3.1
REPORT OF THE SIXTEENTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

1. CHAIRPERSON'S WELCOME AND OPENING REMARKS

Chairperson Desportes welcomed the members of the Scientific Committee (refer to Section 5.4) to their 16th meeting, held at the Marine Research Institute, Reykjavík, Iceland, 19-22 April 2009. She thanked Born (Greenland) for his past contribution to the work of the Scientific Committee (SC) and welcomed his replacement Ugarte as a new member of the SC, regretting that bad weather had prevented him from joining the meeting. She also welcomed the Observers Zabavnikov and Mishin from the Russian Federation, Murase from Japan and Stenson from Canada. She expressed the SC's appreciation than an observer from Canada was again present at the meeting this year.

She commended the flexibility of the Faroese delegation, which accommodated the wish of the Icelandic delegation for holding the meeting in Iceland because of the present economic situation.

She finally mentioned that Walløe unfortunately would not take part in the meeting due to other engagements and regretted that miscommunication had apparently led to this situation. She stressed again that she thinks it is important for the SC's expertise, and therefore the image of NAMMCO, that the already comparatively small SC meets with full capacity every year and that the possibility of sending stand-in members should be fully utilised. She thanked Greenland for having responded positively to her demand in this direction this year when Born communicated that he would not be able to attend the meeting because of fieldwork.

2. ADOPTION OF AGENDA

The Draft Agenda (Appendix 1) was adopted with minor changes.

3. APPOINTMENT OF RAPPORTEUR

Acquarone, Scientific Secretary of NAMMCO was appointed Rapporteur, with the help of Lockyer and members as needed. Members were requested to provide summaries of their presentations to the meeting.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The list of available documents and reports is given in Appendix 2.

4.1 National Progress Reports

National Progress Reports (NPR) for 2008 from the Faroes, Greenland, Iceland and Norway were presented to the SC. In addition, the SC was pleased to receive progress reports from Canada, Japan and the Russian Federation.

The observers from Canada, Japan and the Russian Federation made a short presentation of their NPR, underlining what was relevant to the work of the NAMMCO SC. The SC welcomed these presentations.

Canada

Stenson presented a summary of research activities on marine mammals being carried out in Canada (SC/16/NPR-C). The research described was primarily carried out under the direction of the Centre of Expertise for Marine Mammals (CEMAM) which is comprised of scientists from the Department of Fisheries and Oceans, Canada, working in cooperation with researchers from a variety of Universities (e.g. Memorial, Dalhousie, Laval, Waterloo, Manitoba, Alberta, British Columbia) and international agencies (US National Marine Fisheries Service, Norwegian Institute of Marine Research, Norwegian Polar Institute, Sea Mammal Research Unit, Greenland Institute of Natural Resources, etc.). CEMAM is producing a report of their activities from 2006 to 2008 that will be available soon.

A wide variety of research is being carried out in Canada, involving most of the major species present in the area. Many of these studies address questions on the status and management of marine mammals in the Arctic, Atlantic and Pacific oceans. Other general topics addressed include interactions between human activities and marine mammals (e.g. by-catch, noise production, fisheries interactions), ecological role of marine mammals and habitat use (e.g. migration and distribution), the identification of critical habitat (e.g. physical and biological components), the impact of climate change (e.g. ice related mortality) and disease (e.g. toxic algal blooms, the use of harbour seals as ecosystem indicators). Canadian researchers also are active in the development of and/or use of new technologies to improve the understanding of marine mammals.

Canadian catches are presented in SC/16/NPR-C. Although the commercial quota for harp seals was 275,000 in 2008, catches were less than 220,000 due to poor markets and hunting conditions. Low numbers of grey (1,474), hooded (5), and ringed (51) seals were reported taken although the number of ringed seals is underestimated. Similarly, the catches of walrus (181) and beluga (357) are under-reported. Over 1,000 narwhal were reported caught, although 625 of these were harvested during an ice entrapment. Three bowheads were taken in 2008.

Japan

Research on small cetaceans undertaken in Japan between May 2005 and March 2007 was summarized by Murase and presented in documents SC/16/NPR-J1 and SC/16/NPR-J2. Japan studied 11 species of small cetaceans as well as other rare species. The studies were mainly conducted by the National Research Institute of Far Seas Fisheries. Sixteen systematic shipboard surveys were conducted and sightings of small cetaceans were recorded. Dart tags were attached to striped dolphins to monitor the movement. Data loggers were attached to Baird's beaked whales to record their diving behaviour. Statistics of direct catches, by-catches and stranded animals were summarized in the reports. Various types of biological samples were collected from small cetaceans.

Research on large cetaceans undertaken in Japan between April 2007 and March 2008 was summarized in SC/16/NPR-J3. Japan studied a total of 11 species of large cetaceans. The studies were mainly conducted by the National Research Institute of Far Seas Fisheries, the Institute of Cetacean Research and Tokyo University of Marine Science and Technology. Eight systematic shipboard surveys, including two scientific permit surveys, were conducted from April 2007 to March 2008 and sightings of large cetaceans were recorded. Natural marking data on southern right, blue, Bryde's and humpback whales were recorded. Satellite tags were attached to sei and Bryde's whales and movement of a Bryde's whale was tracked for 13 days. Statistics of scientific permit catches, by-catches and stranded animals were summarized in the report. Biological samples were collected mainly from the scientific permit catches. Various types of researches such as age determination, stock structure, feeding ecology and pollutants were undertaken in the reported period and the results are reported to the IWC/SC and other scientific communities including NAMMCO.

Russian Federation

Zabavnikov presented a summary of research activities on pinnipeds and cetaceans being carried out in by PINRO in 2008 in the Barents and White Seas (SC/16/NPR-C). Information is provided about ongoing research, catch data, advice given and management measures taken, publications and documents. The main species and stocks studied included 6 pinniped and 13 cetacean species.

The main target for the research activities was assessment of harp seal pup production, distribution and abundance. A dedicated multi-spectral aerial survey of harp seal whelping patches was carried out during March 13 – 20, 2008. In addition, biological samples from pups were collected from the harp seal commercial catch.

Sightings of marine mammals were made from the Russian research vessel during the annual Russian-Norwegian ecosystem survey in August-September. During the survey, the whole the Barents Sea area, excluding the far northeastern part between Franz-Jozef Land and Novaya Zemlya Island, was covered. During May-June, coastal zone abundance surveys for pinnipeds and cetaceans were carried out along the Kola Peninsula, and sightings from shore were treated as sightings from a small boat.

In August, dedicated aerial surveys for pinnipeds and cetaceans were conducted in the Barents Sea (area around Shtokman gas and oil field (SGOF) and close to the pipeline from SGOF to Teriberka-bay in Kola Peninsula as well as adjacent areas). Opportunistic vessel observations for pinnipeds and cetaceans were also carried out in the SGOF area in the periods July 26 – August 4 and November 20 – 26.

Discussion by the NAMMCO SC

The SC thanked the observers for their report and agreed that it would be fair in the future that they be warned that they would be asked to present a summary of their NPR.

4.2 Working Group Reports

Reports of three NAMMCO Working Groups (WG) were available at the meeting:

- Joint NAMMCO/JCNB Scientific WG on narwhals and belugas (Annex 1);
- WG on Large Whale Assessment (Annex 2);
- WG on Marine Mammal and Fisheries Interactions - Marine Mammals and Fisheries in the North Atlantic: Estimating consumption and modelling interactions (Annex 3).

In addition two other WG reports were available:

- ICES Study Group for By-catch of Protected Species (SGBYC);
- ICES/NAFO WG on Harp and Hooded Seals (WGHARP).

All these reports were discussed under the relevant agenda items.

4.3 Other reports and documents

Several other reports and documents were presented to the meeting, and were examined under the relevant items.

5. COOPERATION WITH OTHER ORGANISATIONS

5.1 IWC

The 60th meeting of the SC of the International Whaling Commission was held in Santiago, Chile, 1-13 June 2008 and was chaired by Bjørge. Acquarone and Lockyer attended as observers for the NAMMCO SC. Acquarone presented the report (SC/16/04).

Thirteen sub-committees (including Standing Working Groups, SWGs) were established. The number of available sessions for sub-committee deliberations was 84 over a seven-day period, based on three concurrent sub-committee meetings for each of four work sessions per day. In addition this allowed for several *ad hoc* working groups to meet in the evenings. There were 28 national delegations numbering between one and 25 members and 77 invited participants. NAMMCO was one of six observer organisations present at the meeting.

No report on the activities of the NAMMCO SC was submitted by the nominated IWC observer Walløe as the report of the 15th meeting of the NAMMCO SC has to be presented and approved by the Annual NAMMCO Council meeting in September 2008. There has been no NAMMCO Council meeting during the inter-sessional period, so no report was submitted.

Abundance estimates for fin whales for the Icelandic and Faroese survey areas were presented. Total abundance for a combined platform estimate was 21,628 (95% C.I. 15,731-27,739). This estimate was considered most comparable with the 2001 estimate and was preferred instead of a higher, but not significantly different, single platform estimate.

For the minke whales in the northeast Atlantic (Norwegian and Barents Seas) and CM Small Area (Jan Mayen) new estimates were provided, and the Committee agreed that

they could be used for conditioning Implementation Simulation Trials (IST) but not in the RMP until they are finalised. For the North Sea (EN Small Area) the Committee agreed that the SCANS 2005 shipboard (not aerial) survey estimate could be used both for conditioning the Implementation Review and in the RMP. The Committee agreed that the Icelandic coastal estimates from a reanalysis of the 1987 and 2001 aerial surveys were acceptable for use in conditioning IST's and in the RMP. However there was considerable discussion of the estimates of abundance from the T-NASS aerial survey in 2007. The Committee agreed that the abundance estimate based on data from both observers met the requirements for use in conditioning and for use in the RMP. For West Greenland the Committee noted that the Aboriginal Whaling Management Procedure (AWMP) Standing Working Group accepted the 2005 aerial survey estimate and agreed that this estimate was suitable both for conditioning trials and for the RMP. The Committee recommended that the Medium Areas remained unchanged. Walløe proposed to remove the boundary between EW and EB in the Small Areas. The decision was postponed to the next Annual Meeting pending examination of whether there were differences between the 1997-2002 and the 2003-2007 data and whether these could be explained by changes in laboratory procedures.

In the AWMP sub-committee the main issues of interest for NAMMCO were: (1) general considerations on the provision of interim *ad hoc* advice; (2) all aspects of the management of Greenlandic fisheries. In 2007 the Commission agreed on a quota of 200 minke whales struck annually off West Greenland, in part based on the range 170-230 advised by the Committee. Since then considerable progress has been made by the Committee such as (1) an accepted abundance estimate for the 2005 aerial survey of 10,800 (95% CI=3,600-32,400) and (2) development of an assessment method incorporating the available sex ratio data both at the inter-sessional workshop and at the present meeting. Based on this it should be possible to provide management advice at the 2009 Annual Meeting, and later also developing a full SLA to provide long-term advice. In 2007, the Commission agreed to a quota for the next 5 years of 19 fin whales struck annually off West Greenland based on the range 14-26 advised by the Committee. The Committee agreed that the current strike limit will not harm the stock. The abundance estimate on which this calculation was based was the agreed estimate of 4,656 (CV=0.46). In 2007 the Commission agreed to a quota for the next 5 years of two bowhead whales struck annually off West Greenland, but that the quota for each year shall only become operative when the Commission has received advice from the SC that the strikes are unlikely to endanger the stock. This year the Committee agreed that the current catch limit will not harm the stock, even in the light of takes from the same stock by Canada. The Committee agreed as interim management advice that strikes of up to 10 humpback whales for 2008-12 will not harm the stock.

Preliminary results from the Cetacean Offshore Distribution and Abundance project (CODA) were presented and welcomed by the Committee. The preliminary pooled abundance estimates for all the blocks were: 162,266 (CV=0.46) common dolphins; 82,585 (CV=0.54) striped dolphins and 282,749 (CV=0.38) for a combined group of common, striped and striped/common category; 83,441 (CV=0.47) long-finned pilot whales; 86,722 (CV=0.46) for a combined group of long-finned, short-finned and a *Globicephala spp.* category; 19,295 (CV=0.25) bottlenose dolphins; and 9,771

(CV=0.44) beaked whales (including individuals identified as Cuvier's and Sowerby's beaked whales and unidentified beaked whales).

Discussion by the NAMMCO SC

The Committee thanked Acquarone for his report. The SC notes that the IWC Scientific Committee had, in 2008 for the first time, given formal advice on sustainable annual catches for three large cetacean species off West Greenland: fin whale with a catch of 19 whales, humpback whale with a catch up to 10 whales, and bowhead whale with a catch of 2 whales.

5.2 ASCOBANS

There was no official observer at the 15th meeting of the ASCOBANS Advisory Committee (31 March - 3 April 2008, Bonn, Germany). However, Lockyer provided a quick overview of the report received (SC/16/05).

The following is a selection of items considered at the 15th Advisory Committee meeting of ASCOBANS, which are of direct relevance for the work of the NAMMCO SC.

The main items of interest included mention of the inter-sessional working group on acoustic disturbance which would work through email correspondence and present its findings to the next meeting of the AC. Unfortunately this 16th AC was held on the same dates as the 16th NAMMCO SC meeting.

ASCOBANS has an interest in by-catch and reporting, mainly because member countries as members of the EU have by-catch reporting responsibilities. The UK provided an update on by-catch monitoring, adding that they were now applying the Habitats Directive to marine waters out to 200 miles. They mentioned that they had now developed guidelines to help users understand the legal requirements under the Habitat Directive in relation to the disturbance of cetaceans, which were currently subject to a period of public consultation.

The format for reporting of effort in fisheries with high risk of by-catch was a topic for consideration. ACCOBAMS presented its different forms for its triennial reporting system and reported on its plans to move to continuous on-line reporting.

With respect to marine mammal - fisheries interactions, the Swedish Board of Fisheries was trying out fish traps both to reduce seal damage and to replace the net fishery with alternative fishing gear. So far there had been some positive results from the testing of cod traps.

Results of surveys - SCANS II, CODA Project and T-NASS were on the agenda, but there were no interventions from the participants, and the report only referred to the documents supplied (NAMMCO supplied a document on T-NASS) without comment.

Regarding information on pollution, underwater sound and disturbance, the topics of high

speed ferries, acoustic disturbance and military including munitions were discussed.

Although not of scientific relevance, the most important issues discussed were in connection with the agreement itself and its scope.

ASCOBANS had recently agreed a westward extension of the Agreement Area extending the Agreement Area into the Irish Sea and Atlantic. The process was well under way. In addition, a possible inclusion of all cetacean species (thus including all large whales) in the Agreement Area had been considered. Several delegates commented that they saw no problems arising with the IWC in the event of ASCOBANS deciding to cover all cetaceans. The UK had no objection to the extension of species, adding that should ASCOBANS decide to proceed, then the IWC should be formally notified. Sweden, Denmark and Finland however, were presently opposed to the inclusion of all cetacean species under ASCOBANS. France was in favour of including large cetaceans as it seemed that there was no legal opposition and as France was also a Party of ACCOBAMS. Poland was also in favour.

Finally, the experimental merger between CMS and ASCOBANS Secretariats was to be seen in the wider context of ongoing efforts to streamline International Environmental Governance and improve synergies and coordination among Marine Environmental Agreements (MEAs).

Discussion by the NAMMCO SC

There was no NAMMCO observer at this meeting. Lockyer pointed out that there was an existing reciprocal observer agreement between the two organisations, but ASCOBANS had never attended NAMMCO meetings although NAMMCO had attended several ASCOBANS meetings until 2 years ago. Lockyer also pointed out that ASCOBANS did not have a scientific committee as such, and the topics considered by their Advisory Committee were thus often not primarily of a scientific nature. NAMMCO had regularly forwarded reports on NAMMCO activities to ASCOBANS even when not attending, including information on T-NASS and requesting verbal support for this survey in 2007. However, NAMMCO documentation appears to have been ignored or not considered on these occasions, and the Secretariat was disappointed that there had been no reaction. NAMMCO had not forwarded documentation to the AC meeting this year.

The SC thanked Lockyer for her report. The SC expresses disappointment and some frustration at the apparent disinterest of ASCOBANS in what would appear to be a related organisation (NAMMCO), as well as ignoring relevant activities like T-NASS. Despite some fundamental differences in conservation and management approach, there were still a number of issues that could be of mutual interest, where exchange of information would benefit each organisation.

The SC thus concludes that for the moment there seems little point in sending a NAMMCO observer to future meetings.

5.3 ICES and NAFO

Haug reported on the activities of ICES and NAFO in 2008 (SC/16/06). In addition an update on the jointly convened ICES, NAFO and NAMMCO symposium is given under item 6 and the activities of the Study Group on By-Catch are reported under item 7.

ICES WGMME

The ICES Working Group on Marine Mammal Ecology (WGMME) met 25-29 February 2008 in St Andrews, UK. The WG considered a wide range of issues. It was considered that there are currently no reliable long-term time series for abundance (or abundance indices) available for endemic arctic marine mammals. The lack of these data makes it difficult to reliably assess current impacts of changes in climate on these species' populations. WGMME also had to conclude that no current by-catch estimates for marine mammals in the North Sea are available. Furthermore, although required by the EC regulation, data on by-catch of seals are not reported at all. The WG considered the potential effect of by-catch on seals to be substantial. Cetacean conservation objectives and criteria were reviewed and realistic monitoring options considered, including those recommended by the SCANS II project. The WG also discussed new results from the SCANS II project. This project evaluated and developed methods for monitoring trends in abundance of small cetacean species and provided a comparison of cost effectiveness of the different methods. Additionally, a simulation model considering a wide range of parameters and incorporating uncertainties in e.g. abundance estimates was used to tune a specific by-catch management procedure so that one would expect to achieve the conservation objective in practice. The results of the SCANS II work also showed that uncertainties within abundance estimates need to be considered when assessing by-catch of marine mammals in a reliable way. In addition, there should be focus particularly on the Saimaa and Ladoga ringed seals, and the WG also discussed how data collected in different countries could be brought together in common databases.

ICES WGHARP

The ICES-NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 27 - 30 August 2008 in Tromsø, Norway, to consider recent research and to provide catch advice on the North Atlantic stocks of harp and hooded seals. The WG received presentations related to stock identity and distribution, catch (mortality) estimates, abundance estimates, biological parameters, and ecological relationships of Greenland Sea and White Sea/Barents Sea harp seal stocks, and provided catch options in response to a request from Norway. WGHARP also received information on the Northwest Atlantic harp seal stock. Furthermore, the WG reviewed data available on Greenland Sea hooded seals (providing catch options for this stock) and Northwest Atlantic hooded seals. Finally, WGHARP evaluated a proposed Norwegian management strategy with respect to the precautionary principle for harp and hooded seals, using Greenland Sea harp seals as model stock.

Further reporting of this activity is under items 8.1 and 8.2.

ICES ASC

The 2008 ICES Annual Science Conference (ASC) was held in Halifax, Nova Scotia, Canada, 22-26 September 2008. Several ICES committees (e.g., Living Resource Committee and Marine Habitat Committee) deal with marine mammal issues. Thus, both present and future theme sessions at the ASC are designed with marine mammals included as an integral part. Relevant sessions at the 2008 ASC were:
Theme session B ("The role of sea ice in polar ecosystems"): Presentations focused on how changed ice conditions may have influenced distribution and migrations of minke whales and killer whales; the influence of changed ice quality on ice breeding seals such as ringed and harp seals was also assessed.
In theme session C ("Mid-ocean ridges and seamounts: oceanography, ecology, and exploitation"), results were presented on the seasonal distribution of sperm whales. Theme session D addressed the issue "New trends in diseases of marine organisms: causes and effects", and included presentations with studies of seals and harbour porpoises. In theme session E ("Marine spatial planning in support of integrated management – tools, methods and approaches"), the question of how to keep vulnerable mammals away from fishing grounds was raised. Theme session J ("Comparative dynamics of populations in the Baltic Sea and Gulf of St Lawrence ecosystems") included presentations with ecological studies of blue whales and grey seals.
Of particular relevance was theme session P ("New methodology for tracking fish, mammal, and seabird behaviour and migrations") where both case studies and new methodology were presented.

Upcoming theme sessions, relevant to marine mammal issues, intended for the ASC, 21-25 September 2009 in Berlin, Germany, include issues such as ecosystem research, climate impact and by-catches.

Discussion by the NAMMCO SC
The Committee thanked Haug for the report. The SC discussed the recommendation from ICES WGMME that a database be created on harbour and grey seal population indices for the ICES area. Questions were raised as for what this database was intended.

5.4 Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga

Witting reported that there have been no meetings of the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) in 2006-2008. Following the meeting of the Joint JCNB/NAMMCO Working Group on narwhals and belugas in February this year (see under items 9.5 and 9.6), a meeting of the Commission is planned later in 2009.

6. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

6.1 Update on the ICES, NAFO and NAMMCO symposium (Dartmouth, Nova Scotia, September 29 – October 1, 2008)

Haug and Lockyer reported on the symposium (SC/16/06 and SC/16/07).

In cooperation with NAFO and NAMMCO, ICES arranged the Symposium "The Role of Marine Mammals in the Ecosystem in the 21st Century". The symposium was attended by about 70 scientists from 10 countries. In 1995, NAFO and ICES had sponsored a successful symposium on the ecological role of marine mammals. The current follow-up symposium presented new findings on the syntheses of information over ecosystem components, on biological and physical aspects of the environment, and on new research approaches to understanding the role of marine mammals. The symposium was organised in four theme sessions, each session starting with an invited key-note speaker.

Session 1 (Biological and environmental factors affecting life history traits) included a key-note talk given by Mark Hindell (University of Tasmania, Australia) who particularly examined the complex interplay between phylogenetic history and environmental factors in shaping life history traits in marine mammals. The session included 5 oral presentations and 4 posters that addressed issues related to the reproduction, recruitment and mortality in seal and whale populations. The influence of contaminants and environmental factors were discussed.

Session 2 (Foraging strategies and energetic requirements) started with a key-note talk by Dan Costa (University of Santa Cruz, USA) who addressed the issue by asking what would be the management and conservation implications of species specific foraging strategies and energetic requirements. The session included 8 oral presentations and 6 posters. Issues addressed in these included foraging behaviour, strategies and ecology of baleen whales and dolphins, and habitat use and seasonal changes in energy intake and body condition in seals.

Session 3 (Theoretical considerations on apex predators and multispecies models): key-note speaker Andrew Trites (University of British Columbia, Canada) suggested that, although it is evident that the interaction between marine mammals and their prey influence the structure and dynamics of marine ecosystems and, similarly, that predators and prey have shaped each other's behaviour and life history traits, there is little empirical evidence of these influences. However, ecosystem models are valuable tools to better understand these problems. The session included 9 oral presentations and 5 posters. Issues addressed included diet reconstructions, prey selection, spatial distribution, uncertainty in abundance estimation and multi-species modelling.

Session 4: (Marine mammal – fisheries interactions): The key-note speaker was John Harwood (University of St Andrews, UK) who used his talk to quantify marine mammal – fisheries interactions (both direct and indirect ones) and to discuss how such interactions can be incorporated into the ecosystem approach to fisheries. The session included 10 oral presentations and 4 posters. These addressed various by-catch issues, direct interactions between seals/whales and particular fisheries, and the consumption of resources of interest to fishers by marine mammals.

After the symposium, all contributors were invited to submit final papers which will subsequently follow a peer-review process for publication in a special symposium issue

of the Journal of Northwest Atlantic Fishery Science. The issue will also include a more comprehensive summary of the entire symposium.

6.2 Report of the Working Group on Marine Mammal & Fisheries Interactions (MMFI) - Marine Mammals and Fisheries in the North Atlantic: Estimating consumption and modelling interactions (as relevant to item 6)

In the absence of Walløe, chairman of the WG, Víkingsson presented the report of the WG (Annex 3, SC/16/08) which had met at the MRI just prior to the SC meeting, on 15-17 April.

The report was introduced with the background to the meeting since the topic was first discussed in 1996. The Terms of Reference (ToR) relevant to item 6. and derived from ongoing and new requests to the SC by the Council were:

1. to monitor progress made in multi-species modelling and in the collection of input data;
2. to extend the focus to include all areas under NAMMCO jurisdiction;
3. to investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses, in the light of the distributional shifts (of species) seen under T-NASS 2007;
4. to review the results of the Icelandic programme on the feeding ecology of minke whales.

The WG meeting was structured to consider in sequence a) new developments in the quantitative description of marine mammal diet by species (minke whale, harp seal, all other species), b) new development in the estimation of energy consumption, and then c) recent developments in multi-species modelling including SCENARIO, GADGET, ECOPATH, ECOSIM, and various other approaches.

Discussion by the NAMMCO SC regarding recent developments in the quantitative description of marine mammal diet and in the estimation of energy consumption

The SC **endorses** the main conclusions and recommendations for future research from the WG. The SC welcomes the new information presented, but also notes that in general the degree of progress since the last meeting is not extensive and that a considerable amount of work still remains. Some new approaches to estimating diet appear promising but still required verification.

The SC recognizes the potential of fatty acid (FA) analysis for the determination of the qualitative and quantitative aspects of the diet of marine mammals. The advantage of this method compared to the analysis of stomach contents verges on a longer integration time. However, the methodology has to be further developed and validated as there are indications that the assimilation rates of prey fatty acids in the blubber vary among species and among fatty acids. Furthermore, another aspect to be investigated is the destination of the dietary fatty acids in the blubber profile and the differential utilization of the blubber profile by the animal.

The SC therefore **recommends** further investigations on fatty acid assimilation times, modes and location in the blubber and on differential utilization of different FA.

Account should be taken of the fact that energy content of prey items varies in time and space and the SC also recommends the regular gathering of data on predator and prey distribution and density, as well as diet data.

There is a lack of information on the location of foraging grounds during part of the year for some species (e.g. minke whales). Therefore the SC recommends that effort be made in this area.

Based on new developments in establishing energy turnover in walrus and harbour porpoise based on the use of isotopic methods, the SC recommends that further investigations on the energy requirements of marine mammals, in particular harp seals, be initiated.

The SC **finally recommends** that regular meetings, perhaps on a biennial basis, be held to review progress on dietary studies and estimation of energy consumption.

Witting presented a document (SC/16/24), which argued that scientifically defendable quantitative answers to ecosystem management requests across different species are unlikely to become available for many years to come. A major reason for this is the uncertain link from management measures (harvest levels on one species) to management objectives (changes in possible harvest levels of other species) in ecosystem management. In traditional single species management there is an almost 100% certain link from the removals of individuals to the dynamic effect (because the removal and the effect is in the same species), while this link is inherently uncertain in ecosystem management because it runs between species. What may seem at first to be a firm link (predators eat prey, predator removal will therefore give more prey), is highly uncertain because it is almost impossible to quantify across the different densities and dynamic states of the multiple prey and predator species. A complete integration of the uncertainty across all plausible hypotheses of dynamics and species links is a major task that may not succeed. And even if it succeeds the combined effects of imprecise data and ecological uncertainty may give so uncertain results that any quantitative management advice would be practically useless.

Discussion by the NAMMCO SC regarding recent developments in multi-species modelling

In the light of both the report of the WG and the above document, the SC agrees that multi-species modelling is a valid approach for a better understanding of the ecological relations between species. However, the SC also recognizes that the general public and managers have very high expectations concerning the usefulness of ecosystem models to provide quantitative management advice. Interactions between marine mammals and other components of their ecosystem are often viewed as direct predation that can be described through simple (e.g. 1:1) models.

It is important to recognize that the multi-species modelling required in order to address management questions such as the impact of changes in the abundance of certain marine mammal populations on allowable catch levels for some commercial fish species is, in fact, quite complex. Ecosystem models have significant data requirements, many of which are currently unavailable. Even when available, data are often highly imprecise or of questionable quality. The SC notes that current multi-species models are not sufficient to provide quantitative management advice at this time. In some situations single species models are sufficient to manage a stock. However, in other situations, more complex models are required to understand the interactions that occur among ecosystem components. Before being used to provide management advice, these models must account for all sources of uncertainty and, as a result, may be imprecise. The models should also consider the significant interactions influencing the system and not be restricted simply to the interactions identified, *a priori*, as management concerns.

The degree to which multi-species models will be able to provide precise quantitative answers to questions about the impact of changes in marine mammal abundance in a given situation is still not clear.

However, multi-species models can provide information about ecosystem interactions that will be important considerations when making management decisions and therefore should be developed further.

The SC recognizes that additional research is required in order to develop ecosystem models to a point where they may be used for providing management advice. It is particularly important to understand how different models depict ecosystem interactions and their sensitivity to the inherent assumptions. The best way identified to improve the understanding of multi-species models is to use different modelling approaches to describe the same ecosystem. If the models provide qualitatively different predictions this could provide the basis to determine the factors giving rise to such different predictions, and hence indicate direction to future research to resolve uncertainties about those particular factors.

The SC also notes that it is difficult to determine the accuracy of predictions from a single model. However, it may be possible to provide scientific advice on management questions with some confidence if the outputs from a number of quite different models were in broad qualitative agreement in their predictions of the impact of possible management actions. Thus, for example, to advise reliably that an increased take of a marine mammal would lead to greater potential yield from a commercial fish species would require that a) the confidence/probability ranges about estimates of such an increased yield were entirely positive for a model and associated sensitivity tests; b) this held true not only for one but for a number of different plausible models.

The SC therefore **endorses** the proposal put forward by the WG to carry out a modelling exercise and compare the results of different models developed to describe the same ecosystem using a common dataset. Carrying out such a multi-model

exercise to conclusion will, however, be possible only through a coordinated and funded multi-year project.

The SC **recommends** that this coordinated project be initiated as soon as possible and agrees on the broad lines developed by the WG for such exercise. The first phase of the work would involve fitting different models to the available data and comparing their projection results. Ideally, in a second stage, the models could each be subjected to common simulation testing for an indication of which might be providing the more reliable results.

This exercise should include at least 4 different modelling approaches. The best candidates, together with potential group leaders, were identified as:

- Minimal realistic model implemented using GADGET (Stefansson)
- *Ecopath* with *Ecosim* (Morissette)
- Time series regression (Hjermann)
- A simple biomass-based model such as one recently applied in eastern Canada.

The structure of the models should allow for the possibility of multiple stable equilibria in the absence of exploitation.

The exercise should be carried out preferably for two areas. Likely candidates include the Barents Sea and the region around Iceland. If resources are insufficient, one of these should be chosen, and the advantages and disadvantages of each should be developed for consideration. 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 period as a realistic time-span for the whole process:

1. A meeting to compile detailed proposals and budgets; leaders of the different modelling teams would be essential participants; meeting to be held as soon as feasible.
2. A data oriented meeting – common data would need to be carefully pre-agreed to ensure that the results from the different models were comparable.
3. A meeting of the modelling groups to critically compare and suggest improvements to their first attempts in fitting their models to the data.
4. A meeting at which final model results are tabled for consolidation, and draft consequent management-related recommendations are developed.

It might be possible to combine meetings 1. and 2. above into one.

Such a multi-modelling effort can only be carried out through a coordinated modelling programme.

6.3 Active Request(s) and answers from the SC

6.3.1 Ongoing requests and 6.3.2 New request

There has been a succession of requests from the Council for addressing the role of marine mammals in the ecosystem, their interaction with fisheries and their economical

aspects. In particular the SC has been charged with monitoring the progress in multi-species modelling. The most recent requests for advice are the following:

R-1.4.6. – The SC should monitor progress made in multi-species 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 SC should also consider the feasibility of connecting the multi-species models with simple economic models at that time (NAMMCO 12).

R-1.1.6. - The SC is requested 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 (NAMMCO 16).

At its last meeting the Council asked the SC to expand its focus areas from the two reference areas and species chosen previously, the Barents Sea and Iceland, and the minke whales and harp seals.

R-1.1.8. - 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 (NAMMCO 17).

Response by the SC

The SC convened 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 discussion of the SC reported in item 6.2, based on the WG report and other documents, constitutes the basis of its answer.

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 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.

With regards to the new request, the WG and the SC had reviewed progress made in all areas and for all species.

Regarding the review of the results from the Icelandic Programme on the feeding ecology of minke whales, only preliminary results had been presented to the WG, and it was still too early to undertake a general review of the results.

6.3.3 Future work needed for answering active requests

The SC sees as the only way forward for progressing with ecosystem modelling, to carry out the modelling exercise proposed above, comparing the results of different models developed to describe the same ecosystem(s) using a common dataset. Therefore the SC **recommends** that NAMMCO endorses and secures the funding for such a coordinated modelling effort.

The SC **commends** the progress made by Iceland in the analyses of the data from the minke whale programme and is looking forward to their completion, estimating that the programme will represent an important step in the understanding of minke whale ecology and the Icelandic ecosystem.

6.4 New recommendation for national research

The SC **adopts the recommendation** made by the WG and reported under item 6.2. The SC also **recommends** a swift completion of the analysis of the Icelandic minke whale programme.

6.5 Other matters: Update on the Norwegian-Russian Programme on harp seals ecology

Management agencies in Norway and Russia have expressed concerns over the current size of the Northeast Atlantic harp seal populations and their predation on fish stocks, in particular in the Barents Sea. To be able to assess the ecological role of harp seals by estimation of the relative contribution of various prey items to their total food consumption, a Joint Norwegian-Russian Research Programme on Harp Seal Ecology has been initiated. One of the aims of the programme is to assess the spatial distribution of harp seals throughout the year by conducting experiments with satellite-based tags and marking of animals in the White Sea.

The programme was adopted by the Joint Norwegian-Russian Fisheries Commission and supported by the NAMMCO SC in 2006 and 2008. However, although part of the programme is in progress (ecosystem surveys and abundance estimation), the core activities of the programme have not yet been properly started, the reason being that Russian authorities (the Federal Technical Committee, FTC) refused to permit deployment of satellite tags on harp seals in the White Sea in May in 2007, 2008 and 2009.

To ensure that tagging will take place in 2010, Norway and Russia have agreed to organise a research cruise in late May / early June in 2010, to deploy satellite tags on

harp seals on ice in the Hopen area southeast of Spitsbergen. The cruise will be part of the joint harp seal programme, involving both Norwegian and Russian scientists. However, tagging seals in the White Sea is still the most preferable approach, as it ensures that only seals from the White Sea stock are tagged, and because tagging of different sex and age groups can easily be balanced. Therefore, the Russian part will apply for permission to tag seals in the White Sea also in 2010. The Norwegian part will provide all necessary technical information about the tags and the operation, whereas the Russian part will secure that all logistics in the White Sea area are ready in early May 2010.

At its last meeting the SC strongly regretted the decision made by the Russian FTC to refuse the deployment of satellite tags on harp seals in the White Sea in May. It recommended that Russia permits Norwegian and Russian scientists to conduct this important tagging according to the original plans. The SC strongly reiterates its support to this programme and its recommendation to the Russian authorities for allowing the deployment of the tags.

Last year a request for a support to this programme was forwarded to the Council of NAMMCO. The Council (NAMMCO 2008) "noted the importance for the study of harp seal ecology that satellite tags can be deployed in the White and Barents Sea in 2009 and encouraged the Russian authorities to allow the continuation of this study. The Management Committee for Seals and Walruses "supported the request from the SC for NAMMCO to address a recommendation to the Russian authorities to allow the deployment of satellite tags in the White and Barents Sea in 2009 as part of the harp seal ecology study, and recommends that the Russian authorities allow the continuation of this study."

This recommendation has not been addressed yet to the Russian Authorities, which did not allow tagging in 2009. The SC urges that this be done as soon as possible to facilitate tagging in 2010.

7. BY-CATCH OF MARINE MAMMALS

7.1 Update on monitoring progress by countries

In 2006, SC 14 noted and commended the progress that had been made in instituting a programme for estimating by-catch in Norway, particularly in inshore fisheries. However it was also noted that there had been little progress in improving the system in Iceland, according to the recommendations provided in 2004, and no progress in Greenland or the Faroes. Noting that by-catch may constitute an appreciable proportion of the total removals of coastal seals, harbour porpoises and dolphins in some areas, the SC strongly recommended that all member countries establish by-catch monitoring systems for their fisheries. SC 15 reiterated this recommendation.

Iceland

Ólafsdóttir reported on the progress made in Iceland since the last meeting. The format of fishery logbooks was changed and a new system of electronic log books was implemented in mid-year 2008. The initial version did not specifically instruct on

marine mammal by-catch reporting, leading to a total lack of records in July to December. An update of the system is in progress and an updated version will include reporting of marine mammals.

Data on marine mammal by-catch in the gill net fishery in 2008 were obtained by the annual observer gill net survey conducted by the Marine Research Institute (MRI), where embarked scientists collect catch and effort data, covering about 1% of the total set net fishing effort in Icelandic waters in March and April. The procedure applied has been similar since 2003, providing by-catch data series since then.

Besides the above programme, from 2009 the observers from the Fisheries Directories include reporting on marine mammal and bird by-catch in their regular observer trips onboard fishing vessels in all types of fishery other than the lumpsucker fishery. By-catch data as well as information on fishing gear and effort will be archived and analysed by the MRI.

MRI has initiated a programme on marine mammal by-catch reporting in the lumpsucker fishery in cooperation with selected fishermen, who will voluntary collect and report by-catches of marine mammals and birds for all trips.

Norway

A system for monitoring by-catches of marine mammals in coastal and inshore waters had been initiated in the autumn of 2005. A number of coastal and offshore fishing vessels had been contracted to provide detailed information on their fishing effort, catches and by-catches including incidental catches of seabirds and marine mammals. Data from these "reference fleets" have been collected since 2005, but the reliability of the monitoring system had not been evaluated yet and the extrapolation to the total fishery is not completed yet. Haug reported, however, that the analysis was in progress and that it was expected that results would be available towards the end of the year.

Faroes

No progress has been made on this subject. Reporting of by-catch is not mandatory in the mandatory logbook of vessels larger than 110 BRT, and can only be entered as a comment. There is no logbook system for smaller boats and no voluntary reporting of by-catch asked for. The Ministry of Fisheries has been assigned the task of facilitating by-catch reporting, but Faroese delegates were unaware that much has happened.

Greenland

There is no separate reporting for by-catch of small cetaceans or seals. By-catches are expected to be reported with direct catches. From June this year, harbour seals will probably become listed as "protected" and will therefore have to be reported as by-catch. At the last Council Meeting in 2008 (NAMMCO 17), Greenland informed through the Management Committee that by-catches of large whales, beluga and narwhals should be reported. For harbour porpoises and seals, by-catch is not specified in the legislation. However, this should be dealt with in the new executive government order.

Discussion by the NAMMCO SC

The SC **commends** the new efforts undertaken by Iceland. It pointed out that, in the case of direct contact with selected fishermen for self-reporting of by-catch, it is important to establish a relationship of trust. Likewise, it is important to perform occasional checks to control the reporting. It is especially important to perform calibration checks of fishermen not participating in the programme in order to evaluate differences between them and the selected fishermen.

The Committee notes that in term of management, what is important is that all removals be accounted for and that in the case of Greenland, it was sufficient that by-catches be reported as catches. The Committee also recognizes the absence of gillnet fisheries in the Faroes, which are fisheries usually coupled with high by-catch rates. It strongly underlines, however, that "believings" regarding the extent of by-catch or by-catch reporting are not adequate and both these issues have to be properly investigated. The SC underlines that proper investigations have shown that fisheries which were at first not thought to be responsible for inducing considerable by-catch, actually were, including fisheries involving small vessels and leisure fisheries.

7.2 Report on the ICES Study Group on By-Catch (SGBYC, January, Copenhagen) and response to the NAMMCO proposal for a joint Working Group/Workshop

Desportes participated to the ICES SG for NAMMCO, and presented the points of the report (available as SC/16/09) relevant to the work of the SC.

The SG, which can be seen as a "technical group" feeding the WGMME, examines the monitoring, assessment and mitigation of the incidental capture of protected species. It also coordinates activities conducted under EU Council Regulation 812/2004 on cetacean by-catch, including observer programmes and by-catch mitigation trials, and it reviews annual reports from member states that address the obligations of Regulation 812/2004 and collates data provided in these and other reports with the aim of providing an overview of by-catch levels of protected species impacted in and around the ICES Area.

The SG looked at the NPR from Member States' Annual Reports on 812/2004 for the year 2007 and collated data on by-catch. It also reviewed the other estimates of by-catch of relevant species in the ICES and EU areas. Under this point, information was given on the system existing for by-catch reporting in NAMMCO countries. The group made general recommendations, of which those relevant for NAMMCO are:

Regarding by-catch estimation

- "For the Northern Northeast Atlantic, the SG noted that the data collated from published reports and/or as communicated to the group, do not provide nor allow the estimation of any total by-catch numbers. Most of the data relate to marine mammal by-catch reported from logbooks or from incidental reporting, with no related effort data, preventing any estimation of total by-catch numbers. In some areas where by-catch of some marine mammals could be significant, e.g. Norway and Iceland, the group was aware of the existence of monitoring programmes, although no evaluation of

the programmes and no estimate of by-catch had been made available to the group. The group recommended that total by-catch estimates and details of the monitoring programmes for these areas should be communicated to the group at its next meeting."

Regarding data availability and provision of data

- "The SG was aware that although they had reviewed published estimates of by-catch, there are other sources of data on the by-catch of protected species that have not been fully analysed. These include the results of observer schemes in Norway and Iceland, but also the data that have been collected over many years by EU member states under their Discard Sampling and other at-sea monitoring programmes."

The SG was working on the design and the establishment of a database for cetacean by-catch and also considered technical aspects of by-catch monitoring and assessment.

The SG considered ways in which wider collaboration with other interested parties might be promoted in the ICES Area and adjacent waters, and endorsed a proposal from NAMMCO's SC to hold a joint workshop on by-catch monitoring and assessment.

- "The SG commended this spirit of cooperation and agreed that one way of encouraging other EU and non-EU countries to expand or develop observer programmes was to hold a workshop with wide participation on monitoring programmes, based both on observer programme and also alternative methods, with comparisons of the cost-effectiveness. The SG strongly recommended that the proposition of the NAMMCO SC should be followed up, so that a workshop involving NAMMCO, ICES and other relevant IGOS should be organised to take place at the end of 2009 or beginning of 2010. The SG also suggested that new efforts be made towards promoting coordinated studies in cooperation with other relevant IGOs (e.g. ACCOBAMS, ASCOBANS, NAMMCO, GFCM, IWC, Black Sea Commission, etc.) on different topics. "

Desportes informed that the recommendation for holding a joint workshop, before being endorsed by ICES, had to be examined and endorsed by ACOM, which should be done next month.

Discussion by the NAMMCO SC

The SC thanked Desportes for her report and appreciates that the ICES SG is positive over the NAMMCO proposal and strongly hopes that ACOM will show the same attitude.

The SC notes that progress of the SG in the design and the establishment of a database for cetacean by-catch should be followed by NAMMCO, should a by-catch database become a reality in NAMMCO countries. It also notes that the SG conclusion regarding the technical aspects of by-catch monitoring and assessment would be relevant to NAMMCO countries when elaborating monitoring systems.

7.3 Active Request and answers from the SC

7.3.1 Ongoing request

R–1.1.7. - The Committee requested the SC 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 (NAMMCO 16).

Response by the SC

Last year the SC recommended the organising of a workshop to review the use and applicability of the by-catch monitoring systems in use in different organisations and suggested seeking contact with other organisations dealing with by-catch monitoring in view of initiating collaboration on this matter. Ólafsdóttir was designated NAMMCO chair for this workshop, with the support and help from the NAMMCO Secretariat for the organising.

Subsequently, at its last meeting, the Management Committee agreed that there was need for further guidance from NAMMCO Council in relation to the priority of requests and the workload of the SC, before it could endorse the recommendation for a review of by-catch systems.

In the absence of any guidance from the Council to date on the prioritisation of the work of the SC, and in view of the upcoming meeting of the ICES SG in January, the Chair of the SC decided to go ahead with the preparation of the workshop recommended by the SC, and to contact other organisations.

Steps were taken therefore, towards the organisation of such a workshop, the first step being to contact other organisations. The first organisation contacted was ICES, when Desportes participated in the SG on By-Catch on behalf of Ólafsdóttir (see item 7.2). ACCOBAMS has also been contacted.

7.3.2 Future work needed for answering active requests

The organisation of a workshop for reviewing the use and applicability of the present by-catch monitoring systems as well as alternative methods, was still seen by the SC as the initial best step in answering the request from the Council.

The SC therefore **recommends** continuing the planning of this workshop and looked forward to its timely organisation. At the same time the SC welcomed collaboration with ICES and other suitable IGOs.

7.4 New recommendations for national research

The SC **recommends** that Greenland look into the new reporting system (following the new executive order) and evaluates the efficiency of the reporting of by-catch.

The SC **recommends** that all catches including by-catches be reported for all species. In particular it recommends that in the Faroes this process be facilitated in logbooks by the inclusion of entries for by-catches (real entries, not supplementary comment).

The SC **strongly recommends** that the Norwegian analysis of by-catch and the evaluation of the new monitoring system be completed as soon as possible and presented to the SC at its next meeting.

8. SEALS AND WALRUSES STOCKS - STATUS AND ADVICE TO THE COUNCIL

Advances in national progress and results are reported in the National Progress Reports and only points of special interest, relevance or novelty are given under the species items 'Update on national research progress and future research plans'.

8.1 Harp Seals

8.1.1 Update on national research progress and future research plans

Norway

Haug reported on research on harp seals in Norway. From 14 March to 3 April 2007, aerial surveys were carried out in the Greenland Sea pack-ice (the West Ice) to assess pup production for populations of both hooded and harp seals. The prime target species for the survey was hooded seals, but during the survey it became evident that harp seals could also be adequately surveyed. Results from staging flights suggest that the majority of harp seal females whelped from 15 to 21 March. The calculated temporal distribution of births were used to correct the abundance estimates obtained. The total pup production estimate obtained for harp seals was 102,200 (SE = 25,400, CV = 24.9%) which is not significantly different from the estimate obtained with comparable methodology in the area in 2002.

There are new data from Greenland Sea harp seals to obtain estimates of female reproductive rates - the material was collected in the period 2000-2008. The new estimate of mean age of maturity (MAM) was 7 years and postpartum pregnancy rate of multiparous females was estimated at 0.79 (SD= 0.06). Both of these values represent a decrease in reproductive rates as compared to the earlier used estimates (MAM=5.6 years, F=83.3%), but because of problems with the sampling regime, it is highly questionable if the results reflect a true biological change. Due to sampling bias towards large females these changes may not reflect biological reality – the material will be supplemented with additional sampling in 2009 to solve these problems.

New data on Barents Sea / White Sea harp seal female reproductive parameters have become available. Based on female reproductive samples collected during the Norwegian harp seal hunt in the southeastern Barents Sea in 2006, mean age at maturity was estimated at 7.2 years for the White Sea-Barents Sea stock. This probably represents a decrease in MAM as compared with the previous estimate from the early 1990s (MAM = 8.5 years), but is still high compared to values observed in the Northwest Atlantic. Average post partum pregnancy rate of multiparous females was estimated at 64% and average ovulation rate of parous females was 95%. This pregnancy rate is 20% lower than the previously reported value (84%) based on directly observed implantation rates from a small sample (n = 32). This observed decrease is probably more likely due to differences in method than an actual change in pregnancy rates.

Greenland
2008 saw a situation similar to that in 2007 where 1,000 or more pups (based on tannery data) were sighted by hunters near Cape Farvel. Apparently the seals give birth along the distal front of the East ice. This implies that in some years the area is situated east of Cape Farvel and in some others on the western side or on the south. The fluid ice movements around the southern tip of Greenland experienced in recent years have situated the whelping patch on the west of the Cape. Recent hunter reports indicate that the 2009 situation might be similar to that of the previous 2 years.

Russia
Zabavnikov reported that the dedicated, multi-spectral, aerial survey of harp seal whelping patches carried out during 13 – 20 March 2008, covered not only the White Sea "traditional area" but also part of the coastal Barents Sea, including Cheskaya Bay and the area around Kolguev Island. In addition, biological samples from pups were collected during the harp seal commercial catch.

All harp seal whelping patches were disposed in their "traditional area" in the White Sea. No "untraditional" harp seal whelping patches were found in the coastal area of the Barents Sea. The main area for harp seal pup production in the White Sea was found in the west of the "Gorlo" (close to the Kola Peninsula), in the central and north part of the "Basin". Additionally, some not very dense harp seal whelping patches were observed in the northern part of Mezen Bay.

The reasons for the decline in pup production are not known. The very poor ice conditions observed could have contributed. Further investigations are needed to determine whether this decline could be due to methodological, biological or anthropogenic reasons. About the lattermost, it was noted by traffic control that many vessel routes passed close to the whelping patches or even across them. Due to the high risk of pup mortality, a joint recommendation was issued together with the Arkhangelsk Hydrometeorological Centre and forwarded to the Icebreaker Centre, which resulted in a change in traffic routes away from whelping patches.

Observations were also carried out onboard the Russian research vessel during the annual Russian-Norwegian Ecosystem Survey in August-September 2008. Harp seals were observed close to the ice edge.

Dedicated aerial surveys in the Barents Sea were carried out in August 2008 around the Shtokman gas and oil field (SGOF) and in the vicinity of the pipeline between the SGOF and Teriberka bay in the Kola Peninsula. Harp seals were evenly distributed throughout the total SGOF area.

Canada
Stenson reported the following on progress in harp and hooded seal research:

- The diet of harp (adults n=294; juveniles n=232) and hooded (adults n=115; juveniles n=38) seals were estimated using QFASA from the pre- and post-breeding periods between 1994 and 2004. Evidence was found of inter-and

intra-specific variation in diets, diet quality and breadth, reflecting different foraging tactics.

- The results of a study on the development of diving found that hooded seal adults have the largest body oxygen stores yet reported, while harp seal adults have values similar to other phocids.
- In March 2008, surveys were conducted to estimate pup production of northwest Atlantic harp seals whelping in the Gulf of St. Lawrence and off the coast of Newfoundland. The results of this survey and a full assessment of the status of northwest Atlantic harp seals will be peer reviewed in 2009.
- New information on the diet of harp and hooded seals was collected and analysis made of these samples. A new estimate of harp seal consumption was presented to the seal impact workshop in 2008. The estimates of consumption were highly variable and dependent upon the methods used to estimate the proportion of cod in the diet.
- An ongoing collector programme involving sealers from Newfoundland and Labrador continues to provide annual biological samples of seals captured during the commercial hunt in the region. These data facilitate the long term monitoring of reproductive status, diets, and the growth and condition of seals during a period of significant ecological change.

8.1.2 Review of SC recommendations for research from earlier and "answers" by countries

Norway

SC 15 recommended flying reconnaissance surveys (e.g. south of 67°N in East Greenland) to investigate the possible presence of whelping patches in "untraditional" areas, to continue the sampling for biological parameters, and the characterization of stock identity.

The survey had not received funding and was therefore not conducted. Sampling has been initiated.

8.1.3 Report of the ICES-NAFO WG (08-2008) – harp seals

Haug reported that the ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during in August 2008 in Tromsø, Norway, to consider recent research and to provide catch advice on the North Atlantic stocks of harp and hooded seals. The report was available to the Committee as SC/16/10.

For the Greenland Sea harp seal stock, results from the Norwegian survey of pup production in March-April 2007 (102,200 pups; SE = 25,400) was incorporated along with previous estimates into a population model - this produced a population estimate of 756,200 (SD 105,318) animals in 2007, or 646,400 (SD 104,080) age 1+ seals, and 109,800 (SD 16,100) young of the year. However, the stock is currently considered to be data poor due to the lack of recent data on reproductive parameters, so the catch option should be based upon the use of the Potential Biological Removal (PBR) approach. This produces a recommended Total Allowable Catch (TAC) of 40,383 seals. A harvest at this level, with takes of pups and older age animals in proportion to

their composition of the population, would reduce the 1+ population over the next 10 years by 7%. Takes at twice the PBR level would lead to a 63% reduction in the population.

Russian scientists conducted a survey of the White Sea/Barents Sea harp seal stock during March 2008, and produced an estimate of 123,104 pups (SE = 24,511). The total population for this stock was estimated to be 862,000 animals. The 2008 pup production estimate is not significantly different from the estimate produced in 2005, which suggests that there has been a drop in pup production of two-thirds since 2003. WGHARP expressed concern that the late timing of the survey may have strongly negatively biased the survey's results, and if not, the results (as with the results from the 2005 survey) were difficult to reconcile with previous and current understanding of the population dynamics of this stock. The potentially low accuracy of the survey led WGHARP to conclude that the stock had to be considered (for now) data poor, and to recommend that the PBR approach be used to define the TAC, which was set at 21,881 seals. WGHARP also recommends that 1) inter-sessional discussions (by correspondence) be held to develop a survey design that can firmly establish whether pup production has indeed declined, and 2) a March 2009 pup survey be conducted.

In the 2008 Tromsø meeting, WGHARP members evaluated the proposed Norwegian Greenland Sea harp seal management strategy with respect to the precautionary principle. To a certain degree, the request is moot because the stock is currently considered to be data poor. The Norwegian management framework will, however, be relevant once the stock is considered data rich. The framework proposed by Norway is appropriate because it aligns well with the four-tier precautionary management system WGHARP proposed to and was accepted by ICES in 2005. Thus, WGHARP recommends to Norway that in developing a seal management strategy it should be ensured that a given harvest has:

- for stocks initially above N_{70} (70% of the maximum size of the population ever observed or interpreted, N_{max}) – an 0.80 probability that stock size will remain above N_{70} 10 years in the future;
- for stocks initially above N_{50} and below N_{70} - an 0.80 probability that stock size will be above N_{70} 10 years in the future;
- for stocks initially above N_{lim} (set at 30% of N_{max}) and below N_{50} - an 0.80 probability that stock size will be above N_{50} 10 years in the future;
- for stocks below N_{lim} – no removals be allowed.

A model-based approach would be useful to define the decreasing annual harvests to synchronize with N_{70}, when stocks are above N_{70}. Another consideration is that survey monitoring will be unable to identify the impact on pup production until 8-10 years after implementation. Significant changes can occur in the population before monitoring can distinguish changes. However, it is still useful to continue to survey the population so that the harvest strategy can be updated with new data.

