TECHNICAL SUPPORTING DOCUMENT

Mary River Project | Phase 2 Proposal | FEIS Addendum | August 2018

TSD 17

Marine Environmental Effects Assessment






MARINE ENVIRONMENT TECHNICAL SUPPORTING DOCUMENT SUMMARY

The marine environment Technical Supporting Document (TSD) provides an assessment of the Phase 2 Proposal's effects on the marine environment (marine water and sediment quality, marine fish habitat, and Arctic char health), mitigation measures to minimize or avoid adverse effects, identification of potential residual impacts following implementation of mitigation, and a determination of significance with respect to Project impacts on selected VECs.

The updated marine environment baseline report includes new information collected or published since submission of materials for the Approved Project. Project effects that were previously assessed for marine water and sediment quality remain unchanged in the context of the Phase 2 Proposal. The Phase 2 Proposal builds on the extensive baseline studies and assessments carried out since 2011 for the larger Approved Project and is thus closely linked to the FEIS and previous addendums.

The expanded Project footprint in the marine environment will result in the potential loss of productive fish habitat. Other potential effects of the Project on marine water and sediment quality, marine fish habitat, and Arctic char health may result from port construction, vessel traffic, ballast water discharge (which could introduce invasive species to the marine environment), wastewater discharges, ore dust deposition, and underwater noise.

Proposed mitigation for potential effects includes implementation of management plans, such as the Shipping and Wildlife Management Plan, the Emergency Response and Spill Contingency Plan, Environmental Protection and Monitoring Plans, and the Surface Water and Aquatic Ecosystem Management Plan. Habitat loss will be compensated through the creation of new habitat, as required by the Fisheries Act.

Based on the present assessment with supportive information from the Approved Project and planned mitigation, Project activities proposed as part of the Phase 2 Proposal are predicted to result in insignificant adverse residual effects on established VECs (marine water and sediment quality, marine fish habitat, and Arctic char health).

RÉSUMÉ DE LA DOCUMENTATION TECHNIQUE COMPLÉMENTAIRE SUR LE MILIEU MARIN

La documentation technique complémentaire sur le milieu marin comporte une évaluation des impacts de la proposition de la phase 2 sur le milieu marin (qualité des eaux et sédiments marins, habitat du poisson marin et santé de l'omble chevalier), des mesures d'atténuation pour minimiser ou éviter les impacts nocifs, l'identification des impacts résiduels potentiels après la mise en œuvre des mesures d'atténuation et une détermination de l'importance des impacts du projet sur les CVE sélectionnées.

Le rapport de référence actualisé sur le milieu marin comprend de nouveaux renseignements recueillis ou publiés depuis la soumission des documents pour le projet approuvé. Les impacts du projet qui ont déjà été évalués pour la qualité de l'eau de mer et des sédiments marins demeurent inchangés dans le contexte de la proposition de la phase 2. La proposition de la phase 2 est fondée sur les études préliminaires et les évaluations complètes réalisées depuis 2011 pour l'ensemble du projet approuvé et est donc étroitement liée à l'énoncé des incidences environnementales (EIE) et aux addendas précédents.

L'empreinte élargie du projet dans le milieu marin entraînera la perte potentielle de l'habitat productif du poisson. D'autres impacts potentiels du projet sur la qualité des eaux de mer et des sédiments marins, l'habitat du poisson marin et la santé des ombles chevaliers pourraient résulter de la construction de ports, du trafic maritime, des eaux de ballast (qui pourraient introduire des espèces envahissantes dans le milieu marin), de la décharge d'eaux usées, du dépôt de minerai et du bruit sous-marin.

Les mesures d'atténuation proposées pour contrer de tels impacts comprennent la mise en œuvre de plans de gestion, tels que le plan de gestion de la navigation et de la faune, d'un plan d'intervention d'urgence et de lutte contre les déversements, de plans de protection et de surveillance de l'environnement et d'un plan de gestion des eaux de surface et aquatiques. La perte d'habitat sera compensée par la création d'un nouvel habitat, comme l'exige la Loi sur les pêches.

Selon l'évaluation actuelle et les mesures d'atténuation prévues, les activités proposées dans le cadre de la proposition de la phase 2 entraîneraient des impacts résiduels négatifs insignifiants sur les CVE établies (qualité de l'eau de mer et des sédiments marins, habitat du poisson marin et santé de l'omble chevalier).

ᑕᕆᐅᑉ ᐊᕙᑖᓄᑦ ᐱᔭᕆᐊᑐᔪᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᑦ ᐅᓂᒃᑳᓕᐊᑦ

ᐅᓇ ᑕᕆᐅᑉ ᐊᕙᑖᓄᑦ ᐱᔭᕆᐊᑐᔪᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᑦ ᐅᓂᒃᑳᓕᐊᑦ (TSD) ᓴᖅᑮᒍᖅ ᕿᒥᕐᕈᐃᓂᕐᒥᒃ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖓᑦ ᐅᒃᑑᑎᖓᑕ ᐊᒃᑐᐃᓂᖃᕐᓂᐊᓂᒃ ᑕᕆᐅᑉ ᐊᕙᑖᓄᑦ (ᑕᕆᐅᖅ ᐃᒪᖓᓃᑦᑐᓪᓗ, ᑕᕆᐅᑉ ᐃᖃᓗᖏᑕ ᓇᔪᖓᖏᑦ, ᐊᒻᒪᓗ ᐃᖃᓗᐃᑦ ᐅᑎᖅᑕᓱᑦ ᖃᓄᐃᖏᓐᓂᖏᑦ), ᓄᖅᑲᖓᑎᑦᑎᔾᔪᑎᑦ ᐱᓕᕆᓃᑦ ᐊᒃᐸᓯᒋᐊᕆᓂᕐᒧᑦ ᓴᓂᖅᑯᑦᑎᓂᒻᒥᓪᓘᓐᓃᑦ ᐱᐅᖏᑦᑐᓂᒃ ᐊᒃᑐᐃᓂᓐᓂᒃ, ᓇᓗᓇᐃᕆᓂᖅ ᕿᒪᕈᖅᑕᐅᔪᓄᑦ ᐊᒃᑐᐃᓂᖏᑕ ᐊᑐᓕᖅᑎᑕᐅᒍᑎᒃ ᓄᖅᑲᖓᑎᑦᑎᔾᔪᑏᑦ, ᓇᓗᓇᐃᕆᓂᓪᓗ ᐊᒃᑎᒋᓂᐊᓂᒃ ᐊᒃᑐᐊᔪᑦ ᐅᔾᕿᓐᓂᐊᓐᓂᐅᑉ ᐊᒃᑐᐃᓂᖏᓐᓂᒃ ᓂᕈᐊᖅᑕᐅᓯᒪᔪᓄᑦ ᐊᓐᓂᕈᕈᓐᓃᕆᔭᑦ ᐃᓗᓕᖏᓄᑦ ᐊᕙᑎᐅᑉ (VEC).

ᓄᑖᖑᕆᐊᖅᓯᒪᔪᑦ ᑕᕆᐅᑉ ᐊᕙᑖᓄᑦ ᑐᙳᕕᒃᓴᖅ ᐅᓂᒃᑳᖓᑦ ᐊᒻᒪ ᐃᓚᕐᑲᖅᑯᓂᓗ ᓄᑖᓂᒃ ᑐᑭᓯᐅᒪᔾᔪᑎᒃᓴᓂᒃ ᑲᑎᖅᓱᖓᑦ ᑎᑎᕋᐅᓯᐅᔪᓪᓘᓐᓃᑦ ᑕᐃᑲᙳᓂᑦ ᑎᑎᕋᐅᓯᑦ ᓯᕗᓪᓕᖅᐸᑦ ᑐᓐᓂᕆᔭᐅᓚᐅᖅᑎᓪᓗᒋᑦ ᐊᖏᖅᓯᒪᔭᒧᑦ ᐅᔾᕿᓐᓂᐊᓐᓂᒻᒧᑦ. ᐅᔾᕿᓐᓂᐊᖅᑐᑦ ᐊᒃᑐᐃᓂᖏᑦ ᓯᕗᓂᐊᒍᑦ ᕿᒥᕐᕈᔭᐅᓂᑰᓪᓗᑎᒃ ᑕᕆᐅᑉ ᐃᒪᖏᓄᑦ ᑰᒃᑕᐅᔪᓪᓗ ᐃᓱᕈᑎᒋᓲᖏᑦ ᓱᕐᕋᕐᑯᔭᐅᓇᑎᒃ ᐃᓱᒪᒋᔭᐅᓗᓂ ᐃᓗᓕᖏᑦ ᓴᓇᐅᒪᓂᐅᑉ 2 ᐅᒃᑑᑎᖓᒍᑦ. ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖓᑦ ᐅᒃᑑᑎᖓ ᐃᓚᒋᐊᕆᔭᕐᑲᖅᑐᖅ ᕐᑳᖓᒍᑦ ᐊᖏᕐᔫᑦ ᑐᙳᕕᑦ ᖃᐅᔮᓴᕕᓃᑦ ᐊᕙᑖᓄᑦ ᑕᒪᓐᓇᓗ ᕿᒥᕐᕈᐃᓂᖅ ᑕᐃᑲᖓᑦ 2011-ᒥ ᑖᓯᒨᖓ ᐃᓗᐃᑦᑑᔪᒧᑦ ᐊᖏᖅᓯᒪᔭᒧᑦ ᐅᔾᕿᖕᓂᐊᕐᓂᕐᒧᑦ ᑕᐃᒫᓪᓗ ᓂᒃᓯᒃᓯᒪᓂᕐᑲᖅᐳᖅ ᑭᖑᓪᓕᖅᐸᓪᓕᐹ ᐅᓂᒃᑳᖏᓄᑦ FEIS ᓯᕗᓂᐊᒍᓪᓗ ᐅᐃᒍᒋᐊᖅᑕᐅᓂᑯᔪᒃᑯᑦ.

ᐊᖏᓚᒋᐊᖅᑐᖅ ᐅᔾᕿᖕᓂᐊᖅᑐᑦ ᓄᓇᒃᑯᑦ ᐃᓂᖓ ᑕᕆᐅᑉ ᐊᕙᑖᓂᒃ ᓴᖅᑮᓂᐊᕆᒍᖅ ᐊᓯᐅᔫᑐᐃᓐᓇᕆᐊᖅᑲᕐᓂᕐᒥᒃ ᐊᐅᓚᑦᑎᐊᖅᑐᑦ ᐃᖃᓗᐃᑦ ᓇᔪᒐᕆᔾᔪᖓᓂᒃ. ᐊᓯᖏᑦ ᐊᒃᑐᐃᓂᐅᑐᐃᓐᓇᕆᐊᓕᒃ ᐅᔾᕿᓐᓂᐊᖅᑐᓄᑦ ᑕᕆᐅᑉ ᐃᒪᖓᓄᑦ ᐃᓱᓐᓂᖓᓄᓪᓗ, ᑕᕆᐅᑉ ᐃᖃᓗᖏᑕ ᓇᔪᖓᖏᓐᓄᑦ ᐊᒻᒪ ᐃᖃᓗᐃᑦ ᐅᑎᖅᑕᓱᑦ ᖃᓄᐃᖏᓐᓂᖏᑕ ᓴᖅᑭᑦᑐᓐᓇᖅᐳᑦ ᐅᒥᐊᕐᔪᐊᓕᕆᓭᕕᐅᑉ ᓴᓇᔭᐅᓂᐊᓄᑦ, ᐅᒥᐊᕐᔪᐊᑦ ᐃᖏᕐᕋᓂᖏᓄᑦ, ᐃᒃᑕᖅᑯᑎᖏᑕ ᐃᒪᐅᑉ ᑯᕕᔭᐅᓂᖏᓄᑦ (ᓴᖅᑮᑐᐃᓐᓇᕆᐊᓕᒃ ᑎᑭᕋᖅᑐᓂᒃ ᐆᒪᔪᓂᒃ ᑕᕆᐅᑉ ᐊᕙᑖᓄᑦ), ᐊᑐᖅᓯᒪᔪᑦ ᐃᒪᖏᑦ ᑯᕕᔭᐅᔪᑦ, ᓴᕕᕋᔭᒃᓴᑦ ᐳᔪᖓᓄᑦ ᑲᑕᒑᕐᕕᐅᓂᖓᓄᑦ, ᐊᒻᒪᓗ ᐃᒪᖓᒧᑦ ᓂᐱᖅᑯᖅᑐᓂᐊᓄᑦ.

ᐊᑐᖅᑕᐅᔪᒪᔪᑦ ᓄᖅᑲᖓᔾᔪᑎᑦ ᓴᖅᑭᑐᐃᓐᓇᕆᐊᓕᓐᓄᑦ ᐊᒃᑐᐃᓂᓐᓄᑦ ᐃᓚᕐᑲᖅᑐᑦ ᐊᑐᓕᖅᑎᑦᑎᓂᕐᒥᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐸᕐᓇᐅᑎᓂᒃ, ᓱᕐᓗ ᐅᓯᒃᖃᑕᐃᓃᑦ ᓂᕐᔪᑎᓪᓗ ᑲᒪᒋᔭᐅᓂᖏᓐᓄᑦ ᐸᕐᓇᐅᑎᖓ, ᑐᐊᕕᕐᓇᖅᑐᒃᑯᑦ ᐅᐸᒍᑎᓂᖅ ᐊᒻᒪ ᑯᕕᔪᕐᑲᕈᓂ ᐊᑐᐃᓐᓇᐅᔪᓂᒃ ᐸᕐᓇᐅᑎᖓ, ᐊᕙᑎᒧᑦ ᓴᐳᒻᒥᕝᔪᑎᑦ ᐊᒻᒪᓗ ᕐᑲᐅᔨᓴᐃᓐᓇᕐᓂᕐᒧᑦ ᐸᕐᓇᐅᑎ, ᓄᓇᐅᑉ ᕐᑳᖓᓂ ᐃᒪᖏᑦ ᐃᒪᕐᒥᐅᑕᓪᓗ ᐆᒪᔪᑦ ᑲᒪᔾᔪᑎᖏᑦ ᐸᕐᓇᐅᑎᖏᑦ. ᓇᔪᖓᐅᔪᑦ ᐊᓯᐅᑎᑕᐅᔪᑦ ᑭᖑᕝᕕᖅᑕᐅᓇᔭᖅᑐᑎᒃ ᓄᑖᓂᒃ ᓇᔪᒐᒃᓴᖏᓐᓂᒃ ᓴᓇᔭᕐᑲᕐᓗᑎᒃ ᐃᒪᕐᑲᖅᑐᒥᒃ, ᐊᑐᕐᑯᔭᐅᓂᖓ ᒪᓕᒡᓗᒍ ᐃᖃᓗᓕᕆᓂᐅᑉ ᐱᕐᑯᔭᖓᓄᑦ.

ᑐᙳᕕᓪᓗᓂ ᐅᓪᓗᒥ ᕿᒥᕐᕈᔭᐅᓂᐊᓄᑦ ᐃᑲᔪᐃᔾᔪᑎᕐᑲᖅᑐᓂ ᑐᑭᓯᐅᒪᔾᔪᑎᓂᒃ ᐊᖏᖅᑕᐅᓯᒪᔩᑉ ᐅᔾᕿᓐᓂᐊᕐᓂᕐᒧᑦ ᐊᒻᒪᓗ ᐸᓐᓇᐅᙳᔪᑦ ᓄᖅᑲᖓᔾᔪᑎᖏᓄᑦ, ᐅᔾᕿᓐᓂᐊᖅᑐᑦ ᐱᓕᕆᓂᖏᑦ ᐊᑐᕈᒪᔭᐅᔪᑦ ᐃᓚᒋᔭᑦ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖓᓂ ᐅᒃᑑᑎᖓᑕ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᖅ ᒥᑭᑦᑐᒥᒃ ᕿᒪᐃᒐᔾᕐᓂᖏᓐᓂᒃ ᓴᖅᑭᑕᐅᓯᒪᔪᓄᑦ ᐊᓐᓂᕐᓇᖅᑐᓄᑦ ᐊᕙᑎᒥ (ᑕᕆᐅᑉ ᐃᒪᖓ ᐃᓱᖅᓯᒃᑦᑕᕐᓂᖓ, ᑕᕆᐅᑉ ᐃᖃᓗᖏᑕ ᓇᔪᖓᖏᑦ, ᐃᖃᓗᐃᑦ ᐅᑎᖅᑕᓱᑦ ᖃᓄᐃᖏᓐᓂᖏᑦ).

REPORT

Baffinland Iron Mines Corporation
Mary River Project – Phase 2 Proposal

Technical Supporting Document No. 17: Marine Environment Effects Assessment

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1 August 2018

Distribution List

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviations and Acronyms	Definition
°C	Degree Celsius
AIS	Aquatic invasive species
ANCOVA	Analysis of covariance
Baffinland	Baffinland Iron Mines Corporation
BB	Baffin Bay
BWMP	Ballast Water Management Plan
CCG	Canadian Coast Guard
CCME	Canadian Council of Ministers of the Environment
Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CPUE	Catch per unit effort
CSAS	Canadian Science Advisory Secretariat
dB	decibel
DFO	Fisheries and Oceans Canada
EEZ	Exclusive Economic Zone
EIS	environmental impact statement
ERP	Early Revenue Phase
ESA	*Endangered Species Act*
FEIS	Final Environmental Impact Statement
Golder	Golder Associates Ltd.
IDZ	Initial Dilution Zone
ISQG	Interim Sediment Quality Guidelines
LSA	Local Study Area
Project	Mary River Project
MEEMP	Marine Environmental Effect Monitoring Program

Abbreviations and Acronyms	Definition
MMER	Metal Mining Effluent Regulations
Mtpa	million tonne per annum
µg/L	microgram per litre
µm	micrometre
µPa	micropascal
NIRB	Nunavut Impact Review Board
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic aromatic hydrocarbons
PAL	Probable Effect Level
ppt	Parts per Thousand
PSU	Practical Salinity Unit
PTS	permanent threshold shifts
RSA	Regional Study Area
SEL	sound exposure level
SEM	Sikumiut Environmental Management Ltd.
SMWMP	Shipping and Marine Wildlife Management Plan
SPL	sound pressure level
TTS	temporary threshold shifts
VEC	Valued Ecosystem Component
USFWS	United States Fish and Wildlife Service

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TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

The Mary River Project is an operating iron ore mine located in the Qikiqtani Region of Nunavut (Figure 1-1). Baffinland Iron Mines Corporation (Baffinland; the Proponent) is the owner and operator of the Project. As part of the regulatory approval process, Baffinland submitted a Final Environmental Impact Statement (FEIS) to the Nunavut Impact Review Board (NIRB), which presented in-depth analyses and evaluation of potential environmental and socioeconomic effects associated with the Project.

In 2012, NIRB issued Project Certificate No 005 which provided approval for Baffinland to mine 18 million tonnes per annum (Mtpa) of iron ore, construct a railway to transport the ore south to a port at Steensby Inlet which operates year-round, and to ship the ore to market. The Project Certificate was subsequently amended to include the mining of an additional 4.2 Mtpa of ore, trucking this amount of ore by an existing road (the Tote Road) north to an existing port at Milne Inlet, and shipping the ore to market during the open water season. The total approved iron ore production was increased to 22.2 Mtpa (4.2 Mtpa transported by road to Milne Port, and 18 Mtpa transported by rail to Steensby Port). This is now considered the Approved Project. The 18 Mtpa Steensby rail project has not yet been constructed, however 4.2 MTPA of iron ore is being transported north by road to Milne Port currently. Baffinland recently submitted a request for a second amendment to Project Certificate No.005 to allow for a short-term increase in production and transport of ore via road through Milne Port from the current 4.2 Mtpa to 6.0 Mtpa.

The Phase 2 Proposal (the third project certificate amendment request) involves increasing the quantity of ore shipped through Milne Port to 12 Mtpa, via the construction of a new railway running parallel to the existing Tote Road (called the North Railway). The total mine production will increase to 30 Mtpa with 12 Mtpa being transported via the North Railway to Milne Port and 18 Mtpa transported via the South Railway to Steensby Port. Construction on the North Railway is planned to begin in late 2019. Completion of construction of the North Railway is expected by 2020 with transportation of ore to Milne Port by trucks and railway ramping up as mine production increases to 12 Mtpa by 2020. Shipping from Milne Port will also increase to 12 Mtpa by 2020. Construction of the South Railway and Steensby Port will commence in 2021 with commissioning and a gradual increase in mine production to 30 Mtpa by 2024. Shipping of 18 Mtpa from Steensby Port will begin in 2025.

Phase 2 also involves the development of additional infrastructure at Milne Port, including a second ore dock (Figure 1-2). Shipping at Milne Port will continue to occur during the open water season, and may extend into the shoulder periods when the landfast ice is not being used to support travel and harvesting by Inuit. Various upgrades and additional infrastructure will also be required at the Mine Site and along both the north and south transportation corridors to support the increase in production and construction of the two rail lines.

LEGEND

- PROJECT SITE
- COMMUNITY
- FUTURE SOUTH RAILWAY
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA
- SHIPPING ROUTE
- SIRMILIK NATIONAL PARK
- WATER

0 125 250

1:5,000,000 KILOMETRES

REFERENCE(S)

BASE MAP: © ESRI DATA AND MAPS (ONLINE) (2016). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
PROJECT LOCATION

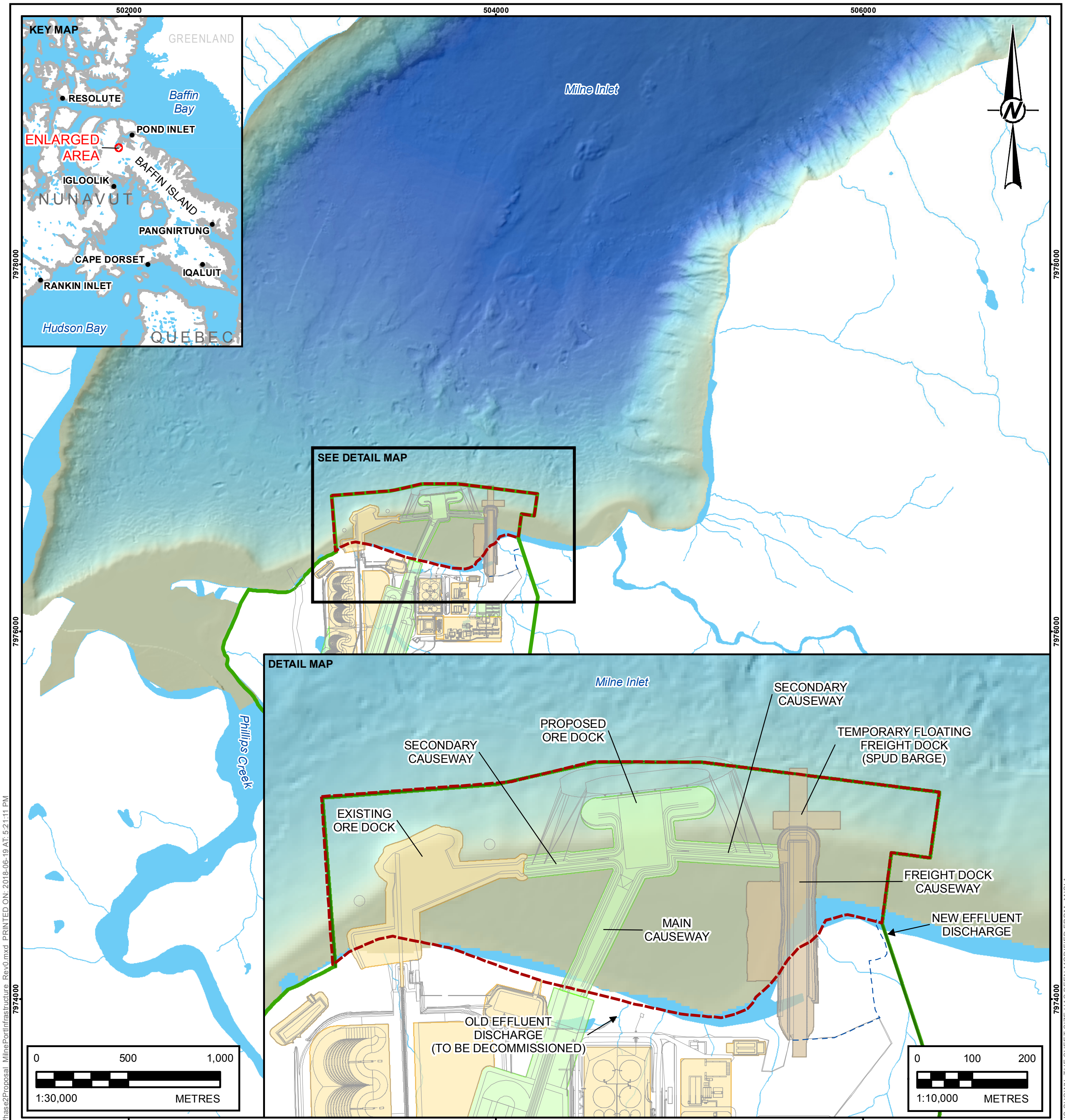
CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-19
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000-504	0	1.1

PATH: I:\2016\1663724\Mapping\MXD\Fish\TSD17_report\1663274_5000_504_TSD17_Fig1_1_Project_Location_Rev0.mxd PRINTED ON: 2018-06-19 AT: 5:19:47 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
25mm



LEGEND

- NEW EFFLUENT PIPELINE
- PDA / QIA COMMERCIAL LEASE
- SITE LAYOUT
- WATERCOURSE
- INAC FORESHORE LEASE
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- EXISTING FREIGHT DOCK AND CAUSEWAY
- WATERBODY

ELEVATION (masl)

High : 25

Low : -225

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT, MAY 28, 2108, AND BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES.. HYDROGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
MILNE PORT MARINE INFRASTRUCTURE

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-19
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000-504	0	1.2

1.1 Scope of the Assessment

1.1.1 Valued Ecosystem Components

This technical supporting document (TSD) provides an assessment of the effects of the Phase 2 Proposal on the marine environment, which includes both a physical and biological component. Marine Water and Sediment Quality was identified as the valued ecosystem component (VEC) for the marine physical environment. Marine Fish Habitat and Arctic Char Health were identified as VECs for the marine biological environment (collectively, representing Marine Habitat and Biota). VECs were selected based on the following rationale:

- High potential to interact with the Project;
- Commercial, social, cultural, and ecological importance in Project area;
- Physical or biological indicators for marine ecosystem health;
- Includes listed or protected species and/or sensitive habitat areas; and
- Identified as important during Inuit Qaujimajatuqangit (IQ) studies and stakeholder meetings.

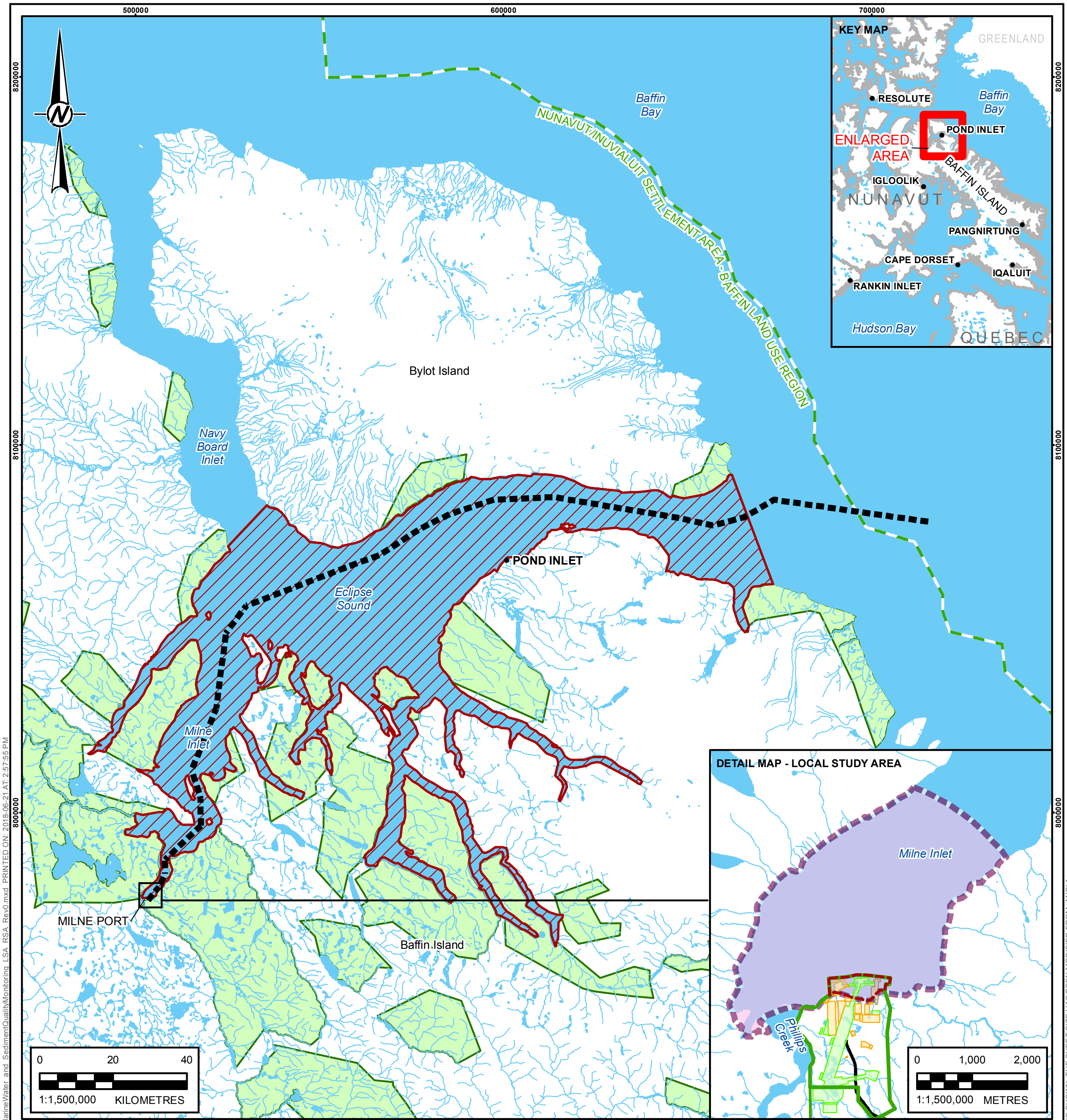
1.1.2 Spatial and Temporal Boundaries

Two spatial boundaries were used for the assessment of effects on the marine environment: a Local Study Area (LSA) and a Regional Study Area (RSA) (Figure 1-3). The LSA allows for an assessment of Project-related effects at a local, operational scale. The RSA allows for an assessment of Project-related effects at a regional, ecologically relevant scale on northern Baffin Island.

The LSA is defined as the area where there exists a reasonable potential for direct measurable effects from Project activities on the marine environment. The LSA includes all of Milne Port (Assomption Harbour) and extends north up to 4 m from the existing terminal (spanning the full width of Milne Inlet at the northern boundary). The southeast boundary of the LSA ends at the confluence of Milne Inlet with Phillips Creek.

The RSA is defined as the area where there is potential for direct and indirect incremental effects from the Project on marine environment VECs, in addition to potential cumulative effects from the Project in conjunction with existing, historical, and reasonably foreseeable developments in the Project area. The RSA encompasses all of Milne Inlet and Eclipse Sound (Baffinland 2012).

The temporal boundaries for the assessment of effects on the Marine Environment includes the construction, operation, closure and post-closure monitoring of the Phase 2 Proposal, which will occur over a total period of 28 years (2018-2046).



LEGEND

- COMMUNITY
- SHIPPING ROUTE (APPROXIMATE)
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- INAC FORESHORE LEASE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- NUNAVUT LAND CLAIMS AGREEMENT – POND INLET INUIT OWNED LAND
- WATERBODY

REFERENCE(S)

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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
MILNE PORT MARINE ENVIRONMENT - LOCAL STUDY AREA AND REGIONAL STUDY AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-21
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000-504	0	1.3

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1.2 Existing Environment

A detailed summary of baseline conditions for the Marine Environment is provided as Appendix A. The updated marine environment baseline report includes new information collected or published since submission of materials for the Approved Project.

1.3 Consultation

In 2015, the Nunavut Impact Review Board (NIRB) developed updated EIS guidelines for the Project (NIRB 2015) that reflected Inuit community and stakeholder concerns associated with potential Project-related effects on marine environment and biota. Primary concerns identified for the Marine Environment in Milne Port and along the Northern Shipping Corridor included potential changes to marine water quality from ballast water releases, potential changes to marine habitat health from Project discharges and runoff to the marine environment, and changes to the abundance and distribution of Arctic char and cod, and subsequent availability of these animals for harvesting.

Community engagement meetings regarding the Phase 2 Proposal were carried out in Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet. There were concerns identified during community meetings related to the marine environment inclusive of marine habitat, marine water/ice and marine sediment quality. Primary concerns identified by the communities with respect to potential Project effects on marine environment and biota included:

- Impacts to marine biota and water quality due to ballast water discharges;
- Contamination and health effects to the marine environment; and
- Fish (i.e. Arctic char and cod) abundance and distribution and subsequent change in harvesting availability.

Since 2012, potential Project effects on marine environment and biota have been discussed with the Marine Environmental Working Group (MEWG). This group was established to serve as an advisory group in connection with mitigation measures for the protection of the marine environment, and in connection with Baffinland's development and execution of the environmental effects monitoring program to address the Terms and Conditions of Project Certificate No. 005, as these pertain to the marine environment. In the context of the Phase 2 Proposal, the terms and conditions applicable to the marine environment focus primarily on monitoring requirements for evaluating physical, chemical and biological changes to the marine environment because of ballast water releases, effluent discharges, and contaminant loading in the marine environment (from run-off or dust dispersion) and subsequent effects on fish and fish habitat.

The present assessment focuses on issues of primary concern related to the marine environment as identified through engagement with the MEWG, Project stakeholders and local communities to date, and is based on the latest information available from the ongoing monitoring programs, as outlined in Section 2.3.

2.0 MARINE WATER & SEDIMENT QUALITY

2.1 Background on Project Effects

The following section provides a summary of Project effects that were previously assessed for marine water and sediment quality as part of the Approved Project. These effects were predicted to be not significant in both the FEIS and FEIS Addendum (Baffinland 2012; Baffinland 2013). Monitoring efforts completed to date support the FEIS determination (see Section 2.3).

2.1.1 Construction of Ore Dock

Pile installation, rock fill placement and backfilling activities during construction of the Milne Port ore dock were assessed as having a potential to affect water and sediment quality in Milne Inlet by introduction of nutrients, metals, and hydrocarbons and by increases in TSS through re-suspension of sediments.

Mitigation measures to prevent or reduce effects on marine water and sediment quality during construction in Milne Port were developed and included in environmental management plans. For instance, mitigation measures in the Dock Construction Environmental Plan (Ruskin, 2014) include: installation of silt curtains around the work site (as close as feasible) to reduce disturbance to local receiving waters; equipment checks, proper refuelling and equipment maintenance procedures to prevent inadvertent hydrocarbon leaks or spills to the marine environment. A Spill Contingency Plan was developed that can be initiated over short order in the event of a spill to contain the event and reduce adverse effects on marine water and sediment quality.

Overall, it was predicted that construction activities in Milne Inlet would result in localized and temporary increases in TSS, metals and associated nutrients in the water column. As a result, potential effects of ore dock construction on marine water and sediment quality were considered to be moderate in magnitude.

Turbidity monitoring outside silt curtains was conducted during construction of the existing ore dock from July 28 to September 12, 2014. Measurements show that turbidity values outside silt curtains did not exceed the long-term threshold CCME guideline (2014) value of 2 NTU above the background conditions except for three separate observations, which were attributed to natural short-term variations (ERM 2015). The construction activities were, therefore, deemed to comply with the conditions of the *Fisheries Act* Authorization with respect to turbidity and confirm the predictions of the FEIS and FEIS Addendum (Baffinland 2012; Baffinland 2013).

2.1.2 Vessel Traffic

Vessel traffic in Milne Inlet was assessed as having a potential to affect marine water and sediment quality through sediment re-suspension from propeller-generated currents and through discharge of effluents such as sewage or bilge water. Currents generated by ship propellers could cause seabed erosion and mobilization of finer seabed material (including sand and gravels) and the subsequent re-deposition of these materials in areas with less vessel activity. This would result in localized short-term increases in TSS, metals and nutrients in the water column. The affected seabed would be generally restricted to the vessel berth area due to the steep bottom gradient along the approaches within the inlet. Also, the frequency of re-suspension events was expected to decline after the seabed environment equilibrated to one with coarser substrates in the vicinity, after finer particulate materials had been redistributed outside of the disturbance area. Therefore, the magnitude of these effects was expected to be low.

Proposed mitigation included operation and maintenance of Project vessels in accordance with all applicable pollution prevention laws and regulations, and response to accidental spills in accordance with the Spill Contingency Plan to reduce potential effects on water and sediment quality. Consequently, residual effects to water or sediment quality due to ship discharges at dock side were determined to be negligible.

2.1.3 Ballast Water Discharge

Shipping in Milne Inlet during the operational phase of the ERP occurs during the open-water period. Ore carriers accessing Milne Inlet exchange ballast in the North Atlantic or Labrador Sea as per the Ballast Water Control and Management Regulations administered under the *Canada Shipping Act* and identified in the Shipping and Marine Wildlife Management Plan. The potential effect on water and sediment quality was assessed due to the difference in water characteristics between the Labrador Sea or Baffin Bay and Milne Inlet. The waters in the Labrador Sea and Baffin Bay have higher temperature and salinity, and lower concentrations of nitrate, silicate, and metals, such as cadmium and iron, compared to water in Milne Inlet.

If ships begin to discharge ballast water upon entry into Eclipse Sound and Milne Inlet, while still in transit, the ballast will be rapidly mixed with the surface water and will therefore have little or no effect on local water quality.

Ballast water dispersion, if discharged at the ore dock, was modeled to estimate potential effects on water quality at the port site. Due to density differences between the ballast water and the receiving waters, as well as the overall volume of the receiving water, it was predicted that water quality guideline thresholds would not be exceeded with exception to a slight increase in temperature (i.e., by more than 1 ^{0}C) within the immediate vicinity of the dock site. A ballast water eddy of lower nutrient (silicate and nitrate) concentrations could also occur at Milne Port moving along the bottom of the inlet to a point about 900 m offshore before dissipating at a depth of 100 m. As a result, the effects of ballast water discharges at Milne Port were determined to be of low magnitude.

2.1.4 Dispersion and Deposition of Dust from Ore Stockpiles and Ship Loading

According to air quality modelling completed at Milne Port, ore dust deposition has the potential to affect marine water and sediment quality via two pathways: (1) direct deposition in the marine environment; and, (2) indirect introduction from land-based runoff. The marine area expected to be affected by the direct aerial deposition of ore dust is approximately 2 km^2 with an expected annual weighted average deposition rate for this area of 8.6 g/m^2. The maximum amount of dust deposited on land is expected to be 360 tonnes per year. Dust deposition would occur year-round but would accumulate over winter on the ice and snow and would be introduced to marine water during the period of ice and snow melt.

In the worst case scenario, if the total annual loading of dust predicted to be directly deposited in the marine environment was instantaneously introduced, it would result in a TSS increase by less than 0.5 mg/L, which would practically be undetectable. Dust accumulated over the mainland within the Phillips Creek drainage basin over winter will result in an increase in TSS in the creek by between 2.6 and 8 mg/L during the 20-day spring freshet. This may cause low-level increases in TSS at Milne Port and may result in localized, short-term exceedances of the CCME water quality guidelines for the Protection of Marine Aquatic Life (CCME 2014) for TSS during the spring freshet. Dust introduced during the freshet via small watercourses, at the most conservative estimate, will result in a TSS increase by approximately 1 mg/L to 3 mg/L. Overall, effects of dust deposition on TSS in Milne Port are predicted to cause periodic, low-level exceedances of CCME guidelines (moderate magnitude) in localized areas near freshwater inputs and in the zone of greatest dust deposition in the marine environment.

Concentrations of metals, particularly iron, in water may measurably increase in the same areas due to introduction of dust, even though marine water quality guidelines for these metals do not exist. The magnitude of effects would therefore range from negligible (i.e., not detectable) to moderate (low-level exceedances) in the LSA.

Assuming uniform settling in the deposition zone, the cumulative total deposition over the life of the ERP would result in a layer averaging 0.049 mm thick. The greatest direct deposition to the marine environment (500 g/m^2/year) is expected to occur within the immediate vicinity of the ore dock (area 12,434 m^2) and would result in the addition of 0.115 mm of sediment annually. If all dust settling on land were introduced to the marine environment and settled in the zone of dust deposition, the accumulation on the bottom would be additional 0.003 mm to 0.008 mm. This is not taking into account retention of dust in the terrestrial ecosystems and dispersion by tidal flux. Dust deposition is not expected to cause a detectable change in sediment quality in Milne Inlet based on the baseline sediment chemistry (naturally high concentrations of iron, magnesium, and aluminum occur in sediment) and the small amount of deposition predicted in the area. No changes in sediment chemistry are likely to occur. Collectively, the effects of dust accumulation on marine sediment quality were predicted to be not detectable and therefore negligible in the context of the assessment.

2.1.5 Wastewater and Site Water Discharge

At Milne Port, four sources of effluent (sewage wastewater, treated melt water from tank farm containment area, ore stockpile runoff and general site drainage) are directed to Milne Inlet through a common drainage ditch. Water from all four sources are treated to meet discharge limits in Baffinland’s Type A Water Licence before being discharged.

Because of the density differences between the effluent and local sea water, the drainage ditch effluent was predicted to be buoyant and disperse horizontally. It was predicted that low-level exceedances of CCME water quality guidelines for metals, pH, and/or TSS may periodically occur within the effluent plume, however, it was anticipated that the effluent would rapidly dilute in the marine environment. As a part of the Wastewater Management Plan, toxicity testing was proposed to be routinely conducted prior to discharge of the drainage ditch wastewater to the marine environment.

No effects on sediment quality were anticipated as introduction of particulate materials were expected to be negligible; and the effluent plume would be buoyant and would therefore not directly interact with sediments.

2.1.6 Removal of Marine Facilities

Partial removal of marine infrastructure (conveyors, ore loaders and above dock platform metallic structures) during the Closure Phase was identified as a Project activity that could alter marine water and sediment quality in Milne Port. Specifically, sediment re-suspension may occur, which could in turn increase TSS, nutrients, and metals in water, and the use of machinery and equipment could introduce petroleum hydrocarbons and metals to the marine environment.

Proposed mitigation to manage potential effects related to sediment re-suspension and dispersion included the use of silt curtains, installed around each Closure site and activity. Although exceedances for TSS and metal concentrations would be possible within the limits of the silt curtain during Closure activities, with the silt curtain maintained in place, sedimentation was expected to remove particulates from the water column. Additional mitigation included monitoring water quality outside of the silt curtain to confirm compliance with guidelines.

Sediment quality was also predicted to be temporarily affected, although the extent of disturbance was predicted to be confined to the actual work areas.

With implementation of mitigation measures outlined in the applicable environmental management plans, the potential effects of hydrocarbons releases (from equipment use) on marine water and sediment quality in Milne Port during the Closure Phase was determined to be negligible. Procedures outlined in the Spill Contingency Plan would be initiated in the event of an accident.

2.2 Changes from FEIS / FEIS Addendum

Components of the Phase 2 Proposal that have potential to result in adverse effects on marine water and sediment quality but were not assessed as part of the Approved Project include the following:

- Sediment resuspension due to construction activities associated with the proposed port expansion;
- Disruption and erosion of sediment due to increased shipping traffic (propeller wash);
- Increase in ballast water discharges;
- Changes in water quality due to increased wastewater discharge and site drainage;
- Changes in water and sediment quality due to increases in dust emission from the secondary ore crusher and stockpile; and
- Increase in sediment disturbance due to removal of additional infrastructure during Project closure.

