REPORT

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

Chairs
Rod Hobbs for NAMMCO and Steve Ferguson for JCBN

EXECUTIVE SUMMARY

The Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga met 17-20 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 (figure 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 behavior 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 TAHs, 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 5. 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 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 MSY. With this estimate, the JWG was for the first time able to provide management advice for narwhals in East Greenland. The JWG present 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^{o}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 that 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 4 . 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 beluga 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 beluga over the next five 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 modeling 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 behavior.

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 (Appendix 1) 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 (ToRs) 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 ToRs.

2 ADOPTION OF JOINT AGENDA

The draft Agenda (Appendix 2) 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 3.

5 NARWHALS

5.1 Stock structure

5.1.1 Genetic information

JWG-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 here:

	Garde et al. 2009		Garde et al. 2007	
	Age (yrs)	**Length (cm)**	**Age (yrs)**	**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		

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 asympototic length data (see Laws 1956). *Average length from East and West Greenland male narwhals.

References:

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

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.

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.

Table 2: Catch Statistics (2003-2007) for Narwhal in selected Eastern Canadian Arctic Communities

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**

* 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.

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 in Figure 1.

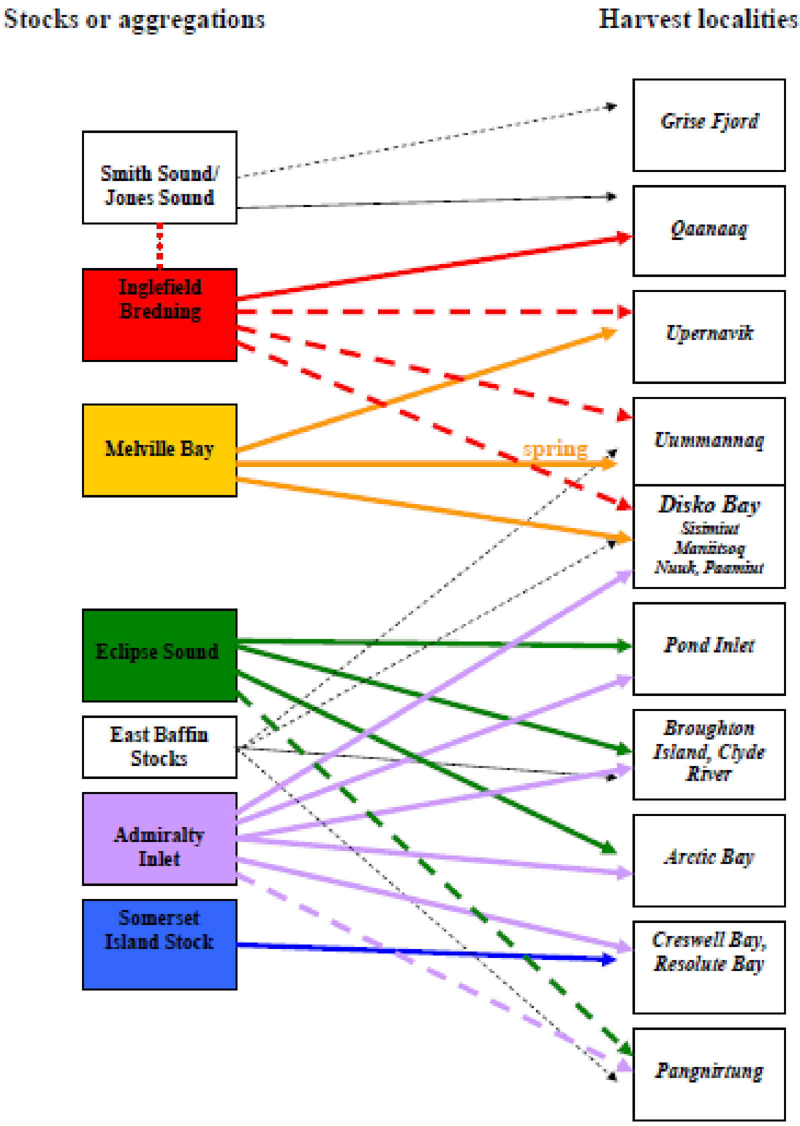

Figure 1: Narwhal stock allocation according to the revised information from JWG-2009-O13 (JWG-2005-16)

