SCIENCE REVIEW OF BAFFINLAND'S MARY RIVER PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT

1.0 Context

The Mary River Project is a proposed iron ore mine located at Mary River on North Baffin Island in Nunavut. Planned Project operations include mining, crushing, screening, rail transport and marine shipping of high grade iron ore. Two port facilities would be constructed on Baffin Island, in Milne and Steensby inlets. The Milne Inlet port will be used mainly during the construction phase of the project and will not be used to ship ore. The Proponent is proposing to use cape sized vessels with ice-breaking capabilities to load ore at the Steensby Inlet port, in northeastern Foxe Basin, and transport it to market in Europe. They are proposing to transit Foxe Basin and Hudson Strait approximately every two days year round. Based on current ore reserves, the mine would operate for 21 years and the duration of the Project, from the start of construction activities to post-closure, is expected to be 33 years.

Baffinland Iron Mines Corporation (BIM) submitted their draft Environmental Impact Statement (EIS) in 2011. Fisheries and Oceans Canada (DFO) Central and Arctic Region's Ecosystems Management sector requested science advice to assist in developing the Departmental response to this draft. DFO Science reviewed the report and provided advice (DFO 2012a, Stewart et al. 2012) to Ecosystem Management for their consideration in developing a departmental response.

On February 13, 2012, BIM submitted their final EIS for the Mary River Project (BIM 2012) to the Nunavut Impact Review Board (NIRB). On February 29, 2012, the NIRB initiated the public technical review period of the Project. DFO Science was asked by Ecosystems Management sector to review and provide advice on the final EIS. The objectives of this review are to assess whether the final EIS provides sufficient evidence to support the Proponent's conclusions regarding potential ecosystem impacts of the Mary River Project on marine aquatic species and habitats, especially increased shipping activities on marine mammals. The scope of this review is limited to production and shipment of 18 million tonnes per annum (Mt/a) of high-grade iron ore. The results will be provided to the Habitat program for consideration in the Department's intervener comments due to NIRB by May 30, 2012.

This Science Response Report results from the Science Special Response Process of May 15, 2012 on the science review of Baffinland's Mary River Project final Environmental Impact Statement.

2.0 Background

Technical review comments on BIM's draft EIS were submitted to NIRB by October 5, 2011. NIRB hosted technical meetings in Iqaluit October 22-25, 2011 and Preliminary Hearing Conferences in Igloolik November 6-7, 2011 and Pond Inlet November 9-10, 2011 to further discuss the draft EIS. Based on these, BIM submitted a list of 356 commitments to NIRB, to be addressed through its continued engagement in the Board's review process and development of the final EIS. BIM submitted their final EIS to NIRB February 13, 2012. On February 29, 2012 NIRB initiated the public technical review period for the final EIS by requesting that interveners submit information requests (IRs) by March 30, 2012 with respect to the final EIS for the Project. IRs were meant to facilitate the technical review. The following organizations submitted IRs: Qikiqtani Inuit Association (QIA), Government of Nunavut (GN), Aboriginal Affairs and Northern Development Canada (AANDC), Canadian Transportation Agency (CTA), Environment Canada (EC), Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan) and Transport Canada (TC). BIM responded to most of the IRs by April 19, 2012. NIRB hosted a meeting of technical experts in Iqaluit May 1-3, 2012 to further facilitate discussions between the Proponent and reviewers although these discussions were not documented. Intervener comments were due to NIRB by May 30, 2012.

The objectives of this review are to assess whether the final EIS provides sufficient evidence to support the Proponent's conclusions regarding potential ecosystem impacts of the Mary River Project on marine aquatic species and habitats, especially increased shipping activities on marine mammals, by…

1. assessing the quality of information presented in the final EIS,
2. determining if appropriate methods were used in the final EIS to develop conclusions,
3. determining whether the final EIS provides sufficient information on alternative means of carrying out the project to support the development of adaptive management strategies,
4. determining the appropriateness and adequacy of proposed mitigation and monitoring measures in the final EIS, and
5. if necessary, recommending additional or alternative mitigation measures (that may be more appropriate) to reduce or avoid impacts to fish and fish habitat, including marine mammals.

3.0 Analysis and Response

3.1 Shipping Route

Final Environmental Impact Statement, Volume 3 Section 6.5; Volume 3 Appendix D in Appendix 3G; Volume 8; BIM Information Request (IR) response to QIA #IR D02 Appendix 1

BIM's position[1]

BIM concludes that *Ice conditions are such that year round shipping is possible via Hudson Strait and Foxe Basin. Thus a shipping route through Foxe Basin is technically feasible*. The width of the shipping route would be no more than 1.5 km and will follow the nominal route identified in the final EIS.

DFO Science's analysis and assessment

The shipping route is new, not existing, and the scope of proposed shipping activity is significantly greater than current levels. For these reasons, impacts along the shipping route and at the port sites should have received equal treatment in the final EIS.

[1] Quotations are identified in italics. For all quotes which do not include a citation, the final EIS is the source.

Although the final EIS concludes year-round shipping by the proposed route is technically feasible, expert advisors to BIM raised serious doubts about the veracity of this claim and recommended empirical demonstration of feasibility. Based on information provided in the final EIS, deviations in track width (in excess of the 1.5 km) and route are expected. Potential route deviations and their relative effects are not adequately addressed in the final EIS. Sites or areas along the shipping route which are likely to have conditions that require the Project vessel to deviate from the established route, for its own safety, are not identified. For example, how often do ice maps suggest difficult conditions around Mill Island, which is a "choke" point along the shipping route in western Hudson Strait? Could the ice conditions east of Rowley Island be sufficiently difficult to necessitate transit west of the island? Are there combinations of weather, tides and ice conditions in Hudson Strait that could limit ship passage at times? Are there shoal areas in northern Foxe Basin that would necessitate changes to the route when ice conditions are heavy? Recent collection of bathymetric data in southern Steensby Inlet led to a revision in the shipping route. The new route has two near 90° turns and very fine navigational tolerances in order for the ore carriers to avoid shoals. If ice conditions limit a ship's ability to safely navigate the revised route what alternate routes will be used? Will there be sufficient bathymetry data available to make these sorts of decisions?

DFO Science's recommendations

- BIM conduct at least two round trips during the peak ice-season from the east entrance of Hudson Strait to Steensby Inlet to demonstrate the feasibility of year-round shipping along the southern route. These trips could also be used to collect data (e.g., animal reaction, underwater and in-air sound measurements).
- BIM needs to identify places along the shipping route where seasonal environmental conditions may require route deviations.
- BIM needs to explain how they will maintain or alter the shipping route in the shallow water of Steensby Inlet if conditions become unsafe for transit.
- All ships undertaking Project-related activities should be equipped with and use vessel monitoring devices to allow tracking of vessels in relation to marine habitat and organisms to better define the actual shipping lane, and improve monitoring and mitigation efforts.

3.2 Project-Related Impacts

3.2.1 Marine Fishes and Invertebrates

Final Environmental Impact Statement, Volume 8 Section 4.4 pages 97-100; Volume 8 Section 4.5.2.1 pages 101-113; Appendix 8A Section 4.1.2.1, 4.1.2.2, 4.2.1, 4.2.2, 4.4.1.2, 4.5.2.1, Figure 4.1-1

BIM's position

BIM concludes that direct mortality of marine fishes due to blasting will be minimized.

Based on air quality modeling, the final EIS predicts an annual rate of 0.12 mm of ore dust deposition on the water/ice surface and concludes that deposition will not cause direct mortality to fish eggs.

BIM expects no harmful alteration, disruption or destruction (HADD) of fish habitat to occur from the use of temporary floating freight docks at the two port sites. In particular, BIM concludes that as no project infrastructure will be placed in the marine environment at the Milne Inlet port site, there is no potential for a HADD in that area.

BIM estimates the total area of affected habitat at Steensby Port as 9.947 ha, representing the footprints of the permanent dock, the causeway and planned dredging. Compared to the total area of the marine fish habitat in the port (13,700 ha), BIM concludes that the habitat loss would represent significantly less than 1% of available habitat therefore the magnitude of effects is negligible.

BIM collected data from 38 transects in Milne Inlet to characterize seabed habitat, including the distribution and occurrence of epibenthic biota. They noted that epibenthic invertebrates were less commonly observed in vegetation/kelp dominated areas, *likely due to fauna being obscured under the high cover of benthic kelps*. Catch per Unit Effort (CPUE) values for gillnet sets were standardized to 24 hours despite the fact that the sets typically lasted less than four hours. Two gillnet sets were left in the water for 48 hours because of weather, but it appears the data from these sets were included in the CPUE calculations without further consideration or comment.

DFO Science's analysis and assessment
Underwater blasting at Steensby will be conducted during early spring, before most Arctic Char have moved into the marine environment, to minimize their exposure. The potential impact on sculpins is also discussed (it is assumed to be minimal because they lack a swim bladder). No other species are considered, such as gadoids, which may present in the area and represent important components of the marine food web. The following section on *Direct Mortality of Eggs Due to Sedimentation* also mentions that sculpin eggs are expected to be present in the blasting area. While the impact of blasting on sculpins is discussed, direct impacts of blasting on egg mortality are not considered. Other species were not considered.

DFO Science believes that ore dust deposition will accumulate on the ice from fall to spring melt resulting in pulsed introduction onto aquatic habitats. BIM's analysis does not consider these seasonal effects. In the spring, ore dust that has accumulated on the ice will be released into the water *en masse*, which will result in higher instantaneous rates of dust exposure in down-current areas. This seasonal release could affect egg survival for species that hatch in the spring, such as sculpins. In addition, black carbon has been proven to have significant climate forcing effects, in addition to its effects on snow and ice albedo, thereby accelerating the retreat of Arctic sea ice (AMSA 2009).

DFO Science disagrees with the conclusion that there is no habitat disruption associated with the use of temporary floating docks at both ports because it ignores the potential and combined impacts of dock deployment and retrieval, habitat shading from the dock and the effects of sound on habitat quality, at the very least. In Table 8-4.8, negative impacts from noise on fish habitat are expected during all project phases at Milne Inlet and from ballast water discharge during decommissioning. Although the anticipated impact levels are low, the cumulative and combined effects of the acknowledged factors, together with other factors, could result in a HADD at Milne Inlet.

DFO Science disagrees that the magnitude of habitat loss will be negligible because the estimate of the affected area does not include habitats that will be impacted by resuspended sediments from vessel traffic, construction, or dredging. Therefore this is an underestimate of the total area affected. Additionally, the calculation is based on the total area and is not broken down by depth strata or habitat types; some habitat types could face considerably larger relative impacts than others.

DFO Science is concerned with the methods used to collect baseline data on marine invertebrates, marine fishes, and habitat. The following are examples.

- The fraction of the total area that was assessed in Milne Inlet to characterize the seabed and its associated faunal communities is unclear since neither the methods in the final EIS or in the cited document provide information about transect width. Regardless, the visual survey was limited to a maximum depth of 25 m, which provides some coverage of nearshore habitats, but only a small fraction of project area was surveyed. This lack of complete coverage makes it impossible to fully assess the diversity and distribution of benthic habitats and epifaunal species present, and therefore the impacts that the project will have on benthic habitats and the epifaunal community.
- Limiting the visual surveys to the nearshore may focus areas on ice-scoured communities with lower species diversity. In Steensby Inlet surveys were focused on sites of Project infrastructure and along the coastline. This also makes it impossible to fully assess the diversity and distribution of benthic habitats and epifaunal species impacted by Project-related activities beyond the immediate infrastructure footprint.
- DFO Science also questions the validity of using visual surveys to assess epibenthic organisms in areas with kelp. Despite acknowledging this limitation of the survey method, an alternative survey was not undertaken.
- Opportunistic epibenthic samples were collected, including specimens that were attached to algal samples and individuals that became entangled in gill nets, but these samples will not be representative of the epibenthic community. Therefore, the results presented for epibenthic species at Steensby Inlet are incomplete and cannot be used to fully assess the impact of the project.
- For marine fishes there is no justification provided for using 24 hours to calculate CPUE. Gillnet catches are subject to gear saturation and escapement, both of which are time-dependent. It may be that CPUE was standardized to 24 hours to accommodate the two extended sets, which should have either been excluded from the analysis or their data should have been examined for any notable deviation from the other catches.
- Inadequate numbers of gillnet sets were conducted in Milne Inlet (16 sets) and in Steensby Inlet (19 in 2007, 25 standard and 6 small in 2010) to adequately characterise the marine fish community.
- Gillnets were set running perpendicular from the shore, which limited the catches to fishes in shallower areas and individuals that moved along the shore.

Overall survey methods were inadequate to provide the baseline data necessary for predicting Project-related impacts and developing mitigation measures.

DFO Science's recommendations

- BIM establish key locations (transects) outside the Project Infrastructure footprint area to collect baseline and long-term monitoring data, focusing on areas where potential impacts are most likely to occur (including northern Steensby Inlet and the shallow area around entrance to Steensby).

- Sufficient sampling effort is required to provide sufficient statistical power to detect patterns and changes. Further sampling will be needed if Project effects are detected in order to develop appropriate mitigation.
- BIM should provide monitoring plans with sufficient details to evaluate their scientific rigour and statistical power. For example, independent replicates are required in all surveys. Marine surveys should include depth stratification, sample sites should be selected through a random process, and organisms sampled should be identified to species.

3.2.2 Marine Mammals

Final Environmental Impact Statement, Volume 8 Section 5.8.2.2 page 205; Volume 10 Section 7.1 Table 10-7.2; Volume 10 Appendix 10D-10 Section 4.5.1.2 Table 2; Section 4.5.1.3; BIM IR response to DFO #IR 7.3-7.4

BIM's position
The final EIS does not predict any significant negative effects on marine mammals from shipping. Potential impacts will be generally addressed through measures to avoid interactions. Modern vessel design criteria will result in low noise generation. The route selection has been chosen to avoid areas of high interaction potential. Other route adjustments can be considered if a potentially negative interaction is identified. Additionally, other potential measures could include reduced speed zones. The presence of surveillance monitoring will serve to provide information on potentially negative interactions. An elevated level of focused EEM would be applied if and when a negative interaction was identified. These efforts, along with other measures would result in the identification, application and assessment of adaptive management measures. An expanded program of marine baseline monitoring is currently underway.

DFO Science's analysis and assessment
The potential for interaction between project activities and marine mammals, including several species with special conservation status under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), exists throughout the year, and is particularly high during winter. DFO Science concludes that measures to lower the potential for interaction with marine mammals were not considered sufficiently in the final EIS. In the following section(s), DFO Science will demonstrate that (1) potential for interaction between marine mammals and shipping is high, (2) there are currently no effective mitigation measures to lower interactions, (3) the surveillance monitoring program is inadequate to document interactions or trigger more focused monitoring and eventual adaptive management, and (4) BIM's prediction of negligible impacts of shipping on marine mammals is not only unsubstantiated, but also not precautionary.

