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February 6, 2020

Solomon Amuno
Technical Advisor II
Nunavut Impact Review Board
Cambridge Bay, NU

Re: WWF-Canada Supplemental Technical Submission regarding the NIRB's Assessment of Baffinland's Mary River Phase 2 Proposal

Dear Solomon Amuno:

In December 2019, the Nunavut Impact Review Board (NIRB) issued its Reasons for Decision Report following the adjournment of its Public Hearing regarding Baffinland's Phase 2 proposal. The accompanying letter and News Release provided direction for subsequent process steps in the assessment, including the opportunity for parties to provide additional or supplemental technical comment on or before February 6, 2020.

WWF-Canada is thankful to have participated in each of the NIRB's processes relating to the Mary River, Early Revenue, Production Increase, and Phase 2 proposals. In response to the NIRB's most recent invitation to provide submissions on the Phase 2 proposal, WWF-Canada submits the following summary of *unresolved* issues to assist the NIRB with planning for discussions during the upcoming Technical Meeting. Please note that our original Final Written Submission document is attached for ease of reference when considering the listing provided herein.

WWF FWS-01 suggested that the current impacts of operations and future impacts and effects associated with Phase 2 have not been appropriately addressed, and specifically, WWF-Canada does not support the advancement of further development to the Northern Transportation corridor until such time as indicators and thresholds for all valued ecosystemic components are developed and that consistent monitoring and rigorous analysis of results are in place and have been proven to be effective.

WWF FWS-02 suggested that in the absence of a structured monitoring program, the Mary River project has not been managed to adapt to changes in the environment. There has been no way of knowing what level of impact the project is (or is not) having. An overarching framework to guide expectations and practical, effective monitoring is required to ensure the programs around impacts are responsive and can reflect project realities. To date no additionally updated framework has been provided for consideration.

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WWF FWS-03 recommended that 1) the NIRB take a more responsive role within the Marine Environment Working Group, 2) that it implement a requirement that Baffinland integrate advice received with unanimous support from members, and provide rationale for not integrating the same into its plans and programs 3) that the NIRB should have ultimate authority to make decisions where Baffinland does not agree with advice from working groups, and 4) that working group discussions, debates, and recommendations be filed publicly with the NIRB.

WWF FWS-04 recommended the NIRB and other parties consider conducting an exercise to develop a comprehensive Marine Spatial Plan to address competing uses and possible impacts from shipping, within the Tallirutiup Imanga National Marine Conservation Area.

In addition, WWF-Canada requests that Baffinland outline how it could contribute to a future Marine Spatial Plan, or how it could participate in the process by which one could be developed.

WWF FWS-06 considered an oil spill probability analysis. WWF-Canada has concerns that our issues remain unresolved. Following the Public Hearing, and submission of our initial report on spill probability, WWF-Canada commissioned a supplemental spill probability analysis based on updated information provided by Baffinland (enclosed). The authors of this analysis have found that the probability of a major ship fuel spill occurring during the project life has not decreased after considering new information from Baffinland, it remains at 1 in 3, or a 33% chance of occurrence over the life of the project.

WWF recommended that the NIRB require Baffinland to utilize lighter distillate fuels (i.e. non-HFO, non-IFO) in its own and contracted shipping vessels, including its ore carriers calling to port in Nunavut. Furthermore, WWF Canada recommended that Baffinland only contract ships for work in Nunavut waters that are fitted with double hulled fuel tanks to protect the waterways and marine species living here from a potentially disastrous spill of HFO/IFO.

WWF FWS-07 suggested that Baffinland be required to develop and implement adequate indicators and thresholds as well as robust monitoring plans to gain useful information about the regional caribou herd, and that no increase to mine throughput or transport beyond 6 Mtpa is approved until such time as it has evidence to support the current assertion of no impact and to support projections of no significant impacts with a 12 Mtpa development scenario.

WWF also recommended that the NIRB set specific monitoring requirements for Baffinland to acquire accurate data about caribou abundance, distribution, and responses to the currently approved activities.

WWF FWS-08 asks NIRB to implement requirements such that Baffinland decreases greenhouse gas emissions and black carbon while executing the project. Though Baffinland’s response highlighted its commitment to providing a next draft of its Climate Change Strategy by March 31, 2020, this does not resolve our request to have amendments made to existing Terms and Conditions, nor does it resolve our request to have Baffinland demonstrate achievements toward reduction.

In addition to previously raised concerns, WWF-Canada suggests that Baffinland’s caribou monitoring efforts to date have proven inadequate and have not generated any results that contribute to a review of impacts from this project. Rather than continuing to generate no results, Baffinland should consider working with the Government of Nunavut to monitor caribou at a regional scale to understand the distribution and migration of caribou in relation to project activities.

Please also note the attached listing of ore carriers transiting into Milne Port during 2019, as well as their ballast water volumes; provided here for general information purposes. We also note that through correspondence, Baffinland clarified the attached phase 2 ship transit details in an email exchange with WWF-Canada.

Again, WWF-Canada appreciates this opportunity to submit and clarify our unresolved items ahead of the upcoming Technical Meeting. We look forward to productive discussions with all parties. Please contact the undersigned at adumbrille@wwfcanada.org with any questions regarding this submission or our participation at the upcoming meeting.

Sincerely,

Andrew Dumbrille

Enclosed:
WWF-Canada Updated Spill Probability Analysis (February 3, 2020)
Clarification of phase 2 ship transits (confirmed in correspondence with BIM) (2020)
WWF-Canada Final Written re Mary River Phase 2 (September 23, 2019)
Listing of ore carriers transiting to Milne Port in 2019 and ballast water volumes (2020)

Baffinland Oil Spill Probability: Updated Analysis (February 2020) for Phase 2 Expansion Proposal Vessel Traffic

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3 February 2020

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February 2020 Update Overview

The 2019 report, *Baffinland Oil Spill Probability: Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic*, prepared by Environmental Research Consulting (ERC) under contract to World Wildlife Fund Canada (WWF-Canada) and delivered on 22 July 2019, was an update of a previous report prepared in June 2016. Since the purpose of the report was to analyze the potential additional risk of spills from vessels with the expansion of the Baffinland project, similar assumptions and approaches were applied. The project scope for both the 2016 and 2019 studies did not allow for a comprehensive vessel traffic modeling study that was specific to the waterways affected by Baffinland vessel traffic. ERC applied a modified approach in which typical accident rates derived from past studies of vessel casualties were applied to different levels of vessel traffic, with assumptions based on previous studies.

This report is an updated version of the 2019 report with updates that are based on new information provided by WWF-Canada as extracted from the 6 January 2020 revised project description prepared by Baffinland Iron Mines Corporation.[1] The updates to the report include changes to:

- The descriptions and classifications of vessels;
- The assumptions of the duration of transits by tugs and tug activities in escort activities;
- The numbers of resupply vessel voyages; and
- The assumptions of the operations of ice breakers.

These amendments resulted in different computed results for some of the probability assessments presented in the July 2019 report. Additional edits were included for clarification.

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[1] Baffinland Iron Mines Corporation 2020.

Baffinland Oil Spill Probability: Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic

Introduction

Environmental Research Consulting (ERC), as a subcontractor to Shoal's Edge Consulting, had conducted an analysis of oil spill risk in Baffin Bay and Lancaster Sound for World Wildlife Fund Canada (WWF-Canada) in June 2016. The 2016 study involved:

- Development of oil spill scenarios for trajectory, fate, and effects modeling;
- Analyses of the probabilities of different types of spills; and
- Analyses of spill response requirements for the largest spills.

The study included oil spill risk from offshore oil exploration and development in Melville Bay and Baffin Bay (Greenland), cruise ship traffic along the Greenland coast, refined oil product tanker traffic in Lancaster Sound, and bulk carrier traffic in Eclipse Sound and Milne Inlet. The latter was for traffic associated with the Baffinland Iron Mines in the Mary River areas of Baffin Island, Nunavut, Canada (Figure 1).

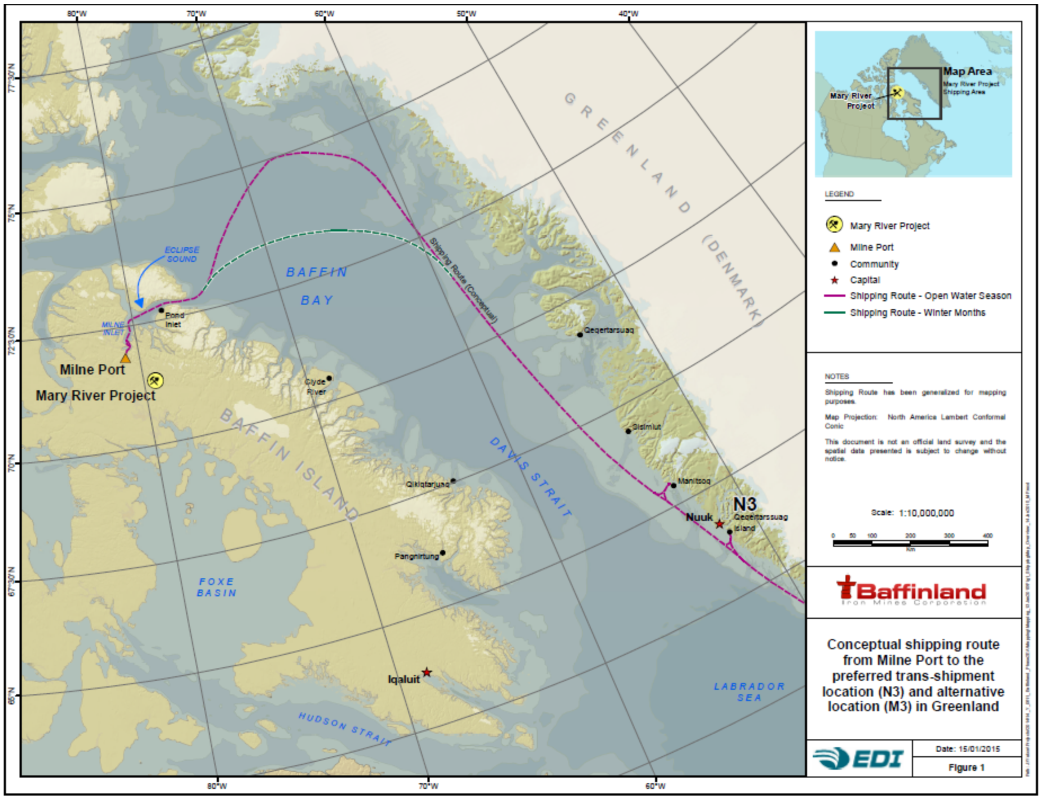
80°W
70°W
60°W
50°W
40°W
77°30'N
75°N
72°30'N
70°N
67°30'N
65°N
GREENLAND
(DENMARK)
ECLIPSE SOUND
MILNE INLET
Pond Inlet
BAFFIN BAY
Shipping Route (Conceptual)
Qeqertarsuaq
Milne Port
Mary River Project
Clyde River
BAFFIN ISLAND
DAVIS STRAIT
Sisimiut
Qikiqtarjuaq
Maniitsoq
N3
Nuuk
Qeqertarssuaq Island
Pangnirtung
FOXE BASIN
Iqaluit
LABRADOR SEA
HUDSON STRAIT
Map Area
Mary River Project Shipping Area
Mary River Project
LEGEND
Mary River Project
Milne Port
Community
Capital
Shipping Route - Open Water Season
Shipping Route - Winter Months
NOTES
Shipping Route has been generalized for mapping purposes.
Map Projection: North America Lambert Conformal Conic
This document is not an official land survey and the spatial data presented is subject to change without notice.
Scale: 1:10,000,000
0 50 100 200 300 400
Km
Baffinland
Iron Mines Corporation
Conceptual shipping route from Milne Port to the preferred trans-shipment location (N3) and alternative location (M3) in Greenland
EDI
Date: 15/01/2015
Figure 1

Figure 1: Baffinland Milne Port Shipping Routes[2]

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[2] Baffinland 2015. Purple line shows shipping route in open water season; green line shows route in winter months (ice season).

In early 2019, Baffinland Iron Mines Corporation (Baffinland) began the permitting process for its Phase 2 expansion project. This expansion would increase the amount of iron ore shipped from to the current 4.2 to 6.0 million tonnes per annum (Mtpa) up to 12.0 Mtpa.[3]

The expansion includes modifications of the marine infrastructure at the Baffinland Milne Inlet Port to accommodate larger vessels. The dock facilities currently only accommodate Post-Panamax ore carriers (85,000 DWT). The Phase 2 expansion infrastructure modifications would allow for the accommodate larger Cape-size ore carriers (180,000–250,000 DWT).

In addition to the change in vessel type, the shipping season would be expanded from its current 90 days (approximately 15 July–15 October) to 135 days (approximately 1 July–15 November). This would allow for more iron ore carrier transits. The shipping "shoulder seasons" would require ice-breaking operations.[4]

The Phase 2 expansion will include an estimated 134 to 176 ore carrier voyages (round trips) per year.[5] There will be two icebreakers and 10 tug vessels to support the shipping operations during the "shoulder seasons."[6] Previously, the annual vessel traffic was approximately 70 ore carrier round trip voyages per year.[7] This represents a 250% increase in vessel traffic. The project is expected to have a 21-year duration.[8] WWF-Canada has requested an analysis of the increased risk of oil spills with the Phase 2 expansion.

The current report focuses on the changing probability of oil spills from vessel traffic to Milne Inlet Port. The estimated probability of oil spills based on the existing vessel operations (baseline) are presented in addition to the estimated probability of oil spills based on the potential vessel operations under the Phase 2 expansion. The baseline spill rate is compared to the Phase 2 expansion spill rate.

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[3] Baffinland 2015.
[4] Golder Associates 2019.
[5] Baffinland 2018a.
[6] Golder Associates 2019.
[7] Baffinland 2015; Curran 2015.
[8] Baffinland 2015.

Baffinland Vessel Traffic

Oil Spill Potential from Vessels

There are five major types of vessels serving the Baffinland operations that could potentially spill oil in Eclipse Sound or Milne Inlet:

- Iron ore bulk carriers;
- Tug vessels;
- Icebreaking vessels;
- Resupply ships; and
- Fuel tankers or barges.

Potential spills from ore carriers could involve heavier bunker fuels, such as intermediate fuel oil or IFO 380, that would be used in the ocean-going segments of their voyages, marine diesel, that would be used in their in-port operations, and various types of lubricating oils. Note that ore-carriers would have bunker tanks that contain both heavier bunker fuels and marine diesel while transiting the Milne Inlet and port area and that either or both of these could spill in the event of an accident. The same would be true for resupply ships that come from outside of the region.

Tug vessels (tugboats) and ice-breaking vessels that operate solely in the Milne Inlet would likely contain marine diesel in their bunker tanks and could spill this in the event of an accident, in addition to any lubricating oils.)

Ore carriers, tug vessels, icebreakers, and resupply ships would not be carrying refined petroleum products as cargo. This limits the amount of oil that might be spilled from these vessels to the maximum amount of bunker fuel (heavier fuel oils and/or marine diesel). The other types of oils (e.g., lubricating oils) would be carried in significantly smaller quantities. The potential volumes of spillage depend on the specific sizes of the vessels.

Fuel tankers or barges servicing the vessels and the mine operations would be able to spill larger quantities of oil due to their larger capacity. Fuel tankers could also spill bunker fuel used for their own operations. Their bunker fuel would likely consist of both heavier bunker fuels and marine diesel for at-sea and in-port operations, respectively. They could spill either or both in the event of an accident. Fuel barges would have no bunker fuel of their own, but would have tow or tug boats to maneuver them. These vessels would have bunker fuel onboard, which would likely be marine diesel.

Vessel spills could occur due to collisions, allisions,[9] and groundings. These impact-caused accidents have the potential to cause larger spills. Other types of spills occur due to mechanical or equipment failures, structural failures, and miscellaneous operational errors.

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[9] The distinction between a "collision" and an "allision" is that the former involves two moving objects hitting each other, and the latter involves a moving object hitting a stationary object. A collision could involve two vessels hitting each other. An allision could involve a moving vessel striking a pier. A moving vessel striking a submerged object is generally considered a "grounding."

For tanker spills, in addition to all the aforementioned types of incidents, there may also be spills associated with transfer operations. These spills would involve spills that occur during fueling operations, often from leaking hose connections.

Existing Vessel Traffic (Baseline)

The Baffinland vessel traffic at present (during the early operations phase) in the Milne Inlet Port is summarized in Table 1. ***Note that the term "voyage" as used in various reports by Baffinland Iron Mines Corporation[10] is a two-way (round-trip) voyage. A voyage consists of two one-way transits. Transits are use in the analyses of spill probability because the likelihood of an accident with potential spillage exists for both one-way transits in a voyage. Vessel casualty studies generally express probabilities of accidents on a per-transit basis as in some cases, depending on the waterway or port configuration, a vessel may only transit in a particular location once***

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[10] For example, Baffinland Iron Mines Corp. 2020.

Table 1: Baseline Baffinland Vessel Traffic in Milne Inlet

Vessel Type	Vessel Size	Oil Capacity	Annual One-Way Transits
Panamax PC4 Ore Carrier[11]	85,000 DWT	2,226 m^3	140 transits[12]
Fuel Tanker	13,000 DWT	17,000 m^3	6 transits[13]
Tug Boat[14]	6,000 hp (90 GT)	600 m^3	292 transits[15]
Resupply Ship[16]	2,890 DWT	1,050 m^3	6 transits[17]
Icebreaker	-	-	0 transits
Total			**444 transits**

Expected Phase 2 Expansion Vessel Traffic

The Baffinland overall vessel traffic in the Milne Port Inlet that is projected for Phase 2 is summarized in Table 2. The exact makeup of the ore carrier fleet will depend on market and availability factors. A hypothetical distribution of the vessel sizes for ore carriers is included in Table 2.[18] The updated expected schedule of icebreaker traffic is shown in Table 4.

Table 2: Updated Phase 2 Baffinland Vessel Traffic in Milne Inlet[19]

Vessel Type	Vessel Size	Oil Capacity	Annual One-Way Transits	
			Lower Traffic	Higher Traffic
Ice Class Supramax Ore Carrier	55,000 DWT	1,440 m^3	101 transits	132 transits
Ice Class Ultramax Ore Carrier	64,000 DWT	1,700 m^3	37 transits	48 transits
Ice Class Panamax Ore Carrier	85,000 DWT	2,226 m^3	101 transits	132 transits
Non-Ice Class Panamax Ore Carrier	85,000 DWT	2,226 m^3	8 transits	10 transits
Non-Ice Class Kamsarmax Ore Carrier	80,000 DWT	2,000 m^3	2 transits	2 transits
Non-Ice Class Cape-Size Ore Carrier	105,000 DWT	4,452 m^3	21 transits	28 transits
Fuel Tanker[20]	13,000 DWT	17,000 m^3	11 transits	15 transits
Tug Boat[21]	6,000 hp (90 GT)	600 m^3	550 transits	724 transits

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[11] Bunker capacity from data in Curran 2015.

[12] Based on 70 loads transiting from Milne Port to the trans-shipment area in Greenland for unloading. After each unloading, the vessels transit back to Milne Port (Baffinland 2015).

[13] Baffinland 2015. Note that for half of the transits, the fuel cargo would largely have been unloaded unless the vessel was also making a delivery to another port.

[14] Information on tug boat fuel capacity derived from http://www.tugboatinformation.com/tug.cfm?id=4548 based on 6,000 hp tug as described in Baffinland 2015.

[15] Assumes two tug boats per vessel as per description in Baffinland 2015.

[16] Information on vessel size and fuel capacity based on M/V Botnica (TS Shipping, undated). This vessel is mentioned in an application by Baffinland Iron Mines for a licence to operate an ice management and multipurpose support vessel (https://www.otc-cta.gc.ca/eng/ruling/w-2019-77).

[17] Curran 2015.

[18] Distribution of ore carrier classes based on Baffinland Iron Mines Corp. 2020. (Note that this distribution is identical to that previously presented in ERC's 2019 report. Those data had been based on information in Golder 2019, which, in turn, was based on Baffinland 2018b.

[19] Updated based on Baffinland Iron Mines Corp. 2020.

[20] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers.

[21] Tug boat transits for Phase 2 are based on data in Baffinland Iron Mines Corp. 2020. There are 10 individual tugs that transit once into the port at the beginning of the season and then make back-and-forth transits between the dock and the anchorage. Each ore carrier has two tugs escorting it. All 10 tugs transit out of Milne Inlet at the end of the season. The tugs do not support the resupply ships. Since the data provided by Baffinland Iron Mines Corp. does not

Table 2: Updated Phase 2 Baffinland Vessel Traffic in Milne Inlet[19]

Vessel Type	Vessel Size	Oil Capacity	Annual One-Way Transits	
			Lower Traffic	Higher Traffic
Resupply Ship[22]	2,890 DWT	1,050 m^3	18 transits	24 transits
Icebreaker[23]	43–55 m Beam	2,000 m^3	48 transits	64 transits
Total			**897 transits**	**1,179 transits**

Table 3: Updated Phase 2 Icebreaker Traffic in Milne Inlet[24]

Season/Approximate Dates[25]	Annual One-Way Transits[26]	
	Lower Traffic	Higher Traffic
1 July–4 August (2 Icebreakers required per transit)	46 transits	60 transits
5 August–15 October (Icebreakers not required)	0 transits	0 transits
16 October – 15 November (2 Icebreakers required per transit)	2 transits	4 transits
Total	**48 transits**	**64 transits**

An updated comparison of the projected Phase 2 traffic and the baseline traffic for Milne Inlet is shown in Table 4.

Table 4: Updated Comparison of Baseline/Phase 2 Baffinland Vessel Traffic Levels in Milne Inlet

Vessel Type	Annual One-Way Transits			Increase with Phase 2 (Additional Vessels)	
	Baseline Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic
Ice Class Supramax Ore Carrier	0	101	132	101	132
Ice Class Ultramax Ore Carrier	0	37	48	37	48
Ice Class Panamax Ore Carrier	140	101	132	-39	-8
Non-Ice Class Panamax Ore Carrier	0	8	10	8	10
Non-Ice Class Kamsarmax Ore Carrier	0	2	2	2	2
Non-Ice Class Cape-Size Ore Carrier	0	21	28	21	28
Total Ore Carriers	**140**	**270**	**352**	**130**	**212**
Fuel Tanker[27]	6	11	15	5	9
Tug Boat	292	550	724	258	432

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include mention of fuel tankers being escorted, this analysis assumes that there are no escorts. However, it is common practice in many ports to have escorts with tankers.

[22] Resupply ship transits for Phase 2 are based on data in Baffinland Iron Mines Corp. 2020.

[23] Updated based on Baffinland Iron Mines Corp. 2020. The icebreakers are larger than the resupply ships (with 43–55 m beam widths compared to 24.3 m for resupply ship), which can perform some ice-breaking operations.

[24] Updated based on Baffinland Iron Mines Corp. 2020.

[25] Shipping season is assumed to begin 20 July and is completed on 16 October of each year as in Example Shipping Schedule 1 (Baffinland Iron Mines Corp. 2020).

[26] Lower and higher traffic transits for icebreakers are based on ore carrier traffic in Table 2.

[27] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

Table 4: Updated Comparison of Baseline/Phase 2 Baffinland Vessel Traffic Levels in Milne Inlet					
Vessel Type	**Annual One-Way Transits**			**Increase with Phase 2 (Additional Vessels)**	
	Baseline Traffic	**Phase 2 Lower Traffic**	**Phase 2 Higher Traffic**	**Phase 2 Lower Traffic**	**Phase 2 Higher Traffic**
Resupply Ship[28]	6	11	15	5	9
Icebreaker[29]	0	48	64	48	64
Total Support Vessels	**304**	**620**	**818**	**316**	**514**
Total	**444**	**890**	**1,170**	**446**	**726**

To provide a perspective on the degree of congestion, the change in vessel traffic in terms of vessels per day were calculated, as shown in Table 5. The calculations of vessels per day are based on the assumptions:

- There is a six-hour transit time through Milne Inlet and Eclipse Sound (i.e., each vessel spends about a quarter of a day in transit) for ore carriers, resupply ships, and icebreakers;[30]
- Tug boats only provide escort to and from the dock to an anchorage that is two km from the dock, for which each transit is estimated to take two hours, accounting for maneuvering, (i.e., each tug spends 0.083 days for each transit);[31]
- The days per-year of vessel traffic for the baseline is 90 days and for Phase 2 is 135 days.[32]

Note that the trips by vessel type are calculated as hours, which are then divided into days.

It is important to note that the traffic levels do not include any other vessels that may be transiting in the area. There are no reliable data for these numbers. With an increase in vessel traffic associated with the Bafflinland operations, there is a greater likelihood of a collision with another vessel, such as a fishing boat, recreational vessel, or tourist boat.[33] It is assumed that the level of this vessel traffic is consistent through both the baseline and Phase 2 time periods.

The data in Table 5 show the number of vessels that would be in transit (underway) at any one time that could encounter each other. There may be vessels that are docked. While the numbers of vessels may be significantly higher than before the Baffinland operations began, these data indicate a relatively low level of congestion at present and projected into the future compared with much busier ports, such as Vancouver, BC.

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[28] Resupply ship transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[29] Based on information in Baffinland Iron Mines Corp. 2020 and detailed in Table 3.

[30] Each one-way transit through Milne Inlet and Eclipse Sound is assumed to take six hours based on a visual estimate of the distance involved and typical vessel speeds, with verification from AIS records.

[31] Based on information provided by WWF Canada and information in Baffinland Mines Corp. 2018a.

[32] Golder Associates 2019.

[33] In the event of a collision between a fishing boat, recreational vessel, or small tourist boat, it is likely that the smaller boat would be the one to experience a spill, if any, rather than the larger vessel.

Table 5: Updated Per-Day Baffinland Vessel Traffic Levels in Milne Inlet

Vessel Type	Vessels Per Day During Operating Period			Increase with Phase 2 (Additional Vessels/Day)	
	Baseline Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic
Ice Class Supramax Ore Carrier	0.00	0.19	0.24	0.19	0.24
Ice Class Ultramax Ore Carrier	0.00	0.07	0.09	0.07	0.09
Ice Class Panamax Ore Carrier	0.39	0.19	0.24	-0.20	-0.14
Non-Ice Class Panamax Ore Carrier	0.00	0.01	0.02	0.01	0.02
Non-Ice Class Kamsarmax Ore Carrier	0.00	0.00	0.00	0.00	0.00
Non-Ice Class Cape-Size Ore Carrier	0.00	0.04	0.05	0.04	0.05
Total Ore Carriers	**0.39**	**0.50**	**0.65**	**0.11**	**0.26**
Fuel Tanker[34]	0.02	0.02	0.03	0.00	0.01
Tug Boat[35]	0.27	0.34	0.45	0.07	0.18
Resupply Ship[36]	0.02	0.02	0.03	0.00	0.01
Icebreaker[37]	0.00	0.09	0.12	0.09	0.12
Total Support Vessels	**0.84**	**1.15**	**1.51**	**0.30**	**0.67**
Total	**1.23**	**1.65**	**2.17**	**0.41**	**0.93**

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[34] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[35] Tug boat transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[36] Resupply ship transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[37] Based on information in Golder 2019 for average duration of “shoulder season” assuming one ice breaker per ore carrier, resupply ship, and fuel tanker transit in shoulder season. The

Vessel Oil Spill Probability Analysis Methodology

Vessel oil spills due to accidents are dependent on the specific vessel operations (numbers of transits, types of vessels, operational decisions) and the navigational and weather hazards in the region. An extensive vessel traffic modeling analysis was outside the scope of this study, but a brief analysis of probabilities of vessel spills follows.

General Approach to Calculating Vessel Oil Spill Probability

The probability of an oil spill for the vessel traffic in Milne Inlet and Eclipse Sound associated with the Baffinland Mary Mine operations is dependent on the probabilities of accidents and other failures occurring and then the probabilities that these accidents or failures will result in the release of oil. When vessel accidents occur, there is not necessarily a spillage of oil involved. In fact, only between 2% and 18% of vessel accidents may actually result in spillage.[38] The volume of spillage also has a distribution of probabilities associated with it (Figure 2).

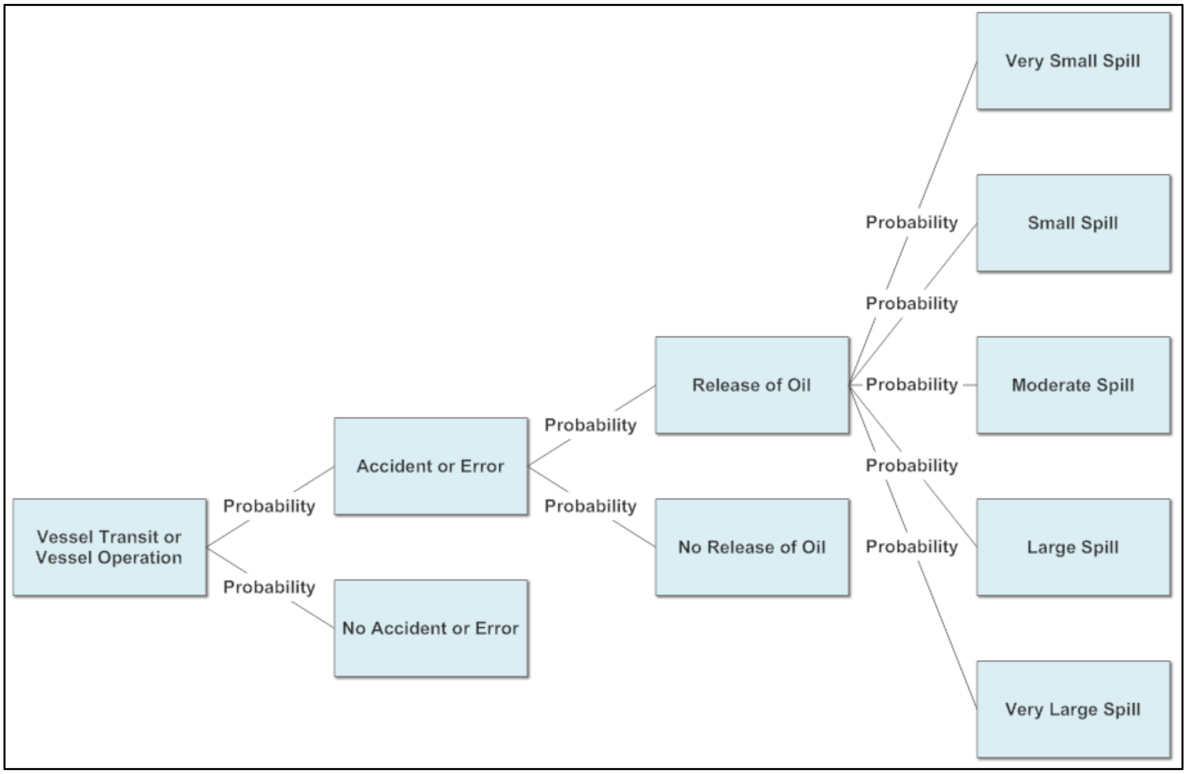
Very Small Spill
Probability
Small Spill
Probability
Release of Oil
Probability
Moderate Spill
Probability
Accident or Error
Probability
Probability
Vessel Transit or Vessel Operation
Probability
No Release of Oil
Probability
Large Spill
Probability
No Accident or Error
Very Large Spill

Figure 2: Series of Probabilities Leading to Vessel Oil Spill

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[38] Based on data from a variety of vessel casualty studies, the probability that an accident will result in a spillage from bunker varies from about 0.02 to 0.18 (or 2% to 18%) depending on whether the bunker tanks are double-hulled or single-hulled and on the accident type. The probability of a collision, allision, or grounding resulting in spillage from bunker tanks is 0.02 for double-hulled bunker tanks and 0.05 for single-hulled tanks. Other non-impact accidents or casualties (structural failures, broken hoses, engine-room fires, etc.) result in spillage is about 0.20, regardless of whether the bunker tanks are double-hulled or single-hulled. The proportion of single and double-hulled vessels is assumed to be 30%/70% at present. By 2030, all cargo ships are expected to have double-hulled bunker tanks (Barone et al. 2007; Etkin and Michel 2003; Herbert Engineering et al. 2003; Michel and Winslow 1999; and Michel and Winslow 2000.

If there is a release of oil, the volume may vary from a very small spill of a few litres to worst-case discharge scenario. Previous analyses, including the modeling of spill scenarios,[39] identified discharge scenarios as: 1,000 m^3 bunker fuel from a Panamax ore carrier and 2,400 m^3 diesel cargo from a product tanker (fuel tanker). These cases represent "reasonable" or most-probable worst-case discharges. Theoretically, a worst-case discharge would be the release of the entire oil contents of the vessel. This would be about 2,200 m^3 for the ore carrier and 15,000 m^3 for the product tanker. The product tanker spill would be expected to involve only half of the total capacity–or 7,500 m^3 because double hulls on tankers reduce the amount of outflow by 50% in the event of hull breach in an accident (in addition to reducing the likelihood of a hull breach).[40]

The probabilities of accidents and spills are generally calculated on a per-vessel trip or per-transit basis. The more vessel trips or transits, the greater the likelihood of spills. In general, increasing the numbers of vessels increases the likelihood of accidents and spills. This assumes that there is an equal chance of an accident or other failure that causes a spill with each transit. This is not strictly true for vessel spills. There are conditions for which the likelihood is greater or less (e.g., weather, presence of ice, degree of operator training, vessel maintenance, presence of vessel traffic systems). The probabilities of accidents and spills is based on averages from other waterways around the world, not the specific conditions in Milne Inlet or Eclipse Sound.

For very congested waterways, the degree of congestion (the numbers of vessels in close proximity to each other in relatively confined areas) can affect the numbers of collisions exponentially. This is because collisions involve two (or more) vessels and with more vessels there are increasingly greater chances of encounters. [This is akin to the likelihood of bumping into another pedestrian on a sidewalk. If there are few people walking, it is very unlikely that someone will collide with another person. If there are twice as many people walking, it becomes slightly more likely there will be a collision. If there are hundreds of pedestrians moving at different speeds and in different directions, the likelihood of bumping into another person increases significantly.] Vessel congestion is not likely a significant factor in Milne Inlet or Eclipse Sound (based on data in Table 5).

Terminology for Probability, Chance, Percent Chance, and Expected Frequency

The probability that something will occur is the expected frequency of events or the number of events that is expected in a specified time frame. That time frame might be a year or the lifetime of the oil transport associated with mining project vessel traffic, for example. If the term "probability" is used, it is related to a specific time frame. In this case the "events" are oil spills or releases from vessels. Spill probabilities are dependent on the number of vessel transits or operations and the amount of time that is being considered.

The percent probability or percent chance is the likelihood of an event occurring is based on a scale of 0 (no chance) to 1, or 100% (definite occurrence of an event). These expressions are useful if one is concerned with just determining whether or not an event may occur. However, in this analysis, it is important to determine the expected number of spills and the potential increase in spills. This requires an absolute number of spills or an expected frequency of spills. Note that if the expected frequency is less than one over the time period considered (e.g., 0.01 spills per year, or 0.21 spills over 21 years), the percent probability is the same as the frequency. With a spill frequency of 0.01 per year, the chance of a spill in any particular year is 1 in 100 or 1%. If there is a spill frequency of 2.7 per year or 3.5 per year, the chance of a spill is 100% in both cases. In these cases, it is more informative to refer to spill frequency, which is the way in which the data are presented in this report.

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[39] Etkin 2016; Reich et al. 2016; Amec Foster Wheeler 2016.

[40] Rawson and Brown 1998; Yip et al. 2011b. NRC 1998, 2001.

For vessel spills, the expected number of spills is based on the likelihood or probability of an accident and the probability that that accident will result in the discharge of oil. The more vessels and/or the more time considered, the greater the expected number of spills. Hypothetically, for example, if there is a 0.1% probability (or a one in 1,000 chance–0.001) of a spill for each vessel per year, the number of vessels and the time period need to be considered. If there are 15 vessels, there is a 15 times 0.001 chance–or an 0.015 (or one in 67) chance that there will be a spill in any particular year. The expected frequency of spills is 0.015 per year. If the mining project lasts for 21 years, the expected frequency of spills over the lifetime of the mining operations is 0.315. This would mean a 1 in 3 chance that there would be a spill at some point in those 21 years–or a 1 in 67 chance in any one year.

Probability analysis results are sometimes expressed as *return periods*. (Return period is also sometimes called “recurrence interval.”) The expected frequency is an estimate of the likelihood or probability that an event (in this case, a spill of a certain volume from a vessel) will occur in any given year. The inverse of this is the return period. For example, if there is a 1% chance, or a one in 100 chance, that a large spill event will occur in one year. The “return period” for this event is 100 years. The return period is the inverse of the frequency.

$$Frequency(event) = \frac{number(events)}{year}$$

$$Return = \frac{1}{Frequency(event)} = \frac{years}{event}$$

$$Frequency(event) = \frac{0.01}{year}$$

$$Return(event) = \frac{1}{0.01} = 100$$

The return period (e.g., 100 years) is used in an attempt to simplify the definition of a specific statistically-determined chance of an event occurring in any one year (1%). It does not however mean that it will necessarily take 100 years before this event occurs or that it will only occur once in a 100-year time frame. There can be expected frequencies greater than one in a time period, such as a year. If there is an expected frequency of six in one year, this means that there is a return period of about two months.

Because the concept of “return period” often creates confusion and the mistaken expectation that events will occur on a regular basis, it is often advisable to express the probabilities as expected frequencies in a particular time period. This can also be expressed as the chances that an event will occur in a particular time period. An 0.1% probability in a single year is a 1 in 1,000 “chance” that the event will happen in any particular year. The probability that the event will happen over the course of 5 years is five times the probability, or 0.5%. This is the equivalent of a 5 in 1,000 (or 1 in 200) chance. Over the course of 21 years, the probability is 2.1% or 1 in 48 chance.

Rounding of Numbers and Significant Digits

In summary tables, such as those providing estimates of annual frequencies of specific volumes of spills, the results have been rounded to two or three significant digits, as appropriate, starting with the first non-zero digit. This is a standard methodology applied in many analyses to avoid the implication that one could be so precise in determining the frequency of spill events in the future. For example, if the calculated spill frequency is 0.00128 per year, which would bring a return period of 781.25 years, the spill frequency would be rounded to 0.0013 per year and the return period would be expressed as 780 years. Note that "significant digits" are also called "significant figures."

Probabilities of Spills by Vessel Type and Accident Type

The probabilities of accidents and the corresponding probabilities of spillage by vessel type are summarized in Table 6. *Note that the per-transit probabilities are for spills of any volume, not necessarily a large spill.* The probabilities of accidents are based on studies of historical data and modeling. In the future, the probabilities of accidents may be reduced based on safety and spill prevention measures taken.

Table 6: Updated Per-Transit Probabilities of Spills by Vessel Type and Accident Type

Vessel Type	Accident Type	Accident Probability per Transit[41]	Spill Probability per Accident[42]	Spill Probability per Transit	Spill Chance per Transit
Ore Carrier (All Sizes)	**Collision**	0.0000023	0.04	0.000000093	1 in 430,000
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.000003	0.04	0.00000012	1 in 330,000
	Other (Non-Impact)	0.00003	0.2	0.0000060	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000
Fuel Tanker	**Collision**	0.0000021	0.15	0.00000031	1 in 490,000
	Allision	0.0000004	0.15	0.000000060	1 in 2.5 million
	Grounding	0.0000018	0.18	0.00000032	1 in 560,000
	Other (Non-Impact)	0.0007	0.4	0.00028	1 in 1,400
	Transfer Error	0.000045	0.92	0.000041	1 in 22,000
Tug Boat[43]	**Collision**	0.000000032	0.04	0.0000000013	1 in 790 million
	Allision	0.00000013	0.04	0.0000000053	1 in 190 million
	Grounding	0.00000016	0.04	0.0000000064	1 in 160 million
	Other (Non-Impact)	0.00012	0.2	0.000023	1 in 43,000
	Transfer Error	0.000037	0.92	0.000034	1 in 30,000
Resupply Ship	**Collision**	0.000000095	0.04	0.000000004	1 in 11 million
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million

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[41] Probabilities based on data in DNV-GL 2011a, 2011b; The Glosten Associates et al. 2013. Assuming six-hour transit time through Milne Inlet and Eclipse Sound for ore carriers, resupply ships, icebreakers, and fuel tankers, and a two-hour time per transit for tug boats.

[42] Spill probabilities for bunker tanks on ore carriers are based on the fleet having double hulls on bunker tanks for 70% of vessels. The other 30% of vessels are assumed to have single hulls. By 2030, all cargo ships will have double hulls on bunker tanks.

[43] The tug boat data were updated from the 2019 report to reflect the shortened transit times (two hours rather than six hours, as previously assumed).

Table 6: Updated Per-Transit Probabilities of Spills by Vessel Type and Accident Type

Vessel Type	Accident Type	Accident Probability per Transit[41]	Spill Probability per Accident[42]	Spill Probability per Transit	Spill Chance per Transit
	Grounding	0.0000010	0.04	0.000000041	1 in 980,000
	Other (Non-Impact)	0.00003	0.2	0.000006	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000
Icebreaker	**Collision**	0.000000095	0.04	0.000000004	1 in 10.5 million
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.0000010	0.04	0.000000041	1 in 980,000
	Other (Non-Impact)	0.00003	0.2	0.000006	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000

Note that these accident rates are based on a variety of studies of global accident rates. The likelihood of a vessel accident in any particular port or waterway is dependent on a large number of factors, including local weather conditions, waterway configuration, bathymetry (bottom depth), navigational hazards (submerged rocks or shallows e.g.), congestion, presence of vessel traffic systems and vessel traffic lanes, presence of ice, visibility issues (fog, limited sight distances in curves, darkness), to name a few. The conditions in the Milne Inlet and Eclipse Sound will be considerably less congested than other waterways, but there may be other factors, such as the presence of ice and longer hours of darkness in the fall and spring, that may affect accident rates. A comprehensive vessel traffic study was outside of the scope of this analysis.

Baffinland Vessel Oil Spill Frequencies by Traffic

The per-transit vessel spill rates were applied to current (baseline) and projected future traffic levels to determine the expected numbers of spills.

Approach to Calculating Expected Spill Frequencies

The expected spill frequencies are based on a series of independent probabilities which are multiplied together (as previously illustrated in Figure 2):

- The estimated probability of having an accident (collision, allision, grounding, other non-impact, or transfer error), which was derived from studies cited in the report. The probabilities differ by vessel type.
- The probability that an accident of a particular type of vessel will result in a spill, which are based on probabilities for single- and double-hulled bunker tanks, as described above.
- The probability that a spill will involve different percentages of outflow – i.e., the probability distribution of different outflows. A spill is most likely to be small and then there are decreasing probabilities of increasingly larger spills. The outflow probabilities were applied to the probability of a spill occurring in the first place.

Updated Expected Frequencies of Spills Based on Vessel Traffic

The annual expected frequencies of spills based on current and projected Phase 2 traffic are shown in Table 7. *Note that the per-transit probabilities are for spills of any volume, not necessarily a large spill.* The same data are shown as “chances” in Table 8.

Table 7: Updated Annual Expected Spill Frequency by Vessel/Accident Type by Vessel Traffic[44]

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier (All Sizes)	**Collision**	0.000000093	0.000013	0.000025	0.000033
	Allision	0.000000016	0.0000023	0.0000043	0.0000058
	Grounding	0.00000012	0.000017	0.000033	0.000043
	Other (Non-Impact)	0.0000060	0.00085	0.0016	0.002
	Transfer Error	0.00023	0.033	0.063	0.080
Fuel Tanker	**Collision**	0.00000030	0.0000018	0.0000033	0.0000045
	Allision	0.000000060	0.00000035	0.00000065	0.00000090
	Grounding	0.00000033	0.0000020	0.0000035	0.0000050
	Other (Non-Impact)	0.00028	0.0017	0.0030	0.0043
	Transfer Error	0.000043	0.00025	0.00048	0.00065
Tug Boat	**Collision**	0.0000000013	0.0000092	0.000017	0.000023
	Allision	0.0000000053	0.000039	0.000073	0.000097
	Grounding	0.0000000064	0.000047	0.000088	0.00012
	Other (Non-Impact)	0.000023	0.034	0.064	0.084
	Transfer Error	0.000034	0.011	0.020	0.027

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[44] The data in Table 7 were updated to reflect changes in spill rates per transit for tug boats (as in Table 6) and updated vessel traffic data for icebreakers and tugboats.

Table 7: Updated Annual Expected Spill Frequency by Vessel/Accident Type by Vessel Traffic[44]

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Resupply Ship	**Collision**	0.000000004	0.000000023	0.000000043	0.000000058
	Allision	0.000000016	0.000000095	0.000000175	0.00000024
	Grounding	0.000000040	0.00000024	0.000000450	0.00000060
	Other (Non-Impact)	0.0000060	0.000035	0.000065000	0.000090
	Transfer Error	0.00023	0.0014	0.0025	0.0035
Icebreaker	**Collision**	0.000000004	0	0.0000002	0.0000003
	Allision	0.000000016	0	0.0000008	0.0000010
	Grounding	0.000000040	0	0.0000019	0.0000026
	Other (Non-Impact)	0.0000060	0	0.00029	0.00038
	Transfer Error	0.00023	0	0.011	0.015

Table 8: Updated Chances of Spills by Vessel/Accident Type by Vessel Traffic[45]

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier	**Collision**	0.000000093	1 in 77,000	1 in 40,000	1 in 30,303
	Allision	0.000000016	1 in 430,000	1 in 230,000	1 in 172,414
	Grounding	0.00000012	1 in 59,000	1 in 30,000	1 in 23,256
	Other (Non-Impact)	0.0000060	1 in 1,200	1 in 630	1 in 500
	Transfer Error	0.00023	1 in 30	1 in 16	1 in 1 in 13
Fuel Tanker	**Collision**	0.00000030	1 in 560,000	1 in 300,000	1 in 220,000
	Allision	0.000000060	1 in 2.9 million	1 in 1.5 million	1 in 1.1 million
	Grounding	0.00000033	1 in 500,000	1 in 290,000	1 in 200,000
	Other (Non-Impact)	0.00028	1 in 600	1 in 330	1 in 230
	Transfer Error	0.000043	1 in 4,000	1 in 2,100	1 in 1,500
Tug Boat	**Collision**	0.0000000013	1 in 110,000	1 in 57,000	1 in 44,000
	Allision	0.0000000053	1 in 26,000	1 in 14,000	1 in 10,000
	Grounding	0.0000000064	1 in 21,000	1 in 11,000	1 in 8,600
	Other (Non-Impact)	0.000023	1 in 29	1 in 16	1 in 12
	Transfer Error	0.000034	1 in 93	1 in 50	1 in 38
Resupply Ship	**Collision**	0.000000004	1 in 43 million	1 in 23 million	1 in 17 million
	Allision	0.000000016	1 in 11 million	1 in 5.7 million	1 in 4.2 million
	Grounding	0.000000040	1 in 4.2 million	1 in 2.2 million	1 in 1.7 million
	Other (Non-Impact)	0.0000060	1 in 29,000	1 in 15,000	1 in 11,000
	Transfer Error	0.00023	1 in 710	1 in 400	1 in 290
Icebreaker	**Collision**	0.000000004	0	1 in 5.2 million	1 in 3.9 million
	Allision	0.000000016	0	1 in 1.3 million	1 in 980,000
	Grounding	0.000000040	0	1 in 520,000	1 in 390,000

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[45] The data in Table 7 were updated to reflect changes in spill rates per transit for tug boats (as in Table 6) and updated vessel traffic data for icebreakers and tugboats.

Table 8: Updated Chances of Spills by Vessel/Accident Type by Vessel Traffic[45]

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
	Other (Non-Impact)	0.0000060	0	1 in 3,500	1 in 2,600
	Transfer Error	0.00023	0	1 in 91	1 in 68

The updated expected frequencies and chances in Table 7 and Table 8 are on an annual basis. If the mining project continues for 21 years,[46] the expected frequencies and chances are as shown in Table 9 and Table 10. Note that when the expected frequency (over the 21-year period) is more than one, it means that it is likely that there would be at least one spill during the project. However, it does not "guarantee" that there would be a spill. These frequencies are shown as chances of one in a number smaller than one.

Table 9: Updated Expected Spill Frequency for 21-Year Baffinland Project

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier[47]	**Collision**	0.000000093	0.00028	0.00053	0.00068
	Allision	0.000000016	0.000048	0.000090	0.00012
	Grounding	0.00000012	0.00035	0.00068	0.00090
	Other (Non-Impact)	0.0000060	0.018	0.035	0.045
	Transfer Error	0.00023	0.68	1.33	1.7
Fuel Tanker	**Collision**	0.00000030	0.000038	0.000068	0.000095
	Allision	0.000000060	0.0000073	0.000014	0.000019
	Grounding	0.00000033	0.000040	0.000073	0.00011
	Other (Non-Impact)	0.00028	0.035	0.063	0.090
	Transfer Error	0.000043	0.0053	0.010	0.014
Tug Boat	**Collision**	0.0000000013	0.00019	0.00036	0.00048
	Allision	0.0000000053	0.00082	0.0015	0.0020
	Grounding	0.0000000064	0.00099	0.0018	0.0025
	Other (Non-Impact)	0.000023	0.71	1.3	1.8
	Transfer Error	0.000034	0.23	0.42	0.57
Resupply Ship	**Collision**	0.000000004	0.00000048	0.00000090	0.0000012
	Allision	0.000000016	0.0000020	0.0000038	0.0000050
	Grounding	0.000000040	0.0000050	0.000009500	0.000013
	Other (Non-Impact)	0.0000060	0.00073	0.0014	0.0019
	Transfer Error	0.00023	0.030	0.053	0.073
Icebreaker	**Collision**	0.000000004	0	0.0000042	0.0000063
	Allision	0.000000016	0	0.000017	0.000021
	Grounding	0.000000040	0	0.000040	0.000055
	Other (Non-Impact)	0.0000060	0	0.0061	0.0080
	Transfer Error	0.00023	0	0.23	0.32

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[46] Baffinland 2018.

[47] Note that all ore carriers are considered together in this analysis (regardless of size).

Table 10: Updated Chances of Spills for 21-Year Baffinland Project

Vessel Type	Accident Type	Spill Probability per Transit	Annual Chances of Spills Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier	**Collision**	0.000000093	1 in 3,600	1 in 1,900	1 in 1,500
	Allision	0.000000016	1 in 21,000	1 in 11,000	1 in 8,300
	Grounding	0.00000012	1 in 2,900	1 in 1,500	1 in 1,100
	Other (Non-Impact)	0.0000060	1 in 56	1 in 29	1 in 22
	Transfer Error	0.00023	1 in 1.5	1 in 0.8	1 in 0.6
Fuel Tanker	**Collision**	0.00000030	1 in 27,000	1 in 15,000	1 in 11,000
	Allision	0.000000060	1 in 140,000	1 in 73,000	1 in 53,000
	Grounding	0.00000033	1 in 25,000	1 in 14,000	1 in 9,500
	Other (Non-Impact)	0.00028	1 in 29	1 in 16	1 in 11
	Transfer Error	0.000043	1 in 190	1 in 100	1 in 73
Tug Boat	**Collision**	0.0000000013	1 in 5,300	1 in 2,800	1 in 2,083
	Allision	0.0000000053	1 in 1,20	1 in 670	1 in 500
	Grounding	0.0000000064	1 in 1,00	1 in 560	1 in 400
	Other (Non-Impact)	0.000023	1 in 1.4	1 in 0.8	1 in 0.6
	Transfer Error	0.000034	1 in 4.3	1 in 2.4	1 in 1.8
Resupply Ship	**Collision**	0.000000004	1 in 2.1 million	1 in 1.1 million	1 in 830,000
	Allision	0.000000016	1 in 500,000	1 in 270,000	1 in 200,000
	Grounding	0.000000040	1 in 200,000	1 in 110,000	1 in 80,000
	Other (Non-Impact)	0.0000060	1 in 1,400	1 in 730	1 in 530
	Transfer Error	0.00023	1 in 33	1 in 19	1 in 14
Icebreaker	**Collision**	0.000000004	0	1 in 240,000	1 in 160,000
	Allision	0.000000016	0	1 in 60,000	1 in 48,000
	Grounding	0.000000040	0	1 in 25,000	1 in 18,000
	Other (Non-Impact)	0.0000060	0	1 in 160	1 in 130
	Transfer Error	0.00023	0	1 in 4	1 in 3

In evaluating the potential for future spills, as shown in Table 7 through Table 10, it is important to bear in mind that the calculations are based on projections of past accident and spill rates, as experienced in the past. There have been significant reductions in spills from vessels over the last several decades due to vessel engineering and double hulls on bunker tanks as well as on cargo tanks. In addition, there have been improvements in training of crew members, and shipping practices that have contributed to these spill reductions. Over the next 21 years, there are likely to be continued reductions in spills that may significantly reduce the likelihood of spills.

Expected Oil Outflow with Spill

In addition to the potential reductions in the future likelihood of spills, it is important to consider the volumes of potential spills. Spill impacts are greater with larger volumes. The expected spill frequencies and chances shown in the Table 7 through Table 10 are for an unspecified spill volume. Most spills tend to be small. Only a small percentage is large. Spill volume depends on the accident circumstances, vessel capacity, and loaded volume. Oil type affects the way in which it flows out.

Outflow modeling has demonstrated that the volumes of outflows for the very largest incidents involving tankers and tank barges would be reduced by 50% with double hulls. Note also that this is independent of the probability of spillage occurring with an impact accident. Impact accidents are those involving the vessel hitting another vessel or object, as would occur in a grounding, allision, or collision. Double hulls on tankers accomplish two things: reduction of the probability of any spillage occurring in the event of impact, and reduction of the volume of spillage for the very largest incidents by 50%. This is not the case for double hulls on bunker tanks, for which there is a reduction in the probability of spillage occurring in an impact accident, but there is no reduction in spillage volume with large incidents. The percentage oil outflow probabilities from tankers (Table 11) is based on international studies of the amount of oil actually spilled compared with the adjusted capacity of the vessel, which was verified by existing oil outflow models developed for the International Maritime Organization (IMO).[48] Bunker outflow probabilities for impact accidents are shown in Table 12. Oil outflow for non-impact casualties, including structural failure, equipment failure, and fire tends to be smaller than that for impact-related events, as shown in Table 13 for tankers and Table 14 for bunker tanks.[49]

Table 11: Oil Outflow Probability for Double-Hull Tankers in Impact Accidents

% Cargo Outflow	Probability	Cumulative Probability
0.002%	0.3589	0.3589
0.02%	0.1400	0.4989
0.05%	0.1200	0.6189
0.2%	0.1110	0.7299
0.7%	0.0900	0.8199
1.3%	0.0800	0.8999
3.1%	0.0700	0.9699
20%	0.0300	0.9999
50%	0.0001	1.0000

Table 12: Bunker Outflow Probability from All Vessel Impact Accidents[50]

% Bunker Outflow	Probability	Cumulative Probability
0.01%	0.23	0.2300
0.03%	0.17	0.4000
0.15%	0.14	0.5400
1.6%	0.10	0.6400
4.3%	0.09	0.7300
10%	0.08	0.8100
16%	0.06	0.8700
33.3%	0.05	0.9200
59%	0.04	0.9600
100%	0.04	1.0000

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[48] Rawson and Brown 1998; Yip et al. 2011b; NRC 1998, 2001.

