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

1.0 Context

The Baffinland (BIM) Mary River Project is an operating open pit iron ore mine located on North Baffin Island in Nunavut. The mine site is connected to Milne Inlet Port via the Milne Inlet Tote Road and ore is transported to Europe via the Northern Shipping Route through Eclipse Sound, Pond Inlet, and Baffin Bay. The Southern Transportation Corridor via Steensby Port has not been constructed to date (see Baffinland 2018, DFO 2019a).

In December 2018 the Phase 2 Addendum was submitted to the Nunavut Impact Review Board (NIRB), which describes the activities associated with the second phase of the Project (an increase to a total of 12 Mtpa road/rail haulage and marine shipping through Milne Port) and provides an updated Effects Assessment. Throughout the technical review stage of the Phase 2 project, Fisheries and Oceans Canada's (DFO) Fish and Fish Habitat Protection Program (FFHPP; formerly Fisheries Protection Program) requested that DFO Science review and provide advice on the additional materials submitted by BIM to support BIM's conclusions in the Phase 2 Addendum to the Final Environmental Impact Statement (FEIS). The results of these reviews were presented to the NIRB during the first (April 2019) and second (June 2019) technical review meetings as well as in preparation for the November 2019 final hearings (DFO 2019a,b,c).

The objective of the current review is to assess whether the new supporting and supplementary materials (provided between October 8 to January 8, 2020) for the Phase 2 FEIS Addendum provides sufficient evidence to support BIM's conclusions regarding potential ecosystem impacts of an expanded Mary River Project on marine aquatic species and habitats (particularly as it relates to marine mammals and shipping). More specifically, the objectives are to:

1. assess the quality and adequacy of information presented, and determine if any relevant information is missing and if there are gaps in the analyses;
2. determine if appropriate methods were used to develop BIM's conclusions, and if the information presented supports those conclusions;
3. determine the appropriateness and adequacy of the proposed mitigation and monitoring measures;
4. if necessary, recommend additional or alternative mitigation and monitoring measures to reduce or avoid impacts to fish and fish habitat, including marine mammals, and;
5. if necessary, recommend additional information, studies, data collection, etc. that is required for DFO to complete its assessment.

This Science Response Report results from the Science Response Process held February 4, 2020 on the Science Review of Additional Documents Submitted October 8, 2019 – January 8, 2020 for the Final Environmental Impact Statement (FEIS) Addendum for the Baffinland Mary River Project Phase 2. Advice from this Science Response Report will be considered by FFHPP in the development of their final written submission to the NIRB due February 6, 2020.

2.0 Background

On October 5, 2018, BIM submitted an FEIS Addendum for Phase 2 of the project to the NIRB which includes an upgrade to port facilities in Milne Inlet (including a second ore dock to accommodate larger cape size vessels with deadweight tonnage (DWT) of 130,000–250,000 tonnes), construction of a North Railway, and increased shipping activities through Milne Inlet to accommodate the planned production increase up to 12 Mtpa. The proposed changes include icebreaking in the spring and fall to extend the existing shipping season. On October 12, 2018, BIM received its positive conformity decision from the NIRB initiating the NIRB's technical review process. DFO Science was asked by DFO FFHPP to review and provide science advice and subject matter expertise on the Phase 2 Addendum (DFO 2019a).

An estimated 176 ore carrier round trips (upper end of range) would occur per season, as well additional sailings for wet/dry resupply vessels. Shipping would occur seasonally within a window of approximately 135 days between July 1 and November 15, with each chartered vessel making one to three round trips per season. Ice breakers would also be operating, when conditions require, along the Northern Shipping Route and ice management vessels (tugs) would operate as required in the Milne Port/Inlet area.

Between April 8–10, 2019, the NIRB held the first Technical Review meeting with interveners to highlight concerns and information gaps contained within the FEIS impact assessment and/or resolve identified technical issues where the methodology, analysis, or conclusions presented by BIM were not supported by reviewers. The outcome of the Technical Review meeting was a series of commitments from BIM to provide additional supporting materials to address and resolve outstanding issues. As part of the technical review stage, DFO FFHPP requested that DFO Science review and provide advice on the FEIS Phase 2 Addendum and the additional supporting and supplementary materials submitted to DFO Science between May 13 and June 17, 2019 (DFO 2019b).

Between June 18–19, 2019, the NIRB held the second Technical Review meeting with interveners to highlight concerns and information gaps within the FEIS impact assessment, additional supporting documents, and/or resolve identified technical issues with the methodology, analysis, or conclusions presented by the Proponent which are not supported by the reviewers. The second Technical Review meeting resulted in BIM committing to providing new additional supporting materials as well as outstanding documents from the first technical meeting to address outstanding issues. Prior to the final public hearing that was scheduled for November 2–6, 2019, a number of documents were again provided to support the still outstanding issues (e.g., power analysis, ballast water) in early October. Following the postponement of the final public hearing BIM submitted an update on January 8, 2020. The NIRB has since announced a third technical review meeting for March 16–20, 2020. DFO FFHPP has requested that DFO Science review and provide advice on the FEIS Phase 2 Addendum additional supporting materials submitted to DFO Science between October 8, 2019 to January 8, 2020. FFHPP requested that DFO Science review the assessment of impacts to marine mammals and the marine environment in relation to shipping. The results of this review will be provided to FFHPP for consideration in the DFO Departmental final written submission of comments to the NIRB and discussed at the upcoming third Technical Review meeting.

3.0 Analysis and Response

The comments presented in this Science Response are related to the supporting and supplementary materials listed in Table 1. They were submitted by BIM to the NIRB between October 8, 2019 to January 8, 2020. This Science Response is part of a series of reviews conducted by DFO Science for the Mary River Project environmental assessment which should also be considered, as some of the comments here are related to past concerns or information deficiencies (DFO 2019a,b,c).

Table 1. List of additional supporting and supplementary documents reviewed by DFO Science.

Supporting and Supplementary Document	Science Response Section(s)
Golder's Technical Memorandum to Baffinland entitled "Power Analysis for Baffinland's Marine Environmental Effects Monitoring Program (MEEMP)" Tech. memo. 1663724-117.	3.1
Golder's Technical Memorandum to Baffinland entitled "Ballast Water Dispersion Modelling: Ballast Water Model Validation".Tech. memo. 1663724-154	3.2
Baffinland Final Written Comment Responses Phase 2 Proposal – Mary River Project; October 15, 2019 NIRB File No. 08MN053	3.2
Hemmera Technical Memorandum to Baffinland entitled "Review of Mary River Phase 2 Assessment Conclusions on the Effects of Icebreaking to Narwhal. October 15, 2019.	3.3
Technical Memo Analysis of 2018 Narwhal Tagging Data during Fall Shoulder Season, October 15, 2019, 1663724-163-TM-Rev0-12000	3.3
BIM Integration Report: Marine Mammals in Eclipse Sound, Milne Inlet and Pond Inlet. 31 March 2017. Report No. 1663724-006-R-Rev0	3.3
BIM. Phase 2 Proposal Updated Information Package. January 6, 2020	3.3

There were a number of gaps in the information provided and inconsistencies in the material presented in the Phase 2 Addendum. It was consequently difficult to fully assess some of BIM's analyses and, in some cases, their conclusions. Many of the comments and recommendations contained in past DFO Science reviews for the Mary River Project remain, or have become more relevant due to the significant proposed increase in vessel traffic and the proposed addition of an icebreaking component (DFO 2012a,b, DFO 2014a, DFO 2019a,b,c). An example of a deficiency is the design and execution of a comprehensive monitoring program (including indicators and thresholds) to identify impact and risk associated with the project and for future assessment (DFO 2019c). There are also still concerns around local stock depletions of marine mammals due to increased activity and noise, including cumulative noise periods for marine mammals and a lack of evidence that can be provided to support the claim that narwhal will tolerate or habituate to increased levels of vessel activity (DFO 2019c). The overarching uncertainties associated with the impact of ice-breaking on marine mammals is also a concern.

For the purpose of this DFO Science review icebreaking was defined as the use of an ice-breaker or vessel to break or move ice under any condition.

3.1 Power Analysis

BIM position

In response to DFO's (2019c) recommendation, BIM provided a Technical Memorandum (from Golder) entitled "*Power Analysis for Baffinland's Marine Environmental Effects Monitoring Program (MEEMP)*". BIM states that "*in general, the radial gradient (RG) design doesn't necessitate use of a reference site because transects cover a large spatial extent and sampling stations located at far distances from the source point ultimately serve as reference sites. For instance, one of the transects – the Coastal Transect (CT) – extends north along the eastern shore of Milne Inlet, outside of the predicted ZOI [zone of impact] of project activities*".

