MARY RIVER PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME 8
MARINE ENVIRONMENT

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PROJECT FACT SHEET

Location	• Located at Mary River, North Baffin Island. 1000 km north of Iqaluit, 160km south of Pond Inlet
Reserves	• Comprised of nine known iron ore deposits around Mary River. The current project is focused on Deposit No.1 with known reserves of 365 million tonnes estimated at >64 % iron
Construction Phase	• Construction of the project could commence as early as 2013 • Milne Port will support construction activities, receiving materials during the open water season and moving them to the Mine Site along the existing Tote Road • Construction materials will also be received at Steensby Port • 4 years to complete construction
Operational Phase Open Pit Mine Processing	• Operations will involve mining, ore crushing and screening, rail transport and marine shipping to European markets • Projected production of 18 million tonnes per year for 21 years • No secondary processing required; no tailings produced due to the high grade of ore
Rail Transport and Shipping	• A rail system will be built for year round transfer (~150 km) of ore to Steensby Inlet • A loading port constructed at Steensby Inlet will accommodate cape sized vessels • These specially designed ships will transport to the European market year round • Milne Port will be used to receive construction materials in the open water season and then very rarely to ship, during the open water season, oversized materials
Environment	• Baseline studies have been conducted by Baffinland since 2005 • Inuit Qaujimajatuqangit (traditional knowledge) information collected since 2006 • These baseline studies form the foundation for the environmental impact statement and provide information for the development of mitigation and management plans • Studies cover terrestrial environment, marine environment, freshwater environment, air quality, and resource utilization • Extensive ongoing consultation with communities and agencies • Monitoring during project activities will be important in validating predictions and mitigating potential affects
Social and Economic Benefits	• Mineral royalties will flow to NTI • Taxes will flow to governments of Nunavut and Canada • Baffinland finalizing negotiations with the Qikiqtani Inuit Association (QIA) for an Inuit Impact Benefits Agreement (IIBA) • During the four year construction period employment will peak at 2,700 people • Through the 21 years of operations about 950 people on the payroll each year
Closure and Post-Closure Phase	• Conceptual mine closure planning has been completed • Closure will ensure that the former operational footprint is both physically and chemically stable in the long term for protection of people and the natural environment • Post closure environmental monitoring will continue as long as needed to verify that reclamation has successfully met closure and reclamation objectives

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SECTION 1.0 - INTRODUCTION

1.1 THE MARY RIVER PROJECT

The Mary River Project ("the Project") is a proposed iron ore mine and associated facilities located on North Baffin Island, in the Qikiqtani Region of Nunavut (Figure 8-1.1). The Project involves the construction, operation, closure and reclamation of an 18 million tonne-per-annum (Mt/a) open pit mine that will operate for 21 years. The high-grade iron ore to be mined is suitable for international shipment after only crushing and screening with no chemical processing facilities. A railway system will transport 18 Mt/a of ore from the mine area to an all-season deep-water port and ship loading facility at Steensby Port, where it will be loaded into ore carriers for overseas shipment through Foxe Basin. A dedicated fleet of cape-sized icebreaking ore carriers and some non-icebreaking ore carriers and conventional ships will be used during the open-water season.

This volume of the EIS discusses potential effects on the Marine Environment from the proposed Project. Emphasis of the assessment focuses on two primary aspects: shipping-related activities that will occur over large geographic areas and more localized activities associated with development of a year-round port at Steensby Inlet and a seasonal port at Milne Inlet (Figure 8-1.1). Shipping activities include the transport of ore from Steensby Port to market, and the assessment focuses on effects of this activity on sea ice and marine mammals along the shipping route. Port site activities include ore loading and port-site ship operations such as ballast water discharge. The assessment focuses on effects of these activities on local water and sediment quality conditions, and on marine habitat and biota in the vicinity of the port sites.

One important tool developed to assist in effects prediction and to provide input to Project design has been a numerical model of Steensby Inlet. The model has utilized the broad array of available physical oceanographic data, including freshwater flow into the Inlet, tide and current measurements, ice cover patterns and water depths. This numerical model has been employed to make quantitative predictions, e.g. with respect to the distribution of ballast water released by ore carriers into Steensby Port. The model will be refined and improved as more data become available, and in this manner, such data will be incorporated into detailed design of marine and shipping features of the Project.

1.2 REGIONAL SETTING

The following sections are based on information from several sources, including Appendix 8A-1, Appendix 8A-2, Appendix 3G, Mallory and Fontaine (2004) and unpublished ship traffic data.

1.2.1 Shipping Routes

In general, shipping-related effects to sea ice and marine mammals are discussed on a large spatial scale that encompasses all of Milne Inlet and Eclipse Sound to the north and, to the south, all of Steensby Inlet, Foxe Basin and parts of Hudson Strait that lie within Nunavut territorial waters. Ship access to Milne Inlet is primarily from the North Atlantic through Davis Strait and Baffin Bay.

In planning the shipping route, distance, navigability (including water depth of nearshore sections), ice conditions and community concerns were considered. Water depth was evaluated based on available charting, which was not always adequate, so additional survey work was conducted in 2008 around Steensby Inlet. Additional bathymetric survey work is ongoing and as it is completed minor adjustments to the detailed route may be required. To date only one instance has required a minor refinement to the shipping route to avoid shallow areas (< 30 m). As illustrated in Figure 8-1.2 this adjustment will occur well

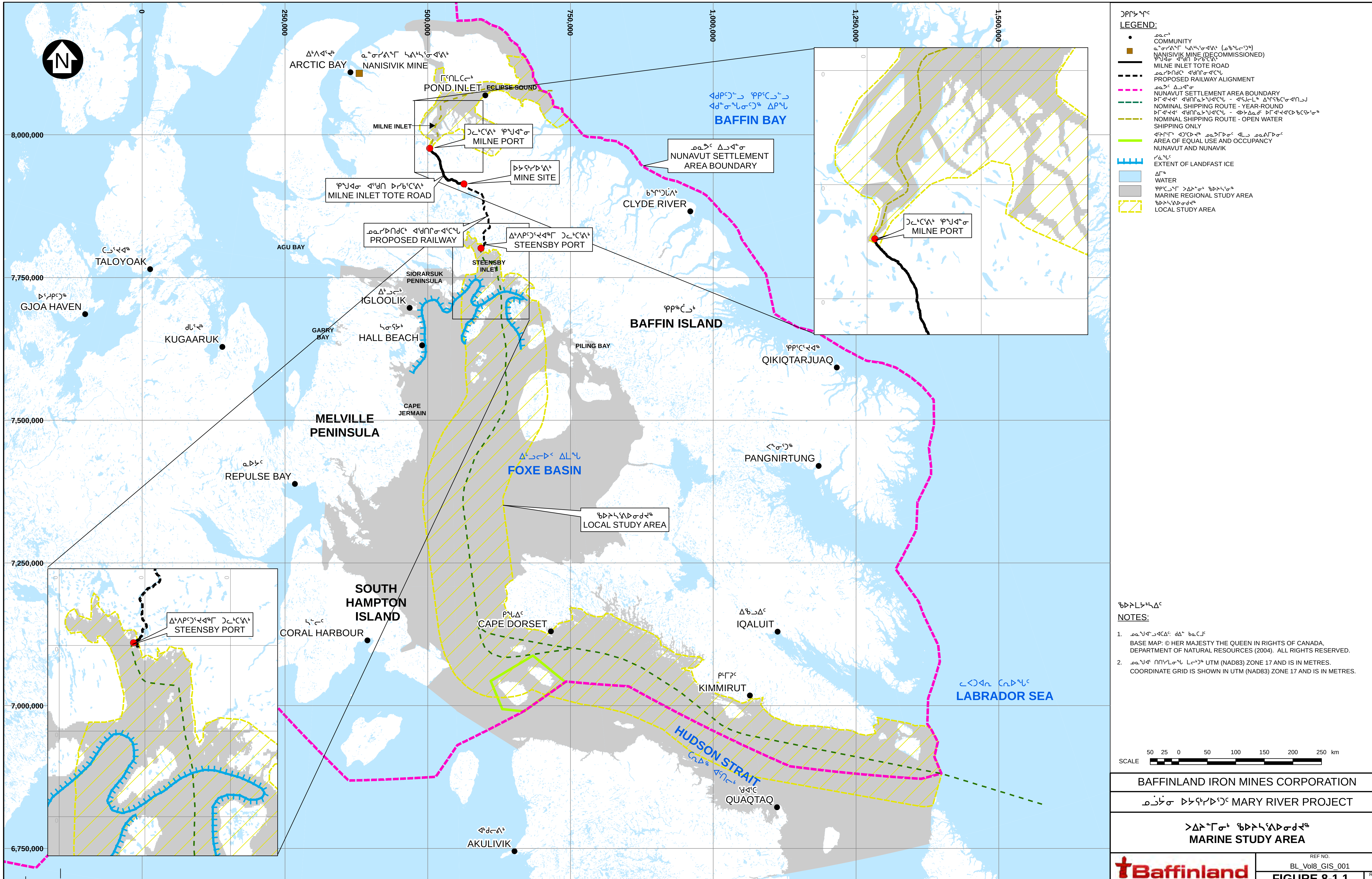
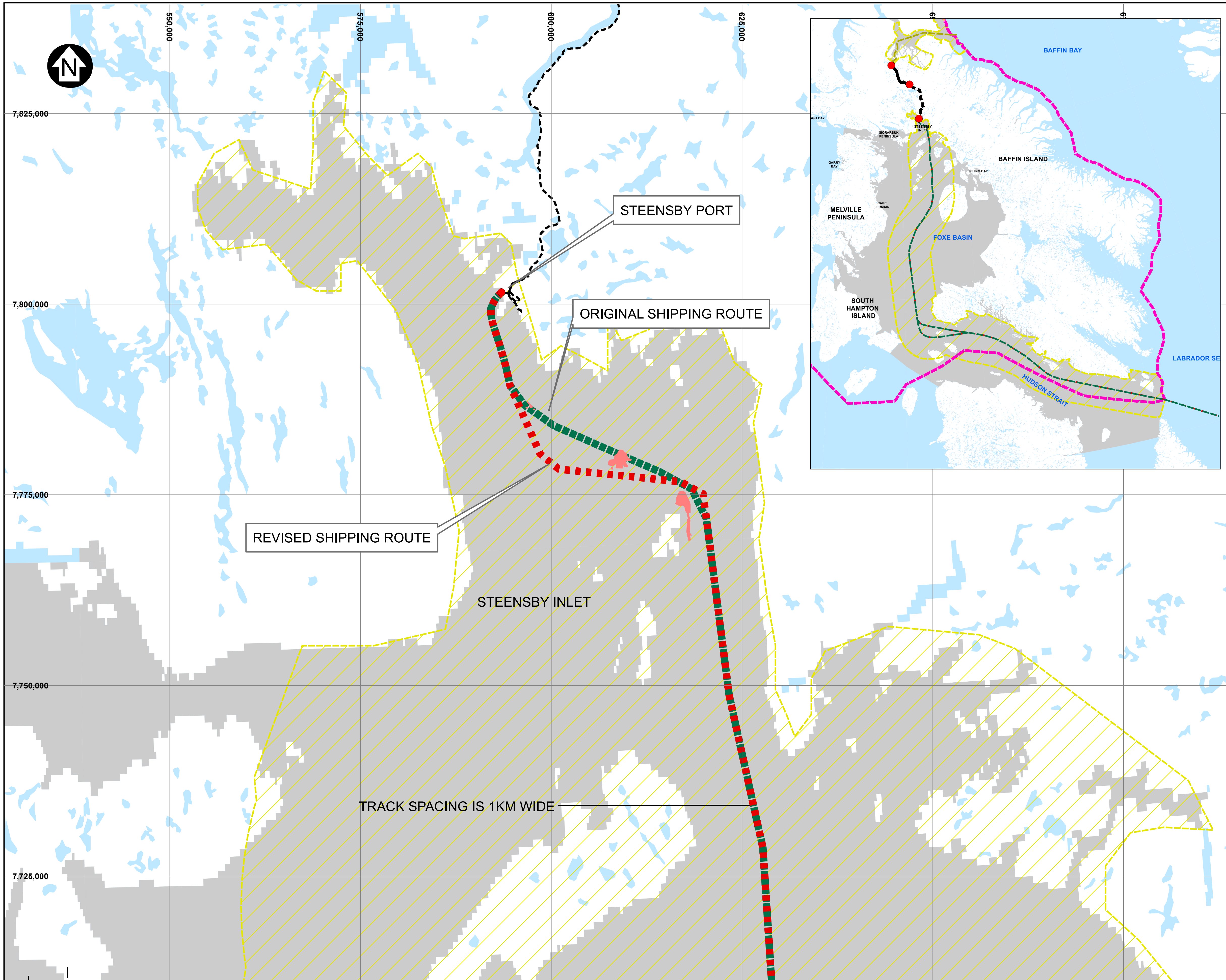


FIGURE ID: BL_Vol8_GIS_001 Marine Study Area Figure 8-1-1.mxd



LEGEND:

- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- NUNAVUT SETTLEMENT AREA BOUNDARY
- ORIGIANL SHIPPING ROUTE
- REVISED SHIPPING ROUTE
- WATER
- MARINE REGIONAL STUDY AREA
- LOCAL STUDY AREA
- DEPTHS LESS THAN 30m

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.

SCALE 0 4 8 16 24 32 KM

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

REFINED SHIPPING ROUTE APPROACHING STEENSBY INLET

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_006

FIGURE 8-1.2

REV 0

FIGURE ID: BL_Vol8_GIS_006 REFINED SHIPPING ROUTE APPROACHING STEENSBY INLET FIGURE 8-1-2.MXD within the identified shipping corridor. In areas of relatively shallow water or narrow channels, navigational aids and routing will be prescribed by regulators and passages defined.

The timing of ice formation in Baffin Bay and Davis Strait is variable, but generally begins in September. Ice begins to abate during June in the vicinity of the Northwater Polanyi, (located at the northern end of Baffin Bay), and open water extends southward across the entrance to Lancaster Sound. On average, clearing of ice occurs by September. All of the waters within Milne Inlet, Eclipse Sound and Navy Board and Pond Inlets are covered by fast ice from about mid-October until early or mid-July. Most shipping activity in the region occurs from July through October and comprises mainly merchant vessels supplying communities in the region, cruise ships, and Canadian Coast Guard vessels. Smaller numbers of commercial fishing vessels also occur.

Regionally, western Baffin Bay and eastern Lancaster Sound are among the most biologically productive areas in the Canadian Arctic, supporting high diversity and abundance of marine mammals, seabirds and other marine biota. Large numbers of marine mammals overwinter in Baffin Bay and use Lancaster Sound as a migration corridor to summering areas in the central Canadian Arctic.

Ship access to Steensby Inlet will be through northern Hudson Strait and Foxe Basin. Throughout Hudson Strait, open-water leads develop from May through June, though the area may not clear until early fall. Freeze-up begins in the western portion of Hudson Strait during November, and proceeds east until the entire area is covered in ice (generally by mid-December). The Strait is characterized by strong currents and winds and, consequently, pack ice in central areas is constantly in motion. Shore lead systems frequently form along the southern coast of Baffin Island, while ice tends to accumulate along the southern shore of Hudson Strait and Ungava Bay. Ice melt in Foxe Basin begins in June, and leads open along shores throughout July. Rather than drifting extensively as in southern Hudson Bay, pack ice tends to move less in the central part of Foxe Basin and disintegrates in place throughout August. Ice formation begins in mid-October in the northern and western portions of the basin, spreading southward to cover the basin by early November. Steensby Inlet is covered by fast ice from mid-October to mid- or late July. Land fast ice in Steensby Inlet generally breaks up during late July and reforms in mid-October. Most shipping activity in the region occurs from July through November and comprises mainly merchant vessels supplying communities in Hudson Strait, Foxe Basin and Hudson Bay, bulk carriers exporting grain from Churchill, Manitoba, cruise ships, and Canadian Coast Guard vessels. Very little winter ship traffic occurs in the region, and comprises Canadian Coast Guard icebreakers and periodic icebreaking ore carriers accessing the Raglan Mine at Deception Bay in Nunivak.

Hudson Strait and northern Foxe Basin are biologically productive areas that support large numbers of seabirds and marine mammals, seasonally and annually. These areas provide important staging and breeding areas for seabirds, and represent an important migration corridor for many marine mammals moving between wintering areas in Hudson Strait or the Labrador Sea and summering areas in Hudson Bay and Foxe Basin. Northern Foxe Basin provides year-round habitat for several species of marine mammals, including walrus, ringed and bearded seals, and polar bears. The Local Study Area (LSA) for assessment is generally as shown in Figure 8-1.1 but the area considered may be adjusted as appropriate to the expected zone of influence of each Project interaction.

<u>Ecological Context</u>

It has been suggested that there exist a number of areas along the shipping route of high biological productivity. These areas are associated with oceanographic mixing that causes upwelling of nutrients into the surface waters, resulting in higher than normal biological productivity by lower trophic levels. In some areas these currents are strong enough to create perennial openings in the sea ice (polynyas or persistent flaw leads) that enable marine mammals and birds to overwinter.

The areas suggested are broadly defined as: northern Foxe Basin and Steensby Inlet; eastern and western Hudson Strait; and Milne Inlet. The selected VECs that occur in these areas have been assessed both in relation to their occurrence in these specific areas as well as their presence and use of the RSA as a whole. The following discussion summarizes the ecological role of these areas in the context of the RSA.

Northern Foxe Basin and Steensby Inlet

Polynyas, which provide critical habitat for over-wintering marine mammals and seabirds, have been identified in this area (Stirling, 1997). Of the marine birds identified as KIs, the Common and King Eiders are known to use polynyas. King and Common Eiders use polynyas during the winter to forage. As the polynyas would provide consistent open water conditions, these seabirds would congregate here to avoid being trapped and potentially crushed in pack ice. Marine mammals such as bearded seal, ringed seal, walrus, beluga whale, and polar bears are also known to use polynyas. Seals, walrus, and beluga whale use polynyas throughout the winter as breathing holes. This allows these species to readily move away from disturbances to alternate breathing hole locations (loose pack ice, leads, holes in landfast ice

Polar bears are also known to use Steensby Inlet as a maternity denning habitat. Denning and concentration sites have been identified in and around Steensby Inlet as well as Northern Foxe Basin (see Figure 8-5.10). IQ knowledge of the area also indicated that the vast majority of bears den on land rather than ice. The identified locations where denning may occur on pack ice are outside the shipping route (see Figure 8-5.10) and as such are not expected to interact with shipping activities.

Northern Foxe Basin was also identified as an important summering and nursery area for bowhead whales and cow-calf pairs. Baffinland identified summering area within the RSA for bowhead whales and found them to reside outside of the footprint of the project and shipping route (see Figure 8-5.9). Large numbers of cow-calf pairs have not been observed in the area during project surveys for bowhead whales, however effects of masking are considered in the FEIS (see Section 5.9.2.4).

Snow Goose, King and Common Eiders and Red-throated Loon are quite common within Northern Foxe Basin and Steensby Inlet especially during the migration period where these areas are used as nesting and foraging habitat. Snow Goose use Steensby Inlet as staging grounds during the spring migration and moulting grounds during the fall migration and are known to occur in high numbers in the Steensby Inlet area, specifically the marine waters and low lying tundra areas. King and Common Eiders are both migratory and resident seabird species that are common within the area. Broods of eiders were noted within the proposed port area in Steensby Inlet. Red-throated loon occur throughout the RSA, however there does not seem to be a preference for habitat within Northern Foxe Basin or Steensby Inlet compared to Snow Goose and King and Common Eider.

Eastern and Western Hudson Strait

Hudson Strait has been identified as an important migratory corridor for marine mammals and marine birds. Baffinland recognizes the importance of Hudson Strait, and as such all key marine species (mammals and birds) occurring in this area were described and their ecological context noted (see Volume 8, Section 5, and Volume 6, Section 4).

Baffinland has identified areas of Walrus occurrence in the western portion of Hudson Strait, around Nottingham and Salisbury islands and along or near the coast. It was noted that a small portion of the summering area overlaps with the shipping route near Cape Dorset. IQ knowledge gathered indicated that walruses tend to stay around the shoreline when a large vessel is present, however no change in behaviour and noted acts of aggression have been observed (see Section 5.7.2.2).

Eastern Hudson Strait was identified as an area where oceanic conditions produce high concentrations of fish and invertebrate species which are of ecological and commercial importance.

It has also been noted that marine birds congregate on the vertical cliff along the north shore of Hudson Strait. The shipping route, for the most part, is over 10 km from the north shore of Hudson Strait. Therefore vessels transiting the shipping route will not interact with cliff dwelling seabirds.

Milne Inlet

Various marine mammals and seabirds use Milne Inlet as foraging and nesting habitat. Baffinland has identified Milne Inlet as a ringed seal pupping and basking location, a walrus calving location, a beluga whale foraging area, a narwhal mating, calving and foraging location, a bowhead whale summering area and a polar bear denning site.

Beluga whale are present in the spring, summer and fall at Milne Inlet. IQ data gathered by Baffinland suggests that Milne Inlet may be both calving and foraging areas for beluga. Noted behaviours of belugas vary greatly, however it is thought they are most susceptible to sound, specifically when ice is present.

Narwhal are quite common within Milne Inlet where calving and mating activity takes place. Bowhead whale summering area encompasses Milne Inlet with mother and calves arriving later in the summer. IQ data gathered by Baffinland suggest that bowhead whale numbers are increasing within Milne Inlet. Disturbances caused by vessel traffic are typically unknown with this species, however avoidance is anticipated.

An assessment of the Project interactions within these areas and the potential effects on the Marine environment is presented in the following sections of Volume 8 and in Volume 6, Section 4.

1.2.2 Port Sites

Milne Inlet is a narrow fjord originating to the south of Eclipse Sound (Figure 8-1.1), and is characterized by deep waters (generally >100 m) and steep surrounding headlands. The Inlet system includes two minor arms: Tremblay Sound to the west (depths to 260 m) and Eskimo Inlet to the east (depths to 285 m) adjacent to the main portion of Milne Inlet. The proposed port is located at the southern tip of Milne Inlet on a fjord-head delta. Shorelines within Milne Inlet include a mix of rock cliffs, alluvial fans and raised beach ridges. Like many peri-glacial shorelines, coastal sediments are coarse boulders, cobbles and sand. The Inlet is ice-covered most of the year, with a short three-month open-water season. Icebergs are common and often become grounded in shallow, nearshore areas. During the open-water season, anadromous Arctic char, as well as a variety of bird and marine mammal species, use Eclipse Sound and Milne Inlet extensively for summer feeding and rearing. On average, approximately 20,000 narwhal summer in Milne Inlet, Eclipse Sound, and other adjoining Inlets.

Steensby Inlet is a wide bay, characterized by shallow waters (<100 m) and gentle terrestrial relief around most of its perimeter. Shorelines include wide tidal flats along the west cost of the Inlet, lagoon complexes to the north, and a mix of bedrock and coarse alluvial shorelines along the east coast. The tidal range within the Inlet is over 4 m and tidal currents dominate water circulation. Steensby Inlet is covered by landfast ice from late October to late July/August. The proposed port is located on the eastern shore, about 50 km into the Inlet (Figure 8-1.1).

Steensby Inlet provides year-round habitat for ringed seals and polar bears, and is used during open-water periods by beluga, bearded seal and walrus. Steensby Inlet is a nesting and staging area for bird species such as Arctic tern, brant, Canada geese, common eiders, glaucous gulls, king eiders, Pacific loons, red-breasted mergansers, red-throated loons, jaegers, and snow geese. Nearshore habitat in Steensby Inlet provides feeding habitat for anadromous Arctic char populations from several watersheds, including the Ikpikitturjuaq, Cockburn, and Rowley rivers.

1.3 STUDY AREAS

Project study areas for the marine environment are defined spatially at local (Local Study Area - LSA) and regional (Regional Study Area - RSA) scales in relation to proposed Project activities and the areal extent of interaction with the marine environment. The Nunavut Impact Review Board (NIRB) provided guidance on the selection of an LSA and an RSA. The LSA was defined as “that area where there exists the reasonable potential for immediate impacts due to project activities, ongoing normal activities, or to possible abnormal operating conditions”, including Project facilities and the full extent of the proposed shipping route within the Nunavut Settlement Area. The RSA was defined as “the area within which there exists the potential for direct, indirect, and/or cumulative biophysical and socio-economic effects” including potential transboundary effects related to shipping activities.

Within this volume, potential Project-related effects on several Valued Ecosystem Components (VECs) and their representative indicators are assessed, ranging from water quality effects at the proposed port sites to shipping-related effects on marine mammals through Foxe Basin and Hudson Strait. As the spatial extent of Project-environment interaction varies by VEC, specific LSAs and RSAs have been defined within the assessment for each VEC.

1.4 ISSUES SCOPING

Scoping of the potential effects of the Project was conducted over several years and involved extensive community consultations, technical workshops, data collection and literature review. These scoping exercises provided the foundation for identifying the design of baseline studies, Study Area boundaries, VECs/Key indicators, issues and Project-related linkages, and impact assessment considerations. Generically, these included the following:

- Literature review (baseline conditions) - scientific literature and Inuit Traditional Knowledge was identified and reviewed;
- Literature review (key issues related to Project effects and VECs/Key indicators) - other project EISs and EIS review comments were compiled and reviewed, with an emphasis on recent Nunavut projects;
- Literature review of recent aquatic effects monitoring programs, with an emphasis on Arctic mining projects to assist in identifying key effects, indicators, thresholds, and baseline study design;
- Consideration of *Fisheries Act*, Metal Mining Effluent Regulations (MMER) and Environmental Effects Monitoring (EEM) requirements, as well as EEM Guidance documents;
- Numerous discussions with, and site visits by, Department of Fisheries and Oceans (DFO), Environment Canada, and Government of Nunavut biologists over the period of 2007 through 2010;

- Consultation with the communities of (listed in alphabetical order) Arctic Bay, Cape Dorset, Clyde River, Hall Beach, Igloolik, Kimmirut, and Pond Inlet, as described in Volume 2, Section 1;
- Inuit knowledge studies carried out in the communities of Arctic Bay, Cape Dorset, Clyde River, Hall Beach, Igloolik, Kimmirut, and Pond Inlet;
- A Mary River Project team scoping meeting held in November 2007 and other aquatic team meetings;
- The conduct of baseline studies for the Project (i.e., Project baseline studies) from 2007 to 2010;
- An environmental assessment workshop with the Qikiqtani Inuit Association and their community representatives; and
- Guidance provided by the NIRB scoping report (NIRB, 2008) and EIS guidelines (NIRB, 2009).

Additional scoping activities conducted specifically for each VEC are identified within the following respective sections.

1.5 VALUED ECOSYSTEM COMPONENTS

Valued ecosystem components identified through scoping activities are the focus of the Project effects assessment in the following sections, and include:

- Sea Ice (Section 2);
- Water and Sediment Quality (Section 3);
- Marine Habitat and Biota (Section 4); and
- Marine Mammals (Section 5).

As noted above, not all VECs are species, however where the effects assessment is with respect to a specific species, the assessment is ecosystem-based and takes into account all potentially affected life cycle stages. Thus, the effects assessment incorporates life cycle stages and the lifespan of the species under evaluation. Marine mammal species used as indicator species were selected due to their cultural and social significance to Inuit or due to their respective conservation status, (i.e., under consideration by SARA or are listed as 'Species of Concern' or 'Threatened' by COSEWIC).

The duration criterion, in common with established EA methodology, addresses the duration of the effects interaction, and consequently is expressed in terms of the Project life cycle. Where duration is described as "short", "medium" or "long", this is in general within the context of the Project life and not in reference to the life cycle, e.g., of a receptor organism. The latter issue is considered in evaluating the ecosystem context of the effects assessment. The assessment also describes trophic levels and inter-relationships. The effects analysis incorporates the primary and secondary trophic levels and their interactions with benthos into the assessment.

The measurable parameters, threshold of effects, and temporal scale of the VEC Key Indicators are presented in Table 8-1.1. These have all been reviewed to ensure they are appropriately selected, adequately described for the marine environment and are quantitative where possible. Note, the effects assessment has been completed in a manner which takes into account the accumulated effect of all the various Project interactions for each VEC/Key Indicator. This consideration is brought forward in the assessment of residual effects for each assessed VEC and/or Key Indicator.

During the review of the Draft EIS, interveners requested that additional consideration be provided with respect to several Subjects of Note (disruption of pack ice through Hudson Strait and Foxe Basin due to ice-breaking ore carrier passage, potential for Invasive Species from Ballast Water, and Spills, Accidents and

Malfunctions). In each case, additional consideration has been given to the noted subjects; however in general there has been no change in the appropriate level of consideration for the identified subjects, i.e. they remain as Subjects of Note.

Table 8-1.1 Temporal Scale of the VEC Key Indicator

VEC - Key Indicator	Measurable Parameter	Threshold	Temporal scale
Sea Ice - Landfast Ice	Surface Area	Proportion of Total Area Disrupted	Per Year
Water and Sediment Quality	Designated metals, chemicals	Concentration Levels	As per Regulatory guidance
Marine Habitat and Biota- Habitat	Habitat	Proportion of Surface Area Affected	Project Life
Marine Habitat and Biota- Arctic Char	Arctic Char Health- water quality	WQ Guidelines – Concentration Levels	Project Life
Marine Mammals- Ringed Seals, Walrus, Beluga, Narwhal, Bowhead, Polar Bear	Habitat (pupping - Ringed Seal; overwintering, feeding, haulout - Walrus; overwintering, summering – Beluga, Narwhal, Bowhead; foraging - Polar Bear.	Proportion of Total Area Disrupted	Project Life
Marine Mammals- Ringed Seals, Walrus, Beluga, Narwhal, Bowhead, Polar Bear	Disturbance	Proportion of Population Reacting	Per Year
	Hearing Impairment (all except Polar Bear)	Proportion of Population exposed	Per Year
	Mortality	• Any Project-induced mortality of a KI • > 1 % of Ringed Seal Population	Per Year

SECTION 2.0 - SEA ICE

2.1 INTRODUCTION

This section provides an assessment of icebreaking activities on sea ice along the shipping route to Steensby Port. Ore carriers accessing Steensby Port will pass through drift/pack ice and landfast ice along the shipping route during most of the year. The route includes waters from the Nunavut Settlement Boundary at the Labrador Sea, the northern portion of Hudson Strait, Foxe Basin, and into Steensby Inlet (Figure 8-2.1). Shipping to Milne Port will occur only during open water periods for Project construction and occasionally (less than once per year) during the open water period throughout the operational phase and, therefore, no shipping-related effects to sea ice are anticipated along that route.

The distribution of sea ice and its relationship to open water plays an important role in determining the distribution, movement patterns, and abundance of marine biota. Microalgae and associated secondary producers establish on the bottom of the ice each spring, providing forage for fish such as Arctic cod and for seabirds (Bradstreet and Cross, 1982; Welch *et al*., 1992; Mallory and Fontaine, 2004). The distribution of marine mammal species such as the Atlantic walrus or of seabird breeding colonies is largely determined by the presence of annually recurring polynyas, shore flaw and lead systems that occur in the sea ice (Stirling *et al*., 1981; Stirling, 1997; Mallory and Fontaine, 2004). Polynyas and shore lead systems may be caused by wind, tidal fluctuations, currents, upwellings, or a combination of those factors and, along with ice edges in general, are characterized as sites of increased biological activity (Stirling 1980; Bradstreet and Cross, 1982; Stirling, 1997). Stirling (1997) indicated that the increased presence of seabirds and marine mammals in the vicinity of ice edges was due to the provision of:

- calmer water, which makes resting on the surface and diving for food easier;
- access to a substrate to rest upon after periods in the water;
- a temporary barrier to migration;
- a navigational aid to migrating species;
- a place where marine mammals can breathe and seabirds can feed in areas of heavy ice cover;
- habitat upon which, or into which, predation and escape from predation can occur; and
- increased productivity near the ice-water interface that results in greater biomass of invertebrates and fish for birds and mammals to feed upon.

In addition, stable areas of landfast ice provide important hunting areas for Inuit.

2.2 STUDY AREAS

Icebreaking will occur along the length of the nominal (planned 1.5 km wide) shipping corridor and the primary interaction between the Project and sea ice will be physical alteration or disturbance due to the passage of the ship. Other effects, particularly increased underwater noise, will have no effect on the sea ice itself, but will interact with marine biota associated with the ice. Consequently, study areas defined for the sea ice assessment reflect those selected for marine mammals (Volume 8, Section 5) to provide context and consistency between the two assessments.

The LSA for the sea ice assessment refers to the area that includes the nominal shipping corridor and a 50 km zone on either side of it. This includes all of Steensby Inlet, the central part of Foxe Basin, and the northern and central parts of Hudson Strait. The RSA for the shipping route includes all of Foxe Basin and Hudson Strait to the Nunavut Settlement Area Boundary. The LSA is illustrated in Figure 8-2.1.

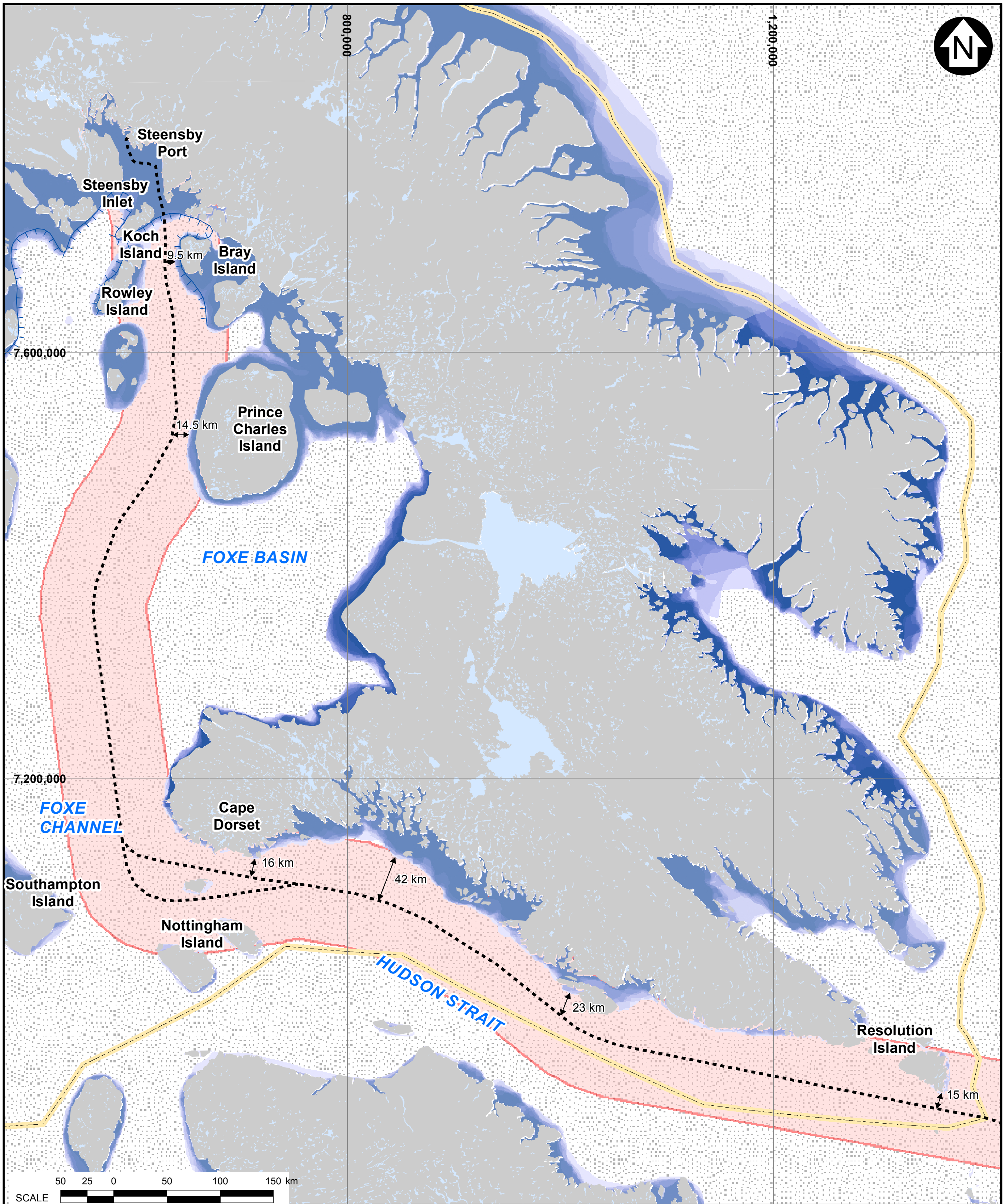


FIGURE ID: BL_Vol8_GIS_002 Shipping Route to Steensby Inlet Figure 8-2-1.mxd

LEGEND:

FREQUENCY OF FAST ICE COVERAGE IN JUNE

10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%

EXTENT OF PACK ICE

ICE EDGE (IQ STUDY)

SHIPPING ROUTE

LSA

NUNAVUT SETTLEMENT BOUNDARY

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.

2. COORDINATE GIRD SHOWN IN UTM (NAD83) ZONE17 AND IS IN METRES.

3. THE FREQUENCY OF LAND FAST ICE FOR THE MONTH OF JUNE IS SHOWN FOR A 10 YEAR PERIOD ENDING JUNE 30, 2009 FOR THE HUDSON BAY AND EASTERN ARCTIC REGIONS

4. DATA SOURCE: CANADIAN SEA ICE SERVICE ENVIRONMENT CANADA

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SHIPPING ROUTE TO STEENSBY INLET

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_002

FIGURE: 8-2.1

REV 0

The shipping route is defined; however, it is not fixed. Through the ongoing detailed bathymetry data collection some minor route adjustments may be required. These minor route changes will assure a safe passage and will all occur within the nominal shipping corridor. As a rule the vessels will adhere to the designated route since it will provide the most direct and best charted alternative. The ships Master is, however, ultimately responsible for the safety of the crew, the vessel and its cargo. In the execution of these duties the Master may vary from the route as required in order to ensure safe passage. As well, a vessel can be called upon to participate in a Search and Rescue response which may cause the vessel to deviate from the nominal shipping corridor. The vessel can be expected to remain within the assigned shipping corridor and will be required to do so to the extent such instruction does not interfere with the responsibilities of the Master.

2.3 BASELINE SUMMARY

Typical sea ice conditions in Steensby Inlet and along the proposed shipping route were identified from literature sources (Markham, 1981; Prinsenberg, 1986) and an ice and marine shipping assessment conducted in support of the Project (Volume 3, Appendix 3G). The ice study supported the selection of Steensby Port as a viable location, helped define the proposed shipping route to Steensby Inlet, and determined the appropriate ice class of vessels.

Data used in the Enfotec Ice and Marine Shipping Assessment (Volume 3, Appendix 3G) included CIS data (1990 to 2010), as well as synthetic aperture radar (SAR) imagery from aircraft (1990-1995) and RADARSAT satellite (1998-2010). Additional CIS ice data (1982-2010) was analysed by Sikumiut Environmental Management Ltd. The 30 year baseline review used the most recent and up-to-date data available for the RSA. Other data such as the Hall Beach ice thickness data and on-site sampling was used for modelling purposes.

Foxe Basin and Hudson Strait undergo an annual pattern of ice formation and ablation. Through most of the year, marine waters in the region are covered by landfast and mobile drift or pack ice. Only during September is Foxe Basin largely ice-free. The Foxe Basin/Steensby Inlet area has a longer ice season than other areas at similar or even higher latitudes (Markham, 1981; Prinsenberg, 1986; Volume 3, Appendix 3G).

Ice formation in northern Foxe Basin begins in mid- to late October. New ice expands southward from north-western Foxe Basin (Markham, 1981; Volume 3, Appendix 3G). Freeze-up begins in the western portion of Hudson Strait during November and proceeds eastward until most of the Strait is covered, generally in mid-December. Shore lead systems frequently form along the southern coast of Baffin Island, while ice tends to accumulate along the southern shore of Hudson Strait and Ungava Bay. Landfast ice forms along coastline areas of Foxe Basin and Hudson Strait. Most inlets and bays across northern Foxe Basin, including Steensby Inlet and Murray Maxwell Bay, are characterized by large extents of landfast ice. In contrast, a narrower band of landfast ice forms along most of the northern shore of Hudson Strait (Figure 8-2.1) because of stronger oceanic currents in that area (Appendix 8A-1). Each year, Steensby Inlet is completely covered by landfast ice that can extend as far south as Koch Island in some years (Figure 8-2.1).

To capture maximum ice thickness values in Steensby Inlet, sampling was conducted in May and June 2008 (Appendix 8A-1; Volume 3, Appendix 3G). This field sampling period was chosen based on 50 years of ice thickness data from nearby Hall Beach and the results were consistent with expected values from that location. Sampling effort was equally divided between the Steensby port site and the entrance to Steensby Inlet. In May, Steensby port site median ice thickness was 1.90 m while the mean (± standard deviation) ice thickness was 1.93 ± 0.36 m. In June the median ice thickness was 1.85 cm and the mean (± standard deviation) ice thickness was 1.94 ± 0.37 m. The sampling stations across the entrance of Steensby Inlet were spaced 5 to 10 km apart and in the month of June had a mean of 1.85 m and a median ice thickness of (± standard deviation) 1.87 ± 0.16 m. Even though the stations were spaced farther apart, the spread of measurements was tighter than that of the port site.

Examination of satellite imagery and historical winter atlases suggests that landfast ice in Steensby Inlet is characterized by few ridges and leads. However, during a shipping-focused thematic workshop held at Mary River during September 2010, Igloolik community members indicated that a recurring lead occurs between one of the small islands in central Steensby Inlet and the eastern shore.

Much of Foxe Basin and Hudson Strait are covered by high concentrations (9/10-10/10 coverage) of pack ice through most of the year. Prevailing winds and ocean currents cause pack ice to be more concentrated and to accumulate in southern Foxe Basin; however, by the end of October, 90 % of the northern half of Foxe Basin is ice covered (Markham, 1981; Prinsenberg, 1986). Vigorous tidal currents and strong winds keep the ice pack in constant motion through the winter, and contribute to extensive and recurring open water lead systems that occur along the boundary between landfast and mobile pack ice (Appendix 3G). These are particularly prevalent along the north-western coast in the vicinity of Hall Beach and Igloolik, across the entrance to Steensby Inlet, and on the northern shore of Hudson Strait (Figure 8-2.1; Stirling, 1997; Volume 3, Appendix 3G, Appendix 8A-1). Recurring polynyas occur near Hall Beach, near Fury and Hecla Strait, and off the northern end of Prince Charles Island (Stirling, 1997).

Spring break-up begins in April and May, when leads in northern Foxe Basin and along the south coast of Baffin Island begin to widen due to increased solar radiation. Ice cover continues to decrease slowly into July as Hudson Strait clears. The landfast ice in Steensby Inlet starts to fracture in late June and may be completely fractured by the end of July. Time-lapse photography at the Steensby Port suggests that break-up is abrupt and the area can be ice free very shortly after break-up (Appendix 8A-1). Rather than drifting extensively, as in Hudson Strait, pack ice tends to move less in the central part of Foxe Basin and disintegrates in place during August and September. In some years, remnant drift ice may remain within the basin at low concentrations (rarely exceeding 2/10 cover) through the summer to become second-year ice when freeze-up begins.

2.4 ISSUES SCOPING

Baffinland carried out numerous studies and consultations to characterize the existing sea ice conditions along the shipping route and assess the feasibility of year-round shipping to Steensby Inlet. These included the following:

- An evaluation of sea ice and an assessment of the feasibility of year-round shipping along proposed routes (Volume 3, Appendix 3G);
- Consultations with FedNav, a Canadian ship owner and operator associated with other northern projects that involve winter shipping in the Arctic: Voisey's Bay Mine in Labrador, Raglan Mine in Hudson Strait and Nanisivik Mine, North Baffin Island. FedNav has been retained by Baffinland to manage shipping operations for the Mary River Project; and
- An environmental assessment workshop with the Qikiqtani Inuit Association and their community representatives.

The principal concern derived from the scoping activities was that icebreaking associated with year-round shipping would cause disturbance to sea ice which, in turn, could affect Inuit travel and hunting activities as well as animals (such as marine mammals and seabirds) that are associated with, and rely on, sea ice and sea ice edges for various life history functions.

2.4.1 Valued Ecosystem Components

During the scoping activities identified in Section 2.4, sea ice and Project-related effects to sea ice were identified as being of utmost importance to Inuit as it relates to their culture, as well as to animals that rely on ice. Therefore, sea ice was identified as VEC.

2.4.2 Key Issues and Pathways

A number of pathways were identified through which construction, operation, and closure activities would interact with sea ice. Identified Project interactions have been categorized as a Level 1 interaction (Subject of Note) or a Level 2 (Key Issue) according to definitions provided in Volume 2, Section 3.5.

Key Issues and Subjects of Note for the sea ice VEC include the following:

Level 2 Interactions (Key Issues):

- Disruption of landfast ice in Steensby Inlet and at Steensby Port by icebreaking ore carriers and ice management activities;
- Disruption of landfast ice at Steensby Port by ballast water discharge from ore carriers; and
- Spills and emergency management during construction and operation (this issue is addressed separately in Volume 9 and 10 and will not be considered further here).

Level 1 Interactions (Subjects of Note):

- Disruption of landfast ice at Steensby Port during construction activities, including on-ice construction activities;
- Treated wastewater discharge during construction and operation of the Project;
- Disruption of landfast ice at Steensby Port due to dust deposition on the ice surface; and
- Disruption of pack ice through Hudson Strait and Foxe Basin by icebreaking ore carrier passage.

The following section provides assessments related to Subjects of Note. Key issues will be addressed in Section 2.5.

2.5 SUBJECTS OF NOTE

2.5.1 Construction Activities

A small amount of blasting is required to prepare the sea bed at the ore dock site for installation of caissons. This activity is scheduled to occur during the winter of Year 1 of construction, and will involve using the landfast ice surface as a work platform for drilling rigs and various support vehicles, creation of holes in the landfast ice to provide access to the sea bed, and possibly some disruption of landfast ice when blasts occur. The area over which this will occur includes a road from the construction camp to the work area, a distance of less than 4 km, and a preparation area at the drill sites. The size of the preparation area has not been determined, but is estimated to be less than 15 hectares. On-ice construction activities will have no effect on landfast ice beyond the immediate area of disturbance and will occur only once during the life of the Project.

In summary, the area of landfast ice affected by on-ice construction activities will be very localized and minimal in relation to the extent of landfast ice within Steensby Inlet and is expected to occur only once during the life of the Project. Based on this information, the effects on sea ice would be negligible and of no consequence to either Inuit travel or marine biota.

2.5.2 Wastewater Discharge

Modelling suggests that treated wastewater effluent will remain at depths well below the subsurface of the landfast ice and consequently there will be little, if any, interaction between treated wastewater discharge and sea ice.

Treated wastewater from construction and permanent camps at Steensby Inlet will be discharged into the marine environment during the construction and operation phases of the Project. The outfall will be directionally drilled through the bedrock to a point north of the ore dock and at a water depth of about 35 m.

Basic modelling to determine the fate of the treated wastewater upon entry into the marine environment was conducted and is presented in Appendix 8B-2. The modelling used temperature and salinity differences between the effluent and the receiving environment to determine the depth at which the wastewater would equilibrate in the water column. Model assumptions were that the wastewater was 10^{o}C at the outfall, and had the same density as fresh water. Results show that the wastewater mass will not rise beyond water depths of 20 m and would therefore not come into contact with sea ice.

2.5.3 Landfast Ice Disruption Due to Ore Dust Deposition

Fugitive dust from ore stockpiles and ship loading operations will be deposited on the sea ice surface near the dock at Steensby Port. The presence of dust on an ice or snow surface decreases its albedo and increases short-wave radiation absorption, potentially resulting in an accelerated melt for a short period of time during spring. Most dust will be deposited in close proximity to the ore docks, over an area that will already be disturbed as a consequence of ship activities near the docks. Consequently, it is thought that any accelerated melt effects due to dust deposition on the sea ice will be negligible.

2.5.4 Disruption of Pack Ice

Pack ice occurs along the shipping route to the Steensby Port throughout most of the year, and some level of disturbance will be expected due to the passage of icebreakers. The primary effect of shipping on the pack ice is the breaking of individual pans into two or more smaller pieces or the formation of brash ice (CCG, 1990). In months where pack ice is minimal, should icebreaking occur, the effects would not be detectable. A measurable interaction will only occur with respect to larger pans of ice as they are most likely to be broken by the ship, whereas smaller pans of ice would be pushed to the side and not broken.

The individual ice pans that comprise the pack ice go through a cycle of formation, break-up and re-consolidation. Pack ice formation occurs in offshore areas through the “in situ” freezing of water under cold, calm condition. Landfast ice also contributes to pack ice through the break-up of the ice edge (sina). Landfast ice break-off commonly occurs under storm conditions when ocean swell propagates into the sina and shifting winds cause the broken pieces to drift offshore. During calm conditions, ice forms quickly, then with changes in weather, combinations of wind and ocean swell conditions can act to break up ice pans. The same conditions that cause the break-off of ice pans from the sina, can also act on pack ice. Under the stress of ocean swells, pans become broken into smaller pieces. This interaction is pronounced on newly formed and relatively thin ice pans which are not strong enough to absorb the force of an ocean swell (Windsor and LeDrew 1979). The action of wind and currents, especially when directed towards a coastline, will place the pack ice under compression, resulting in rafting of thin ice, ridging of relatively thick pans, and consolidation through freezing together of ice pans to form larger pans.

Through each winter season, pack ice in the RSA will cycle through the sequence of ice formation, break-up and re-consolidation. This natural sequence will mask any interactions between the pack ice and transiting vessels along the shipping route.

Within Foxe Basin and Hudson Strait, pack ice is constantly in motion due to strong winds, oceanic currents and tidal pulses. Little or no quantitative data exist describing the effects of icebreaking on pack ice. However, observations made from the *MV Arctic* en route to the Raglan Mine (in Hudson Strait) during winter indicate that, because of the mobility of the pack ice, the ship track through the ice was quickly closed in and little evidence of the ship's passage was apparent after about six hours. Further, a satellite image provided by FedNav captured the *MV Arctic* moving through heavy pack ice in Hudson Strait. Interpretation of the imagery suggested that about 17 km of ship track were captured, but that about 3 km were already closed in. Assuming the vessel was travelling at 6 kt (11.1 km/h) through the ice, then the transit time for the ship track on the image would be about 1.5 hrs. Thus, the disruption of pack ice was limited to a brief period of time over a small physical area, likely not distinguishable from the natural movement of pack ice in this region. As well, in areas like Hudson Strait, the strong tidal currents render the ice very mobile and pans are regularly broken up by ocean swell, and then forced back together by the action of wind and currents so that ice congeals to form large ice pans. The dynamics of pack ice formations has been described by Windsor and LeDrew (1979). Within such a dynamic environment, the passage of a vessel is a minor contributor to this process.

Within the RSA (Hudson Strait, Foxe Basin, Steensby Inlet), pack ice can be present year-round in varied concentrations. Table 8-2.1 provides the mean monthly area of pack ice within the region for a ten-year period ending 31 December, 2010. Data were extracted and summarized from monthly ice charts produced by the Canadian Ice Service (Environment Canada, 2006). For the purposes here, ice concentrations ranging from >1/10 ice cover to <10/10 ice cover were combined, thus eliminating landfast ice and areas of open water that may contain small concentrations of drift ice. The mean annual maximum spatial extent of pack ice within the RSA is about 320,000 km^2, and occurs from January to July. Assuming a ship width of 50 m and a total route length of approximately 1,460 km, a ship could interact with up to approximately 76 km^2 of pack ice on a single transit during periods of maximum pack ice cover. The area of disturbance is approximately 0.025 % of the pack ice occurring in the RSA. Using the same assumptions and determining that the LSA for sea ice is 146,000 km^2 (ship route of 1,460 km x 50 km on either side), much less than 0.05 % of the maximum amount of pack ice could be affected by a ship track during each transit.

Table 8-2.1 Mean Monthly Area of Pack Ice within the RSA and Proportion of Disruption Due to Icebreaking

Month	Area of Pack Ice in RSA[1] (km^2)	Area of Single Ship Transit to Steensby Inlet[2] (km^2)	Proportion Of Pack Ice Disrupted by A Single Ship Track (%)
January	329,943	76	0.02
February	320,344	76	0.02
March	317,129	76	0.02
April	315,207	76	0.02
May	319,687	76	0.02
June	321,575	76	0.02

Table 8-2.1 Mean Monthly Area of Pack Ice within the RSA and Proportion of Disruption Due to Icebreaking (Cont'd)

Month	Area of Pack Ice in RSA[1] (km^2)	Area of Single Ship Transit to Steensby Inlet[2] (km^2)	Proportion Of Pack Ice Disrupted by A Single Ship Track (%)
July	326,496	76	0.02
August	163,393	-	-
September	39,303	-	-
October	10,280	-	-
November	147,844	-	-
December	309,494	-	-

NOTE(S):

1. CALCULATED AS THE AVERAGE MONTHLY AREA OF PACK ICE OF CONCENTRATION 1/10 TO <10/10 FOR A TEN YEAR PERIOD ENDING 31 DECEMBER, 2010.
2. BASED ON A SHIPPING ROUTE LENGTH OF 1500 km AND A NOMINAL SHIP WIDTH OF 50 m.

Using the data collected from Canadian Ice Service (Environment Canada, 2006), the approximate number of ice pans that may interact with a ship passage was calculated (Table 8-2.2). The 204 ship transits were calculated to interact with approximately 371,688 pans throughout an entire year of shipping. In the context of the RSA the interaction with these pans is minimal, in that a single ship transit will disrupt only 0.025 % of the pack ice area (Table 8-2.1). Should all 371,688 pans be split over the course of a year, this would still result in a negligible effect on sea ice within the RSA.

Table 8-2.2 lists the number of ice pans estimated to be struck per month, per year of operation, based on 17 transits per month. Vessels will encounter ice pans of various sizes and thickness throughout the shipping route. Repeated vessel strikes on a single ice pan, even given the multiple transits associated with Project operations, will be infrequent. It is anticipated that the small ice pans (<0.1 km in length) would be pushed to the side while larger (>0.1 km in length) ice pans will be split by the vessel (Bevin LeDrew pers. comm.). As pack ice occurs in a dynamic environment, individual pans are always in motion, and as such any movement of ice pans caused by the vessel will not affect pack ice integrity, or pack ice formation.

Strikes between vessels and ice pans will have the potential to create brash ice which would fill any interstitial spaces between ice pans. The brash ice can cement ice pans together under conditions where the ice is compressed (Windsor and LeDrew 1979). Thus, in addition to the splitting of ice pans, ice pan formation/growth may also result from vessel strikes. As this type of ice pan formation is a naturally occurring phenomenon and any additional brash ice created (and ice pans created as a result of brash ice cementing) would be masked by natural ice dynamics.

Density of pack ice cover affects ice breaking, both with respect to vessel speed, as well as the quantity of ice interacting with the vessel. In low density ice cover, the ice pans are more likely to be pushed aside rather than split by the vessel. Conversely, in high density ice cover, it is more likely that the ice pans would be split. In conditions where the ice is under compression (100 % coverage), vessels could find it necessary to reverse and ram the ice. Under these conditions ice pans may be struck multiple times by a single vessel and the creation of new smaller ice pans and brash ice will occur. Under natural conditions

Table 8-2.2 Characteristics and Number of Ice Pans Estimated to be Struck per Month by Project Vessels

Month	Range of Average Ice Thickness Class (cm)	Range of Average Pan Length (km)	Estimated Number of Pans to be Struck by a Single Project Vessel transit per Month	Estimated Number of Pans to be Struck Annually
January	<10 – 70-120	0 – 10	26	5,304
February	<10 – 70-120	0.02 – 10	612	124,848
March	10-15 – 70-120	0.5 - 10	7	1,428
April	<10 – 70-120	0.5 - 10	21	4,284
May	<10 - >120	0.5 - 10	18	3,672
June	10-15 - >120	0.02 - 10	303	61,812
July	10-15 - >120	0 - 2	178	36,312
August	10-15 – 70-120	0.5 - 2	2	408
September	0	0	0	0
October	0	0	0	0
November	10-15 – 30-70	0.5 – 2	29	5,916
December	<10 – 30-70	0 – 2	626	127,704
Annual Total	0	0	1,822	371,688

of ice compression the same phenomena occur. Friction and rubbing between ice pans results in the fracturing of the pans and brash ice formation. Vessel transit through high density ice coverage will therefore be masked by the natural processes of pack ice dynamics.

As described in Volume 9 Section 3.6.5, no accidents are anticipated as a result of ship-ice interaction, therefore, the risks to the marine environment from ice related shipping accidents is minimized. The 30 year baseline review indicated that no significant amount of multi-year ice or icebergs are present within the shipping route. As well, the shipping route has been designed to avoid the occurrences of multi-year ice and icebergs within the RSA (Volume 3, Appendix 3G). Furthermore, two of the four tug boats anchored at Steensby Inlet will have ice breaking capabilities and will be available for rescue assistance through Foxe Basin and Hudson Strait. The precautions taken for winter navigation are described in Section 3.2.2.5 of the Shipping and Marine Wildlife Management Plan (Volume 10, Appendix 10D-10).

Based on the conservative calculations presented above, it can be prudently estimated that the extent of disturbance to pack ice will be negligible - less than 1 % of the LSA and less than 0.5 % of the RSA. Given that evidence of the ship track in mobile pack ice quickly disappears due to the movement of the ice by winds and tide, and that ship disturbance to pack ice along the route will disrupt less than 0.5 % of available pack ice regionally on an annual basis, it is concluded that vessel transits will be of little consequence to pack ice integrity within the RSA and LSA.

2.5.4.1 Polynyas

Participants in the Technical Hearings in Iqaluit requested additional information on the presence of polynyas in the RSA and relationship of the shipping route to polynyas. To this end, Baffinland commissioned a study of historical ice records to document the presence and location of polynyas. The study yielded two reports prepared by ice experts ASL Environmental Sciences Inc. in Victoria, BC. The first report covers Foxe Channel and Hudson Strait (Ersahin *et al.*, 2011a in Appendix 8A-3) and the second report covers Foxe Basin (Ersahin *et al.*, 2011b in Appendix 8A-3).

Polynyas are persistent and recurring areas of open water and /or thin ice that occur within regions at times of the year where more consolidated and thicker ice is normally present (Barber and Massom, 2007). The size of polynyas can range from tens of square kilometers to thousands or even tens of thousands of square kilometers. The underlying physical processes of polynyas generally take one or both of two forms: mechanically forced (usually by the wind or strong tidal currents) and convectively forced by the uptake of heat from below the nearly freezing upper water layer beneath the sea ice cover (Williams *et al.*, 2007). Polynyas are recurring phenomena and should not be confused with temporary areas of open water that often occur in pack ice. It is the recurring nature of polynyas that make them important for marine mammals (and sea-associated birds).

There are no persistent areas of non-linear, polynya-like features in Foxe Channel. In Hudson Strait, there is a large linear area off the south coast of Baffin Island (the "South Baffin Lead"), on the northern side of Hudson Strait where a persistent shore-lead polynya like feature occurs. This feature is described in some detail in Volume 3, Appendix 3G.

The prevailing north-westerly winds over the region result in the creation of numerous leads along south-facing coastlines in Hudson Strait. The lead is most prominent between Resolution Island and Big Island becoming narrower west of Big Island. The lead is present most of the winter and early spring closing only occasionally under southerly wind conditions for brief periods. The general north-west to south-east forcing of the ice that creates the lead also creates a zone of thinner first year ice in the area. Although termed a "lead", the cold temperatures in the region in midwinter results in the "open water" areas always being covered with thin new, young ice. There is some variation in the timing of the widening of the lead with spring break-up in western Hudson Strait occurring in early May in some years and mid-June in other years. At most times, the ore carriers will travel through the pack-ice to the south of the South Baffin Lead.

Ersahin *et al.* (2011b of Appendix 8A-3) assessed the presence of polynyas in eastern Foxe Basin over the past 20 years. In the early part of the ice season from December through to the beginning of March, polynya like ice features occur only very rarely within the shipping route: only 1 or 2 occurrences were realized in each winter time period over 20 years of ice charts. The occasional occurrences are located just to the west of Prince Charles Island and in the areas immediately to the north of Bray Island and to the east and to the north of Koch Island. Polynya like features occurred more frequently in other areas of Foxe Basin, away from the shipping route during winter with the most frequent being the areas east of Fury and Hecla Strait between Igloolik Island and Jens Munk Island. In the Igloolik-Jens Munk Island area, the rate of occurrence of polynya like features ranges from 30 % to 60 % of the years over the 20 years of available data in the December to early March period. Similarly, frequent occurrences of polynya-like features are also found along the coast of southwestern Foxe Basin around Cape Wilson to the south of Hall Beach.

Starting in early April through to early July, the frequency of occurrence of polynya like features in Foxe Basin increases along the shipping route in the small areas to the north of Koch and Bray Islands with occurrence frequencies of 30-40 % of all years. The polynya-like features also occur, at a lower rate, in the shipping route between Rowley Island and Bray Island. There are also very rare occurrences of polynya like features to the north of Prince Charles Island which immediately adjoin the shipping route. Along the remainder of the shipping route, there are no polynya like features detected further north into neither Steensby Inlet nor are there any detected through the central and southern portions of the Foxe Basin shipping route.

For this spring to early summer period, the frequency of occurrence of polynya-like features becomes much higher and larger in the Igloolik-Jens Munk Island area being present in 60-80 % of all years from early May to late June. Other areas outside of the shipping route with relatively large rates of occurrence of polynya like features occur along the coastlines of western and southwestern Foxe Basin as well as in southeastern Foxe Basin well to the southeast of Prince Charles Island. By early July, the areal extent of the polynya-like features has reached its maximal extent in Foxe Basin although even this late in the ice season, most of the shipping route has zero or very low occurrences of polynya-like features. After early July, the ice concentrations are further reduced to levels where polynya-like features are no longer well defined because of the large areas of open water.

The important point to note about the polynya-like features in the vicinity of the shipping route is that none of them are recurring polynyas and as such they are not likely to be areas of regular concentration by marine mammals. Apart from northwest Foxe Basin, the polynya-like features identified Appendix 8A-3 are fairly small and transitory. They do not differ from the areas of open water that appear and disappear in areas of moving pack ice. Therefore, it is concluded that vessel traffic will have a negligible effect on polynyas or adjacent pack ice.

2.5.4.2 Climate Variability and Change

Climate variability and change has the potential to diminish sea ice habitat (seasonal duration, consolidation, thickness and extent), thereby making the remaining sea ice more valuable to ecosystem components that rely on it (i.e., marine mammals, marine fishes, primary and secondary producers).

There is no definitive methodology for projecting the extent of changes to ice cover expected to occur during the 21st century as a result of climate change. The International Arctic Science Committee presented the results of five models which predicted changes in mean annual northern hemisphere sea ice extent between 2000 and 2100 and showed projections ranging from a 12 % to 46 % decrease (IASC, 2010). These projections should be considered in light of the 25 year project life of the Mary River Project.

As discussed above in Section 2.5.4, under current conditions, the extent of interaction between pack ice and Project related shipping will be negligible – less than 1 % of the LSA and less than 0.5 % of the RSA. Under a worst case climate change scenario using the maximum value predicted for a reduction in sea ice extent by 2100 (46 %) these proportions may increase, however, the area of disturbance would remain negligible, i.e., less than 2 % and 1 % in relation to either the local or regional study areas respectively.

The potential 2 % increase in the relative area of disturbance due to a decrease in pack ice extent resulting from climate variability and change is negligible. Therefore, there is no incremental effect of Project shipping on sea ice or on the ecosystem components dependent on it, as a result of climate variability and change.

2.6 LANDFAST ICE

2.6.1 Assessment Methods

The assessment of significance of potential Project effects was conducted in relation to landfast ice in Steensby Inlet (Note: pack ice effects were treated in the previous section under the heading of Subjects of Note). A single measureable parameter and associated threshold have been defined for the sea ice VEC according to guidance provided in Volume 2, Section 3.0. The sea ice VEC parameter and threshold are presented in Table 8-2.3.

2.6.2 Potential Effects and Proposed Mitigation

Project-related activities identified in Section 2.4.2 that have potential to affect landfast ice in Steensby Inlet include:

- Disruption of landfast ice in Steensby Inlet and at Steensby Port by icebreaking ore carriers and ice management activities; and
- Disruption of landfast ice at Steensby Port by ballast water discharge from ore carriers.

In the following sections, the potential effect of each activity is discussed, along with the proposed mitigation measures to reduce negative effects on landfast ice in Steensby Inlet.

2.6.2.1 Landfast Ice Disruption Due to Icebreaking

Year-round shipping to Steensby Port will require icebreaking through pack ice most of the year and through landfast ice seasonally. The latter will occur November through June or early July and will cover the area south from Steensby Port to Koch Island, a distance of 90 km. In addition, some icebreaking at the dock site is expected due to ship manoeuvres and possible ice management activities at the dock.

Table 8-2.3 Measurable Parameters and Thresholds for the Sea Ice VEC

Measurable Parameter	Thresholds	Duration
Surface area of landfast ice within Steensby Inlet	Disruption of landfast ice within Steensby Inlet should be less than 10 % of the surface area.	Per year.

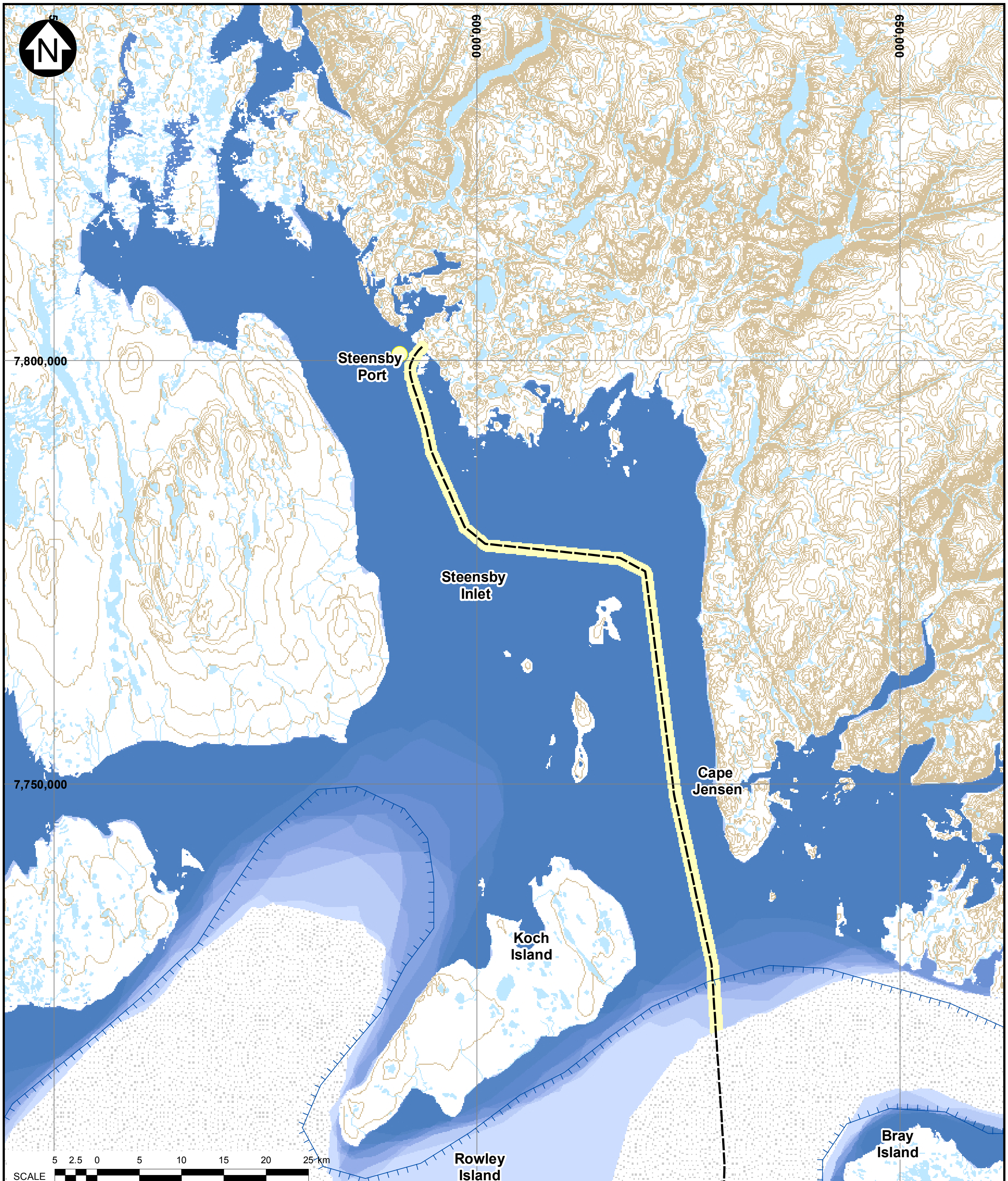
The shipping schedule for Steensby Port anticipates 102 round trips each year. This equates to 204 transits (one-way trips), of which about 136 are expected to occur during periods of landfast ice cover (Volume 3, Section 3.6.3.2). In landfast ice, icebreakers create a track only slightly wider than the ship beam. The ice is broken into small pans, rubble and brash ice. Generally, most of the broken ice remains in the track after the ship passes, but a small portion is forced down and under solid ice alongside the track, where it subsequently freezes. The ship track will immediately begin to refreeze following each passage of the ship. With frequent repeat passages, ice rubble builds up within the track until eventually the ship has to move to adjacent undisturbed ice in order to make progress. Based on their experience with winter shipping in the Arctic, FedNav has estimated that, with the anticipated number of transits into Steensby Inlet, the cumulative width of disrupted ice could reach a maximum width of 1.5 km each year. It should be stressed, however, that this is a conservative estimate and that the actual width may be considerably less, since there will be better performance early and late in the season (more repeats), when the ice is thinner/weaker. This width represents a worst case scenario of only five repeat transits (136 / 5 x 50 m = 1.36 km). Under scenarios of seven repeat transits the width was determined to be 0.97 km and with 20 repeat transits the width was determined to be 0.34 km. Given that the shipping route in landfast ice is over a distance of about 90 km, the area of landfast ice disrupted annually by ships approaching the Steensby Port will be a maximum of 136 km^2. The maximum anticipated extent of ice disturbance is illustrated in Figure 8-2.2.

FedNav anticipates that ships would approach and depart the ore dock unassisted by icebreaking tugs. The approach will be straight to the dock. On departure, the ship will back away from the dock and, using a multi-point ("star") turn completed by moving forwards and backwards, will re-orient itself to depart the area transiting the incoming track. FedNav has estimated that a ship the size of carriers proposed for the Project will require an area of about 1 nautical mile (1.85 km) in diameter or about 2.7 km^2 to complete the turn. Landfast ice in the port area will remain disturbed throughout the winter. Dock-side icebreaking or disruption will occur when the ore carriers approach, remain and depart the dock, through heated ballast water discharge (see Section 2.6.2.2), and potentially the use of a bubbler system (Volume 3, Section 2.6.3). Contingency measures for ice management include the placement of two to four ice re-enforced tugs at the dock during the first year of operation. If used, these vessels will operate within the port area and are not likely to expand the spatial extent of ice disruption. To be conservative, it is estimated that up to 5 km^2 of landfast ice will be disturbed in the dock area, including ice disturbance alongside the dock and potential increases in ice disruption due to expansion of the turning area.

Table 8-2.4 provides the mean monthly area of landfast ice within the RSA for a ten-year period ending 31 December 2009 and within Steensby Inlet for a thirty year period ending December 2011. Data were extracted and summarized from monthly ice charts produced by the Canadian Ice Service (Environment Canada). Throughout the RSA, landfast ice begins to form in November, is at its maximum extent of about 51,000 km^2 in April, and declines in area until July. By August, no landfast ice remains in the RSA. Landfast ice begins to form in Steensby Inlet during late October, reaches its maximum extent of about 5,100 km^2 in March, but does not decrease in surface area until mid-July, when fracturing and clearing occur abruptly.

During February through June, when the extent of landfast ice in Steensby Inlet is at its maximum, from 0.8 % (January) to 4.0 % (July) of the landfast ice will be disrupted by icebreaking carriers accessing the port site, and another 0.2 % will be disrupted by ships manoeuvring at the dock and by ice management activities (Table 8-2.4). On a more regional scale, this equates to 0.05 % and 0.1 % of the mean maximum December landfast ice in the RSA and Foxe Basin, respectively, and 0.7 % and 0.9 % of the mean maximum July landfast ice in the RSA and Foxe Basin, respectively.

Besides physically disrupting the landfast ice within Steensby Inlet, icebreaking could delay formation of a continuous, competent ice surface due to repeated disturbance of newly formed ice. The timing of freeze-up is variable and can begin between late October and late November, depending upon weather conditions. It is thought that any localized disruption in the timing of ice formation will be restricted to a small area around the ship track, the effects of which would be minimal in the context of the naturally occurring variability in the timing of formation, and in the spatial context of landfast ice development in Steensby Inlet and the RSA.



LEGEND:

FREQUENCY OF FAST ICE COVERAGE IN JUNE

- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%
- EXTENT OF PACK ICE
- ICE EDGE (IQ STUDY)
- SHIPPING ROUTE
- 1.5 KM WIDE SHIPPING CORRIDOR

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GIRD SHOWN IN UTM (NAD83) ZONE17 AND IS IN METRES.
3. THE FREQUENCY OF LAND FAST ICE FOR THE MONTH OF JUNE IS SHOWN FOR A 10 YEAR PERIOD ENDING JUNE 30, 2009 FOR THE HUDSON BAY AND EASTERN ARCTIC REGIONS
4. DATA SOURCE: CANADIAN SEA ICE SERVICE ENVIRONMENT CANADA

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MARY RIVER PROJECT

Disturbance to Landfast Ice in Steensby Inlet

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_035

FIGURE: 8-2.2

REV 0

FIGURE ID: BL_Vol8_GIS_035 Disturbance to Landfast Ice in Steensby Inlet Figure 8-2-2.mxd

Table 8-2.4 Mean Monthly Area of Landfast Ice within the RSA and Steensby Inlet

Month	Area of Landfast Ice (km^2)					Ice Disruption[4, 5]			
	RSA[1]	Hudson Strait[1]	Foxe Basin[1]	Steensby Inlet[2]	Average Ice Thickness at Hall Beach (cm)[3]	Ship Corridor (km^2)	% of Steensby	Dock Site (km^2)	% of Steensby
January	35,979	8,577	25,078	4,412	123	34	0.8	5	0.2
February	45,578	12,200	30,950	4,881	147	51	1.0	5	0.2
March	48,751	13,891	32,430	5,022	170	68	1.4	5	0.2
April	50,716	13,744	34,541	5,126	187	85	1.7	5	0.2
May	46,235	10,474	33,330	5,134	193	102	1.9	5	0.2
June	41,072	6,969	31,677	4,641	187	119	2.6	5	0.2
July	18,990	640	1,6108	3,401	163	136	4.0	5	0.2
August	0	0	0	0	0	0	-	0	
September	0	0	0	0	0	0	-	0	
October	0	0	0	259	30	0	-	0	
November	2,428	0	2,190	2,877	56	0	-	-	
December	17,824	157	15,562	3,865	89	17	0.4	5	0.2

NOTE(S):

1. CALCULATED AS THE AVERAGE MONTHLY AREA OF LANDFAST ICE FOR A TEN YEAR PERIOD ENDING 31 DECEMBER, 2010.
2. CALCULATED AS THE AVERAGE MONTHLY AREA OF LANDFAST ICE EXTENT ALONG THE PROPOSED SHIPPING ROUTE WITHIN STEENSBY INLET FOR A THIRTY YEAR PERIOD ENDING DECEMBER 2011.
3. CALCULATED AS THE AVERAGE ICE THICKNESS FROM THE HALL BEACH STATION. DATA FROM 1959 TO 2000 AND 2003 TO 2010.
4. SURFACE AREA OF SHIP CORRIDOR WITH 30-YEAR AVERAGE EXTENT OF LANDFAST ICE IN STEENSBY INLET
5. SHIP CORRIDOR ICE-DISTURBANCE AREA BASED ON A ROUTE LENGTH OF 90 km AND A NOMINAL CUMULATIVE ICE DISTURBANCE CORRIDOR WIDTH OF 1.5 km. IT WAS ASSUMED THAT SHIPS WOULD USE THE SAME TRACK AS LONG AS POSSIBLE BEFORE MOVING TO A NEW TRACK. THUS, AREA OF ICE DISRUPTION WOULD BECOME GREATER THROUGH THE ICE-COVER PERIOD TO A MAXIMUM OF 136 km^2 AT A WIDTH OF 1.5 km.

Ice freeze up occurs during period of low temperature and calm seastate (no winds). Under these conditions, ice forms quickly and newly formed ice then acts as a buffer to retard wind-induced wave formation. During this period of rapid ice formation, high winds or other phenomena can act to break up the newly formed ice and cause it to raft and otherwise break up. Eventually, the low air temperature and even brief periods of calm water will result in formation of an ice cover that is thick enough to resist these disruptive forces and the ice continues to grow both in thickness and aereal extent. At the outer edge of landfast ice, the dynamics of air temperature and wave/current conditions can affect the sina and this area of interaction between landfast and pack ice can result in an area of ice build-up and a moving edge. In mild winters the sina will be closer to shore; in colder winters the sina will extend seaward. Vessel passage during the period of ice freeze up can act to delay ice formation and can produce relatively rough ice surface within the area affected by the ships passage (VBNC, 1997). The delay would be in the order of hours to days, depending on the air temperature and presence of calm conditions (low wind, waves). The effect can be moderated by reducing ships speed as it passes through areas of landfast ice formation. Once landfast ice has formed, ships passage will have a local effect, essentially confined to the width of the ship. At the point of entry into landfast ice, under conditions where pack ice is clear of the edge of the landfast ice (usually an offshore wind and/or falling tide), there can be a drift of ice from the ships track into the open water. This ice will consist of small, rounded pans. On occasion, the seaward edge of the landfast ice can break off and the ice pans so formed will become a feature of the pack ice, a natural phenomenon that may be greatly moderated by the presence of landfast ice. Once a continuous landfast ice cover has formed, there will be no propagating wave that will reach the shore. In extreme conditions (Spring tide) the vessel passage has the potential to result in shoreline cracks or leads, where the vessel speed exceeds about 7 kn. This effect can be reduced or eliminated by reducing the ships' speed.

Ships passage through landfast ice is not predicted to result in the creation of leads. The track behind the vessel as it transits landfast ice will be filled with broken pieces of landfast ice that has passed along the hull of the ship as it passes through the ice. A relatively small portion of the broken ice will pass to the sides of the vessel and rest at the margin of the ships track. The area behind the ships track will, therefore comprise a mixture of small ice pieces and slush. Any interstitial water will quickly refreeze into a relatively rough surface. Only in circumstance where an ocean swell is present and winds are offshore would there be potential for pieces of the edge of the landfast ice to break off. Only under such conditions would the presence of a transiting vessel tend to facilitate such a phenomenon.

As an aside, the presence of even modest surface disturbance due to wind/waves will cause new ice to break up during the initial freeze period. The bow wave and the wake of a ship will have the same effect. With enough cold weather, ice formation will occur regardless of surface disturbance, but ice broken during the initial freezing will have a rougher surface than that which is formed under calm conditions. The spatial extent of this will be highly variable, depending upon the timing and level of disruption by wind, naturally occurring waves, and by ships during the initial freeze period. Alteration of the ice surface will have negligible effect on the sea ice.

Vessel traffic has the potential to advance breakup by accelerating the fracturing process for the melting ice surface. Some limited calving along the shore lead due to ship penetration may occur, but large pans of fast ice are not expected to break loose because of the limited number of leads that form naturally within the Steensby Inlet landfast ice. Notwithstanding FedNav's experience, Inuit have indicated that there is a recurring lead between the islands in central Steensby Inlet and its eastern shore, and have expressed some concern that ship traffic across this lead may cause a large piece of landfast ice to break free.

Mitigation - Icebreaking vessels can minimize the width of the shipping lane (to <1.5 km) by transiting along the same track as much as possible. The shipping lane into Steensby Port will be delineated with markers that will identify the boundaries of previous vessel tracks and act as a guide for the next vessel. Icebreaking tugs and ore carriers will restrict their area of operation to the extent practical, so that the total area of broken landfast ice at the Steensby Port is limited.

2.6.2.2 Landfast Ice Disruption Due to Ballast Water Discharge

Shipping activities in Steensby Inlet will continue year round, whereas, in Milne Inlet, shipping will be restricted to approximately 90 days of open water conditions during the summer season, and will occur infrequently throughout the operation phase of the Project.

All ore vessels will be equipped with sewage treatment plants and incinerators for solid and liquid wastes. Since no sewage effluent or untreated sewage will be discharged from vessels, annual discharge volumes are limited to ballast water. The stern tube seal for the ore carriers will use a Biodegradable lubricant such as Vickers Hydrox 68 (http://www.vickers-oil.com/marine_v2/HYDROXBIO68_MoreInformation.php). The nature of this substance, and the minimal quantities that could be released to the environment, result in a non-measurable effect on receiving water quality.

Ballast water volume requirements differ according to ice-cover with a greater volume of ballast water (200,000 m^3) taken on during winter months to provide extra weight for breaking ice. Open water conditions require a smaller volume (70,000 m^3). The operational phase of the project will see the highest discharge of ballast water as approximately 204 vessels will discharge ballast water annually, at Steensby Port. This will result in the discharge of about 1.71 x 107 m^3 of ballast water per year.

Discharges from chartered vessels associated with Construction traffic and freight during Operations will be fully compliant with the applicable legislated requirements (i.e., the Arctic Waters Pollution Prevention Regulations), however, an estimate of the discharge sources and volumes are not available at this time.

The ballast will be taken on in the North Atlantic, and will be heated slightly (2-4^oC) to prevent freezing while on the vessel. Modelling to determine the fate of the ballast water upon entry into the marine environment was conducted and is presented in Appendix 8B-1. The modelling used temperature and salinity differences between the ballast water (i.e., North Atlantic water) and Steensby Inlet water to determine the fate of the ballast water in the water column.

The anticipated changes in temperature and salinity are less than 0.07 %, and therefore no effects on landfast ice in Steensby Inlet are anticipated from the discharge of ballast water. Because of the greater water depths, the cumulative contribution of ballast water to the entire water column is greatest in the central and south-western parts of Steensby Inlet where values as high as 20 mm are found under the baseline conditions.

The ballast water will have only a limited exposure to sea ice, and consequently will have little or no effect on ice except immediately at the dock side where it is discharged. At that location, the effect may be to help keep ice from accumulating. This will not have any effect on the ice regime beyond the port.

2.6.3 Assessment of Residual Effects

Residual effects are those that persist after the application of mitigation measures. Residual effects were assessed based on the attributes described in Table 2-3.3, Volume 2. Each potentially significant residual effect was subsequently evaluated according to rating criteria described in Table 2-3.4, Volume 2. Note that the criteria ratings were applied only to activities where environmental effects are predicted (i.e., any neutral interaction was not evaluated).

Each potential residual effect was rated according to its predicted magnitude, spatial extent, frequency, duration and reversibility (Volume 2, Table 2-3.4), and the results of the ratings are summarized in Table 8-2.5. The determination of the significance of residual effects is provided in Table 8-2.6. Finally, as per guidance in Section 3.8 of Volume 2, any significant effect prediction was considered in terms of the likelihood of the effect occurring based on its probability of happening and the certainty associated with the prediction (i.e., level of confidence).

The residual effects of annual icebreaking activity will be the physical alteration of a maximum cumulative annual total of 136 km^2 of landfast ice within Steensby Inlet. This represents 4.0 % of the landfast ice within the Inlet and less than 0.5 % of landfast ice within Foxe Basin and the RSA. This effect is an unavoidable result of shipping at Steensby Port. Effects on integrity of the landfast sea ice from shipping are predicted to be "*not significant*" because they will be small in magnitude, confined to within the LSA, long in duration, and fully reversible following Project closure.

Table 8-2.5 Effects Assessment Summary: Sea Ice, Steensby Inlet

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
OPERATION PHASE								
Landfast ice disruption due to ice breaking	Ship passage to Steensby Port including turn-around area will result in the disruption of about 139 km^2 of shore fast ice annually	Negative	Minimize spatial extent of ship corridor	1	1	3	2	1
Landfast ice disruption due to ballast water discharge	Ballast water discharge may result in a reduction of landfast ice cover in the vicinity of Steensby Port	Negative	-	1	1	3	2	1

KEY:
Direction and Nature of Interaction: Positive; Neutral; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

Table 8-2.6 Significance of Residual Effects on Sea Ice, Steensby Inlet

Project Phase/Effect	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
OPERATION PHASE				
Ship passage to Steensby Port including turn-around area will result in the disruption of about 136 km^2 of landfast ice annually	N	2	-	-
Ballast water discharge may result in a reduction of landfast ice cover in the vicinity of Steensby Port	N	3	-	-

KEY:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD: ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

2.6.4 Prediction Confidence

The linkages through which icebreaking can affect sea ice are well understood, and Project activities that may affect sea ice have been considered where appropriate. Icebreaking of the frequency required for the Project has not previously been experienced in Nunavut; however, shipping through landfast ice has been ongoing in the Canadian Arctic for many years, and experience gained from those operations has contributed to the effects assessment presented here.

2.6.5 Monitoring and Follow Up

Monitoring to establish the effect of late season shipping on the timing and nature of landfast formation and break-up in Steensby Inlet may be considered as part of the Shipping Management Plan (Volume 10, Appendix 10D-10).

Adaptive Management – There is potential to modify the shipping route through the landfast ice (during spring only) if monitoring reveals that large pieces of landfast ice prematurely leave the Inlet as a result of icebreaking. *MV Arctic* icebreaking experience in Admiralty Inlet suggests that following a zig-zag pattern within landfast ice can serve as a practical mitigation measure to reduce or eliminate this phenomenon. Other measures could include reduction of ship speed through the melting ice as a means to moderate the bow-wave and wake effects on the ice.

2.7 IMPACT STATEMENT

The residual environmental effect of the Project on sea ice is predicted to be "*not significant*". Although there will be some alteration of landfast ice in Steensby Inlet due to unavoidable icebreaking activities, the area of disrupted ice in relation to local and regional study areas is small and will not have any consequential effects on the local or regional ice regime.

2.8 AUTHORS

This impact statement was prepared by Warren Bernhardt (Senior Aquatic Biologist) and Michael Lawrence (Senior Aquatic Biologist) of North/South Consultants Inc.; and Trevor Ford (Biologist), Larry LeDrew (Senior Scientist) and Bevin LeDrew (Partner) of Sikumiut Environmental Management Ltd.

SECTION 3.0 - WATER AND SEDIMENT QUALITY

3.1 INTRODUCTION

Water quality is an important component of the aquatic environment, as it forms a significant facet of the environment for aquatic life and wildlife. Sediment quality is also important to the health of aquatic biota that live in or on sediments, or that are part of the food chain that includes sediments and/or benthic communities.

The following sections provide a description of the existing water and sediment quality conditions in Milne and Steensby Inlets, a description of the approach and methodology used in assessing potential effects on the environment, an assessment of the predicted effects of the Project on this VEC, a summary of residual effects, and proposed environmental monitoring and follow-up.

3.1.1 Study Areas

LSA selection was based on guidance from NIRB and is described in Volume 2. It is defined as the area where there exists reasonable potential for direct interaction due to Project activities, ongoing normal activities, or possible upset conditions, such as a fuel spill. Project activities could affect water and sediment quality in the vicinity of the proposed port sites and were considered in the development of the LSA, including the following:

- Discharge of ballast water from supply vessels and ore carriers;
- Airborne dispersion of dust from ore stockpiles;
- Discharge of treated wastewater; and
- The modelled 95 % probability distribution of diesel spills.

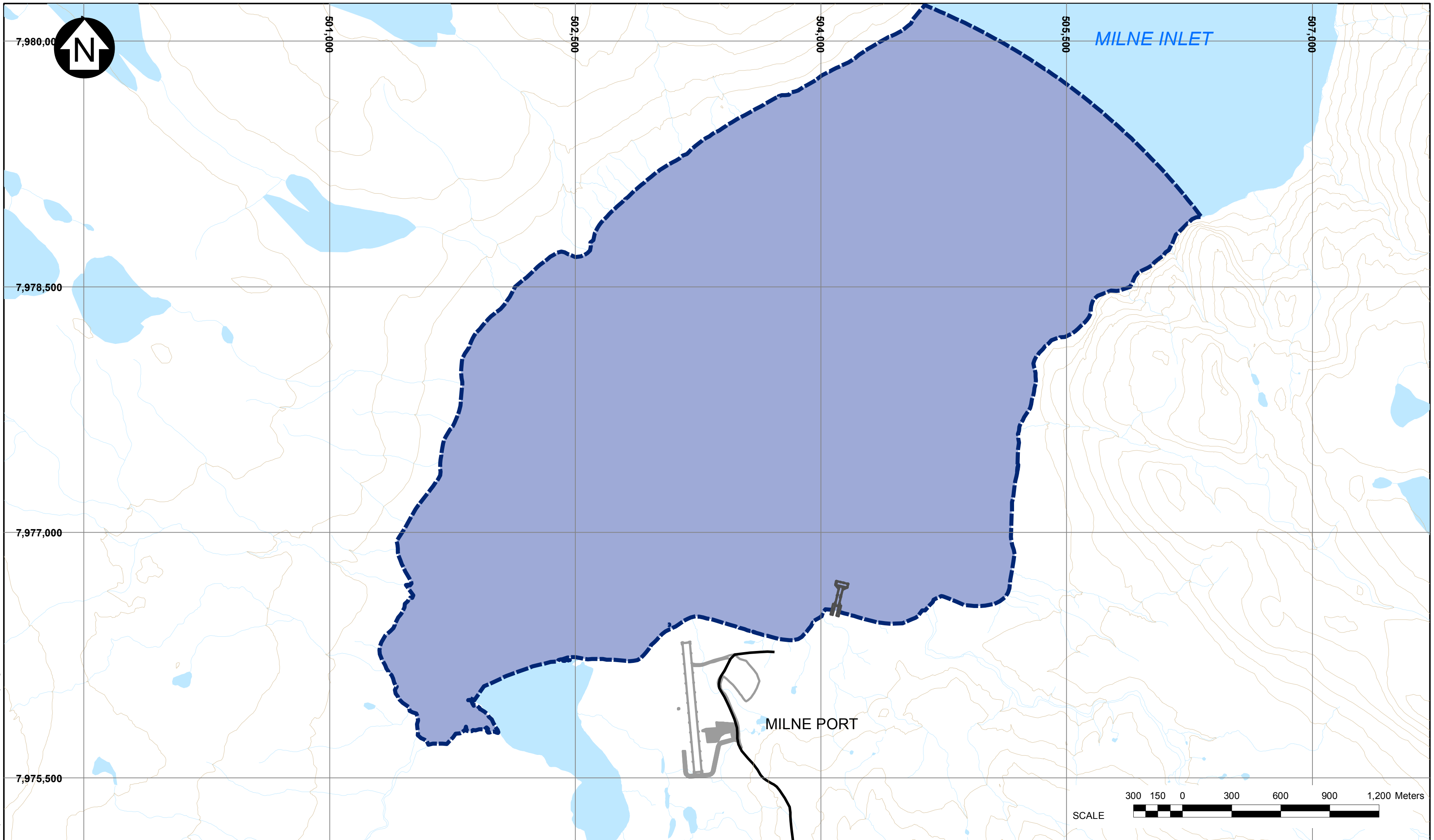
Although the areal extent of a potential diesel spill was included in the development of the LSA for water and sediment quality, all assessments of spills and emergency procedures are discussed in Volume 9 (Accidents and Malfunctions, Section 3.0).

Milne Inlet

The Milne Inlet LSA for water quality and sediment quality extends northeast from the proposed port site (at the south end of the Inlet) for a total of 4 km, and spans the whole width of the Inlet (Figure 8-3.1). The southwest boundary of the LSA ends at the confluence of the Inlet with Phillips Creek. Milne Inlet and Eclipse Sound are the water and sediment quality RSA.

Steensby Inlet

The Steensby Inlet LSA contains all of the marine waters within an 8 km radius of the proposed port site (Figure 8-3.2). This area spans approximately two-thirds the width of Steensby Inlet, and includes the Steensby Port Island and a large part of Ikpikitturjuaq Bay. The water and sediment quality RSA is Steensby Inlet.



LEGEND:

- LOCAL STUDY AREA (4 KM RADIUS)
- WATER
- INFRASTRUCTURE

NOTES:

1. BASE MAP: (1:250 000) © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL IS 25 AND IS IN METRES.
4. MILNE INFRASTRUCTURE PROVIDED BY AMEC DRAWING NO.A1-165926-7420-121-SK-001.DWG (ORE DOCK) AND A1-165926-7440-121-SK-001.DWG (FREIGHT DOCK).

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MARY RIVER PROJECT

MILNE INLET
LOCAL STUDY AREA -
WATER AND SEDIMENT QUALITY

Baffinland Iron Mines Corporation

REF NO.
BL_Vol8_GIS_005

FIGURE: 8-3.1

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FIGURE ID: BL_Vol8_GIS_005 Milne Inlet Local Study Area - Water and Sediment Quality Figure 8-3-1.mxd

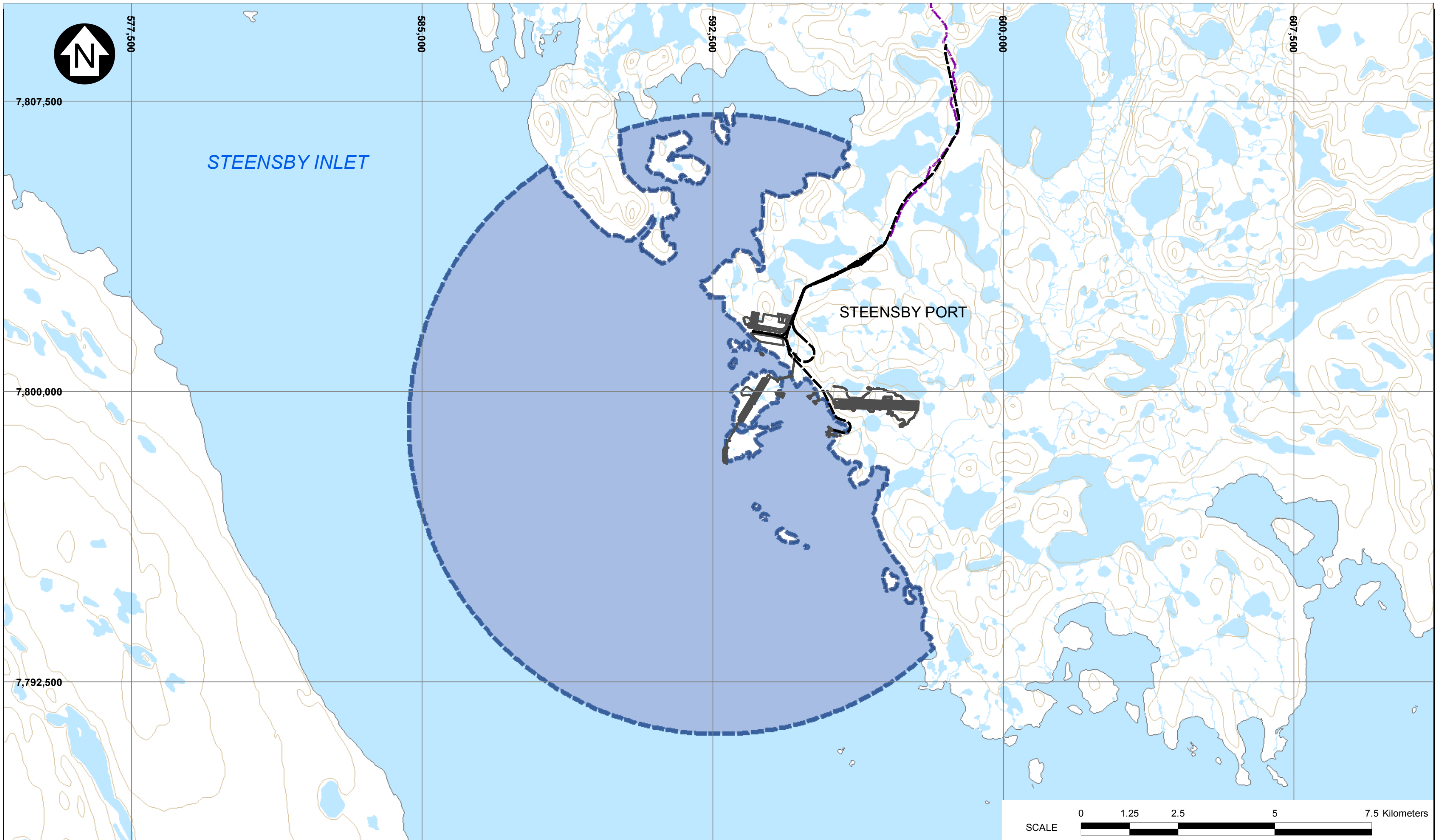


FIGURE ID: BL_VOL8_GIS_004 Steensby Inlet Local Study Area Water and Sediment Quality Figure 8-3.2

LEGEND:

- LOCAL STUDY AREA (8 KM DIAMETER)
- WATER
- INFRASTRUCTURE

NOTES:

1. BASE MAP: (1:250 000) © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL IS 20 AND IS IN METRES.
4. INFRASTRUCTURE PROVIDED BY AMEC A1-164512-8120-121-0900.dwg

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY INLET LOCAL STUDY AREA - WATER AND SEDIMENT QUALITY

Baffinland Iron Mines Corporation

REF NO. BL_VOL8_GIS_004

FIGURE: 8-3.2

3.2 BASELINE SUMMARY

While water and sediment quality are interrelated, for clarity they have been presented separately in Sections 3.2.1 and 3.2.2, respectively. Additional details and results are presented in Appendix 8A-1.