[49] Based on Etkin and Michel 2003; Etkin 2001; Etkin 2002.

[50] Etkin and Michel 2003; Etkin 2001; Etkin 2002; Herbert Engineering et al. 2003; Michel and Winslow 1999, 2000; Barone et al. 2007; Yip et al. 2011a.

Table 13: Oil Outflow Probability for Non-Impact Incidents in Tankers

% Cargo Outflow (Adjusted)	Probability	Cumulative Probability
0.01%	0.50	0.5000
0.02%	0.15	0.6500
0.06%	0.11	0.7600
0.16%	0.08	0.8400
0.54%	0.08	0.9200
11.50%	0.08	1.0000

Table 14: Bunker Outflow Probability from All Vessel Non-Impact Incidents

% Bunker Outflow (Adjusted)	Probability	Cumulative Probability
0.001%	0.20	0.2000
0.003%	0.15	0.3500
0.008%	0.13	0.4800
0.015%	0.11	0.5900
0.06%	0.09	0.6800
0.1%	0.08	0.7600
0.8%	0.04	0.8000
3%	0.04	0.8400
12%	0.04	0.8800
36%	0.04	0.9200
40%	0.02	0.9400
71%	0.02	0.9600
91%	0.02	0.9800
100%	0.02	1.0000

Expected Spill Frequencies by Volume and Vessel Type

Spills of different volumes from ore carriers that would be expected on an annual basis and over the 21-year project time frame under baseline and Phase 2 traffic levels are summarized in Table 15. (The same data are shown as “chances” in Table 16.) Oil capacities and proportions of vessel types are based on the data in Table 1 and Table 2. Data for other vessel types are shown in Table 17 through Table 24.Volumes have been grouped into categories by order of magnitude–0.01 m^3 (0.01–0.9 m^3), 0.1 m^3 (0.1–0.9 m^3), 1 m^3 1 to 9 m^3), 10 m^3 (10–99 m^3), and 100 m^3 (100–999 m^3), and 1,000 m^3 (1,000-9,999 m^3). Generally, the likelihood of larger spills is lower than that of smaller spills. However, in this analysis, because different types of spills (impact-caused and non-impact spills) were combined and there are different percentages of outflow with associated probabilities, there were sometimes more incidents that would fall into a larger volume category.

Table 15: Expected Bunker Spill Frequency by Volume for Ore Carriers

Volume Category	Baseline Traffic[51]		Phase 2 Lower Traffic Level[52]		Phase 2 Higher Traffic Level[53]	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	0.012	0.24	0.022	0.45	0.028	0.59
0.1 m^3	0.0079	0.17	0.018	0.38	0.024	0.50
1 m^3	0.0056	0.12	0.0087	0.18	0.011	0.24
10 m^3	0.0026	0.056	0.0049	0.10	0.0064	0.13
100 m^3	0.0033	0.069	0.0063	0.13	0.0082	0.17
1,000 m^3	0.0020	0.042	0.0041	0.087	0.0054	0.11
Total	**0.033**	**0.69**	**0.064**	**1.3**	**0.083**	**1.7**

Table 16: Chances of Bunker Spills by Volume for Ore Carriers

Volume Category	Baseline Traffic[54]		Phase 2 Lower Traffic Level[55]		Phase 2 Higher Traffic Level[56]	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	1 in 86	1 in 4.1	1 in 46	1 in 2.2	1 in 36	1 in 1.7
0.1 m^3	1 in 130	1 in 6.0	1 in 55	1 in 2.6	1 in 42	1 in 2.0
1 m^3	1 in 180	1 in 8.5	1 in 110	1 in 5.5	1 in 88	1 in 4.2
10 m^3	1 in 380	1 in 18	1 in 200	1 in 9.7	1 in 160	1 in 7.4
100 m^3	1 in 300	1 in 14	1 in 160	1 in 7.6	1 in 120	1 in 5.8
1,000 m^3	1 in 500	1 in 24	1 in 240	1 in 12	1 in 190	1 in 8.8
Total	**1 in 30**	**1 in 1.4**	**1 in 16**	**1 in 0.75**	**1 in 12**	**1 in 0.57**

Table 17: Expected Oil Cargo Spill Frequency by Volume for Fuel Tankers

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.000041	0.00086	0.000074	0.0016	0.00011	0.0023
1 m^3	0.026	0.55	0.047	1.0	0.068	1.4
10 m^3	0.011	0.23	0.020	0.41	0.028	0.59
100 m^3	0.000020	0.00043	0.000037	0.00078	0.000054	0.0011
1,000 m^3	0.0032	0.068	0.0058	0.12	0.0083	0.17
Total	**0.040**	**0.85**	**0.073**	**1.5**	**0.10**	**2.2**

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[51] Expected spill number with baseline traffic on an annual basis and over 21 years at that traffic level.

[52] Expected spill number with lower projected traffic level on an annual basis and over 21 years at that traffic level.

[53] Expected spill number with higher projected traffic level on an annual basis and over 21 years at that traffic level.

[54] Expected number of spills with the baseline (current traffic) on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

[55] Expected number of spills with the lower projected level of traffic on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

[56] Expected number of spills with the higher projected level of traffic on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

Table 18: Chances of Oil Cargo Spills by Volume for Fuel Tankers

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 24,000	1 in 1,200	1 in 13,000	1 in 640	1 in 9,300	1 in 440
1 m^3	1 in 38	1 in 1.8	1 in 21	1 in 1.0	1 in 15	1 in 0.7
10 m^3	1 in 92	1 in 4.4	1 in 51	1 in 2.4	1 in 36	1 in 1.7
100 m^3	1 in 49,000	1 in 2,300	1 in 27,000	1 in 1,300	1 in 19,000	1 in 890
1,000 m^3	1 in 310	1 in 15	1 in 170	1 in 8	1 in 120	1 in 5.7
Total	**1 in 25**	**1 in 1.2**	**1 in 14**	**1 in 0.7**	**1 in 9.6**	**1 in 0.5**

Table 19: Updated Expected Bunker Spill Frequency by Volume for Tug Boats

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.034	0.72	0.064	1.34	0.084	1.77
1 m^3	0.002	0.037	0.003	0.070	0.004	0.092
10 m^3	0.004	0.075	0.007	0.11	0.009	0.19
100 m^3	0.005	0.2	0.010	0.22	0.014	0.29
1,000 m^3	-	-	-	-	-	-
Total	**0.045**	**0.95**	**0.084**	**1.8**	**0.11**	**2.3**

Table 20: Updated Chances of Bunker Spills by Volume for Tug Boats

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 29	1 in 1.4	1 in 16	1 in 0.74	1 in 12	1 in 0.56
1 m^3	1 in 560	1 in 27	1 in 301.72	1 in 14	1 in 230	1 in 11
10 m^3	1 in 280	1 in 13	1 in 149.08	1 in 7.1	1 in 110	1 in 5.4
100 m^3	1 in 180	1 in 8.7	1 in 97.48	1 in 4.6	1 in 74	1 in 3.5
1,000 m^3	-	-	-	-	-	-
Total	**1 in 22**	**1 in 1.1**	**1 in 11.88**	**1 in 0.57**	**1 in 9**	**1 in 0.43**

Table 21: Expected Bunker Spill Frequency by Volume for Resupply Ships

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.021	0.44	0.037	0.78	0.041	0.87
1 m^3	0.0037	0.077	0.0065	0.14	0.0090	0.19
10 m^3	0.0012	0.026	0.0022	0.046	0.0030	0.063
100 m^3	0.0043	0.090	0.0076	0.16	0.010	0.22
1,000 m^3	0.00061	0.013	0.0011	0.023	0.0015	0.031
Total	**0.031**	**0.65**	**0.054**	**1.1**	**0.065**	**1.4**

Table 22: Chances of Bunker Spills by Volume for Resupply Ships

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 48	1 in 2.3	1 in 27	1 in 1.3	1 in 24	1 in 1.2
1 m^3	1 in 270	1 in 13	1 in 150	1 in 7.3	1 in 111	1 in 5.3
10 m^3	1 in 810	1 in 39	1 in 460	1 in 22	1 in 333	1 in 16
100 m^3	1 in 230	1 in 11	1 in 130	1 in 6.3	1 in 95	1 in 4.5
1,000 m^3	1 in 1,600	1 in 77	1 in 920	1 in 44	1 in 670	1 in 32
Total	**1 in 33**	**1 in 1.6**	**1 in 18**	**1 in 0.88**	**1 in 15**	**1 in 0.73**

Table 23: Updated Expected Bunker Spill Frequency by Volume for Icebreakers

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0	0	0.0067	0.14	0.0086	0.18
1 m^3	0	0	0.0019	0.041	0.0025	0.053
10 m^3	0	0	0.00091	0.020	0.0012	0.025
100 m^3	0	0	0.0012	0.025	0.0015	0.031
1,000 m^3	0	0	0.00067	0.015	0.00086	0.019
Total	0	0	**0.012**	**0.25**	**0.015**	**0.31**

Table 24: Updated Chances of Bunker Spills by Volume for Icebreakers						
Volume Category	**Baseline Traffic**		**Phase 2 Lower Traffic Level**		**Phase 2 Higher Traffic Level**	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0	0	1 in 150	1 in 7	1 in 120	1 in 5
1 m^3	0	0	1 in 520	1 in 24	1 in 400	1 in 19
10 m^3	0	0	1 in 1,100	1 in 51	1 in 830	1 in 40
100 m^3	0	0	1 in 870	1 in 41	1 in 670	1 in 32
1,000 m^3	0	0	1 in 1,500	1 in 68	1 in 1,200	1 in 53
Total	**0**	**0**	**1 in 150**	**1 in 7**	**1 in 1200**	**1 in 5**

Summary of Results

The various vessel types have different potential rates of spillage depending on the probability of accidents and errors, the likelihood of accidents and errors resulting in the release of oil, and the oil capacity of the vessels. The expected numbers of spills of different volumes depends on the numbers of vessels in each category.

Updated Summary of Expected Vessel Oil Spills by Volume

The various spill volume categories from the different vessel types were combined as shown in Table 25 and Table 26. The environmental, socioeconomic, and cultural effects of any spill will depend not only on the volume spilled, but on the oil type, location, and season of the incident, in addition to any response and restoration measures that are taken to mitigate effects.

It is important to note that the projections over 21 years assume that the likelihood of accidents and spills would be similar to that over the last couple of decades as the historical data upon which the probabilities are based are from that time period. Future spill frequencies are likely to go down if accident and spill prevention measures continue to be implemented and improved. Note that when the expected frequency is more than one, it means that it is likely that there would be at least one spill during the project. However, it does not "guarantee" that there would be a spill. These frequencies are shown as chances of one in a number smaller than one.

Table 25: Updated Expected Oil Spill Frequency by Volume for All Vessel Types

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	0.012	0.24	0.022	0.45	0.028	0.59
0.1 m^3	0.063	1.3	0.12	2.6	0.16	3.3
1 m^3	0.037	0.78	0.067	1.4	0.095	2.0
10 m^3	0.019	0.39	0.035	0.69	0.048	1.0
100 m^3	0.012	0.36	0.025	0.54	0.034	0.71
1,000 m^3	0.0058	0.12	0.012	0.25	0.016	0.33
Total	**0.15**	**3.1**	**0.29**	**6.0**	**0.37**	**7.9**

Table 26: Updated Chances of Oil Spills by Volume for All Vessel Types

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	1 in 83	1 in 4.2	1 in 45	1 in 2.2	1 in 36	1 in 1.7
0.1 m^3	1 in 16	1 in 0.75	1 in 8.0	1 in 0.38	1 in 6.3	1 in 0.30
1 m^3	1 in 27	1 in 1.3	1 in 15	1 in 0.70	1 in 11	1 in 0.51
10 m^3	1 in 53	1 in 2.6	1 in 29	1 in 1.5	1 in 21	1 in 1.0
100 m^3	1 in 79	1 in 2.8	1 in 40	1 in 1.9	1 in 30	1 in 1.4
1,000 m^3	1 in 170	1 in 8.1	1 in 86	1 in 4.1	1 in 62	1 in 3.0
Total	**1 in 6.7**	**1 in 0.32**	**1 in 3.5**	**1 in 0.17**	**1 in 2.7**	**1 in 0.13**

It is important to note that the majority of spills (75% for the all traffic conditions) would be expected to be less than 10 m^3, and 50% would be expected to be less than 1 m^3. Spills of these volumes would have relatively localized effects.

The chance of a 1,000 m^3 spill is 1 in 170 per year (0.6%) or 1 in 8 over 21 years (12.5%) with the baseline traffic conditions. With the lower level of projected Phase 2 vessel traffic, the chance of a 1,000 m^3 spill increases to 1 in 86 per year (1.1%) or 1 in 3.1 over 21 years (3.2%). With the higher level of projected Phase 2 vessel traffic, the chance of a 1,000 m^3 spill increases to 1 in 62 per year (1.6%) and to 1 in 3 for 21 years (33%).

Comparison Between Spill Frequencies for Current Baseline and Phase 2 Traffic

The expected oil spill frequencies under the two projected levels of traffic in the proposed Phase 2 expansion were compared to the current (baseline) spill frequencies to determine the chance in spill risk, as shown in Table 27. With the increased vessel traffic projected for the Phase 2 expansion, there would be an increase in the expected frequency of oil spills.

Table 27: Updated Comparison of Expected Oil Spill Frequencies for Baseline/Phase 2 Traffic

Volume Category	Annual Expected Spills			Increase with Phase 2 Traffic			
	Baseline Traffic Level	Phase 2 Lower Traffic Level	Phase 2 Higher Traffic Level	Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
				Additional Spills per Year	% Increase	Additional Spills per Year	% Increase
0.01 m^3	0.012	0.022	0.028	0.01	83%	0.016	133%
0.1 m^3	0.063	0.12	0.16	0.057	90%	0.097	154%
1 m^3	0.037	0.067	0.095	0.03	81%	0.058	157%
10 m^3	0.019	0.035	0.048	0.016	84%	0.029	153%
100 m^3	0.012	0.025	0.034	0.013	108%	0.022	183%
1,000 m^3	0.0058	0.012	0.016	0.0062	107%	0.0102	176%
Total	**0.15**	**0.29**	**0.37**	**0.14**	**93%**	**0.22**	**147%**

There would be an overall increased frequency of an additional 0.14 spills per year (or one additional spill every 7.1 years, on average) with the lower-level Phase 2 vessel traffic, and an additional 0.22 spills per year (or an on additional spill every 4.5 years, on average) with the higher-level of Phase 2 vessel traffic. Over the course of 21 years, this would mean an additional 23 spills with the lower-level Phase 2 traffic and an additional 36 spills with the higher-level Phase 2 vessel traffic. The majority of these spills would be expected to be less than 10 m^3, half would be less than 1 m^3.

With lower-level Phase 2 traffic increases, there may be 0.13 additional 1,000 m^3 spills over 21 years, or a 1 in 8 chance that there would be an additional spill of this volume in 21 years. With higher-level Phase 2 traffic increases, there may be 0.21 additional 1,000 m^3 spills over 21 years, or a 1 in 5 chance that there would be an additional spill of this volume in 21 years. Over 21 years, there would be about 1.4 additional spills of at least 1 m^3 with the lower-level Phase 2 vessel traffic, and an additional 2.4 spills of at least 1 m^3 with the higher-level Phase 2 vessel traffic.

These likelihood and frequency of the additional spills could be lower if safety and spill prevention measures are implemented.

Potential for Larger-Volume Spill

An additional risk factor for spills with the Phase 2 traffic is the potential for a larger-volume spill from the fleet of ore carriers. While the largest potential spill is from a fuel tanker, where as much as 8,500 m^3 could be released, this risk exists under the current baseline conditions as well.

For the fleet of ore carriers, there is currently a potential for a worst-case discharge of 2,226 m^3 spill. With the addition of larger ore carriers as proposed for Phase 2, there is a possibility of a bunker fuel spill of that the worst-case discharge could be 4,452 m^3. This is the bunker capacity of the non-ice class Cape-size ore carriers (Table 2). There are projected to be 21 to 28 one-way transits of this type of bulk carrier under the Phase 2 expansion.

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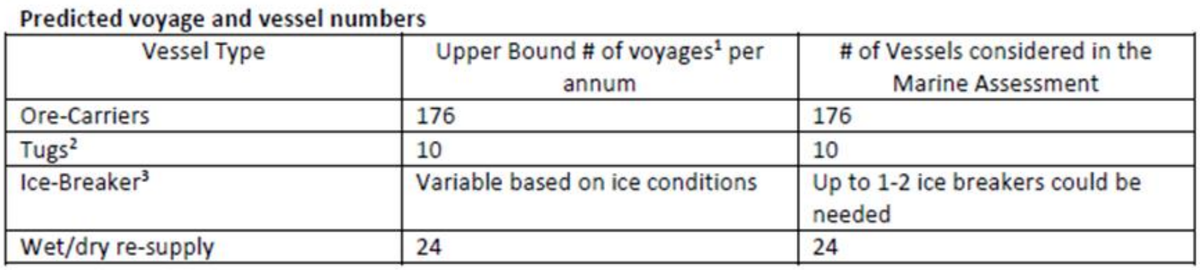

Predicted voyage and vessel numbers

Vessel Type	Upper Bound # of voyages[1] per annum	# of Vessels considered in the Marine Assessment
Ore-Carriers	176	176
Tugs[2]	10	10
Ice-Breaker[3]	Variable based on ice conditions	Up to 1-2 ice breakers could be needed
Wet/dry re-supply	24	24

Further explanation of phase 2 ship transits:

- 176 ore carriers/voyages (352 transits), no breakdown of how many for each type. BIM has narrowed it down in the phase 2 update to 4 types (instead of the 6 types originally speculated)
- 10 tugs. What this means in practice is:
    - 10 individual tugs will be used
    - All 10 tugs transit once into the port at the beginning of the season and then make back and forth transits to and from the dock to the anchorage which is 2KM from the dock.
    - Each ore carrier has two tugs escorting.
    - All 10 tugs transit out at the end of the season
    - Tugs don't support re-supply
- 24 resupply voyages (48 transits)
    - Each vessel anchors about 1KM from the dock at Milne and a barge takes goods to the dock or a hose transports fuel to the dock/tank farm.
- 2 icebreakers. This is the most difficult to quantify.
    - At the beginning of the season
        - first week: one ore carrier transit every 24 hours with two icebreakers for support for each transit, into the port and then out (7 voyages/14 transits)
        - second week: two ore carrier transits every 24 hours with two icebreakers for support for each transit, into the port and then out (14 voyages/28 transits)
        - from August 1 onwards regular operations without icebreaker support until Oct 15. This is an estimate, ice conditions will determine when icebreakers are needed.
    - At the end of the season
        - From Oct 15 to Nov 15 regular operations with 2 icebreakers supporting each transit in and out. An estimate of these operations:
            - (14 + 28 = 42; 352 – 42 = 310; 310 divided by 3.5 months (August/September/October/half of Nov) = 88.6 transits a month). Therefore, from Oct 15 to Nov 15, 88.6 transits of ore carriers with 2 icebreakers supporting, into the port and then out.

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WWF Canada's Final Written Submission for the Nunavut Impact Review Board's reconsideration of the Mary River Project Certificate for Baffinland's Mary River "Phase 2" Proposal

Submitted September 23, 2019
to info@nirb.ca

Executive Summary

In July 2015, the Nunavut Impact Review Board (NIRB) received Baffinland's application and a referral to assess the Mary River Phase 2 proposal. In October 2018, the NIRB accepted and commenced technical review of the associated Final Environmental Impact Statement (FEIS) Addendum. Phase 2 proposes an increase from the previously approved mining rate of 4.2 Million tonnes per year (Mtpa) to 12 Mtpa, and to build and operate a 110 kilometre railway from Mary River to Milne Port for the overland transportation of ore, creating a major impact for the North Baffin caribou herd whose population is currently at a critically low level. Ore would then be shipped from Milne Port during an extended shipping season that includes limited ice breaking during shoulder seasons. The additional mining of ore and increased project intensity would be associated with an increase in ship transits within the rich biodiversity of the newly created Tallurutiup Imanga National Marine Conservation Area and the relatively small confines of Eclipse Sound and Milne Inlet from 210 transits to a maximum of 400 per year.

WWF Canada (WWF) has reviewed the Final Environmental Impact Statement Addendum (FEIS Addendum) for the Phase 2 proposal with a lens of conservation. Our mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by conserving the world's biodiversity, ensuring that the use of natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption. WWF provides this submission in response to the NIRB's August 21, 2019 correspondence inviting Final Written Submissions to the Mary River Phase 2 proposal. Our comments are categorized according to sections within the FEIS Addendum where applicable, and are included as follows: NIRB Assessment and Process Issues, Marine Environment, Terrestrial Environment, The Climate Crisis.

NIRB Assessment and Process Issues

Baffinland continues to assure reviewers that there are no significant impacts from ongoing project activities, and that no significant impacts are expected as a result of the Phase 2 development, however this conclusion is the result of poor monitoring and assessment of impacts, not a result of actual environmental indicators. Without a monitoring framework in place - one that is developed by or with the NIRB in collaboration with parties, there is no way to implement an informed, effective adaptive management strategy for the project.

Given the absence of a structured monitoring program, this project has not been managed to adapt to changes in the environment, because there has been no way of knowing what level of impact the project is (or is not) having. An overarching framework to guide expectations and practical, effective monitoring is required to ensure the programs around impacts are responsive and can reflect project realities.

Baffinland has stated that despite the Phase 2 Proposal involving "a switch from the current truck haulage of ore on the Milne Inlet Tote Road to the Port to a railway to support the targeted 12 Mtpa production rate,…[it would have the] trucking of ore remain a viable alternative should difficulties arise with the development and operation of the North Railway." WWF suggests that the truck haulage of 12 Mtpa of ore via the Milne Inlet Tote road is not sustainable, and has not been adequately assessed as a preferred alternative within the current assessment. WWF recommends that under no scenario the project be permitted to haul beyond 6 Mtpa of ore with trucks on the current road given that the option to increase production and rely on haul trucks without railroad construction has not been adequately assessed during the Phase 2 proposal.

The recent Production Increase Proposal was approved, allowing an increase in Baffinland's mining and transportation rate from 4.2 Mtpa to 6 Mtpa. It is acceptable to allow Baffinland to continue at this rate until such time as Baffinland has developed appropriate thresholds and indicators, its monitoring programs are adequately developed to inform ongoing activities and mitigation, and monitoring results are providing meaningful information about ongoing adaptive management and relevant project impacts.

The Marine and Terrestrial Environment Working Groups (MEWG and TEWG) have not been effectively empowered to ensure mitigation measures and monitoring programs are achieving their intended purpose, and nor has Baffinland or NIRB implemented alternate measures to ensure the marine and terrestrial environments are adequately protected. WWF recommends that the NIRB revisit the intention behind the working groups, and that it assume greater responsibility for the structure and function of the groups or provide a structured monitoring program for Baffinland to implement.

The NIRB's Mary River Project Certificate (Terms and Conditions 99, 110, 111, 112) explicitly requires that Baffinland develop indicators and thresholds for marine mammal VECs (Valued Ecosystem Components). These have not been developed. Without indicators and thresholds in place, Baffinland's monitoring results cannot be relied upon to accurately inform conclusions within the FEIS Addendum. Baffinland is responsible for the development of indicators and thresholds, as is required of project proponents in other jurisdictions across the country. The NIRB cannot protect and promote Nunavut's ecosystemic integrity if it allows an increase in mining and transport of ore beyond the currently expanded throughput at 6 Mtpa without having indicators and thresholds in place to indicate when and to what degree impacts may be occurring, and to compare this against FEIS Addendum predictions.

Marine Environment

WWF recommends that the shipping route, including portions of Tallirutiup Imanga and critical habitat at Pikialasorsuaq, as well as impacts to species outside of Canada's waters that depend on areas inside the Nunavut Settlement Area, and all Project-related shipping activities, be incorporated into the development of a comprehensive Marine Spatial Plan. The marine environment associated with the Mary River project is of high biological and cultural importance and has now also become critically important to the industrial development of the Mary River project. WWF recommends that a marine spatial plan be developed to consider the fragility of this incredibly rich ecosystem and the Inuit and marine species which depend on its continued health and productivity for their own futures before approving a doubling of industrial ship traffic through the Northern Shipping Corridor.

Oil spills pose a hazard everywhere in the Arctic, but the impact of a spill is likely to be especially severe if it were to occur within the highly sensitive and vulnerable waters of Milne Inlet or Eclipse Sound, and especially spills of Heavy Fuel Oil (HFO). HFO is widely accepted by emergency response experts as the world’s most environmentally hazardous fuel if accidentally spilled in the marine environment. It is extremely persistent, lasting in the marine environment for months if not years, making it nearly impossible to clean up. WWF does not find credibility in Baffinland’s suggestion that it cannot influence its contractors with regard to fuel and technology selection. WWF suggests that an approach similar to setting speed limits and setbacks for ships be applied to specifying fuel types that may be utilized by Project ships - that is as a non-regulated but contractual matter, this would very much be within Baffinland’s ability and control.

With respect to Baffinland's request for formal consideration of Navy Board Inlet and/or further through the Northwest Passage as alternative shipping routes, there is inadequate baseline information and consideration of impacts through these corridors to support approval. As such, WWF recommends that the NIRB’s assessment of the Phase 2 proposal not include that routing and the NIRB should clarify that the approved shipping route for vessels contracted by Baffinland remains through the previously approved Pond Inlet/Eclipse Sound/Baffin Bay.

Terrestrial Environment

Baffinland’s FEIS Addendum indicates that impacts to caribou from the Northern Railway and additional Tote Road traffic will be not significant after existing mitigation measures are applied. It is unacceptable that Baffinland has determined, based on the presumed absence of individuals, a) that its current activities are not having an impact, and b) that a doubling of mine throughput and associated traffic on the Tote Road and/or Rail line will have no significant impact on caribou. The proponent is proposing building a railroad in an area and indeed a territory where no such infrastructure has ever been built or monitored. The railroad is also proposed to be built in the habitat of a caribou herd that has never been monitored for impacts from railroad infrastructure and that by some estimations is 99% depleted. To suggest that there will be no impacts from the railroad based on an absence of data and a long list of presumptions is an unacceptable risk given the current conservation status and cultural importance of Baffin Island caribou. WWF recommends that Baffinland be required to develop and implement adequate indicators and thresholds as well as robust monitoring plans to gain useful information about the regional caribou herd, and that no increase to mine throughput or transport beyond 6 Mtpa is approved until such time as it has evidence to support the current assertion of no impact and to support projections of no significant impacts with a 12 Mtpa development scenario.

The Climate Crisis

Given the crisis around climate change as a whole, its increased impacts in the Arctic, and the global pressure to reduce emissions to meet greenhouse gas emissions targets, it is imperative that the Mary River project demonstrate achievements in lessening emissions and the associated impacts. WWF recommends that the NIRB mandate more progressive operations and shipping practices from Baffinland, with the goal of seeing reduced emissions of greenhouse gases and black carbon every year from all mining activities, including shipping.

ᓯᕗᓕᖅᑎᓂᑦ ᓇᐃᓈᖅᑐᑦ

ᔪᓚᐃ 2016ᒥ, ᓄᓇᕘᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦ (ᐊᕙᑎᓕᕆᔩᑦ) ᐱᓚᐅᕐᒪᑕ ᐹᕙᓐᓚᓐᑯᑦ ᐱᓇᓲᑎᖓᓂᒃ ᑎᓕᓯᓪᓗᑎᒡᓗ ᕿᒥᕐᕈᖁᔨᓪᓗᑎᒃ ᓄᓘᔮᖕᓂ ᒪᕐᕈᐊᓂ ᐱᓕᕆᓂᐊᓄᑦ ᐱᔪᒪᓇᓲᑎᒥᒃ. ᐅᑐᐱᕆ 2018ᒥ ᐊᕙᑕᓕᕆᔨᒃᑯᑦ ᐊᖏᓚᐅᖅᑐᑦ ᐱᒋᐊᓕᖅᓱᑎᒡᓗ ᓇᓗᓇᐃᖅᓯᒪᓗᐊᖅᑐᒃᑯᑦ ᕿᒥᕐᕈᓂᕐᒥᒃ ᐃᓚᐅᔪᒧᑦ ᑭᖑᓪᓕᖅᐹᒧᑦ ᐊᕙᑎᒥᒃ ᐊᒃᑐᐃᓂᕐᒥᒃ ᐅᓂᒃᑳᖓᓄᑦ ᐃᓚᒋᐊᕈᑎᒥᒃ. ᒪᕐᕈᐊᓂ ᐱᓕᕆᓂᖅ ᐱᔪᒪᕗᖅ ᐊᖏᒡᓕᒋᐊᖅᑎᑦᑎᔪᒪᓪᓗᑎᒃ ᐊᖏᖅᑕᐅᓯᒪᕙᒌᖅᑑᒥᑦ ᐅᔭᖃᒃᑕᖁᓪᓗᒋᑦ 4.2 ᒥᓕᐊᓐ ᑕᓐᔅ ᐊᕐᕌᒍᑕᒫᑦ 12ᓄᑦ ᒥᓕᐊᓐ ᑕᓐᔅᓄᑦ ᐊᕐᕌᒍᒧᑦ. ᓴᓇᓗᑎᒡᓗ ᐊᐅᓚᓪᓗᒍᓗ 110 ᑭᓛᒥᑕᓂᒃ ᑕᑭᓂᓕᖕᒥᒃ ᓄᓘᔮᖕᓂᑦ ᕿᙳᐊᓄᑦ ᓄᓇᒃᑯᑦ ᐅᓯᑲᖅᑕᖅᓗᑎᒃ ᓴᕕᖅᓴᒃᓴᓂᒃ, ᓴᓇᓗᑎᒃ ᐊᒃᑐᐃᓂᖅᔪᐊᖅᒥᒃ ᕿᑭᖅᑖᓗᑉ ᐅᐊᖕᓇᖓᓂ ᑐᒃᑐᖏᓐᓄᑦ ᐅᓄᕐᓂᖏᑦ ᒫᓐᓇᐅᔪᖅ ᐅᓄᖏᑦᑐᐊᓘᓪᓗᑎᒃ. ᓴᕕᖅᓴᒃᓴᖅ ᐅᓯᑲᖅᑕᖅᑕᐅᓕᕐᒥᓗᓂ ᑭᙳᐊᓂᑦ ᐊᑯᓂᐅᓯᒋᐊᖅᓯᒪᔪᒃᑯᑦ ᐅᓯᑲᖅᑕᕈᓐᓇᕐᓂᕐᒥᓂ ᐱᖃᓯᐅᔾᔨᓗᑎᒃ ᐊᒃᓯᓗᐊᖑᖏᑦᑐᖅ ᓯᑯᓯᐅᕐᓂᕐᒥᒃ ᓯᑯᐃᓕᕌᖓᑦ ᓯᑯᓇᓯᓕᕌᖓᓪᓗ. ᓴᕕᖅᓴᒃᓴᖅᓯᐅᒃᑲᓐᓂᕐᓂᖅ ᐱᓕᕆᓂᖅᓴᐅᓂᖅ ᐊᒃᑐᐊᒐᓴᖅᑐᖅ ᐅᒥᐊᕐᔪᐊᑦ ᐅᑎᖅᑕᖃᐅᔭᕐᓂᖅᓴᐅᓕᖅᑐᓂᒃ ᐃᓗᐊᓂ ᐊᔾᔩᖏᑦᑐᓂᒃ ᐆᒪᔪᖃᕐᓂᕐᔪᐊᒃᑯᑦ ᓴᓇᔭᐅᕋᑖᔭᕐᑑᑉ ᑕᓪᓗᕈᑎᐅᑉ ᐃᒪᖓ ᑲᓇᑕᒥ ᑕᕆᐅᕐᒥ ᓴᐳᔾᔭᐅᓯᒪᕝᕕᖕᒥ ᐱᕕᑭᑦᑐᒃᑯᓪᓗ ᑕᓯᐅᔭᒃᑯᑦ ᕿᙳᐊᓂᓗ 210ᓂᑦ ᐅᑎᖅᑕᖃᐅᔭᖅᑐᓂᑦ ᐅᓄᓛᖃᕐᓗᑎᒃ 400ᓂᒃ ᐅᑎᖅᑕᖃᐅᔭᖅᑐᓂᒃ ᐊᕐᕌᒍᑕᒫᑦ.

ᓄᓇᕐᔪᐊᕐᒥ ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑲᓇᑕᒥ (ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ) ᕿᒥᕐᕈᓯᒪᕗᑦ ᑭᖑᓪᓕᖅᐹᖅ ᐊᕙᑎᒥᒃ ᐊᒃᑐᐃᓂᕐᒧᑦ ᐅᓂᑳᖓᑕ ᐃᓚᒋᐊᕈᑎᖓᓂᒃ ᒪᕐᕈᐊᓄᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔪᒪᓈᑎᐊᓂ ᑕᐅᑐᒃᓱᑎᒃ ᓴᐳᔾᔭᐅᓯᒪᓂᕐᒥᒃ. ᑎᓕᔭᐅᔾᔪᑎᒋᓯᒪᔭᕗᑦ ᓄᖅᑲᖅᑎᑦᑐᒋᑦ ᓯᕿᖅᑕᐅᓂᖏᑦ ᓄᓇᕐᔪᐊᑉ ᐃᓕᖅᑯᓯᖅᑐᖅᑕᐅᓂᖏᑦ ᐊᕙᑎᖏᑦ ᓯᕗᓂᓴᓕᐅᕐᓗᑕᓗ ᐃᓄᐃᑦ ᐃᓅᖃᑎᖃᑦᑎᐊᕐᓗᑎᒃ ᓯᓚᒥᐅᑕᓂᒃ ᓴᐳᑎᓂᒃᑯᑦ ᓄᓇᕐᔪᐊᑉ ᐊᔾᔨᒌᖏᑦᑐᓂᒃ ᐆᒪᔪᖏᓐᓂᒃ, ᐊᔪᕐᓇᖏᑦᑎᐊᓕᕐᓗᓂ ᐊᑐᖅᑕᐅᓂᖏᑦ ᓄᓇᕐᔪᐊᒥ ᐊᑐᒐᒃᓴᑦ ᓄᖑᔭᖏᕐᓗᑎᒃ, ᐊᑐᖅᑕᐅᔪᒪᓕᖅᑎᓪᓗᒋᓪᓗ ᒥᑭᒡᓕᒋᐊᖅᑕᐅᓂᖏᑦ ᓯᑭᐃᑦ ᓴᓂᓕᐅᑐᐃᓐᓇᕐᓗᓂᓗ ᐊᑐᕐᓃᑦ. ᓂᕐᔪᑏᑦ ᑮᓇᐅᔭᖏᑦ ᑐᓂᓯᕗᑦ ᑖᔅᓯᒥᙵ ᑎᑎᖃᒥᒃ ᑭᐅᓪᓗᑎᒃ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᐋᒡᒌᓯ 21,2019ᒥ ᑎᑎᖃᖓᓄᑦ ᑐᙵᓴᐃᓪᓗᑎᒃ ᑭᖑᓪᓕᖅᐹᓂᒃ ᑎᑎᖃᑎᒍᑦ ᑭᐅᔪᓂᒃ ᓄᓘᔮᖕᓂ ᒪᕐᕈᐊᓄᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔪᒪᓇᓲᑎᖓᓄᑦ. ᑭᐅᔾᔪᑎᕗᑦ ᐊᕕᒃᑐᖅᓯᒪᕗᑦ ᒪᓕᒃᑐᒋᑦ ᐊᕕᒃᑐᖅᓯᒪᔪᑦ ᐃᓗᐊᓃᑦᑐᑦ ᑭᖑᓪᓕᖅᐹᒧᑦ ᐊᕙᑎᐅᑉ ᐊᒃᑐᖅᑕᐅᓂᖓᓄᑦ ᐅᓂᒃᑳᑉ ᐃᓚᒋᐊᕈᑖᓂ ᑕᐃᒪᐃᑦᑐᓈᕐᐊᖓᑦ, ᐃᓚᓕᐅᓯᒪᓪᓗᑎᒡᓗ ᐃᒪᓐᓇ: ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᕿᒥᕐᕈᓂᖓ ᐱᓕᕆᔾᔪᓯᑎᒍᓪᓗ ᐊᑲᐅᙱᓕᐅᕈᑏᑦ, ᑕᕆᐅᕐᒥ ᐊᕙᑏᑦ, ᓄᓇᒥ ᐊᕙᑏᑦ, ᓯᓚᒧᑦ ᐊᒃᓯᕐᔪᐊᕐᓇᖅᑐᖅᓗ.

ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᕿᒥᕐᕈᓂᖓ ᐱᓕᕆᔾᔪᓯᑎᒍᓪᓗ ᐊᑲᐅᙱᓕᐅᕈᑏᑦ

ᐹᕙᓐᓚᓐᑯᑦ ᐅᖃᐃᓐᓇᖅᐳᑦ ᕿᒥᕐᕈᒥᔪᓄᑦ ᐊᒃᑐᐃᔪᐊᖅᑐᖅᑕᖃᕐᒋᑦᑐᑮᖃᔪᒌᓇᖅᑐᓂᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᔪᓂᑦ ᐊᒃᑐᐃᔪᐊᖅᑐᖅᑲᖅᑲᓯᒋᓇᑎᓗ ᒪᕐᕈᐊᓂ ᐱᓕᕆᓂᕐᒥ ᐱᓕᕆᔪᓂᑦ, ᑭᓯᐊᓂ ᑕᐃᒪᓐᓇ ᐃᓯᒪᓂᖅ ᓴᖅᑭᑉᐳᖅ ᖃᐅᔨᓴᑦᑎᐊᖕᓇᖕᓂᕐᓂᑦ ᕿᒥᕐᕈᓂᕐᓂᓪᓗ ᐊᒃᑐᐃᔪᓂᒃ, ᑐᙵᖏᓪᓗᑎᒃ ᐱᓪᓚᑖᓂᑦ ᐊᕙᑎᓂᑦ ᓇᓗᓇᐃᒃᑯᑕᓂᑦ. ᖃᐅᔨᓴᕐᓂᕐᓂᑦ ᑐᓴᒪᕕᖕᒥᒃ ᐋᖅᑭᒃᓯᓯᒪᖏᓪᓗᑎᒃ - ᐋᖅᑭᒃᑕᐅᓯᒪᓗᓂ ᐊᕙᑎᓕᕆᔨᒃᑯᓐᓂᑦ ᑲᑐᔾᔨᖅᓴᖅᑐᑎᒃᑐᓂᑦ ᑎᒥᓂᒃ, ᐱᕕᒃᑕᖅᑎᕆᓕᖅᑲᖅᑭᒃᓯᓴᓇᐊᒃᓴᖅ ᑐᓴᐅᒪᑦᑎᐊᖅᑐᒥᒃ, ᐱᓕᕆᑦᑎᐊᓯᒥᒃ ᐋᖅᑭᒋᐊᕈᓐᓇᖅᑐᒥᒃ ᐊᐅᓚᔾᔪᑎᒃᓴᒧᑦ ᐸᕐᓇᐅᑎᒥᒃ ᐱᓕᕆᓂᕐᒧᑦ.

ᐱᑕᖃᖏᓐᓂᖓᓄᑦ ᐋᖅᑭᒃᓯᕐᓯᒪᔪᕐᒥᒃ ᖃᐅᔨᓴᕐᓂᕐᓄᑦ ᐱᓕᕆᓂᕐᒥᒃ, ᑖᓐᓇ ᐱᓕᕆᓂᖅ ᐊᐅᓚᑕᐅᓯᒪᙱᓚᖅ ᐋᖅᑭᒋᐊᕈᓐᓇᕐᓯᓗᓂ ᐊᓯᔾᔨᕐᑐᓄᑕᐊᕙᑎᒥ, ᓱᖃᐃᒻᒪ ᖃᐅᔨᒪᔾᔪᑎᖃᓚᐅᙱᒻᒪᑦ ᖃᓄᑎᒋ ᐱᓕᕆᓂᖅ

ᐊᒃᑐᐃᓂᖃᕐᒪᖔᑦ (ᐊᒃᑐᐃᖏᓪᓗᓂᓘᓐᓃᑦ). ᑕᒪᒃᑮᓕᒫᓄᑦ ᑐᙵᕕᖕᒥᒃ ᑎᓕᐅᕈᑕᐅᓂᐊᖅᑐᒥᒃ ᓂᕆᐅᒋᔭᐅᔪᓄᑕᑑᑎᓕᖏᓪᓗ ᐱᓕᕆᑦᑎᐊᖅᑐᓂᒃ ᖃᐅᔨᓴᕐᓂᖃᕆᐊᖃᖃᔭᖅᐳᑦ ᐊᑐᖅᑕᐅᔭᕆᐊᖃᖁᓪᓗᒋᑦ ᐱᓕᕆᓃᑦ ᐊᒃᑐᐃᓂᕐᓄᑦ ᖃᓄᐃᒋᐊᕈᓐᓇᖁᓪᓗᒋᑦ ᓴᖅᑭᔮᖅᑎᑦᑎᔪᓐᓇᕐᓗᑎᒡᓗ ᐱᓕᕆᓂᕐᒥ ᖃᓄᐃᓪᓚᑦᑖᖅᑐᓂᒃ.

ᐹᕙᓐᓚᓐ ᐅᖃᖅᓯᒪᕗᑦ ᑕᐃᒪᐃᒃᑲᓗᐊᖅᑎᓪᓗᒍ ᒪᕿᐊᓂ ᐱᓕᕆᓂᕐᒥ ᐱᔪᒪᓇᓰᑎ ᐱᖃᓯᐅᔾᔨᓚᓗᐊᖅᓗᓂ "ᐊᓯᔾᔨᕐᓂᖅ ᒫᓐᓇᐅᔪᖅ ᓄᓇᒃᑰᕈᑎᒃᑯᑦ ᓴᕕᕋᔭᒃᓴᕐᓂᖅ ᐅᓯᑲᖅᑕᕐᓂᖅ ᕿᖑᐊᓄᑦ ᐊᖅᑯᑎᒃᑯᑦ ᑐᓚᒃᑕᕐᕕᖕᒧᑦ ᓄᓇᒃᑰᕈᑎᑯᑖᖕᒧᑦ ᐃᑲᔫᑕᐅᓗᓂ ᑎᑭᓐᓇᓱᒃᑕᒥᓄᑦ 12 ᒥᓕᐊᓐ ᑕᓐᔅᓄᑦ ᐊᕐᕌᒍᒥ ᓴᕕᕋᔭᒃᓴᖅᑖᖅᐸᓪᓗᑎᒃ,...(ᐱᖃᕋᔭᖅᑐᖅ) ᓄᓇᒃᑰᕈᑎᒃᑯᑦ ᓴᕕᕋᔭᒃᓴᓂᒃ ᐅᓯᑲᖅᑕᕐᓂᖅ ᓱᓕ ᑲᔪᓯᑦᑎᐊᕈᓐᓇᕐᓗᓂᓇᓪᓚᐅᒃᑯᒫᖑᓗᓂ ᐊᑐᒐᒃᓴᐅᔪᓐᓇᕋᔭᖅᑐᖅ ᐊᑲᐅᙱᓕᐅᕈᑎᑕᖃᓕᕈᓂ ᓴᓇᔭᐅᓂᖓᓄᑦ ᐊᐅᓚᑕᐅᓂᖓᓄᓪᓗ ᐅᐊᖕᓇᒥ ᐊᖅᑯᑎᑯᑖᖕᒧᑦ". ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᐅᖃᖅᐳᑦ ᓄᓇᒃᑰᕈᑎᒃᑯᑦ ᐅᓯᑲᖅᑕᕐᓂᖅ 12 ᒥᓕᐊᓐ ᑕᓐᔅᓂᒃ ᐊᕐᕌᒍᒥ ᕿᖑᐊᓄᑦ ᐊᖅᑯᑎᒃᑯᑦ ᑲᔪᓯᑦᑎᐊᕈᓐᓇᕋᔭᖏᓐᓂᕋᐃᓪᓗᑎᒃ, ᓈᒻᒪᒃᑐᒃᑯᓪᓗ ᕿᒥᕐᕈᔭᐅᓯᒪᓇᓂ ᐊᑐᖅᑕᐅᔪᒪᓂᖅᓴᖅᑐᑦ ᐊᑐᖐᕈᓐᓇᕋᔭᖅᑐᑐᑦ ᒫᓐᓇᐅᔫᑉ ᕿᒥᕐᕈᔭᐅᓂᖓᓂ. ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑎᓕᐅᕈᕗᑦ ᓇᓕᐊᒃᑯᑐᐃᓇᑦᑎᐊᖅ ᐱᓕᕆᓂᖅ ᐊᔪᙱᑎᑕᐅᔭᕆᐊᖃᙱᓚᖅ ᐅᓯᑲᖅᑕᕈᓐᓇᕐᓂᕐᒥᒃ 6 ᒥᓕᐊᓐ ᑕᓐ ᐅᖓᑖᓄᑦ ᓴᕕᕋᔭᒃᓴᓂᒃ ᓄᓇᒃᑰᕈᑎᓄᑦ ᒫᓐᓇᐅᔪᖅ ᐊᖅᑯᑎᒃᑯᑦ ᓰᖅᑲᐃᒻ ᐱᖐᕈᓐᓇᕐᓂᖅ ᓴᕕᕋᔭᒃᑕᕐᓂᖅᓴᐅᕐᑐᑎᒃ ᑐᖅᒪᑐᑎᒃᑐ ᓄᓇᒃᑰᕈᑎᓄᑦ ᐊᖅᑯᑎᑯᑖᓕᐅᖏᓚᑐᑎᒃ ᓈᒻᒪᒃᑐᒃᑯᑦ ᕿᒥᕐᕈᔭᐅᓯᒪᖏᓐᓂᖓᓄᑦ ᒪᕿᐊᓂ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔪᒪᓇᓰᑎᒥ .

ᒫᓇᕋᑖᖅ ᓴᕕᕋᔭᒃᓴᖅᑕᕐᓂᕐᒥᒃ ᐊᖏᒡᓕᒋᐊᕈᑎᒧᑦ ᐱᔪᒪᓇᓰᑎ ᐊᖏᖅᑕᐅᓚᐅᖅᑐᖅ, ᐊᖏᒡᓕᒋᐊᖅᑎᑦᑎᔪᓇᖅᓯᓗᑎᒃ ᐹᕙᓐᓚᓐᑯᑦ ᐅᔭᕋᖕᓂᐊᖅᑕᒥᓂᒃ ᐅᓯᑲᖅᑕᕐᓂᓴᖏᓄᑦ 4.2 ᒥᓚᓐ ᑕᓐᔅᓂᑦ ᐊᕐᕌᒍᒥ 6 ᒥᓕᐊᓐ ᑕᓐᔅᓄᑦ ᐊᕐᕌᒍᒥ. ᓈᒻᒪᒃᐳᖅ ᐱᑏᓇᖅᑐᒍ ᐹᕙᓐᓚ ᑲᔪᓰᓇᖅᑐᑎᒃ ᑕᐃᒻᒪᓇ ᓱᒃᑲᑎᕆᔪᒧᑦ ᑭᓯᐊᓂ ᖃᖓᐅᓕᖅᐸᑦ ᐹᕙᓐᓚᓐᑯᑦ ᓴᓇᓯᒪᓕᕈᑎᑦ ᓈᒻᒪᒃᑐᓂᒃ ᑭᓕᓂᒃ ᓇᓗᓇᐃᒃᑯᑕᓂᒃ, ᖃᐅᔨᓴᕐᓂᕐᓄᑦᐱᓕᕆᓂᕐᒥᒃ ᓈᒻᒪᒃᑐᒃᑯᑦ ᓴᐅᓯᒪᓗᑎᒃ ᑐᓴᐅᒪᑎᑦᑎᑐᑎᑦ ᑲᔪᓰᓇᖅᑐᓂᑦ ᐱᐅᖏᑦᑐᓂᑦ ᒥᑭᓪᓕᕐᕆᐊᑭᓂᑦ, ᖃᐅᔨᓴᕐᓂᕐᓄᓪᓗ ᖃᐅᔨᓴᐅᔫᑦ ᑐᑭᓯᓇᕐᑐᑎᑦ ᑲᔪᓰᓇᖅᑐᓂᑦ ᐊᒡᓯᐅᖅᑎᑦ ᐱᓕᕆᓂᕐᒥᒃ ᐊᒡᓯᐅᒡᓕᐅᓂᑦ.

ᑕᓇᐅᕐᒥ ᓄᓇᒥᓗ ᐊᕙᑎᓂ ᑲᑎᒪᔨᖏᑦ ᐋᑎᖅᑲᖅᑐᒃᑯᑦ ᐱᔭᓇᖅᓯᑎᑕᐅᓯᒪᓕᖕᒪᑕ ᑕᐃᒪᓇᓪᓚᑦᑖᒃᑯᑦ ᒥᑭᒡᓕᕆᐊᑭᑏᑦ ᖃᐅᔨᓴᕐᓃᓪᓗ ᓴᕿᑦᑎᓗᑎᑦ ᓴᖅᑭᑦᑯᖅᑎᓪᓚᕐᑐᒃᓕᐅᖅᑕᖏᓄᑦ, ᐹᕙᓐᓚᓐᑯᓪᓗ ᐊᕙᑎᓕᕆᔩᓪᓗ ᐊᑐᓕᖅᑎᑦᑎᓯᒪᓚᐅᖅᑐᑦ ᐊᓯᓂᒃ ᐊᑐᕐᓇᖅᑐᓂᒃ ᑕᐃᒪᓇᓕᓪᓚᑦᑖᒃᑯᑦ ᑕᓇᐅᕐᓂ ᓄᓇᓂᓗ ᐊᕙᑎᐸᓯᑉᐸᕐᑭᔭᐅᖅᑯᓪᓗᒋᑦ ᓈᒻᒪᒃᑐᑎᒍᑦ. ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᔩᑦ ᐊᕙᑎᓕᕆᔩᑦ ᐊᑐᕐᓯᓴᓂᐊᕐᒥᒍᑦ ᓴᐅᑦᑐᖓᓂᖅ ᐅᐱᐊᑦᑐᓂᑦ ᐊᕙᑎᐅᑉ ᐊᑦᑐᖅᑕᐅᓂᖓᓄᑦ.

ᐊᕙᑎᓕᕆᔩᒃᑯᑦ ᓄᓘᔾᔭᖕᓂ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔭᓇᐅᑎ (ᒪᓕᒋᐊᓘᑦ ᐊᑐᓇᐊᓘᓪᓗ 99, 110, 111, 112) ᐅᖃᖅᓯᒪᓪᓚᑦᑖᖅᓱᓂ ᐱᓯᒪᔭᕆᐊᖃᕐᒪᑦ ᐹᕙᓐᓚᓐᑯᑦ ᓴᓇᓗᑎᒃ ᓇᓗᓇᐃᒃᑯᑕᓂᒃ ᑭᓕᓂᓪᓗ ᑕᓇᐅᕐᒥᐅᑕᓄᑦ ᓂᕐᔪᑎᓄᑦ ᐱᓐᓇᓇᓱᐅᑦᑎᐊᖅᑐᓄᑦ ᐅᒪᔪᕐᑎᓄᑦ ᐃᓕᒋᔭᐅᔪᓄᑦ. ᑖᒃᑯᐊ ᓴᓇᔭᐅᓯᒪᓕᖅᑎᑦ. ᓇᓗᓇᐃᒃᑯᑕᓂᒃ ᑭᓕᓂᓗ ᐃᓕᓯᓯᒪᕐᒋᓗᑎᒃ, ᐹᕙᓐᓚᓐᑯᑦ ᖃᐅᔨᓴᕐᓂᑎᒍᑦ ᖃᐅᔨᓴᖏᑦ ᑑᖓᕙᐅᔭᓇᖏᓚᑦ ᓯᓕᔪᓂᒃ ᑐᑭᐅᔾᔭᐅᑕᐅᔭᓇᐊᒃᓴ ᐃᓗᐊᓂ ᑭᖑᓕᕐᐹᒍᑦ ᐊᕙᑎᐅᑉ ᐊᒃᑐᖅᑕᐅᓂᖓᓄᑦ ᐅᓂᒃᑳᑉ ᐃᓚᒋᐊᑭᑖᓂ. ᐹᕙᓐᓚᓐᑯᑦ ᑎᓕᔭᐅᓯᒪᕗᑦ ᓴᓇᓯᒪᓐᓇᓯᐊᕐᓂᒃ ᑭᓪᓕᓂᓪᓗ, ᐱᓴᓇᐊᓖᑦ ᒪᓕᒃᑯᕐᒋᑦ ᐱᓕᕆᓪᓗᓂᑦ ᐃᓚᐅᓪᓗᓂᑦ ᐊᓯᓂ ᒐᕙᒪᓂ ᑲᓇᑕᐅᑉ ᐃᓗᐊᓂ.

ᐊᖏᓪᓕᒋᐊᖅᓯᒪᔪᖅᑐᑦ 6 ᒥᓕᐊᓐ ᑕᓐᓴᓂᒃ ᐊᕐᕌᒍᒥ ᐃᓕᓯᓯᒪᖏᓪᓗᑎᒃ ᓇᓗᓐᓯᒃᑯᑕᓂᒃ ᑭᒡᓕᓂᒡᓗ ᓇᓗᓇᐃᕈᑕᐅᓂᐊᖅᑎᓂᒃ ᖃᖓ ᖃᓄᑎᒋᒧᓪᓗ ᐊᒃᑐᐃᓃᑦ ᐊᒃᑐᐃᓂᖃᑐᐃᓐᓇᓇᐊᕐᒪᖔᑕ, ᑖᒃᑯᐊᓗ ᕿᒥᕐᕈᓗᒋᑦ ᓴᓂᐊᓂ ᑭᖑᓪᓕᖅᐸᒨᑦ ᐊᕙᑎᐅᑉ ᐊᒃᑐᖅᑕᐅᓂᖏᓐᓄᑦ ᐅᓂᒃᑳᑉ ᐃᓚᒋᐊᕈᑖᓃᑦᑐᑦ ᓇᓚᐅᑦᑖᖅᓯᒪᔪᓂ.

