JOINT DISTURBANCE WORKSHOP

OF THE

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

AND THE

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

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REPORT

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EXECUTIVE SUMMARY

The Disturbance Workshop of the NAMMCO-JCNB Joint Working Group (JWG) on narwhal and beluga took place during December 12th– 16th, at the Greenland Representation in Copenhagen, Denmark, with mixed in-person and virtual attendants, under the leadership of Co-Chairs Cortney Watt (JCNB) and Roderick Hobbs (NAMMCO).

The **Terms of Reference** for this meeting were to:

1. *To assess the impact of anthropogenic activities of the Mary River project (Canada) on marine mammals, with emphasis on: the behavioural response to noise pollution from shipping and ice breaking, the energetic consequences of behavioural adaptations to noise pollution, population responses including changes in abundance and demography of narwhals in Eclipse Sound and adjacent areas, the possible changes in recommended catch levels for narwhals from Eclipse Sound, and disturbance of walrus, belugas and bowhead whales from shipping, anchoring and ice breaking activities.*
2. *To assess the impact of shipping and mining activities in Wolstenholme Fjord (Greenland) on especially the wintering stock of walrus in the area and the fall migration of beluga.*

Impact of noise disturbance on narwhals: results from studies in East Greenland

Results from studies on the **behavioural response of narwals to seismic airgun and vessel exposures** in Scoresby Sound, East Greenland, were presented. In August 2017 and 2018, a total of 16 narwhals were instrumented with different tags collecting data on whale movements, heart rate and buzzing behaviour (associated with feeding activity). It was found that narwhals reacted similarly to both airgun and vessel exposure (although the airguns used in the studies were much smaller than the ones used in industrial seismic surveys), changing their swimming speed and direction at distances between 5 and 24 km depending on the topographical surroundings where the disturbance occurred. Narwhals travelled at their highest horizontal speed to escape vessels, swimming away fom the ship, even when the ship was out of sight, and moving towards the shore as vessels and airgun noises approached. Narwhals reacted to very low ship noise levels (e.g., below background noise levels) and buzzing behaviour decreased with increased noise levels and with proximity to the ship. It was also noted that exposed narwhals in Scoresby Sound did not perform deep dives (>350m), which occur when the animals behave normally. The workshop agreed that ship noise was more disturbing for narwhals than what researchers had previously anticipated and concluded that such individual sensitivity to vessels could be extrapolated to population level effects.

Physiological responses of narwhals to anthropogenic noise were measured in another study conducted in 2014-2018, when instruments recording heart rate, swim speed and direction, and depth were deployed on 13 adult narwhals in Scoresby Sound. Results indicated that during noise exposure the heart of narwhals switched rapidly between bradycardia (slow heart rate) and tachycardia (fast heart rate), with this physiological response increasing the risk of long-term damage to critical tissues (e.g., brain and heart) and potentially harming narwhal populations. It was concluded that this physiological reaction to noise combined with other stressful events (e.g. chasing or herding) could even cause the death of the animal.

A study on the **energetic costs of disturbance** on narwhals was presented, predicting high feeding costs of ship passage in winter (important season for feeding). The study found that decreases in energy intake caused by lost feeding opportunities were more important than the energy losses due to locomotor costs. The workshop concluded that both lost feeding opportunities and population displacement of narwhals may increase in the future due to climate change and decreases in sea ice facilitating shipping through narwhal habitats in the Arctic.

Mary River project activities in Canada

The **Baffinland mining company** acquired in 1973 the **Mary Rive**r property (Nunavut, Canada) to extract iron ore. Operations began in 2015, and since 2018, approximately 6 Mt (million tons) of iron ore have been extracted per year, with a total of 188 one-way transits of project-related ships (including ice breakers) occurring during July-October 2020. To reduce the noise footprint of the ships and the risk of strikes with marine mammals, only one ship transit per 24 hours is allowed when ice concentrations are high (more than 6/10) and speed levels are set at a maximum of 9 knots for project-related ships. Other mitigations include an end-of-season marine mammal aerial survey and the employment of ship convoys.

WPS Golder Inc. (thereafter Golder) was contracted by Baffinland to conduct **aerial surveys** to estimate the abundance of narwhals in the **Eclipse Sound** and **Admiralty Inlet** summer aggregation areas. These surveys followed methods that were previously developed by the Department of Fisheries and Oceans (DFO, Canada). The average of the survey repeats for 2020 and 2021 was used as the stock abundance estimate and presented at the Workshop (see Table 2 of the main report).

Results from a **narwhal tagging program** conducted by DFO during 2016-2018 were presented, indicating that 14/20 individuals came into close contact with ships (<10 km). Of those 14 whales, 93% of their recorded GPS location points were more than 10 km from vessels. Golder concluded that narwhals could tolerate shipping traffic. However, the workshop expressed concerns regarding the analysis methods used in this study, arguing that the conclusion by Golder was speculative and recommended comparing tagging data from Eclipse Sound with data from Greenland to evaluate if there are similar behavioural changes and estimate their cumulative consequences. A growing body of evidence, from harvesters and biologists, suggests that the narwhal population in Eclipse Sound is less than a quarter of what it was before active commercial shipping began in the region in 2015 and, in addition, low body condition has been reported in harvested whales in Eclipse Sound.

Results from a **metapopulation model** analysing population impacts on the eight narwhal populations in East Canada and West Greenland were presented at the Workshop. Fig. 1 shows the population projections for Eclipse Sound and Admiralty Inlet. A total of 24,640 (90% CI:16,640–35,840) narwhals have so far emigrated from the Eclipse Sound population, with a corresponding total of 27,520 (90% CI:14,830–38,080) narwhals immigrating into Admiralty Inlet from 2007 to 2020, and the model predicts that there will be almost no narwhals left in Eclipse Sound in 2023. The Workshop concluded that increased ship traffic is by far the most likely cause for the displacement of narwhals from Eclipse Sound.

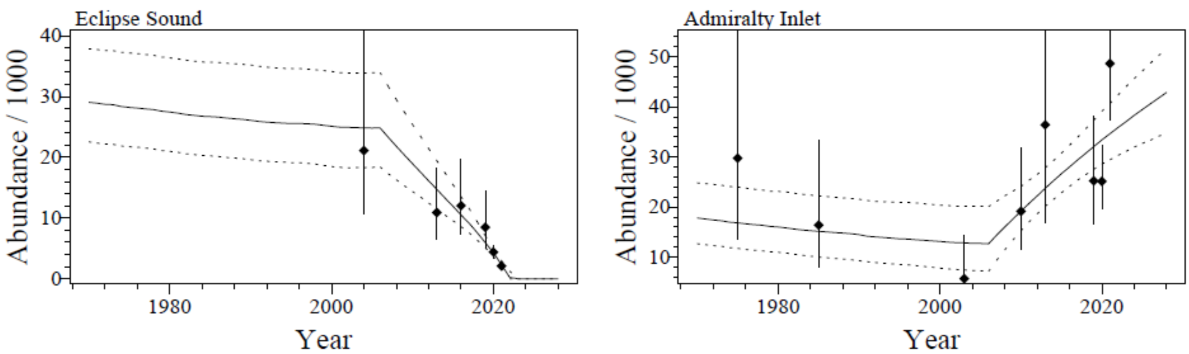

Figure 1 *(modified from figure 3, main report)*: Population trajectories derived from the population models of narwhals in Eclipse Sound and Admiralty Inlet: Points with bars are abundance estimates with 90% CI, solid lines are the median of the estimated trajectories, and dotted lines indicate the 90% credibility intervals.

Other marine mammals occurring in Eclipse Sound are bowhead whales, sperm whales, killer whales, belugas, harp and ringed seals, walrus, and polar bears. Bowhead whales are found in moderate numbers and may be the most affected marine mammals, second to narwhals, based on available knowledge. The Workshop also raised concerns on the risk of oil spills and releases of other toxic materials in the area due to shipping activities, and the potential introduction of invasive species and/or parasites.

Recommendations for the Mary River project

the Workshop concluded that an almost complete displacement of any summer aggregation of narwhals, as has occurred in Eclipse Sound, should be anticipated if sustained shipping activities are planned in the fjord or inlet of that aggregation.

General rules of population regulation predict severe long-term consequences for displaced narwhal aggregations. It is currently impossible to rule out worst case scenarios, where displaced aggregations go extinct within a hundred-year period (due to competition with established aggregations in other areas or displacement to less favourable habitats).

There is no evidence for long-term habituation, or adaptation, of narwhals to shipping disturbance. There are no records of return of a displaced aggregation to a disturbed home-fjord system and it is highly unlikely for the animals to return unless the disturbance that caused the displacement has been drastically reduced.

Recommendations for research

- That complete narwhal surveys of Eclipse Sound and Admiralty Inlet are continued on a yearly basis.
- That photographs from all past and future narwhal surveys in the area are made publicly available for independent research on, e.g., changes in calving rates and sex ratios.
- Conduct tagging studies to understand the timing and extent of seasonal displacement and monitor the behaviour of resident animals.
- Collect tissue samples and morphometric data from harvested animals for understanding narwhal health and body condition.
- Conduct studies to evaluate, in Admiralty Inlet, if diving behaviour changes in large aggregations of narwhal for adjustment of availability bias corrections, also considering temporal changes in group size.
- Conduct studies to determine if whales depart through Navy Board Inlet in the summer and if so, estimate departure times.

Recommendations for the narwhal assessment model

For the next assessment, the mean values of the priors on birth rate, yearly survival and first year survival could be allowed to decline based on total ship traffic. Energetic costs, loss of communication, increased stress and risk of catastrophic dive response will need to be considered once a mechanistic understanding of these parameters is obtained.

- Research to support the assessment model may include:
    - Calf counts from aerial survey photos (2013 DFO survey as control).
    - Sex ratio from aerial survey photos and in visual surveys.
    - Temporal changes in the hunt.
- Research to support further modelling may include:
    - Estimates of energetic costs of ship transits for each type of ship.
    - Review of recent tag data for measures of local displacement and disturbance response and their energetic costs.
    - Examine brains and other organs (reproductive, blubber) from hunted animals for evidence of impairment due to chronic stress or catastrophic dive responses.

Shipping in Baffin Bay

The **shipping** of bulk cargo in **Baffin Bay** has **increased** and is projected to increase in the future due to decreasing ice cover and the opening of the Northwest Passage. This increase in disturbance is expected to affect wintering habitats of narwhals, bowhead whales, beluga whales, walrus, and bearded seals and may have negative impacts on their energy budget and populations. Research results presented at the Workshop showed that the shallow banks in West Greenland are important feeding areas for the Davis Strait walrus population and shipping noise during winter migration affects narwhal feeding and reproductive activity. The **Store Hellefiskebank** in West Greenland is a marine area hosting large cetacean, pinniped and seabird populations that may also be impacted by increases in shipping, and so it was regarded as a highly sensitive area of conservation priority by the Workshop.

Recommendations for Baffin Bay

Recommendations for research

- Conduct tagging studies to determine impacts of shipping in Baffin Bay.
- Obtain biological samples (brains, organs etc.) and morphometrics from the narwhal winter hunt in Disko Bay and the spring hunt in other areas of West Greenland.

Recommendations for management

- Establish a buffer zone of 35 km from ship routes to sensitive areas.
- No ship anchoring should occur in Store Hellefiske bank, due to its importance as a feeding ground for many Arctic seabirds and marine mammal species.

Dundas mining in Greenland

Dundas Titanium A/S is developing the **Dundas Ilmenite Project**, which will extract ilmenite concentrate with high titanium dioxide content from black mineral sand deposits in Northwest Greenland. This mine expects to produce 440,000 tonnes of ilmenite per year that will be shipped during the ice-free period and could **increase the number of vessels in the area by 56-82%**. To reduce the disturbance on marine mammals, a vessel slowdown and use of higher frequency echo sounders will be in effect. The company also has plans for Marine Mammal Surveys and further studies focused on **walrus** are recommended to secure a sustainable population in the area. The Workshop noted that the discharge of silt and clay from mineral processing plants would **harm benthic habitats** and mussel beds that walrus feed on, but the impact of this loss of feeding opportunities could not be evaluated with current data.

Wolstenholme Fjord, where the mining project will be located, is an important winter feeding ground for walrus and has large shallow water areas with accessible bivalve communities. Survey results presented at the Workshop found high densities of walrus on ice and in water and showed they occurred at the fjord opening or further inside depending on ice conditions. In addition, recent satellite tracking results confirmed walrus disperse widely in the Canadian Arctic after leaving the fjord and return in the fall. Canada reviewed documents concerning the proposed mine in Wolstenholme Fjord and expressed concerns at the Workshop about the impacts of shipping and mining activities on marine mammals, especially walrus. DFO informed the proposals raised concerns about the impact of mining activities on bivalve beds and walrus that need to be assessed with data collection and monitoring.

Recommendations for Wolstenholme fjord

Recommendations for research

- It is of high priority that the regional aerial survey of the east side of Smith Sound be the minimum area that should be covered for monitoring abundance and distribution. Surveys

should occur in April, annually during the first 3 years of production, to allow detection of any substantial changes.
- Data from monitoring surveys conducted by the consultant companies who do the assessments for the mine be provided to scientists, upon request, for independent review.
- Satellite imagery of Wolstenholme Fjord be collected annually to determine walrus density, and eventually walrus counts if <30 cm resolution imagery becomes available.
- Telemetry data on walrus habitat use, distribution and migration patterns combined with a study of benthos covering the foraging areas in Wolstenholme Fjord would improve the assessment of the relative importance of the potential foraging area impacted by the mining operation.
- The hunting effort on walrus in Wolstenholme Fjord should be monitored in cooperation with local hunters, to allow for a cumulative impact assessment on the walrus population.

Recommendations for management

- Greenland invites Canadian experts to participate in reviewing monitoring programs, plans and results.
- Ship speed regulations of 8 knots be extended to south of the beluga migration route passing Cape York in September-October. This recommendation does not include a buffer around the timing of shipping.

General recommendations for the management of narwhals in all areas

The Workshop made the following *recommendations for management* of narwhals in all areas:

- Due to the observed displacement of narwhals from Eclipse Sound caused by shipping traffic and associated ice breaking, future developments avoid shipping within the narwhal summering aggregations,
- Because ship traffic causes significant disturbance to narwhals at distances from 0 to 20 km, while icebreaking can cause impacts at distances from 0 to 35 km, these values be used to establish buffer zones around narwhal summer aggregations and establish traffic corridors to protect migration routes and winter foraging grounds,
- Due to its importance as a feeding ground for many Arctic seabirds and marine mammal species, no ship anchoring should occur in Store Hellefiskebank,
- Hunt management advice should account for the displacement and possible associated changes in fecundity and survival, both in disturbed summer aggregations, as well as in aggregations affected by the displaced animals.

MAIN REPORT

1. WELCOME FROM THE CHAIR AND OPENING REMARKS

1.1 WELCOME AND LOGISTICS

The Co-Chairs of the meeting, Cortney Watt (appointed by the Canada-Greenland Joint Commission on Narwhal and Beluga, JCNB) and Roderick Hobbs (appointed by the North Atlantic Marine Mammal Commission, NAMMCO) welcomed the virtual and in-person participants (Appendix 1) to the Joint NAMMCO/JCNB Disturbance Workshop and a round of introductions was made.

1.2 APPOINTMENT OF RAPPORTEURS

NAMMCO Scientific Secretary Albert Chacón was appointed as the primary rapporteur, with assistance from the Co-Chairs when necessary. All participants agreed to provide summaries of the information presented.