2.3 Project Monitoring

Since the commencement of Project activities under the ERP in 2014, Baffinland has conducted an ongoing Marine Environmental Effects Monitoring Program (MEEMP) in Milne Inlet. The MEEMP was developed and implemented in consideration of the anticipated and possible Project-related impacts to the marine environment as identified in the FEIS (Baffinland 2012) and ERP Addendum (Baffinland 2013) and to meet monitoring requirements outlined in Terms and Conditions of Project Certificate No. 005.

The primary objectives of the MEEMP are to:

- Verify effects predictions described in the Approved Project;
- Evaluate the effectiveness of Project mitigation measures;
- Identify unforeseen environmental effects;
- Provide an early warning of an adverse change in the environment; and
- Improve the understanding of cause-and-effect relationships.

The MEEMP included effects monitoring studies for the following components assessed in this section:

- Physical conditions (ice, water circulation, coastal morphology);
- Marine water quality; and
- Marine sediment quality.

Baffinland originally conducted marine environmental baseline studies in the Project area during 2007, 2008, 2010, and 2013, in support of the FEIS (Baffinland 2012) and FEIS Addendum (Baffinland 2013). Additional baseline data was also collected in 2014 (SEM 2015) before operation of Milne Port has commenced.

Environmental effects monitoring was subsequently undertaken in the marine LSA on an annual basis during the open-water season (as part of the MEEMP study design). Three MEEMP studies have been completed to date (2015, 2016 and 2017). Their results are presented in annual monitoring reports (SEM 2016 and 2017; Golder 2018), and are summarized in Appendix A.

Figure 2-1 identifies the water and sediment sampling locations for the MEEMP. The sampling design was based on a radial gradient pattern originating at the ore dock, which represents the potential point source of contaminants (e.g., ore dust, hydrocarbon deposition) and physical perturbations (sediment re-suspension and transportation), and the Project's wastewater discharge location. The radial pattern is designed to detect potential Project-related effects based on a gradient in numerical indicators of key components (e.g., metal concentrations in sediment, abundance of benthic biota) with increasing distance from the point source (ore dock and effluent discharge).

Sediment samples were collected along four transects extending in a radial pattern from the Milne ore dock. Along the East and West transects, sediment sampling stations were located along the 15-m depth contour at approximately 0 m, 250 m, 500 m, 1,000 m, and 1,500 m from the existing ore dock. Along the Coastal Transect, sampling stations were located at the same 15-m depth contour at approximately 500 m, 1,000 m, 2,000 m, and 4,000 m from the East Transect. Along the North Transect, sampling stations were located at approximately 0 m, 250 m, 500 m, 1,000 m, and 2,000 m from the existing ore dock and depths ranging from 37 m to 100 m. Three replicate samples were collected from each sampling station.

Sediment samples were analyzed for particle size composition, organic content and concentrations of metals and hydrocarbons. These concentrations were compared to CCME Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Level (PAL) guidelines for sediments (CCME 2014). Sediment data collected after the start of operations (2015, 2016 and 2017) were compared to 2014 baseline survey data. Percent composition of fine particles (silt and clay) and iron concentration were used as indicators of Project-induced effects in sediments. Sediment stations were resampled every year and gradients in fines and iron concentrations (with distance from ore dock) were examined using regression analysis. Each consecutive year's regression gradient (slope) was compared to the 2014 (baseline) gradient using an analysis of covariance (ANCOVA). Changes in slope would indicate that there is a difference in the relationship between the concentration of fines or iron and the distance, which could be linked to Project activities.

Metal concentrations in sediment samples were comparable among stations and years and were, in general, low with the exception of aluminum and iron, which were consistently found in relatively high concentrations throughout the survey area and years, particularly in sediments with higher content of fines. No metals exceeded

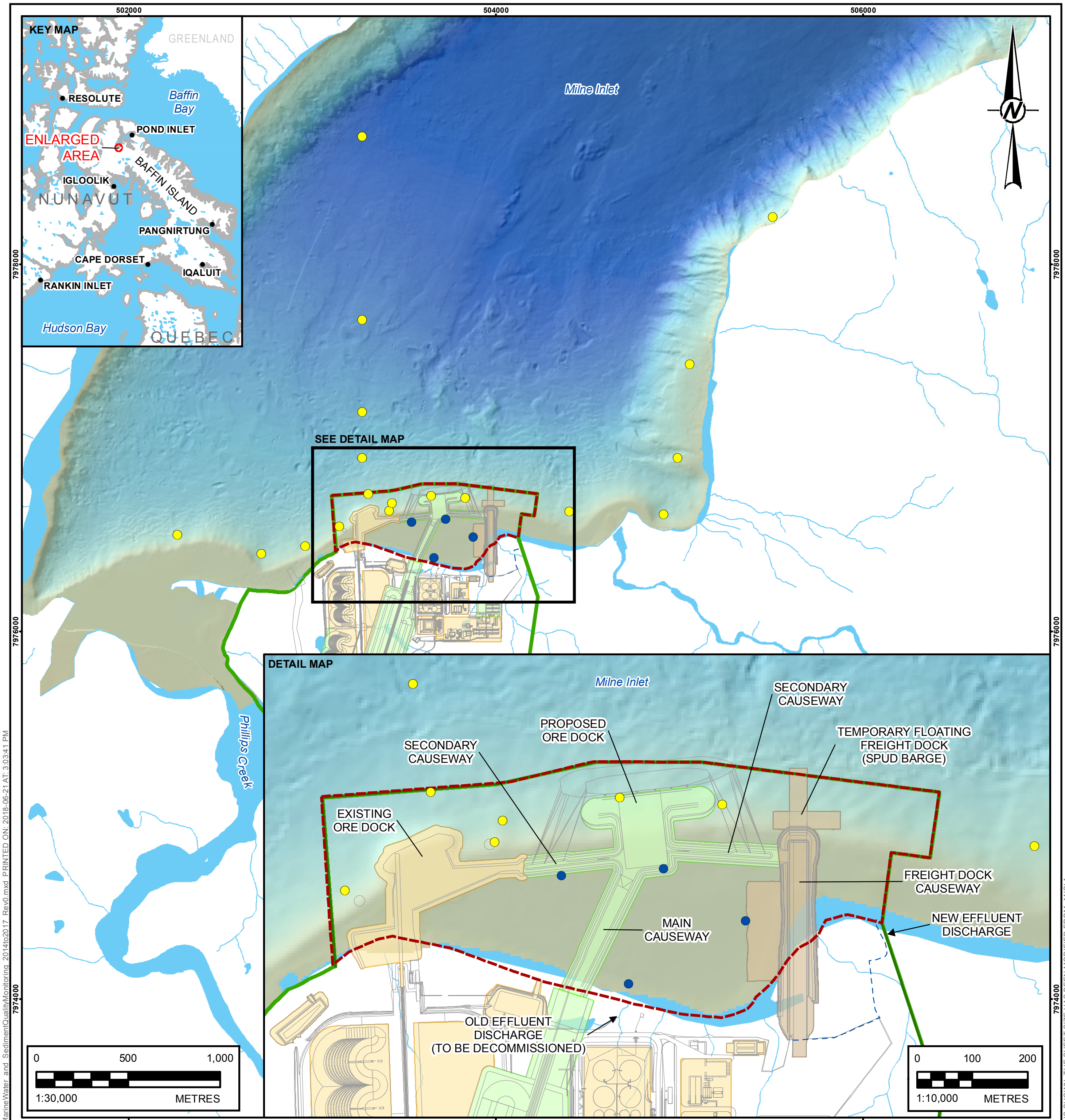
CCME guidelines except for arsenic and zinc. Arsenic concentrations showed low level exceedances of CCME ISQG in three samples in 2014, two samples in 2015 and 2016 each, and three samples in 2017. Zinc concentration in one sample in 2016 exceeded CCME ISQG by less than two times (79±113 mg/kg against CCME 124 mg/kg). No parameters exceeded CCMEs PEL guidelines for the protection of aquatic life in any of the MEEMP surveys. Hydrocarbons were, for the most part, below detection with only trace amounts of petroleum hydrocarbons in the lube oil ranges (C16-C32) with hydrocarbon concentrations found in 2016 generally in lower ranges and in fewer samples than detected in 2013 through 2015. No hydrocarbons were detected in sediments in 2017.

The statistical analysis showed some localized changes in percent fines and iron concentrations in sediments at Milne Port along the East Transect and changes in percent fines in the West Transects although no long-term trend has been observed so far. On the East Transect, changes mostly occurred in the proximity of the dock - 0 m distance for percent fines and from 0 m to 500 m distance for iron - with no long-term trend observed: percent fines and iron concentrations decreased from 2015 to 2016 and increased from 2016 to 2017. These ‘nearshore’ changes in sediment composition in the proximity to the ore dock along the East Transect may be indicative of effects from ore dust deposition or may reflect substrate shifts due changes in local hydrodynamic conditions caused by the presence of the dock. On the West Transect, no differences were observed in percent fines or iron concentrations near the dock, but significant increases were observed at the far-field sampling locations (500 m, 1,000 m, and 1,500 m sampling stations) in percent fines. Percent fines at these stations increased from 2014 to 2017, although measurements in 2015 and 2016 were not significantly different from either 2014 or 2017. Iron concentrations at these stations decreased from 2014 to 2015, but no significant change from 2014 was observed in 2016 and 2017. Changes in percent fines in sediments on the West Transect may be related to changes in alluvial depositions from Philips Creek.

Water quality sampling stations were established on a smaller scale radial design than benthic sediment stations to detect potential changes from the Project’s wastewater effluent. Water quality samples were collected at the sea surface with one station located at the wastewater discharge point, and three others at 250-m distance northwest, north and northeast of the drainage point. Water quality samples were analysed for concentrations of general parameters, nutrients, metals and hydrocarbons. These concentrations were compared to CCME guidelines where applicable.

Analysis of water quality samples collected during the 2015, 2016 and 2017 MEEMP studies (no water quality samples were collected in 2014) showed no exceedances of CCME guidelines, except for concentrations of mercury during one sampling event in 2015, and TSS and turbidity concentrations in one sample in 2017. Mercury concentrations (0.023 µg/L to 0.025 µg/L) exceeded CCME guidelines of 0.016 µg/L (CCME 2014) in all samples collected during the third sampling event in August 2015. Exceedances of CCME guidelines by mercury had been recorded in the LSA during the Definition Phase baseline studies (FEIS Appendix 8.A-1; Baffinland 2012). High TSS and turbidity concentrations were observed in one sample collected near-shore in September 10, 2017. TSS and turbidity concentrations in this sample exceeded the clear flow long-term CCME WQG, but not the clear flow short-term guideline. The sample was collected during a storm event when heavy wave action was observed to be re-suspending sediments from the seafloor at the sampling site; high TSS and turbidity therefore were assumed to be caused by storm and not related to effluent discharge. No hydrocarbons were detected in any of the water samples. In general, water quality parameters detected during MEEMP surveys, e.g., nutrient and metal concentrations, were within ranges observed during baseline studies in 2008 and 2010.

In summary, the water and sediment quality component of the MEEMP confirmed assessment of the Approved Project that assigned negligible to moderate magnitude effects from Project activities on the water and sediment quality VEC, with overall effects rated as not significant. Only a few low-level exceedances of CCME ISQGs were found in sediments, which were likely not Project-related, and no statistically significant long-term trend in sediment quality with distance from the ore dock was detected since the beginning of operations. No effects on water quality were found with the exception of one sampling event in 2015 when mercury concentrations exceeded CCME guidelines by approximately 1.5 times.



LEGEND

- SEDIMENT SAMPLE LOCATION
- WATER SAMPLE LOCATION
- NEW EFFLUENT PIPELINE
- PDA / QIA COMMERCIAL LEASE
- SITE LAYOUT
- WATERCOURSE
- INAC FORESHORE LEASE
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- WATERBODY

ELEVATION (masl)
High : 25
Low : -225

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT, MAY 28, 2108, AND BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES.. HYDROGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
MARINE WATER AND SEDIMENT QUALITY MONITORING LOCATIONS, 2014 TO 2017

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-21
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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2.4 Assessment Methods

The assessment methodology used to assess effects to marine water and sediment quality for the Phase 2 Proposal are consistent with the FEIS (Volume 2, Section 3.0; i.e., rating criteria and method for determining significance; Volume 8). The following documents/studies completed for Milne Inlet have been used as inputs to the marine environment assessment of the Phase 2 Proposal:

- Marine Environment Baseline Report (Appendix A; Golder 2018a);
- Air Quality Modelling Report (RWDI AIR Inc. 2017);
- Ship Wake and Propeller Wash Assessment (Golder 2018b);
- Hydrodynamic Modeling Report for Expanded Port Facility in Milne Port (Golder 2018c);
- Climate Change Assessment (Baffinland 2017); and
- Environmental effects monitoring results from MEEMP studies (SEM 2015; 2016a; 2016b; 2017a; Golder 2018d).

2.4.1 Issues Scoping

A comprehensive review of potential Project interactions with marine sediment and water quality was conducted for the Phase 2 Proposal, and included interactions scoped in the Amended EIS Guidelines (NIRB 2015). A summary of these interactions is presented in Table 2-1. Effects that are not likely to be of notable environmental importance or consequence were defined as Subject of Note, or Level 1 interactions, and were not carried forward in the assessment; however, Level 1 interactions are discussed in Section 2.4.1.1. Key Issues, defined as Level 2 interactions (FEIS, Volume 2, Section 3.5.3; Baffinland 2012) that are of substantial public interest and/or of potentially high environmental importance or consequence, were carried forward in the assessment.

Table 2-1: Phase 2 Proposal Interactions with Marine Water and Sediment Quality

Project Infrastructure or Activity	Interaction	Level
Marine Construction	Sediment resuspension	2
	Disposal of spoils	2
	Circulation alteration	1
Land-based Construction	Terrestrial runoff	1
Ancillary Facilities	Terrestrial runoff	1
Marine Port Operation	Propeller wash	2
	Discharge of ballast water	2
Land-Based Port Operation	Surface runoff	2
Emissions and Wastes	Dust emission and deposition	2
	Wastewater discharge	2

Project Infrastructure or Activity	Interaction	Level
Shipping		
Regular Operations	Vessel wake	1
	Antifouling agent introduction	1
Emissions and Wastes	Wastewater and garbage disposal	1

Notes:
INTERACTIONS ARE RATED AS FOLLOWS:
0 - No Interaction; 1 - Minor interaction post-mitigation, discussion assessment; 2 - Major interaction subject to detailed assessment.

2.4.1.1 Subject of Note Interactions

The following Subject of Note (Level 1) interactions were identified for the Phase 2 Proposal:

- Terrestrial run-off from on-shore construction and closure activities;
- Disruption and erosion of sediment due to ships' wake effect;
- Ship waste disposal;
- Introduction of anti-fouling agents from ore carriers; and
- Effects of circulation alteration by offshore structures.

A brief rationale is provided below as to why the above interactions were not carried forward in the effects analysis.

Terrestrial runoff during construction and closure

Sediment and erosion control measures outlined in the Environmental Protection Plan developed and implemented by Baffinland will avoid/reduce uncontrolled site runoff into the marine environment during construction and closure activities. With effective application of mitigation, concentrations of TSS, nutrients, metals and hydrocarbons in the receiving waters and sediments of Milne Inlet are not expected to increase beyond baseline levels as a result of the Phase 2 Proposal. This pathway was therefore not considered further in the assessment.

Disruption and erosion of sediment due to increases in shipping traffic (wake effect);

Ship wake modeling completed for the Phase 2 Proposal predicted that waves (wakes) generated by ore carriers would be minimal along the Northern Shipping Route, with maximum wave heights of 0.12 m near the sailing line and less than 0.05 m when reaching the shoreline (Golder 2018b). The wake height is primarily constrained by the vessel speed limit of 9 knots along the shipping route. Wind generated waves have greater wave heights than expected ship wakes during both average and peak wind conditions. During a single open water season, the energy flux generated by wind-waves will exceed the energy flux generated by ship wakes by several orders of magnitude and have considerably higher potential effects on sediments along the shoreline. Ship wakes are therefore expected to have negligible effects on the rocky and coarse-grained shorelines along the shipping route. This pathway was therefore not considered further in the assessment.

Ship waste disposal

All ships engaged in Phase 2 Proposal operations will comply with the Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals under the *Canada Shipping Act* (CSA). Under the regulation, all ships need to have an approved sewage treatment plant operating to Canadian standards or holding tank with sufficient capacity to meet grey and black water requirements. Oily waste and sludge from the sewage plant will be incinerated. No treated sewage will be discharged at Milne Port. No untreated sewage disposal will be allowed within 12 nautical miles of the Canadian coast and no oily water or garbage disposal will be allowed to be disposed of within Canadian waters. Ship waste disposal is therefore expected to have negligible effects on marine water or sediment quality during operations of the Phase 2 Proposal. This pathway was therefore not considered further in the assessment.

Introduction of anti-fouling agents from ore carriers

Ore carriers using Milne Port will be subject to the Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals under the *Canada Shipping Act* that ban the use of toxic anti-fouling compounds, such as tributyltin and other organotins, on all ships in Canadian waters and to all Canadian ships everywhere. Adherence to this regulation will provide environmental protection from anti-fouling agents. Effects from ship-borne anti-fouling agents on marine water or sediment quality will therefore be negligible during operations of the Phase 2 Proposal. This pathway was therefore not considered further in the assessment.

Effects of circulation alteration by offshore structures

Hydrodynamic modeling completed for the Phase 2 Proposal (Golder 2018c) predicted that there will be little or no change in current conditions in front of the proposed ore dock and in adjacent nearshore areas, with exception of the area between the proposed dock and freight dock. This area will be separated from the rest of the inlet and, therefore, there will be no sediment transport in or out of this area. There is no apparent change in sediment deposition or erosion seaward of the Milne Port expansion resulting from currents or wind-generated waves or any of the nearshore areas either further to the east or to the west of the Port. Therefore, potential alteration of hydrodynamic circulation caused by new marine infrastructure for the Phase 2 Proposal will have a negligible effect on marine water and sediment quality in Milne Inlet and is not considered further in the assessment.

2.4.2 Assessment Criteria

Assessment criteria used in this report is consistent with the FEIS (Volume 2, Section 3.0; i.e., rating criteria and method for determining significance; Volume 8). CCME guidelines were used for defining thresholds for the surface water and sediment quality VEC, as these thresholds are typically the most stringent. When assessing potential effects of the Project relative to these thresholds, consideration was given to existing conditions in the marine receiving environment prior to the Project (i.e., baseline conditions).

The magnitude of residual effects of the Project on water and sediment quality were described as low (Level I), moderate (Level II), or high (Level III) using the criteria identified in Table 2-2. Effects that were predicted to result in changes unlikely to be detectable were identified as negligible and were not assessed further.

Table 2-2: Criteria for Determination of the Magnitude of Effect on Water and Sediment Quality (Baffinland 2012)

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

2.5 Climate Change Considerations

During the next several decades, climate change will be a major factor influencing the marine coastal environment (Overland and Wang 2007). Climate change is already affecting coastal marine ecosystems in Canada. These include effects on the physical environment, such as changes in water temperature, salinity, frequency and intensity of storms, decreasing sea ice and rising sea level, and associated impacts on the biological environment, such as habitat alteration, invasive species, and biodiversity transformations (Baffinland 2017).

Climate change may affect marine water and sediment quality in the Project LSA through increase in water temperature, decrease in salinity due to an increase in freshwater input (Peterson et al. 2009) and more intensive sea ice melt (Duarte et al. 2012; Kovacs et al. 2011), and change in water pH (Steiner et al. 2013). Increase in precipitation and more intensive snow and permafrost melt may increase freshwater discharge from land and terrestrial sediment and nutrient load into the marine environment increasing seawater turbidity and concentrations of TSS (Peterson et al. 2009), and nutrients and changing sediment composition. Increased frequency and intensity of storms may intensify coastal erosion (Kovacs et al. 2011) and, therefore, also affect water and sediment quality by resuspension and redistribution of particulate matter. More detailed description of various scenarios of climate change effects on the marine environment is presented in Baffinland's Climate Change Assessment (Baffinland 2017).

2.6 Effects Assessment – Marine Water and Sediment

Effects identified as Key Issues or Level 2 interactions that are of substantial public interest and/or of potentially high environmental importance or consequence were carried forward in the assessment. These are summarized in Table 2-3 and discussed in the following sections.

Table 2-3: Summary of Effects on Marine Water and Sediment Quality - Phase 2 Proposal

Project Interaction	Potential Effects
Construction of new marine infrastructure (second ore dock, causeways and ship loader) including removal and disposal of soft sediment	■ Increase in water turbidity, change in concentration of Total Suspended Sediment (TSS), nutrients, metals and hydrocarbons in water; change in pH as a result of concrete works and site runoff during construction; ■ Sediment resuspension and re-deposition, potential change in particle size composition, nutrient, metal and hydrocarbon concentrations.

Project Interaction	Potential Effects
Increase in vessel traffic during the open water season (propeller wash)	■ Changes in water quality (increases in concentrations of TSS, nutrients, metals and other substances) in the water column as a result of sediment disturbance from propeller wash. ■ Changes in sediment composition and quality due to propeller wash.
Discharge of wastewater and site drainage (including site water and overland run-off).	■ Changes in water quality (Increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons in the water). ■ Changes in sediment quality (increases in concentrations of nutrients, metals, and hydrocarbons.
Increase in ballast water discharge	■ Potential changes in water quality (temperature, nutrient and metal concentrations) due to ballast water discharge
Increase in amount and dispersion and deposition of dust from the secondary crusher and ore stockpile	■ Increases in concentrations of TSS and metals (primarily iron) in the water. ■ Increases in concentrations of metals (primarily iron) in the sediment; changes to sediment composition.

2.6.1 Construction of Marine Infrastructure

Pile installation, rock fill placement and backfilling, soft soil removal from the seabed and its disposal during construction of the ore dock has the potential to affect water and sediment quality in Milne Inlet through sediment re-suspension, release of contaminants from sediments into the water column, escape and deposition of fill material, erosion and sedimentation, sea floor disturbance, contact of water with cement, and spills and incidents.

These pathways may result in increase in concentrations of nutrients, metals, and TSS, change in water pH, alteration of sediment physical composition (increase in fines), and introduction of petroleum hydrocarbons.

There are a number of mitigation-by-design features that reduce potential environmental effects during dock construction. The majority of construction work, particularly in shallow water (e.g., access causeway), will take place in winter as land-fast ice is formed. It is expected that, as construction gradually moves offshore, ice will thicken and become grounded. Therefore, ice surrounding construction areas will act as a barrier limiting particulate deposition and spills in surrounding water. To reduce disturbance to the marine environment, the ore dock components will be constructed sequentially, moving from onshore to offshore; the causeway will be constructed in small sections, placing protective layers and armoring immediately after core material is placed to minimize erosion. Backfilling of the birth will only occur after a sufficient length of quay is installed so the fill remains within the structure footprint and no material is dispersed. Machine operation in water will be reduced, e.g., piling and filling equipment will operate on the constructed sections of the ore dock and will not enter the water.

No blasting will occur during construction of the marine infrastructure.

There will be localized removal of up to 2-m-thick upper soft sediment layer in the area of dock construction. The total volume of the removed material will be 10,000 m^3. The material will be removed using a suction pump, which will reduce dispersal of re-suspended sediment in water. Water will be added to the pumped material to provide better fluidity. The removed material will be deposited in one of the two alternative locations: the marine area west of the proposed causeway that will be cut off from the Milne Inlet during the construction of the secondary causeway, or on land within the Project's Potential Development Area (PDA).

Deposition of removed sediment in the marine area west of the proposed causeway will be conducted and managed according to a permit issued under the Disposal at Sea Regulations (SOR/2001-275) under the *Canadian Environmental Protection Act*, 1999 (CEPA; S.C. 1999, c. 33). The removed sediment will be tested in accordance with the regulations.

Marine sediment deposited in the upland PDA will be dewatered. Water from the pile will be collected through a collection channel and treated to remove excess sediments and other substances to meet Type A Water Licence discharge criteria prior to discharge into the marine environment.

An Ore Dock Construction Environmental Plan will be prepared to meet *Fisheries Act* Authorization requirements and implemented during construction of marine facilities in Milne Inlet. A number of mitigation measures will be outlined in the plan to prevent or reduce effects on water and sediment quality. Silt curtains will be installed around localized construction areas during the ice break-up period and around the full perimeter of construction including removed sediment disposal area during the open-water season. Silt curtains will be installed prior to any in-water work in order to encapsulate the entire construction footprint and to reduce disturbance to the marine environment in the surrounding area. Silt curtains will be designed and procured to extend from the sea surface to the seabed and there will be sufficient clearance left between the curtain and construction footprint in order to increase TSS settlement.

The Environmental Plan will include mitigation measures to prevent escapement of hydrocarbon material through leaks and drips and other unplanned events such as routine maintenance and inspection of equipment, fueling procedures, training and competency of personnel and availability of spill response equipment. Procedures outlined in the Spill Contingency Plan will be immediately initiated in the event of an accident.

Construction of concrete components of the dock will consist of installation of prefabricated concrete elements whenever possible. If in-situ concrete production is required, works will be conducted in the way to avoid contact of cement and uncured concrete with surrounding water.

Management plans will also include monitoring to verify effectiveness of control and mitigation measures and compliance of Project activities with environmental requirements, including the *Fisheries Act* Authorization and Disposal and Sea permit, if required. Monitoring will include turbidity monitoring outside silt curtains and regular inspections of environmental protection measures. Turbidity monitoring will include visual observations and measurements with a turbidity sensor conducted at regular intervals. The CCME guideline for turbidity is used as a threshold level based on changes relative to background levels: a short-term (e.g., 24-h period) increase of 8 NTU, and a long-term average (e.g., 30-d period) increase of 2 NTU (CCME 2014).

Taking into consideration the results of turbidity monitoring conducted during construction of the existing ore dock, it is conservatively predicted that the proposed ore dock construction activities may cause localized and temporary increases in TSS and associated nutrients and metals in the water column adjacent to the work zone. These increases may exceed natural levels, but will not exceed water quality guidelines by more than an order of magnitude. These effects will however occur only in limited areas adjacent to the construction site and will only last during construction activities. It is expected that water quality conditions will return to normal soon after construction finishes. Therefore, potential residual effects of this pathway on water and sediment quality at Milne

Inlet are determined to be moderate in magnitude (may be high in the area of sediment disposal), local in extent, infrequent, short-term in duration and reversible (Table 2-7). The effect is determined as not significant.

2.6.2 Vessel Traffic – Propeller Wash

Increased vessel traffic during the Phase 2 Proposal, including traffic of larger capesize vessels, has a potential for bed sediment disturbance as a result of increased bottom shear stress induced by vessel propeller-generated velocities (propeller wash). Propeller wash may result in seabed scour (erosion) and cause an increase in turbidity in the water column. Propeller wash causing seabed scour depends on the ship's power, propeller characteristics, the distance between the propeller and the sediment bed and grain size distribution. Vessels moving through shallow water and narrower channel will generate substantially higher sheer stress on the seabed than vessels in transit in deep waters. The potential for scour due to propeller wash is highest for larger (deep draft) vessels operating at the dock with minimum keel clearance above the bed that manoeuvre and berth unassisted. Propeller wash for vessels in transit can be ignored because there is a greater height of the propeller above the seabed, plus the propeller jet is not sustained at any given location for long enough time.

Potential propeller wash generated by vessels during the Phase 2 Proposal was assessed using a numerical model (Golder 2018b) that took into account vessel (propeller diameter) and environmental (depth, bottom topography, sediment size distribution) parameters, calculated maximum bottom velocities from propeller wash, and estimated bed shear stress and potential bed scour (entrainment, suspension, and scour depth). Modeling used the method outlined in the CIRIA Rock Manual (CIRIA et al. 2007), Soulsby (1997) and Hamill et al. (1999) and was conducted for all vessel types using the proposed dock ranging from a tug to capesize ore carrier. Propeller wash was ignored for vessels in transit (CIRIA et al. 2007) because of the greater ranges of water depths along the majority of the shipping route outside the Milne Port.

The water depth at the proposed ore dock is between -21 and -30 m. Taking into account vessel tracks, the lowest potential for scour is expected to occur for tug operations, and the highest for capesize vessels. The tug has the most clearance, the smallest propeller, and thus lowest estimated maximum bed velocity (0.4 m/s). The capesize vessel has the highest maximum estimated bed velocity (2.3 m/s) due to the lowest keel clearance (less than 5 to 10 m from the seabed). The minimum keel clearance for capesize vessels at the proposed dock is, however, similar in comparison to the clearance for a Supramax or Panamax size vessel at the existing dock.

The maximum velocities for each size vessel class are located in an area on the seabed approximately 50 to 100 m in length and 10 to 50 m wide. Velocities decrease with longitudinal and latitudinal distance from the propeller as the jet dissipates. Maximum seabed velocities based on the vessel tracks at the proposed dock range from 0.6 to 1.5 m/s. The area where sediment is potentially entrained along the vessel track at the proposed dock ranges from 8,100 m^2 for a single tug to 39,900 m^2 for the capesize bulk carrier. The area of sediment suspension is smaller, ranging from a few hundred square metres to 7,000 m^2 for the capesize vessel. In comparison, at the existing dock a Panamax vessel is estimated to have a maximum seabed velocity of 1.1 m/s and entrain sediment in an area of approximately 20,600 m^2. Potential for scour (up to 0.5 m) is predicted along the entire length of the berthing area.

Estimates of potential scour (Table 2-4) in the berthing area indicate that capesize vessels have the potential to entrain and suspend sediment over the largest area. Based on estimates of settling velocity for the fine and sand fractions of the sediment in the Port area, disturbed sediment will remain in suspension for less than one berthing and loading event and therefore a combined effect from successive ships would only occur when a vessel exits the dock and is immediately followed by one entering the berthing area. The capesize vessel has the potential to entrain and suspend sediment over a much larger area than the Panamax (and smaller) size vessels (1.9 times; Golder 2017b); however, the most frequent size vessel (Panamax) calling to the proposed dock is predicted to scour sediment over an area roughly equal to that of a similar size vessel at the existing dock. Tugs will also be primarily responsible for berthing activities and the ship propeller will only be used intermittently, so the estimates of vessel generated velocities and scour potential from bulk carriers are likely conservative.

The estimated propeller wash will result in entrainment of a portion of sediments, particularly finer parts, with propeller jets and re-deposition in areas with less vessel activity. Sediment suspension will likely result in a temporary increase in TSS, nutrients and metals in the water column limited to areas shown in Figure 2-2 However, disturbed sediment is not expected to remain in suspension for less than one berthing and loading event and, therefore, a combined effect from successive ships would only occur when a vessel exits the dock and is immediately followed by one entering the berthing area.. The effects of propeller wash will likely decline after the seabed in the affected areas equilibrates to sediments with coarser particles, after finer materials have been redistributed outside of the disturbance areas.

Overall, the effects on marine water and sediment quality from propeller wash is determined low in magnitude, local, frequent, medium term in duration and reversible. The effects are determined as not significant (Table 2-7.

Table 2-4: Vessel Propeller Wash Summary

	Standard Tug (Ice-class)	Proposed Dock				Existing Dock
		Supramax (55,000 DWT)	Panamax (75,000 DWT)	Post-Panamax (90,000 DWT)	Capesize (250,000 DWT)	Panamax (75,000 DWT)
Maximum velocity - seabed elevation (assuming 21 m)	0.38 m/s	0.66 m/s	0.73 m/s	0.74 m/s	2.26 m/s	1.07 m/s (at 17.5 m water depth)
Maximum velocity – seabed elevation (based on vessel track)	0.57 m/s	0.68 m/s	0.73 m/s	0.75 m/s	1.51 m/s	0.97 m/s
Area of sediment motion potential (m^2)	8,100 m^2	18,500 m^2	20,800 m^2	22,600 m^2	39,900 m^2	20,600 m^2
Area of sediment suspension potential (m^2)	N/A	115 m^2	275 m^2	315 m^2	7,000 m^2	1,700 m^2

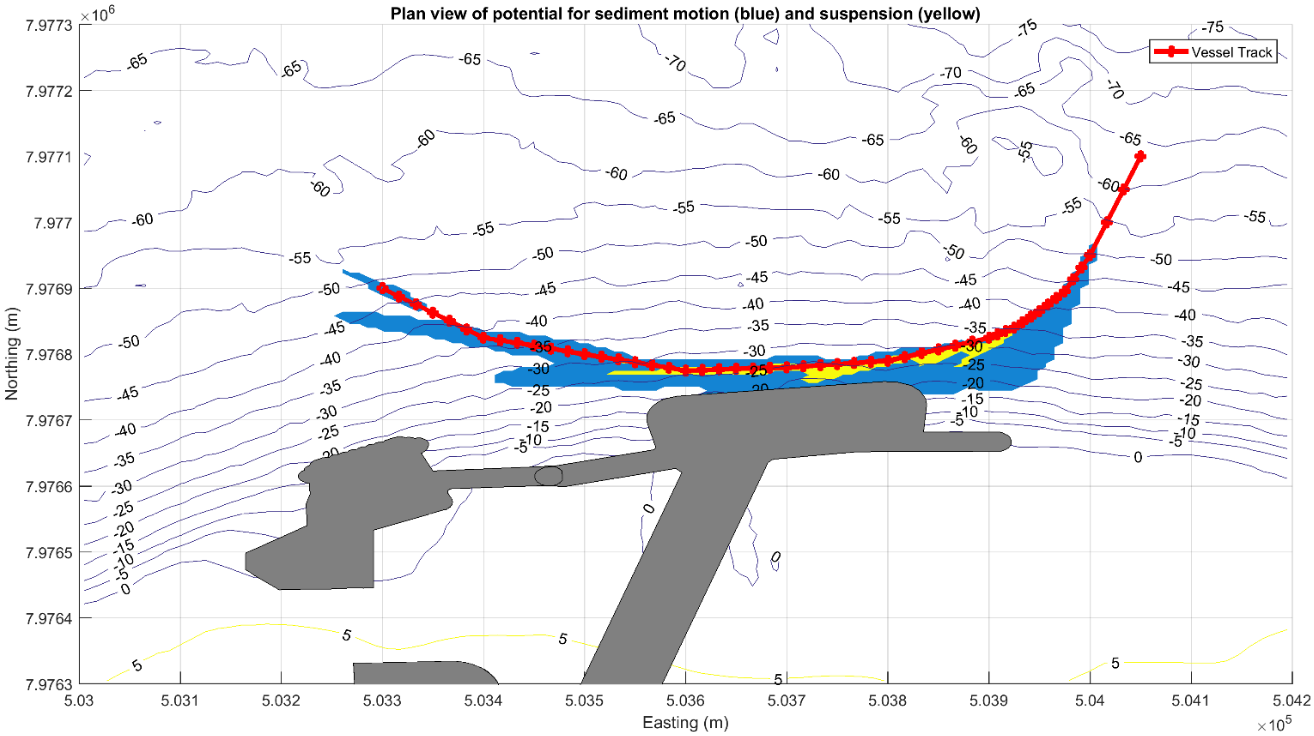


Figure 2-2: Propeller Wash Sediment Motion Potential for a Capesize Ore Carrier at the Proposed Dock

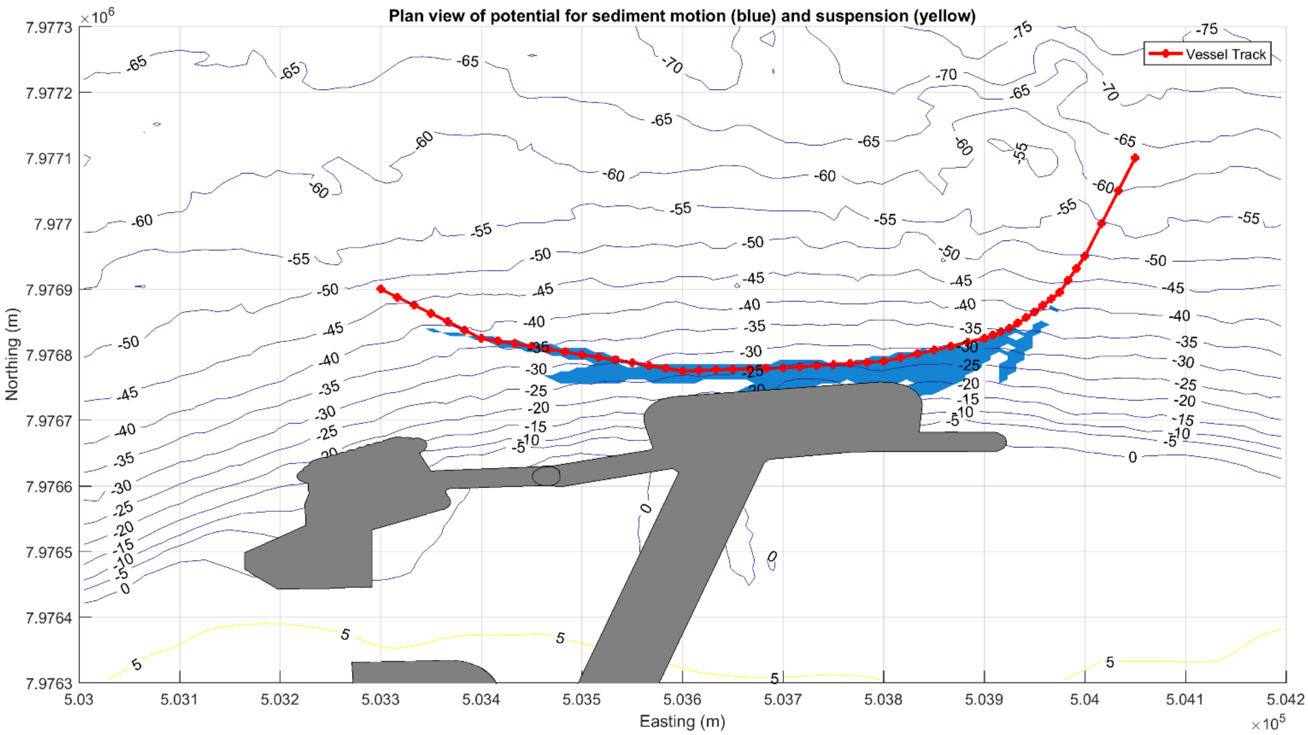


Figure 2-3: Propeller Wash Sediment Motion Potential for a Panamax Ore Carrier at the Proposed Dock

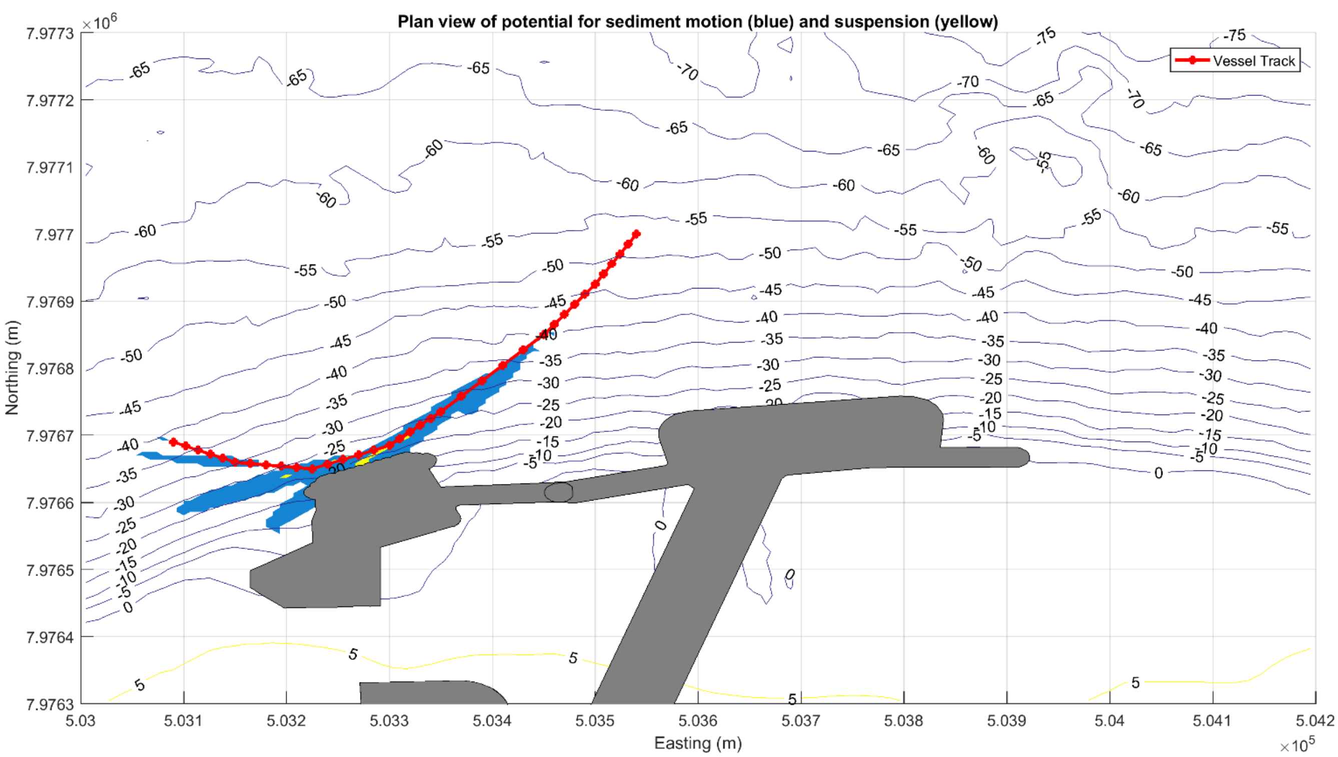


Figure 2-4: Propeller Wash Sediment Motion Potential for a Panamax Ore Carrier at the Existing Dock

2.6.3 Wastewater Discharge and Site Drainage

There is a potential for effects on marine water and sediment quality due to increase of volume from four sources of effluent (sewage wastewater, treated melt water from tank farm containment area, ore stockpile runoff and general site drainage) due to the following new activities associated with the Phase 2 Proposal:

- Increase in the volume of ore stored and shipped and, as a result, increase in ore stockpile size and ore stockpile water management;
- Expansion of fuel storage facility (expansion of Oil Handling Facility (OHF) from 46 ML to 70 ML);
- Increase sewage due to increase in camp occupancy; and
- General expansion of Milne Port site.

Mitigation measures to reduce the effect from the site effluent discharge on the environment will be outlined in Surface Water and Aquatic Ecosystem Management Plan and Freshwater Supply, Sewage and Wastewater Management Plan. The former plan addresses procedures and best management practices to limit the potential for adverse effects to receiving waters, aquatic ecosystems, fish and fish habitat from drainage and runoff from Project facilities. The latter plan contains wastewater treatment, monitoring and discharge requirements and procedures that are consistent with the monitoring requirements and discharge limits outlined in Baffinland's Type A Water Licence.

Sewage at Milne Port is treated using a Membrane Biological Reactor (MBR) to meet the sewage effluent discharge criteria in the Type A Water Licence. The plant consists of a series of effluent tanks designed to operate at low level during the operational phase. This design allows a delay of the discharge if sampling indicates that the effluent quality does not meet the applicable guidelines. Such delay allows the effluent to be mixed, retreated, and retested before discharge. The sludge generated by the MBR is dewatered using a filter press and incinerated. The current Milne Port Sewage Treatment Facility is designed for an average daily flow of 63 m^3/d (Appendix A of the Freshwater, Sewage and Wastewater Management Plan). Additional treatment capacity will be using the same treatment technology will be introduced to accommodate the increase in camp occupancy at Milne Port associated with construction and operation of the Phase 2 Proposal. The daily maximum volume of effluent to be discharged to Milne Inlet will increase to up to 300 m^3/d.

Oily water from vehicle facilities and contact water from the bulk fuel storage farms, landfarm, and contaminated snow berms is collected and treated at Oily Water/Wastewater Treatment Facilities. Oily water collected during the winter time is stored at the Contaminated Snow Containment Berm until the water can be treated during the open water season. All discharges of treated oily water/wastewater to the receiving environment meet effluent discharge criteria of Type A Water Licence. The management of oily water will remain unchanged.

