Baffinland Iron Mines Corporation

Marine Environmental Effects Monitoring Plan

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1 INTRODUCTION

Baffinland Iron Mines Corporation (Baffinland) is committed to implementing an Environmental Effects Monitoring (EEM) Program for the Mary River Project (the Project). The EEM program is a component of the Baffinland Environmental Management Program. This document is Baffinland's Marine Environmental Effects Monitoring Plan (MEEMP). The MEEMP addresses marine ecology and marine mammals. EEM plans also exist for the terrestrial environment (Baffinland 2015) and freshwater aquatic environment (Baffinland 2014).

The MEEMP has been developed in accordance with the principles described in the EEM Framework document (Baffinland 2012; Vol. 10 App 10D-13) and is intended to communicate EEM results to Baffinland, the Marine Environment Working Group (MEWG), regulators, resource managers and the Nunavut Impact Review Board (NIRB). The document will be modified on a regular basis, likely annually, as results from monitoring programs are analysed and assessed.

The objectives of the MEEMP are to:

- address regulatory requirements, especially those listed in NIRB Project Certificate No. 005;
- develop a comprehensive and integrated environmental monitoring program that includes follow-up as required;
- incorporate an ecosystem-based approach for monitoring and management of Project-related environmental effects; and
- coordinate all aspects of project-related marine environment effects monitoring.

1.1 CORPORATE COMMITMENTS AND REGULATORY REQUIREMENTS

The Mary River Project was awarded Project Certificate No. 005 by the Nunavut Impact Review Board (NIRB) in December 2012. Following a supplementary application (Early Revenue Phase-ERP) the certificate was amended in April 2014. A complete reconciliation between NIRB Certificate Conditions and Marine/shipping issues (relevant to the scope of the MEWG) are presented as Appendix G to the Shipping and Marine Wildlife Monitoring Plan (SMWMP 2015). The SMWMP presents the mitigation measures that resulted from Baffinland's planning process, as well from the regulatory review of the Project.

Table 1.1 below provides an overview of the linkages between the original effects predictions made in the Project Environmental Impact Statement (including the EIS Addendum for the ERP), the Project Approval conditions contained in the NIRB Certificate No. 005, and the monitoring program elements contained in this document.

The residual environmental effects of project activities on each VEC were evaluated in the Final EIS Addendum (Baffinland 2013; Volume 8, Tables 8-4.12 & 8-4.17) and the significance rating and associated level of confidence is brought forward in Table 1.1. The NIRB terms and conditions that include monitoring requirements for the marine environment are listed according to each Project-environment interaction.

One of the key determinants of the requirement for monitoring is the level of certainty associated with each specific effects prediction. Combined with the regulatory requirements as issued by NIRB, the basis for the MEEMP is displayed in this overview table.

In the case of effects of construction activities (i.e., pile driving) at Milne Port, mitigation measures were implemented, acoustic measurements were taken, and visual monitoring was conducted in 2014 based on the approach outlined in the FEIS Addendum and the NIRB Project Certificate condition #14(a) requirement. A subsequent monitoring report was prepared by ERM (ERM 2015) and is not considered further in this document.

Table 1.1 Summary of Marine VEC Interactions Relative to EIS Predictions and NIRB Project Certificate Conditions.

Valued Ecosystem Component	Potential Project Interaction(s)[1]	Key Indicator(s)[1]	Significance Rating[1]	Level of Confidence[1]	Project Condition(s)
Marine Water Quality	Ballast water discharge from ore carriers at Milne Inlet	Changes in salinity and/or temperature of receiving environment	Not Significant	Medium	NIRB #86 NIRB #99
	Site discharge to marine environment	Increases in total suspended solids (TSS)	Not Significant	High	NIRB #99
	Dust deposition from activities at Milne Port	Increases in TSS	Not Significant	Medium	NIRB #99
Marine Sediment Quality	Site discharge to marine environment	Increases in sediment metals, hydrocarbons; Changes to sediment particle grain size	Not Significant	High	NIRB #83(a) NIRB #99
	Dust deposition from ore at Milne Port	Increases in sediment metals, hydrocarbons; Changes to sediment particle grain size	Not Significant	Medium	NIRB #83(a) NIRB #99
	Propeller wash from vessel traffic to/from Milne Port	Changes to sediment particle grain size	Not Significant	High	NIRB #85 NIRB #86 NIRB #99
Marine Habitat	Dust deposition from ore at Milne Port	Changes to habitat type/class; Changes to benthic epifauna abundances.	Not Significant	Medium	NIRB #99
	Propeller wash from vessel traffic to/from Milne Port	Changes to habitat type/class; Changes to benthic epifauna abundances.	Not Significant	High	NIRB #83(a) NIRB #85 NIRB #99
Marine Biota: Benthic Fish	Site discharge to marine environment	Decrease in fish health/condition; Decrease in population size.	Not Significant	Medium	NIRB #99
	Dust deposition from ore at Milne Port	Decrease in fish health/condition; Decrease in population size.	Not Significant	Medium	NIRB #99
Marine Biota: Arctic Char	Site discharge to marine environment	Decrease in fish health/condition;	Not Significant	Medium	NIRB #113

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Valued Ecosystem Component	Potential Project Interaction(s)[1]	Key Indicator(s)[1]	Significance Rating[1]	Level of Confidence[1]	Project Condition(s)
		Decrease in population size.			
	Dust deposition from ore at Milne Port	Decrease in fish health/condition; Decrease in population size.	Not Significant	Medium	NIRB #113
	Propeller wash and ballast water from vessel traffic to/from Milne Port	Decrease in fish health/condition; Decrease in population size.	Not Significant	Medium	NIRB #85 NIRB #113
Marine Biota: Aquatic Invasive Species	Ballast water discharge at Milne Inlet from ore carriers	Introductions of aquatic invasive species (Presence/ Absence).	"Lower"[2]	"High Level of Uncertainty"[2]	NIRB #87
	Propeller wash and ballast water from vessel traffic to/from Milne Port	Decrease in fish health/condition; Decrease in population size.	Not Significant	Medium	NIRB #85 NIRB #113
Narwhals	Disturbance from shipping along northern shipping route (Project Phase: Construction, Operation)	Changes in distribution/abundance	Not Significant	Low	NIRB #99, 101, 109, 110, 111, 112
	Disturbance/hearing impairment during construction at Milne Port, notably pile driving (Project Phase: Construction)	Changes in distribution/abundance; Exposure to sound levels from pile driving that exceed established level.	Not Significant	High	NIRB #14(a)
	Ship strike	Mortality/serious injury	Not Significant	High	NIRB #106, 107, 108, 123
Bowhead Whales	Disturbance from shipping along northern shipping route (Project Phase: Construction, Operation)	Changes in distribution/abundance	Not Significant	Low	NIRB #99, 109, 110, 111, 112
	Disturbance/hearing impairment during construction at Milne Port, notably pile driving (Project Phase: Construction)	Changes in distribution/abundance; Exposure to sound levels from pile driving that exceed established level.	Not Significant	High	NIRB #14(a)

Table 1.1 Summary of Marine VEC Interactions Relative to EIS Predictions and NIRB Project Certificate Conditions.

Valued Ecosystem Component	Potential Project Interaction(s)[1]	Key Indicator(s)[1]	Significance Rating[1]	Level of Confidence[1]	Project Condition(s)
	Ship strike	Mortality/serious injury	Not Significant	High	NIRB #106, 107, 108, 123
Beluga Whales	Disturbance from shipping along northern shipping route (Project Phase: Construction, Operation)	Changes in distribution/abundance	Not Significant	Low to Medium	NIRB #109, 110, 111, 112
	Disturbance/hearing impairment during construction at Milne Port, notably pile driving (Project Phase: Construction)	Changes in distribution/abundance; Exposure to sound levels from pile driving that exceed established level.	Not Significant	High	NIRB #14(a)
	Ship strike	Mortality/serious injury	Not Significant	High	NIRB #106, 107, 108, 123
Ringed Seals, Bearded Seals, Walruses	Disturbance from shipping along northern shipping route (Project Phase: Construction, Operation)	Changes in distribution/abundance	Not Significant	High	NIRB #109, 110, 111, 112
	Disturbance/hearing impairment during construction at Milne Port, notably pile driving (Project Phase: Construction)	Changes in distribution/abundance; Exposure to sound levels from pile driving that exceed established level.	Not Significant	High	NIRB #14(a)

1. Information for the Potential Project Interactions, Key Indicators, Significance Rating and Level of Confidence are taken from FEIS Addendum Vol. 8, Section 5.
2. Significance rating and level of confidence determined from Chan *et al*. (2012); Relative Invasion Risk of Milne Inlet by Ballast-mediated Nonindigenous Species ranked "Lower" compared to other arctic ports (Baffinland 2013; Ballast Water Risk Assessment, FEIS Addendum Vol. 8, Appendix 8D-4, revised December 2013)

2 EEM APPROACH

The purposes for conducting an EEM program are to:

1. provide data so that project activities can be scheduled and/or planned to avoid or reduce conflict;
2. evaluate the accuracy of effects predictions;
3. evaluate the effectiveness of mitigations;
4. identify unforeseen environmental effects;
5. provide an early warning of undesirable change in the environment;
6. improve the understanding of cause-effect relationships with respect to Project-induced change; and
7. assist in the identification of target species and linkages for monitoring;

There are three categories of study which follow from these purposes:

Research — background studies intended to establish need for, or parameters of, an EEM program. Research studies may address issues such as natural variability of a measured parameter or monitoring target, or examine the nature, extent or duration of a potential Project/VEC interaction. Research studies address Purpose no. 7 (above).

Surveillance — programs to produce information about the pattern of occurrence of target species/monitoring targets. Surveillance studies (e.g., to establish travel patterns of migratory animals through the Project area) address Purpose no. 1 and 5 (above) for EEM.

EEM — programs to address and quantify cause and effect linkages between Project activities and components of the receiving environment. The full rigor of design criteria would apply to this type of monitoring program, which would address one or more of Purposes no. 1 through no. 6 (above).

Research studies are conducted primarily to determine the need for further monitoring and if a program is deemed necessary, to identify target species and linkages. Research is usually only done once near the beginning of the Project. Upon the determination that an EEM program is necessary, either a surveillance program or an EEM program is initiated. **Surveillance** monitoring is usually short term and is typically designed to identify potential mitigation measures to avoid Project interactions. A surveillance program can also commonly serve to identify a change in conditions which could trigger an EEM. A full scale **EEM** program is typically long term and is usually multifaceted.

Some studies may be one-off research topics that address a fundamental question usually related to determining whether an interaction is possible or is occurring between the Project and the receiving environment. Other selected studies may be grouped into a surveillance category, including programs that can detect a change in the environment, but are not capable of establishing a clear cause and effect link to the Project. These surveillance programs can act as early warning indicators (EWI) and have the potential of triggering a full EEM Study.

In developing the EEM program, Baffinland has sought to ensure that all relevant issues have been addressed, while avoiding the tendency to carry out a broad spectrum of poorly focused efforts. To accomplish this, emphasis is placed on monitoring and studying Project-induced change and addressing the challenge of establishing cause and effect relationships between the Project and the identified monitoring targets.

Monitoring which simply records change is not Effects Monitoring. EEM must be relevant to the Project and to the possible effects which the Project will have on the environment. EEM must be capable of establishing a relationship between any observed change in the environment and some feature of the Project.

In EEM, it is necessary to establish protocols for evaluating data to determine if there is a need to modify monitoring plans or develop and implement corrective action as per the procedure illustrated in Figure 2.1. Thus, thresholds will need to be established for each monitoring program in a number of possible ways:

- Exceedance of background or baseline data by a prescribed proportion (e.g., percentage);
- Exceedance of an established “no observable effects concentration”;
- Exceedance of “meaningful change” threshold criteria;
- Exceedance of background or baseline data by an amount which is “statistically significant”; or
- Observance of levels which are known to cause an environmental effect.

For each monitoring program, appropriate thresholds will be established for the parameters and environmental effects being monitored. When thresholds are exceeded, the appropriate staff and management within Baffinland will be notified. As well, the appropriate regulatory agencies and monitoring partners will be notified and consulted. The cause of the exceedance and its nature will be investigated. An action plan will be developed and appropriate mitigation measures will be implemented. As per Baffinland’s Environmental, Health and Safety (EHS) Management System requirement, the EEM program will be reviewed by the Marine Environment Working Group (MEWG), and, if necessary, modified to ensure that it continues to be relevant and appropriate.

As shown Figure 2.1, Baffinland’s process for response to an identified effect includes a feedback loop to evaluate each program and achieve continuous improvement in EEM design and implementation. By proper selection of monitoring parameters, these can serve as EWI of change. Such indicators occur at the start of the pathway between a Project related influence (e.g., discharge) and a receptor or VEC. Generally, EWIs consist of the direct measurement of an environmental variable (e.g., metal levels in water) in the zone of influence (ZOI) (e.g., compliance monitoring for discharges containing metals).

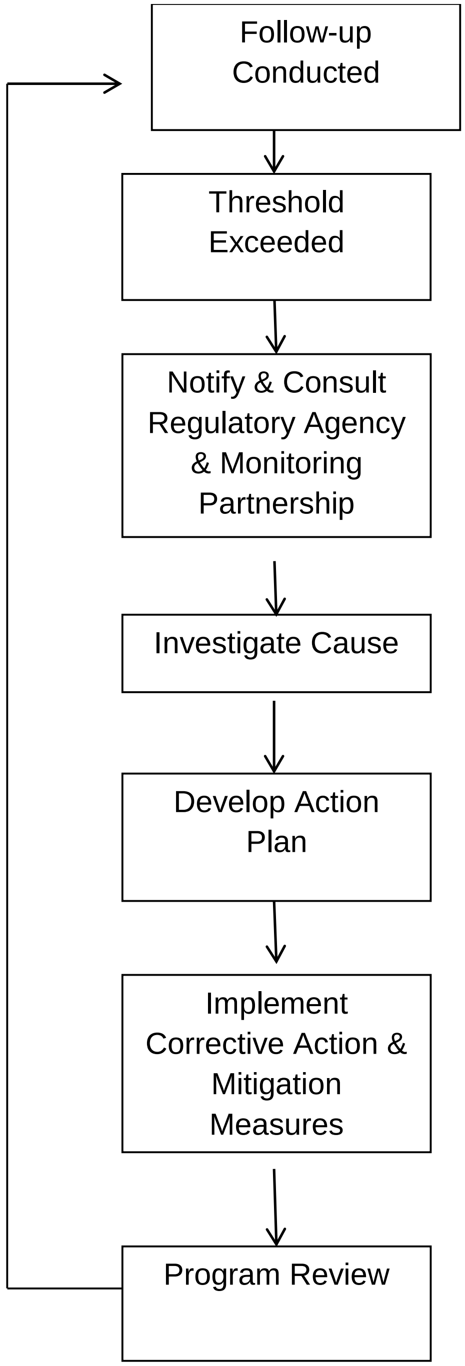

Figure 2.1 Follow-up Threshold Exceedance Procedures.

Surveillance level EEM studies can also serve as EWIs where an observed change in conditions could trigger a more complete EEM study, or increase the temporal and/or spatial scope of monitoring. Results from EEM studies could also serve to initiate other monitoring. An EEM program focused at one ecosystem level (e.g., benthic invertebrates) could produce evidence of change, which triggers further monitoring at other ecosystem levels (e.g., fish populations). In some cases, relatively short-term research programs are conducted as a means to identify or select an EWI. Based on the results of such preliminary studies, a full scale, properly designed EEM program may be initiated.

Program review can be triggered by an exceedance of an EWI. As well, an annual review will be conducted to assess the relevance of each program in light of Project activities, emerging developments in EEM methods and changes in issues or concerns as identified by Baffinland, its partners and stakeholders. The MEWG established for the Mary River Project will play an important role in providing input and review of the EEM Plan and results.

2.1 PROGRAM SELECTION CRITERIA

The set of criteria to be applied in considering candidate monitoring studies include:

- A credible 'cause and effect' relationship can be established;
- The identified effect has the potential to be negative:
    - The effect is considered significant;
    - The likelihood is high or moderate; and
    - The timing of interaction between the Project and the VEC will be sustained;
- A credible, unplanned event which could result in a significant negative effect; and
- The level of confidence in the predicted effect is low.

The result is a pattern of interconnected monitoring programs, each of which meets selection criteria and design requirements for marine EEM, and together, provide a comprehensive monitoring plan. Through examination of the measured changes in the selected indicators, conclusions can be drawn with respect to project interactions and impacts on the marine ecosystem.

3 MARINE ECOLOGICAL EFFECTS MONITORING (MEEMP — ECOSYSTEM)

The MEEMP uses a scientific approach to address regulatory requirements, public concerns and reflect good environmental assessment practice. The goals and objectives of the respective monitoring program components are clearly stated to ensure the results are scientifically defensible and relevant. The objectives of the EEM studies address the need to confirm predictions and to confirm effectiveness of mitigation measures. Predictions of potential effects of Project activities on the marine environment are contained within the Project FEIS (Baffinland 2012) and include consideration of the spatial extent of effects. Predicted residual environmental effects are rated as "Not Significant" in cases where the effect is confined (e.g., to the Local Study Area). Thus monitoring of such effects will be in reference to the predicted geographic extent of measurable environmental changes. Changes that remain within the predicted boundaries will confirm effects predictions; conversely, should changes be detectable beyond the set boundaries, the effects prediction would need to be revised and adaptive management procedures considered.

For the purpose of EEM, the spatial extent of predicted effects will be referred to as the ZOI. From the FEIS, each interaction has been assigned a physical boundary based on available information of Project activities, including dust deposition modeling (Baffinland 2012; Volume 5, Section 2.6) and ballast water dispersion modeling (Baffinland 2012; Volume 8, Appendix 8B-3).

In addition to evaluating predictions and the effectiveness of mitigation measures, the various monitoring programs serve as early warning indicators that will help identify exceedances or unanticipated effects. Identification of such triggers will result in additional monitoring studies or the implementation of mitigation measures and/or corrective actions.

3.1 QUESTIONS FOR HYPOTHESIS FORMULATION

Several questions that arose during the review of the EIS and Addendum (ERP) were helpful in formulating the hypotheses needed to guide development of the MEEMP--Ecosystem. These include the following:

1. Will water quality deteriorate with respect to the Canadian Council of Ministers of the Environment (CCME) guidelines as a result of Project activities at Milne Port?
    a. Will water temperature increase due to ballast water discharge?
    b. Will nutrient concentrations change as a result of combined or confounding effects of ballast water discharge, site discharge and dust deposition?
    c. Will water quality variables (TSS, metals, hydrocarbons) increase due to site discharge and dust deposition in the marine environment?

