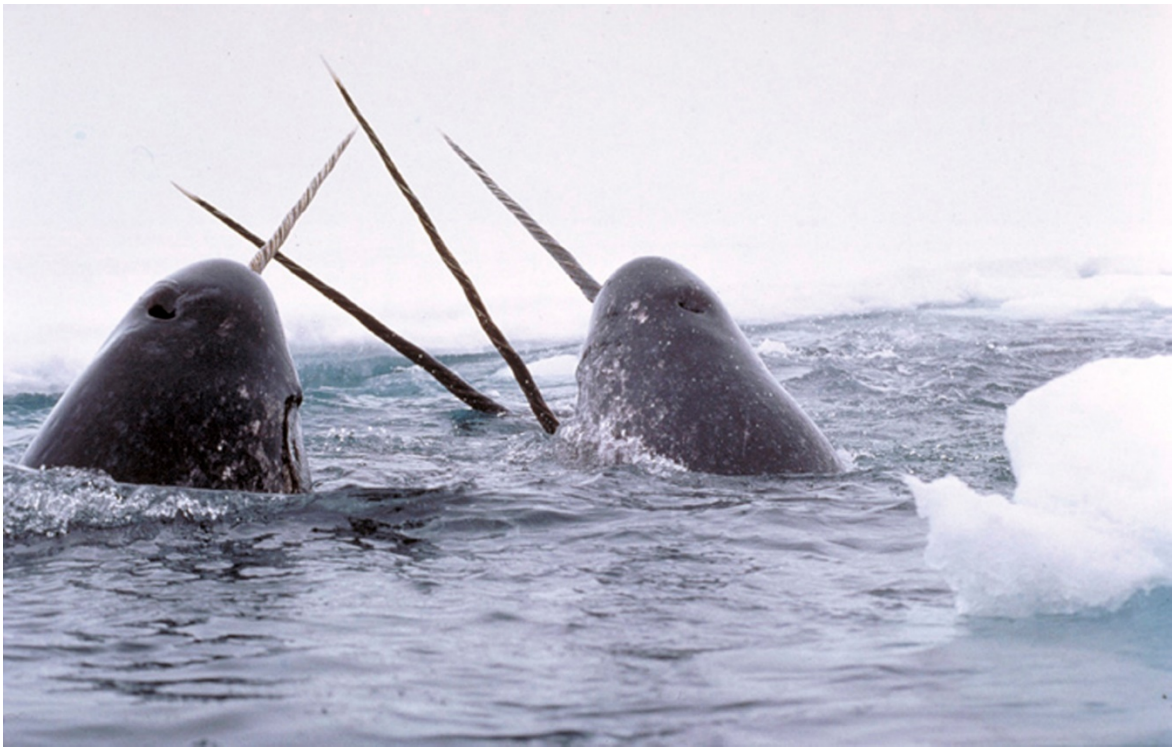
SCIENTIFIC COMMITTEE
AD HOC WORKING GROUP ON NARWHAL IN EAST GREENLAND

25-29 October 2021
Greenland Representation, Copenhagen Denmark

REPORT

Presented to the 28th Meeting of the Scientific Committee as NAMMCO/SC/28/06



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NAMMCO

Postbox 6453, Sykehusveien 21-23, N-9294 Tromsø, Norway, +47 77687371, nammco-sec@nammco.org,

www.nammco.no, www.facebook.com/nammco.no/, www.twitter.com/NAMMCO_sec/

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EXECUTIVE SUMMARY

The NAMMCO Ad hoc Working Group on Narwhal in East Greenland (NEGWG) met for the second time from 25-29 October 2021, with participants from Canada and NTI Inc., Denmark, Faroe Islands, Greenland, Iceland, and the United States.

At its 2021 meeting, the Management Committee for Cetaceans (MCC) was presented both with the management recommendations of the Scientific Committee (SC) for narwhal in East Greenland (based on the conclusions of the 2019 NEGWG meeting) and the observations of East-Greenland hunters. The MCC did not reach consensus for endorsing the SC recommendation that there be an immediate reduction to zero catches of narwhals (*Monodon monoceros*) in all three management areas of East Greenland (i.e., 1: Ittoqqortoormiit, 2: Kangerlussuaq, and 3: Tasiilaq). The MCC requested the SC to investigate ways to improve reporting of user observations to inform assessments, to recognise and include the impact of climate change on narwhals in management decision-making on all stocks, and to clarify the issue regarding payment to hunters for assisting in research.

The tasks for the WG, besides proposing responses to the MCC, involved reviewing its previous advice in the light of new data on stock structure, distribution, abundance, and catch statistics. It should also evaluate the knowledge available to developing management advice for belugas in East Greenland.

Requirements to develop advice on East Greenland belugas.

Increased sightings of belugas have been reported in East Greenland. Preliminary results of genomic analysis in belugas indicate a high degree of population subdivision, and many stocks appear to be genetically distinct. It is presently unknown to which stock belugas in East Greenland should be related. There is currently insufficient information to conduct an assessment in East Greenland, and there is no evidence to conclude that a hunt would be sustainable. **See Recommendations 1.5-1.9.**

Development of advice on East Greenland narwhals

Hunters and User knowledge: The hunters' observation of three different types of narwhals is valuable and useful for generating hypotheses. Preliminary genetic analysis points to genetic differences between the narwhals summering in Scoresby Sound and those from Northeast Greenland/Svalbard. However, there is currently insufficient information to assess whether narwhals from another stock potentially summering in Northeast Greenland, and which fraction of this northeastern stock, are supplying the spring hunt close to Ittoqqortoormiit.

Economic considerations: The costs incurred by the damaging of nets during the capture of live narwhals for scientific purposes are included within the bounty paid to hunters for live captures, which amounted for the period 2010-2020 to over 3 million DKK.

The commercial trade in mattak from East Greenland to other areas has created an incentive for narwhal hunting and the increasing catches can partly be explained by the ongoing price rise of this high-priced product. A socio-economic assessment needs to be carried out by an expert WG, considering both the present trade and its termination, should a population crash materialise.

***Request for hunter and user data and knowledge*:** The WG made recommendations regarding information that the hunters could provide for informing further assessments. S**ee Recommendations 1.1, 1.2, 1.6, 1.7, 1.9.**

Accounting for climate change in recommendations: It is not possible today to quantify the impacts of climate change on the narwhal populations in East Greenland. The increase in ocean temperature can reduce the suitable habitat for narwhals or force animals to move north, which would impact their distribution and availability to hunting in the three management areas. Adapting to new environments may result in changes in reproductive and survival parameters. The impacts of climate change cannot be presently quantified and directly included in model-based assessments. Understanding how they

will affect life history parameters requires having a large sample size and a long time series. Further research is needed to understand the mechanisms of these impacts and enable a better accounting of those in the WG recommendations. **See Recommendation 1.4, 2.1.**

Distribution & Abundance of East Greenland Narwhals

The historical distribution of narwhals indicates that the distribution patterns have not changed. Therefore, the decreasing occurrence at the Hjørnedal field station (manned since 2010) is supporting the larger signal provided by the assessment and indicating a decreasing population.

The analyses leading to the current abundance estimates were reviewed by the Joint NAMMCO-JCNB Scientific WG and deemed appropriate. The reliability of the 2016 abundance estimate, a few hundred narwhals in the Scoresby Sound area, is supported by a matching abundance estimate generated by mark-recapture, a method using a totally different dataset.

The planning of the aerial surveys planned for the spring and the summer 2022 were discussed. The aim of the exploratory spring survey around Scoresby Sound, over an area informed by satellite tracking data and user knowledge, is not intending to provide a count of the putative spring stock but to investigate whether there is a disjunct distribution of two wintering grounds, one in the southern part for narwhals summering in Scoresby Sound and one in the northern part (off Liverpool Land) for narwhals from unknown summer origin. The WG agreed with the adaptive design of the survey and advised that the planning of the survey should consider adding effort on the coastline north of Scoresby Sound to include areas with historical narwhal sightings by hunters.

The latest survey was conducted in 2017 and the decision by the Greenlandic authorities to conduct a new summer survey in 2022 was welcomed. While the planning of this survey should be done in collaboration with the hunters, scientific international survey standards shall be followed to ensure that the abundance estimates are reliable, internationally accepted and useful for assessment. **See Recommendations 2.2, 2.3.**

Biology

Life history: In Scoresby Sound (management area 1), the decreasing trend in pregnancy rate was supported both by the increasing proportion of older animals and the declining proportion of pregnant females in the catch, the analysis of the biological samples, the observation of calves during surveys as well as the information provided in the hunters' Special Reports. The pregnancy rate observed in Scoresby Sound, obtained both from the hunters' Reports and the biological sampling, is significantly lower than in West Greenland and Canada.

It is likely that the hunt has shifted to older animals due to a lack of younger animals, and there is strong indication of a decline in reproduction (few pregnant females and few calves born each year) and loss of females, leading to a loss of recruitment (number of young reaching reproductive age).

Genetics*:* In agreement with other indicators (satellite tagging data, catch and hunters' records), a preliminary genomic analysis suggested a sub-structuring of the Scoresby Sound narwhal stock, with likely a spring and a summer sub-stock in the area. Significant additional information is needed to conduct a separate assessment of the putative spring stock. Because of the likely sub-structuring in East Greenland, the NE Greenland stock cannot be assumed as one continuous large population supplying the spring hunt.

Anthropogenic impacts

Hunt and other removals: Updated catch records were discussed, with only two narwhals reported caught in Scoresby Sound by mid-October 2021. The recent drop in catches in management area 1 (Ittoqqortoormiit) is most likely caused by a decline in narwhal density. By-catch, entanglement and vessel strike of narwhals are uncommon, if any, and not of any concern.

***Non-lethal impacts*:** As evidence suggests, narwhals are very sensitive to noise and disturbance. The noise level from anthropogenic activities is increasing in Scoresby Sound and could become an issue and should be monitored. Shipping activities from large vessels in East Greenland should be regulated to avoid further negative impacts on the narwhal populations. **See Recommendation 1.3.**

Habitat of East Greenland narwhals

Increased local observations of killer whales have been reported in East Greenland, with associated concerns that these may have a negative impact on narwhals. There was, however, insufficient evidence to suggest that this increased presence was influencing narwhal distribution.

Stock Assessments

Stock structure: An emerging weight of evidence points to two separate aggregations in Scoresby Sound (management area 1), one coming in the spring and one in the summer. No evidence supports the presence of an offshore stock. Stock structure in management areas 2 and 3 remains unchanged.

Stock assessment model: The assessments are based on the same age-structured modelling framework that has been used by the NAMMCO SC for two decades in its assessments of beluga, narwhal, walrus, and harbour porpoise. The method is thoroughly peer-reviewed and agreed by NAMMCO as suitable to provide management advice.

Ittoqqortoormiit (management area 1)**:** The model for the area is developed in more detail than any previous assessments, it reconciles not only abundance, age structure and removal data, but also data on life history parameters, including the negative trend in the birth rate reported in the hunters' Special Reports. The model estimates a small and depleted aggregation, with no more than 207 (90% CI: 42-441) individuals left. The narwhal population in management area 1 cannot sustain any further hunt. With continued catches at the current level, there is a 30% risk that the hunt causes the population to go extinct by 2025, a risk that increases to 74% by 2028, and reduced to 0% if there are no removals after 2021.

The WG concluded that there is a significant threat of extinction from a continued hunt, even on a timescale as short as a couple of years, as supported by the apparent collapse of the hunt in 2021. **See Recommendation 1.0, 2.4.**

Kangerlussuaq (management area 2): The model estimates a small and depleted aggregation with no more than 260 (90% CI: 142-442) individuals left. The current depletion ratio is of 0.24 (90% CI:0.11–0.52), with an annual production (birth) of no more than 6 (90% CI:0–18) individuals.

With loss rates and potential underreporting added on top of an uncertain growth rate, the WG concluded that the narwhal population in management area 2 cannot sustain any further hunt. **See Recommendation 1.0, 2.4.**

Tasiilaq (management area 3): The model estimates a small and depleted aggregation with no more than 123 (90% CI: 12-394) individuals left. With an estimated production of no more than 5 (90% CI: 1–21) individuals per year, the narwhal population in management area 3 cannot sustain any further hunt. With continued catches at the current level, there is a 34% risk that the hunt causes the population to go extinct by 2025, a risk that increases to 62% by 2028, and reduced to 0% if there are no removals after 2021.

The assessment for Tasiilaq includes only a single abundance estimate (2008), as no sightings were made during the 2016 survey. The density of narwhals in this area may be too low to be detected by traditional survey methods, thus the assessment was statistically adjusted to nonetheless acknowledge the presence of narwhals in the area.

The WG concluded that there is a significant threat of extinction from a continued hunt, even on a timescale as short as a couple of years. **See Recommendation 1.0, 2.4.**

Recommendations for Conservation and Management:
In addition to the assessment model, there is ample evidence that indicates the narwhal stocks in Southeast Greenland are severely depleted and require immediate protection:

1. several indicators suggesting multiple small, isolated populations of narwhals
2. low and declining abundance estimates of narwhals in all three management areas
3. mark-recapture estimate of narwhals from the summer population in Scoresby Sound supporting the low abundance estimate
4. severe depletion of narwhals in all three management areas
5. apparent collapse of total catches of narwhals in management areas 1 in 2021
6. drop of summer narwhal catches inside the Scoresby Sound fjord
7. collapse of live captures of narwhals in Scoresby Sound for research purposes
8. decline of females in the population in all three management areas as indicated by the proportion in the catch of narwhals
9. decline in younger animals in the population in management area 1
10. a reduction of more than 50% in observations of calves over a 40-year period of aerial surveys in management area 1
11. declining pregnancy rate in management area 1
12. low pregnancy rates in management area 1 compared to Canada and West Greenland
13. loss of habitat in the southern part of the range
14. contraction in distributional range of narwhals

Rec. 1.0 Therefore, **the WG strongly reiterated its previous recommendation of zero catches of narwhals in all three management areas in Southeast Greenland.** The risk of hunting-imposed extinction is very high and the WG therefore **stressed the importance of immediate management actions** to secure the presence of narwhals in Southeast Greenland.

In addition, the WG listed the following recommendations:

Narwhals

Rec. 1.1 *That a community-based biopsy programme of live narwhals be established, given that hunters report seeing narwhals regularly. This would generate information on the rate of encounters and provide samples for stock structure analysis.*

Rec. 1.2 *That, if a narwhal hunt goes ahead despite the WG's strong recommendations for 0 catches in all management areas of East Greenland, additional information be collected from any hunted narwhals besides the already mandatory information (length, sex, date and location of the catch, presence/absence of a foetus). This additional information includes: a skin biopsy sample, the type of the animal according to the three categories described by hunters, photograph of the back, girth measurements, information for females whether there is milk in the mammary glands.*

Rec. 1.3 *That shipping activities from large vessels (including cruise ships) in the summering grounds along the East Greenland coastline be regulated to avoid negative impacts on the narwhal populations, as narwhals are sensitive to noise and these small populations are particularly sensitive to impacts from disturbance.*

Rec. 1.4 *That the effects of climate change be reduced and mitigated to protect the narwhal's habitat, as climate change is probably causing increased habitat fragmentation of narwhal stocks and a drastic reduction of their winter ranges.*

Belugas

Rec. 1.5 *That belugas in East Greenland remain fully protected, as there is insufficient information to perform an assessment of belugas in East Greenland.*

Rec. 1.6 *That documentation of hunter observations of belugas in East Greenland is collected in a structured manner, including photographs or video footage of the animals, information on where and when the sighting took place, and how many individuals were seen.*

Rec. 1.7 *That any by-catch of belugas in East Greenland be documented in the Special Reports.*

Rec. 1.8 *That, in case of live by-caught belugas in East Greenland, all efforts should be made to release the animal.*

Rec. 1.9 *That additional samples be taken from all dead by-caught belugas, besides the already mandatory information (date and location of the by-catch, sex, presence/absence of a foetus). This additional information includes skin biopsy sample, length, a tooth, girth measurements, whether there is milk in the mammary glands of females.*

Recommendations for Research:

Rec. 2.1 *That, for examining the impact of climate change on life history parameters, life history data be collected from non-depleted stocks of narwhals in West Greenland and Canada, where climate change is also expected to have an impact.*

Rec. 2.2 *That different approaches to counting narwhals in the fjords be further examined, but only to the extent that new approaches will be compatible with the existing time-series.*

Rec. 2.3 *That, although the planning of surveys should be done in collaboration with the hunters, the survey methodology (including the design of the track lines) continues to be done according to internationally accepted survey standards, to ensure that abundance estimates derived from the survey can be accepted by NAMMCO and used in the assessment*.

