimum population of about 7,500 and 6,700 harbour seals in 1996-1999 and 2004-2006, respectively, in coastal Norwegian waters. The results suggest an annual reduction by 1-2% between the two periods. In some areas the numbers have been reduced by about 50%. Increased anthropogenic removals, and the phocine distemper virus (PDV) epidemic in the Skagerrak region in 2002, might have both contributed to the observed population decline. New boat based counting surveys started in 2009 in Finnmark. Countings were carried out in the inner parts of

Sognefjorden, in Lysefjorden, Rogaland and along the western Skagerrak coast in 2010. In 2011, aerial photographic surveys were carried out along the southwest Norwegian coast. Photo analyses are in progress and results will be available during 2012 (IMR).

EPIGRAPH (2008-2011) is an ecological project in the Porsangerfjord and Hardangerfjord, which includes a study on the ecological role of **harbour seals** in the Porsangerfjord. In September-October 2009 and 2010, 6 harbour seals each year were equipped with GPS phone tags. Harbour seal scat samples were collected in autumn 2009 and 2010, and are in course of analysis. Scat sampling was unsuccessful during 2011 but will continue through 2012. The same is true for the tagging experiment in 2011, therefore 10 new tags will be deployed on harbour seals in 2012. Data from the seal tags, diet studies and estimates of fish resources carried out in the project will be used to evaluate the ecological role of harbour seals in the area. Preliminary results from the analysis of individual movements showed that harbour seals habitat usage in the Porsangerfjord is limited to a restricted area, the inner part of the fjord, with very few registered trips to the outer areas. Preliminary analysis of the scat contents showed the presence of otoliths of a large number of fish species, particularly from the families Gadidae, Cottidae and Stichaeidae, but also with representatives from Pleuronectidae, Cyclopteridae and Zoarcidae (IMR, UIT).

Studies of some antioxidant enzymes (superoxide dismutase, glutathione peroxidise, catalase) in the brain of **hooded seals** suggests that the antioxidant capacity of the hooded seal brain is higher than in the rat. Also, *in vitro* studies of brain energy metabolism, by use of cerebral and cerebellar brain slices, suggest that brain substrate use (glucose, lactate, pyruvate) in hooded seals differs from that typically seen in non-diving mammals, in a way that conveys enhanced hypoxia tolerance to the seal brain (Universität Hamburg, UIT-AMB).

We have previously reported that the fairly low levels of myoglobin that are found in the skeletal muscles of neonate **hooded seals** display a fairly rapid increase during the first few weeks of living, and then level off before a new, slower increase is seen. We have followed up these studies by continued measurements of myoglobin levels in the same animals until they reached one year of age, and confirmed that there was only minor further increase in myoglobin levels during the second half of their first year of life. We moreover compared levels of myoglobin observed in our laboratory-based study with those of newborn and older (wild) animals that were captured in the Greenland Sea in 2011, to find that a) myoglobin levels appear to display quite large variations (from year to year?) within the same age group and b) that wild animals typically display higher levels than captive animals of similar age. We are currently analysing liver iron contents of animals of various ages to elucidate the dependence of changes in haemoglobin/myoglobin levels on the size of liver-based iron stores (UIT-AMB).

Studies based on satellite-tracking show that **hooded seals** spend many months at the time in the open water, where they have no access to fresh water. To investigate to what extent seawater drinking contributes to maintenance of water balance, we performed controlled experimental dehydration followed by *ad lib* access to seawater for 48 hrs in five subadult hooded seals. For the duration of the experiment total body water and the turnover rates of water was estimated by tritiated water injections and subsequently isotope dilution. All seals maintained relatively stable plasma concentrations of Na^+, Cl^- for the duration of the experiment, while urinary excretion of Na^+ and Cl^- increased. Plasma osmolality and hematocrit values also indicated seawater intake. The amount of seawater drunk by the seals was estimated, based on the difference between total influx and water influx from respiration and endogenous reserves, to ~1900 ml per day, on average (UIT-AMB).

Electroretinography studies of UV-vision in anaesthetized hooded seals show that low-intensity UV light elicits neuronal responses in their retina, suggesting that they can, in fact, exploit UV-radiation for vision. The functional significance of this ability will be discussed in a publication that will be prepared as soon as detailed analyses of the collected data material have been completed (University College of London, UIT-AMB).