2. Will sediment quality variables change as a result of Project activities at Milne Port?
   a. Will particle grain size gradients change as a result of Project-induced re-distribution of sediment and/or dust deposition?
   b. Will metals increase as a result of dust deposition and/or site discharge?
   c. Will hydrocarbons increase as a result of dust deposition and/or site discharge?
3. Will the benthic marine habitat exhibit measurable changes due to Project activities at Milne Port?
   a. Will percent cover of macroflora change as a result of re-distribution of sediments from Project shipping propeller wash and/or dust deposition?
   b. Will the distribution of substrate types exhibit change as a result of re-distribution of sediments from Project shipping propeller wash and/or dust deposition?
4. Will the benthic marine fauna exhibit measurable changes due to Project activities at Milne Port?
   a. Will benthic marine epifauna abundance change as a result of Project-induced changes in marine benthic habitat?
5. Are there any identified differences in contaminant concentrations that can be attributed to the Project?
6. Do contaminant concentrations occur at levels where potential biological effects might occur?
7. Will changes to the marine habitat that can be attributed to Project activities reach an equilibrium at some point during Project operations?

3.2 MARINE ECOSYSTEM EEM CANDIDATE STUDIES SELECTION

To address the potential effects on the marine environment summarized in Table 1.1, a series of monitoring studies were developed with respect to benthic habitat, sediment, water quality, epibenthic community, and selected fish species (summarized in Table 3.1). A detailed justification for the level of monitoring is provided in Sections 3.2.1 to 3.2.7.

3.2.1 BENTHIC HABITAT

Marine benthic habitat comprises several environmental components, including both physical (e.g., water depth, substrate character) and biological (e.g., floral and faunal communities) aspects. An integrated approach to investigating contaminant pathways in the marine benthic habitat could elucidate linkages between Project activities and environmental changes ultimately affecting biological communities. Underwater videography is a powerful technique that can collect data on multiple variables at one time within a large spatial extent around Milne Port. Furthermore, video data can be collected in large quantities and archived for selective analysis at any time. Depending on the extent of environmental change, high level changes in substrate characteristics, percent macroflora coverage, or the epibenthic community cover could be detected using underwater videography. These data could also help elucidate and/or corroborate any changes that might be observed in other datasets for physical or chemical variables.

Table 3.1 Summary of EEM Studies According to Current Program Level.

Study Program Candidate	Type	Description
Benthic Habitat	EEM	Underwater videography to characterize benthic habitat, substrate type/class and compare changes over time as a function of distance from Milne Port to determine linkage to Project activities.
Sediment	EEM	Sediment samples to measure particle size fines percent and compare changes over time as a function of distance from Milne Port to determine linkage to Project activities
Sediment	Surveillance	Sediment samples to measure petroleum hydrocarbon concentrations at select stations and compare to CCME guidelines.
Sediment	EEM	Sediment samples to measure iron concentration gradient as a function of distance from Milne Port and compare changes over time to determine linkage to Project activities.
Water	Surveillance	Water sampling to measure TSS, salinity, temperature, pH, metals, nutrient and hydrocarbon concentrations at select stations and compare to CCME guidelines.
Epibenthic Community	EEM	Underwater videography to enumerate benthic epifauna and compare changes over time to determine linkage to Project activities. Supplemental information on macroflora percent cover and substrate classification used to elucidate potential response of benthic community to Project activities.
Fish: Sculpin species	Surveillance	Opportunistic sampling of contaminants in fish flesh (from mortalities) during routine monitoring of fish communities at Milne Port.
Fish: Arctic char	Surveillance	Opportunistic sampling of contaminants in fish flesh (from mortalities) during routine monitoring of fish communities at Milne Port.
Species Inventory (Aquatic Invasive Species)	EEM	Before/After, Presence/Absence of aquatic organisms in Milne Port (zooplankton, benthic infauna, benthic epifauna, macroflora, encrusting epifauna, fish).

3.2.2 Sediment Quality

Marine sediments can provide a medium for transport and long-term storage of contaminants. As such, they represent a potential exposure pathway for contaminants to enter the marine food web through benthic organisms. Contaminants in sediments and their effects on the ecosystem have been studied extensively and regulatory standards exist to evaluate the level of contaminant accumulation in sediments.

Sediment quality variables that could be linked to Project activities include iron concentrations (iron ore dust deposition from stockpiles and loading at the Milne ore dock), particle size (dust deposition and redistribution of fines due to propeller wash and ballast water discharge at the ore dock), and hydrocarbon concentration (discharge to marine environment of treated waste and site run-off, and fuel and lubricant residues from shipping activity). Sediment quality analysis will be undertaken at an EEM level to quantify linkages between these monitoring candidates and Project activities.

3.2.3 Marine Water Quality

Several Project-related pathways exist for contaminants to enter the water column in the marine environment, including effluent and site drainage discharge at Milne Port (i.e., camp and maintenance shops, fuel depots, wastewater, wastewater management treatment facility, and ore stockpiles), ballast water discharge from vessels docked at port and direct dust deposition during ore loading at the ore dock. There are a number of potential site discharges at the port (e.g., sewage, site runoff, stock pile drainage, runoff from tank farm) and water quality monitoring will capture any potential effects in the marine environment from all discharges at the port. Contaminants entering the water column could be present over the short term and could possibly be captured by routine but instantaneous measurements of water quality. Since sampling efforts could potentially not capture contaminant concentrations that are deposited and disperse quickly, it is anticipated that water quality is not a suitable candidate for a full EEM. Water quality will therefore be addressed at a surveillance level with measurements commencing post-construction, beginning in 2015.

It is likely that water quality will be measured as part of an 'end-of-pipe' compliance monitoring program rather than be integrated into the MEEMP. Measurements of contaminants in other media, such as sediments where contaminants have the potential to accumulate over longer time scales, could potentially prove more useful for detecting environmental changes attributable to Project activities. Initially, water sampling at a surveillance level will be undertaken for selected variables (i.e., TSS, salinity, temperature, pH, metals, nutrient and hydrocarbons) at selected stations and compared to CCME Protection of Aquatic Life (PAL) guidelines. After initial monitoring results become available, Baffinland will discuss with regulatory authorities the requirement for continued surveillance monitoring.

3.2.4 Epibenthic Community

The epibenthic community represents a potential biological indicator of environmental change. It is an ideal candidate for monitoring because it represents a resident population of organisms in the study area exposed to Project induced effects, and the community is closely associated with the benthic marine habitat quality. The epibenthic community is also the likely pathway for contaminants to enter and/or affect the marine food web at higher trophic levels (i.e., fish and marine mammals). Changes, particularly for key indicator taxa, in abundance, relative abundance and community based diversity increase are potentially useful in monitoring project-related environmental changes over time.

The epibenthic community will be monitored at an EEM level to determine Project-induced changes above the natural variability of the ecosystem. The response of the epibenthic community to Project effects could be in relation to changes in marine habitat quality which are reflected in other attributes (i.e., substrate characteristics, macroflora coverage) and these attributes will be monitored concurrently with the epibenthic community.

Initially, benthic infauna data collected in 2010 and 2013 were assessed through power analysis to determine sample size requirements to detect changes in benthic infaunal community structure as related to Project activities. The benthic community is a common monitoring target for environmental effects in the marine environment and is frequently included in monitoring programs conducted under Environment Canada's Metal Mining Effluent Regulations (MMER). The benthic community at Milne Inlet however, was characterized by low species diversity and abundance and had a depth stratified structure (SEM 2014). The power analyses determined the sample size requirements to detect a change in benthic community were prohibitive (D. Schneider, Pers. Comm.), both in terms of sample collection effort and analytical costs. Consequently, benthic infauna is not included as a monitoring target for the MEEMP.

3.2.5 Sculpin Species

Resident fish species like one of the sculpin species, could be a useful biological indicator of environmental change in the study area at a higher trophic level. A variety of sculpin species are present within the study area and these fish are largely benthic in nature (as adults), and have relatively small ranges. Additionally, they are not part of the local subsistence fishery, and therefore there is no anthropogenic pressure on the population(s) that could be a confounding effect on monitoring project interactions. Sculpin are an important link between Project-related effects and higher trophic levels, since they interact with the benthic and pelagic environments throughout their life cycle, and could be consumed by other fish, marine mammals and/or seabirds. These characteristics make sculpins an ideal candidate for monitoring Project-induced environmental change. Fish health (e.g., contaminant levels in fish tissue) will be monitored over time to establish linkages to Project activities. Collection of fish tissue requires sacrificing individuals, therefore to use a sculpin species in a destructive-sampling program, it was necessary to estimate the population size in the study area. If the population size is not adequate to support destructive sampling, the monitoring program itself could negatively impact the marine food web in Milne Inlet.

Consequently, a mark-recapture study was conducted in 2014 to provide an estimate of population size for each of the various species of sculpin in the study area. The results from this study did not provide any recaptures for use in a population estimate. Although the lack of recaptures could suggest a large population, low catch per unit effort (CPUEs) in 2013 and 2014 suggest small and relatively immobile populations and possibly a learned avoidance of fishing gear following release. The persistent low CPUEs indicate that the resident sculpin of any one species are not present in numbers adequate to support EEM studies and that sampling requirements for sacrificed fish would not be sustainable.

Sculpin species will be included in the MEEMP at a Surveillance Level. Sculpins will be sampled on a regular basis during routine monitoring of fish communities to detect trends in contaminant levels from incidental mortalities. This sampling will be opportunistic and will not adhere to any specific sampling design with respect to sample size, size class, age and/or sex. If monitoring results indicate increased levels of contaminants in sculpin flesh, then consideration will be given to expanding the scope of the monitoring program through discussions with regulators.

3.2.6 ARCTIC CHAR

Arctic char, although considered to be an important VEC during environmental assessment, are not a resident population in the study area. They are transient in the marine environment and there are no major char producing rivers in the vicinity of Milne Port.

Variability in the timing and duration of the marine migration of Arctic char, their spatial distribution while at Milne Port and constraints to the field sampling schedule and methods (i.e., focus on use of non-lethal sampling methods) may provide information that will not adequately characterize the Arctic char population or provide data that is not comparable from year to year. Most importantly, the transient nature of the Arctic char at Milne Port prevents direct linkages to be made with Project activities (i.e., exposure to Project-induced effects is minimal and not quantifiable). Consequently, it is inappropriate to include Arctic char in a rigorous sampling program intended to address project related effects.

To satisfy NIRB requirements relating to Arctic char, a monitoring program that evaluates contaminant levels in incidental mortalities is the most logical choice for this VEC. As with monitoring of sculpin species, a portion of the Arctic char population will be sampled on a regular basis during routine monitoring of fish communities to detect trends in contaminant levels from incidental mortalities. This sampling would be opportunistic and will not adhere to any specific sampling design with respect to sample size, size class, age and/or sex. Similarly, if monitoring results indicate increased levels of contaminants in char flesh, then consideration will be given to expanding the scope of the monitoring program through discussions with regulators.

3.2.7 AQUATIC INVASIVE SPECIES

Ballast water exchange at Milne Port and the potential for introduction of invasive species was identified as a concern. Introduced invasive species are typically from lower trophic levels (e.g., zooplankton, phytoplankton, benthic infauna) and can alter the ecosystem resulting in impacts at multiple trophic levels. Baffinland has committed to monitoring for the presence of aquatic invasive species (AIS) at Milne Port. A comprehensive inventory of aquatic species, at several trophic levels, was established through baseline studies (2008, 2012, 2013 and 2014) and this inventory will be used to assess potential changes in species composition during Project shipping operations. For AIS monitoring there would likely be a clear cause and effect between Project activities (shipping, ballast water exchange) and impact (introduction of an AIS).

AIS monitoring will be a simple Before/After experimental design, focusing on areas with highest potential for occurrence of invasive species, particularly the port infrastructure where the ballast water exchange will occur. Studies will be conducted at a full EEM level and will involve monitoring species occurrence at all levels of aquatic biota to detect non-indigenous species.

3.3 MARINE ECOLOGY STUDY SCHEDULE

Table 3.2 is the proposed master schedule for the Marine Ecology EMP, by year, through to 2025. Several of the EEM programs are proposed to be monitored for a two to three year period initially, with a less frequent sampling schedule thereafter based on preliminary analyses and suitability of data collected to inform Project management. Programs at a research level (e.g., sculpin population levels) are for defined periods of time with continuation of monitoring at a higher level (surveillance or EEM) to be determined based on the research study results. Programs to be conducted at a surveillance level will be undertaken in accordance with the schedule in Table 3.2, subject to changes in response to any observed effects that could trigger an expanded monitoring program (both spatially and temporally). All marine ecology studies occur from late June through to September. The proposed seasonal schedule for years when the studies are conducted is summarized in Table 3.3.

Table 3.2 Marine Ecology EEM Master Schedule.

Subject	Frequency	'14[1]	'15[1]	'16	'17	'18	'19	'20	'21	'22	'23	'24	'25	'26
Benthic Habitat	First two years, then every third year	X	X	X	-	-	X	-	-	X	-	-	X	-
Water	First two years, then review[2]	-	X	X	X	-	-	-	-	-	-	-	-	-
Sediment	First three years, then every third year	X	X	X	X	-	-	X	-	-	X	-	-	X
Benthic epifauna	First two years, then every third year	X	X	X	-	-	X	-	-	X	-	-	X	-
Sculpin species	Non-destructive monitoring and opportunistic sampling of fish flesh - first three years, then every third year	X	X	X	X	-	-	X	-	-	X	-	-	X
Arctic Char	Non-destructive monitoring and opportunistic sampling of fish flesh - first three years, then every third year	X	X	X	X	-	-	X	-	-	X	-	-	X
Aquatic Invasive Species (Benthic Component)	First two years, then every third year	X	X	X	-	-	X	-	-	X	-	-	X	-
Aquatic Invasive Species (Fish and Zooplankton)	First three years, then every second year	X	X	X	X	-	-	X	-	-	X	-	-	X

[1] 2014 was for filling in gaps of baseline data collection and initial evaluation of EEM protocols, 2015 is the first full year of EEM implementation, post- Milne Port ore dock construction.
[2] Blank years indicate monitoring schedule to be determined based on results of first two years of sampling.

Table 3.3 Marine Ecology EEM Monthly Schedule.

Subject	Frequency	Annual Cycle			
		June	July	Aug	Sept
Benthic Habitat	Once per year in August or September				X
Sediment	Once per year in the open water season			X	
Water	Every 2 weeks during open water period		X	X	X
Epibenthic Community	Once per year in August or September				X
Sculpin species	Once per year in August or September				X
Arctic Char	Once per year in August			X	
Aquatic Invasive Species	Twice per year	X		X	

3.4 MARINE ECOLOGY EEM STUDY DESIGN AND DESCRIPTIONS

3.4.1 SAMPLING DESIGN

The sampling design for the MEEMP was based on key principles used for the design of EEM programs for other mining operations near coastal environments (e.g., Voisey's Bay EEM, 2006; INAC 2009; Environment Canada 2012) and in consideration of EEM programs currently in place for large developments with the potential of affecting the marine environment (e.g., offshore oil and gas development). Environment Canada (2012) identified three fundamental 'philosophical' approaches to EEM, as follows:

- Control Impact (C-I) or multiple-control impact (MC-I) designs, including before:after, control:impact (BACI), which are ANOVA-based designs used to detect significant differences between exposure and reference areas;
- Repeat measures (RM, e.g., annual measurements) gradient designs measuring biological responses along a gradient (e.g., effluent exposure) based on regression analyses or analysis of covariance (ANCOVA); and
- Multivariate statistical analyses comparing the reference condition approach (RCA) between potential 'test' stations to a selection of appropriate 'reference' stations.

In determining the most appropriate approach for the Milne Port MEEMP a number of factors were considered including:

- Sources of potential environmental perturbation (single or multiple);
- Configuration of Lower Milne inlet including bathymetry and oceanographic circulation;
- Baseline data collections;
- Statistical approach(es) to determining an effect;
- Methods applicable to arctic environments; and
- Accepted approaches used in other similar EEM programs.

The design of the Milne Port MEEMP is based on repeated measures (RM) distance regression analyses where the same replicates (stations) will be re-sampled at specific time intervals (years). Stations were established along a distance gradient from a potential point source of environmental perturbation (e.g., chemical contamination or physical disturbance) associated with the Milne ore dock. The outfall from the Milne camp, including the ore stockpiles, are in the same general location and are considered within the spatial extent of a single point source. The RM regressions are similar to regressions based on single year data incorporating response variables that are some combination or integration of data from multiple years (e.g., difference from baseline or a before:after difference). Significant regressions of the multi-year response variable on the distance from the point source will indicate distance gradients in relation to some Project activity. The RM regression design is an alternative to the Before:After Control:Impact (BACI) analyses of variance (ANOVA) design and is considered more sensitive to change and therefore more powerful than the simple differencing between control and impact locations.

The structure of the MEEMP plots was based on a radial gradient design as described in detail in Environment Canada (2012) and advocated by Ellis and Schneider (1997). The radial gradient design removes the problem of having to select a suitable control site that must be similar to the potential impact sites but removed from any potential Project related effects. The gradient design enables physical, chemical and biological changes to be assessed as a function of distance from a point source. This design is very effective at elucidating the spatial scale of impacts and therefore can provide considerable insights into potential mitigations and/or alterations to Project activities to address any observed negative environmental effects. Radial gradient designs are effective at addressing threshold of effects as a function of distance and/or quantification (e.g., contaminant level) of effect.

The sampling program for the MEEMP was designed to collect data along four transects radiating out from the Milne Port potential point source of contaminants and/or physical impacts associated with shipping activities. For each transect, a gradient of a given response variable will be compared as a function of distance over time to identify changes that could be attributable to Project activities. Gradients of data collected during each monitoring year will be compared to the baseline gradients.

Gradients of monitoring targets or species will be calculated along four transects in the Milne Port area (Figure 3.1). Three transects originating from the Milne ore dock include: West Transect (WT); East Transect (ET); and North Transect (NT). A fourth transect — Coastal Transect (CT) — originates at the end of the East Transect and extends north along the eastern shore of Milne Inlet, terminating outside the predicted ZOI of project activities. The Coastal Transect captures a gradient beyond the ZOI which is not provided by the other transects given the shape of the Inlet. Data collected along this transect will be important in determining if the identified ZOI is accurate and will be important in delineating the spatial scale of Project effects. Additionally, the end point of the Coastal Transect is located in proximity to Reference Site 1, established in 2013, thereby maximizing the use of existing baseline data.

There are four primary transects with sampling stations location along each transect (Figure 3.1):

1) West Transect (~1.5 km) — The West Transect extends from the ore dock and follows the 15 m contour in a westerly direction. The transect has five sampling stations (SW-1 to SW-5) at approximately 0 m, 250 m, 500 m, 1,000 m and 1,500 m.

2) East Transect (~1.5 km) — The East Transect extends from the ore dock and follows the 15 m contour in an easterly direction. The transect has five sampling stations (SE-1 to SE-5) at approximately 0 m, 250 m, 500 m, 1,000 m and 1,500 m.

3) Coastal Transect (~4 km) — The Coastal Transect extends from the terminus of the East Transect and follows the 15 m contour in a northeasterly direction, along the eastern shore. The transect has five sampling stations (SC-1 to SC-5) at approximately 0 m (identical to station 1,500 m of East Transect), 500 m, 1,000 m, 2,000 m and 4,000 m.

4) North Transect (~2km) — The North Transect extends from the Ore Dock in a northerly direction at increasing depths. The transect has five sampling stations (SN-1 to SN-5) at approximately 0 m, 250 m, 500 m, 1,000 m and 2,000 m.

The Coastal Transect extends to beyond the predicted Zone of Influence for the Project and as such includes sampling locations that are considered 'Control' sites outside of the influence of the Project.