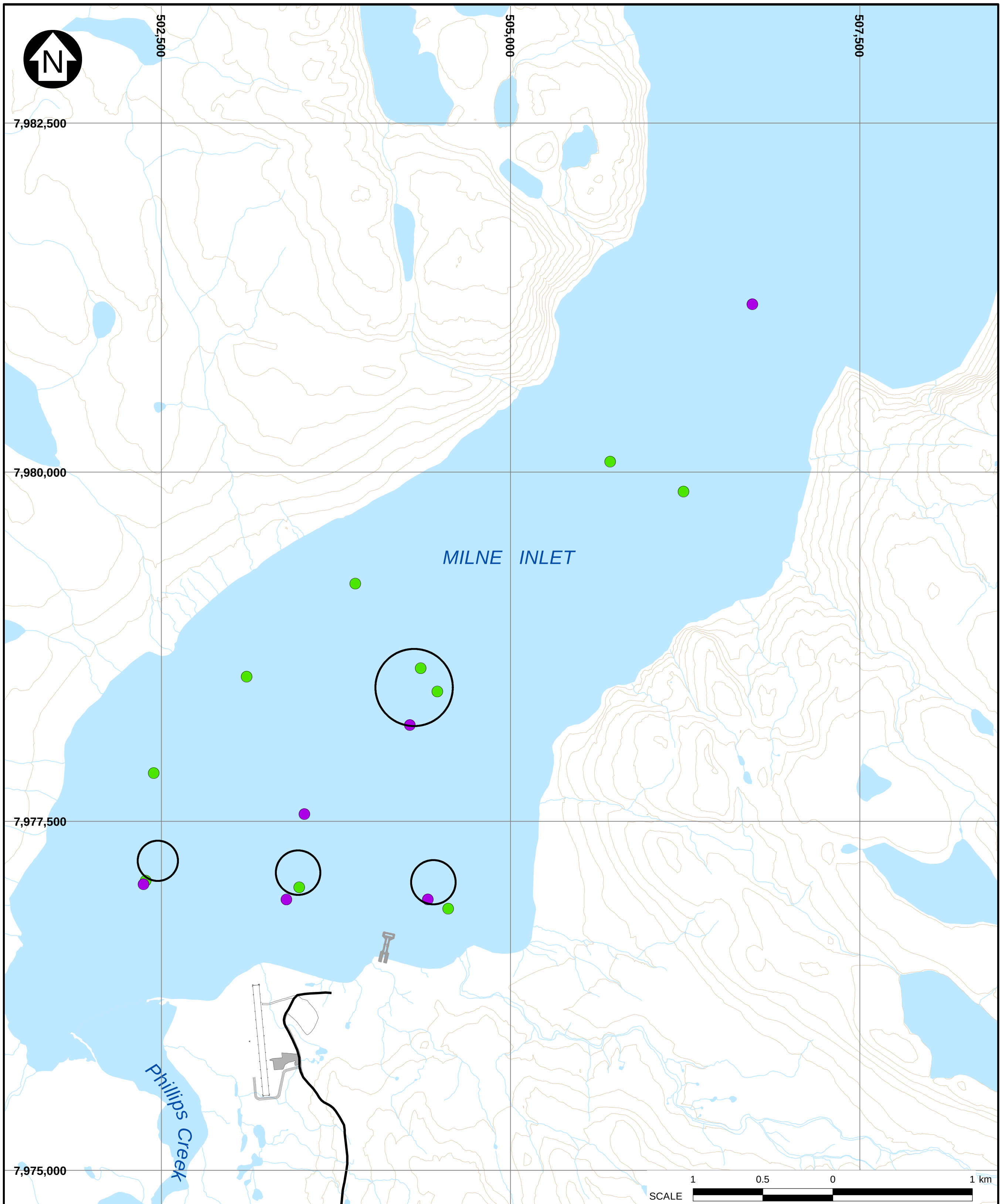
3.2.1 Water Quality

Surveys of Milne and Steensby Inlets were conducted during the open-water (i.e., August or September) and ice-cover (i.e., May or June) seasons of 2007 and 2008 (Steensby Inlet), and 2008 and 2010 (Milne Inlet). Surface and deep-water (1 m above the bottom or to a maximum of 30 m) samples were collected at various depths and distances from shore to characterize the overall conditions within each Inlet (Figure 8-3.3 and Figure 8-3.4). Analyses were carried out at accredited laboratories (EXOVA Laboratories, Ottawa, ON; ALS Laboratories, Vancouver, BC). Results were compared to the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of marine aquatic life (PMAL) (CCME, 1999; updated to 2010). A guideline is a recommended upper limit for protection, but is not a legally binding value. Guidelines for marine environments exist for pH, nitrate, arsenic, cadmium, chromium and mercury. The CCME (1999; updated to 2010) has also issued guidelines for total suspended solids (TSS), turbidity and salinity but the guidelines refer to a departure from background conditions. Where detection limits exceed the guidelines, the results are conservatively assumed to be at or above the guideline.

Milne Inlet

The surface waters of Milne Inlet were near neutral (pH: 7.33 to 7.98), brackish (23 psu to 30 psu), hard (total hardness: 1620 mg/L to 5990 mg/L) and clear (turbidity: 0.3 NTU to 0.6 NTU) with moderate amounts of nutrients (0.3 to 3.1 mg/L, and 0.011 mg/L to 0.54 mg/L for total nitrogen [TN] and total phosphorus [TP], respectively; Table 8-3.1). Similar to trends noted in the literature (LGL Limited, 1983; Mose Jensen *et al*., 1999; Michel *et al*., 2006), nutrient concentrations measured during the open-water season tended to be higher in deep waters than at the surface. Nutrients in the Inlet were also generally higher during the ice-cover season than during the open-water season. Overall, nutrient concentrations in Milne Inlet were generally within range of those found by previous studies conducted in nearby Arctic waters (Table 8-3.2). Results for all sites, seasons and depths were within the CCME guidelines for the protection of marine aquatic life for pH (7.0 to 8.7) and nitrate (3.6 mg N/L).

The predominant elements (major ions and metals) in water samples collected from Milne Inlet were those that typically dominate marine waters (chloride, sodium, sulphate and magnesium; Figure 8-3.5). Total and dissolved metal concentrations were mostly similar, illustrating that metals were present in the water column in the dissolved form and were not typically associated with particulates. Several metals (including arsenic, cadmium, iron and mercury) were generally below the analytical limits of detection; however, concentrations of most metals detected in samples from Milne Inlet were higher at depth than they were near the surface, particularly during the open-water season (Figure 8-3.5). Most metals that were detected were also present at higher concentrations during the ice-cover season than during the open-water season. Mercury concentrations exceeded the CCME guideline for the protection of marine aquatic life in two samples collected from Milne Inlet in June 2008. No other exceedances were observed; however, the CCME guideline was regularly less than the detection limit (DL) for cadmium, chromium, arsenic, and occasionally mercury; therefore, comparison to these guidelines (0.00012 mg/L; 0.056 mg/L [Cr III] and 0.0015 mg/L [Cr VI]; 0.0125 mg/L; and, 0.000016 mg/L, respectively) is not possible.



LEGEND:

- 2008 WATER QUALITY SITES
- 2010 WATER QUALITY SITES
- MILNE INLET TOTE ROAD (EXISTING)
- CONTOUR
- WATER
- INFRASTRUCTURE

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL IS 25m AND IS IN METRES.
4. MILNE INFRASTRUCTURE PROVIDED BY HATCH.

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MARY RIVER PROJECT

**MILNE INLET
WATER QUALITY SITES**

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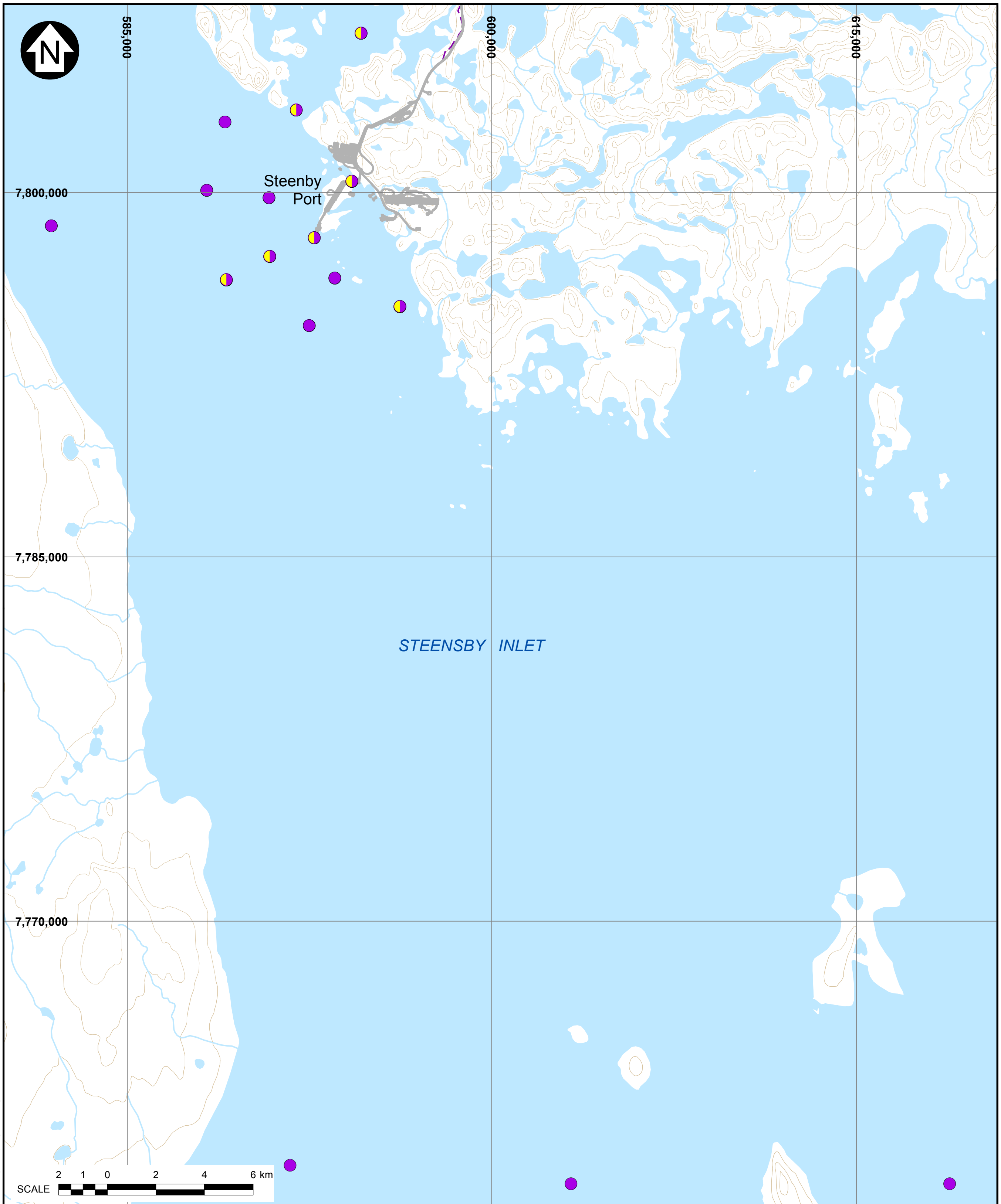
BL_VOL8_GIS_034

FIGURE: 8-3.3

FIGURE ID: BL_VOL8_GIS_034 Milne Inlet Water Quality Sampling Sites Figure 8-3.3



LEGEND:

- 2008 WATER QUALITY SITES
- 2007 AND 2008 WATER QUALITY SITES
- CONSTRUCTION ACCESS ROAD (PROPOSED)
- CONTOUR
- INFRASTRUCTURE
- WATER

NOTES:

1. BASE MAP: (1:250 000) © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.
4. PROPOSED RAILWAY CONSTRUCTION ACCESS ROAD ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC. DRAWING NO.: RAILWAY ALIGNMENT AND CONST ACCESS RD - MARY RIVER STEENSBY 2010 -12AUG2010.DWG
5. STEENSBY INLET PORT SITE INFRASTRUCTURE PROVIDED BY HATCH.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY INLET WATER QUALITY SITES

Baffinland Iron Mines Corporation

REF NO. BL_VOL8_GIS_029

FIGURE: 8-3.4

FIGURE ID: BL_VOL8_GIS_029 Steensby Inlet water Quality sampling Sites Figure 8-3.4

Table 8-3.1 Water Quality Summary Statistics for Milne Inlet, Open-water 2008 and 2010 (Open) and Ice-Cover 2008 (Ice)

	Parameter	Season	DL[1]	Surface							At Depth (to a maximum of 30 m)						
				Mean	SD[2]	Min	Max	Median	n	%>DL	Mean	SD[2]	Min	Max	Median	n	% > DL
Routines	Alkalinity, as $CaCO_3$ (mg/L)	Open	5	89	9.3	82	106	84	14	100	111	0.8	110	112	111	14	100
		Ice	5	114	0.5	113	114	114	6	100	114	0.6	113	115	114	6	100
	pH	Open	-	7.82	0.153	7.33	7.98	7.85	14	100	7.84	0.095	7.72	7.98	7.83	14	100
		Ice	-	7.97	0.008	7.96	7.98	7.97	6	100	7.81	0.01	7.8	7.83	7.81	6	100
	Conductivity (S/cm)	Open	5	29.5	8	14.5	41.2	27.6	14	100	46.4	1.39	44.8	48.6	45.9	14	100
		Ice	5	48.4	0.44	47.6	48.9	48.5	6	100	49	0.22	48.7	49.3	48.9	6	100
	Hardness, as $CaCO_3$ (mg/L)	Open	5	3496	876.7	1620	4737	3375	14	100	5859	108.2	5700	6020	5860	14	100
		Ice	10	5770	164.4	5530	5990	5780	6	100	6087	49.3	6030	6170	6085	6	100
Nutrients	Ammonia (mg N/L)	Open	0.02	<0.02	0.015	<0.02	0.05	<0.02	14	21	0.18	0.083	0.13	0.46	0.17	14	21
		Ice	0.02	0.16	0.028	0.11	0.18	0.17	6	100	0.19	0.06	0.15	0.31	0.17	6	100
	Nitrate (mg N/L)	Open	0.10 / 1.00 / 2.00	<2.0	-	<0.1	<2.0	<2.0	14	0	<2.0	-	<0.1	<2.0	<2.0	14	0
		Ice	0.10 / 1.00 / 2.00	<0.1	-	<0.1	<0.1	<0.1	6	0	0.13	0.014	0.12	0.15	0.13	6	100
	Nitrite (mg N/L)	Open	0.005 / 0.10	<0.005	0.001	<0.005	0.005	<0.005	14	7	<0.005	0.002	<0.005	0.007	0.005	14	57
		Ice	0.005 / 0.10	<0.1	0	<0.1	<0.1	<0.1	6	0	<0.1	0	<0.1	<0.1	<0.1	6	0
	Nitrate/nitrite (mg N/L)	Open	0.10 / 1.00 / 2.00	<2.0	-	<0.1	<2.0	<2.0	14	0	<2.0	-	<0.1	<2.0	<2.0	14	0
		Ice	0.10 / 1.00 / 2.00	<0.1	-	<0.1	<0.1	<0.1	6	0	0.13	0.014	0.12	0.15	0.13	6	100
	TKN (mg/L)	Open	0.50 / 1.0 / 2.0	<1.0	0.75	<1.0	3	<1.0	14	21	<2.0	0.85	<2.0	4	<2.0	14	29
		Ice	0.50 / 1.0 / 2.0	0.73	0.46	<0.50	1.35	0.68	6	67	0.577	0.402	0.25	1.1	0.41	6	50
	Total Nitrogen (mg/L)	Open	-	1.64	0.755	0.55	3.1	1.5	14	-	2.12	0.572	1.5	4.05	2	14	-
		Ice	-	0.78	0.46	0.3	1.4	0.73	6	-	0.71	0.403	0.37	1.22	0.55	6	-
	Dissolved Inorganic Nitrogen (mg/L)	Open	-	0.72	0.427	0.06	1.01	1.01	14	-	0.87	0.43	0.18	1.19	1.16	14	-
		Ice	-	0.21	0.028	0.16	0.23	0.22	6	-	0.32	0.054	0.29	0.43	0.3	6	-
	Total Phosphorus (mg/L)	Open	0.003 / 0.25	<0.25	0.048	0.011	<0.25	0.016	14	71	<0.25	0.041	0.024	<0.25	0.045	14	71
		Ice	0.003 / 0.25	0.31	0.206	<0.25	0.54	0.29	6	50	0.44	0.245	<0.25	0.68	0.56	6	67
	Total Organic Carbon (mg/L)	Open	0.5	0.3	0.14	<0.5	0.6	<0.5	14	29	<0.5	0.07	<0.5	0.5	<0.5	14	7
		Ice	0.5	0.6	0.05	0.5	0.6	0.6	6	100	<0.5	0.17	<0.5	0.7	0.5	6	67
	Dissolved Organic Carbon (mg/L)	Open	0.5	<0.5	0.14	<0.5	0.6	<0.5	14	21	<0.5	-	<0.5	<0.5	<0.5	14	0
		Ice	0.5	0.5	0.04	0.5	0.6	0.5	6	100	<0.5	0.14	<0.5	0.6	<0.5	6	17
	Soluble Reactive Silica (mg/L)	Open	0.02	0.45	0.394	0.07	1.61	0.38	14	100	0.43	0.237	0.18	1.02	0.37	14	100
		Ice	0.02	1.06	0.935	0.14	2.43	1.03	6	100	1.9	0.739	0.73	2.5	2.21	6	100
Water Clarity	Total Dissolved Solids (g/L)	Open	0.005	23.6	6.5	10.9	33	22.1	14	100	37.1	1.11	35.8	38.9	36.7	14	100
		Ice	0.005	38.7	0.34	38.1	39.1	38.8	6	100	39.2	0.16	39	39.4	39.1	6	100
	Total Suspended Solids (mg/L)	Open	2 / 100	53	9	36	<100	<100	14	29	52	6	44	<100	<100	14	29
		Ice	2 / 100	5	1.4	3	7	5	6	100	3	1.4	<2	5	3	6	83
	Turbidity (NTU)	Open	0.1	0.4	0.09	0.3	0.6	0.4	14	100	0.3	0.21	0.1	0.9	0.3	14	100
		Ice	0.1	0.3	0.05	0.3	0.4	0.3	6	100	0.1	0.04	0.1	0.2	0.1	6	100

NOTES:

1. ANALYTICAL DETECTION LIMIT.
2. STANDARD DEVIATION OF THE MEAN.

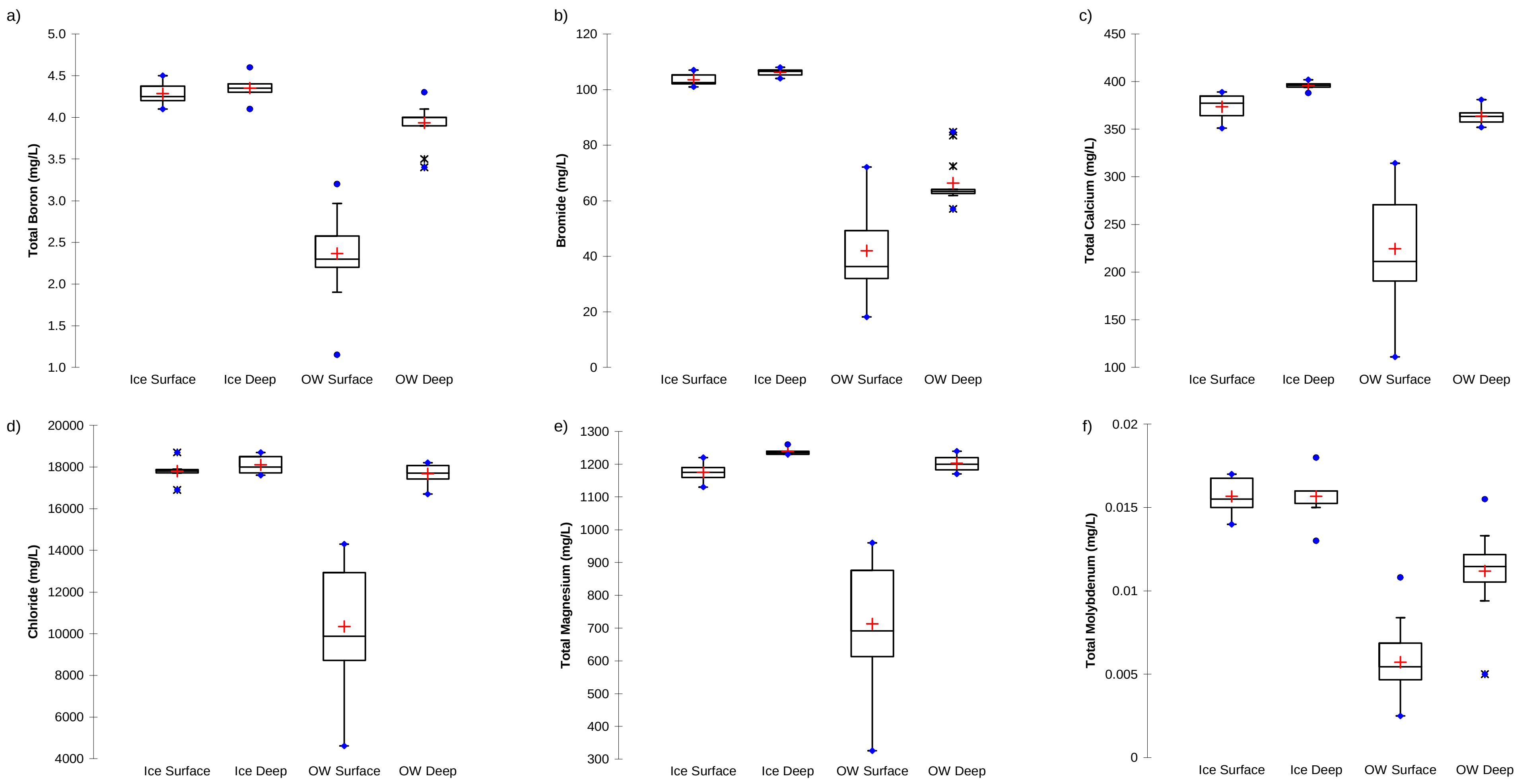
Table 8-3.2 Nutrient Concentrations from the Literature (Eastern Canadian Arctic) and the Current Study

Location	Sampling Date(s)	Depth (m)	Nitrate (mg N/L) Mean	Nitrate Min	Nitrate Max	Nitrate n	Phosphate (mg P/L)[1] Mean	Phosphate Min	Phosphate Max	Phosphate n	Silicate (mg Si/L)[2] Mean	Silicate Min	Silicate Max	Silicate n	Source
Pond Inlet	May, 1979	Surface	0.001	-	-	5-18	0.39	-	-	5-18	4.4	-	-	5-18	Cross 1982[5]
Pond Inlet	June, 1979	Surface	0.0001	-	-	5-18	0.24	-	-	5-18	1.8	-	-	5-18	Cross 1982[5]
Baffin Bay (off west coast of Greenland)	July/Aug, 1993	Surface	ND	ND	NR	-	NR	0.003	0.006	NR	NR	0.01	0.03	NR	Mose Jensen *et al.* 1999
Baffin Bay (off west coast of Greenland)	July/Aug, 1993	Euphotic	-	0.00 (0.00)[3]	0.03 (0.04)[3]	81	-	0.003 (0.003)[3]	0.012 (0.009)[3]	81	-	0.01 (0.0)[3]	0.05 (0.02)[3]	81	Mose Jensen *et al.* 1999
Baffin Bay (off west coast of Greenland)	July/Aug, 1993	Deep Water	-	0.12 (0.01)[4]	0.12 (0.01)[4]	15	-	0.006 (0.003)[4]	0.0314	15	-	0.01 (0.1)[4]	0.19 (0.04)[4]	15	Mose Jensen *et al.* 1999
Labrador Sea	Summer (various years)[5]	Surface	0.056	-	-	-	0.012	-	-	-	0.08	-	-	-	Louanchi and Najjar 2001
Labrador Sea	Winter (various years)[5]	Surface	0.20	-	-	-	0.031	-	-	-	0.21	-	-	-	Louanchi and Najjar 2001
Roberts Bay	Summer, 1996-1998	<20	<2.5[6]	<0.001	<5	13	0.024[6]	0.012	0.027	13	0.18[6]	0.137	0.54	8	RL&L / Golder 2002
Barrow Strait	April, 1984-2003[7]	<25	-	-	-	-	-	-	-	-	0.55	-	-	30	Michel *et al.* 2006
Barrow Strait	April, 1984-2003[7]	>25	-	-	-	-	-	-	-	-	0.69	-	-	26	Michel *et al.* 2006
Barrow Strait	May, 1984-2003[7]	<25	-	-	-	-	-	-	-	-	0.55	-	-	99	Michel *et al.* 2006
Barrow Strait	May, 1984-2003[7]	>25	-	-	-	-	-	-	-	-	0.70	-	-	69	Michel *et al.* 2006
Barrow Strait	June, 1984-2003[7]	<25	-	-	-	-	-	-	-	-	0.52	-	-	71	Michel *et al.* 2006
Barrow Strait	June, 1984-2003[7]	>25	-	-	-	-	-	-	-	-	0.67	-	-	3	Michel *et al.* 2006
Barrow Strait	August, 1984-2003[7]	<25	-	-	-	-	-	-	-	-	0.17	-	-	5	Michel *et al.* 2006
Barrow Strait	August, 1984-2003[7]	>25	-	-	-	-	-	-	-	-	0.70	-	-	3	Michel *et al.* 2006
Barrow Strait	Dec/Jan, 1984-2003[7]	<25	-	-	-	-	-	-	-	-	0.55	-	-	10	Michel *et al.* 2006
Barrow Strait	Dec/Jan, 1984-2003[7]	>25	-	-	-	-	-	-	-	-	0.63	-	-	5	Michel *et al.* 2006
Labrador Shelf	May-July (1994-2005)	<100	-	0.00	0.18	-	-	-	-	-	-	0.11	0.31	-	Harrison and Li 2008
Greenland Shelf	May-July (1994-2005)	<100	-	0.00	0.21	-	-	-	-	-	-	0.00	0.20	-	Harrison and Li 2008
Labrador Basin	May-July (1994-2005)	<100	-	0.00	0.24	-	-	-	-	-	-	0.00	0.22	-	Harrison and Li 2008
Steensby Inlet	May/June 2008	Surface	<0.10	<0.10	<0.10	27	0.29	<0.25	0.63	27	0.63	0.33	1.41	26	Current Study
Steensby Inlet	May/June 2008	At Depth (max 30m)	<0.10	<0.10	0.11	27	0.36	<0.25	0.96	27	0.60	0.32	1.12	27	Current Study
Steensby Inlet	Sept 2007/2008	Surface	<0.10	<0.002	<0.10	20	<0.25	<0.02	<0.25	20	0.19	0.08	0.57	13	Current Study
Steensby Inlet	Sept 2007/2008	At Depth (max 30m)	<0.10	0.006	<0.10	20	<0.25	<0.02	<0.25	20	0.20	0.09	0.58	13	Current Study
Milne Inlet	Sept 2008/Aug 2010	Surface	<2.0	<0.1	<2.0	14	<0.25	0.011	<0.25	14	0.45	0.07	1.61	14	Current Study
Milne Inlet	Jun-08	Surface	<0.1	<0.1	<0.1	6	0.31	<0.25	0.54	6	1.06	0.14	2.43	6	Current Study
Milne Inlet	Sept 2008/Aug 2010	At Depth (max 30m)	<2.0	<0.1	<2.0	14	<0.25	0.024	<0.25	14	0.43	0.18	1.02	14	Current Study
Milne Inlet	Jun-08	At Depth (max 30m)	0.13	0.12	0.15	6	0.44	<0.25	0.68	6	1.90	0.73	2.5	6	Current Study

NOTE(S):
VALUES IN PARENTHESES REPRESENT STANDARD DEVIATIONS.
n = SAMPLE SIZE.
ND = NOT DETECTED (DETECTION LIMIT NOT SPECIFIED).
NR = NOT REPORTED.

1. RL&L / GOLDER 2002 AND CURRRENT STUDY MEASURED TOTAL PHOSPHORUS.
2. SILICATE MEASURED AS SiO_3 IN CROSS 1982; AS SiO_2 IN MOSE *et al.* 1999; AS $SiOH_4$ IN MICHEL *et al.* 2006; AND, AS SOLUBLE REACTIVE SILICA IN THE CURRENT STUDY.
3. MINIMUM/MAXIMUM OF 1-6 DUPLICATE SAMPLES COLLECTED FROM 16 STATIONS.
4. MINIMUM/MAXIMUM OF 1 INDIVIDUAL TO 3 DUPLICATE SAMPLES COLLECTED FROM 16 STATIONS.
5. SUMMER (JULY, AUGUST, AND SEPTEMBER) AND WINTER (JANUARY, FEBRUARY, MARCH).
6. MEDIAN VALUE REPORTED IN THIS STUDY.
7. SAMPLING YEARS WERE 1984, 1985, 1986, 1988, 2002, AND 2003.

FIGURE ID: BL_Vol8_EXL_001 Boxplots of Selected Metals and Major Ions in Milne Inlet Figure 8-3-5



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BOXPLOTS OF SELECTED METALS MILNE INLET OPEN-WATER (OW) 2008/10 AND ICE-COVER (ICE) 2008

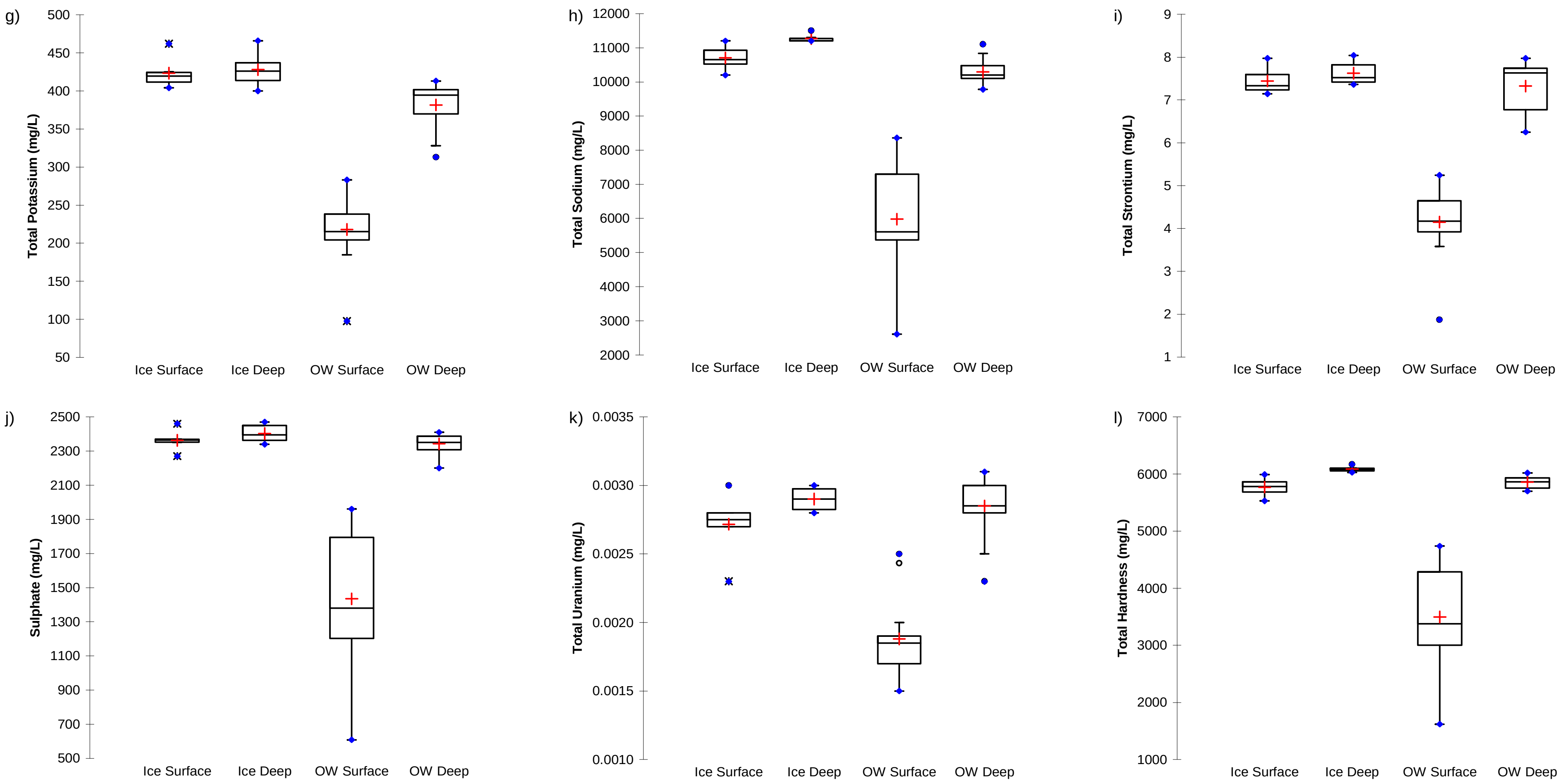
Baffinland Iron Mines Corporation

REF NO.: BL_Vol8_EXL_001

FIGURE 8-3.5

REV 0

FIGURE ID: BL_Vol8_EXL_001 Boxplots of Selected Metals Milne Inlet Figure 8-3-5 CONT.



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BOXPLOTS OF SELECTED METALS MILNE INLET OPEN-WATER (OW) 2008/10 AND ICE-COVER (ICE) 2008

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_EXL_001

FIGURE 8-3.5 CONT.

REV 0

Steensby Inlet

The water quality of Steensby Inlet was near-neutral (pH: 7.54 to 7.96), brackish (25 psu to 32 psu), hard (total hardness: 3760 mg/L to 6680 mg/L), and clear (turbidity: 0.1 NTU to 1.3 NTU), with moderate concentrations of nutrients (0.1 mg/L to 4.56 mg/L, and <0.2 mg/L to 0.63 mg/L for TN and TP, respectively; Table 8-3.3). During the open-water and ice-cover seasons, most routine parameters were fairly consistent across depth, indicating that the Inlet is generally well-mixed within the upper 30 m. The exceptions to this trend were conductivity, alkalinity and ammonia measured during the open-water season, which were generally higher at depth (to a maximum of 30 m) than at the surface (Table 8-3.3). Alkalinity, TP, reactive silica, total dissolved solids and conductivity in Steensby Inlet were also generally higher during the ice-cover season than the open-water season; whereas turbidity was slightly lower during the ice-cover season. Generally, nutrient concentrations in Steensby Inlet were within the range of results from previous studies conducted in nearby Arctic waters (Table 8-3.2). Results for all sites, seasons and depths were within the CCME guidelines for the protection of marine aquatic life for pH and nitrate.

The major elements in water samples collected from Steensby Inlet were those that would be expected to occur in marine waters (e.g., chloride, sodium, sulphate and magnesium; Figure 8-3.6). Total and dissolved metal concentrations were often similar, illustrating that metals were present in the water column in the dissolved form and were not typically associated with particulates. Several metals (including arsenic, cadmium, iron and mercury) were present in such low concentrations that they were generally below the analytical limits of detection. For the most part, metal concentrations at depth were similar to those near the surface; however, a few metals were higher in deep waters than at the surface during open-water season.

Most metals (that were detected) were present at higher concentrations during the ice-cover season. Mercury concentrations were within the CCME guideline for protection of marine aquatic life (0.000016 mg/L) during both seasons of 2008. The DL exceeded the CCME guidelines for the protection of marine aquatic life for mercury in September 2007 and in all sampling periods for arsenic (0.0125 mg/L), cadmium (0.00012 mg/L), and chromium (0.056 mg/L [Cr III] and 0.0015 mg/L [Cr VI]); therefore, no comparison could be made with respect to these guidelines.

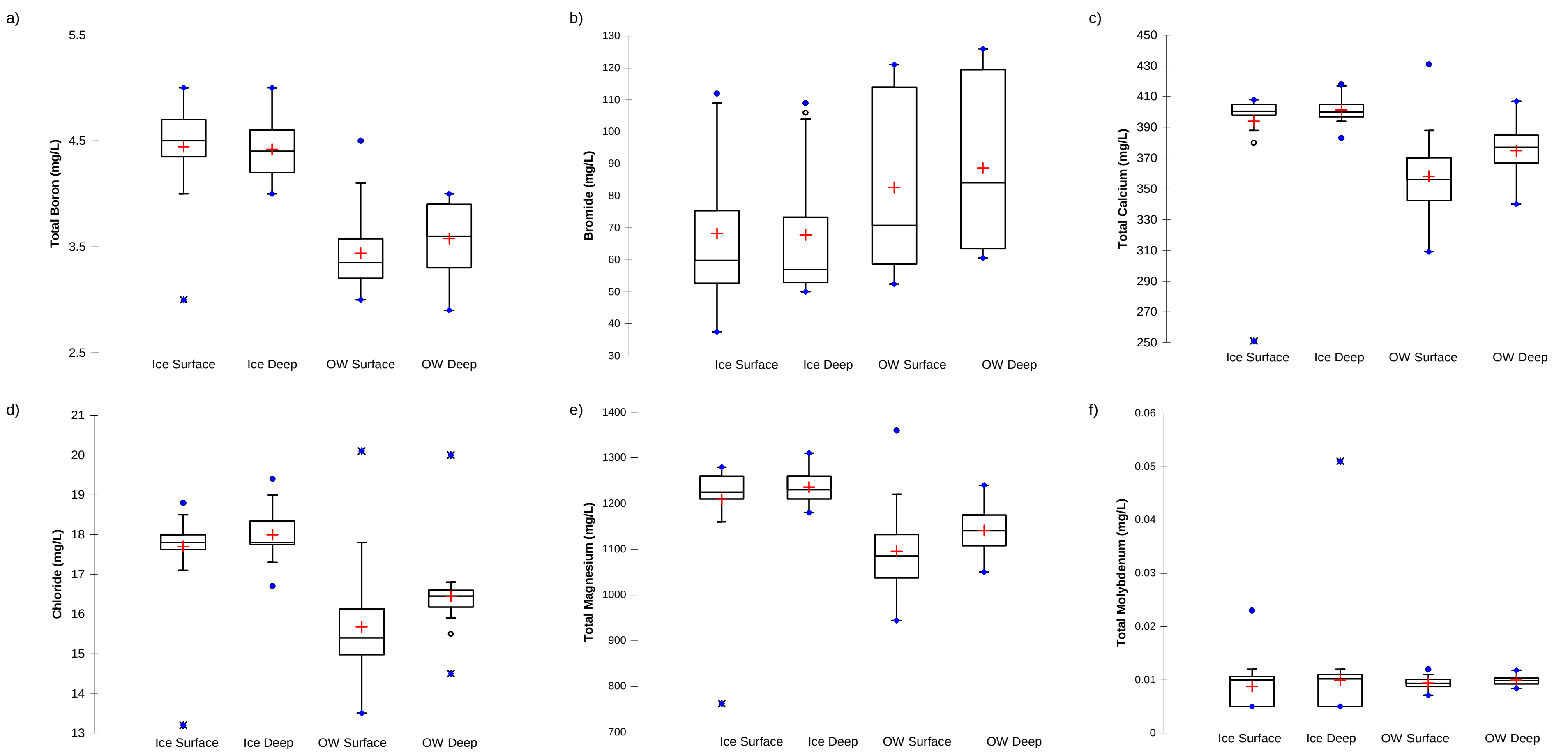
Table 8-3.3 Water Quality Summary Statistics for Steensby Inlet, Open-water 2007 and 2008 (Open) and Ice-cover 2008 (Ice)

Parameter		Season	DL[1]	Surface							At Depth (to a maximum of 30 m)						
				Mean	SD[2]	Min	Max	Median	n	% > DL	Mean	SD[2]	Min	Max	Median	n	% > DL
Routines	Alkalinity, as $CaCO_3$ (mg/L)	Open	5	103	3.4	95	107	103	20	100	108	1.2	105	110	109	20	100
		Ice	5	120	5.9	92	125	122	27	100	122	2	113	124	122	27	100
	pH	Open	-	7.86	0.096	7.54	7.96	7.87	20	100	7.87	0.046	7.77	7.94	7.87	20	100
		Ice	-	7.84	0.036	7.77	7.93	7.83	27	100	7.84	0.032	7.78	7.89	7.85	27	100
	Conductivity (S/cm)	Open	5	43	1.58	39.2	44.9	43.3	20	100	45.3	0.59	43.4	46.1	45.5	20	100
		Ice	5	50.3	2.27	39.4	51.5	50.9	27	100	50.9	0.78	47.4	51.6	51	27	100
	Hardness, as $CaCO_3$ (mg/L)	Open	5	5409	423.8	4660	6680	5360	22	100	5590	206.1	5170	5920	5630	17	100
		Ice	10	5952	529.9	3760	6240	6042	20	100	6071	129.9	5890	6430	6045	20	100
Nutrients	Ammonia (mg N/L)	Open	0.02	0.07	0.07	0.03	0.36	0.05	20	100	0.11	0.081	0.05	0.43	0.1	20	100
		Ice	0.02	0.12	0.171	0.01	0.75	0.05	27	95	0.1	0.094	0.01	0.42	0.06	27	95
	Nitrate (mg N/L)	Open	0.002 / 0.1	<0.10	0.021	<0.002	<0.10	<0.10	20	35	<0.10	0.021	0.006	<0.10	<0.10	20	35
		Ice	0.1	<0.10	-	<0.10	<0.10	<0.10	27	0	<0.10	0.012	<0.10	0.11	0.05	27	5
	Nitrite (mg N/L)	Open	0.10 / 0.005	<0.10	-	<0.005	<0.10	0	20	0	<0.10	-	<0.005	<0.10	<0.005	20	0
		Ice	0.005 / 0.1	<0.10	0.019	0.01	<0.10	0.01	27	50	<0.10	0.019	0.01	<0.10	0.013	27	50
	Nitrate/nitrite (mg N/L)	Open	0.1	<0.10	0	<0.10	<0.10	<0.10	20	0	<0.10	0	<0.10	<0.10	<0.10	20	0
		Ice	0.1	<0.10	0	<0.10	<0.10	<0.10	27	0	<0.10	0	<0.10	0.11	<0.10	27	5
	TKN (mg/L)	Open	0.1 / 1	0.7	0.38	<0.1	1.6	0.5	20	40	<1.0	0.27	0.4	1.3	<1.0	20	55
		Ice	0.05 / 0.5 / 1	1	1.02	<0.5	4.5	<1.0	27	80	<1.0	1.01	<0.5	5.4	<1.0	27	65
	Total Nitrogen (mg/L)	Open	-	0.81	0.409	0.1	1.65	0.55	20	100	0.8	0.31	0.48	1.5	0.67	20	100
		Ice	-	1.06	1.024	0.3	4.56	0.85	27	100	0.98	1.011	0.3	5.48	0.81	27	100
	Dissolved Inorganic Nitrogen (mg/L)	Open	-	0.16	0.146	0.08	0.55	0.11	20	100	0.21	0.157	0.1	0.61	0.15	20	100
		Ice	-	0.17	0.171	0.06	0.8	0.1	27	100	0.15	0.093	0.06	0.47	0.12	27	100
	Total Phosphorus (mg/L)	Open	0.02 / 0.25	<0.25	0.057	<0.02	<0.25	<0.25	20	5	<0.25	0.057	<0.02	<0.25	<0.25	20	5
		Ice	0.25	0.29	0.184	<0.25	0.63	0.27	27	40	0.36	0.221	<0.25	0.96	0.32	27	55
	Total Organic Carbon (mg/L)	Open	0.5	0.7	0.26	<0.5	1.4	0.6	19	89	0.6	0.25	<0.5	1	0.6	20	70
		Ice	0.5	0.5	0.17	<0.5	0.8	0.6	27	70	<0.5	0.15	<0.5	0.7	0.5	27	65
	Dissolved Organic Carbon (mg/L)	Open	0.5	0.6	0.25	<0.5	1.1	0.6	19	74	0.5	0.24	<0.5	0.9	0.6	20	60
		Ice	0.5	<0.5	0.15	<0.5	0.7	0.5	27	75	<0.5	0.17	<0.5	0.7	<0.5	27	40
	Soluble Reactive Silica (mg/L)	Open	0.02	0.19	0.129	0.08	0.57	0.14	13	100	0.2	0.127	0.09	0.58	0.15	13	100
		Ice	0.02	0.63	0.233	0.33	1.41	0.57	26	100	0.6	0.167	0.32	1.12	0.58	27	100
Water Clarity	Total Dissolved Solids (g/L)	Open	0.005	32	2.48	28.5	35.2	33	20	100	33.9	3.25	29.2	36.9	36	20	100
		Ice	0.005	40.2	1.82	31.5	41.2	40.7	27	100	40.7	0.63	37.9	41.3	40.8	27	100
	Total Suspended Solids (mg/L)	Open	2	43	20.9	4	89	39	20	100	48	18.1	28	91	43	20	100
		Ice	2 / 100	<100	24.1	<2	<100	28	26	84	<100	27.5	<2	<100	17	26	89
	Turbidity (NTU)	Open	0.1	0.6	0.3	0.2	1.3	0.5	20	100	0.6	0.23	0.3	1.1	0.6	20	100
		Ice	0.1	0.2	0.21	0.1	1.1	0.2	27	100	0.2	0.11	0.1	0.5	0.2	27	100

NOTES:

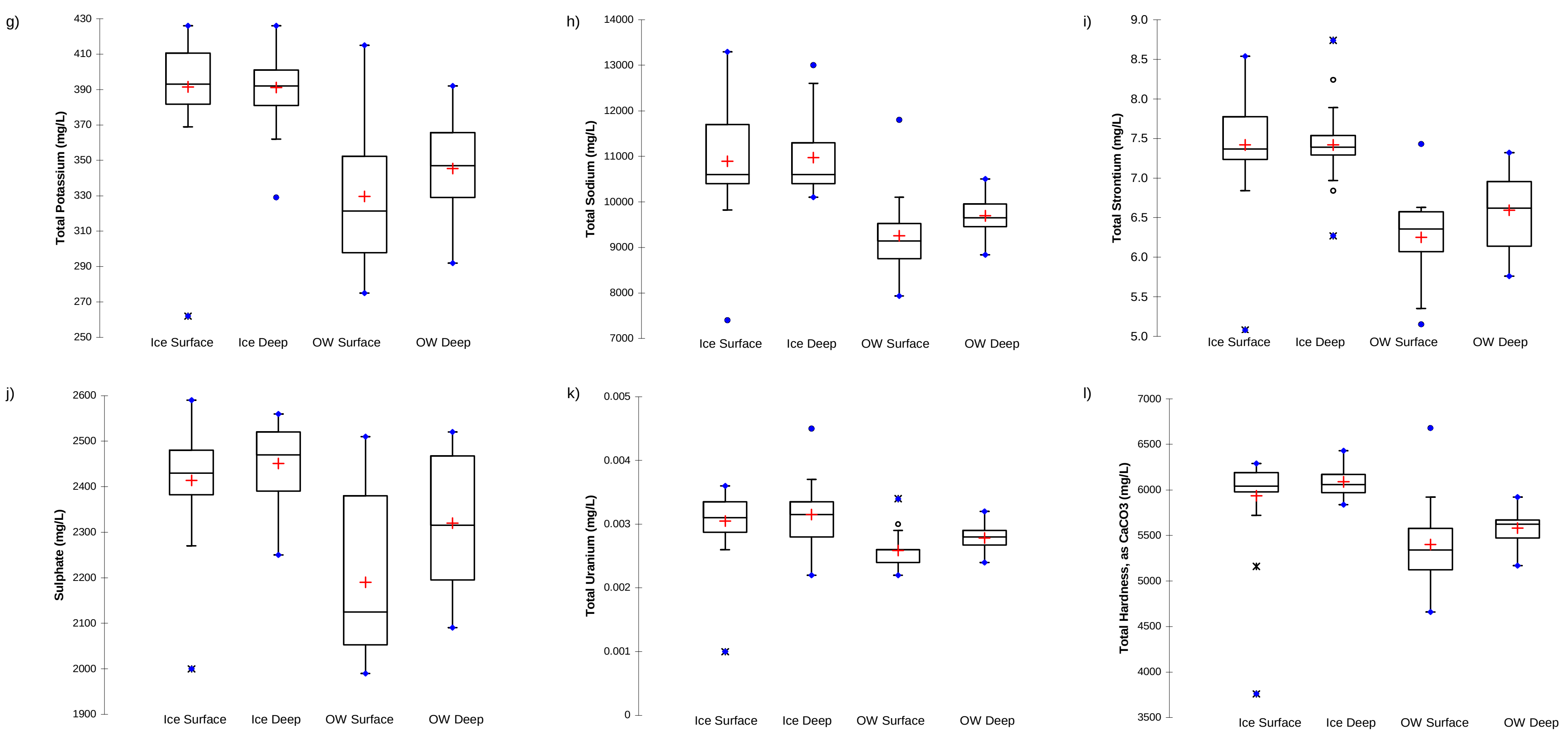
1. ANALYTICAL DETECTION LIMIT.
2. STANDARD DEVIATION OF THE MEAN.

FIGURE ID: BL_Vol8_EXL_002 Boxplots of Selected Metals and Major Ions in Steensby Inlet Figure 8-3-6



BAFFINLAND IRON MINES CORPORATION	
MARY RIVER PROJECT	
BOXPLOTS SELECTED METALS STEENSBY INLET OPEN-WATER (OW) 2007/08 AND ICE-COVER (ICE) 2008	
Baffinland Iron Mines Corporation	REF NO. BL_Vol8 _EXL_002
	FIGURE 8-3.6 REV 0

FIGURE ID: BL_Vol8_EXL_002 Boxplots of Selected Metals and Major Inos in Steensby Ilet Figure 8-3-6 CONT.



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BOXPLOTS SELECTED METALS STEENSBY INLET
OPEN-WATER (OW) 2007/08 AND ICE-COVER (ICE) 2008

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_EXL_002

FIGURE 8-3.6 CONT.

REV #

3.2.2 Sediment Quality

Sediment quality in Milne Inlet was examined during the open-water seasons of 2008 and 2010. Studies in Steensby Inlet were conducted during the open-water seasons of 2007, 2008 and 2010. Samples were collected from nearshore (within the inter-tidal zone, water depths from 0 m to 4 m) and offshore (sites with depths >10 m) areas within each Inlet in order to characterize the overall conditions of the Inlet while also examining specific sites with historic and potential future interactions (Figure 8-3.7 and Figure 8-3.8). Sample analyses were conducted by an accredited laboratory (EXOVA Laboratories, Ottawa, ON). Results were compared to the CCME probable effects level (PEL; the guideline above which severe biological effects can result) and the interim sediment quality guidelines (ISQG; a conservative guideline below which biological effects are rarely seen) (CCME, 1999; updated to 2010). Guidelines for marine sediments exist for arsenic, cadmium, chromium, copper, lead, mercury, zinc and polycyclic aromatic hydrocarbons (PAHs).

Milne Inlet

Sediments in Milne Inlet are dominated by either sand or sand and silt (Table 8-3.4). Nutrient concentrations were low, generally comprising less than one percent of the total amount of sediment. Throughout Milne Inlet, some metals (including cadmium and mercury) were present at concentrations below the analytical limits of detection. When detected, metal concentrations were higher in areas where the sediments had a higher proportion of fines (p-values for linear regressions ranged from 0.070 to <0.001, see Appendix 8A-1 for details).

Since shipping has occurred periodically in Milne Inlet over the past 45 years, sediments from three sites (two near the port and one reference) were tested for the presence of hydrocarbons. No hydrocarbons were detected in the sediments of the reference site; however, some were detected within the port area, including: oil and grease; naphthalene; hydrocarbons C10-16 and C16-C34; and, toluene (Table 8-3.5). Naphthalene was the only PAH detected. Petroleum compounds measured in another study conducted in the region were also low (Levy, 1986).

Sediment concentrations were consistently within the CCME guidelines for protection of marine aquatic life for arsenic, cadmium, chromium, copper, lead, zinc and PAHs (Table 8-3.4 and Table 8-3.5; CCME, 1999; updated to 2010).

Steensby Inlet

As is consistent with the literature, sediments in nearshore areas of Steensby Inlet tended to have a higher proportion of coarse material and lower concentrations of nutrients and metals than those in offshore areas (Thomson, 1982; Kuzyk *et al*., 2010; Table 8-3.6). Overall, sediments throughout the Inlet are composed predominantly of sand and have low concentrations of nutrients. Metals and major ions adsorb to silt and clay more readily than to sand. As a result, offshore sediments had a higher concentration of most metals than did the nearshore sediments; however, regardless of location, some metals were always near or below the DL throughout Steensby Inlet. Concentrations of metals were lower than the CCME PELs at all sites. Concentrations of cadmium, copper, lead and zinc were also consistently below the CCME ISQGs (CCME, 1999; updated to 2010; Table 8-3.6). However, arsenic, chromium and mercury exceeded their respective ISQG in at least one sample collected from Steensby Inlet.

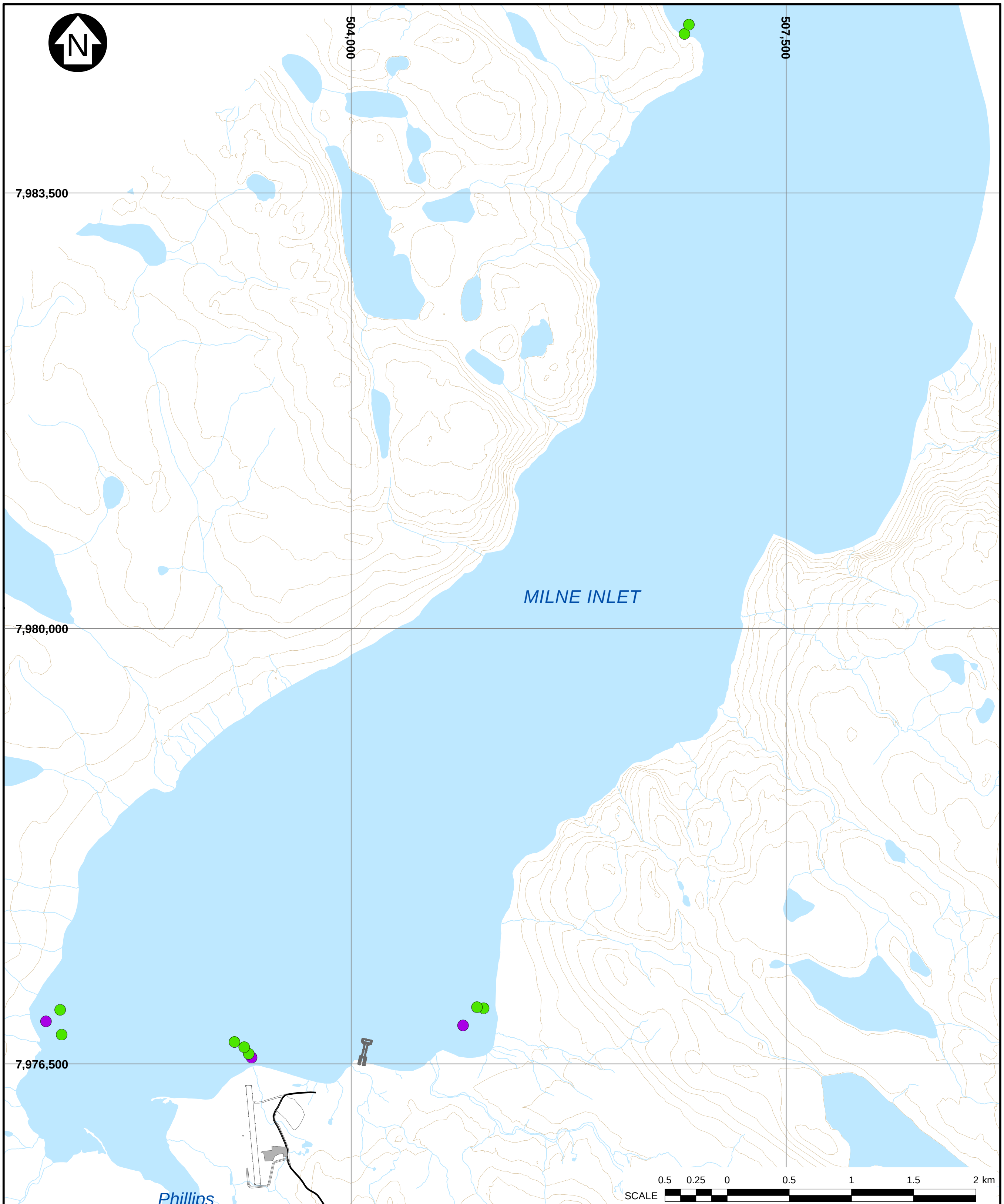


Figure ID: BL_Vol8_GIS Milne Inlet Sediment Quality Sites Figure 8-3.7.mxd

LEGEND:

- 2008 SEDIMENT QUALITY SITES
- 2010 SEDIMENT QUALITY SITES
- MILNE INLET TOTE ROAD (EXISTING)
- CONTOUR
- WATER
- INFRASTRUCTURE

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL IS 25 AND IS IN METRES.
4. MILNE INFRASTRUCTURE PROVIDED BY HATCH.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE INLET
SEDIMENT QUALITY SITES

Baffinland Iron Mines Corporation

REF NO.
BL_Vol8_GIS_009

FIGURE: 8-3.7

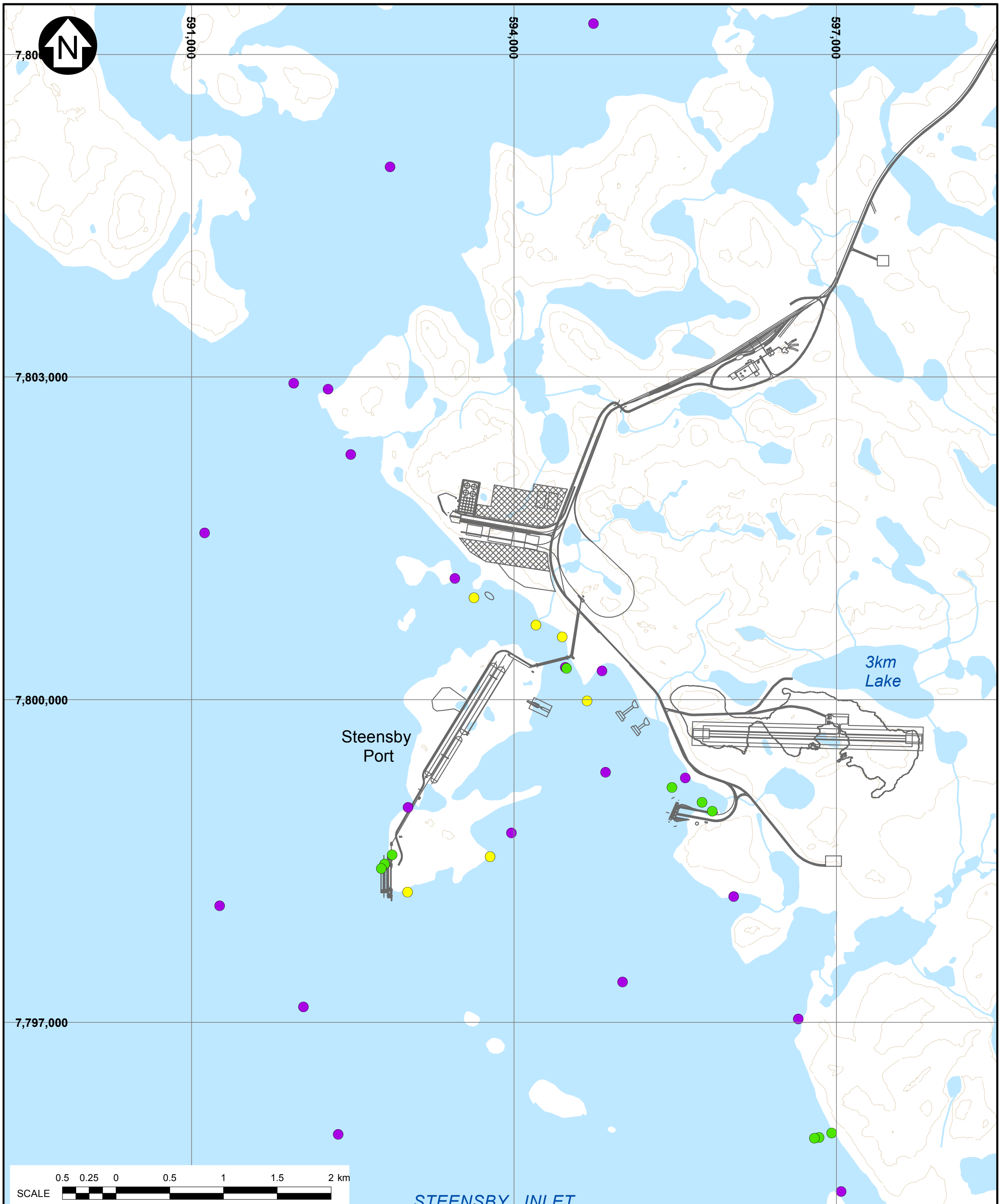


Figure ID: BL_Vol8_GIS_010 Steensby Inlet Sediment Quality Sites Fgiure 8-3-8.mxd

LEGEND:

- 2007 SEDIMENT QUALITY SITES
- 2008 SEDIMENT QUALITY SITES
- 2010 SEDIMENT QUALITY SITES
- CONTOUR
- INFRASTRUCTURE
- WATER

NOTES:

1. BASE MAP: (1:50 000)© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.
4. PROPOSED RAILWAY CONSTRUCTION ACCESS ROAD ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.
5. STEENSBY INLET PORT SITE INFRASTRUCTURE PROVIDED BY HATCH.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY INLET
SEDIMENT QUALITY SITES

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_010

ᑎᑎᕋᐅᓯᐊᓕᐊᖅ FIGURE 8-3.8

Table 8-3.4 Sediment Quality Summary Statistics for Milne Inlet, 2008 and 2010

Parameter		Units	DL[3]	Milne Inlet						CCME Guideline	
				Mean	Min	Max	SD	n	# Detects	ISQG[4]	PEL[5]
Depth		m	-	20	1	62	18.6	12	-	-	-
Particle Size Analysis	Sand (>0.050 mm)	%	1	64	39	95	20.4	12	12	-	-
	Silt (>0.002-0.050 mm)	%	1	32	5	51	16.5	12	11	-	-
	Clay (≤0.002 mm)	%	1	7	4	12	2.77	12	11	-	-
Nutrients	Nitrite	ppm	1	<1	<1	<1	-	12	0	-	-
	Nitrate	ppm	1	6	<1	20	6.2	12	10	-	-
	TKN	%	0.01	0.05	<0.01	0.2	0.05	12	10	-	-
	TOC	%	0.01	0.57	0.11	1.55	0.364	12	12	-	-
	TP	%	0.005 / 0.02	0.05	<0.02	0.08	0.023	12	11	-	-
Total Metals and Major Ions	Aluminum (Al)	µg/g d.w.	1 / 5	5,206	721	8,950	2538.8	12	12	-	-
	Antimony (Sb)	µg/g d.w.	1	<1	<1	<1	-	12	0	-	-
	Arsenic (As)	µg/g d.w.	1	3	<1	4	1.3	12	10	**7.24**	**41.6**
	Barium (Ba)	µg/g d.w.	1	17	2	35	8.1	12	12	-	-
	Beryllium (Be)	µg/g d.w.	1	<1	<1	<1	-	12	0	-	-
	Boron (B)	µg/g d.w.	0.5	6.4	0.9	18	4.66	12	12	-	-
	Cadmium (Cd)	µg/g d.w.	0.5	<0.5	<0.5	<0.5	-	12	0	**0.7**	**4.2**
	Calcium (Ca)	µg/g d.w.	100	81,293	9,320	134,000	35277.3	12	12	-	-
	Chromium (Cr)	µg/g d.w.	1	25	3	43	11.6	12	12	**52.3**	**160**
	Cobalt (Co)	µg/g d.w.	1	3	<1	5	1.4	12	11	-	-
	Copper (Cu)	µg/g d.w.	1	7	1	17	3.9	12	12	**18.7**	**108**
	Iron (Fe)	µg/g d.w.	1 / 5	9,458	1,700	14,250	4025.9	12	12	-	-
	Lead (Pb)	µg/g d.w.	1	6	1	11	3.2	12	10	**30.2**	**112**
	Magnesium (Mg)	µg/g d.w.	100	36,289	3,420	59,050	17854.4	12	12	-	-
	Manganese (Mn)	µg/g d.w.	1	122	25	175	50.5	12	12	-	-

Table 8-3.4 Sediment Quality Summary Statistics for Milne Inlet, 2008 and 2010 (Cont'd)

Parameter		Units	DL[3]	Milne Inlet						CCME Guideline	
				Mean	Min	Max	SD	n	# Detects	ISQG[4]	PEL[5]
Total Metals and Major Ions	Mercury (Hg)	µg/g d.w.	0.1	<0.1	<0.1	<0.1	-	12	0	**0.13**	**0.7**
	Molybdenum (Mo)	µg/g d.w.	1	<1	<1	5	1.3	12	1	-	-
	Nickel (Ni)	µg/g d.w.	1	16	2	24	6.9	12	12	-	-
	Potassium (K)	µg/g d.w.	100	1,848	250	3,537	911	12	12	-	-
	Selenium (Se)	µg/g d.w.	1	<1	<1	<1	-	12	0	-	-
	Silver (Ag)	µg/g d.w.	0.2	<0.2	<0.2	<0.2	-	12	0	-	-
	Sodium (Na)	µg/g d.w.	100	2,970	639	7,567	1961.6	12	12	-	-
	Strontium (Sr)	µg/g d.w.	1	49	9	77	21.4	12	12	-	-
	Thallium (Tl)	µg/g d.w.	1	<1	<1	<1	-	12	0	-	-
	Vanadium (V)	µg/g d.w.	1 / 2	20	4	36	9.7	12	12	-	-
	Zinc (Zn)	µg/g d.w.	1 / 2	16	4	39	9.2	12	12	**124**	**271**

NOTE(S):

1. VALUES IN BOLD BLUE AND RED EXCEED THE CCME SEDIMENT QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE, MARINE ENVIRONMENTS (CCME 1999 UPDATED TO 2010).
2. d.w. = DRY WEIGHT.
3. ANALYTICAL DETECTION LIMIT.
4. INTERIM SEDIMENT QUALITY GUIDELINE.
5. PROBABLE EFFECT LEVEL.

Table 8-3.5 Hydrocarbon Concentrations in Sediments from Milne Inlet, 2008 and 2010

Parameter		Units	DL[1]	Sites Near the Port		Reference Site	CCME Guideline[2]	
				MSQ-04	MSQ-08	MSQ-12	ISQG[3]	PEL[4]
Depth		(m)	-	7	44	62	-	-
Percent Moisture		(%)	0.1	49.2	20.3	35.5	-	-
Volatile Organic Compounds	Ethylbenzene	(µg/g)	0.1	<0.2	<0.1	<0.1	-	-
	Toluene	(µg/g)	0.1	<0.2	0.3	<0.1	-	-
	Benzene	(µg/g)	0.05 / 0.1	<0.1	<0.05	<0.05	-	-
	m/p-xylene	(µg/g)	0.2 / 0.4	<0.4	<0.2	<0.2	-	-
	o-xylene	(µg/g)	0.1 / 0.2	<0.2	<0.1	<0.1	-	-
Total Oil & Grease		(µg/g)	1 / 100	694	<1	<100	-	-
CCME Petroleum Hydrocarbons	F1 (C6-C10)	(µg/g)	10	<20	<10	<10	-	-
	F1 - BTEX	(µg/g)	10	<10	<10	<10	-	-
	F2 (C10-C16)	(µg/g)	10	<10	<10	<10	-	-
	F2 - Napthalene	(µg/g)	10	27	<10	<10	-	-
	F3 (C16-C34)	(µg/g)	20	27	<20	<20	-	-
	F3 - PAHs	(µg/g)	20	<20	<20	<20	-	-
	F4 (C34-C50)	(µg/g)	20	<20	<20	<20	-	-
Polynuclear Aromatic Hydrocarbons (PAHs)	Acenaphthene	(µg/g)	0.003 / 0.006	<0.006	<0.003	<0.003	0.00671	0.0889
	Acenaphthylene	(µg/g)	0.003 / 0.006	<0.006	<0.003	<0.003	0.00587	0.0128
	Anthracene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.0469	0.245
	Benzo(a)anthracene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.0748	0.693
	Benzo(a)pyrene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.0888	0.763
	Benzo(b+k)fluoranthene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	-	-
	Benzo(g,h,i)perylene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	-	-
	Chrysene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.108	0.846

Table 8-3.5 Hydrocarbon Concentrations in Sediments from Milne Inlet, 2008 and 2010 (Cont'd)

Parameter		Units	DL[1]	Sites Near the Port		Reference Site	CCME Guideline[2]	
				MSQ-04	MSQ-08	MSQ-12	ISQG[3]	PEL[4]
Polynuclear Aromatic Hydrocarbons (PAHs)	Dibenzo(a,h)anthracene	(µg/g)	0.003 / 0.006	<0.006	<0.003	<0.003	0.00622	0.135
	Fluoranthene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.113	1.494
	Fluorene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.0212	0.144
	Indeno(1,2,3-c,d)pyrene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	-	-
	Naphthalene	(µg/g)	0.005	0.012	<0.005	<0.005	0.0346	0.391
	Phenanthrene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.0867	0.544
	Pyrene	(µg/g)	0.005 / 0.01	<0.01	<0.005	<0.005	0.153	1.398

NOTE(S):
1. ANALYTICAL DETECTION LIMIT
2. CCME GUIDELINES FOR THE PROTECTION OF MARINE AQUATIC LIFE (CCME 1999, UPDATED 2010)
3. INTERIM SEDIMENT QUALITY GUIDELINE
4. PROBABLE EFFECT LEVEL

Table 8-3.6 Sediment Quality Statistics for Steensby Inlet, 2007, 2008 and 2010

Parameter		DL[2]	Nearshore						Offshore						Significantly Different[3]	CCME Guideline	
			Mean	SD	Min	Max	n	# Detects	Mean	SD	Min	Max	n	# Detects		ISQG[4]	PEL[5]
Depth		-	1.4	0.68	1	3	18	-	43	23.9	10	76	11	-	-	-	-
Particle Size (%)	Sand (>0.050 mm)	1	96	2.5	87	99	18	18	52	12.2	30	64	11	11	Yes	-	-
	Silt (>0.002-0.050 mm)	1	2	2.6	<1	11	18	9	36	9.7	25	55	11	11	Yes	-	-
	Clay (≤0.002 mm)	1	2	1	<1	4	18	17	12	5	7	23	11	11	Yes	-	-
Nutrients	Nitrite (ppm)	1	<1	-	<1	<1	18	0	<1	-	<1	<1	11	0	Yes	-	-
	Nitrate (ppm)	1	3.6	4.45	<1	20	18	17	9	10.8	2	30	11	11	No	-	-
	TKN (%)	0.01	0.01	0.01	<0.01	0.04	18	7	0.13	0.05	0.04	0.24	11	11	Yes	-	-
	TOC (%)	0.005 / 0.01	0.08	0.047	0.03	0.2	18	18	0.94	0.609	0.51	2.65	11	11	Yes	-	-
	TP (%)	0.01 / 0.05	0.04	0.024	0.01	0.11	18	18	0.11	0.03	0.07	0.16	11	11	Yes	-	-
Total Metals and Major Ions (µg/g d.w.)	Aluminum (Al)	1 / 5	1,239	427	906	2,470	18	18	7,557	2048.9	4,970	12,600	11	11	Yes	-	-
	Antimony (Sb)	1	<1	-	<1	<1	18	0	<1	-	<1	<1	11	0	-	-	-
	Arsenic (As)	1.0	<1.0	0.41	<1.0	1.7	18	6	5	1.51	3	**7.5**	11	11	Yes	**7.24**	**41.6**
	Barium (Ba)	1	7	3.7	4	16	18	18	115	97.2	40	369	11	11	Yes	-	-
	Beryllium (Be)	1	<1	-	<1	<1	18	0	<1	-	<1	<1	11	0	-	-	-
	Boron (B)	0.5	1	0.23	0.8	1.7	18	18	9.6	2.83	5.4	16.7	11	11	Yes	-	-
	Cadmium (Cd)	0.5	<0.5	-	<0.5	<0.5	18	0	<0.5	0.13	<0.5	0.6	11	2	-	**0.7**	**4.2**
	Calcium (Ca)	100	6,197	3,922	2,230	16,300	18	18	64,509	30,213	24,800	135,000	11	11	Yes	-	-
	Chromium (Cr)	1	17	15.7	3	**53**	17	17	**64**	30.8	31	**125**	11	11	Yes	**52.3**	**160**
	Cobalt (Co)	1	2	1	<1	4	18	14	5	0.9	4	7	11	11	Yes	-	-
	Copper (Cu)	1	3	2.1	2	11	18	18	10	2.3	6	14	11	11	Yes	**18.7**	**108**
	Iron (Fe)	1 / 5	6,772	5,908	1,830	22,100	18	18	18,109	2,825	14,700	24,800	11	11	Yes	-	-
	Lead (Pb)	1	2	1	<1	4	18	16	8	1.6	6	11	11	11	Yes	**30.2**	**112**
	Magnesium (Mg)	100	2,158	809	1,260	4,090	18	18	15,432	3,790	11,200	21,700	11	11	Yes	-	-
	Manganese (Mn)	1	39	23	20	114	18	18	186	53.3	125	266	11	11	Yes	-	-
	Mercury (Hg)	0.1	<0.1	0.04	<0.1	**0.2**	18	1	<0.1	0.05	<0.1	**0.2**	11	2	-	**0.13**	**0.7**
	Molybdenum (Mo)	1	<1	1.5	<1	7	18	1	2	2	<1	7	11	9	No	-	-
	Nickel (Ni)	1	7	6.4	2	24	17	17	32	14	15	59	11	11	Yes	-	-
	Potassium (K)	100	511	209	314	1,080	18	18	3,639	1,207	2,300	6,830	11	11	Yes	-	-
	Selenium (Se)	1	<1	-	<1	<1	18	0	<1	-	<1	<1	11	0	-	-	-
	Silver (Ag)	0.2 / 0.42	<0.2	-	<0.2	<0.42	18	0	<0.2	-	<0.2	<0.2	11	0	-	-	-
	Sodium (Na)	100	1,660	495	694	2,300	18	18	8,588	7008.9	4,540	29,400	11	11	Yes	-	-
	Strontium (Sr)	1	18	14	5	57	18	18	87	42.6	39	175	11	11	Yes	-	-
	Thallium (Tl)	1	<1	-	<1	<1	18	0	<1	-	<1	<1	11	0	-	-	-
	Vanadium (V)	1 / 2	15	12	5	49	18	18	42	7.7	34	62	11	11	Yes	-	-
	Zinc (Zn)	1 / 2	7	2.7	<1	14	18	17	41	12.3	25	69	11	11	Yes	**124**	**271**

NOTE(S):
1. VALUES IN BOLD BLUE AND RED EXCEED THE CCME SEDIMENT QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE, MARINE ENVIRONMENTS (CCME 1999 UPDATED TO 2010).
2. ANALYTICAL DETECTION LIMIT.
3. SIGNIFICANCE IS BASED ON THE RESULTS OF A MANN-WHITNEY U-TEST AT α = 0.05.
4. INTERIM SEDIMENT QUALITY GUIDELINE.
5. PROBABLE EFFECT LEVEL.

3.3 ISSUES SCOPING

Baffinland carried out several studies and consultations to characterize the water and sediment quality conditions in the vicinity of Milne and Steensby Ports:

- Literature review (baseline conditions) - literature was identified and reviewed, although historical study sites were limited to Pond Inlet, Barrow Strait, Baffin Bay (for relation to Milne Inlet), Foxe Basin, and Hudson Bay (for relation to Steensby Inlet), and data were generally limited to nutrients;
- Literature review (key issues related to Project effects) - reviewing other Project EISs, specifically those from comparable developments in the far north;
- Water and sediment quality studies conducted at Milne Inlet in 2008 and 2010;
- Water quality studies conducted at Steensby Inlet in 2007 and 2008;
- Sediment quality studies conducted in Milne Inlet in 2008 and 2010; and
- Sediment quality studies conducted in Steensby Inlet in 2007, 2008 and 2010.

The primary concern that arose from the scoping activities was whether construction, operation and decommissioning activities of the Project would negatively affect water or sediment quality at Milne and Steensby Inlets, as these components are integral to the health of the biota. As such, water and sediment quality were identified as a VEC for consideration in the Environmental Impact Assessment.

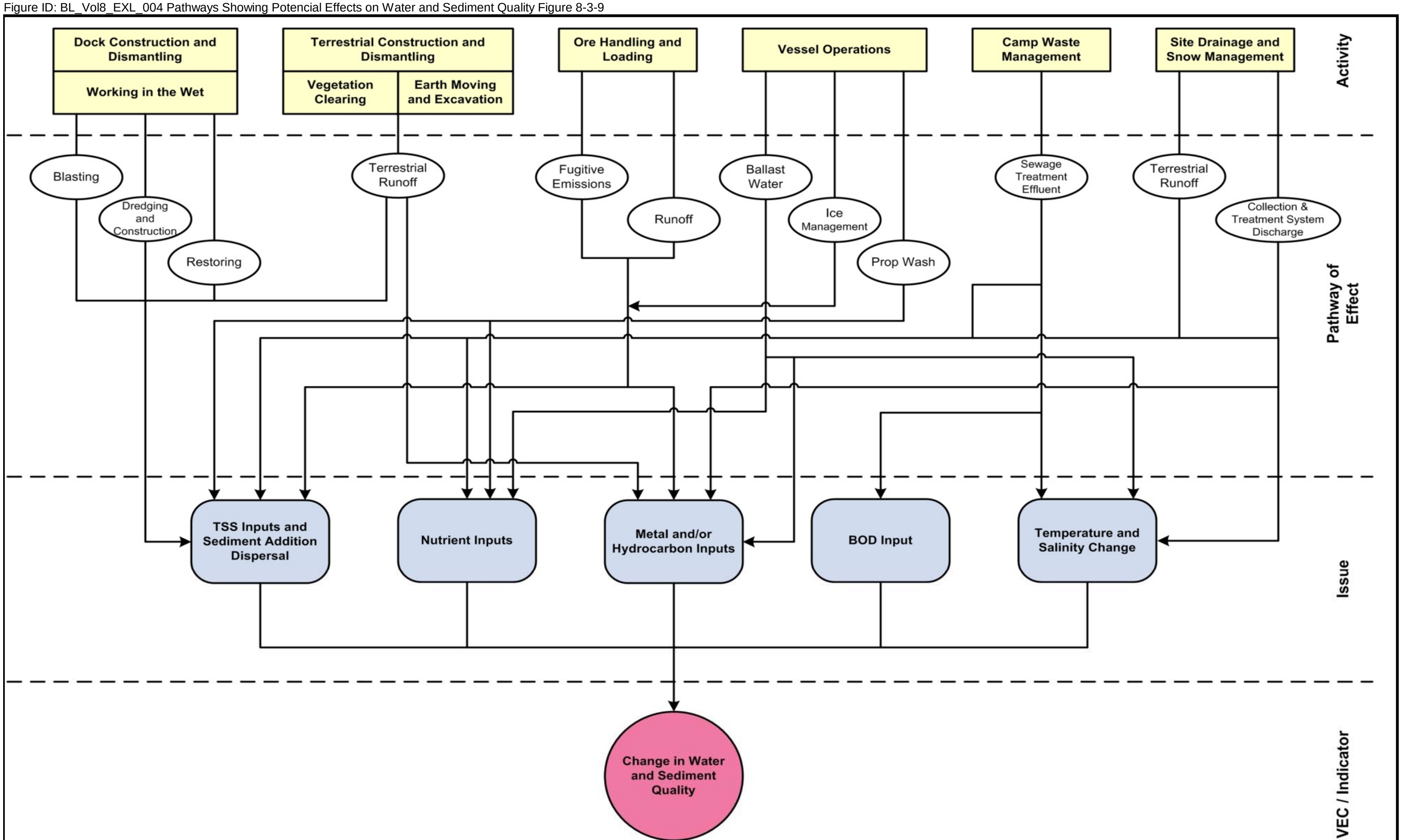
3.3.1 Valued Ecosystem Components

As described in the Impact Assessment Methodology (Volume 2, Section 3.0), VECs were identified based on either legal or formal recognition of ecological or social importance. Formal recognition of the importance of water quality is included in Article 20 of the Inuit Water Rights of the Nunavut Land Claims Agreement (NLCA). Under the NLCA, Inuit have special water rights, and if a project or activity will substantially affect the quality of water through Inuit-owned lands, compensation is required. Additionally, water quality is ecologically important, as it forms an important facet of the environment for aquatic life and wildlife. Sediment quality affects the health of aquatic biota that live in or on sediment, or that directly or indirectly associate with the sediment and/or benthic communities. Thus, water and sediment quality were identified as a VEC.

3.3.2 Key Issues and Pathways

A number of pathways were identified through which the Project (during construction, operation, or decommissioning) could alter water or sediment quality (Figure 8-3.9). Potential effects of these activities were addressed as either Key Issues or Subjects of Note. Key Issues, defined as Level 2 interactions (Volume 2, Section 3.5.3) that are of substantial public interest and/or of potentially high environmental importance or consequence, were carried through the assessment. Subjects of Note, defined as Level 1 interactions (Volume 2, Section 3.5.3), are not likely to be of notable environmental importance or consequence and were not carried through the entire assessment. They are, however, identified in the pathways of effects diagrams, and are discussed in the Subjects of Note section. The interactions categorized under each Level are as follows.

Figure ID: BL_Vol8_EXL_004 Pathways Showing Potencial Effects on Water and Sediment Quality Figure 8-3-9



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PATHWAYS SHOWING POTENTIAL EFFECS OF PROJECT ACTIVITIES ON WATER AND SEDIMENT QUALITY

Baffinland Iron Mines Corporation

REF NO. **BL_Vol8_EXL_003**

FIGURE 8-3.9

REV 0

Level 2 Interactions (Key Issues):

- Construction of the ore and freight dock at Steensby Inlet;
- Barge and ship traffic;
- Discharge of ballast water from ore carriers at Steensby Inlet;
- Dispersion and deposition of dust from ore stockpiles and ship loading at Steensby Inlet;
- Wastewater and site water discharge; and
- Dismantling of marine facilities.

Level 1 Interactions (Subjects of Note):

- Terrestrial run-off from construction and closure activities;
- Snow management;
- Dock ice management;
- Sealift removal of equipment and materials;
- Introduction of anti-fouling agents from ore carriers at Steensby Inlet;
- Effects of vessel wakes on water and sediment quality;
- Effects of circulation alteration by offshore structures on marine water and sediment quality; and
- Spills, accidents, and malfunctions.

3.4 SUBJECTS OF NOTE

Aspects of construction, operation and decommissioning activities at Milne and Steensby Inlets could interact with water and sediment quality; however, proven and effective mitigation measures, as described in the Environmental Monitoring and Mitigation Plan (Volume 10), will be implemented to ensure that negative effects on water and sediment quality are avoided or reduced to an inconsequential level. These Subjects of Note are briefly discussed in this section, both to explain the potential pathways for effects and to outline the applicable mitigation measures. Subjects of Note are not carried forward to the more detailed assessments of residual effects.

Propeller Wash

The ore carriers have the potential to cause propeller wash along the shipping route. The primary effect of a propeller wash (propeller-induced jet) is direct disturbance to seabed sediment, causing erosion that can, in turn, disturb benthic macro-invertebrates and attached aquatic vegetation (US EPA, 2000).

As sand can be mobilized at 0.20 to 0.25 m/s, the seabed at depth of about 90 to 100 m could see a disturbance as a result of propeller wash. In the eastern currents of Hudson Strait however, mean seabed velocities of 0.30 to 0.50 m/s have been recorded at depths between 100 to 200 m (LeBlond *et al.* 1981). Maximum tidal current velocities near the seafloor close to the proposed terminal in Steensby Inlet (20 m water depth) are between 0.03 and 0.35 m/s, occurring less than 1 % of the time. As well, near the port, at a depth of 42 m, tidal currents greater than 0.50 m/s were recorded.

Waves can also mobilize sand sediment on the seafloor. The long fetches available in the Hall Beach area (100 to 200 km), seabed wave orbital velocities capable of mobilizing sand-sized sediment can occur to about 30 m depth. In Hudson Strait, where maximum hourly winds have been recorded at 89 and 93 km/hr at Cape Dorset (Canadian Climate Normals, Environment Canada), sand can be mobilized by surface waves at depths greater than 50 m in open areas with roughly 200 km fetch.

The lower intertidal substrate in Steensby Inlet was described as a 60 % sand/mud, 29 % gravel and 11 % bedrock (Costal and Oceans Resources Inc. 2011). While sand/mud is prevalent in the lower intertidal area, its combination as sand/mud would presumably make it less susceptible to propeller wash effects compared to just sand, due to the cohesive nature of mud. As well, as described above this substrate would be subject to seabed velocities greater than those anticipated from the vessels. These estimates are based on high resolution photographs and aerial video collected in 2007 during low tide periods. Data provided by McGregor Geoscience who conducted bathymetry work in Steensby Inlet in 2007 described a different scenario where a coarse seabed of boulder was predominant (J. Hawken pers. comm.). The sediment within Steensby inlet was mostly noted as boulders, gravel ridges and boulders with glacial till. To estimate the seabed velocities associated with a project ore carrier moving under maximum power the PIANC formulae from the Kitimat LNG Propeller Wash (KLNG) report (Moffatt and Nichol 2005), were used. Using the PIANC formulae from the KLNG report, and assuming a value for α = 0.3 for ducted propellers (Maynord 1998), the seabed velocities are described in Table 8-3.7.

Table 8-3.7 Maximum Seabed Velocities Anticipated at Depths Along the Proposed Shipping Route for Project Vessels

Depth below Propeller (m)	Maximum Seabed velocities (m/s)
10	1.90
20	0.95
30	0.64
40	0.48
50	0.38
60	0.32
70	0.27
80	0.24
90	0.21
100	0.19

While sediment mobilization on the seafloor along the shipping route is expected to occur where water depths are less than 120 m, the effect is brief and in many instances will be exceeded by longer duration natural forces such as tidal currents and wind waves during storms. While greater effects would be expected to occur in the port area, where the duration of the impacts would be longer, most of the manoeuvring of these large vessels will be at very low speeds and will be assisted by tugs moving at similarly low speeds. The sailing lines along the shipping route will never be precisely the same, so any disturbance above natural conditions caused by propeller wash will be spread over a broad swath of seafloor. Thus, the effects are not expected to be any more severe than currently occurs along most of Canada's shipping routes.

Run-off from Terrestrial Areas - Milne and Steensby Ports

Various construction and closure activities at Milne and Steensby Ports are expected to increase surface run-off, including:

- Earth movement during construction of the Complex, including terrestrial excavation, drilling, grading, trenching and backfilling; and
- Dismantling of terrestrial facilities during decommissioning activities, including dismantling of the infrastructure, demolition of certain facilities, drainage restoration, excavation and backfilling, waste management and ground restoration.

The Environmental Monitoring and Mitigation Plan (Volume 10) outlines mitigation measures, including the use of silt curtains, drainage ditches and retention ponds, which will be implemented to prevent increases in the natural concentrations of TSS, nutrients and metals in the water that flows to the marine environment.

Although terrestrial run-off is expected to occur during all phases of the Project, the hydrologic regime is not expected to change (see Volume 7, Section 2.0). Therefore, concentrations of TSS, nutrient, metals or hydrocarbons in the water and sediments in Milne and Steensby Inlets are not expected to increase beyond natural levels as a result of this pathway. Note that contact water, oiled site water and terrestrial run-off from areas affected by ore dust are assessed as key issues.

Snow Management - Milne and Steensby Ports

Snow clearing and stockpiling during construction and operation activities are not expected to affect marine water or sediment quality because the snow will be stockpiled away from the marine environment and snow melt will be treated prior to discharge into the estuary (see Environmental Protection Plan for further details).

Dock Ice Management - Steensby Port

During winter operations at Steensby Port, ice around the docks will be broken and dispersed to provide vessel access. This activity will not alter water or sediment quality. It is possible that fugitive dust from the ore stockpile could be deposited on open water areas created by ice management, and this dust would then enter the water column directly, rather than accumulating on the ice surface until spring, when inputs would be diluted with the freshet. This possibility is included in the consideration of dust emissions to the land and water surfaces in Section 3.5.2.2.

Sealift Removal of Equipment and Materials – Milne and Steensby Ports

The normal operation of tugs and barges to remove marine equipment and materials from Steensby Port during the decommissioning phase is not expected to introduce nutrients, metals or hydrocarbons to the water or sediments. The possible exception relates to any ballast water exchanges that might occur; this interaction has been identified as a Key Issue and is discussed in Section 3.4.2.3. There will be minimal operation of tugs and barges to remove materials from Milne Port during the decommissioning phase, consequently there is little likelihood of introducing nutrients, metals or hydrocarbons to the water or sediments to Milne Inlet.

Introduction of Anti-fouling Agents from Ore Carriers - Milne and Steensby Ports

Organotin compounds such as tributyltin have historically been used as preservatives in paints to protect underwater surfaces from fouling by aquatic biota. Leaching from boat hulls has caused elevated concentrations of these compounds in aquatic environments, creating potentially toxic conditions for biota.

Under the *Canada Shipping Act*, the *Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals* ban the use of tributyltin and other organotins as an anti-fouling system on all ships in Canadian waters and to all Canadian ships everywhere. Ore carriers using Steensby Port and the few vessels using Milne Port will be subject to these regulations. Adherence to these regulations will provide environmental protection from anti-fouling agents.

Potential Effects of Vessel Wakes on Water and Sediment Chemistry

Vessel wakes can alter coastal water and sediment quality by causing erosion, deposition and, if waves approach the coastline at an angle, longshore drift of sediments (Bornhold, 2010). In addition, higher waves may result in the overtopping of natural berms or increased erosion of backshore bluffs, leading to greater addition of sediment to the beach system. If the energy associated with such waves exceeds that of ambient wave conditions, changes to intertidal habitat can also occur.

Specific details of the bow-wave and wake characteristics of icebreaking ore carriers to be used in this Project are not yet known. Bornhold (2010) anticipated that bow-wave amplitudes for the proposed carriers could be in the 1-2 m range for a vessel travelling at approximately 14 kn. Along most of the route to Steensby Inlet, fetch distances are large (tens of kilometres) and maximum wave heights generated by wind events are expected to be well in excess of 1.5 m. Ore carriers will be at least 5 km offshore until the final approach to Steensby Port, and it is expected that bow-wave height will have diminished to well within the wave height observed during natural wind events.

Coastal materials along the shipping route consist primarily of coarse sandy gravels, though exceptions may occur in some protected bays that are sheltered from storm waves and are characterized by sandy and/or muddy sediments on tidal flats. Through effects related to ice processes, Arctic beaches tend, in general, to be coarser than those at more southerly latitudes. In most areas of the route, the natural wave regime results in as much, or more, energy reaching the coastline during storm events than from ship-generated waves. In most instances, sandy beaches and tidal flats are found in protected bays and generally far from the shipping line. Based on these preliminary analyses, and limited number of vessel transits in Milne Inlet, it is unlikely that ships' wakes along the proposed routes will cause any measureable change to coastal erosion, and therefore to water and sediment quality, beyond which occurs naturally.

Potential Effects of Circulation Alteration by Offshore Structures

The construction of facilities along the shore and in the immediately offshore may subsequently alter circulation and sediment dispersal in some situations. Shore structures can block alongshore sediment transport within the intertidal zone and, in some cases, can create circulation patterns that may alter sedimentation patterns in the nearshore, possibly resulting in changes to water and sediment chemistry.

Milne Inlet

It is predicted that presence of the proposed floating dock will have a negligible effect on already weak nearshore currents (see Appendix 8A-1) and that there will be only limited effects to sediment transport processes along the southern end of Milne Inlet. Consequently, it is predicted that the presence of infrastructure at Milne Inlet will have negligible effect on water or sediment quality.

Steensby Inlet

It is predicted that the presence of the proposed ore dock, freight dock, temporary construction docks and crossing structure between the port island and the mainland will have negligible effect on already weak nearshore currents (see Appendix 8A-1) and that there will be only limited effects to sediment transport processes in coastal areas near the Steensby Port. Consequently, it is predicted that the presence of infrastructure at Steensby Inlet will have negligible effect on water or sediment quality.

The ore dock at Steensby Port will be comprised of a multi-span structure supported by several caissons (see Volume 3, Section 2.6.3), and will be constructed on a bedrock shoreline with little potential for disruption of sediment dispersal. Currently, only a minor amount of sediment transport occurs, and is limited to within pocket beaches of boulder/cobble sediments. The subtidal zone is bedrock to 20 m depth.

The caisson structures supporting the ore dock and crossing structure are small and will not impede sediment transport. Tidal currents are generally low at this location (<0.3 m/s) so transport of sand-sized material or larger is unlikely. Caissons may create very localized eddies and current shadows.

The freight dock at Steensby Inlet (fill structure, offshore caissons) will extend from a small rock headland. The shoreline consists of bedrock cliffs and boulder ridges with sand-pebble flats in the intertidal zone and no indications of longshore sediment transport. The dock will not affect sediment transport near the site. Wave shadowing will likely occur in the small embayment to the east of the freight dock and there will also be reduced shore-ice interaction; sediments may become finer as a result.

Two temporary barge loading docks will be established near the Steensby port site in a small embayment. There is no indication of sediment transport at these locations. The easternmost construction dock may cause wave shadowing and a possible fining of the beach sediment in a very localized area.

Spills, Accidents and Malfunctions

Potential effects of this pathway are considered to have a low likelihood of occurrence due to the use of extensive mitigation and implementation of adaptive management plans, as described in detail in Volume 9. Consequently, they are not considered further here.

3.5 WATER AND SEDIMENT QUALITY EFFECTS ASSESSMENT

Potential effects on water and sediment quality in the marine environment that could occur during Project construction, operation, and/or decommissioning phases are discussed below.

3.5.1 Assessment Methods

Mathematical models were developed or applied during the assessment of potential effects on water and sediment quality. These included models of:

- Ballast water dispersion in Steensby Inlet during the open-water and ice-cover seasons (details provided in Appendix 8B-1);
- Dispersion and deposition of ore dust from stockpiles; and
- Treated sewage effluent discharge to Steensby Inlet (details provided in Appendix 8B-2).

For application of the ore dust dispersion modelling to water and sediment quality, a conservative, worst-case condition for particle introduction to marine waters was assumed. The thickness of ore dust deposition at the water/ice surface was calculated based on depositional rates determined from dust dispersion modelling and the specific gravity of the dust. It was then assumed that no further dispersion of the ore dust would occur due to water movement (open-water periods) or by ice during break-up. This approach underestimates the area over which ore dust would be distributed, but maximizes the depositional rate (thus estimating the worst-case scenario). The actual potential effects are expected to be less than those modelled because of dispersion through the marine environment prior to sedimentation.

3.5.1.1 Key Indicators and Thresholds

Indicators and thresholds were used to assess the potential effects of Project activities on the VEC. Specifically, indicators are water or sediment quality parameters that would be of particular interest, while thresholds are the level of change beyond which activities would be considered to affect the environment. For assessing effects on water quality at Milne and Steensby Inlets, a suite of water quality parameters were considered, including TSS, nutrients, metals, salinity and hydrocarbons. For sediments, indicators focused on a suite of metals, as well as PAHs.

Effects on water or sediment quality were identified based on the potential for exceedances of water and sediment quality thresholds, which were defined as:

- The maximum average concentrations listed in the Water License Agreement for the Wastewater Treatment Facility;
- Schedule 1 of the Metal Mining Effluent Regulation under the Federal Fisheries Act;
- The CCME Water Quality Guidelines for the Protection of Marine Aquatic Life (PMAL); and
- The CCME sediment quality guidelines for the PMAL (i.e., ISQGs and PELs; CCME, 1999; updated to 2010).

A list of these thresholds is provided in Table 8-3.8. As a general rule, the CCME PMAL was used for defining thresholds for the surface water and sediment quality VEC, as the CCME PMAL thresholds are typically the most stringent of those identified above. When assessing potential effects of the Project relative to these thresholds, consideration was given to conditions in the Inlets prior to the Project (i.e., baseline conditions).

The magnitude of residual effects of the Project on water and sediment quality were described as low (Level I), moderate (Level II), or high (Level III) using the thresholds identified in Table 8-3.9. Effects that were predicted to result in changes unlikely to be detectable were identified as negligible and were not assessed further.

Table 8-3.8 Key Indicators and Thresholds, Water and Sediment Quality VEC

Component	Key Indicator	Units	ISQG[4]	CCME-PEL[5]
Sediment Quality	Arsenic	µg/g d.w.	7.24	41.6
	Cadmium	µg/g d.w.	0.7	4.2
	Chromium	µg/g d.w.	52.3	160
	Copper	µg/g d.w.	18.7	108
	Lead	µg/g d.w.	30.2	112
	Mercury	µg/g d.w.	0.13	0.70
	Zinc	µg/g d.w.	124	271
	Acenaphthene	µg/g d.w.	0.00671	0.0889
	Acenaphthylene	µg/g d.w.	0.00587	0.0128
	Anthracene	µg/g d.w.	0.0469	0.245
	Benzo(a)anthracene	µg/g d.w.	0.0748	0.693

Table 8-3.8 Key Indicators and Thresholds, Water and Sediment Quality VEC (Cont'd)

Component	Key Indicator	Units	ISQG[4]	CCME-PEL[5]
	Benzo(a)pyrene	µg/g d.w.	0.0888	0.763
	Chrysene	µg/g d.w.	0.108	0.846
	Dibenzo(a,h)anthracene	µg/g d.w.	0.00622	0.135
	Fluoranthene	µg/g d.w.	0.113	1.494
Sediment Quality	Fluorene	µg/g d.w.	0.0212	0.144
	Naphthalene	µg/g d.w.	0.0346	0.391
	Phenanthrene	µg/g d.w.	0.0867	0.544
	Pyrene	µg/g d.w.	0.153	1.398

NOTE(S):
1. MAXIMUM AVERAGE CONCENTRATION.
2. METAL MINING EFFLUENT REGULATIONS.
3. CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) CANADIAN WATER QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE (PAL) – MARINE ENVIRONMENT.
4. CCME INTERIM SEDIMENT QUALITY GUIDELINE.
5. CCME PROBABLE EFFECTS LEVEL.

Table 8-3.9 Criteria for Determination of the Magnitude of Effect of Changes in Water and Sediment Quality

Level	Descriptor	Criteria[1,2]
Not Assessed (Level 0)	Negligible	Water/sediment quality change not expected to be detectable
Level I	Low	Water/sediment quality change may be detectable but would remain within CCME PAL guidelines
Level II	Moderate	Water/sediment quality change within an order of magnitude of the CCME PAL guidelines
Level III	High	Water/sediment quality change greater than an order of magnitude above the CCME PAL guidelines

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL FACTORS/SCIENTIFIC JUDGEMENT.
2. OTHER PUBLISHED WATER QUALITY GUIDELINES OR THRESHOLDS WERE APPLIED FOR PARAMETERS FOR WHICH THERE ARE NO CCME PMAL WATER QUALITY GUIDELINES.

3.5.2 Potential Effects and Proposed Mitigation

Activities that occur at Milne and Steensby Inlets during the construction, operation, or decommissioning phases of the Project that have potential to alter water or sediment quality include:

- Construction of the ore dock and freight dock at Steensby inlet ;
- Disruption and erosion of sediments by barge and ship traffic;
- Discharge of ballast water within Steensby Inlet;
- Emission of dust from ore stockpiles; and
- Discharge of human waste and terrestrial source waters, including wastewater, stockpile run-off and site water.

In the following section, the potential effect of each activity is discussed for each Inlet, along with the proposed mitigation measures to reduce the potential effects.

3.5.2.1 Construction of the Ore and Freight Docks

Dredging, extraction, pile driving, drilling, rock filling, and caisson installation activities in the marine environment during construction of the ore and freight docks could affect water and sediment quality in Steensby Inlet through introduction of nutrients, metals, and increases in TSS. Specifically, nutrient, metal, and TSS concentrations in the water may be increased through re-suspension of sediments during construction activities. Blasting of bedrock to prepare the seabed for installation of the ore docks will involve the use of ammonium nitrate fuel oil (ANFO) explosives which could introduce nitrogenous compounds to the water column. Blasting will occur during the ice-cover season of Year 1. This is also likely to cause increases in concentrations of TSS, nutrients and metals in the water column, but the effects will be short-term. Subsequent to this activity, compounds in the water column are expected to either settle back to the sediment or be rapidly mixed to background levels as a result of tidal mixing. The introduction of ANFO residues could also cause a slight increase in nutrient concentrations in the sediments; however, the blasted materials will be dredged during the following open-water season and used to fill caissons. The potential effects on water and sediment quality are expected to be localized and temporary. Petroleum hydrocarbons and metals could also be introduced during construction.

Various mitigation measures will prevent or reduce effects on water and sediment quality. Silt curtains will be installed in as close proximity as feasible around each work site (see Environmental Monitoring and Mitigation Plan) to minimize disturbance in the surrounding areas. Although TSS, nitrate and metal concentrations in waters within the silt curtain may exceed the water quality thresholds during construction activities, areas over which exceedances occur will be small, and the duration will be short-term. Sediment quality may be affected through removal of the substrate, although sedimentary particulates in the water column should be deposited within the same area as they originated in (i.e., within the silt curtain).

