A Review of the Planned Shipping Activity for the Baffinland Mary River Project: Assessing the Hazards to Marine Mammals and Migratory Birds, and Identifying Gaps in Proposed Mitigation Measures

By

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This work is dedicated to all my friends and family who helped me along the way, but especially to my parents who have always supported and encouraged me in all my endeavours. Thank you for all your love and support.

TABLE OF CONTENTS

List of Tables ix

List of Figures xi

Abstract xiv

List of Abbreviations xv

Acknowledgements xviii

1.0 Introduction 1

1.1 Global Perspectives 1

1.1.1 Resource Exploitation and Marine Environmental Degradation 1

1.1.2 Climate Change, Arctic Warming, and Melting Sea Ice 1

1.1.3 Implications for the International Shipping Industry 3

1.1.4 Vulnerable Arctic Marine Environment 3

1.2 The Particular Issue 5

1.2.1 The Mary River Project 5

1.2.2 Project Highlights 5

1.3 Objectives 8

2.0 Methodology 9

2.1 Literature Review 9

2.2 Species Selection 9

2.3 Risk Analysis 10

2.4 Risk Management 12

3.0 Arctic Mineral Exploration and Extraction 14

3.1 The Link Between Arctic Mining and Shipping 14

3.1.1 Reliance on Marine Transportation 14

3.1.2 Bulk Transport 14

3.2 Mining Within The Arctic States: The United States (US), Russia, Norway, and Greenland (Denmark) 15

3.3 Mining Within The Canadian Arctic 15

3.1.1 The Canadian Mining Industry 15

3.3.2 Past and Present Projects in the Canadian North 16

3.3.3 Opportunities for Nunavut 18

4.0 The Mary River Project 19
4.1 Background 19
4.1.1 Ownership 19
4.1.2 Current Status 20
4.2 Project Overview 21
4.3 Proposed Shipping Activity 22
4.3.1 Steensby Port 22
4.3.2 Icebreaking Ore-Carriers 23
4.3.3 Shipping Routes 24
5.0 Potential Shipping Hazards To Wildlife 31
5.1 Consequences of Increased Ship Traffic 31
5.2 Potential Threats 31
5.2.1 Direct Threats 31
5.2.1 Indirect Threats and Other Exclusions 32
5.3 Pollution 33
5.4 Disturbance 34
5.4.1 Vessel Strikes 34
5.4.2 Noise Disturbance 34
5.4.3 Icebreakers and Habitat Disturbance 35
5.4.4 Light Disturbance 36
6.0 Key Habitat Sites 38
6.1 Marine Eco-regions and Key Areas 38
6.1.1 Arctic Marine Eco-regions 38
6.1.2 Foxe Basin 41
6.1.3 Hudson Strait 43
6.2 Important or Vulnerable Arctic Marine Areas 44
6.2.1 Ecologically and Biologically Significant Areas (EBSAs) 44
6.2.2 Nunavut Land Use Plan (NLUP) 46
7.0 Key Marine Species 48
7.1 Foxe Basin and Hudson Strait: Areas of High Biological Importance (AHBIs) for Numerous Species 48
7.2 Year-Round Residents Vs. Occasional Residents 49
7.3 Bowhead Whale 51

7.3.1 Life history ... *51*

7.3.2 Population status ... *52*

7.3.3 Distribution ... *52*

7.3.4 Reasons for Selection ... *53*

7.4 Atlantic Walrus ... 54

7.4.1 Life history ... *54*

7.4.2 Population Status ... *55*

7.4.3 Distribution ... *56*

7.4.4 Reasons for Selection ... *58*

7.5 Common Eider ... 59

7.5.1 Distinguishing Characteristics ... *59*

7.5.2 Population status ... *60*

7.5.3 Distribution ... *61*

7.5.4 Reasons for Selection ... *63*

7.6 Thick-Billed Murre ... 64

7.6.1 Distinguishing Characteristics ... *64*

7.6.2 Population status ... *65*

7.6.3 Distribution ... *66*

7.6.4 Reasons for Selection ... *69*

8.0 Risk Analysis ... 71

8.1 Bowhead Whale ... 71

8.1.1 Vessel Strikes ... *71*

8.1.2 Noise Disturbance ... *75*

8.1.3 Pollution ... *78*

8.2 Atlantic Walrus ... 80

8.2.1 Noise Disturbance ... *80*

8.2.2 Pollution ... *83*

8.2.3 Icebreakers and Habitat Disturbance ... *86*

8.3 Common Eider ... 88

8.3.1 Noise Disturbance ... *88*

8.3.2 Pollution ... *92*

8.3.4 Light Disturbance ... *95*

8.4 Thick-Billed Murre ... 97

8.4.3 Noise Disturbance *97*
8.4.1 Pollution *100*
8.4.5 Light Disturbance *103*
8.5 Conclusions 105
9.0 Risk Management 106
9.1 Possible Mitigation Strategies 106
9.1.1 Vessel Speed Restrictions *115*
9.1.2 Increased Infrastructure for Arctic Spill Response *116*
9.1.3 VMS, AIS, and LRIT *119*
9.2 Implementation Through Legislation, Regulations, and Policy 120
9.2.1 International, Federal, and Territorial Powers *120*
9.2.2 Potential Conflicts *124*
9.3 Final Recommendations and Considerations for Future Projects 125
10.0 Conclusions 127
11.0 Literature Cited 129

LIST OF TABLES

Table 2.1 Risk Index used to assess the risk of a potential threat to a species, based on the likelihood and consequence of an interaction.............11

Table 5.1 Environmental threats to marine mammals and migratory birds from the proposed shipping activity for the Mary River Project.............32

Table 6.1 List of EBSAs and the CBD criteria met.............46

Table 7.1 Species and species groups found within the AHBIs in the Canadian Arctic.............48

Table 7.2 Marine mammal species found in the Arctic.............50

Table 8.1 Pertinent threats to species selected for risk analysis.............71

Table 8.2 Frequency and Severity Indexes of the Risk for Bowhead Whale Mortality from a Ship Strike.............75

Table 8.3 Frequency and Severity Indexes of the Risk for Bowhead Whale Disturbance from Noise.............77

Table 8.4 Frequency and Severity Indexes of the Risk for Bowhead Whale Disturbance from Oil Pollution.............79

Table 8.5 Frequency and Severity Indexes of the Risk for the Disturbance of Walrus from Noise.............83

Table 8.6 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Walrus.............85

Table 8.7 Frequency and Severity Indexes of the Risk of Habitat Disturbance from Icebreaking impacting Walrus.............87

Table 8.8 Frequency and Severity Indexes for the Risk of Noise Disturbance to Common Eiders.............92

Table 8.9 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Common Eiders.............94

Table 8.10 Frequency and Severity Indexes of the Risk of Light Disturbance for Common Eiders.............96

Table 8.11 Frequency and Severity Indexes for the Risk of Noise Disturbance to Thick-billed Murres.............100

Table 8.12 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Thick-billed Murres……………………………………………………………..………………………..102

Table 8.13 Frequency and Severity Indexes of the Risk of Light Disturbance for Thick-billed Murres…………………………………………………………………………..…………………104

Table 9.1 Potential measures for mitigating environmental impacts from shipping activity, their implementation for the Mary River Project, and further recommendations..107

Table 9.2 Key Actors, Legislation, and Policy in Marine Management in Nunavut..............122

List of Figures

Figure 1.1 Map of the Baffinland Mary River Project..........7

Figure 2.1 Risk matrix used to determine the level of risk for an interaction, based on the likelihood and consequence of a disturbance occurring..........12

Figure 4.1 Map of nominal shipping route through Foxe Basin and Hudson Strait..........25

Figure 4.2 Map of the shipping route options for the Baffinland Mary River Project..........27

Figure 4.3 Map of the extent of landfast ice in Steensby Inlet..........30

Figure 6.1 Map of North America's 24 Marine Eco-regions..........39

Figure 6.2 Map of the Hudson-Boothian Arctic Marine Eco-region..........39

Figure 6.3 Map of the Baffin-Labradoran Arctic Marine Eco-region..........40

Figure 6.4 Map of the areas in the Canadian Arctic with high biological importance..........41

Figure 6.5 Map of the re-occurring polynyas and shore leads in Foxe Basin..........43

Figure 6.6 Map of the EBSAs in the northwest Atlantic marine Arctic area..........45

Figure 6.7 Map of the Key Habitat Sites identified by EC and proposed zoning for the NLUP..........47

Figure 7.1 Species overlap within the AHBIs in the Canadian Arctic..........49

Figure 7.2 Important areas and key habitat sites for seabirds and migratory birds in the Canadian Arctic..........50

Figure 7.3 Physical characteristics of the Bowhead Whale..........51

Figure 7.4 Distribution of the four recognized Bowhead Whale stocks..........53

Figure 7.5 Physical characteristics of the Atlantic Walrus..........55

Figure 7.6 Distribution of the Atlantic Walrus within Canadian Arctic waters..........57

Figure 7.7 Summer and winter distributions of the four Atlantic Walrus populations within the Canadian Arctic..........57

Figure 7.8 Physical characteristics of the Common Eider..........60

Figure 7.9 Distribution of the Common Eider in North America..........61

Figure 7.10 Map of Markham Bay Map where there are approximately 44 500 individual Common Eiders....62

Figure 7.11 Map of the Ungava Bay Archipelago where there are approximately 17 900 breeding Common Eider pairs....63

Figure 7.12 Physical characteristics of the Thick-billed Murre....65

Figure 7.13 North American distribution of the Thick-billed Murre....66

Figure 7.14 Major breeding colonies of Thick-billed Murres in the Canadian Arctic....67

Figure 7.15 Map of Digges Sound where there are two colonies of Thick-billed Murres....68

Figure 7.16 Map of Frobisher Bay where there is a colony of Thick-billed Murres that breed on Hantzsch Island....68

Figure 7.17 Map of Akpatok Island, located in Ungava Bay, where there are two large colonies of Thick-billed Murres....69

Figure 8.1 NOAA operational guidelines for ships in sight of whales....72

Figure 8.2 Seasonal distribution of Eastern Canada-West Greenland Bowhead Whale population....73

Figure 8.3 Matrix demonstrating the risk of Bowhead Whale mortality occurring due to a vessel strike....75

Figure 8.4 Matrix demonstrating the risk of Bowhead Whales being impacted by noise pollution from shipping....77

Figure 8.5 Matrix demonstrating the risk of Bowhead Whales being impacted by oil pollution from shipping....80

Figure 8.6 Matrix demonstrating the risk of Walrus being impacted by noise pollution from shipping....83

Figure 8.7 Matrix demonstrating the risk of Walrus being impacted by oil pollution from shipping....85

Figure 8.8 Matrix demonstrating the risk of Walrus being impacted by habitat disturbance due to icebreaking....88

Figure 8.9 Solved equation demonstrating how noise level produced by icebreaker of 140 dB drops to 60 dB at a distance of 10 km....90

Figure 8.10 Matrix demonstrating the risk of Common Eiders being impacted by noise pollution from shipping……………………………………………………………...92

Figure 8.11 Matrix demonstrating the risk of Common Eiders being impacted by oil pollution from shipping……………………………………………………………………94

Figure 8.12 Matrix demonstrating the risk of Common Eiders being impacted by light disturbance from shipping……………………………………………………………97

Figure 8.13 Matrix demonstrating the risk of Thick-billed Murres being impacted by noise pollution from shipping………………………………………………………100

Figure 8.14 Matrix demonstrating the risk of Thick-billed Murres being impacted by oil pollution from shipping…………………………………………………………102

Figure 8.15 Matrix demonstrating the risk of Thick-billed Murres being impacted by light disturbance from shipping…………………..………………………………..104

Figure 9.1 Response countermeasures often taken in the case of a spill, based on circumstances such as the current season, sea state, and the location of the oil...................118

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ABSTRACT

Exploration for minerals, oil, and natural gas, as well as their exploitation and transportation, is heavily reliant on marine transportation. Global demand for these natural resources, as well as a rise in Arctic warming and a loss of ice-cover, has led to increased interest in the economic potential of the region. As a result, stronger ice-resistant vessels are being constructed to meet the growing commercial demand, designed to endure the hazards posed by the harsh northern operating conditions. However, the Arctic marine environment remains exceptionally vulnerable to disturbance from shipping activity. This project identifies and assesses potential threats to marine mammals and migratory birds from the proposed shipping activities of the Baffinland Mary River Project, specifically threats to the Bowhead Whale, Atlantic Walrus, Common Eider, and Thick-billed Murre. Specifically, this project assesses hazards including oil pollution, disturbance from vessel strikes, noise, light, and disturbance to habitat due to icebreaking. While it was determined that the possibility of an oil spill occurring along the shipping route represents the greatest risk to wildlife with respect to consequence, it is less likely that such an incident will occur compared to the other threats considered. Furthermore, while the immediate consequences of these other threats are not as high, the cumulative impacts of these hazards are a major concern. As such, several methods for minimizing the risks to marine mammals and migratory birds are proposed. The intent is to establish a benchmark for minimizing environmental risks from future development in the Canadian Arctic. Therefore, it is critical that legislation, policy, and enforcement be incorporated into risk management strategies, in order to minimize immediate acute disturbances as well as the cumulative impacts caused by shipping activity over the life of a project.

Keywords: Arctic; mining; risk management; disturbance; Foxe Basin; Hudson Strait; Nunavut; Bowhead Whale; Atlantic Walrus; Common Eider; Thick-billed Murre.

List of Abbreviations

AANDC	Aboriginal Affairs and Northern Development Canada
AHBI	Area of High Biological Importance
AIS	Automatic Information System
AMSA	Arctic Marine Shipping Assessment
APM	Associated Protective Measure
ASPPR	Arctic Shipping Pollution Prevention Regulations
ATBA	Area To Be Avoided
AWPPA	Arctic Waters Pollution Prevention Act
CBD	Convention on Biological Diversity
CCG	Canadian Coast Guard
CEAA	Canadian Environmental Assessment Act
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSA	Canada Shipping Act
CTA	Canadian Transportation Agency
CWA	Canada Wildlife Act
CWS	Canadian Wildlife Service
DEIS	Draft Environmental Impact Statement
DFO	Fisheries and Oceans Canada
DWT	Dead Weight Tonne
EBM	Ecosystem Based Management
EBSA	Ecologically and Biologically Significant Area
EC	Environment Canada
EIS	Environmental Impact Statement
EMS	Environmental Management System
ERP	Emergency and Spill Response Plan

GN	Government of Nunavut
HC	Health Canada
HTO	Hunters and Trappers Organization
IACS	International Association of Classification Societies
ICOM	Integrated Coastal and Ocean Management
IIBA	Inuit Impact and Benefit Agreement
IMO	International Maritime Organization
INAC	Indian and Northern Affairs Canada
IPG	Institution of Public Government
IR	Information Request
ISM	International Safety Management
IWC	International Whaling Commission
LOMA	Large Ocean Management Area
LRIT	Long Range Information and Tracking Systems
LSA	Local Study Area
MARPOL	International Convention for the Protection of Pollution from Ships
MBCA	Migratory Bird Convention Act
MCTS	Marine Communications and Traffic Services
MPA	Marine Protected Area
MSP	Marine Spatial Planning
Mt/a	Million Tonnes per Annum
MWA	Marine Wildlife Area
NIRB	Nunavut Impact Review Board
NLCA	Nunavut Land Claims Agreement
NLUP	Nunavut Land Use Plan
NMC	Nunavut Marine Council
NOAA	National Oceanic and Atmospheric Administration
NORDREG	Northern Canada Vessel Traffic Services
NPC	Nunavut Planning Commission

NRCan	Natural Resources Canada
NSA	Nunavut Settlement Area
NTI	Nunavut Tunngavik Inc.
NWA	National Wildlife Area
NWB	Nunavut Water Board
NWMB	Nunavut Wildlife Management Board
NWP	Northwest Passage
PC	Parks Canada
PSSA	Particularly Sensitive Sea Area
RIA	Regional Inuit Association
RSA	Regional Study Area
S-AIS	Satellite Automatic Information System
SARA	Species At Risk Act
SOLAS	International Convention on the Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
TC	Transport Canada
UN	United Nations
US	United States
VMS	Vessel Monitoring Systems

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1.0 INTRODUCTION

1.1 GLOBAL PERSPECTIVES

1.1.1 RESOURCE EXPLOITATION AND MARINE ENVIRONMENTAL DEGRADATION

In recent decades, the global marine environment has been particularly impacted by anthropogenic stressors, although natural occurrences and processes also play a key role in environmental change. While humans have relied on marine ecosystems for centuries, it is the recent increase in the number of activities occurring, along with their level of intensity, that is causing such significant impacts on the state of the world's oceans. As the global population continues to rise along with the demand for natural resources such as oil, natural gas and various hard minerals, nations around the world are showing increased interest in exploring areas previously undisturbed (AMSA, 2009, p.8). It is critical that these opportunities are pursued with the utmost caution, as increased development has often led to the overexploitation of resources, pollution, and the overall degradation of global biodiversity and critical habitat.

1.1.2 CLIMATE CHANGE, ARCTIC WARMING, AND MELTING SEA ICE

Despite the fact that global climate change has occurred over time due to natural processes, recent trends demonstrate that anthropogenic influences are significantly impacting global warming (Corell, 2006). Carbon dioxide, methane, and nitrous oxide emissions released into the atmosphere from the burning of fossil fuels are major contributors to the Greenhouse Effect; a process which causes the warming of the earth's surface and is leading to major climatic shifts. These include changes in temperature, in the severity of precipitation events, and in ocean circulation. In addition, ocean acidification, the melting of Arctic sea ice and the thermal expansion of ocean waters leading to sea level rise are likely to increase (Nellemann et al., 2009).

Due to the ice-albedo feedback loop, climate change will have a more prominent impact on the poles. In the Arctic, this feedback loop occurs because solar rays hit at a sharper angle during the summer while sea ice is melting to become open water, which then absorbs more radiation (Borgerson, 2008). Therefore, maximum ice extent always occurs at the end of winter in March, and minimum ice extent occurs at the end of summer in September (Perovich et al., 2010). The extent of Arctic sea ice, as well as its average age, are important indicators of global warming and both have decreased in recent decades (Molenaar, 2009). For the purpose of this graduate project, all land and sea located above 60°N latitude is considered to be within the Arctic region.

According to satellite records for the Arctic Ocean dating back to 1979, annual ice extent has decreased by approximately 2.7% per decade, with a decrease in summer ice coverage by approximately 7.4% per decade (Alter et al., 2010). In addition, the years 2007 to 2010 have shown the lowest minimum ice extents in satellite record (Perovich et al., 2010). The amount of multi-year ice, which is thicker and more resilient, has diminished significantly since 1980 when ice age was first recorded, reaching a record low in March 2008. It increased slightly in 2009 and 2010, however the amount in 2010 remains the third lowest ever recorded (Peruvich et al., 2010). Diminished ice extent, age, and thickness over the past several decades have also driven air temperatures in the Arctic to rise at more than double the rate of anywhere else in the world (Williams, 2009; Corell, 2006). Furthermore, "additional Arctic warming of about 4-7°C over the next 100 [years]" is expected to occur due to the burning of fossil fuels (Corell, 2006, p.149).

1.1.3 IMPLICATIONS FOR THE INTERNATIONAL SHIPPING INDUSTRY

The exploration for natural resources, as well as their exploitation and transportation, is heavily reliant on the international shipping industry. Approximately 90% of global trade is seaborne and without maritime transportation the current level of intercontinental trade could not be maintained (Marisec, n.d.). An increase in Arctic warming and a loss in ice-cover have the potential to dramatically alter shipping access within the Arctic region. The potential opening of the Northwest Passage (NWP), located within the Canadian Arctic Archipelago, and the Northern Sea Route, located over Eurasia, would increase shipping opportunities in the Arctic substantially (Borgerson, 2008). Reduced ice cover will result in easier access for resource exploration, tourism, fishing, scientific research, and military operations (Warner, 2009).

The international shipping industry is considered to be the safest and least environmentally damaging form of commercial transportation, yet there are still potential threats to the safety of ships, seafarers and to the marine environment, especially in the Arctic. Although the industry has implemented various safety standards, is regulated by various United Nations (UN) agencies (Marisec, n.d.), and many advancements in maritime technology and ship design have already been made or are currently underway (Borgerson, 2008), the Arctic remains a particularly hazardous environment for shipping activity.

1.1.4 VULNERABLE ARCTIC MARINE ENVIRONMENT

The harsh Arctic environment is characterized by its extremely cold temperatures, ice, and strong seasonal variability. However, this environment that can be exceptionally hazardous to maritime activity is also particularly vulnerable. The short (few trophic levels) and sensitive Arctic food chain is entirely dependent on seasonal phytoplankton and algae blooms that form under the ice and ice edges of Arctic waters. Furthermore, this sea ice algae makes up 4 to 26% of total primary production in seasonally ice-covered waters (Legendre et al., 1992, as cited in Gradinger, 2009). Arctic wildlife have developed various adaptations, such as the ability to store energy for prolonged periods when food is scarce, fur, feathers, and blubber that provide insulation, and a high degree of seasonal migrations, in order to cope with the harsh environment (AMSA, 2009, p.134).

The seasonal migrations of marine mammals and birds also determine the sensitivity of Arctic ecosystems. Seabirds, shorebirds, and waterfowl travel north to breed and feed during the open-water season, while marine mammals have similar northern migrations to feeding areas (AMSA, 2009, p.134). Furthermore, many Arctic species aggregate in large groups for feeding, mating, giving birth, and moulting, making them particularly vulnerable during these periods (AMSA, 2009, p.134). Potential threats to these species and their environment from increased shipping include vessel strikes, noise and habitat disturbance, air pollution, marine pollution from either accidental spills or operational discharge, and the introduction of invasive species through ballast water exchange (AMSA, 2009, p.134).

As the Arctic is considered to be “a storehouse of untapped natural resources” marine transportation to support the exploration and extraction of resources such as oil, gas, and hard minerals is expected to continue expanding into the future (AMSA, 2009, p.8). Therefore, it is critical that the risks to the Arctic marine environment from increased maritime activity be assessed carefully so that precautionary measures can be taken to protect ecologically or biologically significant areas and species.

1.2 THE PARTICULAR ISSUE

1.2.1 THE MARY RIVER PROJECT

In the past, the high cost of operating in the Arctic and low prices for minerals prevented many deposits from being developed. However, the growing demand for minerals and recent rise in their prices is improving the financial viability of these projects (Waldie, 2011). In addition, increasing temperatures and melting sea ice due to global warming add to the feasibility of Arctic mining opportunities. An area of particular interest is Mary River, located on the northern end of Baffin Island, approximately 1000 km northwest of Iqaluit, Nunavut's capital city. This area is rich in high grade iron ore, and plans for its development are already underway. According to the Globe and Mail's Paul Waldie (2011), "it is easily among the most ambitious mining ventures ever undertaken in the Arctic."

1.2.2 PROJECT HIGHLIGHTS

The project will involve the mining of high grade iron ore from a 2 km wide open pit mine, at a production rate of approximately 18 Mt annually (Waldie, 2011). A railway spanning 149 km will transport the iron ore to a deep-water port at Steensby Inlet (Figure 1.1), where custom built ice-breaking ore carriers, larger than any vessel currently operating in the eastern Arctic, will ship the ore to Rotterdam and other European ports (Waldie, 2011). While mining in Nunavut is not a new concept, it has never before been attempted on this scale and the environmental consequences could be severe (Waldie, 2011). Year-round shipping through Foxe Basin and the Hudson Strait could potentially disturb many marine mammal and bird species that rely on habitat along the proposed shipping route. Furthermore, it is critical that a risk assessment be conducted to determine the likelihood and potential consequences of these species being negatively affected by shipping activity associated with the Mary River Project. These risks must be managed effectively and measures must be taken to mitigate impacts.

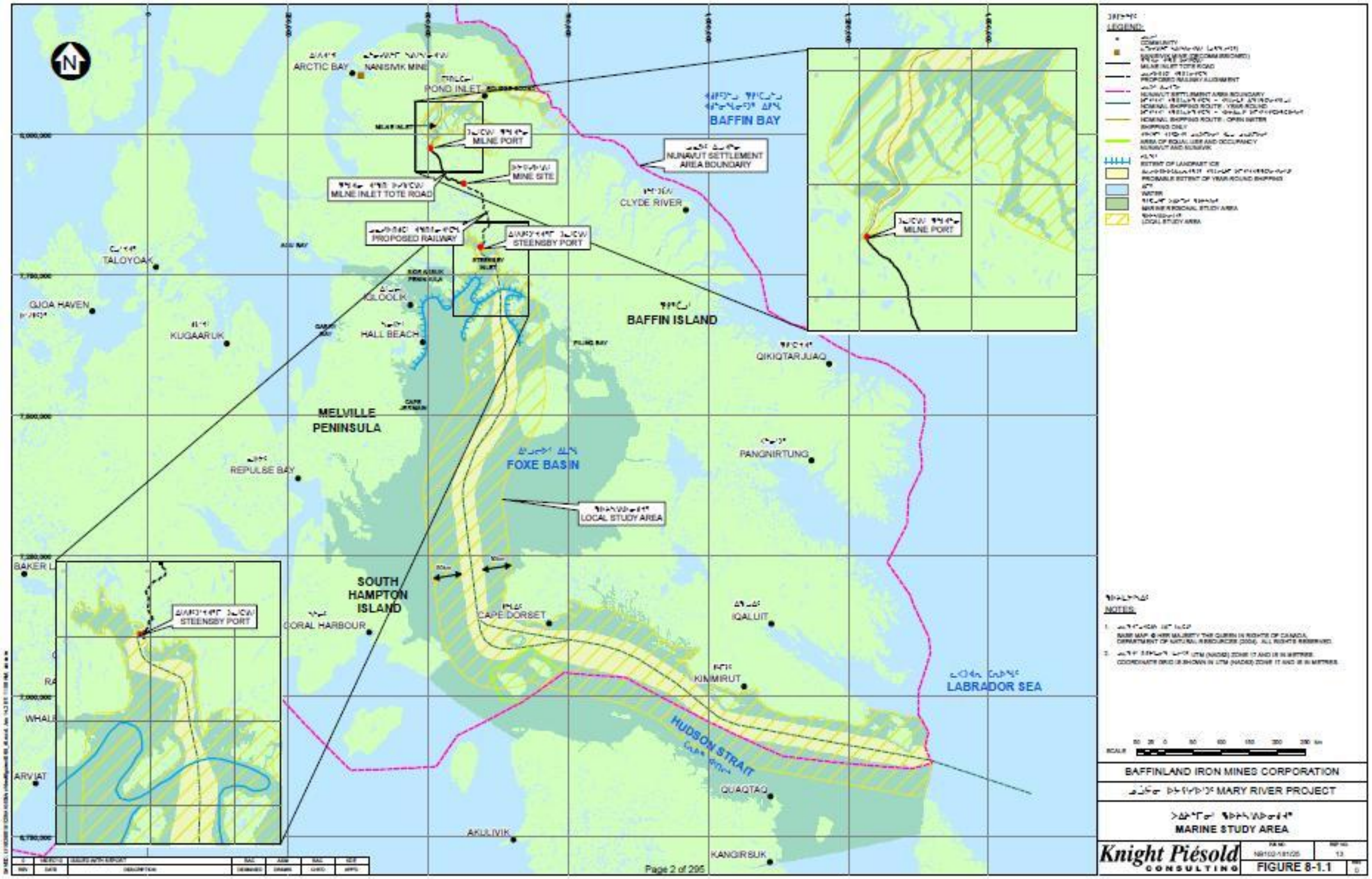

Figure 1.1 Map of the Baffinland Mary River Project (Baffinland, 2010, Vol.8, p.2).

1.3 OBJECTIVES

The purpose of this graduate project will be to identify the potential risks to marine mammals and migratory birds from the proposed shipping activities of the Mary River Project; to determine whether the Environmental Impact Statement (EIS), prepared by Baffinland Iron Mines Corporation in accordance with Knight Piésold Consulting, addresses these risks and proposes suitable methods for their management and mitigation; and to determine how the proposed shipping activities can be adapted, if necessary, to better protect marine mammals and migratory birds, as well as their habitat. Furthermore, this report incorporates some of the relevant legislation, regulations and policies which are in place for the protection of wildlife and habitat in Nunavut, and across Canada. Examining the science-policy interface in Canada, with respect to effectively mitigating risk, will give key insights into what changes must be made to ensure sustainable resource and environmental management.

2.0 METHODOLOGY

2.1 LITERATURE REVIEW

This graduate project is designed to incorporate a detailed literature review of the vulnerability of the Arctic marine environment, the current state of shipping activity within the Canadian Arctic, as well as past and present mining projects operating within the Arctic region. Furthermore an overview of the Baffinland Iron Mines Corporation Mary River Project is given, providing information on the project description and what it will entail, the Nunavut Impact Review Board (NIRB) and review process that is currently underway for the project, and the hazards that year-round shipping will pose to key species and habitat within Foxe Basin and Hudson Strait. The majority of information pertaining to the project itself was obtained from the NIRB and the Baffinland Draft Environmental Impact Statement (DEIS) for the project, as the review process is entirely public. The shipping hazards assessed in this study were identified from several sources including the 2009 Arctic Marine Shipping Assessment (AMSA) Report, and scientific literature.

2.2 SPECIES SELECTION

While year-round shipping activity associated with the Mary River Project could potentially impact numerous species occupying Foxe Basin and Hudson Strait, time constraints required that a limited number of species be chosen for the risk analysis. Furthermore, the four species selected, the Bowhead Whale, the Atlantic Walrus, the Common Eider, and the Thick-billed Murre, were chosen based on a combination of different criteria. The aim was to have an equal focus on both marine mammals and migratory birds, as both are highly represented within Foxe Basin and Hudson Strait and are threatened by shipping hazards. In addition, the decision to choose a cetacean species (Bowhead Whale) as well as a pinniped species (Atlantic Walrus) was consciously made in order to provide more variation within the results.

Literature was consulted in order to determine which species were common within the area of the shipping route. Species distribution maps from the report on the 2010 Arctic Marine Workshop by Stephenson and Hartwig (2010) and the Canadian Wildlife Service's Key Marine Habitat Sites for Migratory Birds in Nunavut and the Northwest Territories by Mallory and Fontaine (2004) proved invaluable. The four species chosen for the risk analysis were selected based on their distribution within Foxe Basin and Hudson Strait, their population status, as well as their vulnerability due to particular behavioural characteristics. More detailed explanations for the selection of each of the individual species can be found in Chapter 7.

2.3 RISK ANALYSIS

For the risk analysis portion of this project, an assessment of the current situation in Foxe Basin and Hudson Strait with regard to shipping activity was conducted for the Bowhead Whale, Atlantic Walrus, Common Eider, and Thick-billed Murre respectively. The direct and acute threats to marine mammals and birds that are considered in this graduate project are oil pollution, habitat disruption from icebreaking, and disturbance from vessel strikes, noise, and light. In addition, the three most pertinent threats to each of the four selected species were identified and assessed, based on the likelihood and consequence of a potential disturbance. Furthermore, for each individual species, only the pertinent threats were assessed as not all threats apply to all species, due to differences in behavioural characteristics and life history traits.

