ANNEX 1

JOINT MEETING OF THE

NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF NARWHAL AND BELUGA IN THE NORTH ATLANTIC

AND THE

CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP

Nuuk, Greenland, 13-16 October 2005

1 OPENING REMARKS

Chairmen Lars Witting and Øystein Wiig welcomed the participants (Appendix 1) to the third 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). The chairmen noted that, since the last meeting of the JWG, the JCNB had met once and NAMMCO Council had met twice.

At the ninth meeting of the JCNB, held in May 2004, the Commission agreed to ask the Scientific Working Group to focus on narwhal and complete that assessment and to update the West Greenland beluga assessment using any new information available. In addition the Commission posed the following questions (not in order of priority) to the SWG:

1) The Scientific Working Group should consider ways to resolve the issue of reproductive rate of narwhal.
2) Recent changes have been observed in the distribution of narwhal in Canada. For instance in Pelly Bay, hundreds of narwhal now regularly occur where they seldom occurred in the past. Are there any explanations available for these distributional changes?

The Scientific Working Group was also requested to consider the implications for its own structure and the organization of its work of a possible extension of the Commission's competence to include walrus or other marine mammal species.

NAMMCO Council endorsed the plan of the NAMMCO Scientific Committee to update and finalise the assessment of West Greenland narwhal in 2005 in cooperation with the Scientific Working Group of the JCNB. The Council also requested that the Scientific Committee carry out an assessment of East Greenland narwhal and provide an estimate of sustainable yield for the stock. The management objective in this case is to maintain the stock at a stable level. If the assessment cannot be completed with available information, the Scientific Committee was asked to provide a list of research that would be required to complete the assessment.

The JWG will therefore concentrate on the following tasks:

a. Update and finalize the assessment of West Greenland narwhal.
b. Make progress on assessments of other stocks of narwhal, particularly stocks summering in Canada. This will include provision of advice for the different putative management units.
c. Identify research required to complete an assessment of East Greenland narwhal.
d. Update the available information on the status of West Greenland beluga, taking into account recent harvest levels.
e. Address the specific questions posed by the Commission of the JCNB, above.

In addition the JWG should look at the recent information and if necessary revise previous statements about the extent of sharing of narwhal between Canada and Greenland.

2 ADOPTION OF JOINT AGENDA

The draft Agenda (Appendix 2) was adopted.

3 APPOINTMENT OF RAPPORTEURS

Daniel Pike and Patrice Simon were appointed as rapporteurs for the meeting, with the assistance of other members as required.

4 REVIEW OF AVAILABLE DOCUMENTS

The list of documents (Appendix 3) available for the meeting was reviewed..

5 NARWHALS

5.1 Stock structure

5.1.1 Genetic information

There was no new genetic information available.

5.1.2 Satellite tracking

JWG-2005-12 Laidre, K. and Heide-Jørgensen, M.P. Late summer and early fall movements of narwhals in Inglefield Bredning, Northwest Greenland

A new technique was developed for instrumenting narwhals in Inglefield Bredning, Greenland involving the deployment of satellite tags by hand harpoon from Inuit hunters in kayaks. Four narwhals were tagged in September 2004 and 2005 and movements of each animal were monitored for approximately one month. Tags were thrown into whales from a distance of 2-3 meters and all placed to the left or right of the dorsal ridge. On 6 September 2004, a female narwhal was tagged and positions were received from this animal for 19 days until 24 September. On 12 September 2004 two whales (one adult female and one adult male) were tagged. Positions were received from these two animals until 26 September and 28 September, respectively. Finally, on 30 August 2005 a male narwhal was tagged and positions were received for 20 days until 18 September. All four whales made localized movements in Inglefield Bredning and were generally stationary in the fjord through September. Shifts to the west and south were observed for all animals by the end of the month, however no data were collected on migration routes or wintering grounds because of the limited tag attachment duration. The assumption that only Inglefield Bredning supplies the fall and winter harvests in Greenland at this point should be taken with caution.

Discussion

The JWG noted the importance of the management issue being addressed by this study, the migratory destination of Inglefield Bredning whales and whether or not they contribute to catches further south, and encouraged further work in this area. For this purpose the duration of the tags must be doubled or tripled. It was considered likely that the relatively short transmission-life of the tags was due to attachment failure rather than tag failure, as the battery life of the tags should have been longer than the longest transmission time. Therefore further attempts will be made to refine the attachment system and deployment methods.

It was also noted that this work was being carried out in cooperation with hunters, who had made an important contribution to the development of the tagging methodology.

5.1.3 Management units

JWG-2005-16: Heide-Jørgensen, M.P., Dietz, R. and Laidre, K. Metapopulation structure and hunt allocation of narwhals in Baffin Bay

A model of the metapopulation structure of narwhals in Baffin Bay and adjacent waters is proposed based on a review of recent genetic studies, heavy metals, oroganochlorines, stable isotopes, satellite tracking, hunting statistics and compilations of local knowledge. This model is similar to the model presented at previous meetings but new evidence on migrations and homing of narwhals from Admiralty has been added. The default definition of a stock or management unit should be based on the assumption that disjunct summering aggregations of narwhals are separate stocks with little or no exchange between whales from other summering grounds. Coastal summering concentrations of narwhals in Canada are proposed to constitute at least five separate stocks: Eclipse Sound, Admiralty Inlet, Somerset Island, East Baffin stocks, and Cumberland Sound. Coastal summering concentrations in Greenland constitute at least two separate stocks: Inglefield Bredning and Melville Bay. Stocks that are shared between Canada and Greenland include Jones and Smith sound. In northwest Greenland, whales in Inglefield Bredning likely migrate south to Uummannaq and winter in Disko Bay, although this is the only major aggregation of narwhals that has not been tracked beyond 1 October. Inuit hunting of narwhals will differentially impact the stocks in Canada and Greenland depending on the temporal dispersal of the whales. Therefore, it is important to identify which stocks and aggregations contribute to which hunt in order to assess the sustainability of the hunt. Eighteen major hunting grounds in Canada and Greenland are identified at which several stocks appear to be hunted more than once. Evidence suggests whales from Canadian stocks have a low risk of being harvested in West Greenland. Similarly Greenlandic stocks also have a low risk of being harvested in Canada. The apparent stock delineation may be maintained through a combination of reproductive isolation at the spring mating season and matrilineally inherited site fidelity.

Discussion
The JWG concluded in 2004 that the model for apportioning of catches to putative stocks presented in the previous version of this paper (see Fig. 1) was acceptable based on the available evidence. This general conclusion was unchanged given the rather limited new information available. However the existence of summer stock of narwhal in Cumberland Sound was disputed, given that harvests are relatively low there during the summer and narwhal have not been seen in any significant numbers in extensive surveys of Cumberland Sound. The model presented in JWG/16 is qualitative in nature, using information from all available sources to identify stock units useful for management. The JWG was fully cognizant of the uncertainty of some of these conclusions. It was emphasized that the JWG will remain open to changing its understanding of narwhal stock structure as new information becomes available.

Some of the relationships between summering aggregations of narwhal and wintering areas are based mainly on very low numbers of satellite tracked narwhal. In particular only 2 narwhal from Melville Bay, both males, have been tracked to their wintering area. There was concern that basing stock relationships on such small sample sizes could lead to erroneous conclusions but there was no way to quantify the uncertainty in these conclusions. However in areas where larger numbers of narwhal have been tagged, such as Eclipse Sound, there has been little variance in migratory behaviour, giving greater confidence to conclusions based on small sample sizes. It was also noted that the identification of putative stock units was based on all available evidence, not just that from satellite tracking.

Given the logistical difficulty of deploying satellite tags, and the lack of success in some areas, the idea of using passive tags that would be recovered in the hunt, such as “spaghetti” or Discovery tags, was considered. However it was noted that deploying such tags would likely be no easier than deploying satellite tags and that large numbers would have to be deployed to have a reasonable expectation of a useful number of recoveries. It was considered preferable to maximize the information gain from every tagging opportunity by using tags that actively collect and transmit data. It was also noted that the deployment of passive tags had been tried on beluga in Canada with little success, probably because of tag rejection.