DFO Science's analysis and assessment

It is important for BIM to interpret "far distance" appropriately. The scale needs to be appropriate to the area of effect so that sampling occurs far enough away and at sufficient increments to allow detection between proximate areas and areas that are completely unaffected or experience a significantly lower impact (considering the effect size and statistical power) (see DFO 2019a).

Recommendation

- As part of adaptive management the appropriateness of the predicted zone of impact needs to be regularly examined to determine if the zone has appropriate extents (i.e., test the assumption and revise if needed).

BIM's position

BIM states in Section 2.0 – Methods (p. 4) that "*Results are presented in terms of the effect size required to achieve a power of 0.8, which is a common goal for power analyses. Details about how the power analyses were implemented for each collected dataset are described within each analysis section. All power analyses were performed in the statistical package R v.3.5.3 (R 2019) using the package emmeans (Length 2019)*".

DFO Science's analysis and assessment

The 0.8 power analysis threshold is a common goal and is in line with EC (2012) cited in this document. However EC (2012) also describes the purpose of an effect size: "*The purpose of defining an effect-size and power level is to determine if the sampling program is collecting sufficient information for decisions to be made. The statistical power of a comparison is a function of the sample size, the variability and the target difference set between areas. To determine the sample size for detecting a specific difference, some knowledge is needed about the statistical power level that is acceptable for the decision-making process and the variability of the population*" (p. 3–26). EC (2012) also suggests a number of critical effect sizes, such as the 10% effect size for fish condition, for monitoring of fishes, benthic invertebrates, and sediment.

DFO Science also explored the documentation related to the "emmeans" package (Length 2019) and was not able to determine the method for power analysis. The models may have been run using this package, so the results were used to produce plots of estimated statistical power, but it is misleading to say power analyses were conducted using the package.

Recommendation

- DFO Science recommends BIM clarify the use of emmeans (Length 2019) or other packages used for power analysis.

BIM's position

BIM states in Section 2.3 – Benthic Infauna (p. 5) that "*The design of the MEEMP benthic infauna sampling is based on a RG where the same replicates (stations) located along a distance gradient are re-sampled at specific time intervals (years). This designed is recommended by Environment Canada (2012) and advocated by Ellis and Schneider (1997) as an alternative to the BACI design*".

DFO Science's analysis and assessment

DFO Science accepts the use of a radial gradient design as an acceptable alternative to Before/After/Control/Impact (BACI). However, in applying a radial gradient design BIM needs to address DFO Science's previous comments about appropriate scale and adaptive monitoring. Specifically, the spatial scale of the radial gradient monitoring program needs to ensure that sampling occurs far enough away and at sufficient increments to allow detection between proximate areas and areas that are completely unaffected or experience a significantly lower impact (considering the target effect size and statistical power).

Recommendation

- As part of adaptive management the predicted zone of impact needs to be regularly examined to determine if the zone has appropriate extents. See also comments from DFO (2019c) with respect to monitoring and adaptive management.

BIM's position

BIM states in Section 2.3 – Benthic Infauna (p. 6) that "*A defined number of samples was drawn from a normal distribution that was based on the model and scenario, and these formed the simulated dataset*". Similarly, in Section 2.4 – Fish Length-weight (p. 6) that "*For each observation in the simulated data set, the weight value was drawn from a normal distribution where the mean was the predicted value calculated using the regression equation for that observation, and the standard deviation was standard deviation of the 2017 model residuals*".

DFO Science's analysis and assessment

DFO Science questions whether any validation was conducted by BIM to determine that a normal distribution was an appropriate distribution for the data.

Recommendation

- When analyzing data BIM should conduct and present their validation in order to determine if a normal distribution is appropriate. This information is required for DFO Science to conduct a proper assessment of monitoring results.

BIM's position

BIM states in Section 3.1 – Sediment – Percent Fines (p. 7) that "*The estimated power for the Coastal Transect was 0 at the observed effect size and remained very low (0 to 0.4) at nearly all simulated effect sizes up to 4 SD, with the exception of a few of the distances in 2014 and 2018 (Figure 1). The estimated power for the Northern Transect was 0 at the observed effect size, but power of 0.8 was achieved at effect sizes of approximately 3 to 4 SD at distances of 0 and 500* *m. At the East and West transects, a power of 0.8 was general achieved at effect sizes of 1 to 4 SD for the 0, 500, and 1000 m distances, but power was very low (< 0.4) at all effect sizes at 1500 and 4000 m"*.

DFO Science's analysis and assessment

DFO Science found that, although interesting, this does not really provide results from the context of monitoring.

Recommendation

- DFO Science requests BIM determine what effect size is expected to have an ecological impact (this is definitely taxon-specific, but the threshold could be based on the most sensitive taxa). What is the power to detect that effect size? Is this effect size in agreement with EC (2012)?

BIM's position

BIM presents *Table 2: Estimated Power under Observed Effect Size for Sediment Per Cent Fines* (p. 7). In Section 3.2 Sediment – Iron Content (p. 9) BIM presents *Table 3: Estimated Power under Observed Effect Size for Sediment Iron Content.* BIM also states that "*Overall, the results suggest reasonable ability to detect significant differences in iron content at the West and East transects, at effect sizes as low as approximately 1 SD*". In Section 3.2 Sediment – Iron Content (p.10) BIM presents *Figure 2: Estimated Power to Detect Significant Differences in Sediment Iron Content between 2018 and Previous Sampling Years (2014-2017) for Varying Effect Sizes and Distances from Transect Origin*.

DFO Science's analysis and assessment

DFO Science is concerned that only three tests exceeded the 0.8 power threshold (see bold numbers in BIM's Table 2). These included the 2016 West Transect at 0 m, 2015 East Transect at 0 m, and 2017 East Transect at 0 m. DFO Science disagrees with BIM's statement that they have reasonable ability to detect significant differences when only 5 out of 12 for the West Transect and 7 out of 12 for the East exceed the 0.8 power threshold. Furthermore, DFO Science notes that only 12 of the 52 data points presented in Table 3 met the 0.8 power threshold (see bold numbers in BIM's Table 3). Of particular note, the Coastal Transect that BIM used as an example in the earlier discussion about the gradient design never met the 0.8 threshold and only 4 of the 16 values presented were greater than 0.2. DFO Science notes that the colour scheme used for this figure is for distance and not sample size, which contradicts text in the body of the report and the figure caption.

Recommendation

- DFO Science requests BIM justify how three tests that exceed the 0.8 power can be used to detect change overall, and where necessary re-design their sampling program for MEEMP. When a statistical test does not have sufficient power to detect a difference, it is misleading to conclude that there is no difference; the proper conclusion is that the test was unable to detect a difference.

BIM's position

In Section 3.4 – Benthic Infauna (p. 11) BIM states "*The lack of statistical power in benthic infauna data collected is attributed to the sample collection methods used. Benthic infauna samples from 2010 to 2018 were collected using a Petit Ponar grab sampler, which has a small opening area (15 x 15 cm) and is normally used in a freshwater environment. In the marine* *environment, sampling with the Petit Ponar grab results in high variability of area and volumes sampled and, consequently, high variability in density and diversity of detected organisms. Use of sampling equipment that is more adequate for the marine environment, such as Van Veen or Ponar grabs, may increase the statistical power of the analysis*". In Section 4.0 – Discussion (p. 16), BIM states that "*These results have prompted a change in the benthic infauna sampling design from 5 stations per transect to 15 stations per transect, as per Baffinland's outlined commitment in Table 1*".

DFO Science's analysis and assessment

DFO Science questions why a Petit Ponar sampler was used in the first place, but notes that this is a great example of where BIM implemented the adaptive management process (i.e., collected, analyzed and interpreted the data and then adjusted their sample design to be more effective).

Recommendation

- The same adaptive management process model should be followed for all monitoring components that currently do not meet the power threshold to detect a significant, meaningful effect size (see also DFO [2019a,c] with respect to monitoring).

BIM's position

In Section 4.0 – Discussion (p. 16), BIM states that "*Fish length-weight regressions had sufficient statistical power (>0.8) to detect a 7% increase in weight-length slope for Arctic Char, and a 15% increase in slope for both Fourhorn Sculpin and Shorthorn Sculpin relative to 2017 data. These effects sizes are well within the recommendations provided by Environment Canada (2012)*".

DFO Science's analysis and assessment

DFO Science cautions the recommended effect size in the cited EC (2012) document is 10% for fish condition (weight-length relationship). The current program meets the target effect size for Arctic Char (*Salvelinus alpinus*) but not the sculpin species.

Recommendation

- DFO Science recommends BIM re-examine the target effect size for sculpin species and ensure monitoring programs comply with EC (2012).

3.2 Environmental effects of ballast water and vessel biofouling

BIM's position

In the Golder Ballast Water dispersal Technical report, "*Golder performed the tasks described…1) validated the ballast water dispersion model to observed 2018 oceanographic data and updated the model with improved wind data, estimates of discharge from Phillips Creek, and more spatially resolved heat-flux inputs (i.e., air temperature and humidity)*" (p. 1).