Runoff water from ore stockpiles is collected in ditches around the perimeter of stockpiles and directed into sedimentation ponds. Two sedimentation ponds currently collect runoff from the stockpiles, and the expanded stockpiles will require an additional two ponds to be constructed. Water in sedimentation ponds will be treated to meet discharge criteria of Type A Water Licence. The ponds are designed with sufficient retention time for the sediment to gravity-settle to the bottom of the pond and allow the runoff to be tested before the water reaches the overflow weirs. In the case that the sedimentation pond effluent quality does not meet the discharge criteria by means of sediment gravity settling alone, the wastewater management includes additional treatment methods (e.g. flocculants, GAC, clay, filters, etc.) that can be employed for effluent compliance.

All Project effluent will be regularly monitored at a number of monitoring points across the site. Effluent from all above sources that meet the water quality criteria will be discharged to Milne Inlet through a new drainage location as shown in Figure 1-2.

Monitoring of seawater at and around the treated effluent discharge location during the two years of operation showed that all analysed parameters were within CCME water quality guidelines and within ranges observed previously during baseline studies (SEM 2016 and 2017; Golder 2018; See Section 2.3) with the exception of mercury concentrations, which exceeded CCME guidelines during one sampling event in 2015 by approximately 1.5 times. No hydrocarbons were detected in any of the water samples.

Therefore, it is conservatively assumed that there might be localized short-term exceedances of baseline values and applicable guidelines in concentrations of some marine water constituents at the drainage site. These concentrations, however, are not expected to exceed CCME water quality guidelines by more than one order of magnitude and will be diluted rapidly within the localized mixing zone. Therefore, potential residual effects of this pathway on water quality at Milne Inlet are determined to be low in magnitude, local in extent, infrequent, medium-term in duration and reversible (Table 2-7). No effects on sediment quality are anticipated as introduction of particulate materials is expected to be negligible, also the effluent plume will be buoyant due to the density differences between the effluent and the sea water and therefore will not directly interact with sediments.

2.6.4 Ballast Water Discharges

There will be an increase in both the number of ship voyages and ship sizes to accommodate the volume of ore shipped. An estimated maximum of 176 shipping trips, mostly Panamax and capesize vessels, is expected to occur during the open water season from mid-July to November. This represents approximately a three-fold increase from the ERP level of shipping. Ore carriers will discharge ballast water prior to loading ore. The volume of discharged water will range from 14,000 m^3 for Supramax vessels to 63,000 m^3 for capesize vessels. Ships may begin ballast water discharge when they enter Eclipse Sound and Milne Inlet. Ballast water discharged while the ship is in transit will rapidly mix with the ocean water and, therefore, will have no effect on water quality. Ballast water discharged at a single point while the ship is berthed at the ore dock may cause an effect on the surrounding marine water quality due to differences between the discharged and receiving water in levels of water quality constituents, such as temperature, salinity, and concentrations of metals and nutrients.

Shipping operators will manage ballast water discharge to comply with the applicable regulations and guidelines as per the Baffinland Ballast Water Management Plan, which includes sampling and measurements of ballast water prior to discharge. According to the Ballast Water Control and Management Regulations under the *Canada Shipping Act* (SOR/2011-237) all ships entering the Canadian Exclusive Economic Zone (EEZ) must exchange their ballast water in open seas, away from coastal waters (i.e., 200 nautical miles from land and in water at least 2,000 metres deep). Baffinland monitors salinity of ore carriers' ballast water prior to discharge to verify that it meets the regulation for salinity (at least 30 parts per thousand [ppt]). With the implementation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Convention; IMO 2017), all ships must install a ballast water treatment system to meet D-2 performance standards and eliminate potential invasive species (a detailed discussion on invasive species control measures is presented in Section 3.6.4). Baffinland will verify that the ballast water treatment system used by ore carriers does not represent a risk for the receiving environment due to introduction of chemicals of concern (e.g., residual chlorine) in excess of water quality guidelines.

Upon the Convention coming into force, new ships must meet the D-2 standard, while the requirements for existing ships will be phased over a period up to 2024 (until renewal of each ship's International Oil Pollution Prevention Certificate [IOPPC]; MEPC 2017). Until then all ships will continue ballast water exchange outside the EEZ.

Ballast water originating from the North Atlantic and the Labrador Sea is assumed to have a temperature of 6°C and salinity of 34 PSU. In Milne Inlet, water temperature in the summer ranges between approximately 5ºC at the surface and -1.5ºC at depth below the pycnocline (5 m to 10 m), while salinity ranges between approximately 23 PSU at the surface and 32 PSU at depth. Because of the density difference, discharged ballast water will sink to the bottom at the discharge point and will follow the depth gradient along the seabed in the offshore direction where the plume will dissipate relatively quickly due to mixing with ambient water.

Ballast water will rapidly cool and be diluted to ambient conditions, but there may be exceedances of CCME guidelines for temperature (±1º C; CCME 2014) and salinity (±10% expressed in ppt; CCME 2014) at the discharge point. These differences, however, will occur only within a limited area at the discharge location. CCME (1999; 2003) recommends allowance for an initial dilution zone (IDZ) while applying these guidelines. No exceedances of CCME guidelines for temperature and salinity are expected outside of the ballast water IDZ. Even within the IDZ, the changes will be temporary; temperature and salinity of ambient water will return to their background conditions as soon as discharge is terminated.

Observed nitrate and silicate concentrations are slightly lower in Labrador Sea than those in Milne Inlet, while phosphorus concentrations are similar (see FEIS table 8-3.2; Baffinland 2012). Metal concentrations, particularly cadmium and iron, are higher in Milne Inlet than in Baffin Bay and Labrador Sea (FEIS table 8-3.2; Baffinland 2012). Therefore, ballast water discharge may result in a slight temporary dilution of nitrate and silicate within the ballast water plume; however, water quality guideline exceedances are not expected.

Overall, the effect of ballast water discharge on water quality will be low in magnitude, local, frequent, medium-term in duration and fully reversible. Significance of the effect is determined to be not significant. No effects from ballast water on sediment quality is expected.

2.6.5 Ore Dust Dispersion and Deposition

In Phase 2 of the Project, the increase in amounts of stored and transported ore at Milne Port site (from 4.2 to 12 Mtpa) will result in an increase in the amount of fugitive dust, mainly from the stockpiles that will eventually be deposited in the marine environment. Both sources of ore dust deposition into the marine environment, direct deposition on the sea-surface and introduction from land-deposited dust with surface runoff, were assessed using air-quality model results. According to the model (RWDI Air Inc. 2017), dust will be dispersed over an area of approximately 2,600 ha with an annual average rate of deposition of between 5 g/m^2/year and 13 g/m^2/year over the sea and between 12 and >38 g/m^2/year on land. The highest concentrations of dust (>55 g/m^2/year) will be deposited within a limited proximity of the ore storage and loading areas (Figure 2-5). Estimates of direct aerial deposition of dust on sea surface and on land are presented in Table 2-5 and Table 2-6, respectively. According to historic observations, approximately 80% of the predicted annual dustfall will occur between mid-December to mid-July during the ice season.

Over the Milne Inlet dust will be dispersed over an area of 1,320 ha with an average annual rate of 8.6 g/m^2/year. Most of it will accumulate on ice and will eventually be deposited in the marine environment during ice-melting period. In fully mixed conditions, it will result in an increase in TSS in water column of less than 1 mg/L, which is below the CCME guidelines level.

The annual amount of dust deposited on the sea surface, whether on ice or on water, if introduced instantaneously, would result in an average additional sediment layer of 0.002 mm (total 0.049 mm over the life of the Phase 2 Proposal). The greatest thickness of sediment deposition from dust of 0.12 mm will occur within a limited area (1.3 ha) immediately adjacent to the port site. This is a conservative estimate that assumes that the entire annual dust amount sinks directly onto the seafloor. However, a large portion of the dust will likely be dispersed by tidal flux over a larger area, thus resulting in a thinner layer.

A considerably larger portion of fugitive dust will be dispersed over land in the vicinity of the ore stockpiles. The largest influx of this dust will occur during ice-melting season when dust accumulated on-land will be introduced into the marine environment with surface drainage. The maximum amount of dust that will be deposited on-land is 552 tonnes/year. A large portion of this dust will accumulate in the Phillips Creek watershed and be transported into Milne Inlet with the spring freshet. A conservative estimate predicts that dust will result in an increase in TSS in Phillips Creek between 1 mg/L and 9 mg/L during the 30-day spring freshet (Knight Piésold Ltd. 2017a). This will result in an increase in TSS levels in Milne Inlet at the mouth of the Phillips Creek estuary during the spring freshet, which will be diluted within a short distance (less than 100 m) below CCME guidelines. In other, smaller, drainage basins within the dust dispersion area that directly report to the marine environment, ore dust will result in an increase of TSS by approximately 1 mg/L to 5 mg/L during the freshet (less than CCME guidelines).

If all dust settling on land were introduced to the marine environment and settled in the zone of marine dust deposition, the accumulation on the bottom would be, on average, 0.003 mm to 0.009 mm per year (0.23 mm over the life of the Project). Higher deposition rates will likely occur near natural discharge locations, e.g., creek estuaries. Tidal flux will facilitate dispersal of particulate solids over larger areas, thus decreasing the depth of potential sediment deposition.

The above estimates are conservative since they assume that the entire dust amount that escapes during the year will be deposited in the marine environment simultaneously. However, in reality, all dust will not be deposited instantaneously, nor will be transported to the marine environment. Highest concentrations of dust will settle in the vicinity of ore stockpiles and will be collected in retention ponds with stockpile runoff water and be removed before release of water into Milne Inlet (see section 2.1.5 for wastewater mitigation measures). Part of the dust outside the perimeter of stockpile runoff collection ditches will be retained within the terrestrial environment.

Ore dust depositions in the marine environment may cause increases in concentrations of metals, particularly iron, in water and sediments. There are no marine water quality guidelines for metals abundant in the ore, therefore a direct comparison cannot be made. However, concentrations of metals, particularly iron, in water may be measurably increased due to introduction of dust, particularly at freshwater discharge locations e.g., the Phillips Creek estuary and in the zone of greatest dust deposition (Table 2-5).

Ore that will be stockpiled and transported through Milne Port is composed primarily of iron, with small amounts of silicon, magnesium, aluminum and other elements (FEIS, Table 8-3.10). These elements are also abundant in sediments in Milne Inlet. Therefore, dust deposition is not expected to result in detectable changes in concentrations of metals in sediment in Milne Inlet.

The effect monitoring studies conducted within MEEMP from 2015 to 2017 showed no statistically significant long-term trend in changes in sediment quality and no significant differences in iron concentrations in sediments in 2017 from 2014 except for a limited area in the eastern proximity of the dock. Only a few low-level exceedances of CCME ISQGs were found in sediments. Therefore, to-date, ERP operations have not resulted in significant effects on sediment quality including from ore dust deposition. No changes in water quality were found with the exception of one sampling event in 2015 when mercury concentrations exceeded CCME guidelines by approximately 1.5 times. Since mercury is not an element abundant in ore, an increase in its concentrations in water is not likely related to ore dust deposition.

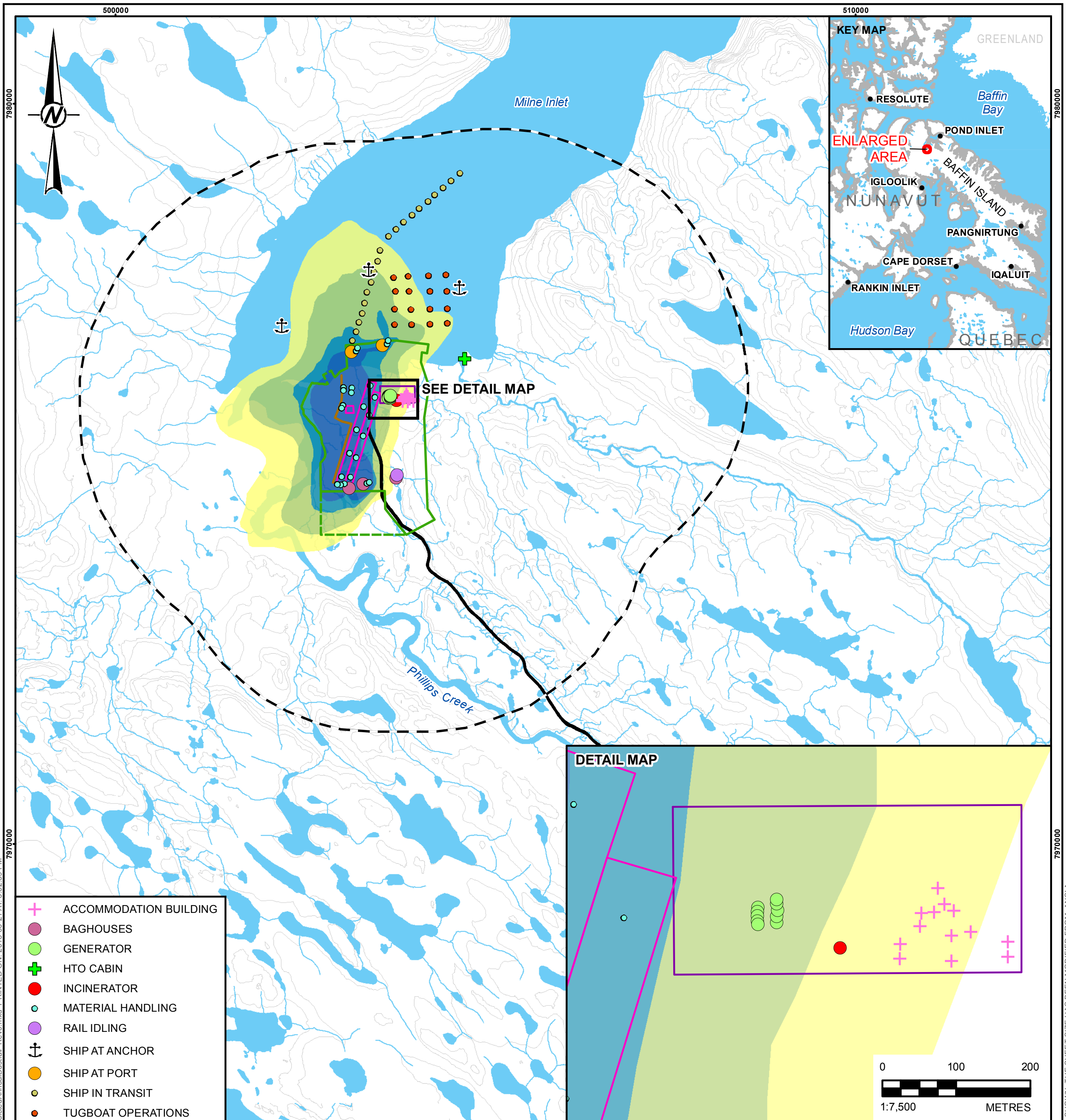
Overall, the magnitude of the effect from ore dust deposition on water quality is determined to be low, extension is beyond the LSA and within RSA, frequent, medium term and fully reversible. Effects on sediment quality are determined not significant.

Table 2-5: Phase 2 Proposal Estimated Direct Aerial Deposition of Dust to the Marine Environment in Milne Inlet

Zone	Deposition rate ($g/m^2/year$)	Area (m^2)	Thickness of Deposition layer (mm)	
			Per Year	Project Life
1	1 – 5	8,224,046	0.000 – 0.001	0.006 – 0.029
2	5 – 10	2,522,700	0.001 – 0.002	0.029 – 0.057
3	10 – 30	1,969,446	0.002 – 0.007	0.057 – 0.172
4	30 – 60	398,296	0.007 – 0.014	0.172 – 0.344
5	60 -120	97,501	0.014 – 0.028	0.344 – 0.688
6	120 – 500	11,591	0.028 – 0.115	0.688 – 2.867
Zones 1-6	8.6	13,223,580	0.002	0.049

Table 2-6: Phase 2 Proposal Estimated Direct Aerial Deposition of Dust to Land at Milne Port

Zone	Deposition rate ($g/m^2/year$)	Area (m^2)	Material Deposited (tonnes)	
			Per Year	Project Life
1	1 - 5	9,915,149	9.9 – 49.6	248 - 1239
2	5 -10	868,320	4.3 – 8.7	109 - 2017
3	10 – 30	672,144	6.7 – 20.2	168 - 504
4	30 – 60	325,665	9.8 – 19.5	244 - 488
5	60 – 120	420,457	25.2 – 50.5	631 - 1261
6	120 – 500	647,228	77.7 – 323.6	1942 - 8090
7	>500	40,214	>20.1	>503
Total	-	12,889,177	154 – 552	3,844 – 13,812



LEGEND

•	COMMUNITY		LOCAL STUDY AREA
	FINE ORE ROAD		FROST FIGHTERS
	MILNE INLET TOTE ROAD		STOCKPILES
	PDA / QIA COMMERCIAL LEASE		WATERBODY
	REVISED PDA FOR PHASE 2 PROPOSAL		**DUSTFALL ($g/m^2/yr$)**
	TOPOGRAPAHIC CONTOUR (20 m INTERVAL)		5 - 10
	WATERCOURSE		10 - 25
			25 - 55
			> 55

0 1,000 2,000
1:75,000 METRES

REFERENCE(S)

HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
PREDICTED ANNUAL DUSTFALL, MILNE PORT AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-21
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000-504	0	2.5

2.6.6 Significance of Residual Effects

The ratings assigned to the residual effects evaluated above are presented in Table 2-7. The effects of the Phase 2 Proposal on marine water and sediment quality are determined to be not significant.

Table 2-7: Significance of Residual Effects on Marine Water and Sediment Quality

Residual Effect	Residual Effect Evaluation Criteria					Significance of Residual Effect	Qualifiers	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of the Effect Occurring)	Certainty (Confidence in the effects prediction)
Changes in Water (Increase in Turbidity, TSS, Metals, and Hydrocarbons, change in pH) and Sediment Quality (Change in Particle Composition, Increase in Metals and Hydrocarbons) Due to Ore Dock Construction	2	1	1	1	1	Not significant	3	3
Propeller Wash, Sediment Redistribution, Increase in Water Turbidity, TSS, Metals and Nutrients Due to Increase in Vessel Traffic	1	1	2	2	1	Not significant	3	3
Increase in Turbidity, TSS, Metals, Nutrients, BOD and Hydrocarbons, Due to Wastewater Discharge and Site Drainage	1	1	1	2	1	Not significant	3	3
Changes in Temperature, Nutrient and Metals Due to Increase in Ballast Water Discharge	1	1	2	2	1	Not significant	3	3

Residual Effect	Residual Effect Evaluation Criteria					Significance of Residual Effect	Qualifiers	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of the Effect Occurring)	Certainty (Confidence in the effects prediction)
Increase in TSS and Metals in Water; Increase in Metals and Change in Physical Composition in Sediments Due to Increase in Dispersion and Deposition of Dust	1	2	2	2	1	Not significant	3	3

Notes:

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

3.0 MARINE HABITAT AND BIOTA

3.1 Background on Project Effects

The following section provides a summary of Project effects that were previously assessed for marine habitat and biota as part of the FEIS and FEIS Addendum (Baffinland 2012 and 2013). These effects were predicted to be not significant. Monitoring efforts completed to date support the Approved Project (see Section 3.3).

The previously assessed effects to marine habitat and biota are summarized below.

3.1.1 Habitat Loss Due to Ore Dock Footprint

Current marine infrastructure at Milne Port includes an ore loading dock occupying a total marine footprint area of 2.5 ha. The total area of marine fish habitat in the LSA is approximately 1,210 ha. Since the area lost to the Project footprint represents approximately 0.2% of available marine habitat, the magnitude of the effect was determined to be negligible.

According to the *Fisheries Act* Authorization (FAA; Ref No. 14-HCAA-00525), Baffinland's commitment to offsetting the habitat loss associated with the ore dock was addressed in the Marine Fish Habitat Offset Plan (SEM 2014). The plan involved addition of coarse rock substrate material around the perimeter of the ore dock to create fish habitat.

3.1.2 Habitat Alteration Due to Port Infrastructure Construction Activities

Construction activities, particularly ore dock infilling and dredging, at Milne Port were predicted to result in re-suspension of sediments in areas of construction and localized, short term increases in TSS that would be partially mitigated with implementation of silt curtains and other mitigation measures of the Ore Dock Construction Environmental Plan. These re-suspension events would occur in the immediate area of the construction activity, and would be reduced by using silt curtains to contain suspended materials. It was predicted that sediment deposition would be contained within very small areas and would have negligible effect on seabed habitat or associated benthic biota.

3.1.3 Change in Habitat Quality Due to Vessel Traffic

It was considered that benthic flora and fauna could be affected by propeller wash in the immediate vicinity of the dock due to substrate erosion. The estimated area of propeller wash effect on benthic habitat around the ore dock in Milne Inlet was 5 ha. Provided that the total LSA for marine fish habitat in Milne Inlet is 1,210 ha, the area of potentially altered habitat would be less than 0.1% of the total LSA habitat. Therefore, it was determined that a change in biological productivity over a small area of coastal habitat would be negligible and would have little effect on productive capacity in the area.

3.1.4 Discharge of Ballast Water from Ore Carriers

Modeling of ballast water dispersal in Milne Inlet predicted that there would be a low magnitude effect on water quality from ballast water discharges and no effect on sediment (Section 2.1.3). Ballast water would contribute less than 0.1 % of the changes in water properties that occur naturally in Milne Inlet on an annual basis. Pelagic and benthic biota would be exposed to a small increase in temperature (by more than 1 ^{0}C) and decrease in nutrient concentrations from ballast water over a small spatial extent. Overall, the magnitude of ballast water effect on marine habitat and biota through water and sediment quality change was determined to be low.

Potential effects from invasive species with ballast water were scoped out from the assessment as a Level 1 (Subject of Note) interaction.

3.1.5 Dispersion and Deposition of Dust from Ore Stockpiles and Ship Loading

Results of air quality modelling indicated that fugitive ore dust would be deposited on the surface of the water or ice over an area of 1.6 km^2 in Milne Inlet (Section 2.1.4). The highest rate of deposition was expected in approximately 1.2 ha area around the ore dock. Using the worst case scenario, dust settlement in the zone of the greatest deposition would result in an increase in water TSS by from 1 mg/L to 3 mg/L and the depth of the sediment layer would increase by 0.002 mm annually. Over most of the affected area, depositional rates would be much lower. Further, ore dust would be dispersed by water and ice movements resulting in an even thinner layer of deposition on the seabed. Therefore, the increased sedimentation due to ore dust deposition will have negligible effect on fish habitat.

The magnitude of the effect from ore dust deposition on Arctic char health is determined to be low in localized areas near freshwater discharge and in the zone of greatest dust deposition in the marine environment.

3.1.6 Wastewater and Site Water Discharge

At Milne Port, effluent from all four sources of effluent (sewage wastewater, treated melt water from tank farm containment area, ore stockpile runoff and general site drainage) would be directed to Milne Inlet through a common drainage ditch. Water from all four sources would be treated to meet CCME and MMER guidelines before being discharged. The magnitude of the effect on water quality was expected to be low (Section 2.1.5).

Sediment introduction from the various effluents would only result in a small increase in fine-grained sediments in limited areas immediately adjacent to the effluent outfall. Therefore, expected effect on seabed habitat and associated benthic biota was determined negligible. Effect on Arctic char health was determined low.

3.1.7 Noise Disturbance

Underwater noise disturbance would occur through all phases of the ERP operations at Milne Port during open-water period only. The propagation of short-term, high energy noises generated during pile-driving could be mitigated through the installation of a bubble curtain (Environmental Monitoring and Mitigation Plan), but most operational noise from vessel activity and ore loading would be chronic and inherently difficult to mitigate beyond minimizing vessel traffic to the extent practicable. It was assumed that resident benthic fish species characterized by a reduced hearing capability (such as sculpin) would habituate to the noise and remain in the area. There might be some avoidance of the dock sites by pelagic species such as Arctic char during periods of intense activity. The spatial extent to which pelagic fish might be affected was difficult to determine, but it was expected that this would encompass some small portion of the LSA. Further, the effects would be frequent (Level II), of medium duration, and completely reversible. Therefore, possible avoidance of marine habitat due to noise disturbance was determined to have a low magnitude effect.

3.1.8 Removal of Marine Facilities

Partial removal of marine infrastructure (conveyors, ore loaders and above dock platform metallic structures) during the closure phase of the Project may potentially result in similar effects as during the construction phase and, therefore, similar mitigation measures were planned. Marine infrastructure removal activities were determined to have a negligible effect on marine habitat and low magnitude effect on Arctic char health.

3.2 Changes from the Approved Project

Components of the Phase 2 Proposal that have potential to result in adverse effects on marine habitat and biota but were not assessed as part of the Approved Project include the following:

- Change in habitat (habitat loss) caused by Milne Port expansion;
- Habitat alteration (changes in water and sediment quality) related to:
  - Construction activities associated with the proposed port expansion;
  - Increase in shipping traffic (propeller wash effect);
  - Increase in ballast water exchange;
  - Increase in wastewater and site drainage;
  - Increase in levels of dust from the secondary ore crusher and stockpile; and
- Underwater noise disturbance related to construction activities (pile driving) and increased shipping.

3.3 Project Monitoring

In addition to environmental effects monitoring for marine water and sediment quality as discussed in Section 2.3, the MEEMP also included effects monitoring for biological components of the marine environment. These also included an Aquatic Invasive Species (AIS) monitoring program implemented as a part of the MEEMP to fulfil Baffinland's commitment to reduce the risk of impact through introduction of invasive species during the Project's shipping operations, mostly via ballast water exchange. The AIS monitoring program is aimed to monitor for presence of alien species in the vicinity of Milne Port.

The scope of biological components of the MEEMP and AIS studies included monitoring of the following marine biological components:

- Benthic habitat, including benthic substrate, macroflora[1] and epifauna[2];
- Fish population and health;
- Zooplankton;

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[1] Large, visible vegetation, e.g. seaweeds or seagrasses.

[2] Animals, e.g. invertebrates and fish, living on the surface of the seabed.

- Benthic infauna[3]; and
- Encrusting epifauna.

Marine benthic habitat characterization was conducted primarily using drop camera video imagery. Drop camera imagery was collected by slowly trolling along survey transects. The analysis of the video imagery provided spatial data on substrate and biota, including distribution and abundance of epibenthic[4] fauna and flora communities.

Data collected in 2014 was considered baseline (pre-operational) and effect monitoring studies have been conducted annually after that during the open-water conditions with three studies completed up to date in 2015, 2016 and 2017 (SEM 2015; 2016; 2017; Golder 2018).

Prior to MEEMP, Baffinland conducted baseline marine environmental studies in 2007, 2008, 2010, and 2013. These studies were carried out in support of the Approved Project. The purposes of the baseline studies included characterization of the background state of environment before the start of Project activities and collection of data to establish baseline conditions for future environmental effects monitoring.

Sampling design of the MEEMP habitat studies was based on a radial gradient pattern originating at the ore dock, which represents the potential point source of contaminants (e.g., ore dust, hydrocarbon deposition) and physical perturbations (sediment re-suspension and transportation), and the discharge location of Project's treated effluent (Figure 3-1). The radial pattern was designed to detect potential Project-related effects based on a gradient in numerical indicators of key components (e.g., metal concentrations in sediment, abundance of benthic biota) with increasing distance from the point source (ore dock and effluent discharge).

The MEEMP benthic habitat studies were conducted along four transects extending on a radial pattern from the ore dock. Three transects (East, West and Coastal) ran along the 15-m depth contour to reduce the confounding influence of depth on sediment and associated biota. The 15 m depth contour was considered to be below any potential influence of ice scour and was associated with relatively large abundances and diversity of marine flora and fauna (SEM 2015). Transects East and West ran in eastern and western directions to approximately 1,700 and 1,800 m respectively on each side of the ore dock. The Coastal Transect extended from the eastern end of the East Transect along the eastern shore of the inlet at 15-m depth contour to approximately 4,250 m from the East Transect. The Coastal Transect extended beyond the Project's predicted zone of influence (ZOI) and encompassed reference area R-1 sampled in 2013. The fourth transect (North) extended directly offshore to a distance of 2,000 m from the ore dock along an increasing depth gradient to a depth of approximately 100 m.

From 2014 to 2016, two replicate video surveys were conducted along each transect described above and identified as replicate 1 (R1) and replicate 2 (R2). Three segments (referred to as S1, S2 and S3) along each transect replicate of recorded video were analyzed amounting to approximately 25% of the total video. Video was analyzed in 5-m increments along each transect and were summarized on a per-transect basis, as well as on a per-segment basis within each transect. Parameters documented included length and area of each survey, video time, substrate type (% coverage, predominant substrate group), macroflora (% coverage, predominant macrofloral class) and macrofauna (abundance and relative abundance of each taxon where it was possible).

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[3] Animals, mostly invertebrate, living in the seabed sediment.

[4] Organisms living on the surface of the seafloor.

The approach utilized in 2014 to 2016 resulted in a non-continuous dataset with significant data gaps and pseudoreplication[5] (SEM 2017). The approach was revised and modified in 2017 to mitigate for these challenges and included removal of the second replicate transect along each of the four established transect lines and to analysis of a larger portion (>90%) of each transect to provide a more representative data set of the study area for comparison against previous years (Golder 2018).

Percent macroflora cover and total abundance of benthic epifauna were used as indicators of project-induced effects in sediments. Benthic habitat surveys were repeated every year and gradients in macroflora cover and total benthic epifauna abundance with the distance from ore dock were examined using regression analysis. Each consecutive year's regression gradient (slope) was compared to 2014 (baseline) gradient using an analysis of covariance (ANCOVA). Changes in slope would indicate that there is a difference in the relationship between the macroflora and epifauna abundance and the distance, which could be linked to Project activities.

There has been high natural variability in macroflora density between transects collected in the same year and considerable variability for each segment along transects in relation to distance from the ore dock. This natural variability may have been the reason why effect on macroflora from Project activities were deemed inconclusive.

Several significant differences were observed between macroflora percent cover over the survey years. However, percent cover was generally variable between years and no identifiable trend was found along the radial transects. Both significant decreases and increases in percent cover were observed between 2016 and 2017 in a comparison of binned 250 m segments of the radial transects. Each of the significant decreases observed between 2016 and 2017 followed a significant increase in percent cover between 2015 and 2016 along the same 250 m segment. The largest change in percent cover was observed between 2015 and 2016 where many of the segments along the East and West Transects showed a significant decrease in percent cover. Percent cover in each of these segments in 2017 showed either an increase from 2016 or a non-significant result, suggesting that a potential trend of decreasing macroflora cover from 2015 did not continue in 2017. Overall, fewer significant decreases were observed between 2016 and 2017 than between 2015 and 2016 and percent cover of macroflora, while variable between years, shows no identifiable trend of decreasing as a result of potential sediment deposition or redistribution (Golder 2018).

As with macroflora, several significant differences were observed between epifauna abundance over the survey years but with one observable trend. Significant decreases in epifauna abundance occurred between 2016 and 2017 within the first 500 m of the West Transect and within portions of the first 1,250 m of the East Transect. Changes in abundance along the East Transect were not reflective of an overall trend, as abundance had significantly increased between 2015 and 2016 and abundance in 2017 was generally comparable with that of 2015. On the West Transect, epifauna abundance was significantly lower in 2017 closer to the ore dock than in all previous years, and higher along the westernmost portion adjacent to the outflow of Phillips Creek. Overall abundance was similar in 2017 to previous years but a change in epifauna distribution may have occurred between 2016 and 2017. Changes in sediment composition showed a potential redistribution of fine sediments from areas near the ore dock to further along the transect, potentially as a result of propeller scour or from deposition of sediments from Phillips Creek. Given that the epifaunal community in this area was dominated by brittle stars and sea urchins, both mobile taxa, it is possible that epifauna have simply re-distributed further along the West Transect in 2017 in response to changes in sediment composition. In general, the relative abundance of epifauna was similar in all areas between 2017 and 2016, suggesting that while changes in distribution may have

[5] Pseudoreplication refers to a case in which replicates are not statistically independent

occurred along the West Transect, the overall community composition has remained unchanged from previous years (Golder 2018).

Population studies of fish and mobile epifauna were conducted using gill nets and baited Fukui traps. These studies were not based on the radial gradient MEEMP study design; they focused around the ore dock targeting local fish populations (e.g. sculpins using Fukui traps) and in traditional Inuit fishing areas at the Eastern shore targeting local and transient species (e.g., Arctic char using gill nets). Fukui trap sampling was conducted every year from 2013 to 2017; gill nets were used during the same surveys and during the baseline studies in 2010. In addition to general fish population studies that were focused on taxonomic community structure, relative abundances and age-and-size composition, opportunistic fish tissue samples were collected for contaminant (body burden) analyses from incidental mortalities. These mortalities have mostly occurred in Arctic char, since Fukui traps that targeted sculpins are a non-lethal fishing method.

Fish studies were also conducted with consideration of selection of a target species for lethal sampling to collect tissue for body burden monitoring. Transient species, such as Arctic char, would have lower value for body burden analysis than resident species due to relatively short-term exposure to environmental perturbations associated with Milne Port; therefore, sculpin species that dominated resident fish catches in the vicinity of Milne Port were considered to be used as a more appropriate target to assessing Project related effects. Mark-recapture surveys of sculpin were conducted during the 2014 - 2016 MEEMP surveys to estimate relative population size and to determine if the population could withstand lethal sampling. All sculpin captured during the first fishing trip of each year were marked by clipping one of the pelvic fins. Despite the considerable effort, however, no marked fish was recaptured. Estimation of population sizes of sculpin species was, therefore, not possible and no target species for lethal body burden analysis was identified. Tissue contaminant monitoring program had to rely almost entirely on accidental mortalities of Arctic char.

Fishing effort, the number of fish caught, and relative species composition of catches varied from year to year. Catch per unit effort (CPUE) as well as the total number of fish caught in gill nets increased from year to year from 2013 to 2016 and ranged from 0.3 to 2.9 of fish per hour of effort (fish/h) and from 8 to 163 of total number of fish caught in 2013 and 2016, respectively. Gill nets proved to be more efficient in catching both transient and resident fish species than Fukui traps. CPUE of Fukui traps was consistent in 2014 to 2016 (0.03 fish/h in 2013 and 2014 and 0.02 in 2016), but was considerably higher in 2013 (0.13 fish/h).

Thirteen fish species were encountered during fish surveys from 2010 to 2016. Arctic char was the most common species in gill net catches in 2013, 2015 and 2016 constituting 75%, 75% and 96% of total number of fish, respectively. A particularly high number of Arctic char of 157 was caught in 2016. Sculpins constituted a great majority of non-char fish species caught with shorthorn sculpin (*Myoxocephalus Scorpius*) and fourhorn sculpin (*Myoxocephalus quadricorni*) being the most abundant; shorthorn sculpin represented 67% (50) of all fish caught in 2010 and fourhorn sculpin constituted 58% of all catches in 2014. Other fish species that were caught more than during one survey were four other sculpin species (Arctic sculpin (*Myoxocephalus scorpioides*), Arctic staghorn sculpin (*Gymnocanthus tricupis*), longhorn sculpin (*Myoxocephalus octodecemspinosus*), and Atlantic hookear sculpin (*Artediellus atlanticus*)), Greenland cod (*Gadus ogac*), fishdoctor (*Gymnelis viridis*) and fourline snakeblenny (*Eumesogrammus parecisus*). Species that were caught during only one survey included twohorn sculpin (*Icelus bicornis*), common lumpfish (*Cyclopterus lumpus*) and Arctic cod (*Boreogadus saida*) that was caught only in 2016, although it had previously been identified in fish stomachs.

Metals in incidental Arctic char mortality tissue samples were mostly below detection limits. Exceptions were concentrations of arsenic, chromium, copper, iron, mercury and zinc. Concentrations of these metals in fish tissue were, in general, consistent from 2010 to 2016. None of the samples exceeded Health Canada’s guideline for mercury in fish tissue for human consumption of 0.5 mg/kg.

Data on water and sediment quality can be used as proxy data for detection of project-caused effects on marine biota. In summary, water and sediment components of the MEEMP confirmed assessment of the Approved Project and showed no significant effect from the Project operations (See Section 2.3).

AIS monitoring is based on a detailed program that commenced in 2014 and consists of benthic invertebrate, zooplankton, encrusting epifauna and fish data collection. Data collected in 2014 and from previous studies is used as baseline data and information collected annually over the life of the project is aimed to monitor for any non-native species that can potentially be introduced as a result of the Project's shipping activity.

Benthic infauna samples were collected along four transects, consistent with the general AIS monitoring study design. Each transect was divided into depth strata (e.g., intertidal, 0-3 m, 3-15 m, 15-25 m, and >25 m) consistent across the study area. Sampling programs were designed to collect 5 samples from each stratum of each transect (Figure 3-1). Benthic samples were collected using either a Petite Ponar or standard Ponar sediment grab.

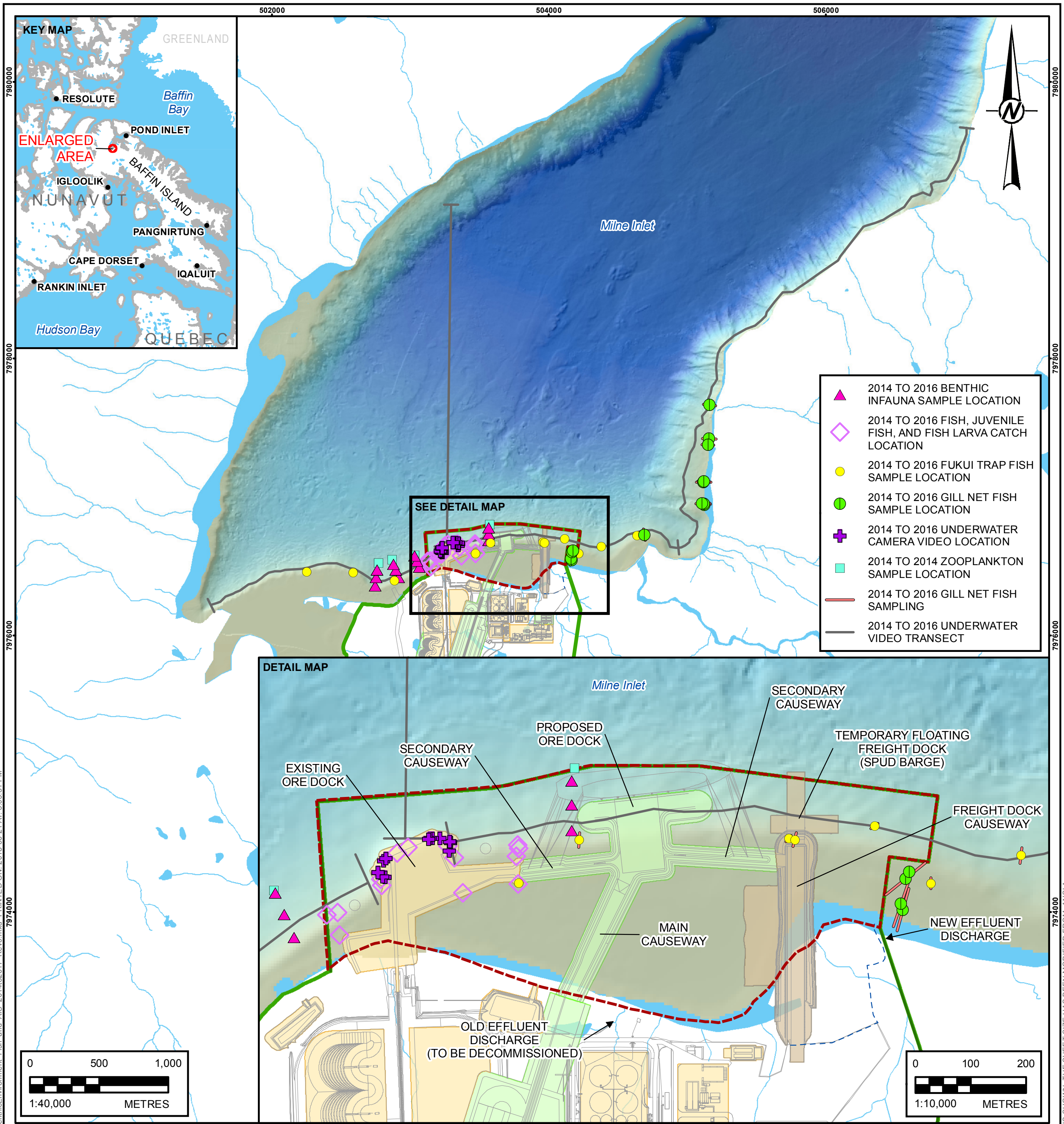
Zooplankton samples were collected at four locations in the vicinity of the Milne Port area (Figure 3-1) by four vertical and four oblique tows during each open-water season (August to September). In addition, four under-ice vertical samples were collected in June 2015. Vertical samples were collected using an 80-µm-mesh plankton net and oblique tows using a 250-µm-mesh plankton net. Both nets had a diameter of 30 cm.

Benthic epiflora, epifauna, fish and mobile benthic invertebrate data collected as a part of MEEMP are also used for the purpose of the AIS monitoring program. Taxonomic identification of fish and mobile benthic invertebrates is used to detect potential non-native species in the vicinity of Project facilities.

Deployment of settlement baskets to assess rates of colonization of hard substrate by encrusting epifauna is also a part of the AIS studies. Settlement baskets were deployed during the field surveys in 2014 to 2016; however, due to a slow rate of colonization in 2015 and loss of baskets in 2016, possibly due to removal by boat traffic, no data has been obtained to date. The program continues with more settlement baskets deployed in 2016 and 2017 with data potentially available in the future.

Data collected during each survey is used to update the inventory list of taxa, which is examined for evidence of new taxa not previously identified and to determine if any of these new taxa may potentially be invasive. Numbers of samples collected during each survey were considered sufficient to capture species diversity for each ecological component studied. No invasive species have been detected as a result of the AIS monitoring studies conducted up to the 2016 field season (T. Macdonald, pers. com.).

In general, monitoring studies have not shown any effect on the marine habitat and biota VEC from Project activities.



LEGEND

- NEW EFFLUENT PIPELINE
- PDA / QIA COMMERCIAL LEASE
- SITE LAYOUT
- WATERCOURSE
- INAC FORESHORE LEASE
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- WATERBODY

ELEVATION (masl)
High : 25
Low : -225

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT, MAY 28, 2108, AND BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES.. HYDROGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
BENTHIC ENVIRONMENT, FISH AND AQUATIC INVASIVE SPECIES (AIS) STUDY LOCATIONS, 2014 TO 2017

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-21
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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3.4 Assessment Methods

The assessment methodology used herein to assess effects to marine habitat and biota are consistent with the FEIS (Volume 2, Section 3.0; i.e., rating criteria and methods for determining significance) and the inputs of the following documents/studies:

- Marine Environment Baseline Report (Appendix A; Golder 2018a);
- Underwater Acoustic Modelling Report (Quijano et al. 2018);
- Air Quality Modelling Report (RDWI Air Inc. 2017);
- Ship Wake and Propeller Wash Assessment (Golder 2018b);
- Hydrodynamic Modeling Report for Expanded Port Facility in Milne Port (Golder 2018c);
- Climate Change Assessment (Baffinland 2017);
- Environmental effects monitoring results from MEEMP studies (SEM 2015; 2016a; 2016b; 2017a; Golder 2018);
- Milne Ore Dock Fish Offset Monitoring reports (SEM 2017b; Golder 2017a); and
- Aquatic Invasive Species Risk Assessment (Golder 2017b).

3.4.1 Issue Scoping

A comprehensive review of potential Project interactions with marine habitat and biota was conducted for the Phase 2 Proposal, and included interactions scoped in the amended EIS Guidelines (NIRB 2015). A summary of these interactions is presented in Table 3-1. Effects that are not likely to be of notable environmental importance or consequence were defined as Subject of Note, or Level 1 interactions, and were not carried forward in the assessment; however, are discussed in Section 3.4.1.1. Key Issues, defined as Level 2 interactions (FEIS, Volume 2, Section 3.5.3; Baffinland 2012) that are of substantial public interest and/or of potentially high environmental importance or consequence, were carried forward in the assessment.