ᑕᕆᐅᕐᒥ ᐊᕙᑎ

ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᕗᑦ ᐅᒥᐊᕐᔪᐊᒃᑯᑦ ᐅᓯᑲᖅᑕᕐᕕᐅᓂᐊᖅᑐᖅ, ᐱᖃᓯᐅᓪᓗᒋᑦ ᐃᓚᖏᑦ ᑕᓪᓗᓇᑎᐅᑉ ᐃᒪᖏᑦ ᐊᑑᑎᖃᑦᑎᐊᖅᑐᕐᓗ ᐆᒪᔩᕚᐅᔪᖅ ᐱᑭᐊᓚᓱᖅᓯᐊᕐᒥ, ᐱᖃᓯᐅᕐᓗᒋᑦ ᐊᒃᑐᐃᔪᑦ ᓂᕐᔪᑎᓂᒃ ᑲᓇᑕᐅᑉ ᐃᒪᖏᑕ ᓯᓚᑖᓃᑦᑐᓂᒃᑑᖓᓲᓄᑦ ᓄᓇᓄᑦ ᓄᓇᕗᑖᕈᑎᐅᑉ ᐃᓗᐊᓃᑦᑐᓄᑦ, ᐊᒻᒪᓗ ᐱᓕᕆᓂᕐᒧᑦ ᐊᒃᑐᐊᔪᓕᒫᑦ ᐅᓯᑲᖅᑕᕐᕖᑦ, ᐃᓚᓕᐅᔅᔭᐅᓗᑎᒃ ᓴᓇᔭᐅᓂᖓᓄᑦ ᐋᖅᑭᒃᓱᕈᓘᔭᖅᓯᒪᔪᕐᒧᑦ ᑕᕆᐅᕐᒥ ᑭᓯᑯᑦᑐᓕᒫᖏᑎᒍᑦ ᐸᕐᓇᐅᑎᒍᑦ.ᑕᕆᐅᕐᒥ ᐊᕙᑎᐅᔪᖅ ᐊᒃᑐᐊᔪᖅ ᓄᓘᔮᖕᓂ ᐱᓕᕆᓂᕐᒧᑦ ᐊᑑᑎᖃᑦᑎᐊᕐᒪᑦ ᐆᒪᔪᓄᑦ ᐃᓅᓯᑐᖃᒃᑯᓪᓗ ᒫᓐᓇᓗ ᐊᑑᑎᖃᓗᐊᒪᔾᔭᓕᖅᓗᓂ ᓴᓇᔭᐅᕐᔪᐊᕐᓂᖓᓄᑦ ᓄᓘᔮᖕᓂ ᐱᓕᕆᓂᕐᒧᑦ. ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᕗᑦ ᑕᕆᐅᕐᒥ ᑭᓯᑯᑦᑐᓕᒫᖏᑎᒍᑦᐸᕐᓇᐅᑎᓕᐅᖅᑕᐅᓗᑎᒃ ᐃᓱᒪᒋᔭᐅᕐᑯᓗᒍ ᓂᑲᓇᓪᓚᓇᖏᓂᐊᓗᐊ ᐆᒪᔪᖃᐅᕈᔾᔭᖅᑐᐊᓘᑉ ᐆᒪᔪᖃᑦᒌᒃᑯᕕᐅᑉ ᐃᓄᐃᓪᓗ ᐆᒪᔪᓪᓗ ᑐᙵᕕᓕᖕᓂᒃ ᑲᔪᓰᓐᓇᖅᑐᒃᑯᑦ ᖃᓄᐃᖏᓐᓂᖓᓄᑦ ᐆᒪᔪᓕᐅᕐᓂᖓᓄᓪᓗ ᓇᖏᓂᖅ ᓯᕗᓂᒃᓴᒥᓄᑦ ᐊᖏᖅᓯᓚᐅᖏᓐᓂᖏᓐᓂ ᒪᕈᐃᖅᓱᓪᓗᐊᕐᓗᒋᑦ ᐅᓄᖅᓯᒋᐊᕐᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᕐᔪᐊᓂᒃ ᐃᖏᕐᕋᔪᓂ ᐅᐊᙳᕐᒥ ᐅᓯᑲᖅᑕᕐᕕᐅᑉ ᓱᓪᓗᐊᒍᑦ.

ᑭᓂᖅᑐᑦ ᑯᕕᔪᑦ ᐅᓗᓇᐊᓇᕐᒪᑕ ᓇᓂᓕᒫᖅ ᐅᑭᐅᖅᑕᖅᑐᖅᑐᒥ, ᑭᓯᐊᓂ ᑯᕕᔫᑉ ᐊᒃᑐᐃᓂᖓ ᐱᓗᐊᒪᔩᓗᐊᕌᔭᖅᐳᖅ ᑕᐃᒪᐃᓐᓂᕈᓂ ᐃᒃᐱᒍᓱᒃᓴᐃᕋᐃᑦᑐᓖᓗᙵᓂ ᓂᑲᓇᖅᑐᓂᓗ ᐃᒪᓂ ᕿᙳᐊᓂ ᑕᓯᐅᔭᕐᒥᓗ, ᐱᓗᐊᖅᑐᒥᒡᓗ ᓱᕈᓗᐊᓄᑦ ᐅᖅᓱᓄᑦ. ᓱᕈᓗᐊᑦ ᐅᖅᓯᑦ ᐃᓕᓴᓇᔭᐅᓯᒪᑦᑎᐊᕐᒪᑦ ᑐᐊᕕᕐᓇᖅᑐᓄᑦ ᐅᐸᔩᓄᑦ ᖃᐅᔨᒪᔨᑕᕐᓄᑦ ᓄᓇᕐᔭᐊᒥ ᐊᕙᑎᒧᑦ ᓱᕈᓰᙳᕆᑎᑐᑦ ᐱᔭᖅᑰᖏᑦᑐᒃᑯᑦ ᑯᕕᒍᓂ ᑕᕝᕙᐅᖏᓐᓇᔭᑦᑐᑦ, ᐊᕙᑎᒥᔅᓯᓂ ᑕᖅᑭᓄᑦ ᐊᕐᕌᒍᓅᖏᒃᑯᓂ, ᐊᔾᔨᓇᒃᓴᑦᑎᐊᕈᑎᒋᓪᓗᓂᐅᒃ ᓴᓗᒻᒪᖅᓴᕆᐊᒃᓴᖅ. ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑕᐃᒪᓐᓇᐅᔪᓐᓇᕋᓱᖏᓐᖏᓕᑦ ᐹᕝᕙᓪᓚᓐᑯᑦ ᐅᖃᖅᑕᖓᓄᑦ ᑎᓕᐅᕆᔪᓐᓇᖏᓐᓂᕋᐃᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᖅᑎᒥᓂᒃ ᐅᖅᓱᖅᓴᐅᔪᓄᑦ ᑭᓯᓕᕆᔪᑎᓄᓪᓗ ᐊᑐᖅᑕᐅᔪᓄᑦ. ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᐅᖃᖅᐳᑦᐱᓕᕆᓗᒍ ᐊᔾᔨᐸᓗᐊᑐᑦ ᓱᒃᑲᓂᑎᑦ ᒪᓕᒋᐊᓕᒃᑎᑦ ᐅᖓᓯᖕᓂᐅᔭᕆᐊᓕᒃᑎᑐᓪᓗ ᐅᒥᐊᕐᔪᐊᓄᑦ ᐊᑐᖅᑕᐅᓗᑎᒃ ᓇᓗᓇᐃᕐᓗᒋᑦ ᓇᓕᐊᑦ ᐅᖅᓱᐃᑦ ᐊᑐᖅᑕᐅᔪᓐᓇᕐᒪᖔᑕ ᐱᓕᕆᓂᕐᒧᑦ ᐅᒥᐊᕐᔪᐊᓄᑦ – ᐊᐅᓚᑕᐅᖏᒃᑲᓗᐊᕐᓗᓂ ᑭᓯᐊᓂ ᐊᑐᖅᑕᐅᔪᓐᓇᕐᓂᕐᒧᑦ ᐊᑕᓗᑎᒃ, ᑕᐃᒪᓐᓇ ᐹᕝᕙᓪᓚᓐᑯᓐᓂᑦ ᐱᔪᓐᓇᖁᔭᖅᑕᕗᑦ ᐊᐅᓚᑕᐅᔪᓐᓇᓗᐊᖁᔭᕐᓂᓗ.

ᐃᓱᒪᒋᓗᒍ ᐹᕝᕙᓪᓚᓐᑯᑦ ᑐᒃᓯᕋᖅᑕᖓ ᐃᓕᓴᖅᓯᔭᐅᓯᒪᔪᑎᒍᑦ ᐃᓱᒪᒋᔭᐅᕐᑯᓗᒍ ᐃᓪᓗᐊᑕ ᓯᓚᕐᔪᐊᕐᓂᖅ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᐅᖓᓯᖕᓂᖅᓴᒧᓘᓐᓃᑦ ᑕᕆᐅᑉ ᐊᑭᐊᑕ ᐊᖅᑯᑎᐊᒍᑦ ᐊᓯᐊᒍᑦ ᐊᖅᑯᑎᐅᕐᑯᓗᒋᑦ ᐅᓯᑲᖅᑕᖅᑐᓄᑦ, ᖃᐅᔨᒪᔭᐅᙱᑦᑐᓕᐅᕐᒪᑕ ᖃᓄᐃᑦᑐᖃᓕᐅᖅᑎᓇᒍ ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᐃᓯᒪᒋᔭᐅᓂᕐᓂᒡᓗ ᐊᒃᑐᐃᓂᕐᓂᒃ ᑖᒃᑯᑎᒍᑦ ᓱᓗᑎᒍᑦ ᐃᑲᔫᑕᐅᓇᓱᒃᓗᑎᒃ ᐊᖏᖅᑕᐅᓂᖏᓐᓄᑦ ᑕᐃᒪᐃᒻᒪᑦ ᓂᕐᔪᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᕗᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᕿᒥᕐᕈᓂᖓᑦ ᒪᕐᕈᐊᓄᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔭᒪᓇᓰᑎ ᐃᓚᖃᖏᓪᓗᒥ ᑕᐃᑯᓇ ᐊᖅᑯᑎᒥᒃ ᐊᕙᑎᓕᕆᔨᒃᑯᓪᓗ ᓇᓗᓇᐃᖅᓯᔭᐅᑲᐅᑉ ᐊᖏᖅᑕᐅᓯᒪᔪᑦ ᐅᓯᑲᖅᑕᓂᖏᑦ ᐊᖅᑯᑎᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᔪᓄᑦ ᐸᕐᓇᐅᑎᓂᒃ ᑕᐃᒪᐃᖏᓐᓇᖅᓯᒪᔪᖅ ᐊᖏᖅᑕᐅᕕᒃᓯᒪᔭᒃᑯᑦ ᒥᑦᑎᒪᑕᓕᒃᑯᑦ/ᑕᓯᐅᔭᒃᑯᑦ/ᕿᑭᖅᑖᓗᒃ ᐃᑭᐊᓴᖓᓂᑦ.

ᓄᓇᓂ ᐊᕙᑏᑦ

ᐹᕝᕙᓪᓚᓐᑯᑦᑭᖑᓪᓕᖅᐹᖅ ᐊᕙᑎᒥᒃ ᐊᒃᑐᐃᓂᖏᑦ ᐅᓂᒃᑳᖓᑕ ᐃᓚᒋᐊᕈᑎᖓ ᓇᓗᓇᐃᖅᓯᖓᒪᑦ ᐊᒃᑐᐃᓃᑦ ᑐᒃᑐᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐊᖅᑯᑎᑯᑖᖑᒥᑦ ᖃᒃᑲᓂᐊᒍᓪᓗ ᓄᓇᒃᑯᕈᑎᒃᑯᑦ ᐅᓯᑲᖅᑕᖅᑐᑦ ᐱᕐᔪᐊᓗᐊᒍᔾᔭᙳᕆᓚᑦ ᒫᓐᓇᐅᔪᖅ ᐱᐅᖏᑦᑐᓄᑦ ᒥᑭᓪᓕᒋᐊᕈᑏᑦ ᐊᑐᓕᖅᑎᑕᐅᒍᑎᒃ. ᓈᒻᒪᒋᔭᒃᓴᐅᙱᓚᖅ ᐹᕝᕙᓪᓚᓐᑯᑦ ᑐᑭᓯᒪᒻᒪᑕ, ᑐᙵᕗᖃᖅᑲᓐᓂᒃ ᑕᐃᒪᓐᓇᐅᓇᓱᒋᔭᐅᔪᓄᑦ ᒪᓕᒃᓱᒋᑦ ᐃᓄᖃᖅᑎᖓᓂᖓᓂᑦ, ᐄ) ᒫᓐᓇᐅᔪᖅ ᐱᓕᕆᓂᖏᑦ ᐊᒃᑐᐃᓂᖃᖏᒪᑕ, ᐊᒻᒪᓗ ᐱ) ᒪᕐᕉᐃᓕᓪᓗᐊᖅᑐᑦ ᐅᑎᖅᑕᕋᐅᔭᖅᑐᑦ

ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᐊᒃᑐᐊᔪᓄᓪᓗ ᐃᖏᕐᕋᔪᓄᑦ ᐅᓯᑲᖅᑕᕐᕕᐅᑉ ᐊᖅᑯᑎᐊᒍᑦ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᐊᖅᑯᑎᑯᑦᑖᒃᑯᓪᓘᓃᑦ ᐊᒃᑐᐃᓂᖃᓗᐊᔾᔫᖏᓐᓂᕋᖅᓱᒋᑦᑐᒃᑐᓂᒃ. ᐱᔪᒪᔪᑦ ᐊᖅᑯᑎᑖᓕᐅᕈᒪᕗᑦ ᓄᓇᒥ ᐄᓛᓪᓗ ᐊᕕᒃᑐᖅᓯᒪᔪᒥ ᑕᐃᒪᐃᑦᑐᓂᒃ ᐱᖁᑎᕐᔭᐊᓂᒃ ᓴᓇᕕᐅᓚᐅᖅᓯᒪᖏᑦᑐᒥ ᓇᐅᑦᑎᖅᓱᖅᑕᐅᓪᓗᓂᓘᓃᑦ. ᐊᖅᑯᑎᑖᓪᓗ ᓴᓇᔭᐅᔪᒪᕆᓪᓗᓂ ᑐᒃᑐᑦᖃᕐᕕᖕᓂ ᑐᒃᑑᖃᑎᒌᖏᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᓯᒪᖏᑦᑎᐊᖅᓗᑎᒃ ᐊᒃᑐᐃᓂᕐᓄᑦ ᐊᖅᑯᑎᑖᕐᔭᐅᓕᐅᖅᑲᐅᔭᒧᑦ ᐱᖁᑎᕐᔭᐊᖏᓐᓂᑦ ᐃᓚᖏᑎᒍᓪᓗ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑎᒍᑦ 99% ᓂᒃ ᓄᖑᓯᒪᑎᒋᓕᖅᑐᑐᑦ. ᐅᖃᕋᓱᓪᓗᓂ ᐊᒃᑐᐃᓂᖃᔾᔫᖏᓐᓂᕋᐃᓗᓂ ᐊᖅᑯᑎᑖᖕᒥᑦ ᑐᙵᓗᑎᒃ ᐱᑕᖃᖏᓐᓂᖏᓐᓄᑦ ᖃᐅᔨᒪᔭᐅᔪᓄᑦ ᐅᓄᖅᑐᓄᓪᓗ ᐃᒪᓐᓇᐅᓂᐊᕋᓯᒋᔭᐅᔪᓄᑦ ᐊᖏᑲᒃᓴᐅᙲᒋᓕᖅ ᐅᓗᕆᐊᓇᖅᒥ ᒪᓕᒡᓗᒋᑦ ᐅᓪᓗᒥᐅᔪᖅ ᐱᐅᖅᓱᐊᕐᓃᑦ ᐃᓕᖅᑯᓯᑐᖃᒃᑯᓪᓗ ᐊᑑᑎᖃᑦᑎᐊᕐᓂᖏᑦ ᕿᑭᖅᑖᓘᑉ ᑐᒃᑐᖏᑦ.ᓂᕐᔪᑎᓄᑦ ᕿᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᕗᑦ ᐹᕝᕙᓚᓐᓇᑯᑦ ᐋᕿᒃᓯᓇᐊᖃᕐᓗᑎᒃ ᐊᑐᓕᖅᑎᑦᑎᓗᑎᓪᓗ ᓈᒪᒃᑐᓂᒃ ᓇᓚᐃᒃᑯᑕᓂᒃ ᑮᓕᓂᓪᓗ ᐱᖃᓯᐅᔾᔨᓗᑎᒃ ᖃᐅᔨᓴᓪᓚᑭᓘᔭᖅᑐᓄᑦ ᖃᐅᔨᓴᕐᓂᕐᓄᑦ ᐸᕐᓇᐅᑎᓕᐅᕐᓗᑎᒃ ᑐᑭᓯᔪᓐᓇᐅᑎᒋᓗᒋᑦ ᑕᒫᓂᕐᒥᐅᓂᒃ ᑐᒃᑑᖃᑎᒌᓂᒃ, ᐊᒻᒪᓗ ᓇᓕᐊᑐᐃᓐᓇᖅ ᐅᓄᖅᓯᕆᐊᕐᓂᖅ ᐅᑎᖅᑕᕋᐅᔭᕐᓂᕐᓄᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᐅᓯᑲᖅᑕᕐᓂᕐᓘᓃᑦ 6 ᒥᓕᐊᓐ ᑕᓐᔅ ᐊᕐᕌᒍᒥ ᐅᖓᑖᓄᑦ ᐊᖏᖅᑕᐅᖏᓪᓗᓂ ᑭᓯᐊᓂ ᖃᖓᒥ ᖃᐅᔨᓯᒪᔭᖃᓕᑭᓂ ᐃᑲᔪᖅᑐᐃᔪᓂᒃ ᒫᓇᐅᔪᖅ ᐅᖃᐅᓯᓇᔭᐅᔪᒧᑦ ᐊᒃᑐᐃᖏᓂᖃᐃᓪᓗᑎᒃ ᐃᑲᔪᖅᑐᖅᑐᓂᓪᓗ ᓯᕗᓂᕐᒥ ᐊᒃᑐᐃᓗᐊᕋᔭᖏᑦᑐᓄᑦ 12 ᒥᓕᐊᓐ ᑕᓐᔅᓄᑦ ᐊᕐᕌᒍᒥ ᓴᓇᓕᕈᒪᒐᔭᖅᑎᓪᓗᒋᑦ.

ᓯᓚᒧᑦ ᐊᒃᓱᕈᕐᓇᖅᑐᕐᔭᖅ

ᒪᓕᒃᓗᒍ ᐊᒃᓱᕈᕐᔭᐊᕐᓇᖅᑭᖅ ᓯᓚᐅᑉ ᐊᓯᔾᔨᕐᓂᖓᓄᑦ ᐃᓗᐃᑦᑐᒃᑯᑦ, ᐊᒃᑐᐃᓂᒃᑲᓐᓂᓇᓕᖅᑕᖏᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ, ᓄᓇᕐᔭᐊᕐᒥᐅᓄᓪᓗ ᐊᒃᓱᕈᖅᑎᑕᐅᕙᓪᓕᐊᓂᖏᑕ ᐳᔪᕐᓗᓕᐅᙱᖅᓴᐅᓕᕐᑯᔭᐅᓪᓗᑎᒃ ᓇᓕᒧᓕᕐᑯᓪᓗᒋᑦ ᓯᓚᒥᒃ ᐊᖕᒪᐃᔭᓐᓇᖅᑐᓂᒃ ᐳᔫᕐᓂᕐᓗᖕᓄ ᐊᑐᓕᕐᑯᔭᐅᔭᓄᑦ, ᐊᑑᑎᖃᑦᑎᐊᖅᐳᖅ ᐹᕝᕙᓚᓐᓇᑯᑦ ᓄᓘᔭᖕᓂ ᐱᑕᖃᓂᖓᑦ ᓴᖅᑭᔮᖅᑎᑦᑎᓗᓂ ᐱᑕᖄᓯᒪᓯᒥᓂᒃ ᐳᔪᕐᓗᖏᓐᓂᖅᓴᐅᑎᑦᑎᓂᕐᒧᑦ ᐋᒃᑐᐊᔪᓄᓪᓗ ᐊᒃᑐᐃᓂᕐᓂᒃ. ᓂᕐᔪᑎᓄᑦ ᕿᓇᐅᔭᖏᑦ ᑎᓕᐅᕆᕗᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᐊᑐᓇᐊᖅᑎᑦᑎᓗᑎᒃ ᐱᑕᓇᓂᖅᓴᓂᒃ ᐊᐅᓚᓂᕐᓂᒃ ᐅᒥᐊᕐᔪᐊᓄᓪᓗ ᐃᓕᖅᑯᓯᓂᒃ ᐹᕝᕙᓚᓐᓇᑯᓂᒃ, ᑎᑭᓐᓇᓯᓪᓗᑎᒃ ᐳᔪᕐᓗᖏᓐᓂᖅᓴᕐᒧᑦ ᕿᓂᖅᑕᓂᓪᓗ ᐸᐅᕿᔭᖏᓐᓂᖅᓴᐅᓗᑎᒃ ᐊᕐᕌᒍᑕᒫᑦ ᐅᔭᕋᖕᓂᐊᕐᓂᑕᓇᔪᑕᒫᓂᑦ, ᐱᖅᑲᓯᐅᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒃᑯᑦ ᐅᓯᑲᖅᑕᕐᓃᑦ.

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Introduction

WWF Canada (WWF) is dedicated to promoting conservation of the planet's natural environment, and to stop its degradation, working to build a future in which humans live in harmony with nature by conserving the world's biodiversity, ensuring that the use of natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption. WWF has been involved in the Mary River project since its inception, and have indicated in numerous submissions to the NIRB that this project, if managed appropriately, could be a model of sustainable development and adaptive management in the Arctic. We are grateful for the opportunity to participate in this assessment and submit the following comments and recommendations in good faith that the Nunavut Impact Review Board will recognize the value in our participation and heed the advice provided.

Specific Technical Comments

1. NIRB Assessment and Process Issues

a) Effects Monitoring

WWF-FWS 01 EFFECTS MONITORING

References

Phase 2 FEIS Addendum

Summary

WWF has participated in the NIRB assessment of Mary River and the subsequent Project Certificate amendment processes, providing insight and comment regarding effects assessment and predictions, and the necessary mitigation and monitoring that would be required to address potential/indicated impacts. In addition, we have provided similar comment through the ongoing activities of the environmental working groups and the NIRB's requirements for Baffinland's annual reporting.

We have provided comment on a number of matters multiple times, with no or partial response from Baffinland and/or NIRB:

a) the lack of appropriate monitoring - both, as we expect should be developed by NIRB, and as could or should be self-imposed by Baffinland,
b) the lack of data collection to inform the ongoing consideration of project effects,
c) the lack of indicators and thresholds, and
d) the limited interpretation and integration of results, or application of adaptive management, undertaken by Baffinland to date.

Importance of issue to the impact assessment process

This is Baffinland's third application for amendment to the Mary River project; the need for rigorous monitoring and informed assessment to evaluate possible impacts of current activities and proposed works has never been greater.

The onus is on NIRB to ensure the approved Project, and any amendments that follow, are managed in such a way that the Proponent(s) collect and analyze data that inform the public about the approved activities. This is required of the NIRB, given its primary objective per the Nunavut Agreement and subsequent legislation that is to protect and promote the existing and future well-being of the residents and communities of the Nunavut Settlement Area, and to protect the ecosystemic integrity of the Nunavut Settlement Area.

The impact assessment process relating to the Mary River project continues to be seriously shortchanged where monitoring, data collection and assessment, development of indicators and thresholds, and integration and interpretation of this information remain unaddressed by Baffinland, and in some cases, the NIRB.

Detailed Review Comments

1. Gap/Issue

Each year the NIRB invites interested parties to make submissions on Baffinland's Annual Reporting, including giving consideration of compliance with Terms and Conditions, to comment on whether the conclusions reached by Baffinland in its Annual Monitoring Report are valid; and to identify any areas of significance requiring further supporting information.

The Proponent is then given an opportunity to respond to comments and questions submitted by parties, and the NIRB follows up with an Annual Monitoring Report of its own, usually addressing items of concern from its site visit and comments from agencies. The NIRB provides recommendations to Baffinland identifying areas within project monitoring and operations which require improvement or correction.

The NIRB's involvement with regard to term and condition compliance issues is quite clear and effective, with NIRB having made recommendations and requests of Baffinland that have had important and positive contributions to the compliance status of the overall project. However, with regard to effects monitoring, the NIRB must do more to address deficiencies in effects monitoring, especially gaps in the monitoring of impacts which are not measurable via compliance to terms and conditions. Specifically, the NIRB must engage in at a minimum, semi-annual review and consideration of effects monitoring, must require or work with Baffinland to develop indicators and thresholds for key species and environmental components, and undertake its own independent analysis of results and discussion of trends.

Baffinland has not developed or implemented appropriate programs to determine effects or trends from project activities. NIRB approved the project and subsequent amendments and has responsibilities to ensure the impacts to the ecosystem are mitigated and appropriately managed. Current and future impacts and effects have not been appropriately addressed, and specifically, we do not support the advancement of further development to the Northern Transportation corridor until such time as these essential items are in place and have been proven to be effective.

2. Disagreement with FEIS Addendum conclusion

Baffinland continues to assure reviewers that there are no significant impacts from ongoing project activities, and that no significant impacts are expected as a result of the Phase 2 development, however this conclusion is qualitative in nature, based on data uninformed by adequate monitoring and a weak projection of impact that is based largely on professional judgement, not a result of actual environmental indicators or observed trends measured against defined thresholds.

The NIRB's Mary River Project Certificate (Terms and Conditions 99, 110, 111, 112) explicitly require that Baffinland develop indicators and thresholds for marine mammal VECs (Valued Ecosystem Components). These have not been developed. Without indicators and thresholds in place, Baffinland's monitoring results cannot be relied upon to accurately inform conclusions within the FEIS Addendum. WWF recommends that Baffinland develop indicators and thresholds as is required of project proponents in other jurisdictions across the country, and suggests that the NIRB not recommend this proposed amendment proceed without necessary and adequate indicators and thresholds in place to indicate when and how much an impact is occurring

3. Reasons for disagreement with FEIS Addendum

The effects of the Mary River Project have not been properly or accurately quantified and understood, nor can they be understood, without NIRB providing clear and formal direction to Baffinland regarding the monitoring and effects assessments required, and without Baffinland developing quantifiable indicators and thresholds, and conducting the necessary data collection, review, and integration of those monitoring results to interpret what effect the project may (and/or may not) be having.

Baffinland has been allowed to conduct limited monitoring, and claim an inability to make inferences from results, yet is permitted to continue with its activities. As well in two cases, Baffinland has had major project amendments approved, despite not having adequate information to determine impacts of its operations at each prior stage of development.

Recommendation(s)

WWF recommends that with respect to annual reporting, the NIRB analyze parties' comments, undertake its own independent analysis and interpretation of Baffinland's monitoring results, provide direction to Baffinland in the design of and subsequent alterations to its monitoring programs, and provide results of its own interpretation of impacts and effectiveness of mitigation strategies.

Given the obvious holes in monitoring and data collection and the subsequently weak and uninformed basis from which its impact predictions are based, WWF recommends that no increase to throughput beyond the current operation at 6 Mtpa be approved until such time as Baffinland has appropriate thresholds and indicators in place to inform adequate monitoring programs, and until such time as the same have been accepted by NIRB and intervenors and have proven able to render adequate monitoring information.

WWF recommends that under no scenario the project be permitted to haul beyond 6 Mtpa of ore with trucks on the current road given that the option to increase production and rely on haul trucks without railroad construction has not been adequately assessed during the Phase 2 proposal.

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b) Adaptive Management:

WWF-FWS 02 ADAPTIVE MANAGEMENT

References

Phase 2 FEIS Addendum

Summary

Without a monitoring framework in place - one that is developed by or with the NIRB in collaboration with parties, it is impossible to implement an informed, effective adaptive management strategy for the project.

The NIRB has advised Baffinland to move forward with selection/development of indicators and thresholds to inform its monitoring work, which is a promising step in the right direction. However, the Mary River project is well into production, and on its third Project Certificate amendment request, and yet there are still no measures in place to guide the collection or interpretation of monitoring results.

Importance of issue to the impact assessment process

Given the absence of a structured monitoring program, this project has not been managed to adapt to changes in the environment. There has been no way of knowing what level of impact the project is (or is not) having. An overarching framework to guide expectations and practical, effective monitoring is required to ensure the programs around impacts are responsive and can reflect project realities.

Detailed Review Comments

1. Gap/Issue

In the absence of a monitoring framework to guide the Proponent, NIRB should have required the timely development of indicators and thresholds so there would be markers against which to measure project impacts and to help determine whether, and to what extent, impacts may have been occurring. At this point, it is impossible to determine whether impacts have occurred, nor what thresholds may have been exceeded in terms of levels of impacts that have occurred. This is a serious shortfall of the project to date, and one that NIRB should correct through amendment to the existing Project Certificate.

2. Disagreement with FEIS Addendum conclusion

Baffinland's FEIS Addendum states that its "Environment, Health, and Safety (EHS) Management System is the framework for adaptive management based on international best practices. The EHS embraces the Precautionary Principle and Sustainable Development. Within this framework, individual plans have been developed to address all aspects of the company's activities and contain the detailed mitigation measures and monitoring to be implemented throughout the life of the Project in order to eliminate, limit or minimize adverse effects."

Without adequate benchmarks against which to compare results, it is impossible to gauge whether mitigation or monitoring have been appropriately implemented thus far in the Project life, nor whether adverse impacts have been eliminated, limited or minimized in any way. Adaptive management cannot be implemented without the selection of appropriate indicators and thresholds to identify when and where impacts are occurring, and to develop customized mitigation measures that may be applied to address them. Finally, monitoring programs have not been able to determine impact with any reliable degree of certainty, and have not informed the efficacy of mitigation measures or adequacy of predictions.

3. Reasons for disagreement with FEIS Addendum

Without this information in hand, Baffinland cannot provide more than a "best guess" at whether or not impacts have occurred, and whether or not the activities associated with Phase 2 are likely to cause any additional impact(s). In absentia of comprehensive, consistent, scientifically robust data to inform monitoring programs and interpretation, Baffinland can make no supported statements regarding impacts to narwhal and other marine species from shipping or ice breaking, or to caribou and terrestrial wildlife from road/rail development and operation.

Recommendation(s)

WWF recommends that as part of the reconsideration of the Mary River Project Certificate, the NIRB include a Monitoring Framework to be appended to the Certificate for review and comment by parties. We also recommend that the NIRB include a timeline for the finalization of the Framework within the Appendix itself, to ensure parties are able to track the development and participate at relevant stages.

Given the absence of adequate (comparable, integrated, consistent) results from project monitoring, the inability to measure or interpret impacts and trends from that data, and proposed mitigation measures that cannot therefore be related to observed impacts, current predictions about impacts from Phase 2 are not supported by any empirical evidence related to the current operations and monitoring programs.

WWF therefore recommends, given this uncertainty with regard to current operations and limited understanding of impacts, no further mine throughput and transport beyond the approved 6 Mtpa be approved until such time as these critical aspects of the adaptive management framework are implemented and are informing the current level of activity.

c) Inadequacy of Working Groups

WWF-FWS 03 CHANGES TO WORKING GROUPS

References

NIRB Project Certificate No. 005 Amendment 1

Summary

As noted in numerous prior correspondences to the NIRB, the current approach for both the Terrestrial and Marine Environment Working Groups (TEWG, MEWG) has proven ineffective in its aim to improve understanding of project-related impacts and provide advice and direction for incorporation into Baffinland's mitigation and monitoring protocol and processes. Despite questions and advice provided by participants at the MEWG and TEWG meetings and via comments and submissions, Baffinland has largely determined its own priorities and methods in its monitoring program, with little to no incorporation of advice provided by organizations involved. As the working group deliberations are not part of the public record, with the exception of meeting minutes, any concerns or issues raised by experts within municipal, territorial, and federal levels of government which are mandated to act in the public interest, are kept within the confines of the working groups.

Importance of issue to the impact assessment process

Within the original Mary River Project Certificate, NIRB outlined the role of the working groups to provide advice to Baffinland on matters pertaining to its monitoring programs and plans, and mitigation measures relating to the project's development.

Baffinland has not met the expectations set out in the Project Certificate, and the NIRB has not provided the necessary level of oversight with regard to the working groups to ensure those expectations are met. The monitoring programs put in place by Baffinland do not adequately reflect or respond to concerns raised by the working group. Given Baffinland's weak approach to project monitoring and analysis/interpretation of results, the NIRB, having ultimate authority for ensuring project developments do not have significant adverse impacts, remains uninformed with regard to those impacts,

Detailed Review Comments

1. Gap/Issue

Conditions 49 (Terrestrial) and 77 (Marine) establish these groups, specifically noting they will act as advisory groups in connection with mitigation measures for the protection of the terrestrial and marine environments and in connection with Baffinland's Environmental Effects Monitoring Programs.

The advisory function has not been realized in the last 6 years. Baffinland has insisted that meetings are confidential, and has not demonstrated accountability and transparency regarding discussions which occur, changes that are/are not incorporated based on advice from the group, and votes are not taken to help set course for monitoring or mitigation measures/programs. Further, the NIRB does not, to our knowledge, require or review information regarding advice that may be provided by members on various monitoring programs and plans, nor, despite requests for it to do so, has the NIRB required Baffinland to provide justification for making changes to, or not making changes to, its mitigation measures, monitoring plans and programs where these are discussed/determined behind the doors of the working groups.

2. Disagreement with FEIS Addendum conclusion

With the Project Certificate Terms and Conditions subject to revision, the NIRB should consider revising the conditions related to the working groups. At the very least, Baffinland should be required to vet proposed changes to monitoring programs through the NIRB, subject to the NIRB's approval. We respectfully submit that NIRB holds the primary responsibility for understanding and ensuring effects of the project are adequately managed. It necessarily follows then, that the NIRB should be weighing in on the ways mitigation and monitoring plans are designed and implemented. Confirming or questioning Baffinland's conclusions regarding non-significant impacts from the current operations and/or predictions of the same for the Phase 2 development ultimately rest with the NIRB, and the current approach to working groups and Baffinland holding sole responsibility with no oversight has proven ineffective.

3. Reasons for disagreement with FEIS Addendum

Without NIRB formally overseeing and providing direction regarding Baffinland's monitoring programs and proposed changes, monitoring results, and the comments and requests of working group members, Baffinland has essentially been allowed to self-regulate and self-report on all aspects of marine and terrestrial environment and specific mitigation and monitoring measures. While it is intended that these groups function in some manner to provide this oversight, Baffinland has stated its opinion that the groups provide advice only and that none of the advice/direction from members is actually binding.

As the recommending/approving body, the NIRB assumes ultimate responsibility for monitoring and managing effects of the Mary River project, and as such, it must weigh in on the design and implementation of mitigation measures and monitoring plans and programs.

The current Phase 2 assessment provides an opportunity to improve the working group format and function and the overall monitoring program for the Mary River Project, something that, considering the scope and scale of amendment being considered, is paramount to any approval rendered.

Recommendation(s)

WWF recommends that the NIRB revise conditions relating to the working groups, taking into consideration any revised Terms of Reference filed by working group members, and that revised terms and conditions be issued to reflect a more responsive role for the NIRB, a requirement that Baffinland integrate advice received with unanimous support from members, and provide rationale for not integrating the same into its plans and programs. The NIRB should have ultimate authority to make decisions where Baffinland does not agree with advice from working groups. Revision should also clarify a requirement that working group discussions, debates, and recommendations be filed publicly with the NIRB.

While the working groups can and should provide advice and oversight of monitoring programs and plans for the project, the ultimate responsibility for ensuring Baffinland's monitoring programs are mitigating significant impacts rests with the NIRB. Through an amendment to the Project Certificate, this must be clarified via revisions to the existing Terms and Conditions 49 and 77, as well as any others deemed necessary by the NIRB.

2. Marine Environment

a) Marine Spatial Planning

WWF-FWS 04 NEED FOR MARINE SPATIAL PLAN

References

Baffinland Phase 2 FEIS Addendum

NIRB Final Report for the SEA on Oil and Gas Development in Baffin Bay and Davis Strait (File No. 17SN034), Volume 3, July 2019

A New Shared Arctic Leadership Model, From Mary Simon, Minister's Special Representative, March 2017 (http://publications.gc.ca/site/eng/9.842964/publication.html)

Summary

Baffinland has indicated during the current Project Certificate reconsideration assessment process, as it did during the assessment of the original Mary River project, Early Revenue Phase, and Production Increase Proposal, that the proposed increase in ship traffic associated with the Phase 2 proposal will have **no significant impact** to marine mammals (including ice-dependent wildlife), the ice as its own ecosystem, or Inuit harvesters.

WWF does not agree with that conclusion, and disagrees that Baffinland’s current approach to individual/ship-specific mitigation measures (i.e. lessening speed, giving right of way to mammals) has had the desired impact of lessening impact. WWF suggests that effective management of the impacts from industrial shipping would best be achieved via the development and implementation of a Marine Spatial Plan (MSP) which reaches outside the current Regional Study Area (RSA). This would take into account a broader perspective when considering the predicted and potentially observed impacts from the Phase 2 proposal to, among other things, ice habitat and marine species. A longer-term, regional approach that results in a comprehensive MSP -is needed to manage competing interests and activities within the Tallirutiup Imanga National Marine Conservation Area (NMCA) than current project-by-project considerations of impacts and mitigation measures introduced by a single shipping proponent.

Importance of issue to the impact assessment process

Baffinland has proposed significant increases to ship traffic through Milne Port, Pond Inlet and Eclipse Sound as part of its Phase 2 activities. It has been anticipated that at a maximum, 176 ore carrier return trips (total of 352 one-way transits) could be undertaken, in addition to up to 50 other ships making their way to Milne Port for routine mine resupply (100 return trips). Considering that this upward limit of 450 maximum transits would all occur within the Tallirutiup Imanga NMCA, significant investment in appropriately managing and planning for shipping and other uses of these areas is required to support sustainable use of this corridor. Baffinland's proposed plans to mitigate impacts of project shipping to wildlife and Inuit are not adequate. An MSP, could be required as a long-term tool or mitigation measure, used to manage the impacts that arise from Baffinland and other industrial users within the NMCA.

Detailed Review Comments

1. Gap/Issue

It is concerning that the originally proposed Mary River project involved no shipping of ore through this corridor, and that only weeks after receiving NIRB's approval for the original project, Baffinland filed an "amendment" to allow for 3.5 Mtpa (4.2 Mtpa operational flexibility) of ore to be shipped through the northern route. After a significant assessment of the Early Revenue Phase proposal, the NIRB approved the increase, only to be approached *again* by BIMC in 2018 to increase the amount shipped by nearly doubling that amount - to 6 Mtpa of ore via the northern shipping route. Despite the NIRB having significant concerns about impacts to the marine environment and recommending the increase not be allowed, the federal Ministers pushed the Production Increase Proposal amendment through. We are now, a year later, being asked to consider an additional doubling of the throughput and transport via the north, to 12 MT annually. Baffinland continues to assert, as was the case with original Mary River project resupply shipping, Early Revenue Phase shipping, and Production Increase Proposal shipping, that the Phase 2 increase in traffic through this routing, will have no significant impact on marine mammals (including ice-dependent wildlife), the ice as its own ecosystem and as habitat, or Inuit harvesters and use of the area.

2. Disagreement with FEIS Addendum conclusion

The original project, as initially proposed and considered by the NIRB and intervenors, included a variation on the northern shipping route. The project was never intended to support the shipment of ore - nor for a limited time in support of phased development, nor for the multi-generational projected life of this Project. Baffinland failed to consider the Northern shipping route during the initial assessment, and that lack of foresight now threatens to bring impacts on the marine environment and marine species dependent on the ecologically rich areas specifically planned for project shipping via the north. Baffinland, now with its "foot in the door" with the Early Revenue Phase and Production Increase amendment approvals is presenting the northern shipping of ore as now being necessary to the project's development. Approaching this application as a mere "amendment" to the initially reviewed Project has undermined the level of rigour applied through this assessment and has diluted the consideration of this northern shipping route as merely a slight Project change, requiring a much shorter and less robust review than was conducted on the originally proposed Project.

We recommend that the NIRB consider whether further shipping of iron ore through the northern corridor should be approved at all. If so, we recommend the NIRB require such a significant increase in the volume of ore through the northern route, and over a significantly long project life, be resubmitted for consideration as a separate and distinct transportation project.

3. Reasons for disagreement with FEIS Addendum

The proposed Phase 2 activities must be considered in light of Baffinland's inadequate monitoring programs and the resultant significant uncertainty around impacts to marine mammals which WWF, and other reviewers, have been expressing issues with for years.

Baffinland's FEIS Addendum has provided an inadequate consideration of the impacts of shipping - during both open water, and shoulder seasons and periods of ice cover - to marine species, including that share a boundary with Greenland (i.e. narwhal, polar bear, other species that migrate east-west throughout Baffin Bay) and utilize the North Water polynya, or Pikialasorsuaq. These impacts of shipping, including those transboundary matters, which could perhaps be better reflected in the status and impact to transboundary species, have not been adequately considered.

Recommendation(s)

The limited assessment provided within Baffinland's FEIS Addendum and supporting documentation is not adequate to support shipping additional ore via the Northern Transportation Corridor. Should any shipping through the northern route be allowed to proceed by the NIRB, and/or is approved by the responsible Ministers, it is WWF's recommendation that the shipping route, including portions of Tallirutiup Imanga and critical habitat at Pikialasorsuaq, as well as species outside of Canada's waters that depend on areas inside the Nunavut Settlement Area, and all Project-related shipping activities, be subject to the development of a strategic Marine Spatial Planning exercise.

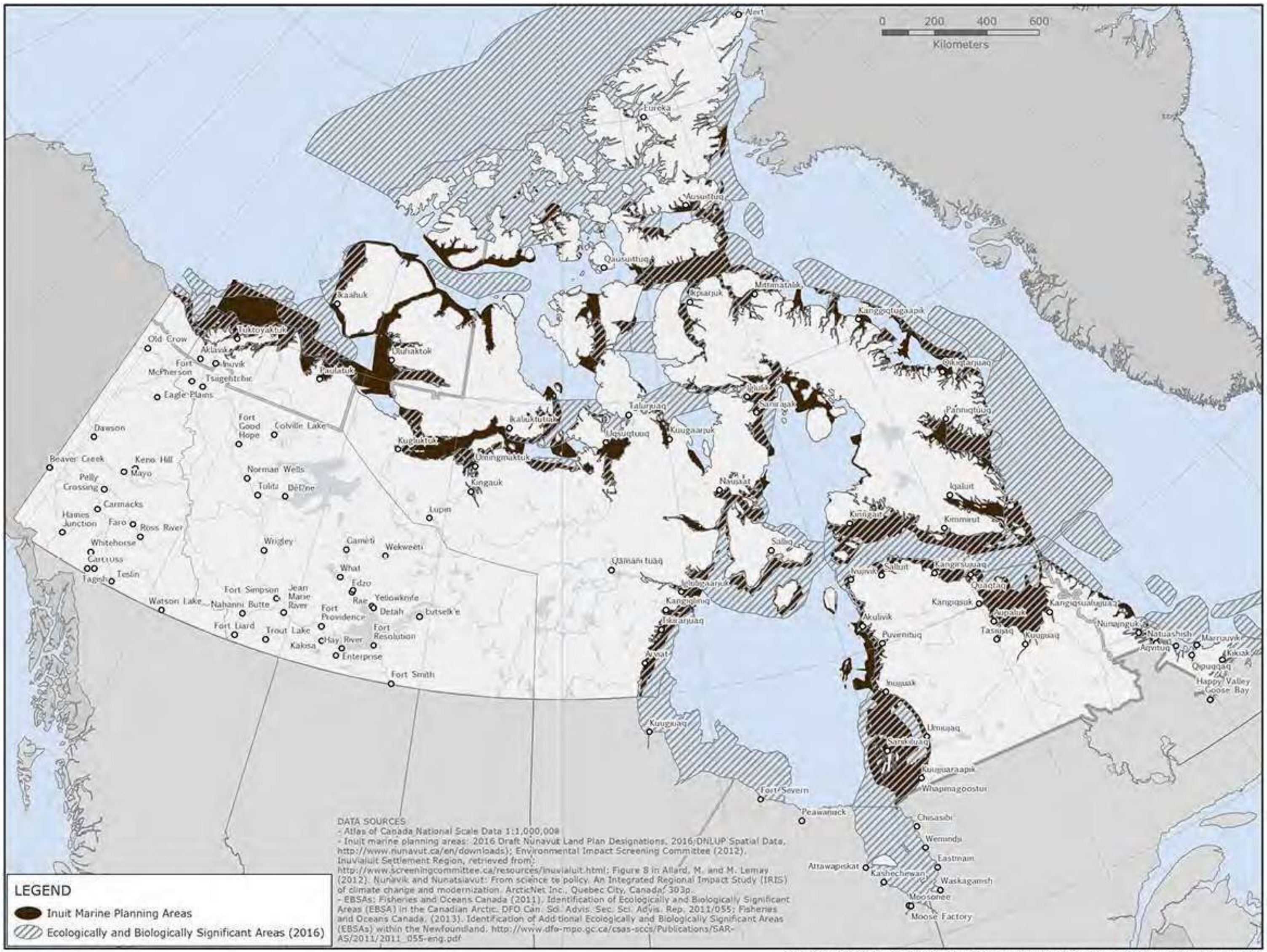
We note that the NIRB's recommendation in its recent Final Report on the SEA for Oil and Gas Development in Baffin Bay and Davis Strait addressed this concept of marine spatial planning, recommending the initiation of "marine-based regional planning throughout the Area of Focus, including the development of regional priorities." While the basis for that recommendation was around the development of oil and gas resources, we suggest that the same emphasis should be placed on marine planning around the Phase 2 development, since the area in question is of very high biological and cultural importance, and has now become critically important to the development of the Mary River project. For this reason, and considering the NIRB's separate but related recommendation, we submit that such an exercise must be undertaken and should consider the fragility of the ecosystem and the communities and marine species which depend on its continued health and productivity for their own futures.

One of the important components of MSP is to identify areas that should be protected; the newly released Arctic framework also acknowledges this need:

> *"We will take an active role in supporting the development of a pan-Arctic network of marine protected areas at the Arctic Council and we will continue to partner with Indigenous peoples to recognize and manage culturally and environmentally significant areas and pursue additional conservation measures, including those led through Indigenous management authorities."*

We also reference Mary Simon's A New Shared Arctic Leadership Model as it relates to the need for marine protections and planning in the Arctic and specifically notes the desire of Inuit to have environmental management of coastal areas (see also Figure 1):

> *"Marine conservation initiatives in the Arctic have not kept pace with land conservation with less than 1% of the waters of Inuit Nunangat under any form of recognized protection (see appendix 4). In spite of having the world's longest Arctic coastline, Canada's Arctic has* [at that time] *only two existing marine protected areas, Tarium Niryutait and Anguniaqvia Niqiqyuam. These areas represent less than half a percent of Canadian Arctic waters. Yet, nearly all Inuit communities are situated on the Arctic coastline adjacent to marine areas of ecological and biological importance. Inuit have classified through local planning processes approximately 21% of Arctic waters as requiring distinct environmental management. The federal government, through a mix of planning processes, has identified 55% Arctic waters as ecologically and biologically significant. Maintaining healthy coastal and marine habitats is critical for food security, cultural continuity and increased economic opportunities from fisheries and tourism."*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Pelly Crossing
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Haines Junction
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Fort Simpson
Jean Marie River
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Fort Liard
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Fort Providence
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Rigolet
Happy Valley Goose Bay
Kuugjuaq
Fort Severn
Peawanuck
Chisasibi
Wemindji
Eastmain
Attawapiskat
Kashechewan
Waskaganish
Moosonee
Moose Factory
LEGEND
Inuit Marine Planning Areas
Ecologically and Biologically Significant Areas (2016)

DATA SOURCES
- Atlas of Canada National Scale Data 1:1,000,000
- Inuit marine planning areas: 2016 Draft Nunavut Land Plan Designations, 2016 DNLUP Spatial Data, http://www.nunavut.ca/en/downloads); Environmental Impact Screening Committee (2012). Inuvialuit Settlement Region, retrieved from: http://www.screeningcommittee.ca/resources/inuvialuit.html; Figure 8 in Allard, M. and M. Lemay (2012). Nunavik and Nunatsiavut: From science to policy. An Integrated Regional Impact Study (IRIS) of climate change and modernization. ArcticNet Inc., Quebec City, Canada; 303p.
- EBSAs: Fisheries and Oceans Canada (2011). Identification of Ecologically and Biologically Significant Areas (EBSA) in the Canadian Arctic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/055; Fisheries and Oceans Canada. (2013). Identification of Additional Ecologically and Biologically Significant Areas (EBSAs) within the Newfoundland. http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2011/2011_055-eng.pdf

Map Projection: Modified Canada Albers Equal Area Conic. Central meridian -100; standard parallels 50 and 70; latitude of origin 40N.

FIGURE 1. MAP OF OVERLAP OF INUIT AND FEDERAL NORTHERN MARINE CONSERVATION-PLANNING AREAS (EXCERPT FROM A NEW SHARED ARCTIC LEADERSHIP MODEL)

WWF has identified a network of Priority Areas for Conservation, several of which are located in Lancaster Sound, Pikialasorsuaq and in Baffin Bay and Davis Strait - we note that in all of these areas, shipping continues to occur absent any strategic or conservation planning. A visual of these areas is provided in Appendix A.

The Priority Areas for Conservation (PACs) identified in the 3 scenarios in Appendix A have been developed using current Scientific data and Inuit knowledge and should be used as the foundation for future conservation work in the Arctic. The MECCEA PACs would thus form the conservation layer for a future Marine Spatial Plan.

We further suggest as an example, the NIRB consider Marine Spatial Planning in place in British Columbia, and suggest the NIRB develop recommendations that at a minimum, consider speed limits, number of ships transiting at any one time, restrictions on fuel types and emission controls, stringent requirements for refueling and ballast water management, zero discharge of sewage/grey water/scrubber effluent, ship design and operational measures which reduce underwater noise, and detailed requirements pertaining to marine monitoring and the consideration of cumulative effects.

It is our expectation that project-specific recommendations around shipping will exceed those that exist in current regulations on shipping and related procedures in Canada’s Arctic, and we suggest Baffinland assume any associated costs as being within the terms of operating in the Nunavut Settlement Area.

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b) Route Planning

WWF-FWS 05 SHIPPING ROUTE(S) - NAVY BOARD INLET AND NWP

References

Memorandum Re Supplement to TSD 27 - Cumulative Effects Assessment (May 16, 2019)

FEIS Addendum, Alternatives Analysis Report TSD 1 (s. 3.2)

Supporting Document: Environmental Review of Shipping through the Northwest Passage (July 12, 2019)

Summary

Baffinland has included information in the Phase 2 FEIS Addendum which indicates an intention to utilize additional shipping routes via Navy Board Inlet, the North side of Bylot Island, and west via the Northwest Passage to transport ore and move project ships.

Baffinland has not adequately assessed the proposed option to include the additional routing for project ships - including ore carriers - through Navy Board Inlet, north of Bylot Island, nor to utilize corridors through the west, i.e. the Northwest Passage (NWP) route. Additional shipping routes have not received adequate consideration to be subject to approval.

Importance of issue to the impact assessment process

Baffinland has proposed significant increases to ship traffic through Milne Port, Pond Inlet and Eclipse Sound as part of its Phase 2 activities. It has been anticipated that at a maximum, 176 ore carrier return trips (total of 352 one-way transits) could be undertaken, in addition to up to 50 other ships making their way to Milne Port for routine mine resupply (100 return trips). Considering that this upward limit of 450 maximum transits would all occur within the Tallirutiup Imanga NMCA, and possibly within waters and regions not previously considered for project shipping (Western Nunavut, NWT), significant additional assessment and consideration are required to fully understand and gauge the potential impacts of this proposed activity.

Detailed Review Comments

1. Gap/Issue

Baffinland's TSD 1 states: "subject to prevailing ice conditions and Arctic Ice Regime Shipping System (AIRSS) calculations, Baffinland may advise relevant Ice Class Ore Carriers to proceed to Milne Inlet via Navy Board Inlet." It also references moving its project ships west, through the Northwest Passage (NWP) as a possible alternative.

In its May 2019 Memorandum to TSD 27, Baffinland indicated that with regard to potential cumulative effects to marine mammals, "shipping through Lancaster Sound, Navy Board Inlet, Eclipse Sound and Milne Inlet potentially interacts with the same populations of marine mammals affected by the Project" and that because this shipping "impact[s] the same marine mammal populations, having all project shipping captured under Eclipse Sound is acceptable."

Baffinland continues to assert, as was the case with original Mary River project resupply shipping, Early Revenue Phase shipping, and Production Increase Proposal shipping, that the Phase 2 increase in traffic through this routing, will have no significant impact on marine mammals (including ice-dependent wildlife), the ice as its own ecosystem, or Inuit harvesters.

Despite having included this potential option within its Alternatives Analysis, Baffinland has not undertaken the necessary and relevant impact assessment for activities related to shipping via the NWP. Its FEIS Addendum included details pertinent only to shipping through Milne Port, Pond Inlet and Eclipse Sound, and through Baffin Bay to the east. The Navy Board Inlet and NWP routes have not been subject to adequate impact assessment, including the provision of baseline information and proposed strategies for impact mitigation/monitoring, and consultation with potentially affected communities along the NWP. Baffinland has not provided an adequate assessment to support conclusions about the NWP route and associated impacts of its use for the Phase 2 proposal.

2. Disagreement with FEIS Addendum conclusion

As initially proposed and considered by the NIRB and intervenors, the northern shipping route was never intended to support the shipment of ore - nor for a limited time in support of phased development, nor for the multi-generational projected life of this Project.

Baffinland has now introduced additional shipping routes, far outside of the previously considered assessment scope, and has not provided adequate consideration of impacts to support any activity in these areas (NWP, Navy Board Inlet).

3. Reasons for disagreement with FEIS Addendum

Baffinland's assertion of "no impact" from shipping via this alternate route has not been supported by any additional research, baseline, or adequate impact assessment and is an over-simplified conclusion based on desktop information. Specifically, Baffinland's Environmental Review of Shipping through the Northwest Passage specifically notes that the "report is not an environmental assessment, and does not present conclusions as to the significance of residual environmental effects."

Baffinland's suggestion that marine species throughout Navy Board Inlet would not be subject to additional impacts outside of those already assessed for the proposed Pond Inlet-Eclipse Sound routing demonstrates a gross misinterpretation of factors that influence habitat selection, disturbance and displacement, and biological productivity for those species impacted by marine shipping.

If narwhal or other species are demonstrating avoidance or displacement behaviour due to impacts in the previously approved shipping route - something that Baffinland has not yet been able to determine - and move to Navy Board Inlet as an alternative habitat, adding cumulative impacts from shipping into that area further impacts those animals. Similarly, if Inuit are now needing to travel up into Navy Board Inlet to harvest wildlife that has moved to avoid the approved shipping route, impacts that cause the animals to be displaced even further to avoid ships transiting north, will also be impacts to Inuit and Inuit harvesting.

Further to this, there has been no consultation with communities along the NWP which may be impacted by Project related shipping thorough that corridor. Baffinland has not included any consideration of these communities, or wildlife using the corridor, as such, the currently submitted assessment of significance and impacts is entirely without merit and should be disregarded by the NIRB in its assessment.

Recommendation(s)

There is inadequate baseline information and consideration of impacts from shipping via Navy Board Inlet and through the Northwest Passage to even consider routing through these options. As such, the NIRB's assessment of the Phase 2 proposal should not include any alternative routings proposed by Baffinland at this time.