Mitigation measures in the Environmental Monitoring and Mitigation Plan will ensure that equipment used during construction activities is clean and free of oil and lubricant leaks, and that refuelling and equipment maintenance procedures do not adversely affect water or sediment quality in Steensby Inlet through inadvertent hydrocarbon leaks or spills. Procedures outlined in the Emergency Response and Spill Contingency Plan will be initiated immediately in the event of an accident. Therefore, negligible effects on petroleum hydrocarbon and associated metals are predicted.

Overall, it is predicted that construction activities may cause localized and temporary increases of TSS and associated nutrients and metals in the water column. Therefore, potential effects of this pathway on water and sediment quality at Steensby Inlet are considered to be moderate in magnitude.

3.5.2.2 Barge and Ship Traffic

Barge and ship traffic in Milne and Steensby Inlets could affect water and sediment quality through sediment re-suspension from propeller-generated currents or through discharge of effluents such as sewage or bilge water. Propeller-generated currents were discussed as a Subject of Note and ballast water discharge is considered in the following section. Steensby and Milne Inlets are considered concurrently because the linkages and discussions are the same for both, however, activities at Milne Inlet will be much less than those at Steensby Port..

Hydrocarbon and nutrient concentrations could increase as a result of discharges of bilge water or sewage while a ship is docked. Vessels will be operated and maintained in accordance with all applicable pollution prevention laws and regulations to ensure releases to the marine environment are within regulated limits. In the event of a refuelling spill, (See Volume 9, Section 3.0) effects to water and sediment quality will be managed through the Emergency Response and Spill Contingency Plans (Appendix 10C). Consequently, any effects to water or sediment quality due to ship discharges at dock side will be negligible.

3.5.2.3 Discharge of Ballast Water

Milne Inlet

Shipping through Milne Inlet will occur during the open-water period for Project Construction and occasionally (less than one per year) during the open-water period throughout the operational phase of the Project. The ships travelling to Milne Inlet will be carrying cargo and thus will not have on board large volumes of ballast water to be discharged into Eclipse Sound and Milne Inlet. As per the *Ballast Water Control and Management Regulations* administered under the *Canada Shipping Act* (see Shipping and Marine Mammals Management Plan, Appendix 10D-10), ships entering Canadian waters are required to exchange ballast offshore prior to entering Canadian waters. Ships accessing Milne Inlet will exchange ballast in the North Atlantic or the Labrador Sea. It is anticipated that ships will begin to discharge ballast upon entry into Eclipse Sound and Milne Inlet.

On the infrequent occasions when ballast water is discharged in Milne Inlet, it is predicted that localized effects on temperature (i.e., slight increase) will occur in the immediate vicinity of the dock site, that salinity and metal concentration thresholds will not be exceeded, and that a ballast eddy of lower nutrient (silicate and nitrate) concentrations could occur in offshore areas. Therefore, it is predicted that the effects of ballast water discharge will be of low magnitude.

Steensby Inlet

In Steensby Inlet, discharge of ballast waters will occur year-round during the operation and closure phases of the Project. During open-water conditions, it is anticipated that ballast discharge will begin once ships move into protected waters in northern Foxe Basin or Steensby Inlet. Ships will retain full complements of ballast during periods of ice cover to facilitate icebreaking and, therefore, the full load of ballast will be discharged at dock side during those periods. Ballast water onboard ore carriers accessing Steensby Inlet will be taken on in the North Atlantic or Labrador Sea.

The surface waters of the Northwest Atlantic are characterized by a marked seasonal variation in nutrients, with higher concentrations occurring in winter (Table 8-3.2; Louanchi and Najjar, 2001; Harrison and Li, 2008). There are indications from the baseline studies that nutrient concentrations in Steensby Inlet are similarly higher during winter than in summer. A direct comparison, however, between nutrient concentrations in the ballast water and those of Steensby Inlet is restricted due to the relatively high analytical detection limits (DL) provided during the baseline studies. Although comparison cannot be made for Steensby Inlet, nutrient concentrations in Foxe Basin (NODC, 2010) appear to be similar to those in the Northwest Atlantic (Table 8-3.2). Assuming that the water quality of Foxe Basin is a proxy for Steensby Inlet, changes in nutrient concentrations in Steensby Inlet are not expected to occur as a result of ballast water discharge.

Modelling of ballast water discharge at Steensby Inlet was conducted by CORI (Appendix 8B-1). The dispersal modelling was based on time-varying, three-dimensional circulation in Steensby Inlet derived using advanced Regional Ocean Modelling System (ROMS). Several modifications to the model were applied to ensure that it represented an accurate depiction of ballast water dispersal. As the full version of ROMS was not designed for the full coupled dynamics and thermodynamics of the ocean-sea-ice interaction, the modelling was restricted to specific cases of "ice-free" and "ice-covered" conditions, i.e., the physical process of freeze-up and ice break-up were not incorporated into the model. These two conditions were provided by the Institut des Science de la Mer (ISME) at the Unviersité du Québec à Rimouski and DFO (Saucer *et al.*, 2004).

Basic scenarios for the modelling included:

- Ballast water originates from the central North Atlantic;
- 200,000 m3 of ballast water are discharged twice a week at the dock during ice-covered conditions in the inlet;
- 70,000 m3 of ballast water are discharged twice a week during open water conditions;
- There are 104 transits of vessels discharging ballast water per year (i.e., two transits per week); and,
- Modelling is to show the cumulative effects in the basin after one year of discharging at Steensby Port.

A sensitivity analysis was also performed wherein: (1) twice as much ballast water was discharged during both ice-covered and open-water conditions (i.e., 200,000 m^3 four times per week when ice is present; 70,000 m3 four times per week during open water conditions); and, (2) half as much ballast water is discharged (i.e., 200,000 m^3 once per week when ice is present; 70,000 m^3 once per week during open water conditions).

The following assumptions were made.

- Ballast water during the winter would be 6°C and a salinity of 35.0 psu (practical salinity units);
- Ballast water physical properties, such as temperature, are assumed to remain constant between the area where ballast water was taken and the discharge site at the port;
- Ballast water will be discharged from a single point near the ocean surface;

The modelling revealed the following nine attributes:

1. Most of the ocean currents in Steensby Inlet are of tidal origin with strongly dominating semidiurnal currents. A weak counter-clockwise circulation regime exists in Steensby Inlet with new water entering the inlet in the southeast from Foxe Basin and exiting in the southwest.

2. In addition to the tides, both wind-induced and estuarine circulation is important during the ice-free period.

3. Ballast water, originating in the North Atlantic, is entrained in ambient seawater to be distributed throughout much of Steensby Inlet, particularly in the northern, western and south-western sectors, under both ice-covered and ice-free conditions. The southwestern sector has the greatest depths in Steensby Inlet.

4. The "instantaneous" anomaly at the port site during ballast water discharge is about 0.004 (0.4 %) based on the results of this coarse-grid model. This very quickly dissipates as ballast water is mixed with ambient sea water.
5. Advection is, as expected, more significant during ice-free conditions due in large part to a stronger estuarine circulation regime bringing in more bottom water from Foxe Basin and delivering a greater volume of southward-flowing fresher surface water.
6. Maximum cumulative ballast water contribution to seawater at the end of the ice-covered season is at the port area and reaches about 0.07 %. After 12 months, this diminishes to about 0.017 % at the port site.
7. After 10 months of ballast water discharge, under ice-covered conditions at the port site, ballast water concentrations within Steensby Inlet are seen to be still rising. Open water, wind-driven, and especially estuarine circulation, however, intensifies the advection, nearly clearing ballast water from the northern part of the Steensby Inlet system. Some ballast water remains in Steensby Inlet at the beginning of the next ice-covered season.
8. Cumulative ballast water concentrations after a year of discharge are low everywhere, even when discharge rates are doubled. The concentration of ballast water at all places in the inlet varies nearly linearly with the discharge rate of ballast water.
9. Because of the greater water depths, the cumulative contribution of ballast water to the entire water column is greatest in the central and south-western parts of Steensby Inlet where values as high as 20 mm are found under the baseline conditions of 200,000 m^3 twice per week in ice-covered conditions and 70,000 m^3 twice per week during open water

Overall, the ballast water concentrations are predicted to be low within Steensby Inlet after a year, reaching a cumulative concentration of 0.07 % and a one time maximum of 0.4 %. The anticipated changes in temperature and salinity are less than 0.07 %, and therefore no effects on water quality in Steensby Inlet are anticipated from the discharge of ballast water.

3.5.2.4 Dispersion and Deposition of Dust from Stockpiles

Milne Port

At Milne Port, ore dust deposition will not occur. Consequently there will be no changes in Milne Inlet either as a result of direct reposition or through freshwater inflows. Collectively the dust accumulation in marine sediments will have no effect on sediment quality and will not be detectable.

Steensby Port

Dust deposition in Steensby Inlet is predicted to be largely through direct deposition onto the marine environment, while indirect contributions from the freshwater environment will be negligible (Volume 5, Section 2.0). The anticipated chemical composition of ore dust is presented in Table 8-3.10. Assuming the total annual loading of dust (loading to terrestrial and marine environments collectively) is instantaneously deposited in Steensby Inlet and mixed within the volume of water contained in the modelled dust deposition zone, TSS is predicted to increase by <1 mg/L. This level of change would likely not be detectable. However, to be conservative, it has been assumed that infrequent low-level (within one order of magnitude) exceedances of the CCME PMAL guideline for TSS may occur in the zone of greatest deposition and near freshwater inputs. It is also assumed that infrequent low level exceedances of CCME PMAL water quality guidelines for metals may occur in these areas. Therefore, the overall magnitude of effects on water quality have been designated to range from negligible (not detectable) to moderate (Level II) within the LSA.

The marine area predicted to be affected by the direct aerial deposition of ore dust is approximately 12 km^2 (Table 8-3.11; Figure 8-3.10). The average deposition rate for this area is expected to be 9.7 g/m^2/year, which would result in an average deposition of 0.056 mm over the life of the Project (i.e., cumulative).

Even within the area of greatest aerial deposition (the area immediately southeast of the stockpile), annual deposition is estimated to be no greater than 0.115 mm. This amount of sedimentation is therefore expected to cause negligible changes to sediment chemistry and only slight increases in the proportion of fines contributing to substrates.

The annual maximum amount of ore dust that could potentially be introduced to the marine environment from terrestrial runoff is predicted to range between 34 and 143 tonnes, which would result in an average deposition of 0.004 to 0.017 mm/year (Table 8-3.12). Again, this amount is a worst-case scenario; it assumes that all the dust deposited on the land will reach the marine environment, rather than the realistic condition where some dust is retained on land or retained within the stockpile area and treated appropriately. Runoff will be dispersed throughout the Inlet during the diurnal tidal flux; accumulation in the sediments is not expected.

Collectively, effects of dust deposition on sediment quality in Steensby Inlet are not expected to be detectable and are therefore considered to be negligible.

Table 8-3.10 Chemical Composition of Ore Dust

Compound/Element	Contribution to Dust Sample (%)			
	Minimum	Maximum	Mean	Median
Fe, total	48.95	70.4	65.623	66.39
Magnetite (Size 10<12.5 mm)	0.4	96.4452	52.008	55.9
FeO	0.25	30.89	16.188	16.83
$Si0_2$	0.15	18.85	3.148	2.053
$A_{12}0_3$	0.16	3.48	0.885	0.73
CaO	0.01	4.85	0.358	0.138
MgO	0.035	6.65	1.099	0.82
P	0.005	0.32	0.047	0.019
S	0.003	2	0.355	0.21
Na_20	0.003	0.019	0.007	0.006
K_20	0.004	0.21	0.015	0.008
Mn	0.01	2.28	0.272	0.113
$Ti0_2$	0.004	0.16	0.033	0.024
V	0.001	0.01	0.002	0.002

Table 8-3.11 Estimation of Direct Aerial Deposition of Total Solid Particulate (TSP) to the Marine Environment in Steensby Inlet

Waterbody	Zone	TSP Deposition Rate (g/m^2/year)	Area (m^2)	Thickness of Depositional Layer (mm)	
				Per Year	Project Life
Steensby Inlet	1	0.5 - 1	4,314,114	0.000 - 0.000	0.003 - 0.006
	2	1 - 5	5,121,323	0.000 - 0.001	0.006 - 0.029
	3	5 - 60	2,668,993	0.001 - 0.014	0.029 - 0.344
	4	60 - 120	59,333	0.014 - 0.028	0.344 - 0.688
	5	120 - 500	23,976	0.028 - 0.115	0.688 - 2.867
	Zones 1-5	9.7[1]	12,187,739	0.002[1]	0.056[1]

NOTE(S):

1. CALCULATIONS ARE BASED ON AN ESTIMATED SPECIFIC GRAVITY OF 4.36 g/m^3 FOR THE DUST PARTICLES.
2. WEIGHTED AVERAGE BASED ON CONTRIBUTION OF EACH ZONE TO THE TOTAL AREA. THE MEDIAN DEPOSITION RATE FOR EACH ZONE WAS USED FOR THE CALCULATION.

Table 8-3.12 Estimation of Aerial Deposition of Total Solid Particulates (TSP) to Land in the Vicinity of Steensby Ore Stockpile

Waterbody	Zone	TSP Deposition Rate (g/m^2/year)	Area (m^2)	Total Material Deposited (tonnes)	
				Per Year	Project Life
Steensby Inlet	1	0.5 - 1	338,214	0.2 - 0.3	4 - 8
	2	1 - 5	790,091	0.8 - 4	20 - 99
	3	5 - 60	673,128	3.4 - 40	84 - 1010
	4	60 - 120	182,595	11 - 22	274 - 548
	5	120 - 500	153,365	18 - 77	460 - 1917
	Total	-	2,137,393	34 - 143	842 - 3582

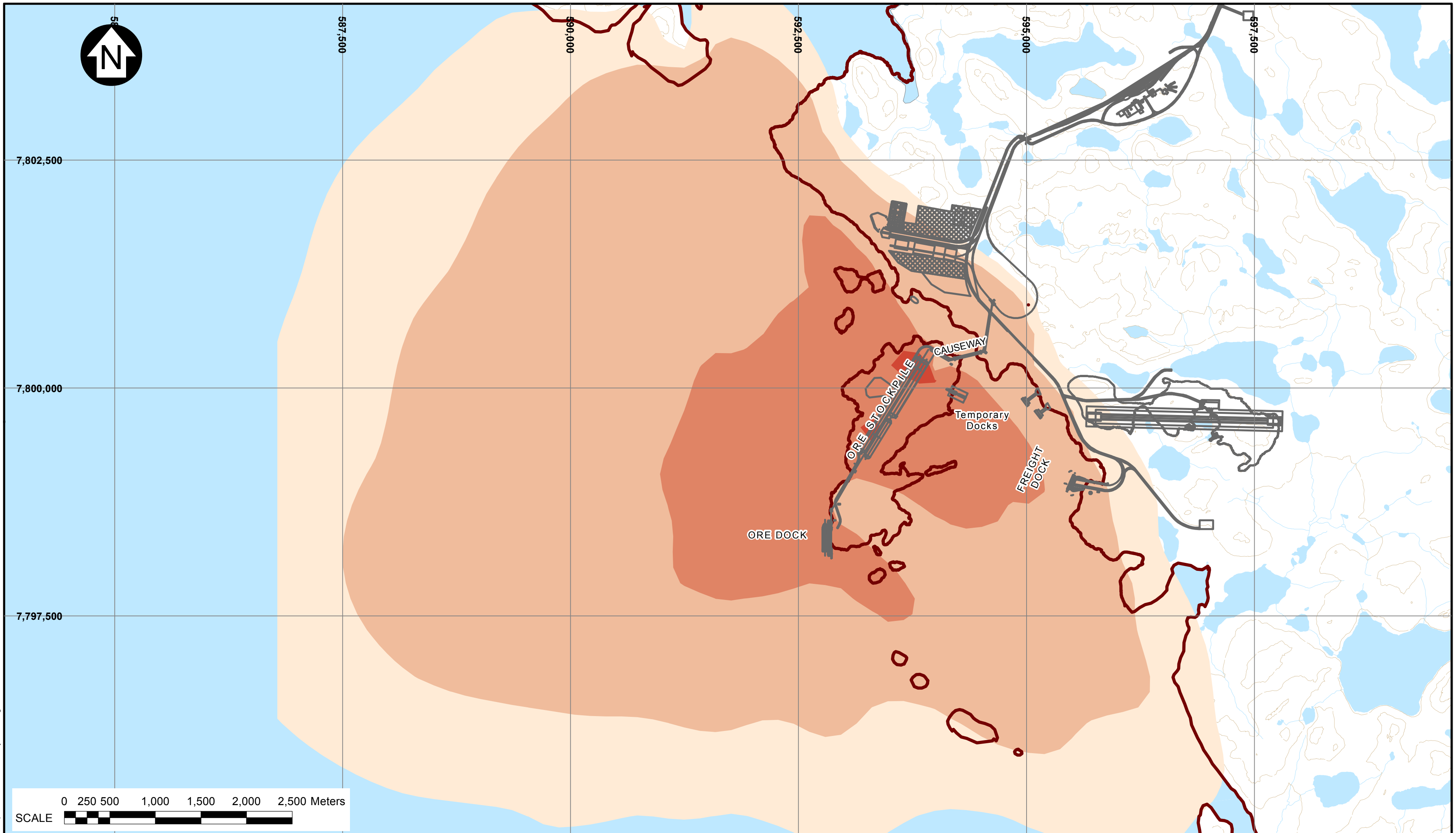


Figure ID: BL_Vol3_GIS_012 Total Solid Particulate Deposition In Steensby Inlet Figure 8-3-10.mxd

LEGEND:

Annual TSP Deposition (Land)
g/m²/year

- 0.5 - 1
- 1 - 5
- 5 - 55
- 55 - 120
- 120 - 500
- WATER
- INFRASTRUCTURE
- SHORELINE

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. INFRASTRUCTURE PROVIDED BY HATCH.
3. PREDICTED ANNUAL TSP DEPOSITION - STEENSBY INLET PROVIDED BY RWDI, NOVEMBER 2011.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

TOTAL SOLID PARTICULATE DEPOSITION IN STEENSBY INLET

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_012

FIGURE 8-3.10

3.5.2.5 Wastewater and Site Water Discharge

Milne Port

At Milne Inlet, three point sources that will be released to the marine environment could affect water quality:

- Treated sewage effluent (during Construction only);
- Treated melt water from the tank farm containment area; and
- General site drainage.

All of these sources will be pumped to a common drainage ditch that discharges to the marine environment (Volume 3, Figure 3-2.1).

The discharge rate for treated sewage effluent is estimated at 18 - 63 m^3/day during construction and 6 m^3/day during operation (with year-round discharge). Sewage will be treated with rotating biological contactors and will undergo tertiary treatment; effluent will meet the conditions of the water license.

Run-off from site drainage (during all phases of production) will occur during the ice-free period (June to September) and will contain suspended solids, nutrients and metals, and potentially petroleum hydrocarbons. Runoff may also affect pH in the marine environment. The discharge rate and chemical composition of these run-off sources are expected to vary seasonally, with most of the flow occurring during the freshet. As necessary, these source waters will be treated to meet the MMER before being released to the drainage ditch.

During all Project phases, water, snow or ice that accumulates in the tank farms or otherwise becomes contaminated with oil or petroleum products will be contained at the site and treated in an oil-water separator prior to release (Volume 3). Thus no increases to the hydrocarbon content of water or sediment are anticipated as part of the normal operations, and the effects of this pathway are considered to be negligible. Fuel spills (see Section 3.6, Volume 9) will be managed under the Emergency Response and Spill Contingency Plans.

All treated effluents from the aforementioned source waters will be discharged through a common drainage ditch to Milne Inlet. During winter months, the discharge is expected to freeze before entering the marine environment. Flow from the drainage ditch during the freshet is expected to occur over a period of about four weeks, thus moderating the effect of inputs of this accumulated material to the marine environment.

Because of density differences between the effluent and sea water, the drainage ditch effluent is expected to be buoyant and to disperse horizontally. It is assumed that low-level exceedances of CCME PMAL water quality guidelines for metals, pH and/or TSS may periodically occur within the effluent plume. It is anticipated that the effluent will be rapidly diluted in the marine environment. As part of the Waste Water Management Plan and MMER, toxicity testing will be routinely conducted before drainage ditch wastewaters are discharged into the marine environment.

No effects on sediment quality are anticipated because introduction of particulate materials is expected to be negligible and the plume will be buoyant and therefore will not directly interact with sediments.

Steensby Port

Four sources (sewage wastewater, treated melt water from tank farm containment area, ore stockpile runoff and general site drainage) could affect water and sediment quality in the marine environment at Steensby Inlet; however, at Steensby Port, these sources will be discharged discretely.

Treated sewage effluent will be continuously discharged to the marine environment during Construction and Operations Phases (Volume 3, Appendix 3B, Attachment 9). The effluent discharge rate is estimated at 360 m^3/day during construction and 55 m^3/day during operation. Therefore, effects would be greatest during the construction period. Sewage effluent will be treated prior to discharge to comply with the conditions of the Water License. Dispersion will be enhanced through the use of a 1000:1 outfall diffuser. Effluent is predicted to contain concentrations of 10 mg/L of BOD and TSS, <200 CFU/100 mL of faecal coliforms and 2 mg N/L of ammonia.

Plume modelling indicates that the effluent would remain below approximately 15 m and 19 m depth during the ice-cover and open-water seasons, respectively (Appendix 8B-2). Use of a diffuser will increase mixing and dispersion; however, to be conservative, it has been assumed that infrequent low-level exceedances of CCME PMAL water quality guidelines may occur, most notably at depth near the outfall. Parameters for which there are no CCME PMAL water quality guidelines, including nutrients, may also be measurably increased in that immediate vicinity.

During the operation phase, run-off from the ore stockpile at Steensby Port - located on the Port Island - will be directed to a retention pond for treatment prior to release (Section 3.6.1.1, Volume 3). Run-off will occur during the ice-free season (June to September), primarily during the freshet. Water will be retained in the pond and allowed to settle, to reduce concentrations of TSS and metals; it will be tested and treated to meet MMERs as needed, then batch-released to Steensby Inlet during the ice-free season. Modelling of ore stockpile runoff quality indicates that MMERs will be met for TSS, pH, arsenic, copper, lead and nickel; Radium 226, cyanide, and zinc were not modelled.

Tidal dispersion is expected to rapidly reduce nutrient and metal concentrations in the ore stockpile runoff when it enters the marine environment. However, to be conservative it has been assumed that infrequent, low-level exceedances of CCME PMAL water quality guidelines may occur in the vicinity of the discharge point.

Site drainage at the Port has the potential to affect water quality during the ice-free season during all Project phases. The volume and chemical composition will vary seasonally, although the largest discharges will occur during the freshet. Site runoff will be treated to meet CCME PMAL water quality guidelines before release, and effects of this pathway are considered to be negligible.

During all Project phases, water, snow or ice that accumulates in the tank farms or otherwise becomes contaminated with oil or petroleum products will be contained at the site and treated in an oil-water separator prior to release (Environmental Protection Plan). Thus, no increases to the hydrocarbon content of water or sediment are anticipated as part of the normal operations, and the effects of this pathway are considered to be negligible.

3.5.2.6 Dismantling of Marine Facilities

Steensby Port

Removal of docks and other infrastructure from within the marine environment during the closure phase could alter water and sediment quality in Steensby Inlets. Specifically, sediment re-suspension may occur, which could in turn increase TSS, nutrients and metals in water, and use of machinery and equipment could introduce petroleum hydrocarbons and metals. Potential effects related to sediment re-suspension will be mitigated through the use of silt curtains, which will be installed to surround each decommissioning site and activity. Although TSS and metal concentrations in waters within the silt curtain may exceed CCME PMAL water quality guidelines, this effect is expected to subside as sedimentation removes the particulates from the water column. Concentrations in waters outside of the silt curtain will be monitored to confirm compliance with water quality guidelines. Sediment quality will also be temporarily affected, although the extent of disturbance will be confined to the actual work areas. Due to implementation of mitigation, residual effects are expected to be localized and of moderate magnitude outside of the isolated work areas.

The Environmental Monitoring and Mitigation Plan will ensure that hydrocarbons from equipment used during decommissioning activities do not adversely affect water or sediment quality in Milne Inlet, and the effects of this pathway on water and sediment quality are considered to be negligible. Procedures outlined in the Emergency Response and Spill Contingency Plan will be initiated in the event of an accident.

3.5.3 Assessment of Residual Effects

Residual effects of the Project on water and sediment quality are summarized in Tables 8-3.13 to 8-3.16. Effects identified as "negligible" are not considered to be residual effects.

3.5.3.1 Construction of the Ore and Freight Docks

With the application of proven mitigation measures, the residual effects of dock construction on water and sediment quality in Steensby Inlet will be of moderate magnitude (Level 2), confined to a small area within the LSA (Level I), continuous (Level 3), short-term (Level 1), and reversible (Level I). The environmental effects of dock construction on water and sediment quality in Steensby Inlet are therefore predicted to be "*not significant*".

3.5.3.2 Barge and Ship Traffic

Milne Inlet

The residual effects of barge and ship traffic on water and sediment quality in Milne Inlet during the construction and operational phases of the Project will be of moderate magnitude (Level 2), confined to a small area within the LSA (Level 1), frequent (Level 2), of short duration (Level 1), and largely reversible (Level 1). Barge and ship traffic is expected to have little or no effect on water or sediment quality during the closure phase of the Project. Therefore, the environmental effect of barge and ship traffic on water and sediment quality in Milne Inlet is predicted to be "*not significant".*

Steensby Inlet

The residual effects of barge and ship traffic on water and sediment quality in Steensby Inlet during the construction and operational phases of the Project will be of moderate magnitude (Level 2), confined to a small area within the LSA (Level 1), frequent (Level 2), of short duration (Level 1), and largely reversible (Level 1). Barge and ship traffic is expected to have little or no effect on water or sediment quality during the closure phase of the Project. Therefore, the environmental effect of barge and ship traffic on water and sediment quality in Steensby Inlet is predicted to be "*not significant".*

Table 8-3.13 Effects Assessment Summary: Water and Sediment Quality, Milne Inlet

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
CONSTRUCTION PHASE								
Barge and ship traffic to/from Milne Inlet	-Increases in concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance from propeller currents. -Sediment suspension and redeposition downslope. -No change in the concentration of hydrocarbons in water or sediments as a result of the normal vessel operation.	Negative	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	2	1	2	1	1
Discharge of wastewater and site drainage (including oiled site water and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment. -Effects resulting from the mixing of multiple sources in a single drainage ditch, which is subsequently discharged to the marine environment, require further investigation in conjunction with the scheduled monitoring outlined in the Waste Water Management Plan and under MMER.	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the drainage ditch -The combined effluent will be tested for acute and chronic toxicity prior to discharge to the marine environment.	2	1	2	1	1
OPERATIONS PHASE								
Barge and ship traffic to/from Milne Inlet (less than one per year)	-Negligible effects to TSS, nutrient, or metal concentrations in the water or sediment due to resuspension of substrates from propeller currents, as it is expected that the new equilibrium state will be reached early within the operation phase of the Project. -No anticipated increases in hydrocarbon concentrations in water or sediments through normal vessel operations.	Negative	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	1	1	1	1	1
Discharge of ballast water	Open-water season: no anticipated effects to water or sediment quality. -Ice-cover season: increases in temperature and nitrate concentrations in the water; increases in nitrogen concentrations in the sediment; no anticipated changes in the concentrations of metals or other nutrients in water or sediment.	Negative	The ballast water will be exchanged in nutrient poor areas of the high seas (according to the Ballast Water Control and Management Regulations administered under the Canada Shipping Act; see the Shipping Management Plan), and is expected to be discharged over a large area (e.g., within protected waters).	1	1	1	1	1
Discharge of wastewater and site run-off (including run-off from the oiled site water, and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment. -	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the drainage ditch	2	1	2	2	1

Table 8-3.13 Effects Assessment Summary: Water and Sediment Quality, Milne Inlet (Cont'd)

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
DECOMMISSIONING PHASE								
Barge and ship traffic to/from Milne Inlet (ice-free season only)	-No anticipated effects to TSS, nutrient, or metal concentrations in the water or sediment due to resuspension of substrates from propeller currents, expected that the seafloor will have stabilized -No anticipated increases in hydrocarbon concentrations in water or sediments through normal vessel operations.	Neutral[1]	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	-	-	-	-	-
Discharge of ballast water	-Ballast discharge may result in localized temperature threshold exceedences -Ballast discharge may result in localized reduction in nutrient concentrations in water	Negative	The ballast water will be exchanged in nutrient poor areas of the high seas (according to the *Ballast Water Control and Management Regulations* administered under the *Canada Shipping Act;* see the Shipping Management Plan), and is expected to be discharged over a large area (e.g., within protected waters).	1	1	1	1	1
Discharge of wastewater and site run-off (oiled site water, and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment.	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the drainage ditch.	2	1	2	2	1

Key:
Direction and Nature of Interaction: Positive; Neutral; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTES:
1. CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE NO ENVIRONMENTAL EFFECTS WERE EXPECTED (I.E., A NEUTRAL INTERACTION).

Table 8-3.14 Effects Assessment Summary: Water and Sediment Quality, Steensby Inlet

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
CONSTRUCTION PHASE								
Construction of the ore, freight, and temporary docks, including piling, blasting, dredging, extraction, rock filling, and drilling activities	-Increases to concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance and introduction of ammonium nitrate explosive. -Sediment suspension and redeposition near the site of origin; increases in nitrogen concentrations in the sediment.	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	2	1	3	2	1
Barge and ship traffic to/from Steensby Inlet	-Increases in concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance from propeller currents. -Sediment suspension and redeposition downslope. -No change in the concentration of hydrocarbons in water or sediments as a result of the normal vessel operation.	Negative	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	2	1	2	1	1
Discharge of wastewater and site run-off (including oiled site water and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment.	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the marine environment; water from different sources will be discharged separately.	2	1	3	2	1
OPERATION PHASE								
Barge and ship traffic to/from Steensby Inlet	-No anticipated effects to TSS, nutrient, or metal concentrations in the water or sediment due to resuspension of substrates from propeller currents, as it is expected that the new equilibrium state will be reached during the construction phase of the Project. -No anticipated increases in hydrocarbon concentrations in water or sediments through normal vessel operations.	Negative	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	2	1	2	1	1
Discharge of ballast water	Open-water season: no anticipated effects to water or sediment quality. -Ice-cover season: increases in temperature and nitrate concentrations in the water; increases in nitrogen concentrations in the sediment; no anticipated changes in the concentrations of metals or other nutrients in water or sediment.	Negative	The ballast water will be exchanged in nutrient poor areas of the high seas (according to the *Ballast Water Control and Management Regulations* administered under the *Canada Shipping Act;* see the Shipping Management Plan), and is expected to be discharged over a large area (e.g., within protected waters).	2	1	2	2	1
Dispersion and deposition of dust from the ore stockpile	-Increases in concentrations of TSS and metals (primarily iron) in the water. -Increases in concentrations of metals (primarily iron) in the sediment.	Negative	-	2	2	2	2	1
Discharge of wastewater and site run-off (including run-off from the ore stockpile, contact water, oiled site water, and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment.	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the marine environment; water from different sources will be discharged separately.	2	1	3	2	1

Table 8-3.14 Effects Assessment Summary: Water and Sediment Quality, Steensby Inlet (Cont'd)

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
DECOMMISSIONING PHASE								
Dismantling of marine infrastructure (including docks)	-Increases to concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance. -Sediment suspension and redeposition near the site of origin.	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	2	1	2	1	1
Barge and ship traffic to/from Steensby Inlet	-No anticipated effects to TSS, nutrient, or metal concentrations in the water or sediment due to resuspension of substrates from propeller currents, expected that the seafloor will have stabilized -No anticipated increases in hydrocarbon concentrations in water or sediments through normal vessel operations.	Neutral[1]	All ships will comply with the Anti-Fouling Systems Convention and will not introduce tributyl-tin to the environment (Shipping Management Plan).	-	-	-	-	-
Discharge of ballast water	-Open-water season: no anticipated effects to water or sediment quality. -Ice-cover season: increases in temperature and nitrate concentrations in the water; increases in nitrogen concentrations in the sediment; no anticipated changes in the concentrations of metals or other nutrients in water or sediment.	Negative	The ballast water will be exchanged in nutrient poor areas of the high seas (according to the *Ballast Water Control and Management Regulations* administered under the *Canada Shipping Act;* see the Shipping Management Plan), and is expected to be discharged over a large area (e.g., within protected waters).	2	2	2	1	1
Discharge of wastewater and site run-off (including run-off from the ore stockpile, oiled site water, and overland run-off)	-Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water. -Increases in concentrations of nutrients, metals, and hydrocarbons in the sediment.	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge to the marine environment; water from different sources will be discharged separately.	2	1	3	2	1

Key:
Direction and Nature of Interaction: Positive; Neutral; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTES:
1. CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE NO ENVIRONMENTAL EFFECTS WERE EXPECTED (I.E., A NEUTRAL INTERACTION).

Table 8-3.15 Significance of Residual Effects on Water and Sediment Quality, Milne Inlet

Project Activity	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Barge and ship traffic to/from Milne Inlet	N	2	-	-
Discharge of wastewater and site run-off (oiled site water, and overland run-off)	N	2	-	-
OPERATION PHASE				
Barge and ship traffic to/from Milne Inlet	N	2	-	-
Discharge of wastewater and site run-off (including run-off from oiled site water, and overland run-off)	N	2	-	-
DECOMMISSIONING PHASE				
Barge and ship traffic to/from Milne Inlet	N	2	-	-
Discharge of wastewater and site run-off (including run-off from oiled site water, and overland run-off)	N	2	-	-

KEY:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD: ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

Table 8-3.16 Significance of Residual Effects on Water and Sediment Quality, Steensby Inlet

Project Activity	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Construction of the ore, freight, and temporary docks, including piling, blasting, dredging, extraction, rock filling, and drilling activities	N	2	-	-
Barge and ship traffic to/from Steensby Inlet	N	2	-	-
Discharge of wastewater and site run-off (including run-off from the ore stockpile, oiled site water, and overland run-off)	N	2	-	-
OPERATION PHASE				
Barge and ship traffic to/from Steensby Inlet	N	2	-	-
Discharge of ballast water	N	2	-	-
Dispersion and deposition of dust from the ore stockpile	N	2	-	-
Discharge of wastewater and site run-off (including run-off from the ore stockpile, oiled site water, and overland run-off)	N	2	-	-
DECOMMISSIONING PHASE				
Dismantling of marine infrastructure (including docks)	N	2	-	-
Barge and ship traffic to/from Steensby Inlet	N	2	-	-
Discharge of wastewater and site run-off (including run-off from the ore stockpile, oiled site water, and overland run-off)	N	2	-	-

KEY:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD: ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

3.5.3.3 Discharge of Ballast Water

Milne Inlet

The residual effects of the discharge of ballast water at Milne Inlet during the construction and operation phases are expected to be of low magnitude (Level 1); confined to areas within the LSA (Level 1): infrequent (Level 1); short duration (Level 1); and fully reversible (Level 1)

Steensby Inlet

In Steensby Inlet the residual effects are expected to be of moderate magnitude (Level 2), confined to areas within the RSA (Level 2), frequent (Level 2), of medium duration (Level 2), and fully reversible (Level 1). The environmental effect of the discharge of ballast water on water and sediment quality in Steensby Inlet is predicted to be "*not significant*".

3.5.3.4 Dispersion and deposition of Dust from Stockpiles

Milne Inlet

No ore dust deposition to the marine environment will occur at Milne Inlet; hence no residual effects are identified.

Steensby Inlet

Residual effects of ore dust deposition on the marine environment will be of moderate magnitude (Level 2), confined to the RSA (Level 2), frequent (Level 2), of moderate duration (Level 2), and reversible (Level 1). Low magnitude effects (Level I) will occur frequently. Due to the low magnitude, reversibility and limited spatial extent, residual effects are deemed to be "*not significant*".

3.5.3.5 Wastewater and Site Water Discharge

Milne Inlet

During each phase of the Project, the environmental effects of wastewater and site water discharges to Milne Inlet will be moderate magnitude (Level 2), confined to within the LSA (Level 1), frequent (Level 2), of moderate duration (Level 2), and reversible (Level 1). The environmental effect of wastewater and site water discharges to Milne Inlet is predicted to be "*not significant*".

Steensby Inlet

Effects will be of moderate magnitude (Level 2), confined to within the LSA (Level 1), continuous (3), of moderate duration (Level 2), and reversible (Level I). The environmental effect of wastewater and site discharges to Steensby Inlet is predicted to be "*not significant*".

3.5.3.6 Dismantling of Marine Facilities

Milne

There are no marine facilities to be installed at Milne Inlet, therefore, there will be no dismantling required.

Steensby Inlet

With the application of proven mitigation measures, the residual effects of dismantling the marine facilities at Steensby Port on marine water and sediment quality will be of moderate magnitude (Level 2), confined to within a small area within the LSA (Level 1), frequent through the decommissioning period (Level 2), of short duration (Level 1), and reversible (Level 1).

The environmental effect of dismantling of marine facilities on marine water and sediment quality in Steensby Inlet is predicted to be "*not significant*".

3.5.4 Prediction Confidence

The pathways for effects of mining developments on marine water and sediment quality are well established, and mechanisms specific to this Project (e.g., ice management) have been considered where appropriate. Where possible, the assessment of effects on water and sediment quality was based on the known efficacy of well-established mitigation measures, and on either chemical analyses from the site or those provided in the literature. Estimates of the potential effects of the Project have been modelled to the extent that the available information allowed. Thus, there is a moderate level of confidence in the prediction of the environmental effects of the Project on marine water and sediment quality.

3.5.5 Monitoring and Follow Up

A detailed aquatic effects monitoring program (AEMP), to be developed, will include physical oceanography, water and sediment quality, and aquatic biota and habitat components to:

- Monitor the effectiveness of mitigation measures;
- Confirm impact assessment predictions;
- Monitor for unforeseen and/or cumulative effects;
- Monitor for compliance with regulatory requirements;
- Provide a means for adaptive management and to identify additional mitigation that may be required over the life of the Project; and
- Address requirements for monitoring as identified in the Metal Mining Effluent Regulations (MMER), including Environmental Effects Monitoring (EEM).

It is anticipated that the AEMP would include monitoring of aquatic biota and habitat at Milne and Steensby Ports, although the monitoring approach and design may vary between locations. Further, the MMERs apply to all "mines", "mines under development" or "recognized closed mines" that: discharge an effluent containing deleterious substances with a flow rate that exceeds 50 m^3/day, based on effluent deposited from all the final discharge points (including seeps) of the mine; and deposit a deleterious substance in such a way that it enters or can enter any water that is frequented by fish. It is anticipated that these regulations will also apply at Milne and Steensby Inlets.

The MMER requires that all metal mines in Canada to which the regulations apply undertake EEM studies, including effluent and water quality monitoring studies, as well as biological monitoring studies. Accordingly, it is anticipated that the AEMP would include detailed EEM in the marine environment, which would include effluent, water and sediment quality monitoring.

3.6 IMPACT STATEMENT

Impact Statement for Water Quality

The Project is predicted to have no significant residual environmental effects on water quality. Through various activities, the Project could increase TSS, nutrient, metal and hydrocarbon concentrations. Exceedances of temperature or salinity thresholds may occur due to ballast water discharge, but these are expected to be of moderate magnitude and fully reversible.

Impact Statement for Sediment Quality

The Project is predicted to have no significant residual environmental effects on sediment quality. Project activities could increase nutrient, metal, or hydrocarbon concentrations in the sediments, but the effects are unlikely to cause exceedances of the CCME sediment quality guidelines.

3.7 AUTHORS

The impact assessment was prepared by Warren Bernhardt and Meagan Cooley, North South Consultants.

SECTION 4.0 - MARINE HABITAT AND BIOTA

4.1 INTRODUCTION

The following provides a description of:

- The aquatic biota and habitat in local study areas (LSAs) potentially affected by Project activities. This description provides the baseline for assessing potential environmental effects of the Project;
- The approach and methods for the assessment of potential Project-related effects on marine biota and habitat;
- The results of the effects assessment, including a description of proposed mitigation; and
- A summary of residual effects.

Detailed methods and results of marine baseline studies conducted in support of this Project are provided in Appendix 8A-1.

4.1.1 Study Areas

LSA selection was based on guidance from NIRB and is described in Volume 2. It is defined as the area where there exists reasonable potential for direct interaction due to Project activities, ongoing normal activities, or possible upset conditions such as a fuel spill. Project activities that could affect marine fish habitat and Arctic char and were considered in the development of the LSAs, including:

- Discharge of ballast water from supply vessels and ore carriers;
- Airborne dispersion of dust from ore stockpiles;
- Discharge of treated wastewater; and
- The modelled 95 % probability distribution of diesel spills.

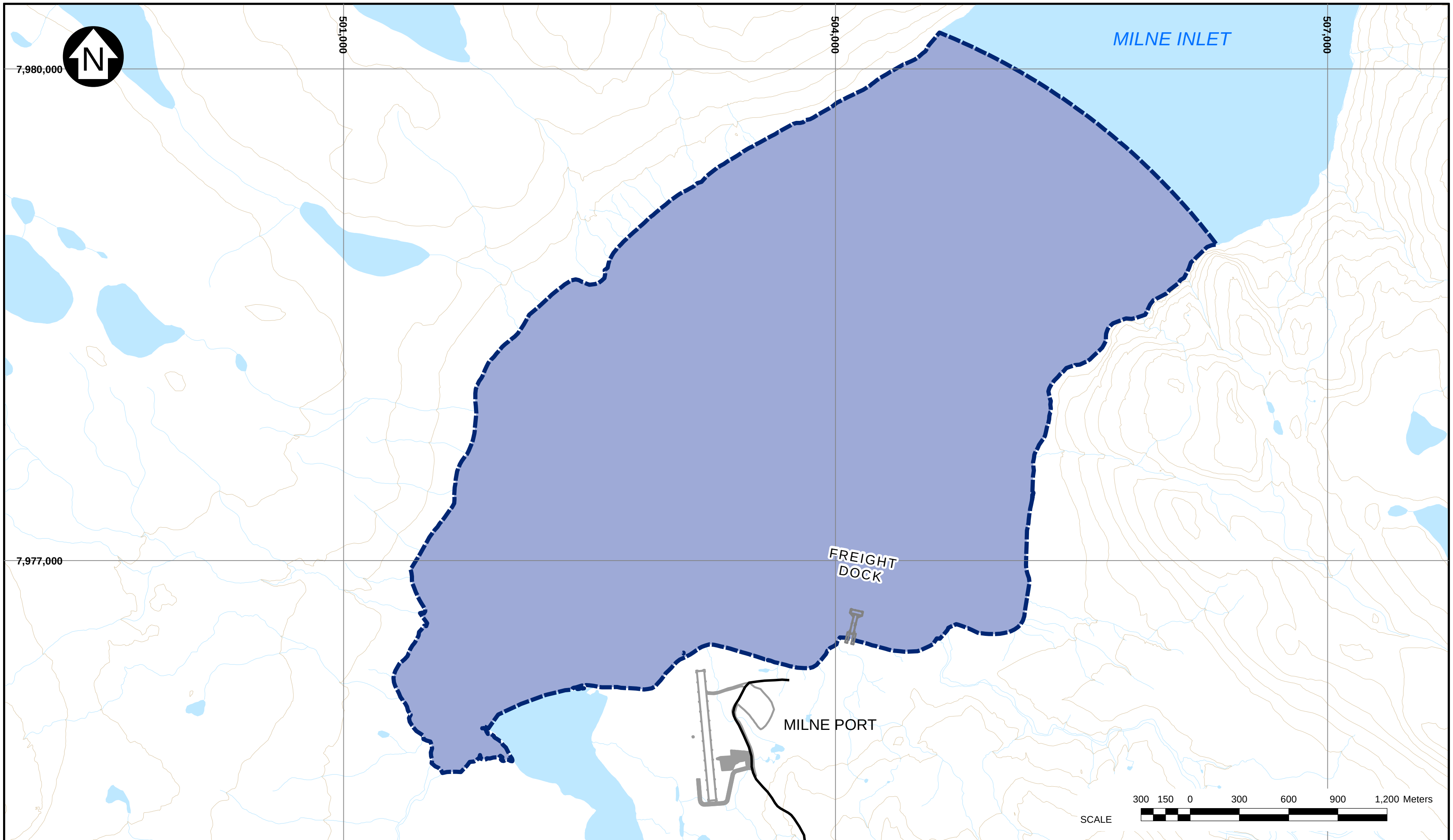
Note that although the areal extent of a potential diesel spill was included in the development of the LSA for marine fish habitat and Arctic char, the assessment of fuel spills will not be considered within this volume. All assessments of spills and emergency procedures are discussed in Volume 9, Section 3.0.

Milne Inlet

The Milne Inlet LSA for marine fish habitat and Arctic char extends northeast from the proposed port site (at the south end of the Inlet) for a total of 4 km, and spans the whole width of the Inlet (Figure 8-4.1). The southwest boundary of the LSA ends at the confluence of the Inlet with Phillips Creek. The southern portion of Milne Inlet extending northward to Eclipse Sound is the marine fish habitat and Arctic char RSA.

Steensby Inlet

The Steensby Inlet LSA contains all of the marine waters within an 8 km radius of the proposed port site (Figure 8-4.2). This area spans approximately two-thirds the width of Steensby Inlet, and includes the Steensby Port Island and a large part of Ikpikitturjuaq Bay. The marine fish habitat and Arctic char RSA is Steensby Inlet.



LEGEND:

- LOCAL STUDY AREA (4 KM RADIUS)
- WATER
- INFRASTRUCTURE

NOTES:

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3. CONTOUR INTERVAL IS 25 AND IS IN METRES.
4. MILNE INFRASTRUCTURE PROVIDED BY HATCH.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MILNE INLET
LOCAL STUDY AREA -
MARINE FISH HABITAT AND ARCTIC CHAR

Baffinland Iron Mines Corporation

REF NO.
BL_Vol3_GIS_013

FIGURE: 8-4.1

Figure ID: BL_Vol3_GIS_013 Milne Inlet Local Study Area - Marine Fish Habitat and Arctic Char.mxd

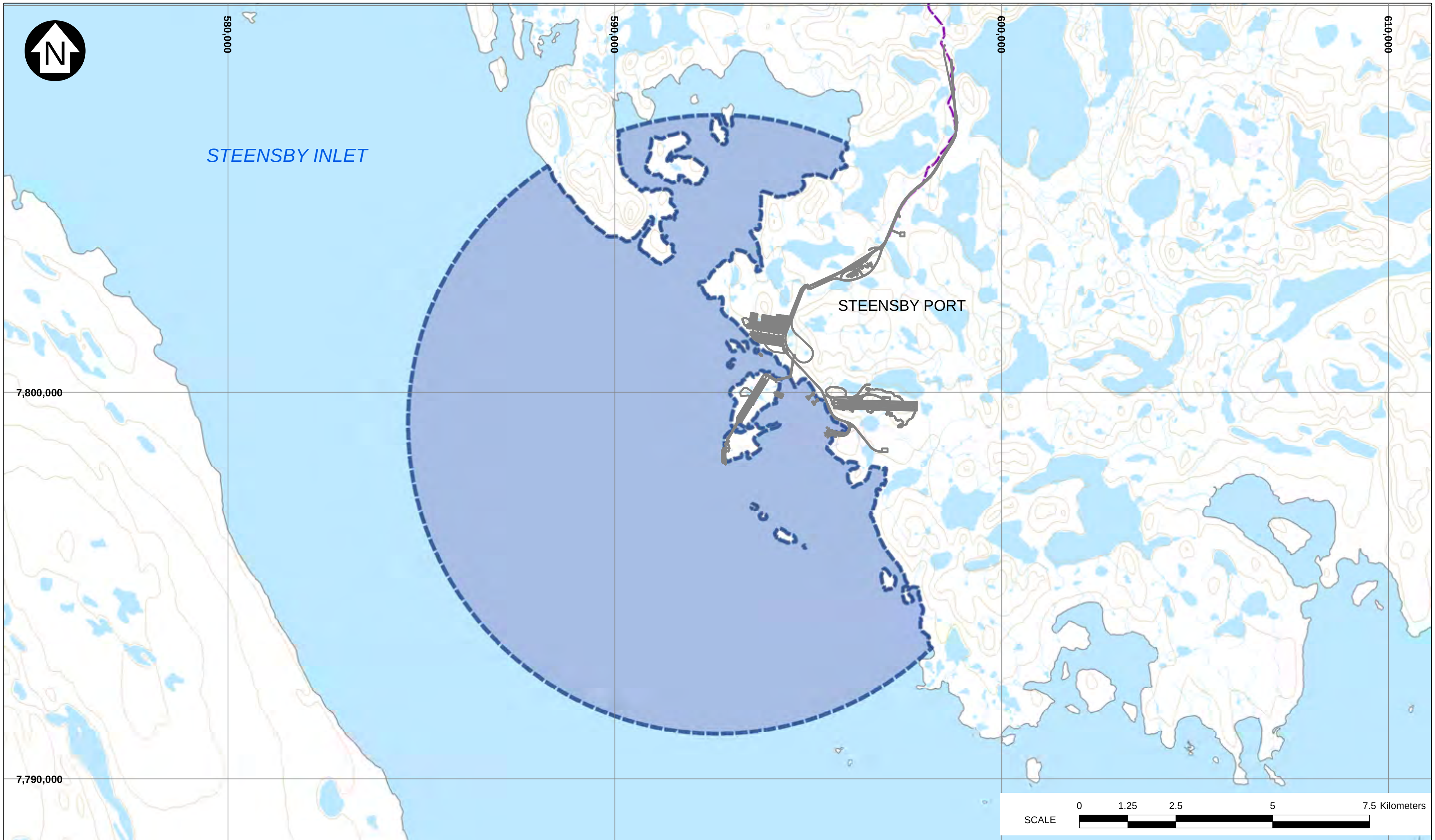

FIGURE ID: BL_VOL8_GIS_030 Steensby Inlet Local Study Area - Marine Fish Habitat and Arctic Char Figure 8-4.2.mxd

LEGEND:

- LOCAL STUDY AREA (8 KM DIAMETER)
- WATER
- INFRASTRUCTURE

NOTES:

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3. CONTOUR INTERVAL IS 20 AND IS IN METRES.
4. INFRASTRUCTURE PROVIDED BY HATCH.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY INLET
LOCAL STUDY AREA -
MARINE FISH HABITAT AND ARCTIC CHAR

Baffinland Iron Mines Corporation

REF NO.
BL_VOL8_GIS_030

FIGURE: 8-4.2

4.2 BASELINE SUMMARY

Information sources for describing the existing marine habitat and organisms in Milne and Steensby Inlets included baseline studies conducted in support of the Project, Inuit traditional knowledge collected during the Inuit Qaujimajatuqangit (IQ) study, and a review of available literature. Field investigations were conducted from 2007 to 2010 and included the collection of information on:

- Seabed and coastal habitat;
- Primary producers (phytoplankton and attached algae);
- Secondary producers (zooplankton, benthic invertebrates);
- Fish communities and populations;
- Fish condition; and
- Metals in Arctic char.

Baseline conditions are briefly summarized in the following sections. Methodology and additional description of results of the field programs are provided in Appendix 8A-1.

4.2.1 Milne Inlet LSA

Seabed Habitat

Observations made with underwater video imagery formed the basis of the nearshore seabed habitat mapping at the Milne Inlet Port Site. Substrates are gravelly sands that become finer with depth. Vegetative cover was the dominant biotic feature in nearly all observations, with bladed kelps and filamentous red algae being the dominant flora. Associated fauna at Milne Inlet is depth stratified, generally sparse, and was most often observed in places where algal cover was low. Brittle stars, sea urchins and bivalve siphons were commonly observed in Milne Inlet. The seabed was classified into three habitat categories based on substrate size, water, depth, and biotic assemblages (Table 8-4.1).

Coastal Habitat

Surveys conducted in 2007 revealed that the coastal habitats of Milne Inlet are typical of periglacial coastal environments, where most of the shoreline is dominated by either rock or coarse sediment beaches comprising poorly sorted boulder, cobble, pebble and sand. Limited open-water seasons and the coarse nature of the shorelines result in complex, poorly organized shoreline morphology. In some locations, glacial rebound has created prominent raised beach complexes. The presence of sea ice limits the development of intertidal biota, although rockweed was commonly observed (45-55 % of the shoreline). Milne Inlet displays considerable evidence of human use, with hundreds of tent rings, dozens of active hunting camps, and several large and abandoned construction camps; human debris is common along the shoreline.

Primary Producers

Overall, concentrations of chlorophyll *a* at Milne Inlet were within the range of concentrations previously reported for Arctic marine waters (Table 8-4.2). The observed trend of higher chlorophyll *a* in deep water (<0.2-1.9 mg/m^3) in Milne Inlet is consistent with the literature and indicates that maximum concentrations typically occur near the bottom of the mixing zone. Contrary to the literature, chlorophyll *a* was higher during the ice-cover season than during the open-water season. However, chlorophyll *a* in the water column is known to increase as the ice begins to melt and ice-associated algae are released. This phenomenon may explain the higher chlorophyll *a* concentrations that were observed under ice-cover (<0.2-1.7 mg/m^3), as sampling occurred near the end of the ice-cover season (May and June) when melting was underway.

Table 8-4.1 Seabed Habitat Classification in Milne and Steensby Inlets

Location	Habitat Class	Description[1]	Depth Range (m)	Habitat Quality[2]
Milne Inlet	1	**Intertidal/Upper Subtidal:** Gravelly sand with filamentous brown algae and few fauna	< 3	Low
	2	**Shallow Subtidal:** Gravelly sand with bladed kelps, algae, and diverse fauna	3-15	High
	3	**Subtidal:** Muddy, sandy gravel with filamentous red algae, kelps, and brittle stars and urchins	> 15	Moderate
Steensby Inlet	1	**Intertidal/Upper Subtidal:** Sandy gravel with rockweed and brown algae, and few fauna	< 3	Low
	2	**Shallow Subtidal:** Muddy, sandy boulder-cobble with bladed kelps and algae, anemones main part of diverse fauna	3-15	High
	3	**Subtidal:** Muddy, sandy gravel with red algae, kelps, and anemones main part of relatively diverse fauna	15-25	High
	4	**Intertidal/Upper Subtidal:** Muddy, sandy gravel with red algae, anemones, and crinoids dominant	> 25	Moderate

NOTE(S):
1. HABITAT DESCRIPTION BASED ON DOMINANT SUBSTRATE, VEGETATION, AND FAUNA.
2. HABITAT QUALITY ASSIGNED ON THE BASIS OF ESTIMATED PRODUCTIVE CAPACITY.

Table 8-4.2 Photosynthetic Pigment Concentrations, Milne and Steensby Inlets

Location	Parameter	Season	DL[1]	Surface							Bottom						
				Mean	SD[2]	Min	Max	Median	n	% > DL	Mean	SD[2]	Min	Max	Median	n	% > DL
Milne Inlet	Chlorophyll a (mg/m^3)	Open	0.2	0.5	0.63	<0.2	1.7	<0.2	14	43	0.5	0.73	<0.2	2	<0.2	14	21
		Ice	0.2	0.8	0.77	<0.2	2.1	0.6	6	67	2.9	1.55	1.1	5.2	2.9	6	100
	Pheophytin a (mg/m^3)	Open	0.2	0.2	0.26	<0.2	0.9	<0.2	14	14	2.1	7.4	<0.2	27.8	<0.2	14	14
		Ice	0.2	1	1.72	<0.2	4.4	<0.2	6	17	<0.2	-	<0.2	<0.2	<0.2	6	0
Steensby Inlet	Chlorophyll a (mg/m^3)	Open	0.2	0.7	0.85	0.1	2.7	0.1	20	45	0.7	0.67	<0.2	1.9	0.3	19	68
		Ice	0.2	1.1	2	<0.2	7.3	<0.2	25	37	0.5	1.05	<0.2	4.9	<0.2	25	26
	Pheophytin a (mg/m^3)	Open	0.2	0.8	1.61	<0.2	7	<0.2	25	16	1.1	1.44	<0.2	6.5	0.6	25	47
		Ice	0.2	0.8	1.61	<0.2	7	<0.2	25	16	1.1	1.44	<0.2	6.5	0.6	25	47

NOTE(S):
1. ANALYTICAL DETECTION LIMIT.
2. STANDARD DEVIATION.

Abundances of nearshore algae were estimated from analysis of the georeferenced underwater video imagery collected at Milne Inlet (Table 8-4.1). The shallowest depth category (<3 m) had the lowest average algal cover in Milne Inlet. The 3 - 15 m depth category had the highest algal cover, which primarily consisted of benthic bladed kelps (BKS; 38 % mean coverage). Foliose red algae averaged 4 % cover, while the filamentous red algae were only observed as trace amounts. Vegetative cover decreased in depths over 15 m, although community composition remained similar to that of the 3 - 15 m depth range.

Secondary Producers

Twenty-three invertebrate taxa were collected from vertical zooplankton tows conducted in Milne Inlet during 2008 and 2010. The cyclopoid copepod *Oithona similis* dominated in both years, followed by *Calanus finmarchicus/glacialis* in 2008 and calanoid copepodites in 2010 (Table 8-4.3). *Calanus finmarchicus*, *Pseudocalanus minutus, O. similis*, Harpacticoida, *Parasagitta elegans*, and *Fritillaria borealis* occurred in 100 % of samples in 2008 and 2010. Average densities and dominant species in Milne Inlet were similar to those reported from Lancaster Sound.

Drop camera videography conducted from the shoreline to a depth of 25 m provided information on benthic epifauna (living on the seabed surface) within Milne Inlet; clams (Bivalvia), brittle stars and sea urchins were most frequently observed. Brittle stars collected in benthic infauna samples suggest that the density of these echinoderms increases with depth.

Benthic infauna (living within the surface layers of the seabed) sampling in Milne Inlet was conducted in 2010, using benthic grabs collected along transects from shallow subtidal (<3 m) to deep-water (>60 m) sites. A total of 146 benthic infauna species were identified. Polychaetes and ostracods were the most abundant taxa, although copepods, amphipods, and several species of bivalves were also common (Table 8-4.4). As reported in previous studies of the Canadian Arctic, the abundance and community composition of benthic infauna in Milne Inlet varies with depth. Copepods were more prevalent at shallow sites and clams dominated at deeper sites. The highest density of organisms occurred between 15 m and 25 m, and there was a small decrease in density with increasing depth beyond 25 m depth (Table 8-4.1).

Nearshore Fish Community

The nearshore marine fish community of Milne Port is characterized by low species diversity and abundance. Small numbers of anadromous Arctic char, fourhorn sculpin (*Myoxocephalus quadricornis*), shorthorn sculpin (*M. scorpius*), Arctic staghorn sculpin (*Gymnocanthus tricuspis*), and Greenland cod (*Gadus ogac*) were captured during baseline studies, with sculpin species accounting for 80 % of the catch (Table 8-4.5). Arctic char are distributed throughout coastal areas in the Milne Inlet LSA, but no rivers supporting anadromous char populations drain into the LSA. The two nearest rivers known to support anadromous Arctic char are the Tuggat and Robertson rivers, both of which drain into the RSA 10-15 km from the port site (Figure 8-4.3). It is assumed that most anadromous char occurring at the Milne port site originate from one of those rivers

Table 8-4.3 Zooplankton Summary Statistics, Milne and Steensby Inlets

Location	Year	Total Density[1]						Dominant Class			Dominant Species	
		Mean	SE[2]	Min	Max	Median	n	Taxon #1	Taxon #2	Taxon #3	Taxon #1	Taxon #2
Milne Inlet	2008	1612	307	1041	2095	1700	3	Cyclopoida	calanoida	harpaticoida	*Oithona similis*	*Calanus finmarchicus/glacialis*
	2010	548	51	293	742	587	10	Cyclopoida	calanoida	harpaticoida	*Oithona similis*	Unidentified Calanoida spp.
Steensby Inlet	2008	1861	306	1066	3693	1676	8	Calanoida	larvacea	thoracica	*Pseudocalanus minutus*	*Fritillaria borealis*
	2010	1904	510	693	5245	1599	8	thoracica	calanoida	larvacea	*Balanus* spp.[3]	*P. minutus*

NOTE(S):
1. # OF INDIVIDUALS / m^3.
2. STANDARD ERROR.
n = NUMBER OF SITES SAMPLED.
3. INCLUDES NAUPLII AND CYPRIS LIFE HISTORY STAGES.

Table 8-4.4 Benthic Infauna Summary Statistics, Milne and Steensby Inlets 2010

Common Name	Scientific Name	Milne Inlet					Steensby Inlet				
		Mean	SE[1]	Min	Max	Median	Mean	SE[1]	Min	Max	Median
Hydroids/Anemones/Medusae	*P. Cnidaria*	0	-	-	-	-	5	5	0	43	0
Unsegmented Worms	*P. Nemertea*	18	8	0	58	0	118	24	0	231	130
	P. Sipuncula	0	-	-	-	-	3	3	0	26	0
	P. Priapulida	3	3	0	29	0	6	6	0	58	0
Worms	*Cl. Oligochaeta*	0	-	-	-	-	5	5	0	43	0
Bristle Worms	*Cl. Polychaeta (Errantia)*	1,265	434	244	4,628	897	1,722	408	14	4,043	1 261
	Cl. Polychaeta (Sedentaria)	695	149	205	1,449	513	2,186	618	101	4,768	1 754
Insects	*Cl. Insecta*	17	17	0	154	0	2	2	0	14	0
Mites	*Cl. Arachnida*	252	225	0	2,051	0	0	-	-	-	-
Sea Spiders	*Cl. Pycnogonida*	3	3	0	26	0	0	-	-	-	-
Copepods	*Cl. Copepoda*	185	98	0	821	13	133	51	0	478	77
Seed Shrimps	*Cl. Ostracoda*	1,355	238	410	2,769	1,167	635	164	0	1,159	826
Barnacles	*Cl. Cirripedia*	0	-	-	-	-	24	19	0	174	0
Water Scuds, Cumaceans, Isopods, Crabs, and Shrimp	*Cl. Malacostraca*	994	279	147	2,885	769	1,042	312	58	2,269	848
Snails	*Cl. Gastropoda*	46	22	0	154	6	58	24	0	217	43
Clams	*Cl. Bivalvia*	1,428	257	558	3,058	1,500	155	35	0	283	159
Chitons	*Cl. Polyplacophora*	0	-	-	-	-	3	2	0	14	0
Sea Urchins	*Cl. Echinodea*	1	1	0	10	0	0	-	-	-	-
Sea Cucumbers	*Cl. Holothuroidea*	0	-	-	-	-	2	2	0	14	0
Brittle Stars	*Cl. Ophiuroidea*	28	16	0	135	0	23	9	0	87	14
Sea Stars	*Cl. Stelleroidea*	0	-	-	-	-	2	2	0	22	0
Total		6,290	788	2,641	10,333	6,510	6,124	1,262	188	10,452	6 754

NOTE(S):

1. NINE QUANTITATIVE BENTHIC INVERTEBRATE SAMPLES WERE COLLECTED FROM EACH OF MILNE AND STEENSBY INLETS.
2. SE = STANDARD ERROR.

Table 8-4.5 Number of Fish Captured and Mean Catch Per Unit Effort (CPUE), Milne and Steensby Inlets

Gill Net Type	Fish Species	Milne Inlet		Steensby Inlet	
		Catch	Mean CPUE	Catch	Mean CPUE
Standard Index	Arctic char	11	4.54	270	24.05
	Arctic staghorn sculpin	3	1.24	0	-
	Atlantic spiny lumpsucker	0	-	1	0.09
	Fourhorn sculpin	7	2.89	14	1.25
	Greenland cod	4	1.65	0	-
	Shorthorn sculpin	50	20.63	5	1.25
Small Mesh	Arctic char	N/A	-	9	84.36

NOTE(S):

1. NINE QUANTITATIVE BENTHIC INVERTEBRATE SAMPLES WERE COLLECTED FROM EACH OF MILNE AND STEENSBY INLETS.
2. # FISH/100 m NET/ 24 hrs.

Metals in Fish

Summary statistics for muscle mercury and total metals concentrations in muscle and liver from Arctic char captured at Milne Inlet in 2010 are presented in Table 8-4.6 (results for individual fish are provided in Appendix 8A-1). Mercury concentrations were above the detection limit in all samples (n = 11 fish). Concentrations in muscle tissue ranged from 0.0254 to 0.105 µg/g [wet weight- ww] with a mean concentration of 0.050 µg/g [ww] and an average length-standardized muscle mercury concentration of 0.0326 µg/g [ww]. None of the fish sampled at Milne Inlet had muscle mercury concentrations that exceeded the Health Canada commercial export limit of 0.5 µg/g [ww] (Health Canada, 2007; NSC, 2010b).

Arsenic, calcium, chromium, copper, iron, magnesium, manganese, phosphorus, potassium, selenium, sodium, strontium and zinc were detected in all muscle and liver samples. In addition, all liver samples contained detectable levels of cadmium, cobalt, molybdenum and thallium. In general, trace element concentrations were lower in muscle than in liver tissue. Only calcium, magnesium and potassium were present in greater concentrations in muscle than in liver. Twelve metals in muscle and ten metals in liver were rarely ($\leq$10 % of sampled fish) or never present at concentrations above the minimum detection limit.

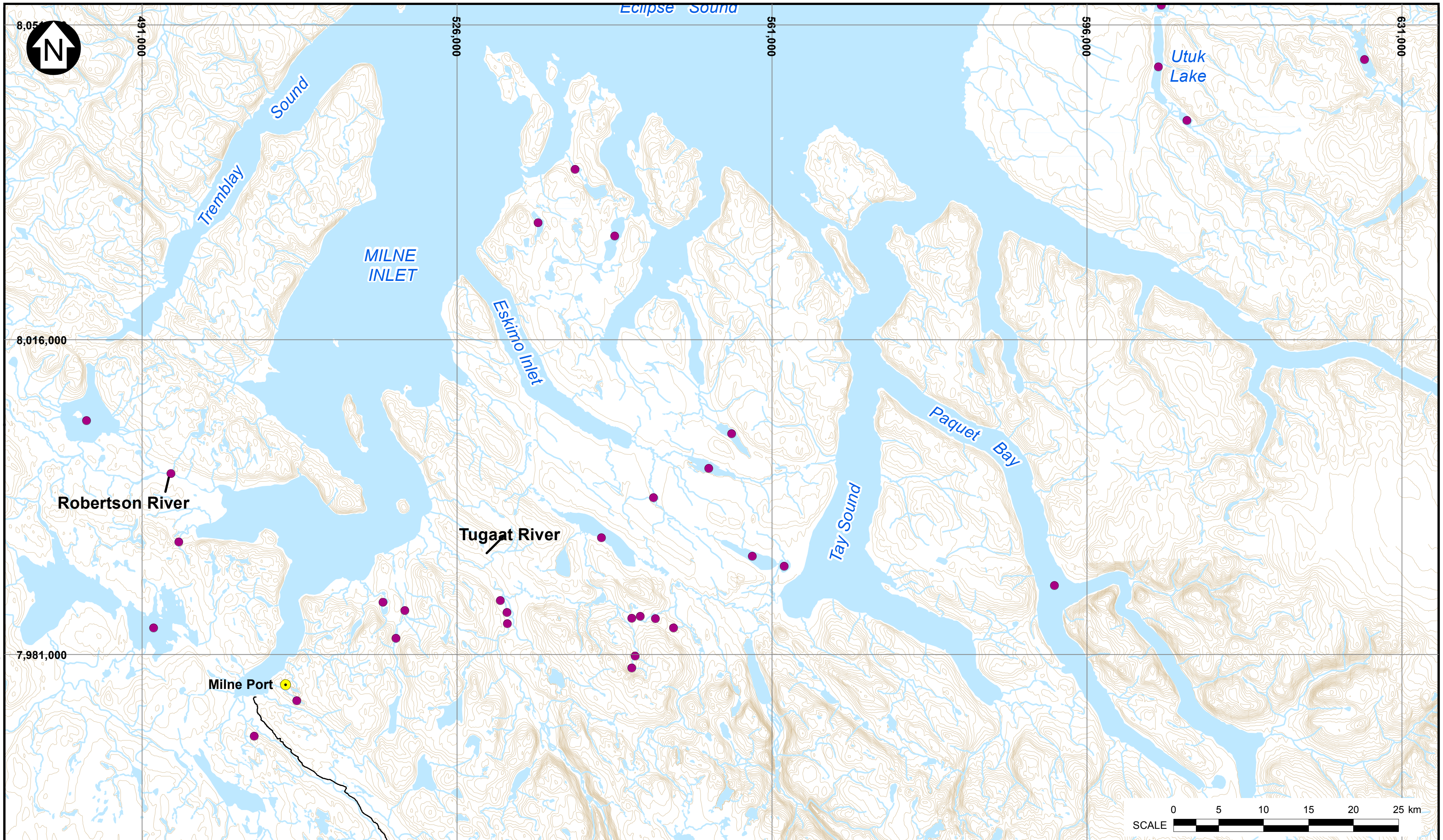

FIGURE ID: BL_VOL8_GIS_032 Arctic Char Distribution in Milne Inlet Figure 8-4.3.mxd

LEGEND:

- ANADROMOUS ARCTIC CHAR (IQ STUDY)
- MILNE INLET TOTE ROAD (EXISTING)

NOTES:

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2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING THE INUIT QAUJIMAJATUQANGIT (IQ) STUDIES AND COMMUNITY WORKSHOPS. THIS INFORMATION SHOWS LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ARCTIC CHAR DISTRIBUTION IN MILNE INLET

Baffinland Iron Mines Corporation

REF NO. BL_VOL8_GIS_031

FIGURE: 8-4.3

Table 8-4.6 Mean Concentration of Select Trace Elements in Arctic Char Muscle and Liver Tissue, Steensby (2007 and 2010) and Milne (2010) Inlets

Location	Tissue	Sample Size	Length Range (mm)	Trace Element Mean Concentration (µg/g [ww])							
				As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Milne Inlet	Muscle	11	287-746	0.816	0.0057	0.59	0.848	< 0.020	0.0497	0.30	6.2
	Liver	11	287-746	1.369	0.3079	0.91	18.719	< 0.020	0.0485	0.48	31.6
Steensby Inlet	Muscle	59	203-840	1.131	0.0052	0.52	0.654	< 0.020	0.0451	0.31	6.2
	Liver	47	203-703	1.208	0.3084	0.36	25.399	< 0.020	0.0638	0.18	33.5

4.2.2 Steensby Inlet LSA

Seabed Habitat

Four depth-stratified seabed habitat classes were described from bathymetry and geo-referenced underwater digital videography collected in nearshore areas in the Steensby Port area (Table 8-4.1). Each class is defined by the dominant substrate and assemblage of benthic algae and epifauna. High resolution bathymetry and side-scan sonar images were combined with the mapped habitat classes to extrapolate areas of habitat classes across the nearshore. Ice scour ridges, troughs and wallow depressions were commonly observed, in particular at depths less than 9 m. Substrates are generally coarse sediment in the nearshore, tending towards muddy gravelly sands in the deeper areas. Vegetative cover is the dominant biotic feature in nearly all observations, with bladed kelps and foliose red algae being the most abundant flora. Associated fauna are depth stratified, generally sparse, and most often observed in places where algal cover is low.

Coastal Habitat

Shoreline surveys conducted in 2007 revealed that the coastal habitats of Steensby Inlet are typical of periglacial coastal environments where most of the shoreline is dominated by either rock or coarse sediment beaches comprised of poorly sorted boulder, cobble, pebble and sand. Limited open-water seasons and the coarse nature of the shorelines result in complex, poorly organized shoreline morphology. In some locations, glacial rebound has created prominent raised beach complexes, and although ice ride-up features occur, they are less common than in Milne Inlet. The presence of sea ice limits the development of an epibiotic community in shallow areas, although rockweed was commonly observed (45 % to 55 % of the shoreline), and salt marshes are found along about 13 % of the coast in Steensby Inlet. Kelps are rare in the intertidal zone, but occur throughout the Inlet and are very common offshore in water depths greater than 10 m. The shoreline of Steensby Inlet has little evidence of anthropogenic disturbances – a few active camps were noted and a number of older archaeological sites were observed.

Approximately 16 km of Steensby Inlet shoreline was mapped with a total intertidal area was estimated at 742,000 m^2. Estimates of sand/mud substrate were made of the lower half of the intertidal zone as only this portion of the shore is likely to be inhabited by clams. As such, the key index of suitable habitat is likely the lower intertidal area of sand/mud. Gravel substrate may include sand/mud but in the port area, consists primarily as a veneer of boulder/cobble over sand, and as such, is likely a much poorer habitat for clams. Bedrock intertidal areas are assumed to be totally unsuitable clam habitat.

A more important index of potential clam habitat is the percent sand/mud cover in the lower intertidal of a unit. For the total 460,000 m^2 of lower intertidal zone mapped, 60 % of that area appears to be suitable clam habitat (i.e., sand/mud) while 29 % was gravel and 11 % bedrock.

Primary Producers

Overall, concentrations of chlorophyll *a* at Steensby Inlet were within the range of concentrations previously reported for Arctic marine waters (Table 8-4.2). As in Milne Inlet, chlorophyll *a* was higher during the ice-cover season (<0.2-7.3 mg/m^3) than during the open-water season (0.1-2.7 mg/m^3).

Algal community information was collected using underwater videography in Steensby Inlet in 2007 and 2008. Sample collection in Steensby Inlet in 2008 was used to supplement the videography data (Table 8-4.2). The shallowest depth category (<3 m) has the lowest average algal cover. The 3 - 15 m category has the highest algal cover and primarily consists of BKS, which averaged 34 % cover. Foliose red algae averaged 8 % cover and filamentous red algae averaged 14 % cover. Vegetation cover decreases at depths greater than 15 m, although community composition remains similar to that of the 3 -15 m depth range.

Secondary Producers

Thirty invertebrate taxa were identified from vertical zooplankton tows conducted in Steensby Inlet in fall 2008 and fall 2010. Calanoida had the highest average density in 2008, followed by the Larvacea and Thoracica (Table 8-4.3). In 2010, Thoracica had the highest average density followed by Calanoida and Larvacea. Species dominance and richness were similar between the two years. The species *P. minutus* and *Balanus sp*. (nauplius or cypris) were present in 100 % of samples in both years, while *F. borealis, C. finmarchicus*, and unidentified polychaete larvae were each absent from only one sample. In 2010, Harpaticoida and unidentified calanoid copepodites were also present in 100 % of samples. The dominance of copepods in Steensby Inlet samples appears to be typical for the region, as reported in the literature.

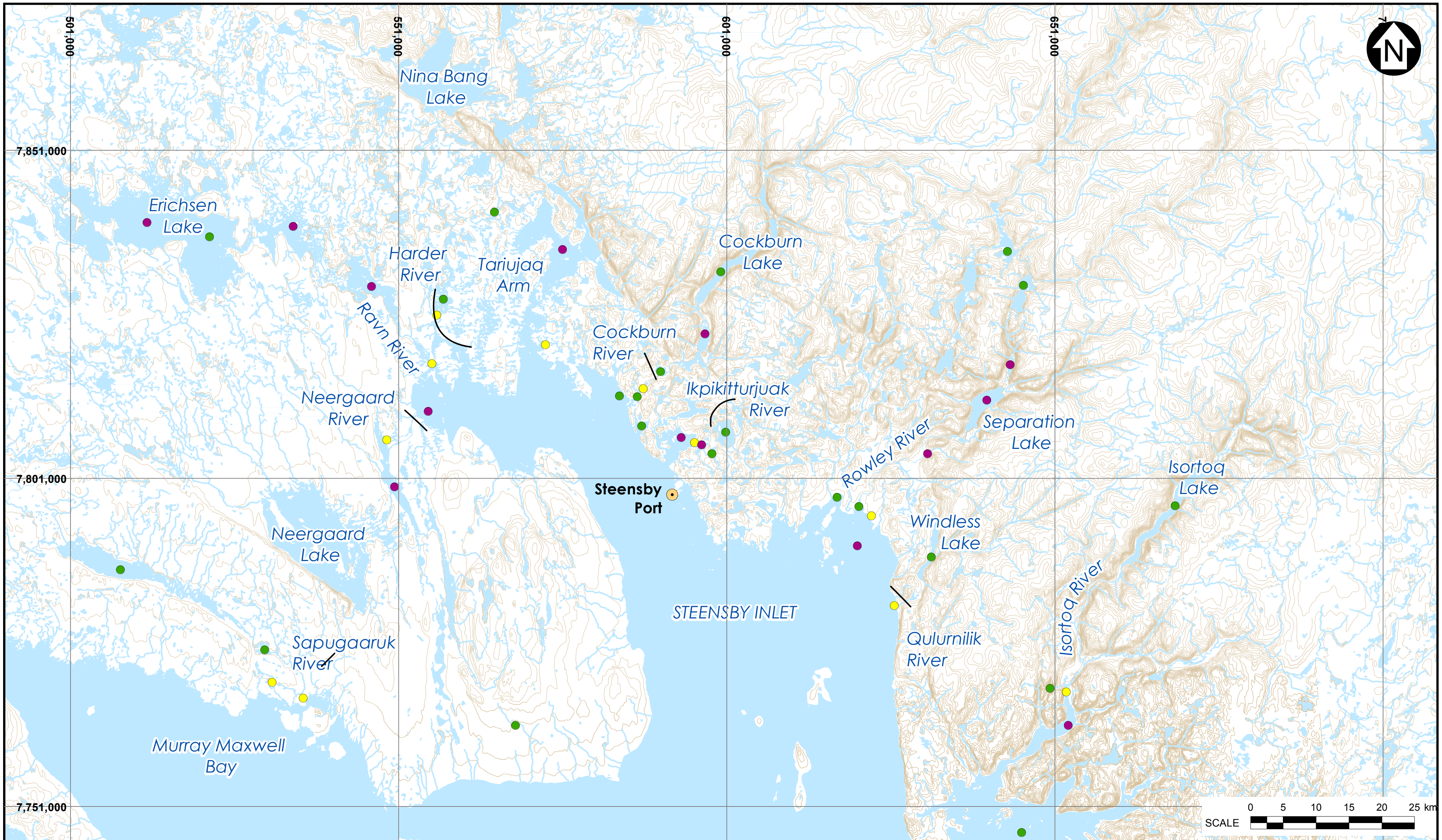
In 2007 and 2008, distribution and abundance of epifauna were classified from underwater towed videography. Samples were collected opportunistically during Steensby Inlet algal sampling in the same years. Like the infauna samples (see below), epifauna species are stratified by depth. Although barnacles and bacterial mats are common at shallow depths and feather stars are common in deeper waters, anemones are the most abundant taxa at all depths (Table 8-4.1).

Benthic infauna sampling in Steensby Inlet was conducted along transects from shallow subtidal (<3 m) to deep-water (>60 m) sites. Polychaetes, usually followed by either Malacostraca or Ostracoda, were the most abundant taxa of the 202 benthic infauna species identified from the Steensby Inlet samples (Table 8-4.4). Benthic invertebrate community composition and densities changed with depth. The highest benthic infauna densities occurred between 10 m and 45 m and the lowest occurred at 3 m (likely due to disruption of habitat from ice scour).

Marine and Anadromous Fish

In general, the marine fish community near the Steensby Port is characterized by low species diversity and abundance. Arctic char, fourhorn sculpin, shorthorn sculpin, and Atlantic spiny lumpsucker (*Eumicrotremus spinosus*) were captured during experimental gillnetting programs (Table 8-4.5). Arctic cod (*Boreogadus saida*) and larval sculpin (most likely ribbed sculpin, *Triglops pingeli*) are also present, as indicated by Arctic char stomach contents. Arctic char were the most common species observed, comprising 90.6 % of the total catch between 2007 and 2010. The average concentration of mercury within muscle tissue samples collected from the Arctic char catch was within the Health Canada commercial export limit of 0.5 ug/g (Table 8-4.6).

Arctic char are distributed throughout coastal areas in the vicinity of the port site (Figure 8-4.4), but were captured in much greater abundance in Ikpikitturjuaq Bay (a large bay just to the north of the Steensby Port site). The Ikpikitturjuaq River enters into Ikpikitturjuaq Bay and has long been known to support a population of anadromous Arctic char that was sufficient in size to support a commercial fishery. Scientific literature and IQ contend that most anadromous char display strong fidelity to their natal stream, remaining in close proximity to the outlet. Thus, it is likely that most of the char captured in the vicinity of the Steensby Port were members of the Ikpikitturjuaq River population. Numerous other rivers within Steensby Inlet support anadromous populations of Arctic char. Some, such as the Cockburn River or the Rowley River, are in close proximity (10-15 km) to the Steensby Port.



LEGEND:

- ANADROMOUS ARCTIC CHAR WINTER LOCATION (IQ STUDY)
- ARCTIC CHAR GENERAL LOCATION (IQ STUDY)
- COMMERCIAL TEST FISHERY (KROEKER 1986)

NOTES:

1. BASE MAP: 1:250,000© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING THE INUIT QAUJIMAJATUQANGIT (IQ) STUDIES AND COMMUNITY WORKSHOPS. THIS INFORMATION SHOWS LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.
4. INFORMATION FROM PUBLISHED LITERATURE INCLUDED

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ARCTIC CHAR DISTRIBUTION IN STEENSBY INLET

Baffinland Iron Mines Corporation

REF NO. BL_VOL8_GIS_032

FIGURE: 8-4.4

FIGURE ID: BL_VOL8_GIS_032 Arctic Char Distribution in Steensby Inlet Figure 8-4.4.mxd

4.3 ISSUES SCOPING

As described in Volume 2, VECs are components of the natural biophysical environment and have been identified as of social, ecological or regulatory importance. Marine aquatic habitat and biota were identified as the VEC for this component of the Project as per the NIRB EIS guidelines.

Scoping of the potential Project effects on marine habitat and biota was conducted through:

- Review of scientific literature pertaining to resident aquatic biota biology/life history and issue-related topics; and
- The conduct of marine aquatic biota and habitat baseline studies for the Project (i.e., Project baseline studies) from 2007 to 2010.

Two key indicators were selected to represent the marine aquatic habitat and biota VEC:

- marine fish habitat; and
- Arctic char.

Marine fish habitat was selected as an indicator because it supports marine biota and their food supply. Any Project-related changes to fish habitat have the potential to negatively affect both. Further, fish habitat is protected under the federal *Fisheries Act* and its accompanying policy framework.

Arctic char was identified as an appropriate key indicator for marine biota and habitat. Arctic char are seasonally abundant in marine coastal waters, and are of value as a cultural, subsistence and commercial resource. The species is one for which there is considerable IQ information available. There is also considerable literature on habitat requirements, life cycle stages, diet, and food chain linkages. This literature supports the importance of this species in the marine food chain. The species is known to use shallow intertidal/sub-tidal zones of the type potentially affected by such Project features as dock shoreline construction. In addition, during the HADD determination process, Arctic char will also almost certainly be selected by DFO as a primary species for the purpose of calculating Habitat Suitability Indices as input to the calculation of Habitat Equivalence Units.

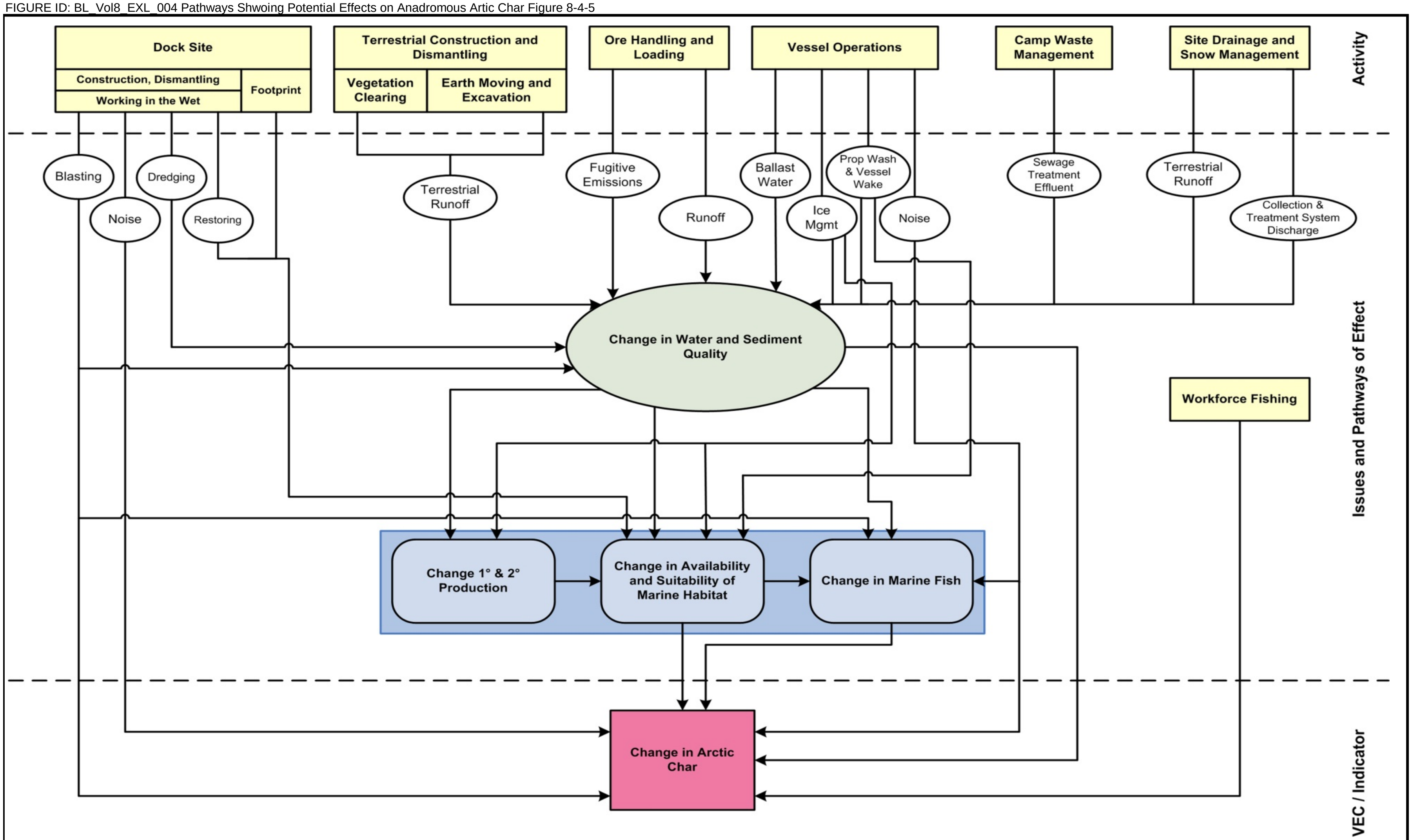
4.3.1 Key Issues and Pathways

Potential linkages between the Project components/activities and marine habitat and biota are presented graphically in Figure 8-4.5. These lead to the identification of three general pathways:

- Pathway # 1: Potential effects on marine (and Arctic char) fish habitat;
- Pathway # 2: Potential effects on the health and condition of Arctic char; and
- Pathway # 3: Potential effects on the population size of Arctic char.

Potential effects of linkages were addressed as either Key Issues or Subjects of Note. Key Issues, defined as Level 2 interactions (Volume 2, Section 3.5.3) that are of substantial public interest and/or of potentially high environmental importance or consequence, were carried through the assessment. Subjects of Note, defined as Level 1 interactions (Volume 2, Section 3.5.3) are not likely to be of notable environmental importance or consequence and were not carried through the entire assessment. They are, however, identified in the pathways of effects diagrams, and are discussed in the Subjects of Note section.

FIGURE ID: BL_Vol8_EXL_004 Pathways Shwoing Potential Effects on Anadromous Artic Char Figure 8-4-5



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PATHWAYS SHOWING POTENTIAL EFFECS OF PROJECT ACTIVITIES ON ANADROMOUS ARCTIC CHAR

Baffinland Iron Mines Corporation

REF NO. **BL_Vol8_EXL_004**

FIGURE 8-4.5

REV 0

Pathways potentially affecting Arctic char population size are considered to have a low likelihood of occurrence due to the use of mitigation and management plans, as described in Volume 9. Consequently, these are briefly discussed as a Subject of Note and are not carried forward through the assessment.

Two key issues are subsequently considered in the effects assessment:

Key Issue # 1: Marine Fish Habitat

Project activities with the potential to affect marine fish habitat were assessed, including:

- Habitat loss due to the placement of Project footprints in the marine environment (i.e., infrastructure permanent for the life of the Project); and,
- Physical habitat alteration (changes due to ore dust deposition, re-suspension of sediments due to prop wash from ships); reduction in productivity due to Project-related effects pathways (i.e., lower trophic level effects).

Key Issue # 2: Arctic char Health and Condition

Effects considered under this Key Issue relate to effects of Project-related changes in water and/or sediment quality on the health and condition of Arctic char. An assessment of potential Project-related effects on water and sediment quality is presented in Section 3.0 of this volume.

4.4 SUBJECTS OF NOTE

Several Project activities have the potential to affect marine habitat and fish, including Arctic char, but will be managed and mitigated through adherence to Federal guidelines and/or standard, well-established mitigation methods, and through detailed management plans.

Potential Effects of Construction Activities on Nearshore Stability

Dredging and blasting activities at Steensby Inlet could potentially destabilize seafloor and shoreline habitats beyond areas where activities are directly occurring. Caisson placement, dredging and onshore blasting activities at Milne Inlet could affect marine habitat and biota in that area.

Although the seafloor at both sites comprises unconsolidated sediments, subsurface intertidal and supratidal sediments are bonded by permafrost. As such, it is unlikely that any excavation or dredging procedures will cause sediment instability along the shoreline.

Construction activities at Steensby Inlet will include blasting and dredging during construction of two permanent docks (Volume 3, Section 2.6). Both are located on bedrock shorelines and, consequently, no shoreline stability issues are anticipated at those areas.

Overall, it is expected that construction activities will have no measureable effect on seafloor or shoreline habitat in the vicinity of the construction areas.

Potential Effects of Vessel Wakes on Coastal Habitat

Vessel wakes can change coastal habitat through erosion, deposition and, if waves approach the coastline at an angle, longshore drift of sediments (Bornhold, 2010). If the energy associated with such waves exceeds that of ambient wave conditions, a steepening of the shoreline and nearshore profile may occur, similar to that between summer and winter on a natural beach. In addition, higher waves may result in the overtopping of natural berms or increased erosion of backshore bluffs, leading to greater addition of sediment to the beach system.

Section 3.4 provides a brief discussion of the predicted magnitude of vessel wakes and their potential effects on water and sediment quality along the proposed shipping routes to Milne and Steensby Inlets. It is expected that the height of bow waves generated by ore carriers will be within the range of waves generated during natural wind events and, consequently, that there will be little or no effect to coastal habitats along the shipping route or in the vicinity of the port sites.

Direct Mortality Due to Fishing

Fishing by Mine employees will not be permitted and harvesting is therefore not considered further in the assessment.

Direct Mortality Due to Blasting

As described in Volume 3 Section 2.6, through-ice blasting will be conducted during the first year of construction to prepare the seabed for installation of the ore dock facilities at Steensby Inlet. DFO "Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters" (Wright and Hopky, 1998) are intended "to provide information on the conservation and protection of fish, marine mammals, and their habitat from impacts arising from the use of confined or unconfined explosives in or near Canadian fisheries waters." Blasting will not be conducted in-the-wet under ice cover in freshwater habitat. Scientific literature indicates that detonation of explosives in, or adjacent to, fish-bearing waters may cause injuries and mortalities to fish, including:

- Swimbladder rupture (Aplin, 1947: Falk and Lawrence, 1973; Ferguson, 1962; Fitch and Young, 1948; Gaspin, 1975; Houghton and Munday, 1987; McAnuff *et al*., 1994; Roguski and Nagata, 1970; Teleki and Chamberlain, 1978);
- Broken ribs (Aplin, 1947; Fitch and Young, 1948; Indrambarya, 1949; Roguski and Nagata, 1970);
- Ruptured blood vessels (Coker and Hollis, 1950; Cronin, 1948; Ferguson, 1962; Indrambarya, 1949; Kearns and Boyd, 1965; Paterson and Turner, 1968; Sverdrup *et al*., 1994);
- Ocular protrusion (Coker and Hollis; 1950; Kearns and Boyd, 1965; Thompson, 1958);
- Kidney damage (Houghton and Munday, 1987; Linton *et al*., 1985; Roguski and Nagata, 1970; Sakaguchi *et al*., 1976; Wiley *et al*., 1981; Yelverton *et al*., 1975);
- Distension and rupture of abdominal walls (Houghton and Munday, 1987; Linton *et al*., 1985; Roguski and Nagata, 1970; Thompson, 1958; Yelverton *et al*., 1975); and
- Vibrations from the detonation of explosives may cause damage to incubating eggs (Wright, 1982).

Potential for injury or direct mortality to Arctic char will be reduced or avoided by conducting underwater blasting at Steensby Inlet during early spring (May or June) when most Arctic char have not yet moved into marine waters for the summer. Further mitigation will be provided through the development of a detailed blasting management plan that will follow DFO blasting guidelines (e.g., Wright and Hopky, 1998) as well as stay current with ongoing research studies and policy development that flows from such work. Baffinland will adjust blasting criteria as DFO Guidelines change. If issues associated with meeting these guidelines are identified, they will be discussed with DFO before blasting activities commence.

Besides Arctic char, other fish in the vicinity of the Steensby Port include several sculpin species that may be present when blasting occurs. Available information suggests that non-swimbladder bearing fish such as sculpins are less susceptible to adverse effects from instantaneous pressure changes from blasting. For example, Godard (2010) found that instantaneous pressure changes of up to 127 kPa (in excess of the current DFO blasting guideline of 100 kPa; Wright and Hopky, 1998) had little effect on sculpin. Although some mortality of a small number of sculpins may be unavoidable in the immediate area of the blast, adherence to the DFO blasting guidelines, development of a detailed blasting management plan, and use of a bubble curtain to chase fish from the area and reduce pressure changes will help minimize effects these on those species.

Direct Mortality of Eggs Due to Sedimentation

Arctic char spawn in freshwater environments, so any increases in sedimentation in marine environments will have no effect on egg survival. Several sculpin species are present in nearshore coastal habitats in the vicinity of the port sites and, although reproductive information is limited for most species, available information suggests that most spawn during late fall/early winter in nearshore areas. Incubation occurs through the winter. Literature suggests that shorthorn sculpin and fourhorn sculpin eggs hatch in late spring, prior to break-up (Scott and Scott, 1988).

Deposition of airborne fugitive dust from ore stockpiles and loading operations is expected to be the largest contributor of sediments to marine waters (including effluents or sediment re-suspension due to Project activities). Only a limited amount of dust at the immediate vicinity of the docks will enter marine waters during periods of ice cover when sculpin are spawning and eggs are incubating (most dust will be deposited on the ice surface). Fudge and Bodaly (1984) indicated that lake whitefish mortality occurred when sedimentation exceeded 1 mm during the incubation period. Air quality modelling suggests that only 0.12 mm of ore dust will be deposited to the water/ice surface annually in areas of highest deposition (Section 3.5.2.4). Thus, ore dust deposition would not be expected to cause mortality to fish eggs incubating during open-water conditions.

Potential for Acute Toxicity to Arctic Char

The Project is not expected to result in acutely toxic conditions to Arctic char due to adherence to effluent discharge criteria, MMERs, and implementation of various mitigation measures that would limit or avoid changes in water quality conditions. Effluent quality monitoring will also be conducted at Milne and Steensby Ports to provide a mechanism for addressing unforeseen issues and supporting adaptive management.

Potential for Invasive Species from Ballast Water

Icebreaking and conventional ore carriers will discharge large volumes of ballast water as they approach Steensby Port. A large concern associated with this practice is the potential to introduce non-indigenous (not native to the area) biota into the marine environment. Ships take on ballast water to provide stabilization while in transit. This water is often taken on at one port location and may be discharged or exchanged at another. Biota including phytoplankton, zooplankton, invertebrates and fish may be taken on board with the ballast water and then released at a new location, resulting in the possible introduction and colonization of species not native to the area.

Aquatic habitats are particularly vulnerable to species invasions and hundreds of aquatic invasive species have become established in North America during the past century (Mills *et al*., 1993, 1996;

Cohen & Carlton 1998). In most cases, the ecological consequences of invasive species on the native biota and habitat are unknown, but may include:

- unexpected disease transmission (e.g., Gozlan *et al*., 2005);
- changes in the genetic structure of native populations (e.g., Ferguson, 1990; Berg *et al*., 2002);
- alterations of the physical/chemical habitat (e.g., Olenin & Leppäkoski, 1999; Simberloff & Von Holle, 1999; Ojaveer *et al*., 2002);
- changes in species diversity, reduced abundance or extinction of native species (e.g., Haag *et al*., 1993; Ketelaars & van Breemen, 1993; Leppäkoski & Olenin, 2000); and
- effects at multiple levels of ecological organization (e.g., Simon & Townsend, 2003).

Accidental introduction of foreign biota from ballast water could potentially affect marine biota in Milne or Steensby Inlets through several of these linkages.

Ore carriers will be subject to the *Ballast Water Control and Management Regulations* administered by Transport Canada under the *Canada Shipping Act* (see Shipping and Marine Mammals Management Plan; Appendix 10D-10). Under the *Ballast Water Control and Management Regulations,* ships entering Canada's Exclusive Economic Zone from foreign waters are required to exchange ballast water before entering. The intent is to replace foreign coastal species with oceanic species that are less likely to survive when discharged into Canadian coastal waters and are less diverse and abundant than coastal communities (Levings *et al*., 2004; Simard and Hardy, 2004). Programs to monitor onboard ballast water and the reviving waters will be designed and implemented as part of the Project Environmental Effects Monitoring Program (Volume 10).

The International Maritime Organization (www.imo.org) has found that treatment of ballast water should be safe, environmentally acceptable, practicable, cost effective, and biologically effective. In the IMO's opinion, few technologies meet all five criteria and most technologies are under development. Currently, ballast water exchange is accepted as an effective ballast water management method, and adherence to regulations and protocols will reduce the potential for invasive species to be introduced into Milne and Steensby Inlets. However, it is anticipated that prior to the beginning of Project operations the IMO will require ballast water treatment. Therefore, Baffinland is committed to conducting both a mid ocean exchange and using an IMO and North American (Transport Canada) approved Ballast Water Treatment System to treat ballast water

<u>Spills, Accidents and Malfunctions</u>

Introduction of contaminants through spills, accidents and malfunctions have the potential to affect water and sediment quality and therefore the health and condition of Arctic char. Potential effects of this pathway are considered to have a low likelihood of occurrence due to the use of extensive mitigation and implementation of adaptive management plans, as described in detail in Volume 9, Section 3.0.

4.5 MARINE FISH HABITAT

4.5.1 Assessment Methods

Two measurable parameters were chosen to assess Project-related effects on marine fish habitat. These include:

- The amount (area in hectares) of marine habitat lost due to the Project footprint; and
- The amount (area in hectares) of marine habitat harmfully altered or disrupted during activities.

Marine fish habitat may be altered, disrupted or destroyed as a result of the Project. The magnitude of potential effects on marine fish habitat was defined as indicated in Table 8-4.7 for each LSA. For the purposes of the assessment, it was assumed that the productive capacity of marine habitat was directly related to area.

Table 8-4.7 Criteria for Determination of the Magnitude of Effect on Marine Fish Habitat

Level	Descriptor	Criteria[1]
Not Assessed (Level 0)	Negligible	Negligible: <1 % reduction in productive capacity
Level I	Low	Low: 1-10 % reduction in productive capacity
Level II	Moderate	Moderate: 10-20 % reduction in productive capacity
Level III	High	>20 % reduction in productive capacity

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL CONTEXT/SCIENTIFIC JUDGEMENT

Scaled and georeferenced drawings of Project infrastructure features were overlaid onto bathymetry maps of each port site and the spatial extent of all infrastructure was extracted to determine the area of habitat lost due to Project infrastructure. Magnitude of effect was estimated as a proportion of lost versus available habitat for each port site.

