JOINT WORKING GROUP 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

26-30 October 2020, Online

REPORT

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EXECUTIVE SUMMARY

The NAMMCO-JCNB Joint Working Group (JWG) on narwhal and beluga met online from 26–30 June 2020 under the leadership of Co-Chairs Cortney Watt (JCNB) and Roderick Hobbs (NAMMCO).

The **Terms of Reference** for this online meeting were to: a) *review information on abundance, distribution, movements and harvest locations of narwhal and beluga*; b) *update and review the narwhal allocation model to assign harvested animals to individual summer stocks*. Given the restrictions on time associated with this needing to be an online meeting, three additional terms of reference were deferred to the next JWG meeting, which it is hoped can take place in person in 2021. This included: a) *review the latest abundance estimate for East Greenland narwhal*; b) *assess the impacts of climate change on narwhal and beluga movements, distribution, population dynamics, habitat and hunt methods, timing and location*; c) *revise advice models to incorporate climate change impacts where information is available and identify additional information requirements*.

Narwhal

The JWG did not manage to address all the terms of reference related to narwhal within the timeframe of the meeting and therefore no management advice is provided in the report for this species. This was partly because the corrections for availability bias on the survey estimates required a more focused review before updating the narwhal metapopulation and allocation models. To address this, a quantitative subworking group (QSG) was established to work intersessionally. The terms of reference for this QSG are available in Appendix 4 of the report and the outcomes of their work will be presented to the next meeting of the JWG. Despite not finalising management advice, the issues related to narwhals that were discussed and agreed upon by the JWG are outlined below.

Genetic analysis has revealed that nuclear markers are more suitable than mitochondrial genomes for inferring population structure for narwhals. While technical issues have delayed the completion of a range-wide analysis of population structure, preliminary results indicate three main populations of narwhals: West Greenland-Eastern Canada, East Greenland and North-East Greenland-Svalbard. Preliminary results on the fine-scale genetic structure in East Greenland also indicate that the narwhals that summer in Scoresby Sound may be genetically isolated from the rest of the narwhals in East Greenland, including those that enter Scoresby Sound in the spring. The research on genetic analysis will continue for the next 2 years.

Satellite tracking of narwhals in Eclipse Sound indicates that some whales also visit Admiralty Inlet. The JWG noted that this movement violated the assumption that narwhals were only available to hunters in their summering grounds. It was noted that such movements may have been observed because some recent tagging was conducted earlier in the summer season and thus allowed more time for movement to Admiralty Inlet, or because the animals are responding to environmental changes or industrial developments in the region. The JWG agreed that the new tracking data were suitable for use in the availability matrix of the allocation model. However, some analysis will be necessary to understand the fraction of each summering area used by narwhals and to determine potential impacts on management advice. This analysis and review of the availability matrix will continue within the QSG.

Abundance estimates for Eclipse Sound, Inglefield Bredning and Melville Bay were presented. In *Eclipse Sound*, an abundance estimate (corrected for availability bias) of 12,039 narwhals (CV=0.23, 95% CI: 7,768–18,660) was accepted for use in the allocation and population models. Estimates from an aerial survey performed by Golder Associates Ltd. for Baffinland Iron Mines Corporation were discussed and although the surveys were deemed sound, the choice of estimates most appropriate for use and the calculation of the associated CVs were seen to require further discussion and analysis.

For *Inglefield Bredning and Melville Bay*, estimates from a summer 2019 aerial survey, together with results from a reanalysis of previous surveys, were presented. In *Melville Bay*, a high number of sightings on a small number of transect lines in one stratum complicated the analysis. It was particularly noted that between 2007 and 2019, there had been a significant contraction of the area narwhals were sighted in *Melville Bay*, which may indicate a population decline. Given the challenges in analysing the 2019 survey data, and the fact that the recalculated abundance estimates from earlier surveys used a different availability correction factor, the JWG agreed that the choice of models and correction factors required more in-depth discussion before the estimates could be accepted for use. The work to finalise acceptable abundance estimates will therefore continue within the QSG.

Catch statistics from Canada for the period 1970-2019, and an update on catch statistics in Greenland for the period 2005-2019, were presented and accepted for use in the population models. An in-depth analysis of hunting in Melville Bay was provided and the JWG highlighted that the level of hunting taking place within the Melville Bay Nature Reserve increased from 2005–2019. To assist with accurate determinations of maturity, the JWG **recommended** that reports from hunters in both Greenland and Canada include the body length of the animal.

Management advice and further recommendations will follow the findings of the QSG and a subsequent meeting of the JWG in late summer/early fall 2021.

Beluga

Genetic analysis of full genome sequences indicates at least 5 genetically distinct groups of belugas in the western Atlantic, with preliminary fine-scale analysis also revealing further sub-structuring in some of these groups. Work continues to finalise this analysis, examine divergence times, and identify local genomic adaptations. The JWG also highlighted productive areas for future genetic research to help inform management advice.

No new data from **satellite tracking** of belugas was presented. However, the JWG **recommended** a half day workshop to exchange knowledge on effective tagging practices to improve tag retention.

A new **abundance estimate** for the eastern part of the North Water based on a visual aerial survey conducted in April 2018 was presented. The fully corrected estimate of 2063 (CV=0.81, 95% CI: 513–8289) belugas was similar to estimates from the 2014 survey and was approved for use in the assessment.

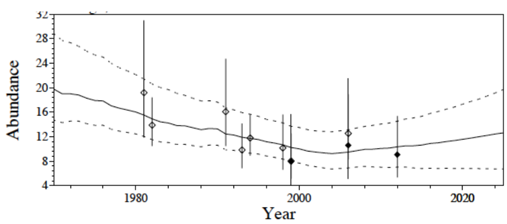
Catch statistics for the Nunavut communities since 2011, and an update for Greenland focused on the period 1993–2019, were presented and accepted for use in the population assessment model. There was a recognised need to examine whether beluga in the North Water (north of Cape York) are a separate population and the JWG decided to use a precautionary approach and treat this aggregation as a separate stock in the assessment. It was also **recommended** that genetic analysis of fall catches in the Qaanaaq area be conducted to establish stock structure.

Under **development of model structure for beluga,** the population assessment for West Greenland was updated and a new assessment model was developed for beluga in the North Water. It was noted that following request 1.6.5 from the NAMMCO Council (2017), management advice should provide recommendations on total allowable landings rather than total removals (i.e. the number of struck and lost animals should be taken out during the calculation of a sustainable number of landed animals).

Management Advice: *West Greenland*

Probability of Meeting Management Objectives	*Landed Catch of Belugas in West Greenland*
0.50	354
0.55	333
0.60	313
0.65	289
0.70	265
0.75	242
0.80	217
0.85	186
0.90	154
0.95	113

To maintain a 70% probability for population increase, the assessment for *West Greenland* recommends an annual landed catch of no more than 265 individuals south of Cape York and north of 65°.



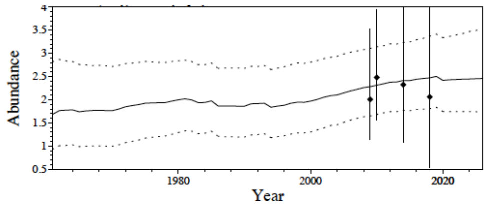
Projected median and 90% credibility interval for abundance in West Greenland

Management Advice: *North Water*

Probability of Meeting Management Objectives	*Landed Catch of Belugas in Qaanaaq*
0.50	44
0.55	42
0.60	41
0.65	39
0.70	37
0.75	36
0.80	34
0.85	31
0.90	29
0.95	23

To maintain a 70% probability for population increase, the assessment for the *North Water* recommends an annual landed catch of no more than 37 individuals north of Cape York.

** Note that previous recommendations that belugas be protected in Qaanaaq during summer (July–August) have been revised in light of the presumed North Water stock. The JWG now recommends that landed catches during all seasons be counted against the North Water stock quota.*



Projected median and 90% credibility interval for abundance in the North Water

Under **other business,** an update was given on the review of the impact assessment for Phase 2 of the Baffinland Mary River mine. The cumulative, combined and transboundary nature of the potential impacts related to icebreaking, shipping, and risk of ice entrapment were discussed. Recognising that there was insufficient time available to review the full impact assessment, the JWG **recommended** that an expert workshop be held to review the impacts of noise disturbance on hunted populations of narwhals, belugas and walrus from shipping connected to the Baffinland Mary River iron ore mine.

Additional recommendations: *Beluga*

Previous recommendations reiterated at this meeting (with a slight amendment based on the prevision of an assessment of a North Water stock) included:

- Implement the following seasonal closures:
  - Northern (Uummannaq, Upernavik, Savissivik): June through August
  - Central (Disko Bay): June through October
  - Southern (South of Kangaatsiaq): May through October
- In the area south of 65°N, no harvesting of beluga be allowed at any time.

New Recommendations for Conservation & Management

- Emphasise the importance of reporting on kill dates and locations.
- Carry out new surveys in Somerset Island in the summer and West Greenland in the winter.

New Recommendations for Research

- Collate the Canadian catch statistics required to develop a joint model at a future meeting.
- Present the latest research on senescence at the next meeting and investigate how this information may be incorporated into the population model.
- Perform a genetic analysis on samples from fall catches in the Qaanaaq area to establish their stock.
- Determine summer grounds and seasonal movements and distribution of the proposed North Water stock.
- Develop a joint beluga allocation model for the High Arctic/Baffin Bay population, that will consider Greenland/Canada movement data from tagging, dates and locations of kills, and abundance data.

MAIN REPORT

1. WELCOME AND OPENING REMARKS FROM THE CO-CHAIRS

1.1 WELCOME AND LOGISTICS

The co-chairs of the meeting, Cortney Watt (appointed by the Canada-Greenland Joint Commission on Narwhal and Beluga, JCNB) and Roderick Hobbs (appointed by the North Atlantic Marine Mammal Commission, NAMMCO) noted the exceptional circumstances surrounding this year´s meeting of the Joint Working Group and welcomed participants to the online event. A round of virtual introductions was made (see Appendix 2 for a list of participants), followed by information regarding the practical arrangements for communication and discussion through the online meeting platform.

1.2 APPOINTMENT OF RAPPORTEURS

NAMMCO Scientific Secretary Fern Wickson agreed to serve as rapporteur for the meeting, with assistance from participants as necessary.

1.3 REVIEW OF TERMS OF REFERENCE

The Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) was formed in 1989 via a Memorandum of Understanding between Fisheries & Oceans Canada, and the Ministry of Fisheries and Industry of the Greenland Home Rule Government. The role of the Joint Commission on the Conservation and Management of Narwhal and Beluga is to make recommendations to the Parties with respect to research, conservation, and management of shared stocks of narwhal and beluga. A Scientific Working Group was established to provide scientific advice as requested by the Joint Commission and to coordinate the exchange of data and assessment of research results.

The collaboration between the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga and the North Atlantic Marine Mammal Commission (NAMMCO) Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic is known as the Joint Working Group (JWG). This JWG met online from 26–30 October 2020.