In order to analyze the level of risk to a species from a particular threat, it is necessary to select indicators that help to define the likelihood or consequence of a direct or indirect interaction occurring between a vessel and one or more individuals of a particular species. Furthermore, the parameters used to define likelihood and consequence should be based on scientific literature, traditional knowledge, or current regulations that are in place. Each species may be more or less likely to be impacted by a particular interaction than another, or may be impacted more severely than another species. Furthermore, how the likelihood and consequence of a potential interaction is defined for a disturbance is explained in detail for each species in Chapter 8. A Risk Index was used, incorporating a Frequency Index (Likelihood) and Severity Index (Consequence). Subsequently, risk matrices were created using these indexes to determine the relative level of risk posed to each species for each of the three relevant threats selected.

Table 2.1 Risk Index used to assess the risk of a potential threat to a species, based on the likelihood and consequence of an interaction

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare		1	Negligible	
2	Unlikely		2	Low	
3	Moderate		3	Moderate	
4	Likely		4	Very High	
5	Almost Certain		5	Extreme	

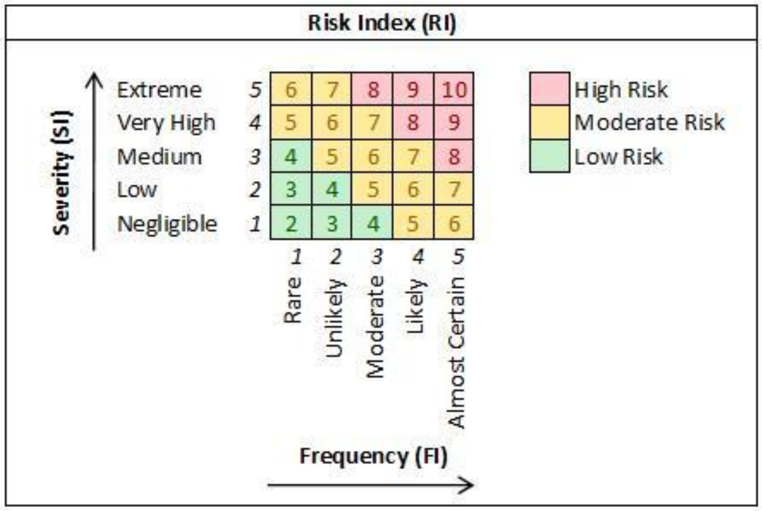

Figure 2.1 Risk matrix used to determine the level of risk for an interaction, based on the likelihood and consequence of a disturbance occurring. Lower numbers in the matrix (2-4) represent low risk, mid-range numbers (5-7) represent moderate risk, and high numbers (8-10) represent high risk.

2.4 Risk Management

The risk management portion of this graduate project takes the results from the risk analysis and uses it to propose mitigation strategies that will effectively lower risk, either through minimizing the likelihood of a disturbance, the consequence of a disturbance, or in some cases both. The implementation process of putting these protective measures in place is also discussed in this section. This part of the management process is based on current policy, legislation, and regulations. While some management strategies or mitigation measures may be more effective at minimizing risk than others, they may also be more difficult to implement or enforce. Incorporating this aspect of management into the overall process ensures that the final recommended strategies are practical, as well as effective. Therefore, the goal of the risk management portion of this graduate project is to provide useful recommendations for minimizing risk and monitoring the impacts of the Baffinland Mary River project into the future, but to also set a precedent for assessing risks to fauna in future development projects within the Arctic marine environment.

3.0 Arctic Mineral Exploration and Extraction

3.1 The Link Between Arctic Mining and Shipping

3.1.1 Reliance on Marine Transportation

While mining development in the Arctic is influenced by global markets and prices, it is often almost entirely dependent on marine transportation due to accessibility issues, challenges regarding infrastructure, and the harsh climate. Many areas of the Arctic are so remote that they can only be accessed by air or by sea, the latter being the most financially viable. Furthermore, marine transportation is more energy efficient than any other mode of transportation, including air, rail, or truck; using less fuel for every tonne of cargo moved one kilometre (Marisec, n.d.). In addition, the rough terrain of the Arctic and the seasonal thawing and freezing of permafrost presents challenges to the construction and long term stability of critical infrastructure such as roads, railways, buildings, and containment facilities (Prowse et al., 2009).

3.1.2 Bulk Transport

Due to the reliance of mineral exploration, exploitation, and transportation on the shipping industry, it should be no surprise that the bulk transport of hard minerals, as well as oil and gas, represents a significant part of Arctic vessel traffic. For the most part, bulk transport occurs during the open-water season or in areas of the Arctic that remain ice-free, such as the Norwegian Arctic and parts of the Russian Arctic (AMSA, 2009, p.76). Many bulk carriers currently operating in the Arctic are not ice-strengthened or Polar Class, therefore bulk cargo is stored over the winter and shipped out during the ice-free season (AMSA, 2009, p.76). Exceptions to this are perishable, high-value cargoes which will degrade if they are not processed within a short period and as a result must be shipped year-round (AMSA, 2009, p.76). It is expected that the impacts of climate change could result in more year-round bulk transport and stimulate further mining exploration and development in the Arctic (Prowse et al., 2009).

3.2 Mining Within The Arctic States: The United States (US), Russia, Norway, and Greenland (Denmark)

There are various large mines within the Arctic states, producing nickel, zinc, and other types of ore. The Red Dog mine in Alaska is one of the largest zinc mines in the world and is dependent on seasonal marine transportation. As the sea ice continues to diminish in the Chukchi Sea, the United States (US) could potentially extend the length of the shipping season (AMSA, 2009, p.98). The Norilsk mine near the port of Dudinka in the Russian Federation is the largest producer of nickel and palladium in the world (AMSA, 2009, p.76). Nickel is transported year-round from this mine in Siberia to world markets, and is therefore almost entirely dependent on the shipping industry (AMSA, 2009, p.98). With the increase in prices for minerals, Norway has recently re-opened two iron ore mines in its far north that had been abandoned for 14 years (Waldie, 2011). Furthermore, several mining companies have set their sights on rich deposits of uranium, zinc, and rare earth minerals discovered in Greenland (Waldie, 2011). For example, the Kvanefjeld Project in southwest Greenland consists of exploiting a multi-element deposit containing rare elements including uranium and sodium fluoride (AMSA, 2009, p.98).

3.3 Mining Within The Canadian Arctic

3.1.1 The Canadian Mining Industry

Canada's diverse geology yields a variety of mineral resources, and there are currently around 60 minerals and metals being produced in Canada (NRCan, 2011a). Canada is the world's leading producer of potash and is one of the top five producers for primary aluminum, cadmium, cobalt, diamonds, molybdenum, nickel, platinum group metals, salt, titanium concentrate, tungsten, and zinc (NRCan, 2011a). In addition, interest in rare earth metals has led to increased exploration efforts in Canada (NRCan, 2011a). In the northern territories the main mineral deposits found are diamonds, gold, tungsten, silver, lead, iron, copper, zinc, nickel, coal, tantalum, niobium, lithium, cobalt, bismuth, uranium, beryllium, and barium (Prowse et al., 2009).

In 2009, the global economic crisis had a major impact on the Canadian mining industry, leading to a 31.5% decrease in the total value of minerals produced in Canada from $47 billion in 2008 to $32.2 billion (NRCan, 2010). The value of most metals decreased, except for a few elements such as gold and uranium. Furthermore, low demand and reduced market prices led to significant declines in the total value of nickel, copper, iron ore, and cobalt (NRCan, 2010). While there was considerable economic uncertainty remaining in 2010, the industry was able to recover almost half of the expenditures that were lost between 2008 and 2009, and it is expected that it will be "back to record territory in 2011" (NRCan, 2011b).

3.3.2 Past and Present Projects in the Canadian North

Although logistics make mining in the north extremely challenging, there have been a number of successful projects in the past. The Polaris lead-zinc mine, located on Little Cornwallis Island just northwest of Resolute Bay was active between 1981 and 2002, producing over 21 Mt of lead-zinc ore valued at a total of $1.5 billion (Spitzer, 2001). Also, the Nanisivik zinc mine was located on northern Baffin Island, east of Arctic Bay. While the mine produced millions of tonnes of zinc for 26 years between 1976 and 2002, it was closed 4 years ahead of schedule due to the low price of zinc and the struggling market (George, 2001).

Irregular winter shipping has taken place for past Arctic mines in Canada, as well as for the Raglan mine and Voisey's Bay mine. The Raglan nickel mine, located in the Nunavik region of northern Quebec near Deception Bay, produces 1.3 Mt of nickel per year (Waldie, 2011). The nickel degrades quickly if it is left too long without being processed, and therefore must be shipped year-round (AMSA, 2009, p.76). In addition, the Voisey's Bay nickel mine, located on the coast of northern Labrador near the bay of the same name, began production in 2005 (VBNC, 2011). Shipments of nickel from the Voisey's Bay mine are made from Edward's Cove during the winter months using ice-strengthened bulk carriers such as the MV Arctic and the Umiak 1 (VBNC, 2006).

Currently, there are three major mines in the northern territories; two diamond mines in the Northwest Territories and one in Nunavut (Waldie, 2011). The Ekati diamond mine opened in 1998 and is located 300km northeast of Yellowknife (CBC, 2007). The Diavik diamond mine opened in 2003 and is approximately 100 km southeast of the Ekati mine (CBC, 2007). The Jericho diamond mine is located in Nunavut, about 400km northeast of Yellowknife. The mine was previously owned by Tahera Diamond Corporation and was operational from 2006 to 2008 (CBC, 2010). Financial troubles led to its closure in 2008, and in 2010 it was sold to Shear Minerals Limited for $38 million. The Jericho mine is expected to reopen in late 2011 (CBC, 2010).

3.3.3 Opportunities for Nunavut

There are also two relatively new projects underway in Nunavut that will have a significant impact on Arctic mining in Canada. The Meadowbank gold mine is an open pit mine owned by Agnico-Eagle Mines Limited, located approximately 300km west of Hudson Bay (AEM, 2010). Production at the Meadowbank mine began in early 2010 and it is the company's largest gold mine (AEM, 2010). In addition, the EIS for the Mary River Project on Baffin Island is currently being assessed by the NIRB, as well as federal and territorial government agencies, Inuit organizations, local communities, and other stakeholders (Baffinland, 2010, Executive Summary, p.1). This project will be one of the largest mining ventures ever undertaken in the Arctic and will have major impacts on the territory and the communities within it (Waldie, 2011). Further details of the Mary River Project will be discussed in the following chapter.

4.0 The Mary River Project

4.1 Background

4.1.1 Ownership

The iron ore deposits at Mary River are 100% owned by Baffinland Iron Mines Corporation. Baffinland is a "publicly traded Canadian junior mineral exploration company," based out of Toronto, Ontario (Baffinland, 2010, Executive Summary, p.1). In Canada, the mining industry is a two-tiered system, consisting of junior companies and senior companies, with the latter having producing mines. Junior companies focus mainly on exploration and deposit appraisal with the aim of discovering a significant deposit that they can either develop or sell to a senior company (NRCan, 2011a). While Baffinland acquired the site in 1986, costs were too high then for development to proceed.

In 2004, Baffinland raised enough money to conduct testing and surveying at the site, which confirmed the high quality of the deposit, in addition to it being one of the largest undeveloped iron ore deposits in the world (Waldie, 2011). By 2007, it was estimated that the project would cost more than $4 billion, an amount far too high for a junior company to raise itself (Waldie, 2011). In 2010, the recovery of the world's financial markets and the rising price of iron ore caused a bidding war for Baffinland to begin (Waldie, 2011).

ArcelorMittal, the largest steelmaker in the world, and Nunavut Iron Ore Acquisition Incorporated, backed by the US private equity firm Energy & Minerals Group, fought for months over the company until they finally decided to make a joint offer in January, 2011 for C$1.50 per share for a total of C$590 million (Rocha, 2011). The takeover of the company was completed in March, 2011 (Waldie, 2011), with ArcelorMittal and Nunavut Iron acquiring 70% and 30% of the company respectively (Blenkinsop, 2011).

4.1.2 Current Status

The Mary River Project is currently under review by the NIRB, which is a public government institution established under the Nunavut Land Claims Agreement (NLCA). The mandate of the NIRB is to assess the potential ecological and socio-economic impacts of development projects proposed for the Nunavut Settlement Area (NSA), using scientific methods as well as traditional knowledge (NIRB, n.d.). This environmental assessment process is conducted in order to determine the extent of the impacts a project will have on surrounding regions and communities and to determine under what conditions a project should proceed, if at all (NIRB, 2008). The NIRB then reports its findings and determination to the Minister of Aboriginal Affairs and Northern Development Canada (AANDC), previously known as Indian and Northern Affairs Canada (INAC), who is responsible for making the final decision (NIRB, 2008).

The environmental review process involves numerous stages once the screening process is complete and once the decision is made for a review to be conducted under either Part 5 or Part 6 of Article 12 of the NLCA. The difference is that while a Part 5 review is conducted by the NIRB, a Part 6 review would be conducted according to the Canadian Environmental Assessment Act (CEAA) (NIRB, 2008). This decision is made by the Minister of AANDC "where required, by law or otherwise" according to Article

12, Part 4 of the NLCA (1993). In the case of the Baffinland Mary River Project, the environmental assessment process is the responsibility of the NIRB.

Currently, the DEIS is in the process of undergoing a technical review, where various parties were given the opportunity to submit Information Requests (IRs) to the Proponent and provide comments on the ensuing responses (NIRB, 2011). Some of these parties include federal government departments such as Fisheries and Oceans Canada (DFO), Environment Canada (EC), Health Canada (HC), INAC, Natural Resources Canada (NRCan), and Parks Canada (PC), the territorial Government of Nunavut (GN), independent organizations such as the Canadian Transportation Agency (CTA), and various community groups and Inuit organizations.

4.2 Project Overview

The Mary River Project has been described as a potential 'game changer' by WWF due to the immense scale of the project (Latimer, 2011). The director of the Arctic programme at WWF in Canada, Martin von Mirbach, has stated that the project is "of a scale that would be massive anywhere in the world" (Latimer, 2011). While this is certainly the case, the Arctic has never before seen industrial development of this scale and as previously stated, the project will be one of the largest mining ventures ever to be undertaken in the Arctic (Waldie, 2011). The project will consist of mining high grade iron ore at an average iron grade of 64.66% from an open pit mine (Baffinland, 2010, Vol. 3, p.1). The iron ore deposit, Deposit No. 1, contains approximately 365 Mt of ore that can be directly shipped without additional processing. The life of the project is expected to be 21 years at a production rate of 18 Mt/a (Baffinland, 2010, Vol. 3, p.1). The DEIS details the plans for the construction, operation, closure, and reclamation of the mine, as well as the infrastructure necessary for the extraction, transport, and shipment of the iron ore (Baffinland, 2010, Vol. 3, p.1).

The iron ore will be transported by railroad from the mine site to Steensby Port, where custom built icebreaking ore carriers will transport 18 Mt iron ore to Europe each year (Baffinland, 2011, Vol. 3, p.3). While the DEIS proposed that Milne Port would be used for the shipment of 3 Mt/a transport of ore during the open-water season, an addendum was submitted in June 2011, which states that the project plans no longer include the transport of iron ore to Milne Port for shipment (Baffinland, 2011, Vol. 3, p.3). The final EIS will incorporate these changes and Milne Port will only be used during the open-water season for the transport of construction materials, supplies, fuel and equipment (Baffinland, 2011, Vol. 3, p.3). While shipping to and from Milne Port will also pose hazards to the marine environment, this graduate project will only be focusing on the operational year-round transport of iron ore from the Mary River mine site. Therefore, the scope of this risk management study will look exclusively at the shipping route from Steensby Inlet through Foxe Basin and the Hudson Strait. Further details regarding this shipping activity will be discussed in the following section.

4.3 PROPOSED SHIPPING ACTIVITY

4.3.1 STEENSBY PORT

The proposed Steensby Port will be constructed in Steensby Inlet, located in northern Foxe Basin. Steensby Inlet consists of tidal flats along its west coast, lagoons along the northern coast, and both bedrock and coarse alluvial shorelines along the east coast of the bay where the port will be constructed (Baffinland, 2010, Vol. 8, p.4). The bay is also characterized by shallow waters, less than 100 m deep (Baffinland, 2010, Vol. 8, p.4). The infrastructure at Steensby Port will be extensive, and as previously stated, the port will remain operational year-round. While the iron ore will be stored in stockpiles and then loaded onto ore carriers for shipment throughout the year, the majority of trips for the re-supply of materials and equipment will be delivered during the open-water season, defined as mid-July through mid-October according to the DEIS (Baffinland, 2011, Vol. 3, p.97). On average, 12 ore carriers will be received at the ore dock each month. During the open-water season, non-icebreaking vessels will be chartered to carry additional ore, with the dock receiving up to a maximum of 17 vessels per month (Baffinland, 2011, Vol. 3, p.98).

4.3.2 Icebreaking Ore-Carriers

The transportation of ore from Steensby Port to Europe throughout the year will require specialized ships capable of withstanding the winter ice. Baffinland has proposed that 10 to 12 ice class cape-size vessels each with a capacity of 160 000 to 190 000 DWT be constructed for the transport of the ore to European markets (Baffinland, 2011, Vol. 3, p.100). It is expected that together, these ore carriers will make 102 round trips from Steensby Port to ports across the Atlantic Ocean each year. Therefore, a ship will transit through the shipping lane roughly every 1.8 days or 43 hours (Baffinland, 2011, Vol. 3, p.100). The frequency of vessel traffic will increase during the open-water season, as other vessels are chartered to ship additional ore and to re-supply equipment and fuel (Baffinland, 2011, Vol. 3, p.100).

The designs for the icebreaker ore carriers have been scaled up from the design of the MV Arctic, which has been used to ship to and from the Polaris, Nanisivik, and

Raglan mines. These icebreaking vessels will be designed as Polar Class 4 vessels, the equivalent of somewhere between a CAC 3 and CAC 4 classification in Canada (Baffinland, 2011, Vol. 3, p.100). According to the International Association of Classification Societies (IACS), this classification should enable these vessels to operate year-round in "thick first-year ice, which may include old ice inclusions" (TC, 2010d). At full draught, the service speed of these vessels is about 14.5 knots and the maximum speed is more than 18.5 knots (Baffinland, 2011, Vol. 3, p.100). These vessels should be capable of traveling at a speed of 7 knots if ice is around 1.2 m thick, or 3 knots if it is 2 m thick. Therefore, while a round trip from Steensby Port to a destination port in Europe is approximately 20 days during the open-water season, it could take more than 45 days in heavy ice conditions (Baffinland, 2011, Vol. 3, p.100).

4.3.3 Shipping Routes

Baffinland has enlisted Fednav Ltd., to manage the shipping operations for the Mary River Project. The privately owned company is "Canada's largest ocean-going, dry-bulk shipowning and chartering group" (Fednav, 2011). Fednav plans to form a "consortium of ship owners to design, build, and own the ships that will be used to carry the iron ore from Steensby Port to markets in Europe" (Baffinland, 2011, Vol. 3, p.101). These ships will then be chartered from the shipping consortium by Baffinland. The nominal shipping route these vessels will use to access Steensby Port will consist of traveling through the Hudson Strait and Foxe Basin (Figure 4.1).

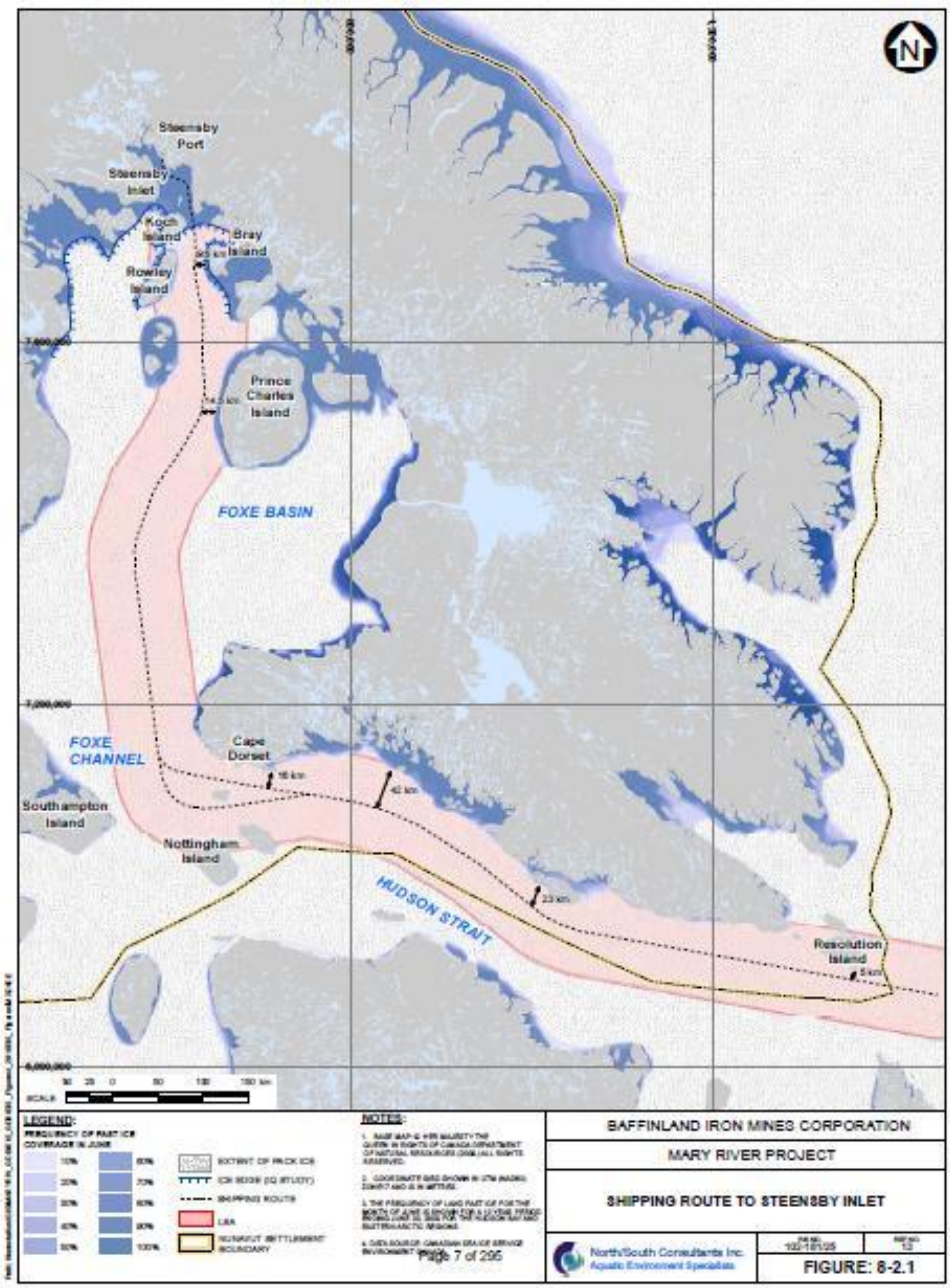

Figure 4.1 Map of nominal shipping route through Foxe Basin and Hudson Strait (Baffinland, 2010, Vol.8, p.7).

Through the Hudson Strait, ships will remain within the NSA (Baffinland, 2011, Vol. 3, p.102). Although the ice conditions are better along the coast of Baffin Island, the community of Cape Dorset requested that the ships remain as far away from the community as possible (Baffinland, 2011, Vol. 3, p.102). Therefore, the nominal shipping route passes south of Mill Island, although in cases where the Master of the vessel deems the ice conditions too poor for safe travel, he or she may decide to navigate the ship around the northern side of the island, where ice conditions are usually better (Baffinland, 2011, Vol. 3, p.102).

Ships will move through the southern Foxe Basin following shipping lanes established for access to Hall Beach and Igloolik. Furthermore, an eastern and a western shipping corridor through northern Foxe Basin, where vessels would either pass to the east or west of the Spicer Islands, Rowley Island, and Koch Island, were considered and assessed (Figure 4.2) (Baffinland, 2011, Vol. 3, p.102). The eastern route was preferred by Baffinland as well as by the communities of Hall Beach, Igloolik, and three other North Baffin communities, according to the Inuit Knowledge Studies that were conducted (Baffinland, 2011, Vol. 3, p.102).

Figure 4.2 Map of the shipping route options for the Baffinland Mary River Project. Option B and D represent the nominal shipping route, although Option C may be used if ice conditions along Option D are too poor for safe transit (Baffinland, 2010, Vol.3, p.138)

Shipping year-round will require icebreaking through pack ice most of the year and through landfast ice seasonally (November through June or early July). Pack ice moves constantly with the wind, currents, and tides present in the Foxe Basin and Hudson Strait (Baffinland, 2010, Vol. 8, p.11). Due to this mobility, after a vessel passes through the ship track is quickly closed in. Using data from monthly ice charts produced by the Canadian Ice Service, it was estimated that the mean annual maximum extent of pack ice within the Regional Study Area (RSA) is about 320 000 km^2 from January to July (Baffinland, 2010, Vol. 8, p.11). Assuming that a ship has a beam of 52 m and travels a total distance of around 1 460 km, it could interact with approximately 76 km^2 of pack ice on a single trip (1 460 km x 0.052 km). Therefore, the area of disturbance is 0.025% of the pack ice in the RSA, and 0.05% of the pack ice in the 146 000 km^2 Local Study Area (LSA) (Baffinland, 2010, Vol. 8, p.11).

Landfast ice will cover a 90 km distance between Steensby Port and Koch Island (Figure 4.3)(Baffinland, 2010, Vol. 8, p.12). When traveling through landfast ice, the icebreakers will create a track slightly wider than the ship beam, as the ice is broken into "small pans, rubble, and brash ice" (Baffinland, 2010, Vol. 8, p.13). Most of the broken ice will remain in the track, but some will be forced down and under the solid ice along the edges of the track where it will freeze. Once a ship passes through the ice, the track will immediately begin to refreeze (Baffinland, 2010, Vol. 8, p.13). However, a higher frequency of passages will cause the broken ice to build up and as it comes under pressure it will re-freeze, creating a thicker layer of ice until ships are forced to move to adjacent, undisturbed ice. It is estimated that due to the frequency of ships transiting the shipping route to and from Steensby Inlet, the width of disturbed ice could reach a maximum of 1.5 km each year from the initial width of 100 m (Baffinland, 2011, Vol. 3, p.104). Therefore, a maximum of 136 km^2 of landfast ice could be disturbed by the 102 total transits per year (Baffinland, 2010, Vol. 8, p.14).

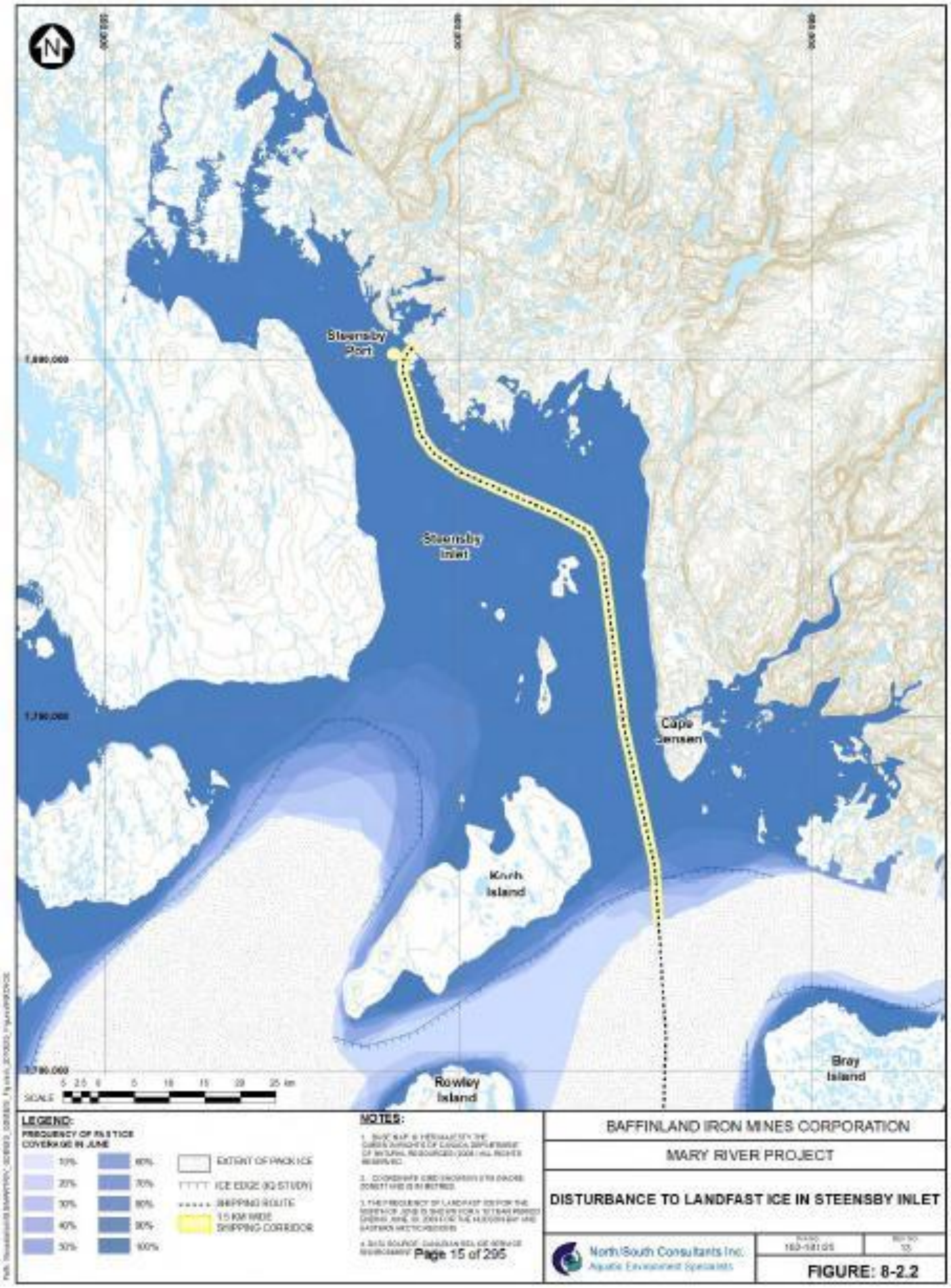

Figure 4.3 Map of the extent of landfast ice in Steensby Inlet. The width of disturbed ice could reach a maximum of 1.5 km each year (Baffinland, 2010, Vol.8, p.15).

5.0 POTENTIAL SHIPPING HAZARDS TO WILDLIFE

5.1 CONSEQUENCES OF INCREASED SHIP TRAFFIC

Increased shipping in the Canadian Arctic poses multiple risks to the marine Arctic environment, specifically to marine species and habitat. This chapter will focus on the threats to marine mammals and migratory birds from increased shipping activity within Foxe Basin and Hudson Strait. Species that are likely to be impacted by increased shipping in the Arctic include both year-round residents and occasional residents of Arctic waters (Huntington, 2009). Possible interactions between wildlife and icebreaking ore carriers, traveling through the Foxe Basin and Hudson Strait, are numerous and varied. Furthermore, both the likelihood and potential consequences of an encounter will depend on a range of factors.

5.2 POTENTIAL THREATS

5.2.1 DIRECT THREATS

There are a number of threats that could negatively impact the marine environment as a result of shipping iron ore year-round through the Foxe Basin and Hudson Strait. The AMSA 2009 Report places these threats into three different categories; pollution, disturbances, and introductions. While all three categories are important to consider, this assessment will only focus on the first two categories, as they pose direct threats to marine mammals and migratory birds. Direct threats from shipping iron ore year-round from Steensby Port through Foxe Basin and the Hudson Strait to Europe are shown in Table 5.1.