WGHARP also considered the minimum size of a harp seal population that can be considered sustainable and that at the same time could give a maximum continued

yield. The ideal level at which the population "should be" will depend primarily upon the management objective proposed. If the objective is to maintain a harvest of a given level, the population required to provide this yield can be estimated using the population models developed for Greenland Sea harp and hooded seals. If the management objective is to reduce the population to a minimum level, WGHARP has identified a critical limit (N_{lim}) below which a further reduction in the population may cause serious and irreversible harm. A management objective to reduce predation on a specific prey species to aid in its recovery is more difficult to define. Current scientific knowledge on the population dynamics of the prey and mortality by seals (and other predators) is not sufficient to estimate this level for any population. Finally, if the management objective is to maximize yield then the N_{70} level is in the range of the maximum sustainable yield estimated for many marine mammal populations.

Discussion by the NAMMCO SC

The SC **endorses** the conclusion of the WGHARP, as well as the recommendation for management advice and research made by the WGHARP for harp seals. The SC was informed that Russia had conducted the requested new pup survey in the White Sea on 14-16 March 2009, and that the data were now being analysed, which is commended by the committee.

8.1.4 Active Requests and answers from the SC

8.1.4.1 Ongoing request

R-2.1.4. - The Management Committee therefore reiterated its previous request to the SC 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 (NAMMCO 12).

Response by the SC

An update of the stock status of North Atlantic harp 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.

8.1.4.2 Pending requests

R-2.1.6. – The Management Committee recommended that the SC evaluate how a projected decrease in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland (NAMMCO 14).

Rosing-Asvid summarised data presented to the MMFI WG and showed the correlation between the estimates of the northwest Atlantic population and catches in Greenland (SC/16/MMFI/12). The catch history of harp seals in Greenland shows that catches are strongly correlated with the size of the northwest Atlantic population. The correlation was exponential for catches south of the ice edge (67°N), where both the number of seals and the duration of their stay increased when the population increased. More seals are seen late in the season and in recent years, and whelping has been observed several

times along the coast. A reduction in the harp seal population from N_{max} (5.9 million) by 30% (4.1 million) will reduce the population to levels last seen in the early 1990s, when catches in southwest Greenland were about 50% below the current level. A 50% reduction (2.95 millions) would bring the population back to the 1983 level, when the catches in southwest Greenland were about 5% of current levels.

Response by the SC

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 estimates. This would also allow the calculation of confidence limits associated with any estimate of a decrease in catch.

R-2.1.10. - 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 (NAMMCO 17).

Response by the SC

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 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.

8.1.4.3 Future work needed by the SC for answering active requests
None required besides the research activities recommended by WGHARP.

8.1.5 New recommendation for national research
Norway will conduct a seal health study where the major aim will be to perform a coherent evaluation of possible influencing biological factors that may have contributed to the recently observed regional differences in population productivity in harp and hooded seals in the North Atlantic. The study will have several sub-goals: 1) Health assessments of harp and hooded seals in the North Atlantic; 2) Evaluation of (region-specific) biological effect parameters; 3) Assessment of concentrations and tissue distribution of selected environmental pollutants; 4) Assessment of relevant life history parameters; 5) Comparison of the two seal species. Sampling for the study has started, but some extra funding is needed for a full scale study along the lines described above.

The SC **supports** this Norwegian health study, and recommends its immediate continuation.

Similarly the SC **reiterates its recommendation** from last year to investigate the possible presence of alternative whelping patches (see also under item 8.2.4.2 and 8.2.4.3).

The SC **recommends** that questions related to the problems for harp seals in the White Sea (decreasing pup production) are addressed jointly by Norwegian and Russian scientists, and that Norway secures that harp seals in the northeast Atlantic are maintained as data rich.

Lydersen calls for samples of eyes (whole, frozen) from known-age animals to be included in a comparative study of ageing methods based on teeth and aspartic acid racemisation.

8.1.6 Other business
The SC **expresses concern** over the information that the Joint Norwegian Russian Fisheries Commission (JNRFC) had decided to increase the TAC substantially (to 35,000 animals from the 21,881 seals advised by ICES).

Haug reported on the symposium "Prospects for future sealing in the North Atlantic" (Pike *et al.*, 2008), which was arranged at the Polar Environmental Centre in Tromsø, Norway, on 25 - 26 August 2008 (including two informative papers about seal status).

8.2 Hooded seals
8.2.1 Update on national research progress and future research plans
Norway
From 14 March - 3 April 2007, aerial surveys were carried out in the Greenland Sea pack-ice (the West Ice) to assess pup production for populations of both hooded and harp seals, but with hooded seals as the prime target species for the survey. Results from the staging flights suggested that the majority of hooded seal females whelped

between 23 and 29 March. The calculated temporal distribution of births was used to correct the abundance estimates obtained. The total estimate of hooded seal pup production was 15,370 (SE = 1,675). This estimate is not significantly different from the pup production estimate obtained with similar methodology in the Greenland Sea in 2005, and is considerably lower than in 1997.

Historical Norwegian and Russian data which describe the trends in fertility rate and mean age at maturity (MAM) for hooded seals in the Greenland Sea have recently been subjected to joint Russian-Norwegian analyses. Age at maturity was determined by fitting Richards' curves to age specific proportions of mature females in scientific samples taken by Russian scientists in the Greenland Sea pack ice in May-June in the years 1990-94. Samples from the Denmark Strait (1956-60) and South Greenland (1970-71) previously analysed by the back calculation method were also included in the present analyses. Although there were annual differences in MAM among the Greenland Sea samples, a common MAM of 4.8 years could be fitted to all years. Similarly, a common MAM of 3.1 year could be fitted to the two northwest Atlantic samples. This represents a temporal and a stock-specific split in the sample and it cannot be concluded which factor is more important. Ovulation rates of mature females ranged from 0.68 in May 1990 to 0.99 in June 1991 and 1992, but the average ovulation rate of 0.88 was similar to previous estimates for northwest Atlantic hooded seals. For breeding and moulting patch samples taken in the period 1986-1990, indirect measures of pregnancy rates derived from patterns of alternation in corpora formation between ovaries, ranged from 0.74 to 0.97, and were significantly lower in 1987 and 1988 than in all other samples including the older data for the northwest Atlantic stock ranging from 0.94 to 0.97.

New samples to assess biological parameters in hooded seals have been collected (2007, 2008). These also include material to be used in studies of general health, pollution load, etc. An important aim of these studies will be to address questions related to the maintained low pup production of the species in the Greenland Sea.

Lydersen reported on MEOP – Marine mammals Exploring the Oceans pole to Pole - an IPY programme with 10 participating countries, led by the Norwegian Polar Institute, where hooded seals were instrumented in the North Atlantic and southern elephant seals in the South Atlantic. The purpose of this study in the north was to gather information on movement patterns of hooded seals concomitantly with collecting data on oceanographic conditions along their tracks. A total of 20 Conductivity-Temperature-Depth – Satellite-Relayed-Data-Loggers (CTD-SRDLs) were deployed on hooded seals of various sex- and age-classes; 3 were deployed post-moulting in July 2007 and 17 were deployed during the breeding period in March 2008. These animals roamed widely, covering an area of more than 3,000,000 km^2 of the Greenland and Norwegian seas ranging all the way from south of the Faroe Islands (59ºN) to almost the North Pole (88.5ºN). The seals were diving to 1,000+ m and collecting more than 7,000 CTD profiles and more than 110,000 C- and T-measurements along their tracks. These data were made available to the Global Telecommunication Systems in near real time and used among other things for weather forecast. An enormous amount of data was also obtained to study water circulation,

water mass mixing and freshwater output from this extremely important area for climate modelling (the Fram Strait). It is hoped that one will also learn a lot about habitat choice and selection by the hooded seals, perhaps based on knowledge of the oceanographic conditions that seals collect data on themselves.

See item 8.1.1 for Canada's update on harp and hooded seal research.

8.2.2 Review of SC recommendations for research from earlier and "answers" by countries

The SC 14 recommended that biological samples for determination of vital parameters be collected from the Greenlandic hunt in Ittoqqotoormiit. Greenland reported that there has been no progress on the sampling from this hunt but that the catches are minimal in the northeast Atlantic, which makes sampling a challenge.

8.2.3 Report of the ICES-NAFO WG (08-2008) – hooded seals

WGHARP recognised that the Norwegian 2007 survey of pup production in the Greenland Sea had produced an estimate for hooded seal pup production (15,370 pups; SE = 1,675) which was not significantly different from the estimate obtained with comparable methodology in the Greenland Sea in 2005, but considerably lower than the 1997 estimate. Incorporating these estimates into a population model produced a population estimate of 82,380 animals in 2007, or 66,890 (SD 8,645) age 1+ seals, and 15,490 (SD 1,528) young of the year. This stock size is well below N_{lim} (30% of N_{max} ~ 789,000 animals). As such, WGHARP recommends that no harvest be allowed for Greenland Sea hooded seals at this time because the stock size is below N_{lim}. This follows the Precautionary harvest strategy developed by WGHARP in previous meetings.

Discussion by the NAMMCO SC

The SC **supports** the conclusion of the WGHARP with regards to the status of the Greenland sea stock, as well as its recommendation for research. However the SC concludes as in SC 14 that some catches in the Greenland Sea could be allowed, equivalent to the necessary scientific catches and to satisfy local needs at roughly current levels since the results of the 2007 survey were similar to the 2005. This should be accompanied by a careful monitoring programme.

8.2.4 Active Requests and answers from the SC

8.2.4.1 Ongoing request

R-2.1.4. – See under point 8.1.4.1 for the text of the request.

Response by the SC

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.

8.2.4.2 New request

R-2.1.9. - The Council requested the SC to - Investigate 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 (NAMMCO 17).

Answer from the SC

This request was forwarded to the ICES-NAFO WG, which dealt with this request at its last meeting (see item 8.2.3 above). 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 in addressing the questions of the maintained low pup production of hooded seals in the Greenland Sea.

8.2.4.3 Future work needed by the SC for answering active requests

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.

The SC also **strongly recommends** that the possible relocation of breeding be examined by using aerial surveys to investigate whether a southward relocation of breeding has occurred for parts of the harp and hooded seal populations in the Greenland Sea. If new breeding patches are observed, this will have considerable implications for future research, management and hunting activities in the area.

8.2.5 New recommendation for national research

The SC **recommends** the sampling of biological samples both from the Greenland Sea and from the northwest Atlantic hooded seals, and their analysis. See also recommendations above.

8.3 Ringed seal (no active request)

8.3.1 Update on national research progress and future research plans

Greenland

Satellite tags will be deployed on flippers of ringed seals netted opportunistically in South Greenland in summer 2009. Future plans include the addition of temperature

sensors to the tags as well as other sensors for parameters useful for oceanographic sampling. It was noted that oceanographic data sampled by ringed seals would yield useful glaciological data if the seals were caught and instrumented in winter when animals are local.

Norway
Levels of a family of contaminants such as PCBs, DDEs and Polybrominated diphenylethers (PBDEs, flame retardants) were studied in the period 1996 – 2004 in young, sub-adult and adult male ringed seals from Svalbard. A dramatic reduction in the levels of these contaminants in blubber was observed which may reflect the ban on use of such components (Wolkers *et al.* 2008).

8.3.2 Review of SC recommendations for research from earlier and "answers" by countries

Greenland and Norway
The SC 15 reiterated its recommendation for initiating studies on ringed seals on sea ice in offshore areas, for addressing importance of pack-ice breeding, especially in the present context of climatic changes and subsequent changes in ice condition and cover.

Such surveys have not yet been conducted. It was noted that they would be difficult to conduct and very costly with regards to the potential data acquisition versus cost.

8.3.3 New recommendation for national research

The SC **reiterates its previous recommendations** to perform abundance estimates on sea ice in offshore areas. It recommends obtaining new abundance estimates and increasing the effort in tagging for the better understanding of movements of individuals, recognizing the difficulties and the expense of surveys.

8.4 Grey seal (no active request)

8.4.1 Update on national research progress and future research plans

Norway
Haug presented SC/16/23 dealing with recent assessment of grey seals in Norway. In the period September-December in 2006-2008, ship-based registrations of grey seal pups, including tagging, counting and staging of pups, were conducted along the Norwegian coast.

Aerial photographic surveys were conducted in some areas in 2007. All known breeding sites were surveyed from Rogaland County in the south to Finnmark County in the north. Most of the breeding sites were surveyed twice but some sites were surveyed only once due to difficult weather conditions. The investigations resulted in a total minimum estimate of 1,275 grey seal pups born in Norwegian waters. Total population estimates were derived from the recorded number of pups born by estimating a range of multipliers (4.0-4.7), based on observed annual growth rates of 6.4-12 % in other grey seal populations. This gave a total estimate of approximately 5,100-6,000 one year and older (1+) grey seals in Norwegian waters. The numbers are higher than numbers obtained in similar surveys in 2001-2003.

Updated information on life history parameters are necessary for proper modelling of grey seal populations based on pup production estimates. Sampling of such data is in progress.

Pilot studies on the applicability of aerial surveys as an alternative to boat-based surveys were done. The results from these experiments will decide upon the usefulness of aerial photographic grey seal pup surveys.

Russian grey seal breeding colonies on the Murman Coast, last covered in 1991, should be covered again. The Ainov islands were partly surveyed in 2006. These surveys should be completed, and also the Seven Islands further east should be surveyed soon, preferably in 2010. Ideally each colony should be visited three times (minimum twice) during the breeding period, and the possibilities of multi-spectral surveys carried out using a smaller aircraft should be explored.

Iceland

In August 2008, grey seal pups were counted from the air all around the country. The grey seal pup production was preliminarily estimated to be 1,677 (95% C.I. 1,629 – 1,703). The results cannot be directly compared to the results of the count in 2005, mainly due to poor coverage in the North West areas. The estimate for the total stock size was 7,300 (95% C.I. 5,900 – 9,000) which is an increase of 6% (4.5-7.9) per annum in the period 2005 to 2008. The greatest increase was observed in Breiðafjörður where the pup estimate changed from 645 pups (630-671) in autumn 2005 to 859 pups (836-892) in 2008, but less in other areas. The reverse was observed in Faxaflói where the pup estimate was 40 (40-45) in 2005 and 18 (18-21) in 2008.

The results of a comprehensive seal count in Vatsnes peninsula on 20 July resulted in the counts of 20 grey seals. The number of seals in Vatsnes will be monitored by repeating the count annually in the coming years.

Faroes

Three adult females and 7 juveniles (both sexes) were equipped with tags in 2007 and 2008. The movements of the seals remained very local, mainly inside the 100m depth contour. During the breeding season (Oct– Dec) contact was lost with adult females for 15 to 22 days, most likely because they were giving birth in caves.

Future plans include mapping of breeding sites as well as direct pup counts. Also, placement of cameras for direct pup counts will be attempted. A sampling programme for seals shot by farmers will be initiated to obtain life history parameters and help determine the impact of the hunt.

8.4.2 Review of SC recommendations for research from earlier and "answers" by countries

Norway

The SC 15 reiterated its recommendation on the quota level in Norway, estimated non-sustainable, but commended that a management plan was on its way and recommended that it should be presented to NAMMCO for endorsement.

The Norwegian management plan is this year presented to NAMMCO with a request for evaluation. See item 8.4.3.

Faroes
The SC 15 reiterated its recommendation that immediate effort be undertaken to obtain better information on the nature and impact of the take in the Faroes, and to obtain information on population and pup production.

Though tagging studies have pinpointed some breeding sites there was no progress made in the evaluation of the impact of takes, nor the estimation of abundance, although the SC noted plans for a reconnaissance survey this year and a full survey next year.

Iceland
The SC recommended that Iceland make available the new data on age composition of the catch.

At the NAMMCO Council 17 Iceland answered that "Iceland will try to obtain these data and to present them at the next meeting of the SC, providing that the issue of private ownership of the data is resolved". Unfortunately, no progress was made on this point (Ministry level) as the question of ownership of the data has not yet been resolved.

8.4.3 Review of the new Norwegian management plan for grey seals
Haug presented a draft management plan for Norwegian grey seals (SC/16/11) for evaluation and comments.

The Norwegian governmental goal is to ensure sustainable populations of grey seals within their natural distribution areas. In practical management, however, the government must weigh the desire for the preservation of relatively large seal populations, in local context, for the benefit of outdoor life and hunting, against the desire to reduce the damage on fisheries and aquaculture in the coastal zone. The basis for increased hunting quotas of grey seals, aiming to reduce the population in areas where the seals are claimed to do much damage, must be based on realistic measures of damage. Also, the grey seals role in the ecological system is incompletely mapped along the Norwegian coast. It is therefore essential to conduct ecological studies, especially in areas where the fishing industry interests have strong opinions about interactions between grey seals and fisheries.

The management plan proposes that current population levels of the grey seal in the three management areas Lista-Stad, Stad-Lofoten and Vesterålen-Varanger are defined as the target levels (målnivå = MN) for the species in Norway. Population-regulating measures should be designed to ensure that they have the greatest impact in areas where significant damage to the fishing industry caused by grey seals is documented. It is assumed that the MN is fixed over time, but that it will be possible to adjust the MN level in relation to new population estimates, new knowledge about the damage to the

fishing industry, new environmental threats, etc. Table 1 shows proposed strategies for the determination of appropriate management measures adapted to population levels at MN and at levels above and below MN. As a part of the management plan, a simple administrative procedure should be established with an algorithm for the calculation of quotas based on updated data on the population development in relation to MN, including withdrawals from the populations. This means a gradual escalation or reduction of the exploitation level based on the population status, if it is above MN (and increasing), or less than MN (and decreasing).

Population size (1+)	**Regulations**
Above MN	Exploitation equal to sustainable catch, within 1.5 x sustainable catch
Equal to MN	Exploitation equal to sustainable catch
Below MN and 0.7MN	Exploitation equal to 0.7 x sustainable catch
Below 0.7MN and 0.5MN	Exploitation equal to 0.5 x sustainable catch
Less than 0.5MN	0-quota
Less than 0.5MN and decreasing with 0-quota	Restrictions on disturbance at the breeding areas

Table 1. Strategies for the management of the grey and harbour seal populations in relation to the political goals for the population. Hunting quotas set in relation to the population levels are attempts to regulate the populations of grey seals in relation to the target level. MN = target level.

It is suggested that estimates of grey seal pup production take place approximately every 5 years along the Norwegian coast. In order to convert these figures to models of total population, also additional biological parameters such as mortality of 1 + animals and pups, age at sexual maturation and reproduction rates are important. In addition, removals from the population such as hunt and by-catches must be included. Data on pup production, age at maturation, reproductive rates are collected during surveys. Data on pup mortality are also obtained through observations during pup production surveys. Mortality data can to some degree be obtained during tagging and recapture studies. Natural mortality can also be estimated by modelling.

Three grey seal pup production estimates covering the entire Norwegian coast have been conducted in the period 1996-2008. Updated data on grey seal reproduction are, however, still lacking. Before such data are obtained, the grey seal populations in Norway will be characterised as "data poor" when using the requirements for data introduced by ICES (through WGHARP) for the management of harp and hooded seals in the North Atlantic. According to these criteria, three population measurements (pup production) and updated reproduction data (age at sexual maturation and pregnancy rates) within a period of 15 years are required in order to define the population to be

"data rich". There are plans to collect more data on grey seal reproduction in 2009 and thus change the status of the Norwegian grey seals from "data poor" to "data rich". When such data are available, population modelling of the species will be conducted. Such modelling can be used to predict the future population development at different levels of catch and by-catch.

A Total Allowable Catch (TAC) is calculated based on population size and production. TAC should be fixed between each time the population is counted, and adjusted according to count results. Estimated by-catches should be drawn from the estimated TAC, and the remaining number can be released as hunting quotas. One method for calculating the TAC is the Potential Biological Removals (PBR) used during the Marine Mammal Protection Act in the United States – it is suggested that this method be used when the population is in a "data poor" condition. For a "data rich" population, population modelling could be applied.

Research and management of grey seals in Norway should be evaluated in an international system, preferably NAMMCO.

Discussion by the NAMMCO SC

The SC welcomes the proposed management plan from Norway and sees this as a potential way forward. It takes note that removals were set to 0 for a population size equal to 50% of the target level and that under this limit, restrictions on disturbance at the breeding areas were also implemented.

However the SC **recommends** that a better way of taking uncertainties into consideration be developed before implementation. The SC **strongly recommends** that an expert WG on coastal seals makes an in- depth evaluation of this management plan, including a comparison with existing management models for e.g. harp and hooded seals, with the idea of possibly developing a common consistent seal model approach.

The SC underlines that it could be an advantage of having a single management model for all seal species in NAMMCO.

8.4.4 New recommendation for national research

Norway

The SC **recommends** maintaining efforts to keep populations as "data rich", with reviews every 5 years.

Russian grey seal breeding colonies on the Murman Coast were last covered in 1991, and the SC **recommends** that they be surveyed again. It also **recommends** that the Seven Islands further east should be surveyed soon, preferably in 2010.

Faroes

The SC notices again, that according to the present estimate (Mikkelsen, 2007), the Faroese could be harvesting up to 40% of their population, with a population estimated to be between 1,000 to 2,000 animals and removals estimated to lie between 200 to 400 annually, not including by-catch. The SC expresses strong concerns that this situation,

if correct, will lead to a rapid reduction in population, with a high risk of extinction. Therefore, the SC urges the Faroes to estimate their present removals and abundance off the Faroes. The SC **strongly recommends** that all efforts be made in providing a proper estimate of population size and catch at its next meeting.

Iceland

The SC **recommends** Iceland to compile research data from various bodies conducting work on seals and archive centrally where it is available for assessment work. The SC reiterates the importance of making the age data available; with a special thought to the reorganisation in the grey seal research in Iceland.

8.4.5 Other business

The SC considers that it is timely to hold a Working Group meeting on grey seals (or preferably on coastal seals, jointly with harbour seals, see also 8.5.6) and **recommends** its convening in early 2011. This WG would make a thorough review of the Norwegian Management plan and could proceed with an assessment.

The SC **recommends** that the Faroes define clear management objectives for grey seals.

The SC also **recommends** that the reporting of grey seal catches in the Faroes be made mandatory and enforced.

8.5 Harbour seal

8.5.1 Update on national research progress and future research plans

Greenland

Using helicopters, automatic cameras were set out 11 July 2008 in the inland areas where harbour seals have been reported, to detect and monitor animals (4 pictures per day for one year). An archive with pictures will be set up for photo-ID. From June 2009 however, the seals will likely be protected (in government in May).

Norway

Haug informed about a pilot study conducted between summer 2007 and spring 2008 to assess the prey consumption, feeding behaviour and habitat use of harbour seals in the Gavlfjord in Vesterålen, Norway. Recently developed GPS-GSM tags were deployed on 5 harbour seals during late August 2007. These tags collect and relay data (on dives, haulout, positions, and summary behavioural data) at a much higher temporal resolution and spatial accuracy than could be obtained from conventional satellite tags. During summer and autumn 2007 scat samples from the harbour seal population were collected and diet composition estimated. Two acoustic samplings were carried out in summer 2007 and the following winter to assess the distribution and abundance of potential harbour seal prey species in the study area. The analysis of the movement patterns of the tagged seals revealed that those individuals used primarily the areas around the haulout sites, without travelling long distances from the tagging and releasing site. They used mostly the shallow areas near the coast, diving on

average all the way to the bottom (50% of the dives were between 12-32 m) and showed marked individual differences in the choice of feeding grounds. No spatial relation was found between the density of potential prey and the choice of feeding grounds. Analysis of scat sampling suggested that gadoids dominated the diet (62%) followed by herring (35%). Comparison between the abundance of fish species in the study area, based on the resource surveys, and prey occurrence in the seal diet indicated that harbour seals have no preference for a particular prey species. On the other hand, within gadoids, they appeared to prefer small size classes. Therefore fish size, rather than species, could be a potential selection criterion in foraging. The local abundance of fish in the area is likely to allow harbour seals to feed on what is available close to the haulout sites. Targeting of small size classes might therefore be a consequence of habitat selection based on accessibility rather than size selection. The methodology applied in the Vesterålen experiment will be used in a larger fjord ecology project, starting in 2009 and aimed to study the entire ecosystem (harbour seals included) in Porsangerfjord, Finnmark.

Haug also informed about ongoing haulout behaviour studies of harbour seals in Vesterålen, using VHF transmitters. The aim of these studies is to develop correction factors for aerial photographic surveys of harbour seal abundance where only hauled out animals are recorded and counted, i.e. to find the ratio between hauled out animals and animals in the water.

Harbour seal aerial survey in Svalbard and satellite tracking

An attempt to estimate the size of the Svalbard harbour seal population using aerial surveys (eliko) and infrared and conventional photographic techniques failed due to equipment problems and because the helicopter scared the seals. A new attempt will be made in 2009 using a fixed wing airplane. Satellite tagging of pups will be attempted with conventional satellite tags (SMRU tags) while adults will be instrumented with SMRU CTD tags in the autumn. Scats will be collected throughout the year.

Impact of Greenland sharks on seals

Lydersen reported that during a study to evaluate the potential impact of Greenland sharks as predators of seals in general and harbour seals in particular, 49 sharks were caught in Kongsfjorden, Svalbard. Nine were equipped with satellite pop-up tags, 9 other were partly eaten by other sharks while being attached to the line before it was pulled, and the rest were sampled for various investigations including studies of stable isotopes to assess at which trophic levels the sharks were feeding. The stomach contents revealed that these sharks feed a lot on larger (2-4 kg) specimens of various fishes like Atlantic cod and wolffish. About 20 % of the stomachs contained pieces of seals, and many also contained pieces of minke whales. Based on the shape of the latter these are likely blubber pieces dumped from whaling vessels in the area, since their shape indicates that they were cut out with knives. Additional research will be conducted in summer 2009.

8.5.2 Review of SC recommendations for research from earlier and "answers" by countries

Greenland

The past recommendation of the SC for a research programme continues to be addressed, and is commended by the SC.

Iceland

The Committee had reiterated a recommendation for a formal assessment of the stock and the establishment of clear management objectives. No progress has been reported.

Iceland and Norway

The SC had reiterated its recommendation that both countries ensure better information on by-catch as well as collect information on the proportion of direct catch and by-catch and age composition. Continued and frequent abundance surveys were also recommended. Significant progress has been made (see under item 7.1).

8.5.3 Review of the new Norwegian management plan for harbour seals

Upon request from the NAMMCO SC, Haug presented the draft for a management plan for Norwegian harbour seals (SC/16/22) for evaluation and comments. Norway has committed itself to protecting the diversity of Norwegian nature through the 'Convention on Biological Diversity', and the governmental goal is to ensure sustainable populations of harbour seals within their natural distribution areas. In practical management, however, the government must weigh the desire for the preservation of relatively large seal populations, in local context, for the benefit of outdoor life and hunting, against the desire to reduce the damage on fisheries and aquaculture in the coastal zone.

It is assumed that the total exploitation (hunting and by-catches) may have caused a small decrease in the harbour seal population after 1999 (cf. comparable counts in 1999 and 2006). Norwegian management authorities (the Ministry of Fisheries and Coastal Affairs) aim to stabilize the population at current level. This level is about 10,000 animals, corresponding to an uncorrected level of 7,000 animals recorded on land during moult using current aerial monitoring methodology. This population level is defined as the Target Level (Målnivå = MN) in the suggested management plan. Small, unique and geographically isolated populations will not be exposed to hunting, and these populations should be managed with a clear margin to the minimum viable population size, which currently has been set to 50 individuals per colony without hunting or secondary catches.

Population-regulating measures should be designed to have the greatest impact in areas where significant damage to the fishing industry caused by harbour seals is documented. It is assumed that the MN is fixed over time, but that it will be possible to adjust the MN level in relation to new population estimates, new knowledge about the damage to the fishing industry, new environmental threats, etc. In principle, the management strategy for harbour seals is similar to the strategy for grey seals (see Table 1 above, item 8.4.3). This applies also to requirements related to updating of necessary data to assess population size ("data rich" versus "data poor") and to the use

of the PBR approach as an alternative to population modelling to assess catch options. It is therefore suggested that estimates of harbour seals take place approximately every 5 years along the Norwegian coast. In order to convert these figures to total population, correction factors that take into account seals not covered by the aerial, photographic surveys are also secured and applied. Removals from the population such as hunt and by-catches must be included in the modelling framework.

Research and management of harbour seals in Norway should be evaluated in an international system, preferably NAMMCO. A number of research activities are necessary to implement the suggested management plan:

1. Knowledge of the ecological role of harbour seals must be increased.
2. Research in order to concretize damage to the fishing industry, including the nature of the damage, magnitude and geographical area, should be conducted.
3. Studies of population structure (basis for administrative units) and spatial distribution throughout the year must be continued and increased for the harbour seals.
4. Risk analysis in order to ensure vigorous populations should be carried out.
5. Small, isolated populations and distinctive populations should be identified and not be exposed to hunting.
6. Regular monitoring of population development must be continued and methods of monitoring must be developed and improved.

Discussion by the NAMMCO SC

As for the grey seal, the SC welcomes the proposed management plan from Norway and sees this as a potential way forward. It recommends however that better ways of taking uncertainties into consideration be included before implementation.

The SC **recommends** that an expert WG on coastal seals evaluate this proposal in the same manner as that for the grey seal, with the idea of developing a common consistent management approach for seal species.

8.5.4 Active Request and answer from the SC

8.5.4.1 Ongoing request

R-2.5.2. - The Council requested the SC to conduct a formal assessment of the status of harbour seals around Iceland and Norway as soon as feasible (NAMMCO 16).

Response by the SC

At its last meeting, 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.

8.5.4.2 Future work needed by the SC for answering active requests

Data on removals are still needed both for Iceland and Norway.

8.5.5 New recommendation for national research

Greenland

The SC **commends** the Greenlandic approach to its past request and **recommends** the continuation of the effort in monitoring the Greenlandic harbour seal population.

Norway

The SC **recommends** that the population be maintained as "data rich" for proper management, and **recommends** a continued collecting programme in Norway for teeth for age determination and estimation of biological and demographic parameters. Sampling of relevant tissues for assessment of genetic structure has been initiated. The SC **recommends** that this sampling is continued, and that subsequent DNA-analyses be conducted.

Iceland and Norway

The SC **reiterates its recommendation** that both countries ensure better information on by-catch and on the proportion of direct catch and by-catch and age composition. Continued and frequent abundance surveys are again **recommended**.

8.5.6 Other business

The SC **reiterates its recommendation** of a total ban on hunt for this species in Greenland and was very pleased to see that a proposal in this direction was in the hand of the ministry and would be considered in May. The SC **strongly recommends** and hopes that the protection be enforced.

The Committee **reiterates its recommendation** for a formal assessment of the stocks in all areas and the establishment of clear management objectives.

8.6 Walrus

8.6.1 Update on national research progress and future research plans

Norway

Year-round data on movement patterns of walruses in the High Arctic, including at-sea positions are reported in SC/16/O02. Using first-passage times (FPT) to study habitat use and quantifying habitat selection using mixed-effects Cox proportional hazards models, the conventional perception that seasonal movement patterns of Atlantic walruses are simply a result of them following the retraction and expansion of annually formed sea ice is dispelled. Walruses in this study (17 males) actively moved into areas of high ice concentration (>90%) during winter; travelling far into the ice pack, as far as 600 km from ice-free water. Additionally, high inter-annual, seasonal site fidelity was documented. Seasonal differences in habitat use patterns were also observed. In summer, when walruses feed intensively, FPTs were affected by water depth and distance to the coast (r^2 = 0.571), but these variables had no effect on walrus habitat use in winter.

Sea ice concentration was the most important environmental condition during the winter season (r^2 = 0.162), though there are clearly other factors influencing where

individuals occur in winter that are currently unaccounted for in these analyses. The male walruses in this study did not do much benthic diving during winter, suggesting that they did not feed often during the time that they are known to breed. Instead, they remained in areas with high ice coverage, far from their coastal summering areas, spending much of their time hauled out or in surface waters.

Lydersen also reported on the installation of photo boxes taking pictures every hour on Svalbard to study the dynamics of walrus haul out behaviour and possible impact of visiting tourists at these haulout sites. Photo boxes have been installed at three locations and have been operational for summer 2007-2008 and plan to be operational for the next 3 years.

Lydersen also mentioned information from a paper on Laptev walruses showing that genetically, these animals are of the same origin as Pacific walruses (Lindqvist *et al.* 2009).

Greenland

During April 2008, an aerial survey was conducted by the Greenland Institute of Natural Resources (GINR) in Central West Greenland with the main purpose of estimating numbers of walrus in the West Greenland stock, and secondarily to target narwhal and other marine mammals.

Genetic analyses conducted by the National Environmental Research Institute (NERI) and GINR involving microsatellite markers, compared samples of walruses from southeast Baffin Island (SEB, 2006), Hudson Strait (HS), Central West Greenland (CWG) and Northwest Greenland (i.e. “The North Water stock”).

Russia

Zabavnikov reported on a Russian project for studying the Atlantic walrus population (*Odobenus rosmarus*) in the Pechora Sea (southeast part of the Barents Sea) close to Dolgij Island in 2010 (so-called “Walrus Project”). Different institutes - Russian Fisheries State Agency, Russian Academy of Science and Ministry of Natural Resources, will participate. The “Walrus Project” will start in May 2009 and last until 2012 and will be funded jointly by WWF and the Oil and Gas Company “Lukoil”.

8.6.2 Review of SC recommendations for research from earlier and “answers” by countries

Greenland

The SC had recommended progress be made on the old catch series which accounts for takes up to 2006, because it was required for a reliable assessment. No progress has been made.

8.6.3 Active Requests and answers from the SC

R-2.6.3. – The SC 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 (NAMMCO 15).

Response by the SC

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 discussion of the JWG on Narwhal and Beluga (item 9.6), which may represent a way forward.

R-2.6.4. – The Council requested the SC 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 planned 2007 survey are available. The SC is then requested to provide estimates of sustainable yields for the North Water and West Greenland stocks of walrus (NAMMCO 16).

R-2.6.5. – The Management Committee requested the SC to provide a full assessment of North Water, West Greenland-Eastern Baffin Island and East Greenland stocks (NAMMCO 17).

Response by the SC

The above two requests are pending the walrus assessment WG meeting in November 2009.

8.6.3.1 Report on the preparation for the Working Group on Walruses

The SC regrets that the NAMMCO Council did not respond in a timely fashion to the proposals for a list of invited participants for the Walrus WG meeting sent on March 4. A response would have enabled the WG Chair to continue the planning of the WG, and in particular investigate its financial implication.

Besides the exiting list of invited participants, the SC **recommends** that additional expert(s) who have previously been involved in abundance estimation of Pacific walrus be invited to attend the WG meeting, so that the WG has the relevant external expertise for endorsing the abundance estimates to be used in the assessment (see item 14.1.5). Considering the answer received from Council on April 15, and the states of the SC budget (see item 16.2), the SC **recommends** that the WG Chair proceeds with the organization of the meeting, following the recommendation above. The Secretariat will write to Council Chair and Council members stating that the SC will continue with the planning and the invitation of all proposed experts, including the additional expert(s) noted.

8.6.3.2 Future work needed by the SC for answering active requests

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.

8.6.4 New recommendation for national research

None is identified.

8.6.5 Other business

Lydersen reported from a successful meeting between Russian and Norwegian scientists held in Tromsø, November 2008. Here future possibilities for cooperative research on common stocks of walruses and beluga were discussed. Two research programmes were written based on this meeting, and dealt with satellite tracking, genetics and pollution/health issues for each species. The walrus fieldwork will be conducted in Franz Josef Land and the Pechora Sea, while the beluga fieldwork will be conducted in Svalbard, Franz Josef Land, the White Sea and the Finnmark coast of Norway.

The SC notes the Norwegian-Russian initiative for walrus research in the Svalbard and adjacent Russian regions reported by Lydersen, and welcomed this development. The SC **expresses full support** for these Russian-Norwegian research programmes and **recommends** that the Russian authorities facilitate these programmes, especially allowing for the deployment of the satellite tags, both for walruses and belugas. The SC also **recommends** that a request for a support to these programmes be forwarded to the Council of NAMMCO.

The SC **reiterates** its concerns that the present removals of walrus from the North Water and West Greenland stocks were likely not sustainable. New advice is expected after the meeting of the Walrus WG in November 2009. Quotas for 2008 were: 80 walruses from the North Water and 65 the West Greenland stocks. In order to compensate for a lack of reporting of “struck and lost” animals, the quotas for 2009 were reduced to 75 walruses from the North Water stock and 38 from the West Greenland stock.

8.7 Bearded seal (no active request)

There is a hunt in Greenland where 1,566 animals were taken in 2007, as well as a small hunt of 40 animals taken annually in Svalbard.

A wide variety of studies on bearded seals have been conducted on Svalbard. They include studies of growth, population parameters, diet, energetics, behaviour and vocalisation. Two years ago, Canada assessed bearded seals, but determined the population as "data poor". Elsewhere in the Faroes and Iceland there are occasional stragglers.

There is no abundance estimate nor information on stock status despite a continued exploitation of the species. Therefore the SC **recommends** that the status of the species be assessed.

9. CETACEAN STOCKS - STATUS AND ADVICE TO THE COUNCIL

Advances on national progress and results are reported in the National Progress Report and only points of special interest, relevance or novelty are given under the species items ‘Update on national research progress and future research plans’.

A database of the historic North Atlantic whaling statistics (regarding blue, fin, sei, humpback, minke, sperm, right, bottlenose, killer and pilot whales), including the pelagic Norwegian catch and catches from land stations in Ireland, the Hebrides, the Shetlands, the Faroes, Norway and Greenland, is close to completion in the Faroes. This and the historic Icelandic catch data have been controlled in collaboration with the IWC office.

9.1 Fin whale

9.1.1 Update on national research progress (including new estimates) and future research plans

Greenland

Preliminary analysis of the moored hydrophone shows surprisingly high numbers of fin whale calls during winter in Davis Strait.

Iceland

Various studies were conducted as a part of the 2-year process of RMP Implementation Assessment of North Atlantic fin whales within the IWC Scientific Committee. These include genetic studies showing low variability within the North Atlantic and a new abundance estimate for the Central North Atlantic. The RMP implementation process will be completed in June 2009.

Norway

DNA suitable for PCR amplifications has been extracted from historic fin whale samples from South Georgia. It provides suitable material for studying historic population structures. A manuscript is under publication in Marine Mammal Science. The project is done in cooperation with Tony Martin, British Antarctic Survey.

9.1.2 Review of SC recommendations for research from earlier and "answers" by countries

In the light of previous indications that Faroese fin whales might differ from other North Atlantic fin whales, SC 15 urged rapid completion of the genetic analysis of these samples using techniques compatible with those used currently on Icelandic samples. No progress is reported.

9.1.3 Active Requests and answers from the SC

9.1.3.1 Ongoing request

R-1.7.10. - Once the survey (T-NASS) has been completed, the SC is requested 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 (NAMMCO 16).

Response by the SC

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).

9.1.3.2 New requests

R-3.1.6. –The SC is requested 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 (NAMMCO 16).

R-3.1.7. - 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 next meeting of the SC (NAMMCO 17).

Response by the SC

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.

9.1.4 Future work needed by the SC for answering active requests

Validated fin whale catch statistics will be needed for an assessment. The SC **recommends** that the ongoing work on the database be completed in a timely fashion to allow the use of this database in the work preparatory to the January 2010 assessment meeting.

The Faroes informed that skin biopsies from fin whales off the Faroes were sent to Per Palsbøll in 2006 for genetic analysis. A report of the findings was never delivered to the Faroes. However, in a Fin whale WG meeting in Reykjavík in 2006, the results indicated that the Faroese fin whales differed from all the other North Atlantic samples studied. A joint examination of the all North Atlantic samples was planned but did not get funding from NORA.

In view of the potential importance of this finding and its significance in determining stock structure in the North Atlantic, the SC **recommends** that funding is sought again to undertake this study as soon as possible and before the next assessment meeting.

9.1.5 New recommendation for national research

See above.

9.1.6 Other business

In its 2008 assessment, IUCN maintained the fin whale listing as endangered. As long as the IUCN does not revert from its practice to pool all fin whale stocks into single assessments, the outcome will be completely dominated by the heavily depleted Southern Hemisphere stocks(s) and North Atlantic fin whales will be classified as endangered even if the IUCN assessment clearly shows that they would qualify as "least concern" listing if evaluated on an ocean area basis (see Fig. 1 below showing Figure 1 from the IUCN report (2008)). See also under item 12 on the subject.

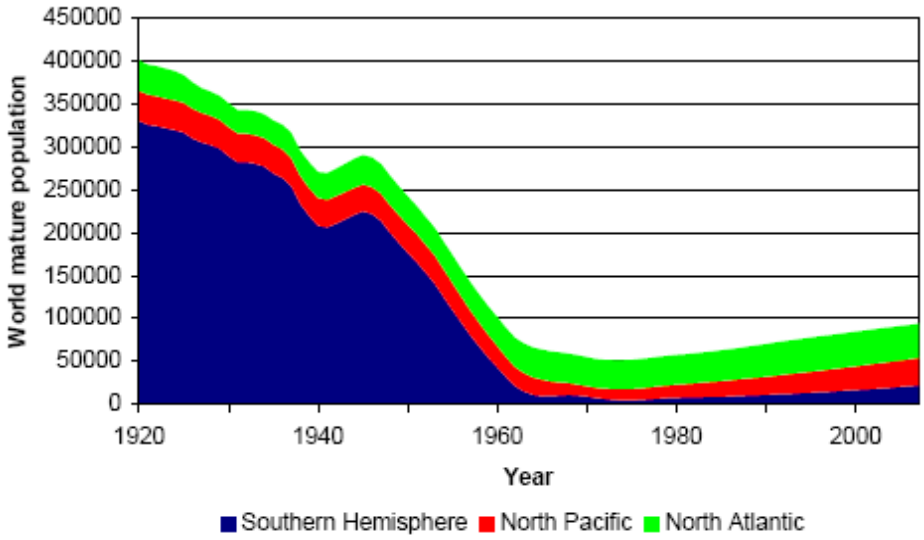

Fig. 1. Estimated population trajectory of fin whales, 1920-2007, from Figure 1 of the 2008 IUCN report.

9.2 Humpback whale

9.2.1 Update on national research progress (incl. new estimates) and future research plans

Norway

The photo-ID sampling programme continues this year. The cataloguing of identification photos collected on incidental occasions and during surveys in Norwegian and adjacent waters is progressing.

As for fin whales, DNA suitable for PCR amplifications has been extracted from historic humpback whale samples from South Georgia. See under item 9.1.1.

Iceland

During 4-7 November two humpback whales were instrumented with a satellite tag by MRI staff in Eyjafjörður, northern Iceland. Position signals were received until early December. One of the animals stayed in Eyjafjorður and nearby areas while the other humpback whale moved counter-clockwise along the coast of Iceland to the southwest corner where it spent three weeks apparently moving between concentrations of herring (see: http://www.hafro.is/images/frettir/2008/hnufubakur04.JPG).

A whale included in the central Icelandic humpback whale photo-ID catalogue, maintained by the MRI, has newly been matched with a humpback whale taken in the Bequia hunt in the Caribbean Sea. Collection of photo-ID material by the MRI and whale watching companies continues.

9.2.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 recommended that biopsies and photo-ID data from all the areas be analyzed before the initiation of a new assessment. Analyses are progressing in all areas.

9.2.3 Active Request and answer from the SC

9.2.3.1 New request

R-3.2.5. - The SC is requested to assess the long-term effects of catches of 0, 2, 5, 10, 20 humpback whales off West Greenland and estimate sustainable yields for other stocks, as well as to conduct a formal assessment following the completion of the T-NASS. In addition, the relationship between the humpback whales summering in West Greenland and other areas should be investigated and this knowledge incorporated into the estimate of sustainable yields of West Greenland humpback whales. (NAMMCO 17)

Response by the SC

SC 14 provided interim advice on safe removal levels off West Greenland, on the basis of the 2005 population estimate. Considering that the new 2007 abundance estimate was higher than the estimate of 2005, SC 15 saw no reason to revise this interim advice until a full assessment was conducted (NAMMCO 2008). SC 15 noted that the novelty of the humpback whale assessment will surely require more than one meeting. The Committee recommended that the preliminary work (state of the art with evaluation of available information) should be done in connection with the fin whale assessment meeting before a separate meeting schedule is set up for humpback whale assessment alone.

Again the SC recognizes the magnitude of the task that an assessment of humpback whales represents, especially due to a complicated stock structure. The SC **recommends** that the Council evaluates the urgency of this task in relation to the large number of active requests on other species and ranks them in order of priority.

9.2.4 Future work needed by the SC for answering active requests

None is identified, until guidance from Council is received.

9.2.5 New recommendation for national research

The SC **recommends** that the analysis of biopsies and photo-ID data from all the areas proceeds, as well as the completion of the T-NASS survey analysis (see also under item 9.12.1, T-NASS update).

9.3 Sei whale

9.3.1 Update on national research progress (including new estimates) and future research plans

Norway

As for fin whales, DNA suitable for PCR amplifications has been extracted from historic sei whale samples from South Georgia. See under item 9.1.1.

9.3.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 recommended that T-NASS sei whale data were combined with CODA sei whale data for analysis. The SC noted that no action had been taken in this direction.

9.3.3 Active Requests and answers from the SC

9.3.3.1 New requests

R-3.5.1. – The SC is requested to investigate the status of sei whales in East and West Greenlandic waters, and provide estimates of sustainable yield (NAMMCO 16).

R-3.5.2. – The SC is requested to review the new data from T-NASS and associated surveys and report on the status of sei whales through the fin whale Assessment WG (NAMMCO 17).

Response by the SC

The SC **reiterates its recommendation** that the 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.

The information available is likely insufficient to proceed to a full assessment, but the WG on Large Whale Assessment (Annex 2, SC/16/13) recommended that Iceland take the lead in compiling the available information in terms of catch series, abundance estimate and stock structure, and present this at the next meeting of the SC or at the next meeting of the Assessment WG in 26-28 January 2010. Iceland is progressing with the compilation.

9.3.3.2 Future work needed by the SC for answering active requests

The latest abundance estimate that could be used for assessment purposes is from 1989 as the timing and area coverage of subsequent surveys has not been adapted to develop abundance estimates for this species. A new abundance estimate is required before an assessment can be made.

9.3.4 New recommendation for national research

See above.

9.4 Common minke whale

9.4.1 Update on national research progress (incl. new estimates) and future research plans

Norway

Norwegian seismic investigations are planned in prime feeding areas for minke whales during summer 2009. Norwegian scientists have been requested to assess how these activities may affect minke whales by measuring the level of stress hormones (cortisol) in blood, blubber and faeces of whales captured in areas with and without seismic activities. Sampling of relevant data will be conducted by scientific personnel on selected whaleboats during the 2009 whaling season.

No minke whale diet studies have been performed in Norwegian waters after 2004. It is, however, regarded important to resume the sampling and data collection to monitor

minke whale feeding habits in the area. The fore-mentioned seismic programme represents an opportunity to make such sampling feasible and new diet data will be collected during field work. A pilot study to assess the usefulness of fatty acid compositions in blubber profiles for estimating the diets will also be conducted. If the results are positive, future monitoring of minke whale diets might be conducted using the fatty acid method.

Iceland

Preliminary results from the research programme on common minke whales in Icelandic waters show considerable changes in diet over time that appear to reflect changes in abundance of prey species in the area (SC/16/MMFI/04).

In the summer of 2008 the MRI conducted an aerial cetacean sightings survey southwest of Iceland in the Faxaflói Bay area. The frequency of minke whale sightings in 2008 was in total similar to the average from earlier surveys in mid-summer. By far the lowest mid-summer densities were observed in 2007 (TNASS), on the level with spring surveys, while the highest densities had been observed in 2004. Thus the latest agreed abundance estimate appears to represent a highly unusual year in terms of minke whale abundance in Icelandic waters. A new full scale mid-summer aerial survey is scheduled in 2009.

A rarely sighted event was recorded and filmed from a whale watching boat in Skjálfandi Bay in July 2008 when a pod of 20-30 killer whales attacked and killed a minke whale. Although there are several accounts of killer whale predation on marine mammals in Icelandic waters, this is the first one filmed.

9.4.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 recommended that the sighting rate for the T-NASS Extension survey in the Norwegian Sea be calculated and used for comparison with the other T-NASS areas and previous estimates in this area. This analysis is in progress.

SC 15 also recommended the analysis of all the minke whale data from the Greenlandic (aerial and shipboard), T-NASS Extension and Icelandic/Faroese (shipboard) surveys on minke whales as soon as possible. Provisional abundance estimates for the Icelandic and Faroese shipboard surveys were presented at the Assessment WG (Annex 2, SC/16/13) in March 2009. The analysis of the Greenlandic aerial survey data has been carried out and will be presented at the next meeting of the IWC SC, the analysis of the shipboard data has not been done.

SC 15 recommended the spatial analysis of both the historical and present survey data including the Norwegian data, to check whether the absence of whales in 2007 could be predicted to be in the areas not covered by the T-NASS survey. This analysis has not been done.

SC 15 recommended an investigation of potential changes in the ecosystem within the

framework of the WG on Marine Mammals and Fisheries Interactions. No progress has been made on this.

9.4.3 Report of the WG on Large Whale Assessment (Assessment WG) – minke

In the absence of Walløe, chairman of the WG, Witting presented the report of the WG on Large Whale Assessment (Annex 2, SC/16/13), which met on March 23 in Copenhagen, with as one of its task: "to assess the short-term (2-5 year) effects of the following total annual catches: 0, 100, 200 and 400 for the Central North Atlantic stock of minke whale."

Stock structure was discussed in detail at the WG meeting in 2003 (NAMMCO 2003), and there was insufficient new information for a re-examination. Hence, the WG assumed the currently accepted stock structure. There was no new information on biological parameters, and catch histories were updated with recent catches by Iceland, Norway and Greenland.

The estimates from the 2007 aerial survey in the Central Coastal Iceland area (CIC) were endorsed at the last SC meeting (NAMMCO in press). Two estimates were accepted; one based on all sightings but with no data to estimate detection bias, and another estimate based only on the single observer for whom duplicate sightings were available. Provisional abundance estimates from the Icelandic and Faroese 2007 shipboard surveys in the Central North Atlantic were reported to the meeting for four alternative analyses.

The 2007 estimate of abundance for the CIC area was considerably lower than the estimates from earlier surveys. A partial 2008 survey found a significantly higher sighting rate of minke whales than in 2007, with the rate in 2008 being comparable with earlier surveys. This indicates that minke whales move in and out of the CIC area from year to year, suggesting that the area does not encompass a separate sub-stock. The low 2007 abundance estimate should thus not be taken as evidence for an appreciable decrease in the overall abundance of minke whales.

Given the variation in the 2007 abundance estimates, the assessments were selected to hit the point and lower 5%-ile of either the 2007 abundance or the inverse variance weighted average of all surveys applied to 1998: the middle year for the survey period.

The 2003 assessment was updated with the new abundance and catch data. Assessments were carried out for the two options of the 2007 aerial survey combined with the four options for the shipboard survey, but the WG considered results only from the most and the least optimistic of these options. Runs were conducted for the CIC and the complete Central Area, using a $MSYR^{1+}$ of 1%, 2% and 4%.

For the current meeting, the Council had requested an assessment of the short-term (2-5 year) effects of annual catches of 0, 100, 200 and 400 whales.

The WG agreed that projections treating the CIC area in isolation and considering only the 2007 survey should be discounted. The Table 2 below summarizes the resulting

projections across $MSYR^{1+}$ rates from 1 to 4%, and annual catches (C) from 200 to 400 whales. The results give the 2008 and 2018 abundance as a proportion of the pre-exploitation abundance and the ranges encompass the point and lower 5%-iles of the abundance estimates.

Given a $MSYR^{1+}$ of 2%, the range for the MSY was estimated to 244-354 for the CIC case, to 420-557 for the Central Median (87, 01, 07) case, and to 181-584 for the Central Median 2007 survey only case. In the absence of catches the abundance would increase slightly from 2008 to 2018.

Area	**Survey 2008**	**2018 (C=200)**	**2018 (C=400)**
CIC 87, 01, 07	0.89 – 1.00	0.83 – 0.94	0.74 – 0.87
Central 87, 01, 07	0.88 – 0.98	0.85 – 0.96	0.80 – 0.91
Central 07 only	0.69 – 0.98	0.63 – 0.96	0.52 – 0.92

Table 2. Resulting projections across $MSYR^{1+}$ rates from 1 to 4%, and annual catches (C) from 200 to 400 whales. The results give the 2008 and 2018 abundance as a proportion of the pre-exploitation abundance and the ranges encompass the point and lower 5%-iles of the abundance estimates.

Given the low abundance estimates for 2007, there is now the possibility that the resource could fall to near 50% of its pre-exploitation abundance given a yearly catch of 400 whales (for a 5-year period, this reduction would be approximately halved.) Furthermore, the estimated MSY could fall below 300 (given a $MSYR^{1+}$= 2%), and even slightly below 200 for the least optimistic scenario (lower 5%-iles of the lowest aerial plus shipboard abundance estimate and the highest historical catch series).

The WG considered that yearly catches of 400 whales for the next five years, while not likely to put the resource under any serious threat, could nevertheless cause a reduction in abundance at a higher rate than might be considered appropriate (possibly exceeding 2% per year). Therefore, the WG recommends that 200 minke whales per year be considered as the largest short-term catch that should be contemplated.

There are nations other than Iceland that take minke whales from the Central Medium area and the catch levels above refer to all removals from the CIC or Central Medium areas.

Discussion by the NAMMCO SC

The SC **commends** the work of the WG and agrees with its conclusion regarding short-term catches. The SC also agrees with the recommendation of the WG.

The SC **supports** the planned aerial survey for the CIC area in 2009, considering that the main concentration of minke whales in the Central area has always, with the exception of 2007, been in the CIC. The SC also **recommends** simultaneous sampling of diet and related data.

The SC **recommends** the analysis of prey abundance in relation to minke whale density from past and future surveys, in order to examine if the fluctuating distribution of minke whales could be explained by prey density.

The SC **strongly recommends** that a review of the stock structure be on the agenda of the next meeting, and it encourages progress in the fields of genetics (in particular regarding the Skaug's method of parent-offspring linkages) and satellite tagging (especially for looking at in-season short term movements).

9.4.4 Active Request and answer from the SC

9.4.4.1 Active request

R-1.7.10. - Once the survey has been completed, the Committee requested the SC 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 (NAMMCO 16).

Response by the SC

This request is being addressed with the near completion of most of the analyses of T-NASS minke whale survey data.

9.4.4.2 New request 3.3.4

R-3.3.4. - 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 (NAMMCO 17).

Response by the SC

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.