1.3 REVIEW OF TERMS OF REFERENCE

Co-Chair Hobbs reviewed the terms of references for this workshop, which were:

1) To assess the impact of anthropogenic activities of the Mary River project (Canada) on marine mammals, with emphasis on:
   - the behavioural response to noise pollution from shipping and ice breaking
   - the energetic consequences of behavioural adaptations to noise pollution
   - population responses including changes in abundance and demography of narwhals in Eclipse Sound and adjacent areas
   - the possible changes in recommended catch levels for narwhals from Eclipse Sound
   - disturbance of walrus, belugas and bowhead whales from shipping, anchoring and ice breaking activities
2) To assess the impact of shipping and mining activities in Wolstenholme Fjord (Greenland) on especially the wintering stock of walrus in the area and the fall migration of beluga.

1.4 ADOPTION OF AGENDA

Co-Chair Hobbs reviewed the draft agenda and asked participants for feedback on any further changes. A number of requests were received regarding changes in the draft agenda. The final adopted version can be found in Appendix 2.

2. LESSONS FROM A CONTROLLED DOSE EXPOSURE STUDY OF NARWHALS IN EAST GREENLAND

2.1 INTRODUCTION WITH OVERALL DESIGN OF STUDY

Eva Garde presented the overall design, field operations and study area of the seismic effect study on narwhals in East Greenland.

Summary:

The study took place in Scoresby Sound, East Greenland, in August 2017 and August 2018. In 2017, the Greenland Institute of Natural Resources research vessel "Paamiut" was used as a platform for the seismic part of the study, whereas in 2018, the Danish navy ship "Lauge Koch" was used as the platform. The experiments ran for approximately 10 days in both years. In 2017, a 210 in^3 (3.4 l) airgun was shot every 12th sec for the seismic survey, while in 2018 a 1040 in^3 (17.0 l) airgun was shot every

80th sec. In the same period as the seismic experiment was running, the "tagging" team in Hjørnedal caught narwhals and mounted animal-borne tags on a total of three males in 2017 and eight males in 2018. In 2017, the three whales stayed the entire period of the experiment in Gåsefjord (a southern fjord part of the Scoresby Sound fjord system), while in 2018 the eight tagged whales went all over the Scoresby Sound fjord system. A movie was presented including drone footages and other videos of the study area, narwhal habitat, the airguns blasting, retrieval of tags by the "seismic" teams, a soundtrap experiment launched from Lauge Koch in 2018, and the tagging operations in Hjørnedal. It was noted that Scoresby Sound is the world's largest fjord system measuring 300 km east to west and 200 km north to south; the boat trip from Ittoqqortoormiit to Hjørnedal is 250 km. Also, even though there is open water in the fjord during summer, the amount of ice in specific locations within the fjords can vary a lot from day to day. These varying conditions within the fjords impacted the experiment in several ways.

Discussions:

Due to the presentation showing many drone-taken photographs and video footage of the Scoresby Sound fjord systems, it was asked whether there was any drone footage of whale behaviour. Garde indicated that such footage was lacking and also noted that narwhals could not be seen from the ship (they were always some km away), therefore no behaviour was observed directly.

2.2 BEHAVIOURAL RESPONSE STUDY ON SEISMIC AIRGUN AND VESSEL EXPOSURES IN NARWHALS

Mads Peter Heide-Jørgensen presented For Information document 05 - Behavioural response study on seismic airgun and vessel exposures in narwhals. (JWG/2022/FI05)

Summary:

One of the last pristine marine soundscapes, the Arctic, is exposed to increasing anthropogenic activities due to climate-induced decrease in sea ice coverage. In this study we combined movement and behavioral data from animal-borne tags in a controlled sound exposure study to describe the reactions of narwhals, *Monodon monoceros*, to airgun pulses and ship noise. Sixteen narwhals were live-captured and instrumented with satellite tags and Acousonde acoustic-behavioral recorders, and 11 of them were exposed to airgun pulses and vessel sounds. The sound exposure levels (SEL) of pulses from a small airgun (3.4 l) used in 2017 and a larger one (17.0 l) used in 2018 were measured using drifting recorders. These airguns were considerably smaller than the ones typically used in seismic surveys. The experiment was divided into trials with both airgun and ship-noise exposure, and intertrials with only ship-noise during pre- and post-exposure periods. Both trials and intertrials lasted ~4 hr on average per individual. Depending on the location of the whales the number of separate exposures ranged between 1 to 8 trials or intertrials. Received pulse SELs dropped below 130 dB re 1 μPa2-s by 2.5 km for the small airgun and 4–9 km for the larger airgun, and background noise levels were reached at distances of ~3 km and 8–10.5 km, respectively, for the small and big airguns. Avoidance reactions of the whales could be detected at distances >5 km in 2017 and >11 km in 2018 when in line of sight of the seismic vessel. Meanwhile, a ~30% increase in horizontal travel speed could be detected up to 2 hrs before the seismic vessel was in line of sight. Applying line of sight as the criterion for exposure thus excludes some potential pre-response effects and our estimates of effects must therefore be considered conservative. The whales reacted by changing their swimming speed and direction at distances between 5 and 24 km depending on topographical surroundings where the exposure occurred. The propensity of the whales to move towards the shore increased with increasing exposure (i.e., shorter distance to vessels) and was highest with the large airgun used in 2018, where the whales moved towards the shore at distances of 10-15 km. No long-term effects of the response study could be detected.

Table 1. Overview of instrumentations of narwhals used in the controlled dose exposure studies in August 2017 and 2018 in Scoresby Sound, East Greenland. Sixteen whales were instrumented with a Fastloc GPS-receiver or Fastloc-CTD tag attached surgically, in addition 13 of the whales had acoustic and orientation tags (Acousonde; attached via suction cup) and eight had heart-rate recorders (HTR; attached via suction cup). Individual A1 and B1 refer to the same individual which was captured and instrumented in both years. Positions per hr (shown in parenthesis) was calculated for the tags that provided movement data during trials and intertrials. The Fastloc-CTD tags provided two positions per day.

Year	Whale	Sex	Body/tusk length (cm)	Instrument	Deployment date (Positions/hr)	Deployment duration (days)
2017	A1	M	492/207	Fastloc-GPS (168435)	11 Aug. (4.6)	249
				HTR2		2.2
				Acousonde 27		8.42
	A2	M	457/220	Fastloc-GPS (22853)	11 Aug. (6.7)	277
				Acousonde 32		4.27
	A3	M	454/195	Fastloc-GPS (20165)	11 Aug. (4.6)	130
				HTR1		2.0
				Acousonde 31		0.54
	A4	F	393	Fastloc-CTD (24639)	22 Aug.	86
				HTR3		0.25
				Acousonde 23		8.62
	A5	M	477/198	Fastloc-GPS (22849)	22 Aug.	112
				HTR4		1.8
				Acousonde 26		0.41
	A6	M	430/193	Fastloc-CTD (37282)	23 Aug.	165
	A7	F	379	Fastloc-GPS (20162	24 Aug.	290
				Acousonde 23		2.33
	A8	M	330/40	Fastloc-GPS (168434)	24 Aug.	14
				Acousonde 31		1.42
2018	B1	M	492/207	Fastloc-GPS (168437)	23 Aug. (5.4)	152
				HTR1		2.63
				Acousonde 31		8.20
	B2	M	460/157	Fastloc-GPS (21791)	23 Aug. (7.2)	11
				Acousonde 28		6.24
	B3	M	436/136	Fastloc-GPS (20158)	23 Aug. (5.8)	132
				Acousonde 32		8.04
	B4	M	410/83	Fastloc-GPS (20160)	24 Aug. (5.0)	249
				HTR3		0.05
				Acousonde 27		4.63
	B5	M	470/167	Fastloc-GPS (168433)	24 Aug. (5.5)	223
				Acousonde 23		4.49
	B6	M	409/73	Fastloc-GPS (168436)	25 Aug. (6.8)	137
				HTR5		1.08
				Acousonde 11		8.35
	B7	M	402/125	Fastloc-CTD (20696)	25 Aug.	152
	B8	M	380/97	Fastloc-CTD (21793)	26 Aug.	169
				HTR		2.4

Discussion:

From the results shown, the group agreed that the presence of a ship alone was enough to disturb narwhals and that seismic airguns were not the only factor, with individual narwhals not reacting more to airguns than to vessels. However, it should be noted that the airguns used in the study were much smaller than the ones used for industrial scale seismic surveys, so the response to the airguns may, in other cases, be much greater than the response to the vessels. It was emphasized that narwhals travelled at their highest horizontal speed (5 knots) to escape vessels, swimming away even when the ship was out of sight, and that such individual sensitivity to vessels could be extrapolated to the population level. This is double the normal speed for horizontal travel of narwhals. However, the levels of disturbance in Scoresby Sound are usually minimal, compared to West Greenland and other parts of the Arctic, due to a lack of vessel traffic apart from two cargo vessels per year going to the community in Ittoqqortoormiit and some cruise ships visiting the area in summer.

2.3 RECEIVED LEVELS OF SOUNDS FROM AIRGUN PULSES

Susanna Blackwell presented research on received levels of sounds from airgun pulses.

Summary:

Two airgun sizes were used during the sound exposure studies in Scoresby Sound. In 2017 the airgun had a volume of 210 in^3 (3.4 litres) and a source level of 231 dB re 1 µPa-m (peak-to-peak). It was deployed at a depth of 3 m, fired every 12 seconds and was generally towed at a speed of 5 knots. In 2018 the airgun had a volume of 1040 in^3 (17 litres) and a source level of 241 dB re 1 µPa-m (peak-to-peak). It was deployed at a depth of 6 m, fired every 80 seconds and was generally towed at a speed of 4.5 knots. Measurements of the received levels of airgun pulses were made on Acousonde recorders carried by the whales (see table under item 2.2 for details) as well as during sound source verifications (SSVs) using SoundTrap recorders. Values obtained with the two types of recorders were similar, but the Acousonde values showed more variability. This was mainly due to higher levels of water flow noise and variability likely introduced by the whales' behaviour (e.g., pulses received at different depths). Received sound exposure levels from airgun pulses (larger airgun in 2018) were roughly 152 dB re 1 μPa^2-s at 1 km, decreasing to 125 dB re 1 μPa^2-s at 10 km, where they approached background levels. When a high-frequency weighting function was applied to these data, however, the airgun pulse levels were generally below ambient levels even at the closest distances.

Discussion:

The study emphasized the importance of vessel noise as a source of disturbance. It was noted that background noise levels in the environment were quite variable due to melting icebergs, falling and floating ice, running freshwater, etc. Some difficulties in the use of Acousondes for airgun pulse measurements were also noted, in particular the presence of variable water flow noise due to the whales pulsatile stroking movements. In addition, the Acousonde data had more variability in received levels of airgun pulses (compared to data collected with SoundTraps) due to whale behaviour, e.g. whale depth or position in the water column.

2.4 NARWHALS REACTION TO NOISE DISTURBANCE

2.4.1 Narwhals reaction to ship noise and airgun pulses embedded in background noise

Outi Tervo presented For Information document 06 – Narwhals reaction to ship noise and airgun pulses embedded in background noise. (JWG/2022/FI06)

Summary:

Anthropogenic activities are increasing in the Arctic, posing a threat to niche-conservative species with high seasonal site fidelity, such as the narwhal *Monodon monoceros*. In this controlled sound exposure study, six narwhals were live-captured and instrumented with animal-borne tags (see table under item 2.2 for details) providing movement and behavioural data, and exposed to concurrent ship noise and airgun pulses. All narwhals reacted to sound exposure with reduced buzzing rates, where the response was dependent on the magnitude of exposure defined as 1/distance to ship. Buzzing rate was halved at 12 km from the ship, and whales ceased foraging at 7–8 km. Effects of exposure could be detected at distances > 40 km from the ship. At only a few kilometres from the ship, the received high-frequency cetacean weighted sound exposure levels were below background noise indicating extreme sensitivity of narwhals towards sound disturbance and demonstrating their ability to detect signals embedded in background noise. The narwhal's reactions to sustained disturbance may have a plethora of consequences both at individual and population levels. The observed reactions of the whales demonstrate their auditory sensitivity but also emphasize that anthropogenic activities in pristine narwhal habitats need to be managed carefully if healthy narwhal populations are to be maintained.

Discussion:

In the presented study, changes in behaviour were observed with very low noise levels, confirming previous findings regarding narwhal sensitivity to sound disturbance. In this case, buzzing behaviour (associated with feeding activity) decreased with increased noise levels and with proximity to the ship.

2.4.2 Effects of noise disturbance on narwhal diving behaviour

Tervo presented results from ongoing research on the effects of disturbance on narwhal diving behaviour.

Summary:

In the Arctic, human disturbance is increasing rapidly due to climate change-induced reduction of sea-ice. Here, we show that the narwhal *Monodon monoceros*, an Arctic specialist with a narrow ecological niche and high site-fidelity, is extremely sensitive to ship and airgun noise. Narwhals eliminated deep diving with a simultaneous cessation of foraging, and increased shallow diving activity as a response to either ship noise alone or ship noise with concurrent airgun sounds. Between 50% and 100% reduction of normal behavior occurred at received sound levels below background noise. Narwhals were equally responsive to both disturbance types hence demonstrating their acute sensitivity to ship noise. This sensitivity coupled with their special behavioral-ecological strategy make them especially vulnerable to human impacts in the Arctic.

Discussion:

The group agreed that ship noise was more disturbing for narwhals than what researchers had previously anticipated, with animals reacting to very low ship noise levels (e.g., below background noise levels). To the question on whether animals could be reacting to high frequency sounds at long distances, it was confirmed that high frequency sounds could not travel far, with the multi-beam echo sounder directed towards the seafloor (as in this study) attenuating faster with distance, so animals must be reacting to some sort of low frequency noise at long distances.

2.4.3 Short-term response of narwhals to repeated noise disturbance

Tervo presented new results from ongoing research on the short-term response of narwhals to repeated noise disturbance.

Summary:

Possible short-term habituation of narwhals to noise disturbance was investigated using buzzing bout rate as a behavioural metric. The response model included duration of exposure (min) and number of separate exposures that an individual has experienced prior to the observation (N), in addition to distance to ship and the two different exposure types ship and ship+seismic. Individual was included as a random effect. The model also included a memory component to account for autocorrelation in the data. No indication of short-term habituation was found i.e. the response was more severe with increasing number of exposures and increasing duration of exposure.

Discussion:

The group welcomed the research results presented and agreed there was a good deal of evidence on the sensitivity of narwhals to noise disturbance.

2.5 PHYSIOLOGICAL RESPONSES OF NARWHALS TO ANTHROPOGENIC NOISE: A CASE STUDY WITH SEISMIC AIRGUNS AND VESSEL TRAFFIC

Terrie Williams presented For Information document 08 – Physiological responses of narwhals to anthropogenic noise: a case study with seismic airguns and vessel traffic. (JWG/2022/FI08)

Summary:

As part of a larger program assessing the impact of seismic airguns and ships on narwhals (see Garde and Heide-Jørgensen summaries), we deployed custom-made heart rate-accelerometer-depth recorders on 13 adult narwhals (see table under item 2.2 for details) in Scoresby Sound, East Greenland across a five-year period (2014-2018). Physiological responses (heart rate and recovery breathing rates, stroke frequency) of the cetaceans were monitored in the absence or presence of experimentally directed, seismic airgun pulses and associated vessels (full volume source level = 241 dB re 1 µPa-m). During control years, the narwhals displayed an escape reaction immediately following tagging that combined diving, exercise and fear responses (Fig. 1). Exposure to anthropogenic noise during the seismic tests also resulted in marked cardiovascular, respiratory and locomotor reactions by the tagged narwhals. The general behavioral response to seismic and vessel noise included an 80% reduction in the duration of gliding during dive descents by seismic-exposed narwhals compared to controls, and the prolongation of high intensity activity with elevated stroke frequencies exceeding 40 strokes per minute. Noise exposure also resulted in intense (< 10 bpm) bradycardia that was decoupled from stroking frequency. This decoupling instigated increased variability in heart rate, with the heart switching rapidly between bradycardia and exercise tachycardia during noise exposure. Maximum respiratory frequency following seismic exposure, 12 breaths/min, was 1.5 times control levels.

