Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

C S A S

Canadian Science Advisory Secretariat

Proceedings Series 2012/031

Central and Arctic and National Capital regions

Proceedings of the Zonal Peer Review of Stock Identification, Abundance, Hunt Sustainability, and Tracking and Movements of Canadian Narwhal

10-11 May 2012
Winnipeg, Manitoba

Meeting Chairperson: Don Bowen
Editor: Lia Kruger

Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg MB R3T 2N6

Fisheries and Oceans Canada
200 Kent Street
Ottawa, ON K1A 0E6

November 2012

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

ISSN 1701-1272 (Printed)
ISSN 1701-1280 (Online)

Published and available free from:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200, rue Kent Street
Ottawa, Ontario
K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
CSAS-SCCS@DFO-MPO.GC.CA

Correct citation for this publication:

DFO. 2012. Proceedings of the zonal peer review of stock identification, abundance, hunt sustainability, and tracking and movements of Canadian narwhal; 10-11 May 2012. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2012/031.

Aussi disponible en français :

MPO. 2012. Compte rendu de l'examen zonal par les pairs du repérage des stocks, de l'abondance, de la viabilité de la chasse, du repérage et des déplacements du narval canadien ; les 10 et 11 mai 2012. Secr. can. de consult. sci. du MPO, Compte rendu 2012/031.

TABLE OF CONTENTS

SUMMARY

These proceedings summarize the relevant discussions and key conclusions that resulted from the Fisheries and Oceans Canada (DFO) zonal peer review of stock identification, abundance, hunt sustainability, and tracking and movements of Canadian narwhal held in Winnipeg on May 10 -11, 2012. The meeting was attended (in person and via phone and WebEx) by experts from DFO Science, DFO Fisheries Management, the Government of Nunavut, Nunavut Wildlife Management Board (NWMB), Kivalliq Wildlife Board, Arviq Hunters and Trappers Organization (HTO), Nunavut Tunngavik Inc., Assiniboine Park Zoo and the U.S. National Marine Fisheries Service, as well as independent scientists/experts.

Several objectives were accomplished during the meeting. A new population estimate and sustainable harvest level were determined for the Northern Hudson Bay narwhal population, based on an analysis of the 2011 aerial survey data. The most recent satellite tracking results for narwhals tagged in Admiralty Inlet and Eclipse Sound in 2009-2011 and the use of stable isotopes for stock identification in narwhal were peer reviewed. Sustainability of the 2011 Baffin Bay narwhal harvest was assessed based on a retrospective analysis using a harvest attribution model.

Five working papers were reviewed during the meeting. Four were accepted and will be made publicly available as Research Documents on the Canadian Science Advisory Secretariat (CSAS) Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm. Two science advisory reports were reviewed and will also be posted on the CSAS website.

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions tenues pendant l'examen zonal par les pairs de Pêches et Océans Canada (MPO) du repérage des stocks, de l'abondance, de la viabilité de la chasse, du repérage et des déplacements du narval canadien, qui a eu lieu à Winnipeg les 10 et 11 mai 2012, ainsi que les conclusions qui en découlent. Plusieurs experts du Secteur des Sciences et de la Direction générale de la gestion des pêches de Pêches et Océans Canada, du gouvernement du Nunavut, du Conseil de gestion des ressources fauniques du Nunavut, du Kivalliq Wildlife Board, de l'Organisation de chasseurs et de trappeurs d'Arviq, de la Nunavut Tunngavik inc., du zoo du parc Assiniboine et du National Marine Fisheries Service des États-Unis ont participé à cette réunion, en personne, par téléconférence et par conférence en ligne WebEx, de même que d'autres experts et scientifiques indépendants.

Au cours de la réunion, plusieurs objectifs ont été atteints dont la détermination d'une nouvelle estimation de la population et d'un niveau viable de prises pour la population de narvals du nord de la baie d'Hudson, selon une analyse des données du relevé aérien de 2011, l'examen par les pairs des résultats les plus récents du repérage satellite des narvals marqués dans l'inlet de l'Amirauté et dans le détroit d'Eclipse entre 2009 et 2011 et de l'utilisation d'isotopes stables pour le repérage des stocks de narvals. De plus, on a procédé à l'évaluation de la durabilité des prises de narvals de la baie de Baffin en 2011 selon une analyse rétrospective qui s'appuyait sur le modèle d'attribution des prises.

En tout, cinq documents de travail ont été examinés pendant la réunion, dont quatre ont été approuvés et seront publiés sous forme de documents de recherche dans le calendrier des avis scientifiques du Secrétariat canadien de consultation scientifique (SCCS) à l'adresse http://www.dfo-mpo.gc.ca/csas-sccs/index-fra.htm. De plus, deux avis scientifiques ont été examinés et seront publiés sur le site Web du SCCS.

INTRODUCTION

The two narwhal (*Monodon monoceros*) populations in Canada (Northern Hudson Bay and Baffin Bay) are comprised of at least five summering aggregations which are named based on their locations: Northern Hudson Bay (NHB), Somerset Island, Admiralty Inlet, Eclipse Sound and East Baffin Island. Fisheries and Oceans Canada (DFO) has recommended that narwhal be managed according to these summering aggregations. Narwhals are also known to occur in the areas of the Parry Islands, Jones Sound, and Smith Sound in the Canadian High Arctic; however the relationship of these whales to those in the summering aggregations and in Greenland waters is currently unknown.