3.4.2 Statistical Design

The radial pattern sampling design permits the capture of a gradient of key environmental variables (e.g., sediment quality) that could change over time and be linked to Project activities. The radial design allows for the comparison of changes in gradients over time for the key parameters and provides greater statistical power than comparing changes at individual stations. Combining the radial design with the analysis of the individual stations provides a substantial amount of information to feed back into the MEEMP to further refine the design and monitoring targets. An EWI for change in gradients or in individual stations is set at two standard deviations of the slope or mean, respectively (as per Environment Canada 2012).

The MEEMP design required evaluation of sample sizes necessary to meet the needs of statistical analyses. A power analysis (alpha=0.05, power=80%) for the iron concentration from the 2013 baseline data was used to determine the sample size required to detect changes within two standard deviations of the mean (as per Environmental Canada 2012). It was determined that a minimum of four samples was the preferred sample size for analysis. The results from each station will be compared to those of the previous year. A comparison of each subsequent year of data will add to the statistical power of the analysis. Furthermore, capturing a gradient with the dataset will reduce the minimum sample size requirements thereby increasing both the efficiency (i.e., effort and cost) and effectiveness (i.e., scientific confidence) of the MEEMP as the program progresses.

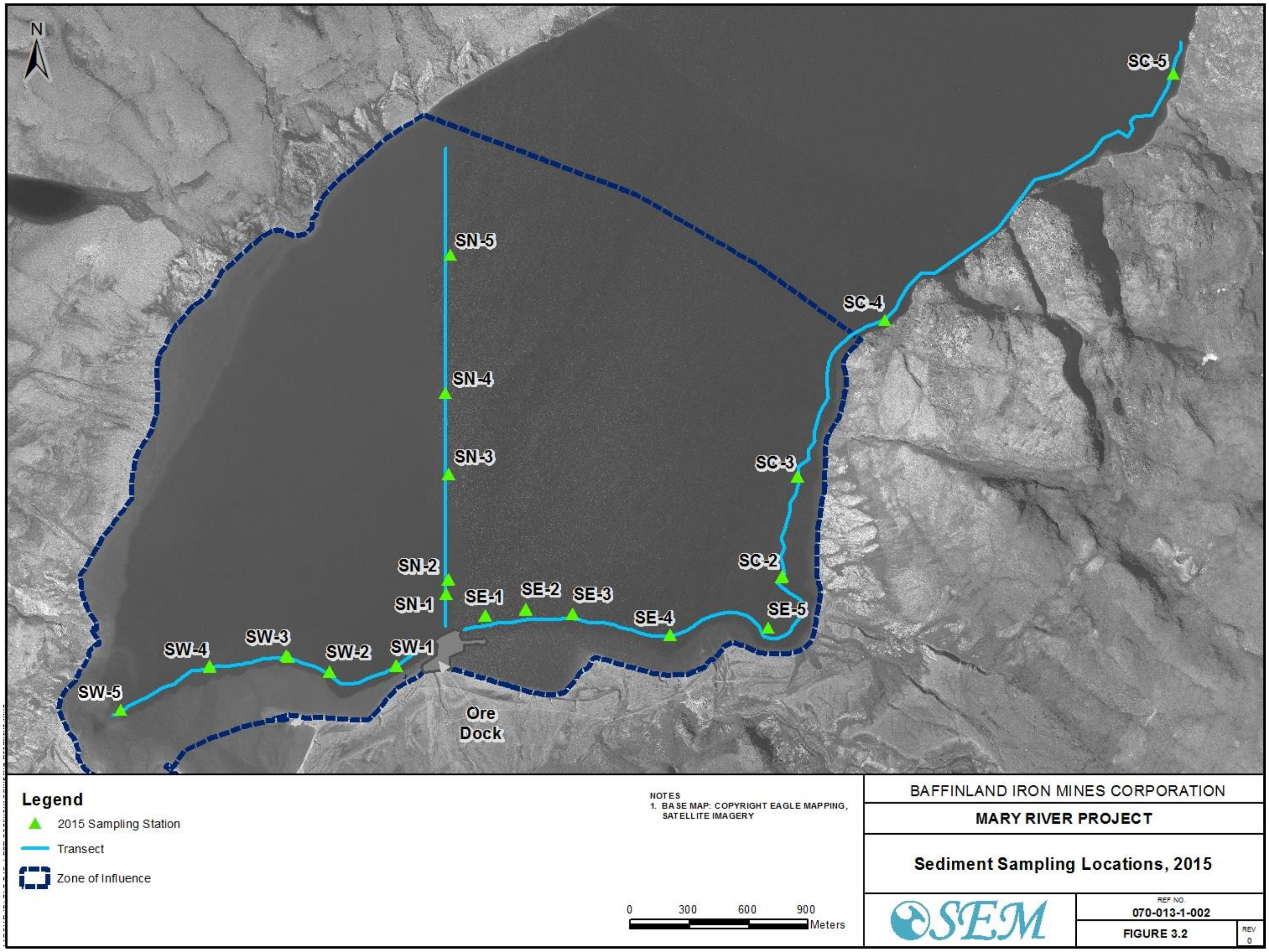

Figure 3.1 Radial Gradient Study Design and Sediment Sampling Locations.

Initially, linear regression analysis will be used to describe the dependence of one variable (the response variable) on one or more explanatory variables. A linear regression model is a 'line of best fit' that attempts to explain the dataset by reducing the distance between each data point and the regression line to the extent possible. The slope of a linear regression line, also known as the gradient, can be negative or positive and indicates the rate of change that can be expected in the response variable, based on the change in the explanatory variable(s). The R-squared value, which ranges from 0 to 1, provides a measure of the proportion of the variation in the dataset that is explained by the linear regression model.

Prior to Project operations, linear regression analyses was used to determine the baseline gradients of potential monitoring targets with respect to the distance from what will be the future contaminant point source (Milne ore dock and proximal site discharge location).

3.4.2.1 Addressing High Levels of Variance

A common issue that will likely be encountered is a high level of variance of the monitoring target gradients as a function of distance from the point source or simply as a function of natural variability. There are several ways to address the issue to maintain practical use of the monitoring variables:

1) Increasing sample size;
2) Introducing other variable(s) that explain the variance; and
3) Using a more appropriate error structure (i.e., a non-normal error structure).

Increasing sample size can be an effective way to reduce variance, however, it often increases the time and cost of the MEEMP. Furthermore, an increased sample size does not always decrease variance. If a gradient is close to being significantly different from zero (i.e., p-value slightly higher than 0.05), an increase in sample size can be simulated in the regression analysis by increasing N and maintaining the variance. The sample size required to make the gradient significantly different from zero ($p < 0.05$) can be calculated using this method, and the cost-benefit of incorporating this sampling effort (i.e., increased sample size) into the MEEMP can be evaluated.

The introduction of additional explanatory variables is another way to reduce variance. For example, introducing depth as a covariate would produce a depth-corrected gradient for a given environmental variable. Other explanatory variables might include organic carbon and/or particle size for the response variable iron concentration, or substrate class for the response variable benthic epifaunal abundance.

A different error structure can be useful when the variance is too large. A non-normal error structure gives less weight to high variance data, where variance increases with the mean, for example. This may resolve issues with high variance where the residuals are heterogeneous. This solution is likely to be very useful for benthic epifaunal abundance where a normal error structure will almost certainly be indefensible. The use of these alternative error structures can be difficult to explain and justify to regulatory authorities, and many commercially available statistical software packages do not accommodate applications of non-normal error structures.

3.4.2.2 Alternatives to Linear Regression Model

A variety of methods of analyzing data from multiple years will be explored to identify a method that is both informative and practical. This may include bivariate or multivariate models that assist in describing relationships that are not linear and increase the statistical power by reducing variance. It is possible that the analyses may provide insight into the addition of sampling sites above the current sample design. For example, evidence of an effect in close proximity to the point source with no effect at more distant stations may indicate the need to increase the number of near-field stations to provide greater spatial resolution of effects.

3.4.3 Benthic Habitat

3.4.3.1 Review of Baseline Benthic Habitat and Epifauna

The collection of baseline benthic habitat data at Milne Inlet began in 2008 using drop-camera videography and continued in 2010, 2013 and 2014. Data collected included macrofloral assemblage, substrate classification and benthic epifauna.

Most of the sampling covered areas around the proposed Milne ore dock with efforts in 2013 aimed at characterizing an impact site around the ore dock as well as two reference sites at increasing distance from the Project's ZOI.

The Milne Port Area inshore habitats consisted of mixed fine/medium substrates in the upper subtidal and intertidal zone. The backshore was characterized mainly by fine sediment. Subtidal habitats contained primarily fine substrates (71%). There was a relatively abundant but low diversity of macroflora, dominated by brown algae (99.8%). Several macrofauna were observed with brittle star and sea star being the most abundant.

The reference site located at the closer distance to Milne Port was characterized by mixed medium/coarse substrate with scattered boulders and sections of fine sediment. The backshore was characterized by cliffs and rocky outcrops. Medium/fine substrates were the dominant substrate class, followed by fine substrates. There was a relatively abundant but low diversity of macroflora, dominated by brown algae (99.92%). A variety of macrofauna were observed in the underwater video with brittle star and various zooplankton being the most abundant.

3.4.3.2 Benthic Epifauna and Benthic Habitat Study Design

Underwater videography will be used to record benthic habitat features including benthic epifaunal abundances, substrate classification and macroflora cover. Sampling will be conducted along each of the West Transect, East Transect, North Transect and Coastal Transect (Figure 3.1). Video recordings of each transect will be replicated, to the extent possible, to provide a pair of recordings for each of the four transects. The duplicate recording will help address sample variance related to attempting to replicate transects precisely between years.

The video data will be analysed by an experienced technician to identify and quantify benthic epifauna and macroflora to the lowest possible taxonomic level. The video data will be analysed frame by frame to determine total epifauna abundance and the percent macroflora coverage. A gradient of two biological metrics, benthic epifaunal abundance and percent macrofloa coverage, will be established as a function of distance from the point source of contaminant using linear regression analysis or other methods suited to the data. A summary of the EEM level study design is presented in Table 3.4. Sampling requirements were estimated using a power analysis of the 2013 underwater video benthic epifauna results. These calculations indicated the video coverage proposed in the four transect design described above will be adequate to capture the natural variability of the system and provide a means of detecting changes over time. Linking observed benthic habitat changes, as indicated by the biological metrics, to Project activities will be the next step in monitoring. Project activities associated with potential changes to the marine benthic habitat have been described in Table 3.4.

3.4.4 Sediment Quality

3.4.4.1 Review of Baseline Sediment Quality

The collection of sediment quality data began in 2008 and continued in 2010, 2013 and 2014. Samples from sediment grabs were analyzed for metals, hydrocarbons and particle size. Sampling was most intensive in 2013 and 2014 where the number of samples collected (>120 samples) were an order of magnitude greater than those of 2008 and 2010 (ten samples).

In 2008 and 2010, sediments in Milne Inlet were found to be dominated by either sand or sand and silt. Nutrient concentrations were low, generally comprising less than one percent of the total amount of sediment. Some hydrocarbons were detected within the port area, including: oil and grease; naphthalene; hydrocarbons C10-16 and C16-C34; and toluene. Naphthalene was the only PAH detected.

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. Sediment concentrations were consistently within the CCME guidelines for protection of marine aquatic life for arsenic, cadmium, chromium, copper, lead, zinc and PAHs.

In 2013, samples were mainly composed of sand and gravel. Silt and clay were also present in considerable amounts at depths >15 m. Organic carbon concentration was generally low but was moderate to high in finer sediment. No polycyclic aromatic hydrocarbons (PAHs) were detected and only low concentrations of modified total petroleum hydrocarbons (TPH) were detected in the possible lube oil fraction at a few locations.

Metals detected in 2013 include: aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, nickel, rubidium, strontium, thallium, uranium, vanadium and zinc. There were no exceedances of the CCME PAL guidelines.

Table 3.4 Summary of Benthic Epifauna and Habitat Study Design.

Project Interaction	Activity	Propeller wash, site discharge, ballast water discharge, dust dispersion
	Environmental Effect/Issue	Alteration of benthic habitat and changes to epifaunal community
Hypothesis Formation		Increase in temperature from ballast water discharge could reduce benthic productivity Re-suspension of sediments and dust dispersion could alter benthic habitat.
Monitoring Target		Benthic epifaunal community abundances Macrofloral percent cover Substrate Classification
Design Type		Radial Gradient Design as a function of distance from Milne Port point source
Testable Hypotheses		H_0 Benthic epifauna abundance gradient does not significantly change over time. H_A Benthic epifauna abundance gradient changes over time. H_0 Macroflora cover and/or substrate classification do not explain changes to benthic epifauna abundances H_A Macroflora cover and/or substrate classification help to explain changes to benthic epifauna abundances
Sample Size Requirements		Approximately 2–3 km per transect based on data collection of 1 frame/metre)
Sampling	Frequency	Annually, during the open water season;
	Location	Continuously along West, North, East, Coastal Transects
	Timing	August/September
Data Collection Methods		Underwater videography
Sample Handling and Analysis		Identification and enumeration of benthic epifauna Classification of substrate type identification of macroflora and determination of percent cover
Data Interpretation and Reporting		Linear regression analysis of benthic epifauna abundances as a function of distance from Milne Port point source to establish gradient; Use of macroflora and/or substrate data as additional explanatory variables (covariates) in the regression analysis
Triggering Levels		A measured gradient within two standard deviations of the baseline or previous year, as applicable.

3.4.4.2 Sediment Quality Study Design

The sampling design is based on a radial pattern extending out from the Milne ore dock and sampling stations are established along four transects at increasing distance from the point source and as previously described. Descriptions of the four transects are presented in Section 3.4.1. A summary of the EEM level study design is presented in Table 3.5.

Sediment will be analyzed for metals, hydrocarbons and particle size. The principle variables of interest with respect to the MEEMP are iron concentrations, particle size and hydrocarbon concentrations, since each of these may be linked to Project activities. Linear regression analysis will be used to establish baseline gradients of each sediment quality variable. When a transect does not follow a single depth contour (i.e., the North Transect), depth will be used as a second explanatory variable to provide a depth-corrected gradient for each variable.

Other explanatory variables might be included in future multiple linear regressions, such as organic carbon concentration or fines percent for the iron concentration response variable.

Sediment quality guidelines for marine environments exist for several metals and hydrocarbons. The CCME (1999; updated to 2015) has both Interim Sediment Quality Guidelines (ISQG) and Probable Effects (Table 3.6) and are reported as half of the CCME ISQG levels as an EWI. In cases where the CCME ISQG guideline falls below the reportable detection level (RDL), the RDL may be used as an EWI.

Table 3.5 Summary of Sediment Quality Study Design.

Project Interaction	Activity	Propeller wash, site discharge, dust deposition, shipping
	Environmental Effect/Issue	Benthic habitat alteration due to sediment re-distribution and contaminant accumulation
Hypothesis Formation		Does particle size gradient change over time as a function of distance from the Milne Port point source? Do metal concentration gradients change over time as a function of distance from the Milne Port point source? Do hydrocarbon concentration gradients change over time as a function of distance from the Milne Port point source?
Monitoring Target		Particle size — Fines % Metal Concentrations — Iron Hydrocarbon Concentrations
Design Type		Radial gradient design
Sample Size Requirements		Three replicates per station; 5 sampling stations on 4 transects
Sampling	Frequency	Annually during the open water season
	Location	SW-1, SW-2, SW-3, SW-4, SW-5 SN-1, SN-2, SN-3, SN-4, SN-5 SE-1, SE-2, SE-3, SE-4, SE-5 SC-1, SC-2, SC-3, SC-4, SC-5
	Timing	Once per year during open water season
Data Collection Methods		Petit Ponar grab or other suitable benthic grab
Sample Handling and Analysis		Shipped in glass jars to laboratory; Acid Extraction — ICPMS (metals); GCMS (hydrocarbons); Pipette and Sieve (particle size analysis).

Table 3.5 Summary of Sediment Quality Study Design.

Data Interpretation and Reporting		Linear regression analysis as a function of distance from Milne Port.
Triggering Levels		See Table 3.6 for triggering values related to CCME guidelines. Changes in gradient greater than two standard deviations.
Testable Hypotheses		H_0 Fines % gradient does not change over time as a function of distance from Milne Port. H_A Fines % gradient changes as a function of distance from Milne Port. H_0 Iron concentration gradient does not change over time as a function of distance from Milne Port. H_A Iron concentration gradient changes as a function of distance from Milne Port. H_0 Hydrocarbon concentration gradients do not change over time as a function of distance from Milne Port. H_A Hydrocarbon concentration gradients change as a function of distance from Milne Port.
Sample Size Requirements		Three replicates per station; 5 sampling stations on 4 transects
Sampling	Frequency	Annually during the open water season
	Location	SW-1, SW-2, SW-3, SW-4, SW-5 SN-1, SN-2, SN-3, SN-4, SN-5 SE-1, SE-2, SE-3, SE-4, SE-5 SC-1, SC-2, SC-3, SC-4, SC-5
	Timing	Once per year during open water season
Data Collection Methods		Petit Ponar grab or other suitable benthic grab
Sample Handling and Analysis		Shipped in glass jars to laboratory; Acid Extraction – ICPMS (metals); GCMS (hydrocarbons); Pipette and Sieve (particle size analysis).
Data Interpretation and Reporting		Linear regression analysis as a function of distance from Milne Port.
Triggering Levels		See Table 3.6 for triggering values related to CCME guidelines. Changes in gradient greater than two standard deviations.

Table 3.6 Early Warning Indicators (Triggers) for Sediment Quality

Sediment Quality Variables	Units	RDL[1]	CCME-ISQG[2]	CCME-PEL[3]	Early Warning Indicator (Triggering Value)[4,]
Metals					
Extractable Arsenic (As)	$mg \cdot kg^{-1}$	2.0	7.24	41.6	3.62
Extractable Cadmium (Cd)	$mg \cdot kg^{-1}$	0.30	0.7	4.2	0.35
Extractable Chromium (Cr)	$mg \cdot kg^{-1}$	2.0	52.3	160	26.15
Extractable Copper (Cu)	$mg \cdot kg^{-1}$	2.0	18.7	108	9.35
Extractable Lead (Pb)	$mg \cdot kg^{-1}$	0.50	30.2	112	15.1
Mercury (Hg)	$mg \cdot kg^{-1}$	0.017	0.13	0.7	0.065
Extractable Zinc (Zn)	$mg \cdot kg^{-1}$	5.0	124	271	62
Hydrocarbons					
Methylnaphthalene (2-)	$mg \cdot kg^{-1}$	0.010	0.0202	0.2010	0.0101
Acenaphthene	$mg \cdot kg^{-1}$	0.010	0.00671	0.0889	0.003355
Acenaphthylene	$mg \cdot kg^{-1}$	0.010	0.00587	0.1280	0.002935
Anthracene	$mg \cdot kg^{-1}$	0.010	0.0469	0.2450	0.02345
Benzo(a)anthracene	$mg \cdot kg^{-1}$	0.010	0.0748	0.6930	0.0374
Benzo(a)pyrene	$mg \cdot kg^{-1}$	0.010	0.0888	0.7630	0.0444
Chrysene	$mg \cdot kg^{-1}$	0.010	0.1080	0.8460	0.054
Dibenz(a,h)anthracene	$mg \cdot kg^{-1}$	0.010	0.00622	0.1350	0.00311
Fluoranthene	$mg \cdot kg^{-1}$	0.010	0.1130	1.4940	0.0565
Fluorene	$mg \cdot kg^{-1}$	0.010	0.0212	0.1440	0.0106
Naphthalene	$mg \cdot kg^{-1}$	0.010	0.0346	0.3910	0.0173
Phenanthrene	$mg \cdot kg^{-1}$	0.010	0.0867	0.5440	0.04335
Pyrene	$mg \cdot kg^{-1}$	0.010	0.1530	1.3980	0.0765

1 Reportable Detection Limit; RDLs vary as a function of concentration and/or volume as defined by the analytical laboratory. RDLs presented here are from sediment samples taken in Milne Inlet in 2014 (SEM, 2015a Draft)

2 Canadian Council of Ministers of the Environment — Interim Sediment Quality Guidelines

3 Canadian Council of Ministers of the Environment — Probable Effects Levels

4 Based on one half the CCME ISQG guideline values. Note: only values above the RDL are useful as triggering values

Sediment will be analyzed for metals, hydrocarbons and particle size. The principle relevant variables are iron, particle size and hydrocarbon concentration since these may be linked to Project activities. Linear regression analysis will be used to establish baseline gradients of each sediment quality variable. For the North transect (which does not follow a single depth contour) depth will be used as a second explanatory variable to provide a depth-corrected gradient. Other explanatory variables might be included in future multiple linear regressions, such as organic carbon concentration or fines percent for the iron concentration variable.