9.4.4.3 Future work needed by the SC for answering active request

The SC **recommends** that genetic work using Skaug's method for reviewing the stock structure of North Atlantic minke whales be completed as soon as possible and be presented to the next Assessment WG meeting on 26-28 January 2010. A British study on relatedness by Anderwalt is under review. The SC notes that she could be a useful participant to the next Assessment WG meeting.

The SC **recommends** that satellite tagging continues in Iceland (CIC) in spring 2009, to look at in-season short term movements as well as the autumn migration.

9.4.5 New recommendation for national research

See also above.

The SC commends the resumption of the collection of diet data from the catch and the continuation of minke whale data sampling in Norwegian waters in conjunction with the study on the impact of geological-seismic activities on whales. Furthermore, the SC **recommends** that the Icelandic catch be sampled with special attention to environmental changes.

The SC **recommends** that the analysis of the Greenlandic T-NASS shipboard survey be carried out and presented to the next WG on Abundance Estimate (AE WG) in October 2009 for endorsement, together with results of the aerial survey.

Provisional abundance estimates of minke whale for the Icelandic and Faroese shipboard surveys were presented at the Assessment WG. The SC **recommends** that final analysis be presented to the next WG on AE WG in October 2009 for endorsement.

The SC **recommends** that the spatial distribution analysis be undertaken, and that body condition indices in the Barents Sea and Iceland be analysed.

The SC **reiterates its recommendation** that an investigation of potential changes in the ecosystem be done within the framework of the WG on MMFI. This investigation would complement the spatial analysis of survey data. The SC noted that cooperation with Japanese scientists with experience in similar studies would be fruitful.

9.5 Narwhal

9.5.1 Update on national research progress (incl. new estimates) and future research plans

Greenland

A successful survey was performed in East Greenland in August 2008, covering the summering areas (Scoresby Sound, Blosseville Coast, Kangerlussuaq and Tasiilaq). The abundance estimates developed for East Greenland are the first estimates in the Scoresby Sound fjord system south to Ammassalik.

The abundance estimate for narwhals in Melville Bay, developed from the August 2007 survey, is the first estimate from this locality, since past aerial surveys had failed with no narwhals detected.

9.5.2 Review of SC recommendations for research from earlier and "answers" by countries

The SC recommended the analysis of survey data, with full correction of bias, which was done.

The SC also recommended the monitoring for "struck and lost", and noted that no studies had been implemented in Greenland.

SC15 recognized that the preliminary data on abundance of narwhal and beluga show higher estimates and encouraged Greenland to submit fully corrected estimates derived from the March 2006 and August 2007 surveys to the NAMMCO/JCNB Joint Working Group (JWG). The recommendation was followed and estimates were submitted to and endorsed by the JWG in February 2009 (item 9.5.3 below).

9.5.3 Report on the Joint NAMMCO/JCNB Scientific Working Group – narwhal

Witting presented the report of the JWG (Annex 1, SC/16/15) concerning narwhals, on behalf of the NAMMCO JWG chair, Rod Hobbs.

Stock structure

New information on movement patterns of narwhals in Baffin Bay from satellite tracking data were used to update the meta-population model adopted previously by NAMMCO. Compared with the previous model, the following changes were endorsed by the JWG, with the updated information as shown in Fig. 2:

1. the Smith Sound stock and Inglefield Bredning stock may be connected;
2. satellite tracking shows that narwhals from Melville Bay contribute to the hunt in Disko Bay and may contribute to the spring hunt in Uummannaq;
3. satellite tracking shows that narwhals from Admiralty Inlet may contribute to the winter hunt in Disko Bay and to the hunts in Eclipse Sound, Somerset Island, and the east coast of Baffin Island;
4. narwhals in Cumberland Sound do not seem to be a discrete unit; instead the hunt in Pangnirtung is likely supported by whales from fjords on East Baffin Island and from Admiralty Inlet.

The JWG agreed that satellite tagging provides the best available method to investigate inter-stock movements. However, to this day the sample size does not allow for reasonable probabilistic modelling. The JWG recognized the need for a larger dataset and encouraged further tagging.

Biological parameters

Recent work on ageing using aspartic acid racemisation of eye lenses shows that narwhals live longer than previously believed. No difference was found in the age structure and reproductive rates between narwhals in East and West Greenland.

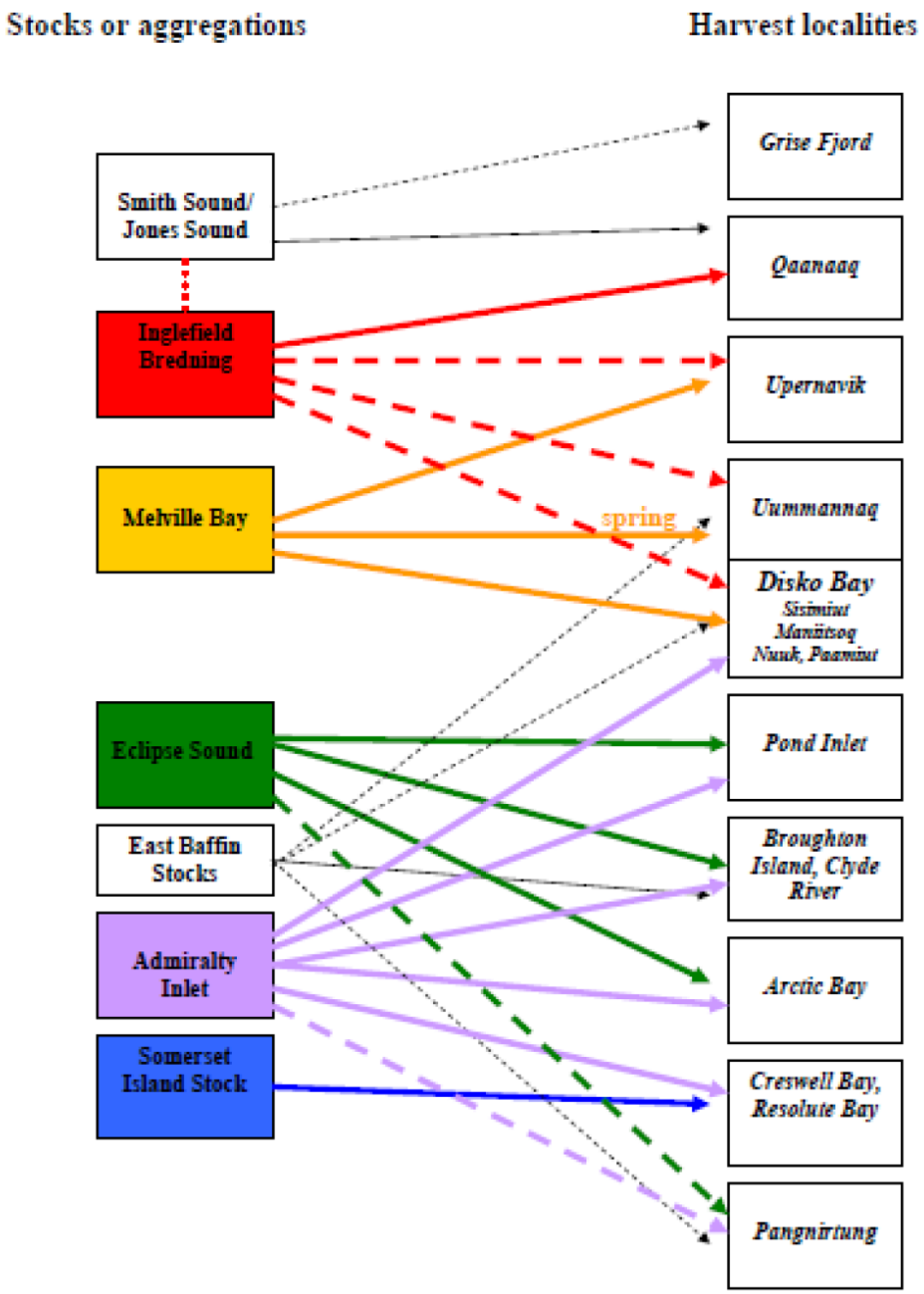

Fig. 2. Conceptual model of the relationships between stocks or aggregations and hunts in different areas for Canadian and West Greenland stocks of narwhals, as updated at the 2009 JWG (SC/16/15). The solid arrows indicate known contributions, while the dashed and dotted arrows illustrate unknown varying levels of contributions to the hunt.

Stomach samples indicate that narwhals in both East and West Greenland do not feed intensively while on the summering grounds.

Catch statistics

The JWG reiterated the importance of addressing the problem of "struck and lost" animals. Canada has initiated a hunt monitoring programme in Admiralty Inlet and Repulse Bay that requires one more season of data collection. In Greenland the reporting of "struck and lost" is a component of the catch reporting system, however, the method has not been validated.

Two ice entrapments were reported in 2008. In February, 30-45 narwhals were taken from an entrapment in the Sermilik fjord-system in East Greenland. In November, hunters of Pond Inlet took 629 narwhals from a pressure crack extending southwards from Bylot Island.

The reconstructed catch histories for narwhals in West and East Greenland were updated with recent catches, and a reconstruction of the commercial and subsistence harvests of narwhals from the Canadian Eastern Arctic had been compiled in response to a request raised at the 2003 JWG meeting.

Abundance

Surveys of all the major narwhal hunting grounds in West and East Greenland were conducted between 2006 and 2008 and fully corrected abundance estimates were calculated for all areas. These surveys were conducted as line-transect surveys from a Twin Otter with two independent bubble window observer platforms (4 observers). The estimate of the abundance of narwhals on the West Greenland wintering ground was 7,819 (95% C.I.: 4,358 – 14,029). The summer estimates were 8,447 (95% C.I.: 5,224 – 13,658) for Inglefield Bredning, 6,235 (95% C.I.: 1,461 – 26,603) for Melville Bay, and 6,583 (95% C.I. 2,541 – 17,052) for East Greenland. All the estimates were endorsed for use in assessments.

A double-platform visual aerial survey over the narwhal wintering grounds in Baffin Bay, West Greenland in April 2008 yielded a fully corrected estimate of 17,000-19,000 narwhals (95% C.I. 8,342-44,810). The uncorrected estimate of 3,484 (CV=0.45) compare with an estimate of 5,348 (CV=0.43) for the same transects in March 2000. This area is an important wintering area for narwhals from Admiralty, Eclipse and Melville stocks and may provide the bulk of the annual energy budget of narwhals, which feed extensively on Greenland halibut in that area. The JWG concluded that the area is critical to these narwhal populations, and supported the recent measures taken by DFO to close an area within NAFO Division 0A to Greenland halibut fishing. The JWG requested that this fishing closure continue in order to protect the narwhal, their major food, and winter habitat.

The 2002 to 2004 aerial surveys of narwhals in the Canadian High Arctic had been reanalysed in response to a request at the last (2005) JWG meeting. This resulted in approved estimates of 27,662 narwhal for the Prince Regent and Gulf of Boothia area, of 20,211 for the Eclipse Sound area, of 10,078 for the East Baffin Island fiord area,

and of 5,361 for the Admiralty Inlet area (latter estimate is thought to be negatively biased). These results showed that the summering range of narwhals in the Canadian High Arctic was vast and that the total number of narwhals may exceed 60,000 animals.

A survey is planned for Admiralty Inlet in mid-August 2009 and for the North Water and Smith Sound in May 2009.

Assessment

West Greenland

As at previous meetings, the JWG agreed to use a Bayesian approach to assess the status of narwhal in Greenland. It was found that West Greenland narwhal had declined in numbers more or less continuously until the present, and that an average annual removal of 360 narwhal over the last 3 years is close to an estimated replacement yield of 380 (95% C.I.:160-570) individuals. The population in 2009 was estimated to be at 51% (95% C.I.: 27-79%) of the carrying capacity, with a 2009 abundance of 12,000 (95% C.I.: 6,200-26,000) individuals. Assuming a uniform prior on the msyr from 0.015 to 0.04, it was estimated that annual takes of 185 to 270 narwhal over the coming 5 years will leave the population an 80 to 95% probability of a continued increase until 2014.

Probability population will increase	Total catch	Inglefield Bredning stock	Melville Bay stock
95%	185	137	48
90%	218	161	57
80%	270	199	71
70%	310	229	81
60%	350	258	92
50%	378	279	99

Table 3. Recommended total annual removal levels for narwhals in West Greenland under different probabilities of population increase. The catches are distributed relative to the point estimates of abundance in Inglefield Bredning (8,447) and Melville Bay (6,235). Catches from the Melville Bay stock are assumed to supply the hunt in Upernavik and Savissivik. Catches from Inglefield Bredning are supposed to supply Qaanaaq (incl. catches in Smith Sound but not Savissivik), Uummannaq and Disko Bay.

The assessment model assumed that narwhals harvested in West Greenland belong to a single stock. While this may unlikely be the case, the single stock approach was applied as an averaging approach that made it possible to reconcile the majority of the abundance and catch data in a single model for the estimation of a recommended harvest level for West Greenland as a whole. Abundance data from different areas were then used afterwards to allocate the total recommended removals between areas. The

uncertainty associated with this approach was tested by a two-stock model that applied two assessment runs; one for Inglefield Bredning and another for Melville Bay with catches taken outside these areas being divided between the two stocks. The estimates of total removals were practically identical between the single-stock and the two-stock model. Table 3. above gives the probabilities of increase for West Greenland narwhal given different levels of annual removal.

The results of the assessment at this meeting are quite different from the results of the last two meetings. The 2005 assessment suggested that narwhals in West Greenland were highly depleted with safe harvest levels being as low as 15 to 75 whales per year. The reason for the change in the recommendation between the two meetings is the new abundance estimates for the two summer aggregations in West Greenland. In the 2005 assessment, the low abundance estimates from Inglefield Bredning in 2001 and 2002 suggested a decline from a much higher abundance in 1986, and there was no abundance estimate for Melville Bay. Surveys conducted in 2007 and 2008 suggest instead that the number of narwhals in Inglefield Bredning has fluctuated, and there is now also an estimate for Melville Bay.

East Greenland

Historical catches and the abundance estimate from 2008 were combined with density regulated population models to perform a Bayesian assessment of narwhal in East Greenland. It was estimated that East Greenland narwhals have declined slowly in number since 1955, that they are relatively un-depleted with abundance above the maximum sustainable yield level, and that an average annual removal of 105 narwhal over the last 5 years is just above 90% of the point estimate of MSY. It was estimated that annual takes of 50 to 73 narwhal over the coming 5 years will give an 80% to 95% probability that takes are smaller than 90% of the MSY.

Probability	Total removals
95%	50
90%	60
80%	73
70%	85
60%	97
50%	109

Table 4. Total annual removal levels for narwhals in East Greenland under different probabilities of fulfilling management objectives.

It was noted that narwhals in East Greenland are estimated to be above the MSY limit. The most appropriate management objective is therefore not a continued increase in abundance. The JWG therefore apply the management objective that catches should be no more than 90% of the MSY, should the population be above the MSY level; while the objective is an increase, should the population be below the MSY level. Table 4.

presents annual total removal levels for narwhals in East Greenland given different risk probabilities of fulfilling management objectives from 2009 to 2014.

Implementation of earlier advice
For narwhals in Greenland a quota has been implemented which reduced the catch level. How this has affected the narwhal populations is unclear.

IUCN
The JWG commented on the recent IUCN species listing of beluga and narwhal in the category of "Near Threatened". It noted that this classification was overly pessimistic. Concerns that JWG has expressed with respect to specific stocks in the past should not automatically be applied to the species as a whole. Given both the fact that narwhals and belugas are not harvested in many parts of their range, harvests are low relative to global species abundance, and the new data presented at the last two meetings of the JWG on recent large abundance estimates for Greenland-Canada populations, the JWG suggests IUCN should revisit or revise their classification.

Discussion by the NAMMCO SC
The SC thanks the JWG for its thorough review of status and endorses the assessment. The SC **commends** particularly the recent abundance survey in Melville Bay. It notes that the surveys conducted in 2007 and 2008 in Inglefield Bredning (IB) suggested that the number of narwhals in IB had fluctuated, and the outcome of this assessment compared to that of 2005 had changed for the better. It welcomes the survey in East Greenland and the assessment for that stock, so that now for the first time, the SC is in a position where it can provide management advice for narwhals in East Greenland. The SC **supports the recommendation** for research given by the JWG.

The SC takes note of the JWG recommendation to close the Greenland halibut fisheries on the narwhal wintering grounds in Baffin Bay and the suggestion for IUCN to revisit or revise their classification of narwhals.

9.5.4 Active Requests and answers from the SC

9.5.4.1 Ongoing request 3.4.10

R-3.4.10. - 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 Council therefore recommends that future surveys for beluga and narwhal should be planned using the international expertise available through the SC 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 (NAMMCO 15).

Response by the SC

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.

9.5.4.2 New request 3.4.11

R-3.4.11. - The SC is requested to update the assessment of both narwhal and beluga, noting that new data warrant such an exercise (NAMMCO 17).

Response by the SC

The SC **endorses the assessment** performed by the JWG, 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 West and East Greenland narwhals, i.e. maximum total removals of 310 and 85 narwhals in West and East Greenland respectively.

9.5.4.3 Future work needed by the SC for answering active requests

All active requests have been answered.

9.5.5 New recommendation for national research

The SC **recommends** that the following research recommendation be implemented:

- further tagging studies to collect information on the behaviour of individuals, while acknowledging that other methods such a photo identification and genetic mark-recapture may be necessary to fully characterize the relationships between harvest locations and stocks;
- surveys repeated every 3 to 5 years to update abundance estimates;
- collection of struck and lost data from all areas and types of hunt;
- data on age structure included in the assessment model if appropriate.

9.5.6 Other business

The narwhal quotas for West Greenland and Melville Bay for the period from 2004 to 2009 are given in Table 5 below.

Period	Original quota	Final quota	Recommended quota for WG
July 2004 – June 2005	WG 300 (incl. 100 for Qaanaaq) MB ???	WG 300	WG 135
July 2005 – June 2006	WG 260 MB ???	WG 310	WG 135
July 2006 – June 2007	WG 260 MB 115 + 10 for distribution in spring	WG 217 MB 115	WG 135
July 2007 – June 2008	WG 200 MB 100	WG 210 MB 90	WG 135
July 2008 – June 2009	WG 260 MB 130		WG 135

Table 5. West Greenland and Melville Bay quotas for narwhals.

The SC notes that the quotas given for the period July 2008 - June 2009 of 260 and 130 narwhals in West Greenland (WG) and Melville Bay (MB) respectively, gave a 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). The SC expresses concerns should such quota levels be maintained, and **reiterates its recommendation** that the probability of population increase be at least 70% both for West and East Greenland narwhals.

The SC **recommends** that IUCN revisits its classification of narwhals in the light of the new abundance estimates and the new assessment.

9.6 Beluga

9.6.1 Update on national research progress (incl. new estimates) and future research plans

Nothing special to be mentioned.

9.6.2 Review of SC recommendations for research from earlier and "answers" by countries

See item 9.5.2.

9.6.3 Report on the Joint NAMMCO/JCNB Working Group – beluga

Witting presented the report of the JWG (Annex 1, SC/16/15) concerning belugas.

No new information on stock structure was available to the meeting.

The historical catch series of beluga in West Greenland were updated, and catch statistics from selected communities in Nunavut were presented for landed animals for 2004 to 2008. In general Canadian takes have increased slightly since the previous report (with a 5-year average of 42 belugas landed in 2003, and a 5-year average of 59 today). High catches reported for Pond Inlet and Taloyoak require further examination.

Abundance

An aerial survey of wintering beluga in West Greenland in March-April 2006 updated a time series of beluga surveys going back to 1981. The fully corrected estimate was 10,595 (95% C.I. 4,904-24,650).

The largest abundance was found at the northern part of Store Hellefiske Banke at the eastern edge of the Baffin Bay pack ice, a pattern similar to that in the surveys conducted since 1981. A clear relationship between decreasing sea ice and increasing offshore distance of beluga sightings suggested that belugas expand their distribution westward with decreasing spring ice.

Assessment update

As at previous meetings, the JWG agreed to use a Bayesian approach to assess the status of beluga in West Greenland. West Greenland belugas have declined in numbers until 2004, where a two-fold decline in the catch, from more than 400 to less than 200 belugas per year, allowed the population to increase by approximately 8% until 2009.

The population in 2009 was estimated to be at 31% (95% C.I.: 14-61%) of the carrying capacity, with a 2009 abundance of 11, 000 (95% C.I.: 5,400-21,000) individuals. Table 6. gives the probability of an increase of West Greenland belugas given annual levels of removals.

It was remarked that the reduced takes may already be having a positive effect on population size. It was estimated that annual takes between 180 to 265 individuals over the next 5 years will leave the population an 80% to 95% probability of a continued increase until 2014. The 2005 model gave an 80% probability of increase with catches of 100, and a 51% probability for annual catches of 200. That model was based on index surveys and the 1998-99 abundance estimate. The JWG noted that the modelling for belugas rests on a more solid background than that for narwhals because of a simpler stock structure.

Probability of increase	Total catch
95%	180
90%	210
80%	265
70%	310
60%	355
50%	400

Table 6. Total annual removal levels for beluga in West Greenland under different probabilities of an increasing population between 2009 and 2014.

Ageing workshop for beluga and narwhal

A brief review of methods for age estimation in belugas and narwhals indicated a need to standardize ages using growth layers with new methods involving Aspartic Acid Racemisation. The JWG expressed broad support for a workshop convened and organized by NAMMCO. The JWG recommends that a steering group (chaired by Lockyer and including Stewart, Hobbs and Hohn) work inter-sessionally by e-mail to scope the problems and produce draft terms of reference for one or more workshops. The steering group will report inter-sessionally to the JWG with the expectation of an initial workshop before the end of 2010.

Discussion by the NAMMCO SC

The SC thanked the JWG for its thorough review of status and **endorses** its assessment. The SC is pleased to notice that the advised reduction of catches may already be having a positive effect on the population size and that the modelling exercise indicates a sign of recovery.

The SC **supports the recommendation** for research given by the JWG. It supports in particular the Ageing Workshop plans and encouraged the designated steering group to proceed with the preliminary work and produce Terms of Reference for the Group.

The SC takes note of the JWG suggestion for IUCN to revisit or revise their classification of belugas.

9.6.4 Active Requests and answers from the SC

9.6.4.1 Ongoing requests 3.4.9 and 3.4.10

R-3.4.9. - The SC 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 (NAMMCO 15).

Response by the SC

The SC is not in the position to progress on this issue at this point and recommends that habitat-related concerns becomes a standing item on the 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.

R-3.4.10. - See agenda item 9.5.4.1 above.

9.6.4.2 New request 3.4.11

R-3.4.11. - The SC is requested to update the assessment of both narwhal and beluga, noting that new data warrant such an exercise (NAMMCO 17).

Response by the SC

The SC **endorses** the assessment performed by the JWG. 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.

9.6.4.3 Future work needed by the SC for answering active requests

The SC **recommends** the organisation of a WG on the impact of human activities other than hunting, see item 9.6.4.2 above.

9.6.5 New recommendation for national research

The SC **recommends** cooperation between Canada and Greenland on collection of life history samples, and that data on “struck and lost” whales are collected from all areas and types of hunt.

The SC **recommends** that the validation of the new ageing method based on Aspartic Acid Racemisation continues. Also the SC **recommends** that NAMMCO supports an Ageing Workshop for standardizing ages using growth layers with new methods. It **recommends** proceeding with its organisation following the lines provided by the JWG. Zabavnikov informed that Russia is interested in participating in such a workshop.

9.6.6 Other business

The beluga quotas for West Greenland for the period from 2004 to 2009 are given in Table 7. The SC notes that the quota given for the period July 2008 and June 2009 of 260 belugas for West Greenland corresponds to a probability of population increase just above 80%, which is therefore within the recommendation of the SC.

Period	Quota	Recommended quota
July 2004 – June 2005	320	100
July 2005 – June 2006	220	100
July 2006 – June 2007	140 + 20 for Qaanaq	100
July 2007 – June 2008	145 + 20 for Qaanaq	100
June 2008 – June 2009	240 + 20 for Qaanaq	100

Table 7. West Greenland quotas for beluga.

Lydersen reported that Norway had for several years tried to get funding for a joint Norwegian-Russian genetics study of belugas in Finnmark and the White Sea, Frantz Josef Land and Svalbard without any success. The SC highly recommended that this project be funded at its 15th meeting.

The SC **reiterates its recommendation**, especially now that a preliminary organizational meeting has been held successfully in Tromsø, November 2008. See under item 8.6.5 above for more information on the meeting.

The SC **recommends** that IUCN revisits its classification of belugas in the light of the new abundance estimates and the new assessment.

9.7 Northern bottlenose whale (no active request)

9.7.1 Update on national research progress (incl. new estimates) and future research plans

Iceland

Thirty eight incidents of cetacean strandings were recorded in 2008 - the highest number since regular monitoring of strandings was initiated around 1980 – of which 11 were bottlenose whales. In the period 18 August 18 - 6 October 2008, a group of 5 bottlenose whales resided in the inner part of the fjord Eyjafjörður in northern Iceland. One of the animals got killed after getting entangled in fishing gear.

9.7.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 strongly recommended that the Faroese and Icelandic data on bottlenose whale feeding be made available as soon as possible. Faroes informed that the completion of these awaited the analysis of the 2008 samples.

9.7.3 New recommendation for national research

The SC **reiterates its recommendation** that Faroese and Icelandic feeding data be worked up into a paper and urges its presentation as a document to the next SC meeting.

The SC **reiterates** the request to analyse T-NASS acoustic data for this species.

9.8 Killer whale

9.8.1 Update on national research progress (incl. new estimates) and future research plans

Iceland

The project on acoustic communication in killer whales around Vestmannaeyjar, South Iceland was carried out jointly by the University of St Andrews, Scotland, scientists from Húsavík Research Center, Marine Research Institute (MRI), Reykjavik, and Zoovisions, Copenhagen, Denmark. The collaborative study between MRI scientists and colleagues from Norway and Scotland initiated in 2007 on stock structure and movements on killer whales in the northeastern Atlantic (Foote *et al.* 2007) continues.

Common minke whales were confirmed as a prey species of killer whales in Icelandic waters (see 9.4.1 above).

9.8.2 Review of SC recommendations for research from earlier and "answers" by countries

There were none.

9.8.3 Active Request and answer from the SC

9.8.3.1 Ongoing request 3.7.2

R-3.7.2. - The SC was requested 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 (NAMMCO 13).

Response by the SC

At their last meeting, the SC concluded that there was not enough information to carry out the assessment at this time, particularly for the West Greenland area. This situation remains unchanged.

9.8.3.2 Future work needed by the SC for answering active requests

Abundance estimate and information on stock structure are lacking for all areas.

9.8.4 New recommendations for national research

See 9.8.3 above.

9.9 Pilot whale

9.9.1 Update on national research progress and future research plans

Faroes

There has been no pilot whale drive in the Faroes in 2008, and no pods were observed off the islands. It is the first time since 1927 without any pilot whaling, although this was a regular phenomenon around 1900. In 2009 the first drive took place on 5 January.

9.9.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 reiterated its recommendation from SC14 that the latest satellite tagging data be published as a priority. This has not been done, but the SC was informed that the manuscript was close to being finished.

SC 15 made several recommendations regarding the monitoring of the Faroese drive fishery, including continuing the official logging of all catches, including length at age, calculating indices of abundance for all NASS/T-NASS surveys so that all surveys can be used in trend analyses, undertaking a new analyses and re-analyses of catch data and statistics and finally implementing an intensive short – term catch sampling programme of sex and age distribution over a 3-year period. No progress had been made on these issues but the Faroes have started a small *ad-hoc* sampling programme of the drive fishery.

9.9.3 Report of the Large Whale Assessment WG – pilot whale

The T-NASS 2007 abundance estimates for pilot whales were reviewed by the assessment Working Group in Copenhagen on the 23 March (Annex 2, SC/16/13).

A generalized additive model with spatial covariates used T-NASS Icelandic (shipboard and aerial) and Faroese (shipboard) data, as well as data from a concomitant seabird ship survey, to estimate the spatial density of pilot whales from the east coast of Greenland, over Iceland, to the Norwegian Sea as far south as the northern British Isles. The WG acknowledged the effort, but expressed concerns about the utility of the estimates provided given the wide confidence interval ranging from *ca* 40,000 to 4-7,000,000 pilot whales.

The primary objective of abundance estimation for management advice is to produce a series of absolute estimates that are comparable in time. The WG recommended that the first priority for further analyses should be to consistently apply a simpler method to the various pilot whale survey data sets available. The results from such an exercise should be presented at the Abundance Estimates WG in October 2009. The WG agreed that in the absence of a more precise estimate, it would not be able to complete an assessment.

Sixteen sightings of pilot whales from the aerial T-NASS survey off West Greenland in August and September 2007 were analysed by mark-recapture distance sampling to yield an availability uncorrected estimate of 3,900 pilot whales (CV: 53%). The WG suggested comparison of group size with previous surveys and possible correction for availability bias, and recommended that a re-analysis be presented for acceptance at the Abundance Estimates WG in October 2009.

Discussion by the NAMMCO SC

The SC acknowledges the review of the Assessment WG and **endorses its recommendation** that the first priority for further analyses from the 'Faroese' side should be to consistently apply a simpler method to the various pilot whale survey data sets available and to present these at the next Abundance Estimates WG meeting. The SC **strongly recommends** that the revised analyses of these two data sets, Faroese-Icelandic and Greenlandic, be presented at the next meeting of the AE WG in October 2009.

9.9.4 Active Requests and answers from the SC

9.9.4.1 Ongoing requests 1.7.10 and 3.8.4, 3.8.3

R-1.7.10. - Once the survey has been completed, the Committee requested the SC 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 (NAMMCO 16).

R-3.8.4. - ... In addition, priority should be given to the analysis of data on pilot whales after the completion of T-NASS.

Response by the SC

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 this year.

R-3.8.3. - 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 implemented. The Council requested therefore the SC to develop a proposal for the details of a cost-effective scientific monitoring programme for pilot whales in the Faroes.

Response by the SC

Last year, the SC presented a detailed plan with 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 this year.

9.9.4.2 Future work needed by the SC for answering active requests

Further analysis of the T-NASS data is needed, following the recommendation above.

The implementation of the 3-year intensive short–term catch sampling programme of sex and age distribution is a prerequisite to the identification of a long-term monitoring programme of the Faroese drive fishery.

9.9.5 New recommendation for national research

The SC **reiterates its previous recommendations** that the latest satellite tagging data from 2004 be published as a priority.

The SC also **reiterates the recommendation** from SC 15 regarding the Faroese drive fishery see under 9.9.2.

9.10 White-beaked, white-sided and bottlenose dolphins

9.10.1 Update on national research progress (incl. new estimates) and future research plans

Iceland

Results from an experiment conducted in Faxaflói Bay demonstrated that white-beaked dolphins have the most sensitive high frequency hearing of any known dolphin (Nachtigall *et al.* 2008).

Photographs for individual identification of white-beaked dolphins and common minke whales were collected from whale watching platforms in Faxaflói Bay in 2008.

Faroes

Tags have been purchased for initiating a satellite tracking study for this species.

Russia

The ecosystem survey in 2008 sighted more than 100 animals close to Hopen Island, more than 100 close to the Stockman Oil Field and around 50 in Kola Bay, while no observation had been made in 2007.

9.10.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 recommended that data from the T-NASS survey and the Norwegian shipboard surveys be analyzed for this species. No progress has been made on this.

9.10.3 Active Request and answer from the SC

9.10.3.1 Ongoing request 3.9.6

R-3.9.6. - The Management Committee has asked the SC to carry out assessments of these species (*Tursiops truncatus, Lagenorhynchus sp.*), 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 item 9.3) should provide information on distribution and abundance in some areas. The Committee endorsed the plan of the SC to proceed with the assessments once the above-mentioned studies have been completed, probably by 2007 (NAMMCO 13).

Response by the SC

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.

9.10.3.2 Future work needed by the SC for answering active requests

The SC **reiterates its recommendation** that data from T-NASS (including Greenlandic and Icelandic aerial surveys) and the Norwegian shipboard surveys be analyzed for these species, at least for white-beaked, and maybe white-sided dolphins.

The SC notes that the result from the programme on the biology of the white-sided dolphin in the Faroes was awaited for the completion of an assessment and recommends that this programme proceed swiftly and that results, even partial, be presented at the next meeting of the SC.

9.10.4 New recommendation for national research

See item 9.10.3 above.

9.11 Harbour porpoise

9.11.1 Update on national research progress (incl. new estimates) and future research plans

Faroes

One porpoise was tagged in September 2008 and tracked for 49 days. The animal remained in the tagging area during the whole period. A small research project on abundance of harbour porpoises on the Faroe plateau is planned for summer 2009.

9.11.2 Review of SC recommendations for research from earlier and "answers" by countries

SC 15 noted that estimates of abundance and removals are still needed in all areas.

Iceland

The abundance data from T-NASS for the Icelandic coastal areas are presently being analysed. See under item 7.1 for progress on removals.

Greenland

The analysis of T-NASS data is planned.

Faroes

No progress on abundance nor removals, but see item 9.11.1 above.

Norway
No progress on abundance. See under item 7.1 for progress on removals.

9.11.3 Active Request and answer from the SC

9.11.3.1 Ongoing request 3.10.1

R-3.10.1. - 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 SC to perform such an assessment, which might include distribution and abundance, stock identity, biological parameters, ecological interaction, pollutants, removals and sustainability of removals (NAMMCO 7).

Response by the SC
Information was still lacking on abundance in all areas and removals in Faroes, Iceland and Norway (see also under item 7.1) 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.

9.11.3.2 Future work needed by the SC for answering active requests
The assessment of total catches (direct and indirect) as well abundance estimates are still needed in all areas. The SC recommends that these be obtained as soon as feasible.

9.11.4 New recommendation for national research
Regarding the Faroese plans for a shipboard survey on the Faroese plateau in 2008-2009, the SC **reiterates its recommendation** that this survey be designed to be compatible with SCANS II and later harbour porpoise surveys, with compatibility with SCANS II as a minimum.

The SC **recommends** that the analysis of T-NASS data be presented for review at the next AE WG in October 2009.

9.12 Surveys
9.12.1 T-NASS update
The next meeting of the AE WG will be in October 2009 in Quebec, Canada, just prior to the Society for Marine Mammalogy Biennial Conference, together with representatives from CODA and SNESSA. The SC **recommends** that the estimates not yet reviewed and endorsed by the group would be presented there.

The AE WG meeting will be followed by a half-one day workshop with the following aim:
"This workshop will provide participants an overview of the large-scale marine mammal surveys conducted in the north Atlantic in the summer and fall of 2007. Rationale, methods, analytical approach and results (and many anecdotes!) will be

presented from the Trans North Atlantic Sightings Survey (T-NASS), Southern New England to Scotian Shelf Abundance (SNESSA), and Cetacean Offshore Distribution and Abundance (CODA) surveys. In addition to providing information on the first pan-Atlantic marine mammal surveys, workshop attendees will be invited to comment and contribute to further analysis and interpretation. It is planned that a report will be created from these deliberations that will summarize the results of the three surveys, and provide suggestions and solutions for future surveys at similar scales." (http://www.marinemammalscience.org/index.php?option=com_content&view=article&id=327:tnass-snessa-coda-survey-review&catid=918:workshops&Itemid=215).

The SC welcomes this information and tasks the group with, in particular, identifying the best 2007 abundance estimate for minke whale in the Central Iceland Coastal (CIC) area.

The SC reminds that SC 15 had agreed that further cooperation in coordinating the output from the T-NASS project was of great importance. It recommended also that a primary publication on the planning, conduct and results of the T-NASS, particularly pertaining to general distribution of cetaceans throughout the entire survey area, including the extension areas, be produced as a priority. CODA and SNESSA had agreed to participate in this. The Committee had recommended that the publication be given a high priority.

The SC noted that not much progress had been made towards this publication and **highly recommends** that the publication be prepared for presentation at the next meeting of the AE WG in October.

The SC 15 also recommended the analysis of sperm whale T-NASS acoustic data. Iceland informed that the present plan was to start the analysis in the autumn in cooperation with Universities of St. Andrews and Iceland. The first step would be to organize a course in Iceland on the analysis of such acoustic data, with a teacher from St. Andrews. Abundance estimates were expected for sperm whales, while probably only distributional data would be obtained for bottlenose whales. This acoustic course will be held in September - October 2009, and will be sponsored by NAMMCO (some funding is already secured from the 2008 SC budget) and will be open for all NAMMCO countries, although the number of participants will be limited to a small number. The SC **recommends** proceeding swiftly to the organization of this course.

The SC **recommends** a timely completion of all T-NASS analyses and their presentation to the next WG on AE.

9.12.2 Future surveys

The SC noted that if NAMMCO was willing to continue the 5-6 years' cycle of surveys, the next survey will be in 2012 or 2013, which is quite soon noting that the preparation of T-NASS 2007 started at the SC 12 meeting in October 2004.

The SC noted that SC 15 had reiterated the importance of synoptic surveys in interpreting shifts in distribution and recommended that recent indications of changes

in distribution (i.e. spatial dynamics) related to environmental changes should be taken into account when designing future surveys.

Canada informed that it could probably not join a large cetacean survey on the Atlantic coast survey in 2012-13 without external funding, due to the financial priorities in Canada. It could probably join the following large survey.

The SC **recommends** that the planning of a future survey and its extent should be taken up at the next meeting of the AE WG at the October 2009 meeting.

10. GENERAL MODELS FOR MANAGEMENT

10.1 New request and answer from the SC

R-3.10.1. - The SC is requested to study general models for conservation and management of baleen whales, *inter alia* based on Norwegian studies presented to the SC of the IWC (in 2008).

Response by the SC

The SC discussed the way to proceed through correspondence and agreed to task the AE WG to make recommendations on this issue.

10.1.1 Report of the Large Whale Assessment WG – general management models

In the absence of Walløe, Chair of the WG, Witting presented the report of the WG, which met in Copenhagen on March 23 (Annex 2, SC/16/13).

The WG suggested that the simulation tested Management Procedure approach developed in the IWC provides the preferred process for provision of advice on management measures for baleen whales, such as catch limits in NAMMCO. It has a number of advantages over the more *ad hoc* approach based on current "best assessments", for reasons that have been elaborated by various authors (e.g. Butterworth, 2007; Punt and Donovan, 2007).

There was, however, a substantial burden in terms of the resources (primarily professional time) required to implement this approach, though once implemented it can run more smoothly and at less cost than the "best assessment" approach. It should be noted that substantial additional resources would be required, but these can be somewhat reduced by making use of work already carried out, particularly that in the IWC SC.

A start could be made with Management Procedures already developed and tested, such as those of Cooke (IWC 1994) and Aldrin *et al.* (2006 a, b) , and for simpler situations that of Witting (2008). A list of stocks for which management advice might be required should be developed, so that for each case an initial appraisal can be made of which of these procedures might be the most appropriate to apply initially.

Over time, the control parameters of the Procedures could be adjusted to provide performance that better meets the Council's objectives for whaling. The costs of the

simulation testing required to ensure that the Procedures adjusted in this way remain sound could be much reduced if it can be developed in a way that uses software already developed in the IWC for simulation testing.

Discussion by the NAMMCO SC

The SC **agrees** that the RMP implementation simulation process (IST), which has been intensively validated and is freely available, provides a good framework for identifying sustainable management approaches.

Applying this approach would, however, significantly increase the workload of NAMMCO and there will be a need to strengthen the assessment capabilities including inviting external experts. All requests would be referred to the AE WG.

The implications are that NAMMCO will need extra manpower and funds. It is paramount that Council is made aware of the cost implications of their decisions about how to proceed with management decisions.

In conclusion, 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.

10.2 Discussion on ways to proceed and future work

The SC awaits further instruction from Council.

11. NAMMCO SCIENTIFIC PUBLICATIONS

11.1. NASS (NAMMCO *Sci. Publ.* vol. 7)

This publication on the North Atlantic Sightings Surveys is currently in technical editing with Daniel Pike. The long delay in publication since last year's SC meeting's expectation that the volume would now be published, has been partly due to problems with computing at the Secretariat and relocation of the office. The publication date will now be, at the latest, June 2009. Acquarone urged the SC to send in photos depicting survey-related activities to illustrate the book.

The SC **expresses strong regrets** about the delay but was pleased that the volume will be published now.

11.2 Harbour seal (NAMMCO *Sci. Publ.* vol. 8)

The editors are Desportes, Bjørge, Rosing-Asvid and Waring. The original planned date for publication was January 2009. Thirty one manuscripts were proposed for the volume, 28 have been received of which two have been rejected. 3 manuscripts have not yet been received, one of them being the general introduction to the volume and is being worked upon. From the 26 manuscripts recommended for publication, 14 are to date finally accepted and at the Secretariat.

There is funding in the NAMMCO budget for getting the volume published in 2009. It is now imperative to proceed with publication in 2009 even if two papers are excluded.

The SC **strongly recommends** that all efforts be made in getting the volume published in the early autumn. This was specifically important for the image of the NAMMCO special publication, after the enormous delay in publication of the NASS volume. The SC **strongly recommends** that all means be taken towards finalizing these two publications, including use of external expertise/technical editing if needed for keeping to the deadline.

11.3 Future plans

11.3.1 T-NASS volume

The IWC had proposed a special journal publication issue for T-NASS, SNESSA and CODA. This was acceptable to both SC and Council. However, as this is a journal, NAMMCO cannot feature in the cover of the book. There could nevertheless be two volume editors – Donovan (IWC) and Acquarone (NAMMCO). This matter can probably be settled at the AE WG meeting in October 2009, when the number of analyses and papers available for publishing will be known. The SC **strongly encourages** that the contributions to this WG meeting be published in the common publication.

11.3.2. Other: Mode of publication of scientific volumes

There was a discussion on the relative merits of web publication vs. hard copy publication. At its last meeting the SC recommended looking into the possibility of making the NAMMCO Publications Series available online. All members were still in favour of web publication as the visibility and availability of publications to the scientific community increased and expenses were also reduced, and not the least, speeded up publication time.

Online publication of all of the NAMMCO Scientific Publications will increase circulation among the research community and other domains. It will also reduce costs of publication. This option may make it also feasible to publish key papers contributed to most major WG meetings, also when a Special Volume on that particular issue was not warranted.

Assuming that the series would then become available online, the Council could however decide to keep producing a small quantity of hard copy publication for distributing to libraries and maybe to authors and reviewers.

The SC **recommends** that Council takes a decision at its next meeting, since it will be applicable to the harbour seal volume, which will then be hopefully close to completion.

One problem now is also the delay between the meeting of a WG and the subsequent publication of a special volume. For the grey seal volume, the WG met in April 2003, and the volume was published late in 2007. For the harbour seal volume the WG met in October 2006 and hopefully the volume will be published autumn 2009. This delay

sometimes implies losing key papers because the authors want to make sure that they are published rapidly. It makes the NAMMCO publication less attractive. One of several reasons for this delay is that the publication has first to be accepted by the SC, then by Council. Then contact has to be taken again with the WG members, who have meanwhile moved to other things.

One solution could be to have an annual allowance for publication of e.g. 60,000 NOK to allow for publication of one volume of WG papers. Principle approval could be obtained from Council in advance of WG meetings. If the work presented at the WG meeting warrants such a publication, and the WG agrees, then a 2-3 month deadline for submission can be given at the WG itself. The final decision to follow through could always be retracted.

The SC **recommends** that Council takes a decision on this at its next meeting, since it could then be applicable immediately to the WG on Walrus Assessment.

The SC **recommends** that all volumes published in hard copy to date should over time be uploaded online in .pdf format to the NAMMCO website.

There was a suggestion also to upload certain key working documents onto the NAMMCO website. The SC had diverse opinions on this. However Stenson informed that this route had been very successful in Canada.

The Canadian Science Advisory Secretariat (CSAS) coordinates the peer review of scientific issues for the Department of Fisheries and Oceans. Working with the CSAS, the different Regions of Canada conduct resource assessment reviews. In addition to identifying national issues of concern, the CSAS coordinates communication of the results of the scientific review and advisory processes by publishing reports on the status of stocks, environmental and ecosystem overviews, research documents featuring detailed scientific information and proceedings of peer review meetings. These documents are available online (www.dfo-mpo.gc.ca/csas) in Portable Document Format (PDF).

Three basic types of documents are available. Science Advisory Reports document the status of different stocks of fish, invertebrates and marine mammals in Canada as well as some ecosystem and environmental issues. They are intended to provide summaries of the information in an easy to understand format that is available to the general public. The Proceedings Series contains publications which record the activities at meetings or workshops. The Proceedings generally record decisions, recommendations, and major points of discussion at these meetings and workshops. Research Documents record the scientific basis for the evaluation of fisheries resources and provision of advice. These documents describe the science used to support the assessment. As such, they describe, in detail, the scientific studies available and together with previously published documents, provides the basis for the scientific advice provided during the assessment meeting. Research documents are based upon working papers presented at the meeting that have addressed concerns and/or questions raised by participants during

the scientific review. These documents are often progress reports on ongoing investigations and as such, carry a *proviso* that they are not to be cited without prior approval of the authors. They often form the basis for more detailed publications that are published in the primary literature.

The SC considers that this option was interesting to NAMMCO and potentially valuable as a resource, but more time would be needed to make a decision on this matter.

12. PROPOSAL FOR THE DEVELOPMENT OF A NAMMCO "SPECIES STATUS LIST"

Desportes presented a proposal for the development of a NAMMCO Species Status List (SC/16/25). On several occasions SC members have questioned the appropriateness of the current listing of different species (and/or stocks) in the CITES appendix and the IUCN Red List. The two most recent occasions are for fin whale in 2006 and for beluga and narwhal at the last Joint JCNB/NAMMCO Working Group on Narwhal and Beluga (JWG) in February 2009. SC14 concluded that "on the basis of biological information including population distribution and abundance and stock structure, with reference to CITES criteria A, B and C, the fin whale population in the region of the Central North Atlantic (the EGI stock) does not meet any of the biological criteria for listing under CITES Appendix I (threatened with extinction)" (NAMMCO 2006). The JWG agreed that the recent IUCN species listing (2008) of beluga and narwhal in the category of "Near Threatened" was overly pessimistic and that IUCN should revisit or revise this classification (See under points 9.5.3 and 9.6.3).

Also, the SC has several times considered unappropriate that, in most cases, species were considered as a whole and not stock by stock (e.g. fin whale, beluga and narwhal in the CITES Appendix and IUCN Red List), as the conservation status of different stocks often varies greatly. Besides, the species status was not updated very often and that updating is a rather heavy process, in particular when down listing is proposed. The IUCN Red List has also in recent years been criticised for poor documentation surrounding the sources of data and sometimes the process leading to the final listing, after the review process.
Compared to other status lists, the NAMMCO List, which would not have any legal implication (e.g. regarding trade), and should only be seen as an information list, would have at least three big advantages:

1. Stocks and not species as a whole would be considered and given a conservation status.
2. Good documentation on and accessibility of the documents forming the basis for the assessment. The data and analysis forming the basis of the assessment would be clearly referred to and made accessible through the website.
3. The List would be updated at each SC meeting, i.e., on an annual basis. The conservation status of the stocks would stand as a standard element on the agenda of the SC every year, as well as being a specific point of the agenda of relevant WGs. The status list would therefore be updated annually after every

meeting of the SC, taking into consideration the most recent analysis endorsed by the SC.

NAMMCO would not make its own classification system, but reuse an accepted classification system. Several candidates were identified, The FAO FIRMS classification was considered a better candidate than the CITES or the IUCN classification, because it was built with the same purpose as the NAMMCO List, while the two others were built for two very different purposes, respectively trade control and conservation flagging.

Discussion by the NAMMCO SC

The SC agrees with the background of the proposal, and criticizes the general approach adopted in generating the IUCN and CITES listings (e.g. fin whale, beluga and narwhal in the CITES Appendix and IUCN Red List) and of applying the criteria on species globally rather than stock by stock because the conservation status of different stocks often varies greatly. For baleen whale species with a global distribution (including fin whales, see under item 9.1.6) such a global assessment will always be completely dominated by the heavily depleted southern hemisphere stocks because of their great historical abundance.

Therefore the SC **recommends** that NAMMCO looks into the possibility of developing its own Conservation Status List for the population/stocks relevant to the NAMMCO areas. The NAMMCO Status List would be placed on the NAMMCO website, but also be directly accessible, without passing through the NAMMCO website, in the same way as other Species Status Lists.

The SC **recommends** that NAMMCO does not make its own classification system, but uses an accepted and validated classification system. Should the Council approve of the idea of a list, the SC recommends that an email correspondence group make a review of the different classification systems existing (*pros* and *cons*), especially in relation to workloads required. The group should be composed of a member of each country as suggested (Desportes (Chair), Ólafsdóttir, Rosing Asvid and Walløe).

13. ESTABLISHING NAMMCO DATABASES FOR SURVEY AND CATCH DATA

13.1 Catch data - direct and indirect catch

13.1.1 Format for catch reporting, including input to assessments

The SC **recommends** that NAMMCO uses a joint IWC-NAMMCO database for large whales. Bloch informed that her database may be more detailed but nevertheless includes the same base data as the IWC. The Secretariat agrees to contact the IWC about this matter.

Compiling databases and validating data in NAMMCO requires much manpower. It was proposed that each country have a responsible person who manages national data.

For the moment, it was suggested to have all catch data, including historic catch data – already validated - compiled nationally and then updated annually for a central

database at NAMMCO. It was noted that large whale data sent to the IWC were already validated.

The SC agrees that catch data should be removed from Progress Reports and instead placed in an Appendix to the SC report. All data should be supplied as historic catch series, updated annually, in electronic format.

The SC **recommends** that Acquarone consult with SC members for designing new formats for data reporting and the modified progress reports, in due time before the next meeting.

13.1.2 Format for by-catch reporting

The SC **recommends** that a standard format be developed by the WG on By-Catch for all countries, based on the model developed by the ICES SG on By-catch.

13.2 Survey and sightings data

The SC **recommends** that for abundance estimates adopted by NAMMCO to be used in stock assessments, corresponding block coordinates as well as papers and references that relate to the estimation, be archived at the Secretariat for all species as soon as possible.

The SC **recommends** that the Secretariat starts with narwhal and beluga, for which part of the compilation has already been done (see e.g. NAMMCO 2005, page 245). The Secretariat would then continue with compiling the information regarding the species which will be dealt with at the next assessment WG, so this is ready by that time. The SC **recommends** that the AE WG meeting in the fall advise on the best format that should be used.

The SC discussed the storage of validated sightings data (T-NASS) at the NAMMCO Secretariat. At its last meeting the SC recommended that T-NASS data be transformed in a format similar to the one employed by the IWC and be archived at the NAMMCO Secretariat with the necessary clauses for use restrictions. It was noted that there were some questions regarding differentiation between NAMMCO (T-NASS) data and national data and the role of NAMMCO as an archive store or merely a backup facility.

13.2.1 OBIS-SEAMAP database

Víkingsson presented information about OBIS-SEAMAP database in SC/16/20. The SC agrees that the site looks very good and promising, but there were reservations about data security, although it was stated that permission must be given before any data can be used publicly by others. Placing data here (e.g. from NASS surveys) would increase the visibility of such data. However, probably only the most basic information should be submitted. Stenson reported that DFO, Canada, had considered using this service but there were some questions about security and data quality. The SC notes that members were free to submit national data, but more time was required to consider the participation by NAMMCO.

The SC agreed at its last meeting that distribution maps for all T-NASS species, including sightings from the main T-NASS and extension areas, as well as the CODA and SNESSA surveys, should be developed and posted as a priority on the NAMMCO website. The SC **reiterates this recommendation** that distribution data from the T-NASS survey (and NASS) be made visible on the NAMMCO website, as distribution maps. This would be a good way to increasing the visibility of the data but also of the work accomplished under NAMMCO. The bulk of the work will have been done during the preparation of the T-NASS – SNESSA – CODA publication, see under point 9.13.1 above.

13.2.2 Others: conclusion

SC members expressed different points of view on the degree to which NAMMCO should hold databases of catch and sightings data. Therefore it was proposed that a small group be set up, under the chairmanship of Acquarone, for discussing the aspects of database management and come with proposals, possibly including formats, for the next SC meeting.

14. WORK PROCEDURE IN THE SC

This item was set on the agenda for addressing the difficulties encountered in planning the SC work over the last year. In particular, because many of the SC routines and procedures were only kept orally, the change in Scientific Secretary and some WG chairs implied some haziness regarding division of responsibilities, especially regarding the organisation of WG work.

14.1 SC

14.1.1 Input from the Council

After NAMMCO 17, no prioritisation of work had been provided to date by Council to the SC, even after several requests. The SC found this unacceptable because of the need for advanced work planning and apportioning costs in the budget. Adequate time is needed for answering requests. See also item 7.3 above.

Also, currently the SC meeting is about 6 months before the Council meeting. This means a reduced time of about six months for addressing the requests to the SC before the next Council meeting. The SC agrees that it would be more appropriate to have the SC meeting as close as possible before the Council meeting, leaving more time to answer requests after the Council meeting. Therefore, the SC **recommends** that Council reconsiders if it is really necessary that the Council meeting shall be at least three months after the SC meeting (three months which, because of holidays and field work, are generally six months).

The SC also **recommends** that Council provides the final text of the requests and the work priorities in list form to the SC before the end of the Council meeting so that the SC can proceed immediately with work plans.

14.1.2 Scientific advice on new requests to the SC

The SC **recommends** that most requests from Council be discussed with scientists before they are forwarded to the SC in order to ensure, not only that they are formulated in a language that reduces potential misunderstandings between the Council and the SC as much as possible, but also so that Council *a priori* gets a feeling for the degree to which it is actually possible for the SC to answer a request. In some cases, the Council may decide to continue forward with a request that is impossible for the SC to answer, in other cases it may decide to withdraw such a request.

The SC also **recommends** that requests be written in such way, that they indicated which other request they replace, if they do, so the list of active requests can be kept as short as possible.

The SC would also like Council to note that it has only a limited number of national scientists and international experts available and that most of these have duties that relate also to other international organisations. Hence, there is a trade-off between the overall number of requests put forward in the different organisations and the scientific quality of the advice given. It is therefore important to avoid duplication of work, in particular in the sense that the different international organisations should respect the legal responsibilities of each other. Requests put forward in an organisation that does not have the legal responsibility on that request, results not only in time wasted for the involved scientists, but also likely in a reduced quality of the scientific advice that can be given in the organisation that has the legal responsibility.