Antibodies against *Brucella spp.* were detected in **hooded seals**, **harp seals**, **Weddell seals**, **Ross seals**, **crabeater seals** and **southern elephant seals**. Especially high seroprevalence was detected in hooded seals and weddell seals. Although the zoonotic potential of marine mammal brucellae is largely unexplored, reports of human disease exist. Studies of the mechanisms of bacterial intracellular invasion and multiplication involving the marine mammal *Brucella* spp. are however scarce. The *in vitro* infection of macrophages showed that the hooded seal strains of *Brucella* were able to enter all macrophage cell lines tested, including the human macrophage-like cells, but were not able to multiply. These findings raise questions regarding the pathogenicity and the zoonotic potential of the hooded seal strains of *Brucella*. The experimental infection of mice with *B. pinnipedialis* from hooded seal showed that the strain was able to establish an infection but the infection was not sustained longer than three weeks. The results indicate a lower pathogenicity than in some of the terrestrial strains, but still ability to establish an infection. PCB 153 did not alter the bacterial load in the mice, the immunological parameters have not yet been analysed. The experimental injection of inactivated *B. pinnipedialis* in hooded seals with the following use of the Brucellergene showed that the Brucellergene is not suited for diagnostic purposes in hooded seals. Further analysis of the material is being performed (NVH-SAV).

The results for the *T. gondii* serology suggest that the **Antarctic fur seals** have not been exposed to *T. gondii*. Conversely the titration curves suggested that the **Weddell seals** and the **southern elephant seals** have been exposed to *T. gondii* (NVH-SAV).

Cetaceans

To try and develop a simpler way of describing **minke whale** diets (as compared with stomach sampling), the predator-prey relationship with respect to fatty acids was studied in 28 minke whales taken in the 2010 hunt off Vesterålen and in the Svalbard area. The fatty acid composition was determined in the inner and outer sections of the whale blubber – these two sections differed considerably. Fatty acid composition in the inner blubber (assumed to be the most active metabolically) differed between hunting areas (Vesterålen and Svalbard) and between whales with different stomach contents. When fatty acid composition in whale blubber was compared with potential prey species, considerable differences were found. Analyses are still in progres. New samples from minke whales were collected in 2011 – analyses are in progress (IMR, UIT).

The Norwegian **minke whale** DNA register is a data base monitoring commercial harvest and trade of whale products. The register's logistics and specifications have now been reviewed, and the potential to apply similar registers to control the exploitation of other marine species has been evaluated. The application of genetics for the management of natural resources is expanding, and within this field, DNA registers will play an increasing role. The Norwegian minke whale DNA register, established in 1996, was designed primarily as a control system to detect any attempts at illegal trade of products derived from other stocks of minke whale, or other whale species, under cover of the legal Norwegian harvest originating from the Northeast Atlantic. The register contains genetic data for 7,644 of 7,751 whales landed in the period 1997–2010. Profiles are established from sequencing part of the mtDNA control region, analysis of 10 STRs and a sex determining marker. Probabilities of genotypes matching between two randomly selected whales are 6.0^{-04} and 3.0^{-08} for five and eight of the STR loci, respectively. This permits verification of traded whale products via match to the register. The register has also been used in a number of ad hoc scientific studies resulting through the accumulation of genetic, demographic and biological data (IMR).

Antibodies against *Brucella spp.* were detected in **minke whale**, **fin whale** and **sei whale**, from which serum samples were sampled between 1983 and 1997 in the Svalbard area, on the coast of Norway, around the Kola Peninsula and around Iceland (NVH-SAV).

The properties of whale oil compared to fish oil have been investigated in a bioavailability study where 43 adult healthy volunteers were randomized to ingesting whale oil (WO) or fish oil (FO) capsules (n=22 and n=21, respectively) for 6 weeks, both oils providing 0.8 g EPA + DHA daily. Marine omega-3 fatty acid intake was restricted starting two weeks before intervention. The n-3 index increased significantly from mean ± SD of 7.0 ± 1.9 to 8.0 ± 1.1 in WO group and 6.9 ± 1.7 to 8.3 ± 1.5 in FO group respectively, which suggests a lowered risk of cardiovascular diseae (CVD). Urinary F2 isoprostanes were generally low though significantly increased in WO group after 6 weeks, but not compared with FO group. 25 Hydroxy vitamin D levels in serum taken late winter suggests that FO but not WO is a good source of vitamin D. Whale oil seems to be as good an omega-3 source as fish oil, when given in equivalent medium dosage in the present short-term study performed in healthy volunteers with a relatively high baseline omega-3 intake. The study will be presented at Issfal-conference in Canada in May 2012 and will be submitted for publication in an international peer review journal (NIFES).

Results from BFR and PFC analyses of project: ""New" POPs in marine mammals in Nordic Arctic and NE Atlantic areas during three decades", were published in a final report for the Nordic Council of Ministers (NCM): TemaNord 2011:564. Chemical analyses were performed at the MTM Research Center, Örebro, Sweden. Norway contributed with minke whale, harbour porpoise and hooded seal samples.