There is no demonstration in the final EIS that any measures will be implemented as part of the proposed Project '*to avoid interactions*' with marine mammals, nor that ore carrier route selection was made in a way so as to '*avoid areas of high interaction potential*'. In reality, current distribution data available for bowhead whales (Ferguson et al. 2010, Fig. 1), Northern Hudson Bay narwhal (Richard 1991; Koski and Davis 1994; Westdal et al. 2010), and beluga whales (Finley et al. 1982; Luque and Ferguson 2010) indicate that the proposed shipping route largely overlaps with areas of core use for these three species, especially during winter when open water areas and ice leads provide the only habitat available for these species. BIM acknowledges the relatively high abundance of ringed seal and walrus along the shipping route, particularly in northern Foxe Basin where the proposed port would be established. While Steensby Inlet doesn't appear to represent a core area of use for any of the pinniped species based on the data available from BIM, there is no demonstration that the proposed shipping route avoids areas of highest densities as those were not identified in the final EIS.

The final EIS identifies in an Environment Monitoring and Mitigation Plan (EMMP) for marine wildlife that scheduling of ships constitutes a potential mitigation measure (i.e., that shipping rates could be reduced during periods of the year when interactions with marine mammals would be highest). However, this appears to be at odds with BIM's position that reducing the ore shipping rate is an economically unviable option.

The proponent briefly describes 'surveillance monitoring' as a way to obtain information on negative interactions with project shipping, and as a trigger for more focused environmental monitoring and mitigation. However, the proposed surveillance monitoring appears to consist of a limited number of MMOs aboard a few selected transits of ore carriers and thus, is extremely limited and undoubtedly ineffective for this role. Considering that marine mammals can exhibit strong negative reactions to ships and icebreakers typically while vessels are still several, or even tens of kilometres, distant (e.g., Finley et al. 1990), such reactions will go undetected and undocumented with the proposed surveillance program. Ship operators have limited capacity to manoeuvre 300 m ice-breaking ore carriers over short distances to avoid marine mammal aggregations or whales in leads. The proposed surveillance monitoring is unlikely to achieve its goals of providing information on negative interaction and facilitating a means to avoid such interactions. BIM proposes to *review the marine mammal data and discuss with the Inuit Advisor/Monitors to determine if a need exists to modify shipping routes and/or vessel speeds in order to reduce or eliminate the potential for creating severe effects on marine mammals*. This approach does not have the necessary rigor in data analysis to detect less-than-extraordinary effects (such as ship strike mortality) on marine mammals. BIM's proposal to reduce vessel speed as a mitigation measure, while it might lower collision risks in open water (Vanderlaan and Taggart 2007; Silber et al. 2010) and to some extent reduce vessel noise output, it is unlikely to reduce or eliminate the risk for whales in dense pack ice.

For all these reasons, DFO Science concludes there are currently no effective mitigation measures proposed in the final EIS to monitor interactions or avoid/reduce potential impacts of shipping on marine mammals. Therefore, a portion of several already-vulnerable populations would be at risk of ship strike, and would be exposed to noise with potential consequences to their health, behaviour and habitat use.

3.3 Impacts of Shipping

A number of threats have been identified that could negatively impact the marine environment as a result of shipping iron ore year-round through Foxe Basin and Hudson Strait for the Mary River Project (Megannety 2011). On a broad scale, threats from shipping can be classified into three categories: pollution, disturbances, and introductions (AMSA 2009). Our review focuses on threats in these broad categories within the marine environment and primarily on marine mammals.

3.3.1 Ship Noise

Final Environmental Impact Statement, Volume 8 Sections 5.6−5.12; Volume 8 Section 5.7.2.2 Table 8-5.7; Volume 8 Section 5.9.2.2 page 221; Volume 8 Appendix 8C, Tables 8C-3.1 to 3.10

BIM's position
The effects assessment examined hearing impairment, masking, and behavioural responses (e.g., disturbance) of marine mammals to shipping-related noise. BIM concluded that for all

marine mammal Valued Ecosystem Components (VECs), disturbance, hearing impairment, and masking as a result of ship noise was not significant.

DFO Science's analysis and assessment

Exposure to shipping-related noise may lead to negative effects on marine mammal health, behaviour and habitat use. Various factors affect their degree of reaction to noise and vessel traffic (Richardson et al. 1995), and effects can be categorized as follows:

(1) the noise may be too weak to be heard, i.e., below ambient level (in the final EIS the ambient noise measures used may not pertain to winter and offshore contexts), or below the hearing threshold at the specific frequencies where anthropogenic noise is emitted;

(2) the noise may be audible but not result in negative behavioural or physiological response;

(3) the noise can result in a negative response that can range from temporary alertness, to active avoidance of the area for short to prolonged period of time, and from short-term to longer-term change in stress levels;

(4) the noise can result in a progressive decrease in response as the animals habituate to it or alternatively, may cause repeated and persistent disturbance or stress effects;

(5) the noise may mask differing components of incoming communication calls or interfere with calls or environmental sounds useful to some vital functions such as foraging, navigation, or finding mates and reproduction;

(6) the noise can cause persistent physiological stress[2] if the animal remains in the area because of its importance for vital functions or because of a lack of alternate location to fulfill essential biological needs; and

(7) the noise, if it is very strong, can lead to temporary or permanent hearing damage.

There are currently no data available to assess the effects of the proposed shipping on impacts to marine mammal health, reproduction, or survival. One step towards estimating the significance of impacts is to determine the number of individuals potentially affected relative to total population size. Another is to determine whether specific segments of the population are likely to be impacted more than others (e.g., calving females).

In the only well-documented case of beluga and narwhal reaction to icebreakers in a relatively noise-pristine area (Finley et al. 1990), beluga exhibited strong overt reactions to ships still 35−50 km away, displacement distances of up to 80 km, and return times to the disturbed area of nearly two days. Reactions and return times were less for narwhal than beluga, as the former exhibited no visible panic reaction to the approaching ship but rather a "freeze" response and returned to the disturbed area within 1 to 2 days. As BIM pointed out *the strong reactions of narwhals (and belugas) at long ranges are unique in the literature of vessel noise responses by marine mammals. Possible reasons provided by LGL and Greeneridge (1986)* [as cited in BIM 2012] *are the fact that the whales were trapped in open water along the ice-edge as the ships*

[2] Until recently, it was not known if exposure to shipping noise could result in physiological responses in large whales that may lead to significant consequences for individuals or populations. Rolland et al. (2012) showed that reduced ship traffic in the Bay of Fundy following the events of 11 Sept. 2001, resulted in a 6 dB decrease in underwater noise with a significant reduction at low frequencies. This noise reduction was associated with decreased levels of stress-related faecal hormone metabolites in local North Atlantic right whales (*Eubalaena glacialis*). This is evidence that exposure to low-frequency ship noise may be associated with chronic stress in whales, and has implications for all baleen whales in heavy ship traffic areas (Rolland et al. 2012), such as bowhead whales in Hudson Strait should ore carriers operate year-round.

approached, their lack of previous experience with ships in the High Arctic in spring, and good sound propagation conditions.

Bowhead whale exhibited avoidance responses to a drill site with high levels of associated icebreaker activity at ranges up to 25 kilometres (Brewer et al. 1993 as cited in BIM 2012), as well as a drilling operation with relatively little associated icebreaking. These whales may have responded to several features of these sites, such as the icebreaker or drilling noise or the ice characteristics, so further icebreaker studies are warranted (e.g., Richardson et al. 1995).

Using BIM's conclusion that underwater sounds loud enough to elicit disturbance to pinnipeds in the RSA could propagate up to 15 km from the sources, it is apparent that these sounds would reach the haulout sites at Mill, Koch, Bray and almost (16.5 km) Big islands. While this would not impact animals hauled out, these are places where the animals aggregate in water before and after hauling out and may be impacted by such anthropogenic underwater sound levels.[3]

The marine mammals that would be exposed to the proposed project are industrially-naïve populations. Therefore, reactions from beluga and narwhal from Hudson Strait and Foxe Basin might be expected to be similar to those documented in the High Arctic. Considering that the time elapsed between successive ore carriers transits will be less than two days in the proposed Project, and thus shorter than the time documented for beluga to return to normal activity in the High Arctic, DFO Science is concerned about the long-term impacts of this new, and unprecedented, scale of shipping activity for marine mammals in this relatively pristine environment.

DFO Science agrees with BIM's conclusions that the shipping component of the proposed Project is unlikely to lead to hearing damage. However, these relatively noise-naïve marine mammals will be subject to frequent shipping and ice-breaking noise. The absence of alternate wintering grounds for potentially displaced bowhead whales, beluga and narwhal, or year-round habitat in the case of walrus, might result in temporary or persistent physiological (stress) and behavioural responses for a portion of the individuals exposed to these anthropogenic noise sources.

For noise sources that are continuous, negative responses ranging from alertness, to minor to strong avoidance of the area ensonified is presumed to begin at sound pressure levels (SPL) of 120 dB re 1 µPa for cetaceans such as beluga, narwhal or bowhead whale, while levels eliciting similar reactions from pinnipeds[4] remain uncertain (Southall et al. 2007), and thus, were assumed to be similar to those of cetaceans for the present exercise. The Zone of Influence (ZOI) for cetaceans around an ice-breaking ore carrier corresponding to a SPL of 120 dB re 1 µPa is unknown, but was estimated to be 8 km based on a study conducted elsewhere. This is likely an underestimate as it is based on underwater noise levels (20−1000 Hz) from an icebreaker (*Robert Lemeur*) that was not in ice-breaking mode (Richardson et al. 1995, Fig. 6.12). BIM assumed much greater distances for "disturbance" and "avoidance" for all the marine

[3] Further, at Mill Island, the ore carriers would pass within 7.5 km of the haulout site where the ships might be seen by walrus, even as a "blob" against the horizon. There are no studies to suggest what reactions this visual exposure would elicit, but walrus are known to react negatively to unusual things on their visual horizons.

[4] Pinnipeds are not addressed in this discussion of noise impacts, but this should not be construed as meaning that DFO Science considers that there will be no such effects on these mammals – simply that noise level thresholds to judge these impacts are less well researched in Arctic pinniped populations.

mammals than used in Appendix 4 (below), suggesting that DFO Science's assessment of potentially impacted animals is more conservative.

The number of individual whales potentially affected by the proposed project and shipping can then be estimated by multiplying the ZOI around a ship track (i.e., with noise levels in excess of 120 dB re 1 µPa) by local cetacean density estimates correcting for seasonal use and number of ship transits during the period of overlap between these mammals and the ships (see Appendix 4, below). DFO Science acknowledges that odontocetes such as beluga and narwhal have lower hearing sensitivity at low frequencies than mysticetes such as bowhead whale (Southall et al. 2007). However, avoidance reactions of beluga to an icebreaker more than 35 km away (Finley et al. 1990) indicate that an 8 km ZOI for odontocetes remains conservative as a threshold to estimate the number of individuals aware of the presence of an ore carrier, and the number of those potentially harassed by shipping noise. Given the proposed shipping route overlaps with areas of core use and not "average" areas for the three cetacean species, it is also expected that above-average densities will be encountered in areas of overlap with ore shipping.[5] Therefore, the use of average densities of mammals to assess exposure to noise and collision risks further underestimates the impact of noise on marine mammal VECs.

Even using the non-precautionary average density and the above-mentioned calculation methods, the estimated number of bowhead whale potentially harassed each year through their exposure to ore carrier noise while on their wintering ground varies from approximately 2,000 to 19,000 individuals (animal-exposures[6]) depending on the density estimate used in the calculation (see Appendix 5, below). The numbers of exposed individuals (animal-exposures[6]) per year varies between 18,000 and 24,000 narwhal and between 19,000 and 45,000 beluga (see Appendix 5, below). Note that for beluga, numbers are uncorrected for whales missed during surveys, adding more negative bias. The numbers of exposed pinnipeds (animal-exposures[6]) varies between 1,000 and 7,000, but again, these numbers are not corrected for animals diving or available but missed during surveys. These calculations don't take into account individuals potentially exposed at other seasons, or in other areas during winter - such as bearded seal, ringed seal or walrus in northern Foxe Basin where densities are much higher for these species. On the other hand, DFO Science's estimates represent an upper boundary as it is likely that individual whales will be exposed multiple times to the noise from passing ships over a given year.

These estimates greatly exceed population size in the case of narwhal and Ungava Bay and Eastern Hudson Bay beluga, while they represent 14 to 130% of the bowhead whale population, and 33 to 75% of the western Hudson Bay beluga population. Marine mammal survey design was inadequate to determine densities for ringed seal and walrus and thus, estimates of potentially harassed individuals need to be interpreted with caution. While DFO Science doesn't have national standards for assessing the magnitude of impacts of projects, an index of the severity of acoustic interactions associated with the proposed Project can be obtained using methods employed in the U.S. (California) for assessing impacts of seismic

[5] While the average densities can be calculated and have been used in DFO Science's analyses, we remain concerned about aggregations of whales. For example, if most bowhead mothers and their calves overwinter in west Hudson Strait, an average summer density undervalues the fact that 100% of these animals will be exposed to shipping noise and strike risk. Nonetheless using average densities serves to highlight DFO Science's concerns about the proposed shipping through core areas of habitat used by these cetaceans.

[6] As the report was being prepared for posting on the DFO website it became apparent that additional clarification was needed. These numbers represent animal-exposures not necessarily individual animals as some may be exposed repeatedly.

projects. Considering that four of the six species likely affected by the proposed Project have special conservation status under COSEWIC, and that more than 2.5% of the total population is likely to be exposed to potential disturbance (see Appendix 1, below), severity of impact would be considered high using the California criteria, regardless of the extent (regional or local), duration or frequency of effects (Wood et al. 2012; NSF 2011). The percentage of the populations affected would be even higher if we were to use the U.S. approach as they considered minimum population size rather than mean population size as DFO Science did to assess the proportion of the population potentially disturbed by the project (e.g., NSF 2011; Wood et al. 2012).

DFO Science concludes that the number of individuals potentially harassed each year by the noise originating from the ore shipping component of the proposed Project is not negligible, and the magnitude of effects is high.

3.3.2 Ship Strikes

Final Environmental Impact Statement, Volume 8 Section 5.4.2, 5.7.1.5

BIM's position
BIM concluded that *it is conceivable that the marine mammals in the LSA*[7] *could experience direct injury or mortality from collisions with vessels.* They considered the risk of collisions generally to be low, given marine mammal avoidance of ships, and stated it was not significant. Seal pups in lairs in landfast ice would be at highest risk. Potential interactions would be along the shipping routes to Milne and Steensby Ports, where vessels are transiting at higher speeds. Baleen whales are more susceptible to collision than smaller toothed whales. The final EIS provided qualitative discussions of the potential for ships to strike marine mammals. For narwhal, beluga and bowhead whale the final EIS indicated it is not possible to provide a meaningful quantitative risk assessment of the potential for vessel-whale collisions in the areas of interest because there are no quantitative data from these specific situations.

DFO Science's analysis and assessment
A more direct source of negative interaction between marine mammals and large-scale shipping would be the mortality or severe injury resulting from ship strikes. Like the North Atlantic right whale, the bowhead whale has certain characteristics (e.g., relatively slow swimming speed, small group size, a mid-water, or surface feeding strategy, and positive buoyancy due to high body fat content), that probably make it as vulnerable to ship strikes as right whales. For example, right whales appear to exhibit a small degree of escape response to avoid a ship strike, perhaps only in the closing seconds (Kite-Powell et al. 2007). Silber (unpubl. rep.) suggested that bowhead whales could be expected to exhibit similar behaviour.