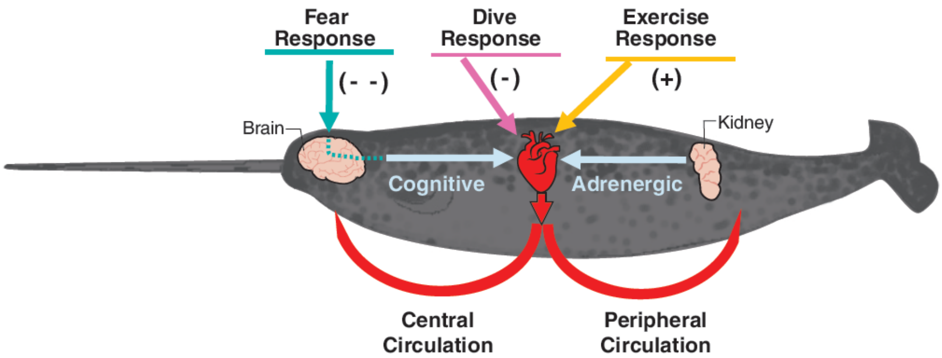

Figure 1. Relative effect of diving, exercise, and neurocognitive fear responses on heart function during escape reactions in narwhals. Cognitive and adrenergic pathways (highlighted in blue) provide additional short- and long-term signals, respectively, to the cardiovascular system and support of key organ systems. Ongoing research is investigating the effects of anthropogenic disturbance including vessel and seismic noise on these pathways (from Williams et al., Science 358, 2017)

Overall, the physiological effect of seismic/ship noise exposure on wild narwhals was a 2.0 – 2.2-fold increase in the energetic cost of diving, which paradoxically occurred during suppression of the cardiac exercise response. This unusual relationship between diving heart rate and exercise intensity represents a new metric for characterising the level of fear reactions of wild marine mammals exposed to different environmental stressors. Locomotor-cardiovascular coupling usually used to regulate blood pressure in critical organs of diving cetaceans may be compromised by these extreme physiological responses. Together, the multi-level reactions to anthropogenic noise by this deep-diving cetacean demonstrates how a cascade of effects along the entire oxygen pathway could challenge physiological homeostasis especially if disturbance is prolonged. One possible lethal effect of stress of a whale was observed in 2016 when one tagged narwhal died, arguably unable to recover from a prolonged stressful event which involved being herded and entangled in nets; the animal was not harvested and only the tag was retrieved. Analysis of the data from the tag showed that the whale moved offshore and dove for a short period. During the last dive this animal exhibited erratic behaviour and stopped stroking, whereafter it descended to the seabed and never recovered. The duration of herding of this whale was longer than the standard procedure used for the capture of narwhals and is considered a contributing factor to its distress.

Discussion:

The group welcomed the presentation by Williams, highlighted as the 1st ever monitoring study of heart, breathing and stroking rate conducted in any cetacean species. Due to the combination of physiological responses seen in seismic exposed animals and their elevated potential for hypoxic tissue damage, the group agreed that exposure to seismic blasts and shipping noise could lead to sublethal effects for individuals. Long-term damage to critical tissues (e.g., brain and heart) would subsequently have the potential to seriously harm narwhal populations. The underlying cause of death for the tagged narwhal that died in 2016 was discussed. Possible factors included: 1) cardiac problems, 2) exercise-induced overheating (hyperthermia), 3) a general stress response, and/or 4) myopathy (cardiac or skeletal muscle damage) as has been observed for other odontocetes released from a capturing operation. It was noted that similar deaths, caused by arrhythmia, have been reported in California sea otters captured in nets. In the case of narwhals, it is not known if all animals fully recover from extreme stressful events (e.g. shipping noise and chasing).

2.6 STATISTICAL TREATMENT OF BEHAVIOURAL CHANGE DATA

Susanne Ditlevsen presented the statistical approaches used and results of the analysis of behavioural data on narwhals.

Summary:

Natural variability in behavioural data is large, with individuals socialising, travelling, foraging and resting at different moments and in different ways, so that distinguishing between natural and disturbed behaviour is challenging. To disentangle normal from affected behaviour in narwhals, 4 sources of data were used: location data, depth data, accelerometer data and acoustic data. To analyse location data, a threshold of 200m was established to determine whether an animal was close or far from a ship. The distance of the animal to the coast was also considered an indicator of normal or affected behaviour, with animals moving closer to the coast when affected by approaching ships. The time required by narwhals to come back to normal behaviour (in terms of location) is much shorter during seismic airgun intertrials (ship noise only) than during trials (ship + seismic airgun noises). In addition, the ship must travel further away during trials, for the animal to come back to normal. Depth data were analysed using a competing risk model to estimate the probability of doing deep or shallow dives, for individuals being at the surface. These probabilities change with noise exposure, with animals spending less time at the surface (more time diving) and moving closer to the coast under exposure. Accelerometer data (ODB) were analysed using a quantile regression approach that can capture variance changes as a function of exposure. This analysis shows a stronger reaction of animals to ships approaching, also showing that, during trials, distance to the ship had to increase more than during intertrials before the animal would return to normal behaviour. Finally, to analyse acoustic data (buzzing), a threshold of 40 km from the ship is established, to determine what is considered a normal buzzing rate. Fast increases in buzzing rate were detected once the ship was more than 8 km away, whereas buzzing ceased when distance was less than 8 km. Depth and buzzing were the activities that were most affected by distance to the ship.

Discussion:

The group welcomed the presentation by Ditlevsen, who emphasised that the main statistical challenge was not the number of data points, which were many, but the few number of individual whales used to generate the data. This problem made it difficult to distinguish between individual effects and population effects. Similarly, due to the large variability in behavioural data between and within individuals, another challenge was to distinguish between natural (normal) and disturbed (affected) behaviour. Assumptions can be made on what constitutes each, but it was agreed that the best way to disentangle them would be by measuring behaviour before a ship arrives, then fixing the parameters related to this normal behaviour and estimating the deviation. The group agreed that statistically robust thresholds values (e.g. distance to ship, buzzing rates) could be established.

2.7 LOCOMOTION COSTS DURING EXPOSURE OF NARWHALS

Tervo presented a paper in preparation on the locomotion costs during exposure of narwhals.

Summary:

As stroking rates can be assigned specific energetic costs for an individual, changes in stroking rate and locomotion mode due to disturbance provide a measure of excess energy expenditure. This in turn can be used to assess the effects and significance of a stressor on the energy budget of an individual. Changes in locomotion were investigated using data from animal borne tags during a sound exposure study. The response variable stroke mode was defined as a state with 3 behavioural levels in a Markov model: gliding (≤ 6 strokes/min), preferred stroking or maximum stroking rates, where the two latter had individual specific cut-off values. The results showed clear changes in locomotion modes during both exposure types: seismic airguns and ship noise combined and ship noise alone. Seismic and ship noise combined induced a stronger reaction than ship noise alone. Narwhals showed a higher probability to use fast stroking during exposure that included seismic airguns. Conversely when only exposed ship noise, the whales had a higher probability of using slow stroking modes compared with normal behaviour. During exposure to either the disturbance type, narwhals reduced the amount of gliding. Consistent with the changes in locomotion, both exposure types induced higher energetic locomotor costs compared with normal behaviour. These costs were highest during descents. The effects were seen only in the vicinity of the ship.

Discussion:

It was noted that deep dives (>350m) occur when the animals are behaving normally, but narwhals in the study area in Scoresby Sound were not observed to perform dives beyond medium depths (20-350m) when disturbed. Due to the change in diving behaviour, there was an increase in locomotion costs. It was observed that increased locomotion costs occurred within 5 km of the ship.

2.8 THE COSTS OF DISTURBANCE FOR NARWHALS

Heide-Jørgensen presented Working document 06 – Key factors dictating the price of disturbance for narwhals. (JWG/2022/06)

Summary:

Large areas of the Arctic have until recently remained pristine with little human disturbance. This is changing rapidly with reduced sea ice coverage that allows for increased ship traffic and exploration of both living and non-renewable resources in previously ice-covered areas. One noise-sensitive species that inhabits remote and pristine areas of the Atlantic sector of the Arctic is the narwhal. Although this deep-diving cetacean is considered particularly vulnerable to increases in human activities, the relationship between the anthropogenic disturbance and actual energetic costs is poorly understood. In this study we model the relative changes in energetic costs and energy balance that occur with disturbance from ship passage for an average-sized narwhal. Added costs were divided into predicted energy loss due to reduced feeding opportunities, and the additional energy expended with increased levels of locomotion during noise exposure. Key factors affecting the energetic cost of disturbance included season (summer vs. winter), distance of the ship to the animals, and exposure period as dictated by the speed and trajectory of the vessel. Because feeding activity of the narwhals is reduced during summer, and two months of migrations to and from summering grounds, the main feeding occurs during seven months in winter. As a result, disturbance occurring during this critical feeding period has a marked impact on energetic costs. The observed distribution of narwhal prey ranged between 20 g and 1 kg, with the distribution of prey masses assumed to be heavily skewed to the lower end. Locomotion costs were dependent on the number and duration of dives during exposure to ship noise, where periods without dives were assumed to be transit swimming. Energetic costs of these activities were estimated from allometric costs of stroking (Williams et al., 2022) and depended on the duration of exposure based on the speed, distance, and position of the vessel relative to the narwhal. The highest energetic costs (~4001 kJ per seismic/ship event in summer and 7716 kJ in winter) were associated with the passage of the slowest vessels (5 km/h) with the longest duration of exposure. In comparison, the passage of the fastest vessel (15 km/h) had energetic costs of ~1700 kJ and ~2926 kJ per event in summer and winter, respectively. Overall, we found a 65% difference in the energetic costs between summer (with little feeding) and winter (with substantial feeding). Thus, rather than simply an escape response impacting locomotor energetics, the total cost of disturbance involves a significant impact on energetic balance due to proportionally large decreases in energy intake with lost feeding opportunities compared to increased locomotor costs.

Discussion:

The group noted that winter, not summer, was the more important season for feeding, making the potential feeding costs of ship passage higher in winter, as shown in the study. However, the group agreed on the necessity to include both seasons in the study, due to the higher levels of ship traffic occurring in summer and the expected future increase in spatio-temporal overlap between ships and narwhal in winter due to climate change. Due to the low plasticity and conservative spatial behaviour of narwhals compared to other cetaceans, it is feared that future increases in ship traffic and associated feeding costs may cause substantial displacement of narwhal in Baffin Bay.

A discussion on the percentage of time narwhals spent on feeding followed, with the group agreeing that the time spent buzzing was an indicator of feeding activity. It was noted that, on average, narwhals spend 26% of their time echolocating, and stop buzzing when a ship passes, and hence stop feeding. In the presented study, metrics of lost feeding opportunities were based on reduced buzzing activities.

In the energetics model, the various costs of disturbance on narwhals are added. If an animal is scared by a ship, it is assumed to react identically to the next ship and the two costs can be added together. The effects of higher ship speeds than used in this study should also be evaluated due to the increase in noise associated with elevated speeds.

2.9 OTHER STUDIES

Regarding calling rate, Blackwell informed that there were no specific results to report on. Calls from more than 1250 hours of Acousonde data from 8 different narwhals in 2017 and 2018 (9 records, one whale tagged in two consecutive years) had been detected in the records and classified. These data will be used to examine the effects of the seismic vessel—alone and while using its airgun—on the numbers of calls used by the whales.

3. STUDIES OF DISTURBANCE IN OTHER AREAS

3.1 HARBOUR PORPOISES IN EUROPE

Nabe-Nielsen presented Working Document 11 (JWG/2022/11) - Using agent-based models for management of marine mammal populations

Summary:

Marine species are exposed to anthropogenic disturbances that cause animals to change behaviour, reduce their access to food, cause them to die, and that may ultimately result in population declines. Here I describe how knowledge of behavioural responses to disturbances can be incorporated in highly realistic agent-based models to assess whether populations are able to survive the different disturbances that we expose them to. I use the harbour porpoise (*Phocoena phocoena*) as model organism and demonstrate how to predict the combined population impacts of noise from wind farm construction (piling or pile driving) and ships. The model is based on general mechanisms and could potentially be adapted for other marine species when movement data are available. I argue that spatially explicit, process-based models are needed to fully understand how competition for food and behavioural reactions to disturbances will shape the dynamics of populations when we change the marine environment.

Discussion:

Clarification was requested on the meaning of porpoise positive minutes (PPM) and whether this was an appropriate measure of probability of occurrence. Despite the fact that this measure did not provide information on whether a porpoise had escaped to a different location or quietly remained in place, as a result of a passing vessel, it was agreed that such a metric could be used as a proxy of porpoise density. Regarding the Agent-Based Model (ABM) used, it was noted that in the case of the harbour porpoise the approach always resulted in the population recovering, no matter the type of disturbance and it showed population recovery before the disturbance (piling) had ended. However, it was indicated that, for large areas, the ABM assumption of population recovery was a realistic one, and that if piling was spread out, there could always be piling-free areas where the population could recover.

The group agreed that the ABM model presented could be applicable to other marine mammals of similar body mass and that additional information on energetics could be added to the model for applications on larger size marine mammal species. It was noted that the type of individual data required by ABMs was not more demanding than classical population models which required life history parameter values such as fecundity and survival.

The group was informed that harbour porpoise populations in the North Sea seemed to have reached their carrying capacity, inferred from a lack of fluctuations in density over the last years. However, it was noted that this was unlikely to be the carrying capacity that the population would have reached in the absence of human activity. It was emphasized that there was a need to identify good predictors of harbour porpoise distribution (via improved species distribution models) before assessing the impacts of disturbance on the population.

3.2 BOWHEAD WHALES IN ALASKA

Blackwell presented effects of sound on bowhead whale calling rates.

Summary:

Between 2000 and 2014, DASARs (Directional Autonomous Seafloor Acoustic Recorders) were deployed in the Beaufort Sea and their directional ability was instrumental in the four main findings summarized below. DASARs are deployed in arrays of 7 recorders placed at the vertices of equilateral triangles with 7 km sides. Each recorder includes a particle velocity sensor in addition to the omnidirectional sensor. This provides a bearing to a sound of interest, such as a whale call. When several DASARs detect the same whale call, the bearings can be combined to triangulate the position of the calling whale. Studies using DASARs are generally set-up as dose-response studies. The dose is the level of the sound of interest (e.g., airgun pulses, vessel sounds, ambient levels) received at the DASAR, while the response is the number of whale calls detected within a certain distance from the DASAR. For example, 2 km has been used as a cut-off distance in some analyses because the probability of detecting a bowhead call is very high within that distance. Limiting the allowed distance between recorder and sound source accounts for masking, which results in a negative correlation between the number of calls detected and the average sea state. In other words, the calmer the weather, the more calls at greater distances can be detected.

Four main findings were presented: (1) In response to increasing levels from airgun pulses, bowhead whale calling rates increase as soon as airgun pulses are detected in the background. At higher levels (127 dB re 1 µPa^2-s cumulative sound exposure levels (CSELs) over 10 minutes), calling rates start dropping, and by the time CSELs are about ~160 dB, whales have stopped calling. (2) Bowhead whale calling rates increase as a result of increasing background levels. (3) The source level (SL) of bowhead calls increases with increasing background levels (Lombard effect), up to a point at which SLs no longer increase with background levels. (4) Multiple sources of man-made sound can have an additive effect on the whales' calling response. For example, the whales' response to tones from vessels and machinery is much stronger when airgun pulses are also present.

When the quality of a communication signal decreases, two ways to compensate are to repeat the signal (call more often) or increase the signal strength (call louder). Bowhead whales have been shown to do both. At some point, however, neither of these strategies will prevent information that is contained in the call to be lost. It is suggested that this may be the reason whales start reducing their calling rates until calling ceases completely.