Rec. 2.4 *That definitions be developed for what constitutes small stocks, depleted stocks and stocks at risk of extirpation, and that frameworks for advice and management then be articulated for what actions should be taken for these different categories.*

MAIN REPORT

1. CHAIRMAN WELCOME AND OPENING REMARKS

The Chair, Roderick Hobbs, welcomed participants to this hybrid meeting of the NAMMCO Ad hoc Working Group (WG) on Narwhal in East Greenland (NEGWG 2021), the second meeting of the WG. He gave the participants the opportunity to introduce themselves.

The Chair noted that the discussion of the implementation of earlier recommendations was moved to the beginning of the agenda, as it would be an important component of this meeting. The agenda was accepted without any further changes or additions.

The NAMMCO Assistant Scientific Secretary, Heleen Middel, was appointed as rapporteur for the meeting, with assistance from NAMMCO Scientific Secretary, Fern Wickson, and NAMMCO General Secretary, Geneviève Desportes, as well as participants as necessary.

2. DEVELOPMENT OF ADVICE ON EAST GREENLAND NARWHALS

2.1 IMPLEMENTATION OF EARLIER RECOMMENDATIONS

2.1.1 Review of MCC & MCJ response to recommendations from SC26 and SC27 (based on the Report of NEGWG 2019)

The Chair presented the report of the 2021 Meeting of NAMMCO's Management Committee for Cetaceans (MCC) (available as SC/28/NEGWG/FI02), highlighting and summarising the following items:

- The MCC did not endorse the recommendation of the NAMMCO Scientific Committee (SC) that there be an immediate reduction to zero catches of narwhals (*Monodon monoceros*) in all three management areas of East Greenland (i.e., Ittoqqortoormiit, Kangerlussuaq, and Tasiilaq). Greenland had already determined a quota for 2020-2023, with a stepwise reduction over time. Greenland also emphasised that the Government is required by law to consider both scientific advice and hunter and user knowledge in their decision making. A new executive order, which will encourage hunter and user knowledge to be gathered in a more structured manner is in development.
- For belugas (*Delphinapterus leucas*), the MCC did not endorse the recommendation of the SC that in West Greenland, there be seasonal closures and no hunt south of 65˚, stating that more research was required to assess whether such measures would be effective in restoring stocks in the area. It was, however, also noted that although belugas were previously rarely seen in East Greenland, hunters were now reporting that belugas were being seen more frequently, and in increasing numbers. Although the NEGWG was created to assess the status of narwhals in East Greenland, as many in the WG also have expertise on belugas, NEGWG 2021 could make a preliminary evaluation of the knowledge available to develop advice for this species.
- Clarification on the issue regarding payment to hunters for assisting scientific research was required.
- The SC26 (2019) recommendations for research to *1. Investigate ways to improve reporting of user observations to inform future assessments*, and *2. Recognise and include the negative impact of climate change on narwhals in management decision-making on all stocks*, were endorsed by MCC 2021.

The Chair also presented the report of the 2021 Joint Meeting of NAMMCO's Management Committees (MCJ) (available as SC/28/NEGWG/FI04), highlighting and summarising the following items:

- There has been an ongoing discussion within NAMMCO on the application of the precautionary approach within management advice. SC 26 proposed that *"NAMMCO develop guidance on a principle-based approach for how to manage and provide harvest advice for small stocks."* In 2021, the MCJ endorsed this proposal and requested the SC to "*explain how and at what level the precautionary approach is, or can be, integrated into advice provided by the SC for use in conservation and management, with a particular focus on depleted stocks.*" While the JCNB-NAMMCO Joint Working Group on Narwhal and Beluga (JWG) will consider the issue of providing advice on small and depleted stocks, it is also an issue of relevance for the NEGWG given the status of narwhals in East Greenland.
- Greenland acknowledged that hunter and user knowledge needs to be collected in a more structured way than is currently done. Greenland also informed the MCJ of the community consultations that have taken place on narwhal issues to date, and the plans to continue these.

2.1.2 Hunter and User Knowledge

The Chair reviewed the content of the PowerPoint presentation made to the MCC 2021 by two representatives from the KNAPK (The Greenlandic Association for Fishers and Hunters), one from Tasiilaq and another from Ittoqqortoormiit. This presentation is available as SC/28/NEGWG/FI03.

Summary of the Presentation

The hunters presented their observations of narwhals in East Greenland and described three different types: ordinary, slim, and offshore narwhals.

According to the hunters, slim narwhals have less meat than the other types, are considerably faster, and their colouration is spotted over their entire body. They are taken primarily in and around Ittoqqortoormiit and are found in late spring (May-July), and have also been observed in summer in Kangerlussuaq

Offshore narwhals have a relatively large girth and a lot of meat, a lot of spots on their back, and swim calmly. They only appear in the summer (July-September) at the entrance of the Scoresby Sound fjord system, inside the fjord system, and near Tasiilaq.

Ordinary narwhals have a light stomach and a dark back, can be seen all year round along the Southeast Greenland coast and were assumed to be the type most familiar to scientists.

Discussion

The WG acknowledged the hunters' observations as valuable. It was noted, for example, that such information can be used as a basis to generate hypotheses that can then be further tested through collaborative research, the results of which can be used to inform assessments.

The WG asked whether the genetic data support the classification of types suggested by the hunters. Louis informed that preliminary analysis does indicate that there are genetic differences between the narwhals summering in Scoresby Sound and narwhals from Northeast Greenland/Svalbard (see Section 5.2 for further details). Samples taken from narwhals in Scoresby Sound in spring also had more genetic similarity with the Northeast Greenland/Svalbard stock than with the Scoresby Sound summer stock. The samples that have been analysed to date were not accompanied with information on the proposed type (i.e., according to the 3 categories used by hunters) the animal came from. This information would be valuable to better assess whether there was agreement between the stock structure being identified by scientists and the different types described by hunters.

The WG recognised at its previous meeting that it is possible that narwhals from another stock, potentially a stock summering in Northeast Greenland, are supplying the spring hunt taken by hunters close to Ittoqqortoormiit, which is consistent with the separation between the locations of narwhals tagged in summer in Scoresby Sound and the genetic analysis by Louis (see Section 5.2). However, it was agreed that there is currently insufficient information to assess if this is indeed the case, and what

fraction of a northeastern stock would be available to hunters in Ittoqqortoormiit. It was noted that a spring survey had been planned to provide more information on the distribution of narwhals in spring at the entrance to the Scoresby Sound fjord system but this had been delayed due to COVID-19 (see Section 4.4 for more details on the survey plans).

2.2 ECONOMIC CONSIDERATIONS

Heide-Jørgensen presented working paper NAMMCO SC/28/NEGWG/06 - *The economic incentive behind narwhal hunting and the hunter-biologist cooperation in Greenland.*

Summary

The main commercial product from narwhal hunting is the mattak (the skin of the whales). Depending on the size of the whale, the amount of mattak can vary between 50 and 250kg; on average, a narwhal provides 132kg of mattak. The mattak is primarily sold to consumers in Southwest Greenland and the retail price per kilo has increased exponentially from 50 DKK/kg in 1982 to 499 DKK/kg in 2019 (see Figure 1). Another source of income from narwhal hunting is the trade in narwhal tusks. The price in 2019 for a tusk was 1250 DKK/kg but the actual sales price by the hunter varies depending on length, shape and condition of the tusk.

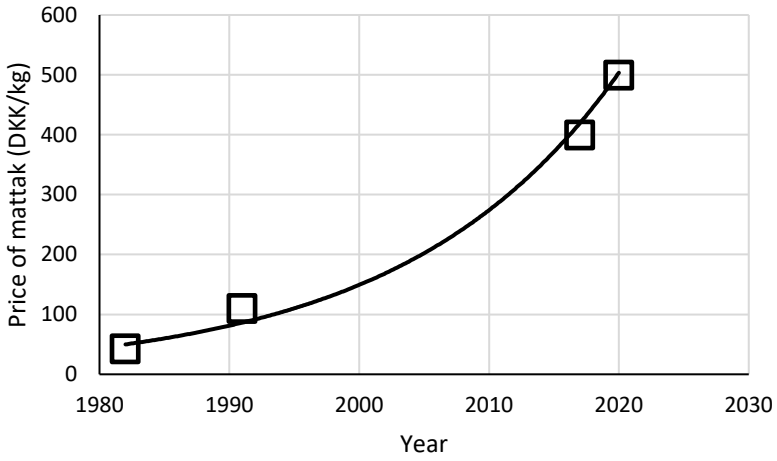


Figure 1. Exponential increase in the price of mattak between 1981 and 2020.

The utilisation of narwhals in Greenland is part of an extinction spiral where the increasing economic incentives drive the hunting, and the increasing demand for the product leads to increasing prices. The costs of harvesting are likely increasing, but these costs are being offset by government subsidies for vessels. Therefore, the harvest is still increasing, which leads to reduced abundance and range contractions. The density in the main concentration areas may still be high and therefore the hunters may perceive the population as doing fine, until the density suddenly drops and extinction becomes the next step. Climate change and disturbance may also contribute to the range contraction and competition from fisheries could reduce prey availability and contribute to the decline in density.

An example of the economic value of narwhals is the price biologists pay for live whales that can be used for instrumentation. During 2010-2020 the bounty for live narwhals in East Greenland was 25,000 DKK for a female, 30,000 DKK for a male with a tusk <1m and 35,000 DKK for a male with a tusk >1 m. This price includes compensation for possible damage to nets. A total of more than 3 million DKK was spent on salaries to hunters in Ittoqqortoormiit, East Greenland, during 2010-2020 (see Table 1), of which more than half was received by three hunters. In that period, a total of 72 narwhals were captured and about 2/3 of the money that GINR provided to the hunters was spent on paying for live narwhals. Boat chartering, field assistants, and sampling of dead whales constituted the remaining 1/3 of the money.

Table 1. Payment in Danish kroner to hunters from Ittoqqortoormiit for assistance with live capturing of whales, sailing and pick-up of instruments and for rewards for samples from dead whales.

Hunter code	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	SUM
Hunter 1	25,500		1,000	54,500	5,000	130,000	110,500	52,500	96,910	43,650		519,560
Hunter 2	96,000	25,400	54,500	53,500	8,000	57,000						294,400
Hunter 3	36,000				26,000							62,000
Hunter 4	28,500	27,000	27,300	30,600	34,200	41,200	59,850	111,900	41,750	38,050	59,950	500,300
Hunter 5		60,000						70,500	80,400	35,000		245,900
Hunter 6		93,700	54,500	25,000	85,000	27,000	110,500	55,200	96,250	12,350	8,850	568,350
Hunter 7		35,000	13,000									48,000
Hunter 8			5,830	2,000	15,000	1,000						23,830
Hunter 9			30,000	90,000	50,000	61,314	38,000					269,314
Hunter 10			4,500	57,000	38,000	51,000		57,500	38,000	43,500		289,500
Hunter 11			4,000		3,000		1,765					8,765
Hunter 12			25,000									25,000
Hunter 13				16,000	19,000	19,000					2,000	56,000
Hunter 14			16,000									16,000
Hunter 15					57,000	1,000	5,000	5,030	38,500	38,300		144,830
Hunter 16					3,000			1,000				4,000
Hunter 17										500		500
TOTAL	186,000	241,100	235,630	328,600	343,200	388,514	325,615	353,630	391,810	211,350	70,800	3,076,249

Discussion

During the MCC meeting in 2021, the KNAPK representatives stated that they had not been reimbursed for costs incurred by the damaging of nets during the capture of live narwhals for scientific purposes. The WG was informed that these costs were viewed as included within the bounty paid to hunters for the live capture (see Table 1).

The WG noted that the commercial trade in mattak from East Greenland to other areas has created an incentive for narwhal hunting and that the increasing catches at least partly can be explained by the ongoing price rise. This trade in a high-priced product provides a strong incentive to continue the hunt and arguably places an even higher demand on implementing a precautionary approach to management for these already depleted stocks. The implementation of such a precautionary approach is required if a sustainable hunt has any chance to resume in the future.

The WG discussed that social and economic impacts over a long-term basis could be documented and quantified. When social and/or economic arguments are used to inform management decisions, assessments of these factors should be conducted at an equivalent standard to that applied in the biological assessments. The WG **agreed** and underlined that such socio-economic assessments would need to be carried out by those with specific expertise in performing this type of research and analysis and NAMMCO could establish a new working group on this.

The WG stressed that any economic value placed on mattak now will eventually decline to zero if the population is permitted to crash. In the long-term, if the population is given time to recover (e.g., through a pause in hunting), the economic value may return and then be managed at a sustainable level. The WG pointed to the fact that live narwhals have economic value besides the value of mattak, e.g., from tourism and as assistance to scientific research.

This WG underlined that in this specific case an immediate halt to the catches is required and cannot wait for further economic/social assessment.

2.3 IMPROVE SUPPORT FOR EXISTING RECOMMENDATIONS

It was discussed whether the advice table that is currently used needs to be expanded to provide more detailed information on predicted population responses to different levels of removal, and the possible rate of extinction risk. It was also suggested to provide a long-term projection (i.e., of several decades) under a scenario of zero hunting, to explore and demonstrate the potential for recovery of the populations. The WG **agreed** that a table of extinction risk in the near future caused by hunting was appropriate for this assessment, but underlined the importance of acknowledging the uncertainties involved, including the impact of environmental and demographic factors.

2.4 ACCOUNTING FOR CLIMATE CHANGE IN RECOMMENDATIONS

Agenda items 2.4.1 – 2.4.3 were discussed together and are therefore reported as one discussion under this section.

The WG was concerned that climate change is placing an additional stress on the already depleted stocks of narwhals in East Greenland. The increase in ocean temperature can reduce the suitable habitat for narwhals or possibly force animals to move north. In the likely scenario that narwhals have insufficient plasticity in their behaviour to adapt to such changes, this would impact their distribution and their availability to hunting in the three management areas. The adaptation to new environments may result in changes in reproductive and survival parameters. Changes in life history parameters are indeed already being observed in terms of reduced reproduction, however a direct causal link between these observations and climate change has not been established.

The WG **agreed** that there is uncertainty which parameters within the assessment model would be affected by climate change, and that further data is required to identify and understand the mechanisms through which climate change may impact life history parameters. However, the WG also noted that in areas where data on changing life history parameters exists, these changes may be incorporated into the assessment without necessarily directly referencing to climate change.

The WG **agreed** that although it could discuss possible impacts from climate change on the populations, with these likely to be negative, such impacts cannot be directly quantified and included in model-based assessments with the currently available knowledge. The WG also noted that understanding the impact of climate change on life history parameters requires having a large sample size and a long time series, which can only be achieved by sampling a non-depleted population. The WG therefore emphasised the value of, and **recommended**, collecting life history data from non-depleted stocks in West Greenland and Canada, where climate change is also expected to have an impact.

2.5 CONSIDER ALTERNATIVE MANAGEMENT OBJECTIVES

The WG considered the population abundance too low to consider any other management objectives than to halt the decline of the stocks.

2.6 REQUEST FOR HUNTER AND USER DATA AND KNOWLEDGE

The finalised request for hunter and user data and knowledge can be found in Chapter 9, this Section 2.6 provides context to these requests and the discussion held by the WG.