Sediment quality guidelines exist for several metals and hydrocarbons in the marine environment. The CCME (1999; updated to 2015) has Interim Sediment Quality Guidelines (ISQG) and Probable Effects Levels (PEL). Sediment quality triggering levels are reported in Table 3.6 and are reported as half of the CCME ISQG levels as an EWI. In cases where the CCME ISQG guideline falls below the reportable detection level (RDL), the RDL is used as the EWI.

3.4.5 Water Quality

3.4.5.1 Review of Baseline Water Quality

The collection of water quality data took place in 2008 and 2010, with the majority of sampling taking place during the open water season. One third of the data collected were under-ice samples. Water samples were analyzed for nutrients, water clarity, salinity, temperature and pH and results are presented in the Mary River FEIS (Baffinland 2012).

The surface waters of Milne Inlet were near neutral (pH: 7.33 to 7.98), brackish (23 psu to 30 psu), hard (total hardness: 1,620 $mg \cdot L^{-1}$ to 5,990 $mg \cdot L^{-1}$) and clear (turbidity: 0.3 NTU to 0.6 NTU) with moderate amounts of nutrients (0.3 to 3.1 $mg \cdot L^{-1}$ and 0.011 to 0.54 $mg \cdot L^{-1}$ for total nitrogen [TN] and total phosphorus [TP], respectively). Nutrient concentrations measured during the open-water season tended to be higher in deep waters than at the surface.

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). 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.

3.4.5.2 Water Quality Study Design

After completion of the ore dock construction and prior to shipping operations, a radial gradient sampling design has been established. Sampling will be completed at three stations at increasing distances (250 m) from Milne Port along each of three transects originating at the port site water discharge location (Figure 3.2). The location of the transect sampling stations has followed the overall radial gradient design, the extent of these transects is shorter than previously described overall MEEMP design, as potential water quality effects are expected to be only detectable in close proximity to the point source. At the end of each transect, conductivity/temperature/depth profiles will be collected to determine if the water column is stratified. Water samples will be collected at the surface and just above bottom, and if CTD cast determine the water column is well stratified, an additional sample will be collected mid-water column, in association with any detected thermocline and/or halocline. Water quality measurements will include salinity, temperature, total suspended solids (TSS) and nutrient, metal and hydrocarbon concentrations. The CCME (1999; updated to 2015) has issued guidelines for TSS, turbidity and salinity, but the guidelines refer to a departure from background conditions. Water quality sampling in 2015 was intended to fill gaps in baseline information and provide background conditions for salinity, turbidity and TSS against which to measure potential future changes attributable to Project activities. Sampling in 2015 will also evaluate the adequacy of the study design in terms of length and orientation of transects. There are no CCME guidelines issued for temperature, therefore a EWI, or trigger, of $\geq$1˚C has been selected. Surveillance level monitoring will begin in 2016, and a summary of the design is presented in Table 3.7.

Water quality variables will be expressed as gradients as a function of distance from the point source of contaminants/perturbations.

Measurements will be taken in 2015 following the completion of the construction of the ore dock at Milne Port and in advance of operational shipping of ore. An expansion of sampling efforts could be triggered by detection of significant changes in parameters during surveillance monitoring and/or increases in metals and hydrocarbons in sediments. Expansion of water quality monitoring both temporally (increased frequency) and spatially may then be considered.

Water quality guidelines for marine environments exist for pH, nitrate, arsenic, cadmium, chromium and mercury (Table 3.8). The CCME (1999; updated to 2015) also issued guidelines for total suspended solids (TSS), turbidity and salinity, however guidelines refer to a ‘departure from background conditions’. Recommended water quality triggering levels are provided in Table 3.8 and are reported as half of the CCME guidelines as an EWI. In cases where the CCME guideline falls below the RDL, the RDL may be substituted as the EWI.

Figure 3.2 Water Quality Sampling Sites.

Table 3.7 Summary of Marine Water Quality Monitoring Study Design.

Project Interaction	Phenomena	Ballast water discharge, site discharge, dust deposition
	Environmental Effect/Issue	Increase in water temperature and salinity, changes to nutrient concentrations, increases in TSS, metals and hydrocarbon concentrations
Hypothesis Formation		Does water temperature and salinity increase as a result of ballast water discharge? Does nutrient concentration change due to dilution from ballast water discharge (decrease) or due to site discharge (increase)? Do TSS, metal and hydrocarbon concentrations increase as a result of dust deposition and site discharge?
Monitoring Target		Water temperature Salinity Nutrient concentrations TSS, metal concentrations, hydrocarbon concentrations
Design Type		Selected stations along a radial gradient design, three transects
Testable Hypotheses		H_0 Water temperature does not increase $\geq$1˚C due to ballast water discharge. H_A Water temperature does increase $\geq$1˚C due to ballast water discharge. H_0 Water salinity does not increase due to ballast water discharge. H_A Water salinity does increase due to ballast water discharge. H_0 Nutrient concentration gradients do not change over time. H_A Nutrient concentration gradients do change over time. H_0 Metal concentration gradients do not change over time. H_A Metal concentration gradients do change over time. H_0 Hydrocarbon concentration gradients do not change over time. H_A Hydrocarbon concentration gradients do change over time.
Timing		Bi-weekly during open water period (n=6 per year)
Data Collection Methods		Niskin bottle
Sample Handling and Analysis		Preserved as necessary and shipped to lab for analysis; Analyses to be completed by qualified laboratory (Canadian Association for Laboratory Accreditation Inc. certification). Appropriate QA/QC standards implemented in the field and laboratory
Data Interpretation and Reporting		Determine if variables are above detection. Compare to CCME guidelines, where applicable. Compare gradient of nutrient, metal and hydrocarbon concentrations over time to determine existence of Project-related change.
Triggering Levels		See Table 3.8 for triggering values related to CCME guidelines. Changes in concentration gradient greater than two standard deviations. Changes in temperature $\geq$1˚C.

Table 3.8 Early Warning Indicators (Triggers) for Water Quality.

Water Quality Variable	Units	RDL[1]	CCME[2]	Early Warning Indicator (Triggering Value)[3]
pH	-	N/A	7.0–8.74	-
Turbidity	NTU	0.1	-	-
Conductivity	$\mu S \cdot cm^{-1}$	1	-	-
Total Suspended Solids	$mg \cdot L^{-1}$	1	5-255	-
Nitrate	$mg \cdot L^{-1}$	0.05	200–1,500	100–750
Nitrite	$mg \cdot L^{-1}$	0.01	N/A	-
Ammonia	$mg \cdot L^{-1}$	0.05	N/A	-
Total Phosphorus	$mg \cdot L^{-1}$	10	N/A	-
Arsenic	$mg \cdot L^{-1}$	0.1	0.0125	0.0063
Cadmium	$mg \cdot L^{-1}$	0.03	0.00012	0.00006
Chromium	$mg \cdot L^{-1}$	0.1	0.0015	0.00075
Mercury	$mg \cdot L^{-1}$	0.000013	0.000016	0.000008

1 Reportable Detection Limit; RDLs vary as a function of concentration and/or volume as defined by the analytical laboratory. RDLs presented here are from water samples taken in Milne Inlet in 2014 (SEM 2014)

2 Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life

3 Values are based on one half CCME Guideline values. Note: only values above the RDL are useful as triggering values.

4. The pH of marine and estuarine waters should fall within the range of 7.0 – 8.7 units unless it can be demonstrated that such a pH is a results of natural processes. Within this range, pH should not vary by more than 0.2 pH units from the natural pH expected at that time. Where pH is naturally outside this range, human activities should not cause pH to change by more than 0.2 pH units from the natural pH expected at that time, and any change should tend towards the recommended range.

5. Short term — not to exceed 25 mg/L over baseline levels, Long term – not to exceed 5 mg/L over baseline levels (CCME 1999, updated to 2015)

3.4.6 Finfish Species

3.4.6.1 Review of Baseline Data

Fish sampling began in 2010 and continued in 2013 and 2014. In 2010 and 2013, measurements such as length, weight, sex, age and stomach contents were taken for fish catches. In 2014, destructive sampling was not conducted, therefore only length and weight were recorded. In 2014, a mark-recapture program was attempted to get an estimate of the population size of the various sculpin species. Total fish catch for baseline studies is presented in Table 3.9.

Table 3.9 Total Fish Catch Comparison, 2010, 2013 and 2014.

Species	2010	2013	2014
Arctic char	11	6	3
Arctic sculpin	0	0	4
Shorthorn sculpin	50	4	9
Fourhorn sculpin	7	3	39
Arctic staghorn sculpin	3	0	0
Longhorn sculpin	0	2	4
Arctic hookear sculpin	0	0	5
Greenland cod	4	0	1
Common lumpfish	0	0	1
Fish doctor	0	1	0
Fourline snakeblenny	0	0	1
Total	**75**	**16**	**67**

3.4.6.2 Sculpin Species

The resident population of a fish species must be large enough to support lethal sampling of fish at the required sample size for tissue analysis in an EEM program. Therefore, to utilize sculpin body burden for an ongoing monitoring program, a population estimate was required to determine if the sampling requirement was sustainable without affecting the resident population. In 2014, a mark-recapture study to estimate the sculpin populations was conducted in the vicinity of Milne Port. No recaptures were obtained in 2014 hence no estimation of population size was possible. The fact that no recaptures were obtained in 2014, despite considerable fishing effort, could indicate a large population size however the low CPUE in both 2013 and 2014 suggested very small populations. The lack of recaptures was indicative of the large survey area, short times between surveys, the small home ranges of sculpin and fishing methods used (primarily non-lethal sampling techniques). It has been concluded that the sculpin populations in the vicinity of Milne Port, representing six different species, are not large enough to sustain a dedicated EEM program requiring lethal sampling. Sampling in 2015 included mark-recapture methods to again attempt to determine the relative size of the sculpin population in association with the Milne Port. Results of this effort are currently underway and will be used to update then document when available.

Sculpin species morphometrics (length, weight, age) will be measured for all sculpin catches while determination of sex, stomach contents and body burden analysis will be monitored on incidental mortalities during routine fish sampling (as described above in Section 3.2.5). Contaminant levels will be compared to baseline levels and guidelines set by Health Canada (2012; mercury, 0.5 mg·kg^{-1}). A summary of the surveillance level study design is presented in Table 3.10.

Table 3.10 Summary of Sculpin Study Design.

Project Interaction	Phenomena	Propeller wash, site discharge, dust deposition
	Environmental Effect/Issue	Reduction in fish health condition and/or population dynamics due to habitat alteration and/or contaminant dispersion.
Hypothesis Formation		Does sculpin health deteriorate as a result of habitat alteration from propeller wash, ballast water discharge, site discharge or dust deposition? Does sculpin population decrease as a result of habitat alteration from propeller wash, ballast water discharge, site discharge or dust deposition?
Monitoring Target		Sculpin CPUE (by species) as indicator of abundance Sculpin condition factors (e.g., length, weight, external condition, external determination of sex and age, stomach contents if possible) Sculpin tissue analysis (metals, contaminants) from incidental mortalities
Design Type		Near shore sampling around Milne Inlet
Testable Hypotheses		H_0 Sculpin health is reduced as a result of Project activities. H_A Sculpin health is not reduced as a result of Project activities. H_0 Sculpin population size does not decrease as a result of Project activities. H_A Sculpin population size decreases as a result of Project activities.
Sample Size Requirements		Not applicable
Sampling	Frequency	During the open water season
	Location	Sampling stations along the western and eastern shores of Milne Inlet, and near the Milne Port ore dock.
	Timing	August/September
Data Collection Methods		Fukui traps and/or gill nets

3.4.6.3 Arctic Char

Arctic char in Milne Inlet are anadromous and spend limited time in the marine environment and are therefore only present near the Milne Port for a short period of time with limited exposure to Project activities. The timing of migration to, and within, the marine environment can vary considerably on a yearly basis depending on local weather patterns, timing of the spring freshet, and oceanographic conditions. The lack of char producing rivers in the vicinity of Milne Port further reduces the likelihood of capturing a significant number of fish at this location. The short and variable residency time of Arctic char in the vicinity of the Milne Port, would indicate that a full population assessment and body burden analysis would not be statistically robust. Arctic char morphometrics (length, weight, age, sex, stomach contents) will therefore be non-destructively measured for all catches and sex, stomach contents, and body burden analysis will be monitored on incidental mortalities during routine fish sampling (as described above in Section 3.2.6). Contaminant levels will be compared to baseline levels and guidelines set by Health Canada (2012; mercury, 0.5 mg·kg^{-1}). A summary of the surveillance level study design is presented in Table 3.11.

Table 3.11 Summary of Arctic Char Study Design.

Project Interaction	Phenomena	Propeller wash, ballast water discharge, site discharge, dust deposition
	Environmental Effect/Issue	Reduction in fish health condition and/or population size due to habitat alteration and/or contaminant dispersion.
Hypothesis Formation		Does arctic char health deteriorate as a result of habitat alteration from propeller wash, ballast water discharge, site discharge or dust deposition? Does arctic char population decrease as a result of habitat alteration from propeller wash, ballast water discharge, site discharge or dust deposition?
Monitoring Target		Arctic Char CPUE as indicator of abundance Arctic Char condition factors (e.g., length, weight, external condition, external determination of sex and age, if possible) Arctic Char tissue analysis (metals, contaminants) from incidental mortalities
Design Type		Near shore sampling around Milne Inlet
Testable Hypotheses		H_0 Arctic char health is reduced as a result of Project activities. H_A Arctic char health is not reduced as a result of Project activities. H_0 Arctic char population size does not decrease as a result of Project activities. H_A Arctic char population size decreases as a result of Project activities.
Sample Size Requirements		Not applicable
Sampling	Frequency	During the open water season
	Location	Sampling stations along the western and eastern shores of Milne Inlet, and near the Milne Port ore dock.
	Timing	August/September
Data Collection Methods		Gill nets
Sample Handling and Analysis		Photograph catch (if necessary) to confirm identification, measure length and weight of each fish, collect tissue sample from incidental mortalities

3.4.7 Aquatic Invasive Species

3.4.7.1 Review of Baseline Data

Collection of baseline information on aquatic marine species in the vicinity of Milne Port has been ongoing with data collection beginning in 2008 and continuing in 2010, 2013 (SEM 2014a) and 2014 (2015a). A comprehensive review and gap analysis was completed of baseline monitoring to 2013 (SEM 2014b) prior to completing final baseline studies in 2014. Studies to date have involved the collection of species inventories for zooplankton, benthic infauna and epifauna, finfish and macroflora. Artificial substrates (settlement baskets) were deployed in 2014 in order to include encrusting epifauna in the species inventory. These substrates will be retrieved after sufficient time for colonization (minimum one year) and processed to identify epifauna and algae species associated with hard substrates. A compilation of species inventories for all work completed to 2014 at Milne Port is in preparation (SEM 2015b, in prep.).

3.4.7.2 Study Design for Aquatic Invasive Species

AIS monitoring will be a simple Before/After experimental design, focussing on areas with highest potential for marine invasions, notably the Milne Port infrastructure. Monitoring will include studies at the surveillance level and the threshold would be detection of a single occurrence of a non-indigenous species. The purpose is to detect, as an early warning indicator, the invasion of non-native flora and fauna such that a response (e.g., increase scope of monitoring, surveys to determine if the AIS have become established, increase or alteration in mitigation activity [ballast water treatment], implementation of eradication measures [if feasible] can be initiated). Monitoring will include aquatic flora and fauna at a variety of trophic levels including finfish, zooplankton, benthic infauna, epifauna (including encrusting epifauna), and macroflora. Initially all monitoring components will be assessed annually with the frequency of sampling determined through discussion with regulators. This may, in part, be determined by the results of other monitoring programs (i.e., the monitoring of AIS in ballast water).

The monitoring design was developed in consideration of the Canadian Aquatic Invasive Species Network (CAISN II) Arctic Sampling Program sampling protocols (Howland *et al*. 2013) as well as aquatic invasive species monitoring programs and protocols in use in other jurisdictions, specifically Australia's Surveys for Introduced Marine Pests (Hewitt and Martin 2001), the National Atmospheric and Oceanographic Administration (NOAA) Port Surveys for Invasive Species in the USA (Power *et al*. 2006), and the Helsinki Commission (HELCOM) ALIENS 2 Program in the Baltic Sea (Helsinki Commission 2013). The CAISN II Arctic Sampling Program had prepared a species inventory for four Arctic Canadian ports (Churchill, Iqaluit, Deception Bay and Steensby Inlet) and Fisheries and Oceans Canada (DFO) had suggested that these protocols be used to guide the development of existing species inventories and future monitoring at Milne Port.

The various study components to be addressed in the AIS EEM program are identified in Table 3.12. As with the CAISN II program and other AIS programs globally, the focus is on fauna and lower trophic levels. Fish have been included as part of the AIS monitoring, only because fish sampling will be completed as part of the overall MEEMP and the fishing methods are applicable to the collection of mobile epifauna. A generalized location map showing locations for collection of samples for the various AIS EEM components is provided in Figure 3.3. These locations were used to complete additional AIS baseline data in 2014. Locations for future AIS EEM sample collections may be modified slightly, if required, in consideration of any disturbances of 2014 locations during construction.

Table 3.12 Recommended Study Components for a Marine Aquatic Invasive Species Environmental Effects Monitoring Program.