The distances at which behavioural effects can be detected are very different depending on the type of behaviour. In the Beaufort Sea with a large airgun array (3147 in3, 52 l), bowhead whales start increasing their calling rate 100 km (or more) from the seismic ship. 10-20 km from the seismic ship, they have entirely stopped calling. On the other hand, some whales will continue feeding only 1-2 km from the seismic ship.

Discussion:

It was noted that bowhead whales were not as vocal as narwhals, with calls probably used to keep family members (e.g., mothers and calves) in contact. However, the reason behind the calls is usually unknown, as recorded calls cannot be assigned to a specific animal (they are separated in space and time) and what the animal was doing at that moment is not known. The group also noted that seismic airguns were not only applied to oil exploration but also to more general geological surveys.

3.3 ACCOUNTING FOR CUMULATIVE STRESSORS IN POPULATION MODELS

Hobbs reviewed the Baffin Bay Narwhal Assessment Model.

Summary:

The Baffin Bay narwhal assessment model models eight populations of narwhals, accounting for annual migration patterns, population growth and hunt removals.

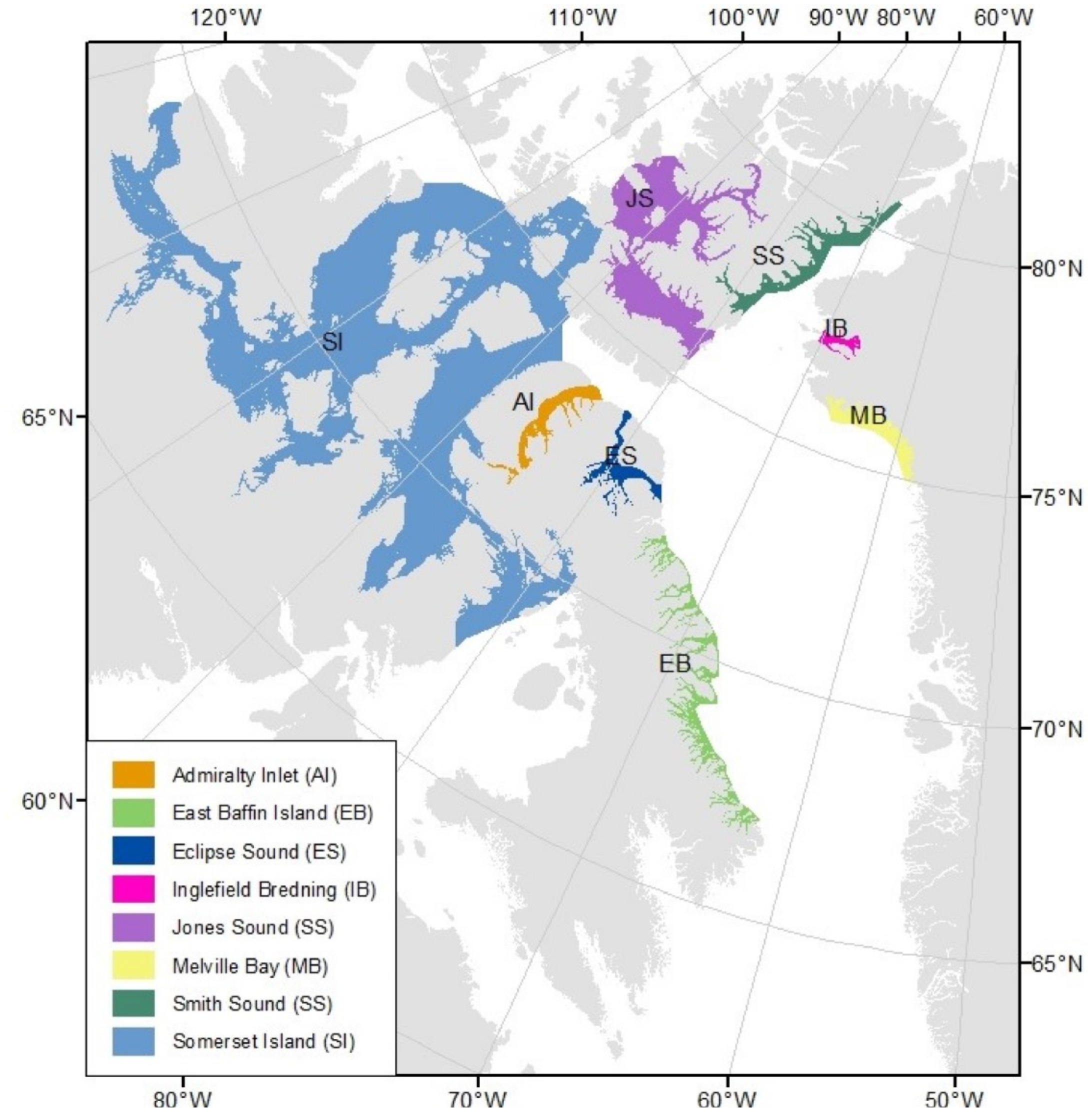

Figure 2: Summer distribution of narwhal populations in Northeast Canada and Northwest Greenland. From Watt et al. (2019)

Model Assumptions:

- Summer aggregations are distinct.
- Narwhal fidelity to summer aggregation, migration route and winter grounds.
- Tag tracks represent typical migration behaviour of the summer aggregation of origin.
- Population size and life history parameters remain constant through model time frame.
- Population growth and recovery is determined by management of hunting.

Model Components:

Population Models: Each summer aggregation is a separate stock and the stock is modelled as a distinct population.

Hunt Allocation Matrix: A matrix which assigns portions of each hunt (location and season) to each of the stocks. Each cell of the hunt allocation matrix, ***A***, has the value

$$A_{ijy} = \frac{P_{ij} N_{iy}}{\sum_i P_{ij} N_{iy}}$$

Where, $\boldsymbol{A}_{ijy}$ is the proportion of the *j*th hunt that is assigned to the *i*th stock in year y; P_{ij} is the proportional availability of the *i*th stock to the jth hunt; and N_{iy} is the abundance of the *i*th stock in year y.

Annual Iteration

1. For each year an Availability matrix is drawn and the Allocation matrix is constricted using the Availability matrix elements and the population sizes in that year. The Allocation matrix is then multiplied by the vector of hunting removals (landed catch + struck-but-lost) by each hunt to determine the hunting removals from each stock.
2. The removals are subtracted from the populations and the resulting populations are projected forward to the next year.

Population Model

Age and sex structured density regulated model, with older ages lumped into a single age class. Parameters include: b the birth rate, θ the female fraction at birth, γ (gamma) the density regulation parameter, m the average age of reproductive maturity, m0 the first age of reproductive maturity, N* the equilibrium abundance with no hunting, p0 the first year survival, and p the yearly survival.

Bayesian Assessment Runs

1. Parameters for each population are drawn from prior distributions.
2. Model runs begin in 1970 and project 5+ years into the future with various proposed levels of landed catch.
3. Likelihood of each model run is determined by how closely it matches the abundance time series from aerial surveys.

Outputs

- Posterior distributions of parameters are examined to determine if they are representative of the population.
- Results for each test level of landed catch are compiled to estimate the probability of population decline over five years resulting from each proposed catch level.

Discussion:

It was asked whether the model was taking into account the impact of population size on reproduction rate and demographic stochasticity. It was noted that the model included density regulation on the birth rate, but demographic stochasticity was not included because it is minimal for the relatively large populations considered here, while it is included in the models for the small narwhal stocks in East Greenland. However, improvements could be made regarding data availability on the age structure of harvested narwhals. It was noted that in previous meetings the JWG had discussed making model parameters time-sensitive to observed changes in the habitat such as the loss of sea ice, increased sea surface temperature, and increased ship traffic due to climate change, but more data was needed. Changes to the availability matrix had also been discussed in the case of tagged narwhals that had moved from Eclipse Sound to Admiralty Inlet during the summer.

4. MARY RIVER ACTIVITIES IN COASTAL AREAS OF CANADA

Marianne Marcoux presented background information on the Baffinland Iron Mines Corporation (hereafter, Baffinland) Mary River Mine on Baffin Island, Nunavut, Canada.

4.1 BACKGROUND INFORMATION

4.1.1 History

Mary River's iron ore was first noted by Watts and Sheardown in 1962, and the mine was acquired by Baffinland mining company in 1973. Baffinland started the exploration and development of the property in 1986.

The original proposal that was approved consisted of shipping iron ore (18mt/y) through a southern route, with icebreaking activity year-round and using Milne Inlet only during the construction phase. A second proposal established the early revenue phase in 2014, in which the northern shipping route was considered less costly, with trucks sending iron ore to Milne port, an infrastructure built specifically for stocking and shipping the ore. Operations began in 2015. In 2022, Phase 2 proposal, involving doubling of the shipping through Milne Inlet, the potential construction of a railway and a substantial increase in shipping activity, was rejected, for reasons including significant adverse impacts on wildlife.

4.1.2 Current activities and future plans

Since 2018, approximately 6 Mt of iron ore have been extracted per year. A total of 188 one-way transits of project-related ships occurred during July-October 2020, with icebreakers used early and late in the season. Ice breakers are considered noisy vessels, also damaging the ice that local people use to hunt and move around. As a mitigation measure, only one ship transit per 24 hours is allowed when ice concentrations are high (more than 6/10). There are also mitigations on speed levels, which are set at a maximum of 9 knots for project-related ships, thus decreasing the noise footprint of the ship and the risk of strikes with marine mammals. Other mitigations include an end-of-season aerial survey, to make sure that the area is clear and to detect ice entrapments, as well as the employment of ship convoys, to reduce the overall length of acoustic disturbance per day.

Aerial surveys have been conducted by the mine in the area since 2006, and since 2019 such surveys are conducted following Fisheries and Oceans Canada (DFO)'s's survey design and methods. Narwhal shore-based counts from Bruce Head are intended to provide a relative index of narwhal abundance standardised by effort (total narwhal/total hours). However, observer variability and other factors affecting detection of narwhal were not analysed.

Discussion:

It was noted that the raw data from the shore-based and aerial surveys were not available to this group and no analyses were presented.

4.2 NARWHAL TRENDS IN DISTRIBUTION AND ABUNDANCE IN ECLIPSE SOUND AND ADMIRALTY INLET

Marcoux presented Working document 10 - Review of the 2020 and 2021 narwhal surveys in Eclipse Sound and Admiralty Inlet conducted by WPS Golder Inc. (JWG/2022/10).

Summary:

WPS Golder Inc. (thereafter Golder) was contracted by Baffinland to conduct aerial surveys to estimate the abundance of narwhals in the Eclipse Sound and Admiralty Inlet summer aggregation areas. The surveys took place in August 2019, 2020, and 2021. A review of the 2019 survey was provided in a previous meeting (JWG/2022/FI02). This presentation reviews the methods and results of the 2020 and 2021 surveys.

In general, surveys followed methods that were previously developed by DFO. The design included a double platform visual survey in areas where narwhals are expected to be found in lower densities and a photographic survey in areas where narwhals are expected to gather in higher densities. In addition, an adaptive survey method was followed to initiate a photographic survey in areas with an unexpectedly high concentration of narwhals.

The two Golder surveys used older availability bias correction factors (C_a) that were developed for previous aerial surveys. However, new data on the dive cycle of narwhals have been used recently to develop new availability bias correction factors (JWG/2022/10). In addition, an updated correction factor that takes into account the time that narwhals are in view of the survey observers was used to adjust the surface estimates in the visual strata of the survey (C_a=2.93). An instantaneous correction was used for the photographic portions of the survey (C_a=3.22)

The average of the survey repeats for each year was used as the stock abundance estimate and are presented in the table below.

Table 2.

Year	Admiralty Inlet	Pond Inlet
2020	25,166 ± 0.15	4381 ± 0.14
2021	48,652 ± 0.16	2081 ± 0.17

Discussion:

It was noted that abundance estimates from Admiralty Inlet were quite high, raising concerns about the availability bias correction used to generate the estimates. Advice was given on being conservative with the average estimates shown, or alternatively, treat them as trends or relative abundance estimates, assuming the same error has been made in previous abundance calculations. It was discussed that the decrease in narwhal numbers in Eclipse Sound, coupled to the larger numbers detected in Admiralty Inlet, could indicate that narwhals were moving to Admiralty Inlet as a response to increased shipping in Eclipse Sound. Therefore, this displacement response could represent a prime example of the impact of industrial activity on narwhals. The group discussed that studies to evaluate if diving behaviour changes in large aggregations of narwhal are needed for development of availability bias corrections, with consideration of spatial and temporal changes in group size and composition.

4.3 NOISE LEVELS AND NARWHAL RESPONSE IN ECLIPSE SOUND AND ADMIRALTY INLET.

4.3.1 Baffinland study of narwhal response to ship noise

Marcoux informed the working group of a narwhal tagging program conducted by the Department of Fisheries and Oceans (DFO) during the period 2016-2018, and in collaboration with Golder in 2017-2018 (available as For Information document 32 - JWG/2022/FI32). Tagging involved the passive capture of narwhals at shore using nets, with some individuals being equipped with Acousondes, in addition to satellite tags.

Results from the monitoring of tagged narwhals indicated that 14/20 individuals came into close contact with ships, and of those 14 whales, 93% of their recorded GPS location points were more than 10 km from vessels (Golder data, JWG/2022/FI32). The fact that most narwhals did not get close to passing ships is considered a major finding, although whether narwhals moved close to the shore to avoid ships remains unknown in this area, as distance to coast was not included in the analyses. A significant effect of ships on time at surface was also found, with narwhals spending more time at the surface with exposure, as well as significant effects on dive duration and bottom dives. Golder concluded that narwhals could tolerate shipping traffic, arguing that they do not usually encounter ships in close proximity (<10 km) and, if exposed, the impact of the ship on narwhal behaviour was temporary.

Regarding icebreakers, Marcoux informed that, in 2016, 2 of 5 tagged narwhals were detected in the vicinity of icebreakers. That year, the minimum recorded distance to an icebreaker was 11.7 km, with the longest encounter having a duration of 49 hrs within 50km of an icebreaker. In 2018, the minimum distance to the icebreaker was 1.5 km, however it is not known whether the icebreaker was actively breaking ice at the time or simply escorting ships.

Discussion:

The group expressed concerns regarding this study including: 1) The captures for tagging occurred in a fjord adjacent to the main shipping route and thus the captured whales may have been preselected to be more tolerant of ship disturbance, 2) The area of impact of 10km was rather arbitrarily chosen and much narrower than empirical evidence from other studies 3) The conclusion that narwhals could tolerate shipping was entirely speculative because they did not show that the temporary impacts on behavior did not have cumulative effects over a season. The group **recommended** comparing tagging data from Eclipse Sound to data from Greenland to evaluate if there are similar behavioural changes and estimate their cumulative consequences. The group also welcomed the results provided on icebreaker effects, as it was previously assumed that narwhals did not get so close to icebreakers. However, it is not known whether the icebreakers were actively managing ice or transiting in open water.

4.3.2 Noise levels and narwhal response

Westdal presented Working Document 05 - Narwhal behavioural response to vessels: is 120 dB the best gauge for assessing disturbance? (JWG/2022/05).