Some participants expressed concerns that too active participation of scientists at Council meetings could blur the role and influence of scientists, politicians and managers.

14.1.3 Decision on budget, work priorities, etc.

In some years too many WG meetings were proposed relative to the budget. Some prioritization according to outstanding requests and relative importance is required, but must come from Council.

Budgets for WGs are affected by the numbers of invited experts. In view of the problem of this year regarding planning of WGs and their financial implication relative to each other's budget, the SC recommends that the Secretariat, in consultation with the SC Chair, prepares a budget immediately after the SC meeting of the likely costs of all WGs in the coming year and then update it after the Council meeting. Such a budget should include the foreseeable expenses for the potential invited participants as well as *ad hoc* external contracted work needed. In that way, the budget can be better divided into the different WGs, ensuring that all WGs have equal possibility of gathering the best expertise. It will also allow if necessary a sound prioritizing by the SC. Although recognizing that Council has the last word on prioritization, the SC recommends however that the potential chairs identified by the SC be informally contacted as soon as possible after the SC meeting so that the most appropriate list of potential invited participants – and therefore cost - can be established.

14.1.4 Deadlines for submitting progress reports and other documents to the SC meeting

Progress Reports should be sent one month before the SC meeting. The Secretariat is requested to remind members to provide Progress Reports 6 weeks ahead of the meeting. Working papers can be produced at and during the meeting, but most meeting documents should be submitted at the latest before members travel to the meeting so that there is a chance to read them prior to the meeting. The report of the SC should be finalised within 2-3 weeks from the end of the meeting.

14.1.5 Data and analysis quality check and endorsement: who/where/how should it be done?

The SC recognizes that it is not qualified to make assessments and review abundance estimates without external expertise. As also recommended by Council at its last meeting, the SC **recommends** that this be done by an expert WG, which can be either the AE WG or an assessment WG. Since reliable abundance estimates are a prerequisite to reliable assessments, the SC must ensure that the relevant external expertise is available in the relevant WGs, so that the quality of the data in input to NAMMCO assessments is controlled both by NAMMCO and external experts.

Scientists should be advised to have, when feasible, their abundance estimate and assessment externally reviewed before they are presented to a NAMMCO WG.

14.1.6 Possible consequences for the SC from NAMMCO extended responsibility on large whales

The SC did not discuss this item in length, but recommends that the organisational and financial implication of such an extension for the work of the SC, and as a consequence for the Secretariat, be thoroughly and realistically estimated and taken into consideration. See also item 10.2 above.

14.1.7 Other matters

The Secretariat pleaded for minimising and avoiding back to back meetings as this created backlog problems with reporting and administration.

Recognizing the workload involved in any case with the reporting process, the SC **recommends** that reporting be shared out among pre-identified experts attending meetings, with the role of the Scientific Secretary being mostly that of compiler and editor of the report. This should in particular apply to the more specialised aspects of the report.

The SC **recommends** that the Secretariat edits the list of *Requests to the SC and answers*, so references to other requests in the answers fits the new format.

To avoid the problems of non-attendance of SC members to SC meetings due to other engagement, sometimes several years in a row, the SC **recommends** that the Rule of Procedures for the SC be modified so to that each Contracting Party can nominate more than 3 scientists as members of the SC. Each party should then send 3 of the standing members to each SC meeting, chosen for their expertise with regards to the

given agenda. This would allow for flexibility and eliminate the formalities behind nominating stand-in members. The SC would encompass a stronger and wider expertise, and more scientists would be kept informed of the SC matters and be dedicated to its work.

Also, to facilitate the convening of its members, the SC decided as a rule that a provisional date of the next year's meeting should be set before the closure of the meeting.

14.2 Working Groups

14.2.1 Work division, deadlines, timing, etc.

Witting and Desportes developed guidelines for Rules and Procedures for NAMMCO SC WG. The document provides information on responsibility division between Secretariat, SC Chair and WG chair, as well as a set of deadlines and procedures for invitation, organisation and reporting.

The SC welcomed this document and discussed a few amendments. It **recommends** that an edited version be incorporated as an appendix to the SC report (Appendix 4) and that this document be provided to all WG Chairs on appointment for guidance.

The document sets, among other matters, a deadline to Council for providing its answer regarding the acceptance of potential invited participants. The SC would like Council to note that scientists working in public institutions may have a deadline of several months for requesting permission for travelling abroad (e.g. 3 months for NOAA employees and up to 11 months for the MRI).

14.2.2 Rules/Guidelines for data input (deadline and quality) for assessment

On a request from the AE WG and with its advice, Desportes elaborated guidelines for data input to assessment work (SC/16/21). The SC did not discuss the details of the guidelines, but welcomed the document and **recommends** that it is amalgamated with the document providing general procedures for WGs, and together form an appendix to the SC report (Appendix 4).

The SC **recommends** that this final document, when finalised, be regarded as an Appendix to the SC Rules of Procedures and, as a routine, be communicated to chairs of WGs, as well as participants.

15. FUTURE WORK PLANS

15.1 SC

The venue for the 2010 SC meeting will be Ny Ålesund, Svalbard, Norway scheduled for the second half of week 16 (19-26 April). Two planes per week – Monday and Thursday – fly between Longyearbyen and Ny Ålesund. It will be necessary to allow a full week for the meeting to encompass work and travel.

Considering the increasing agenda of SC meetings, the SC recommends that a SC meeting of 5 days be envisaged.

15.2 Working groups

SC/16/18 presented the WGs executed or planned in 2009 and 2010. From this meeting, there come additional proposed meetings connected with the MMFI WG modelling proposal, the coupling of the grey and harbour seals WG as coastal seals WG, and the rescheduling of these meeting from 2010 to 2011, the proposition for a WG on human disturbances other than hunting as well as for a harbour porpoise WG in 2011.

Finally the SC **recommends** the following plan for its work, noting that other meetings may be held depending on new requests received from the Council:

2009	
October 09-11	WG on Abundance Estimate, Québec City - Chair: Pike. (Just prior to the Biennial Conference of the SMM)
November 23-26	WG on Walruses Assessment, Copenhagen - Chair: Born. Assessment for both West and East Greenland stocks
2010	
January 26-28:	WG on Large Whale Assessment, Copenhagen – Chair: Walloe. Minke whales (with new survey data for CIC stock) Fin whales Humpback whale: review of available information Sei whales: review of available information
Early Spring:	WG on By-Catch monitoring - Chair: Ólafsdóttir. Focus on By-catch monitoring methods and jointly with other bodies dealing with by-catch monitoring
Early 2010:	WG on MMFI Modelling
April 19-23:	SC meeting, Ny Ålesund, Svalbard – Chair: Witting.
????:	WG on Human Disturbance other than Hunting – Chair: Ugarte
2011	
Early:	WG on Coastal seals Assessment for grey seals (Faroes, Iceland and Norway) Assessment for harbour seals (Iceland and Norway) Review of the Norwegian Management plans for grey and harbour seals and hopefully others (Iceland and Faroes)
Early:	JWG-NAMMCO / JCNB
????:	WG on Harbour porpoise
????:	WG on MMFI Modelling

16. BUDGET

16.1 Final expenditure 2008

Final expenditure of the SC for 2008 was NOK 225,722, out of a budget of NOK 400,000, adjusted mid-year down to NOK 250,000.

16.2 Budget 2009 and budget plan for 2010

Acquarone presented the 2009 budget and its present status. About NOK 324,600 of the budget of NOK 400,000 has so far been spent or projected for in 2009. The projected spending should cover all remaining commitments before the end of 2009, i.e. including the Walrus Assessment WG and the AE WG. It was noted that there may be additional meetings following new requests by Council and also that the MMFI WG have proposed a meeting in the latter part of the year. Funds could also be used for the T-NASS acoustic analysis if necessary.

In 2010 it is likely that NOK 400,000 will be approved for the SC budget. There are already some WGs scheduled and in addition, if the MMFI WG proposal for modelling experiments is endorsed by Council, additional funding will likely be necessary.

The SC **strongly recommends** that the work and financial burden implied by new proposals on management procedures, database and "Conservation list", etc… be made clear to Council. Ignoring this could mean a delay in the completion of activities.

17. ANY OTHER BUSINESS

17.1 Election of officers

Lars Witting was elected Chair, Droplaug Ólafsdottír was elected as Vice-Chair, for the 3-year term beginning after the next meeting of the NAMMCO Council in September 2009. The Committee thanked Desportes for her able and dedicated chairmanship over the past 3 years. Acquarone and the Secretariat thanked Desportes for having been very supportive in the 'introduction' period of the new Scientific Secretary.

17.2 IUCN - resolution and petition

Desportes mentioned a new resolution (Res 4.018) from 2008 (Doc SC/16/O10) providing the following guidance concerning implementation of the IUCN Programme 2009-2012 and requesting the Director General in consultation with the Species Survival Commission (SSC) to:

- increase participation of national scientists in the preparation of the IUCN Red List; and
- develop a mechanism that guarantees that all members of the SSC Specialist Groups can contribute their experience of the corresponding field or taxa, so that the IUCN Red List contains the best and most relevant information on each country's species.

The practical significance that this resolution could have for NAMMCO and NAMMCO countries should be investigated further.

Desportes also reported the possibility to petition against classification of species, with petitions made on the basis of the "Red List" and supporting documentation.

This could be interesting for NAMMCO with respect to certain species and stocks, e.g. such as fin and beluga whales. The SC **recommends** forwarding this information to Council after the Secretariat has looked further into this process and who can petition and how it can be done.

18. MEETING CLOSURE

18.1 Acceptance of report

The most important parts of the draft report were accepted at the end of meeting. The final version of the report was accepted by correspondence, and completed on 29 May 2009.

18.2 Closing remarks.

The Chair thanked all the Committee members for their contribution to the meeting and the reporting. She thanked the Rapporteurs for their work and Sverrir Daniel Halldorssón and the NAMMCO Secretariat for taking care of the practical details. She thanked the Marine Research Institute for having hosted the meeting. The SC in turn thanked Desportes for her able chairing of the meeting.

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

4.1 National Progress Reports
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 Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga

6. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

6.1 Update on the Dartmouth conference, Sep/Oct 2008
6.2 Report on the Working Group on Marine Mammal & Fisheries Interactions - Marine Mammals and Fisheries in the North Atlantic: Estimating consumption and modelling interactions
6.3 Active Requests and answers from the SC
    6.3.1 Ongoing requests – several, incl. 1.1.6 and 1.4.6
    6.3.2 New request – 1.1.8
    6.3.3 Future work needed for answering active requests
6.4 New recommendations for national research
6.5 Other matters: Update on the Norwegian-Russian Programme on harp seals ecology

7. BYCATCH OF MARINE MAMMALS

7.1 Update on monitoring progress by countries
7.2 Report on the ICES SG on By-Catch and response to the proposal for a joint WG/WS
7.3 Active Request and answer from the SC
    7.3.1 Ongoing request – 1.1.7
    7.3.2 Future work needed for answering active requests
7.4 New recommendations for national research

8. SEALS AND WALRUSES STOCKS - STATUS AND ADVICE TO THE COUNCIL

8.1 Harp Seals
    8.1.1 Update on national research progress and future research plans

8.1.2 Review of SC recommendations for research from earlier and "answers" by countries
8.1.3 Report of the ICES-NAFO WG (08-2008) – harp seals
8.1.4 Active Requests and answers from the SC
8.1.4.1 Ongoing request 2.1.4
8.1.4.2 Pending requests 2.1.6 & 2.1.10
8.1.4.3 Future work needed by the SC for answering active requests
8.1.5 New recommendations for national research
8.1.6 Other business

8.2 Hooded seals
8.2.1 Update on national research progress and future research plans
8.2.2 Review of SC recommendations for research from earlier and "answers" by countries
8.2.3 Report of the ICES-NAFO WG (08-2008) – hooded seals
8.2.4 Active Requests and answers from the SC
8.2.4.1 Ongoing request 2.1.4
8.2.4.2 New request 2.1.9
8.2.4.3 Future work needed by the SC for answering active requests
8.2.5 New recommendations for national research

8.3 Ringed seal (no active request)
8.3.1 Update on national research progress and future research plans
8.3.2 Review of SC recommendations for research from earlier and "answers" by countries
8.3.3 New recommendations for national research

8.4 Grey seal (no active request)
8.4.1 Update on national research progress and future research plans
8.4.2 Review of SC recommendations for research from earlier and "answers" by countries
8.4.3 Review of the new Norwegian management plan for grey seals
8.4.4 New recommendations for national research
8.4.5 Other business

8.5 Harbour seal
8.5.1 Update on national research progress and future research plans
8.5.2 Review of SC recommendations for research from earlier and "answers" by countries
8.5.3 Review of the new Norwegian management plan for harbour seals
8.5.4 Active Request and answer from the SC
8.5.4.1 Ongoing request 2.5.2
8.5.4.2 Future work needed by the SC for answering active requests
8.5.5 New recommendations for national research
8.5.6 Other business

8.6 Walrus
8.6.1 Update on national research progress and future research plans

8.6.2 Review of SC recommendations for research from earlier and "answers" by countries
8.6.3 Active Requests and answers from the SC: 2.6.3, 2.6.4 and 2.6.5
8.6.3.1 Report on the preparation for the Working Group on Walruses
8.6.3.2 Future work needed by the SC for answering active requests
8.6.4 New recommendations for national research
8.6.5 Other business
8.7 Bairded seal (no active request)

9. CETACEAN STOCKS - STATUS AND ADVICE TO THE COUNCIL

9.1 Fin whale
9.1.1 Update on national research progress (incl. new estimates) and future research plans
9.1.2 Review of SC recommendations for research from earlier and "answers" by countries
9.1.3 Active Requests and answers from the SC
9.1.3.1 Ongoing requests 1.7.10
9.1.3.2 New requests 3.1.6 & 3.1.7
9.1.4 Future work needed by the SC for answering active requests
9.1.5 New recommendations for national research
9.1.6 Other business

9.2 Humpback whale
9.2.1 Update on national research progress (incl. new estimates) and future research plans
9.2.2 Review of SC recommendations for research from earlier and "answers" by countries
9.2.3 Active Requests and answers from the SC
9.2.3.1 New request 3.2.5
9.2.4 Future work needed by the SC for answering active requests
9.2.5 New recommendations for national research

9.3 Sei whale
9.3.1 Update on national research progress (incl. new estimates) and future research plans
9.3.2 Review of SC recommendations for research from earlier and "answers" by countries
9.3.3 Active Requests and answers from the SC
9.3.3.1 New requests 3.5.1 & 3.5.2
9.3.3.2 Future work needed by the SC for answering active requests
9.3.4 New recommendations for national research

9.4 Minke whale
9.4.1 Update on national research progress (incl. new estimates) and future research plans
9.4.2 Review of SC recommendations for research from earlier and "answers" by countries

9.4.3 Report of the Large Whale Assessment WG – minke
9.4.4 Active Request and answer from the SC
9.4.4.1 Active request 1.7.10
9.4.4.2 New request 3.3.4
9.4.4.3 Future work needed by the SC for answering active request
9.4.5 New recommendations for national research
9.5 Narwhal
9.5.1 Update on national research progress (incl. new estimates) and future research plans
9.5.2 Review of SC recommendations for research from earlier and "answers" by countries
9.5.3 Report on the Joint NAMMCO/JCNB Working Group – narwhal
9.5.4 Active Requests and answers from the SC
9.5.4.1 Ongoing requests 3.4.4, 3.4.10 & 3.4.11
9.5.4.2 New request 3.4.11
9.5.4.3 Future work needed by the SC for answering active requests
9.5.5 New recommendations for national research
9.5.6 Other business
9.6 Beluga
9.6.1 Update on national research progress (incl. new estimates) and future research plans
9.6.2 Review of SC recommendations for research from earlier and "answers" by countries
9.6.3 Report on the Joint NAMMCO/JCNB Working Group – beluga
9.6.4 Active Requests and answers from the SC
9.6.4.1 Ongoing request 3.4.9 & 3.4.10
9.6.4.2 New request 3.4.11
9.6.4.3 Future work needed by the SC for answering active requests
9.6.5 New recommendations for national research
9.6.6 Other business
9.7 Northern Bottlenose whale (no active request)
9.7.1 Update on national research progress (incl. new estimates) and future research plans
9.7.2 Review of SC recommendations for research from earlier and "answers" by countries
9.7.3 New recommendations for national research
9.8 Killer whale
9.8.1 Update on national research progress (incl. new estimates) and future research plans
9.8.2 Review of SC recommendations for research from earlier and "answers" by countries
9.8.3 Active Request and answer from the SC
9.8.3.1 Ongoing request 3.7.2

9.8.3.2 Future work needed by the SC for answering active requests
9.8.4 New recommendations for national research
9.9 Pilot whale
9.9.1 Update on national research progress and future research plans
9.9.2 Review of SC recommendations for research from earlier and "answers" by countries
9.9.3 Report of the Large Whale Assessment WG – pilot whale
9.9.4 Active Requests and answers from the SC
9.9.4.1 Ongoing requests 1.7.10, 3.8.3 & 3.8.4
9.9.4.2 Future work needed by the SC for answering active requests
9.9.5 New recommendations for national research
9.10 White-beaked, white-sided and bottlenose dolphins
9.10.1 Update on national research progress (incl. new estimates) and future research plans
9.10.2 Review of SC recommendations for research from earlier and "answers" by countries
9.10.3 Active Request and answer from the SC
9.10.3.1 Ongoing request 3.9.6
9.10.3.2 Future work needed by the SC for answering active requests
9.10.4 New recommendations for national research
9.11 Harbour porpoise
9.11.1 Update on national research progress (incl. new estimates) and future research plans
9.11.2 Review of SC recommendations for research from earlier and "answers" by countries
9.11.3 Active Request and answer from the SC
9.11.3.1 Ongoing request 3.10.1
9.11.3.2 Future work needed by the SC for answering active requests
9.11.4 New recommendations for national research
9.12 Surveys
9.12.1 T-NASS update
9.12.2 Future surveys

10. GENERAL MODELS FOR MANAGEMENT
10.1 New request (1.6.3) and answer from the SC
10.1.1 Report of the Large Whale Assessment WG – General management models
10.2 Discussion on ways to proceed and future work

11. NAMMCO SCIENTIFIC PUBLICATIONS
11.1.NASS volume
11.2 Harbour seal volume
11.3 Future plans

11.3.1 T.NASS volume
11.3.2 Others

12. PROPOSAL FOR THE DEVELOPMENT OF A NAMMCO "STATUS LIST"

13. ESTABLISHING NAMMCO DATABASES FOR SURVEY AND CATCH DATA

13.1 Catch data - direct and indirect catch
13.1.1 Format for catch reporting, including as input to assessments
13.1.2 Format for by-catch reporting
13.2 Survey and sightings data
13.2.1 OBIS-SEAMAP database
13.2.2 Others

14. WORK PROCEDURE IN THE SC

14.1 SC
14.1.1 Input from the Council
14.1.2 Scientific advice on new requests to the SC
14.1.3 Decision on budget, work priorities, etc.
14.1.4 Deadlines for submitting progress report and other documents to the SC meeting
14.1.5 Data & analysis quality check and endorsement: who/where/how should it be done?
14.1.6 Consequences for the SC from NAMMCO's possible extended responsibility on large whales
14.1.7 Other matters
14.2 Working Groups
14.2.1 Work division, deadlines, timing, etc.
14.2.2 Rules/Guidelines for data input (deadline and quality) for assessment

15. FUTURE WORK PLANS

15.1 Scientific Committee
15.2 Working groups

16. BUDGET

16.1 Final expenditure 2008
16.2 Budget 2009 and budget plan for 2010

17. ANY OTHER BUSINESS

17.1 Election of officers
17.2 IUCN - resolution and petition

18. MEETING CLOSURE

18.1 Acceptance of report
18.2 Closing remarks.

Appendix 2

LIST OF DOCUMENTS

SC/16/01	List of participants
SC/16/02	Provisional Annotated Agenda
SC/16/03	List of Documents
SC/16/04	Observers Report: 60th Meeting of the IWC Scientific Committee, Chile, May 2008
SC/16/05	Report of the 15th ASCOBANS Advisory Committee Meeting
SC/16/06	Report from the 2008 activities in ICES
SC/16/07	Observer report: Dartmouth conference
SC/16/08	Report of the NAMMCO SC WG on Marine Mammal and Fisheries Interaction, Reykjavík, April 2009
SC/16/09	Final Draft Report of the ICES Study Group on By-Catch, Copenhagen, January 2009
SC/16/10	Report of the ICES/NAFO Working Group on Harp and Hooded Seals, Tromsø, August 2008
SC/16/11	Kjell T.Nilssen and Arne Bjørge: Suggested management plan for Norwegian grey seals.
SC/16/12	Plans for the NAMMCO SC WG on walrus
SC/16/13	Report of the NAMMCO SC WG on Large Whale Assessment, Copenhagen, March 2009
SC/16/14	Compilation of assessment input data available for sei whales
SC/16/15	Report of the Joint NAMMCO/JCNB WG on narwhal and beluga, Winnipeg, February 2009
SC/16/16	Summary of requests by NAMMCO Council to the SC and responses
SC/16/17	Status of NAMMCO Scientific Publications – Harbour Seal volume
SC/16/18	Draft of SC work plan for 2009 and 2010
SC/16/19	SC Budget, incl. accounting for 2008 and draft budget for 2009 and 2010
SC/16/20	Proposition for inclusion of NAMMCO data to the OBIS-SEAMAP database
SC/16/21	Templates for Rules/Guidelines for data input to assessment work
SC/16/22	Arne Bjørge and Kjell T. Nilssen: Suggested management plan for Norwegian harbour seals.
SC/16/23	Grey seal (Halichoerus grypus) pup production along the Norwegian coast in 2006-2008
SC/16/24	A devil's advocate opinion on ecosystem-based management
SC/16/25	Proposal for the development of a NAMMCO "Species Status List"

SC/16/NPR-F	National Progress Report – Faroe Islands
SC/16/NPR-G	National Progress Report – Greenland
SC/16/NPR-I	National Progress Report – Iceland
SC/16/NPR-N	National Progress Report – Norway
SC/16/NPR-C	National Progress Report – Canada
SC/16/NPR-R	National Progress Report – Russian Federation
SC/16/NPR-J/1	National Progress Report– Japan / Small Cetaceans 2005
SC/16/NPR-J/2	National Progress Report– Japan / Small Cetaceans 2006
SC/16/NPR-J/3	National Progress Report– Japan / Large Whales 2007
NAMMCO/17/05	Report of the Fifteenth Meeting of the Scientific Committee
SC/16/O01	Prospects for future sealing in the North Atlantic 13th Norwegian-Russian Symposium, Tromsø, 25-26 August 2008
SC/16/O02	Deep into the ice: over-wintering and habitat selection in male Atlantic walruses – Freitas *et al*
SC/16/O03	Ringed seal post-moulting movement tactics and habitat selection
SC/16/O04	Report of the ICES WG on Marine Mammal Ecology (WGMME)
SC/16/O05	IUCN-Red-List_Categories-and-Criteria_V3-1
SC/16/O06	IUCN-Red-List_Cetacean-Update-2008
SC/16/O07	CITES-criteria_Co9-24-revCoP14
SC/16/O08	CITES-appendices_07-2008
SC/16/O09	List of FIRMS reference terms
SC/16/O10	IUCN increased participation note.

Appendix 3

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Appendix 4

RESPONSIBILITIES ASSOCIATED WITH WG MEETINGS and GUIDELINES FOR DATA INPUT TO ASSESSMENT WORK

I - Responsibilities associated with WG meetings

At its annual meeting, the SC decides which working groups (WG) shall meet for helping answering active request from the council. It specifies the terms of references for each WG. The SC appoints a WG Chair, and may discuss experts to be invited. If the WG Chair is not a member of the SC, the SC Chair contacts the proposed WG Chair immediately after the meeting to get an acceptance or decline for the position. In all cases the SC Chair ensures that the WG Chair receives and agrees on the terms of references.

If new requests from the Council are addressed to the SC, after the Council meeting, then the SC chair in consultation with the Committee and the Secretariat decides how these requests will be best answered and whether it necessitates the formation of a non standing WG.

Prior to meeting

The WG Chair in consultation with the SC Chair and the Secretariat decides upon a date and a place for the WG meeting. In consultation with the SC Chair and relevant members of the SC, the WG Chair comes up with a list of experts to be invited (after a consultation with the Secretariat on budget constraints, i.e. depending on the location of the meeting). The WG Chair emails the list to the SC and the Secretariat for a final discussion. Hereafter the Secretariat sends the list for approval to the Council with a deadline of 10 days for comments. If no comments are received before the deadline, the list is considered as approved by the Council.

The WG Chair contacts informally the potential invited participants and the Secretariat sends an official letter of invitation, including the terms of reference and draft agenda and list of participants, to those having answered positively. Invitation should be sent out no later than 3 months prior to the meeting, though remembering that some scientists have a deadline of up to 9 months for requesting permission for travelling abroad.

The Secretariat sets up the practical arrangements and sends meeting information to all WG participants and SC members as well as information on document submission (all documents go to the Secretariat that uploads the documents to the internet) not later than two months prior to the meeting. The WG Chair finalises the agenda from the terms of reference, and the Secretariat makes the final list of meeting participants and the list of documents.

Titles of meeting documents and documents shall, if possible, reach the Secretariat of NAMMCO no less than 10 days in advance of the meeting in question and be

distributed to the members of the Working Group prior to the meeting. All documents registered before the end of the first day of the meeting shall be considered Primary Documents for consideration at the meeting.

If contracting work is to be done for NAMMCO before the meeting, the WG Chair informs the Secretariat as soon as possible and formal arrangements are made by the Secretariat. The WG Chair ensures that it is clear to the Consultant what he is contracted to do (this can be mediated through another SC member of the WG).

During meeting
The rapporteurs of the WG are responsible for the reporting of the discussions, decisions and recommendations of the WG, while the WG members submit summary reports of their own presentations/papers.

A draft report has to be accepted by the WG before the end of the meeting. Only text improvement can be made later through email.

The WG Chair is responsible for the final wording of the report, although it is often the rapporteurs that do the text editing. The Secretariat is responsible for the final language editing, formatting and setting of the report.

Before the SC meeting
The WG Chair makes a Chairman's summary of the WG report and emails it to the Secretariat, at the latest 10 days prior to the SC meeting. The summary should have a wording that can go directly into the main part of the SC report, if accepted by the SC. The Secretariat is responsible for the final formatting and setting of the summary.

If the WG Chair cannot/do not present the WG summary at the SC meeting it is the WG Chair's responsibility, in consultation with the SC chair, to find a SC member that can present the summary at the meeting. If the WG Chair is not a member of the SC, the SC Chair finds a member that can present the report. This should be done well in advance of the meeting, so the presenter has time to prepare the presentation.

II - Guidelines for data input to Assessment work

These guidelines have been elaborated on the request of the Working Group on Large Whale Assessment, which met in Copenhagen in March 2009, and felt that NAMMCO should have Guidelines for data input in assessment work, in particular regarding deadlines for input and control quality of the data. A summary table is provided at the end of this Appendix.

Input	**To NAMMCO Secretariat**			**To NAMMCO SC**	**To 'Run' group**	**To WG participants**
	Deadline	Form	Quality assessment	Deadline	Deadline [5]	Deadline
WG meeting draft agenda[1, 2] By WG chair in agreement with SC delegates from the country demanding the new assessment[1]	4 months pre-meeting	Stipulating which new data will be used in the assessment		3.5 months pre-meeting Then to Council		3 months pre-meeting
Tentative Working Group composition[1, 2] By WG chair in agreement with SC delegates from the country demanding the new assessment	4 months pre-meeting			3.5 months pre-meeting Then to Council		3 months pre-meeting
Invitation letter[1] By Secretariat						3 months pre meeting
Updated Catch Series [3, 6]	2 months pre-meeting	Detailed yearly catch with no combination of categories: Direct catch, Struck and	The NAMMCO Secretariat maintains an updated register of all such catches. Revisions and new data should be confirmed and endorsed at each SC meeting		1.5 month pre-meeting, if update of an existing assessment given new data; 3 months in the	Same as for 'Run' group

		Lost and By-catches reported separately	under a standard item on the agenda. Only those data should be used in assessments.		case of a new assessment or radical changes in input (e.g. radically different stock structure)	
New Abundance Estimates	2 months pre-meeting		Preferably endorsed by the SC, through the WG on AE. Or endorsed by assessment group.		As above	As above
Changes in Stock Structure[4]	2 months pre-meeting		Preferably reviewed by two referees with at least one from outside NAMMCO countries, before being presented to the Assessment WG		As above	As above
Changes in Biological Parameters[4]	As above		Same as above		As above	As above
Changes in Ecology and Habitat issues[4]	2 months pre-meeting		Same as above		As above	As above
Analysis providing the initial assessment runs and population trajectories						Two weeks pre-meeting

[1] Rules/Guidelines which are common to all NAMMCO WGs

[2] The Agenda and WG composition are included as 'input data': there is a need for an agenda stipulating which new data will be considered/used for the assessment, so the WG Chair, together with the SC Chair and the SC, is able to decide on the right expertise which need to be assembled for the WG to be competent e.g. in endorsing new data.

[3] Updated catch series: The country requiring the assessment is responsible for ensuring that the data are provided in due time. It is not responsible for providing all the data, but must insure that the other tentative providers are contacted and provide the data in due time. The 'requiring' country has the duty of being the most active player, especially ensuring that things are running smoothly and pace is kept.

[4] Data quality check: The SC does not have pre-defined group for endorsing changes/new data in Stock Structure, Biological Parameters or data on Ecological or Habitat Issue. Therefore the Assessment WG, should as a first step, formally endorsed the new data presented to be used in the assessment. It is, therefore, very important that the composition of the WG reflects the need for expert in the relevant fields.

However a major, complete "overhaul" on stock structure should really first go through the previous SC meeting for adoption before any consequential assessments are done – even with reviewer reports, it'll be the SC discussion that is crucial in getting to agreement. Changes in stock structure may involve reallocation of historical catches in terms of changes area boundaries, then the Secretariat should do that prior to the meeting. A trickier issue is resultant changes in abundance estimates by (revised) area, where variance calculations in particular can be difficult. The WG on AE should develop a system under which this can be done faster than having to wait for the next SC meeting.

[5] Appropriateness of Deadlines: One month given to the 'Run Group' to perform the assessment is enough if what is involved is a near routine update of work done previously given new data. It should be extended to at least 3 months if substantial changes are made (e.g.

radically different stock structure) - such situations should be picked up at the previous SC meeting and a schedule agreed there that is compatible with the extent of developmental work required.

[6] Catch series to be used in the assessment: The SC should agree on which kind of final series should be used in the assessment and give a precise definition of what they should include (e.g., best and high vs low and high). It would be useful to have a generic standard approach –also probably relevant to use “best” with the same meaning as IWC uses.

ANNEX 1

REPORT OF THE 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

Winnipeg, Canada, 17-20 February 2009

EXECUTIVE SUMMARY

The Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) met 17-20 February 2009 in Winnipeg, Canada. 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 23 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 been positive since the 2005 JWG meeting.

NARWHALS

Stock structure

No new genetics data were available to identify stocks. A paper on ancient DNA indicated that the limited genetic diversity in narwhal dated back 50,000 years or more indicating that low diversity preceded human harvesting of narwhals.

Inglefield Bredning

Nothing is known about the fall migratory routes or wintering grounds of this group of whales. Twenty whales tagged in 2004-2008 did not move extensively during the summer. There is no evidence of contact between the stock in Inglefield Bredning and Melville Bay in the summer. Tagging efforts should be continued.

Baffin Bay

New information on movement patterns of narwhals in Baffin Bay from satellite tracking data updates the meta-population concept previously adopted by NAMMCO (Heide-Jørgensen *et al*. 2005). Narwhals from the Admiralty Inlet stock move in the fall into regions used by the Somerset Island and Eclipse Sound stocks in summer. A narwhal from Canada (Admiralty Inlet stock) travelled to the hunting grounds in West Greenland in January 2006. Narwhals from Melville Bay remained in the bay during the summer then moved to the Baffin Bay wintering ground. Narwhals from Melville Bay visited Disko Bay in winter suggesting the Disko Bay winter aggregation is a composite of whales from several localities. Melville Bay narwhals were located outside Uummannaq in spring and results from one whale suggest that Melville Bay

may be a summer destination for whales from Uummannaq. None of the tagged whales from Uummannaq travelled to Disko bay leaving unresolved the source of the autumn and winter hunted whales from Uummannaq and Disko Bay. The delegates mostly agreed that satellite tagging provides the best available method to investigate interstock movements, however to this day the sample size of the data gathered do not allow for reasonable conclusion on the population movements. The JWG recognized the need for a larger dataset and encouraged further tagging studies in this area.

The JWG reviewed distribution and habitat use of narwhal in southeast Baffin Bay in an area designated as the Southern Wintering Ground. Most narwhal winter in this area for feeding despite heavy ice conditions. Reduced ice coverage may result in smaller home ranges and lower whale movements. Greenland halibut are abundant in this area and are known to comprise a significant proportion of narwhal diet. This area also contains fragile cold water corals that may contribute to the ecosystem that support halibut. The JCNB is supportive of recent measures taken by DFO to close an area within NAFO Division 0A, comprising a significant proportion of the narwhal's southern wintering area, to Greenland halibut fishing and requests that this fishing closure continue in order to protect the narwhal, their major food, and their winter habitat.

Tags on the northern Hudson Bay narwhal in Repulse Bay, Nunavut, and local and other scientific knowledge suggest that a portion of the summer home range falls to the east of past aerial survey coverage. Migration routes of tracked animals coincide with local knowledge of narwhal migration indicating that these narwhal are rarely hunted by communities en-route between summer and winter grounds.

A study of stock structure using skull measurements from museum specimens failed to show significant differences between stocks, possibly due to low sample size. These measures confirm the uniformity of narwhals inferred from genetic data. Thus, morphometrics may have limited utility in stock identification. It was suggested that biological tags, such as parasites, may be used to help differentiate the stocks.

Based on the new information presented to this meeting an updated stock structure (Fig.6 in document JWG-2005-16) representing the relationships among narwhal stocks, is presented under point 5.3.3.

Biological parameters

Recent work on ageing using aspartic acid racemization of eye lenses from 110 narwhals updated information on narwhal age structure and reproduction in the working paper presented at the 2005 meeting of the JWG. Results indicate that narwhal live longer than previously known. No difference was found in life history parameters for the East and West Greenland narwhals. A table comparing the rates from this and a previous study are presented in section 5.2.2 in the main document.

A review of stomach samples indicated that narwhals do not feed intensively while on the Scoresby Sound summer grounds and indicates a similarity in seasonal feeding habits of West and East Greenland narwhals.

A study including photo-identification, acoustic analysis and focal group observation was presented. It was noted that these would be useful methods for studying local abundance and behaviour of narwhal groups by communities. However, it was also noted that these methods are not currently developed to the point that they could be used to estimate stock abundance or determine movements and distribution.

Catch statistics

The JWG indicated its support of the conclusions of the November 2006 NAMMCO Workshop to address the problem of struck and lost in marine mammals.

Canada has initiated a hunt monitoring programme in Admiralty Inlet and Repulse Bay that requires one more season of data collection. DFO provides a conservative total allowable harvest recommendation which incorporates estimates of struck and lost. In Greenland the reporting of struck and lost is a component of the catch reporting system. However the method has not yet been validated. The JWG highlighted the difficulty in assessing the severity of wounds and the necessity to adopt a definition of lethal wound. Struck and lost represents a fraction of the total removals and needs to be including in advice on Total Allowable Harvest (TAH), so better data are required.

Two ice entrapments, both in 2008, were reported: one in Canada and the other in Greenland. On 15 November 2008 hunters of Pond Inlet found narwhals in holes along a pressure crack running south from Bylot Island. In total 629 whales were harvested by local hunters. A total of 566 animals were assessed by the hunters according to size (68 calves, 210 juveniles and 288 adults) and 249 frozen animals left on the ice were sampled (chunk of skin-fat-muscle). More detailed collections, including eyes, were taken from 9 juveniles.

In Greenland during Feb 2008, 30-45 animals were entrapped in the ice in the Sermilik fjord-system in East Greenland. No samples were taken.

Canadian catch statistics

Narwhal catch statistics from communities in Nunavut were presented for 2004-2008. Four of the communities are under the Community Based Management (CBM) programme which sets harvesting limits as opposed to quotas. CBMs allow borrowing against tags from future years in times of good harvest. Communities under CBM presented in the table include Arctic Bay, Pelly Bay, Qikiqtarjuaq, and Pond Inlet. The hunts in these communities were consistent across the 5 years with the exception of Pond Inlet, which took 711 narwhal in 2008, 629 narwhals due to an ice entrapment (see above). A complete table of catch statistics are included in Appendix 4. The 2008 data was incomplete so the table was revised to show 2003-2007 data and the corresponding 5 year average.

A reconstruction of commercial and subsistence harvests of narwhals from the Canadian Eastern Arctic had been requested at the 2003 JWG meeting. The contracted report summarized data available in ship logs, sales records and other sources. Of particular interest was the reliability of the reported catch of 2,800 narwhals in Eclipse

Sound in 1919-1920, since this period and number were coincident with records of an ice entrapment event. The JWG had no further information required to corroborate the two reports.

Reconstructed catch statistics for narwhals in Greenland 1862 to 2008, were provided as a preliminary compilation. Detailed statistics split by hunting grounds are missing for most of the years. For the most recent three decades a time series is constructed for West Greenland with catches split into hunting grounds.

The meta-population model for the structure of narwhal populations in Baffin Bay presented at the last few meetings (JWG-2009-O13) was revised as follows by JWG:

1. The Smith Sound stock and Inglefield Bredning stock may be connected and cannot be treated as entirely separate stock units (JWG-2009-20, JWG-2009-07).
2. Satellite tracking of narwhals from Melville Bay show that this stock contributes to the hunt in Disko Bay and may contribute to the hunt in Uummannaq in spring but not likely the fall hunt in Uummannaq (JWG-2009-19).
3. Satellite tracking of narwhals from the Admiralty Inlet stock show that this stock may contribute to the hunt in Disko Bay in winter and to the hunt in Eclipse Sound, Somerset Island, and along the east coast of Baffin Island (JWG-2009-19).
4. The previously proposed stock of narwhals in Cumberland Sound does not seem to be discrete and instead the hunt in Pangnirtung is likely supported by whales from the fjords on East Baffin Island and from Admiralty Inlet (JWG-2009-19).

An updated model for the dispersal of narwhals in Baffin Bay was presented.

Abundance

Surveys of all the major narwhal summering grounds in West and East Greenland were conducted between 2006 and 2008 and fully corrected abundance estimates were calculated for these areas. The surveys were conducted as line transect surveys from a Twin Otter with two independent observer platforms (4 observers) using bubble windows. Estimated abundance of narwhals on the wintering ground in West Greenland was 7,819, in Inglefield Bredning 8,447 and in Melville Bay 6,235, respectively. The abundance in East Greenland was 6,583. The JWG endorsed the new abundance estimates for use in the assessment.

A double-platform visual aerial survey over the narwhal wintering grounds in Baffin Bay, West Greenland in April 2008 yielded a fully corrected estimate of 17000-19000 narwhals. The uncorrected distance sample estimate of 3,484 compares to an earlier distance sample estimate developed in March 2000 of 5,348 whales based on sightings of narwhals along the same transects. The JWG encourages the authors to revisit the ice information from 2000 to seek an explanation for the large difference in abundance. This area is an important wintering area for narwhals from Admiralty, Eclipse and Melville stocks and may provide the bulk of the annual energy budget of

narwhals, which feed extensively on the turbot in that area. The JWG concludes that this zone is therefore critical to these narwhal populations.

An assessment of the current population size of the Canadian High Arctic narwhals was developed from aerial surveys of narwhals in the Canadian High Arctic each August from 2002 to 2004. The analysis had been revised from that presented in 2005, fulfilling a request from the JWG, resulting in estimates of 27,700 for the Prince Regent and Gulf of Boothia area, of 20,200 for the Eclipse Sound area and of 10,100 for the East Baffin Island fiord area. The estimate for the Admiralty Inlet area was 5,400 but is thought to be negatively biased. Results of these surveys show that the summering range of narwhals in the Canadian High Arctic is vast and that, its population could number in excess of 60,000 animals. An updated overview of narwhals in the Canadian Arctic is presented in Table 3 in section 5.4.2.

Future surveys in Canada: a survey is planned for Admiralty Inlet in mid-August 2009.
Future surveys in Greenland: a north water survey is planned for May 2009 (Smith Sound).

Assessment
The JWG agreed that for the assessments of Greenland narwhal and beluga age-structured models are not necessary and a discrete catch-before-birth model was chosen as the preferred assessment model to use for population projections.

A comparison between the Bayesian assessment model (BAM; JWG-2009-09) and single survey approach (SSA; JWG-2009-21) for management advice noted that a BAM had been endorsed at previous JWG meetings. While the SSA used similar logic to the PBR approach followed by the USA, it lacked the theoretical underpinnings. Doubts were expressed in three areas: 1) basing the SSA on only the most recent survey and no population modelling made it more vulnerable to infrequent events, such as changes in behaviour or distribution of narwhals; 2) little support was provided to indicate that the proposed 5% removal rate was sustainable; and 3) the SSA did not assess risk in relation to removal level. The JWG agreed to continue with the BAM for management advice.

The BAM model for the allowable narwhal harvest in West Greenland used a 2009-abundance of 12,000 (95% CI: 6,200-26,000) narwhals, that is 51% (95% CI: 27-89%) of the historical abundance (see Table). The JWG has agreed that it is more appropriate to forward a range of options and let managers set the preferred balance between risk and removal levels of narwhals. A table showing annual total removal levels given for narwhals in West Greenland given different probabilities of increase from 2009 to 2014 was presented.

The results of the assessment at this meeting are quite different from the results of the assessment at the last two meetings. The assessment at the 2005 meeting suggested that narwhals in West Greenland were highly depleted with safe harvest levels being as low as 15 to 75 whales per year. The change in recommendations reflects new

abundance estimates for the two summer aggregations in West Greenland. In the 2005 assessment, the low abundance estimates from Inglefield Bredning in 2001 and 2002 suggested a decline from a much higher abundance in 1986, and there was no abundance estimate for Melville Bay. However, surveys conducted in 2007 and 2008 suggest that the number of narwhals in Inglefield Bredning has fluctuated, and there is now also an estimate for Melville Bay.

A paper (NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-10) was presented indicating that most odontocete (narwhal and beluga) population assessments in Nunavut are data-poor, meaning that there is often only one survey of their population size, no trend data, and little information on their population dynamics. As a result, Total Allowable Catches for Nunavut odontocete whales were calculated using the Potential Biological Removal (PBR) method and a simple growth model used to determine the risk probability of decline. In this model, uncertainty distributions were used to model the imprecision of population size and hunting loss rate and to model uncertainty in the population growth rate. This paper was presented for information, JWG advice will be provided when further analyses are presented at future meetings.

East Greenland historical catches from 1955 and one abundance estimate from 2008 were combined with density regulated population models to perform a Bayesian assessment of narwhal in East Greenland. It is estimated that East Greenland narwhal have declined slowly in number since 1955, that they are not depleted with abundance above the maximum sustainable yield level (MSY), and that an average annual removal of 105 narwhals over the last 5 years is just above the 90% point estimate of MSY. It is estimated that annual takes of 50 to 73 narwhals over the coming 5 years will give an 80% to 95% probability that takes are smaller than 90% of MSY. With this estimate, the JWG was for the first time able to provide management advice for narwhals in East Greenland. The JWG presents annual total removal levels for narwhals in East Greenland given different risk probabilities of fulfilling management objectives from 2009 to 2014.

Future research requirements

- Stock ID: Each of the stocks around Baffin Bay is taken in more than one harvest location and several of these locations may take narwhal from more than one stock. Consequently, it is necessary to determine the contribution of each stock to each harvest location. Currently, it is not possible to identify stocks of narwhals using genetics, so individual movements are the best available approach. The JWG recommends further tagging studies to collect information on the behaviour of individuals but acknowledges that other methods such as photo- identification and genetic mark-recapture may be necessary to fully characterize the relationships between harvest locations and stocks.
- Surveys: The JWG recommends that surveys be repeated every 3 to 5 years to update abundance estimates, and determine the distribution of narwhals in relation to habitat features. Current abundance estimates are necessary to insure that the harvest is sustainable.

- Struck and Lost: The JWG recommends the collection of struck and lost data from all areas and types of hunt and documentation of improvements in practices and techniques that result in lower struck and lost. The JWG highlighted the difficulty in assessing the severity of wounds and the necessity to adopt a definition of lethal wound.

BELUGA

No new information on stock structure was available for this meeting.

Past and Recent catch statistics

Information and statistics including trade statistics on catches of belugas in West Greenland since 1862, indicate that the period before 1952 was dominated by large catches south of 66°N that peaked with 1380 reported kills in 1922. Catch levels in the past five decades are evaluated on the basis of official catch statistics, trade in muktuk (whale skin), sampling of jaws and reports from local residents and other observers and 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 peaked around 1970 [number]. 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 by about 5% per year during 1979-2007. Reported catches in East Greenland are considered erroneous and should perhaps be added to the narwhal catches.

The beluga catch statistics from selected communities in Nunavut were presented for landed animals for the last 5 years (2004-2008). Several communities have yet to report their harvest information for 2008. Catch statistics for beluga in selected Eastern Canadian Arctic Communities are summarized in a table in Appendix 3. The 2008 data was incomplete so the table was revised to show 2003-2007 data and the corresponding 5 year average. In general the takes have increased slightly since the previous report when the 5-year average was 42, whereas for the most recent 5-year average is 69. High catches reported for Pond Inlet and Taloyoak require examination. This total does not include beluga catches at Igloolik and Hall Beach, which may, in whole or in part, come from Hudson Bay stocks.

Abundance

An aerial survey was conducted to estimate the abundance of belugas in West Greenland in March-April 2006. This survey augmented a time series of surveys for belugas started in 1981. The total abundance of belugas was estimated at 10,600. The largest abundance was found at the northern part of Store Hellefiske Bank at the eastern edge of the Baffin Bay pack ice, a pattern similar to that found in eight systematic surveys conducted since 1981. A clear relationship between decreasing sea ice cover and increasing offshore distance of beluga sightings suggests that belugas expand their distribution westward with the sea ice margin as new areas on the banks open up earlier in spring.

It was noted that the animals were concentrated at the western edge of some of the surveyed area, suggesting that the survey might have missed animals. The JWG recommend that lines be extended beyond the current survey limits so that the coverage of future surveys is more complete, depending on ice conditions. The more offshore distribution of the belugas in relation to the change in ice distribution may explain why catches did not reach the quota in some recent years.

Assessment update

Historical catches from 1862 and three time series of abundance estimates were combined with density regulated population models to perform a Bayesian assessment of beluga in West Greenland. It was found that West Greenland beluga declined in numbers until 2004. Thereafter, a two-fold decline in the catch, from more than 400 to less than 200 belugas per year, allowed the population to increase by approximately 8% by 2009. The population in 2009 was estimated to be at 31% (95% CI: 14-61%) of carrying capacity, with a 2009 abundance of 11, 000 (95% CI: 5,400-21,000) individuals. It was estimated that annual takes between 180 to 265 belugas over the next 5 years will leave the population an 80% to 95% probability of a continued increase until 2014. Total annual removal levels for beluga in West Greenland under different probabilities of an increasing population between 2009 and 2014 were presented.

It was remarked that reduced takes may already be having a positive effect on population size. The 2005 model gave 80% probability of increase with catches of 100, and 51% if catches of 200. That model was based on index surveys and the 1998-99 abundance estimate. The JWG noted that the modelling for belugas rests on a more solid background because of simpler stock structure compared to narwhals.

Future research requirements

Since the last survey of belugas in the Somerset Island area was in 1996, the JWG recommended that this survey should be repeated.

It was agreed that the recommendation from the last meeting regarding cooperation by Canada and Greenland to collect life history samples should be repeated.

Similarly, it was agreed that the previous recommendation regarding the need to collect data required to improve estimates of hunting loss should be repeated.

IMPLEMENTATION OF EARLIER ADVICE

The catch of belugas in West Greenland has been reduced in response to previous advice, and modelling suggests that the reduced harvest has led to a reversal of the previously declining trend.

For narwhals in Greenland a quota has been implemented which reduced the catch level. How this has affected the narwhal populations is not clear.

In response to the recommendation for struck/loss monitoring, it was noted that there had been some monitoring in Canada (for narwhals) and this study is ongoing. These results will be presented to this meeting at the next JWG. No new studies have been implemented in Greenland.

TRADITIONAL KNOWLEDGE

The new abundance estimate for narwhals in Melville Bay agrees with information provided by hunters that there is a relatively large population there in summer. The coverage in previous aerial surveys had been based on positions obtained from radio-tagged narwhals and was likely too far offshore to capture the large groups of animals in coastal and southern portions of the bay.

The JWG acknowledged the importance of receiving information from local people concerning any changes observed in narwhal or beluga distribution, movements, and behaviour.

OTHER BUSINESS

Implications of the inclusion of other species (e.g. walrus) in the work of the JWG, was discussed. The JWG noted that it is still waiting to hear how the JCNB has decided to handle this issue. As indicated after previous discussions, the JWG continues to believe that walrus assessments would require separate meetings from those devoted to narwhal and beluga assessments.

NAMMCO question regarding Ageing workshop in beluga and narwhal

A brief review of methods for age estimation in belugas and narwhals indicated a need to standardize ages using Growth Layer Groups (GLGs) in tooth dentine, and reconcile these with new methods involving Aspartic Acid Racemization (AAR) techniques using eye lens. Experimental methods currently applied with some success in other cetacean species using fatty acid profiles were also discussed. The JWG expressed broad support for the workshop initiative, noting, for example, the value of cross-laboratory calibration, standardization of methods, and the use of racemization of eye lenses to calibrate growth layers in small embedded tusks in narwhal. Such calibration might make existing collections more useful for life history analyses. It was suggested that consideration should be given to how the insights on age determination developed at the workshop(s) will be incorporated into assessment 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 determination (e.g. fatty acids) explored in a workshop context.

The authors of the brief review expressed their view that NAMMCO likely would be willing to help convene and organize the workshop(s) and that selection of the venue(s) would be critical. For the practical components, it will be necessary to hold the workshop(s) in an appropriately and adequately equipped laboratory.

Recognizing that there are a number of problems with age determination for both species and that these need to be studied in more detail, the JWG recommends 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 group will report before the next session to the JWG with the expectation that an initial workshop will take place before the end of 2010.

Human impact on narwhal and beluga habitat (NAMMCO request)
The JWG previously expressed its interest in reviewing new information on human-caused changes to narwhal and beluga habitat caused, for example, by shipping (noise and other disturbance), fishing and pollution. No papers on this subject were presented at this meeting but there was a brief general discussion. Specific reference was made to the potential for expanded oil and gas development in the Lancaster Sound region, mining projects on Baffin Island, increased ship traffic through the Northwest Passage, and increased fishing activity (e.g. for Greenland halibut) in narwhal wintering areas in southern Baffin Bay and northern Davis Strait.

The JWG reiterated its interest in this topic and encouraged efforts to develop habitat models and assess impacts. It was agreed that habitat-related concerns should be a standing item on the agenda for future meetings of the JWG and that relevant papers, including summaries or reviews of specific types of activities or specific development projects, would be welcome. It was noted that many of the habitat concerns apply to other marine mammals as well as beluga and narwhals and therefore it may be appropriate to treat all species together in addressing this topic.

The JWG was not in the position to answer the request forwarded by NAMMCO. The JWG concluded that NAMMCO should consider establishing a working group on the impacts of human activities other than hunting on marine mammals in Greenland and northern Canada. The scope of such a working group might best be framed in terms of the Baffin Bay ecosystem as a whole, including Baffin Bay and adjacent waters of Canada and Greenland.

Requests for observer status at meetings
Lockyer raised the question of whether the JWG had specific procedures for dealing with requests for observer status at its meetings. In the absence of such procedures, she agreed to prepare a draft text for consideration at the next meeting.

Other
The group commented on the recent IUCN species listing of beluga and narwhal in the category of "Near Threatened" and noted that this classification was overly pessimistic. Concerns that JWG has expressed with respect to specific stocks in the past should not necessarily be applied to the species as a whole. Given both the fact that narwhals and belugas are not harvested in many parts of their range, harvests are low relative to global species abundance, and the new data presented at the last two meetings of the JWG on recent large abundance estimates for Greenland-Canada populations, the working group suggested IUCN should revisit or revise this classification. http://cmsdata.iucn.org/downloads/cetacean_table_for_website.pdf

MEETING REPORT

1. OPENING REMARKS

Chairmen Steve Ferguson (JCNB) and Rod Hobbs (NAMMCO) welcomed the participants (refer to Section 5.6) to the fourth 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).

In 1998 the Council of NAMMCO (NAMMCO 7) made a general request for the Scientific Committee (SC) to 'examine the status of narwhal and beluga throughout the North Atlantic', which was subsequently specified in later meetings (NAMMCO 1999 (8), 2001 (10), 2002 (11), 2003 (12), 2004 (13), 2005 (14)). Subsequently the SC has held 5 specialist working groups, the last three jointly with the JCNB, each concentrating on different aspects of the request.

In 2006, the NAMMCO Management Committee (NAMMCO 15) further requested that the SC 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 2008, the NAMMCO Council, following the recommendation of the SC, recommended that the SC update the assessment of both narwhal and beluga, noting that new data warranted such an exercise. The NAMMCO / JCNB Joint Working Group should meet before March 2009, to allow the updated assessment to be available for setting the new quota series.

The NAMMCO Terms of Reference (ToR) for this meeting are (a) to provide or update the assessment in all areas of narwhal and beluga in West Greenland, and narwhal in East Greenland, as well as (b) to provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas and narwhals, particularly in West Greenland. In addition the SC requested the JWG to (c) consider whether the organizing of an Age Determination and Methods Validation workshop was warranted; such a workshop would not only include tooth layer reading but also other techniques such as aspartic acid racemization and fatty acid ratios in blubber.

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 JWG will therefore concentrate on the following tasks:

a) Update the assessment of both narwhal and beluga for all areas;
b) Provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas and narwhals, particularly in West Greenland;
c) Consider the need for an Age Determination and Methods Validation workshop and eventually advice on its ToR.

2. ADOPTION OF JOINT AGENDA

The draft Agenda (Appendix 1) was adopted.