It was emphasized that the mechanism (genetic and/or behavioural) by which independent summer stocks are defined is not relevant to the importance of these stocks as management units and that management advice could be based on these units in either case. There is little evidence to support the contention put forward in JWG-16 that summer stocks of narwhal are in the main reproductively isolated from one another and it was noted in particular that the very low genetic diversity found between narwhal areas does not support this. The observed isolation of summering aggregations from one another could be maintained by maternally directed philopatry, which would not leave a genetic signal if the summer stocks are interbreeding elsewhere. In such a case some separation would be expected in the mitochondrial genetics, as is seen in beluga. That this separation is not seen in narwhal suggests that some mixing is taking place or that there has not been sufficient time since the separation of summering stocks for such differences to develop.

Sharing of stocks between Canada and Greenland
In 2004 the JCNB requested the JWG to look at the recent information and if necessary revise previous statements about the extent of sharing of narwhal between Canada and Greenland. In 2004 the JWG agreed that all available evidence suggests whales from Canadian stocks have a low risk of being harvested in West Greenland and that whales from Greenlandic stocks have a low risk of being harvested in Canada. No new evidence has been presented to change this conclusion. However it was emphasized that this conclusion is preliminary and based on incomplete evidence. The migratory destinations of some summer aggregations in Canada are unknown. These include the East Baffin, Smith Sound, Jones Sound and Parry Island stocks. It is therefore not known if these stocks are at risk of harvest in Greenland. In addition, the lower rate of depletion of the overwintering stock at Disko Bay compared to that of the Inglefield Bredning summer stock suggests that Inglefield Bredning cannot be the sole source of narwhal wintering at Disko Bay, implying that some of the narwhal harvested at Disko Bay must come from stocks summering elsewhere.

The JWG therefore revised its previous statement to conclude that there is a low risk that narwhal summering in the Somerset Island, Admiralty Inlet and Eclipse Sound areas are subject to harvest in Greenland. These groups constitute a large proportion of the total known number of narwhal summering in Canada. The migratory routes and destinations of other Canadian summer stocks, such as the East Baffin, Jones Sound and Parry Island stocks, are unknown and there remains a chance that these stocks are subject to harvest in Greenland, particularly at Uummannaq and Disko Bay during the fall and winter.

Stock structure in East Greenland
No new information has become available on stock structure in East Greenland since the NAMMCO Working Group last considered this in 1999 (NAMMCO 2000). There are summer aggregations at Scoresbysund, Kangerlussuaq, and Ammassalik which are subject to catches. Narwhal also occur north of Scoresbysund but these are likely not harvested. There is genetic evidence that East Greenland narwhal are distinct from those in West Greenland and Canada. However at present there is no basis for further distinguishing East Greenland stocks beyond that of their observed summer distribution.

5.2 Biological parameters

5.2.1 Age estimation

WG-2005-8 Garde, E., Heide-Jørgensen, M. P., Hansen, S. H. and Forchhammer, M. C. Age-specific growth and high longevity in narwhals from West Greenland estimated via aspartic acid racemization.

Age estimation of odontocetes (toothed whales) has traditionally been done by counting of growth layer groups (GLGs) in the teeth or mandible. However, this method has failed to provide reliable results for narwhals and development of a reliable method is needed. Here, we present new results for the age estimation of narwhals using the aspartic acid racemization technique. The technique utilizes

the fact that, in metabolically inactive tissues, such as eye lens nuclei and teeth, aspartic acid is converted or racemized from the L-form to the D-form with a constant rate over time. In this study eyeballs and teeth from a total of 75 narwhals taken by Inuit hunters were collected and analyzed. The D/L aspartic acid ratio was measured using High Performance Liquid Chromatography (HPLC). Due to difficulties with the HPLC analysis (aspartic acid peak separation) of the teeth samples, only the results of the eye samples are presented here. Age estimates were successful for all 75 narwhals. The aspartic acid racemization rate (k_{Asp}) was estimated to be 1.045 x 10^{-3} yr^{-1} by regression of D/L ratios to age estimated by length of 15 young narwhals (≤298 cm in length, ≤2.5 years) supplemented with data from 13 fin whales (Nerini 1983) that had been age estimated by counting of earplug laminations. The initial D/L ratio ($(D/L)_0$) was estimated by regression of D/L ratios to estimated age for the 15 young narwhals. The $(D/L)_0$ value was estimated to be 0.02880. About 20% of the whales were older than 50 yrs and there seemed to be a tendency for greater longevity in females than in males. The maximum age obtained was from a 115 year (SE±10 years) old female. The oldest male in the sample was 84 years (SE±9 years). Using the Von Bertalanffy growth model, length at physical maturity was estimated to be 396 (95% CI: 387-404 cm) and 457 cm (95% CI: 443-470 cm) in females and males, respectively. Based on the assumption that cetaceans attain sexual maturity at about 85% of their physical maturity (Laws 1956), length and age at sexual maturity was estimated to be 337 cm and 6-7 yrs for females, respectively, and 388 cm and 9 yrs for males, respectively.

Discussion

The JWG welcomed this important advance in determining the ages of narwhal, for which previously no reliable method was available. It was noted that there were some uncertainties, particularly relating to the lack of studies of known age animals. Such data are mainly available for humans. It was recommended that the method should be applied to other marine mammals, such as some other toothed whales and seals, for which ages are available through other methods, and to captive animals of known age, to verify the reliability of racemization ages. It was also recommended that the method be applied to beluga, in order to resolve the question of whether beluga teeth accrue 1 or 2 growth layer groups per year.

The estimates of age of sexual and physical maturity for male and female narwhal were similar to those from other studies. It was however recommended that the uncertainty in age estimation should be included in the estimation of growth curves.

The JWG found the method very promising and recommended that eyeballs be collected in all future sampling programs for narwhal and beluga. Once sufficient numbers of reliably aged animals have been collected, it should be possible to estimate the survival rate for narwhal stocks, which is an important parameter in stock modelling.

5.2.2 Reproductive rates

In 2004 the JCNB requested that the JWG should consider ways to resolve the issue of the reproductive rate of narwhal. The current scientific view is that narwhal reproduce about every third year. This is based mainly on the observation that roughly 1/3 of mature females in the catch are pregnant. It is also consistent with reproductive rates observed for other toothed whales. Some hunters, based on their own observations, have concluded that narwhal (and beluga) have the capacity to reproduce at a faster rate,

The JWG emphasized that the reproductive rate of one calf every 3 years is an average and does not preclude that some narwhal, at some periods of their lives, may reproduce at faster or slower rates. For example it is entirely possible and likely that younger females may reproduce at a faster rate than older ones: this is observed in other cetacean species.

It was considered that improving the estimate of reproductive rate, or calculating age-specific rates of reproduction, will be difficult. Although a method of ageing narwhal has become available (see 5.2.1), it is not possible to determine the number of pregnancies a female narwhal has had by examination of

the reproductive tract, because of the production of accessory *corpora* and resorption of *corpora albicans*. The JWG considered the idea of determining the proportion of females accompanied by calves in aerial photographs, but concluded that this was not feasible because it is often difficult to determine the sex of narwhal from aerial photographs, and because calves are often very difficult to spot. Another possibility is through repeated observations of known individuals, identified through external markings or genetics. In this way individual females could be followed throughout their lives to determine their reproductive output. However, given the large numbers of narwhal in most areas and the lack of readily identifiable external markings, it is likely that a very large sampling effort would be required to achieve this.

While recognizing that the question of the reproductive rates of narwhal and beluga is important, the JWG emphasized that the assessment models that have been developed and used are not very sensitive to changes in the reproductive rate. A wide range of rates of increase are commonly used in these models. In all cases better information on stock structure, abundance and catch history is of far greater importance than a precise estimate of reproductive rate.

5.3 Catch statistics

JWG-2005-6. Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in Greenland 1862 to 2005: A preliminary compilation.