Summary

(see Table 2, below). Numerous Inuit observations spanning this period of reductions in narwhal abundance indicate a correlation between narwhal decline and increased shipping (Ariak and Olson, 2019). Recent studies suggest that narwhal exhibit significant behavioural responses to ships (Golder, 2021) at distances where measured broadband received sound pressure levels from commercial ships (e.g. McKenna et al., 2012; Golder, 2018; Zhang et al., 2020; Jones et al., 2021) are substantially lower than 120 dB re 1 µPa, the level at which behavioural responses have been predicted for similar cetacean species (Southall et al., 2007). Recent research suggests that narwhal in Greenland also exhibit behavioural disturbance at received levels less than 120 dB (Tervo et al., 2021; Heide-Jørgensen et al., 2021; Williams et al., 2022). Here we review a combination of publicly available behavioural response data from tagged narwhal in Eclipse Sound (Golder, 2020) and received sound pressure level measurements of underwater noise (recorded on seafloor anchored hydrophones between 2015 and 2019) from 50 bulk carrier one-way transits in the same region. Results demonstrate that changes in narwhal behaviour occur when animals are exposed to broadband sound levels substantially lower than 120 dB. Advancement of species- and region-specific understanding of noise impacts to natural behaviour is needed for effective management of risks to narwhal and other marine mammals from anthropogenic noise (Southall et al., 2021). Clear, consistent information on noise/response relationships and their situational contexts are key elements missing from even the best available science on marine mammals (Gomez et al., 2016). The results of this research are useful for regional management decisions and have implications for environmental assessment processes.

Table 3. Narwhal population estimates in Eclipse Sound

Survey year	Abundance estimate	Source
2013	10,489	Doniol-Valcroze et al. 2015
2016	12,039	Marcoux et al. 2019
2019	8,464	JWG/2021/09
2020	4381	JWG/2022/10
2021	2081	JWG/2022/10

Discussion:

It was agreed by the group that 120 dB120dB was not a suitable threshold for narwhal disturbance. Behavioural disturbance and vessel avoidance occurs at levels lower than 120dB. A question was posed on whether it was possible to obtain carcasses or organs (e.g., brains) from harvested animals in Eclipse Sound, to compare with other populations, such as the East Greenland population or others in more pristine areas (e.g.,, without ship traffic). and efforts would be made to get samples from the hunters. The group also agreed that initiating a monitoring study would be necessary to assess the body condition of the animals (i.e., by measuring lipid content in blubber).

4.4 POPULATION EFFECTS ON NARWHAL

4.4.1 Metapopulation analysis

Witting presented Working Document 04 – Huge narwhal displacement following ship traffic increase in the Canadian Arctic Archipelago (JWG/2022/04)

Summary:

The Canadian Arctic Archipelago has the largest concentration of narwhals in the world, with estimates exceeding 100,000 individuals (Doniol-Valcroze et al. 2015). Until recently the area was largely undisturbed, but shipping activities have increased over the last three decades with a steep regime shift in overall shipping in 2007 (Pizzolato et al. 2014). This relates not only to traffic into the Northwest Passage at Lancaster Sound but even more so to intense shipping of iron ore from the Mary River Mine through Milne Inlet and Eclipse Sound (Kochanowicz et al. 2021).

Marine shipping is known to disturb narwhals (Golder 2021; Tervo et al. 2021), but the long-term consequences for individuals and populations are unknown. Rather than reacting to disturbance directly, a disturbance-imposed population displacement may e.g., follow as a gradual yearly change in the average migration of individuals, with critical population regulation effects emerging on even longer timescales. Working paper (WP) 04 uses the meta population model to analyse for such accumulated population impacts on the eight narwhal populations in East Canada and West Greenland.

By allowing for independent emigration/immigration before and after the steep in- crease in shipping activity in 2007, WP04 obtains 16 posterior migration estimates across the eight populations. All posterior migration estimates except two are either weakly updated by the Bayesian model or updated and centred around zero, showing absence of evidence for emigration and immigration. The two exceptions are Eclipse Sound after 2007 with a proportional annual emigration estimate of 12% (90% CI:7.0%–15%), and Admiralty Inlet after 2007 with a proportional annual immigration estimate of 14% (90% CI:11%–19%). With Admiralty Inlet and Eclipse Sound being neighbouring populations, this suggests substantial displacement of narwhals from Eclipse Sound to Admiralty Inlet. A second model with constant, instead of proportional, migration was used for final estimates, with Fig. 3 showing the posterior population projections for Eclipse Sound and Admiralty Inlet. These are based on a posterior estimate of 1,540 (90% CI:1,040–2,240) narwhals emigrating annually from Eclipse Sound from 2007 to 2022, and 1,720 (90% CI:927–2,380) narwhals immigrating annually to Admiralty Inlet. A total of 24,640 (90% CI:16,640–35,840) narwhals have so far emigrated from the Eclipse Sound population, with a corresponding total of 27,520 (90% CI:14,830–38,080) narwhals immigrating into Admiralty Inlet from 2007 to 2022. With a posterior population estimate of 203 (90% CI:0–1,170) narwhals in 2022, it is estimated that there will be almost no narwhals left in Eclipse Sound in 2023.

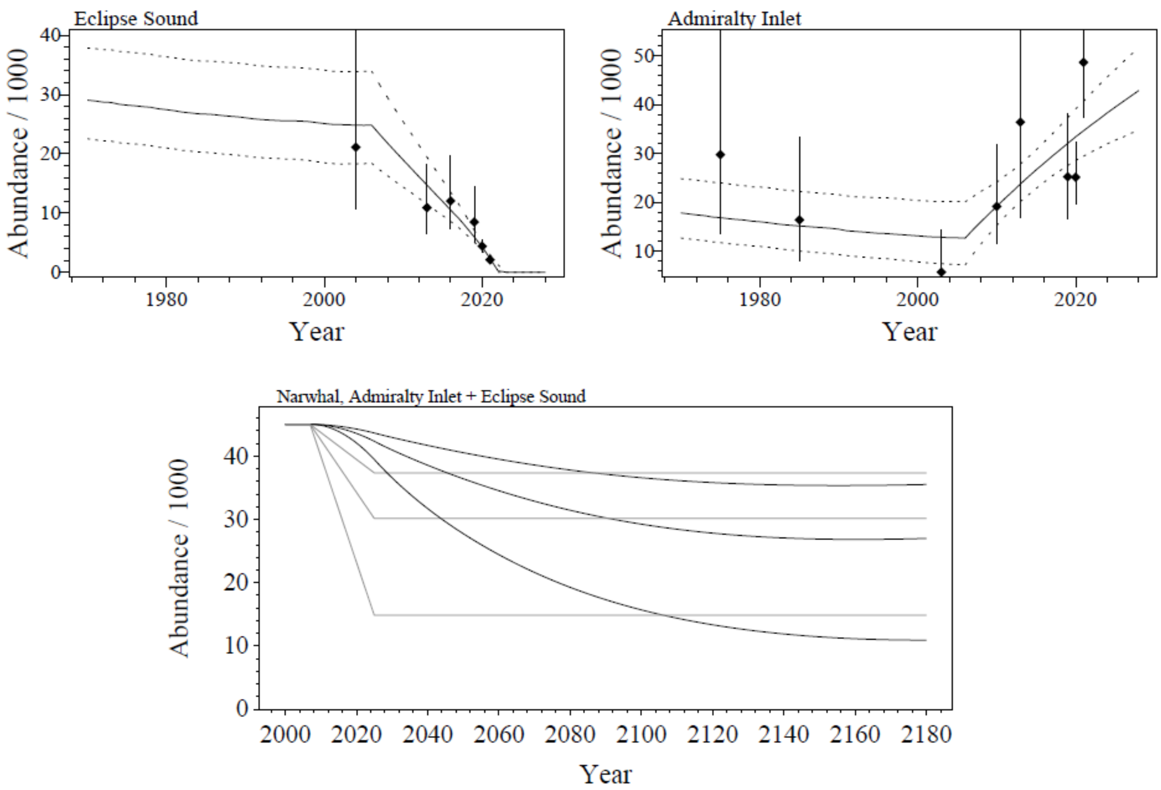

Figure 3: Population trajectories for narwhals. Top plots for Eclipse Sound and Admiralty Inlet: Points with bars are abundance estimates with 90% CI, solid curves the median of the estimated trajectories, and dotted curves the 90% credibility intervals. Bottom plot: Assuming 100,000 narwhals from the Canadian Arctic Archipelago in Admiralty Inlet by 2025 and a historical abundance of 15,000, black curves are expected trajectories should 1/6, 1/2 or the complete population regulation occur during August and September, and grey curves the corresponding equilibria.

Having pronounced preferences for sea ice and cold Arctic water, narwhals are consid- ered sensitive to climatic changes (Laidre et al. 2008; Heide-Jørgensen et al. 2020). The observed displacement, however, is not in line with climate changes in sea surface tem- perature (SST). While mean SST during the open water season (August and September) in Eclipse Sound was lower in the 1990s (-0.1◦C) than during the migration period from 2007 to 2022 (1.5◦C), we do not expect a climate response in the latter period where SST declined in Eclipse Sound and Admiralty Inlet (Chambault et al. 2020; Fig. 4; Table S, JWG/2022/04). During the first half of the period (from 2007 to 2014) where the displacement started, SST was even lower in Eclipse Sound (2.1◦C) than in Admiralty Inlet (2.8◦C), and it was higher along East Baffin Island (3.2◦C) where no emigration was observed between surveys in 2003 and 2013.

Other potential factors include distributional shifts in predators and prey (Breed et al. 2017; Lefort et al. 2020; Golder 2022). While these hypotheses are undocumented for the observed displacement, the collapse of the Eclipse Sound population follows the increase in ship traffic in the area. Not only is no migration estimated by the metapopulation model prior to the steep traffic increase in 2007 (Pizzolato et al. 2014), but the migratory response after 2007 is in agreement with area specific differences in ship traffic. Kochanowicz et al. (2021) used Automatic Identification System data from 2015 to 2018 to identify areas with ship noise above 120dB, which may negatively impact marine mammal hearing and behaviour (NMFS 2016; Gomez et al. 2016). Eclipse Sound and Milne Inlet have by far the highest frequency of exposures above 120dB, following the increased shipment of iron ore from the Mary River Mine (Kochanowicz et al. 2021). With two ore carrier vessel transits per day during the open water season in 2020 (Golder 2021), no other fjord system with narwhals in Northeast Canada and Northwest Greenland have similar amounts of heavy ship traffic. The second highest, and much lower, frequency of exposures above 120dB is found in Lancaster Sound and Parry Chanel, and no exposures above

120dB were estimated for the majority of Admiralty Inlet (Kochanowicz et al. 2021).

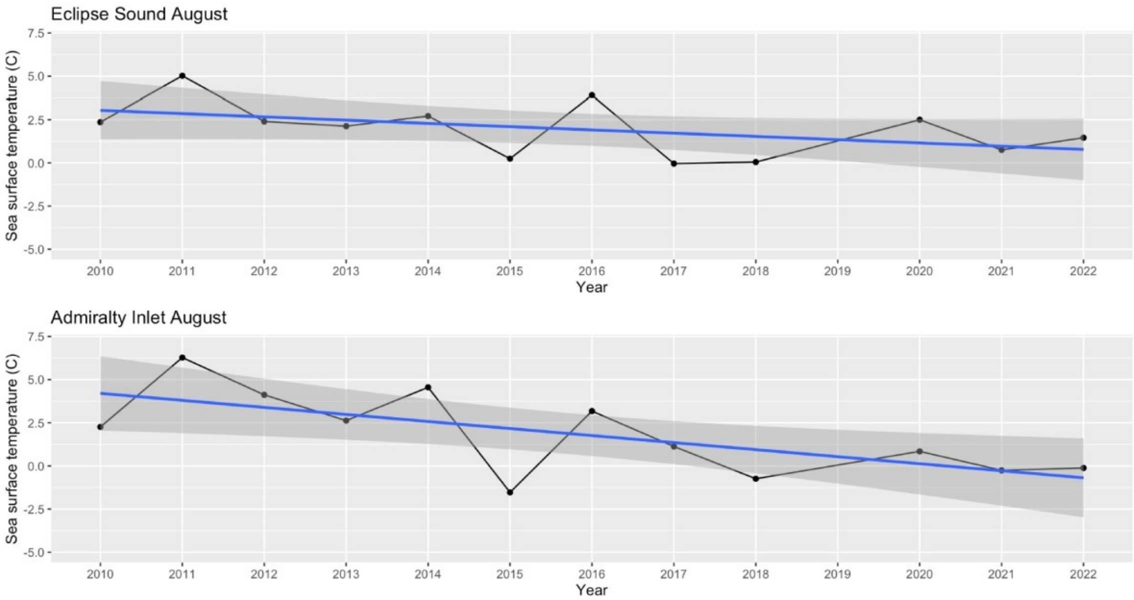

Figure 4: The climate change hypothesis for the displacement is not supported by the observed decline in mean surface temperature in Eclipse Sound and Admiralty Inlet since 2010. Dots are data obtained from the Global Ocean Physics Reanalysis Glorys S2V4 (PHYS-001-024) and the Global Ocean Physics Reanalysis Glorys12v1 (PHY-001-030), see Chambault et al. (2020) for details. Lines and grey areas are linear regressions with 95% CI. Fig. S5 shows a similar trend for September.

It is concluded that increased ship traffic is by far the most likely cause for the huge— almost complete population—displacement of narwhals from Eclipse Sound. Unless ship- ping is increasingly regulated, or narwhals adapt to the changes and reinhabits the abandoned areas, we may expect long-term population consequences that extend far beyond the currently observed lumping of narwhals. The metapopulation model estimates that the equilibrium abundance of Admiralty Inlet is 17,800 (90% CI:12,700–24,800) only. While narwhal populations are likely partially regulated by winter feeding, if summer regulation is essential, it cannot be excluded that up to about 30,000 narwhals will vanish (Fig. 3, bottom plot).

Discussion:

No evidence suggested that the loss of animals in Eclipse Sound and the gains in Admiralty Inlet were caused by climate change. The group discussed whether the surface temperature measurements by satellite were representative of the temperature strata in Eclipse Sound and Admiralty Inlet. The group agreed these are the best available data. There is also no evidence of large-scale predator-based displacement due to killer whales.

The group highlighted a better understanding of the mechanism underlying the movement of narwhals between Eclipse Sound and Admiralty Inlet was desirable. Suggestions were made to conduct summer surveys or to look at available survey data for that period to investigate narwhal movement out of Eclipse Sound and determine whether summer shipping activity is pushing these narwhals to Admiralty Inlet. The group also noted that data on narwhal catches in Pond Inlet from the floe edge vs. open water hunts could also be useful to investigate movement dynamics and that surveys conducted by Baffinland during 10-22 July, encompassing the start of summer shipping activity in Eclipse Sound, were available.

It was noted that the metapopulation model presented in Working Document 04 considered the displaced component of the Eclipse Sound aggregation as part of the aggregation in Admiralty Inlet; these animals were not expected to return to Eclipse Sound in the future as long as there is continued disturbance, and thus were no longer available for the hunters in Pond Inlet. The group agreed that changes in the allocation matrix needed to be considered and that the appropriate numbers to be used would be discussed at future meetings of the Joint NAMMCO/JCNB Working Group on narwhal and beluga.

4.5 OTHER MARINE MAMMALS POTENTIALLY AFFECTED

Other marine mammals occurring in Eclipse Sound are bowhead whales, sperm whales, killer whales, belugas, harp and ringed seals, walrus, and polar bears. The most abundant species, aside from narwhals, are ringed and harp seals. Although these species may be affected by shipping activities, it is primarily ice-breaking during the pupping season that would be a concern. Walrus and beluga whales are unlikely to be impacted within Eclipse Sound, as these two species are found in very low numbers. Bowhead whales are found in moderate numbers and may be the most affected marine mammals, second to narwhals, based on available knowledge. Abundance estimates are not available and instead maximum counts from aerial surveys can be used as an index of relative abundance (see Table 4 below).

Table 4. Maximum counts, abundance status and COSEWIC status of each species observed during aerial surveys in Eclipse Sound.