Table 5.1 Environmental threats to marine mammals and migratory birds from the proposed shipping activity for the Mary River Project.

Category	Activities/Threats	Potential Impacts
Pollution	Accidental or operational discharges of oil and hazardous material	Physical oiling causing impaired thermal insulation and death of birds and mammals with fur Toxicological effects
Disturbance	Noise disturbance	Disruption of feeding, breeding or other behavioural activities Interference with marine mammal communication
	Ice breakers and disturbance	Changes in behaviour and communication between mammals Ice entrapment of whales in artificial leads
	Vessel strikes	Injury or death of marine mammals from a collision
	Light disturbance	Injury or death of birds attracted to lighted ships

5.2.1 Indirect Threats and Other Exclusions

Although the potential introduction of an invasive species to Arctic waters from increased shipping activity could result in a cascade of effects on the marine environment, it is difficult to predict the level of consequence that could occur as a result. Furthermore, the extent of impacts an invasive species could have on an area is dependent on many factors and can become extremely complex. Marine mammals and migratory birds could be indirectly affected by a reduction or increase in species lower or higher on the food chain, particularly key prey or predator species. Due to the challenges surrounding this category, it will not be further discussed in this project. In addition, within the pollution category the focus will be on oil pollution as it will have both acute and chronic effects on marine mammals and migratory birds, while the effects of pollution from air emissions, garbage, and other waste will not be as evident in the short-term. Furthermore, this project will focus on the immediate and acute impacts of hazards on marine mammals and birds, as the cumulative impacts are more difficult to assess.

5.3 Pollution

Overall, the maritime shipping industry contributes minimally to the degradation of the marine environment in comparison to other human activities; however critical marine habitat and species are still at risk. Although the average frequency and size of large oil spills has decreased significantly over the past several decades, due to the implementation of pollution prevention standards, the risk of a large spill occurring can never be completely eradicated (ITOPF, 2010). Furthermore, marine pollution discharged from ships is a hazard because although the likelihood of a major incident (over 700 tonnes spilt) is rare, the consequences would be severe. In addition, incidents classified as small and medium spills of less than 7 tonnes and of 7 to 700 tonnes respectively, are also an issue and can negatively impact habitat and wildlife (ITOPF, 2010).

An increase in vessel traffic through Foxe Basin and Hudson Strait as a result of the Mary River Project, could potentially lead to a spill in the near future; and since oil spills pose a potential threat to all marine mammals, seabirds, and waterfowl, this issue must be addressed accordingly. Migratory birds and pinnipeds are more likely to be affected by oiling than cetaceans because of their feathers and fur, which lose their insulating properties when oiled. However, oil may still harm the eyes and baleen of a whale, and inhaling vapors from the water's surface could also be hazardous (Alter et al., 2010). In addition, spills within Arctic waters are much more difficult to contain and mitigate due to the likelihood of operational difficulties based on the presence of sea ice. Colder water temperatures also reduce the ability for petroleum hydrocarbons to be naturally broken down, making it more likely for cumulative impacts to be felt in the long-term (Alter et al., 2010). Therefore, the consequences of a spill could be quite high, as there is potential for direct mortality as well as long-term impacts.

5.4 Disturbance

5.4.1 Vessel Strikes

Increased vessel traffic through Foxe Basin and the Hudson Strait poses severe risks for cetaceans, with respect to potential ship strikes. As whales must surface for respiration as well as for feeding in some species, this proximity to the surface puts them at risk for potential collisions. Furthermore, studies have shown that large whales do not always make attempts to avoid vessels. Whether this is because they have become accustomed to the sound of approaching vessels or because of other unidentified reasons remains unknown (Vanderlaan et al., 2008). In some instances, acoustic devices used for scare tactics have been employed to deter cetaceans from approaching fishing gear; however these have shown conflicting results (Vanderlaan et al., 2008). Furthermore, these 'alarms' sometimes cause whales to swim to the surface, which puts them at even greater risk of being struck by a vessel (Vanderlaan et al., 2008).

5.4.2 Noise Disturbance

Another potential threat to marine mammals and migratory birds due to increased ship traffic in the Arctic, is interference due to noise disturbance. Increased ambient noise in Foxe Basin and Hudson Strait may disrupt species behaviour, cause the abandonment or trampling of young, or displacement from traditional habitat (Molenaar, 2009). Cetaceans rely on sound for communication, navigation, and for detecting predators, therefore noise from ship propellers as well as from icebreaking is a major issue and could even cause temporary or permanent hearing loss in some instances (COSEWIC, 2009). Recently, it has been found that many whales are calling louder to be heard over noise produced by vessels, and in some cases have stopped calling altogether (Dell'Amore, 2009). In addition, icebreaking near important haul-out sites, where pinnipeds maneuver themselves out of the water onto land or ice using their pectoral flippers, or important areas for birds, could disrupt behaviours critical to mating, foraging, or migrating, and could even lead to site abandonment (Alter et al., 2010; Wright et al., 2007).

The speed of sound in water is also much greater than it is in air, which allows sound to travel much greater distances in water. In addition, vessel size, speed, propulsion type, and horsepower may all have an impact on the level of noise produced and the subsequent implications for marine species in general (Kipple & Gabriele, 2007). As a result, the more ships present in a specific area, the more difficult it will be for species to avoid ships and the noise being produced. Therefore, unlike rare incidents such as a large oil spill, noise disturbances are almost guaranteed in Foxe Basin and Hudson Strait due to proposed shipping activity for the transportation of iron ore from Steensby Port. However, the consequences associated with such a disturbance are much lower.

5.4.3 Icebreakers and Habitat Disturbance

In addition to the issue of noise disturbance caused by icebreakers, the process can also have an impact on critical habitat for various marine Arctic species. Sea ice is of the utmost importance for marine mammals such as pinnipeds and polar bears. Therefore year-round icebreaking in Foxe Basin and Hudson Strait will aggravate the issue of reduced ice cover for these species. Furthermore, pinnipeds including various species of seal as well as the walrus, are highly dependent on sea ice for pupping, foraging, moulting, and resting (DeMaster & Davis, 1995, as cited in Tynan & DeMaster, 1997). Polar bears are also reliant on the sea ice for efficient hunting and traveling (Burns et al., 1981, as cited in Tynan & DeMaster, 1997). In addition, the timing of migration for Arctic cetaceans is affected by the breakup of seasonal ice, which has been documented in Baffin Bay and Davis Strait for narwhal (Tynan & DeMaster, 1997). Therefore, extensive icebreaking in Foxe Basin and Hudson Strait could cause major shifts in marine mammal migrations and distributions.

5.4.4 Light Disturbance

A final concern is the potential impact of light disturbance from ships on birds. It seems that all bird species are attracted to lights, which puts them at risk of colliding with lighted structures. Factors that may influence the likelihood of collision include weather, season, and the age of a bird (AMSA, 2009, p.149). In the Arctic, the fall migration period appears to be when most collision issues emerge, as young birds are traveling for the first time and storms become more frequent, leading to more difficulty staying aloft and for navigation (AMSA, 2009, p.150). In general, the risks to Arctic marine birds from light disturbance are minimal, as most birds are in the Arctic during the summer to breed, when there is little to no darkness. Furthermore, most Arctic-breeding birds are diurnal and are only active during the day (AMSA, 2009, p.150). However, the likelihood of a collision increases with a larger presence of lighted ships during the non-breeding period. While nocturnal species such as storm-petrels are particularly vulnerable, diurnal seaducks such as the common and king eider have been shown to collide with large vessels off the coast of western Greenland (AMSA, 2009, p.150).

6.0 KEY HABITAT SITES

6.1 MARINE ECO-REGIONS AND KEY AREAS

6.1.1 ARCTIC MARINE ECO-REGIONS

North America's ocean and coastal waters are separated into twenty-four marine eco-regions based on "oceanographic features and geographically distinct assemblages of species" (Wilkinson et al., 2009, p.179). The Arctic marine area that is being assessed, with respect to the proposed shipping activity associated with the Mary River Project, is separated into two different marine eco-regions; the Hudson-Boothian Arctic, and the Baffin-Labradoran Arctic (Figure 6.1). Foxe Basin is located within the Hudson-Boothian Arctic marine eco-region (Figure 6.2), which is characterized by its seasonal ice regimes (Wilkinson et al., 2009, p.32). Vast and open seascapes are rare in this region, except for in the Hudson Bay area. Furthermore, this is one of the richest eco-regions for marine mammals in the world (Wilkinson et al., 2009, p.33). Hudson Strait is located within the Baffin-Labradoran Arctic marine eco-region (Figure 6.3), which is characterized as a transition area between cold northern waters and more temperate southern waters (Wilkinson et al., 2009, p.38). In addition, it is an extremely important eco-region for North American and world populations of seabirds (Wilkinson et al., 2009, pg. 39).

Figure 6.1 Map of North America's 24 Marine Eco-regions (Wilkinson et al., 2009).

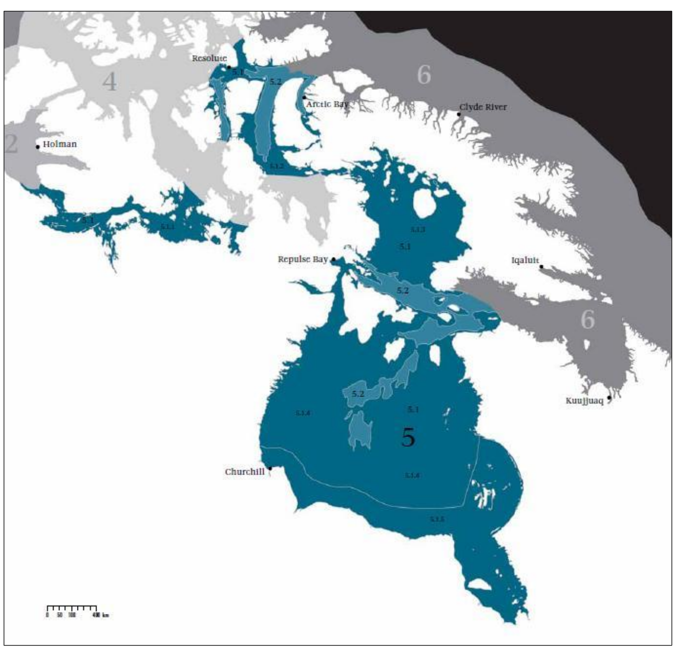

Figure 6.2 Map of the Hudson-Boothian Arctic Marine Eco-region (Wilkinson et al., 2009).

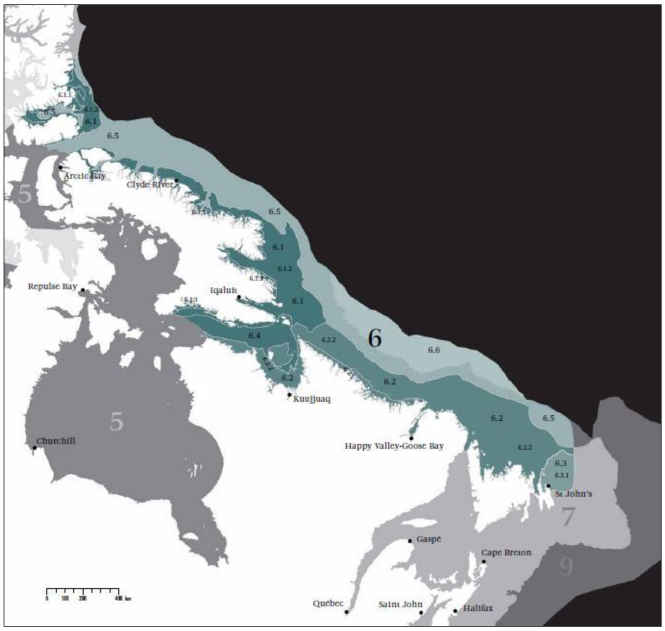

Figure 6.3 Map of the Baffin-Labradoran Arctic Marine Eco-region (Wilkinson et al., 2009).

Both Foxe Basin and Hudson Strait are biologically significant areas in the Arctic marine environment (Figure 6.4) and provide habitat for a large number of seabirds and marine mammals (Baffinland, 2010, Vol. 8, p.3). They act as critical staging and breeding areas for birds, and as a migration corridor for various marine mammal species (Baffinland, 2010, Vol. 8, p.3). The specific characteristics of these areas will be described in more detail in the subsequent sections of this chapter.

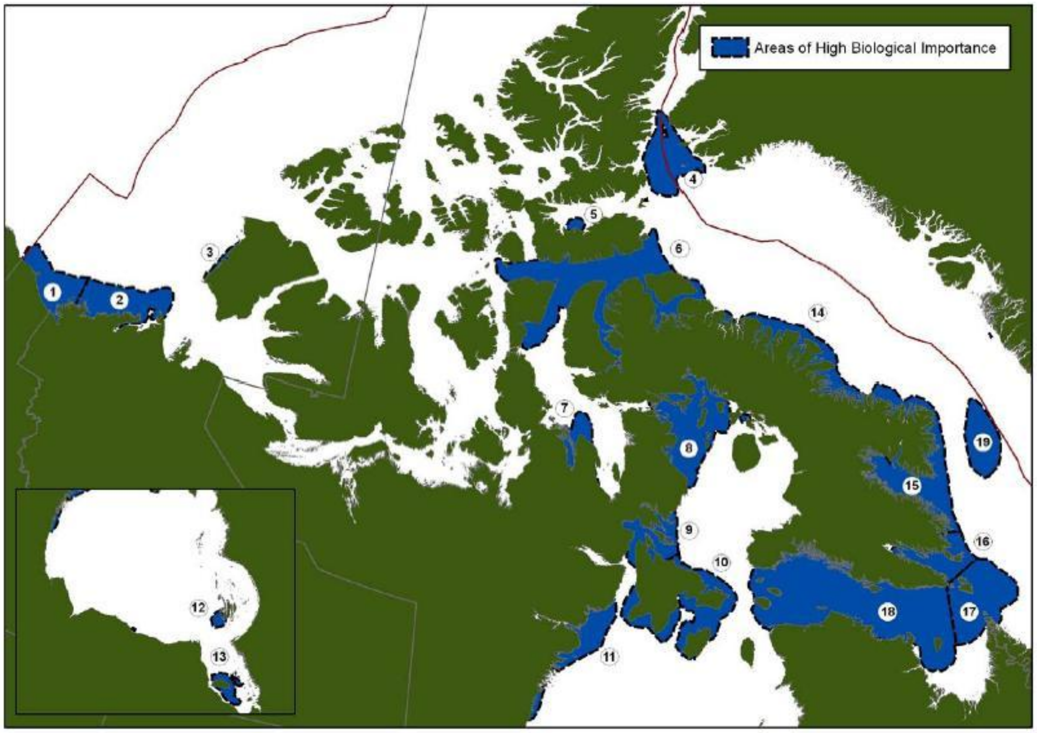

Figure 6.4 Map of the areas in the Canadian Arctic with high biological importance (Stephenson & Hartwig, 2010, p.65).

6.1.2 Foxe Basin

The relationship between sea ice and open water impacts the presence and distribution of marine species (Baffinland, 2010, Vol. 8, p.6). Polynyas are areas of open water within sea ice that remain unfrozen for the majority of the year, while leads are long stretches of open water, usually found along the coast, that open during the summer season. Polynyas and lead systems may be caused by wind, tides, currents, and/or upwelling (Stirling, 1980). Species may aggregate near these open-water areas due to: (1) the calmer water, in which diving and resting on the surface requires less energy; (2) access to a substrate to rest upon after spending time in the water; (3) a temporary barrier to migration; (4) a navigational aid for migrating species; (5) open-water for respiration and feeding in areas of heavy ice cover; (6) habitat for predator avoidance; and, (6) increased food supply due to greater biomass of invertebrates and fish (Stirling, 1997).

In Foxe Basin the ice usually begins to melt in June, with leads opening throughout July along the coastline (Baffinland, 2010, Vol. 8, p.3). Pack ice is found throughout Foxe Basin and is less mobile than in southern Hudson Bay. In the central part of Foxe Basin especially, the ice drifts minimally and melts throughout the month of August (Baffinland, 2010, Vol. 8, p.3). In October, ice begins to form again in the northern and western regions of Foxe Basin, and spreads southward by early November. While pack ice extends over the majority of the basin, Steensby Inlet is covered by landfast ice (Baffinland, 2010, Vol. 8, p.3).

The numerous re-occurring polynyas in northern Foxe Basin provide critical habitat to marine mammals and seabirds (Figure 6.5) (Mallory & Fontaine, 2004, p.56). For example, northern Foxe Basin is home to the largest concentration of Atlantic Walrus in Canada, and may act as the only Bowhead Whale nursery in the Canadian Arctic (Stephenson & Hartwig, 2010, p.32). In addition, islands along the western coast of Baffin Island provide habitat for large colonies of Atlantic Brant, Sabine's gulls, Red Phalaropes, Iceland and Glaucous Gulls, Black Guillemots, Common Eiders, and King Eiders (Mallory & Fontaine, 2004, p.56).

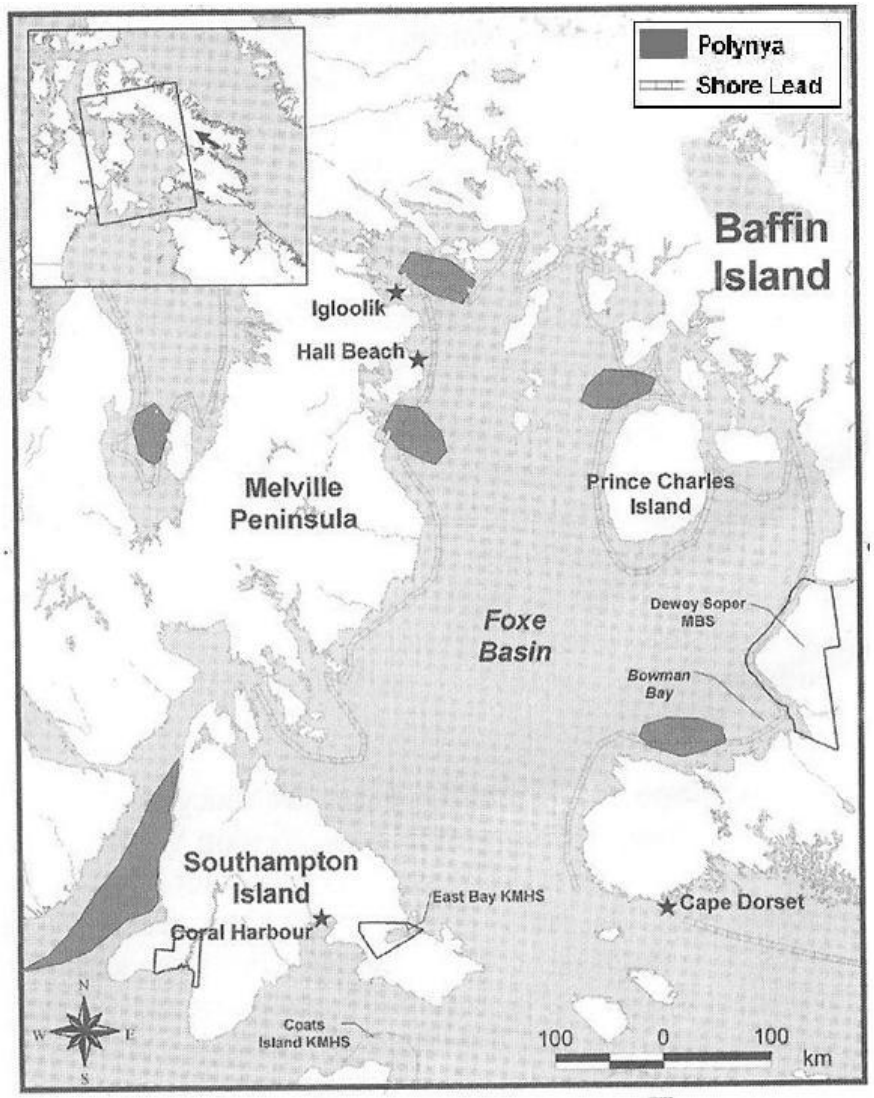

Figure 6.5 Map of the re-occurring polynyas and shore leads in Foxe Basin (Mallory & Fontaine, 2004, p.56).

6.1.3 HUDSON STRAIT

Open-water leads develop throughout Hudson Strait from May through June, although it may not clear completely until fall (Baffinland, 2010, Vol. 8, p.3). These leads are generally found along the southern shore of Baffin Island, while ice accumulates along the coast of northern Quebec and in Ungava Bay. In November, the western portion of the strait begins to freeze and spreads east until it is entirely covered by December (Baffinland, 2010, Vol. 8, p.3). It is common for Hudson Strait to have strong winds and currents, therefore pack ice is constantly drifting (Baffinland, 2010, Vol. 8, p.3).

Furthermore, Hudson Strait is an area of high primary productivity (rate of generating biomass) because of a "good balance between mixing of water and flow rate which can be observed in the high tide ranges" (Stephenson & Hartwig, 2010, p.21). This high level of primary productivity is what draws so many marine mammals and migratory birds to this area. Hudson Strait is an important wintering area for many marine mammals, including Atlantic Walrus, Narwhal, Beluga Whales, and Bowhead Whales (Stephenson & Hartwig, 2010, p.33). In addition, there are several important seabird colonies located along the coast of the strait and the ice edge provides essential habitat to many species (Stephenson & Hartwig, 2010, p.33). Areas within Hudson Strait that are particularly important for migratory birds include Markham Bay, Digges Sound, Resolution Island, the Button Islands, Akpatok Island, and Ungava Bay (Mallory & Fontaine, 2004, p.61, 64-72). Species common within these areas include Arctic Terns, Black Guillemots, Black-legged Kittiwakes, Common Eiders, Glaucous, Iceland, and Ivory Gulls, Harlequin Ducks, Northern Fulmars, and Thick-billed Murres (Mallory & Fontaine, 2004, p.61, 64-72).

6.2 Important or Vulnerable Arctic Marine Areas

6.2.1 Ecologically and Biologically Significant Areas (EBSAs)

In order to effectively implement Ecosystem Based Management (EBM) in the Arctic marine environment, criteria developed through the Convention on Biological

Diversity (CBD) have been used to identify ecologically significant and vulnerable marine areas in the Arctic that need better protection (Speer & Laughlin, 2010, p.5). These seven criteria include (1) uniqueness, (2) life history importance, (3) importance to endangered or threatened species, (4) vulnerable, fragile, slow recovery areas, (5) areas of high productivity, (6) areas of high diversity, and (7) naturalness. In addition, the importance of an area for subsistence or culture was also considered (Speer & Laughlin, 2010, p.5-6). Ecologically and Biologically Significant Areas (EBSAs) for the Northwest Atlantic Region, which consists of Labrador, Hudson Bay, Baffin Bay, and the Canadian Arctic were identified and are shown in Figure 6.6. Several of these EBSAs make up parts of Foxe Basin or Hudson Strait and are within the region that will be affected by year-round iron ore shipping from Steensby Port to Europe (Table 6.1) (Speer & Laughlin, 2010, p.19).

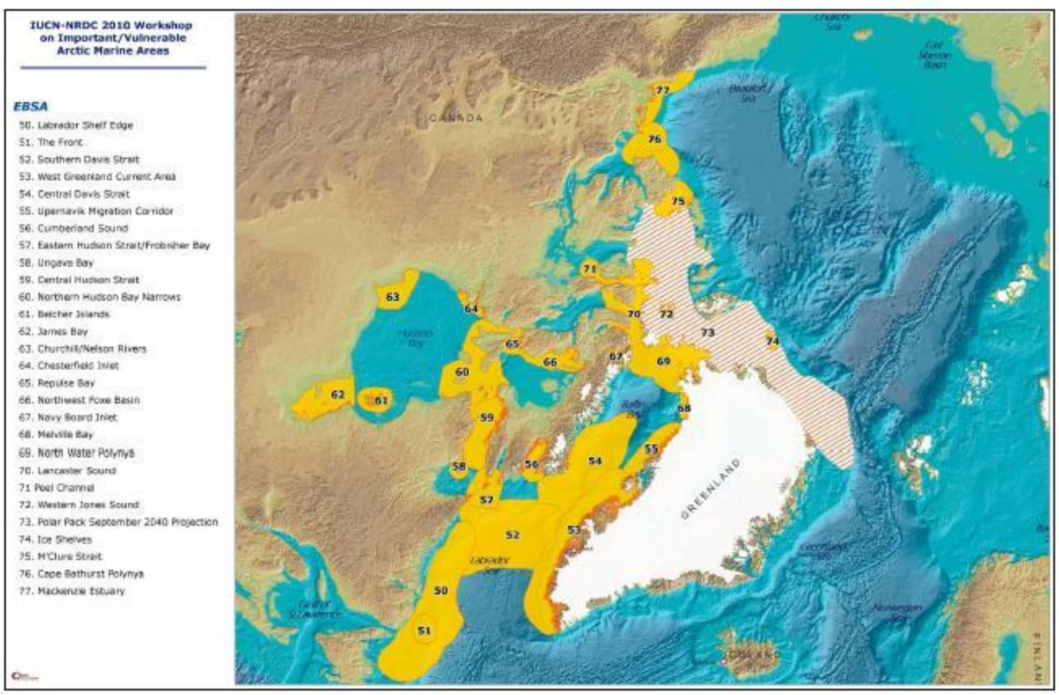

Figure 6.6 Map of the EBSAs in the northwest Atlantic marine Arctic area (Speer & Laughlin, 2010, p.19).

Table 6.1 List of EBSAs and the CBD criteria met (Speer & Laughlin, 2010, p.22).

ID #	EBSA Name	Uniqueness	Life history	Endangered/ Threatened	Vulnerability	Productivity	Diversity	Naturalness
54	Central Davis Strait	x	x	x		x		x
55	Upernavik Migration Corridor		x	x	x		x	x
56	Cumberland Sound	x	x	x	x		x	x
57	Eastern Hudson Strait/Frobisher Bay	x	x	x		x	x	x
58	Ungava Bay	x	x					x
59	Central Hudson Strait	x	x	x		x		x
60	Northern Hudson Bay Narrows		x			x		x
61	Belcher Islands	x	x	x			x	x
62	James Bay	x	x	x	x		x	
63	Churchill/Nelson Rivers	x	x		x		x	
64	Chesterfield Inlet		x	x			x	x
65	Repulse Bay	x	x	x		x		x
66	Northwest Foxe Basin	x	x	x	x		x	x
67	Navy Board Inlet	x	x	x				x
68	Melville Bay		x	x				
69	North Water Polynya	x	x	x	x	x	x	x
70	Lancaster Sound	x	x	x	x	x	x	x
71	Peel Channel		x					x
72	Western Jones Sound	x	x			x	x	x
73	Polar Pack September 2040 Projection	x	x	x	x		x	x
74	Ice Shelves	x		x	x	x	x	x
75	M'Clure Strait		x					x
76	Cape Bathurst Polynya	x	x		x		x	x
77	Mackenzie Estuary	x	x		x	x	x	

EBSAs within Foxe Basin and Hudson Strait are shown in black.

6.2.2 NUNAVUT LAND USE PLAN (NLUP)

The Nunavut Planning Commission (NPC) was established under Article 11 of the NLCA (2003) to develop land use plans for Nunavut, in order to outline priorities for the conservation, development, management, and the use of land and resources within the NSA (NPC, 2011). Furthermore, land use refers to activities including but not limited to traditional use, harvesting of wildlife, tourism, protected area designation, mineral or oil and gas exploration and development, transportation, and communication (NPC, 2011). The process of creating one overarching land use plan for all of Nunavut has only just begun and will take years to complete (NPC, 2011). However, efforts are already being made to identify key habitat sites that should be protected within the Nunavut Land Use Plan (NLUP) for migratory bird species in particular. The proposed zoning of EC key habitat sites for the NLUP is shown in Figure 6.7 (Callaghan & Toure, 2011).

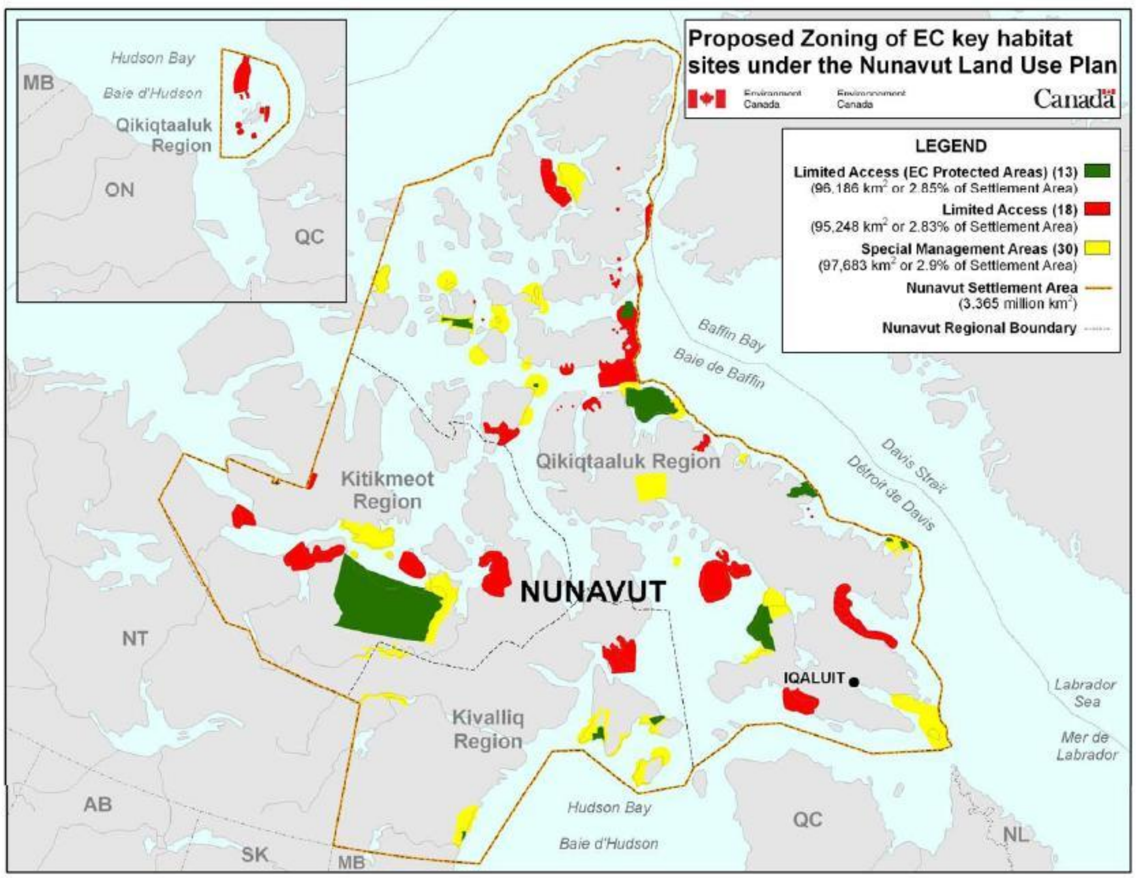

Figure 6.7 Map of the Key Habitat Sites identified by EC and proposed zoning for the NLUP (Callaghan & Toure, 2011).