Table 3-1: Phase 2 Proposal Interactions with Marine Habitat and Biota

Project Infrastructure or Activity	Interaction	Marine Fish Habitat VEC	Arctic Char Health and Conditions VEC
Marine Construction	Project Footprint	2	0
	Circulation alteration	1	0
	Sediment resuspension	2	2
	Underwater noise	2	2
	Effect on nearshore stability	1	1
	Effect from blasting	0	0
Land-based Construction	Terrestrial runoff	1	1

Project Infrastructure or Activity	Interaction	Marine Fish Habitat VEC	Arctic Char Health and Conditions VEC
Ancillary Facilities	Terrestrial runoff	1	1
Marine Port Operation	Propeller wash	2	1
	Ballast water – water quality	0	1
	Ballast water – invasive species	2	1
Land-Based Port Operation	Surface runoff	1	2
Emissions and Wastes	Dust emission and deposition	2	2
	Wastewater discharge	1	2
Shipping			
Regular Operations	Vessel wake	1	1
	Antifouling agent introduction	1	1
Emissions and wastes		0	0

Notes:
1. Interactions are rated as follows:
   0 - No Interaction.
   1 - Minor interaction post-mitigation, discussion assessment.
   2 - Major interaction subject to detailed assessment.

3.4.1.1 Subject of Note Interactions

The following Subject of Note (Level 1) Project interactions with Marine Habitat and Biota were identified for the Phase 2 Proposal:

- Effects of construction on nearshore stability;
- Effects of circulation alteration from offshore facilities;
- Runoff from onshore construction activities;
- Ships’ wake effect on nearshore habitat; and
- Effect on Arctic char health from ballast water discharge.

A brief rationale is provided below as to why the above interactions were not carried forward in the effects analysis.

Effects of construction on nearshore stability

The ore dock and causeways constructed as part of the Phase 2 Proposal will be constructed sequentially by placing protective layers and armoring immediately after core material is placed to minimize erosion and sheet-piling will be performed from the constructed section of the ore dock. Given the presence of well-drained soils and absence of ice at the dock location identified for the Phase 2 Proposal, meaningful settlement induced by ore dock construction and climate change is not expected (Knight Piésold, 2017b). Therefore, it is unlikely that Phase 2 Proposal port construction will cause shoreline instability and subsequently this pathway is not considered further in the assessment.

Effects of circulation alteration by offshore structures

There will be little or no change in current conditions in front of the proposed ore dock and in the adjacent nearshore areas with exception of the area between the proposed dock and freight dock that will be segregated from the rest of the inlet (see Section 2.4.1.1). There will be no change in sediment deposition or erosion seaward of the Milne Port expansion resulting from currents or wind-generated waves or any of the nearshore areas either further to the east or to the west of the Port. The effects on fish habitat from circulation alteration caused by offshore structures are, therefore, negligible and not considered further in the assessment.

Terrestrial runoff from construction activities

Due to implementation of sediment and erosion control measures outlined in the Environmental Protection Plan, no effect on marine water or sediment quality is expected during construction of the Milne Port on-land facilities (Section 2.4.1.1). Therefore, no effect on marine fish habitat or Arctic char health and condition is expected from terrestrial runoff during construction activities and this pathway is not considered further in the assessment.

Ship wake effects on nearshore habitat

Modeling (Golder 2017b) predicted that effect from ships wake on the shoreline would be negligible in comparison to wind generated waves, whose energy flux will exceed the energy flux generated by ship wake by several orders of magnitude. Effects from ship wakes on shore and nearshore marine habitat and biota are, therefore, negligible and not considered further in the assessment.

Effect on Arctic char health from ballast water discharge

Ballast water discharge will not result in exceedances of applicable water quality guidelines (Section 2.6.4). Therefore, effects on Arctic char health from ballast water discharges are considered negligible and this pathway is not considered further in the assessment.

3.4.2 Assessment Criteria

The assessment criteria and thresholds used herein to assess effects to marine habitat and biota (i.e., rating criteria and methods for determining significance) are consistent with the FEIS (Volume 2, Section 3).

3.4.2.1 Assessment Criteria for Marine Fish Habitat

The area of marine habitat loss due to the Project footprint or harmfully altered during Project activities was used as a parameter to assess project related effects on marine fish habitat. For the purposes of the assessment, it was assumed that the productive capacity of marine habitat was directly related to area. The magnitude of effect was estimated as the proportion of altered or lost habitat versus available habitat within the LSA using criteria presented in Table 3-2.

Table 3-2: Criteria for Determination of the Magnitude of Effect on Marine Fish Habitat (from Baffinland 2012)

Level	Descriptor	Criteria
Not Assessed (Level 0)	Negligible	Less than 1 % reduction in productive capacity
Level I	Low	Between 1% and 10 % reduction in productive capacity
Level II	Moderate	Between 10% and 20 % reduction in productive capacity
Level III	High	More than 20 % reduction in productive capacity

3.4.2.2 Assessment Criteria for Arctic Char Health

Potential effects on Arctic char health from Project activities relate to changes in water quality changes are based on comparisons to CCME guidelines. The criteria for effect magnitude determination are presented in Table 3-3.

Table 3-3: Criteria for Determination of the Magnitude of Effect on Arctic Char Health (from Baffinland 2012)

Level	Descriptor	Criteria
Not Assessed (Level 0)	Negligible	Water quality change within CCME guidelines
Level I	Low	Water quality change is from 1 to 10 times the CCME guidelines
Level II	Moderate	Water quality change is from 10 to 100 times the CCME guidelines
Level III	High	Water quality change is more than 100 times the CCME guidelines

3.5 Climate Change Considerations

The most influential physical drivers of change for biological components of the Arctic marine environment associated with climate change within the next decades will most likely include sea-ice cover decrease (Duarte et al. 2012; Kovacs et al. 2011), increase in temperature and precipitation, and reduction of permafrost, and resulted decline in salinity (Peterson et al. 2009), intensification of storm activity (Kovacs et al. 2011), changes in contaminant pathways (Guo et al. 2007; Prowse et al. 2009) and seawater acidification (Steiner et al. 2013). Some of these drivers (e.g., ice cover reduction) may be critical for regime shifts and initiate large persistent socio-economic changes.

Changes in sea-ice may disrupt primary phytoplankton production and, consequently, alter the entire food web. Life in Arctic marine waters depend on two distinct categories of primary producers; ice algae (sympagic algae) growing within and on the underside of the sea ice and phytoplankton growing in open waters (Søreide et al. 2010). Accordingly, there are two peaks of primary production with the first occurring in late April at the onset of the ice algal bloom and the second occurring in early July just after the ice break-up at the onset of the phytoplankton bloom. Reproduction and growth of the copepod *Calanus glacialis,* the dominant zooplankton species, perfectly coincided with these two bloom events. Reduction in sea ice thickness and coverage area will likely alter this primary production regime due to earlier ice break-up and onset of the phytoplankton bloom resulting in a mismatch between primary production and the zooplankton with possible repercussions throughout the food web (Søreide et al. 2010). Calanoid copepods have considerably higher energy lipid compounds and essential fatty acids than other zooplankton species and are believed to provide more energy to higher trophic levels (Darnis et al. 2012) and therefore, support higher secondary productivity of the ecosystem. Also, ecosystems with larger zooplankton tend to have shorter food chains resulting in less energy wasted at each consumer level in the food chain and more energy available to the higher trophic levels (Darnis et al. 2012). Disruption in calanoid copepods productivity and shift of zooplankton communities towards dominance by smaller, more numerous copepods, such as *Oithona similis*, *Triconia borealis*, *Pseudocalanus* spp. and *Microcalanus* spp., will likely result in less energy transfer through the food chain and, thus, lower biological production of the ecosystem in general (Darnis et al. 2012).

Most species in the Arctic benthos are deposit feeders and, therefore, their food supply depends on the import of organic matter that ultimately originates from primary production in the upper euphotic layers of the water column, either from pelagic/sympagic production or in the form of large food falls (Piepenburg 2005). The dependence of the food supply on vertical flux of organic matter to the seabed means that if climate change results in a shift from a diatom-dominated to picoplankton-dominated algal community, as described above, less food may be available to benthic species. This in turn may affect food availability to higher trophic levels e.g., walrus and bearded seals feed primarily on benthic invertebrates.

Calanus and its main predator pelagic amphipod *Themisto libellula* constitute the bulk of the diet of Arctic cod an important component of the regional fish community (Welch et al. 1992). Cod in turn constitutes the majority of the diet of ringed seal, narwhal, beluga, and harp seal (Welch et al. 1992). Welch et al. (1992) estimated that this fish species could account for as much as 75% of the transfer of energy between the zooplankton and vertebrate predators. Gaston et al. (2012) speculated that rapid decline in bird nesting observed at Coats Island, Nunavut in the mid-1990 was associated with switching of bird diet from one dominated by Arctic cod to one dominated by capelin, *Mallotus villosus*, caused by a “step change” of ice cover in June and November in northern Hudson Bay. Arctic cod is strongly associated with seasonally ice-covered waters and capelin typically have a more subarctic distribution. The length of the open-water season was a good predictor of the switch between Arctic cod and capelin.

Among factors determining Arctic char’s vulnerability are complexity in reproductive strategy (Stewart and Lockhart 2005), slow growth rate (Scott and Crossman 1973), and dependence on stream hydrologic regimes and temperature during critical reproductive life stages (Scott and Crossman 1973), which makes Arctic char susceptible to changes in air temperature and precipitation. In addition, Arctic cod is an important food source for Arctic char and a decrease in Arctic cod population due to reduction of sea-ice is likely to affect Arctic char, although the latter has a remarkably diverse diet (Scott and Crossman 1973). More detailed description of various scenarios of climate change effects on the marine environment is presented in Baffinland’s Climate Change Assessment (Baffinland 2017).

3.6 Effects Assessment – Marine Fish Habitat

Effects identified as Key Issues or Level 2 interactions resulting from the Phase 2 Proposal that are of substantial public interest and/or of potentially high environmental importance or consequence, were carried forward in the assessment. These are summarized in Table 3-4 and discussed in the following sections.

Table 3-4: Summary of Effects on Marine Fish Habitat – Phase 2 Proposal

Project Interaction	Potential Effects
Habitat loss due to Project footprint	■ Direct habitat loss due to the new marine infrastructure footprint (ore dock)
Habitat alteration due to construction of the new port infrastructure	■ Change in water quality (increase in water turbidity, TSS, nutrient, metal and hydrocarbon concentrations, change in pH) as a result of sediment disturbance and site runoff during construction; ■ Change in substrate quality (sediment suspension and re-deposition, potential change in particle size composition, nutrient, metal and hydrocarbon concentrations).
Habitat alteration due to increase in vessel traffic (propeller wash)	■ Temporary changes in water quality (increases in turbidity, TSS, nutrients, metals and other substances) in the water column as a result of sediment resuspension from propeller wash. ■ Altered substrate (sediment) composition and quality and effects on marine biota
Habitat alteration due to discharge of wastewater and site drainage (including oiled site water and overland run-off).	■ Wastewater discharge and site runoff may result in changes in water quality (increases in BOD and concentrations of TSS, nutrients, metals, and hydrocarbons); ■ potential increases in concentrations of TSS and other substances in the water column and accumulation of fines in the sediments could alter composition and quality of the nearshore habitat, although tidal fluxes are expected to disperse the effluents and reduce effects on habitat
Increase in ballast water discharge	■ Potential introduction of aquatic invasive species (AIS)
Habitat alteration due to increase in fugitive ore dust deposition	■ Change in water quality (increases in TSS and metals, primarily iron) ■ Change in sediment quality and composition ■ Potential change to benthic productivity
Underwater noise disturbance	■ Short-term (pulsed) high energy noise during construction (i.e., pile driving) ■ Continuous noise disturbance due to increases in the size and frequency of shipping vessels at the port ■ Noise may result in possible avoidance of the area by fish

3.6.1 Project Footprint – Habitat Loss

Phase 2 Proposal marine infrastructure components include a new ore loading dock with main and temporary causeways including areas where soft sediment will be removed and scour protection installed (Figure 1-2). However, the marine footprint of Phase 2 Proposal also includes two areas of water isolated from the rest of Milne Inlet, since they will be lost to fish habitat, and areas of existing habitat offset facilities that will be built over with the new structures. A breakdown of habitat loss is provided in Table 3-5. The area of the marine infrastructure is 5.18 ha, while the area of the isolated water bodies is 12 ha. The area of lost marine habitat is 17.32 ha, which is approximately 1.4% of the Project marine habitat LSA (approximately 1,210 ha).

Table 3-5: Phase 2 Proposal Marine Habitat Footprint

Component	Area (Ha)
Proposed Ore Dock Including Scour Protection	5.18
Isolated Waterbodies	12
Habitat Offset Lost	0.14
Total Marine Habitat Footprint	17.32
Marine LSA	1,210

Benthic habitat at the proposed ore dock location is primarily composed of soft sediment substrate (gravel/sand/rubble) that is generally considered to be less productive habitat as compared to coarser and harder substrate. The site also avoids sensitive life stages of fish such as anadromous char since they spawn in freshwater environments.

Baffinland is committed to offsetting project-related effects to fish and fish habitat that contribute to the sustainability and ongoing productivity of local fisheries by proposing to implement an offsetting plan (Golder 2018b) that maintains or increases the quality and type of habitat for the local fisheries in Milne Inlet likely affected by Phase 2 Proposal. Offsetting habitat will be designed to enhance productivity, e.g. increase food resources for both Arctic char and Arctic cod, and provide a higher productivity than the majority of the habitat affected by the Project.

The offsetting proposed for the Phase 2 Proposal will likely consist of creation of coarse rock substrate that acts as an artificial reef and provides productive fish habitat. Creation of artificial reefs at sites with homogenous, low relief substrate increases habitat complexity and heterogeneity resulting in colonization by invertebrates and fish (DFO, 1990). The reef will provide substrate for macroalgae and additional habitat for invertebrates, such as amphipods and mysids, and sculpins (and other fish) that are an important food source for Arctic char and Arctic cod (Bradstreet *et al. 1*986; Craig et al. 1982). The offsetting habitat will enhance productivity and offset effects to habitat loss related to the ore dock construction.

Currently, Baffinland considers several habitat offset location options. A desktop review of the Milne Port area and surrounding region resulted in the selection of a six sites that suggest reasonable potential for habitat offsetting through habitat enhancement (Golder 2018b). Benthic surveys of the local marine environment indicate that higher productivity habitat ranges in depth from 3 m to 25 m depth. Additionally, species of local concern are known to prefer habitat along the coastline ranging from the high water mark out to 30 m within 25 km of freshwater spawning areas (SEM 2014). The creation of highly productive and complex habitat within these areas will likely benefit local fishery species by improving food and shelter availability. Also, rock armouring of the northern (seaward) slopes of the secondary dock causeways will also serve as enhanced fish habitat.

Coarse rock substrate was built around the existing ore dock as an offsetting habitat for the ERP phase of the Project (SEM 2017b). Surveys were conducted in 2015, 2016 and 2017 to assess structural integrity of the offsetting habitat, its biological utilization, and, ultimately its effectiveness. The studies showed the armour stone was stable and there was no evidence of any movement or slumping and the habitat was utilized by a variety of organisms. Organisms encountered during the fish offset monitoring surveys included green and brown macroalgae, epibenthic and planktonic invertebrates, such as sea urchins, sea stars, shrimps, krill, jellyfish, fish, including Arctic char, sculpins, Arctic cod, Greenland cod, Northern sand lance and eelpout, and marine mammals (ringed seal) (SEM 2017b; Golder 2017). Therefore, the offsetting habitat was effective and offset the loss of habitat caused by the Project footprint.

The residual effect from loss of approximately 1.4% of marine habitat due to the Project footprint after the mitigation measures is determined of low magnitude, local in geographic extent, continuous in frequency and long-term in duration. The effect is determined not significant.

LEGEND

NEW ORE DOCK AND CAUSEWAY

EXISTING FREIGHT DOCK AND CAUSEWAY

HABITAT TYPE

LAND

INTER-TIDAL

UPPER SUB-TIDAL (< 3 m)

SHALLOW SUB-TIDAL (3-15 m)

MODERATE/DEEP SUB-TIDAL (> 15 m)

0 100 200

1:7,500 METRES

REFERENCE(S)

SATELLITE IMAGERY BY DIGITALGLOBE (AUGUST, 2016), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. NEW MILNE PORT FOOTPRINT PROVIDED BY CLIENT, MAY 28, 2018. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT – PHASE 2 PROPOSAL

TITLE
PHASE 2 PROPOSAL MARINE FOOTPRINT

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-21
DESIGNED	DV
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000-504	0	3.2

3.6.2 Ore Dock Construction

Pile installation, rock fill placement and backfilling, soft soil removal from the seabed and its disposal during construction of the ore dock may cause re-suspension and introduction of sediment in the water column with subsequent deposition on the seafloor. This may result in changes in sediment quality, such as increase in fines (silt-clay) and concentrations of metals and hydrocarbons, and effects on benthic habitat and associated changes in biological communities and productivity.

The construction design includes a number of mitigation features that reduce potential environmental effects during dock construction. The majority of construction work, particularly in shallow water (e.g., access causeway), will take place in winter as land-fast ice is formed. It is expected that, as construction gradually moves offshore, ice will thicken and become grounded. Therefore, ice surrounding construction areas will act as a barrier limiting particulate deposition and spills in surrounding water. To reduce disturbance to the marine environment, the ore dock components will be constructed sequentially, moving from onshore to offshore; the causeway will be constructed in small sections, placing protective layers and armoring immediately after core material is placed to minimize erosion. Backfilling of the birth will only occur after a sufficient length of quay is installed so the fill remains within the structure footprint and no material is dispersed. Machine operation in water will be reduced, e.g., piling and filling equipment will operate on the constructed sections of the ore dock and will not enter the water.

Use of a suction pump for localized removal of soft sediment layer will reduce dispersal of re-suspended sediment in water. Disposal of removed sediment will be conducted in accordance in a way to minimize effects on water and sediment quality (see Section 2.6.1).

A number of mitigation measures outlined in the Dock Construction Environmental Plan will be implemented to meet *Fisheries Act* Authorization requirements and to avoid or reduce adverse effects on marine environment. Silt curtains will be installed around localized construction areas during the ice break-up period and around the full perimeter of construction including removed sediment disposal area during the open-water season. Silt curtains will be installed prior to any in-water work in order to encapsulate the entire construction footprint and to reduce disturbance to the marine environment in the surrounding area. Silt curtains will be designed and procured to extend from the sea surface to the seabed and there will be sufficient clearance left between the curtain and construction footprint in order to increase TSS settlement.

The management plans will also include monitoring to verify effectiveness of control and mitigation measures and compliance of Project activities with environmental requirements, including the *Fisheries Act* Authorization. Monitoring will include turbidity monitoring outside silt curtains and regular inspections of environmental protection measures. Turbidity monitoring will include visual observations and measurements with a turbidity sensor conducted at regular intervals. The CCME Guideline for turbidity is used as a threshold level based on changes relative to background levels: a short-term (e.g., 24-h period) increase of 8 NTU, and a long-term average (e.g., 30-d period) increase of 2 NTU (CCME 2014).

Turbidity monitoring outside silt curtains was conducted during construction of the existing ore dock (ERP) from July 28 to September 12, 2014 (ERM 2015). Observation data shows that turbidity values outside silt curtains did not exceed the long-term threshold CCME guideline value of 2 NTU above the background conditions except for three separate observations, which were attributed to natural short-term variations. Therefore, construction activities were in compliance with the Authorization with respect to turbidity.

As a part of MEEMP, sediment samples were collected to assess the influence of construction and operation activities on the marine seabed during the Project's ERP (See Section 22.4). The surveys showed that there were no significant changes in percent composition of fine particles and concentrations of irons in the two monitoring years (2015 and 2016) since the beginning of Project operations in comparison to the baseline year (2014; SEM 2016; 2017). Therefore, no effect on benthic substrate from Project construction and operations was detected.

Based on the results of previous construction monitoring, it is conservatively determined that ore dock and barge landing construction activities may cause localized and temporary increases of suspended sediments in the water column and their consecutive settling on the sea floor in areas adjacent to the constructed facilities. This may result in localized changes in sediment composition, such as an increase in fine particles (silt-clay). There is also a potential for an associated increase in metals, organic carbon and other constituents. Since this deposition will be contained within a limited area of approximately 1.5 % of the total LSA), it will have a low-magnitude effect on benthic habitat and biota, local in geographic extent, infrequent, short-term and fully reversible. The effect is determined not significant (Table 3-10).

3.6.3 Vessel Traffic (Propeller Wash)

Propeller wash from increased vessel traffic may result in potential alteration of benthic habitat by causing seabed erosion and changing sediment particle size distribution. As a result, benthic flora and infauna inhabiting finer sediment will be affected as finer sediment will be removed by propeller generated jetties. Propeller wash generated by a capesize ore carrier can potentially remove sediment to a depth of up to 0.5 m (Figure 3-3); however, these effects will be localized within the zone of propeller scour or immediately adjacent to the proposed dock (Golder 2018b). Scour depth caused by a more frequent Panamax size ore carrier will also be shallower (Figure 3-4). Effects on fauna and flora attached to harder substrate is unknown but removal of finer sediment and alteration of seabed (e.g., formation of coble and boulder veneer) habitat will change the benthic community.

The model showed that the maximum area of sediment motion potential created by a capesize ore carrier is 39,900 m^2 or approximately 4 ha (Table 2-4), while the total LSA area is approximately 1,210 ha. The propeller wash effect will, therefore, potentially result in less than 1% reduction of the habitat. Thus, the magnitude of the Phase 2 Proposal propeller wash effect is determined negligible.

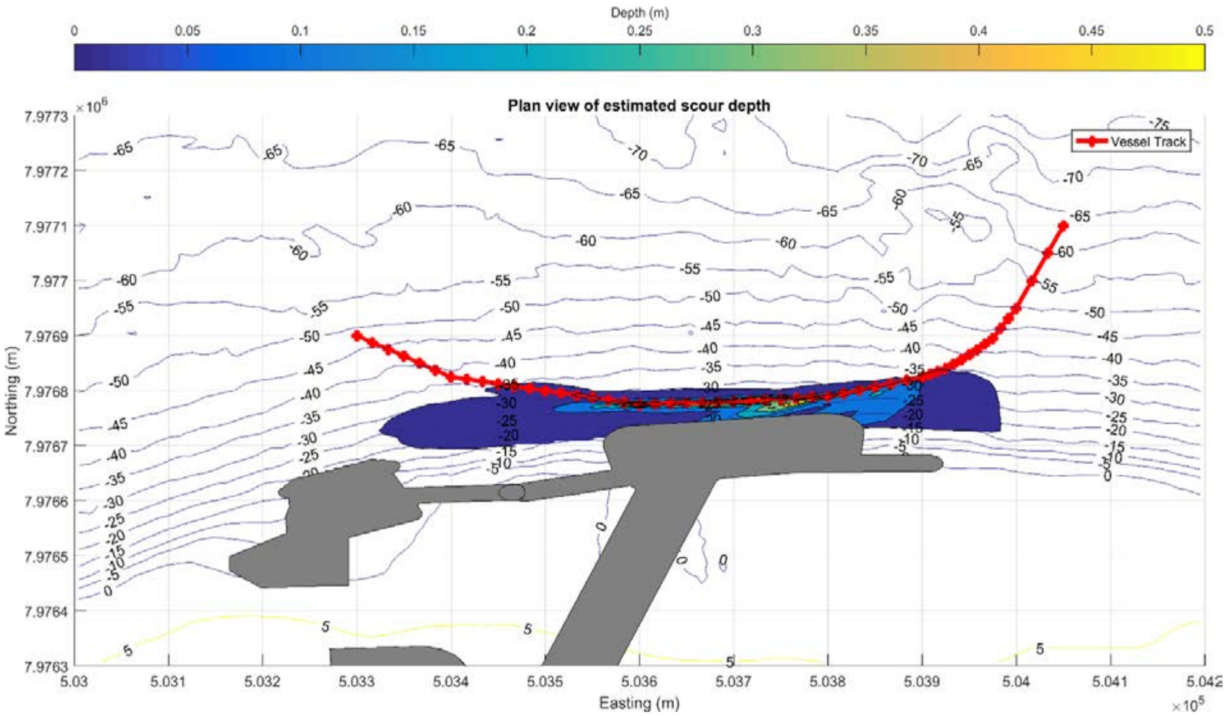

Figure 3-3: Propeller Scour Depth at the Proposed Dock for a Capesize Ore Carrier (Golder 2018b)

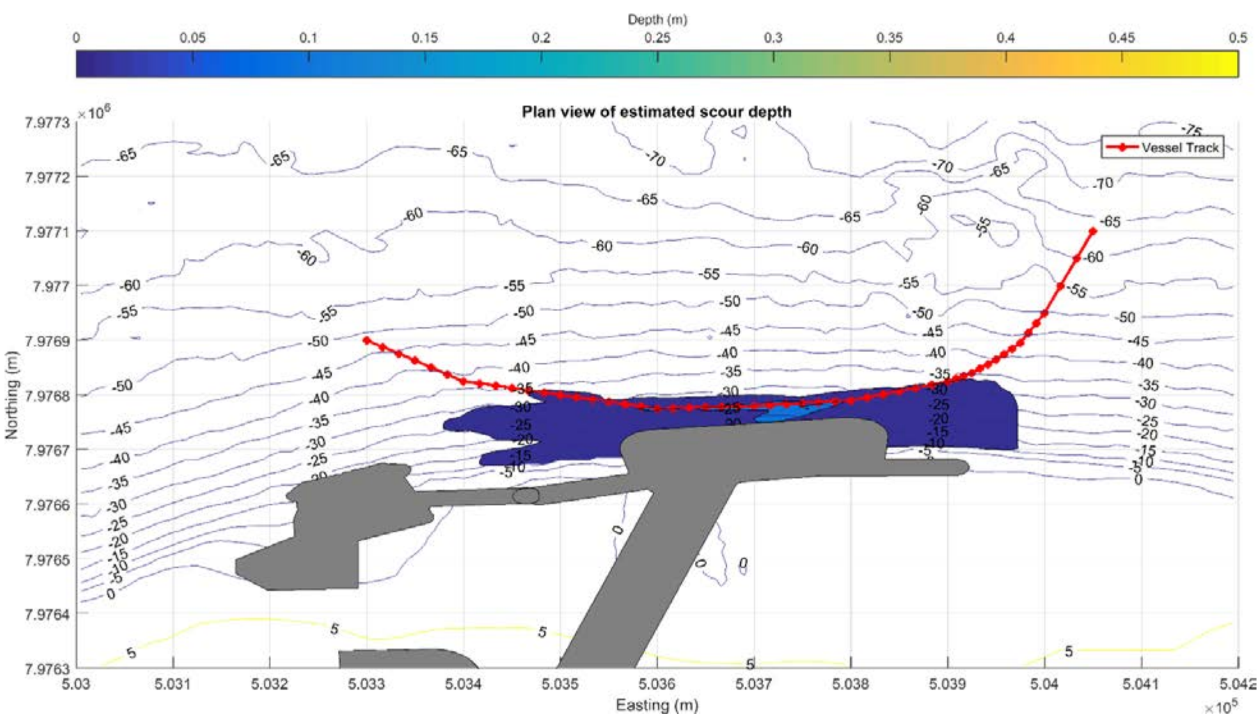

Figure 3-4: Propeller Scour Depth at the Proposed Dock for a Panamax Ore Carrier (Golder 2018b)

3.6.4 Introduction of Invasive Species with Ballast Water Discharge

During Phase 2 operations, there is an increased risk of invasive species introductions to the marine environment from ship ballast water releases due to the relative increase in ore carrier traffic, including the use of larger ships (capesize vessels). A risk assessment for the potential introduction of Aquatic Invasive Species (AIS) in Milne Port was previously completed by Baffinland based on shipping volumes applicable to the ERP (Baffinland 2013b). The methodology that was applied closely followed the methods described by Chan et al. (2012), which allowed for a comparison of invasion risks between Milne Port and other Canadian Arctic ports servicing international merchant vessels. Baffinland subsequently conducted a revised risk assessment (Golder 2017c), updated to reflect new shipping volumes and ship specifications applicable to the Phase 2 Proposal, as well as relevant guidance provided by Fisheries and Oceans Canada (DFO 2012; 2014; Casas-Monroy et al. 2014).

The AIS risk assessment approach (Casas-Monroy et al. 2014) involves a three-step process that consists of (i) calculating the probability of introduction based on the probability of arrival and probability of survival of non-native species to Milne Inlet; (ii) defining the consequence of invasion; and (iii) determining the overall risk of invasion. Probability of arrival was based on the ballast water volume to be discharged at the port corrected to mid-ocean exchange that is implemented as a mandatory management activity in compliance with the *Canada Shipping Act* regulation. The probability of survival was based on similarities between the source and recipient ports, mostly determined by water temperature and salinity. The magnitude of consequences was established by considering the number of high impact (harmful) aquatic nonindigenous species that may be introduced into the receiving port using the Marine Invasive Database of the Nature Conservancy (Molnar et al. 2008) and a database available online at http://www.conservationgateway.org/ConservationPractices/Marine/Pages/marineinvasives.aspx. Finally, the invasion risk was determined by combining probability of introduction and magnitude of consequences in a symmetrical mixed-rounding matrix (Table 3-6; Chan et al. 2012).

Table 3-6: Matrix used to Assess Invasion Risk (adapted from Chan et al. 2012)

		Probability of Introduction				
		Very Low	**Low**	**Intermediate**	**High**	**Very High**
Magnitude of Consequence	**Very High**	Intermediate	Intermediate	High	High	High
	High	Intermediate	Intermediate	Intermediate	High	High
	Intermediate	Low	Intermediate	Intermediate	Intermediate	High
	Low	Low	Low	Intermediate	Intermediate	Intermediate
	Very Low	Low	Low	Low	Intermediate	Intermediate

Note: High, intermediate and low 'Invasion Risk' highlighted in red, yellow and green, respectively.

Based on the calculated probability of arrival, which was assessed as very high, and the probability of survival, which was also evaluated as very high, the probability of introduction of invasive species was predicted to be very high. The magnitude of consequence was also ranked as very high due to a high number of AIS (166) determined to potentially arrive by ships to the Canadian Arctic region by the national risk assessment (Casas-Monroy et al. 2014). As a result, the level of risk of AIS invasion with ballast water was ranked as *high*.

Under the assumptions of the AIS risk assessment, all vessels arriving from outside Canada's Exclusive Economic Zone (EEZ) will comply with the Ballast Water Control and Management Regulations (Regulations) under the *Canada Shipping Act* (SOR/2011-237), and will exchange their ballast water outside the EEZ (outside the 200 nautical mile limit) and in water at least 2,000 metres deep (e.g., North Atlantic Ocean or Labrador Sea). The objective of this open-ocean ballast water exchange is to release non-native coastal species from ballast tanks in order to reduce their potential colonization of Canadian coastal waters, and to replace them with oceanic biota that are less likely to survive in the Canadian coastal waters (Levings et al. 2002). To enforce compliance with the plan and regulations, Baffinland implements a compulsory monitoring of ships' ballast water to verify that the salinity is above 30 ppt. However, even with open-water ballast water exchange, the potential for AIR introductions to the marine environment as a result of the Phase 2 Proposal shipping remains high. Since mid-ocean exchange is not 100% effective (on average 90%) and environmental conditions of the exchanged water and destination port are similar (Casas-Monroy et al. 2014), the projected volume of shipping and discharged ballast water remains high.

The Shipping and Wildlife Management Plan will be revised, and will include reference to the D-2 standard of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (Convention; IMO 2017) ratified by Canada. The Convention came into force in 2017 and requires that all ships implement a Ballast Water Management Plan and comply with the D-2 performance standard that specifies the maximum amount of organisms and indicator microbes allowed to be discharged to the receiving marine environment. According to the Convention, ships entering Canadian waters from abroad will need to install an on-board system to treat ballast water and eliminate unwanted organisms to meet the D-2 performance standard according to the schedule set by the IMO (MEPC 2017). The requirements of the reference to the D-2 standard will reduce the risk of AIS introduction in the Milne Inlet ecosystem.

Baffinland has developed and implemented an AIS monitoring program that includes collection of data on taxonomic composition of zooplankton, benthic infauna, epibenthos, macroflora, fish and encrusting epifauna and constant updates of taxa inventory lists. The lists are examined for evidence of new taxa for early warning of a potential case of any new taxa being invasive. To-date, no indication of presence of any invasive species in the Milne Inlet ecosystem has been detected (Section 3.3; Golder 2018d).

Implementation of mitigation plans and continuing AIS monitoring will minimize the potential for AIS introduction with ballast water. The residual effect is, therefore, determined as negligible.

3.6.5 Ore Dust Deposition

According to the air quality model, fugitive ore dust will be deposited on the surface of Milne Inlet over an area of approximately 1,320 ha with an annual average deposition rate between 5 and 13 g/m^2/year (Section 2.6.5). Deposition rate varies with distance from the source with more dust deposited in close proximity. Using the highest rate of deposition as a conservative indicator, the depth of the sediment layer predicted to be deposited is 0.002 mm annually, or a total of 0.049 mm over the life of the Phase 2 Proposal (Table 2-5). Over much of the affected area at Milne Port, depositional rates on the water/ice surface will be much less. Further, ore dust will be dispersed by water and ice movements and a thinner layer of deposition on the seabed assuming water or ice transport distributes the dust uniformly.

Dust will also be deposited on land over an area of 1,290 ha with the rate between 12 and >38 $g/m^2/year$ (Table 2-6). Dust deposited on land will be introduced to Milne Inlet with surface runoff, most of it during the spring freshet. If introduced instantaneously, this may, by a very conservative estimate, result in additional maximum sediment thickness of 0.003 mm to 0.009 mm per year (0.23 mm over the life of the Project). However, all dust will not be deposited instantaneously nor will it be transported to the marine environment. A portion of the dust will likely be retained within the terrestrial ecosystem or collected with drainage waters in the ore stockpile settlement ponds and removed before water is discharged. Additionally, any runoff entering Milne Port will be dispersed by tidal flux, so accumulation in the sediments is expected to be minimal.

The effect from ore dust deposition on sediment quality is determined negligible. Therefore, ore dust deposition will have negligible effect on fish habitat and is not considered further.

3.6.6 Underwater Noise

Underwater noise generated by Project activities can potentially affect marine biota including fish. Anthropogenic effects from underwater noise on fish depends on the species of fish and the nature of the noise exposure (e.g., duration, peak pressure, rise times, accumulation of energy with time). Effects may range from behavioral responses to physiological traumas and include the following (Popper and Hastings 2009; Popper et al 2014):

- Mortality and mortal injury. These may be caused by tears or rupture of the swim bladder or other tissues, which may affect buoyancy or cause internal bleeding and ultimately mortality. This can result from exposure of fish to very high sound pressure, such as impulses created by blasts;
- Recoverable injury – injuries, including hair cell damage, minor internal or external hematoma, etc. None of these injuries are likely to result in mortality;
- Auditory tissue damage that results in temporary hearing loss (temporary threshold shift (TTS)) or permanent hearing loss (permanent threshold shift (PTS)). TTS is defined as short or long term changes in hearing sensitivity that may or may not reduce fitness. Popper et al (2014) determines TTS as any change in hearing of 6 dB or greater that persists. Hearing loss may result in impaired ability to respond to other noise cues and thus be more susceptible to predation or less able to find food;
- Masking – impairment of hearing sensitivity by greater than 6 dB, including all components of the auditory scene, in the presence of noise;
- Startle responses or swimming out and temporary avoidance of areas exposed to underwater noise; and
- Behavioral effects that result in substantial changes in behavior for fish exposed to a sound. These effects include long-term changes in behavior and distribution, alteration of feeding, reproduction areas or migration patterns.

There is considerable variation among fish species in sound detection and processing based on differences in their anatomical and physiological traits (Popper and Fay 1993; Popper et al. 2003; Yan et al. 2000). Although the concept has been under revision in later years (Popper and Fay 2011), a broad consensus divides fish into two categories in terms of sound sensitivity: hearing ‘generalists’ (or ‘non-specialists’) and hearing specialists (Popper et al. 2003; Ladich and Popper 2004).

Hearing 'specialists' have complex anatomical structures that enhance hearing; in most hearing "specialists" there is connection of inner ear with gas bladder (through otic bullae or Weberian ossicles (Popper and Fay 1993; Higgs 2012)) or, even, lateral line (Popper and Fay 1993). Hearing 'specialists' have a wide frequency range of hearing and lower auditory threshold than 'generalists', and are generally more sensitive to high-amplitude noise introduced to the marine environment (e.g., impact pile driving).

Hearing 'generalists' usually lack auditory system specialization and, therefore, have relatively poor auditory sensitivity (Popper et al. 2003). This group includes fish species that have no swim bladder at all (e.g., elasmobranchs such as sharks and rays), those that have undeveloped swim bladder during their adult life (most bottom-dwelling species such as flatfish), or those whose swim bladder is not in close proximity, or mechanically connected to the ears (Popper et al. 2003). The majority of fish species are 'non-specialists', have peak sensitivities around 300 to 500Hz and generally are not sensitive to frequencies above about 800Hz, (Ladich and Popper 2004). They have higher sound pressure detection threshold, as high as 120 decibel (dB) re 1 micro Pascal (µPa) at the most sensitive frequency (Nedwell et al. 2004). Fish without swim bladders are only sensitive to the particle motion component of the sound.

Underwater noise changes during the Phase 2 Proposal in the vicinity of Milne Port that will affect fish will occur primarily during the construction phase of the Project. These increases are considered to have a potential to result in injuries and/or behavioural effects on fish, such as avoidance of areas exposed to underwater noise, therefore causing loss of available fish habitat. The main sources of project-generated underwater noise during the Phase 2 Proposal construction of new ore dock will include pile driving, rock fill placement and backfilling, and vessel traffic. The most significant underwater noise is expected to be generated by pile driving, while other activities will produce considerably lower sound levels.

Pile driving, particularly impact-driven, can result in physiological impacts on fish, including hearing loss. Vibratory driving is considerably less damaging to fish and is often used as a mitigation measure to reduce the effects on fish from impact pile driving (Buehler et al. 2015).

Acoustic Impact Criteria for Fish

Assessment of the potential effects of pile driving noise on fish requires acoustic thresholds against which received sound levels can be compared. Underwater sound levels are expressed in decibel (dB) which is a logarithmic ratio relative to a fixed reference pressure of 1 µPa (re 1 µPa) (equal to 10^{-6} Pa or 10^{-11} bar). Auditory injury thresholds from underwater noise are expressed using two common metrics: sound pressure level (SPL), measured in dB re: 1 µPa, and sound exposure level (SEL), a measure of energy in dB re: 1 uPa^2s. SPL is an instantaneous value represented as either root-mean-square (SPL^{rms}) or peak sound pressure level (SPL_{Pk}), whereas SEL is the total noise energy to which an organism is exposed over a given time period, typically one second for pulse sources. As such, the cumulative SEL metric is appropriate when assessing effects to fish from cumulative exposure to multiple pulses. Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for 'serious harm[6]' to fish from underwater noise is typically based on 'best available evidence', as documented in the scientific literature, available Best Management Practices (BMPs) and/or established by other government agencies.

[6] includes the destruction of fish habitat or an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes (DFO 2013b)

In 2006, the Working Group on the Effects of Sound on Fish and Turtles (the Working Group) was formed to continue developing sound exposure thresholds for fish and turtles, work begun by a NOAA panel two years earlier. The Working Group developed guidelines with specific thresholds for different levels of effects for several species groups (Popper et al. 2014). The guidelines define quantitative thresholds for three types of immediate effects:

- Mortality and potential mortal injury;
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma; and
- Temporary threshold shift.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend on activity-based subjective ranges, these effects were not addressed in this report, and are included for completeness only. Because the presence or absence of a swim bladder may have a role in hearing, a fish's susceptibility to injury from noise exposure depends on the species as well as the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Fish eggs and larvae were considered separately.

Table 3-7 lists relevant effects thresholds from Popper et al. (2014) for impact pile driving. In general, any adverse effects of sound on fish behaviour depends on the species, the state of the individual exposed, and other factors. Similar to marine mammals, Popper et al. (2014) recommend a standard period for SEL accumulation being either the duration of the activity or 24 hours; however, the publication also includes caveats about considering the actual exposure times if fish move.

Table 3-7: Guidelines for Pile Driving Noise Exposure for Fish (Adapted from Popper et al. (2014))

Type of animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{24h} or > 213 dB PK	> 216 dB SEL_{24h} or > 213 dB PK	>> 186 dB SEL_{24h}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	>> 186 dB SEL_{24h}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	186 dB SEL_{24h}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	> 210 dB SEL_{24h} or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes:
Peak sound pressure level dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N; tens of meters from the source), intermediate (I; hundreds of metes from the source), and far (F; thousands of meters from the source).

Construction of the new ore dock will require installation of cylindrical piles using impact driving methods. Impact pile driving was acoustically modelled by JASCO Applied Sciences (JASCO) based on the following pile driving scenario:

- Impact driving of steel cylindrical piles (70 m length ×1.829 m diameter with 2.54 cm pile wall thickness) at the new ore dock (front berth face) installed using an APE D180-42 impact hammer to seat the pile. Water depth = 21 m.

Modelling results indicated that the maximum range for fish mortality and potential mortal injury, based on the SEL_{24h} criterion from Popper et al. (2014), is 250 m km for 'fish with swim bladders involved with hearing', 140 m for both 'fish with swim bladders not involved with hearing' and 'fish eggs/larvae', and 30 m for 'fish with no swim bladders'. The maximum range for fish mortality or injury, based on the Peak SPL threshold, is 210 m for both 'fish with swim bladders' and 'fish eggs/larvae', and 90 m for 'fish without swim bladders'. Modeling results are summarized in Table 3-8 and Table 3-9. Detailed modelling results are presented in Quijano et al. (2018).

Table 3-8: SEL24h - Based Threshold Distances for Phase 2 Proposal Impact Pile Driving Noise Exposure for Fish, Including Eggs and Larvae (Quijano et al. 2018)

Fish type	SEL_{24h} threshold (dB re 1 µPa²·s)	Threshold distance (km)	
		Rmax	R95%
Fish mortality and potential mortal injury			
I*	219	0.03	0.03
II* Fish eggs and larvae	210	0.14	0.11
III*	207	0.25	0.20
Fish recoverable injury			
I*	216	0.05	0.05
II*, III*	203	0.44	0.35
Fish Temporary threshold shift			
I*, II*, III*	186	10.57	6.03

Notes:
* Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing (Adapted from Popper et al 2014). Acoustic modelling completed by JASCO Applied Sciences (Quijano et al. 2018).

Table 3-9: Peak Based Threshold Distances for Phase 2 Proposal Impact Pile Driving Noise Exposure for Fish, Including Eggs and Larvae (Quijano et al. 2018)

Fish type	PK threshold (dB re 1 µPa)	Threshold distance (km)	
		R_{max}	$R_{95\%}$
I*	213	0.09	0.07
II*,III* Fish eggs and larvae	207	0.21	0.17

Notes:
* Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing (Adapted from Popper et al 2014). Acoustic modelling completed by JASCO Applied Sciences (Quijano et al. 2018).

Proposed mitigation during construction will be captured in an ‘Ore Dock Construction Environmental Plan’ and will include the following measures:

- Most acoustically sensitive fish will avoid the immediate impact area once impact pile driving is underway. Operators are encouraged to take advantage of this behaviour by adopting a ramp-up / soft-start procedure when operating the impact hammer, when this is technically feasible. A ramp-up procedure consists of initial activation of the equipment using the lowest energy source / pulse and gradually increasing the intensity of the sound until it reaches the required intensity, thus allowing time and incentive for acoustically sensitive fish to leave the area prior to operating the impact driver at full power;

- Concurrent impact pile driving activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned, they will be sequenced where possible to minimize acoustic impacts;
- Underwater noise generated during impact pile driving will not exceed 207 dB re 1µPa^2·s (SPL_{Pk}) at a distance of 200 m from the source. If the sound level exceeds 30 kPa at a distance of 10 m from the source, measures will be undertaken to reduce either the intensity of the sound generated or the level of sound propagation through the water column. The appropriate measure will be chosen based on practicality and effectiveness and may include:
  - The placement of bubble curtains around the wetted pile during impact driving. Bubble curtains are proven to be an effective mitigation measure for dampening underwater noise generated by pile driving, and are reported to reduce peak pressures by up to 30 dB (Buehler et al. 2015);
  - The use of a vibratory hammer in place of an impact hammer for pile driving;
- Impact pile driving activities will be temporarily suspended if aggregations of fish are spotted within the immediate work area or if any fish spawn is observed attached to equipment or structures in the water; and
- Impact pile driving will be scheduled when practical to avoid sensitive fish periods such as fish spawning and migratory periods.