The specific Terms of Reference of the 2020 online meeting of the JWG were to:

- review information on abundance, distribution, movements and harvest locations of narwhal and beluga;
- update and review the narwhal allocation model to assign harvested animals to individual summer stocks;

In addition to this online meeting, the JWG has an intention to hold a future in person meeting when travel restrictions have been lifted. The Terms of Reference that already exist for that meeting include:

- review the newest abundance estimate for East Greenland narwhal;
- assess the impacts of climate change on narwhal and beluga movements, distribution, population dynamics, habitat and hunt methods, timing and location;
- revise advice models to incorporate climate change impacts where information is available and identify additional information requirements.

An overview of the requests for advice from NAMMCO and the JCNB is provided in Appendix 5.

1.4 REVIEW OF AVAILABLE DOCUMENTS

Co-chair Roderick Hobbs drew participants' attention to the list of documents (available in Appendix 3) and noted that for each document listed, the relevant agenda item was also indicated.

1.5 ADOPTION OF AGENDA

Following a summary of the draft agenda from Hobbs, a change in the order of how the agenda items would be addressed was proposed by a member of the group. This report follows the structure of the draft agenda (see Appendix 1) rather than the order of discussion.

2. NARWHAL

2.1 NARWHAL STOCK STRUCTURE

2.1.1 Genetic information

A presentation was given by Marie Louis from the University of Copenhagen on the latest results from genetic analysis of narwhals.

Summary from Presenter

Low levels of population structure and genetic diversity have been reported for narwhals across their range using a small portion of the mitochondrial control region and microsatellite markers (Palsbøll et al. 1997; Petersen et al. 2011). In our study, we use Next-Generation-Sequencing to generate full mitochondrial genomes and nuclear genomes, which include millions of markers to infer population structure, demographic history and adaptation. Our work includes samples from all the stocks recognised by the Global Review of Monodontids (Hobbs et al. 2019).

Our results with the mitochondrial genomes (n=121) indicate that there is no geographical distribution of haplotypes (Louis et al. 2020), and that mitochondrial genomes cannot be used to discriminate among stocks. Narwhals, together with sperm whales, show the lowest ever recorded levels of genetic diversity in cetacean species. Low levels of genetic diversity are also found in the nuclear genome of narwhals (Westbury et al. 2019) and may be the result of a long-term low effective population size.

Nuclear markers are usually more suitable than mitochondrial data to infer population structure. Our nuclear study has unfortunately been delayed due to issues with our sequencing provider changing sequencing platform. This clearly impacted our study, in particular samples were clustering by sequencing platform in West Greenland. Due to these issues, we do not yet have results for the range-wide population structure of narwhals and the West Greenland and Eastern Canada stocks. Once we get all the data, our dataset will consist of 46 samples with a coverage (i.e. the number of times a DNA base in the genome is covered by sequencing data) of 1 to 4x across all the stocks, as well as low-coverage data (0.3x) from 100 individuals.

Preliminary results indicate three main populations of narwhals: West Greenland-Eastern Canada, East Greenland (Scoresby Sound in the summer) and North-East Greenland-Svalbard. We generated higher-coverage data (7-11x) from 25 individuals of these three populations to make inferences about demographic history, genetic health (levels of inbreeding, mutation load) and adaptation.

Another focus of our study is fine-scale genetic structure in East Greenland (n=26), and includes samples from North-East Greenland, Svalbard, Scoresby Sound in the summer and spring, Kangerlussuaq and Tasiilaq. Preliminary results indicate that the narwhals that summer in Scoresby Sound might be genetically isolated from the rest of the narwhals in the East Greenland, including the narwhals which enter Scoresby Sound in spring.

We have also analysed stable isotopes in bone collagen of West Greenland belugas and West and East Greenland narwhals for a project looking at the influence of sex and size on the long-term foraging ecology of both species (Louis et al. in review). Regarding population structure, our results show long-term differences (i.e. several years) in the foraging ecology of West and East Greenland narwhals in bone collagen, similar to short-term differences found in skin, which has a shorter turn-over of a few months (Watt et al. 2013).

To conclude, our genomic work on population/stock structure, and relevance for management, is in progress. Preliminary results indicate fine-scale genetic structure in East Greenland, to be confirmed with larger sample sizes. This work will be continued by Louis over the next two years as part of a postdoc project "From DNA to management: developing genomic tools for narwhal conservation" at the Greenland Institute of Natural Resources and the Globe Institute.

Discussion

Louis was asked whether it would be valuable to have enhanced sampling to increase the sample size for the genetic analysis. She answered that for narwhals in West Greenland, if there was a finer-level stock structure, it should be possible to see it with the data that is already available and that the focus for the analysis right now is on addressing issues associated with the sequencing service moving to a new platform. For East Greenland, she noted that the current focus was on analysing more of the already available samples to confirm or deny the patterns being observed. The JWG was informed that further information on the time of divergence would be available when the ongoing analysis is complete.

It was suggested that the structure illustrated in the preliminary results from East Greenland indicated the possibility that long-term behavioural patterns may become detectable as genetic differences and that it was interesting to consider what this may mean for other stocks.

It was highlighted that the preliminary genetic analysis presented for East Greenland provides a valuable confirmation of indications from telemetry data regarding stock structure in Scoresby Sound.

2.1.2 Satellite tracking

Marianne Marcoux from Fisheries and Oceans Canada (DFO) presented *Working Paper 16* "Update on the movement of narwhals from the Eclipse Sound stock (2016–2018)" (JWG/2020/16).

Summary from Presenter of JWG/2020/16

This paper provides new information on the movement of narwhals from the Eclipse Sound stock. Twenty-five narwhals were captured and instrumented with satellite tags in 2016–2018 in Eclipse Sound. Tracks from tagged narwhals were overlaid on top of traditional hunt locations. These data were used to determine the proportional availability of the tagged narwhals to the different hunt locations, for each season. Of the 25 tagged whales, 14 had data spanning the summer season, 24 had data spanning the fall, but only two tagged whales had data into the winter months. Maps of individual narwhal movement were shown and the proportion of narwhals tagged in Eclipse Sound that were available in the different hunting areas were presented. In the summer, 21.4% of narwhals tagged in Eclipse Sound between 2016–2018 visited the Arctic Bay hunting area during the summer. They visited the Arctic Bay (33.3%), the Baffin Island Center (78.6%) and the Baffin Island South (4.1%) hunting areas during the fall. Finally, they visited the Baffin Island Center (50%) hunting area during the winter.

Discussion

The evidence that some tagged whales are visiting two summering grounds, also supported by local Inuit knowledge, was noted as raising questions for the current approach to delineating management units. Differences in how countries, organisations and hunting communities may define the beginning of summer was noted as potentially relevant for further discussion of the matter. It was also considered important to have an understanding of the fraction of the areas used to determine whether and how this new information may affect management advice. Furthermore, a question was raised regarding how the tracks showing whales going close to defined hunting grounds, without going into them as such, should be interpreted.

It was noted as possible that because the tagging in previous years had been done in mid-August, it may not have been early enough to see the movements observed in the more recent data. It could, however, also be that the whales are behaving differently due to changes in the region, e.g. the Baffinland development or other environmental changes.

Although future tagging efforts are planned, the JWG was informed that these plans are currently being disrupted by COVID-19.

It was agreed that the new tagging data presented are suitable to be incorporated in the availability matrix of the allocation model.

2.2 NARWHAL ABUNDANCE

2.2.1 Recent estimates

2.2.1.1 Eclipse Sound

Marianne Marcoux from DFO presented *Working Paper 13* "Estimate of the abundance of the Eclipse Sound narwhal (*Monodon monoceros*) summer stock from the 2016 photographic aerial survey" (JWG/2020/13).

Summary from Presenter of JWG/2020/13

In August 2016, an aerial survey was completed to estimate the size of the summer stock of narwhal in Eclipse Sound. The survey was entirely based on aerial photography. Strip transect analyses were performed for the Eclipse Sound, Pond Inlet, Navy Board Inlet, and Milne Inlet strata. A density surface modelling approach estimated the abundance in the Tremblay Sound and Koluktoo Bay strata to accommodate the irregular survey track lines. Although other surveys of strata occurred, the stock abundance estimate was obtained by adding the stratum estimates from August 7–10, a relatively short period when all strata were covered. The abundance estimate, corrected for narwhals that could not be detected because they were submerged below 2 meters (correction factor of 3.18), was 12,039 (coefficient of variation (CV)= 0.23, 95% confidence interval (CI): 7,768–18,660). A Total Allowable Landed Catch of 117 narwhals was estimated using the Potential Biological Removal (PBR) method.

Discussion

The combined use of photo analysis and density modelling was emphasised as valuable.

Future analysis may consider using the overlapping sections of the aerial photographs to help estimate time at or near the surface.

The decision by the authors to use only data from August 7, 9, 10 was because complete coverage of all strata occurred over four days while the other survey days later in August did not cover all of the strata completely or in as short a time interval. This approach was supported and deemed precautionary by the Canadian National Marine Mammal Peer Review Committee. The JWG agreed with this approach and with the use of this abundance estimate in the allocation and population models.

It was brought to the attention of the JWG that a draft report prepared by Golder Associates Ltd. for the Baffinland Iron Mines Corporation with results from a 2019 Marine Mammal Aerial Survey in Eclipse Sound and Admiralty Inlet had recently become available. Given that this report is on the public registry and presents abundance estimates generated using a similar method and approach, the group agreed that it was relevant to have the report presented at the meeting.

Baffinland Aerial Survey Report

Marianne Marcoux from DFO presented *For Information Document 09* - the report on the 2019 aerial survey of marine mammals performed by Golder Associates Ltd. for Baffinland Iron Mines Corporation (JWG/2020/FI09).

Summary from Presenter of JWG/2020/FI09

Golder Associates Ltd., on behalf of Baffinland Iron Mines Corporation (Baffinland), completed an aerial survey in August 2019 designed to assess narwhal distribution and abundance in the Eclipse Sound and Admiralty Inlet areas. This survey was completed to fulfil requirements to operate the mine under Baffinland's project certificate. Survey design and data collection methodology closely followed methods that are currently adopted by Fisheries and Oceans Canada for their surveys. The survey included two components, a visual observers survey in the areas of low narwhal densities and a photographic survey in the areas of high narwhal densities. The visual survey was completed as a double platform mark-recapture analysis. The photographic survey was completed in Milne Inlet and Tremblay Sound. In these two strata, the photographs were covering the entire area (complete coverage). Narwhal abundance was estimated for three different survey repeats on Aug 21-22, Aug 25-27 and Aug 29-30 2019. For the Eclipse Sound areas, the stock abundance estimates were 7,765 (coefficient of variance (CV) of 0.04), 12,088 (CV= 0.08) and 4,879 (CV=0.06) for the three survey repeat. For the Admiralty Inlet stock, the abundance estimates were of 20,396 (CV=0.19), 19,918 (CV=0.44) and 17,621 (CV=0.21) for the three survey repeats. It was mentioned that Fisheries and Oceans Canada aims at surveying narwhal stocks between July 24 and August 24. Therefore, the first survey repeat corresponds to the same survey period as DFO survey.