Species	Maximum counts from Golder surveys in Eclipse Sound*	Abundance in Eclipse Sound	COSEWIC Status
Bowhead whale	118	Migrant	Special Concern
Harp seal	2306	Abundant	Not assessed
Ringed seal	568	Common	Special Concern
Beluga whale	4	Rare	Special Concern
Killer whale	20	Irregular	Special Concern
Bearded seal	5	Rare	Data deficient
Walrus	1	Rare	Special Concern
Polar bear**	2	Rare	Special Concern

**maximum sightings from 2019, 2020 and 2021 (not effort corrected); ** observed in the water*

4.6 OTHER CONSIDERATIONS

The group raised concerns on the risk of oil spills and releases of other toxic materials in the area due to shipping activities, and the potential introduction of invasive species and/or parasites.

4.7 RECOMMENDATIONS FOR THE MARY RIVER PROJECT

Given,

1) aerial surveys show a large displacement of narwhals from Eclipse Sound to Admiralty Inlet, and

2) ship traffic causes significant disturbance to narwhals (e.g., disruption in foraging) at distances from 0 to 20 km, while icebreaking can cause impacts at distances from 0 to 35 km, and

3) the lack of support for a climate-change driven displacement (sea surface temperature) from Eclipse Sound to Admiralty Inlet, and

4) the overlap between the narwhal displacement and the development of ship traffic in Eclipse Sound, and

5) the lack of evidence for large scale predator-based displacement by killer whales,

the Workshop concluded that an almost complete displacement of any summer aggregation of narwhals, as has occurred in Eclipse Sound, should be anticipated if sustained shipping activities are planned in the fjord or inlet of that aggregation.

General rules of population regulation predict severe long-term consequences for displaced narwhal aggregations. It is currently impossible to rule out worst case scenarios, where displaced aggregations go extinct within a hundred-year period (due to competition with established aggregations in other areas or displacement to less favourable habitats).

There is no evidence for long-term habituation, or adaptation, of narwhals to shipping disturbance. There are no records of return of a displaced aggregation to a disturbed home-fjord system and it is highly unlikely for the animals to return unless the disturbance that caused the displacement has been drastically reduced.

4.7.1 High priority research recommendations

To understand the impact on the Eclipse Sound and Admiralty Inlet narwhal aggregations it is recommended that the following monitoring activities are conducted:

- That complete narwhal surveys of Eclipse Sound and Admiralty Inlet are continued on a yearly basis.
  That photographs from all past and future narwhal surveys in the area are made publicly available for independent research on, e.g., changes in calving rates and sex ratios.

4.7.2 Additional research recommendations

Data from narwhal monitoring conducted by the consultant companies who do the assessments for the mine should be requested for independent scientific review. Additional research recommendations include:

- Conduct tagging studies to understand the timing and extent of seasonal displacement and monitor the behaviour of resident animals.
- Collect tissue samples and morphometric data from harvested animals for understanding narwhal health and body condition.
- Conduct studies to evaluate, in Admiralty Inlet, if diving behaviour changes in large aggregations of narwhal for adjustment of availability bias corrections, also considering temporal changes in group size.

- Conduct studies to determine if whales depart through Navy Board Inlet in the summer and if so, estimate departure times.

4.7.3 Recommendations for the narwhal assessment model

1. For the next assessment, the mean values of the priors on birth rate, yearly survival and first year survival could be allowed to decline based on total ship traffic. Energetic costs, loss of communication, increased stress and risk of catastrophic dive response will need to be considered once a mechanistic understanding of these parameters is obtained.
2. Research to support the assessment model may include:
    a. Calf counts from aerial survey photos (2013 DFO survey as control).
    b. Sex ratio from aerial survey photos and in visual surveys.
    c. Temporal changes in the hunt.
3. Research to support further modelling may include:
    a. Estimates of energetic costs of ship transits for each type of ship.
    b. Review of recent tag data for measures of local displacement and disturbance response and their energetic costs.
    c. Examine brains and other organs (reproductive, blubber) from hunted animals for evidence of impairment due to chronic stress or catastrophic dive responses.

5. SHIPPING ACTIVITIES IN BAFFIN BAY

5.1 OVERVIEW OF IMPORTANCE OF EASTERN BAFFIN BAY

Anders Mosbech informed the group that shipping of bulk cargo had increased in Baffin Bay in the last decade and that it was projected to increase even more in the future with the opening of the Northwest Passage, due to decreasing ice cover. Under ice-free conditions, the shortest route for ships crossing the Northwest Passage towards lower latitude American destinations goes close to Baffin Island, so an increase in disturbance is expected there. In addition, Mosbech informed the group of Greenland's plans to designate 30% of their waters as protected areas, with marine mammal hotspots around Greenland being priority locations and that seismic exploration has been halted in Greenland, with no future plans for oil exploration. However, there are intentions to conduct a geophysical survey linked to potential diamond extraction in Southwest Greenland.

5.2 MARINE MAMMAL POPULATIONS IN WEST GREENLAND POTENTIALLY AFFECTED

Rikke Hansen presented information on populations of marine mammals potentially affected by shipping during winter and summer off West Greenland (Table 5). Among the winter species affected are bowhead whales, beluga whales, walrus and bearded seals. Bowhead whales in West Greenland occur relatively close to Disko Island, whereas beluga, walrus and bearded seals occur at similar locations and along the West Greenland coast and are shared stocks with Canada, with belugas and bearded seals following the ice to the west during the past two decades. During summer, potentially affected species are humpback whales, minke whales, fin whales, sperm whales, pilot whales, harbour porpoises, bottlenose whales and white-beaked dolphins. The Store Hellefiskebank in West Greenland has been assessed to qualify for the highest PSSA (Particular Sensitive Sea Areas) ranking according to the International Maritime Organizations ranking criteria of sensitive marine areas (however not designated as a PSSA by IMO) and it is further categorized as an Ecologically and Biologically Significant Area with IUCN criteria.

Table 5. Seasonal species' abundance at Store Hellefiske Bank (West Greenland).

Season	Species	Abundance	Year of survey	Reference
Summer	Minke whale	5095 (171-11,961)	2015	Hansen et al. 2018
	Humpback whale	993 (434-2272)		
	Fin whale	2215 (1017-4823)		
	Pilot whale	9190 (3635-23,234)		
	White-beaked dolphin	15,261 (7048-33,046)		
	Harbour porpoise	83,321 (43,377-160,047)		
	Sperm whale	?		
	Bottlenose whale	?		
	Harp seal	7400000*	2012	Hammill et al. 2011
Winter	Bowhead	1538 (827-2249)	2012	Rekdal et al. 2015
	Beluga	9072 (4895-16,815)		Heide-Jørgensen et al. 2017
	Narwhal	18,583 (7308-47,254)		Hansen et al. 2018
	Walrus	1408 (922-2150)		Heide-Jørgensen et al. 2014
	Bearded seal	abundant		
	Hooded seal	?		
	Ringed seal	285,000*	?	Lunn et al. 1997

*Summer: July 1 - September 30; Winter: November 1 - May 31; Confidence interval (CI) in parentheses; ? = no abundance estimation attempted; *= Total Northwest Atlantic stock*

5.3 EFFECTS OF DISTURBANCE ON NARWHALS

Tervo presented a working paper on spatiotemporal overlap of shipping routes and narwhals in Baffin Bay.

Summary:

Baffin Bay is a key winter habitat for the Canadian and Greenlandic narwhals. Narwhals feed intensively during winter, thereby developing substantial blubber stores; narwhals are dependent on successful foraging at this time to meet their energetic needs for the remainder of the year. The estimated shipping lane supplying Mary River iron mine via Milne Port overlaps spatially with the core winter habitats of Somerset Island and Melville Bay summering stocks of narwhals. With reducing ice-cover, the shipping activity can overlap with a larger portion of the narwhal wintering ground in the future affecting all summering stocks wintering in Baffin Bay. As narwhals are shown to react to noise disturbance by reduced foraging, this disturbance can have profound negative effects on the energy budget of individuals and ultimately on populations.

Discussion:

The group welcomed the information presented by Tervo about potential future overlap between narwhal stocks and shipping routes, noting that temporal overlap between narwhals and ships in Baffin Bay was already occurring with spring migration. Given that ship noise exceeds ambient noise levels more than 30 km from the ship and noise propagates further in the open waters of Baffin Bay, the group agreed that the noise corridor could extend out to 35 km from the ship. It was also **recommended** that an agreement between Greenland and Canada to guide vessels or designate a

vessel route across Baffin Bay would be necessary. However, it was noted that the central part of Baffin Bay is within international waters and would require an international agreement.
The group agreed that shipping in July in northern Baffin Bay was the major concern now for all the narwhal stocks wintering in Baffin Bay and in relation to Baffinland. Shipping noise during this period affects narwhal feeding and reproductive activity during their migration to summer aggregations in Canada and Greenland. Ice entrapments in the fall may also become an issue, if narwhals affected by ships take different migration routes to feeding grounds during fall migration.

5.4 EFFECTS OF DISTURBANCE ON WALRUS

Heide-Jørgensen presented information on walrus (*Odobenus rosmarus*) in the 'west ice' of Greenland.

Summary:

The walrus in West Greenland is primarily found on the banks along the coast where they are using drift ice (the so called 'West Ice) for haul out. Annual catches of walrus in the area have been reported since 1952, and aerial surveys of the occurrence and abundance of walrus in late winter in West Greenland have been conducted at irregular intervals since 1981, and since 2006 positions of the catches have been compiled. The mean western position of the walrus on the banks did not vary with the sea ice concentration indicating that the walrus chose the same winter-feeding area even in years where there was a major lack of sea ice that could be used for haul-out. The apparent lack of sightings or catches close to the shore at Store Hellefiske Bank and Disko Bank, off West Greenland, suggests that walrus did not show strong affinity towards their historical terrestrial haul-out sites, perhaps because they were only used in the fall, when walrus nowadays are still in Canada, or perhaps because of disturbance from human activities including hunting along the coast. There are no recent fall observations nor catches of walrus at or close to the historical haul-outs and nothing suggests that they currently are in use. Evidently, the shallow banks in West Greenland are critically important feeding areas for the Davis Strait walrus population. The declining albeit highly variable sea ice coverage in eastern Baffin Bay since the 1950s does not yet seem to affect the strong affinity that the walrus maintains to West Greenland in winter months. The walrus uses the very same areas on the banks in all the survey years independent of the variable sea ice concentrations and the variable access to sea ice as a haul-out substrate. The walrus is not the only marine predator that is capitalising on the rich productivity on the banks of West Greenland in winter. Belugas, narwhals and bowhead whales are also present in the area as well as several seal species of which the bearded seal has the greatest overlap of prey selection with walrus. The King eider that occurs in numbers up to about 1 million birds for a period of 3 to 6 months (Merkel et al. 2019), also feed on the same bivalve species that are targeted by walrus but they feed on water depths <50 m at the central part of the banks. It has been estimated that about 200 g wet weight m-2 of the clam, *Mya*, which is a major prey item of walrus, are present within a depth range from 50 to 150 m at the northern edge of Store Hellefiske Bank in an area of approx. 11.600 km^2, corresponding to a standing stock of >2.000.000 tons of bivalves (wet> 2.00 <1% of the weight). The walrus population on the banks thus consume <1% (0.20%) of the standing stock of *Mya* and even though walrus are not alone to feed on the clam the area seems to have the capacity to hold a much larger population of walrus than at present.

Discussion:

It was noted that walrus can come back to abandoned terrestrial haul-out sites after decades, if the area is undisturbed, with known examples of this from Northwest Greenland and Svalbard (Norway). In the past, haul-out site abandonment or local extinction of walrus occurred because of hunting. It was also noted that ships consider Store Hellefiske bank as a safe, shallow water area for anchoring. However, because ship anchoring can be a threat to walrus and other fauna in the area, including a large population of King eiders, due to risk of oil spills and disturbance, the group **recommended** no ship anchoring should occur in Store Hellefiske bank in order to protect this important feeding ground for many Arctic seabirds and marine mammals.

5.5 MARINE MAMMALS AND SEABIRDS POTENTIALLY AFFECTED

Table 6. List of marine mammal and seabird species potentially affected by shipping activities in Baffin Bay.

Species	Abundance in Assessment area	Greenland Red List status
Narwhal	Winter migrants	Near Threatened
Polar bear	Common	Vulnerable
Walrus	Migrants	Critically Endangered
Hooded seal	Numerous	Least Concern
Bearded seal	Abundant	Data deficient
Harp seal	Numerous	Least Concern
Ringed seal	Common	Least Concern
Bowhead whale	Abundant	Near Threatened
Minke whale	Common	Least Concern
Blue whale	Few	Data deficient
Fin whale	Abundant	Least Concern
Humpback whale	Abundant	Least Concern
Killer whale	Irregular	Not applicable
Beluga	Abundant	Critically Endangered
Harbour porpoise	Abundant	Least Concern
White-beaked dolphin	Common	Least Concern
King eider	Abundant	Least Concern
Common eider	Abundant	Least Concern
Thick-billed murre	Abundant	Vulnerable

5.6 OTHER CONSIDERATIONS

Given that narwhals react to icebreaker noise within a range of 35 km in Baffin Bay (JWG/2022/FI24), the group **recommended** to establish a buffer zone of 35 km from ship routes to sensitive areas.

5.7 RECOMMENDATIONS FOR BAFFIN BAY

5.7.1 Recommendations for research

- Conduct tagging studies to determine impacts of shipping in Baffin Bay.
- Obtain biological samples (brains, organs etc.) and morphometrics from the narwhal winter hunt in Disko Bay and the spring hunt in other areas of West Greenland.

5.7.2 Recommendations for management

- Establish a buffer zone of 35 km from ship routes to sensitive areas.
- No ship anchoring should occur in Store Hellefiske bank, due to its importance as a feeding ground for many Arctic seabirds and marine mammal species.

6. DUNDAS MINING IN GREENLAND

6.1. HISTORY, CURRENT ACTIVITIES AND FUTURE PLANS

Mosbech presented information on the Dundas titanium mining project, available as For Information documents 16, 17 and 18 (JWG/2022/FI16, JWG/2022/FI17 and JWG/2022/FI18)

Summary:

Dundas Titanium A/S will develop the Dundas Ilmenite Project (hereafter, the Project), which will extract ilmenite concentrate with high (3.45%) titanium dioxide content from the black mineral sand deposits found along the coastline of Steensby Land in North-west Greenland.

Following public consultations, the Terms of Reference was approved by the Greenland authorities in 2017 and 2018. Following public consultations, the EIA and Whitebook were approved by the Greenland authorities in 2020. In the current phase of the project specific plans must be approved by the authorities before the production is initiated. This includes approval of an environmental monitoring plan based on the conceptual monitoring plan (see below), which was part of the approved EIA.

The mining rate will be 7.4 million tonnes per annum, at which rate the Project is expected to produce approximately 440,000 tonnes of ilmenite product per year. All oversized material (rocks and gravel) and light sand material removed during the processing is hauled back to the mine void where it is backfilled. This represents c. 90% of the mined material. The separation takes place at Wet Plants using seawater, and a considerable amount of silt and clay will be discharged with the seawater and settle in the marine environment. It is estimated that an area of 9 × 1 km along the coast with depths up to 25 m will be heavily impacted by sedimentation. This area has a relatively low bivalve biomass compared to a few stations further east.