Should Baffinland desire to ship via a western routing, WWF recommends that an application for amendment to the current Project Certificate be filed with the Board. Considering information currently before us, we do not support the inclusion of westward passage of vessels or Navy Board Inlet routing for any Project ships within the present assessment.

It is recommended that the NIRB clarify that the approved shipping route for all project related vessels remains through the previously approved Pond Inlet/Eclipse Sound/Baffin Bay corridor until such future time as appropriate assessment and consideration, along with marine spatial planning, are given to this proposed activity.

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c) Spills

WWF-FWS 06 FUEL SPILLS AT SEA, HFO VS. LIGHTER DISTILLATES

References

Phase 2 FEIS Addendum

TSD 1 Alternatives Analysis Report

Memo 07b Response to WWF Questions Regarding Black Carbon Emissions (July 2, 2019)

August 15, 2019 WWF Email to Baffinland Re: Spill Probability (Appendix B)

WWF Report: Baffinland Oil Spill Probability: Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic (Appendix C)

WWF Report: Phasing Out the Use and Carriage for Use of Heavy Fuel Oil in the Canadian Arctic: Impacts to Northern Communities
http://assets.wwf.ca/downloads/phasing_out_heavy_fuel_oil_report.pdf (Appendix E)

Summary

WWF has previously made submissions commenting on the unacceptability of continued use of Heavy Fuel Oil (HFO) as the primary ship fuel, and have heard in responses from Baffinland that stipulating the type(s) of fuel utilized by contracted ships is not possible.
HFO is widely accepted by emergency response experts as the world's most environmentally hazardous fuel if accidentally spilled in the marine environment. It is extremely persistent, lasting in the marine environment for months if not years, making it nearly impossible to clean up. WWF continues to suggest that Baffinland move away from the use of HFO in its project's ships, and recommends that NIRB consider implementing restrictions on Baffinland to ensure protection for the marine environment.

Importance of issue to the impact assessment process

Given the significant proposed increase in shipping traffic that would occur as a result of the Phase 2 project, it is essential that considerations be given to limiting impacts from the transportation and use of fuels in ships at sea.

WWF has raised similar comments at numerous meetings and in submissions regarding the Mary River Project over many years, and we again raise the issue of Baffinland's resistance to considering the use of anything other than Heavy and Intermediate Fuel Oils for its contracted ore carriers, and submit an appeal to NIRB to ensure a Proponent shipping in such biologically important areas such as those proposed for Phase 2 is held to an unparalleled standard of care.

Detailed Review Comments

1. Gap/Issue

Within a response to WWF's comments on black carbon emissions and the use of HFO, Baffinland has stated:

> *"…there are a limited number of vessels that can service the Project and the ability to influence the fuel those vessels burn where it is compliant with international regulations is limited. Similarly, Baffinland cannot influence the technologies its contracted vessels employ to manage their emissions. Baffinland is committed to reducing the emissions generated by the Project and is willing to work with regulators to do so throughout the life of mine, however, certain constraints do exist and must be considered."*

WWF recently provided Baffinland with information and an email requesting input regarding an analysis we commissioned with respect to the Mary River 2016 shipping oil spill probability analysis, attached as Appendix B, as related to the WWF oil spill trajectory modelling, included as Appendix C.

The recent Oil Spill Probability Analysis found that Phase 2 activities increased the chances of a significant bunker fuel (HFO) spill occurring during the life of the project to 1 in 3, or 33%. WWF requested that Baffinland comment on the analysis and explain how it planned to integrate these results into its spill preparedness plan and other risk reduction measures to address potential spills. WWF has said in the past that one concrete measure to reduce spill risks would be to switch away from Heavy Fuel Oil - this alone would substantially reduce the impacts if a spill occurred, in addition to having an immediate reduction on emissions of black carbon from between 30-80%.

In addition, WWF reviewed Baffinland's Spill at Sea Response Plan and requested more detail regarding Baffinland's plans to prioritize the protection of shoreline areas that have been identified as ecologically, socioeconomically, or culturally sensitive. The SSRP Appendix has a map of these areas, but includes no site-specific response planning. In an open-water spill scenario, shoreline impacts are highly likely. The modelling we commissioned found that in 98% of the open water spill scenarios, HFO/bunker fuel oil reached shore, and did so fairly quickly. The minimum time for oil to reach shore was 4.8 hours, and the average time was 1.2 days. According to Baffinland's SSRP, the travel time for its tugs to transit from Milne Port to a spill site are between 4-12 hours (depending on the spill location). Since shoreline oiling could potentially occur before the response activities are fully mobilized, site-specific planning for particularly sensitive shoreline areas is needed.

We note that Baffinland's recent response to Environment and Climate Change (ECC) technical comment 3.22 states: "The overall conclusion related to ice breakup scenarios is that the effect of ice (if encountered) is to keep the fuel offshore and delay drift to one of the shorelines. The overall conclusion related to ice freeze-up scenarios is that the effect of ice is to keep the fuel offshore and delay any drift to one of the shorelines and in practice, effectively trapping the fuel in the ice as it freezes." This response is misleading. Spilled fuel is able to mix with ice, and depending on the time of year, may pass through ice floes to reach the shoreline. Further, WWF disagrees with Baffinland's conclusion that having fuel trapped in the ice thereby ends or negates any further responsibility for spill cleanup. Where does the fuel end up once the ice moves off/melts, and why has Baffinland's spill modelling and response planning not considered the ultimate effects of a spill? With a highly persistent fuel such as HFO, which remains in the environment for months and years, spill trajectory modelling and response planning needs to incorporate a longer time horizon to determine impacts and effective response.

2. Disagreement with FEIS Addendum conclusion

WWF disagrees with Baffinland's position that it cannot influence its contractors with regard to fuel and technology selection. Where Baffinland has set conditions upon ship operations such as speed limits and ballast water treatment/release, WWF suggests that a similar approach to specifying fuel types to be utilized by Project ships as a non-regulated but contractual matter, is very much within its ability.

As indicated above, WWF disagrees with BIMC's suggestions regarding the likelihood of a fuel spill at sea, and also with its conclusions regarding the fate of oil spilled at sea (in shoulder/ice and open water conditions).

We have requested input and comment from Baffinland regarding the analysis presented in Appendices A and B, but had not received any additional information as of the date of our filing.

3. Reasons for disagreement with FEIS Addendum

With regard to fate of oil spilled in ice, no demonstrable case has been made by Baffinland that a) a significant volume of fuel/oil will become frozen/entrapped in the ice, and b) freezing into the ice is a suitable mitigation measure for fuel/oil spilled at sea.

Use of a non-HFO fuel for project shipping would decrease risks associated with spills. We do not agree that Baffinland is unable to place contractual requirements regarding the types of fuel utilized by the ships it hires to transport materials and ore because it is the author of the shipping contracts.

Recommendation(s)

WWF recommends that the NIRB require Baffinland to utilize lighter distillate fuels (i.e. non-HFO, non-IFO) in its own and contracted shipping vessels, including its ore carriers calling to port in Nunavut.

Furthermore, we recommend that Baffinland only contract ships for work in Nunavut waters if they are fitted with double hulled fuel tanks to protect the waterways and marine species living here from a potentially disastrous spill of HFO/IFO.

3. Terrestrial

a) Caribou

WWF-FWS 07 CARIBOU IMPACT PREDICTIONS, MITIGATION & MONITORING PLANS

References

Phase 2 FEIS Addendum

COSEWIC assessment and status report on the Caribou Rangifer tarandus , Barren-ground population, in Canada. 2016. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Inuit land use and occupancy project - Volume 1 (p. 159-260). 1976. INAC. (http://publications.gc.ca/site/eng/9.850125/publication.html)

Summary

Baffinland has indicated in many working group meetings and in responses to comments provided during this assessment that the Phase 2 proposal will have no significant impacts on caribou.

It has also implied that as there are very few caribou in the Baffin Island population, the Project has had, and will continue to have, limited impacts on caribou, and that monitoring, and mitigation measures are of little importance until such time as caribou numbers begin to show an increase.

WWF does not agree with these conclusions, especially considering the proposed increase of truck and combination of road and rail traffic via the Milne Tote Road and proposed Northern railway.

Importance of issue to the impact assessment process

Given the significant proposed increase in overland traffic that would occur as a result of the Phase 2 project, WWF believes it is essential that Baffinland work diligently to develop an accurate and useful understanding of Baffin Island caribou, including appropriate baseline information, and demonstrating a robust effort to collect monitoring information on an ongoing basis.

Detailed Review Comments

1. Gap/Issue

The potential impacts to caribou from utilizing a railway and road for this project have not been predicted with any confidence or certainty, and have underestimated the level of potential impact. This is an issue considering the Baffin Island population is expected to be on the way to recovering/increasing in number in the years to come.

Baffinland has presented the railway and road combination as infrastructure which "***might*** be perceived to represent" a barrier to movement (*emphasis added*). Taken in context, Baffinland's FEIS Addendum states: "Many of the initial impacts in terms of disturbance to wildlife are significantly mitigated over time as the natural population accustoms itself to the change. The greatest potential impact [of the railway] will be in the barrier it might be perceived to represent." With no significant backing in science or observations applicable to a herd that has never been exposed to railway infrastructure, this conclusion is largely based on professional judgement, which is an inadequate method of determining accuracy of predictions and subsequently, whether the level of mitigation proposed can be deemed adequate.

A report of the Committee on the Status of Endangered Wildlife in Canada related to barren ground caribou states: "Behavioural responses to disturbance from human and industrial activities include local displacement which is measurable as indirect habitat loss. Incremental and cumulative loss of habitat can occur through the footprint of mines, … and roads as partial barriers to movements." (COSEWIC, 2016)

Baffinland's FEIS Addendum suggests that "The Tote Road and North Railway do not intersect known traditional caribou movement corridors including caribou crossings and are therefore not expected to present substantial barriers to caribou movement."

2. Disagreement with FEIS Addendum conclusion

"Many of the initial impacts in terms of disturbance to wildlife are significantly mitigated over time as the natural population accustoms itself to the change. The greatest potential impact [of the railway] will be in the barrier it might be perceived to represent." Baffinland is suggesting the actual impact of the railway is conceptual, i.e. perceiving that it represents a barrier to movement. It is not clear whether this perception is borne by caribou, or by the intervenors to NIRB's assessment. WWF suggests that the railway could indeed serve as s barrier, or as a track for caribou to use as an insect/predator relief route, which may lead to accidents or increased mortality. This would actually facilitate movement along the rail line, something that Baffinland's FEIS Addendum does not consider adequately.

Baffinland's FEIS Addendum suggests that "The Tote Road and North Railway do not intersect known traditional caribou movement corridors including caribou crossings and are therefore not expected to present substantial barriers to caribou movement." WWF disagrees with the simplified suggestion that having road and rail *not* being intersected by caribou corridors limits the road's barrier to movement. We suggest further that Baffinland's weak approach to monitoring caribou over the past 8 years has resulted in a significant deficit of information regarding caribou in the RSA and that drawing conclusions from an absence of caribou is not a credible source of evidence. Undertaking inadequate monitoring results in poor data, which cannot then be turned to as evidence of no impact to caribou, or, to confirm that there are no caribou in the area to be impacted.

Furthermore, while the FEIS Addendum for Phase 2 states "The information collected for baseline characterization and Project monitoring were sufficient to inform the environmental impact assessment on wildlife and wildlife habitat," Baffinland's collection of applicable baseline data prior to ERP and PIP operations cannot be relied upon. How, for instance, are pre-operations data able to provide relevant baseline conditions related to the current impact assessment? For instance, collaring and aerial survey data has not been updated for 8 years, and the only population surveying or "inventory" work Baffinland has engaged in over the past number of years are its few annual height of land survey occurrences, which WWF has on numerous occasions, suggested are an inadequate measure to even estimate relative abundance and/or distribution, not to mention trends related to project level impacts. With inadequate current information about herd abundance, distribution, and dynamics, Baffinland's effects prediction provides weak conclusions that cannot be relied upon to accurately inform this assessment.

3. Reasons for disagreement with FEIS Addendum

Per COSEWIC's suggestion that "Road-related impacts are dependent on the location of the subpopulation," WWF suggests that while impacts from the Tote Road on terrestrial wildlife may not have presented an issue thus far in the project's development, an increase in the effort level and intensity of monitoring to detect presence, distribution and abundance is required to confirm FEIS Addendum predictions, to identify the need for mitigation measures, and to trigger any adaptive management that may be required.

This is also the case considering the proposed increase from 250 round trips of iron ore via truck per day, to 560 round trips per day via the Tote Road (prior to and/or instead of implementing rail transport). Waiting to increase monitoring effort level until caribou numbers have increased, as suggested by Baffinland, is an unacceptable approach. In line with the COSEWIC report, it is necessary to have a highly informed understanding of the distribution of the North Baffin herd, and to be prepared for its interaction with the road and railway infrastructure, rather than waiting to see if, when, and where they arrive, and responding with reactionary measures.

The Inuit Land Use and Occupancy study indicates that Inuit traditionally tracked and harvested Baffin Island caribou throughout the area currently proposed for development of Baffinland's Phase 2 railroad, along the corridor east of the Tote Road and a long-used travel route between Pond Inlet and Igloolik. If Baffinland disturbs these areas, caribou could be deterred from migrating back to traditional habitats which may in turn, affect the recovery of the herd's population.

We question Baffinland's overarching conclusion that the "activities proposed as part of the Phase 2 Proposal are not predicted to result in significant adverse residual effects on wildlife and wildlife habitat."

Baffinland is proposing to build a railroad in an area and indeed a territory where no such infrastructure has ever been built or monitored. The railroad is also proposed to be built in the habitat of a caribou herd that has never been monitored for impacts from railroad infrastructure and that by some estimations is 99% depleted. To suggest that there will be no impacts from the railroad based on an absence of data and a long list of presumptions is an unacceptable risk given the current conservation status and cultural importance of Baffin Island caribou.

WWF does not have confidence in Baffinland's assessment of impacts to caribou, nor in its monitoring plans or proposed mitigation measures.

We submit that this conclusion is based on 1) outdated baseline information (i.e. from prior to current operations), 2) inadequate monitoring data collected since Project approval, and 3) a faulty assumption that the information collected for initial baseline data and recent project monitoring are adequate to support such conclusions. WWF does not believe the prior baseline and inadequate annual monitoring data are viable sources of information to support impact assessment findings as presented.

Recommendation(s)

WWF recommends that Baffinland be required to develop and implement adequate indicators and thresholds as well as robust monitoring plans to gain useful information about the regional caribou herd, and that no increase to mine throughput or transport beyond 6 Mtpa is approved until such time as it has evidence to support the current assertion of no impact and to support projections of no significant impacts with a 12 Mtpa development scenario

WWF recommends that the NIRB set specific monitoring requirements for Baffinland to acquire accurate data about caribou abundance, distribution, and responses to the currently approved activities.

4. The Climate Crisis

---

a) Emissions

WWF-FWS 08 DECREASING GREENHOUSE GAS EMISSIONS

References

Phase 2 FEIS Addendum

TSD 1 Alternatives Analysis Report

Supporting Document: Climate Change Action Plan (March 2019)

WWF Report: Arctic Heavy Fuel Oil Ban: Fuel and Voyage Cost Effects on Bulk Carriers used in Canadian Arctic Mining Operations (Appendix D)

Summary

Considering the intensive level of marine and terrestrial transportation proposed for Phase 2, as well as its projected lifespan, and that we are in a global climate crisis, Baffinland should, without exception, be moving toward a more sustainable approach to these project activities, and this should be front and centre during our assessment of the proposed Phase 2 development.

Importance of issue to the impact assessment process

The impacts, or costs, of emissions from industrial projects are externalized as the systematic way of doing business - responsibility for costs and impacts associated with greenhouse gas and black carbon emissions is not generally levied toward a Proponent such as Baffinland. We recommend Baffinland take a progressive approach to activities which will lower associated emissions over time. This impact assessment must consider impacts over time, and suggested mitigation measures to address or limit those impacts which may occur.

Detailed Review Comments

1. Gap/Issue

Given the continued increasing of climate change and level of crisis and the pressure to reduce emissions to meet GHG targets globally, it is imperative that this project go beyond simply measuring emissions and be required to demonstrate ongoing achievements in lessening emissions and associated impacts.

Given the significant transportation component of the Phase 2 development, Baffinland should be required to implement transport options which limit emissions. Specifically, moving away from Heavy Fuel Oil use in ships toward lighter distillates is one method to reduce black carbon that could have significantly less impact and less risk to the receiving environment, if implemented by Baffinland.

2. Disagreement with FEIS Addendum conclusion

As referenced in a prior comment re: ship fuels, Baffinland's rationale of not being able to afford the extra cost associated with using alternative fuels or finding more efficient shipping technologies is an unacceptable reason to continue utilizing high polluting transportation options. WWF recently commissioned a cost analysis of using alternative fuels in project ships, which indicates the overall voyage cost does not increase significantly, and that using non-HFO in ships without scrubbers installed are also less affected by increases in associated costs. This and other findings are included as Appendix D.

3. Reasons for disagreement with FEIS Addendum

Recognizing that economic feasibility is an important consideration for project viability to take into account, it can no longer be the only consideration, or the consideration given highest priority when implementing project planning and executing decisions. Limiting emissions must become a priority and WWF recommends that for a project so heavily dependent on transportation infrastructure, Baffinland should be required to look at ways to decrease its footprint over time.

Baffinland must be working to go beyond simply reporting GHG and black carbon emissions annually. Given the transportation component of this project, and of the proposed Phase 2 development, Baffinland should demonstrate continued improvement in the reduction of GHG emissions and move toward more sustainable, less emitting technologies.

Recommendation(s)

Existing Term and Condition 3 requires that Baffinland provide within its Annual Reporting, results of any emissions calculations conducted to determine the level of sulphur dioxide (SO2) emissions, NOX emissions and GHG generated by the Project using fuel consumption or other relevant criteria as a basis.

WWF recommends that Baffinland be required to demonstrate how it has decreased its GHG and black carbon emissions annually. Similarly, existing Conditions 4, 8, and 9 require the use of various methods to measure and report on emissions - in the example of Condition 4, Baffinland is required to undertake continuous monitoring at port sites to capture ship generated SO2 and NO2 emissions at the Port, and to continue this for several seasons to determine that emissions are at acceptable levels.

WWF recommends that Baffinland be required to demonstrate annual improvements above and beyond federal targets for these emissions. Specifically, the objective of Condition 9 is to "Provide feedback on the Project's emissions." These conditions should be revised to require additional measures and steps from Baffinland to demonstrate improvement over predicted values and emissions targets.

Summary of Recommendations

1. The NIRB analyze parties' comments, undertake its own independent analysis and interpretation of Baffinland's monitoring results, provide direction to Baffinland in the design of and subsequent alterations to its monitoring programs, and provide results of its own interpretation of impacts and effectiveness of mitigation strategies.

2. A compromise approach be considered by allowing the recent production approval from 4.2 Mtpa to 6 Mtpa to become permanent but with no increase to throughput beyond that amount until such time as Baffinland has appropriate thresholds and indicators in place to inform adequate monitoring programs, and until such time as the same have been accepted by NIRB and intervenors and have proven able to render adequate monitoring information.

3. The NIRB include a Monitoring Framework to be appended to the Certificate for review and comment by parties, including a timeline for the finalization of the Framework within the Appendix itself, to ensure parties are able to track the development and participate at relevant stages.

4. WWF recommends that under no scenario the project be permitted to haul beyond 6 Mtpa of ore with trucks on the current road given that the option to increase production and rely on haul trucks without railroad construction has not been adequately assessed during the Phase 2 proposal.

5. Revise conditions relating to the marine and terrestrial environment working groups, taking into consideration any revised Terms of Reference filed by working group members, and issue revised terms and conditions to reflect a more responsive role for the NIRB, a requirement that Baffinland integrate advice received with unanimous support from members, and provide rationale for not integrating the same into its plans and programs. The NIRB should have ultimate

authority to make decisions where Baffinland does not agree with advice from working groups. Revision should also clarify a requirement that working group discussions, debates, and recommendations be filed publicly with the NIRB.

6. Clarify via revisions to existing Terms and Conditions 49 and 77, as well as any others deemed necessary by the NIRB, that while working groups can and should provide advice and oversight of monitoring programs and plans for the project, the ultimate responsibility for ensuring Baffinland's monitoring programs are mitigating significant impacts rests with the NIRB.

7. The limited assessment provided within Baffinland's FEIS Addendum and supporting documentation is not adequate to support shipping additional ore via the Northern Transportation Corridor. Should any shipping through the northern route be allowed to proceed by the NIRB, and/or is approved by the responsible Ministers, the shipping route, including portions of Tallirutiup Imanga and critical habitat at Pikialasorsuaq, as well as species outside of Canada's waters that depend on areas inside the Nunavut Settlement Area, and all Project-related shipping activities, must be subject to the development of a strategic Marine Spatial Planning exercise.

8. There is inadequate baseline information and consideration of impacts from shipping via Navy Board Inlet and through the Northwest Passage to even consider routing through these options. As such, the NIRB's assessment of the Phase 2 proposal should not include any alternative routings proposed by Baffinland at this time.

9. An application for amendment to the current Project Certificate must be filed with the NIRB for any westward passage of vessels or Navy Board Inlet routing for any Project ships within the present assessment. The present assessment does not support these alternative routes.

10. It is recommended that the NIRB clarify that the approved shipping route for all project related vessels remains through the previously approved Pond Inlet/Eclipse Sound/Baffin Bay corridor until such future time as appropriate assessment and consideration, along with marine spatial planning, are given to this proposed activity.

11. The NIRB require Baffinland to utilize lighter distillate fuels (i.e. non-HFO, non-IFO) in its own and contracted shipping vessels, including its ore carriers calling to port in Nunavut.

12. Baffinland only contract ships for work in Nunavut waters if they are fitted with double hulled fuel tanks to protect the waterways and marine species living here from a potentially disastrous spill of HFO/IFO.

13. The NIRB set specific monitoring requirements as a way for Baffinland to acquire accurate data about caribou abundance, distribution, and responses to the currently approved activities.

14. That Baffinland be required to demonstrate how it has decreased its GHG and black carbon emissions annually and to demonstrate annual improvements above and beyond federal targets for these emissions.

List of Appendices

Appendix A: WWF Priority Areas for Conservation

Appendix B: August 15, 2019 WWF Email to Baffinland Re: Spill Probability (Appendix B)

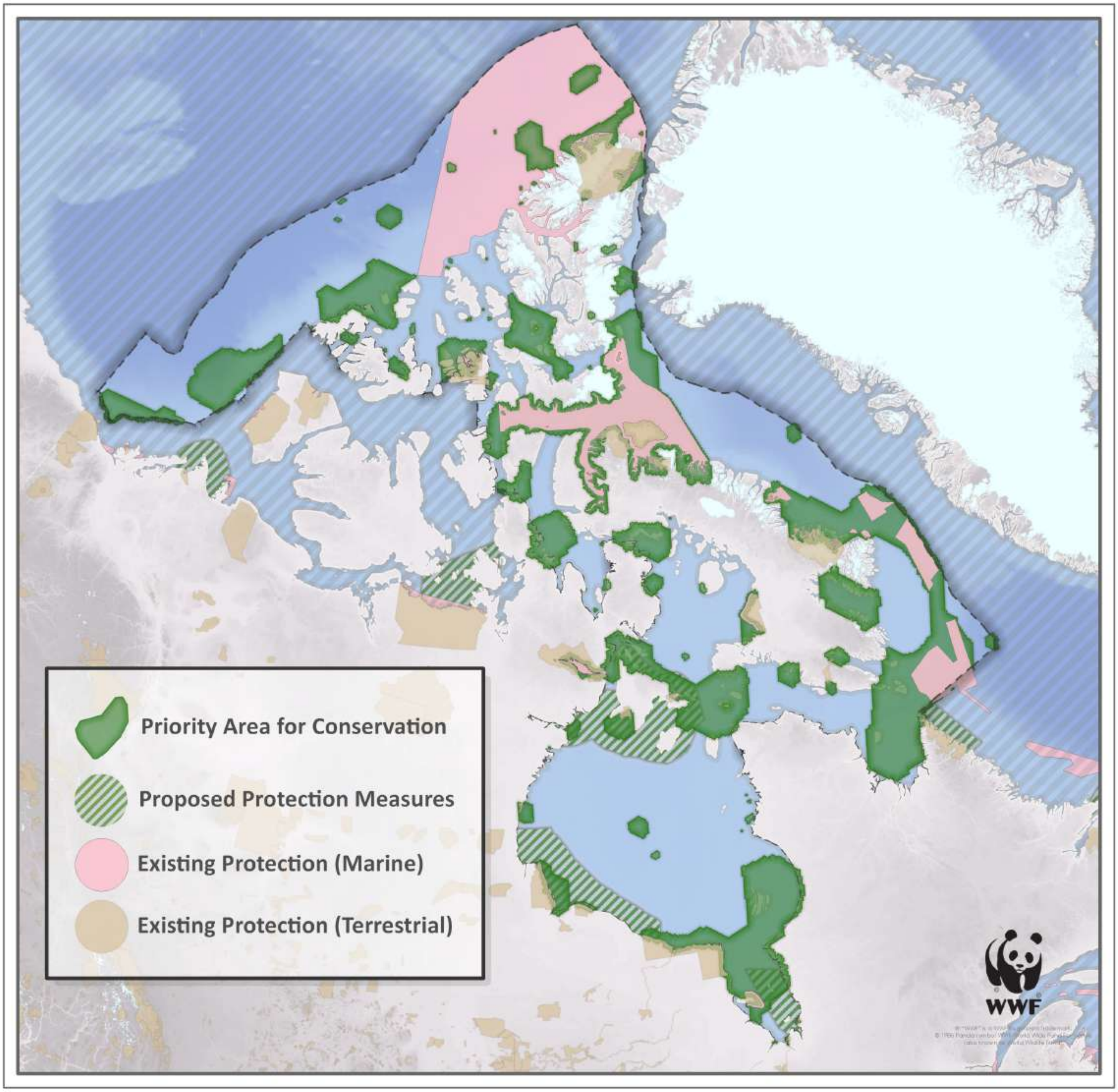
Appendix C: Baffinland Oil Spill Probability: Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic

Appendix D: Arctic Heavy Fuel Oil Ban: Fuel and Voyage Cost Effects on Bulk Carriers used in Canadian Arctic Mining Operations

Appendix E: WWF Report: Phasing Out the Use and Carriage for Use of Heavy Fuel Oil in the Canadian Arctic: Impacts to Northern Communities http://assets.wwf.ca/downloads/phasing_out_heavy_fuel_oil_report.pdf

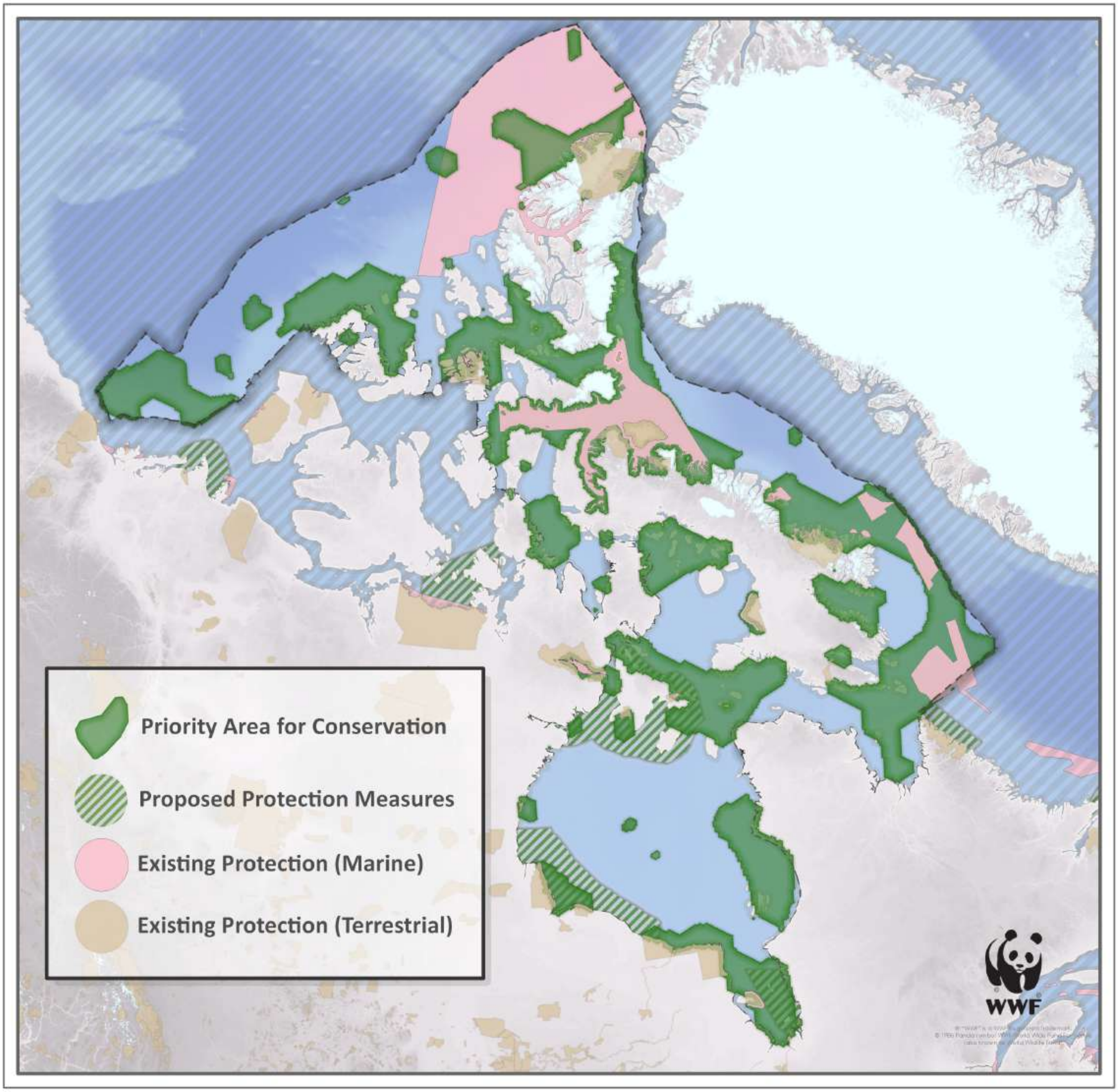
Priority Areas for Conservation

Minimum Protection Target Scenario


Priority Area for Conservation
Proposed Protection Measures
Existing Protection (Marine)
Existing Protection (Terrestrial)
WWF

Priority Areas for Conservation

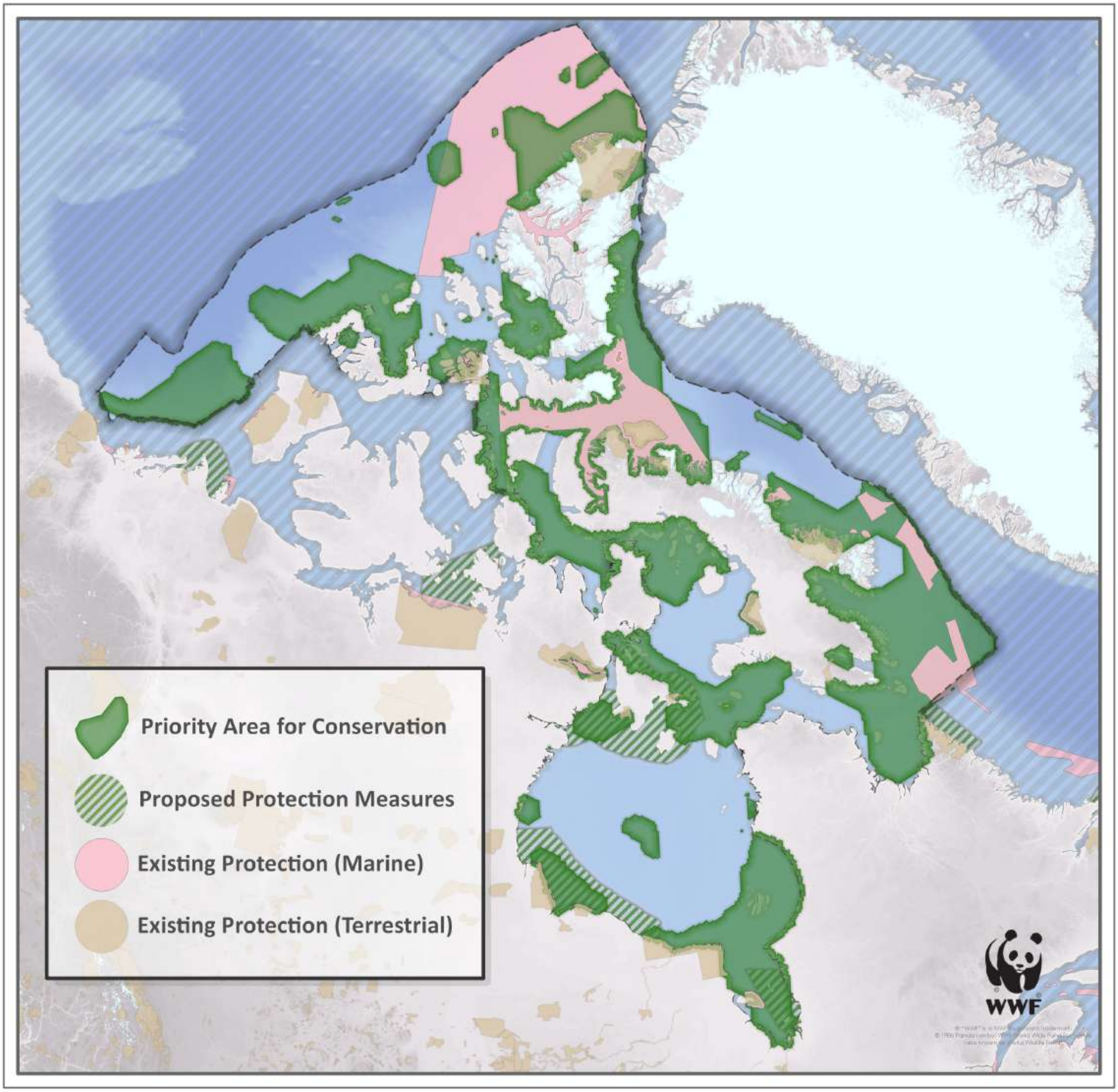
Median Protection Target Scenario



🟩 Priority Area for Conservation
▨ Proposed Protection Measures
🟥 Existing Protection (Marine)
🟫 Existing Protection (Terrestrial)
WWF

Priority Areas for Conservation

High Protection Target Scenario


🟩 Priority Area for Conservation
▨ Proposed Protection Measures
● Existing Protection (Marine)
● Existing Protection (Terrestrial)
WWF

From: **Andrew Dumbrille** ADumbrille@wwfcanada.org
Subject: Baffinland phase 2 shipping spill probability analysis + shoreline spill response planning
Date: August 15, 2019 at 11:29 AM
To: Lou Kamermans lou.kamermans@baffinland.com
Cc: Cory Barker cbarker@nirb.ca, Solomon Amuno samuno@nirb.ca, JOttenhof@qia.ca, pond@baffinhto.ca, jacquie.bastick@canada.ca, Marianne.Marcoux@dfo-mpo.gc.ca, stephen.atkinson@xplornet.com, Stacey, Colin colin.stacey@tc.gc.ca, Nichols, Megan Megan.Nichols@tc.gc.ca, Mark.D'Aguiar@dfo-mpo.gc.ca, david.abernethy@canada.ca, Anne.Wilson2@canada.ca, Anita.ChampagneGudmundson@tc.gc.ca, Neil.O'Rourke@dfo-mpo.gc.ca

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Lou,

WWF recently commissioned an update of our Mary River 2016 shipping oil spill probability analysis which was connected to the WWF oil spill trajectory modelling, see attached. I'll highlight some of the key findings below but an important take away is that with phase 2 activities there is a 1 in 3 chance of a significant bunker fuel spill over the life of the project. In relation to this new analysis our ask of BIMC is to 1) provide a response to the analysis by September 10 in order for consideration in final submissions; 2) confirm if BIMC is willing to integrate the results; 3) explain how, where, and when that integration will be done, whether it's by updating BIMC's spill preparedness plan and other risk reduction measures to address potential spills. WWF has said in the past that one concrete measure to reduce spill risks would be to switch away from heavy fuel oil, that would substantially reduce the impacts if a spill occurred and have an immediate reduction on black carbon emissions between 30-80%.

Additionally we've reviewed BIMC's updated spill response at sea plan and we'd like to ask for more detail about how BIMC would prioritize the protection of shoreline areas that were identified as ecologically, socioeconomically, or culturally sensitive. The appendix, attached, has a map of these areas, but there is no site-specific response planning. In an open-water spill scenario, shoreline impacts are highly likely. The modeling done for WWF (http://assets.wwf.ca/downloads/baffinbay.pdf) found that in 98% of the open water spill scenarios, oil reached shore, and reached shore fairly quickly. The minimum time for oil to reach shore was 4.8 hrs, and the average time was 1.2 days. According to the spill response plan, the travel times for BIMC tugs to transit from Milne Port to a spill site are 4-12 hrs (depending on the spill site location). If BIMC agrees with this analysis, and that shoreline oiling could potentially occur before the response activities are fully mobilized, will BIMC commit to site-specific planning for particularly sensitive shoreline areas?

Background, methodology and key findings from the shipping oil spill probability analysis.

Background and Methodology:

- Current operations were used as a baseline to compare to phase 2 proposed shipping volumes. A high and low traffic scenario was chosen based on information from Baffinland's EIS documents and 21 years was used as the lifetime of the project.
- The environmental, socioeconomic, and cultural effects of any spill will depend not only on the volume spilled, but on the oil type, location, and season of the incident, in addition to any response and restoration measures that are taken to mitigate effects.
- The accident rates are based on a variety of studies of global accident rates and not specific to the Arctic, Canadian Arctic, or Eclipse and Milne. A vessel traffic study of Eclipse and Milne was not part of this analysis.
- 1,000 m3 is used as the most probable worst case scenario of a fuel oil spill from a

Panamax vessel. This isn't the worst case scenario but rather what's likely to be spilled if there was a severe accident. The worst case scenario for a Panamax vessel is 2,226 m3 of fuel, and for a non-ice class Cape-size ore carriers of the type to be used in phase 2 the worst case scenario is 4,452 m3 of fuel.

Results:

- Over 21 years of the project the chance of a most probable worst case scenario spill of 1000 m3 of fuel rises from the baseline currently of 12.5% to 33% for phase 2 high traffic volume. That means there is a 1 in 3 chance of a significant bunker fuel spill over the life of the project. The specifics from the report:
    - 'The chance of a 1,000 m3 spill is 1 in 170 per year (0.6%) or 1 in 8 over 21 years (12.5%) with the baseline traffic conditions. With the lower level of projected Phase 2 vessel traffic, the chance of a 1,000 m3 spill increases to 1 in 81 per year (1.2%) or 1 in 4 over 21 years (25%). With the higher level of projected Phase 2 vessel traffic, the chance of a 1,000 m3 spill increases to 1 in 60 per year (1.7%) and to 1 in 3 for 21 years (33%).'
- On an annual basis… 'There would be an overall increased frequency of an additional 1.1 spills per year with the lower-level Phase 2 vessel traffic, and an additional 1.7 spills per year with the higher-level of Phase 2 vessel traffic. Over the course of 21 years, this would mean an additional 23 spills with the lower-level Phase 2 traffic and an additional 36 spills with the higher-level Phase 2 vessel traffic. The majority of these spills would be small (less than 1 m3).'

Thanks for your consideration of this analysis.

Andrew Dumbrille | Senior Specialist, Sustainable Shipping | WWF-Canada
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Spill probability compa…WF.pdf

BAF-PH1-830-P16-00…es.pdf

Baffinland Oil Spill Probability:
Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic

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22 July 2019

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ENVIRONMENTAL RESEARCH CONSULTING

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Baffinland Oil Spill Probability: Updated Analysis for Phase 2 Expansion Proposal Vessel Traffic

Introduction

Environmental Research Consulting (ERC), as a subcontractor to Shoal's Edge Consulting, had conducted an analysis of oil spill risk in Baffin Bay and Lancaster Sound for World Wildlife Fund Canada (WWF-Canada) in June 2016. The 2016 study involved:

- Development of oil spill scenarios for trajectory, fate, and effects modeling;
- Analyses of the probabilities of different types of spills; and
- Analyses of spill response requirements for the largest spills.

The study included oil spill risk from offshore oil exploration and development in Melville Bay and Baffin Bay (Greenland), cruise ship traffic along the Greenland coast, refined oil product tanker traffic in Lancaster Sound, and bulk carrier traffic in Eclipse Sound and Milne Inlet. The latter was for traffic associated with the Baffinland Iron Mines in the Mary River areas of Baffin Island, Nunavut, Canada (Figure 1).

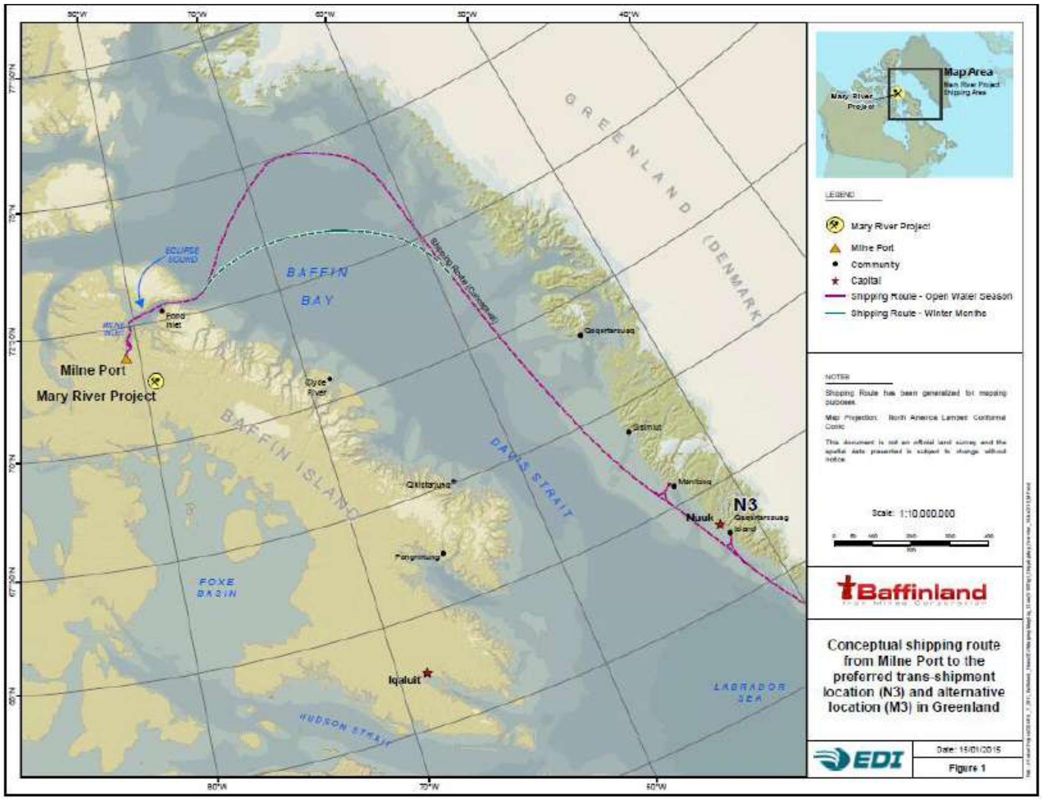
GREENLAND (DENMARK)
BAFFIN BAY
ECLIPSE SOUND
Pond Inlet
Milne Port
Mary River Project
Clyde River
BAFFIN ISLAND
DAVIS STRAIT
Qeqertarsuaq
Sisimiut
Maniitsoq
N3
Nuuk
Qeqertarsuaq Island
Qikiqtarjuaq
Pangnirtung
FOXE BASIN
Iqaluit
LABRADOR SEA
HUDSON STRAIT
80°W
70°W
60°W
50°W
40°W
75°N
70°N
65°N
Map Area
Mary River Project
LEGEND
Mary River Project
Milne Port
Community
Capital
Shipping Route - Open Water Season
Shipping Route - Winter Months
NOTES
Shipping Route has been generalized for mapping purposes.
Map Projection: North America Lambert Conformal Conic
This document is not an official land survey and the spatial data presented is subject to change without notice.
Scale: 1:10,000,000
Baffinland
Conceptual shipping route from Milne Port to the preferred trans-shipment location (N3) and alternative location (M3) in Greenland
EDI
Date: 15/01/2015
Figure 1

Figure 1: Baffinland Milne Port Shipping Routes[1]

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[1] Baffinland 2015. Purple line shows shipping route in open water season; green line shows route in winter months (ice season).

In early 2019, Baffinland Iron Mines Corporation (Baffinland) began the permitting process for its Phase 2 expansion project. This expansion would increase the amount of iron ore shipped from to the current 4.2 to 6.0 million tonnes per annum (Mtpa) up to 12.0 Mtpa.[2]

The expansion includes modifications of the marine infrastructure at the Baffinland Milne Inlet Port to accommodate larger vessels. The dock facilities currently only accommodate Post-Panamax ore carriers (85,000 DWT). The Phase 2 expansion infrastructure modifications would allow for the accommodate larger Cape-size ore carriers (180,000–250,000 DWT).

In addition to the change in vessel type, the shipping season would be expanded from its current 90 days (approximately 15 July–15 October) to 135 days (approximately 1 July–15 November). This would allow for more iron ore carrier transits. The shipping "shoulder seasons" would require ice-breaking operations.[3]

The Phase 2 expansion will include an estimated 134 to 176 ore carrier voyages (round trips) per year.[4] There will be two icebreakers and 10 tug vessels to support the shipping operations during the "shoulder seasons."[5] Previously, the annual vessel traffic was approximately 70 ore carrier round trip voyages per year.[6] This represents a 250% increase in vessel traffic. The project is expected to have a 21-year duration.[7] WWF-Canada has requested an analysis of the increased risk of oil spills with the Phase 2 expansion.

The current report focuses on the changing probability of oil spills from vessel traffic to Milne Inlet Port. The estimated probability of oil spills based on the existing vessel operations (baseline) are presented in addition to the estimated probability of oil spills based on the potential vessel operations under the Phase 2 expansion. The baseline spill rate is compared to the Phase 2 expansion spill rate.

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[2] Baffinland 2015.

[3] Golder Associates 2019.

[4] Baffinland 2018a.

[5] Golder Associates 2019.

[6] Baffinland 2015; Curran 2015.

[7] Baffinland 2015.

Baffinland Vessel Traffic

Oil Spill Potential from Vessels

There are five major types of vessels serving the Baffinland operations that could potentially spill oil in Eclipse Sound or Milne Inlet:

- Iron ore bulk carriers;
- Tug vessels;
- Icebreaking vessels;
- Resupply ships; and
- Fuel tankers or barges.

Potential spills from the first four types of vessels could involve bunker fuel (such as intermediate fuel oil, IFO 380), marine diesel, and various types of lubricating oils. These vessels would not be carrying crude oil or refined petroleum products as cargo. This limits the amount of oil that might be spilled from these vessels to the maximum amount of bunker fuel. The other types of oils would be carried in significantly smaller quantities. The potential volumes of spillage depend on the specific sizes of the vessels.

Fuel tankers or barges servicing the vessels and the mine operations would be able to spill larger quantities of oil due to their larger capacity. Fuel tankers could also spill bunker fuel used for their own operations. Fuel barges would have no bunker fuel of their own, but would have tow or tug boats to maneuver them. These vessels would have bunker fuel onboard.

Vessel spills could occur due to collisions, allisions,[8] and groundings. These impact-caused accidents have the potential to cause larger spills. Other types of spills occur due to mechanical or equipment failures, structural failures, and miscellaneous operational errors.

For tanker spills, in addition to all the aforementioned types of incidents, there may also be spills associated with transfer operations. These spills would involve spills that occur during fueling operations, often from leaking hose connections.

Existing Vessel Traffic (Baseline)

The Baffinland vessel traffic at present (during the early operations phase) in the Milne Inlet Port is summarized in Table 1.

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[8] The distinction between a “collision” and an “allision” is that the former involves two moving objects hitting each other, and the latter involves a moving object hitting a stationary object. A collision could involve two vessels hitting each other. An allision could involve a moving vessel striking a pier. A moving vessel striking a submerged object is generally considered a “grounding.”

Table 1: Baseline Baffinland Vessel Traffic in Milne Inlet

Vessel Type	Vessel Size	Oil Capacity	Annual One-Way Transits
Panamax PC4 Ore Carrier[9]	85,000 DWT	2,226 m^3	140 transits[10]
Fuel Tanker	13,000 DWT	17,000 m^3	6 transits[11]
Tug Boat[12]	6,000 hp (90 GT)	600 m^3	292 transits[13]
Resupply Ship[14]	2,890 DWT	1,050 m^3	6 transits[15]
Icebreaker	-	-	0 transits
Total			**444 transits**

Expected Phase 2 Expansion Vessel Traffic

The Baffinland vessel traffic in the Milne Port Inlet that is projected for Phase 2 is summarized in Table 2. The exact makeup of the ore carrier fleet will depend on market and availability factors. A hypothetical distribution of the vessel sizes for ore carriers is shown in Table 2.[16]

Table 2: Phase 2 Baffinland Vessel Traffic in Milne Inlet

Vessel Type	Vessel Size	Oil Capacity	Annual One-Way Transits	
			Lower Traffic	**Higher Traffic**
Ice Class Supramax Ore Carrier	55,000 DWT	1,440 m^3	101 transits	132 transits
Ice Class Ultramax Ore Carrier	64,000 DWT	1,700 m^3	37 transits	48 transits
Ice Class Panamax Ore Carrier	85,000 DWT	2,226 m^3	101 transits	132 transits
Non-Ice Class Panamax Ore Carrier	85,000 DWT	2,226 m^3	8 transits	10 transits
Non-Ice Class Kamsarmax Ore Carrier	80,000 DWT	2,000 m^3	2 transits	2 transits
Non-Ice Class Cape-Size Ore Carrier	105,000 DWT	4,452 m^3	21 transits	28 transits
Fuel Tanker[17]	13,000 DWT	17,000 m^3	11 transits	15 transits
Tug Boat[18]	6,000 hp (90 GT)	600 m^3	555 transits	730 transits
Resupply Ship[19]	2,890 DWT	1,050 m^3	11 transits	15 transits
Icebreaker[20]	43–55 m Beam	2,000 m^3	100 transits	130 transits
Total			**947 transits**	**1,242 transits**

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[9] Bunker capacity from data in Curran 2015.

[10] Based on 70 loads transiting from Milne Port to the trans-shipment area in Greenland for unloading. After each unloading, the vessels transit back to Milne Port (Baffinland 2015).

[11] Baffinland 2015. Note that for half of the transits, the fuel cargo would largely have been unloaded unless the vessel was also making a delivery to another port.

[12] Information on tug boat fuel capacity derived from http://www.tugboatinformation.com/tug.cfm?id=4548 based on 6,000 hp tug as described in Baffinland 2015.

[13] Assumes two tug boats per vessel as per description in Baffinland 2015.

[14] Information on vessel size and fuel capacity based on M/V Botnica (TS Shipping, undated). This vessel is mentioned in an application by Baffinland Iron Mines for a licence to operate an ice management and multipurpose support vessel (https://www.otc-cta.gc.ca/eng/ruling/w-2019-77).

[15] Curran 2015.

[16] From information in Golder 2019, which was based on Baffinland 2018b.

[17] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers.

[18] Tug boat transits for Phase 2 are estimated based on the percentage increase of ore carriers.

[19] Resupply ship transits for Phase 2 are estimated based on the percentage increase of ore carriers.

[20] Based on information in Golder 2019 for average duration of "shoulder season" assuming one ice breaker per ore carrier, resupply ship, and fuel tanker transit in shoulder season. The icebreakers are larger than the resupply ships (with 43–55 m beam widths compared to 24.3 m for resupply ship), which can perform some ice-breaking operations.

A comparison of the projected Phase 2 traffic and the baseline traffic for Milne Inlet is shown in Table 3.

Table 3: Comparison of Baseline and Phase 2 Baffinland Vessel Traffic Levels in Milne Inlet

Vessel Type	Annual One-Way Transits			Increase with Phase 2 (Additional Vessels)	
	Baseline Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic
Ice Class Supramax Ore Carrier	0	101	132	101	132
Ice Class Ultramax Ore Carrier	0	37	48	37	48
Ice Class Panamax Ore Carrier	140	101	132	-39	-8
Non-Ice Class Panamax Ore Carrier	0	8	10	8	10
Non-Ice Class Kamsarmax Ore Carrier	0	2	2	2	2
Non-Ice Class Cape-Size Ore Carrier	0	21	28	21	28
Total Ore Carriers	**140**	**270**	**352**	**130**	**212**
Fuel Tanker[21]	6	11	15	5	9
Tug Boat[22]	292	555	730	263	438
Resupply Ship[23]	6	11	15	5	9
Icebreaker[24]	0	100	130	100	130
Total Support Vessels	**304**	**677**	**890**	**373**	**586**
Total	**444**	**947**	**1,242**	**503**	**798**

To provide a perspective on the degree of congestion, the change in vessel traffic in terms of vessels per day were calculated, as shown in Table 4. The calculations of vessels per day are based on the assumptions:

- There is a six-hour transit time through Milne Inlet and Eclipse Sound (i.e., each vessel spends about a quarter of a day in transit); and
- The days per-year of vessel traffic for the baseline is 90 days and for Phase 2 is 135 days.[25]

The traffic levels do not include any other vessels that may be transiting in the area. There are no reliable data for these numbers. With an increase in vessel traffic associated with the Bafflinland operations, there is a greater likelihood of a collision with another vessel, such as a fishing boat, recreational vessel, or tourist boat.[26] It is assumed that the level of this vessel traffic is consistent through both the baseline and Phase 2 time periods.

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[21] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[22] Tug boat transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[23] Resupply ship transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[24] Based on information in Golder 2019 for average duration of "shoulder season" assuming one ice breaker per ore carrier, resupply ship, and fuel tanker transit in shoulder season. The

[25] Golder Associates 2019.

[26] In the event of a collision between a fishing boat, recreational vessel, or small tourist boat, it is likely that the smaller boat would be the one to experience a spill, if any, rather than the larger vessel.

These data show the number of vessels that would be in transit (underway) at any one time that could encounter each other. There may be vessels that are docked. While the numbers of vessels may be significantly higher than before the Baffinland operations began, these data indicate a relatively low level of congestion at present and projected into the future compared with much busier ports, such as Vancouver, BC.