Discussion

The JWG noted that the survey methods used were sound, thorough and largely aligned with the approaches used by the group. The fact that the estimates presented in the report fall within the confidence intervals of the latest estimates from DFO was also noted.

The JWG briefly discussed the different estimates presented in the report and which of these would potentially be most sound to use in population assessments. The authors of the Golder report advocate taking an average of the surveys carried out on August 22–23 and August 25–27. An alternative proposal made by JWG members, however, was to use the estimate from the first survey only since this survey was conducted within the period defined as summer by the JWG and within the same time period used by DFO to carry out surveys in the area. The JWG agreed that the aerial survey provided relevant data to include in future assessments. However, deciding exactly which estimate was most appropriate for use required further consideration of the report and discussion within the group.

The particularly low CV on estimates from the photographic survey, and the difference between this and the CV on estimates from the visual survey, were highlighted, with the concern that the uncertainty might be underestimated. It was noted that should the estimates from this survey be used in future assessments, additional CV calculations may be required.

2.2.1.2 Inglefield Bredning and Melville Bay

Rikke Hansen from the Greenland Institute of Natural Resources (GINR) presented *Working Paper 17* "Trends in abundance and distribution of narwhals (*Monodon monoceros*) on the summering grounds in Inglefield Bredning and Melville Bay, Greenland from 2007–2019" (JWG/2020/17).

Summary from Presenter of JWG/2020/17

Narwhal abundances were estimated from aerial surveys during summer in Melville Bay (MB) in 2007, 2012, 2014 and 2019 and in Inglefield Bredning (IB) in 2007 and 2019. Analyses were completed using Hidden Markov Line Transect (HMLT) techniques that take account of stochastic animal availability by using independent estimates of the availability process together with forward sighting distances as well as perpendicular sighting distances of sightings from a double platform design. The HMLT techniques do not assume certain detection at perpendicular distance zero; they assume only certain detection of animals that are available (i.e. not too deep to be seen) at radial distance zero. The estimation requires detailed information on the availability process, and this was obtained from a time-depth-recorder on a tagged narwhal from East Greenland with 1Hz sampling of depth during a sub-sample of 12 days.

Separate models were fitted to each survey. HMLT models were fitted to the MB 2012, 2014 and 2019 surveys but because no forward distances were available in 2007, a conventional distance sampling model was fitted to this survey, and the resulting abundance estimate "corrected" for *g(0)*<1 using the *g(0)* estimator of Laake et al. (1997) with a somewhat subjectively chosen forward distance, in a way that made it consistent with *g(0)* estimates from the fitted HMLT models.

Fully corrected abundance was estimated at 4109 (CV=0.21, 95% CI: 2738–6168) and 2874 (CV=0.21, 95% CI: 1938–4354) in Inglefield Bredning in 2007 and 2019, respectively.

In Melville Bay the abundance was 1834 (CV=0.92, 95% CI: 396–8500) in 2007, 915 (CV=0.44, 95% CI: 431–2141) in 2012, 1768 (CV=0.39, 95% CI: 864–3709) in 2014 and 4755 (CV=0.84, 95% CI: 1158–20,066) in 2019.

The abundance estimates were used to estimate trend in abundance between 2007 and 2019 and while there is a suggestion of an increase in abundance in Melville Bay since 2012, this is largely due to the highly uncertain 2019 estimate, and the estimated trend it is not significantly different from zero. The trend in Melville Bay is highly susceptible to the abundance estimate from 2019 where sightings on one transect line contribute about half the abundance estimate. The two estimates from Inglefield Bredning suggest a decrease in abundance, but this is also not significantly different from zero.

The distribution of sightings of narwhals in Inglefield Bredning were similar between years. The sightings in Melville Bay were concentrated in the central stratum in 2019, which is remarkably different from 2007 were narwhals were detected in all four surveyed strata. In 2012 narwhals were detected in three out of four strata and in 2014 in only two strata. The area on a stratum level where narwhals have been sighted has gone from ~16,400 km^2 in 2007 to 2,610 km^2 in 2019; a decrease in area usage of 84%. The average group size has not changed throughout the years but the distance between groups has dropped significantly after 2007. The large groups that are still available are in a smaller area, which can give the hunters the impression that the population is still large. However, the monotonic decline in area usage in the coastal part of Melville Bay observed between 2007 and 2019 may be an indication of a decline in the population.

Discussion

The JWG noted that the recalculated abundance estimates were lower than those produced through previous analyses. The value of different models for re-analysing survey data across different years was discussed, including how the available data may influence model choice, as well as how the choice of models and correction factors affects the abundance estimates generated. The JWG agreed that the significance of these issues warranted further and more in-depth discussion.

A question was raised regarding the validity of using data on the dive cycle from one whale from East Greenland as the basis for calculating an availability correction factor for narwhal populations in West Greenland given that dive behaviour may be different across populations. Data from this particular animal had been used because it had the longest period of detailed time-depth-recording data (>12ds). It was noted that although it may be possible to include data from tags with shorter records from East Greenland having data from tags deployed on populations in West Greenland might still show differences in dive cycles. It was, however, also noted that any regional difference in dive cycles might not generate different correction factors for instantaneous availability for detection in the 0–2 meter bin as longer dives require longer resting times on the surface (0–2m) and vice versa (but might affect analyses that take into account the time-in-view). It was emphasised that having dive data from animals in Inglefield Bredning and Melville Bay would be valuable.

It was also clarified that because of the variance in daily dive behaviour, the analysis presented did not use an average from the entire lifetime of the tag of the single animal, but rather took into account the day-to-day variability in diving behaviour.

The potential for dive behaviour to be correlated amongst individuals and whether such a correlation should then be incorporated in availability correction factors was also discussed. It was agreed that it would be valuable to see if dive behaviour was correlated through exploring existing tagging data (when multiple individuals are tagged concurrently) as well as more tagging efforts.

A question was asked regarding whether differences in ice cover may explain the variance in Academy Bay from survey to survey. It was noted in response that local knowledge suggests that the animals move in and out with the tide and therefore it may be relevant to look at the time of day between surveys to assess whether this may be a factor.

The possibility for a bias in the Inglefield Bredning analysis due to poor model fit was discussed but dismissed due to the high number of sightings and mark recapture rates. The possibility of integrating perception bias (i.e. mark-recapture) in hidden Markov models was also discussed. Again, the experience level of the observers was emphasised as leading to low perception bias (combined p>97%) in this case. Nonetheless, the group agreed that a further development of the hidden Markov approach that would use double-platform data to estimate perception bias would constitute an improvement.

The high CV on the abundance estimate for Melville Bay from the 2019 survey was linked to a high number of observations being on one transect line. How to handle such clusters in the analysis and modelling was highlighted as requiring more consideration and work. Having an estimate with such a high CV adds only little information to an assessment model that includes more accurate surveys, and therefore researchers at the GINR had also performed density surface modelling (DSM) for 2019. This work is presented below.

Results from Density Surface Modelling

Outi Tervo from GINR presented *Working Paper 19* "Preliminary results on estimation of abundance of narwhals (*Monodon monoceros*) using density surface modelling" (JWG/2020/19).

Summary from Presenter of JWG/2020/19

The visual aerial survey of narwhals in Melville Bay in August 2019 showed a high degree of aggregation of animals on a few transects in one stratum of the surveyed area. A Hidden Markov Line Transect Model (HMLTM) analysis provided an abundance of 4655 (CV=0.84, 95% CI: 1158–20066) narwhals (Hansen et al. 2020). The HMLTM analysis was highly sensitive to the inclusion of just one transect that had 2/3 of the sightings. It was therefore decided to analyze the survey with density surface modelling (DSM) where a smooth surface of the sightings over the survey region was fitted. The distance to coast of the sightings was included as an explanatory environmental variable in the density prediction. The modelled surface was low in areas without sightings and increased smoothly around the areas with higher densities. The predicted distribution of narwhals in Melville Bay in 2019 was concentrated in two small areas in the middle of the 5th and 8th transect line. The highest predicted abundance in a cell according to the model was 30 animals. The associated coefficient of variation of these estimates was greatest in areas with no sightings. Two distribution families were tested and the Tweedie distribution was selected to fit seven models. The total abundance for the survey area was calculated by summing the individual estimates from each cell and the seven models gave at-surface-estimates ranging between 767 and 1173 whales. Depending on model selection and acceptable level of degrees of freedom two models with an explained deviance >70% were selected. The at-surface-estimate from the two selected models were 931 (CV=0.44) and 767 (CV=0.38) with 14 and 22 degrees of freedom, respectively. The estimate of the survey-bias *g(0)* from the HMLT model was 0.41 (CV=0.10, Hansen et al. 2020). Dividing the abundance estimate with *g(0)* resulted in a fully corrected abundance estimate of 2271 (CV=0.45, 95% CI: 980–5263) or 1871 (CV=0.39, 95% CI: 890–3931) narwhals in Melville Bay in August 2019 dependent on model selection. In traditional line transect sampling (including HMLTMs) each transect is assumed to be representative of the density of the region as a whole, whereas DSM acknowledges environmental stratification affecting animal density. Whether DSM is the best modelling approach for aggregated data, as observed in Melville Bay in 2019, should be explored. Similarly, the effect of user increased flexibility and addition of variables in the models to the at-surface abundance and associated coefficient of variance estimates requires further investigation.

Discussion

The work on the DSM analysis was praised as well executed. The JWG did, however, discuss some of the methodological choices and particularly trade-offs between overfitting and the resulting estimate.

While it was agreed that DSM can be useful for working with the constraints arising from relatively small populations, having relatively few data points was also seen as challenging as there are not a lot of points to inform habitat relations. It was, however, emphasised that DSM can also just work to account for spatial variance. It was proposed that the author also try DSM with a richer data set, from previous surveys in Melville Bay.

The value of using an adaptive sampling approach to handle the high number of sightings on one transect line was discussed (e.g. by adding transect lines on either side of the line with dense sightings and/or switching from visual to photographic mode when large groups are encountered). The JWG was informed that adding extra transect lines had not been done in this case because the transect lines were already considered to be relatively close together and trying to achieve consistency of effort with that from earlier surveys had been prioritised. It was proposed that in future survey efforts, consistency could be maintained by including additional transect lines and then performing the analysis with and without them. It was also noted that some lines could be removed from the analysis of different surveys as a simulation exercise. The JWG was informed that impact of removing some transect lines from the analysis had been examined in the distance sampling, but not in the DSM.

Following this discussion, it was noted that although DSM has become standard, it contains significant flexibility in the approaches and parameters used, which can result in subjective choices on how it is implemented in practice. It was therefore noted as valuable for the JWG to agree on some guidelines or rules of thumb for its use.

2.2.2 Review of corrections for availability and perception bias

The JWG agreed that a review of the corrections for availability and perception bias required enhanced and focused attention by an intersessional Quantitative Subworking Group (QSG). The terms of reference for this QSG were developed and agreed (see Appendix 4). The QSG will report their conclusions at the next meeting of the JWG (proposed to take place during late summer or fall of 2021) when a new narwhal assessment will also be carried out to deliver management advice.