The purpose of this meeting was to peer review recent scientific findings related to stock identification, abundance, hunt sustainability, and tracking and movements of Canadian narwhals. This information is important for making decisions related to the management of narwhals, such as determining harvest levels, integrated fisheries management planning and issuance of non-detriment findings (NDF) under the C*onvention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

The meeting followed the terms of reference (Appendix 1). Meeting participants (Appendix 2) included DFO Science, DFO Fisheries Management, the Government of Nunavut, NWMB, Kivalliq Wildlife Board, Arviq HTO, Nunavut Tunngavik Inc., Assiniboine Park Zoo and the U.S. National Marine Fisheries Service, as well as independent scientists/experts. Five working papers were distributed prior to the meeting and formed the basis of the discussions at the peer review. The meeting generally followed the agenda (Appendix 3).

These proceedings summarize the relevant meeting discussions and present the key conclusions reached.

DISCUSSION

CANADIAN NARWHAL STOCK IDENTIFICATION

Working paper: <u>Using stable isotopes analysis as a tool for narwhal (*Monodon monoceros*) stock delineation</u>
Authors: Cortney A. Watt, Steven H. Ferguson, Aaron Fisk, and Mads Peter Heide-Jørgensen
Presenter: Cortney Watt

<u>Presentation Summary</u>

Diet and geography influence stable isotope ratios of carbon and nitrogen in animal tissue. This research project examined isotope signatures from narwhals to test whether stable isotopes could be used to discriminate different narwhal stocks. Samples have been collected from narwhals for at least 30 years from summering aggregations belonging to the Baffin Bay population in the Canadian Arctic and also from Greenland. In addition, samples were obtained from the Northern Hudson Bay and East Greenland populations, as well as the High Arctic hunting area in Canada, though sample sizes available for analysis varied by community/summering aggregation. Since diet may vary seasonally and by sex, samples were also divided and analysed by season of collection and gender.

The results showed that narwhals from East Greenland and NHB are genetically and spatially segregated from the Baffin Bay animals, and these two populations had isotope values that clearly distinguished them in spring and summer. Summering aggregations in the Baffin Bay population were more difficult to distinguish; however, there was a significant difference between Admiralty Inlet and Eclipse Sound narwhals in the spring and summer models, and in the model that included all hunting areas regardless of season. Admiralty Inlet and Eclipse Sound had larger confidence limits due to small sample sizes. Only two summering aggregations were available for comparing winter and spring isotope values. Significant differences were found between the West Greenland and Melville Bay narwhals in winter and those in Eclipse Sound and West Greenland in autumn.

When the model that included all hunting areas was compared to that which considered males and females independently, there was some overlap with the Melville Bay and West Greenland narwhals for the females not seen in the model that combined males and females, but the discrimination among males was not significantly different from this model.

Isotopic signatures of narwhals in relation to the signatures of their prey were also examined to investigate why these differences exist. Although squid is an important component of the narwhal diet, its isotopic signature mirrors the signatures of Arctic Cod and Greenland Halibut thus it was too wide to be useful for detecting differences and was excluded from the analysis. The proportion of each prey type (i.e., cod, shrimp, sand lance, capelin, Greenland Halibut < 30 cm and > 30 cm in length) was examined for each group. Samples from capelin and sand lances were collected in NHB and used for comparison for all summering aggregations/populations except for East Greenland narwhals, for which samples from Iceland were used. The results showed that shrimp appear to be important food item for NHB narwhals and capelin for East Greenland narwhals. One possible explanation for these differences could be that stable isotope signatures may simply reflect geographic differences in the presence of carbon and nitrogen.

Overall, stable isotope analysis may be useful for delineating stocks, especially if used in combination with other techniques currently used for stock assignment. This method has some advantages: it requires a small amount of tissue, and for that reason can be a minimally-invasive technique, and is cost-effective. The next step will be to assess the power and utility of the approach using samples throughout the narwhal range. Additional samples from the Somerset Island and Grise Fiord hunts are especially needed.

Discussion

The primary objective of the study was to determine if stable isotope signatures in narwhals were variable and, if so, whether it reflected their diet and/or geography. Overlap in stable isotopes from the Eclipse Sound samples collected in the spring was noted. This may reflect a mixed aggregation composed of animals from the local summering aggregation as well as animals passing through en route to a different summering area.

Participants stated that seasonal sampling, gender differences and tissue/skin turnover rates should be considered potential sources of uncertainty. The geographic distribution of the prey samples used in the analysis was discussed. Prey samples came from each of the areas where narwhal samples were collected. Ideally, prey samples from each of the summering aggregations would be used in the analysis. The presenter noted that even though there is some geographic and temporal variation in the stable isotope values of narwhal prey, they are still very small relative to the differences in stable isotope values in narwhals. For example, stable isotopes signatures for prey sampled in Hudson Bay and Davis Strait were indistinguishable. Participants commented that narwhals feed on a great variety of prey compared to other species. Extensive and intensive sampling would be needed to confirm the level of uncertainty in the stable isotope values of their prey. Participants agreed the paper should focus on the use of stable isotopes for stock delineation rather than diet.

Variability in narwhal stable isotope signatures by gender was then considered. Some differences were detected between males and females from the Eclipse Sound summering aggregation but not the NHB population. A participant suggested that perhaps in narwhals both sexes forage similarly, in contrast to the gender-based differences seen in belugas. In this study, sample sizes were not large enough or the sex of all samples known to allow all aggregations/populations to be separated by gender. Participants agreed that sample size is an important consideration and that male-versus-female comparisons are an important aspect of assessing this technique.

No temporal variation in stable isotope signatures was identified in the study. One participant indicated that a shorter tissue/skin turnover time, closer to six weeks, should have been considered rather than the year-long turnover reported. Summer samples would reflect the winter diet when males and females overwinter together so it is expected that summer signatures may be similar for both sexes. Stable isotope signatures from the fall would show summer differences when sexes may have different diets. Different turnover rates would determine whether seasonal stable isotopes signatures are valid. The presenter said that stable isotope signatures could reflect diet on the order of months or up to a year and that research has been conducted on turnover of carbon isotopes in alpacas (*Lama pacos*); similar work on nitrogen is not available. Participants suggested the report authors investigate the consequences of using different turnover times on the narwhal results.