Pinnipeds and Cetaceans
BFRs: The samples were analysed for BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153, BDE-138 and BDE-183 (Σ10PBDEs). The highest concentrations of Σ10PBDEs were found in toothed whales, including the **pilot whales** (~1,200 ng/g LW), the **white-sided dolphins** (~650 ng/g LW) and the **harbour porpoises** (~250 ng/g LW). BDE-47 was the most abundant congener accounting for 30–75% of the total burden in the different marine mammals. Deca-BDE was analysed in samples of **ringed seal**, pilot whale and **minke whale** (Norway), but was not detected in any samples in levels above the detection limits (range 0.5–3.0 ng/g lipid). The partly naturally occurring methoxylated PBDEs (2PMDBE68, 6MBDE47, 5MBDE47, 4PMBDE49, 5PMBDE100, 4PMBDE103 and 5PMBDE101) were analysed, but only 2PMDBE68 and 6MBDE47 were detected and quantified in every of the samples. Congener 6MBDE47 occurred in higher concentration than 2PMBDE68, with ratios between the congener 6MBDE47 to 2PMBDE68 varying from 2 to 120. Only weak correlation between the PBDEs and methoxylated BDEs was found. The temporal trend analysis of BFRs showed that the levels of Σ10PBDEs increased from the 1980s to the late 1990s, thereafter declined during the first part of the 2000s. This trend was seen in all the marine mammals studied and was significant for the **fin whales** and **white-sided dolphins**. A decline of Σ10PBDEs during the period 2000–2006 was observed in all species and was largest (44%) for the ringed seals from Greenland. However, this decline was very low for the Icelandic fin whale. It is therefore of importance to include this species also in future studies. In addition, selected samples were analysed for other brominated compounds than BDE including HBB, PBT, BTBPE and DBDPE, PBB-153, TBECH and brominated dioxin and furans. All compounds were below the current LOD except for PBB-153 and HBB (NVH/VI).

PCNs: PCNs were found in much lower concentration than the PBDEs but are of concern due to their dioxin-like behaviour and toxicity. The highest concentrations of Σ14PCNs (~4 ng/g LW) were found in **pilot whales**. Differences in PCN-congener patterns were found between the different mammalian species. In general, no consistent temporal trend of decreasing PCNs in recent years was found for the marine mammals. However, in **hooded seals** and **fin whale** significant decreasing trends for Σ14PCNs were observed. For other species, the decrease could be seen for individual congeners only. Concentrations of PCNs in **minke whale** from the Norwegian coast in 1999 were not significantly different from those taken in 1993 (NVH/VI).

PFCs: Unlike other compounds in his study, which were analysed in blubber, PFCs were analysed in livers except for the fin whale samples where muscle tissue was analysed. Eighteen PFCs were analysed, of which PFOS was found in the highest concentrations. The highest PFOS concentrations were found in the **white-sided dolphin** (~110 ng/g WW), followed by similar concentrations in **ringed seal** (NW-Greenland), **hooded seal**, **pilot whale**, **minke whale** (W-Greenland) and **harbour porpoise** (W-Iceland) (~50ng/g WW). The concentrations of PFOS in the **fin whale** muscle samples were very low (0.4 ng/g WW), and for most PFCs close to or below the detection limit. A significant decrease in PFOS was found in **hooded seals** (1990–2007). On the other hand, increasing trends of one or more PFCs were found in samples of ringed seals, in pilot whale, white-sided dolphins and harbour porpoise. For PFUnDA a significantly increasing trend was found for ringed seal, pilot whale and white-sided dolphins indicating that levels of the larger PFCs are still increasing (NVH/VI).

Geographic differences could only be studied in minke whales and harbour porpoises as they were the only species which were sampled at more than one location. The levels of Σ10PBDEs in **minke whales** and **harbour porpoises** were higher in Norway compared to corresponding levels in Iceland and Greenland, but were not significant. The PBDE levels in one of the Norwegian minke whale samples from 1999 was about four times higher than the other samples from that year. This pool was made from animals caught in the North Sea while the other animals were caught along the north Norwegian coast (NVH/VI).

3. ONGOING (CURRENT) RESEARCH

IMR conducted aerial surveys to assess pup production for populations of both **hooded** and **harp seals** in the Greenland Sea in 2007. The results are now published and implemented in the management of both species. Following the request from ICES concerning data rich populations (the most recent abundance estimate should be prepared from surveys and supporting data (*e.g*., birth and mortality estimates) that are no more than 5 years old), new surveys will be conducted in the Greenland Sea in 2012. Harp seals will be the prime target species since this population is still hunted. If possible, however, both species will be surveyed. Hooded seals have been protected since 2007 – to assess the effect of protection on the pup production, more than 5 years are needed due to the usually 4-5 years age at maturity observed in hooded seals (IMR).

Analyses of **hooded seal** reproduction data (historical as well as new, sampled in 2010) from the Greenland Sea are in progress; some of the results were recently submitted (IMR).