7.0 KEY MARINE SPECIES

7.1 FOXE BASIN AND HUDSON STRAIT: AREAS OF HIGH BIOLOGICAL IMPORTANCE (AHBIS) FOR NUMEROUS SPECIES

Both Foxe Basin and Hudson Strait provide critical habitat to numerous Arctic species, as previously stated. Furthermore, certain areas within the Arctic show greater species overlap than others. The overlap of marine species within Areas of High Biological Importance (AHBIs) in the Canadian Arctic is shown in detail in Table 7.1. In addition, a map of marine species overlap in the Arctic marine environment is shown in Figure 7.1. Therefore, icebreaking ore carriers traveling from Steensby Inlet through Foxe Basin and Hudson Strait will pass through areas with high species overlap, and threaten the fragile state of the Arctic marine environment. It is essential that the threats posed by year-round shipping to Arctic marine species be identified and mitigated.

Table 7.1 Species and species groups found within the AHBIs in the Canadian Arctic (Stephenson & Hartwig, 2010, p.29).

	SPECIES/SPECIES GROUP									
AREA	Toothed whales	Bowhead Whale	Seals	Walrus	Fishes	Polar Bear	Seabirds	Shrimp, coral and sponges	Productivity	Total overlapping in area
1. Yukon North Slope	X	X	X		X	X	X			6
2. Cape Bathurst/Tuktoyaktuk Peninsula	X	X	X		X	X	X		X	7
3. Banks Island East Coast		X	X			X	X			4
4. North Water Polynya	X	X	X	X			X		X	6
5. Jones Sound			X	X	X	X				4
6. Lancaster Sound complex	X	X	X	X		X	X		X	7
7. Pelly Bay/Cape Chapman	X	X	X		X	X				5
8. Northern Foxe Basin	X	X	X	X	X					5
9. Frozen Strait/Repulse Bay	X	X	X	X	X		X			6
10. Southampton Island		X	X	X		X	X			5
11. Chesterfield Inlet	X	X	X	X	X					5
12. Belcher Islands			X	X	X		X		X	5
13. Akimiski Island/James Bay	X		X			X	X			4
14. East Baffin Coast	X	X	X	X			X	X		6
15. Cumberland Sound	X	X	X	X	X	X	X			7
16. Frobisher Bay	X	X	X	X	X	X	X			7
17. Resolution Island	X	X	X	X			X	X		6
18. Hudson Strait	X	X	X	X			X	X	X	7
19. Davis Strait	X	X	X					X		4

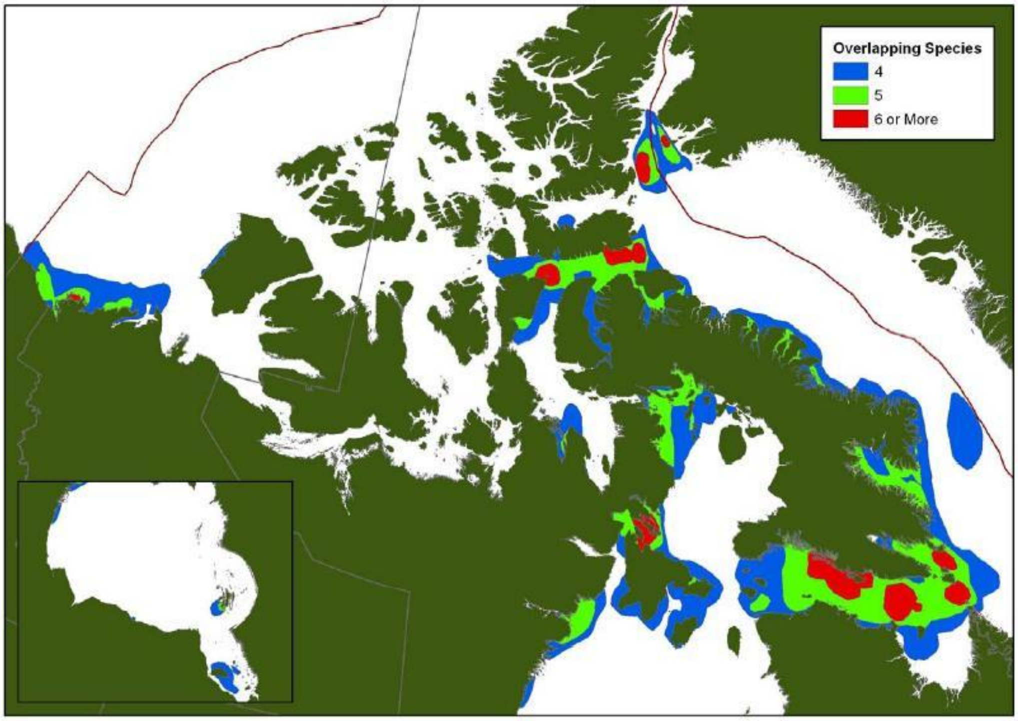

Figure 7.1 Species overlap within the AHBIs in the Canadian Arctic (Stephenson & Hartwig, 2010, p.64).

7.2 YEAR-ROUND RESIDENTS VS. OCCASIONAL RESIDENTS

Both year-round residents and seasonal or occasional residents of Arctic waters are likely to be impacted by increased shipping in the Arctic (Huntington, 2009). A list of marine mammals found in the Arctic is shown in Table 7.2. The species that have populations living in Arctic waters year-round are shown in bold and include the Bowhead Whale, Beluga Whale, Narwhal, Bearded Seal, Ringed Seal, Walrus, and Polar Bear (Huntington, 2009). In comparison, most migratory birds in the Arctic, including various species of seabirds, waterfowl, and shorebirds, are only there during the summer months to breed (AMSA, 2009, p.150). Furthermore, important areas and key habitat sites for migratory birds in the Canadian Arctic are depicted in Figure 7.2 (Stephenson & Hartwig, 2010, p. 55). Therefore, while there are numerous species that have critical roles in the Arctic marine ecosystem, time constraints only allow for a select few to be studied in this graduate project. The species that were chosen for this study are described in the following sections, along with the reasons for their selection.

Table 7.2 Marine mammal species found in the Arctic (Huntington, 2009).

Cetaceans	**Bowhead whale**	*Balaena mysticetus*
	Beluga or **white whale**	*Delphinapterus leucas*
	Narwhal	*Monodon monoceros*
	Gray whale	*Eschrichtius robustus*
	Killer whale	*Orcinus orca*
	Minke whale	*Balaenoptera acutorostrata*
	Fin whale	*Balaenoptera physalus*
	Humpback whale	*Megaptera novaeangliae*
Pinnipeds	**Bearded seal**	*Erignathus barbatus*
	Ringed seal	*Phoca hispida*
	Walrus	*Odobenus rosmarus*
	Harp seal	*Phoca groenlandica*
	Hooded seal	*Cystophora cristata*
	Ribbon seal	*Phoca fasciata*
	Spotted seal	*Phoca largha*
Fissipeds	**Polar bear**	*Ursus maritimus*

Year-round marine mammal residents are bolded.

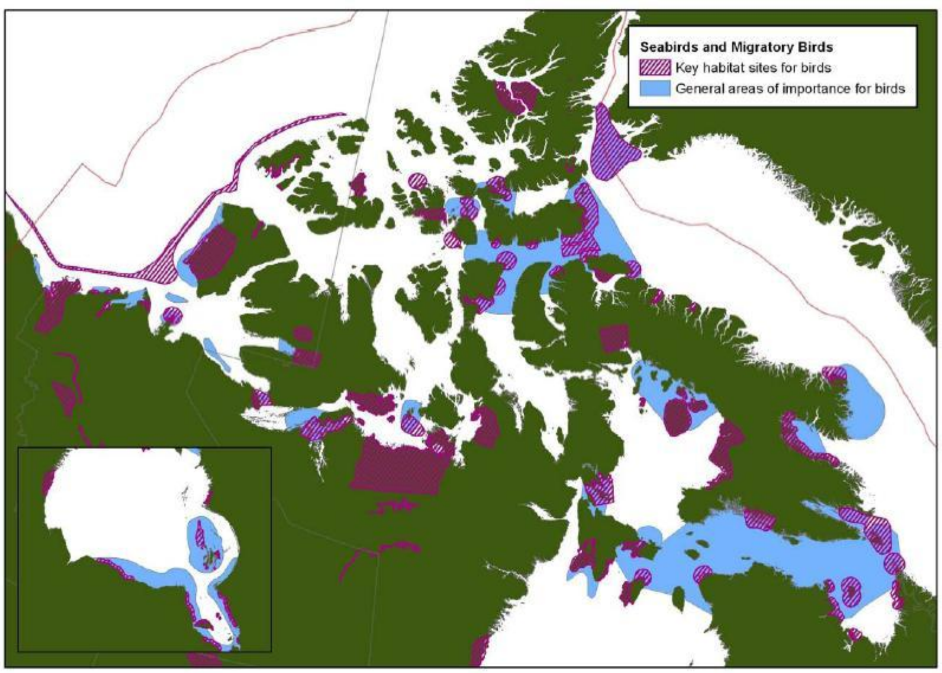

Figure 7.2 Important areas and key habitat sites for seabirds and migratory birds in the Canadian Arctic (Stephenson & Hartwig, 2010, p.55).

7.3 BOWHEAD WHALE

7.3.1 LIFE HISTORY

The Bowhead Whale (*Balaena mysticetus*) is the largest Arctic cetacean and the only baleen whale that resides in the Arctic year-round (OSPAR, 2010). Its name is derived from the "bowed" shape of its jaw and it is usually identified by its dark colouring and the white markings on its chin, stock and flukes (Figure 7.3) (DFO, 2008). Bowhead whales are very well adapted to their Arctic environment. They have large heads for breaking through pack ice, a thick blubber layer for insulation, and their acoustic abilities and lack of dorsal fin allow them to effectively navigate under the ice (DFO, 2008).

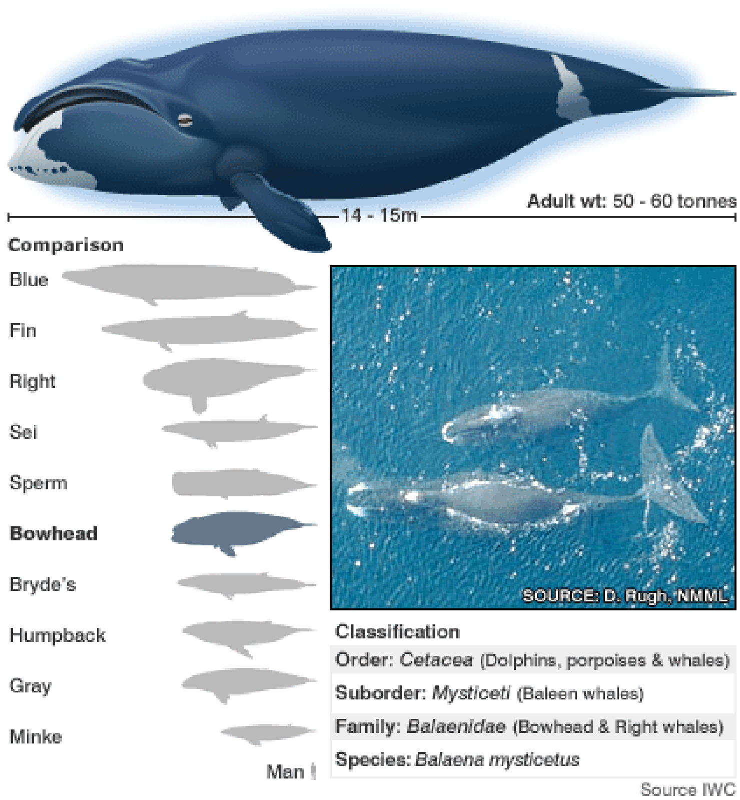

Figure 7.3 Physical characteristics of the Bowhead Whale (BBC, n.d.).

7.3.2 Population status

Bowhead Whale populations were hunted commercially throughout the 17th, 18th, and 19th centuries, and as a result their numbers declined substantially and have never completely recovered (Higdon & Ferguson, 2010). The Bowhead was listed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) during the 1980s. However, a steady increase in their populations in recent years, led to their downgrade to "threatened" status in 2005, and then again in 2009 to "special concern" (COSEWIC, 2009, as cited in Higdon & Ferguson, 2010). Although effective management has helped the Bowhead Whale's population numbers to increase over time, the low numbers of adult bowhead whales within its stocks are still a major concern (OSPAR, 2010). Furthermore, the Bowhead Whale 2009 COSEWIC Assessment and Update Status Report estimates that the overall population is made up of approximately 6344 individuals.

7.3.3 Distribution

Bowhead Whales inhabit Arctic and Subarctic waters between 54° and 85°N latitude, and have a circumpolar distribution. The overall population of Bowhead Whales is divided into several individual stocks (Figure 7.4), most likely due to physical barriers between them (Heide-Jorgensen & Laidre, n.d.). Three of these stocks are found within Canada, however, there is debate as to whether the Baffin Bay-Davis Strait and the Hudson Bay-Foxe Basin stocks make up one or two separate stocks. The International Whaling Commission (IWC) originally classified them separately so as to protect the species more conservatively. As a result of this debate, research using satellite tracking technology was conducted and the results suggested that Bowhead Whales between

Canada and Greenland belong to one single stock, now referred to as the East Canada-West Greenland stock (Heide-Jorgensen & Laidre, n.d.). In addition, these Bowhead Whales share the same summering and wintering grounds, and no genetic differentiation has been found to suggest they should be classified separately (Heide-Jorgensen & Laidre, n.d.).

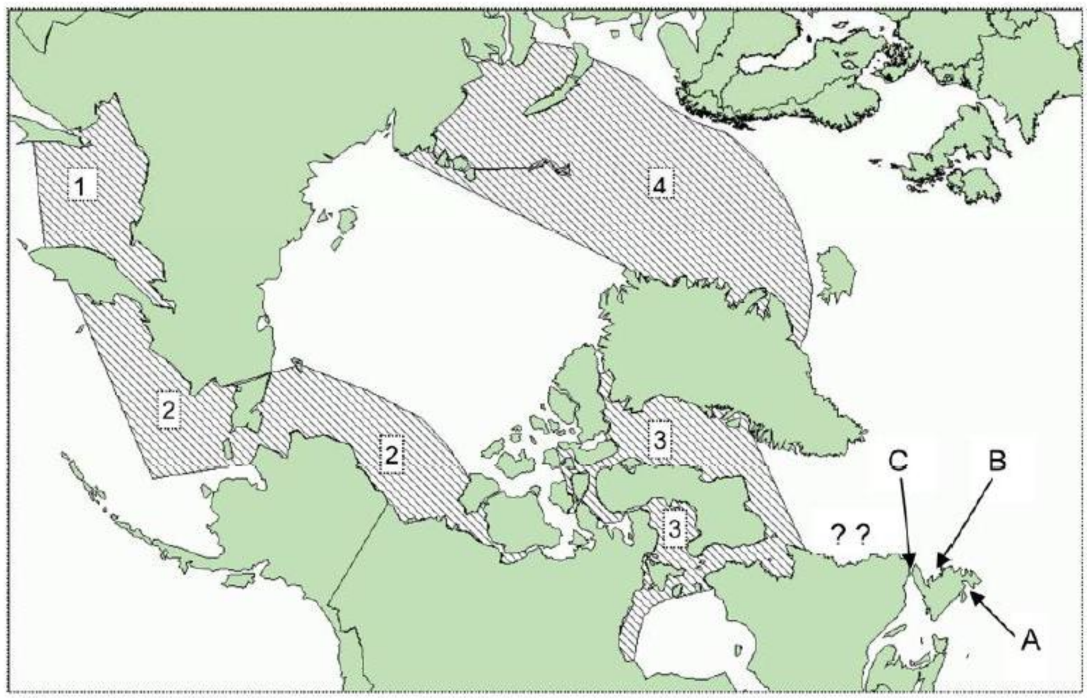

Figure 7.4 Distribution of the four recognized Bowhead Whale stocks: 1. Okhotsk Sea, 2. Bering-Chukchi-Beaufort seas, 3. Eastern Canada-West Greenland, 4. Svalbard/Barents Sea. The question marks represent areas where harvesting is believed to have occurred in the past. In addition, Bowhead Whales were hunted by Basque Whalers in the Strait of Belle Isle (C), and floating or stranded Bowhead carcasses were sighted at Rattling Brook (B) in 1998 and Mobile Point (A) in 2005 (COSEWIC, 2009).

7.3.4 Reasons for Selection

The year-round shipment of iron ore from Steensby Port threatens to impact Bowhead Whale stocks summering in northern Foxe Basin and wintering in Hudson Strait (Stephenson & Hartwig, 2010, p.48). While the Beluga Whale has a similar range to the Bowhead and is also listed under COSEWIC, the Bowhead Whale is more likely to be involved in a collision with a vessel or to be affected by an oil spill. More specifically, as part of the right whale family, it is slow moving averaging a speed of 3.9 to 4.5 km/h (Koski et al., 2001; Rugh, 1990; Richardson et al., 1995b, as cited in COSEWIC, 2009). Furthermore, as a baleen whale, the Bowhead Whale feeds on zooplankton near the water's surface putting it in close proximity to moving ships (COSEWIC, 2009). Narwhal could also potentially be impacted, however they prefer deeper, northern waters and are less common in the study area (Stephenson & Hartwig, 2010, p.11). In addition, the removal of Bowhead Whales from the marine food web results in a rise in zooplankton levels, leading to major ecosystem shifts (Higdon & Ferguson, 2010). Therefore, due to the important role Bowhead Whales play in the Arctic marine ecosystem and their diminished population sizes, it is necessary to minimize their interaction with ore carriers and to prevent disturbance.

7.4 Atlantic Walrus

7.4.1 Life history

The Walrus (*Odobenus rosmarus*) is a large pinniped with front flippers which allow it to support itself upright, similar to otariids. However, its hind flippers are structured and function similarly to those of phocids (COSEWIC, 2006). Walrus are distinguished by their size, long tusks, and "moustache of quill-like vibrissae" (Figure 7.5) (COSEWIC, 2006, p.iv). In addition, the Walrus is the only living member of the Odobenidae family and *Odobenus* genus. There are two extant subspecies of the Walrus, the Atlantic Walrus (*O. r. rosmarus*) and the Pacific Walrus (*O. r. divergens*). The

Atlantic Walrus is the subspecies that will be focused on for this graduate project, as the Pacific Walrus is not found within the study area (COSEWIC, 2006).

Figure 7.5 Physical characteristics of the Atlantic Walrus (National Geographic Society, 2011).

7.4.2 Population Status

Most of the data that exist regarding Walrus population sizes are considerably outdated. Therefore, little is known about current population numbers. However, stocks appear to be stable and no significant changes in abundance have been observed (Stephenson & Hartwig, 2010, p.6). The Northern Hudson Bay-Davis Strait population may consist of several subpopulations inhabiting northern Hudson Bay, Hudson Strait, and Davis Strait, but there is currently not enough information to confirm this distinction. The size of this population was roughly estimated based on sightings, at 4850-5350 individuals in 1988, and at 6000 individuals in 1995 (COSEWIC, 2006). In 1989, an aerial survey was conducted over northern Foxe Basin and counted 475 Walruses. It was estimated that the Foxe Basin population consisted of 5500 individuals (95%CI 2700-11 200). However, this survey did not cover the entire northern Foxe Basin area and was not corrected for individuals that may have been out of view (COSEWIC, 2006).

7.4.3 DISTRIBUTION

The Canadian range of the Atlantic Walrus extends from Bathurst and Prince of Wales islands east to Davis Strait, and from James Bay northward to Kane Basin (Figure 7.6) (COSEWIC, 2006). There are currently four populations of Atlantic Walrus in Canada; the South and East Hudson Bay population, the Northern Hudson Bay-Davis Strait population, the Foxe Basin population, and the Baffin Bay (High Arctic) population (Figure 7.7) (COSEWIC, 2006). Of the four populations of Atlantic Walrus in Canada, two occupy areas of Foxe Basin and Hudson Strait: the Foxe Basin population and the Northern Hudson Bay-Davis Strait population, respectively (COSEWIC, 2006). Therefore, individual Walrus belonging to these populations are likely to interact with ore carriers traveling from Steensby Port through Foxe Basin and Hudson Strait towards Europe (COSEWIC, 2006).

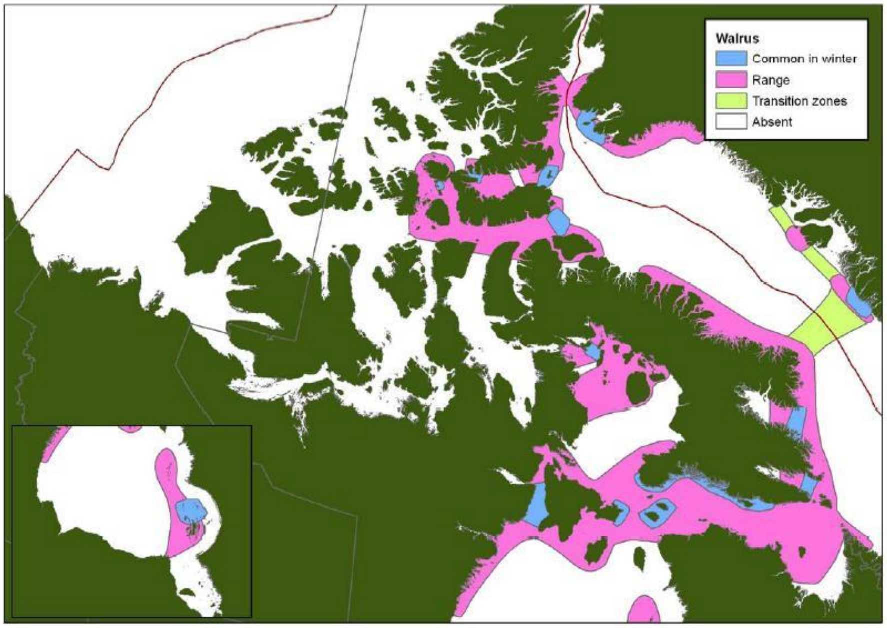

Figure 7.6 Distribution of the Atlantic Walrus within Canadian Arctic waters (Stephenson & Hartwig, 2010, p.47).

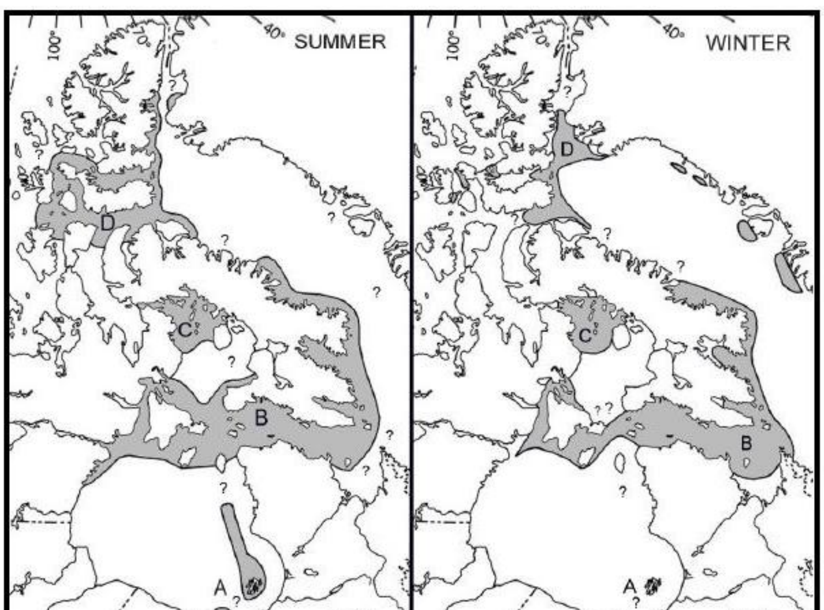

Figure 7.7 Summer and winter distributions of the four Atlantic Walrus populations within the Canadian Arctic: (A) South and East Hudson Bay, (B) Northern Hudson Bay-Davis Strait, (C) Foxe Basin, and (D) Baffin Bay. Question marks represent uncertainty regarding distribution and/or movements (COSEWIC, 2006).

7.4.4 Reasons for Selection

The Walrus was selected for this risk analysis because it occupies a narrow ecological niche, as it has very specific habitat requirements and has a limited diet (COSEWIC, 2006). Furthermore, the majority of its key habitat sites are not sufficiently protected (COSEWIC, 2006). Walrus require large areas of shallow water less than 80 m deep, with a large abundance of bivalves, open water, and nearby ice or land suitable for hauling out (COSEWIC, 2006). In addition, Walrus demonstrate high site fidelity, and return to the same few haul-out sites each year, suggesting that they may have difficulty adapting to changes in the environment or habitat disturbance (Stephenson & Hartwig, 2010, p.6).

Therefore, any physical impacts that icebreaking ore carriers, traveling through Foxe Basin and Hudson Strait, have on ice could greatly impact the Walrus. Furthermore, noise from icebreaking could cause Walruses to leave their haul-outs causing stampedes, could interrupt foraging, increase energy expenditure and stress, mask communication, and impair thermoregulation (COSEWIC, 2006). Chronic exposure to disturbance could cause Walrus populations to abandon key haul-out sites altogether, requiring them to find new sites further from ideal feeding grounds (Stephenson & Hartwig, 2010, p.6).

The 2006 COSEWIC Assessment and Update Status Report for the Walrus classifies it as a species of Special Concern. Furthermore, there is a considerable knowledge gap with respect to the Walrus' ability to re-colonize or adapt after being exposed to environmental change or disturbance (COSEWIC, 2006). Walrus are also still harvested in the Canadian Arctic and although the populations seem stable, the ability of the populations to sustain the harvest remains unknown. The quality of data for Walrus harvests in Canada also varies considerably (COSEWIC, 2006). Therefore, due to the importance of haul-out sites to the Walrus and uncertainty with regard to its status, it is necessary to minimize its interaction with ore carriers and to prevent disturbance.

7.5 COMMON EIDER

7.5.1 DISTINGUISHING CHARACTERISTICS

The Common Eider (*Somarteria mollissima*) is the largest duck in the Northern Hemisphere, and is more dependent on marine habitat than any other seaduck (Goudie, Robertson, & Reed, 2000). It can be distinguished by its size, its short, stout neck, and its distinctive wedge-shaped bill (Goudie, Robertson, & Reed, 2000). In addition, the plumage of the Common Eider can help to identify it (Figure 7.8). From fall until early summer, the adult male is mostly white on its upper parts, but with a black crown, belly, and rear-end. In addition, the nape and sometimes a line below the black crown and eye is tinged green (Goudie, Robertson, & Reed, 2000). During the summer through to early fall, the adult male’s basic plumage consists of an overall dark-brown colour, a brown breast with white flecking, with white secondaries and wing-coverts (Goudie, Robertson, & Reed, 2000). The female Common Eider is mainly rust coloured and evenly barred black, especially on its sides and flanks. Throughout the summer until early fall, the female’s colouring is generally more muted than in other months (Goudie, Robertson, & Reed, 2000).

Figure 7.8 Physical characteristics of the Common Eider. The male is shown on the left, and the female on the right (Goudie, Robertson, & Reed, 2000).

7.5.2 Population status

There are several subpopulations of Common Eider, three of which have important key habitat sites in Nunavut and the Northwest Territories (Mallory & Fontaine, 2004, p.15). These include the Pacific Common Eider (*S. m. v-nigrum*), Hudson Bay Common Eider (*S. m. sedentaria*), and Northern Common Eider (*S. m. borealis*) (National Geographic Society, 2008, p.36). The Northern Eider subpopulation breeds in the eastern Canadian Arctic and west Greenland, with key nesting areas along Hudson Strait (Heide-Jorgensen & Laidre, 2004). Population estimates for this subpopulation are approximately 300 000 breeding pairs (Mosbech, unpubl. data, as cited in Mallory & Fontaine, 2004, p.15).

7.5.3 Distribution

The Common Eider occupies Arctic and Subarctic coastal marine habitats and has a circumpolar distribution (Figure 7.9) (Goudie, Robertson, & Reed, 2000). Common Eiders are also colonial nesters, and can be found in groups of ten to several thousand pairs on coastal islands, islets, and low-lying coastal areas. In addition, female Common Eiders show high fidelity to their natal and previous breeding areas, often reusing the same nest site (Goudie, Robertson, & Reed, 2000). While there are some small colonies of Northern Common Eiders in Foxe Basin near Turton Island, a large portion of the breeding population is found in areas along Hudson Strait from April until October (Mallory & Fontaine, 2004, p.56).

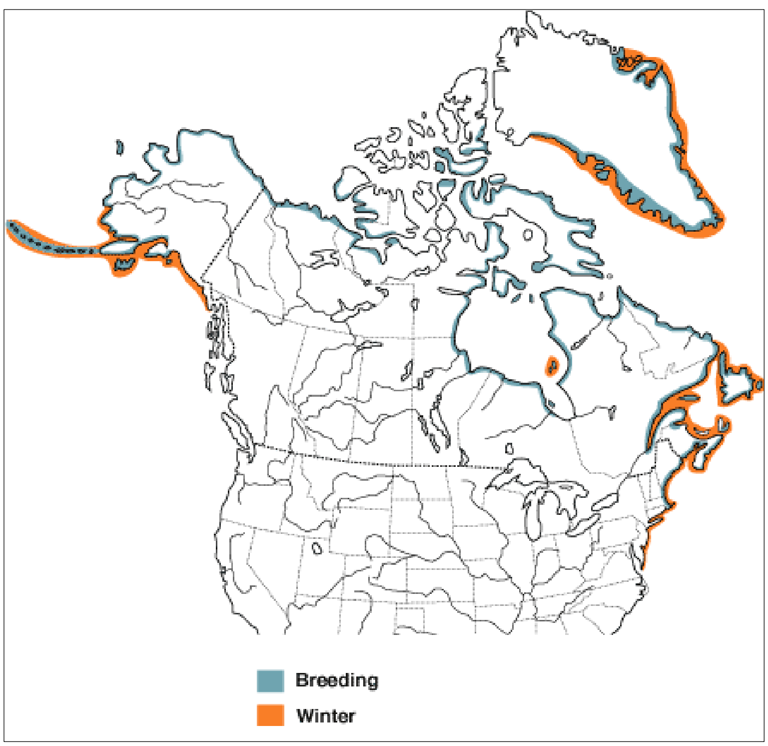

Figure 7.9 Distribution of the Common Eider in North America (Goudie, Robertson, & Reed, 2000).

Markham Bay is a low-lying area of small islands along the southern coast of Baffin Island (Figure 7.10). In 1998 and 1999, aerial surveys were conducted revealing approximately 44 500 individual eiders, representing 7% of the Canadian population of this subspecies (Mallory & Fontaine, 2004, p.61). In addition, the Ungava Bay Archipelago is inhabited by approximately 17 900 breeding pairs, representing another 6% of the Canadian population of this subspecies (Figure 7.11). Nesting sites are found on the Eider Islands, Plover and Payne Islands, Gyrfalcon Islands, and Northeast Ungava Bay Islands (Mallory & Fontaine, 2004, p.72).