It was noted that in spite of differences in stable isotope values between males and females, there seem to be clear differences between the Admiralty Inlet and Eclipse Sound summering aggregations. A participant suggested that current sample sizes for Somerset Island and East Baffin are too small so they should be removed from the analysis. Presumably, larger sample sizes of tissue/skin for isotope analysis would reduce the amount of within-stock variability so it can be determined if there are significant differences between stocks. A minimum sample size of 30 narwhals (or 30 females and 30 males, if divided by sex) is typical for statistical analysis.

As a tool, stable isotope signatures can be used in two ways: to test the current stock delineation and re-classification success. If the two ideas were separated more clearly, this would help in determining the value of the tool for these two points. Participants recommended the report authors split the samples and used half to develop the classification and the other half for re-classification. The report authors agreed to provide tables that show the success of re-classification between summering aggregations.

A participant reported that Inuit would have difficulty accepting the delineation of narwhal stocks using differences in stable isotope signatures as a measure of diet. The current approach of using summering aggregations would have more credibility.

NHB NARWHAL ABUNDANCE AND HUNT SUSTAINABILITY

Working paper: Results of narwhal (*Monodon monoceros*) aerial surveys in northern Hudson bay, August 2011
Authors: Natalie C. Asselin, Steven H. Ferguson, Pierre R. Richard, and David G. Barber
Presenter: Natalie Asselin

Abstract

Aerial surveys were conducted 4-17 August 2011 to estimate the abundance of the NHB narwhal population. The survey was designed to use visual observations and aerial photographs to cover the entire summering range of the Northern Hudson Bay narwhal population based on published sources and information from Repulse Bay's Arviq HTO. After preliminary surveying, the final survey design was stratified according to observed narwhal densities and ice conditions. The final survey occurred 14-17 August covering, Repulse Bay, Frozen Strait, Wager Bay, Roes Welcome Sound, Lyon Inlet, Gore Bay and parts of Foxe Channel and yielded an estimate of 12,485 (CV=0.26) narwhals. The current population abundance estimate was used with the Potential Biological Removal (PBR) method to calculate a new recommended Total Allowable Landed Catch (TALC) for the Northern Hudson Bay narwhal stock of 157 narwhals.

Discussion

Participants discussed the correction factor for time in view of the survey observer (availability bias). The presenter said there may have been occasions when the observer recorded the perpendicular declination angle to the narwhal or narwhal group a little after it passed abeam. Another participant said that if the distance a narwhal was from the track line affected the length of time in view, then some double counting may have occurred because those animals longer in view have been taken into account in the sighting curve. The estimate of abundance is mainly derived from the plateau at the top and half of the slope of the detection curve plateau; the tail of the curve does not contribute much to the estimate. Thus, the correction for time in view should only be applied to the closest targets. Many of the animals close to the aircraft would be seen for a shorter time so the bias would be less and thus closer to an instantaneous correction. Another participant said that animals closer to the plane are visible for a shorter time making it less likely the observers would see them. The presenter said the closer animals are better taken into account by Distance 6.0 (the software program used to analyze the sighting data) than sightings farther from the aircraft. Some participants suggested applying the correction factor before fitting the sighting curve. A table showing how time in view varies with the distance from the aircraft would be useful. The presenter said that weather and ice conditions also affect time in view, not just distance from aircraft.

Some participants reported that killer whales were seen in the study area prior to the survey. Inuit have seen changes in the behaviour of narwhals, including clumping and moving into small inlets, when killer whales come within tens of miles. The presence of killer whales might bias a narwhal survey. The presenter said that killer whales were not sighted during the survey although they may have been present therefore it is important to survey as large an area as possible, including all small bays where they might aggregate, and to have transect lines close together to catch any aggregations that may be present. Narwhal movement, although not a factor in this survey, should be noted and considered as it may indicate the presence of killer whales. One of the report authors commented that during a survey in Admiralty Inlet large herds of narwhals were observed moving along the coastline. For all future surveys it may be useful to cover coastlines to ensure that any clumping of narwhals in response to killer whales is not missed.

There had been considerable ice cover in the survey area during August 14-17. As narwhals cannot be counted under the ice, a participant asked how this was dealt with in the survey analysis. One of the report authors said that the model compensates for this and the correction factor takes some of this into account. Although there was ice in Lyon Inlet, many narwhals were seen on transect in that body of water. A target exercise in the future might be useful for developing a better correction factor when ice concentrations are high. The presenter said the dive data used for the availability bias correction was obtained from narwhals during ice and non-ice conditions.

Photographs taken during the survey were used to correct for incomplete sighting information. Participants discussed whether they could be used to develop an independent estimate of abundance. Analysis of the photographs would be a lengthy process. An automated system would be needed but glare and waves might give false positives. Someone asked whether the effects of observer 'exhaustion' were taken into consideration in the model. The report authors were aware of observer fatigue and tried to reduce it as much as possible. Survey flights were never longer than five hours. Two observers were used on each side of the plane and their counts were analyzed using the mark-recapture component of the model to reduce missed sightings due to possible observer fatigue. To measure whether observer fatigue was a problem during the surveys it is possible to sub-sample the photographs to see if the results are similar to the observer counts but there would need to be a good reason to justify the additional use of resources needed to complete such an exercise. While the cost of digital photographs is relatively low relative to the overall cost of the survey, identifying species in photographs still requires human confirmation which makes it a time consuming process. Thus, the photographs were only used to confirm discrepancies in observers' species identification.