Discussion

While the survey conducted in 2016 indicated extremely low abundance of narwhals in all three management areas, with no sightings at all around Tasiilaq (management area 3), hunters report regularly seeing aggregations of narwhals and state that the population is healthy and abundant. The WG **agreed** it would be valuable to have documentation of these sightings (i.e., in terms of photographs, video footage, together with registration of date and location). Different possible ways

to collect and collate this information were discussed but the WG acknowledged that the Government of Greenland itself was currently working on collecting user knowledge in a more structured and systematic manner. The WG welcomes any documentation of narwhal incidental sightings made by hunters. Receiving a collated report on such sightings for consideration at the next NEGWG meeting would support the work of the WG.

Given that hunters report regularly seeing narwhals, the WG also **recommended** that a community-based biopsy programme of live animals be established. This would generate information on the rate of encounters and provide samples for stock structure analysis. If locals were interested in participating in such a program, the WG proposed that a dedicated person within the community be tasked with collating information on the efforts and results and present this information to the next meeting of the NEGWG.

The WG **agreed** that if a hunt goes ahead, despite the WG's strong recommendations for 0 catches in all management area of East Greenland (see Chapter 9), it is crucial that more information be collected from any hunted narwhal to help address the question of a putative spring stock within management area 1, better understand how this may relate to the types described by the hunters (in Section 2.1.2), and deliver relevant information on life history parameters. The WG **recommended** the mandatory collection of the following data from any hunted narwhal:

- skin biopsy sample
- the type according to the three categories of narwhals described by hunters
- photograph of the back (for colouration pattern)
- girth measurement (i.e., the maximum circumference measured from dorsal ridge to the midline on the belly and multiplied by two to get the full circumference)
- for females, information on whether there is milk in the mammary glands (requires only a cut in the mammary gland).

if possible:

- an eye (to be used for age estimation), should be frozen immediately

This information was requested in addition to the already requested and mandatory information, including

- length measurement
- sex of the whale
- date and location of the catch
- presence/absence of a foetus

To help determine the summer distribution of the putative spring stock in Scoresby Sound, the WG also discussed that a satellite tagging program could be established in collaboration with the hunters. For this to be effective, it would have to be combined with a closure of the spring hunt (i.e., a closure in the period 1st January – 31st June) to conduct the tagging operation without competition with the hunt. The spring catch has, however, declined in importance and it is generally difficult to catch narwhals in nets in spring due to the sea ice. Another option, that will require some technical developments, is to tag narwhals from a helicopter in spring in areas outside Scoresby Sound (of which the feasibility has been demonstrated, see Section 4.2.1).

In addition, the WG welcomed the attendance of user experts at the next NEGWG meeting. Scientists from the NEGWG were also encouraged to attend the MCC meetings as members of their national delegations, to help increase dialogue between hunters, scientists, and managers.

3. INFORMATION REQUIREMENTS TO DEVELOP ADVICE ON EAST GREENLAND BELUGAS

Agenda items 3.1, 3.2, and 3.3 were discussed together.

Tervo presented working paper NAMMCO SC/28/NEGWG/12 – *Occurrence of belugas in East Greenland.*

Summary

There is no evidence of a stock of beluga whales residing in East Greenland. The few animals that are sporadically observed along the coast of East Greenland are likely to stem from the Svalbard or West Greenland stock. Both now and historically, belugas have been rare in East Greenland.

Greenland has had three systems for reporting catches. Between 1955 and 1992 a catch reporting system ("Fangstlistesystemet") was in place that appointed locals in each settlement to keep track of the hunt in that settlement. In 1993, a new reporting system ("Piniarneq") was started to include hunting date and community. Since 2009, the hunters are asked to additionally fill out "Special Reports" with more detailed information on hunting date, location, biological information of the animal, and on the hunting method. The Special Reports provide the best quality information.

While quotas are given for the different beluga stocks in WGL, the species has been protected in East Greenland (EGL) since 2011. Reported catches in EGL are therefore either by-caught animals or illegal catches. Between 1993 and 2021, 35 animals have been reported by-caught, with the majority of reports coming from Tasiilaq (n=29). The highest annual catch occurred in 2003 when 12 animals were by-caught in Sermiligaaq (Southeast Greenland). The latest catch was 3 animals by-caught in Ittoqqortoormiit in 2020.

Discussion

Questions were raised about whether the reported catches of beluga were accurate. There may be linguistic confusion between narwhal ("black beluga" in Greenlandic) and beluga ("white beluga") and the lines to report the two species are above each other in the Piniarneq reporting scheme, which makes accidental mis-reporting possible. This is known to have happened for other species. The catches reported in the Special Reports (which need to be completed in addition to the Piniarneq reporting for every individual from a 'quota' species) have been quality-assured since they were introduced in 2009 (e.g., by calling the hunters both randomly and to check on specific unusual events). The largest reported catch of 12 animals that took place in 2003 has, however, not been validated. The WG acknowledged that in addition to the numbers of caught animals registered, the hunters during the MCC meeting reported an increase in the sightings of belugas in East Greenland since 2010, while they described beluga sightings as rare in the past until 2010.

The WG **agreed** that there is currently insufficient information to conduct an assessment of belugas in East Greenland. Methods discussed to obtain the required information included collaboration with the hunters to tag and release live by-caught belugas, documenting sightings, and collecting biopsies.

The WG **recommended** that any by-catch of beluga in East Greenland be documented in a special report and that a mandatory collection of data be implemented, similar to that for narwhal, including:

- skin biopsy sample,
- one tooth for age determination,
- girth measurement (i.e., the maximum circumference measured from dorsal ridge to the midline on the belly and multiplied by two to get the full circumference)
- for females, information on whether there is milk in the mammary glands (requires only a cut in the mammary gland).

The WG noted that this information being requested was in addition to the already required information on:

- date and location of the by-catch,
- length measurement,
- sex of the whale,
- presence/absence of a foetus.

Although there are some uncertainties on how genetically differentiated the belugas from different locations are, the Svalbard population, the likely stock of origin of the East Greenland belugas, is a rather genetically distinct population. It was noted that there are samples from 3 belugas by-caught in the Scoresby Sound area that can be used for genetic analysis to investigate which stock they belong to.

Lorenzen presented the preliminary results from an ongoing genetic analysis of beluga samples from Svalbard, Canada and Greenland that provides insight into stock structure.

Summary

Ongoing genomic work on belugas provides preliminary insights into the degree of genetic structuring among stocks across the circumpolar range of the species. The genomic data represent a reference panel of genetic information of the species; it includes genome-wide data from 199 beluga sampled across 23 stocks. Preliminary analysis of the data indicates a high degree of population subdivision, and many stocks appear to be genetically distinct. This will potentially allow samples of unknown provenance to be assigned to a geographic origin with genomic analysis.

Of interest to the recent observations of belugas in the waters off East Greenland, the beluga genomic reference panel includes samples from Svalbard, Yenisei and White Sea. These three stocks group together in a genetic cluster and are well-differentiated from other beluga stocks elsewhere. Hence, by DNA sequencing beluga individuals from East Greenland and comparing the data with the reference genomic panel, it should be possible to ascertain from where they came.

Discussion

Lorenzen informed that although the genetic analyses being performed by her team began with an interest in evolutionary history, there was now an increasing focus on investigating how the work can contribute to determining stock structure and provenance of individuals, both for belugas and narwhals.

It was noted that to estimate the divergence time, high-quality genome samples are required. High-quality genome samples are samples with a high level of information from a few individuals (vertical sampling). Low-quality genome samples, i.e., less information per individual but more information across a larger number of individuals (horizontal sampling), are generally cheaper to obtain. The purpose of the analysis determines which sampling strategy is most appropriate. It was noted that for belugas, the latter option (many low-quality genome samples) had been adopted.

Although there is no doubt that belugas may be observed along the coast of East Greenland, the WG **agreed** that there is no concrete evidence to conclude that the numbers are high enough to sustain a hunt. Even if genetic analyses suggest that the belugas in East Greenland are related to the Svalbard stock, it was underlined that the recommended catch is zero until a solid stock connection has been established and an assessment of the relevant stock has been agreed within NAMMCO.

The WG **agreed** that there is currently insufficient information to perform an assessment of belugas in East Greenland and therefore **recommended** that belugas in East Greenland remain fully protected. If belugas in East Greenland are live by-caught, the WG **recommended** that all efforts should be made to release the animals. The WG also **recommended** that samples be taken from all dead by-caught individuals (including skin samples and teeth). Furthermore, the WG **recommended** the collection of documentation of hunter observations in a structured manner, similar to that recommended for

narwhal (Section 2.6), including photographs or video footage of the animals, information on where and when the animals were observed, and how many were seen.

4. DISTRIBUTION AND ABUNDANCE OF EAST GREENLAND NARWHALS

4.1 INFORMATION ON HISTORICAL DISTRIBUTION OF NARWHALS IN THE GREENLAND SEA

Tervo presented NAMMCO SC/28/NEGWG/13 – *Occurrence of narwhals at Hjørnedal field station in Scoresby Sound, East Greenland.*

Summary

Hjørnedal field station was established in 2010 by the Greenland Institute of Natural Resources (GINR) to function as a base for narwhal research. The station has been manned since 2010 every year for on average one month between July and September. During this time, the area is frequently visited by narwhals as determined from satellite tracks (GINR data) and catch reports from the area.

The occurrence of narwhals in Hjørnedal was investigated using live-capture records and reported catch records. A negative trend has been observed in both datasets. Since 2020 no narwhals have been live-captured or harvested in the area. This is significantly less than the average 23% of the total harvest in management area 1 usually taken in Hjørnedal annually. It was concluded that narwhal numbers in Hjørnedal have decreased since 2018.

Discussion

It was asked whether the hunting effort around Hjørnedal had remained the same in recent years, and whether there had been hunting at this site before the field station was built. The locality has since the 1980s been used by hunters but has become more popular after the field station was established, partly because of the opportunity for hunters to cooperate with scientists and thus receive a supplementary income. The increased size of boat engines had also made it easier to reach the area.

Possible reasons for the number of narwhals declining in the Hjørnedal area were discussed. Since the mark-recapture study (discussed in Section 4.5) shows the same individuals reoccurring in the area after human encounters through tagging, the presence of human activity alone does not seem to lead to displacement. The WG did however emphasise that boat traffic and engine size (from both hunting vessels and Icelandic tourist operations) may have increased, meaning that there may have been an increase in anthropogenic noise in the area and narwhal were known to be sensitive to noise (noise disturbance is further discussed in Section 6.3).

The WG acknowledged that although the information from Hjørnedal cannot be extrapolated to a larger population, the significance of the changes observed in this location are important as they support the larger signal provided by the assessment, which shows a decreasing population.

Hansen presented working paper NAMMCO SC/28/NEGWG/11 – *Observations of narwhals offshore in East Greenland.*

Summary

Narwhal observations have been documented in the Greenland Sea and in Denmark Strait for the past 150 years. Here, a comparison of last century bowhead whalers' effort and observations of narwhals from the northern (May-June) and southern (July-August) hunting grounds in the Greenland Sea were compared to opportunistic observations of narwhals in the same area between 1880-1982. Observations from this period were compared to the distribution range of narwhals found from dedicated aerial surveys in winter and summer covering the Greenland Sea (2017) and in Denmark Strait (2015). Observations of narwhals show no apparent changes in distribution patterns from historic to modern times. In general, there are few observations made offshore during summer with

the majority of observations made close to the coast. In addition, tracks from European bowhead whalers' hunting effort were compared to tracks from bowhead whales tagged with satellite transmitters in 2017. Again, there was no apparent change in the distribution pattern of bowhead whales from past centuries and the current seasonal distribution pattern.

In the Denmark Strait, both historic and several present aerial surveys offshore from Scoresby Sound to Cape Farewell indicate no narwhals summer offshore in this area.

Discussion

The WG noted that this information on distribution patterns over time would be used in the planning of the spring survey.

The plans for the planned spring and summer surveys are further described under Section 4.4.

4.2 REVIEW OF MOVEMENTS AND DIVE BEHAVIOUR DATA

4.2.1 Satellite tracking studies

Heide-Jørgensen presented NAMMCO SC/28/NEGWG/05 – *Narwhal in Northeast Greenland – observations, biopsies and satellite tagging (from helicopter).*

Summary

During fieldwork in 2018 narwhals were observed all the way from some 250-300 km east of Greenland across the entire shelf area right up to the coast of Greenland. In 2019, biopsy samples from narwhals in this area were successfully collected from helicopter. Based on experience from 2019, the easiest animals to approach were large males, while females and younger animals often dove before being closed on. Several times adult males laying still at the surface resting were encountered; these individuals were generally easily approached. During 3 days in August 2021, over 180 narwhals in an area close to the Greenland coast between 79˚ and 80˚N were observed. They often occurred in small, loosely connected groups, many of which contained females with calves. A total of 12 biopsies were collected, 8 from adult males and 4 from females. In addition, 4 attempts were performed to attach satellite tags (limpet tags); 2 of these attempts were successful. The two first attempts were conducted using a crossbow with a custom-made cup on the tip of the dart. The power of the crossbow when fired was too strong to hold the tag in the cup so during the first attempt it separated from the cup in the air before reaching the whale. The next limpet tag was then attached to the cup with 4 small points of cyanoacrylate glue to prevent separation from the cup before hitting the narwhal. When trying to deploy this tag, playback in slow motion (all tagging and biopsies were filmed with Go-Pro) showed that the arrow did not fly straight because of the heavy weight of the tag at the tip of the dart. The arrow hit the whale sideways and the tag was lost. The DanInject system was therefore used instead, continuing to use fast-setting glue to attach the tag to the cup. Using 20 bar pressure, the next two attempts to attach satellite tags were successful. The limpet tags were both deployed on adult males a bit offshore at about 80˚N. Post deployment both animals swam into fjords adjacent to their tagging locations (Figure 2). The tags reported for 7 and 20 days with track lengths of 443 km and 1363 km, respectively. Maximum dive depth ranged between 10 and 250 m with an average of 100 m. The maximum depth point identified on the TDR data stream was 217 m. The maximum dive duration was 28 min with an average of 14 min. All of these dives were shallow and short dives for narwhals, likely reflecting the shallowness of the areas the whales occupied while the tags reported data. Limpet tags were developed for deployment on the dorsal fin of killer whales, i.e., a relatively flat surface. When hitting more rounded surfaces, such as narwhals, the tag started to rotate as soon as the first barb hits the whale. This likely impacts the solidity of the attachment. The authors suggest that a single spear instead of double point attachment be developed for tagging narwhals remotely. Helicopter tagging is the only feasible way of approaching narwhals in areas with heavy drift ice. The new mini-tag development within NAMMCO could be interesting with regards to narwhals. Adult narwhal males have a blubber layer that is as thick as a minke whale, and unlike minke whales the narwhals have a

strong connective tissue between the epidermis and the blubber so if the petals on the anchors of the tag get below the connective tissue the potential for long tracks should be very good.