2.3 NARWHAL CATCH STATISTICS

2.3.1 Review by management units

2.3.1.1 Canada

Cortney Watt from DFO presented *Working Paper 4* "Catch statistics for narwhal in Canada 1970–2019" (JWG/2020/04).

Summary from Presenter of JWG/2020/04

Catch statistics from 1970–2019 for 13 Canadian communities that hunt narwhals from the Baffin Bay population are reviewed. Detailed statistics by community are missing from some of the communities, particularly before quotas were implemented in 1977. In these cases, an average value calculated from reported hunts in the following 10 years is used as approximation. Many catches were reported with date of kill, which allowed a separation of hunt statistics across seasons. Catches were then divided into seasons for all years. When date of kill was not reported, as with total catch, we averaged catches over the next 10 years to estimate catch by season. Finally, catches were attributed to 6 different hunting regions in Canada, including Grise Fjord, Central Canadian Arctic, Arctic Bay, Pond Inlet, Baffin Island Central, and Baffin Island South and assigned different struck and loss corrections by period (1979–1989, 1990–2004, and 2005–2019), and when possible by type of hunt (open water, ice edge/crack), and community. The results can be used for data modelling purposes and thereby provide more reliable estimates of sustainable hunt management advice.

Discussion

Whether there were any trends visible in the catch statistics was questioned. The JWG was informed that although hunters report that changes are taking place and this is now being analysed, there does not appear to have been significant changes over the last 5 years. However, there have been anomalous events. This includes a high catch in Grise Fjord in 2017, which was actually the largest reported catch in the series, although the catch level did not stay high in the last 2 years. Pond Inlet also had an anomalous year in 2018, with not many whales available, however availability increased again in 2019.

It was noted that the same struck and lost rate is used across different types of hunts (i.e. ice crack, floe edge and open water hunts). It was clarified that the research done in the 1980s on struck and lost examined rates for different types of hunts; however, the more recent community monitoring program did not. Information on the type of hunt is not included in hunter reports but some inferences may be made based on the season.

The JWG agreed to accept the catch statistics presented for use in the population models.

2.3.1.2 Greenland

Eva Garde from GINR presented *Working Paper 11* "Update on catch statistics for narwhal, *Monodon monoceros*, in Greenland, 2005 to 2019" (JWG/2020/11), as well as *Working Paper 10* "Narwhal hunting in Melville Bay, West Greenland, 2005–2019" (JWG/2020/10).

Summary from Presenter of JWG/2020/11

This paper is an update on 'Narwhal, *Monodon monoceros*, catch statistics in Greenland, 1862–2017' from Garde et al. (2019). It consists of updated catch statistics from the Special Reports (2020) for the period from 2005–2019. A database with revised and quality assured catch statistics from the Special Reports for the years 2005–2019 was provided by the Government of Greenland in February 2020 and this is now considered to represent the official catch statistics for narwhals from 2005–2019. The revision of catches has, however, resulted in altered catch numbers especially for the early years (2005–2009). As a consequence, there are some differences between catch numbers presented in Garde et al. (2019) and the catch numbers presented in the present paper. Discrepancies in catch numbers are highest for the early years and are probably a result of the transition from the previous catch reporting system (Piniarneq) to the current system from 2005 (the Special Reports). For assessments, catches published in Garde et al. (2019) should be used through to 2015. From 2016 to 2019, catches in the present paper should be used. From 1993 to 2010, catches in Siorapaluk were subtracted from the catches in Inglefield Bredning as they were assumed to be from the Smith Sound stock; in 2011 this practice was, however, changed to allocate any catches with location data north of Siorapaluk to the Smith Sound (Garde et al. 2019). In the present paper, catches from Siorapaluk are in Table 2 included in the Inglefield Bredning Stock from 2005–2019, as has been the practice since 2011 while in Table 4, Siorapaluk has been included in the Smith Sound stock (Etah and Siorapaluk) and thus subtracted from catches from Inglefield Bredning (= Qaanaaq, Qeqertat and Moriusaq). It was roughly assessed, based on information on hunting location from the Special Reports (2020), that about 1/3 of catches from hunters from Siorapaluk are taken at Etah and 2/3 are taken in Inglefield Bredning.

Summary from Presenter of JWG/2020/10

Narwhals in Melville Bay are hunted by Greenlandic hunters from Upernavik and Savissivik. In the 'Nature Reserve Melville Bay' narwhal hunting is restricted/prohibited. In this paper, catch data from 2005–2019 from the Greenland catch reporting system the Special Reports (2020) were used to split narwhal catches into time periods and hunting locations within Melville Bay. Besides information on time and location of the hunt, the Special Reports also provide data on hunting method, sex and age of the animal and presence of a foetus, which was used to investigate hunting methods used per month and through time, the proportion of females in the hunt, and the pregnancy rate. In the period 2005–2019, 1337 narwhals were reported taken in Melville Bay, 50% were taken during summer (July, August and September) and 1271 of the catches could be assigned a GPS position based on information on hunting location. Number of catches taken per year were fluctuating with a slightly decreasing trend during the period. In three time periods (2005–2011, 2012–2013, and 2014–2019), the proportion of catches taken in summer (July–September) within the Nature Reserve Melville Bay increased from 18% to 24% and 36%, respectively. The hunt in Melville Bay peaks twice a year; in spring (from dinghies) and in summer (from qajaqs) but during 2005–2012 the majority of catches were taken during summer while from 2013–2019 most catches were taken in spring. The number of catches taken annually from qajaq has decreased, while the number of catches from dinghies has increased in the period from 2005 to 2019. One third of the catches taken in Melville Bay were females and it was assessed that 83% were sexually mature. The overall pregnancy rate for the period from 2005–2019 was 18%, but the monthly rate ranged from 8% (September) to 31% (April) for sample sizes ≥ 5 mature females. The results gained from data from the Special Reports need to be further assessed regarding the sexual status of the females and pregnancy rates before this information can be used in assessments. In conclusion, through the period, narwhal hunting in summer seems to have moved northwards, the area of hunting has diminished, and hunting occurring within the Nature Reserve Melville Bay has increased. The reduction in distribution that appears from both hunters' registrations and from aerial surveys could be caused by a reduced abundance of whales.

Discussion of JWG/2020/10

The JWG was informed that Canada asks for length and sex data when sample kits are sent in and analysis has revealed significant discrepancy between the reported sex and genetic sex. It was suggested that while sex is often determined based on the presence or absence of a tusk, reports may be more accurate in cases where all organs of the animals are used. The JWG was informed that although this practice is more common in Greenland than Canada, the extent to which it is done can also vary with the location of the hunt. To assist with accurate determinations of maturity, the JWG **recommended** that reports from hunters in both Greenland and Canada include the body length of the animal.

Whether killer whales may be playing a role in the apparent reduction of inhabited area was discussed. The JWG was informed that there is no quota or regulated hunt of killer whales in the area so information is limited. There was a large catch in the area in 2011 but in general, there has only been a relatively small increase in killer whale catches in West Greenland since 2007. Therefore, killer whales were not thought to play a significant role in explaining changes in distribution for narwhals.

The JWG also discussed whether the gradual decline in narwhal takes in the summer could be linked to an increase in hunting effort required by each hunter. The JWG was informed that due to data privacy laws, the names of those engaged in narwhal hunting is not able to be shared by the administration. The reduction of catches during summer can be a result of quotas being used up during spring. The reported spring catch is around Upernavik, where the animals are close to the town and subsequently less effort may be required.

The JWG was informed that the spring hunt has been increasing and that the whole quota is now often taken within this season. This can lead to "extra quota" being awarded by the authorities throughout the year. It was noted that this extra quota was not included in the presented graphs. It was proposed as potentially valuable to assemble an overview of advice given, quota allocated, extra quota given, and catch in the different areas over time.

The JWG noted that narwhal hunting within parts of the reserve is permitted through a special executive order that gives permanent residents the possibility to hunt using a limited range of methods. However, it was also agreed that it was important to draw attention to the fact that the level of hunting taking place within the Melville Bay Nature Reserve has increased from 2005–2019.

It was mentioned that locals have reported an increase in the sightings of narwhals close to Upernavik in summer in the last few years.

The JWG agreed to accept the catch statistics presented for use in the population models.

2.4 REVIEW OF MANAGEMENT MODEL STRUCTURE FOR NARWHAL

The JWG agreed that a review of the management model required the focused attention of the intersessional QSG. The terms of reference for the QSG were developed and agreed (see Appendix 4). The JWG Co-Chairs will coordinate the meetings of the QSG. The QSG will report its conclusions to the next meeting of the JWG (proposed to take place during late summer or fall of 2021) when a new narwhal assessment will also be carried out to deliver management advice.

3. BELUGA

3.1 BELUGA STOCK STRUCTURE

3.1.1 Genetic information

A presentation was made by Mikkel Skovrind from the University of Copenhagen on "Belugas of the western Atlantic: Applied genomics in beluga management".

Summary from Presenter

Beluga genetics has played an important role in the management of belugas in the north-west Atlantic Ocean for close to three decades, and traditional genetic markers such as the mitochondrial control region and microsatellites have been applied to thousands of individuals (Brown Gladden et al. 1997; Brown Gladden et al. 1999; Turgeon et al. 2012; Colbeck et al. 2013).

However, these markers only represent a small fraction of the genetic variation found across the ~2.4 billion base pairs of the beluga genome, and rely on frequency-based analyses of large sample sizes (Skovrind et al. 2019). However, over the last decade, technological advances and cost reductions have enabled the sequencing of genome-wide data, an approach which is yet to be applied in beluga management.

At the University of Copenhagen, as part of our beluga genomics research project, we have sequenced 135 individuals sampled across 13 different locations in Greenland and Canada (St Lawrence Estuary, Frobisher Bay, Cumberland Sound, Qeqertarsuaq, Qaanaaq, Grise Fjord, Cunningham Inlet, Repulse Bay, Arviat, Churchill, Nelson River, James Bay and Nastapoka) (Figure 1). For these samples, we have generated low-coverage nuclear genomes (0.5-3x) and identified ~2.5 million variable sites. As part of our research, we are investigating the population differentiation of belugas in the western Atlantic region, potentially of interest to the committee.