3. APPOINTMENT OF RAPPORTEURS

Mario Acquarone and Christine Abraham, Pierre Richard, and Randall Reeves were appointed as rapporteurs for the meeting, with the assistance of other members as required.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents that were available for the meeting are listed in Appendix 2.

5. NARWHALS

5.1 Stock structure

5.1.1 Genetic information

WG-2009-18: Garde, E. and Willerslev, E. Long-term low genetic diversity in narwhals - insights from ancient DNA

The narwhal (*Monodon monoceros*) is presently found in arctic waters in East Canada, North West and North East Greenland, and Russia. The modern narwhal populations in Canada and Greenland show remarkably low mtDNA genetic diversity, whereas the Russian populations are not well studied. It has been suggested that the low diversity was caused by a rapid and relatively recent expansion from a small founding population, probably facilitated by retreating ice and thereby habitat expansion after a glaciation. The aim of this study was to show when in time, and why, the narwhal populations crashed, using ancient mtDNA and climatic data. Preliminary results show that this low genetic diversity is not just a modern phenomenon, but extends back among samples going as far back in time as 50,000 years. It is suggested that the

bottleneck in the narwhal populations happened more than 50,000 years ago, and was therefore not caused by humans or by the last glaciation.

Discussion

The JWG noted the importance of investigating the origin of the low genetic diversity in the management of narwhals. Some sources have speculated that the low genetic diversity could have been caused by overharvesting of narwhals in recent times. This study and Palsbøll *et al* (1997) indicated that the low genetic diversity preceded human harvesting of narwhals by over 50,000 years.

5.1.2 Satellite tracking

JWG-2009-13: Laidre, K.L. and Heide-Jørgensen, M.P. Late summer and early fall movements of narwhals in Inglefield Bredning, Northwest Greenland, 2004-2008.

Nothing is known about the fall migratory routes or wintering grounds of the Inglefield Bredning narwhal population in West Greenland. Live capture for satellite tracking studies have proven essentially impossible, despite traditional net capturing working well in most other areas of the Arctic because of offshore preferences and skittish behaviour. This paper presents results from work based at a field station at Siunertalik, Inglefield Bredning, on the southern coast at 77°22'N, 67°58'W in 2004. In all years (2004-2008), satellite tags were deployed by Inuit hunters from kayaks using hand-held harpoons. Tags were thrown into whales from a distance of 2-3 meters and all placed to the left or right of the dorsal ridge. In 2004, 3 whales were tagged and tag durations were as long as 19 days. In 2005, one whale was tagged and the tag duration was 20 days. In 2006, one whale was tagged but the transmitter only lasted for one day. In 2007, six whales were tagged but durations were less than 9 days. And in 2008, nine whales were tagged with the transmitters not lasting more than 9 days. Data from the transmitters suggest whales remain in Inglefield Bredning until at least the end of September and there is no summertime connection with the other summering stock in West Greenland (Melville Bay). Tag performance throughout the period of this study has been poor and declined in recent years despite a concurrent increase in sample size. The reason for the tag failures is not clear. Whale movements out of Inglefield Bredning are an important missing puzzle piece in determining stock identity in West Greenland and continued efforts will be make to improve tag longevity and performance so that migration routes and wintering grounds can be identified for this population.

Discussion

The ensuing discussion examined the methods for capturing the whales which are limited by whale behaviour. These do not allow alternative catch methods such as deploying nets from land or floating ice thus making deployment from kayaks preferred.

The reasons for the poor tag longevity in the two later years compared with the first two are unknown. The hypothesis that the tags during the two later years were placed differently on the whales is impossible to verify as the only account of the tagging consists of unclear descriptions from the hunters.

The information presented in this study indicates that the whales do not move extensively during the summer. Furthermore, at the moment there is no evidence of contact between the stock in Inglefield Bredning and Melville Bay in the summer. Further tagging efforts to increase the longevity of the tags should be continued.

JWG-2009-19: Heide-Jørgensen, M.P. and Laidre, K.L. Update on satellite tracking of narwhals in Baffin Bay.
This study presents new information on movement patterns of narwhals in Baffin Bay based on satellite tracking data in order to update the meta-population concept previously adopted by NAMMCO (Heide-Jørgensen *et al*. 2005). Narwhals from the Admiralty Inlet stock are well separated from other Canadian stocks during summer. However, in the fall there is some movement into regions used by the Somerset Island and Eclipse Sound stocks. The first movement of a narwhal from Canada (Admiralty Inlet stock) to the hunting grounds in West Greenland was observed in January 2006. Thus, it cannot be excluded that there are regular winter visits to West Greenland by whales from Canada. Tracking of narwhals from Melville Bay confirmed the high summer affinity to the bay and demonstrated again that narwhals indeed return to the summering areas where they were tagged. Tracking studies from Melville Bay also demonstrate the importance of the Baffin Bay wintering ground; however also suggest whales from Melville Bay visit Disko Bay in winter where they may be hunted. This, combined with evidence from Admiralty Inlet, suggest the Disko Bay winter aggregation may be a composite of whales from several localities moving in and out of the area throughout the winter. Tracking from Melville Bay also show that narwhals can be found outside Uummannaq in spring, where they can be accessed by local hunters. The northbound spring movement of one whale in 2008 suggests that Melville Bay may be the summer destination for whales from Uummannaq. The major issues that remain unresolved are the migratory route and destination of narwhals from the Inglefield Bredning stock, as well as which stocks supply the autumn and winter hunts in Uummannaq and Disko Bay. Discussion: Melville Bay animals actually go to Disko Bay. The origin of the Uummannaq spring hunt is not evident. None of the animals tagged in Uummannaq went down to Disko bay.

Discussion
The delegates mostly agreed that satellite tagging provides the best available method to investigate interstock movements, however to date the sample size of the data gathered does not allow for good probabilistic modelling. The JWG recognized the need for a larger dataset and encouraged further tagging studies in this area, but also recognized the limitations of the method. It was pointed out that careful interpretation of the data involves considering the representativeness of animals tagged. The discussion failed to define the magnitude of a sufficient sample size, but underlined the importance of the behaviour of individual animals in understanding possible connections between stocks.

JWG-2009-15: Laidre, K.L., Heide-Jørgensen, M.P., Stern, H., Dietz, R., Richard, P., Orr, J. and Schmidt, H.C. Variability in Baffin Bay sea ice and its influence on the movements of narwhals from Kakiak Point, 2003-2005.

Thirty-four narwhals were captured in August between 2003 and 2005 at Kakiak Point, Admiralty Inlet, Baffin Island and tagged with satellite transmitters. Of these, movement of whales tagged in 2003 and 2004 were reported in detail in Dietz *et al.* (2008). This manuscript provides details on the results from the tagging in 2005 and tracking through spring 2006 (n=13 whales) and compares data with previous years and contrasting sea ice conditions. Tracking durations ranged widely, from 10 to 219 days, with the longest lasting transmitter providing positions through 24 March 2006. There was a high degree of inter-individual variability in the date whales departed from Kakiak Point and in the choice of migratory route to the wintering grounds. Some individuals visited regions where other stocks of narwhals occur, both in summer (Creswell Bay/Somerset Island, Canada) and in winter (Disko Island, West Greenland). When data from tags lasting longer than three weeks were examined, whales tagged in 2005 departed the summering grounds in two migratory waves about 20 days apart. The overwintering area in 2005-06 was large (>128,000 km^2), and ranged across 6 degrees of latitude (between 64 and 70°N) into Davis Strait. This was in contrast to the wintering ground in 2004-05, where whales used only 21,000 km^2 within Baffin Bay, but was similar to that in 2003-04 (>153,000 km^2) which also ranged into Davis Strait. No significant differences in mean latitude during the winter period were found across the three years, however median winter velocity (km/day) was significantly different across years ($p=0.002$), with 2004-05 having the lowest velocity and 2003-04 and 2005-06 not different. These differences in range and velocity coincided with large variability in annual sea ice conditions in Baffin Bay. Narwhals ranged most widely and had the highest winter velocities in years with the most dense sea ice cover (2003-04 and 2005-06), suggesting heavy ice years requires whales to conduct compensatory movements to keep up with moving leads and cracks. On the contrary, low sea ice cover on the wintering grounds resulted in whales remaining stationary over their preferred foraging ground for longer periods and lower daily velocities without requiring large movements. In general the migration of whales occurred far ahead of the forming fast ice, and narwhals did not encounter dense sea ice until the migration had ceased and they were in their wintering grounds.

Discussion

Apparently reduced ice coverage results in smaller home ranges and lower velocities in winter for the animals included in this study. Further investigations are needed to attain an understanding of the dynamics of the process and of the causes of the phenomenon. In particular the importance of the details of ice movements (ice velocity) and concentration was recognized. In years with abundant ice cover whales move more, spending more energy. This seems to originate from an effort to stay in the foraging areas counteracting the effect of currents. Further analysis on the relationship of animal movement with ice velocity is planned. The JWG suggested integrating data on prey distribution and abundance to these analyses.

The JWG reviewed distribution and habitat use of narwhal in southeast Baffin Bay in an area designated as the Southern Wintering Ground. It was noted that most narwhal winter in this area despite heavy ice conditions and utilize this habitat for 4 months during winter for feeding. Greenland halibut are abundant in this area at the depths to which narwhal are diving and it is known that Greenland halibut comprise a

significant proportion of narwhal diet in areas of West Greenland adjacent to the Southern Wintering Ground. It was further noted that this deep water area also contains fragile cold water corals that may contribute to the ecosystem properties that support halibut as food for the narwhal. The JCNB is supportive of recent measures taken by DFO to close an area within NAFO Division 0A, comprising a significant proportion of the SWG, to Greenland halibut fishing and requests that this fishing closure continue in order to protect the narwhal, their major food, and their winter habitat.

JWG-2009- O16: Westdal, K. and Richard, P. Seasonal movements of Northern Hudson Bay narwhals.

The northern Hudson Bay narwhal (*Monodon monoceros*) population gathers in the area of Repulse Bay, Nunavut in the summer season. This population is hunted by local Inuit and co-managed by the Nunavut Wildlife Management Board and the Department of Fisheries and Oceans. There is some uncertainty as to the size of the population, what migration route this population takes to its wintering areas, if its winter range overlaps with that of other narwhal populations and, while migrating, whether it is hunted by other communities.

The purpose of this research is to provide summer home range data to determine if past aerial surveys covered appropriate areas and for determining boundaries of future aerial population surveys; to determine if this population is geographically separate from other narwhal populations; and to add to written documentation of local knowledge on the distribution of the species.

Five narwhals were tagged with satellite tracking devices in August 2006 and four narwhals were instrumented in August 2007 in the vicinity of Repulse Bay, Nunavut. Whales were tracked using the ARGOS system for 100 to 305 days with two of the tags transmitting long enough to show the beginning of the migration from wintering grounds back to summer grounds in early May. Location data were filtered using a movement state-space model as well as by location quality. Home range size was calculated using 95% and 50% kernel estimates. In addition, seventeen hunters and elders were interviewed in the community of Repulse Bay in order to gather local knowledge of the species to add to the scientific analysis. Results of local and scientific knowledge suggest that a portion of the summer home range falls to the east of past aerial survey coverage and that winter range does not overlap with that of other narwhal populations. Migration route of tracked animals coincide with local knowledge of narwhal migration and suggests that this population is likely rarely hunted by other communities en-route between summer and winter grounds.

Discussion

The terminus of the rapid offshore migration October-November occurred in December when the whales were located in southern Davis Strait south and east of Cumberland Sound. This wintering habitat is at such a distance from the Baffin Bay stock as to likely exclude any mixing of the two groups of whales.

5.1.3 Other information

JWG-2009-16: Wiig, Ø., Heide-Jørgensen, M.P., Laidre, K.L., Garde, E. and Reeves, R.R. Geographic variation in cranial morphology of narwhals (*Monodon monoceros*) from Greenland and the Eastern Canadian Arctic

Present results from a study of cranial morphology of narwhals from different populations. Variation in nine non-metric and eight metric variables in the skulls of 132 narwhals from five localities in Greenland (Qaanaaq, Melville Bay, Uummannaq, Qeqertarsuaq, and Scoresbysund,) and one in the Eastern Canadian Arctic (Milne Inlet) were examined. Metric variables were used to compare the combined Qeqertarsuaq and Uummannaq sample with the samples from Qaanaaq and Scoresbysund using three different multivariate techniques for each sex. None of the results were significant, however this may be attributed to low sample sizes. Six of the non-metric variables were independent of age and sex and were used in comparing samples from the six localities. No differences were found between the four localities in West Greenland. One of the six variables (number of *foraminae* in the *maxillae*) showed differences between the combined West Greenland samples and Milne Inlet. One variable (number of *alveoli* in the front of the *premaxillae*) showed differences between the combined West Greenland sample and the one from Scoresbysund. Thus, it appears to be possible to detect differences between stocks based on skulls, but with non-metric variables. A major shortcoming of this analysis is the small sample size from several of the areas which made distinguishing differences difficult or impossible. It is therefore recommended to continue collection of skulls of narwhals to augment samples sizes in future studies.

Discussion

During the harvest only body length and fluke width are recorded therefore museum specimen have been used in this study. These measures seem to confirm the uniformity of narwhals inferred from genetic data and morphometrics may have limited utility in stock identification. To extend the dataset it was mentioned that the use of parasites as biological tags may be used to help differentiate the stocks. [This needs work. Looking at parasites does not extend the morphometric data set, which was deemed useless anyway.]

5.1.4 Management units

New information presented at this meeting was used by JWG to update the stock structure model (Fig. 6 of JWG-2005-16) representing the relationships among narwhal stocks is presented under point 5.3.3 (Fig.1).

5.2 Biological parameters

5.2.1 Age estimation

JWG-2009-17: Garde, E., Heide-Jørgensen, M.P. and Hansen, S.H. Age, growth, and reproduction in narwhals (*Monodon monoceros*) from West and East Greenland as estimated by aspartic acid racemization – preliminary results

This work provides new information on narwhal age structure and reproduction compared to the working paper presented at the last meeting of the JWG in Nuuk in 2005 (Garde *et al*. 2005, 2007). Eyes from 110 narwhals (*Monodon monoceros*) were collected in East and West Greenland in 2006-2008 for the purpose of age estimation using aspartic acid racemization. The ratio of D- and L-enantiomers of aspartic acid

was measured using high-performance liquid chromatography (HPLC). The aspartic acid racemization rate (k_{Asp}) was estimated to be 0.00115/year ± 0.000096 *SE* by regression of D/L ratios on age estimated by length from 10 young narwhals (≤280 cm), and by counting of growth layer groups in the tusks from 5 narwhals. The D/L ratio at age 0 ($(D/L)_0$) was estimated to be 0.04305 by regression of D/L ratios against the estimated ages of the 15 narwhals. The intercept of the regression slope, providing twice the $(D/L)_0$ value, was 0.0861± 0.00373 *SE*. Asymptotic body length, from whales from East and West Greenland, respectively, was estimated to be 401 and 399 cm for females and 432 and 425 cm for males from length versus age estimates. Age at sexual maturity was estimated to be ~6 years for females and ~9 years for males, using Laws 1956 that stated that cetaceans become sexual mature at 85% of their asymptotic body length. This approach was taken for comparison of the age at sexual maturity estimated in the two papers by Garde *et al*. (2007 and 2009) from length versus age data. From reproductive data, age at sexual maturity for females was estimated at ages between 8-12 years, and growth of testis in males was estimated to start at ~10 years of age and cease about 19 years of age. For a more accurate estimate of female age at sexual maturity more data on *corpora* counts is needed. Samples for this work have been collected and is planned finalized at latest in the spring 2010. The maximum estimated age was a 99-year-old (± 12.2 *SE*) female. The maximum age for males was 94.5(± 11.9 *SE*). This study showed no difference in life history parameters for the East and West Greenland narwhals.

Discussion

The comparison of ageing through Aspartic Acid Racemization (AAR) and counting of Growth Layer Groups (GLG) in harp seals presented during this talk provides qualified support for the AAR method in marine mammals. The counting of GLG is also subject to possible bias but it is robust with a long history of research. For the results presented on harp seals, AAR ageing seems to underestimate seals under 7 years old while the GLG method underestimates the ages of seals older than 12 years. As indicated in the paper's title, work is in progress. Racemization rates for different species will have to be further investigated.

Another factor to be further investigated is the influence of body temperature on the racemization rate in different species of animal. In particular it is important to understand how and in what measure differences in eye temperature influence racemization and whether it would be possible to infer eye temperature from body temperatures also in Arctic marine environments.

GLGs in tusks could be a useful for calibration of the AAR method in narwhals. The calibration with the embedded tooth would allow for the analysis of archival collections.

The number of *corpora albicantia* and *lutea* presented in this study originates from analysis of the intact ovaries. The maximum number of 9 to 11 corpora observed in the oldest females was considered low compared to other species. The JWG pointed out that serially slicing the ovaries and undertaking detailed histological examination

would yield more complete counts of the reproductive history, especially for older females where the older *corpora* would be very small and difficult to identify.

5.2.2 Reproductive rates

A table of life parameters for narwhals based on recent publications by Garde *et al.* is presented below in Table 1.

Source	**Garde *et al.* 2009***		**Garde *et al.* 2007***	
	Age (yr)	**Length (cm)**	**Age (yr)**	**Length (cm)**
Length data				
Physical maturity (F)	**17**	400	**21**	396
Physical maturity (M)	**21**	*429	**26**	457
Sexual maturity (F) based on length #	6	340	6-7	337
Sexual maturity (M) based on length #	9	365	9	388
Asymptotic tusk growth	50	180	53	178
Longevity (F)	**99**	441	**115**	425
Longevity (M)	**94.5**	472	**84**	435
Reproduction data				
First ovulation (F)	8-12	<356		
Testis growth	10-19	400-425		

*References:

Garde, E., M. P. Heide-Jørgensen, S. H. Hansen and Forchammer, M.C. Age-specific growth and high longevity in narwhals (*Monodon monoceros*) from West Greenland estimated via aspartic acid. NAMMCO/SC/13-JCNB/ SWG/2005-JWG/8: 40 pp.

Garde, E., Heide-Jørgensen, M. P., Hansen, S. H., Nachman, G., and Forchammer, M. C. 2007. Age-specific growth and remarkable longevity from narwhals (*Monodon monoceros*) from West Greenland as estimated by aspartic acid racemization. *Journal of Mammalogy* 88(1): 49-58.

Table 1. Life history parameters in narwhals from Greenland as estimated in two different studies (Garde *et al.* 2007, 2009). # sexual maturity estimated as xx% of asymptotic length data (see Laws 1956). *Average length from East and West Greenland male narwhals.

5.2.3 Other information

JWG-2009-05: Heide-Jørgensen, M.P. and Laidre, K.L. Feeding habits of narwhals in Scoresby Sound.

This working paper reports on feeding habits of narwhals in East Greenland. A total of 79 narwhal stomachs were collected from the local hunt in Scoresby Sound between April 2005 and November 2006 and examined for amount and composition of prey remains. Only six stomachs collected had signs of fresh remains, of which only one had a measurable amount of prey remains (<0.5 kg). Twenty-six stomachs had no remains at all and the remainder had sparse otoliths and squid beaks caught in the stomach folds. Only two prey species could be identified; *Gonatus* squid and polar cod, *Boreogadus saida*. The absence of stomachs full of fresh remains indicates that Scoresby Sound is not important as a feeding ground for narwhals in summer and fall, and likely means there is a similar pattern of high feeding intensity in winter and spring as observed on the west coast of Greenland.

Discussion

It appears from this paper that narwhals do not feed intensively while in Scoresby Sound. The possibility of whales regurgitating and completely emptying their stomachs during capture was examined and excluded. In West Greenland stomachs of whales killed in winter are often full. The absence of intestinal content of whales hunted in summer further confirms this observation. This study indicates a similarity in the feeding habits of West and East Greenland narwhals.

JWG-2009-O07: Auger-Méthé, M. 2008. Photo-Identification of Narwhals. MSc thesis, Biol. Dept. Dalhousie University and

JWG-2009-O15: Marcoux, M. and Auger-Méthé, M. Update on narwhal research in Koluktoo Bay

These presentations reported on the authors' work on narwhal from 2006 to 2008 in Koluktoo Bay (Nunavut). The observations were made at the mouth of the bay where narwhals are funnelled into a 5 km wide entrance and can be observed from shore. The study was based on three techniques: observations from shore, underwater sound recording and photo-identification (photo-id). Regarding the observations from the shore it was noted that the sighting rates are cyclic with groups of narwhals entering the bay almost every day and that they seem to relate to the tide even though the pattern was different between the years. The sex and age composition of the "clusters" of whales varied according to the group size where e.g. larger groups were almost exclusively composed of males. These observations have yielded the assignment of an Index of Gregariousness for calves, females and males. The baseline behavioural data collected has implications for management as it facilitates the assessment of potential impacts of environmental change and development in the Arctic. For example, other cetacean species reacted to shipping disturbance by changing their behaviour or group size. Underwater recordings allowed the correlation between sightings and vocalizations. The observations indicate that the intensity of vocalizations is proportional to the group size and that it might be employed as an index of whale abundance by the communities. The photo-id part of this project envisaged to develop a cheap and non-invasive technique for the individual recognition of narwhals. This species does not present the salient characteristics used for the photo-id of other cetacean species thus a new method had to be developed. To be suitable for photo-id a

type of mark is required to be complex, prevalent and relatively stable over time. The marking of the dorsal ridge appears to have these characteristics and a computer programme was written to speed up the comparison of new photos with the ones on archive. The aim of the programme is to select the best candidate photographs from the archive. These photographs are subsequently visually verified for potential matches. Among the applications of this photo-id protocol are studies of site fidelity and movement patterns, population estimate and trends and social structure. One advantage of this technique is that it is adaptable to community based programs, it is cheap and the software is freely available. Furthermore the protocol can be adapted to other species such as belugas.

Discussion

There are at the moment about 250 individuals in the catalogue. Discussion addressed concerns about defining the initial and final point of the measurements corresponding to the anterior and posterior extremities of the dorsal ridge. In this particular case the software implements multiple methods to determine the proportional distances between the notches. First, to correct for the error in placing the extremity points on the ridge, the software does not measure distances as values but as error distributions. Second, the programme compares the proportional distances using alternatively the first and the last point on the ridge. The sensitivity to the angle at which the photos are taken might be relatively high and requires a careful selection of photos. The computer programme does not contribute to false positive errors as the selection and determination of a match are finally made by the operator. False positive errors made by the user does not appear to be an issue as all matches made between photographs from the same side and taken the same year were confirmed by other mark types found on the narwhal.

It was also suggested to use an array of listening points along the coast in order to detect the relative numbers and the direction of the passage of whales through the 5 km wide inlet. But it was underlined that in some species the vocal behaviour follows daily patterns and also that external factors such as predation can radically modify vocal behaviour. Further analyses of the acoustic behaviour are ongoing and are needed before recordings can be used as an index of abundance.

5.3 Catch statistics

5.3.1 Struck and lost

In November 2006 NAMMCO organized a Workshop to address the problem of struck and lost of hunted marine mammals, attended by scientists, managers, hunters and other interested participants from 10 countries. The overall goal of the Workshop was to improve catch relative to effort, to reduce animal suffering and improve public image, and to formulate recommendations on methods, techniques and equipment to reduce struck and loss that are applicable at the local level. A series of general recommendations was made among which: (a) to minimize animal suffering, (b) to establish and develop accurate monitoring programs in cooperation among hunters, managers and scientists, (c) to promote the use of appropriate hunting equipment, (d) to establish a cooperative management system among the hunters and (e) to share technology and knowledge. In particular, for small whales, the Workshop

recommended (a) extensive hunter training, (b) the use of state of the art techniques and equipment, (c) the implementation of regulatory measures, and (d) the establishment of monitoring plans (NAMMCO 2006).

Canada has initiated a hunt monitoring programme in Admiralty Inlet and Repulse Bay that has one more season of data collection. DFO provides a conservative total allowable harvest recommendation which incorporates estimates of struck and lost. While in Greenland, the reporting of struck and lost is a component of the catch reporting system. However the method has not yet been validated. The catch from kayaks in Greenland cannot easily be monitored because of the nature of the craft and the hunt, but probably this kind of hunt experiences minimal loss as the animals are harpooned (before being shot).

The JWG highlighted the difficulty in assessing the severity of wounds and the necessity to adopt a definition of lethal wound. Struck and lost represents a fraction of the total removals and it is necessary to account for it when providing advice. The JWG reiterated the continued importance of the collection of struck and lost data from all areas and types of hunt and documentation of improvements in practices and techniques that result in lower struck and lost rates.

5.3.2 Ice entrapments

Two ice entrapments, both in 2008, were reported: one in Canada and the other in Greenland.

On the 15 November 2008 the hunters of Pond Inlet found narwhals in holes along a pressure crack running from south from Bylot Island. The water had been open until a few days before when the temperature suddenly dropped until below -30°C promoting a rapid freeze-up that extended across Eclipse Sound and Pond Inlet. In the days preceding the entrapment thousands of narwhals were seen passing by Pond Inlet, later in the season than usual.

The Community asked for permission to take the animals and this was accorded as the entrapment was certain. The whales were then harvested from the ice holes in large numbers. In total 629 whales were taken directly and more may have died from suffocation. Among the harvested whales at least 93 tusked animals were counted as well as females and calves. A total of 566 animals were assessed by the hunters according to size (68 calves, 210 juveniles and 288 adults). In spite of the adverse meteorological conditions, 249 frozen animals left on the ice were sampled (chunk of skin-fat-muscle) and will be analyzed for genetics, *Brucella* and fatty acid composition. More detailed collections, including eyes, were taken of 9 juveniles (mostly yearlings) by DFO personnel during the last day of harvesting.

In Greenland during Feb 2008, 30-45 animals were entrapped in the ice in the Sermilik fjord-system in East Greenland. This phenomenon was recorded on video and an examination confirmed the entrapment. No samples were taken.

5.3.3 Histories by management units

JWG-2009-22: Baker, C. Canadian catch statistics.

The narwhal catch statistics from selected communities in Nunavut were presented for landed animals for the last 5 years (2004-2008). Four of the communities are under the Community Based Management (CBM) programme. This programme has specific reporting requirements and other conditions, which differ from communities that are not part of the CBM programme. The CBM programme is currently under review and the future of the programme is unknown at this time. The communities under CBM have harvesting limits as opposed to quotas and are able to borrow against tags in for future years in times of good harvest. Communities under CBM presented in the table include Arctic Bay, Pelly Bay, Qikiqtarjuaq, and Pond Inlet. The hunts in most of these communities were fairly consistent across the 5 years of harvest. The exception is Pond Inlet, which increased from an average harvest of 69 narwhals from 2004-2007 to 711 narwhal in 2008. The explanation for the significant increase was in November 2008 there was a humane harvest of 629 narwhals due to an ice entrapment. It was also noted that there has been a request from Fisheries Management to Science to determine the potential impact of the 2008 humane harvest on the population. There are a number of communities that are yet to report the harvest for 2008. Efforts are being made by the Iqaluit Area office to get the 2008 harvest information. Most communities are harvesting near their harvesting limit for most years. However, Pangnirtung has consistently been under harvesting narwhal for the last 5 years (i.e. harvest limit = 40, 5 year average = 9). The reason for this is not known.

Community	**Quota or Harvest Limit**	**2003**	**2004**	**2005**	**2006**	**2007**	**5-year Total**	**5-year Average**
Arctic Bay	130*	129	122	131	130	127	639	128
Clyde River	50	53	50	39	43	42	227	45
Gjoa Haven	10	0	0	0	0	1	1	0
Grise Fiord	20	8	9	1	21	23**	39	10
Hall Beach	10	2	11	3	1	0	17	3
Igloolik	25	0	27	24	25	1	77	15
Pangnirtung	40	30	25	3	1	1	60	12
Pelly Bay	25*	24	16	28	48	40	156	31
Qikiqtarjuaq	90*	90	96	88	88	88	450	90
Pond Inlet	130*	67	65	62	87	65	346	69
Resolute Bay	32	2	5	13	28	9	57	11
Taloyoak	10	1	0	0	33	0	34	7
Totals		**406**	**426**	**392**	**505**	**394**	**2103**	**423**

Notes:

* Community Based Management Quotas
Totals do include Hall Beach and Igloolik
23** 3 tags were from Resolute

Table 2. Catch Statistics (2003-2007) for Narwhal in selected Eastern Canadian Arctic Communities.

Discussion
Struck and lost information was provided for the communities under CBM, which are the only communities that provide this information. The information presented was from 2003-2007. The 2008 information has not yet been analyzed. The JWG expressed concern that not all communities provide struck and lost information.

JWG-2009-07: Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in Greenland 1862 to 2008. A preliminary compilation.
It provides a preliminary compilation of catch statistics for narwhals in East and West Greenland. Information and statistics including some trade statistics on catches of narwhals in Greenland since 1862 are reviewed. 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 underreporting 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 of somewhat realistic catch levels from 1862 through 2006 (data from 2007 and 2008 are still preliminary). 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=0.002). The decline was most pronounced in Uummannaq (p=0.002) and Disko Bay (p=0.03) and could not be detected in the other areas (Qaanaaq p=0.5, Upernavik p=0.6). Catches in East Greenland seem to be increasing steadily at a rate of 12% yr-1 (p=0.001). Current catch levels (2000-2005) are 35 per year in the Smith Sound area, 82 in Qaanaaq, 134 in Melville Bay, 131 in Uummannaq and 117 in Disko Bay and south.

Discussion
This JWG incorporated the updated information in its assessment.

JWG-2009-O09: Stewart, D.B. Commercial and subsistence harvests of narwhals (*Monodon monoceros*) from the Canadian eastern Arctic.
Bruce Stewart gave a presentation of his contract report "Commercial and Subsistence Harvests of Narwhals (*Monodon monoceros*) from the Canadian Eastern Arctic." A reconstruction of commercial and subsistence harvests of narwhals from the Canadian Eastern Arctic had been requested at the 2003 JWG meeting. The contracted report summarized data available in ship logs, sales records and other sources. The JWG welcomes this study, notes the difficulty in assessing historical catch prior to 1977, and looks forward to its use in assessing the sustainability of the Canadian narwhal catch.

In discussion, a question was raised concerning the reliability of the reported catch of 2,800 narwhals in Eclipse Sound in 1919-1920. This number is associated in the literature with an ice entrapment event but there is no way to validate it.

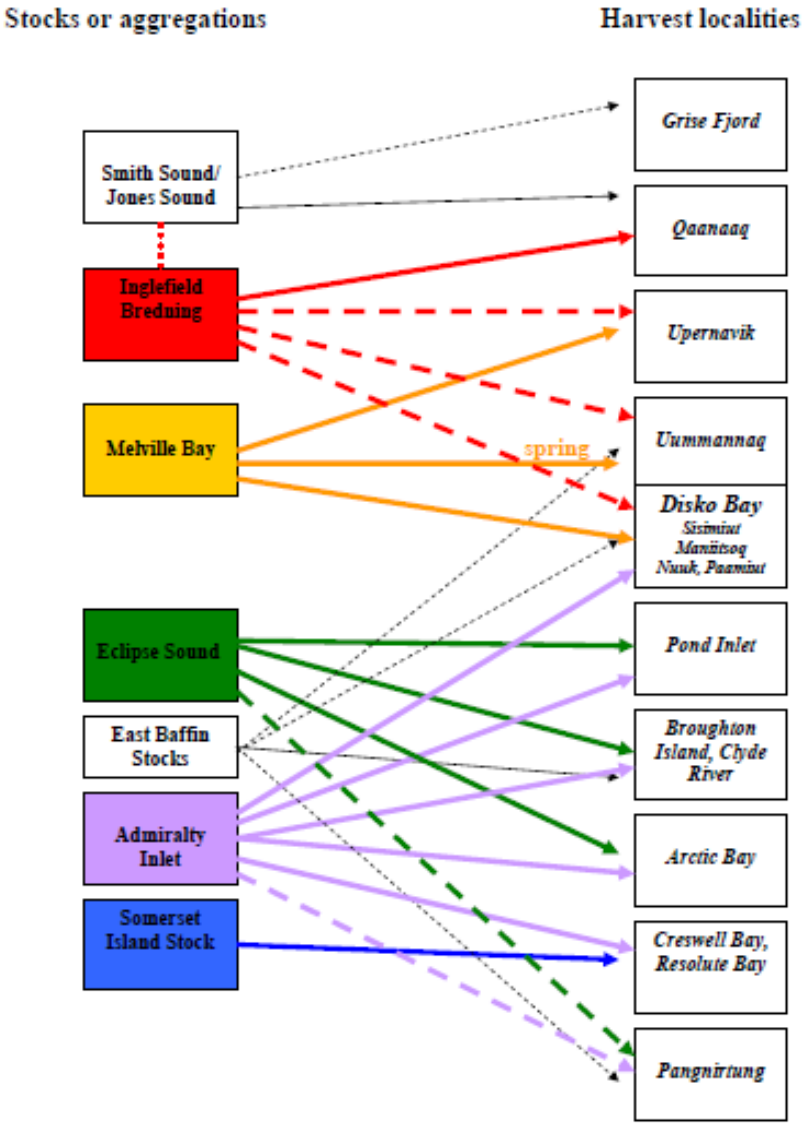

Fig. 1. Narwhal stock allocation according to the revised information from JWG-2009-O13 (JWG-2005-16).

JWG-2009-O13: Heide-Jørgensen, M.P., Dietz, R. and Laidre, K. 2005. Metapopulation structure and hunt allocation of narwhals in Baffin Bay. Working paper. NAMMCO/SC/13-JCNB/SWG/2005-JWG/16

Based on the meta-population model for the structure of narwhal populations in Baffin Bay presented at the last few meetings (JWG-2009-O13), the following changes were endorsed at the meeting by JWG:

1. The large fluctuations in abundance in Inglefield Bredning and the variable catches in the Smith Sound region indicate that the Smith Sound stock and

Inglefield Bredning stock may be connected and cannot be treated as entirely separate stock units (JWG-2009-20, JWG-2009-07).

2. Satellite tracking of narwhals from Melville Bay show that this stock contributes to the hunt in Disko Bay and that it may contribute to the hunt in Uummannaq in spring. Satellite tracking however indicates that Melville Bay does not likely contribute to the fall hunt in Uummannaq (JWG-2009-19).
3. Satellite tracking of narwhals from the Admiralty Inlet stock show that this stock may contribute to the hunt in Disko Bay in winter and that Admiralty Inlet contributes to the hunt in Eclipse Sound, Somerset Island, and along the east coast of Baffin Island (JWG-2009-19).
4. The previously proposed stock of narwhals in Cumberland Sound does not seem to be discrete and instead the hunt in Pangnirtung is likely supported by whales from the fjords on East Baffin and from Admiralty Inlet (JWG-2009-19).

An updated model for the dispersal of narwhals in Baffin Bay is presented above in Fig. 1.

A map showing place names for stocks and harvests is given in Fig. 2 below.

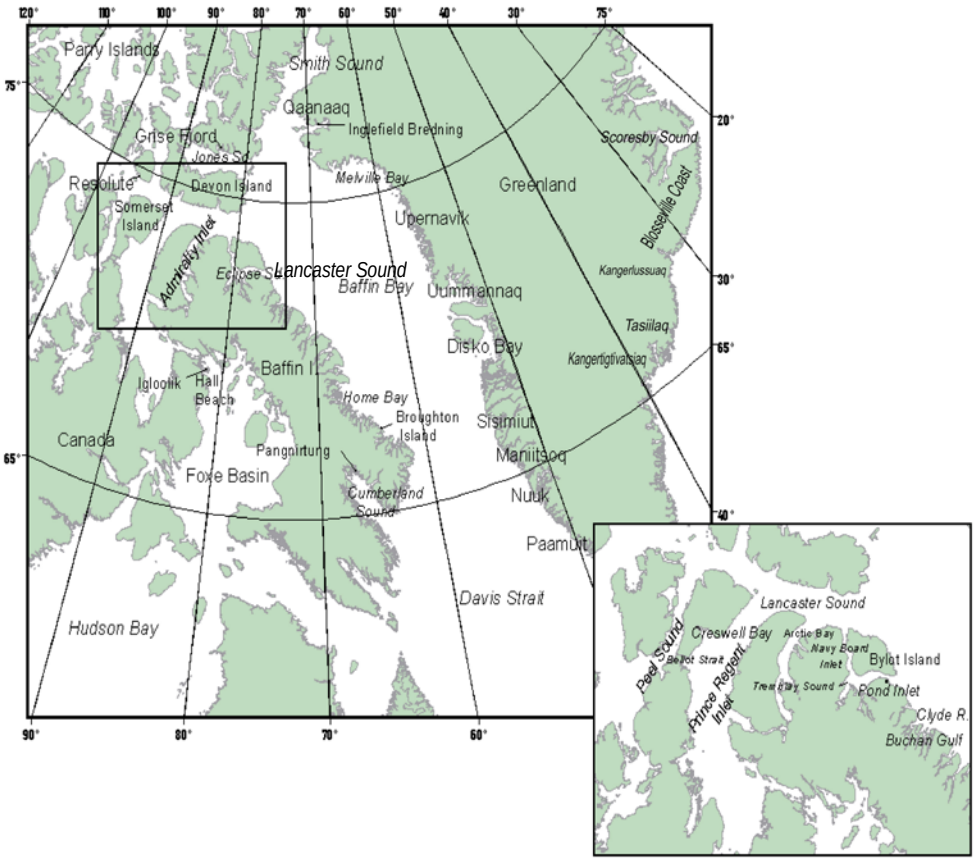

Fig. 2. Map of place names for narwhal stocks and harvests.

5.3.4 Other information

There was no other information.

5.4 Abundance

5.4.1 Recent estimates

There were no new recent estimates.

5.4.2 Estimates by management units

JWG-2009-20: Heide-Jørgensen, M.P., Laidre, K.L., Burt, M.L., Borchers, D.L., Hansen R.G., Rasmussen, M. and Fossette, S. Abundance of narwhals (*Monodon monoceros*) in Greenland.

This paper reports on surveys of all the major narwhal hunting grounds in West and East Greenland and provides fully corrected abundance estimates for these areas. Visual aerial sighting surveys of narwhals were conducted over the wintering ground in West Greenland in March-April 2006, over two summering areas in Northwest Greenland (Melville Bay and Inglefield Bredning) in August 2007, and over the summering areas in East Greenland (Scoresby Sound, Blosseville Coast, Kangerlussuaq and Tasiilaq) in August 2008. The surveys were conducted as line transect surveys from a Twin Otter with two independent observer platforms (4 observers) at bubble windows. Fully corrected abundance estimates were developed including correction for perception bias estimated for each survey with double-observer methods and availability bias estimated from two whales instrumented with satellite-linked time-depth-recorders in Melville Bay in August-September 2007 one of which was tracked throughout a year. The abundance of narwhals on the wintering ground in West Greenland was 7,819 (95% CI: 4,358 – 14,029). The abundance in Inglefield Bredning and Melville Bay was 8,447 (95% CI: 5,224 – 13,658) and 6,235 (95% CI: 1,461 – 26,603), respectively. The abundance in East Greenland was 6,583 (95% CI 2,541 – 17,052). These surveys provide the first narwhal abundance estimates from important areas in East and West Greenland and it provides larger and more reliable estimates from the hunting ground in Inglefield Bredning.

Discussion

The authors specify different data corrections have been used in the past. New availability correction factors were developed for these surveys and were implemented for all the areas.

The JWG recommends the collection of more TDR data (time at surface) around Greenland and of data about the winter aggregation in Northern Hudson Strait/Davis Strait. It endorsed the new abundance estimates for use in the assessment.

JWG-2009-14: Laidre, K.L. and Heide-Jørgensen, M.P. Winter density and abundance of narwhals in the Baffin Bay pack ice in 2000 and 2007.

A double-platform visual aerial survey was conducted from an Air Greenland Twin Otter with long-range fuel tank over the narwhal wintering grounds in Baffin Bay, West Greenland on 3 April 2008. Two abundance estimates were developed. The first was based on Conventional Distance Sampling (CDS) using sightings from the front

observers only. The second abundance estimate was based on the point conditional Mark-Recapture (MR) distance sampling technique and used sampling methods allowing for double platform estimation of sightings missed by both observers. This estimate was used to develop a fully corrected survey specific abundance estimate for 2008. The CDS analysis used 44 sightings to calculate an Effective Search Half-Width (ESW) of 385 m (CV=0.12) based on a half-normal detection function. The expected group size was 2.31 (CV=0.01) and the sighting rate was 0.11 sightings/km (CV=0.45). The fully corrected estimate was 17,239 narwhals (CV=0.58). The MR estimate used a half-normal detection with distance as a continuous variable. The average probability of detection on the trackline for the primary and secondary observers was 0.79 and the detection for both was 0.96. The abundance of narwhals at the surface was 3,484 whales (CV=0.45) including whales missed by the observers. The fully corrected estimate was 19,356 (CV=0.45). These estimates compare to an abundance estimate developed in March 2000 of 5,348 whales (CV=0.43) based on twenty sightings of narwhals along the exact same transects. Sea ice habitat analysis suggests the estimated 17,000-19,000 narwhals in the ~9,500 km^2 survey area were in a habitat with only 233 km^2 of open water, or 2% of the surveyed area. This would result in a density of ~73 narwhals per square kilometer of open water.

Discussion

The JWG fully recognizes the importance and the difficulty of winter surveys and encourages the authors to revisit the ice information from 2000 to seek further explanation for the large difference in abundance compared to the 2008 results.

JWG-2009-14 shows that an estimated 17000-19000 narwhals occupied the survey area in southern Baffin Bay in late winter 2008. This area has also been shown to be occupied by narwhals tracked from several Canadian and Greenland stocks (Admiralty, Eclipse and Melville stocks). These areas are thought to provide the bulk of the annual energy budget of narwhals, which feed extensively on the turbot in that area. The authors announced that the bio-energetic model (Laidre K. L., M. P. Heide-Jørgensen, O. A. Jørgensen, and Treble, M. A. (2004). Deep ocean predation by a high Arctic cetacean. *ICES Journal of Marine Science* 61(3): 430-440.) will be revisited based on this new information. The JWG concludes that this zone is critical to these narwhal populations.

The JWG endorsed the estimate for this area.

JWG-2009-O08: Richard, P., Laake, J.L., Hobbs, R.C., Heide-Jørgensen, M.P., Asselin, N. and Cleator, H. Baffin Bay narwhal population distribution and numbers: aerial surveys in the Canadian High Arctic, 2002-2004. *Submitted to Arctic 5 Feb 2009*

An assessment of the current population size of the Canadian High Arctic narwhals was needed to address questions of status and sustainability of that population, which is hunted by Nunavut Inuit. To that end, aerial surveys of narwhals (*Monodon monoceros*) were conducted in the Canadian High Arctic during the month of August from 2002 to 2004. The surveys covered the waters of Barrow Strait, Prince Regent Inlet, Gulf of Boothia, Admiralty Inlet, Eclipse Sound, and the eastern coast of Baffin

Island, using systematic sampling methods. Fiords were flown with a single transect down the middle. Near-surface population estimates were obtained from the number of narwhals visible to observers on line transects, corrected for the estimated proportion of whales missed by observers, and adjusted to account for observations without a distance measurement. The estimates were further adjusted for individuals that were not seen because they were diving when the survey plane flew over. This correction was derived from dive data from narwhals tagged with time-depth recorders. These corrections resulted in estimates of 27,662 (SE= 15,002) for the Prince Regent and Gulf of Boothia area, of 20,211 (SE =7311) for the Eclipse Sound area and of 10,078 (SE = 3159) for the East Baffin Island fiord area. The estimate for the Admiralty Inlet area was 5,361 (SE = 2698) but is thought to be biased. Surveys in other known areas of occupation, such as the waters of the Cumberland Peninsula of East Baffin, and channels farther west of the areas surveyed (Peel Sound, Viscount Melville Sound, Smith Sound and Jones Sound, and other channels of the Canadian Arctic archipelago) could not be done. Despite these probable biases and the incomplete coverage, results of these surveys show that the summering range narwhals in the Canadian High Arctic is vast and that, if narwhals are philopatric to their summering areas as they appears to do, its population could number in excess of 60,000 animals. The large numbers in the western portion of their summer range, around Somerset Island and the Eclipse Sound area. However, these survey estimates have large variances due to narwhal aggregation in some parts of the surveyed areas. Comparison with past surveys for trend estimation was not possible due to this large CV of the estimates.

Discussion

At the 2005 meeting this JWG agreed that a sub-committee, coordinated by Richard, would meet by email to try to resolve the issue of the analysis of survey data from fiord areas (JWG-2005-04). The work of this sub-committee was completed with this revised analysis and publication. An updated overview of narwhals in the Canadian Arctic is presented below in
Table 3.

5.4.3 Future survey plans

Canada: a survey is planned for Admiralty Inlet in mid-August. Surveys in this area may utilize an adaptive sampling by intensifying the effort and using post-stratification where large aggregations are found. In this case a north-south total count could define the area where the effort should be intensified. Another option is to use acoustic monitoring to detect the position of the large aggregations.

Greenland: a north water survey is planned for May 2009 to count the aggregations of narwhals (Smith Sound).

5.4.5 Recent changes in distribution in Canada

No recent changes in distribution were reported in Canada.

Putative stock	Year and ref.	Method	Estimate (CV)	Perception bias	Availability bias	Fully corrected stock size estimate	Reservations
BAFFIN BAY							
Inglefield Bredning Stock surveyed in Inglefield Bredning	1984 a)	Land	4,000-8,000	-	-	-	Covering ~1/3 of the area
	1985 b)	Line t.	1,091 (0.12)	-	-	-	Late in the season, 27 August -3 September
	1986 b)	Line t.	3,002 (0.25)	0.75 (0.25) *	0.38 (0.06) *	10,533 (0.36)	Perception biased assumed
	2001 b)	Photo	873 (0.35)	0	0.38 (0.06)	2,297 (0.35)	
	2002 b)	Photo	562 (0.24)	0	0.38 (0.06)	1,478 (0.25)	
Inglefield Bredning Stock surveyed in Inglefield Bredning	2007	Line t. Double observ.	1,774 (0.23)	0.96 (0.02) (incl. in estimate)	0.21 (0.09)	8,447 (0.25)	
Central West Greenland or Inglefield Bredning Stock wintering in central West Greenland	1981 c)	Strip	358 (0.31)			Index	
	1982 c)	Strip	440 (0.20)			Index	
	1990 c)	Strip	252 (0.34)			Index	Late in the season: 9-14April
	1991 c)	Strip	273 (0.28)			Index	
	1993 c)	Strip	63 (0.48)			Index	
	1994 c)	Strip	263 (0.36)			Index	
	1998 c)	Strip	213 (0.60)			Index	
	1999 c)	Strip	206 (0.32)			Index	

Putative stock	Year and ref.	Method	Estimate (CV)	Perception bias	Availability bias	Fully corrected stock size estimate	Reservations
	1998-99 c)	Line t.	524 (0.51)	0.5 (0.25)	0.35 (0.23)	2,861 (0.61)	
West Greenland	2006	Line t. Double observ.	1,407 (0.30)	0.80 (0.08) (incl. in estimate)	0.18 (0.04)	7,819 (0.31)	MRDS analysis
West Greenland	2006	Strip	38 (0.58)			Index	
Southern Wintering Ground	2008	Line t. Double observ.	3,484 (0.45)	0.96 (0.03) (incl. in estimate)	0.18 (0.04)	19,356 (0.45)	MRDS analysis
Melville Bay	2002 d)	Photo	-	-	-	Low numbers	
Melville Bay	2007	Line t. Double observ	1309 (0.85)	0.96 (0.02) (incl. in estimate)	0.21 (0.09)	6,235 (0.85)	MRDS analysis
Eclipse Sound	1984 e)	Photo	1,218 (0.59)	0	0.38 (0.06) *	3,205 (0.59)	Partial coverage
Eclipse Sound	2004 i)	Line t.			0.38 (0.25)	20225 (0.36)	
Admiralty Inlet	1984 f)	Photo	5,556 (0.22)	0	0.38 (0.06) *	14,621 (0.23)	
Admiralty Inlet	2003 i)	Line t.			0.38 (0.25)	5,362 (0.50)	
Somerset Island	1981 f)	Strip	11,142 (0.09)		-	-	Partial coverage
Somerset Island	1996 g)	Line t.			0.38 (0.25)	45,358 (0.35)	Partial coverage
Somerset Island	2002 i)	Line t.			0.38 (0.25)	27,656 (0.54)	Partial coverage
East Baffin	2002	Line t.				10073 (0.31)	Partial coverage

Putative stock	Year and ref.	Method	Estimate (CV)	Perception bias	Availability bias	Fully corrected stock size estimate	Reservations
Cumberland Sound	-	-	No data	-	-	-	
Jones Sound	-	-	No data	-	-	-	
Parry Islands	-	-	No data	-	-	-	
Smith Sound	1978 h)	Total	>1,500	-	-	-	
Mixed stock surveyed in Baffin Bay	1979 h)	Strip	34,363 (0.24)	-	-	-	
EAST GREENLAND							
Scoresby Sund	1983	Line t.	300 (0.31)	0.75 (0.25) *	0.38 (0.06) *	1,053 (0.40)	Late in season, probably neg. bias.
East Greenland from Scoresby Sound and south	2008	Line t. Double observ.	1,382 (0.51)	0.81 (0.10) (incl. in estimate)	0.21 (0.09)	6,583 (0.52)	No survey effort north of Scoresby Sound MRDS analysis

Table 3. Estimates and indices of stock sizes of narwhals in Baffin Bay and adjacent waters adopted for by NAMMCO/JCNB Scientific Working Group to be used for stock assessment. * indicate that corrections were applied by the NAMMCO / JCNB Working Group. a) Born (1986), b) Heide-Jørgensen (2004), c) Heide-Jørgensen and Acquarone (2002), d) Heide-Jørgensen (2003), f) Richard *et al*. (1994), g) Innes *et al*. (2002), h) Koski and Davis (1994), i) NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-08.

5.5 Assessment

5.5.1 Update of West Greenland assessment

JWG-2009-12: Witting, L. Model uncertainty on assessments of West Greenland beluga **and narwhals**

This paper used beluga in West Greenland to analyze for model sensitivity in the case of Bayesian assessments based on density regulated population dynamics. Assessments were made for one age-structured and four structurally different discrete models, with all assessments using the same data: two time series of relative winter abundance, one estimate of total winter abundance, and two time series of historical catches. All models gave similar estimates of the current abundance and production levels, showing that the choice of model is a matter of taste.

Discussion

The JWG agreed that for the type of analysis that is performed in the assessments of Greenland narwhal and beluga it is not necessary to use models that incorporate age-structure. It noted that the discrete catch-before-birth model that was chosen as the preferred assessment model is an obvious choice as it has the simplest structure, while the performance of all the applied models were similar.

The papers below are discussed together after the abstracts. Following the discussion, one parameter (the MSYR) was changed in all assessments (JWG-2009-09 for West Greenland narwhal; JWG-2009-10 for East Greenland narwhal; JWG-2009-12 for West Greenland beluga). The abstracts have been changed accordingly, so that the numbers in the abstracts give the results of the agreed-upon assessment models.

JWG-2009-09: Witting, L. and Heide-Jørgensen, M.P. Assessment runs for West Greenland narwhals

Historical catches from 1862 and four time series of abundance estimates were combined with density regulated population models to perform a Bayesian assessment of narwhal in West Greenland. It is found that West Greenland narwhal had declined in numbers more or less continuously until the present, and that an average annual removal of 360 narwhal over the last three years is close to an estimated replacement yield of 380 (95% CI:160-570) individuals. The population in 2009 was estimated to be at 51% (95% CI:27-79%) of the carrying capacity, with a 2009 abundance of 12,000 (95% CI:6,200-26,000) individuals. Assuming a uniform prior on the MSYR from 0.015 to 0.04, it was estimated that annual takes of 185 to 270 narwhal over the coming 5 years will leave the population an 80 to 95% probability of a continued increase until 2014.

The model in this paper was based on the assumption that narwhals harvested in West Greenland belong to a single stock. While the authors noted that this was unlikely the case, the single stock approach was applied simply as an averaging approach that made it possible to reconcile the majority of the abundance and catch data in a single model for the estimation of a recommended harvest level for West Greenland as a whole. Abundance data from different areas could then be used afterwards to allocate the total allocable removals between areas. The uncertainty associated with this approach was tested by a two-stock model that applied two assessments runs; one for

Inglefield Bredning and another for Melville Bay with catches taken outside these areas being divided between the two stocks (each of these models were based only on a single abundance estimate; the 2007 summer abundance from each of the two areas). The estimates of total removals were practically identical between the single stock model and the two-stock model.

JWG-2009-21 Heide-Jørgensen, M.P. and Laidre, K.L. A proposal for the allocation of catches for narwhals in Greenland.
This paper proposes a minimal realistic approach to setting catch limits for the narwhal hunt in East and West Greenland. Considering the longevity and potential growth rates for narwhals and the large new abundance estimates relative to previous years it is suggested that a 5% catch level of the lower 95 % confidence interval of the 2007 fully corrected abundance estimates from Melville Bay (1461) and Inglefield Bredning (5,224) and the 2008 estimate from East Greenland (2,541) be used as the upper bound for the catch limits. To avoid over-exploitation of narwhals in Melville Bay it is suggested that catch levels from this stock (73 whales) are only applied to Upernavik. It is suggested that catches from Inglefield Bredning are allocated by allowing 100 whales to Qaanaaq and the rest (161 whales) to be shared between Uummannaq and Disko Bay. This approach puts emphasis on the latest abundance estimates, is in agreement with information of stock separation in West Greenland, and minimizes the risk for over-exploitation of narwhals of the smaller stock in Melville Bay.

JWG-2009-21b: Heide-Jørgensen, M.P. and Laidre, K.L. Rate of increase of narwhal population
Paper 21b presents a reformulation of the Lotka model to determine finite growth rates for narwhal populations given a maximum longevity of 100 years and a pregnancy rate of 0.33 with 50% females at birth. Intrinsic growth rates of 1.065 are possible using an annual survival rate of 0.98 for adults and a total survival of 0.80 through the 8 year sub-adult period, and mean age at parturition ranging between 4 and 8 years.