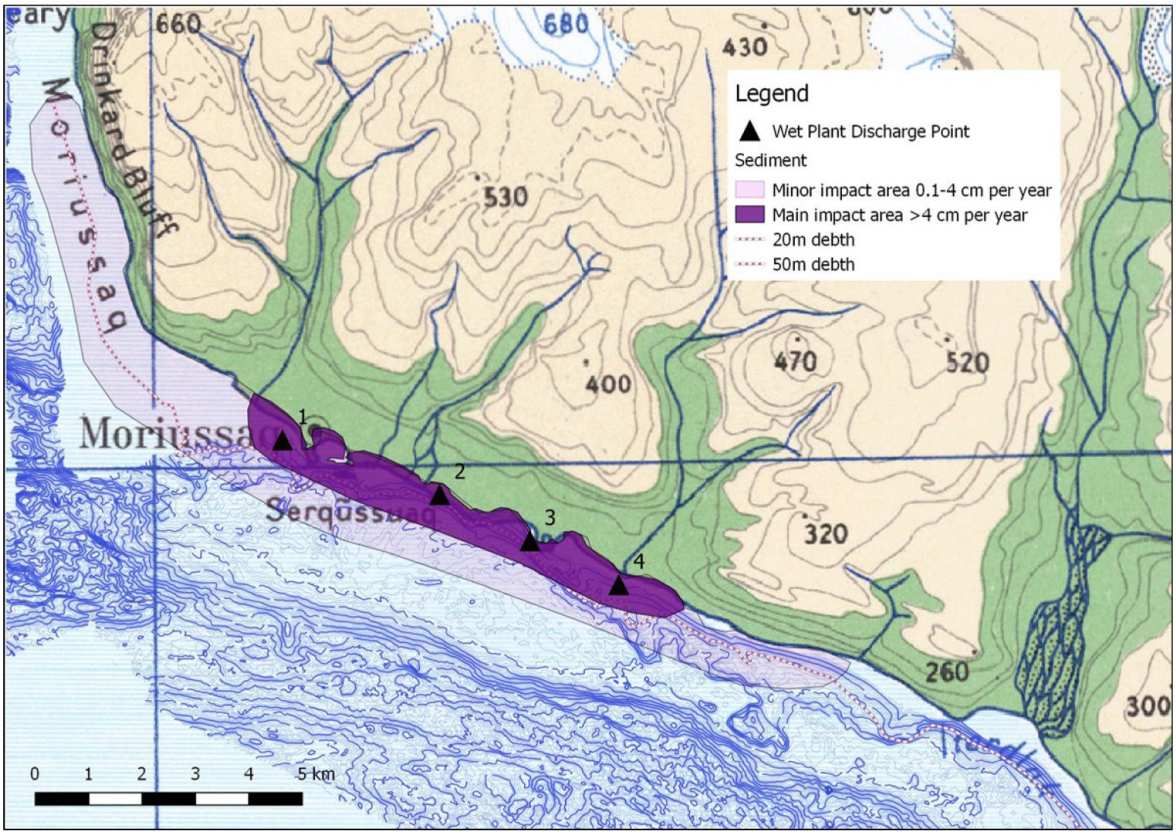

Figure 5: Major and minor impact zones around the four discharge points.

Shipping to and from the Project port will take place in the ice-free period from early July to mid-October. 11 ships per year (40,000 DWT) will transport the product and an additional 2-3 ships will supply the operation. Shipping to the Project port is estimated to increase the number of vessels in the eastern section of the NOW by 56-82%.

Walruses winter and migrate along the south coast of Steensby Land in May-June and large pods of white whale often migrate close to the coasts of the Project area in September – October. During the ice-free period from early July to mid-October, when shipping will take place, practically the entire walrus population is in Canadian waters.

To reduce the disturbance of migrating marine mammals, a vessel slowdown to 8 knots must apply to all ships calling at the Project port and must stay in effect from entering the North Water Polynya to the Project port, that is the northernmost c. 150 km of the planned shipping route. When passing through the same area ships should only use echo sounders of a frequency above 150 kHz, in which case they are inaudible to marine life in the area. With this mitigating measure in place disturbance from shipping underwater noise is assessed as Low in the EIA.

The company has presented the following plans for Marine Mammal Surveys as part of the Conceptual Monitoring Program (see also Table 7). Further data on the timing and magnitude of marine mammal movements in the area will be carried out using SoundTraps or similar acoustic dataloggers. This will be combined with data collection of shipping noise. Experts on underwater noise monitoring will be consulted when the noise monitoring program is developed. This monitoring activity will be designed to collect information on noise from all ships in the area (not just vessels calling in at the Project port) and this could make it possible to further refine the speed restrictions.

Additional aerial surveys of walrus will be carried out in the Wolstenholme Fjord system in spring. The surveys will follow the same survey method as in 2017-2018 and described in document JWG/2022/FI17. This will provide more information on the spatial, temporal and numerical changes in the walrus population in the area and establish a firmer baseline. This information will be important when determining if mining activities in the western sections of the mine area could disturb walruses at the known shallow banks off the coast with high density of the preferred mussels. The extent of this monitoring and reporting requirements will be defined in cooperation with the Greenlandic authorities.

Table 7. Summary of the Conceptual Monitoring Program presented by the Company.

Marine mammals and ships	*SoundTraps or similar acoustic dataloggers* deployed in the sea off license area	Number and species of whales	Spring and autumn	Construction, operational phases	To be defined in cooperation with EAMRA	Annual Monitoring Report
Walrus	Aerial survey of Wolstenholme Fjord system	Spatial, temporal and numerical distribution	Spring (June)	To be agreed with the authorities	To be defined in cooperation with EAMRA	Annual Monitoring Report

Prior to project operations, a more detailed study design will be developed for each of the EMP's elements. This will be done in cooperation with the Greenland authorities.

GINR and DCE has pointed out that although the Dundas EIA gives an adequate assessment of the expected impact of the project on marine mammals, there is considerable uncertainty on how the seasonal shipping and the year-round activities on land will impact the walrus in Wolstenholme fjord. There is further a lack of knowledge and a need for specific studies on walrus habitat use, and habitat quality, in Wolstenholme Fjord and the sensitivity of the walrus in the Fjord to disturbances. To supplement the monitoring program further studies of walrus is recommended to secure a sustainable population development. Studies which address the cumulative impact from both industrial disturbances and hunting, should be developed in dialogue with local hunters.

Discussion:

The group agreed that the discharge of silt and clay from the mineral processing plants to the sea would destroy benthic habitats and mussel beds where walrus could potentially graze, resulting in the loss of feeding opportunities, in addition to other cumulative impacts such as climate change and hunting. However, it was noted that the importance of the loss of feeding opportunities could not be evaluated with the available information, and the area had no permanent inhabitants and that it was not considered an important hunting area.

6.2. BIOLOGY AND MIGRATIONS OF WALRUS IN SMITH SOUND

Garde presented information on movements, diving and foraging of walrus in Northwest Greenland. This presentation covered findings from two published papers: 1) *Diving behavior of the Atlantic walrus in high Arctic Greenland and Canada* (Garde et al. 2018), and 2) *Walrus Movements in Smith Sound: A Canada – Greenland Shared Stock* (Heide-Jørgensen et al. 2017b).

Summary 1:

Investigations of diving behavior of the Atlantic walrus (*Odobenus rosmarus rosmarus*) in the high Arctic Greenland and Canada are important for understanding behavioural adaptations and area utilization of this Arctic benthic feeder. Furthermore, such information along with estimations of annual consumption and carrying capacity of walruses are needed in management decisions of this utilized species. Satellite-linked transmitters deployed on 27 walruses from 2010 to 2013 provided data for investigations of diving behavior in three predefined main areas: NW Greenland, Smith Sound and NE Canada. Sub-areas within each main area were also compared. Depth of dives, dive rates, time at depth of dives, haul-out periods and vertical speeds were estimated. Majority of dives targeted depths from 10 to 100 m, which correspond to the distribution of walrus' preferred food items. Four dives to depths > 500 m occurred and are the deepest ever documented for a walrus. Dive rates and time at depth of dives were significantly different between sub-areas ($p < 0.0001$), whereas haul-out periods were not ($p = 0.072$). Mean vertical speeds to destination depths ranged from 1.0 m s^{-1} (95% CI: 0.8–1.2) to 1.8 m s^{-1} (95% CI: 1.0–2.6). Based on dive rates, time at depth, haul-out and percentage of feeding dives Alexandra Fjord and Princess Mary Bay in NE Canada and Carey Island in NW Greenland were identified as the most important areas for walrus feeding during summer. Walrus predation on the standing bivalve biomass in NW Greenland (within 5–100 m of depth) was estimated to 3.2% annually based on assessments of mean biomass of walrus preferred prey items. From a simple relationship between available shallow water habitat, current population size (n=2544) and walrus pre-exploitation population sizes it is furthermore proposed that the carrying capacity in the Smith Sound region does not exceed 5000 walruses.

Summary 2:

Fifty of 58 walruses (*Odobenus rosmarus rosmarus*) instrumented with satellite-linked transmitters in four areas in eastern Smith Sound, Northwest Greenland, during May and June of 2010 – 13 and 2015 provided data for this study. These animals departed from the feeding banks along the Greenland coast in June – July (average 14th June), simultaneously with the disappearance of sea ice from these areas. Most of them moved to Canadian waters in western Smith Sound. The most frequently used summering grounds were along the coasts of Ellesmere Island: on the eastern coast, the area around Alexandra Fjord, Buchanan Bay, and Flagler Bay (west of Kane Basin) and Talbot Inlet farther south, and on the southern coast, Craig Harbour. This distribution of tagged walruses is consistent with prior understanding of walrus movements in summer. In addition, however, nine tracks of these tagged animals entered western Jones Sound and four entered the Penny Strait-Lancaster Sound area, crossing two putative stock boundaries. Since these 13 tracks were made by 12 animals, one walrus entered both areas. It is possible that some of the tracked walruses used terrestrial haul-out sites in the largely ice-free areas of Jones Sound and Lancaster Sound for short periods during the summer, though this cannot be confirmed with certainty. The return migration from western Smith Sound to the wintering area in eastern Smith Sound takes place in October. The tracked walrus showed high affinity to coastal areas, while walruses moving between Greenland and Canada also used offshore areas in Smith Sound. This study demonstrates that the walrus population that winters along the northwestern coast of Greenland is shared more widely in Canada than previously thought and should be managed accordingly.

Discussions:

Historically, walrus occupied terrestrial haul-out sites in North and West Greenland (incl. Smith Sound). Walrus probably abandoned the haul-out sites due to hunting and they have never returned, except that in later years walrus have hauled out on few occasions on the Edderfugle Islands in Wolstenholme fjord. To the question of whether there was evidence that haul-outs in Greenland had been previously abandoned due to hunting, it was indicated that this relationship was inferred from the timing when haul-out abandonment happened (<1900 CE). It was discussed that walrus are probably able to return to abandoned terrestrial haul-out sites as long as the sites remain undisturbed by humans. It was also noted that the estimation of bivalve consumption by walrus (56% of annual production of two bivalve species) may be positively biased. The estimation of consumption was based on old data on bivalve distribution and abundance in the region from literature that is out of date. Independent of the accuracy of the bivalve estimates there is no doubt that shallow areas in eastern Smith Sound are critically important as foraging grounds for the Baffin Bay stock of walrus.

6.3. POTENTIAL POPULATION EFFECTS ON WALRUS AND PROPOSAL FOR MONITORING

Heide-Jørgensen presented Working document 09 – Update on tracks of walrus in Smith Sound (JWG/2022/09).

Summary:

The primary concern for the Dundas mine in Wolstenholme fjord is the walrus that are believed to have one of their two main winter feeding grounds in Wolstenholme fjord where large shallow water areas are supporting bivalve communities that can be accessed by walrus. Recent satellite tracking results from 2022 (n=3) confirm published results that after leaving Wolstenholme Fjord the walrus disperse widely in the Canadian Arctic and appear to be homing towards Wolstenholme fjord in fall. Regional aerial surveys confirm that high densities of walrus are found on ice and in water at both wintering grounds, and dependent on ice conditions walrus occur at the opening of Wolstenholme fjord or further inside the fjord. The Orbicon company that has done environmental studies for the mining company has used both a zig-zag survey technique and reconnaissance flights in spring and fall of 2017 and 2018. Concentration areas of walrus were identified based on these surveys and observations of narwhal and beluga migrating through Wolstenholme Fjord were noticed.

Discussion:

Because walrus are known to be sensitive to disturbance and to abandon haul out sites, there were concerns that the aerial zig-zag surveys conducted by Orbicon outside the mining site might be scaring walrus. However, this was considered unlikely due to the elevation of the aircraft and the fact that the engine was quieter than the planes used in many scientific surveys.

It was noted that monitoring plans from the mine were not settled yet, and that the mine would like to monitor mussels and marine mammals only in the local area, using acoustic monitoring, and aerial surveys. The group agreed that regional (eastern part of Smith Sound) monitoring of the whole area was the minimum coverage and that it was best for the mine company to expand the survey area. After discussing the most appropriate timing and frequency for the aerial surveys, the group **recommended** that surveys for monitoring abundance and distribution occurred annually in April. The timing of the survey (April) is supported by distribution maps of sightings of walrus indicating the existence of a hotspot of walrus distribution in eastern Wolstenholme Fjord (see For Information document JWG/2022/FI37). In addition to the aerial surveys and other monitoring tools used by the mine, the group also **recommended** collecting satellite imagery of Wolstenholme Fjord annually to determine walrus density, and eventually walrus counts, if <30 cm resolution imagery becomes available.

It was also noted that belugas begin to migrate through that area in September and may overlap with shipping in September-October. The group **recommended** to extend ship speed regulations of 8 knots to south of the beluga migration route passing Cape York in September-October.

It was noted early July – mid October was the only time when ship traffic may be a cause of concern, but that there was no temporal overlap with walrus. However, disturbance for the remainder of the year from mining activities on land would overlap temporally, and ringed seals in particular would be impacted year-round in the area.

MITIGATION BUFFER ZONES FOR ATLANTIC WALRUS

Cory Mathews participated virtually and presented For Information document 26 - Mitigation Buffer Zones for Atlantic Walrus (*Odobenus rosmarus rosmarus*) in the Nunavut Settlement Area (JWG/2022/FI26), and For Information document 34 - Response to ESPOO Convention Reply on the Review of Transboundary impacts from a Greenland Titanium Mine (JWG/2022/34).

Summary:

The Science Response was written to provide data to the Nunavut Planning Commission, who was seeking advice on walrus haul-out locations and appropriate buffer zones to mitigate disturbance from vessels at sea and aircraft. Matthews highlighted the literature that contributed to the review and noted that most of the research that formed the basis of proposed guidelines was performed on Pacific walrus in Alaska. The Canadian government maintains an up-to-date database on terrestrial walrus haul-out sites from regularly conducted aerial surveys. The literature review summed up all available data on walrus disturbance from vessels of several size classes as well as different types of aircraft (helicopters and fixed wing aircraft). Distances (along with altitudes of aircrafts) eliciting responses ranging from head raising to stampeding were evaluated, and it was decided for the Nunavut Planning Commission's objectives, adoption of current US federal and state (Alaska) guidelines regarding approaches to walrus on land and in water would be appropriate (attendees were referred to specifics in the provided document). Finally, it was noted that much of the available data were anecdotal in nature and focused primarily on haul-outs, which leaves out a considerable portion of walrus habitat used for foraging and other purposes during which they are also prone to disturbance.

Matthews provided a general overview of the Espoo process, which is a UN Convention requiring signature parties to notify other parties when an environmental assessment in their jurisdiction may or is likely to have transboundary impacts. Canada was invited to review documents submitted by the mining company concerning the proposed mine site in Wolstenholme Fjord and ask for clarification or additional details. DFO's concerns focused primarily along two main themes: 1) impacts of shipping and mining activities on marine mammals, and 2) impacts of habitat degradation on marine mammals. Regarding point 1, DFO largely agreed that most of the summer shipping activity would take place when marine mammal stocks move into Canadian waters but had concerns about shipping during the shoulder seasons when animals like walrus or belugas may still be migrating out of or back into the area. Point 2 was related primarily to walrus, as Wolstenholme Fjord is one of the main winter foraging areas of walrus that summer in Canada. The proposals did not provide a lot of information on activities in winter that could directly impact walrus (e.g., noise and lights from mine site), but there were also concerns about impacts of mining activity on bivalve beds through siltation and contaminant biomagnification (which, as the main prey of walrus, could have important indirect impacts). DFO provided suggestions for the types of monitoring and data collection that could be gathered to assess mine impacts. Two sets of documents containing the detailed Espoo Convention submissions were provided to participants.