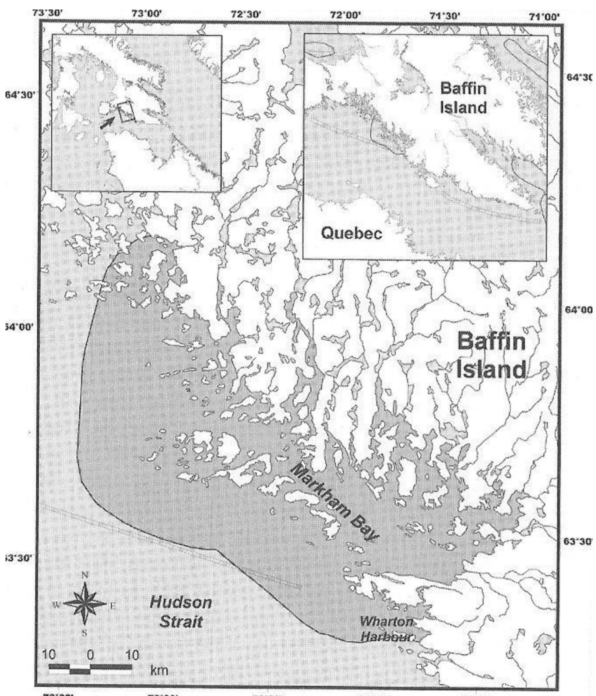

Figure 7.10 Map of Markham Bay Map where there are approximately 44 500 individual Common Eiders (Mallory & Fontaine, 2004, p.61).

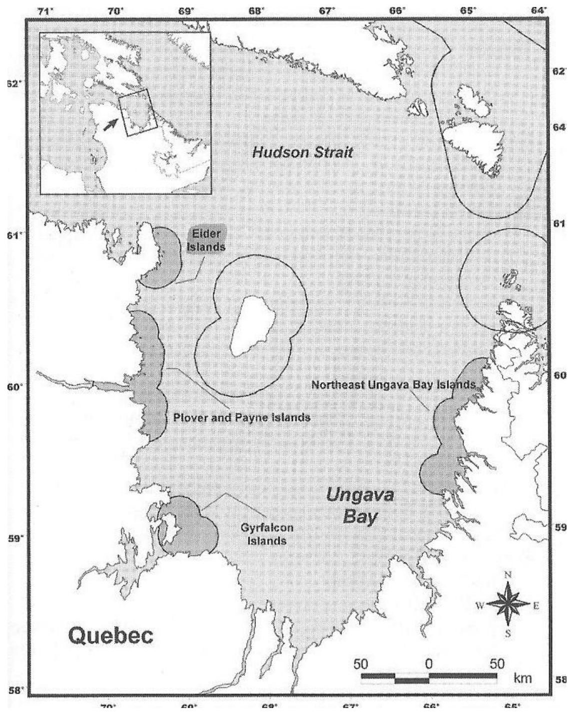

Figure 7.11 Map of the Ungava Bay Archipelago where there are approximately 17 900 breeding Common Eider pairs (Mallory & Fontaine, 2004, p.72).

7.5.4 Reasons for Selection

The Common Eider was selected for this risk analysis because of some of its key behavioural characteristics, and because its numbers have been diminishing in recent years due to harvesting practices. As previously stated, the Common Eider is a colonial nester and can be found in colonies of thousands of nesting pairs (Goudie, Robertson, & Reed, 2000). This behavioural characteristic of aggregating in large groups suggests that if an oil spill were to occur within the Hudson Strait, a significant portion of the population could be severely impacted.

In addition, Common Eiders nest in low-lying coastal areas and there is concern as to whether an increase in vessel traffic and the consequent wake of these large vessels could impact Common Eider nesting habitat. Other forms of disturbance, including noise, is also an issue as Common Eider females may leave their nests, leaving eggs to be preyed upon by gulls or other predators (Goudie, Robertson, & Reed, 2000). Furthermore, high site fidelity may indicate that Common Eiders will have difficulty adapting to habitat, or noise disturbance caused by ore carriers transiting Hudson Strait.

Finally, Northern Common Eiders have been traditionally harvested in the coastal areas of Newfoundland and Labrador, and northern Quebec (Reed & Erskine, 1986; Wendt & Silieff, 1986; Wendt, 1989, as cited in Goudie, Robertson, & Reed, 2000). It is expected that harvests likely surpass sustainable levels, therefore the Common Eider population may already be in a particularly vulnerable state (Goudie, Robertson, & Reed, 2000). Furthermore, it is essential that all these factors be taken into consideration and that management strategies incorporate ways to minimize interaction between this species and ore carriers transporting iron ore from Mary River.

7.6 THICK-BILLED MURRE

7.6.1 DISTINGUISHING CHARACTERISTICS

The Thick-billed Murre (*Uria lomvia*) is a true Arctic seabird, in that it spends its entire life in the Arctic and Subarctic (Gaston & Hipfner, 2000). It is also a member of the Alcidae family, made up of Auks, Murres, and Puffins, which are considered to be the "penguins of the north" (National Geographic Society, 2008, p.206). They are distinguished by their black and white colouring, and their set-back legs which allow them to stand upright on land (Figure 7.12) (National Geographic Society, 2008, p.206). The Thick-billed Murre is distinguished from the Common Murre by its shorter and thicker bill, for which it is named. It is also distinguished by its darker colouring around the throat and upper parts. Furthermore, the white of the Thick-billed Murre's under parts rises to a point on its neck, while the Common Murre's is rounded (National Geographic Society, 2008, p.206).

Figure 7.12 Physical characteristics of the Thick-billed Murre (Gaston & Hipfner, 2000).

7.6.2 Population status

The world population of Thick-billed Murres is estimated at around 15 to 20 million individuals, with 16% of that population residing in the eastern Canadian Arctic (Gaston & Jones, 1998, as cited in Gaston & Hipfner, 2000). The Atlantic subpopulation of Thick-billed Murres (*U. l. lomvia*), which occupies the eastern Canadian Arctic, is estimated at approximately 1 448 200 breeding pairs (Gaston & Hipfner, 2000, as cited in Mallory & Fontaine, 2004, p.15). Furthermore, geographic variation is evident between colonies in the western Atlantic, with larger individuals occurring in the Gulf of St. Lawrence, and the smallest in Ungava Bay (Storer, 1952, as cited in Gaston & Hipfner, 2000). Differences in physical measurements between colonies in Hudson Strait have also been observed (Gaston et al., 1984, as cited in Gaston & Hipfner, 2000).

7.6.3 Distribution

The Thick-billed Murre has a circumpolar distribution and resides in Arctic and Subarctic regions, breeding from 46° to 82°N latitude in the North Atlantic and Arctic Ocean (Figure 7.13) (Gaston & Hipfner, 2000). It nests in dense colonies, sometimes consisting of more than a million individuals, on steep cliffs found along the coast (Gaston & Hipfner, 2000). While there are no major colonies of murres found in Foxe Basin, more than 900 000 pairs of Thick-billed Murres breed in four colonies in Hudson Strait (Figure 7.14) (Gaston & Hipfner, 2000).

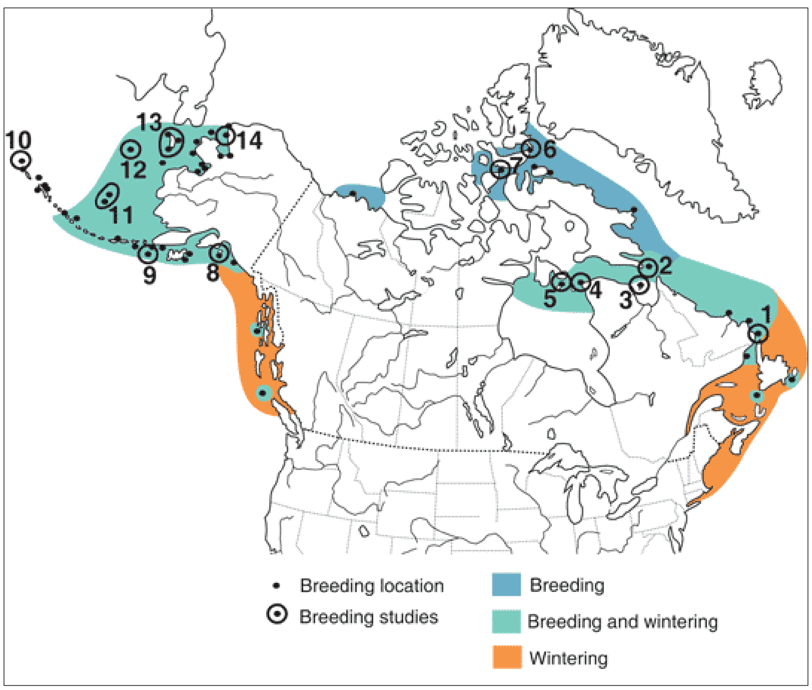

Figure 7.13 North American distribution of the Thick-billed Murre (Gaston & Hipfner, 2000).

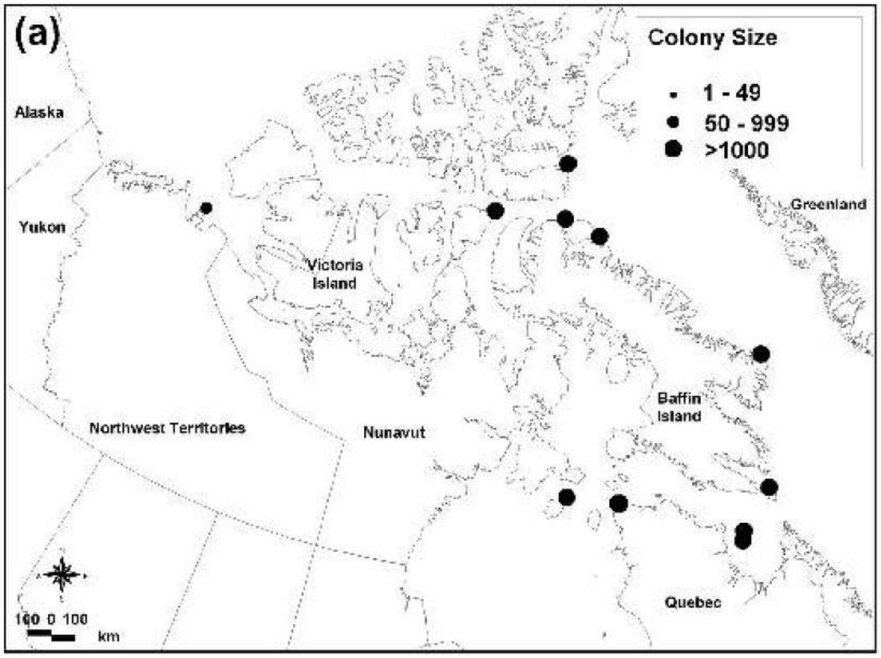

Figure 7.14 Major breeding colonies of Thick-billed Murres in the Canadian Arctic (Mallory & Fontaine, 2004, p.16).

In Digges Sound, located on the southwestern edge of Hudson Strait, there are two colonies of Thick-billed Murres, collectively made up of approximately 300 000 pairs, the equivalent of 20% of the Canadian population (Figure 7.15) (Gaston et al., 1985, as cited in Mallory & Fontaine, 2004, p.64). Another colony of around 50 000 Thick-billed Murre pairs is located on Hantzsch Island, representing approximately 3% of the Canadian population (Figure 7.16) (Nettleship, 1980, as cited in Mallory & Fontaine, 2004, p.66). Finally, two large colonies of Thick-billed Murres inhabit Akpatok Island, which is located within Ungava Bay (Figure 7.17). Together, the northern and southern colony are made up of approximately 520 000 breeding pairs (Gaston, 1991, as cited in Mallory & Fontaine, 2004, p.70). Therefore, Akpatok Island supports more than 20% of the Canadian population of Thick-billed Murres (Gaston & Hipfner, 2000).

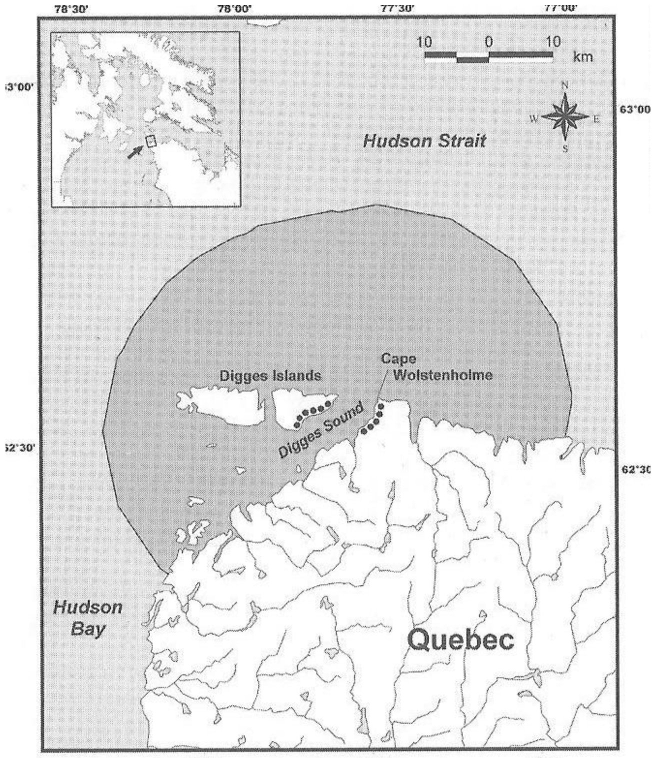

Figure 7.15 Map of Digges Sound where there are two colonies of Thick-billed Murres (Mallory & Fontaine, 2004, p.64).

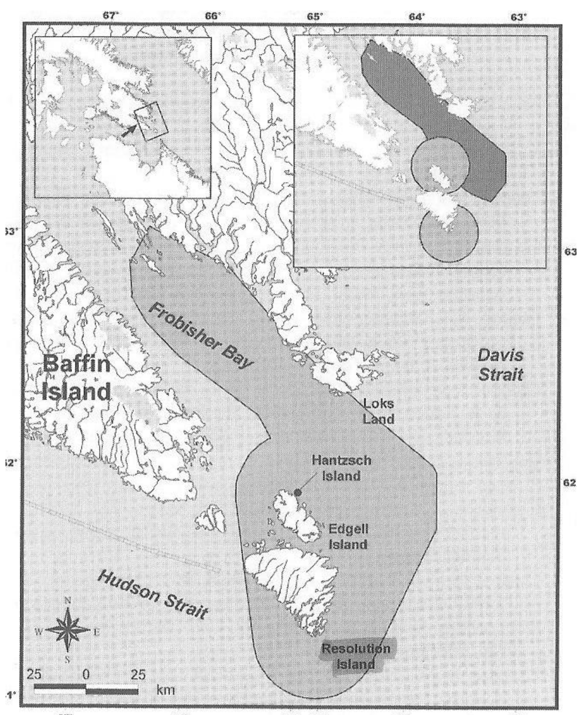

Figure 7.16 Map of Frobisher Bay where there is a colony of Thick-billed Murres that breed on Hantzsch Island (Mallory & Fontaine, 2004, p.66).

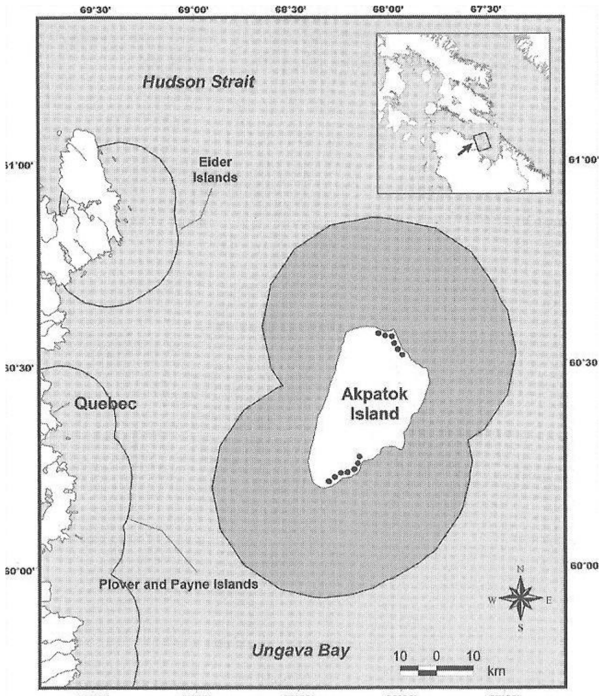

Figure 7.17 Map of Akpatok Island, located in Ungava Bay, where there are two large colonies of Thick-billed Murres (Mallory & Fontaine, 2004, p.70).

7.6.4 Reasons for Selection

The year-round shipment of iron ore from Steensby Port poses considerable threats to the Thick-billed Murre colonies found along Hudson Strait. As previously stated, more than 900 000 pairs collectively breed in this area; around 62% of the entire Canadian population (Gaston & Hipfner, 2000). Therefore, because this species aggregates in large groups a large portion of the Canadian population of Thick-billed Murres could be severely impacted by an incident such as an oil spill.

In addition, Thick-billed Murres are skilled divers and undergo a swimming migration with their young in the fall; traveling through Hudson Strait and south along the coast of Labrador (Gaston, 1982; Gaston & Elliot, 1991, as cited in Mallory & Fontaine, 2004, p.68). Since breeding is well synchronized within colonies, more than half of the birds from an individual colony could be starting this migration around the same time (Mallory & Fontaine, 2004, p.15). Due to these behaviours, Thick-billed Murres are arguably one of the most vulnerable seabird species to oil pollution.

8.0 RISK ANALYSIS

An analysis of the current situation in Foxe Basin and Hudson Strait for the Bowhead Whale, Atlantic Walrus, Common Eider, and Thick-billed Murre, with regard to current shipping activity is provided in this section. In addition, the potential risks to these species from the proposed year-round shipping for the Mary River Project, based on likelihood and consequence are assessed. The most pertinent threats to each of the four selected species, which will be assessed in this risk analysis are shown in Table 8.1.

Table 8.1 Pertinent threats to species selected for risk analysis

Species	Relevant Threats				
	Vessel Strikes	Noise	Pollution	Habitat Disturbance	Light
Bowhead Whale	X	X	X	--	--
Atlantic Walrus	--	X	X	X	--
Common Eider	--	X	X	--	X
Thick-Billed Murre	--	X	X	--	X

8.1 BOWHEAD WHALE

8.1.1 VESSEL STRIKES

In order to define the likelihood of a collision occurring between a Bowhead Whale and iron ore carrier, the distance between a vessel and whale was used as a key factor. Currently, there are no specific operational guidelines with respect to whale sightings for ships in the Canadian Arctic. However, general guidelines are provided to vessels by the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, as to what should be done if a whale is sighted (Figure 8.1). These guidelines are based on the distance between the whale and the ship and the intervals are defined as: 1 to 2 miles, 600ft to 1 mile, 300ft to 600 ft, 100 ft to 300 ft, and within 100ft (NOAA, 2010). The closer a vessel comes to a whale, the higher the risk of a collision occurring.

Therefore, the intervals used in the NOAA guidelines were used to define the likelihood of a collision occurring between a Bowhead Whale and iron ore carrier in this risk analysis.

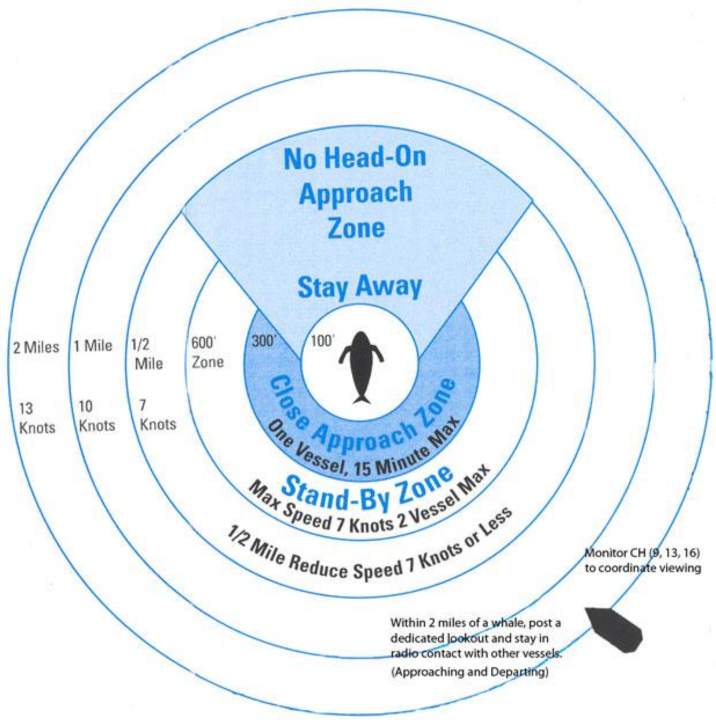

Figure 8.1 NOAA operational guidelines for ships in sight of whales (NOAA, 2010).

In addition to defining the likelihood of an incident occurring, it is also necessary to define the consequence of a vessel strike. This was done using abundance estimates for Bowhead whales occupying Foxe Basin and Hudson Strait. Although the Hudson Bay-Foxe Basin stock and Davis Strait-Baffin Bay stock are now considered one Eastern Canada-West Greenland stock, abundance estimates for the Hudson Bay-Foxe Basin stock (under the two-stock hypothesis) were used for this risk analysis. Furthermore, it was assumed that the abundance of the bowhead whale population wintering in the Hudson Strait is equal to the Foxe Basin-Hudson Bay population abundance (1525 individuals), as this is the group known to winter there regularly (COSEWIC, 2009). However, during the summer months whales are more likely to be on the western coast of Foxe Basin or Hudson Bay, as summering grounds range from areas in northern Foxe Basin as well as northwestern Hudson Bay around Southhampton Island (Figure 8.2) (COSEWIC, 2009). It is reasonable to assume that Bowhead Whales are less likely to be struck by ore carriers traveling from Steensby Port during the spring and summer, simply based on the fact that they are unlikely to be in the same area. Therefore, focus will be placed on the location of whales during the winter season, as this will provide a more conservative risk analysis.

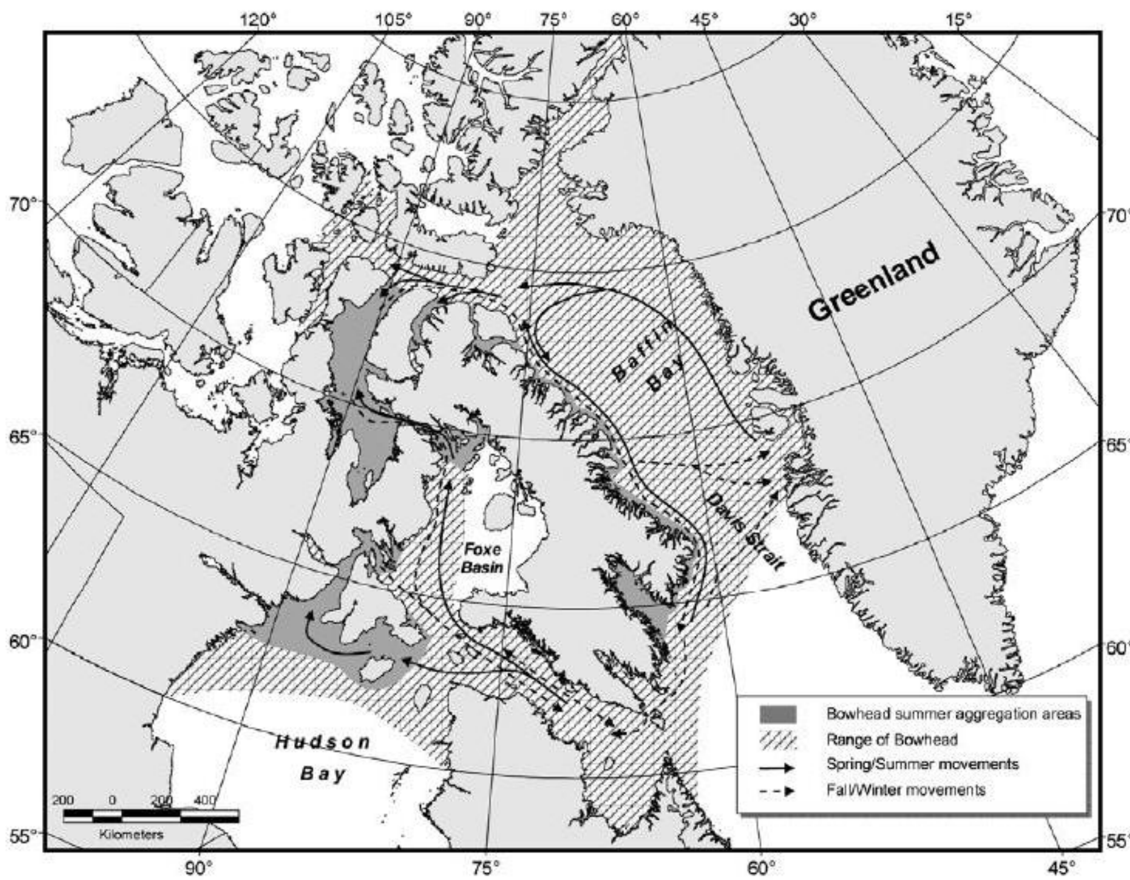

Figure 8.2 Seasonal distribution of Eastern Canada-West Greenland Bowhead Whale population, including summer aggregation areas, spring/summer movements, and fall/winter movements (COSEWIC, 2009).

According to DFO officials, the Eastern Canada-West Greenland Bowhead Whale population could sustain a hunt of up to 18 whales per year (CBC, 2009). At this point in time, DFO allows for two whales to be harvested each year for Inuit subsistence, however there is potential for this to increase (CBC, 2009). To define the various levels of consequence that could result from vessel strikes with Bowhead Whales, it is assumed that about one third of the Eastern Canada-West Greenland stock is wintering within Hudson Strait (1525/6344 individuals). Therefore, six whale strikes should be considered an extreme consequence. This is used as a guideline for the risk analysis and categories for consequence are defined as: more than 5 whales, 3 to 4 whales, 2 whales, 1 whale, and no whales per year.

Year-round shipping of iron ore from Steensby Port through Foxe Basin and Hudson Strait will increase the risk of mortality for Bowhead Whales from vessel strikes. The higher number of ships, especially in the Hudson Strait, will increase the likelihood of a ship coming within close proximity to Bowhead Whales. As a result, the chance of a ship strike occurring increases along with the potential for Bowhead Whale mortality. Furthermore, year-round shipping of iron ore for the Baffinland Mary River Project will also pose risks for Bowhead Whales to be injured from vessel strikes, potentially resulting in lower fitness and survival (COSEWIC, 2009). However, assuming that the Bowhead Whale population is capable of sustaining more injured whales than whale fatalities, the risk of injury from ship strikes will not be covered further.

Table 8.2 Frequency and Severity Indexes of the Risk for Bowhead Whale Mortality from a Ship Strike.

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	1-2 miles	1	Negligible	0 whales
2	Unlikely	600ft-1 mile	2	Low	1 whale
3	Moderate	300ft-600ft	3	Moderate	2 whales
4	Likely	100ft-300ft	4	Very High	3-4 whales
5	Almost Certain	<100ft	5	Extreme	>5 whales

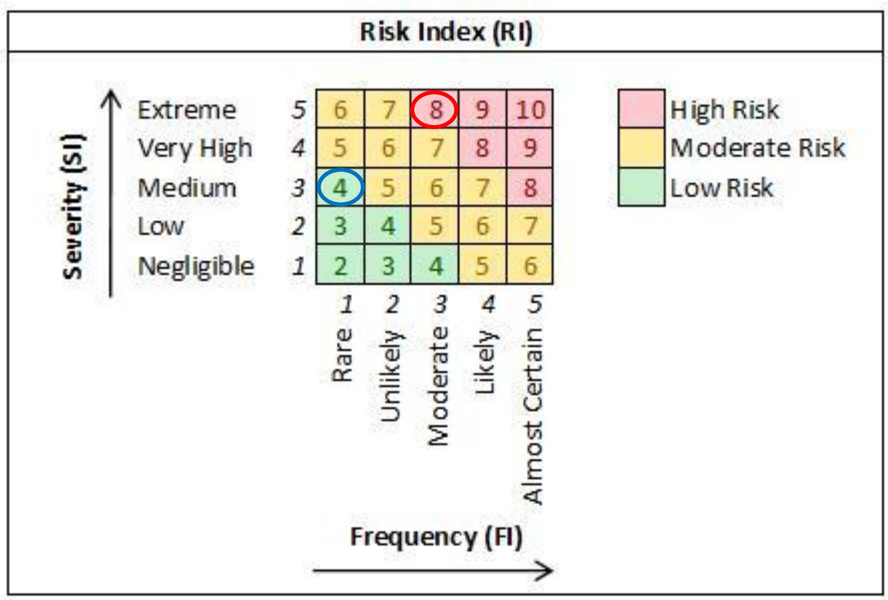

Figure 8.3 Matrix demonstrating the risk of Bowhead Whale mortality occurring due to a vessel strike. The blue point represents the current state. The red point represents the potential future state of risk with year-round shipping through Foxe Basin and Hudson Strait.

8.1.2 Noise Disturbance

Ships traveling more frequently through Foxe Basin and Hudson Strait will also increase the amount of ambient noise in the surrounding area. Cetaceans, such as the Bowhead Whale use sound to communicate, navigate, and detect predators (COSEWIC, 2009). If noise increases due to icebreaking ore carriers traveling from Steensby Port to Europe, it could potentially disturb important behaviours of the Bowhead Whale population. Kipple and Gabriele (2007) studied a variety of vessels in Glacier Bay, Alaska, and found that at a speed of 10 knots, the minimum sound level produced by a vessel was 157 dB and the maximum was 182 dB. However, ice-breaking vessels have been known to produce sound levels over 200 dB (Erbe, 1997, as cited in EIA, 2010; Erbe & Farmer, 2000).

In this analysis, it is assumed that the average sound intensity for an icebreaking ore carrier is 200 dB referenced to 1 μPa (in water). The level of disturbance to a whale from noise pollution depends on the distance between it and the ship emitting noise. Furthermore, according to the Bowhead Whale 2009 COSEWIC Assessment and Update Status Report, Bowhead Whales will react to vessels starting one to four kilometres away. Therefore, the distance range chosen to define the likelihood of noise disturbance in the matrix is as follows: within 1000 m disturbance is almost certain, and at a distance greater than 4000 m disturbance is rare.

Noise disturbance to whales can lead to temporary or permanent hearing loss. However, most whales will attempt to avoid vessels producing continuous noise above 120 Db (Richardson et al., 1995, as cited in EIA, 2010). In addition, stress from noise can impact critical behaviours related to reproduction and foraging (Wright et al., 2007). Since the consequences of noise disturbance are not typically life-threatening and are only expected to cause indirect impacts on behaviour and survival, the threshold for the extreme consequence category from the previous analysis for vessel strikes was classified as only a moderate level of consequence for noise disturbance.

At this point in time the amount of noise produced by vessels in Foxe Basin and Hudson Strait is minimal due to the low number of vessels traveling through the area and the low frequency of their trips. However, more frequent trips through Foxe Basin and Hudson Strait for the transportation of iron ore from Steensby Port to markets in Europe, will greatly impact the amount of ambient noise in those areas. Noise can travel further considerable distances in water than in air due to differences in density, and an increase in vessel traffic will make it more difficult for Bowhead Whales to avoid vessels and high noise levels. While minor disturbance is not major concern, continuous exposure to noise and subsequent stress could lead to more serious consequences.