DFO Science's analysis and assessment

DFO Science is satisfied that available quantitative metrics were included in the model validation section of the report as requested. However, the hydrodynamic model does not perform well close to Milne Port. The model overestimates the current speed and underestimates the stratification of the water column, which would result in overestimating the dispersion of ballast water close to the discharge location.

DFO Science notes that a dispersion model requires reasonable representation of the currents (speed and direction). As noted during two teleconference calls, on September 6 and October 28, 2019 (and acknowledged in the Golder Ballast Water dispersal Technical report), specialized instrumentation is required to accurately measure currents, in particular direction, at high latitudes. BIM acknowledges that precautions were not taken to ensure accurate measurements of the currents and an estimate of the uncertainty in the current direction is not provided. As a result, the model's ability to simulate ballast water dispersion is inconclusive.

Recommendations

- DFO Science recommends that BIM continue collecting relevant and accurate data (e.g., tides, currents) and use data assimilation to improve the model in the future (Moore et al. 2019).
- DFO Science recommends collecting accurate current observations utilizing equipment designed to collect accurate direction measurements near the magnetic poles (Hamilton 2001). These observations should then be used to validate the model and assimilate if necessary (Moore et al. 2019).
- DFO Science also recommends that BIM apply this revised model to the Phase 2 discharge scenario and any future extensions of dispersion modelling with particle dispersion/risk assessment for assessing the potential spread of AIS by ballast water (e.g., see Goldsmit et al. 2019a) as detailed below.
- A requirement for regular updating of the model as new data becomes available should be added as a Project Term and Condition.

BIM's position

The report states on pg. 26, that "*Based on the conclusions and under the current ballast water disposal methods, Golder believes that re-running the Phase 2 model is not warranted as the anticipated Phase 2 conditions are not expected to alter the ballast water dispersion results*". During the October 28, 2019 teleconference with BIM, BIM reaffirmed that shipping under Phase 2 scenario is not expected to alter the ballast water dispersion model results (176 vessels/yr. vs. 71 used in the model).

DFO Science's analysis and assessment

In the report (p. 27), BIM states that "*Estimates of ballast water discharge volumes and characteristics (i.e., salinity and temperature) were based on available 2018 ballast water discharge records*" (a total of 71 vessels). However, shipping under the Phase 2 scenario is expected to be approximately 2.5 times that amount for a total of 176 ore carriers (see table below from TSD 21, section 3.1).

Table 3.1: Annual Predicted Ballast Water Discharge at Milne Port for Phase 2 Proposal

Port	Year/ Phase	Number of Discharges (per year)	Total Ballast Water Discharged per year (metric tonnes)	Corrected Foreign Exchange (x 0.1) (metric tonnes)
Milne[1]	2012	53	662,000	66,200
Milne	Phase 2	176	3,023,750	302,375

[1] From Chan et al. 2012 and SEM 2013

Section 3.2 of this report provides BIMs estimates for the amount of ballast water discharged in 2018, with the assumption that each of the 71 vessels discharged 24,000 m^3 over a 1-day period, for a total of 1,740,000 m^3 (metric tonnes) for 2018.

DFO Science questions what the expected Phase 2 conditions will be and how they will compare to the statistics used from 2018? BIMs conclusion to not re-run the model with the expected Phase 2 conditions is an inappropriate extrapolation/application from the present study. Re-running the simulation with the expected Phase 2 conditions is warranted given the uncertainty in the present results, and the expected increase in shipping and ballast volume.

Recommendations

- DFO Science recommends BIM re-run the model simulations with the expected Phase 2 discharge levels (≥12 Mtpa of ore) given the uncertainty in the present results and the expected substantial increase in shipping and ballast discharge volume. Without this information DFO Science cannot conduct a proper assessment.
- DFO Science recommends that BIM apply the revised model (i.e., validated with more accurate oceanographic data) to the Phase 2 shipping scenario in the future. The model should consider the cumulative effect of discharging ballast related to the project (i.e., include all vessels associated with the project that will be discharging ballast).
- DFO Science recommends regular updates to the model as new oceanographic data are collected and/or if future ballast discharge volumes/ characteristics change (e.g., if vessels do not conduct ballast exchange in the future).

BIM's position

BIM reports ballast water dispersion results as minimum dispersion over the three-month simulation. "*"Figure 24 presents the minimum ballast water dilution at each horizontal location over the 3-month simulation…. The larger the dilution factor the lower the concentration value and so the minimum dilution is a proxy for the highest ballast water concentration. In the immediate vicinity of the discharge point at the Milne Port Ore Dock the ballast water is diluted by 1 to 50 times…*" (p. 23).

DFO Science's analysis and assessment

DFO Science has concerns that the hydrodynamic model does not perform well close to Milne Port. The model overestimates the current speed and underestimates the stratification of the water column, which would result in overestimating the dispersion of ballast water close to the discharge location. A dispersion model requires reasonable representation of the currents (speed and direction). As noted during the teleconference on September 6, 2019 (and acknowledged in the report), specialized instrumentation is required to accurately measure currents (in particular, direction) at high latitudes. The report author acknowledges that precautions were not taken to ensure accurate measurements of the currents and an estimate of the uncertainty in the current direction is not provided. Thus the model's ability to simulate ballast water dispersion is inconclusive (however, it is useful in identifying gaps and inadequacies with data collected to date). DFO Science questions if, for example, the reported dilution of 1 to 50 times at the Milne Port Ore Dock is at the end of the 3-month simulation, or represents the minimum dilution (or maximum concentration) predicted at any one time over the 3 month simulation period? A time-series of concentration for a selection of locations could be used to see how this metric changes throughout the simulation. A minimum dispersion of 1 (maximum concentration) for an extended period of time at a given location could have adverse effects on the marine ecosystem. This was requested by DFO Science at the September 6, 2019 teleconference with BIM.

DFO Science acknowledges the presented model results show a low magnitude of change in salinity and temperature. However, DFO Science has low confidence in the model output due to a lack of adequate data for validation (as detailed above), but also because only the results at the end of a 3-month shipping season are presented. Shorter term impacts are likely to occur when there are higher concentrations discharged over short time frames (i.e., discharge 'event'), the effects of which cannot be evaluated without seeing the results of the entire 3-month simulation.

DFO Science notes that the most biologically relevant model results are the extent of the plume and what that may mean for the spread of organisms, including non-indigenous species (NIS) and aquatic invasive species (AIS), that could be entrained in ballast (i.e., simulated particles). The dispersion of ballast water, with or without simulated particles (i.e., proxy NIS/AIS), is mainly driven by advection (currents). Thus one would expect a similar dispersion pattern if the model were run with simulated particles (e.g., highest concentration of particles near the port). However, a full risk assessment (e.g., see Stewart et al. 2015 and Goldsmit et al. 2019a) would need to be conducted to consider the biological impact(s).

Recommendation

- DFO Science recommends reporting simulated concentration/dilution of ballast water as a time-series over the three-month simulation period.
- DFO Science recommends collection of accurate current data for model validation and assimilation, if necessary (see Hamilton 2001).
- DFO Science recommends regular model updates as new data are available and/or if future ballast volumes/characteristics change.
- DFO Science recommends including simulated particles in future model runs to conduct a more comprehensive assessment of biological and ecological impacts of ballast discharge by project vessels by adapting methods outlined in Stewart et al. (2015) and Goldsmit et al. (2019a). DFO Science notes that future collection of robust and representative data on biota in ballast tanks (see DFO 2019b) would enable BIM to refine particle dispersion models by providing more accurate information on overall densities of organisms entrained in ballast water and proportions that are NIS/AIS.

BIM's position

BIM states that "*in the immediate vicinity of the discharge point at the Milne Port Ore Dock*" (p. 23) and that "*The ballast water Box Model Analysis addresses the potential incremental increase and/or decrease in ambient water temperature and salinity as a result of ballast water discharge at Milne Port*" (p. 25).

DFO analysis and assessment

Based on the information provided in the report, DFO Science understands that ballast water discharge is occurring at the Milne Port dock and anchorages. DFO Science requires clarification if discharge is also occurring at the Ragged Island anchorages, and how this is incorporated into the model.

Recommendation

- DFO Science requires BIM to clarify the discharge locations (GPS coordinates where each vessel discharges) and ensure that modelling reflects these release points at all locations (DFO 2019a,b).

BIM's position

All vessels calling to Milne Port are required to operate in accordance with Transport Canada's Ballast Water Control and Management Regulations (Regulations; SOR/2011-237) pursuant to the *Canada Shipping Act*, 2001 (S.C. 2001, c. 26) and the International Maritime Organization's International Convention for the Control and Management of Ship's Ballast Water and Sediment (IMO 2017). BIM wishes to emphasize that current ballast water sampling by Baffinland remains a voluntary measure that exceeds federal and international guidelines for ballast water management.