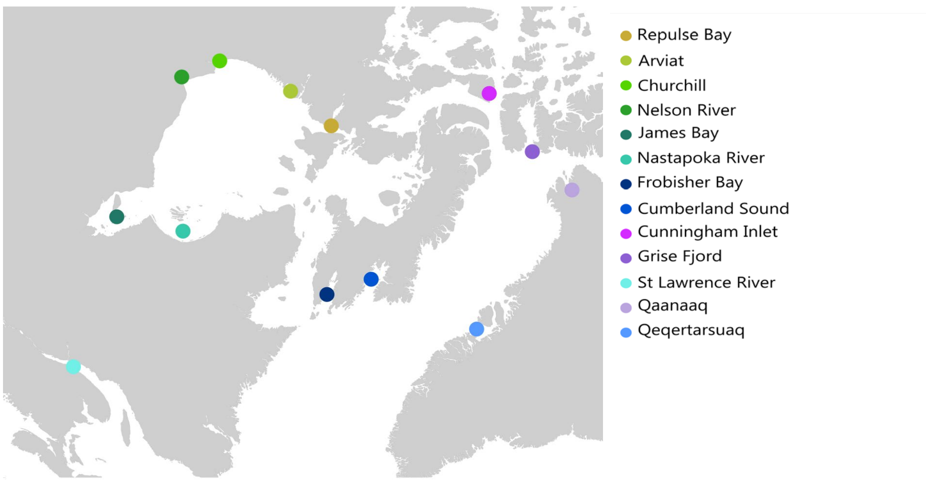


Figure 1. Western Atlantic sample localities

Preliminary results indicate that there are five main, genetically distinct groups of belugas in the western Atlantic.

Group 1) all samples from the St Lawrence Estuary;

Group 2) all samples from James Bay;

Group 3) all samples from Repulse Bay, Arviat, Churchill, Nelson River, Nastapoka and Frobisher Bay, and one sample from Grise Fjord;

Group 4) all samples from Qeqertarsuaq and Cumberland Sound, and three samples from Grise Fjord;

Group 5) all samples from Qaanaaq and Cunningham Inlet, and five samples from Grise Fjord.

However, fine-scale analyses indicate further substructuring within group 4, separating samples from Qeqertarsuaq and Cumberland Sound. There is also a fine-scale subdivision within group 5, separating samples from Qaanaaq and Cunningham Inlet. It is further indicated that the Grise Fjord samples in group 4 cluster with the Qeqertarsuaq and not the Cumberland Sound samples and that the Grise Fjord Samples in Group 5 cluster with the Cunningham Inlet and not the Qaanaaq samples. However, it should be noted that these are preliminary results that will need further validation.

We are further pursuing population genomic research at the University of Copenhagen, and continue to analyze the nuclear data, which will be prepared for scientific publication in the coming months. The planned activities include sequencing of high-coverage genomes from James Bay, Cunningham Inlet, Qeqertarsuaq and St Lawrence Estuary. Combined with the existing genome from Churchill, the high-coverage genomes will enable us to estimate divergence times between the genetic groups and identify local genomic adaptation. We will also be able to estimate historic changes in population size and quantify the accumulation of harmful mutations in each group.

In addition to the analysis of the nuclear genomes, we have analysed the mitochondrial genomes of a global dataset of 206 individuals, which includes the 135 individuals from the western Atlantic detailed above. These results are included in a manuscript titled "Circumpolar phylogeography and demographic history of beluga whales reflect past climatic fluctuations", which is currently under review in a scientific journal and will hopefully be published soon.

Discussion

The JWG agreed that this work was both interesting and important for management. In the discussion, the significance that one sample can have in this type of analysis was highlighted and the possibility to include additional samples asked. It was noted that while it is difficult to include new individual samples in this type of analysis, which primarily aims to establish a baseline of knowledge, once this is established, it becomes easier to examine new individual samples. The ability to assess individual samples to identify stock was highlighted as particularly important for cases such as Cumberland Sound, where there are disagreements regarding where the hunted animals are coming from, which has important implications for management.

It was also emphasised as particularly important for Greenland to know if the animals being hunted in Qaanaaq are harvested from a population inhabiting the area all year round. The JWG was informed that all the samples analysed from Qaanaaq in the study presented were from hunts carried out in April. Migration patterns observed in the past have indicated that animals do not move from East Canada to Greenland until late September so this supported a belief that there is a population overwintering in the North Water and that it is unknown if the animals hunted in the summer are from the same stock as those caught in the fall. The JWG was informed that Greenland is now asking for a specific assessment of the hunt in Qaanaaq and therefore it was important to know from which stock the summer hunt may be being taken from. Given that the recent genetic analysis and survey data are implying a potential for there to be a stock spending summer in the North Water area, the need to take a precautionary approach was emphasised. It was, however, also noted that the genetic analyses presented at the meeting were still preliminary unpublished results and more research may be required to change current approaches to management.

Related to the possible explanations for some of the interrelations between stocks indicated by the genetic analysis, the JWG was reminded that while one explanation was ongoing geneflow between the groups, another was a shared evolutionary history in which a single population went on to populate different areas. This means that what is seen in the genetics may not reflect a contemporary situation of genetic exchange, but rather an event in the past.

Productive areas for future work were highlighted. This included: a) collection and analysis of samples from the late summer/fall hunt in Qaanaaq, to determine whether those are the same whales hunted during spring/early summer in the North Water Polynya, b) analysis of historical samples from extirpated stock of Southeast Greenland (from the Natural History Museum of Denmark), c) inclusion in the analysis of the unusual genetic signatures found in samples taken from ice entrapment events in southern Hudson bay (Belcher Islands), indicating a possible relationship to the St. Lawrence stock, d) adaptations present across genetically divergent groups, e) the inclusion of additional groups in the analysis aimed at estimating time of divergence, and f) the development of a relatively simple toolkit for facilitating analysis that does not require full genome sequencing, such as a global snip panel. In a general sense, it was also noted that enhanced collaboration between the researchers performing the genetic analysis, those collecting the samples, and those with knowledge of the biology and ecology of the animals would be a valuable way to build a more comprehensive picture for informing future decisions on stock structure.

3.1.2 Satellite tracking

There were no new updates from either Greenland or Canada on tagging efforts. However, during the review of abundance estimates, the discussion turned to tagging for the purpose of developing correction factors.

The JWG was informed that Canada is recommending new tagging activities (e.g. around Somerset Island), while there are no current plans to attempt tagging of belugas in West Greenland, which is very difficult to do in practice. Canada noted that it is moving towards the use of less invasive tags, but that there is a concern that these tags will not last as long and may not be able to track the animals all the way to West Greenland (although it was highlighted that even if deployed during the hunting season, tags lasting 3 months would still give useful information). Acknowledging that the tag retention time in Canada had declined in recent years, the JWG **recommended** holding a half day discussion/workshop during the next meeting to share information on tagging practices. It was suggested that colleagues tagging beluga in Svalbard, Alaska and Russia could also be invited to contribute.

3.2 BELUGA ABUNDANCE

3.2.1 Recent estimates

Hansen from GINR presented *Working Paper 15* “Abundance of narwhals and belugas in the eastern part of the North Water in April 2018” (JWG/2020/15) (as well as For Information papers 3 and 4) on behalf of the first author Mads Peter Heide-Jørgensen who was unable to attend the meeting. The presentation was noted as being particularly motivated by the new request from Greenland for a specific assessment of the Qaanaaq hunt.

Summary from Presenter of JWG/2020/15

A visual aerial survey of the abundance of belugas was conducted in the eastern part of the North Water (Smith Sound) in April 2018. The survey was conducted with the same double observer procedures used in a previous survey in April 2014 in the same area, and the data were analysed with standard strip census and mark-recapture line transect methods and corrected for both availability and perception bias when possible. Belugas were primarily found in the central part of the surveyed area whereas narwhals were detected both further north and south. The beluga abundance was calculated from 44 sightings with mark-recapture distance sampling, whereas a single sighting of a group of 71 animals was treated separately in a strip census analysis. The fully corrected combined result of the two estimates was 2063 (CV=0.81, 95% CI: 513–8289) belugas. Abundance estimates are similar to estimates from an earlier survey in 2014.

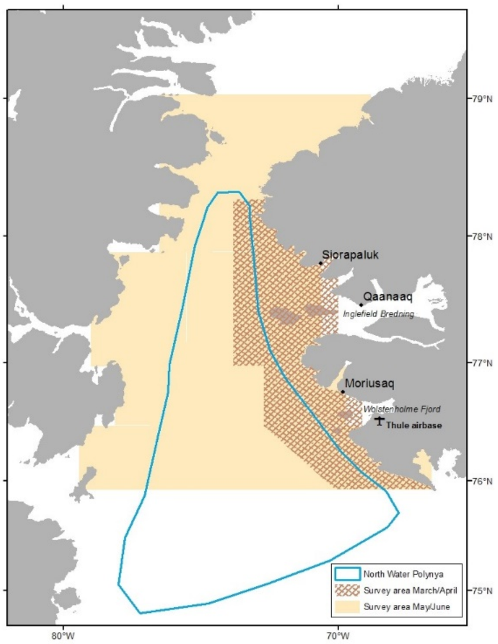


Figure 2. Survey areas for beluga whales in the North Water polynya

Discussion

Clarification was sought on exactly how the large group had been included in the estimate as the method for this was not clear in the working paper. A revised version of the document was presented to the group, which explained that the approach amounted to a stratification by group size.

Three methods of calculation were presented in the Working Paper, with the proposal to use the estimate generated by the MRDS approach. After reviewing the revised paper, the JWG agreed that the abundance estimate generated through the MRDS model was the most reliable for use in the assessment.

Comparing the results obtained from MRDS with density surface modelling was proposed as potentially informative future work to enhance confidence in abundance estimates involving either few sightings and/or large groups. Where large differences in the estimates are observed through such a comparison, further investigations into how best to handle the data become important. While it was agreed that this cross-model comparison could be valuable, it was noted that on its own, this would not solve the specific issue of how to handle rare large group encounters. It was also noted that for narwhals, DSM had been carried out because of the high CV on the estimate, which was not the case for belugas.

The JWG was informed that although a winter survey had been planned for West Greenland in 2022, it was unclear how disruptions due to the coronavirus may affect the plans for future years. It was noted that the last survey of the Somerset Island stock in Canada was carried out in 1996 (over 20 years ago) and that the JWG had not yet discussed the implications of using surveys older than 10 years. The JWG **recommended** that new surveys be carried out in Canada (Somerset Island) in the summer and West Greenland in the winter.

3.3 BELUGA CATCH STATISTICS

3.3.1 Update by management units

3.3.1.1 Canada

Cortney Watt from DFO presented *Working Paper 5* "Landed catches of beluga whales reported by select Nunavut communities since 2011" (JWG/2020/05).

Summary from Presenter of JWG/2020/05

Catch statistics from 1977–2019 for 12 Canadian communities that hunt belugas from the Baffin Bay beluga population and one community that hunts from the Cumberland Sound beluga population are summarized. Struck and lost corrections of 0.41 and 0.36 are applied to the Baffin Bay and Cumberland Sound beluga catches, respectively, to estimate total whales removed from the populations each year. Community and hunt specific struck and lost information should be collected to improve estimates. The results can be used for data modelling purposes and thereby provide more reliable estimates of sustainable hunt management advice.

Discussion

In addition to the data on the number of catches, reports from hunters are supposed to contain the sex of the animal as well as the date and location of the catch. It was noted that while this information is regularly received for narwhal, it is less often provided for beluga. Where it is provided, location information is often given on a community level rather than as GPS coordinates. This type of additional information on catches was still being processed by DFO and was therefore not available for this meeting. The JWG **recommended** that the importance of reporting on seasonal dates and locations for the catches be emphasised in communications with the hunters.