JWG-2009-23: Witting, L. and Garde, E. Life history parameters and population dynamic growth rate of Greenland narwhals.
This paper combined the age structure and corpus counts in JWG-2009-17 with a Bayesian method to calculate population level estimates of the exponential growth rate and four life history parameters (adult survival, juvenile survival, age of reproductive maturity, and yearly reproductive rate) for narwhals in West and East Greenland. Assuming a stable age structure, the point estimate for the exponential growth rate after harvest was 3%, with a 95% confidence interval between 0 and 5%. This estimate is preliminary, in particular, the data originates both from West and East Greenland and consequently it should be employed cautiously because the age structure of the two populations are likely to differ.

Discussion
The JWG compared the Bayesian Assessment Model (BAM; JWG-2009-09) and Single Survey Approach (SSA; JWG-2009-21) for management advice. A BAM had been endorsed at previous meetings and new information could be employed to update

the model-based advice. The SSA used logic similar to the PBR approach followed by the USA but lacked the theoretical underpinnings. Doubts were expressed in three areas: 1) basing the SSA on only the most recent survey and no population modelling made it vulnerable to changes in behaviour or distribution of narwhals; 2) little support was provided in JGW-2009-21 to indicate that the proposed 5% removal rate was sustainable; and 3) there is not enough known about the current growth rate and its probability distribution to allow the SSA to be generalized and used to assess risk in relation to removal level. During a break between daily sessions two new papers providing some of the theoretical support for the SSA were produced and presented the following morning. Theoretical maximum growth rates were calculated for various values of survival, birth rate and age at first birth (JWG-2009-21b). Among the choices, the JWG found the model result in column 8 of the table presented in JWG-2009-21b, with an adult annual survival of 0.98 and an age at first birth of 8 years, to be the most realistic for narwhals, resulting in an annual growth multiplier of 1.065. Data presented in JWG-2009-17 were analyzed to estimate the current growth, survival and birth rates of the population (JWG-2009-23). Estimated growth rates ranged from 0% to 5% with a point estimate of 3%. The group also noted that the current harvest was approximately 3% (400/14,000) which gave a minimum estimate of the potential growth rate without harvest of 3%. While the BAM was still preferred over the SSA the growth rate results could be used to inform the prior distribution of the maximum sustainable yield rate in the BAM. It was therefore agreed to continue with the BAM for management advice and to use the SSA only for the allocation of the total allowable removals between areas.

There was a long discussion on how the BAM method would best reflect our current knowledge on life history and abundance. An upper limit of 4% in the model prior on the maximum sustainable yield rate (MSYR) was in reasonable agreement with our current knowledge on the maximal growth rate in narwhals, and it was recommended that a literature study be undertaken to obtain a better understanding of the maximal possible growth rate. The lower 95% confidence limit of the growth rate estimate in JWG-2009-23 indicated a lower limit on the MSYR of 1.5% to 2%. JWG agreed to use the base-case model in JWG-2009-9 for management advice, once its prior on the MSYR had been updated to cover the range from 1.5% to 4%. This model estimated that the narwhal harvest in West Greenland is supplied by a 2009-abundance of 12,000 (95% CI: 6,200-26,000) narwhals, that this is 51% (95% CI: 27-89%) of the historical abundance, and that the 2009 replacement yield is 380 (95% CI: 160-570) narwhals.

Table 1 shows annual total removal levels given for narwhals in West Greenland given different probabilities of increase from 2009 to 2014. The authors of the paper presenting the SSA noted that in this particular case, the 60% or less probability corresponded with the removal proposed in the SSA. The table also shows the recommended allocation of the catches between the stocks of Inglefield Bredning and Melville Bay.

This JWG provided management advice in 2003 based on a fixed probability of increase for narwhal set at 70%. However the JWG has agreed that it is more

appropriate to forward a range of options and let managers set the preferred balance between risk and removal levels of narwhals, using Table 4.

The results of the assessment at this meeting are quite different from the results of the assessment at the last two meetings. The assessment at the 2005 meeting suggested that narwhals in West Greenland were highly depleted with safe harvest levels being as low as 15 to 75 whales per year. The change in recommendations between reflects new abundance estimates. In the 2005 assessment, the low abundance estimates from Inglefield Bredning in 2001 and 2002 suggested a decline from a much higher abundance in 1986, and there was no abundance estimate for Melville Bay. However, surveys conducted in 2007 and 2008 suggest that the number of narwhals in Inglefield Bredning has fluctuated, and there is now also an estimate for Melville Bay.

Probability population will increase	Total catch	Inglefield Bredning stock	Melville Bay stock
95%	185	137	48
90%	218	161	57
80%	270	199	71
70%	310	229	81
60%	350	258	92
50%	378	279	99

Table 4. Recommended total annual removal levels for narwhals in West Greenland under different probabilities of that the population will increase. The catches are distributed relative to the point estimates of abundance in Inglefield Bredning (8,447) and Melville Bay (6,235). Catches from the Melville Bay stock are assumed to supply the hunt in Upernavik and Savissivik. Catches from Inglefield Bredning are supposed to supply Qaanaaq (including catches in Smith Sound but not Savissivik), Uummannaq and Disko Bay.

5.5.2 Canadian summer stocks

JWG-2009-O10: Richard, P.R. On determining the Total Allowable Catch for Nunavut odontocete stocks (2008)

Most odontocete (narwhal and beluga) population assessments in Nunavut are data-poor, meaning that there is often only one survey of their population size, no trend data, and little information on their population dynamics. As a result, Total Allowable Catches for Nunavut odontocete whales were calculated using the Potential Biological Removal (PBR) method. The PBR results were also compared to simple growth model used to determine the risk probability of decline. In this model, uncertainty distributions were used to model the imprecision of population size and hunting loss rate and to model uncertainty in the population growth rate.

Discussion

This document illustrates an approach for providing advice on catches in a data poor situation. The limitations of the method are fully acknowledged. JWG advice will be provided when further analyses are presented at future meetings.

5.5.3 East Greenland

JWG-2009-10: Witting, L. and Heide-Jørgensen, M.P. Assessment runs for East Greenland narwhals

Historical catches from 1955 and one abundance estimate from 2008 were combined with density regulated population models to perform a Bayesian assessment of narwhal in East Greenland. It is estimated that East Greenland narwhal have declined slowly in number since 1955, that they are relatively non-depleted with an abundance above the MSYL, and that an average annual removal of 105 narwhal over the last five years is just above 90% the point estimate of the MSY. The population in 2008 is estimated to be at 86% (95% CI:64-95%) of the carrying capacity, with a 2008 abundance of 6,600 (95% CI:2,400-18,000) individuals. Assuming a uniform prior on the MSYR from 0.015 to 0.04, it is estimated that annual takes of 50 to 73 narwhal over the coming five years will give a 80 to 95% probability that takes are smaller than 90% of the MSY.

Discussion

Relative to the West Greenland assessment runs (JWG-2009-09) it should be noted that this paper is base only on a single abundance estimate from 2008. As such, JWG is now for the first time in a position where it can provide management advice for narwhals in East Greenland.

This assessment was based on the single-stock assumption and JWG acknowledges that this is a widespread “stock” only hunted in two locations. Further information regarding stock identity is required.

Probability	Total removals
95%	50
90%	60
80%	73
70%	85
60%	97
50%	109

Table 5. Total annual removal levels for narwhals in East Greenland under different probabilities of fulfilling management objectives.

Narwhals in East Greenland are estimated to be above the maximum sustainable yield limit. The most appropriate management objective is therefore not a continued increase in abundance. JWG-2009-10 therefore applied a management objective that

catches should be no more than 90% of the MSY if the population is above the MSY level, while the objective is an increase if the population is below MSYL.

Given that the assessments for East and West Greenland are based on similar methods, following the discussion under West Greenland narwhals, it was concluded to base management advice for East Greenland on a model that applied a uniform prior on the MSYR between 1.5% and 4%.

Table 5 above presents annual total removal levels for narwhals in East Greenland given different risk probabilities of fulfilling management objectives from 2009 to 2014.

5.6 Future research requirements

- ***Stock ID:*** Each of the stocks around Baffin Bay is hunted in more than one harvest location and hunters at several of these locations may take narwhal from more than one stock. Consequently, it is necessary to determine the contribution of each stock to each harvest location. It is not possible to identify stocks of narwhals using mtDNA, so individual movements are the best available approach. The JWG recommends further tagging studies to collect information on the behaviour of individuals but acknowledges that other methods such as photo-id and genetic mark-recapture may be necessary to fully characterize the relationships between harvest locations and stocks.
- ***Abundance:*** The JWG recommends that surveys should be repeated at regular intervals (e.g. every 3 to 5 years) to update abundance estimates, and determine the distribution of narwhals in relation to habitat features. Timely abundance estimates are necessary insure that the harvest is sustainable.
- ***Removals:*** The JWG recommends that reported data struck and loss be confirmed by independent observations and obtained where not available, in both Canada and Greenland. The JWG recommends the documentation of improvements in practices and techniques that result in lower struck and lost. The JWG highlighted the difficulty in assessing the severity of wounds and the necessity to adopt a definition of lethal wound.

6. BELUGA

6.1 Stock structure

No new information

6.2 Recent catch statistics

JWG-2009-8: Heide-Jørgensen, M.P. Catch statistics for belugas in Greenland 1862 to 2008.

This paper presents information and statistics including trade statistics on catches of belugas in West Greenland since 1862. 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 1,874 and they peaked around 1970. Correcting for under-reporting 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 at about 5% per year 25 during 1979-2007. Reported catches in East Greenland are considered erroneous and should perhaps be added to the narwhal catches.

Discussion

Discussion focussed on the problem of under-reporting. The author, specifying that the figures for 2008 are incomplete, was confident that under-reporting is minimal as there is a good agreement between the number of lower jaws submitted and the quantity of mattak sold. In certain cases the problem might be the opposite with more than one hunter reporting the killing of the same whale when hunting in parties, but this is considered an occasional event. There might be a problem when hunters travel outside of their home areas in the northern areas because the whales could come from the North Water stock. The whales hunted in the other communities in West Greenland belong to the same stock.

JWG-2009-22: Baker, C. Canadian catch of beluga and narwhal.

The beluga catch statistics from selected communities in Nunavut were presented for landed animals for the last 5 years (2004-2008). There are still a number of communities that have yet to report their harvest information for 2008. Efforts are being made by the Iqaluit Area office to get the information. The method for collecting the harvest information varies from community to community. In some communities, the local Hunters' and Trappers' Organizations (HTO) require that the hunters provide the numbers for the hunts. In other communities hunters provide estimates. The 5-year averages for the annual harvests for Hall Beach, Repulse Bay, and Kugaaruk from 2004-2008 were fairly consistent with the 5-year averages from 2001-2005 harvests as reported in the JCNB 2005 report. There was only one community that had a 5-year harvest average that had decreased from the 5-year average from the JCNB 2005 report. This community was Grise Fiord, where the harvest decreased from 16 to 5 belugas. Five of the communities had a 5-year average harvest which had increased from the JCNB 2005 report. These include Igloolik (11 to 19.3), Pond Inlet (0 to 8.6), Arctic Bay (0 to 4.8), Gjoa Haven (1 to 11) and Taloyoak (22 to 43). There was a notable increase in the beluga harvest in 2008 for Pond Inlet and in Taloyoak in 2007. The reasons for these increases are not known at this time.

Canadian catch statistics (2003-2007) for beluga in selected Eastern Canadian Arctic Communities are summarized in Table 6. below.

Discussion

The author specified that Grise Fiord is the only community where the 5-year average beluga catch has decreased. Others have increased. In general the takes have increased slightly: in previous reports the total of 5 year averages was 42. It is now 59. There are high catches reported for Pond Inlet and Taloyoak that deserve scrutiny.

Some of the beluga catches at Igloolik and Hall Beach may come from Hudson Bay stocks. These communities are known to get belugas from both Gulf of Boothia (High Arctic population) and Foxe Basin (probably Hudson Bay origin).

	2003	**2004**	**2005**	**2006**	**2007**	**5-year Total**	**5-year Average**
Hall Beach*	15	12	2	0	10	39	8
Igloolik*	23	NR	15	27	18	83	21
Qikitarjuaq	1	0	0	0	0	1	0
Clyde River	0	0	0	0	0	0	0
Pond Inlet	0	0	0	2	0	2	0
Arctic Bay	0	0	0	5	14	19	4
Resolute Bay	5	2	13	31	5	56	11
Grise Fiord	17	8	4	6	2	37	7.5
Kugaaruk	0	0	0	0	0	0	0
Gjoa Haven	0	NR	0	26	6	32	6.5
Taloyoak	20	NR	0	30	100	150	30
Totals	**43**	**10**	**17**	**100**	**127**	**297**	**59**

Notes:

NR - no record of harvest was sent to DFO

*Totals do not include Igloolik and Hall Beach

Table 6. Catch Statistics (2003-2007) for Beluga in selected Eastern Canadian Arctic Communities. **(Note these have been amended since the original report.)**

6.3 Abundance

6.3.1 Recent and future estimates

JWG-2009-6: Heide-Jørgensen, M.P., Laidre, K.L., Borchers, D., Stern, H. and Simon, M. The effect of sea ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland.

Reports on an aerial survey conducted to estimate the abundance of belugas on their wintering ground in West Greenland in March-April 2006. This survey augmented a time series of surveys for belugas going back to 1981. The survey was conducted as a sight-resight double platform aerial line transect survey, and sampled approximately 17% of the total survey area of ~125,000 km^2. The total abundance of belugas was 10,595 (95% CI 4,904-24,650). The largest abundance was found at the northern part of Store Hellefiske Bank at the eastern edge of the Baffin Bay pack ice, a pattern similar to that found in eight systematic surveys conducted since 1981. A clear

relationship between decreasing sea ice cover and increasing offshore distance of beluga sightings was established from all previous surveys suggesting belugas expand their distribution westward as new areas on the banks of West Greenland open up earlier in spring with reduced sea ice coverage or early annual ice recession. This is in direct contrast to the relatively confined distribution of belugas near the coast in limited open areas in the early 1980s when sea ice cover was higher. However, the effects of the changes in coastal availability of belugas can also be observed with the correlation between catches from the local Inuit hunt and sea ice cover, where the catches increased significantly with increasing sea ice coverage during 1954-2006.

Discussion

The authors specified that they flew farther north in 2006 and found large numbers of belugas. But they also noted that with the change in the index area in 2006, it is not possible to make a proper comparison with the distribution among years. They pointed out that there is great need for more data to improve availability bias correction factor – currently this factor is much lower for beluga than for narwhal. The data being used for the beluga correction are from satellite tags in the North Water primarily.

The animals were concentrated on edge of some of the strata, suggesting that the survey might have missed animals. The JWG recommends that lines be extended beyond the current strata limits, depending on ice conditions, so that the coverage of future surveys is more nearly complete.

To an enquiry about data on hunting effort the authors responded that the quota is limiting the catches or at least keeping a higher boundary on them. When ice is too far west, the hunters say they cannot reach the animals. This may explain why the catches have not reached the quota in some recent years.

6.4 Assessment update

6.4.1 West Greenland

JWG-2009-11: Witting, L. and Heide-Jørgensen, M.P. Assessment runs for West Greenland beluga

Historical catches from 1862 and three time series of abundance estimates were combined with density-regulated population models to perform a Bayesian assessment of beluga (*Delphinapterus leucas*) in West Greenland. It is found that West Greenland beluga declined in numbers until 2004, where a two-fold decline in the catch, from more than 400 to less than 200 belugas per year, caused the population to increase by approximately 8% until 2009. The population in 2009 was estimated to be at 31% (95% CI: 14-61%) of the carrying capacity, with a 2009 abundance of 11,000 (95% CI:5,400-21,000) individuals. Assuming a uniform prior on the MSYR from 0.015 to 0.04, it is estimated that annual takes between 180 to 265 belugas over the coming 5 years will leave the population an 80 to 95% probability of a continued increase until 2014.

Discussion

The preferred assessment model for West Greenland beluga was based only on the two fully corrected abundance estimates because beluga models that also incorporated

the time-series of relative abundance gave unrealistically high estimates of current abundance.

Given that the Greenland beluga and narwhal assessments are based on similar methods, following the discussion under West Greenland narwhals, it was concluded to base management advice for West Greenland beluga on a model that applied a uniform prior on the MSYR between 1.5 and 4%.

The JWG provided management advice in 2005 for beluga based on a fixed 80% probability of an increase in abundance but now agrees that it is more appropriate to forward a range of options and let managers set the preferred balance between risk and removal levels of beluga, using Table 7.

Probability of increase	Total catch
95%	180
90%	210
80%	265
70%	310
60%	355
50%	400

Table 6. Total annual removal levels for beluga in West Greenland under different probabilities of an increasing population between 2009 and 2014.

Reduced takes may already be having a positive effect on population size. The 2005 model gave 80% probability of increase with catches of 100, and 51% if catches of 200. That model was based on index surveys and the 1998-99 absolute abundance estimate.

The JWG noted that the modelling for belugas rests on a more solid background because of simpler stock structure compared to narwhals.

6.4.2 Other stocks

There was no other information.

6.5 Other information

There was no other information.

6.6 Future research requirements

Since the last survey of belugas in the Somerset Island area was in 1996, the JWG recommended that this survey should be repeated.

It was agreed that the recommendation from the last meeting regarding cooperation by Canada and Greenland to collect life history samples should be repeated.

Similarly, it was agreed that the previous recommendation regarding the need collect data to improve estimates of hunting loss (again) should be repeated here.

7. IMPLEMENTATION OF EARLIER ADVICE

The catch of belugas in West Greenland has been reduced in response to previous advice, and modelling suggests that the reduced harvest has led to a reversal of the previously declining trend.

For narwhals in Greenland a quota has been implemented which reduced the catch level. How this has affected the narwhal populations is not clear.

In response to the recommendation for struck and loss monitoring, it was noted that there had been some monitoring in Canada (for narwhals) and this study is ongoing. These results will be presented to this meeting at the next WG. No new studies have been implemented in Greenland.

8. TRADITIONAL KNOWLEDGE

The new abundance estimate for narwhals in Melville Bay agrees with information provided by hunters that there is a relatively large population there in summer. The coverage in previous aerial surveys had been based on positions obtained from radio-tagged narwhals and was too far offshore to capture the large groups of animals in coastal and southern portions of the bay.

The JWG acknowledged the importance of receiving information from local people concerning any changes observed in narwhal or beluga distribution, movements, behaviour, etc.

9. OTHER BUSINESS

9.1 Implications of the inclusion of other species (e.g. walrus) in the work of the JWG

The JWG noted that it is still waiting to hear how the JCNB has decided to handle this issue. As indicated after previous discussions, the JWG continues to believe that walrus assessments would require separate meetings from those devoted to narwhal and beluga assessments.

9.2 NAMMCO question regarding Ageing workshop

JWG-2009-4: Lockyer, C. and Hohn, A. Is there a need for a workshop to address age determination in beluga and narwhal?

A brief review of methods for age estimation in belugas and narwhals is presented. The methods include those currently accepted for belugas using Growth Layer Groups (GLGs) in tooth dentine, and new methods involving Aspartic Acid Racemization (AAR) techniques in narwhals using eye lens. Experimental methods currently applied with some success in other cetacean species using fatty acid profiles are also discussed. The paper highlights some of the issues associated with these methods that

are problematic, and also the implications of recent acceptance of greatly increased longevity in belugas (with the acceptance of one rather than two tooth GLGs per year) and also ages approaching 100 yr in narwhals. The paper discusses the needs for standardization in tooth GLG reading among researchers and labs, which could be addressed in a practical workshop, and also the development of new techniques which could be the focus of a different type of workshop where invited experts could present their work as talks. Validation of new techniques such as AAR against known age, using cross-correlation with independent methods of ageing such as from narwhal embedded teeth GLGs and relative age from ovarian corpora could be explored and reported on. A number of questions specific to different methods are raised, and recommendations made and listed – some also drawn from previous age workshops - that could be addressed in a new workshop. In any event, the workshops should produce publishable reports and also be a means to publishing a manual for guidance of all researchers on age determination from teeth in belugas.

Discussion

During discussion, participants expressed broad support for the workshop initiative, noting, for example, the value of cross-laboratory calibration, standardization of methods, and the use of racemization of eye lenses to calibrate growth layers in small embedded tusks and/or *vice versa.* With regard to the latter point, such calibration might make existing collections more useful for life history analyses. It was suggested that at some point, consideration should be given to how the insights on age determination 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 determination (e.g. fatty acids) explored in a workshop context.

The authors expressed their view that NAMMCO likely would be willing to help convene and organize the workshop(s) and that selection of the venue(s) would be critical. For the practical components, it will be necessary to hold the workshop(s) in an appropriately and adequately equipped laboratory.

Recognizing that there are a number of problems with age determination for both species and that these need to be studied in more detail, the JWG recommends 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. The steering group will report inter-sessionally to the JWG with the expectation that an initial workshop will take place before the end of 2010.

9.3 Human impact on narwhal and beluga habitat (NAMMCO request)

The JWG had previously expressed its interest in reviewing new information on human-caused changes to narwhal and beluga habitat caused, for example, by shipping (noise and other disturbance), fishing and pollution. No papers on this subject were presented at this meeting but there was a brief general discussion. Specific reference was made to the potential for expanded oil and gas development in the Lancaster Sound region, mining projects on Baffin Island, increased ship traffic

through the Northwest Passage, and increased fishing activity (e.g. for Greenland halibut) in narwhal wintering areas in southern Baffin Bay and northern Davis Strait.

The JWG reiterated its interest in this topic and encouraged efforts to develop habitat models and assess impacts. It was agreed that habitat-related concerns should be a standing item on the agenda for future meetings of the JWG and that relevant papers, including summaries or reviews of specific types of activities or specific development projects, would be welcome. It was noted that many of the habitat concerns apply to other marine mammals as well as beluga and narwhals and therefore it may be appropriate to treat all species together in addressing this topic.

The JWG was not in the position to answer the request forwarded by NAMMCO. The JWG concluded that NAMMCO should consider establishing a working group on the impacts of human activities other than hunting on marine mammals in Greenland and northern Canada. The scope of such a working group might best be framed in terms of the Baffin Bay ecosystem as a whole, including Baffin Bay and adjacent waters of Canada and Greenland.

9.4 Requests for observer status at meetings

Lockyer raised the question of whether the JWG had specific procedures for dealing with requests for observer status at its meetings. In the absence of such procedures, she agreed to prepare a draft text for consideration at the next meeting.

9.5 Other

The group commented on the recent IUCN species listing of beluga and narwhal in the category of "Near Threatened" and noted that this classification was overly pessimistic. Concerns that JWG has expressed with respect to specific stocks in the past should not necessarily be applied to the species as a whole. Given both the fact narwhals and belugas are not harvested in many parts of their range, harvests are low relative to global abundance, and the new data presented at the last two meetings of the JWG on recent large abundance estimates, the working group suggested IUCN should revisit or revise this classification.
http://cmsdata.iucn.org/downloads/cetacean_table_for_website.pdf

10. ADOPTION OF REPORT

The report was adopted at the end of the meeting on Friday, 20 February 2009.

11. ADJOURN.

Appendix 1

AGENDA

1. OPENING REMARKS

2. ADOPTION OF JOINT AGENDA

3. APPOINTMENT OF RAPPORTEURS

4. REVIEW OF AVAILABLE DOCUMENTS

5. NARWHALS

- 5.1 Stock structure
  - 5.1.1 Genetic information
  - 5.1.2 Satellite tracking
  - 5.1.3 Other information
  - 5.1.4 Management units
- 5.2 Biological parameters
  - 5.2.1 Age estimation
  - 5.2.2 Reproductive rates
  - 5.2.3 Other information
- 5.3 Catch statistics
  - 5.3.1 Struck and lost
  - 5.3.2 Ice entrapments
  - 5.3.3 Histories by management units
  - 5.3.4 Other information
- 5.4 Abundance
  - 5.4.1 Recent estimates
  - 5.4.2 Estimates by management units
  - 5.4.3 Future survey plans
  - 5.4.5 Recent changes in distribution in Canada
- 5.5 Assessment
  - 5.5.1 Update of West Greenland assessment
  - 5.5.2 Canadian summer stocks
  - 5.5.3 East Greenland
  - 5.6 Future research requirements

6. BELUGA

- 6.1 Stock structure
- 6.2 Recent catch statistics
- 6.3 Abundance
  - 6.3.1 Recent and future estimates
- 6.4 Assessment update
  - 6.4.1 West Greenland
  - 6.4.2 Other stocks
- 6.5 Other information
- 6.6 Future research requirements

7. IMPLEMENTATION OF EARLIER ADVICE

8. TRADITIONAL KNOWLEDGE

9. IMPACT OF HUMAN-MADE-NOISE

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
10.3 Human Impact on beluga habitat (NAMMCO request): No papers, discuss future workshop?

11. ADOPTION OF REPORT

12. ADJOURN.

Appendix 2

LIST OF DOCUMENTS

NAMMCO/SC/16-JCNB/SWG/2009-JWG/1	List of participants.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/2	Agenda.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/3	List of documents.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/4	Lockyer, C. and Hohn, A. Is there a need for a workshop to address age determination in beluga and narwhal?
NAMMCO/SC/16-JCNB/SWG/2009-JWG/5	Heide-Jørgensen, M.P. and Laidre, K.L. Feeding habits of narwhals in Scoresby Sound.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/6	Heide-Jørgensen, M.P., Laidre, K.L., Borchers, D., Stern, H. and Simon, M. The effect of sea ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/7	Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in Greenland 1862 to 2008. A preliminary compilation.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/8	Heide-Jørgensen, M.P. Catch statistics for belugas in Greenland 1862 to 2008.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/9	Witting, L. and Heide-Jørgensen, M.P. Assessment runs for West Greenland narwhals
NAMMCO/SC/16-JCNB/SWG/2009-JWG/10	Witting, L. and Heide-Jørgensen, M.P. Assessment runs for East Greenland narwhals.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/11	Witting, L. and Heide-Jørgensen, M.P. Assessment runs for West Greenland beluga.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/12	Witting, L. Model uncertainty on assessments of West Greenland beluga and narwhals.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/13	Laidre, K.L. and Heide-Jørgensen, M.P. Late summer and early fall movements of narwhals in Inglefield Bredning, Northwest Greenland, 2004-2008.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/14	Laidre, K.L. and Heide-Jørgensen, M.P. Winter density and abundance of narwhals in the Baffin Bay pack ice in 2000 and 2007.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/15	Laidre, K.L., Heide-Jørgensen, M.P., Stern, H., Dietz, R., Richard, P., Orr, J. and Schmidt, H.C. Variability in Baffin Bay sea ice and its influence on the movements of narwhals from Kakiak Point, 2003-2005.

NAMMCO/SC/16-JCNB/SWG/2009-JWG/16	Wiig, Ø., Heide-Jørgensen, M.P., Laidre, K.L., Garde, E. and Reeves, R.R. Geographic variation in cranial morphology of narwhals (*Monodon monoceros*) from Greenland and the Eastern Canadian Arctic.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/17	Garde, E., Heide-Jørgensen, M.P. and Hansen, S.H. Age, growth, and reproduction in narwhals (*Monodon monoceros*) from West and East Greenland as estimated by aspartic acid racemization – preliminary results.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/18	Garde, E. and Willerslev, E. Long-term low genetic diversity in narwhals - insights from ancient DNA.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/19	Heide-Jørgensen, M.P. and Laidre, K.L. Update on satellite tracking of narwhals in Baffin Bay.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/20	Heide-Jørgensen, M.P., Laidre, K.L., Burt, M.L., Borchers, D.L., Hansen R.G., Rasmussen, M. and Fossette, S. Abundance of narwhals (*Monodon monoceros*) in Greenland.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/21	Heide-Jørgensen, M.P. and Laidre, K.L. A proposal for the allocation of catches for narwhals in Greenland.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/21B	Heide-Jørgensen, M.P. and Laidre, K.L. Rate of increase of narwhal populations.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/22	Baker, C. Canadian catch of beluga and narwhal.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/23	Witting, L. and Garde, E. Life history parameters and population dynamic growth rate of Greenland narwhals.

DOCUMENTS FOR INFORMATION

NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-01	Lockyer, C., Hohn, A.A., Doidge, D.W., Heide-Jørgensen, M.P. and Suydam, R. 2007. Age Determination in Belugas (*Delphinapterus leucas*): A Quest for Validation of Dentinal Layering. *Aquat. Mamm.* 33(3):293-304.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-02	Stewart, R.E.A., Campana, S.E., Jones, C.M. and Stewart, B.E. 2006. Bomb radiocarbon dating calibrates beluga (*Delphinapterus leucas*) age estimates. *Can. J. Zool.* 84:1840-1852.

NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-03	Robeck, T.R., Monfort, S.L., Calle,P.P., Dunn, J.L., Jensen, E., Boehm, J.R., Young, S. and Clark, S.T. 2005. Reproduction, Growth and Development in Captive Beluga (*Delphinapterus leucas*). *Zoo Biol.* 24:29-49.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-04	Neve, P.B. 1995. Narhvalen (*Monodon monoceros*) i Vest Grønland. MSc thesis, *in Danish*.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-05	George, J.C., Bada, J., Zeh, J., Scott, L., Brown, S.E., O'Hara, T. and Suydam, R. 1999. Age and growth estimates of bowhead whales (*Balaena mysticetus*) via aspartic acid . *Can. J. Zool.* 77:571-580.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-06	Luque, S. P., Higdon, J. and Ferguson, S. H. 2007. Dentine deposition rates in beluga (*Delphinapterus leucas*): an analysis of the evidence. *Aquat. Mamm.* 33:241-245.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-07	Auger-Méthé, M. 2008. Photo-Identification of Narwhals. MSc thesis, Biol. Dept. Dalhousie University.
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-08	Richard, P., Laake, J.L., Hobbs, R.C., Heide-Jørgensen, M.P., Asselin, N. and Cleator, H. Baffin Bay narwhal population distribution and numbers: aerial surveys in the Canadian High Arctic, 2002-2004. *Submitted to Arctic 5 Feb 2009.*
NAMMCO/SC/16-JCNB/SWG/2009-JWG/O-09	Stewart, D.B. Commercial and subsistence harvests of narwhals (*Monodon monoceros*) from the Canadian eastern Arctic.
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Appendix 3

BELUGA STATUS REPORT

Introduction

This report summarises current knowledge about the stock identity, sizes, vital parameters, harvest rates, and other impacts relevant to belugas in Davis Strait, Baffin Bay, and the waters of the Canadian archipelago. These whales are referred to as the Baffin Bay stock.

Stock Definition

In the eastern Arctic of Canada, belugas are found from the south and east coasts of Ellesmere Island to James Bay, although they are rare around Clyde River (~70°N) and Qikiqtarjuaq (67°N). In western Greenland, they range from approximately 79°N south to Kap Farvel but mainly in autumn or winter. They occur in low numbers south of approximately 66°N. The belugas found south of the Arctic Circle in Canada are thought to belong to different stocks, separated from the belugas of the Baffin Bay area by this break in distribution. The failure of belugas to reappear in South Greenland after commercial hunting stopped suggests that belugas found there were not part of the Baffin Bay stock.

Genetic analyses (Brown Gladden *et al*. 1997, 1999) reported considerable genetic variation among putative beluga stocks in North America. Analyses of high Arctic populations based on mitochondrial DNA demonstrated beluga in four locations in West Greenland in 1990 were significantly different from Lancaster Sound/Barrow Strait, but not from Grise Fiord (de March *et al.* 2002, also SWG-2001-5). Grise Fiord beluga were not significantly differentiated from Lancaster Sound/Barrow Strait. These patterns existed for most years within locations, although data from some years did not match the general patterns. Palsbøll *et al.* (2002) showed further genetic differentiation among West Greenland stocks on the basis of mtDNA.

The general distribution patterns, the timing of occurrence of belugas in different areas, and results of radio satellite tagging studies suggest that Greenland and Canada share one stock. Twenty-six satellite-linked radio tags were applied to belugas in the Canadian High Arctic in summer, in estuaries along Somerset Island and southeast Devon Island. Almost all transmitted until September, and 15 of the tags continued to transmit during the period when belugas are normally observed migrating along the West Greenland coast (late September-early October). Tagged belugas moved to eastern Jones Sound, as has been observed in previous studies (Martin and Smith 1994, Smith and Martin 1993). Only one was observed to cross Baffin Bay to West Greenland waters, and was still heading south when the transmission was lost in southern Baffin Bay. All other belugas were still in the North Water (Northeast Baffin Bay and Smith Sound) when last detected. It is important to note that some summer aggregations have not been tagged, particularly those of Southern Devon Island. It is not known if these belugas migrate on courses similar to those that were tagged. Aside from the satellite tracking, the observations of beluga migration have not been systematic and migration evidence of a shared stock remains circumstantial.

Morphometric data have been used to suggest that there is no exchange of belugas between Greenland and Canada (Sergeant and Brodie 1969). However, these Canadian and Greenlandic data were collected 40 years apart and the Greenlandic sample came from South Greenland where belugas are no longer found. Other analyses indicate that belugas sampled in 1984-87 at Grise Fjord and Pangnirtung, and in 1985 and 1989-92 in West Greenland attain similar final body size (Heide-Jørgensen and Teilmann 1994, Stewart 1994a). Some Greenlandic hunters observed differences in the appearance of belugas which they attributed to "Canadian" whales, but the majority of those who had expressed an opinion, had not noted different types of belugas (Thomsen 1993).

Multivariate analyses of organochlorine concentrations in blubber of belugas found a significant differences among samples from Grise Fiord and West Greenland (Innes *et al.* 2002, also SWG-2001-5), and Kimmirut, Iqaluit, and Pangnirtung (de March e*t al.* SWG-2001-6). It is believed that organochlorine signature may useful for discriminating stocks, however data used must be standardised between laboratories and appropriate statistical models using contaminants with known effects must be used (de March *et al.* SWG-2001-6).

Stock Size

The summer distribution and abundance of Baffin Bay belugas in the Canadian High Arctic was surveyed most recently between July 31 and August 3, 1996, with a line transect survey. The estimate of this population adjusted for missed data, whales at the surface but missed by observers, and for belugas beneath the surface, was 21,200 belugas (95% CI = 11,000 - 32,600) in the summer in the Canadian High Arctic (Innes *et al*. 2002).

Surveys of the West Greenland coast from Disko Bay south to Paamiut and Kap Farvel were conducted in March of 1998 and 1999, continuing the index series begun in 1992 and reviewed previously by JCBN. These surveys, reviewed in previous NAMMCO meetings, provided a total abundance estimate of 7,941 beluga (95% CI 4,262-14,789) wintering in West Greenland in 1998-1999, when corrected for beluga that were either submerged or at the surface but missed by observers. The winter surveys noted some belugas on the western boundary of the survey tract, and beluga are known to occur in small numbers north of Disko Island, so this value underestimates the wintering population in West Greenland in 1998/99 to an unknown extent. Changes to details for survey operations and the near absence of large pods (>20 beluga) in surveys of more recent years, mean that these survey results may not be exactly comparable, even as an index, to survey results from 1981 and 1982. Nonetheless, it was considered highly likely that the overall large decline in survey estimates between the two sets of surveys reflected some degree of real decline in over-wintering population size. The complete absence of beluga in the southernmost portion of the surveyed area, between Maniitsoq and Paamiut, suggests that the decline is not completely a result of a redistribution of over-wintering beluga to more southerly areas, a factor proposed by some hunters.

In March-April 2006 a new aerial survey was conducted to estimate the abundance of belugas on their wintering ground in West Greenland. The total abundance of belugas was 10,595 (95% CI 4,904-24,650). A clear relationship between decreasing sea ice cover and increasing offshore distance of beluga sightings was established from all

previous surveys suggesting belugas expand their distribution westward as new areas on the banks of West Greenland open up earlier in spring with reduced sea ice coverage or early annual ice recession. This is in direct contrast to the relatively confined distribution of belugas near the coast in limited open areas in the early 1980s when sea ice cover was higher. However, the effects of the changes in coastal availability of belugas can also be observed with the correlation between catches from the local Inuit hunt and sea ice cover, where the catches declined significantly with increasing sea ice coverage during 1954-2006.

Vital Parameters

Published estimates of vital rates for the West Greenland stock are:

Age of first ovulation	8-14 years (Heide-Jørgensen and Teilmann 1994*)
Age of first pregnancy	10-16 years (Heide-Jørgensen and Teilmann 1994*)
Pregnancy rate	0.31 (Heide-Jørgensen and Teilmann 1994)
Mean calving interval	3 years (Heide-Jørgensen and Teilmann 1994)

For other beluga stocks, estimated rates are:

Mean age at first ovulation	5 years (Brodie 1971*, Sergeant 1973*)
	13 yr (Stewart 1994b*)
Pregnancy rate	0.36 (Stewart 1994b)
Mean calving interval	3 years (Brodie 1971*, Stewart 1994b*)
Maximum rate of population increase (r_{max})	
	2-3% per year (Béland *et al.* 1988)
	3-4% per year (Kingsley 1989)

* Note: Beluga ages have been doubled to reflect results of dentinal aging research recently published (Stewart *et al.* 2007). However, previously using 2 GLGs may have created rounding errors which would make 8-14 actually (9-15).

Past investigations have supported the conclusion that the maximum annual rate of population growth (called "net recruitment rate" in previous reports) of the population is likely to be between 2-4% per year (SWG reports 1992, 1993), and that 4% rate of growth is possible only with very high survival rates or a population size which is a small fraction of carrying capacity (SWG Report 1997). Catches in West Greenland in the 1990s included disproportionate numbers of young animals and more females than males (Heide-Jørgensen and Lockyer 1995). Both of those factors would increase the likelihood that the annual rate of population growth would lie in the lower part of the possible range, compared to the rate of growth that would be possible if catches had been proportionate to age or directed to adult males (Kingsley *et al.* 1995). Analytical results reviewed at previous meetings support the past conclusions, and indicate that if higher fecundity rates, as proposed by traditional knowledge, are used in the

population models, compensatory changes to survivorship schedules are necessary to fit the survey and catch data, so the net rate of increase the population remains within the range of 2-4%.

Current Catch Levels

The average annual landed catch on Eastern Canadian High Arctic belugas is 59 belugas between 2003 and 2007 (Table 1, DFO, unpublished data). The allocation of this catch between the North Water stock and the West Greenland stock is not known with certainty. However genetic and contaminate indicators suggest they come predominately from the North Water stock (deMarch *et al*. 2002, Innes *et al*. 2002, SWG 2001). Landings in West Greenland averaged 208 whales per year between 2003 and 2007 (Table 2). These landings do not include beluga killed but lost during hunts. Killed-and-lost rates vary greatly, depending on details of local conditions such as location (e.g. near-shore *vs* ice-edge), season, and hunting methods, so it is not possible to calculate a reliable and universally applicable correction factor. However, both hunters' reports and analytical results are consistent with total kills being between 120% and 150% of total landings. Since the 1990s both Canada and Greenland have implemented procedures for improved reporting of belugas landed and killed-but-lost, but the reliability of these reporting systems has not yet been established.

	2003	**2004**	**2005**	**2006**	**2007**	**5-year Total**	**5-year Average**
Hall Beach*	15	12	2	0	10	39	8
Igloolik*	23	NR	15	27	18	83	21
Qikitarjuaq	1	0	0	0	0	1	0
Clyde River	0	0	0	0	0	0	0
Pond Inlet	0	0	0	2	0	2	0
Arctic Bay	0	0	0	5	14	19	4
Resolute Bay	5	2	13	31	5	56	11
Grise Fiord	17	8	4	6	2	37	7.5
Kugaaruk	0	0	0	0	0	0	0
Gjoa Haven	0	NR	0	26	6	32	6.5
Taloyoak	20	NR	0	30	100	150	30
Totals	**43**	**10**	**17**	**100**	**127**	**297**	**59**

Notes:
NR - no record of harvest was sent to DFO
*Totals do not include Igloolik and Hall Beach

Table 1. Catch Statistics (2003-2007) for Beluga in selected Eastern Canadian Arctic communities. **(Note these have been amended since the original report.)**

Other Impacts

Any commercial fishery which competes with belugas for food may reduce carrying

capacity and could cause a population decline or impede recovery. There is no indication that such an interaction exists but the impact of Greenlandic fisheries and developing Canadian shrimp and turbot fisheries have not been examined. Mineral exploration and mining can expose the whales to contaminants (Muir *et al.* 1990; Wagemann *et al.* 1990) and, along with fishing, to disruptive industrial noise (Cosens and Dueck 1988; Finley *et al.* 1984; Remnant and Thomas 1992; Thomsen 1993). Contaminants from sources outside the High Arctic also are known to enter Arctic marine food chains, and are found in belugas (Innes *et al.* 2002 als SWG-2001-5, de March *et al.* 1998). The effects of contaminants and noise pollutants on the biology of belugas are unknown. Belugas respond to ship noise (Cosens 1995) but it is difficult to determine whether there are long-term population effects. Noise may be more disruptive to belugas in hunting areas than in non-hunting areas.

Killer whales are observed in North Baffin areas and are now being seen in the area of Pelly Bay where they have not been seen in the past. Incidence of beluga predation have been reported by local people and observed by researchers (Higdon 2007).

Status

The 1996 summer survey of the Canadian High Arctic estimated the beluga numbers to be 21,200 (11,000 - 32,600), although this estimate may be revised with further analyses. Catches in the Canadian High Arctic are low compared to the estimated stock size. The number of belugas wintering off West Greenland declined from 1981 through 1998-99 but showed signs of recovery in 2006 (SWG Report 1992, 1993, 1994, 1997, 2009).

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Year	Qaanaak (Q)	Upernavik (UP)	Uummannaq	Disko Bay (DB)	Sisimiut (S)	Maniitsoq	Nuuk	Paamiut – Qaqortoq	Under-reporting		Total	Mortality in ice entrap-ment
									All	Regions		
1954		16	61	1,774	23						1,874	1,774
1955		10	3	275	11	1					300	
1956		9	8	373	29	5					424	
1957		6	11	391	95						503	
1958		3	4	182	35	1					225	
1959		12	12	243	42						309	50
1960		13	6	179	17		1				216	
1961	32	15	6	219	47	1	11	14			345	
1962	85	9	7	186	23	8	11				329	
1963	75	18	12	93	8	12	11				229	
1964	125	4	6	166	8	4	18				331	
1965	150	20	53	214	24	18	9				488	
1966		25	88	398	24	13	12	1			561	
1967		34	66	369	76	47	4				596	50
1968		97	65	1,013	46	38					1,259	234
1969		111	36	661	100	40	30				978	
1970	17	334	6	1,133	10	24					1,524	1,050
1971	2	238	3	328	123	4	41				739	
1972		293	25	362	135	11	14	1			841	
1973		262	33	581	121		70				1067	

1974	21	195	15	512	135	8	25	2			913	
1975	50	150	19	268	130	4	33			47 Q	654	
1976	50	77	12	953	72		48			37 Q	1,212	653
1977	50	240	49	379	43	13	65			36 Q	839	
1978	20	104	44	452	77	5	17				719	
1979	25	250	22	379	35	12	18				741	
1980	30	191	100	412	109	45	1				888	
1981	76	343	95	340	62	23	78				1,017	
1982	127	329	17	313	95	13					894	100
1983	53	233	19	194	99	2	1			10 Q, 165 UP, 100 DB, 50 S	601	
1984	21	333	15	352	25	16	1			60 UP, 150 DB, 25 S	763	220
1985	190	188	6	177	25	17	8			135 UP, 75 DB, 25 S	611	
1986		500	4	114		2			75	335 UP	695	
1987		550	13	29		8	6		90		696	
1988		125		125					25		275	125
1989		427	2	30		40				311 UP, 18 DB	499	
1990	2	346	8	684		23				2 Q, 346 UP, 591 DB	1063	500
1991	50	400		100						50 Q, 400	550	

										UP, 100 DB		
1992		661		26						661 UP, 26 DB	687	
1993	119	328	26	191	79	24	14	1		169 UP	782	
1994	24	188	19	239	105	38	3	2		90 UP	618	
1995	26	252	18	301	117	56	10	4		111 UP	784	
1996	7	86	21	244	131	26	25	1			541	
1997	17	162	29	228	100	7	11	2			556	
1998	71	163	41	304	105	15	4	11			714	
1999	36	189	25	184	38	4	10	6	0		492	
2000	8	303	21	202	57	6	7	8			612	
2001	4	131	26	207	64	19	1	3			455	
2002	5	203	38	149	15	11	1	8			430	
2003	54	119	16	149	48	19	0	7			412	
2004	2	14	8	96	61	4	1	7			193	
2005	3	26	13	102	36	4	0	0			184	
2006	9	31	13	49	28	3	3	1			137	
2007	7	20	2	59	19	9	0	0			116	
2008	2	8	1	32	4	2	0	0			49	

Table 2. Catches of belugas from official reports by municipality, 1954-2008 with corrections for under-reportings (in parenthesis) for 1954 to 1998. The year 1999 only covers the period from January through September. The column ‘under-reporting’ shows the sum of the corrections for under-reporting or ‘ALL’ if it is a general correction factor for all areas. ‘Disko Bay’ includes the municipalities Kangaatsiaq, Aasiaat, Qasigiannguit, Ilulissat and Qeqertarsuaq.

Appendix 4

NARWHAL STATUS REPORT

Introduction

This report summarises current knowledge about the stock identity, sizes, vital parameters, catch levels, and other impacts relevant to narwhals in the waters of Davis Strait, Baffin Bay, West Greenland and the Canadian Arctic Archipelago.

Stock Definition

The summer range of Baffin Bay narwhals probably covers most of the waters of the Canadian Arctic Archipelago and northwest Greenland. Baffin Bay narwhals winter in northern and central Baffin Bay and off Central West Greenland and they occur in large numbers in Uummannaq in November. Main summering areas in Canada are Peel Sound, Prince Regent Inlet, Admiralty Inlet and the Eclipse Sound area. Narwhal in northern Hudson Bay are not considered as part of the Baffin Bay population. Main summering areas in West Greenland are Melville Bay and Inglefield Bredning.

Results of a genetic study of mitochondrial DNA indicate differences between stocks in East and West Greenland. Low genetic diversity in narwhals from eastern Canada and western Greenland makes it difficult to resolve any stock structure in that area (de March *et al*. 2003). High Arctic narwhals appear distinct from narwhals landed in Repulse Bay and Grise Fiord narwhals were very weakly differentiated from other Canadian stocks. There is evidence for genetic differences between narwhal samples from different localities in West Greenland but there is also evidence of inter annual differences at the same locality (Palsbøll *et al.* 1995, Riget *et al*. 2002).

Canonical discriminant function analysis using organochlorine (OC) contaminants separated narwhals hunted in Repulse Bay, Broughton Island, Pond Inlet, and Grise Fiord (de March and Stern 2004). Narwhals from Pond Inlet and Grise Fiord were most similar but narwhals from Pond Inlet generally had lower OC contaminants.

Satellite tracking of narwhals from three aggregations in West Greenland and Eastern Canadian High Arctic showed that these whales did not move to other areas of narwhal concentration in August. Narwhals from Melville Bay and Eclipse Sound moved to a common wintering ground in the middle of northern Davis Strait. Narwhals from Somerset Island moved to a wintering ground that was in southern Baffin Bay, distinct from the wintering ground of the other narwhals. The narwhals made only local movements on their wintering grounds and tracking results from 2 individuals over 14 months show a migration back to the summering areas where they were tagged (Heide-Jørgensen *et al*. 2003). None of the 27 narwhals tagged in Canadian waters went into areas where they would be subjected to hunting from Greenland. Narwhals from Eclipse Sound visited several East Baffin fjords during their fall migration, within the range of hunters from East Baffin communities. The first two years of tagging indicate no movements towards West Greenland. Tagging results indicated that these whales wintered in the west central part of Baffin Bay and in the middle of Davis Strait. Tracking of narwhals from Admiralty Inlet indicate that they follow a similar migration route and overlap in their wintering areas in Davis Strait with the Eclipse sound and

Melville Bay narwhals (Dietz *et al.* 2008). Additional 13 narwhals were tagged in Admiralty Inlet at Kakiak Point in 2005. The whales followed a similar path as observed in the previous years where few of them made brief visits to the two neighboring stocks (Somerset Island and Eclipse Sound) and they all left Lancaster Sound in September-October for a southbound migration either along the east coast of Baffin Island or somewhat of Baffin Island at the edge of the continental shelf. Some of the whales extended their southbound migration to the northern part of Davis Strait where they have also been observed to winter in previous tracking studies (Dietz *et al*. 2008). One male moved to the coastal areas of West Greenland in January close to Disko Island and Uummannaq. Even though it was only in West Greenland for a brief period it demonstrated that narwhals from Admiralty Inlet, and perhaps other stocks in the Canadian high Arctic, can contribute to the winter hunting West Greenland south of Upernavik.

Rrecent tracking of Northern Hudson Bay narwhals showed that they summered north of Southampton Island, migrated through Hudson Strait and wintered offshore of Resolution Island, well south of the wintering range of other Canadian and Greenland narwhal populations (Westdal and Richard, 2009).

About 40% of resource users have noted differences in narwhal appearance that may be indicative of different stocks (Remnant and Thomas 1992, Thomsen 1993).

The SWG considered a conceptual model for stock delineation based on summering aggregations as the most likely and conservative model for narwhal stock structure based on Heide-Jørgensen *et al*. (2005). The model operates with seven different stocks in West Greenland and the Canadian High Arctic (Smith Sound/Jones Sound, Somerset Island, Admiralty Inlet, Eclipse Sound, East Baffin, Melville Bay and Inglefield Bredning). Narwhals in East Greenland and in northern Hudson Bay are considered isolated from the above mentioned stocks. This model is based on incomplete knowledge about the movements of the whales but is intended to be evaluated continuously as new information becomes available.

A particular problem with stock structure of narwhals in Baffin Bay is that several of the stocks are being harvested outside their summering range and allocation of catch levels is therefore complex and in many cases also uncertain.

Stock Size

In 2003 and 2004 the Admiralty Inlet, Eclipse Sound and East Baffin stocks were surveyed and estimated to number 5362 (95% CI: 1,920-12,199), 20225 (95% CI: 9,471-37,096) and 10,073 (95% CI: 5,333-17,474) narwhals, respectively (Richard *et al*. 2009).

In a survey for belugas around Somerset Island in the summer of 1996, the estimated number of narwhals was 45,358 (95% CI 23,397-87,932, Innes *et al* 2002). This estimate includes adjustment for several sources of observational error including adjustment for narwhals below the surface. However, the survey did not cover all areas known to be inhabited by narwhals in summer, and thus underestimates the total

population. Another survey was done in 2002 to extend the coverage but due to weather, did not cover the a significant portion range of the Somerset stock. Peel Sound, in particular, is an area where a substantial number of narwhals is known to aggregate in summer. It could not be surveyed that year or in 2003-2004 due to poor flying weather..

Aerial digital photographic surveys of narwhals in Inglefield Bredning in Northwest Greenland gave fully corrected stock estimates of 2,297 (95% CI 1,472-3,122) and 1,478 (95% CI 1,164-1,793) in August 2001 and 2002, respectively.

Visual aerial sighting surveys of narwhals were conducted over the wintering ground in West Greenland in March-April 2006, over two summering areas in Northwest Greenland (Melville Bay and Inglefield Bredning) in August 2007, and over the summering areas in East Greenland (Scoresby Sound, Blosseville Coast, Kangerlussuaq and Tasiilaq) in August 2008. The abundance of narwhals on the wintering ground in West Greenland was 7,815 (95% CI: 4,375-13,964). The abundance in Inglefield Bredning and Melville Bay was 8,447 (95% CI: 5,224 – 13,658) and 6,235 (95% CI: 1,461 – 26,603), respectively. The abundance in East Greenland was 6,583 (95% CI 2,541 – 17,052).

Vital Parameters

Reproduction	**Neve (1995)**	**Garde *et al.* (2007)**	**Garde *et al.* (2009)**
Age of female sexual maturity	6-7 yr	6-7 yr	6 yr
Mean calving interval	3 yr		
Age of male sexual maturity		9 yr	9 yr
Longevity Females		115 yr	99 yr
Longevity Males		84 yr	94.5 yr
First Ovulation			8-12 yr

Maximum rate of population growth rate (r_{max}) of 3-4% used by analogy to published beluga rates of increase.

Current Catch Levels

Average reported landed catch in West and East Greenland between 2003 and 2007 was 400 and 109 narwhals per year, respectively. This figure does not include any correction for either non-reporting, which is thought to have been fairly high in some areas over at least some of those years, or for narwhals killed-and-lost (Tables 1 and 2).

Average reported landed catches in the Eastern Canadian Arctic for 2003-2007 were 423 narwhals per year (Table 3, DFO unpubl. data), and non-reporting rates are thought to be quite low. Reported information on narwhal killed-and-lost rates were variable between communities and years (Roberge and Dunn 1990, Romberg 2005), with reported numbers of narwhal killed-and-lost ranging from below 10% to above 58% of

landed catches for a few selected communities in 1999-2004. Recently, hunter-reported losses suggest that narwhal hunting mortality averages 128% of the landed catches (Richard 2008). Considering just reported catches and reasonable allowances for narwhals killed-and-lost, mortality due to hunting has been in excess of 500 narwhals annually through 2003-2007. The sex ratio of reported catches is in favour of males in most communities and seasons (Romberg and Richard 2005).

Other Impacts

Any commercial fishery which competes with narwhals for food could reduce carrying capacity and cause a population decline or impede recovery if the population has been reduced well below the usual carrying capacity. This is especially important on the narwhal wintering grounds where most of the feeding of the whales seem to take place (Laidre and Heide-Jørgensen 2004, Laidre *et al*. 2004). During winter it has been noted that narwhals feed intensively on Greenland halibut (*Reinhardtius hippoglossoides*) (Laidre and Heide-Jørgensen 2004). It is unclear if the present fisheries in Baffin Bay and Davis Strait are of sufficient level to compete with narwhal feeding. Fisheries interactions involving narwhals have not been examined.

Killer whales are observed in North Baffin areas and are now being seen in the area of Pelly Bay where they have not been seen in the past. Incidence of narwhal predation have been reported by local people and observed by researchers (Laidre and Heide-Jørgensen 2005).

Mineral exploration and mining can expose the whales to contaminants (Muir *et al.* 1992; Wagemann *et al.* 1983) and, along with fishing, to disruptive industrial noise (Cosens and Dueck 1988; Remnant and Thomas 1992; Thomsen 1993). Contaminants from sources outside the High Arctic also are known to enter Arctic marine food changes, and are found in narwhals (de March *et al.* 2001, AMAP 1997). The effects of contaminants and noise pollutants on the biology of narwhals are not well studied.