The spatial extent of altered habitat was estimated by examination of pathways of effects and estimating the extent of possible habitat alteration/disruption through each pathway. The magnitude of effect was estimated as the proportion of altered versus available habitat within the LSA for each port site.

4.5.2 Potential Effects and Proposed Mitigation

Potential Project-related effects to marine fish habitat are summarized in Table 8-4.8 (Milne Inlet) and Table 8-4.9 (Steensby Inlet) and briefly discussed below.

4.5.2.1 Habitat Loss

A temporary floating freight dock is the single project infrastructure component to be installed in the marine environment at Milne Port, therefore, there is no habitat alteration or loss associated with construction or operation activities at Milne Port.

At Steensby Port, new infrastructure components will include two temporary freight docks (to be used during the construction phase and then removed), a permanent ore-loading dock (seven caissons spanned by the deck of the dock), a permanent freight dock, and a rock filled causeway between the port island and Baffin Island (Figure 8-4.6; also see Section 2.6, Volume 3). A raised knoll on the seabed (approximately 2.78 ha) near the ore-loading dock will be dredged to allow ore carriers to turn when departing the dock. The total area of habitat directly affected by dock and causeway footprints and the dredging is 9.947 ha (Table 8-4.10), while the Steensby Inlet marine fish habitat LSA covers an area of approximately 13,700 ha. Therefore, the area of habitat to be lost represents substantially less than 1 % of available habitat and the magnitude of the effect is considered to be negligible.

A limited amount of new habitat may be provided by Project infrastructure. Many of the underwater structures at the port sites are vertical concrete caissons or sheet piles that may be colonized to a limited extent by marine biota. Rock fill structures such as berms or freight docks are expected to provide some new habitat for invertebrates and small fish.

The value of habitat created on, or because of, infrastructure components is expected to be small and most will be of limited value.

The loss of less than 0.1 % of nearshore marine habitat at Milne and Steensby Ports is predicted to have negligible effects. Further, Baffinland is committed to compliance with the *Fisheries Act* requirements related to fish habitat. Thus, any identified Harmful, Alteration, Damage and Destruction (HADD) of productive fish habitat will be addressed in the Fish Habitat Compensation Plan for the Project.

<u>Mitigation</u>

The primary mitigation for habitat loss is through compliance with the No Net Loss Guiding Principle of the Department of Fisheries and Oceans. The goal of which is to compensate for any Habitat alteration, disruption or destruction (HADD) of fish habitat so as to achieve a no net loss of productive capacity. The first step in this process is the quantification of the HADD resulting from the construction and operation of the Project.

As there is no project infrastructure to be placed in the marine environment at Milne Inlet, there is no potential for a HADD at that location. To quantify the extent of the HADD associated with Project activities and infrastructure at Steensby Inlet, an approach developed by the DFO in the Newfoundland and Labrador Region (DFO NL) (Kelly *et al.* 2009 Draft) was used (Baffinland, *In prep.*). This approach was adapted, as necessary, to consider the habitat features, biota, and environmental conditions associated with the Mary River Project. The DFO NL system combines the detailed habitat information, including measured habitat parameters, with information on fish species habitat preference information, to derive a habitat suitability estimate for each habitat type present. The system is conceptually based on the Habitat Evaluation Procedures approach developed by the U.S. Fish and Wildlife Service (Terrell *et al.* 1982). These approaches recognize that direct measures of fish productivity and habitat productive capacity are difficult to obtain and species habitat preferences and utilization information, as habitat suitability indices (HSIs), are used as surrogates of productivity.

Table 8-4.8 Effects Assessment Summary: Marine Fish Habitat, Milne Inlet

Potential Impacts				Residual Effect				
Project Activity	Environmental Effect	Direction and Nature of Interaction	Mitigation Measure(s)	Magnitude	Extent	Frequency	Duration	Reversibility
PROJECT DURATION								
CONSTRUCTION PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- wastewater discharge may introduce small amounts of TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point	Negligible	- Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan); - Wastewater and contact water will be treated to reduce TSS prior to discharge	-	-	-	-	-
Habitat Alteration (Substrate alteration)	- sediment resuspension due to propeller-generated currents - removal and redistribution of fine grained sediments on seabed - altered seabed sediment composition and effects to benthic biota	Negligible	-	-	-	-	-	-
Habitat Alteration (Noise disturbance)	- noise due to vessel activity - possible avoidance of area by fish	Negative	-	1	1	1	1	1
OPERATION PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- wastewater discharge and site runoff may introduce TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point; - potential increases in concentrations of TSS in the water column and accumulation of fines in the sediments could alter the nearshore habitat, although tidal fluxes are expected to disperse the effluents and minimize effects on habitat.	Negligible	Wastewater and contact water will be treated to reduce TSS prior to discharge	-	-	-	-	-
Habitat Alteration (Substrate alteration)	- sediment resuspension due to occasional (<1 per year) vessels and propeller-generated currents expected to lessen as fine grained sediments on seabed are removed and seabed sediment composition stabilizes - removal of fine-grained sediments may alter benthic community composition	Negligible	-	-	-	-	-	-
Habitat Alteration (Noise disturbance)	- intermittent noise disturbance due to occasional vessel operations and loading activities	Negative	Minimize vessel operations to the extent possible	1	1	1	2	1

Table 8-4.8 Effects Assessment Summary: Marine Fish Habitat, Milne Inlet (Cont'd)

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
DECOMMISSIONING PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- - wastewater discharge may introduce small amounts of TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point	Negligible	- Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan); - Wastewater and contact water will be treated to reduce TSS prior to discharge	-	-	-	-	-
Habitat Alteration (Substrate alteration)	- sediment resuspension due to be minimal as most fine grained sediments on seabed will have previously been removed - removal of fine-grained sediments may alter benthic community composition	Negligible	-	-	-	-	-	-
Habitat Alteration (Noise disturbance)	- chronic and intermittent noise disturbance due to occasional vessel operations and infrastructure removal activities - possible avoidance of area by fish	Negative	Minimize vessel operations to the extent possible	1	1	2	1	1
Habitat Alteration (Ballast water discharge)	- localized and short-term water temperature guideline exceedences may occur due to ballast discharge at the Milne dock site - ballast water has lower concentrations of some nutrients than Milne Inlet waters - may be some reduction in benthic productivity	Negative	Maximize the volume of ballast discharged prior to arrival dock side	1	1	2	1	1

Key:
Direction and Nature of Interaction: Positive; Negligible; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTES:
1. CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE ENVIRONMENTAL EFFECTS WERE EXPECTED TO BE NEGLIGIBLE.

Table 8-4.9 Effects Assessment Summary: Marine Fish Habitat, Steensby Inlet

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
PROJECT DURATION								
Habitat Loss (Project footprint)	-direct loss of marine habitat within Project footprint areas	Negligible	Mitigation by Design	-	-	-	-	-
CONSTRUCTION PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- construction of port infrastructure (dredging, blasting, infilling) will cause localized increases in TSS in the water column, followed by re-deposition; - wastewater discharge may introduce small amounts of TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point	Negligible	- Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan); - Wastewater and contact water will be treated to reduce TSS prior to discharge	1	1	1	1	1
Habitat Alteration (Substrate alteration)	- sediment resuspension due to propeller-generated currents - removal and redistribution of fine grained sediments on seabed - altered seabed sediment composition and effects to benthic biota	Negligible	-	-	-	-	-	-
Habitat Alteration (Noise disturbance)	- short-term high energy noise due to blasting and pile driving - noise due to dredging and vessel activity - possible avoidance of area by fish	Negative	Minimize noise propagation with bubble curtains during blasting	1	1	2	1	1
OPERATION PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- wastewater discharge, stockpile run off, and site runoff may introduce TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point; - potential increases in concentrations of TSS in the water column and accumulation of fines in the sediments could alter the nearshore habitat, although tidal fluxes are expected to disperse the effluents and minimize effects on habitat.	Negligible	Wastewater and contact water will be treated to reduce TSS prior to discharge	-	-	-	-	-
Habitat Alteration (Substrate alteration)	- sediment resuspension due to propeller-generated currents expected to lessen as fine grained sediments on seabed are removed and seabed sediment composition stabilizes - removal of fine-grained sediments may alter benthic community composition	Negligible	-	1	1	1	1	1
Habitat Alteration (Fugitive ore dust deposition)	- fugitive ore dust deposition to marine environment; - possible change to water and sediment chemistry and seabed grain size composition; - possible change to benthic productivity	Negative	-	1	1	2	2	1
Habitat Alteration (Noise disturbance)	- chronic and intermittent noise disturbance due to vessel operations and loading activities - possible avoidance of area by fish	Negative	Minimize vessel operations to the extent possible	1	1	2	2	1

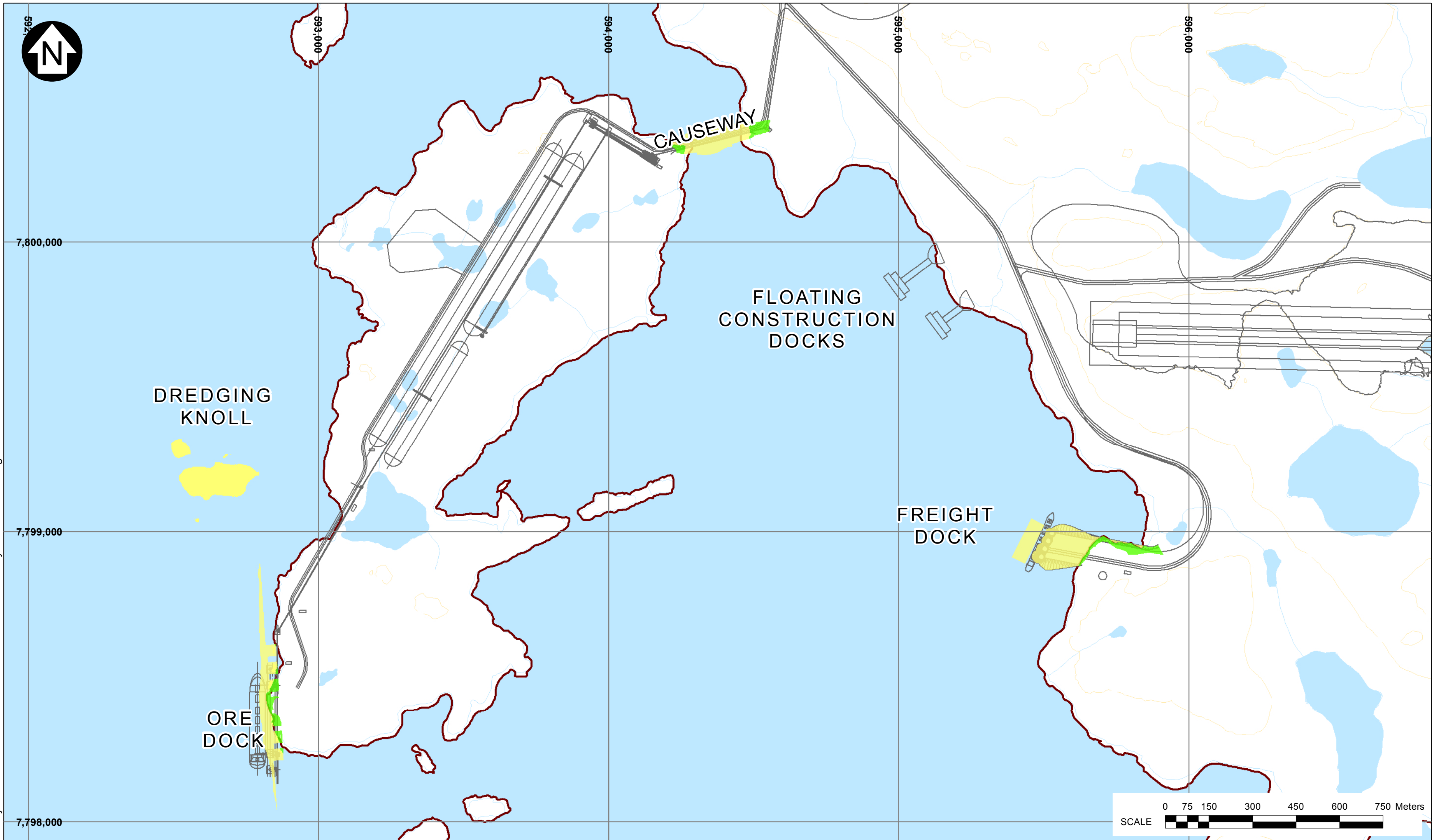
Table 8-4.9 Effects Assessment Summary: Marine Fish Habitat, Steensby Inlet (Cont'd)

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
PROJECT DURATION								
Habitat Alteration (Ballast water discharge)	- localized salinity guideline exceedences will occur during open water periods due to ballast discharge at the Steensby dock site - ballast water has higher salinity concentrations than Steensby Inlet during open water periods - may be some reduction in benthic productivity	Negative	Maximize the volume of ballast discharged prior to arrival dock side	1	2	2	2	1
DECOMMISSIONING PHASE								
Habitat Alteration (Sediment introduction and resuspension)	- removal of port infrastructure will cause localized increases in TSS in the water column, followed by re-deposition; - wastewater discharge may introduce small amounts of TSS into the water column, increasing the amount of fine-grained sediments in the immediate vicinity of the discharge point	Negligible	- Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan); - Wastewater and contact water will be treated to reduce TSS prior to discharge	-	-	-	-	-
Habitat Alteration (Substrate alteration)	- sediment resuspension due to be minimal as most fine grained sediments on seabed will have previously been removed - removal of fine-grained sediments may alter benthic community composition	Negligible	-	-	-	-	-	-
Habitat Alteration (Noise disturbance)	- chronic and intermittent noise disturbance due to vessel operations and infrastructure removal activities - possible avoidance of area by fish	Negative	Minimize vessel operations to the extent possible	1	1	2	1	1
Habitat Alteration (Ballast water discharge)	- localized salinity guideline exceedences will occur during open water periods due to ballast discharge at the Steensby dock site - ballast water has higher salinity concentrations than Steensby Inlet during open water periods - may be some reduction in benthic productivity	Negative	Maximize the volume of ballast discharged prior to arrival dock side	1	2	2	1	1

Key:
Direction and Nature of Interaction: Positive; Negligible; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTES:
1.CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE ENVIRONMENTAL EFFECTS WERE EXPECTED TO BE NEGLIGIBLE

FIGURE ID: BL_VOL8_GIS_033 Steensby infrastructure Located in Intertidal and Permanently Wetted Zones Figure 8-4.6.mxd



LEGEND:

- WATER
- INFRASTRUCTURE
- SHORELINE
- INFRASTRUCTURE/DREDGING IN PERMANENTLY WETTED ZONE
- INFRASTRUCTURE IN INTERTIDAL ZONE

NOTES:

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. INFRASTRUCTURE PROVIDED BY HATCH

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STEENSBY INFRASTRUCTURE LOCATED IN INTERTIDAL AND PERMANENTLY WETTED ZONES

Baffinland Iron Mines Corporation

REF NO.
BL_VOL8_GIS_033

FIGURE: 8-4.6

Table 8-4.10 Marine Fish Habitat within Project Footprints

Location	Infrastructure	Infrastructure Component	Area in Intertidal Zone (ha)	Area in Subtidal Waters (ha)	Total
Steensby Port	Causeway	Caisson and abutments	0.442	1.967	2.409
	Dredging Knoll	Dredging	0	2.786	2.786
	Ore Dock	Dock	0.476	2.175	2.651
	Freight Dock	Dock Caissons, berm and infill	0.487	1.614	1.663
	Total		**1.405**	**8.542**	**9.947**

The DFO NL habitat quantification approach is relatively simple in that depth, substrate and substrate/flora combinations are the key aspects of habitat characterization. Impacts within the water column itself are not part of the assessment and therefore, the primary vertical habitat zones assessed are the demersal, benthic and epibenthic zones. In the case of the horizontal habitat zone, (i.e., the Shore Zone), calculations are performed for each zone where a species can possibly be found, extending from the inter-tidal to the deep sub-tidal. This approach is precautionary in that regardless of the extent to which the habitat is being used, (High, Moderate, Low, Nil), it will still be considered in the assessment.

Three representative species (two fin fish and one benthic invertebrate) were selected in order to determine the effect of the port development at Steensby Inlet. The three species included Arctic char, Arctic cod and blunt gaper (*Mya truncata)*:

Arctic Char were selected as a species to be considered during the HADD determination for Steensby Inlet due to the results from the aquatic inventory, harvesting records and recognition of the species as a Key Indicator of Marine Habitat and Biota. As these three factors all involve the marine juvenile and adult phases in the anadromous Arctic char life cycle, both life stages were included in the HADD determination.

Documented results on the importance of Arctic cod as both a forage species for Arctic char and a key component in other Arctic food webs, plus its role in the traditional diet of Inuit justify the selection of Arctic cod as a species to be considered during the HADD determination for Steensby Inlet. Both juveniles and adults have a tendency for schooling and it is during this activity that predation by other fishes, marine mammals and sea birds typically occurs (Bradstreet *et al*., 1986). Adult Arctic cod are harvested and utilized as a food supply by Inuit. Accordingly both the juvenile and adult life stages of Arctic cod were included in the marine HADD determination.

Benthic invertebrates form the basis of the marine food web for many finfish, marine mammals and seabirds in the High Arctic. IQ has indicated that Walrus are one of the main large marine mammals harvested in Northern Foxe Basin. Walrus are listed as a species of Special Concern under COSEWIC. Pauly *et al.* (1998) reported that benthic invertebrates (mainly molluscs, notably bivalves and gastropods) made up 85 % of the diet of walrus. Fisher and Stewart (1997) reported the bivalve, blunt gaper contributed 81.4 % of the total gross energy in the diet of a sample of 107 Atlantic walrus taken by Inuit hunters in northern Foxe Basin in 1987 and 1988. Walrus feed on these molluscs by raking the substrate with their tusks and sieving out the larger bivalves. Due to the importance of the blunt gaper in the diet of walrus and their presence in Steensby Inlet it was included in the HADD determination for Steensby Inlet.

The preferred marine habitat of juvenile and adult Arctic char can be characterized as that area along the coastline ranging out to the 10 m contour within 25 km of freshwater breeding areas. There is a temporal component to this habitat use, extending from mid-June to mid-September, when juvenile and adult anadromous char utilize the marine environment. Nearshore habitats with water depths up to 30 m are considered to be a key marine habitat component for juvenile and adult stages of the Arctic cod. From a temporal perspective, these nearshore habitats are used by juvenile and adult Arctic cod during a three month period, extending from July to September. *Mya truncata* have been reported from intertidal zones to deep sub-tidal areas (up to 80 m) (Welch *et al.*, 1992). On the basis of past investigations, sublittoral habitats with sand/mud/silt substrate extending out to the 15 m contour are considered a key marine habitat component of the adult stage of the species.

In determining the extent of the HADD related to development of port facilities at Steensby Inlet, two quantifications have been completed. From the extent of the effects on the habitat of pelagic fishes (Arctic cod and Arctic char), it was determined that the HADD was in the order of 7,647.76 m^2 (0.76 ha). From the extent of the effects on the habitat of the blunt gaper, it was determined that the HADD was in the order of 43,709 m^2 (4.37 ha).

In terms of total area of the Steensby Inlet marine fish LSA (approximate area 13,700 ha) the effect of the port development on the habitat of two representative fish species and one benthic invertebrate species is less than 1 % and is considered to be not significant.

Following quantification of the HADD, Baffinland will prepare a Fish Habitat Compensation Plan to compensate for the loss of the 5.13 ha of affected habitat. In developing the Fish Habitat Compensation Plan, various compensation options have been reviewed to identify feasible alternatives to be brought forward for consideration.

Following the hierarchy of compensation options presented in DFO (2010) a comprehensive review of opportunities that may be relevant with respect to potential impacts on the marine environment as a result of the Mary River Project was undertaken by Sikumiut Environmental Management Ltd (2011). This review considered opportunities from both a biological and physical perspective and noted that few marine habitat compensation projects have been undertaken in the North. Potential concepts that may be applicable that were noted in Sikumiut Environmental Management Ltd (2011) included:

- Construction of artificial reefs;
- Removal of anthropogenic materials;
- Salt marsh enhancement;
- Various works in freshwater; and
- Provision of funds to local organizations for specific projects.

On the basis of the habitat requirements of the three representative species considered in the Steensby Inlet HADD determination, construction of artificial reefs, removal of anthropogenic materials and salt marsh enhancement were not deemed applicable. Compensation concepts that may have application include:

- Improvement of freshwater Arctic char habitat. Activities such as obstruction removal and spawning habitat enhancement would eventually result in increases of anadromous juvenile and adult Arctic char;
- Deposition of fine grain dredge spoils in nearshore, low energy habitats. Such activities would provide habitat for benthic invertebrates, including the blunt gaper; and
- Provision of funds to local organizations for specific projects. Providing an opportunity for local organizations to identify opportunities and implement projects can result in compensation for habitat loss.

The HADD quantification for the Mary River Project and the subsequent Fish habitat Compensation Plan is being developed under requirements of the *Fisheries Act*, and will be submitted to the Department of Fisheries and Oceans for approval.

<u>Habitat Alteration</u>

The potential for alteration or disturbance of marine habitats and subsequent reduction in productive capacity in Milne and Steensby Inlets could occur through several pathways, including:

- Sediment resuspension or introduction due to construction activities and effluent discharge;
- Substrate alteration due to propeller generated currents;
- Habitat alteration due to ore dust deposition (Steensby Port only);
- Habitat disturbance due to underwater noise; and
- Habitat disturbance due to ballast water discharge (Steensby Port only).

<u>Sediment Resuspension or Introduction</u>

The resuspension or introduction of sediments to the water column and their subsequent deposition could alter marine seabed habitat if the rate of deposition is substantial enough to change the existing sediment size composition at the depositional area. Changes to benthic communities could result from changes to seabed sediment composition.

Construction activities at Steensby Port (dredging, blasting, infilling) were predicted to resuspend sediments in areas of construction, thus causing localized and short-term increases in TSS that would be partially mitigated by the use of silt curtains. Activities associated with infrastructure removal during the closure phase of the project would have similar effects. These resuspension events will occur in the immediate area of the construction activity, and will be reduced by using silt curtains to contain re-suspended materials to the greatest extent possible. It is predicted that sediment deposition will be contained within very small areas and will have negligible effects on seabed habitat or associated benthic biota.

Small amounts of sediments will be introduced into the marine environment with wastewater and site water discharge. Although effluents will be treated to reduce TSS, it was predicted that sediment introduction from the various effluents could lead to an increase in the proportion of fine-grained sediments immediately adjacent to the effluent outfall. However, the area over which this might occur is expected to be very small, and overall is predicted to have negligible effects on availability or quality of seabed habitat and associated benthic biota.

Substrate Alteration Due to Propeller-generated Currents

Deep-draft propellers of bulk carriers and tug boats are capable of generating very strong currents (propwash) at the seabed, even at distances of 50 - 100 m from the vessel. Given the design draft of the bulk carrier vessels and the water depth at the dock in Milne and Steensby Ports, it is probable that there will be in the order of 5 - 10 m from the maximum depth of the propellers to the seabed.

There is abundant evidence that seabed propwash velocities of 1.0 to 2.0 ms^{-1} are possible (e.g., Jay, 2002). Prolonged or frequent exposure of the seabed to such velocities could result in substantial scour pits and establishment of a protective veneer (“armour”) of cobbles and boulders, which would become too large to be mobilized. While the movement of bulk carriers towards and away from the docks will largely result in effects to a zone beneath the vessel and immediately alongside the dock, the movement of tug boats towards and away from the dock during operations could possibly result in effects to substrates in shallower depths upslope from the dock. Downslope remobilization of sandy sediments would be expected as the site comes to equilibrium with these forces.

Benthic flora and fauna would be affected by propwash in the immediate vicinity of the dock as finer sediments (sands) are removed. The likely effects on fauna or flora attached to large substrates (cobbles, boulders or bedrock) are largely unknown, but the coarsening of the seabed through the formation of a cobble-boulder veneer would alter the benthic community.

Areas of general disturbance by propwash effects were estimated around the ore and freight docks based on buffer zones that attempted to account for ship size and the activities occurring at each port site during all phases of the Project. It was estimated that 1.04 ha of habitat would be affected at Milne Inlet and 8.83 ha at Steensby Inlet (Table 8-4.11). The LSA for marine fish habitat in Milne and Steensby Inlets are 9,000 ha and 3,165 ha, respectively. Therefore, the area of habitat where productive capacity may be altered is less than 0.1 % of coastal habitat available within the LSA in either Inlet. Consequently, it is expected that a change in biotic productivity over a small area of coastal habitat would be negligible and would have little effect on productive capacity in the area.

Ore Dust Deposition

Air-borne distribution of fugitive ore dust from stockpiles and loading operations at Steensby Port will introduce ore dust into the marine environment, thereby increasing sedimentation rates. Results of air quality modelling indicate that dust will be deposited on the surface of water or ice over large areas of Steensby Inlets (12 km^2). The rate of deposition varies with distance from the source, with more dust in close proximity (see Section 3.5.2.4). Using the highest rate of deposition as a conservative indicator, thesediment layer is predicted to be 0.12 mm annually, or a total of 2.9 mm over the operational phase of the Project (Table 8-3.8). Over much of the affected area, depositional rates will be much lower. Further, ore dust will be dispersed by water and ice movements, resulting in an even thinner layer of deposition on the seabed (assuming that water or ice transport distributes the dust uniformly). Consequently, increased sedimentation due to ore dust deposition will have negligible effect on fish habitat and is not considered further.

Ballast Water Discharge

Ballast water discharged into Milne Inlet will be negligible and hence will produce no measurable changes in either water temperature or concentrations of nutrients compared to naturally occurring conditions in Milne Inlet.

Ballast water discharged into Steensby Inlet will have similar temperature, salinity and nutrient concentrations to ambient water during ice-covered conditions. Freshwater inputs from melting sea ice and river discharge during spring will reduce salinity concentrations in the vicinity of the Steensby Port to approximately 27 ppt during summer. However, the modelling of ballast water dispersal in Steensby inlet (Appendix 8B-1) concluded that the ballast water concentrations are predicted to be low within Steensby Inlet after a year, reaching a cumulative concentration of 0.07 % and a one time maximum of 0.4 %. The anticipated changes in temperature and salinity from ambient conditions are less than 0.07 %, and therefore no effects on fish habitat in Steensby Inlet are anticipated from the discharge of ballast water.

Table 8-4.11 Marine Fish Habitat Altered or Disturbed Due to Project Activities

Location	Infrastructure	Infrastructure Component	Area in Intertidal Zone (ha)	Area in Subtidal Waters (ha)	Total
Milne Inlet	Floating Dock	Disturbance Area (post-construction)	-	1.04	1.04
	Total		**-**	**1.04**	**1.04**
Steensby Inlet	Ore Dock	Blasting Area	0.00	0.52	0.52
		Disturbance Area (post-construction)	0.00	6.77	6.77
		Sub-total	**0.00**	**7.29**	**7.29**
	Freight Dock	Disturbance Area (post-construction)	0.00	0.75	0.75
	Construction Dock 1 (west)	Disturbance Area (construction)	0.00	0.39	0.39
	Construction Dock 2 (east)	Disturbance Area (construction)	0.00	0.39	0.39
		Sub-total	**0.00**	**1.53**	**1.53**
	Total		**0.00**	**8.83**	**8.83**

NOTE(S):
1. SOURCE: AMEC A1-165926-7440-121-0987.dwg.
2. SOURCE: PERS. COMM. NOVEMBER 28, 2008; JORDAN O'FARRELL, SANDWELL ENGINEERING INC.
3. SOURCE: AMEC A1-164512-8120-121-0900.dwg.

Benthic biota in Steensby Inlet are exposed annually to salinity levels within the range of the ballast, and it is reasonable to expect that the species present would be able to adjust to the minimal shift in salinity imposed by the ballast. Further, the volume of ballast discharged during summer, the season during which the contrast between ballast and ambient water properties is greatest, is expected to be considerably less than that during winter, when ships will begin to discharge ballast prior to arrival at the dock site. Hence, the volume of the saltier ballast will be very small in relation to the receiving environment. There may be some shift in benthic productivity due to ballast introduction, but this is expected to be of low magnitude in the context of overall productivity in the LSA.

Habitat Disturbance due to Underwater Noise

Fish detect sound based on particle displacement and acceleration rather than by acoustic pressure (as in terrestrial animals). Thus, sound detection capability differs between fish species with or without swim bladders, and also varies between species with swim bladders, depending on differences in the characteristics of the bladder (Corwin, 1978; Dunning *et al*., 1992; Nestler *et al*., 1992; Astrup and Møhl, 1993; McCauley, 1994; Casper *et al*., 2003). In general, fish without swim bladders tend to be less sensitive to sound than those with (Hawkins, 1981; Turnpenny and Nedwell, 1994), and pelagic fish tend to have more sensitive hearing than benthic species, primarily due to differences in feeding behaviour (Corwin, 1978; Casper *et al*. 2003).

Fish responses to noise disturbance are highly variable, depending upon many factors including fish species, type of noise, age of fish, activity (e.g., feeding vs. spawning). Some generalizations can be made regarding responses. Short-term, high energy noises such as those generated during blasting or pile driving can include sustained or temporary startle and alarm responses (Myrberg, 1990; Pearson *et al*., 1992; Skalski *et al*., 1992; Wardle *et al*., 2001; McCauley *et al*., 2003). Fish have shown avoidance behaviour at the approach of large vessels at constant speed and to small vessels that are accelerating (Schwarz and Greer, 1984; Myrberg, 1990; Jørgensen *et al*., 2004). Response to vessel noise seems to vary with distance, water depth, and natural light levels (Vabø *et al*., 2002). Marine fish tend to respond consistently only to sounds or vibrations of either very low or very high frequencies (Nestler *et al*., 1992; Knudsen, 1994), while mid-range frequencies generally produce only short-term startle responses (Knudsen, 1994). Short-term effects of avoidance behaviour have been shown; however longer-term effects on distribution have not been proven (Bowles et al., 2007). Fish have been known to move out of an area when a vessel is present, and return to normal activities when the vessel has left. Handegard and Tjostheim (2005) showed that fish avoided the area approximately 15 minutes before the passage of a vessel, while Draštik and Kubečka (2005) demonstrated that, while smaller fish avoided the vessel, larger fish did not. Information on the physiological effects of shipping noise on fish is also limited (Bowles *et al*., 2007).

Underwater noise disturbance will occur through all phases of the Project at Milne (open-water period only) and Steensby (year-round) Inlets. The propagation of short-term, high energy noises generated during blasting and pile driving may be mitigated through the installation of a bubble curtain (Appendices 8C-1 and 8C-2), but most operational noise (vessel activity and ore loading) will be chronic and inherently difficult to mitigate beyond minimizing traffic to the extent practicable. It is thought that resident benthic fish species characterized by a reduced hearing capability (such as sculpin) will habituate to the noise and remain in the area. There may be some avoidance of the dock sites by pelagic species such as Arctic char during periods of intense activity. The spatial extent to which pelagic fish may be affected is difficult to determine, but it is expected that this will encompass some small portion of each LSA. Further, the effects will be frequent (Level II), of medium duration, and completely reversible. Therefore, possible avoidance of marine habitat due to noise disturbance is predicted to have a low magnitude effect.

Summary

Alteration of less than 0.1 % of nearshore marine habitat at each of Milne and Steensby Inlets due to propwash and other dock side activities will have negligible effects on productive capacity within either LSA. The potential effects of noise disturbance on biota and benthic productivity due to ballast water discharge are more difficult to define, but may occur over larger areas within the respective LSAs. Conservatively, it is anticipated that these habitat effects will be of low to moderate magnitude.

Further, Baffinland is committed to compliance with the *Fisheries Act* requirements related to fish habitat. Thus, any identified HADD of productive fish habitat will be addressed in the Fish Habitat Compensation Plan (Volume 10, Appendix 10D- 7) and subsequent habitat compensation. Until DFO has made a HADD determination for fish habitat, it will not be possible to prescribe the required scale or nature of habitat compensation options. A review of marine fish habitat compensation works competed throughout Canada has included a consideration of suitability/applicability with respect to the Mary River Project. Potentially suitable concepts include; artificial reefs, excavated habitat, eelgrass planting, shellfish habitat creation, saltmarsh restoration, debris removal, removal of abandoned infrastructure / fishing gear, shoreline enhancement and freshwater works. Once the quantification of total HADD (marine and freshwater), has been established, concepts for compensation works will be developed by both DFO and Baffinland in order to receive input and to confirm suitability and appropriateness by the identified candidate compensation works.

The final fish habitat compensation plan will require DFO approval prior to its implementation.

4.5.3 Assessment of Residual Effects

Residual effects are those that persist after the application of mitigation measures. The general approach for the determination of significance and identification of the level of confidence is described in Volume 2, Section 3.8. Each potential residual effect on marine fish habitat was rated according to its predicted magnitude, spatial extent, frequency, duration and reversibility (as per Volume 2, Table 2-3.4) and the results are summarized in Table 8-4.12 and Table 8-4.13. Criteria ratings were not applied to activities where no environmental effects were expected (i.e., a neutral interaction).

Milne Inlet

Following mitigation and through the use of adaptive management plans, residual effects of the Project on marine fish habitat in Milne Inlet are predicted to be *"not significant"*. Specifically, any residual effects are anticipated to be low in magnitude (Level I), remain within the RSA (Level II), be frequent (Level II), be of short or medium duration (Level I or II), and be fully reversible (Level I).

Table 8-4.12 Significance of Residual Effects on Marine Fish Habitat in Milne Inlet

Project Activity (Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
PROJECT DURATION				
Establishment of floating freight dock	N	3	-	-
CONSTRUCTION PHASE				
Discharge of wastewater and site drainage (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Barge and ship traffic to/from Milne Inlet (redistribute sediments and alter sediment composition)	N	2	-	-
Noise disturbance by construction and vessel activities (avoidance by fish)	N	2	-	-
OPERATION PHASE				
Discharge of wastewater and site run-off (including run-off from the oiled site water, and overland run-off) (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Barge and ship traffic to/from Milne Inlet (redistribute sediments and alter sediment composition)	N	3	-	-
Noise disturbance by loading and vessel activities (avoidance by fish)	N	3	-	-
DECOMMISSIONING PHASE				
Discharge of wastewater and site drainage (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Barge and ship traffic to/from Milne Inlet (ice-free season only) (no change in TSS, sediment composition, or productive capacity)	N	2	-	-
Noise disturbance due to infrastructure removal and vessel activities (avoidance by fish)	N	2	-	-

Table 8-4.12 Significance of Residual Effects on Marine Fish Habitat in Milne Inlet (Cont'd)

Project Activity (Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
DECOMMISSIONING PHASE				
Ballast water discharge (water temperature and water-borne nutrient concentration change, decrease in benthic productivity)	N	3	-	-

Key:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

Table 8-4.13 Significance of Residual Effects on Marine Fish Habitat in Steensby Inlet

Project Activity (Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
PROJECT DURATION				
Establishment of freight dock	N	3	-	-
CONSTRUCTION PHASE				
Construction of ore and freight docks, discharge of wastewater and site drainage (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Barge and ship traffic to/from Steensby Inlet (redistribute sediments and alter sediment composition)	N	2	-	-
Noise disturbance by construction and vessel activities (avoidance by fish)	N	3	-	-

Table 8-4.13 Significance of Residual Effects on Marine Fish Habitat in Steensby Inlet (Cont'd)

Project Activity (Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
OPERATION PHASE				
Discharge of wastewater and site run-off (including run-off from the oiled site water, and overland run-off) (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Dispersion and deposition of dust from the ore stockpile (including deposition to marine environment and run-off from land) (Increase TSS, alter sediment composition, alter productive capacity	N	2		
Barge and ship traffic to/from Steensby Inlet (redistribute sediments and alter sediment composition)	N	3	-	-
Noise disturbance by loading and vessel activities (avoidance by fish)	N	2	-	-
Ballast water discharge (salinity change during open-water, possible decrease in benthic productivity)	N	2		
DECOMMISSIONING PHASE				
Dismantling of the freight dock, discharge of wastewater and site drainage (Increase TSS, alter sediment composition, alter productive capacity)	N	3	-	-
Barge and ship traffic to/from Steensby Inlet (ice-free season only) (no change in TSS, sediment composition, or productive capacity)	N	2	-	-
Noise disturbance due to infrastructure removal and vessel activities (avoidance by fish)	N	2	-	-
Ballast water discharge (salinity change during open-water, possible decrease in benthic productivity)	N	2	-	-

Key:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD ONLY APPLICABLE TO SIGNIFICANT EFFECTS

Steensby Inlet

Residual effects of the Project on Arctic char habitat in Steensby Inlet are predicted to be "*not significant*", as effects are anticipated to be low or moderate in magnitude (Level I or II), remain within the RSA (Level II), be frequent or continuous (Level II or III), be of short or medium duration (Level I or II), and be fully reversible (Level I).

4.5.4 Prediction Confidence

There is a moderate to high level of confidence associated with the assessment of Project-related effects on marine fish habitat. Determination of effects on marine habitat was based on clearly defined Project footprints, as well as results of baseline studies that described existing habitat conditions and usage. Modelling was used to determine the spatial distribution of fugitive ore dust deposition and ballast water discharged from ore carriers. The effects pathways between the Project and marine habitat (and biota) are common issues and the nature of the effects is well established and understood. Some uncertainty remains, however, regarding the duration of certain modelled effects. Aquatic effects monitoring and adaptive management will be applied throughout the Project phases to verify the impact predictions and to address uncertainty.

4.5.5 Monitoring and Follow Up

Direct loss and alteration of marine habitat due to Project footprints and activities will be considered in further detail and compensated as required in the No Net Loss Plan (Volume 10, Appendix 10D-7).

Further, a detailed aquatic effects monitoring program (AEMP) will be developed (see Section 3.5.5) to include physical oceanography, water and sediment quality, and aquatic biota (including benthic invertebrates and fish) and habitat components to:

- Monitor the effectiveness of mitigation measures;
- Confirm impact assessment predictions;
- Monitor for unforeseen and/or cumulative effects;
- Monitor for compliance with regulatory requirements;
- Provide a means for adaptive management and to identify additional mitigation that may be required over the life of the Project; and
- Address requirements for monitoring as identified in the Metal Mining Effluent Regulations (MMER), including Environmental Effects Monitoring (EEM).

It is anticipated that the AEMP will include monitoring of Project-related effects to marine habitat at Milne and Steensby Inlets. An EEM Framework has been developed that includes: a) the principles for selection of candidate EEM programs based on predicted effect, confidence in predictions and regulatory requirements; b) describes a process for reporting and feedback to adaptive management; c) describes the various forms (levels) of monitoring (research, surveillance, effects monitoring) d); establishes a protocol for EEM design; and e) starts the process of EEM study selection and design.

4.6 ARCTIC CHAR

Key Issues identified during scoping activities that relate to Arctic char included potential pathways that may affect:

- Arctic char habitat;
- Arctic char population size through direct mortality; and
- Arctic char health and condition.

Project-related effects on marine fish habitat have been assessed in Section 4.5 where effects on Arctic char habitat were also considered, consequently, they will not be assessed again here, but will be carried forward for inclusion with the assessment of residual effects on Arctic char.

Potential Project-related linkages that may result in direct mortality to Arctic char, and therefore affect char population size, were deemed to be negligible or were eliminated through mitigation. These have previously been discussed as Subjects of Note (Section 4.4), and are not considered here.

4.6.1 Assessment Methods

Potential effects of the Project on Arctic char health relate to water and/or sediment quality changes and are therefore based on comparisons to CCME water and/or sediment quality. These thresholds are referred to hereafter as "water quality thresholds."

Residual effects from the water and sediment quality effects assessment, summarized in Tables 8-3.12 and 8-3.14, were carried forward to the assessment of effects on Arctic char. Project-related water quality changes that were predicted to remain within water quality thresholds (see Section 3.5.3) were considered to have a negligible effect and were not assessed further. Potential effects on Arctic char were assessed where Project-related changes indicated the potential for exceedance of a water quality threshold.

The magnitude of potential effects of water quality changes on Arctic char health and condition were ranked based on the water quality thresholds (Table 8-4.14). Exceedances were ranked in terms of order of magnitude, ranging from one to more than two orders of magnitude higher than the water quality thresholds. This approach provides a quantifiable estimation of the magnitude of potential effects. The overall premise incorporates the method used in the derivation of CCME water quality guidelines, as it recognizes that those guidelines are typically developed on the basis of safety factors, generally ranging from 10 to 100 (CCME 1999; updated to 2010). Typically, CCME water quality guidelines are derived by identifying the lowest effect level (LOEL) for aquatic biota reported in the scientific literature for a given substance, and dividing the LOEL by a factor of 10 or 100 to provide additional conservatism (i.e., safety factor).

Table 8-4.14 Criteria for Determination of the Magnitude of Effect on Arctic Char Health and Condition Due to Changes in Water Quality

Level	Descriptor	Criteria[1]
Not Assessed (Level 0)	Negligible	Water quality change within CCME PAL guidelines
Level I	Low	Water quality change 1-10 times the CCME PAL guidelines
Level II	Moderate	Water quality change 10-100 times the CCME PAL guidelines
Level III	High	Water quality change >100 the CCME PAL guidelines

NOTE(S):
1. MAGNITUDE OF EFFECT MODIFIED BASED ON ECOLOGICAL FACTORS/SCIENTIFIC JUDGEMENT.

As CCME criteria are often derived with limited information generated from a limited number of aquatic species, and because the site-specific applicability of the guidelines may vary between sites, additional information available in the scientific literature was also considered. This is consistent with the general guidance provided by the CCME: "Canadian water quality guidelines for aquatic life are not restricted to a particular (biotic) species, but species-specific information is provided in the respective fact sheets, and, more detailed, in the supporting documents, so that the water quality managers and other users may determine the appropriateness of the guideline for the protection and enhancement of local species…it is possible that the guidelines are over- or under-protective at sites with unique conditions." For example, the most sensitive species that occurs at a site may be more or less sensitive than the most sensitive species represented in the toxicological data set used to derive the guidelines. Similarly, a substance may be more or less toxic in site water (i.e., due to factors such as pH, water hardness or complexing agents) than it is under the range of conditions, represented in the toxicological data set. In some cases, natural background concentrations of a substance may exceed the guideline without any apparent effect on biota (i.e., if the substance is not present in a bioavailable form). Under these circumstances, it might be necessary to modify the WQGs [water quality guidelines] to account for conditions that occur at the site. Although the Canadian Water Quality Guidelines are broadly used within Canada and elsewhere to assess and manage water quality conditions, they should not be regarded as blanket values for national environmental quality (CCME, 1999). Variations in environmental conditions across the country have the potential to influence their applicability. More specifically, factors such as elevated natural background levels of COPCs [contaminants of potential concern], the atypical levels of water quality variables that influence the bioavailability and/or toxicity of COPCs, and the sensitivity ranges of resident species can limit the applicability of generic WQGs. Therefore, it may be necessary to establish site-specific WQGs that account for such variations in environmental conditions.

4.6.2 Potential Effects and Proposed Mitigation

As indicated in Section 3, the Project is expected to cause small and localized changes in water quality in Milne and Steensby Inlets during all phases, which in turn could potentially affect Arctic char health and condition. Residual effects (as identified in Section 3.4.3) are related to the following major linkages:

- Resuspension of sediments;
- Wastewater and site water discharge;
- Ballast water discharge at Steensby Port; and
- Introduction of dust to surface waters (i.e., airborne emissions at Steensby Port).

Subsequent effects to Arctic char are discussed below and summarized in Table 8-4.15 and Table 8-4.16.

Resuspension of Sediments

The effects of sediment resuspension on water and sediment quality are discussed in Section 3. Anticipated increases in TSS and associated metals in the water column due Project-related construction (dredging, drilling), operation (barge and ship traffic), and closure activities (infrastructure removal) are predicted to result in short-term and localized threshold exceedances that are expected to be moderate in magnitude.

The use of silt curtains will reduce the affected areas during construction and closure activities. Chronic resuspension of sediments due to propwash currents in areas of high vessel activity (i.e., alongside the dock) will decline over time (through construction and into the operational phase) as fine grained particles are redistributed out of those areas. Sediment grain size composition will eventually equilibrate, the seabed will stabilize, and the amount of sediment resuspension will become negligible. Consequently, it is predicted that effects to anadromous Arctic char health or condition due to sediment resuspension will be negligible to low in magnitude.

Ballast Water Discharge

Ballast water taken on in the North Atlantic will be discharged into Steensby Inlet and infrequently into Milne Inlet, along the ship route and at dock side. There will be negligible to nil interaction between ballast water and the environment at Milne Inlet and hence no potential effects on Arctic char health in that area.

Metal concentrations within the ballast water are generally less than naturally occurring levels in Steensby Inlet waters, and results of the water quality assessment (Section 3.0) predicted that water or sediment quality thresholds for metals would not be exceeded. Consequently, it is predicted that ballast water discharge will lead to negligible increases in fish tissue metal concentrations, and therefore also have negligible effects on Arctic char health.

Table 8-4.15 Effects Assessment Summary: Arctic Char Health at Milne Inlet

Potential Impacts				Residual Effect				
Project Activity	**Environmental Effect**	**Direction and Nature of Interaction**	**Mitigation Measure(s)**	**Magnitude**	**Extent**	**Frequency**	**Duration**	**Reversibility**
CONSTRUCTION PHASE								
Sediment Resuspension	- Short-term exposure to small, temporary increases in concentrations of TSS, nutrients, and metals (through dredging and infilling during construction of port infrastructure) is expected to have minimum potential to negatively affect fish health; - The redistribution of sediments near construction activities is not expected to directly affect fish health or condition	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	1	1	3	1	1
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Combined effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	1	1
OPERATION PHASE								
Sediment Resuspension	- Increases in concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance from propeller currents are expected infrequently during operation. Short-term exposure of arctic char to these conditions has minimum potential to affect fish health. - The redistribution of sediments near the docks is not expected to directly affect fish health or condition	Negative	-	1	1	2	1	1
Discharge of ballast water	Slight reductions in nutrient concentrations and short-term, localized increases water temperature in Milne Inlet are expected to have negligible effects on fish health and condition. - Metal concentrations in water and fish tissues are not expected to change	Negligible						
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Combined effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	2	1
DECOMMISSIONING PHASE								
Sediment Resuspension	- There is potential for slight increases in fish metal concentrations and declines in condition as a result of short-term exposure to small, temporary increases to concentrations of TSS, nutrients, and metals that are expected in the water column resulting from dismantling port infrastructure. - The redistribution of sediments near construction activities is not expected to directly affect fish health or condition	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	1	1	3	1	1
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Combined effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater, oiled water, and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	1	1
Discharge of ballast water	- Slight reductions in nutrient concentrations and short-term, localized increases water temperature in Milne Inlet are expected to have negligible effects on fish health and condition. - Metal concentrations in water and fish tissues are not expected to change.	Negligible	-	-	-	-	-	-

Key:
Direction and Nature of Interaction: Positive; Negligible; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTE(S):
1. CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE NO ENVIRONMENTAL EFFECTS WERE EXPECTED (I.E., A NEUTRAL INTERACTION).

Table 8-4.16 Effects Assessment Summary: Arctic Char Health at Steensby Inlet

Potential Impacts				Residual Effect				
Project Activity	Environmental Effect	Direction and Nature of Interaction	Mitigation Measure(s)	Magnitude	Extent	Frequency	Duration	Reversibility
CONSTRUCTION PHASE								
Sediment Resuspension	- Short-term exposure to small, temporary increases in concentrations of TSS, nutrients, and metals (through dredging and infilling during construction of port infrastructure) is expected to have minimum potential to negatively affect fish health; - The redistribution of sediments near construction activities is not expected to directly affect fish health or condition	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	1	1	3	1	1
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	1	1
OPERATION PHASE								
Sediment Resuspension	- Increases in concentrations of TSS, nutrients, and metals in the water column as a result of sediment disturbance from propeller currents are expected in the early years of operation. Short-term exposure of arctic char to these conditions has minimum potential to affect fish health. - The redistribution of sediments near the docks is not expected to directly affect fish health or condition	Negative	-	1	1	2	1	1
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	2	1
Discharge of ballast water	- Slight reductions in nutrient concentrations and localized increases in salinity during open water conditions in Steensby Inlet are expected to have negligible effects on fish health and condition. - Metal concentrations in water and fish tissues are not expected to change.	Negligible	-	-	-	-	-	-
Fugitive ore dust deposition	- Increases in metal concentrations in fish tissues and reductions in fish health and condition as a result of increased metals (primarily iron) in the water and sediment.	Negative	-	2	1	3	2	1
DECOMMISSIONING PHASE								
Sediment Resuspension	- There is potential for slight increases in fish metal concentrations and declines in condition as a result of short-term exposure to small, temporary increases to concentrations of TSS, nutrients, and metals that are expected in the water column resulting from dismantling port infrastructure. - The redistribution of sediments near construction activities is not expected to directly affect fish health or condition	Negative	Silt curtains will be placed in as close proximity as feasible around the construction activity to minimize disturbance to the surrounding waters (Environmental Protection Plan).	1	1	3	1	1
Discharge of wastewater, contact water, and site drainage	- Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment. - Effluents will be tested to ensure that they are not acutely toxic	Negative	All discharges of wastewater and contact water will be treated to meet the respective guidelines prior to discharge	1	1	3	1	1
Discharge of ballast water	- Slight reductions in nutrient concentrations and localized increases in salinity during open water conditions in Steensby Inlet are expected to have negligible effects on fish health and condition. - Metal concentrations in water and fish tissues are not expected to change.	Negligible	-	-	-	-	-	-

Key:
Direction and Nature of Interaction: Positive; Negligible; Negative
Magnitude: 1 (Level I) = a change that is less than threshold values; 2 (Level II) = a change that is greater than threshold values; 3 (Level III) = a change that is an order of magnitude greater than threshold values; includes consideration of environmental sensitivity
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term; 2 (Level II) = medium-term; 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete

NOTES:
1. CRITERIA RATINGS WERE NOT APPLIED TO ACTIVITIES WHERE NO ENVIRONMENTAL EFFECTS WERE EXPECTED (I.E., A NEUTRAL INTERACTION)

Ore Dust Deposition

Dust deposition also has the potential to increase concentrations of metals, notably aluminum and iron, in water. Modelled dust composition (see Table 8-3.10) indicates approximately 50 % of the dust is iron. As there are no marine water quality guidelines for any of the metals identified in the ore dust, a direct comparison to thresholds cannot be made. However, it is anticipated that concentrations of metals, particularly iron, may be measurably increased due to the introduction of dust, most notably near freshwater inputs and in the zone of greatest dust deposition. To be conservative, it is also assumed that low level exceedances of CCME PAL guidelines for metals may occur infrequently in these areas.

Overall, effects of dust deposition on Steensby Inlet are predicted to cause periodic, low-level exceedances of CCME PMAL water quality guidelines (Level II magnitude) in localized areas near freshwater inputs and in the zone of greatest dust deposition in the marine environment.

4.6.3 Assessment of Residual Effects

Each potential residual effect on Arctic char was rated according to its predicted magnitude, spatial extent, frequency, duration and reversibility (as per Volume 2, Table 2-3.4). Criteria ratings were not applied to activities where negligible environmental effects were expected.

Significance rankings for marine habitat are provided in Tables 8-4.12 and 8-4.13, and for Arctic char health in Tables 8-4.17 and 8-4.18.

Effects to Arctic Char Habitat

Milne Inlet

From Section 4.5, residual effects of the Project on marine fish habitat in Milne Inlet are predicted to be *"not significant"*. Specifically, any residual effects are anticipated to be small in magnitude (Level I), remain within the RSA (Level II), be frequent (Level II), be of short or medium duration (Level I or II), and be fully reversible (Level I).

Steensby Inlet

Residual effects of the Project on marine fish habitat in Steensby Inlet are predicted to be "*not significant*", as they are anticipated to be small in magnitude (Level I), remain within the RSA (Level II), be frequent or continuous (Level II or III), be of short or medium duration (Level I or II), and be fully reversible (Level I).

Effects to Arctic char Population Size through Direct Mortality

No residual effects on direct mortality of Arctic char have been identified.

Effects to Arctic char Health and Condition

Milne Inlet

Residual effects of the Project on Arctic char health and condition are predicted to be small in magnitude (Level I), confined to the LSA (Level I), frequent or continuous (Level II or III), of short or medium duration (Level I or II), and fully reversible (Level I). As such, the residual effects are predicted to be "*not significant*".

Steensby Inlet

It is anticipated that residual effects of the Project on Arctic char health and condition will be small in magnitude (Level I), confined to the LSA (Level I), frequent or continuous (Level II or III), of short or medium duration (Level I or II), and fully reversible (Level I). As such, the residual effects are predicted to be "*not significant*".

Table 8-4.17 Significance of Residual Effects on Arctic Char Health, Milne Inlet

Project Activity (Potential Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Construction activities; Barge and ship traffic to/from Milne Inlet (Resuspend sediments and increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
OPERATION PHASE				
Barge and ship traffic to/from Milne Inlet (Resuspend sediments and increase metals, reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
DECOMMISSIONING PHASE				
Infrastructure removal; Barge and ship traffic to/from Milne Inlet (Resuspend sediments and increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of ballast water (Slight increases in metal concentrations in biotic tissues; reduce fish condition)	N	2	-	-

Key:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

Table 8-4.18 Significance of Residual Effects on Arctic Char Health, Steensby Inlet

Project Activity (Potential Effect)	Significant of Predicted Residual Environmental Effect		Likelihood[1]	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Construction activities; Barge and ship traffic to/from Steensby Inlet (Resuspend sediments and increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
OPERATION PHASE				
Barge and ship traffic to/from Steensby Inlet (Resuspend sediments and increase metals, reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of ballast water (Slight increases in metal concentrations in biotic tissues; reduce fish condition)	N	2	-	-
Dispersion and deposition of dust from the ore stockpile (including deposition to marine environment and run-off from land) (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
DECOMMISSIONING PHASE				
Infrastructure removal; Barge and ship traffic to/from Steensby Inlet (Resuspend sediments and increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of wastewater, contact water, and site drainage (Increase metals in biotic tissues; reduce fish condition)	N	2	-	-
Discharge of ballast water (Slight increases in metal concentrations in biotic tissues; reduce fish condition)	N	2	-	-

Key:
Significance Rating: S=Significant; N=Not Significant
Level of Confidence: 1=Low; 2=Medium; 3=High
Certainty: 1=Low; 2=Moderate; 3=High
Probability: 1=Unlikely; 2=Moderate; 3=Likely

NOTE(S):
1. LIKELIHOOD: ONLY APPLICABLE TO SIGNIFICANT EFFECTS.

Prediction Confidence

There is a moderate to high level of confidence associated with the assessment of effects on Arctic char. The pathways of effects between the Project and Arctic char are well understood, as the issues are common to previous projects and the nature of effects is well established. The baseline data and modelling used to assess residual effects on water and sediment quality were of moderate to high quality and, therefore, a moderate to high level of confidence is placed in the assessment of the effects of these ecosystem components on marine biota. The efficacy of the mitigation measures is also well established, as the techniques have been used in a variety of environments and circumstances. Finally, a conservative approach was applied when uncertainty was considered to be moderate to high.

4.6.4 Monitoring and Follow Up

As discussed in Section 3.5.5, a detailed AEMP will be developed and will include studies of physical oceanography, water and sediment quality, and aquatic biota and habitat components.

The MMER require that all metal mines in Canada to which the regulations apply perform EEM studies within specified periods (set out in Schedule 5; EEM Studies of the MMER). This schedule specifies effluent and water quality monitoring studies and biological monitoring studies, and states that effluents must be examined for acute toxicity prior to release into the environment. Monitoring for metals in fish tissues (i.e., mercury) will also be incorporated, as prescribed in the MMER. A MMER Environmental Effects Monitoring Study Design Framework has been developed (see Volume 10, Appendix 10D-14).

4.7 IMPACT STATEMENT

Marine Fish Habitat

The Project will have no significant adverse residual effects on marine fish habitat. The Project will cause a negligible loss of habitat within Project footprints. Residual effects may include some habitat alteration or reduction in productive capacity in each of the LSAs due to vessel operations, ballast water discharge, and avoidance of a small area around the dock sites by some fish species due to underwater noise. It is expected that the magnitude of these residual effects will be low or moderate. Project activities leading to residual effects on water quality (short-term water quality guideline exceedances) would be reversible and related effects on marine habitat (e.g., changes due to ballast water) are also expected to be reversible.

Arctic char

The Project will have no significant adverse residual effects on anadromous Arctic char in Milne and Steensby Inlets. Habitat-related effects include the loss of a negligible amount of habitat contained within infrastructure footprints, possible reduced benthic productivity due to ballast water discharge, and possible avoidance of a small area around the dock sites due to underwater noise. It is expected that these effects will be contained to within the respective LSAs, and would be of small consequence in the context of feeding habitat available within Milne and Steensby Inlets. These effects are expected to be reversible. Project activities are expected to cause no direct mortality (e.g., fishing by Mine employees will not be permitted) or effect the size of anadromous Arctic char populations. Residual effects on water and sediment quality may result in low magnitude effects on char health and condition, but these effects are expected to be confined to within the Milne and Steensby Inlets LSAs. Project activities leading to residual effects on water quantity will be reversible and effects on Arctic char are also expected to be reversible.

4.8 AUTHORS

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SECTION 5.0 - MARINE MAMMALS

5.1 BASELINE SUMMARY

An environmental baseline report on marine mammals has been prepared in support of the EIS for Baffinland's Mary River Project by LGL Limited and North South Consultants (Appendix 8A-2). The baseline report includes a review of scientific information of marine mammal species that occur within the Project RSA and those that occur along the shipping routes outside of the RSA. In addition, traditional knowledge collected during Project-specific IQ studies and other sources of IQ is provided. Aerial surveys were conducted in support of the Project periodically during 2006, 2007 and 2008 to document the distribution and abundance of marine mammals in the vicinity of the Milne Inlet and Steensby Inlet port sites and along potential shipping routes. The results of these surveys are presented in detail in Appendix 8A-2 and are summarized below.

Twenty-two marine mammal species are known or expected to occur in the RSA and along the proposed shipping routes in Baffin Bay and Davis Strait. Table 8-5.1 provides a listing of the conservation status of the marine mammal species and populations in the RSA. In conducting this environmental assessment, the status of each species and population has been considered and taken into account, along with any requirements for a Management Plan for Special Concern species and allowance made for the information requirements of any Recovery Plan. Specifically, the assessment of polar bear allows for possible future scenarios where polar bear status could change. Species accounts are provided for all species in Appendix 8A-2. Only one mysticete or baleen whale species, the bowhead whale (*Balaena mysticetus*), occurs regularly in the RSA. Narwhals (*Monodon monoceros*) and belugas (*Delphinapterus leucas*) are abundant in the RSA; other odontocetes that occur (albeit in low numbers) in the RSA include killer whale (*Orcinus orca*) and northern bottlenose whale (*Hyperoodon ampullatus*). Pinniped species that occur regularly in the RSA include the ringed seal (*Pusa hispida*), bearded seal (*Erignathus barbatus*), harp seal (*Pagophilus groenlandicus*), and walrus (*Odobenus rosmarus*). The polar bear (*Ursus maritimus*) also occurs throughout the RSA. The summary provided below focuses on indicator species in the EIS: ringed seal, bearded seal, walrus, beluga whale, narwhal, bowhead whale and polar bear.

5.1.1 Ringed Seal

The ringed seal is an important component of the Arctic marine system as main prey of polar bears and as a major consumer of marine fish and invertebrates (Lowry *et al.,* 1980a; Smith, 1987). Ringed seals occur year-round along both proposed shipping routes and in the vicinity of both proposed port sites, and are a major traditional food source for the Inuit.

Ringed seals establish a series of breathing holes and subnivean (under snow) lairs on the sea ice; many of these structures are created shortly after freeze up and maintained through the winter and spring. Birth lairs are constructed on the landfast ice in mid-March (Smith *et al*., 1991) and pups are born in April. Pups are nursed for 38–44 days (Smith *et al*., 1991) and rely on their white fur, high metabolic rates and the birth lair for protection from the cold while building an adequate layer of blubber. Landfast ice rather than pack ice is preferred for breeding (McLaren, 1958; Kelly, 1988). IQ also suggests that ringed seal dens will not be constructed on moving pack ice in areas of strong ocean currents, but a large breeding population of ringed seals was documented on the offshore pack ice in Baffin Bay (Finley *et al*., 1983).

The population of ringed seals in the Canadian Arctic is estimated to be at least a few million (Reeves, 1998), but no reliable quantitative estimates are available. Canadian populations are not listed under SARA and are listed as "Not at Risk" by COSEWIC.

Table 8-5.1 The Status and Regional Distribution of Marine Mammal Species in the RSA and in Baffin Bay and Davis Strait

Species	Status			Region		
	SARA[1]	COSEWIC[2]	IUCN[3]	Eclipse Sound, Navy Board Inlet, Pond Inlet	Baffin Bay, Davis Strait	Foxe Basin, Hudson Strait
BALEEN WHALES (MYSTICETES)						
Bowhead whale	UC	SC	LC	present	present	present
Humpback whale	NS	NAR	LC	absent	present	absent
Minke whale	NS	NAR	LC	absent	present	present
Sei whale	NS	DD	EN	absent	uncommon	absent
Fin whale	Sc1:SC	SC	EN	absent	common	absent
Blue whale	Sc1:EN	EN	EN	absent	uncommon	absent
TOOTHED WHALES (ODONTOCETES)						
Sperm whale	NS	NAR/CWS: 3	VU	absent	common	absent
Northern bottlenose whale	NS	NAR	DD	absent	present	present
Beluga	UC	EN,SC [4]	NT	abundant	abundant	abundant
Narwhal	UC	SC	NT	abundant	abundant	abundant
White-beaked dolphin	NS	NAR	LC	absent	present	absent
Atlantic white-sided dolphin	NS	NAR	LC	absent	uncommon	absent
Killer whale	NS	SC	DD	uncommon	uncommon	uncommon
Long-finned pilot whale	NS	NAR	DD	absent	present	absent
Harbour porpoise	UC	SC	LC	absent	present	absent
SEALS AND WALRUS (PINNIPEDS)						
Walrus	UC	SC/CWS: 1	DD	common	present	common
Bearded seal	NS	DD	LC	abundant	abundant	abundant
Harbour seal	NS	NAR	LC	uncommon	present	uncommon
Ringed seal	NS	NAR/CWS: 2	LC	abundant	abundant	abundant
Harp seal	NS	CWS: 3	LC	abundant	abundant	common
Hooded seal	NS	NAR/CWS: 3	VU	absent	present	absent

Table 8-5.1 The Status and Regional Distribution of Marine Mammal Species in the RSA and in Baffin Bay and Davis Strait (Cont'd)

Species	Status			Region		
	SARA[1]	COSEWIC[2]	IUCN[3]	Eclipse Sound, Navy Board Inlet, Pond Inlet	Baffin Bay, Davis Strait	Foxe Basin, Hudson Strait
BEARS (URSIDS)						
Polar bear	SC	SC	VU	present	present	present

NOTE(S):
1. *SPECIES AT RISK ACT*: NS = NO STATUS (GOC, 2009); UC = Under Consideration; SC = Special Concern; T = Threatened; En = Endangered; Sc1 = Schedule 1.
2. COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA (COSEWIC, 2010): NAR = Not at Risk; DD = Data Deficient; SC = Special Concern; T = Threatened; EN = Endangered; NL = Not Listed; CWS= Candidate Wildlife Species Priority List for Assessment: 1=HIGH PRIORITY, 2=MID-PRIORITY, 3=LOW PRIORITY.
3. INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN, 2010): EN = Endangered; VU = Vulnerable; NT=Near Threatened; LC = Least Concern; DD = Data Deficient. CLASSIFICATIONS ARE FROM THE 2010 IUCN RED LIST OF THREATENED SPECIES.
4. EN: Ungava Bay and Eastern Hudson Bay Populations, SC: Western Hudson Bay And Eastern High Arctic-Baffin Bay Populations.
5. The species at risk registry was reviewed and there are no Recovery Strategy and Action Plans available for Endangered marine mammal species. There are no Management Plans available on the SARA website for species considered of Special Concern.

5.1.1.1 Steensby Port and Shipping Route

Ringed seals are abundant along the proposed shipping route in Steensby Inlet, occurring throughout Foxe Basin, including the landfast ice of Steensby Inlet and Hudson Strait. Southern Steensby Inlet, Igloolik, Hall Beach, Murray Maxwell Bay, and Rowley Island into Fury and Hecla Strait have been mentioned as important hunting and/or pupping areas. IQ suggests that most ringed seal denning in northern Foxe Basin occurs in fast ice, but that some denning and pupping may occur in moving pack ice in southern Foxe Basin and in the western part of Fury and Hecla Strait.

Ringed seals were present in all areas of Foxe Basin and Hudson Strait where aerial surveys for the Project were conducted from April to October, and most sightings occurred during June and to a lesser extent August, when seals were easily observed basking on pack ice. Aerial surveys in 2006, 2007 and 2008 indicated that the densities in Steensby Inlet were 20, 157, and 71/100 km^2, respectively. The densities of ringed seals in Murray Maxwell Bay and on the fast ice between Igloolik and Hall Beach in June 2008 were 126/100 km^2 and 51/100 km^2, respectively.

5.1.2 Walrus

The walrus has a discontinuous circumpolar distribution and is migratory, moving south as the ice advances in fall and north as it recedes in spring (Fay, 1981b). It winters in the offshore pack ice of Davis Strait and along the west coast of Greenland, the North Water Polynya and polynyas off western Devon Island and northern Labrador (Loughrey, 1959; Davis *et al*., 1978; Boles *et al.,* 1980), and in Foxe Basin from the floe edge along the north side of Rowley Island south to the Melville Peninsula (COSEWIC, 2006).

Little information is available about walrus breeding and calving in Canadian waters. In northwest Greenland, pups are born from early April to mid-July, with peak whelping in late May and early June (Born, 1990; COSEWIC, 2006). Lactation generally lasts 25–27 months (Fisher and Stewart, 1997). Calves are able to nurse in the water, and they accompany females into the water when they forage (Loughrey, 1959; Miller and Boness, 1983; Kovacs and Lavigne, 1992). IQ suggests that walruses are highly territorial and will aggressively defend their territories; they have been observed to challenge ships passing into their territory.

Walruses are primarily benthic feeders on bivalve molluscs and other invertebrates, and are generally confined to shallow coastal waters up to 100 m deep (Vibe, 1950; Outridge *et al.,* 2003; NAMMCO, 2005b; 2006).

Four extant stocks occur within Canadian waters; however, these stocks may be further subdivided based on genetic, isotopic, body size, and distributional differences (Stewart, 2002). Three of the four identified stocks occur within the confines of the RSA: the Baffin Bay (High Arctic) population, the Foxe Basin population, and the North Hudson Bay-Davis Strait population (COSEWIC, 2006). IQ suggests that different populations can be distinguished based on physical differences such as coloration, tusk size, firmness of liver, taste, skin toughness and smell, believed to be associated with differences in diet.

The Canadian walrus population has no status under SARA but is listed as Special Concern by COSEWIC (2006b). Population numbers or trends are not well known, but shifts in walrus distribution, abandonment of main haul-out sites, and increased areas over which hunters must now travel to access walruses suggest that some stocks may be declining (Stewart, 2002).

5.1.2.1 Milne Port and Shipping Route

The Baffin Bay walrus population is estimated to be between 1,700 and 3,000 (Born *et al*., 1995; DFO, 2002), with summering populations in Kane Basin, Buchanan and Princess Marie bays, Jones Sound, eastern Ellesmere Island, and the Lancaster Sound-Barrow Strait area (Born *et al*., 1995).

Walruses that occur in the Milne Inlet area winter in the North Water and other polynyas among the Canadian Arctic islands, inhabiting northwest Baffin Bay north from Pond Inlet to Kane Basin, Lancaster Sound, Barrow Strait and Jones Sound. They are also distributed along the west coast of Greenland. They move westward along the southern coast of Devon Island during spring to summering areas in the Canadian Arctic islands. Only a few individuals are now observed among the inlets and fjords south of Bylot Island. IQ indicates that calving locations have existed in Admiralty Inlet, near the outlet of Navy Board Inlet, and off the north coast of Bylot Island.

It is thought that timing and route of the fall return migration is primarily driven by ice conditions, and likely follows the same route used during spring migrations. Aerial surveys for the Project in 2007 and 2008 recorded only two walruses; one in Eclipse Sound and one in Milne Inlet.

5.1.2.2 Steensby Port and Shipping Route

Walruses are considerably more abundant along the shipping route to Steensby Inlet. They are year-round residents in northern Foxe Basin, overwintering in small polynyas and shore lead systems near the outlet of Fury and Hecla Strait, to the east of Hall Beach, and among the islands (Rowley, Koch, and the Spicer islands) located farther to the east of Hall Beach and south of Steensby Inlet. Their distribution appears to be driven by ice and open-water conditions during winter. During summer open-water period, they haul out onto beaches and coasts among the islands south of Steensby Inlet and onto drifting pans of ice. Walruses have been observed well within Steensby Inlet during late summer, but the degree to which they use the Inlet, or whether they haul out anywhere within the Inlet, is not known. Foxe Basin and the landfast ice edge at the entrance to Steensby Inlet accommodate the largest concentration of walruses in Canada (Stephenson and Hartwig, 2010). IQ indicates that the main calving area in Foxe Basin is in the north-western portion of the basin. A decade and a half ago, the Foxe Basin walrus population was estimated, albeit with low certainty, to number ~5,500 (Born *et al*., 1995).

Walruses were abundant within the northern Foxe Basin portion of the Project aerial survey route in 2006. They were observed in pack ice and open water. The highest densities were 15/100 km^2 in northwest Foxe Basin in June and 4.3/100 km^2 in Steensby Inlet in September. This trend was also observed in 2008; on average, walrus densities in northwest Foxe Basin were about seven times higher than those observed in the northeast or southern areas of the basin. During the aerial surveys, two terrestrial walrus haul-out sites were observed, one at Manning Island (mid-way between Hall Beach and Spicer Islands) and the other at Bushnan Rock (a small sandy islet west of the gap between Rowley and Koch islands). Walrus densities in Hudson Strait (0.1/100 km^2) were lower than any observed in Foxe Basin. The low abundance of walruses in the area between northern Hudson Bay and southern Foxe Basin appears to be primarily attributable to a lack of islands that can be used as haul-outs (Stephenson and Hartwig, 2010). IQ indicates that walruses occur along the north coast of Hudson Strait and concentrate in the vicinity of Cape Dorset. Hudson Strait is an important overwintering area for many marine mammals including walrus; it is considered a highly productive area, and the ice edge through the strait is likely an important habitat for walruses and other species (Stephenson and Hartwig, 2010).

5.1.3 Beluga Whale

The beluga whale has a circumpolar distribution and occurs seasonally along the shipping route. An opportunistic feeder, it consumes a wide array of fish and invertebrates. Mating is thought to peak prior to mid-April; however, little is known about mating behaviour. Many calves have already been born when the whales begin to arrive at summering areas, suggesting that calving occurs in offshore areas during late spring migration (COSEWIC, 2004a). Calving has also been observed in July and early August in the High Arctic (Finley *et al*., 1974; Finley 1976). IQ cites observations of newborn calves along the floe edge in June, July, August and September (Stewart, 2001). Calving is believed to occur within bays, inlets and the mouths of rivers (Stewart, 2001) but has also been detected offshore.

Beluga whales occupy different habitats seasonally. During early spring, they concentrate along ice edges as the fast ice breaks up, following leads into still ice-covered areas near their summering locations (Stirling, 1980). During summer, they are typically found along coastlines in shallow waters, often frequenting and concentrating in river estuaries or glacier fronts (Sergeant, 1973; Michaud *et al*., 1990; Smith and Martin, 1994; Lydersen *et al*., 2001). Beginning in mid-August, they move away from nearshore habitats into deep-water areas, where they spend several weeks feeding on Arctic cod and diving to the seafloor, presumably to feed on deep-water fish (Finley, 1976; Smith and Martin, 1994; Richard *et al*., 2001b). Throughout winter, they tend to be found in areas of loose pack ice or polynyas.

Of the seven recognized populations in Canada, four occur in the RSA: the Eastern High Arctic-Baffin Bay, Western Hudson Bay, Eastern Hudson Bay, and Ungava Bay populations. The Eastern High Arctic-Baffin Bay and Western Hudson Bay populations are listed as Special Concern, and the Eastern Hudson Bay and Ungava Bay populations are listed as Endangered by COSEWIC (COSEWIC, 2010). All four subpopulations are under consideration for listing under SARA. The most recent abundance estimate for the Eastern High Arctic-Baffin Bay population summering in the Canadian High Arctic is 21,213 (Innes *et al*., 2002). The most recent population estimate for the Western Hudson Bay population is 57,300 (Richard, 2005). The Eastern Hudson Bay population has declined from 3,849 in 1985 to 2,453 in 2001 (Bourdages *et al*., 2002).

IQ suggests that, although the current size of beluga populations may vary from year to year, numbers generally remain the same. However, IQ from other sources suggests that current beluga populations are substantially smaller than they were five decades ago.

5.1.3.1 Milne Port and Shipping Route

The Eastern High Arctic-Baffin Bay population summers in the Canadian Arctic archipelago and winters in the loose pack ice of two distinct areas: in Davis Strait or southern Baffin Bay off the west coast of Greenland and in the North Water Polynya in northern Baffin Bay. It has been suggested that these represent two distinct populations, although considerable uncertainty exists with regard to abundance, distribution and summering habitat (Thomsen, 1993; de March *et al*., 2002; Heide-Jørgenson *et al*., 2003a; COSEWIC, 2004a). A limited amount of harvest occurs in the Pond Inlet area, but considerable hunting takes place along the west coast of Greenland during winter.

Belugas from the smaller population wintering in the North Water enter Lancaster Sound from the north in late April or early May (Finley and Renaud, 1980). Those that winter off west Greenland move north along the Greenland coast in May and June, cross over northern Baffin Bay, and Lancaster Sound from the north in June and July (Koski and Davis, 1979). In most years, the large numbers from the Eastern High Arctic-Baffin Bay population migrate past Bylot Island during spring on their way to summering areas concentrated near Somerset Island. In some years, when fast ice in Lancaster Sound delays westward migration, they congregate along the ice edge across Lancaster Sound, primarily near Devon Island but also near Bylot Island. IQ indicates that small numbers of belugas are common in waters near Pond Inlet in spring, summer and fall (Remnant and Thomas, 1992). They have been observed mating in May and July at the Admiralty Inlet floe edge, and breeding near Pond Inlet may take place in August when floating ice is present. IQ indicates that Koluktoo Bay and the southern portion of Milne and Navy Board inlets may be calving areas. Other mating and calving areas that have been identified include along the floe edge at Pond Inlet and Navy Board Inlet, offshore areas in Lancaster Sound and Baffin Bay, and Eclipse Sound.

Eastward fall migrations begin in September, and are concentrated almost exclusively along the southern coast of Devon Island. Small numbers were observed in Eclipse Sound and White Bay during aerial surveys. In August and September 2007, belugas were observed in Eclipse Sound and White Bay during aerial surveys for the Project, with density estimates of 0.1 and 0.3/100 km^2, respectively. In August and September 2008, belugas were observed in Eclipse Sound, Eskimo Inlet, Koluktoo Bay, Milne Inlet, and White Bay with density estimates ranging from 0.1 to 8.3/100 km^2 depending on location and day. The highest densities were observed in White Bay.

5.1.3.2 Steensby Port and Shipping Route

All four populations of belugas in the RSA are known or expected to occur along or in the vicinity of the shipping route to Steensby Inlet.

The Western Hudson Bay and Eastern Hudson Bay populations occur near the southern shipping route from late October through April when the whales are on their wintering grounds, and during fall migrations in late September and October. Beluga whales from both populations occur in the vicinity of Igloolik, Hall Beach, and likely Steensby Inlet during July–early September.

IQ indicates that belugas are not expected in Igloolik until late August or early September, and sometimes as late as December. Some Igloolik elders believe that belugas have been arriving in the area much later than usual in recent years, suggesting that northern migrations may have become delayed.

The summer distribution of the Western Hudson Bay population centers along the Manitoba coastline, with large aggregations occurring in the Seal, Churchill and Nelson river estuaries. The wintering location has not been confirmed, but it is thought to be in Hudson Strait and off the coast of Labrador (Richard *et al*., 1990; Richard, 1993; Richard and Orr 2003, 2005). Spring migration occurs during late April–May (Sergeant, 1973). Most animals likely follow the eastern coast of Hudson Bay south to the Belcher Islands, and then proceed westwards to the Manitoba coast in late May and early June (Figure 7 *in* COSEWIC, 2004a). A segment of the population move westwards toward Southampton Island. Belugas generally remain within estuaries along the coast, and in September begin a northward migration towards Southampton Island (Sergeant, 1973).

The very small (possibly extirpated) Ungava Bay beluga population possibly occurs year-round within the RSA. It is unclear if the few whales that have been seen in the summer in southern Ungava Bay are remnants of the Ungava Bay group or if they belong to another population.

Based on Project aerial survey results, beluga whales were widespread in Foxe Basin and Hudson Strait during the months with survey effort (April to October), with abundance varying with location and month. In Hudson Strait, observed densities in 2008 decreased from 3.0/100 km^2 in April to none in October. In northwest Foxe Basin, densities were low in April and June, increased in August, and reached the highest observed density in September (1.0/100 km^2). In Steensby Inlet, belugas were observed most frequently in September (1.0/100 km^2), with no sightings in April, June and August, and one in October. With the exception of August, belugas were consistently observed in small numbers during spring and fall in northeast Foxe Basin. In southern Foxe Basin, they were observed in low numbers in spring and summer.

5.1.4 Narwhal

Narwhals inhabit deep Arctic waters of Baffin Bay, the eastern Canadian Arctic and the Greenland Sea (Reeves *et al*., 2002), and are seldom found south of 61°N (COSEWIC, 2004b). Their diet consists primarily of small cod, flatfish such as Greenland halibut, squid, and other small fish and invertebrates. Although little information is available about reproduction, gestation is thought to be 14–15 months (COSEWIC, 2004b). Calving generally occurs in July and August, although it can take place as early as late May (Mansfield *et al*., 1975; Cosens and Dueck, 1990; Gonzalez, 2001). Some hunters believe that narwhals mate at any time of the year, whereas others believe it to occur in spring, summer or fall (Remnant and Thomas, 1992; Stewart *et al*., 1995; Stewart, 2001).

Narwhals tend to prefer coastal areas that provide deep water and protection from the wind during summer (Kingsley *et al*., 1994; Koski and Davis, 1994; Richard *et al*., 1994). In general, they winter in the offshore heavy pack ice of Baffin Bay and northern Davis Strait (Koski, 1980). Narwhals are highly social animals and usually travel in small groups (Strong, 1988). They have been observed in groups of hundreds or thousands during migration, and concentrations usually occur along fast ice edges (Strong, 1988).

Based largely on summer distributions, two tentative populations occur in Canadian waters: the Hudson Bay population (Richard, 1991) and the Baffin Bay population (Koski and Davis, 1994; Dietz *et al.,* 2001; Heide-Jørgenson *et al.,* 2003a; Laidre and Heide-Jørgenson, 2005; Richard *et al.,* 2010).Many Inuit believe that at least two different narwhal stocks exist in the Arctic; However, narwhals are currently assessed as a single population in the eastern Arctic (COSEWIC, 2004b). This population is under consideration for listing under SARA and is listed as Special Concern by COSEWIC (2010). Narwhal abundance summering in the Canadian High Arctic is estimated at >63,000 animals (NAMMCO, 2010).

5.1.4.1 Milne Port and Shipping Route

Narwhals occur throughout the area of the shipping route into Milne Inlet year-round but are found in the RSA primarily during the open-water period. Those that winter in Baffin Bay typically summer in the eastern Canadian Arctic. IQ indicates that within the Project RSA narwhals concentrate in Admiralty Inlet, Milne Inlet, Eclipse Sound, Koluktoo Bay, Tremblay Sound, Tay Sound, Creswell Bay, Pond Inlet, Navy Board Inlet, and Admiralty Inlet in the summer. The Lancaster Sound complex, including Navy Board and Pond inlets, has been identified as one of the most productive in the Arctic (Stephenson and Hartwig, 2010).

Recent estimates indicate that 20,211 narwhals summer in the Eclipse Sound area (NAMMCO, 2010). Survey results from the late 1980s and early 1990s indicated that the summer distribution within Eclipse Sound, Milne Inlet, Koluktoo Bay and Tremblay Sound is driven by the presence and distribution of ice and the presence of killer whales (Kingsley *et al*., 1994).

Narwhals begin to migrate out of their summering areas in groups of a few hundred to several thousand just before freeze-up begins in late September (Koski and Davis, 1994). Those summering near Somerset Island enter Baffin Bay north of Bylot Island in mid to late October (Heide-Jørgenson *et al*., 2003b), whereas the population summering in Pond Inlet begins migrating down the east coast of Baffin Island in late September (Dietz *et al*., 2001). Narwhals generally arrive at their wintering areas in November (Heide-Jørgenson *et al*., 2003b). The Baffin Bay population winters at two areas, with most in the pack ice in Baffin Bay (Koski and Davis, 1979, 1994; Heide-Jørgenson *et al*., 1993; Heide-Jørgenson *et al.,* 2002; Laidre *et al.,* 2004), and small number in polynyas at the north end of Baffin Bay (Richard *et al*., 1998).

Considerable aerial survey effort was focused on Eclipse Sound and Milne Inlet and nearby bays and inlets during the open-water periods of 2006, 2007, and 2008 as part of the Project's baseline data collection program. Narwhals were present in Eclipse Sound, Milne Inlet and Koluktoo Bay throughout the survey periods in 2007 and 2008 (~late July to mid-September). Numbers observed during a typical survey often were in the thousands. Maximum densities were recorded in Koluktoo Bay (176/100 km^2) in the first half of August 2007 and in Milne Inlet during the later part of August 2007 (305/100 km^2); they were also frequently seen in Tremblay Sound and White Bay in high densities, reaching a maximum of 760/100 km^2 in White Bay in August 2008. Aerial surveys documented fine-scale movements of large groups of narwhals between various areas of Eclipse Sound and surrounding fjords. Densities increased from August through September in Eclipse Sound with corresponding decreases in density in Milne Inlet and surrounding bays and Inlets.

5.1.4.2 Steensby Port and Shipping Route

A much smaller number of narwhals inhabit waters along the shipping route to Steensby Inlet. The Hudson Bay population was estimated at 1,780 in 2000 (COSEWIC, 2004b), although it may be as many as 3,500 during summer (COSEWIC, 2004b).

The timing and routes of migration used by the Hudson Bay narwhal population are less well understood than those of the Baffin Bay population. This population is thought to winter in eastern Hudson Strait (Richard, 1991; Koski and Davis, 1994); during late June they move towards summering areas located primarily in the Repulse Bay area north of Southampton Island (Gonzalez, 2001), although small numbers may move north towards Fury and Hecla Strait, in the vicinity of Igloolik (Stewart *et al*., 1995). IQ indicates that narwhals from the Gulf of Boothia and from Hudson Strait arrive in the Igloolik area at different times, and that narwhal abundance in northern Foxe Basin is irregular; the whales may be observed one year, but not the next. Fall migrations to Hudson Strait begin in late August or early September, depending on ice conditions. A small number of narwhals that winter in Baffin Bay are thought to move through Fury and Hecla Strait into northern Foxe Basin during spring migration in April and May (Brody, 1976; Stewart *et al*., 1995).

During aerial surveys for the Project in April–October 2008, narwhals were present in Hudson Strait in moderate numbers but infrequently encountered in Foxe Basin. In Foxe Basin, there was one sighting of seven narwhals in April, three sightings of five in June, and no sightings during August, September or October. In Hudson Strait, the highest densities were in April and June—0.63/100 km^2 (22 sightings) and 0.84/100 km^2 (29), respectively. Narwhals were absent in August, were observed in moderate densities (0.55/100 km^2) in September, and were absent in October.

5.1.5 Bowhead Whale

The bowhead is one of only three whales that spend their entire lives in the Arctic. They occur seasonally along the shipping route and are typically found singly or in small groups. Bowheads are adapted to living in areas of heavy unconsolidated ice cover during winter, can navigate extensive distances under ice, and are capable of breaking up to 20 cm of ice in order to breathe (George *et al*., 1989). During open-water periods bowhead distribution is likely driven by the distribution of prey species (Thomas, 1999). Bowheads are baleen whales (filter feeders), eating pelagic crustaceans (primarily copepods and euphausiids) and epibenthic invertebrates (Lowry, 1993). Because invertebrate distributions are often subject to changing physical and chemical conditions, characteristics such as water temperature, salinity, nutrient availability, ocean currents and marine water upwelling can indirectly affect their distribution (Mackas *et al*., 1985). Traditionally, bowheads have been observed feeding along the floe edge, and their presence often depends on the tides.

Bowheads are highly vocal animals, although call type and regularity may vary appreciably with season (Tervo *et al*., 2009). Mating can occur throughout the year, although most conceptions occur during late winter or early spring (Koski *et al*., 1993). Gestation lasts 12–16 months, and single calves are born during spring migration (Nerini *et al*., 1984; Koski *et al*., 1993).

There are four recognized bowhead stocks, one of which (the Eastern Canada-West Greenland stock) occurs within the RSA. This stock ranges throughout the eastern and central northern Arctic and from northern Baffin Bay to Hudson Strait (Heide-Jørgensen *et al*., 2006). Bowheads in Davis Strait and Baffin Bay were commercially over-exploited in the early 1900s, reduced from an estimated 11,800 whales to perhaps as low as 1,000 (Woodby and Botkin, 1993); however, there has been a major recovery in recent decades (Heide-Jørgensen *et al*., 2006). The current estimate, which is likely negatively biased, is 6,344 whales (CI 3,199-12,906; IWC 2009). The Eastern Canada-West Greenland stock is listed as a Special Concern by COSEWIC (2010) and is under consideration for listing under SARA.

5.1.5.1 Milne Port and Shipping Route

Bowheads occur along the shipping route into Milne Inlet during summer and fall. They may summer along the east coast of Baffin Island, or move westward through Lancaster Sound during June and July to feed and nurse calves in Inlets and sounds within the Canadian Arctic archipelago. Milne Inlet, Eclipse Sound, and to a lesser extent Koluktoo Bay are used during the open-water season. Mothers and calves tend to arrive later in the season. IQ suggests that the number of bowheads using Eclipse Sound appears to be increasing in recent years. Moderate numbers were sighted in Eclipse Sound during August–September aerial surveys for the Project in 2007 and 2008; overall densities ranged from 0.02 to 0.29/100 km^2. Fall migration to wintering grounds begins in September and occurs over the next few months. It is thought that fall migrants wintering in Davis Strait follow the east coast of Baffin Island south to wintering areas, whereas whales that winter along the west coast of Greenland may cross north Baffin Bay and then move south.

5.1.5.2 Steensby Port and Shipping Route

Bowheads congregate to feed and nurse calves in spring and summer around Southampton Island, along the western Hudson Bay coast, and in a relatively small area in northern Foxe Basin between Igloolik and Fury and Hecla Strait. Bowheads north of Igloolik in summer are primarily juveniles and females with newborn calves, suggesting that this location is a nursing area (Cosens and Blouw, 2003). The area has been identified as potentially the only bowhead nursery area in the Canadian Arctic (Stephenson and Hartwig, 2010), and it is considered a potential Area of Interest for a Marine Protected Area.

IQ indicates that bowheads observed near Hall Beach in spring migrate there from southern Foxe Basin. Migrations are not well documented, although most movement is thought to take place through the western and central portion of Foxe Basin, and may be influenced by ice cover. During summer, they tend to select areas of high ice cover (Ferguson *et al*., 2010), presumably to reduce the risk of predation by killer whales. Northern Hudson Bay and Foxe Basin have been identified as summering areas, with whales moving farther into Inlets and bays as the ice breaks up.

During aerial surveys for the Project, small numbers of bowheads were observed in north western Foxe Basin in fall 2006, with density estimates of 0.4–0.5/100 km^2. Bowheads were also observed in northwest Foxe Basin in September and October of 2008, with density estimates of 0.4/100 km^2 and 0.1/100 km^2, respectively. None were observed in Steensby Inlet during aerial surveys in 2006 or 2008.

Hudson Strait has been identified as a primary wintering area (late December to late March) for bowhead whales (Koski *et al*., 2006; COSEWIC, 2009; Ferguson *et al*., 2010). IQ suggests that they are not particularly numerous in Hudson Strait, although it is thought that the corridor is used extensively for migration. They begin winter migration in October as the sea ice begins to form, heading south toward northeastern Hudson Bay and Hudson Strait. In 1981, ~1,349 bowheads were estimated to occur in Hudson Strait (Koski *et al*., 2006). During the 2008 aerial surveys for the Project, bowheads were observed in Hudson Strait in April and August, with density estimates of 0.1/100 km^2 in both months.

5.1.6 Polar Bear

The polar bear has a circumpolar distribution and occurs in relatively low densities throughout most of the ice-covered areas in the RSA. It tends to be more abundant along shore lead systems and polynyas during winter, where less consolidated ice cover provides habitat for prey species (Stirling and McEwan, 1975; Stirling and Smith, 1975; Smith 1980; Stirling *et al*., 1993). Non-pregnant females, juveniles, and adult males remain active on the pack ice throughout the year, often moving considerable distances with the ice (Garner *et al*., 1994; Amstrup *et al*., 2000; Peacock *et al*., 2008, 2009). Polar bear distribution and population size are likely regulated by the extent of sea ice and the distribution and numbers of their primary prey, the ringed seal (Stirling and Øritsland, 1995; V. Sahanatien, pers. comm.). IQ indicates that they also prey on walruses and whales.

Females give birth to 1–3 cubs every 3–4 years (Stirling *et al*., 1975; Lentfer *et al*., 1980; Jefferson *et al*., 1993). Mating occurs from April to June, and females give birth the following December or January (Harington, 1968; Jefferson *et al*., 1993) in maternity dens, which are excavated in accumulations of snow on stable parts of landfast ice, offshore pack ice, and most often on land within ~ 50 km of the coast (Harington, 1968; Stirling *et al*., 1984; Ramsay and Stirling, 1990; Stirling and Andriashek, 1992; Amstrup and Gardner, 1994). Denning sites in Foxe Basin occur inland (V. Sahanatien, pers. comm.). Maternity dens are created in the fall and used until April. Cubs remain with their mothers for 1.4–3.4 years (Stirling *et al*., 1975; Ramsay and Stirling, 1988a; Derocher *et al*., 1993).

The global polar bear population is estimated at 22,000–25,000, of which at least 15,500 occur in Canada or in subpopulations shared with Canada (COSEWIC, 2008). Three subpopulations occur within the RSA: the Foxe Basin, Baffin Bay, and Davis Strait subpopulations. Between 1994 and 1997, the Baffin Bay polar bear subpopulation was estimated at 2,074 (Taylor *et al*., 2005). The Davis Strait subpopulation was estimated at 2,100 (Peacock *et al*., 2006 in COSEWIC 2008). From 1989–1994, 2,197 polar bears were estimated in the Foxe Basin population (Taylor *et al.* 2006). The preliminary estimate for the Foxe Basin population in 2009–2010 is 2,850 (S. Stapleton, pers. comm.). The polar bear was listed as a species of Special Concern under SARA in October 2011; it is listed as Special Concern by COSEWIC (2008).

5.1.6.1 Milne Port and Shipping Route

Polar bears are distributed on the ice and along coastal areas throughout Baffin Bay and Lancaster Sound. Polar bears from the Baffin Bay subpopulation occupy drifting pack ice and landfast ice between Baffin Island and west Greenland during winter, and can concentrate along the Lancaster Sound fast ice edge (Koski, 1980; Ferguson *et al*., 2000; Ferguson *et al*., 2001). Bears are also concentrated along landfast ice edges across Pond and Navy Board inlets during spring. Bylot Island and coastal Baffin Island are used as summer retreats when sea ice melts, and they also provide denning habitat for pregnant females. The Davis Strait subpopulation occurs in the Labrador Sea, eastern Hudson Strait, Davis Strait south of Cape Dyer, and an undetermined portion of southwest Greenland (Stirling and Kiliaan, 1980; Stirling *et al*., 1980; Taylor and Lee, 1995). Polar bears are harvested domestically as well as during a commercial sport hunt based out of Pond Inlet in spring.

During aerial surveys for the Project in 2007 and 2008, only six polar bears were observed during the open-water season in Milne Inlet, Eclipse Sound and Eskimo Inlet. They were also observed in low numbers on landfast ice in Milne Inlet, Koluktoo Bay, and Navy Board Inlet in June 2006.

5.1.6.2 Steensby Port and Shipping Route

Polar bears from the Foxe Basin subpopulation range over Foxe Basin, northern Hudson Bay and western Hudson Strait during winter. They are forced ashore during the open-water period. Based on harvest records from 1970–2011 and recent aerial surveys during late summer, polar bears are concentrated in central Foxe Basin (eastern Southampton Island and Vansittart Island, White Island, and adjacent islands) as well as northern Foxe Basin (Rowley Island, Koch Island, and the Spicer Islands). Fewer bears are found on the east side of Foxe Basin, and along the south shore of Hudson Strait (Peacock *et al*., 2008, 2009; Stapleton and Garshelis, 2010). IQ indicates that polar bears are more concentrated in northern Foxe Basin and through Fury and Hecla Strait into the Gulf of Boothia. Polar bear denning locations have been identified in Grant Study Bay, Murray Maxwell Bay, on South Spicer Island, on Southhampton Island, Nottingham Island, on Foxe Peninsula, on Rowley and Koch islands, and on the north shore of Hudson Strait (Nunavut Planning Commission 2011; V. Sahanatien, pers. comm.). Hall Beach Elders indicated that the southeastern portion of Steensby Inlet provides good denning habitat.

Non-pregnant females, juveniles, and adult males move in the RSA throughout the year and home ranges vary seasonally (Peacock *et al.*, 2008, 2009). Seasonal areas of high utilization by female polar bears in Foxe Basin and Hudson Strait remain generally stable across years (V. Sahanatien, pers. comm.). Areas of high utilization occur along the shipping route in central and south Foxe Basin in spring and fall and in southern Foxe Basin and Hudson Strait in winter (V. Sahanatien, unpub. data).

During aerial surveys for the Project, small numbers of polar bears were observed on landfast ice and pack ice, in terrestrial areas, and in open-water areas, primarily in northern Foxe Basin but also in Hudson Strait. They were most frequently observed in September and October along the shorelines of Steensby Inlet and Foxe Basin including Koch, Rowley, and Bray islands. During the aerial surveys with ice cover, highest polar bear densities were observed in northwestern Foxe Basin (0.5/100 km^2).

5.1.7 Bearded Seal

Bearded seals are common in the RSA throughout the year and primarily occur in areas with shallow water (<200 m) and pack ice. They are seldom found in landfast ice areas, but are widely dispersed in open-water areas of pack ice where leads and cracks are frequent, and where ice pans are sufficient for haul-out sites (McLaren and Davis, 1982). Pups are typically born on unstable pack ice or near the landfast ice edge where they are weaned after about three weeks (Gjertz *et al.*, 2000). Unlike ringed seals, bearded seals give birth on top of the ice and snow. The pupping period varies depending on location and seems to encompass the period from mid-March to early May (Burns, 1981). Moulting occurs in spring and bearded seals commonly haul out on ice during summer. Bearded seals are generally considered to be benthic feeders that prey on an array of benthic invertebrates and fish, although pelagic fish are also taken (Lowry *et al.*, 1980b; Finley and Evans, 1983; Antonelis et al., 1994).

The bearded seal is a vocal species; its sounds are a dominant component of the ambient noise in many arctic areas during spring. From late March to late June or early summer, bearded seals produce distinct trills or frequency-modulated vocalizations (Cleator *et al.*, 1989). It is believed that only male bearded seals produce trills and that trill duration may serve as a useful indicator of male condition and reproductive success (Van Parijs *et al.*, 2003).

Discrete populations of bearded seals have not been delineated in Canadian waters, but strong site fidelity to breeding sites is thought to occur (Cleator *et al.*, 1989). There is no reliable abundance estimate for bearded seals in Canadian waters; however, Cleator (1996) suggested an estimate of >190,000. IQ from some community elders in the Baffin region indicate a decrease in bearded seal abundance since the advent of firearms and motorized transportation. The bearded seal has no status under SARA and is listed as Data Deficient by COSEWIC.

5.1.7.1 Milne Port and Shipping Route

Bearded seals are relatively less abundant along the Milne shipping route than the Steensby shipping route given that this species predominantly occurs in areas of pack ice. During aerial surveys of seals on landfast ice in Milne Inlet and Koluktoo Bay in June 2008, only four bearded seals were sighted; the corresponding density was 1.7/100 km^2 (see Appendix 8A-2). During the open-water period, bearded seals are also expected to occur in relatively low numbers given the absence of ice.

5.1.7.2 Steensby Port and Shipping Route

Bearded seals are considered common along the shipping route to Steensby Inlet. This species occurs in both Hudson Strait and Foxe Basin and is most abundant in shallow water areas. The polynyas of northern Foxe Basin are thought to be an area of high density for bearded seals (Beckett *et al*. 2008). IQ notes that bearded seals give birth in April along the southern part of Steensby Inlet (see Figure 8-5.11, later).

During aerial surveys for the Project in June 2006, bearded seals were distributed throughout northern Foxe Basin and also occurred in Steensby Inlet (see Appendix 8A-2). The densities observed in northwest Foxe Basin, northeast Foxe Basin, and Steensby Inlet were 1.7/100 km^2, 2.7/100 km^2 and 0.2/100 km^2, respectively.

During similar aerial surveys conducted in June 2008, most bearded seals were sighted near the mouth of Steensby Inlet and the density of seals in that area was 2.0/100 km^2. Densities of bearded seals on pack and to a limited extent landfast ice in southern Foxe Basin and Hudson Strait were 0.3 and 0.6/100 km^2, respectively.

5.2 ISSUES SCOPING

A number of studies and consultations were conducted to characterize the existing conditions in the LSA, determine the most appropriate indicator species, identify the most important marine mammal issues as well as those that did not require a full assessment (see Subjects of Note, Section 5.3), and determine the most appropriate sound modelling and assessment methods and mitigation measures. Scoping activities by the Project team for the marine mammal VEC involved the following:

- Literature review (baseline conditions) - review of primary and grey literature;
- Literature review (key issues related to Project effects) - review of available primary and grey literature, including other EIS documents (Arctic Pilot Project);
- Discussion with GN biologists - meeting with Mitch Taylor in 2007 re. polar bear issues;
- Discussion with CWS biologists - teleconference with Evan Richardson in 2007 re. polar bear issues;
- Discussion with DFO biologists - numerous teleconferences and meetings held in 2006 through 2008 and in 2010 (Steve Ferguson, Pierre Richard, Larry Dueck, Sue Cosens, and Rob Stewart) re. issues and current research;
- Discussion with discipline experts, including:
    - Meetings with FedNav (shipping) in 2008;
    - Review and discussions with underwater noise experts (W. John Richardson and Rolph Davis, LGL; Charles Greene, Greeneridge Sciences; and Mikhail Zykov, JASCO Applied Sciences);
- Consultations with communities of Arctic Bay, Cape Dorset, Hall Beach, Igloolik, Kimmirut and Pond Inlet, as described in Volume 2, Section 1.0;
- Inuit knowledge studies carried out in the communities identified above;
- A Mary River Project Team scoping meeting held in November 2007;
- Review of GN, COSEWIC, SARA, and IUCN lists; and
- Marine mammal surveys for the project in 2006, 2007 and 2008.