Participants noted the inconsistencies in survey coverage and methods used during previous surveys in NHB which makes between-year comparisons and trend analysis difficult or impossible. The 2011 survey covered areas that had not been previously surveyed, notably Wager Bay and farther north in Lyon Inlet, which may partially explain the higher population estimate compared to previous surveys. Although no narwhals were counted in Roes Welcome Sound, it is the conduit to Wager Bay. Participants stated the need for consistent coverage and stratification in future surveys. The presenter agreed but noted that excluding Roes Welcome Sound and Wager Bay from the 2011 survey makes it comparable with previous surveys. The survey area changed over the years in response to input from the Arviq HTO and stratification was revised to deal with changes in ice conditions. The more recent surveys are more consistent than they used to be.

The necessity for consistent survey coverage was discussed. It might not be prudent as narwhals move and their range may expand or change. Local Inuit can provide details on new areas that should be surveyed. The same area does not have to be surveyed each time but it is important to have consistent stratification so strata can be added or dropped as appropriate and between-year comparisons can be made more easily. However, if a new area is added then it is unknown whether narwhals moved into that area or whether they were there all along and the area simply was not surveyed. It would be possible to re-analyze the older surveys using the new stratification though comparing a stratum in 2000 with the same area in 2011 may not be valid because ice conditions, the presence of killer whales and possibly other factors may affect where narwhals are found.

A participant asked if the observers' reported angles had been calibrated against the angles estimated from the photos of the same sightings. Some checks were done to verify the formula but they were not all done systematically. Pitch of the aircraft influenced the angles calculated from the photos. Regardless, the photographed narwhals that were examined added 15% to the overall sightings.

No justification was provided for the selection of the model reported in Table 5. Participants agreed this should be included in the document.

STOCK-DYNAMIC MODEL FOR THE NHB NARWHAL

Working paper: An updated stock-dynamic model for the Northern Hudson Bay narwhal population based on 1882-2011 aerial surveys
Authors: Michael C.S. Kingsley, Natalie Asselin, and Steven H. Ferguson
Presenter: Michael Kingsley

Abstract

Updated science and documented management approach is required for sustainable narwhal management and to provide evidence of sustainable domestic management that conforms to requirements for international trade. To provide appropriate science advice for resource management decisions, we used a stock-dynamic model for the Northern Hudson Bay narwhal population previously developed (Kingsley et al. 2012) that was updated to include the 2011 aerial survey estimate (Asselin et al. 2012). Results provide a review of the sustainability of recent hunting levels relative to recent population abundance estimates and to estimate risk of various catch levels to population status. Survey data and information on survey coverage was used in conjunction with assumptions of a constant growth rate. Limits to population growth at high densities were not considered. The model was built to fit available data using Bayesian methods and generally prior distributions were assumed as being uninformative. Narwhals were assumed to have a gross annual birth rate of approximately 10% and to be long lived. Results confirm previous indications that the 2008 survey provided a gross underestimate of population abundance and therefore a correction term for this survey was fitted. Survey coverage varied considerably among surveys creating problems with comparability and in assessing the overall population trend. Survey data presented problems due to variation in stratification methods among surveys and incomplete survey coverage. Generally, over the period of aerial surveys, population abundance estimates have increased with the exception of 2008. In spite of the larger average catch recorded since 1998, results suggest a population continuing to increase in size with a basic population growth rate of 3.4%/yr. Model results indicate that predation by killer whales does not have a significant effect on population growth. The positive trend in narwhal numbers, in spite of recent catch levels, suggests that the population can withstand continued catches at current levels over a ten-year forecast.

Additional Information Presented in Presentation Summary

The presenter described the methods used. Available data were input to the model on the basis of five strata: Repulse Bay and Frozen Strait, northern Gore Bay and Lyon Inlet, northwestern Foxe Channel, northeastern Roes Welcome Sound, and Roes Welcome Sound and Wager Bay. The catch data, updated for 1996-2011, showed two distinctive catch periods (mean level of reported catches of 19 in 1977-96 and 108 in 1999-2009) though there was no significant trend. The dive correction for narwhals in the visual survey was based on a tagging study in NHB in which nine whales were tagged (taken as independent estimates), a 2-m criterion was used for visibility and some data were from outside surveyed areas. On average, the tagged narwhals were visible 26.1%–40% of the time. The unknowns included relative visibility between photographic and visual surveys (availability bias), survey precision, and distribution between different survey areas (survey coverage varied and no standard stratification), loss rates in the hunt, and the population's natural rate of growth.

Process error is a measure of the slope between the predicted population estimate for the next year and the actual abundance. For this modelling exercise, process error was kept fairly small because narwhals produce a relatively small number of calves. The 2012 analysis had significant differences from 2010 including a 3.5% growth rate in population growth. Error in visual surveys is now 44%, but was previously 56%. The population proportions are different for the 2012 than the 2010 analysis because Wager Bay and Roes Welcome Sound account for about 30% but are new areas not previously surveyed. Wager Bay and Roe Welcome Sound were separated from the other areas surveyed. The proportion of animals in the different strata should be proportional to the size of each stratum. There are no data overall to correct that estimate but a revision could be done in the future with consistent stratification. The 2011 survey produced a much healthier population dynamic than the 2008 survey.

To fit all the surveys, the model tried to find an average population growth rate but to fit the 2000 survey it required negative process errors up to that year and only positive process errors after that. That resulted in the population producing far more calves than it's supposed to since 2000. Serial correlation of the consecutive negative process errors between the early 1980s and 2000 followed by positive process errors is about 76%, which is extremely unlikely.

<u>Discussion</u>

One participant wondered if it would be useful to incorporate a time lag between births and reproduction, so that births in a given year are dependent on the birth and maturation of females in the past. The presenter said that could be done if an appropriate time lag was determined; then the model could start with these biological processes already underway.