Information and statistics including some trade statistics on catches of narwhals in West 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 with catches split into hunting grounds and corrected for under-reporting estimated from purchases of mattak (*low option*), for periods without catch records (*medium option*) and from rates of killed and lost (K/L) whales (*high option*). This reveals a time series of somewhat realistic catch levels from 1862 through 2004. Since 1993 catches have declined in West Greenland especially in Uummannaq where the decline is significant. In East Greenland there has been an increase of 8% per year since 1993.

Discussion

There was a discussion on the correction factors used for struck and lost and they were considered appropriate. The correction for underreporting and stuck and lost adds an average of 42% to the harvest statistics for 1954-1998.

Sex ratio is available for some of the years and there is no apparent bias. It is believed that there has been no bias toward males as females also have a high monetary value because of meat/maktak sale.

A new narwhal harvest-monitoring system has been in place since 2004. Information on the date and location of harvest and the sex of harvested animals is collected under this system. Since 2004, it has been forbidden to hunt females accompanied by a calf; this may lead to a bias toward males in the sex ratio as was observed in 2004.

According to the catch statistics provided, there has been an increase in narwhal catches in East Greenland of 8% per year since 1993. The harvest reporting system changed in 1993 and the impacts of this change on the catch statistics are unknown. There should be a better analysis of the reason for this apparent increase in harvest.

JWG-2005-9. Romberg, S. and Richard, P. Seasonal distribution and sex ratio of narwhal catches in Baffin region of Nunavut territory, Canada.

The distribution of seasonal catches and sex ratio of narwhals in the Baffin region of Nunavut Territory, Canada, was studied using hunter tag information archived at the Department of Fisheries and Oceans (DFO) from 1990 to 2004. Histograms of catches by calendar date and a breakdown of

catches pre-calendar day 205, between calendar days 205 (roughly floe edge season) and 274 (roughly summer open water season) and post calendar day 274 (later than 30 September) are given to estimate the proportion of animals taken during these periods. The results indicate that, in many communities, there is more than one season of hunting. Many communities hunt mostly in summer but several communities take a substantial proportion of their catch in spring or autumn. These results are used in allocating the catch to different putative sub-stocks, either local summering sub-stocks or spring or autumn migrating sub-stocks. The distribution of catch by sex shows that the majority of the communities take a greater proportion of males than females throughout the seasons.

Discussion
Underreporting of female in catch statistics may have happened in the past, when harvest was recorded under a different reporting system. However, the authors are confident that the present reporting system is working well.

In Canada, regulations forbid the harvest of female accompanied of a calf. This, as well as the high monetary value of the tusk, leads to bias towards males in the sex ratio of the harvest.

Fisheries officers and biologists carry out hunt observation in various communities each year. However, there is no observer program in place to provide consistent hunt observation or to verify information on struck-and-lost.

JWG-2005-10. Romberg. S. Catch Statistics (1996-2004) for narwhal and beluga in selected communities in the eastern Canadian arctic.

Catch statistics for narwhal in Canadian High Arctic region (Nunavut) for the period 1996-2004 are presented. In general, it is believed that the catch reports are accurate as a tag system is in place. Communities receive a specific number of tags and hunters are required to fill in specific information on the catch, report the sex of the animal, and attach a portion of the tag to the tusk when present. The other portion of the tag is returned to DFO which records the information. For communities participating in Community-Based Management, there is the possibility to transfer up to 50% of the annual harvest limit to the following year or to "borrow" up to 15% from the following year's harvest limit.

Igloolik and Hall Beach have been included however it is not clear on what proportion of narwhals are taken from the Somerset Island s and Northern Hudson Bay stocks.

The average reported landed catch for the period is 373 which does not include Igloolik and Hall Beach.

Struck and lost includes the two categories 'killed and lost' and 'wounded and escaped'.

In the communities which are part of a Community-Based Management program, total hunting mortality is reported. The struck and lost information is based on self-reported data by the hunters. Systems of reporting vary from community to community. In general, hunters are required to report animals that are wounded (wounded and escaped) and animals that have been killed but not retrieved (sunk and lost). Estimates of hunting mortality are calculated based on minima and maxima (min = landed + killed and lost; max = landed + killed and lost + wounded and escaped). Not all wounds result in latent mortality. Many hunting wounds are superficial and heal leaving the scars that are sometimes observed on narwhals. In some cases hunters report scars and whether animals that they have wounded are likely to survive or not.

Discussion:

There was discussion on the variation of the struck and lost rate between years within some communities. There is a need for a more consistent monitoring of struck and lost to provide better information on total removal due to hunting.

There is conflicting information on the lost rate in the narwhal hunts. While the data provided in document JWG-2005-10 indicate a somewhat low level of struck and lost in most communities and years, some anecdotal information suggests that higher loss rates are possible. To address this, and to improve our knowledge on total removal at various hunting sites and using various hunting methods, the JWG recommended the development of a program to collect struck and lost information from direct observation of hunts in Greenland and Canada. This may also assist in improving hunting techniques and efficiency and minimizing hunting losses.

NAMMCO informed the group that it will be holding a workshop on struck and lost in November 2006. The workshop will include participation from hunters, scientists and managers.

5.4 Abundance

5.4.1 Recent estimates

JWG-2005-5. Heide-Jørgensen, M.P. An attempt to survey narwhals and belugas in West Greenland March 2004.

A digital aerial photographic survey for belugas and narwhals was attempted in West Greenland during 19-30 March 2004. The survey aircraft was a twin engine Piper Aztec equipped with two Hasselblad cameras with digital databacks (Phase One) that downloaded images every 3rd second to onboard hard disks together with information on altitude, speed and position. Due to inclement weather with constant wind and/or fog the survey effort proved to be very low with only an insignificant proportion of the total area being covered. The survey was designed to cover the traditional strata used for estimating the winter abundance of belugas in West Greenland. Following advice from the hunters organisation, KNAPK, the survey was extended to cover Vaigat as well as the ofshore parts of Uummannaq. This extension, that was conducted under favorable conditions, did not reveal any observations of whales. However, on the 20 March pods of up to 25 belugas were seen in the northern part of Vaigat where it is known that some belugas winter. No other sightings of belugas or narwhals were made during the survey but one bowhead whale was seen on 18 March outside Ilulissat and prior to the beginning of the survey. Unusual light ice conditions were experienced in West Greenland during spring 2004. The low ice coverage created relatively unstable weather conditions with more wind (average 5.4 m/s) than usually encountered at this time of the year (<3 m/s). The wind over the wide open water fields made it impossible to complete the survey.

Discussion

Although weather often makes it difficult to complete a spring survey in West Greenland waters, the JWG reiterated its recommendation of the previous two meetings that a survey of west Greenland beluga should be conducted. It is planned to conduct a survey in March 2006.

JWG-2005-17. Heide-Jørgensen, M.P., K.L. Laidre and M.J. Simon. Video recordings of narwhal pods in the Melville Bay, northwest Greenland, 2004-2005

Digital aerial photographic surveys of Melville Bay in 2002 resulted in no sightings of whales despite 990 km of transect effort covered resulting 4.558 km^2 digital images. Hunters utilizing the Melville Bay for hunting were not satisfied with the recommendation for a zero catch quota so they proposed to make video recordings of some of the large pods that they frequently encounter in the Melville Bay to demonstrate the occurrence and perhaps numbers of whales in the area. This study reports on the results of hunter-based video recordings of narwhal pods in Melville Bay in August 2004 and 2005. Recordings of narwhal pods were collected on two days in 2004: the 21 and 23 August. On 21 August, 141 whales were estimated to be swimming to the right of the promontory and 34 were estimated to be swimming to the left. Since it is possible that the same whales were recorded on both

days the highest minimum count from 21 August is the safest estimate of the minimum number of whales recorded in 2004. In 2005, video recordings were made between 2 - 15 August at Balgoni Islands in central Melville Bay. The largest number of whales was observed on the 12 August where 147 whales were counted from which 35 should be subtracted to account for possible double observations. The achieved number of 112 whales is in the same magnitude as the number from 2004. There are evidently narwhals consistently present in Melville Bay during summer, which is also obvious from the catch statistics. However the low number of narwhals spread over a very large area makes traditional surveys prohibitively expensive and generally unsuccessful.