5.2.1 Key Questions

Through issue scoping, including community consultations, key questions regarding shipping, construction, and operations at the Steensby and Milne Ports and along shipping routes were derived for the marine mammal VEC. Key concerns expressed during community consultations specific to indicator species are provided in the assessment section for that species.

5.2.1.1 Shipping

- Will frequent and long-term shipping to the Steensby Port affect the distribution and abundance of marine mammals?
- If there are disturbance effects on marine mammals from shipping, how long will the effects last?
- Will marine mammals habituate (become accustomed) to shipping?
- Will marine mammals experience mortality from collisions with vessels?
- Will icebreaking along the shipping route limit pinniped habitat?

5.2.1.2 Steensby and Milne Ports

- Will construction activities cause potential hearing impairment or physical effects (including potential mortality) to marine mammals?
- Will continuous vessel traffic at the ports result in marine mammals abandoning the area?
- Will aircraft overflights affect marine mammal behaviour?
- Will icebreaking and ice management at Steensby Port limit available pinniped habitat?

5.3 SUBJECTS OF NOTE

Scoping indicated that the influences of noise on the behaviour, health, distribution and abundance of marine mammals in the LSA and RSA were of primary concern. The FEIS therefore focuses on the potential effects of noise from various Project activities. Other Project activities such as the discharge of wastewater will interact with some marine mammals, but with mitigation measures in place residual effects are expected to be negligible to very minor. The effects of an accidental release of fuel on marine mammals are considered in Volume 9, Section 3.0.

The EIS Guidelines requested consideration of contaminant loading in marine mammals such as seals and walrus, which are important local food sources. A review of contaminants in marine mammals of the Canadian Arctic was provided in Appendix 1 of the marine mammal baseline report (Appendix 8A-2). Contaminants from fossil fuel combustion and run-off from ore stockpiles were assessed in Sections 3.5 and 4.6. It was predicted that with mitigation measures in place, contaminants from the Project will not significantly affect prey (or prey habitat) of marine mammals.

5.4 PROJECT INTERACTIONS WITH MARINE MAMMALS

Four primary interactions represent potential effects on marine mammals from routine Project activities: noise (in-water and in-air), collision with vessels, habitat change, and indirect effects from changes in prey.

5.4.1 Noise

The key issues for marine mammals are the effects of underwater noise and related disturbances, and in the case of pinnipeds and polar bears, airborne noise as well, on the behaviour and health of VECs. The environmental effects of noise on marine mammals are highly variable, and can be categorized as follows (based on Richardson *et al*., 1995a):

- The noise may be too weak to be heard at the location of the animal, i.e., lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both;
- The noise may be audible but not strong enough to elicit any overt behavioural response, i.e., the animal may tolerate it, either without or with some deleterious effects (e.g., masking, stress);

- The noise may elicit behavioural reactions of variable conspicuousness and variable relevance to the well-being of the animal; these can range from subtle effects on respiration or other behaviours (detectable only by statistical analysis), to active avoidance reactions;
- Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat;
- Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as surf noise or ice noise. Continuous noise (e.g., vessel noise) is more likely to cause masking than intermittent noise (e.g., pile driving, blasting); and
- Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity or other physical or physiological effects, and in extreme cases (e.g., exposure to large explosions), mortality. Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift to occur, and levels must be even higher for a risk of permanent hearing impairment or other injury.

5.4.1.1 Fundamentals of Underwater Sound

Most treatments of the effects of underwater sound are based on the Source:Path:Receiver concept. In this case, there are several sources, e.g., vessels or aircraft. Water is an efficient medium through which sound travels long distances. The receiver of these sounds is a marine animal of interest (VEC). The sounds received depend on the distance between the source and the receiver. The ability of the receiver to detect these signals depends on the hearing capabilities of the species and on the amount of natural ambient or background noise in the sea around it. The sea is a naturally noisy environment, and this noise can "drown out" or mask weak signals from distant sources.

Humans hear sounds with a complicated non-linear type of response. The ear responds logarithmically and so acousticians use a logarithmic scale for sound intensity and denote the scale in decibels (dB). In underwater acoustics, sound is usually expressed as a Sound Pressure Level (SPL):

- Sound Pressure Level = 20 log (P/Po)

Where P is the sound pressure and Po is a reference level, usually 1 µPa. Other reference levels have been used in the past and so the reference level needs to be shown as part of the SPL unit. A sound pressure (P) of 1,000 Pascals (Pa) has a SPL of 180 dB re 1 µPa and a pressure of 500 Pa has a SPL of 174 dB re 1 µPa. In this scale, a doubling of the sound pressure means an increase of 6 dB. In order to interpret quoted sound pressure levels, one must also have some indication of where the measurement applies. SPLs are usually expressed as received sound level at the receiver location or at the source. A source level is usually calculated or measured as the SPL at 1 m distance from the source. However, for aircraft sounds, the concept of a 1-m source level for underwater noise is not very meaningful. The SPL can be expressed in different metrics: the difference in pressure between the highest positive pressure and the lowest negative pressure is the peak-to-peak pressure (p-p). The peak positive pressure, usually called the peak or zero-to-peak pressure (0-p), is approximately half the peak-to-peak pressure. The average pressure recorded during the pressure pulse can be expressed as the root mean square (rms) or average pressure. The rms pressure is integrated over the duration of the sound signal. A difficulty with this type of measurement is that it is often hard to interpret because it depends on the averaging time.

More recently, some sounds have been measured as Sound Exposure Levels or SELs. This is directly proportional to the total energy density of the acoustic signal. Energy is proportional to the time integral of the pressure squared; hence, SEL includes time as a dimension and is expressed as μPa^2-s. Energy levels are not directly comparable to pressure levels. In most cases, energy values are < "average pressure squared over the pulse duration", measured in dB re 1µPa, but the difference is variable (Richardson *et al*., 1995a). As most of the literature on effects of sound on marine animals is presented as SPLs, the discussion in this EIS focuses on pressure levels.

Sound measurements are often expressed as broadband, meaning the overall level of the sound over a range or band of frequencies. The level at a specific frequency will be lower than the broadband sound level for some bands containing that frequency, because the broadband sound includes the components over a wide range of frequencies. Sound signatures consist of measurements of the sound level at each frequency (a sound spectrum). Sound level can also be measured and summed over groups or bands of frequencies (e.g., octaves or third octaves).

Aircraft—The characteristics of aircraft sound received by a marine mammal below the surface are influenced by the transmission of the sound to water, which depends on the receiver's depth and the source's strength, its altitude, and the angle at which the noise intersects the surface along a direct line between the receiver and the source (Richardson *et al*., 1995a). At angles >13º from vertical most of the airborne sound is reflected, except when high waves result in appropriate angles (Richardson *et al*., 1995a). However, aircraft sounds are dominated by low frequencies, which have wavelengths longer than most ocean wave heights, rendering the surface essentially flat for these frequencies of sound. Water depth and the hardness of the bottom affect the propagation of aircraft sounds underwater. In shallow water, propagation of sound laterally may be greater than in deep water, particularly with a reflective bottom (Richardson *et al*., 1995a). Consequently, multiple reflections in shallow water may lengthen the time interval during which the sound of a passing aircraft is received underwater (Richardson *et al*., 1995a).

The main source of noise from propeller-driven aircraft is the rotation propeller blades through the air. The fundamental frequencies of this noise depend on the rotation rate and number of blades (Richardson *et al*., 1995a). The greatest noise levels of these sounds primarily occur at frequencies below 500 Hz (Richardson *et al*., 1995a). As the aircraft passes, the Doppler shift causes a drop in these frequencies. Fixed-wing aircraft are generally quieter than helicopters.

5.4.1.2 Fundamentals of Airborne Sound

For airborne sound it is conventional to use 20 µPa as the reference pressure 26 dB above the 1-µPa reference pressure for underwater sound. Airborne sounds are often expressed as broadband, A-weighted sound levels expressed in dBA. A-weighted refers to frequency-dependent weighting in accordance with the sensitivity of the human ear to different frequencies (see Section 5.6 of Richardson *et al*., 1995a). Sound energy at frequencies <1 kHz and >6 kHz is deemphasized. Few data are available on airborne sound levels in marine environments, but surf noise has been measured at 64 dBA re 20 µPa (90 dBA re 1 µPa; BBN 1960 in Richardson *et al*., 1995a).

In the marine environment, the in-air sound of most relevance from the Project is aircraft noise. When dealing with aircraft, an altitude of 300 m is the usual reference distance for in-air measurements and predictions, and the same convention is appropriate for underwater sounds (Richardson *et al*., 1995a).

Most of the energy from aircraft is low frequency. Sound levels from an approaching aircraft are detectable much longer in air than in water. Also, duration of audibility tends to increase with increasing aircraft altitude. Airborne sounds will be diminished inside seal (and polar bear) lairs. Cummings and Holliday (1983) reported that over the 105–200 Hz frequency band, the received level of airborne noise was reduced by an average of 11 dB beneath snow cover of 70 cm.

5.4.1.3 Marine Mammal Hearing

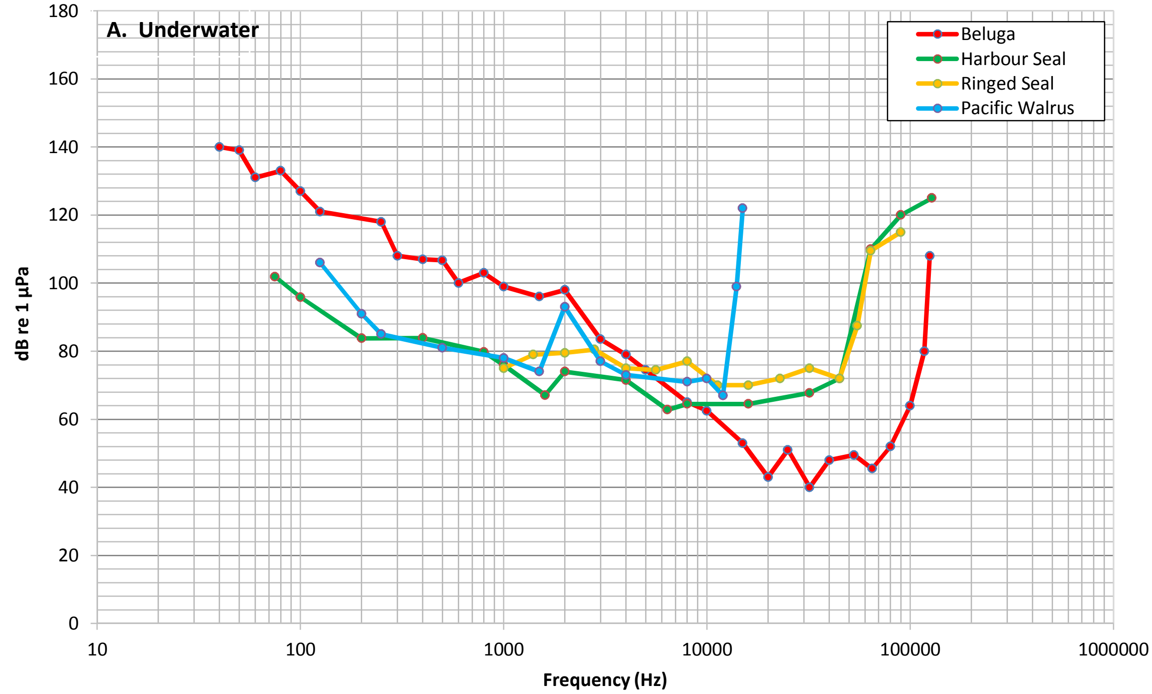
It is necessary to understand marine mammal hearing abilities in order to assess their detection of man-made sounds. Audiogram data are available for several of the indicator species (Figure 8-5.1). The hearing capabilities in the audiograms represent the lowest received sound levels that can be detected by a captive trained animal under experimental conditions. Generally, the sound used in the experiments is a tone of ~0.5-s duration.

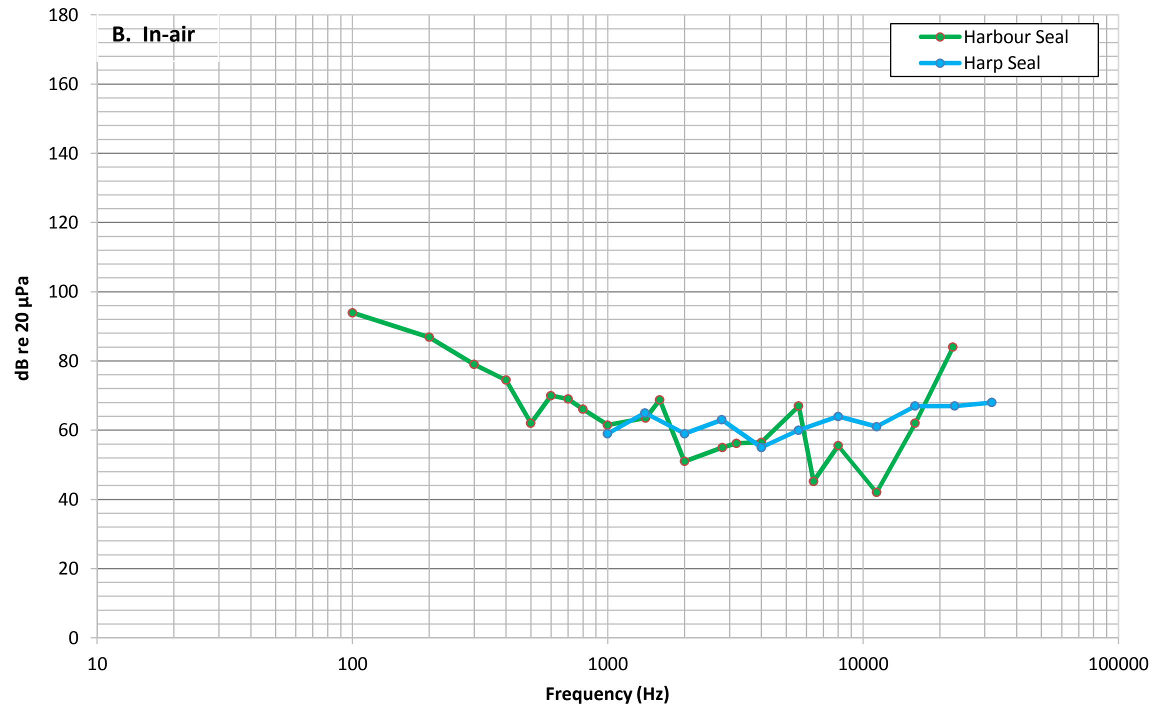
Ringed Seal - The underwater hearing sensitivity of ringed seals has been studied by Terhune and Ronald (1975). The study was limited to frequencies above 1 kHz but it is known that seal hearing extends below this range, as evidenced by harbour seal audiogram data (Figure 8-5.1). There are no data on the sensitivity of ringed seals to airborne sounds, but sensitivity of harbour seals to airborne sounds has been studied (see Figure 8-5.1). Because harbour and ringed seals are close relatives (Árnason *et al*., 1995), and hearing abilities of phocinid seals as a group appear to be similar (Richardson *et al*., 1995a), it has been assumed that both the underwater and in-air hearing abilities of ringed and harbour seals are similar. Audiogram data (in water) exist for ringed seals as well as the following pinnepeds: harbour seal, harp seal, northern elephant seal, Hawaiian monk seal, grey seal, northern fur seal, California sea lion and walrus (Southall *et al*., 2007). There are no data on the sensitivity of ringed seals to airborne sounds. Of species with audiometric data, available evidence indicates that the ringed seal is most closely related to the harbour seal (Árnason *et al*., 1995). Compared to odontocetes, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the best frequency.

Walrus – Upon completion of a detailed literature review, no in-air audiogram for walrus was found. Kastelein *et al.* (1996) showed that walruses react to airborne sounds at 0.25 to 8 kHz, but absolute thresholds were not determined. The range of best hearing for walruses was 1–12 kHz, and maximum sensitivity (~67 dB re 1 µPa) occurred at 12 kHz (Kastelein *et al*., 2002). Sensitivity fell gradually below 1 kHz and dropped off sharply above 12 kHz, in contrast to ringed and harbour seal audiograms. Walrus hearing is relatively sensitive to low frequency sound, compared to odontocetes.

Beluga Whale - Belugas and other toothed whales hear best at frequencies of about 20–100 kHz. The hearing thresholds of these species decrease progressively outside of this 20–100 kHz range. For comparison, much of the sound energy from shipping is below the 1000-Hz (=1 kHz) range. Shipping sounds at and below 1000 Hz are approximately 40–50 dB above the hearing threshold of beluga. This means that belugas are capable of hearing sounds at those frequencies, but this distribution is not within their best hearing range. Sounds need to be above the hearing threshold to be readily detectable, especially relative to ambient noise levels. There are no specific hearing data for narwhals but it is assumed belugas and narwhals have similar hearing abilities because of their taxonomic similarity; the two are the only species in the family Monodontidae.

BL_Vol8_EXL_005 Underwater (A) and In-Air (B) Audiograms for Marine Mammals Figure 8-5.1.EXL





NOTES:

1. RINGED SEAL UNDERWATER AUDIOGRAM FROM TERHUNE AND RONALD (1975).
2. HARBOUR SEAL UNDERWATER AUDIOGRAM BASED ON FOUR SETS OF MEASUREMENTS: TERHUNE (1988, 1989), TERHUNE AND TURNBULL (1995), AND KASTAK AND SCHUSTERMAN (1998).
3. WALRUS UNDERWATER AUDIOGRAM FROM KASTELEIN ET AL. (2002).
4. BELUGA AUDIOGRAM ADAPTED FROM RICHARDSON ET AL. (1995) BASED ON BELUGA DATA (AVERAGED) OF WHITE ET AL. (1978), AWBREY ET AL. (1988), JOHNSON ET AL. (1989), AND ERBE AND FARMER (1998).
5. HARBOUR SEAL IN-AIR AUDIOGRAM BASED ON THREE SETS OF MEASUREMENTS: MOHL (1968), TERHUNE AND TURBULL (1995), AND KASTAK AND SCHUSTERMAN (1998).
6. HARP SEAL IN-AIR AUDIOGRAM FROM TERHUNE AND RONALD (1971).
7. NOTE USE OF STANDARD "IN-AIR" SCALE (dB re 20 uPa) IN B.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

UNDERWATER (A) AND IN-AIR (B) AUDIOGRAMS FOR MARINE MAMMALS

Baffinland Iron Mines Corporation

REF NO. **BL_Vol8_EXL_005**

FIGURE 8-5.1

REV 0

Bowhead Whale - The hearing abilities of baleen whales, including the bowhead, have not been studied directly. Behavioural and anatomical evidence indicates that they hear well at frequencies below 1 kHz (Richardson *et al*., 1995a; Ketten 2000), and they may detect sounds in the 10s of kHz. Frankel (2005) noted that gray whales reacted to a 21–25 kHz whale-finding sonar. Some baleen whales react to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at 36 kHz or above (Watkins, 1986). In addition, baleen whales produce sounds at frequencies up to 8 kHz and, for humpbacks, with components to >24 kHz (Au *et al*., 2006). The anatomy of the baleen whale inner ear appears to be well adapted for detection of low-frequency sounds (Ketten, 1991, 1992, 1994, 2000). For baleen whales as a group, the functional hearing range is thought to be ~7 Hz to 22 kHz, and they constitute the "low-frequency" (LF) hearing group (Southall *et al*., 2007). The absolute sound levels that they can detect below 1 kHz are probably limited by increasing levels of natural ambient noise at decreasing frequencies (Clark and Ellison, 2004). Ambient noise levels are higher at low frequencies than at mid frequencies. At frequencies below 1 kHz, natural ambient levels tend to increase with decreasing frequency.

Polar Bear - Data on the specific hearing capabilities of polar bears are limited. A recent study of the in-air hearing of polar bears applied the "auditory evoked potential method" while tone pips were played to anesthetised bears (Nachtigall *et al*., 2007). Hearing was tested in 1/3 octave steps from 1 to 22.5 kHz, and best hearing sensitivity was found between 11.2 and 22.5 kHz. Although low-frequency hearing was not studied, the data suggested that medium- and some high-frequency sounds may be audible to polar bears. However, polar bears' usual behaviour (i.e., on ice, at the water surface or on land) reduces or avoids their exposure to underwater sounds.

Bearded Seal – There are no hearing data for bearded seals, but it is assumed that the ringed seals and the bearded seals have similar hearing abilities.

5.4.1.4 Hearing Impairment

Temporary Threshold Shift, or TTS, is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. It is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or "injury" (Southall *et al*., 2007). Rather, the onset of TTS is an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility.

The magnitude of TTS depends on the level and duration of noise exposure, and to some degree on frequency, among other considerations (Kryter, 1985; Richardson *et al*., 1995a; Southall *et al.* 2007). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. In terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. Only a few data have been obtained on sound levels and durations necessary to elicit mild TTS in marine mammals (none in mysticetes; Southall *et al*., 2007).

When Permanent Threshold Shift (PTS), occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985). Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times (time required for sound pulse increase from the baseline p-p).

In their review, Southall *et al.* (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB, on an SEL basis, for there to be risk of PTS. Thus, for cetaceans exposed to a sequence of sound pulses, they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 $\mu Pa^2 \cdot s$ (15 dB higher than the TTS threshold for an impulse). M-weighted refers to frequency-dependent weighting in accordance with the sensitivity of the marine mammal ear to different frequencies (see p. 433-434 *in* Southall *et al*., 2007).

Additional assumptions had to be made to derive a corresponding estimate for pinnipeds, as the only available data on their TTS thresholds pertain to non-impulse sound (see below). Southall *et al.* (2007) estimated that the PTS threshold could be a cumulative M_{pw}-weighted SEL of ~186 dB re 1 $\mu Pa^2 \cdot s$ in the case of a harbour seal exposed to impulse sound ($_{pw}$ refers to pinnipeds in water). The PTS threshold for the California sea lion and northern elephant seal would probably be higher, given the higher TTS thresholds in those species. Southall *et al.* (2007) also noted that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean or pinniped received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 µPa, respectively.

Sound impulse duration, peak amplitude, rise time, number of pulses and inter-pulse interval are thought to be the main factors in determining the onset and extent of PTS. Ketten (1994) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species-specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

5.4.2 Vessel Collisions

It is conceivable that the marine mammals in the LSA could experience direct injury or mortality from collisions with vessels. While the risk of collisions is generally considered low, given their avoidance of ships, the risk would be highest for ringed seal pups in lairs in landfast ice. Another potential interaction 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.

5.4.3 Habitat Change

Marine habitat within the LSA will be directly changed by the footprint of dock structures at Steensby Port. These structures occur in relatively shallow waters, which are used more frequently by pinnipeds than cetaceans. Habitat will also be affected by icebreaking activities along the ship track into Steensby Port as well as the area near the ore dock, where ice will be continuously altered during each ice-cover season of the Operation Phase. This primarily has implications for ringed seals, which use ice to establish breathing holes and lairs for resting and pupping.

5.4.4 Change in Prey

Marine mammals may be indirectly affected by Project activities because of changes in prey availability and quality. Fish and invertebrates might move to avoid sound sources. Any such distributional shifts would be localized and temporary. Polar bears that forage near the Steensby Port could experience a temporary reduction of ringed seal availability in the area of disturbed landfast ice.

Given the mitigation measures to be applied, wastes, including contaminants from ore stockpiles, are not likely to affect the prey of marine mammals; hence they would not contribute to the bioaccumulation of contaminants in marine mammals in the RSA.

5.4.5 Biological 'Hotspots'

The QIA has identified biological 'hotspots' in northern Foxe Basin (Steensby), eastern Hudson Strait, and western Hudson Strait but the requirements for such a designation have not been defined. Presumably such areas possess habitat characteristics that attract species, including marine mammals in higher than average numbers. The distributions of each of the species of marine mammals are given in the species sections of the FEIS. An evaluation has been completed along the Shipping Route of all of the identified "hotspots" and these concentrations of biological activity have been taken into account in the assessment of effects on the selected Key Indicators.

Polynyas are important features during periods of ice cover in that they provide access to surface for marine mammals. As discussed in Section 2.5.4.1, the important point to note about the polynya-like features in the vicinity of the shipping route is that none of them are recurring polynyas and as such there are not likely to be areas of regular concentration by marine mammals. Apart from northwest Foxe Basin, the polynya-like features identified by Ersahin (2011a, b of Appendix 8A-3) are fairly small and transitory. They do not differ from the areas of open water that regularly appear and disappear in areas of moving pack ice.

5.5 ASSESSMENT METHODS COMMON TO MARINE MAMMAL INDICATOR SPECIES

A detailed description of the assessment approach to all VECs is provided in Volume 2, Section 3.0. Note that the assessment of marine mammals incorporates a consideration of the overall impacts of the Project and the cumulative effect of within-Project interactions on each species or population. The assessment of the potential effects of noise on marine mammals involved several steps common to all selected indicator species. The work starts with a review of the hearing abilities of the species under consideration, then is followed by a review of known effects of relevant noise sources, and a listing of relevant noise criteria for assessing effects. A key component in assessing noise effects and establishing appropriate mitigation criteria was estimating the area around a sound source where the noise causes a known or expected effect (i.e., a response criterion or zone of influence).

Acoustic modelling was used to provide much of the information needed for the environmental assessment, including distance estimates and characterization of the acoustic environment of the LSA and RSA. The results have been reported for Steensby Inlet (Matthews *et al*., 2010; Zykov, 2011) and Milne Inlet (Zykov and Matthews, 2010) and the associated shipping routes at various distances from the sound source.

5.5.1 Acoustic Modelling

Modelling at Steensby Port and along the shipping route examined three time periods: open-water, "thin" ice (February), and "thick" ice (May). Underwater sound levels from blasting, pile driving, drilling, dredging and vessel traffic were modelled. Sound levels from ore carriers were modelled at three locations along the shipping route: southern Steensby Inlet, central Foxe Basin, and western Hudson Strait (Matthews *et al*., 2010). Acoustic modeling sites were reviewed by JASCO acousticians and Dr. John Richardson of LGL. The Hudson Strait site was selected because it was on the nominal shipping route and it was in a deep water location that had a "direct path" into the Labrador Sea as well as into Hudson Bay and the south end of Foxe Basin.

Given that construction and operation activities at Milne Inlet are limited to the open-water period, modelling was limited to that time period. At Milne Port, underwater sound levels from vessel traffic were modelled. Sound levels from vessels were modelled at four locations along the shipping route: Pond Inlet, Eclipse Sound, Koluktoo Bay and Milne Inlet (Zykov and Matthews, 2010).

In general, icebreaking produces stronger and more variable sound levels than would normally be produced by a ship transiting in open-water (Richardson *et al*., 1995b). Physical crushing of ice contributes little to the overall increase in noise during icebreaking. Based on several field studies, icebreakers pushing ice radiate noise about 10-15 dB higher than when underway in open water, primarily due to stronger propeller cavitation (Richardson *et al*., 1995b). In general, spectra of icebreaker noise are wide and highly variable over time given the alternating periods of ramming and backing. Sound levels from an icebreaking ore carrier (Cape-size) were modelled at Steensby Inlet, Foxe Basin, and Hudson Strait during periods with thin and thick ice cover (Matthews *et al*., 2010).These modelling results were incorporated into the assessment.

5.5.2 Composite Audiogram and Noise Plots

For most indicator species, except bowhead whales and polar bears, graphs were generated to depict the audiogram, ambient noise levels (5, 50, and 95 percentiles) and predicted 1/3-octave band noise levels for each modelled sound source (Matthews *et al*., 2010; Zykov and Matthews, 2010). Ambient noise levels for open water and periods of heavy ice cover were obtained from Burgess and Greene (1999) and Greene and Hanna (1997). Ambient noise levels from these two periods were averaged to produce values for periods of thin ice cover. These types of graphs provided a convenient means of comparing radiated noise with ambient noise, hearing sensitivity, or with a selected response criterion (see below). Each graph was examined to determine the 1/3-octave band level that had the highest sound level and that was within the hearing range of an indicator species. Estimated distances from the 1/3-octave band with the highest sound level were then used to establish various 'zones of influence' (based on a response criterion) for a given Project activity and in some instances were used to establish safety zones for mitigation purposes.

5.5.3 Response Criteria

In general, data to support specific response criteria for marine mammals are limited (e.g., Southall *et al*., 2007). Therefore, the level of certainty, particularly for behavioural responses to noise, is in many instances not high. For the purposes of the EIS, response criteria were generally included for hearing impairment (TTS), disturbance, and avoidance of a sound source. The text below highlights some recent studies on response thresholds for marine mammals. Studies used to select response criteria specific to indicator species are provided in Sections 5.6 to 5.11.

5.5.3.1 Hearing Impairment

The U.S. National Marine Fisheries Service (NMFS, 1995, 2000) has concluded that pinnipeds and cetaceans in water should not be exposed to impulse noise at received levels exceeding 190 dB re 1 µPa (rms) and 180 dB re 1 µPa (rms), respectively. These exposure criteria were intended as a conservative estimate below which TTS would not occur from airgun pulses. There was, however, no empirical evidence indicating that higher levels of pulsed sound would cause hearing or other injuries.

In Canada, minimum exposure criteria for hearing impairment or injury to marine mammals have not been established. In recent years, a panel of (mainly U.S.) experts in acoustic research from behavioural, physiological and physical disciplines has worked to produce scientific recommendations for updated marine mammal noise exposure criteria (Southall *et al*., 2007). For various marine mammal groups and sound types (single pulse, multiple pulses, nonpulse, or continuous), Southall *et al.* (2007) proposed levels above which there is a scientific basis for expecting that noise exposure would cause injury. These new exposure criteria incorporate frequency-weighting functions (M-weighting; see Section 3.5 *in* Matthews *et al.* 2010) for assessing the effects of sound on marine mammals, which accounts for the major differences in auditory capabilities across marine mammal groups and species. Minimum exposure criteria for injury are defined as the energy level at which a single exposure to sound is estimated to cause onset of permanent hearing loss (PTS). TTS was not considered an injury (Southall *et al*., 2007).

5.5.3.2 Behavioural Response

Southall *et al.* (2007), despite an extensive review of the available literature, were not able to derive explicit and broadly applicable numerical threshold values for delineating behavioural disturbance. For some marine mammal species and situations, there appears to be a relationship between received sound level and the magnitude of behavioural response; for others, such relationships clearly do not exist or have not been established. The available literature on indicator species and derived response criteria for each species was examined in order to propose these criteria. These are presented in Sections 5.6 to 5.11, along with associated caveats.

5.5.4 Estimating Numbers of Marine Mammals

The areas exposed to a particular noise level from modelled Project activities were calculated. For construction activities and stationary vessels at Milne and Steensby Ports, the response criteria distance was assumed to be the radius of a circle and the marine area around the sound source was calculated. For ore carriers transiting to and from Milne and Steensby Ports, the length of the ship's transit route was multiplied by the response distance. In both cases, the calculations were done using GIS to eliminate any land areas that would be included with a simple calculation. Densities derived from aerial survey data were corrected for detection and availability biases, then used with the calculated areas to estimate the expected numbers of marine mammals exposed to a given sound level.

Assessment methods unique to each marine mammal indicator species are provided in the respective species section below.

5.5.5 Key Assumptions in Assessment Approach

The approach for predicting how many marine mammals might be exposed to noise of sufficient level (and duration) that could elicit a behavioural response or cause hearing impairment is intended to provide guidance on the expected level of effect. The actual numbers of marine mammals predicted to exhibit behavioural responses or, in the extreme, to experience hearing impairment is based on the following assumptions.

- For all studied marine mammals it is clear that behavioural responses are strongly affected by the context of exposure and by the animal's motivation and experience.
- Threshold values for delineating behavioural disturbance are based on several studies, but the data do not converge on specific exposure conditions resulting in particular reactions. In reality, there is expected to be much variation in response to sound type and level.
- Sound exposures that elicit TTS in cetaceans are based on laboratory studies of two mid-frequency species—bottlenose dolphin and beluga. There are no published data for mysticetes, including the bowhead whale, or other cetaceans (narwhal).
- Sound exposures that elicit TTS in pinnipeds (in water) are based on laboratory studies of three species—harbour seal, California sea lion and northern elephant seal. There are no published data for ringed seal, bearded seal or walrus.
- Hearing impairment is likely a cumulative sound exposure phenomenon for which empirical data are lacking.

- In the absence of a species-specific audiogram, it was assumed that narwhals have the same hearing sensitivity as belugas, and that ringed seals and bearded seals have the same in-air hearing sensitivity as harbour seals. Similarly, it was assumed that bowhead whale hearing was ambient-limited.
- Assumptions about the Project were made based on general knowledge of construction and operation activities. These served as input for acoustic modelling (Matthews *et al*., 2010; Zykov and Matthews, 2010) where specific details of Project activities, equipment and vessels were not yet developed. Where such generic information was used, modelling methods employed conservative assumptions.
- The method for estimating the numbers of marine mammals exposed to a given sound level assumes that marine mammals are stationary, whereas in reality they would likely move away from the sound source. This is particularly relevant when considering the numbers of marine mammals that might incur hearing impairment.
- Correction factors for aerial survey density estimates were often based on studies in other regions and assumed to be applicable to the RSA.

There are assumptions to be made about the biology, distribution and abundance of some of the indicator species. For example, feeding, calving and mating areas have not been definitively identified for belugas and narwhals in the RSA. In such cases, the assessment has relied on the available IQ. While acknowledging these assumptions and cautions, the best available information has been used to identify the numbers of animals that will interact with the Project. The estimated numbers of affected marine mammals are meant to provide an approximate effect size relative to measurable parameters and threshold levels. As such, they serve as a guide for assessing the significance of Project activities on marine mammal populations and the need for follow-up monitoring and adaptive management.

5.5.6 Sound Levels from Two Ore Carriers and Likely Locations Where Ore Carriers Will Pass

During technical review of the Draft EIS, questions were asked about the potential increase in received sound level if two cape-size ore carriers occurred in close proximity to each other. Ore carriers are expected to maintain a minimum separation distance of 1 nautical mile (T. Keane, FedNav, pers. comm.) along the shipping route, so, for purposes of this assessment, it was conservatively assumed that the minimum separation distance between two ore carriers will be 1 km. The acoustic noise literature (e.g., Richardson *et al.* 1995; Hansen 2005; Bies and Hansen 2009) indicates that the combined source level of two identical and co-located incoherent noise sources is the value of the source level from one of the sources plus 3 dB. The more dissimilar the two noise sources, then the lower the adjustment factor will be; for example, when the source levels are 20 dB different, then the combined source level will be one source level plus 0.0432.

The maximum increase (3 dB) in the combined received levels will occur at locations near or far from both vessels where the separate received levels from both sources are identical. For two identical ships and in the case of marine mammals, this would occur when the marine mammal is perpendicular to the mid-point of the shortest path between the two vessels. If the two vessels are abeam of each other, then this location would be forward or astern of the two vessels. If one vessel is astern of the other then this location would be abeam of both vessels. The effects of two ore carriers passing in close proximity to each other along the shipping route is addressed for each KI.

The likely locations of where ore carriers will pass each other along the shipping route were examined. The nominal shipping schedule would see one vessel docking at the ore loading dock in Steensby Port immediately (within six hours) following the departure of a loaded vessel. It will normally take two days to load a vessel with ore. Therefore, to maintain a continual movement of ore, a third vessel must be two days out, and the next vessel two days behind that vessel, etc.

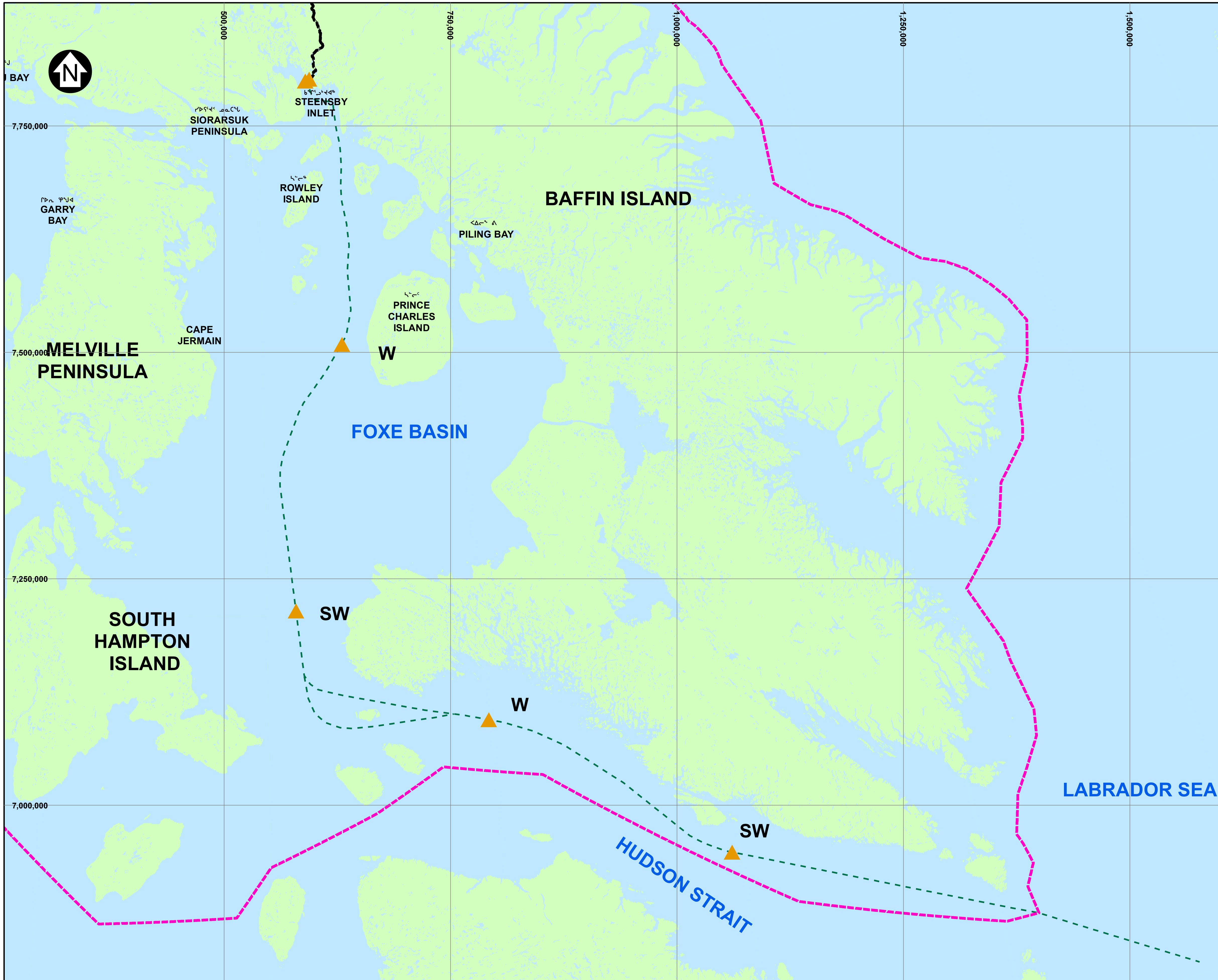
It is anticipated that during the open-water period (August to December) vessels will travel at an average speed of 14 kts. (26 km/h.), while during the ice-covered period (January to August) vessel speed will be reduced to an average of 7 kts (13 km/h.). For normal operating conditions, the likely locations where ore carriers will pass each other during each period are presented in Table 8-5.2 and illustrated in Figure 8-5.2. During the open-water period with vessels travelling at a speed of 14 kts, there would be three vessels in the RSA at the time of departure of a loaded vessel from Steensby Port: two at the dock (one leaving and one arriving); and one 1243 km from Steensby Port. During the ice-cover period and at an assumed vessel speed of 7 kts, there would be five vessels in the RSA at the time of departure of a loaded vessel from Steensby Port: two at the dock (one leaving and one arriving) and one each at 621, 931 and at 1243 km from Steensby Port (Table 8-5.2). With regards to transit time, a vessel travelling at 7 kts would be within the RSA for 11.7 days, whereas, at a speed of 14 kts it would be in the RSA for 6.9 days (includes two days loading at dock).

5.5.7 Other Analysis Approaches Considered

During review of the Draft EIS, it was suggested that an impact analysis approach used in a thesis prepared by Booth (2010) be considered for application in the FEIS. The thesis estimated hearing impairment effects on harbour porpoise exposed to acoustic deterrent devices. Estimates relied on the calculation of the time necessary to reach threshold sound exposure levels (SEL) that cause TTS and PTS at various ranges from the acoustic source. This approach is less useful for noise sources that are moving and continuous. In addition, the proposed approach requires estimates of SEL thresholds that induce TTS or PTS as well as reliable estimates of species-specific recovery times. These data are not available for the key indicator species in the FEIS. For this reason, this approach was not incorporated in the FEIS.

It was also suggested during review of the Draft EIS that the LSA should be expanded to at least 250 km on each side of the shipping route because some marine mammals are likely to be able to detect the ship noise at that distance. However, mere detection of distant ship noise should not be considered a disturbance to a mammal receptor. Any potential negative effects from the shipping will occur at much closer distances from the ships. The geographic scope of the LSA for the marine mammal VEC was based on suggested boundaries provided in the NIRB Guidelines (p. 15):

"Local Study Area (LSA): the Local Study Area shall be defined as that area where there exists the reasonable potential for immediate impacts due to project activities, ongoing normal activities, or to possible abnormal operating conditions. The Local Study Area includes the Project facilities, buildings and infrastructure, and all areas proposed for Project activities, including the entire proposed shipping route in the NSA."



LEGEND:

- Ship Location
- PROPOSED RAILWAY ALIGNMENT
- NUNAVUT SETTLEMENT AREA BOUNDARY
- NOMINAL SHIPPING ROUTE - YEAR-ROUND

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.

SCALE 50 25 0 50 100 150 200 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

LIKELY PASSING LOCATIONS OF PROJECT ORE CARRIERS WITHIN THE RSA DURING THE OPEN-WATER PERIOD (S=SUMMER) AND ICE-COVERED PERIOD (W=WINTER)

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_027

FIGURE 8-5.2 REV 0

Figure ID: BL_Vol8_GIS_027 Passing Locations of Ore Carriers within the RSA during Summer (S) and Winter (W) Figure 8-5-2.mxd

Table 8-5.2 Likely locations where Project ore carriers will pass each other within the RSA during open-water and ice-covered periods

Period	Vessel Speed (kts)	Number of passing locations within RSA	Passing Mark--distance from Steensby Port
August – December (open-water period)	14 (26 km/h)	2	621 km (336 nmi)
			1243 km (671 nmi)
January – July (ice-cover period)	7 (13 km/h)	4	310 km (168 nmi)
			621 km (336 nmi)
			931km (503 nmi)
			1243 km (671 nmi)

5.6 RINGED SEAL

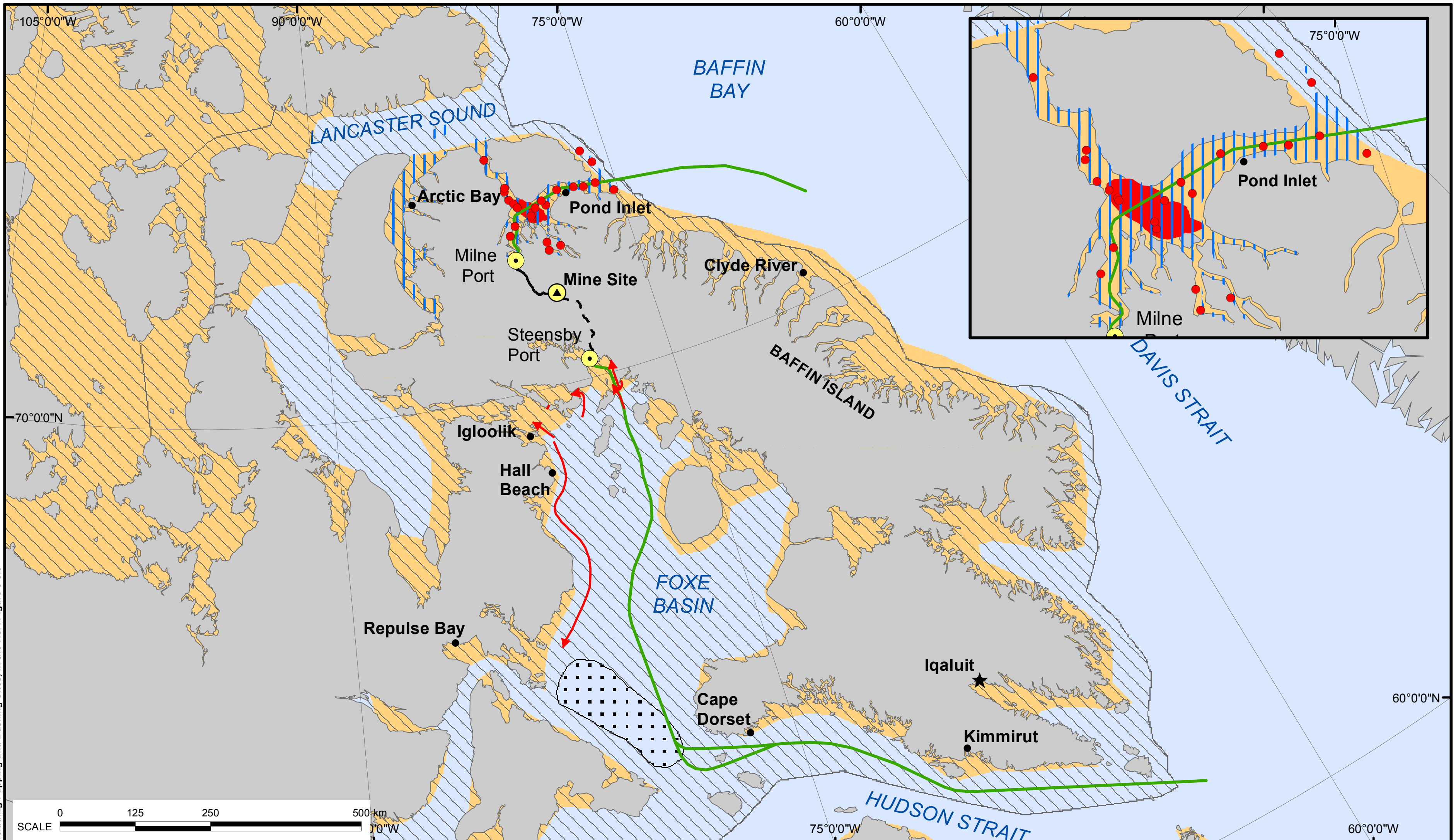
Ringed seals occur in the LSA and RSA throughout the year (Figure 8-5.3). Early in the ice-cover season, they establish a series of breathing holes and lairs. The stable landfast ice offers preferred habitat. Females give birth in March and April and nurse their pups for five to eight weeks; in May and June they abandon their lairs and haul out on top of the snow and ice to moult; they disperse during the open-water period. Ringed seals, particularly pups, are thought to be most susceptible to disturbance during birthing and lactation.

During consultations for the Project, the key concern expressed by community members was the effect of icebreakers on ringed seal pups on landfast ice; they noted that Steensby Inlet is an important location for seal pupping, and that icebreakers transiting through areas with seal lairs may kill pups (Arctic Bay Working Group and Public Meeting; Hall Beach Public Meeting; Igloolik Marine Mammal Workshop; Pond Inlet Working Group and HTO Meeting).

5.6.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on ringed seals: habitat change, disturbance, hearing impairment, masking and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in ringed seal habitat, behaviour, and health (Table 8-5.3). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour, or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant. The reader is referred to Volume 2, Section 3.8, for the criteria used to establish significance determination.



BL_Vol_GIS_019 Ringed Seal Distribution, Including Pupping and Basking Sites, in the RSA Figure 5-5.3

LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- KNOWN OR EXPECTED RANGE
- LIKELY ABUNDANT
- COMMON IN WINTER
- RINGED SEAL PUPPING LOCATION (IQ)
- SEALS BASKING ON ICE (IQ)
- RINGED SEAL MOVEMENT (IQ)

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

ᓄᓘᔮᓂ ᐅᔭᖅᓯᐅᖅᑐᑦ MARY RIVER PROJECT

RINGED SEAL DISTRIBUTION, INCLUDING PUPPING AND BASKING SITES, IN THE RSA

Baffinland Iron Mines Corporation

REF NO. BL_Vol8_GIS_019

ᑎᑎᖅᐅᔭᖅᓯᒪᔪᖅ FIGURE 8-5.3

REV 0

Table 8-5.3 Measurable Parameters and Threshold Values for Ringed Seals

Effect	Measurable Parameter [1]	Threshold [2]
Change in habitat caused by ice-breaking and/or ice management	Decrease in suitable pupping habitat in the landfast ice	Decrease of 10 % or greater in suitable ringed seal pupping habitat at Steensby Inlet
Disturbance caused by airborne and/or underwater noise	Change in occupancy of an area that has been identified as important for feeding, nursing, breeding, and hauling out. It is assumed that seals exposed to continuous sound levels from shipping or dredging where the sensation level exceeds 80 dB re 1 µPa (Davis and Malme, 1997) would exhibit an avoidance response [a]	≥10 % of ringed seals in the RSA exhibit strong avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat
Hearing impairment in water, pulsed or continuous sound	In water, pulsed sound: Ringed seals exposed to sound levels from blasting that exceed 180-190 dB re 1 µPa (rms) in water (NMFS, 2000) In water, "continuous" sound: Seals exposed to sound levels from shipping, vibratory pile driving, or dredging where the sensation level exceeds 100 dB re 1 µPa (Davis and Malme, 1997)	In water, pulsed sound: >10 % of ringed seals in the LSA are exposed to sound levels (pulsed) that exceed 190 dB re 1 µPa (rms) In water, continuous sound: >10 % of ringed seals in the LSA are exposed to sound levels (continuous) that exceed a 100 dB re 1 µPa sensation level
Mortality from construction activities (blasting) and vessel collisions	Increase above natural mortality per annum	>1 % of population in Steensby Inlet (including pups)

[1] Although specific data are lacking, measureable parameter levels necessary to elicit behavioural responses in feeding, nursing, or breeding ringed seals (versus seals conducting other activities) are likely higher than considered here

[2] Timeframe for all parameters and thresholds unless otherwise stated is "per year"

5.6.1.1 Habitat Change

The footprints of dock structures at Steensby Port were calculated to determine how much seal habitat would become unavailable. In fast ice, icebreakers create a narrow zone in which the ice is changed; in this zone, which is slightly wider than the ship for a single passage, the fast ice is broken up into small pans and brash ice. It has been assumed that icebreaking ore carriers will require an operating corridor of up to 1.5 km wide during the course of the ice-cover season because they will not be able to use a single track more than seven times before the ice become too difficult to traverse. Within the corridor, it is expected that the ice will consist of relatively small pieces that will refreeze after each passage, likely suitable for ringed seals to maintain breathing holes, but probably less so for establishing lairs. The assessment calculated the area of altered ice along the ship track into Steensby Port as well as the area near the ore dock (assuming a 1.85-km turning radius for ore carriers) where ice will be continuously altered during the ice-cover period. The area of changed ice was compared to the amount of landfast ice available to ringed seals in Steensby Inlet and Foxe Basin.

5.6.1.2 Disturbance

An approach similar to that used in Davis and Malme (1997) to assess the effects of icebreaking ore carriers on ringed seals near Voisey's Bay, Labrador, was used to assess the potential disturbance effects of shipping associated with the Project.

As noted in Davis and Malme (1997), human auditory research has been the basis for much of the efforts to estimate the auditory response of non-human species. The human auditory approach was simulated by subtracting the ringed seal audiogram (hearing threshold data) from the estimated received sound levels of Project activities at various distances and 1/3-octave bands (see Matthews *et al*., 2010; Zykov and Matthews, 2010). Results were plotted to create 1/3-octave sensation levels (see, e.g., Figure 8-5.4 for tugs operating in Steensby Port, and Appendix 8C-3, Figures 8C-3.1 to 8C-3.10). A 70-dB sensation level was used as a threshold to indicate the potential onset of disturbance, when some ringed seals may show minor behavioural changes such as alert responses or change in swim speed. This sensation level is merely suggested as a guide for the level at which some seals may exhibit a response. A sensation level of 80 dB was used as the threshold for a behavioural response that results in avoidance, albeit temporary. These estimated sensation levels assume that ringed seals exhibit similar auditory responses as do humans. From these graphs, it is possible to estimate the maximum distance in the 1/3-octave bands that the noise equals or exceeds the sensation level threshold (Appendix 8C-3, Table 8C-3.1).

5.6.1.3 Hearing Impairment

For impulse-sound sources like those from blasting, the 190-dB re 1 µPa (rms) criterion was used to calculate the area where seals may incur TTS (NMFS, 2000). Densities from aerial survey data, corrected for detection and availability biases, were used to provide estimates of the numbers of seals that may be present inside of the 190-dB zone. The approach used by Davis and Malme (1997) and described above (Section 5.6.1.2) was used to estimate numbers of seals that may be exposed to "continuous" sound levels high enough to cause TTS, using an assumed sensation level of 100 dB.

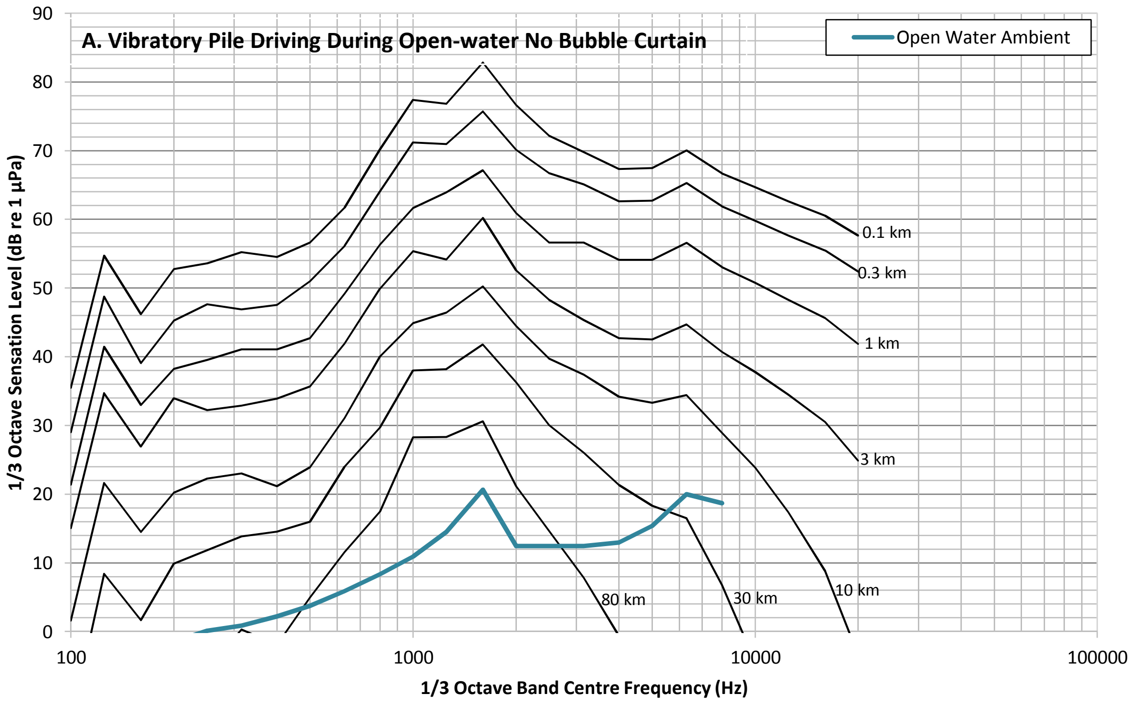
5.6.1.4 Masking

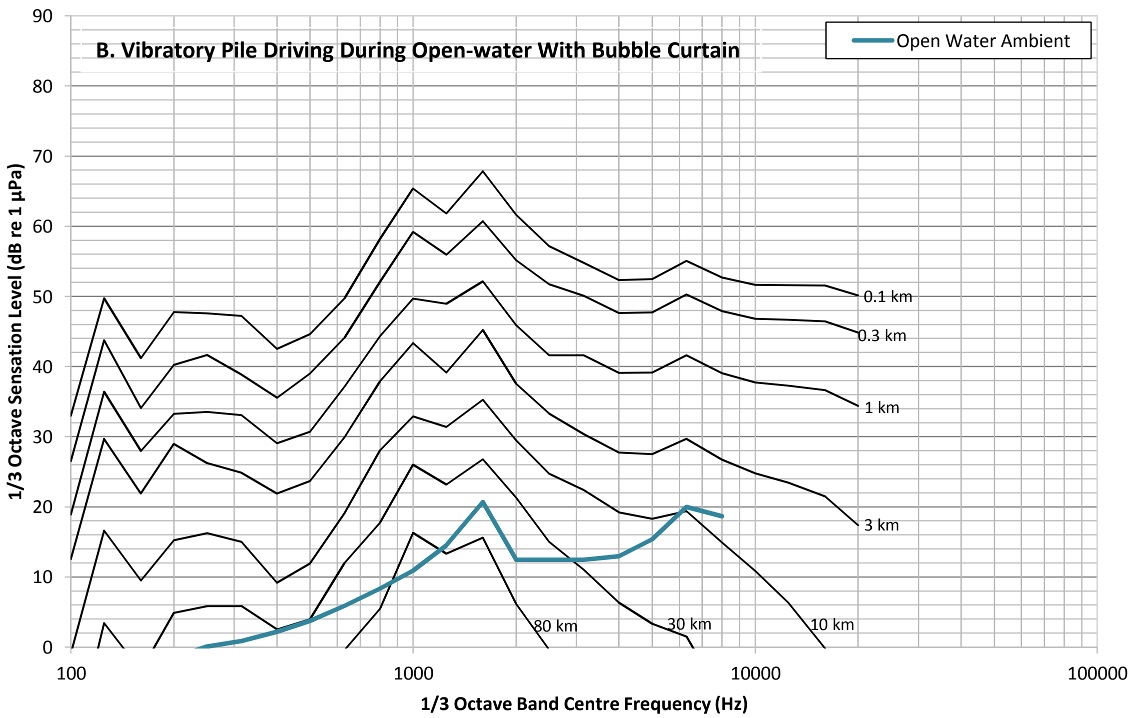
A qualitative discussion on the potential for ringed seal masking caused by Project activity noise is provided.

5.6.1.5 Mortality

The number of seal pups that may occur along a ship track in the landfast ice of Steensby Inlet was calculated based on aerial survey data and information on seal habitat and biology from the literature. Based on a study of the movement and growth of nursing ringed seal pups (Lydersen and Hammill, 1993), it is expected that newly-born pups are vulnerable to direct mortality from icebreaker traffic for no more than the first three weeks of life (Davis and Malme, 1997). As such, it was assumed that mortality along the ship track in the landfast ice of Steensby Inlet would be limited to a three-week period in late March and early April.

FIGURE ID: BL_Vol8_EXL_006 Ringed Seal 1/3 Octave Band Sensation Level Plot Figure 8-5-4





NOTES:
1. AMBIENT NOISE DATA FROM BURGESS AND GREENE (1998).
2. PREDICTED 1/3 OCTAVE NOISE LEVELS FROM ZYKOV (2011).
3. ANALYSIS APPROACH BASED ON DAVIS AND MALME (1997).
4. AUDIOGRAM DATA FROM TERHUNE (1988, 1989), TERHUNE AND TURNBULL (1995), AND KASTAK AND SCHUSTERMAN (1998).

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

EXAMPLE OF A 1/3-OCTAVE BAND SENSATION LEVEL PLOT USED IN THE RINGED SEAL EFFECTS ANALYSIS

Baffinland Iron Mines Corporation

Ref NO. BL_Vol8_EXL_006

FIGURE 8-5.4

REV 0

The areas exposed to noise levels that exceeded the threshold for avoidance were calculated for all modelled Project activities at both Milne and Steensby Ports and along shipping routes. For shipping during the ice-cover season, the shipping route areas were classified by ice type (landfast, pack, and open-water) based on 10 years of ice data (2000–2009) acquired from the Canadian Ice Services division of Environment Canada. These areas and aerial survey data were used to estimate the numbers of ringed seals that would be exposed to shipping noise and were adjusted to allow for seals hauled out but not sighted by observers (x 1.22, based on Frost *et al.*1988) and for the proportion of ringed seals not hauled out during the survey coverage (x 2.33, based on Kelly and Quakenbush, 1990). Data acquired during the June aerial surveys were the basis for estimating the numbers of ringed seals exposed to sensation levels ≥ 80 dB because it is likely that seals are more abundant in the LSA during the ice-cover period than during the open water, when they are known to disperse.

5.6.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on ringed seals considered in the assessment are listed below. Effects that are not assessed in detail (i.e., those ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking and/or ice management plus the footprints of dock structures;
- **Disturbance** caused by airborne and/or underwater noise from construction, shipping and aircraft overflights;
- **Hearing impairment** and/or damage caused by noise from construction activities;
- **Masking** of environmental sounds by vessel and construction noise; and
- **Mortality** from collisions with vessels and blasting during construction.

5.6.2.1 Habitat Change

There is some evidence to suggest that ringed seals preferentially establish breathing holes in the tracks of icebreakers (Alliston, 1980, 1981); however, it has been assumed that this habitat will not be available for ringed seals to establish structures (i.e., breathing holes and lairs). Similarly, it has been assumed that ice-covered habitat being maintained for ship traffic (i.e., vessel turning and standby operations) in the area of the ore dock at Steensby Port will also be available.

Ringed seals also occur, presumably in lower numbers, in areas of pack ice in Foxe Basin and Hudson Strait. Evidence of the ship track in mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Volume 3, Appendix 3G). It is not known if seals will avoid the ship track or take advantage of the frequently broken ice between transits. There is some evidence that seals use areas of ice altered by industrial activities, including icebreaking (see Section 5.6.2.2, below).

Planned Mitigation - Dock structures were designed to minimize the footprint in the marine environment. Icebreaking vessels will control the width of the shipping lane to <1.5 km by sailing along the same track as much as possible through landfast ice in Steensby Inlet. The shipping lane into Steensby Port will be delineated with markers to identify the boundaries of previous vessel tracklines. Icebreaking tugs and ore carriers will minimize the area of broken landfast ice to the extent possible.

Residual Effects - The footprint of dock structures in water depths adequate for breathing holes and lairs (i.e., >3 m deep; Moulton *et al*., 2002) is negligible at Steensby Port: 0.07 km^2). At Steensby Port, 136 km^2 of landfast ice at the ore dock and along the shipping route into Steensby Inlet will become less suitable for the creation of lairs and perhaps breathing holes. This changed habitat in the landfast ice represents 5.6 % and 0.36 % of the suitable landfast ice habitat in Steensby Inlet and Foxe Basin, respectively. This decrease in suitable seal pupping habitat is lower than the threshold value of 10 % (Table 8-5.2). Pack ice along the shipping route in Hudson Strait and Foxe Basin will also be changed, albeit temporarily, by icebreaking. Evidence of the ship track in the mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Volume 3, Appendix 3G). Ringed seals in pack ice are likely adapted to the constantly shifting habitat. It is estimated that an ore carrier will temporarily change ~76.5 km^2 of pack ice during a single transit to and from Steensby Port. This represents <1 % of pack ice in Hudson Strait, Foxe Basin and near Steensby Inlet.

With mitigation measures in place, it is predicted that effects of habitat change on ringed seals will be of low magnitude (Level I), medium term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.4). The residual environmental effect of habitat change on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.2.2 Disturbance

Construction activities, vessel traffic, icebreaking and aircraft overflights have the potential to interact with ringed seals. Disturbance can lead to effects on lair attendance, nursing, reproductive output, habitat use (avoidance), and (potentially) individual survival, especially of pups. Construction will occur at both Milne and Steensby Ports. Dredging, vibratory pile driving, blasting and drilling will occur at Steensby Port only.

Based on the results of acoustic modelling and analyses of audiogram and ambient noise level data, ringed seals may detect Project activity sounds at ranges of at least 75 km (drilling) to 250 km (ore carriers). At these extreme distances, project noise is likely to be perceived as a slight increase in ambient noise rather than identified as a specific activity. In any event, the mere detection of a distant sound will not negatively affect a seal (see Richardson *et al*., 1995a). Available evidence, which is reviewed below, indicates that ringed seals are quite tolerant of industrial activities during both the ice-covered and open-water seasons. As noted earlier, it is assumed that they will temporarily avoid areas where the sensation level reaches ~80 dB in the 1/3-octave band with the highest sound level (see Davis and Malme, 1997). Some seals are assumed to exhibit minor behavioural responses at a 70-dB sensation level.

Construction: Drilling, Blasting, and On-ice Activity - In-water blasting will be used late in the ice-cover season (i.e., late May) to level the seabed for placement of caissons at the Steensby ore dock. It is estimated that there will be 12 nominal blast events (nine at the ore dock and perhaps three at the bridge site). It is assumed that the blasts will be detonated periodically over one week. DFO's published overpressure guideline (100 kPa) for explosives will be met. Pinnipeds seem quite tolerant of noise pulses from "small" explosives (Richardson *et al*., 1995a). Firecracker-like explosives initially startle seals and sea lions, and often induce them to move away, but avoidance wanes after repeated exposure. Northern fur seals breeding on land did not exhibit any obvious response to nearby (0.6–2 km) blasts from quarries (Gentry *et al*., 1990). South American fur seals, sea lions and grey seals exposed to blasting operations showed little or no reactions. The specific responses of ringed seals have not been published. Ringed seals in and near the blast sites will likely be engaged in moulting and as such would typically spend large periods of time hauled out on top of the ice and snow.

Prior to blasting, blast charge holes will have to be drilled. It is estimated that drilling at the ore dock site will take about one month and the bridge site about two weeks, late in the ice-cover period. The specific responses of ringed seals to drilling have not been published. In recent years, studies of the effects of other on-ice industrial activity on ringed seals have been undertaken by researchers in the Alaskan and Canadian

Table 8-5.4 Effects Assessment Summary: Ringed Seals

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only), drilling (Steensby only), dredging (Steensby only), and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for seals in the area of blasting; bubble curtain system; discourage seals from the blast area with acoustic deterrent device. Drilling in late April/May. Monitoring for seals in and near safety zone for blasting and vibratory pile driving. Reduce vessel idling at dock side.	Level I	Level I	Level I, Level II	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet.	Level I	Level I	Level II	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over seals for passengers to 'get a better look' or for photography.	Level I	Level I	Level II	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level II	Level II	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking [4] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side. Minimize footprint of ice disturbance at ore dock and along shipping route. Commence icebreaking activity prior to period of lair and breathing hole creation.	Level I	Level II	Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over seals for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.5 Significance of Residual Effects to Ringed Seals

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

Beaufort Sea (Moulton *et al*., 2003, 2005; Harwood *et al.,* 2007) and, while relevant, it should be noted that these studies cover a more intense and longer level of industrial activity than is proposed for the Project.

Based on intensive and replicated aerial surveys during springs 1997–1999 (pre-industry) and 2000-2002 (industry) in the Alaskan Beaufort Sea, there was no evidence that construction, drilling or production activities at an artificial island (BP's Northstar oil development) affected local ringed seal distribution, abundance or structure use (Moulton *et al*., 2005; Williams *et al*., 2006). Seal densities were not reduced near Northstar in industry years either in comparison with more distant areas or the same area in pre-industry years. Active seal structures were found (by dogs) as close as 140, 325, and 168 m from an ice road, the artificial island, and pipeline, respectively, after a winter of intensive construction (Williams *et al*. 2006). Seals at these locations were exposed to broadband underwater sound levels of ~114, 123, and 120 dB re 1 µPa at times when gravel trucks were driving by, vibratory sheet piling was taking place at the island, and a Ditchwitch was cutting ice for a pipeline trench, respectively. Similarly, there was no evidence that drilling and production activities at the Northstar oil development affected ringed seal densities or structure use (Moulton *et al*., 2005; Williams *et al.* 2006). Many active structures were found close to the artificial island and ice road, including an open breathing hole located 34 m from the island and an active lair 403 m from the island. Received broadband levels of underwater sound from drilling could have been >115 dB re 1 µPa at 34 m and ~99 dB re 1 µPa at 403 m (Greene *et al*., 2008). Similarly, in the Canadian Beaufort Sea, Harwood *et al.* (2007) also found no direct negative effect on ringed seals using the fast ice near Devon's Paktoa drilling site, where there was active well testing, abandonment, and demobilization activities, as well as construction and maintenance of ice roads. This assessment was based on density and distribution of lairs, movement and behaviour of tagged seals, and the distribution of seals during their moulting period.

Associated with the drilling and blasting operations at the ore dock site will be on-ice support vehicles, e.g., snowmobile traffic. In addition to the studies described above, there is further evidence that seals do not react overtly to on-ice traffic. Weddell seals (mother and pup pairs) showed little reaction to Hagglund vehicles that approached within 100–400 m; sound levels at 250 m were reported as 24 dB re 20 µPa (van Polanen Petel *et al.* 2007). Kelly *et al.* (1988) reported that three ringed seals were observed to depart their lairs as snow machines approached within 0.5–2.8 km, and others stayed in their lairs at distances of 0.5 km; "In all instances in which seals departed lairs in response to noise disturbance, they subsequently reoccupied the lair." A ringed seal was shown to temporarily leave its lair in response to a vibroseis unit that was idling between surveying (Kelly *et al*., 1988); Holliday *et al.* (1984) estimated that noise levels near and in the seal's lair at the time were 136 dB re 1 µPa underwater and 69 dB re 20 µPa in air. Also, of note, more than half of the holes within 150 m of vibroseis lines remained in use, but holes <150 m from the lines were more likely to be abandoned than were holes farther away (Burns *et al*., 1982). The authors concluded that there was some localized displacement of ringed seals close to the vibroseis lines but that overall, displacement was insignificant.

Overall, ringed seals seem quite tolerant of on-ice industrial activities of much longer duration and greater intensity than will be associated with on-ice construction activities at Steensby Inlet.

Residual Effects of Drilling, Blasting, and On-ice Activity - Sensation levels from drilling operations (through ice and the seafloor) are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance, respectively (Appendix 8C-3, Table 8C-3.1, Figure 8C-3.2). However, it is quite likely that seals in the vicinity of drilling operations and the associated on-ice activity (snowmobiles, etc.) will exhibit localized and temporary avoidance of the area. Blasting operations (assuming 12 events) will occur intermittently over ~1 week in late May. With appropriate mitigation measures in place (bubble curtain, overpressure <100 kPa—see Section 5.6.2.3), the zones of avoidance and disturbance onset are estimated at 3 km and 10 km, respectively (Appendix 8C-3, Table 8C-3.1, Figure 8C-3.1). Based on aerial survey observations (corrected for detection and availability biases) made in Steensby Inlet in June, it is estimated that 52 ringed seals may occur within the zone of avoidance and that 400 could be present in a 10-km zone around the blast site (Appendix 8C-3, Table 8C-3.2). Any avoidance is expected to be temporary and localized (based on studies in the Alaskan and Canadian Beaufort Sea

Construction: Pile Driving - Ringed seals exposed to pile-driving pulses exhibited little or no reaction to impact pipe-driving sounds at a shallow water site in the Alaskan Beaufort Sea (Blackwell *et al.*, 2004). At the closest point (63 m) where sound levels were measured, received levels were 151 dB re 1 µPa (rms) and 145 dB re 1 $\mu Pa^2 \cdot s$ SEL. Other seal species seem less tolerant of pile driving, at least at their haul-out sites. Harbour seal haul-out behaviour was affected by pile driving at an offshore wind farm (Nysted) in the western Baltic (Edrén *et al.*, 2004). The authors found a 31–61 % reduction during periods with pile driving vs. no pile driving in the number of seals hauled out at a beach approximately 10 km from the construction site. Sound levels were not measured and observations of seals in the water were not made. The authors suggested that seals may have spent more time in the water because that is a typical response to disturbance, or the seals may have used an alternate haul-out site. At an adjacent wind farm to Nysted (Horns Rev), no seals were observed during ship-based surveys in the wind farm during pile driving. The reactions of harbour seals to the pile driving appeared to be short-term because aerial surveys did not reveal any decrease in overall abundance during the 2002–2003 construction period or 2004-2005 operation period (Teilmann *et al.*, 2006).

Residual Effects of Pile Driving - Pile driving with a vibratory pile driver will occur intermittently over a two-month period at the Steensby Port site during the first year of the Construction Phase. Vibratory pile driving will be used to install sheet piles (50 cm x 22 m) at the freight dock site in water depths of about 15 m. Vibratory pile driving produces non-impulsive sound at much reduced sound pressure levels compared to impact pile driving. A source level of 185 dB re 1µPa @ 1 m was assumed for modelling purposes (Zykov, 2011 in Appendix 8C-4). The zones of avoidance and disturbance onset are estimated as 0.15 km and 0.7 km, respectively (Appendix 8C-5, Table 8C-5.1, Figure 8C-5.1). There are no density estimates available for ringed seals during the open-water period in the RSA. As noted earlier, ringed seals exhibited little or no reaction to impact pipe-driving sounds at a shallow water site in the Alaskan Beaufort Sea (Blackwell *et al.*, 2004). Some ringed seals in Steensby Inlet may exhibit temporary and localized avoidance of the pile-driving (and other construction) activities at the freight dock site.

Construction: Dredging - Dredging is planned at Steensby Inlet Port site only during the open-water season of Year 1. There have been no published accounts of ringed seal response to dredging.

Residual Effects of Dredging - Sensation levels from dredging are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance, respectively, at the Steensby Port site (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.3 and 8C-3.8). However, it is likely that seals in the vicinity will exhibit localized and temporary avoidance of the area, based on published accounts of this species response to other types of industrial activity during both the open-water and ice-cover periods.

Vessel Traffic - Ringed seals occur along the entire shipping route into the Milne and Steensby Port sites throughout the periods when vessel traffic will occur. The numbers and types of vessels are provided in Volume 3, Table 3-1.1. Few authors have described the responses of pinnipeds to boats, particularly large ore carriers, and most of the available information concerns pinnipeds hauled out on land or ice. Ringed seals hauled out on ice pans often showed short-term escape reactions when a ship came within 250–500 m (Brueggeman *et al*., 1992). However, during the open-water season in the Beaufort Sea, ringed (and bearded) seals are commonly observed close to vessels (e.g., Harris *et al*., 1997, 1998, 2001, 2007, 2009). Several Hunter and Trapper Committee members in the Inuvialuit Settlement Region in the Beaufort Sea indicated that during seal hunting, they often create underwater noise to attract ringed seals to their boat, noting that seals are “curious”. In places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance. In England, harbour and grey seals at some haul-out sites appear to have habituated to close approaches by tour boats (Bonner, 1982).

When in the water (vs. hauled out), seals appear less responsive to approaching vessels. Some seals will approach a vessel out of apparent curiosity, including noisy vessels such as those operating airgun arrays (Moulton and Lawson, 2002). Suryan and Harvey (1999) reported that Pacific harbour seals (*Phoca vitulina richardsi*) commonly left the shore when powerboat operators approached to observe them. These seals apparently detected a powerboat at a mean distance of 264 m, and seals left their haul-out sites when boats approached to within 144 m. Harbour seals hauled out on floating ice in fjords in Disenchantment Bay, Alaska, were more likely to enter the water when a cruise ship approached within 500 m (Jansen *et al*., 2010). Seals that were approached as close as 100 m were 25 times more likely to enter the water than those approached at 500 m. Cruise ships that approached directly vs. abeam resulted in more seals entering the water. Based on available information, some seals are likely to avoid approaching vessels by a few hundreds of metres, and some curious seals are likely to swim toward them.

Planned Mitigation for Vessel Traffic - Ore carriers transiting the shipping route have a modern design that is expected to limit noise output (see Volume 3, Section 3.6.2). All vessels will maintain a constant course and speed whenever possible. In addition, vessels will minimize idling of engines when docked.

Residual Effects of Vessel Traffic - Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that ringed seals in the water would avoid ore carriers travelling during the open-water period at the Steensby shipping route by <100 m (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.5 to 8C-3.7, 8C-3.9 and 8C-3.10). Ringed seals hauled out on ice may temporarily avoid an ore carrier (by diving into the water) transiting to and from Steensby Inlet, perhaps at distances up to 500 m. Ringed seal avoidance to a passing ore carrier during the open-water period is expected to be localized and short-term.

Vessel traffic at the Milne and Steensby Port sites will vary throughout the Project but is expected to be most intense during the Construction Phase. Eight to 10 vessels, including sealifts, tankers, line boats, barges and ore carriers (Steensby Port only), could be present at the port sites during construction. Noise levels from tugs were modelled at both sites (Matthews *et al*., 2010; Zykov and Matthews, 2010). Sensation levels from tugs are not expected to exceed the 80-dB criterion for avoidance at either the Steensby or Milne Port site (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.4 and 8C-3.8). It is expected that some ringed seals will exhibit localized avoidance of both port sites, particularly during the Construction Phase. It is possible that they may habituate to vessel presence and noise, given the length of the Project.

Icebreaking - Ringed and bearded seals on pack ice approached by an icebreaker typically dove into the water within ~0.9 km of the vessel, but tended to be less responsive when the same ship was underway in open water (Brueggeman *et al*., 1992). In another study, ringed and harp seals remained on the ice when an icebreaker was 1–2 km away, but often dove into the water when closer (Kanik *et al*., 1980).Ringed seals have also been seen feeding among overturned ice floes in the wake of icebreakers (Brewer *et al*., 1993), and ship's crew on the MV *Arctic* often have noted them in the track of broken ice behind the ship (Canarctic and Roche, 1993). Ringed seals, including mothers and pups, were observed hauled out on the landfast ice within 1 km of an icebreaker track into the Voisey's Bay site in Anaktalak Bay, Labrador (Sikumiut, 2007). A female ringed seal was observed diving in response to an icebreaker, whereas her pup stayed on the ice (Arctic Bay Working Group Meeting; Koonoo, pers. comm.). Hunters from Pond Inlet noted that an icebreaker elicits the same reaction as a killer whale (Q. Sanguya, pers. comm.). During an August–October seismic survey off northeast Greenland, an icebreaker led the seismic vessel through intermediate pack ice (Jones *et al*., 2009); seals (including hooded, harp, bearded and ringed) were seen in ice concentrations of 1/10–9/10, and 59 of the 63 seal sightings were of seals first observed on ice. Of those, 15 dove into the water as the vessels approached. However, the observer in all cases was aboard the seismic vessel and may not have observed animal reactions occurring at distances beyond ~2.5 km or obscured by the icebreaker ahead. Observations made from an icebreaker (or nearby vessel) should be interpreted with caution, because animals that may avoid the vessel at longer distances would not be detected. Seals hauled out on ice also show mixed reaction to approaching vessels and icebreakers. Some may dive if the icebreaker comes within 1 km. There are some indications that seals in the RSA have become "used to ships" and do not seem to be affected (M. Akumalik and I. Shooyook, Arctic Bay, pers. comm.).

Alliston (1980, 1981) examined the abundance and distribution of ringed seals during spring at study sites in the Beaufort Sea and in Labrador where icebreakers had travelled through landfast ice during the previous winter. There was no indication of reduced seal numbers. Densities of ringed seals in Lake Melville were higher along the old icebreaker track of the CCGS *Sir John Franklin* than in unaffected, unbroken ice (Boles *et al*., 1983). Ringed seals may have preferentially established breathing holes in the ship tracks. Of note, the studies by Alliston involved winter icebreaking passages during one or two periods. The ship track used by icebreaking ore carriers in the Project will be subject to regular, approximately every two days, passages of large ore carriers. It is uncertain whether seals will avoid the ship track or take advantage of the broken ice.

Residual Effects of Icebreaking - Icebreaking by Cape-size ore carriers will occur throughout ice-cover season during the Operation Phase. It is expected that an icebreaking ore carrier will transit through the southern LSA to and from Steensby Port every two days. In addition, icebreaking tugs will be present at Steensby Port throughout ice-cover periods. Based on corrected seal density estimates from aerial surveys conducted in Steensby Inlet, Foxe Basin and Hudson Strait during June, it is estimated that ~220 ringed seals may exhibit temporary avoidance of an ore carrier passing through the southern LSA during a single vessel passage. This corresponds to estimated distances of 0.3–0.7 km of avoidance based on the 80-dB sensation level criterion (Appendix 8C-3, Table 8C-3.1). At the Steensby Port ore dock, icebreaking tugs may cause ~17 ringed seals to avoid the area of changed ice (Appendix 8C-3, Table 8C-3.2). It is quite likely that at least some of the same ringed seals, particularly those in landfast ice in Steensby Inlet, will be affected multiple times by icebreaking during the course of a single ice-cover season. Based on available evidence, ringed seals seem tolerant of industrial activity, and disturbance effects are expected to be localized and temporary.

Aircraft Overflights - There has been little systematic study of the reactions of seals to aircraft overflights, and most of the available data concern seals hauled out on land or ice rather than those in the water (Richardson *et al*., 1995a). During the Construction phase, aircraft will regularly use the airstrips at Milne and Steensby Inlets. It is projected that a Boeing 737 (or equivalent) aircraft will take off and land at the Steensby airstrip daily during the four-year construction period. During Operations, flights will be less frequent, on the order of two times a month at the Steensby airstrip. At the Milne airstrip, a Dash-8 or ATR is expected to be the largest aircraft, although Twin Otters may also be used. During construction, the Milne airstrip will be used approximately twice a week throughout the year; during Operations, flights to Milne Inlet will be infrequent.

Received noise levels underwater have been recorded for a few aircraft, including the de Havilland Canada DHC-6 Twin Otter (Richardson *et al*., 1995a; Patenaude *et al.* 2002). The Twin Otter's PT6A-27 engines produce prominent tones primarily at 83 Hz and harmonics of this frequency (Richardson *et al*., 1995a; Patenaude *et al*., 2002). With the aircraft flying at an altitude 150 m above the surface, levels received by a hydrophone 3 m below the surface in the 10–500 Hz bandwidth (averaging time 0.75 s) ranged from ~97 dB re 1 µPa for aircraft travelling at ~185 km/h to ~114 dB re 1 µPa at ~280 km/h (Patenaude *et al*., 2002). At 18 m below the surface, received levels varied from ~95 dB re 1 µPa at ~185 km/h to ~120 dB re 1 µPa at ~280 km/h (Patenaude *et al*., 2002). Sound levels from a Boeing 737 taking off (assumed altitude of ~300-450 m; C. Greene, Greeneridge Sciences, pers. comm.) from the Anchorage International Airport were measured at ~102 dB re 1 µPa in the 1/3-octave band, with the highest sound level at a hydrophone deployed 10 m deep in the water column, located <0.8 km from the sound source and at an estimated 45° angle from the receiver (Blackwell and Greene, 2002). There are no reports of the underwater sound levels produced by the Dash-8 or ATR.

In-air sound from aircraft would have most of the energy at low frequency. Blackwell and Greene (2002) found that most of the energy was between 100 and 1000 Hz, dropping off steeply between 3 and 10 kHz. In-air sound levels from a Boeing 737 taking off measured <0.8 km from the Anchorage International Airport, at an assumed altitude of ~300–450 m (C. Greene, Greeneridge Sciences, pers. comm.), was estimated at ~80 dB re 20 µPa in the 1/3-octave band with the highest sound level (Blackwell and Greene, 2002).

Born *et al.* (1999) assessed the responses of ringed seals hauled out on the ice to overflights by fixed-wing twin-engine aircraft (Partenavia PN68 Observer) and a helicopter (Bell 206 III). Both flew over seals at an altitude of 150 m. Overall, 6 % of 5,040 seals left the ice in reaction to the fixed-wing aircraft and 49 % of 227 seals left the ice in response to the helicopter. Similarly, a small percentage of ringed seals (~2.3 % of 2,963) were observed to dive into holes or cracks in response to overflights at 91-m altitude by a fixed-wing Turbo Commander 690A (Moulton *et al*., 2003). A slightly higher percentage was observed diving into holes or cracks (4.0 % of 3,007 seals) during overflights by a Twin Otter at the same altitude. Most seals were observed looking (22.9 %) at the aircraft or exhibiting no detectable response (58.6 %; Moulton *et al*., 2000). Responses of seals inside lairs will likely be lessened, because airborne sound levels from aircraft will be diminished as snow attenuates sound transmission.

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of ~450 m over marine areas, when weather conditions allow. In addition, aircraft will be prohibited from flying low over seals for passengers to 'get a better look' or for photography.

Residual Effects of Aircraft Overflights - Ringed seals may be exposed to aircraft sound while they are in their lairs, hauled out on snow and ice, or in the water. Reactions to overflights by the aircraft (Twin Otter, Dash-8, and ATR) at Milne Inlet are expected to be limited to a brief alert or startle response and sometimes a dive as the aircraft flies over. These types of behavioural responses would have little consequence for individual seals or their populations. Ringed seals in Steensby Inlet will be exposed to daily overflights by large aircraft (e.g., Boeing 737). Ringed seals are more abundant in Steensby Inlet during the ice-cover season than at other times of the year, and they primarily occur inside of lairs. Airborne sounds from aircraft will be diminished inside lairs. Cummings and Holliday (1983) reported that, over the 105–200 Hz frequency band, the received level of airborne noise was reduced by an average of 11 dB below snow 70 cm deep. Some seals may leave the lair during an overflight but, based on previous studies of ringed seal response to industrial activity, the absence is expected to be temporary. Ringed seals will be more dispersed during the open-water period, and individuals, particularly those under the direct flight path of the Boeing 737, may be exposed to sound levels that cause a disturbance response.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on ringed seals from construction, shipping, and aircraft overflights will be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting and aircraft overflights during Operation Phase; Level I), intermittently (pile driving, shipping and aircraft overflights; Level II), or frequently (vessels at ports; Level III), and confined to the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.4). The residual environmental effects of disturbance from Project activities on ringed seals are predicted to be "*not significant*" (Table 8-5.5).

5.6.2.3 Hearing Impairment

Ringed seals near the Steensby Inlet Port site during periods of construction may be exposed to sound levels that are high enough to cause hearing impairment. A review of hearing impairment studies relevant to ringed seals is provided below.

Temporary Threshold Shift (TTS) - TTS for underwater sounds has been measured in individuals of three pinniped species: harbour seal, California sea lion and northern elephant seal. Studies to date involved exposures either to broadband or octave-band non-pulse noise over durations ranging from 12 minutes to several hours, plus limited data on exposure to underwater pulsed sound. For the conditions tested, the harbour seal experienced TTS at lower exposure levels than did the sea lion or elephant seal.

Two California sea lions did not incur TTS when exposed to single brief pulses with received levels of ~178 and 183 dB re 1 μPa (rms) and total energy fluxes of 161 and 163 dB re 1 $\mu Pa^2 \cdot s$ (Finneran *et al*., 2003). However, initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower levels than do small odontocetes exposed for similar durations. For sounds of relatively long duration (20–22 min), Kastak *et al.* (1999a, b) reported that these could induce mild TTS in California sea lions, harbour seals and northern elephant seals by exposing them to underwater octave-band noise at frequencies in the 100–2000 Hz range. Mild TTS became evident when the received levels were 60–75 dB above the respective hearing thresholds, i.e., at received levels of about 135–150 dB. Three of the five subjects showed shifts of ~4.6–4.9 dB and all recovered to baseline hearing sensitivity within 24 h of exposure.

Schusterman *et al.* (2000) showed that TTS thresholds of these pinnipeds were somewhat lower when the animals were exposed to the sound for 40 minutes compared to 20–22 minutes, confirming that there is a duration effect. Similarly, Kastak *et al.* (2005) reported that threshold shift magnitude increased with increasing SEL in California sea lion and harbour seal. They noted that doubling the exposure duration (+3 dB SEL or from 25 to 50 minute exposure) had a greater effect on TTS than did an increase of 15 dB (95 vs. 80 dB) in exposure level. Mean threshold shifts were 2.9–12.2 dB, with full recovery within 24 h (Kastak *et al*., 2005). Kastak *et al.* (2005) suggested that sound exposure levels resulting in TTS onset may range from 183 to 206 dB re 1 $\mu Pa^2 \cdot s$.

TTS in pinnipeds for airborne noise has been measured following exposure to single pulses and to non-pulse noise. A review of these studies is provided in Southall *et al.* (2007).

PTS - Physical damage to the hearing apparatus of a marine mammal can occur if it is exposed to sound impulses that have high peak pressures, especially if there are very short rise times, or if the animal is exposed to long periods of high noise levels. Such damage can result in hearing damage or loss at some or all frequencies; this is termed PTS. When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, and in other cases, the animal is unable to hear sounds at specific frequency ranges.

Single or occasional occurrences of mild TTS do not cause permanent auditory damage in terrestrial mammals, and presumably do not do so in marine mammals. However, very prolonged exposure to noise strong enough to elicit TTS, or shorter-term exposure to noise levels well above the TTS threshold, can cause PTS. In terrestrial mammals, the received sound level from a single noise exposure must be far above the TTS threshold for there to be any risk of permanent hearing damage (Kryter, 1985, 1994). Sound impulse duration, peak amplitude, and rise time are the main factors thought to determine the onset and extent of PTS. Based on existing data, Ketten (1995) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species-specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

Relationships between TTS and PTS thresholds have not been studied in marine mammals but are assumed to be similar to those in humans and other terrestrial mammals. Southall *et al.* (2007) used available data on PTS in terrestrial mammals plus data on TTS in marine mammals to derive proposed injury criteria for individual marine mammals exposed to "discrete" noise events within a 24-hour period (see Table 3 in Southall *et al.* (2007)). These criteria were defined for three sound types: single pulses, multiple pulses, and nonpulses. For pinnipeds exposed to single or multiple pulses the PTS-onset as a SPL in water was estimated at 218 dB re 1 µPa (peak)(flat) and 186 dB re: 1 $\mu Pa^2 \cdot s$ as a SEL. For nonpulses, the corresponding levels are 218 dB re 1 µPa (peak)(flat) and 203 dB re: 1 $\mu Pa^2 \cdot s$. For pinnipeds exposed to airborne noise, injury criteria for PTS-onset as SPLs are 149 dB re 20 µPa (peak)(flat) for all three sound types and 144 dB re 20 $\mu Pa^2 \cdot s$ for single and multiple pulses and 144.5 dB re 20 $\mu Pa^2 \cdot s$ for nonpulses as SELs.

For purposes of this assessment, it has been conservatively assumed (protective of seals) that ringed seals exposed to pulsed sound levels of ≥180 dB re 1 µPa (rms) may experience TTS or temporary hearing impairment. Based on the results of the acoustic modelling studies (Matthews *et al*., 2010; Zykov and Matthews, 2010) undertaken for the Project, blasting operations at Steensby Port site could produce sound levels of 180 dB within 885 m of the source (assuming no bubble curtain was in place and calculated from broadband, 10–2,000 Hz sound fields. For Project activities that produce "continuous" sound (shipping, operation of tugs, drilling, dredging, vibratory pile driving) a sensation level of 100 dB could cause TTS. This is discussed in detail below.

Planned Mitigation - Blasting will occur late in the ice-cover season (late May) when only ringed seals are expected to be present. Blasting in late May will ensure that pupping and nursing periods are avoided. A blasting plan will be designed by an explosives contractor and in consultation with DFO to ensure that the 100-kPa waterborne acoustic overpressure threshold is not exceeded. To reduce sound transmission, an underwater bubble curtain will, as necessary, be employed. Underwater bubbles inhibit sound transmission through water because of density mismatch and concomitant reflection and absorption of sound waves. Some studies have shown that a bubble curtain can reduce the peak pressure of a shock wave by 15.4–17 dB (see Matthews *et al*., 2010). During blasting, it may be practical to sub-divide large charges into a series of smaller, time-delayed events (Wright and Hopky, 1998), to reduce sound levels. Based on a recommendation by DFO (Wright, 2002), a 500-m zone around the blast site will be visually monitored. If densities of seals are high, consideration will also be given to use of an acoustic deterrent device to encourage seals to leave the work area. Inuit monitors may be employed to convey their knowledge about ringed seals and their local habitat. As well, an environmental monitor will be on site during blasting operations. As part of the blasting protocol, the area will be assessed for seal presence and monitored for seal behaviour in response to on-ice activities.

Vibratory pile driving at Steensby Inlet will occur over a two-month period during open-water construction in Year 1. Acoustic modelling indicates that sound levels will not exceed 190 dB (rms) (Zykov, 2011 in Appendix 8C-4). As a conservative approach, a 50-m "safety zone" (which corresponds to sound levels of <160 dB (rms)) will be established and monitored around the pile driving site. An acoustic contractor will measure actual sound levels from pile driving at the earliest possible time during the construction season to verify acoustic modelling predictions. Observers (an Inuit monitor and an Environmental Monitor) will be present at the pile driving site to monitor the appropriate safety zone. Prior to pile driving operations, the safety zone will be monitored and if a seal is present within this zone, pile driving will not be permitted to commence. Observers will continue to monitor the zone during pile driving and if a seal is observed within or approaching the zone, pile driving will be halted until the seal has left the area.

Residual Effects - Based on acoustic modelling results and the implementation of mitigation measures, ringed seals are not expected to be exposed to receive sound levels high enough to elicit TTS. Using the conservative 180-dB threshold for impulsive sounds, and assuming that a bubble curtain effectively reduces sound levels, ringed seals would have to occur <45 m away from blasting to potentially incur temporary hearing impairment (Appendix 8C-3, Table 8C-3.1). There is little to no risk of seals incurring PTS. Ringed seals are unlikely to appear that close to a construction site with ongoing industrial activities. Also, monitors at construction sites will delay start up and implement shut downs for any ringed seals seen within the appropriate safety zone distance. Ringed seals in Steensby Inlet are not predicted to be exposed to in-air sound levels from aircraft overflights (Boeing 737) that exceed thresholds for hearing impairment in pinnipeds: 149 dB re 20 µPa (peak)(flat) or 144 dB re 20 $\mu Pa^2 \cdot s$ (M_{pa}) in air (Southall *et al*., 2007).

With mitigation measures in place, ringed seals are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects on ringed seals (if any) from Project activities will be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.4). The residual environmental effect of hearing impairment on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.2.4 Masking

Ringed seal call characteristics are relevant in assessing potential masking effects of anthropogenic sounds and their likely frequency range of best hearing. Ringed seals are a relatively quiet species, most vocal during the spring mating season (Stirling *et al*., 1983). Their calls are at frequencies from a few hundred to a few thousand Hz—above the frequency range of the most intense ship noise and construction activities. They produce clicks with a fundamental frequency of 4 kHz and varying harmonics up to 16 kHz (Schevill *et al*., 1963) as well as barks, high-pitched yelps, and low and high-pitched growls (Stirling, 1973). Most calls have most energy below 5 kHz (Stirling, 1973; Cummings *et al*., 1984). Source levels, ranging from 95 to 130 dB re 1 uPa·m/Hz (peak source spectrum levels), are low when compared to other marine mammals. This implies that detection ranges of those sounds are only ~1 km (Cummings *et al*., 1984), and in areas with average or lower densities, seals often may not be able to hear their nearest neighbours.

There are no published accounts of masking in ringed seals. Masking effects on calls by transient sounds like those from blasting and other natural sounds are likely limited because of their brief duration, although there are few specific data on this. Types and rates of calls were similar before and after exposure to playbacks of vibroseis sound. Some seals called during playbacks (Cummings *et al*., 1984). Masking during continuous shipping sounds is unlikely to be important because most sounds important to seals are predominantly at much higher frequencies than shipping noise; however, masking of some environmental sounds is possible.

Residual Effects - Given that sounds important to seals are predominantly at much higher frequencies than shipping noise, and given the intermittent nature of construction activity sounds, it is unlikely that masking would affect ringed seals.

With mitigation measures in place, it is predicted that residual effects of masking on ringed seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.4). The residual environmental effect of masking on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.2.5 Mortality

Although there are no specific studies on seal mortality from icebreaking, it is possible that ringed seals could be struck by icebreaking ships In a detailed analysis of the potential effects of icebreaking ore carriers on ringed seals off the Labrador coast, Davis and Malme (1997) concluded that adult ringed seals have more than enough mobility under the ice to avoid the close approach of an icebreaker, and that it is unlikely that icebreaking vessels will strike adult seals and cause mortality. Ringed seal pups are vulnerable to strikes, particularly if a vessel passes through a birth lair, as very young pups might be killed by crushing or exposure to cold water. Based on a study of the movement and growth of nursing pups (Lydersen and Hammill, 1993), it is expected that newborns are vulnerable to direct mortality from icebreaker traffic for the first three weeks of life (Davis and Malme, 1997).

Another potential source of mortality for ringed seals is blasting at the Steensby Port site during the first year of construction. There are several reports that pinnipeds near explosives (detonated in the water) were killed, including some pinnipeds exposed to charges in the kilogram or larger range (Richardson *et al*., 1995a: 306-307). However, other reports indicate that pinnipeds seem to show little response to small blasts (see Section 5.6.2.2 above).

During review of the Draft EIS, it was suggested that marine mammals, including ringed seals, may become susceptible to new predators (i.e., killer whales) that gain access to these animals from lead systems generated by ice breaking ore carriers. Given the temporary nature of the icebreaker track in pack ice (see Volume 8, Section 2.5.4), it is highly unlikely that killer whales would follow this rather tenuous track through Hudson Strait and into Foxe Basin. Because of their large dorsal fins, killer whales must avoid entering ice-covered waters.

Planned Mitigation - Shipping traffic along the southern route will occur year-round, including the period before and during which ringed seals begin to establish breathing holes and, more importantly, lairs. Females will not have the opportunity to create birthing lairs along at least a portion of the proposed shipping track and at the Steensby Port because the ice will already have been altered, and will continue to be altered by icebreaking vessels every two days—not permitting adequate conditions or time for the construction of lairs. Therefore, the risk of a vessel colliding with seals is reduced. In addition, ore carrier routing through landfast ice in Steensby Inlet will be restricted to a previously disturbed section of landfast ice during the pupping and nursing period (March and April). A mitigation measure similar to this has been employed at an artificial drilling island and its associated ice road in the Alaskan Beaufort Sea to minimize the risk of affecting ringed seals, particularly pups, during the pupping/nursing period. Vessel speed in areas of landfast ice (~11 km/h) and pack ice (approximately 13 km/h) will be reduced relative to speeds during the open-water season (approximately 26 km/h), thereby reducing the likelihood of collisions.

Residual Effects - Vessel collisions with ringed seals during the open-water period are highly unlikely, given that seals exhibit localized avoidance of vessels, they are fast swimmers, and they are much smaller than most vessels. Also, mitigation measures of maintaining a constant course and speed will reduce the already low potential for collisions. Icebreaking along the shipping route into Steensby Inlet will occur during the Operations phase. The timing and frequency of ore-carrier transits are expected to reduce the risk of vessel collisions with ringed seals during the ice-cover season, more specifically seal pups hauled out in lairs. It is possible that a new track through landfast ice will need to be established after seals have given birth. During the three-week period that pups are expected to be most vulnerable, ore carriers may have to make up to three new shipping routes into the Steensby Port site, assuming that the vessel establish a new route every seven days.

Ore carriers will traverse ~94 km of landfast ice in Steensby Inlet to reach the ore dock. Thus, young ringed seal pups on about 14.7 km^2 of landfast ice (94 km length x 0.052 km width x 3 routes) might be affected. The density of birth lairs in this region is not known. A density of 1 birth lair/km^2 is assumed (Davis and Malme, 1997). Thus, a maximum of 15 seal pups could suffer mortality from collisions with icebreaking ore carriers over a relatively short period each year during Operations. Although the effects on these individual pups would be irreversible, it would have a negligible and unmeasurable effect on the seal population in the area.

With mitigation measures in place, the risk of ringed seals experiencing mortality from blasting is very limited. The bubble curtain and meeting the 100-kPa overpressure guideline, blast timing, monitoring, and potential use of seal deterrent devices will greatly reduce the likelihood of a seal occurring close enough to a charge to experience mortality.