The catch series data used in the model were discussed. Some participants noted a discrepancy between the catch information presented in Appendix 1 and the most recent harvest tables available. The most up-to-date catch data will be provided to the authors. A participant gave an overview of how narwhal catch levels in NHB have evolved over time. The harvest numbers obtained before 1999 were based on historical harvests. The NWMB instituted community-based management for some communities in Nunavut in 1999 to reduce struck-and-lost rates. Repulse Bay was the only participating community for the NHB population and their narwhal harvest increased. Catches by the other communities that hunt the NHB population have remained fairly constant over time. Oral stories from Repulse Bay indicate narwhals have always been abundant and current Inuit knowledge reports that this is still the case, according to one participant. The 2011 survey results correlate well with what Inuit have observed. It is thought there are more than 5,000 or 10,000 narwhals in the NHB population and the population has been increasing. Not many narwhals were hunted in the early years. The catch rate today is much higher due to the larger size of the community of Repulse Bay.

Participants discussed comparability of the NHB narwhal surveys. Ice conditions varied from year to year but, overall, have been comparable across the decades. The areas surveyed and stratum boundaries have varied somewhat between surveys though the analysis has accounted for that to some extent. Repulse Bay and Frozen Strait, the main survey area, was consistently covered during all surveys. Foxe Channel, Gore Bay and Lyon Inlet account for a relative small amount of total numbers of narwhals. Changes in narwhal distribution may be a bigger problem across the years than survey coverage. Participants noted that Wager Bay accounted for a significant proportion of the 2011 survey estimate. In the 1980s a reconnaissance survey was flown in Wager Bay but no narwhals were seen. The authors reported that during analysis of the 2011 survey results the model fitted a proportion of the population to Wager Bay so it could derive two survey estimates: one using data for all areas surveyed in 2011 and another using only the data for the main survey area. The latter survey estimate could be compared with previous survey estimates. As these estimates only cover Repulse Bay and Frozen Strait they are model estimates of total numbers not survey estimates. The apparent increase in narwhal numbers between the 1980s and 2011 may be partly explained by improvements in survey techniques for this population over the years. For example, population abundance estimates derived from line transects can be 50% to 80% higher than estimates derived from strip transects.

Differences in technique were compared between the surveys conducted in the 1980s versus 2011. The 1982 visual survey used a strip-transect method which would have underestimated abundance compared to the line-transect method used for the visual surveys conducted in more recent years. Previous analysis shows the outer edge of the strip transects flown during the 1982 surveys were set 800 m on either side of the aircraft, almost double the area covered using the line-transect approach. If the results of that visual survey were increased by 50-80%, to account for differences between strip- and line-transect surveys, that could bring the abundance estimate for 1982 in line with some of the subsequent surveys and potentially change the historical growth rate of the population and sustainability of the harvest. One participant noted there are photo data from the 1982-84 surveys that should be comparable to the 2011 survey. It was suggested the 1982 visual strip-transect survey be thrown out in favour of using only the photographic surveys but the group disagreed, in part because in 1982 the two survey types were flown on different days and areas.

In 2000, one photographic and two visual surveys were flown. The photographic survey produced a lower estimate of abundance. The model uses the set of survey results to calculate the relative visibility for the two kinds of surveys by comparing the results for surveys conducted at, or close to, the same time. The working paper presents the estimated relative visibility of the two survey types. The visual surveys conducted in 2000 were conventional line-transect surveys unlike the 2011 mark-recapture (i.e., double platform) survey which might explain some differences between the results.

Ability of the stock-dynamic model's to fit the available survey data was discussed. If a correction that produced a higher abundance estimate was made to $g(0)$ (i.e., the probability of detection at zero distance from the survey track-line) for the 2000 survey, then the stock-dynamic model might have to incorporate a density-dependent effect in order to fit the available abundance estimates for all survey years. Changes in harvest rates between the 1980s and 2000 would also have an effect on model fitting. Prior to 1999 the harvests may have been under-reported or under estimated which would have contributed to the growth rate predicted by the model. However, some participants reported that although that time period predates the Nunavut Wildlife Harvest Study, harvests were likely reported fairly accurately thus the accuracy of reported catches is fairly comparable over the years. If data for the 1980s surveys were left out of the analysis the model would likely predict a higher growth rate. The same struck-and-loss rate was used in the model across all years.

Participants talked about how to deal with the different survey methods, thus potentially different biases, inherent in the series of NHB narwhal surveys conducted to date in order to improve the accuracy of the trend analysis. It was agreed that the visual, not photographic, survey data should be used and that reanalysis of results from the 2011 double-platform line-transect survey offered the best method. It would require reanalyzing the 2011 data as a single platform survey, for comparability with the survey results from 2000, and further reanalyzing the 2011 data as a strip transect survey for comparability with the survey results from 1982. In this way, correction factors would be developed to apply to the older surveys to make them comparable with the most recent survey. The survey report authors agreed to undertake this reanalysis. Once the revised data are available the stock-dynamic model can be re-run and the working paper updated and peer reviewed.

A participant asked about the impact of killer whale predation on the NHB narwhal population. Killer whale predation was taken in account in the current analysis given it is part of the balance of narwhal births and deaths which go into making the annual 3.5% increase. No change in killer whale predation over time has been included in the model because the current analysis shows the realized narwhal population growth rate has been higher since 2000 so predation is not needed to explain the population trend. However, an increase in killer whale predation may need to be considered again depending on the updated survey results (e.g., if the reanalysis reveals the 2000 survey estimate is much higher than currently thought and the population growth is constant or declines from 2000 to 2011).