Assuming no deployment of bubble curtains, the most conservative estimate of potentially affected fish habitat in the LSA (in which the injury threshold of 207 dB re 1 µPa would be exceeded) represents approximately 1.6% of available fish habitat in this area of Milne Port.

The majority of fish species encountered in the vicinity of Milne Port are hearing ‘generalists’; most of these species, particularly ones with reduced hearing capability (such as sculpins) will likely be less affected by the noise. However, it is conservatively assumed that some species, such as Arctic char and cods, may be affected by the underwater noise produced by pile driving and may display behavioural response by avoiding the area of ore dock construction to a distance of several hundred meters (less than 10% of the marine habitat LSA). The magnitude of the effect from underwater noise during construction is determined low, local in geographic extent, intermittent in frequency, short-term (lasting only during the period of construction), and fully reversible. The effect is determined not significant.

3.6.7 Significance of Residual Effects

The ratings assigned to the residual effects evaluated above are presented in Table 3-10. The effects are determined to be not significant.

Table 3-10: Significance of Residual Effects to Marine Fish Habitat

Residual Effect	Residual Effect Evaluation Criteria					Significance of Residual Effect	Qualifiers	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of the Effect Occurring)	Certainty (Confidence in the effects prediction)
Habitat Loss due to Project Footprint	1	1	3	3	1	Not significant	3	3
Habitat Alteration due to Port Construction	1	1	1	1	1	Not significant	3	3
Habitat Alteration due to Increased Vessel Traffic (Prop Wash)	Negligible	-	-	-	-	-	-	-
Introduction of Invasive Species with Ballast Water	Negligible	-	-	-	-	-	-	-
Habitat Alteration due to Ore Dust Deposition	Negligible	-	-	-	-	-	-	-
Underwater Noise Effect	1	1	1	1	1	Not significant	3	3

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

Qualifiers- only applicable to non-negligible effects:
Probability: 1 = Unlikely; 2 = Moderate; 3 = Likely
Certainty: 1 = Low; 2 = Moderate; 3 = High

3.7 Effect Assessment – Arctic Char Health

Effects identified as Key Issues or Level 2 interactions resulting from the Phase 2 Proposal that are of substantial public interest and/or of potentially high environmental importance or consequence were carried forward in the assessment. These are summarized in Table 3-11 and discussed in the following sections.

Table 3-11: Summary of Effects on Arctic Char Health and Condition – Phase 2 Proposal

Project Interaction	Potential Effects
Sediment resuspension due to construction and decommissioning activities and vessel traffic	■ Short-term exposure to small, temporary increases in concentrations of TSS, nutrients, and metals in water (through pile driving and infilling during construction of Ore Dock) may have some potential to negatively affect fish health;
Discharge of wastewater, contact water, and site drainage	■ Potential increases in metal and hydrocarbon concentrations in fish tissues and reductions in fish health and condition are possible as a result of release of site drainage (with elevated BOD and concentrations of TSS, nutrients, metals, and hydrocarbons) to the marine environment.
Fugitive ore dust deposition	■ Increases in metal concentration in fish tissues and reductions in fish health and condition as a result of increased metals (primarily iron) in the water and sediment.
Underwater noise	■ Mortality or serious injury due to exposure to underwater noise generated by pile-driving

3.7.1 Sediment Resuspension during Construction

Pile installation, rock fill placement, backfilling, removal and disposal of soft sediments and other activities associated with construction of new ore dock may cause re-suspension and introduction of sediment in the water column affecting marine water quality. Effects on marine water quality are discussed in Section 2.6.1. Changes in water quality may negatively affect Arctic char health.

Mitigation measures to reduce environmental effects from construction of marine facilities in Milne Inlet will be addressed in the Ore Dock Construction Environmental Plan. The plan will include measures to reduce siltation and introduction of harmful substances in marine waters adjacent to construction site. These measures are discussed in Section 2.6.1.

Turbidity monitoring was conducted outside silt curtains during construction of the existing ore dock (ERM 2015) and showed that mitigation measures were effective in avoiding and reducing effects on marine water quality. Therefore, ore dock construction activities were in compliance with the *Fisheries Act* Authorization.

It is conservatively predicted that ore dock construction activities may cause localized and temporary increases of TSS and associated nutrients and metals in the water column adjacent to the work zone (Section 2.6.1). These increases may exceed baseline levels, but will not exceed water quality guidelines by more than an order of magnitude. Therefore, potential residual effects of this pathway on Arctic health are determined to be negligible to low in magnitude, localized in extent, continuous, short-term in duration and reversible (Table 3-12). The effect is determined not significant.

3.7.2 Wastewater Discharge and Site Runoff

There is a potential for effects on marine water quality due to increase in discharges from all four sources of effluent (sewage wastewater, treated melt water from tank farm containment area, ore stockpile runoff and general site drainage) resulting from expansion of Project operations, personnel, site area and volumes of transported ore and stored materials. Effects on marine water quality are discussed in Section 2.6.3. Changes in water quality may subsequently result in negative effects on Arctic char health.

Mitigation measures to reduce the effect from the site effluent discharge on the environment will be outlined in Surface Water and Aquatic Ecosystem Management Plan and Freshwater Supply, Sewage and Wastewater Management Plan. The former plan addresses procedures and best management practices to limit the potential for adverse effects to receiving waters, aquatic ecosystems, fish and fish habitat from drainage and runoff from Project facilities; the latter contains wastewater treatment, monitoring and discharge requirements and procedures. These measures are discussed in Section 2.6.3.

Monitoring of seawater at and around the discharge location during the two years of operation showed that all analysed parameters were within CCME water quality guidelines and within ranges observed previously during baseline studies with exception to concentrations of mercury, which exceeded CCME guidelines during one sampling event in 2015 by approximately 1.5 times. No hydrocarbons were detected in any of the water samples.

Arctic char tissue samples collected during Project’s baseline and effect monitoring field programs showed no changes in concentrations of detected metals from 2010 to 2017 (Section 3.3). None of the samples exceeded Health Canada’s guideline for mercury in fish tissue for human consumption.

It is conservatively assumed that there may be localized short-term exceedances of CCME water quality guidelines in concentrations of some constituents, such as pH, TSS or metals, at the drainage site. These concentrations, however, will not exceed CCME water quality guidelines by more than 10 times. Therefore, potential residual effects of this pathway on Arctic char health is determined to be low in magnitude, localized in extent, infrequent, short-term in duration and reversible (Table 3-12). The effect is determined not significant.

3.7.3 Invasive Species

There is a potential of introduction of invasive species and harmful bacteria and parasites that may negatively affect Arctic char health and conditions. The AIS risk assessment and mitigation measures are discussed in Section 3.6.4. As the result of the mitigation measures implemented by Baffinland, the residual effect from AIS introduced with ballast water will be negligible (Table 3-12).

3.7.4 Ore Dust Deposition

Effect from fugitive ore dust deposition on water quality is discussed in Section 2.6.5. Ore dust depositions in the marine environment may cause increases in TSS and concentrations of metals, particularly iron, in water and sediments. There are no marine water quality guidelines for metals present? In the ore, therefore no direct comparisons can be made. It is considered that low-level (no more than 10 times) exceedances of CCME guidelines for TSS may occur infrequently in areas near freshwater discharge, e.g., the Phillips Creek estuary, and in the zone of greatest dust deposition. Therefore, the effect of dust deposition on Arctic char health in Milne

Inlet is determined to be of low (Level I) magnitude, local extent, continuous, medium-term duration, and fully reversible. The effect is determined not significant.

3.7.5 Underwater Noise

There is a potential for mortality or injury of Arctic char due to exposure to underwater noise generated by impact pile driving during the proposed ore dock construction. Without the deployment of bubble curtains as mitigation, modelling results indicate that the maximum distance from the pile at which mortality or injury may occur is 250 m (Quijano et al. 2018; see Section 3.6.6). However, most of the pile-driving will be conducted during the ice-covered season (December to early June), which falls outside of the period when Arctic char are usually present in the marine environment. With application of underwater noise mitigation measures, as outlined in Section 3.6.6 and the Ore Dock Construction Environmental Plan, any adverse effects from impact pile driving on fish are expected to be eliminated or considerably reduced. The magnitude of effects from pile driving on Arctic char conditions and health is conservatively considered medium, local in extent, intermittent in frequency, short-term in duration, and fully reversible. The effect is determined not significant.

3.7.6 Significance of Residual Effects

The ratings assigned to the residual effects evaluated above are presented in Table 3-12. The effects are determined to be not significant.

Table 3-12: Significance of Residual Effects on Arctic Char Health and Condition

Residual Effect	Residual Effect Evaluation Criteria					Significance of Residual Effect	Qualifiers	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of the Effect Occurring)	Certainty (Confidence in the effects prediction)
Effect from sediment resuspension due to construction and vessel traffic	1	1	3	1	1	Not significant	3	3
Effects on health from wastewater discharge and site runoff	1	1	1	2	1	Not significant	3	3
Effects from introduction of invasive species with ballast water	Negligible	-	-	-	-	-	-	-
Effect on Arctic char health from ore dust deposition	1	1	3	2	1	Not significant	3	3
Mortality or injury from noise exposure	2	1	2	1	1	Not significant	3	3

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

Qualifiers- only applicable to non-negligible effects:
Probability: 1 = Unlikely; 2 = Moderate; 3 = Likely
Certainty: 1 = Low; 2 = Moderate; 3 = High

4.0 MITIGATION AND MONITORING PLAN UPDATES

Four of Baffinland's existing environmental management plans and three of Baffinland's ongoing monitoring programs are relevant to the marine environment. Proposed updates or revisions to management plans to address the outcome of the marine environmental effects assessment for the Phase 2 Proposal are presented in Table 4-1. Proposed updates and revisions to existing monitoring programs are presented in Table 4-2.

Table 4-1: Proposed Management Plan Updates

Management Plan	Required Update for the Phase 2 Proposal
Ore Dock Construction Environmental Plan	The plan will be updated to address potential effects from construction of the new ore dock
Surface Water and Aquatic Ecosystem Management Plan	The plan will be updated to address an increase in surface runoff due to increase in the total area of Project facilities, including expansion of ore stockpile and fuel storage facility.
Freshwater Supply, Sewage and Wastewater Management Plan	The plan will be updated to address an increase in the volume of sewage and wastewater for Phase 2 Proposal due to increase in site personnel and expansion of site facilities and operations.
Shipping and Wildlife Management Plan	The plan will be updated to include ballast water treatment options and monitoring to address the increased risk from invasive species and D-2 requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

Table 4-2: Proposed Monitoring Program Updates

Monitoring Program	Required Update for the Phase 2 Proposal
Marine Environmental Effects Monitoring Program (MEEMP)	The plan will be updated to address construction of an additional ore dock, expansion of ore stockpiles and increase in wastewater discharge. In addition, sampling design and approach may be revised to optimize statistical power and increase robustness of statistical analysis.
Aquatic Invasive Species (AIS) Monitoring Program	The program will be updated to address increase in the ballast water discharge volume and location of the new ore dock. Sampling and measurements of ballast water will be addressed in the Shipping and Wildlife Management Plan (see Table 4-1).
Fish Offsetting Habitat Monitoring Program	The plan will be updated to include the new fish offsetting habitat that will be constructed to offset for the Project footprint increase and associated loss of fish habitat. Offsetting habitat and monitoring will be a part of Baffinland's commitment under a future *Fisheries Act* Authorization.

5.0 CLOSURE

We trust that the information contained in this report meets your present requirements. Please contact us if you have any questions or concerns regarding the above.

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Associate, Senior Environmental Scientist

AO/DC/asd

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APPENDIX A

Marine Environmental Baseline Report

REPORT

Baffinland Iron Mines Corporation
Mary River Project – Phase 2 Proposal

Marine Environment Baseline Report

Submitted to:

Baffinland Iron Mines Corporation
2275 Upper Middle Road East Suite 300
Oakville, ON L6H 0C3

Submitted by:

Golder Associates Ltd.

Suite 200 - 2920 Virtual Way, Vancouver, British Columbia, V5M 0C4, Canada

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1663724-067-R-Rev0

28 June 2018

Distribution List

1 e-copy - Baffinland Iron Mines Corporation

List of Acronyms and Abbreviations

Abbreviation and Acronyms	Definition
°C	Degree Celsius
AIS	Aquatic invasive species
ANCOVA	Analysis of covariance
Baffinland	Baffinland Iron Mines Corporation
CCME	Canadian Council of Ministers of Environment
CPUE	Catch per unit effort
DFO	Fisheries and Oceans Canada
DL	Detection limit
ERP	Early Revenue Phase
ESQG	Interim Sediment Quality Guidelines
LSA	Local Study Area
MEEMP	Marine Environmental Effect Monitoring Program
m	Metre(s)
mg/kg	Milligrams per kilogram
mm	Millimetre
Mtpa	Million tonnes per annum
µg/L	Microgram per litre
µm	micrometre
NTU	Nephelometric Turbidity Unit
NIRB	Nunavut Impact Review Board
No.	Number
PAH	Polycyclic aromatic hydrocarbons
PAL	Probable Effect Level
PSU	Practical Salinity Unit
SEM	Sikumiut Environmental Management Ltd.

Abbreviation and Acronyms	Definition
TN	Total nitrogen
VEC	Valuable Ecosystem Component
ZOI	Zone of influence

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

The Mary River Project is an operating iron ore mine located in the Qikiqtani Region of Nunavut (Figure 1-1). Baffinland Iron Mines Corporation (Baffinland; the Proponent) is the owner and operator of the Project. As part of the regulatory approval process, Baffinland submitted a Final Environmental Impact Statement (FEIS) to the Nunavut Impact Review Board (NIRB), which presented in-depth analyses and evaluation of potential environmental and socioeconomic effects associated with the Project.

In 2012, NIRB issued Project Certificate No 005 which provided approval for Baffinland to mine 18 million tonnes per annum (Mtpa) of iron ore, construct a railway to transport the ore south to a port at Steensby Inlet which operates year-round, and to ship the ore to market. The Project Certificate was subsequently amended to include the mining of an additional 4.2 Mtpa of ore, trucking this amount of ore by an existing road (the Tote Road) north to an existing port at Milne Inlet, and shipping the ore to market during the open water season. The total approved iron ore production was increased to 22.2 Mtpa (4.2 Mtpa transported by road to Milne Port, and 18 Mtpa transported by rail to Steensby Port). This is now considered the Approved Project. The 18 Mtpa Steensby rail project has not yet been constructed, however 4.2 MTPA of iron ore is being transported north by road to Milne Port currently. Baffinland recently submitted a request for a second amendment to Project Certificate No.005 to allow for a short-term increase in production and transport of ore via road through Milne Port from the current 4.2 Mtpa to 6.0 Mtpa.

The Phase 2 Proposal (the third project certificate amendment request) involves increasing the quantity of ore shipped through Milne Port to 12 Mtpa, via the construction of a new railway running parallel to the existing Tote Road (called the North Railway). The total mine production will increase to 30 Mtpa with 12 Mtpa being transported via the North Railway to Milne Port and 18 Mtpa transported via the South Railway to Steensby Port. Construction on the North Railway is planned to begin in late 2019. Completion of construction of the North Railway is expected by 2020 with transportation of ore to Milne Port by trucks and railway ramping up as mine production increases to 12 Mtpa by 2020. Shipping from Milne Port will also increase to 12 Mtpa by 2020. Construction of the South Railway and Steensby Port will commence in 2021 with commissioning and a gradual increase in mine production to 30 Mtpa by 2024. Shipping of 18 Mtpa from Steensby Port will begin in 2025.

Phase 2 also involves the development of additional infrastructure at Milne Port, including a second ore dock (Figure 1-2). Shipping at Milne Port will continue to occur during the open water season, and may extend into the shoulder periods when the landfast ice is not being used to support travel and harvesting by Inuit. Various upgrades and additional infrastructure will also be required at the Mine Site and along both the north and south transportation corridors to support the increase in production and construction of the two rail lines.

LEGEND

- PROJECT SITE
- COMMUNITY
- FUTURE SOUTH RAILWAY
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA
- SHIPPING ROUTE
- SIRMILIK NATIONAL PARK
- WATER

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REFERENCE(S)

BASE MAP: © ESRI DATA AND MAPS (ONLINE) (2016). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
PROJECT LOCATION

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	VV
REVIEWED	PR
APPROVED	PR

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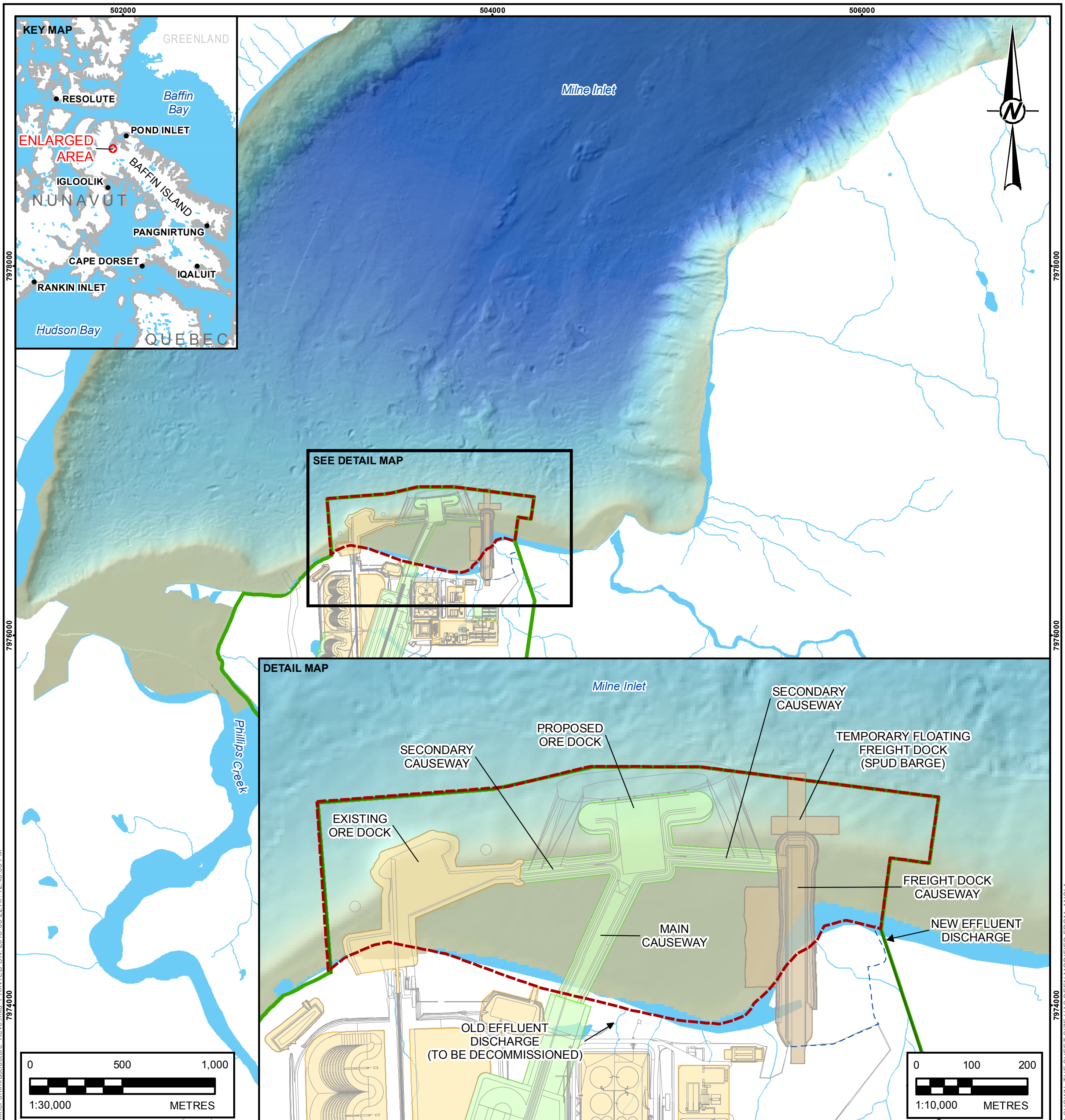

LEGEND

- NEW EFFLUENT PIPELINE
- PDA / QIA COMMERCIAL LEASE
- SITE LAYOUT
- WATERCOURSE
- INAC FORESHORE LEASE
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- EXISTING FREIGHT DOCK AND CAUSEWAY
- WATERBODY

ELEVATION (masl)
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Low : -225

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT, MAY 28, 2108, AND BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES.. HYDROGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
MILNE PORT MARINE INFRASTRUCTURE

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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1.1 Objectives

This environmental baseline report provides a summary of existing literature, Inuit traditional knowledge (Inuit Qaujimajatuqangit (IQ)), and results from Project-specific studies conducted up to date to provide a description of the marine environmental conditions in the Milne Inlet Local Study Area (LSA). This information will be used to support Addendum 2 of the FEIS for the Project. The objectives of the report are as follows:

- To characterize the existing environment;
- To provide a summary of findings of Project-specific studies conducted up to date;
- To provide information for assessment of potential environmental effects from the proposed activities based on data collected during monitoring of effects from existing facilities and operations; and
- To collect data to establish baseline conditions for future environmental effects monitoring.

The report will be used to support environmental assessment of two valued ecosystem components (VECs), Water and Sediment Quality, and Marine Habitat and Biota. However, the report provides descriptions of a broader scope of components. The overall scope of the report includes the following:

- Physical oceanography: marine water circulation, temperature and salinity;
- Water quality;
- Sediment quality;
- Pelagic biological components, such as phytoplankton (primary consumers) and zooplankton;
- Benthic habitat features, including substrate, benthic flora (macroflora - large, visible vegetation, e.g., seaweeds or seagrasses), and benthic epifauna (animals, e.g., invertebrates and fish, living on the surface of the sea floor),
- Benthic infauna; and
- Fish communities and health, including contaminant accumulation.

1.2 Study Area

The study area for the marine environment baseline includes Milne Port and the Northern Shipping Route which encompasses Milne Inlet, Eclipse Sound, Pond Inlet, and adjacent water bodies. Milne Port is located at the head of Milne Inlet at the north end of Baffin Island. Milne Inlet is a narrow fjord characterized by high surrounding headlands and deep water that is covered by landfast ice for much of the year. Eclipse Sound separates Baffin Island from Bylot Island, and extends from Milne Inlet to the South-west, Navy Board Inlet to the North-west, and Baffin Bay to the east via Pond Inlet.

Two spatial boundaries were identified for the marine environment baseline in accordance with guidance from NIRB (NIRB 2015): a Local Study Area (LSA) and a Regional Study Area (RSA) (Figure 1.3). Baseline characterization focused primarily on the LSA (local, operational scale), where Project effects were most likely to occur. The LSA includes all of Milne Port (Assomption Harbour) and extends north up to 4 m from the existing terminal (spanning the full width of Milne Inlet at the northern boundary). The southeast boundary of the LSA ends at the confluence of Milne Inlet with Phillips Creek. The RSA allows for an assessment of Project-related effects at a regional, ecologically relevant scale on northern Baffin Island. The RSA encompasses all of Milne Inlet and Eclipse Sound (Baffinland 2012).

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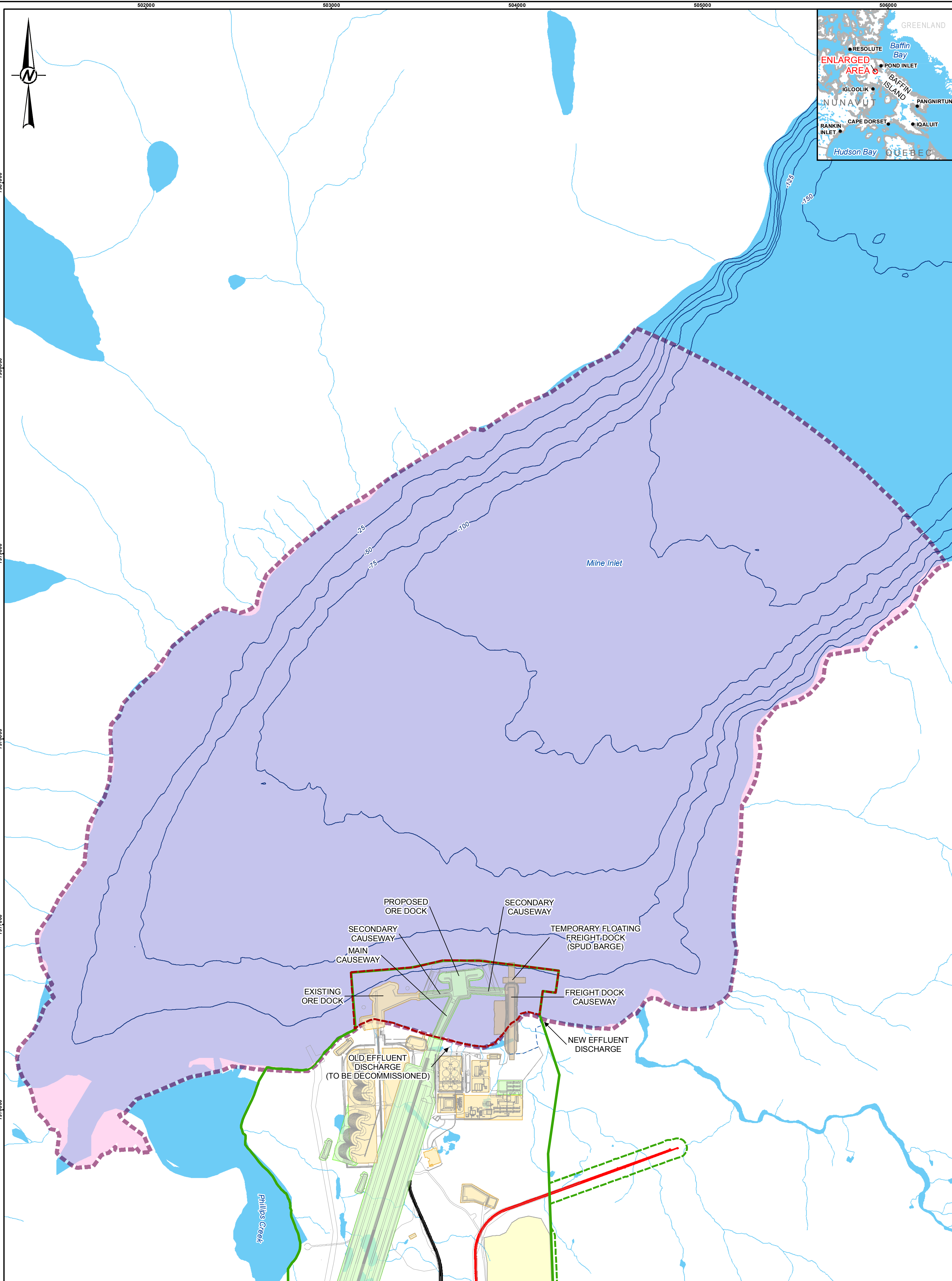

LEGEND

- • POPULATED PLACE
- BATHYMETRIC CONTOUR (25 m INTERVAL)
- MILNE INLET TOTE ROAD
- NEW EFFLUENT PIPELINE
- PROPOSED NORTH RAILWAY
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- AGGREGATE SOURCE (BORROW PIT OR QUARRY)
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- INAC FORESHORE LEASE
- LOCAL STUDY AREA
- REVISED PDA FOR PHASE 2 PROPOSAL
- WATERBODY

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REFERENCE(S)

LOCAL STUDY AREA BOUNDARY DIGITIZED FROM THE MARY RIVER PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT (FEBRUARY 2012). BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES. HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND FROM HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
PROJECT FOOTPRINT AND LOCAL STUDY AREA (LSA)

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	AA / VV
REVIEWED	PR
APPROVED	PR

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2.0 INFORMATION SOURCES

The present report is based on a review of scientific literature, Inuit traditional knowledge, Inuit Qaujimajatuqangit (IQ) and technical reports prepared for Baffinland and analysis of site-specific data collected during marine environmental baseline surveys and effect monitoring studies conducted in the Project area between 2008 and 2016, as listed below:

- 2010 Oceanography Baseline, a synthesis of physical, chemical and biological oceanography information on Milne Inlet prepared for the Mary River FEIS (Baffinland 2012) based on data collected during field studies in 2008 and 2010;
- 2013 Marine Environmental Baseline Surveys conducted in support of the FEIS Addendum (Baffinland 2013) based on surveys conducted during the summer of 2013 (SEM 2014);
- 2014, 2015 and 2016 Marine Environmental Effect Monitoring Program (MEEMP) surveys (SEM 2015; 2016a; 2017a);
- 2014, 2015 and 2016 Aquatic Invasive Species (AIS) Baseline and Environmental Effect Monitoring (EEM) studies (SEM 2015; 2016b; SEM 2017a); and
- 2015 and 2016 Milne ore dock fish offset monitoring studies (Baffinland 2016; SEM 2017b).

The majority of sampling effort for the marine environment has occurred in the LSA in the immediate vicinity of the port site (Figure 1-3). A complete summary of marine field surveys and monitoring studies conducted in the LSA between 2008 and 2016 is presented in Table 2-1.

Table 2-1: Summary of marine field surveys completed for the Mary River Project (2007–2016)

Environmental component	Methods	Baseline				AIS			MEEMP			2016 Fish Offset Monitoring
		2007	2008	2010	2013 ERP	2014	2015	2016	2014	2015	2016	
Physical oceanography - currents	ADCP probe			X					X	X	X	
Physical oceanography - CTD	In situ probe			X					X	X	X	
Water quality	Laboratory analysis	---	X	X	---	---	---	---	---	X	X	---
Phytoplankton biomass	Laboratory analysis	---	X	X	---	---	---	---	---	X	X	---
Zooplankton	Net tows	---	X	X	---	---	---	---	---	---	---	---
Sediment quality	Laboratory analysis	---	X	X	---	---	X	X	X	---	---	---
Benthic substrate	Underwater video survey	---	X	X	X	---	---	---	X	X	X	---
Benthic macroflora	Underwater video survey	---	X	X	X	X	X	X	X	X	X	X
Benthic epifauna	Underwater video survey	---	X	X	X	X	X	X	X	X	X	X
Encrusting epifauna	Settlement baskets	---	X	X	X	X	X	X	X	X	X	X

Environmental component	Methods	Baseline				AIS			MEEMP			2016 Fish Offset Monitoring
		2007	2008	2010	2013 ERP	2014	2015	2016	2014	2015	2016	
Benthic Infauna	Benthos grabs	---	---	---	---	X	X	X	---	---	---	---
Fish and mobile epifauna	Gillnet and traps	---	---	X	X	X	X	X	---	---	---	---
Fish tissue contaminants	Laboratory analysis	X	---	X	X	---	---	---	X	X	X	X

Baseline studies in 2008 and 2010 focused on collection of background environmental information in the southern end of Milne Inlet, in the general vicinity of the Milne Port site. The studies evaluated overall oceanographic and water quality conditions within the inlet and conditions of seabed habitat and biological communities in the coastal areas. During the baseline surveys in 2013, in addition to the Milne Port area, surveys were conducted at two reference sites, R-1 and R-2 (Figure 4-1, Figure 5-1, Figure 7-1).

Sampling design for the MEEMP program (2014 to 2016) was based on a radial gradient pattern originating at the Milne ore dock and the discharge location of the Project's treated effluent (Figure 4-1). The dock represents the potential point source of contaminants (e.g., ore dust, hydrocarbon deposition) and physical perturbations (sediment re-suspension and transportation). The radial pattern is designed to detect potential Project-related effects based on a gradient in numerical indicators of key components (e.g., metal concentrations in sediment and abundance of benthic biota) with increasing distance from the point source (ore dock and effluent discharge).

The MEEMP benthic studies (focusing on sediment and epi-benthic habitat) were conducted along four transects extending on a radial pattern from the ore dock. Three transects (East, West, and Coastal) were defined along the 15 m depth contour to minimize the confounding influence of depth on sediment and associated biota. The 15 m depth contour was considered to be below any potential influence of ice scour and was associated with relatively large abundances and diversity of marine flora and fauna (SEM 2014). The East and West transects extended to the east and the west of the dock to approximately 1,700 m and 1,800 m, respectively. The Coastal Transect extended from the eastern end of the East Transect along the 15 m contour of the eastern shore of the inlet to approximately 4,250 m from the East Transect. The Coastal Transect extended beyond the Project's predicted zone of influence (ZOI) and encompassed reference area R-1, sampled in 2013. The North Transect extended directly offshore to a distance of 2,000 m from the ore dock, across a gradient of depths, to a depth of approximately 100 m.

The MEEMP water quality studies were established to surround the Project's effluent discharge in a radial gradient design with increasing distance in three directions from the discharge point.

Aquatic invasive species baseline and EEM studies were designed to detect potential introduction of non-native species, mainly with ships' ballast water. The AIS monitoring did not follow the radial gradient design but rather was based on a Before/After experimental design, focusing on the areas with the highest likelihood of marine invasions. Since the majority of ballast water exchange occurs in Milne Port, data collection was focused on the location of the Milne Port infrastructure. Baseline AIS surveys were conducted in 2014 to complete the datasets of marine flora and fauna species inventories collected during 2008 and 2013 studies at Milne Port. Surveys for AIS EEM were carried out in 2015 and 2016 and were focused on detection of fauna and flora that were not identified in baseline species inventories as primary indicators of invasion.

Milne ore dock fish offset monitoring studies were conducted in 2015, after the construction of the fish habitat offsetting, and in 2016. The purpose of the studies was to assess effectiveness of the facility in terms of creation of new fish habitat and its biological utilization.

3.0 PHYSICAL SETTINGS

Milne Inlet is part of a complex and deep fjord system with several deep basins and mid-channel islands. The water depth near Milne Port is approximately 30 to 50 m and increases to 100 m to 150 m water depth approximately 200 m north of the Port site. The inlet is U-shaped with consistent water depths along the middle of the channel with steeply sloping shorelines. A series of three sills are present along the fjord of Milne Inlet separating the deep basins of the inlet and which play a role in the circulation and dynamics. Phillips Creek is located to the west of Milne Port and has created a deltaic feature along the southern fjord-head of Milne Inlet. A deep basin is present in the channel near Koluktoo Bay with water depths reaching 318 m. Robertson River feeds into the west side of Koluktoo Bay. North of Koluktoo Bay are a series of small mid-channel islands and deep basins. The deepest portion of Milne Inlet reaches 841 m water depth. North of Ragged Island, Milne Inlet joins Eclipse Sound to the east-northeast and Navy Board Inlet to the north.

Milne Inlet shorelines are dominated by steep rocky cliffs and coarse pebble and cobble beaches. The limited open water season and post-glacial rebound have created prominent raised beaches and a generally complex shoreline. The port facility at the south end of Milne Inlet sits atop a delta consisting of predominantly coarse-grained material with abundant ice push features (Baffinland 2012 [Appendix 8A-1]).

The oceanography of Milne Inlet is similar to other neighbouring Arctic inlets with full ice cover and no freshwater input during the winter. The inlet typically begins to freeze up in early October with ice melt occurring in June and July. The tides at the project site are semidiurnal. Minimum and maximum tidal ranges at the end of Milne Inlet are approximately 2.2 m to 2.3 m respectively (Baffinland 2012 [Appendix 8A-1]). Temperature and salinity remain relatively consistent throughout the water column during winter with temperatures of -1.5ºC and salinities of 32 PSU (Buckley et al. 1987). During the open-water season, large freshwater inputs create a strong stratification in the water column with a typical pycnocline depth of 5 m to 10 m. Temperatures in the summer range between approximately 5ºC at the surface and -1.5ºC at depth, while salinity ranges between approximately 23 PSU at the surface and 32 PSU at depth (Baffinland 2012 [Appendix 8A-1]). Currents in Milne Inlet are mostly driven by tides and are generally small except around headlands where larger currents have been recorded between 0.15 m/s and 0.3 m/s (Buckley et al. 1987). Wind forces and estuarine flow have less effect on currents as the open water season is typically short. The dominant wind and wave direction is from the northeast with recorded wave heights remaining below 0.6 m but estimated potential heights based on fetch and wind conditions of up to 1.3 m (AMEC 2010).

4.0 WATER QUALITY

Baseline water quality surveys in Milne Inlet commenced in 2008; no studies had been conducted in the inlet in previous years. Also, limited information is available in scientific literature on quality of surrounding Arctic waters. Therefore, the summary of information presented in this report is primarily based on data obtained in Project-specific studies: data collected in 2008 / 2010 for the baseline study by Baffinland (2012) and by Sikumiut Environmental Management Ltd. (SEM) during the 2015 / 2016 effects monitoring study (SEM 2016a, 2017a).

Marine water quality samples were collected in Milne Inlet under ice-cover in June 2008 and during open-water season in September 2008 and August 2010, as a part of the baseline studies, and in August of 2015 and 2016 as a part of the MEEMP. During the 2008 and 2010 surveys, water quality samples were collected from various locations in the inlet with ranging water depths and distances from the shore to characterize the overall conditions within the inlet (Figure 4-1). Samples in 2008 and 2010 were collected at 1 m depths, and either at 1 m above the sediment or at 30 m depth (in locations deeper than 31 m).

In 2015 and 2016, water quality samples were collected from near-surface in four locations: at the Project drainage outflow point and approximately 250 m northeast, north, and northwest of that point to characterize Project wastewater discharge effect on water quality. Water quality samples were collected during two sampling events in 2015 and during five sampling events, approximately one week apart, in 2016. Collected water samples were sent to an analytical laboratory (Exova Accutest and Maxxam) and analysed for general chemistry, major ions, nutrients, metals and hydrocarbons.

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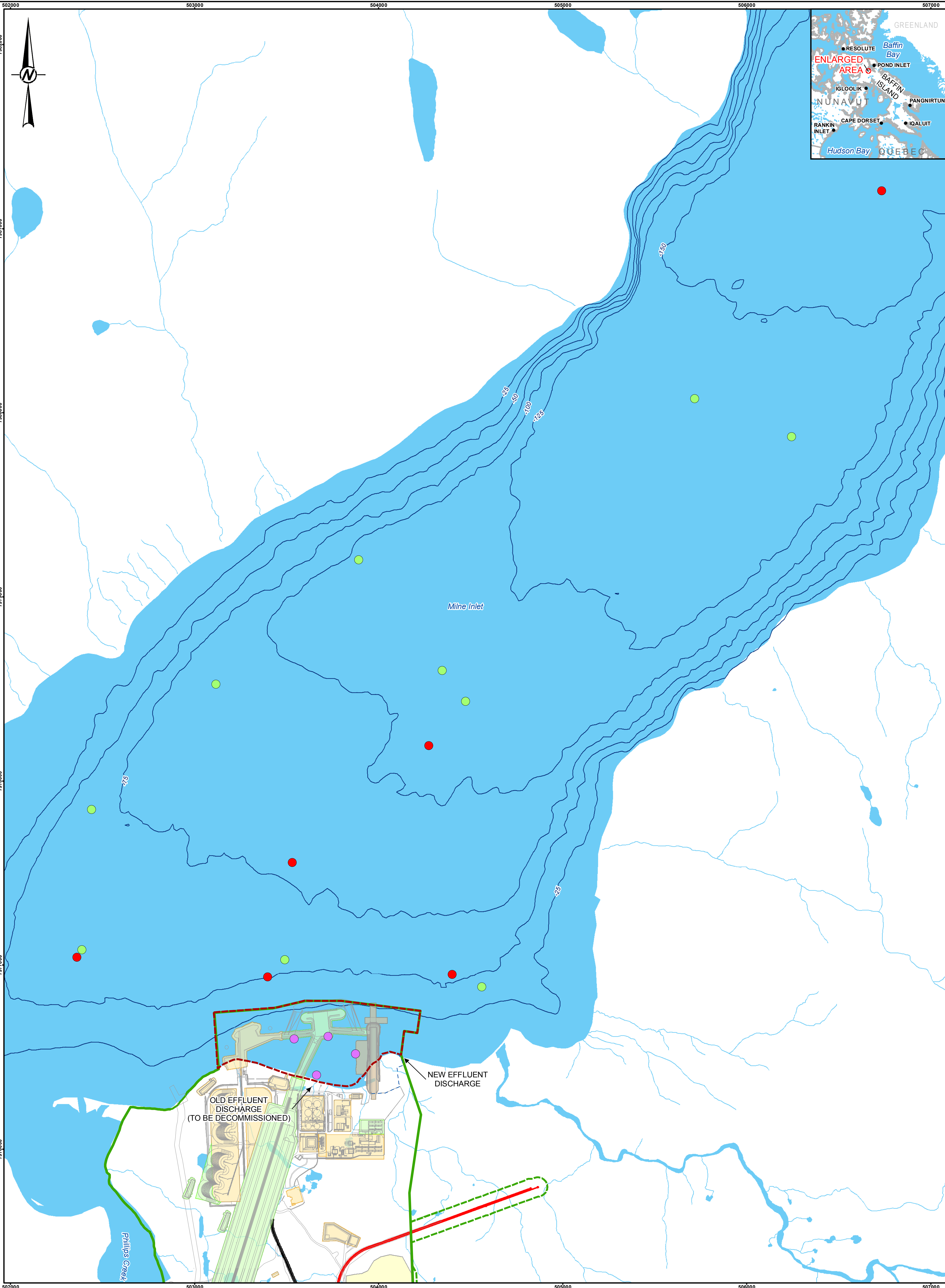

LEGEND

- 2008 WATER QUALITY SAMPLE LOCATION
- 2010 WATER QUALITY SAMPLE LOCATION
- 2015 AND 2016 WATER QUALITY SAMPLE LOCATION
- POPULATED PLACE
- BATHYMETRIC CONTOUR (25 m INTERVAL)
- MILNE INLET TOTE ROAD
- NEW EFFLUENT PIPELINE
- PROPOSED NORTH RAILWAY
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- AGGREGATE SOURCE (BORROW PIT OR QUARRY)
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- INAC FORESHORE LEASE
- REVISED PDA FOR PHASE 2 PROPOSAL
- WATERBODY

0 500 1,000

1:20,000 METRES

REFERENCE(S)

2008 AND 2010 WATER QUALITY SAMPLING LOCATIONS WERE DIGITIZED FROM THE MARY RIVER PROJECT OCEANOGRAPHIC BASELINE SYNTHESIS (NOVEMBER 2010). BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES. HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND FROM HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
SAMPLING LOCATIONS FOR WATER QUALITY (2008, 2010, 2015 AND 2016)

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	AA / VV
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000	0	4.1

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25mm

General water quality parameters and concentrations of major ions in Milne Inlet recorded during the open-water season in 2008 and 2010 were typical for a stratified column, with brackish (mean salinity 18 PSU) water layer, 8 m to 10 m in depth from the surface, and a higher saline (30 PSU) water mass below. During the ice-cover season, salinity was higher than during the open-water season and relatively uniform throughout the water column, with average salinity ranging from 31.5 PSU at the surface to 32 PSU near the bottom.

Water was clear, with turbidity ranging from 0.3 NTU to 0.6 NTU, and with low levels of dissolved solids and concentrations of nutrients. These conditions correspond to marine ecosystems with a mesotrophic status; i.e., ecosystems with moderate levels of nutrients available for primary production. Nutrient concentrations were higher at depth than near the surface, particularly during the open-water season, when the water column was stratified. Total nitrogen (TN) ranged from 0.55 mg/L at the surface to 4.1 mg/L near the bottom, and total phosphorus ranged from 0.011 mg/L at the surface to 0.045 mg/L near the bottom. Overall, turbidity, major ion, and nutrient concentrations were generally within the range of those found in previous studies conducted in nearby Arctic waters (Mose Jensen et al. 1999; Michel et al. 2006; Kuzyk et al. 2010).