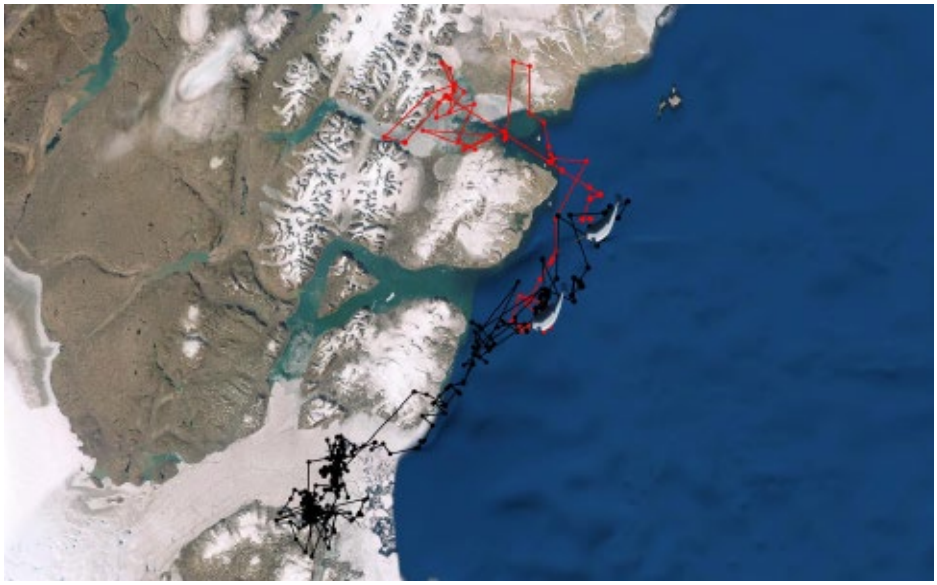


Figure 2. Tagging site (narwhal symbol) and tracks for two narwhals instrumented with limpet tags, deployed from a helicopter August 2021

Discussion

The WG welcomed the new data from narwhals in such a remote area where the animals are not hunted. The possibility of using this approach (tagging and biopsy sampling from a helicopter) to study the summer distribution of the spring sub-stock of narwhals in Scoresby Sound was discussed. The WG acknowledged that there were, however, logistic challenges such as helicopter deployment in a remote area and/or need for ship support. The limpet tags used in this study only lasted 7 and 20 days. The WG discussed how longer retention times could be achieved, e.g., by using a harpoon head attachment as in a beluga study in Canada (with up to 42 days retention time). It was noted that single prong tags had been tried but did not attach effectively nor lead to longer retention times.

4.2.2 Time-depth recorder studies (review of JWG-QSG recommendations)

During its meeting in 2020, the NAMMCO-JCNB Joint Working Group on Narwhal and Beluga (JWG) established a quantitative sub-group (QSG) to review methods for estimating availability bias. This included looking at data from different time-depth recorders and assessing the impact of variations in how the instruments recorded depths. This particularly related to the lag time that can occur in connection with the change of temperature, which can then impact the estimate of the time the animal spends at the surface. The QSG met 5 times throughout 2021, and each meeting occurred over multiple days. Following their extensive discussions, the QSG identified the data sets that should be used for estimating time at surface. A report presenting the conclusions of the QSG is currently being prepared and will be presented to the next JWG meeting in December 2021.

4.3 REVIEW OF AERIAL SURVEYS IN EAST GREENLAND IN LIGHT OF REVIEW BY JWG-QSG

As noted in Section 4.2.2 above, the JWG established a sub-group (QSG) of experts in quantitative analyses to discuss and resolve what is deemed to constitute the most appropriate method for correcting for availability bias in aerial surveys. The QSG involved experts in aerial surveys and abundance estimation of narwhals from both Canada and Greenland. This expert sub-group had extensive discussions of the various methods that could be used to correct for availability bias. The QSG concluded that there was no reason to adjust the Hidden Markov Models used in the calculation of estimates from the aerial surveys in East Greenland. The currently available abundance estimates in East Greenland were therefore deemed appropriate for use in assessment without any further

revision. Some of the abundance estimates from the Canadian surveys were, however, deemed to require revision.

The WG thanked the QSG for their work and noted that the QSG review of the East Greenland abundance estimates confirmed their reliability.

4.4 REVIEW OF PLANNED SURVEYS

Spring survey of area around Scoresby Sound

Hansen presented NAMMCO SC/28/NEGWG/18 – *Spring survey to further investigate the distribution of the putative spring stock of Scoresby Sound.*

Summary

At the last NEGWG, the WG agreed that the question of whether the animals being caught in Ittoqqortoormiit between April-June are coming from a different stock than the stock summering in Scoresby Sound is important and difficult to answer with the data currently available. The stock structure in this area requires further work to be resolved. Following the advice from NEGWG 2019, an aerial survey covering the area indicated by the blue box in Figure 3a was scheduled for May 2020 but postponed twice due to COVID-19 and is now scheduled for May 2022. The aim of the survey is not to develop a total abundance estimate for the wintering ground of narwhals but to investigate if there is a disjunct distribution of two wintering grounds, thus indicating a possible segregation between narwhals wintering in the southern part of the area (determined as wintering ground for narwhals summering in Scoresby Sound) and a possible narwhal wintering ground in the northern part of the area (off Liverpool Land) for narwhals from unknown summer origin. In preparation for the survey, the local fisheries and hunter's organization (KNAPK) was asked to provide local knowledge of narwhal observations between January-June (Figure 3b) and their willingness to participate in the survey to observe how an aerial survey is conducted. Areas suggested by KNAPK are areas where narwhals have previously been observed, e.g., from the Norwegian photographic seal surveys in March-April.

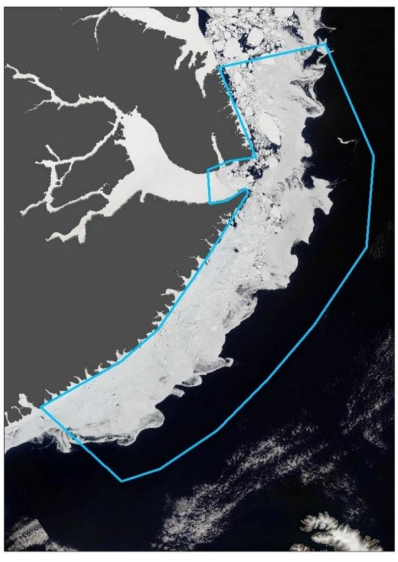
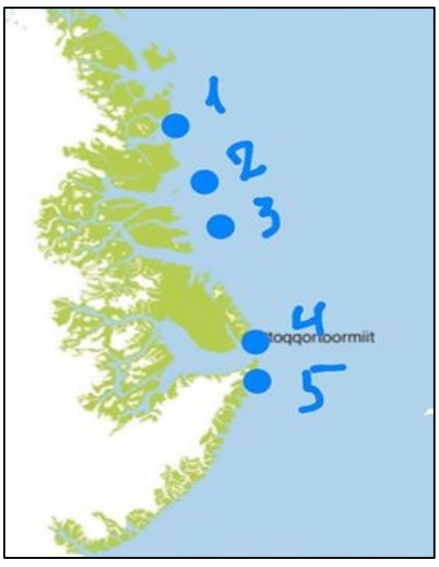
(a)  (b) 

Figure 3. (a) Proposed area for a spring survey (scheduled for May 2022). (b) Number 1-3 refer to old polar bear hunting trips where hunters observed narwhals in March-April. Number 4, narwhals observed in January - March and number 5, narwhals are observed in February.

Discussion

The WG underlined that it was not the intention of this survey to provide a count of the putative spring stock of Scoresby Sound narwhals and that it would probably not provide an estimate for an assessment of this stock. It was noted that this would be an exploratory and adaptive survey, where

transect lines could be added as the effort progresses north, with the expectation that a distributional gap could be reached.

The WG **agreed** with the adaptive design of the survey and advised that the planning of the survey should consider adding effort on the coastline north of Scoresby Sound and to include areas with historical narwhal sightings by hunters.

New summer survey of East Greenland

Ugarte informed the WG that the Government of Greenland had recently decided that a new aerial survey should be performed in summer and possibly in 2022. He then reported on the GINR's plan regarding that survey. In October 2021, the Greenland Parliament approved a proposal from the two largest parties to allocate funding for a summer survey of narwhals in East Greenland. This survey should cover all summer hunting areas (Ittoqqortoormiit, Kangerlussuaq and Tasiilaq) and extend further south than previous surveys. There should also be more hunter participation than in previous surveys. By the time of this meeting (October 2021), there had been no official announcement from the Government and financing is pending on approval of the 2022 budget. If funding is provided, GINR plans to consult with hunters from East Greenland about which important areas for narwhals should be covered, so that their knowledge is taken into consideration when designing a survey that complies with Distance Sampling procedures. GINR also plans to invite a hunter to the survey, so they can see how it is done and hopefully gain some understanding about the methodology. GINR has also published a video, in both Danish and Greenlandic, that describes how aerial surveys are performed (GINR 2021).

Discussion

The WG **agreed** that although the 2019 assessment was performed with sufficient information to have confidence in the results, since the last survey was in 2017, a new survey providing updated information on these depleted stocks and their distribution was welcome. The WG did, however, stress that there are many different factors other than the abundance estimates that influence the result of the assessment (e.g., changes in the sex ratio of a population, the number of reproductive females and the birth rate), and that they therefore did not expect a new survey to radically change the current advice.

It was noted that the previous survey of southern areas of East Greenland received criticism from the hunters on the appropriateness of the survey effort. Hunters expressed concerns that areas with high densities of narwhals, particularly within certain fjords, were not surveyed properly. They also expressed a desire to be present in the planes during the aerial surveys.

The WG discussed several ways to cover additional areas in the 2022 survey, and how to handle areas of possible high density while still providing a survey that followed scientific standards and delivered data useful for trend analysis. This included conducting full photographic surveys in fjords and/or high-density aggregations, stratifying according to high- and low-density areas, mixing a line transect design with total counts in some areas (which may or may not then be included in survey analysis) and the hunter proposal to document observations from high land/cliffs. The WG **recommended** that different approaches to counting narwhals in the fjords be further examined, but only to the extent that new approaches generate results compatible with those of the existing time-series. The WG also **strongly recommended**, that although the planning should be done in collaboration with the hunters, it was very important that the survey methodology (including the design of the track lines) continue to be done according to internationally accepted survey standards, to ensure that abundance estimates derived from the survey can be accepted by NAMMCO and used in the assessment. It would therefore likely be beneficial to explain the important aspects of survey planning and methodology to hunters in advance of the survey plan being finalised.

4.5 MARK-RECAPTURE ABUNDANCE ESTIMATE FOR SCORESBY SOUND

Heide-Jørgensen presented working paper NAMMCO SC/28/NEGWG/10 – *A mark-recapture abundance estimate from Scoresby Sound in 2019*

Summary

A total of 65 narwhals have been instrumented with recorders and satellite transmitters (excluding tusk-mounted transmitters and heart rate recorders) in Hjørnedal, Scoresby Sound, between 2010-2019. The instruments leave a permanent scar on the skin of the whales that are easily recognisable by the hunters and personnel involved in the live capturing operations. In August-September 2019 a total of five whales (four with scars and one with a satellite transmitter) were recaptured from the Greenlanders summer hunt (post 1 July) of 50 whales and the live capturing operation in August. Together with the large number of recaptures in previous years (2010-2018; n=5), this high level of recapture in 2019 raises concerns about the size of the narwhal population in Scoresby Sound. A Chapman estimator was used to generate a mark-recapture estimate of abundance of the narwhals in 2019. The estimated abundance in 2019 was 530 whales (95% CI: 179-882). If an annual natural mortality of 2 percent from 2010 is assumed, the corrected abundance estimate is 514 whales (95% CI: 174-854).

Discussion

This paper presented a revised and updated version of the paper presented to the WG in 2019, with one supplementary recapture in 2019 (5 recaptures instead of 4 previously), one instrumented animal less (65 animals instrumented since 2010 instead of 66 previously), and an overview of the captures, recaptures and catches of narwhals in Scoresby Sound in summer.

In 2019, the WG had concluded that given the concerns regarding the mark-recapture sampling, the estimate should not be included in the assessment. However, the work was considered valuable and the WG recommended that it be continued, and that further analysis be presented at future meetings.

The WG welcomed the updated mark-recapture abundance estimate. It noted that, although generated through a totally different method, the mark-recapture abundance estimate is of the same order of magnitude as that generated through the last aerial survey, i.e., a population of a few hundred narwhals in the Scoresby Sound area. This provides further confidence in the accuracy of the aerial survey estimate.

However, the WG considered that the concerns related to the study program, which was not initially designed as part of a formal mark-recapture exercise, still remain, and that they may engender a positive bias in the estimate. These concerns include:

- The mortality rate currently used to correct the abundance estimate is assumed but not known.
- The fraction of the population represented in this estimate is not clear, as the recaptures were not just at the tagging site but also in other areas of the fjord. Therefore, the extent to which this work could generate an abundance estimate for all of Scoresby Sound was not clear.
- The independence of the recaptures was not clear since several animals had sometimes been marked within a group and narwhals exhibit coordinated behaviour.
- The rate of narwhals killed but sunk/lost (estimated at 30% in this area), and thus *de facto* not available to recapture, should be taken into account.
- The reasons for the high level of recapture in 2019 compared with previous years is not well understood and might be due in part to an increased interest (notably financial) of the hunters in reporting when marked animals are killed.

The WG also noted that adding a mark-recapture abundance estimate, with a relatively lower variance, as a last data point in a time series of survey-generated abundances would have a strong effect on the modelled population trajectory.

In conclusion, the WG **agreed** that presently, there are too many uncertainties associated with the mark-recapture estimate, particularly regarding the associated biases, to use it in the assessment as a supplementary point estimate. However, the WG also underlined that it was reassuring that this estimate was of the same magnitude as the latest aerial survey estimate. Avenues that could be explored to improve the estimate or the associated biases are conducting a sensitivity analysis to investigate how a change in the number of recaptures changes the estimate.

5. BIOLOGY

5.1 LIFE HISTORY

Garde presented NAMMCO SC/28/NEGWG/FI07 – *Biological parameters in a declining population of narwhals in Scoresby Sound, Southeast Greenland.*

Summary

A decreasing trend in narwhal abundance has been identified in a small population in Scoresby Sound, Southeast Greenland. It was hypothesised that excessive hunting has affected the life history and population dynamics of this population. Biological samples collected from the Inuit hunt, from satellite-tagged narwhals, and from official hunter reports were used to estimate age, growth and reproduction. From 2007 through to 2019, a decreasing proportion of young and increasing proportion of older whales were harvested. Male and female body length and male tusk length increased significantly, while male and female body mass showed a non-significant increase. The probability of catching a female decreased significantly, while a non-significant decline of catching a pregnant female was observed in both biological samples and hunters' reports (Figure 4). Narwhal swimming speed correlated with fluke widths indicated that larger whales attain greater speed. The decline in juveniles and females are probably due to an opportunistic hunting practice targeting the easiest-to-catch whales, where bigger whales are faster and more difficult to catch. The cumulative effect of overharvest with a declining proportion of females, an overrepresentation of large males and a lack of calves and juveniles, has detrimental implications for this small narwhal population. The results have been accepted for publication in Arctic Science (Garde et al. 2021).

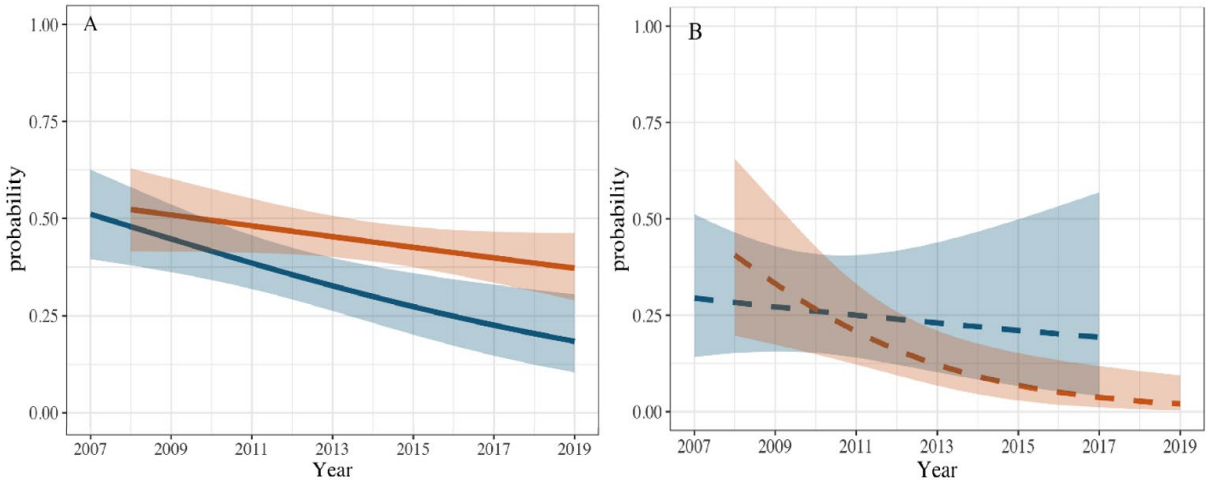


Figure 4. Model outputs for the probability of catching a female (A; n=606) and for the probability of catching a pregnant female (B; n=155) as a function of year separately for the two source of data GINR (blue) and hunter Special Reports (chocolate). The solid line indicates a significant effect of year ($p<0.01$), the dashed line a non-significant effect ($p>0.05$), and the shaded area marks the 95% confidence interval. There was no significant difference between the two datasets GINR and hunter Special Reports in either case ($p>0.05$).