Discussion
This study confirms that narwhal occur in some numbers in Melville Bay during the summer. Neither survey effort nor coverage could be estimated based on the results presented in this study. The height of the observer can significantly affect detectability, but the height from which each video recording was made was not indicated. For these reasons these results cannot be expanded into an estimate of density. Only a minimum estimate of the numbers seen in the video can be determined.

There is no intention to repeat this study.

JWG-2005-04. Richard, P., Laake, J.L., N. Asselin, and H. Cleator. Baffin Bay narwhal population distribution and numbers: aerial surveys in the Canadian high arctic, 2002-2004.

Narwhals were surveyed in Eclipse Sound, Admiralty Inlet, Prince Regent Inlet, Barrow Strait, Gulf of Boothia, and in fiords and bays along the eastern coast of Baffin island during the month of August of 2002 to 2004 with visual line transect aerial surveys. The visual survey estimates were based on the number of narwhals visible to the observers using systematic line transect methods, corrected for whales that were missed by the observers, and adjusted to account for observations without distance measurements. Using data from narwhals tagged with time-depth recorders, the estimates were further adjusted for individuals that were diving when the survey plane flew by. This correction gave estimates of 20,788 (SE: 24,132) for the Eclipse Sound area in 2002 and 18,733 (SE 6,437) in 2004 , 25,809 (SE: 14,972) for the sum of the Prince Regent and Gulf of Boothia strata in 2002 and 28,346 (SE: 15,015) for that number added to the Barrow Strait strata in 2004, and 14,957 (SE: 6,437) in the east Baffin Island bay stratum in 2003. The estimates from Admiralty Inlet should be considered biased due to extreme clumping of the animals off transects in both 2003 and 2004 and the poor weather conditions in 2004, which halted the survey of southern end of the Inlet. Considering the bias in the Admiralty Inlet survey and the lack of survey in known areas of occupation, such as Peel Sound, Viscount Melville Sound and channels north of Resolute, we conclude that the narwhal population in the Canadian High Arctic is very large. It probably numbers in excess of 70,000 animals, with a large proportion of the animals in the western end of its summer range. It is also probable that over ten thousand narwhals summer in the bays and fiords along the previously un-surveyed East Baffin coastline. Survey estimates had large standard errors due to clumping on certain transects within each stratum. Attempts to reduce the sampling error by stratifying new surveys and increasing survey coverage were successful in the 2004 Eclipse Sound survey but not in the 2004 Admiralty Inlet survey. More dive data is required to refine the availability correction factor used in expanding the surface estimates.

Discussion:
Preliminary results of these aerial surveys were presented at the last JWG meeting in February 2004 and several recommendations to improve the analysis were made (see 2004 JWG report). The JWG noted that some of the recommendations provided in the 2004 meeting were not addressed due to logistical constraints.

The clumped distribution of narwhal and the unexpected high abundance of narwhal in eastern Baffin fiords were problems for the survey design and subsequent analyses.

Several areas known to contain narwhal (Peel Sound, Viscount Melville Sound, channels north of Resolute and east Baffin coastline) were not surveyed due to weather conditions so this survey could not provide a complete abundance estimate of the entire summer range in Canada.

The analysis of the survey data from fiord areas (most of which were at least 2000 meters wide) was discussed at length. In this part of the survey, a single line was flown up the centre of each fiord due to constraints of flying in the fiord environment, with the results extrapolated to the entire area of the fjord. This survey design resulted in uneven coverage probability; not all areas in a fiord had the same probability of being surveyed, possibly causing a bias depending on how the whales are distributed in the fiord. It was agreed that a sub-committee, coordinated by the lead author, would meet by email to try to resolve this issue.

There was some discussion as to the appropriateness of the application of an instantaneous correction for diving whales to a sighting process that is not instantaneous. It was argued that the duration of the chance of seeing a narwhal at the surface is very short such that it might be considered nearly instantaneous, especially for high-density areas where observers are busy with declination measurements. The surface intervals (or rather, the time at depths where they could be detected by an aerial survey crew) for some narwhals have been measured as 2-3 minutes for tagged individuals, but the actual time available to see a whale from a Twin Otter may be less than 3 seconds.

A separate issue is how widely the limitied tag data can be extrapolated. The surface interval used is based on a limited number of tagged narwhal and may not apply to all narwhal in all areas. The JWG agreed that the correction was appropriate given the available data on narwhal diving behaviour, but recommended that more such data be collected.

The serial difference method of variance estimation was suggested in 2004 but results to date have not indicated an improvement using this approach.

In 2004 it was recommended that the criteria for assigning duplicate sightings should be clarified and this recommendation was reiterated.

Although the paper combined the “best” estimates from different areas and years into single estimates, this approach could confound variance estimation (the true variance is likely larger than estimated). In addition the JWG suggested providing a more detailed description of what is defined as “best”.

There were extensive discussions of how to address large groups observed off-transect such as the large groups observed in Admiralty Inlet during the survey. While there was disagreement on this issue, it was decided not to include these sightings in the Admiralty Inlet survey estimate because they were seen off-transect. Other approaches, including adaptive sampling, greater survey effort or changes in stratification, were suggested for future surveys.

Reconnaissance survey in Davis Strait/Baffin Bay
Gosselin presented the preliminary results of an aerial survey conducted in March 2005 of the area from 60° to 65° N to search for the hooded seal whelping patch. The survey was conducted at an altitude of 300 ft and a speed of 200 kts, which is lower and faster than is normal for cetacean surveys. While the target species were seals, observers also noted marine mammals in open water. A total of 55 narwhal were sighted and 1 beluga whale was sighted at the southern end of the area.

5.4.2 Estimates by management units
Abundance estimates that have been accepted for use in assessments by the JWG are presented in Table 1.

5.4.3 Recent changes in distribution in Canada

In 2004 the JCNB was informed that recent changes have been observed in the distribution of narwhal in Canada. For instance in Pelly Bay, hundreds of narwhal now regularly occur where they seldom occurred in the past. The JCNB therefore requested that the JWG look into this matter.

There was no document presented on this topic to the JWG. It was reported that lighter ice conditions had prevailed in this area in recent years, although no quantitative data were presented. It is therefore possible that narwhal are able to penetrate into areas that were not usually available to them previously because of heavier ice cover. The JWG was also informed that narwhal sometimes use the track of an icebreaker to enter the area and that icebreakers began coming to Pelly Bay quite recently. In addition, local people have reported an increased frequency of killer whale sightings in the area, which might also change the distribution of narwhal.

The JWG could not provide any firm explanation as to why more narwhal are coming to this and other areas where previously they were seen infrequently. As a first step to addressing this question, trends in the extent and duration of ice cover in the area should be quantified. These data should be available from satellite and aerial ice reconnaissance. It was also suggested that the use by narwhal of icebreaker tracks should be studied and that the frequency of sightings of killer whales should be monitored.

5.4.4 Future survey plans
It is planned to conduct a narwhal survey in West Greenland in March 2006 .Currently, there are no plans for narwhal surveys in Canadian areas.

5.5 Assessment

5.5.1 Update of West Greenland assessment
JWG-2005-15 Witting, L. A model selection based assessment for West Greenland narwhals with uncertain stock structure.

This paper uses a density regulated population dynamic model in a model selection framework to identify the more likely stock structure hypotheses for West Greenland narwhals. The framework performs Bayesian assessments on 28 of the most likely three, two and one stock hypotheses, and it uses Akaike weights to determine the relative probabilities of the different models, given four time series of abundance data and historical catches from 1862 to 2004. The analysis discards 12 of the original hypotheses as being unlikely, it agrees with other information on the most likely stock structure hypotheses, and it integrates the 16 most likely hypotheses into estimates of sustainable harvest levels.