With mitigation measures in place, it is predicted that residual effects of mortality on ringed seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (Level II), and confined to the LSA (Level I); mortality effects are considered fully reversible at the population level (Level I; Table 8-5.4). The residual environmental effect of mortality on the ringed seal population is predicted to be "*not significant*" (Table 8-5.5).

5.6.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on ringed seals are summarized in Tables 8-5.4 and 8-5.5 and below.

5.6.3.1 Habitat Change

It is predicted that residual effects of habitat change on ringed seals will be of low magnitude (Level I), medium term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.4). The residual environmental effect of habitat change on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.3.2 Disturbance

It is predicted that residual disturbance effects on ringed seals from construction, shipping and aircraft overflights will be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting and aircraft overflights during Operation Phase; (Level I), intermittently (vibratory pile driving, shipping and aircraft overflights; Level II), or frequently (vessels at ports; Level III), and confined to the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.4). The residual environmental effects of disturbance from Project activities on ringed seals are predicted to be "*not significant*" (Table 8-5.5).

5.6.3.3 Hearing Impairment

Ringed seals are not expected to be exposed to sound levels high enough to cause hearing impairment with mitigation measures in place. It is predicted that hearing impairment effects on ringed seals (if any) from Project activities will be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I;

Table 8-5.4). The residual environmental effect of hearing impairment on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.3.4 Masking

It is predicted that residual effects of masking on ringed seals (if any) will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.4). The residual environmental effect of masking on ringed seals is predicted to be "*not significant*" (Table 8-5.5).

5.6.3.5 Mortality

With mitigation measures in place, it is predicted that residual effects of mortality on ringed seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (Level II), and confined to the LSA (Level I); mortality effects are considered fully reversible at the population level (Level I; Table 8-5.4). The residual environmental effect of mortality on the ringed seal population is predicted to be "*not significant*" (Table 8-5.5).

5.6.3.6 Cumulative Effects Within the Project

During review of the Draft EIS, reviewers requested that the effects of multiple Project activities, or what is sometimes referred to as "within Project cumulative effects", be considered. As discussed previously, ringed seals will be exposed to construction activities (i.e., dredging, pile driving, vessel traffic, aircraft overflights) at the Milne and Steensby Inlet port sites during the first four years of the Project. With mitigation measures in place, hearing impairment and mortality are not expected to result from construction activities. It was predicted that some ringed seals may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port sites; however, any avoidance is predicted to be localized. During the Operation Phase, ringed seals will be exposed to noise from ore carriers plus vessels located at the Steensby port site. It was predicted that some ringed seals may avoid the immediate area around each vessel. It is possible that this area of avoidance may increase slightly when multiple vessels are present at the port site; however, any avoidance is predicted to be localized. In addition, predicted ringed seal pup mortality that may occur annually as a result of collisions with ore carriers transiting the landfast ice in Steensby Inlet will not contribute significantly to within Project cumulative effects. However, the combination of disturbance from vessels and mortality of seals may marginally influence the availability of ringed seals in Steensby Inlet to local hunters.

5.6.4 Prediction Confidence

Based on the available evidence on ringed seal responses to on-ice industrial activity and vessel traffic, the planned mitigation measures, the overall health and population size of ringed seals in the RSA, and the baseline data used in the assessment, there is a high level of certainty in the predictions of residual effects (Table 8-5.4). No significant residual environmental effects are predicted for this indicator species.

5.6.5 Follow Up

The planned mitigation and monitoring for ringed seals were summarized in Section 5.6.2 and are provided in the marine mammal mitigation and monitoring management plan. Significant effects of Project activities on ringed seals are not expected and the level of confidence associated with this prediction is generally high. There is some uncertainty associated with acoustic modelling results, particularly because details of blasting parameters were limited during preparation of this report. Acoustic measurements can be acquired at the beginning of Construction to confirm safety zones for this activity to further ensure that ringed seals are afforded adequate protection from potential hearing impairment.

The need for additional follow-up monitoring will be determined, in large part, by the outcomes of workshops that will be held with communities (notably Igloolik and Hall Beach) on the marine mammal monitoring program. The relative merits of assessing changes in ringed seal pupping habitat caused by icebreaking ore carriers versus other monitoring programs will be discussed and the outcomes will be presented in the EEM Framework document as well as the marine mammal monitoring and mitigation plan. Similarly, the merits of examining other biological parameters of ringed seals will be considered where such information would assist in validating impact predictions or in confirming the effectiveness of mitigation measures.

5.7 WALRUS

Walruses occur year-round in the LSA and RSA, and are known to occur in relatively high numbers in northern Foxe Basin (Figure 8-5.5). Animals summer around Jens Munk, Koch, Rowley and the Spicer islands where they haul out, and move into Foxe Channel during winter (Orr *et al*., 1986). The degree to which walruses occur in Steensby Inlet is uncertain, but IQ reports that walruses regularly occur there in small numbers.

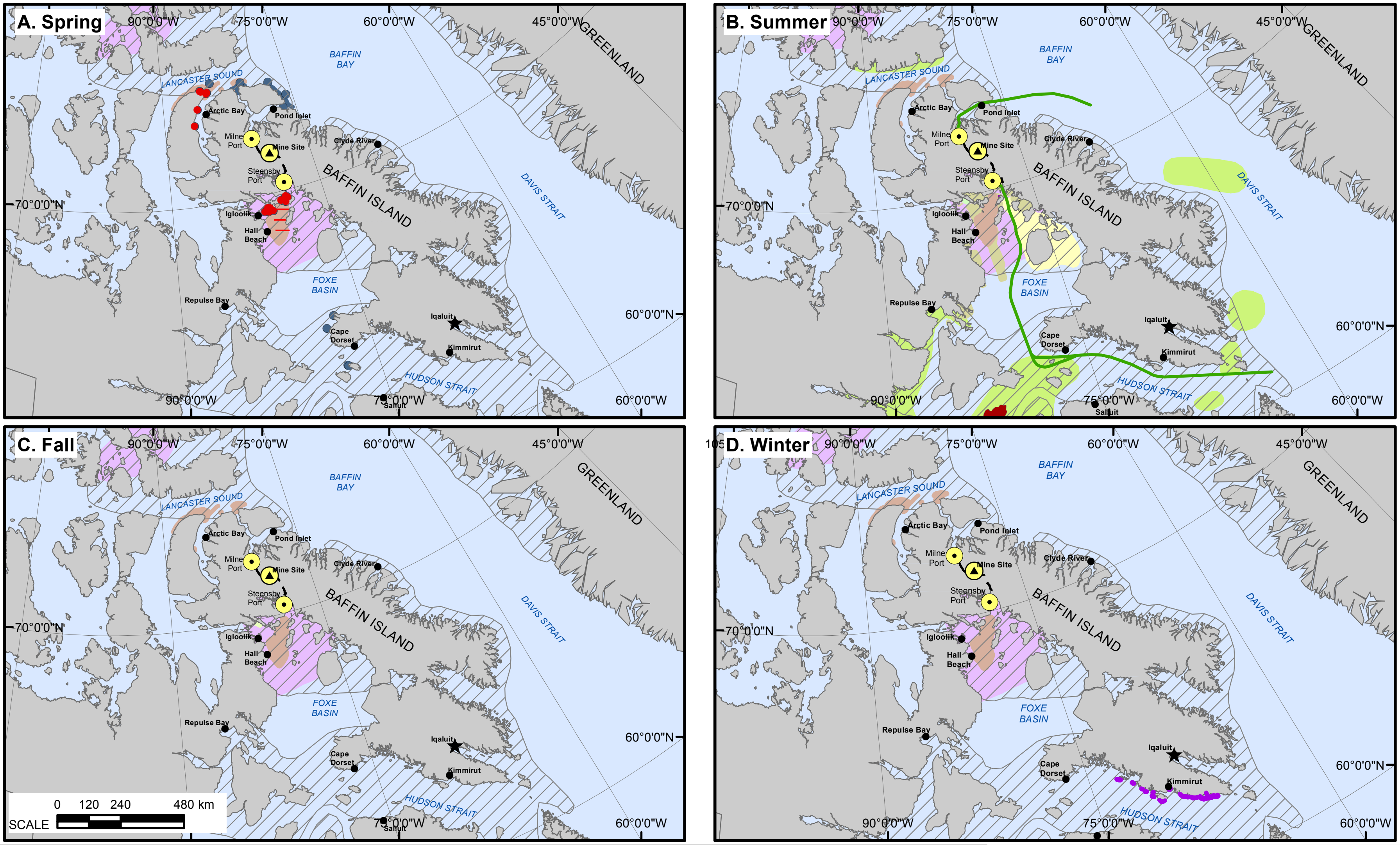
IQ also identifies that walruses calve in areas west of Rowley Island, along the ice floe edge or on moving pack ice. Timing of calving in the RSA is uncertain but in northwest Greenland, calves are born from early April to mid-July (Born, 1990; COSEWIC, 2006), and IQ states that calves are born between March and July in Foxe Basin. Along the shipping route through Hudson Strait, IQ indicates that walruses forage along the coastline near Kimmirut and summer around the Mill, Salisbury and Nottingham islands, near Cape Dorset (Figure 8-5.5). Very few walruses occur along the shipping route in Eclipse Sound and Milne Inlet.

During consultations for the Project, the key concerns about walruses expressed by community members were that the ore carriers along the shipping route and at the dock in Steensby Inlet would lead to the disruption and displacement of animals (Arctic Bay Working Group and HTO Meeting; Cape Dorset IQ Workshop; Clyde River Public Meeting; Hall Beach Public Meeting and Marine Mammal Workshop; Igloolik Marine Mammal Workshop and Public Meeting; Pond Inlet Meeting). It was acknowledged that walruses may get used to shipping sounds but that the effect of year-round traffic is uncertain (Hall Beach Marine Mammal Workshop).

5.7.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on walrus: habitat change, disturbance, hearing impairment, masking and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in walrus habitat, behaviour, and health (Table 8-5.6). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour, or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant. The reader is referred to Volume 2, Section 3.8, for the criteria used to establish significance determination.



LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- STOCK DISTRIBUTION
- YEAR ROUND CONCENTRATION
- FEEDING AREA (IQ)
- ISLAND WITH LARGEST KNOWN HAUL-OUT SITE
- GENERAL LOCATION (IQ)
- CALVING LOCATION (IQ)
- CALVING AREA (IQ)
- SUMMER CONCENTRATION
- AREA OF CONCENTRATION (IQ)
- AREA OF OCCURRENCE- SUMMER (IQ)
- AREA OF CONCENTRATION- SUMMER / FALL (IQ)

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

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WALRUS SEASONAL OCCURRENCE BASED ON SCIENTIFIC AND IQ INFORMATION

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_020

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REV A

Figure ID: BL_Vol8_GIS_020 Walrus Seasonal Occurrence Based on Scientific and IQ Information Figure 8-5-5.mxd

Table 8-5.6 Measurable Parameters and Threshold Values for Walrus

Effect	Measurable Parameter [1]	Threshold [1]
Change in habitat caused by icebreaking. Change in habitat caused by dock footprints.	Decrease in suitable walrus habitat for overwintering. Decrease in suitable walrus habitat for feeding and hauling out.	Decrease of 10 % or greater in suitable walrus overwintering area in Hudson Strait and Foxe Basin or feeding or haulout area in Steensby Inlet.
Disturbance caused by airborne, underwater noise and/or wave height generated by an ore carrier.	Change in occupancy of an area that has been identified as important feeding, nursing, breeding, or haul-out habitat. It is assumed that walruses exposed to continuous sound levels from shipping or dredging where the sensation level exceeds 80 dB re 1 µPa (Davis and Malme, 1997) would exhibit an avoidance response.	≥10 % of walruses in the RSA exhibit strong disturbance and avoidance reactions that lead to seasonal abandonment of areas identified as important habitat.
Hearing impairment in water, pulsed or continuous sound.	In water, pulsed sound: Walruses exposed to sound levels from blasting that exceed 180-190 dB re 1 µPa (rms) in water (NMFS, 2000). In water, "continuous" sound: Walruses exposed to sound levels from shipping, vibratory pile driving, or dredging where the sensation level exceeds 100 dB re 1 µPa (Davis and Malme, 1997).	In water, pulsed sound: >10 % of walruses in the LSA are exposed to sound levels (pulsed) that exceed 190 dB re 1 µPa (rms). In water, continuous sound: >10 % of walruses in the LSA are exposed to sound levels (continuous) that exceed a 100 dB re 1 µPa sensation level.
Mortality from collisions with vessels or stampeding at haul-out sites.	Increase above natural mortality per annum.	Any project-caused mortality.

[1] Timeframe for all parameters and thresholds unless otherwise stated is "per year"

5.7.1.1 Habitat Change

Walruses occur throughout the RSA but are most abundant in northern Foxe Basin, particularly in the area west of Rowley Island. They are known to occur in Steensby Inlet but the extent of their occurrence is unknown. Potential walrus habitat will change for the life of the Project as a result of the footprint of the dock structures. The footprint of the dock structures in Steensby Port is small (0.07 km^2).

Walruses are not expected to occur in areas of solid fast ice but may occur along the edge of the fast ice in Steensby Inlet and Hudson Strait. The shipping route does not overlap with landfast ice in Hudson Strait, and only a small portion of the landfast ice edge (maximum of 1.5 km) will be changed at the entrance to Steensby Inlet. Walruses are also expected to occur in areas of pack ice in Foxe Basin and perhaps in

Hudson Strait. The area of changed ice during periods of maximum pack ice coverage was calculated and compared to overall available pack ice in Foxe Basin.

5.7.1.2 Disturbance

Assessment of the potential level of disturbance to walrus used the same approach as for ringed seals (see Section 5.6.1.2 for details). The human auditory approach (Davis and Malme, 1997) was simulated by subtracting the walrus audiogram (hearing threshold data) from the estimated received sound levels of Project activities at the Steensby Port site and associated shipping route at various distances and 1/3-octave bands (see Matthews *et al*., 2010). (Project activities at Milne Inlet were not considered because of the near absence of walruses in that area). Results were plotted to create 1/3-octave sensation levels (Appendix 8C-3, Figures 8C-3.11 to 8C-3.17). From these graphs, an estimate was made of the maximum distance in the 1/3-octave bands that the noise equals or exceeds the sensation level thresholds for disturbance onset (70-dB sensation level) and avoidance (80-dB sensation level; Appendix 8C-3, Table 8C-3.3).

The areas exposed to noise levels that exceeded the threshold for disturbance onset and avoidance were calculated for all modelled Project activities at the Steensby Port site and shipping route. The estimated numbers of walruses exposed to sensation levels of 70 dB and 80 dB were calculated for months with available aerial survey data (April, June, August, September and October). Correction factors of 2.28, 1.22, and 4.7 were applied to densities for availability bias (Wiig *et al*., 1993; Jay *et al*., 2001; Lydersen *et al*., 2008), detection bias during the ice-cover period (Frost *et al*., 1988), and detection bias during the open-water period (assumed the same as for other large pinnipeds; Feldkamp *et al*., 1989; Stewart and Yochem, 1994), respectively.

To assess the effects of ship generated waves on walrus haulouts, the method described by Kriebel *et al*. (2003) was used.to model wave height generated by an ore carrier. This model does not account for shoaling or wind-wave effects. The Kriebel *et al*. model estimates the lateral surface wave height produced by a vessel of a certain size and shape, at a specific speed, and at a specific water depth. The vessel size and shape was based on the description of the ore carrier provided in Volume 3, Section 3.6.2. Surface wave heights were modelled at a vessel speed of 14 knots, which correspond to the maximum transit speed in open-water (T. Keane, Fednav, pers. comm.) in the RSA. For modelling purposes, a water depth of 25 m which is 5 m deeper than the draft of the proposed ore carrier was assumed. This is considered conservative because wave heights are typically greater in shallow versus deep water. A water depth of 25 m was assumed to be the minimum water depth the vessel would transit at maximum speed. Estimates of wave height at increasing lateral ranges (5 m interval) from the vessel were estimated. The distances from the shipping lane that produced wave heights at 0.05 m height intervals were derived and used in a GIS to create zones along the shipping lane corresponding to different wave heights. A second component to this analysis examined the sensitivity of shorelines, including those used as haulout sites for walrus, to erosion from ship-generated waves (see Appendix 8D-2 for details). A part of this analysis involved comparing wave heights generated by ore carriers to those generated by ambient storm events.

The effects of aircraft overflights on walrus located at known haulout sites in northern Foxe Basin were assessed, in part, by estimating the in-air sound levels of a Boeing 737 taking off and landing at the Steensby airstrip, and along the flight path to Iqaluit. Details of the modelling approach are provided in Appendix 8D-1. The source level of a Boeing 737 aircraft was back-calculated based on the sound level (at 300 m from the aircraft) presented in Richardson *et al*. (1995). Noise levels for the various 1/3 octave bands at systematic distances from the aircraft were calculated using a formula described in Plotkin *et al*. (2000). The 1/3 octave band with the consistently highest noise level across all range values was used to estimate the noise levels at a variety of increasing aircraft altitudes (50 m altitude interval, up to 9100 m), and increasing lateral range (100 m interval out to 40 dB re 20 µPa) from the aircraft flight path. Contour maps of estimated sound levels at the water surface were generated and overlaid with the known walrus haulout locations; these results were also interpreted relative to the in-air hearing ability of walrus (Kastelein *et al*. 1996).

5.7.1.3 Hearing Impairment

For impulse sound sources such as those from blasting, the 190-dB re 1 µPa (rms) criterion was used to calculate the area where walruses may incur TTS (NMFS, 2000). Aerial survey data, corrected for detection and availability biases, were used to estimate the numbers of walruses that may occur inside of the 190-dB zone. The approach, used by Davis and Malme (1997) and described above (Section 5.6.1.2), was used to estimate numbers of walruses that may be exposed to continuous sound levels high enough to cause TTS, using an assumed sensation level of 100 dB.

5.7.1.4 Masking

A qualitative discussion on the potential for walrus masking caused by Project activity noise is provided.

5.7.1.5 Mortality

A qualitative discussion on the potential for walrus mortality as a result of ship strikes and stampeding at haul-out sites is provided.

5.7.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on walruses considered in the assessment are listed below. Effects that are not assessed in detail (i.e., that were ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking and footprint of dock structures;
- **Disturbance** caused by airborne and/or underwater noise from construction, shipping, and aircraft overflights, waves generated by an ore carrier;
- **Hearing impairment** and/or damage from construction activities;
- **Masking** of environmental sounds; and
- **Mortality** from collisions with vessel and stampeding at haul-out sites.

5.7.2.1 Habitat Change

Walruses occur throughout the RSA but are most abundant in northern Foxe Basin, particularly in the area west of Rowley Island. They are known to occur in Steensby Inlet but the extent of their occurrence is unknown. Potential walrus habitat will change for the life of the Project as a result of the footprint of the dock structures, which is quite small at Steensby Port: (0.07 km^2). Walruses are known to occupy the edges of landfast ice as well as areas with pack ice. As noted earlier, an estimated 1.5 km wide section of landfast ice edge leading into Steensby Inlet will be changed by icebreaking ore carriers each season. The area of pack ice that will be disrupted by a single passage is estimated at 76.5 km^2 during the period of maximal ice coverage. Evidence of the ship track in the mobile pack ice will quickly disappear because of winds and tide (Volume 3, Appendix 3G) and it is assumed that walruses could re-use this area.

Planned Mitigation - Dock structures were designed to reduce the footprint in the marine environment. Icebreaking vessels will limit the width of the shipping lane to <1.5 km by sailing along the same track as much as possible through landfast ice in Steensby Inlet. The shipping lane into Steensby Port will be delineated with markers to notify the ships' crews of the boundaries of previous vessel tracklines.

Residual Effects - About half of footprint of the Steensby Port dock structures is unsuitable as walrus feeding habitat because the only invertebrates present in such shallow water are mobile epibenthos such as amphipods and mysids. In any case, the small area is a negligible part of nearshore habitat in the inlet. Less than 2 % of the total landfast ice edge leading into Steensby Inlet will be changed by icebreaking. During a single transit to and from Steensby Port, an ore carrier will temporarily change <1 % of pack ice in Hudson Strait, Foxe Basin and near Steensby Inlet. This change in habitat caused by dock structures and temporary decrease in suitable walrus overwintering habitat is lower than the threshold value of 10 % (Table 8-5.6).

With mitigation measures in place, it is predicted that effects of habitat change on walruses would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of habitat change on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.2.2 Disturbance

Construction activities, vessel traffic, icebreaking and aircraft overflights have the potential to disturb walrus, particularly along the southern shipping route and at the Steensby Port site. Few walrus are present in Milne Inlet and along the northern shipping route within the RSA.

Based on the results of acoustic modelling and analyses of audiogram and ambient noise level data, walruses may detect Project activity sounds at ranges of 10 km (drilling through ice) to 250 km (ore carriers). However, the mere detection of a distant sound source will not have a negative effect (see Richardson *et al*., 1995a). Available evidence indicates that walruses tend to exhibit localized avoidance to vessels and that they show variable responses to aircraft overflights, but in some instances show strong reactions when hauled out. As noted earlier, for purposes of analyses, they are assumed to avoid areas where the sensation level is above 80 dB in the 1/3-octave band with the highest sound level (see Davis and Malme, 1997). Some are assumed to exhibit minor behavioural responses at a 70-dB sensation level.

Construction Activities - While the scientific literature lacks specific studies of the effects of construction activities on walrus, there is information on component activities, and noise from construction activities is expected to have similar disturbance effects on walruses as noise from vessels and aircraft.

Residual Effects of Construction Activities - With the exception of drilling and blasting at the Steensby Port site during the ice-cover season of Year 1 of Construction, all other construction activities will occur during the open-water season, when walruses are primarily in and around terrestrial haul-out sites and perhaps among remnants of pack ice. Drilling and blasting operations in the seabed will occur in late April and May, when walruses in Foxe Basin are typically associated with pack ice. While some animals may occur near the edge of the landfast ice in Steensby, this is over 90 km from the work areas. At this distance, sound levels are predicted to be <100 dB re 1 uPa (rms), and sensation levels are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance (Matthews *et al*., 2010; Appendix 8C-3, Table 8C-3.3, Figures 8C-3.11 and 8C-3.12).

Dredging will occur for up to four weeks at the Steensby Inlet Port site during the open-water period of the first year of construction. Dredging will likely be carried out using a cutter head suction dredger or a clamshell operation. Sensation levels from dredging are not expected to exceed either the 70-dB or 80-dB criterion for disturbance onset and avoidance, (Appendix 8C-3, Table 8C-3.3, Figure 8C-3.13). The Steensby Inlet site is not known as a key haul-out site, but some walruses do use the area during the construction period. Walruses in the vicinity of dredging operations and the associated construction activity (vessel traffic, dock construction) may exhibit localized avoidance of the area, but affected animals will be few.

Vessel Traffic - For walruses hauled out on ice, the response to a vessel depends on vessel distance (Brueggeman *et al*., 1990, 1991, 1992) and speed (Fay *et al*., 1984). When an icebreaker was underway in open water, more than 50 % of walruses hauled out on ice pans responded by entering the water or becoming attentive when the vessel approached within 460 m; at distances >460 m, a lower percentage responded (Brueggeman *et al*., 1990, 1991, 1992). Fay *et al*., (1984) reported that walruses responded at farther distances when a ship approached from downwind as compared with upwind, and that those in water show less reaction than those on ice.

Walruses at a terrestrial haulout did not appear to be disturbed by boats with an outboard motor when approached at distances >400 m (see Fay, 1981a). Salter (1979) reported that no walruses were disturbed at a terrestrial haul-out during six approaches by Zodiacs at distances of 1.8 to 7.7 km. However, noise from outboard motors may be more disturbing than sounds from a diesel engine (Fay *et al*., 1984). Born *et al.* (1995) noted that some walruses may react to ships as far as 2 km away. Animals from hunted populations are typically skittish around small boats (see Malme *et al*., 1989; Born *et al*., 1995), but Born *et al.* (1995) noted that some could be approached within 10–20 m when asleep.

At Round Island, Alaska, walruses have been observed during disturbances over the past several years. During 44 potential boat disturbance events (primarily tour boats) in 2008, walruses raised their heads in response to two boats, re-oriented in response to three boats, and dispersed when disturbed by 11 boats; during 28 other events, walruses did not react (Okonek *et al*., 2008). Similarly, for 43 potential boat disturbances in 2007, walruses had no response during 27 events; head raises occurred on four occasions, and dispersal occurred on 12 occasions (Okonek *et al*., 2007).

An apparent correlation between increased noise during the yellowfin sole fishery and observed declines in numbers of walruses using haulouts in northern Bristol Bay, Alaska, led to the establishment in 1990 of protection zones around the Walrus Islands (see Wilson and Evans, 2009). Additionally, native hunters in Bristol Bay were concerned that noise from fishing activities disturbed walruses and made it more difficult to hunt them (Wilson and Evans, 2009).

During consultations for the Project, it was noted that walruses exhibit a “scare” response to large ships and tend to stay around the shoreline when such vessels start to arrive (M. Akoomalik, Pond Inlet, pers. comm.). Some individuals commented that walruses avoid small boats and ships, even at great distances (Cape Dorset IQ Workshop; E. Panipakoocho, Pond Inlet, pers. comm.). Others have observed no behavioural changes in response to a big ship by walruses basking and in the water (A. Ulayuruluk, Igloolik, pers. comm.). It was thought that marine mammals eventually get used to new sounds and return to areas they may have temporarily left; however, there is uncertainty about the effects of year-round shipping (Hall Beach Marine Mammal Workshop). While other IQ suggests that walruses are highly territorial and will aggressively defend their territories; they have been observed to challenge ships passing into their territory. Challenging a ship does not make a walrus more susceptible to vessel collisions, nor is it a systematic behaviour observed from all walruses. In addition, if a walrus challenges a vessel, it also implies that the animal is aware of its presence and unlikely to be struck by it.

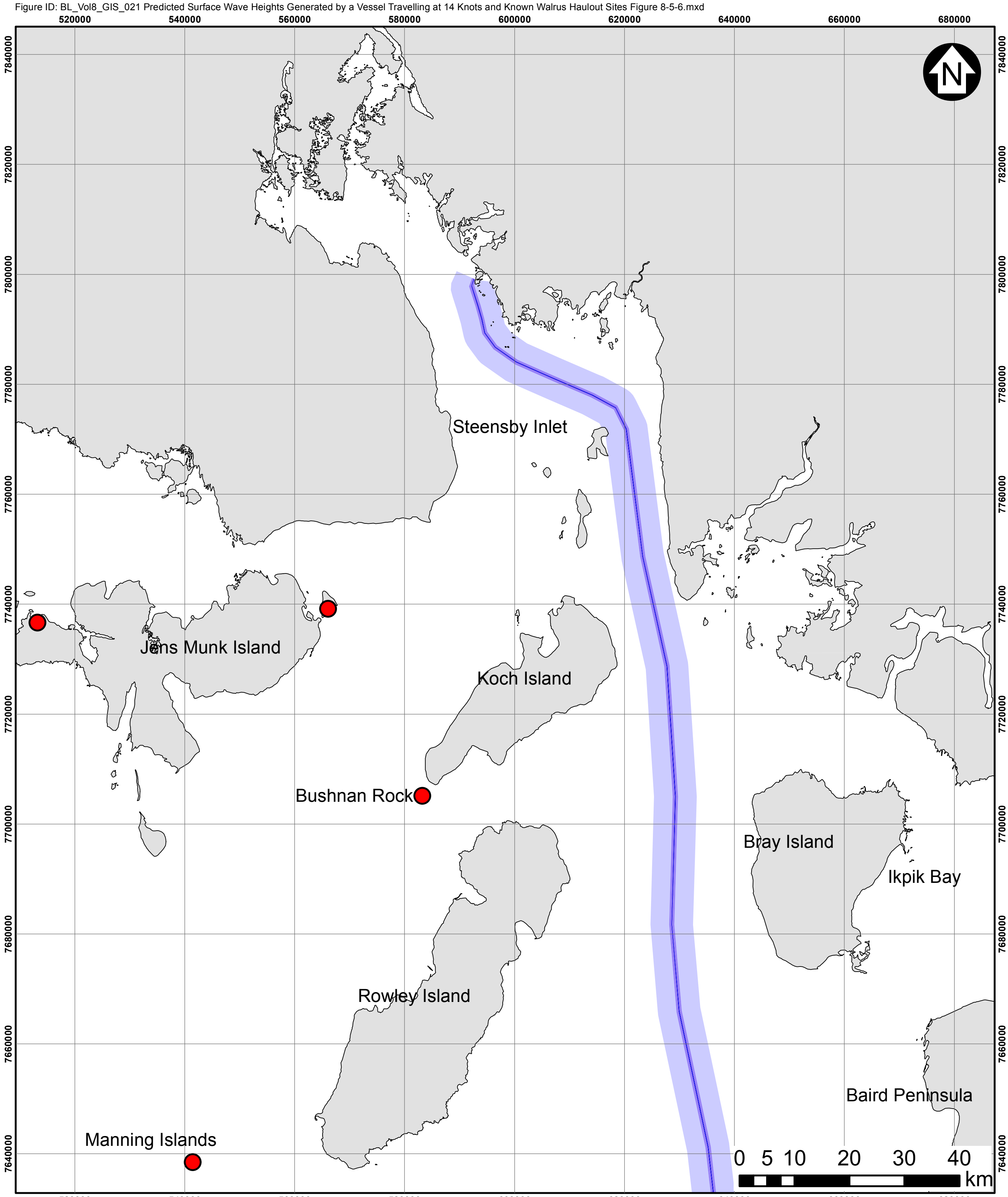
Based on the results of the modelling of wave height generated by an ore carrier travelling at 14 knots along the shipping lane, waves are estimated to be 0.20, 0.15, 0.10, and 0.05 m high within 0.06, 0.14, 0.48 and 3.86 km of the vessel respectively. It is evident that wave heights are expected to quickly dampen as they move laterally away from the vessel, particularly at the slower vessel speed.

At the expected maximum transit speed (14 knots) of the ore carrier in Foxe Basin during the open-water period, the known walrus haulout locations are located well beyond the distance from the vessel where wave heights of 0.05 m are predicted (Figure 8-5.6). In the case of the Bushnan Rock haulout site, a shallow channel between Koch and Rowley islands would likely further dampen waves produced by a vessel transiting to or from Steensby Inlet. Waves produced by the Project's ore carriers are not expected to affect walruses hauled out at any of the known haul-out sites in northern Foxe Basin. In addition, waves generated by ore carriers (travelling at 14 knots) are not expected to cause shoreline erosion at known walrus haulout sites in Foxe Basin (and Hudson Strait) because waves will have dissipated at these locations and the shorelines are considered to have a low sensitivity to ship wake erosion. This low sensitivity is attributable to the coarse sediment shorelines that are naturally resistant to erosion, shorelines are naturally advancing (i.e., isostatically rebounding), and ship wakes produce waves that are similar in height to wind-generated storm waves, which are comparatively common during fall months.

Planned Mitigation for Vessel Traffic - Ore carriers that will be used on the southern shipping route have been designed to reduce noise output (see Volume 3, Section 3.6.2). All vessels will maintain a constant course and speed whenever possible. In addition, vessels will minimize idling of engines when docked at port. The shipping route through Hudson Strait will (whenever possible) occur south of Mill Island, in part to avoid the known walrus haulout location on the north side of the island (O. Akesuk, QIA Board Member for Cape Dorset, pers. comm.).

Residual Effects of Vessel Traffic - Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that walruses in the water would avoid ore carriers travelling during the open-water period along the Steensby shipping routes by <100 m (Appendix 8C-3, Table 8C-3.3, Figures 8C-3.15 to 8C-3.17). Perhaps of more relevance is their response to vessel traffic when they are hauled out and the response cue is perhaps olfactory and/or in-air sound. During the open-water period, walruses haul out at many terrestrial sites along the shipping route (see Table 8-5.7); the closest site in Foxe Basin is Koch Island, >8 km away from the nominal shipping route. In Hudson Strait, walruses are known to haul out on the north side of Mill Island (O. Akesuk, QIA Board Member for Cape Dorset, pers. comm.) which is a minimum of 4.6 km from the nominal shipping route south of this island. Based on available evidence, walruses are not expected to leave terrestrial haul-out sites in response to passing ore carriers at these distances. Consequently there is no potential for walrus mortality from stampeding at haulout sites as a consequence of vessel traffic. Those hauled out on ice may temporarily avoid an ore carrier by diving into the water, perhaps at distances ranging from 400–500 m up to several km. The area west of Rowley Island (located >18 km west of the nominal shipping route) is thought to be a calving area for walrus from March to July (Figure 8-5.5). Walruses in the calving area are not expected to respond to ore carriers transiting through eastern Foxe Basin either during the ice-covered or open water period. IQ indicates that if ideal ice conditions are met walruses may also calf on the eastern side of Rowley Island (S. Frame, DFO, pers. comm.).

Figure ID: BL_Vol8_GIS_021 Predicted Surface Wave Heights Generated by a Vessel Travelling at 14 Knots and Known Walrus Haulout Sites Figure 8-5-6.mxd



LEGEND:

PREDICTED WAVE HEIGHT (METRES)

- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- > 0.20

● KNOWN WALRUS HAULOUT SITES

LAND

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. CO-ORDINATE GRID IS IN METRES.
   DATUM: NAD83/WGS84
   PROJECTION: UTM ZONE #17
3. CONTOUR INTERVAL IS METRES.

BAFFINLAND IRON MINES CORP.

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Predicted Surface Wave Heights Generated by a Vessel Travelling at 14 Knots and Known Walrus Haulout Sites

Baffinland Iron Mines Corporation

REF NO. **BL_Vol8_GIS_021**

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Table 8-5.7 Distances of Known and Potential Walrus Haul-out Sites to Nominal Ore Carrier Shipping Route in Foxe Basin and Hudson Strait

Haul-out Site	Minimum Distance from Nominal Shipping Route (km)
Koch Island	8.6
Jens Munk Island	59
Rowley Island	18.7
Manning Island	97.6
Bushnan Rock	44.7
Spicer Islands	33.2
Mill Island	4.6
Bray Island	14.2
Prince Charles Island	38.3
Salisbury Island	20.7
Nottingham Island	41.3
Big Island	16.5
Coast line west of Kimmirut	52.9
Coast line east of Kimmirut	52.8

NOTE(S):

1. SHIPPING ROUTE IS 7.5 km FROM MILL ISLAND IF NORTHERN ROUTE IS USED.
2. SHIPPING ROUTE IS 41.5 km FROM SALISBURY ISLAND IF NORTHERN ROUTE IS USED.
3. SHIPPING ROUTE IS 73.7 km FROM NOTTINGHAM ISLAND IF NORTHERN ROUTE IS USED.

Vessel traffic at the Milne and Steensby Port sites will vary throughout the Project. A total of 8–10 vessels, including sealifts, tankers, line boats, barges and ore carriers, could be present at the port sites at one time during construction. During the Operation Phase, only an occasional (less than one trip per year) vessel will ship to Milne Port during the open water shipping season. No service vessels (tugs or line boats) will be stationed at Milne Port to service the few vessel transits. Thus, there will be negligible interaction potential between Project vessel traffic and walruses at Milne Port following the construction period. At Steensby Port, shipping traffic during the operation phase includes approximately 102 voyages by the dedicated fleet of icebreaking ore carriers, 3-6 voyages by sealifts and tankers, and possibly additional voyages by chartered ore carriers during open-water season. Up to four tugs will also be stationed at Steensby Port. Noise levels from tugs were modelled at both port sites (Matthews *et al*., 2010; Zykov and Matthews, 2010). Sensation levels from tugs are not expected to exceed the 80-dB criterion for avoidance at either site (Appendix 8C-3, Table 8C-3.3, Figures 8C-3.14). It is expected that if walruses occur near vessels at Steensby Port site, they may exhibit localized avoidance, particularly during the Construction Phase; however, the affected numbers of walruses are expected to be low.

Icebreaking - Reactions of walrus to icebreakers are described more thoroughly than for other pinnipeds. When comparing the reaction distances of walruses to icebreaking ships vs. ships in open water, Fay *et al.*

(1984) found that they reacted to icebreakers at greater distances. They were aware of the icebreaker when it was >2 km away, and females with pups entered the water and swam away when the ship was 0.5–1 km away; adult males did so at distances of 0.1–0.3 km. However, it was also noted that some animals also scrambled onto ice when an icebreaker was oriented toward them. In the presence of icebreaker-supported drillships, the dominant influence appeared to be icebreaking rather than drilling noise (see Brueggeman, 1993; Richardson *et al*., 1995a). Brueggeman *et al.* (1992) examined the broad-scale effects of drilling and icebreaking and concluded that walrus density, association with pack ice, and distance from ice edge did not change with operations; however, the number of walruses tended to increase with increasing distance from the sound source.

In a Chukchi Sea study, of 202 walrus groups observed on ice floes during icebreaking activities, 32 % dove into the water and 6 % became alert while on the ice (Brueggeman *et al*., 1990, 1991, 1992), as summarized by Richardson *et al.* 1995a). Escape reactions were more likely as distance to the icebreaker decreased, and at closer distances for the icebreaker than other vessel types. When the icebreaker was within 0.46 km, most of the groups reacted (Brueggeman *et al*., 1990, 1991). Some groups reoccupied the abandoned ice floes shortly after the disturbance (Brueggeman *et al*., 1990, 1991). Walruses tended to move deeper into the pack ice during icebreaking activities; concurrent aerial surveys indicated that those hauling out on ice floes may have avoided icebreaking activities by 10-15 km (Brueggeman *et al.* 1990). In contrast, it was noted that icebreakers that went through Steensby Inlet did not cause walruses to scatter (Igloolik Public Meeting, anonymous, pers. comm.).

Residual Effects of Icebreaking - Icebreaking by Cape-size ore carriers will occur throughout ice-cover season during the Operation Phase. It is expected that an icebreaking ore carrier will transit through the southern LSA to and from Steensby Port every two days. Results of the sensation level analyses indicate that disturbance onset and avoidance may occur at distances of 1.5 km and 0.1 km, respectively, from the ore carrier during the ice-cover season in Foxe Basin (Table 8C-3.3); these estimates pertain to underwater noise.

Based on the response distances (i.e., 0.1–15 km) of walruses hauled out on ice (see above) and the corrected walrus density estimates from aerial surveys conducted in Foxe Basin and Hudson Strait during the ice-cover period, it is estimated that approximately <10 to 400 walruses may exhibit avoidance of a single ore carrier passing through the southern LSA. It is likely that at least some individuals will be affected multiple times by icebreaking during a single season although habituation to the vessels is likely to occur when it becomes clear to the animals that the vessels do not pose a threat. However, there is uncertainty regarding how repeated exposure to icebreaking ore carriers will affect walruses. Walruses known to occur and potentially feed along the coastline near Kimmirut during the ice-cover season are not expected to be affected by ore carriers, as identified feeding areas are >50 km from the nominal shipping route. Similarly, those known to occur west of the Rowley Island area to calve are not expected to be affected by Project shipping during the ice-cover season, as this area is >18 km from the shipping route. Based on available evidence, walruses in pack ice may exhibit temporary, localized avoidance of icebreaking ore carriers.

Aircraft Overflights - Responses of walruses to overflights appear to be variable and depend on age, sex, group size, distance, type of aircraft, altitude and flight pattern (Salter, 1979; Fay *et al*., 1984; Johnson *et al.,* 1989; Richardson *et al.* 1995a). Low-flying (~150 m) aircraft have caused walruses at terrestrial haul-out sites to stampede and crush calves at distances >400 m (see Loughrey, 1959; Tomilin and Kibal'chich, 1975 *in* Fay, 1981a; Johnson *et al.*1989). Aircraft flying higher (~800 m) have also elicited stampedes, causing the deaths of 102 walruses of various ages (Ovsyanikov *et al*., 1994).

Fay *et al.* (1984) reported that several passes of low-flying (60–80 m) aircraft flushed all 1,000 hauled-out walruses into the water at Cape Seniavin, Alaska; animals were also flushed into the water on subsequent days during other aircraft overflights. At Punuk Islands, Alaska, low-flying (60 m) aircraft caused only ~2 % of hauled out walruses to enter the water, although a larger proportion raised their heads (Fay *et al*., 1984). Roseneau (1988) noted that low-flying aircraft did not cause disturbance to hauled-out walruses near the Air Force Station at Cape Lisburne, Alaska. Born *et al*. (1995) suggest that walruses may habituate to disturbance.

In 1989, 12 % of 34 walrus groups in open water responded to overflights of a Twin Otter at an altitude of 305 m by diving, and 38 % of 229 walrus groups hauled out on pack ice entered the water during overflights (Brueggeman *et al*., 1990). In 1990, 17 % of 24 walrus groups responded to overflights at an altitude of 305 m by entering the water, but none of 25 groups hauled out on land responded to overflights at an altitude of 152 m (Brueggeman *et al*., 1991).

At a terrestrial haulout site in the Canadian High Arctic, walruses responded to 35 % of 31 fixed-wing aircraft flights; three of these flights caused walruses to leave their terrestrial haul out (Salter, 1979). Two overflights of a Single Otter at altitudes of 1,000–1,500 m caused escape responses at distances <1 km away, and a Twin Otter flying at an altitude of 150–300 m caused 1 of 34 walruses to enter the water at a distance of 1 km (Salter, 1979). At the same haul-out site, walruses responded to 27 % of 71 helicopter flights at distances up to 8 km away; they entered the water on one occasion, when a helicopter flying at an altitude of <150 m approached within 1.1–2.5 km (Salter, 1979). Salter (1979) reported that on occasions that caused large-scale disturbance, it took up to 9 hours for the number of hauled-out walruses to reach pre-disturbance levels. Salter (1979) also noted that females and calves appeared to be more susceptible to disturbance than males.

Fay *et al.* (1984) reported that walruses hauled out on pack ice in the Chukchi Sea entered the water when a helicopter approached within 400–600 m flying upwind or 1,000–1,800 m flying downwind. This is similar to findings that walruses responded at greater distances when vessels approached downwind.

Walrus responses during disturbances have been observed at Round Island, Alaska, for several years. Responses appear to be quite variable. When a jet flew overhead at an altitude of ~9 km in August 2008, 48 walruses dispersed; the jet sound could easily be heard (Okonek *et al*., 2008). In response to another jet overflight, walruses merely raised their heads (Okonek *et al*., 2008). During helicopter overflights in 2008, walruses raised their heads on one occasion and did not respond on another occasion (Okonek *et al*., 2008).

The probable flight path of Boeing 737s arriving from and departing Steensby Inlet for Iqualit were examined. The aircraft would be at an approximate altitude of 8500 m at its closest horizontal distance to Koch Island where walrus are known to haul out in relatively high numbers. It would be at an approximate altitude of 9100 m when it crosses the landfast ice edge into pack ice between Koch Island and the Baffin Island shoreline. A preliminary estimate of the sound level at the air/water surface in both these locations would be less than 40 dB at the 100 Hz frequency. Noise levels from passenger jets at near cruising altitudes are almost undetectable from the ground. Walruses and other marine mammals are unlikely to respond to these noise levels.

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow. In addition, aircraft will be prohibited from flying low over walruses for passengers to ‘get a better look’ or for photography. These mitigations are applicable to small fixed-wing aircraft and helicopters. Boeing 737 jets during take off gain altitude at a rapid rate and would fly at a much higher altitude over marine waters; there would be no chance that these aircraft would change course/altitude to allow passengers to view marine mammals. Terrestrial haulout sites where walruses congregate in relatively high numbers (e.g., Koch, Spicer, Jens Munk, Manning, and Rowley islands, plus Bushnan Rock) will be mapped and project aircraft (including Boeing 737) will be prohibited from flying directly over these sites (unless an emergency situation arises).

Residual Effects of Aircraft Overflights - Aircraft approaches to and from the airstrips at Milne and Steensby Inlets will be most frequent during the Construction Phase. During the Operation Phase, the primary airstrip will be located at the Mine Site. Very few walruses are expected in the area of the Milne Inlet Port site where Twin Otters, Dash-8s and ATRs will use the airstrip. If any walruses do occur there, they may respond by diving or possibly avoiding the area, likely on a temporary basis. These types of behavioural responses would have little consequence for individuals.

Based on the results of the in-air noise modelling of the Boeing 737 aircraft, none of the known walrus haulout locations in northern Foxe Basin are located within estimated noise level contours greater than 40 dB re 20 µPa (see Figures 8D-1.1 to 8D-1.4 in Appendix 8D-1). Walruses would not detect noise levels less than ambient conditions that are conservatively assumed to be approximately 55 dB (Blackwell and Greene 2002). In addition, Kastelein *et al*. (1996) has shown that the minimum in-air sound levels they can perceive are approximately 55 dB or greater. Therefore, it is unlikely that walruses hauled out at the known haulout 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. Therefore, Boeing 737 overflights are not expected to affect hauled out walruses at known haulout sites in Foxe Basin. If they haul out adjacent to the shoreline near the proposed Steensby airstrip during the Construction Phase, they may respond to aircraft overflights—perhaps by dispersing from the area. It is uncertain if walruses that occur in Steensby Inlet will habituate to daily overflights of a commercial jet. Unlike other areas in and near the LSA, Steensby Inlet is not considered an area where walrus haul out in high numbers; however, monitoring will occur during the Construction Phase at Steensby Inlet in order to document walrus occurrence and potential reaction to site activity, including aircraft overflights.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on walruses from construction, shipping and aircraft overflights would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; Level I) or intermittently (vibratory pile driving, shipping and aircaft overflights; Level II), and confined to the LSA (Level I); effects of disturbance are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of disturbance from Project activities on walruses is predicted to be “*not significant*” (Table 8-5.9).

5.7.2.3 Hearing Impairment

Hearing impairment has not been directly studied in walruses. A review of relevant hearing impairment studies, based on the study of other pinnipeds, was provided in Section 5.6.3.2. Walruses in close proximity to the Steensby Port site during periods of construction may, on occasion, be exposed to sound levels high enough to cause hearing impairment.

Planned Mitigation - Blasting will occur late in the ice-cover season (late May) to reduce the likelihood of walruses being nearby. None are expected in the landfast ice near the blast site; however, some may be present at the landfast ice edge, over 90 km away. There is very little chance that they will be exposed to sound levels high enough to cause TTS. In addition to the timing, a blasting plan designed by an explosives contractor in consultation with DFO will ensure that the 100-kPa waterborne acoustic overpressure threshold is met and minimized, and a bubble curtain will be employed as necessary. As noted earlier, it is anticipated that environmental monitors will be on site during blasting operations to assess the area for marine mammal presence. In the highly unlikely event that a walrus is observed within the 500-m safety zone (Wright, 2002), blasting will not commence until the walrus(es) have left the area.

Vibratory pile driving at Steensby Inlet will occur over a two-month period during open-water construction in Year 1. Acoustic modelling indicates that sound levels will not exceed 190 dB (rms) (Zykov 2011 in Appendix 8C-4). As a conservative approach, a 50-m "safety zone" (which corresponds to sound levels of <160 dB (rms)) will be established and monitored around the pile driving site. .To protect ringed seals, an acoustic contractor will measure actual sound levels from pile driving at the earliest possible time during the construction season to verify acoustic modelling predictions. An Inuit monitor and an Environmental Monitor will be present at the pile driving site to monitor the appropriate safety zone. Prior to pile driving operations, the safety zone will be monitored and if a ringed seal or walrus is present within this zone, pile driving will not be permitted to commence. Observers will continue to monitor the zone during pile driving and if a walrus is observed within or approaching the zone, pile driving will be halted until the marine mammal has left the area.

Residual Effects - Based on acoustic modelling results and the implementation of mitigation measures, walruses are not expected to be exposed to receive sound levels high enough to elicit TTS. Walruses in Steensby Inlet are not predicted to be exposed to in-air sound levels from aircraft overflights (Boeing 737) that exceed thresholds for hearing impairment in pinnipeds (149 dB re 20 µPa (peak)(flat) or 144 dB re 20 $\mu Pa^2 \cdot s$ (M_{pa}) in air (Southall *et al*., 2007).

With mitigation measures in place, walruses are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of hearing impairment on walruses is predicted to be "*not significant*" (Table 8-5.9).

Table 8-5.8 Effects Assessment Summary: Walrus

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only), drilling (Steensby only), dredging, and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for walrus in the area of blasting; bubble curtain system; discourage walrus from the blast area with acoustic deterrent device. Drilling in late April/May. Monitoring for walrus in and near safety zone. Reduce vessel idling at dock side.	Level I	Level I	Level I, Level II	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet.	Level I	Level I	Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance [2] Mortality	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over walrus for passengers to 'get a better look' or for photography. Prohibit overflights of known terrestrial haul-out sites used by large numbers of walrus.	Level I	Level I	Level II	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level II	Level I	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking	Maintain constant speed and course when possible. Reduce vessel idling at dock side. Reduce vessel speed in areas of pack ice. Minimize footprint of ice disturbance at ore dock and along shipping route.	Level I	Level II	Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over walrus for passengers to 'get a better look' or for photography. Prohibit overflights of known terrestrial haul-out sites used by large numbers of walrus.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.9 Significance of Residual Effects to Walrus

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	2		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

5.7.2.4 Masking

Walrus call characteristics are relevant in assessing potential masking effects of anthropogenic sounds and their likely frequency range of best hearing. Walruses produce underwater sounds consisting of clicks, rasps, bell-like tones and grunts (Schevill *et al*., 1966; Ray and Watkins, 1975; Stirling *et al*., 1983), with frequencies ranging from 400 to 1,200 Hz (Richardson *et al*., 1995a). Adult male Atlantic walruses produce stereotyped underwater vocalizations during the breeding season, from January to mid-April (Stirling *et al*., 1987), when vocalizations consisting of short repetitious pulses can occur for several hours at a time. These pulse cycles appear to differ among individuals (Stirling *et al*., 1987). In air, calls include barking, coughing and roaring, calls from females to calves, and alarm calls by calves (Kastelein, 2002). Young adult males lift their heads from the water to produce whistles; frequencies are 1–2 kHz (Miller, 1985; Verboom and Kastelein, 1995) and source levels are ~120 dB re 1 pW (Kastelein, 2002). The energy of roars by female walruses is mostly at low frequencies, ~300 Hz (Miller, 1985). Miller (1985) also recorded grunts with most energy concentrated at 150–250 Hz, but with considerable energy at lower frequencies, and guttural sounds at frequencies as low as 13 Hz. Calves and juveniles often bark, with frequencies of

300–450 Hz (Miller, 1985). Calls are distinct and are used for mother-calf communication (Charrier *et al*., 2009). There are no published accounts of masking in walrus.

Residual Effects - Masking effects by transient sounds (blasting), on marine mammal calls and other natural sounds are likely limited, because the construction sounds will be intermittent and each sound pulse will be very short. Walrus calls are primarily at frequencies from a few hundred to several thousand Hz, and the range of best hearing for walruses is 1–12 kHz—above the frequency range of the most intense ship noise. Any masking that might be made, as a vessel passed by, would occur for only a short time (2-3 h) relative to the interval between transits (48 h) on the assumption that eastbound and westbound vessels will maintain a substantial lateral separation. This accounts for 6.3 % of a 48 h period. The amount of masking will be a function of how close to the ship's path the walrus is located. The closest that the planned shipping route will be to known walrus calving sites in Foxe Basin is >10 km. In addition, Koch and Rowley Islands will provide a partial noise barrier to these sites on the west side of Koch Island as the vessel passes on their eastern side.

Furthermore, many marine mammal species such as killer whales (Holt *et al*., 2009), blue whales (Di Iorio and Clark, 2009), right whales (Parks *et al*., 2007), harp seals (Serrano and Terhune, 2002), and Weddell seals (Terhune *et al*., 1994) have adapted acoustic communication strategies to compensate for changes in ambient noise. These strategies can include increasing the amplitude of calls, increasing calling rate, shifting calling frequency, and increasing the duration of calls. It is possible that walrus, including mother-calf pairs, use one of these many strategies to adapt to changing ambient noise levels and counter the potential reduction of their communication space, in the unlikely scenario that such a reduction in communication space occurs. Given that sounds important to walruses are predominantly at higher frequencies than shipping noise, and that construction activities sounds are intermittent in occurrence, it is unlikely that masking would significantly affect walrus.

It is predicted that residual effects (if any) of masking would be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of masking on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.2.5 Mortality

Mortality resulting from human activity has been reported in a few studies of walrus response to aircraft overflights. Low-flying (~150 m) aircraft at distances of more than 400 m have caused walruses to stampede and crush calves (see Loughrey, 1959; Tomilin and Kibal'chich, 1975 *in* Fay 1981a; Johnson *et al*., 1989). Tomilin and Kibal'chich (*in* Fay, 1981a) also reported that an aircraft overflight at 150 m caused the abortion of two walrus foetuses. Aircraft flying higher (~800 m) have also elicited stampedes, causing the deaths of 102 walruses of various ages (Ovsyanikov *et al*., 1994).There have been no published accounts of walrus mortality caused by collisions with vessels. IQ suggests that some walruses are highly territorial and will aggressively defend their territories; they have been observed to challenge ships passing into their territory. During review of the DEIS, it was suggested that this behaviour would make walruses susceptible to being struck by a ship. However, challenging a ship does not make a walrus more susceptible to vessel collisions, nor is it a systematic behaviour observed from all walruses. In addition, if a walrus challenges a vessel, it also implies that the animal is aware of its presence and unlikely to be struck by it.

Planned Mitigation - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow. Terrestrial haulout sites where walruses congregate in relatively high numbers (e.g., Koch, Spicer, Jens Munk, Manning and Rowley islands, plus Bushnan Rock) will be mapped and project aircraft will be prohibited from flying directly over these sites. In addition, aircraft will be prohibited from flying low over walruses for passengers to 'get a better look' or for photography.

Residual Effects - It is unlikely that walruses will experience mortality from vessel collisions because walruses, including mothers and calves, exhibit at least localized avoidance of vessels. Ore carriers will reduce speeds to approximately 13km/h in areas of pack ice, further reducing the risk of collision. During the Construction Phase, with daily flights of Boeing 737s at the Steensby airstrip, some walruses may occur along the flightpath. However, large herds as in instances where stampeding has been observed, are not expected in Steensby Inlet. As part of the proposed marine mammal monitoring program, the shoreline area around the Steensby Inlet construction site will be monitored to document walrus responses to aircraft overflights.

With mitigation measures in place, no mortality is expected. There are no residual effects to walrus as a result of potential mortality.

5.7.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on walruses are summarized in Tables 8-5.8 and 8-5.9 and below.

5.7.3.1 Habitat Change

It is predicted that residual effects of habitat change on walruses would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of habitat change on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.3.2 Disturbance

It is predicted that residual disturbance effects on walruses from construction, shipping, and aircraft overflights would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; Level I) or intermittently (vibratory pile driving, shipping and aircaft overflights; Level II), and confined to the LSA (Level I); effects of disturbance are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of disturbance from Project activities on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.3.3 Hearing Impairment

With mitigation measures in place, walruses are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of hearing impairment on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.3.4 Masking

It is predicted that residual effects (if any) of masking on walruses would be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.8). The residual environmental effect of masking on walruses is predicted to be "*not significant*" (Table 8-5.9).

5.7.3.5 Mortality

With mitigation measures in place, no mortality is expected, and therefore, residual effects on walruses are considered negligible.

5.7.3.6 Cumulative Effects Within the Project

During review of the Draft EIS, reviewers requested that the effects of multiple Project activities be considered. As discussed previously, walruses will be exposed to construction activities (i.e., dredging, pile driving, vessel traffic, aircraft overflights) at the Steensby Inlet port site during the first four years of the Project. With mitigation measures in place, hearing impairment and mortality are not expected to result from construction activities. It was predicted that some walruses may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port sites, however, any avoidance is predicted to be localized. During the Operation Phase, walruses will be exposed to noise from ore carriers plus vessels located at the Steensby port site. It was predicted that walruses may avoid an area ranging from hundreds of metres up to 15 km (considered conservative) around each vessel. It is possible that this area of avoidance may increase slightly when multiple vessels are present at the port site or when two ore carriers pass each other along the shipping route (see areas identified in Foxe Basin and western Hudson Strait in Figure 8-5.2). However, given the relatively small increase in sound levels, the increase in the numbers of walruses potentially exhibiting avoidance is predicted as not significant.

5.7.4 Prediction Confidence

Based on the available evidence of walrus responses to vessel traffic, including icebreaking, the baseline data used in the assessment, the planned mitigation measures, the location of the port sites and shipping routes relative to walrus haulout sites, winter feeding areas, and potential calving areas, there is a high level of certainty in the residual effects predictions (Table 8-5.9). No significant residual environmental effects are predicted for this indicator species.

5.7.5 Follow Up

The planned mitigation and monitoring for walruses were summarized in Section 5.7.2 and are also provided in the marine mammal mitigation and monitoring management plan. Significant effects of Project activities on walruses are not expected, and the level of confidence associated with this prediction is generally high. There is some uncertainty associated with acoustic modelling results, particularly because details on blasting parameters were limited during preparation of this report. Thus, acoustic measurements will be acquired to refine safety zones for these activities. This will further ensure that walruses are afforded adequate protection from potential hearing impairment. There is some uncertainty about how many walruses use Steensby Inlet during the open-water period and how walruses that may occur there will respond to daily overflights of Boeing 737s during the Construction Phase. Thus, monitoring will be undertaken at the Steensby Inlet Port site before, during and after the Construction Phase to document walrus occurrence and the potential response to site activity, including overflights. Noise levels produced by aircraft will be monitored at the port site and at select haulout sites during the Construction Phase.

In addition, the effects of ore carrier passages on walruses at known haulouts may be investigated based upon a recommendation by DFO. Most known walrus haulout locations are located large distances from the nominal shipping route; the exception being Mill Island in Hudson Strait which is 4.6 km from the shipping route. However, this study is pending further input from DFO. Aerial surveys of walruses may be undertaken during the winter (March, April) 2012 in Foxe Basin to provide a baseline against which potential future surveys during Baffinland's shipping operations could be compared as part of a longer-term monitoring program. These data would contribute to addressing uncertainties regarding the effects of repeated exposure to ore carrier transits on walrues.

5.8 BELUGA

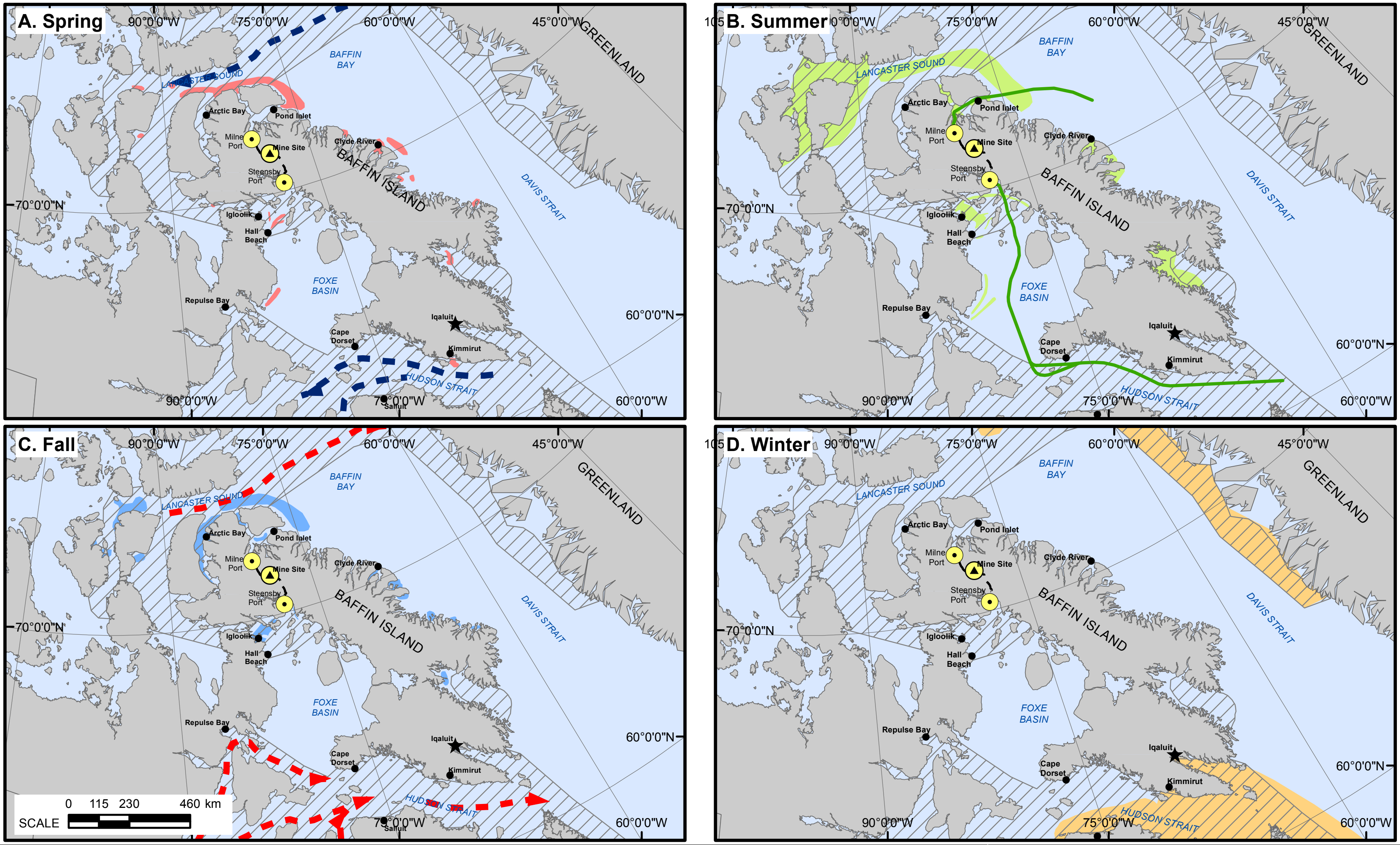
Beluga whales occur in the RSA year-round (Figure 8-5.7). Calving areas and timing have not been definitively identified. Calves have already been born when the whales begin to arrive at summering areas, suggesting that calving occurs in offshore areas during late spring migration (COSEWIC, 2004a). However, IQ suggests that newborn calves have been observed along the floe edge in June, July, August and September (Stewart, 2001). Relatively small numbers of belugas occur in Eclipse Sound and Milne Inlet during the open-water period. IQ indicates that Koluktoo Bay and the southern portion of Milne and Navy Board Inlets may be calving as well as feeding areas. Hudson Strait has been identified as an overwintering area for three populations of belugas and, according to deep dive profiles of satellite-tagged animals, belugas feed there in winter (P. Richard, DFO, pers. comm.). In Foxe Basin, small numbers from the Western and Eastern Hudson Bay populations occur in the vicinity of Igloolik, Hall Beach, and likely Steensby Inlet from July to early September. Beluga whales that overwinter in Hudson Strait enter into northern Foxe Basin during spring and remain in the general area of eastern Fury and Hecla Strait throughout the summer (Brody 1976; Stewart *et al*., 1995). They typically remain in shallower waters where feeding is thought to occur. The major feeding areas within the LSA and RSA have not been definitively identified.

During consultations for the Project, it was noted that shipping might frighten belugas, causing them to move closer to shore (Arctic Bay Working Group Meeting; Cape Dorset Public Meeting; Kimmirut IQ Workshop; Pond Inlet Meeting).

5.8.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on belugas: habitat change, disturbance, hearing impairment, masking and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in beluga whale habitat, behaviour and health (Table 8-5.10). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant. The reader is referred to Volume 2, Section 3.8, for the criteria used to establish significance determination.



LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- SPRING MIGRATION
- FALL MIGRATION
- KNOWN RANGE
- SPRING OBSERVATIONS (IQ)
- SUMMER CORE AREA AND SUMMER OBSERVATIONS (IQ)
- FALL OBSERVATIONS (IQ)
- WINTER CORE AREA

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

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BELUGA SEASONAL OCCURRENCE BASED ON SCIENTIFIC AND IQ INFORMATION

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_023

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REV A

Figure ID: BL_Vol8_GIS_023 Beluga Seasonal Occurrence Based on Scientific and IQ Information Figure 8-5-7.mxd

5.8.1.1 Habitat Change

The footprints of dock structures at Steensby Ports were calculated to determine how much potential open-water beluga habitat would become unavailable. Belugas are not expected to occur in areas of solid landfast ice, but are expected in areas of pack ice in Hudson Strait. The area of changed ice during periods of maximum pack ice coverage was calculated and compared to overall available pack ice in Hudson Strait.

5.8.1.2 Disturbance

To assess the potential level of disturbance from Project activities on belugas, the approach described in Section 5.5 was used. The beluga audiogram, ambient noise levels, and predicted 1/3-octave band noise levels from the acoustic modelling report for each modelled sound source were plotted (Appendix 8C-3, Figures 8C-3.18 to 8C-3.27). From these graphs, the maximum distance in the 1/3-octave bands that the sound was within the hearing range of beluga, above ambient noise levels, and equal to or higher than the relevant thresholds for disturbance onset and avoidance for continuous and pulsed sound were estimated (Appendix 8C-3, Table 8C-3.5). As noted earlier, these thresholds, selected based on a review of the literature, are meant to serve as a guide for potential behavioural responses and to allow the calculation of numbers of potentially affected belugas. Studies of belugas and their responses to noise have yielded highly variable results (see Section 5.8.2.2 below) and as such, the results of the analyses presented here should be interpreted with these caveats in mind. "Disturbance onset" is considered to be behavioural responses ranging from subtle changes in swim speed and direction to minor and localized avoidance of a sound source, and "avoidance" to be avoidance of an area for a period longer than the sound source is in operation.

The areas exposed to sound levels that exceeded the threshold for disturbance onset and avoidance were calculated for all modelled Project activities at the Steensby Inlet and Milne Inlet Port sites, and along both shipping routes. The estimated numbers of belugas exposed to sound levels that exceeded the assumed thresholds for disturbance onset and avoidance were calculated for months with available aerial survey data (April, June, August, September and October). Correction factors of 5.00 and 2.26 were applied to density estimates for availability bias in winter (Heide-Jorgenson *et al*., 1998) and summer (Martin and Smith, 1992; Harwood *et al*., 1996), respectively; and a correction factor of 2.84 was applied for detection bias (Harwood *et al*., 1996).

5.8.1.3 Hearing Impairment

For impulse sound sources like those from blasting, the 180 dB re 1 µPa (rms) criterion was used to calculate the area where belugas may incur TTS (NMFS, 2000). For continuous or non-impulse sound sources like dredging, vibratory pile driving, and shipping, the best available estimate is that of Southall *et al.* (2007) for mid-frequency odontocetes, which is 195 dB re 1 $\mu Pa^2 \cdot s$ for non-impulse or continuous sound. This estimate cannot be translated to a sound pressure level without allowance for duration of exposure, i.e., 195 dB re 1 uPa for 1 s; 185 dB re 1 uPa for 10 s, 175 dB re 1 uPa for 100 s. Extrapolation to times longer than 100 s, though necessary to deal with noise from a ship transit, is not advisable (W. John Richardson, LGL Ltd., pers. comm.).

As with the assessment of disturbance, from the composite audiogram and noise graphs, the maximum distance in the 1/3-octave bands that the sound within the hearing range of beluga, above ambient noise levels, and equal to or higher than the relevant thresholds for hearing impairment was estimated (Appendix 8C-3, Table 8C-3.5). Aerial survey data, corrected for detection and availability biases, were used to provide estimates of the numbers of belugas that may occur inside the hearing-impairment zones.

Table 8-5.10 Measurable Parameters and Threshold Values for Beluga Whales

Effect	Measurable Parameter [3 4]	Threshold [4]
Change in habitat caused by icebreaking. Change in habitat caus-ed by dock footprints.	Decrease in suitable beluga habitat for overwintering. Decrease in suitable summering habitat.	≥10 % decrease in suitable beluga overwintering area in Hudson Strait or summering area in Milne and Steensby Inlets.
Disturbance caused by underwater noise, pulsed or continuous.	Change in occupancy of an area that has been identified as important feeding, nursing, calving, breeding, wintering, or summering habitat. Pulsed sound: It is assumed that belugas exposed to sound levels from blasting where the received level exceeds 155 dB re1 µPa (rms) would exhibit "disturbance"[1] and "avoidance"[2] responses. "Continuous" sound: It is assumed that belugas exposed to sound levels from shipping, vibratory pile driving, or dredging where the received level exceeds 120 dB re 1 µPa (rms) and 135 dB re 1 µPa (rms) would exhibit "disturbance"[1] and "avoidance"[2] responses, respectively.	≥10 % of belugas in RSA exhibit strong disturbance and avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat.
Hearing impairment, pulsed or continuous sound.	Continuous sound: Belugas exposed to sound levels from shipping, vibratory pile driving, or dredging that exceed 175 dB re 1 µPa (rms) over a duration of 100 s.	Continuous sound: ≥10 % of the population in the LSA exposed to these continuous sound levels.
Mortality from collisions with vessels.	Increase above natural mortality per annum.	Any project-caused mortality, particularly of animals from the endangered Ungava Bay and Eastern Hudson Bay populations.

NOTE(S):

1. DISTURBANCE = ONSET OF BEHAVIOURAL RESPONSES THAT CAN RANGE FROM SUBTLE CHANGES IN SWIM SPEED AND DIRECTION TO MINOR AND LOCALIZED AVOIDANCE OF A SOUND SOURCE.
2. AVOIDANCE= AVOIDANCE OF AN AREA FOR A PERIOD LONGER THAN THE SOUND SOURCE IS IN OPERATION
3. ALTHOUGH SPECIFIC DATA ARE LACKING, MEASUREABLE PARAMETER LEVELS NECESSARY TO ELICIT BEHAVIOURAL RESPONSES IN FEEDING, NURSING, OR BREEDING BELUGA WHALES (VERSUS BELUGAS CONDUCTING OTHER ACTIVITIES) ARE LIKELY HIGHER THAN CONSIDERED HERE.
4. TIMEFRAME FOR ALL PARAMETERS AND THRESHOLDS UNLESS OTHERWISE STATED IS "PER YEAR"

5.8.1.4 Masking

A qualitative discussion on the potential for beluga masking caused by Project activity noise is provided.

5.8.1.5 Mortality

A qualitative discussion on the potential for beluga mortality as a result of ship strikes is provided. It is not possible to provide a meaningful quantitative assessment of the potential for vessel-beluga collisions in the areas of interest as there are no quantitative data from these specific situations.

5.8.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on beluga whales considered in the assessment are listed below. Effects that are not assessed in detail (i.e., that were ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking plus footprints of dock structures;
- **Disturbance** caused by underwater noise from construction, shipping, and aircraft overflights;
- **Hearing impairment** and/or damage caused by noise from construction activities and shipping;
- **Masking** of environmental sounds caused by vessel and construction noise; and
- **Mortality** from collisions with vessels.

5.8.2.1 Habitat Change

In the RSA, beluga whales are widespread during open-water period, during the ice-cover period they are thought to occur primarily in Hudson Strait. The footprints of the dock structures (0.07 km^2) at Steensby Port will be unavailable to marine mammals for the life of the Project; however, beluga whales are considered uncommon around the proposed dock sites at Steensby Inlet.

Throughout winter, belugas tend to be found in areas of loose pack ice or polynyas, preferring ice cover of $^{4}/_{10}$ – $^{8}/_{10}$ (Koski and Davis, 1979; Finley and Renaud, 1980; COSEWIC, 2004a). An ore carrier will transit through their overwintering habitat in Hudson Strait about every two days, breaking through areas of pack ice within a nominal shipping route (Figure 8-5.7). The area of pack ice that will be disrupted (in areas with $^{4}/_{10}$ – $^{8}/_{10}$ ice cover) is estimated at 30 km^2. Evidence of a ship track in the mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Volume 3, Appendix 3G). Consequently the threshold condition is not cumulative throughout the year but confined to each separate vessel passage. No studies have examined whether frequent ship passages in ice-covered wintering habitat affect beluga whales.

Planned Mitigation - Dock structures were designed to minimize the footprints in the marine environment. Icebreaking vessels will attempt to minimize the width of the shipping lane to <1.5 km in the landfast ice by sailing along the same track as much as possible.

Residual Effects - The dock footprints are negligible parts of nearshore habitat in Steensby Inlet. It is expected that belugas could re-use areas of pack ice changed by the passage of an ore carrier. Much less than 1 % of pack ice with $^{4}/_{10}$ – $^{8}/_{10}$ ice cover in Hudson Strait will be changed during a single transit to the Steensby Port. The changes in habitat caused by dock structures and temporary changes in overwintering habitat are lower than the threshold value of 10 % (Table 8-5.9).

With mitigation measures in place, it is predicted that effects of habitat change on belugas would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of habitat change on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.2.2 Disturbance

Beluga whale responses to industrial activity are quite variable, ranging from tolerance to extreme sensitivity, depending on the whale's activity, its previous exposure to industrial activities, its habitat, and the type of industrial activity. Based on the results of acoustic modelling and analyses of audiogram and ambient noise level data, belugas may detect Project construction activity sounds tens of kilometres away and ore carriers more than 250 km away (Appendix 8C-3, Figures 8C-3.18 to 8C-3.27). As noted earlier, the mere detection of a distant sound source will not negatively affect a marine mammal (see Richardson *et al*., 1995a).

Construction Activities - Belugas are not expected to occur at the Steensby or Milne Inlet construction sites. However, some whales could be exposed to sounds from dredging, vibratory pile driving, and vessel traffic at the port sites. Belugas will not occur near the Steensby ore dock site during blasting and drilling because these construction activities will occur during the ice-cover period before belugas arrive in the area.

In the Mackenzie Estuary, Canada, belugas have approached as close as 400 m to stationary dredges, but were more sensitive to associated barge traffic (Ford, 1977; Fraker, 1977b). In contrast, in 1999, Cook Inlet belugas were seen in waters near the docks at the Port of Anchorage, Alaska, during vessel transits from a dredging operation near Fire Island, but none were observed near the dredging site itself (Moore *et al*., 2000). At the Port of Anchorage, belugas occurred within 500 m during construction of a marine terminal in 2006 (Markowitz and McGuire, 2007); in 2007 and 2008, 29–34 % of beluga whale sightings were within the project area (Cornick and Saxon Kendall, 2008, 2009). No behavioural changes or avoidance responses were observed during in-water pile driving or construction activities for the marine terminal (Cornick and Saxon Kendall, 2009; Saxon Kendall *et al*., 2009). In contrast, beluga whales appeared to avoid the area immediately around the DeLong Mountain Terminal in the Chukchi Sea, although the reasons for this avoidance were uncertain (Tetra Tech, 2008).

Other small odontocetes have shown variable responses to pile driving. Indo-Pacific humpback dolphins (*Sousa chinensis*) occur in nearshore waters near Hong Kong, where in-water pile driving has been used extensively for building piers and other structures (Jefferson *et al.*, 2009). A study indicated that some Indo-Pacific humpback dolphins exposed to sound pressure levels of 170 dB re 1 µPa (rms) remained within 300–500 m of the pile driving area before, during, and after operations (Würsig *et al.*, 2000). Although some dolphins temporarily abandoned the work area, their numbers had returned to pre-construction levels during the follow-up survey seven months after construction activities ended (Würsig *et al.*, 2000). Several studies of harbour porpoises during construction of two offshore wind farms off the coast of Denmark have shown that that this species is quite responsive to large-scale pile-driving programs (e.g., Carstensen *et al.*, 2006; Teilmann *et al.*, 2008; Tougaard *et al.*, 2009). Responses included decreases in feeding behaviour, the number of individuals in the area, and perhaps echolocation activity.

Table 8-5.11 Effects Assessment Summary: Beluga Whale

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only), drilling (Steensby only), dredging, and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for belugas in the area of blasting; bubble curtain system. Drilling in late April/May. Monitoring for belugas in and near safety zone. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet.	Level I	Level I	Level II	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over belugas for passengers to 'get a better look' or for photography.	Level I	Level I	Level II	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level II	Level II	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking [4] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I, Level II	Level II	Level II, Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over belugas for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.12 Significance of Residual Effects to Beluga Whale

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	1		
Hearing Impairment	N	3		
Masking	N	2		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

Although belugas will not be exposed to drilling activities, it is noteworthy that they show considerable tolerance of drill rigs and support vessels (Richardson *et al*., 1995b). Beluga whales in the Mackenzie Delta, Canada, were seen within 100–150 m of a small artificial island when construction or drilling was occurring (Fraker, 1977b; Fraker and Fraker, 1979). During drilling noise playbacks experiments in Alaska, some belugas approached the projector within ~200 m, some came within 50–100 m, and others reacted to the noise at distances of 200–400 m (Richardson *et al*., 1995b). Thus, reactions to actual drill sites were predicted to be a few hundred metres (Richardson *et al*., 1995b).

Residual Effects of Construction Activities - Belugas are expected to be present in low numbers at the Steensby Port site during the open-water period and will be absent when the port sites are encompassed by landfast ice. Drilling for the placement of blast charges and blasting will occur at the Steensby Port site during late April and May in Year 1 of Construction; at that time, belugas will not be present. All other construction activities will occur during the open-water season. Dredging will occur at Steensby Port site during the open-water period of the first year of construction, for up to four weeks, using a cutter head suction dredger or a clamshell operation. At Steensby Inlet, the zones of avoidance and disturbance onset for belugas are estimated at 0.5 km and 2 km, respectively, for a cutter-suction dredge operating thrusters

(Appendix 8C-3, Table 8C-3.5, Figure 8C-3.20). Based on corrected aerial survey data, fewer than 10 belugas are predicted to occur within 2 km of the dredging site at a given time in August, September or October (Table 8C-3.6). Sound levels are much reduced for a clamshell bucket dredge (Matthews *et al*., 2010; Table 8C-3.5).

As noted earlier, vibratory pile driving will occur during a two-month period at the Steensby Port site during the first year of the Construction Phase. The zones of avoidance and disturbance onset for belugas are estimated at 1.5 km and 10 km, respectively (Appendix 8C-5, Table 8C-5.5, Figure 8C-5.3). Belugas are expected to occur only in low numbers in Steensby Inlet during the period when pile driving will occur (July to September). Based on corrected density estimates for the open-water period, seven belugas are expected to occur within the zone of disturbance onset and none are expected to occur within the predicted 1.5 km zone of avoidance (Table 8C-5.6). There is some uncertainty associated with these estimates (see Section 5.5.5 for details), including the avoidance threshold level, density estimates and their correction factors, and how belugas in the RSA respond to vibratory pile driving during the open-water period. However, the estimates suggest that beluga avoidance of pile driving is not expected to exceed, or even come close to, the disturbance threshold level (10 % of population in the RSA) in Table 8.5-10.

Vessel Traffic - Beluga responses to vessels are also quite variable, ranging from tolerance to extreme sensitivity, depending on the whale's activity and experience, its habitat, and boat type and behaviour (Fraker, 1978; Richardson *et al*., 1995a).

In Bristol Bay, Alaska, belugas have been seen feeding among hundreds of salmon fishing boats (Frost *et al*., 1984). Stewart *et al.* (1982) reported that the whales were more responsive to outboard motorboats than to other vessels, and Kleinenberg *et al.* (1964) noted that they sometimes stopped feeding and moved out of an area in response to motorboats. However, Fish and Vania (1971) reported that feeding belugas were not displaced when harassed by motorboats. Belugas that are hunted from motorboats generally return each summer to estuarine concentration areas, even though hunting causes short-term displacement (e.g., Fraker 1980; Seaman and Burns 1981; Burns and Seaman 1985; Caron and Smith 1990). In upper Cook Inlet, they do not avoid vessels (Markowitz and McGuire, 2007). They have also been shown to be tolerant of frequent passages by large vessels traveling in consistent directions in the St. Lawrence River, the Beaufort Sea, and Cook Inlet, Alaska (e.g., Fraker, 1977b; Burns and Seaman, 1985; Pippard, 1985). However, flight from fast and erratically moving boats is often observed.

Small-scale dispersal of belugas has been observed when small ships approach within 2.5 km (Fraker, 1977a, 1978). In the Mackenzie estuary in 1976, Fraker (1977a) noted that belugas swam rapidly away to about 2.5 km from loaded barges that were being pushed by tugs; the change in whale distribution persisted at least 3 hours but <30 hours. In Kugmallit Bay in 1978, beluga responses were variable; some animals moved away from a vessel that approached to within 400 m, whereas whales that were apparently feeding did not respond to a tug that passed ~400 m away (Fraker, 1978). Similarly, whales accompanied by calves moved away in apparent response to a vessel 1.5–3 km away, whereas those that were apparently feeding did not respond to a vessel ~1.5 km away (Fraker, 1978). Harwood *et al.* (2005) also suggested that belugas in deep-water regions of the Canadian Beaufort Sea avoided vessels.

Norton, Fraker and Fraker (1982) suggested that belugas are more sensitive to vessel sounds when ice is present. Belugas may also be more sensitive to ship noise when whales are in open-water leads during spring than at other times (Norton Fraker and Fraker, 1982; Burns and Seaman, 1985). In June 1981, a group of 250 whales encountered two anchored drillships and three supply vessels while moving west in the main lead seaward of the landfast ice north of Kugmallit Bay. At a distance of 1 km from the first drillship, the whales milled briefly, then turned toward the ice and swam around the ship, keeping a distance of ~1 km. When a supply vessel began moving ~3 km away, they abruptly turned into the ice and swam under it, passing within 100 m of a stationary supply vessel. Similar avoidance of a moving supply vessel in ice leads was noted on the next day in two groups of whales 1–2 km from the vessel.

Although belugas in the St. Lawrence River occasionally show positive reactions to ecotourism boats by approaching and investigating, one study found that they surface less frequently, swim faster, and group together in the presence of boats (Blane and Jaakson, 1994). The degree of disturbance varied with the number and speeds of the approaching vessels, the activity and age of the whales (young belugas were less likely to respond than adults), and location (Blane, 1990; Blane and Jaakson, 1994). Feeding or traveling belugas were less likely to react, but when they did, responses were typically stronger. Blane (1990) cautioned that beluga use of high-traffic areas should not be interpreted as a lack of disturbance effects, although some habituation to boats is likely. Caron and Sergeant (1988) noted that a decrease in beluga numbers coincided with an increase in boat activity in one part of the St. Lawrence River, but no causative relationship could be established. Declines in abundance and possibly reduced reproductive success have been reported for dolphins disturbed by tourism vessels (Bejder, 2005; Bejder *et al*., 2006). Lerczak *et al.* (2000) tagged belugas in the Susitna delta during the summers of 1994 and 1995 and observed that belugas appeared to recover quickly from vessel disturbance; even when being incidentally harassed or intentionally pursued by small boats with outboard motors, they never left the immediate study area. If the pursuit vessel stopped, whales approached to within ~100 m after ~15 minutes, and if the engines were turned off the whales approached closely or passed underneath.

Lesage *et al.* (1999) examined the effect of vessel noise on belugas in the St. Lawrence River estuary, Québec. They used controlled experiments to record surface behaviour and vocalizations before, during and after the passing of two different types of vessels—an outboard motorboat moving rapidly and erratically on an unpredictable course, and a ferry moving regularly and slowly on a predictable route. Belugas changed their vocalizations in response to both vessels, using higher frequencies, greater redundancy (more calls emitted in a series) and a lower calling rate, which persisted for longer during exposure to the ferry than to the motorboat. Investigators attempting to record beluga whale vocalizations off Norway found them to be surprisingly silent most of the time, during 72 % of the recordings when the whales were known to be in the vicinity (Karlsen *et al*., 2002). The researchers suggested that the relative silence of this usually vocal species could be attributed to the presence of the research vessel in an area not accustomed to vessel traffic.

In the RSA, belugas have been observed to stay near the shoreline when large ships arrived (M. Akoomalik, Pond Inlet, pers. comm.; Kimmirut IQ Workshop, anonymous, pers. comm.). Some residents have noticed that belugas seem to have become used to ships and now ignore them (I. Shooyook, Arctic Bay, pers. comm.). This observation is supported by studies in the St. Lawrence River, Beaufort Sea and Cook Inlet (e.g., Fraker ,1977a; Burns and Seaman, 1985; Pippard, 1985), which suggest that some beluga populations may become habituated to vessel noise and traffic—particularly frequent passages by large vessels travelling in consistent directions. There are also reports of habituation to vessel traffic for other toothed whale species, e.g., killer whales (Trites and Bain, 2000; Williams *et al*., 2002; Marsh, 2008), sperm whales (Richter *et al*., 2006), and harbour porpoise (Evans *et al*., 1993).

Planned Mitigation for Vessel Traffic - Ore carriers will have a modern design that is expected to reduce noise output (see Volume 3, Section 3.6.2). All vessels will maintain a constant course and speed whenever possible. In addition, vessels will minimize idling of engines when docked at Steensby Port.

During review of the Draft EIS, it was suggested that ore carriers reduce speed from 14 knots to 10 knots (as was proposed for narwhals in Milne Inlet) when they transit along the shipping route between Prince Charles Island and the proposed Steensby port. It should be noted that this mitigation measure was proposed for Milne Inlet because of the high densities of narwhals in the relatively narrow and small area of Milne Inlet during the open-water period. Similar densities of cetaceans do not occur in northeastern Foxe Basin along the shipping route between Prince Charles Island and Steensby port during the open-water period. During the ice-covered period, ore carrier speeds will be much reduced.

Residual Effects of Vessel Traffic - Beluga responses to vessels during periods of open water are variable, ranging from tolerance to avoidance, and likely depend on the type of vessel, its speed and course, and the whales' activity and previous exposure to industrial activity. Belugas (and other toothed whales) in some areas with frequent vessel traffic have shown signs of habituation. Their responses to large ore carriers during periods of open water have not been studied. Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that they would avoid ore carriers during the open-water period along the Steensby Inlet shipping route by 6–7 km, depending on location and vessel speed (Appendix 8C-3, Table 8C-3.5, Figures 8C-3.22 to 8C-3.24). This is based on the 135-dB re 1 µPa (rms) level criterion for avoidance of continuous sound (Appendix 8C-3, Table 8C-3.5). Similarly, few are estimated to be exposed to sound levels assumed to cause disturbance onset (Appendix 8C-3, Table 8C-3.6). Belugas occur more frequently along the Steensby Inlet shipping route, but important areas for calving and feeding during the open-water period have not been specifically identified along the route. Based on corrected density estimates for August, September and October, 668, 421, and 40 belugas, respectively, are estimated to occur within the calculated zone of avoidance (Appendix 8C-3, Table 8C-3.6). There is some uncertainty associated with these estimates (see Section 5.5.5 for details), including the avoidance threshold level, density estimates and their correction factors, and how belugas in the RSA respond to large ore carriers during the open-water period. However, the estimates suggest that beluga avoidance of ore carriers along the shipping route is not expected to exceed the disturbance threshold level (10 % of population in the RSA) in Table 8.5-10.

Vessel traffic at the Milne and Steensby Port sites will vary throughout the Project. A total of 8–10 vessels, including sealifts, tankers, line boats and barges could be present at the port sites simultaneously during construction. During the operation phase at Milne Port, only occasional (less than one per year) vessel traffic will occur. Thus the assessment of vessel traffic at Milne Port applies only to the construction phase. At Steensby Port, shipping traffic during the Operation Phase includes approximately 102 voyages by the dedicated fleet of icebreaking ore carriers, 3-6 voyages by sealifts and tankers, and possibly additional voyages by chartered ore carriers during the open-water season. Up to four tugs will also be stationed at Steensby Port. Noise levels from tugs were modelled at both port sites (Matthews *et al*., 2010; Zykov and Matthews 2010). Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that belugas would avoid tugs during the open-water period at the Steensby and Milne Inlet Ports by 0.7 km and 1 km, respectively (Appendix 8C-3, Table 8C-3.5, Figures 8C-3.21 and 8C-3.25). This is based on the 135-dB re 1 µPa (rms) level criterion for avoidance of continuous sound. Few belugas are expected to occur at the port sites, and based on corrected density estimates for the open-water period, no belugas are expected to occur within the 0.7-km and 1-km avoidance zones around tugs (Appendix 8C-3, Table 8C-3.6). Similarly, few belugas are estimated to be exposed to sound levels assumed to cause disturbance onset (Appendix 8C-3, Table 8C-3.6). If belugas *do* occur near the Milne and Steensby Port sites, they may exhibit localized avoidance of tugs and other vessels, particularly during the Construction Phase. If belugas avoid an area in response to vessel noise, they can return to that area once the source of disturbance has left. They are not necessarily displacing animals in adjacent areas, particularly in open-water situations. Given the long life of the Project, it is also possible that belugas may habituate to vessel presence and noise.

Icebreaking - The most comprehensive study of beluga (and narwhal—see Section 5.9.2.2) responses to icebreaking ships was undertaken during June in each of 1982, 1983 and 1984 in Lancaster Sound, which includes the northern portion of the RSA (LGL and Greeneridge, 1986; Finley *et al*., 1990). In each study year, the icebreaking ore carrier MV *Arctic*, (20,000 DWT) was accompanied by icebreakers, the CCG *John A. MacDonald* (1982, 1983) or the CCG *Louis St. Laurent* (1984), as it moved through Lancaster Sound enroute to the Nanisivik mine in Admiralty Inlet. Belugas at fast-ice edges waiting to continue their migration to summering areas responded to approaching vessels by fleeing at speeds of up to 20 km/h from distances 20–80 km, abandoning normal group structure, and modifying vocal behaviour and/or emitting alarm calls. Strong avoidance reactions occurred when ships were 35–50 km away (Finley *et al*., 1990). At those distances, received sound levels were 94–105 dB re 1 µPa in the 20–1,000 Hz band—barely above typical levels of natural background noise. In 1982, after the MV *Arctic* had travelled 48 km into the fast-ice from the ice edge and 43 hours had passed, the belugas returned and resumed apparently normal activities along the ice edge, although the ship was still audible to them. However, in 1983, beluga distribution along the ice edge and offshore appeared to return to normal only >60 hours after the ships had passed and were >45–50 km into the ice (Finley *et al*., 1990).

Similar displacement observations were reported during a later study by Cosens and Dueck (1988). Cosens and Dueck (1993) suggested that icebreakers generating more high-frequency noise are likely to have greater impacts on belugas. The high degree of responsiveness may be attributable to their partial confinement by ice, lack of experience with ships because of the low number of ships in the area, and good sound propagation in that area (LGL and Greeneridge, 1986). During consultations for the Project, it was noted that belugas respond differently in areas with ice vs. open water. In areas of open water, they do not seem frightened because they are free to go anywhere, whereas in areas with ice, they are not free to go, so they behave differently (Koonoo, Arctic Bay Working Group, pers. comm.).

In 1991 and 1994 in the Alaskan Beaufort Sea, Richardson *et al.* (1995b) recorded reactions of beluga (and bowhead) whales to playbacks of underwater propeller cavitation noise from the icebreaker *Robert Lemeur* operating in heavy ice. Migrating belugas were observed close to the playback projectors on three dates, but interpretable data were only collected on 17 groups for two of those occasions. A minimum of six groups apparently altered their path, but whales approached within a few hundred (and occasionally tens of) metres before exhibiting a response. Icebreaker sounds were estimated at 87–84 dB re 1µPa in the 1/3-octave band centered at 5000 Hz, or 8–14 dB above ambient sound levels in that band, for the six groups that reacted. The authors estimated that reactions at this level would be estimated to occur at distances of ~10 km from an operating icebreaker.

Residual Effects of Icebreaking - Icebreaking by ore carriers will occur throughout the ice-cover season during the Operation Phase. It is expected that one ore carrier will transit through the shipping route LSA to and from Steensby Port every two days. Belugas from three populations (Western Hudson Bay, Eastern Hudson Bay, and perhaps Ungava Bay) are thought to overwinter in Hudson Strait, and available dive profile information suggests they forage there (P. Richard, DFO, pers. comm.). It is estimated that an ore carrier that is actively breaking and moving ice will take 2–3 d to transit Hudson Strait at a speed of 13 km/h. Based on the results of acoustic modelling and analyses of audiogram and ambient noise level data, belugas may detect sounds at ranges of at least 70 km (periods of thin ice) to 100 km (periods of thick ice;

Appendix 8C-3, Figures 8C-3.22 to 8C-3.24). As noted previously, mere detection does not mean that belugas will respond at these distances (see Richardson *et al*., 1995a).

Based on corrected beluga estimates from aerial surveys conducted in Hudson Strait during April, it is estimated that ~10,000 belugas may exhibit avoidance of an icebreaking ore carrier passing through Hudson Strait during a single transit (Appendix 8C-3, Table 8C-3.6). This corresponds to an estimated 15-20 km avoidance distance (30–40 km swath along ship track, depending on ice conditions) based on the 135-dB re 1 µPa (rms) level criterion for continuous sound (Appendix 8C-3, Table 8C-3.5). The corresponding estimate of the numbers of belugas exhibiting avoidance in June, (the only month during the ice-cover period with available aerial survey data), is lower (~4,800 belugas estimated to exhibit avoidance; Appendix 8C-3, Table 8C-3.6). If it is assumed that ~5,000–10,000 belugas in Hudson Strait avoid an icebreaking ore carrier during each vessel transit, this represents ~8–15 % of those that may occur there during winter, based on available population estimates and assuming that all belugas in the Western and Eastern Hudson Bay populations overwinter in Hudson Strait.

As noted earlier, these estimates are meant to serve as a guide for potential effects and indicators for monitoring and follow-up. There is much uncertainty associated with the estimates (see Section 5.5.5 for details), including the avoidance threshold level, density estimates and their correction factors, and how overwintering belugas that are potentially foraging will respond to icebreaking vessels as compared to those migrating to summering habitat. There is also much uncertainty about the duration of the effect. Some belugas may avoid the ore carrier track for a period after the vessel has passed, and may not return for hours or even days. Another ore carrier may pass through the area before they return. It is possible that belugas may avoid some distance (estimated at ~10–20 km here) around the ship's track for the duration of the ice-cover season. It is also possible that they will habituate to frequent icebreaking and eventually move closer to the ship track. If they avoid an area in response to an approaching icebreaking ore carrier, they can return to that area once the source of disturbance has left. They are not necessarily displacing animals in adjacent areas. Of note, recurring polynyas where marine mammals are known or expected to concentrate have not been identified along the shipping route (see Ersahin *et al.*, 2011a,b in Appendix 8A-3). This reduces the likelihood that belugas (and other marine mammals) would be displaced from "important" polynya habitat into less preferred habitat. Apart from northwest Foxe Basin which is located well away from the shipping route, the polynya-like features identified along the shipping route are fairly small and transitory and do not differ from areas of open water that appear and disappear in areas of moving pack ice. Regardless, using the indicator and threshold criteria provided in Table 8.5-9 as a guide, monitoring and follow-up are required to examine the effects of shipping (including potential displacement and the effects of repeated exposures to ice breaking ore carriers) on belugas in Hudson Strait during the ice-cover season (see Section 5.8.5).

Aircraft Overflights - Toothed whales show variable reactions to overflights (e.g., Richardson *et al*. 1995a; Würsig *et al.* 1998). Reactions can be elicited by sound, visual cues or both (Patenaude *et al*., 2002). Some belugas ignored aircraft flying at 500-m altitude, with aircraft at altitudes of 150–200 m, they dove for longer periods and sometimes swam away; feeding belugas appeared to be less prone to disturbance (Bel'kovich, 1960; Kleinenberg *et al*., 1964). Those in summering areas, including the Mackenzie Estuary, often reacted to aircraft by diving or swimming away (e.g., Fraker and Fraker, 1979; Caron and Smith, 1990). Belugas in Cook Inlet may be habituated to aircraft, as there are several airports in the area; they did not react to repeated overflights by a fixed-wing aircraft (Rugh *et al*., 2000).

During a spring flight that opportunistically examined the short-term behavioural responses of migrating beluga (and bowhead) whales to overflights by a Twin Otter fixed-wing aircraft, a small proportion of belugas were observed to react to the aircraft at altitudes of 60–460 m (Patenaude *et al*., 2002). Considering observations made during all fixed-wing aircraft altitudes, 3.2 % (24 of 760) of beluga singletons or groups reacted overtly, exhibiting behaviours such as diving with tail thrash, changing heading, and twisting to look up at the aircraft; direct overflights generated the most obvious reactions. The proportion of belugas reacting to the Twin Otter at low altitudes (≤182 m) was relatively low at 5.4 % (18 of 336); however, the authors acknowledge this is likely an underestimation as observation opportunities were brief (Patenaude *et al*., 2002). Overall, most (14 of 24) reactions by belugas occurred when the Twin Otter was at altitudes ≤182 m and lateral distances ≤250 m (Patenaude *et al*., 2002). Patenaude *et al.* (2002) suggested that the mid-frequency components of Twin Otter sounds from overflights at 150-m altitude should be readily audible to belugas just below the surface but overflights at 300 m might be barely detectable. A greater proportion (38 % of 40) reacted to helicopters than to fixed-wing aircraft; most reactions (86 %) occurred when the helicopter was at altitudes ≤150 m and lateral distances ≤250 m (Patenaude *et al*., 2002). Seven of 14 beluga groups reacted up to 320 m away when a helicopter was on the ice with its engines running (Patenaude *et al*., 2002).

During consultations for the Project, it was noted that belugas flee from the ice edge during aircraft over-flights (Cape Dorset IQ Workshop, anonymous, pers. comm.).

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow. In addition, aircraft will be prohibited from flying low over beluga whales for sightseeing or photography.

Residual Effects of Aircraft Overflights - Belugas near the flight paths of aircraft in Milne and Steensby Inlets will likely be exposed to aircraft sound; however, available data suggest that few belugas occur in these inlets. Aircraft approaches to and from the airstrips at Milne and Steensby Inlets will be most frequent during the Construction Phase. During the Operation Phase, the primary airstrip will be located at the Mine Site. Reactions to overflights by aircraft (Twin Otter, Dash-8, and ATR) at Milne Inlet are expected to be limited to a brief alert or startle response and sometimes a dive. These types of behavioural responses would have little consequences for individual whales or their populations. It is unknown how belugas in Steensby Inlet will react to daily overflights by a large aircraft like the Boeing 737. Belugas are not expected to occur in large numbers in Steensby Inlet, but any individuals that do occur there, particularly those under the direct flight path of the Boeing 737, may exhibit a disturbance response.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on belugas from construction, shipping, and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (blasting, dredging; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of disturbance from Project activities on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.2.3 Hearing Impairment

TTS – The majority of these data concern non-impulse sound, but there are some limited published data concerning TTS onset upon exposure to a single pulse of sound from a watergun (Finneran *et al*., 2002). A detailed review of all TTS data from marine mammals can be found in Southall *et al.* (2007). The following summarizes some of the key results for odontocetes.

Recent information corroborates earlier expectations that the effect of exposure to strong transient sounds is closely related to the total amount of acoustic energy received. Finneran *et al.* (2005) examined the effects of tone duration on TTS in bottlenose dolphins by exposing them to 3-kHz tones (non-impulse) for periods of 1, 2, 4 or 8 s, with hearing tested at 4.5 kHz. For 1-s exposures, TTS occurred with SELs of 197 dB, and for exposures >1 s, SEL >195 dB resulted in TTS (SEL is equivalent to energy flux, in dB re 1 $\mu Pa^2 \cdot s$). At an SEL of 195 dB, the mean TTS (4 minutes after exposure) was 2.8 dB. Finneran *et al.* (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and belugas exposed to tones of durations 1–8 s (i.e., TTS onset occurs at a near-constant SEL, independent of exposure duration).

Mooney *et al.* (2005) exposed a bottlenose dolphin to octave-band noise ranging from 4 to 8 kHz at SPLs of 160–172 dB re 1 μPa for periods of 2–30 minutes. Recovery time depended on the shift and frequency, but full recovery always occurred within 40 minutes. Consistent with the results of Finneran *et al.* (2005) based on shorter exposures, Mooney *et al.* reported that, to induce TTS in a bottlenose dolphin, there is an inverse relationship between exposure time and SPL; as a first approximation, as exposure time was halved, an increase in noise SPL of 3 dB was required to induce the same amount of TTS. In other words, for toothed whales receiving single, short exposures to non-impulse sound, the TTS threshold appears to be a function of the total energy received (Finneran *et al*., 2002, 2005).