Several metals, including cadmium and iron, in samples collected during the 2008 and 2010 baseline studies were generally below the detection limits. Mercury concentrations exceeded the Canadian Council of Ministers of Environment (CCME) guideline for the protection of marine aquatic life (CCME guidelines) in two samples in June 2008. No other exceedances were observed; however, regularly, the detection limits (DL) for cadmium, arsenic, and occasionally mercury were above the CCME guidelines (Baffinland 2012 [Appendix 8A-1]).

In 2015 and 2016, water quality samples were collected during the open-water season from near-surface at four stations surrounding the effluent discharge point of Mile Port as part of the MEEMP surveys (SEM 2016a, 2017a). The following describes the findings detailed in SEM (2017a). Samples collected in 2015 indicated that water was brackish (salinity varied from 14 PSU to 20 PSU) and clear, with low total suspended solids, low turbidity, and low colour. Nutrient concentrations were either very low or below DL. Most metals were below DL, except for aluminum, boron, mercury, strontium, and uranium. Mercury concentrations (0.023 µg/L to 0.025 µg/L) exceeded the CCME guideline (0.016 µg/L) in all samples during the third sampling event in August. Hydrocarbons were not detected in any water samples.

Samples collected in August and September 2016 indicated that water ranged from brackish (4.9 PSU) to saline (30.5 PSU), and was clear, with low total suspended solids, low turbidity, and low colour. Nutrients were either very low or below DL. Most metals were below DL, except for aluminum, barium, boron, cadmium, molybdenum, strontium, titanium, uranium, and zinc and none of the metals exceeded CCME guidelines. Mercury and hydrocarbons were below DL in 2016.

5.0 SEDIMENT QUALITY

Some limited information is available in the literature on sediment quality within the region, e.g. from Lancaster Sound (Thomson 1982) and Strathcona Sound in Admiralty Inlet (Thomas et al. 1983 and Schneider-Vieira 1996). No sediment studies had been conducted in Milne Inlet prior to baseline surveys commencing in 2008.

Sediment samples for baseline and effect monitoring studies were collected in Milne Inlet during the open-water seasons in 2008, 2010, and from 2013 through 2016. In 2008 and 2010, sediment samples were collected from 12 stations with depths varying from 1 m to 62 m; 10 stations were located in the southern portion of the inlet in the proximity of the proposed port site and two stations were approximately 9 km north-northeast of the port site (Figure 5-1).

During the baseline surveys in 2013, sediments were sampled at three main areas: the Milne Port area, and two reference sites, R-1 and R-2 (SEM 2014; Figure 5-1). At each area, sediments were collected at four depth strata: intertidal zone, 0-3 m, 3-15 m, and 15-25 m, with 5 samples collected at each stratum; in addition, 5 extra replicates were collected from R-1, stratum 0-3 m.

During the MEEMP surveys in 2014 through 2016, sediment samples were collected along four transects extending in a radial pattern from the Milne ore dock as described in Section 2.0 (SEM 2017a; Figure 5-1). At the East and West transects, sediment sampling stations were located along the 15 m depth contour at approximately 0 m, 250 m, 500 m, 1,000 m, and 1,500 m from the existing ore dock. At the Coastal Transect, the sampling stations were located at the same 15 m depth contour at approximately 500 m, 1,000 m, 2,000 m, and 4,000 m from the East Transect. At the North Transect sampling stations were located at approximately 0 m, 250 m, 500 m, 1,000 m, and 2,000 m from the existing ore dock and depths ranging from 37 m to 100 m. Three replicate samples were collected from each sampling station.

Collected samples were analysed in an analytical laboratory (Maxxam) for physical characterization (particle size compositions) and chemical analyses (organic carbon, metals, petroleum hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs)).

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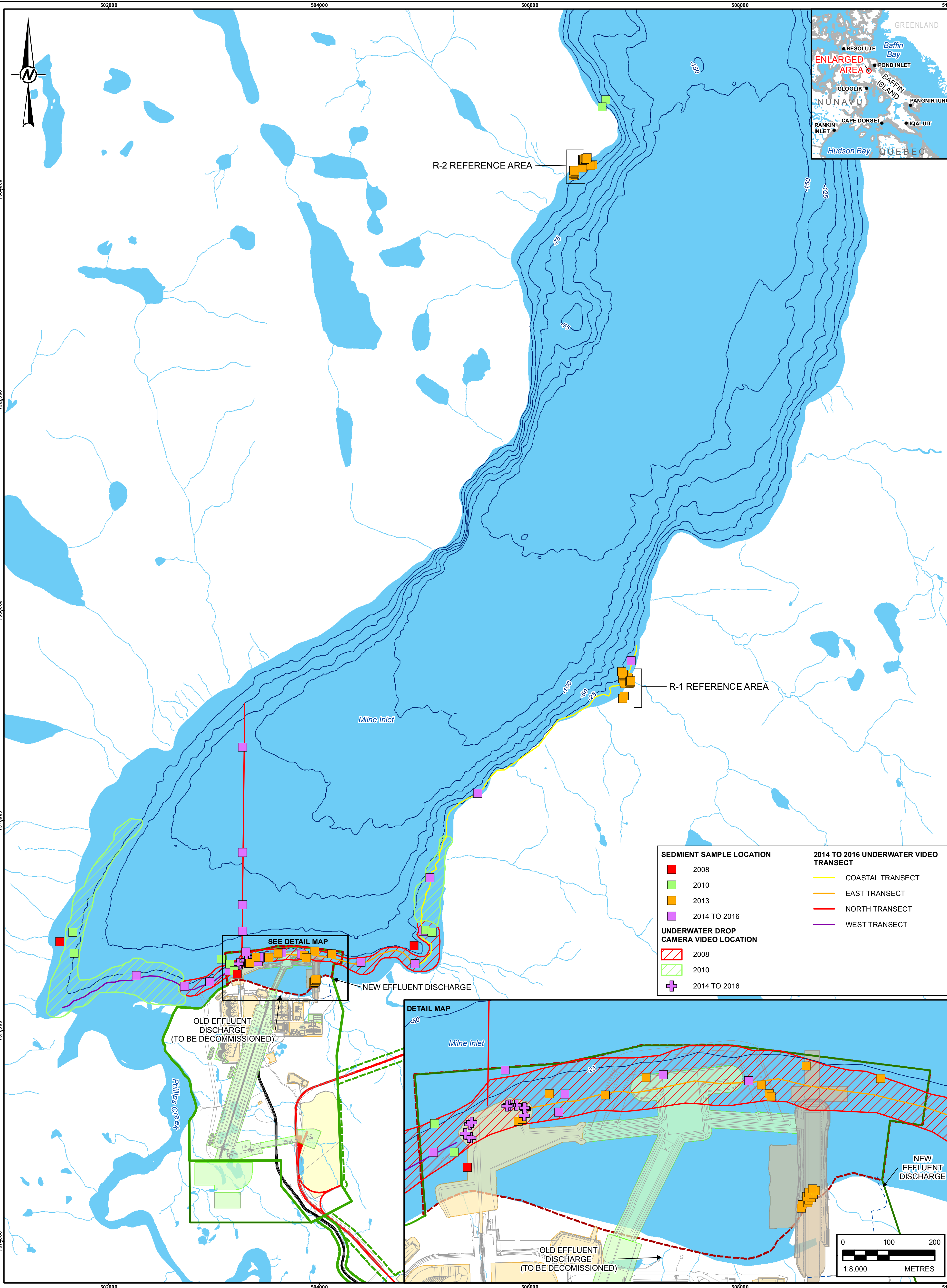

LEGEND

- POPULATED PLACE
- BATHYMETRIC CONTOUR (25 m INTERVAL)
- MILNE INLET TOTE ROAD
- NEW EFFLUENT PIPELINE
- PROPOSED NORTH RAILWAY
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- AGGREGATE SOURCE (BORROW PIT OR QUARRY)
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- INAC FORESHORE LEASE
- REVISED PDA FOR PHASE 2
- WATERBODY

0 500 1,000

1:35,000 METRES

REFERENCE(S)

2008 AND 2010 SEDIMENT SAMPLING LOCATIONS WERE DIGITIZED FROM THE MARY RIVER PROJECT OCEANOGRAPHIC BASELINE SYNTHESIS (NOVEMBER 2010). 2013 SEDIMENT SAMPLING LOCATIONS WERE DIGITIZED FROM THE ____________REPORT (DATE NEEDED). BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES. HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND FROM HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
SAMPLING LOCATIONS FOR SEDIMENT QUALITY AND UNDERWATER VIDEO (2008, 2010, 2014-2016)

CONSULTANT		
GOLDER	YYYY-MM-DD	2018-06-22
	DESIGNED	AO
	PREPARED	AA / VV
	REVIEWED	PR
	APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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Typically, sediment in Arctic coastal areas is characterized by distribution of fine material (silt and clay) in deeper areas and prevalence of sand, cobble and pebbles in the shoreline due to influence of fast ice, ice scour, and tides (Thomson 1982). Sediment carbon content is associated with finer particles and, therefore, is higher in deeper areas (Thomson 1982). Sediment samples from Strathcona Sound in Admiralty Inlet collected during pre-development studies for Nanisivik Lead-Zinc Mine showed naturally elevated concentrations of cadmium, lead and zinc (Thomas et al. 1983). Concentrations of these metals increased following commencement of the mine operations (Schneider-Vieira 1996).

Similar to water quality, the only sediment quality data for Milne Inlet found during an online literature review were collected during Project-specific baseline studies in 2010 (Baffinland 2012 [Appendix 8A-1], Appendix 8.A-1) and in 2015 and 2016 (SEM 2016a, 2017a). Sediment samples collected during these studies were analysed for particle size composition, organic content, and concentrations of metals and hydrocarbons. These concentrations were compared to CCME Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Level (PAL) guidelines for sediments.

Samples collected in Milne Inlet during 2010 baseline studies showed that sediments were dominated by either sand or sand and silt and had low nutrient levels (Baffinland 2012 [Appendix 8A-1]). Concentrations of some metals (aluminum, arsenic, calcium, chromium cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, strontium, and vanadium) were correlated with silt content and were higher in samples with greater proportion of silt. Antimony, beryllium, cadmium, mercury, selenium, silver, and thallium were below DL in all samples from Milne Inlet. None of the detected metals exceeded CCME guidelines for sediments.

Sediment samples from three locations were analysed for hydrocarbon concentrations in 2010; one from the reference site and two from the vicinity of the future Milne Port (Baffinland 2012 [Appendix 8A-1]). No hydrocarbons were detected at the reference site, but some low-level hydrocarbon concentrations were detected at Milne Port, such as oil and grease, naphthalene, hydrocarbons of C10-16 and C16-C34 groups, and toluene. No applicable CCME guidelines for PAHs were exceeded.

In 2013, sediment samples were collected in at Milne Port and two reference areas (SEM 2014). At each area, samples were collected from four depth strata, including the intertidal zone. Samples showed similar physical composition of sediments as in 2010; sediments were generally composed of sand and gravel or sand and fines (silt), and the proportion of fines increased with depth. Organic carbon content also increased with depth, most likely due to correlation with the proportion of fines.

In 2013, sediment samples were analysed for extractable metals and hydrocarbons (SEM 2014). A number of trace metals were detected, including aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, nickel, rubidium, strontium, thallium, tin, uranium, vanadium, and zinc. Concentrations of trace metals, in general, increased with depth, correlating with the proportion of finer particles. In general, concentrations of metals in sediment were moderate, except for aluminum and iron, whose concentrations were relatively high (SEM 2014). Mean concentrations at Milne Port and the two reference sites were 2,107 mg/kg, 2,388 mg/kg, and 2,147 mg/kg respectively for aluminum and 4,860 mg/kg, 5,664 mg/kg, and 4,230 mg/kg respectively for iron. There were no exceedances of the CCME guidelines for metals from any of the study areas sampled in 2013. A comparison of sediment metal concentrations between 2010 and 2013 is not possible due to changes in laboratory methods. In 2010, sediment samples were analysed for total metals, while in 2013, an extractable metal analysis was conducted.

Hydrocarbons in 2013 were mostly below DL, with the exception of 17 out of the total of 65 samples where petroleum hydrocarbons of C16-C32 fraction (lube oil) were detected, with concentrations ranging from 18 mg/kg to 57 mg/kg, and one sample where hydrocarbons of C10-C32 (fuel fraction, 14 mg/kg) were detected. Samples with detected hydrocarbons were collected from all three survey areas (Milne Port and two reference areas). There were no exceedances of the CCME guidelines for hydrocarbons in any samples collected in 2013 (SEM 2014).

During the three years of MEEMP studies (2014 to 2016) sediment samples were collected as part of the effect monitoring program (MEEMP). Sediment samples were collected along three transects (West, East, and Coastal) positioned parallel to the shore along the 15 m depth contour and one transect (North) positioned perpendicular to the shore, with depths ranging from 37 m to 100 m depths. Sediment data collected during the monitoring surveys after Project operations started (2015 and 2016) were compared to data from the 2014 survey, identified as baseline, to detect potential changes caused by Project activities.

Sediment physical composition in samples collected in 2014-2016 was consistent with values recorded during previous surveys (2008, 2010, and 2013) in Milne Inlet (SEM 2014, 2017a). Overall, sediments were mainly composed of sand and silt. Some stations had higher proportions of gravel, while others contained equivalent proportions of the four substrate size classes. As in previous studies, differences in particle size composition were related to depth, with higher proportion of fines (silt and clay) found in deeper areas of the North Transect. However, during MEEMP surveys, higher contents of finer fractions were also found at the Coastal Transect (depth of 15 m; Figure 5-2). The presence of a higher proportion of finer sediments at 15 m at the Coastal Transect, could be related to differences in nearshore hydrodynamics.

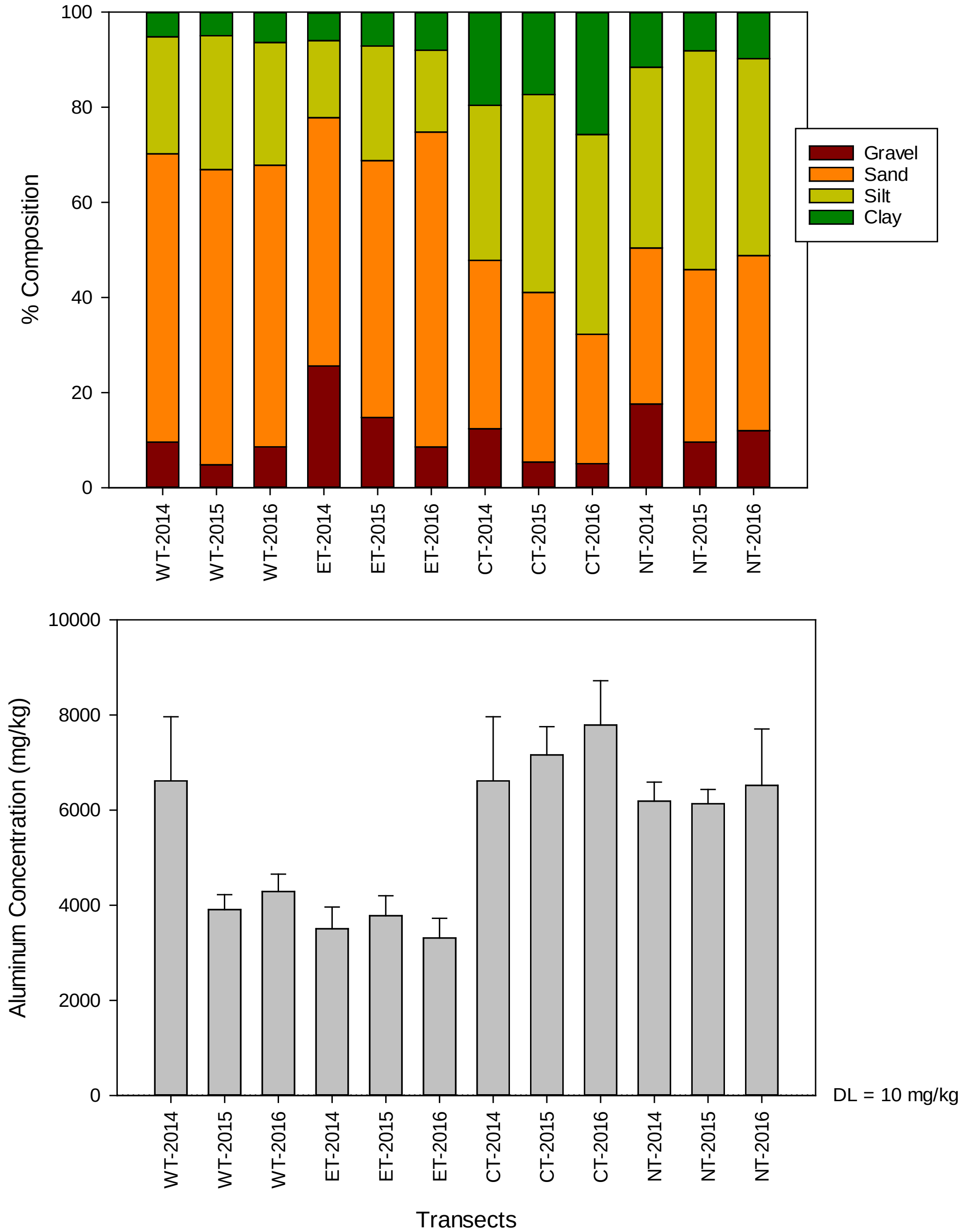
Sediments along the West and East transects consisted predominantly of coarse fractions (sand and gravel); mean percent composition of sand and gravel along these two transects ranged from 67% (West Transect in 2015) to 78% (East Transect in 2014). Sediments along the North and Coastal transects had higher proportions of fines (silt and clay); mean percent composition of silt and clay along these two transects ranged from 50% (North Transect in 2014) to 68% (Coastal Transect in 2016).

Metal concentrations in sediment samples from 2014-2016 MEEMP surveys were comparable among stations and years and were, in general, consistent with concentrations from previous baseline studies. Detected metals included aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, nickel, rubidium, strontium, thallium, uranium, vanadium, and zinc. Most metal levels were low, with the exception of aluminum (Figure 5-2) and iron (Figure 5-3), which were consistently found in relatively high concentrations throughout the survey area and years, particularly in sediments with higher proportion of fine particles (North and Coastal transects). Mean aluminum concentrations ranged from 3,311 mg/kg (East Transect in 2016) to 7,850 mg/kg (Coastal Transect in 2016), whereas mean iron concentrations ranged from 6,653 mg/kg (East Transect in 2016) to 13,000 mg/kg (Coastal Transect in 2015).

No metals in 2014-2016 samples exceeded CCME guidelines, except for arsenic and zinc. Arsenic concentrations showed low-level exceedances of CCME ISQG (7.24 mg/kg) in three samples in 2014 (West and North transects; 7.50±0.40 mg/kg and 7.40±1.40 mg/kg [mean ± standard deviation], respectively), two samples in 2015 (West Transect; 6.77±1.17 mg/kg), and two samples in 2016 (West and North transects; 7.30±0.50 mg/kg and 6.40±1.0 mg/kg, respectively; Figure 5-3. Zinc concentration exceeded its CCME ISQG (124 mg/kg) in one sample in 2016 (79±113 mg/kg). No parameters exceeded CCMEs PEL guidelines for the protection of aquatic life in any of 2014-2016 MEEMP surveys. Hydrocarbons were mostly below DL, with only trace amounts of petroleum hydrocarbons in C16-C32 fraction (lube oil). Generally, hydrocarbon concentrations found during the most recent survey in 2016 were detected in fewer samples than in 2013-2015, and the detected values were generally lower than those from 2013-2015 (SEM 2017a).

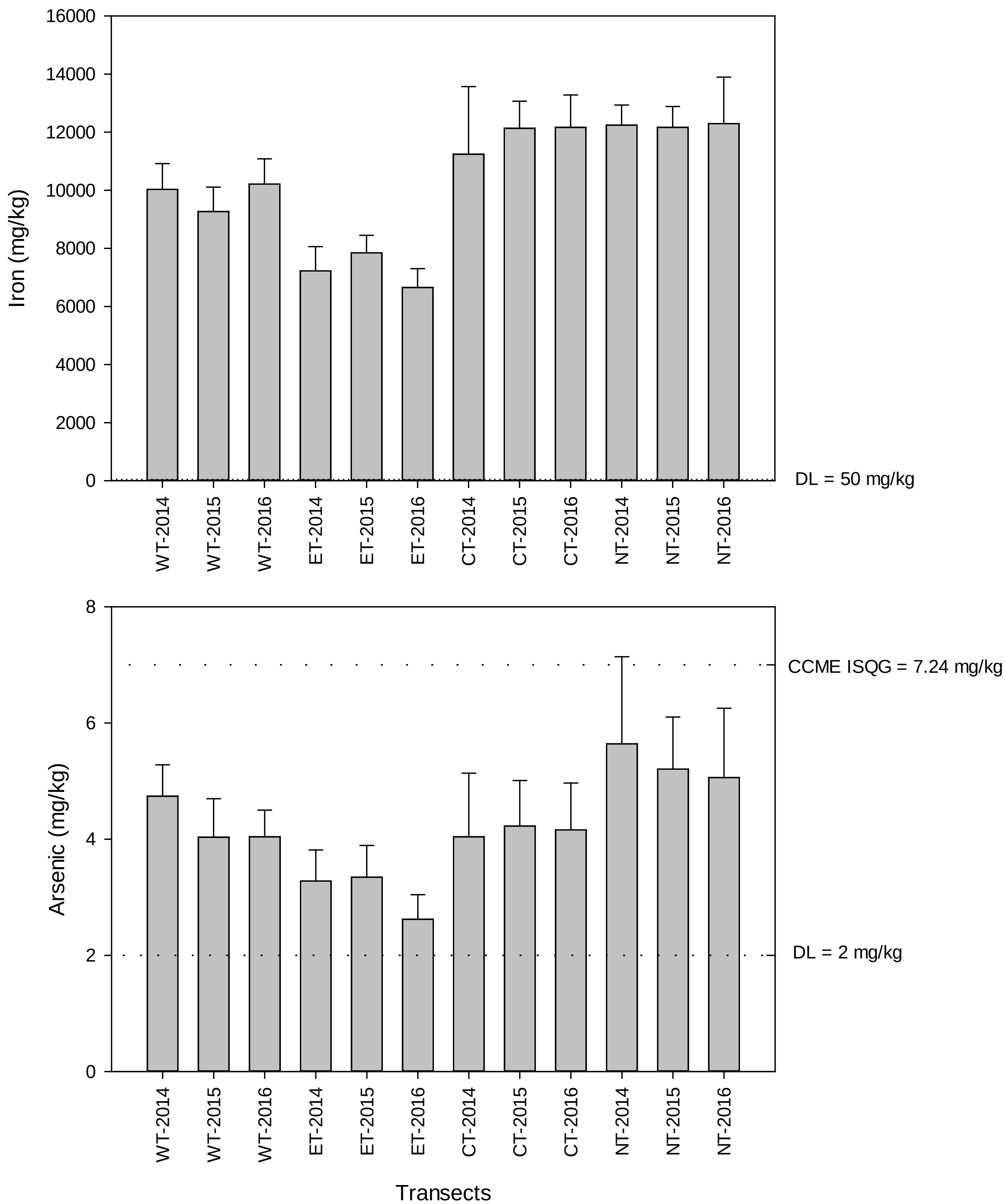
Percent composition of fine particles (silt and clay) and concentration of iron were used as indicators of Project-induced effects in sediments. Sediment stations were resampled every year and gradients in fines and iron concentrations with the distance from ore dock were examined using regression analysis. Each consecutive year's regression slope was compared to the 2014 (baseline) slope using an analysis of covariance (ANCOVA). Changes in slope would indicate that there is a difference in the relationship between distance and the concentration of fines or iron, which could be linked to Project activities.

The results of MEEMP surveys showed no changes in sediment quality in the two monitoring years (2015 and 2016) since the beginning of Project operations in relation to the baseline year (2014). Statistical comparison between different years showed that there was not a significant difference between the baseline year and consecutive years in content of fines and iron concentrations (SEM 2017a).



Notes: WT - West Transect; ET - East Transect; CT - Coastal Transect; NT - North Transect
DL - detection limit
Error bars represent standard deviation

Figure 5-2: Sediment particle size composition (top) and aluminum concentrations (bottom), Milne Inlet 2014 - 2016



Notes: WT - West Transect; ET - East Transect; CT - Coastal Transect; NT - North Transect
DL - detection limit
Error bars represent standard deviation

Figure 5-3: Sediment iron (top) and arsenic (bottom) concentrations, Milne Inlet, 2014 – 2016

6.0 BENTHIC HABITAT

Benthic habitat surveys were conducted in Milne Inlet since 2008 as part of the marine baseline program, as well as the MEEMP, AIS, and fish offset monitoring programs. Each of these programs was unique in terms of its benthic habitat survey design. Seabed characterization was conducted using towed underwater video methods along pre-determined survey transects. Video analysis provided spatial data on substrate and biota, including distribution and abundance of epibenthic fauna and flora communities.

During the 2008 and 2010 baseline surveys, video surveys were recorded along a series of transects perpendicular to the shoreline from the shore, and extending from depths of -2 to -3 m to -25 m. Transects were spaced a few hundred metres apart along a 6.5 km segment of the coastline of the southern tip of Milne Inlet (Figure 5-1). During the 2013 baseline surveys, benthic habitat characterization was conducted in three areas: the Milne Port area and reference areas R-1 and R-2 (Figure 5-1). Underwater video was recorded along transects parallel to the shore in shallow subtidal zones, at depths ranging from 0 m to -32 m.

The 2014-2016 MEEMP surveys were conducted along four transects: East, West, North and Coastal, extending in a radial pattern away from the Milne ore dock (except for 2014, when the North transect was not surveyed due to safety reasons; Figure 5-1). This design provided a gradient of substrate, macroflora, and benthic epifauna with increasing distance from the Milne ore dock; a point source of potential Project effects. For the West, East, and Coastal transects, underwater video was recorded along the -15 m depth contours. For the North Transect, video data were collected along an increasing depth gradient. Two replicate video surveys were conducted along each of these transects and were identified as replicate 1 (R1) and replicate 2 (R2).

To reduce effort of video analysis, three sub-segments (S1, S2, and S3) were defined along each of the transect replicates (R1 and R2) and analyzed, reducing the video footage to approximately 25% of the initial footage collected. Video was analysed in 5 m increments along each segment and data were summarized by segment within-transect, and well as by transect (across segments). Variables included surveyed length and area, video time, substrate type (predominant group, % coverage), macroflora (% coverage, predominant class) and macrofauna (abundance and relative abundance where possible).

The AIS monitoring habitat surveys in 2014-2016 were conducted along four transects in proximity to the ore dock, extending perpendicular to the shoreline from the low tide level to beyond the -15 m depth contour (Figure 7-1). Of the four transects, one was positioned to the east of the ore dock, and three were positioned to the west. The AIS video survey contributed to the baseline species inventory and detection of invasive species and, therefore, it only required the identification of individual macroflora and epifauna taxa. Assessment of distribution or relative abundance of these taxa was not in the scope of AIS surveys.

For the 2015 and 2016 fish offset monitoring program, video transects were conducted along the perimeter of the armour stone of the ore dock to a depth of -24 m. The purpose of the surveys was to assess the structural stability of the offsetting facility and evaluate its utilization by the local fauna.

6.1 Benthic Substrate

Detailed substrate characterization was provided based on the video footage. Substrate was categorized using combinations of up to five substrate types according the Wentworth-Udden classification (Wentworth 1922), which were aggregated into broader substrate types (Table 6-1). Percent coverage of each substrate group in each 5 m video segment was estimated.

Table 6-1: Marine Substrate Classification (adapted from SEM 2014)

Substrate Category		Definition
Broad	**Detailed[1]**	
Bedrock	Bedrock	Continuous solid rock exposed by scouring forces.
Coarse	Boulder	Rocks greater than 250 mm in diameter.
	Rubble	Large rocks ranging from 130 mm – 250 mm in diameter
Medium	Cobble	Rocks ranging from 30 mm – 130 mm.
	Gravel	Granule size or coarser, 2 mm – 30 mm.
Fine	Sand	Fine deposits ranging from 0.06 mm – 2 mm
	Mud	Material encompassing both silt and clay <0.06 mm
Organic	Organic / Detritus	Soft material 85% or more organic materials.
Shell	Shell	Calcareous remains of shellfish and other invertebrates

[1] from Wentworth-Udden (Wentworth 1922).

The identified substrate was generally a combination of two or more types, with relative proportions that depended on the depth. Overall, the Milne Port area contained primarily fine substrates with a heterogeneous mix of medium sized substrate. According to 2008 and 2010 studies, substrate in intertidal and upper subtidal zones (depth <3 m) predominantly consisted of gravelly sand and sandy gravels. In deeper areas (3-15 m and >15 m), substrates were dominated by finer material (muddy sand; Baffinland 2012 [Appendix 8A-1]).

Baseline surveys in 2013 identified gravel, sand, and shells as predominant substrate classes, mixed with cobble in shallower areas. Due to the large number of substrate combinations observed, the data were aggregated into a smaller number of substrate classes (Table 6-1): “fine” was the most dominant aggregated class observed in 71% of the total video footage, with “medium” and “medium/fine” observed in 15 and 14% of total time, respectively (SEM 2014).

MEEMP surveys in 2014 to 2016 revealed little variation in substrate composition among different transects. The most common substrate classes observed in all transects were gravel, sand, and shell (sometimes mixed with cobble). Rubble was another substrate class that was observed to be dominant in some locations; a mixture of sand, shell, and organic debris was recorded as dominant substrate in one replicate section in West Transect in 2014 (SEM 2015). The relative composition of substrate classes varied from transect to transect and year to year, but the most frequent dominant aggregate substrates were “fine”, “medium” and “medium/fine” (Table 6-2; SEM 2015, SEM 2016a, SEM 2017a).

Table 6-2: Aggregated Substrate Classes, Milne Inlet MEEMP, 2014 - 2016

Substrate Type/Class	West Transect			East Transect			North Transect		Coastal Transect		
	2014	2015	2016	2014	2015	2016	2015	2016	2014	2015	2016
Fine	86	30	53	51	17	8	1	66	22	29	1
Medium	2	58	28	16	16	82	80	11	50	12	77
Medium/fine	11	7	18	28	61	10	18	23	27	51	2
Not classifiable	1	5	1	5	6	-	1	-	1	8	20

6.2 Benthic Macroflora

The macroflora observed during video analysis was identified to the lowest practical taxonomic level (species, genus, or vegetation class; Table 6-3. Identification to species or genus was not always possible due to trolling speed, visibility, and distance from seafloor. The relative abundance of each identifiable taxon was recorded as percent coverage, in 5% increments.

Table 6-3: Marine Vegetation Classification, as Provided by SEM (2014)

Vegetation Class	Definition
Red Algae	Common name for Rhodophyta (e.g., *Chondrus crispus* – Irish moss, *Lithothamium* – coralline algae, *Ptilota*, *Porphyra, Rhodymenia* – dulse, etc.)
Brown Algae	Common name for the seaweeds of the Laminariales (Phaeophyta), brown alga with a large broad-bladed thallus attached to the substrate by a tough stalk and holdfast (e.g., *Laminaria longicruris* – cabbage kelp, *L. digitata* – finger kelp, *Alaria esculenta* – winged kelp, *Chorda filum* – Mermaid's trusses, *Agarium clathratum, Saccorhiza deratodea*, etc.)
Green Algae	Common name for Chlorophyta (e.g., *Chlamydomonas, Spirogyra, Ulva lactuca* – sea lettuce, *Urospora*, etc.)
Rockweed	*Fucus* sp. – rock weed, *Ascophyllum nodosum* – knotted wrack
Eelgrass	*Zostera marina* is a green flowering plant (Anthophyta) and is primarily a subtidal species that penetrates to some extent into the intertidal zone. It is common on mud flats that are exposed at low tide, in estuaries and shallow, protected bays.
Salt Marsh	Aquatic plants developing on wet soil (e.g., tidal or salt marshes)
Other	Any other type of flora not identified in the above categories

Marine algae observed in the Arctic typically consisted of various taxa adapted to low light conditions, short growing seasons, and cold temperatures, and included green algae, bladed and filamentous brown algae, and red algae (Lee 1973). The distribution of algae is influenced by currents, depth, processes such as ice scouring, and by the amount of sediment runoff from nearshore areas. The shallow subtidal zone (0 m to 3 m) is typically barren due to ice scour, except in some sheltered nearshore areas where rockweed (*Fucus* sp.) is sometimes abundant (Wilce 1997). Macroflora abundance is typically highest between 3 m and 15 m, with decreasing abundance at greater depths due to decreasing light penetration. Areas with higher amounts of sediment have been found to contain more homogeneous algae assemblages than areas with little to no coastal erosion (Cross et al. 1984).

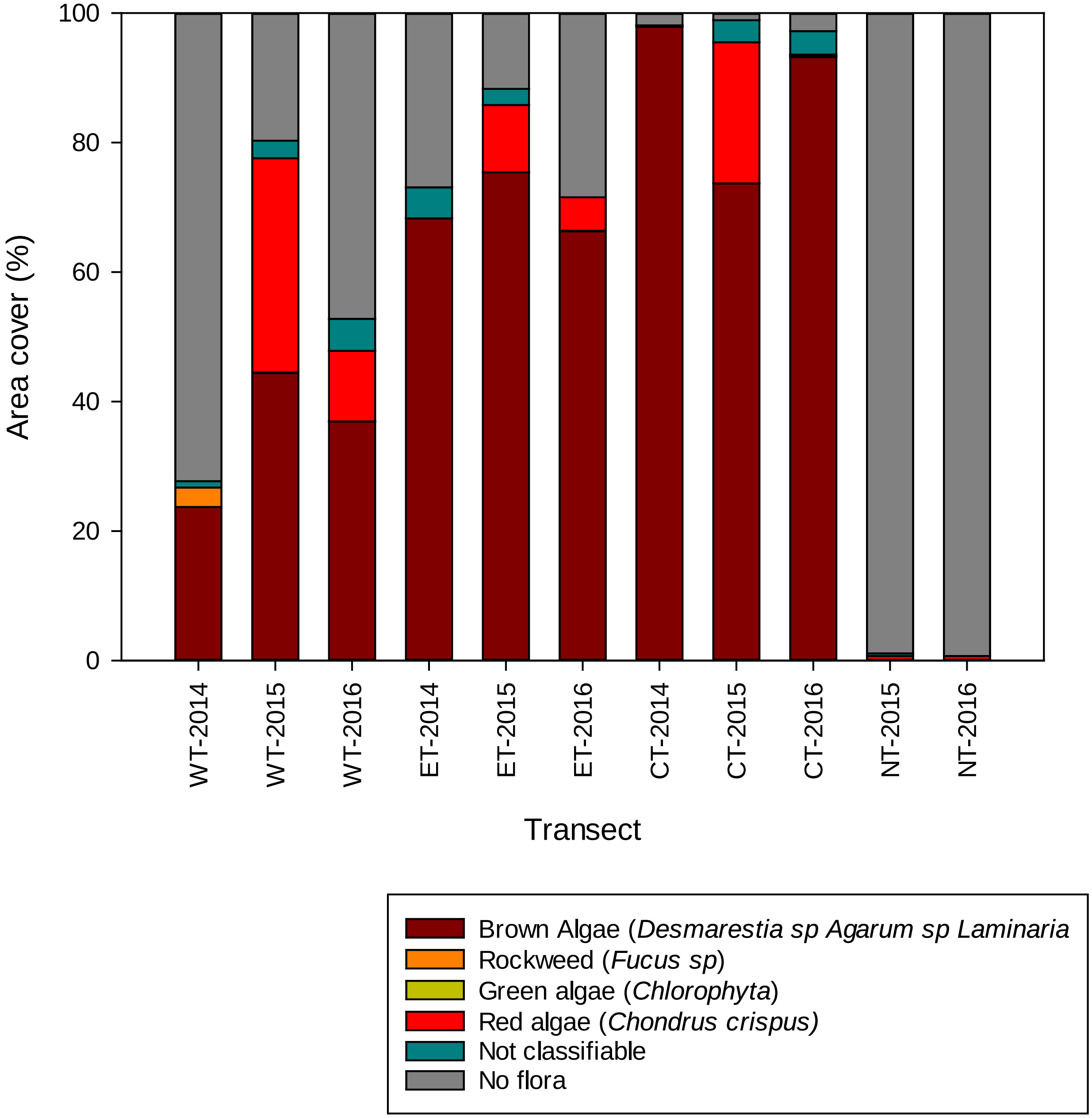
Surveys in 2008 and 2010 were conducted in transects perpendicular to the shore, and found a relatively dense cover of benthic algae in Milne Inlet, with a pronounced vertical zonation (Baffinland 2012 [Appendix 8A-1]). In the intertidal and shallow subtidal areas (<3 m), macroalgal presence was scarce and communities were mainly represented by filamentous brown algae, including sour weed (*Desmarestia* sp.) and *Pylaiella* sp., and rockweed (*Fucus distichus* subsp. *edentatus*). The mid-subtidal zone (3-15 m) had the highest density of algal cover, with bladed kelps (mostly *Saccharina longicruris, Saccharina latissimi,* and *Laminaria solidungula*) constituting the greatest majority of all benthic flora and accounting 38% of the total area cover. Abundance of bladed brown kelps in the 3 m to 15 m depth range was similar to that in the zones of highest diversity and abundance in other nearby inlets (Wilce 1997). Bladed kelps were also the dominant group at depths below 15 m although less abundant (6% area cover). Foliose algae (mostly represented by *Phyllophora truncata* and *Odonthalia dentata*) and filamentous red algae (mostly *Polysiphonia arctica*) were also commonly observed in deeper areas (3-15 m and >15 m). Encrusting and foliose coralline red algae were also relatively common on boulders, but were only present at water depths greater than 15 m (Baffinland 2012 [Appendix 8A-1]).

Baseline survey in 2013 showed a similar taxonomic composition of macroflora assemblages as 2008 and 2010 studies (SEM 2014). The epiflora had a skewed distribution, with 99.8% and 0.2% of all observed macroflora constituted of brown algae and green algae sea lettuce (*Ulva lactuca*), respectively. Most likely due to the predominantly shallower depths of observations, the most abundant taxa were sour weed and rockweed, which accounted for 57% and 22% of all macroflora observed, respectively. These two taxa were reported in shallow (<3 m) depth zones in the previous baseline studies (Baffinland 2012 [Appendix 8A-1]). Bladed kelps *Laminaria* sp. and sea colander (*Agarum cribrosum*) accounted for 13% and 8% of all observed algae respectively (SEM 2014).

The MEEMP surveys in 2014 to 2016 showed relatively high abundance of macroflora in the three transects along the 15 m contour lines (SEM 2017a). The assemblages were dominated by brown algae, mainly sour weed (48%-77%), sea colander (9%-43%), bladed kelps *Laminaria* sp. (1%-12%), and red algae *Chondrus crispus* (0.2%-37%) (Table B1). The highest epifloral density was consistently found in the Coastal Transect, where vegetation cover in 2015 and 2016 was 98.9% and 97.2% of total observed area, respectively (Figure 6-1). Macroflora percent cover ranged from 28% in 2014 to 80% in 2015 in the West Transect and from 72% in 2016 to 88% in 2015 in the East Transect (Figure 6-1). Low density and diversity of macroflora were observed in the North Transect, which extended perpendicular to the shore, since most of the transect was below the euphotic zone. Only red algae *Chondrus crispus* was observed in the North Transect, covering 0.7% and 0.6% of total area in 2015 and 2016, respectively. Other epifloral taxa observed during the 2014 to 2016 surveys were rockweed, green algae (Chlorophyta), brown algae *Punctaria* sp., and unidentified seagrass (SEM 2017a).

Data on percent macroflora cover collected during the MEEMP surveys between 2014 and 2016 were used to identify Project-induced effects on marine biota. Benthic habitat surveys were repeated every year and gradients in macroflora cover with the distance from ore dock were examined using regression analysis. Each consecutive year’s regression slope was compared to the 2014 (baseline) slope using an analysis of covariance (ANCOVA). Changes in slope would indicate a difference in the relationship between the macroflora density and the distance, which could be linked to Project activities.

There was high natural variability in macroflora density between transects collected in the same year (Table B1) and considerable variability for each segment along the transects in relation to distance from the ore dock. This natural variability may have been the reason for the inconclusive results regarding Project effects analysis for macroflora (SEM 2017a). The North Transect observations showed no significant between-year change in relationship with distance due to the very low macroflora cover in this transect (SEM 2017a). There were significant between-year differences in the relationships between macroflora cover and distance from the dock for the West, East, and Coastal transects (SEM 2017a). However, the relationship with distance was not always positive (i.e., macroflora cover did not always increase with distance), and there was no increase of the gradient over the years, as would have been expected for Project-related effects. For instance, at West Transect the gradient changed from negative in 2014 to positive in 2015 and back to negative in 2016. At the East and Coastal transects, the gradients, in general, decreased (SEM 2017a). Therefore, these significant differences in slopes of regression lines among years cannot be interpreted as indications of Project-related effects on macroflora.



Notes: WT - West Transect; ET - East Transect; CT - Coastal Transect; NT - North Transect

Figure 6-1: Macroflora density (area cover) in Milne Inlet, 2014 - 2016

6.3 Benthic Epifauna

Benthic epifauna encountered in the video footage was identified to the lowest practical taxonomic levels (species, genera, or classes), as applicable. During 2008 to 2013 studies, the relative abundance of macrofauna for each identifiable taxon was assessed and described on a relative scale using semi-quantitative categories ('abundant', 'common', 'occasional' and 'uncommon'). In the 2014-2016 MEEMP studies, epifauna was enumerated, providing quantitative indicators of abundance. In addition to video recording, benthic epifauna was captured coincidentally with fish in Fukui traps that were set as a part of both MEEMP and AIS monitoring studies. More detailed description of Fukui traps methods is provided in Section (10.1).

Attempts were made to assess rates of colonization of hard substrate by encrusting epifauna by deployment of settlement baskets during AIS studies in 2014 to 2016 (SEM 2017a). Settlement baskets, measuring 16.5 cm in diameter and 28 cm in length and filled with cobble ranging in size from 8 cm to 12 cm, were deployed in August 2014. They were initially retrieved in 2015, one year after deployment, but due to the low rate of colonization, the baskets were redeployed for an additional year. They were not found in 2016 possibly due to removal by boat traffic. Baskets were redeployed in 2016 and were tethered to the port infrastructure to reduce the possibility of removal by marine traffic.

Benthic epifauna communities in the Arctic are generally dominated by mobile invertebrates such as brittle stars, sea urchins, sea cucumbers, sea stars, bivalves, crabs, and other crustaceans (Bluhm and Gradinger 2008). In Milne Inlet, clams, brittle stars, and sea urchins were abundant in 2008 and 2010, with brittle stars being more abundant in deeper areas than in shallow nearshore areas (Baffinland 2012 [Appendix 8A-1]).

The most common epifauna taxa identified during benthic habitat surveys in Milne Inlet in 2008 and 2010 were unidentified clams (Bivalvia; 30% occurrence), brittle stars (Ophiuroidea; 32% occurrence), and sea urchins (likely green sea urchins (*Strongylocentrotus droebachiensis*; 30% occurrence). Other taxa encountered included scallops, mussels, anemones, tube-dwelling anemones, sea cucumbers, and tunicates (Baffinland 2012 [Appendix 8A-1]).

Benthic macro-invertebrate communities observed during the 2013 baseline studies were similar to those found in 2008 and 2010 (SEM 2014). Epifauna was dominated by brittle stars, which constituted from 19% (Reference Site 2) to 44% (Milne Port area) of total number of organisms observed, green sea urchins (from 15% to 20% of total organisms at the Milne Port and Reference Site 2, respectively), sea stars (from 5% to 21% at Reference 1 and the Milne Port areas, respectively) and cnidarians (from 7% to 31% at Reference 1 and Reference 2 areas, respectively; SEM 2014). Other commonly observed epifauna included molluscs, such as common whelk (*Buccinum undatum*), mussels (Mytilidae), sea angel (*Clione limacina*), and sea butterfly (*Limacina helicina*), sea cucumbers (Holothuroidea), crustaceans, including shrimps (*Pandalus* sp.) and copepods, zooplankton species, and fish, mostly sculpins (*Myoxocephalus* spp.).