TRACKING AND MOVEMENTS OF NARWHAL (ECLIPSE SOUND AND ADMIRALTY INLET)

Working paper: Satellite tracking of narwhals (*Monodon monoceros*) from Admiralty Inlet (2009) and Eclipse Sound (2010-2011*)*
Authors: Cortney A. Watt, Jack Orr, Bernard LeBlanc, Pierre Richard, and Steven H. Ferguson.
Presenter: Cortney Watt

Presentation Summary

The objective of the investigation was to gather information on movements, overwintering regions, and site fidelity within and between years for the Admiralty Inlet and Eclipse Sound narwhal summering aggregations. The primary goal was to determine if the two aggregations show site fidelity and remain spatially segregated from each other during summer. Seven satellite tags were attached to narwhals in 2009 in Admiralty Inlet and five and seven tags in Tremblay Sound in 2010 and 2011, respectively. A greater degree of range overlap between Eclipse Sound and Admiralty Inlet, both within and between years, was found than had been documented in past studies. There was some degree of mixing during the 2011 summer season as well as some spatial overlap outside the summer season. A single narwhal overwintered in northern Foxe Basin, a region in which narwhals have rarely been known to spend the winter. Another narwhal spent time in January in Disko Bay, Greenland. This is the first time a narwhal tagged in Canada spent time along the West Greenland coast where winter hunting occurs. Further tracking of narwhals from these two summering aggregations is required to determine if the recent movements are typical of a greater proportion of the population.

Discussion

Participants discussed the evidence of site fidelity for the two summering aggregations. Only one of the tagged narwhals had a tag that lasted from one summer to the next. That narwhal changed summering locations and that speaks to the issue of site fidelity. Some of the other tagged animals moved from one area to another during the summer, which is unusual but that does not provide evidence for the site fidelity question. Less than 10 narwhals have had tags last from one tagging year to the next.

Participants asked what parameters define ‘summer’. The narwhal allocation model defines summer as the period from July 24 to September-October. The summer period was defined as August 1 to September 30 for this paper based on peaks in hunting. One of the purposes of this research document was to support the harvest attribution model though it does not specifically refer to the model. The tagging data showed that narwhals move quite a bit in September. Participants thought the paper would benefit from more quantitative information to help understand seasonal movements. A participant reminded the others that the allocation model was a first try and will be revised as new information comes available. These tagging data demonstrate the allocation model is not perfect. That said, the movement patterns of one or a few narwhals should not demand a wholesale change to the model.

A participant said that in recent years the people of Pond Inlet report seeing fewer narwhals. The whales are moving due to the presence of ships and activity associated with the Mary River Mine. One participant inquired whether narwhals also move in response to tagging. It was noted that most narwhals do not leave the area after being tagged and that is why this paper says that the Eclipse Sound narwhals moving to Admiralty Inlet are the exception rather than the rule. Researchers hope to investigate fine-scale movements after tagging (e.g., from Tremblay Sound to Navy Board Inlet) in a more quantitative way in the future to see what effects tagging have on narwhals.

A number of suggestions were made for improvements to the working paper. These included a table showing each tagged narwhal’s location(s) by month and separation of the data by gender. Site fidelity within a summer versus between years should be clarified in the document. The presenter indicated that Figure 3 in the stable isotopes paper shows that narwhals harvested from Admiralty Inlet and Eclipse Sound had different nitrogen and carbon signatures. However, some participants reported that if whales stayed in the same area for one summer and then moved to another area in a following summer, the stable isotopes would not show that. The results would depend on the length of time a stable isotope signature reflects. Clarification was sought for the term ‘proximity’ which was used in the document to describe two animals swimming together. The presenter said the timeframe was similar for the two males that entered Cumberland Sound but they do not have enough tracking precision to say with confidence that they were swimming side by side. This will be clarified in the document. Overall, participants suggested the authors include more information from previous studies, and a more fulsome description of the results and discussion about what they mean.

EVALUATION OF BAFFIN BAY NARWHAL SUSTAINABILITY

Working paper: <u>2011 harvest attributions for Baffin Bay narwhals</u>
Author: Christine Abraham
Presenters: Andrea White and Pierre Richard

<u>Presentation Summary</u>

DFO Science requested a retrospective analysis of the sustainability of the 2011 Baffin Bay narwhal catches using a previously reviewed narwhal allocation model to attribute historical recorded catches and seasonal catch proportions. The analysis included sensitivity analyses to evaluate the risk associated with the assumption of proportional stock size and the risk associated with the assumption of separate Admiralty Inlet and Eclipse Sound summering aggregations.

The attribution model results demonstrated that the 2011 Baffin Bay narwhal catches were sustainable. The sensitivity analyses demonstrated no risk associated with the harvests of all stocks in 2011 except when the attribution model was revised to treat Admiralty Inlet and Eclipse Sound summering aggregations as one group. In that case the moderate and extreme risk scenarios demonstrated a ~35% and ~ 85% risk, respectively, associated with the harvest of the combined Admiralty Inlet-Eclipse Sound summering aggregations in 2011, while the risk to other stocks remained negligible.

Sources of uncertainty included incorrect harvest dates from tag data, combining abundance estimates for summering aggregations not surveyed in the same year, TALC calculations based on dated surveys, the possibility of sub-aggregation structuring in the Somerset Island and East Baffin summering aggregations and uncertainty associated with the proportion of each summering aggregation that is available to each community during spring and fall migrations.

Little or no scientific information is currently available on population abundance or harvest levels for narwhals that occur around the Parry Islands or in Jones Sound or Smith Sound so they were not included in the analysis.

Discussion

The Chair confirmed that the allocation of narwhal tags was not part of the request for science advice.

Participants asked about including the Greenland harvest in the allocation model. A request of this nature would have to go forward to the Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga for their consideration. It was suggested that the Greenland harvest be listed as a source of uncertainty in the document and the report author look at 'what if' scenarios to see how important the Greenland harvest could be. Until 2011, no tags put on narwhals in Canadian waters moved to areas where they could be caught by Greenlanders. This has since changed suggesting that the Greenland catch could be incorporated into harvest scenarios in the model.