BIM has put into place additional measures that exceed regulatory and industry standards to include the requirement for all vessels calling on Milne Port that treat their ballast under the D-2 Standard to also perform a ballast water exchange prior to treatment. This practice will continue until BIM provides updated ballast water dispersion modelling that more accurately reflects the spectrum of salinity and temperature that can be expected to be discharged at Milne Port. The Ballast Water Management Plan will be updated post-Phase 2 Proposal approval to reflect the commitments described above. (BIM response to DFO final submission ID#: DFO 3.10.2).

DFO Science's analysis and assessment

DFO Science commends BIM on their decision to implement DFO Science's recommended measures that will require all vessels calling on Milne Port that treat their ballast under the D-2 Standard to also perform a ballast water exchange prior to treatment. DFO Science also generally agrees with the new revised wording that has been provided by BIM as a result of discussions on October 25 and 28, 2019. However, DFO Science requests clarification on the order with which exchange and treatment will be carried out as this has implications for efficacy of these ballast management measures.

DFO Science also requests clarification on how BIM intends to verify compliance with D-2 standards for vessels that will be calling on Milne Port. With whom will accountability for meeting D-2 standards lie and what will trigger BIM to discontinue exchange + treatment? Verification of compliance will be important at least until reliability has been demonstrated under a wide range of environmental conditions.

DFO Science requests clarification about BIM requirements for ballast water management by vessels with domestic (Canadian) last port-of-call, which are not regulated under the current *Canada Shipping Act*. It is not clear if these vessels are currently managing their ballast water using ballast water exchange following depth and distance from shore requirements in the *Canada Shipping Act*, or following science-based recommendations by DFO Science regarding lower ecological risk options for alternate ballast water exchange zones (as per Stewart et al. 2015 and Goldsmit et al. 2019a).

Recommendation

- DFO Science recommends that BIM require ballast water management according to D-1 and D-2 regulations for all vessels, irrespective of last port-of-call (both domestic and international trips).
- DFO Science recommends that treatment is applied during ballast uptake at the source port, and a second time during the process of ballast water exchange. The exchange should be conducted in accordance with Canada's Ballast Water Regulations (distance from shore and depth requirements). If the use of treatment during flow-through exchange would result in the release of active substances to the sea without neutralization, then the exchange should not be conducted.
- DFO Science recommends that BIM evaluate compliance of all project vessels through indicative analysis. Contingency measures should be developed in case of noncompliance. In addition, DFO Science recommends representative sampling with detailed biological analysis, including taxonomic identification, be conducted (as detailed below in DFO Science's recommendations on BIM response to DFO final submission ID#: DFO 3.10.3). Representative sampling, together with comprehensive indicative testing results, will inform risk assessments, enabling Baffinland to evaluate efficacy of different ballast management measures in minimizing the risk of introducing AIS.

BIM's position

BIM remains committed to continued temperature and salinity test sampling of one randomly selected ballast water tank for all vessels calling to Milne Port, and biological sampling in the marine receiving environment to monitor for non-native species in Milne Port and at Ragged Island. The Ballast Water Management Plan will be updated post-Phase 2 Proposal approval to reflect the commitments described above. (BIM response to DFO final submission ID#: DFO 3.10.3).

BIM is continuing to discuss a resolution to TC-02 regarding the sampling of multiple ballast water tanks in circumstances where ballast water is taken on at multiple locations. Baffinland will mirror any commitment to TC here for DFO (BIM response October 31, 2019 to DFO final submission ID#: DFO 3.10.3).

BIM will implement a pilot ballast water biological monitoring program for ships calling on Milne Port. This program will be designed to reflect a more appropriately scoped form of a ballast water sampling protocol provided by DFO to Baffinland in 2017. This program will include sampling from one ballast tank on a total of five vessels per shipping season. (BIM response October 31, 2019 to DFO final submission ID#: DFO 3.10.3).

DFO Science's analysis and assessment

DFO Science does not support sampling only one tank/vessel since compliance monitoring on the Great Lakes indicates that when noncompliance occurs, it is typically only one or two tanks per vessel that are noncompliant. Tanks within a single ship are rarely managed identically, with individual tanks having ballast sourced from different locations or being exchanged at different positional coordinates. Sampling should be conducted in a more comprehensive manner to improve the probability of detecting non-compliant tanks across a variable population of tanks.

While DFO Science recognizes BIM's plan to initiate biological sampling of ballast as a positive step, sampling 5 out of the 176 expected vessels/year is not expected to be representative given the range of ballast management measures (exchange, exchange + treatment, different types of treatment), source ports, exchange locations, and transit times, all of which are known to affect quantity and types of biota in tanks. DFO Science would like clarification on how BIM decided on the sample size of 5 for their biological ballast sampling program and how they expect this level of sampling to provide reliable information for use in future risk assessments as well as accurate verification of overall level of compliance (efficacy) for ballast management of vessels calling on Milne Port.

Recommendation

- DFO Science reiterates the recommendation (previously stated in DFO 2019b) to sample all tanks on all vessels (as currently practiced in the Great Lakes) to verify salinity as an indication of compliance with regulation D-1. If sampling all tanks is not possible due to access limitations, then fewer tanks could be sampled, such that one tank from each pair or set of tanks having identical ballast history (e.g. simultaneously managed as port/starboard pair) is sampled.
- DFO Science recommends that BIM conduct representative biological sampling of all vessels subject to D-1 and D-2 standards (as a matter of due diligence and following the same logic stated above for verifying salinity). Below, we provide similar guidance and references related to sampling of vessels subject to D-2 standards. Recognizing that parties are still in the experience-building phase with the International Maritime Organization (IMO) ballast water convention, sampling methodology should be updated as improved testing methods are developed and recommended by DFO, Transport Canada (TC), or IMO.
- DFO Science's recommendations for D-2 sampling (based in ICES and IMO guidance documents and DFO Science's own representative testing of vessels across Canada) should be conducted through the discharge sampling port on the main ballast line, not from tanks. DFO Science recommends sampling a minimum of 3 cubic meters of water for zooplankton (> 50 um size class) and 10 L for phytoplankton (10-50 um size class) and bacteria. BIM should also be measuring Total Residual Oxidant (TRO) in the discharge to evaluate compliance with limits set by the IMO for individual treatment systems (to confirm that neutralization has been applied, as required).

BIM's position

BIM indicated that they cannot implement a biological fouling program due to the location of biological growth on vessels, the need to use divers, and the associated requirements of 'lockout' during collections. BIM has also indicated that they collect biological AIS data for evaluating hull biofouling via high definition remote-operated vehicle (ROV) video surveys of the hulls for a subset of vessels. They have indicated that the cost/insurances for collection of organisms with divers is not warranted given that they have a high definition ROV program in place. (BIM response October 31, 2019 to DFO final submission ID#: DFO 3.10.4).

DFO Science's analysis and assessment

DFO Science is aware of the required lockout safety procedures when diving around commercial vessels and has successfully carried out this type of sampling of cargo vessels with divers (e.g., Churchill Port, see Chan et al. (2015)). DFO Science therefore requests clarification as to why lockout during sampling for biofouling with divers is not possible on BIM's ore carriers, even though they spend extended periods at anchor at both Ragged Island and Milne Port.

DFO Science would like confirmation of: 1) annual proportions of vessels surveyed to date, 2) the proportion BIM proposes to survey in the future, 3) the process by which vessels will be selected for sampling (e.g., random, or using a risk-based approach?), 4) whether niche areas (e.g., sea chests, propellers, anchor chains) of vessels are/will be examined, 5) the number of organisms identified to species level in past surveys, and 6) how BIM proposes to assess identities and quantities of different biofouling organisms, including NIS and AIS, using video-based approaches, given that a number of these taxa require dissection or microscopic methods to distinguish one species from another.

Recommendation

- Given the importance of biofouling in the global spread of AIS and NIS, DFO Science recommends the development of a biofouling sampling program prior to project approval. This plan should include an assessment of percent cover and physical collection of organisms in a representative, standardized and comprehensive manner (including both hull and niche areas) that will allow for identification of non-native species that may be transported through project shipping. This information is needed to assess effectiveness of biofouling management measures and level of risk, and to conduct adaptive management for mitigation of the spread of NIS and AIS (IMO 2011).
- Recognizing the above-described challenges of using divers to survey vessels, DFO Science recommends BIM develop risk-based approaches to select a subset of vessels for dive-based surveys. A risk-based approach is used for vessels entering Australia based on an online screening protocol called "Vessel Check". "Vessel Check" is a voluntary, self-assessment risk-based tool that is based on the IMO Biofouling Guidelines and provides vessels with a biofouling related biosecurity risk rating (IMO 2011). DFO Science recommends that BIM consider adaptation of this type of tool for vessels calling on Milne Port.