Table 4: Per-Day Baffinland Vessel Traffic Levels in Milne Inlet

Vessel Type	Vessels Per Day			Increase with Phase 2 (Additional Vessels/Day)	
	Baseline Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic	Phase 2 Lower Traffic	Phase 2 Higher Traffic
Ice Class Supramax Ore Carrier	0.00	0.19	0.24	0.19	0.24
Ice Class Ultramax Ore Carrier	0.00	0.07	0.09	0.07	0.09
Ice Class Panamax Ore Carrier	0.39	0.19	0.24	-0.20	-0.14
Non-Ice Class Panamax Ore Carrier	0.00	0.01	0.02	0.01	0.02
Non-Ice Class Kamsarmax Ore Carrier	0.00	0.00	0.00	0.00	0.00
Non-Ice Class Cape-Size Ore Carrier	0.00	0.04	0.05	0.04	0.05
Total Ore Carriers	**0.39**	**0.50**	**0.65**	**0.11**	**0.26**
Fuel Tanker[27]	0.02	0.02	0.03	0.00	0.01
Tug Boat[28]	0.81	1.03	1.35	0.22	0.54
Resupply Ship[29]	0.02	0.02	0.03	0.00	0.01
Icebreaker[30]	0.00	0.19	0.24	0.19	0.24
Total Support Vessels	**0.84**	**1.25**	**1.65**	**0.41**	**0.80**
Total	**1.23**	**1.75**	**2.30**	**0.52**	**1.07**

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[27] Fuel tanker transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[28] Tug boat transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[29] Resupply ship transits for Phase 2 are estimated based on the percentage increase of ore carriers and overall operations at the St. Mary mine.

[30] Based on information in Golder 2019 for average duration of "shoulder season" assuming one ice breaker per ore carrier, resupply ship, and fuel tanker transit in shoulder season. The

Vessel Oil Spill Probability Analysis Methodology

Vessel oil spills due to accidents are dependent on the specific vessel operations (numbers of transits, types of vessels, operational decisions) and the navigational and weather hazards in the region. An extensive vessel traffic modeling analysis was outside the scope of this study, but a brief analysis of probabilities of vessel spills follows.

General Approach to Calculating Vessel Oil Spill Probability

The probability of an oil spill for the vessel traffic in Milne Inlet and Eclipse Sound associated with the Baffinland Mary Mine operations is dependent on the probabilities of accidents and other failures occurring and then the probabilities that these accidents or failures will result in the release of oil. When vessel accidents occur, there is not necessarily a spillage of oil involved. In fact, only between 2% and 18% of vessel accidents may actually result in spillage. The volume of spillage also has a distribution of probabilities associated with it (Figure 2).

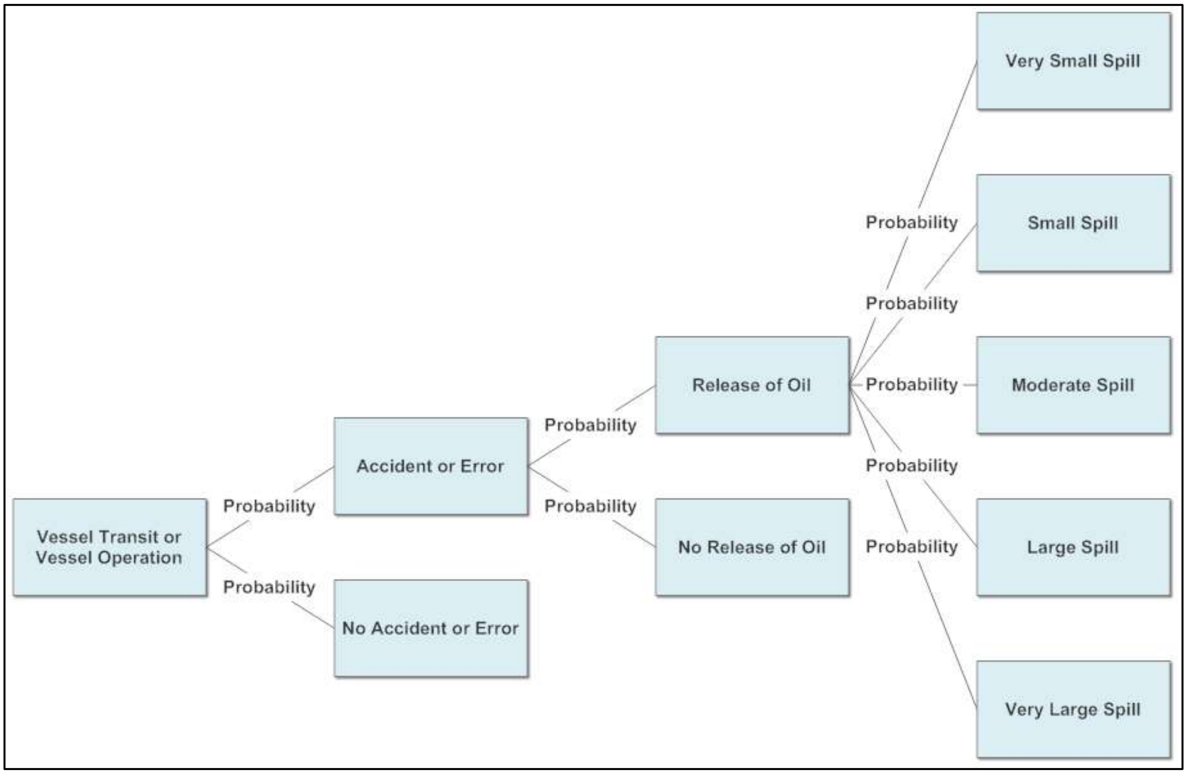
Very Small Spill
Probability
Small Spill
Probability
Release of Oil
Probability
Moderate Spill
Probability
Accident or Error
Probability
Probability
Vessel Transit or Vessel Operation
Probability
No Release of Oil
Probability
Large Spill
Probability
No Accident or Error
Very Large Spill

Figure 2: Series of Probabilities Leading to Vessel Oil Spill

If there is a release of oil, the volume may vary from a very small spill of a few litres to worst-case discharge scenario. Previous analyses, including the modeling of spill scenarios,[31] identified discharge scenarios as: 1,000 m^3 bunker fuel from a Panamax ore carrier and 2,400 m^3 diesel cargo from a product tanker (fuel tanker). These cases represent "reasonable" or most-probable worst-case discharges. Theoretically, a worst-case discharge would be the release of the entire oil contents of the vessel. This would be about 2,200 m^3 for the ore carrier and 15,000 m^3 for the product tanker. The product tanker spill would be expected to involve only half of the total capacity–or 7,500 m^3 because double hulls on tankers reduce the amount of outflow by 50% in the event of hull breach in an accident (in addition to reducing the likelihood of a hull breach).[32]

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[31] Etkin 2016; Reich et al. 2016; Amec Foster Wheeler 2016.

The probabilities of accidents and spills are generally calculated on a per-vessel trip or per-transit basis. The more vessel trips or transits, the greater the likelihood of spills. In general, increasing the numbers of vessels increases the likelihood of accidents and spills. This assumes that there is an equal chance of an accident or other failure that causes a spill with each transit. This is not strictly true for vessel spills. There are conditions for which the likelihood is greater or less (e.g., weather, presence of ice, degree of operator training, vessel maintenance, presence of vessel traffic systems). The probabilities of accidents and spills is based on averages from other waterways around the world, not the specific conditions in Milne Inlet or Eclipse Sound.

For very congested waterways, the degree of congestion (the numbers of vessels in close proximity to each other in relatively confined areas) can affect the numbers of collisions exponentially. This is because collisions involve two (or more) vessels and with more vessels there are increasingly greater chances of encounters. [This is akin to the likelihood of bumping into another pedestrian on a sidewalk. If there are few people walking, it is very unlikely that someone will collide with another person. If there are twice as many people walking, it becomes slightly more likely there will be a collision. If there are hundreds of pedestrians moving at different speeds and in different directions, the likelihood of bumping into another person increases significantly.] Vessel congestion is not likely a significant factor in Milne Inlet or Eclipse Sound (based on data in Table 4).

Terminology for Probability, Chance, Percent Chance, and Expected Frequency

The probability that something will occur is the expected frequency of events or the number of events that is expected in a specified time frame. That time frame might be a year or the lifetime of the oil transport associated with mining project vessel traffic, for example. If the term "probability" is used, it is related to a specific time frame. In this case the "events" are oil spills or releases from vessels. Spill probabilities are dependent on the number of vessel transits or operations and the amount of time that is being considered.

The percent probability or percent chance is the likelihood of an event occurring is based on a scale of 0 (no chance) to 1, or 100% (definite occurrence of an event). These expressions are useful if one is concerned with just determining whether or not an event may occur. However, in this analysis, it is important to determine the expected number of spills and the potential increase in spills. This requires an absolute number of spills or an expected frequency of spills. Note that if the expected frequency is less than one over the time period considered (e.g., 0.01 spills per year, or 0.21 spills over 21 years), the percent probability is the same as the frequency. With a spill frequency of 0.01 per year, the chance of a spill in any particular year is 1 in 100 or 1%. If there is a spill frequency of 2.7 per year or 3.5 per year, the chance of a spill is 100% in both cases. In these cases, it is more informative to refer to spill frequency, which is the way in which the data are presented in this report.

For vessel spills, the expected number of spills is based on the likelihood or probability of an accident and the probability that that accident will result in the discharge of oil. The more vessels and/or the more time considered, the greater the expected number of spills. Hypothetically, for example, if there is a 0.1% probability (or a one in 1,000 chance–0.001) of a spill for each vessel per year, the number of vessels and the time period need to be considered. If there are 15 vessels, there is a 15 times 0.001 chance–or an 0.015 (or one in 67) chance that there will be a spill in any particular year. The expected frequency of spills is 0.015 per year. If the mining project lasts for 21 years, the expected frequency of spills over the lifetime of the mining operations is 0.315. This would mean a 1 in 3 chance that there would be a spill at some point in those 21 years–or a 1 in 67 chance in any one year.

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[32] Rawson and Brown 1998; Yip et al. 2011b. NRC 1998, 2001.

Probability analysis results are sometimes expressed as *return periods*. (Return period is also sometimes called "recurrence interval.") The expected frequency is an estimate of the likelihood or probability that an event (in this case, a spill of a certain volume from a vessel) will occur in any given year. The inverse of this is the return period. For example, if there is a 1% chance, or a one in 100 chance, that a large spill event will occur in one year. The "return period" for this event is 100 years. The return period is the inverse of the frequency.

$$Frequency(event) = \frac{number(events)}{year}$$

$$Return = \frac{1}{Frequency(event)} = \frac{years}{event}$$

$$Frequency(event) = \frac{0.01}{year}$$

$$Return(event) = \frac{1}{0.01} = 100$$

The return period (e.g., 100 years) is used in an attempt to simplify the definition of a specific statistically-determined chance of an event occurring in any one year (1%). It does not however mean that it will necessarily take 100 years before this event occurs or that it will only occur once in a 100-year time frame. There can be expected frequencies greater than one in a time period, such as a year. If there is an expected frequency of six in one year, this means that there is a return period of about two months.

Because the concept of "return period" often creates confusion and the mistaken expectation that events will occur on a regular basis, it is often advisable to express the probabilities as expected frequencies in a particular time period. This can also be expressed as the chances that an event will occur in a particular time period. An 0.1% probability in a single year is a 1 in 1,000 "chance" that the event will happen in any particular year. The probability that the event will happen over the course of 5 years is five times the probability, or 0.5%. This is the equivalent of a 5 in 1,000 (or 1 in 200) chance. Over the course of 21 years, the probability is 2.1% or 1 in 48 chance.

Rounding of Numbers and Significant Digits

In summary tables, such as those providing estimates of annual frequencies of specific volumes of spills, the results have been rounded to two or three significant digits, as appropriate, starting with the first non-zero digit. This is a standard methodology applied in many analyses to avoid the implication that one could be so precise in determining the frequency of spill events in the future. For example, if the calculated spill frequency is 0.00128 per year, which would bring a return period of 781.25 years, the spill frequency would be rounded to 0.0013 per year and the return period would be expressed as 780 years. Note that “significant digits” are also called “significant figures.”

Probabilities of Spills by Vessel Type and Accident Type

The probabilities of accidents and the corresponding probabilities of spillage by vessel type are summarized in Table 5. *Note that the per-transit probabilities are for spills of any volume, not necessarily a large spill.* The probabilities of accidents are based on studies of historical data and modeling. In the future, the probabilities of accidents may be reduced based on safety and spill prevention measures taken.

Table 5: Per-Transit Probabilities of Spills by Vessel Type and Accident Type

Vessel Type	Accident Type	Accident Probability per Transit[33]	Spill Probability per Accident[34]	Spill Probability per Transit	Spill Chance per Transit
Ore Carrier (All Sizes)	**Collision**	0.0000023	0.04	0.000000093	1 in 430,000
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.000003	0.04	0.00000012	1 in 330,000
	Other (Non-Impact)	0.00003	0.2	0.0000060	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000
Fuel Tanker	**Collision**	0.0000021	0.15	0.00000031	1 in 490,000
	Allision	0.0000004	0.15	0.000000060	1 in 2.5 million
	Grounding	0.0000018	0.18	0.00000032	1 in 560,000
	Other (Non-Impact)	0.0007	0.4	0.00028	1 in 1,400
	Transfer Error	0.000045	0.92	0.000041	1 in 22,000
Tug Boat	**Collision**	0.000000095	0.04	0.000000004	1 in 10.5 million
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.00000048	0.04	0.000000019	1 in 2.1 million
	Other (Non-Impact)	0.00035	0.2	0.00007	1 in 2,900
	Transfer Error	0.00011	0.92	0.0001	1 in 9,300
Resupply Ship	**Collision**	0.000000095	0.04	0.000000004	1 in 10.5 million
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.0000010	0.04	0.000000041	1 in 980,000
	Other (Non-Impact)	0.00003	0.2	0.000006	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000
Icebreaker	**Collision**	0.000000095	0.04	0.000000004	1 in 10.5 million
	Allision	0.0000004	0.04	0.000000016	1 in 2.5 million
	Grounding	0.0000010	0.04	0.000000041	1 in 980,000
	Other (Non-Impact)	0.00003	0.2	0.000006	1 in 33,000
	Transfer Error	0.00025	0.92	0.00023	1 in 4,000

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[33] Probabilities based on data in DNV-GL 2011a, 2011b; The Glosten Associates et al. 2013. Assuming six-hour transit time through Milne Inlet and Eclipse Sound.

[34] Spill probabilities for bunker tanks on ore carriers are based on the fleet having double hulls on bunker tanks for 70% of vessels. The other 30% of vessels are assumed to have single hulls. By 2030, all cargo ships will have double hulls on bunker tanks.

Note that these accident rates are based on a variety of studies of global accident rates. The likelihood of a vessel accident in any particular port or waterway is dependent on a large number of factors, including local weather conditions, waterway configuration, bathymetry (bottom depth), navigational hazards (submerged rocks or shallows e.g.), congestion, presence of vessel traffic systems and vessel traffic lanes, presence of ice, visibility issues (fog, limited sight distances in curves, darkness), to name a few. The conditions in the Milne Inlet and Eclipse Sound will be considerably less congested than other waterways, but there may be other factors, such as the presence of ice and longer hours of darkness in the fall and spring, that may affect accident rates. A comprehensive vessel traffic study was outside of the scope of this analysis.

Baffinland Vessel Oil Spill Frequencies by Traffic

The per-transit vessel spill rates were applied to current (baseline) and projected future traffic levels to determine the expected numbers of spills.

Expected Frequencies of Spills Based on Vessel Traffic

The annual expected frequencies of spills based on current and projected Phase 2 traffic are shown in Table 6. *Note that the per-transit probabilities are for spills of any volume, not necessarily a large spill.* The same data are shown as "chances" in Table 7.

Table 6: Annual Expected Spill Frequency by Vessel Type and Accident Type by Vessel Traffic

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier (All Sizes)	**Collision**	0.000000093	0.000013	0.000025	0.000033
	Allision	0.000000016	0.0000023	0.0000043	0.0000058
	Grounding	0.00000012	0.000017	0.000033	0.000043
	Other (Non-Impact)	0.0000060	0.00085	0.0016	0.002
	Transfer Error	0.00023	0.033	0.063	0.080
Fuel Tanker	**Collision**	0.00000030	0.0000018	0.0000033	0.0000045
	Allision	0.000000060	0.00000035	0.00000065	0.00000090
	Grounding	0.00000033	0.0000020	0.0000035	0.0000050
	Other (Non-Impact)	0.00028	0.0017	0.0030	0.0043
	Transfer Error	0.000043	0.00025	0.00048	0.00065
Tug Boat	**Collision**	0.000000004	0.0000011	0.0000021	0.0000028
	Allision	0.000000016	0.0000048	0.0000090	0.000012
	Grounding	0.000000019	0.0000055	0.000011	0.000014
	Other (Non-Impact)	0.000070	0.021	0.040	0.050
	Transfer Error	0.00010	0.030	0.055	0.073
Resupply Ship	**Collision**	0.000000004	0.000000023	0.000000043	0.000000058
	Allision	0.000000016	0.000000095	0.000000175	0.00000024
	Grounding	0.000000040	0.00000024	0.000000450	0.00000060
	Other (Non-Impact)	0.0000060	0.000035	0.000065000	0.000090
	Transfer Error	0.00023	0.0014	0.0025	0.0035
Icebreaker	**Collision**	0.000000004	0.0	0.00000038	0.00000050
	Allision	0.000000016	0.0	0.0000016	0.0000021
	Grounding	0.000000040	0.0	0.0000040	0.0000053
	Other (Non-Impact)	0.0000060	0.0	0.00060	0.00075
	Transfer Error	0.00023	0.0	0.023	0.030

Table 7: Chances of Spills by Vessel Type and Accident Type by Vessel Traffic

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier	**Collision**	0.000000093	1 in 77,000	1 in 40,000	1 in 30,303
	Allision	0.000000016	1 in 430,000	1 in 230,000	1 in 172,414
	Grounding	0.00000012	1 in 59,000	1 in 30,000	1 in 23,256
	Other (Non-Impact)	0.0000060	1 in 1,200	1 in 630	1 in 500
	Transfer Error	0.00023	1 in 30	1 in 16	1 in 1 in 13
Fuel Tanker	**Collision**	0.00000030	1 in 560,000	1 in 300,000	1 in 220,000
	Allision	0.000000060	1 in 2.9 million	1 in 1.5 million	1 in 1.1 million
	Grounding	0.00000033	1 in 500,000	1 in 290,000	1 in 200,000
	Other (Non-Impact)	0.00028	1 in 600	1 in 330	1 in 230
	Transfer Error	0.000043	1 in 4,000	1 in 2,100	1 in 1,500
Tug Boat	**Collision**	0.000000004	1 in 910,000	1 in 480,000	1 in 360,000
	Allision	0.000000016	1 in 210,000	110,000	1 in 83,000
	Grounding	0.000000019	1 in 180,000	1 in 91,000	1 in 71,000
	Other (Non-Impact)	0.000070	1 in 48	1 in 25	1 in 20
	Transfer Error	0.00010	1 in 33	1 in 18	1 in 14
Resupply Ship	**Collision**	0.000000004	1 in 43 million	1 in 23 million	1 in 17 million
	Allision	0.000000016	1 in 11 million	1 in 5.7 million	1 in 4.2 million
	Grounding	0.000000040	1 in 4.2 million	1 in 2.2 million	1 in 1.7 million
	Other (Non-Impact)	0.0000060	1 in 29,000	1 in 15,000	1 in 11,000
	Transfer Error	0.00023	1 in 710	1 in 400	1 in 290
Icebreaker	**Collision**	0.000000004	0	1 in 2.6 million	1 in 2 million
	Allision	0.000000016	0	1 in 630,000	1 in 480,000
	Grounding	0.000000040	0	1 in 250,000	1 in 190,000
	Other (Non-Impact)	0.0000060	0	1 in 1,700	1 in 1,300
	Transfer Error	0.00023	0	1 in 43	1 in 33

The expected frequencies and chances in Table 6 and Table 7 are on an annual basis. If the mining project continues for 21 years,[35] the expected frequencies and chances are as shown in Table 8 and Table 9. Note that when the expected frequency (over the 21-year period) is more than one, it means that it is likely that there would be at least one spill during the project. However, it does not "guarantee" that there would be a spill. These frequencies are shown as chances of one in a number smaller than one.

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[35] Baffinland 2018.

Table 8: Expected Spill Frequency for 21-Year Baffinland Project

Vessel Type	Accident Type	Spills per Transit	Annual Expected Spill Frequency Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier[36]	**Collision**	0.000000093	0.00028	0.00053	0.00068
	Allision	0.000000016	0.000048	0.000090	0.00012
	Grounding	0.00000012	0.00035	0.00068	0.00090
	Other (Non-Impact)	0.0000060	0.018	0.035	0.045
	Transfer Error	0.00023	0.68	1.33	1.7
Fuel Tanker	**Collision**	0.00000030	0.000038	0.000068	0.000095
	Allision	0.000000060	0.0000073	0.000014	0.000019
	Grounding	0.00000033	0.000040	0.000073	0.00011
	Other (Non-Impact)	0.00028	0.035	0.063	0.090
	Transfer Error	0.000043	0.0053	0.010	0.014
Tug Boat	**Collision**	0.000000004	0.000023	0.000043	0.000058
	Allision	0.000000016	0.00010	0.00019	0.00025
	Grounding	0.000000019	0.00012	0.00022	0.00030
	Other (Non-Impact)	0.000070	0.43	0.85	1.1
	Transfer Error	0.00010	0.63	1.2	1.5
Resupply Ship	**Collision**	0.000000004	0.00000048	0.00000090	0.0000012
	Allision	0.000000016	0.0000020	0.0000038	0.0000050
	Grounding	0.000000040	0.0000050	0.000009500	0.000013
	Other (Non-Impact)	0.0000060	0.00073	0.0014	0.0019
	Transfer Error	0.00023	0.030	0.053	0.073
Icebreaker	**Collision**	0.000000004	0.0	0.0000080	0.000011
	Allision	0.000000016	0.0	0.000033	0.000043
	Grounding	0.000000040	0.0	0.000085	0.00011
	Other (Non-Impact)	0.0000060	0.0	0.013	0.016
	Transfer Error	0.00023	0.0	0.48	0.63

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[36] Note that all ore carriers are considered together in this analysis (regardless of size).

Table 9: Chances of Spills for 21-Year Baffinland Project

Vessel Type	Accident Type	Spill Probability per Transit	Annual Chances of Spills Based on Traffic		
			Baseline	Phase 2 Lower	Phase 2 Higher
Ore Carrier	**Collision**	0.000000093	1 in 3,600	1 in 1,900	1 in 1,500
	Allision	0.000000016	1 in 21,000	1 in 11,000	1 in 8,300
	Grounding	0.00000012	1 in 2,900	1 in 1,500	1 in 1,100
	Other (Non-Impact)	0.0000060	1 in 56	1 in 29	1 in 22
	Transfer Error	0.00023	1 in 1.5	1 in 0.8	1 in 0.6
Fuel Tanker	**Collision**	0.00000030	1 in 27,000	1 in 15,000	1 in 11,000
	Allision	0.000000060	1 in 140,000	1 in 73,000	1 in 53,000
	Grounding	0.00000033	1 in 25,000	1 in 14,000	1 in 9,500
	Other (Non-Impact)	0.00028	1 in 29	1 in 16	1 in 11
	Transfer Error	0.000043	1 in 190	1 in 100	1 in 73
Tug Boat	**Collision**	0.000000004	1 in 43,000	1 in 24,000	1 in 17,000
	Allision	0.000000016	1 in 10,000	1 in 5,300	1 in 4,000
	Grounding	0.000000019	1 in 8,700	1 in 4,500	1 in 3,300
	Other (Non-Impact)	0.000070	1 in 2.4	1 in 1.2	1 in 1.0
	Transfer Error	0.00010	1 in 1.6	1 in 0.9	1 in 0.7
Resupply Ship	**Collision**	0.000000004	1 in 2.1 million	1 in 1.1 million	1 in 830,000
	Allision	0.000000016	1 in 500,000	1 in 270,000	1 in 200,000
	Grounding	0.000000040	1 in 200,000	1 in 110,000	1 in 80,000
	Other (Non-Impact)	0.0000060	1 in 1,400	1 in 730	1 in 530
	Transfer Error	0.00023	1 in 33	1 in 19	1 in 14
Icebreaker	**Collision**	0.000000004	0	1 in 130,000	1 in 95,000
	Allision	0.000000016	0	1 in 31,000	1 in 24,000
	Grounding	0.000000040	0	1 in 12,000	1 in 9,100
	Other (Non-Impact)	0.0000060	0	1 in 80	1 in 63
	Transfer Error	0.00023	0	1 in 2.1	1 in 1.6

Expected Oil Outflow with Spill

The expected spill frequencies and chances shown in the Table 6 through Table 9 are for an unspecified spill volume. Most spills tend to be small. Only a small percentage is large. Spill volume depends on the accident circumstances, vessel capacity, and loaded volume. Oil type affects the way in which it flows out.

Outflow modeling has demonstrated that the volumes of outflows for the very largest incidents involving tankers and tank barges would be reduced by 50% with double hulls. Note also that this is independent of the probability of spillage occurring with an impact accident. Impact accidents are those involving the vessel hitting another vessel or object, as would occur in a grounding, allision, or collision. Double hulls on tankers accomplish two things: reduction of the probability of any spillage occurring in the event of impact, and reduction of the volume of spillage for the very largest incidents by 50%. This is not the case for double hulls on bunker tanks, for which there is a reduction in the probability of spillage occurring in an impact accident, but there is no reduction in spillage volume with large incidents. The percentage oil outflow probabilities from tankers (Table 10) is based on international studies of the amount of oil actually spilled compared with the adjusted capacity of the vessel, which was verified by existing oil outflow models developed for the International Maritime Organization (IMO).[37] Bunker outflow probabilities for impact accidents are shown in Table 11. Oil outflow for non-impact casualties, including structural failure, equipment failure, and fire tends to be smaller than that for impact-related events, as shown in Table 12 for tankers and Table 13 for bunker tanks.[38]

Table 10: Oil Outflow Probability for Double-Hull Tankers in Impact Accidents

% Cargo Outflow	Probability	Cumulative Probability
0.002%	0.3589	0.3589
0.02%	0.1400	0.4989
0.05%	0.1200	0.6189
0.2%	0.1110	0.7299
0.7%	0.0900	0.8199
1.3%	0.0800	0.8999
3.1%	0.0700	0.9699
20%	0.0300	0.9999
50%	0.0001	1.0000

Table 11: Bunker Outflow Probability from All Vessel Impact Accidents[39]

% Bunker Outflow	Probability	Cumulative Probability
0.01%	0.23	0.2300
0.03%	0.17	0.4000
0.15%	0.14	0.5400
1.6%	0.10	0.6400
4.3%	0.09	0.7300
10%	0.08	0.8100
16%	0.06	0.8700
33.3%	0.05	0.9200
59%	0.04	0.9600
100%	0.04	1.0000

Table 12: Oil Outflow Probability for Non-Impact Incidents in Tankers

% Cargo Outflow (Adjusted)	Probability	Cumulative Probability
0.01%	0.50	0.5000
0.02%	0.15	0.6500
0.06%	0.11	0.7600
0.16%	0.08	0.8400
0.54%	0.08	0.9200
11.50%	0.08	1.0000

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[37] Rawson and Brown 1998; Yip et al. 2011b; NRC 1998, 2001.

[38] Based on Etkin and Michel 2003; Etkin 2001; Etkin 2002.

[39] Etkin and Michel 2003; Etkin 2001; Etkin 2002; Herbert Engineering et al. 2003; Michel and Winslow 1999, 2000; Barone et al. 2007; Yip et al. 2011a.

Table 13: Bunker Outflow Probability from All Vessel Non-Impact Incidents

% Bunker Outflow (Adjusted)	Probability	Cumulative Probability
0.001%	0.20	0.2000
0.003%	0.15	0.3500
0.008%	0.13	0.4800
0.015%	0.11	0.5900
0.06%	0.09	0.6800
0.1%	0.08	0.7600
0.8%	0.04	0.8000
3%	0.04	0.8400
12%	0.04	0.8800
36%	0.04	0.9200
40%	0.02	0.9400
71%	0.02	0.9600
91%	0.02	0.9800
100%	0.02	1.0000

Expected Spill Frequencies by Volume and Vessel Type

Spills of different volumes from ore carriers that would be expected on an annual basis and over the 21-year project time frame under baseline and Phase 2 traffic levels are summarized in Table 14. (The same data are shown as "chances" in Table 15.) Oil capacities and proportions of vessel types are based on the data in Table 1 and Table 2. Data for other vessel types are shown in Table 16 through Table 23.Volumes have been grouped into categories by order of magnitude–0.01 m^3 (0.01–0.9 m^3), 0.1 m^3 (0.1–0.9 m^3), 1 m^3 1 to 9 m^3), 10 m^3 (10–99 m^3), and 100 m^3 (100–999 m^3), and 1,000 m^3 (1,000-9,999 m^3). Generally, the likelihood of larger spills is lower than that of smaller spills. However, in this analysis, because different types of spills (impact-caused and non-impact spills) were combined and there are different percentages of outflow with associated probabilities, there were sometimes more incidents that would fall into a larger volume category.

Table 14: Expected Bunker Spill Frequency by Volume for Ore Carriers

Volume Category	Baseline Traffic[40]		Phase 2 Lower Traffic Level[41]		Phase 2 Higher Traffic Level[42]	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	0.012	0.24	0.022	0.45	0.028	0.59
0.1 m^3	0.0079	0.17	0.018	0.38	0.024	0.50
1 m^3	0.0056	0.12	0.0087	0.18	0.011	0.24
10 m^3	0.0026	0.056	0.0049	0.10	0.0064	0.13
100 m^3	0.0033	0.069	0.0063	0.13	0.0082	0.17
1,000 m^3	0.0020	0.042	0.0041	0.087	0.0054	0.11
Total	**0.033**	**0.69**	**0.064**	**1.3**	**0.083**	**1.7**

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[40] Expected spill number with baseline traffic on an annual basis and over 21 years at that traffic level.

[41] Expected spill number with lower projected traffic level on an annual basis and over 21 years at that traffic level.

[42] Expected spill number with higher projected traffic level on an annual basis and over 21 years at that traffic level.

Table 15: Chances of Bunker Spills by Volume for Ore Carriers

Volume Category	**Baseline Traffic**[43]		**Phase 2 Lower Traffic Level**[44]		**Phase 2 Higher Traffic Level**[45]	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	1 in 86	1 in 4.1	1 in 46	1 in 2.2	1 in 36	1 in 1.7
0.1 m^3	1 in 130	1 in 6.0	1 in 55	1 in 2.6	1 in 42	1 in 2.0
1 m^3	1 in 180	1 in 8.5	1 in 110	1 in 5.5	1 in 88	1 in 4.2
10 m^3	1 in 380	1 in 18	1 in 200	1 in 9.7	1 in 160	1 in 7.4
100 m^3	1 in 300	1 in 14	1 in 160	1 in 7.6	1 in 120	1 in 5.8
1,000 m^3	1 in 500	1 in 24	1 in 240	1 in 12	1 in 190	1 in 8.8
Total	**1 in 30**	**1 in 1.4**	**1 in 16**	**1 in 0.75**	**1 in 12**	**1 in 0.57**

Table 16: Expected Oil Cargo Spill Frequency by Volume for Fuel Tankers

Volume Category	**Baseline Traffic**		**Phase 2 Lower Traffic Level**		**Phase 2 Higher Traffic Level**	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.000041	0.00086	0.000074	0.0016	0.00011	0.0023
1 m^3	0.026	0.55	0.047	1.0	0.068	1.4
10 m^3	0.011	0.23	0.020	0.41	0.028	0.59
100 m^3	0.000020	0.00043	0.000037	0.00078	0.000054	0.0011
1,000 m^3	0.0032	0.068	0.0058	0.12	0.0083	0.17
Total	**0.040**	**0.85**	**0.073**	**1.5**	**0.10**	**2.2**

Table 17: Chances of Oil Cargo Spills by Volume for Fuel Tankers

Volume Category	**Baseline Traffic**		**Phase 2 Lower Traffic Level**		**Phase 2 Higher Traffic Level**	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 24,000	1 in 1,200	1 in 13,000	1 in 640	1 in 9,300	1 in 440
1 m^3	1 in 38	1 in 1.8	1 in 21	1 in 1.0	1 in 15	1 in 0.7
10 m^3	1 in 92	1 in 4.4	1 in 51	1 in 2.4	1 in 36	1 in 1.7
100 m^3	1 in 49,000	1 in 2,300	1 in 27,000	1 in 1,300	1 in 19,000	1 in 890
1,000 m^3	1 in 310	1 in 15	1 in 170	1 in 8	1 in 120	1 in 5.7
Total	**1 in 25**	**1 in 1.2**	**1 in 14**	**1 in 0.7**	**1 in 9.6**	**1 in 0.5**

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[43] Expected number of spills with the baseline (current traffic) on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

[44] Expected number of spills with the lower projected level of traffic on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

[45] Expected number of spills with the higher projected level of traffic on an annual basis and over the course of 21 years if that level of traffic were to be maintained.

Table 18: Expected Bunker Spill Frequency by Volume for Tug Boats

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.81	17	1.6	32	2.0	42
1 m^3	0.042	0.890	0.082	1.7	0.10	2.2
10 m^3	0.085	1.8	0.16	3.4	0.21	4.4
100 m^3	0.13	2.7	0.25	5.2	0.31	6.6
1,000 m^3	-	-	-	-	-	-
Total	**1.1**	**22**	**2.1**	**43**	**2.6**	**55**

Table 19: Chances of Bunker Spills by Volume for Tug Boats

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 1.2	1 in 0.06	1 in 0.64	1 in 0.03	1 in 0.51	1 in 0.02
1 m^3	1 in 24	1 in 1.1	1 in 12	1 in 0.58	1 in 9.6	1 in 0.46
10 m^3	1 in 12	1 in 0.56	1 in 6.1	1 in 0.29	1 in 4.8	1 in 0.23
100 m^3	1 in 7.9	1 in 0.37	1 in 4.1	1 in 0.19	1 in 3.2	1 in 0.15
1,000 m^3	-	-	-	-	-	-
Total	**1 in 0.94**	**1 in 0.04**	**1 in 0.49**	**1 in 0.02**	**1 in 0.38**	**1 in 0.02**

Table 20: Expected Bunker Spill Frequency by Volume for Resupply Ships

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	**21-Years**	**Annual**	**21-Years**	**Annual**	**21-Years**
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.021	0.44	0.037	0.78	0.041	0.87
1 m^3	0.0037	0.077	0.0065	0.14	0.0090	0.19
10 m^3	0.0012	0.026	0.0022	0.046	0.0030	0.063
100 m^3	0.0043	0.090	0.0076	0.16	0.010	0.22
1,000 m^3	0.00061	0.013	0.0011	0.023	0.0015	0.031
Total	**0.031**	**0.65**	**0.054**	**1.1**	**0.065**	**1.4**

Table 21: Chances of Bunker Spills by Volume for Resupply Ships

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	1 in 48	1 in 2.3	1 in 27	1 in 1.3	1 in 24	1 in 1.2
1 m^3	1 in 270	1 in 13	1 in 150	1 in 7.3	1 in 111	1 in 5.3
10 m^3	1 in 810	1 in 39	1 in 460	1 in 22	1 in 333	1 in 16
100 m^3	1 in 230	1 in 11	1 in 130	1 in 6.3	1 in 95	1 in 4.5
1,000 m^3	1 in 1,600	1 in 77	1 in 920	1 in 44	1 in 670	1 in 32
Total	**1 in 33**	**1 in 1.6**	**1 in 18**	**1 in 0.88**	**1 in 15**	**1 in 0.73**

Table 22: Expected Bunker Spill Frequency by Volume for Icebreakers

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0.0	0.0	0.014	0.29	0.018	0.38
1 m^3	0.0	0.0	0.0040	0.084	0.0052	0.11
10 m^3	0.0	0.0	0.0019	0.040	0.0025	0.052
100 m^3	0.0	0.0	0.0024	0.050	0.0031	0.065
1,000 m^3	0.0	0.0	0.0014	0.030	0.0018	0.039
Total	**0.0**	**0.0**	**0.024**	**0.50**	**0.031**	**0.65**

Table 23: Chances of Bunker Spills by Volume for Icebreakers

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	-	-	-	-	-	-
0.1 m^3	0	0	1 in 72	1 in 3.4	1 in 55	1 in 2.6
1 m^3	0	0	1 in 250	1 in 12	1 in 190	1 in 9.1
10 m^3	0	0	1 in 530	1 in 25	1 in 410	1 in 19
100 m^3	0	0	1 in 420	1 in 20	1 in 330	1 in 15
1,000 m^3	0	0	1 in 710	1 in 34	1 in 540	1 in 26
Total	**0**	**0**	**1 in 42**	**1 in 2.0**	**1 in 33**	**1 in 1.6**

Summary of Results

The various vessel types have different potential rates of spillage depending on the probability of accidents and errors, the likelihood of accidents and errors resulting in the release of oil, and the oil capacity of the vessels. The expected numbers of spills of different volumes depends on the numbers of vessels in each category.

Summary of Expected Vessel Oil Spills by Volume

The various spill volume categories from the different vessel types were combined as shown in Table 24 and Table 25. The environmental, socioeconomic, and cultural effects of any spill will depend not only on the volume spilled, but on the oil type, location, and season of the incident, in addition to any response and restoration measures that are taken to mitigate effects.

It is important to note that the projections over 21 years assume that the likelihood of accidents and spills would be similar to that over the last couple of decades as the historical data upon which the probabilities are based are from that time period. Future spill frequencies are likely to go down if accident and spill prevention measures continue to be implemented and improved.

Note that when the expected frequency is more than one, it means that it is likely that there would be at least one spill during the project. However, it does not "guarantee" that there would be a spill. These frequencies are shown as chances of one in a number smaller than one.

Table 24: Expected Oil Spill Frequency by Volume for All Vessel Types

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	0.012	0.24	0.022	0.45	0.028	0.59
0.1 m^3	0.84	18	1.7	33	2.1	44
1 m^3	0.077	1.6	0.15	3.1	0.19	4.1
10 m^3	0.10	2.1	0.19	4.0	0.25	5.2
100 m^3	0.14	2.9	0.27	5.5	0.33	7.1
1,000 m^3	0.0058	0.12	0.012	0.26	0.017	0.35
Total	**1.2**	**24**	**2.3**	**47**	**2.9**	**61**

Table 25: Chances of Oil Spills by Volume for All Vessel Types

Volume Category	Baseline Traffic		Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
	Annual	21-Years	Annual	21-Years	Annual	21-Years
0.01 m^3	1 in 83	1 in 4.2	1 in 45	1 in 2.2	1 in 36	1 in 1.7
0.1 m^3	1 in 1.2	1 in 0.057	1 in 0.60	1 in 0.030	1 in 0.48	1 in 0.023
1 m^3	1 in 13	1 in 0.61	1 in 6.7	1 in 0.32	1 in 5.2	1 in 0.24
10 m^3	1 in 10	1 in 0.47	1 in 5.3	1 in 0.25	1 in 4.0	1 in 0.19
100 m^3	1 in 7.3	1 in 0.35	1 in 3.8	1 in 0.18	1 in 3.01	1 in 0.14
1,000 m^3	1 in 170	1 in 8.1	1 in 81	1 in 3.8	1 in 59	1 in 2.9
Total	**1 in 0.83**	**1 in 0.041**	**1 in 0.43**	**1 in 0.021**	**1 in 0.35**	**1 in 0.016**

It is important to note that the majority of spills (71% for the baseline traffic conditions, 75% for the lower-level Phase 2 traffic conditions, and 73% for the higher-level Phase 2 traffic conditions) are less than 1 m^3. Spills of these volumes would have relatively localized effects.

The chance of a 1,000 m^3 spill is 1 in 170 per year (0.6%) or 1 in 8 over 21 years (12.5%) with the baseline traffic conditions. With the lower level of projected Phase 2 vessel traffic, the chance of a 1,000 m^3 spill increases to 1 in 81 per year (1.2%) or 1 in 4 over 21 years (25%). With the higher level of projected Phase 2 vessel traffic, the chance of a 1,000 m^3 spill increases to 1 in 60 per year (1.7%) and to 1 in 3 for 21 years (33%).

Comparison Between Spill Frequencies for Current Baseline and Phase 2 Traffic

The expected oil spill frequencies under the two projected levels of traffic in the proposed Phase 2 expansion were compared to the current (baseline) spill frequencies to determine the chance in spill risk, as shown in Table 26. With the increased vessel traffic projected for the Phase 2 expansion, there would be an increase in the expected frequency of oil spills.

Table 26: Comparison of Expected Oil Spill Frequencies for Baseline and Phase 2 Traffic

Volume Category	Annual Expected Spills			Increase with Phase 2 Traffic			
	Baseline Traffic Level	Phase 2 Lower Traffic Level	Phase 2 Higher Traffic Level	Phase 2 Lower Traffic Level		Phase 2 Higher Traffic Level	
				Additional Spills per Year	% Increase	Additional Spills per Year	% Increase
0.01 m^3	0.012	0.022	0.028	0.01	83.3%	0.02	133.3%
0.1 m^3	0.84	1.7	2.1	0.86	102.4%	1.26	150.0%
1 m^3	0.077	0.15	0.19	0.07	94.8%	0.11	146.8%
10 m^3	0.10	0.19	0.25	0.09	90.0%	0.15	150.0%
100 m^3	0.14	0.27	0.33	0.13	92.9%	0.19	135.7%
1,000 m^3	0.0058	0.012	0.017	0.01	106.9%	0.01	193.1%
Total	**1.2**	**2.3**	**2.9**	**1.10**	**91.7%**	**1.70**	**141.7%**

There would be an overall increased frequency of an additional 1.1 spills per year with the lower-level Phase 2 vessel traffic, and an additional 1.7 spills per year with the higher-level of Phase 2 vessel traffic. Over the course of 21 years, this would mean an additional 23 spills with the lower-level Phase 2 traffic and an additional 36 spills with the higher-level Phase 2 vessel traffic. The majority of these spills would be small (less than 1 m^3).

With the Phase 2 traffic increases at either level, there may be 0.2 additional 1,000 m^3 spills over 21 years. Over 21 years, there would be about 6 additional spills of at least 1 m^3 with the lower-level Phase 2 vessel traffic, and an additional 10 spills of at least 1 m^3 with the higher-level Phase 2 vessel traffic.

These likelihood and frequency of the additional spills could be lower if safety and spill prevention measures are implemented.

Potential for Larger-Volume Spill

An additional risk factor for spills with the Phase 2 traffic is the potential for a larger-volume spill from the fleet of ore carriers. While the largest potential spill is from a fuel tanker, where as much as 8,500 m^3 could be released, this risk exists under the current baseline conditions as well.

For the fleet of ore carriers, there is currently a potential for a worst-case discharge of 2,226 m^3 spill. With the addition of larger ore carriers as proposed for Phase 2, there is a possibility of a bunker fuel spill of that the worst-case discharge could be 4,452 m^3. This is the bunker capacity of the non-ice class Cape-size ore carriers (Table 2). There are projected to be 21 to 28 one-way transits of this type of bulk carrier under the Phase 2 expansion.

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Arctic Heavy Fuel Oil Ban: Fuel and Voyage Cost Effects on Bulk Carriers used in Canadian Arctic Mining Operations

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4 September 2019

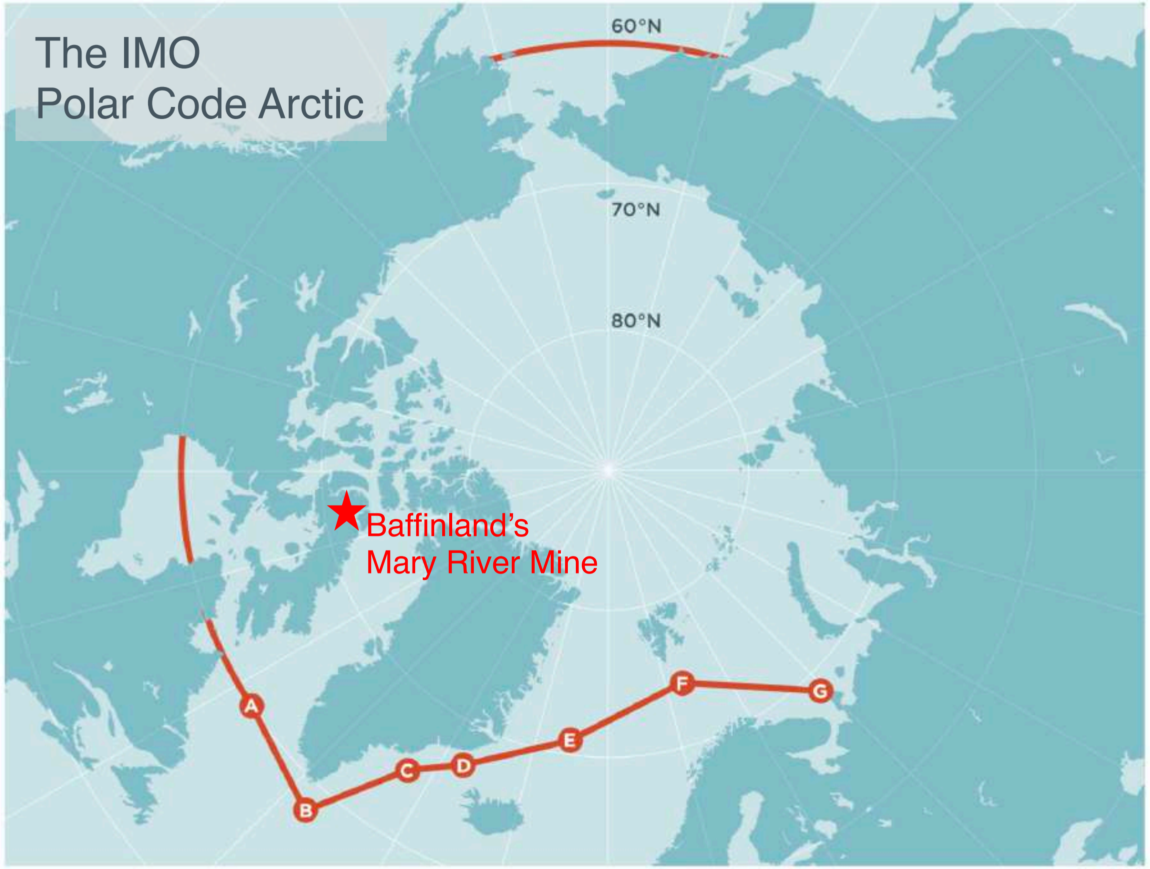
icct
THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

Research Question

What are the potential fuel and voyage cost effects of an Arctic HFO ban on bulk carriers serving Baffinland mines?

Background

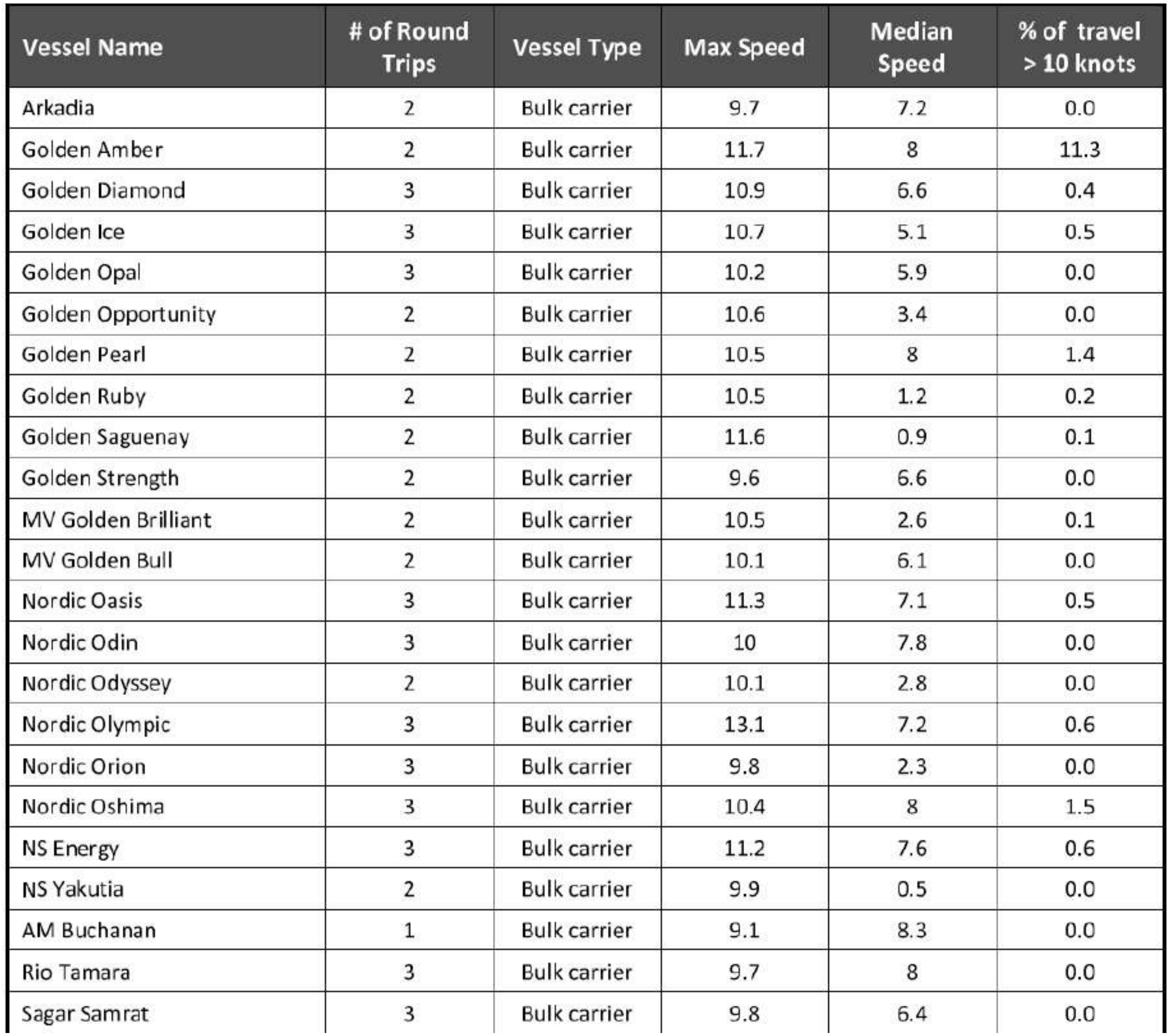
- The International Maritime Organization (IMO) has instructed its Pollution Prevention and Response (PPR) subcommittee to develop a ban on the use and carriage for use of heavy fuel oil (HFO) by ships in Arctic waters.
- An Arctic HFO Ban could be in place as early as 2023.
- An Arctic HFO Ban could affect fuel costs for ships that sail in Arctic Waters, including bulk carriers that serve Arctic mining operations.
- Baffinland's Mary River Mine is a large, open pit iron ore mine in the Canadian Arctic. Its Milne Inlet port is located within the IMO Polar Code Arctic but outside the North American Emission Control Area (ECA)



A	B	C	D	E	F	G
60°00'.0N 056°37'.1W	58°00'.0N 042°00'.0W	64°37'.0N 035°27'.0W	67°03'.9N 026°33'.4W	(Sørkapp, Jan Mayen) 70°49'.56N; 08°59'.61W	(by the Island of Bjørnøya) 73°31'.6N; 019°01'.0E	(Cap Kanin Nos) 68°38'.29N; 043°23'.08E

2017 Baffinland Bulk Carrier Activity and Ambitions for the Future

- In 2017, 23 bulk carriers completed 56 round-trip voyages, shipping 4.1 million tonnes (Mt) of ore, averaging 72,600 tonnes per ship.[1] At $70/t (average iron ore price Jul-Oct 2017), that implies a revenue of $US 287 million.
- In 2018, Baffinland shipped a record 5.1 Mt of iron ore, requiring 71 voyages. This included, for the first time, two trans-Arctic shipments to Asia via the Northern Sea Route.[2]
- In the long-term, Baffinland's goal is 30 Mt per year,[3] implying over 400 voyages each year using panamax vessels.



Vessel Name	# of Round Trips	Vessel Type	Max Speed	Median Speed	% of travel > 10 knots
Arkadia	2	Bulk carrier	9.7	7.2	0.0
Golden Amber	2	Bulk carrier	11.7	8	11.3
Golden Diamond	3	Bulk carrier	10.9	6.6	0.4
Golden Ice	3	Bulk carrier	10.7	5.1	0.5
Golden Opal	3	Bulk carrier	10.2	5.9	0.0
Golden Opportunity	2	Bulk carrier	10.6	3.4	0.0
Golden Pearl	2	Bulk carrier	10.5	8	1.4
Golden Ruby	2	Bulk carrier	10.5	1.2	0.2
Golden Saguenay	2	Bulk carrier	11.6	0.9	0.1
Golden Strength	2	Bulk carrier	9.6	6.6	0.0
MV Golden Brilliant	2	Bulk carrier	10.5	2.6	0.1
MV Golden Bull	2	Bulk carrier	10.1	6.1	0.0
Nordic Oasis	3	Bulk carrier	11.3	7.1	0.5
Nordic Odin	3	Bulk carrier	10	7.8	0.0
Nordic Odyssey	2	Bulk carrier	10.1	2.8	0.0
Nordic Olympic	3	Bulk carrier	13.1	7.2	0.6
Nordic Orion	3	Bulk carrier	9.8	2.3	0.0
Nordic Oshima	3	Bulk carrier	10.4	8	1.5
NS Energy	3	Bulk carrier	11.2	7.6	0.6
NS Yakutia	2	Bulk carrier	9.9	0.5	0.0
AM Buchanan	1	Bulk carrier	9.1	8.3	0.0
Rio Tamara	3	Bulk carrier	9.7	8	0.0
Sagar Samrat	3	Bulk carrier	9.8	6.4	0.0

Source: Baffinland's Mary River Project 2017 NIRB Annual Report, March 2018
Table 4.27 "Project-related ship speeds during transits on northern shipping route -2017 shipping season

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[1] http://www.baffinland.com/latest-news/baffinland-iron-mines-concludes-record-setting-shipping-season-with-4-1-million-tonnes-of-iron-ore-shipped-over-75-days/?lang=en

[2] http://www.baffinland.com/latest-news/baffinland-iron-mines-set-new-5-1-million-tonne-shipping-record/?lang=en

[3] http://www.baffinland.com/downloadocs/201903312018-nirb-annual-report_2019-04-56-56.pdf

Basic Methodology (1/4)

1. Identify bulk carriers that have transported materials from Bafflinland mines in the past.
2. Randomly select a bulk carrier for analysis.

NORDIC OASIS
ARCTIC
EXPRESS
© Claus Schaefe
MarineTraffic.com
Schiffsfotos@t-online.de

Nordic Oasis panamax bulk carrier (IMO 9727120)
Deadweight: 75,800 t
Flag: Panama
Built: 2016

Basic Methodology (2/4)

3. Use Automatic Identification System (AIS) data to identify one round trip voyage.

4. For each hour, estimate fuel consumption using ICCT's Systematic Assessment of Vessel Emissions (SAVE) model, described in detail in this report: https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015.