It was highlighted that the model-based estimation of struck and lost (as employed for Cumberland Sound) usefully also estimates unreported catch. Given that there is no quota for the high arctic beluga stock, there may be a high unreported harvest rate and therefore using the modelled estimate is important. It was noted that although there was a community-based monitoring program with reporting on struck and lost for narwhals (1999–2005), no similar program had been run for beluga. Without a quota system in place for the high arctic stock, it may be argued that such community-based monitoring programs will not be prioritised. However, given that the rate of struck and lost is a sensitive subject within the communities, it could also be argued that this is a good time to investigate the issue as reporting will have no perceived penalty for quota allocation. Observations from the field of bullet scars and long-lasting wounds on some animals indicate that some struck animals do survive, although it is very difficult to know the death/survival rates following strikes.

The JWG agreed to accept the catch statistics from Canada for use in the population assessment model.

3.3.1.2 Greenland

Eva Garde from the GINR presented *Working Paper 12* "Update on catch statistics for belugas, *Delphinapterus leucas*, in Greenland, 1993–2019" (JWG/2020/12).

Summary from Presenter of JWG/2020/12

This paper is an update on a previous working paper "Catch statistics for belugas in Greenland 1862 to 2016" (Heide-Jørgensen & Garde 2017). It consists of updated catch tables for the period 2016 to 2019 based on beluga catch data from the Greenlandic catch reporting system the Special Reports (2020, which includes the official catch statistics for belugas from 2005–2019). Beluga catches were split by municipality, where 'Qaanaaq' includes catches from Qaanaaq and Savissivik and by area where 'North' includes catches from the municipalities of Qaanaaq, Upernavik and Uummannaq. Catches of beluga were also split into the two proposed beluga stocks in West Greenland: The North Water stock (north of Cape York and including catches from Qaanaaq, Qeqertat and Siorapaluk) and the West

Greenland stock (including catches from Savissivik and south). The hunt in the municipality of Qaanaaq includes: 1) catches in the fall that are possibly whales from the Somerset Island summering stock migrating towards the wintering ground in West Greenland and therefore possibly part of the same stock that is exploited in the rest of West Greenland (during winter and spring). The catches in fall could potentially or in part also be from the stock wintering (possibly summering) in the North Water area, 2) catches in spring (May) and summer (June–August) from the stock in the North Water. The monthly distribution of the catches indicates the relative contribution of the two stocks and Savissivik is solely exploiting the fall migration of belugas that are moving along the coast towards West Greenland. Catches in Qaanaaq (incl. Qeqertat and Siorapaluk) were previously (2006–2012) dispersed over a longer period of the year with a peak in September (28%), when the whales were moving south along the coast. In later years (2013–2019), it seems that the timing of the catch in Qaanaaq has changed to most catches being taken in October (67%), although this is not statistically significant. Approximately one hundred belugas were taken in Qaanaaq in October 2019, but even with an exclusion of 2019 data, the timing of the catch (2013–2018) seems to have changed to later in the year with 33% taken in September and 38% in October. From 2006–2012, catches in spring (18%, May) and summer (44%, June–August), which are supposedly supplied by the North Water stock, constituted a larger part of the total annual catches than in later years (2013–2018/19), where only 4% (May) of catches were taken in the spring and <10% taken during summer (June–August). In conclusion, catches of belugas in spring and summer probably originate from the (isolated) wintering and possible summering stock of belugas in the North Water while the hunt in the fall may originate from the Somerset Island summering stock that migrates towards the wintering ground in West Greenland. However, the fall catches could potentially or in part be whales from the North Water stock. The proportion of North Water belugas taken in spring and summer in Qaanaaq seem to have decreased from 2006 to 2019, although this is not statistically significant. Savissivik is solely exploiting the fall migration of belugas that are moving along the coast towards West Greenland.

Discussion

It was noted that catches taken in the fall in the Qaanaaq area (north of Cape York) could originate from a stock that spend summer in this area. However, this is not known for sure and DNA analysis on samples from the fall catch are important to check this assumption. The JWG **recommended** that genetic analysis be carried out on fall catches from the Qaanaaq area.

Hunting in the Qaanaaq area is opportunistic, with apparent changes in the availability of whales to the hunters over the years. It was proposed that the catch variation may therefore be indicative of large groups entering the area rather than any change in abundance *per se*. According to a precautionary approach, it is currently assumed that this catch is from a local population in the North Water area. However, the JWG agreed and reemphasised that genetic analysis of the catches taking place in the fall in Inglefield Bredning is important to establish what stock they are being taken from.

It is unclear whether the whales that are counted during the winter and spring North Water surveys are also summering in the area or elsewhere. The JWG noted the need to examine whether beluga in the North Water (north of Cape York) are a separate population and decided to use a precautionary approach where this aggregation is treated as a separate stock in the assessment.

The JWG agreed to accept the catch statistics for use in the population assessment model.

3.4 DEVELOPMENT OF MODEL STRUCTURE FOR BELUGA

3.4.1 Review of beluga analysis

3.4.1.1 West Greenland

Lars Witting from the GINR presented *Working Paper 7* "Assessment of beluga wintering off West Greenland - 2020" (JWG/2020/07).

Summary from Presenter of JWG/2020/07

The JWG updated the assessment of beluga wintering in West Greenland based on new catch data. Where earlier assessments advise on total removals, JWG/2020/07 follows request 1.6.5 from the NAMMCO Council (2017) to provide advice with recommendations on total landings instead. This was done by including struck and lost animals through a prior on the catch history of landings, with the posterior distribution on struck and lost being integrated out during the calculation of a sustainable number of landed animals.

The catch history was re-estimated to include catches only from Savissivik and south, separating the stock component that winter in West Greenland from the component in the North Water. Assuming an initial abundance below carrying capacity, the model estimates a population of 19,800 (90% CI: 14,700–28,800) individuals wintering in West Greenland in 1970. The projection declined initially by 54% (90% CI: 68%–35%) to an abundance of 9,250 (90% CI: 6,730–12,800) animals in 2004. It then increased by 37% (90% CI: -18%–93%) to 10,900 (90% CI: 6,280– 16,500) individuals in 2021. The assessment estimates a 70% chance of increase given an annual landed catch of 265 individuals.

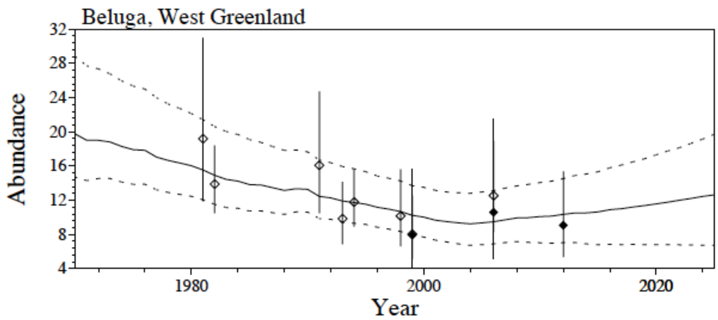


Figure 3. Projected median and 90% credibility interval for abundance

Discussion

The JWG discussed and approved the changes made since the last assessment, i.e. changes to a beta prior on catch loss rates and integration of the struck and lost rate directly in the model output.

Significant discussion was had regarding the values used for age of maturity in the model. The difference between the age at which the first females become mature, and the median age of maturity (reflecting the whole distributional spread) was clarified. However, the accuracy of the age of first maturity was discussed in relation to recent knowledge and published data from other areas. It was also noted that age of first pregnancy is not necessarily the same as age at first successful reproduction, which means that it may be more precautionary to assume an older rather than a younger age at maturity. The JWG agreed that based on current information, the model should use an age of first maturity range from 6-8 years and median age of maturity between 7-13 years.

Questions were asked regarding whether senescence should be included in the model, given recent research (and publications in press) indicating the presence of this within beluga populations. Relatedly, whether the shape of the maturity curve accurately represented biological realities was also discussed. Noting that it would be difficult to include senescence in the assessments performed during this meeting, the JWG **recommended** that the new research be presented at the next meeting (following publication) and how this information may be incorporated into the population model investigated then.

3.4.1.2 North Water

Until now, there has not been any assessment of belugas in the Qaanaaq area, only an informal advice that catches at the current level are sustainable. Given the rarity of sightings in Qaanaaq in summer though, it has been proposed that belugas should be protected during the summer period. Following the request from the JCNB to develop an allocation model for beluga, including a request for advice for the Qaanaaq area, a separate assessment for beluga in the North Water (north of Cape York) was presented.

Lars Witting from the GINR presented *Working Paper 6* "An assessment model for beluga in the North Water - 2020" (JWG/2020/06).

Summary from Presenter of JWG/2020/06

JWG/2020/06 presented the first assessment for the aggregation of beluga in the North Water, treating it as a separate stock, and following the same premises and modelling framework as applied to West Greenland beluga over the past 15 years. The assessment includes four fully corrected abundance estimates from 2009 to 2018, and it assumes that catches taken north of Cape York relate to the stock component of beluga in the North Water.

The population model estimates an abundance of 1,690 (90% CI:932–2,820) beluga in 1961, with an increase to 2,300 (90% CI:1,640–3,200) individuals in 2021. It estimates that an annual landing of 37 beluga taken north of Cape York gives a 70% probability that the stock will increase (or takes that are no larger than 90% of the maximum sustainable yield should the aggregation be above the maximum sustainable yield level).

Discussion

The assessment paper included both an exponential and density regulated model. The JWG agreed that the density regulated model was preferred over an exponential model since it represented a more precautionary approach and should therefore be used to provide management advice in this case.

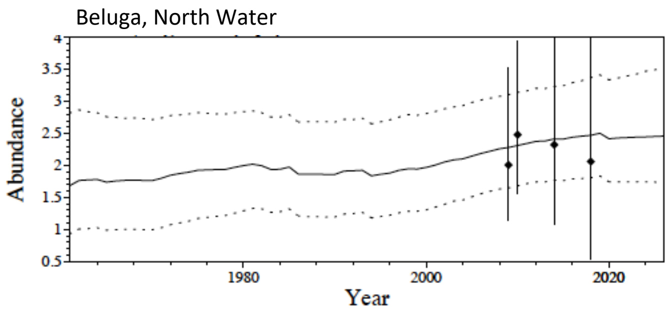


Figure 4. Projected median and 90% credibility interval for abundance

3.5 BELUGA MANAGEMENT ADVICE

The JWG reemphasises that in contrast to previous years, the management advice provided here refers to total landed animals rather than total removals.

West Greenland

The estimated relationship between the total landed catch per year (from 2021 to 2025) and the probabilities for a population increase are provided in Table 1. To maintain a 70% probability for population increase, the assessment for West Greenland recommends an annual landed catch of no more than 265 individuals south of Cape York and north of 65°.

The JWG also **reiterated** advice from 2005 and 2012 (with a slight amendment to account for the new North Water assessment presented below) and **recommended** the following seasonal closures:

- Northern (Uummannaq, Upernavik, Savissivik): June through August
- Central (Disko Bay): June through October
- Southern (South of Kangaatsiaq): May through October.