BIM's position

Identification of high-risk biological species or groupings of species of concern is the responsibility of DFO. BIM will continue to share all results of the Marine Environment Effects Monitoring Program and AIS Monitoring Program with DFO to assist in this regard. (BIM response to DFO final submission ID#: DFO 3.10.5 recommendation that BIM conduct "*An assessment of potential biological and ecological effects of ballast discharge and identification of the high risk species or groupings of species of concern. These species may include, but not be limited to any NIS/AIS that have been detected in the course of past AIS/MEEMP monitoring, and should be updated in the event that new NIS/AIS are detected in future monitoring*").

DFO Science's analysis and assessment

DFO Science is looking for a commitment from BIM to conduct risk assessments to assess the potential for spread/ecological impacts of NIS within the project area, identify (i.e., determine or flag) high risk NIS/AIS, and evaluate level of risk associated with species that could be, or have already been, introduced to Milne Inlet as a result of project shipping activities. This is a proactive approach that can help in determining geographic locations where monitoring for NIS/AIS should be focused and if there should be more rigorous surveillance for particular species with a high risk for introduction. While DFO is already doing some of this type of work in the Arctic, it is BIM's responsibility to obtain information on what types of organisms they could potentially introduce through project shipping activities, and to conduct risk assessments to determine which of those species may be of higher risk for introduction/impact. This information will enable BIM to determine if certain species should be more intensively screened/monitored for, both on vessels, in ballast and in the receiving environment (e.g., through use of genetic methods such as qPCR for target species with eDNA). This information can also inform development of species-specific early response plans that should accompany a more general rapid response plan. Species-specific response plans can be developed and tailored based on aspects of an organism's life history and knowledge of eradication or control measures that have been successful for that species or similar species in other locations.

Recommendation

- DFO Science recommends combined use of complementary risk assessment approaches (broad ecological, pathway and species-specific; see Drolet et al. 2016, Goldsmit et al. 2018, Goldsmit et al. 2019a,b) to assess potential for spread/ecological impacts of NIS within the project area to identify (i.e., flag) high risk NIS and evaluate level of risk associated with species that could be, or have already been, introduced to Milne Inlet as a result of project shipping activities. A combined approach is expected to be more comprehensive and robust (e.g., Goldsmit et al. 2019b).

BIM's position

In BIM's March 2019 response to Technical Comment DFO 3.8.2, Baffinland has committed to the following: "*Should it be confirmed that an AIS has become established in the Project area and that this introduction was a direct result of Baffinland shipping operations, Baffinland is committed to working with DFO to develop management actions for control of the AIS in accordance with DFO's Canadian Action Plan to Address the Threat of AIS. The level of intervention would correspond proportionally to the level of threat of the AIS"*. It is also noted that Baffinland's management of AIS is focused on prevention through regular ship inspections and on-board ballast water testing (as outlined in Baffinland's Ballast Water Management Plan) and through comprehensive AIS monitoring in the marine receiving environment as outlined in the Marine Environment Effects Monitoring Program and AIS Monitoring Program Annual Reports (BIM response to DFO final submission ID#:DFO 3.10.5 recommendation that: "*An early response plan (similar to an oil spill response plan) be developed with applicable regulators and local communities so that, should an NIS/AIS be detected, significant environmental effects or major change to species composition could be avoided*").

DFO Science's analysis and assessment

DFO Science cannot evaluate if response/mitigation measures will be effective if there is no plan in place before the project is approved (this was requested in both technical meetings and in DFO 2019b). Working with DFO to figure out a plan after something is released will cause unnecessary delays and increase the risk for an NIS to spread and establish after introduction. It is the responsibility of BIM to develop a plan incorporating project-specific procedures; this could be based on the framework previously provided by DFO (DFO 2019b).

DFO Science has noted concerns that the ballast testing and hull sampling programs are not sufficiently robust to conduct risk assessments that could inform strategies to improve preventative measures (e.g., determining efficacy of various treatment systems or detecting presence of unwanted species in arriving ships; see above DFO Science recommendations regarding BIM responses to 3.10.3 and 3.10.4). DFO Science further notes that monitoring for AIS in the receiving environment, no matter how comprehensive, is not a prevention strategy, which requires procedures that prevent introduction in the first place, and usually involves risk assessment to identify high risk vectors and pathways and strategies to manage them (e.g., use of ballast treatment + exchange is a prevention strategy). Monitoring in the environment only facilitates early detection and rapid response, which depending on the species and situation may allow for control, eradication or adaptation to the presence of the new organism (e.g., Drolet et al. 2014).

Recommendation

- DFO Science recommends that BIM develop a management and mitigation plan with a clear sequence of procedures to be followed should the introduction and/or establishment of a non-indigenous species occur. Due to the need to act quickly in response to such an event, DFO Science recommends that a rapid response framework be developed prior to any Phase 2 project approval.
- DFO Science further recommends the development of taxa-specific response plans for high risk species or groups of species identified through species level risk assessments as detailed in our 3.10.5 recommendations (above).
- DFO Science recommends BIM utilize the existing framework developed by DFO as a basis for developing a general response plan (Locke et al. 2010). Other examples to consider include the Emergency Prevention and response Plan for Viral Hemorragic Septicemia by the US Parks Service and the Grand Portage Band of Lake Superior Chippewa, and the policy framework by the International Joint Commission's Aquatic Invasive Species Rapid Response Policy Framework Work Group.

3.3 Marine Mammals

BIM's position

BIM states that "*Results from the 2014-2017 Bruce Head shore-based Monitoring Program indicate that the relative abundance of narwhal in the Bruce Head area has remained relatively constant over the four years of sampling, despite the relative increase in shipping over this period*" (Hemmera Memorandum to BIM October 15, 2019, p. 9).

DFO Science's analysis and assessment

DFO Science questions the power to detect changes in relative abundance based on the shore-based observations. The shore-based program was designed to monitor the behaviour and group structure of narwhals in the presence/absence of ships, as well as their direct reaction to ships. This program was not designed to estimate absolute abundance because it was not designed as a systematic survey with coverage of the entire summer area of the Eclipse Sound stock. In addition, in the BIM integration report 1663724-006-R-RevA (Table 1; p. ii), there is a clear statement regarding the results of the shore-based monitoring that "*Results are inconclusive because of the high spatial and temporal variability in abundance and distribution of narwhal. Some of the highest abundances of narwhals were observed in conjunction with* *some large vessel transits. At other times the narwhals appear to have left Milne Inlet, but the causal link to vessel transits is unclear*".

Recommendation

- DFO Science recommends that BIM provide more information on how the relative abundances were calculated and how the power to detect change was assessed.

BIM's position

In the Hemmera memorandum to BIM it states: "*Aerial surveys were conducted along the Northern Shipping Route in 2006, 2007, 2008, 2013, 2014, and 2015 to evaluate marine mammal abundance and distribution in this region during the open-water season (Golder 2018, TSD24). Surveys conducted between 2006 and 2014 represented baseline conditions, while surveys conducted post-2015 are intended to represent post-Project conditions*" (October 15, 2019, p. 10).

DFO Science's analysis and assessment

DFO Science is concerned with the use of some of the aerial surveys to estimate the abundance of narwhals in Eclipse Sound. The 2013-2015 aerial surveys were not designed to assess abundance but rather to detect changes in overall spatiotemporal distribution patterns of narwhals in response to large vessel traffic. Similarly to BIM, DFO Science has noted problems with the data collected during these surveys makes them not compatible with the estimation of abundance such as a high proportion of sighting with missing distances (Matthews et al. 2019, BIM 1663724-002-R-Rev0).

As stated in p. 90 of Appendix 8A-2 Marine Mammal Baseline of Volume 8 of the Final Environmental Impact Statement the 2006-2007-2008 surveys: "*The survey objectives were to document the daily and seasonal distribution of narwhal and other marine mammals summering in the area, and to attempt to document the responses of narwhal to ship movements to the Milne Inlet Port Site*". Similarly, these surveys were not designed to estimate abundance. Specifically, the report for the 2007 and 2008 surveys only provide densities of narwhal without any measure of variation (coefficient of variation or confidence intervals).

Aerial surveys tend to have large confidence intervals that make detection of any changes in abundance very difficult. Therefore DFO Science disagrees with BIM's ability to detect significant adverse changes to the Eclipse Sound narwhal stock. For example, the confidence intervals for the survey on August 15, 2016 are from 6,449 to 104,339 (coefficient of variation of 56.58%) and on August 21, 2016, the confidence interval is from 7,245 to 23,166 (coefficient of variation of 15.93%) (Table 8; 2016 Marine Mammal Aerial Photographic Survey – Milne Inlet and Eclipse Sound. 2 Feb. 2018, BIM 1663724-036-R-Rev0).

Recommendation

- DFO Science recommends BIM conduct a power analysis of the aerial survey data to demonstrate the sample size needed to detect a change if one were to occur.