Component	Spatial Extent	Sampling Approach
Zooplankton	Sampling from deep water at port location	Zooplankton tows during open water and under ice
Benthic Infauna	Sampling from four depth strata/habitats	Grab samples or quadrats from soft sediments
Epifauna	Sampling from four depth strata/habitats	Data collected from baited Fukui traps and underwater video
Encrusting Epifauna	Sampling from project infrastructure and artificial substrates	Scrapings from project's infrastructure and deployed artificial substrates
Fish	Sampling from four depth strata/habitats	Sampling from Fukui traps and tended gill net sets

DFO, under the CAISN II Program and with support from the National Science and Engineering Research Council (NSERC), is exploring the development of novel methods for the detection of AIS including the use of DNA barcoding (Briski *et al*. 2011) or the application of rapid assessment techniques (e.g., Minchin 2007), which could potentially involve the participation of local communities in AIS monitoring. Should any of these novel approaches become 'operational' in the context of accepted EEM practices, consideration will be given to integrating these methods into the AIS component of the MEEMP.

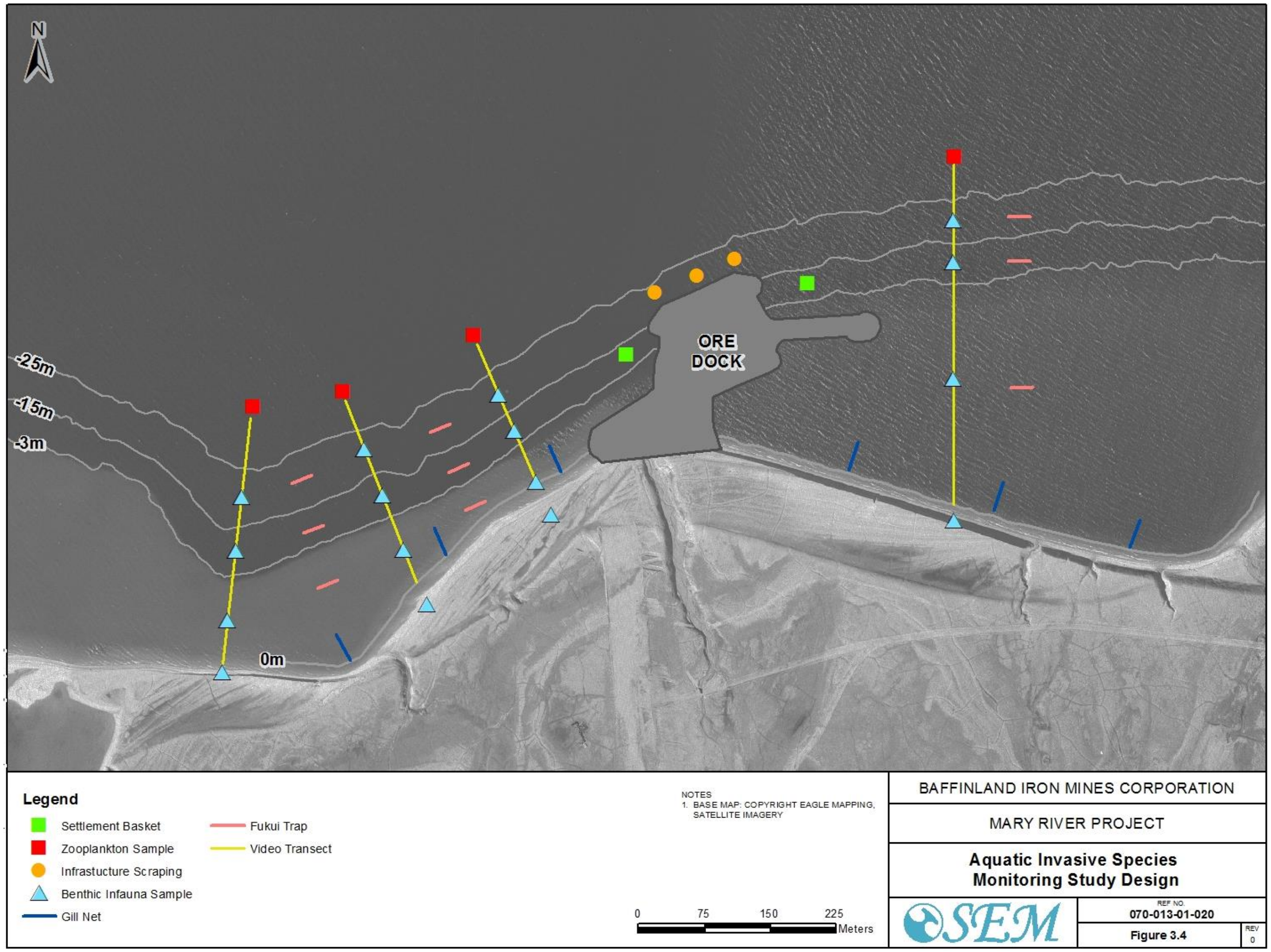

Figure 3.3 Aquatic Invasive Species Monitoring Study Design.

3.4.7.3 EEM Components

Zooplankton — The objective of this component of the AIS monitoring is to conduct annual monitoring at a surveillance level to detect a single occurrence of a non-indigenous zooplankton species. Should an invasive zooplankton species be detected, EEM could be adjusted for example to determine the distribution of the invader (e.g., increased spatial extent of monitoring) and if the invader is affecting the existing zooplankton populations (e.g., data analyses using community indices).

Zooplankton will be collected during the open water period (July to September) by vertical tows with an 80 µm mesh plankton net and oblique tows using a 250 µm mesh plankton net at a deep water location (>25 m depth) at the end of each of four transects in the vicinity of the Milne ore dock (Figure 3.3). Oblique tows will be collected by trailing the plankton net behind the sampling platform in a figure eight fashion for a defined period of time, in the vicinity of the vertical tow location. Zooplankton collections will also be made under the ice in June with vertical tows at the same location as open water tows with an 80 µm mesh plankton net. All taxa will be identified to the lowest practical taxonomic level (LPL) by qualified taxonomists and a reference collection of all identified taxa will be made and updated annually. Note that experience during baseline data collection has determined that not all zooplankton can be identified to species and this is a potential constraint on the AIS monitoring.

The faunal list from each monitoring survey will be cross checked against the baseline species inventory compiled during baseline surveys. Samples will also be screened for the presence of non-native ichthyoplankton.

Benthic Infauna — As above, EEM monitoring of benthic infauna will be at a surveillance level to detect a single occurrence of a non-indigenous benthic species. Should an invader be detected, the EEM program could be adjusted as described above.

Benthic infauna samples will be collected from soft sediments in the vicinity of the Milne Port using grab samplers. Replicates (n=5) will be collected from each of four habitat/depth strata; inter-tidal zone, 0–3 m, 3–15 m and 15–25 m (Figure 3.3). The requirement for replication is not an explicit requirement for AIS monitoring, as the focus is on early detection of a single AIS, however replication will increase the sample size and will improve chances for AIS detection. Should an AIS be detected, data analyses using community indices, as permitted by sample replication, will assist in determining effects of an AIS on the indigenous benthic community. All taxa will be identified to the lowest practical taxonomic level (LPL) by qualified taxonomists. A reference collection of all identified taxa will be made and updated annually. As with zooplankton, not all benthic infauna can be identified to species and this is a potential constraint on the AIS EEM.

The faunal list from each monitoring survey (annual) will be cross checked against the list compiled during baseline surveys.

Epifauna — EEM monitoring of benthic epifauna will be at a surveillance level to detect a single occurrence of a non-indigenous epifaunal species. Should an invader be detected, the EEM program could be adjusted and/or expanded. If a suspected invader is identified during EEM, increased surveying and sampling effort to capture and confirm identification of the suspected benthic epifauna invader would be undertaken.

Epifauna will be monitored through the use of baited Fukui traps, which will capture the mobile epifauna, and underwater video, which will document the larger and possibly less mobile taxa. This monitoring component is also being used to assess the effects of other project operations, specifically the effects of sediment redistribution and/or deposition and accumulation of contaminants in sediments. The metric used in those EEM components will be total abundance of epifauna, using the underwater video data only.

Baited Fukui traps will be set in the four habitat/depth strata identified above (Figure 3.3). All epifauna captured will be identified to species in the field, and if identification is not possible, detailed photographs will be collected or the specimen will be sacrificed for subsequent taxonomic identification.

Underwater video data will be collected along transects in three of the four habitat/depth strata identified above. Similar shoreline transects will be walked in the inter-tidal habitats at low tide, as an extension of the underwater transects. In the shoreline surveys, all taxa will be field identified, photographed, and/or sacrificed as above. In the video data, all taxa will be identified to the lowest practical taxonomic level (LPL) by a qualified technician. Experience has indicated that it may not be possible to identify all taxa to species from the video footage which is a potential constraint on AIS monitoring. As specimens are collected for taxonomic identification and more exposure to the native epifauna community occurs, it is expected more of the epifauna will be identified to species.

The faunal list from each monitoring survey will be cross checked against the list compiled during baseline surveys.

Encrusting Epifauna — EEM monitoring of encrusting epifauna will be at a surveillance level to detect a single occurrence of a non-indigenous epifaunal species. Should an invader be detected, the EEM program could be adjusted and/or expanded to determine the distribution of the invader by sampling other hard substrates over a larger spatial area (e.g., navigation buoys). The baseline species inventory for this component was initiated in 2014.

Encrusting epifauna will be monitored through the collection of samples by physical removal (scraping) from the port infrastructure including different types of hard surfaces (metal, concrete, wood, rock, rope, chains, etc.). Samples will be collected from exposed surfaces in the intertidal areas at low tide. Samples in the 0–3 m strata may be collected using a custom designed scraping net (see Power *et al.* 2006) or through the deployment of settlement baskets or plates. Sample collection from the deeper strata (5–15 m and 15–25 m) will be from the deployment of settlement baskets.

The length of time that settlement baskets are to be deployed will be determined initially by evaluating cumulative species curves for each depth/habitat strata. As the settlement baskets are left in place for longer periods of time, additional colonizing species will decrease until an asymptote is approached. This will then provide guidance as to the length of time for deployment for refinement of the EEM protocol.

All taxa will be identified to the lowest practical taxonomic level (LPL) by qualified taxonomists and a reference collection of all identified taxa will be made and updated annually.

The faunal list from each monitoring survey will be cross checked against a compiled list developed during the initial EEM surveys. It is recognized that, owing to the harsh northern environments, colonization of project infrastructure and settlement baskets may take some time, extending into project operations, which could compromise characterization of a true baseline for encrusting epifauna.

Fish — Fish fauna monitoring will be conducted at a surveillance level to detect a single occurrence of a non-indigenous fish species. Monitoring will be completed primarily in relation to adults or large juvenile fish using conventional sampling methods. Should an invasive fish species be detected, EEM could be adjusted to determine the distribution of the invader (e.g., increased spatial and potentially temporal extent of monitoring) and if the invader has become established (i.e., the presence of an adult specimen would likely indicate successful survival, growth and potentially reproduction).

Fish will be collected in the vicinity of the Milne Port using baited Fukui traps and tended gill net sets. This monitoring component will also be used to assess several environment effects monitoring objectives (e.g., bioaccumulation of contaminants in fish flesh) in addition to monitoring for the invasion of non-indigenous fish fauna. Traps and gill nets will be set in each of four habitat/depth strata; inter-tidal zone, 0–3 m, 3–15 m and 15–25 m (Figure 3.3). The use of gill nets will likely be constrained by conditions placed on experimental licenses issued by DFO (i.e., to minimize mortalities during sampling).

In addition to nets and traps, zooplankton samples will be screened for the presence of ichthyoplankton (eggs and larvae) and any unidentifiable specimens will be retained for identification by taxonomic experts.

4 MARINE MAMMAL EFFECTS MONITORING (MEEMP — MAMMALS)

This is the third revision of the Marine Mammal Effects Monitoring Plan for shipping activities associated with the Mary River Project (see LGL 2014). Specific marine mammal study designs have been modified based on recent field analyses and results. Flexibility in the EEM approach is necessary to account for the complexity of the Project- marine mammal interactions.

4.1 QUESTIONS FOR HYPOTHESIS FORMULATION

Several questions arose during the preparation and review of the EIS and Addendum (ERP), as well as during the issuance of the NIRB Project Certificate (No. 005). These served to formulate hypotheses needed to guide development of the EEM program. The following were considered:

1) Will marine mammal distribution and abundance change as a result of Baffinland shipping activity along the northern shipping route during the open-water season?
    a) What is the spatial-temporal distribution of marine mammals in the absence of shipping?
    b) How far away from the ship will marine mammals avoid it?
    c) What is the duration of avoidance for a single ship passage?
    d) What received sound levels from ore carriers result in marine mammal avoidance? Or do mammals respond to the approaching vessel rather than just the received noise levels.
    e) Will marine mammals habituate to frequent and regular ship passages?
    f) If yes to (e), how long will it take marine mammals to habituate?
    g) What natural factors influence narwhal distribution and abundance, independent of shipping?
2) Will narwhal behaviour change during and after a project vessel passage?
    a) What is narwhal behaviour in Milne Inlet before Project shipping?
    b) Does relative abundance and distribution of narwhals change during and after a ship passage?
    c) Is narwhal group composition affected?
    d) Does narwhal behaviour change during and after a ship passage?
    e) How does subsistence hunting affect narwhal behaviour?
    f) Do the number and characteristics of narwhal calls change in the presence of shipping?
3) What are short-term, long-term, and cumulative effects of shipping and underwater noise on marine mammals?

4.2 MARINE MAMMAL EEM CANDIDATE STUDIES SELECTION

A series of monitoring studies have been developed to address potential Project shipping effects on marine mammals during the ERP. The monitoring studies are designed to complement each other and to allow effects monitoring at both a regional and local scale. Results will be integrated to provide a more complete understanding of marine mammal response to Baffinland shipping activities during the ERP (see Section 4.3.8). A summary of the monitoring studies is provided in Table 4.1. These studies were primarily selected because of low levels of certainty with effects predictions and because of NIRB Project Certificate requirements.

Table 4.1 Summary of EEM – Mammal Studies According to Current Program Level

VEC (Key Indicator)	Type	Description
All marine mammals	Surveillance	Ship-based observers on some Baffinland vessels
Narwhals and bowhead whales	EEM	Shore-based monitoring of narwhals from Bruce Head, Milne Inlet before, during and after ship transits.
	EEM	Regional-level aerial surveys of Pond Inlet, Eclipse Sound, Milne Inlet, Navy Board Inlet, and Koluktoo Bay
	EEM	Acoustic recordings of ambient noise levels, shipping sounds, and marine mammal calls.
Narwhals	EEM	Local-level aerial photographic surveys of narwhals in northern Milne Inlet and Tremblay Sound before, during and after ship transits.

4.3 EEM STUDY SCHEDULE

A nominal schedule for the MEEMP-Marine Mammals will be developed following the completion of data analyses for the 2015 field season. A schedule will be presented by year, through to 2025. To date, monitoring programs (with the exception of the acoustic study) have been conducted annually for three years. Subsequent to establishment of a firm baseline, and development of statistically valid null hypotheses, a less frequent sampling schedule will be employed. Programs at a research level are for defined periods of time with continuation of monitoring at a higher level (surveillance or EEM) to be determined based on the research study results. Programs to be conducted at a surveillance level will be subject to changes in response to any observed effects that could trigger an expanded monitoring program (both spatially and temporally).

4.4 EEM STUDY DESIGN AND DESCRIPTIONS

4.4.1 RATIONALE AND BACKGROUND

The MEEMP is designed to investigate the responses of marine mammals to shipping through Eclipse Sound, Milne Inlet, Pond Inlet, and Koluktoo Bay during the open-water season. The numbers and species of marine mammals that occur in the vicinity of Baffinland's northern shipping route vary with date and environmental conditions and different species of marine mammals rely on different resources while in the vicinity of northern shipping route. The monitoring studies need to be able to address the possibility of habituation by the animals. It is known that mammals react differently to ships (and other anthropogenic activities) depending on their previous level of experience with shipping and their activities during exposure (Ellison *et al*. 2012).

One of the MEEMP's objectives is to gain an understanding of the natural variability of marine mammal distribution, abundance and behaviour along the northern shipping route. The design of the monitoring program is premised on (and designed to test) the expectation that, while some avoidance behaviour of shipping will occur, it is likely that animals will have minimal response to and will habituate to the slow moving, regular pattern of shipping traffic associated with the Project.

The main null hypotheses to be tested during the study are:

> *H_o: Marine mammal distribution and relative abundance does not change in the presence of open-water shipping.*
>
> *H_o: Marine mammal behaviour does not change in the presence of open-water shipping.*

Associated hypotheses related to the length of time that any distributional or behavioural responses persist will be addressed to determine whether habituation occurs over time. Specific hypotheses are provided in each EEM study below.

The NIRB Project Certificate includes requirements (Condition #106 and #123) that Baffinland employ ship-based observers to monitor interactions with marine mammals and seabirds with Project shipping activities. It was also important that Baffinland provide the opportunity for local stakeholders to be involved in these marine mammal monitoring activities (Condition #126).

4.4.2 Study Area and Key Species

The overall study area includes Koluktoo Bay, Milne Inlet, Eclipse Sound, Pond Inlet, Navy Board Inlet, and Tremblay Sound. The monitoring effort and schedule in each of these areas varies and is outlined below for each EEM study. A map of the overall study area is provided (Figure 4.1) to put the MEEMP in a regional context.

Narwhals are the primary species of interest in the Eclipse Sound – Milne Inlet area because they are present in large numbers during the open-water season when shipping occurs and because it is a major resource used by local hunters. The other regularly occurring cetacean species (albeit in much reduced numbers) that will be studied (if possible) is the bowhead whale. There will be small numbers of belugas and killer whales in the area on occasion but their numbers are too small to form the basis for a quantitative effects study. Information on pinnipeds (ringed seal, bearded seal, walrus, and harp seal) and polar bears will also be recorded but they are not a focus of MEEMP.

Monitoring efforts for the ERP are focused on the open-water period when Baffinland shipping will occur. The open-water season is tentatively defined as the period from break-up of the landfast ice in Milne Inlet in mid to late July to sometime in late October or early November when ships can last operate within Eclipse Sound, Milne Inlet and Pond Inlet without icebreaker support.