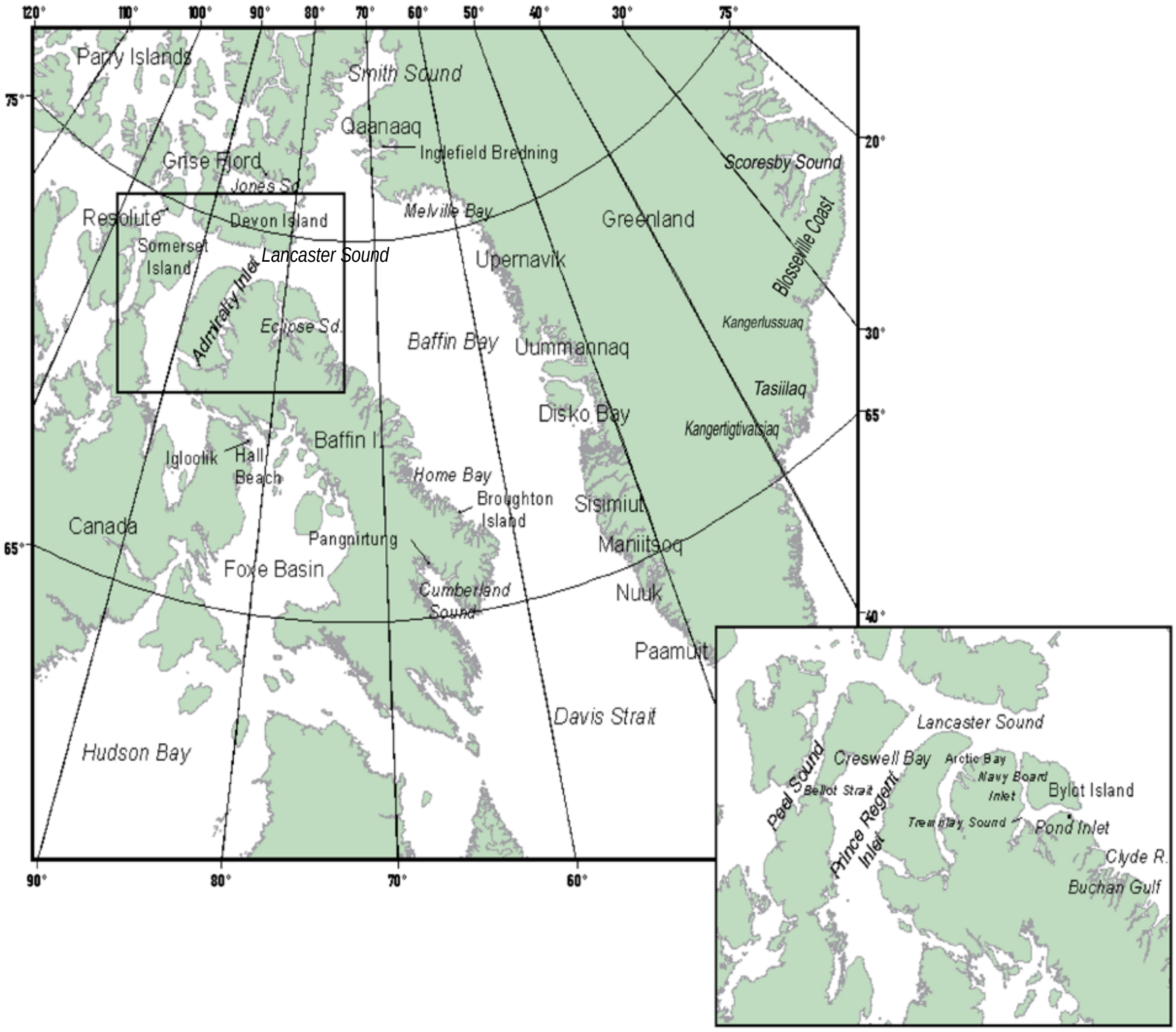

Figure 2. Map of place names for narwhal stocks and harvests

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 MD 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 ~9500 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 M. A. Treble. 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 in Table 3

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	
	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	

Putative stock	Year and ref.	Method	Estimate (cv)	Perception bias	Availability bias	Fully corrected stock size estimate	Reservations
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
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

5.4.3 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.