Table 8.3 Frequency and Severity Indexes of the Risk for Bowhead Whale Disturbance from Noise

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>4000 m	1	Negligible	0 whales
2	Unlikely	3000-4000 m	2	Low	1-2 whale
3	Moderate	2000-3000 m	3	Moderate	3-5 whales
4	Likely	1000-2000 m	4	Very High	6-9 whales
5	Almost Certain	<1000 m	5	Extreme	>10 whales

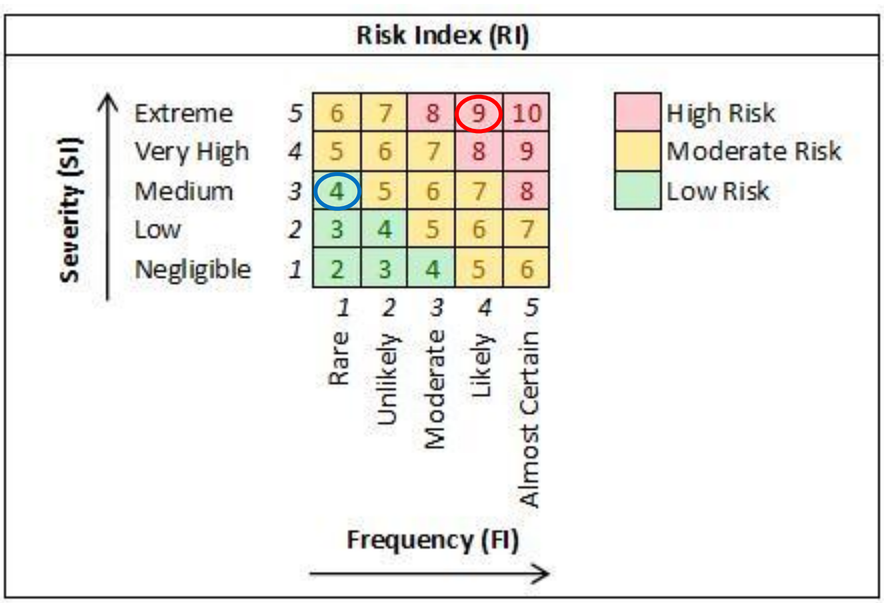

Figure 8.4 Matrix demonstrating the risk of whales being impacted by noise pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk with year-round traffic through Foxe Basin and Hudson Strait.

8.1.3 POLLUTION

A rise in the number of ships traveling through Foxe Basin and Hudson Strait from Steensby Port towards Europe and back again may also lead to pollution disturbances for Bowhead Whales. Furthermore, the possibility of an oil spill occurring in the Arctic is a major concern for all marine mammals (COSEWIC, 2009). This risk to baleen whales, in particular, is high because they feed on krill by skimming the ocean's surface and as a result, are more likely to ingest oil than toothed whales, such as the Narwhal and Beluga (COSEWIC, 2009).

In this analysis, the likelihood of an oil spill impacting bowhead whales in Foxe Basin and Hudson Strait is defined by the amount of oil that could be released during a spill. While the distance of a whale to the point source is important, it is difficult to predict the spill area without information on the flow rate, and environmental conditions such as wind, currents, and tides. Furthermore, it was necessary to simplify this due to the limits of this project and it is also more critical to focus on the total amount of oil spilt. This is due to the fact that the size of the spill directly impacts the extent of negative impacts at a distance away from the source. Spill are classified as <7 tonnes, between 7 to 700 tonnes, and >700 tonnes (ITOPF, 2010). These categories were used as a guideline to define the likelihood of disturbance occurring due to an oil spill. The consequence of pollution disturbance for the Bowhead Whale population was defined by the number of whales impacted within the assumed population of 1525 individuals occupying Foxe

Basin and Hudson Strait. Since oil pollution could lead to significant whale mortality, a similar scale to that used in the vessel strike analysis is used here.

Currently, the potential for a large oil spill to occur in Foxe Basin or Hudson Strait is rare due to small number of ships regularly transiting this area. However, the implementation of the Mary River Project will greatly increase the number of vessels and number of trips occurring in this area. Shipping iron ore year-round will pose challenges such as free-flowing ice and unpredictable weather, which make the Arctic environment particularly hazardous to ships. Fuel tankers, which pose an even greater threat, will also make three to five trips per year to Steensby Port during the open-water season to deliver fuel (Baffinland, 2010, Vol.3, p.112). Furthermore, the risk of a spill will increase as more ships travel to and from Steensby Port through Foxe Basin and Hudson Strait, although a large spill will still remain unlikely. However, it is important to note that while the likelihood of such an incident is rare, the consequences would be severe.

Table 8.4 Frequency and Severity Indexes of the Risk for Bowhead Whale Disturbance from Oil Pollution

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	<7 tonnes	1	Negligible	0 whales
2	Unlikely	7-200 tonnes	2	Low	1 whale
3	Moderate	200-400 tonnes	3	Moderate	2 whales
4	Likely	400-700 tonnes	4	Very High	3-4 whales
5	Almost Certain	>700 tonnes	5	Extreme	>5 whales

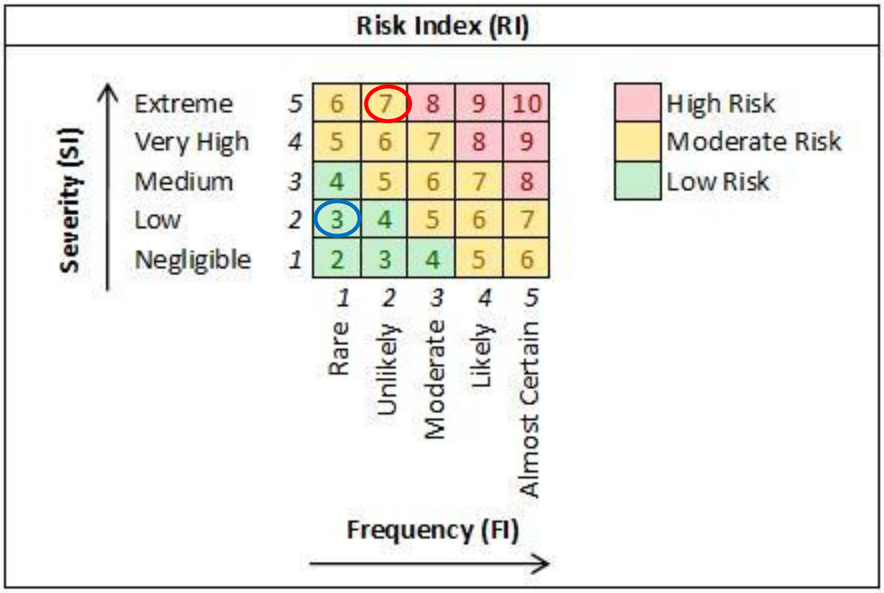

Figure 8.5 Matrix demonstrating the risk of whales being impacted by oil pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.2 Atlantic Walrus

8.2.1 Noise Disturbance

Like other marine mammals, the Walrus uses sound to communicate and can be negatively impacted by noise pollution (COSEWIC, 2006). Year-round shipping from Steensby Port through Foxe Basin and Hudson Strait, is expected to increase the amount of ambient noise in this area. While underwater noise may disrupt breeding songs, airborne noise can also impact the behaviour of Walrus hauled-out on the ice by sometimes causing them to stampede into the water expending valuable energy, trampling young, or leaving them to be preyed on by Polar Bears (COSEWIC, 2006; Richardson et al., 1995).

As in the analysis for the Bowhead Whale, it is assumed that the level of disturbance to Walrus from noise pollution depends on the distance between it and the ship emitting noise. In addition, studies have shown that icebreaking causes female Pacific Walruses to enter the water when the ship is within 500-1000 m, and causes male Walruses to enter the water when it is within 100-300 m (COSEWIC, 2006). Another study observed that icebreaking within 230 m caused more than 80% of the Walrus at a site to flee, but caused less than 10% to flee when icebreaking was more than 930 m away (Brueggman et al., 1990, 1991, 1992b, as cited in Richardson et al., 1995). Therefore, using this as a guideline, the distance range chosen to define the likelihood of noise disturbance in the matrix is as follows: within 250 m is almost certain, and at a distance greater than 1000 m disturbance is rare.

Defining the consequence of noise disturbance was done using abundance estimates for Walrus of the Northern Hudson Bay-Davis Strait population and the Foxe Basin population. According to the 2006 COSEWIC Assessment and Update Status Report for the Walrus, the population estimate for the northern Foxe Basin is 5 500 individuals. In addition, approximately 3000 individuals are expected to inhabit Hudson Strait (Born et al., 1995, as cited in Heide-Jorgensen & Laidre, 2004). While there is considerable uncertainty with respect to population estimates for Walrus, these are the best currently available (COSEWIC, 2006). Therefore, for the purpose of this analysis, it is assumed that the number of Atlantic Walrus occupying Foxe Basin and Hudson Strait that could interact with year-round iron ore shipping is 8 500 individuals.

The level of mortality that Atlantic walrus populations can sustain is not currently known. However, due to this lack of information, DFO uses yield rates of 2 to 5%, inferred from cetacean species with similar life characteristics and reproductive patterns (COSEWIC, 2006). Assuming that collectively the 8 500 Walrus in northern Foxe Basin and Hudson Strait could sustain a 3.5% loss each year (approximately 300 individuals) from harvesting, the population should be able to sustain noise disturbance to more individuals since the consequences of noise disturbance are not typically life-threatening. Therefore, the threshold for mortality (300 individuals) is set as a moderate level of consequence for this analysis. Therefore, the categories for consequence of noise disturbance are defined as: fewer than 150 Walrus, 150-300 Walrus, 300 to 450 Walrus, 450 to 600 Walrus, and more than 600 Walrus per year.

The current level of noise disturbance that Walrus populations are subjected to on a regular basis is quite low, due to infrequent shipping through the Arctic. However, shipping activity associated with the Mary River Project will greatly impact the risk of noise disturbance for Atlantic Walrus. Furthermore, noise produced by icebreaking ore carriers traveling through water as well as air has the potential to interrupt critical breeding and feeding behaviours, and to cause unnecessary stress. Potential stampedes caused by noise pollution could also lead to more serious consequences. Finally, continued exposure to high noise levels could eventually cause groups of Walrus to abandon important haul-out sights (COSEWIC, 2006).

Table 8.5 Frequency and Severity Indexes of the Risk for the Disturbance of Walrus from Noise

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>1000 m	1	Negligible	<150 Walrus
2	Unlikely	750-1000 m	2	Low	150-300 Walrus
3	Moderate	500-750 m	3	Moderate	300-450 Walrus
4	Likely	250-500 m	4	Very High	450-600 Walrus
5	Almost Certain	<250 m	5	Extreme	>600 Walrus

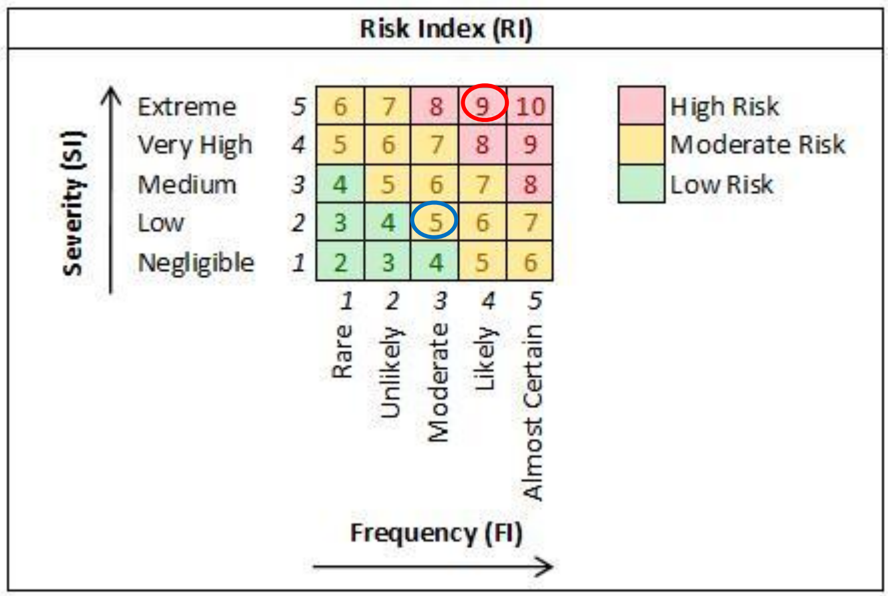

Figure 8.6 Matrix demonstrating the risk of Walrus being impacted by noise pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk with year-round traffic through Foxe Basin and Hudson Strait.

8.2.2 Pollution

While the direct and indirect impacts of oil on Walrus have not been sufficiently studied, it is expected that the behavioural characteristics of the Walrus and its life history would make it vulnerable to oil pollution (Born et al., 1995, as cited in COSEWIC, 2006). Being very social animals, Walrus are likely to spread oil to one another, and their preference for coastal areas and loose pack ice puts them in areas where oil is likely to accumulate (COSEWIC, 2006). Furthermore, the likelihood of an oil spill affecting Walrus populations can be defined by the amount of oil released into the area. Like the scale used for pollution disturbance to Bowhead Whales, the categories for the likelihood of disturbance are set as: less than 7 tonnes, 7-200 tonnes, 200-400 tonnes, 400-700 tonnes, and greater than 700 tonnes.

With respect to consequence, the level of pollution disturbance for the Walrus population was defined by the number of walruses impacted within the assumed population of 8500 individuals, occupying Foxe Basin and Hudson Strait. Since oil pollution could lead to Walrus mortality, the 3.5% sustainable yield (300 individuals) of the population for annual harvest was again used as a guideline. Harvest data suggests that Walrus inhabiting northern Foxe Basin and Hudson Strait may already be experiencing an annual loss of around 5% (425 individuals) of the population from harvesting. Therefore, it is unlikely that the population could withstand the loss of many more individuals on top of the annual harvest. Taking this into consideration, more than 10 Walrus fatalities from a spill should be considered an extreme consequence. This is used as a guideline for the risk analysis, and categories for consequence are defined as: 0 Walrus, 1 to 2 Walrus, 3 to 5 Walrus, 6 to 9 Walrus, and more than 10 Walrus.

As previously stated, the risk of a major spill occurring in Foxe Basin or Hudson Strait, is currently quite low. This is due to there being few ships that travel through these areas on a regular basis and because ships that do transit these areas usually do so during the open-water season. However, year-round shipping associated with the Mary River Project from Steensby Port through Foxe Basin and Hudson Strait, will greatly increase the number of vessels and the frequency of trips being made in these areas. Traveling through ice-covered waters in winter can be hazardous, as severe weather and moving ice are not uncommon. Furthermore, although a large spill will still remain unlikely with year-round shipping, it remains important to consider that the consequences of such an incident would be very severe.

Table 8.6 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Walrus

Frequency Index (FI)			Severity Index (SI)		
FI	Frequency	Definition	SI	Severity	Definition
1	Rare	<7 tonnes	1	Negligible	0 Walrus
2	Unlikely	7-200 tonnes	2	Low	1-2 Walrus
3	Moderate	200-400 tonnes	3	Moderate	3-5 Walrus
4	Likely	400-700 tonnes	4	Very High	6-9 Walrus
5	Almost Certain	>700 tonnes	5	Extreme	>10 Walrus

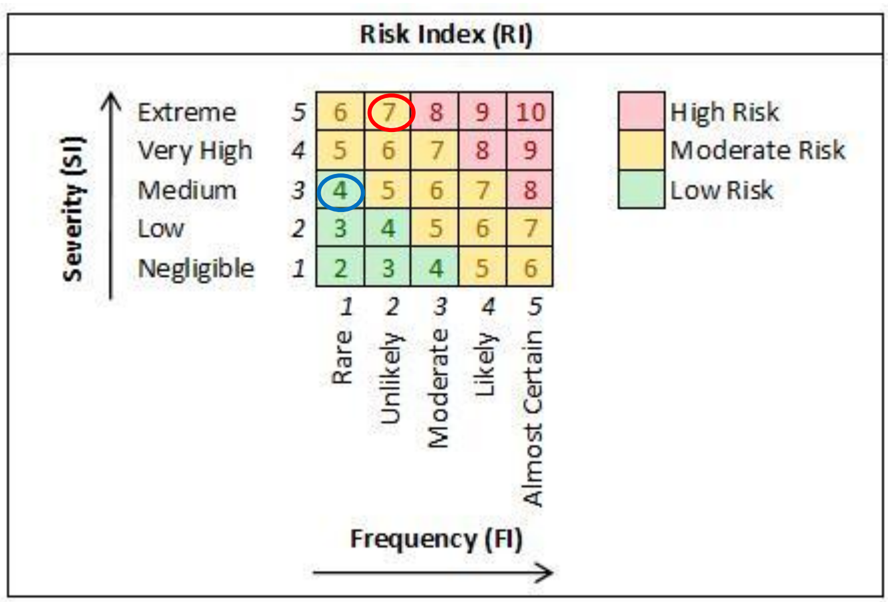

Figure 8.7 Matrix demonstrating the risk of Walrus being impacted by oil pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.2.3 ICEBREAKERS AND HABITAT DISTURBANCE

Walrus are highly sensitive to sea ice changes, as they are extremely reliant on suitable substrate near feeding areas for hauling-out and resting (Laidre et al., 2008). They also occupy a narrow ecological niche, requiring large areas of shallow water, with high amounts of bivalve molluscs and open water (COSEWIC, 2006). Therefore, any physical impacts that icebreaking ore carriers, traveling through Foxe Basin and Hudson Strait, have on ice and important haul-out areas could greatly impact the Walrus. In addition, while Walrus populations display high site fidelity (Stephenson & Hartwig, 2010, p.6), degradation of ideal habitat could force groups of Walrus to find new, less desired areas for hauling-out.

The likelihood of icebreaking ore carriers impacting ice haul-outs for Walrus in Foxe Basin and Hudson Strait is dependent on the location of haul-out sites relative to the nominal shipping route proposed for the Mary River Project. Year-round shipping will require icebreaking through pack ice most of the year. According to Laidre et al. (2008), dense annual pack ice is critical for Walrus populations, followed by loose annual pack ice. Pack ice is constantly in motion, therefore once a vessel passes through, the ship track produced is quickly closed in. It is expected that the area of disturbance caused by icebreaking through pack ice will equate to 0.025% of the pack ice in the RSA (320 000 km^2), and 0.05% in the LSA (146 000 km^2) (Baffinland, 2010, Vol. 8, p.11).

It is unknown whether icebreaking will cause increased motion in nearby pack ice or impact the Walrus' ability to haul-out, therefore the likelihood of disturbance is difficult to define. As a result, in this analysis the risk of disturbance to Walrus in Foxe

Basin and Hudson Strait will be based on distance from the shipping corridor. The LSA for the sea ice assessment in Baffinland's DEIS includes the shipping corridor as well as a 50 km wide zone on either side of it (Baffinland, 2010, Vol.8, p.8). This was used as a guideline in defining the likelihood of disturbance to important Walrus habitat as: less than 5 km, 5 to 15 km, 15 to 30 km, 30 to 50 km, and more than 50 km.

As habitat disturbance from icebreaking is not directly life-threatening, a similar scale to that used for noise disturbance was used to define the consequence of habitat disturbance from icebreaking on Walrus in Foxe Basin and Hudson Strait. Currently, the level of habitat disturbance from icebreaking in Foxe Basin and Hudson Strait is relatively low, due to a lack of shipping during the winter months. However, shipping activity associated with the Mary River Project will greatly impact the risk of habitat disturbance if there are important Walrus haul-out sites within 50 km of the shipping corridor. For this analysis it is assumed that there may be haul-out sites within this area, therefore the closer a ship is to that habitat the more likely it is to be disturbed. More information will need to be gathered on where critical haul-out sites are with respect to the shipping route and studies on the impacts of icebreaking on pack ice will need to be done in order to complete a more accurate analysis.

Table 8.7 Frequency and Severity Indexes of the Risk of Habitat Disturbance from Icebreaking impacting Walrus

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>50 km	1	Negligible	<150 Walrus
2	Unlikely	30-50 km	2	Low	150-300 Walrus
3	Moderate	15-30 km	3	Moderate	300-450 Walrus
4	Likely	5-15 km	4	Very High	450-600 Walrus
5	Almost Certain	<5 km	5	Extreme	>600 Walrus

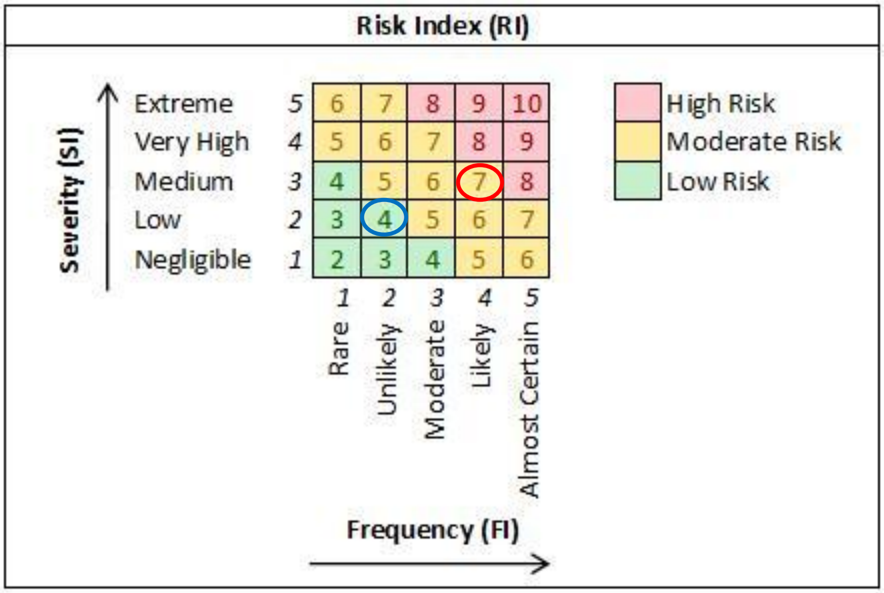

Figure 8.8 Matrix demonstrating the risk of Walrus being impacted by habitat disturbance due to icebreaking. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.3 Common Eider

8.3.1 Noise Disturbance

All vessels produce noise as a result of their operation, with larger ships traveling at greater speeds producing more noise than those that are smaller and traveling less quickly (AMSA, 2009, p.145). While all vessels could potentially cause noise disturbances to wildlife, icebreaking ships produce louder and more variable noise, caused by ramming forward into ice, reversing, and then beginning the process again (AMSA, 2009, p.146). Year-round shipping activity for the Mary River Project will increase the amount of ambient noise in Foxe Basin and Hudson Strait, potentially impacting bird colonies that breed in those areas from April through October, such as the Common Eider.

Anthropogenic disturbance from noise can cause deleterious responses in various species, such as increased stress. These responses usually begin to occur when an individual is exposed to a noise level of 55 to 60 dB in air (Dooling & Popper, 2007, as cited in Barber, Crooks, & Fristrup, 2009). As in the analysis done for the Bowhead Whale and Walrus, the noise emitted by an icebreaker is assumed to be 200 dB in water, making it the equivalent of approximately 140 dB in air (Acoustic Ecology Institute, 2001). While the majority of the breeding period for Common Eiders overlaps with the open-water season, Baffinland expects that ore carriers will have to travel through pack-ice for the majority of the year (Baffinland, 2010, Vol. 8, p.11). Therefore, for simplicity and to ensure a conservative estimate this noise level will be used with respect to the entire breeding season.

The level of disturbance to Common Eiders from noise pollution depends on the distance between it and the icebreaker emitting sound. Noise level decreases by 6 dB each time the distance between the receiver and sound source is doubled (Hansen, n.d., p.38). The expression $L_p = L_m - 20\log_{10} [r/r_m]$ allows for the sound pressure level, L_p, to be estimated at some distance, r, from the sound source, where L_m represents the sound pressure level measured at a reference distance, r_m, from the sound source (usually at least 1 m) (Hansen, n.d., p.38). Based on the noise level produced by an icebreaker in air (140 dB) and given that most responses begin to occur when an individual is exposed to a noise level of 55 to 60 dB, it was determined that when L_m = 140 dB and L_p = 60 dB, the distance between them is 10 km (assuming the reference distance is 1 m) (Figure 8.9). This was used as a guideline to define the likelihood of noise disturbance. The categories are as follows: less than 1 km, 1 to 3 km, 3 to 6 km, 6 to 10 km, and more than 10 km.

$$L_p = L_m - 20\log_{10}[r/r_m]$$

$$L_p = L_m - 20\log_{10}(r) - 20\log_{10}(r_m)$$

$$L_p - L_m = -20\log_{10}(r) - 20\log_{10}(r_m)$$

$$60 - 140 = -20\log_{10}(r) - 20\log_{10}(1)$$

$$-80 = -20\log_{10}(r) - 0$$

$$80 = 20\log_{10}(r)$$

$$4 = \log_{10}(r)$$

$$r = 10^4$$

$$r = 10\,000\text{ m}$$

Figure 8.9 Solved equation demonstrating how noise level produced by icebreaker of 140 dB drops to 60 dB at a distance of 10 km.

The level of exposure to Common Eiders from noise pollution was determined based on population estimates for the species within Foxe Basin and Hudson Strait. Population estimates for the Northern Common Eider are around 300 000 pairs (Mallory & Fontaine, 2004, p.15). However, based on estimates from key sites within Hudson Strait, as colonies of Common Eiders are rare along the western coast of Baffin Island and in northern Foxe Basin, there are approximately 200 000 pairs that breed within this area and that are subject to disturbance from year-round shipping.

Common Eiders are hunted in the north, both in Canada and Greenland. Furthermore, Northern Common Eiders wintering in west Greenland, around 460 000 birds (Merkel et al., 2002, as cited in Merkel, 2004) which consist of approximately 90% of Canadian breeding birds, are one of the most heavily hunted species of bird in

Greenland (Piniarneq, 2003, as cited in Gilliland et al., 2009). Annual harvest in Western Greenland averages between 55 000 to 70 000 per year. For it to be sustainable, this harvest would have to be reduced by 40% to 33 000 individuals per year (7% yield) (Gilchrist et al., 2001, as cited in Merkel, 2004). Furthermore, the level of mortality that Common Eiders inhabiting the Hudson Strait can sustain is 7% of 400 000 birds; equal to 28 000 individuals. Logically, the population should be able to sustain noise disturbance to more individuals, as the consequences of noise disturbance are not usually life-threatening. Therefore, the threshold for mortality from harvesting at a sustainable level (28 000 individuals) was set as a moderate level of consequence for this analysis. The categories for consequence are defined as: less than 10 000, 10 000 to 20 000, 20 000 to 30 000, 30 000 to 50 000, and more than 50 000 Common Eiders per year.

At this point in time, it is unlikely that Common Eiders are regularly being exposed to high noise levels, due to the low number of ships traveling through Foxe Basin and Hudson Strait. While currently most shipping only occurs during the open-water season, year-round transportation of iron ore for the Mary River Project will consist of at least 102 round trips from Steensby Port to Europe each year (Baffinland, 2011, Vol. 3, p.100). This will have a major impact on the level of ambient noise in Foxe Basin and Hudson Strait and will increase the risk of Common Eiders being disturbed by noise pollution.

Table 8.8 Frequency and Severity Indexes for the Risk of Noise Disturbance to Common Eiders

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>10 km	1	Negligible	<10 000 CE
2	Unlikely	6 to 10 km	2	Low	10 000-20 000 CE
3	Moderate	3 to 6 km	3	Moderate	20 000-30 000 CE
4	Likely	1 to 3 km	4	Very High	30 000-50 000 CE
5	Almost Certain	<1 km	5	Extreme	>50 000 CE

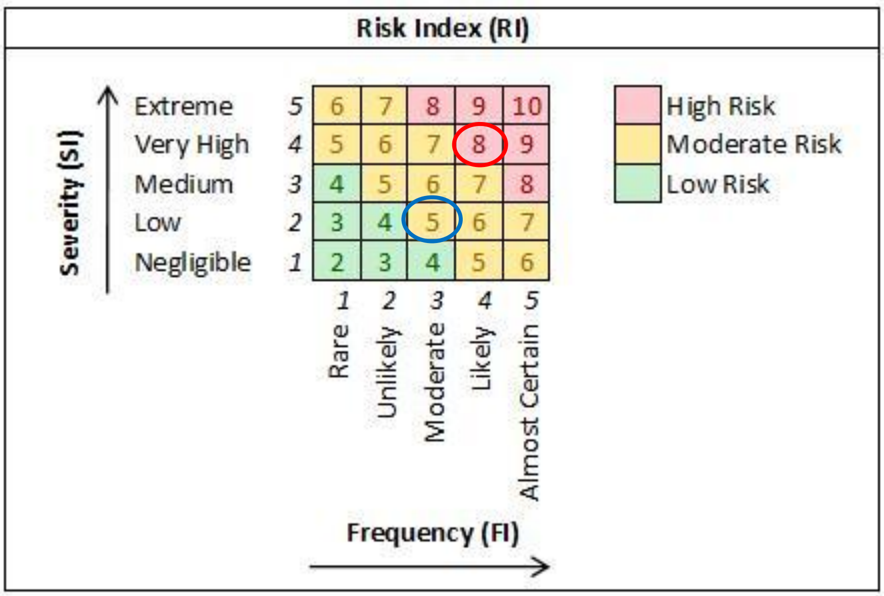

Figure 8.10 Matrix demonstrating the risk of Common Eiders being impacted by noise pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk with year-round traffic through Foxe Basin and Hudson Strait.

8.3.2 POLLUTION

The Common Eider nests in large colonies with thousands of other breeding pairs in coastal areas (Goudie, Robertson, & Reed, 2000). This behaviour of aggregating in large groups near the shore puts it at particular risk of being affected by a possible oil spill in the Arctic marine environment. As a significant portion of Canada's Northern

Common Eider population is found within colonies along the Hudson Strait, a significant portion of the population could be severely impacted if a spill were to occur due to increased activity associated with the Mary River Project. Therefore, the likelihood of an oil spill affecting Common Eiders can be defined by the amount of oil released into the area. Like the scale used for pollution disturbance to Bowhead Whales and Walrus, the categories for the likelihood of disturbance are set as: less than 7 tonnes, 7-200 tonnes, 200-400 tonnes, 400-700 tonnes, and greater than 700 tonnes.

The Common Eider, like other waterfowl and seabirds, is at great risk of being oiled if a spill were to occur. This could impair its ability to regulate body temperature, as feathers are used for insulation, which would most likely result in death. Therefore, the level of exposure pertaining to pollution disturbance for the Common Eider population was defined as the number of Common Eiders within Foxe Basin and Hudson Strait impacted by pollution, assuming the population to be around 400 000 individual birds. Since oil pollution would likely lead to mortality in the Common Eider population, the 7% sustainable yield for the population was again used as a guideline. In this case, harvest levels are already too high, which makes it unlikely that this population could sustain a substantial loss of individuals. Taking this into consideration, more than 2% of the population being lost due to an oil spill should be considered an extreme consequence. This is used as a guideline for the risk analysis and the categories for consequence are defined as: less than 1000, 1000 to 3000, 3000 to 5000, 5000 to 8000, and more than 8000 Common Eiders.

While the likelihood of a large oil spill occurring in Foxe Basin or Hudson Strait is low because of the small number of ships traveling through the area, this does eliminate the threat and does not mean that necessary precautions should not be taken. In addition, year-round shipping of iron ore from Steensby Port will require ore carriers to traverse through the study area under particularly hazardous conditions, such as severe weather and heavy ice conditions. This increases the potential for an accident to occur and as a result, the risk of a large oil spill increases as well.