BIM's position

As stated in the Hemmera memorandum to BIM: *"Narwhal tagging studies were undertaken in 2017 and 2018, in collaboration with DFO, to investigate narwhal behavioural response to shipping activities (i.e., during open-water conditions) along the Northern Shipping Route in Milne Inlet. Study results provide evidence of behavioural disturbance in the presence of large* *vessels (Golder 2018a)[…] However, there is also some indication in study results for the potential of narwhals to habituate to vessel presence, as suggested by the following:*

- *Temporal changes in distance between narwhal and vessels decreased at close ranges over study period (i.e., the distance between narwhal and vessels decreased from a mean of 7.6km to 5.6km over the course of the study)*
- *Narwhal crossed vessel track shortly before and shortly after vessel passage (min 4 minutes).*

While monitoring programs have been ongoing for multiple years, it should also be acknowledged that the findings presented above are based on only two years of tagging to date, such that knowledge about the balance between the capacity of narwhal to endure disturbance versus the benefit of being in this preferred habitat is limited. Again, this can be addressed through continued monitoring, including tagging studies over the long-term" (Hemmera memorandum to BIM October 15, 2019, p 22).

"Preliminary tagging data of two narwhal during fall 2018 indicate that neither tagged narwhal showed "freeze" responses, abandonment of the Regional Study Area, or large scale displacement behaviour when exposed to icebreaker noise and close icebreaker or ship approaches (Golder 2019 pers. comm.). Rather, narwhal response to Project vessels appear to be localized, small-scale changes in behaviour (e.g., swimming speed, travel direction), which is aligned with what is presented in the IOA [Icebreaking Operation Assessment]" (Hemmera memorandum to BIM, October 15, 2019, p. 10).

DFO Science's analysis and assessment

As stated by Hemmera memorandum to Baffinland (Section 8.1, p. 8) "*In addition, there are perceptions that shipping is causing shifts in narwhal abundance and distribution in the RSA. This concern was particularly amplified in 2018, where narwhal numbers in the RSA appeared to be at record lows and where Project-related icebreaking was introduced for the first time during the spring season*", 2018 was a year when narwhal numbers were low, indicating that most Eclipse Sound narwhals spent their summer in a different summering location than Eclipse Sound. The results from the two female narwhals equipped with satellite tags in Eclipse Sound that summer cannot be used to generalize to the entire Eclipse Sound stock, as narwhals are likely to show a range of reactions to disturbance. In a review modelling exercise of marine megafauna tagging studies, Sequeira et al. (2019) suggested sample sizes of more than 100 individuals are required to assess anthropogenic impacts on animal movement..

DFO Science notes and supports the suggestion provided in the Hemmera report to BIM to change the level of magnitude of masking from 1 to 2, given that relatively large areas of the RSA will experience underwater noise levels capable of masking from icebreaking (e.g., > 90% acoustic masking is predicted within ~25 km from the sound source for burst pulse calls) and for periods of ~6 hours per day (depending on icebreaking activity/speed).

Recommendation

- DFO Science recommends that BIM revise their conclusion from the 2018 tagging study due to the limited number of narwhals (i.e., data) considered in the study.
- We also recommend multiple lines of evidence instead of relying only on tagging (e.g., acoustic, aerial surveys, and land-based observations). The development of early warning indicators should be considered as part of the multiple lines of evidence approach.

BIM's position

BIM states that *"…it is still unknown whether continued exposure to shipping and icebreaking operations over time will result in habituation (i.e., a decrease in response to stimuli despite continual exposure) or whether narwhal will experience increased stress levels (because they are unwilling to abandon the area), with potential fitness consequences. Such questions can be addressed through the long-term monitoring programs proposed by Baffinland*" (Hemmera memorandum to BIM, October 15, 2019, p. 12). However, empirical information on narwhal usage and response to vessels at the spring floe edge is not available, nor were the potential effects in this area, at this time, explicitly monitored. It is acknowledged that the floe edge was considered in acoustic modelling scenarios (see IOA Section 5.3.2).

DFO Science's analysis and assessment

DFO Science agrees with the statement in the Hemmera memorandum to BIM (October 15, 2019) that it is "*unknown whether continued exposure to shipping and icebreaking operations over time will result in habituation (i.e., a decrease in response to stimuli despite continual exposure) or whether narwhal will experience increased stress levels (because they are unwilling to abandon the area), with potential fitness consequences"*. DFO Science also agrees with the statement that the spring floe edge use by narwhal is unknown.

Recommendation

- Project Condition (PC) #109 states that "*The marine mammals survey shall be designed to address effects during the shipping seasons, and include locations in Hudson Strait and Foxe Basin, Milne Inlet, Eclipse Sound and Pond Inlet. The survey shall continue over a sufficiently lengthy period to determine the extent to which habituation occurs for narwhal, beluga, bowhead and walrus*" (BIM Marine Monitoring Plan, BAF-PH1-830-P16-0046, June 10, 2019, p. 13). DFO Science recommends BIM design a long-term monitoring plan that uses a multiple line of evidence (e.g., acoustic, aerial surveys, satellite tagging, and land-based observations) to assess the effects of shipping. This approach would provide for a larger temporal and spatial scale of monitoring as well as address gaps among monitoring methods.

BIM's position

In Section 3.1.2 BIM states*, "Review of multiple lines of evidence consistently indicates that there is variability regarding narwhal abundance and use of the regional study area. Specifically, observations by Inuit and regulators suggest that narwhal use of the area was low in 2018; unfortunately, there was little survey effort in 2018, so there are little to no empirical data to corroborate anecdotal reports of particularly low narwhal abundance*. *Based on their observations, DFO (2019a) raised concerns about the possibility that noise from icebreaking and shipping activities may have deterred whales from entering Eclipse Sound; however, no data or evidence was provided to substantiate this concern and thus, for the purposes of this review, it is considered an unsubstantiated theory. Rather, it is more likely that a combination of variables, particularly ice cover, was driving anecdotal reports of anomalies in abundance and distribution of narwhal in 2018, and this is supported by literature (see Section 3.1.1.4 above)"* (Hemmera memorandum to BIM, October 15, 2019, p. 14).

DFO Science's analysis and assessment

It is not clear how Section 3.1.1.4 supports this affirmation and what literature it refers to. Moreover, DFO considers Inuit hunters observations as more than anecdotal, as characterized by BIM. IQ/Traditional Knowledge provides information on long term trends in abundance throughout the summer, whereas surveys are short-term and not conducted annually. In addition to hunter observations, harvest statistics from summer 2018 showed only 8 narwhal were hunted in Eclipse Sound in July and August (DFO, unpublished data) compared to an average of 46 (7.6 Standard Error [SE]) narwhal hunted annually from 2005–2015 in the same timeframe (Watt and Hall 2018), corroborating that there were fewer narwhal in Eclipse Sound in 2018. In addition, an index of narwhal presence based on shore-based observations in Tremblay Sound (west of Milne Inlet in Eclipse Sound) indicated that relative presence of narwhals in Tremblay Sound was lower in 2018 than 2017 (DFO, unpublished data).

Ultimately, in the absence of quantitative data resulting from a lack of consistent monitoring by BIM, observational data is the best available.

Recommendation

- The analysis and assessment from DFO Science above highlights the importance of continuous annual data collection and a comprehensive monitoring plan.

BIM's position

BIM states that *"A consistent observation across all aerial surveys is the considerable year over year variation in narwhal abundance and distribution. In light of this, the average abundance of Eclipse Sound narwhal across the three surveys will be used in this report, totaling 14,246 individuals"* (Hemmera memorandum to BIM, October 15, 2019, p. 17).

DFO Science's analysis and assessment

DFO Science maintains that the most up-to-date estimate of the size of the Eclipse Sound stock is 12,039 (95% confidence interval = 7,768-18,660; Marcoux et al. 2019).

Recommendation

- DFO Science recommends using the most recent estimate of the Eclipse Sound stock.

BIM's position

BIM states that, *"With respect to avoidance, a 135 dB re 1 µPa threshold was used in the IOA. No rationale within existing Baffinland submissions, nor precedent in the literature or from other environmental assessments could be located for the use of the 135 dB re 1 µPa avoidance threshold. Communication with LGL Limited (2019 pers. comm.), who authored the ERP assessment, indicates the origin of the threshold comes from Richardson et al. (1995b) and seems based on noise levels that bowheads were shown to tolerate when in heavy ice (without leaving the area) when exposed to drilling playback sounds at levels up to 135 dB. While this threshold did receive approval by DFO during the ERP review, in light of IQ (e.g., see Section 3.1.1.1 for a summary) and western science identifying narwhal as particularly sound sensitive (see Section 3.3.1.1 below), it is Hemmera's professional opinion that the 120 dB re 1 µPa generic threshold be used for both disturbance and avoidance onset*" (Hemmera memorandum to BIM, October 15, 2019, p. 19).