Furthermore, the JWG also **reiterated** its previous **recommendation** that for the area south of 65°N, no harvesting of beluga be allowed at any time.

It was again highlighted that the function of these closures is to protect the few beluga that may remain from historical summer aggregations in Greenland, and to allow for the possibility of reestablishment of the aggregations.

Probability of Meeting Management Objectives	***Landed Catch of Belugas in West Greenland***
0.50	354
0.55	333
0.60	313
0.65	289
0.70	265
0.75	242
0.80	217
0.85	186
0.90	154
0.95	113

Table 1. Total allowable annual landed catches in West Greenland at various probabilities of meeting management objectives. The simulated period is from 2021–2025 and the fraction of females in the catch is assumed to be 50%.

Discussion

A landed catch of 265 beluga, plus the average struck and lost from the model of 13%, reflects a total removal of around 300 individuals. This advice is slightly lower than the total removals of 320 and 310 estimated as giving 70% probability of population increase by the assessments in 2015 and 2017. It was clarified that while the projected median increase in abundance over the period from 2015 generates an increase in the number of sustainable removals, the increased uncertainty of the projection (partly following from an abundance estimate that is eight years old) generates a decline. An additional decline follows from the splitting of the catch history between the North Water and West Greenland; with fewer whales taken historically from West Greenland, the assessment model compensates with a lower estimate of production in the population. It was noted that when the recommended catch for the North Water is added to this advice for West Greenland, the recommendation is actually for a higher level of catch than given in the previous advice. It was also emphasised that this recommendation is also higher than the level of actual catch in the area. The average catch per year over the last 5 years has been 173 animals. Furthermore, the recommended catches are now for landed animals, while struck and lost animals needed to be subtracted from the previous advice.

A discussion of the management goals was raised and it was noted that the goal applied here was to ensure an increase in the population (or if the population is above the maximum sustainable level, that the total removals do not exceed 90% of the maximum sustainable yield). It was acknowledged that deciding management objectives was not within the mandate of the JWG. The possibility to present information in various ways (e.g. including information on population trajectories over time given different harvest levels) was discussed. The JWG agreed not to set any new precedent for how it presented assessment information during this online meeting. However, the JWG agreed that the presentation format for management advice should be discussed during the next meeting.

It was noted that this assessment does not account for Canadian harvest and that the JWG should ideally be working towards developing a joint allocation model, as has been done for narwhal. It was highlighted that since local abundance estimates are used, Canadian catch is implicitly incorporated in the model as part of the natural mortality. It was also noted that the Canadian catch is taken from a significantly larger proportion of the population. The JWG agreed that developing a joint model for beluga was desirable. Options for working on such a model were discussed, including incorporating additional data in a new model run, developing the model intersessionally by a sub-group, and discussing the topic at the next meeting. The JWG **recommended** that the Canadian catch statistics required for developing a joint model be collated and the model discussed and developed at a future meeting when an updated abundance estimate from Canada is also available.

North Water

The estimated relationship between the total landed catch per year (from 2021 to 2025) and the probabilities for a population increase are provided in Table 2. To maintain a 70% probability for population increase, the assessment for the North Water recommends an annual landed catch of no more than 37 individuals north of Cape York. Earlier recommendations that belugas should be protected in Qaanaaq during summer (July-August) due to the scarcity of animals in the area in that season and the uncertainty of which stock they originated from are now revised in light of this presumed North Water stock. The JWG now recommends that any landed catches during the summer as well as other seasons should be counted against the same North Water stock quota.

Probability of Meeting Management Objectives	***Landed Catch of Belugas in Qaanaaq***
0.50	44
0.55	42
0.60	41
0.65	39
0.70	37
0.75	36
0.80	34
0.85	31
0.90	29
0.95	23

Table 2. Total allowable annual landed catches from the North Water stock at various probabilities of meeting management objectives. The simulated period is from 2021–2025 and the fraction of females in the catch is assumed to be 50%.

4. OTHER BUSINESS

4.1 BAFFINLAND UPDATE

Marianne Marcoux from DFO provided an update on the development of the Baffinland Mary River mine project.

Summary from Presenter

A presentation was given to provide an update on the review of the impact assessment for the Phase 2 of the Baffinland Mary River mine. Potential impacts on narwhals were presented related to icebreaking, noise from shipping, and risk of ice entrapment. The cumulative, combined and transboundary nature of the impacts were also discussed. The JWG is concerned about the potential impact on narwhals and belugas related to this project but also recognises that it was not possible to review the documents related to the impact assessment.

Discussion

The JWG has been asked to monitor the situation regarding this project and following the presented status update, expressed its concern regarding the possible impacts on narwhals and belugas. The order of magnitude of change involved in the proposed 2nd and 3rd phases of the project was particularly emphasised.

It was noted that in the current proposal for Phase 2, ships waiting to enter Eclipse Sound during periods of high ice will anchor at Store Hellefiskebank in West Greenland, which is a prime habitat area for a shared Canadian-Greenlandic walrus population and an area with high biodiversity. Although ships are already anchoring at this site, no specific review of the impacts has been performed. It was highlighted that since this is an international issue, it was within the realm of responsibility of the Foreign Affairs Ministry in Denmark and the Government of Greenland. Canada informed the JWG that it had agreed to include Greenland as a consultation partner in the environmental assessment of the project, although currently all parts are waiting for the company to submit its report on transboundary impacts, according to the ESPOO agreement. It was emphasised that Greenland needs additional resources (human and financial) to be able to effectively engage in any thorough review process and avenues for obtaining such resources are currently being investigated. It was noted that having consistency across the concerns raised by Canada and Greenland is likely to have greater impact.

The JWG **recommended** that an expert workshop be held to review the impacts of noise disturbance on hunted populations of narwhals, belugas and walrus (including the development of P-COD models) from shipping connected to the Baffinland Mary River iron ore mine.

5. RECOMMENDATIONS

General

- Hold an expert workshop to review the impacts of noise disturbance on hunted populations of narwhals, belugas, walrus and seals from shipping connected to the Baffinland mine.
- Hold a half day workshop to exchange information on effective tagging practices.

Beluga

Recommendations for Conservation & Management

- Emphasise the importance of reporting on kill dates and locations.
- Carry out new surveys in Somerset Island in the summer and West Greenland in the winter.

Previous recommendations for conservation and management that were reiterated at this meeting:

- Implement the following seasonal closures:
  - Northern (Uummannaq, Upernavik, Savissivik): June through August
  - Central (Disko Bay): June through October
  - Southern (South of Kangaatsiaq): May through October
- In the area south of 65°N, no harvesting of beluga be allowed at any time.

Recommendations for Research

- Collate the Canadian catch statistics required to develop a joint model at a future meeting.
- Present the latest research on senescence at the next meeting and investigate how this information may be incorporated into the population model.

- Perform a genetic analysis on samples from fall catches in the Qaanaaq area to establish their stock.
- Determine summer grounds and seasonal movements and distribution of the proposed North Water stock.
- Develop a joint beluga allocation model for the High Arctic/Baffin Bay population, that will consider Greenland/Canada movement data from tagging, dates and locations of kills, and abundance data.

Narwhal

Recommendations for Conservation & Management

- Include body length of the animal in reporting requirements in Greenland and Canada.

Further recommendations for narwhals will follow the findings of the QSG and a subsequent meeting of the JWG in late summer early fall of 2021.

6. MEETING CLOSE

The Co-Chairs thanked the participants for their active engagement in the virtual meeting and the group expressed their appreciation for the way the Co-Chairs effectively steered the agenda given the time limits and restrictions involved.

The meeting was closed at 17:10 CET on October 30th 2020. A draft of the report was approved during the meeting, with a clean version circulated for review on November 3rd. Based on the feedback received, a revised version was sent to the group on November 11th and the report was finalised on November 16th 2020.

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APPENDIX 1: AGENDA

NAMMCO-JCNB
JOINT WORKING GROUP MEETING

26-30 October, Online

AGENDA

1. CHAIRS WELCOME AND OPENING REMARKS

- 1.1. Welcome & Logistics
- 1.2. Appointment of Rapporteurs
- 1.3. Review of Terms of Reference
- 1.4. Review of Available Documents
- 1.5. Adoption of Agenda

2. NARWHAL

- 2.1. Narwhal stock structure
  - 2.1.1.Genetic information
  - 2.1.2. Satellite tracking
- 2.2. Narwhal abundance
  - 2.2.1. Recent estimates
  - 2.2.2. Review of corrections for availability and perception biases
- 2.3. Narwhal catch statistics
  - 2.3.1.Update by management units
- 2.4. Review of management model structure for narwhal

3. BELUGA

- 3.1. Beluga stock structure
  - 3.1.1. Genetic information
  - 3.1.2. Satellite tracking
- 3.2. Beluga abundance
  - 3.2.1. Recent estimates
- 3.3. Beluga catch statistics
  - 3.3.1. Update by management units
- 3.4. Development of model structure for beluga
  - 3.4.1. Review of preliminary beluga analysis
- 3.5. Review of final analysis for beluga management advice
- 3.6. Report preparation for beluga

4. OTHER BUSINESS

- 4.1. Baffinland Update

5. ADJOURN

APPENDIX 2: PARTICIPANT LIST

NAMMCO-JCNB
JOINT WORKING GROUP MEETING

26-30 October, Online

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APPENDIX 3: DOCUMENT LIST

NAMMCO-JCNB
JOINT WORKING GROUP MEETING

26-30 October, Online

LIST OF DOCUMENTS

Working Papers

Doc. No.	Title	Agenda item
JWG/2020/00	Terms of Reference	1.3
JWG/2020/01	Draft Agenda	1.5
JWG/2020/02	Draft List of Participants	1
JWG/2020/03	Draft List of Documents	1.4
JWG/2020/04	Watt, C. and Young, J. (2020). Catch statistics for narwhal in Canada from 1970-2019.	2.3
JWG/2020/05	Watt, C. Landed catches of beluga whales reported by select Nunavut communities since 2011.	3.3
JWG/2020/06	Witting, L. (2020). An assessment model for beluga in the North Water – 2020.	3.4
JWG/2020/07	Witting, L. (2020). Assessment of beluga wintering off West Greenland – 2020.	3.4
JWG/2020/08	Witting, L. (2020). Meta-population model for narwhals in East Canada and West Greenland – 2020.	2.4
JWG/2020/09	Witting, L. (2020). Optimal meta population removals for narwhals in East Canada and West Greenland – 2020.	2.4
JWG/2020/10	Garde, E., Hansen, R.G. and Heide-Jørgensen, M.P. (2020). Narwhal hunting in Melville Bay, West Greenland, 2005 to 2019.	2.3
JWG/2020/11	Garde, E. and Heide-Jørgensen, M.P. (2020). Update on catch statistics for narwhal, *Monodon monoceros,* in Greenland, 2005 to 2019.	2.3
JWG/2020/12	Garde, E., and Heide-Jørgensen, M.P. (2020). Update on catch statistics for belugas, *Delphinapterus leucas*, in Greenland, 1993–2019.	3.3
JWG/2020/13	Marcoux, M. Montsion, L.M. Dunn, J.B., Ferguson, S.H., and Matthews, C.J.D. (2020). Estimate of the abundance of the Eclipse Sound narwhal (*Monodon monoceros*) summer stock from the 2016 photographic aerial survey.	2.2