Discussion

The decreasing trend in pregnancy rate is supported by the information from the hunters on foetus presence in catches. Further support for declining reproduction has come from the latest aerial survey in 2016 when no calves were observed, although they had been seen during previous surveys. The WG **agreed** that the disproportional hunt of young females, has led to now fewer and older females in the population, older females which may tend to have a lower average pregnancy rate. Although there have been some initial investigations into the onset of senescence in narwhals, the data are not conclusive. In the population around Ittoqqortoormiit though, the WG **agreed** that there are strong indications of a decline in productivity, a loss of females, and thus a loss of recruitment.

The question was raised whether stress from hunting could lower reproductive rates. Watt informed that increased cortisol levels recorded in a small population of beluga in Cumberland Sound suggested that historical drive hunting in this area could be contributing to elevated stress levels. Blubber samples (taken closer to the skin than the muscle tissue) could provide a baseline level for stress, as outer blubber takes longer to integrate cortisol than blood. It was noted that there are some blubber samples from females available from Scoresby Sound and if combined with samples from Canada and West Greenland, an analysis could be done to investigate whether there is a pattern in increased cortisol levels and lowered reproductive rates.

Pregnancy rates calculated based on data from the Special Reports may be an underestimation. When a caught female is reported by the hunter to be "adult", this animal is assumed in the analyses to be a sexually mature female, although she might be sexually immature. Additionally, small foetuses are hard to detect (in June and July) and it is possible that, even though the hunter has reported "No" in the foetus category, the number of reported pregnant females is an underestimation. An overestimation of the amount of sexually mature females, and an underestimation of pregnant females, would result in an underestimation of pregnancy rate. The pregnancy rate calculated based on the Special Reports, however, does also suggest a declining trend. The trends from the biological samples as well as the hunter records are consistent (see Figure 4).

The WG underlined that the results of this study are specific to the narwhal population in Scoresby Sound. In Tasiilaq and Kangerlussuaq where the hunt is done by kayak there has not been the same level of disproportionate catch of pregnant females.

Garde presented working paper NAMMCO/SC/NEGWG/08 – *New pregnancy rate(s) for narwhals in West Greenland.*

Summary

New information on pregnancy from 20 sexually mature female narwhals (14 from Qaanaaq (n=11) and Disko Bay (n=3), West Greenland; 6 from Tremblay Sound, Canada) were located in the GINR database and included in the estimation of two pregnancy rates (including and excluding whales from Tremblay Sound) for narwhals in West Greenland. Of the 20 females, 7 were pregnant of which 4 were from West Greenland (Qaanaaq (n=3); Disko Bay (n=1)) and 3 from Tremblay Sound. The information was added to data on 15 pregnant out of 40 mature females from West Greenland (Garde et al. 2017) estimating two new pregnancy rates of 19/54=0,352 (excluding Tremblay Sound) and of 22/60=0,366 (incl. Tremblay Sound). The new pregnancy rate of 0,352 for narwhals in West Greenland (excluding whales from Tremblay Sound) are suggested to be used in future assessments of West Greenland narwhals.

Discussion

It was noted that these pregnancy rates for narwhals in West Greenland are higher than the pregnancy rates (presented in SC/28/NEGWG/FI07) for narwhals in Scoresby Sound. The pregnancy rates in Canada are also higher than those observed in East Greenland.

Since there is an estimated gestation period of 11-15 months for narwhals (Heide-Jørgensen and Garde 2011), the question was raised as to whether it was possible that the pregnancy rates are overestimated. Females are believed to become pregnant around May and June and give birth in June and July the following year. No large (>140cm) foetuses have been observed in August, indicating that there is no overlap between pregnancies from different years during August.

The WG concluded that, based on the results presented in both FI07 and WP08, it is likely that the hunt has shifted to older animals due to a lack of younger animals, and that there are strong indications of a loss of females and a decline in productivity, and thus a loss of recruitment.

5.2 GENETICS AND PHYSIOLOGY

Louis presented NAMMCO SC/28/NEGWG/19 – *A preliminary genetic analysis of narwhal samples to explore and clarify stock structure.*

Summary

A genomic analysis of 24 narwhal individuals sampled has been conducted, using ~10x whole-genome re-sequencing data. We show three genetically distinct groups: West Greenland; East Greenland; Northeast Greenland/Svalbard (Figure 5). A Principal Component Analysis (Figure 5a) shows the separation of the West and East Greenland populations on the first axis of differentiation, with NE Greenland/Svalbard being intermediate. The latter population is separated out on the second axis of the PCA. Our admixture analyses (Figure 5b) also show that West and East Greenland are genetically distinct, and support NE Greenland/Svalbard as an intermediate population; three of nine individuals (each individual is represented by a vertical coloured bar) analysed show a sign of admixture from W and E Greenland (indicated by the three vertical bars that include a proportion of blue and orange).

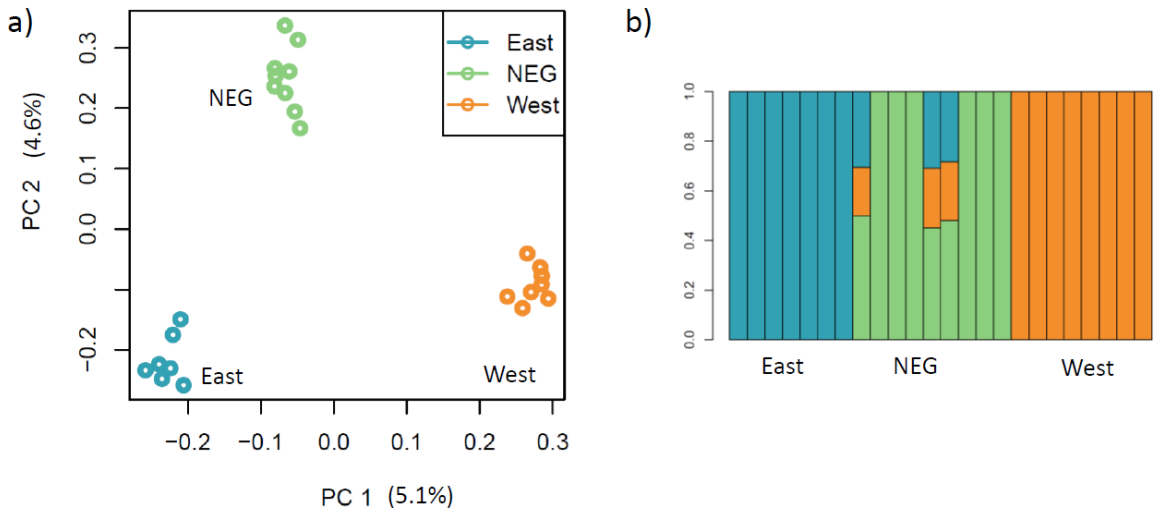


Figure 5. a) Principal component analysis of 24 individual narwhals showing first and second principal components (PCs). The proportion of genetic variance explained by each component is indicated between parentheses. b) Ancestry proportions for each of the 24 narwhal individuals for three clusters.

Analyses of genetic diversity reveal very low and relatively similar levels of genetic variation in the three populations. An analysis modelling changes in population size through deep time (>20,000 years ago) shows all three populations have the same demographic history, with a low long-term population

size followed by a population expansion; this pattern of genetic expansion could be due to actual census size increase, or due to the onset of population structure. The analysis cannot accurately reconstruct recent changes (<20,000 years ago) and those are currently being investigated using other methods.

Preliminary analyses of additional data from whole-genome resequencing data from several localities in East Greenland (Figure 6a) show fine-scale population structure (Figure 6b). Individuals sampled in Hjørnedal in the summer cluster separately to the narwhals sampled in the other regions and in Ittoqqortoormiit in the spring (Figure 6b). These results suggest genetic differentiation between narwhals present within Scoresby Sound in the summer, and those occurring in spring at the entrance of Scoresby Sound.

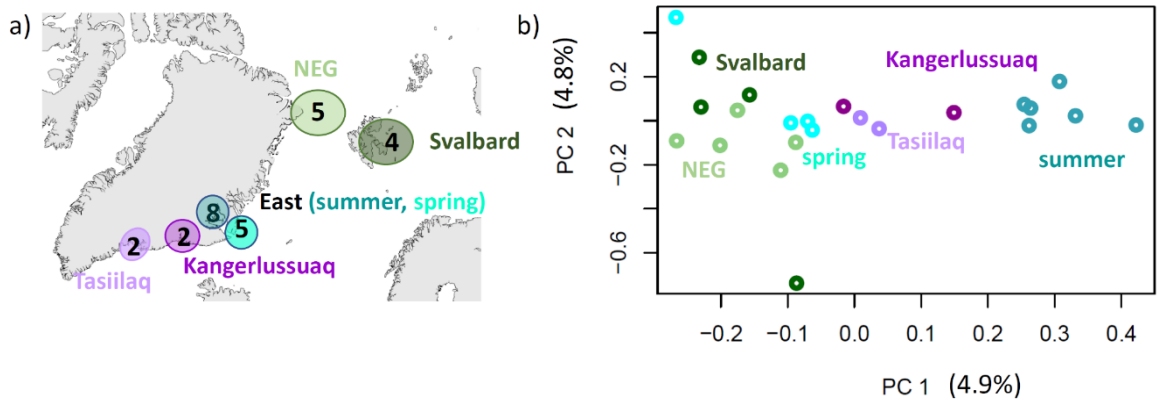


Figure 6. a) Sampling locations and b) principal component analysis of narwhal individuals sampled in East of Greenland. The proportion of genetic variance explained by each component is indicated between parentheses. Some samples have been removed from the PCA as they were related individuals

Discussion

The WG noted with interest that the preliminary analysis presented clearly showed separate clustering of the spring and summer samples from Scoresby Sound, providing further evidence to support the hypothesis of sub-structure within this stock. The WG also noted that the putative spring stock more closely resembles narwhals from Northeast Greenland than narwhals present in the summer in Scoresby Sound. It is important to note that the 5 spring samples were all taken from the same hunt and collected the same day. Louis informed that there are plans to include further samples in the analysis and emphasised that having information on both the time and location of samples collecting in Scoresby Sound is needed for determining whether the sample would be expected to fall into spring or summer sub-stocks.

The low genetic diversity in narwhals requires high quality genetic data (i.e., highly detailed information from few individuals) in order to be able to discriminate sub-structuring. The WG noted that despite the preliminary analyses in both East and West Greenland being performed using high quality/high information samples, sub-structuring in the stocks had only been indicated in East Greenland to date.

The WG discussed the possibility that there could be sub-structuring of narwhals along the whole coastline, including the NE Greenland stock. The WG **agreed** that it cannot be assumed that the NE Greenland stock is one continuous large population supplying the spring hunt. Determining whether there is structure in NE Greenland requires further analysis. There are plans to sequence more samples from Northeast Greenland, as well as from Tasiilaq and Kangerlussuaq, to help clarify any potential sub-structure. The WG also highlighted the potential value of analysing samples from animals in Dove Bay (located halfway between Scoresby Sound and the area where the Northeast Greenland samples were collected), as well as at other summering grounds along the northern coastline, to help identify

where the animals supplying the spring hunt may be coming from. Collecting these samples poses significant practical challenges given the remoteness of the locations.

The WG also suggested that it could be interesting to analyse historical samples (e.g., bones held in the Natural History Museum of Greenland) and was informed that the same three primary stock clusters (i.e., East, West and Northeast Greenland) were seen in the ancient samples (going back around 7000 years) that had already been analysed.

Regarding estimates of divergence time, the WG was informed that the methods currently available to determine this may not be at a resolution of value for management purposes as they operate in timeframes of thousands of years.

The WG concluded that this preliminary genetic analysis strongly supported the other indicators suggesting a sub-structuring of the Scoresby Sound stock. The WG **agreed** that a weight of evidence – the combination of satellite tagging data, catch and hunters' records, and genetic analysis – indicates that there likely were a spring and summer sub-stocks in Scoresby Sound. The WG noted that although significant additional information was required to make a separate assessment of the putative spring stock, the assessment of the summer stock may need to be updated based on this information, specifically by removing spring catches from the assessment.

6. ANTHROPOGENIC IMPACTS

6.1 HUNT REMOVALS

Tervo presented document SC/28/NEGWG/09 – *Update on catch statistics for narwhals in East Greenland 2019-2021.*

Summary

The objective of this paper was to update the catch record for the narwhal hunt in East Greenland and calculate total removals (including struck and loss) of narwhals in Tasiilaq, Kangerlussuaq and Ittoqqortoormiit management area for 2019-2021. Data for 2021 was available until October 28 and is therefore preliminary. The total catch for Tasiilaq (n=60) + Ittoqqortoormiit (n=95) between 2019 and 2021 was 155 narwhals and total removals was estimated to be 202 narwhals (Tasiilaq n=83; Ittoqqortoormiit n=119). The catches taken in Tasiilaq and Ittoqqortoormiit have in recent years been split into geographical locations and by season (Ittoqqortoormiit). For Ittoqqortoormiit the spring hunt was separated from the summer hunt because whales hunted in spring (before 1 July) in Scoresby Sound potentially could come from a separate stock. One animal caught in February 2021 east of Ittoqqortoormiit probably represented this stock. Only two narwhals were reported caught in the Ittoqqortoormiit management area in 2021 by mid-October, representing the lowest yearly catch since the 1980s.

For Tasiilaq, the geographical division was done to distinguish the hunts in Kangerlussuaq and adjacent fjords management area from the hunt in the Taxila management area. In 2021, 11 narwhals were caught in the Kangerlussuaq management area that marks a potential peak in a fluctuating trend in the catches observed for the last decade.

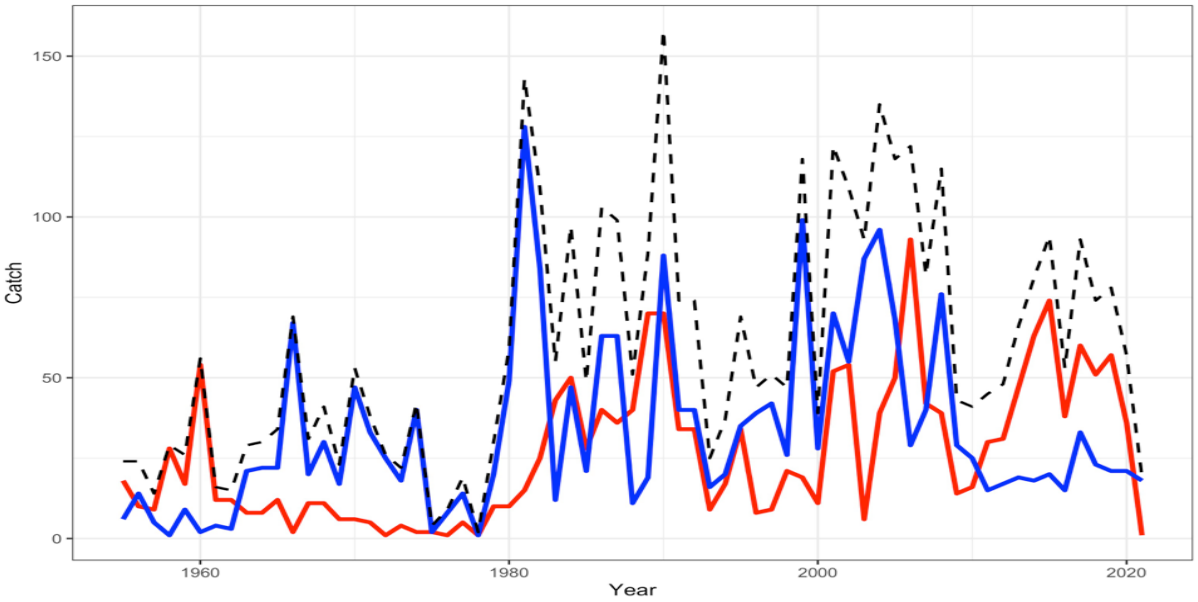


Figure 7. Reported catches of narwhals in Ittoqqortoormiit (red) and Tasiilaq (blue), East Greenland, from 1955–2021. The dashed line represents total catches (NAMMCO SC/28/NEGWG/09).