DFO Science's analysis and assessment

In light of recently published information available on behavioural response to noise (e.g., Gomez et al. 2016), DFO Science agrees with the Hemmera memorandum to BIM that the 135 db threshold was not supported and that the suggested 120 db is more appropriate for narwhals.

Recommendation

- DFO Science recommends using the 120 db threshold.

BIM's position

With respect to recent EAs/DFO CSAS reviews for the recent Roberts Bank Terminal 2 Project (RBT2), BIM states that *"proposed in critical habitat of the endangered Southern Resident Killer Whales (SRKW; a toothed whale also belonging to the "Mid-Frequency Cetacean" hearing group, like narwhal), a call masking model was developed to calculate masking as a proportional loss of foraging function in a three-dimensional listening space. The SRKW call masking model predicted that the RBT2 would result in an increase in masking of ~3.6 hours per whale per year. Under existing conditions, each whale is exposed to 2.55 days of masking per year. With RBT2, each whale is predicted to be exposed to 2.70 days of acoustic masking per year after accounting for noise produced during RBT2 operation and incremental vessel traffic associated with RBT2"* (Hemmera memorandum to BIM October 15, 2019, p. 31-32).

DFO's Science's analysis and assessment

DFO Science identifies some problems in the interpretation of the Sea Mammal Research Unit (SMRU) 2014 report. Specifically, the report was tasked to look at the reduction of the total foraging time in relation to operation and incremental vessel traffic associated with a new terminal. However, under the current conditions, killer whales are already exposed to a high level of noise and the new terminal will not increase the noise level significantly. Therefore, the loss of foraging time is minimal overall. It is still important to note that from this same report under the current shipping conditions, the model results predicted that killer whales lose 19.1 foraging days/year per animal due to combined behavioural disturbance and making under existing conditions (SMRU 2014).

Some of the information from the SMRU (2014) is taken out of context. In the SMRU report, masking was calculated as a residual from acoustic disturbance, i.e., the report acknowledges that masking can occur from the point source of sound. Their calculation of masking for the purpose of their model only included masking outside the disturbance zone (the blue zone in Figure 1) as opposed to including masking in the acoustic disturbance in addition to the masking zone (green and blue zone in Figure 1).

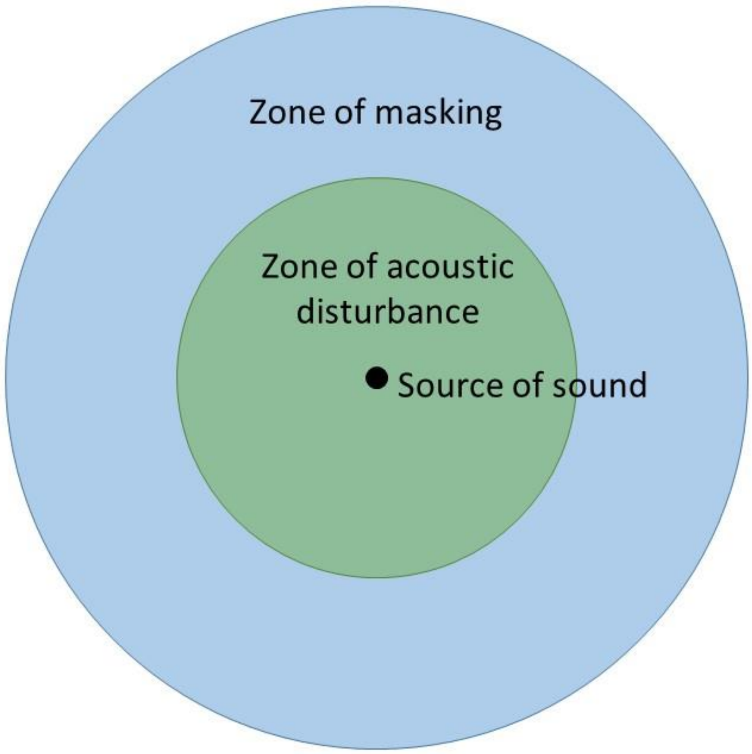

Figure 1. Theoretical zones of acoustic influence with highest level at the source of sound (adapted from Richardson et al. 1995).

Recommendation

- DFO Science recommends BIM re-interpret the relevance of the SMRU (2014) report to the Baffinland Mary River Project.
- DFO Science recommends that the total amount of masking should include the time that whales experience acoustic disturbance.

BIM's position

Hemmera is of the opinion that masking will not affect the narwhal population, based on the work conducted for Southern Resident killer whale (SRKW): "*Results of the PCOD model showed that predicted auditory masking during existing conditions and future conditions (i.e., with the Project and Project-associated shipping traffic) did not change the survival or reproductive rates of individual SRKW from existing conditions. No change was therefore predicted to the relative growth rate or size of the SRKW population. The RBT2 assessment of acoustic masking effects on SRKW provides a recent and pertinent example of how outputs of acoustic masking modelling to an individual whale can be integrated to evaluate potential population-level consequences from anthropogenic noise*" (Hemmera memorandum to BIM October 15, 2019, p. 32).

DFO Science's analysis and assessment

DFO Science does not agree with the conclusion from the Hemmera memorandum to BIM (October 15, 2019) due to the different environmental baseline conditions between these two projects. The results from the SRKW model showed that there was only a small difference in the loss of time for foraging between the current and the predicted shipping scenario because the current noise related to shipping for that project is already high. Therefore, it is not surprising that there was no difference in the relative growth rate or the size of the SRKW population between the current and the predicted shipping rate. In the case of Baffinland Mary River Phase 2 project, the baseline noise level in the regional study area is low (Frouin-Mouy et al 2019).

Recommendation

- BIM should base their conclusion on reference projects with comparable environmental conditions. (i.e., noise level at Mary River is low when compared to current conditions at Roberts Bank Terminal).

BIM's position

In their memorandum, Hemmera states (p.18, footnote #3.): "*Higher than typical numbers of bowhead whales were observed in the RSA in 2019, based on preliminary data from ship-based observations and aerial surveys (Golder 2019b), in seeming contrast to the rationale given for assessing ship strikes as negligible (i.e., limited occurrence of bowhead in the RSA). Irrespective of bowhead abundance in any given year, the measure typically applied to mitigate ship strikes is restricting vessel speeds. The Government of Canada has implemented a 10 knot restriction in the Gulf of St. Lawrence to protect endangered North Atlantic right whales whereas Baffinland has already implemented – and is currently enforcing – a more conservative 9 knot speed limit along the Northern Shipping route, despite the fact that neither bowhead nor narwhal carry any designations under the federal Species at Risk Act. No vessel strikes have been reported since the commencement of shipping operations*".

DFO Science's analysis and assessment

DFO Science acknowledges that BIM has conducted a literature review on the risk of ship strikes, however we cannot currently assess the impacts of ship strikes on bowhead whales within the RSA based on the information presented. There is still uncertainty associated with the reaction of bowhead whales to the increase in vessel presence and movement, especially in the presence of ice, where the ice may restrict movement and where several ships will be escorted at the same time (DFO 2019a,b).

There was no reported North Atlantic right whale mortality in Canada in 2018, but DFO Science confirms that there were 8, and possibly 9 mortalities, reported in Canada in 2019. Three of 5 necropsies conducted in 2019 concluded that the evidence was compatible with vessel strikes. The causes of the mortalities for the other 5 (possibly 6) are unknown. These deaths occurred despite the continuation of the 10 knot limit initiated in August 2017 throughout 2018 and 2019 (North Atlantic Right Whale Unusual Mortality Events). Whale strikes occurred between early June and mid-July and it appears a distribution/behavioral factor in 2017 and 2019 made the whales more susceptible to ship strikes (M. Hammill, DFO Science Quebec Region, pers. comm.). DFO Science thus notes that the slow down mitigation reduces the risk of mortality but does not eliminate it or the risk of a ship strike. Monitoring is an essential component to better understand the significance of ship strikes.

Recommendation

- DFO Science still requires monitoring of the potential for ship strikes on bowhead whales. This is relevant to consider potential depletion of whales within the RSA and the cumulative impacts to the Eastern Canada-West Greenland (EC-WG) bowhead population that exists outside the RSA.

BIM position

BIM states that *"Baffinland will update the Marine Monitoring Program to make it clear what behavioural indicators are being recorded during the Ship Board Observer Program. These indicators include breaching, flipper slapping, lobtailing, diving, fluking, blowing, resting, looking, feeding, hauled-out, milling, swimming, surfacing. Other recorded information includes initial distance from vessel, minimum distance from vessel (i.e., closest point of approach), and bearing from vessel and movement direction. These methods and indicators are currently described in annual Ship Board Observer Reports"* (Phase 2 Proposal Updated Information Package, Attachment 2 – Commitments and Terms and Conditions Following the Public Hearings, p.2, FWIS ID# DFO 3.5.6).