JWG/2020/14	Heide-Jørgensen, M.P. (2020) Abundance of narwhals in Inglefield Bredning in 1985 and 1986.	2.2
JWG/2020/15	Heide-Jørgensen, M.P. and Hansen, R.G. (2020). Abundance of narwhals and belugas in the eastern part of the North Water in April 2018.	2.2
JWG/2020/16	Marcoux, M. and Shuert, C. (2020). Update on the movement of narwhals from Eclipse Sound stock (2016-2018).	2.1
JWG/2020/17	Hansen, R.G., Borchers D.L., and Heide-Jørgensen M.P. (2020). Trends in abundance and distribution of narwhals (*Monodon monoceros*) on the summering grounds in Inglefield Bredning and Melville Bay, Greenland from 2007–2019.	2.2
JWG/2020/18	Heide-Jørgensen, M.P. (2020). Abundance of narwhals in Inglefield Bredning in 2001 and 2002.	2.2
JWG/2020/19	Tervo, O.M., Hansen, R.G., Borchers, D. and Heide-Jørgensen, M.P. (2020). Preliminary results on estimation of abundance of narwhals (*Monodon monoceros*) using density surface modelling.	2.2
JWG/2020/20	Garde, E. (2020). Female narwhal age at sexual maturity.	2.4
JWG/2020/21	Witting, L. (2020). Abundance matrix for the meta model in 2017 and 2020	2.4

For Information Documents

Doc. No.	**Title**	**Agenda item**
JWG/2020/FI01	Heide-Jørgensen, M. P., Laidre, K. L., Burt, M. L., Borchers, D. L., Marques, T. A., Hansen, R. G., Rasmussen, M. & Fossette, S. (2010). Abundance of narwhals (Monodon monoceros) on the hunting grounds in Greenland. *Journal of Mammalogy*, *91*(5), 1135-1151.	2.2
JWG/2020/FI02	Bröker, K. C., Hansen, R. G., Leonard, K. E., Koski, W. R., & Heide-Jørgensen, M. P. (2019). A comparison of image and observer based aerial surveys of narwhal. *Marine Mammal Science*, *35*(4), 1253-1279.	2.2
JWG/2020/FI03	Heide-Jørgensen, M. P., Sinding, M. H. S., Nielsen, N. H., Rosing-Asvid, A., & Hansen, R. G. (2016). Large numbers of marine mammals winter in the North Water polynya. *Polar Biology*, *39*(9), 1605-1614.	2.2
JWG/2020/FI04	Heide-Jørgensen, M. P., Burt, L. M., Hansen, R. G., Nielsen, N. H., Rasmussen, M., Fossette, S., & Stern, H. (2013). The significance of the North Water polynya to Arctic top predators. *Ambio*, *42*(5), 596-610.	2.2
JWG/2020/FI05	Garde, E., Hansen, R. G., & Heide-Jørgensen, M.P. (2019). Narwhal*, Monodon monoceros*, Catch Statistics in Greenland, 1862–2017. *Marine Fisheries Review*, *81*(3-4), 105-115.	2.3

JWG/2020/FI06	Heide-Jørgensen, M.P. & Garde, E. (2017). Catch statistics for belugas in Greenland 1862-2016. Working Paper NAMMCO JCNB/SWG/2017-JWG/06rev	3.3
JWG/2020/FI07	Louis, M., Skovrind, M., Samaniego Castruita, J. A., Garilao, C., Kaschner, K., Gopalakrishnan, S., ... & Heide-Jørgensen, M. P. (2020). Influence of past climate change on phylogeography and demographic history of narwhals, Monodon monoceros. *Proceedings of the Royal Society B*, *287*(1925), 20192964.	2.1
JWG/2020/FI08	Louis, M., Skovrind, M., Garde, E., Heide-Jørgensen, M.P., Szpak, P., and Lorenzen, E.D. (2020). Population-specific sex and size variation in long-term foraging ecology of belugas and narwhals (submitted)	2.4, 3.4
JWG/2020/FI09	Golder Associates Ltd. (2020). 2019 Marine Mammal Aerial Survey: Mary River Project. Report submitted to Baffinland Iron Mines Corporation.	2.2, 3.2, 4.1
JWG/2020/FI10	Watt, C.A., Marcoux, M., Ferguson, S.H., Hammill, M.O. and Matthews, C.J.D. (In press). Population dynamics of the threatened Cumberland Sound beluga population.	3.3
JWG/2020/FI11	Robeck, T. R., Monfort, S. L., Calle, P. P., Dunn, J. L., Jensen, E., Boehm, J. R., ... & Clark, S. T. (2005). Reproduction, growth and development in captive beluga (Delphinapterus leucas). *Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association*, *24*(1), 29-49.	3.4

APPENDIX 4: QUANTITATIVE SUBWORKING GROUP TERMS OF REFERENCE

Intersessional Quantitative Subworking Group (QSG) of

Joint Working Group 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

Online as needed November 2020-September 2021

Background

Analysis of recent aerial surveys of narwhals and reanalysis/correction of older surveys presented during the October 2020 JWG meeting demonstrated that the choice of analysis method made substantial differences in both the final point estimate and its standard error. Of particular concern are the choices of correction methods for availability and perception bias including the forward distribution and the assumptions regarding the spatial distribution of narwhals in the survey area. In the past, each survey and analysis result has been considered separately. The quantitative subworking group (QSG) is requested to review analysis methods for abundance estimation used by this group, and identify preferred and/or comparable methods that can be applied to the current and past survey data.

Also recent tag data from Eclipse sound has brought into question some of the assumptions on which the hunt availability matrix is based. The QSG is requested to revise the matrix to accommodate the new movement and distribution data and update the probable zeros and hunts.

Each of these can not be completed during the period of the Oct 26-30, 2020 meeting of the JWG thus this QSG is requested to work through these issues and report back to the JWG at its next plenary session.

The **Terms of Reference** of this QSG are to:

- review recent information on abundance, distribution, movements, and harvest locations of Baffin Bay narwhals to revise and update the availability matrix to assign harvested animals to individual summer stocks;
- review methods and dive data used to analyse and correct aerial surveys to identify a set of preferred methods and corrections that meet criteria developed by this QSG; and apply these to the recent and past surveys where needed;
- review surveys and analysis of Eclipse Sound and Admiralty Inlet narwhal abundance prepared by Golder Associates Ltd.; and revise estimates of variance and recommend to JWG which if any surveys or combination of surveys are suitable for use in the assessment;
- Update allocation matrix and assessment with the revised inputs.

APPENDIX 5: REQUESTS FOR ADVICE & RESEARCH PRIORITIES

Relevant requests for management advice from the NAMMCO Council to its Scientific Committee regarding Narwhal & Beluga

Request 1.6.5: Struck and loss rates should be subtracted from future advice on sustainable removals in Greenland, with the advice being given as total allowable landings.

Request 3.4.9: Provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of beluga, particularly in West Greenland.

Expanded in 2014 to include the impacts of disturbance on narwhal and walrus.

Request 3.4.11: To update the assessment of both narwhal and beluga.

Research priorities and questions for the JWG identified in the draft report of the 14th meeting of the Canada/Greenland Joint Commission on Narwhal & Beluga

Identified by the Greenlandic delegation:

1. Demonstrate implications for other hunting areas if Disko Bay is allowed highest possible take of narwhal.
2. Demonstrate implications for other hunting areas if Melville Bay is allowed highest possible take of narwhal.
3. Identify wintering areas of Inglefield Bredning and Melville Bay narwhal.
4. Develop catch allocation model for West Greenland beluga.
5. Develop Jones/Smith Sound catch allocation model for Etah and Qaanaaq to determine if the quota of five narwhal for this large stock is appropriate. Etah area was closed for hunting more than 30 years ago and was reopened in 2016, because of the difficulty of accessing the area, increasing the quota would make it more viable.
6. Provide information to hunters on the effects of whale predation on Greenland halibut.

The KNAPK (Kalaallit Nunaanni Aalisartut Piniartullu Kattuffiat, The Association of Fishermen and Hunters in Greenland) stated that interviews done as part of the work by the Pikialasorsuaq Commission in Qaanaaq and Upernavik areas, tells about observations of a more northern distribution of large whales.
Aerial surveys are done using fixed transects, but if the whales change distribution, fixed transects may have to be evaluated.

The Upernavik area (Melville Bay), a coast stretching about 500 km and a population of about 2800 people, has an annual quota of 52 narwhals, often the quota is caught within a short time in a small area depending on where the narwhal are present. After the quota is caught and narwhal are present, there is a clear decline in catches of Greenland halibut (GHL). The negative correlation between the presence of narwhal and reduced GHL catches is also well known in other areas. The demand for extra narwhal quotas are high in those periods. The KNAPK would like more studies on the impact of whale predation on Greenland halibut and their effects on the food chain.

Identified by the Canadian delegation:

1. Comparison of samples from Cumberland Sound beluga and West Greenland for genetic analyses to determine if there was historical stock connectivity.
2. Determine current range and distribution of Cumberland Sound beluga through satellite tagging.

3. Determine effects of shipping noise from Mary River mine on narwhal behaviour and migration.
4. Collect movement data for East Baffin and Jones Sound narwhal as there is currently no movement data on these two stocks.
5. Development of an allocation model for beluga for Canadian and Greenland stocks.
6. Collection of Traditional Knowledge for East Baffin Island narwhal in Home Bay which are hunted in the winter in Disko Bay.

Recommendations from the JCNB on Future Research

The JCNB reiterates the following recommendations for narwhal and beluga, as outlined in the 13th meeting report:

1. Development of a multi-year survey and tagging plan for stocks of narwhal and beluga to ensure that there is a regular re-assessment of each stock (e.g. frequency and numbers), so abundance estimates do not become outdated.
2. Research to determine impacts of killer whales on behaviour and survival of narwhal and beluga (ongoing).
3. Research to examine the effect of changing ice conditions on narwhal and beluga populations including ice conditions and currents.
4. Identify the research priorities for beluga and narwhal which need to be addressed in order to fill gaps identified by the JWG in the development of the allocation model.
5. What level of science information is sufficient to move from data-poor to data-rich management approaches and is there a middle ground? Furthermore, what should be considered when developing harvest scenarios that maintain population levels or allow the population to increase to assumed historical levels?

The JCNB also includes the following recommendations from the JWG's 2017 report:

1. Genetic analysis for stock identity of the summer takes of beluga in Greenland.
2. The re-evaluation of the Larsen et al (1994) survey.
3. An aerial survey in Scoresby Sound.
4. Determining stock identity of the Scoresby Sound narwhal winter hunt.