The TTS threshold for odontocetes exposed to a single impulse from a watergun (Finneran *et al*., 2002) appeared to be somewhat lower than that for exposure to a non-impulse sound. This was expected, based on evidence from terrestrial mammals showing that broadband pulsed sounds with rapid rise times have greater auditory effect than do non-impulse sounds (Southall *et al*., 2007). The received energy level of a single seismic pulse that caused the onset of mild TTS in the beluga, as measured without frequency weighting, was ~186 dB re 1 μPa2 · s or 186 dB SEL (Finneran *et al.*, 2002). If the low-frequency components of the watergun sound used in the experiments of Finneran *et al.* (2002) are downweighted as recommended by Miller *et al.* (2005a) and Southall *et al.* (2007) using their Mmf-weighting curve, the effective exposure level for onset of mild TTS was 183 dB re 1 μPa2 · s (Southall *et al.* 2007). Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS on exposure to repeated, low-frequency pulses of sound with variable received levels. There is a data gap in the exposure levels necessary to cause TTS in toothed whales when the signal is a series of pulsed sounds separated by silent periods.

PTS – The relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals (Southall *et al*., 2007). Sound levels assumed to cause PTS in cetaceans were reviewed in Section 5.4.1.4.

Planned Mitigation - Blasting will occur late in the ice-cover season (late May) to eliminate the likelihood of belugas occurring nearby. No belugas are expected to occur in the landfast ice near the blast site, but some could occur at the landfast ice edge located >90 km away. There is virtually no chance that they will be exposed to sound levels high enough to cause TTS. In addition to the timing of blasting, a blasting plan will be designed by an explosives contractor, in consultation with DFO, to ensure that the 100-kPa waterborne acoustic overpressure threshold is met and minimized, and a bubble curtain will be employed as necessary, primarily to protect ringed seals. It is anticipated that an Inuit Elder knowledgeable about marine mammals and an Environmental Monitor will be on site during blasting operations to assess the area for marine mammal presence. In the unlikely event that a beluga is observed within the 500-m safety zone (Wright, 2002), blasting will not commence until the animal has left the area.

Vibratory pile driving at Steensby Inlet will occur over a two-month period during open-water construction in Year 1. Acoustic modelling indicates that sound levels will only exceed 180 dB (rms) (Zykov 2011 in Appendix 8C-4) less than 30 m from the pile driving site. As a conservative approach, a 50-m "safety zone" (which corresponds to sound levels of <160 dB (rms)) will be established and monitored around the pile driving site. An Inuit monitor and an Environmental Monitor will be present at the pile driving site to monitor the appropriate safety zone. Prior to pile driving operations, the safety zone will be monitored and if a beluga is present, pile driving will not be permitted to commence. Observers will continue to monitor the zone during pile driving and if a beluga is observed within or approaching the zone, pile driving will be halted until the beluga has left the area.

Residual Effects - Based on acoustic modelling results and the implementation of mitigation measures, belugas are not expected to be exposed to sound levels high enough to elicit TTS. Blasting at the Steensby ore dock will occur during May when landfast ice is present, and any belugas are expected to occur 90–120 km away—well beyond the small area where sound levels over 180-dB re 1 µPa (rms) threshold would elicit hearing impairment.

Belugas may incur temporary hearing impairment from exposure to continuous sources of sound of sufficient level and duration. It is assumed that exposure to a sound pressure level of 175 dB re 1 µPa for 100 s or more could induce TTS (see Southall *et al*., 2007). It is quite unlikely that belugas would incur TTS from vibratory pile driving, particularly with mitigation measures in place. Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that if belugas occur within 100 m of a Cape-size ore carrier that is breaking ice in Foxe Basin and remain there for 100 sec, they could incur TTS. This is highly unlikely, given that they are expected to avoid the immediate area. Also, TTS is not considered an injury and if it occurs, hearing impairment would be temporary. Belugas could not be exposed to sound levels from shipping that would cause PTS.

With mitigation measures in place, it is predicted that hearing impairment effects on belugas (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of hearing impairment on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.2.4 Masking

Beluga call characteristics and their likely frequency range of best hearing are relevant in assessing potential masking effects of anthropogenic sounds. Belugas are highly social and vocal cetaceans. At least 50 different calls have been reported for the beluga whale including groans, grunts, screams, buzzes, trills and roars (O'Corry-Crowe, 2002; Chmelnitsky, 2010; Vergara *et al*., 2010). Karlsen *et al.* (2002) found that during summer, adult males in Svalbard, Norway, vocalized little but produced most calls during milling and joining behaviours. Belugas produce whistles and pulsed tones with frequencies 0.2–20 kHz, with dominant frequencies at 1–11 kHz (e.g., Schevill and Lawrence, 1949; Sjare and Smith, 1986a, b; Karlsen *et al*., 2002; Belikov and Bel'kovich, 2006, 2007, 2008; Chmelnitsky, 2010). Broadband pulsed calls are thought to function to maintain group cohesion and mother-calf recognition (Vergara *et al*., 2010). Belugas also produce echo-location clicks at frequencies of 30–120 kHz and source levels of 206–225 dB re 1 µPa·m (e.g., Au *et al*., 1985, 1987; Au, 1993; Roy *et al*., 2010). Belugas and other toothed whales hear best at frequencies of about 20–100 kHz (see Section 5.4.1.3).

Residual Effects - Beluga calls are primarily at frequencies from a few hundred Hz to 120 kHz, with dominant frequencies >1 kHz. As noted earlier, a specific tone is masked principally by sounds at frequencies near the frequency of that tone. The potential effect of auditory masking for beluga whales is limited by the small amount of overlap between the predominant frequencies produced by ship noise and construction activities (<1 kHz) and the frequencies at which they call and hear. There is little chance of masking of beluga calls during blasting operations because sounds will be intermittent in nature and the sound pulse is very short. However, shipping (and vibratory pile driving) sounds and beluga communications have some overlap in frequency, so there is a potential for masking (Hotchkin *et al*., 2010), out to an unknown distance from the vessel(s). In enclosed areas with shipping noise, such as the port sites during the Construction Phase, masking of communication in the few belugas expected there could occur over extended periods. Along the shipping route, any masking would occur as a vessel passed by, which is likely to be a short time relative to the interval between transits. If masking does occur, belugas may change their call types and frequencies during noise exposure to overcome the masking (e.g., Au *et al*., 1985; Lesage *et al*., 1999). Given that most sounds important to belugas are predominantly at much higher frequencies than shipping noise, and given the intermittent nature of construction activities noises, it is unlikely that masking would adversely affect belugas.

With mitigation measures in place, it is predicted that residual effects of masking on belugas would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; Level I) or intermittently (vibratory pile driving and shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of masking on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.2.5 <u>Mortality</u>

Belugas are small relative to vessels, especially ore carriers, and are capable of very high swim speeds, which should enable them to avoid collisions. Also, it is likely that they would avoid vessels under way (see Section 5.8.2.2.), maintaining distances that would prevent ship strikes. However, it is possible that beluga whales could experience serious injury or mortality as a result of collisions with vessels. Based on necropsy reports, mortality in the Gulf of St. Lawrence could have been caused by collisions with ships; however, in some cases, disease could have made the beluga more susceptible to strikes (L. Measures, DFO, pers. comm.). It was noted that comparing mortality from potential ship strikes in the Gulf of St. Lawrence to those in the eastern Arctic would be tenuous, because some belugas in the Gulf respond quite differently to vessels (often approaching closely) than do those in the Arctic.

Planned Mitigation - Vessel speed in areas of pack ice (approximately 13 km/h) will be lower than speeds during the open-water season (approximately 26 km/h), thereby reducing the likelihood of collisions with belugas during periods when their movements are restricted by ice. In addition, vessels will maintain a constant course and speed whenever possible.

Residual Effects - Mortality from collisions is unlikely because belugas exhibit avoidance of vessels. Also, ore carriers will reduce speeds to 13 km/h in areas of pack ice further minimizing the risk of collision. Belugas are capable of very high swim speeds, which should enable an individual to avoid a collision even if it were close to a vessel. With mitigation measures in place, no mortality is expected. There are no residual effects to belugas as a result of potential mortality.

5.8.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on beluga whales are summarized in Tables 8-5.11 and 8-5.12 and below.

5.8.3.1 Habitat Change

It is predicted that residual effects of habitat change on belugas would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of habitat change on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.3.2 Disturbance

It is predicted that residual disturbance effects on belugas from construction, shipping, and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (blasting, dredging; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of disturbance from Project activities on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.3.3 Hearing Impairment

It is predicted that residual hearing impairment effects on belugas (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of hearing impairment on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.3.4 Masking

It is predicted that residual effects of masking on belugas would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; Level I) or intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.11). The residual environmental effect of masking on beluga whales is predicted to be "*not significant*" (Table 8-5.12).

5.8.3.5 Mortality

With mitigation measures in place, no mortality is expected, and therefore, residual effects on belugas are negligible. With mitigation measures in place, no mortality is expected (Table 8-5.11). The residual environmental effect on belugas is predicted to be "*not significant*" (Table 8-5.12).

5.8.3.6 Cumulative Effects Within the Project

Reviewers of the draft EIS requested that the effects of multiple Project activities be considered. As discussed previously, belugas may be exposed to construction activities (i.e., dredging, pile driving, vessel traffic, aircraft overflights) at the Steensby Inlet and Milne Inlet port sites during the first four years of the Project. With mitigation measures in place, hearing impairment and mortality are not expected to result from construction activities. It was predicted that some belugas may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port sites; however, any avoidance is predicted to be localized. In addition, few belugas are predicted to occur near the port site. During the Operation Phase, belugas will be exposed to noise from ore carriers plus vessels located at the Steensby port site. It was predicted that they may avoid an icebreaking ore carrier in Hudson Strait by 15 to 20 km. It is possible that this area of avoidance may increase slightly when two ore carriers pass each other along the shipping route (particularly the areas identified in Hudson Strait—see Figure 8-5.2); however, given the relatively small increase in sound levels, the increase in the numbers of belugas potentially exhibiting avoidance is predicted as minimal.

5.8.4 Prediction Confidence

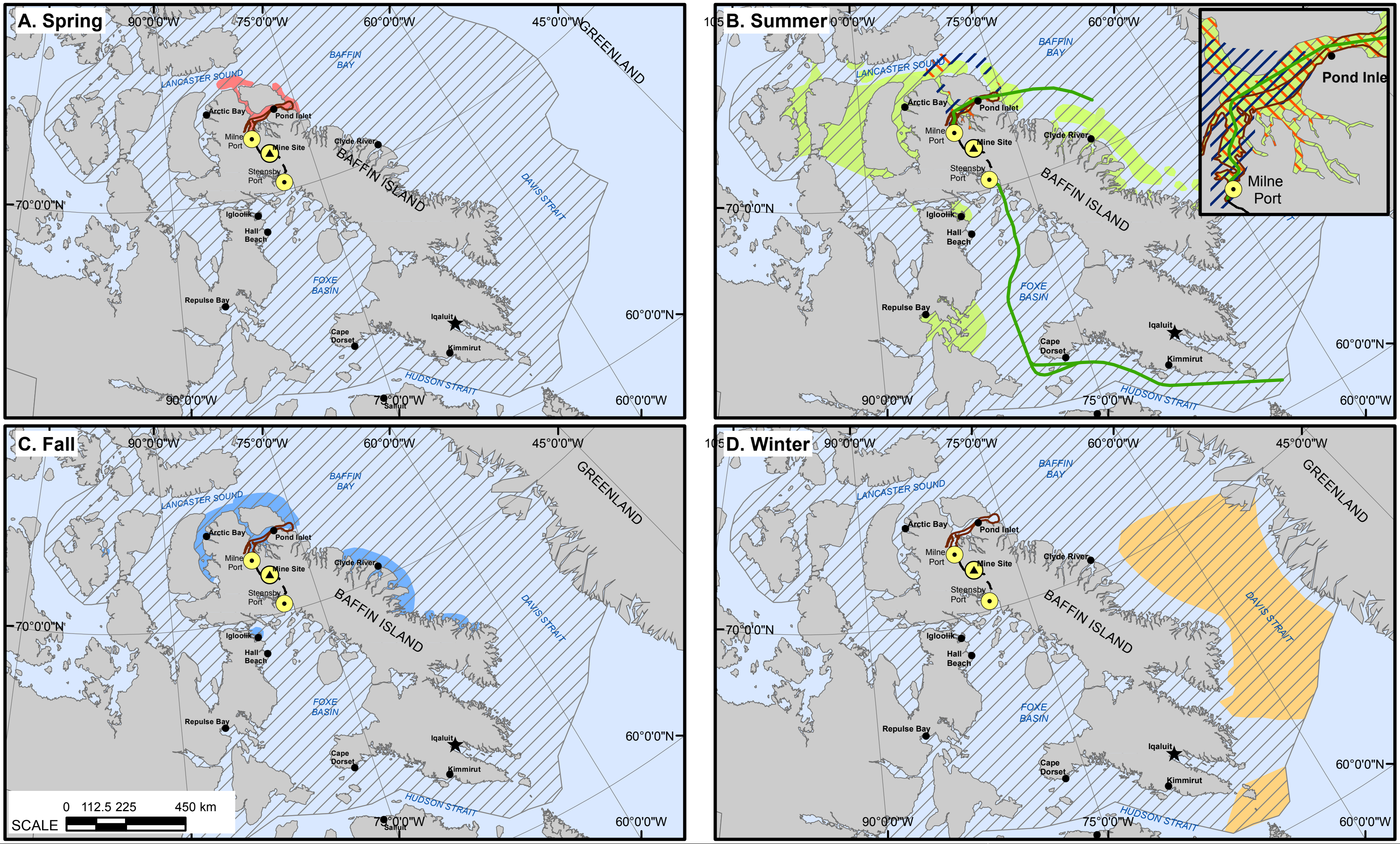
Based on the planned mitigation measures, the baseline data used in the assessment, the location of port sites and shipping routes relative to potential feeding and calving areas, and the available evidence on beluga responses to vessel traffic and construction activities, there is a high level of certainty in the residual effects predictions, with the exception of disturbance effects in Hudson Strait and the potential effects of masking by project noise (Table 8-5.12). No significant residual effects are predicted for this indicator species. However, follow-up is required to monitor beluga responses to ore carrier traffic in Hudson Strait (see below).

5.8.5 Follow Up

The planned mitigation and monitoring for belugas are summarized in Section 5.8.2 and in the marine mammal mitigation and monitoring management plan. Significant residual effects of Project activities on belugas are not expected, and the level of certainty associated with this prediction is generally high with exceptions. There is a low level of certainty with the prediction of disturbance and masking effects of ore carriers transiting Hudson Strait during the ice-cover season. Therefore, a monitoring program and an adaptive management plan will be undertaken to address this uncertainty and ensure that belugas do not incur significant negative effects (see the Shipping and Marine Mammal Management Plan, Appendix 10D-10). The monitoring program will include Marine Mammal Observers (MMOs) positioned onboard a representative number of ore carriers, aerial surveys with a fixed-wing aircraft and potentially using an unmanned airborne system, and an ice imagery study. Aerial surveys for cetaceans are planned to be undertaken during the winter (March, April) 2012 in Hudson Strait to provide a baseline against which potential future surveys during Baffinland's shipping operations could be compared as part of a longer-term monitoring program. There is some uncertainty associated with acoustic modelling results, primarily because details of blasting were limited during preparation of this assessment and the final design of the ore carriers has not been determined. Acoustic measurements will be acquired to ensure that the 100 kPa overpressure guideline for blasting is met, and to provide necessary information on sound levels from ore carriers.

5.9 NARWHAL

Narwhal abundance in the Canadian High Arctic is estimated to be in excess of 60,000 (NAMMCO, 2010), with two putative populations: Baffin Bay and Hudson Bay. Narwhals occur in the northern portion of the RSA primarily during the open-water period, and recent estimates indicate that ~20,000 narwhals summer in the Eclipse Sound and Milne Inlet area (Figure 8-5.8; NAMMCO, 2010). They are thought to calve and feed in this summering area. A much smaller number inhabit waters along the southern shipping route. Relatively few occur in Foxe Basin but the putative Hudson Bay population is thought to overwinter in the eastern portion of Hudson Strait. It is unknown if they forage there, but it is likely.



LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- CALVING (IQ)
- MATING (IQ)
- FEEDING (IQ)
- KNOWN RANGE
- SPRING CONCENTRATIONS (IQ)
- SUMMER CONCENTRATIONS (IQ)
- FALL CONCENTRATIONS (IQ)
- WINTER CONCENTRATIONS (IQ)

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

ᓄᓘᔮᓂ ᐅᔭᕐᓯᐅᕐᑐᑦ MARY RIVER PROJECT

NARWHAL SEASONAL OCCURRENCE BASED ON SCIENTIFIC AND IQ INFORMATION

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_024

ᑎᑎᕐᐅᔭᕐᓯᒪᔪᖅ FIGURE 8-5.8

REV A

Figure ID: BL_Vol8_GIS_024 Narwhal Seasonal Occurrence Based on Scientific and IQ Information Figure 8-5-8.mxd

During community consultations, the key area of concern was the effect of shipping on narwhals. Numerous individuals thought that narwhals responded negatively to ships, particularly larger ships (Arctic Bay Working Group and HTO Meeting; Cape Dorset HTA Meeting; Clyde River Public Meeting; Hall Beach Marine Mammal Workshop; Pond Inlet Public Meeting). There was concern that narwhals would leave the area, particularly Milne Inlet.

5.9.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on narwhal: habitat change, disturbance, hearing impairment, masking, and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in narwhal habitat, behaviour, and health (Table 8-5.13). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour, or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant at the population level. The reader is referred to Volume 2, Section 3.8 for the criteria used to establish significance determination.

5.9.1.1 Habitat Change

The footprints of dock structures at Steensby Port were calculated to determine how much potential open-water narwhal habitat would become unavailable. Narwhals are not expected to occur in areas of solid landfast ice, but do occur in areas of pack ice in Hudson Strait. The amount of changed ice caused by ship passages during periods of maximum pack-ice coverage was calculated and compared to overall available pack ice in Hudson Strait.

5.9.1.2 Disturbance

The assessment approach for belugas was used to assess the potential level of disturbance from Project activities on narwhals (see Section 5.8.1.2), since no comparable measurements on narwhals have been made, the beluga audiogram, ambient noise levels, and predicted 1/3-octave band noise levels from the acoustic modelling report for each modelled sound source were plotted (Appendix 8C-3, Figures 8C-3.18 to 8C-3.27).

From these graphs (Appendix 8C-3, Figures 8C-3.18 to 8C-3.27), the maximum distance in the 1/3-octave bands that the sound was within the hearing range of narwhal, above ambient noise levels, and equal to or higher than the relevant thresholds for disturbance onset and avoidance for continuous and pulsed sound was estimated (Appendix 8C-3, Table 8C-3.5). As noted earlier, these thresholds, selected based on a review of the literature, are meant to serve as a guide for potential behavioural responses and to allow the calculation of numbers of potentially affected narwhals. There have been few studies of narwhals and their responses to noise (see Section 5.9.2.2 below) and as such, the results of the analyses presented here should be interpreted with some caution. As with belugas, “disturbance onset” was considered to be behavioural responses ranging from subtle changes in swim speed and direction to minor and localized avoidance of a sound source, and “avoidance” to be avoidance of an area for a period longer than the sound source is in operation.

Table 8-5.13 Measurable Parameters and Threshold Values for Narwhal

Effect	Measurable Parameter [d]	Threshold [d]
Change in habitat caused by icebreaking. Change in habitat caused by dock footprints.	Decrease in suitable narwhal habitat for overwintering. Decrease in suitable summering habitat.	≥10 % decrease in suitable narwhal overwintering area in Hudson Strait or summering area in Milne and Steensby Inlets.
Disturbance caused by underwater noise, pulsed or continuous.	Change in occupancy of an area that has been identified as important feeding, nursing, calving, breeding, wintering, or summering habitat. Pulsed sound: Narwhals exposed to sound levels from blasting where the received levels exceed 145 dB re 1 µPa (rms) and 155 dB re1 µPa (rms) would exhibit "disturbance"[a] and "avoidance"[b] responses, respectively. [c]	≥10 % of narwhals in the RSA exhibit strong disturbance and avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat.
Disturbance caused by underwater noise, pulsed or continuous.	"Continuous" sound: Narwhals exposed to sound levels from shipping, vibratory pile driving, or dredging where the received levels exceed 120 dB re 1 µPa (rms) and 135 dB re 1 µPa (rms) may exhibit "disturbance"[b] and "avoidance"[a] responses, respectively.[c]	
Hearing impairment, pulsed or continuous sound.	"Continuous" sound: Narwhals exposed to sound levels from shipping, vibratory pile driving, or dredging that exceed 175 dB re 1 µPa (rms) over a duration of 100 s.	Continuous sound: ≥10 % of the population in the LSA exposed to these continuous sound levels.
Mortality from collisions with vessels.	Increase above natural mortality per annum.	Any project-caused mortality

NOTE(S):

NOTE THAT FINLEY et al. (1990) STATE THAT "WE COULD NOT DISCERN ANY INFLUENCE OF RECEIVED NOISE LEVELS AS HIGH AS 120 dB ON THE LEVEL OF NARWHAL VOCAL ACTIVITY OR ON THEIR SURFACE BEHAVIOUR

a) DISTURBANCE = ONSET OF BEHAVIOURAL RESPONSES THAT CAN RANGE FROM SUBTLE CHANGES IN SWIM SPEED AND DIRECTION TO MINOR AND LOCALIZED AVOIDANCE OF A SOUND SOURCE.

b) AVOIDANCE= AVOIDANCE OF AN AREA FOR A PERIOD LONGER THAN THE SOUND SOURCE IS IN OPERATION.

c) ALTHOUGH SPECIFIC DATA ARE LACKING, MEASUREABLE PARAMETER LEVELS NECESSARY TO ELICIT BEHAVIOURAL RESPONSES IN FEEDING, NURSING, OR BREEDING NARWHALS (VERSUS NARWHALS CONDUCTING OTHER ACTIVITIES) ARE LIKELY TO BE HIGHER THAN CONSIDERED HERE.

d) TIMEFRAME FOR ALL PARAMETERS AND THRESHOLDS UNLESS OTHERWISE STATED IS "PER YEAR"

The areas exposed to sound levels that exceeded the threshold for disturbance onset and avoidance were calculated for all modelled Project activities at the Steensby and Milne Inlet Port sites, and along both shipping routes. The estimated numbers of narwhals exposed to sound levels that exceeded these thresholds for disturbance onset and avoidance were calculated for months with available aerial survey data (April, June, August, September, and October). Correction factors of 1.11 and 2.91 were applied to narwhal density estimates for availability and detection biases, respectively (Richard *et al*., 2010).

5.9.1.3 Hearing Impairment

For impulse sound sources like those from blasting, the 180-dB re 1 µPa (rms) criterion was used to calculate the area where narwhals could incur TTS (NMFS, 2000). For continuous sound sources like dredging, vibratory pile driving, and shipping, the best available estimate is that of Southall *et al.* (2007) for mid-frequency odontocetes, which is 195 dB re 1 $\mu Pa^2 \cdot s$ for non-impulse or continuous sound. This estimate cannot be translated to a sound pressure level without allowance for duration of exposure, i.e., 195 dB re 1 µPa for 1 s, 185 dB re 1 µPa for 10 s, 175 dB re 1 µPa for 100 s. Extrapolation to times longer than 100 s, although necessary to deal with noise from a ship transit, is not advisable (W. John Richardson, LGL Ltd., pers. comm.).

As with the assessment of disturbance, from the composite audiogram and noise graphs, the maximum distance in the 1/3-octave bands that the sound was (1) within the hearing range of narwhals, (2) above ambient noise levels, and (3) equal to or higher than the relevant thresholds for hearing impairment was estimated (Appendix 8C-3, Table 8C-3.5). Aerial survey data, corrected for detection and availability biases, were used to provide estimates of the numbers of narwhals that could occur inside the hearing-impairment zones.

5.9.1.4 Masking

A qualitative discussion on the potential for narwhal masking caused by Project activity noise is provided.

5.9.1.5 Mortality

A qualitative discussion on the potential for narwhal mortality as a result of ship strikes is provided. It is not possible to provide a meaningful quantitative assessment of the potential for vessel-narwhal collisions in the areas of interest because there are no quantitative data from these specific situations.

5.9.2 Potential Effects and Proposed Mitigation

Potential effects of the Project on narwhals considered in the assessment are listed below. Effects that are not assessed in detail (i.e., that were ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking plus footprints of dock structures;
- **Disturbance** caused by underwater noise from construction, shipping, and aircraft overflights;
- **Hearing impairment** and/or damage caused by noise from construction activities and shipping;
- **Masking** of environmental sounds caused by vessel and construction noise; and
- **Mortality** from collisions with vessels.

5.9.2.1 Habitat Change

Narwhals occur in high numbers in Milne Inlet and Eclipse Sound during the open-water period. They overwinter in areas of heavy pack ice in eastern Hudson Strait (Koski *et al*., 2006; see Figure 8-5.8D). Narwhals are considered uncommon in Steensby Inlet but are expected to occur regularly near the Milne Inlet Port site. At Steensby Port site, the footprints of the dock structures (0.07 km^2, which includes the intertidal zone where narwhals are not expected to occur) will be unavailable to marine mammals for the life of the Project. In Hudson Strait, an ore carrier will transit through potential narwhal overwintering habitat roughly every two days, breaking through areas of pack ice within a nominal shipping route (Figure 8-5.8).

The area of pack ice that will be disrupted temporarily by a single ore carrier passage in Hudson Strait is estimated at 44 km^2 during the period of maximal ice coverage. Evidence of a ship track in the mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Volume 3, Appendix 3G). There have been no studies that have examined how frequent ship passages in ice-covered wintering habitat affect narwhals.

Planned Mitigation - Dock structures were designed to minimize the footprints in the marine environment.

Residual Effects - The small area of the dock footprints is a negligible part of nearshore habitat in Steensby Inlet. It is expected that narwhals could re-use areas of pack ice changed by the passage of an ore carrier. It is estimated that an ore carrier will temporarily change ~44 km^2 of pack ice in Hudson Strait during a single transit through the entire strait; this is a conservative estimate because narwhals are thought to winter in the eastern portion of Hudson Strait. Regardless, ~44 km^2 represents much <1 % of pack ice in Hudson Strait. This change in habitat caused by dock structures and temporary decreases in narwhal overwintering habitat is lower than the threshold value of 10 % (Table 8-5.13).

With mitigation measures in place, it is predicted that effects of habitat change on narwhals would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of habitat change on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.2.2 Disturbance

Construction - To the best of our knowledge there is no available information on narwhal response to construction activities such as dredging and pile driving. There is some information for other odontocetes, which was summarized in Section 5.8.2.2. Perhaps of some relevance is that narwhals avoid areas frequented by snowmobiles (Pond Inlet Public Meeting, anonymous, pers. comm.).

Residual Effects of Construction Activities - Narwhals are considered more common at the Milne Port site than at the Steensby site, where few individuals are expected during the open-water period. Narwhals will be absent when the port sites are covered by landfast ice.

With the exception of blasting and drilling late in the ice-cover season, all other construction activities will occur during the open-water season. Dredging will occur at Steensby Port site during the open-water period of the first year of construction for up to four weeks, likely using a cutter head suction dredger or a clamshell. At Steensby Inlet, the zones of avoidance and disturbance onset for narwhals are estimated at 0.5 km and 2 km, respectively, for a cutter-suction dredge operating thrusters (Appendix 8C-3, Table 8C-3.5, Figure 8C-3.20). Sound levels are much reduced for a clamshell bucket dredge (Matthews *et al*., 2010; Table 8C-3.5).

Few narwhals are expected to occur at the Steensby Inlet Port site and in adjacent waters. Based on corrected aerial survey data, none are predicted to occur within 2 km of the Steensby dredging site during the open-water period (Table 8C-3.7). However, it is possible that small numbers will occur there, and that they may exhibit localized avoidance of the area.

Few narwhals are expected to occur at the Steensby Inlet port site and in adjacent waters during periods when vibratory pile driving will occur. Based on corrected aerial survey data, none are predicted to occur within the areas where pile driving sound levels are predicted to elicit disturbance onset (10 km) and avoidance (1.5 km) (Table 8C-5.7). However, it is possible that small numbers will occur there, and these whales may exhibit localized avoidance of the area.

Table 8-5.14 Effects Assessment Summary: Narwhal

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only) drilling (Steensby only), dredging, and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for narwhals in the area of blasting; bubble curtain system. Drilling in late April/May. Monitoring for narwhals in and near safety zone. Reduce vessel idling at dock side.	Level I	Level I	Level I, Level II, Level III	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet.	Level I	Level I	Level II	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over narwhals for passengers to 'get a better look' or for photography.	Level I	Level I	Level II	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I, Level II	Level II	Level III	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking [4] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I, Level II	Level II	Level II, Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over narwhals for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.15 Significance of Residual Effects to Narwhal

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood [1]	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	3		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	1		
Hearing Impairment	N	3		
Masking	N	2		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: :1= Low; 2= Medium; 3=High

Vessel Traffic - During aerial surveys conducted for the Project in 2007 and 2008, several ships transited to and from the Milne Inlet Port site, allowed a semi-quantitative assessment of narwhal densities before and after transits. Biologists attempted to time aerial surveys of given areas (i.e., Milne Inlet, Koluktoo Bay, and Eclipse Sound) so that they coincided with a period before and after a ship had left that area. The time between a ship transit and the period of aerial surveys ranged from 1 hour to 48 hours. To assess potential changes in narwhal numbers, observed densities were compared during aerial surveys before the ship's arrival and after its departure. It should be noted that, while this is not an ideal method to examine narwhal response to shipping, it does provide some valuable observations. As noted in Appendix 8A-2, there is much fine-scale movement by large groups of narwhals among various areas of Eclipse Sound and the fjords around it, day to day and over longer time intervals. This natural variation complicates the examination of density estimates during a study not specifically designed to address potential response to ship transits.

During the aerial survey period in 2007, two ships transited into and out of the port site at Milne Inlet. A sealift delivered construction materials into Milne Inlet on 31 July 2007 and transited out of the area on

7 August 2007 (travelling at an estimated speed of ~37 km/h). On 9 September 2007, a fuel tanker sailed into Milne Inlet and departed on 15 September. No consistent trends in densities were observed during the four transits (Appendix 8A-2). In some areas and during some transits, narwhal density estimates were similar before and after a vessel transited, whereas estimates also decreased or increased after a vessel transited through an area. There was no obvious evidence to indicate that they immediately abandoned an area transited by a vessel.

During the aerial survey period in 2008, three ships transited into and out of the Milne Inlet Port site: a fuel tanker (in 5 August, out 9 August), a sealift vessel (in 25 August, out 2 September), and an ore carrier (in 26 August, out 31 August). Relative to density estimates obtained prior to a vessel transit, declines were observed for 10 of 18 vessel transit-area combinations in Eclipse Sound, Koluktoo Bay and Milne Inlet (Table 4.4 in Appendix 8A-2). Densities before and after vessel transits were similar for about a third of vessel transit-area combinations, and observed densities increased in Milne Inlet after the sealift and ore carrier entered on consecutive days. As noted earlier, it is difficult to differentiate between natural variations in narwhal abundance and the potential effects of shipping. The data suggest that some narwhals may have left some areas after a ship's passage but that others did not.

During consultations for the Project, it was noted that narwhals tend to stay near the shoreline when large ships arrive (M. Akoomalik and M. Kyak, Pond Inlet, pers. comm.) and that they do not follow ships (Pond Inlet Public Meeting; Jayco, pers.comm.). They also seemed to exhibit temporary avoidance of Milne Inlet when a ship was loading, but they came back (Pond Inlet Public Meeting, anonymous, pers. comm.).

Planned Mitigation for Vessel Traffic - Ore carriers used on the shipping route have a modern design expected to minimize noise output (see Volume 3, Section 3.6.2). Project vessels transiting the northern shipping route will decrease shipping speed from 26 km/h to 18.5 km/h in Milne Inlet; this reduces noise output. All vessels will maintain a constant course and speed whenever possible, and will minimize idling of engines when docked at Milne and Steensby Ports.

Residual Effects of Vessel Traffic - There have been few studies of narwhal response to vessels during periods of open water. Based on the results of aerial surveys conducted for the Project, there were no clear trends in narwhal densities before and after passage of large vessels in Eclipse Sound and Milne Inlet during August and September 2007 and 2008. There was no evidence to indicate they immediately abandoned an area transited by a vessel. Their response likely depends on the type of vessel and its speed and course, their activity and their previous exposure to industrial activity. Other toothed whales, including belugas, have shown signs of habituation in some areas with frequent vessel traffic (see Section 5.8.2.2). Finley *et al.* (1990) suggested that narwhal (and beluga) sensitivity to ship noise in Lancaster Sound declined after subsequent exposures.

Based on acoustic modelling and an assessment of generic audiogram and ambient noise data, it is predicted that narwhals would avoid ore carriers travelling during the open-water period along the Steensby inlet shipping route by 6–7 km, depending on location (Appendix 8C-3, Table 8C-3.5, Figures 8C-3.22 to 8C-3.24). This is based on the 135-dB re 1 µPa (rms) level criterion for avoidance of continuous sound (Appendix 8C-3, Table 8C-3.5). With the exception of Hudson Strait, few narwhals are predicted to occur along the Steensby Inlet shipping route during the open-water period. Those in the southern portion of the RSA primarily occur around northern Southampton Island including Repulse Bay, Frozen Strait, western Foxe Channel, and Lyon Inlet during summer (Richard, 1991; DFO, 1998; Gonzalez, 2001). Based on corrected density estimates from aerial surveys, ~230 narwhals are expected to exhibit avoidance of a single Cape-size ore carrier transiting to Steensby Port in September (Appendix 8C-3, Table 8C-3.7). If narwhals avoid an area in response to vessel noise, they can return to that area once the source of disturbance has left. They are social animals and are not necessarily displacing animals in adjacent areas, particularly in open-water situations.

Narwhals are much more common along the shipping route into Milne Inlet but the ore carriers will not be transiting that route. Narwhals could also be exposed to vessel sounds at the Milne and Steensby Ports. Vessel traffic at the port sites will vary throughout the Project. A total of 8–10 vessels, including sealifts, tankers, line boats, barges (but not ore carriers), could be present at the port sites simultaneously during construction. During the operation phase, only occasional vessels (fewer than one per year) will transit to Milne Port each open-water shipping season. At Steensby Port, shipping traffic during the operation phase includes approximately 102 voyages by the dedicated fleet of icebreaking ore carriers, 3-6 voyages by sealifts and tankers, and possibly additional voyages by chartered ore carriers during the open-water season. Up to four tugs will also be stationed at Steensby Port. Noise levels from tugs were modelled at Steensby Port sites (Matthews *et al*., 2010; Zykov and Matthews, 2010). Based on acoustic modelling and an assessment of generic audiogram and ambient noise data, it is predicted that narwhals would avoid tugs during the open-water period at the Steensby by 0.7 km (Appendix 8C-3, Table 8C-3.5, Figures 8C-3.21 and 8C-3.25). Few narwhals are expected to occur at the Steensby Port site and none are expected to occur within the 0.7-km avoidance zone around tugs (Appendix 8C-3, Table 8C-3.7). The numbers of narwhals potentially avoiding port sites completely because of disturbance is predicted to be small.

Icebreaking - The most comprehensive studies of narwhals (and belugas—see Section 5.8.2.2) response to icebreaking ships was undertaken during June of 1982, 1983 and 1984 in Lancaster Sound (LGL and Greeneridge, 1986; Finley *et al*., 1990). In each study year, the MV *Arctic*, an icebreaking ore carrier (20,000 DWT) was accompanied by the CCG *John A. MacDonald* (1982, 1983) or the CCG *Louis St. Laurent* (1984) in Lancaster Sound as it approached the landfast ice-edge and then moved through the fast ice enroute to the Nanisivik mine in Admiralty Inlet.

Narwhals at ice edges waiting to continue their migration to summering areas responded to oncoming vessels and periodic icebreaking by; 1) demonstrating a “freeze” response, typically lying motionless or swimming slowly away (as far as 37 km along the ice edge), 2) huddling in groups, and 3) ceasing sound production. After initially being displaced in response to relatively low levels of noise from the approaching ship (94–105 dB re 1µPa in the 20–1,000 Hz band), narwhals sometimes returned 1–2 days later when icebreaker noise levels were still as high as 120 dB in that band (Finley *et al*., 1990) and engaged in diving and foraging behaviour. The differing responses of narwhals and belugas to ships are similar to their respective responses to killer whales (Finley *et al*., 1990). Finley *et al.* (1990) also noted that narwhals initially appeared attracted to and conducted “exploratory” dives of the rubble-filled ship track; however, the attraction was short-lived.

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) are the fact that the whales were trapped in open water along the ice-edge as the ships approached, their lack of previous experience with ships in the High Arctic in spring, and good sound propagation conditions. Based on limited observations in the present project, narwhals do not seem to respond to vessels (including the passage of an ore carrier) in Eclipse Sound and Milne Inlet to the same extent as responses documented during the 1982–1984 icebreaking study. However, follow-up study is required.

During consultations for the Project, it was noted that narwhals would leave the area for three days in response to ships when there was ice and that they would return three days later (Arctic Bay Working Group

Meeting, anonymous, pers. comm.). It was also noted that narwhals were excluded from leads because of icebreakers transiting to Nanisivik in May but that the narwhals returned after Nanisivik closed (Arctic Bay Public Meeting, Koonoo, pers. comm.). In contrast, others reported no negative effects on narwhals (or other marine mammals) caused by icebreakers at Nanisivik (Iqaluit City Council Public Meeting, Councillor S. Nattaq, pers. comm.).

Residual Effects of Icebreaking - Icebreaking by Cape-size ore carriers will occur throughout the ice-cover season during the Operation Phase, one every two days through the southern LSA to and from Steensby Port. Narwhals from the Hudson Bay population are thought to overwinter in eastern Hudson Strait. An ore carrier actively breaking and moving ice will take 2–3 d to transit Hudson Strait based on a ship speed of approximately 13km/h. Of this time, it would take about 0.5 d to transit the eastern portion of Hudson Strait identified as a wintering concentration area for narwhals (see Figure 8-5.8). Narwhals may detect icebreaking ore carrier sounds at ranges of at least 70 km (periods of thin ice) to 100 km (periods of thick ice; Appendix 8C-3, Figures 8C-3.22 to 8C-3.24). As noted previously, this does not mean they will respond at these distances (see Richardson *et al*., 1995a).

Based on estimates from aerial surveys conducted in Hudson Strait during April, it is estimated that ~500 narwhals may exhibit avoidance of an icebreaking ore carrier passing through Hudson Strait during a single transit (Appendix 8C-3, Table 8C-3.7). This corresponds to an estimated 15–20 km avoidance distance (30–40 km swath along ship track depending on ice conditions) based on the 135-dB re 1 µPa (rms) level criterion for continuous sound (Appendix 8C-3, Table 8C-3.5). In June, the only other month during the ice-cover period with available aerial survey data ~430 narwhals are estimated to exhibit avoidance (Appendix 8C-3, Table 8C-3.7). If it is assumed that ~500 narwhals in Hudson Strait avoid a carrier during each transit, this represents ~14 % of the narwhals that may occur there during winter, based on available population estimates and assuming that all narwhals in the putative Hudson Bay population overwinter in Hudson Strait. It is not known what proportion of the population will be exposed to levels above 135 dB at some point during the entire winter ice-cover period when all of the ship passages are considered.

As noted earlier, these estimates are meant to serve as a guide for potential effects and indicators for monitoring and follow-up. As noted, there is uncertainty associated with the estimates (see Sections 5.5.5 and "*Vessel Traffic*" above for details). Narwhals may move away from the shipping route to other areas in Hudson Strait where sound levels are expected to be lower. It is also probable that they will habituate to frequent, non-threatening icebreaking vessel transits and reduce the size of the zone of avoidance. There is uncertainty about how repeated exposure to icebreaking ore carriers will affect narwhals. Using the indicator and threshold criteria provided in Table 8.5-12 as a guide, monitoring and follow-up are required to examine the effects of shipping on narwhals in Hudson Strait (including potential displacement and the effects of repeated exposure to icebreaking ore carriers) during the ice-cover season (see Section 5.9.5).

Aircraft Overflights - There are no published observations of narwhal responses to aircraft overflights. Narwhals have been observed turning on their sides to look up at a Twin Otter and sometimes diving during aerial surveys conducted at an altitude of ~150 m; generally, the observed dives were not typical of startle responses (W. Koski, LGL, pers. comm.). It is thought that their response to aircraft overflights were similar to that exhibited by beluga whales (W. Koski, LGL, pers. comm.).

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow, and will be prohibited from flying low over narwhals for sightseeing or photography.

Residual Effects of Aircraft Overflights - Aircraft approaches to and from the airstrips at Milne and Steensby Inlets will be most frequent during the Construction Phase. During the Operation Phase, the primary airstrip will be located at the Mine Site. Narwhal reactions to overflights by aircraft (Twin Otter, Dash-8, and ATR) at Milne Inlet are expected to be limited to a brief alert or startle responses and sometimes a dive as the aircraft flies over. These types of behavioural responses would have little consequences for individual whales or their populations. It is unknown how narwhals in Steensby Inlet will react to overflights by a large aircraft like the Boeing 737. Narwhals are uncommon in Steensby Inlet, but any individuals that do occur there, particularly those under the direct flight path of the Boeing 737, may exhibit a disturbance response and potentially swim away.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on narwhals from construction, shipping, and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (vibratory pile driving; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of disturbance from Project activities on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.2.3 Hearing Impairment

There have been no studies of narwhal hearing impairment. Studies of belugas summarized in Section 5.8.2.3 are used to evaluate potential effects on narwhals.

Planned Mitigation - Blasting will occur late in the ice-cover season (late May), which will eliminate the likelihood of narwhals being nearby, as they are expected to be moving from wintering areas in Hudson Strait and Baffin Bay. In addition to the timing of blasting, a plan will be designed by an explosives contractor in consultation with DFO to ensure that the 100-kPa waterborne acoustic overpressure threshold is met and minimized, and a bubble curtain will be employed as necessary. As noted earlier, it is anticipated that an Environmental Monitor and two Inuit knowledgeable about marine mammals and will be on site during blasting operations to assess the area for marine mammal presence. In the highly unlikely event that a narwhal is observed within the 500-m safety zone (Wright 2002), blasting will not commence until it has left the area.

Vibratory pile driving at Steensby Inlet will occur over a two-month period during open-water construction in Year 1. Acoustic modelling indicates that sound levels will only exceed 180 dB (rms) (Zykov 2011 in Appendix 8C-4) less than 30 m from the pile driving site. As a conservative approach, a 50-m "safety zone" (which corresponds to sound levels of <160 dB (rms)) will be established and monitored around the pile driving site. An Inuit monitor and an Environmental Monitor will be present at the pile driving site to monitor the appropriate safety zone seals and other marine mammals. Prior to pile driving operations, the safety zone will be monitored and if a narwhal is present within this zone, pile driving will not be permitted to commence. Observers will continue to monitor the zone during pile driving and if a narwhal is observed within or approaching the zone, pile driving will be halted until the narwhal has left the area.

Residual Effects - Based on acoustic modelling results and the implementation of mitigation measures, narwhals are not expected to be exposed to sound levels from construction activities high enough to elicit TTS. Blasting at the Steensby ore dock will occur during May when they will be absent from the area. Similarly, they are not expected to occur near the freight dock at Steensby Inlet during vibratory pile driving. In addition, available evidence and acoustic modelling as well as mitigation measures, indicate that narwhals that may occur near the site, will not be exposed to sound of sufficient level to elicit TTS.

Narwhals could incur temporary hearing impairment from exposure to continuous sources of sound of sufficient level and duration. It is assumed that exposure to a sound pressure level of 175 dB re 1 µPa for 100 s could induce TTS in the narwhal (see Southall *et al.* 2007). Based on acoustic modelling and an assessment of the beluga audiogram (no measurements for narwhal) and ambient noise data, narwhals are not expected to be exposed to continuous sound levels thought to cause TTS (Appendix 8C-3, Table 8C-3.5). Those within ~10 m of a Cape-size ore carrier in Hudson Strait could incur TTS but this is highly unlikely, given that narwhals are expected to avoid at least the immediate area around ore carriers. Also, TTS is not considered an injury and if it occurs, hearing impairment would be temporary.

With mitigation measures in place, narwhals are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level I), infrequent (Level I), and confined to the LSA (Level I); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of hearing impairment on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.2.4 Masking

Narwhal call characteristics and their likely frequency range of best hearing are relevant in assessing potential masking effects of anthropogenic sounds. Narwhals produce whistles, narrow-band pulsed sounds, and pure tones at frequencies of 300 Hz–24 kHz (Watkins *et al*., 1971; Ford and Fisher, 1978). Pulsed sounds are likely used for orientation and communication (Ford and Fisher, 1978). Shapiro (2006) suggested that narwhals produce signature vocalizations that are distinctive among individuals. They also use echo-location clicks that have maximum amplitudes at 19–48 kHz, but can range up to 100 kHz (Miller *et al*., 1995). Møhl *et al.* (1990) noted that clicks have a source level of 218 dB re 1 $\mu Pa^2 \cdot m$. Narwhals and other toothed whales are thought to hear best at frequencies of about 20–100 kHz (see further in Section 5.4.1.3), although they can hear loud sounds down to 1 kHz or below.

Residual Effects - Narwhal calls are primarily at frequencies from a few hundred Hz to 100 kHz, with dominant frequencies >1 kHz—above the frequency range of the most intense ship noise and construction activities. Low-frequency (<10 kHz), narrow-band click signals are the prevalent sounds produced by narwhals in Lancaster Sound, along with pulsed toned calls (Finley *et al*., 1990). Masking effects by transient sounds such as those from blasting are likely limited, because the construction sounds will be intermittent and each sound pulse will be very short. There is some overlap in frequency between shipping sounds and narwhal communications; therefore, there is a potential for masking, out to an unknown distance from the vessel(s). In enclosed areas with shipping noise (e.g., the Milne Port site during the Construction phase), masking of narwhal communication could occur during the open-water season but this effect would be quite localized. Along the shipping route, masking will occur as a vessel passes by, which likely will be a short time relative to the interval between transits (less than one per year).

If masking does occur, narwhals (like belugas), may change their call types and frequencies to overcome it (e.g., Au *et al*., 1985; Lesage *et al*., 1999); however, this has not yet been studied in narwhals. Given that sounds important to narwhals are predominantly at much higher frequencies than shipping noise and the intermittent nature of construction activities sounds, it is unlikely that masking would measurably affect them.

With mitigation measures in place, it is predicted that residual effects of masking on narwhals will be of low magnitude (Level I), medium-term (Level II), occurring infrequently (Level I) or intermittently (vibratory pile driving, shipping Level 1), and confined to the LSA (Level I); masking effects are considered fully reversible

(Level I; Table 8-5.14). The residual environmental effect of masking on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.2.5 Mortality

Narwhal mortality is not expected to result from Project activities. Narwhals are small relative to vessels, especially ore carriers, and are capable of very high swim speeds, which enable them to avoid collisions. Also, it is likely they would avoid vessels underway (see Section 5.9.2.2), maintaining distances that would prevent ship strikes.

Planned Mitigation - Vessel speed in areas of pack ice (approximately 13 km/h) will be lower than speeds during the open-water season (approximately 26 km/h), thereby reducing the likelihood of collisions with narwhals during periods when their movements may be restricted by ice. Vessels will maintain a constant course and speed whenever possible.

Residual Effects - It is unlikely that narwhals will experience mortality from collisions because they exhibit avoidance of vessels. With mitigation measures in place, no mortality is expected. There are no residual effects to narwhals as a result of potential mortality.

5.9.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on narwhals are summarized in Tables 8-5.14 and 8-5.15 and below.

5.9.3.1 Habitat Change

It is predicted that residual effects of habitat change on narwhals would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of habitat change on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.3.2 Disturbance

It is predicted that residual disturbance effects on narwhals from construction, shipping and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (dredging; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of disturbance from Project activities on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.3.3 Hearing Impairment

It is predicted that residual hearing impairment effects (if any) on the narwhals from Project activities would be of negligible to low magnitude (Level I), short-term (Level I), infrequent (Level I), and confined to the LSA (Level I); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.14). The residual environmental effect of hearing impairment on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.3.4 Masking

It is predicted that residual effects of masking on narwhals would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (Level I) or intermittently or possibly frequently at times (shipping; Level II or III), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I;

Table 8-5.14). The residual environmental effect of masking on narwhals is predicted to be "*not significant*" (Table 8-5.15).

5.9.3.5 Mortality

With mitigation measures in place, no mortality is expected, and therefore, residual effects on narwhals are negligible.

5.9.3.6 Cumulative Effects Within the Project

Reviewers of the Draft EIS requested that within Project cumulative effects be considered. As discussed previously, narwhals may be exposed to construction activities (i.e., dredging, vessel traffic, aircraft overflights) at the Milne Inlet port site during the first four years of the Project. Few narwhals are expected to occur at the Steensby Inlet port site and in adjacent waters. Hearing impairment and mortality are not expected to result from construction activities. It was predicted that narwhals may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port site, however, any avoidance is predicted to be localized in the Milne Inlet port area. During the Operation Phase, narwhals will be exposed to noise from ore carriers and perhaps vessels located at the Steensby port site. It was predicted that they may avoid an icebreaking ore carrier in Hudson Strait by 15 to 20 km. It is possible that this area of avoidance may increase slightly when two ore carriers pass each other along the shipping route (particularly the areas identified in Hudson Strait—see Figure 8-5.2); however, given the relatively small increase in sound levels, the increase in the numbers of narwhals potentially exhibiting avoidance is predicted as not significant.

5.9.4 Prediction Confidence

Based on the planned mitigation measures, the baseline data used in the assessment, the location of port sites relative to potential feeding and calving areas, and the available evidence on narwhal responses to vessel traffic, the level of confidence in residual effects predictions is generally high (Table 8-5.15). No significant residual effects are predicted for this indicator species. However, follow-up is required to monitor narwhal responses to ore carrier traffic in Hudson Strait (see below).

5.9.5 Follow Up

The planned mitigation and monitoring for narwhals are summarized in Section 5.9.2 and are provided in the marine mammal mitigation and monitoring management plan. There are uncertainties in the prediction of disturbance effects of ore carriers transiting Hudson Strait during the ice-cover season. Therefore, a monitoring program and an adaptive management plan will be undertaken to address these uncertainties and ensure that narwhals do not incur significant negative effects (see the Shipping and Marine Mammal Management Plan, Appendix 10D-10). The monitoring program will include Marine Mammal Observers (MMOs) positioned onboard a representative number of ore carriers, aerial surveys with a fixed-wing aircraft and potentially using an unmanned airborne system, and an ice imagery study (Hudson Strait). Aerial surveys for cetaceans are planned to be undertaken during the winter (March, April) 2012 in Hudson Strait to provide a baseline against which potential future surveys during Baffinland's shipping operations could be compared as part of a longer-term monitoring program.

5.10 BOWHEAD WHALE

Bowhead whales occur seasonally in different areas of the RSA throughout the year (Figure 8-5.9). Hudson Strait has been recognized as an important overwintering area (Koski *et al*., 2006) and north western Foxe Basin is considered a nursing area (Higdon and Ferguson, 2010; Figure 8-5.9). Milne Inlet,

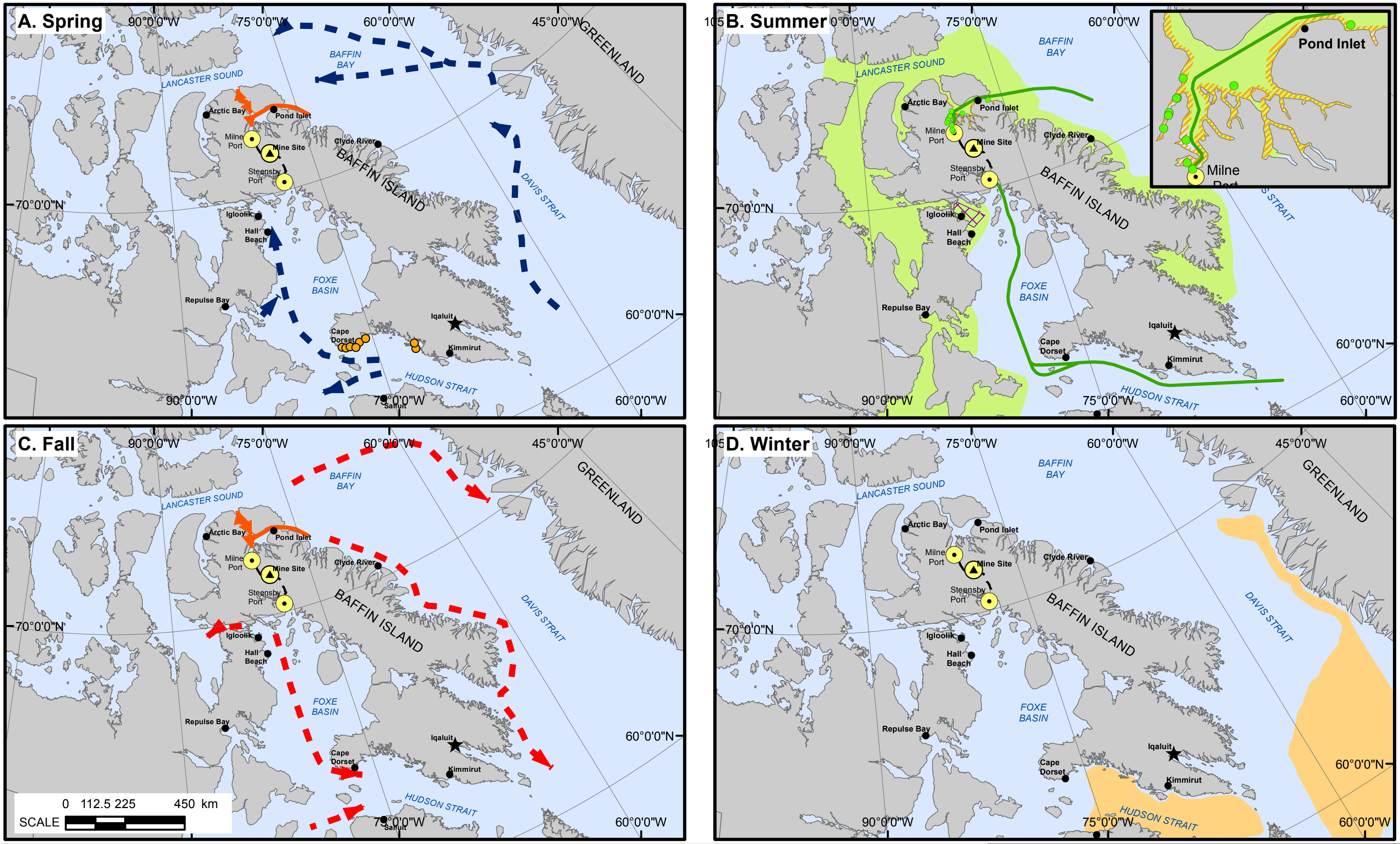


Figure ID: BL_Vol8_GIS_025 Bowhead Seasonal Occurrence Based on Scientific and IQ Information Figure 8-5-9.mxd

LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- SPRING MIGRATION
- BOWHEAD AREA OF CONCENTRATION AND MOVEMENTS (IQ)
- FALL MIGRATION
- BOWHEAD SIGHTING (IQ)
- SUMMERING AREA
- BOWHEAD CALVING AREAS (IQ)
- BOWHEAD NURSERY
- WINTERING AREA

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

ᓄᓗᔾᒐ ᐅᔭᕐᔪᐅᑦᑕᑦ MARY RIVER PROJECT

BOWHEAD SEASONAL OCCURRENCE BASED ON SCIENTIFIC AND IQ INFORMATION

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_025

ᑎᑎᖅᑲᖅᑐᒪᔪᖅ FIGURE 8-5.9

REV A

Eclipse Sound and, to a lesser extent, Koluktoo Bay are used by bowhead whales, including mothers and calves, during the open-water season. According to IQ, feeding usually takes place in nearshore, sheltered, shallow waters in summer. Mating can occur throughout the year, although most conceptions occur during late winter or early spring, and single calves are born during spring migration (Nerini *et al*., 1984; Koski *et al*., 1993).

Relative to other marine mammal indicator species, few concerns were expressed about the effects of the Project on bowhead whales during consultations, although there was some concern about the effects of shipping noise, particularly during springtime (Hall Beach Public Meeting; Igloolik Meeting).

5.10.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on bowhead whales: habitat change, disturbance, hearing impairment, masking and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in bowhead whale habitat, behaviour, and health (Table 8-5.16). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour, or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant at the population level. The reader is referred to Volume 2, Section 3.8 for the criteria used to establish significance determination.

5.10.1.1 Habitat Change

The footprints of the dock structures at Steensby Port were calculated to determine how much potential open-water bowhead habitat would become unavailable. Bowheads are not expected to occur in areas of solid fast ice but are expected to occur in areas of pack ice in Hudson Strait. The area of changed ice resulting from a single transit of an ore carrier during periods of maximum pack ice coverage was calculated and compared to overall available pack ice in Hudson Strait.

5.10.1.2 Disturbance

To assess the potential level of disturbance from Project activities on bowhead whales, the approach described in Section 5.5 was modified. For species like the bowhead (and all other baleen whales) whose hearing thresholds are unknown, an assumption is necessary about whether the animals are threshold- or ambient-limited. It was assumed that bowhead whales have sensitive hearing at the low to moderate frequencies, where most man-made noises are concentrated. Thus, it is assumed that bowheads are ambient-limited, at least in the 20-1000 Hz range; hence, hearing threshold data are not necessary to estimate radii of audibility of sounds at these frequencies (Richardson *et al.* 1995a). Ambient noise levels and predicted 1/3-octave band noise levels from the acoustic modelling report for each modelled sound source were used to estimate the maximum distance in the 1/3-octave bands that the sound was (1) above ambient noise levels and (2) equal to or higher than the relevant thresholds for disturbance onset and avoidance for continuous and pulsed sound (Appendix 8C-3, Table 8C-3.8). As noted earlier, these thresholds, selected based on a review of the literature, are meant to serve as a guide for potential behavioural responses and to allow the calculation of numbers of potentially affected bowheads. Studies of bowhead whales and their responses to noise have yielded variable results (see Section 5.10.2.2 below), and the results of the analyses presented here should be interpreted with this variability in mind. “Disturbance onset” is considered to be behavioural responses ranging from subtle changes in swim speed

Table 8-5.16 Measurable Parameters and Threshold Values for Bowhead Whales

Effect	Measurable Parameter [d]	Threshold [d]
Change in habitat caused by icebreaking. Change in habitat caused by dock footprints.	Decrease in suitable bowhead habitat for overwintering. Decrease in suitable summering habitat.	≥10 % decrease in suitable bowhead overwintering area in Hudson Strait or summering areas in Milne and Steensby Inlets.
Disturbance caused by underwater noise, pulsed or continuous.	Change in occupancy of an area that has been identified as important feeding, nursing, calving, breeding, wintering, or summering habitat. Pulsed sound: Bowhead whales exposed to sound levels blasting where the received level exceeds 145 dB re 1 µPa (rms) and 160 dB re1 µPa (rms) would exhibit "disturbance"[a] and "avoidance"[b] responses, respectively. [c] "Continuous" sound: Bowhead whales exposed to sound levels from shipping, vibratory pile driving, or dredging where the received level exceeds 120 dB re 1 µPa (rms) and 135 dB re 1 µPa (rms) would exhibit "disturbance"[a] and "avoidance"[b] responses, respectively. [c]	≥10 % of bowheads in the RSA exhibit strong disturbance and avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat.
Hearing impairment, pulsed or continuous sound.	Pulsed sound: Bowhead whales exposed to sound levels from blasting that exceed 180 dB re 1 µPa (rms) (NMFS 2000). Continuous sound: Bowhead whales exposed to sound levels from shipping, vibratory pile driving, or dredging that exceed 175 dB re 1 µPa (rms) over a duration of 100 s.	Pulsed sound: A bowhead whale enters the defined safety zone during blasting. Any single incident Continuous sound: ≥10 % of the population in the LSA exposed to these continuous sound levels.
Mortality from collisions with vessels.	Increase above natural mortality per annum.	Any project-caused mortality.

NOTE(S):

a) DISTURBANCE = ONSET OF BEHAVIOURAL RESPONSES THAT CAN RANGE FROM SUBTLE CHANGES IN SWIM SPEED AND DIRECTION TO MINOR AND LOCALIZED AVOIDANCE OF A SOUND SOURCE.

b) AVOIDANCE= AVOIDANCE OF AN AREA FOR A PERIOD LONGER THAN THE SOUND SOURCE IS IN OPERATION.

c) ALTHOUGH SPECIFIC DATA ARE LACKING, MEASUREABLE PARAMETER LEVELS NECESSARY TO ELICIT BEHAVIOURAL RESPONSES IN FEEDING, NURSING, OR BREEDING BOWHEAD WHALES (VERSUS WHALES CONDUCTING OTHER ACTIVITIES) ARE LIKELY HIGHER THAN CONSIDERED HERE.

d) TIMEFRAME FOR ALL PARAMETERS AND THRESHOLDS UNLESS OTHERWISE STATED IS "PER YEAR" and direction to minor and localized avoidance of a sound source, and "avoidance" to be avoidance of an area for a period longer than the sound source is in operation.

The areas exposed to sound levels that exceeded the threshold for disturbance onset and avoidance (see Table 8-5.16) were calculated for all modelled Project activities at the Steensby and Milne Inlet Port sites, and along both shipping routes. The estimated numbers of bowhead whales exposed to sound levels that exceeded the thresholds were calculated for months with available aerial survey data (April, June, August, September and October). Correction factors of 6.94 and 2.07 were applied to density estimates for availability and detection biases, respectively (Thomas *et al*., 2002).

5.10.1.3 Hearing Impairment

For impulse sound sources like those from blasting, the 180-dB re 1 µPa (rms) criterion was used to calculate the area where bowhead whales could incur TTS (NMFS 2000). For "continuous" sound sources like dredging, vibratory pile driving, and shipping, the best available estimate for TTS is that of Southall *et al.* (2007:444), which is 195 dB re 1 $\mu Pa^2 \cdot s$ for non-impulse or continuous sound. This estimate cannot be translated to a sound pressure level without allowance for duration of exposure, i.e., 195 dB re 1 uPa for 1 s; 185 dB re 1 uPa for 10 s, 175 dB re 1 uPa for 100 s. Extrapolation to times longer than 100 s, though necessary to deal with noise from a ship transit, is not advisable (W. John Richardson, LGL Ltd., pers. comm.).

As with the assessment of disturbance, the maximum distance in the 1/3-octave bands that sound sources were above ambient noise levels and equal to or higher than the relevant thresholds for hearing impairment was estimated (Appendix 8C-3, Table 8C-3.8). Aerial survey data, corrected for detection and availability biases, were used to provide estimates of the numbers of bowhead whales inside the hearing-impairment zones.

5.10.1.4 Masking

A qualitative discussion on the potential for bowhead whale masking caused by Project activity noise is provided.

5.10.1.5 Mortality

A qualitative discussion on the potential for bowhead mortality resulting from ship strikes is provided. It is not possible to provide a meaningful quantitative risk assessment of the potential for vessel-bowhead collisions in the areas of interest because there are no quantitative data from these specific situations.

5.10.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on bowhead whales are listed below. Effects that are not assessed in detail (i.e., that were ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking plus footprints of dock structures;
- **Disturbance** caused by underwater noise from construction, shipping, and aircraft overflights;
- **Hearing impairment** and/or damage caused by noise from construction activities and shipping;
- **Masking** of environmental sounds caused by vessel and construction noise; and
- **Mortality** from collisions with vessels.

5.10.2.1 Habitat Change

The footprint of dock structures in water depths seaward of the intertidal zone (i.e., <3 m deep) is negligible at Steensby Port: 0.07 km^2. An ore carrier will transit through potential bowhead overwintering habitat in

Hudson Strait about every two days, breaking through areas of pack ice within a nominal shipping route. The area of pack ice that will be disrupted temporarily by a single passage in Hudson Strait is estimated at 44 km^2 during the period of maximal ice cover. Evidence of a ship track in the mobile pack ice will quickly disappear because of winds and tide (Volume 3, Appendix 3G). No studies have examined how frequent ship passages in ice-covered wintering habitat affect bowhead whales.

Planned Mitigation - Dock structures were designed to minimize the footprints in the marine environment.

Residual Effects - Bowhead whales are considered uncommon in the immediate area of the proposed dock site at Steensby Inlet. In any case, the small area (0.06 km^2) of the footprints is a negligible part of nearshore habitat. Less than 1 % of pack ice in Hudson Strait will be temporarily changed by an icebreaking ore carrier during a single transit to Steensby Port. The change in habitat caused by dock structures and temporary decrease in bowhead overwintering habitat is much lower than the threshold value of 10 % (Table 8-5.15).

It is predicted that residual effects of habitat change on bowhead whales would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of habitat change on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.2.2 Disturbance

Bowhead whale responses to industrial activity are variable; as with other cetaceans, they appear to depend on the whale's activity, its habitat and the type of industrial activity. Based on the results of acoustic modelling and analysis of ambient noise level data, bowhead whales may detect Project construction activity sounds tens of kilometres away and ore carriers more than 250 km away. As noted earlier, the mere detection of a distant sound source is unlikely to negatively affect a marine mammal (see Richardson *et al.* 1995a).

Construction Activities - Bowheads have been seen within 800 m of an artificial island construction site where a suction dredge and other vessels were active (Richardson *et al.* 1985a, b, c, 1990). During play-back experiments of recorded noise from a suction dredge, whales exposed to sounds 122–131 dB stopped feeding and moved >2 km away from the sound projector (Richardson *et al*., 1990). Although avoidance was demonstrated during the playback experiments, some bowheads exposed to actual dredging noise at similar distances did not show avoidance (Richardson *et al*., 1995a); this may indicate habituation to steady dredge noise (Richardson *et al*., 1995a). Based on drillship and dredge noise playbacks, summering bowheads typically do not react overtly until continuous received levels reach ~115 dB re 1 μPa or ~20 dB above the ambient level (Richardson *et al*., 1990, 1995a).

Table 8-5.17 Effects Assessment Summary: Bowhead Whale

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only), drilling (Steensby only), dredging, and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for bowheads in the area of blasting; bubble curtain system. Drilling in late April/May. Monitoring for bowheads in and near safety zone. Reduce vessel idling at dock side.	Level I	Level I	Level I, Level II, Level III	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet.	Level I	Level I	Level II	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over bowheads for passengers to 'get a better look' or for photography.	Level I	Level I	Level II	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I, Level II	Level II	Level III	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking [4] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I, Level II	Level II	Level II, Level III	Level I, Level II	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over narwhals for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel speed in Milne Inlet. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.18 Significance of Residual Effects to Bowhead Whale

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	2		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	1		
Hearing Impairment	N	3		
Masking	N	1		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: : 1= Low; 2= Medium; 3=High

There was some indication that, after the first few years of oil exploration in the Canadian Beaufort Sea in the 1980s, bowhead whales avoided the main industrial area where construction, dredging and drilling operations occurred (Richardson *et al*., 1987). Gray whales in Laguna Guerrero Negro, Mexico, provide one of the few documented cases of a long-term change in baleen whale distribution as a result of industrial activities. It is thought that constant dredging operations needed to keep a channel open for shipping salt (from 1957 to 1967) may have been the main source of disturbance to the whales and cause of a decline of whale numbers from 1964 to 1970; gray whales re-occupied the lagoon after salt shipping subsided (Bryant *et al*., 1984). However, subsequent surveys suggested that the seasonal abundance of gray whales in the lagoon had decreased 90 % since the 1980s (Jones *et al*., 1994). Fishermen in the area have suggested that the decline of whales may be caused by the accumulation of sand at the entrance of the lagoon because of the lack of dredging (Urbán *et al*., 2003).

Information on the effects of other construction activities on bowheads is limited. However, humpback whale responses to underwater (sub-bottom) explosions and dredging associated with construction activity in Trinity Bay, Newfoundland, were examined during 1992–1995 (Todd *et al*., 1996; Borggaard *et al*., 1999).

Blasting using 690–1254 kg of explosives and dredging occurred in 1991, 1992 and 1994. Todd *et al.* (1996) reported that received sound levels in 1992 typically were 140–150 dB re 1 µPa (maximum 153 dB) near 400 Hz, with an estimated source level of 209 dB re 1 µPa·m). However, it is not clear what acoustic metric was used (i.e., rms, 0-peak, peak-peak), or what broadband sound levels resulted from the blasts. Behavioural observations suggested that the foraging humpbacks were not reacting to the intense acoustic stimuli from the blasting (Todd *et al*., 1996; Borggaard *et al*., 1999), whereas they moved away from the industrial site during continuous dredging, and re-sightings were often made farther away (Borggaard *et al*., 1999). Photo-identification of individuals showed that there was a significant decrease in return rate to the feeding area during some years of the study, indicating a possible long-term effect. In addition, it was unclear whether an increase in humpback entrapments in fishing nets in 1992 was related to the underwater explosions; whales could have become disoriented during blasting (Todd *et al*., 1996).

The following studies of bowhead whale responses to drilling operations are not directly relevant to the assessment, but the results indicate the sound levels and distances at which they respond to continuous industrial sounds. Summering bowheads within 10–20 km of drillships appeared to show little response to operations; in fact, within 4–5 km of drillships, where received levels reached 118 dB re 1 µPa, some bowheads did not show any distinct responses (Richardson *et al.*1985a, c, 1990). In contrast, playbacks of drillship noise at received levels near 94-118 dB caused disturbance reactions, such as decreased call rates and cessation of feeding, in a small number of bowheads (Richardson *et al*., 1985a, c, 1990; Wartzok *et al*., 1989). These differences may represent habituation to actual drillship noise or variable sensitivity (Richardson *et al*., 1995a). Migrating bowheads appear to be more responsive than summering bowheads (Richardson *et al*., 1995c). During autumn migration in the Alaskan Beaufort Sea, they avoided an area of active drillships and support vessels by at least 10 km, and some animals began to divert around a drillsite as far as 20 km away (LGL and Greeneridge 1987; Hall *et al.* 1994); broadband noise levels within 10 km averaged 114 dB (Greene, 1987). Playback experiments of drilling platform sounds during the spring migration through leads in the ice showed that there were changes in behaviour when whales were 1–2 km or possibly 2–4 km from the sound source; within 1 km, avoidance behaviour was evident (Richardson *et al*., 1991); however, numerous bowheads approached within a few hundred metres. When the only available lead was within 200 m from the sound projector, bowhead whales continued to migrate through the area (Richardson *et al*., 1991).

Although seismic surveys will not be part of the current program, numerous studies have examined the effects of these types of surveys on bowheads, and they provide insight into how bowheads respond to pulsed sounds. Bowhead whales show variable responsiveness to seismic surveys depending on their activity (migrating vs. feeding). Bowheads migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source at received sound levels ~120–130 dB re 1 µPa rms (Miller *et al*., 1999; Richardson *et al*., 1999; see also Manly *et al*., 2007). When the airguns were not active, many bowheads moved into the area close to the vessel. Avoidance of the area of seismic operations did not persist beyond 12–24 h after seismic shooting stopped. However, recent studies have shown that bowheads at the summer feeding grounds in the Canadian Beaufort Sea are not as sensitive to seismic sources (Miller *et al*., 2005; Harris *et al*., 2007). Nonetheless, statistical analysis revealed subtle but statistically significant changes in surfacing–respiration–dive cycles (Richardson *et al*., 1986). In summer, bowheads typically begin to show avoidance reactions at received levels of ~152–178 dB re 1 µPa (rms) (Richardson *et al*., 1986, 1995a; Ljungblad *et al*., 1988; Miller *et al*., 2005).

Residual Effects of Construction Activities - Dredging will occur at the Steensby Inlet Port site over approximately four weeks during the open-water period of the first year of construction. Dredging will likely be carried out by a cutter head suction dredger or a clamshell operation. At Steensby Inlet, the zones of avoidance and disturbance onset for bowhead whales are estimated at 6 km and 25 km, respectively, for a cutter-suction dredge operating thrusters (Appendix 8C-3, Table 8C-3.8). Sound levels are much reduced for a clamshell bucket dredge (Matthews *et al*., 2010; Table 8C-3.8). Few bowheads are expected to occur at the Steensby Inlet Port site or in adjacent waters. Based on corrected aerial survey data, none are predicted to occur within 25 km of the dredging site during the open-water period (Table 8C-3.9). If bowheads do occur there, they may exhibit localized avoidance of the area.

As noted earlier, vibratory pile driving will occur for two months during mid-July to mid-September at the Steensby Port site during the first year of the Construction Phase. The zones of avoidance and disturbance onset for bowhead whales are estimated at 1.5 km and 10 km, respectively (Appendix 8C-5, Table 8C-5.8). Few bowheads are expected to occur at the Steensby Inlet Port site or in adjacent waters. Based on corrected aerial survey data, none are predicted to occur within 10 km of the pile driving site during the open-water period (Table 8C-5.9). If bowheads do occur there, they may exhibit localized avoidance of the area. The pile driving site is over 125 km from the bowhead nursery and sounds from pile driving are not expected to exceed ambient noise levels in this area.

Vessel Traffic - Bowheads begin to avoid approaching vessels at distances of 4 km or greater, where received levels are as low as 84 dB re 1 μPa (Richardson *et al*., 1995a). If a vessel approaches within several hundred metres, the avoidance response usually is conspicuous: the whale may increase its swimming speed, attempt to out-swim the vessel or change direction to swim perpendicularly away from the vessel's path, or decrease its time at the surface (Richardson *et al*., 1985a, b, 1995a; Richardson and Malme, 1993). Koski and Johnson (1987) reported that bowheads 1–2 km from a supply vessel swam rapidly away to distances of 4–6 km from the vessel track; displaced individuals returned to feeding locations within one day.

If the vessel travels slowly, bowhead whales often are more tolerant, and may show little or no reaction, even when the vessel is within several hundred metres (e.g., Richardson and Finley, 1989; Wartzok *et al*., 1989). This is especially so when the vessel is not directed toward the whale and when there are no sudden changes in direction or engine speed (Wartzok *et al*., 1989; Richardson *et al*., 1995a). Wartzok *et al.* (1989) noted that bowheads often approached small ships within 100–500 m when the vessel was not moving toward them. Bowhead whales engaged in social interactions or mating may be less responsive than other bowheads (Wartzok *et al*., 1989).

During review of the DEIS, the question of whether shipping may result in the separation of mother and calf pairs was raised. There are few specific data available; however, it is highly unlikely that mothers and calves would become separated as a result of Project activities. The mother-calf bond is very strong; it has evolved to insure that nursing calves do not become permanently separated from their mothers. Many marine mammals have been shown to maintain strong mother/calf bonds by establishing distinct calls. Koski *et al.* (1988) examined the likelihood of a vessel permanently separating a bowhead mother and calf pair when they were on their summering grounds. The primary concern noted in that study was the potential for a ship's noise to mask communication between the mother and calf when the mother was foraging and separated from her calf. Cows and calves are often separated in the late summer and fall as females forage up to 1 km from the calf (Würsig *et al*., 1985). If an approaching ship masked communication between the mother and calf and then caused them to move in opposite directions, it is conceivable that they would be unable to relocate each other. Based on modelling of vessel noise and bowhead whale calls, and the known response of bowhead whales to vessel noise, Koski *et al.* (1988) concluded that bowhead cow-calf pairs are very unlikely to become separated by noise and/or disturbance from approaching ships. In the unlikely event that temporary separation did occur, it was surmised that the pair would have no difficulty re-establishing contact after the ship has passed.

Further evidence that cow-calf pairs are very unlikely to become separated by the passage of a ship is found in areas with intensive shipping activity. For example, the entire Eastern Pacific gray whale population migrates north along the west coast of North America during spring. The young calves that were born in Mexican waters accompany their mothers through some of the most intensively used shipping lanes in the world to reach the summering grounds off Alaska. This population is healthy (Allen and Angliss, 2010) and does not show any long-term effects from disturbance, including induced calf mortality.

Planned Mitigation for Vessel Traffic - Ore carriers that will be used on the southern shipping route have a modern design that is expected to reduce noise output (see Volume 3, Section 3.6.2). Freight vessels transiting the northern shipping route will decrease shipping speed from 26 km/h to 18.5 km/h in Milne Inlet; this reduces noise output (see Section 5.9.2.2). All vessels will maintain a constant course and speed whenever possible, and will minimize idling of engines when docked at Milne and Steensby Ports.

Residual Effects of Vessel Traffic - Based on acoustic modelling and an assessment of ambient noise data, it is predicted that bowhead whales would avoid ore carriers travelling during the open-water period along the Steensby Inlet shipping route by 6–7 km depending on location (Appendix 8C-3, Table 8C-3.8). This is based on the 135-dB re 1 µPa (rms) level criterion for avoidance of continuous sound. With the exception of Hudson Strait, few bowheads are predicted to occur along the southern shipping route during the open-water period. During summer, bowhead whales in the southern portion of the RSA primarily occur in and around Repulse Bay and Frozen Strait, as well as in northwest Foxe Basin (COSEWIC, 2009). Based on corrected density estimates from aerial surveys, ~170 bowhead whales (mostly in Hudson Strait) are expected to exhibit avoidance of a single Cape-size ore carrier transiting to Steensby Port in August (Appendix 8C-3, Table 8C-3.9). The corresponding estimate for disturbance onset is ~480 (Appendix 8C-3, Table 8C-3.9). The reported nursery area (see Figure 8-5.9(B)) is more than 85 km from the nominal shipping track into the Steensby Inlet Port; at that distance, sound levels from Cape-size ore carriers are predicted to be lower than the disturbance onset threshold of 120 dB re 1 µPa (rms). It is possible that some whales in and near the nursery may exhibit minor behavioural responses to transiting ore carriers, but the duration of exposure is expected to be limited because Koch and Rowley islands act as an acoustic barrier to sound transmission between the nursery area and the route.

Bowhead whales regularly occur along the northern shipping route, and it is thought that this summering area is used for feeding. To decrease potential disturbance effects, vessels will reduce transit speed from ~26 km/h to 18.5 km/h in Milne Inlet, resulting in an estimated decrease in the sound source level of the vessel by over half (8.8 dB - see Table 16 in Zykov and Matthews, 2010). It is predicted that bowhead whales would avoid vessels travelling during the open-water period along the along the Milne Inlet shipping route by 0.6–3 km, depending on location, vessel speed and vessel type (Appendix 8C-3, Table 8C-3.8). Based on corrected density estimates for August, ~15 and 75 bowhead whales are estimated to occur within the calculated zones of avoidance and disturbance onset, respectively, of the largest vessel expected to operate along this route (Appendix 8C-3, Table 8C-3.9). Avoidance of such vessels, particularly if whales are engaged in feeding, is likely to be localized and short-term. If bowhead whales avoid an area in response to vessel noise, they can return to that area once the source of disturbance has left. They are not necessarily displacing animals in adjacent areas, particularly in open-water situations.

As noted earlier, these estimates are meant to serve as a guide for potential effects and indicators for monitoring and follow-up. Although there is uncertainty associated with these estimates (see Section 5.5.5 for details), bowhead whale avoidance of vessels along the Milne Inlet shipping route is estimated to be much less than the disturbance threshold level (10 % of bowhead whales summering in Milne Inlet and Eclipse Sound) in Table 8-5.16.

Small numbers of bowhead whales may be exposed to vessel sounds at the Milne and Steensby Ports. Vessel traffic at the port sites will vary throughout the Project. A total of 8–10 vessels, including sealifts, tankers, line boats, barges (but not ore carriers), could be present at the port sites at any one time during construction. During the Operation Phase, fewer than one vessel per year will ship to Milne Port each open-water shipping season. No support vessels will be stationed at Milne Port during Operations. At Steensby Port, shipping traffic during the operation phase includes approximately 102 voyages by the dedicated fleet of icebreaking ore carriers, 3-6 voyages by sealifts and tankers, and possibly additional voyages by chartered ore carriers during the open-water season. Up to four tugs will also be stationed at Steensby Port. Noise levels from tugs were modelled at both port sites (Matthews *et al*., 2010; Zykov and Matthews, 2010). Based on acoustic modelling and an assessment of ambient noise data, it is predicted that bowhead whales would avoid tugs during the open-water period at both ports by 1 km (Appendix 8C-3, Table 8C-3.8). Based on aerial survey data, no bowheads are predicted to occur that close to the port sites (Appendix 8C-3, Table 8C-3.9); if they do, they will likely exhibit localized avoidance.

Icebreaking - As noted above, bowhead whales are expected to avoid vessels that are underway, including icebreakers. In 1991 and 1994 in the Alaskan Beaufort Sea, Richardson *et al.* (1995b) recorded reactions of beluga and bowhead whales to playbacks of underwater propeller cavitation noise from the icebreaker *Robert Lemeur* operating in heavy ice. Bowheads migrating in a nearshore lead appeared to tolerate exposure to projected icebreaker sounds at received levels up to 20 dB or more above ambient noise levels. However, some appeared to divert their paths to remain farther away from the projected sounds, particularly when exposed to levels >20 dB above ambient or received levels of 100 dB re 1 µPa (Richardson *et al*., 1995b). Turning frequency, surface duration, number of blows per surfacing, and two multivariate indices of behaviour were significantly correlated with the signal-to-noise ratio (S:N); behaviours were significantly different when the S:N exceeded 20 dB or, for turning frequency, exceeded 10 dB. The authors suggested that bowheads may commonly react to icebreakers at distances up to 10–50 km, but noted that reactions were also dependent on several variables not controlled in the study.

During the fall of 1992, migrating bowhead whales apparently avoided (by at least 25 km) a drillsite that was supported near-daily by intensive icebreaking activity in the Alaskan Beaufort Sea (Brewer *et al*., 1993). However, in the fall of another year they also avoided a nearby drillsite that had little supporting icebreaking (LGL and Greenridge, 1987). Thus, it is uncertain from these studies what the relative roles of icebreaking, ice concentration, and drilling noise were in determining bowhead whale responses.

Residual Effects of Icebreaking - Icebreaking by Cape-size ore carriers will occur annually throughout the ice-cover season during the Operation Phase, transiting through the southern LSA to and from Steensby Port every two days. An ore carrier that is actively breaking and moving ice will take 2–3 d to transit Hudson Strait, based on a ship speed of 13 km/h.

Based on corrected density estimates from aerial surveys conducted in Hudson Strait during April, it is estimated that ~340 bowhead whales may exhibit avoidance of an icebreaking ore carrier passing through Hudson Strait during a single transit (Appendix 8C-3, Table 8C-3.9). This corresponds to an estimated 15-20 km avoidance distance (30–40 km swath along ship track depending on ice conditions) based on the 135-dB re 1 µPa (rms) level criterion for continuous sound (Appendix 8C-3, Table 8C-3.8). If it is assumed that ~340 bowhead whales in Hudson Strait show some avoidance during each vessel transit, this represents ~16 % of the bowheads that could occur there during winter, based on available population estimates and assuming that all bowheads in Foxe Basin and Hudson Bay overwinter in Hudson Strait. A larger number of bowheads may exhibit more subtle changes in behaviour (see Appendix 8C-3, Table 8C-3.9). These estimates make the unlikely assumption that there will be no habituation to ship noise over the life of the Project.

These estimates are meant to serve as a guide for potential effects and indicators for monitoring and follow-up. There is uncertainty associated with the estimates (see Section 5.5.5 for details). Bowhead whales that move away from the shipping route presumably would move to other areas in Hudson Strait where sound levels are lower. It is also likely they will habituate to frequent icebreaking vessel transits and eventually stop reacting. There is uncertainty regarding how repeated exposure to icebreaking ore carriers will affect bowheads in Hudson Strait. Based on available information, it seems unlikely that disturbance effects on bowhead whales would extend outside the RSA and influence animals as they migrate to summering areas in Hudson Bay. Using the indicator and threshold criteria provided in Table 8.5-12 as a guide, monitoring and follow-up will be required (see Section 5.10.5).

Aircraft Overflights.—Bowhead response to aircraft appears to be variable and may be partially dependent on behavioural state and habitat (Richardson *et al*., 1995a). Bowheads actively feeding, socializing, or mating appear to be less responsive than when resting (Richardson and Malme, 1993). However, based on available evidence, most bowheads do not exhibit overt reactions to single straight-line aircraft overflights, even at low altitudes. Some react to single straight-line overflights at altitudes of 150–300 m by diving, turning abruptly, or exhibiting other quick changes in behaviour (see Richardson *et al*., 1985a, b, 1995a; Ljungblad, 1986). Richardson *et al.* (1985b, c) reported that bowhead whales frequently responded to circling aircraft at an altitude of ≤305 m, infrequently at 457 m, and rarely at ≥610 m. During overflights at low altitude, intervals between respirations decreased (Richardson *et al*., 1985a, b). During low-altitude photogrammetry airplane passes, bowhead whales sometimes dive hastily; however, during the summer feeding period, the same individuals were sighted in the same areas over periods of days or weeks (Koski *et al*., 1988), indicating little or no displacement from the feeding area.

Of 507 bowhead whale groups sighted during overflights by a Twin Otter at altitudes ~145-460 m, only 2.2 % were observed to react overtly to the aircraft (Patenaude *et al*., 2002). These bowheads were undergoing their spring migration in the Alaskan Beaufort Sea. Reactions consisted of unusually brief surfacings, abrupt dives, and an unusual turn. Most of the reactions were observed when the aircraft approached within a lateral distance of 250 m and at altitude of ~180 m. The proportion of bowheads reacting to the Twin Otter at that altitude was still relatively low at 3.7 % (8 of 218), but the authors acknowledged that reaction frequency was likely underestimated as observation opportunities, especially at low altitudes, were brief. Two of the 11 reacting groups were mother-calf pairs (Patenaude *et al*., 2002). Some (14 % of 63 groups) whales dove or exhibited behavioural changes in response to helicopters; most responses occurred when the helicopter was at altitudes <150 m and lateral distances <250 m (Patenaude *et al.* 2002).

Bowhead whales in shallow water may be more responsive to Twin Otter overflights than whales in deep water because lateral propagation of aircraft sound is better in shallow water (Richardson and Malme, 1993; Richardson *et al*., 1995a). In summer, bowheads in water <10 m deep seemed to be more sensitive to aircraft than those in deeper water (Richardson *et al*., 1985a, b). Prolonged exposure to an aircraft at low altitude (e.g., an aircraft circling at ~300 m), often resulted in dispersal and departure (Richardson *et al*., 1985a, b). There is no indication that single or occasional overflights cause long-term displacement of whales (Richardson *et al*., 1995a).

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow. In addition, aircraft will be prohibited from flying low over bowhead whales for sightseeing or photography.

Residual Effects of Aircraft Overflights - Aircraft approaches to and from the airstrips at Milne and Steensby Inlets will be most frequent during the Construction Phase. During the Operation Phase, the primary airstrip will be located at the Mine Site. Reactions to overflights by aircraft (Twin Otter, Dash-8, and ATR) at Milne Inlet are expected to be limited to a brief alert or startle response and sometimes a dive as the aircraft flies over. These types of behavioural responses would have few consequences for individual whales or their populations. It is unknown how bowheads in Steensby Inlet will react to overflights by a large aircraft like the Boeing 737 during the Construction Phase. Bowheads are uncommon in Steensby Inlet, but any individuals that do occur there, particularly those under the direct flight path of the Boeing 737, would likely exhibit a disturbance response.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on bowhead whales from construction, shipping, and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (dredging; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of disturbance from Project activities on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.2.3 Hearing Impairment

There are no data available on hearing impairment in mysticetes. Related studies of odontocetes were summarized in Section 5.8.2.3.

Planned Mitigation - Blasting will occur late in the ice-cover season (late May) when bowheads are expected to be moving from wintering areas in Hudson Strait and Baffin Bay/Davis Strait. In addition to the timing of blasting, a blasting plan will be designed by an explosives contractor and in consultation with DFO to ensure that the 100-kPa waterborne acoustic overpressure threshold is met and minimized, and a bubble curtain will be employed as necessary. As noted earlier, it is anticipated that an Environmental Monitor and Inuit knowledgeable about marine mammals and will be on site during blasting operations to assess the area for marine mammal presence. In the highly unlikely event that a bowhead whale is observed within the 500-m safety zone (Wright, 2002), blasting will not commence until it has left the area.

Vibratory pile driving at Steensby Inlet will occur over a two-month period during open-water construction in Year 1. Acoustic modelling indicates that sound levels will only exceed 180 dB (rms) (Zykov, 2011 in Appendix 8C-4) less than 30 m from the pile driving site. As a conservative approach, a 50-m "safety zone" (which corresponds to sound levels of <160 dB (rms)) will be established and monitored around the pile driving site. Observers (an Inuit monitor and an Environmental Monitor) will be present at the pile driving site to monitor the appropriate safety zone for seals and whales. Prior to pile driving operations, the safety zone will be monitored and if a bowhead whale is present within this zone, pile driving will not be permitted to commence. Observers will continue to monitor the zone during pile driving and if a bowhead whale is observed within or approaching the zone, pile driving will be halted until the whale has left the area. .

Residual Effects - Whales could occur <25 m away from construction activity and not potentially incur temporary hearing impairment (Appendix 8C-3, Table 8C-3.8). Bowhead whales are unlikely to occur that close to a construction site. Mitigation and monitoring will greatly reduce the likelihood that they would be exposed to sound levels that may cause TTS.

Bowhead whales can incur temporary hearing impairment from exposure to continuous sources of sound of sufficient level and duration. Assuming that exposure to a sound pressure level of 175 dB re 1 µPa for 100 s could induce TTS in bowheads (see Southall *et al*., 2007), acoustic modelling, an assessment of ambient noise data, and aerial survey data indicate that bowheads would not be exposed to continuous sound levels thought to cause TTS (Appendix 8C-3, Table 8C-3.9). Sound levels within 100 m of a Cape-size ore carrier operating in areas of heavy ice in Foxe Basin and Steensby Inlet could reach 175 dB re 1 µPa but bowhead whales are not expected to occur there. It is also unlikely that bowhead whales would incur TTS from vibratory pile driving, particularly with mitigation measures in place.

With mitigation measures in place, bowheads are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects on bowhead whales (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level I), infrequent (Level I), and confined to the LSA (Level I); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of hearing impairment on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.2.4 Masking

Bowhead whale call characteristics and their likely frequency range of best hearing are relevant in assessing potential masking effects of anthropogenic sounds. Würsig and Clark (1993) recognized seven types of bowhead calls. Three of these — pulsed tonal calls, pulsive calls, and high-frequency calls – have also been described as growls, trumpets, roars and screams, and are often produced by breeding bowheads (Richardson *et al*., 1995b). There are four types of low-frequency calls including upsweeps, inflected, downsweeps and constant frequency (Würsig and Clark, 1993). These types of sounds were not commonly produced by socially active bowheads in Baffin Bay (Richardson *et al*., 1995b). Most calls produced by bowhead whales are tonal frequency-modulated sounds in a frequency range of 50–400 Hz (Clark and Johnson, 1984; Würsig and Clark, 1993). While remaining less frequent than simple calls, complex calls are more commonly encountered in spring than summer (Würsig and Clark, 1993). Moans have a frequency range of 25–900 Hz, with dominant frequencies at 100–400 Hz; source levels are ~128-178 dB re 1 µPa-m, but can range as high as 185-189 dB (Clark *et al*., 1986; Cummings and Holliday, 1987). Pulsive sounds range in frequency from 25 to 3500 Hz, with source levels of 152-185 dB re 1 µPa·m (Clark and Johnson, 1984; Cummings and Holliday, 1987). Most songs have frequencies of 20–500 Hz, with source levels of 158–189 dB re 1 µPa·m (Ljungblad *et al*., 1982; Cummings and Holliday, 1987; Würsig and Clark, 1993). Würsig and Clark (1993) reported songs during spring, summer and autumn off Alaska. Bowhead whales emit songs during spring migration in northern Alaska (Ljungblad *et al*., 1982; Cummings and Holliday, 1987; Würsig and Clark, 1993), and during winter and spring feeding in Davis Strait (Tervo *et al*., 2009). Tervo *et al.* (2009) recorded vocalizations including frequency-modulated calls, amplitude-modulated calls, and song notes; winter vocalizations tended to have a higher diversity of calls.

Residual Effects - The potential effect of auditory masking for bowhead whales is increased by the large amount of overlap between the predominant frequencies produced by ship noise and construction activities (<1 kHz) and the frequencies at which bowheads call and presumably hear. In enclosed areas with shipping noise, such as the Milne Port site during the Construction phase, masking of bowhead whale communication could occur during the open-water season; this effect would likely be quite localized if it occurred. Along the shipping route, any masking would occur as a vessel passed by, which likely will be a short time relative to the interval between transits.

With mitigation measures in place, it is predicted that residual effects of masking on bowhead whales would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (Level I) or intermittently or possibly frequently at times (shipping; Level II or III), and beyond the LSA and within the RSA (Level II); masking effects are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of masking on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.2.5 Mortality

Bowhead whale mortality is not expected to occur as a result of Project activities. All available information indicates that bowheads would avoid vessels under way (see Section 5.10.2.2), maintaining distances that would prevent ship strikes. Although strikes are possible, George *et al.* (1994) reported that only a small percentage (~1 %) of bowheads in the Bering-Chukchi-Beaufort seas stock had scars from collisions with propellers. In addition, vessel transit speeds reduce the risk of serious injury and mortality—particularly in areas of ice.

During the October to June period, the ore carriers will be travelling through pack-ice and some fast-ice. At those times, the ship speed is expected to be approximately 13 km/h (7 kt). During the open-water period, the ore carriers will travel at a maximum speed of 26 km/h (14 kt) although in Milne Inlet, the speed will be reduced to 18.5 km/h (10 kt).

Much of the literature on ship strikes is about the endangered North Atlantic right whale. Ship strikes have been identified as a major cause of mortality for that species. The small remnant population of approximately 325 individuals inhabits areas within or near important shipping lanes (Waring *et al.,* 2009). More than half (53 %) of the documented right whale deaths are the result of ship strikes (Campbell-Malone *et al.,* 2008). While nearly all species of large whale have been victims of collisions with ships (Laist *et al.,* 2001; Glass *et al.,* 2008), right whales are especially vulnerable likely because of certain characteristic behaviours during which they may be less aware of their surroundings. These behaviours include: surface active group (SAG) activity (individuals interacting at the surface with frequent physical contact); skim feeding (swimming slowly at the surface with mouth open); and logging (resting motionlessly at the surface), an activity frequently observed in nursing mothers (Knowlton, 1997). In contrast, bowhead whales are not noted for their surface activity in groups; they rest at the surface and occasionally skim feed at or near the surface (see Table 8-5.19).

Table 8-5.19 Surfacing, respiration and dive behavior of undisturbed bowhead whales engaged in various activities during the spring, summer, and fall (Thomas et al., 2002)

Group Activity			Median			Number of Blows			Duration of			Duration of		
			Blow Intervals (s)			per Surfacing			Surfacing (min)			Dive (min)		
Status		Season	mean	s.d.	*n*	mean	s.d.	*n*	mean	s.d.	*n*	mean	s.d.	*n*
Traveling														
	Subadult		14.35	5.00	105	5.51	3.67	69	1.21	1.04	78	4.78	5.20	37
		Spring	14.11	5.65	48	6.24	3.79	34	1.35	1.22	39	4.54	5.70	19
		Summer	18.70	-	1	4.50	4.95	2	1.22	1.53	2	-	-	0
		Fall	14.47	4.43	56	4.82	3.46	33	1.06	0.81	37	5.04	4.76	18
	Adult		19.19	7.87	246	5.51	3.33	195	1.59	1.06	200	8.79	7.46	171
		Spring	20.52	8.89	161	4.92	3.23	154	1.46	1.08	154	6.69	6.19	134
		Summer	16.48	1.97	4	10.00	-	1	2.65	-	1	24.38	2.19	3
		Fall	16.70	4.60	81	7.70	2.75	40	1.99	0.86	45	15.72	6.49	34
	Mother		19.56	7.52	84	5.75	3.30	68	1.62	1.00	74	8.83	6.40	67
		Spring	19.97	8.01	50	5.16	2.96	44	1.38	0.85	48	8.23	6.27	45
		Summer	18.26	5.79	16	6.31	4.46	13	2.01	1.36	15	7.60	5.95	14
		Fall	19.58	7.73	18	7.45	2.50	11	2.14	0.74	11	14.41	5.69	8
		Nursing	23.98	12.63	28	5.11	2.54	19	2.24	1.21	20	12.60	6.76	17
	Neonate		12.42	5.50	146	4.64	3.53	140	0.85	0.83	150	2.49	2.26	144
		Nursing	14.59	6.78	16	3.52	2.41	23	0.63	0.57	23	0.89	1.10	24
	Calf Summer		16.51	8.23	14	3.00	2.07	16	1.17	1.43	19	3.56	3.84	17
	Calf Fall		11.70	2.73	33	6.88	4.12	17	1.47	1.01	18	7.06	4.24	13
		Nursing	11.94	5.31	17	2.26	3.48	39	0.20	0.35	40	0.83	1.84	42
Feeding														
	Subadult		11.34	4.86	102	6.72	3.21	50	1.31	0.58	57	9.24	7.25	16
	Adult		13.41	4.89	61	7.00	3.04	22	1.50	0.41	28	11.70	6.31	20
	Mother		16.22	3.67	33	4.00	3.16	6	1.66	1.46	9	11.09	7.27	11
	Neonate		11.08	3.32	12	8.57	6.36	14	1.87	2.46	14	2.73	1.26	13
	Calf Fall		14.37	6.94	18	6.60	4.39	5	1.46	1.18	6	6.56	4.42	5
Socializing														
	Subadult		12.21	4.80	63	4.42	2.89	24	0.95	0.56	30	6.48	5.56	13
	Adult		16.98	10.02	98	6.05	3.72	42	1.38	0.88	46	4.46	4.47	17
	Mother		16.37	5.22	47	4.67	3.93	30	1.62	1.35	36	7.29	6.65	26
	Neonate		-	-	0	-	-	0	-	-	0	-	-	0
	Calf Fall		9.51	3.65	15	5.70	2.87	10	1.06	1.00	11	2.91	1.85	7

Notes: Neonates refers to calves in the spring. Traveling includes travel alone and travel+feed. Feeding includes only whales that were only feeding. Socializing includes whales that were social, travel+social, social+feed, and travel+social+feed. Data highlighted with grey are a subset of those in line preceding box. Based on observations from an aircraft at altitude ≥460 m. The only lines that include any data from mothers or calves engaged in nursing are the 3 lines labeled "Nursing".

There is evidence suggesting that a greater rate of mortality and serious injury correlates with a greater vessel speed at the time of a ship strike (Laist *et al.* 2001; Vanderlaan and Taggart 2007; Vanderlaan *et al.* 2009). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 26 km/hr (14 kt) or greater (Laist *et al.* 2001), speeds not uncommon among large ships and not limited to high-speed vessels. Vanderlaan and Taggart (2007) found that if vessel speeds are less than 28 km/hr (15 kt), the probability of a lethal injury (mortality or severely injured) due to a ship-strike substantially decreases. In a review of 58 large whale ship strikes in which the vessel speed was known, the average speed of vessels involved in ship strikes that resulted in mortality or serious injuries to the whale was found to be 34.4 km/hr (19 kt) (Jensen and Silber 2003). In the only two documented right whale ship strike mortalities in which the vessel speed was known with some degree of certainty, the vessels were travelling at 40.8 km/hr (22 kt) and 28 km/hr (15 kt) (NOAA Fisheries 2004). The probability of a ship strike is a function of vessel density, animal density and vessel speed.