Analyses of historical and new data on demography, reproduction and body condition of **harp seals** in the Greenland Sea and Barents Sea / White Sea are in progress. The analyses include new data from 1yr+ animals sampled during the commercial hunt in the East Ice in April 2011 (IMR).

Final analyses of **grey seal** diet data from the Norwegian coast are in progress; a publication will be submitted shortly (IMR).

Genetic and population studies of **harbour** and **grey seals** continue (IMR).

Aerial surveys aimed to obtain a new abundance estimate for **harbour seals** in Norway were conducted in August 2011. The covered area was the southern coast of

Norway up to Trøndelag. Due to financial constraints, the rest of the Norwegian coast will not be covered until 2013-2014 (IMR).

Ecological studies designed to provide data on habitat use, diet and food consumption of **harbour seals** will be continued in North Norway (IMR, UIT).

An additional study on haul out behaviour will be carried out in the summer and autumn of 2012, to compare the **harbour seals** population's haul out patterns in three different fjords in Finnmark (Porsangerfjord, Tanafjord and Kongsfjord). The results of this comparison will be used to refine annual population estimates made by aerial photography of the hauled out harbour seals colonies. Moreover, the haul out data collected in Porsangerfjord will be used to understand how the individual behaviours, registered through the deployed tags, sum up to a collective general pattern at the population level (IMR, UIT).

During the period September-November 2012, ship based registrations of **grey seal** pups, including tagging, counting and staging of pups, will be conducted in Troms and Finnmark – this is the first of a three year program aimed to provide a new abundance estimate for the species along the entire Norwegian coast from Rogaland county in the south to Finnmark county in the north. All known and many other potential whelping areas along the Norwegian coast will be surveyed (IMR).

Behavioral responses of cetaceans to naval sonar have been studied by investigating the hearing sensitivity at different sonar frequencies on **killer**, **sperm** and **long-finned pilot whales**. Data have been obtained by use of Dtags, towed hydrophones and visual observation before and during exposure to sonars at two frequencies (1-2 kHz and 6-7 kHz). Overall, the results indicate little consistent influence of sonar frequency on either the severity of behavioral changes or avoidance response thresholds. (FFI, in cooperation with several international institutes).

Studies of neuronal hypoxia tolerance in diving mammals and studies of the development of oxygen storing capacity in newborn **hooded seals** are continued. (UIT-AMB).

Brucella spp. has been isolated and serologically indicated in several different marine mammals from most of the world. From the circum arctic area *Brucella spp.* has been isolated from a minke whale (*Balaenoptera acutorostrata)* and several hooded seals. There is also serological evidence of the infection in hooded seal (35 %), harp seal (2 %), ringed seal (10 %), minke whales (8 %), fin whales (*Balaenoptera physalus*) (11 %), sei whales (*Balaenoptera borealis*) (14 %) and polar bears (*Ursus maritimus*) (5,4 %). *Brucella* spp. has been isolated from organs in apparently healthy marine mammals, and has also been found in association with a wide range of pathological changes in cetaceans, also in conduction with abortions and lesions in the reproductive organs, indicating that the infection might be affecting the reproductive ability of the marine mammals, like it does in terrestrial animals. The Northeast Atlantic population of hooded seal is now only 10-15 % of what it was in 1946. The situation for the Northwest Atlantic population is very different; the population size has increased since the mid-1980s. Based on the quotas and the number of hunted seals it seems unlikely that the large difference in population development can be due to seal hunting alone. Based on available information, it is not possible to rule out if the high prevalence of *B. pinnipedialis* in the Northeast Atlantic population of hooded seals may be associated to the decline in pup production, an issue which is under investigation (NVH/SAV).

Present studies aim to provide knowledge of the infective capacity of the marine mammal brucellae measured by the ability to invade and replicate in professional phagocytes *in vitro*. Special emphasis is devoted to *Brucella pinnipedialis* strains isolated from hooded seal previously shown not to enter human or murine macrophages in culture. Emphasis is also paid toward examining the intracellular mechanisms involved in the survival or destruction of the invading brucellae (NVH-SAV).

High levels of persistent organic pollutants (POPs) are registered in top predators in the Arctic region. The POPs have a wide spectre of negative effects, for instance; interference with the sex hormones followed by reproductive failure, inadequate immune function, increased risk of tumours and changes in metabolism. We have established an experimental mouse model in which mice are exposed to POPs and infected with *B. pinnipedialis* in order to model the POPs potential effect on development of disease. We evaluate the immunologic effect of the exposure by measuring the change in production of cytokines. Evaluation of cytokines is done by gene expression studies (qRT-PCR) and directly by measuring protein expression in serum and spleen cells in culture (BioRad Bio-Plex cytokine assays). This model will make us able to predict whether the exposure to POPs is affecting the seals to such a degree that the outcome of an infection is altered (NVH-SAV).