Narwhal and beluga are likely less vulnerable to ship strikes than bowhead whale, given their greater overall maneuverability relative to large whales, echolocation capabilities, and social behaviour (in which groups of individuals may enhance vessel detection and flight – assuming such flight is not constrained by local conditions). Nevertheless, records of odontocete cetacean species such as beluga whale, pilot whale (*Globicephala* spp.), killer whale (*Orcinus orca*), and various species of beaked whales do appear in ship strike databases (Silber unpubl. rep.; DFO 2012a), suggesting some degree of vulnerability to ship strike.

The number of individual bowhead, narwhal, or beluga whales potentially struck by the large

[7] Local Study Area

ore carriers in the proposed Project can be determined by multiplying the volume of water swept by one of these vessels at any one instant by the total transit length which contains cetaceans, then by local cetacean density estimates and body sizes, and then correcting for seasonal use of the area by cetaceans, and the number of ship transits during periods of overlap between these mammals and the ships (see Appendix 4, below). The model uses the whale as a horizontal linear target at random orientation to the carrier's line of travel.

Given the assumptions used in the model, and the generalized nature of the model itself, there are a number of sources of error in these estimates. We have reduced the magnitude of these potential sources of error by using the lowest estimate of whale density in the study area, a body length size which is not the maximum for the species, used only surface interval time rather than the additional time the whale might be at a position within a few metres of the surface (and hence shallower than an ore carrier's keel), and assumed ships encounter whales as single individuals rather than groups (or that the loss of an adult does not affect the survival of a dependent offspring or relative). Variations in the local densities of the whale species of interest have probably the largest impact on the magnitude of the ship strike risk estimate. For example, ore carriers crossing migratory pathways, feeding aggregations or other areas of core use would have a higher risk of striking a whale. If whales have an avoidance reaction to approaching carriers, and are able to move away without being constrained by ice or bathymetry, then ore carrier passage would entail lower risks. The whales' flukes and caudal peduncles may present a lower risk of mortality if struck than the body, making the "risk length" shorter than assumed in this exercise. On the other hand, the time interval during which the whales are just below surface will also be a source of risk as the whale will not be visible to facilitate avoidance manoeuvres by the vessel. And finally, in open water the displacement of a whale by the water flow around the large bow (pressure wave) may reduce the injury risk in this part of the vessel. However, there is a whale strike modelling study which used towed ship and whale models to detail laminar flow around large vessels; its authors concluded that in some cases, whales beside or below the stern of the large vessel could be drawn towards the stern and propellers by a low-pressure water flow effect (Silber et al. 2010).

A factor lowering ship strike risk for these large vessels would be ship speed. Vanderlaan and Taggart (2007) analysed worldwide records of vessels striking large whales to examine the influence of vessel speed. The probability of a lethal injury (P_{lethal}) to a large whale when struck by a vessel at speeds from 8.6 to 15 knots was 0.21 to 0.79. Above 15 knots, P_{lethal} asymptotically approached 1.0 indicating an almost certainty of whale death following a ship strike. The probability of a lethal injury dropped below 0.5 at 11.8 knots, although this proportion becomes highly variable at lower ship speeds. If these relationships hold true for bowhead whale and the BIM ore carriers, then a ship strike during the open-water season will likely be fatal. It is anticipated that during the open-water period (August to December) vessels will travel at an average speed of 14 knots (26 km/h), while during the ice-covered period (January to August) vessel speed will be reduced to an average of 7 knots (13 km/h). During the winter the vessels will be moving more slowly, so it is hoped that a ship strike will be less probable, and a whale struck by an ore carrier would be less likely to be killed or seriously harmed. This assumes that movements of animals are not constrained when in ice.

Based on the above-mentioned calculation methods (Table 1 in Appendix 4, below), the estimated number of bowhead whales potentially injured seriously or killed each year through being struck by an ore carrier while on their wintering grounds could be up to five individuals. The numbers of narwhal and beluga struck by ore carriers were estimated at 49 and 14, respectively (Table 1 in Appendix 4 below). These values may represent an upper boundary as it is likely that individual whales will be able to move out of the path of passing ships, unless they are constrained by ice or bathymetry. DFO Science concludes that the number of individual whales seriously injured or killed by strikes from BIM ore carriers each year is probably not negligible.

Summary – Ship Noise and Ship Strike Impacts

The combined significance of these two types of interactions for the cetacean population of interest can then be determined by comparing the number of potentially affected individuals to an estimate of total allowable harm (TAH) for each population. TAH includes all human-induced mortality, including those currently arising from the subsistence harvest, and takes into account population size, uncertainty around density estimates and conservation status (see Appendix 4 below for details). The cumulative impact of the proposed project on marine mammal populations needs to be evaluated using the residual allowable harm (AH), i.e., the AH once harvest mortality has been taken into account (see Appendix 1, below).

The ship strike simulation suggests that a yearly loss of up to five bowhead whale, 49 narwhal, and 14 beluga might be expected from Project-related ship collisions. A comparison of these numbers to the residual AH indicate that the threshold for maintaining conservation objectives may be exceeded without taking noise impacts into account for each cetacean population except western Hudson Bay beluga and Northern Hudson Bay narwhal. Potential impacts on pinniped populations are difficult to assess given the lack of information on population size. In the absence of abundance data, a precautionary approach should be adopted. Effects should be deemed significant, and every effort should be made to reduce them to a minimum. Again, using methods applied in California as an index for magnitude of impacts related to mortality/severe injury, the Project would be rated as potentially causing high magnitude effects on marine mammal populations based on ship strikes alone (NSF 2011; Wood et al. 2012).

It is difficult to predict the proportion of animals for which exposure to shipping noise will result in negative responses of sufficient magnitude to cause detrimental effects on reproduction or survival. However, with the current level of hunting exploitation for some of the cetacean populations exposed to shipping, noise-related impacts on reproduction or survival of even a few individuals could lead to negative impacts on population recovery (see above). The loss of just a few whales from eastern Hudson Bay and Ungava Bay beluga due to the Project may jeopardize management objectives.

DFO Science thinks that BIM's conclusion of negligible effects of shipping on marine mammals is unsupported by the data at hand, and not precautionary. DFO Science's analysis indicates that impacts from the shipping component of the proposed Project are likely to be high in magnitude for marine mammals. The final EIS proposes surveillance monitoring that in all likelihood would not detect Project effects and few mitigation measures with relatively limited efficacy.

DFO Science's recommendations

BIM should undertake the following measures aimed at reducing the potential for interaction with marine mammals, particularly in Hudson Strait:

- give careful consideration to reducing shipping rates during winter months when interactions with marine mammals are likely to be the most problematic;
- give careful consideration to alternate shipping routes through Hudson Strait (repeated winter aerial survey results showing marine mammal distribution and densities in Hudson Strait would greatly assist in this task);

- prior to commencing the Project, develop a well-designed long-term monitoring program to document impacts of shipping on health and habitat use, particularly in Hudson Strait during the winter period of high occupancy (the current monitoring program would not be effective at detecting less-than-extraordinary impacts);
- revise the proposed surveillance monitoring to improve the likelihood of detecting strong marine mammal responses occurring too far ahead of the ship to be detectable by the MMOs aboard the ore carriers[8].
- ensure that data produced by the surveillance monitoring program are analysed rigorously by experienced analysts (i.e., not simply "discussed" as proposed in the final EIS) to maximize their effectiveness in providing baseline information and for detecting potential effects of the Project on marine mammals in the RSA. Data from the long-term monitoring program should be treated with the same rigor.

3.3.3 Vessel Traffic and Icebreaking

Final Environmental Impact Statement, Volume 1 Executive Summary; Volume 3 Section 3.6.3.2 page 88-89; Volume 3 Appendix 3G (Enfotech Report); Volume 3 Appendix D of Appendix 3G; Volume 8; Volume 9 Section 3.6.5; Volume 9 Section 3.8 Table 9-3.6; Volume 10 Appendix 10D-D Section 3.2.2.5 page 17-18

BIM's position
BIM concludes that shipping-related accidents and malfunctions are unlikely to occur; only diesel spills during ship-to-shore transfer and along the shipping route will result in Project-related residual effects.

BIM deems ice/ship interaction likely but insignificant. The final EIS states that the ship track in mobile pack ice will disappear within six hours of the ship passing based on evidence from the *MV Arctic* transit of Hudson Strait in winter. BIM concludes that ice-breaking activity is indistinguishable from ice dynamics under natural conditions. Within the landfast ice, the ship track will remain throughout the winter with continuous ice formation producing a build-up of rubble in the track over time and gradual widening of the ship track of 1.5 km or more by late winter.

DFO Science's analysis and assessment
DFO Science disagrees with BIM's conclusion that the risk of most shipping-related accidents and malfunctions is low. Judson (2011) reports that of the 599 marine casualties[9] recorded in the Canadian Arctic, 27 percent (164/599) were ice damage events and of 213 recorded casualties since 1991, 128 have occurred within ASPPR (Arctic Shipping Pollutions Prevention Regulations) Shipping Safety Control Zones. While the casualty record shows that most incidents occur in the Arctic along the primary traffic routes, they are concentrated in three regions: Mackenzie River delta, Lancaster Sound, and Hudson Strait.

DFO Science assessed BIM's *Relative Risk Value of a "Worst-case Spill Scenario" per Vessel Type* (Volume 9 Table 9-3.6 page 100) to examine the risk of shipping-related accidents (see

[8] A baseline study early in the shipping operations could employ additional surveillance to detect potential changes in distribution patterns and behaviour. At an ambitious scope, this might be achieved using unmanned aircraft flown well ahead of ships, or over haulout sites in the case of walruses.
[9] A marine casualty is a reportable accident or incident including occurrences such as injury, death, sinking, collision, explosion, grounding, power failure or marine spill.

Appendix 3 below). According to the Transportation Safety Board of Canada (TSB), The rate of accidents among commercial ships in Canada over the past 10 years has ranged from 3.1-4.7 with an average of 3.7/1000 movements (http://www.tsb.gc.ca/eng/stats/marine/2010/ss10.asp#sec1 Table 3). With 4,982 vessel movements over 29 years (Appendix 3 below) BIM can expect to have, on average, 18 accidents. Not all of those would result in foundering, capsizing, or sinking. TSB summaries suggest only about 10% (about two) of the predicted accidents would include loss of the vessel (TSB 2010). This may be optimistic because most TSB records are not from the Arctic and reflect less challenging maritime environments. A recent Lloyd's of London report (Emmerson and Lahn 2012) noted that *Ship owners and shipping companies operating in the Arctic face a number of risks over and above the normal risks they would expect to face.* These include ice contact to the hull and as well as the propeller, rudder and associated machinery, grounding, icing, extreme weather conditions, collision, delay/lack of salvage exacerbated by remoteness, limited hydrographic and meteorological data, and communication problems.

BIM proposes frequent ship passages in a corridor only 1.5 km wide and at times, two ore carriers will be passing each other within this shipping corridor. The TSB data indicates that over 70% of ship-to-ship collisions occur in head-on encounters (see Allen 2005). An Automated Identification System (AIS) is often used as a means to identify and locate vessels and avoid collisions. AIS errors have been noted and coverage in the Arctic may not be as complete and comprehensive as in other areas. The hazards of navigation are more challenging in winter with long hours of darkness, winter storms, and ice. BIM's ice-navigation experts have cautioned about the hazards and even the feasibility of passage through Hudson Strait in winter (Ice Management Workshop Agenda and Facilitator's Report). In the absence of data in the final EIS that verifies accidents will occur only rarely, TSB data predict accidents far more frequently and suggest that, over the life-span of the project, the probability of a serious marine accident is all but certain. DFO Science disagrees with BIM's conclusion that a major diesel spill is the only Project-related residual effect that could occur as a result of shipping-related accidents and malfunctions.

BIM's statement regarding pack ice closure is based on a single satellite image of the *MV Arctic* which is capable of travelling through ice 1.5 m thick at a speed of 2 knots (http://en.wikipedia.org/wiki/MV_Arctic citing FedNav for 1986 specifications). The Project ore carriers are reported to travel at a speed of 7 knots through winter ice. There is insufficient support for BIM's conclusion that the ship track will be indiscernible in pack-ice within six hours of the ship passing, and thus ice breakup along the ship track will have little or no impact on marine mammals. More environmental data are needed to assess the impact of ship tracks through pack ice and resulting implications for marine species. As pack ice is dynamic in its movements, ship tracks may affect a broader area than described in the final EIS. The higher frequency of occurrence, timing and location of ice breaking along the ship track mean that Project-related ice breakage differs from natural (undisturbed) ice dynamic processes. As a result, there will be biological implications including changes to the epontic (sub-ice) community that have not been evaluated.

DFO Science's recommendations

- As shipping-related accidents and malfunctions are likely to occur over the life of the Project that will result in environmental degradation and/or loss of marine organisms and/or habitat, a clear reporting mechanism should be in place to identify occurrences. In addition, a response plan should be developed, which includes performance indicators, for all possible marine scenarios not just diesel spills.

- BIM provide additional evidence or a plan to collect data on ship-track closure in pack ice to validate their assumptions and to evaluate the biological impacts based on all available data.

3.3.4 Oil Spills

Final Environmental Impact Statement, Volume 1 Section 7.2 page 99-102; Volume 3 Appendix 3B Attachment 5; Volume 8; Volume 9 Section 3.1 Table 9-3.2; Volume 9 Section 3.6 page 95-118; Volume 9 Section 3.8 pages 99-114; Volume 9 Appendix 9B; Volume 10 Appendix 10-D10 Table 2; BIM IR response to EC #IR 6 and DFO #IR 6.2b; Draft EIS Volume 9 page 82.

BIM's position
BIM concludes that a major diesel fuel spill is "unlikely" (i.e., a frequency of once every 100-1,000 years, Table 9-3.2) with a low risk for a variety of reasons. Fuel tankers operating along the southern shipping route were used to develop a credible worst-case scenario for BIM's oil spill risk assessment. The final EIS indicates that if a spill were to occur, the impact would be low because much of the bulk fuels used by the project are diesel which is lighter than water and will undergo evaporation, emulsification, natural dispersion, dissolution, sedimentation and biodegradation. The final EIS also states that a diesel spill by a tanker in open water *could result in a moderate magnitude effect to most marine environmental components…a large spill, depending on location and sensitivity of the area, could have a large extent…but effects are short-lived due to the volatility of diesel fuel*.

BIM recognizes that oil can affect marine species through dermal contact, ingestion, inhalation and fouling of baleen. *A number of sublethal effects of oil exposure or the consumption of oil-contaminated prey has been documented for seals, including changes in behaviour and physiology, but there is little evidence to irrevocably link seal mortalities to oil exposure*. The final EIS also indicates that *likely effects include consumption of oil-contaminated prey, changes in behaviour and changes in physiology due to fouling*. The final EIS concludes that all marine mammals excluding walrus are considered to be at low risk from an oil spill along the southern shipping route. Walruses are most likely to come in contact with a spill if one occurs near a walrus haulout site, therefore they are considered to be at moderate risk.

DFO Science's analysis and assessment
DFO Science agrees with BIM that if a major diesel fuel spill occurs along the shipping lane, it *would have a significant environmental effect*. Also, that a *large spill, depending upon the location and sensitivity of the area, could have a large extent (level II or possibly level III) and effects are potentially permanent (level III duration) and only partially reversible (level II reversibility)*.