5. For each hour, identify when the ship was:
   a) Inside or outside an Emission Control Area (ECA)
   b) Inside or outside the IMO Polar Code Arctic (the Arctic)

Basic Methodology (3/4)

6. Estimate fuel costs under four scenarios:

		Fuel Choice[1]				
	Scenario (2020 compliance option)	**ECA** (from Europe)	**Open Sea** (to mine)	**In Arctic**	**Open Sea** (from mine[2])	**ECA** (to Europe)
1	No Ban (HFO + Scrubbers)	HFO + scrubbers[3]	HFO + scrubbers	HFO + scrubbers	HFO + scrubbers	HFO + scrubbers
2	Ban (HFO + Scrubbers)	HFO + scrubbers	HFO + scrubbers	MGO	MGO	MGO
3	No Ban (VSLFO)	MGO	VLSFO	VLSFO	VLSFO	MGO
4	Ban (VSLFO)	MGO	VLSFO	MGO	MGO	MGO

Fuel	**Price ($US/t)**[4] **large spread**	**Price ($US/t)**[5] **typical spread**
MGO	530	622
VLSFO	500	583[6]
HFO	302	425

[1] HFO is heavy fuel oil (<3.5% S); MGO is marine gas oil (<0.10% S); VLSFO is very low sulfur fuel oil (<0.50% S)

[2] Assumes HFO or VLSFO cannot be bunkered on the return trip if an Arctic HFO ban is in effect

[3] Scrubber operating and maintenance costs are not included

[4] Rotterdam, Aug 9, 2019: heavily influenced by upcoming 2020 regulations that may have artificially lowered HFO prices that could rebound as the market stabilizes post 2020

[5] Rotterdam, Aug 9, 2018: representative of typical MGO-to-HFO price spreads in recent years.

[6] Estimated because VLSFO was not yet on the market in Aug 2018; assumes 80%/20% MGO/HFO blend.

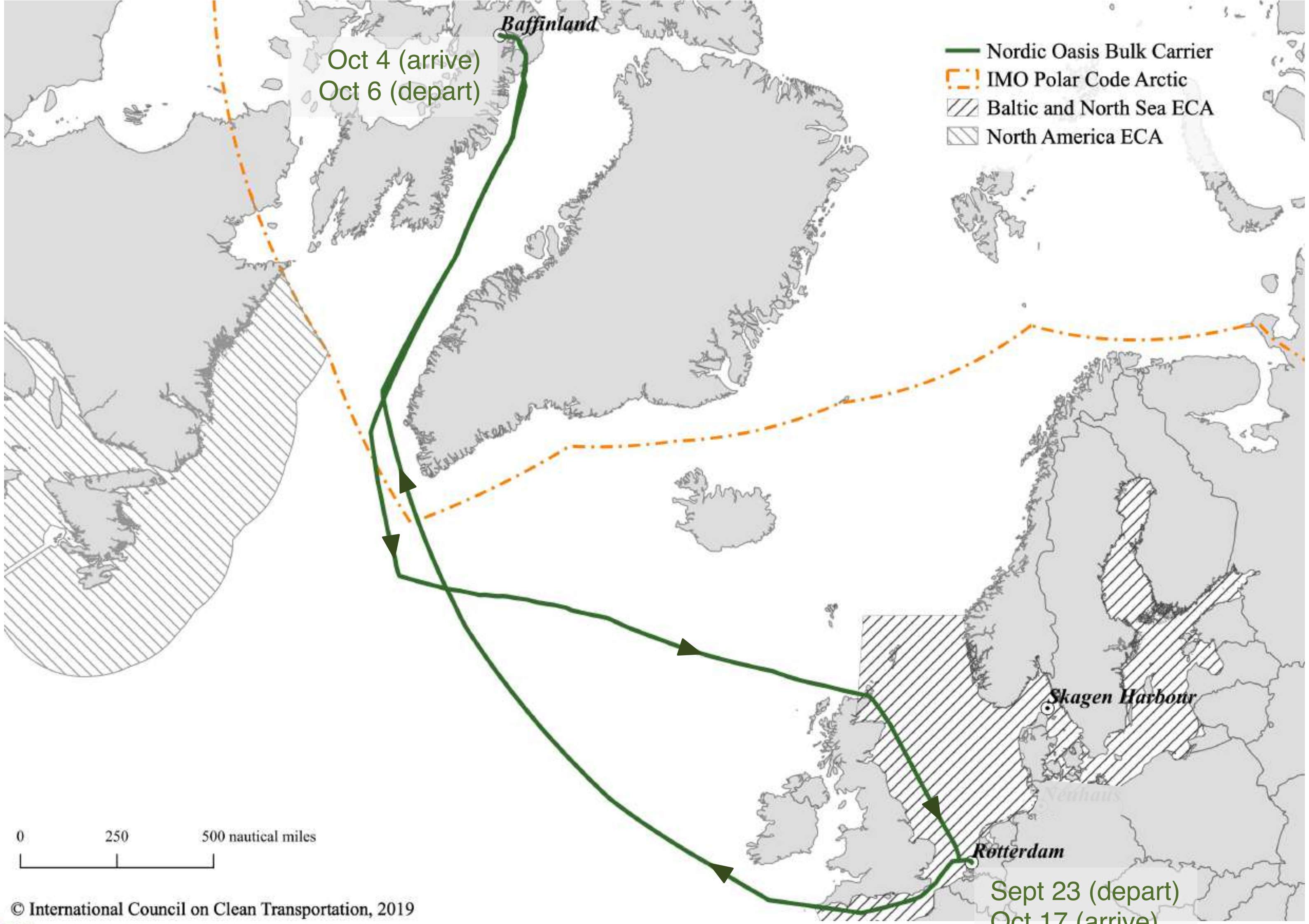
Basic Methodology (4/4)

7. Estimate round-trip voyage costs
    a) Total voyage costs, which are paid by Baffinland = daily charter rate + fuel costs + additional fees such as port dues.
        i. Time charter rates for panamax bulk carriers were about $10,000/day (USD) in Oct 2017 (UNCTAD, 2018)
        ii. Rotterdam port dues are approximately $50,000 for a panamax bulk carrier
            1) Rotterdam port tariffs explained here: https://www.portofrotterdam.com/en/shipping/sea-shipping/port-dues/seaport-dues

8. Compare change in round-trip fuel costs and total round-trip voyage costs under each scenario.

UNCTAD (2018). Review of Maritime Transport 2018. United National Conference on Trade and Development. Available at https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2245

Nordic Oasis Route, Autumn 2017


Baffinland
Oct 4 (arrive)
Oct 6 (depart)
Nordic Oasis Bulk Carrier
IMO Polar Code Arctic
Baltic and North Sea ECA
North America ECA
Skagen Harbour
Neuhaus
Rotterdam
0
250
500 nautical miles

Sept 23 (depart)
Oct 17 (arrive)

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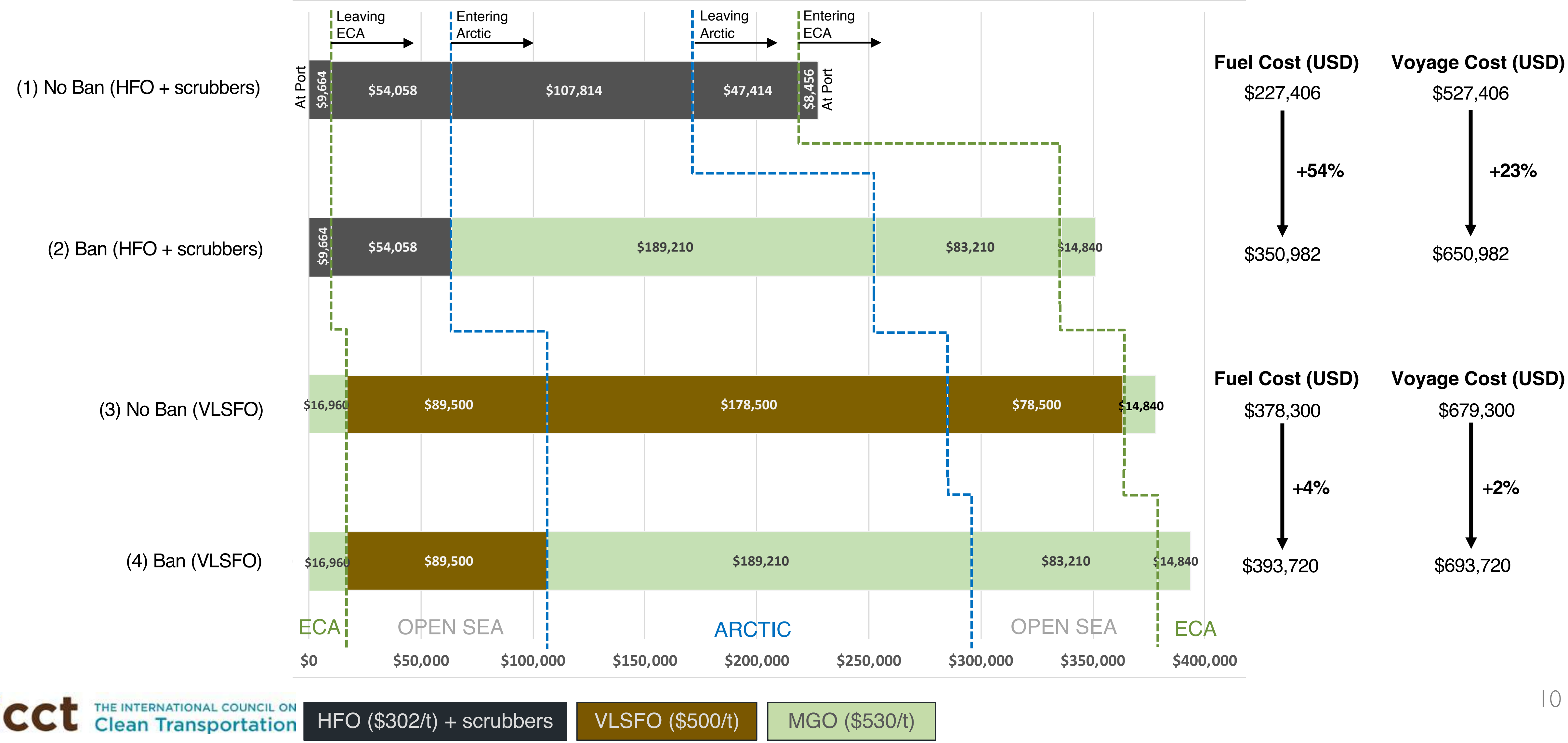
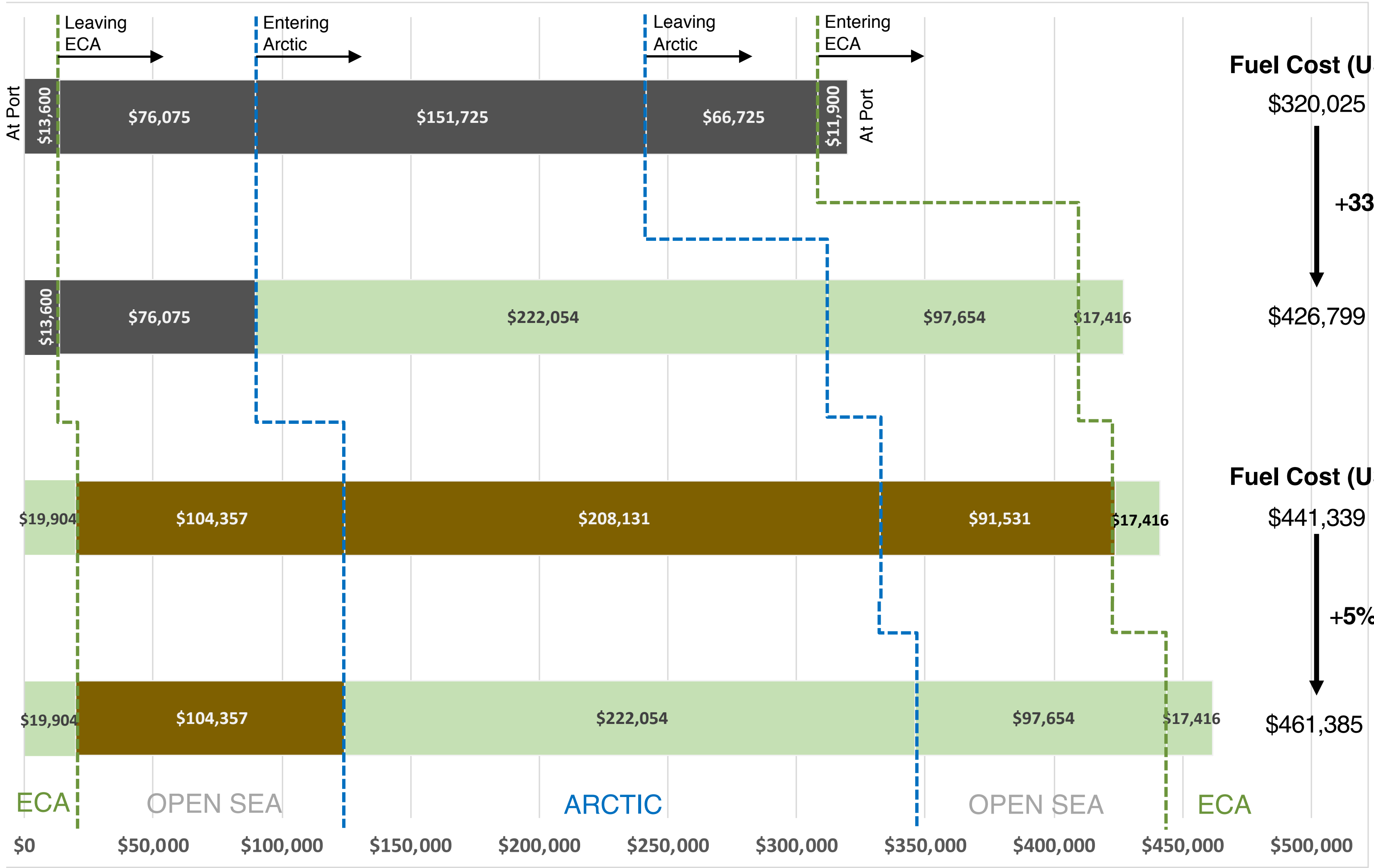
Nordic Oasis round-trip costs (high fuel price spread)

25 days = ~$250,000 charter fee + fuel + $50,000 port dues



Nordic Oasis round-trip costs (typical fuel price spread)

25 days = ~$250,000 charter fee + fuel + ~$50,000 port dues



Fuel Cost (USD)	Voyage Cost (USD)
$320,025	$620,025
+33%	+17%
$426,799	$726,799

Fuel Cost (USD)	Voyage Cost (USD)
$441,339	$741,339
+5%	+3%
$461,385	$761,385

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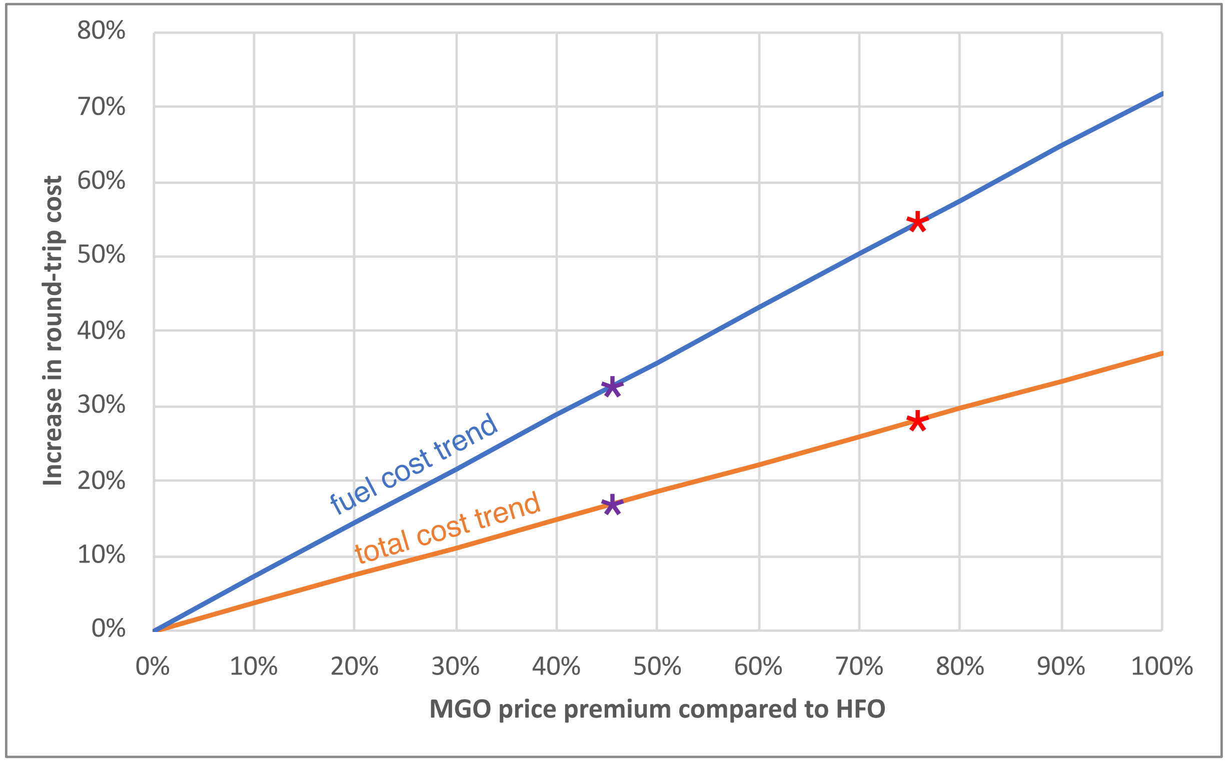
HFO ($425/t) + scrubbers | VLSFO ($583/t) | MGO ($625/t)

For ships that use HFO + scrubbers, cost impacts depend on MGO-to-HFO price premium

Relationship between fuel price spread and round-trip fuel costs and total costs for a Baffinland bulk carrier using HFO + scrubbers to comply with IMO 2020



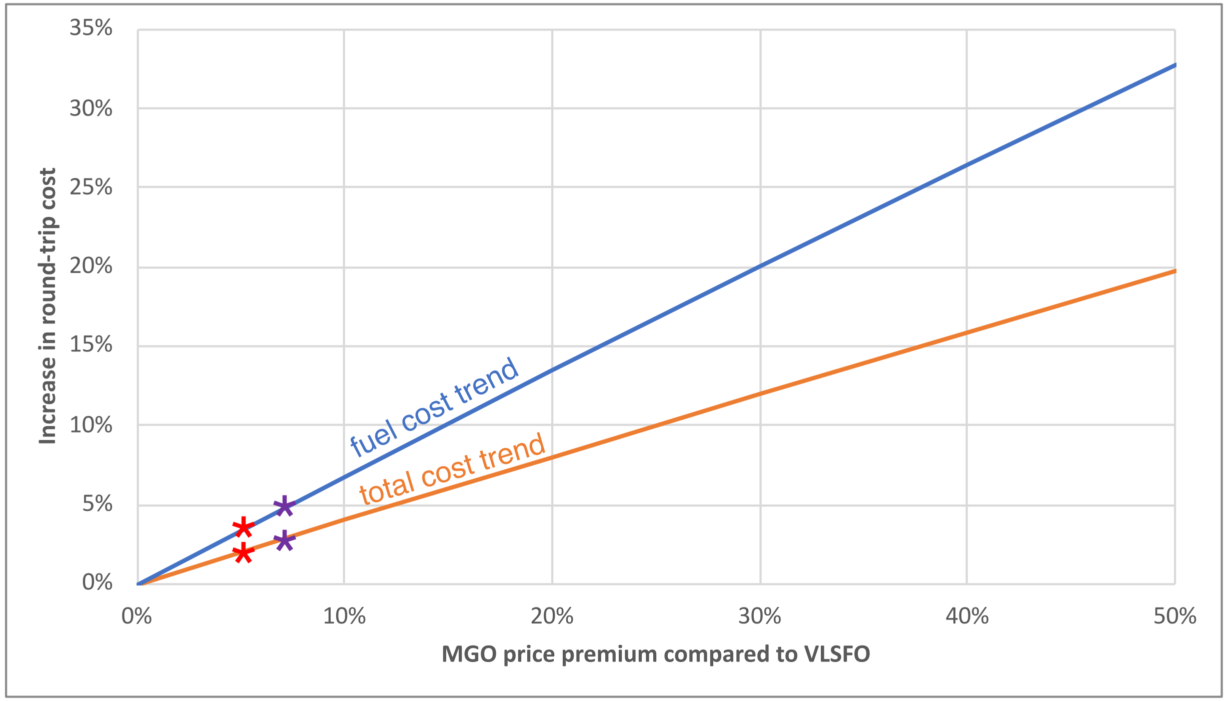
For the ship we analyzed:

*When MGO costs 75% more than HFO (e.g., Aug 2019), round-trip fuel costs increase 54% but total round-trip voyage costs (charter + fuel + port dues) increase only 23%.

*When MGO costs 46% more than HFO (e.g., Aug 2018), round-trip fuel costs increases 33% but total round-trip voyage costs (charter + fuel + port dues) increase only 17%.

For ships that use VLSFO, cost impacts depend on MGO-to-VLSFO price premium

Relationship between fuel price spread and round-trip fuel costs and total costs for a Baffinland bulk carrier using VLSFO to comply with IMO 2020



For the ship we analyzed:

*When MGO costs 6% more than VLSFO (e.g., Aug 2019), round-trip fuel costs increase 4% but total round-trip voyage costs increase only 2%.

*When MGO costs 7% more than VLSFO (best estimate of "typical" spread), round-trip fuel costs increase 5% but total round-trip voyage costs increase only 3%.

(Note the shorter x- and y-axes compared to the previous slide because the price spread between MGO and VLSFO has been relatively small.)

Conclusions (1/2)

- An HFO ban will affect fuel costs and voyage costs for ships that service Baffinland's Mary River Mine. However, these impacts are extremely sensitive to relative fuel prices and depend on how ships comply with IMO 2020:
  - For ships that use HFO + scrubbers, an HFO ban may substantially increase fuel costs (+33% to +54% in this analysis); however, total voyage costs would increase less dramatically, about half as much (+17% to +23%).
  - For ships that use VLSFO, an HFO ban would only slightly increase fuel costs (+4% to +5%) and total voyage costs (+2% to +3%).

[1] https://lloydslist.maritimeintelligence.informa.com/LL1128795/Golden-Ocean-sees-dramatic-recovery-in-dry-bulk-rates

Conclusions (2/2)

- If ships servicing the mine do not use scrubbers, we expect the fuel and voyage cost impacts of an Arctic HFO ban to be negligible.
    - None of the bulk carriers serving the mine in 2017 had scrubbers installed, as far as we can tell from publicly available data.
        - Golden Ocean Group owns 11 of the 23 ships that served the mine in 2017. While they are installing scrubbers on 23 of their capesize ships,[1] these are twice as large as the panamax ships that serve the mine. We have seen no plans for using scrubbers on their panamax fleet.
        - Nordic Bulk Carriers owns 6 of 23 ships that served the mine in 2017; we have not seen any announcement that they plan to use scrubbers.

---

[1] https://lloydslist.maritimeintelligence.informa.com/LL1128795/Golden-Ocean-sees-dramatic-recovery-in-dry-bulk-rates

Keep in mind… (1/2)

- Many factors influence the profitability of mining operations, especially the market price of iron ore.
  - From Aug 2017 through Aug 2019, the price of iron ore has ranged from \$60/t to \$120/t, with an average of \$77/t according to marketindex.com.
  - Over that same period, the price of HFO has ranged from \$282/t to \$482/t, with an average of \$395/t according to shipandbunker.com.
  - The Baffinland Mary River Mine has been in operation since 2015 and has weathered these ore and fuel price fluctuations.

- Scrubber operating and maintenance costs are not included in this analysis and could increase the costs of using HFO + scrubbers post-2020.

Comer, B. (2019). *Transitioning away from heavy fuel oil in Arctic Shipping.* International Council on Clean Transportation.
Available at https://theicct.org/sites/default/files/publications/Transitioning_from_hfo_Arctic_20190218.pdf

Keep in mind… (2/2)

- The benefits of an HFO ban (economic, environmental, and social) are not considered in this analysis.
  - These benefits should be considered when assessing the net effect of an HFO ban on Baffinland mining operations.
    - ICCT research finds that:
      - The costs associated with spilling even a small amount of HFO outweigh the fuel cost savings of using HFO instead of MGO (Comer, 2019).
      - Large 2-stroke engines, such as those used in panamax bulk carriers, can emit up to 80% less black carbon when operating on MGO instead of HFO (Comer et al. 2017).

Comer, B., Olmer, N., Mao, X., Roy, B., and Rutherford., D. (2017). *Black carbon emissions and fuel us in global shipping 2015*. International Council on Clean Transportation. Available at https://theicct.org/sites/default/files/publications/Global-Marine-BC-Inventory-2015_ICCT-Report_15122017_vF.pdf

Comer, B. (2019). *Transitioning away from heavy fuel oil in Arctic Shipping.* International Council on Clean Transportation. Available at https://theicct.org/sites/default/files/publications/Transitioning_from_hfo_Arctic_20190218.pdf

Questions? Comments?

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PHASING OUT HEAVY FUEL OIL IN THE CANADIAN ARCTIC

© Canon / Brutus Östling / WWF-Sweden

IDENTIFYING COMMUNITY COSTS AND BENEFITS OF AN ARCTIC BAN

WWF-Canada is advocating nationally and internationally for the phase out of both the use and carriage for use of heavy fuel oil in the Arctic, without driving up costs for northern and remote communities.

Heavy fuel oil (HFO) is the world's dirtiest, most polluting ship fuel, and can cause the most damage in the event of a spill. This is especially true in the Arctic, where unpredictable weather, remote locations, and a lack of response resources make spills virtually impossible to contain and clean up. In the event of a large spill, damage to the fragile Arctic ecosystem would likely be widespread and irreparable. The International Maritime Organization (IMO) has pledged to phase out HFO from Arctic shipping, with support from many countries including United States, Norway, Finland, Sweden, Iceland and Denmark, and HFO is already banned in other Arctic jurisdictions (e.g.: Norway) and in the Antarctic. In Canada, Prime Minister Justin Trudeau has promised to phase down HFO from Arctic shipping. However, Canada remains one of the only Arctic countries that has not yet officially supported an Arctic-wide ban.

WHY BAN HFO?

SPILLS: HFO mixes and spreads throughout the water column, making cleanup impossible. It's also stickier than other fuels, matting feathers and fur and leading to hypothermia and death in seabirds and animals with fur, like polar bears.

SOOT: Burning HFO produces much more soot and particulate matter than other fuel alternatives, decreasing air quality and causing health problems for people and wildlife.

CLIMATE CHANGE: Burning HFO produces black carbon particles that absorb sunlight and heat the atmosphere when it accumulates on snow and ice.

To better understand the impacts and benefits of a ban on HFO to Arctic communities, WWF-Canada commissioned a study of the potential increase in the price of consumer goods due to a ban, the comparative costs of spills between HFO and diesel fuels, and the benefits of a ban to community food security.

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COST TO COMMUNITY: FUEL AND GOODS PRICING

A review of historical fuel costs and food prices does not indicate a correlation between fuel costs and food prices.

While HFO prices fell by nearly 65 per cent from 2014 to 2017, the average cost of select shelf-stable food items likely transported by vessel to communities increased by about 15 per cent. The price of HFO has varied significantly in recent years, yet community resupply vessels continued to deliver goods to northern communities during times when HFO prices were higher than 2017 average distillate fuel prices.

COST TO COMMUNITY: PROJECTED COST IMPACT ON GOODS

Incremental costs of using more expensive but less dangerous fuel is about $11 per cargo tonne, or about one cent per kilogram of cargo transported.

A modelled analysis of a vessel using MGO rather than HFO along a Nunavut route in 2017, when MGO prices were more than double those of HFO, showed that the incremental costs of using more expensive MGO fuel is about $11 (2018 Canadian dollars) per cargo tonne, or about one cent per kilogram of cargo transported.

These estimates decrease if the price differential between HFO and MGO decreases as predicted due to the global Sulphur cap regulation, down to a half cent per kilogram of cargo in 2020 and beyond.

COST TO COMMUNITY: SPILL IMPACTS

An Arctic HFO spill would be more challenging to clean up, more persistent and likely more damaging than a distillate spill.

HFO spills are also costlier to clean up than distillate fuel spills. An HFO spill is estimated at between $106,000 and $512,000 per tonne spilled, including shoreline clean-up, socio-economic, and environmental costs whereas distillate spills range from $32,000 to $193,000 per tonne spilled.

> *”We are constantly reminded how taking action on greenhouse gas emissions will negatively impact our economy … which is a very outdated card to play at this stage with our climate crisis. I would say do not play this card when it comes to banning HFO which has potential to create extreme irreparable damage to our Arctic oceans … The oceans are the life force and source of life for us as Inuit of the Arctic.”*
>
> Sheila Watt-Cloutier
> Environmental and human rights advocate
> and former International Chair for the
> Inuit Circumpolar Council

Food security for many Arctic communities has strong social implications. An HFO spill near an Arctic community would threaten subsistence and other marine resources, endangering food security, jobs and related revenue from marine-based livelihoods (e.g.: fishing) and cultural practices. An HFO spill could devastate the Arctic ecosystem, harming fish and marine mammals, and compromising the food security of Inuit communities that have subsisted on these resources for millennia.

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RECOMMENDATIONS:

- ***Ban HFO use, and carriage for use, through Canada's delicate marine ecosystem***
- ***Explore and enact policy options to mitigate short-term impacts of fuel-switching on the price of goods***
- ***Build Arctic oil spill response capacity and enhance prevention measures for permitted fuels***

FOR MORE INFORMATION

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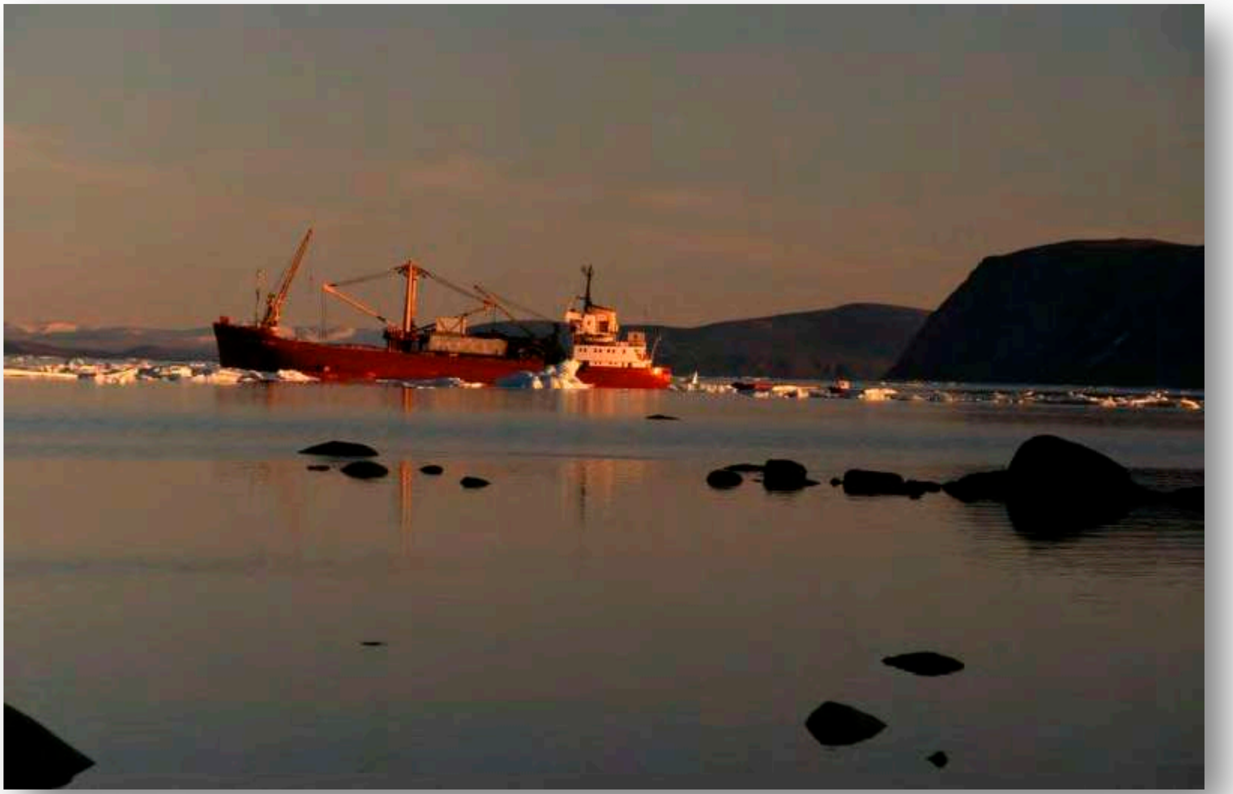
Phasing Out the Use and Carriage for Use of Heavy Fuel Oil in the Canadian Arctic: Impacts to Northern Communities

Report to WWF-Canada



Supply ship, Clyde River, Nunavut, Canada. © Peter Ewins, WWF-Canada

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Executive Summary

This report examines possible impacts to communities associated with a ban on the use and carriage for use of HFO by vessels operating in the Canadian Arctic. The analysis focuses on three types of impacts associated with an HFO ban: (1) potential increased shipping costs to transport commodities to Canadian Arctic communities; (2) potential impacts from a heavy fuel oil spill in the Canadian Arctic; and (3) potential costs incurred by Canadians as a result of a heavy fuel oil spill in the Arctic. Qualitative and quantitative methods are applied to evaluate each type of impact, based on the authors' respective areas of expertise as economic and oil spill analysts.

Key findings include:

- The price of IFO 380 (a type of HFO commonly used as marine fuel) has varied significantly in recent years, yet community resupply vessels continued to deliver goods to northern communities during times (i.e. the late 2013s) when IFO 380 prices were higher than 2017 average marine gas oil (MGO) prices.
- A review of historical IFO 380 fuel cost data and historic food prices in Nunavut does not indicate a correlation between fuel costs and food prices. In fact, while IFO 380 prices fell nearly 65% from 2014 to 2017, the average cost of select shelf-stable food items in communities increased by about 15%.
- A modeled analysis of vessel using MGO rather than IFO 380 along a Nunavut resupply route in 2017, when MGO prices were more than double those of IFO, showed that the incremental costs of using more expensive fuel is about $11 (2018 Canadian dollars) per cargo tonne, or about one cent per kilogram of cargo transported. These estimates decrease if the price differential between IFO and MGO decreases as predicted.
- An Arctic HFO spill would be more challenging to clean up, more persistent, and likely more damaging than a distillate spill; this factor should be incorporated into any community impact analysis.
- HFO spills are more costly than distillate fuel spills, but existing oil spill cost models are not readily applied to Arctic spills. Improved cost modeling is needed to estimate the potential cost impacts of oil spills in the Canadian Arctic.
- The current Canadian liability regime does not require adequate ship owners' insurance to cover the potential costs of an Arctic fuel oil spill.
- If an HFO ban were to result in an increased cost of goods to Canadian Arctic communities, policy options should be explored to mitigate these short-term impacts in order to realize long-term benefits of removing HFO from Arctic waters.

Impact of Fuel Prices on Cost of Goods in Nunavut

The fuel cost analysis focused on two types of marine fuel: IFO 380, a heavy residual fuel oil; and marine gas oil (MGO), a distillate fuel that is compliant with both the 2020 sulphur emission cap and the proposed Arctic HFO ban. Historical price data for both fuels from late 2013 through 2017 shows significant variability, with a trend toward overall price reduction of both fuel types. The price difference between IFO 380 and MGO ranged from a low of $268/tonne in September 2016 to a high of $522/tonne in February 2014. Prices remained relatively stable through out 2017, with MGO costing about 1.5 times as much as IFO 380.

Over the roughly four years of monthly fuel price data, the highest price for IFO 380 ($654 in November 2013) was higher than the lowest price for MGO ($526 in January 2016), suggesting that the shipping industry has adapted to extreme price fluctuations in the past, since historic IFO 380 prices have been higher than the current MGO prices. Average monthly MGO prices in Montreal were lower than the average November 2013 price for IFO 380 every month from August 2015 through December 2017.

Predicting future marine fuel prices is challenging because of the complexities and interdependencies in the global refining and marine fuel markets. Most analysts agree that there will be a period of volatility in the years leading up to the 2020 global sulphur cap, but that eventually the markets will settle out and global refining capacity will adjust to higher demand for distillate fuels. This will narrow the price gap between HFO and distillate fuels.

Since distillate fuels are currently more expensive than HFO, a ban on the use and carriage for use of HFO could result in increased fuel costs for community resupply (sealift) vessels. Before projecting potential future impacts of fuel switching, the past relationship between fuel prices and cost of goods in Canadian Arctic communities were explored. Past IFO 380 prices (averaged by year) were compared to food basket costs as compiled by the Nunavut Statistics Board. The data do not correlate fuel prices with food basket costs. For example, the cost of IFO 380 went down by nearly 50% from 2014 to 2015, while the food basket survey showed that food prices in all three Nunavut regions increased during the same time period.

While this analysis shows no clear correlation between marine fuel costs and food item costs, additional analysis was performed to explore the potential for increased fuel costs to carry through to individual food items that are typically delivered by sealift. A simple cost model was used to estimate the incremental cost associated with using distillate fuel rather than HFO, on a per-kilometer and per-kilogram cargo basis.

Based on 2017 average Montreal fuel prices, the modeled analysis predicted that it would cost about $11/tonne for a sealift vessel to burn MGO rather than IFO 380 along a community resupply route (2018 Canadian dollars). Spread further, the per-kg cost increase from the use of MGO is just over one cent, and it decreases if the future cost spread between IFO and MGO decreases as predicted.

Considering the incremental cost impacts of fuel switching on a per-kilometer or per-kilogram cargo basis provides additional context for considering the trade-offs associated with replacing HFO with less polluting fuels. For example, a modeled analysis showed that the net effect of doubling fuel costs breaks down to pennies or less in increased transportation costs by weight, which is how most freight costs are established. In order to accurately estimate the potential impacts of an Arctic HFO ban on the cost of goods in Canadian Arctic communities, more information is needed about the relationship between fuel costs and sealift prices. Refined estimates of future price differences between IFO 380 and MGO or other less polluting fuels will also inform estimates of cost-of-good impacts from the pending HFO ban.

Impact of a Heavy Fuel Oil Spill in Canadian Arctic Waters

Oil spills from vessels operating in Arctic waters – whether community resupply vessels, cruise ships, or large freight vessels transiting the northern sea route – can have significant and long-lasting impacts on Arctic coastal communities. The risks associated with an Arctic HFO spill are one of the main drivers of the HFO ban; therefore, the impact of eliminating this risk is an important consideration in assessing overall community impacts.

All oil spills have the potential to devastate wildlife and habitat and to impact the people and communities that rely on an intact ecosystem for food and socio-cultural activities. Arctic conditions complicate the oil spill response process, potentially adding to the severity of oil spill impacts. Arctic conditions may also exacerbate the consequences of an oil spill for a number of reasons, including: slower biodegradation; encapsulation of oil in sea ice; slower reproductive cycles of Arctic species; smaller food webs; aggregate stressors due to climate change; and heavy reliance on subsistence foods in the north.

While any Arctic spill could have significant adverse impacts, an HFO spill would likely be more challenging to clean up and more harmful to the environment than a distillate spill. Residual oil spills are slow to naturally degrade and difficult to clean up, because they are denser and more viscous than distillates, and are usually harder for oil spill response systems to skim, pump, and store. The typical response to a residual oil spill involves cleaning the tarry residue off whatever it contacts. Any HFO that is not removed would persist in the environment much longer than distillate fuels, with more widespread geographic and temporal impacts.

The potential impacts from spilling new and emerging hybrid fuels and residual fuel blends are poorly understood, especially in the Arctic. Because these fuels are blended specifically to reduce sulphur air emissions, they retain many of the characteristics of HFO that make it particularly persistent and challenging to clean up. Information is sparse about how these low sulphur residual fuel blends and hybrids behave when spilled, but based on published research, they appear to have similar characteristics to diluted bitumen. An Arctic HFO ban should include these hybrid fuels, which have a similar risk profile to HFO.

Cost Impact of an Arctic Heavy Fuel Oil Spill

HFO spills are typically much more persistent and therefore more expensive to clean up than distillate fuel spills, with more extensive damages to wildlife, habitat, subsistence foods, and socio-economic values. Canada's "polluter pays" system, which establishes the financial responsibility of vessel owners and operators to pay for the cleanup costs and damages associated with fuel oil spills, may not provide adequate assurance that all costs will be paid by the polluter's insurance. Additional funds are available through Canadian and international trust funds, but disbursements from these sources are also limited. Any costs above these financial responsibility limits would fall to the governments, communities, individuals, and private companies that incur expenses to clean up oil spills or suffer damages from the spill impacts.

The costs associated with oil spill response are generally grouped into the following three categories: (1) cleanup costs; (2) environmental costs; and (3) socioeconomic costs. In addition to these three broad cost categories, there are a number of oil spill costs that are not always taken into consideration. For an Arctic ship-source fuel oil spill, these may include: private costs incurred by the spiller; death or harm to individuals involved in the ship accident; response costs incurred by government agencies; cost of repairing damaged infrastructure; losses by affected businesses; loss of consumer value from shifting purchases; natural resource damages and restoration costs; cost of litigation to all injured parties; societal costs associated with focusing government and public resources away from day-to-day functions; and social costs that cannot be compensated through a transfer of funds.

The most commonly cited oil spill cost model – which is not Arctic-specific – estimates the cost per volume of spill cleanup for HFO compared to distillate spills. The cost per tonne of an HFO spill is estimated at between U.S.$106,000 and U.S.$512,000 per tonne spilled, including shoreline clean up costs, socio-economic costs, and environmental costs. By comparison, the per-ton costs estimated for a distillate spill range from U.S.$32,000 to $193,000 per tonne. Anecdotal data from other (non-Arctic) HFO spills show that HFO cleanup costs may be as much as $300,000 to $800,000 per tonne spilled.

Shipowner liability for fuel oil spills in Canada is based on the ship's tonnage; for example, for a 6,000 GT cargo vessel (typical of a community resupply/sealift ship serving communities) has a liability limit of approximately $7.2M for a bunker fuel spill. Assuming the fuel capacity for a 6,000 GT cargo vessel is 570 tonnes, the liability limit on the vessel owner would calculate to about $13,000/tonne. This is significantly lower than the per-tonne cleanup costs derived from models or anecdotal data. Even for a relatively small spill (10% of fuel capacity on a small cargo ship, or 57 tonnes), the liability limit of the vessel owner under Canadian law would be $6.8M lower than the estimated response costs derived from the model, which is not Arctic-specific. This gap grows to over $167M in the event of a total loss of bunkers. If the anecdotal cost data from past spills were applied, the gap would increase by nearly threefold.

The Canada's Ship-source Oil Pollution Fund (SOPF) provides supplemental funding in the event that spill costs exceed the funds available through the ship's insurance. The maximum liability per incident is adjusted annually; the 2017 limit is approximately $172M. Theoretically, this would be sufficient to cover the conservatively estimated gap for the 100% fuel loss scenario. However, such a claim would be an order of magnitude greater than any claims paid out of the fund to date (total expenditures for all claims combined since 1972 have been about $19M). The criteria for evaluating SOPF claims excludes any damage that might be related to lost use, such as lack of opportunity to gather subsistence foods, loss of recreational opportunities, or socio-cultural impacts that cannot be monetized.

Paying a significant portion of oil spill response costs for an Arctic heavy fuel oil spill out of the Canadian fund would transfer the cost burden from the polluter to the government and taxpayers of Canada.

Mitigating Community Impacts

Banning HFO use and carriage for use through Canada's delicate marine ecosystem offers a number of benefits to ecological and human health. However, there are also economic costs associated with switching Arctic ships over to cleaner burning fuels. While the per-tonne costs associated with switching from IFO 380 to MGO will likely decline over time as global marine fuels market adjusts to new regulatory requirements, it is also likely that shipping companies will pass along some or all of their initial cost increase to communities. A higher cost of goods may seem like a reasonable trade-off for slowing ice melt and protecting ecological and human health, yet high north communities are understandably concerned that any increases will threaten their economic well-being.

Policy options that mitigate the impacts to community members from higher sealift fuel costs should be explored alongside the implementation planning for an HFO ban. Several options are identified for consideration including:

- Using government subsidies to protect communities from increased cost of goods during initial price inflation, if one occurs.
- Adopting a phased or adaptive implementation process that incentivizes fuel switching.
- Continuing to explore and analyze the relationship between fuel costs and cost of goods in northern communities.

Banning HFO use and carriage for use in Arctic waters will significantly diminish the risk of HFO spills. However, an HFO ban does not remove the potential for other types of marine fuel oils or bulk oil shipments to spill and impact Arctic waters. Many of the issues raised in this study bear consideration even after an HFO ban takes effect, including:

- Creating a more robust Arctic oil spill response capacity;
- Enhancing oil spill prevention measures; and
- Exploring new funding sources to build spill response capacity.

An Arctic HFO spill would not only be catastrophic, but would be extremely cost-intensive to clean up. The current liability system for fuel oil spills caps a ship owner's liability at a level that removes any incentive for switching away from HFO. The fact that so many of the costs of an oil spill are borne by government and society makes the cost/benefit equation more complex, and worth considering through a different lens. Incentives that reward risk-reduction and spill prevention measures could be created to offset additional fuel costs associated with the HFO ban.

1 Introduction

Nuka Research and Planning Group, LLC (Nuka Research) and Northern Economics, Inc. (NEI) developed this report for WWF-Canada to support their ongoing evaluation of the impacts associated with phasing out the use of Heavy Fuel Oil (HFO) by ships operating in the Canadian Arctic.

1.1 Purpose

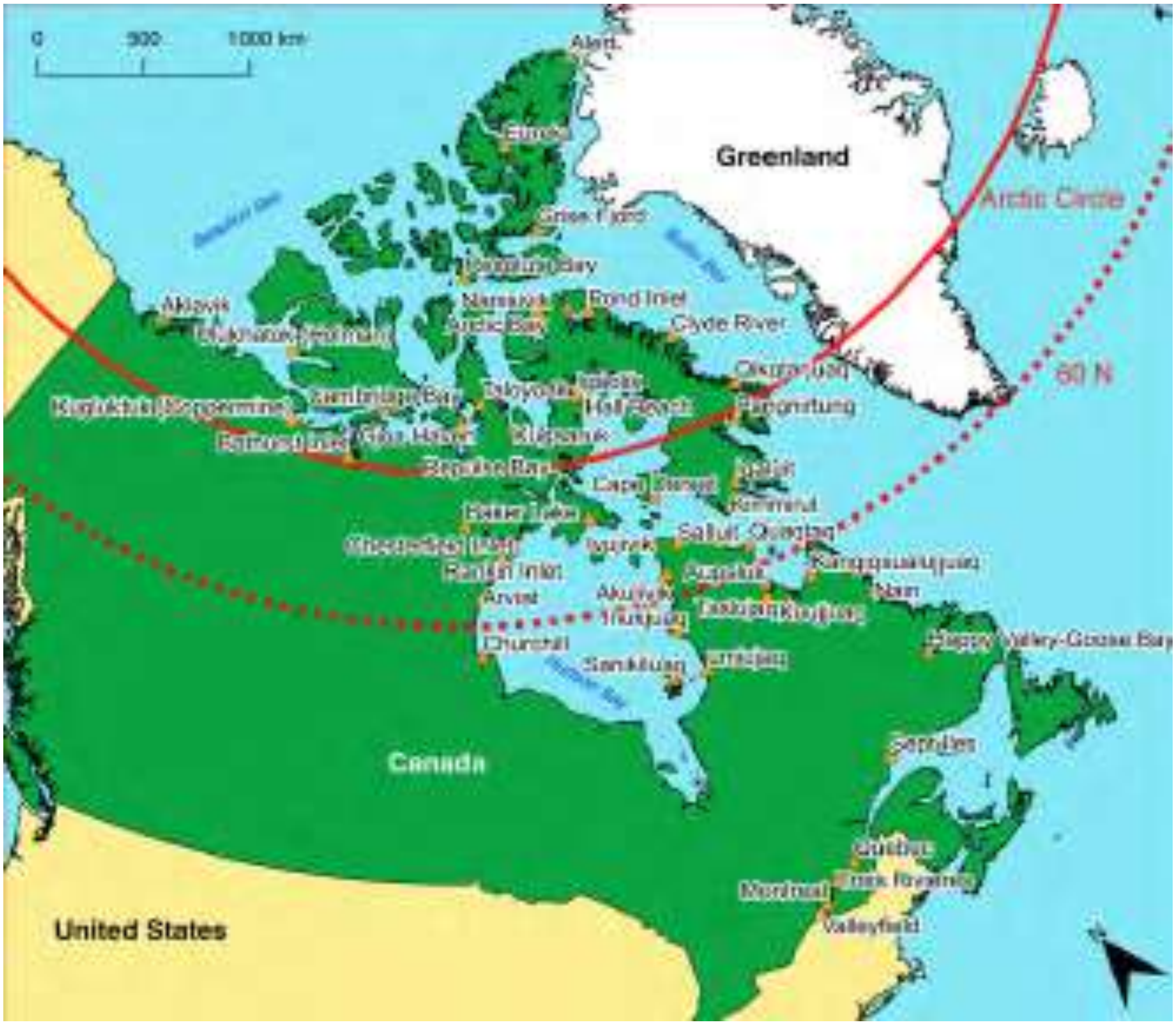
The purpose of this report is to estimate impacts to communities resulting from a ban on the use and carriage for use of HFO by vessels operating in the Canadian Arctic.

This report was developed to support ongoing discussions within the International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC), and to inform the development of an impact assessment methodology, which is scheduled for discussion at the 73rd session in October, 2018.

1.2 Scope

The report considers certain impacts – both positive and negative – associated with the switch from HFO to less polluting fuels for community resupply vessels and other commercial shipping vessels that may transit northern shipping routes. The analysis focuses on three types of impacts associated with an HFO ban: (1) potential increased shipping costs to transport commodities to Canadian Arctic communities; (2) potential impacts from a residual fuel spill in the Canadian Arctic; and (3) potential costs incurred by Canadians as a result of a heavy fuel oil spill in the Arctic. Qualitative and quantitative methods are applied to evaluate each type of impact, based on the authors' respective areas of expertise as economic and oil spill analysts.

Figure 1-1 shows the study region and identifies communities in the north that rely on shipping for the transport of some goods. The map shows both the Arctic Circle and the 60° North latitude line, which represents the boundary of the Polar Arctic. This report is inclusive of Hudson Bay communities south of 60° North, because they also rely on sea lifted cargo for community resupply.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Cambridge Bay
Taloyoak
Igloolik
Hall Beach
Pangnirtung
Bathurst Inlet
Gjoa Haven
Kugaaruk
Repulse Bay
Cape Dorset
Iqaluit
Kimmirut
Baker Lake
Salluit
Quaqtaq
Chesterfield Inlet
Ivujivik
Kangiqsualujjuaq
Rankin Inlet
Aupaluk
Nain
Arviat
Akulivik
Puvirnituq
Tasiujaq
Kuujjuaq
Happy Valley-Goose Bay
Churchill
Sanikiluaq
Inukjuak
Hudson Bay
Canada
Sept-Iles
Quebec
Trois Rivieres
Montreal
Valleyfield
United States

Figure 1-1. Map of Canadian northern communities

1.3 Contents and Organization of this Report

This report is organized into six sections, including this introduction. Section 2 provides background information about marine fuel use by vessels operating in the IMO Arctic, and in the Canadian Arctic. Section 3 presents a cost analysis that considers the relationship between marine fuel costs and the cost of goods in northern communities. Section 4 identifies key considerations for understanding the potential ecological impacts and response challenges associated with Arctic HFO spills. Section 5 considers the potential impacts of paying for oil spill cleanup costs and damages in the event of a major HFO spill in the Canadian Arctic. Section 6 considers options to mitigate the impacts described in Sections 3 through 5.

2 Marine Fuel Use and Carriage in the Canadian Arctic

WWF-Canada has worked within Canada and internationally on a range of efforts to study and understand the tradeoffs associated with the shipping industry's shift from the use of HFO to lower-emitting and less persistent fuels such as diesel and marine gas oil (MGO). This section provides context for evaluating the impacts of an HFO ban to Canadian Arctic communities.

2.1 Marine Fuel Oils

Marine vessels may opt to use different types of fuel for propulsion, depending upon their size, configuration, operating routes, and other operational, logistical, and financial considerations (Ocean Conservancy, 2017). All marine fuel oils begin with crude oil in some form; from there, different levels of processing and blending result in a range of fuel oil types.

Marine fuel oils are broadly characterized as either residual oils or distillates (Bomin Group, 2015b). Distillates are the petroleum products created by refining crude oil. They are called distillates because distillation is a key step in upgrading these products; however, depending upon the refinery, there may be additional steps involved (such as vacuum distillation, catalytic cracking, and breaking). Distillate fuels include gas, naptha, kerosene, and diesel (in this case, diesel refers to the specific distillation cut of petroleum, not the type of engine used to burn oil).

Residuals are all of the leftover components of crude oil that are separated from the upgraded, distilled products. Residual marine fuels typically do not undergo any type of upgrading, although they may be mixed with distillates to achieve certain desired chemical or physical properties.

Table 2-1 summarizes the terminology used in this report to describe marine fuels, and indicates whether each is considered residual or distillate.

Table 2-1. Marine Fuel Oil Terminology

TERMINOLOGY U.S.ED TO DESCRIBE MARINE FUEL OILS		
Marine Fuel Oil Name	**Composition**	**Type**
Bunker C/Fuel oil No. 6	Residual oil	HFO
Intermediate Fuel Oil (IFO) 380	Residual oil (~ 98%) blended with distillate	HFO
Intermediate Fuel Oil (IFO) 180	Residual oil (~88%) blended with distillate	HFO
Low sulphur marine fuel oils	Residual oil blended with distillate (higher ratio of distillate to residual)	HFO derivative
Marine diesel oil (MDO)/ Fuel oil No. 2	Distillate fuel that may have traces of residual oil	Distillate
Marine gas oil (MGO)	100% distillate	Distillate

2.1.1 Residual Oils and HFO

The term HFO is used to describe both a category of marine fuels and certain marine fuel oil blends. Heavy fuel oils (as a category of marine fuels) are created from residuum, the tar-like sludge that is the end product of upgrading crude oil (Ramberg and Van Vactor, 2014). The quality and chemical makeup of HFO is highly variable, depending on its components and the way they are blended to achieve the desired viscosity and flow characteristics (McKee et al., 2014).

The MARPOL Convention defines HFO as a general category of marine fuels that have a density above 900 kg/m^3 at 15°C, or a viscosity of more than 180 mm^2/s at 50°C (Bomin Group, 2015). Residual fuel blends such as Number 6 oil and Bunker C oil are common in the marine industry and are often referred to as HFO. Heavy fuel oils typically have higher sulphur content than distillate fuels and create more particulates when burned, resulting in higher air emissions of sulphur, black carbon, greenhouse gasses, and other pollutants (Bomin Group, 2015).

HFOs are the cheapest fuel oils that refineries can produce. Since most developed economies prohibit burning HFOs, the marine fuel market is the primary consumer for HFO (Ramberg and Van Vactor, 2014). The low cost of HFO compared to other fuels has contributed to its widespread use for marine propulsion (O'Malley, et al., 2015).