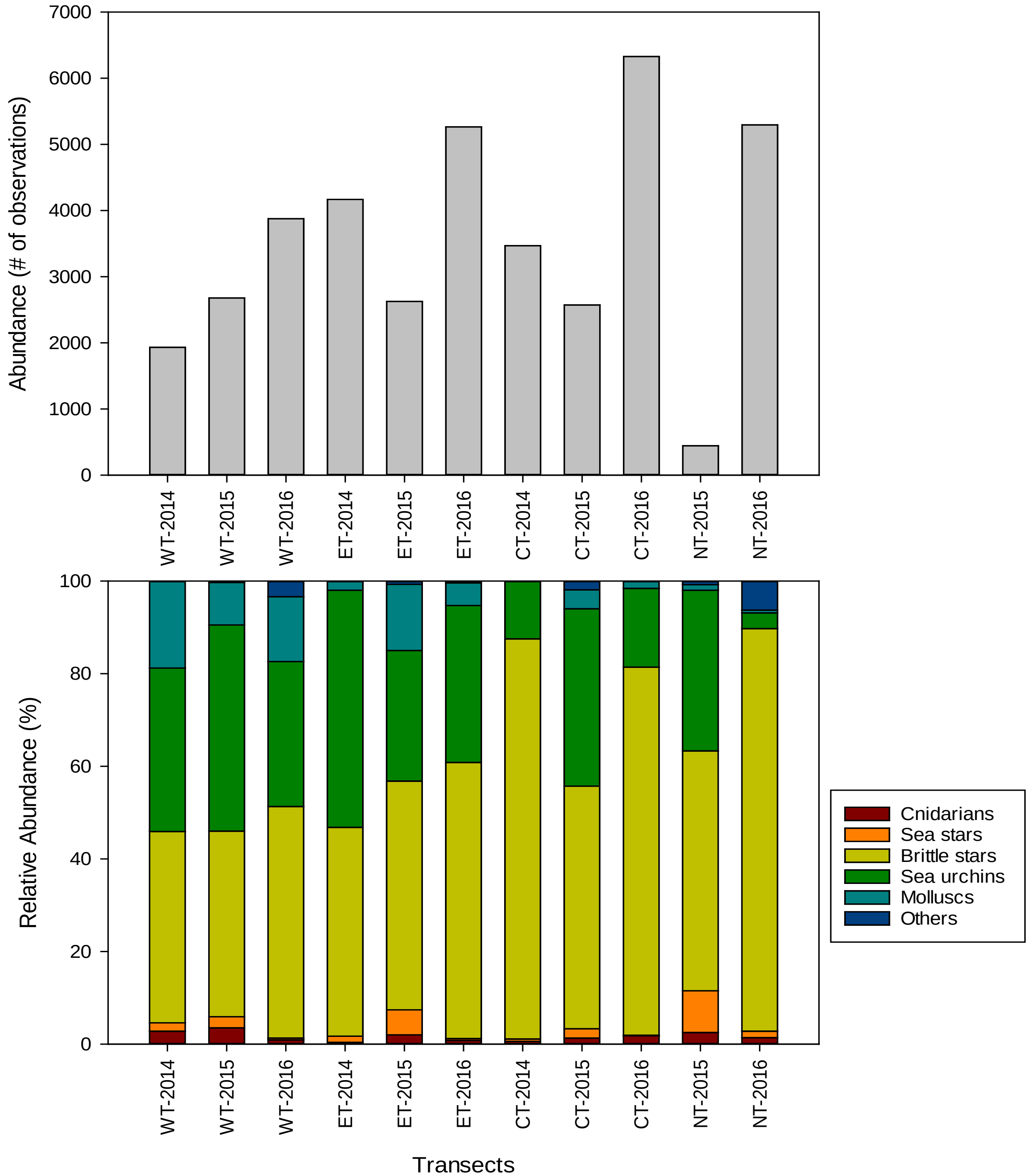
Abundance of epifauna, as the number of observations in each of four transects during 2014-2016 MEEMP studies, varied from 444 in the North Transect in 2015 to 6,328 in the Coastal Transect in 2016. For each of the transects, the total abundance was highest in 2016, particularly for the North Transect, where the total abundance rose from 444 in 2015 to 5,294 in 2016 (Figure 6-2, Table C1), mostly due to drastically increased number of brittle stars (from 230 in 2015 to 4,602 in 2016), most of which observed near the port site. Brittle stars were also the dominant taxa in all other transects, with relative abundance ranging from 40% in the West Transect in 2015 to 86% in the Coastal Transect in 2014. The other dominant group was sea urchins, mostly green sea urchins, whose relative abundance ranged from 3% in the North Transect in 2016 to 51% in the East Transect in 2014

(Figure 6-2, Table C1). The other observed taxa during the 2014-2016 MEEMP surveys included species of sea stars, including mud star (*Ctenodiscus crispatus*) and sun star (*Crossaster papposus*), cnidarians, such as anemones (Actiniaria), sea combs (Ctenophora), and jelly fishes (Scyphozoa), molluscs, such as common whelks, sea scallops (*Placopecten magellanicus*), sea butterfly, sea lily (*Bourgueticrinina* sp.), crustaceans, such as shrimp and crabs (Brachyura), and fish, such as sculpins and eelpout (Zoarcidae; Figure 6-2, Table C1). The total number of taxa identified in each transect ranged from 11 (West Transect in 2014) to 19 (Coastal Transect in 2015; SEM 2017a).

A number of mobile benthic invertebrate species was also captured in Fukui traps during 2014-2016 surveys. These included green sea urchins, red sea urchins, brittle stars, ocean quahog (*Arctica islandia*), common whelk, scallops and a number of clam species, such as razor clam (*Siliqua* sp.), northern propeller clam (*Cyrtodaria siliqua*), *Macoma calcarea*, *Hiatella arctica*, and *Musculus laevigatus* (SEM 2015; SEM 2016a; SEM 2017a).

The relationship between total abundance of benthic epifauna and distance from the ore dock was used as one of the indicators of Project-induced effects on the marine environment. Each consecutive year's regression slope was compared to the 2014 (baseline) slope using an analysis of covariance (ANCOVA). Changes in slope across years would indicate that a change in the relationship between the epifauna abundance and the distance, which could be linked to Project activities.

A comparison of regression slopes for epifauna abundance indicated significant among-year differences for the West, East, and North transects, but not for the Coastal Transect (SEM 2017a). These differences, however, cannot be interpreted as indicators of a negative Project-related effect. To indicate a negative effect, the regression slope would have to be positive and to increase as operations continue. However, in West Transect, the estimated slope was negative in 2015 and 2016. Also, in 2016, the total abundance was higher than in both 2014 and 2015 for all transects. In general, benthic epifauna data collected over the course of the 2014-2016 MEEMP surveys are still insufficient for interpretation given the high variability within the benthic ecosystem coupled with the spatial variability in survey locations from year to year. Continuous re-sampling in consecutive years will help to increase the power of analysis.



Notes: WT - West Transect; ET - East Transect; CT - Coastal Transect; NT - North Transect

Figure 6-2: Figure 6.2: Total (top) and relative (bottom) abundance of epibenthic macrofauna in Milne Inlet, 2014 to 2016

7.0 BENTHIC INFAUNA

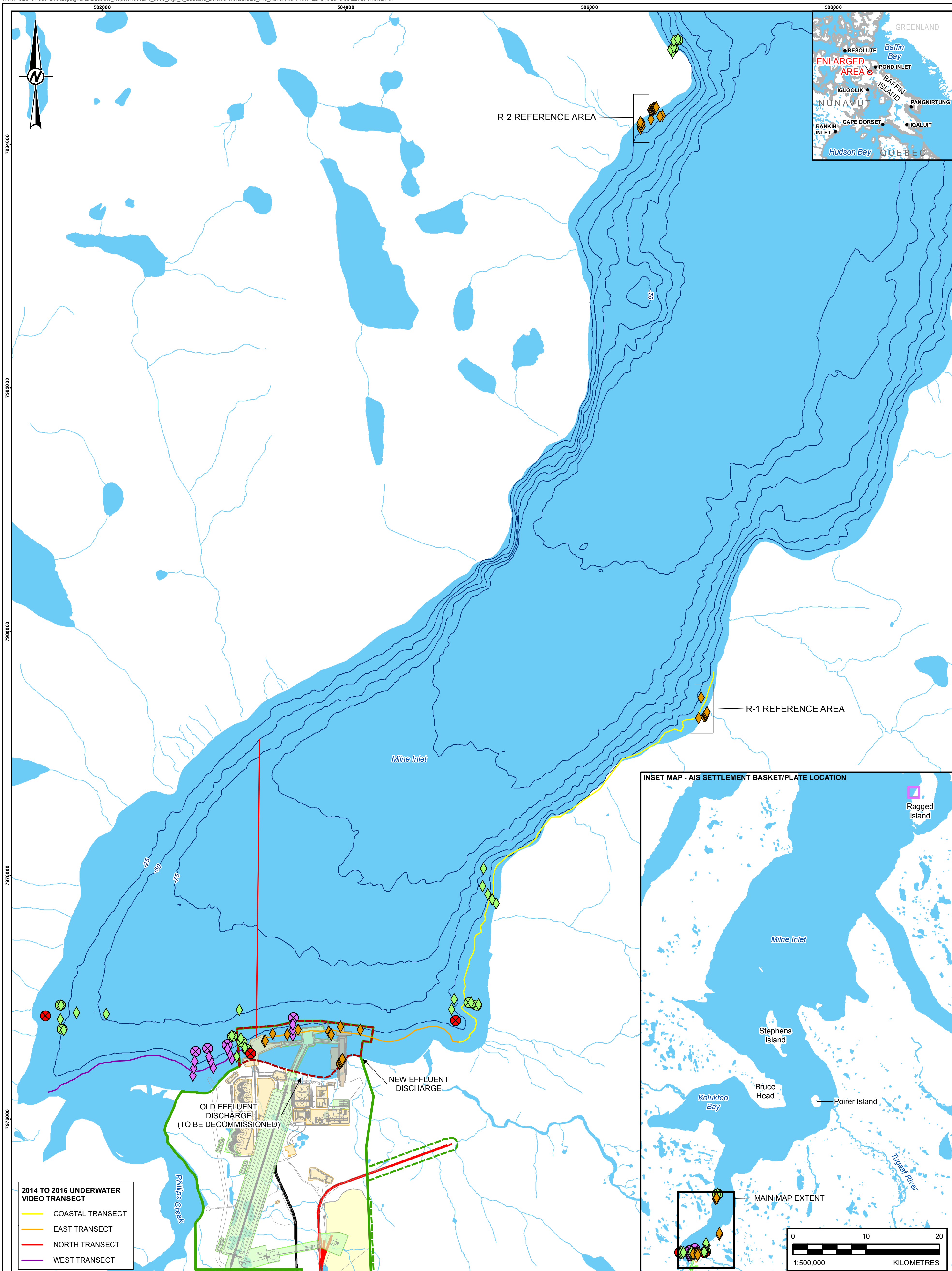
Information on benthic infauna composition in the Arctic, particularly in northwest Baffin Bay and adjacent waters, including Eclipse Sound, Lancaster Sound and Admiralty Inlet, is available from several literature sources (Thomson 1982; LGL 1982; 1983; Stewart and Lockhart 2005; Ellis 1960; Welch et al. 1992; Cross and Thomson 1982; 1987). In 1981, extensive benthic infauna surveys were conducted as close to Milne Inlet as at Cape Hatt in Eclipse Sound (Cross and Thomson 1982). However, no data on benthic invertebrates in Milne Inlet were available prior to the baseline surveys conducted for the Mary River Project in 2010.

Benthic crustaceans at Cape Hatt included ostracods, amphipods, cumaceans, isopods, decapods, and nebaliacean, and were dominated by ostracods amphipods (64 and 30% of collected organisms, respectively; Cross and Thomson 1987). In Hudson Bay, benthic productivity is likely low, despite large numbers of shorebirds (Stewart and Lockhart 2005). Maximum richness recorded from a single sampling was 35 species, with maximum biomass of 13 g/m²; these values are lower than reported elsewhere for the Eastern Arctic, but comparable to values from the southern Beaufort Sea (Stewart and Lockhart 2005). In James Bay, high densities of the clam *Macoma* and the gastropod *Hydrobia* were found in sheltered bays, whereas in areas close to river mouths, invertebrate densities were very low (Stewart and Lockhart 2005). In both Hudson Bay and James Bay, few benthic species are found in the intertidal zone on a permanent basis, likely due to ice scour, however many species can be found in the intertidal zones during the open-water season. Important benthic species described from the Eastmain River estuary included the bivalves *Macoma balthica* and *Mytilus edulis*, the gastropods *Cylichna alba* and *Margarites olivaceus*, the polychaetes *Terebellides stroemi* and *Aglaophamus neotenus*, the cumacean *Diastylis rathkei*, and the amphipods *Atylus carinatus* and *Onisimus littoralis* (Stewart and Lockhart 2005). The distribution of benthos was positively correlated with salinity and organic matter presence.

In 2010, 24 benthic infauna samples were collected from five transects near the head of the inlet and one transect located approximately 9 km north of the port site (Figure 7-1. At each transect, infauna samples were collected from multiple depth strata: <3, 3-15, 15-25, and >25 m. In 2013, benthic invertebrate samples were collected from three locations: the Milne Port area, Reference Site 1 (R1) and Reference Site 2 (R2). Benthic invertebrate sampling locations were established in four different depth strata (intertidal, 0-3, 3-15 and 15-25 m) and co-located with sediment sampling stations where possible. Five replicate samples were collected from each location and habitat stratum (5 additional replicates were collected from the Milne Port area, stratum 0-3 m).

In the 2014 baseline MEEMP survey, it was deemed that previously collected benthic infauna data were sufficient to establish a species inventory, and infauna sampling was not conducted (SEM 2015). From 2015 to 2016, benthic infauna was studied within the AIS monitoring program. Benthic infauna samples were collected along four transects, consistent with the general AIS monitoring study design. Each transect was divided into depth strata (0-3 m, 3-15 m, 15-25 m, and >25 m), and 5 samples were collected from each stratum of each transect using a Petite Ponar or a standard Ponar grab. Samples were sieved within a few hours of collection through a 500 µm mesh screen and organisms were preserved in 95% ethanol. Samples were shipped to an analytical laboratory (e.g., Envirosphere Consulting) for taxonomic identification to the lowest practical level and enumeration.

In 2010, the highest density of benthic infauna was found at the 15-25 m stratum with an average density of 8,421 organisms per m² (organisms/m²). The 3-15 m and the >25 m strata had average benthic infauna densities of 7,185 and 5,079 organisms/m², respectively. The average density of infauna in Milne Inlet was 6,290 organisms/m². Infauna was dominated by polychaete worms (Polychaeta); other common taxa in samples included crustacean copepods (Copepoda) and amphipods (Amphipoda) and clams (Baffinland 2012 [Appendix 8A-1]).



LEGEND

- 2014 TO 2016 AIS SETTLEMENT BASKET / PLATE
- 2010 BENTHIC INFAUNA SAMPLE LOCATION
- 2013 BENTHIC INFAUNA SAMPLE LOCATION
- 2014 TO 2016 BENTHIC INFAUNA SAMPLE LOCATION
- 2008 ZOOPLANKTON SAMPLE LOCATION
- 2010 ZOOPLANKTON SAMPLE LOCATION
- 2014 TO 2016 ZOOPLANKTON SAMPLE LOCATION
- POPULATED PLACE
- BATHYMETRIC CONTOUR (25 m INTERVAL)
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- AGGREGATE SOURCE (BORROW PIT OR QUARRY)
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- INAC FORESHORE LEASE
- REVISED PDA FOR PHASE 2 PROPOSAL
- WATERBODY

0 500 1,000
1:30,000 METRES

NOTE

AIS: AQUATIC INVASIVE SPECIES

REFERENCE(S)

2008 AND 2010 ZOOPLANKTON AND BENTHIC INFAUNA SAMPLING LOCATIONS WERE DIGITIZED FROM THE MARY RIVER PROJECT OCEANOGRAPHIC BASELINE SYNTHESIS (NOVEMBER 2010). 2013 ZOOPLANKTON AND BENTHIC INFAUNA SAMPLING LOCATIONS WERE DIGITIZED FROM THE ____________REPORT (DATE NEEDED). BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES. HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND FROM HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
SAMPLING LOCATIONS FOR BENTHIC INVERTEBRATES AND AIS (2008, 2010, 2014-2016)

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	AA / VV
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	5000	0	7.1

In the 2013 baseline study at Milne Port, the lowest abundance and richness of benthic infauna was found in the intertidal zone, with a single taxon (oligochaete worm [Oligochaeta]) recorded at 12.5 organisms/sample (Figure 7-2). Two other invertebrate taxa detected in the intertidal zone, ostracod crustacean (Ostracoda) and nematode worm (Nematoda), are classified as meiofauna. Low abundance and richness were also recorded at 0-3 m depths, with an average abundance of 35 organisms/sample (SD=26 organisms/sample) and mean taxonomic richness of 1.4 taxa/sample (SD=0.7 taxa/sample); the stratum was overwhelmingly dominated by oligochaetes. The highest abundance was found at the 3-15 m stratum, with a maximum value of 657 organisms/sample and an average of 328 organisms/sample (SD=205 organisms/sample). Maximum taxonomic richness at this stratum was 44 taxa/sample with an average taxonomic richness of 29 taxa/sample (SD=11 taxa/sample). Highest average richness was recorded at the 15-25 m depth stratum (mean of 35.0 taxa/sample, SD of 8 taxa/sample). Benthic infauna abundance generally decreased with depth between the three strata deeper than 3 m.

At the two reference locations sampled in the 2013 baseline study, the relationship between depth and infauna abundance and richness differed from the patterns recorded at Milne Port (Figure 7-2). At R-1, infauna abundance was largest at the 0-3 m stratum, although data were also highly variable (maximum of 610 taxa/sample, mean of 266.7 taxa/sample, and SD of 264.5 taxa/sample). Abundance variability decreased with depth, however no consistent depth effect on mean abundance was recorded. Taxonomic richness at R-1 was low in both intertidal and the 0-3 m strata, and increased abruptly at the 3-15 m stratum. Mean richness remained similar between the 3-15 m and the 15-25 m stratum. Overall, the R-1 abundance was comparable to the Milne Port abundance values, whereas taxonomic richness was slightly lower. At R-2, abundance values and variability increased consistently with depth (Figure 7-2). The highest abundance and taxonomic richness were recorded at the 15-25 m stratum, with means of 300 organisms/sample and 37.0 taxa/sample, respectively. The relationship between abundance and depth at R-1 was opposite to the pattern recorded at Milne Port and different from the pattern observed at R-1.

In the 2015-2016 MEEMP surveys, abundance recorded at each depth stratum was considerably lower than in the 2013 baseline survey (Figure 7-2). For example, at the 3-15 m stratum, mean abundances were 328.4 organisms/sample, 105.9 organisms/sample, and 140.2 organisms/sample in 2013, 2015, and 2016, respectively. In 2015, abundance was highest at the 3-15 m stratum (105.9 organisms/sample), although the >25 m stratum had a similar mean value (103.9 organisms/sample). The 2015 benthic infauna samples were dominated by bivalves, polychaete worms (Polychaeta), and ostracods (SEM 2017a).

The 2016 abundance values were overall similar to the 2015 data, although the pattern with depth was slightly different. Taxonomic richness in 2015 was considerably lower than in 2013 across the 3-15 m and the 15-25 m strata, and richness increased consistently with depth (Figure 7-2). The highest richness value (as well as the highest mean richness) recorded in 2015 were at the >25 m stratum (54 taxa/sample and 29 taxa/sample, respectively). In 2016, maximum richness was recorded at the >25 m stratum (53 taxa/sample), whereas the highest mean was recorded at the 15-25 m stratum (36.8 taxa/sample). Similar to the 2015 results, the 2016 benthic infauna samples were dominated by bivalves, polychaete worms, and ostracods (SEM 2017a).

A total number of benthic infaunal taxa found during 2013, 2015 and 2016 surveys was 347 species. Taxa accumulation plots of the pooled data for these three years reached an asymptote (see Figure 3.42 in SEM 2017a) and calculated species richness estimator Chao 2 (expected number of species in an infinitive number of samples (Chao 1987) exceeded the total number of observed species by 7% (SEM 2017a), suggesting that the three-year sampling effort was sufficient to capture the biodiversity at Milne Inlet. Sampling of benthic infauna to date has not identified any non-native species (Macdonald, pers. comm.).

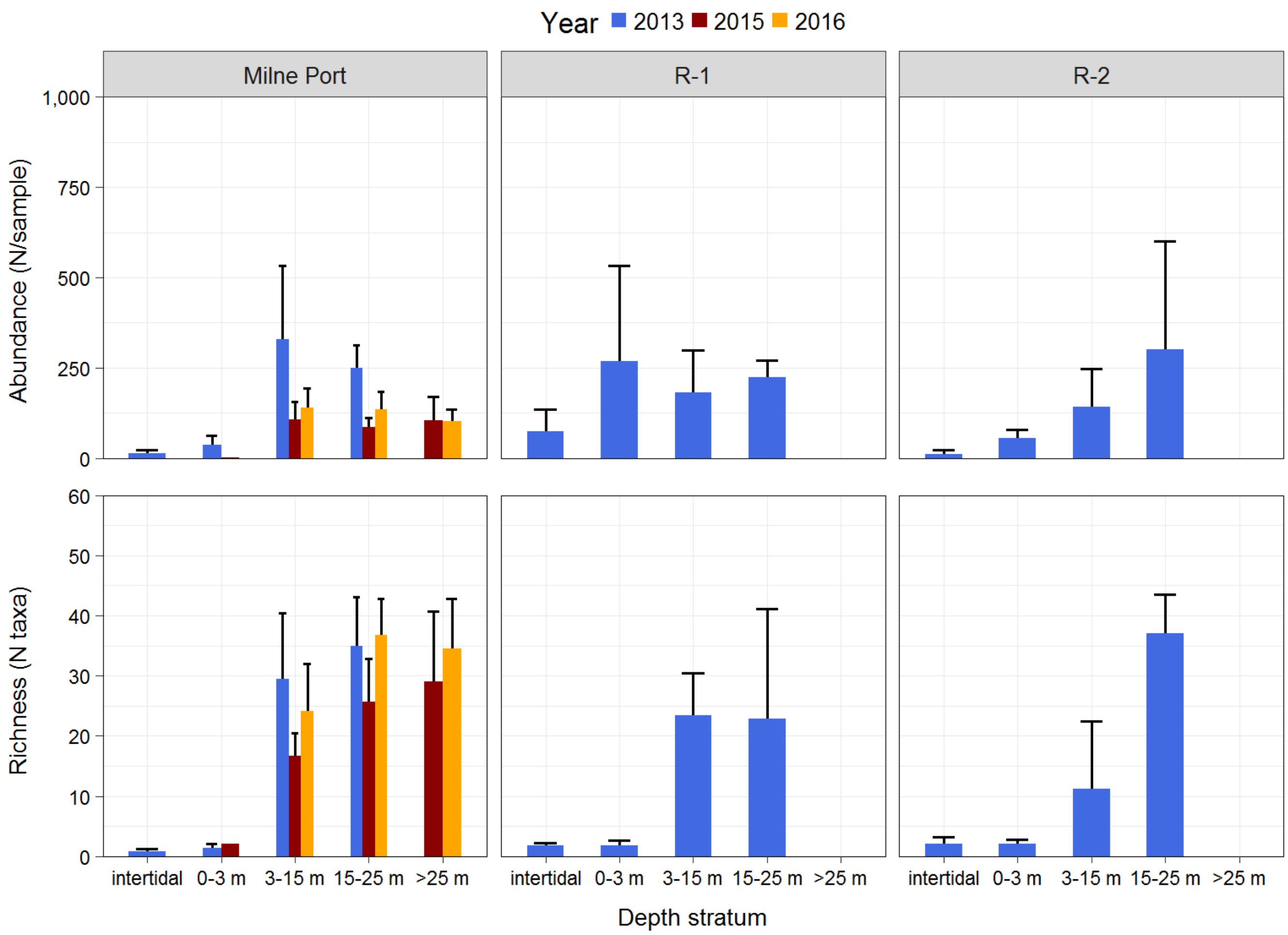


Figure 7-2: Mean benthic infauna values from 2013, 2015, and 2016 studies; error bars are 1 SD

8.0 PHYTOPLANKTON

Life in the Arctic Ocean ultimately depends on the production of marine microalgae. The Arctic bloom consists of two distinct categories of primary producers, ice algae (sympagic algae) growing within and on the underside of the sea ice, dominated by pennate diatoms, and phytoplankton growing in open waters (Søreide et al., 2010). In the Lancaster Sound region, approximately 90% of annual carbon fixation was contributed by phytoplankton, 10% by sympagic algae, and 1% by kelp (Welch et al., 1992).

The timing and extent of primary production is strongly affected by the patterns of ice formation. Studies in Arctic have suggested two algal bloom seasons. For instance, a survey in Baffin Bay in 2015 demonstrated an increase in sympagic algae abundance in sea-ice from the end of April to mid-June, reaching 3000 cells/mL, but as spring set in, the abundance decreased rapidly to 250 cells/mL (Grondin et al., 2016). At the same time, sympagic algal numbers were increasing in the water column, suggesting a “flushing” of algae from sea ice. A phytoplankton bloom in the water column started in July (Grondin et al., 2016). The reproduction and growth of the copepod perfectly coincided with these two bloom events.

Phytoplankton biomass studies were conducted only during the baseline surveys in 2008 and 2010. Phytoplankton biomass and productivity was estimated by collecting water samples to measure the concentrations of chlorophyll *a* and pheophytin a, a standard proxy for phytoplankton biomass. Sampling was conducted concurrently with water quality sampling (see Section 4.0) and occurred during open-water conditions in August and September and under ice-cover in May and June. Samples were collected from locations with ranging water depths and distances from shore to characterize the overall conditions within the inlet (Figure 4-1). Samples were collected using a van Dorn or Kemmerer water sampler from one metre below the water surface, and either at 1 m above the sediment or at 30 m depth.

Mean concentrations were calculated where replicate samples were collected. The resulting mean was used to represent the site conditions during that particular sampling event. Summary statistics, including mean, standard deviation (SD), minimum, and maximum, were then calculated from the data collected during each season.

Phytoplankton biomass measured during the field surveys was, in general, low, which is consistent with data reported for Arctic waters previously. Chlorophyll *a* concentrations were slightly higher at depth than at the surface, which is consistent with literature that suggests that maximum phytoplankton biomass occurs near the bottom of the mixing zone (Gallegos et al. 1983; Harrison et al. 1982; Mitchel et al. 2006), and slightly higher during the ice-cover season than during the open water season. At the surface, chlorophyll a concentrations ranged from <0.2 µg/L to 1.7 µg/L and from <0.2 µg/L to 2.1 µg/L during the open water season and ice-cover season, respectively; at the depth, chlorophyll *a* concentrations ranged from <0.2 µg/L to 2.0 µg/L and from 1.1 µg/L to 5.2 µg/L. Higher concentrations during the ice-cover season could be explained by the timing of sampling, which occurred in June when ice began to melt and ice-associated algae were released into the water column (Cross 1982; Baffinland 2012 [Appendix 8.1-A]).

9.0 ZOOPLANKTON

No scientific literature exists on zooplankton communities within Milne Inlet, but considerable information is available for Lancaster Sound and western Baffin Bay (Buchanan and Sekerak 1982; Sameoto et al. 1986; Welch et al. 1992). The marine planktonic ecosystem of the Arctic is characterized by a brief summer period of intense productivity following the spring phytoplankton bloom, and zooplankton composition is largely dominated by copepods (Darnis et al. 2012; Steiner et al. 2013). Small-bodied copepods such as *Oithona similis*, *Tricornia borealis*, *Pseudocalanus* spp., and *Microcalanus* spp. are numerically dominant, however a few species of Arctic/Subarctic copepods are relatively large and dominate in terms of biomass. These are copepods of the genus *Calanus* (e.g., *C. hyperboreus, C. glacialis*, and *C. finmarchicus*) that feed extensively on algal primary producers, contain high lipid reserves and essential fatty acids, and are therefore key drivers of the energy transfer through Arctic marine ecosystems. The mature *Calanus* species perform long-range seasonal vertical migrations to ocean depths of several hundreds of metres where they remain during the winter period. Small-bodied copepods and young stages of the larger species have smaller energy reserves and feed opportunistically all year long, perhaps having a greater significance in the food web dynamics during winter and late fall (Darnis et al. 2012).

In Milne Inlet, zooplankton assessments were conducted during the baseline studies in 2008 and 2010 (Baffinland 2012 [Appendix 8A-1]) and within AIS monitoring program in 2014 through 2016 (SEM 2017a). Zooplankton sampling was conducted at three locations in Milne Inlet in September 2008 and 10 locations in August 2010 (Figure 7-1. Samples were collected using vertical tows of a conical net of 1 m in length, 0.25 m in diameter, with 63 µm mesh. During 2014-2016 AIS monitoring studies, zooplankton samples were collected at four locations in the vicinity of the Milne Port area (Figure 7-1) by four vertical and four oblique tows during the open-water season (August and September). In addition, four under-ice vertical samples were collected in June 2015. Vertical samples were collected using an 80 µm mesh plankton net and oblique tows using a 250 µm mesh plankton net; both nets had a diameter of 30 cm.

Vertical samples were collected by lowering the plankton net to 1 m above the bottom and retrieving the net to the surface at a rate of 10 m/min. Oblique samples were collected by towing the plankton net at the water surface behind a vessel travelling 1.8 km/h for a period of ten minutes. Under-ice zooplankton tows were completed by first drilling a hole through the ice and completing vertical sampling at depths from 10-30 m as described above.

Samples were fixed in the field with either 95% alcohol or 10% formalin, packaged, and shipped to a laboratory for taxonomic identification to lowest practical taxonomic level. Samples collected in 2008 and 2010 were enumerated, and taxon-specific densities were estimated dividing the number of organisms per cubic metre of water (organisms/m^3). Species list from samples collected for the AIS program were used to create a zooplankton inventory, to monitor presence of any new species not previously identified, and to determine if any newly identified species are possibly invasive (non-native).

Vertical zooplankton tows were conducted in 2008, 2010, and 2014-2016 (Baffinland 2012 [Appendix 8A-1], SEM 2017a). Average densities were measured as 1,616 organisms/m^3 in 2008 and 548 organisms/m^3 in 2010; densities recorded in 2014-2016 were considerably lower. The recorded zooplankton taxa were comprised of 12 taxa and 23 taxa in total in 2008 and 2010, respectively, and were dominated by copepods (Baffinland 2012 [Appendix 8A-1]).

Average density (organisms/m³) and taxa richness for the 2014-2016 sampling years are provided in Figure 9-1 and Figure 9-2 respectively. Density of organisms in oblique zooplankton tows was lower (14-88 organisms/m³) than vertical tows (155-180 organisms/m³). Average density was similar across the three sampling years for vertical tows, but a higher density was found in oblique tows in 2015 compared to the other years. Under-ice vertical tows conducted in 2015 had higher average density (418 organisms/m³), but taxa richness (19) was comparable to vertical tows in open-water season. Taxa richness in vertical tows increased with each sampling year. However, taxa accumulation plots of the pooled 2014-2016 data reached an asymptote (see Figure 3.40 in SEM 2017a), suggesting that the three-year sampling effort was sufficient to capture the biodiversity at Milne Inlet. A total of 63 taxa were documented during the 2014-2016 sampling, and 17 taxa were found in all three years (SEM 2017a). Zooplankton sampling to date has not identified any non-native species (Macdonald, pers. comm.).

Samples were dominated by copepods, followed by arrow worms and other appendicularians and mollusc larvae (Figure 9-2. The taxonomic composition of zooplankton sampling conducted in all years of sampling was typical of Arctic and Subarctic ecosystems. Plankton samples for the Milne Inlet contained *C. hyperboreus, C. glacialis*, and *C. finmarchicus,* as well as the small-bodied but numerically more dominant copepods such as *Oithona similis, Triconia borealis*, and *Pseudocalanus* spp (Figure 9-2 BIM 2012 [Appendix 8A-1], and Table 3.61-3.62 in SEM 2015, Table 4.4-4.6 in SEM 2016a, and Tables 3.70-3.71 in SEM 2017a). Vertical tows in 2016 differed from previous years as the samples were largely dominated by echinoderm larvae than by copepods.

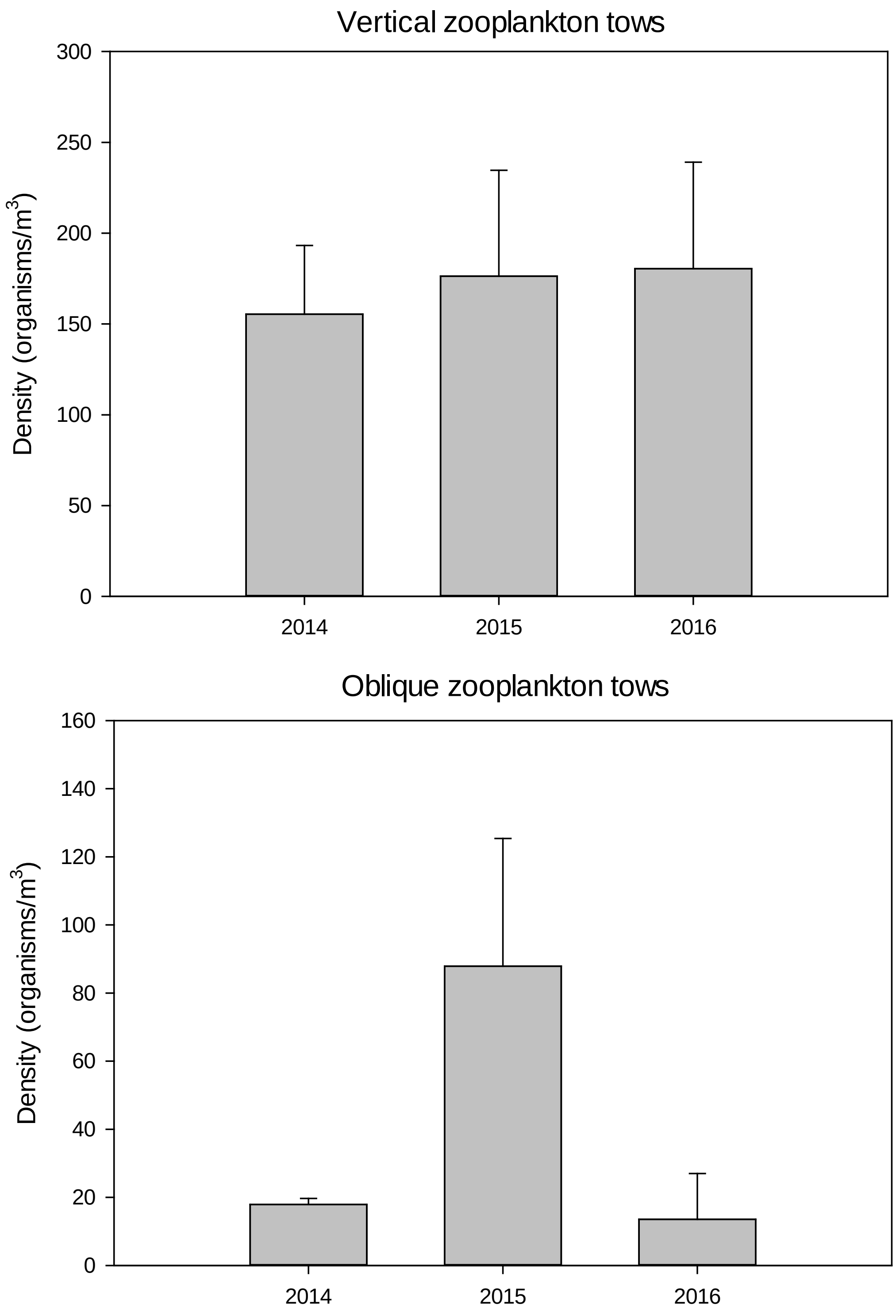


Figure 9-1: Average density of zooplankton organisms sampled using vertical and oblique tows in 2014-2016. Error bars represent 1 standard deviation

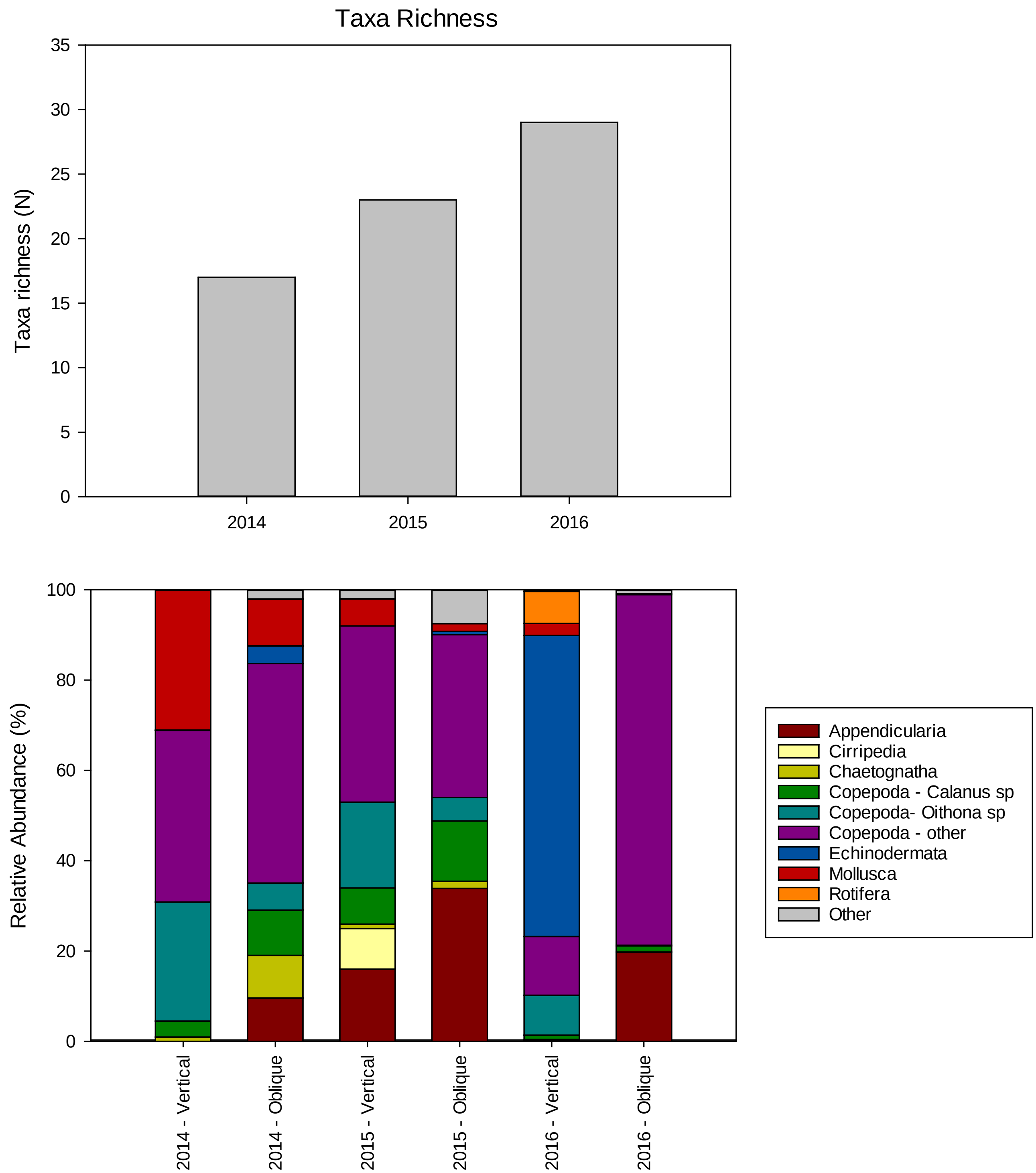


Figure 9-2: Taxa richness (top) and relative abundance (percent composition; bottom) of major taxa in vertical and oblique zooplankton tows in 2014-2016

10.0 FISH

Limited information is available on marine fish communities in the northern Baffin Island area. Available sources suggest that coastal fish communities in the Arctic have relatively low species diversity and abundance (LGL 1982). The most common species are anadromous Arctic char (*Salvelinus alpinus)* that occur seasonally throughout the region. Arctic cod (*Boreogadus saida*) are also ubiquitous in the Arctic and frequently occur in nearshore waters in relative abundance. The species is an important prey source for other fish, including Arctic char, as well as for many seabirds and marine mammals. Benthic marine fish species such as sculpins, eelpouts, and lumpfish are also relatively common in nearshore waters, although often in low abundance (LGL 1982). Other species known to occur in Milne Inlet include Greenland sharks and Greenland cod.

Most of the marine fish studies conducted in this region were focused on commercially important Greenland halibut fisheries (Chambers and Dick 2007; Jorgensen et al. 2005) and were conducted mainly in Baffin Bay and Davis Strait. Considerably more information is available on anadromous Arctic char, including the species' distribution in Milne Inlet, due to its importance to local residents (Kristofferson and McGowan 1981; Moshenko 1981; Read 2004). Tugaat and Robertson rivers, located in the southern portion of Milne Inlet, support anadromous Arctic char populations (Moshenko 1981; Kristofferson and McGowan 1981; Read 2004). Robertson River, which drains into Koluktoo Bay, supported a small commercial fishery that closed in the mid-1970s due to a population decline and to support a sports fishery established by the Pond Inlet Co-op (Moshenko 1981; Read 2004). The Tugaat River commercial fishery for Arctic char, operating between the early 1970s and 1990s, also closed due to population decline (Kristofferson and McGowan 1981; Read 2004). Pond inlet residents continue harvesting Arctic char in Tugaat River for subsistence use (Kristofferson and McGowan 1981; Read 2004).

Arctic char are distributed widely in circumpolar regions and are present in 21 countries, including Canada, United States, Norway, Iceland, and Russia (FishBase 2017). In the marine environment of the north-eastern Canada, Arctic char is found along the western and northern coast of Hudson Bay and coastal areas of Hudson Strait (Coad and Reist 2004; FishBase 2017), with areas of abundance identified at Arviat, Rankin Inlet, the entrance of Chesterfield Inlet, Cape Dorset, and Kimmirut, and surrounding areas of Baffin Island and Greenland (FishBase 2017; NPC 2012; Schneider-Vieira et al. 1994; Scott and Crossman 1973). In the freshwater environment, Arctic char occurs in the majority of lakes and rivers of the Kivalliq Region including Baker Lake (NPC 2012).

Arctic Char is iteroparous and exhibits both anadromous and land-locked life history strategies (Scott and Crossman 1973; Stewart and Watkinson 2004; FishBase 2017). The anadromous form of this species spends most of its life in the freshwater environment and takes annual spring migrations to marine waters after the first two to six years of life (DFO 2006; Stewart and Lockhart 2005). It spends 30 to 60 days in the marine environment where most of its feeding and growth occurs (Moore et al. 2014). In the fall, before rivers freeze, adults migrate back to freshwater habitats to overwinter (Richardson et al. 2001; Moore et al. 2014). Arctic char spawns in gravel bottom freshwater lakes and rivers from September to November, with spawning events separated by two to five years (Moore et al. 2014).

Arctic char are carnivorous, but have a remarkably diverse diet (Scott and Crossman 1973). A study of 450 char stomachs from Frobisher Bay, Baffin Island revealed 30 different species of vertebrate and invertebrate animals (Grainger 1953; Scott and Crossman 1973). The common Arctic char diet includes crustaceans and fish, including capelin (*Mallotus villosus*), sand lance (Ammodytes spp.), Arctic cod, and juvenile Greenland cod (Richardson et al. 2001; Coad and Reist 2004).