Discussion

Tervo informed the WG that the data used from the Special Reports were limited to:

- Catch locality, to look at shifts in distribution within the area (with the problems of there being some gaps in data, and differentiation between Tasiilaq/Kangerlussuaq not being possible for some data because the locality of the hunter and not that of the catch was provided).

- Hunting method, to transform the catch to total removals by applying the related struck-and-lost rate.

- Catch date, to allow dividing the reported catch in the Ittoqqortoormiit management area between the summer stock and the putative spring stock.

- For 2021, the Department of Fisheries and Hunting supplied the information already divided between Tasiilaq and Kangerlussuaq, but it is unsure if this was differentiated according to the actual locality of the catch or the settlement from which the hunter is from. This would be verified.

Several remarks were made:

Kangerlussuaq and Tasiilaq catches fluctuate in opposition to one another, which could illustrate a seasonal or temporal variation in the narwhal distribution.

Quota was introduced in 2011, resulting in a somewhat lower variability in the catches in recent years (Figure 7). Catches in the 1960s and 1970s were much lower than later catches because the hunting vessels had no or smaller engines than today, and therefore hunters could only reach the closest hunting localities (and not for example a locality like Hjørnedal in Scoresby Sound). The hunting range was therefore much smaller and less narwhals were *de facto* available to hunting. In those early years, all the catches from Ittoqqortoormiit can probably be attributed to the putative spring stock, which takes place closer to the community.

By mid-October 2021, only two narwhals had been reported caught in Scoresby Sound. Other species, such as minke whales and killer whales were also caught outside the Scoresby Sound fjord system. These catch data are preliminary, but the catch was not expected to increase during the rest of this year as it was difficult for the hunters to go out during winter. There may, however, be a delay in the transmission of hunter reports to the Department.

A question was raised as to whether there was a change in the relative proportion of animals caught in open water and by netting in Ittoqqortoormiit and whether the sex ratio in these two types of hunts were different, but this had not been investigated.

There was also a discussion on whether there is a decreasing trend in the summer catches, apart from the recent decrease in 2020 and 2021 in Ittoqqortoormiit. In Tasiilaq, the catches have been relatively stable since the implementation of the quota in 2011.

The WG discussed how reliable the reported catches were. The data reported in the Special Reports is validated by the Department, although this had not yet occurred for the 2021 data. The WG **agreed** that while a large underreporting of catches is unlikely, underreporting is known to occur e.g. in relation to animals taken in Kangerlussuaq. Hunters are typically proud to report catches, and this information is often shared in social media as well as in formal reports, and the communities are small in which people are typically aware of each other's activities.

The explanation from hunters for the drop in catches in 2020 and 2021 in management area 1 have been diverse, including increased offshore presence of killer whales scaring the narwhals away from the areas, although direct interactions had not been reported (see Chapter 7); and an increase in disturbance from vessel traffic, although this declined considerably during the last 2 years due to COVID-19. Although other factors, such as a disturbance from boats or killer whales, could result in decreased narwhal catches, the WG **agreed** that a decline in narwhal density is the most reliable explanation and is in line with the other evidence presented in this report for a declining narwhal population.

6.2 OTHER REMOVALS

6.2.1 Fisheries by-catch or entanglement data

By-catch and entanglement of narwhal is uncommon in Greenland and are not considered a concern for narwhals in East Greenland or Greenland in general.

6.2.2 Vessel strikes

Vessel strikes have not been reported for narwhals in East Greenland or West Greenland.

6.2.3 Elevated levels of predation

The possibility of needing to include significantly higher levels of predation by killer whales and polar bears in the assessment was discussed under Section 7.1 and in relation to document SC/28/NEGWG/17.

6.3 NON-LETHAL IMPACTS

Evidence suggests that narwhals are very sensitive to noise and disturbance.

A study on the impact of ship noise and airgun pulses on narwhals conducted in 2017 and 2018 at Hjørnedal in Scoresby Sound using tagged narwhals (see Document SC/26/NEGWG/08) showed that the tagged narwhals responded to the noise exposure by decreasing and changing their acoustic

activity, as well as moving to avoid the sound. The observed displacement and decreased foraging activity were, however, temporary and the animals remained in the fjord and left together with other non-tagged narwhals at the end of the summer. It was noted that large catches of narwhal were taken in 2017, 2018 and 2019. The large catches from the summer hunt in Ittoqqortoormiit in 2019 and normal migration behaviour during autumn 2018 and early winter 2019 showed that there was no long-term effect on the population from exposure to noise during this study.

As noted by the hunters, narwhals are sensitive to disturbance from boats, including sailboats, tourist boats, cruise ships and the hunters' own dinghies. This has also been noted in Canada, where the increased ship traffic before COVID had become of concern. However, in Scoresby Sound, noise disturbance from anthropogenic activities is currently minimal, with the majority stemming from the hunters' dinghies in the summer. The WG noted that both ship traffic and hunter activity in the area is increasing. Cruise ships are relatively few. Mining and resource exploration activities have been minimal, and no licenses have been applied for 2021 for Scoresby Sound. There had been two small operations in one fjord north of Kangerlussuaq.

Watt reported that in Eclipse Sound (Canada) a study had recently been conducted to examine risk of disturbance in narwhals in connection with the extensive shipping connected to the Baffinland mine. This work will soon be published. There were many confounding factors, which made it difficult to conclude with certainty what primary triggers for observed avoidance responses were. The study did, however, suggest that shipping will have an impact. The WG noted that Eclipse Sound has a significantly higher level of shipping activity, involving much larger ships, than Scoresby Sound. Lee noted that at Milne Inlet in Eclipse Sound, where there was a constant level of vessel traffic and ships waiting to enter the two ports, both the observation scheme and the hunters reported an absence of narwhals in the area.

The WG noted that the current level of marine traffic in East Greenland was minimal compared to the human activity and ship traffic that took place in the 1980s when there was a higher level of mining exploration, together with the related drilling effort, air and ship traffic.

The WG was informed that ship traffic was currently unregulated, and ships do not need to apply for permission to enter the fjord systems. In the National Park, research vessels are required to apply for a permit, however all other ship traffic in that area remained unregulated. The GINR is consulted on applications for licenses for mining or exploration activities, but research vessels going to the national park obtain their permit from Danish authorities, so this information is less directly accessible. The WG **recommended** that that shipping activities from large vessels (including cruise ships) in the summering grounds along the East Greenland coastline be regulated to avoid negative impacts on the narwhal populations. The possible overlap between shipping activity and narwhal distribution could be further investigated.

The WG noted that impacts on narwhals from disturbance will be further discussed by the NAMMCO-JCNB Joint Working Group during their meeting in December.

The WG concluded that there is evidence that noise (including from smaller boats) impacts the behaviour of narwhals. While there are not currently high levels of noise from anthropogenic activities in Scoresby Sound, this is increasing and could become an issue in the future and should therefore be monitored. As far as the assessment is concerned, there is no reason at this point to specifically include noise/disturbance as an additional component.

7. HABITAT OF EAST GREENLAND NARWHALS

The WG discussed items 7.1 and 7.2 together.

Heide-Jørgensen presented working paper NAMMCO SC/28/NEGWG/16 – *A regime shift in Southeast Greenland.*

Summary

Two major oceanographic changes have recently propagated through several trophic levels in coastal areas of Southeast Greenland (SEG). The amount of drifting pack of polar origin that is exported from the Fram Strait and transported with the East Greenland Current (EGC) along East Greenland south to Cape Farewell has decreased significantly over the past two decades and has almost disappeared in the summer months in SEG. The warm Irminger Current that advects the warm, saline Atlantic Water northward through the Denmark Strait to the East Greenland shelf has changed its temperature regime from 5.5-6.5˚C to 6.5-7.5˚C after 1997. This has, together with the absence of sea ice, been a major driver for increasing sea temperatures in SEG shelf area. The lack of pack ice in summer together with a warming ocean has had cascading effects on the marine ecosystem in SEG that is manifested in a changed fish fauna with an influx of capelin in coastal areas and mackerel, herring, and tuna in offshore areas. At higher trophic levels there has been an increase in the abundance of several boreal cetaceans such as, humpback whales, fin whales, killer whales, pilot whales and white-beaked dolphins, that are either new to this area of the Arctic or occur in surprisingly large numbers. It is estimated that the new cetacean species in SEG are responsible for an annual predation level of 700.000 tons of fish. In addition, predation on krill species is estimated at >1.500.000 tons that are mainly consumed by the large number of fin whales. There has at the same time been a reduction in the abundance and catches of narwhals and walrus in SEG and it is speculated that these species, that are endemic to the Arctic and depends on cold polar water, have been reduced in numbers due to habitat changes from increasing sea temperatures and perhaps increasing competition with sub-Arctic species.

Ugarte presented working paper NAMMCO SC/28/NEGWG/17 – *Local knowledge about killer whales in narwhal grounds of West and East Greenland.*

Summary

Observations of killer whales in coastal waters of East Greenland were rare before around 2008. Since then, there have been yearly catches off Tasiilaq and in 2021 they were observed close to Scoresby Sound and Kangerlussuaq as well. GINR interviewed narwhal hunters who saw killer whales in 2021 in Qaanaaq (Northwest Greenland), Scoresby Sound, Kangerlussuaq and Tasiilaq. In Qaanaaq, where narwhals are abundant and killer whales have been regular visitors for a long time, killer whales are not hunted and seen as beneficial for the narwhal hunt, since they bring narwhals close to shore, where they are easier for the hunters to catch. In East Greenland, where killer whales are newcomers and narwhals are severely depleted, killer whales are seen as competitors and therefore hunted. Observations of killer whales, minke whales, humpback whales and fin whales in Scoresby Sound in 2021 could either be a rare event, or early signs of shift towards a warmer ecosystem with seasonal presence of boreal species, similar to the changes already observed in Tasiilaq. Hunters manifested their worries that killer whale predation may have a negative impact on narwhals. Stomach contents of killer whales in Tasiilaq show, however, that the main prey of killer whales in East Greenland are seals, baleen whales and fish. Given narwhal density, killer whale distribution, frequency of killer whale visits, and data from harvested killer whale stomachs, killer whale predation is very unlikely to be the reason for the decline in the narwhal population in East Greenland. So far, no data are available to suggest that the presence of killer whales along the coast of East Greenland is preventing the narwhals from a recovery or introducing an additional risk of further depletion. However, the fact that killer whales were encountered while a hunter was hunting narwhals suggests that predation on narwhals

by killer whales is possible, and it cannot be ruled out that it could have some effect on the potential recovery of narwhals in East Greenland. However, this effect would be minimal, compared to the impact of current hunting pressure.

Discussion

The WG noted that there was no direct evidence of killer whales predating on narwhals in East Greenland, although it was recognised that this was known to occur in Canada and West Greenland. Given that East Greenland does not contain the same type of large aggregations of narwhals found in West Greenland, the WG consider it unlikely that narwhals would be a specific target for killer whales in East Greenland. The WG underlined that the killer whales killed near Ittoqqortoormiit this year were 30kms outside Scoresby Sound and not in the fjord system itself (where narwhals are distributed) and there was no documentation of a distributional overlap between narwhals and killer whales in East Greenland.

Hunters from Tasiilaq have suggested that killer whales may be a reason for the decline in the narwhal population, while hunters from Ittoqqortoormiit have claimed that killer whale presence this year has changed the narwhal distribution. Given the lack of evidence of killer whales predating on narwhals in East Greenland, the WG did not believe that presence of killer whales offshore could be responsible for the dramatic decline in the populations. Although predation is included in the model under natural mortality, given the small size of the populations, it is possible that any new killer whale predation that may be occurring could have a significant effect. Just as is done for large ice entrapments, it would be possible to add additional mortality into the model as single events. However, this would require data on predation, which is not currently available.

While it was possible that killer whale presence may elicit a response from narwhals in terms of a distributional shift, the WG **agreed** that this response would likely be the same for how narwhals react to other forms of disturbance and threat, i.e., moving closer to the shore. There was, however, no indication of this occurring in East Greenland, leading the WG to conclude that there was insufficient evidence to suggest that killer whale presence was changing narwhal distribution in the area.

During the discussion it was also mentioned that polar bears are potential predators on narwhals in East Greenland and that claw marks from polar bears have been observed on the back of narwhals. However, it is unknown if polar bear predation is a significant mortality factor for narwhals in East Greenland.

The suggestion from the communities that killer whales could be regulated (i.e., culled or killed) as a measure to help protect the narwhals was discussed. The WG does not consider the cull of killer whales an effective protection measure for narwhals due to the lack of clear evidence of killer whale predation on narwhals. Additionally, the WG noted that any culling plans should take into consideration the UNEP protocol to cull marine mammals (UNEP 1999). The WG underlined the current advice from NAMMCO that the killer whale hunt in Greenland should be regulated in a precautionary way as there is currently insufficient information to perform an assessment of the sustainability of the harvest.

8. STOCK ASSESSMENTS

8.1 STOCK STRUCTURE

All sub-items of Section 8.1 on the agenda were discussed together.

Following the review of the new data available since the last NEGWG meeting in 2019, the WG concluded that there was no reason to change the stock structure in management area 2 and 3.

In management area 1, the WG **agreed** that there was an emerging weight of evidence (i.e., from satellite tagging, catch records and preliminary genetic analysis) to suggest that there were two separate aggregations in Scoresby Sound - one present in the fjord system during the summer, the other during the spring. Noting that the genetic analysis was still preliminary, and the work presented had been conducted on a set of 5 samples from the spring that all came from a single hunt rather than being 5 independent samples, the WG **agreed** that, if any hunt should be conducted against its recommendation, it would be important to secure and analyse further samples from the spring hunt. as well as from the summer hunt, as this would help confirm whether there was a clear separation or whether there was some degree of mixture and overlap. Until this work was available, the WG agreed that the spring aggregation should be treated as a putative stock.

The WG agreed to perform a sensitivity analysis on the assessment of the summer stock to investigate the impacts of removing catches in Scoresby Sound in the spring (1 January-1 July). However, since there was currently insufficient data to perform an assessment of the putative spring stock, the WG agreed that the recommendation of zero takes relates both to the summer and spring hunt.

The WG **agreed** that there was no evidence to support the presence of a separate offshore stock.

8.2 STOCK ASSESSMENT MODEL

The originally prepared stock assessments were reviewed during the meeting and revised following the WG's input. The final versions are referred to here.

Ittoqqortoormiit

Witting presented NAMMCO SC/28/NEGWG/04 – *Assessment of narwhals at Ittoqqortoormiit 2021.*

Summary

This paper assessed the status of narwhals in the Ittoqqortoormiit area by the use of population models that reconcile diverse data from scientists and hunters. These include two absolute and three relative abundance estimates from aerial surveys, the age-structure of 119 individuals caught by hunters, the age of maturity of six females, a deteriorating birth rate as reported from samples of 92 females by hunters (in Special Reports) and from samples of 41 females by biologists (Figure 8b), and a history of total removals starting in 1955. Given the data, the assessment concludes that the population is small and depleted, that it is in a deteriorated demographic state with negative growth, and that it is immediately threatened by extinction from an unsustainable hunt.