A maritime emergency, which may lead to or include fuel loss, along the shipping route relies on tugs based at Steensby Inlet to respond. The response route could by 600-1,200 km and take many hours. An emergency response to Hudson Strait in winter will be even more problematic. BIM proposes to have two of the four ice-breaking tugs at Steensby Inlet (up to four tugs in total) but their transit times will be greater in ice than in the open water season. BIM considers the Canadian Coast Guard's (CCG) current levels of service in the Foxe Basin, Hudson Strait, and the east coast of Baffin Island to be adequate for current and foreseeable needs. The CCG, on the other hand, notes in its plans for 2011-2016, that after November, there are no CCG ice breakers in the Arctic; the closest are in Newfoundland (http://www.ccg-gcc.gc.ca/NMAB-Icebreaking/Annex-C). Thus response times will not be short (see Appendix 3, below).

While the final EIS did not consider a spill in ice it does note that different types of sea ice can significantly affect weathering processes. *The oil found on the upper ice surface weathers predominantly through evaporation, but the portion incorporated in the ice does not undergo weathering until the melting season.* A report prepared for the National Energy Board (NEB) in 2011 (S.L. Ross Environmental Research Limited 2011) stated that during freeze-up and winter (December through July) an active response would be deferred until the following melt season. For those types of spills, the response technique is to track the oil through the winter months while it remains encapsulated in the ice, and then to apply *in situ* burning when the oil appears on the surface of the ice during the subsequent melt season (S.L. Ross Environmental Research Limited 2011). All the evidence provided in the final EIS indicates that a response to a winter maritime emergency will be untimely and, for an oil spill, inadequate. There is no plan to manage a motive-fuel spill along the shipping route.

The behavior of oil spills in ice and implications for Arctic spill response has been studied through the use of field experiments conducted over the past 40 years (Dickins 2011). Some notable response challenges related to the unique aspects of oil behavior in ice have been reported. This includes the following: (1) difficulty in accessing oil trapped on or under ice especially offshore in moving pack where crews cannot maintain sustained operations on the ice without continuous, reliable and immediate means of evacuation; (2) lack of oil spreading or flow within often slush and brash-filled leads and openings in the pack ice, making skimming operations extremely difficult and ineffective; and (3) sensitivity of oil spreading in ice to subtle changes in floe geometry and ice coverage. The implications of the latter are that the very action of manoeuvering a vessel close enough to access the oil using, say, over-the-side skimmers may create rapid spreading of the slick into much thinner, less recoverable films.

The worst-case oil spill scenario presented in the final EIS is 5 million litres (ML) of diesel being spilled. The oil spill assessment assumed a spill from a fuel tanker where two of 14 separated storage compartments released 75% of their contents (10% of the total cargo) during the open water season. The grounding of the Clipper Adventure in August 2010 in the western Arctic is a recent example where *13 double–bottom tanks and compartments including 4 full diesel oil tanks were holed* (http://www.bst-tsb.gc.ca/eng/rapports-reports/marine/2010/m10h0006/m10h0006.asp). Extensive damage to the ship occurred in spite of its sturdy design.

The type of diesel spilled affects the environmental impact. The lighter refined products are more volatile, and their evaporation reduces the amount of oil remaining on the surface. However, the lighter oils dissolve and disperse more readily into the water column and are expected to have greater impacts on fish and invertebrates in the water and on demersal fish and invertebrates in the benthic zone. The final EIS notes that most fuels being delivered are diesels which they claim will be *completely evaporated within days of a spill*. Based on information presented in the draft EIS, but removed from the final EIS, their evidence relies on a spill of ~16,000 L and its evaporation under 10 knot winds and 20°C temperatures, conditions not typically found in Foxe Basin and Hudson Strait. Colder temperatures would reduce evaporation rates. The final EIS states this temperature is *similar to what could be expected during the open water shipping season* and also notes that *evaporation does increase viscosity and density of the remaining oil.* The diesel spill modelling assumes a spill of limited extent occurs during open water for a short duration. The fate of heavier, more persistent residue is not discussed but would likely contribute to the ill effects of emulsification and dispersion (onto ice and shorelines) while increasing the accumulation in sediments and impeding natural degradation by dissolution and biodegradation. Marine diesel oil has a low viscosity (http://en.wikipedia.org/wiki/Fuel_oil, accessed 1 May 2012) and should have been addressed on its own rather than being lumped with other diesel fuels.

The final EIS concludes that sea birds, estuarine habitats including salt marshes important for geese and co-occurring with many anadromous Arctic Char streams, and marine mammal congregations, including walrus haulouts, are vulnerable to significant exposure in a worst-case, open water diesel spill. Marine mammals and birds are particularly vulnerable in winter when confined to reduced areas of open water. The final EIS properly indicates that the risk of a fuel spill event is a combination of probability (likelihood) of occurrence and consequences (impact) of the event. However all they include in their assessment of a worst-case scenario of a major diesel spill is the likelihood of a fuel spill based on the various vessel types. DFO Science does not agree with BIM's assessment of the fate of the spilled oil as it relates to persistence in the Arctic marine environment and sensitive environmental components impacted. The fate of the oil depends largely on location and season, both of which influence response time and ability to clean up and thus the impact on the surrounding environment. While the risks of a spill along the route appear mathematically equivalent to those in port, response times, hence spill persistence, vary greatly. DFO Science's reanalysis of BIM's data (see Appendix 3, below) shows that the risk of oil spills is highest for a transiting ore carrier during the ice season and secondly a fuel tanker operating along the shipping route (in open water). A tanker in port represents a much lower risk.

The final EIS describes impacts of a worst-case spill scenario on the environment. Although the final EIS identifies harm to marine mammals arising through ingestion and inhalation, it does not discuss these pathways. The final EIS points out that in birds, oil exposure through diet can have serious non-lethal and latently lethal effects but does not discuss the same effects in marine mammals. The final EIS notes that oil residues are taken up quickly and persist in benthic organisms and that these organisms can be ingested by walrus (and presumably other marine mammals). It notes that there can be behavioural and physiological changes in seals and walrus but there is no discussion of what these physiological changes might be or how they might have life-history consequences for the mammals, such as increases in cancer or decreases in reproductive success. The US National Marine Fisheries Service has published a short summary of the impacts of oil on marine mammals (http://www.nmfs.noaa.gov/pr/pdfs/health/oil_impacts.pdf). The report lists a wide range of potential effects resulting from inhalation, ingestion, absorption of petroleum compounds which produce various effects including irritation, chemical burns, infections, organ damage and long-term chronic effects.

DFO Science's recommendations

Given the number of ship movements planned and TSB statistics on accidents in Canadian waters, the likelihood and severity of shipping-related accidents and malfunctions including a major diesel spill, have been underestimated in the final EIS. For those reasons a precautionary approach should be used, and the following should be done.

- Clarify the types of fuel used for the Project and the types of fuel ships will be using for propulsion, and whether an accidental spill would require specific clean-up as this was not provided in the final EIS.
- Develop a plan that would monitor spill response, recovery capability and track the fate of oil in the event of a spill along the shipping lane, especially during the winter months when clean-up may be delayed until spring melt. Make use of the available body of literature on the behavior of oil spills in ice and implications for Arctic spill response and the environment.

- The Emergency Response and Spill Contingency Plan for marine spills must include spills that may occur along the shipping lane, not just at the port sites, and for winter conditions. Proposed spill response procedures for wildlife protection must address mitigation for marine mammals.
- The EMMP, which includes mitigation measures for marine mammals (Shipping & Marine Wildlife Management Plan), must include mitigation measures in the event of a fuel spill along the shipping lane. Mitigation should take into account the impact of spilled fuel on marine mammals (e.g., damage to ocular surfaces and interferences with olfactory cues such as mother-young bonds, ingestion or inhalation pathways and sub-lethal effects to seals including reproductive failures) particularly during winter when they cannot escape coming into contact with diesel and fumes.
- Avoiding polynyas (i.e., areas of less ice) during winter months is one possible mitigation measure that would protect marine mammals.

3.3.5 Ballast Water

Final Environmental Impact Statement, Volume 1 Executive Summary; Volume 8 Section 2.6.2.2; Volume 8 Table 8-4.9; Volume 8 Appendix 8B-1; Volume 10 Appendix 10D10 Appendices 5 and 6; BIM IR response to EC #IR 5 and QIA-IR-D-02-04, QIA-IR-D-16, DFO #IR 5; BIM IR response Appendix 1

BIM's position
In the final EIS, BIM indicates that *ore carriers will carry ballast water during their inbound trips to Steensby Port. In order to reduce or eliminate the risk of invasive aquatic species and pathogens being introduced into Canadian waters… only mid-ocean ballast water will be released into Steensby Inlet* and *all ore carriers will be treating their ballast water from the onset of shipping. Ballast water will only be slightly different (in temperature and salinity) from the water in the Inlet.* BIM concludes based on its ballast dispersal modeling that 17.1 million cubic meters of ballast will be discharged annually but it *will not alter the quality of water in Steensby Inlet. Baffinland is committed to regular testing of ballast water discharged both from the vessel and in Steensby Inlet.*

DFO Science's analysis and assessment
Very high volumes of ballast will be discharged into and around Steensby Inlet over the life of the Project. There has been no ballast exchanged in these areas before. The final EIS includes the anticipated regulatory requirements for ballast treatment and indicates that ballast will undergo mid-ocean exchange. The modelling provided by BIM indicates that a large and persistent lens of foreign water will form in Steensby Inlet and increase in size each year. The ballast water will differ from the receiving waters and may result in reduced benthic productivity particularly during open-water periods. There is the potential for ecosystem impacts as a result of the ballast water release. This is in addition to the potential for introduction and successful establishment of non-native species in the waters of northern Foxe Basin. The combination of exchange and treatment should lower the risk of invasive species but it will not eliminate it as ballast water exchange is not 100% effective (e.g., Bailey et al. 2011) nor is ballast water treatment. The modelling should have included a risk assessment that considers the primary source ports and the efficacy of ballast water exchange as a cumulative impact. It should have considered the long-term discharge of ballast water and differences in the properties of untreated and treated ballast water. The fate of ballast water discharge outside of Steensby Inlet is not considered in the final EIS either in terms of the discharge of 130,000 m^3 ballast/ship approaching the port and the plume of ballast water that flows out of Steensby into Foxe Basin.

Little information is provided in the final EIS about the impacts of ballast inputs on lower trophic levels including eggs and larval stages of benthic organisms. A contingency plan should be developed in the event that ballast water exchange or treatment is not effective. Biofouling is another source of non-native introductions that BIM considered in the final EIS.

DFO Science's recommendations

- When a decision about ballast treatment options is made, BIM should consider the following: (1) time required for effective treatment and the duration of the voyage from the exchange point to Steensby Inlet (to determine if the treatment will have sufficient time to be fully effective), (2) source and receiving port characteristics, and (3) potential effects of treated ballast on marine organisms and communities in Steensby Inlet.

- A contingency plan should be developed in the event that ballast water exchange or treatment is not effective. For example, ballast could be released prior to entering Hudson Strait with the ore carrier escorted by icebreaker through Hudson Strait and Foxe Basin.

- BIM needs to develop a detailed monitoring program (for the environment and fauna) at a number of sites (e.g., northern Steensby Inlet, the port site, entrance to Steensby Inlet) over the long term both to evaluate changes to marine habitat and organisms and to monitor for non-native introductions. The program needs sufficient statistical power to detect changes that have biological consequences. This should be implemented several years prior to any ballast discharge into Steensby Inlet to collect sufficient baseline data and should continue over the life of the Project.

- BIM should develop a detailed monitoring plan for biofouling. It should include sampling areas on ships where antifouling treatment is not applied (e.g., anchor chain, sea chest, block marks, areas where coating is damaged) as the areas where non-native species are most likely to occur.

- The ballast water modelling should be reevaluated once more detailed bathymetry of Steensby Inlet is acquired and sampling should be undertaken to evaluate the model results and to inform sampling sites and the monitoring plan.

3.3.6 Ship Wake Effects

Final Environmental Impact Statement, Volume 8 Section 5.7.2.2 Figure 8-5.6 Table 8-5.7; Volume 8 Appendix 8D-2; BIM response to DFO #IR 5.2

BIM's position

BIM provided additional information on ship wake effects on shorelines in their final EIS. They concluded that *ship wakes are unlikely to cause any measurable erosion or habitat alteration along the proposed shipping routes*. BIM also indicated that there was unlikely to be an interaction between ship-generated wakes and walrus or seals.

DFO Science's analysis and assessment

Given uncertainties associated with the shipping route (e.g., deviations), wake characteristics of the as yet unbuilt ore carriers and haulout locations of pinnipeds especially walrus, the modelling results presented in the final EIS are best estimates given the available information.

DFO Science's Recommendations

- BIM should develop a monitoring plan to verify the accuracy of the modelling predictions.
- If impacts from ship wakes are more significant than the final EIS predicts then additional mitigation measures will need to be implemented, such as re-routing vessels and altering ship speeds.

3.3.7 Sediment Redistribution

Final Environmental Impact Statement, Volume 8 Section 3.4; Volume 8 Section 4.5.2.1

BIM's position

BIM concludes in the final EIS that sediment deposition at the port site is expected to be contained within very small areas (8.83 ha of bottom at Steensby Inlet port and 1.04 ha at Milne Inlet port) and will therefore have negligible effects on seabed habitat or benthic species. The final EIS indicates that the ore carriers have the potential to cause sediment mobilization on the seafloor along the shipping route, as a result of propeller wash, where water depths are less than 120 m. However, the effect will be brief and *in many instances will be exceeded by longer duration natural forces such as tidal currents and wind waves during storms*. The ship track will never be precisely the same so any disturbance caused by prop wash above what would naturally occur will be spread over a broad area of seafloor therefore *the effects are not expected to be any more severe than currently occurs along most of Canada's shipping routes*.

DFO Science's analysis and assessment

The conclusion of sediment containment at the port sites appears to stem from the use of bubble curtains to contain sediments, but there is no discussion or analysis of how far any escaping material is likely to travel. The effects of changing direction and manoeuvering of vessels in particularly shallow areas along the shipping route are not discussed. The fate of re-suspended sediment is unstated. Presumably it will drift until water velocities allow it to settle. Although the final EIS says these areas would likely be small, there is no analysis of re-sedimentation plumes. The area of impact was not quantified but the final EIS indicates that *any disturbance above natural conditions caused by propeller wash will be spread over a broad swath of seafloor*. If it settles in sufficient quantities *changes to benthic communities could result from changes to seabed sediment composition*. This could impact walrus feeding areas. The final EIS contains limited discussion of the effect of re-suspended sediment on quantity and quality of benthos. Additionally, re-suspension can increase the uptake of naturally occurring metals by clams, and thus bioaccumulated by walrus. This pathway of effect was not considered in the final EIS.

DFO Science's recommendations

- BIM should develop a monitoring plan to verify the accuracy of their conclusion about level and area of sediment impacts resulting from propeller wash.
- If impacts from sediment redistribution are more significant and cover a broader area than the final EIS predicts then additional mitigation measures will need to be implemented.