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 five 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 (5224) and the 2008 estimate from East Greenland (2541) 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 and Laidre 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 subadult 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 Table 1, 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 (8447) and Melville Bay (6235). 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.

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 undepleted 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.

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

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.

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 (Doc. No. 8)

JWG-2009-8: Heide-Jørgensen, M.P. Catch statistics for belugas in Greenland 1862 to 2008.

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 66oN 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 mattak (whale skin), sampling of jaws and reports from local residents and other observers. Options are given for corrections of catch statistics based upon auxiliary statistics on trade of mattak, catches in previous decades for areas without reporting and on likely levels of loss rates in different hunting operations. The fractions of the reported catches that are caused by ice entrapments of whales are estimated. During 1954-1999 total reported catches ranged from 216 to 1874 and they peaked around 1970. Correcting for underreporting and killed-but-lost whales increases the catch reports by 42% on average for 1954-1998. If the whales killed in ice entrapments are removed then the corrected catch estimate is on average 28% larger than the reported catches. Catches declined 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 underreporting. The Authors, specifying that the figures for 2008 are incomplete, were 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 areasin 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.

Canadian catches (C. Baker)

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 Hunter's and Trapper's Organization's (HTO's) 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 was fairly consistent to 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

Canadian catch statistics (2004-2008) for beluga in selected Eastern Canadian Arctic Communities are summarized in Table 6.

Discussion

The Author specified that Grise Fiord is 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).

Table 6: Catch Statistics (2003-2007) for Beluga in selected Eastern Canadian Arctic Communities.

	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
Kugaaruk	0	0	0	0	0	0	0
Gjoa Haven	0	NR	0	26	6	32	8
Taloyoak	20	NR	0	30	100	150	38
Totals	**43**	**10**	**17**	**100**	**127**	**297**	**69**

NR - no record of harvest was sent to DFO

Totals do not include Igloolik and Hall Beach

Table 6:Canadian catch statistics for 2003-2007.

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 km2. 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 beluga 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 beluga over the coming five 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.

Table 7

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

Table 7: 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

No other information.

6.5 Other information (Doc. No. 6)

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 modeling 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 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 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.[I think this suggestiuon was made then turned around – use the GLGs to calibrate eyes.] 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 Feb. 2009.

11 Adjourn

APPENDIX 1

DRAFT LIST OF PARTICIPANTS

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

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APPENDIX 2

AGENDA

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

Chairs
Rod Hobbs for NAMMCO and Steve Ferguson for JCBN

Work schedule:
Begin 1300 17 February, End 1200 20 February

Daily schedule plan as follows, but allow for some flexibility:
Start: 0830
Break: 1015-1030
Lunch: 1200-1300
Break: 1445-1500
End: 1630

1 OPENING REMARKS

2 ADOPTION OF JOINT AGENDA

3 APPOINTMENT OF RAPPORTEURS (Mario Acquarone NAMMCO, Christine Abraham JCNB)

4 REVIEW OF AVAILABLE DOCUMENTS

5 NARWHALS
- 5.1 Stock structure
  - 5.1.1 Genetic information (Doc. No. 18)
  - 5.1.2 Satellite tracking (Docs. No. 13, 15, O-11, O-12)
  - 5.1.3 Other information (Docs. No. 16, 19)
  - 5.1.4 Management units

Tuesday COB

- 5.2 Biological parameters
  - 5.2.1 Age estimation (Doc. No. 17)
  - 5.2.2 Reproductive rates
  - 5.2.3 Other information (Doc. No. 5, O-07)

5.3 Catch statistics
- 5.3.1 Struck and lost
- 5.3.2 Ice entrapments
- 5.3.3 Histories by management units (Doc. No. 7, O-09, O-13)
- 5.3.4 Other information

5.4 Abundance
- 5.4.1 Recent estimates
- 5.4.2 Estimates by management units (Docs. No. 14, 20, O-08)
- 5.4.3 Future survey plans
- 5.4.5 Recent changes in distribution in Canada