Narwhals respond to icebreaker, ship, and aircraft noise (Born *et al*. 1994; Cosens 1995) but it is difficult to determine whether there are long-term, population effects. Narwhal reactions to ice breaker sounds differ from beluga whales in that the former tend to exhibit "freeze / silent" behaviour rather than "flight / alarm call" behaviour such as belugas. This may relate to the fact that narwhals and belugas also have different responses to killer whales (e.g. Finley *et al*. 1990). It should be noted that observers aboard ice breakers have not reported these strong reactions by narwhals, but this is likely a function of the need for observers to be on separate platforms (such as aircraft or the ice edge) to study such reactions (Richardson *et al*. 1995). Narwhals have been observed entering leads fast ice following the passage of ice breakers in summer (P. Richard, DFO, pers. comm.), but there is no evidence that they subsequently became entrapped.

Status

It is estimated that West Greenland narwhal have declined in number since 1986 and that an average annual removal of 185 to 378 narwhals over the next five years will provide an 50% to 95% probability that the population will increase.

The status of the Somerset and Eclipse Sound stocks were considered at the previous meeting and it was accepted that the catches are sustainable (Richard 2005). Concern was expressed about the sustainability of the Admiralty stock, where surveys yielded smaller estimate than in the 1980s and risk modelling suggest a finite probability of future decline in all scenarios considered. New East Baffin stock estimates were reviewed and are now considered adequate to do an assessment of sustainability. Such an assessment has not been done. However, it is not believe that there is a problem with the sustainability of the catch level as removals from this putative stock are low.

Canada has produced a database on historic catches, which can now be used for subsequent assessments. Co-operative programs with selected communities are providing more information on the relationship between reported landings and actual mortality due to hunting. In particular, the reported sex ratio indicates that catches may favour males and therefore sustainability of the catches could be higher than estimated in Canadian hunts.

Expanded work on stock identification in both Greenland and Canada is needed to allow better allocation of catches in all seasons and areas to the summer population units.

It is estimated that East Greenland narwhal have declined slowly in number since 1955, that they are not depleted with abundance above the maximum sustainable yield level (MSYL), and that an average annual removal of 105 narwhal over the last five years is just above the 90% point estimate of MSY. It is estimated that annual takes of 50 to 73 narwhal over the coming five years will give an 80% to 95% probability that takes are smaller than 90% of the MSY.

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YEAR	QAANAAQ	UPER-NAVIK	UUMMANNAQ	DISKO BAY	SISIMIUT	MANIITSOQ	NUUK	PAAMIUTQA-QORTOQ	TOTAL	ICE ENTRAPMENT
1949	38	16	1	6					61	
1950										
1951										85 DB
1952										450 DB
1954	na	45			1			1	47	
1955	na	179	2	14					195	
1956	na	15	282	21					318	156 UPV, 250 UUM
1957	na	55	11	15					81	
1958	na	24	3	45		1			73	
1959	na	32	8	16				1	57	
1960	na	25	296	7	1	1	1	1	332	
1961	134	25	5	38				1	203	272 UUM
1962	182	17	11	12				1	213	
1963	275	10	3	29					317	
1964	275	17	11	11					314	
1965	na	33	37	33	1	1			105	
1966	na	39	23	43		3	2		110	
1967	na	131			9				140	31 DB
1968	na	454			18				472	161 DB, 50 UPV, 84 UUM
1969	na	174			30				204	Some DB, 50 UPV
1970	na	313			9				322	100 DB
1971	na	146			40				186	
1972	na	84			23				107	
1973	na	191			8				199	
1974	8	136			3				147	

Table 1. Catches of narwhals from official reports by municipality, 1949-2008, with corrections for under-reportings (in parenthesis) for 1954 to 2001. The column 'under-reporting' shows the sum of the corrections for under-reporting or 'ALL' if it is a general correction factor for all areas. 'na' means that no data are available. Numbers for year 2001 are preliminary. DB=Disko Bay, UUM=Uummannaq, UPV=Upernavik. Data were compiled from Prime Minister's Second Department (1951), Kapel (1977), Kapel (1983), Kapel and Larsen (1984), Kapel (1985), Born and Kapel (1986) and Born (1987). **Table 1 contd on next page.**

YEAR	QAANAAQ	UPERNAVIK	UUMMANNAQ	DISKO BAY	SISIMIUT	MANIIT-SOQ	NUUK	PAAMIUT-QAQORTOQ	TOTAL	ICE ENTRAPMENT
1975	1	54	11	44		6		1	266 (149)	
1976	9	22	27	57					264 (141)	
1977	16	62	113	53	8	1			387 (134)	
1978	110	56	183	262		1			612	
1979	120	22	132	100			3		377	
1980	130	61	146	20		4	1		462	
1981	118	83	140	249			18	1	609	
1982	164	59	162	76					461	45 DB
1983	135 (25)	72 (30)	164	68 (10)					439 (65)	
1984	274	80	245	66 (15)	1				666 (15)	35 UUM
1985	115 (115)	34 (20)	39	67		1			256 (135)	
1986	na	81	97	23		36			237	
1987	na	145	334	25			1		505	
1988	na		206						500 (294)	
1989	na	37	288	2			5		332	
1990	na	100 (73)	101 9	11					1057 (100)	
1991	na		27	> 40					na	27 UUM
1992	na	37	288	2			5		342	
1993	144	66	301	75	10	6	4	8	614	
1994	183	59	297	268	6	14	7	11	845	150 DB

Table 1. Catches of narwhals from official reports by municipality, 1949-2008, with corrections for under-reportings (in parenthesis) for 1954 to 2001. The column 'under-reporting' shows the sum of the corrections for under-reporting or 'ALL' if it is a general correction factor for all areas. 'na' means that no data are available. Numbers for year 2001 are preliminary. DB=Disko Bay, UUM=Uummannaq, UPV=Upernavik. Data were compiled from Prime Minister's Second Department (1951), Kapel (1977), Kapel (1983), Kapel and Larsen (1984), Kapel (1985), Born and Kapel (1986) and Born (1987). **Table 1 contd on next page.**

YEAR	QAANAAQ	UPERNAVIK	UUMMANNAQ	DISKO BAY	SISIMIUT	MANIITT-SOQ	NUUK	PAAMIUT-QAQORTOQ	TOTAL	ICE ENTRAPMENT
1995	107	94	159	108	4	5	8		485	
1996	45	69	405	154	10	4	2	2	691	
1997	66	90	381	156	13	5	9	26	746	
1998	94	105	344	163	21	18	6	24	775	
1999	115	119	253	174	28	24	17	15	745	
2000	109	150	106	155	27	8	0	6	561	
2001	145	155	95	119	1	2	15	3	535	
2002	94	164	180	97	12	11	3	2	563	
2003	113	146	174	114	4	0	2	2	554	
2004	178	53	67	73	2	1	0	0	374	
2005	[70] 137	[74] 71	[137] 161	[47] 39	0	0	0	0	[328] 408	
2006	[94] 99	[58] 62	[55] 72	[4] 53	1	2	0		[211] 289	
2007	[21] 139	[17] 102	[52] 67	[56] 63	0	2	0	1	[146] 374	
2008	69	40	[17] 1	44	0	0	0	0	[17] 154	

Table 1. Catches of narwhals from official reports by municipality, 1949-2008, with corrections for under-reportings (in parenthesis) for 1954 to 2001. The column ‘under-reporting’ shows the sum of the corrections for under-reporting or ‘ALL’ if it is a general correction factor for all areas. ‘na’ means that no data are available. Numbers for year 2001 are preliminary. DB=Disko Bay, UUM=Uummannaq, UPV=Upernavik. Data were compiled from Prime Minister’s Second Department (1951), Kapel (1977), Kapel (1983), Kapel and Larsen (1984), Kapel (1985), Born and Kapel (1986) and Born (1987).

YEAR	ITTOQQORTORMIUT	TASIILAQ	ALL
1955	18	6	24
1956	10		10
1957	9	5	14
1958	28	1	29
1959	17	9	26
1960	54	2	56
1961	12	4	16
1962		3	3
1963	8	21	29
1964	8		8
1966	2	67	69
1967		20	20
1968		30	30
1969	6	17	23
1970	6	47	53
1971	5	33	38
1972	1	25	26
1973	4	18	22
1974	2	40	42
1975	2	2	4
1976	1	8	9
1977	5	14	19
1978	1	1	2
1979	10	20	30
1980	10	49	59
1981	15	128	143
1982	25	84	109
1983	43	12	55
1984	50		50
1985	28	21	49
1986		63	63
1987		19	19
1988	40	11	51
1989	70	19	89
1990	70	88	158

Table 2. Catches of narwhals in East Greenland. Data from 1955-1990 from Dietz *et al*. (1994) and data from 1993-2008 from Piniarneq. Data from 2008 are preliminary. There was one ice entrapment in Tasiilaq in February 2008 that involved about 30 narwhals. Note no catch or data for 1965, 1991 and 1992. **Table 2 contd on next page.**

YEAR	ITTOQQORTORMIUT	TASIILAQ	ALL
1993	9	16	25
1994	17	20	37
1995	34	35	69
1996	8	39	47
1997	9	42	51
1998	21	26	47
1999	19	99	118
2000	11	28	39
2001	52	70	122
2002	54	55	109
2003	6	87	93
2004	39	96	135
2005	50	68	118
2006	93	29	122
2007	39	40	79
2008	30	40	70

Table 2. contd.

Community	**Quota or Harvest Limit**	**2003**	**2004**	**2005**	**2006**	**2007**	**5-year Average**	**5-year Total**
Arctic Bay	130*	129	122	131	130	127	639	128
Clyde River	50	53	50	39	43	42	227	45
Gjoa Haven	10	0	0	0	0	1	1	0
Grise Fiord	20	8	9	1	21	23**	39	10
Hall Beach**	10	2	11	3	1	0	17	3
Igloolik**	25	0	27	24	25	1	77	15
Pangnirtung	40	30	25	3	1	1	60	12
Pelly Bay	25*	24	16	28	48	40	156	31
Qikiqtarjuaq	90*	90	96	88	88	88	450	90
Pond Inlet	130*	67	65	62	87	65	346	69
Resolute Bay	32	2	5	13	28	9	57	11
Taloyoak	10	1	0	0	33	0	34	7
Totals		**406**	**426**	**392**	**505**	**394**	**2103**	**423**

Notes:

* Community Based Management Quotas

**Totals do include Hall Beach and Igloolik

23** 3 tags were from Resolute bay

Table 3. Catch Statistics (2003-2007) for Narwhal in selected Eastern Canadian Arctic Communities.

ANNEX 2

REPORT OF THE NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON ASSESSMENT

Copenhagen, Denmark, 23 March 2009

1. OPENING REMARKS

Chair Lars Walløe welcomed the delegates and noted that the main tasks of the group at this meeting were to help the Scientific Committee answer several requests of three natures:
a) The Scientific Committee was requested (NAMMCO 17) about the Central North Atlantic Minke Whale stock: "to assess the short-term (2-5 year) effects of the following total annual catches: 0, 100, 200, 400";
b) The Scientific Committee was requested (NAMMCO 17): "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"; the WG was therefore charged to explore which possibilities existed;
c) The Scientific Committee had been requested to continue its assessment of humpback whales in the North Atlantic and examine the status of sei whales; and the Working Group (WG) was charged with defining the best way to proceed with these requests.

Furthermore, the WG had been charged by the SC to review the new pilot whale abundance emanating from Trans-North Atlantic Sightings Surveys (T-NASS) and its implication for the assessment of the stock.

2. ADOPTION OF THE AGENDA

The agenda shown in Appendix 1 was adopted.

3. APPOINTMENT OF RAPPORTEUR

Participants are listed in Section 5.7. Mario Acquarone was appointed as rapporteur.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The available documents are listed in Appendix 2.

5. THE CENTRAL NORTH ATLANTIC MINKE WHALE STOCK

5.1 Stock structure

Stock structure was discussed in detail at the 2003 meeting of this WG (NAMMCO 2003). Some indications of genetic exchange between the Southern Barents Sea and Jan Mayen areas have since been reported. However, the WG agreed that there was insufficient new information to warrant re-examining the differentiation between the two areas or revising the stock structure for the purpose of this meeting. Consequently,

the WG decided to base the present work on the stock structure currently accepted by NAMMCO.

5.2 Biological parameters

No new information was available for this meeting. The WG thus decided to use the estimates of parameters used in the previous assessments (NAMMCO 1999, 2004).

5.3 Catch data

Catch data for the Coastal Iceland (CIC) and Central areas were compiled in SC/16/AS/05. The catch series were the same as used in the 2003 assessment, with the addition of more recent catches by Iceland, Norway and Greenland.

In preparation for this meeting there have been some difficulties in updating the catch series in a consistent format, mainly due to terminological ambiguity. Recommendations for how to proceed in preparing future meetings are reported under item 8.

5.4 Abundance estimates

The results of the 2007 aerial survey in the CIC area had been examined at the last meeting of the Scientific Committee (NAMMCO 2007). Two estimates were accepted at that meeting: one of which was based on all sightings but lacked data to quantify negative detection bias and another, higher estimate which was based only on the one observer for whom there were duplicate sightings available. Provisional abundance estimates from the Icelandic and Faroese shipboard surveys in the Central North Atlantic were reported to the meeting for four alternative analysis assumptions (full documentation for these results was awaited). The assessment analyses (see item 5.5) had been carried out for two options for the aerial survey combined with the four options for the shipboard survey. This meeting would consider the most and the least optimistic of these options in combination.

5.5 Assessments

In 2008 a partial aerial survey covered the area to the southwest of Iceland (Faxaflói) where the highest density has been observed in previous surveys (about a third of the sightings).

Gunnlaugsson presented NAMMCO/SC/16/AS/04 that compared sighting rates and distribution in the 12 surveys in this area. The two primary observers in each survey have made a similar number of sightings, although their detection functions have differed leading to significantly different estimates of abundance in some cases. In general the area has been covered twice in each survey with similar outcomes. However the sightings distribution of minke and humpback whales differs remarkably between the years. In particular, the sightings per search hour for minke whales during the 2007 survey was statistically significantly less than that for 2008, where the 2008 sightings rate was broadly comparable with that in earlier years.

These results suggested to the WG that minke whales move in and out of the survey area from year to year. In turn this indicates both that the CIC area does not encompass

a separate sub-stock of minke whales, and that the low abundance estimate for this area from the 2007 survey should not be taken as evidence for an appreciable decrease in overall minke whale abundance. In consequence it is not reasonable to consider only a single survey estimate from the CIC area for an assessment. However, if an assessment is conducted for the CIC area in isolation, it is preferable to incorporate the results from a number of surveys in the assessment.

Butterworth presented document NAMMCO/SC/16/AS/05, which updated HITTER-based assessments and projections of minke whales in the Central North Atlantic contained in an earlier analysis by Cunningham and Butterworth (2003)[1]. Further catch and survey abundance information since that earlier time were taken into account. These assessments, together with projections under the future catch levels specified by the Council, were conducted for both the CIC and the complete Central Medium Area, and for MSYR^{1+} values of 1%, 2% and 4%. Given both the variety and the low values of some of the new abundance estimates from surveys in 2007, the population abundances selected to be hit included estimates and lower 5%-iles for both the 2007 survey and for the inverse variance weighted average of all surveys, which was taken to apply to the middle year of the survey period of 1998; furthermore, where various combinations of survey results were possible, the strategy adopted was to report results for both the highest and the lowest abundances amongst those combinations. The results obtained are discussed in the sub-section following.

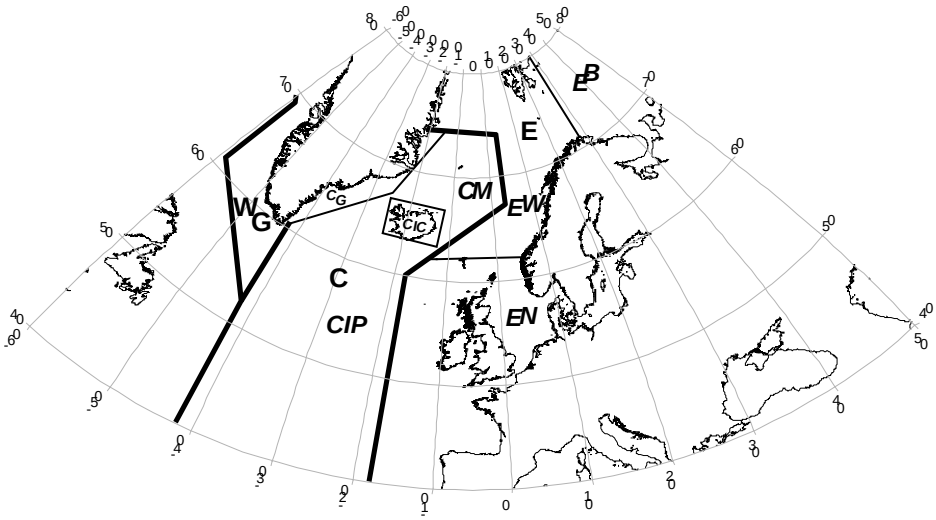

Fig. 2. Minke whale stock areas as defined by the IWC. Thick lines separate medium areas.

[1] Cunningham, C.L., and Butterworth, D.S. 2003. Updated Assessments of the Central Stock of Minke Whales and the East Greenland-Iceland and Faroese Stocks of Fin Whales in the North Atlantic. North Atlantic Marine Mammal Commission Document SC/11/MF/5. 50pp.

Management advice

On the last occasion (2003) that the NAMMCO Scientific Committee was asked for advice on the Central North Atlantic stock of minke whales (considered to be bounded by the Central Medium Area, as defined by the IWC,
Fig. 2 above), it provided the following comments:

> "Projections over the next 20 years using HITTER indicate 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 2003)."

For this meeting the Commission had requested an assessment of the short-term (2-5 year) effects of annual catches of 0, 100, 200 and 400 whales.

Based on the discussion of NAMMCO/SC/16/AS/04 summarised above, the WG considered that projections treating the CIC area in isolation and taking only the 2007 survey estimate of abundance into account could be discounted. The following Table 1 summarises the 10-year projection results in NAMMCO/SC/16/AS/05 for three other options across $MSYR^{1+}$ rates from 1 to 4%, and annual catches of 200 and 400 whales. The results given are for abundance as a proportion of the pre-exploitation level, and the range shown encompasses lower 5%-iles to best estimates for abundance.

Area	**Survey**	**2008**	**2018 (Catch= 200)**	**2018 (Catch=400)**
CIC	87, 01, 07	0.89 – 1.00	0.83 – 0.94	0.74 – 0.87
Central Medium	87, 01, 07	0.88 – 0.98	0.85 – 0.96	0.80 – 0.91
Central Medium	2007 only	0.69 – 0.98	0.63 – 0.96	0.52 – 0.92

Table 1. 10-year projection results for three other options across $MSYR^{1+}$ rates from 1 to 4%, and annual catches of 200 and 400 whales.

For these three scenarios, MSY estimates for $MSYR^{1+}$= 2% range over 244-354; 420-557 and 181-584 respectively. In the absence of any catch the estimates shown for 2008 would increase slightly.

Given the lower abundance estimates for 2007 compared to those of previous years, the results above do now include the possibility that over the next 10 years the resource could fall to near 50% of its pre-exploitation level under a catch of 400 per year. (Note that over a 5-year period, the extent of these reductions would be approximately

halved.) Furthermore MSY estimates for $MSYR^{1+}$= 2% can fall below 300, and even slightly below 200 though this only applies in case of the least optimistic scenario where a combination of lower 5%-iles of the lowest abundance estimate (aerial and shipboard) and the highest historical catch series is assumed.

In the light of these results, the WG considered that the effect of catches of 400 whales per year for the next 5 years, while not likely to put the resource under any serious threat, could nevertheless cause a reduction in abundance at a higher rate (possibly exceeding 2% per year) than appropriate. Therefore, in the light of the results above and in the context of possible short term effects on the population, the WG **recommends** that in the short term 200 minke whales per year be considered as the largest catch that should be contemplated.

It should be noted that there are nations other than Iceland taking minke whales from the Central Medium area and that the catch levels shown above refer to all removals from the areas indicated: CIC or Central Medium.

5.6 Recommendation for future research

Víkingsson reported that an aerial survey for the total CIC area is planned for late June to late July 2009. The WG commended this project, in particular considering that the main concentration of whales in the total CM area has always, with the exception of the 2007 survey, been observed within the CIC area in past surveys. To follow up on the hypothesis of a fluctuating distribution of whales as a consequence of a fluctuating distribution of prey species, the WG **recommended** the analysis of prey abundance in relation to minke whale density from past and future surveys. The WG **recommended** that a survey of the total Central area be planned in the future.

The WG deemed that a new review of the stock structure of North Atlantic minke whales is desirable. This point should be on the agenda for the next meeting. For this reason the WG encouraged progress in the fields of genetics, especially with attention given to Skaug's method (parent-offspring linkages) and satellite tagging, especially for in-season short term movements.

6. LONG-FINNED PILOT WHALE

6.1 Review of the T-NASS estimate

Mikkelsen presented document NAMMCO/SC/16/AS/06 which estimates the abundance of pilot whales by fitting a generalized additive model with spatially referenced covariates to data collected during the 2007 Icelandic (shipboard and aerial) and Faroese (shipboard) components of the T-NASS, as well as to data from a seabird ship survey conducted during the same period. The shipboard surveys extended from the east coast of Greenland, around Iceland, to the Norwegian Sea as far south as the northern British Isles. In contrast, the aerial surveys were limited to Icelandic coastal waters only. The aim of this analysis was to predict density, and hence abundance, of long-finned pilot whales throughout the survey region. The density was estimated in two stages; presence-absence of whales was modelled logistically, then non-zero presence was assumed to be constant. The product of the predictions obtained from the

two models provided an estimate of abundance. The spatially referenced covariates considered were longitude, latitude, depth, sea-surface temperature as well as survey type. Additionally, g(0) was calculated and the estimates took into consideration the presence or absence of responsive movements. Variance was estimated using non-parametric bootstrapping. The ship surveys were run in three different configurations and three abundance estimates were produced. The considered best estimate over the entire region was a full-independent platform configuration, with no combined effort, and assuming responsive movements. The estimate was 203,300; 95% CI: 38,400 – 6,697,600). Additional estimates were a combined platform effort, i.e. platforms not independent at all distances, with responsive movements assumed (estimate: 610,600; 95% CI: 40,700 – 7,725,524) and a point-independent estimate, assuming the detections on the trackline to be independent (estimate: 164.700; 95% CI: 44,800 – 4,260,945). High confidence intervals were due to problems in the bootstrapping.

The WG acknowledged the effort made by the authors to provide new information to aid assessment of the pilot whale population; however due to the late submission of this paper (on the day of the meeting) it was not possible to undertake an evaluation of the methods (including the spatial modelling component) and of the results. Concern was expressed about the utility of the abundance estimate reported, given its wide 95% confidence interval of 40,000 to 7 million.

Guldborg Hansen presented document NAMMCO/SC/16/AS/07. The T-NASS in 2007 included the area 71˚N 58˚W to 59˚N 44˚W off the coast in West Greenland; in total the survey region covered an area of 220,924 km^2, divided into 21 *strata*. The area was surveyed in August-September 2007 (25th August to 30th September), using a Twin Otter airplane with 4 observers in a double platform design, covering a total of 8,670 km of survey effort in Sea State below 5 in 14 *strata* with a total *stratum* area of 213,996 km^2. The search method used an independent observer configuration where observers 1 and 2 acted independently of each other. Seventeen sightings of long-finned pilot whales (*Globicephala melas*) were collected; 16 sightings were made from the front observer, 13 by the rear, and 12 were seen by both. The declination angles were collected when the whale or pod was abeam, and subsequently converted to perpendicular distance of the whale (or centre of a pod) to the track line. From the Mark-Recapture Distance Sampling (MRDS) model the probability of detection on the track line for both observers combined was estimated to be 0.97 (CV= 0.49). Analysis of the detection histories using logistic regression allows the probability that an animal on the track line is detected by an observer to be estimated, and thus, abundance can be estimated without assuming *g*(0) is 1. The proportion of time spent at the surface was estimated as 60% for pilot whales instrumented with satellite-linked data loggers at Faroe Islands (Heide-Jørgensen *et al.* 2002), but since pilot whales swim in structured groups (pods) it would be more appropriate to have a "pod availability correction factor". The assumption is made that at least one member of the group is always present in the surface and hence the correction for availability was not applied. With that assumption the abundance was estimated using MRDS methods (variables being observer and Sea State) and the total uncorrected abundance was estimated at 3,932 whales (CV=0.53). The average uncorrected group size was estimated to be 6.7. It is

unlikely that all pods were represented at the surface during the brief passage of the plane and the survey most therefore be considered negatively biased.

The WG wished further comparison of group size with previous surveys and possible correction for availability bias, and recommended that the analysis presented for acceptance at the Abundance Estimates WG in the autumn 2009.

6.2 Implications for and recommendation in the context of an assessment

The primary objective of abundance estimation for input to analyses aimed at providing management advice is to produce a series of absolute estimates of abundance that are comparable over time; some bias may be acceptable if more complex methods that seek to remove sources of bias lead to estimates with large variance.

In this context, it may be that the pilot whale assessment of document NAMMCO/SC/16/AS/06 strayed across the boundary of attempting to correct for too many biases without sufficient data to prevent an explosion in variance. The WG recommended that the first priority for further analyses should be to consistently apply a simpler (although perhaps biased) method to the various pilot whale survey data sets available. The results from such an exercise should be presented at the October 2009 NAMMCO Abundance Estimate WG meeting in Quebec. Discussion at that meeting should include a critical evaluation of the potential of more sophisticated methods (for example, attempting to take account of $g(0)$, vessel reaction, and using spatial modelling approaches) to provide estimates with reduced bias for which variance would nevertheless not be excessive.

It was agreed that in the absence of a more precise abundance estimate from the T-NASS 2007, the WG would not be in a position to complete an assessment for this species.

7. DESIGNING GENERAL MODELS FOR CONSERVATION AND MANAGEMENT OF BALEEN WHALES IN NAMMCO: WHICH APPROACH?

The Scientific Committee has been 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 (NAMMCO 17).

The WG suggested that the simulation tested Management Procedure approach developed in the IWC provides the preferred process for provision of advice on management measures such as catch limits in NAMMCO. It has a number of advantages over the more ad hoc approach based on current “best assessments”, for

reasons that have been elaborated by various authors (e.g. Butterworth, 20072; Punt and Donovan, 20073).

However there is a substantial burden in terms of the resources (primarily professional time) required to implement this approach, though once implemented it can run more smoothly and at less cost than the "best assessment" approach. It should be noted that substantial additional resources would be required, but these can be somewhat reduced by making use of work already carried out, particularly that in the IWC Scientific Committee.

Towards this end, a start could be made with Management Procedures already developed and tested, such as those of Cooke[4] and Aldrin *et al.*[5], and for simpler situations that of Witting[6]. A list of stocks for which management advice might be required should be developed, so that for each case an initial appraisal can be made of which of these Procedures might be the most appropriate to apply initially.

Over time, the control parameters of these Procedures could be adjusted to provide performance that better meets the Council's objectives for whaling. The costs of the simulation testing required to ensure that the Procedures adjusted in this way remain sound could be much reduced if it can be developed in a way that uses software already developed in the IWC for simulation testing.

8. NEXT NAMMCO SC WG ON ASSESSMENT – PREPARATION

The WG considered that there is sufficient information for a full assessment of Central North Atlantic minke whales and North Atlantic fin whales, and the WG should proceed with these at its next meeting.

For sei whales, the information available is likely insufficient to proceed to a full assessment, but the WG **recommended** that Iceland take the lead in compiling the available information in terms of catch series, abundance estimate and stock structure,

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[2] Butterworth, D. S. 2007. Why a management procedure approach? Some positives and negatives. *ICES Journal of Marine Science* 64:613–617

[3] Punt, A. E. and Donovan, G. P. 2007. Developing management procedures that are robust to uncertainty: lessons from the International Whaling Commission. *ICES Journal of Marine Science* 64:603-612.

[4] IWC. 1994. The Revised Management Procedure for baleen whales. *Rep. int. Whal. Commn* 44: 145-152

[5] Aldrin, M., Huseby, R.B. and Schweder, T. 2006. Simulation trials for a re-tuned Catch Limit Algorithm. NR-note SAMBA/10/06, Norwegian Computing Center. Also presented to the IWC Scientific Committee in 2006 as SC/58/RMP; Aldrin, M. and Huseby, R.B. 2006. Simulation trials 2007 for a re-tuned Catch Limit Algorithm. NR-note SAMBA/12/07, Norwegian Computing Center. Also presented to the IWC Scientific Committee in 2007 as SC/59/RMP4

[6] Witting, L. 2008. Long-term safety of strike limits for large whales off West Greenland. Presented to the IWC Scientific Committee in 2008 as IWC/SC/60/AWMP2 here NAMMCO/SC/16/AS/O08.

and present this at the next meeting of the NAMMCO Scientific Committee to allow an informed decision on how to proceed.

The WG recognized the magnitude of the task that an assessment of humpback whales represents, especially due to *inter alia* a complicated stock structure. At its next meeting it should review the available information on humpback whales and explore routes on how to proceed for an assessment for this species. The WG **recommended** that the Scientific Committee evaluate the urgency of this task and provide indications for the further work required.

The WG agreed that there is a need for specific rules for input data to be used in an assessment (how and when the components of the assessment should be delivered, and what quality of input data is needed). The Scientific Committee Chair and Scientific Secretary will compile a proposal for such rules, and circulate to the WG, so that a proposal can be tabled for the SC at its next meeting.

The main data inputs required for an assessment were identified as follows:

- Catch series
- Abundance estimates
- Stock structure
- Biological parameters
- Ecology and habitat issues.

This WG strongly **recommends** that the NAMMCO Secretariat gathers and updates catch series, including struck-and-lost and by-caught animals, and abundance estimates prior to the assessment of any species and maintains them thereafter. The WG also **recommended** that the Secretariat compiles and maintains a list of abundance estimates endorsed by the NAMMCO Scientific Committee, and archives the relevant documents.

It was suggested that the next Assessment WG meeting be held on 26-28 January 2010 in Copenhagen.

9. Other business

There was no other business

10. Adoption of the report

The final draft of this report was adopted by e-mail on 6 April 2009.

Appendix 1

AGENDA

1. OPENING REMARKS
2. ADOPTION OF THE AGENDA
3. APPOINTMENT OF RAPPORTEUR
4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS
5. THE CENTRAL NORTH ATLANTIC MINKE WHALE STOCK [1]
   - 5.1 Stock structure
   - 5.2 Biological parameters
   - 5.3 Catch data
   - 5.4 Abundance estimates
   - 5.5 Assessments
   - 5.6 Recommendation for future research
6. LONG-FINNED PILOT WHALE[2]
   - 6.1 Review of the T-NASS estimate
   - 6.2 Implications for and recommendation in the context of an assessment
7. DESIGNING GENERAL MODELS FOR CONSERVATION AND MANAGEMENT OF BALEEN WHALES IN NAMMCO: WHICH APPROACH? [3]
8. NEXT NAMMCO SC WG ON ASSESSMENT - PREPARATION
9. OTHER BUSINESS
10. ADOPTION OF THE REPORT

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[1] From NAMMCO 17

The Scientific Committee 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 Scientific Committee is requested to assess the short-term (2-5 year) effects of the following total annual catches: 0, 100, 200, 400.

[2] From NAMMCO 16

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.

[3] From NAMMCO 17

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.

Appendix 2

LIST OF DOCUMENTS

NAMMCO/SC/16/AS/01	List of participants.
NAMMCO/SC/16/AS/02	Agenda.
NAMMCO/SC/16/AS/03	List of documents.
NAMMCO/SC/16/AS/04	Thorvaldur Gunnlaugsson, Gísli A Víkingsson and Marianne H Rasmussen. Aerial survey in Faxaflói, Southwest Iceland in 2008, report and comparison to earlier surveys.
NAMMCO/SC/16/AS/05	Carryn L de Moor and Doug S Butterworth. Updated Assessment of the Central Stock of Minke Whales in the North East Atlantic.
NAMMCO/SC/16/AS/06	Charles GM Paxton, Thorvaldur Gunnlaugsson and Bjarni Mikkelsen. Density surface fitting of the T-NASS 2007 Pilot Whale Sightings.
NAMMCO/SC/16/AS/07	Rikke Gulborg Hnasen and Mads Peter Heide-Jørgensen Abundance and distribution of long-finned pilot whales (Globicephala melas) in West Greenland in 2007.
NAMMCO/SC/16/AS/O-01	C. L. Cunningham and D. S. Butterworth. Updated Assessments of the Central Stock of Minke Whales and the East Greenland-Iceland and Faroese Stocks of Fin Whales in the North Atlantic
NAMMCO/SC/16/AS/O-02	Report of the Joint Meeting of the Scientific Committee Working Groups on Northern Bottlenose and Killer Whales and Management Procedures. Copenhagen, 2 February 1995
NAMMCO/SC/16/AS/O-03	Report of the Scientific Committee Working Group on Management Procedures. Copenhagen, 13 - 14 October 1997
NAMMCO/SC/16/AS/O-04	NAMMCO Scientific Committee Working Group on minke and fin whales. Copenhagen, 20-22 November 2003
NAMMCO/SC/16/AS/O-05	Report of the study group on long-finned pilot whales. Cambridge, 22-26 April 1996. ICES
NAMMCO/SC/16/AS/O-06	Report of the Scientific Committee Working Group on Abindance Estimates. Reykjavik, 21-23 February 1997
NAMMCO/SC/16/AS/O-07	PS Hammond, K Macleod, D Gillespie, R Swift, A Winship. Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA)
NAMMCO/SC/16/AS/O-08	Witting L. (2008) Long-term safety of strike limits for large whales off West Greenland. Presented to the IWC Scientific Committee in 2008 as IWC/SC/60/AWMP2

ANNEX 3

REPORT OF THE NAMMCO WORKING GROUP ON MARINE MAMMALS AND FISHERIES IN THE NORTH ATLANTIC: ESTIMATING CONSUMPTION AND MODELLING INTERACTIONS

Reykjavik, Iceland, 15-17 April 2009

1. OPENING REMARKS

Chair Walløe welcomed the participants (Section 5.8) to the meeting.

By way of background in 1996 a Working Group (WG) looked at the feeding ecology of minke whales, harp and hooded seals and found that there were many uncertainties involved in estimating consumption by these species (NAMMCO 1998). It also considered the use of multi-species models to assess species interactions in the Barents Sea and Central North Atlantic. The Scientific Committee, based on the results from the WG, concluded that minke whales, harp seals and hooded seals in the North Atlantic might have substantial direct and / or indirect effects on commercial fish stocks.

In 1997, the Council requested the Scientific Committee to pay special attention to studies related to competition and the economic aspects of marine mammal-fisheries interactions. The Scientific Committee, in response, convened a WG on the Economic Aspects of Marine Mammal - Fisheries Interactions (NAMMCO 1999). This WG considered bio-economic models of varying complexity and associated ecosystem models, and concluded that "many of the analyses were in a preliminary stage and should only be taken as first indications". They further concluded that, despite the preliminary nature of the results, the emerging cost-benefit figures warranted serious consideration, as the overall costs to the fishing, whaling and sealing industries incurred by not whaling and/or not sealing could be quite considerable, and that the effects due to predation could be an important part of the overall picture.

At its 8th meeting in Oslo, September 1998, the NAMMCO Council tasked the Scientific Committee with providing advice on the following:

1. to identify the most important sources of uncertainty and gaps in knowledge with respect to the economic evaluation of harvesting marine mammals in different areas;
2. to advise on research required to fill such gaps, both in terms of refinement of ecological and economic models, and collection of basic biological and economic data required as inputs for the models,
3. to discuss specific areas where the present state of knowledge may allow quantification of the economic aspects of marine mammal-fisheries interaction;
   a) what could be the economic consequences of a total stop in harp seal exploitation, versus different levels of continued sustainable harvest?
   b) what could be the economic consequences of different levels of sustainable harvest vs. no exploitation of minke whales?

The WG on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts 1) and 2) of the request. One of the conclusions of the WG was that significant uncertainties remained in the calculation of consumption by marine mammals, and this uncertainty was the most important factor hindering the development of models linking consumption with fishery economics (NAMMCO 2001). Considering this conclusion, the Scientific Committee decided to convene a WG to further investigate the methodological and analytical problems in estimating consumption by marine mammals.

At its meeting in Tromsø, 26-28 September 2001 the WG continued work on the above mentioned Terms of Reference (TOR) and considered the methodological approaches to the calculation of consumption by marine mammals, making a detailed assessment of their relative merits. The two approaches of analyses of stomach contents in combination with estimates of stomach evacuation rates, and analyses of stomach or intestinal content or faeces scaled to satisfy the estimated energy expenditure of the animals were considered. The level of assumptions required and general lack of data about evacuation rate for most marine mammals render these methods unsuitable for the calculation of consumption by North Atlantic marine mammals. For the latter method diet composition and energy expenditure may be investigated independently to each other. The WG concluded that the proportions of various prey items in the diet can be safely derived from undigested items in fresh stomach samples if such samples are available. Interpretation becomes increasingly more difficult as digestion proceeds. However, errors associated with identifying the prey eaten by seals from intestinal contents or faeces can be assessed using captive feeding experiments. There is a range of methods available for measuring metabolic rate of seals in the field, but all have serious limitations. However, a main conclusion was that for all the relevant species of marine mammals in the North Atlantic the uncertainties in energy expenditure are small compared to the uncertainties in the estimates of abundance and compared to the uncertainties and lack of knowledge of the diet composition. As a first approximation it can be assumed that the marine mammals eat 3% of their body weight per day.

The Scientific Committee hosted a workshop in Reykjavik, Iceland in September 2002 under the title “Modelling Marine Mammal – Fisheries Interactions in the North Atlantic”. This workshop recommended a general modelling approach involving the use of “minimum realistic” models, and developed specific recommendations for their application to candidate areas of the North Atlantic. However the WG emphasized that better data on diet and consumption were needed before marine mammals could be adequately represented in models.

In Oslo, 22-24 October 2004 the WG reviewed the progress made in the previous two years, in two specific areas: 1) quantifying the diet and consumption of marine mammals, and 2) the application of multi-species models that include marine mammals to candidate areas of the North Atlantic. The WG concluded that the development of multi-species modelling was not proceeding as fast as it should, given the emphasis politicians and management authorities have placed on multi-species (ecosystem) approaches to the management of marine resources. Once again the WG emphasised

that progress in this area will not be made unless substantial additional resources are dedicated to it.

At its recent 17th meeting, in Sisimiut, Greenland 2-4 September 2008 the NAMMCO Council, acknowledging the standing requests to the Scientific Committee:

- *to monitor progress made in multi-species modelling and in the collection of input data and to decide when enough progress has been made to warrant further efforts in this area;*
- *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;*

requested the Scientific Committee:

> *"In addressing the standing requests on ecosystem modelling and marine mammal and fisheries interaction, to extend the focus to include all areas under NAMMCO jurisdiction. In the light of the distributional shifts (of species) seen under T-NASS 2007, the Scientific Committee should investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses."*

The Working Group was therefore given the task:

a. to monitor progress made in multi-species modelling and in the collection of input data;
b. to extend the focus (Barents Sea and Iceland) to include all areas under NAMMCO jurisdiction;
c. to investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses, in the light of the distributional shifts seen under T-NASS 2007;
d. to review the results of the Icelandic programme on the feeding ecology of minke whales.

And in addition

e. to evaluate how a projected decrease in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.

The Chair reminded the members that the WG should provide an indication of the kind of research needed to proceed towards ecosystem based management within NAMMCO. In this respect work conducted in other oceans is welcomed as it is useful for the definition of methods and applications which can be transferred to the North Atlantic and areas around Greenland.

2. ADOPTION OF AGENDA

The agenda was adopted. (Appendix 1)

3. APPOINTMENT OF RAPPORTEUR

Acquarone, Scientific Secretary of NAMMCO, was appointed as rapporteur for the meeting, with the help of other members as needed.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents available to the meeting are listed in Appendix 2.

5. RECENT DEVELOPMENTS IN THE QUANTITATIVE DESCRIPTION OF MARINE MAMMAL DIETS

a) Minke whales

Western North Pacific

Murase presented document SC/16/MMFI/07 in which the stomach contents of common minke, sei and Bryde's whales sampled in the western North Pacific from May to September were analysed. Sampling was conducted in the second phase of the Japanese Whale Research Programme in the Western North Pacific (JARPN II) from 2002 to 2007. The purpose of this study was to estimate the amount of fish resources consumed by the three whale species. Prey species of whales were identified by examining their stomach contents. The amount of prey consumed in the research area was estimated by extrapolation using information on prey consumption per individuals and abundance of whales. Daily prey consumption was estimated based on Sigurjónsson and Víkingsson (1997). Minke whales fed mainly on higher trophic level prey whereas sei and Bryde's whales mainly fed on lower trophic level prey. The results of this study suggested that these three baleen whales species should be considered as euryphagous. Length compositions of prey in the stomachs suggested that minke whales tended to feed on large size prey in comparison with sei and Bryde's whales. Daily prey consumption rates were estimated by maturity stage for three baleen whales and ranged between 2 % to 6 % of their body weight. The total prey consumption by these three baleen whale species in the survey area during the feeding season was estimated as 1.6 million tonnes per year.

Comments:

- The WG notes that the diet of minke whales in the North Pacific and in the North Atlantic were similar but that sei whales in the North Pacific feed on small fish as well as crustaceans which constitute their complete diet in the North Atlantic.

Murase went on to present document SC/16/MMFI/11 where prey preferences of common minke, Bryde's and sei whales at the meso scale were estimated using data from the cooperative surveys of cetacean sampling and prey of cetaceans. The surveys were conducted as a part of the offshore component of JARPN II from 2002 to 2007. This constitutes the first evaluation of prey preferences of minke, Bryde's and sei whales in the offshore region of the western North Pacific. A prey preference index, Manly's α, was used in the analysis. Though prey of the three baleen whale species overlapped, Manly's α suggested the species' preferences were different from each other. Minke and Bryde's whales showed a preference for pelagic fishes while sei whales showed a preference toward copepods. Accumulation of prey preference data

for long periods will provide the basis for appropriate choice of functional response form which is required by ecosystem models for fisheries management. Continuation of long term synoptic research such as JARPN II is important to develop reliable ecosystem models.

Comments:

- The WG notes that the spatio-temporal differences in feeding location might explain the differences in prey preference among the whale species as location might constrain prey choice.

- Furthermore the group underlines the importance of stomach content sampling for determination of whale diets and especially the trophic level of whale prey species. Alternatively information on prey trophic level could be obtained via stable isotope analysis of biopsies. For the Barents Sea there is a wealth of information that would facilitate a similar experiment on prey preferences and food partitioning.

Iceland

Víkingsson presented document SC/16/MMFI/04 which gives an account of an ongoing study into the feeding ecology of common minke whales in Icelandic waters. Sampling of a total of 200 minke whales took place during 2003-2007. Progress has been reported annually to the NAMMCO Scientific Committee and some preliminary results were presented in 2004 (NAMMCO SC/12/IN/4). Overall, sandeel was the most common prey, while other important prey species included herring, haddock, capelin, cod and krill. Compared to limited data collected opportunistically during 1977-1997, the present study showed higher proportions of sandeel and large benthic fish species and lower incidence of krill and capelin.

Although the sample size was small, indications of considerable geographical variation were found in the minke whale diet as well as appreciable changes over the study period. The latter appear to be related to changes in other components of the marine ecosystem in the Icelandic continental shelf area. Thus a decreasing contribution of sandeel to the diet during the study period coincided with a recruitment failure of sandeel in 2005 and to a lesser degree in 2004. Increased proportions of herring and haddock are also in good agreement with information on increasing trends in these species in recent years.

In relation to the large recent changes observed in hydrographical parameters and various components of the ecosystem in the Icelandic continental shelf area it is noteworthy that the abundance of minke whales in this area in 2007 was less than half that in 2001.

Comments:

- The WG notes that Atlantic cod represented an important part of the diet of Icelandic minke whales; on several occasions the stomachs contained this species only. The apparent geographical differences in the diet may have been affected by the small sample size and / or inter-annual variations.

- The WG suggests comparing samples collected annually from the same areas collected in different years to determine whether the past changes observed represent inter-annual variations or are a consequence of geographic variations in sampling locations.

Barents Sea

Haug reported on the status of Norwegian progress on the description of minke whale diets. After the research whaling under scientific permit in 1992-1994, Norwegian scientists continued to collect stomach samples of minke whales caught in the commercial hunt until 2004. The first part of this time series on minke whale diet (1992-1999, including only the Barents Sea area) was published by Haug *et al.* (2002)[20] , whereas document SC/16/MMFI/O07 summarises the continued sampling in 2000-2004. Substantial changes have occurred in the Barents Sea ecosystem over the past 30 years, the most conspicuous being related to the rises and falls of stocks of the two dominant pelagic shoaling fish species: capelin and herring. Effects of these ecological changes are clearly seen in the diet of minke whales. Following a collapse in the capelin stock in 1992/1993, minke whales foraging in the northern Barents Sea apparently switched from a capelin-dominated diet to a diet comprised almost completely comprised of krill. The second half of the 1990s saw a clear improvement in the capelin stock, and the species was again observed in the whale diet in the northern areas in 2000. In the southern area of the Barents Sea, capelin has increasingly been observed as prey of minke whales since 1995. In this area, gadoids and, more importantly, krill and herring, are also the food items of interest for the whales. The southern region of the Barents Sea includes important nursery areas for the Norwegian spring spawning herring. Good recruitment to this stock gives strong cohorts (e.g. 1991, 1992 and 1998) and large numbers of adolescent herring (0-3 years old) which serve as the main minke whale prey in the area. Recruitment failure with subsequent weak cohorts (e.g. 1993-1997) seems, however, to reduce the availability of adolescent herring to such an extent that minke whales switch to other prey items such as krill, capelin and, to some extent, gadoid fish. After 1999, sampling was extended to include areas outside the Barents Sea in addition. The material collected during late May-June 2000-2004 revealed a relatively mixed diet at the population level, whereas on an individual level, each whale had fed upon mainly one species. There were significant differences in diet composition between areas and some significant differences between years. The importance of krill in the Barents Sea increased with latitude and dominated the Spitsbergen diet. Capelin dominated the diet around Bear Island and contributed considerably to the diet along the coast of northern Norway. In the latter area, herring and haddock were also a large part of the diet. The diet in the Norwegian Sea consisted of mainly mature herring, while the diet in the North Sea was dominated by sandeels and mackerel. The whales were found to feed on a wide range of prey sizes apparently determined by the availability of different size classes.

[20] Haug, T., Lindstrøm, U. and Nilssen, K.T. 2002. Variations in minke whale *Balaenoptera acutorostrata* diets in response to environmental changes in the Barents Sea. *Sarsia* 87: 409-422.

No minke whale diet studies have been performed in Norwegian waters since 2004. It is, however, considered important to resume the sampling and data collection for long term monitoring of minke whale feeding habits in these areas, and new collections will most probably be undertaken during commercial whaling in 2009. A pilot study to assess the usefulness of fatty acid compositions in blubber profiles to estimate the diets of some captured animals will also be conducted. If the results are positive, future monitoring of minke whale diets might be conducted using the fatty acid method. For modelling purposes, it is also recommended that some process orientated studies be performed, where collection of diet data are combined with simultaneous mapping of prey abundance. As seen from document SC/16/MMFI/O08, current knowledge of the Barents Sea ecosystem is already comprehensive at many trophic levels – this area may therefore be particularly well suited for such studies.

Comments:

- The WG noted the Norwegian plans to resume the sampling of data to monitor minke whale feeding habits in Norwegian waters with appreciation. Regular sampling of such data is of great importance for understanding the ecological role of minke whales.
- The WG noted that fatty acid analysis may be able to help discriminate among size classes of the prey if they exhibit changes in diet during development (e.g. Atlantic cod).

b) Harp seals

Barents Sea

Haug reported on progress in the quantitative description of harp seal diets (document SC/16/MMFI/O12). In 2001 and 2002, Norwegian and Russian scientists undertook an aerial survey to assess whether there was an overlap in distribution, and thus potential predation, between harp seals and capelin in the Barents Sea. This experiment is now being followed by boat-based surveys aimed to study pelagic feeding by harp seals in the Barents Sea during summer and autumn. In May/June 2004, June/July 2005, and May/June 2006, Norwegian surveys were conducted, aimed at studying the feeding habits of harp seals occurring in the open waters of the Barents Sea (document SC/16/MMFI/O12). Very few seals were observed along the coast of Finnmark, and no seals were seen in the open, ice-free areas. In the north-western parts of the Barents Sea, however, very large numbers of seals were observed along the ice edge and 20-30 nautical miles south of this. In 2004, 2005 and 2006, 33, 55 and 57 harp seals respectively were shot and sampled (stomachs, intestines, and blubber cores) in these areas. Additionally, samples of faeces were taken from haul out sites on the ice. Preliminary results from the analyses of gastrointestinal tract contents and scats indicate that the summer consumption was to a large extent dominated by krill, with polar cod also contributing importantly. All sampling was performed during a period of low capelin abundance – this may have influenced the results. The 2006 survey also included synoptic assessment of prey abundance (using acoustics and trawling) in the areas where the seals were captured – these data are now being analyzed to assess potential prey preferences of the seals. Furthermore, potential prey items from the trawl hauls are now being analyzed for fatty acid composition – this will be compared with

results from similar analyses of blubber cores from the captured seals in order to see if this is a useful way to describe harp seal diets.

Haug added that management agencies in Norway and Russia have expressed concerns over the current size of the Northeast Atlantic harp seal populations and their predation on fish stocks, in particular in the Barents Sea. To be able to assess the ecological role of harp seals by estimation of the relative contribution of various prey items to their total food consumption, a Joint Norwegian-Russian Research Programme on Harp Seal Ecology has been initiated. The focus of this programme will be to:

1. assess the spatial distribution of harp seals throughout the year (experiments with satellite-based tags)
2. assess and quantify overlap between harp seals and potential prey organisms (ecosystem surveys)
3. identify relative composition of harp seal diets in areas and periods of particular intensive feeding (seal diet studies in selected areas)
4. secure the availability of data necessary for abundance estimation
5. estimate the total consumption by harp seals in the Barents Sea (modelling)
6. implement harp seal predation in assessment models for other relevant resources (modelling).

The Programme was adopted by the Joint Norwegian-Russian Fisheries Commission and supported by the NAMMCO Scientific Committee in 2006 and 2008. However, although both ecosystem surveys and abundance estimation of harp seals are in progress, the core activities of the Programme have not yet been started fully, the reason being that Russian authorities refused to permit deployment of satellite tags on harp seals in the White Sea in May, all of 2007, 2008 and 2009. To ensure that tagging will take place in 2010, Norway and Russia have agreed to organize a research cruise in late-May/early-June that year, to deploy satellite tags on harp seals on ice in the Hopen area southeast of Spitsbergen. The cruise will be part of the joint Harp Seal Programme, involving both Norwegian and Russian scientists. However, tagging seals in the White Sea is still the most preferable approach, as it ensures that only seals from the White Sea stock are tagged, and because tagging of different sex and age groups can be balanced easily. Therefore, the Russian scientists will apply for permission to tag seals in the White Sea also in 2010. The Norwegian scientists will provide all necessary technical information about the tags and the operation, whereas the Russian scientists will secure that all logistics in the White Sea area are ready in early May 2010.

Comments:

- There is an urgent need for more data on the feeding habits of harp seals in the Northeast Atlantic. The WG commended the planned Norwegian-Russian efforts to conduct a comprehensive Harp Seal Ecology Research programme in the Barents Sea and recommended that this very important programme be facilitated by the Russian authorities.
- The use of fatty acid compositions in blubber profiles may present a useful way to estimate the diets of seals and whales. The WG acknowledges, however, that there

are many questions that need to be answered by methodological studies before the method's usefulness can be assessed.

- For modelling purposes, the WG recommends that some process orientated studies be performed for the most important mammal predators, where collection of diet data is combined with simultaneous mapping of prey abundance.

Atlantic Canada

Stenson presented information on recent estimates of diet and consumption by Northwest Atlantic harp seals. Dramatic declines in the abundance of a number of groundfish species along the Atlantic coast of Canada were observed during the late 1980s and early 1990s. The largest of these was the stock of Atlantic cod found off the east coast of Newfoundland in NAFO Divisions 2J3KL ('Northern Cod'). Although commercial fishing was halted in 1992, this stock has failed to recover. A number of reasons for this failure have been postulated but a serious concern continues to be the impact of predation by harp seals. The first step in determining the potential impact of predation is to estimate the amount of Atlantic cod consumed by harp seals. Consumption of Atlantic cod by harp seals off the east coast of Newfoundland in NAFO Divisions 2J3KL was estimated in 2001 using data available up to the late 1990s. Since that time, considerable efforts have been made to update data on abundance, movements and diets in this area. Recent consumption by harp seals was estimated by integrating information on the numbers at age, age specific energy requirements, seasonal distribution and diet of harp seals in the Newfoundland area. Abundance was estimated using a population model integrating pup production between the late 1970s and 2004, annual estimates of reproductive rates from 1954-1998 and data on age specific removals from 1952-2008. Energy requirements of the population were estimated using a simple allometric model based on body mass obtained from monthly, sex-specific growth curves. The proportion of energy obtained in 2J3KL was estimated using data obtained from satellite telemetry and traditional tagging studies. The diet of harp seals in nearshore and offshore waters during winter (October – March) and spring (April – September) was determined by reconstructing the wet weight of stomachs collected in 1982 and 1986-2007. The impact of different diet determination methods was explored by estimating consumption based upon the proportion of cod in the diet obtained using a multinomial regression approach and fatty acid signatures. Uncertainty in the consumption estimates was approximated by incorporating the uncertainty in the numbers at ages, diets, energy requirements and seasonal distribution.