DFO Science's analysis and assessment

DFO Science notes that BIM has committed to updating the Marine Monitoring Program.

Recommendation

- DFO Science recommends BIM provide the updated Marine Monitoring Program to DFO and other relevant parties for review, allowing sufficient time in advance of initiating ice breaking activities to discuss, provide comments and make necessary changes and alterations to the program. DFO Science requires clarification on the selection of indicators BIM intends to use.

BIM's position

BIM states that *"Baffinland is committed to undertaking an end-of-season aerial survey of the LSA for each year shoulder season shipping occurs, to confirm no narwhal entrapment events have occurred. Baffinland will work directly with the Mittimatilik HTO in the implementation of this survey"* and that *"Baffinland will describe how survey results will be reported and analyzed in an aerial survey monitoring plan. This plan will be provided to MEWG members prior to carrying out the fall aerial surveys for review and comment, with sufficient time to implement changes to the survey plan, if necessary. This plan will include provisions for adaptive management, should repetitive ice entrapments occur"* (Phase 2 Proposal Updated Information Package, Attachment 2 – Commitments and Terms and Conditions Following the Public Hearings, p. 3, FWIS ID# DFO 3.62 and 3.6.6).

DFO science's analysis and assessment

DFO Science supports BIM's proposal for the end of season aerial survey, however DFO Science is uncertain as to how Baffinland defines "*repetitive ice entrapments*".

Recommendation

- DFO Science recommends BIM provide specific detailed information on how survey results will be reported and analyzed in an aerial survey monitoring plan. This plan should be provided to DFO, Parks Canada, The Mittimitalik Hunters and Trappers Organization, and other relevant parties, for review within an agreed upon timeframe that includes sufficient time in advance of the fall aerial survey to review, comment, and implement changes to the survey plan.

- DFO Science recommends BIM define criteria for "*repetitive ice entrapments*".
- DFO Science further recommends the aerial survey plan include adaptive management for developing mitigations should "*repetitive ice entrapments*" occur.

BIM's position

BIM states that "*Baffinland will implement a system where any bowhead whale observations will be reported to the Port Captain, who will send a notification to all incoming and outgoing ships to proceed with caution in the designated area*" (Phase 2 Proposal Updated Information Package, Attachment 2 – Commitments and Terms and Conditions Following the Public Hearings, p. 1, FWIS ID# DFO 3.3).

DFO science's analysis and assessment

DFO Science is not clear as to how BIM will be able to detect bowhead whales given that there are no marine mammal observers on-board of the ore carrier and given that the bridge on the ore carrier is located at the rear of the ship. During the summer, the only observation platform is at Bruce Head which correspond only a small proportion of the shipping route.

Recommendation

- DFO Science recommends Baffinland provide a copy of their "reporting system" that encompasses the entire range of bowhead whales in the regional study area.

BIM's position

BIM states commits to the "*Implementation of a 40-km buffer zone around the floe edge at the entrance of the RSA to reduce interactions between Project vessels and marine mammals (vessels entering the RSA during the spring shoulder season must wait 40 km to the east of the RSA until clearance from the Port Captain is obtained to enter the RSA)*" Phase 2 Proposal Updated Information Package, Attachment 2 – Commitments and Terms and Conditions Following the Public Hearings, p. 2, FWIS ID# DFO 3.5.5)

DFO science's analysis and assessment

BIM did not provide justification for the chosen buffer distance. In addition, there was no noise propagation analysis done outside the RSA, therefore, the noise propagation propriety at the floe edge is unknown. Previous studies at the Admiralty Inlet floe edge indicated that the distance at which narwhals reacted to icebreaker varied and therefore, there in uncertainty around the effectiveness of this measure and the distance required to be effective (Finley et al 1990).

Recommendation

- DFO Science recommends that BIM use acoustic monitoring to evaluate appropriate buffer distance to minimize the noise from waiting vessels at the floe-edge.

BIM's position

Analyses will be conducted using data collected during the 2019 shipping season to characterize the degree of conservatism in the sound propagation modelling that has been conducted. Additional AMARs have been deployed and will collect data during the Fall 2019 and Spring 2020 seasons to further this analysis.

A comparison of model estimates and measured data is presented in Frouin-Mouy et al. (2019). Similar analyses will be conducted using data collected during the 2019 shipping season to characterize the degree of conservatism in the sound propagation modelling that has been conducted. Additional AMARs have been deployed and will collect data during the Fall 2019 and Spring 2020 seasons. We are confident that the model provides a conservative estimate of the sound field, allowing for a precautionary assessment of the potential acoustic impacts. Monitoring data to date indicate that the narwhal are not showing pronounced reactions to the current levels of vessel activities.

DFO analysis and assessment

DFO Science notes Baffinland's statement that "*AMARs have been deployed and will collect data during the Fall 2019 and Spring 2020 seasons*". These data will be used validate the model estimates. The variation in noise conditions between years is unknown. Several years of data collection is required to determine how much variation there is between years and how many years are required to properly capture the variation.

Recommendation

- DFO Science recommends that BIM commit to collect data with the AMARs several year, as is described for the fall 2019 and spring 2020 season. DFO Science recommends that BIM first collect data for enough year to capture the inter-year variability and determine the frequency of the acoustic monitoring in subsequent years.

4.0 Conclusions

As stated in previous DFO Science reviews, based on the material presented in the FEIS and the new supporting documents that were submitted by BIM from October 8, 2019 – January 8, 2020, DFO Science is concerned that BIM’s statements and conclusions are not always supported by robust evidence (e.g., small sample sizes and lack of appropriate data analyses), justification, or rationale (e.g., that restriction of ship vessel speed removes any significant risk of ship strike). DFO Science has previously raised these concerns (DFO 2012a,b, 2014a, 2019a,b,c), and the conclusions provided here should be considered in conjunction with these past reviews.

More specifically, the review detailed in this Science Response concluded the following:

- All monitoring plans should include the collection of sufficient data (e.g., baseline) on indicator species and species groups and environmental conditions (biotic and abiotic) in both affected and control or reference sites to facilitate timely assessment of drivers of observed changes and subsequent adaptive management, if warranted (DFO 2019c). The power analysis that was presented in the Technical Memorandum that Golder provided to Baffinland (“*Power Analysis for Baffinland’s Marine Environmental Effects Monitoring Program (MEEMP)*”) should be used to adjust BIMs current sampling plans to meet the 0.8 power threshold. This should also be followed up with an annual process to review and assess the effectiveness of the monitoring plan(s) and adapt as necessary (i.e., increase sample size and/or spatial scale).
- The objective of past BIM marine mammal aerial survey were to detect changes in distribution patterns or habitat use, not to detect change in stock abundance. In addition, the use of stock abundance as an early warning indicator is not recommended. For this measure, there is high variance and the power is very low; therefore there is a limited ability to detect any effect; for this reason BIM should define the effect size.

- Any new or updated conclusions reached by BIM based on DFO Science advice should be captured in an amendment table and circulated to the NIRB.
- Shipping (through ballast and vessel fouling) is the main means by which non-native marine species are inadvertently moved from one place to another. AIS have caused significant ecological harm in most areas of the world, being cited as one of the top factors responsible for extinction globally (next after habitat alteration). BIM has committed to "*prevent and/or minimize potential adverse impacts to the marine environment that could result from the accidental introduction of non-native aquatic invasive species (AIS) via Project vessel activities*" (Ballast Management Plan, Shipping and Marine Wildlife management Plan) and have made a number of positive steps to help achieve this goal. That said, there are still concerns within DFO Science that require further clarification or commitment from BIM to be confident they are using all possible means to prevent/and or minimize adverse impacts of non-native species to the marine environment through project shipping.

  DFO Science would like to re-emphasizes the importance of the management of ballast water and bio-fouling prevention and the need to understand what works and what doesn't and the effectiveness of mitigation measures through long-term monitoring. Therefore, potential risks of AIS released from ship ballast or from hull fouling, and the potential consequences should be regularly assessed, should the project proceed.
- DFO Science would like to see all Early Warning Indicators for marine mammals (e.g., physiological impacts and behavior, abundance, and distribution) to be developed and implemented with thresholds as soon as possible.
- DFO Science is concerned about the lack of a scientifically rigorous approach with appropriate spatial-temporal scale and sample sizes to the collection of baseline and monitoring data for impact assessment of the project activities and their conclusions (e.g., ship strikes, ice breaking, ballast water discharge, etc.).

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(March 2, 2020)

7.0 Sources of information

This Science Response Report results from the Science Response Process of February 4, 2020 on the Science Review of Additional Documents submitted October 8, 2019 – January 8, 2020 for the Final Environmental Impact Statement (FEIS) Addendum for the Baffinland Mary River Project Phase 2.

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