Datasets have been obtained for 24 different serum chemistry parameters (enzymes, metabolites, minerals) and full protein profile for previously collected samples from **harbour seals** (Svalbard; Norwegian Polar Institute) and **bearded seals** (Polaria + Svalbard; Norwegian Polar Institute). These datasets will be published during 2012.

Cetaceans

The baleen whale (humpback, fin and minke whales) distributions and associations with habitat and prey, as well as other major marine top predators have been investigated using data from the Russian-Norwegian Ecosystem Surveys (Skern-Mauritzen et al. 2011, Skern-Mauritzen et al. submitted). These results suggest that the late summer baleen whale distributions are associated with certain habitats rather than the distribution of specific prey species. The baleen whales have predominantly occupied shallow banks along and north of the polar front, independent of changing distribution and abundance of one of the main prey species, the capelin. A plausible explanation is that the whales are diet generalists, and feeding on a variety of prey species within their preferred habitats. Furthermore, the pelagic top predators (*i.e.*, seabirds, whales, cod) are in this season confined to species specific niches that are geographically more narrow than that of their prey species. In the summer season when summer migrants inhabit the Barents Sea, there is a plethora of top predator species foraging on more or less the same prey (*e.g.*, a few species of pelagic fish, krill and amphipods). The top predators may be confined to their narrow niches due to interspecific competition and/or a high functional diversity among predators increasing the diversity of optimal foraging habitat among the top predators. Also the white-beaked dolphins have a rather narrow niche in this system. Based on data from the same survey, a master project demonstrated that, contrary to our expectations, these dolphins were more associated with blue whiting than with capelin in this system (Fall 2011). However, in the later years, when blue whiting abundance in the Barents Sea has been reduced, and the capelin abundance has been high, the white-beaked dolphin distributions have shifted from the southern Barents Sea and frontal areas, to mainly occupy frontal areas. This shift has increased the spatial overlap with capelin, but their spatial associations still remains limited possibly due to divergent habitat requirements. This work will be submitted for publication this spring. To further explore whale spatial responses to changes in ocean climate and abundance and distribution of prey species we will combine sighting survey data and ecosystem survey data from the Norwegian and Barents Seas. In this study, we can test if there is e.g. potential common responses (e.g., northward distribution shifts) to a warmer ocean climate between the ecosystems, or if prey abundance in one ecosystem may shift whale distributions into neighboring ecosystems (IMR).

In the ENAC project, funded by NFR, we have started to estimate the consumption **by marine mammals** in the North-East Atlantic and the Barents Sea. Although such calculations are associated with large and unquantifiable uncertainties it is a useful approach for assessing the implementation of whale consumption in models that are and will be implemented for the Nordic and Barents Seas, such as the Atlantic end-to-end ecosystem model and the Norwecom individual based model-complex. These calculations, and the models, when established, will be used to assess the sensitivity to the different parameters used, the potential role of marine mammals in top-down trophic control in these ecosystems (currently and prior to the intense whaling periods), as well as to assess potential effects of different management regimes on whales (IMR).

Multispecies modelling: The need to boost multispecies modelling on the interrelationship between **marine mammals** and fish is acknowledged, and effort to achieve funding for this is ongoing. A group consisting of researchers from Iceland, Faroe Islands, Canada, South Africa and Norway has been formed, administered by Anna Kristin Danielsdottir and Cecilia Elisabeth Klitgaard Kvaavik at Matis, Iceland, and had some funding in 2011 (from the Nordic Council of Ministers) for collaboration and writing applications. In 2011, the group sent two applications, one to NORA (Nordic Council of Ministers, Nordic Atlantic Co-operation) and one to EU (FP7 Environment Research). The core of the project is to apply four different modelling approaches to the same ecosystems, using the same data sets. The four approaches are: 1) Minimal realistic model implemented using GADGET (Prof. Gunnar Stefánsson, University of Iceland, Iceland), 2) Ecopath with Ecosim (Dr. Lyne Morissette, Université du Québec à Rimouski, Canada), 3) Time Series Regression (Prof. Nils Chr. Stenseth and Dr. Dag Ø. Hjermann, Centre for Ecological and Evolutionary Synthesis, University of Oslo, Norway), and 4) Bioenergetic-allometric