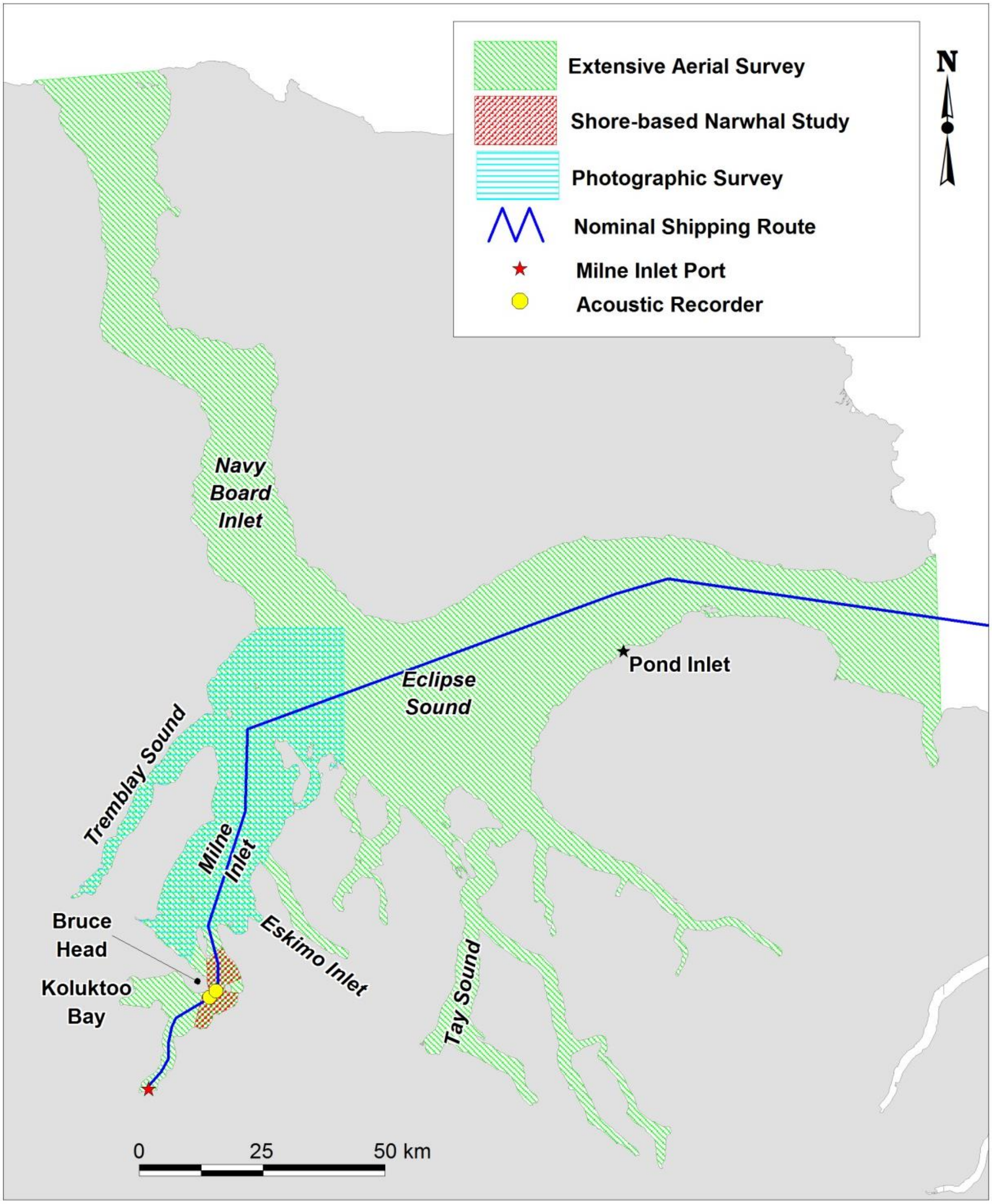

Figure 4.1 Study Areas for Marine Mammal and Acoustic Monitoring Studies.

4.4.3 Statistical Approach

4.4.3.1 Rationale for Sampling Approaches

The primary objective of marine mammal monitoring is to test for and quantify effects from Baffinland shipping activity on narwhal distribution, relative abundance, and behaviour. The monitoring studies required various sampling and modelling approaches due to the differing spatial-temporal scales of the responses being tested. Three sampling approaches are summarized below along with their advantages and disadvantages. Taken together, all three complement each other to form a synergistic effects monitoring program for narwhals and Project shipping activity during the ERP.

Extensive Aerial Surveys — At the largest spatial scale, annual variation in the general distribution of narwhals across the Eclipse Sound complex (i.e., Pond Inlet, Eclipse Sound, Milne Inlet, Koluktoo Bay, Tremblay Sound, Navy Board Inlet, smaller fjords) throughout a typical open-water season had to be understood to anticipate when and where narwhals will likely occur in relation to vessel transits along the northern shipping route. This knowledge was gained from expanded aerial surveys of the entire study area spread over the open-water season for multiple years (see Elliott et al. 2015; Thomas et al. 2015). Though some season-area combinations were missed due to logistical limitations, the extensive aerial surveys conducted in 2007, 2008, and 2013–2015 provide the data necessary to describe the general seasonal pattern in distribution and the annual variation therein. While this sampling regime is adequate to detect large-scale movements of narwhals from a given area-time period combination that deviates from baseline, more acute and less severe narwhal responses to shipping require greater sampling resolution.

Photographic Aerial Surveys — In 2015, directed aerial surveys were conducted over Milne Inlet and Tremblay Sound before, during, and after vessels passed through northern Milne Inlet. These surveys collected high-resolution photographs that will be analyzed after the field season. From these images, the number, exact location, and direction of travel for narwhal groups will be determined. Thus, this sampling effort provides the greatest spatial resolution of narwhal density and behaviour (albeit only one aspect of behaviour) in relation to shipping events. The disadvantage of this approach is the restricted amount of flying time, which limited observation of shipping events co-occurring with substantial narwhal presence in the study area. Moreover, in 2015, the surveys were never performed in the complete absence of a shipping event (particularly given that ships were anchored within the Study Area at Ragged Island). Nevertheless, sufficient data were obtained to test for shipping effects on narwhals (the nominal modelling approach is outlined below).

Shore-based Study — The shore-based study (2013–2015) from Bruce Head, Milne Inlet provides more continuous data on narwhal abundance and behaviour both on days without shipping events and also on days before, during, and after a shipping event. These data afford greater temporal resolution than the two approaches mentioned above, but spatial resolution for the shore-based survey is restricted to a smaller geographic area (described below).

4.4.3.2 Experimental Design and Model Specifications

Defining Narwhal Response Variables — For all three survey types, several response variables were used to index the distribution and abundance of narwhals. The extensive aerial surveys enumerated narwhals for each 2-min sample along the transect lines, while the photographic survey and shore-based study provided the same information for each photograph and spatial stratum, respectively. Both the number of narwhal sightings and the group size for each sighting was recorded for each sampling unit. Both number of sightings and total number of narwhals can be modelled with a negative binomial distribution that accounts for over-dispersion in the data.

For the photographic survey, two other types of responses are available. First, the perpendicular distance from the vessel's ultimate track line can be recorded for each group sighted, and can be considered a response in itself. Evidence for vessel effects on narwhals (i.e., an avoidance response) would be indicated if this distance increases as a vessel comes closer. This response has the advantage of removing all zero observations, and can likely be modelled as a log-normal distribution. Second, the headings for each narwhal group sighted within a photograph can be summarized and binned into four categories: (1) parallel to the vessel track line and headed toward the vessel, (2) parallel and headed away from the vessel, (3) perpendicular and headed toward the track line, and (4) perpendicular and headed away. These data would form a multinomial response for each photograph that could be tested against the vessel's approach.

Finally, for the shore-based study the number of narwhals in each spatial substratum across the study area could be considered a multinomial response as well. There are 26 possible substrata, but some may be pooled together during analyses. An effect on narwhals would be evidenced if their distribution pattern shifts during vessel transits.

Quantifying Vessel Transits — Important metrics describing a vessel transit will include (1) whether a vessel is approaching or leaving with respect to a sampling unit, (2) the vessel's bearing in relation to the sampling unit, and (3) the line-of-sight distance between the vessel and the sampling unit. Metrics 2 and 3 can be combined into polar coordinates (Polar X and Polar Y). The axis of each sample's "pole" will always be placed perpendicular to the track line. The interaction of this coordinate with the categorical variable vessel "Approaching/Leaving" will be incorporated into the analyses.

When testing the sightings, number and presence/absence responses, each sampling unit's distance from the vessel track line will be interacted with Polar X. If the vessel transit is having an effect, these responses should increase in samples further from, and decrease in samples closer to, the track line as Polar X becomes smaller (i.e., the ship approaches closer).

Modifying the Before-After-Control-Impact Design — The photographic surveys and shore-based study were designed to test for acute responses by narwhals to shipping events. The most powerful experimental design used to assess environmental effects is the before-after-control-impact (BACI) design. The heterogeneous habitat in the study area and the ecology of narwhals precludes the selection of a suitable "control" or reference site. However, a before-after-control-gradient (BAG) design can be applied (Ellis and Schneider 1997). Under the BAG design, the terms in a statistical model that characterize the disturbance are continuous instead of categorical. The term designating control versus impact becomes the continuous variable, and the variable "time since vessel presence" gets interacted with the binary term designating before versus after. Depending on feasibility of this approach, refinements will be made.

Accounting for Extraneous Variables — Extraneous variables are defined as those forces that partially confound the levels of the factor of interest. For example, visibility would be an extraneous variable if it happened to be poor during most of the shipping activity, but good in absence of shipping. Other variables are not confounding, but merely add variability to responses, and therefore lower the power to detect effects from the factor of interest. Analyses of the effects of shipping on narwhals are complicated by such variables including other anthropogenic factors such as hunting.

Available environmental covariates will be entered into the models for these surveys to account for as much natural variation in narwhal responses as possible. However, a key confounding factor in attempting to determine the effects of vessel transits on narwhals is the frequent occurrence of narwhal hunting at the base of Bruce Head and in surrounding areas. At present it is difficult to account for hunting activity because shore-based and aerial observers can only record hunting activity when they are surveying; in other words, there is much time when this information is unavailable. Community-based monitoring may contribute to quantifying hunting activity.

4.4.4 Ship-based Observers

4.4.4.1 Overall Approach

The Project commenced in 2013 with the transport of fuel and supplies by vessels transiting between Quebec City and Milne Inlet and concurrently, the Ship-based Observer Program was initiated as a pilot study (SEM 2013). In 2014 and 2015, the Ship-based Observer Program was continued during construction activities in Milne Port (SEM 2015c). Fuel tanker and sealift vessel traffic in and out of Milne Port provided the opportunity to conduct ship-based observations between Pond Inlet and Milne Port. Ship-based observers surveyed the shipping route embarking at Pond Inlet and disembarking at Milne Port. Future ship-based observer monitoring will include observers being placed on Baffinland ore carriers during Project operation.

4.4.4.2 Study Design

Marine mammal surveys will be completed during daylight hours with scheduled breaks to avoid observer fatigue. Observers will continually scan a 180° viewing area (from port to starboard side, out to the horizon) for the presence or sighting cues of marine mammals (dorsal fins, blows, breaching). Observers will use 7 x 50 range finder binoculars to determine mammal species and distance from the vessel, once a sighting is confirmed. An "Incidental Marine Mammal Sighting Form" will be completed for each confirmed sighting. Ledwell (2003) and Reeves *et al*. (1992) will be used as reference material for marine mammal identification.

The survey method for seabird surveys is the Partial Tasker, Method 1 (SEM 2015c), which provides data fundamental for seabird survey designs, and is considered effective for the experience levels of the observers. During each seabird survey, all birds within a 300 m transect of the observer's viewing area will be identified to the species level where possible, counted and recorded as either flying or on the water. Birds observed outside of the transect will be counted but recorded as outside the survey transect. Birds initially sighted by eye will be observed with 7 x 50 binoculars to allow for species identification as required. Each survey will be conducted for 20 minutes in duration; ten minutes with a 90° scanning area from the bow to starboard side, followed by another ten minutes with a 90° scanning area from the bow to port side (for a total of 180°). All surveys will be conducted from the bridge of the vessel.

4.4.5 Shore-based Study of Narwhals

4.4.5.1 Overall Approach

The shore-based monitoring of narwhals began in 2013 and this first year was considered a pilot study. A pilot approach was taken to allow potential logistical issues and data collection protocols to be refined prior to increases in shipping activities associated with the ERP. In 2013, the study team consisted of three marine biologists and three Pond Inlet residents. Narwhal distribution and relative abundance data as well as focal group composition behaviour data were collected from August 6–26, 2013. The shore-based study continued in 2014 and 2015 and each year's approach and study design was improved based on lessons learned the previous year. A notable change was that the study team size and the study period were doubled after 2013 to increase the amount of data collected.

The study is currently designed to collect three primary types of narwhal data (relative abundance and distribution, group composition, and behaviour). Data were collected from a shore-based location on Bruce Head (N 72°4'17.76", W 80°32'35.52") at an elevation of ~215 m above mean sea level (Figure 4.2). Ship track logs for large vessels were compiled from various sources and integrated into a single database. Environmental and other anthropogenic activity data (including local hunting activity) were collected to investigate and to account for, additional sources of variability in narwhal relative abundance, distribution, and behaviour. As well, data were collected to sample the full 24-hour period to account for potential daily variation in narwhal numbers. Baseline data collected in the absence of large vessels are valuable and necessary for the investigation of narwhal response to any type of disturbance.

Figure 4.2 The Observation Platform at Bruce Head, 2014.

4.4.5.2 Study Design

Visual observations by biologists and trained local observers (from Pond Inlet) were used to document narwhal response to Baffinland vessels in waters near Bruce Head, Milne Inlet. A summary of the Study Design is provided in Table 4.2. As noted above, three primary types of narwhal data were the focus of this study: (1) relative abundance and distribution, (2) group composition, and (3) behavioural data. An overview of the methods and hypotheses associated with each type of data are provided below. Detailed methods for the 2014 study are provided in Smith *et al*. (2015). Based on results to date (primarily 2013 and 2014; see Thomas *et al*. 2014 and Smith *et al*. 2015), key issues that will have to be addressed include the natural variation of narwhal distribution/abundance as well as behaviour, and the effects of narwhal hunting in the Bruce Head study area.

Table 4.2 Summary of Shore-based Narwhal Study Design.

Project Interaction	Project Activity	Shipping
	Environmental Effect	Narwhal avoidance of shipping; changes in narwhal behaviour related to shipping
Hypothesis Formation		Will narwhal distribution and relative abundance change as a result of Baffinland shipping activity? Will narwhal behaviour change during and after a vessel transit? If changes in distribution and relative abundance occur, how long will they last? Will the duration of an effect decrease as narwhals possibly habituate to regular and repeated vessel traffic?
Monitoring Target		Narwhal distribution and relative abundance Narwhal group composition Narwhal behaviour
Design Type		Before-after-control-gradient (BAG)
Testable Hypotheses		$H1_0$: Narwhal distribution and relative abundance does not significantly change in response to a large vessel transit. $H1_A$: Narwhals move away from a vessel and narwhal numbers decrease in response to a large vessel transit. $H2_0$: Narwhal group characteristics do not significantly change in the presence of a vessel. $H2_A$: Narwhal group characteristics do significantly change in the presence of a vessel. $H3_0$: Narwhal behaviour does not significantly change in the presence of a vessel. $H3_A$: Narwhal behaviour does significantly change in the presence of a vessel. $H4_0$: Narwhals do not habituate to large vessel shipping. $H4_A$: Narwhals habituate to large vessel shipping.
Sample Size Requirements		To be determined.
"Sampling"	Frequency	Annually, during the open water season; minimum of three years
	Location	Southern Milne Inlet, adjacent to Bruce Head
	Timing	August/early September
Data Collection Methods		Visual observations using scan sampling, abundance counts, and group follows.
Analyses Approach		Generalized linear mixed model (GLMM)
Data Interpretation and Reporting		GLMM of relative abundance and distribution data that can account for influences of natural environmental factors and other sources of anthropogenic activity. To date, behaviour and group composition data have been examined with univariate statistical tests but will potentially be examined via modelling.

4.4.5.3 Relative Abundance and Distribution Data

Relative abundance and distribution (RAD) data have been collected before, during and after a large vessel entered the Stratified Study Area (SSA; Figure 4.3) as well as during periods when no vessels are in the area. Group size, direction of travel and substratum were recorded for each narwhal sighting. During each count of the nine strata (A to I, see Figure 4.3) observers recorded environmental conditions within each substratum (e.g., A1, A2, etc.) and the type and location of any anthropogenic activity that occurred within the SSA.

The key hypothesis is whether large vessel presence affected narwhal abundance in the SSA. More specifically:

> *$H1_{0:}$ Narwhal distribution and relative abundance does not significantly change in response to a large vessel transit.*
>
> *$H1_{A:}$ Narwhals move away from a vessel and narwhal numbers decrease in response to a large vessel transit.*

To statistically test the above hypothesis, narwhal count data have been modelled using a generalized linear mixed model (GLMM), with a discrete probability distribution to calculate the likelihood of observing the counts that were recorded. The "mixed" terminology of the GLMM indicates that the model incorporates some predictors as "fixed" terms and some as "random" terms. Fixed terms are used mostly when the researcher is interested in how the mean response differs across only those levels of the factor, whereas random terms are used when the only interest is removing variation due to a factor and generalizing the results across all of its possible levels. In the GLMM used for narwhal count data, vessel presence has been modelled as a fixed term. Environmental covariates were entered into the model to account for natural variation in narwhal count data. As briefly noted above, a key confounding factor in attempting to determine the effects of large vessel transits on narwhals is the frequent occurrence of narwhal hunting at the base of Bruce Head and in surrounding areas.

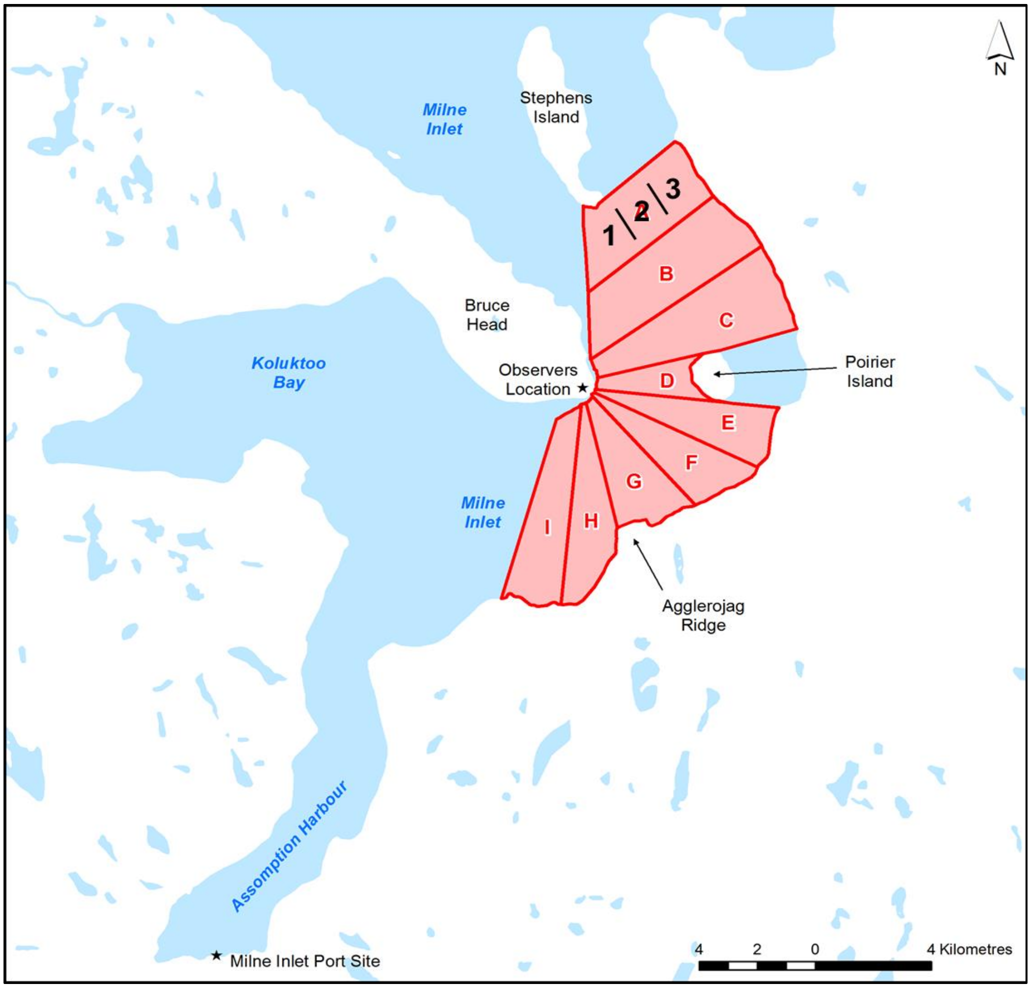

Figure 4.3 The Stratified Study Area (SSA) for Shore-based Observations of Narwhal Relative Abundance and Distribution at Bruce Head.