The population in 2022 is depleted to 10% (90% CI:2%–21%) of the abundance in 1955 with no more than 207 (90% CI:42–441) individuals left (Figure 8a). With a negative production of 7 (90% CI:0-15) individuals per year, the narwhal aggregation at Ittoqqortoormiit cannot sustain any further hunt. With continued catches at the current quota level, there is a 30% risk that the hunt causes the population to go extinct by 2025, a risk that increases to 74% by 2028 (Table 2). This risk of hunting induced extinction is removed (i.e. reduced to 0%) if there are no removals after 2021.

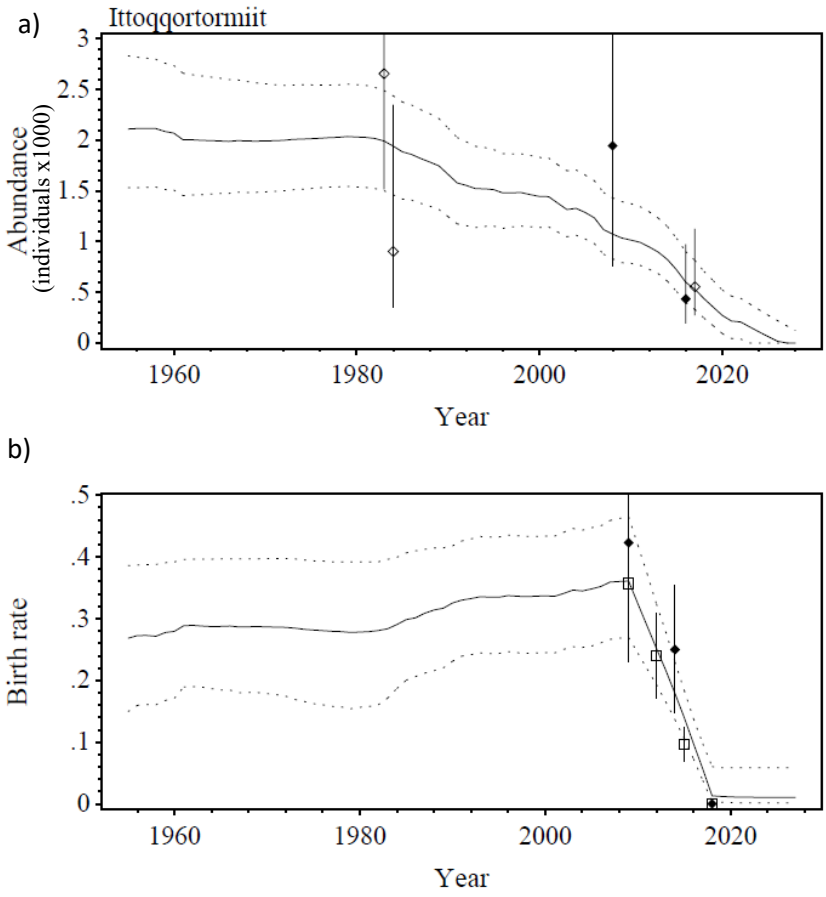


Figure 8. The projected medians (solid curves) and 90% credibility intervals (dashed curves) for abundance (a) and birth rate (b) for narwhals in the Ittoqqortormiit area. Data: Absolute (solid diamonds) and relative (open diamonds) abundance estimates, and birth rate estimates reported by biologists (solid diamonds) and hunters in Special Reports (open squares).

Table 2. Extinction of the Ittoqqortoormiit narwhal population. The risk that the hunt will cause the Ittoqqortoormiit population of narwhals to go extinct between 2023 and 2028, given different levels of annual landed catches (C; 34 is the actual quota in 2021).

C	2023	2024	2025	2026	2027	2028
34	0.07	0.17	0.30	0.43	0.57	0.74
25	0.05	0.12	0.20	0.30	0.38	0.52
20	0.03	0.09	0.16	0.22	0.31	0.37
15	0.03	0.07	0.11	0.17	0.21	0.29
10	0.01	0.03	0.05	0.09	0.12	0.16
5	0.01	0.01	0.03	0.03	0.05	0.07
0	0	0	0	0	0	0

Discussion

The WG noted that this assessment, as well as those for the Kangerlussuaq and Tasiilaq management areas, are based on the same age-structured modelling framework that has been used by the NAMMCO SC for two decades in its assessments of beluga, narwhal, walrus, and harbour porpoise.

This method is thoroughly peer-reviewed and agreed by NAMMCO as suitable to provide management advice.

The current model for the Ittoqqortoormiit area was developed in more detail than any previous assessment, in the sense that it is able to reconcile not only abundance, age structure, and removal data, but also data on life history parameters including the trend in the birth rate that has been reported in the hunters' Special Reports. The WG welcomed this development, which makes it possible to make more accurate predictions that are based on a larger, collaborative dataset.

The WG discussed a statistical problem relating to the fitting of harvest models to low abundance estimates. There is a long tradition of fitting population models to abundance data by a log-normal likelihood that reflects the multiplicative behaviour of population dynamics. If a model is fitted to a single abundance estimate, the median, upper, and lower quantiles of the projection should hit the corresponding median. This, however, is often not the case when the log-normal likelihood is used to fit a model to a low abundance estimate with a high CV. The median and upper quantile of the model may then overshoot the data estimate because the statistical distribution of trajectories of a harvested population that is downward bound by zero abundance does not fully agree with the log-normal distribution.

This has been an issue in some of the earlier narwhal assessments for East Greenland, and the new assessment for all areas introduces a skewness parameter to the log-normal likelihood function to correct for the positive bias. By comparing fits with and without the skewness parameter, the WG agreed to continue with the skewed likelihood function as it removed the positive abundance bias of the models.

Relating to the estimated risks of extinction, the WG noted that the population may become extinct for other reasons than direct removals, especially on longer timescales if it is unable to recover from the demographic deterioration imposed by hunting in the past. A more indirect extinction from demographic variation is also potentially possible given the depleted state of the population. Finally, there is the risk imposed by climate changes, operating through, e.g., fragmentation of suitable habitats, a risk that is more realistic for the aggregation around Tasiilaq. None of these risks are included in Table 2 and Table 3, and for the near future they are orders of magnitudes smaller than the extinction risks from hunting listed in the tables.

The WG noted that a sensitivity model that did not include the catch of the spring hunt provided similar results as the base case, implying that the conclusions from the assessments of the local stock are unaffected by the uncertainty in the stock structure.

In conclusion, the WG noted that there is a significant threat of extinction from a continued hunt, even on a timescale as short as a couple of years. The risk agrees with the apparent collapse of the hunt in 2021 (only 2 narwhals landed by October 15) and it stresses the immediate need for management actions to secure the presence of narwhals in the area.

Kangerlussuaq

Witting presented NAMMCO SC/28/NEGWG/14 – *Assessment of narwhals at Kangerlussuaq 2021.*

Summary

This paper assessed the status of the summer aggregation of narwhals around Kangerlussuaq in East Greenland (from 67◦N00' to 68◦N30'). Based on the abundance estimates from 2008 and 2016 and the catch history of total removals, it is estimated that the population is small and depleted. The pristine population in 1955 is estimated at an abundance of 1,050 (90% CI:730–1,640) individuals, with a hunting induced decline to a 2022 abundance of no more than 260 (90% CI:142–442) individuals (Figure 9). This implies a current depletion ratio of 0.24 (90% CI:0.11–0.52), with an annual production (birth) of no more than 6 (90% CI:0–18) individuals.

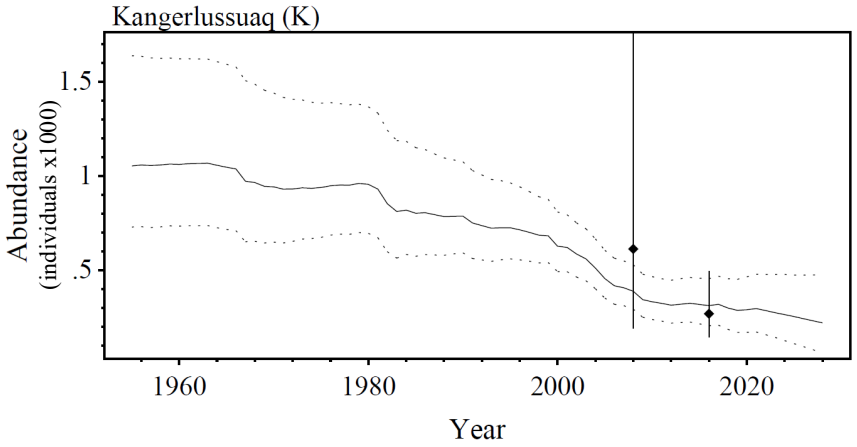


Figure 9. The projected median (solid curve) and 90% credibility intervals (dashed curves) for the abundance of narwhals in the Kangerlussuaq area. The solid diamonds are the absolute abundance estimates from 2008 and 2016.

Discussion

The WG noted the absence of data to inform on the growth rate of the population, which implies that the assessment is based on the WG's base-case understanding of narwhal life histories. While this implies an assumed positive growth rate, it is critical that the annual production of the whole population sums up to no more than 6 (90% CI: 0–18) individuals.

In conclusion, with loss rates and potential underreporting added on top of the uncertain growth rate, the WG **agreed** that there is no possibility for a sustainable hunt of narwhals in the Kangerlussuaq area.

Tasiilaq

Witting presented NAMMCO SC/28/NEGWG/15 – *Assessment of narwhals around Tasiilaq 2021.*

Summary

This paper assessed the status of narwhals in the Tasiilaq area south of 67°N00'. Based on the abundance estimate of 206 narwhals (95% CI: 76–562) in 2008 and the catch history of total removals, it is estimated that the population is small, depleted, and severely threatened by extinction from an unsustainable hunt.

The 2022 population is depleted to 16% (90% CI: 1%–55%) of the abundance in 1955 with no more than 123 (90% CI: 12–394) individuals left (Figure 10). With an estimated production of no more than 5 (90% CI: 1–21) individuals per year, the East Greenland aggregation of narwhals south of 67°N00' cannot sustain any further hunt. With continued catches at the current quota level, there is a 34% risk that the hunt causes the population to go extinct by 2025, a risk that increases to 62% by 2028 (Table 3). This risk is removed (i.e., reduced to 0%) if there are no removals after 2021.

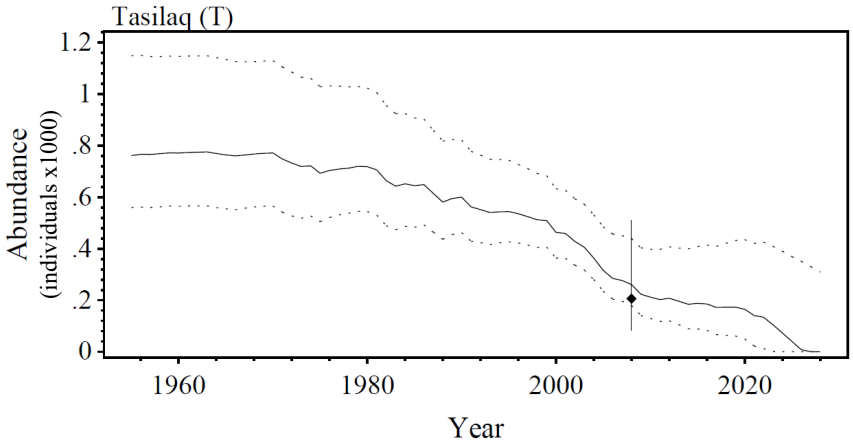


Figure 10. The projected median (solid curve) and 90% credibility intervals (dashed curves) for the abundance of narwhals in the Tasiilaq area. The solid diamond is the absolute abundance estimate from 2008.

Table 3. Extinction of the Tasiilaq narwhal population. The risk that the hunt will cause the Tasiilaq population of narwhals to go extinct between 2023 and 2028, given different levels of annual landed catches (C;22 is the actual quota in 2021).

C	2023	2024	2025	2026	2027	2028
22	0.09	0.24	0.34	0.45	0.54	0.62
20	0.09	0.22	0.32	0.42	0.50	0.58
15	0.09	0.18	0.27	0.34	0.41	0.48
10	0.07	0.12	0.18	0.24	0.28	0.33
5	0.03	0.07	0.09	0.12	0.15	0.17
0	0	0	0	0	0	0

Discussion

The WG noted that the assessment for Tasiilaq includes only a single abundance estimate from 2008. The estimated depletion is, however, supported also by the lack of estimate from 2016, when there were no sightings during an aerial survey. While the density of narwhals in this area may be too low to be detected by traditional survey methods, the assessment was statistically adjusted to acknowledge the presence of narwhals in the area. This was done by discarding the simulated trajectories that go extinct before 2023, a method that was applied also to the assessment for the Ittoqqortoormiit area.

In conclusion, the WG noted the large threat of extinction from a continued hunt, even on a timescale as short as a couple of years. This stresses the immediate need for management actions to secure the presence of narwhals in the area.

9. RECOMMENDATIONS FOR RESEARCH & MANAGEMENT

9.1 RECOMMENDATIONS FOR CONSERVATION AND MANAGEMENT

Main Management Recommendations

Based on

- separate population models for the three management areas that include all available abundance estimates, catch history and for Scoresby Sound also a sample of age distribution in catches

  and

- the decline in pregnancy rate indicating severe depletion, which strongly indicate declining stocks that cannot sustain any further harvest,

The WG reiterated its previous recommendation of zero catches of narwhals in all three management areas in East Greenland.

High risks of hunting-imposed extinction were estimated for two of the management areas:

- With continued catches at the total 2021 quota level, there is a 30% risk that the hunt causes the population of narwhals at **Ittoqqortoormiit** to go extinct by 2025, a risk that increases to 74% by 2028. This risk of hunting-induced extinction is removed, i.e., reduced to 0%, if there are no removals after 2021.
- With continued catches at the total 2021 quota level, there is a 34% risk that the hunt causes the population of narwhals around **Tasiilaq** to go extinct by 2025, a risk that increases to 62% by 2028. This risk of hunting-induced extinction is removed, i.e., reduced to 0%, if there are no removals after 2021.

These risks are very high and the WG therefore **stressed** the importance of immediate management actions to secure the presence of narwhals in Southeast Greenland.

In addition to the assessment model, there is ample evidence that indicates the narwhal stocks in Southeast Greenland are severely depleted and require immediate protection:

1. several indicators suggesting multiple small, isolated populations of narwhals
2. low and declining abundance estimates of narwhals in all three management areas
3. mark-recapture estimate of narwhals from the summer population in Scoresby Sound supporting the low abundance estimate
4. severe depletion of narwhals in all three management areas
5. apparent collapse of total catches of narwhals in management areas 1 in 2021
6. drop of summer narwhal catches inside the Scoresby Sound fjord
7. collapse of live captures of narwhals in Scoresby Sound for research purposes
8. decline of females in the population in all three management areas as indicated by the proportion in the catch of narwhals
9. decline in younger animals in the population in management area 1
10. a reduction of more than 50% in observations of calves over a 40-year period of aerial surveys in management area 1
11. declining pregnancy rate in management area 1
12. low pregnancy rates in management area 1 compared to Canada and West Greenland
13. loss of habitat in the southern part of the range
14. contraction in distributional range of narwhals

Conclusion:

- Based on the updated assessments of the three management areas, which are built on more accurate models that include more data than the 2019 models, and
- Given the high risk of extinction of the narwhals in the three management areas in a very short term, and
- Given the sum of other concurrent evidence,

the WG **strongly reiterated its recommendation** of zero catches of narwhals in all three management areas in Southeast Greenland and that it be implemented immediately to avoid extinction of these stocks in the near future.