In addition to their use as marine fuels, residual oils are used for power generation in some developing countries. Residuum is also used to produce asphalt. As air emissions standards have become stricter, the global demand for residual oils has steadily declined since the mid-1980s, with future predictions supporting continued reductions in demand (O'Malley et al., 2015).

Refineries do have the ability to upgrade residuum into petroleum coke (used to produce synthetic crude oils) or into middle distillates and gasoline. For some refineries, upgrading residuum would require additional capital investments, while other refineries have existing capability to upgrade residuum. The decision to upgrade is typically driven by market forces; if distillate fuel prices are sufficient to cover the additional refinery costs associated with upgrading residuum, then refineries may choose to upgrade and sell distillate products rather than residual fuels (Ramberg and Van Vactor, 2014).

2.1.2 Distillate Fuels

The International Standards Organization (ISO) has established fuel standards for marine distillate fuels. Common types of distillate marine fuels are marine diesel oil (MDO), distillate marine diesel (LDO or DMA, DMB, or DMX) and marine gas oil (also called MDC or MGO). Marine distillate fuels have a density at or below 900 kg/m^3 at 15°C, and a viscosity range between 1.4 and 11.0 mm^2/s at 40°C. The sulphur content of marine distillate fuels is below 1.5% (ISO 8217, 2017). These fuels require additional processing by refineries, and are therefore more expensive than residual fuels.

Distillate fuels are used for propulsion on a range of vessel types, from fishing boats to cruise ships and cargo vessels. Some ships that use HFO as a primary propulsion fuel may carry a smaller supply of distillate fuel for secondary engines.

2.1.3 Residual Blends

Newly emerging low sulphur marine fuel oil (LSMFO) blends are become more popular as an HFO alternative that complies with newly emerging air emission standards. These blends – also called hybrid fuels – are made when residual oils are combined with lighter products such that when the fuel burns, the plume that is emitted does not exceed prescribed thresholds. Larger vessels (container ships, ro-ro ships, and general cargo ships) operating in emission control areas, primarily in Europe, are using these hybrid oils as an alternative to distillate fuels (HelstrØm, 2017).

Ultra and very low sulphur residual fuel oils available on the market fall well below the HFO viscosity limit, but some still exceed the 900 kg/m^3 density threshold.[1] One European refinery is developing a low sulphur blend with a higher viscosity (around 300 mm^2/s at 50°C) to solve the engine lubrication problems that sometimes result when ships switch from high viscosity HFO to low viscosity distillates or blends (James, 2017). From an oil spill fate and behavior perspective (discussed in Section 4.3), these oils would still behave more like a heavy fuel oil than like a lower density distillate fuel.[2]

A representative of Finland refiner Neste pointed out in a news article that low sulphur marine fuel blends are similar to distillates, but still retain some characteristics of residual oils. "If you look at the low-sulphur [sic] fuel oil available in the market, it is not fuel oil, it is distillates…just a little bit dirtier that's all." (James, 2017)

A recent analysis of residual fuel blends found that there is some variability in product properties depending upon the refinery batch, which may reflect differences in the composition and properties of the fuels blended to make the hybrid (HelstrØm, 2017).

2.1.4 Other Marine Propulsion Options

In addition to residual oils, distillates and residual blends, ships may opt for other propulsion systems. Liquefied natural gas (LNG) is becoming more prevalent, particularly on newer ships. LNG-powered vessels require specific infrastructure and fuel availability (DNV-GL, 2017). Some ships use alternative fuels such as biofuels or methanol. Battery and hydrogen power are other alternatives to burning marine fuel oils.

These other options are not explored in this study, but are acknowledged as less-polluting alternatives to HFO.

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[1] For example, the specification sheet for Shell's ULSFO cites typical density between 700-910 kg/m^3; ExxonMobil's Premium HDME 50 blend, designed specifically for ECA compliance, is also well below the viscosity threshold but has a density of 900-915 kg/m^3.

[2] Typical density for a marine gas or marine diesel oil is around 860 kg/m^3.

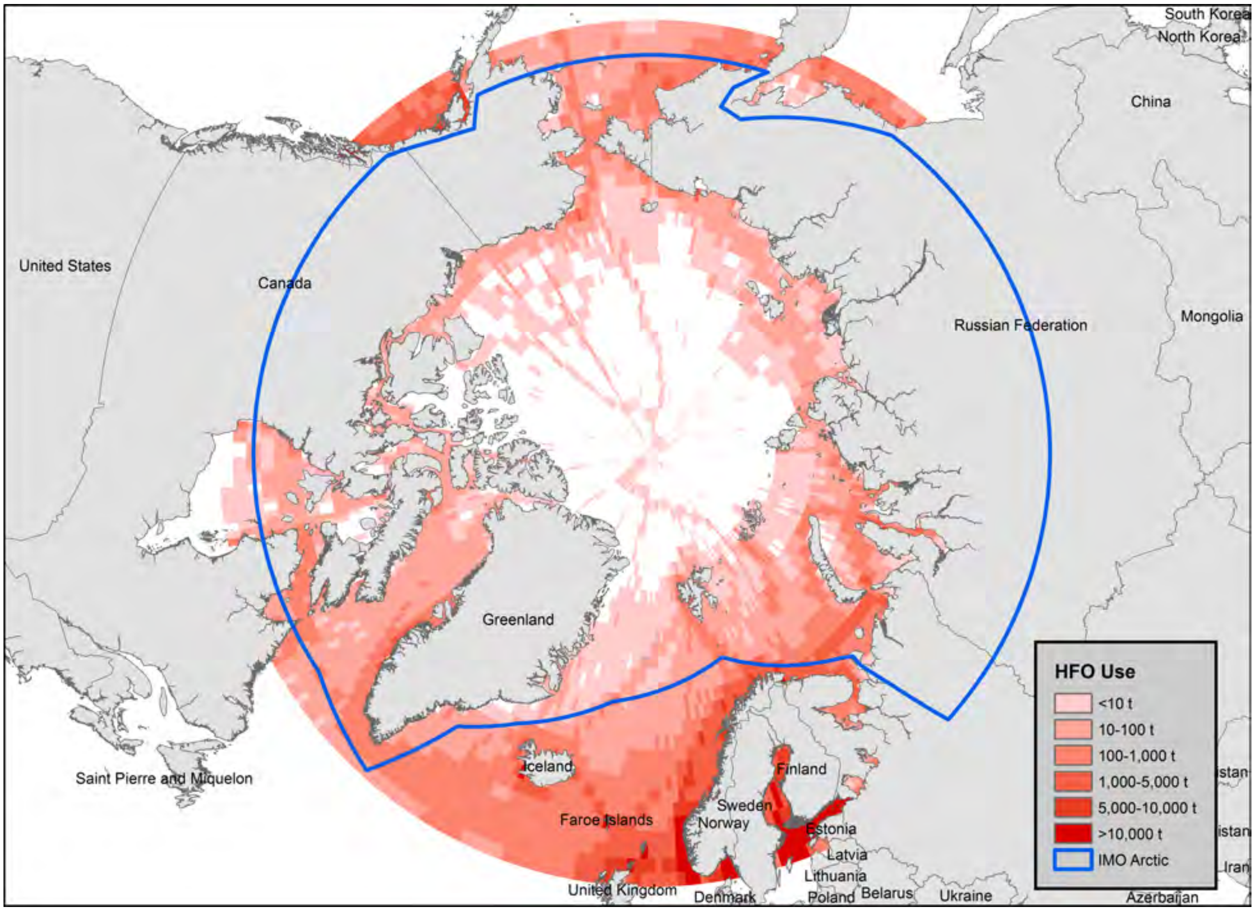
2.2 Marine Fuel Use in Arctic Shipping

2.2.1 HFO Use in Polar Code Arctic

Less than half of the vessels that transit the Polar Code Arctic burn HFO, but because heavy fuels are primarily used on larger vessels with bigger fuel tanks, more than 75% (by mass) of the fuel oil used in the Arctic is HFO (Comer et al., 2017; DNV, 2013a; DNV, 2013b). Bulk carriers, container ships, oil tankers, general cargo vessels, and – in some areas – fishing vessels all burn HFO along Arctic routes. While 75% of the fuel carried through the Arctic is HFO, it accounts for about 57% of the fuel burned by ships operating in the Arctic (Comer and Olmer, 2016; Comer et al.; 2017).

Recent trends show an increase in HFO carriage in the Arctic – from 400,000 tonnes in 2012 to 830,000 tonnes in 2015 (Comer et al., 2017; DNV, 2013a; DNV 2013b). The exposure from these transits, based on the number of transits and volume carried onboard, combined with projected increases in Arctic vessel traffic due to diminishing sea ice, increases the potential for HFO spillage in Arctic waters (Comer et al., 2017; Azzara et al., 2015).

Figure 2-1 shows HFO use by ships in the IMO Arctic based on 2015 data (Comer et al., 2017).


South Korea
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Russian Federation
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Saint Pierre and Miquelon
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IMO Arctic

Figure 2-1. HFO Use in Arctic during 2015 (Comer et al., 2017)

2.2.2 Canadian Arctic Shipping Traffic

Vessel traffic patterns in Canada's Arctic waterways are changing as sea ice conditions open new travel routes. Cruise ships and personal recreational boats are visiting previously inaccessible Arctic regions, alongside military ships, cargo traffic, and fishing boats. Most of the cargo ships operating in the Canadian Arctic call on one or more ports in the region; however, large cargo ships operating between Asian and European ports are also transiting northern sea routes.

The distance traveled by ships through the Canadian Arctic has increased significantly over time. During the 26-year period from 1990 through 2015, the distance traveled by ships through the Canadian Arctic nearly tripled from 364,179km to 918,266 km. The largest proportion of ship traffic in the region is from general cargo vessels and government ships (icebreakers and research vessels). Recreational vessels (private yachts and pleasure craft) represent the fastest growing vessel activity in the Canadian Arctic. Shipping routes include vessels serving mining operations as well as international transits along the northern and southern Northwest Passage routes (Dawson et al., 2018).

WWF-Canada analyzed Automated Information System (AIS) data to estimate the use of HFO by ships transiting the Canadian Arctic (Figure 2-2).

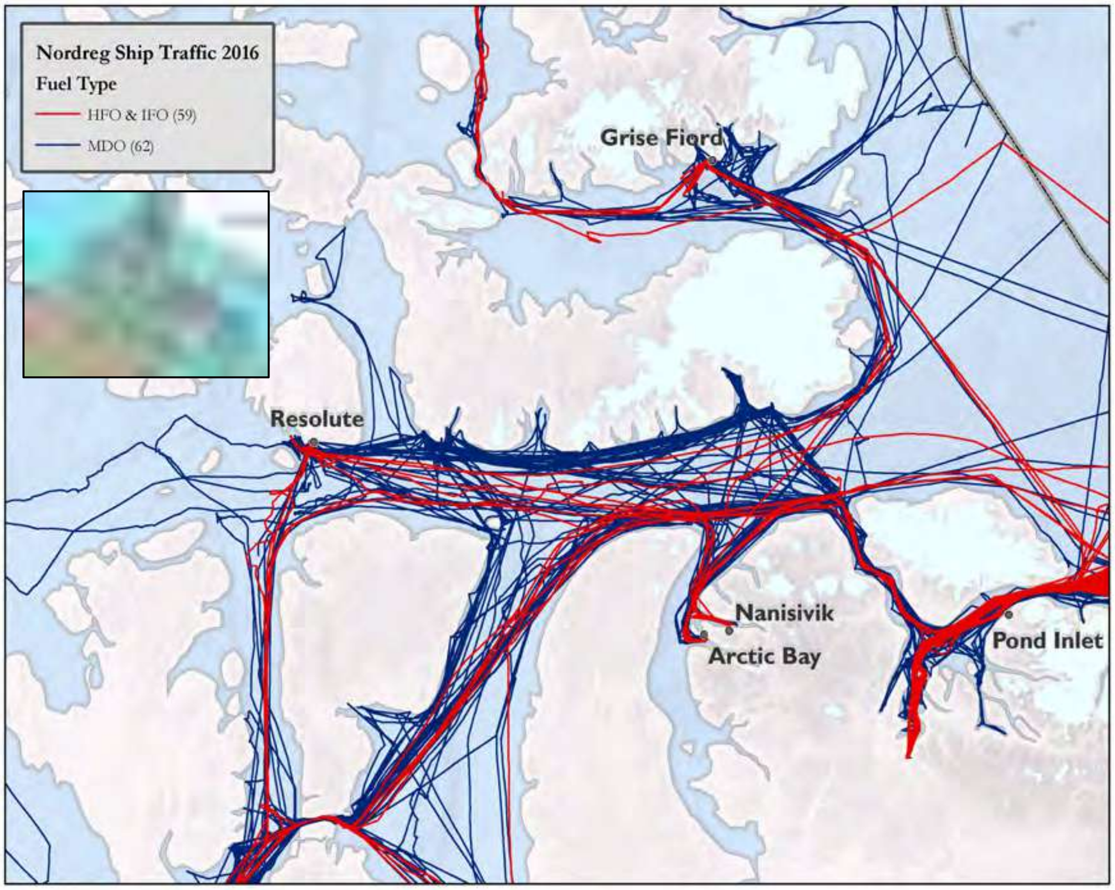

Figure 2-2. Fuel use by vessels operating in region of Canadian Arctic in 2016

Figure 2-2 shows the fuel use by vessels operating along the northern Northwest Passage route as well as local traffic among several Nunavut communities. Of the 123 transits mapped, approximately half of the vessels were burning a residual fuel (HFO or IFO), and the other half used distillate fuels (MDO).

2.2.3 Community Resupply Vessels

Canada's far northern communities lack rail or road infrastructure to support the movement of goods, so most cargo is delivered either by community resupply vessels (sealift) or airplanes. Sealift deliveries are typically an annual event, and one that is critical to supporting communities in Nunavut, Northern Quebec, and coastal areas of the Northwest Territories. Cargo rates for community resupply are already very high, and any factor that increases the operating costs for sealift operators could potentially increase shipping costs to communities that are already dealing with a high cost of living (Vard, 2016).

Due to the nature of the shipping route (ice conditions, short operating season), only a few shipping companies operate along northern resupply routes, and their vessels run on HFO (Vard, 2016). Figure 2-3 shows traffic routes for vessels burning residual fuel oils in Nunavut, based on 2016 AIS data. Bulk carriers, general cargo ships, and tankers all used HFO, with nearly 70% of the traffic made up of general cargo ships. All three types of vessels appear to have been traveling between communities, likely for resupply.

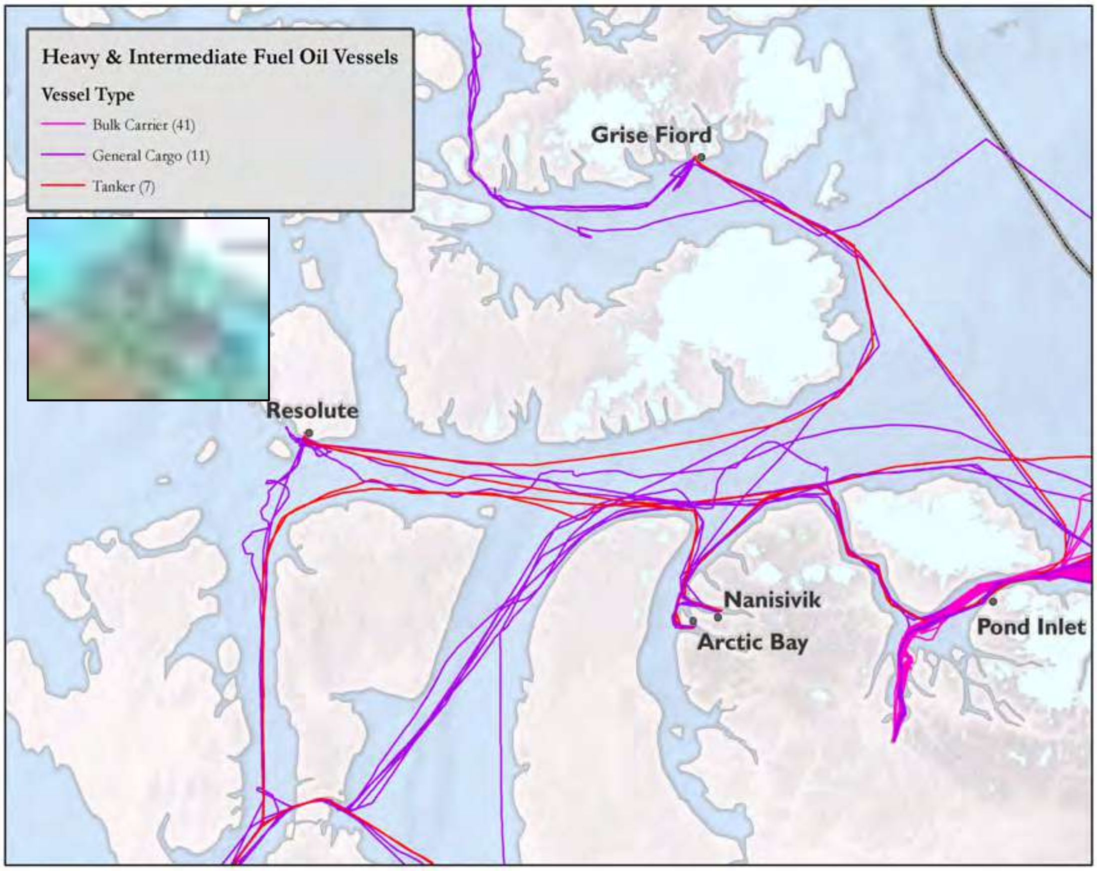

Figure 2-3. Vessels using heavy fuel oils in region of Canadian Arctic in 2016

2.3 Phasing out HFO Use and Carriage for Use by Ships Operating in the Arctic

The use of HFO as a marine fuel has diminished in many regions of the globe due to stricter international, national and port-level regulations and standards.

2.3.1 Existing Emission Standards Limit HFO Use in Many Regions

While the proposed phase out of HFO use and carriage for use is tied primarily to the potential impacts of an HFO spill in Arctic waters, there is a relatively long history of HFO regulations that are tied to air emissions. Air emissions from ships burning HFO contain more pollutants than emissions from burning distillate fuels. Of particular concern are sulphur, nitrogen oxide, and black carbon; all cause adverse impacts to human and environmental health.

International policies limiting the amount of sulphur emissions from marine fuels have been in place for over 20 years. In 1997, MARPOL Annex VI established a 4.5% sulphur cap. In 2008, the MEPC lowered the cap to 3.5% (effective 2012), and set a limit for 2020 of 0.5% sulphur. (FOEI et al., 2016). Beginning in 2015, the IMO designated certain areas in North America and Europe as Emission Control Areas (ECA), subject to a sulphur emissions cap of 0.1% (or equivalent control measures).[3] The North American ECA, which extends to 200nm offshore, incorporates the entire Pacific Coast and the Atlantic Coast as far north as the southern opening to Hudson Strait. Arctic regions are excluded from the existing ECAs.

In addition to the IMO designated ECAs, local and national authorities have established additional emission control areas in China, California, and the EU (CARB, 2017; Gard, 2014).

Compliance strategies for vessels facing sulphur emission control standards have been unfolding as new standards take effect. Available options for complying with emissions caps generally fall into one of three categories: (1) transitioning from high sulphur residual fuel oils to either distillate fuels (such as MGO) or low sulphur hybrid fuels; (2) retrofitting vessels to utilize alternative fuels like LNG; or (3) installing scrubber systems that reduce the level of sulphur in vessel air emissions to below 0.5%, allowing vessels to continue to burn residual oils. Other technologies, such as biofuels and water injection, are described in the literature but have not been widely adopted. (O'Malley et al., 2015)

A fourth option is not to comply at all, and based on a 2017 estimate of 8% non-compliance with ECA emission standards, industry experts estimate that non-compliance with the 2020 global sulphur standard could be as high as 15% (Gallagher, 2018; Leavens, 2018).

2.3.2 Existing and Proposed HFO Bans

Currently, there are only a few regions of the world's oceans where HFO use and carriage is prohibited; HFO bans exist in the AntArctic Ocean and in the Svalbard region of Norway (EPPR, 2017; IMO, 2011).

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[3] Prior to this, ECAs had been in place in the Baltic and North Seas with a 1% sulphur limit (MARPOL Annex VI Regulation 14).

Banning HFO use and carriage for use in the Arctic has been advocated for by European Parliament and some Arctic nations (European Parliament, 2017) for many years. In April 2018, an eight-nation coalition proposed to the IMO's MEPC an HFO ban for vessels operating in the Polar Code Arctic. The ban would take effect in 2021, with provision for delayed implementation (five years) for HFO-burning vessels that have fuel tank protections in place (IMO, 2018).

Eliminating the use of heavy fuel oils would not only achieve the global emissions standards, but would also eliminate the potential for a heavy oil spill. An Arctic HFO ban may influence how some vessels opt to comply with global sulphur standards, creating a disincentive for scrubber use on vessels that operate in the Arctic, which will likely lead to a more widespread use of low sulphur fuel oil or distillates.

For community resupply shipping in the Canadian Arctic, an HFO ban would require these vessels to switch to distillate fuels, as this is the only option that satisfies both the global sulphur emission standard and the Arctic HFO ban. Since the proposed HFO ban extends to both use and carriage for use of heavy fuel oils, sealift vessels would presumably not be allowed to have any HFO onboard, even if they had other measures in place to comply with the sulphur emissions cap for the portions of their journey south of 60°N. These scenarios presume that Arctic resupply vessels will be required to comply with both the global sulphur cap and the Arctic HFO ban, despite the fact that community resupply vessels that service northern communities are currently exempted from emission standards by the federal government when they transit through the North American ECA.

3 Estimating the Impacts of HFO Ban to Shipping Costs and Cost of Goods in Canadian Arctic

Any significant increases to the cost of goods would adversely impact the Arctic communities that already face a high cost of goods against limited economic opportunities. Several studies have estimated the cost to communities of an HFO ban based on the increases to shipping costs (Vard, 2016; Kalli et al., 2009; Martino et al., 2009; UNCTAD, 2010). The results have generally supported the concept that rising fuel prices lead to higher consumer costs, but the relationship between cost of goods and fuel costs is complex and calculated estimates for future price scenarios vary based on the assumptions and coefficients applied.

This section considers the relationship between fuel prices and the cost of specific consumer goods in Canadian Arctic communities by exploring the relationship between actual fuel costs and price of goods over recent years, and modeling the potential impacts of an HFO ban to the cost of goods along a specific Arctic resupply route.

3.1 Fuel Costs for Northern Community Resupply

3.1.1 Fuel Cost Variability and Ship Operating Costs

The price of fuel is one of many operating costs that affect the cost of transporting goods over northern sea routes. Other costs include labor, port costs, materials and repair, overhead and other indirect costs, and insurance. Determining the contribution of fuel costs to journey costs depends upon the price of fuel, but is also influenced by market trends in the price of consumer goods and commodities, fuel consumption rates, and cargo capacities of individual vessels (Martino et al., 2009).

Marine fuel prices are set daily at ports around the world and are influenced by a complex web of economic factors and market forces. Figure 3-1 shows a daily fuel cost summary from May 8, 2018, reflecting the daily variations across individual ports and global averages from major ports for two marine fuels (IFO 380 and MGO) for this particular day (Ship and Bunker, 2018).

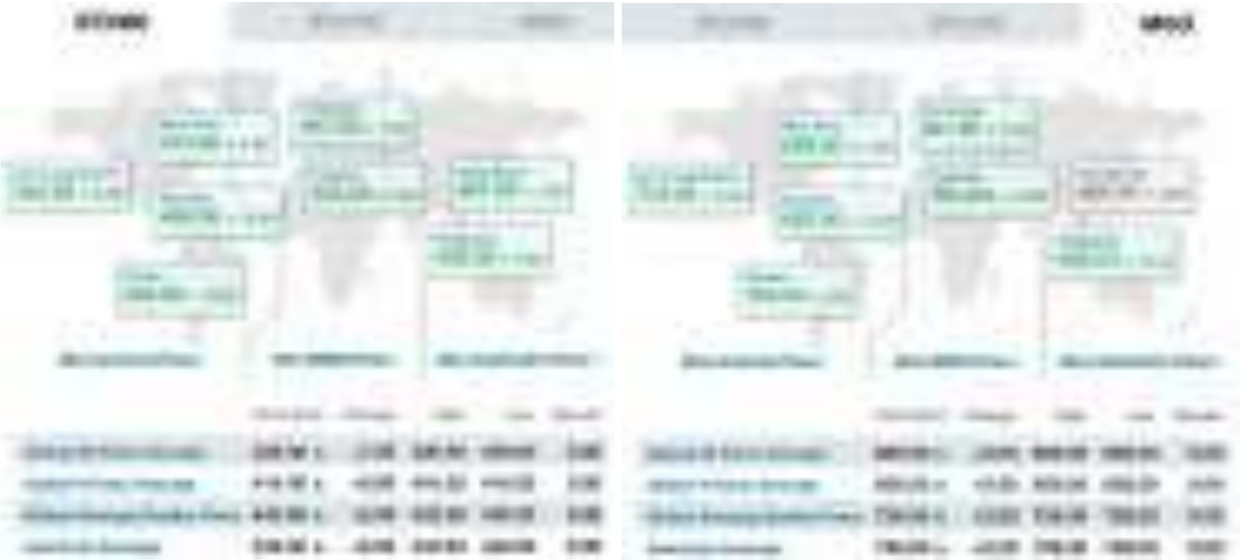

Figure 3-1 Example of daily marine fuel price for IFO 380 (left) and MGO (right) at select ports worldwide in U.S. dollars (Source: shipandbunker.com)

3.1.2 Montreal Fuel Price Variability

To characterize the variability in marine fuel pricing that would impact Arctic resupply vessels, fuel price data for Montreal was compiled for a 50-month time period from November 2013 through December 2017. Daily price data for two types of marine fuels – a residual oil (IFO 380) and a distillate (MGO) were compiled and then averaged across each calendar month. The data were then analyzed to evaluate overall price trends as well as the cost spread between the two fuel types. Figure 3-2 summarizes this information, showing an overall price reduction trend for both the higher-priced MGO and lower-priced IFO 380 since November 2013. The figure highlights the spread between prices at several points in time.

The price spread in Figure 3-2 was calculated both as the U.S. dollar amount difference per metric ton (tonne) of fuel oil and as the percentage difference between the price of IFO 380 and the price of MGO. The cost spread ranged from a high of $522/tonne in February 2014 to a low of $268/tonne in September 2016. The highest percentage spread occurred in January 2016, when the price of MGO ($526/tonne) cost 3.47 times more than IFO 380 ($152/tonne). The lowest percent spread occurred in November 2013, when the price of MGO ($1,058/tonne) cost 1.62 times more than the cost of IFO 380 ($654/tonne). Because of the way the spread percentage was calculated, it was highest during months when IFO 380 was at its least expensive.

Throughout 2017, the spread between MGO and IFO 380 was relatively stable by both measures, with a price spread of around $350 between MGO (which stayed in the $600/tonne range) and IFO 380 (which stayed in the $250 range). Based on Montreal prices, MGO cost about 1.5 times as much as IFO 380 throughout 2017.

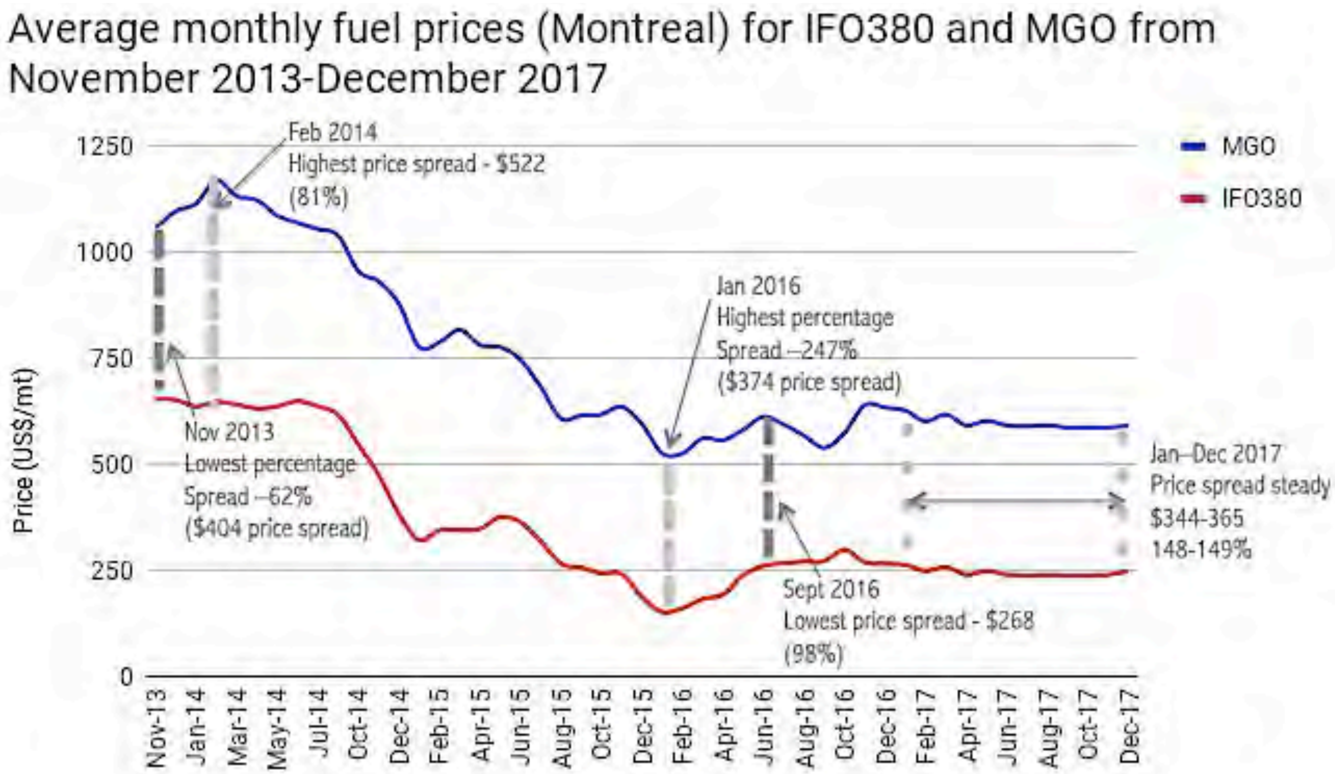

Figure 3-2. Average monthly prices for IFO-380 and MGO in Montreal from November 2013 through December 2017 (Sources: Bunkerworld and Ship and Bunker)

Over the roughly four years of monthly fuel price data, the highest price for IFO 380 ($654 in November 2013) was actually higher than the lowest cost for MGO ($526 in January 2016).

Essentially,[4] the fuel cost for a vessel burning MGO in January 2016 would have been lower than the fuel costs for a vessel burning IFO 380 in November 2013. In fact, the average monthly MGO prices in Montreal were lower than the average November 2013 price for IFO 380 every month from August 2015 through December 2017.

The fuel price data used to generate Figure 3-2 is included in Appendix A.

3.1.3 Predicting Future Marine Fuel Prices

Distillate fuels cost more than residual fuels, and while the fluctuations in both prices and price differentials have varied significantly from 2013-2016, data from 2017 show that both fuel prices and the spread between IFO 380 and MGO have held relatively steady. Data from the first four months of 2018 (not shown) indicate that IFO 380 prices have fluctuated from U.S.$382 to $440/tonne and MGO prices have varied from $645 to $722/tonne. The prices of both IFO and MGO appear to be slowly rising over 2017 prices, with slightly more variability in the price spread, but nothing approaching the $512 difference between IFO 380 and MGO prices in February 2014.

In addition to the changes over time to both fuel prices and the IFO/MGO spread, there are significant interdependencies among international shipping policies, ship operations, and refinery operations that also influence pricing. Impending policy initiatives like the global sulphur cap and potential Arctic HFO ban will eventually influence how refineries allocate their feed stocks to create and maintain inventories. Most analysts agree that there will be a period of volatility ahead of the 2020 sulphur cap, but that eventually the markets will settle out (Gallagher, 2018; Leavens, 2018). One study suggested that global refinery capacity is sufficient to meet the increased demand for distillate and low-emitting fuels in 2020 (CE Delft, 2016).

Nonetheless, the long-term price differentials between HFO, low sulphur residual blends and distillate fuels are a source of uncertainty. Present differentials between residual oils, residual hybrid blends, and distillates are still high, but there have been some suggestions that changing demands in the coming years will change this dynamic. Figure 3-3 shows one estimate from a 2017 working paper published by the International Council on Clean Transportation (ICCT). The ICCT study shows that while distillate oils are expected to remain as the most expensive fuels, the price difference between HFO and distillate fuels will be lower in the future than in 2015, and that the price difference between low sulphur residual blends and distillate fuels is expected to narrow considerably. Other analysts have pointed to reduced demand for HFO as a factor that will drive residual fuel prices down and increase the difference between distillate and residual fuels (Healing, 2018).

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[4] This example does not consider inflation or fuel efficiency/consumption for the two different fuel types; it is presented to emphasize that the potential price of using MGO is within the range of past fuel prices for IFO 380.

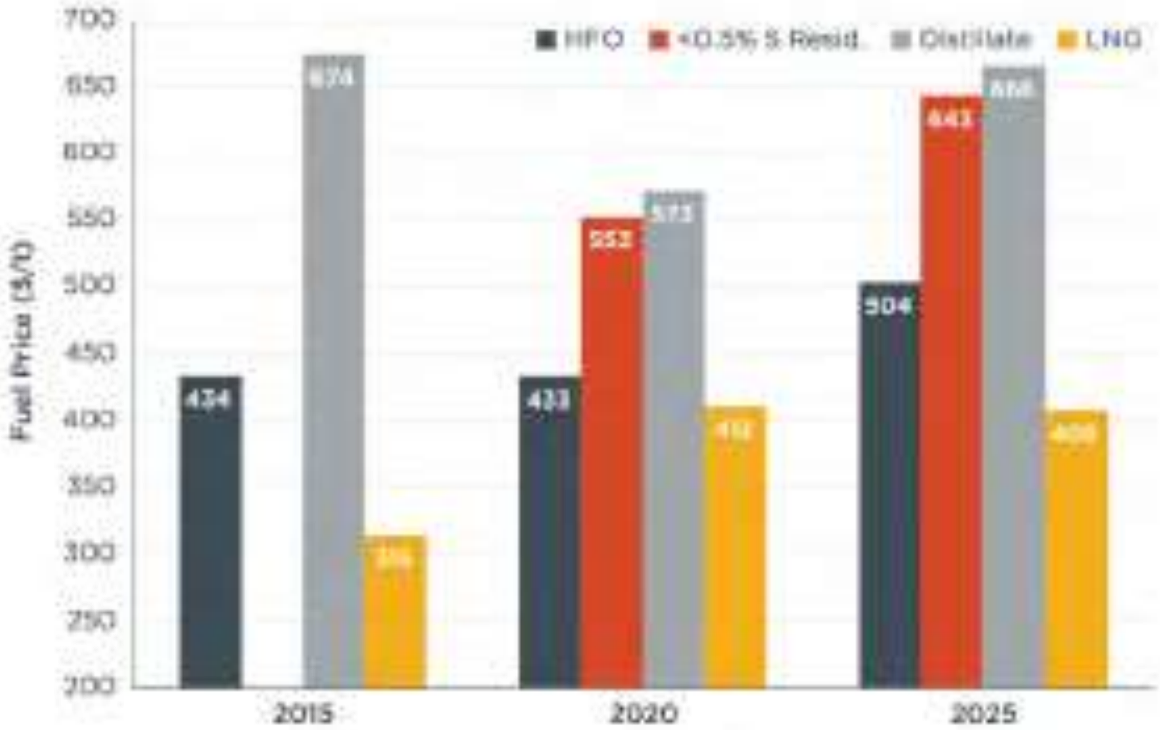

Figure 3-3. Estimated price of marine fuels in 2020 and 2025 (Roy and Comer, 2017)

3.2 Relationship between Fuel Prices and Cost of Goods in Nunavut Communities

3.2.1 Fuel Prices

Community resupply ships operating in the Canadian Arctic burn residual oils, which may include IFO 180, IFO 380, or bunker C oil. While marine fuel prices fluctuate daily, the shipping season for community resupply is condensed to the ice-free summer months. Montreal marine fuel price data from July of each calendar year from 2014-2017 were used as an index for fuel prices, as summarized in Table 3-1. Change in price from previous years is shown as a percentage of cost change from one year to the next. In this case, IFO 380 prices fell each year, with the most significant drop from 2014 to 2015.

Table 3-1. Average July Prices for IFO 380 in Montreal, 2014-2017

Average July Prices for IFO 380 (Montreal) by Year		
Year	**IFO Price**	**Change from previous year**
2014	$637/tonne	n/a
2015	$319/tonne	-49%
2016	$267/tonne	-16%
2017	$238/tonne	-11%

3.2.2 Food Prices

To explore the relationship between fuel prices and the price of goods in Nunavut communities, price data from the Nunavut Bureau of Statistics[5] were compiled from 2014 through 2017. Price survey data for food and non-food items is compiled annually through community surveys to evaluate changes over time and across communities. The Bureau of Statistics also compares the price of goods in Nunavut communities to those in the rest of Canada. Compiled data from March 2016 shows that on average, consumers pay about twice as much for goods in Nunavut communities as they do in the rest of Canada (NBS, 2018).

Data is available for individual food and non-food items, food baskets (consisting of a standard assortment of commonly purchased items), and per-kg or liter costs for specific food items. To compare changes in fuel prices to changes in cost of goods year-over-year, food basket cost[6] averages for three regions of Nunavut – Baffin, Kivalliq, and Kitikmeot – were compiled for 2014 through 2017, as summarized in Table 3-2 (NBS, 2018).

From 2014 to 2015, fuel basket prices increased across all regions, ranging from 3.4% to 3.8%. From 2015 to 2016, prices increased in the Baffin and Kivalliq regions by roughly 5-7%, but decreased in Kitikmeot by 1%. In 2017, only Kivalliq saw a price increase over 2016 food basket prices; prices in Baffin and Kitikmeot both fell by about 2%. By comparison, the consumer price index rose by 1.1-1.4% from 2014 to 2015 and 2015 to 2016 respectively.

Table 3-1. Average Food Basket Prices by Nunavut Regions by Year, Compared to Consumer Price Index Annual Changes

Average Food Basket Prices for Nunavut Regions by Year							Canada CPI Annual Change
Year	Baffin Region		Kivalliq Region		Kitikmeot Region		
	Cost (CAD)	Change from Prior Year	Cost (CAD)	Change from Prior Year	Cost (CAD)	Change from Prior Year	
2014	$160.86	n/a	$144.80	n/a	$165.81	n/a	n/a
2015	$167.03	3.8%	$149.66	3.4%	$182.75	10.2%	1.1%
2016	$178.30	6.7%	$157.15	5%	$180.90	-1%	1.4%
2017	$174.61	-2.1%	$160.38	2.1%	$177.30	-2%	n/a[7]

3.2.3 Comparison

Figure 3-4 plots the changes to average annual IFO 380 prices against the changes to average regional food basket prices in Nunavut. It is not a rigorous analysis of the relationship between food costs and fuel prices; it is presented to illustrate a general lack of correlation based on the data examined. This does not mean that fuel prices and food costs are unrelated; however, it shows clearly that the significant variability in fuel prices year-to-year, particularly the nearly 50% reduction in the cost of IFO 380 from 2014 to 2015, does not correspond to a significant reduction in the cost of food items. In fact, the food basket survey shows that food prices in all three Nunavut regions increased from 2014 to 2015, against significant declines in fuel prices.

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[5] http://www.stats.gov.nu.ca/en/Economic%20prices.aspx

[6] Food basket items include milk, margarine, eggs, frozen corn, frozen French fried potatoes, frozen pizza, soda crackers, canned salmon, canned baked beans, canned cream of mushroom soup, instant rice, spaghetti noodles, macaroni and cheese dinner, oatmeal, white flour, baby food in jars, white bread, apples, bananas, carrots, potatoes, ground beef, pork chops, and wieners.

[7] Data available through 2016 on Nunavut Bureau of Statistics website.

The data available through Nunavut Statistics does not equivocally state whether all items in the food basket are transported by sealift. However, the reality that marine fuel prices do not impact goods that are transported to communities through other means than sealift is an important point that sometimes gets lost in the assessment of the potential impact of marine fuel costs to consumer goods in the north. If the result of an HFO ban was, in fact, an increase in the cost of goods – which is open to further exploration – these impacts would be limited to those consumer goods transported by sealift.

The comparison of fuel prices and food costs does not factor in other considerations that might influence pricing, such as retailer markups.

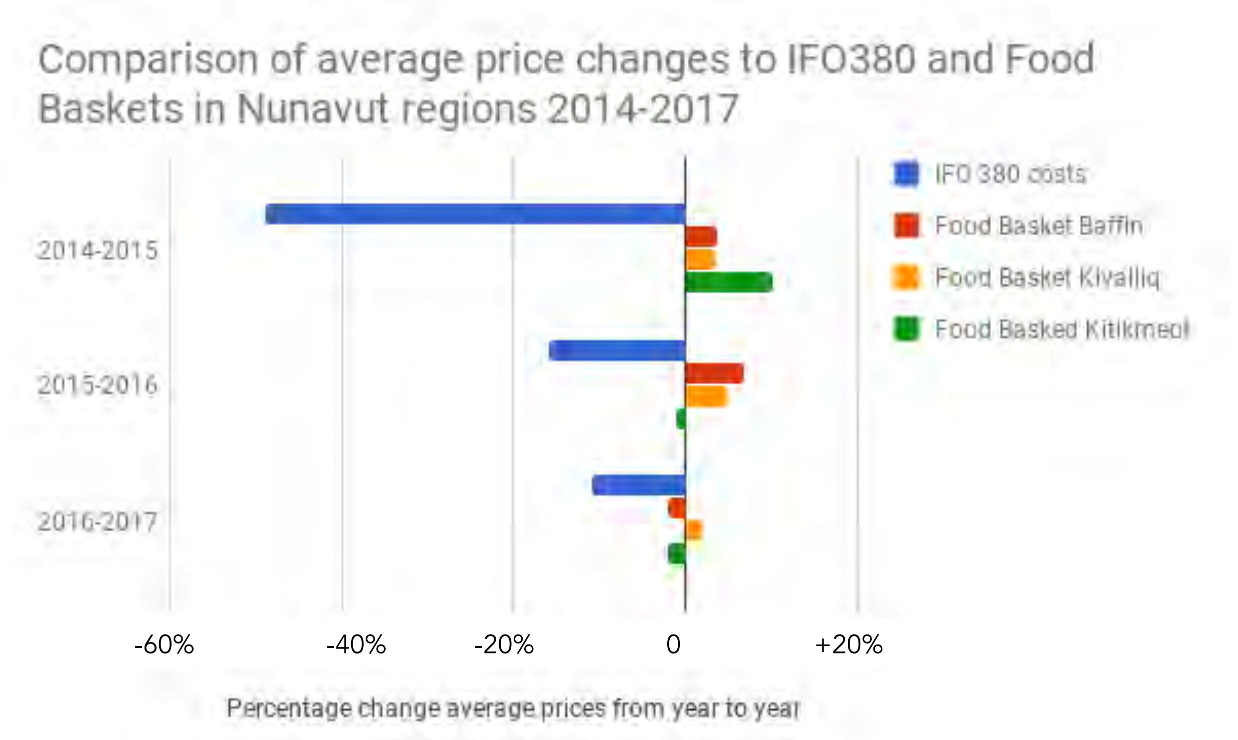

Figure 3-4. Comparison of average annual changes to fuel prices and food basket costs in Nunavut, 2014-2017

3.3 Estimating Potential Impacts of HFO Ban to Cost of Goods

While historical data does not show a clear correlation between marine fuel costs and the cost of food items in Nunavut, it is still possible that a ban on the use and carriage for use of HFO in the Arctic would increase fuel costs to shipping companies, and that these costs would be passed along to consumers. Even with current MGO prices lower than historic IFO 380 prices and projections suggesting the cost differential will decline over time (Figure 3-3), MGO prices in 2018 are still about one-and-a-half times more expensive than IFO 380 (see Figure 3-1).

A cost model[8] was developed to evaluate how increased fuel costs to ships operating along Canadian Arctic community resupply routes might influence the costs of goods transported by sealift, based on the fuel cost per tonne incurred by a vessel along a specific route, as well as past and predicted future marine fuel prices.

3.3.1 Relationship between Past Fuel Cost and Food Prices in Nunavut

To estimate the fuel cost per tonne of cargo transported, several community resupply vessel routes were evaluated, along with vessel-specific factors to estimate fuel usage and cargo capacity. Table 3-2 summarizes the input factors for three of the vessel routes evaluated. A different shipping company operates each vessel. Vessel A was selected as the basis for further analysis.

Table 3-2. Community resupply routes, vessel characteristics, and fuel use assumptions

Vessel	Maine Engine power[9]	DWT[10]	Max speed[11]	Fuel use per kWh[12]	Route	Total distance[13]
Vessel A	5,430 kW	12,760	14.5 kts (13.7 kts service)	205 g/kWh	Valleyfield – Pangnirtung – Iqaluit - Coral Harbour - Chesterfield Inlet - Rankin Inlet – Arviat - Whale Cove - Deception Bay - Valleyfield	11,010 km (433 hours at sea)
Vessel B	5,400 kW	12,776	14 kts (13.3 kts service)	195 g/kWh	Ste. Catherine – Matane – Kuujjuaq – Salluit - Repulse Bay - Rankin Inlet – Churchill – Arviat - Whale Cove - Chesterfield Inlet - Rankin Inlet - Coral Harbour – Kangiqsujuaq – Becancour – Ste. Catherine	11,013 km (448 hours at sea)
Vessel C	6,600 kW	17,034	14.5 kts (13.7 kts service)	205 g/kWh	Lewisport-Iqaluit-Cape Dorset-Coral Harbour-Arviat-Whale Cove-Rankin Inlet-Baker Lake-Resolute-Bathurst Inlet-Kugluktuk-Lewisport	13,902 km (547 hours at sea)

To estimate the fuel cost per tonne of cargo incurred by the ship operator, average monthly fuel costs from July of 2014 through 2017 were used, adjusted to 2015 U.S. dollars.[14] The fuel costs for Vessel A on the route shown in Table 3-2 was estimated for each year based on July IFO 380 prices and the estimated fuel usage derived from route distance, travel time, and estimated fuel usage. The resulting total fuel cost was then divided by the tonnage of the vessel to estimate the cost of fuel per tonne of mass in a fully loaded ship. Table 3-3 shows the inputs and formula for fuel consumption estimation for Vessel A in this scenario.

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[8] Northern Economics, Inc. developed a spreadsheet model with input from Nuka Research and Planning Group, LLC. Data sources are cited in text, and shipping experts and operators, on condition of anonymity, validated certain assumptions and inputs.

[9] Source: Seaweb.

[10] Dead Weight Tonnage, which is a measure of the ship's carrying capacity by weight (inclusive of cargo, fuel, and ship's stores).

[11] Source: Seaweb.

[12] From MEIT for a 4-stroke engine, built before 2000.

[13] Calculated using Google Earth.

[14] The inflation calculator at https://www.officialdata.org/ was used for all adjustments.

Table 3-3. Estimating fuel consumption for Vessel A over specified route

Vessel A Fuel Consumption Estimate over Specified Route									
Maine Engine power[15]	**DWT**	**Service speed[16]**	**Engine Load**	**Power demand per hour**	**Fuel use per kWh[17]**	**Hourly fuel consump-tion**	**Total distance for Route[18]**	**Operating hours[19]**	**Fuel used along route[20]**
5,430 kW	12,760	13.7 kts	0.85	4,616 kW/h	205 g/kWh	0.95 t/h	11,010 km	433 h	410 t
Formula to estimate fuel use: *(Main Engine Power) * (Engine Load) * (Fuel use per kWh)/ (10^6 g fuel/tonne fuel) * (operating hours) = fuel use*									

Fuel Cost Estimates Based on July IFO 380 prices from 2014 to 2017 (in 2015 USD)								
	Fuel Prices[21]		**Total Fuel Costs per Trip**		**Fuel Costs per km[22]**		**Fuel Costs per tonne[23]**	
	IFO 380	**MGO**	**IFO 380**	**MGO**	**IFO 380**	**MGO**	**IFO 380**	**MGO**
2014	$648	$1056	$265,680	n/a	$24	n/a	$21	n/a
2015	$319	$683	$130,790	n/a	$12	n/a	$10	n/a
2016	$264	$586	$108,240	n/a	$10	n/a	$8	n/a
2017	$230	$571	$94,300	$234,110	$9	$21	$7	$18

The total fuel costs associated with Vessel A's Nunavut community resupply run steadily declined from roughly $266,000 in 2014 to $94,000 in 2017; this is approximately a 65% reduction in fuel costs over the three-year time span. Spreading fuel costs across the journey, either by distance or by cargo weight, provides perspective on the incremental cost increases over the course of a trip. Because of the decline in IFO 380 prices during this time, the fuel cost per tonne fell from $24 (2015 U.S.D) in 2014 to $9 in 2017; the per-km fuel costs dropped from $21 in 2014 to $7 in 2017. Because both calculations are tied to total fuel costs, the total cost reduction is still approximately 65%.

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[15] Source: Seaweb.

[16] Estimated for vessel based on 85% maximum engine load and max speed of 14.5 kts.

[17] From MEIT for a 4-stroke engine, built before 2000.

[18] Calculated using Google Earth.

[19] Derived from route distance and service speed.

[20] Calculated based on fuel consumption and hours at sea, assuming that a vessel traveling at service speed uses about 85% of the ship's main engine power.

[21] Average July price (Montreal) converted to 2015 US dollars.

[22] (Total fuel costs)/(Total distance for route) = cost per km (rounded to nearest dollar)

[23] (Total fuel costs)/(Deadweight tonnage) = cost per tonne (rounded to nearest dollar)

To explore whether there was a correlation between fuel cost per tonne and the cost by weight of shelf-stable food items that may have been included in community resupply, past food prices were analyzed, based on published price data from the NBS.[24] Price per kilogram for four food items (skim milk powder, spaghetti noodles, canned pink salmon, and peanut butter) were compiled for 2015-2017[25] for three communities along the Vessel A resupply route: Pangnirtung, Chesterfield Inlet, and Coral Harbour, as shown in Table 3-4.

Table 3-4. Price of Food Items per kg in Three Nunavut Communities

Food Item	**Nunavut Community**	**Price of food items per kg**		
		2015	**2016**	**2017**
Skim milk powder (500g)	Pangnirtung	$22.70	$22.75	$22.78
	Chesterfield	$18.99	$18.35	$18.75
	Coral Harbour	$15.99	$24.58	$21.98
Spaghetti noodles (900g)	Pangnirtung	$8.11	$8.25	$7.52
	Chesterfield	$10.15	$10.17	$10.17
	Coral Harbour	$6.24	$7.82	$8.51
Canned pink salmon (213g)	Pangnirtung	$21.24	$29.06	$26.90
	Chesterfield	$16.84	$13.10	$19.44
	Coral Harbour	$19.18	$24.93	$32.19
Peanut butter (1kg)	Pangnirtung	$12.72	$11.33	$10.89
	Chesterfield	$10.99	$9.12	$10.99
	Coral Harbour	$9.94	$12.49	$14.85
Average across community and food item		**$14.42**	**$16.00**	**$17.08**

Food prices were averaged by community, and then by year, and plotted against fuel costs per vessel tonnage. Figure 3-5 shows no apparent correlation between fuel cost reduction and per-kg food prices, which is consistent with the lack of correlation between food basket costs and fuel prices (Figure 3-4). In other words, while IFO 380 prices fell nearly 65% from 2014 to 2017, the average cost of select food items in communities increased by about 15%.

The apparent lack of correlation between past IFO 380 costs and past food prices does not necessarily mean that these costs are unrelated, as there are many complexities involved in food pricing beyond the scope of this report. Shipping companies have access to internal data and analysis that would better describe the influence of fuel costs on the price of goods transported by sealift. This is an issue for further exploration as Canada attempts to understand the impact of an HFO ban to sealift transport costs.

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[24] http://www.stats.gov.nu.ca/en/Economic%20prices.aspx

[25] Price per kg data was not available for 2014.

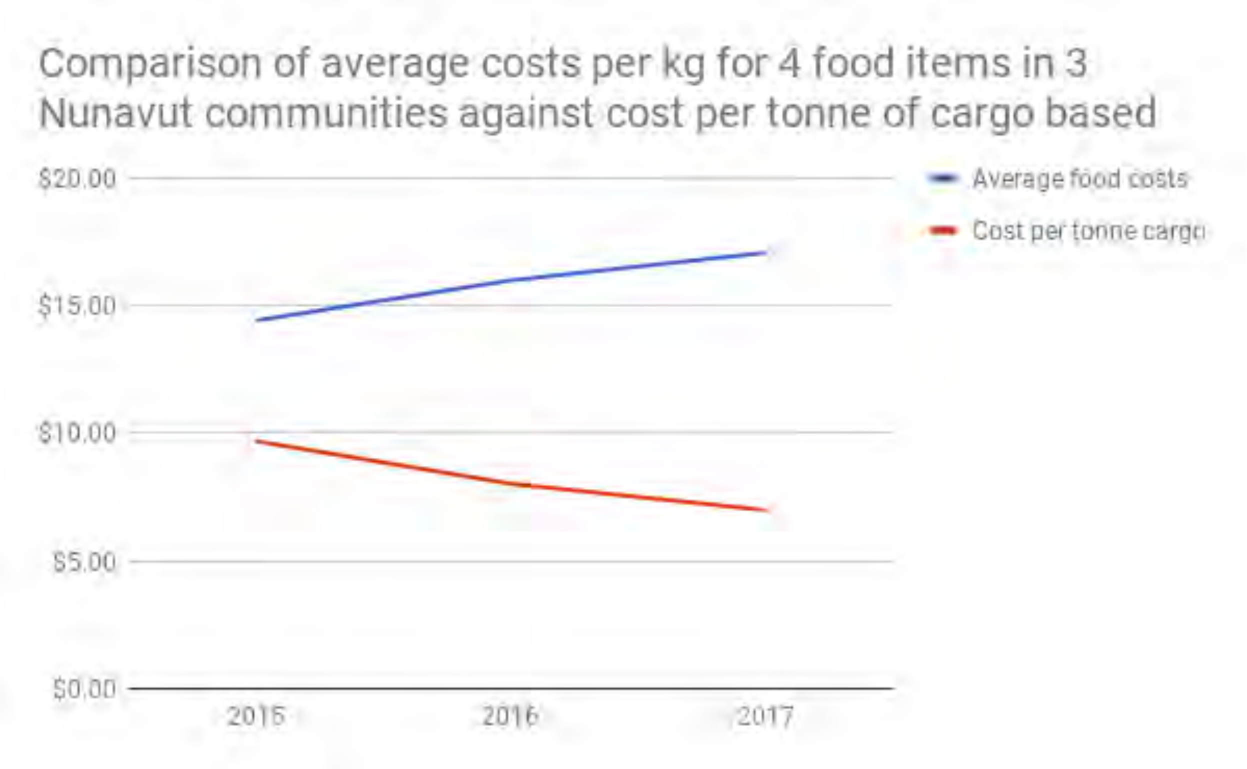

Figure 3-5. Comparison of cost per kg of four shelf-stable food items in three Nunavut communities served by Vessel A, compared with fuel cost per tonne of cargo transported on that vessel along a route serving the three communities

3.3.2 Estimating Costs of Fuel Switching Based on Increases to Per-tonne Cargo Costs

To estimate the per-tonne impact for cargo transport based on increased fuel costs associated with switching from IFO 380 to MGO, actual fuel price data from 2017 was compared to projections for 2020 and 2025 (based on Roy and Comer, 2017). All costs were adjusted to 2015 U.S. dollars. Table 3-5 shows the average Montreal fuel costs for MGO and IFO 380 for 2017 (entire year average), and the 2020 and 2025 estimates, applied to the Vessel A route (Table 3-2) to estimate the cost difference per kilometer and per tonne of cargo transported in this scenario.