Arctic char is harvested by the Inuit for both commercial and subsistence purposes (Moore et al. 2014; Nanuk 1999; Agnico Eagle 2014). Subsistence fisheries are managed by local hunters and trappers organizations, while DFO manages commercial harvests (Moore et al. 2014). Within Nunavut, commercial harvests between 2001 and 2008 ranged from 74,124 kg to 95,558 kg (total mass annually; Roux et al. 2011) with annual quotas ranging from 281,500 kg to 409,800 kg (Moore et al. 2014). Abundance estimates have been attempted in some localities within the Territory, however estimates are deemed unreliable due to the variable migratory behaviour of Arctic char (Moore et al. 2014; Roux et al. 2011). However, stocks are widely distributed in Nunavut and a total available quote for Arctic char harvest is 427,200 kg round mass (i.e., mass of whole, head-on, undressed fish; Roux et al. 2011).

Project-specific studies on marine fish populations in Milne Inlet commenced in August 2010 and continued through all subsequent marine environmental study programs. Studies were conducted to obtain information on the taxonomic composition of fish communities, their abundance, age and size distribution, diet, health and accumulation of contaminants in tissue. Data collection techniques included gillnets, Fukui traps, specialized traps for larvae and juvenile fishes, and qualitative observations using underwater videography.

10.1 Fish Community

Fish community assessment during the baseline and effect monitoring studies from 2010 to 2016 was conducted using non-lethal methods, mainly Fukui traps and experimental, multi-panel, multi-mesh size gillnets for bottom deployment. The exception was the 2010 survey when only gillnets were used for fish capture. In addition to traps and gillnets, qualitative observations using underwater videography were used for fish community studies. Fish samples were collected at various locations in the vicinity of the Milne Port area (Figure 10-1) and in reference areas R-1, and R-2 (in 2013 only; SEM 2014).

In 2010, the gillnet used consisted of six twisted nylon panels, each 22.9 m long by 1.8 m deep, with mesh size of 38 mm, 51 mm, 76 mm, 95 mm, 108 mm, and 127 mm stretch mesh. Throughout 2013-2016 sampling, gillnets consisted of six panels, each 15.24 m long by 2.45 m deep, with mesh size of 25 mm, 38 mm, 51 mm, 64 mm, 76 mm, and 102 mm mesh. Gillnets were set perpendicular to the shoreline, and were weighted using a lead line. Apart from the 2010 sampling, gillnetting followed a standardized protocol consistent with the Fisheries and Oceans Canada (DFO) experimental license: gillnets were set in the morning, checked every two hours, or sooner, and retrieved each evening. In 2010, gillnets were deployed for less than four hours. These short soaking times aimed to minimize fish mortality.

Fukui traps in 2013 were set on two strings of 12 (nine small, three large) and 13 (11 small, two large) traps, respectively. In 2014-2016, Fukui traps were set in strings of, on average, ten traps; each trap was 61 cm by 46 cm by 20 cm, with 1.25 cm stretch mesh (in 2013, larger traps were used in addition to the traps described above; these larger traps were 81 cm by 61 cm by 28 cm and same 1.25 cm stretch mesh. Fukui traps were baited with salted herring and mackerel. Traps were retrieved and redeployed every 12 h to sample different areas and habitats within each sampling location and were left to fish continuously as they are a live trapping method.

All captured fish were released alive, whenever possible, after taxonomic identification, and recording length, weight, location, time of capture, depth, habitat, and other general comments or observations. All accidental mortalities were examined for sex and maturity, and otolith samples were collected for age identification. Stomach contents from dead fish were examined and identified and quantified (generally, class or family for invertebrates and species for fish) either in the field, when possible, or in a laboratory. Tissue samples for contaminant accumulation analyses (body burden; see Section 10.3) were taken from accidental mortalities.

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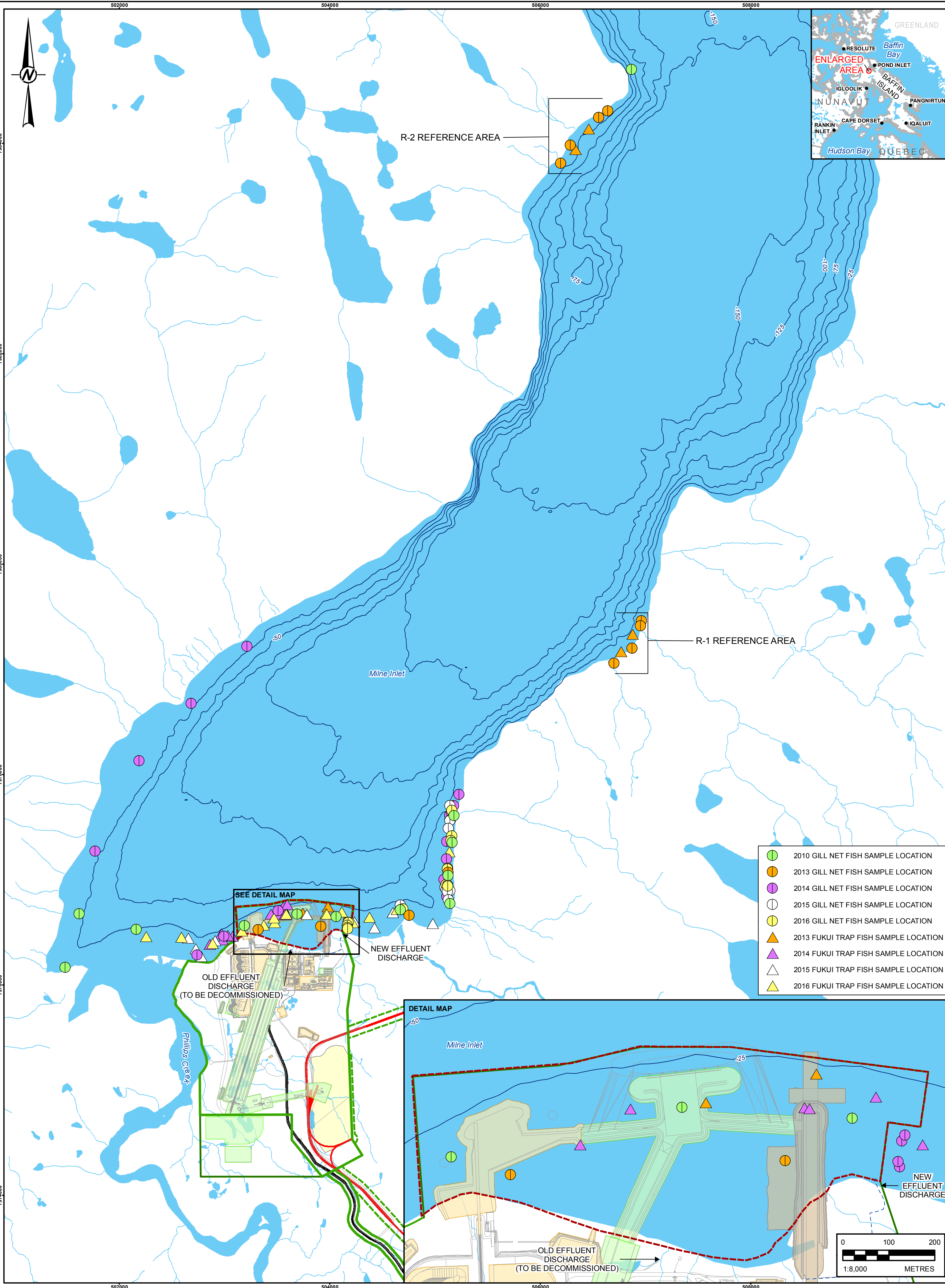

LEGEND

- POPULATED PLACE
- BATHYMETRIC CONTOUR (25 m INTERVAL)
- MILNE INLET TOTE ROAD
- NEW EFFLUENT PIPELINE
- PROPOSED NORTH RAILWAY
- PDA / QIA COMMERCIAL LEASE
- WATERCOURSE
- AGGREGATE SOURCE (BORROW PIT OR QUARRY)
- EXISTING FREIGHT DOCK AND CAUSEWAY
- EXISTING ORE DOCK
- NEW ORE DOCK AND CAUSEWAYS
- INAC FORESHORE LEASE
- REVISED PDA FOR PHASE 2 PROPOSAL
- WATERBODY

0 500 1,000

1:35,000 METRES

REFERENCE(S)

2010 FISH SAMPLING LOCATIONS WERE DIGITIZED FROM THE MARY RIVER PROJECT OCEANOGRAPHIC BASELINE SYNTHESIS (NOVEMBER 2010). 2013 FISH SAMPLING LOCATIONS WERE DIGITIZED FROM THE ____________REPORT (DATE NEEDED). BATHYMETRY CREATED BY GOLDER FROM MULTIPLE DATA SOURCES. HYDROGRAPHY AND TOPOGRAPHY DATA BY EAGLE MAPPING (2005), RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE, MAY 2017. MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND FROM HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
SAMPLING LOCATIONS FOR FISH STUDIES (2010, 2013-2016)

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-22
DESIGNED	AO
PREPARED	AA / VV
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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25mm

Fishing effort, the number of fish caught, and relative species composition of catches varied from year to year. Catch per unit effort (CPUE; expressed as fish per 1 h of effort) at the Milne Port area increased with time from 0.3 fish/h in 2013 to 2.9 fish/h in 2016. The total number of fish caught in gill nets also increased from 8 to 163 in 2013 and 2016, respectively (Figure 10-2). Gill nets were more efficient in catching both transient and resident fish species than Fukui traps. The CPUE of Fukui traps was similar throughout the 2014-2016 sampling, ranging between 0.02 fish/h and 0.03 fish/h, but was considerably higher in 2013 (0.64 fish/h; Figure 10-3).

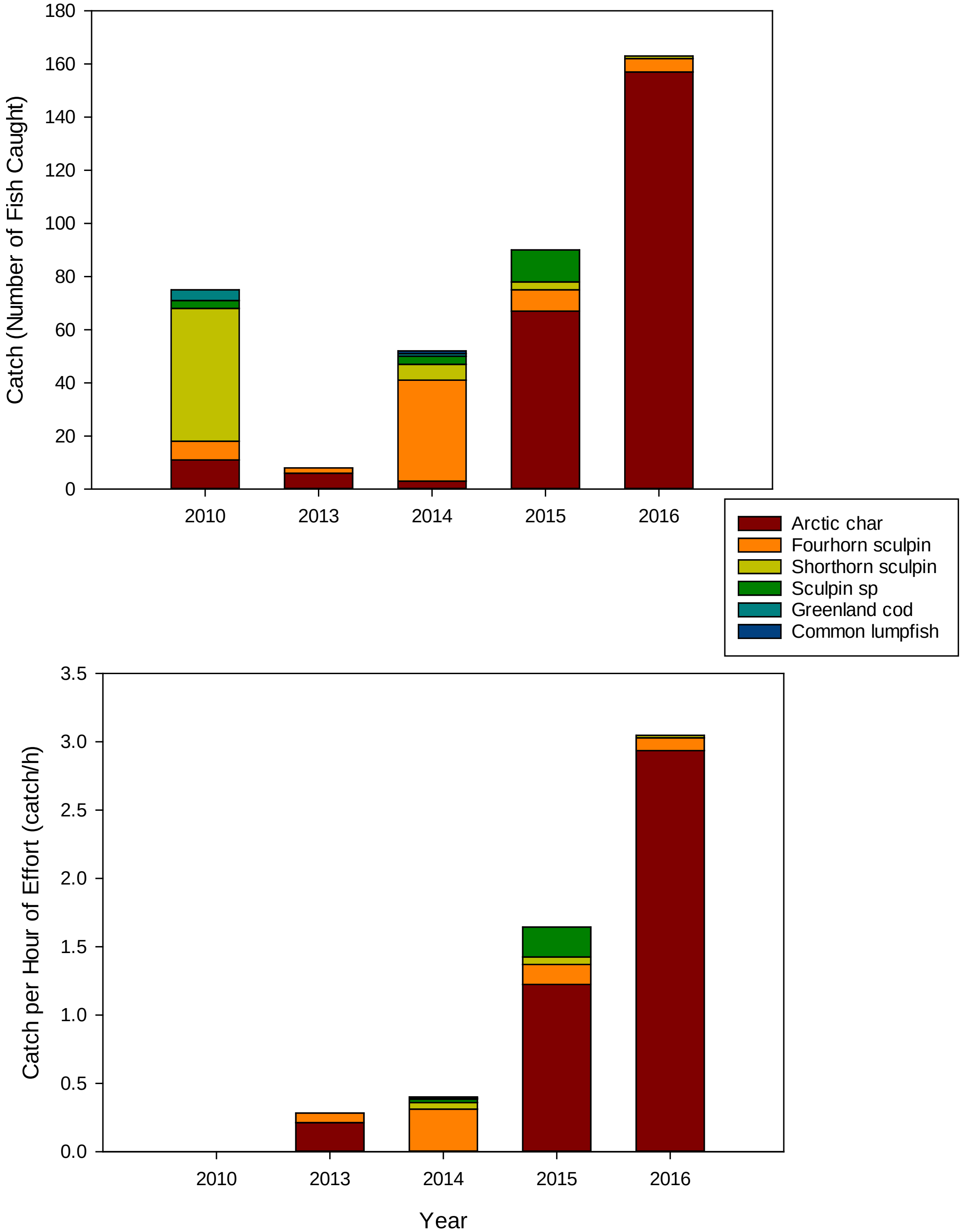
Eleven identified fish species were captured during fish surveys in the Milne Port area from 2010 to 2016 (Table 10-1). Arctic char was the most common species in gillnet catches in 2013, 2015, and 2016, constituting 75%, 75% and 96% of total number of fish caught by gillnetting, respectively. Relatively abundant catches of Arctic char in 2015 (n = 67) and 2016 (n = 157) occurred during the species' migration through the area (SEM 2017a). Spatial differences in Arctic char catches were recorded; e.g., 2013 catches in the Milne Port area and Reference Site 1 were relatively poor (n = 6 in both), however catch was substantially larger (n = 52) at Reference Site 2, approximately 8 km northeast of Milne Port.

Sculpins constituted a great majority of non-char fish species caught, with shorthorn sculpin (*Myoxocephalus scorpius*) and fourhorn sculpin (*Myoxocephalus quadricorni*) being the most abundant (Table 10-1); shorthorn sculpin represented 67% of all fish caught in 2010 and fourhorn sculpin constituted 58% of all catches in 2014. Other fish species that were caught in two or more survey years were Arctic sculpin (*Myoxocephalus scorpioides*), Arctic staghorn sculpin (*Gymnocanthus tricuspis*), longhorn sculpin (*Myoxocephalus octodecemspinosus*), and Atlantic hookear sculpin (*Artediellus atlanticus*), Greenland cod (*Gadus ogac*), fishdoctor (*Gymnelis viridis*), and fourline snakeblenny (*Eumesogrammus parecisus*). Arctic cod was never captured but was observed in large schools around Milne Port in 2016 (SEM 2017b), although it had been identified in Arctic char stomach content (SEM 2017a).

Table 10-1: Total fish catches in the Milne Port area, 2010 to 2016

Common Name	Taxonomic ID	2010	2013	2014	2015	2016
Arctic char	*Salvelinus alpinus*	11	6	3	67	157
Arctic sculpin	*Myoxocephalus scorpioides*	0	0	4	1	-
Shorthorn sculpin	*Myoxocephalus scorpius*	50	4	9	8	18
Fourhorn sculpin	*Myoxocephalus quadricorni*	7	3	39	13	18
Arctic staghorn sculpin	*Gymnocanthus tricuspis*	3	0	0	2	-
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	0	2	4	2	2
Arctic hookear sculpin	*Artediellus atlanticus*	0	0	5	1	-
Unidentified sculpin	Cottidae	-	-	-	12	-
Greenland cod	*Gadus ogac*	4	0	1	0	-

Common Name	Taxonomic ID	2010	2013	2014	2015	2016
Common lumpfish	*Cyclopterus lumpus*	0	0	1	0	-
Fishdoctor	*Gymnelis viridis*	0	1	0	3	-
Fourline snakeblenny	*Eumesogrammus parecisus*	0	0	1	2	2
Total		75	16	67	111	197



Notes: Information on CPUE for 2010 is not available

Figure 10-2: Gill net total catch and catch per unit of effort (CPUE) by year, Milne Port area

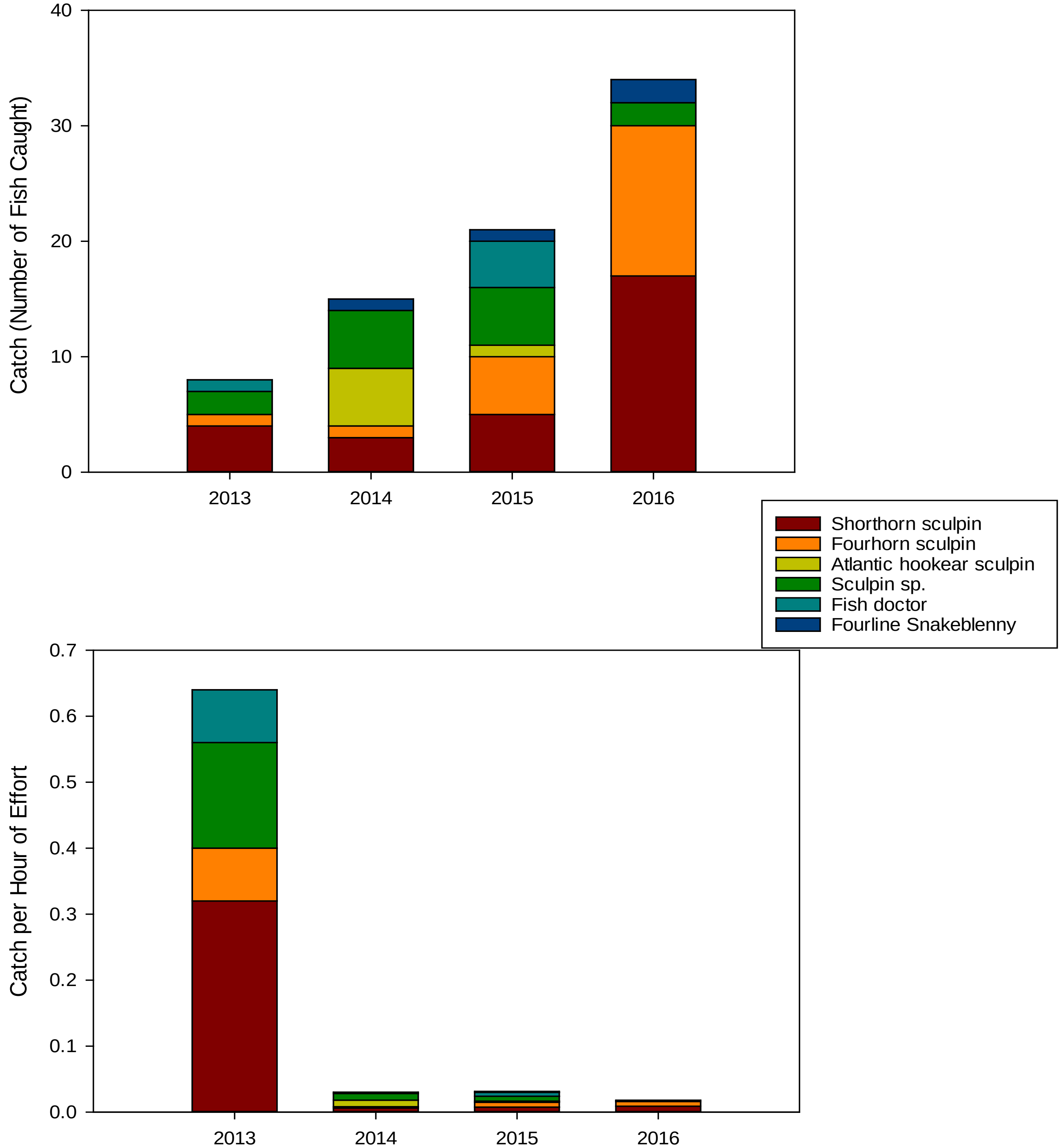


Figure 10-3: Fukui trap total catch and catch per unit of effort (CPUE) by year, Milne Port area

10.2 Mark-Recapture

A mark-recapture study design was used in an attempt to gather information on the relative population sizes of the different species, mainly sculpins, in order to determine target species for tissue sampling in future MEEMP surveys. Target species could be used for contaminant accumulation monitoring program as a biological indicator of Project-induced changes. In order to utilize a species as a target for an ongoing monitoring program, the resident population must be large enough to support lethal sampling of the required number of fish for tissue analysis. Mark-recapture surveys were conducted annually between 2014 and 2016.

Sculpins, as resident species, were targeted in the mark-recapture study. Fish were marked using pelvic fin clips, which is a non-lethal, cost effective marking method that allows for easy identification of recaptured individuals. Population estimates can then be calculated using the Schnabel method, which is applicable for cases where marking and recapture are conducted repeatedly. The method assumes a constant population with no recruitment or mortality, no movement into or from the study area, and equal catchability between marked and unmarked individuals (Ricker 1975). These assumptions are likely correct at Milne Inlet, as the area surveyed was large, there was a relatively short time between surveys, and sculpin were assumed to have a relatively small home range.

Throughout the 2014-2016 MEEMP surveys, none of the marked sculpin were recaptured (SEM 2017a) and it was not possible to estimate a population size for the species. Therefore, sculpins were deemed unsuitable as target species for tissue sampling; instead, accidental Arctic char mortalities were used for body burden analysis.

10.3 Fish Tissue

In 2010, muscle and liver tissue were collected from a length-stratified (100 mm intervals) sub-sample of Arctic char for metal (including mercury) analysis. In subsequent surveys, incidental fish mortalities were used to collect opportunistic (non-targeted) tissue samples (minimum of 50 g, skin off) from the dorsal musculature of each dead fish. Samples were frozen within eight hours of collection, and sent to an analytical laboratory (Maxxam) for trace metals (including mercury), petroleum hydrocarbons, and polycyclic aromatic hydrocarbons. Numbers of fish used for tissue sampling varied between surveys, depending on the number of mortalities during fish capture, however samples were taken almost entirely from Arctic char, as it was the most abundant species caught in gillnets. Apart from Arctic char, two fourhorn sculpin and one Arctic staghorn sculpin were used for tissue sample collection in 2013. No tissue samples were collected in 2014 since no fish mortality occurred during the surveys.

Arctic char is a transient species, therefore the species' exposure to environmental conditions associated with the Project would be lower than expected for resident species, resulting in lower body burdens. However, since the population size of the local sculpin could not be determined (Section 10.2), no target species for lethal body burden analysis was identified, and tissue contaminant monitoring program had to rely almost entirely on accidental mortalities of Arctic char.

Metals in Arctic char tissue samples from incidental mortalities were mostly below DL, except for arsenic, cadmium, chromium, copper, iron, mercury, and zinc, whose concentrations exceeded detection limits during at least one sampling event. Concentrations of these metals in fish tissue were generally consistent throughout 2010 to 2016 (Table 10-2). None of the samples exceeded Health Canada's guideline for mercury in fish tissue for human consumption of 0.5 mg/kg.

Table 10-2: Summary (mean and SD) of detected metal concentrations (mg/kg) in Arctic char accidental mortality tissue samples in the Milne Port Area, 2010 to 2016

Metals	Health Canada Guideline	2010 (n = 11)		2013 (n = 6)		2015 (n = 5)		2016 (n = 13)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Arsenic	-	0.82	0.17	0.61	0.12	1.38	0.91	0.97	0.21
Cadmium	-	0.01	0.003	<0.05	0	<0.05	0	<0.05	0
Chromium	-	0.59	0.90	<0.5	0	<0.5	0	<0.5	0
Copper	-	0.85	0.27	1.06	0.26	0.55	0.20	1.63	1.18
Iron	-	9.90	5.03	<15	0	<15	0	8.38	3.19
Mercury	0.5	0.05	0.03	0.03	0.01	0.04	0.01	0.04	0.02
Zinc	-	6.20	0.80	9.20	1.96	6.92	1.71	7.18	1.27

11.0 SUMMARY

Milne Inlet oceanography is similar to other neighbouring Arctic inlets, with full ice cover and no freshwater input during the winter. Open-water and ice-cover seasons typically start in June and early October, respectively. In the winter, the water column is relatively mixed, with relatively consistent temperature and salinity. During the open-water season, large freshwater inputs create a strong stratification in the water column with a typical pycnocline depth of 5 m to 10 m. Currents in Milne Inlet are mostly driven by tides and are generally small.

Water quality parameters and major ion concentrations in Milne Inlet recorded during the open-water season in 2008 and 2010 were typical for a stratified water column, with brackish (mean salinity 18 PSU) water layer, 8 m to 10 m in depth from the surface, and a more saline (30 PSU) water mass below. During the ice-cover season, salinity was higher than during the open-water season (approximately 32 PSU) and relatively uniform throughout the water column. Water was clear, with turbidity ranging from 0.3 NTU to 0.6 NTU, and with low levels of dissolved solids and concentrations of nutrients, indicative of mesotrophic conditions. Nutrient concentrations were higher at depth than near the surface, particularly during the open-water season. Several metals, including cadmium and iron, in water samples collected during the 2008 and 2010 baseline studies were generally below the detection limits. Mercury concentrations exceeded the CCME guidelines in two samples in June 2008

In 2014 and 2015, water samples collected during open-water season were brackish (14-20 PSU), with low total suspended solids, low turbidity, and low colour. Most metals were below DL, except for aluminum, boron, mercury, strontium, and uranium. Mercury concentrations (0.023 µg/L to 0.025 µg/L) exceeded the CCME guideline (0.016 µg/L) in all samples during the third sampling event in August. Hydrocarbons were not detected in any water samples. In comparison, both mercury and hydrocarbons were below DL in 2016 (SEM 2017a).

Sediment samples for baseline and effect monitoring studies were collected in Milne Inlet during the open-water seasons in 2008, 2010, and from 2013 through 2016. Sediment samples collected in Milne Inlet throughout the sampling years were dominated by either sand or sand and silt and had low nutrient levels. Concentrations of some metals (aluminum, arsenic, calcium, chromium cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, strontium, and vanadium) were correlated with silt content and were higher in samples with greater proportion of silt. None of the detected metals or hydrocarbons exceeded CCME guidelines for sediments, except for arsenic and zinc in seven samples during the 2014-2016 samples. Results of ANCOVA analysis of percent fine particles and concentration of iron, as indicators of Project effects on sediments, did not suggest Project-related effects, since no significant differences were found between the baseline year and consecutive years in content of fines and iron concentrations (SEM 2017a).

Benthic habitat in Milne Inlet was studied using underwater videography since 2008. The recorded footage provided spatial data on substrate and biota, including distribution and abundance of epibenthic fauna and flora. Substrate type was generally related to depth. Overall, the Milne Port area contained primarily fine substrates with a heterogeneous mix of medium sized substrate. In 2008 and 2010 studies, substrate in intertidal and upper subtidal zones (depth <3 m) was predominantly gravelly sand and sandy gravels. In deeper areas (3-15 m and >15 m), substrates were dominated by muddy sand. Baseline surveys in 2013 identified gravel, sand, and shells as predominant substrate classes, mixed with cobble in shallower areas.

Marine algae observed in the Arctic typically consisted of taxa adapted to low light conditions, short growing seasons, and cold temperatures, and included green algae, bladed and filamentous brown algae, and red algae. Areas <3 m in depth were typically barren due to ice scour. Macroflora abundance was typically highest between 3 m and 15 m, with decreasing abundance with depth due to decreasing light penetration. Surveys in 2008 and

2010, performed perpendicular to the shore, found a relatively dense cover of benthic algae in Milne Inlet, with strong vertical zonation. At shallow depths (<3 m), macroalgae were sparse and communities were dominated by filamentous brown algae and rockweed. The mid-subtidal zone (3-15 m) had the highest density of algal cover, with bladed kelps constituting the greatest majority of all benthic flora. The MEEMP surveys in 2014 to 2016 showed relatively high abundance of macroflora in the three transects along the 15 m contour lines (SEM 2017a). The assemblages were dominated by brown algae, sea colander, bladed kelps, and red algae. The highest epifloral density was consistently found in the Coastal Transect, where vegetation cover in 2015 and 2016 was 98.9% and 97.2% of total observed area, respectively.

Benthic epifauna communities in the Arctic are generally dominated by brittle stars, sea urchins, sea cucumbers, sea stars, bivalves, crabs, and other crustaceans. The most common taxa identified during benthic habitat surveys in Milne Inlet in 2008, 2010, and 2013 were unidentified clams, brittle stars, and sea urchins. Abundance, as the number of observations in each of four transects during 2014-2016 MEEMP studies, varied from 444 in the North Transect in 2015 to 6,328 in the Coastal Transect in 2016. Within each of the MEEMP transect, total abundance was highest in 2016, mostly due to the increase in abundance of brittle stars, most of which observed near the port site. Significant among-year differences in the relationship of epifauna abundance as a function of distance from the ore dock were found. However, the changes were not indicative of a Project-related effect, since some slopes indicated a decrease in abundance with an increasing distance from the dock.

In 2010, the highest density of benthic infauna was found at the 15-25 m depth stratum. Infauna was dominated by polychaete worms (Polychaeta); other common taxa in samples included crustacean copepods (Copepoda) and amphipods (Amphipoda) and clams. In the 2013 baseline study, the lowest abundance and richness of benthic infauna was found in the intertidal zone, with a single taxon (oligochaete worm [Oligochaeta]). The highest abundance was found at the 3-15 m stratum, whereas highest average richness was recorded at the 15-25 m depth stratum. Benthic infauna abundance generally decreased with depth between the three strata deeper than 3 m. In the 2015-2016 MEEMP surveys, abundance recorded at each depth stratum was considerably lower than in the 2013 baseline survey. The 2015 benthic infauna samples were dominated by bivalves, polychaete worms (Polychaeta), and ostracods (SEM 2016). The 2016 abundance values were overall similar to the 2015 data, although the pattern with depth was slightly different. Similar to the 2015 results, the 2016 benthic infauna samples were dominated by bivalves, polychaete worms, and ostracods (SEM 2017a). Taxa accumulation plot and calculated species richness estimator Chao 2 (expected number of species in an infinitive number of samples (Chao 1987) for pooled data for 2013, 2015 and 2016 (SEM 2017a), suggest that the three-year sampling effort was sufficient to capture the benthic infaunal biodiversity in Milne Inlet. Sampling of benthic infauna to date has not identified any non-native species (Macdonald, pers. comm.).

Zooplankton taxa richness in vertical tows increased with each sampling year. However, taxa accumulation plots of the pooled 2014-2016 data reached an asymptote, suggesting that the three-year sampling effort was sufficient to capture the biodiversity at Milne Inlet. Samples were dominated by copepods, followed by arrow worms and other appendicularians and mollusc larvae. Vertical tows in 2016 differed from previous years as the samples were largely dominated by echinoderm larvae than by copepods.

Fishing effort, the number of fish caught, and relative species composition of catches varied from year to year. Catch per unit effort at the Milne Port area increased with time from 0.3 fish/h in 2013 to 2.9 fish/h in 2016. The total number of fish caught in gill nets also increased from 8 to 163 in 2013 and 2016, respectively. Eleven identified fish species were captured during fish surveys in the Milne Port area from 2010 to 2016. Arctic char was the most common species in gillnet catches in 2013, 2015, and 2016, and sculpins accounted for the majority of the remainder of the catch. Throughout the 2014-2016 MEEMP surveys, none of the marked sculpin were recaptured; therefore, it was not possible to estimate a population size for the species (SEM 2017a).

Metals in Arctic char tissue samples from incidental mortalities were mostly below DL, except for arsenic, cadmium, chromium, copper, iron, mercury, and zinc. None of the samples exceeded Health Canada’s guideline for mercury in fish tissue for human consumption.

12.0 CLOSURE

We trust that the information contained in this report meets your present requirements. Please contact us if you have any questions or concerns regarding the above.

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APPENDIX A

Summary Statistics for Select Water Quality Variables

Table A-1: Summary statistics for select water quality parameters from baseline and effects monitoring programs in Milne Inlet

Parameter	Ice Season (May/June) 2008/2010								Open-water Season (Aug/Sep) 2008-2010								Aug 2015					Aug/Sep 2016				
	DL	Surface			Bottom			CCME	DL	Surface			Bottom			CCME	DL	Surface			CCME	DL	Surface			CCME
		Mean	Min	Max	Mean	Min	Max			Mean	Min	Max	Mean	Min	Max			Mean	Min	Max			Mean	Min	Max	
Standard																										
pH	-	7.97	7.96	7.98	7.81	7.80	7.83	-	-	7.82	7.33	7.98	7.84	7.72	7.98	-	-	7.83	7.52	7.91	7.0-8.7	-	7.85	7.67	7.94	7.0-8.7
Conductivity (µS/cm)	5	48,400	47,600	48,900	49,000	48,700	49,300	-	5	29,500	14,500	41,200	46,400	44,800	48,600	-	1	29,417	23,000	33,000	-	1	29,390	8,800	47,000	-
TSS (mg/L)	2 /100	5	3	7	3	<2	5	-	2 / 100	53	36	<100	52	44	<100	-	2.0	1.20	0.50	2.20	-	2.0	1.61	1.00	3.00	-
Turbidity (NTU)	0.1	0.3	0.3	0.4	0.1	0.1	0.2	-	0.1	0.4	0.3	0.6	0.3	0.1	0.9	-	0.10	0.23	0.05	0.92	-	0.10	0.43	0.10	0.99	-
TOC (mg/L)	0.5	0.6	0.5	0.6	<0.5	<0.5	0.7	-	0.5	0.3	<0.5	0.6	<0.5	<0.5	0.5	-	0.50	0.99	0.25	1.70	-	0.50	0.71	0.55	0.92	-
Nutrients																										
Ammonia (mg/L)	0.02	0.16	0.11	0.18	0.19	0.15	0.31	-	0.02	<0.02	<0.02	0.05	0.18	0.13	0.46	-	0.050	0.39	0.17	0.87	-	0.050	0.15	0.06	0.23	-
Nitrate (mg/L)	0.10 /1.00 /2.00	<0.1	<0.1	<0.1	0.13	0.12	0.15	-	0.10 /1.00 /2.00	<2.0	<0.1	<2.0	<2.0	<0.1	<2.0	-	0.050	0.04	0.03	0.16	-	0.050	0.16	0.05	0.58	-
Nitrite (mg/L)	0.005 /0.10	<0.1	<0.1	<0.1	<0.1	<1.0	<0.1	-	0.005 /0.10	<0.005	<0.005	0.005	<0.005	<0.005	0.007	-	0.010	ND	ND	ND	-	0.010	<0.010	<0.010	<0.010	-
Nitrate + Nitrite (mg/L)	0.10 /1.00 /2.00	<0.1	<0.1	<0.1	0.13	0.12	0.15	-	0.10 /1.00 /2.00	<2.0	<0.1	<2.0	<2.0	<0.1	<2.0	-	0.050	0.04	0.03	0.16	-	0.050	0.34	0.05	0.58	-
TKN (mg/L)	0.50 /1.0 /2.0	0.73	<0.50	1.35	0.577	0.250	1.100	-	0.50 /1.0 /2.0	<1.0	<1.0	3.0	<2.0	<2.0	4.0	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	-	0.78	0.30	1.40	0.71	0.37	1.22	-	-	1.64	0.55	3.10	2.12	1.50	4.05	-	-	-	-	-	-	-	-	-	-	-
Metals (mg/L)																										

Parameter	Ice Season (May/June) 2008/2010								Open-water Season (Aug/Sep) 2008-2010								Aug 2015					Aug/Sep 2016				
	DL	Surface			Bottom			CCME	DL	Surface			Bottom			CCME	DL	Surface			CCME	DL	Surface			CCME
		Mean	Min	Max	Mean	Min	Max			Mean	Min	Max	Mean	Min	Max			Mean	Min	Max			Mean	Min	Max	
Aluminum Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.050	-	-	0.050	-	0.005 /0.050	0.016	0.009	0.025	-
Barium Dissolved	-	-	-	-	-	-	-	-	0.0025 /0.005 /0.01	0.007	0.005	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium Total	-	-	-	-	-	-	-	-	0.00005 0.005 /0.01	0.008	<0.01	0.009	-	-	-	-	0.01	<0.01	<0.01	<0.01	-	0.001 /0.010	0.0058	0.0052	0.0067	-
Boron Dissolved	-	-	-	-	-	-	-	-	0.5 /1.0	2.3	1.1	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron Total	-	-	-	-	-	-	-	-	0.01 /1.0	2.4	1.2	3.2	-	-	-	-	0.50	2.45	2.0	7.90	-	0.05 /0.50	2.501	0.660	4.400	-
Cadmium Total	-	-	-	-	-	-	-	-	0.00001 /0.001 /0.002	<0.001	<0.0005	<0.002	-	-	-	0.0001	0.00001	<0.00001	<0.00001	<0.00001	0.00012	0.00001 /0.00010	0.000016	0.000013	0.000018	0.00012
Chromium total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.010	<0.010	<0.010	<0.010	0.056, 0.0015	0.001 /0.010	<0.001 /<0.010	<0.001 /<0.010	<0.001 /<0.010	0.056, 0.0015
Iron Total	-	-	-	-	-	-	-	-	0.03 /0.3 /0.6	<0.3	<0.2	<0.6	-	-	-	-	0.50	<0.50	<0.50	<0.50	-	0.05 /0.50	<0.05/ <0.50	<0.05/ <0.50	<0.05/ <0.50	-
Mercury Total	-	-	-	-	-	-	-	-	0.00001	<0.00001	<0.00001	<0.00001	-	-	-	0.000016	0.000013	0.00001	0.00001	0.00003	0.000016	0.000013	<0.000013	<0.000013	<0.000013	0.000016
Molybdenum Dissolved	-	-	-	-	-	-	-	-	0.0025 /0.005 /0.01	0.008	<0.005	0.031	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenum Total	-	-	-	-	-	-	-	-	0.00005 /0.005 /0.010	0.006	<0.005	0.011	-	-	-	-	0.020	<0.020	<0.020	<0.020	-	0.002 /0.020	0.0029	0.0021	0.0036	-
Strontium Dissolved	-	-	-	-	-	-	-	-	0.005 /0.01	3.94	1.86	5.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium Total	-	-	-	-	-	-	-	-	0.0001 /0.01	4.15	1.87	5.24	-	-	-	-	0.020	4.07	3.10	4.60	-	0.002/ 0.020	4.155	1.20	7.00	

Parameter	Ice Season (May/June) 2008/2010								Open-water Season (Aug/Sep) 2008-2010								Aug 2015					Aug/Sep 2016				
	DL	Surface			Bottom			CCME	DL	Surface			Bottom			CCME	DL	Surface			CCME	DL	Surface			CCME
		Mean	Min	Max	Mean	Min	Max			Mean	Min	Max	Mean	Min	Max			Mean	Min	Max			Mean	Min	Max	
Uranium Dissolved	-	-	-	-	-	-	-	-	0.0005 /0.001	0.002	0.002	0.003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium Total	-	-	-	-	-	-	-	-	0.00001 /0.001	0.002	0.002	0.003	-	-	-	-	0.001	0.00213	0.00200	0.00230	-	0.0001/ 0.0010	0.0023	0.0014	0.0032	-
Zinc Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.050	<0.050	0.050	0.050	-	0.005/ 0.050	0.015	0.005	0.025	-

APPENDIX B

Macroflora Percent Cover

Table B-1: Macrofloral Relative Percent Cover at West, East, North, and Coastal Transects (WT, ET, NT, and CT, Respectively), 2014-2016

Taxon	Common name	Macroflora group	Transect	Percent Cover (%)		
				2014	2015	2016
Agarum cribrosum	Sea colander	Brown Algae	West Transect	32.2	12.8	9
Desmarestia sp.	Sour weed	Brown Algae		53.4	46.2	66.1
Laminaria sp.	Brown bladed kelp	Brown Algae		6.8	2.9	2.2
Fucus sp.	Rockweed	Brown Algae		7.7	-	0.04
Chondrus crispus	Red Irish moss	Red Algae		-	37.9	21
Chlorophyta	-	Green Algae		-	0.1	-
-	Seagrass	Seagrass		-	-	1.6
Agarum cribrosum	Sea colander	Brown Algae	East Transect	37.9	16	15.1
Desmarestia sp.	Sour weed	Brown Algae		61.3	62.7	77.5
Laminaria sp.	Brown bladed kelp	Brown Algae		0.7	11.8	0.8
Fucus sp.	Rockweed	Brown Algae		-	-	0.1
Chondrus crispus	Red Irish moss	Red Algae			9.6	6.6
Chlorophyta	-	Green Algae		-	-	-
-	Seagrass	Seagrass		-	-	-
Agarum cribrosum	Sea colander	Brown Algae	North Transect		-	-
Desmarestia sp.	Sour weed	Brown Algae			-	-
Laminaria sp.	Brown bladed kelp	Brown Algae			-	-
Fucus sp.	Rockweed	Brown Algae			-	11.8
Chondrus crispus	Red Irish moss	Red Algae			100	88.2
Chlorophyta	-	Green Algae			-	-
-	Seagrass	Seagrass			-	-
Agarum cribrosum	Sea colander	Brown Algae		45.6	26.1	19.7

Taxon	Common name	Macroflora group	Transect	Percent Cover (%)		
				2014	2015	2016
Desmarestia sp.	Sour weed	Brown Algae	Coastal Transect	53.5	47.9	76.5
Laminaria sp.	Brown bladed kelp	Brown Algae		0.9	9.5	3.5
Fucus sp.	Rockweed	Brown Algae		-	-	-
Chondrus crispus	Red Irish moss	Red Algae		-	16.5	0.2
Chlorophyta	-	Green Algae		-	-	-
-	Seagrass	Seagrass		-	-	-

APPENDIX C

Benthic Epifauna Abundance, 2014-2016

Table C-1: Benthic Epifauna Abundance, 2014-2016

Taxa	Common Name	West Transect			East Transect			Coastal Transect			North Transect	
		2014	2015	2016	2014	2015	2016	2014	2015	2016	2015	2016
Actiniaria	Sea Anemone	3	6	3	2	30	16	1		3	4	23
Ctenophora	Ctenophore	51	86	31	12	21	17	11	23	50	4	57
Cnidaria	Undetermined Cnidarian		4		1		3	1	8	55	2	7
Scyphozoa	Jelly fish							2	1		1	
Hydrozoa	Hydromedusae							8	3			
Asteroidea	Sea star	21	52		30	86	15	10	47	4	29	39
Crossaster papposus	Sun Star	4	2	15	2	27		2	1	2	3	17
Ctenodiscus crispatus	Mud star	9	11		22	30		4	2		8	12
Ophiuridea	Brittle star	799	1,070	1,937	1,878	1,298	3,141	2,995	1,349	5,028	230	4,602
Gorgonocephalus	Basket star							1	2			
Echinoida sp	Sea urchin		1,138	1,190		674	1,783		984	1,071	153	179
Strongylocentrotus droebachiensis	Green sea urchin	534			2,113			430				
Clypeasteroida	Sand dollar	148	54	19	21	42	2		1	3	1	
Echinocardium cordatum	Sea potato					24						1
Bivalvia	Clam		22				26		40	3		
Buccinum undatum	Common whelk			4		290	1			1		11
Placopecten magellanicus	Sea scallop	6	185	400	2	77	198	1	43	95	2	1
Limacina helicina	Sea butterfly		40	149		8	32		8	7		2
Bourgueticrinina	Sea lily	353		2	82		4				3	17
Pteropoda	Unknown pteropod	4							10			
Cephalopod	Cephalopod								1			
Pandalus sp	Red shrimp		6	1	1	3		2	18		1	1
Brachyura	Crab										1	

Taxa	Common Name	West Transect			East Transect			Coastal Transect			North Transect	
		2014	2015	2016	2014	2015	2016	2014	2015	2016	2015	2016
Cladocera	Water flea			23								
Polychaeta	Polychaete worm										1	
Sabellidae	Feather duster worm									1		318
Annelidae	Unidentified worm			76								
Tunicata	Sea squirt			24								
Myoxocephalus sp.	Sculpin		2	2		3	8		2	4	1	2
Zoarcidae	Eelpout											7
	Plankton					13			29			
N taxa		11	14	15	12	14	13	13	18	14	16	17
Total		1,932	2,678	3,876	4,168	2,626	5,264	3,468	2,572	6,328	444	5,294

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