3.4 Impacts of Aircraft Noise

Final Environmental Impact Statement, Volume 8 Section 5.7.1.2; Volume 8 Sections 5.7.2.2 and 5.7.2.5; Volume 8 Appendix 8D-1 Figures 8D-1.2 and 8D-1.4

BIM's position
BIM modelled aircraft noise over known haulout sites for walrus. They concluded that none *of the known walrus locations are within estimated noise level contours greater than 40 dB. Therefore, it is unlikely that walruses hauled out at the known haul out sites would hear an overhead Boeing 737. Given the geographic separation of the known haulout sites and the aircraft flight paths and the estimated altitude of the aircraft, it is very unlikely that hauled out walruses on Jens Munk Island and Bushnan Rock (two closest known haulout sites) would visually detect Boeing 737s.* BIM has indicated that Project aircraft will be prohibited from flying directly over walrus haulout sites. The final EIS indicates that mortality from stampeding is linked to large herds and concludes that since large herds are not expected in Steensby Inlet there should be no mortality from stampeding.

DFO Science's analysis and assessment
The aircraft noise modelling does not appear to take into account various weather and ice conditions which can significantly alter ambient noise levels, marine mammal haulout behaviour and sound propagation. Lack of habituation among walrus to repeated over-flights also was not considered. The large but undefined concentration of walrus at the floe edge east of Koch Island will be over-flown frequently by Boeing 737s during the four-year construction period. The final EIS includes evidence of direct mortality from stampedes and induced abortions among walrus due to low-flying aircraft (~150 m altitude) over 400 m away and higher over-flights at ~800 m (altitude). Although large herds may not be found in Steensby Inlet this is not true for the entire area under the flight path. Flights over walrus aggregations on pack ice will be at higher altitudes but literature cited by the final EIS indicates they may still result in non-zero impacts. While flight frequency will be less after construction, when ore carriers are passing through the ice regularly, the combined effects of various sources of disturbance (e.g., broken ice, ship noise, regular over-flights) was not discussed. Thus, the aircraft sound modelling and predicted responses of marine mammals are best estimates.

DFO Science's recommendations

- BIM should develop a monitoring plan to verify the accuracy of their conclusion about the impacts of aircraft noise on walrus.
- If impacts from aircraft noise are more significant than the final EIS predicts then additional mitigation measures will need to be implemented, such as altered approaches and schedules.
- Monitoring should continue beyond the construction phase of the Project and include more than the port site and select haulout sites.

3.5 Alternate Way of Looking at Project-Related Impacts

Final Environmental Impact Statement, Volume 2 Table 2-3.4; Volume 8 Section 1.1; Volume 8 Section 5.1.2.2; Volume 8 Section 5.5.5; Volume 8 Section 5.7; Volume 8 Appendix 8A-2; Appendix 8B-1 Figures 5 and 8c

The foregoing discussion of Project impacts is presented by threat. Another way to look at Project impacts is from the perspective of the organism. In this section walrus is used as an exemplary VEC to illustrate this approach. Similar issues apply to each of the marine mammal VECs.

BIM's position
The final EIS considers the potential effects of the Project on walrus to include (1) habitat change resulting from icebreaking and the footprint of dock structures, (2) disturbance caused by airborne and/or underwater noise from construction, shipping, and aircraft overflights and waves generated by an ore carrier, (3) hearing impairment and/or damage from construction activities, (4) masking of environmental sounds and (5) mortality from collisions with vessel and stampeding at haulout sites. The final EIS indicates that *it is likely that at least some individuals will be affected multiple times by icebreaking during a single season…* but also speculates that *habituation to the vessels is likely to occur when it becomes clear to the animals that the vessels do not pose a threat.* The overall conclusion in the final EIS is no significant residual environmental effects for walrus with a high level of certainty in the residual effects predictions.

DFO Science's analysis and assessment
Walrus in the regional study area (RSA) occur in two main areas: Foxe Basin and Northern Hudson Bay/Hudson Strait. For organizational purposes, they are separated here although there is overlap.

Walrus occupy northeastern Foxe Basin year round. They use Steensby Inlet in the summer. The concentrations of walrus at the floe edge are the largest in Canada. In the ice-on season, walrus are vulnerable to threats at both the floe edge and in the pack ice. Animals may move between these habitats and be impacted by project-related activities multiple times. The final EIS presents no baseline data to assess the numbers of walrus present at the floe edge, nor any quantitative description of their distribution along the floe edge. Without evidence to the contrary, we must assume large concentrations could be everywhere or anywhere along the ice edge. The final EIS indicates that the extent of the fast ice disrupted is small (1.5 km) and therefore there is no impact but cannot claim with any certainty that the 1.5 km of destroyed floe edge will never coincide with the large concentration of walrus. There is no discussion about walrus which may enter the fast-ice area in a ship track and become entrapped when the track re-freezes.

Walrus breed and calve in winter and spring when they are in the pack ice. There are calving areas both east and west of Rowley Island, with the east 'preferred' by walrus if ice conditions are appropriate. Specific breeding sites in Foxe Basin have not been identified, but it is reasonable to assume they also occur in the pack-ice and polynyas of the area. Surveys conducted were inadequate to estimate the numbers of walrus present in the pack ice segment of the shipping area during breeding and calving. Using average densities is inappropriate because walrus are gregarious and because certain segments of the population will be impacted differently than the population as a whole. It is therefore impossible to determine if large herds may be directly impacted by vessels transits or if large percentages of breeding animals or mothers with calves will be impacted. Evidence that ice-breakers can approach walrus to within 460 m means a sudden stampede or collision is more likely because the walrus were caught 'unaware.'

There is no evidence to support the conclusion that mortality from vessel collisions is trivial because walruses avoid the ships, nor is there any assessment of the cost of that avoidance. There is no indication of mitigative action to be taken if the prescribed shipping route, to which the ore carriers must adhere, lines up with a major concentration of walrus near the floe edge or in the pack ice.

The impact on pack-ice was determined on the basis of a 50 m track without recognition that the newly re-organized pack ice would be different than before the ship passed through; the epontic community may be altered with consequences for walrus food. There is no information in the final EIS by which to assess this impact. From this narrow perspective, the residual effect of habitat change (pack ice) was deemed *not significant*, but it remains a non-zero impact.

Neither the ship track (50-75 m) nor the ship corridor (1.5 – 2 km) adequately describe more than the physical habitat disruption. The final EIS predicts that walrus may avoid ships at distances up to 15 km around each vessel. This means that ship impacts on walrus would extend 15 km on both sides of the shipping route. A more precautionary estimate of the area of disturbance through ice would be 20 km which would mean that 100% of the suitable habitat between Cape Bazin on Koch Island and Cape Jensen (Nuvuit) would be impacted. In the pack ice, the swath of disturbance between the fast-ice limit and Foxe Peninsula is equal to 10,700 km^2 (i.e., 535 km ship track length multiplied by 20 km disturbance width). The local study area (LSA) is 53,500 km^2 (i.e., 535 km multiplied by 100 km). The area of disturbance represents 20% of the LSA but a much higher percentage of the area of ice occupied by walrus. Even if the 15 km disturbance width is used, the total area of disturbance represents 15% of the LSA.

Both breeding and mother-calf bonds rely heavily on acoustic signals. The final EIS allows that masking may occur during these biologically sensitive periods but dismissed them because they will be brief (2-3 hours), and because 3 hours represents only 6.3% of the 48-hour period between vessel transits. Calves can experience greater mortality if their acoustic communication is disrupted for 3 hours. If communications are masked for 3 of every 24 hours, calf mortality may increase. Similarly, masking breeding songs for 3 hours a day for duration of the breeding season is likely to result in reduced reproductive success. The final EIS speculates that walrus will habituate to ship traffic. But this is contrary to scientific literature that shows a lack of habituation among walrus to repeated vessel interactions or to repeated over-flights (Stewart et al. 2012). The final EIS concludes that the residual environmental effect of masking on walruses will be *not significant*, yet the effects are non-zero.

In the open-water season in northeastern Foxe Basin, the walrus from the floe edge will penetrate farther north into the area previously covered with fast ice. There they would encounter the heaviest concentration of near-bottom ballast water. The impact of that ballast water on walrus food is unstated in the final EIS. Ballast water modelling indicates that the ballast water of one year does not completely clear before the next winter's input is added. Thus, ballast water and its potential impacts would increase through the life of the project. There is no indication of the fate of ballast water released in Steensby Inlet or along the shipping route as ships approach the port during the open water season. Walrus that remain in the pack ice in winter may nonetheless encounter ballast water moving from Steensby with attendant impacts on their benthic food. As walrus move closer to the port site, they would also encounter greater noise levels underwater (1-2 ore carriers, 2- 4 tug boats), more bottom scour due to propeller wash and areas where the fuel spills are more likely. Finally, walrus seem apprehensive about new structures that appear on the sky-line from the walrus perspective. There is no discussion of this possible impact in the final EIS.

Walrus in northeastern Foxe Basin would be exposed to numerous non-zero impacts both sequentially and concurrently over the life of the project. They will be exposed to the immediate presence of ice-breakers passing near large herds every other day with frequent jet over-flights. They will be subjected to frequently repeated episodes of masked communications during breeding and post-partum bonding while confronted with changes in benthic habitat and food caused by scouring, re-sedimentation, and ballast water accumulation. Their food may have increasing levels of heavy metals from sediment disturbance. Individual animals can expect to encounter any or all of these impacts repeatedly and ultimately, they may abandon the area. Additionally, if there is an oil spill in winter, the walrus could be exposed to it until spring. Chronic oil discharge, or an accidental spill and subsequent clean-up only exacerbate the overall situation.

The walrus in northern Hudson Bay and Hudson Strait are thought to belong to a different stock than those in Foxe Basin. This area includes significant haulout areas (summer) around Nottingham, Salisbury and Mill islands. Ships are expected to pass on both sides of Mill Island. While the ships will pass south of Mill Island whenever possible to avoid the known walrus haulout on the north side of the island, no ice data were presented in the final EIS to assess the frequency with which ships would have to pass by the north-side haulout. The north shore of Hudson Strait is used by walrus in summer but, more importantly, is a key wintering area. The area is highly productive and contains important walrus feeding areas. Distribution of walrus between seasons appears more dynamic in Hudson Strait than in northeastern Foxe Basin.

There are no baseline data on numbers or distribution of walrus in Hudson Strait so it is not possible to assess potential impacts or to monitor for changes. However, in winter the potential for walrus-ship interactions is greatest as both seek out areas of less ice. Less is known about the breeding and calving locations in Hudson Strait but the same concerns about disrupting breeding and mother-calf bonds exist here as in Foxe Basin. Sediment scour and redistribution, and attendant changes to prey quantity, may be less serious here than in other regions because average depths are generally greater. However that means shallow waters suitable for feeding are more restricted. Off Foxe Peninsula and to a greater extent through Hudson Strait, currents and tidal shifts are large and the fate of re-suspended sediment is unknown. The reorganization of pack-ice from shipping activity would result in consequences for walrus use of the changed pans and alteration of the epontic community in this area but these impacts are not discussed in the final EIS.

Walrus in northern Hudson Bay and Hudson Strait would be exposed to similar accumulating non-zero impacts as in Foxe Basin. Walrus occupying the area would be subject to frequently repeated episodes of masked communications during breeding and post-partum bonding. There would be less aircraft noise but more ship noise because project noise is added to existing shipping noise. As with northeastern Foxe Basin, shipping noise in winter is a new impact. The degree to which sedimentation affects the quality and quantity of walrus food is unknown although feeding areas are restricted. It is difficult to assess ballast water discharge in the area as it is not clear where ships may start discharging ballast en route to Steensby port during the open water season. The volumes of ballast water and its persistence will be less in Hudson Strait but the potential for increased use of the Alternate Ballast Water Exchange Zone in eastern Hudson Strait may offset that advantage. By far the greatest concern centers on the potential for a spill of motive fuel oil in Hudson Strait in winter (see 3.4.3 Oil Spills above). If one was to occur, the spill response would likely be deferred until the following melt season. The physical habitat of Hudson Strait is a challenge to navigation. So in addition to the multitude of accumulating 'planned' impacts, Hudson Strait is the area most vulnerable to a large accidental impact.

DFO Science has identified issues with some of the data and methods used in the effects assessment and interpretation of the results. For example, the significance of call masking in relation to walrus reproductive success, and the method used to conduct cumulative impacts assessment. Additionally, some potential project impacts for walrus were not considered in the effects assessment but should have. These include the following:

- habitat change on (1) haulout and breeding suitability from pack ice restructuring and (2) walrus food web (epontic community, clams, walrus);
- disturbance caused by airborne and/or underwater noise on (1) the effect of concurrent or rapidly sequential noise episodes and (2) stampedes from ice;
- hearing impairment and/or damage from construction activities considering cumulative sound exposure;
- masking of (1) sounds critical for breeding , (2) sounds critical for mother-calf bonds and (3) the effect of concurrent or rapidly sequential noise episodes;
- mortality from stampeding from ice;
- effects from oil on ice due to (1) PAH inhalation, (2) prolonged exposure, (3) sub-lethal effects (e.g., mixed-function oxygenase), and (4) impacts of clean-up;
- effect of re-suspended sediment on quantity and quality of clams as walrus food; and
- effect of ballast water inputs on clam abundance and distribution (walrus food).

The assessment of residual effects should have considered all potential impacts regardless of whether individual effects exceeded the set thresholds.

In summary, DFO Science disagrees with BIM's risk assessment that there is a high level of certainty of no significant residual environmental effects predicted for walrus. Certainty is described in the final EIS as limitations in the overall understanding of the ecosystem and ability to predict future conditions. High Certainty is defined as *baseline data are comprehensive; predictions are based on quantitative data; effect relationship is well understood*. A number of uncertainties associated with impacts of project activities on walrus have been identified in the final EIS as well as planned mitigation and monitoring projects to address them. This indicates that the level of confidence in the effects predictions is not high, or even generally high, as reported. Based on the definitions of certainty provided in the EIS a rating of 'low' or 'medium' would be more appropriate.

DFO Science's recommendations

- BIM should acquire acoustic measurements to refine safety zones for blasting activities and develop appropriate mitigation measures.
- BIM should undertake monitoring at the Steensby Inlet Port site and along the shipping lane before, during and after the construction phase to document walrus occurrence and the potential response to site activity, including overflights.
- BIM should monitor aircraft noise levels before, during and after the Construction Phase and include more than just the port site and select haulout sites identified in the final EIS.
- BIM should investigate the effects of repeated exposure of walrus to ore carrier passages by conducting aerial surveys of walruses during winter in Foxe Basin.

3.6 Thresholds

Final Environmental Impact Statement, Volume 2 Section 3.5; Volume 8 Section 1.5 Table 8-1.1; Volume 8 Section 5.5; BIM IR response to DFO #IR 2.2 Appendix 5

BIM's position

Thresholds were developed for measureable parameters used to aid in determining the magnitude of project effects on VECs. In general, thresholds were selected to reflect available scientific knowledge and regulatory context for each interaction and where possible reflect known effects levels or regulated standards that are usually based on such knowledge. In some cases where no information is available the selected threshold reflects a conservative but realistic set of assumptions, e.g., an effect that influences a defined portion of a local (or exposed) population would be of a magnitude that can produce a significant negative residual effect. In cases where there is uncertainty as to the absolute population numbers (more the rule than the exception) a conservative approach was taken, i.e., the evaluation is based on a portion of the known total range of the affected species/population. This approach is commonly used in environmental impact predictions and results in biologically appropriate thresholds, i.e., the affected portion of the species/population lies within the known or accepted range of natural mortality levels. Thus, even in the most extreme case where the interaction under consideration could result in mortalities, the effect at the population level would not result in a net reduction of population size. When considering marine mammals, the final EIS relied on the professional judgment of highly-experienced and credible professionals who have prepared many environmental impact statements using the methods applied to the Mary River project final EIS. The rationale for selection of threshold values used in the final EIS was based on past use for a limited number of other projects cited in the final EIS.