Discussion
There was disagreement within the JWG about the appropriateness of using apparent stock dynamics as a method of selection between stock hypotheses. One view was that stock identification should be by means independent of the stock dynamics. Harvest history and abundance may be correlated in 2 areas for indirect reasons, for example the economic situation in West Greenland, that have nothing to do with the relatedness of the animals in the 2 areas. Therefore using stock dynamics as a means of assigning probabilities to stock structures could be erroneous because of spurious correlations. Another view held that, given a set of stock hypotheses, it was only reasonable to give greatest weight to those that provided the best fit to the catch and abundance/trend information at hand, unless there was other information that made them unlikely. However it was recognized that this disagreement did not preclude the JWG from itself reaching conclusions about the most likely stock structures in the area and selecting assessment models appropriately.

The models presented in JWG-15 used, as input, the data on abundance, catch history, and biological parameters that have been agreed in the past by this committee. Nevertheless there was concern about possible biases in some of the input data, particularly abundance estimates and indices. For Inglefield Bredning, the 1986 and 2001/2 estimates were produced using different survey methodologies that

have not been directly calibrated against one another. There was concern that this might have influenced the apparent negative trend in the estimates between 1986 and 2001/2. The JWG therefore recommended modelling that incorporated only the later surveys and options that considered them as index rather than absolute estimates.

For Disko Bay, the index surveys conducted in the early 1980's were done by a somewhat different methodology than those done in the 1990's and it has been recognized by this Committee that, for beluga, the two sets require different treatment. Specifically, different bias correction factors were used in beluga modelling for the two index sets. There is no reason to suppose that the situation should be different for narwhal, but in the modelling reported in JWG-15 a single bias correction factor was used for all the index surveys. The JWG therefore recommended modelling that incorporated separate bias correction factors for surveys conducted in the 1980's and 1990's.

While past harvesting of narwhal in West Greenland has not been sex-selective, it was expected that the new regulatory structure will lead to a selection for male narwhal. The JWG therefore recommended that the sensitivity of the results to selection for males be examined.

The greatest difficulty in providing advice for sustainable harvest of West Greenland narwhal is the uncertainty in stock structure. The models using the stock structures considered most likely by the JWG were examined further. A probability of 70% of some stock increase within 5 years was considered an appropriate objective. To meet this objective, depending on the model, a total annual removal ranging from 15 to 75 narwhals is allowed for the entire area This strengthens the conclusion reached in 2004, that West Greenland narwhal are heavily depleted and substantial reductions in catch are required immediately to arrest the decline in numbers However the JWG could not agree on the quantitative results of the model presented in JWG-15 because of the above noted uncertainties in stock structure and input parameters. There was no general agreement within the JWG on which model scenarios should be used in a final assessment. However, the JWG agreed that the recommendation provided in 2004, that the total removal in West Greenland should be reduced to no more than 135 individuals, should be provided again and with greater emphasis. This greater emphasis is due to the fact that all models reviewed by the JWG allowed total annual removals lower than 135.

The JWG recognized that the new information presented in JWG-17 confirmed that narwhal do occur in Melville Bay, but without an abundance estimate the JWG was unable to recommend a sustainable removal level for this stock.

The JWG recommends the following research to provide more specific advice on sustainable catches:

1) Modeling:
The model described in JWG 15 should be revised and used with the M|IUD as the base case and M|IU|D, M|I|UD, and M|I|U|D as alternate cases. MSYR will be limited to a range of 0.01 to 0.04, and survey data from Inglefield Bredning should be included as index estimates when combined with harvest data from other areas. As the 1986 estimate for Inglefield Bredning may not be directly comparable with the later estimates, it should be included with a doubling of the CV or excluded from the runs. Also for the survey estimates from Disko Bay, the effect of treating the 1982 and 1981 estimates as a separate index series independent of the earlier estimates (as done for beluga) should be investigated. Trials should also be conducted with pseudo-data sets to determine to what degree the model can identify the true stock structure. Alternate runs could be conducted to determine to what extent new data or independent biological data will improve the performance. These runs should include testing for the existence of an unidentified stock contributing to the harvest at one or more locations, new survey and tagging data and sex ratios in the harvest other than 50:50. (Time frame:1 year)
2) Stock Structure:

a. Reanalysis of existing genetics and contaminants data from harvested samples to account for season of take. (Time frame: 1 year)
b. Satellite tracking from harvest areas beginning with Uummannaq and Inglefield Bredning. (Time frame: 2-5 years)
c. Satellite tracking from areas in northern Canada (East Baffin, Smith Sound, Jones Sound, Kane Basin, Parry Islands) that are poorly known and may contribute to these harvests.

3) Abundance Estimates:

New surveys to extend the current abundance time series and estimate abundance in areas with no distribution or abundance surveys (E. Baffin, Parry Islands, Smith Sound, Jones Sound, Kane Basin). Priorities are a beluga/narwhal survey in Disko Bay and a survey of Melville Bay/ Inglefield Bredning. (Time frame: 2-10 years)

5.5.2 Canadian summer stocks

JWG-2005-11 Richard, P. A risk analysis of narwhal hunting in the Canadian High Arctic.

A simple stochastic dynamic growth model was used to determine the risk of change (-5% and -10%) over a period of ten years. The model runs either assumed no stock structure, a single panmictic stock, or a metapopulation structure with 4 different sub-stocks (Somerset, Admiralty, Eclipse, East Baffin). The structured model runs consider the summer hunting on local sub-stocks and the hunting of these sub-stocks by all communities during migration to or from the wintering areas. Results indicate little or no risk of decline over the time span in all but one case, the Admiralty Inlet sub-stock. The model runs pertaining to the Admiralty Inlet sub-stock assume a population size based on surveys which are considered biased because of extreme clumping of narwhals in the area. Therefore the risk analysis results for this sub-stock are questionable. Finally, risk probabilities are based on a simple model with no density dependent effects. It is conceivable that the decline of a large population will trigger increased productivity and that the real risk is smaller than estimated here.

Discussion

The JWG welcomed this contribution as an important first step in the quantitative assessment of Canadian summering stocks of narwhal.

The range of rates of increase from 1.01 to 1.03 did not include the maximum rate that is likely for narwhal. However the JWG agreed with the author of JWG-11 that this was appropriate given that the relative depletion status of these stocks was unknown, and only stocks that are at or below the maximum sustainable yield level could be expected to exhibit a higher rate of increase. The effect of a higher rate of increase would be to decrease the probability of a stock decline, so in this sense the model is conservative.

The mean loss rates used to estimate total removals were themselves estimated using recent data collected under the Community Based Management system in Canada. However the JWG had already expressed concern that these data may not be reliable and might underestimate true loss rates (see 5.3.1).

For communities taking narwhal in the spring and the fall, the catch may be composed of a mixture of animals from 2 or more summer stocks. In the model it is assumed that the relative proportion of animals from each stock in the catch is proportional to the abundance of each stock. It was considered that, for spring hunts in particular, animals from stocks that summer near to the spring hunting location might be taken in a higher proportion than that of their relative abundance. This was considered especially important for Arctic Bay, for which the spring catch constitutes over half the total.

Given these concerns, it was considered that the model could be improved by including a wider range of some parameters in sensitivity analyses. Specifically the JWG requested that that the following sensitivity analyses be conducted:

i. Higher struck and lost rates, of up to 2x those used initially;
This sensitivity analysis was performed at the meeting. The effect of doubling the loss rate was to increase the probability of a decline at Admiralty Inlet but not substantially so at Eclipse Sound except under the lowest examined rate of population increase.
ii. Higher probability that Admiralty Inlet narwhal are taken at the Arctic Bay ice edge.
There was insufficient time to perform this sensitivity analysis, but it could be expected to result in an increased probability of a decline at Admiralty Inlet.

The model used only recent average catches to project hunting mortality in the future. As yet an historical analysis of Canadian narwhal catches has not been developed, but published figures are available as far back as 1979. In 2004 the JWG concluded that it would be feasible to develop a set of annual removal estimates (*e.g.* low, best, high) for the Canadian Arctic, based on what is presently available in the literature, and it was recommended that the possibility of a longer catch series, spanning at least the time period of the survey estimates, be investigated.

The model incorporated only recent abundance estimates and did not use earlier estimates from Admiralty Inlet and Eclipse Sound from 1984. For Admiralty Inlet, the estimate for 1984 was nearly 3 times that for 2003 although the difference in point estimates is not statistically significant. In contrast the estimate for Eclipse Sound for 1984 was significantly lower than that for 2004.