Table 8.9 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Common Eiders

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	<7 tonnes	1	Negligible	<1000 CE
2	Unlikely	7-200 tonnes	2	Low	1000-3000 CE
3	Moderate	200-400 tonnes	3	Moderate	3000-5000 CE
4	Likely	400-700 tonnes	4	Very High	5000-8000 CE
5	Almost Certain	>700 tonnes	5	Extreme	>8000 CE

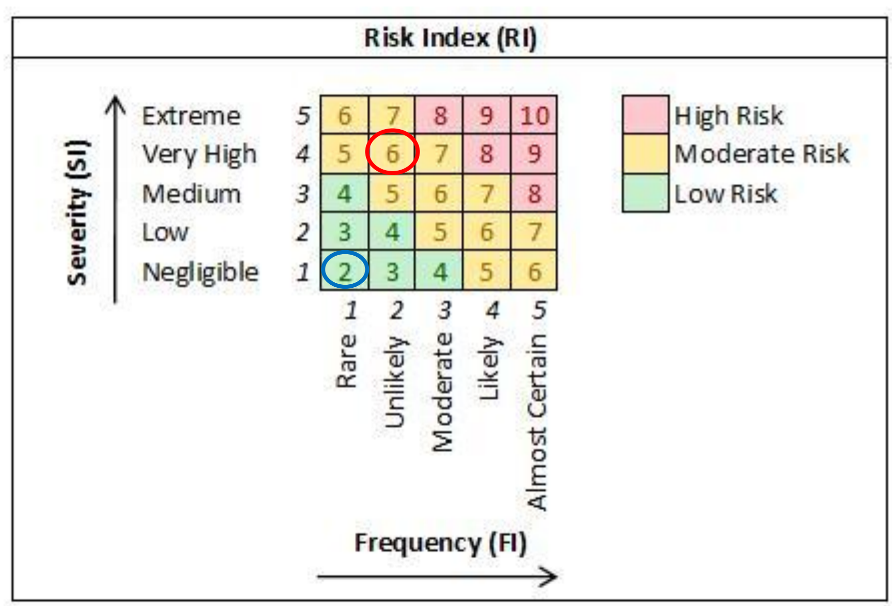

Figure 8.11 Matrix demonstrating the risk of Common Eiders being impacted by oil pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.3.4 Light Disturbance

In the Arctic, the fall migration period appears to be when light disturbance is most likely to cause collisions with birds. This is because young birds are traveling for the first time and storms become more frequent (AMSA, 2009, p.150). Furthermore, year-round vessel traffic through Foxe Basin and Hudson Strait will require ships to be lighted when operating in darkness. Assuming that there is a possibility for Arctic breeding birds to interact with lighted ships during fall and spring migrations, the likelihood of a collision occurring is defined by flight altitude above sea level. Studies have shown that migration altitude varies considerably, but that species migrating at lower altitudes are more likely to be disturbed by light. Furthermore, a study by Cooper and Ritchie (1995, as cited in Ogden, 1996), found that a large proportion of birds fly below an altitude of 500 m, while others found that it ranges from anywhere below 2000 m (Able, 1970; Eastwood & Rider, 1965; Nisbet, 1963; Richardson, 1971a,b, 1972, as cited in Ogden, 1996). This was used as a guideline to define likelihood of light disturbance in categories of: less than 250 m, 250 to 500 m, 500 to 1000 m, 1000 to 2000 m, and greater than 2000 m.

Light can disorient or entrap birds at night, sometimes resulting in a collision (Ogden, 1996). Collisions with vessels due to light disturbance usually cause mortality in birds (Dick & Donaldson, 1978). Therefore, for this analysis the level of consequence will be defined by the number of Common Eider fatalities each year. As the population of Common Eiders is already declining, a loss of more than 2% of the group inhabiting Foxe Basin and Hudson Strait due to light disturbance, should be considered extreme.

Therefore, the categories for consequence are defined as: less than 1000, 1000 to 3000, 3000 to 5000, 5000 to 8000, and more than 8000 Common Eiders.

While the likelihood of such an incident occurring is minimal due to there being little darkness during the shoulder seasons, inclement weather could increase the risk as birds are likely to fly closer to sea level (Longcore & Rich, 2004). In addition, Common Eiders have been shown to collide with large vessels off the coast of western Greenland (AMSA, 2009, p.150). Therefore, the risk of Common Eiders colliding with ore carriers transporting iron ore from Steensby Port through Foxe Basin and Hudson Strait is relatively low through the majority of the breeding period. However, in cases of severe weather where birds are forced to fly at lower altitudes during spring and fall migration, it is much more likely.

Table 8.10 Frequency and Severity Indexes of the Risk of Light Disturbance for Common Eiders

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>2000 m	1	Negligible	<1000 CE
2	Unlikely	1000-2000 m	2	Low	1000-3000 CE
3	Moderate	500-1000 m	3	Moderate	3000-5000 CE
4	Likely	250-500 m	4	Very High	5000-8000 CE
5	Almost Certain	<250 m	5	Extreme	>8000 CE

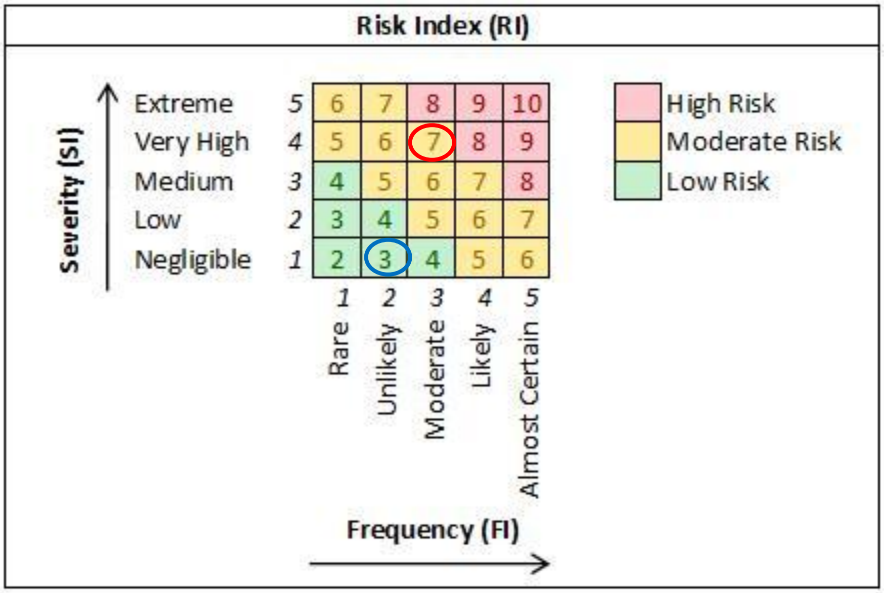

Figure 8.12 Matrix demonstrating the risk of Common Eiders being impacted by light disturbance from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.4 THICK-BILLED MURRE

8.4.3 NOISE DISTURBANCE

As previously stated, year-round shipping activity for the Mary River Project will increase the amount of ambient noise in Foxe Basin and Hudson Strait, potentially impacting bird colonies that breed in those areas from spring until fall, such as the Thick-billed Murre. Anthropogenic disturbance caused by noise pollution can increase stress levels in various species. These types of responses usually begin to occur when an individual is exposed to a noise level of 55 to 60 dB in air (Dooling & Popper, 2007, as cited in Barber, Crooks, & Fristrup, 2009). As in the analysis done for the Common Eider, the noise emitted by an icebreaker is assumed to be approximately 140 dB in air (200 dB in water) (Acoustic Ecology Institute, 2001). The level of disturbance to Thick-billed Murres from noise pollution depends on the distance between it and the sound source. As was determined in the analysis for the Common Eider, 140 dB drops to around 60 dB at a distance of 10 km. Therefore, the likelihood of noise disturbance, with respect to distance, was defined in these categories: less than 1 km, 1 to 3 km, 3 to 6 km, 6 to 10 km, and more than 10 km. The level of exposure to Thick-billed Murres from noise pollution was determined based on population estimates for the species within Foxe Basin and Hudson Strait. While there are no major colonies of Murres found in Foxe Basin, it is estimated that more than 900 000 pairs of Thick-billed Murres breed in four colonies in Hudson Strait (Gaston & Hipfner, 2000).

Thick-billed Murres are extremely vulnerable to oil pollution and it is estimated that they represented approximately 56.3 to 87.5% of the estimated annual kill from oil in Newfoundland (160 735-274 877 individuals) from 1998 to 2001 (Wiese, 2002a, as cited in Wiese, Robertson, & Gaston, 2003). For this analysis, an average of approximately 220 000 individuals will be used. In addition, wintering Thick-billed Murres are hunted annually in Newfoundland and Labrador. Harvest data suggests that around 200 000 individuals are hunted each year. It is believed that 80% of the Thick-billed Murres wintering in Newfoundland and Labrador breed in the eastern Canadian Arctic (Tuck, 1961; Gaston, 1980; Kampp, 1988; Donaldson et al., 1997, as cited in Wiese, Robertson, & Gaston, 2003).

Despite limitations, it was assumed that 80% of this annual harvest consists of Thick-billed Murres that breed in the eastern Canadian Arctic (160 000 individuals) for this analysis. Therefore, approximately 380 000 Thick-billed Murres (220 000+160 000) are killed each year due to oiling and harvest in Newfoundland and Labrador. Due to subsistence harvesting that occurs throughout the Canadian Arctic, this value will be raised to 400 000 individuals per year (10% of the 1.95 million breeding pairs in the eastern Canadian Arctic) (Nettleship & Evans, 1985; Gaston & Jones, 1998, as cited in Wiese, Robertson, & Gaston, 2003). Since it is believed that the Thick-billed Murre population is stable within the Canadian Arctic, it is assumed that the population can currently sustain this loss. Therefore, assuming that loss is evenly distributed across the population, the level of mortality that Thick-billed Murres inhabiting the Hudson Strait (200 000 pairs) experience annually is approximately 40 000 birds. Logically, the population should be able to sustain noise disturbance for more individuals, as the consequences of noise disturbance impact behaviour and are not usually life-threatening. Therefore, the level of mortality of 40 000 individuals was set as a moderate level of consequence for this analysis. Furthermore, the five categories for defining consequence in this analysis are: less than 20 000, 20 000 to 40 000, 40 000 to 60 000, 60 000 to 80 000, and more than 80 000 Thick-billed Murres per year.

While the risk of Thick-billed Murres being regularly exposed to high noise levels at this time is low, an increase in regular vessel traffic due to year-round shipping activity for the Mary River Project through Foxe Basin and Hudson Strait will increase this risk substantially. It is also important to note that due to the behavioural characteristics of the Thick-billed Murre, such as its annual swimming migration in the fall, it could be impacted significantly by underwater noise as well as sound traveling in air. Although, not many studies have been done to analyze the effects of underwater sound on birds, their swimming migration increases the likelihood of the Thick-billed Murre being disturbed by noise pollution and is important to consider.

Table 8.11 Frequency and Severity Indexes for the Risk of Noise Disturbance to Thick-billed Murres

Frequency Index (FI)			Severity Index (SI)		
FI	Frequency	Definition	SI	Severity	Definition
1	Rare	>10 km	1	Negligible	<20 000 TBM
2	Unlikely	6 to 10 km	2	Low	20 000-40 000 TBM
3	Moderate	3 to 6 km	3	Moderate	40 000-60 000 TBM
4	Likely	1 to 3 km	4	Very High	60 000-80 000 TBM
5	Almost Certain	<1 km	5	Extreme	>80 000 TBM

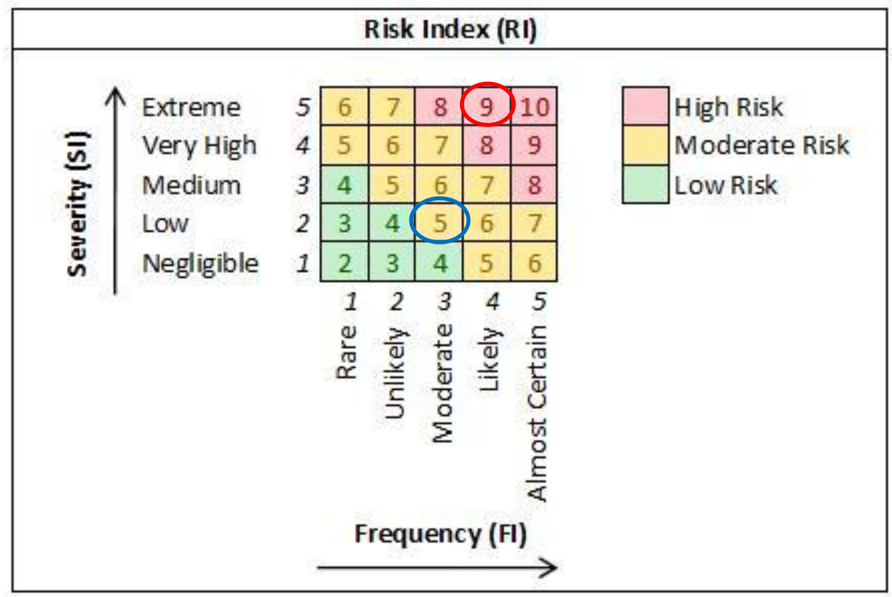

Figure 8.13 Matrix demonstrating the risk of Thick-billed Murres being impacted by noise pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk with year-round traffic through Foxe Basin and Hudson Strait.

8.4.1 Pollution

As previously stated, the Thick-billed Murre is a skilled diver and undergoes a swimming migration through Hudson Strait and south along the coast of Labrador to waters off of Newfoundland where it winters (Gaston, 1982; Gaston & Elliot, 1991, as cited in Mallory & Fontaine, 2004, p.68). Furthermore, as breeding is highly synchronized within colonies, more than half of the birds from an individual colony could be starting this migration around the same time (Mallory & Fontaine, 2004, p.15). As a result, Thick-billed Murres are arguably one of the most vulnerable seabird species to oil pollution. As a significant portion of Canada's Thick-billed Murre population is found in the Hudson Strait, the population could be severely impacted if a spill were to occur due to increased activity associated with the Mary River Project.

For this analysis, the likelihood of an oil spill affecting Thick-billed Murres can be defined by the amount of oil released into the area. The categories are set as: less than 7 tonnes, 7-200 tonnes, 200-400 tonnes, 400-700 tonnes, and greater than 700 tonnes. If Thick-billed Murres were to be oiled by a spill, this could impair its ability to regulate body temperature, most likely resulting in death. Therefore, the level of exposure pertaining to pollution disturbance for the Thick-billed Murre is defined as the number of individuals within Foxe Basin and Hudson Strait impacted by pollution, assuming the population to be around 400 000 individual birds. Since oil pollution would likely lead to mortality in the Thick-billed Murre population, the current level of 10% annual mortality was used as a guideline. Taking into consideration that this level of mortality is already quite high, more than another 2% of mortality would be detrimental. Therefore, for this risk analysis the categories for consequence are defined as: less than 1000, 1000 to 3000, 3000 to 5000, 5000 to 8000, and more than 8000 Thick-Billed Murres.

While the likelihood of a large oil spill occurring in Foxe Basin or Hudson Strait is low because of the small number of ships traveling through the area, this does not suggest that a spill could not occur and that necessary precautions should not be taken. In addition, year-round shipping of iron ore from Steensby Port will require ore carriers to traverse through the study area under particularly hazardous conditions, such as severe weather and heavy ice conditions. This increases the potential for an accident to occur, and as a result the risk of a large oil spill increases as well. Furthermore, due to the migration behavior of the Thick-billed Murre, the consequences of an oil spill could have immense ramifications for its overall population.

Table 8.12 Frequency and Severity Indexes of the Risk of Oil Pollution Disturbing Thick-billed Murres

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	<7 tonnes	1	Negligible	<1000 TBM
2	Unlikely	7-200 tonnes	2	Low	1000-3000 TBM
3	Moderate	200-400 tonnes	3	Moderate	3000-5000 TBM
4	Likely	400-700 tonnes	4	Very High	5000-8000 TBM
5	Almost Certain	>700 tonnes	5	Extreme	>8000 TBM

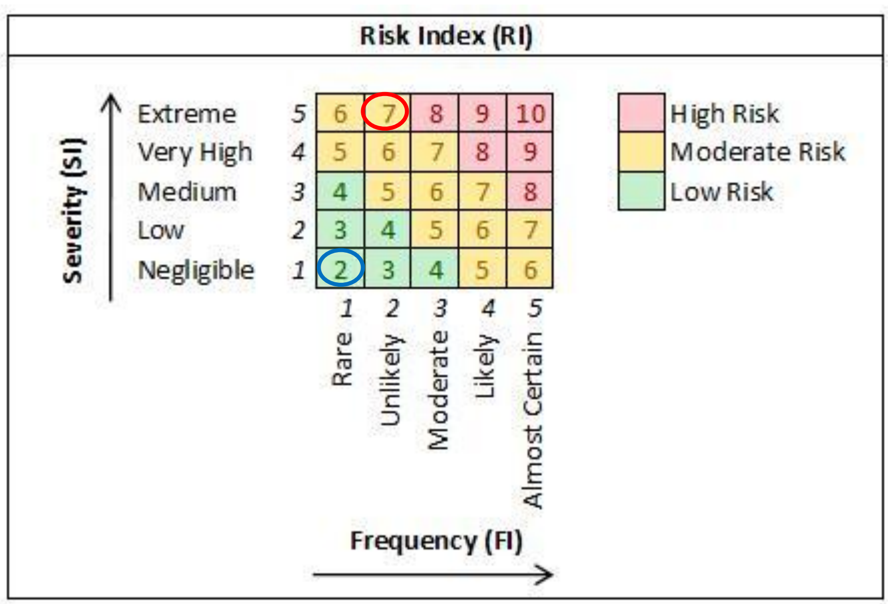

Figure 8.14 Matrix demonstrating the risk of Thick-billed Murres being impacted by oil pollution from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.4.5 LIGHT DISTURBANCE

In the Arctic, light disturbance is most likely to impact birds during their migration periods. In addition, year-round iron ore shipments from Steensby Inlet through Foxe Basin and the Hudson Strait require ships to be lighted when operating in darkness. Assuming that there is a possibility for Arctic breeding birds to interact with lighted ships during fall and spring migrations when there is some darkness, the likelihood of a collision occurring is defined by flight altitude above sea level. As in the analysis for the Common Eider, the likelihood of light disturbance was defined in categories of: less than 250 m, 250 to 500 m, 500 to 1000 m, 1000 to 2000 m, and greater than 2000 m.

Light can cause disorientation in birds and because birds fly at lower altitudes during storms they are more likely to collide with vessels under these conditions, causing mortality (Ogden, 1996). Therefore, for this analysis the level of consequence will be defined by the number of Thick-billed Murre fatalities each year. As the population of Thick-billed Murres already experiences loss each year due to oiling and harvesting, a loss of more than 2% of the group inhabiting Foxe Basin and Hudson Strait due to light disturbance, should be considered extreme. Therefore, the categories for consequence are defined as: less than 1000, 1000 to 3000, 3000 to 5000, 5000 to 8000, and more than 8000 Thick-billed Murres.

The likelihood of this type of incident occurring is minimal due to there being little darkness, and because Thick-billed Murres undergo a swimming migration in the fall. That being said, inclement weather could increase the risk of light disturbance during other periods, as birds are likely to fly closer to sea level in storms (Longcore and Rich, 2004). Therefore, the risk of Thick-billed Murres colliding with ore carriers transporting iron ore from Steensby Port through Foxe Basin and Hudson Strait is relatively low through the majority of the breeding period. However, in cases of severe weather where birds are forced to fly at lower altitudes, there is potential for an incident to occur.

Table 8.13 Frequency and Severity Indexes of the Risk of Light Disturbance for Thick-billed Murres

Frequency Index (FI)			Severity Index (SI)		
FI	**Frequency**	**Definition**	**SI**	**Severity**	**Definition**
1	Rare	>2000 m	1	Negligible	<1000 TBM
2	Unlikely	1000-2000 m	2	Low	1000-3000 TBM
3	Moderate	500-1000 m	3	Moderate	3000-5000 TBM
4	Likely	250-500 m	4	Very High	5000-8000 TBM
5	Almost Certain	<250 m	5	Extreme	>8000 TBM

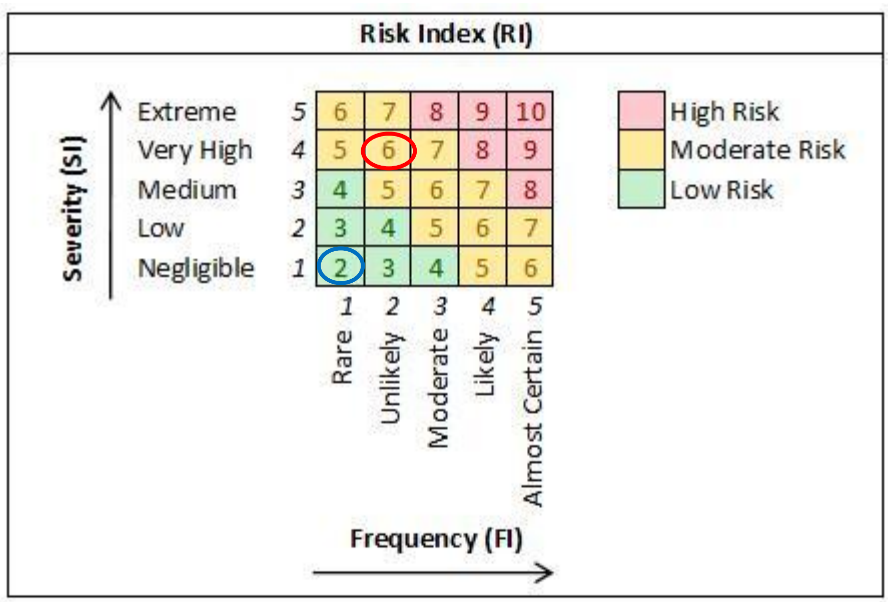

Figure 8.15 Matrix demonstrating the risk of Thick-billed Murres being impacted by light disturbance from shipping. The blue point represents the current state. The red point represents the potential future state of risk if year-round traffic through Foxe Basin and Hudson Strait.

8.5 Conclusions

Overall, the greatest threat to both marine mammals and migratory birds in Foxe Basin and Hudson Strait, with respect to consequence, is the potential for an oil spill. However, this an unlikely incident in comparison to other threats such as noise disturbance, habitat disturbance and light disturbance, that may occur due to regular operational activity. While vessel strikes are another potential threat, they are also considered rare due to the noise levels that will be emitted by icebreaking ships, which will deter whales from approaching. Furthermore, while all these hazards pose different levels of risk for the four species studied in this analysis, there is potential for all of them to occur in the near future. Therefore, the next chapter will focus on effective risk mitigation strategies that can be implemented in order to reduce the likelihood of disturbances, the potential consequences, or in some cases both.

9.0 RISK MANAGEMENT

9.1 POSSIBLE MITIGATION STRATEGIES

When implementing mitigation measures to minimise the risks associated with year-round iron ore shipping through Foxe Basin and Hudson Strait, it is essential that policy decision be made in a way that errs on the side of caution; otherwise known as using a precautionary approach. Furthermore, due to the complexity of the Arctic marine environment, critical information is sometimes difficult to obtain and is usually characterized by high levels of uncertainty. Effective marine management requires that this uncertainty be addressed in accordance with the precautionary principle.

While it is important to proactively mitigate risks, it is also essential to have measures in place to respond to an incident that could potentially occur. These ‘responsive’ management strategies will help to minimize the consequence of a threat or hazard when preventative measures have failed. In addition, management strategies should be established to effectively monitor and enforce both preventative and responsive mandatory regulations put in place. Table 9.1 identifies and describes some of the potential risk management strategies and measures for mitigation, specifically regarding year-round shipping for the Mary River Project. Effective risk management will require that a combination of preventative and responsive measures be implemented, along with strategies that facilitate monitoring and enforcement.

Table 9.1 Potential measures for mitigating environmental impacts from shipping activity, their implementation for the Mary River Project, and further recommendations.

Mitigation Measures			
Preventative- Aid in reducing the likelihood of a potential threat/incident from occurring			
	Description	**Mary River Project**	**Recommendations**
*Vessel Speed Restrictions**	Increased vessel speed makes it more difficult to identify a whale and for a ship to react if a whale is discovered in its path. In addition, as the speed of a vessel increases so does the risk for a strike to be lethal (Vanderlaan & Taggart, 2007). Research shows that a collision is more likely to be lethal if the vessel is traveling at speeds over 10 knots (Vanderlaan & Taggart, 2007). Vessels traveling at lower speeds would also lead to less noise from propeller movements and the potential for groundings, leading to an oil spill, would be reduced.	Baffinland has stated in their Environmental Management System (EMS), that during the open-water season vessels traveling along the northern shipping route will reduce their speed from 14 to 10 knots in Milne Inlet and Koluktoo Bay (Baffinland, 2010, Vol.10, App.10D-10, p.32). However, no speed restrictions are in place for the southern shipping route (through Foxe Basin and Hudson Strait).	It is recommended that Baffinland consider placing vessel speed restrictions on iron ore carriers traveling along the southern shipping route to and from Steensby Port. While icebreaking will prevent vessels from traveling at speeds greater than 10 knots during the winter season, vessels traveling at lower speeds during the open-water season would help to reduce the likelihood and consequence of ship strikes and would also decrease the level of noise pollution and the likelihood of an oil spill occurring.
Canadian Navigational Charts and Publications	All vessels entering Canadian ports, regardless of registration, are required to carry the appropriate charts and marine publications according to the Canadian Charts and Nautical Publications Regulations (Baffinland, 2010, Vol.10, App.10D-10, p.16). Furthermore, the most recent information available and the most up to date navigational charts will reduce the likelihood of a ship being grounded.	All ships chartered by Baffinland will be required to have the most up to date information, as indicated under the Canadian Charts and Nautical Publications Regulations (Baffinland, 2010, Vol.10, App.10D-10, p.16).	According to the CCG, there are two major problems with using navigational charts in the Arctic; the uncommon projections that must be used, and the accuracy of the surveys (CCG, 2010). The preferred Mercator projection cannot always be used, as the meridians converge near the poles causing distortion in the chart. In addition, the accuracy of charts can vary widely according to survey dates (CCG, 2010). Frequently travelled areas such as Lancaster Sound and the Barrow Strait are well surveyed, but most other areas are

			not (CCG, 2010). Therefore, it is recommended that proper surveys be conducted in order to update nautical charts for the Arctic, especially for Steensby Inlet, Milne Inlet, Foxe Basin and Hudson Strait.
Established Shipping Lanes	Established shipping lanes within Hudson Strait and Foxe Basin will aid in preventing groundings or collisions, which could potentially lead to the discharge of hazardous fuel or cargo into Arctic waters. Shipping lanes identify a safe route for vessels and can be designed to avoid areas considered to be critical habitat or where there may be high concentrations of threatened species.	Baffinland has designated a northern and southern shipping route chosen from a variety of options based on safety, and concern from local communities (Baffinland, 2011, Vol. 3, p.102). The nominal shipping routes are provided in the DEIS, along with the alternative shipping corridors that were considered.	It is recommended that Baffinland follow the statements made in the DEIS, with respect to ore carriers traveling along the previously disturbed section of landfast ice as much as possible (Baffinland, 2010, Vol.10, App.10D-10, p.32), and traveling south of Mill Island in Hudson Strait if safety allows, as was requested by the community of Cape Dorset (Baffinland, 2011, Vol. 3, p.102). It is also recommended that if new information is obtained suggesting that the shipping routes should be moved, that Baffinland will oblige.
Pilotage and Tug Requirements	Pilotage is used to safely guide vessels to a destination. Pilots are individuals with extensive knowledge of an area, allowing them to navigate more efficiently and safely. By requiring that pilotage and tugs be used for the Mary River Project, accidents become less likely to occur and the risk to the marine environment are minimized.	There are currently no pilotage requirements for the Canadian Arctic. However, Baffinland has indicated that vessel docking will be assisted at Steensby Inlet by harbour tugs during the ice-free season (Baffinland, 2011, Vol.3, p.102).	Requirements for pilotage and navigational aids are at the discretion of the Canadian Coast Guard (CCG) (Baffinland, 2011, Vol.3, p.102). It is recommended that the CCG request Baffinland to use ice pilots and ice resistant tugs during the winter season.
Experienced Ice Navigators	Under particular circumstances outlined in the Arctic Shipping Pollution Prevention Regulations (ASPPR), ice navigators must be on	Baffinland has stated that "experienced ship captains will be responsible for commanding the ore carriers on the Project"	It is recommended that Baffinland, together with Fednav Ltd., ensure that the masters of all ore carriers and chartered vessels are highly

	board vessels in Canadian Arctic waters. Ice navigators "must have served on a ship as master or person in charge of the deck watch for 50 days or more. Thirty of those days must have been spent in Arctic waters where the ship required assistance from an icebreaker or had to make manoeuvres to avoid concentrations of ice" (TC, 2010b).	(Baffinland, 2011, Vol.3, p.102). Furthermore, Baffinland has stated that the iron ore carriers, as well as other chartered vessels will comply with the ASPPR (Baffinland, 2011, Vol.3, p.101).	experienced and have appropriate qualifications. Baffinland should aim to have ice navigators onboard vessels transiting Foxe Basin and Hudson Strait at all times of the year, whether or not it is required under the circumstances laid out in the ASPPR. In addition, there is currently no standardized ice navigation training or international standard (AMSA, 2009, p.167). Canada, along with the other Arctic states should work together to develop universal standards for qualified ice navigators.
Ship Track Markers	These are used to indicate where the boundaries of the ship track are located. This will aid in ensuring ships travel along the previously disturbed section of landfast ice as much as possible. Furthermore, in difficult weather conditions or periods of darkness (24hrs in winter) they will help to prevent ships from accidently entering areas that may potentially be unsafe.	Baffinland has indicated in their DEIS that reflective highway markers will be used to define the boundaries of the section of the ship track that occurs through landfast ice. The markers will be placed 500m clear of the actual track during the winter season; red along one side and green along the other. Baffinland has proposed that patrols be conducted on a weekly basis to ensure they are operating properly (Baffinland, 2010, Vol.10, App.10D-10, p.18).	N/A
Minimizing lights and using Black-out Blinds on Ore Carriers	Light may disorient or entrap birds at night, sometimes resulting in a collision (Ogden, 1996). Collisions with vessels, due to light disturbance, usually cause mortality in birds (Dick & Donaldson, 1978). By keeping lights at a low level and using black-out	No mitigation measures have been included in the DEIS that attempt to address the impacts of light disturbance on marine birds.	While the majority of birds are in the Arctic to breed during the summer, when there is little darkness, collisions can occur during the spring and fall migration periods (AMSA, 2009, p.150). Therefore, it is recommended that black-out blinds

	blinds on portholes and windows, there is less chance of birds colliding with ships (IAATO, 2009).		be used on ore carriers and that deck and ice lights are kept at a minimum when safety allows, in order to reduce the likelihood of marine birds becoming disoriented and colliding with ships.
*Noise Reducing Ship Design**	Underwater noise produced by ships is dominated by propeller cavitation noise, while the icebreaking process also contributes to overall noise output (AMSA, 2009, p.145). Underwater noise and noise traveling through air can both have significant impacts on species within Foxe Basin and Hudson Strait (AMSA, 2009, p.145). Ship design features have the potential to reduce noise output from ships, reducing the level of disturbance.	Baffinland has stated that the modern design of the proposed iron ore carriers for the Mary River Project will result in less noise being produced. However, much is still unknown with regards to the impacts of noise on marine mammals, especially with regards to masking effects on communication (Baffinland, 2010, Vol.10, App.10D-10, p.32). In addition, the DEIS does not discuss the expected noise output of these ore carriers nor the design features being implemented. Therefore, it is difficult to determine whether the design will in fact significantly reduce the amount of noise produced.	While Baffinland intends to determine the acoustic signature of an iron ore carrier in transit, it is recommended that further research be done to determine the impacts of noise on marine mammals and migratory birds occupying Hudson Strait and Foxe Basin. Any future monitoring programs should address the potential cumulative impacts of noise as vessel traffic rises along with increased activity in the Canadian Arctic.
Marine Mammal and Seabird Observers	Observers are often used on vessels to monitor the reactions of marine mammals or migratory birds to shipping operations and to collect information on their numbers and distribution. By obtaining this information the effectiveness of current mitigation measures can be more easily assessed (Baffinland, 2010, Vol.10, App.10D-10, p.32). Therefore, observers will help to	Baffinland has proposed that locals with extensive knowledge of the area be hired to provide information regarding tides, sensitive areas for birds or mammals, and ice information to ship masters. Therefore, a representative number of ore carriers will have advisors on board, who will also collect marine mammal observations and evaluate	It is recommended that observers be present on all ore carriers traveling through Foxe Basin and Hudson Strait, whether hired by Baffinland or provided by other agencies such as DFO, EC, or Transport Canada (TC). It is also recommended that observations be recorded for birds as well as marine mammals.