From these studies the total population of Northwest Atlantic harp seals was estimated to be 5.6 million (95% C.I. 3.9-7.2 m) in 2008. Of their total energy requirement, approximately 20% and 19% were obtained in the Newfoundland areas during the winter and spring periods respectively. Although specific diets varied with season, location, year and method of estimation, forage fish such as capelin, Arctic cod, sandlance (sandeel) and herring were the primary prey consumed. Incorporating data obtained from the reconstruction of stomach contents collected up to 2007 resulted in important changes in the average diet compared to previous estimates. Reduced proportions of American plaice and other pleuronectids were observed, along with lower proportions of Arctic cod in the near-shore diets and capelin in offshore diets. In

contrast, higher proportions of shrimp were observed, particularly in the offshore, while the proportion of Atlantic cod was slightly higher. These changes were also observed when annual diets were estimated using a multinomial regression method. However, this method also resulted in estimates of appreciable proportions of Atlantic cod in the offshore diets. In contrast, diet estimates based on fatty acid signatures showed extremely low levels of Atlantic cod in the diet and none in offshore diets. Diets of seals collected in different areas and seasons obtained from fatty acids were more similar than those estimated from reconstructed hard parts, likely as a result of the longer integration period represented by this method. This method also resulted in higher estimates of sandlance (sandeel), redfish and amphipods, and lower estimates of Arctic cod, capelin and Atlantic herring in the harp seal diet.

Stenson continued that using these three methods of estimating diets resulted in very different estimates of cod consumption, although all were highly imprecise. Based upon the average diet obtained from reconstructed hard parts in the stomachs, consumption of Atlantic cod increased from approximately 40,000 tonnes in 1960 to over 80,000 tonnes by the mid 1990s. Since then it has remained relatively constant. Dividing the diet into northern and southern areas resulted in slightly higher estimates. Using the diet estimated from the multinomial regression method resulted in estimates of cod consumption approximately three times higher, primarily due to the higher proportion of cod in all components of the diet. Unlike the average diet, cod consumption is estimated to be increasing in recent years. In contrast to diets based on harp part analysis, only 1,000 tonnes of Atlantic cod are estimated to have been consumed by harp seals based upon the diets obtained from the fatty acid signatures. The length of cod consumed was estimated from the otoliths; samples collected in the 1980s and 1990s indicated that the vast majority of cod consumed were between 5 and 15 cm in length. Samples collected since 2000, however, indicate that larger cod have been consumed in recent years.

He went on to add that although these data indicate that considerable quantities of cod may be consumed by harp seals, this alone does not indicate their impact on the population dynamics of the 2J3KL cod stock. Other hypotheses have been proposed including reduced recruitment and / or survival due to reduced prey availability and / or food quality (i.e. lack of capelin), as well as fisheries catches and environmental effects. To explore the potential importance of these various hypotheses, a bioenergetic-allometric biomass dynamic model was constructed which incorporates seal predation, capelin availability, and fisheries catches as external drivers of the Northern cod dynamics. The model was fitted by maximum likelihood to the cod biomass fall survey index for the period 1985-2007, and different model configurations were compared using the Akaike Information Criterion corrected for sample size (AICc). In order to fully represent the high variability across estimates of cod consumed by harp seals, two different shapes for the trend in consumption were used. One assumes consumption by seals was that obtained from the average seal diet over time, and hence, the trend in consumption follows the seal population trajectory, while the other one assumed the consumption estimated from a multinomial regression approach to diet analysis (i.e. larger amounts with an increasing consumption over the entire study period). In addition, both consumption series were also allowed to scale up

or down by fitting a scale parameter that multiplied them. All these alternative representations of seal consumption, plus the inclusion or removal of capelin and fisheries effects were used to define the scenarios explored. Overall, the best model to fit the data was one including capelin and fisheries catches, but without seal consumption. The differences in AICc between this model fit and the ones from other scenarios (all differences >10) indicated that all alternative models could be dismissed from further consideration. Based upon the results of this simple model, consumption of cod by harp seals does not appear to be an important driver of Northern cod during the study period. Instead, fisheries and availability of food appear to be the important drivers of the dynamics of this stock. Furthermore, these results indicate that a depressed capelin stock could be a serious impediment for cod rebuilding. The current model is being refined to determine if these preliminary results are supported.

Comments:

- It may be possible to determine diets using fatty acid signatures but the assumptions and biases inherent in this method need to be examined in more detail.
- Every method of diet determination has inherent biases; these must be identified and considered when interpreting the results.
- Using multiple methods of estimating diet is likely necessary to understand the true diet.
- The uncertainty associated with all inputs into the models used must be accounted for in a realistic manner.
- The level of precision required depends upon the questions being asked; determining precise estimates of consumption may not be necessary.
- The multinomial regression method for filling data gaps for diet studies appears to be more reliable for large sample size.

c) Other cetaceans and pinnipeds

Harp and hooded seals - Norway

Haug reported on a Norwegian project on harp and hooded seals in the North Atlantic. To enable an assessment of the ecological role of harp and hooded seals throughout their distributional range of the Nordic Seas (Iceland, Norwegian, Greenland Seas), a project was initiated in 1999 by members of the NAMMCO Scientific Committee. The project paid special attention to the period July-February period (i.e. between moulting and breeding), which is known to be the most intensive feeding period for both harp and hooded seals. Seals were collected for scientific purposes on expeditions conducted in the pack ice belt east of Greenland in September/October 1999, 2002 and 2003 (autumn), July/August 2000 (summer), and February/March 2001 and 2002 (winter).

During sampling in summer (July/August) in 2000 and winter (February/March) in 2001, harp and hooded seals were observed to co-occur in the sampling areas. This facilitated description and comparison of their diets (document SC/16/MMFI/O11). For hooded seals, the squid *Gonatus fabricii* and capelin were the dominant food items in

winter 2001, but the summer 2000 diet comprised a mixture of this squid and polar cod. Pelagic amphipods (*Parathemisto libellula)* were most important for the harp seals during summer 2000, whereas in winter 2001 the contribution from krill and capelin were comparable to that of *Parathemisto*. Multivariate analyses revealed significant differences in the intestinal contents of hooded and harp seals in areas where the two species showed spatial overlap. Different foraging depths of the two seal species may have contributed to the observed differences in diets.

Haug added that studies of diving behaviour of harp and hooded seals in the Greenland Sea have revealed that both species usually perform more shallow dives during summer than during winter, and that hooded seals dive to deeper waters than harp seals in both these periods. Except for the youngest stages, which may occur in the upper water layers during summer, the major hooded seal prey *G. fabricii* has a typical mesopelagic distribution with occurrence mainly at depths greater than 400 m. This is in contrast to the distribution of the major food of harp seals: the observed krill and amphipod species are usually confined to the more upper water layers (<200m depth).

Results from analyses of stomach and intestinal contents of hooded seals captured during the entire study period revealed that the diet of the species was comprised of relatively few prey *taxa* (document SC/16/MMFI/O10). The squid *G. fabricii* and polar cod were particularly important, whereas capelin and sandeels contributed more occasionally. *G. fabricii* was the most important food item in autumn and winter, whereas the observed summer diet was more characterized by polar cod, though with important contribution also from *G. fabricii* and sandeels. The latter was observed on the hooded seal menu only during the summer period, while polar cod, which contributed importantly also during the autumn survey, was almost absent from the winter samples. During the latter survey, capelin also contributed to the hooded seal diet. Samples obtained in more coastal waters indicated a varied, fish based (polar cod, redfish, Greenland halibut) diet.

Haug informed the WG that during the 1999-2003 surveys to the Greenland Sea, blubber and muscle tissues were also secured from the captured harp and hooded seals. The sampled tissues were used for analyses of fatty acid profiles and stable isotopes (document SC/16/MMFI/O09). The application of fatty acids analysis combined with stable isotopes in food web studies in marine ecosystems is an efficient tool, as it reflects dietary intake and assimilation over longer time periods than stomach content analysis. The use of Fatty Acid Trophic Markers (FATM) to trace the energy transfer from phytoplankton to top predators is based on the observation that primary and some secondary producers synthesize characteristic fatty acids and that this fatty acid signal is conservatively transferred through food chains. Stable isotopes reveal information about food carbon sources and trophic position of the species. The stable isotopes ratios of carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) in consumer proteins and fatty acid signature in consumer lipids both reflect those of their prey. Even if the two seal species showed considerable overlap in diet and occur at relatively similar trophic levels, the fatty acid profile indicated that the base of the food chain of harp and hooded seals was different. The fatty acids of harp seals originated from diatom based food chain, typically for high Arctic ice-covered ecosystems. The fatty acids of hooded

seals originated from dinoflagellate and the prymnesiophyte *Phaeocystis pouchetii* based food chain, which associates this species with more open Atlantic waters ecosystems.

Hooded seals – Canada

Stenson presented recent work on the diet of Northwest Atlantic hooded seals[21]. Reconstructing the stomach contents of hooded seals collect in the waters off the coast of Newfoundland and southern Labrador, Canada indicated that diets vary spatially and temporally. The main prey species in nearshore waters were squid (*Gonatus* sp.) and Greenland halibut, while the main prey species identified in a small sample of seals collected in offshore areas (n=40) were flatfish (Pleuronectidae), Atlantic cod and squid. Greenland halibut and redfish were also important prey.

The diet of hooded seals was also estimated using fatty acid signatures. Generally, the diets of adult males and females were similar, but differed from those of juveniles. During the pre-breeding period, adult hooded seals fed primarily upon redfish, amphipods, capelin and Atlantic argentine. Juveniles fed mainly upon capelin although argentine, sandlance (sandeel), amphipods and herring were also eaten. During the post breeding period, redfish were the most important prey for adult hooded seals. Lower proportions of capelin, argentine and long fin hake were also consumed. In contrast to data obtained from hard part analyses, fatty acids suggest that amphipods and argentine are important prey for hooded seals. The latter species has never been seen in the stomach contents although this may be due to its off-shelf distribution.

Impact of seals on Atlantic cod in Canada

Stenson presented document SC/16/MMFI/13. In the past two decades, virtually all of the stocks of Atlantic cod (*Gadus morhua*) in Atlantic Canada have collapsed. These stocks have shown little or no signs of recovery in spite of lengthy moratoria or reduced fishing. Many of these stocks continue to exhibit high levels of unexplained natural mortality. During this same period, populations of harp (*Pagophilus groenlandicus*), hooded (*Cystophora cristata*) and grey (*Halichoerus grypus*) seals in the area have increased significantly which has resulted in considerable speculation about the impact of seals on cod population dynamics. Workshops to review the evidence on impacts of seals on Atlantic cod stocks in eastern Canadian waters were held in Halifax November 12-16, 2007 and November 24-28, 2008. The first workshop reviewed what is known about seal-cod interactions and identified 1) gaps in our understanding, 2) analyses that could be completed for review at the second workshop, and 3) longer term research needs. The workshop report is available as CSAS Proceedings 2008/021. The second workshop reviewed additional analyses relevant to cod-seal interactions and examined evidence for and against various hypotheses for the cause of elevated natural mortality of cod. The report of this workshop is not yet completed, but preliminary conclusions are presented here.

[21] Tucker, S., Bowen, W.D., Iverson, S.J., Blanchard, W. and Stenson, G.B. 2009. Sources of variation in diets of harp (*Pagophilus groenlandicus*) and hooded (*Cystophora cristata*) seals estimated from quantitative fatty acid signature analysis (QFASA). *MEPS* (in press).

A small, but seasonally variable proportion (9-20%) of the grey seal population uses the 4X area. Grey seals presumably contribute directly to the mortality of 4X cod, but the level of this contribution is unknown due to a lack of diet data for 4X. Assuming the diet indicated by fatty acids for 4VsW, the effect would be negligible.

A large proportion of the Northwest Atlantic grey seal population used the 4VsW area throughout the year where they are known to consume cod. However, estimates derived from fatty acids indicate only a small fraction (~2%) of the diet is cod while historical estimates based on otoliths indicate that cod account for a higher (~12%) proportion. Based on diets estimated by fatty acids, grey seal predation is considered to be a minor factor in the lack of recovery of cod; however, given the uncertainties in the diet, a more important contribution to the lack of recovery cannot be ruled out.

There are temporal and spatial corrections between the abundance of grey seals and changes in natural mortality (*M*) of cod in the southern Gulf of St. Lawrence (4T). Estimates of consumption indicate that significant amounts of 4T cod are being consumed (10,000-12,000 tonnes) but the stomach content data indicate that the diet is dominated by fish smaller than 35 cm long which is inconsistent with *M* being high for larger adult cod. Although the causes of elevated *M* in this stock remain unknown, the hypothesis which cannot be eliminated is that predation by grey seals is an important cause of this elevated *M*.

Harp seals are estimated to consume 28,000 tonnes of 3Pn4RS cod, predominantly (56%) pre-recruits under 3 years of age. Grey seals were estimated to consume 14,000 tonnes of 3Pn4RS cod in 1996, with a preference for larger cod than harp seals (25-35 cm versus 10-15 cm). Modelling indicates harp seals could have significant impact on recruitment, under good conditions. Under poor oceanographic conditions other factors limiting recruitment are more important than harp seal predation.

Estimates of Atlantic cod consumption by harp seals in the 2J3KL area are imprecise and dependent on the diet assumed. There are indications of an increase in the amount of cod consumed by harp seals since the late 1980s, due primarily to increased occurrence of Atlantic cod in offshore diet samples. Modelling results are inconclusive. A mass-balance model developed in 2001 indicated that harp seals may have an impact on the recovery of 2J3KL cod, whereas a recent simple biomass model suggests that seal predation is not a significant factor in the lack of recovery to date. The recent model suggests that low productivity, as indicated by capelin abundance, is the major factor in failure of cod to recover.

The impact of seals on 3Ps cod has not been examined. Although harp seals are known to consume cod in this area, they are transient and resident for only short periods. The use of this area by other seal species (e.g. grey seals) appears to be relatively minor. Similarly, impacts of seals on 3NO cod are thought to be insignificant because relatively few seals use this area.

The impact of cetaceans on cod has not been examined. Significant numbers occur in many of these areas and although the diet of most cetaceans species in the region are

unknown, data from harbour porpoise and cetaceans in other areas indicate that Atlantic cod are consumed. Therefore, the recovery of cod may be impacted by cetaceans with through direct predation or competition for food.

Fin whales - Iceland

Lockyer presented published data for fin whales based on research in Iceland in the period 1978 – 1985 (Lockyer, 1987a[22], 1987b[23], 2007[24]). She emphasised that the prey taken by baleen whales ranged from copepods to pelagic fish, and noted that despite the large size of fin whales, their feeding had been focused on the pelagic euphausiid *Meganyctiphanes norvegica* around Iceland for a consistently long period of time. There can be up to a threefold difference in energy density between some planktonic crustaceans and fish, so that fin whales are not feeding on optimum energy density prey. Referring to findings of Víkingsson (1992[25], 1997[26]) the daily consumption of euphausiids by fin whales of average size 18.6 m is 677 – 1,356 kg, based on passage time and full stomach of 500-600 kg. Pregnant females consume the most of all classes. Lockyer focused on the female 2-year cycle of reproduction and annual migration where concentrated feeding occurs every summer (June – September) in Icelandic waters for about 3-4 months. The difference in weight between the lean post-lactation female and pregnant female is about 18.5 t after 12 weeks of feeding, representing an energy density approaching 100 x 10^6 Kcal. This amount represents the cost of the two-year reproductive cycle (11 months' pregnancy and 6 months' lacatation) and would be met by a consumption of about 120 tonnes of euphausiids (Lockyer, 1987a[3]). This also emphasizes the importance of including estimation of consumption by age and maturity class in a population.

Lockyer pointed out the potential effects of temporal and spatial changes in feeding conditions and demonstrated the extreme variation in body mass (in terms of fat condition) between 1978 and 1985, with lows and highs directly correlated with euphausiid abundance in the area, and also reflected in ovulation / pregnancy rate in females. Lockyer pointed out the importance of acknowledging such variations in any ecosystem model. Finally, data were presented showing that poorer prey availability (thus affecting the female's feeding intensity and fat deposition) can have effects on the

[22] Lockyer, C. 1987a. The relationship between body fat, food resource and reproductive energy costs in North Atlantic fin whales (*Balaenoptera physalus*). *Symposium of the Zoological Society of London* 57, 343–361.

[23] Lockyer, C. 1987b. Evaluation of the role of fat reserves in relation to the ecology of North Atlantic fin and sei whales. In *Approaches to marine mammal energetics* (ed. A.C. Huntley et al.), pp. 183–203. Society for Marine Mammalogy Special Publication, no. 1.

[24] Lockyer, C. 2007. All creatures great and smaller: a study in cetacean life history energetic. *J. Mar. Biol. Ass. U.K.* (2007) 87, 1035–1045.

[25] Víkingsson, G.A. 1992. Feeding of fin whales off Iceland—diurnal variation and feeding rates. *Report of the International Whaling Commission* 42, 768.

[26] Víkingsson, G.A. 1997. Feeding of fin whales (*Balaenoptera physalus*) off Iceland—diurnal and seasonal variation and possible rates. *Journal of North East Atlantic Fisheries Science* 22, 77–89.

body weight of near-term foetuses (Lockyer, 1990[27]). In turn this could affect recruitment and survival of young in the whale population.

East Greenland Walrus

Acquarone presented a published work on walrus diet by Born *et al.* (2003)[28]. Food consumption of Atlantic walruses (*Odobenus rosmarus rosmarus* L.) was quantified by combining underwater observations of feeding with satellite-telemetry data on movement and diving activity. The study was conducted between 31 July and 7 August 2001 in Young Sound (74°N–20°W) in Northeast Greenland. On ten occasions, divers were able to accompany foraging walruses to the sea floor and collect the shells of newly predated bivalves (*Mya truncata*, *Hiatella arctica*, *Serripes groenlandicus*) for determination of number of prey and biomass ingested per dive. Simultaneously, the activity of a 1,200 kg adult male walrus was studied by use of satellite-telemetry during an entire foraging cycle that included 74 hr at sea followed by a 23 hr rest on land. An average of 53.2 bivalves were consumed per dive, corresponding to 149.0 g shell-free dry matter, or 2,576 kJ per dive. During the foraging trip, the walrus spent 57% of the time diving to depths of between 6 and 32 m, and it made a total of 412 dives that lasted between 5 and 7 min (i.e. typical foraging dives). If the entire feeding cycle is considered (97 hr), the estimated daily gross energy intake was 214 kJ per kg body mass, corresponding to the ingestion of 57 kg wet weight bivalve biomass per day, or 4.7% of total walrus body mass. Due to ice cover, walrus access to the plentiful inshore bivalve banks in the area is restricted to the short summer period, where walruses rely on these banks for replenishing energy stores.

General comments to all presentations under item 5c:

The WG welcomes the new information presented, and in particular the Icelandic data on minke whale diet, as well as the recent research in the North Pacific and Northwest Atlantic. However, the WG notes that in general, the degree of progress from the last meeting is not extensive and considerable amount of work still remains to be completed. Some new approaches to estimating diet appear promising but still required verification.

Regarding the request "*to review the results of the Icelandic programme on the feeding ecology of minke whales*" the WG commends the progress made in the analysis. However, the analysis is not yet completed and an overall review of the results must await the finalisation of the programme. The WG **recommends** that Iceland proceed swiftly with these analyses.

6. RECENT DEVELOPMENTS (IF ANY) IN THE ESTIMATION OF ENERGY CONSUMPTION

[27] Lockyer, C. 1990. The importance of biological parameters in population assessments with special reference to fin whales from the N.E.Atlantic. In, *Whaling Communities in the North Atlantic, North Atlantic Studies* 2(1 and 2):22-31.

[28] Born, E.W., Rysgaard, S., Ehlmé, G., Sejr, M., Acquarone, M. and Levermann, N. 2003. Underwater observations of foraging free-living Atlantic walruses (*Odobenus rosmarus rosmarus*) and estimates of their food consumption. *Polar Biol*. 26:348-357.

Isotope studies in walrus

Acquarone presented a published paper on the metabolic rates of walrus (Acquarone *et al.* 2006[29]). Although costly and difficult to apply, the double-labelled water (DLW) method is one of the few possible methods generating estimates of energy demands for unrestrained, free-living animals. The results of its application on two free-living adult, male, Atlantic Walruses (*Odobenus rosmarus rosmarus*), weighing 1,370 kg and 1,250 kg respectively (estimated from length and girth measures) were presented. These data extend the size range of the 7 pinniped species for which the DLW method has been applied by a factor of 10. The animals were measured at a site in northeast Greenland (76° N) during the summer. Field metabolic rate (*FMR*) was dependent on the pool model for estimating metabolic rate and was approximately 13% higher when using the single-pool compared with the two-pool model. The estimates using the two-pool model were 328.1 MJ•day^{-1} and 365.4 MJ•day^{-1} for each of the two walruses. These figures were combined with estimated *FMR* using the same method in 7 other pinniped species to derive a new, refined predictive equation for pinniped *FMR* of

1. $$Ln\,FMR\left[MJ * day^{-1}\right] = 0.173 + 0.816 * Ln\,Total\ Body\ Mass\left[kg\right]$$

This equation suggests that pinniped food requirements might sometimes be twice as high as often assumed in some fisheries models, which are based on multiples of the theoretical basal metabolism.

Isotope studies in harbour porpoise

Acquarone reported on an unpublished study in which he and colleagues had measured the *FMR* of an adult male harbour porpoise (40.5 kg) in human care by the labelled bicarbonate technique. The results estimated *FMR* to 22,285 kJ•day^{-1}. During the same period the porpoise was fed fish of approximately 26,000 kJ•day^{-1} in raw energy, corresponding to 8.5% of the animal's body weight. After taking into consideration losses by digestive and assimilation efficiency the results from the bicarbonate measure are remarkably similar and suggest that daily food ingestion rates for this species might be remarkably higher than the 4% of body weight customarily assumed for cetaceans (Sergeant, 1969)[30], but similar to the 7-9.5% body weight reported by Lockyer *et al.* (2003)[31] for porpoises.

Comments:

- The high metabolic rates observed in walruses and porpoises are results that should be taken in to account in considering metabolic rates for other species, particularly for harp seals (considering their population size).

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[29] Acquarone, M., Born, E.W. and Speakman, J.R. 2006. Field Metabolic Rates of Walrus (*Odobenus rosmarus*) Measured by the Doubly Labeled Water Method. *Aquatic Mammals* 32(3):363-369.

[30] Sergeant, D.E. 1969. Feeding rates of *Cetacea*. *Fiskeridir. Skr. (Havunders.)* 15:246-258.

[31] Lockyer, C., Desportes, G., Hansen, K., Labberté, S. and Siebert, S. 2003. Monitoring growth and energy utilisation of the harbour porpoise (*Phocoena phocoena*) in human care. *NAMMCO Sci.Publ.* 5:107-120.

7. RECENT DEVELOPMENTS IN MULTI-SPECIES MODELLING

a) The SCENARIO model (*post-mortem*)

Schweder presented the SCENARIO BARENTS SEA project[32]. In this project, management of the marine ecosystem is regarded as a game played by the Government Agency against Nature. The quality of the management strategy is evaluated using models for the strategy taken by Nature. These models should be sufficiently realistic, but also practical to implement and investigate on a computer. Whaling and sealing in the Barents Sea are of little economic interest in themselves, but might impact some other fisheries positively. The model to evaluate strategies for whaling and sealing includes cod, herring, capelin, harp seals and minke whales, and emphasises interactions between these populations caused by predation. For proposed management strategies, the stochastic system is repeatedly simulated over 100 years, and the strategies are evaluated by the resulting cod, capelin and herring Total Allowable Catches (TACs) that are calculated from fixed rules. This line of study was first pursued in the 1990s with an emphasis on management strategies for cod, herring and minke whales. The model is structured with respect to area (7 regions) and length for fish (5 cm groups for cod), and has a time step of one month. The model is fitted piecewise to available data, and using published results. It was later improved particularly with respect to the spatial structure and migration, the estimation method, and the predation model. The estimation is conducted simultaneously for all the available raw data by maximizing the joint likelihood. Inspired from discrete choice models in economics, a logistic model was established for how the consumption need for each predator is distributed over the potential prey units. The fraction taken by a predator of each respective prey population depends also on the abundance in the region of all other prey populations. The model was also extended to include harp seals. There are some 5 million harp seals in the Barents Sea consuming cod, herring, capelin and other prey. Despite their importance as predators, data are scarce and possibly less than representative with respect to diet choice for harp seals. As it turned out, the model parameters were difficult to estimate. Having struggled to estimate recruitment- and mortality parameters by fitting the model to historical data, the fitted models were not satisfactorily balanced. When simulating the model, stock trajectories in some of the runs were implausible, and varied too much between runs compared to historical data. The project must be regarded as unsuccessful, as when harp seals were included, no comparative simulation experiments useful for management could be performed. The project might have been useful as a learning exercise, but more research is needed to establish a sufficiently credible model as would be needed for ecosystem management.

Comments:

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[32] Schweder, T. 2006. The Scenario Barents Sea study: a case of minimal realistic modelling to compare management strategies for marine ecosystems. In: *Top Predators in Marine Ecosystems. Their Role in Monitoring and Management.*. Cambridge, UK.: Cambridge University Press. ISBN 978-0-521-84773-5. s. 310-323

1. Inclusion of the harp seal in the model made it difficult to estimate the parameters. This is most likely due to the weak data on harp seal feeding ecology, and the fact that the harp seal is a major top predator in the system.
2. The, probably sub-optimally, estimated model gave simulation results that were implausible in part. The model was simply not sufficiently stable. A possible reason for this is that important feedback mechanisms are lacking.
3. The WG considers that the model had many attractive features, both in its structure, and not the least in the functional response part, and in that a rather comprehensive handling of uncertainty was attempted. The *post-mortem* is unfortunate – it should rather have been a revival.
4. The WG underlines the importance of all modelling exercises even when the resulting model does not successfully reflect the actual situation. In the case of the Scenario Barents Sea project, elements of the model might be of value for other approaches.

b) Globally applicable Area-Disaggregated General Ecosystem Toolbox (GADGET) based models

Stefansson gave a presentation on the GADGET (Globally applicable Area-Disaggregated General Ecosystem Toolbox) based models as summarised below. GADGET is a fully parametric forward simulation model which can be used for parameter estimation. A simulation results in population trends by species, size class, age group, area and time step. These trends can subsequently be compared to data using appropriate likelihood functions, eventually minimizing a negative log-likelihood function to obtain parameter estimates.

Consumption within GADGET is modelled using suitability functions and mortality can be due either due to predation, other natural causes or fishing. Growth is implemented via movement up through length classes and can be based on consumption or growth functions, with several growth update mechanisms already available. Migration is implemented through movement matrices. In principle these can vary by time step, but in typical case studies they are assumed to be fixed in time. The species life cycle can be closed within GADGET, so the spawning component (or mature females) can generate a new year-class. The model is completely symmetric across species and areas so that e.g. a predator's behaviour is defined only through associated data sets and parameterisation.

Parameters are estimated using maximum likelihood. A number of likelihood functions have been implemented but recent work indicates that many common data sets defy the most common statistical assumptions. It has also been seen that model "stiffness" implies that too much weight given to a data source (i.e. incorrect likelihood function) can lead to widely varying population trends, which is in stark contrast to well-known results in linear statistical models where incorrect variance assumptions tend to be of minor significance.

Since GADGET is a parametric model, it can in principle run without data. For data-poor species, highly detailed models which require large numbers of parameters cannot

be reasonably implemented and the modeller is forced to use simpler models with fewer parameters. For some marine species highly detailed data are available and these can then be used to fine-tune more detailed models.

Given the data requirements, it is obvious that if data are entered into GADGET data files by hand or using manual extractions from raw data bases, revisions of spatial aggregations or length groupings would require considerable revisions of the data files. For this reason a data warehouse has been defined in such a way that it consists of mildly aggregated data in standardized tables. Extraction routines for assessment purposes have been written along with extraction routines for GADGET.

Case studies include several species within Icelandic waters, the Barents Sea, the Celtic Sea, North Sea herring, the Tyrrhenian Sea and the Bay of Biscay. For each of these areas single or multispecies models have been implemented using GADGET with data extracted from standardized tables for each area.

Current implementations include several species within Icelandic waters (single species, single area and up through 3-species in 10 areas) and Barents Sea cod. In spite of known problems, the program is currently used for assessments in several cases where no alternatives exist to account for known important processes within the system.

Recent work includes obtaining apparently reliable bootstrap estimates of uncertainty, implementations of tagged sub-populations, development of new likelihood functions and closing the life cycle. Given the correlated nature of the measurements, the most promising approach to variance estimation appears to be bootstrapping of aggregates from the GADGET database.

Planned work includes setting up the GADGET data base for minke whales in Icelandic waters, based on the Marine Research Institute (MRI) data bases and developing initial simple models of the population dynamics based on earlier work with GADGET models for seals. Subsequently the minke whale model should be linked to updated models for cod, but it is not clear whether reasonable models for sand eels can be developed although this may be quite important.

Several sets of parameters can in principle be modelled as random effects rather than the traditional fixed effects. This has considerable potential and will be investigated.

c) Ecopath with Ecosim (EwE) models

Morissette presented document SC/16/MMFI/15. Food webs have always been considered as a central issue of ecology, and their value and usefulness are frequently discussed. Consequently, the comparability of different food webs is a key to possible applications. In that sense, comparative analyses based on a common modelling approach are of great interest. It was thus decided to use different *Ecopath with Ecosim* (*EwE*) models for these analyses. *EwE* is a software package which has become widely used for the analysis of exploited aquatic ecosystems. Currently, the software counts

more than 2,800 registered users from approximately 120 countries. A good coverage based on the same modelling methodology is thus available throughout the world's oceans, and it is therefore possible to use models based on this approach to quantify and analyse the trophic interactions between marine mammals and fisheries.

In *EwE*, several systems' indices are computed to describe the food web, its complexity, and the way trophic groups interact with one another. The software also allows making dynamic simulations based on *Ecosim*, a dynamic modelling application for exploring past and future impacts of fishing and environmental disturbances. *Ecosim* converts the trophic flows of *Ecopath* into dynamic, time-dependent predictions (full details of the *EwE* modelling approach and equations are available from http://www.ecopath.org).

Morissette presented different approaches on how to quantitatively assess the impact of marine mammals in marine ecosystems. She had used the Mixed Trophic Impacts (MTI) routine from *EwE*'s network analysis to quantify direct and indirect interactions between all trophic groups in different food webs (examples are provided in Morissette et al. 2006[33], and other ecosystems were also presented). This routine assesses the direct and indirect interactions between species in the ecosystem and gives an ecosystem overview of the trophic interactions. In that sense, it represents an interesting tool for studying marine mammals-fisheries interactions. It synthesizes the effects that a small change in the biomass of a group will have on the biomass of other groups in a system (in other words, it shows if the presence of a predator is beneficial or detrimental to all the other species of the system). The approach is derived from Leontief economic input-output analysis, and quantifies all the direct and indirect trophic impacts of all groups in the system based on the assumption that the direct impact between group *i* and group *j* can be estimated from the difference between the proportion that group *i* contributes to the diet of group *j*, and the proportion that group *i* takes from the production of group *j* (see *EwE* user's guide on http://www.ecopath.org). The MTI for living groups is calculated by constructing a matrix, where the i,j^{th} element representing the interaction between the impacting group *i* and the impacted group *j* is:

2. $MTI_{ij} = DC_{ij} - FC_{j,i}$

where DC_{ij} is the diet composition term expressing how much *j* contributes to the diet of *i*, and $FC_{j,i}$ is a host composition term giving the proportion of the predation on *j* that is due to *i* as a predator. When calculating the host compositions, the fishing fleets are included as "predators". Beneficial predation is calculated as the percentage of the overall trophic impact by marine mammals, that is positive for any prey group of this predator. Although counter-intuitive, beneficial predation is frequent, due to the important indirect effects occurring in ecosystems.

[33] Morissette, L., Hammill, M.O. and C. Savenkoff. 2006. The trophic role of marine mammals in the Northern Gulf of St. Lawrence. *Marine Mammal Science* 22(1): 74-103.

The last part of Morissette's presentation referred to work in progress, regarding these indirect effects in marine ecosystems. Trophic interactions between marine mammals and fisheries have been the subject for considerable research during the last decade. However, the extent to which the issue is addressed in an ecosystem, multi-species context is still limited. Consequently, there is still a lack of unequivocal evidence for competition between marine mammals and fisheries on a global scale. This may be due to (1) the absence of appropriately scaled information on marine mammals' diet and ecology; (2) the lack of consideration of all trophic groups in the ecosystems where these interactions might happen; or (3) the indirect effects being more important than initially thought in food webs. Recent efforts to understand how interaction strengths affect both structure and dynamics in food webs have shown that the indirect effects have a fundamental importance in governing ecosystem dynamics. Thus, the use of an ecosystem approach integrating the whole range of trophic diversity (from plankton to marine mammals) is essential for assessing the true interactions between marine mammals and fisheries. SC/16/MMFI/15 (work in progress) will investigate the importance of indirect effects from 30 marine ecosystem models, and will assess the overall impact of marine mammals in these systems. Beneficial predation from marine mammals on their prey will be quantified and particular attention will be given to the magnitude of indirect effects in food webs. The structure and pathways allowing this to happen will be discussed, along with the importance of addressing the interactions between marine mammals and fisheries with a multi-species modelling approach.

Comments:

- *EwE* is a good tool for developing an overview of how the whole ecosystem works, and to address ecological questions. However, the *Ecopath* analysis has to deal properly with uncertainty before it could be considered for other uses. Consequently, there is a need for more uncertainty analyses for these models but these are rarely conducted.
- The proposed work on the indirect trophic effects is interesting and challenging. However, since there is no way to control the quality of input data in all the 30 models, reliability of the results of the meta-analysis becomes questionable. *Ecoranger* could be a way to impose the same sensitivity control to all models and show uncertainty on the results (indirect effects).
- There needs to be an investigation of how far down the indirect effects go, through the food webs. Estimating trophic effects by considering only a few species of marine mammals and fish (the top of the food web) might not capture the behaviour of trophic interactions in the ecosystem fully. Benthos and plankton, although further down the food web, might be important ecosystem components that must be examined in such trophic analyses.
- In order to use *EwE* for management advice, the models will have to address uncertainty better than in many cases so far.

Developments based on Ecopath-with Ecosim

Murase presented document SC/16/MMFI/09 by Mori *et al*. To evaluate the possible impact of whales (minke, Bryde's, sei and sperm whales) on Japan's fisheries resources, an initial ecosystem model of the western North Pacific is built using the

Ecopath-with *Ecosim* software. The impact of no harvesting and harvesting 4% of the whales for the coming 50 years on catch of the fisheries are investigated. When running the harvesting scenario, uncertainties in the functional response forms and trophic flow are considered. The results suggest that in average terms: 1) when minke, sei and Bryde's whales are all harvested by 4% of their biomass, an increase in catch is expected for most of the fish resources, indicating the effectiveness of harvesting several whale species simultaneously; and 2) when sperm whales are the only species that is harvested at 4% of its biomass annually, depending on the functional response form assumed for the species, the catch of neon-flying squid may increase. The main advantage in building such a model is that it allows quantitative evaluation of the possible effects of whaling on fisheries resources.

Comments:
The WG commended this interesting work, but noted that the *Ecopath* structure of this model is recognized to require some rebalancing. Moreover, it is important to add extensive uncertainty analysis to the estimates provided. The paper presented some exploration of uncertainty into the type of functional response assumed, but uncertainty in parameter inputs also needs to be incorporated.

d) Other types of modelling approach

Butterworth presented a summary of a multispecies model of the Antarctic ecosystem which he had co-authored with Mori (Mori and Butterworth 2006[34]). He first briefly summarised the history of human harvests of seals, whales, fish and krill in the Antarctic, and emphasised the central role played by krill. The background to the hypothesis of a krill surplus in the mid-20th century was described, and the information on population and trend levels that has become available since the postulation was first advanced was listed. The objective of the study had been to determine whether predator-prey interactions alone can broadly explain observed population trends without the need for recourse to environmental change hypotheses. The model developed included krill, four baleen whale (blue, fin, humpback and minke) and two seal (Antarctic fur and crabeater) species. The model commenced in 1780 (the onset of fur seal harvests) and distinguished the Atlantic / Indian and Pacific Ocean sectors of the Southern Ocean in view of the much larger past harvests in the former. Amongst the key inferences of the study are that: (i) species interaction effects alone can explain observed predator abundance trends, though not without some difficulty; (ii) it is necessary to consider other species, in addition to baleen whales and krill, to explain observed trends – crabeater seals seemingly play an important role and constitute a particular priority for improved abundance and trend information; (iii) the Atlantic / Indian Ocean sector shows major changes in species abundances, in contrast to the Pacific Ocean sector, which is much more stable; (iv) baleen whales have to be able to achieve relatively high growth rates in order to explain observed trends; and (v) Laws' estimate in 1977 of some 150 million tonnes for the krill surplus may be appreciably too high as a result of his calculations omitting consideration of density-dependent

[34] Mori, M. and Butterworth, D.S. 2006. A first step towards modelling the krill-predator dynamics of the Antarctic ecosystem. *CCAMLR Science* 13: 217–277.

effects in feeding rates. Further work on the approach awaits improved estimates of the time series of abundance of the major species in the ecosystem – an exercise currently being jointly conducted by the IWC and CCAMLR scientific committees.

Comments:
It was noted that this is a broad scale multispecies model, however there were a number of problems, in particular:

- Insufficient data on abundance and trends of key species such as crabeater seals.
- The somewhat arbitrary nature of the values accorded to the density-dependent mortality parameters introduced for each predator species.
- Might the incorporation of further species, particular ones with faster dynamics than whales and seals, qualitatively change predictions?
- Specification of a northern boundary, which has implications for the proportion of consumption by fin whales considered to occur in the region being modelled.

SeaStar, Bifrost and GADGET (Barents Sea)
Lindström presented different models applied to the Barents Sea with reference to documents SC/16/MMFI/O012, -O013, -O014, and -O015. The Barents Sea, with its relatively simple food web (low diversity) and long and detailed time series of data, provides an ideal setting to develop, calibrate and compare multi- and extended single species models. The current modelling approaches in the Barents Sea, including multispecies interactions, range from extended single species assessment models to detailed age-length structured multispecies models. The models presented were SeaStar (Tjelmeland and Lindstrøm 2005[35]), Bifrost and GADGET (Lindstrøm *et al.* 2008[36]).

SeaStar is an extended single species assessment model, developed for the assessment of Norwegian Spring spawning herring, which has incorporated the predation by minke whales. The estimated consumption is included in the objective function and the parameters determining the modelled consumption are estimated together with other free parameters of the model in a single operation. From an ecosystem perspective it is important to be able to separate the total natural mortality into different mortality components. The modelling results suggest that minke whales can inflict major mortality on adult and juvenile herring and that minke whales display a type III functional response.

Fish stocks are generally managed on a strictly single species basis. One exception is the assessment model of capelin in the Barents Sea (Bifrost), in which predation on pre-spawning and juvenile capelin by cod and juvenile herring, respectively, is accounted for. Bifrost, in which species are structured by age, length and maturity, can potentially serve as a simulator where the herring-cod-capelin harvesting control rules

[35] Tjelmeland, S. and Lindstrøm, U. 2005. An ecosystem element added to the assessment of Norwegian spring-spawning herring: implementing predation by minke whales. *ICES J. Mar. Sci.* 62: 285-294.
[36] Lindstrøm, U., Smout, S., Howell, D. and Bogstad, B. 2008. Modelling multispecies interactions in the Barents Sea with special emphasis on minke whales, cod, herring and capelin. *Deep Sea Research* II: Topical Studies in Oceanography. *In Press.*

can be studied. Presently, the predation on cod and capelin by harp seals has been included in the model. Preliminary results indicate that harp seals have considerable impact on the capelin stock. By running two harp seal abundance scenarios, one with the stock being constant at the present level and another with the stock being constant at 50% of the present level, indicate that the maximum long-term catch of capelin is sensitive to number of harp seals in the Barents Sea; a reduced harp seal population generated a 100% greater maximum long-term catch of capelin.

More recently, an age-length structured multispecies model (GADGET) has been parameterised for the Barents Sea ecosystem. The species modelled are cod, capelin, herring and minke whales with minke whales and cod as predators, and capelin, herring and cod as prey. The model has been fitted to historical data and then been used to examine possible effects of a number of plausible biological and fisheries scenarios in hind casting and in the future. Indirect effects are shown to be important in the Barents Sea; cod fishing pressure, cod cannibalism and whale predation on cod having an indirect impact on capelin, emphasising the importance of multi-species modelling in understanding and managing ecosystems.

Comments:

- The model reproduces well the historical patterns of fish stocks.
- It was noted that details of modelled fishing, stock dynamics and predation can be provided.
- The model can be projected into the future.
- There is the potential to include uncertainty in model projections.

Statistical regression approach

Hjermann presented a review of some population models developed for the Barents Sea (Hjermann *et al.* 2004a[37],b[38], Hjermann *et al.* 2007[39]). These models concentrate on the two large fish stocks: Northeast Arctic cod and Barents Sea capelin, and the interactions between these fish stocks and Norwegian Spring-spawning herring, as well as effects of climate. They used a statistical regression approach based on age-specific abundance (and possibly mean length). The results give some insight into the dynamics and the importance of variation in different processes.

In the authors' view the model reflects good explanatory power for historical data. The main disadvantage of this approach is that it is basically a correlation approach, and

[37] Hjermann, D. Ø., Ottersen, G. and Stenseth, N.C. 2004a. Competition among fishermen and fish causes the collapse of Barents Sea capelin. *Proceedings of the National Academy of Sciences (USA)* 101:11679–11684.

[38] Hjermann, D. Ø., Stenseth, N. C., and Ottersen, G. 2004b. The population dynamics of North-east Arctic cod through two decades: an analysis based on survey data. *Canadian Journal of Fishery and Aquatic Science* 61:1747–1755.

[39] Hjermann, D.Ø., Bogstad, B., Eikeset, A. M., Ottersen, G., Gjosaeter, H. and Stenseth, N.C. 2007. Food web dynamics affect Northeast Arctic cod recruitment. *Proceedings of the Royal Society B* 274:661–669.

correlations tend to break down at some point in time. Also, it is based on survey data – in contrast to VPA, it cannot be used if only catch-at-age data are available. Also, nothing stops it from breaking fundamental biological principles (mass-balance, physiology, etc.).

Comments:

- The WG considered that this approach is useful for understanding the past, but in its current implementation (separately estimated regression models), it is not a good tool for simulating the results of applications of different management scenarios in the future.
- The parameters were fitted for each sub-model (abundance or length at a specific age) separately. This method is not the optimal statistical methodology. Also, there are estimation errors on both sides of each equations; this is not taken into account.
- The model should be developed into a state-space model with simultaneous fitting of parameters; this would also allow realistic bounds to be placed on parameter values. Such a model could be used to simulate the results of applying different management scenarios in the future.

8. RECOMMENDATIONS FOR FUTURE RESEARCH

a) Diet

The WG recognized the potential of Fatty Acid (FA) analysis for the determination of both qualitative and quantitative aspects of the diet of marine mammals. The advantage of this method compared to the analysis of stomach contents relate to the longer integration time. However, the methodology has to be further developed and validated as there are indications that the assimilation rates of prey fatty acids in the blubber may vary among species and among fatty acids. Furthermore, another aspect which needs to be investigated is the destination of the dietary fatty acids in the blubber profile and the differential utilization of the blubber profile by the animal.

The **WG therefore recommends** further investigations on:

- FA assimilation times, modes and location in the blubber
- Differential utilisation of different FA.

Based on the developments mentioned under item 6, the **WG recommends** that further investigations on energy consumption should be initiated in particular for harp seals.

The **WG further recommends** the regular gathering of data on predator and prey distribution and density, as well as diet data. Account should be taken of the fact that energy content of prey items varies in time.

The **WG also recognizes** that there is lack of information on the location of foraging grounds during part of the year for some species (e.g. minke whales) and **recommends** that further information be gathered as soon as possible.

b) Modelling

The multispecies modelling required for addressing management questions such as the impact on allowable catch levels for some commercial fish species of changes in the abundance of certain marine mammal populations is complex.

In some circumstances different models, whose merits cannot be distinguished given existing data, can provide very different answers to such a question. Thus **the only basis** on which scientific advice on such management questions could potentially be provided with confidence is if the outputs from a number of quite different models were in broad qualitative agreement in their predictions of the impact of possible management actions. Thus, for example, to advise reliably that an increased take of a marine mammal would lead to greater potential yield from a commercial fish species would require that:

a) the confidence / probability ranges about estimates of such an increased yield were entirely positive for a model and associated sensitivity tests;
b) furthermore, this held true not only for one but for a majority of different plausible models.

Carrying through such a multi-model exercise to conclusion will be possible only for a coordinated and funded multi-year project. The **WG recommends** that the NAMMCO Scientific Committee endorses and motivates for funding support for such a coordinated modelling effort.

This effort would need to include at least 3 different modelling approaches. Possible candidates, together with group leaders were identified as:

- Minimal realistic model implemented using GADGET (Stefansson)
- *Ecopath with Ecosim* (Morissette)
- Time series regression (Hjermann)

It was suggested that a simple biomass-based model such as one recently applied in eastern Canada should also be considered, and that model structures should allow for the possibility of multiple stable equilibria in the absence of exploitation.

If the models give qualitatively different predictions this could provide the basis to determine the factors giving rise to such different predictions, and hence indicate the risk of being wrong in choosing a certain management scenario, and also designate direction to future research to resolve uncertainties about those particular factors. The first phase of the work would involve fitting the different models to the available data and comparing their projection results. Ideally, in a second stage, the models could each be subjected to common simulation testing for an indication of which might be providing the more reliable results.

The exercise should be carried out for a single area, or two areas if resources are sufficient. Candidates put forward were the Barents Sea and the region around Iceland.

The pros and cons of each of these two areas will need to be listed for the consideration of the Scientific Committee.

c) Other recommendations

There were no other recommendations.

9. NORTHWEST ATLANTIC HARP SEALS – REQUEST FOR ADVICE RE. GREENLAND SUMMERING HARP SEALS

Rosing-Asvid presented document SC/16/MMFI/12 which described the catch history of harp seals in Greenland and showed that catches are strongly correlated with the size of the Northwest Atlantic harp seal population. The correlation was exponential for catches south of the ice edge (67°N), where both the number of seals and the duration of their stay increased when the population increased. More seals are seen late in the season and in recent years, whelping has been observed along the coast.

A reduction in the harp seal population from N_{max} (5.9 million) by 30% (4.1 million) would reduce the population to levels last seen in the early 1990s, when catches in Southwest Greenland were about 50% below the current level. Reduction by 50% (2.95 million) would bring the population back to the 1983 level, when the catches in Southwest Greenland were about 5% of current levels.

Rosing-Asvid added that high catch numbers and the observation of seals whelping off West Greenland is a pattern that also existed prior to the commercial sealing. Other species have also reverted to a previously existing distribution pattern during the recent decades. The number of polar bears caught along the Greenlandic west coast increased from close to zero during the 1970s and early 1980s to more than 100 polar bears in some of the years before a quota system was introduced after 2005. Bowhead whales increased in the same period from being extremely rare in the 1980s to a point estimate of more than 1,200 in 2006 in the Disko Bay area and humpback whales and fin whales have also increased strongly. The paper discussed how a change of the harp distribution might influence the ecosystems and thereby potentially have influenced the distribution patterns of other species.

Comments:

- In response to the request *"to evaluate how a projected decrease in the total population of Northwest Atlantic harp seals might affect the population of animals summering in Greenland"* the WG agreed 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 if numbers off Canada decreased, it is likely that the catches off Greenland would also decrease.

- Estimating the magnitude of a decrease in the Greenland catch for a given drop in abundance off Canada is, however, less straightforward. If one wishes to attempt estimating this relationship, this should be done through multi-linear regression analysis which takes account, at least, of any information available on annual

hunting effort and periods for which the seals stay off Greenland, as well as the Canadian abundance estimates. This would also allow the calculation of confidence limits associated with any estimate of a decrease in catch.

10. WORKPLAN

Diets
Regular meetings, perhaps on a biennial basis, should be held to review progress on dietary studies.

Modelling
Should the coordinated modelling exercise be endorsed by the Scientific Committee and NAMMCO, the key steps in the project development would be:

1) A meeting to compile detailed proposals and budgets; leaders of the different modelling terms would be essential participants. To be held before the end of 2009.
2) A data oriented meeting – common data would need to be carefully pre-agreed to ensure that the results from the different models were comparable.
3) A meeting of the modelling groups to critically compare and suggest improvements to their first attempts to fit their models to the data.
4) A meeting at which final model results are tabled for consolidation, and draft consequent management-related recommendations are developed.

Two years would probably be a realistic time-span for the whole process. It might be possible to combine meetings 1) and 2) above into one.

11. OTHER BUSINESS

There was no other business

12. ADOPTION OF REPORT

The draft report was approved in a preliminary form at the closing of the meeting and was circulated for approval by correspondence. The final draft was approved by correspondence.

Appendix 1

AGENDA

1. OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEUR(S)
4. REVIEW OF AVAILABLE DOCUMENTS
5. RECENT DEVELOPMENTS IN THE QUANTITATIVE DESCRIPTION OF MARINE MAMMAL DIETS
   a) Minke whales
   b) Harp seals
   c) Other cetaceans and pinnipeds
6. RECENT DEVELOPMENTS (IF ANY) IN THE ESTIMATION OF ENERGY CONSUMPTION
7. RECENT DEVELOPMENTS IN MULTISPECIES MODELLING
   a) The SCENARIO model (*post-mortem*)
   b) GADGET-based models
   c) ECOPATH-ECOSIM models
   d) Other types of modelling approach
8. RECOMMENDATIONS FOR FUTURE RESEARCH
   a) Diet
   b) Modelling
   c) Other recommendations
9. NORTHWEST ATLANTIC HARP SEALS – REQUEST FOR ADVICE RE. GREENLAND SUMMERING HARP SEALS
10. WORKPLAN
11. OTHER BUSINESS
12. ADOPTION OF REPORT.

Appendix 2

LIST OF DOCUMENTS

Document	Title	Presenting author
SC/16/MMFI/01	List of Documents	Secretariat
SC/16/MMFI/02	Draft Agenda	Chair
SC/16/MMFI/03	List of participants	Chair, Secretariat
SC/16/MMFI/04	Diet of of common minke whales (*Balaenoptera acutorostrata*) in Icelandic waters during 2003-2007. Preliminary results.	Gísli Víkingsson
SC/16/MMFI/05	Regression-based models of the Barents Sea ecosystem	Dag Hjermann
SC/16/MMFI/06	Prey consumption and feeding habits of common minke, sei and Bryde's whales in the western North Pacific (presentation)	Hiroto Murase
SC/16/MMFI/07	Prey consumption and feeding habits of common minke, sei and Bryde's whales in the western North Pacific (paper)	Hiroto Murase
SC/16/MMFI/08	Development of and ecosystem model of the Western North Pacific (presentation)	Hiroto Murase
SC/16/MMFI/09	Development of and ecosystem model of the Western North Pacific (paper)	Hiroto Murase
SC/16/MMFI/10	Prey preferences of minke, Bryde's and sei whales in the offshore component of JARPN II from 2002 to 2007 (presentation)	Hiroto Murase
SC/16/MMFI/11	Prey preferences of common minke (*Balaenoptera acutorostrata*), Bryde's (*B. edeni*) and sei (*B. borealis*) whales in offshore component of JARPN II from 2002 to 2007 (paper)	Hiroto Murase
SC/16/MMFI/12	How do changes in the West Atlantic harp seal population affect the number of harp seals summering in Greenland?	Aqqalu Rosing-Asvid
SC/16/MMFI/13	The Current State of Knowledge of Seal-Fisheries Interactions in Atlantic Canada	Garry Stenson

SC/16/MMFI/14	Marine mammals - fisheries interactions: the role of ecosystem modelling to capture ecological complexity	Lyne Morisette
SC/16/MMFI/O01	Report of the WG on the Economic Aspects of Marine Mammal – Fisheries Interactions, 16-17 February 2000, Copenhagen	
SC/16/MMFI/O02	Report of the Workshop on Marine Mammals: from Feeding Behaviour or Stomach Contents to Annual Consumption – What are the Main Uncertainties? Tromsø, 26 - 28 September, 2001	
SC/16/MMFI/O03	Report of the workshop on Modelling Marine Mammal – Fisheries Interactions in the North Atlantic, Reykjavik, 13 - 15 September, 2002	
SC/16/MMFI/O04	Report of the WG on Marine Mammals and Fisheries in the North Atlantic: Estimating Consumption and Modelling Interactions, Oslo, 22-24 October, 2004	
SC/16/MMFI/O05	Report of the *Ad Hoc* WG on Enhancing Ecosystem-based Management, Copenhagen, 3-4 December 2003	
SC/16/MMFI/O06	Report of the *Ad Hoc* WG on Enhancing Ecosystem-based Management, Aberdeen, 20-21 September 2005	
SC/16/MMFI/O07	Relative abundance and size composition of prey in the common minke whale diet in selected areas of the northeastern Atlantic during 2000-04	Tore Haug
SC/16/MMFI/O08	Food webs and carbon flux in the Barents Sea	Tore Haug
SC/16/MMFI/O09	Transfer of lipids from plankton to blubber of harp and hooded seals off East Greenland	Tore Haug
SC/16/MMFI/O010	Diets of hooded seals (*Cystophora cristata*) in coastal waters and drift ice waters along the east coast of Greenland	Tore Haug

SC/16/MMFI/O011	Feeding habits of harp and hooded seals in drift ice waters along the east of Greenland in summer and winter	Tore Haug
SC/16/MMFI/O012	Prey consumption by Barents Sea harp seals in the period 1990-2005	Ulf Lindström
SC/16/MMFI/O013	An ecosystem element added to the assessment of Norwegian Spring-spawning herring: implementing predation by minke whales	Ulf Lindström
SC/16/MMFI/O014	Multispecies functional response of the minke whale *Balaenoptera acutorostrata* based on small-scale foraging studies	Ulf Lindström
SC/16/MMFI/O015	Modelling multi-species interactions in the Barents Sea ecosystem with special emphasis on minke whales and their interactions with cod, herring and capelin	Ulf Lindström
SC/16/MMFI/O016	Role of predation by harp seals *Pagophilus groenlandicus* in the collapse and non-recovery of northern Gulf of St. Lawrence cod *Gadus morhua*	Garry Stenson
SC/16/MMFI/O017	Current Research on the Impact of Pinnipeds on Commercial Fish Stocks in the Northwest Atlantic	Garry Stenson
SC/16/MMFI/O018	Proceedings of the National Workshop on the Impacts of Seals on Fish Populations in Eastern Canada (Part 1), Halifax, Nova Scotia, 12-16 November 2007	Garry Stenson
SC/16/MMFI/O019	The trophic role of marine mammals in the northern Gulf of St Lawrence	Lyne Morisette