The JWG therefore recommended that a model incorporating all abundance estimates considered useable for assessment, with an historical catch series, be developed, as has been done for West Greenland beluga and narwhal. Such a model would show the trajectories of the stocks over time and provide estimates of yield that would be useful in assessing stock status and determining sustainable removal levels.

In the interim and until a new modelling framework is developed, the JWG decided to use the model provided in JWG-11 to arrive at some preliminary conclusions about the status of Canadian summer stocks.

Somerset Island
This stock is the largest of the Canadian summer stocks. It is subject to a low level of harvesting in the summer but may be hunted by several communities in the spring and fall. However, even under the most pessimistic scenarios of stock size, hunting loss rates, and rate of increase, there is a negligible chance that the stock will be depleted in the next 10 years. The JWG therefore concluded that present catch levels were sustainable for this stock.

Admiralty Inlet
Under scenarios of high loss rate and/or low rate of population increase, the model predicts that there is a high probability that this stock will decline in the next 10 years. In addition the survey estimate for 2003 is substantially lower than that for 1984, indicating that there may have been a population decline over that period. However it was recognized that the recent estimate may be biased because of the extreme clumping of narwhal in the area. The JWG concluded that there is a risk that present catch levels are not sustainable for this stock and recommended thata new modelling framework as described above be developed to provide estimates of sustainable removals.

Eclipse Sound
Under all but the most pessimistic scenarios of high loss rates combined with low rates of increase, the model indicated that there is a very low risk that this stock will decline in the next 10 years with present catch levels. The JWG therefore concluded that present catch levels were likely sustainable for this stock but, again, recommended that a new modelling framework as described above be developed to provide estimates of sustainable removals.

East Baffin

Because the abundance estimate for this area was not accepted (see 5.4), the JWG could not provide advice on the sustainability of catch levels in this area. It was also noted that there was no information about the seasonal distribution of this stock so it was not known if it was subject to harvesting outside of the East Baffin area. The JWG therefore recommended that a new abundance estimate be developed for this area and that studies be conducted to determine the seasonal distribution of this stock.

5.5.3 East Greenland

The JWG considered that, given that almost nothing is known about the stock structure and seasonal migrations of East Greenland narwhal (see 5.1.4), and that the abundance estimate for Scoresbysund is more than 20 years old, a reliable assessment will not be possible without new information. Nevertheless *ad hoc* modelling carried out at the meeting indicated that, under the assumption of an independent stock at Scoresbysund with a present abundance similar to that in 1983, present harvest levels are not sustainable. However the validity of these assumptions cannot be assessed without further research.

Insufficient information was available to carry out assessments for other areas of East Greenland.

5.6 Ecology

JWG-2005-13: Laidre, K.L. and Heide-Jørgensen, M.P. The behavior of narwhals (*Monodon monoceros*) before, during, and after an attack by killer whales (*Orcinus orca*) in the Eastern Canadian Arctic

On the 19 and 20 of August, 2005 a predation event by killer whales on narwhals was witnessed at Kakiak Point, in Admiralty Inlet, Canada. Approximately 12-15 killer whales (group structure consisted of one adult male, 7-10 adult females and rest were juveniles) were observed attacking narwhals approximately 0.3 - 1 nm off the coast of Kakiak Point. Two explicit attacks were documented on the same day, one occurred at approximately 12 noon and the second occurred at approximately 4 pm. At least 4 narwhals (or 4 independent kill events) occurred over a 6 hour period based on direct counts of observations of oil/blubber slicks at the surface, congregations of fulmars in the center of the slicks, and killer whales moving and diving in the center of oiled areas. When the killer whales entered the vicinity of Kakiak Point, the narwhals were observed to immediately move very close to the coast (<2-3 m). Some narwhals formed tight groups near the shore and lay very still at the surface. One whale was observed to strand itself on a flat gravel beach and violently thrash it tail for >30 seconds. Within hours after the attack, narwhals were observed to resume their pre-attack behavior and distance from the shoreline, and narwhals were no longer observed in extreme proximity to the coast. Narwhals instrumented with satellite tags moved offshore and utilized a wider section of the coastline after the attack. Whether this dispersal is an effect of the killer whale occurrence or a seasonal change in behavior remains unresolved.

5.7 Future research requirements

Research recommendations specific to refining assessments for West Greenland narwhal are listed under 5.5.1.

The JWG supported and reiterated the recommendations from previous meetings. The following were identified as most important at this meeting:

All areas

- Better estimates of struck and loss rates are required from all areas.
- There should be a coordinated effort between Canada and Greenland to collect samples from the catch and from animals of known age, and to conduct analyses to determine the age structure of narwhal stocks using the amino acid racemization technique.
- large-scale effort to obtain dive time data for survey correction, from different areas and seasons;

West Greenland

- The West Greenland index area should be surveyed in 2006 in a manner consistent with previous surveys. If a new survey methodology is used, experiments should be conducted to calibrate the new method with the old.
- Development of a monitoring plan, including survey intervals;
- Stock structure: investigate movements from Inglefield Bredning, Uummannaq and from the wintering grounds.

Canada

- Provide a revised abundance estimate for East Baffin narwhal.
- Conduct a new survey of Admiralty Inlet.
- Develop a longer catch series (at least a series that spans the time period of the survey estimates) incorporating options for high, low and medium catches as has been done for West Greenland.
- Develop assessment models for the next meeting for each stock component, incorporating the catch series (above) and all abundance estimates for each area that have been accepted for use in assessment by this committee (Table 1).
- Provide an abundance estimate from winter surveys in Cumberland Sound.

East Greenland

- Studies of the stock structure of narwhal, through satellite tagging, genetics, contaminants or other means;
- Determination of the seasonal distribution of narwhal, through satellite tagging;
- Abundance surveys for all summer stocks that are harvested;

6 BELUGA

6.1 Stock structure

There was no new information tabled on this subject.

6.2 Recent catch statistics

Greenland

WG-2005-07 Heide-Jørgensen, M.P. Catch statistics for belugas in Greenland 1862 to 2004.

Information and statistics including trade statistics on catches of white whales or belugas in West Greenland since 1862 are presented. 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 5 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 2% per year during 1979-2004. Reported catches in East Greenland are suspected to be erroneous and should perhaps be added to the narwhal catches.

Discussion

It was noted that the harvest in 2004 had been very low because of the introduction of the quota system and bad weather in some areas.

The JWG recommended that the occurrence of beluga in East Greenland be investigated, perhaps through a traditional knowledge study, to determine if they do occur there or if the reported harvests are erroneous.

Canada

JWG-2005-10: Romberg, S. Catch Statistics (1996-2004) for Narwhal and Beluga in Selected Communities in the Eastern Canadian Arctic.

Catch statistics for beluga in Nunavut for the period 1996-2004 are presented. In general it is believed that the reports for beluga are accurate. The Hunters and Trappers Organizations (HTO) for each community are contacted by phone by DFO throughout the hunting season and are asked to report catch statistics. In some cases the HTO requires their hunters to report and in other cases the HTO will give an estimate of hunting that has occurred.

In some communities which are part of a Community-Based Management Program, hunting mortality is required to be reported. Systems of reporting vary from community to community but in general they are required to report animals that are wounded (wounded and escaped) and animals that have been killed but not retrieved (sunk and lost). Estimates of hunting mortality are calculated based as minima and maxima (min = landed + wounded and escaped; max = landed + sunk and lost + wounded and escaped).

The average reported landed catch from communities hunting from the Baffin Bay beluga stock for the period is 42.

Discussion

The JWG noted that, as in the case for narwhal, reporting of struck and lost is variable between years and communities and may be unreliable for some communities. It was recommended that the harvest figures in this compilation be compared to the figures from the Nunavut Wildlife Harvest Study, which examined the period 1996-2001.