DFO Science's analysis and assessment

DFO Science questions the scientific basis for the selected thresholds. BIM's rationale for choosing their thresholds is, in DFO Science's opinion, unsatisfactory. They were based on precedents set in a limited number of previous operations which are not comparable in scope, duration, potential impacts, or marine species composition with the regional study area (RSA) and magnitude of Arctic operation proposed for the Mary River Project. Evidence was not provided that these thresholds have proven efficient in other contexts to detect changes, and most importantly, in a timely manner. For instance, BIM proposed a 10% threshold for changes in population size. However, an investigation of the power of most monitoring programs in the U.S. has determined they are unlikely to detect population declines smaller than 50% (Taylor et al. 2007). Furthermore, DFO Science's analysis indicates that population declines of a smaller magnitude than 10%, as a result of the Project, would jeopardize recovery of several marine mammal populations that are already of special conservation status (see Appendix 1, below).

DFO Science also does not agree on what constitutes a "significant" effect on marine mammal abundance, distribution, behaviour or health in the context of the Mary River Project. And as mentioned above, even after significance thresholds are set, there are operational hurdles which make it difficult to measure these parameters with adequate precision to know when a (likely low) threshold effect has actually been exceeded. In effect,

- BIM has not proposed any appropriate or rigorous monitoring protocol of noise and shipping effects on marine mammal distribution, behaviour, reproduction, or health;
- BIM appears to assume that any project-induced mortality is subsumed in, not additive to, natural mortality unless project mortality rates exceed natural rates;

- BIM has failed to demonstrate that potential impacts of the project can be adequately detected using the proposed "surveillance monitoring" or "monitoring" plan;
- BIM has not demonstrated they can mitigate significant impacts of shipping, even in situations where they are detected.

DFO Science's recommendations

- BIM should provide better rationales for the thresholds employed in the proposed mitigation plan. The rationales need to be supported by quantitative analyses and should include power analysis of monitoring efficacy.
- In considering allowable mortality levels, BIM should take into account indirect mortality into their impact assessment resulting from prevented and aborted reproduction as well as increased indirect calf/pup mortality that could have an impact on the population equal to direct mortality.
- BIM should make better use of marine mammal survey data by examining the existing, albeit old, survey estimates with the goal of conducting a power analysis to determine the scope of survey coverage and precision necessary to detect a local abundance change (as a proxy for displacement or mortality) in the marine mammal species of concern.
- BIM should consider incorporating biological parameters likely to provide an early warning for detecting reduced population growth in their monitoring program. These could include an index for gross annual reproduction and age structure for each marine mammal species to assess reproductive failures and indirect calf/pup mortalities, short-term behavioural changes in relation to shipping, etc.

3.7 Baseline Studies and Monitoring

Final Environmental Impact Statement, Volume 8 Section 5.1; Volume 8 Appendix 8C-1, 8C-2; BIM IR response to DFO #IR 4.1c, 7.3-7.4

BIM's position

BIM predicts no cetacean population decline of 10% or more. They have committed to acquire baseline information on marine mammal behaviour and habitat use, and have begun to do so by conducting an aerial survey in March 2012. They have also committed to the development of a detailed Environmental Effects Monitoring Plan (EEMP) and concomitant adaptive management measures, to address potential effects of shipping on marine mammals. The Shipping and Marine Wildlife Management Plan and the Biophysical Environmental Effect Monitoring Framework provide frameworks for the development of the EEMP including adaptive management measures. While baseline data will be acquired for some marine mammal VECs, *an elevated level of focused Environmental Effects Monitoring would be applied if and when a negative interaction was identified.*

DFO Science's analysis and assessment

From DFO Science's perspective the baseline information presented is, in some cases, inadequate to assess potential Project effects on the marine environment either to make predictions or to monitor and, as necessary, mitigate. The proposed surveillance monitoring is unlikely to identify the occurrence of negative interactions of shipping with marine mammals and thus trigger more focused Environmental Effects Monitoring (EEM). Waiting until a negative interaction has been identified is almost certain to prevent timely reversal of the interaction. BIM has committed to acquire baseline information on marine mammal behaviour and habitat use, and has begun to do so by conducting an aerial survey in March 2012. BIM's March 2012 Hudson Strait aerial survey provides a good start to providing necessary baseline but must be continued to collect sufficient baseline data for comparison with data collected In the future through a well-designed monitoring program. This approach would have the potential to allow early detection and mitigation of Project impacts.

DFO Science is also concerned about the adequacy of some methods proposed to monitor patterns and effectively detect changes in characteristics of VECs (e.g., effects of shipping on marine mammal behaviour and habitat use). The final EIS includes a description of the Framework for design of candidate EEMPs but lacks sufficient details about the sampling regime prior to and during project development and operation. Most importantly, there is no evidence of scientific rigour in data analysis.

There are as yet no operational "standards" for monitoring the impacts of anthropogenic effects on marine mammals in Canada. The following general approach would be needed to achieve such monitoring during Baffinland's Mary River Project shipping operations (see also Appendix 2, below). First, agreement is needed on what constitutes a "significant" effect on marine mammal abundance and distribution (both magnitude and rate). This will be contingent on the life history of the marine mammal and its current population status with respect to a naturally-changing environmental carrying capacity. Second, even after guidelines are set for "significant" effects, there is the operational hurdle of potentially being unable to measure abundance and distribution with adequate precision to know when a (likely low) threshold effect has actually been reached. Third, it is possible that to attribute an observed population or distribution change to industrial development will require mechanistic studies that are currently not usually possible with the resources and tools available to study marine mammals.

Proposed project operations would require that monitoring (and mitigation) be tailored to the type and size of the development activity, and the life histories of the marine mammals that might be impacted. More importantly, it must be assumed that transiting large ore carriers through the study area year-round would have a non-zero likelihood of negatively impacting marine mammal population growth there. Given this precautionary assumption, BIM should spend additional time designing approaches to mitigate Project effects as currently there appears to be no adequate mitigation measures in place if impacts are deemed important.

Detecting impacts in excess of the thresholds defined currently in the final EIS will be extremely difficult. BIM predicts no cetacean population decline of 10% or more. Surveys should be conducted with sufficient precision to be able to detect changes of this magnitude. However, given the low precision of the baseline cetacean abundance and distribution data presented in the final EIS, detecting a population decline of 10% would be difficult, especially given the uncertainty about impacts and their potential gravity for some of the populations involved. Given this, it might be more realistic for BIM to improve the precision of their baseline data, assess the population regularly, and/or re-design their monitoring and mitigation measures (including alternate ports, routes and shipping patterns) in ways that would allow for rapid detection of changes in marine mammal habitat use or population dynamics, and minimize such impacts.

Well-designed baseline studies are important not only to assess and qualify the components of ecosystems that might be impacted by the Project, but also to disentangle natural versus project-related variation in the system. Documenting effects such as those related to shipping traffic on marine mammal behaviour, distribution, habitat use, reproduction or health is particularly challenging scientifically given the natural variability of environmental characteristics and the myriad of factors intrinsic to species that might affect their behaviour and population dynamics. This task is exacerbated in the RSA by the ongoing changes in Arctic climate and thus, the expected changes in ice and other oceanographic conditions which have direct and indirect effects on marine mammal distribution and local abundance and health. In this context, it is particularly crucial to develop scientifically sound protocols that have enough power to ensure that project-induced cumulative changes smaller than those that are extraordinary in magnitude can be detected (see Taylor et al. 2007).

In summary, based on DFO Science's analysis the impacts of Project-related shipping on marine mammals may not be negligible. There are currently no measures proposed by BIM that would effectively mitigate impacts of shipping, even if some were detected. BIM intends to enact focused EEM only if negative interactions with marine mammals are identified. However, the proposed "surveillance monitoring" is, in DFO Science's opinion, inadequate to detect such interaction, thus is unlikely to trigger more focused EEM. In the event where focused EEM would be triggered, thresholds proposed in the final EIS may not be precautionary in some cases, given the variability expected in the data and biology of the species involved. Therefore, BIM should adopt the most scientifically rigorous approaches to monitoring (such as acoustic monitoring and double-platform approaches to aerial surveys), and avoid postponing the development of monitoring protocols.

DFO Science's recommendations
Whatever monitoring protocols are enacted for the Project, they must be carried out in a scientifically defensible way, and with sufficient precision to ensure that potential effects at or above carefully-chosen threshold levels can be identified. In instances when sufficient precision cannot be assured without extraordinary logistical limitations, the Proponent should adopt precautionary approaches such as diverting shipping route away from known or newly-discovered whale aggregations, or pinniped haulout areas within ZOIs.

3.7.1 Overall Monitoring of Marine Operations

- BIM should continue to acquire valid and relevant baseline data on marine mammal VEC distribution and abundance prior to project development and during operations.
- Prior to the Project proceeding, BIM should develop detailed protocols both for data acquisition and analysis, including sampling regime and methods, for each VEC and issue of concern. The proposed approaches should have sufficient statistical power to detect less-than-extraordinary biologically significant effects.
- Given uncertainty about the potentially significant impacts of this Project on several of the VECs, BIM should develop, prior to the Project proceeding, a suite of options for mitigation that have demonstrated effectiveness in mitigating similar impacts elsewhere.

3.7.2 Monitoring Ore Carriers in Transit

The final EIS presents underwater noise modelling. However, there remain significant concerns that the actual sound levels to which marine species would be exposed along the proposed shipping route and near Steensby Port would exceed levels which have been shown to have effects on the same, or similar, marine organisms in other locales. In fall 2011, DFO deployed three acoustic receivers far to the south of the shipping lane to provide ambient noise baseline data for another study. As those receivers are well outside the LSA the data they provide may not be useful to establish baseline for the Mary River Project.

- BIM should conduct an acoustic monitoring program to characterize underwater ambient noise, shipping noise, sound propagation characteristics (and compare this to the pre-project acoustic models), and marine mammal acoustic behaviour and responses to BIM shipping noise in the period before and just as ore shipment begins[10]. These efforts should be augmented by additional in-air and underwater acoustic monitoring of pinniped haulouts, including ice haulouts.
- BIM should deploy year-long autonomous acoustic receivers – the equipment and deployment costs need not be excessive – to provide critical measures of ambient noise. More importantly, should such acoustic data be collected during trial passages of ice-breaking ore carriers, scientists would be able to assess the reality of the pre-operation modelled sound exposures. If acoustic data from certain areas prove to be unexpectedly high, follow-on deployments can better characterise the results. This would be especially important during operational shipping with heavy ice and multiple large ore carriers associated with the Project, possibly in addition to shipping from other mines that are being proposed in or near the eastern Canadian Arctic.
- During the early stage of shipping operations BIM should have experienced Marine Mammal Observers (MMOs) aboard the ore carriers to monitor reactions and provide localized measures of marine mammal densities along the shipping route(s). BIM could consider using standard optical aides (medium-eye or big-eye binoculars, high-resolution video cameras) to detect and identify marine mammals at greater distances from the ships. There are well-established protocols for such monitoring.
- If MMOs are used in the early stages of the shipping program, BIM must ensure that rigorous data collection and analysis procedures are in place to ensure maximal value for the data returned.
- BIM needs to ensure the MMOs are able to monitor marine mammals at distances from the ships that are large enough to ascertain densities and behaviour patterns needed to delineate a ZOI.
- BIM should continue aerial surveys during the Project to monitor densities of marine mammals within, near, and far from the proposed ship track, and also collect data on local ice conditions as a potential correlative factor.
- BIM should couple the ship-based visual observation program with the underwater acoustic monitoring of ship noise, ambient noise, and marine mammal vocal behaviour and responses within, near, and far from the shipping route(s).
- A system that could provide much useful information on marine mammal distribution and responses to shipping operations would be to have Unmanned Aerial Vehicles (UAVs) fly far enough ahead of ships during the first year of operations. These platforms could provide the data to ascertain marine mammal densities and behaviour patterns before the ship's ZOI reaches them.
- Minimum project-long monitoring should include ship's crew training for species identification and mandatory recording of all sightings, reactions and ship strikes - the same would be true for smaller vessel operations.

[10] The ore carriers have not yet been built for the Mary River Project. Data should be collected as soon as possible including using other large-sized ships such as during a possible pre-development test run.

- There should be detailed, minimum ship-mammal distance thresholds, which when exceeded will result in vessel manoeuvres likely to reduce the risk of a ship strike; these manoeuvres could take the form of course changes or speed reductions, within the limitations of vessel and environment safety. Such responses could be enacted by the MMOs or the trained ship's crew, and the distance thresholds refined by the early-operation visual and acoustic studies.
- If, during the course of monitoring, a marine mammal aggregation is detected on the shipping route, all Project and other vessels must be notified and crews (including MMOs if aboard) must be additionally vigilant against ship strikes. In Canada and elsewhere, whale aggregations can trigger implementation of temporary or permanent vessel exclusion zones or vessel speed reductions. These should be considered in the RSA.

3.7.3 Monitoring Construction of In-water Infrastructure

- BIM should collect adequate baseline data near the construction site before development is undertaken to allow for comparisons with construction and operational phases.
- During the early stages of such operations BIM should have trained MMOs nearby to monitor reactions and marine mammal densities. This would provide baseline values, a method to assess marine mammal responses, and a means to mitigate the effects of sounds from very loud activities (such as underwater blasting or pile driving).
- BIM should couple the visual monitoring with underwater acoustic monitoring of operation noise, ambient noise, and marine mammal vocal behaviour and responses. This would provide baseline values, a method to assess marine mammal responses, and a means to better mitigate the effects of sounds from very loud activities when used in conjunction with visual monitoring. These data could also be used to corroborate the acoustic modelling presented in the final EIS.
- BIM would be able to monitor marine mammals at distances large enough to ascertain densities and behaviour patterns needed to delineate a ZOI.
- If MMOs are used in the construction program, BIM must ensure that rigorous data collection and analysis procedures are in place to ensure maximal value for the data returned.
- Minimum project-long monitoring should include training of relevant construction crew in species identification and mandatory recording of all sightings, reactions, and mortalities.

3.7.4 Marine Mammal Baseline and Monitoring

Baseline data and monitoring plans for marine mammals presented in the final EIS are inadequate to make reliable predictions and monitor impacts of the Project. Using walrus as an example, the following are gaps in key baseline data:

- walrus numbers, age/sex components, and distribution of walrus at the floe edge (northeastern Foxe Basin) and in summer and winter (Hudson Strait);
- proportion of the breeding population present at the floe edge (northeastern Foxe Basin) and in the pack ice areas (both areas);
- proportion of mother-calf pairs occupying the shipping area (20 km noise swath);
- the consequences on reproduction of blocking breeding calls for 3 hours a day;
- the consequences on calf survival of blocking communication with mother for 3 hours a day;

- ambient and delivered (jet) noise levels (northeastern Foxe Basin);
- consequences of sediment scour and sediment relocation on walrus food; and
- environmental space to accommodate displaced walrus.

As ore shipments will not commence for several years, BIM should undertake some well-designed baseline studies to fill in gaps identified above. These should include the following.