No new scientific information on narwhals around Grise Fiord is available to inform narwhal abundance or hunt sustainability in the area. This should be noted in the science advisory report. Inuit in Grise Fiord have been documenting their narwhal information and will send a proposal to the NWMB. DFO has sought funding for 2012 to assess narwhals in the area.

NHB NARWHAL

Science advisory report: Abundance and total allowable landed catch for the Northern Hudson Bay narwhal population

Participants reviewed the draft science advisory report and revised it based on discussions. The hunting loss rate correction used to calculate TALC was talked about at length during the discussion about sources of uncertainty. The need for more current estimates of loss rate specific to Repulse Bay and different types of hunts (e.g., floe edge versus open water) was noted. It was also flagged that uncertainty in the loss rate correction was not considered when converting PBR to TALC.

BAFFIN BAY NARWHAL

Science advisory report: Evaluation of Baffin Bay narwhal hunt sustainability

The science advisory report was reviewed and revised by the meeting participants. During part of that discussion it was noted that the document states there are four summering aggregations but it is now known there may be mixing between the Eclipse Sound and Admiralty Inlet aggregations in summer. The Chair said the text must remain as is to reflect the current status until a future peer review of the summering aggregations hypothesis indicates otherwise.

APPENDIX 1: TERMS OF REFERNCE

Stock Identification, Abundance, Hunt Sustainability, and Tracking and Movements of Canadian Narwhal

Zonal Peer Review – Central and Arctic and National Capital regions

10-11 May 2012
Winnipeg, Manitoba and teleconference/WebEx
Chairperson: Don Bowen

Context

The two narwhal populations in Canada (NHB and Baffin Bay) are comprised
Of five stocks which are named for the locations of their known summering aggregations: NHB, Somerset Island, Admiralty Inlet, Eclipse Sound and East Baffin Island. DFO has recommended that narwhal be managed according to summering aggregations. The purpose of this meeting is to peer review the latest scientific findings on stock identification, abundance, hunt sustainability, and tracking and movements for the five stocks of narwhal in Canadian waters. Determining the sustainability of the narwhal hunt is important for making decisions related to the management of narwhal, such as determining harvest levels, Integrated Fisheries Management planning and issuance of non-detriment findings (NDF) under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

Canadian narwhal stock identification

Identification of stock structure is needed to facilitate management of narwhal. Various methods are being investigated to see how well they can be used to define stock identity in narwhals. Using chemical tracers of narwhal feeding ecology (i.e., carbon and nitrogen isotope ratios) can help delineate summering stocks and their relative contributions to Inuit harvests. Stable isotope analysis of narwhal samples, collected from Canada (NHB and Baffin Bay populations) and Greenland, has been conducted.

Northern Hudson Bay narwhal abundance and hunt sustainability

The NHB narwhal population is an important regional subsistence fishery. The population was previously assessed from aerial photographic surveys of summer aggregations in 1984, 2000 and 2008. The August 2008 survey was intended to provide information necessary for a full assessment of the population. However, it provided only a partial estimate owing to camera malfunction, sea ice conditions and poor weather conditions. That partial estimate of population size was only a fraction of the 2000 estimate.

After the 2008 survey results were reviewed, a stock-dynamic model using Bayesian methods was run to assess whether the low estimate derived from the 2008 survey might be explained by a decrease in stock size due in part or in whole to either recent increases in reported takes or by increased predation, and to estimate a sustainable harvest from the population. Based on the analysis it was concluded that it would be difficult to estimate stock trend and future sustainable catches for the NHB narwhal population using the available data. It was recommended that a new survey be conducted as soon as possible to inform the population modelling and advice.

Central and Arctic Resource Management requested a current abundance estimate and sustainable harvest level recommendation for the NHB narwhal population. A new aerial survey was flown in August 2011 and the data analyzed. A stock-dynamic model was used to evaluate the most recent survey in light of previous surveys and review the sustainability of hunting for different catch scenarios taking into account the current and predicted impact of killer whale predation on narwhals.

Tracking and movements of narwhal (Eclipse Sound and Admiralty Inlet)

Satellite tracking of narwhals in Canadian waters in recent years has provided a better understanding of the distribution and movements of this species and has provided useful information to assist with resource management decisions related to stock discrimination. The most recent results were obtained from narwhals tagged in summer in Admiralty Inlet (2009) and Eclipse Sound (2010 and 2011).

Evaluation of Baffin Bay narwhal hunt sustainability

Each of the four Baffin Bay stocks (Somerset Island, Admiralty Inlet, Eclipse Sound and East Baffin Island) has been identified as a separate management unit, with a sustainable harvest recommendation derived from aerial survey abundance estimates. A harvest allocation model was used to conduct a retrospective analysis of the 2011 Canadian narwhal hunts from these four Baffin Bay stocks, to determine their sustainability.

A fifth management unit comprises narwhal found seasonally in Jones Sound, Smith Sound and Parry Channel, but their abundance and relationship to the Baffin Bay population is not known. Sustainability of narwhal hunts in this management unit will also be reviewed.

Objectives

Canadian narwhal stock identification

1. Review the use of stable isotopes for stock identification of narwhal on the basis of samples collected in Canada and Greenland.

Northern Hudson Bay narwhal abundance and hunt sustainability

2. Determine the population estimate for Northern Hudson Bay narwhal based on an analysis of the 2011 aerial survey data.

3. Determine the sustainable harvest recommendation for Northern Hudson Bay narwhal taking into account the current and predicted impact of killer whale predation on narwhals. Evaluate sustainability of recent harvest levels. (The meeting will not include management discussions about harvest allocations.)