6.3 Abundance

6.3.1 Recent and future estimates

West Greenland

JWG-5 described an attempt to survey the West Greenland index area in March 2004, which was not successful due to inclement weather (see 5.4.1). The survey will likely be attempted again in 2006. The JWG noted that a digital photographic survey was attempted, whereas all previous surveys have been visual. The index used to monitor trends abundance since 1982 is based on a visual strip transect, and could not be produced from a photographic survey. The JWG therefore recommended that either a visual survey be conducted, or that experiments be conducted to calibrate the two survey methodologies.

Canada

In 2004 the JWG recommended that the abundance of beluga be estimated from the survey carried out between 2002 and 2004 described in JWG-4 (see 5.4.1). However it was recognized that because the survey did not cover Peel Sound, where beluga are concentrated at this time of year, and did not cover estuaries used by beluga, it could not provide an estimate of abundance for beluga.

6.4 Assessment update

6.4.1 West Greenland

JWG-2005-14 Witting, L. An assessment for West Greenland beluga.

This study combined historical catches from 1862 and 3 time series of abundance estimates with density regulated population models to update the assessments for belugas in West Greenland. Given models and data, the population was projected under the influence of historical catches, to estimate the current status and the probabilities of fulfilling management objectives for different levels of

future harvest. Seven model combinations were applied to test for sensitivity of the assessment to i) variation in the prior on the MSYR, ii) the presence versus absence of additional variance in abundance estimates, iii) the presence versus absence of an absolute abundance estimate, iv) high versus low catch histories, and v) the effects of choosing an age-structured or a discrete population dynamic model. All models estimate similar dynamics, where West Greenland beluga are severely depleted, with median depletion ratios in 2005 varying between 16 and 42 percent of the carrying capacity. The median of the current replacement yield was estimated to lie between 248 and 494 beluga, with the lower 2.5th percentile between 40 and 104 beluga.

Discussion
The new assessment produced results that are very similar to those from previous assessments, all of which indicate that the stock is substantially depleted.

The JWG considered that the "low MSYR" case provided the most realistic assessment based on presently available information on the rates of increase of beluga and other odontocetes. The assessment can be updated if new information on rates of increase or other parameters is provided. Table 2 provides the probability of halting the decline in beluga numbers in the next 5 years for a range of catch options for this case. Reduction of catches to 100 per year will have an 80% chance of meeting this objective by 2010. Maintaining higher catches reduces the probability of halting the decline, and delay in implementing harvest reductions will increase the risk of continued stock decline.

The JWG also reiterated recommendations made by the NAMMCO Working Group in 2000 (NAMMCO 2001) pertaining to other measures that would improve the conservation status of beluga in this area.

It was recommended that catch limits be distributed over 3 hunting areas to avoid possible local depletions, as per previous advice (NAMMCO 2001): Northern – N of 72° N; Central – 67.30° to 72° N; Southern - 65° to 67.30° N.

Seasonal Closures
Beluga occurred seasonally in large numbers in Southwest and South Greenland before 1930, and probably disappeared because of overharvesting (JWG-7). Beluga are however occasionally sighted during the summer in S and SW Greenland and other areas of West Greenland. Few beluga are normally caught during these periods, and the occasional stragglers seen at these times should be allowed to establish themselves. The following seasonal closures are recommended:
Northern: June through August
Central: June through October
Southern: May through October.
For the area south of 65° N, it is recommended that no harvesting of beluga be allowed at any time.

6.4.2 Other stocks

Canada
Reported harvests by communities hunting Baffin Bay beluga continue to be low, averaging 42 annually over the last 9 years (see JWG-10, section 6.2). Given that this harvest is very low relative to the summer abundance of beluga in the area (Innes *et al.* 2002), stock assessment in this area is not considered a priority at present. However some proportion of animals summering in Canada migrate to West Greenland and are at risk of harvest there. It was considered important to determine where in Canada these animals can be found in the summer, to determine if they are harvested in Canada.

6.5 Future research requirements

All stocks
- Better estimates of struck and lost rates are required from all areas.

- There should be a coordinated effort between Canada and Greenland to collect samples from the catch and from animals of known age and compare racemization age estimates to tooth layer age estimates.

In 2001 the JWG supported a proposal for a new effort to elucidate the origin of the large number of whales presently being harvested in West Greenland. It was proposed that a two-year field period should be launched to tag a large number of belugas and to track them through the winter. Areas that have not previously been sampled would be given priority and samples for genetic analyses would be taken as well. The results of the tracking will be used to develop a model for the dispersal of the belugas that can be tested by the genetic studies. If possible long-term tag attachments and/or passive tags should be used to find out whether individual animals use the same summer and winter areas repeatedly. The JWG reiterated its support for this proposal and recommended that the research be carried out as a high priority.

West Greenland

- The West Greenland index area should be surveyed in 2006 in a manner consistent with previous surveys. If a new survey methodology is used, experiments should be conducted to calibrate the new method with the old.
- The assessment of West Greenland beluga should be updated once a new abundance estimate has been produced.
- Determine if beluga occur in East Greenland, perhaps through a traditional knowledge study, and attempt to determine if reports of beluga harvest there are correct.

Canada

- Harvest records from DFO should be compared with those from the Nunavut Wildlife Harvest Study.

7. IMPLEMENTATION OF EARLIER ADVICE

On February 12, 2004, Greenland Ministry of Fisheries and Wildlife introduced quotas for narwhal and beluga for the season 1 July 2004 to 30 June 2005. The quotas were set at 300 narwhal and 320 beluga to be divided among municipalities of West Greenland (Table 3). Preliminary catches of beluga reported for the 2004-2005 season were lower than the established quota due to weather conditions. The 2004-2005 narwhal catches had a skewed sex ratio favouring males.

For the hunting season 1 July 2005 to 30 June 2006, the quotas have been established at 260[2] narwhal and 220 beluga, to be divided among the municipalities of West Greenland.

It was noted that the reported catches include whales that are struck and lost. The reporting of catches to management authorities in Greenland is functioning well.

There was a discussion on the management system in place in Canada and Greenland to monitor harvest level and struck and lost animals. There is a need to share information on the reporting system that is in place in Greenland and Canada. This discussion should take place at the JCNB and reported in their proceedings so that there is a better understanding of the reporting system in place in both areas. Information on catches and struck and lost is critical to the assessment of narwhal and beluga.

8. TRADITIONAL KNOWLEDGE

There was no information provided under this item.

9. IMPACT OF HUMAN-MADE NOISE

[2] After the meeting the narwhal quota for 2005/2006 was raised by 50 to a total of 310. See Table 3.

JWG-2005-18: Lawson, J. Overviews: Beluga whale and noise.
Beluga whales have their best hearing sensitivity in the 40-100 KHz frequency range, with poorer hearing at lower and higher frequencies. Natural and man-made noise in the environment has the potential to reduce the probability of detecting biologically relevant signals; this process is termed masking. Beluga whales can detect echolocation signals when they are as little as 1 dB above the level of ambient noise. In studies of ice breaker noise, bubbler noise appeared to be most effective at masking beluga calls, followed by ramming noise, and lastly, ice-cracking noise. Models predicted ice breaker noise would be audible to belugas at distances as great as 35-78 km, cause masking of beluga calls at 14-71 km, and possibly cause temporary changes in hearing sensitivity if belugas stayed within 1-4 km of a large ice breaker for at least 20 minutes. Beluga responses to manmade noise areare highly variable and dependent on a variety of factors which include: local habitat, age, prior experience with the noise, the beluga's activity, resource availability, sound transmission characteristics of the location OR the noise of interest, behavioural state of the whale, and individual variability in beluga behaviour. Reported responses of beluga whales to manmade noise range from the most sensitive reported for any marine mammal to ignoring intentional harassment by boats. Beluga responses include altering their swim direction and speed, changing their dive, surfacing, and respiration patterns, and/or changing their vocalization patterns. There have been few studies of non-auditory physiological effects of exposure to noise in belugas, but several suggest that there are few if any measurable effects.

Discussion
The JWG welcomed this information which addresses a recommendation made in 2001 by JCNB.

10. OTHER BUSINESS

10.1 Implications of the inclusion of other species (*e.g.* walrus) in the work of the SWG

The cooperation between the JCNB SWG and NAMMCO WG has been very productive in providing scientific advice on narwhal and beluga.