Modelling (Dr. Garry Stenson and Dr. Mariano Koen-Alonso, Canadian Department of Fisheries and Oceans, Canada; and Dr. Ulf Lindstrøm, Norwegian Institute of Marine Research, Tromsø, Norway). For the NORA project, two ecosystems were picked: the Barents Sea and Icelandic waters. In addition, the EU proposal had a large number of partners (altogether 27 partner institutions in 12 countries). Lars Walløe (UiO) and Doug Butterworth (Univ. of Cape Town) acted as project coordinators for the NORA proposal, while Gunnar Stefansson was coordinator for the EU proposal. Both NAMMCO and several sea mammal experts were involved, such as Gisli Vikingsson and Bjarni Mikkelsen (as well as the already mentioned Garry Stenson and Lars Walløe). Both applications were turned down (however, the group has again applied to NORA in 2012). The interrelationship between sea mammals and fish is also an aspect of the modelling part of the ADMAR project (Adaptive Management of Marine Resources; leader: Olav Sigurd Kjesbu), a joint project between IMR-Bergen and the Centre for Ecological and Evolutionary Synthesis, University of Oslo, but there is so far no concrete results on this aspect of the project (CEES, IMR).

Abundance data collected during recent sightings surveys on large whales and odontocetes are being analysed with respect to trend information and the use of whale sightings collected during ecosystem surveys are under evaluation (IMR).

Local abundance, migration and habitat use of **humpback whales** in the Barents Sea are studied based on photo ID (IMR).

4. CATCH DATA

4.1 Pinnipeds

Sealing

Norwegian catches in the Greenland Sea in 2011 was taken by 4 vessels, whereas no Russian seal vessels participated in the area. Due to the uncertain status for Greenland Sea hooded seals, no animals of the species were permitted taken in the ordinary hunt operations in 2011. Only some animals were taken for scientific purposes. The 2011 TAC for harp seals in the Greenland Sea was set at 42 400 1+ animals (where 2 pups balance one 1+ animal), i.e. the removal level that would reduce the population with 30% over the next 10 year period.

A possible reduction in harp seal pup production in the White Sea may have prevailed after 2003. Due to concern over this, ICES recommended that removals be restricted to 30,062 animals in the White and Barents Sea in 2011. The Joint Norwegian-Russian Fisheries Commission has followed this request and allocated 7 000 seals of this TAC to Norway.

Table 4.1 shows the Norwegian catches of harp and hooded seals in 2011. The total quotas given were not fulfilled in any area: In the West Ice, 24% of the harp seal quota was taken. Russian sealing in 2011 was planned to be continued using the new boat-based approach introduced in the White Sea catch in 2008. This catch, using ice class vessels fitted with small catcher boats, would focus primarily on weaned pups (beaters), to a much less extent on adult seals. No white-coats would be taken.

However, as was also the case in 2009 and 2010, Russian authorities implemented a ban of all White Sea pup catches. Despite considerable effort from PINRO specialists to explain that a sustainable harvest from the population would be perfectly possible, the Russian authorities concluded that all pup catches in the White Sea should be banned in 2011. Due to this, there were no Russian harp seal catches in the White Sea in 2011. One Norwegian vessel made an attempt to conduct hunting in the southeastern Barents Sea in 2011 – however, due to late start (departure from Tromsø on 20 April) there were very little ice left in the traditional hunting areas in the East Ice and only 200 1+ animals were taken

Table 4.1 Norwegian catches of harp and hooded seals in 2011. 1+ means one year old or older seals.

Catching area:	***The West Ice (Greenland Sea)***			***East Ice (White Sea)***		
Species \ Age group	Pups	1+	Total	Pups	1+	Total
Harp seals	5,361	4,773	10,134	0	200	200
Hooded seals	15	4	19	na	na	na

4.2 Cetaceans

<u>Whaling</u>

After a temporary suspension, the traditional small type Norwegian **minke whaling** was again permitted in 1993 and quotas were implemented based on the Revised Management Procedure (RMP) developed by the International Whaling Commission's (IWC) Scientific Committee. The RMP allocates catch quotas to specific management areas. There are five such management areas within the region of interest to Norwegian whalers. The present areas are a revision of the original implementation and introduced by the IWC/SC at their Implementation Review of North Atlantic minke whales conducted at the 2003 Annual Meeting and later kept at the Implementation Review made in 2008. The areas are (1) the Svalbard-Bear Island area (coded ES), (2) the eastern Barents Sea (EB), (3) the Norwegian Sea and coastal zones off North Norway, including the Lofoten area (EW), (4) the North Sea (EN) and (5) the western Norwegian Sea-Jan Mayen area (CM).

In total, 19 vessels participated in the 2011 season of whaling and the catching period was 1 April to 31 August. Table 4.2 shows the number of minke whales taken by area in the 2011 season. The quotas are given as 5-year block quotas but is not fully utilised in all areas. There are several reasons for that, including problems with processing the catches and accessing remote areas like the Jan Mayen area and the eastern Barents Sea. The present 5-year quota period started in 2009 and is given as annual basic quotas of 885 animals within Medium Area E and 135 whales within the Small Area CM.

Table 4.2 Quotas and catches of minke whales in 2011 by management area as defined in RMP.