	identify disturbance due to shipping activity and may also help to reduce the likelihood of ship strikes.	measures taken to avoid negative environmental impacts (Baffinland, 2010, Vol.10, App.10D-10, p.33).	
Acoustic Monitoring and Communication between Vessels	Monitoring the presence of marine mammals and developing a communication system to share information with regards to sightings and their locations could help to reduce the likelihood of strikes or disturbance (Brown et al., 2007, as cited in Vanderlaan et al., 2008).	N/A	It is recommended that a communication system be established for all ships traveling through the Canadian Arctic. As shipping activity increases in the Hudson Strait, Foxe Basin, and other areas of the Arctic, this type of system will become more critical in order to protect wildlife and important habitat.
*Marine Spatial Planning (MSP) and Management**	MSP is defined as a "public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process" (UNESCO, 2010). Furthermore, it is used to manage interactions between users, and to balance development with environmental protection (UNESCO, 2010). Through zoning, certain activities could be prohibited in particularly vulnerable areas, reducing the risk of environmental degradation or disturbance.	N/A	Canada has already made some progress with regards to MSP and Integrated Coastal and Ocean Management (ICOM). Five Large Ocean Management Areas (LOMAs) have been identified within Canadian waters, however none have been established for the eastern Canadian Arctic. Canada also distinguishes 19 marine eco-regions within its waters (UNESCO, 2010). It is recommended that progress be made towards establishing one or more LOMAs for the eastern Canadian Arctic and that an integrated management plan be developed for this region. This would require collaboration between DFO and AANDC under the Oceans Act and the NLCA.
Seasonal No-Traffic Zones or Areas To Be Avoided (ATBAs)	In some cases, particular areas represent critical habitat to vulnerable species and require a higher level of protection. Seasonal	N/A	Currently, there is a lack of information with respect to population numbers and distribution for the majority of species in the

	no-traffic zones or ATBAs could be established in order to prevent high levels of vessel traffic in certain areas, reducing the likelihood of vessel strikes and disturbance (Vanderlaan & Taggart, 2009).		Arctic marine environment. It is recommended that once more reliable information is obtained through monitoring programs and scientific research for various species within Foxe Basin and Hudson Strait, that this option be considered in more detail.
Joint Proposal for Particularly Sensitive Sea Areas (PSSA) designation	The International Maritime Organization (IMO) defines a PSSA as "an area that needs special protection through action by IMO because of its significance for recognized ecological, socio-economic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities" (IMO, 2011b). Once an area is designated as a PSSA, Associated Protective Measures (APMs) which fall within the competences of the IMO, are established to protect the area (IMO, 2010b).	N/A	There is considerable opportunity for the designation of one or more PSSAs within the Canadian Arctic. The vulnerability of the marine ecosystem, as well as the ecological, socio-economic, and cultural significance of the area satisfy the criteria for PSSA designation. Furthermore, the increase in vessel traffic expected to occur will place the area at greater risk from disturbance and pollution. In addition, efforts could also be made to develop a joint proposal to designate the entire Arctic as one large PSSA, which would require collaboration between all Arctic states, transcending issues of sovereignty (Warner, 2009).
Responsive- Aid in effectively responding to a threat or incident and/or minimizing the consequence or level of exposure			
	Description	**Mary River Project**	**Recommendations**
Northern Canada Vessel Traffic Services (NORDREG) and Increased Infrastructure for Oil Response	The CCG is the lead response agency for spills in the Arctic. Masters of vessels 300 gross tonnage or more are required to use NORDREG, operated by Marine Communications and Traffic Services (MCTS) (TC, 2010c). When a spill occurs it must be immediately reported. Logistics is a limiting factor in effective	Baffinland has stated that it will work closely with the CCG to plan for any type of environmental emergency. The Central and Arctic Regional Response Plan and the Baffin Region, Nunavut Area Plan delineate the CCG's response capability in this region of the Arctic. These plans have been used	While communities have been supplied with response equipment, the CCG must now focus on training community members how to use the equipment provided (CCG, 2011). It is also recommended that the Government of Canada continue to expand and re-fit the CCG's icebreaking fleet over time, as most

	emergency response in the Arctic (AMSA, 2009, p.169). Therefore, existing infrastructure is a vital component of reducing the level of exposure and disturbance to marine organisms if a spill occurs. The CCG recently spent more than $2 million supplying 19 Arctic communities with environmental response equipment. Containers with surface booms and accessories, shoreline clean-up equipment, small vessels, outboard motors and trailers were provided (DFO, 2010).	as a resource in developing spill response plans for the Mary River Project (Baffinland, Vol.10, App.10C-1, p.24).	of these vessels are over 30 years old and do not operate in the Arctic year-round (AMSA, 2009, p.181).
Response Equipment On-board Ore Carriers	Due to the vastness of the Arctic and the difficulty of navigating during the winter season, spill response becomes increasingly difficult. There is some general debate as to whether ships should carry a limited amount of oil spill response equipment (ITOPF, 1998).	Baffinland has developed an Emergency and Spill Response Plan (ERP) in case of a spill. In addition, all ships will have a specific Shipboard Oil Pollution Emergency Plan (SOPEP) as is required under the International Safety Management (ISM) code for the Safe Operation of Ships and for Pollution Prevention (Baffinland, Vol.10, App.10C-1, p.20). It has also been indicated that iron ore carriers will carry oil response equipment, however detailed information is still under development and is not provided in the DEIS (Baffinland, Vol.10, App.10C-3, p.2).	While having plans in place is crucial, the remoteness of the Arctic will limit the ability of Baffinland and the CCG to respond to an emergency in a timely manner. Therefore, it would be beneficial for ships to carry a limited amount of response equipment, such as surface boom and accessories, and protective gear for crewmembers. It is recommended that Baffinland consult the CCG and other interested parties with regards to the equipment that should be carried onboard.
Further Research to Identify Critical Areas for Species	Information regarding the population status of the majority of species in the Arctic is either lacking or outdated. Furthermore, there is	Baffinland has proposed several types of follow-up monitoring, including vessel-based monitoring of marine mammals, monitoring of	It is essential that joint monitoring programs be established through government agencies, NGOs, or universities in order to fill in the

	considerable uncertainty with respect to the impacts of disturbance on migratory birds, as well as marine mammals. Without reliable data, the ability of various agencies to implement effective mitigation strategies is limited.	the acoustic signature of ore carriers, aerial surveys, shore-based monitoring, and an ice imagery study in Hudson Strait (Baffinland, 2010, Vol.10, App.10D-10, p.32).	information gaps. By facilitating the sharing of information between these groups, more can be done efficiently to protect critical species and habitat.
Monitoring and Enforcement- Aid in monitoring and enforcing vessel traffic regulations or restrictions			
	Description	**Mary River Project**	**Recommendations**
Vessel Monitoring Systems (VMS), Automatic Information Systems (AIS), and Long Range Information and Tracking (LRIT) systems	The purpose of VMS and information systems is to improve safety and minimize the environmental impacts of shipping accidents (IMO DE 55/12/9, 2011). They lead to improved response time for emergencies, but also better compliance and enforcement. AIS provides information such as the vessel's IMO number, type, position, course, speed, possible hazardous cargo, and destination (IMO DE 55/12/9, 2011). VMS data can also be retained for improved long term spatial planning, and environmental protection.	Under Regulation 19 of the International Convention on the Safety of Life at Sea (SOLAS) Chapter 5, all internationally voyaging ships of 300GT, as well as cargo ships of 500GT and all passenger vessels must have AIS onboard (IMO DE 55/12/9, 2011). However, the lack of communication infrastructure limits the use of AIS in the Arctic (IMO DE 55/12/9, 2011). In addition, VHF signals from traditional AIS only have a range of 74 km, which restricts coverage (IMO DE 55/12/9, 2011).	Forms of AIS that use satellite technology can be used in the Arctic and Antarctic. Satellite Automatic Information Systems (S-AIS) allow global coverage of shipping activity and could provide the Arctic states with a common reporting and data sharing system (IMO DE 55/12/9, 2011). The development of LRIT was adopted by the IMO in 2006 (IMO DE 55/12/9, 2011). The Government of Canada should work alongside the other Arctic states to develop a mandatory Polar Code and ensure that vessel traffic monitoring and information systems are required for all ships traveling through Arctic waters.

* Indicates mitigation measures that may fall under both the preventative and responsive category.

**Indicates mitigation measures that may fall under the responsive category as well as the monitoring and enforcement category.

A select few of the measures outlined in Table 9.1 will be discussed in detail in the following sections of this chapter in order to determine which are likely to have the most success in decreasing disturbance to marine mammals and migratory birds occupying Foxe Basin and Hudson Strait. These include vessel speed restrictions, an increase in infrastructure for Arctic spill response, and VMS, AIS, and LRIT. While these mitigation measures will be discussed in more detail, all of the previously discussed strategies should be considered by Baffinland, the Government of Canada, and appropriate international agencies.

9.1.1 Vessel Speed Restrictions

While a potential oil spill is the greatest overall threat to both marine mammals and migratory birds in Foxe Basin and Hudson Strait in terms of consequence, it is less likely to occur than other threats such as noise disturbance, habitat disturbance and light disturbance, which may occur due to regular operational activity. Furthermore, the likelihood of a vessel strike is also rare, as the noise levels emitted by icebreaking ships are expected to deter most marine mammals from approaching. The implementation of vessel speed restrictions helps to address the threat of vessel strikes, noise disturbance, and pollution, which is why it was selected to be discussed in more detail.

Studies done on North Atlantic Right Whales, which belong to the same family as Bowhead Whales, have determined that a collision is more likely to cause death if the vessel is traveling at a speed greater than 10 knots (Vanderlaan & Taggart, 2007). In addition, greater vessel speed makes it more difficult to identify a whale and for the crew of a vessel to react to the discovery of a whale in its path. Therefore, a positive aspect of this mitigation strategy is that it addresses the consequence of a ship strike occurring as well as the likelihood of it occurring. In addition, lower vessel speed would reduce the amount of noise emitted by a ship's propeller movements and would also give ships more opportunity to avoid free-floating ice or other hazards (AMSA, 2009, p.145). As a result, the level of exposure to noise disturbance and the potential for an accidental spill would be minimized.

There are positive and negative aspects of this risk management strategy for the company. A benefit is that reducing the probability of a ship strike also avoids large potential costs for a potential clean-up, property loss (ship and/or cargo), liability costs, and reputation loss. However, a negative aspect is that as a result of implementing speed restrictions, travel time would increase along with the cost of transportation. Therefore, industry cooperation would be necessary at this point in time, as no speed restrictions are currently in place. In addition, it may be more practical to implement seasonal speed restrictions or restrictions in particular areas along the shipping route, where conditions are particularly hazardous or where there are high concentrations of wildlife. According to research that has previously been done, Hudson Strait and northern Foxe Basin have both been identified as AHBIs (Stephenson & Hartwig, 2010, p.64). Therefore, speed restrictions no greater than 10 knots should be considered for these areas in particular.

9.1.2 Increased Infrastructure for Arctic Spill Response

Unlike the implementation of vessel speed restrictions, increasing infrastructure for Arctic spill response only addresses the risk of an environmental emergency due to an oil spill. This is considered a responsive mitigation strategy, as it will help allow the proponent and the CCG to respond more quickly and efficiently to a spill. As a result, it minimizes the exposure of wildlife to pollution disturbance. The consequence of a potential oil spill represents the greatest threat to marine mammals and migratory birds within the Arctic marine environment. Therefore, the implementation of this mitigation strategy is of the utmost importance.

The CCG has already made a considerable effort to increase its response capability in the Arctic, however overcoming the region's vastness, hazardous environment, and the cost of operating in the Arctic is challenging. The Canadian government's Health of the Oceans Initiative recently funded the allocation of more than $2 million worth of environmental response equipment to 19 Arctic communities (DFO, 2010). While increasing equipment in Arctic communities is a step forward, the CCG has not yet trained community members to use the equipment (CCG, 2011). In addition, the CCG icebreaking fleet is aging and will require that its vessels are refit or replaced over time (AMSA, 2009, p.181).

A promising aspect of increased activity in the Arctic region is that the Government of Canada is concerned about Arctic sovereignty and security. As a result, it funding will likely be provided to increase infrastructure for the CCG and Canadian Forces in the Canadian Arctic. However, a negative aspect of increasing resources for environmental response is that even if equipment is nearby, it is not always effective at cleaning up a spill. Furthermore, the most environmentally friendly response methods typically involve the mechanical recovery of oil using surface booms and skimmers (AMSA, 2009, p.170). In the Arctic, these methods produce limited results, as snow and ice limit the ability of equipment to efficiently recover oil (AMSA, 2009, p.170). Various measures for responding to a spill, with respect to season and spill location are shown in Figure 9.1.

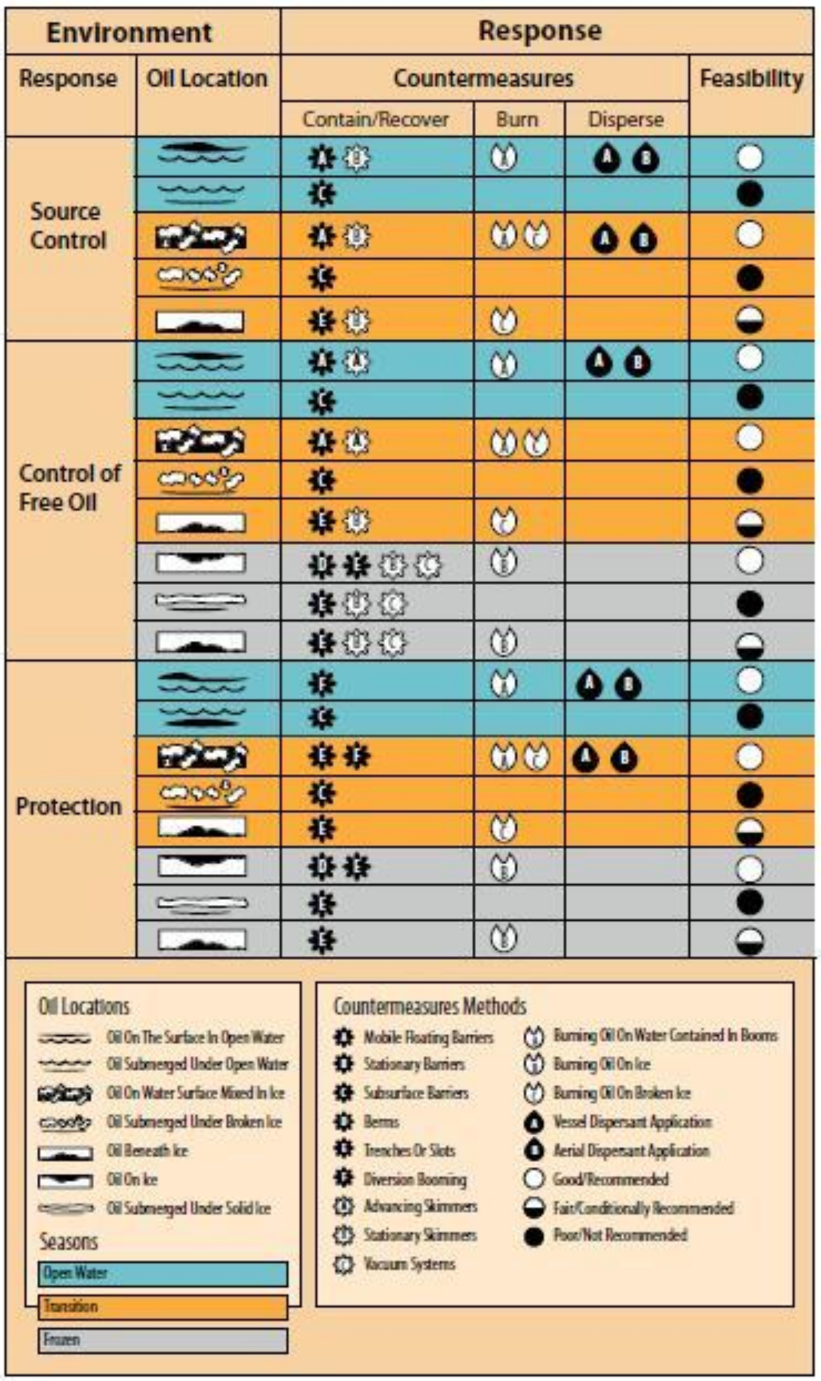

Figure 9.1 Response countermeasures often taken in the case of a spill, based on circumstances such as the current season, sea state, and the location of the oil (AMSA, 2009, p.169).

9.1.3 VMS, AIS, AND LRIT

Although the implementation of preventative and responsive measures is critical for risk management, it is unlikely that these measures will accomplish their intended purpose if methods for monitoring and enforcing regulations and restrictions are not established as well. Furthermore, the best way in which to monitor vessel traffic is through the use of VMS, AIS, and LRIT systems. While facilitating communications, which could be invaluable in the case of an emergency, these systems allow maritime authorities to track vessels and their activity. Information provided may include a vessel's IMO number, the type of vessel, as well as its position, course, speed, destination, and what hazardous cargo it may be carrying (IMO DE 55/12/9, 2011). Therefore, these systems could help ensure compliance with respect to vessel speed restrictions, ATBAs, and APMs associated with PSSAs, etc.

A positive aspect of using VMS and information systems to facilitate enforcement and mitigation effectiveness is that the technology is already becoming available. While the range of VHF signals from traditional AIS has limited its use in the poles, LRIT and S-AIS will provide better coverage of shipping activity in the Arctic (IMO DE 55/12/9, 2011). In addition, the use of these systems facilitates improved response time for emergencies, including environmental spill response. In contrast, while this type of monitoring and enforcement system aids in preventing vessels from entering restricted areas or traveling too fast, they cannot be used to enforce regulations with respect to spills or other forms of disturbance that may occur during transit, as could the increased presence of the CCG or of other maritime authorities.

9.2 Implementation Through Legislation, Regulations, and Policy

Although the measures presented in Table 9.1 could help to mitigate the risks of year-round shipping through Foxe Basin and Hudson Strait, it is important to consider the process required for their implementation. Legislation, regulations, and policy play an essential role in the implementation of risk management strategies and may facilitate or limit effective mitigation of risk. Furthermore, it is important to examine the relationship between science and policy, and recognize the need for collaboration between the two. Communication across the two fields is a vital part of successfully addressing environmental issues. In addition to challenges posed to monitoring and enforcement by the remoteness of the Arctic region and its hazardous characteristics, another is balancing the need for further economic development as well as the need for further environmental protection.

9.2.1 International, Federal, and Territorial Powers

Canada is a member of the IMO and is a signatory to various IMO agreements including the SOLAS Convention, the International Convention for the Prevention of Pollution from Ships (MARPOL), the International Safety Management Code (ISM) and the International Loadline Conventions (Baffinland, 2010, Vol.10, App.10D-10, p.2). Furthermore, shipping operations are federally regulated by Transport Canada through the Canada Shipping Act (CSA). Other legislation and regulations have also been put in place by federal government agencies such as DFO, EC, the Canadian Wildlife Service (CWS), and PC, to prevent detrimental disturbance to wildlife and their habitat.

Within Canada's three territories, the federal government is responsible for delegating powers to the territories through devolution (Daoust, Haider, & Jessen, 2010). Devolution negotiations between the Government of Canada, the GN, and Nunavut Tunngavik Inc. (NTI) under the Nunavut Act are ongoing and both the GN and NTI have shown interest in gaining jurisdiction over marine areas (NTI, 2007; Mayer 2007, as cited in Daoust, Haider, & Jessen, 2010). However, until devolution takes place, the GN and Inuit organizations established under the NLCA have very limited jurisdiction over the marine environment, which has led to a lack of territorial legislation or policy for marine management and planning (Daoust, Haider, & Jessen, 2010). The NLCA governs how land and resources, including marine and coastal resources, are managed in the NSA (Daoust, Haider, & Jessen, 2010). Furthermore, the NLCA contains provisions for the Nunavut Wildlife Management Board (NWMB), NPC, Nunavut Water Board (NWB), and NIRB to jointly form the Nunavut Marine Council (NMC). The NMC would give advice and recommendations to federal departments regarding the marine environment, however it has not yet been officially established (Daoust, Haider, & Jessen, 2010).

In this section, the relevant international, federal, and territorial policy associated with Arctic shipping in Canada will be discussed. Key policy actors, along with their specific roles with respect to regulating shipping through Foxe Basin and Hudson Strait are identified in Table 9.2 (adapted from Table 1 found in Daoust, Haider, & Jessen, 2010). In addition, conflicts which may hinder risk management through policy are discussed further in the following chapter.

Table 9.2 Key Actors, Legislation, and Policy in Marine Management in Nunavut.

Actor	Role and Relevance in Nunavut
International Agencies	
IMO	The IMO is a specialized agency within the UN, which is responsible "for the safety and security of shipping and the prevention of marine pollution by ships" (IMO, 2011a). **Relevant Legislation/Policy:** *IMO Guidelines for Ships Operating in Polar Waters, SOLAS, Convention on the International Regulations for Preventing Collisions at Sea (COLREG), MARPOL*
Federal Government Agencies	
TC	TC regulates marine transportation in Canada and promotes safe, secure and sustainable marine practices. It oversees marine infrastructure, regulates the transportation of dangerous cargo and helps to protect the marine environment (TC, 2011). **Relevant Legislation/Policy:** *CSA, Navigable Waters Protection Act, Canadian Transportation of Dangerous Goods Act, Arctic Waters Pollution Prevention Act (AWPPA)*
DFO-CCG	DFO is the lead agency with respect to marine management and the establishment of a national network of Marine Protected Areas (MPAs). Furthermore, DFO establishes and (co)manages MPAs under the Oceans Act (Daoust, Haider, & Jessen, 2010). The CCG is a Special Operating Agency within DFO and is the lead response agency for spills in the Arctic. In addition, the CCG's MCTS program operates the NORDREG system (TC, 2010a). **Relevant Legislation/Policy:** *Oceans Act, Fisheries Act, Species at Risk Act (SARA)*
EC-CWS	EC and the CWS establish and (co)manage National Wildlife Areas (NWAs), Marine Wildlife Areas (MWAs) and Migratory Bird Sanctuaries (MBSs), which contribute to the national network of MPAs (Daoust, Haider, & Jessen, 2010). **Relevant Legislation/Policy:** *Canadian Wildlife Act (CWA), Migratory Birds Convention Act (MBCA), SARA*
PC	The role of PC is to establish and (co)manage National Parks with marine components and National Marine Conservation Areas, which both contribute to the national network of MPAs (Daoust, Haider, & Jessen, 2010). **Relevant Legislation/Policy:** *Canada National Marine Conservation Areas Act, Canada National Parks Act, SARA*
AANDC	AANDC is responsible for the control and management of terrestrial, marine and mineral resources, as well as oil and gas in Nunavut (Daoust, Haider, & Jessen, 2010). **Relevant Legislation/Policy:** *AWPPA, NLCA*
Territorial Agencies	
NTI	NTI represents Inuit in the NLCA and ensures that it is being properly implemented. In addition, NTI negotiates Inuit Impact and Benefit Agreements (IIBAs) on behalf of the Inuit in Nunavut (Daoust, Haider, & Jessen, 2010).
Regional Inuit Associations (RIAs)	RIAs including Kitikmeot, Kivalliq, and Qikiqtani Inuit Associations, hold rights for Inuit owned surface lands and represent and protect the rights and benefits of Inuit. In addition RIAs help negotiate IIBAs for proposed MPAs (Daoust, Haider, & Jessen, 2010).
Hunters and Trappers Organizations	HTOs are community-based groups that manage harvesting within an Inuit community. They may be involved in IIBA negotiations and may advise or consult government agencies with respect to the potential impacts activities could have on traditional harvesting practices (Daoust, Haider, & Jessen, 2010).

(HTOs)	
NWMB	The NWMB is an Institution of Public Government (IPG) established under the NLCA, which advises governments and other institutions on wildlife issues. In addition, the NWMB must approve the establishment of disestablishment of MPAs in Nunavut (Daoust, Haider, & Jessen, 2010).
NWB	The NWB is an IPG which advises governments and other institutions on issues regarding the inland waters of Nunavut (Daoust, Haider, & Jessen, 2010).
NPC	NPC is an IPG which prepares land use plans to manage terrestrial and marine resource development in Nunavut. Furthermore, the NPC must approve the establishment of new marine conservation areas (Daoust, Haider, & Jessen, 2010).
NIRB	The NIRB is an IPG responsible for assessing potential development projects (including those that impact the marine environment) through an impact assessment process (Daoust, Haider, & Jessen, 2010).

9.2.2 *POTENTIAL CONFLICTS*

The regulatory process with regards to marine management in Nunavut is complex and there is potential for significant conflict to occur. As was stated earlier, the devolution of federal government powers to the territory of Nunavut is under negotiation. The GN and NTI have both requested some level of jurisdiction over marine areas, enabling the territory to collect revenue from offshore resource extraction (Mayer, 2007, as cited in Daoust, Haider, & Jessen, 2010). However, the amount of resources available to these territorial agencies for effective management, in comparison to federal government resources, may prove to be an issue. While it has been suggested that the transfer of responsibility to the territorial government could result in the development of a "more comprehensive policy for marine use" in Nunavut, the devolution of responsibilities could also lead to various challenges (Daoust, Haider, & Jessen, 2010, p.88). Furthermore, the reorganization of the system could stall current initiatives being developed for marine conservation (Daoust, Haider, & Jessen, 2010).

In addition, conflicting legislation can cause further complexities within the regulatory process. For example, Canada is a signatory to various IMO conventions including MARPOL, however the MARPOL Convention does not apply to Canadian Arctic waters, as Canada's ratification excludes waters north of 60°N latitude (TC, 2010e). Therefore, the AWPPA regulates the release of vessel sourced oil pollutants in Canada's Arctic waters, but there is limited information provided with respect to other types of vessel pollution in comparison to the MARPOL Convention. Furthermore, there is international dispute related to the applicability of the AWPPA to foreign vessels, which hinders Canada's ability to implement effective mitigation measures for shipping activity in Arctic waters. Finally, the environmental assessment process in Nunavut is typically conducted by the NIRB under the NLCA; a process which was examined in Chapter 4. However, the Minister of AANDC has the ability to refer a project proposal to the Minister of the Environment for review under the Canadian Environmental Assessment Act (CEAA) (NIRB, 2008). The NCLA states that this referral is done "where required, by law or otherwise" (NLCA, 1993, Article 12, Part 4), however no detailed information is provided on the particular circumstances under which this would occur.

9.3 Final Recommendations and Considerations for Future Projects

It is imperative that more information with respect to population status and distribution is acquired for species in the Arctic marine environment, as data is currently lacking or outdated for the majority of species occupying this region. Furthermore, the mitigation strategies presented in this chapter should be considered by Baffinland, the Government of Canada, and other appropriate international agencies. While all of these measures could potentially minimize the risk of disturbance to migratory birds and marine mammals in Foxe Basin and Hudson Strait, it is unlikely that they will all be implemented for the Mary River Project. However, the intention is to provide a list of potential mitigation measures for future shipping activities as the demand for marine transportation increases in the Arctic marine environment.

Considerations for future development are that the current Baffinland DEIS is based on the status of shipping in the Arctic at this point in time under the assumption that year-round shipping is quite rare. While this is currently true, the Mary River Project will likely change the face of Arctic shipping, and as vessel traffic continues to increase in the Arctic during the winter season, the cumulative environmental impacts of frequent but low consequence disturbance will be amplified. In addition, as development in the Arctic continues to expand, more project proposals will need to be reviewed by the NIRB and other interested parties. However, the majority of government agencies in Nunavut do not currently have the capacity nor resources to complete this process for more than one or two of these reviews at a time. Therefore, the issues of cumulative environmental impacts and the ability of the government agencies in Nunavut to cope with increasing Arctic development are of major concern and more will need to be done to specifically address these issues.

10.0 CONCLUSIONS

Exploration for natural resources, as well as their exploitation and transportation, is heavily reliant on the international shipping industry. An increase in Arctic warming and a loss in ice-cover have the potential to dramatically alter shipping capabilities within the Arctic region. The harsh Arctic environment is characterized by its extremely cold temperatures, ice, and strong seasonal variability. However, while this environment can be hazardous to maritime activity, it is also exceptionally vulnerable to disturbance.

The purpose of this study was to identify the potential risks to marine mammals and migratory birds from the proposed shipping activities of the Baffinland Mary River Project; to determine whether the DEIS addresses these risks and proposes suitable methods for their management and mitigation; and to determine how the proposed shipping activities can be adapted, if necessary, to minimize the risks of disturbance and better protect marine mammals and migratory birds, as well as their habitat. These risks included disturbance due to pollution, vessel strikes, noise, and light, as well as habitat disturbance caused by icebreaking.

It was determined that the possibility of an oil spill occurring along the shipping route represents the greatest risk to wildlife with respect to consequence, although the likelihood of such an incident occurring is rare. Furthermore, while multiple mitigation measures were proposed, it is unlikely that they will all be incorporated into the management plans for the Mary River Project. However, the intent of this project is to set a precedent for future development in the Canadian Arctic, with the aim of providing guidance to industry and government for the future protection of the Arctic marine environment. In addition, continuing to analyze the science-policy interface for Nunavut, with respect to effectively mitigating risk associated with shipping activity, will give key insight into what changes must be made to ensure sustainable resource and environmental management of Arctic waters.

In conclusion, as the global population continues to increase along with the demand for natural resources such as oil, natural gas and various hard minerals, nations around the world will continue to explore previously undisturbed areas (AMSA, 2009, p.8). Therefore, it is critical that risk management be utilized and that legislation, policy, and measures for enforcement be in place to minimize the threat of immediate disturbance and negative cumulative impacts to marine mammals and migratory birds within the Arctic marine environment.

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