Planned Mitigation - Given that no significant bowhead/vessel interactions are predicted, no specific mitigation measures for bowheads are proposed. The one exception is that the speed reduction from 26 km/h to 18.5 km/h in Milne Inlet in the open water season will reduce the potential for interactions with bowheads although the reduction is in place to protect narwhals. In the early stages of project operations, marine mammal observers will be present on some vessel passages to monitor the close responses of marine mammals to the vessels.

Residual Effects - The bowhead whale is an ice species that spends most of its life in the presence of ice, except for a brief period during the summer when the ice melts. During the October to June period, the speed of Project vessels is expected to be approximately 13 km/h (7 kt). At those low speeds, bowheads will have little difficulty avoiding the oncoming ships which will be detectable many kilometres away. During the open water period, the ships will travel at a maximum speed of 26 km/h. These speeds are at or below the minimum speeds that have resulted in whale/ship collisions based on the worldwide experience. Most of the fatal ship strikes occur at speeds substantially higher than 26 km/h (14 kt).

Bowheads have had little direct experience with shipping and little information is available. However, it is instructive to examine the information from the Canadian Beaufort Sea where a large bowhead whale population summers. The offshore Beaufort Sea was subject to intensive offshore oil and gas exploration from the mid 1970s to the mid 1980s. During the peak of the activity, there were as many as 50-60 vessels operating including large drillships and dredges, icebreakers, supply ships, fast crew boats, seismic vessels, research vessels, plus the regular community re-supply vessels (Brouwer *et al.* 1988; Richardson and Finley 1989). During that 10-year period, there were no reports of ship strikes involving bowheads or any whale species. Any such strike would have been reported because of the intensive research on bowheads that was ongoing in the region during that period. The lack of strikes indicates that bowheads are able to avoid ships during the open water period.

With mitigation measures in place, no mortality is expected and no residual effects are predicted to occur.

5.10.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on bowhead whales are summarized in Tables 8-5.17 and 8-5.18 and below.

5.10.3.1 Habitat Change

It is predicted that residual effects of habitat change on bowhead whales would be of low magnitude (Level I), medium-term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking, Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of habitat change on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.3.2 Disturbance

It is predicted that residual disturbance effects on bowhead whales from construction, shipping, and aircraft overflights would be of low to medium magnitude (Levels I and II), medium-term (Level II), occurring infrequently (pile driving, dredging; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of disturbance from Project activities on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.3.3 Hearing Impairment

With mitigation measures in place, bowhead whales are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects on bowhead whales (if any) from Project activities would be of negligible to low magnitude (Level I), short-term (Level I), infrequent (Level I), and confined to the LSA (Level I); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of hearing impairment on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.3.4 Masking

It is predicted that residual effects of masking on bowhead whales would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (Level I) or intermittently or possibly frequently at times (shipping; Level II or III), and beyond the LSA and within the RSA (Level II); masking effects are considered fully reversible (Level I; Table 8-5.17). The residual environmental effect of masking on bowhead whales is predicted to be "*not significant*" (Table 8-5.18).

5.10.3.5 Mortality

With mitigation measures in place, no mortality is expected, and therefore, residual effects on bowhead whales are negligible.

5.10.3.6 Cumulative Effects Within the Project

Reviewers of the Draft EIS requested that within Project cumulative effects be considered. As discussed previously, bowhead whales may be exposed to construction activities (i.e., dredging, vessel traffic, pile driving, aircraft overflights) at the Milne Inlet and Steensby Inlet port sites during the first four years of the Project. With mitigation measures in place, hearing impairment and mortality are not expected to result from construction activities. It was predicted that bowheads may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port sites; however, any avoidance is predicted to be localized. During the Operation Phase, bowhead whales will be exposed to noise from ore carriers and vessels located at the Steensby port site. It was predicted that bowhead whales may avoid an icebreaking ore carrier in Hudson Strait by 15 to 20 km. It is possible that this area of avoidance may increase slightly when two ore carriers pass each other along the shipping route (particularly the areas identified in Hudson Strait—see Figure 8-5.2); however, given the relatively small increase in sound levels, the increase in the numbers of bowhead whales potentially exhibiting avoidance is predicted as not significant.

5.10.4 Prediction Confidence

Based on the planned mitigation measures, the baseline data used in the assessment, the location of port sites and the shipping route relative to potential feeding and calving areas, and the available evidence on bowhead whale responses to vessel traffic, there is a generally high level of certainty in the residual effects predictions. There is some uncertainty regarding the extent of masking that might occur. No significant residual environmental effects are predicted for this indicator species. However, follow-up is required to monitor bowhead whale response to ore carrier traffic in Hudson Strait (see below).

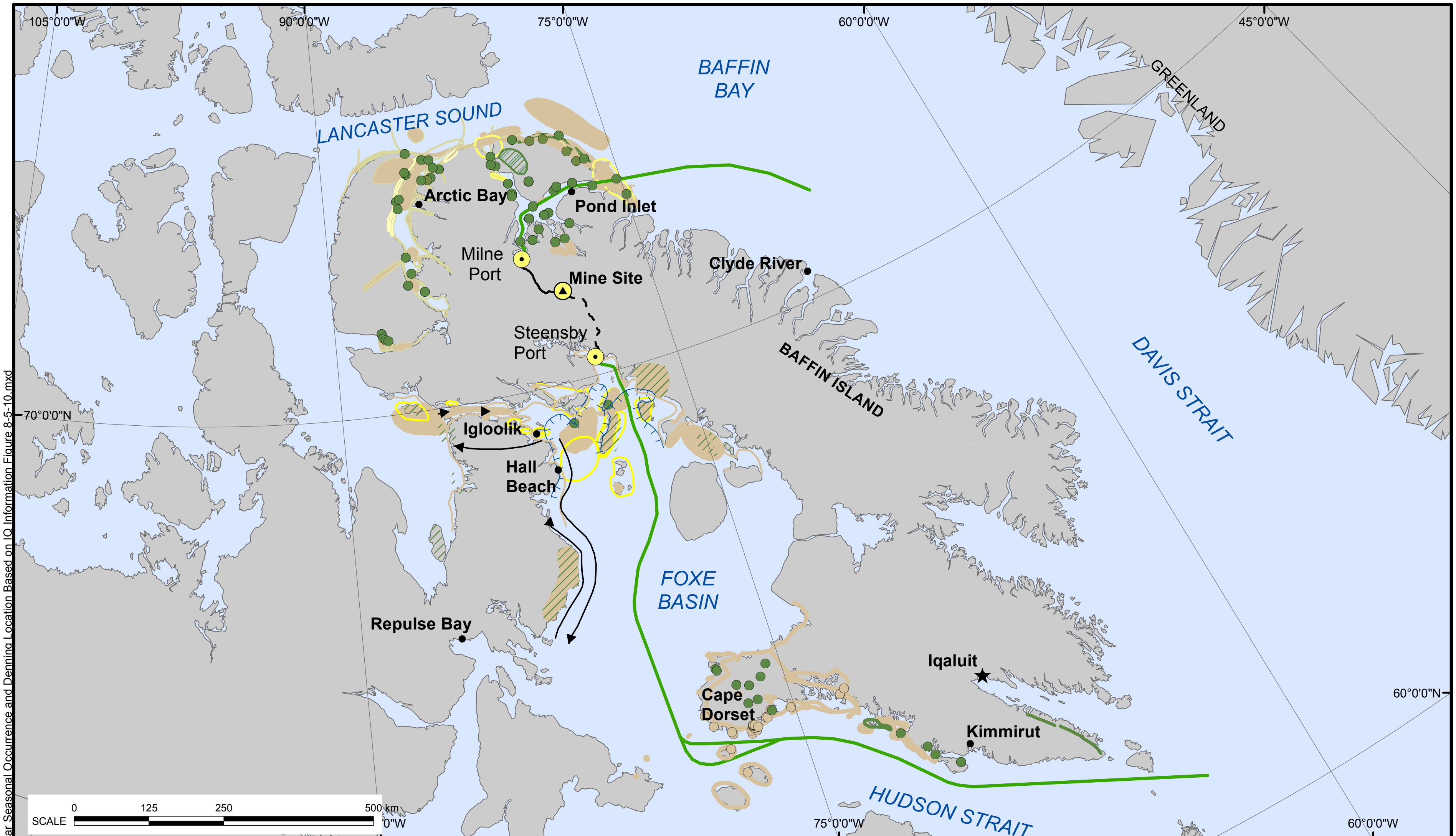
5.10.5 Follow Up

The planned mitigation and monitoring for bowhead whales are summarized in Section 5.10.2 and the marine mammal mitigation and monitoring management plan. Significant residual effects are not expected, and the level of certainty associated with this prediction is generally high. However, there is a low level of certainty with the prediction of disturbance effects of ore carriers transiting Hudson Strait during the ice-cover season. Therefore, a monitoring program and an adaptive management plan will be undertaken to address this uncertainty and ensure that bowhead whales do not incur significant negative effects (see the Shipping and Marine Mammal Management Plan, Appendix 10D-10). The monitoring program will include Marine Mammal Observers (MMOs) positioned onboard a representative number of ore carriers, aerial surveys with a fixed-wing aircraft and potentially using an unmanned airborne system, and an ice imagery study. Aerial surveys for cetaceans are planned to be undertaken during the winter (March, April) 2012 in Hudson Strait to provide a baseline against which potential future surveys during Baffinland's shipping operations could be compared as part of a longer-term monitoring program. There is some uncertainty associated with acoustic modelling results, primarily because details on the final design of the ore carriers were limited during preparation of this assessment. As such, acoustic measurements will be acquired to provide necessary information on sound levels from ore carriers and vibratory pile driving.

5.11 POLAR BEAR

During the review of the DEIS officials from the GN asserted that they had reports and data available on polar bears that would result in a change to the effects prediction. Extra efforts were made to contact the sources identified by GN and as a result, information current to mid-December 2011 and available to the public record has been incorporated into the FEIS

Polar bears occur in the RSA throughout the year (Figure 8-5.10). IQ and aerial survey results show they are abundant in northern Foxe Basin, including the shorelines of Steensby Inlet and Koch, Rowley and Bray islands. Polar bear denning locations have been identified in Grant Study Bay, Murray Maxwell Bay, on South Spicer Island, on Southhampton Island, Nottingham Island, on Foxe Peninsula, on Rowley and Koch Islands, and on the north shore of Hudson Strait (Nunavut Planning Commission 2011; V. Sahanatien, pers. comm.). Hall Beach Elders noted that the southeastern portion of Steensby Inlet provides good denning habitat. Mating occurs from April to June, dens are created in the fall by females, who give birth the following December or January (Harington, 1968; Jefferson *et al.*, 1993). The bears leave their dens in April. Polar bears from the Foxe Basin subpopulation also overwinter in western Hudson Strait (COSEWIC, 2008), whereas those from the Davis Strait subpopulation occupy the eastern portion of Hudson Strait.



LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- ICE EDGE (IQ)
- DENNING LOCATION / AREA (IQ)
- AREA OF CONCENTRATION / SIGHTING (IQ)
- AREA OF OCCURRENCE - SUMMER (IQ)
- MOVEMENT / MIGRATION (IQ)

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

ᓄᑑᔫᓂ ᐅᔭᖅᓯᐅᕐᑐᑦ MARY RIVER PROJECT

POLAR BEAR SEASONAL OCCURRENCE AND DENNING LOCATIONS BASED ON IQ INFORMATION

Baffinland Iron Mines Corporation

REF NO. BL_Vol3_GIS_026

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REV A

Figure ID: BL_Vol8_GIS_026 Polar Bear Seasonal Occurrence and Denning Location Based on IQ Information Figure 8-5-10.mxd

Small numbers are expected to occur in Milne Inlet and Eclipse Sound during the open-water period. Bylot Island and coastal Baffin Island are used as summer retreats when sea ice melts.

During community consultations, it was noted that shipping would not likely directly affect polar bears but that effects on their prey may cause bears to look for food elsewhere (Hall Beach Marine Mammal Workshop).

5.11.1 Assessment Methods

Assessment methods consider the following effects on polar bears: habitat change, disturbance and mortality. Measurable parameters (or indicators) were derived to provide guidance in assessing changes in polar bear habitat, behaviour and health (Table 8-5.20). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant at the population level. The reader is referred to Volume 2, Section 3.8 for the criteria used to establish significance determination.

5.11.1.1 Habitat Change

Habitat for polar bears will change because of dock structures at the Steensby Port site, icebreaking and management of landfast ice in Steensby Inlet, and icebreaking in pack ice in Foxe Basin and Hudson Strait. The areas of changed habitat were calculated and then compared to available habitat in Steensby Inlet, Foxe Basin, and Hudson Strait. Habitat changes in areas of pack ice would not necessarily be negative for polar bears. A discussion of habitat change as it relates to availability of prey (ringed seals) is also included.

During review of the Draft EIS, a request was made to consider the effect of changes in ice pan size resulting from icebreaking along the shipping route, and the consequences this may have for polar bears. An analysis of pack ice disruption (see Section 2.5.4 and Sikumiut Environmental Management Ltd., 2011) was conducted to examine the effects of icebreaking ore carriers on the number and size of ice pans along the shipping route each month. This analysis was considered in light of information that suggests polar bears prefer ice floes >2 km in diameter except during freeze-up when smaller ice floes (<500 m) are used more frequently (Peacock *et al.*, 2009).

5.11.1.2 Disturbance

Underwater noise is of little relevance to polar bears. The analysis of disturbance effects on this indicator species is mostly qualitative in nature with the exception of estimating the zone of influence around icebreaking ore carriers. The area of likely avoidance was calculated based on known responses of polar bears to icebreaking vessels. This area was then compared to available habitat in Foxe Basin and Hudson Strait. The proportion of “disturbed habitat” was used as a proxy for the relative number of bears disturbed by icebreaking ore carriers. A discussion of the shipping route relative to identified denning sites in the LSA is also provided.

5.11.1.3 Mortality

A qualitative discussion on the potential for polar bear mortality as a result of human-bear interactions is provided.

Table 8-5.20 Measurable Parameters and Threshold Values for Polar Bears

Effect	Measurable Parameter [1]	Threshold [1]
Change in habitat caused by icebreaking and ice management. Change in habitat caused by dock footprints.	Decrease in suitable polar bear habitat for foraging.	Decrease of 10 % or greater in suitable polar bear foraging area in Steensby Inlet and pack ice habitat in Foxe Basin and Hudson Strait.
Disturbance caused by noise.	Change in occupancy of an area that has been identified as important feeding or denning habitat.	≥10 % of polar bears in the RSA exhibit strong disturbance and avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat.
Mortality from human interactions.	Increase above natural mortality per annum	Any project-caused mortality.

1. Timeframe for all parameters and thresholds unless otherwise stated is "per year"

5.11.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on polar bears considered in the assessment are listed below. Effects that are not assessed in detail (i.e., were ranked 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking and/or ice management plus footprints of dock structures;
- **Disturbance** caused by noise from construction, shipping, and aircraft overflights; and
- **Mortality** from human-bear interactions.

5.11.2.1 Habitat Change

Landfast ice habitat will be unavailable because of the presence of dock structures at Steensby Port during the Construction and Operation Phases. The size of the footprint of dock structures is negligible (0.07 km^2).

At Steensby Port, 136 km^2 of landfast ice at the ore dock and along the shipping route into Steensby Inlet will be changed so that it may be less suitable for the creation of ringed seal lairs and the same could be true for breathing holes, although there is some evidence to suggest that ringed seals preferentially establish breathing holes in the tracks of icebreakers (Alliston, 1980, 1981); it is thus assumed that landfast ice changed by icebreakers will result in decreased foraging opportunities for polar bears. Similarly, ice-covered habitat that will be maintained for ship traffic (i.e., vessel turning and standby operations) in the area of the ore dock at Steensby Port is assumed to be unsuitable for foraging. In Section 5.6.2.4, it was predicted that up to 15 ringed seal pups could experience mortality from collisions with icebreaking ore carriers each winter during the Operation Phase. It can be assumed that these pups, or at least a proportion of them, would be lost foraging opportunities for polar bears. However, based on satellite-tagging information, female polar bears spent no time in the landfast ice of Steensby Inlet (see Figure 2.16 in Appendix 8A-2).

Polar bears and their primary prey, ringed seals, also occur in areas of pack ice in Foxe Basin and Hudson Strait. The area of pack ice that will be disrupted temporarily by a single vessel passage is estimated at 76.5 km^2. Evidence of the ship track in the mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Section 2.5.4; Volume 3, Appendix 3G; Sikumiut Environmental Management Ltd., 2011). It has been assumed that ice pans (<0.1 km in diameter) would be pushed to the side of the icebreaking ore carrier while larger pans (>0.1 km) would be split. Average ice pan size along the shipping route ranges from 0.02 to 10 km in length during February to June, which indicates that average floe sizes of >2 km (suggested preferred floe size for polar bears) are not uncommon along the shipping route. In the context of the RSA, a single ore carrier transit will disrupt 0.025 % of the pack ice area. Polar bears in pack ice are adapted to a constantly shifting habitat. The split pans, while smaller and potentially less stable still provide suitable habitat for polar bear. During periods when large floe sizes are unavailable, polar bears will use smaller floe sizes (V. Sahanatien, pers. comm.) including those during freeze up (October and November). As well, very little of the pack ice struck by an ore carrier will be turned into brash ice; therefore, pack ice habitat for polar bear will still be present within the shipping route. It is likely that polar bears will be able to use the area of changed ice shortly after the ore carrier has passed. In addition, pans re-form during the winter and new large pans are created. It is not known if seals will avoid the ship track or take advantage of the frequently broken ice between ship transits. There is some evidence that seals use areas of ice altered by industrial activities, including icebreaking (see Section 5.6.2.2). This may attract polar bears to the vessel track.

Planned Mitigation - Mitigation measures include icebreaking vessels limiting the width of the shipping lane to <1.5 km by sailing along the same track as much as possible through landfast ice in Steensby Inlet. The shipping lane into Steensby Port will be delineated with markers to notify the ships' crews of the boundaries of previous vessel tracklines. Icebreaking tugs and ore carriers will minimize the area of broken landfast ice at the Steensby Port to the extent possible. Dock structures were designed to reduce the footprint in the marine environment.

Residual Effects - The 136 km^2 of changed habitat in landfast ice represents 5.6 % and 0.36 % of the suitable landfast ice habitat in Steensby Inlet and Foxe Basin, respectively. The temporarily changed 76.5 km^2 of pack ice during a single transit to and from Steensby Port represents much <1 % of pack ice in Hudson Strait, Foxe Basin and near Steensby Inlet. This change in polar bear foraging habitat is transient and substantially lower than the threshold value of 10 % (Table 8-5.20).

With mitigation measures in place, it is predicted that effects of habitat change on polar bears would be of low magnitude (Level I), medium term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.21). The residual environmental effect of habitat change on polar bears is predicted to be "*not significant*" (Table 8-5.22).

5.11.2.2 Disturbance

Construction - The reactions of polar bears to anthropogenic disturbance are highly variable, and on-ice activities such as blasting and associated traffic can have various effects related to disturbance. Polar bears are known to be curious at times and commonly approach ships, drill sites (Stirling, 1988b) and tundra vehicles (Dyck, 2001; Dyck and Baydack, 2004). They often approach stationary drillships and drillsites when ice is nearby (Stirling, 1988b); Blix and Lentfer (1992) noted that any acoustic effects from drillrigs are likely confined to a small area. Polar bears have been scared away by pyrotechnics and warning shots, but habituation to these sounds can occur if they are used repeatedly (Shideler, 1993).

Table 8-5.21 Effects Assessment Summary: Polar Bear

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving, drilling (Steensby only), dredging, and vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; bubble curtain system. Drilling in late April/May. Use of bear monitor for on-ice activities, use of bear deterrent devices.	Level I	Level I	Level I	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance	Maintain constant speed and course when possible.	Level I	Level I	Level I	Level I	Level I
Operation of worker camps.	Negative. [1] Mortality	Educate workers about bear safety; work areas kept clean of food scraps, garbage, and toxic materials; use of bear monitor at camp sites; use of bear deterrent devices.	n/a				
Aircraft overflights	Negative. [1] Disturbance	Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over polar bears for passengers to 'get a better look' or for photography.	Level I	Level I	Level III	Level I	Level I
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level II	Level I	Level I	Level I

Table 8-5.21 Effects Assessment Summary: Polar Bear (Cont'd)

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
OPERATIONS PHASE							
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side. Minimize footprint of ice disturbance at ore dock and along shipping route.	Level I	Level II	Level III	Level I	Level I
Operation of worker camps.	Negative. [1] Mortality	Educate workers about bear safety; work areas kept clean of food scraps, garbage, and toxic materials; use of bear monitor at camp sites; use of bear deterrent devices.	n/a				
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over polar bears for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Operation of worker camps.	Negative. [1] Mortality	Educate workers about bear safety; use of bear monitor at camp sites; use of bear deterrent devices.	n/a				
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance [2] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.22 Significance of Residual Effects to Polar Bear

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		
Mortality	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: :1= Low; 2= Medium; 3=High

Although polar bears are quite tolerant of some anthropogenic activities, they are known to be susceptible to disturbance. Some polar bears reportedly approach tundra vehicles in Churchill, Manitoba, but a study has found they showed a significant increase in vigilance behaviour in the presence of tundra vehicles compared to when no vehicles were present (Dyck, 2001). During experimental tundra vehicle approaches, 25 % of observed polar bears responded to approaching vehicles by getting up, walking or running away, with an average response distance of 43 m (Eckhardt, 2005). Maternal polar bear groups that denned within 1.6 km of a heavily used ice road were less vigilant than those in undisturbed areas, likely because the bears near heavy truck traffic had habituated to it (Smith *et al*., 2007).

Polar bears are thought to be especially susceptible to disturbance during the denning period (Amstrup and Durner, 1995; Linnell *et al*., 2000). Even after they emerge from their dens, disturbance can lead to den abandonment before cubs are of adequate size or strength to survive on the ice (Amstrup, 1993). Denning bears have been reported to stay in the den during nearby construction and drilling activities (Amstrup, 1993). Similarly, some polar bears remain in their dens when on-ice vehicles pass by within a few hundred metres, while others emerge from dens (Amstrup, 1993). Female polar bears with cubs have also been reported to abandon their dens when seismic crews were operating on the ice nearby (J. Lentfer *in* Trasky, 1976; Amstrup, 1993). Blix and Lentfer (1992) studied the propagation of sounds and vibrations from human activities into artificial bear dens, and concluded that only seismic testing activities <100 m from a den produced noise appreciably louder than ambient levels inside the den. During remediation activities on Flaxman Island in the Alaskan Beaufort Sea, noise from the use of heavy equipment, helicopter activity and blasting was recorded in artificial dens; vehicle noise was typically not detected in the den when the sound source was >500 m, although on occasion sounds were detected from vehicles up to 2000 m away (MacGillivray *et al*., 2003). Sound levels in the dens were lower than just outside by 25–40 dB, depending on the frequency of the sounds measured (MacGillivray *et al*., 2009). Both studies indicated that snow is an important insulative substrate that can reduce disturbance to denning bears.

Polar bears may avoid or approach construction sites. In the first year of construction, drilling and blasting will occur at the Steensby dock site during April and May, when polar bears will have emerged from dens and will be foraging, so will likely avoid the immediate area around drilling and blasting operations. However, if a polar bear approaches the on-ice construction site, a bear monitor will use appropriate deterrent techniques to keep it away from personnel. During the open-water period, few bears are expected at the port sites, and disturbance effects are predicted to be low.

Vessel Traffic - Polar bears exhibit variable responses to boats, but most individuals appear to be little affected by shipping (Fay *et al*., 1984). If bears do react by walking, running or swimming away, the responses are typically brief; other bears do not respond to vessels at all, or approach the ship (Brueggeman *et al*., 1991; Rowlett *et al*., 1993; Harwood *et al*., 2005). During consultations for the Project, it was noted that it is difficult to predict how polar bears will respond to ships but that it is unlikely they will be directly affected (Hall Beach Marine Mammal Workshop, anonymous, pers. comm.).

Interactions between polar bears and vessel traffic along the shipping routes during the open-water period will be limited because bears are primarily located on shorelines and islands then. A swimming bear may avoid a vessel, including an ore carrier, if it gets close enough, but such effects would have little consequence. Small numbers of polar bears may avoid or approach vessels at and near the docks in Milne and Steensby Inlets; if a bear approaches a vessel and poses a risk to personnel, appropriate deterrent techniques will be used.

Mitigation measures to reduce the potential disturbance effects of shipping on polar bears include all vessels maintaining a constant course and speed whenever possible. In addition, vessels will minimize idling of engines when docked at Milne and Steensby Ports.

Icebreaking - There is little published information on the reactions of polar bears to icebreaking activities. Polar bears show variable responses to shipping, ranging from approach to avoidance (Harwood *et al*., 2005). Four polar bears were sighted from a seismic vessel accompanied by an icebreaker off northeast Greenland; two dove into the water and swam away and two remained on the ice watching the vessel (Jones *et al*., 2009). Similarly, polar bears have been noted to typically watch or ignore an icebreaking vessel until it approached to within ~500 m (B. Mactavish, LGL Limited, pers. comm.). During most approaches within 500 m, polar bears were observed walking away on the ice and then entering the water and swimming away. Polar bears will also approach icebreaking vessels. For example, a polar bear has been observed walking on the ice within 30 m of the side of a vessel (that was travelling at 7.4 km/h) and looking up at crew members on the deck. On another occasion, a polar bear was observed swimming toward the side of a vessel and then following in its wake for about two minutes before turning away (B. Mactavish, LGL Limited, pers. comm.).

Icebreaking by Cape-size ore carriers will occur throughout the ice-cover season during the Operation Phase. It is expected that one carrier will transit through the southern LSA to and from Steensby Port every two days. Some polar bears will exhibit localized avoidance. Available evidence suggests that at 500 m from an icebreaker, they will generally move away. They may be temporarily excluded from ~90 km^2 and 1500 km^2 of landfast and pack ice habitat, respectively, during a single transit of an ore carrier. This represents 2.6 % of available landfast ice in Steensby Inlet and <1 % of available pack ice in Foxe Basin and Hudson Strait. Some individuals may be affected multiple times by icebreaking during a single ice-cover season.

It is possible that polar bears will den in pack ice, although IQ and scientific information indicates that bears den on land. Preferred denning sites in Foxe Basin occur inland, generally in hilly terrain where snow can form deep drifts (V. Sahanatien, pers. comm.). IQ notes that polar bears den at numerous coastal sites along the southern shipping route (Figure 8-5.10). At the closest point, the nominal shipping lane is 5.4 km from an identified terrestrial denning area near the mouth of Steensby Inlet, i.e., the shoreline north of Cape Jensen. Most identified denning areas are >15 km from the shipping lane. Polar bears in dens at these identified sites are not expected to be affected by Project shipping.

Aircraft Overflights - The reactions of polar bears to aircraft overflights is variable. They often run away when aircraft pass by at altitudes <100 m (Richardson *et al*., 1995a). Those in snow dens have been reported to remain inside when aircraft approach (Amstrup, 1993). The disturbance effects on denning bears are likely reduced, as snow attenuates aircraft noise (Blix and Lentfer, 1992). However, some polar bears left their dens when helicopters flew or hovered overhead (Amstrup, 1993). At Flaxman Island in the Alaskan Beaufort Sea, noise from helicopters was not detected in artificial dens until the aircraft was at least 100 m from dens (MacGillivray *et al*., 2003). Helicopters have been used to scare bears away (Shideler, 1993); in Churchill, bears were displaced when helicopters hovered at altitudes <50 m (Dyck, 2001).

Polar bears observed incidentally during aerial surveys for seals in the Alaskan Beaufort Sea during the springs of 1997–2002 exhibited little (i.e., looked at plane) to no reaction to fixed-wing aircraft traveling at a speed of 220 km/h and at an altitude of 90 m. During 1999, the only year that a Twin Otter was used, one of four bears exhibited an apparent reaction–it looked up at the aircraft without running or showing any other overt reaction (Moulton and Williams, 2002).

Reactions by polar bears to overflights by aircraft (Twin Otter, Dash-8 and ATR) at Milne Inlet are expected to be limited to a brief alert or startle response. Few bears are expected at Milne Inlet and these types of behavioural responses would have little consequences. It is unknown how bears in Steensby Inlet will react to overflights by a large aircraft like the Boeing 737 that will make daily flights during the Construction Phase. Polar bears are common in northern Foxe Basin, and terrestrial areas in southeast Steensby Inlet are thought to provide good denning habitat (Hall Beach Elders, pers. comm.). It is unlikely that bears inside of dens in southeast Steensby Inlet (or on the islands, e.g., Rowley Island, in northern Foxe Basin) would be affected by aircraft overflights. Polar bears travelling or foraging in and near the flight path may exhibit startle and avoidance responses at Steensby Inlet; they may habituate to daily overflights or they may avoid the area. The numbers of affected bears is predicted to be low.

Mitigation measures are in place to reduce the potential disturbance effects. Except during takeoff and landing, Project aircraft will be operated at a minimum altitude of 450 m over marine areas, when weather conditions allow, and will be prohibited from flying low over polar bears for sightseeing or photography.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on polar bears from construction, shipping, and aircraft overflights would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (construction activities; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.21). The residual environmental effect of disturbance from Project activities on polar bears is predicted to be "*not significant*" (Table 8-5.22).

5.11.2.3 Mortality

There is a risk of mortality as a result of interactions with humans and ingestion of toxic materials. Polar bears are known to eat toxic non-food items such as car batteries (Lunn and Stirling 1985) and hydraulic and lubricating fluids (Derocher and Stirling, 1991). One is known to have died as a result of antifreeze consumption [ethylene glycol coloured with rhodamine B; Amstrup *et al.* (1989), sometimes used for marking roads and runway centerlines on snow and ice.] There is risk that "problem" bears posing a risk to human life may have to be killed. Dyck (2006) examined the circumstances of polar bears killed in defense of life and property (DLP) in Nunavut during 1970–2000. The majority of DLP kills (74 %) occurred at native camps, which is similar to findings in the Northwest Territories (Stenhouse *et al*., 1988). In Nunavut, during 1988–2000, permanent camps at industry sites (mines, well sites and exploration camps) accounted for 4 % of DLP kills. The number of DLP kills has been decreasing since 1980, with DLP kills at industry camps declining substantially, which Dyck (2006) attributed to educating industry personnel about ways to minimize polar bear-human encounters. Similarly, no polar bears have been killed because of encounters associated with the current oil and gas industry activities on the North Slope of Alaska, since monitoring and deterrent programs for polar bears have been implemented (C. Perham, U.S. Fish and Wildlife Service, pers. comm.).

Planned Mitigation - As outlined in the Environmental Protection Plan, mitigation measures and monitoring will be employed to reduce the risk of a bear encounter, chances that a bear would have to be killed in defence of human life, and the risk that a bear will accidentally ingest toxic material. These measures include:

- Site and working areas will be kept clean of food scraps, garbage and toxic materials;
- Workers will be educated about the risks and safety measures related to encounters with polar bears (including the prohibition of feeding bears and following or otherwise harassing them);
- Bear monitors will be posted at appropriate coastal locations and will accompany remote field crews to areas that do not provide appropriate refuge for workers; monitors will maintain a watch for bears and deter them using non-lethal methods (e.g., bear banger, rubber bullets, flares, and air horns) whenever possible;
- The Operations Manager will authorize which deterrent measures will be made available during the Project; and
- A defense kill is considered a last resort.

Residual Effects - As noted in the EPP, the potential for human-polar bear interactions is highest in coastal areas; however, they can be found anywhere on Baffin Island. The Mary River camp was visited by polar bears in the summer of 2006, and bears were sighted at both Milne and Steensby Inlets in the summer of 2007. With mitigation measures in place, mortality is considered unlikely. In the event of polar bear mortality as a result of the Project, it is anticipated that the mortality will be deducted from the harvest quota and that appropriate compensation will be provided to hunters. This ensures that polar bear mortality per year does not exceed allowable quotas for sustaining populations.

With mitigation measures in place, the risk of killing a polar bear in defense of human life is considered low. If a defense kill occurs, the mortality will be deducted from the harvest quota and appropriate compensation will be provided to hunters. Residual environmental effects on polar bears are considered negligible.

5.11.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on polar bears are summarized in Tables 8-5.21 and 8-5.22 and below. Note that the status of polar bear as a Species of Special Concern has been taken into account for this assessment. Special efforts were made to glean all available research data and reports as input to this assessment. Consequently, the effects assessment and significance determination has been completed with full consideration of polar bear status and following incorporation of the best available information.

5.11.3.1 Habitat Change

It is predicted that residual effects of habitat change on polar bears would be of low magnitude (Level I), medium term (Level II), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.21). The residual environmental effect of habitat change on polar bears is predicted to be "*not significant*" (Table 8-5.22).

5.11.3.2 Disturbance

It is predicted that residual disturbance effects on polar bears from construction, shipping, and aircraft overflights would be of low magnitude (Level I), medium-term (Level II), occurring infrequently (construction activities; Level I) or frequently (shipping, aircraft overflights; Level III), and within the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.21). The residual environmental effect of disturbance from Project activities on polar bears is predicted to be "*not significant*" (Table 8-5.22).

5.11.3.3 Mortality

It is predicted that residual effects of mortality on polar bears would be negligible.

5.11.4 Prediction Confidence

Based on the available evidence on polar bear response to on-ice industrial activity and vessel traffic, the planned mitigation measures, and the baseline data used in the assessment, the level of certainty in the residual effects predictions is high (Table 8-5.22). No significant environmental residual effects are predicted for this indicator species.

5.11.4.1 Cumulative Effects Within the Project

Reviewers of the Draft EIS requested that within Project cumulative effects be considered. As discussed previously, polar bears may be exposed to construction activities (i.e., dredging, vessel traffic, pile driving, aircraft overflights, on-ice traffic associated with drilling/blasting), particularly at the Steensby Inlet port site during the first four years of the Project. With mitigation measures in place, mortality from interactions with humans at the construction sites is not expected. If a defense kill occurs, the mortality will be deducted from the harvest quota and appropriate compensation will be provided to hunters. Hence, effects from the Project are not expected to contribute to overall mortality from harvesting. Polar bears may avoid or be attracted to the construction activites. It is possible that this attraction or avoidance may increase slightly if construction activities occur simultaneously at each of the port sites. During the Operation Phase, bears will be exposed to ore carriers and vessels located at the Steensby port site. It was predicted that they may avoid an icebreaking ore carrier by 500 m. It is unlikely that this area of avoidance would increase in a synergistic nature when two ore carriers pass each other along the shipping route given the minimum separation distance required in the shipping lane. Cumulative effects of habitat change, i.e., disruption of pack ice from multiple vessel transits, are not predicted given the temporary and restricted nature of the ship track.

5.11.5 Follow Up

The planned mitigation and monitoring for polar bears were summarized in Section 5.11.2 and are provided in the marine mammal mitigation and monitoring management plan.

5.12 BEARDED SEAL

Bearded seals are common in the LSA and RSA throughout the year (Figure 8-5.11) and primarily occur in areas with shallow water (<200 m) and pack ice. They are seldom found in landfast ice areas, but are widely dispersed in open-water areas of pack ice where leads and cracks are frequent, and where ice pans are sufficient for haul-out sites (McLaren and Davis, 1982). The polynyas of northern Foxe Basin are thought to be an area of high density for bearded seals (Beckett *et al*., 2008). The studies of polynyas conducted by ASL Environmental Sciences Limited for the present project suggest that those areas are really areas of moving pack ice with temporary openings and closings rather than recurring polynyas in fixed locations. The pupping period varies depending on location and seems to encompass the period from mid-March to early May (Burns, 1981). Pups are typically born on unstable pack ice or near the landfast ice edge where they are weaned after about three weeks (Gjertz *et al*., 2000). IQ notes that bearded seals give birth in April along the southern part of Steensby Inlet. Moulting occurs in spring and bearded seals commonly haul out on ice during summer. Bearded seals are generally considered to be benthic feeders that prey on an array of benthic invertebrates and fish, although pelagic fish are also taken (Lowry *et al*., 1980b; Finley and Evans, 1983; Antonelis et al., 1994).

During consultations for the Project, there were few specific comments about effects of the Project on bearded seals. It was noted that bearded seals tend to stay around the sea shore when large ships arrive up north (M. Akoomalik, Pond Inlet, pers. comm.).

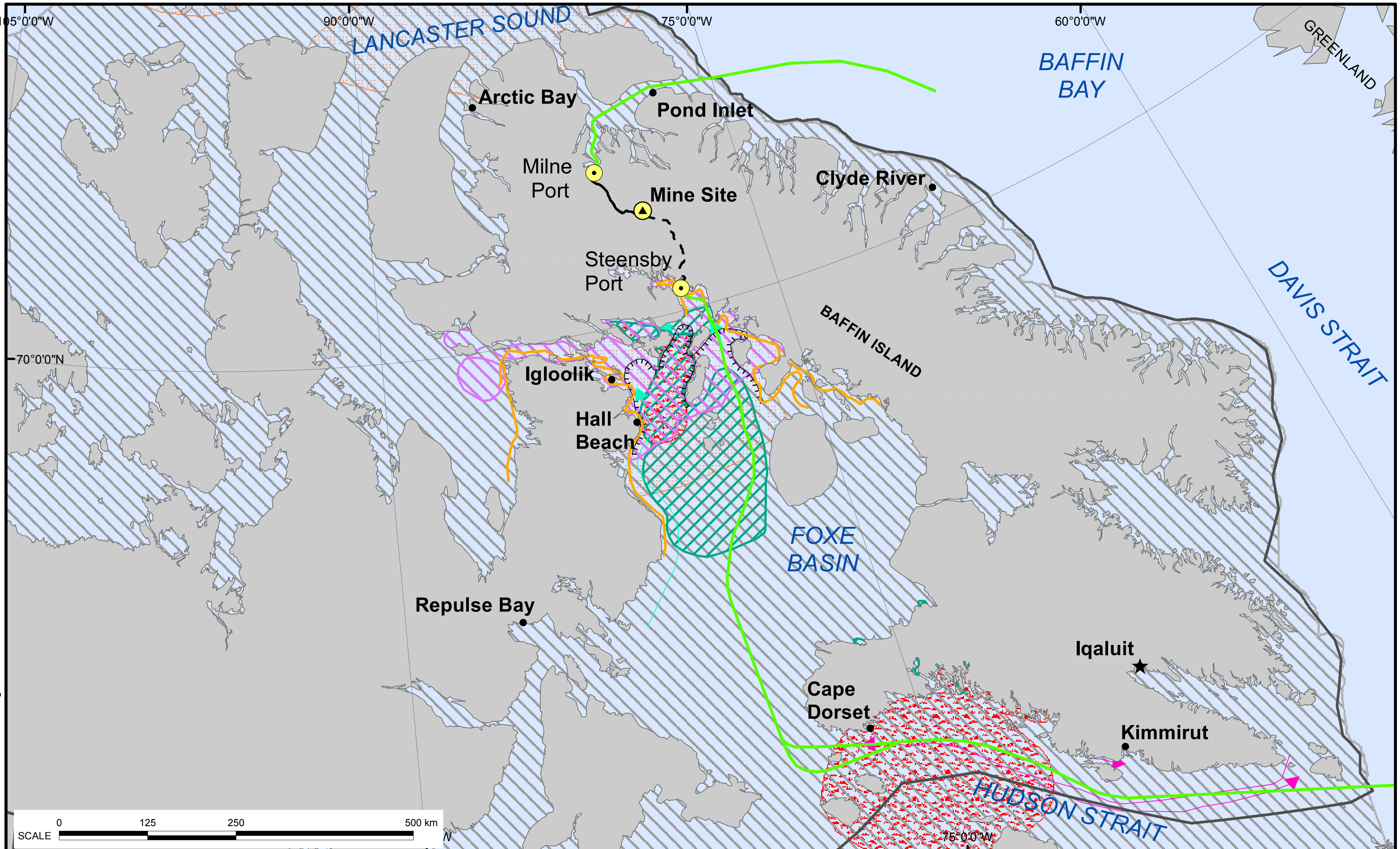
5.12.1 Assessment Methods

Assessment methods were specifically designed to consider the following effects on bearded seals: habitat change, disturbance, hearing impairment, masking, and mortality.

Measurable parameters (or indicators) were derived to provide guidance in assessing changes in bearded seal habitat, behaviour and health (Table 8-5.23). The selected threshold for each measurable parameter is intended to identify a level that would be considered an unacceptable change. If a change in habitat, behaviour or health approached or exceeded a threshold, or if the level of certainty with the assessment was low, then a commitment to follow-up monitoring was made. Exceedence of a threshold level does not necessarily mean that the effect is biologically significant at the population level. The reader is referred to Volume 2, Section 3.8 for the criteria used to establish significance determination.

5.12.1.1 Habitat Change

The footprint of dock structures at the Steensby Port site was calculated to determine how much potential bearded seal habitat would become unavailable. Bearded seals are considered uncommon in areas of solid fast ice but likely to occur along the edge of the fast ice in Steensby Inlet and Hudson Strait. The shipping route does not overlap with landfast ice in Hudson Strait, and only a small portion of the landfast ice edge



LEGEND:

- NOMINAL SHIPPING ROUTE
- RAILWAY ALIGNMENT (PROPOSED)
- MILNE INLET TOTE ROAD (EXISTING)
- KNOWN OR LIKELY RANGE
- HIGH OR LIKELY HIGH DENSITY
- BEARDED SEAL CONCENTRATION AREA (IQ)
- BEARDED SEAL PUPPING LOCATION (IQ)
- SEALS BASKING ON ICE (IQ)
- BEARDED SEAL MOVEMENT (IQ)
- BEARDED SEAL SIGHTINGS (IQ)
- GENERAL SEAL MOVEMENT (IQ)
- LANDFAST ICE EDGE

NOTES:

1. BASE MAP:© HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. GRATICULE IS IN DEGRESS MINUTES SECONDS. PROJECTION - LAMBERT CONFORMAL CONIC
3. PROPOSED RAILWAY ALIGNMENT PROVIDED BY CANRAIL CONSULTANTS INC.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BEARDED SEAL DISTRIBUTION, INCLUDING PUPPING AND BASKING SITES, IN THE RSA

Baffinland Iron Mines Corporation

P/A NO.	REF NO.
NB102-181/25	13

FIGURE 8-5.11 REV A

Figure ID: BL_Vol8_GIS_028 Bearded Seal Distribution in the RSA Figure 8-5-11.mxd

Table 8-5.23 Measurable Parameters and Threshold Values for Bearded Seals

Effect	Measurable Parameter [1]	Threshold [1]
Change in habitat caused by ice-breaking. Change in habitat caused by dock footprints.	Decrease in suitable pupping habitat in the pack ice and edge of landfast ice. Decrease in suitable bearded seal habitat for foraging.	Decrease of 10 % or greater in suitable bearded seal pupping habitat in Hudson Strait and Foxe Basin or feeding area in Steensby Inlet.
Disturbance caused by airborne and/or underwater noise.	Change in occupancy of an area that has been identified as important for feeding, nursing, breeding, and hauling out. It is assumed that seals exposed to continuous sound levels from shipping, vibratory pile driving, or dredging where the sensation level exceeds 80 dB re 1 µPa (Davis and Malme, 1997) would exhibit an avoidance response.	≥10 % of bearded seals in the RSA exhibit strong avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat.
Hearing impairment in water, pulsed or continuous sound.	In water, pulsed sound: Bearded seals exposed to sound levels from blasting that exceed 180-190 dB re 1 µPa (rms) in water (NMFS, 2000). In water, "continuous" sound: Bearded seals exposed to sound levels from shipping, vibratory pile driving, or dredging where the sensation level exceeds 100 dB re 1 µPa (Davis and Malme, 1997).	In water, pulsed sound: >10 % of bearded seals in the LSA are exposed to sound levels (pulsed) that exceed 180-190 dB re 1 µPa (rms). In water, continuous sound: >10 % of bearded seals in the LSA are exposed to sound levels (continuous) that exceed a 100 dB re 1 µPa sensation level.
Mortality from construction activities (blasting) and vessel collisions.	Increase above natural mortality per annum.	>1 % of population in Hudson Strait and Foxe Basin (including pups).

1. Timeframe for all parameters and thresholds unless otherwise stated is "per year"

(maximum of 1.5 km) will be changed at the entrance to Steensby Inlet. Bearded seals are also expected to occur in areas of pack ice in Foxe Basin and Hudson Strait. The area of changed ice during periods of maximum pack ice coverage was calculated and compared to overall available pack ice in Foxe Basin and HudsonStrait.

5.12.1.2 Disturbance

To assess the potential level of disturbance of bearded seals, the same approach that had been employed for ringed seals was used (see Section 5.6.1.2 for details). There is no audiogram available for bearded seals so the ringed seal audiogram was used. Bearded and ringed seals produce calls at similar frequencies (see Sections 5.6.2.3 and 5.11.2.3) so for the purposes of analyses, it was assumed their hearing abilities were similar. The human auditory approach (Davis and Malme, 1997) was simulated by subtracting the audiogram (hearing threshold data) from the estimated received sound levels of Project activities at the Steensby Port site and associated shipping route at various distances and 1/3-octave bands (see Matthews *et al*., 2010). Results were plotted to create 1/3-octave sensation levels (Appendix 8C-3, Figures 8C-3.1 to 8C-3.10). From these graphs, an estimate was made of the maximum distance in the 1/3-octave bands that the noise equals or exceeds the sensation level thresholds predicted for disturbance onset (70-dB sensation level) and avoidance (80-dB sensation level; Appendix 8C-3, Table 8C-3.1).

The areas exposed to noise levels that exceeded the threshold for disturbance onset and avoidance were calculated for all modelled Project activities at the Steensby Port site and along the shipping route. The estimated numbers of bearded seals exposed to sensation levels of 70 dB and 80 dB were calculated for months with available and suitable aerial survey data (April, June, August, September, and October 2008). Data collected during September 2006 and 2007 were not used in quantitative analyses because the survey altitude of 305 m was not suitable for pinnipeds. Correction factors of 2.33, 1.22, and 4.7 were applied to densities for availability bias (Kelly and Quakenbush, 1990), detection bias during the ice-cover period (Frost *et al*., 1988), and detection bias during the open-water period (assumed the same as for other large pinnipeds; Feldkamp *et al*., 1989; Stewart and Yochem, 1994), respectively.

The areas exposed to noise levels that exceeded the threshold for avoidance were calculated for all modelled Project activities at both the Milne and Steensby Ports and shipping routes. For shipping during the ice-cover season, the shipping route areas were classified by ice type (landfast, pack, and open-water) based on 10 years of ice data (2000–2009) acquired from the Canadian Ice Services division of Environment Canada. These areas and aerial survey data acquired during baseline surveys over ice for the Project were used to calculate the numbers of bearded seals that could be exposed to shipping noise.

5.12.1.3 Hearing Impairment

The only expected impulse-sound source from the Project is blasting and the 180-190-dB re 1 µPa (rms) criterion was used to calculate the area where seals may incur TTS. Densities from aerial survey data, corrected for detection and availability biases, were used to provide estimates of the numbers of seals that may be present inside of the 190-dB zone. The approach used by Davis and Malme (1997) and described above (Section 5.11.1.2) was used to estimate numbers of bearded seals that may be exposed to continuous sound levels high enough to cause TTS using an assumed sensation level of 100 dB.

5.12.1.4 Masking

A qualitative discussion on the potential for bearded seal masking caused by Project activity noise is provided.

5.12.1.5 Mortality

A qualitative discussion on the potential for bearded seal mortality as a result of ship strikes is provided.

5.12.2 Potential Effects and Proposed Mitigation

The potential effects of the Project on bearded seals considered in the assessment are listed below. Effects that are not assessed in detail (i.e., those ranked as 1 in the interaction matrices) are outlined in Section 5.3.

- **Habitat change** resulting from icebreaking plus the footprints of dock structures;

- **Disturbance** caused by airborne and/or underwater noise from construction, shipping, and aircraft overflights;
- **Hearing impairment** and/or damage caused by noise from construction activities;
- **Masking** of environmental sounds caused by vessel and construction noise; and
- **Mortality** from collisions with vessels and blasting during construction.

5.12.2.1 Habitat Change

Bearded seals primarily occur in areas of pack ice and along the edges of landfast ice where they have a substrate for hauling out. They may use the areas around the Steensby Port site for foraging. Potential habitat will permanently change as a result of the footprint of the dock structures, which is quite small at Steensby Port (0.07 km^2). As noted earlier, an estimated 1.5 km wide section of landfast ice edge leading into Steensby Inlet will be changed by icebreaking ore carriers each season. The area of pack ice that will be disrupted temporarily by a single ore carrier passage is estimated at 76.5 km^2 during the period of maximal ice coverage. Evidence of the ship track in the mobile pack ice will quickly disappear because of the movement of the ice by winds and tide (Volume 3, Appendix 3G) and it is assumed that bearded seals will re-use this area of ice.

Planned Mitigation - Dock structures were designed to reduce the footprint in the marine environment. Icebreaking vessels will control the width of the shipping lane to <1.5 km by sailing along the same track as much as possible through landfast ice in Steensby Inlet. The shipping lane into Steensby Port will be delineated with markers to notify the ship's crew of the boundaries of previous vessel tracklines.

Residual Effects – It is unclear if the footprints of the Steensby Port dock structures represents suitable foraging habitat for bearded seals. Bearded seals are unlikely to use these areas during the ice-cover period because they occur in areas of solid landfast ice. In any case, the small area of the dock structures is a negligible part of nearshore habitat in both inlets. Less than 2 % of the total landfast ice edge leading into Steensby Inlet will be changed because of icebreaking. During a single transit to and from Steensby Port, an ore carrier will temporarily change ~ 0.025 % of pack ice (or 76 km^2) in Hudson Strait, Foxe Basin and near Steensby Inlet. Bearded seals in pack ice are adapted to the constantly shifting habitat of pack ice. This change in habitat caused by dock structures and temporary decrease in suitable bearded seal ice habitat is lower than the threshold value of 10 % (Table 8-5.23).

With mitigation measures in place, it is predicted that effects of habitat change on bearded seals will be of low magnitude (Level I), medium to long-term (Level II to Level III for icebreaking and dock structures, respectively), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of habitat change on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.2.2 Disturbance

Construction activities, vessel traffic, icebreaking, and aircraft overflights have the potential to interact with bearded seals. Disturbance can lead to effects on nursing bouts, reproductive output, habitat use (avoidance), and (potentially) individual survival, especially of pups. Construction will occur at both the Milne and Steensby Ports but will be much more intense at the Steensby Port. Dredging, blasting, vibratory pile driving and drilling will only occur at Steensby Port.

Table 8-5.24 Effects Assessment Summary: Bearded Seals

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
CONSTRUCTION PHASE							
Dock Construction: blasting (Steensby only), vibratory pile driving (Steensby only), drilling (Steensby only), dredging, vessel traffic near dock sites.	Negative. [1] Habitat Change [2] Disturbance [3] Hearing Impairment [4] Masking [5] Mortality	Blasting control plan (blast size, timing); blasting in late May; meeting 100 kPa overpressure limit; monitor for seals in the area of blasting and pile driving; bubble curtain system; discourage seals from the blast area with acoustic deterrant device. Drilling in late April/May. Reduce vessel idling at dock side.	Level I	Level I	Level I, Level II	Level I	Level I
Vessel traffic to/from Milne and Steensby Ports (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible.	Level I	Level I	Level II	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Small aircraft maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over seals for passengers to 'get a better look' or for photography.	Level I	Level I	Level II	Level I	Level I

Table 8-5.24 Effects Assessment Summary: Bearded Seals (Cont'd)

Potential Impacts			Evaluation Criteria				
Project Phase/Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
OPERATIONS PHASE							
Vessel traffic to/from Milne Port (open-water period only).	Negative. [1] Disturbance [2] Masking	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level II	Level I	Level I	Level I
Vessel traffic to/from Steensby Port (year-round), including ice management at dock.	Negative. [1] Habitat Change [2] Disturbance [3] Masking [4] Mortality	Maintain constant speed and course when possible. Reduce vessel idling at dock side. Minimize footprint of ice disturbance at ore dock and along shipping route.	Level I	Level II	Level III	Level I	Level I
Aircraft overflights	Negative. [1] Disturbance	Primary use of Mary River airstrip. Small aircraft maintain altitude of 450 m over marine waters when possible. Prohibiting aircrafts from flying low over seals for passengers to 'get a better look' or for photography.	Level I	Level II	Level I	Level I	Level I
CLOSURE PHASE							
Vessel traffic: Sealift removal of equipment and materials.	Negative. [1] Disturbance	Maintain constant speed and course when possible. Reduce vessel idling at dock side.	Level I	Level I	Level I	Level I	Level I

Table 8-5.25 Significance of Residual Effects to Bearded Seals

Project Phase/Effect	Significance of Predicted Residual Effect		Likelihood (1)	
	Significance Rating	Level of Confidence	Probability	Certainty
CONSTRUCTION PHASE				
Habitat Change	N	3		
Disturbance	N	3		
Hearing Impairment	N	3		
Masking	N	2		
Mortality	N	3		
OPERATIONS PHASE				
Habitat Change	N	3		
Disturbance	N	2		
Hearing Impairment	N	3		
Masking	N	1		
Mortality	N	3		
CLOSURE PHASE				
Disturbance	N	3		

KEY:
Significance Rating: S= Significant, N = not Significant, P = Positive
Level of Confidence : 1= Low; 2= Medium; 3=High
(1)Likelihood – only applicable to significant effects
Probability: 1= Unlikely; 2= Moderate; 3=Likely
Certainty: :1= Low; 2= Medium; 3=High

Based on the results of acoustic modelling and analyses of audiogram and ambient noise level data, bearded seals may detect Project activity sounds at ranges of at least 75 km (drilling for deployment of blast charges) to 250 km (ore carriers). At these extreme distances, project noise is likely to be perceived as a slight increase in ambient noise rather than be identifiable as a specific activity. In any event, the mere detection of the presence of a distance sound will not negatively affect a seal (see Richardson *et al.*, 1995a). As noted earlier, it is assumed that bearded seals will temporarily avoid areas where the sensation level reaches ~80 dB in the 1/3-octave band with the highest sound level (see Davis and Malme, 1997). Some seals are assumed to exhibit minor behavioural responses at a 70-dB sensation level.

Construction: Drilling, Blasting, and On-ice Activity - In-water blasting will be used late in the ice-cover season (i.e., late May) to level the seabed for placement of caissons at the Steensby ore dock. It is estimated that there will be 12 nominal blast events (nine at the ore dock and perhaps three at the causeway site). It is assumed that the blasts will be detonated periodically over a one week period. DFO's published overpressure guideline (100 kPa) for explosives will be met. Pinnipeds seem quite tolerant of noise pulses from "small" explosives (Richardson *et al.*, 1995a). Firecracker-like explosives initially startle seals and sea lions, and often induce them to move away, but avoidance wanes after repeated exposure. Northern fur seals breeding on land did not exhibit any obvious response to nearby (0.6–2 km) blasts from quarries (Gentry *et al*., 1990). South American fur seals and sea lions and grey seals exposed to blasting operations showed little or no reactions. The specific responses of bearded seals to in-water blasting have not been published.

Prior to blasting, drilling is required to install blast charges into the rock. It is estimated that drilling at the ore dock site will take about one month and drilling at the causeway site will take about two weeks, late in the ice-cover period. The specific responses of bearded seals and other phocids to drilling holes for blast charges have not been published.

Associated with the drilling and blasting operations at the ore dock site will be on-ice support vehicles, e.g., snowmobile traffic. There is evidence that seals do not react overtly to on-ice traffic. Weddell seals (mother and pup pairs) showed little reaction to Hagglund vehicles that approached within 100–400 m; sound levels at 250 m were reported as 24 dB re 20 µPa (van Polanen Petel *et al.* 2007). Kelly *et al.* (1988) reported that three ringed seals were observed to depart their lairs as snow machines approached within 0.5–2.8 km, and others stayed in their lairs at distances of 0.5 km. The authors state: “In all instances in which seals departed lairs in response to noise disturbance, they subsequently reoccupied the lair.”

Residual Effects of Drilling, Blasting, and On-ice Activity - Sensation levels from drilling operations (through ice and the seafloor) are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance, respectively (Appendix 8C-3, Table 8C-3.1, Figure 8C-3.2). Bearded seals are not expected to occur in the landfast ice near the Steensby Port site during May. Blasting operations (assuming 12 blasting events) will occur intermittently over ~1 wk in late May. With appropriate mitigation measures in place (bubble curtain, overpressure <100 kPa—see Section 5.6.2.3), the zones of avoidance and disturbance onset are estimated at 3 km and 10 km, respectively (Appendix 8C-3, Table 8C-3.1, Figure 8C-3.1). Few, if any bearded seals are expected to occur in the landfast ice near the blasting sites during late May.

Construction: Dredging - Dredging is planned at Steensby Inlet Port site during the open-water season of Year 1. There have been no published accounts of bearded seal response to dredging.

Residual Effects of Dredging - Sensation levels from dredging are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance, respectively, at the Steensby Port site (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.3 and 8C-3.8). Few bearded seals are expected to occur near the proposed port sites during the open-water period. However, it is likely that seals in the vicinity of dredging operations and the associated construction activity (vessel traffic, dock construction) will exhibit localized and temporary avoidance of the area based on published accounts of bearded seal (and other phocid) response to industrial activity during both the open-water and ice-cover periods.

Construction: Vibratory Pile Driving – Vibratory pile driving of sheets will occur at the Steensby Inlet freight dock site for two months during the open-water period of Year 1 of the Construction Phase. There have been no published accounts of bearded seal response to pile driving.

Residual Effects of Pile Driving - Sensation levels from vibratory pile driving are not expected to exceed either the 70-dB or 80-dB criteria for disturbance onset and avoidance, respectively, at the Steensby Port site (Appendix 8C-5, Table 8C-5.1, Figure 8C-5.1). Few bearded seals are expected to occur near the proposed port sites during the open-water period. However, it is likely that seals in the vicinity of pile driving operations and the associated construction activity (vessel traffic, dock construction) will exhibit localized and temporary avoidance of the area based on published accounts of bearded seal (and other phocid) response to industrial activity during both the open-water and ice-cover periods.

Vessel Traffic - Bearded seals are expected to occur along the shipping route into the Steensby and Milne Port sites, particularly in areas where water depths are <200 m. The numbers and types of vessels involved over the life of the Project are provided in Volume 3, Table 3-1.1. Few authors have described the responses of pinnipeds to boats, particularly large ore carriers, and most of the available information concerns pinnipeds hauled out on land or ice. During the open-water season in the Beaufort Sea, bearded (and ringed) seals are commonly observed close to vessels (e.g., Harris *et al*., 1997, 1998, 2001, 2007, 2009). In places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance. In England, harbour and grey seals at some haul-out sites appear to have habituated to close approaches by tour boats (Bonner, 1982).

When in the water (vs. hauled out), seals appear less responsive to approaching vessels. Some seals, including bearded seals, will approach a vessel out of apparent curiosity, including noisy vessels such as those operating airgun arrays (Harris *et al*., 2001; Moulton and Lawson, 2002). Harwood *et al.* (2005) noted the behaviour of two bearded seals in the Canadian Beaufort Sea from a research vessel; one seal swam away and the other swam alongside the vessel. Suryan and Harvey (1999) reported that Pacific harbour seals commonly left the shore when powerboat operators approached to observe them. These seals apparently detected a powerboat at a mean distance of 264 m, and seals left their haul-out sites when boats approached to within 144 m. Harbour seals hauled out on floating ice in fjords in Disenchantment Bay, Alaska, were more likely to enter the water when a cruise ship approached within 500 m (Jansen *et al*., 2010). Seals that were approached as close as 100 m were 25x more likely to enter the water than those approached at 500 m. Cruise ships that approached directly vs. abeam of hauled out seals resulted in more seals entering the water. Based on available information, some seals are likely to avoid approaching vessels by a few 100s of metres, and some "curious" seals are likely to swim toward vessels.

Planned Mitigation for Vessel Traffic - Ore carriers that will be used on the southern shipping route have a modern design that limits propeller cavitation and reduces noise output (see Volume 3, Section 3.6.2). All vessels will maintain a constant course and speed whenever possible. In addition, vessels will minimize idling of engines when docked at Milne and Steensby Ports.

Residual Effects of Vessel Traffic - Based on acoustic modelling and an assessment of audiogram and ambient noise data, it is predicted that bearded seals in the water would avoid ore carriers travelling during the open-water period along the Steensby shipping route by <100 m (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.5 to 8C-3.7, 8C-3.9 and 8C-3.10). Bearded seals hauled out on ice may temporarily avoid an ore carrier (i.e., by diving into the water) transiting to and from Steensby Inlet, perhaps at distances up to 500 m. Bearded seal avoidance to a passing ore carrier during the open-water period is expected to be localized and short-term.

Vessel traffic at the Milne and Steensby Port sites will vary throughout the Project but is expected to be most intense during the Construction Phase. Eight to 10 vessels, including sealifts, tankers, line boats, barges, and ore carriers, could be present at the port sites during construction. Noise levels from tugs were modelled at the Steensby Port site (Matthews *et al*., 2010). Sensation levels from tugs are not expected to exceed the 80-dB criterion for avoidance by bearded seals (Appendix 8C-3, Table 8C-3.1, Figures 8C-3.4 and 8C-3.8). If bearded seals respond to noise levels below this sensation level, avoidance is expected to be localized.

Icebreaking - Bearded seals on pack ice approached by an icebreaker typically dove into the water within ~0.9 km of the vessel, but tended to be less responsive when the same ship was underway in open water (Brueggeman *et al*., 1992). During August–October seismic surveys off northeast Greenland, bearded seal observations were collected by biologists aboard the seismic vessel that was led through intermediate pack ice by an icebreaker (Jones *et al*., 2009). Three bearded seals were observed on ice floes at 300 m, 368 m, and 400 m from an active airgun array; these seals did not show any overt reaction to the icebreaking vessel or airgun arrays other than looking toward the vessel (T. Lang, Biologist, LGL Limited, pers. comm. July 2011). Similarly, two bearded seals observed on ice floes as close as 400 m and 500 m to the seismic vessel during periods when the airgun array was inactive did not exhibit an overt reaction; the only noticeable change in behaviour was the seals looked toward the vessel. One bearded seal observed in the water swam in the opposite direction of the seismic vessel (during a period when the airguns were silent), which came as close as 45 m to the seal. This seal did not change its behaviour or direction of travel even as the vessel approached it (T. Lang, Biologist, LGL Limited, pers. comm., July 2011). The observers in all cases were located on the seismic vessel and may not have observed animal reactions occurring at distances beyond ~2.5 km or obscured by the icebreaker ahead. Observations made from an icebreaker (or nearby vessel) should be interpreted with caution because animals that may avoid the vessel at longer distances would not be detected. Seals hauled out on ice often show mixed reaction to approaching vessels and icebreakers. There are some indications that seals in the RSA have become “used to ships” and do not seem to be affected (M. Akumalik and I. Shooyook, Arctic Bay, pers. comm.).

Residual Effects of Icebreaking - Icebreaking by Cape-size ore carriers will occur throughout the ice-cover season during the Operation Phase. It is expected that an icebreaking ore carrier will transit through the southern LSA to and from Steensby Port every two days. Based on corrected seal density estimates from aerial surveys conducted in Steensby Inlet, Foxe Basin, and HudsonStrait during June, it is estimated that ~18 bearded seals may exhibit temporary avoidance of an ore carrier passing through the southern LSA during a single vessel passage. This corresponds to estimated distances of 0.3–0.7 km of avoidance based on the 80-dB sensation level criterion (Appendix 8C-3, Table 8C-3.1). Icebreaking tugs may cause bearded seals to avoid the area of changed ice near the Steensby Port (Appendix 8C-3, Table 8C-3.10). It is likely that at least some of the same bearded seals, particularly those located at the landfast ice edge of Steensby Inlet, will be affected multiple times by icebreaking during the course of a single ice-cover season. Based on available evidence, disturbance effects on bearded seals are expected to be localized and temporary.

Aircraft Overflights - There has been little systematic study of the reactions of seals to aircraft overflights, and most of the available data concern seals hauled out on land or ice rather than those in the water (Richardson *et al*., 1995a). The primary airstrip for the Project is located at the Mine Site. The Steensby airstrip will accommodate daily flights of a Boeing 737 (or equivalent) aircraft during the four-year construction period. During the Operation Phase, the Steensby airstrip will be used for emergency/alternate landings only. There will be no regularly scheduled flights at the Milne airstrip during the Project but it is possible that aircraft may use the site once a week. A Dash-8 or ATR is expected to be the largest aircraft to use the Milne airstrip; Twin Otters may also be used.

Received noise levels underwater have been recorded for a few aircraft, including the de Havilland DHC-6 Twin Otter (Richardson *et al*., 1995a; Patenaude *et al.* 2002). The Twin Otter’s PT6A-27 engines produce prominent tones primarily at 83 Hz and harmonics of this frequency (Richardson *et al*., 1995a; Patenaude *et al*., 2002). With the aircraft flying at an altitude 150 m above the surface, levels received by a hydrophone 3 m below the surface in the 10–500 Hz bandwidth (averaging time 0.75 s) ranged from ~97 dB re 1 μPa for aircraft travelling at ~185 km/h to ~114 dB re 1 μPa at ~280 km/h (Patenaude *et al*., 2002). At 18 m below the surface, received levels varied from ~95 dB re 1 µPa at ~185 km/h to ~120 dB re 1 µPa at ~280 km/h (Patenaude *et al*., 2002). Sound levels from a Boeing 737 taking off (assumed altitude of ~300-450 m; C. Greene, Greeneridge Sciences, pers. comm.) from the Anchorage International Airport were measured at ~102 dB re 1 µPa in the 1/3-octave band with the highest sound level at a hydrophone deployed 10 m deep in the water column and located <0.8 km from the sound source and at an estimated 45° angle from the receiver (Blackwell and Greene, 2002). There are no reports of the underwater sound levels produced by the Dash-8 or ATR.

In-air sound from aircraft would have most of the energy at low frequency. Blackwell and Greene (2002) found that most of the energy was between 100 and 1000 Hz, dropping off steeply between 3 and 10 kHz. In-air sound levels from a Boeing 737 taking off measured <0.8 km from the Anchorage International Airport, at an assumed altitude of ~300–450 m (C. Greene, Greeneridge Sciences, pers. comm.), was estimated at ~80 dB re 20 µPa in the 1/3-octave band with the highest sound level (Blackwell and Greene, 2002).

Planned Mitigation for Aircraft - Except during takeoff and landing, Project aircraft (Twin Otter, Dash-8, and ATR) will be operated at a minimum altitude of ~450 m over marine areas, when weather conditions allow. In addition, these aircraft will be prohibited from flying low over seals for passengers to 'get a better look' or for photography.

Residual Effects of Aircraft Overflights - Bearded seals may be exposed to aircraft sound while they are hauled out on top of the ice or in the water. Reactions to the infrequent overflights by the aircraft (Twin Otter, Dash-8, and ATR) at Milne Inlet are expected to be limited to a brief alert or startle response and sometimes a dive as the aircraft flies over. These types of behavioural responses would have little consequences for individual seals or their populations. During the ice-cover season, bearded seals are not expected to occur in Steensby Inlet but are expected to occur at the landfast ice edge at the mouth of the inlet. At this location, the Boeing 737 will be at an estimated altitude of ~6100 m and airborne sound levels were estimated as only ~50 dB re 20 µPa in the 1/3-octave band with the highest sound level (see response to DFO Information Request 05e). Based on in-air audiograms for pinnipeds (see Figure 8-5.1), it is unlikely that bearded seals would detect these sound levels. Bearded seals do occur in low numbers in Steensby Inlet during the open-water period. Reactions to overflights by the Boeing 737 are expected to range from a brief alert or startle response and sometimes a dive as the aircraft flies over. These types of behavioural responses would have little consequences for individual seals or their populations.

Summary of Residual Disturbance Effects - With mitigation measures in place, it is predicted that disturbance effects on bearded seals from construction, shipping, and aircraft overflights will be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; aircraft overflights during Operation Phase; Level I), intermittently (shipping and aircraft overflights; Level II), or frequently (vessels at ports; Level III), and confined to the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.24). The residual environmental effects of disturbance from Project activities on bearded seals are predicted to be "*not significant*" (Table 8-5.25).

5.12.2.3 Hearing Impairment

Bearded seals are not expected to be exposed to sound levels that are high enough to cause hearing impairment. Although there have been no direct studies of hearing impairment in bearded seals, studies of other pinniped species, reviewed in Section 5.6.2.2 are relevant.

For purposes of this assessment, it has been conservatively assumed (i.e., protective of seals) that bearded seals exposed to pulsed sound levels of ≥180 dB re 1 µPa (rms) may experience TTS or temporary hearing impairment. Based on the results of the acoustic modelling studies (Matthews *et al*., 2010) undertaken for the Project, blasting operations at Steensby Port site could produce sound levels of 180 dB within 885 m of the source (assuming no bubble curtain was in place and calculated from broadband, 10–2,000 Hz sound fields). For Project activities that produce continuous sound, like shipping, operation of tugs, drilling, vibratory pile driving, and dredging, a sensation level of 100 dB could cause TTS. This is discussed below.

Planned Mitigation - Blasting at the Steensby Port site will occur late in the ice-cover season (late May) when bearded seals are expected to be absent. As noted earlier, bearded seals are typically located in areas of pack ice and the landfast ice edge. The mitigation plan designed to protect ringed seals will also protect bearded seals in the unlikely event that one or two occur in the area during that period. Similarly, the mitigation plan designed to protect ringed seals, and other marine mammals, (i.e., delay of start and shut downs within 50 m of the pile driving site) will also minimize the potential for bearded seals to experience hearing impairment from vibratory pile driving sounds.

Residual Effects - Based on acoustic modelling results and the implementation of mitigation measures, bearded seals are not expected to be exposed to sound levels high enough to elicit TTS. Using the conservative 180-dB threshold for impulsive sounds and assuming that a bubble curtain effectively reduces sound levels, bearded seals would have to occur <45 m away from blasting to potentially incur temporary hearing impairment (Appendix 8C-3, Table 8C-3.1). There is no risk of seals incurring permanent hearing loss (PTS). Bearded seals in Steensby Inlet are not predicted to be exposed to in-air sound levels from aircraft overflights (Boeing 737) that exceed thresholds for hearing impairment in pinnipeds: 149 dB re 20 μPa (peak)(flat) or 144 dB re 20 $\mu Pa^2 \cdot s$ (M_{pa}) in air (Southall *et al*., 2007).

With mitigation measures in place, bearded seals are not expected to be exposed to sound levels high enough to cause hearing impairment. It is predicted that hearing impairment effects on bearded seals (if any) from Project activities will be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of hearing impairment on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.2.4 Masking

Bearded seal call characteristics are relevant in assessing potential masking effects of anthropogenic sounds and their likely frequency range of best hearing. The bearded seal is a vocal species; its sounds are a dominant component of the ambient noise in many arctic areas during spring. From late March to late June or early summer, bearded seals produce distinct trills or frequency-modulated vocalizations (Cleator *et al*., 1989). Bearded seal trills are at frequencies from 0.2 to 6 kHz, with dominant frequencies at 1-2 kHz—above the frequency range of the most intense ship noise and construction activities (Richardson *et al*., 1995a). Cummings *et al.* (1983) estimated source levels of trills up to 178 dB re 1 uPa·m. It is thought some parts of these calls may be detectable over 25 km away (Cleator *et al*., 1989). Trills are relatively long in duration; in Svalbard, the mean duration is about 30 s (Van Parijs *et al*., 2001). It is believed that only male bearded seals produce trills and that trill duration may serve as a useful indicator of male condition and reproductive success (Van Parijs *et al*., 2003). Other call types identified include a moan, sweep, and flat tone; all of these call types were shorter in duration than trills, and in the case of the flat tone lower in frequency (Van Parijs *et al*., 2001). Bearded seals from different Arctic regions appear to have identifiable geographic dialects (Cleator *et al*., 1989) and there is much individual variation in trills produced by males (Van Parijs and Clark, 2006).

There are no published accounts of masking in bearded seals. Masking effects by transient sounds such as those from blasting on marine mammal calls and other natural sounds are limited because of their short duration, and blasting will occur for a short time period in the landfast ice. The potential for masking during continuous shipping sounds is somewhat reduced given that the dominant frequencies in bearded seal calls are predominantly at higher frequencies than the dominant frequencies of shipping noise. However, masking of some environmental sounds is likely to occur.

Residual Effects – It is possible that an ore carrier passing through pack ice or the landfast ice edge area in Steensby Inlet during late spring and early summer may mask bearded seal calls. As noted above, bearded seal males produce trills as an indicator of their condition and reproductive success. During this time female bearded seals are thought to seek suitable ice habitat for nursing their pups and for foraging requirements. Ore carriers that occur in relatively close proximity to bearded seals during the breeding season may mask calls important for breeding. However, any masking that might occur along the shipping route, as a vessel passed by, would occur for a short time (2-3 h) relative to the interval between transits (48 h) on the assumption that eastbound and westbound vessels will maintain a lateral separation of >1 km. The amount of masking will be a function of how close to the ship's path the bearded seals occur.

It is predicted that residual effects of masking on bearded seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of masking on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.2.5 Mortality

There are no specific studies on seal mortality from icebreaking. Although bearded seals are capable of maintaining breathing holes in landfast ice, their preferred habitat is drifting ice floes or the edge of landfast ice, leads and polynyas (Lydersen *et al*., 1994). These habitat preferences allow them to readily move away from disturbances. There is some concern that bearded seal pups may be at risk of mortality from vessel collisions. Based on a study conducted in Svalbard, Norway, bearded seals give birth primarily in free-floating pack ice very close to the water's edge (Kovacs *et al*., 1996). This affords them quick access to the water in the event they have to escape from polar bears; bearded seal pups are born on the open ice without a sheltering lair. Unlike ringed seal pups, bearded seal pups enter the water within hours of birth (approximately two hours in one instance; Kovacs *et al*., 1996). Nursing pups less than one week old spend about ~50 % of their time in the water, where they can dive as deep as 84 m (Lydersen *et al*., 1994). Within two months, bearded seal pups dive to depths >400 m (Gjertz *et al*., 2000). Lydersen *et al.* (1994) noted that the "development of swimming and diving skills at this early age may enhance their ability to avoid predation and permit the use of many different nursing platforms in their very unstable drifting ice habitat." It stands to reason that the same skills would help bearded seals to avoid icebreaking vessels.

Another potential source of mortality for bearded seals is blasting at the Steensby Port site during the first year of construction. There are several reports that pinnipeds near explosives (detonated in the water) were killed, including some pinnipeds exposed to charges in the kilogram or larger range (Richardson *et al*., 1995a: 306-307). However, other reports indicate that pinnipeds seem to show little response to small blasts (see Section 5.6.2.2 above).

Planned Mitigation -Vessel speed in areas of pack ice (approximately 13 km/h) will be reduced relative to speeds during the open-water season (26 km/h), thereby reducing the likelihood of collisions with bearded seals during periods when movements may be restricted by ice. In addition, ore carriers will attempt to sail along a previously disturbed section of landfast ice, including the landfast ice edge where bearded seals may occur, to the extent possible, particularly during the pupping and nursing period, i.e., April and May.

Residual Effects - Vessel collisions during the open-water period are highly unlikely given that bearded seals exhibit localized avoidance of vessels and they are fast swimmers. Also, mitigation measures of maintaining a constant course and speed will reduce the already low potential for collisions. Icebreaking along the shipping route into Steensby Inlet will occur during the Operation Phase. Adult bearded seals using pack ice in Foxe Basin and Hudson Strait and the edge of landfast ice in Steensby Inlet would readily be able to move out of the way of an icebreaker given that they haulout in close proximity to open water. Unlike ringed seals, bearded seal pups enter the water within hours of birth and develop good swimming and diving skills early (within days) in the lactation period. It is possible that a pup encountered within an hour or so of birth may not be able to avoid an approaching icebreaker and that it could suffer mortality. This is expected to occur infrequently since the period of time that pups are unable to move off the ice is so limited. Because bearded seals are nongregarious, the icebreaker would not transit through concentrations of pupping seals. Although any mortality effects on individual pups would be irreversible, it would have a negligible and unmeasurable effect on the seal population in the area.

Bearded seals are not expected to occur in the area of landfast ice where blasting will occur. In addition, with mitigation measures in place, even if they did occur in the fast-ice, the risk of mortality from blasting is very limited. The bubble curtain and meeting the 100-kPa overpressure guideline, blast timing, monitoring, and potential use of seal deterrent devices will virtually eliminate the likelihood of a seal occurring close enough to a charge to experience mortality.

With mitigation measures in place, it is predicted that residual effects of mortality on bearded seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (Level II), and confined to the LSA (Level I); mortality effects are considered fully reversible at the population level (Level I; Table 8-5.24). The residual environmental effect of mortality on the bearded seal population is predicted to be "*not significant*" (Table 8-5.25).

5.12.3 Assessment of Residual Effects

The residual effects, i.e., effects after consideration of mitigation measures, of Project activities on bearded seals are summarized in Tables 8-5.24 and 8-5.25 and below.

5.12.3.1 Habitat Change

It is predicted that residual effects of habitat change on bearded seals will be of low magnitude (Level I), medium to long term (Level II, Level III), occurring continuously (dock structures; Level III) or intermittently (icebreaking; Level II), and confined to the LSA (Level I); effects of habitat change are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of habitat change on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.3.2 Disturbance

It is predicted that residual disturbance effects on bearded seals from construction, shipping, and aircraft overflights will be of low magnitude (Level I), medium-term (Level II), occurring infrequently (blasting; aircraft overflights during Operation Phase; Level I), intermittently (shipping and aircraft overflights; Level II), or frequently (vessels at ports; Level III), and confined to the LSA (Level I); disturbance effects are considered fully reversible (Level I; Table 8-5.24). The residual environmental effects of disturbance from Project activities on bearded seals are predicted to be "*not significant*" (Table 8-5.25).

5.12.3.3 Hearing Impairment

Bearded seals are not expected to be exposed to sound levels high enough to cause hearing impairment with mitigation measures in place. It is predicted that hearing impairment effects on bearded seals (if any) from Project activities will be of negligible to low magnitude (Level I), short-term (Level 1), infrequent (Level I), and confined to the LSA (Level 1); effects of hearing impairment are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of hearing impairment on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.3.4 Masking

It is predicted that residual effects of masking on bearded seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (shipping; Level II), and confined to the LSA (Level I); masking effects are considered fully reversible (Level I; Table 8-5.24). The residual environmental effect of masking on bearded seals is predicted to be "*not significant*" (Table 8-5.25).

5.12.3.5 Mortality

With mitigation measures in place, it is predicted that residual effects of mortality on bearded seals will be of low magnitude (Level I), medium-term (Level II), occurring intermittently (Level II), and confined to the LSA (Level I); mortality effects are considered fully reversible at the population level (Level I; Table 8-5.24). The residual environmental effect of mortality on the bearded seal population is predicted to be "*not significant*" (Table 8-5.25).

5.12.3.6 Cumulative Effects Within the Project

Reviewers of the Draft EIS requested that the effects of multiple Project activities be considered. As discussed previously, bearded seals may be exposed to construction activities (i.e., dredging, pile driving, vessel traffic, aircraft overflights) at the Milne and Steensby Inlet port sites during the first four years of the Project. With mitigation measures in place, hearing impairment and mortality are not expected to result from construction activities. It was predicted that some bearded seals may avoid the immediate area around each of the construction activites. It is possible that this area of avoidance may increase slightly if construction activities occur simultaneously at the port sites, however, any avoidance is predicted to be localized. During the Operation Phase, bearded seals will be exposed to noise from ore carriers plus vessels located at the Steensby port site. It was predicted that some may avoid the immediate area around each vessel. It is possible that this area of avoidance may increase slightly when multiple vessels are present at the port site; however, any avoidance is predicted to be localized.

5.12.4 Prediction Confidence

Based on the available evidence on bearded seal responses to vessel traffic, the planned mitigation measures, the overall health and population size of bearded seals in the RSA, and the baseline data used in the assessment, there is a generally high level of certainty in the predictions of residual effects (Table 8-5. 25). There is some uncertainty regarding the extent of masking caused by shipping during the ice-covered season. However, no significant residual environmental effects are predicted for this indicator species.

5.12.5 Follow Up

The planned mitigation and monitoring for bearded seals were summarized in Section 5.12.2 and are provided in the marine mammal mitigation and monitoring management plan. Significant effects of Project activities on bearded seals are not expected and the level of confidence associated with this prediction is generally high. There is some uncertainty associated with acoustic modelling results, particularly because details on blasting parameters were limited during preparation of this report. Acoustic measurements can be acquired at the beginning of Construction to confirm safety zones for this activity to further ensure that bearded seals are afforded adequate protection from potential hearing impairment.

5.13 IMPACT STATEMENT

The Project is predicted to have no significant residual effects for any marine mammal species. However, follow-up monitoring will be undertaken to ensure that beluga whales, narwhals, and bowhead whales do not incur significant disturbance effects from shipping. Residual effects are considered reversible.

Impact Statement for Key Indicator 1 - Ringed Seal

The Project is predicted to have no significant residual effects on ringed seals. Habitat change, disturbance, hearing impairment, masking, and mortality effects are predicted to be low magnitude and confined to the LSA.

Impact Statement for Key Indicator 2 - Walrus

The Project is predicted to have no significant residual effects on walruses. Habitat change, disturbance, hearing impairment, and masking effects are predicted to be low magnitude and confined to the LSA. No mortality is expected.

Impact Statement for Key Indicator 3 - Beluga Whale

The Project is predicted to have no significant residual effects on beluga whales. Habitat change, hearing impairment, and masking are predicted to be low magnitude and confined to the LSA. No mortality is expected. Disturbance effects are predicted to be low to medium magnitude and to occur within the LSA. There is a low level of certainty with the prediction of disturbance effects of ore carriers transiting Hudson Strait during the ice-cover period. There is also uncertainty with masking predictions. A monitoring program and an adaptive management plan will be undertaken to address these uncertainties and ensure that beluga whales do not incur significant effects.

Impact Statement for Key Indicator 4 - Narwhal

The Project is predicted to have no significant residual effects on narwhals. Habitat change, hearing impairment, and masking are predicted to be low magnitude and confined to the LSA. No mortality is expected. Disturbance effects are predicted to be low to medium magnitude and to occur within the LSA. There is a low level of certainty with the prediction of disturbance effects of vessels transiting Eclipse Sound and Milne Inlet during the open-water period and with ore carriers transiting Hudson Strait during the ice-cover period. There is also uncertainty with masking predictions. A monitoring program and an adaptive management plan will be undertaken to address these uncertainties and ensure that narwhals do not incur significant effects.

Impact Statement for Key Indicator 5 - Bowhead Whale

The Project is predicted to have no significant residual effects on bowhead whales. Habitat change, hearing impairment, and masking are predicted to be low magnitude and, with perhaps the exception of masking, confined to the LSA. No mortality is expected. Disturbance effects are predicted to be low to medium magnitude and to occur within the LSA. There is a low level of certainty with the prediction of disturbance effects of ore carriers transiting Hudson Strait during the ice-cover period. There is also uncertainty with masking predictions. A monitoring program and an adaptive management plan will be undertaken to address these uncertainties and ensure that bowhead whales do not incur significant effects.

Impact Statement for Key Indicator 6 - Polar Bear

The Project is predicted to have no significant residual effects on polar bears. Habitat change and disturbance effects are predicted to be low magnitude and confined to the LSA. A minimal number of bears may be killed to protect humans but this would be taken out of the quota with compensation provided.

Impact Statement for Key Indicator 7 – Bearded Seals

The Project is predicted to have no significant residual effects on bearded seals. Habitat change, disturbance, hearing impairment and masking effects are predicted to be low magnitude and confined to the LSA.

Potential for Cumulative Effects

The marine mammal VEC was carried forward into the cumulative effects assessment in Volume 9, primarily because of the residual disturbance effects associated with shipping.

5.14 INDIRECT EFFECTS ON MARINE MAMMALS IN AREAS BEYOND THE RSA

During the Technical Hearings, there was a request to consider the predicted effects of the Project beyond the RSA. Reviewers did not expect that direct project effects would extend beyond the RSA, but rather that effects within the RSA might have indirect effects in areas beyond the RSA. Such effects might occur in Hudson Bay or in Davis Strait. For example, if wintering belugas in Hudson Strait were negatively affected by winter shipping, then there might be subsequent effects on the harvest of belugas by communities along the shores of Hudson Bay. However, given that the FEIS predicts no serious project effects on marine mammals within the RSA, it is not likely that there will be any residual indirect effects from the project in areas beyond the RSA. Therefore, no further consideration of this issue is considered necessary.

5.15 EFFECTS OF SHIPPING ON MARINE MAMMALS IN DAVIS STRAIT AND THE NORTHERN LABRADOR SEA

At the Technical Hearings in Iqaluit, the question was raised about the potential effects of the project on marine mammals in Davis Strait and the northern Labrador Sea. These had not been explicitly addressed in the DEIS because that area was outside Nunavut. The following paragraphs provide an overview of the projected effects in Davis Strait and northern Labrador Sea. During winter and spring, the vessels in western Davis Strait and northwestern Labrador Sea will pass through areas of pack ice similar to the habitat in Hudson Strait. Beyond the ice zone, the vessels will travel through open water. During summer and fall, the vessels will be in ice-free waters through the whole area.

During the winter and spring ice-covered period, the ships will be transiting through pack ice areas occupied by small numbers of bowheads, narwhals, belugas, and ringed and possibly hooded and bearded seals. The effects of the ship passages through this habitat will be the same as those predicted for these species in Hudson Strait. The interval between ship passages will likely be greater in this area than closer to the Steensby Inlet port site where ships are slowed down by heavier ice.

The one situation that is unique to the ice-covered period in Davis Strait is the presence of a large whelping patch of hooded seals. This patch is occupied during February and March and occurs within the pack ice near the southern edge of the ice. After the hooded seal pups are weaned, the adults and pups disperse along the Davis Strait ice-edge zone. The whelping patch occurs offshore from the Baffin Island coast toward the middle of Davis Strait; therefore, there is no risk of the ore carriers passing through or near it. Given that the female seals give birth on the ice and that the pups spend the first few weeks of life on the ice, there should be no detrimental effects from underwater noise from the distant ships.

In general, the ice-related indicator marine mammal species do not occur in the open waters of Davis Strait and northern Labrador Sea. They abandon that area when the ice recedes from it. Those species are replaced by more southern species of whales and harp and hooded seals that are exposed to shipping on a year-round basis throughout their habitat. The presence of the ore carriers passing through the open water areas of Davis Strait and northern Labrador Sea are not expected to have different effects there than does any other shipping throughout the range of the open water species.

5.16 AUTHORS

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SECTION 7.0 - DEFINITIONS AND ABBREVIATIONS

7.1 DEFINITIONS

Airgun — A specialized acoustic sound source that creates underwater sound impulses by releasing a burst of compressed air into the water at a great velocity.

Acoustic Intensity — A fundamental measure of propagating sound, but is rarely measured directly. It is defined as the acoustical power per unit area in the direction of propagation; the units are watts/m^2. The intensity, power, and energy of an acoustic wave are proportional to the average of the pressure squared (mean square pressure) (for a more detailed discussion of acoustical issues see Chapter 2 in Richardson *et al*. 1995). For humans, sounds that are faint and barely perceptible have intensities near 1 pW/m^2, whereas those that are painful are near 10 watts/m^2.

Absolute Auditory Threshold — The minimum received sound level at which a sound with particular frequency and other properties can be perceived in the absence of significant background noise. A marine mammal can hear a fainter sound if the threshold is low than if it is high. The concepts of auditory threshold and auditory sensitivity are inversely related; a low threshold indicates high sensitivity, and vice versa.

Ambient Noise — The sea is a naturally noisy environment. The background noise caused by wave action and the sounds of ice and distant shipping is called ambient noise. This environmental background noise is not of direct interest during a measurement or observation.

Amphipods — Small shrimp-like zooplankton of the class Crustacea that live in the water column and on the surface of the bottom sediments in the sea.

Benthic (Invertebrate) Epifauna — Small animals that lack backbones and live on the surface of rocks, plants or the soft substrate at the bottom of a body of water.

Benthic (Invertebrate) Infauna — Small animals that lack backbones and live within the soft substrate at the bottom of a body of water.

Broadband Sound	A sound that includes components over a wide range of frequencies. Music is typically a broadband sound. A tuning fork, in contrast, produces narrowband sound – close to a pure tone at a single frequency. An octave band is originally a musical term that includes 8 successive notes of the western musical scale or a range of frequencies where the upper limit is twice the lower limit. The bandwidth of a 1-octave band is 70.7 % of its centre frequency.
Bubble Curtain	A curtain of small air bubbles in the water column that can provide significant attenuation for sound waves. Bubble curtains can be generated by releasing air through multiple small holes drilled in a hose or manifold deployed on the seabed near the sound source.
Copepods	Small zooplankton of the class Crustacea that live in the water column. Both self-propelled and weakly swimming (planktonic) forms occur.
CSEL	Cumulative Sound Exposure Level. See SEL.
Decibel (dB) –	The marine mammal ear is sensitive to sound energy across a broad range of frequencies. This response is logarithmic, rather than nonlinear; thus acousticians employ a logarithmic scale for sound intensities and levels, and denote the scale in *decibels*. In decibels, the *intensity level* of a sound of intensity I is given by the equation: Intensity Level (dB) = 10 log (I/I_0) Where I_0 is the reference intensity, for example, 1 pW/m^2. Because intensity is proportional to pressure squared, the *sound pressure level* (SPL) of a sound pressure P is given by: Sound Pressure Level (dB) = 20 log (P/P_0) Where P_0 is the reference pressure, e.g., 1 µPa. The phrase “sound pressure level” implies a decibel measure and that a reference pressure has been used as the denominator of the ratio.

Frequency-selective Weighting

A method of measuring sound pressure or energy in a specific frequency band by emphasizing or de-emphasizing particular frequencies depending on sensitivity to those frequencies. For marine mammals, special weighting functions (**M-weighting)** were proposed by Southall *et al*. (2007) based on consideration of weighting functions applied to humans along with information on marine mammal functional hearing bandwidths. M-weighting accounts for the fact that sounds at high and low frequencies must be more intense than sounds at intermediate frequencies in order to have equal auditory effect. The general M-weighting equation uses the estimated frequency cutoffs for each functional marine mammal hearing group, as follows:

$M(f) = 20\log_{10}(R(f)/\max\{|R(f)|\})$

where:

$R(f) = (f^2_{high} f^2/(f^2 + f^2_{high})(f^2 + f^2_{low}))$

and the estimated lower and upper "functional" hearing limits (f_{low} and f_{high}) are described in Table 2 of Southall *et al*. (2007).

Impulse

A positive impulse is the sum of received pressure over time, from arrival of the leading edge of the pulse until pressure becomes negative. Impulse is measured in Pascal-seconds (Pa·s); as contrasted with pressure, in Pa; or total energy in the pulse, proportional to $Pa^2 \cdot s$. Often used as a measure of blast, but not commonly used in relation to airgun sound.

Inverse-square Spreading Loss

Sound levels decrease with distance from a sound source due to several factors. The most pervasive of these, inverse-square spreading loss, is a geometrical decrease of SPL by 6 dB with every doubling of distance from a point sound source.

Landfast Ice

Ice that forms along the coast and remains contiguous with it for extended periods of time (from months to years).

Longshore Sediment Transport

Wave transport of sediment from the bottom of a waterbody to its shoreline. This sediment travels to shore either by becoming suspended within the water column, or by rolling along the bottom of the waterbody.

Masking

Perception of biologically-important sounds is decreased due to interference by sound energy from other sources (including ambient noise). Masking is most pronounced if the interfering sound overlaps in frequency with the sound signal of interest.

Micropascal (µPa) A Pascal is a standard unit of pressure in the SI system of units. One Pascal is the pressure resulting from a force of one Newton exerted over an area of one square metre. Older reports use a different pressure unit, the dyne/cm^2, also called a microbar (µbar). A bar is the pressure of 0.986923 standard atmospheres. The microbar and micropascal are directly related: 1 µPa = 10^{-5} microbar.

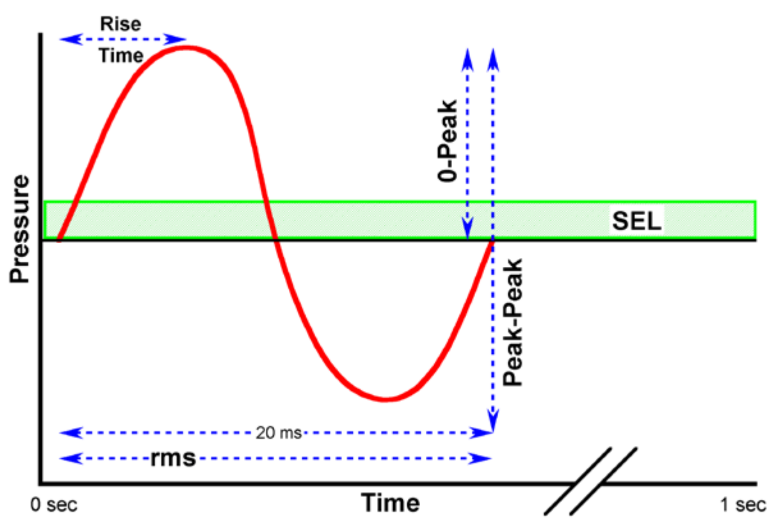
Mysids Small, weakly swimming zooplankton of the class Crustacea.

NMFS National Marine Fisheries Service, a part of the U.S. National Oceanic & Atmospheric Administration (NOAA).

One-third Octave Band A ⅓ octave band is a range of frequencies whose width (in hertz) is 23 % of the center frequency. For example, the ⅓ octave centered at 100 Hz includes frequencies from 89 to 112 Hz.

Pack Ice Ice that forms from frozen seawater or broken pieces of landfast ice; it is carried by wind and currents and its concentration is dependant on the time of the year.

Peak level In describing a transient sound, it is useful to present the *peak level* as well as some description of how the sound varies with time. The peak level is the absolute maximum instantaneous pressure. When transient sounds are so short as to be impulsive, they are best described in terms of their energy levels and energy density spectra.



Permanent Threshold Shift (PTS)	Unlike TTS, PTS is a permanent decrease in hearing sensitivity caused by damage to auditory organs following exposure to sounds with high energy content, or large-amplitude pressure pulses.
Polynya	An area of open water surrounded by sea ice. This opening is naturally maintained in one of two ways: an upwelling of warmer water that never cools to its freezing point, or strong winds/ currents that drive ice away from the surrounding ice-edge.
Received Sound Level	The sound level at a specific location, e.g., the location of an animal hearing a sound. Given a source with constant level over time, the received level (RL) will vary with distance from the source.
Root-mean-square (rms) Level	This is a type of average sound level over some defined interval.
Seismic Survey	The offshore oil and gas industry uses seismic exploration techniques to evaluate the geology that underlies the sea. These techniques involve beaming powerful sounds into the ocean bottom and monitoring the return patterns.
Shore and Flaw Lead Systems	A navigable area of open water that forms between the shore and pack ice (shore lead) or between landfast ice and pack ice (flaw lead).
Sound Exposure Level (SEL)	The time-integral of the square pressure over a fixed time window long enough to include the entire airgun pulse (or other sound of interest). SEL has units of dB re $\mu Pa^2 \cdot s$. It is a measure of sound energy (or exposure) rather than sound pressure. SEL is a cumulative metric. SELs from multiple airgun pulses can be computed by summing (in linear energy) the SELs from multiple individual airgun pulses; this provides a measure sometimes referred to as CSEL (cumulative SEL).

Sound Pressure Level (SPL)	Animals respond to sound as pressure. The corresponding subjective measure of sound intensity, "loudness", is closely proportional to pressure as long as the marine mammal is appropriately sensitive to the frequencies in the sound. For repetitive or continuous sound, a sound pressure level (SPL) is expressed as an average over a certain period of time. Because intensity is proportional to pressure squared, the *sound pressure level* (SPL) of a sound of pressure *P* is computed by: Sound Pressure Level (dB) = 20 log (P/P_0) where P_0 is the reference pressure, e.g., 1 µPa. The phrase "sound pressure level" implies a decibel measure and that a reference pressure has been used as the denominator of the ratio. Sound pressure levels are related as follows: SPL (dB re 1 µPa) = SPL (dB re 1 µbar) + 100 SPL (dB re 1 µPa) = SPL (dB re 0.0002 µbar) + 26 For example, an SPL of -40 dB re 1 µbar, or re 1 dyne/cm^2, is 60 dB re 1 µPa (see Table 2.1 in Richardson *et al*. 1995).
Source Level (SL)	Defined as the sound pressure level that would be measured at a standard reference distance (e.g., 1 m) from an ideal acoustic point source radiating the same amount of sound as the actual source being measured. This concept is necessary because sound measurements near large, distributed sources such as ships depend strongly on source size and measurement location, and are difficult to relate to levels measured far away. Near-field measurements are generally lower than would be obtained at the same distance from a point source radiating the same amount of energy.
Temporary Threshold Shift (TTS)	A temporary decrease in hearing sensitivity caused by exposure to sounds with high energy content, or large-amplitude pressure pulses.

Transmission Loss (TL or Propagation Loss)

A sound wave travelling from point A to point B diminishes in amplitude, or intensity, as it spreads out in space, is reflected, and is absorbed. If the source level (at 1 m) is 160 dB re 1 µPa-m, the received level at a distance of 1 km may be only 100 dB re 1 µPa; in this case TL is 60 dB. TL is generally expressed in dB, representing a ratio of powers, intensities or energies of a sound wave at two distances from the source. The distance at which the denominator measurement was taken is the reference distance for TL. Because dB scales are logarithmic, and because log(ratio) equals log(numerator) minus log(denominator), TL can be expressed as the difference, in dB, between the levels at the two distances.

7.2 ABBREVIATIONS

0-p .... Zero-to-peak pressure
AEMP .... Aquatic effects monitoring program
BKS .... Benthic bladed kelps
CCME .... Canadian Council of Ministers of the Environment
CORI .... Coastal and Ocean Resources Inc.
COSEWIC .... Committee on the Status of Endangered Wildlife in Canada
CPUE .... Catch Per Unit Effort
dB .... Decibels
DFO .... Department of Fisheries and Oceans
DL .... Detection limit
DLP .... Defense of life and property
EEM .... Environmental Effects Monitoring
EPP .... Environmental Protection Plan
HADD .... Harmful, Alteration, Damage, and Destruction
IQ .... Inuit Qaujimajatuqangit
ISQG .... Interim sediment quality guidelines
kHz .... Kilohertz
LF .... Low-frequency
LOEL .... Lowest effect level
LSAs .... Local study areas
MMER .... Metal Mining Effluent Regulations
Mt/a .... Million tonne-per-annum
NIRB .... Nunavut Impact Review Board
NLCA .... Nunavut Land Claims Agreement
NMFS .... National Marine Fisheries Service
P .... Pressure
Pa .... Pascals
PAHs .... Polycyclic aromatic hydrocarbons
PAL .... Protection of Marine Aquatic Life
PEL .... Probable effects level
p-p .... Peak to peak pressure

rms	Root mean square
RSA	Regional Study Area
SPL:	Sound Pressure Level
TSP	Total Solid Particulate
TSS	Total suspended solids
TTS	Temporary Threshold Shift,
VECs	Valued Ecosystem Components
µPa	Micro Pascal
ANFO	Ammonium nitrate fuel oil
Hz	Hertz
kPa	Kilo Pascals
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SL	Source Level
the Project	Mary River Project
TL	Transmission Loss