4.4.5.4 Group Composition

Group composition data have been collected on narwhals that swim through the Behavioural Study Area (BSA; Figure 4.4) and pass within ~1,000 m of shore. Group composition data were collected by a team of three observers employing survey and scan sampling protocols (Mann 1999). Photographs were taken when possible and examined later to verify or augment data recorded in the field. Data that have been collected includes group size, number of narwhals with tusks, age category, spread, formation, direction of travel, speed of travel, and distance from shore. These data were used to test the following hypothesis regarding group composition:

$H2_{0:}$ Narwhal group characteristics do not significantly change in the presence of a vessel.

$H2_{A:}$ Narwhal group characteristics do significantly change in the presence of a vessel.

Group characteristics (i.e., group spread, formation, swim speed and distance from shore) in the presence and absence of shipping were tested with parametric tests (Pearson's Chi-squared statistic) when sample sizes permit, otherwise non-parametric tests like the Mann-Whitney *U* test were used. These analyses have to take into account that groups with different compositions (e.g., presence vs. absence of calves) may respond differently to vessel presence. It is possible that different statistical approaches will be taken to account for factors other than shipping that might affect group composition.

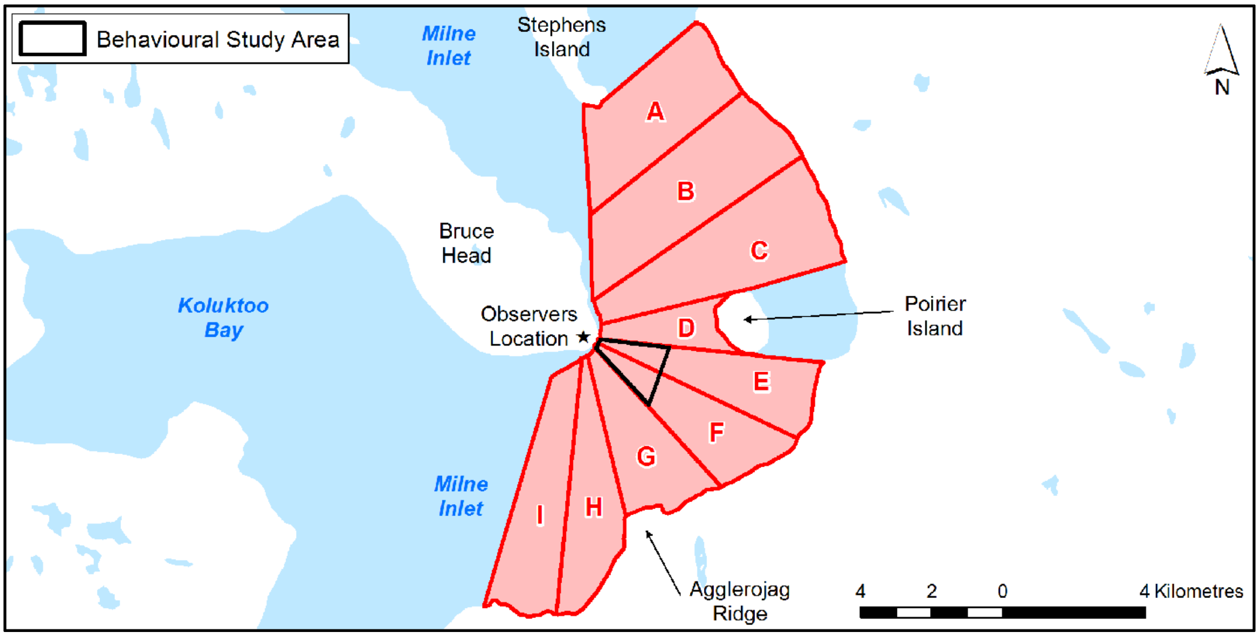

Figure 4.4 Approximate Boundaries of the Behavioural Study Area (BSA) for the Shore-based Narwhal Study at Bruce Head.

4.4.5.5 Behavioural Data

Behavioural observations have been made on narwhals in the BSA (Figure 4.4). Data were collected by a team of three observers employing a modified group-follow and predominant group activity sampling protocols (Mann 1999). Group-follow is defined as monitoring a group of animals for >30 min; predominant group-activity is defined based on the assessment of the activity engaged in by >50% of group (Mann 1999). Beside primary and secondary behaviour types, group size, group composition, group spread and group formation were recorded. The key hypothesis is whether vessel presence affected narwhal behaviour in the BSA. More specifically:

$H3_{0:}$ Narwhal behaviour does not significantly change in the presence of a vessel.

$H3_{A:}$ Narwhal behaviour does significantly change in the presence of a vessel.

Several behavioural parameters were examined in the presence and absence of vessels including trackline metrics and behaviour types.

4.4.6 Aerial Surveys

4.4.6.1 Review of Baseline Data

Systematic aerial surveys of marine mammals in the study area occurred in 2007 and 2008; these data were used in support of the FEIS and its Addendum (Appendix 8A-2 in Volume 8 of the FEIS). During the open-water seasons of 2013 and 2014, baseline data were specifically collected in support of the marine mammal monitoring program (Elliott *et al*. 2015; Thomas *et al*. 2015). The 2013 and 2014 aerial surveys were not designed to systematically determine short-term and localized effects of shipping on cetacean distribution and abundance. The survey design has been modified in 2015 when the frequency of shipping for the ERP will increase substantially relative to 2013 and 2014). A summary of survey effort during 2013 and 2014 is provided in Table 4.3. The aerial survey crew consisted of biologists from LGL and local observers from Pond Inlet.

During all aerial surveys, narwhals were by far the most frequently encountered marine mammal. Narwhal numbers and distribution vary greatly from day-to-day, within a season, and amongst years (see Elliott *et al*. 2015 and Thomas *et al*. 2015). A general trend observed during the surveys was that narwhal densities peaked from mid-August to early September. Densities typically decreased by mid-September. By late September, narwhals had moved out of Milne Inlet, Koluktoo Bay and Tremblay Sound. As the open-water season progressed, narwhals were more frequently observed in Eclipse Sound, and in mid-October narwhals were observed in Pond Inlet. As ice cover becomes extensive, narwhals appear to leave the Eclipse Sound complex and start moving toward their wintering areas. Narwhals were seldom observed in Navy Board Inlet despite substantial survey effort in this area, particularly in 2014. It has become quite clear that the natural variation in narwhal abundance and distribution in the study area and along the shipping route has to be accounted for when attempting to determine the effects of shipping. A power analysis was conducted based on the 2014 dataset to offer insight into EEM design — see below for a summary of the findings and Appendix A for details.

Table 4.3 Summary of Aerial Survey Effort (Baseline Data) for Marine Mammals in the Study Area in Support of ERP Monitoring.

Date	Survey Period	Geographic Strata Surveyed	Linear Distance Surveyed (km)
1–4 August, 2014	Early August	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	2,113.9
14–17 August, 2014	Mid August	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	2,208.8
30 August – 2 September, 2014	Late August	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	2,092.9

Table 4.3 Summary of Aerial Survey Effort (Baseline Data) for Marine Mammals in the Study Area in Support of ERP Monitoring.

Date	Survey Period	Geographic Strata Surveyed	Linear Distance Surveyed (km)
14–17 September, 2014	Mid September	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	2,264.2
29 September – 2 October, 2014	Late September	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	2,160.4
17–22 October, 2014	Mid October	MIS, MIN, KB, TS, ESW, ESE, NBI, PI fjords	1,775.0
Total In 2014			**12,615.12**
31 August – 1 September, 2013	Late August	MIS, MIN KB, TS ESW, NBI	1,047.3
14–15 September, 2013	Mid September	MIS, MIN KB, TS ESW, NBI	1,059.6
29–30 September, 2013	Late September	MIS, MIN, KB, TS, ESW, ESE, NBI	1,510.0
14, 16–18 October, 2013	Mid October	MIS, MIN, KB, TS, ESW, ESE, NBI, PI	1,528.3
Total in 2013			**5,145.5**

Note: MIS=Milne Inlet South, MIN=Milne Inlet North, KB=Koluktoo Bay, TS=Tremblay Sound, ESW=Eclipse Sound West, ESE=Eclipse Sound East, NBI=Navy Board Inlet, PI=Pond Inlet.

4.4.6.2 Study Design

The aerial survey study design includes a two-pronged approach as noted in Section 4.3.3.1; an extensive survey (Figure 4.5A) similar to that surveyed during baseline data collection in 2013 and 2014 (and 2007 to 2008) and a photographic survey (Figure 4.5B) in northern Milne Inlet and Tremblay Sound that will focus on times before, during and after vessel passages. This two-pronged approach will allow for detection of “large-scale” as well as “finer-scale” changes in narwhal distribution and abundance. Further details are provided below and in Table 4.4.

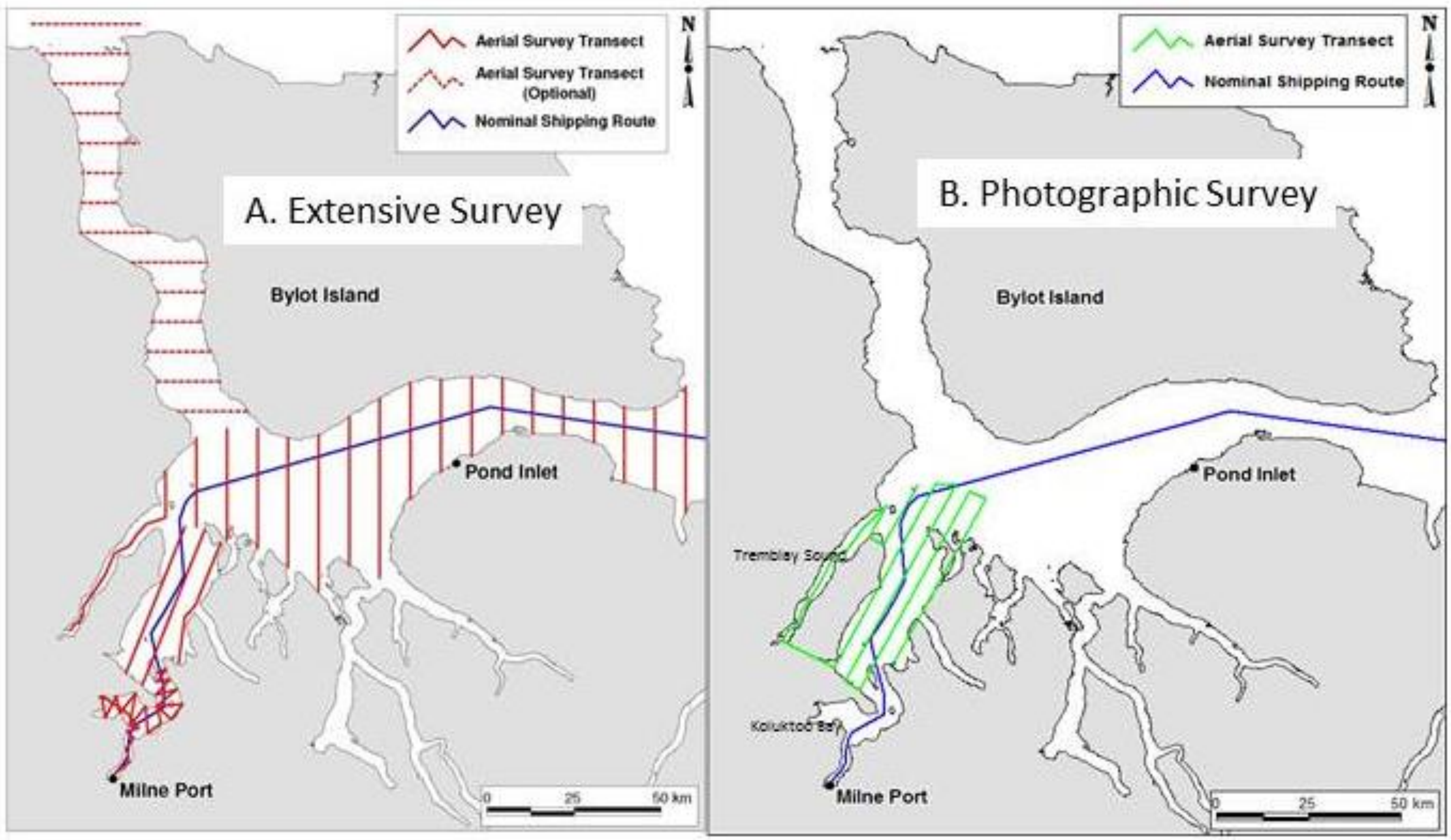

Figure 4.5 Marine Mammal Aerial Survey Transects for the (A) Extensive Surveys and (B) Photographic Surveys in 2015.

Table 4.4 Summary of Aerial Survey Study Design.

Project Interaction	Project Activity	Shipping
	Environmental Effect	Narwhal avoidance of shipping
Hypothesis Formation		Will narwhal distribution and relative abundance change as a result of Baffinland shipping activity? If changes in distribution and relative abundance occur, how long will they last? Will the duration of an effect decrease as narwhals possibly habituate to regular and repeated vessel traffic? How far away from the ship will narwhals exhibit avoidance?
Monitoring Target		Narwhal distribution and relative abundance Narwhal distribution/abundance relative to ship track and time since vessel transit
Design Type		Baseline, Before-after-control-gradient (BAG)
Testable Hypotheses		$H1_0$: Narwhal regional distribution and relative abundance does not significantly change in response to a large vessel transit. $H1_A$: Narwhals move away from a vessel and narwhal numbers decrease in response to a large vessel transit. $H2_0$: Narwhals do not habituate to large vessel shipping. $H2_A$: Narwhals habituate to large vessel shipping.
Sample Size Requirements		To be determined.
“Sampling”	Frequency	Have been conducted annually since 2013, during the open water season. Future frequency to be determined.
	Location	Pond Inlet, Eclipse Sound, Milne Inlet, Koluktoo Bay, Navy Board Inlet, Tremblay Sound and smaller fjords (baseline only).
	Timing	August, September, and October (some years)
Data Collection Methods		Line-transect survey methodology Photographic survey of transects flown at 2,500 ft
Analyses Approach		Generalized linear mixed model (GLMM)
Data Interpretation and Reporting		GLMM of relative abundance and distribution data that can account for influences of natural environmental factors and other anthropogenic activities (e.g., hunting).

Extensive Aerial Surveys — Aerial survey data along and adjacent to the northern shipping route acquired in 2007, 2008, 2013 and 2014 provide a series of “baseline” data for monitoring of shipping effects on narwhals during the operational years of the ERP and beyond. Marine mammal data have been collected along an extensive survey grid (Figure 4.5A) to document potential large changes in narwhal spatial-temporal distribution in response to shipping activity. Also, Baffinland is specifically required to monitor Eclipse Sound, Pond Inlet, and Milne Inlet (see Project Certificate No. 109). Power analysis results indicate that previously collected data along the extensive aerial grid and the approach has sufficient statistical power to detect large scale changes in narwhal distribution and abundance (Raborn 2015). However, detecting smaller scale changes using the extensive survey grid approach is unlikely given the large natural variation in narwhal distribution and abundance (see Section 4.3.3.1). In 2015, an extensive grid was surveyed during each of four survey periods, i.e., every two weeks (early August, mid-August, late August, mid-September) similar to that flown in 2014 (Figure 4.5A). Navy Board Inlet was not surveyed in 2015. However, the aerial crew was prepared to survey Navy Board Inlet (and potentially other areas) in the event that large scale changes in narwhal distribution and abundance were detected during photographic surveys of northern Milne Inlet and Tremblay Sound.

Photographic Surveys — Photographic surveys of northern Milne Inlet and Tremblay Sound (see Figure 4.5B) were conducted periodically over ~30 days during the peak period narwhals occur in these key summering areas and when the majority of Baffinland vessel transits were expected during 2015. Koluktoo Bay was not surveyed photographically to minimize the chance of affecting narwhals in the shore-based study area. Photographic surveys were "centered" around Baffinland vessel (primarily ore carrier) transits in Milne Inlet to the extent possible— i.e., aerial surveys occurred before, during, and after a vessel passage. This approach will allow determination of whether there are movements of narwhals in a substantial portion of their primary summering habitat in response to repeated ship traffic. An assessment at this spatial-temporal scale is particularly important during the first operational years of the ERP. By documenting narwhal relative abundance and distribution in relation to a vessel track before, during and after a transit, it is possible to approximate the extent of potential avoidance, the area(s) where narwhals may move to avoid a ship transit, and approximately how long narwhals avoid an area around a vessel.

4.4.7 Acoustic Monitoring

4.4.7.1 Overall Approach

The use of underwater acoustic recorders provides an important means to monitor marine mammals during periods when visual observations are not possible (due to poor weather/darkness and/or personnel scheduling) and when animals are not at the surface to be seen. Additionally, acoustic monitoring provides information to assist in verification of effects predictions regarding marine mammal response to shipping noise. In 2014, Greeneridge Sciences Inc. implemented a pilot study on passive acoustic monitoring of narwhals and vessels in Milne Inlet (Kim and Conrad 2015). The objectives of the pilot study were to characterize the local soundscape in terms of baseline noise levels, shipping sounds, and marine mammal calls.

During the pilot study, two autonomous underwater acoustics recorders (ASARs) were deployed adjacent to Bruce Head in Milne Inlet (Figure 4.6). One recorder was deployed along the Milne Inlet shipping corridor with the primary goal of measuring vessel sounds. The second recorder, whose primary goal was to measure marine mammal sounds, was deployed 1.2 km offshore of Bruce Head. The ASARs operated on a 100% duty cycle from deployment on 30 July until retrieval on 26 September, 2014.