2011	**Management area**					
Small-type whaling	EB	EN	ES	EW	CM	Total
Catch	100	14	201	218	0	**533**
Quota	1016				270	1286

5. BY-CATCH DATA

Harbour porpoises are caught in gillnets in the coastal fisheries. To estimate the total by-catch of harbour porpoises in fisheries for cod and angler fish along the coast, we have used data collected by contracted small vessels in the Coastal Reference Fleet (CRF) which use the same nets as the commercial coastal fleet. Estimated porpoise catch rates relative to catches of cod and angler fish in the CRF are being used to extrapolate to the entire commercial coastal fleet based on their total catches of cod and angler fish. Furthermore, detailed information from the CRF about the fishing operation allowed us to identify influential factors potentially relevant as mitigation factors. Such factors include bottom depth were nets were set, net soaking times and geographic and seasonal variation in by-catch rates. This work will be finalized during spring 2012 and thereafter submitted for publication.

6. ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

Sealing

Advice on the management of harp and hooded seals is based on deliberations in the ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP). WGHARP met during 15-19 August 2011 at the British Sea Mammal Research Unit (SMRU) at the Scottish Oceanographic Institute, University of St. Andrews, Scotland, to assess the status and harvest potential of stocks of Greenland Sea harp and hooded seals and harp seals in the White Sea. The advice given by ICES in September 2011, based on the 2011 WGHARP meeting, were used by the Joint Norwegian-Russian Fisheries Commission to establish management advice for 2012.

The basis for the advice was a request from Norway in September 2010 where ICES was requested to assess the status and harvest potential of harp seal stocks in the Greenland Sea and White Sea/Barents Sea and of the hooded seal stocks in the Greenland Sea, and to assess the impact on the harp seal stocks in the Greenland Sea and the White Sea/Barents Sea of an annual harvest of: 1) Current harvest levels; 2) Sustainable catches (defined as the fixed annual catches that stabilizes the future 1+ population); 3) Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability.

ICES have developed a Precautionary harvest strategy for the management of harp and hooded seals. The strategy includes two precautionary and one conservation (limit) reference levels. The reference levels relate to the pristine population size, which is the population that would be present on average in the absence of exploitation, or a proxy of the pristine population (which in practical terms is referred to as the maximum population size historically observed, N_{max}). A conservation, or lower limit reference point, N_{lim}, identifies the lowest population size which should be avoided with high probability. The first precautionary reference level is established at 70% (N_{70}) of N_{max}.When the population is between N_{70} and N_{max}, harvest levels may be decided that stabilise, reduce or increase the population, so long as the population remains above the N_{70} level. ICES has suggested that this could be done by designing the TAC to satisfy a specific risk criterion which implicate 80% probability of remaining above N_{70} over a 10-year period. When a population falls below the N_{70} level, conservation objectives are required to allow the population to recover to above the precautionary (N_{70}) reference level. N_{50} is a second precautionary reference point where more strict control rules must be implemented, whereas the N_{lim} reference point (set by ICES at 30% (N_{30}) of N_{max}) is the ultimate limit point at which all harvest must be stopped.

The ICES management of harp and hooded seals require that the populations in question are defined as "data rich". Data rich stocks should have data available for estimating abundance where a time series of at least three abundance estimates should be available spanning a period of 10-15 years with surveys separated by 2-5 years, the most recent abundance estimates should be prepared from surveys and supporting data (*e.g.*, birth and mortality estimates) that are no more than 5 years old. Stocks whose abundance estimates do not meet all these criteria are considered "data poor", and should be managed more conservatively.

Population assessments were based on a population model that estimates the current total population size, incorporating historical catch data, estimates of pup production and historical values of reproductive rates. Modifying the model by incorporating the full range of reproductive data available, as requested by ICES in 2009, gave lower, but more realistic, population estimates and catch options than in the previous modelling. The modelled abundance is projected into the future to provide a future population size for which statistical uncertainty is provided for various sets of catch options. In case of data poor populations, catch limits are estimated using the more conservative Potential Biological Removal (PBR) approach.

Using the modified population assessment model, the size of the **Greenland Sea harp seal** population was estimated at 649,570 (95% C.I. 379,031 – 920,101) animals in 2011. ICES consider this population to be data rich, and above the N_{70} level (i.e., more than 70% of known maximum abundance measured). Thus, it is appropriate to provide catch advice using the assessment model and to apply the Precautionary harvest strategy. Current catch level will likely result in an increase in population size of 23% over the 10 years period 2011-2021, whereas a catch of 16,737 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), per year would sustain the population at present level over the same period. Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability are 25,000 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2012 and subsequent years. Any allowable catch should be contingent on an adequate monitoring scheme to detect adverse impacts before it is too late for them to be reversed, particularly if the TAC is set at a level where a decline is expected.