Further Recommendations

Narwhals

The WG recommended that

- *A community-based biopsy programme of live narwhals be established, given that hunters report seeing narwhals regularly. This would generate information on the rate of encounters and provide samples for stock structure analysis.*

- *If a narwhal hunt goes ahead despite the WG's strong recommendations for 0 catches in all management areas of East Greenland, additional information be collected from any hunted narwhals besides the already mandatory information (length, sex, date and location of the catch, presence/absence of a foetus). This additional information includes: a skin biopsy sample, the type according to the three categories described by hunters, photograph of the back, girth measurements, information for females whether there is milk in the mammary glands.*

- *Shipping activities from large vessels (including cruise ships) in the summering grounds along the East Greenland coastline be regulated to avoid negative impacts on the narwhal populations, as narwhals are sensitive to noise and these small populations are particularly sensitive to impacts from disturbance.*

- *The effects of climate change be reduced and mitigated to protect the narwhal's habitat, as climate change is probably causing increased habitat fragmentation of narwhal stocks and a drastic reduction of their winter ranges.*

Belugas

The WG recommended that

- *Belugas in East Greenland remain fully protected, as there is insufficient information to perform an assessment of belugas in East Greenland.*
- *Documentation of hunter observations of belugas in East Greenland is collected in a structured manner, including photographs or video footage of the animals, information on where and when the sighting took place, and how many individuals were seen.*
- *Any by-catch of belugas in East Greenland be documented in the Special Reports.*
- *In case of live by-caught belugas in East Greenland, all efforts should be made to release the animal.*
- *Additional samples be taken from any and all dead by-caught belugas, besides the already mandatory information (*date and location of the by-catch, sex, presence/absence of a foetus*). This additional information includes skin biopsy sample, length, a tooth, girth measurements, whether there is milk in the mammary glands of females.*

9.2 RECOMMENDATIONS FOR RESEARCH

The WG recommended that

- *For examining the impact of climate change on life history parameters, life history data be collected from non-depleted stocks of narwhals in West Greenland and Canada, where climate change is also expected to have an impact.*
- *Different approaches to counting narwhals in the fjords be further examined, but only to the extent that new approaches will be compatible with the existing time-series.*
- *Although the planning of surveys should be done in collaboration with the hunters, the survey methodology (including the design of the track lines) continues to be done according to internationally accepted survey standards, to ensure that abundance estimates derived from the survey can be accepted by NAMMCO and used in the assessment*.
- *Definitions be developed for what constitutes small stocks, depleted stocks and stocks at risk of extirpation, and that frameworks for advice and management then be articulated for what actions should be taken for these different categories.*

10. OTHER BUSINESS

The WG considered the request from the NAMMCO SC for guidance on management objectives and assessment methods for small and depleted stocks, and stocks at risk of extirpation, and recommended to start by developing clear definitions and a framework for advice for these categories (see Section 9.2). It noted that this topic was also on the agenda for discussion at the next meeting of the JWG in December 2021 and looked forward to reviewing the outcomes from that meeting.

11. MEETING CLOSE

The WG looks forward to a mutually respectful collaboration among all stakeholders in the future work to ensure sustainable conservation and management of narwhals in East Greenland.

The Chair thanked all participants for their active engagement in the meeting. The WG acknowledged and thanked the invited experts as well as a broad range of participants from the SC, participating both virtual and in person and from very different time zones, for their inputs. The WG thanked the Chair for his able and engaged chairing of the meeting.

The meeting was closed at 12:15 on October 29th 2021.

A draft report with recommendations was accepted before the close of the meeting on October 29th 2021. Following minor editing and formatting work, the report was finalised on November 11th 2021.

The WG **recommended** that the NAMMCO SC arrange a special meeting to fast-track the review of this report within 2021 to address the urgency of management of the population of narwhals in Southeast Greenland.

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APPENDIX 1: AGENDA

1. CHAIRMAN 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. DEVELOPMENT OF RECOMMENDATIONS ON EAST GREENLAND NARWHALS
- 2.1. Implementation of earlier recommendations
  - 2.1.1. Review of MCC response to recommendations from NEGWG 2019
  - 2.1.2. Hunter and User Knowledge (hunter presentation to MCC 2021 meeting)
- 2.2. Economic considerations
  - 2.2.1. Review of payments to hunters for support of research activities.
  - 2.2.2. Review of commercial aspects of the hunt
- 2.3. Improve support for existing advice
- 2.4. Accounting for climate change in advice
  - 2.4.1. Changes in distribution and habitat
  - 2.4.2. Changes in life history parameters
  - 2.4.3. Changes in abundance
- 2.5. Consider alternative management objectives including mitigation of economic impacts and develop assessment methods for the alternatives
- 2.6. Prepare request for Hunter and User Data and Knowledge

3. INFORMATION REQUIREMENTS TO DEVELOP RECOMMENDATIONS ON EAST GREENLAND BELUGAS
- 3.1. Review available information on belugas in SE Greenland and identify information needs for an initial assessment
- 3.2. Recommend research necessary for an initial assessment
- 3.3. Prepare request for hunter/user data on belugas in SE Greenland

4. DISTRIBUTION AND ABUNDANCE OF EAST GREENLAND NARWHAL
- 4.1. Information on historical distribution of narwhals in the Greenland Sea
- 4.2. Review of movements and dive behaviour data
  - 4.2.1. Satellite tracking studies (Norway)
  - 4.2.2. Time-depth recorder studies (review of JWG-QSG recommendations)
- 4.3. Review of aerial surveys in East Greenland in light of review by JWG-QSG
- 4.4. Review of planned surveys, including comparison to historical distribution and recent hunter observations, and other scientific activities that could assist the next assessment.

5. BIOLOGY
- 5.1. Life History
- 5.2. Genetics and Physiology

6. ANTHROPOGENTIC IMPACTS
- 6.1. Hunt Removals
- 6.2. Other Removals
  - 6.2.1. Fisheries by-catch or entanglement data
  - 6.2.2. Vessel strikes

6.3. Non-lethal Impacts

7. HABITAT EAST GREENLAND NARWHALS

7.1. Habitat Changes

7.2. Narwhal Response to Changes - Synthesis of Population Response

7.2.1. Changes in seasonal distribution

7.2.2. Changes in life history parameters

7.2.3. Changes in habitat carrying capacity

8. STOCK ASSESSMENTS AND MANAGEMENT RECOMMENDATIONS

8.1. Stock Structure

8.1.1. Genetics

8.1.2. Seasonal distribution

8.1.3. Review of hunter three stock proposal for Area 1 based on behaviour and condition

8.2. Stock Assessment Model

8.2.1. Draft assessment model

8.2.2. Review of model structure: multiple stocks or seasons

8.2.3. Review of population model: time or habitat dependent parameters

8.2.4. Review of model priors

8.2.5. Revise stock assessment model (if necessary)

8.3. Develop Management

8.3.1. Recommendations on management of hunting

8.3.2. Recommendations on management of interacting fisheries

8.3.3. Recommendations on management of other anthropogenic impacts

9. OTHER BUSINESS

9.1. Consider request from NAMMCO-SC to JWG for guidance on management objectives and assessment methods for small and depleted stocks and stocks at risk of extirpation

10. PREPARE REPORT

11. ADJOURN

APPENDIX 2: LIST OF PARTICIPANTS

Geneviève Desportes (NAMMCO Secretariat)
NAMMCO
PO Box 6453
9294 Tromsø
Norway
genevieve@nammco.no

Eva Garde (GL)
Greenland Institute of Natural Resources
c/o Greenland Representation
Strandgade 91, 2
DK-1401 Copenhagen K
Denmark
evga@mail.ghsdk.dk

Sandra M. Granquist (IS, SC) (Online)
The Icelandic Seal Center
Höfðabraut 6
530 Hvammstangi
Iceland
sandra.magdalena.granquist@hafogvatn.is

Rikke Guldborg Hansen (GL, SC)
Greenland Institute of Natural Resources
c/o Greenland Representation
Strandgade 91, 2
DK-1401 Copenhagen K
Denmark
rgh@ghsdk.dk

Mike Hammill (Invited expert)
Institut Maurice-Lamontagne
Fisheries and Oceans Canada
Mont-Joli, Québec
G5H 3Z4
Canada
Mike.Hammill@dfo-mpo.gc.ca

Mads Peter Heide-Jørgensen (GL, SC)
Greenland Institute of Natural Resources
c/o Greenland Representation
Strandgade 91, 2
DK-1401 Copenhagen K
Denmark
mhj@ghsdk.dk

Roderick Hobbs (Invited expert, Chair)
6130 NE 204 Street
Kenmore, WA 98028
USA
rod.hobbs99@gmail.com

David Lee (Invited expert) (Online)
Nunavut Tunngavik Inc.
Suite 1002, 75 Albert st.
Ottawa, ON K1P 5E7
Canada
dlee@tunngavik.com

Eline Lorenzen (Invited expert) (Tuesday & Wednesday)
University of Copenhagen
Øster Voldgade 5-7,
1350 Copenhagen K
Denmark
elinelorenzen@snm.ku.dk

Marie Louis (GL) (Online)
Greenland Institute of Natural Resources
P.O. Box 570
3900 Nuuk
Greenland
marie.louis@natur.gl

Cuong Manh Ngo (GL)
Greenland Institute of Natural Resources
c/o Greenland Representation
Strandgade 91, 2
DK-1401 Copenhagen K
Denmark
manh.cuong.01988@gmail.com

Heleen Middel (NAMMCO Secretariat)
Assistant Scientific Secretary
PO Box 6453
N-9294 Tromsø
Norway
heleen@nammco.org

Bjarni Mikkelsen (FO, SC Chair) (Online)
Faroe Marine Research Institute
Nóatún 1
100 Tórshavn
Faroe Islands
bjarnim@hav.fo

Jonas Teilmann (Invited Expert)
Marine Mammal Section
Department of Bioscience
Aarhus University
Frederiksborgvej 399
4000 Roskilde
Denmark
jte@ecos.au.dk

Outi Tervo (GL)
Greenland Institute of Natural Resources
c/o Greenland Representation
Strandgade 91, 2
DK-1401 Copenhagen K
Denmark
outi@mail.ghsdk.dk

Fernando Ugarte (GL, SC) (Online)
Greenland Institute of Natural Resources
P.O. Box 570
3900 Nuuk
Greenland
feug@natur.gl

Gísli Víkingsson (IS, SC) (Online)
Marine and Freshwater Research Institute
PO Box 1390
IS-121 Reykjavík
Iceland
gisli.vikingsson@hafogvatn.is

Cortney Watt (Invited expert) (Online)
Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, MB, R3T 2N6
Canada
Cortney.Watt@dfo-mpo.gc.ca

Fern Wickson (NAMMCO Secretariat)
NAMMCO
PO Box 6453
9294 Tromsø
Norway
fern@nammco.no

Lars Witting (GL, SC)
Greenland Institute of Natural Resources
P.O. Box 570
DK-3900 Nuuk
Greenland
lawi@natur.gl

APPENDIX 3: LIST OF DOCUMENTS

Working Documents

Doc. No.	Title	Agenda item
SC/28/NEGWG/00	Terms of Reference	1.3
SC/28/NEGWG/01	Draft Agenda	1.5
SC/28/NEGWG/02	Draft List of Participants	1.1
SC/28/NEGWG/03	Draft List of Documents	1.4
SC/28/NEGWG/04	Witting, L. Assessment of narwhals at Ittoqqortormiit - 2021	7.2, 8.2
SC/28/NEGWG/05	Lydersen, C., Heide-Jørgensen, M.P., Blanchet, M. -A., Kovacs, K.M. Narwhal in north-east Greenland – observations, biopsies and satellite tagging (from helicopter).	4.2.1
SC/28/NEGWG/06	Heide-Jørgensen, M.P. The economic incentive behind narwhal hunting and the hunter-biologist cooperation in Greenland	2.2
SC/28/NEGWG/07	Heide-Jørgensen, M.P. The relation between sea ice in the Greenland Sea and the spring hunt for narwhals in Ittoqqortoormiit	2.4, 4.1
SC/28/NEGWG/08	Garde, E. New pregnancy rate(s) for narwhals in West Greenland	5.1
SC/28/NEGWG/09	Tervo, O., Garde, E., Hansen, R. G., Heide-Jørgensen, M.P. Update – Catch statistics for narwhals in East Greenland 2019-2021	6.1
SC/28/NEGWG/10	Heide-Jørgensen, M.P. A mark-recapture abundance estimate from Scoresby Sound in 2019	4.3
SC/28/NEGWG/11	Hansen, R.G. Observations of narwhals offshore in East Greenland	4
SC/28/NEGWG/12	Tervo, O., Hansen, R. G. Occurrence of beluga whales in East Greenland	3.1
SC/28/NEGWG/13	Tervo, O., Heide-Jørgensen, M. P. Occurrence of narwhals at Hjørnedal field station in Scoresby Sound, East Greenland	4, 6.1
SC/28/NEGWG/14	Witting, L. Assessment of narwhals at Kangerlussuaq - 2021	8.2

SC/28/NEGWG/15	Witting, L. Assessment of narwhals around Tasilaq - 2021	8.2
SC/28/NEGWG/16	Heide-Jørgensen, M. P., Chambault, P., Rosing-Asvid, A., Macrander, A., MacKenzie, B., Andresen, C. S. A regime shift in Southeast Greenland	2.4, 7
SC/28/NEGWG/17	Ugarte, F., Hegelund, P., Heide-Jørgensen, M. P., Laidre, K., Rosing-Asvid, A. Local knowledge about killer whales in narwhal grounds	7.1
SC/28/NEGWG/18	Hansen, R. Spring survey plans for a survey to further investigate the distribution of the putative spring stock of Scoresby Sound	4.4
SC/28/NEGWG/19	Louis, M. A preliminary genetic analysis of narwhal samples to explore and clarify stock structure.	5.2

For Information Documents

Doc. No.	**Title**	**Agenda item**
SC/28/NEGWG/FI01	Report of NAMMCO Scientific Committee Ad hoc Working Group on Narwhal in East Greenland – September 2019	Several
SC/28/NEGWG/FI02	Report of NAMMCO Meeting of the Management Committee for Cetaceans – March 2021	2.1
SC/28/NEGWG/FI03	Presentation from the East Greenland hunters for the Meeting of the Management Committee for Cetaceans – March 2021	2.1.2, 8.1.3
SC/28/NEGWG/FI04	Report of NAMMCO Joint Meeting of the Management Committees – March 2021	2.1.2
SC/28/NEGWG/FI05	Press release by the Greenlandic Department for Fisheries, Catch, and Agriculture on Quotas for Beluga and Narwhals – March 2020	2.1, 6.1
SC/28/NEGWG/FI06	Chambault, P., Tervo, O. M., Garde, E., Hansen, R. G., Blackwell, S. B., Williams, T. M., ... & Heide-Jørgensen, M. P. (2020). The impact of rising sea temperatures on an Arctic top predator, the narwhal. *Scientific Reports,* 10(1), 1-10.	2.4, 7
SC/28/NEGWG/FI07	Garde, E., Tervo, O.M., Sinding M. -H. S., Nielsen, N. H., Cornett, C., Heide-Jørgensen, M. P. (in press). Biological parameters in a declining population of narwhals in Scoresby Sound, Southeast Greenland. *Arctic Science.*	5.1
SC/28/NEGWG/FI08	Garde, E., Tervo, O., Heide-Jørgensen, M. P.	5.1

	Life history parameters of narwhals from East Greenland. *Working Paper from NAMMCO Scientific Committee Ad hoc Working Group on Narwhal in East Greenland* – September 2019, SC/26/NEGWG/10	
SC/28/NEGWG/FI09	Hansen, R. G., Borchers, D. L., Heide-Jørgensen, M. P. Abundance of narwhals summering in East Greenland and narwhals wintering in the North Water and Northeast Water polynyas. *Working Paper from NAMMCO Scientific Committee Ad hoc Working Group on Narwhal in East Greenland* – September 2019, SC/26/NEGWG/05	4
SC/28/NEGWG/FI10	Garde, E., Hansen, R. G., Tervo, O., Heide-Jørgensen, M. P. Updated catch statistics of narwhals in East Greenland 1955-2019	5.1, 6.1