- Conduct surveys of walrus at the floe edge area in northeastern Foxe Basin each month it exists and in the wintering area in Hudson Strait for at least two years to map their distribution, quantify abundance and determine herd composition.
- Conduct surveys of the summering area in Hudson Strait for at least two years to quantify walrus distribution.
- Conduct acoustic surveys of the floe edge area in each month it exists in northeastern Foxe Basin and in summer and winter in Hudson Strait for at least two years to quantify ambient noise levels in air and water.

3.8 Mitigation

Final Environmental Impact Statement, Volume 8, Various Effects Assessment Summary tables and Significance of Residual Effects tables

BIM's position
The final EIS predicts that the Project will have no significant residual effects for sea ice, water and sediment quality, marine fish habitat, Arctic Char health or marine mammal species (ringed seal, bearded seal, walrus, beluga, narwhal and bowhead whale). Residual effects are defined as post-mitigation environmental effects. The various mitigation measures proposed would be sufficiently effective to essentially eliminate any Project impacts on the VECS and Key Indicators. They have also committed to using adaptive management measures to address potential project-related effects.

DFO Science's analysis and assessment
If and when monitoring activities identify negative impacts from Project activities, alternate approaches to mitigative actions will be needed. The final EIS indicates that adaptive management will be used to mitigate negative interactions but without sufficient details to evaluate the efficacy of this approach. For some project-related effects there may be few options available to mitigate. For example, for shipping impacts on marine mammals (e.g., noise, ship strikes), few if any reasonable mitigation measures exist other than avoiding shipping in Foxe Basin and Hudson Strait. Thus, a highly plausible mitigative action to protect marine mammals would be cessation of shipping through critical areas during critical periods. Shipping route deviations may also be needed.

DFO Science's recommendations

- BIM should prepare alternate mitigation actions in the event that current mitigations are less effective than predicted at minimizing or eliminating Project impacts.

3.9 Cumulative Effects Assessment (CEA)

Final Environmental Impact Statement, Volume 8 Section 5 Table 8-5.6; Volume 9 Section 1.4.4.4

BIM's position
The final EIS considers the potential effects of the Project on VECs. For example, for walrus these include (1) habitat change resulting from icebreaking and the footprint of dock structures, (2) disturbance caused by airborne and/or underwater noise from construction, shipping, and aircraft overflights and waves generated by an ore carrier, (3) hearing impairment and/or damage from construction activities, (4) masking of environmental sounds, and (5) mortality from collisions with vessel and stampeding at haulout sites. The final EIS predicted no significant residual environmental effects on walrus. The final EIS equates a non-significant effect to be no effect and consequently does not consider the possibility of the effects being cumulative. *Cumulative effects to marine mammals are possible, particularly in the marine LSA.* From November to June, vessels that operate in and near the southern shipping route may cause some localized avoidance behaviour by pinnipeds and whales and some masking in whales but *the effects are predicted to be short-lived and will not affect the overall well-being of the animals.* From July to October, there is potential for cumulative disturbance effects between Project vessels transiting the southern shipping route particularly Hudson Strait. However, during the open water period relatively few pinnipeds and whales occur in Hudson Strait and pinnipeds are widely dispersed or located at and near haulout sites typically located tens of kilometres away from the shipping lane (in the case of walruses).

DFO Science's assessment and analysis
DFO Science agrees that cumulative effects to marine mammals resulting from the Project are possible. However, a quantitative cumulative effects assessment was not presented in the final EIS. DFO Science does not agree with the qualitative assessment provided that concludes that cumulative effects would likely be non-significant. We predict in the shipping noise and ship strike sections, that project-related effects are not negligible (i.e., non-zero) so these impacts should be carried forward into the CEA. DFO Science does not accept the concept that impacts to or responses by, in the case of VECs, below the thresholds (i.e., the limits of acceptable change) set by BIM, are zero. Therefore DFO Science also rejects the conclusion that multiple sub-threshold impacts or responses produce a zero sum. If there are different project effects they would still have a cumulative (non-zero) effect on the overall health and population status of a VEC regardless of whether any are below the set thresholds.

DFO Science does not accept the concept of 'cumulative effect' that considers new impacts to be subsumed by pre-existing effects of human activity. Indeed, such an interpretation is the antithesis of the accepted definition. DFO Science considers a more useful approach would be to examine each VEC to assess all the potential impacts that may impinge upon it in biologically-sensitive seasons, annually and over the life-time of the project.

DFO Science's recommendations
- BIM must develop a monitoring plan to verify the accuracy of their conclusion about within project cumulative effects on VECs, particularly marine mammals.
- Overall project impacts on the environment should be fully verified before the doubling of iron ore production is considered.

3.10 Alternatives – Port Site Location

Final Environmental Impact Statement, Volume 3 Section 6.4 pages 116-118; Volume 3 Appendix 3G Appendix D*;* BIM IR response to DFO #IR 1.1; NIRB Guide 7 (2006); NIRB File No. 08MN053, S 6.1 Alternatives, pages 17-18

BIM's position
BIM concludes that their assessment of alternate port locations is sufficient for the purpose of the final EIS and is compliant with the requirement of the Canadian Environmental Assessment Agency (CEAA) Operational Policy Statement. They believe their analysis of alternatives is sufficient to describe the process they used to ascertain that Steensby Port is viable technically, economically and environmentally for uninterrupted year-round shipping.

DFO Science's analysis and assessment
While BIM's assessment may be compliant with CEAA, it is not in compliance with NIRB guide principle #7 which states *The EIS shall include an explicit analysis of all alternative means of carrying out the Project components, including a "no-go" alternative, the identification, and application of criteria used to determine the technical feasibility and economic viability of the alternatives to the Project (e.g., transportation, natural, social, economic and cultural environment).* The draft EIS contained some analysis that supported the port assessment which is not included in the final EIS. Thus the final EIS does not provide sufficient detail to allow DFO, NIRB, or the public to quantitatively compare Steensby Port with the alternatives in terms of the environmental, social**,** and economic impacts and benefits, and economic costs.

The information presented in the final EIS indicates the alternate port assessment was based solely on technical feasibility with BIM's argument that year-round shipping and cape-sized vessels are necessary requirements for economic feasibility of the Project. *Baffinland has opted for a dedicated fleet of 10 to 12 ice class cape size vessels with a nominal capacity of 160,000 to 190,000 dead weight tonne (DWT) cargo capacity*" (Volume 3 p. 115). While it might be argued that smaller ships offer more flexibility, clearly decisions about ship size have been made and they affected port site selection decisions. This demonstrates that BIM has prejudiced selection of alternatives before making a final decision thereby contravening general principle #7 in NIRB's guide (NIRB 2006).

NIRB's guidance to BIM (NIRB File No. 08MN053, S 6.1 Alternatives, p. 17-18) said that *When the Proponent assesses the economic viability for each alternative option, due consideration must be given to the vulnerability of the arctic ecosystem, as well as the potential for extension of the mine life and/or increased iron ore production rates… the associated cumulative effects of each option should be discussed…alternatives assessment shall also include the following aspects: baseline data, VECs and VSECs and assessment boundaries*." The final EIS did not provide evidence for any of this.

Notwithstanding the absence of several required elements, the final EIS failed to properly weigh information relevant to the elements it did review. In the final EIS, the first economic requirement is for year-round shipping. BIM argues that the northern and eastern Baffin Island port locations do not meet technical feasibility criteria in terms of uninterrupted year-round access to the port. The final EIS states that *ice conditions are such that year-round shipping is possible via Hudson Strait and Foxe Basin. Thus a shipping route through Foxe Basin is technically feasible.* In fact, the technical feasibility of year-round shipping to Steensby Port was challenged by BIM's own ice experts and there is no evidence presented in the final EIS to substantiate BIM's assertion. It is not possible to assess the uncertainty associated with year-round shipping with other review factors (e.g., environmental, social and economic impacts and benefits) because the final EIS stopped at this stage of assessment. DFO Science accepts that there are challenges of ice dynamics in the approaches to northeastern Baffin port sites but similar challenges may exist in Hudson Strait.

Some comparisons made in the assessment of port options are misleading, invalid or incomplete. For example, ice conditions to and within Lancaster Sound are only relevant to two (of 12) port options and within Eclipse Sound to one (of 12) port options. Also, the comparison of ice conditions in Baffin Bay in 1986 and 1989 to current conditions in Hudson Strait is invalid. For the alternate port location accessible via Foxe Basin (Nuvuit) the final EIS does not provide a complete cost/benefit analysis, including environmental impacts or benefits, to fully compare the two sites. There is no discussion of the marine benefits (if any) of a shorter marine route and different port location. Thus, this assessment falls short of the requirements stipulated by NIRB.

DFO Science's recommendations

- BIM should demonstrate the feasibility of year-round shipping into Steensby Inlet.
- In the event that year-round shipping is not feasible along the southern route or if mitigation measures would prevent year-round shipping then BIM should re-assess alternate port sites on northeastern Baffin Island, between Pond Inlet and Clyde River. This should include options for different vessel designs and shipping frequencies and the potential for shipping less than 12 months per year. The evaluation should not be based solely or primarily on economic factors, but rather the potential to reduce the environmental impacts of the proposed project.

3.11 General Comments

1. There is a general lack of detail about sampling methods used for baseline studies presented in the final EIS. In several locations there are statements about replicate samples being taken from sites (e.g., 4.4.2.2 Project-Specific Surveys, Methods). This raises the concern that pseudo-replication was common in the sampling designs and analyses. Repeated sampling within sites can be treated appropriately in statistical analyses; it is not possible to determine if the data were handled correctly since no details are provided for statistical analyses.
2. There is a general lack of statistical analyses presented in the final EIS. Trends and differences are commented on regularly but there is no mention of statistical analyses or presentation of the results of statistical tests. It is therefore impossible to assess the validity of statements about trends or differences among sites or time periods.
3. Certainty is reported in the risk assessment and described as *limitations in the overall understanding of the ecosystem and ability to predict future conditions*. High Certainty is defined as *baseline data are comprehensive; predictions are based on quantitative data; effect relationship is well understood* (Volume 2 Table 2-3.4). There are virtually no cases for which an assessment of project effects on a VEC in the marine environment warrants a high rating of certainty based on this definition.
4. A reductionist approach is used for the within-project effects assessment rather than a more holistic approach. By evaluating the impact of each project activity on each VEC individually the assessment predicts project effects will be insignificant.

5. DFO Science suggested the use of PBR to assess the cumulative impact of the proposed Project on marine mammal populations. PBR considers all human-induced mortality and takes into account population size, uncertainty around estimates and conservation status. Assuming Inuit have first priority for access to wildlife for subsistence purposes, any additional mortality must fall within the residual (i.e., remaining) allowable harm.

4.0 Conclusions

The proposed year-round shipping through Foxe Basin and Hudson Strait associated with the Mary River Project is unprecedented in scale. These waters are relatively unexposed to industrial development and are important for several marine mammal species with special conservation status, including bowhead whale, narwhal, beluga, and walrus, as well as the marine communities that support them. Bearded seals are known to be abundant and considered an important component of the Foxe Basin ecosystem. Based largely on material presented in appendices and its own scientific expertise, DFO Science disagrees with the Proponent's overall conclusion that the proposed project operations will inflict no significant impacts on the marine environment. There is potential for significant residual impacts from the Project on the marine environment that were not assessed adequately in the final EIS. These include shipping-related accidents such as oil spills, ship noise, ship strikes, ballast water release, sediment redistribution, and aircraft noise. DFO Science is concerned by the lack of a scientifically rigorous approach to baseline data collection and monitoring. Use of surveillance monitoring for identifying impacts of some Project components and as a trigger for more focussed monitoring is problematic. Surveillance monitoring would not provide sufficient precision for the statistical power needed to identify potential project effects at or above biologically-appropriate thresholds.

The baseline information presented and proposed thresholds are, in some cases, inadequate to assess potential Project effects on the marine environment either to make predictions or to monitor and, as necessary, mitigate them. DFO Science also questions the feasibility of some of the proposed mitigation measures, particularly those related to shipping, oil spills, and ballast water. DFO Science also notes that many key components of the ecosystem received little consideration in the final EIS. There was limited discussion of trophic effects, sub-lethal effects, or delayed mortality resulting from the Project. The cumulative effects assessment is not sufficiently comprehensive or quantitative to allow for a thorough environmental impact assessment of the Project.

Given uncertainty in the effects assessment and that ore shipments will not commence for several years, there is still an opportunity for BIM to undertake well-designed baseline studies and to develop effective monitoring plans. These must have sufficient precision to allow early detection of project impacts. Although the effects assessment in the final EIS predicts no significant negative impacts, this conclusion is challenged by DFO Science. Given gaps in current knowledge, inclement weather, remoteness, and the potential for unexpected accidents and malfunctions, DFO Science recommends that the Proponent develop realistic and appropriate mitigation measures as a precautionary approach before the Project gets underway. Currently there is insufficient detail presented on alternative means of carrying out the project to mitigate impacts and to support the development of adaptive management strategies.

Serious doubts about the feasibility of year-round shipping along the southern proposed route were raised in the final EIS. DFO Science and other experts believe that at least two test trips during the peak ice season should be conducted to demonstrate that year-round shipping along this route is technically feasible. In the event that it is not, or if mitigation measures would prevent year-round shipping, then alternate port sites should be re-evaluated.

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8.0 Appendices

Appendix 1. *Estimates of total allowable harm (TAH) and residual allowable harm (AH) for harvested cetacean species in the Project area.*

Species	Estimate	Fully-corrected	CV	95% CI	COSEWIC Status	N_{min}	Recovery Factor	TAH	Annual Harvest	Residual AH	Source
Northern Hudson Bay narwhal	12,485	yes	0.26	7,515−20,743	Special Concern	10,040	1.0	157[a]	~100[b]	~57	DFO 2012b
EC-WG bowhead	6,344	no		3,119−12,906	Special Concern	3,119	0.1	6	6	0	IWC 2008
	14,400	yes	0.606	4,810−43,105		8,991	0.1	18	6	12	Dueck et al. 2008
Western Hudson Bay beluga	63,122	yes	0.20		Special Concern	53,563	1.0	908	~550-650[c]	~360−460	Richard 2008; DFO, unpubl. data; Doniol-Valcroze et al. 2012
Eastern Hudson Bay beluga	3,030	yes		1,256−6,535	Endangered	-	-	50[d]	> 50	0	Doniol-Valcroze et al. 2012
Ungava Bay beluga	32	yes		0−94	Endangered	12	0.1	0	0	0	Doniol-Valcroze and Hammill 2012

[a] Total allowable landed catch is presented which is the TAH corrected for hunt losses (1.28; Richard 2008).
[b] Updated survey estimates have yet to be considered by co-managers in Nunavut and Nunavik. If subsistence harvest levels increase it would reduce the residual AH.
[c] Including a harvest of 300−400 individuals in Nunavut, approximately 200 in Nunavik, and a 30% stuck and loss value.
[d] To achieve a 50% probability of increase in stock abundance, as determined from Bayesian modelling of population trajectory.