The provision of advice on species other than beluga and narwhal from the SWG would be challenging. The addition of other species to this WG would require additional national and external expertise, take more time, may require the SWG to deal with species on a rotational basis or through independent meetings, and may require the establishment of a secretariat to deal with the additional workload.

It was noted that NAMMCO has alreadyworking groups to address issues specific to walrus and other species. Greenland being a member of NAMMCO, already participates in these working groups. Canada could also participate through the Walrus WG. This would avoid duplication of work at the scientific level and the JCNB would obtain its scientific advice through NAMMCO.

An obvious approach would be to carry out scientific activities related to walrus and other marine mammals within the existing NAMMCO structure. Alternatively, scientific advice related to other marine mammals needed by JCNB could be directed to scientists in Canada or Greenland who would examine existing literature or set up the appropriate peer review structure to provide the advice. This however might result in duplication of effort.

11 ADOPTION OF REPORT

A draft version of the Report was adopted at the meeting, and the final version was approved by correspondence. The Chairmen thanked all members for their valuable input, the Greenland Institute of Natural Resources for hosting the meeting, and the hard-working rapporteurs for so ably summarizing the discussions. Noting that Lars Witting and Øystein Wiig would be leaving their posts as chairmen, the members of the JWG thanked them for their efforts over the years.

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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	4000-8000	-	-	-	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)	
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)	
Melville Bay	2002 d)	Photo	-	-	-	Low numbers	
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)	18,733 (0.41)	
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)	5,332 (0.76)	
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)	25,809 (0.58)	Partial coverage
Cumberland Sound	-	-	No data	-	-	-	
Jones Sound	-	-	No data	-	-	-	
Parry Islands	-	-	No data	-	-	-	

Putative stock	Year and ref.	Method	Estimate (cv)	Perception bias	Availability bias	Fully corrected stock size estimate	Reservations
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.
Kangerlussuaq			No data				
Tasiilaq			No data				

Table 1. 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/13-JCNB/SWG/2005-JWG/4

CATCH	PROB	CATCH	PROB
0	0	250	0.42
50	0.96	300	0.32
100	0.81	350	0.26
150	0.68	400	0.19
200	0.55		

Table 2. Probability of halting the decline in West Greenland beluga numbers in the next 5 years for a range of catch options for the chosen assessment model (see .6.4.1).

BELUGA			
Municipality	**Quota 04/05**	**Catch 04/05**	**Quota 05/06**
Maniitsoq	7	7	7
Sisimiut	32	18	23
Kangaatsiaq	12	10	10
Aasiaat	3	1	3
Qasigiannguit	9	0	3
Ilulissat	78	14	54
Qeqertarsuaq	15	12	14
Uummannaq	10	8	8
Upernavik	134	19	88
Qaanaaq	20	2	10
Total	**320**	**91**	**220**
NARWHAL			
Kangaatsiaq	5	0	
Aasiaat	23	21	16
Qeqertarsuaq	21	21	16
Uummannaq	88	78	68
Upernavik-Savissivik	63	46	60 + 15
Qaanaaq-Savissivik	100	128	85
Total	**300**	**294**	**260**

Table 3. Quotas and catches of beluga and narwhal in West Greenland, 2004 to 2006. The quota year runs from July 1 to June 30. Qaanaaq including Savissivik, Melville Bay has a five year quota of 100 beluga and 500 narwhal. [NOTE: Since the meeting these quotas have been raised by 50, with the following distribution: 35 to Uummannaq, 5 to Qeqertarsuaq, 5 to Assiaat, 5 to Kangaatsiaq. The total quota for 2005/2006 will be 310.]

APPENDIX 1

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APPENDIX 2

AGENDA

1 OPENING REMARKS
2 ADOPTION OF JOINT AGENDA
3 APPOINTMENT OF RAPPORTEURS
4 REVIEW OF AVAILABLE DOCUMENTS
5 NARWHALS
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  - *5.1.1 Genetic information*
  - *5.1.2 Satellite tracking*
  - *5.1.3 Other information*
  - *5.1.4 Management units*
- 5.2 Biological parameters
  - *5.2.1 Age estimation*
  - *5.2.2 Reproductive rates*
  - *5.2.3 Other information*
- 5.3 Catch statistics
  - *5.3.1 Struck and lost*
  - *5.3.2 Ice entrapments*
  - *5.3.3 Histories by management units*
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- 5.4 Abundance
  - *5.4.1 Recent estimates*
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  - *5.4.5 Recent changes in distribution in Canada*
- 5.5 Assessment
  - *5.5.1 Update of West Greenland assessment*
  - *5.5.2 Canadian summer stocks*
  - *5.5.3 East Greenland*
- 5.6 Future research requirements

6 BELUGA
- 6.1 Stock structure
- 6.2 Recent catch statistics
- 6.3 Abundance
  - *6.3.1 Recent and future estimates*
- 6.4 Assessment update
  - *6.4.1 West Greenland*
  - *6.4.2 Other stocks*
- 6.5 Other information
- 6.6 Future research requirements

7 IMPLEMENTATION OF EARLIER ADVICE
8 TRADITIONAL KNOWLEDGE
9 IMPACT OF HUMAN-MADE-NOISE
10 OTHER BUSINESS
- 10.1 Implications of the inclusion of other species (e.g.walrus) in the work of the SWG.

11 ADOPTION OF REPORT

APPENDIX 3

LIST OF DOCUMENTS

Document No.	
NAMMCO/SC/13-JCNB/SWG/2005-JWG/1	List of participants.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/2	Agenda.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/3	Draft list of documents.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/4	Richard, P. , Laake, J.L., Asselin, N. , and Cleator, H. Baffin Bay narwhal population distribution and numbers: aerial surveys in the Canadian High Arctic, 2002-2004
NAMMCO/SC/13-JCNB/SWG/2005-JWG/5	Heide-Jørgensen, M.P. An attempt to survey narwhals and belugas in West Greenland March 2004
NAMMCO/SC/13-JCNB/SWG/2005-JWG/6	Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in Greenland 1862 to 2005**:** A preliminary compilation
NAMMCO/SC/13-JCNB/SWG/2005-JWG/7	Heide-Jørgensen, M.P. Catch statistics for belugas in Greenland 1862 to 2004.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/8	Garde, E., Heide-Jørgensen, M.P., Hansen, S.H. and Forchhammer, M.C. Age-specific growth and high longevity in narwhals (*Monodon monoceros*) from West Greenland estimated via aspartic acid racemization.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/9	Romberg, S. and Richard, P. Seasonal distribution and sex ratio of narwhal catches in the Baffin region of Nunavut Territory, Canada.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/10	Romberg, S. Catch Statistics (1996-2004) for Narwhal and Beluga in Selected Communities in the Eastern Canadian Arctic.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/11	Richard, P. A risk analysis of narwhal hunting in the Canadian High Arctic
NAMMCO/SC/13-JCNB/SWG/2005-JWG/12	Laidre, K. and Heide-Jørgensen, M.P. Late summer and early fall movements of narwhals in Inglefield Bredning, Northwest Greenland

NAMMCO/SC/13-JCNB/SWG/2005-JWG/13	Laidre, K.L. and Heide-Jørgensen, M.P. The behavior of narwhals (*Monodon monoceros*) before, during, and after an attack by killer whales (*Orcinus orca*) in the Eastern Canadian Arctic
NAMMCO/SC/13-JCNB/SWG/2005-JWG/14	Witting, L. An assessment for West Greenland beluga.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/15	Witting, L. A model selection based assessment for West Greenland narwhals with uncertain stock structure.
NAMMCO/SC/13-JCNB/SWG/2005-JWG/16	Heide-Jørgensen, M.P., Dietz, R. and Laidre, K. Metapopulation structure and hunt allocation of narwhals in Baffin Bay
NAMMCO/SC/13-JCNB/SWG/2005-JWG/17	Heide-Jørgensen, M.P. and Laidre, K. Video recordings of narwhal pods in Melville Bay, West Greenland
NAMMCO/SC/13-JCNB/SWG/2005-JWG/18	Lawson, J. Overviews: Beluga whale and noise.