Recent Russian aerial surveys of the **White Sea/Barents Sea harp** seal stock suggest that there may have been a drop in pup production of since 2003. As a result of the 2009 and 2010 surveys, ICES have suggested that the reduced pup production observed since 2004 does not appear to be a result of poor survey timing, poor counting of imagery, isappearance/mortality of pups prior to the survey or increased adult mortality. The most likely explanation for the change in pup production seems to be a decline in the reproductive state of females.

Although the modified population model used for the White Sea/Barents Sea harp seal population provided a poor fit to the pup production survey data, it was assumed by ICES to provide a reasonable future prediction, and estimated the current total size of the population to be 1,364,700 (95% C.I. 1,230,384 – 1,498,916) seals. Based on current data availability, the Barents Sea / White Sea harp seal population is considered to be data rich, and above the N_{70} level by ICES. Thus, it is appropriate to provide catch advice using the modified assessment model and to apply the Precautionary harvest strategy. Current catch level will likely result in an increase in population size of 11% over the 10 years period 2011-2021, whereas a catch of 15,827 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), per year would sustain the 1+ population at present level over the same period. Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability are 25,000 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2012 and subsequent years.

Results from the most recent (2007) pup survey suggest that current pup production remains low, and significant lower than observed in a comparable 1997 survey. The historical data on pregnancy rates that are available for this population are unreliable. Hence, the population model was run for a range of pregnancy rates, in addition to a run using the original model assuming constant reproduction rates. All model runs indicate a decrease in population abundance from the late 1940s and up to the early 1980s, and gave point estimates for the total population ranging between 85,000 and 106,000 animals, i.e., a population currently well below the N_{lim} of 172,577 (30% of the N_{max} estimate of 575,257). Following the Precautionary harvest strategy and the fact that the population is below N_{lim}, ICES recommend that no harvest be allowed for Greenland Sea hooded seals at this time. Restricted takes for scientific purposes should, however, be allowed.

Traditionally, both Russia and Norway have participated in the sealing operations in the West Ice and the East Ice and have, therefore, allocated quotas on a bilateral basis in negotiations in the Joint Norwegian-Russian Fisheries Commission. However, the Russians cancelled their sealing operations in the West Ice in 2001. The Norwegian shares of the 2012 quotas would be the total TAC of harp seals in the West Ice. In the East Ice, the Norwegian quota was set at 7,000 harp seals.

In 1996 new regulations for the **coastal seal hunt**, including catch reports, were introduced. Quotas were set based on the available information on seal abundance along the coast. In 2003, quotas were increased substantially compared to the recommendations based on scientific advice, when they were set at 1,186 grey seals (25% of abundance estimate) and 949 harbour seals (13% of abundance estimate). In 2003-2010, annual catches varied between 302-516 grey seals and 457-905 harbour seals. In 2010, new management plans for harbour and grey seals were implemented. The goal is to ensure sustainable populations of grey and harbour seals within their natural distribution areas. Regulating measures should be designed to ensure that they have the greatest impact in areas where there is documented significant damage to the fishing industry caused by seals. Target population sizes were decided to be 7,000 harbour seals counted during moult and a grey seal population producing 1,200 pups annually along the Norwegian coast. Hunting quotas should be set in order to regulate the seal populations in relation to the target levels. For 2011, quota for harbour seals was set to 460 and 230 seals were taken. For grey seals recommended quota was 460, set quota was 1040 but only 111 grey seals were taken. Compensations paid for shot seals were stopped for 2011. For 2012, recommended and set quotas were 460 animals of each species. Compensations paid for shot seals were again introduced (250 NOK/seal).

<u>Whaling</u>

At the IWC Annual Meeting in 1992 Norway stated that it intended to reopen the traditional **minke** whaling in 1993. So far, IWC has accepted the RMP developed by its Scientific Committee as a basis for future management decisions but has not implemented the procedure. The Norwegian Government therefore decided to set quotas for the 1993 and following seasons based on RMP, with parameters tuned to the cautious approach level as expressed by the Commission and using the best current abundance estimates as judged by the IWC Scientific Committee. In recent years, research has been conducted on modification and retuning of the procedure to other target levels than the original 0.72, chosen by the Commission.

Starting in 2009, a new 5-year block quota was set with an annual total catch quota of 885 animals of which 750 could be taken within the Northeastern stock area (the E Small Areas, *i.e.* the EW, EN, ES and EB Small Areas) and 135 within the CM area of the Central **minke whale** stock. The catch quotas are set for each of the five management areas, and the whaling within an area is stopped when this quota limit is reached. On the other hand, untaken quotas may be transferred to following years within the time period which the block quota is set for.

For 2012 the total catch quota has been set to 1286 **minke whales**, the same as for 2011. The catching season will be from 1 April to 31 August 2012.

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