Wednesday noon

5.5 Assessment
- 5.5.1 Update of West Greenland assessment (Doc. No. 9)
- 5.5.2 Canadian summer stocks (Doc. No. O-10)
- 5.5.3 East Greenland (Doc. No. 10)
- 5.6 Future research requirements

Wednesday COB

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6 BELUGA

6.1 Stock structure

6.2 Recent catch statistics (Doc. No. 8)

6.3 Abundance
- 6.3.1 Recent and future estimates

6.4 Assessment update
- 6.4.1 West Greenland (Docs. No. 11, 12)
- 6.4.2 Other stocks

6.5 Other information (Doc. No. 6)

6.6 Future research requirements

Thursday noon

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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 (Docs. No. 4, O-01, O-02, O-03, O-04, O-05, O-06)

10.3 Human Impact on beluga habitat (NAMMCO request):
No papers, discuss future workshop?

Thursday COB

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11 ADOPTION OF REPORT

12 Adjourn — Friday 1300

APPENDIX 3

LIST OF DOCUMENTS

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

Document No.	
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.
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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.
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APPENDIX 4: 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

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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

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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%.

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Current Catch Levels

The average annual landed catch on Eastern Canadian High Arctic belugas is 69 beluga 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.

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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Table 1: Catch Statistics (2003-2007) for Beluga in selected Eastern Canadian Arctic communities.

	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
Kugaaruk	0	0	0	0	0	0	0
Gjoa Haven	0	NR	0	26	6	32	8
Taloyoak	20	NR	0	30	100	150	38
Totals	**43**	**10**	**17**	**100**	**127**	**297**	**69**

NR - no record of harvest was sent to DFO

Totals do not include Igloolik and Hall Beach

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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.

YEAR	QAA-NAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIIT-SOQ	NUUK	PAAMIUT-QAQORTOQ	UNDERREPORTING		TOTAL	MORTALITY IN ICE EN-TRAPMENT
									ALL	REGIONS		
1954		16	61	1774	23						1874	1774
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	1013	46	38					1259	234
1969		111	36	661	100	40	30				978	
1970	17	334	6	1133	10	24					1524	1050
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	1212	653
1977	50	240	49	379	43	13	65			36 Q	839	
1978	20	104	44	452	77	5	17				719	

YEAR	QAA-NAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIIT-SOQ	NUUK	PAAMIUT-QAQORTOQ	UNDERREPORTING		TOTAL	MORTALITY IN ICE EN-TRAPMENT
									ALL	REGIONS		
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				1017	
1982	127	329	17	313	95	13					894	100
1983	53	233	19	194	99	2	1			10 Q, 165 UP, 100 DB, 50S	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 UP, 100 DB	550	
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	

YEAR	QAA-NAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIIT-SOQ	NUUK	PAAMIUT-QAQORTOQ	UNDERREPORTING		TOTAL	MORTALITY IN ICE EN-TRAPMENT
									ALL	REGIONS		
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	

APPENDIX 5: 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 yrs	6-7 yrs	6 yrs
Mean calving interval	3 yrs		
Age of male sexual maturity		9 yrs	9 yrs
Longevity Females		115 yrs	99 yrs
Longevity Males		84 yrs	94.5 yrs
First Ovulation			8-12 yrs

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 (Table 1).

Average reported landed catches in the Eastern Canadian Arctic for 2003-2007 were 423 narwhals per year (Table 1, 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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Table 1: Catch Statistics (2003-2007) for Narwhal in selected Eastern Canadian Arctic Communities

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**

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

Table 2. 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	QAANAAQ	UPER-NAVIK	UUMMAN-NAQ	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 2. Continued

YEAR	QAANAAQ	UPER-NAVIK	UUMMAN-NAQ	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	120		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)	1019	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
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	

YEAR	QAANAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIITSOQ	NUUK	PAAMIUT QAQORTOQ	TOTAL	ICE ENTRAPMENT
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 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.

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
1965			0
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
1991			
1992			
1993	9	16	25
1994	17	20	37
1995	34	35	69
1996	8	39	47

Year	Ittoqqortormiut	Tasiilaq	All
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