Discussions:

The group proceeded to list recommendations for management and monitoring of walrus and other marine mammals in the area (see next item).

6.1 RECOMMENDATIONS FOR WOLSTENHOLME FJORD

6.1.1 High priority Research Recommendation

Given,

1) that Dundas mine is proposing acoustic monitoring and annual aerial surveys in Wolstenholme Fjord system in spring,

the Workshop recommends as **high priority** for research:

- that the regional aerial survey of the east side of Smith Sound be the minimum area that should be covered for monitoring abundance and distribution. Surveys should occur in April, annually during the first 3 years of production, to allow detection of any substantial changes.

6.1.2 Additional Recommendations for Research

Assuming acoustic monitoring and that biota (mussels and seaweed) will be monitored for contaminants at the project site, additional recommendations for the mining company are:

- Data from monitoring surveys conducted by the consultant companies who do the assessments for the mine be provided to scientists, upon request, for independent review.

- Satellite imagery of Wolstenholme Fjord be collected annually to determine walrus density, and eventually walrus counts if <30 cm resolution imagery becomes available.

- Telemetry data on walrus habitat use, distribution and migration patterns combined with a study of benthos covering the foraging areas in Wolstenholme Fjord would improve the assessment of the relative importance of the potential foraging area impacted by the mining operation (disturbance and siltification).

- The hunting effort in Wolstenholme Fjord is at present small. However, the hunting effort may change and may impact walrus numbers and distribution within the Fjord, so to allow for a cumulative assessment hunting effort should be monitored in cooperation with local hunters.

6.1.3 Additional recommendations for management

The Workshop additionally recommends that:

- Greenland invites Canadian experts to participate in reviewing monitoring programs, plans and results.

- Ship speed regulations of 8 knots be extended to south of the beluga migration route passing Cape York in September-October. This recommendation does not include a buffer around the timing of shipping.

7. GENERAL RECOMMENDATIONS

Disturbance of narwhals causes displacement and significant energetic impacts which may lead to stress and reduced fecundity and survival. In addition, displaced animals may compete with resident animals in other areas.

Based on the above statement, the Workshop made the following **recommendations for management of narwhals in all areas**:

- Shipping traffic and associated ice breaking has caused an unprecedented displacement of narwhals from Eclipse Sound. The Workshop recommends that future developments avoid shipping within the narwhal summering aggregations.
- Ship traffic causes significant disturbance to narwhals (e.g., disruption in foraging) at distances from 0 to 20 km, while icebreaking can cause impacts at distances from 0 to 35 km. The Workshop recommends that these values be used to establish buffer zones around narwhal summer aggregations and establish traffic corridors to protect migration routes and winter foraging grounds
- No ship anchoring should occur in Store Hellefiske bank, due to its importance as a feeding ground for many Arctic seabirds and marine mammal species.
- Hunt management advice should account for the displacement and possible associated changes in fecundity and survival, both in disturbed summer aggregations as well as in aggregations affected by the displaced animals (see also section 4.7).

The Workshop's recommendation against sustained shipping near summer aggregations of narwhals comes with the following **words of caution**:

- An almost complete displacement of any summer aggregation of narwhals, as has occurred in Eclipse Sound, should be anticipated if sustained shipping activities are planned in the fjord or inlet of an aggregation.
- General rules of population regulation predict severe long-term consequences for displaced narwhal aggregations. It is currently impossible to rule out worst case scenarios, where displaced aggregations go extinct within a hundred-year period (due to competition with established aggregations in other areas or displacement to poor habitat).

8. OTHER BUSINESS

There was no other business

9. REPORT PREPARATION

A first draft of the report with recommendations was reviewed and approved by the participants before the close of the workshop on December 16th, 2022. Following formatting and editorial revisions, the final report was adopted by correspondence on January 9th 2023.

10. CLOSING REMARKS

The Co-Chairs thanked all the participants for their active contribution to the meeting and the excellent research done to inform the discussions. The group thanked the Co-Chairs for efficient guidance through the agenda to arrive at recommendations, and thanked NAMMCO for organizing and the

Greenland Representation at Copenhagen for hosting the event. NAMMCO Scientific secretary, Albert Chacón, was thanked for his comprehensive record of the discussions.

The workshop was closed at 16:50 CST on December 16th, 2022.

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APPENDIX 2: AGENDA

Monday (9:00-17:00 CET)

1. CHAIRS WELCOME AND OPENING REMARKS

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

2. LESSONS FROM A CONTROLLED DOSE EXPOSURE STUDY OF NARWHALS IN EAST GREENLAND

2.1 Introduction with overall design of study
2.2 Behavioral response study on seismic airgun and vessel exposures in narwhals
2.3 Received levels of sounds from airgun pulses
2.4 Narwhals reaction to ship noise and airgun pulses embedded in background noise
2.5 Physiological responses of narwhals to anthropogenic noise: A case study with seismic airguns and vessel traffic
2.6. Statistical treatment of behavioral change data
2.7 Locomotion costs during exposure of narwhals
2.8 The costs of disturbance for narwhals
2.9 Other studies

3. STUDIES OF DISTURBANCE IN OTHER AREAS

3.1. Harbour porpoises in Europe
3.2. Bowhead whales in Alaska
3.3. Accounting for cumulative stressors in population models

Tuesday (9:00-17:00 CET):

4. MARY RIVER ACTIVITIES IN COASTAL AREAS OF CANADA

4.1. History
4.2. Current activities and future plans
4.3. Narwhal trends in distribution and abundance in Eclipse Sound and Admiralty Inlet
- 4.3.1. Review of aerial surveys from Eclipse Sound and Admiralty Inlet
- 4.3.2. Review new abundance estimates from Eclipse Sound and Admiralty Inlet

4.4. Noise levels and narwhal response in Eclipse Sound and Admiralty Inlet
4.5. Population effects on narwhals
4.6. Other marine mammals potentially affected
4.7. Other considerations

Wednesday (9:00-17:00 CET):

5. SHIPPING ACTIVITIES IN BAFFIN BAY

5.1. Overview of importance of eastern Baffin Bay
5.2. Marine mammal populations in west Greenland potentially affected
5.3. Effects of disturbance of bowhead whales
5.4. Effects of disturbance of walrus
5.5. Other marine mammals potentially affected
5.6. Other considerations

Thursday (9:00-17:00 CET):

6. DUNDAS MINING ACTIVITIES IN GREENLAND

6.1. History
6.2. Current activities and future plans
6.3. Biology and migrations walrus in Smith Sound
6.4. Proposal for walrus monitoring
6.5. Potential population effects on walrus
6.6. Mitigation buffer zones for Atlantic walrus
6.7. Other marine mammals potentially affected
6.8. Other considerations

Friday (9:00-17:00 CST):

7. RECOMMENDATIONS

7.1. Monitoring and future studies
7.2. Changes in advice on exploitation of walrus and narwhals
7.3. Suggestions for mitigations

8. OTHER BUSINESS
9. REPORT PREPARATION
10. ADJOURN

APPENDIX 3: LIST OF DOCUMENTS

Working Documents

Doc. No.	Title	Agenda item
JWG/2022/00	Terms of Reference	1.3
JWG/2022/01	Draft Agenda	1.5
JWG/2022/02	Draft List of Participants	1.1
JWG/2022/03	Draft List of Documents	1.4
JWG/2022/04	Huge narwhal displacement following ship traffic increase in the Canadian Arctic Archipelago. Witting, L. 2022.	3.4, 4.6 & 5
JWG/2022/05	Narwhal behavioural response to vessels: is 120dB the best gauge for assessing disturbance. Jones, J. M. and Westdal, K. 2022.	4.5.2
JWG/2022/06	Key factors dictating the price of disturbance for narwhals. Heide-Jørgensen, M.P., Tervo, O. and Williams, T. 2022.	2.8 & 5.4
JWG/2022/07	Spatial overlap of shipping activities and narwhal wintering grounds in Baffin Bay. Tervo, O.M., Hansen, R.G. and Heide-Jørgensen, M.P. 2022.	5
JWG/2022/08	Overlap of shipping activities and marine mammals at Store Hellefiskebanke. Tervo, O.M., Hansen, R.G. and Heide-Jørgensen, M.P.2022.	5
JWG/2022/09	Update on tracks of walrus in Smith Sound. Heide-Jørgensen, M.P. 2022	6.3
JWG/2022/10	Review of the 2020 and 2021 narwhal surveys in Eclipse Sound and Admiralty Inlet conducted by WPS Golder Inc. Marcoux, M.	4.4
JWG/2022/11	Using agent-based models for management of marine populations. Nabe-Nielsen, J. 2022.	3

For Information Documents

Doc. No.	Title	Agenda item
JWG/2022/FI01	2020 JWG Meeting Report	4,5,6 & 7
JWG/2022/FI02	2021 JWG Meeting Report	4,5,6 &7
JWG/2022/FI03	2021 NEGWG Meeting Report	2

JWG/2022/FI04	National Academies of Sciences, Engineering, and Medicine 2017. *Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals.*Washington, DC: The National Academies Press. https://doi.org/10.17226/23479.	3.4
JWG/2022/FI05	Heide-Jørgensen et al. (2021). *Behavioral Response Study on Seismic Airgun and Vessel Exposures in Narwhals*. Frontiers in Marine Science, 8, 658173. https://doi.org/10.3389/fmars.2021.658173	2.2
JWG/2022/FI06	Tervo et al. (2021). *Narwhals react to ship noise and airgun pulses embedded in background noise.* Biology Letters, 17(11), 20210220. https://doi.org/10.1098/rsbl.2021.0220	2.4
JWG/2022/FI07	Williams, T. M. et al. (2017). *Paradoxical escape responses by narwhals (Monodon monoceros)*. Science, 358(6368), 1328–1331. https://doi.org/10.1126/science.aao2740	2
JWG/2022/FI08	Williams, T. M. et al. (2022). *Physiological responses of narwhals to anthropogenic noise: A case study with seismic airguns and vessel traffic in the Arctic.* Functional Ecology, 36(9), 2251–2266. https://doi.org/10.1111/1365-2435.14119	2.5
JWG/2022/FI09	Garde, E., et al. (2018). *Diving behavior of the Atlantic walrus in high Arctic Greenland and Canada.* Journal of Experimental Marine Biology and Ecology, 500, 89–99. https://doi.org/10.1016/j.jembe.2017.12.009	5 & 6
JWG/2022/FI10	Heide-Jørgensen, M. P. et al. (2017). *Walrus Movements in Smith Sound: A Canada–Greenland Shared Stock*. ARCTIC, 70(3), 308. https://doi.org/10.14430/arctic4661	6.3
JWG/2022/FI11	Aariak E., & Olson, R. (2019). Qikiqtani Inuit Association's Tusaqtavut for Phase 2 Application of the Mary River Project. Final Report.	4
JWG/2022/FI12	Gomez, C.,et al. (2016). *A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy*. Canadian Journal of Zoology, 94(12), 801–819. https://doi.org/10.1139/cjz-2016-0098	2,3,4,5 & 6
JWG/2022/FI13	McKenna, M. F., et al. (2012). *Underwater radiated noise from modern commercial ships.* The Journal of the Acoustical Society of America, 131(1), 92–103. https://doi.org/10.1121/1.3664100	2,3,4,5 & 6
JWG/2022/FI14	Southall, B. L., et al. (2021). *Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise.* Aquatic Mammals, 47(5), 421–464. https://doi.org/10.1578/AM.47.5.2021.421	2,3,4,5 & 6
JWG/2022/FI15	Bulk Carriers in the Arctic: Changes with Mine Operations. Arctic Shipping Status Report (ASSR)	3
JWG/2022/FI16	White paper. Environmental Impact Assessment [EIA]. Dundas Titanium A/S.	6

JWG/2022/FI17	Dundas Ilmenite Project. Environmental Impact Assessment. Orbicon Report. December 2020	6
JWG/2022/FI18	Wegeberg, S., Boertmann, D., Blockley, D. Nymand, J. & Mosberg A. 2020. Høringssvar vedr. Dundas Ilmenite Project og selskabets VVM af aktiviteterne. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 7 s. - Fagligt notat nr. 2020|49 https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notatet_2020/N2020_49.pdf	6
JWG/2022/FI19	Halliday, W. D., et al. (2022). *Overlap between bowhead whales (Balaena mysticetus) and vessel traffic in the North American Arctic and implications for conservation and management.* Biological Conservation, 276, 109820. https://doi.org/10.1016/j.biocon.2022.109820	3
JWG/2022/FI20	Recommendations from the Technical Group on Underwater Noise (TG Noise). MSFD Common Implementation Strategy Technical Group on Underwater Noise (TG NOISE). Methodology report. Deliverable 3, 2021.	2 to 7
JWG/2022/FI21	Setting of EU Threshold Values for impulsive underwater sound Recommendations from the Technical Group on Underwater Noise (TG Noise). MSFD Common Implementation Strategy. Technical Group on Underwater Noise (TG NOISE). Deliverable 2, 2022.	2 to 7
JWG/2022/FI22	Setting of EU Threshold Values for continuous underwater sound Recommendations from the Technical Group on Underwater Noise (TG Noise). MSFD Common Implementation Strategy. Technical Group on Underwater Noise (TG NOISE). Deliverable 4, 2022.	2 to 7
JWG/2022/FI23	MSFD Common Implementation Strategy. Technical Group on Underwater Noise (TG-NOISE). Towards threshold values for underwater noise. Common methodology for assessment of impulsive underwater noise. Current state of the art Deliverable 1 of the work programme of TG Noise 2020-2022.	2 to 7
JWG/2022/FI24	Underwater noise from the icebreaker M/S VOIMA. Report by Thiele L. Greenland Fisheries Investigations, 1981.	2 to 7
JWG/2022/FI25	Underwater noise Study from the icebreaker "John A. MacDonald". Report by Thiele L. Ødegaard & Danneskiold-Samsøe ApS, 1988.	2 to 7
JWG/2022/FI26	DFO. 2019. Mitigation Buffer Zones for Atlantic Walrus (*Odobenus rosmarus rosmarus*) in the Nunavut Settlement Area. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/055.	3.5
JWG/2022/FI27	Boertmann, D. & Mosbech, A. 2017. Baffin Bay. An updated strategic Environmental Impact Assessment of petroleum activities in the Greenland part of Baffin Bay. Scientific Report from DCE Danish Centre for Environment and Energy No. 218. http://dce2.au.dk/pub/SR218.pdf	4 & 5

JWG/2022/FI28	Science review of additional documents submitted may 13–june 17, 2019 for the second technical review of the final environmental impact statement addendum for the Baffinland Mary River Project phase 2.	4
JWG/2022/FI29	Science review of the phase 2 addendum to the final environmental impact statement for the Baffinland Mary River Project.	4
JWG/2022/FI30	Science review of additional documents submitted june 18–august 29, 2019 for the final environmental impact statement addendum for the Baffinland Mary River Project phase 2.	4
JWG/2022/FI31	Science review of additional documents submitted October 8, 2019 – January 8, 2020 for the final environmental impact statement addendum for the Baffinland Mary River Project phase 2.	4
JWG/2022/FI32	Mary River Project Report_2020 Marine Mammal Survey	4
JWG/2022/FI33	Review of Transboundary impacts from a Greenland Titanium Mine	6
JWG/2022/FI34	Response to ESPOO Convention Reply on the Review of Transboundary impacts from a Greenland Titanium Mine	6
JWG/2022/FI35	Maps to support the recommendation of regional winter (March/April) surveys of the eastern part of the North Water. GINR.	6