Tracking and movements of narwhal (Eclipse Sound and Admiralty Inlet)

4. Review the most recent satellite tracking results for narwhals tagged in Admiralty Inlet and Eclipse Sound in 2009-2011.

Evaluation of Baffin Bay narwhal hunt sustainability

5. Evaluate the sustainability of Canadian harvests of Baffin Bay and other High Arctic narwhal in 2011.

Expected Publications

- A Science Advisory Report for objectives 2 and 3 (combined)
- A Science Advisory Report for objective 5

- Proceedings
- Five Research Documents for objectives 1-5

Participation

- Fisheries and Oceans Canada: Science and Fisheries Management
- Government of Nunavut
- Nunavut Wildlife Management Board
- Nunavut Tunngavik Inc.
- Kivalliq Wildlife Board
- Qikiqtaaluk Wildlife Board
- Kitikmeot Regional Wildlife Board
- United States National Oceanographic and Atmospheric Administration (National Marine
- Fisheries Service)
- Independent scientist/expert

APPENDIX 2: LIST OF PARTICIPANTS

NAME	Affiliation / Community	E-mail Address
Akkuardjuk, Michel	Arviq Hunters and Trappers Organization	repulsebayhto@qiniq.com
Arnold, Sarah	Government of Nunavut (Department of Environment)	sarnold@gov.nu.ca
Asselin, Natalie	Independent scientist/expert	natalie.asselin@gmail.com
Bowen, Don	DFO (Science, Maritimes region)	don.bowen@dfo-mpo.gc.ca
Cleator, Holly	DFO (Science, Central and Arctic region)	holly.cleator@dfo-mpo.gc.ca
Doniol-Valcroze, Thomas	DFO (Science, Quebec region)	thomas.doniol-valcroze@dfo-mpo.gc.ca
Ferguson, Steve	DFO (Science, Central and Arctic region)	steve.ferguson@dfo-mpo.gc.ca
Hall, Patt	DFO (Fisheries Management, Central and Arctic region)	patt.hall@dfo-mpo.gc.ca
Hammill, Mike	DFO (Science, Quebec region)	mike.hammill@dfo-mpo.gc.ca
Hobbs, Rod	U.S. National Marine Fisheries Service	rod.hobbs@noaa.gov
Kinglsley, Michael	Independent scientist/expert	mcskingsley@gmail.com
Kruger, Lia	DFO (Science, Central and Arctic region)	lia.kruger@dfo-mpo.gc.ca
Lee, David	Nunavut Tunngavik Inc.	dlee@tunngavik.com
Magera, Anna	Nunavut Wildlife Management Board	amagera@nwmb.com
Martin, Kathleen	DFO (Science, Central and Arctic region)	kathleen.martin@dfo-mpo.gc.ca
Nirlungayuk, Gabriel	Nunavut Tunngavik Inc.	gnirlungayuk@tunngavik.com
Petersen, Stephen	Assiniboine Park Zoo	spetersen@assiniboinepark.ca
Postma, Lianne	DFO (Science, Central and Arctic region)	lianne.postma@dfo-mpog.gc.ca
Richard, Pierre	DFO (Science, Central and Arctic region)	richardpr@gmail.com
Romberg, Stefan	DFO Fisheries Management NCR region)	stefan.romberg@dfo-mpo.gc.ca
Stenson, Garry	DFO (Science, Newfoundland region)	garry.stenson@dfo-mpo.gc.ca
Tatty, Ross	Kivalliq Wildlife Board	rosstatty@gmail.com
Watt, Cortney	University of Manitoba / DFO (Science, Central and Arctic region)	watt.cortney@dfo-mpo.gc.ca
White, Andrea	DFO (Science, National Capital region)	andrea.white@dfo-mpo.gc.ca
Young, Rob	DFO (Science, Central and Arctic region)	robert.young@dfo-mpo.gc.ca

APPENDIX 3: MEETING AGENDA

Agenda

Stock Identification, Abundance, Hunt Sustainability, and Tracking and Movements of Canadian Narwhal

Winnipeg, Manitoba and teleconference/WebEx

Day 1 May 10, 2012

8:30 a.m. CDT	Introduction (Don Bowen, chair)

Canadian narwhal stock identification

8:50 a.m.	Working Paper 1 (Cortney Watt) Stable isotope analysis of narwhal samples from Canada (Northern Hudson Bay and Baffin Bay populations) and Greenland

Northern Hudson Bay narwhal abundance and hunt sustainability

9:30 a.m.	Working Paper 2 (Natalie Asselin) August 2011 aerial survey results
10:00 a.m.	Break
10:15 a.m.	Discuss Working Paper 2
11:15 a.m.	Working Paper 3 (Michael Kingsley) Stock-dynamic model for Northern Hudson Bay narwhal
11:45 a.m.	Lunch
12:45 p.m.	Discuss Working Paper 3

Tracking and movements of narwhal (Eclipse Sound and Admiralty Inlet)

2:00 p.m.	Working Paper 4 (Cortney Watt) Satellite tracking of narwhals tagged in summer in Admiralty Inlet (2009) and Eclipse Sound (2010 and 2011)

Evaluation of Baffin Bay narwhal hunt sustainability

2:40 p.m.	Working Paper 5 (Christine Abraham) A retrospective analysis of the 2011 Canadian narwhal hunts using the harvest allocation model
3:00 p.m.	Break
3:15 p.m.	Discuss Working Paper 5

Day 2 May 11, 2012

8:30 a.m. CDT	Review draft Science Advisory Report 1: Northern Hudson Bay Narwhal
10:00 a.m.	Break
10:15 a.m.	Review draft Science Advisory Report 2: Baffin Bay Narwhal
1:30 p.m.	Meeting finished