Appendix 2. *Proposed approaches, ranging from relatively simple (but less effective) to comprehensive (more effective, but more complicated and costly to enact), as means to monitor and mitigate potential impacts of ore shipping on marine mammals in the Baffinland RSA.*

Monitoring Approach	Complexity to Enact	Cost to Enact
Trained MMOs aboard carriers, with expert analysis of data	Low	Low
Acoustic recorders within, near, and far from ore carrier route, with expert analysis of data	Moderate	Moderate
On-going replicate aerial survey coverage of the ore carrier route, with expert analysis of data	High	High
AUVs flown ahead of ore carriers early in shipping program, with expert analysis of data	High	High

Appendix 3. *Proposed revision of final EIS Table 9-3-6 in Volume 9.*

DFO Science identified several problems with Volume 9 Table 9-3.6. While it appears that the volume of oil on board for ore carriers considered both in- and out-bound trips, which produced an average of 3 ML, it did not consider both legs for either tankers or cargo vessels - which should have been done. This is important as the volume of fuel onboard varies significantly between the in- and out-bound legs for tankers. It is worth noting that the Transportation Safety Board compiles their statistics based on the number of vessel movements, which we assume to mean from one dock to the next. Table 9-3.6 also did not partition the data into open water versus ice seasons where impacts of oil spills will differ.

DFO Science proposes a revision to Table 9-3.6 that considers both in- and out-bound trips for all vessel types and both open water and ice seasons as appropriate over the life of the project (~29 years). BIM's table did not include consequences, which have been added to this version, and take into account response time, ability to clean up, and relative exposure of marine mammals to a spill.

Vessel type	Type of trip	Probability indicator			Relative probability of spill	Consequences			
		# trips	% total	Volume of oil (MT) onboard[1,2]		Response time(min)	Ability to clean-up	VEC exposure[3]	Severity[4]
Tanker – open water	in	184	3.7%	50	1.85	30	0.8	2	22.2
Tanker – open water	fuel handling	184	3.7%	50	1.85	1	0.8	1	0.4
Tanker – open water	out	184	3.7%	1	0.04	30	0.8	2	0.5
Cargo vessels – open water	in	175	3.5%	2	0.07	30	0.8	2	0.8
	out	175	3.5%	1	0.04	30	0.8	2	0.5
Ore Carrier – open water (5 months)	in	850	17.1%	3	0.51	30	0.8	2	6.1
	out	850	17.1%	3	0.51	30	0.8	2	6.1
Ore Carrier – ice season (7 months)	in	1,190	23.9%	3	0.72	60	0	3	129.6
	out	1,190	23.9%	3	0.72	60	0	3	129.6
Total		4,982							

[1] Assumed tankers carry as much motive fuel as freighters and assumed ½ of it is used on the way in to port
[2] Used average of 3 MT as per final EIS
[3] VEC exposure is relative species exposure – least in port (1), more in transit (2), most in winter transit (3) when concentrated in polynya and Hudson Strait
[4] Severity = relative risk × response time × (1 - clean-up ability) × VEC exposure

Appendix 4. *Methods used to estimate magnitude of shipping effects on marine mammals*

Zone of noise influence around ship tracks

Southall et al. (2007) compiled studies for various marine mammal species and provide levels of noise exposure for which different types of responses were documented. For noise sources that are continuous, negative responses are presumed to begin at sound pressure levels of 120 dB for cetaceans such as beluga, narwhal or bowhead whales. In the case of pinnipeds, there is much more variability in the types of response observed and noise levels (in air or underwater) causing them, although received levels of 110 to 120 dB re 20 μPa could be used as a reference for causing animals to leave haulouts and enter water.

Based on results from another study, the ZOI around an ore carrier corresponding to SPL of 120 dB re 1 μPa was set at 8 km. This value corresponds to twice the 4 km radius, where underwater noise levels (20−1000 Hz) in excess of 120 dB were recorded from an icebreaker (*Robert Lemeur*). This ZOI likely represents a lower bound, given that the icebreaker was not in ice-breaking mode; the ZOI was nearly doubled when breaking ice (Richardson et al. 1995, Fig. 6.12). This is confirmed by the proponent's own evaluation where larger radii are assumed for most species. The proponent intends to build ore carrier using modern vessel design criteria to lower noise generation. However, it is unlikely that these new designs will reduce the ZOI significantly below 8 km, especially when in ice-breaking mode. The length of Hudson Strait (1,000 km) was used to calculate the total ZOI of an ore carrier transiting through Hudson Strait, i.e., 8 km x 1,000 km = 8,000 km^2. Again, the total ZOI is underestimated as it doesn't take into account transits through Foxe Basin or to the eastern mouth of Hudson Strait where bowhead whale concentrations for instance, are observed during winter (M.-P. Heide-Jorgensen pers. comm.).

Risks of effects from ship noise

The average number of individuals potentially affected by shipping noise each year can then be determined by multiplying the ZOI around a ship track (i.e., with noise levels in excess of 120 dB re 1 μPa) by local marine mammal density estimates, and then correcting for marine mammal seasonal use of the area, and number of ship transits per year.

While allowable harm was calculated on a population basis, density estimates necessary to calculate the number of exposed individuals were obtained specifically from Hudson Strait marine mammal aerial surveys and thus, represent composites of several populations in cases (e.g., beluga) where they are known to share the same wintering area (Hudson Strait). Also, density estimates ignore the gregarious nature of many of the marine mammal species being considered, and the overlap of the proposed shipping route with areas of core use rather than of "average" use. Gregariousness increases the risk that if one animal is impacted, many are. The use of an average density rather than above-average densities in the calculation, also likely negatively bias the estimate of exposed individuals.

The number of ore-carrier transits per year is estimated at 204, i.e., one every 43 h (final EIS: Vol. 3, Section 3.6.1.3). This corresponds to a monthly average of 17 per month. Based on sightings data, peak hunting period and satellite telemetry, DFO Science determined that narwhal (see Richard 1991 for a review; Westdal et al. 2010; 120213-08MN053-final EIS-App.8A-2), beluga whales (Hammill and Lesage 2009; Luque and Ferguson 2010; Bailleul et al. 2012), and bowhead whales (Ferguson et al. 2010) occupy Hudson Strait during roughly seven months of the year, i.e., between approximately November and May, inclusively. Given that all species except narwhal occur throughout the year in Hudson Strait, although in smaller numbers during summer, and that cape-size ore carriers will transit Hudson Strait twelve months a year, the period used for calculating interactions with shipping activity each year is considered minimal, and operational impact risks are likely underestimated.

Risk of ship strikes

Bowhead whale, and to a lesser extent because of their size and speed narwhal and beluga, face some of the same risks as North Atlantic right whales in terms of ship strikes. North Atlantic right whales remain highly endangered because of persistent lethal and sub-lethal vessel strikes and frequent entanglement in commercial fishing gear. Vessel strike and fishing gear trauma have been documented in bowhead, but at a much lower rate than in right whales (see Reeves et al. 2011) likely due to the lower amount of vessel traffic and fishing activities in the Arctic. However, with the proposed introduction of year-round ore shipping associated with the Mary River mine, it is likely that the risk and incidence of Arctic whale injury and mortality from vessel traffic will increase.

Risks of mortality or severe injury related to ship strike can be determined using a simple area-interaction model.

The theoretical and analytical basis of the ore carrier whale strike risk estimation is a mathematical area-interaction model, an example of which is available at http://www.chelonia.co.uk/collision_prediction.htm. This model assumes the following:

1. The vulnerable parts of the bowhead, narwhal or beluga whale can be represented as a line of the same length as the whale.
2. The whale's orientation relative to the direction of travel of an ore carrier is random.
3. The whale does not tend to move into or out of the carrier's path (they may avoid the carriers, but if their mobility is constrained by shallow waters, two vessels passing each other, or available breathing sites in winter this may not be possible).
4. The carrier transit route has an overall density of whales that is the same as some larger area from which a survey has given a density estimate. (This is unlikely in winter when both whales and ships will occur more frequently in areas of minimal ice cover.)
5. Ore carriers do not avoid whales (it is unlikely they would see them unless in daylight and open water, and their speed and size makes avoidance manoeuvering difficult).

The whale strike risk estimation model requires the following inputs (bowhead values given as an example):

L = whale length, m (used a value of 15 meters for bowhead whales).

T = fraction of whale time at surface (used 20% based on Dorsey et al. 1989).

W = damaging width of the ore carrier, m (used 52 meters, from final EIS).

P = whale population density – animals per sq. km. in a survey area including the ore carrier transit route (used 0.002 bowhead/km^2).

D = distance travelled by the carriers within the population survey area, km (used 1,000 km in the model, although a larger figure of 1,460 km is cited in the final EIS (Vol. 8:16).

Y = yearly number of transits by the ore carriers (used 190[11] from Table 3-6.2 of final EIS).

[11] There is contradiction in the final EIS regarding the number of transits per year (listed as 190, but also 204 plus additional transits from chartered ore carriers and other project-related vessels) and therefore the risks of ship strike are likely underestimated in this analysis given that DFO Science used the lower number.

The model uses the whale as a horizontal linear target at random orientation to the carrier's line of travel, and which would present an average "target size" of 0.64 × whale's length. Given the size of the vessels, the whale could be viewed as a point and half the "target size" of the whale can then be added to both sides of the "damaging width" of the ore carrier to give a "collision strip width" of W + 1.27L. From the length of the ore carrier transit a "collision area" can then be derived: (W + 1.27L) × D/1000 km^2.

With the number of transits per year and the density of whales at risk, the annual number of vessel/whale collisions in the modelled area would equal (W + 0.64L) × D/1000 × Y × T × P. For the bowhead whale, this model estimates that approximately five bowhead whales per year might be struck by an ore carrier, given the aforementioned assumptions (Table 1). For the other two whale species of interest, the model assumptions and ship strike estimates are summarized in Table 1 (for values see for example Dorsey et al. 1989; Heide-Jørgensen et al. 2001).

Table 1. Ship strike model assumptions and strike estimates for bowhead, narwhal, and beluga whales within Baffinland's proposed shipping route.

Species	Body Length (m)	Fraction of Time at Surface (%)	Population Density (n/km^2)	Modelled N at Risk of Ship Strike/Year
Northern Hudson Bay narwhal	4.25	25	0.019	49
EC-WG Bowhead whales	15.0	20	0.002	5
Beluga	3.75	23	0.006	14

Given the assumptions used in the model, and the generalized nature of the model itself, there are a number of sources of error in these estimates. This process minimizes the estimated risk by selectively biasing the errors in the most favourable (fewer strikes) direction. DFO Science used

- the lowest estimate of whale density in the study area (although higher densities due to aggregations may be equally valid, since in this case using an average values increases estimate error.)
- a body length size which is not the maximum for the species, although for bowhead at least, a large number of whales in west Hudson Strait are thought to be mature females
- only surface interval time rather than the additional time a whale might be in a position within 20 metres of the surface, and
- assumed ships encounter whales as single individuals rather than groups (or that the loss of an adult does not affect the survival of a dependent offspring or relative).

Variations in the local densities of the whale species of interest have probably the largest impact on the magnitude of the ship strike risk estimate. For example, ore carriers crossing migratory pathways or feeding aggregations would have a higher risk of striking a whale.
If whales have an avoidance reaction to approaching carriers – and are able to move away without being constrained by ice or bathymetry, then ore carrier passage would entail lower risks. The whales' flukes and caudal peduncles may present a lower risk of mortality if struck than the body, making the "risk length" shorter than assumed in this exercise although a tail-strike could still inflict a lethal swimming disability.

On the other hand, the time interval during which the whales are just below surface will also be a source of risk as the whale will not be visible to facilitate avoidance manoeuvres by the vessel.

And finally, in open water the displacement of a whale by the water flow around the large bow (pressure wave) may reduce the injury risk in this part of the vessel. However, there is a whale strike modelling paper which used towed ship and whale models to detail laminar flow around large vessels, and its authors concluded that in some cases whales beside or below the stern of the large vessel could be drawn towards the stern and propellers by a low-pressure water flow effect (Silber et al. 2010).

Given the slow speed of the ore carrier in the winter period, it is possible that the risk of ship strike during this period will be less, and the injuries to bowhead, narwhal, and beluga whales will be less severe. However, even if the estimation of ship-struck animals was restricted to the open water period only, the number of modelled strikes would still not be zero for any species in the RSA.

Significance of impacts from shipping

The significance of noise-related effects for the whale population of interest was examined relative to total population size, whereas significance for ship-strike interactions, and thus, lethal or severe injuries, were determined by calculating residual allowable harm for each population, i.e., allowable harm after taking subsistence harvest into account. Indeed, total allowable harm includes all human-induced mortality, and takes into account population size, uncertainty around estimates, and conservation status (Wade 1998).

TAH was estimated either using a method referred to as the Potential Biological Removal (PBR) (Wade 1998) for stocks where there are insufficient data to make a full assessment (Hammill and Stenson 2007), or using Bayesian model results for stocks that are considered more "data-rich".

The PBR produces a threshold value. If human-induced removals are below the threshold, then the population is likely to increase towards or maintain itself at or above its Maximum Net Productivity Level (MNPL), i.e., the population size at which the combined size and growth rate of the population produces the largest number of animals per year (largest productivity). PBR is estimated as:

$$PBR = 0.5 \times R_{max} \times N_{min} \times F_r$$

N_{min} is the 20th percentile of the log-normal distribution of the estimated population size, equivalent to the lower 60% confidence limit. R_{max} is the maximum rate of increase for the population. When unknown for a particular population, R_{max} is set at a default value of 0.04 for cetaceans, and 0.12 for pinnipeds. It is halved ($0.5 \times R_{max}$) to simulate the effect of logistic density-dependent growth. F_r is the recovery factor with values set to reduce the base PBR value to improve the probability of recovery. Depending on a population's status, F_r is set at 0.1 for a critically-low population status, 0.5 for a depleted status (<MNPL), and 1 for a healthy status (Wade and Angliss 1997).

Appendix 5. *Estimated number of individuals of various species exposed to shipping noise levels at or above 120 dB re 1 μPa on Baffinland's proposed shipping route*[12].

Species	Source[d]	Density estimate (n km^{-2})	Corrected density (n km^{-2})	N exposed per transit	N exposed per period of use (7 months × 17 transits/month)
Northern Hudson Bay narwhal	final EIS (Vol. 8)	0.006−0.008	0.019−0.025[a]	152−200	18,088−23,800
EC-WG bowhead	Koski et al. 2006 final EIS (Vol. 8)	0.002−0.02	0.002−0.02	16−160	1,940−19,040
Beluga	Finley et al. 1982	0.047	N	376	44,744
	final EIS (Vol. 8)	0.02−0.03	N	160−240	19,040−28,560
Ringed seals	final EIS (Vol. 8)	0.002−0.003	N	16−24	1,904−2,856[c]
Bearded seals	final EIS (Vol. 8)	0.006-0.007	N	48−56	5,712−6,664[c]
Walruses	final EIS (Vol. 8)	0.001−0.002	N	8−16	952−1,904[c]

[a] Using a 0.31 correction factor for perception and availability biases (Westdal 2008).
[b] Using a 0.18 correction factor for perception and availability biases (Koski et al. 2006).
[c] This assumes that SPLs potentially eliciting reactions in pinnipeds are similar to those documented in cetaceans.
[d] Density estimates extracted from the final EIS are from Hudson Strait during April and June, i.e., surveys corresponding most closely to the period of use of these wintering grounds for cetaceans.

[12] As the report was being prepared for posting on the DFO website it became apparent that additional clarification was needed. The caption should read as follows: Estimated number of animal-exposures for various species subjected to shipping noise levels at or above 120 dB re 1 μPa on Baffinland's proposed shipping route. Individual animals may be exposed repeatedly.

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