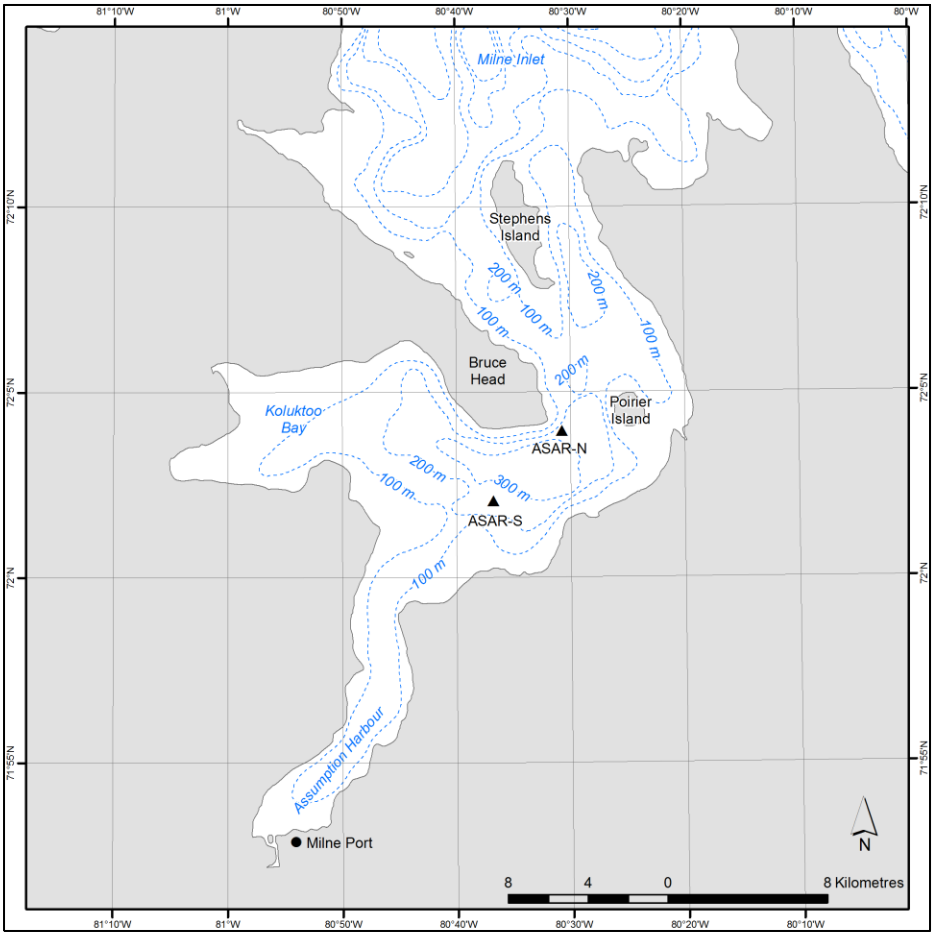

Figure 4.6 Locations of Acoustic Recorders (ASARs) Deployed Near Bruce Head in 2014.

The 2014 pilot study presented interesting findings regarding ship sounds and marine mammal calls but larger sample sizes are required to assess effects of shipping on narwhals. Increased shipping along the northern shipping route during the 2015 open-water season provided an opportunity to assess the effects of repeated large ore carrier transits on narwhals.

4.4.7.2 Study Design

In 2015, two ASARs were deployed near Bruce Head as was done during the 2014 pilot study. One ASAR was deployed in the nominal shipping channel and the other closer to Bruce Head. Acoustic data were collected to overlap with the timing of the shore-based narwhal study and the aerial surveys, i.e., early

August to mid-September (in 2015). The ASARs were configured to sample at a rate of 48,000 samples/s (48 kHz) per hydrophone, creating sound records spanning the frequency band from 2 to 24,000 Hz. Thus, each of the two recorders were capable of detecting low-frequency shipping sounds, whose energy resides primarily below 500 Hz, and marine mammal vocalizations at low to moderately high frequencies, for example, narwhal socialization whistles and some components of their pulsed calls.

Acoustic data is being analysed for ambient noise levels, shipping sounds, other anthropogenic sound sources and marine mammal calls. Narwhal call characteristics (type, frequency) will be examined in the presence and absence of large ships as well as in the presence of hunting activity. The presence and frequency of narwhal calls during periods with shipping and without shipping will also be examined. Acoustic data will also play a key role in the integration of the three marine mammal monitoring components (see Section 4.3.8). A summary of the acoustic EEM study design is presented in Table 4.5.

4.4.7.3 Integration of Narwhal Monitoring Studies

Baffinland has been periodically conducting narwhal studies in the Milne Inlet and Eclipse Sound area since 2007. Prior to this, LGL (Baffinland's marine mammal consultant) undertook some of the first narwhal (and beluga whale) studies in the Eclipse Sound complex and Lancaster Sound. A consistent finding in all studies is the large degree of natural variation in narwhal distribution and abundance. Large numbers of narwhals seemingly regularly move from one area to another in very short periods of time. This has been documented as 'herding' events during the shore-based study at Bruce Head (see Smith *et al*. 2015) and extreme variation in narwhal numbers during back-to-back aerial survey replicates of the same area (Elliott *et al*. 2015; Thomas *et al.* 2015). This presumably natural variation in narwhal distribution and abundance makes it virtually impossible to use a single study in real-time to determine whether adaptive management procedures for Baffinland shipping should be implemented. We cannot, in real time, readily attribute changes (i.e., cause and effect relationship), even seemingly obvious changes, in narwhal distribution and abundance to the passage of a large vessel(s). A further complexity is the frequent marine mammal (primarily narwhal) hunting that occurs from the base of Bruce Head and in the nearshore waters of northern Milne Inlet during the open-water season. Results from all marine mammal monitoring studies need to be considered in an integrated fashion each year and reviewed to determine whether shipping effects on narwhals necessitate adaptive management activities and if so, what level of response is warranted.

Table 4.5 Summary of Acoustic Study Design.

Project Interaction	Project Activity	Shipping
	Environmental Effect	Narwhal avoidance of shipping Change in narwhal vocalizations
Hypothesis Formation		Does presence/absence of narwhal calls change relative to ship transits? Does narwhal call type and frequency of calls change relative to ship transits? What received sound levels (if any) from ore carriers result in marine mammal avoidance? Will the duration of an effect decrease as narwhals possibly habituate to regular and repeated vessel traffic?
Monitoring Target		Ambient noise levels Shipping sounds Narwhal calls Other marine mammal calls
Design Type		Baseline Before, During and After Impact
Testable Hypotheses		$H1_0$: Presence of narwhal calls does not significantly change relative to a large vessel transit. $H1_A$: Presence of narwhal calls does significantly change relative to a large vessel transit. $H2_0$: Narwhal call types and frequency of calls do not significantly change in response to large vessel transits. $H2_A$: Narwhal call types and frequency of calls do significantly change in response to large vessel transits.
Sample Size Requirements		To be determined
"Sampling"	Frequency	Annually, during the open water season since 2014. Future frequency to be determined.
	Location	Milne Inlet near Bruce Head
	Timing	August and September
Data Collection Methods		Deployment of 2 acoustic recorders near Bruce Head. Sampling rate of 48 kHz
Analyses		Ship source levels Ambient noise levels Narwhal call types, frequency of calls
Data Interpretation and Reporting		Comparisons of number of narwhal calls relative to ship transits as well as changes in call types

5 ASSESSMENT OF EEM RESULTS AND MANAGEMENT RESPONSE

Data collected in each of the monitoring studies of the MEEMP are evaluated systematically to determine the existence of a Project-induced change and, if necessary, to determine the appropriate management response (see Figure 2.1). The framework for data assessment and management response will be implemented as illustrated in Figure 5.1. The steps are described below.

Step 1 — Evaluating Data and Detecting Change — For all studies, QA/QC is carried out on the monitoring data. Statistical analyses are carried out on the collected data either to test the null hypothesis (if applicable), or to compare with baseline values or regulatory guidelines. The outcome is a determination whether a change has occurred. If no change has been detected, no further action is required. If a null hypothesis is rejected, or measurable change is observed, then the data will be assessed further under Step 2. For all monitoring programs, Step 1 would occur on an annual cycle.

Step 2 — Determining if Change is Project-related — Step 2 involves determining if the detected change can be linked to Project activities or other factors.

Project activities that have the potential to cause the observed change will be reviewed to determine the likely source of disturbance. In the case of marine ecology, this could include: rates and regimes of discharge to the marine environment, loading activities and dust deposition and ballast water discharge at Milne Ore Dock. Any evidence of natural causes (e.g., changes in discharge from Phillips Creek) and the influence of natural events (e.g., oceanographic and meteorological patterns) would also be investigated. In the case of marine mammals, this could involve, for example, a more detailed investigation into marine mammal hunting activities.

Where the effects predictions indicate a zone of influence from Project activities, the sampling gradient will serve to examine the spatial extent and pattern of observed change. A comparison to sampling sites outside the ZOI will be useful in evaluating the data at this step.

If the identified changes are not linked to the Project, management response would consist of documentation of the analyses and sharing the results.

Step 3 — Determining the Level of Response — Step 3 follows a conclusion in Step 2 that the identified changes are in likely Project-induced. In this step, the required level of management response is determined.

A **low level response** for marine ecosystems is initiated when the triggering level is approached. The triggering level is different for each monitoring program and could be half the guideline value, the guideline value itself, or some assigned change with respect to baseline (e.g., within two standard deviations from baseline).

A **low level response** for marine mammals is initiated when only one null hypothesis from the effects monitoring studies has been rejected. The potential exception is the extensive aerial survey study where rejection of the null hypothesis would lead to a moderate level response.

The low level response might include:

- Identifying the source and location of the observed change (a higher level of detail to what was conducted in Step 2);
- Identifying specific sampling stations that will help monitor the observed change in subsequent years;
- having external reviewers examine the technical soundness of the statistical test;
- examining need for and specific requirements of increased monitoring based on findings of the marine mammal integration report; and
- further evaluation of data to determine next steps.

A **moderate level response** is initiated when the triggering level is exceeded and it has been concluded that the exceedance is likely due to the Project. A **moderate level response** is undertaken for marine mammals when two or more null hypotheses have been rejected and/or the extensive aerial survey null hypothesis has been rejected. The effects of shipping on marine mammals (i.e., narwhals) have to be causally-linked to the Project.

In addition to the actions indicated for a low level response, the moderate level response would include:

- determining if management or mitigation is required based on trend analysis and/or an evaluation of the potential pathways of effect;
- developing a high level response 'trigger' with input from MEWG and other stakeholders
- conducting a risk assessment which considers other monitoring results in combination with the monitoring target where the observed change occurred;
- evaluating the need for increased monitoring or additional monitoring; and
- identifying next steps based on points above.

A **high level response** would be initiated if the response trigger is exceeded. Overall effects on the ecosystem and next steps should be discussed with regulatory agencies, and actions to be taken might include:

- implementing mitigation measures while monitoring to assess their effectiveness; and
- implementing increased monitoring to define the magnitude and/or spatial extent of the effects.

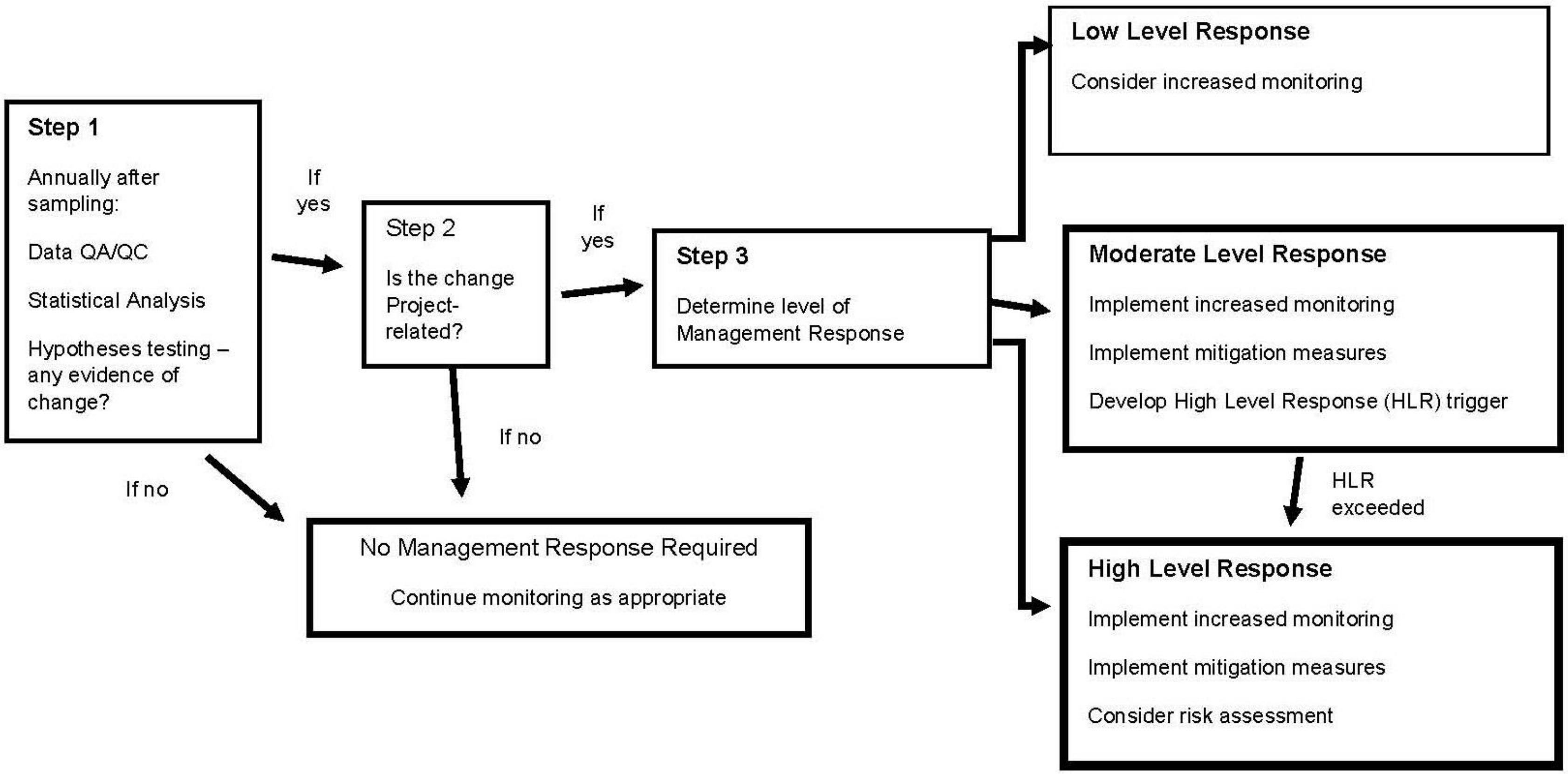

Figure 5.1 Framework for Assessment and Response for Marine Environmental Effects Monitoring.

5.1 FRAMEWORK FOR EVALUATION OF EFFECTS

A risk-based approach to integrating the results of the component monitoring programs will be undertaken, drawing from the approach applied at the Meadowbank Mine to the extent possible (Azimuth 2010). Monitoring results will be evaluated using the following risk-oriented criteria:

- Magnitude — the degree to which an indicator approaches or exceeds the established benchmark (or other guideline, if different than the benchmark);
- Extent — the scale at which the change or exceedance occurs;
- Causation — the strength of evidence for a Project-related cause;
- Reversibility — the likelihood that the effect may be reversed over time; and
- Uncertainty — the confidence or lack thereof in the findings regarding the above criteria.

The above criteria will be applied to each indicator or species for each study program as appropriate. Results can be summarized using the nominal rating system presented in Table 5.1, with particular emphasis given to Causation.

Once data are summarized for each component program, key findings from each program will be evaluated together in the MEEMP so that issues can be identified and response actions developed. This evaluation will be based on the response framework presented in Figure 5.1.

Management actions will also be implemented as identified in Figure 5.1. For marine ecology, in the instance of detecting change among multiple monitoring targets or species, action will be implemented according to the highest action level of any of the components detecting change and/or exceedance of benchmarks.

Mitigation measures can be applied at any time that a change is detected or statistically significant result occurs. It is not necessary to wait until a benchmark is exceeded. In the case of marine ecology, exceedance of a benchmark triggers a moderate action response. Moderate Action Responses may include mitigation measures that are easily implemented at low-cost and in a short time-frame. Such mitigation measures may already be identified as contingency or adaptive management measures within various management plans for the Project.

Key agency and community stakeholders can be consulted in the development of High Action Responses. High Action Responses are those mitigation measures that tend to take longer to implement, at higher cost and may have their own potential effects to be considered.

Table 5.1 Rating Criteria for the Evaluation of Effects.

Criteria	Classification	
Magnitude — The degree of change; specific to the Indicator/VEC and the impact	Level I	Change to the Indicator is not distinguishable from natural variation and is well below EWI
	Level II	Change to the Indicator is clearly distinguishable and approaching EWI
	Level III	Change to the Indicator is clearly distinguishable and exceeds the EWI
Extent — The physical extent of the effect, relative to study area boundaries	Level I	Isolated occurrence or very small area
	Level II	Moderately sized area affected, such as a portion of the ZOI
	Level III	The entire ZOI is likely to be affected
Causation — The strength of evidence that the effect is Project-related	Level I	No evidence that effect is Project-related
	Level II	Some likelihood that the effect is Project-related
	Level III	Very likely to be Project-related
Reversibility — The likelihood of the Indicator/VEC to recover from the effect	Level I	Fully reversible in less than 10 years
	Level II	Reversible over a long period of time (i.e., decades)
	Level III	Largely irreversible for at least several decades
Certainty — Degree of certainty or uncertainty in the findings of the monitoring data	High	High certainty in findings based on monitoring data
	Medium	Moderate certainty in findings based on monitoring data
	Low	Limited or conflicting monitoring data, resulting in a low certainty

6 QUALITY ASSURANCE AND QUALITY CONTROL

QA/QC steps will be in place to ensure that high quality and representative data are obtained in a manner that is scientifically defensible, repeatable and well documented. QA/QC will ensure that rigorous standard methods and protocols are used for the collection of all environmental data/samples. QA/QC begins at the project management level through organization and planning, and is assured by the monitoring of external and internal quality control measures (some of which are listed below). An essential component of QA/QC for the MEEMP is the review of all monitoring procedures/protocols by MEWG members. The MEWG meets twice each year to review the adequacy of the monitoring approach and the findings provided in monitoring technical reports. The following lists summarize the QA/QC procedures and practices to be followed:

- Internal Quality Control:
  - Staffing the project with experienced and properly trained individuals;
  - Checking field data for errors;
  - Ensuring that representative, meaningful data are collected through planning and efficient research;
  - Recording detailed field notes to verify completeness and accuracy of the recorded data;
  - Following standard operating procedures for sample collection, preservation, and documentation;
  - Calibrating and maintaining all field equipment; and
  - Collecting blind duplicates for submission to the laboratory (when appropriate).

- External Quality Control:
  - Employing fully accredited analytical laboratories for the analysis of all samples;
  - Determining analytical precision and accuracy through the interpretation of the analysis reports for the blind duplicate samples;
  - Engaging expert review of statistical analysis approach/methods; and
  - MEWG to review monitoring approach and technical reports.

7 REPORTING

The MEEMP monitoring results will be presented annually and reports will be delivered to NIRB on a schedule as agreed with Baffinland. It is anticipated that two types of reports will be prepared: (1) a higher level integration report that summarizes all monitoring activities and any management recommendations; and (2) detailed technical reports for each of the MEEMP components. The higher level report will provide a compilation, assessment and interpretation of findings across monitoring programs, and present an issue-specific evaluation of effects.

Recommendations will be provided in regard to revisions to study designs or management response actions for each key issue. The MEEMP itself will be updated periodically, as required and determined in conjunction with the MEWG. Updates to the MEEMP may consist of modifications to study designs, or termination of shorter-term targeted studies accompanied by adequate rationale, or implementation of EEM level programs to elucidate results in cases where surveillance level study results warrant.

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