Table 3-5. Fuel cost per trip, kilometer, and tonne cargo for Vessel A operating along Nunavut resupply route

Fuel Price Scenarios	Fuel price per tonne		Fuel cost per trip (Vessel A)		Fuel cost per kilometer traveled		Fuel cost per tonne cargo		Cost difference between IFO and MGO	
	MGO	IFO 380	MGO	IFO 380	MGO	IFO 380	MGO	IFO 380	Per tonne	Per kg
2017	$578	$237	$236,980	$97,170	$21.52	$8.83	$18.57	$7.62	**$10.96**	**$0.011**
2020	$573	$443	$234,930	$177,530	$21.34	$16.12	$18.41	$13.91	**$4.50**	**$0.004**
2025	$666	$504	$273,060	$206,640	$24.80	$18.77	$21.40	$16.19	**$5.21**	**$0.005**

The cost per tonne difference between MGO and IFO 380 declines significantly, based on the predicted future prices, which reflect changing global marine fuel supply as sulphur emission standards come into force in 2020. This transfers to reduced fuel costs per vessel trip, which can be broken down for this particular vessel route based on both distance traveled and cargo weight. Figure 3-6 shows how the fuel price changes and predicted decrease in future price spreads impact the cost per kilometer for Vessel A traveling 11,010 km on the community resupply route shown in Table 3-2.

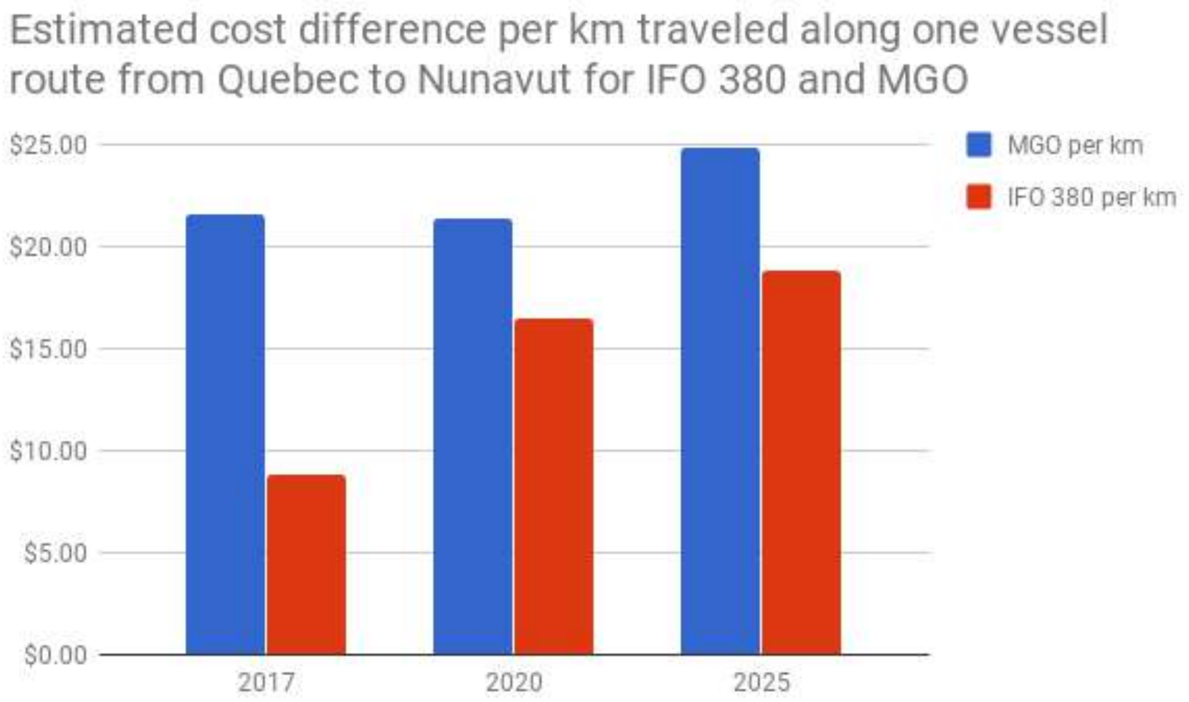

Figure 3-6. Cost per km traveled based on fuel switching at 2017, 2020, and 2025 fuel prices (2015 U.S. dollars)

Figure 3-7 shows the estimated cost per tonne increases along the same resupply route based on actual 2017 fuel prices and estimated future prices (all expressed in U.S. 2015 dollars), assuming the vessel is loaded to capacity (12,760 deadweight tonnes). Based on 2017 prices, the increased cost of using MGO rather than IFO 380 along this particular resupply route would be more than double (Table 3-5), but when this cost is spread across the full vessel load, it increases the cost of transporting one tonne of cargo by about $11. If the price difference between IFO 380 and MGO declines as predicted (Roy and Comer, 2017), by 2020, the increased per-tonne cost of using MGO is about $4.50. Converted to 2018 Canadian dollars,[26] the difference is still less than $12/tonne based on 2017 prices, and less than $5/tonne for predicted 2020 prices.

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[26] The following calculator was used to convert 2015 US dollars to 2018 US dollars. https://www.officialdata.org/2015-dollars-in-2018 An exchange rate of 1.3 Canadian to US dollars was applied based on online rates from May 26, 2018.

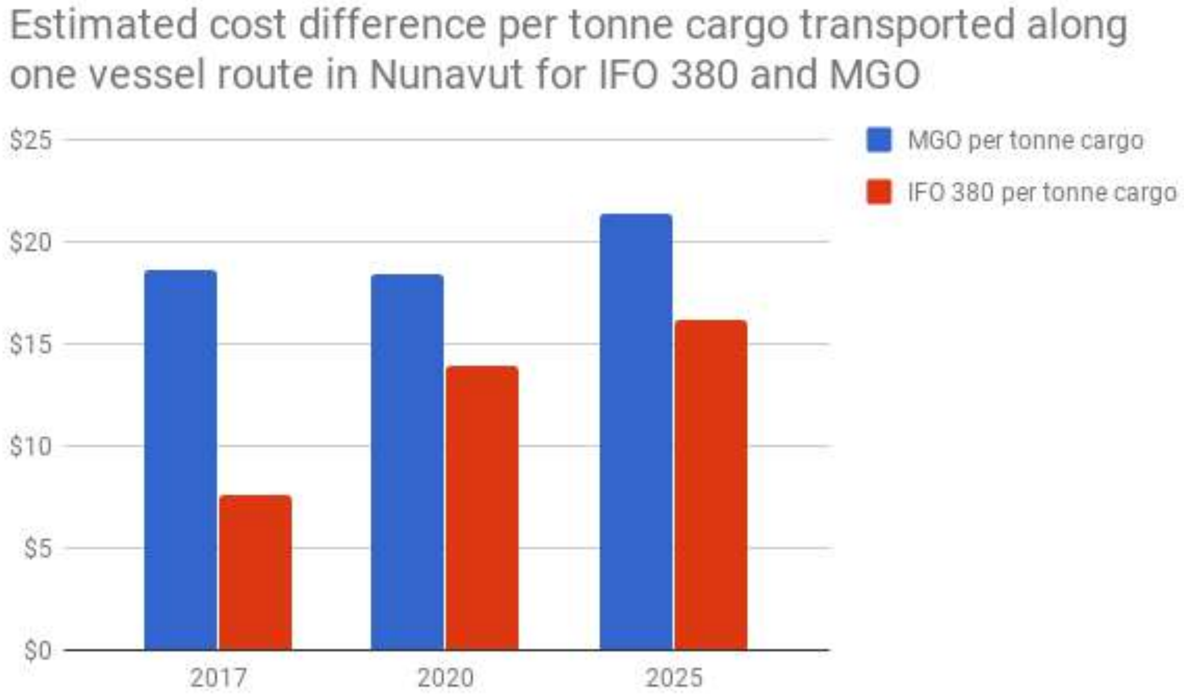

Figure 3-7. Cost per tonne cargo transported based on fuel switching at 2017, 2020, and 2025 fuel prices (2015 U.S. dollars)

If these costs were spread further, the per-kg price difference resulting from an HFO ban (presuming vessels switch from IFO 380 to MGO) would be just over $0.01/kg based on 2017 actual fuel costs. If the price difference decreases as predicted, the per-kg increase to cargo transportation costs for fuel switching is about a half a cent in 2020 and beyond.[27]

Considering the incremental cost impacts of fuel switching on a per-kilometer or per-kilogram cargo basis provides additional context for considering the trade-offs associated with replacing HFO with less polluting fuels. Looking at 2017 as an example, the price of MGO was more than double the price of IFO 380. But in the context of a community resupply trip along an existing route in Nunavut, based on the maximum cargo capacity of an existing resupply ship, the net effect of doubling fuel costs to the per-kg cost of transporting goods is about a one-cent increase. This estimate could be refined or adjusted if additional information was available about cargo loads and pricing structure, but at face value it supports the observation that the cost of goods are minimally effected by fuel price changes.

Table 3-4 carries the food item costs shown in Table 3-3 forward, but also shows what 2017 prices might have been if community resupply Vessel A had been burning MGO rather than IFO 380 ($0.01/kg as calculated above). Even if fuel prices had doubled due to a switch from IFO 380 to MGO, a family purchasing one kilogram of skim milk powder in Pangnirtung might have paid $22.79 rather than $22.78 if the fuel cost difference were spread to a per-kg cargo cost based on one sealift vessel route.

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[27] These are converted from 2015 US dollars to 2018 Canadian dollars using the same method as above.

In order to accurately estimate the potential impacts of an Arctic HFO ban on the cost of goods in Canadian Arctic communities, more information is needed about the relationship between fuel costs and sealift prices. Refined estimates of future price differences between IFO 380 and MGO will also inform estimates of cost-of-good impacts from fuel switching.

Table 3-4. Price of Food Items per kg in Three Nunavut Communities for 2015-2017, with projected costs based on increase from IFO 380 to MGO (2017 actual fuel cost data)

Food Item	Nunavut Community	Price of food items per kg (actual as reported by NBS)			MGO price
		2015	2016	2017	2017
Skim milk powder (500g)	Pangnirtung	$22.70	$22.75	$22.78	$22.79
	Chesterfield	$18.99	$18.35	$18.75	$18.76
	Coral Harbour	$15.99	$24.58	$21.98	$21.99
Spaghetti noodles (900g)	Pangnirtung	$8.11	$8.25	$7.52	$7.53
	Chesterfield	$10.15	$10.17	$10.17	$10.18
	Coral Harbour	$6.24	$7.82	$8.51	$8.52
Canned pink salmon (213g)	Pangnirtung	$21.24	$29.06	$26.90	$26.91
	Chesterfield	$16.84	$13.10	$19.44	$19.45
	Coral Harbour	$19.18	$24.93	$32.19	$32.20
Peanut butter (1kg)	Pangnirtung	$12.72	$11.33	$10.89	$10.90
	Chesterfield	$10.99	$9.12	$10.99	$11.00
	Coral Harbour	$9.94	$12.49	$14.85	$14.86
Average across community and food item		**$14.42**	**$16.00**	**$17.08**	**$17.09**

4 Estimating the Impacts of an Arctic HFO Spill

The commodity costs associated with the increased price of distillate fuels over residual oils is one aspect of community impacts, but the price of goods is not the only consideration. Oil spills from vessels operating in Arctic waterways – whether community resupply vessels, cruise ships, or large freight vessels transiting the northern sea route – can have significant and long-lasting impacts to Arctic coastal communities. The risks associated with an Arctic HFO spill are one of the main drivers of the HFO ban; therefore, the positive impacts of removing the risks of a residual fuel oil spill is an important consideration in assessing overall impacts.

A 2009 Arctic Marine Shipping Assessment highlighted oil spills as the most significant threat to the marine environment from Arctic shipping (Arctic Council, 2009). The risk of oil spills from Arctic shipping is difficult to quantify, but it is generally acknowledged that increased transits of northern shipping routes create an increased risks of vessel accidents and oil spills (Baskh et al., 2018). As traffic levels increase over the coming years, so does the threat of an oil spill.

All oil spills have the potential to devastate wildlife and habitat, and to impact the people and communities that rely on an intact ecosystem for food and socio-cultural activities. There are a number of factors that will influence the severity of oil spill impacts, such as: size of the spill; type of oil spilled; location of the spill; seasonality/timing of spill; and the effectiveness of mitigation measures to contain and recover the spill. This section considers several factors that contribute to the adverse impacts from oil spills in Arctic waters, with a focus on the comparative impacts of residual and distillate fuel spills.

4.1 Arctic Oil Spill Response Considerations

4.1.1 Window of Opportunity

The first line of defense for a ship-source oil spill, whether in Arctic or temperate waters, is to stop the flow of oil and contain the spilled volume of oil as close to the source (the ship) as possible. Therefore, this is a race against time, and the general rule of thumb is that the best opportunity for successful containment and recovery is within 72 hours of the release.

From the moment it is released into the environment, spilled oil experiences a range of physical and chemical changes that drive the window-of-opportunity for containing and recovering the oil. Figure 4-1 illustrates how oil spilled to Arctic waters will spread, change, and partition into various components of the air, water, and sediment.

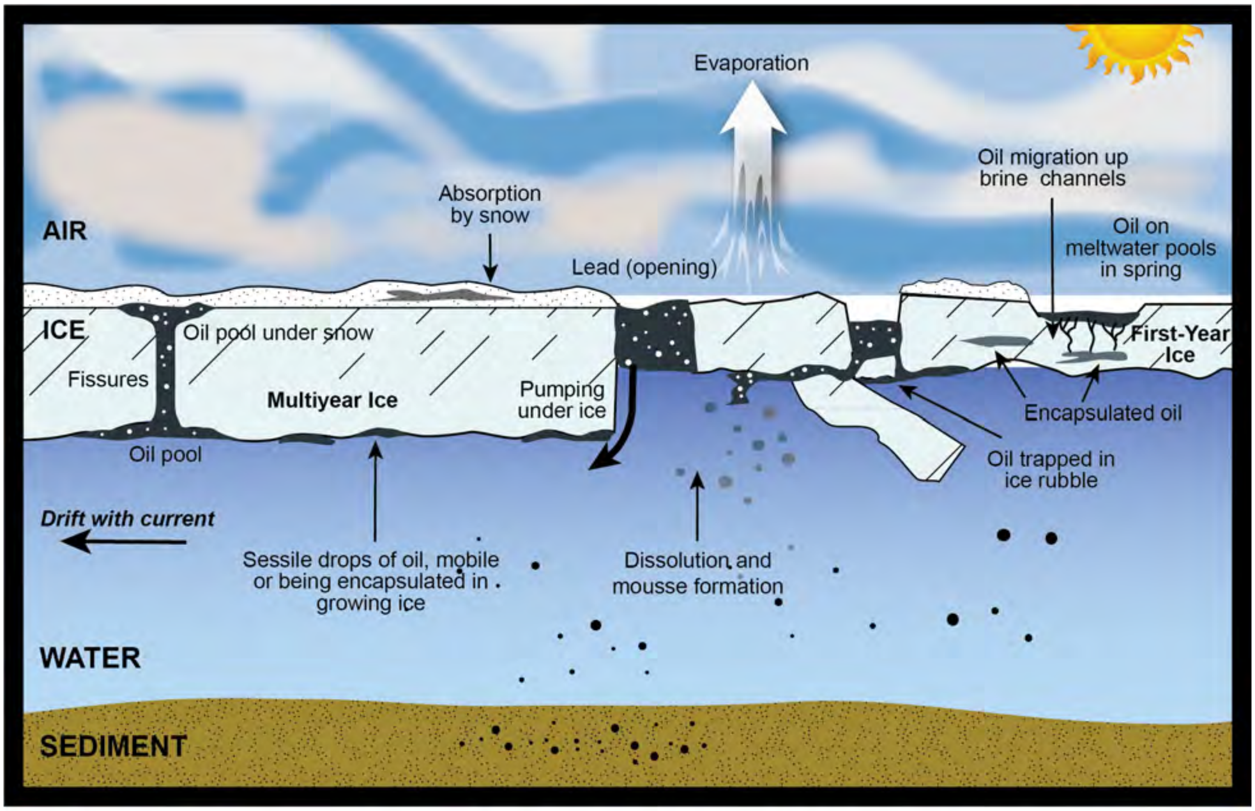

Evaporation
Oil migration up brine channels
Absorption by snow
AIR
Oil on meltwater pools in spring
Lead (opening)
ICE
Oil pool under snow
First-Year Ice
Fissures
Multiyear Ice
Pumping under ice
Encapsulated oil
Oil pool
Oil trapped in ice rubble
Drift with current
Sessile drops of oil, mobile or being encapsulated in growing ice
Dissolution and mousse formation
WATER
SEDIMENT

Figure 4-1. Physical and chemical processes that impact oil fate and behavior in the presence of sea ice

The presence of sea ice adds a layer of complexity, as the oil will interact with the ice both at the air-ice and the water-ice interfaces. As time passes, containment and recovery becomes more difficult, and any oil that has not been recovered within about 72 hours of the spill will typically either wash ashore, where it can be cleaned post-impact, or disperse/evaporate/sink depending upon the type of oil and the environment into which it has been spilled. When sea ice is present, the oil may also be encapsulated within or trapped under the ice, where it may travel great distances along with the ice, or refloat in open water leads some distance from the spill site.

4.1.2 Response Viability Limits

Oil spill response system performance is influenced by a number of factors. In addition to the short window-of-opportunity for encountering floating oil slicks, there are also limits associated with the impact of environmental conditions on oil spill response systems, equipment, and personnel.

Oil spill response even in the most favorable conditions is challenging, with the often-cited statistic that only 10-20% of most major marine oil spills are actually recovered. The percentage of oil mechanically recovered in the Gulf of Mexico during the Macondo blowout in 2010 is estimated at about 5%, and that spill occurred in a temperate ocean during the spring and summer, with a continuous release making the oil more accessible for skimming operations than if it had been a single point release (as is more typical for vessel spills).

There have been several prominent studies about the oil spill response viability limit in the Arctic Ocean – the most recent published by the Arctic Council. In a 2017 analysis of how Arctic meteorological and oceanographic conditions impact spill response, researchers concluded that Arctic conditions would preclude the use of vessels, booms and skimmers to contain and recover oil spills between 65% and 92% of the time year-round (circumpolar Arctic average). Response viability was lowest during November through March, with the best opportunity for mechanical spill response during June through August (DNV GL and Nuka Research, 2017). A previous study that focused on the Canadian Beaufort Sea and Davis Strait found that during periods of open water in central Davis Strait, conditions would be favorable for oil containment and recovery operations between 9% and 36% of the time (SL Ross, 2011).

4.1.3 Ecological Impacts

Figure 4-1 shows how oil can spread, move and change once it enters the environment. The dynamic nature of oil spills can complicate efforts to estimate which proportion of the oil will end up where, and how it will move or change over time. There has been some work done to try to enhance oil spill trajectory models to anticipate where oil would go and how it would change when spilled in Arctic waters, but these models are still being developed and refined.

While the potential ecological impacts of a major oil spill to the Arctic ecosystem are difficult to predict or quantify, it is well accepted that Arctic conditions have the potential to exacerbate the consequences of an oil spill for a number of reasons, including:

- Biodegradation of oil is slower in cold climates;

- Ice trapping oil and creating a cycle of re-oiling every summer, followed by oil being trapped in ice and potentially transported to a new place that would be re-impacted in subsequent years;
- Slower reproductive cycles of many Arctic species;
- Smaller food webs make species more vulnerable to trophic impacts;
- Aggregate stressors from climate change and sea ice loss make species more vulnerable; and
- Heavy reliance of many Arctic communities on subsistence foods.

4.2 Heavy Fuel Oil Spill Impacts

Residual fuels (HFO and others) have many characteristics that make them more challenging to clean up and more harmful to the environment than distillate fuel spills (Brown et al., 2016). Table 4-1 summarizes some of the key considerations, which are discussed in subsequent sub-sections.

Table 4-1. Oil Spill Characteristics and Properties of Different Fuel Types

FUEL TYPE		CHARACTERISTICS AND PROPERTIES		
Marine Fuel	**Composition**	**Behavior when spilled**	**Spill Cleanup**	**Ecological Impacts**
Bunker C/ Fuel oil No. 6	Residual oil	May sink or become neutrally buoyant. Forms tar balls and patties. Emulsifies (incorporates water).	Limited technologies for on-water recovery. Most of the cleanup will likely involve remediating shorelines and oiled substrate.	Coats feathers and fur. Persistent and sticky, can have long-term impacts to shoreline, intertidal, and benthic communities.
Intermediate Fuel Oil (IFO) 380	Residual oil (~ 98%) blended with distillate	May sink or become neutrally buoyant. Emulsifies (incorporates water) and may increase 2-3 times original spill volume.	Fresh product may be recoverable within hours of initial spill, but as oil emulsifies it becomes more difficult to recover with skimmers. Weathered oil will coat surfaces and may be difficult to remove from coarse sediments and substrate.	
Intermediate Fuel Oil (IFO) 180	Residual oil (~88%) blended with distillate			
Low sulphur marine fuel oils	Residual oil blended with distill$ate (higher ratio of distillate to residual)	Initial laboratory and mesoscale testing suggests that it will behave similar to other residual oils, emulsifying and generally acting as a persistent fuel.	Poorly studied. Information from recent pipeline spill in Hawaii suggests that residual blends will pose similar response challenges to other residual fuels.	Poorly studied, likely to be similar to IFO. May have higher initial toxicity than residual fuels because of higher percentage of distillate, which will initially disperse or evaporate.
Marine diesel oil (MDO)/Fuel oil No. 2	Distillate fuel that may have traces of residual oil	High percentage will evaporate or disperse into water column within first few hours of release. Will remain floating but slick will spread in open water.	Can be skimmed from surface if contained to sufficient thickness. As oil spreads and weathers, more difficult to recover.	High initial toxicity to wildlife, particularly in water column, but oil is less persistent in environment. Will still harm fur and feathers when it comes into contact.
Marine gas oil (MGO)	100% distillate			

4.2.1 HFO Response Challenges

Residual oils are denser and more viscous than distillates, and are usually harder for oil spill response systems to skim, pump, and store. In the event that environmental conditions did not allow for any spill response, which is a strong possibility in the Canadian Arctic, an untreated oil slick would be left to weather, spread, dissolve, or strand. Under such a scenario, distillate fuels would break up and change phases much more quickly than residual oils, due to their respective physical and chemical properties. A heavy fuel oil slick would be slower to degrade and change, and would therefore persist in the environment for a much longer period of time, spreading impacts more broadly across both time and space.

The type of oil spilled will influence the selection of equipment and tactics used to remediate the spill. Most of the response methods in use today were originally developed for crude oil spills. Neither residual fuels nor distillates behave exactly like crude oil; the closest similarity is probably between marine diesel oil (Fuel Oil No. 2) and light, sweet crude oils. Otherwise, distillate fuels tend to evaporate and disperse fairly quickly, making booming and skimming challenging. The high volatility of certain distilled fuels (like jet fuel or gasoline for cars) may actually create safety issues for booming it (due to vapor plumes).

Residual fuel oils, on the other hand, are so viscous and high in wax content that they typically resemble peanut butter rather than oil. This makes them difficult to remove with skimmers, and the fact that they quickly emulsify (incorporate water to form a mousse-like substance) makes on-water skimming even more challenging. Residual oil slicks will typically break up into tar mats, tar balls, and tar patties. Depending on the salinity of the water and the availability of suspended sediments or particulate matter in the water, residual oil may eventually become neutrally or negatively buoyant. Once the oil drops below the sea surface, even if it is only by a matter of millimeters, it is essentially unavailable to booming and skimming operations.

Most of the "response" to a residual oil spill will involve cleaning the tarry residue off whatever it contacts. Cleaning beaches can be very labor-intensive, and there is usually some fraction of the spill – possibly rather high- that is left behind on rocks and beach substrate as coating or stain. Freshly spilled residual oil or mousse that comes into contact with fur-bearing mammals and feathered birds will stick to their fur or feathers and can harm or kill the animal. Residual spills are typically viewed as less acutely toxic because they do not contain as much volatile material, which is the most biologically available. But residual oil spills still kill a range of marine life, particularly birds and mammals. Benthic or shoreline communities can also be smothered by oil that sinks or comes ashore.

4.2.2 Ecological Impacts of HFO Spills

HFO is also highly toxic to fish species, and particularly to embryonic fish. Because of its high density, HFO may sink under certain circumstances (low salinity, high sediment interaction), or become stranded in shoreline sediment, posing a risk to fish larvae (Martin et al., 2014). Since HFO contents are variable based upon the refining process, their ecotoxicity also varies (Comber et al., 2011).

While there has not been a major Arctic HFO spill, experience from heavy oil spills in other parts of the globe confirm that the toxic effects can be both acute and long-lasting. For example, the 2002 *Prestige* spill off the coast of Spain caused significant damage to seabird populations, including not only immediate deaths but also long-term effects on reproduction and population dynamics (Alonso-Alvarez et al., 2007).

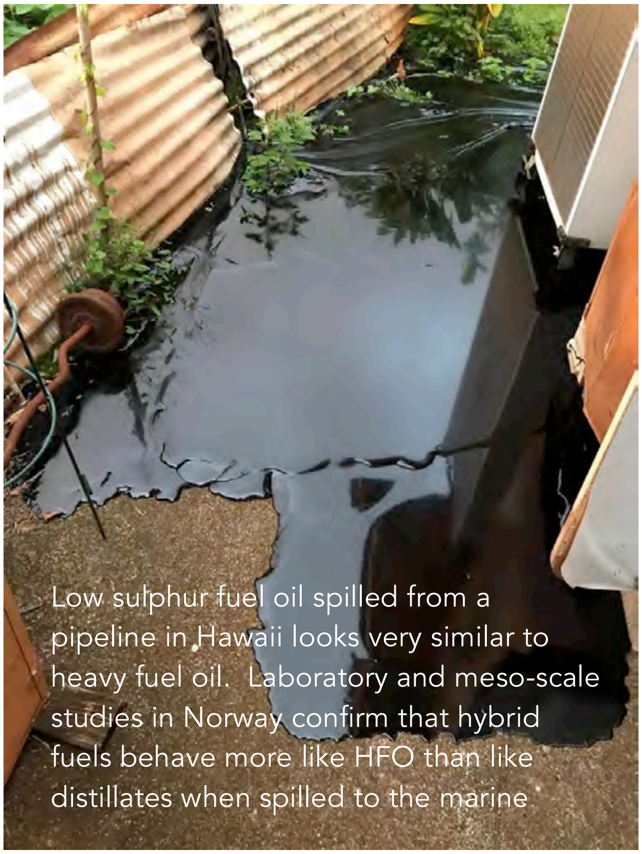
An Arctic heavy fuel oil spill would also harm communities along the Arctic coastline. Most people living adjacent to Arctic waters rely on the ocean for food and transportation. Indigenous peoples also have close cultural and spiritual ties to the marine environment and wildlife. An oil spill has the potential to devastate Arctic communities by contaminating their food sources, imperiling their culture, and disrupting traditional uses that have been in place for thousands of years (Gamble, 2017).

4.3 Potential Impacts from Hybrid and Residual Blend Fuel Spills

4.3.1 Response Considerations

Newly emerging residual blends are being developed to have reduced air emissions, comparable to distillate fuels, but from an oil spill preparedness and response perspective, they have more in common with HFO. Hybrid fuels have a similar density to HFO, and some are nearly as viscous. When spilled, they emulsify like heavy fuel oil, which can make them difficult to recover with mechanical skimmers.

Because these blends are relatively new, there is not much information on their characteristics or behavior when spilled to the marine environment. A 2017 Norwegian study evaluated the physical and chemical properties of two hybrid fuel oils – Exxon HDME 50 and Shell ULSFO – to compare their behavior when spilled in cold climates to marine gas or diesel oils. The hybrid fuels have much higher boiling points, and evaporate much more slowly than distillate fuels (HelstrØm, 2017).



Low sulphur fuel oil spilled from a pipeline in Hawaii looks very similar to heavy fuel oil. Laboratory and meso-scale studies in Norway confirm that hybrid fuels behave more like HFO than like distillates when spilled to the marine.

Experimental data showed that after 5 days of exposure to winter conditions, only about 2% of HDME 50 evaporated; about 18% of ULSFO evaporated (compared to 95% of gas oil). Both fuels emulsify when spilled to seawater, forming mousse similar to heavy fuel oils. After 5 days in winter conditions, HDME 50 had formed 40% water in oil emulsion, and ULSFO had formed 58% water in oil emulsion. In summer conditions, the emulsions were 60% and 78%, respectively. Winter emulsions were highly viscous; summer emulsions were moderate to high viscosity. After one day of weathering in cold water, the ULSFO doubled in volume because of emulsion (HelstrØm, 2017).

In January 2018, a pipeline in Hawaii leaked 500 gallons of low sulphur fuel oil. The spill occurred on land, impacting a few private homes (Mai, 2018). News reports described the spilled substance as "sticky ooze," and press photos show a substance that appears very similar to black HFO (Nagaoka, 2018).

4.3.2 Similarities to Diluted Bitumen and Orimulsion

Residual fuel oil blends are relatively new, and with the exception of the recent study out of Norway, there is little empirical data about how these fuel blends may behave when spilled to the marine environment. Based on the manner in which these blends are formed, it is possible that they could behave similarly to other heavy/residual fuel blends, such as diluted bitumen (tarry bitumen mixed with a light distillate – condensate or light crude oil – to meet pipeline specifications) or orimulsion (a mixture of heavy Venezuelan crude oil and water that is used to ship the product in tankers). One study estimated that diluted bitumen contains about 30% residuum, higher than even heavy crude oils (MathPro, Inc., 2015).

4.3.3 Ecological Impacts

There is very little information available about the toxicity of residual blend and hybrid fuel oils to marine species.

5 Estimating the Cost Impact of an Arctic HFO Spill

A great deal of emphasis has been placed on the relationship between an HFO ban and the cost of goods in northern communities. A less obvious cost consideration, but one that bears further exploration, is the potential cost of an Arctic HFO spill to northern communities and Canadian taxpayers. Since HFO spills are typically much more persistent, they are also more expensive to clean up than distillate fuel spills, with more extensive damages to wildlife, habitat, subsistence foods, and socio-economic values.

The "polluter pays" system that governs the financial responsibility of vessel owners and operators to pay for the cleanup costs and damages associated with oil spills – particularly fuel oil spills – may not provide adequate assurance that all costs will be paid by the polluter's insurance. Additional funds are available through Canadian and international trust funds, but disbursements from these sources are also limited. Any costs above these financial responsibility limits would fall to the governments, communities, individuals, and private companies that incur expenses to clean up oil spills or suffer damages from the spill impacts.

5.1 Oil Spill Response Costs

5.1.1 Types of Costs

The costs associated with oil spill response are generally grouped into the following three categories: (1) cleanup costs; (2) environmental costs; and (3) socioeconomic costs. This approach is the basis for the foundational work in oil spill cost modeling (Etkin,1999; Etkin, 2004). The three categories of costs, examples of the types of expenses they cover, and an identification of who pays the costs under the present Canadian ship-source oil spill system are summarized in Table 5-1. Each element is discussed in subsequent sections.

Table 5-1. Summary of Financial Responsibility for Ship-Source Oil Spills in the Canadian Arctic

Types of Costs Associated with Ship-Source Oil Spills and Who Pays them in the Canadian Arctic			
Cost Category	**Example of types of costs incurred**	**Ship Owner's Responsibility**	**Who Pays for the Rest**
Cleanup Costs	Direct response costs – costs of on-water containment and recovery, clean up of oiled shorelines, wildlife response and treatment, and all associated equipment, people, vessels, logistics, command posts, incident management team, oily waste storage and disposal.	Ship owner must pay for clean up costs up to the insurance limit carried based on Canadian law. For fuel oil spills, insurance levels will vary based on vessel size and the amount of fuel capacity. Rarely exceeds $100M.	Government of Canada pays all costs if ship owner is not known or does not comply, and all costs in excess of ship owner's insurance. Canadian ship-source pollution fund pays up to $171M per incident (less for fuel oil spill). International Oil Pollution Fund will pay for claims up to a certain limit based on vessel size and type (less for fuel oil spills than tanker spills).
Environ-mental Costs	Costs involved with repairing or restoring damages to the ecology, environment, or wildlife caused by an oil spill.	Once ship owner has spent up to insurance limit, there may not be funding available for environmental damages. Canada does not have a system for assessing damages to natural resources. Civil courts could be a remedy.	Government of Canada (ship-source oil pollution fund) and International Oil Pollution Fund may pay for claims, up to established limits. Individuals or communities may have uncompensated losses.
Social, cultural, and economic costs.	Costs associated with damages to tourism, commercial fishing, recreational use, cultural resources, subsistence use of resources, socio-cultural impacts.	Once ship owner has spent up to insurance limit, there may not be funding available for socio-economic damages. Canada does not have a system for assessing damages to social and economic resources. Civil courts could be a remedy.	Government of Canada (ship-source oil pollution fund) and International Oil Pollution Fund may pay for claims, up to established limits. Individuals, communities or businesses may have uncompensated losses.

Within or in addition to these "big three" cost categories, there are a number of oil spill costs that are not always taken into consideration in oil spill cost models. For an Arctic ship-source fuel oil spill, these may include (Cohen, 2010):

- Private costs incurred by the spiller (damage to or loss of vessel, including salvage costs; cargo loss or damage; and litigation costs);
- Morbidity or mortality impacts to individuals involved in the shipping accident;
- Costs incurred by government agencies involved in the response;
- Cost of repairing damaged public infrastructure;
- Losses by affected businesses;
- Lost consumer value from shifting purchases or behavior;
- Natural resource damages;

- Cost of litigation (both to government and injured parties, including individuals or businesses);
- Societal costs associated with focusing government and public resources on the spill response and away from other day-to-day functions); and
- Social costs that cannot be compensated through a transfer of funds from one party to another (e.g. cultural and social value inputs, community mental health impacts, interruption to traditional use of land and resources).

5.1.2 Comparative Costs of Oil Spills from Residual vs. Distillate Oils

There is general consensus among experts that HFO spills are more expensive to clean up and cause more extensive damages than distillate oil spills. Various studies have attempted to quantify the difference in costs, but none of the data from which these coefficients are drawn come from Arctic oil spills. An oil spill risk analysis for the U.S. Arctic used a cost factor of 1.64 to simplify the difference in impacts between heavy and light oil spills – meaning that a heavy fuel oil spill would be 1.64 times more damaging than a distillate spill (Reich et al., 2014).

The most commonly cited oil spill cost model – which is about 15 years old and based on worldwide data, so it is arguably a conservative estimate for Arctic spills – estimates the cost per volume of spill cleanup for HFO compared to distillate, as shown in the table below. Depending upon the volume spilled, the cost per gallon to clean up shorelines in a scenario where 0% and 10% of the oil is recovered was modeled. Table 5-2 summarizes the results, which were originally calculated in 2003 U.S. dollars and have been converted to 2018 U.S. dollars based on inflation rates[28] (Etkin, 2004).

The Etkin model estimates the cost per tonne of an HFO spill at between $106,000 and $512,000 per tonne spilled, including shoreline clean up costs, socio-economic costs, and environmental costs. By comparison, the per-tonne costs estimated for a distillate spill range from U.S.$32,000 to $193,000 per tonne. The Etkin model also suggests modifiers for adjusting oil spill cost estimates based on the impacted shoreline type, the socio-cultural impact severity, habitat and wildlife sensitivity, and the effectiveness of spill response. Each factor may increase or reduce the per-gallon (or per-tonne) cost estimate, though none of these cost multipliers are Arctic-specific.

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[28] 2018 value calculated using 35.6% inflation.

Table 5-2. Comparative spill costs for HFO vs. Distillate Fuels

Cost per gallon estimates based on spill size and oil type (2003 U.S.$)					Total Cost Estimate (2018 U.S.$)[29]	
Type	**Volume Spilled (gallons)**	**Shoreline cleanup costs**	**Socio-economic costs**	**Environ-mental costs**	**Per gallon[30]**	**Per tonne[31]**
HFO	<500	$440	$150	$95	**$930**	**$246,000**
	500-1,000	$438	$600	$90	**$1,160**	**$307,000**
	1,000-10,000	$436	$900	$85	**$1,930**	**$512,000**
	10,000-100,000	$410	$500	$75	**$1,340**	**$355,000**
	100,000-1,000,000	$179	$200	$40	**$570**	**$151,000**
	>1,000,000	$87	$175	$35	**$400**	**$106,000**
Volatile Distillates[32]	<500	$103	$65	$48	**$290**	**$77,000**
	500-1,000	$102	$265	$45	**$560**	**$148,000**
	1,000-10,000	$100	$400	$35	**$730**	**$193,000**
	10,000-100,000	$55	$180	$30	**$360**	**$95,000**
	100,000-1,000,000	$23	$90	$15	**$170**	**$45,000**
	>1,000,000	$7	$70	$10	**$120**	**$32,000**

The UK Offshore Oil and Gas Industry Association evaluated potential oil spill costs associated with an offshore well blowout, taking into account more detailed cost categories, including: cost of establishing command centers; response costs for offshore dispersant application, offshore mechanical recovery, nearshore mechanical recovery, nearshore protective booming, shoreline cleanup, wildlife response, shoreline assessment teams, liaison functions, surveillance, and disposal costs. The model also considered cost impacts to fishing and aquaculture, tourism, and other claims. The resulting cost estimate for the smallest spill modeled – a 180,000 barrel crude oil spill – estimated that total response costs could range from U.S.$180M to $280M in 2010 currency (Oil & Gas UK, 2012). This actually computes as a lower per-tonne cost range than the Etkin model (between $11,000 and $17,000 in 2018 U.S.D); however the spill size equates to nearly 5 million gallons spilled, which is much higher than the ranges in the Etkin model, and consistent with the general assumption that per-tonne clean-up costs decrease as spill volume increases.

A probabilistic spill cost model developed for the Gulf of Finland[33] generated higher total cleanup cost estimates than Etkin for a 5,000 tonne spill of medium crude oil, and slightly lower for a 30,000 tonne spill of heavy crude oil. It does not take into consideration the potential impacts of sea ice, but the authors recommend further research to develop models that consider the potential for Arctic conditions to influence oil spill response costs (Montewka et al., 2013).

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[29] 2018 value calculated using 35.6% inflation.

[30] Rounded to nearest $10.

[31] Rounded to the nearest $1,000 using 265 gallons per tonne as conversion factor for both fuel types, recognizing that in fact density differences between fuel types make universal conversion factors less accurate, but appropriate for the purpose of rounding costs to the nearest thousand dollars.

[32] Etkin (2004) does not model 0% recovery, so cost per gallon reflects 10% of oil being removed (evaporated) before reaching shore.

[33] The model is specific to the geographic area for which it was developed.

5.1.3 Anecdotal Cost Data

Existing oil spill cost models typically derive their algorithms from actual fuel cost data. Another way to consider the cost of oil spills is to look directly at specific incidents with similarities to the risk scenarios of concern. In this case, there are no Arctic HFO spills to evaluate. However, other heavy fuel oil spills in sub-Arctic regions confirm the assumption that the combination of residual oil and harsh cold-water climates can exacerbate spill cleanup costs.

The 1988 *Nestucca* spill, which impacted the coasts of BC and Washington (U.S.), was a relatively small spill with a high price tag. The spill – approximately 800 tonnes of heavy fuel oil – resulted in shoreline cleanup costs of approximately U.S.$126.5M in 1988 (approximately U.S.$267M in 2018). Applying this single data point to a present-day HFO spill, the cleanup costs would work out to U.S.$333,750 per tonne of oil spilled.

More recently, a relatively small (3,000 gallon, about 11.4 tonne) fuel oil spill in Shuyak, Alaska[34] cost a reported U.S.$9M to clean up (Desroches, 2018). This amounts to over $800,000 per tonne. In this example, these costs do not extend beyond the direct cleanup expenses.

5.2 Funding Fuel Oil Spill Response in the Canadian Arctic

5.2.1 Polluter Pays Principle

The Canadian oil spill liability regime follows the "polluter pays" principle, which is well established in international and national law. The International Convention on Civil Liability for Bunker Oil Pollution Damage (BUNKER convention) provides a free-standing instrument that requires ship owners to pay for pollution damage caused by their bunker (fuel) oils.[35] Damages are defined as:

> *"(a) loss or damage caused outside the ship by contamination resulting from the escape or discharge of bunker oil from the ship, wherever such escape or discharge may occur, provided that compensation for impairment of the environment other than loss of profit from such impairment shall be limited to costs of reasonable measures of reinstatement actually undertaken or to be undertaken; and*
>
> *(b) the costs of preventive measures and further loss or damage caused by preventive measures."*

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[34] This spill occurred in U.S. waters and was therefore influenced by the U.S. regulatory regime. The cited costs are limited to cleaning up the spill; assuming that Canadian regulators would hold the spiller to a similar standard of cleanup, then the total costs of the Shuyak spill might have been incurred if it had occurred in Canada.

[35] There are additional liability regimes and funds that apply to oil cargo spills for tankers, but these are outside of the scope of this analysis, which focuses specifically on spill costs associated with fuel oil spills.

Owners of ships over 1,000 gross tons (GT) are required to maintain insurance or financial security up to a liability limit established through international and national policy. The BUNKER convention, implemented in Canada under the Marine Liability Act, allows compensation claims for pollution damage to be brought directly against an insurer. Liability limits are based on the ship's tonnage, as summarized in Table 5-3. For example, for a 6,000 GT cargo vessel (typical of a community resupply/sealift ship serving communities), the total liability limit for a bunker fuel spill would be approximately $7.2M. The vessel operator would be required to carry sufficient liability insurance to cover pollution damage costs up to that amount.

Table 5-3. Liability limits for fuel oil spills from ships in Canadian waters

Vessel tonnage	Liability limit (SDR)[36]	Liability limit (CAD)
Up to 2,000 GT	1.51M total	$2.78M
Each additional ton up to 30,000 GT	604 per tonne	$1,111 per tonne
Each ton from 30,000 GT to 70,000 GT	453 per tonne	$834 per tonne
Each ton above 70,000 GT	302 per tonne	$556 per tonne

5.2.2 Canada's Ship-source Oil Pollution Fund

The Ship-source Oil Pollution Fund (SOPF) is both a "fund of last resort" intended to provide supplemental funding in the event that oil spill costs exceed the funds available through the ship's insurance, and a "fund of first resort" in which claimants may choose to apply directly to the fund in lieu of the shipowner. The fund balance was initially created in the early 1970s by assessing a 15 cent-per-tonne levy on oil companies and other industrial entities that imported or exported, by ship, more than 300 tonnes of oil per year. No fees have been assessed since 1976, although the Minister of Transport maintains the authority to reinstate a levy of up to 51 cents per tonne.

The initial fund balance of approximately $34M has been earning income for the 42 years since, through the Consolidated Revenue Fund of Canada. The Consolidated Revenue Fund is the account into which taxes and revenue are deposited, and from which funds are withdrawn in order to defray the costs of public services.

SOPF revenue is expended to cover fund administration, premiums paid to international compensation funds, and any claims awarded. At the end of the 2016/2017 fiscal year, the SOPF surplus was valued at $404M. From the fund's inception through 2017, about $19M in claims had been paid out; and an equivalent amount was paid over the same time for fund administration. Since 1976, the revenue earned from the Consolidated Revenue Fund has been $458M, with an additional $5M contributed through recovery of costs (SOPF, 2018).

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[36] SDR (Special Drawing Right) is a reserve asset created by the International Monetary Fund. It is converted into Canadian dollars based on the currency calculation values for May 8, 2018.

Any person, corporation or government in Canada that has incurred costs or damages as a result of oil pollution may file a claim to the SOPF. Claims are time-limited (within two years of the time the damage occurs and five years of the event that causes the damage) and can be filed for any location within Canada and its Exclusive Economic Zone (EEZ). The maximum liability per incident is adjusted annually; the 2017 limit is approximately $172M. This is the maximum total amount that can be paid out across all claims for a single oil spill. Unlike tanker spills, fuel oil spills from cargo ships and other non-tank vessels are not eligible for claims compensation under international funds, beyond the ship owner's required insurance (Boulton, 2010).

The SOPF assesses and pays claims based on four criteria: (1) all clean-up measures taken must be reasonable measures; (2) all costs and expenses must have actually been incurred; (3) all costs and expenses must be reasonable; and (4) all claims filed with the SOPF must be investigated by the Administrator. The second parameter has the potential to limit or exclude certain claims related to lost use, such as lack of opportunity to gather subsistence foods, loss of recreational opportunities, or socio-cultural impacts that cannot be monetized. The Marine Liaibility Act does provide a mechanism for claims from loss of income, but claimants are limited to individuals engaged in specific fisheries-related activities.[37]

The SOPF website includes three active reports for Arctic oil spills. A 2010 spill from the cruise ship *Clipper Adventure*, which ran aground in Coronation Gulf, resulted in a $468,802 claim from the Department of Fisheries and Oceans to cover monitoring costs and expenses incurred by the Canadian Coast Guard. The claim is still pending due to ongoing litigation between the Crown and the shipowner. Two other spills were reported in 2016 – one from community gasoline resupply in Rankin Inlet and the other from a fuel barge grounding near Tuktoyaktuk. No claims have been filed to date in association with these incidents (SOPF, 2018).

5.2.3 Gaps in Oil Spill Liability and Compensation Coverage for HFO Spills in Canada

Referring back to the estimated spill costs for HFO spills derived from the Etkin model (Table 5-2) or the actual costs of the *Nestucca* and Shuyak spill responses described in Section 5.1.3, the Canadian liability limits for fuel oil spills seem quite low. The estimated $7.2M total liability insurance for a 6,000 GT cargo vessel resupplying Northern communities would not have been sufficient to cover the cleanup costs for the 11.4 tonne spill in Shuyak, Alaska (estimated at U.S.$9M, or about $11.5M CAD[38]).

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[37] Section 107(2) of the Marine Liaibility Act defines claimants eligible for Loss of Income claims as "(a) an individual who derives income from fishing, from the production, breeding, holding or rearing of fish, or from the culture of harvesting of marine plants; (b) the owner of a fishing vessel who derives income from the rental of fishing vessels to holders of commercial fishing licences issued in Canada; (c) an individual who derives income from the handling of fish on shore in Canada directly after they are landed from fishing vessels; (d) an individual who fisher or hunts for food or animal skins for their own consumption or use; (e) a person who rents or charters boats in Canada for sport fishing; or (f) a worker in a fish plant in Canada, excluding a person engaged exclusively in supervisory or managerial functions, except in the case of a family-type co-operative operation that has a total annual throughput of less than 1400 metric tons or an annual average number of employees of fewer than 50."

[38] Conversion rate of $1.28CAD to $1.00USD based on bank rates for May 10, 2018.

Assuming the fuel capacity for a 6,000 GT cargo vessel is 570 tonnes, the liability limit on the vessel owner would calculate to about $13,000/tonne. This is significantly lower than the $307,000/tonne cost estimate derived from the 2004 Etkin model, or the anecdotal cost data from the Shuyak, Alaska spill, which cost $800,000 per tonne to clean up. Table 5-4 calculates the potential cleanup costs based on the Etkin model for various spill sizes, and indicates the estimated gap (in 2018 CAD) between the ship's insurance and the estimated spill response costs.

Table 5-4. Gaps Between Ship Owner Liability Coverage for Fuel Oil Spills and Estimated Spill Response Costs

Hypothetical Spill from 6,000 GT cargo vessel with 570-tonne fuel capacity	Estimated response costs (Etkin, 2004)[39]	Ship owner's liability limit in Canada	Gap between ship owner's insurance and estimated costs
10% - 57 tonnes	$14M	$7.2M	**$6.8M**
25% - 143 tonnes	$35.2M	$7.2M	**$28M**
50% - 285 tonnes	$70.1M	$7.2M	**$62.9M**
75% - 428 tonnes	$105.3M	$7.2M	**$98.1M**
100% - 570 tonnes	$175M	$7.2M	**$167.8M**

Table 5-4 shows that for even a relatively small spill (10% of fuel capacity on a small cargo ship, which is estimated at 57 tonnes), the liability limit of the vessel owner under Canadian law would be $6.8M lower than the estimated response costs derived from the Etkin model, which is not Arctic-specific, and therefore may underestimate Arctic spill costs. This gap grows to over $167M in the event of a total cargo loss. If the anecdotal cost data from the recent Shuyak, Alaska spill were applied, the gap would increase by nearly threefold.

The SOPF provides a secondary funding mechanism to make up some or all of the gap, depending upon the spill size. The fund can pay up to $172M per incident, which would be sufficient even to cover the conservatively estimated gap for the 100% fuel loss scenario. This would be an order of magnitude greater than any claims paid out of the fund to date (total expenditures since 1972 have been about $19M for all claims combined). Paying a significant portion of oil spill response costs for an Arctic heavy fuel oil spill out of the Canadian fund would transfer the cost burden from the polluter to the government and taxpayers.[40]

The Government of Canada is updating the SOPF claims process as part of the Oceans Protection Plan implementation. This update may address some of the gaps in fuel oil spill liability.

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[39] Converted from 2018 USD (see Table 5-2) to 2018 CAD ($1.28 exchange rate for May 10, 2018).

[40] While the initial capital investment in the SOPF was derived from industry, there have not been any direct payments into the fund by operators since 1976. The interest earned on the fund balance is derived from the Consolidated Revenue Fund of Canada, which is taxpayer-funded.

6 Mitigation Options

6.1 Cost of Goods to Northern Communities

Banning HFO use and carriage for use through Canada's delicate marine ecosystem offers a number of benefits to ecological and human health. HFO emissions contain harmful pollutants, including black carbon, which also accelerates polar ice melt. An HFO spill could devastate the Arctic ecosystem, harming fish and marine mammals, and compromising the food security of Inuit communities that have subsisted on these resources for millennia.

The benefits to the environment and to Arctic peoples are clear – yet, there are also economic costs associated with requiring that Arctic ships switch to cleaner burning fuels. While the per-tonne costs associated with switching from IFO 380 to MGO will likely decline over time as the global marine fuels market adjusts to new regulatory requirements, it is likely that shipping companies will pass along some measure of cost increase to communities. A higher cost of goods may seem like a reasonable trade-off for slowing ice melt and protecting ecological and human health, yet high north communities are understandably concerned that any increases will threaten their economic well-being.

Policy options that mitigate the impacts to Canadian Arctic communities from higher sealift fuel costs should be explored alongside the implementation planning for an HFO ban.

6.1.1 Address Uncertainties

The data exploration presented in Section 3 of this report suggests that the relationship between fuel prices and cost of goods in the Canadian Arctic is not necessarily linear. Reduced fuel prices from 2014-2017 corresponded with increased food prices for most items in most communities year-over-year.

When the price difference between IFO 380 and MGO (based on 2017 averages) is spread across a single cargo load for a resupply vessel, the per-tonne increase is about $11.[41] This is about $0.01/kg of goods transported by sealift. If IFO prices rise and MGO prices fall as predicted, this margin becomes smaller over time. An important part of the conversation around mitigating impacts to communities should be refining estimates of how marine fuel price increases are actually passed along to communities.

6.1.2 Government Subsidies

The Government of Canada already has measures in place to subsidize the high cost of living to northern communities. These may provide models for how to structure a sealift subsidy and avoid common pitfalls experienced by other programs.

Nutrition North Canada (NNC) is a retail subsidy program implemented in 2012 to reduce the cost of nutritious food to residents in remote, northern communities. It subsidizes air freight costs associated with the transport of perishable, healthy food to 128 communities. The program is implemented through agreements between retailers in northern communities and Indigenous and Northern Affairs Canada, or INAC.

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[41] Section 3 uses 2015 US dollars as a standard for comparison; converting to 2018 US dollars and then to Canadian dollars works out to: US$33 2015 → US$34.75 2018 → CAD$45.17.

The NNC program was recently audited, and a number of concerns raised about how the program operated and the metrics used to ensure that the program is meeting its goals. Among issues noted were accountability, inadequately updating or adjusting rates, and ensuring that retailers passed all subsidies along to customers. Following a 2016 audit, the program has undergone additional changes to address some of the noted shortcomings (Galloway, 2017).

There are different ways that the Government of Canada could consider subsidizing the cost differential borne by sealift operators in the event of an HFO ban, and the NNC model provides a tangible starting point.

6.1.3 Phased or Adaptive Implementation

The proposed Arctic HFO ban would follow on the heels of the 2020 global sulphur emissions cap. This will remove HFO as a fuel option for all vessels that are not retrofitted with scrubbers, an option that most experts agree is unlikely to be widely adopted. This leaves vessel operators with a choice between alternative fuels (e.g., LNG, biofuels, electric), distillate fuels, or residual fuel blends. Assuming that the current ECA exemption will not be extended to the sulphur cap, Arctic resupply companies will be faced with the need to comply with the emissions cap in advance of the HFO ban. A phased implementation that considers both requirements, with the goal of encouraging Arctic resupply ships to switch to cleaner burning fuels as an ultimate compliance strategy, could mitigate fuel cost impacts to shipping companies and, to the extent that these are transferred to the cost of goods, minimize cost increases spurred by the HFO ban.

A phased and adaptive implementation process could help to address some of the uncertainties at play between the community impacts of the HFO ban and global sulphur cap to the cost of goods. The Montreal Protocol, which incorporates mechanisms for swift adjustment based on empirical data, could provide a model for how to implement a fuel switching policy in the Canadian Arctic.

A critical first step in this process is to evaluate more precisely the relationship between fuel prices and the cost of goods. The most direct approach to understanding this relationship would be to include the shipping industry in this dialogue. Phased implementation strategies could provide an incentive for the shipping industry to collaborate with regulators, stakeholders, and northern communities on approaches that achieve the ultimate goal of eliminating the use and carriage for use of HFO in the Canadian Arctic.

6.2 Oil Spill Impacts in the Canadian Arctic

The impact of any marine fuel oil spill to Arctic ecosystems, human health, and socio-economic systems could be catastrophic. An Arctic HFO spill has the potential to cause more significant impacts to all sensitive receptors, and these impacts may persist for much longer than would a distillate fuel spill. Banning HFO use and carriage for use in Arctic waters will eventually eliminate this hazard, and reduce Arctic oil spill risks. However, an HFO ban does not remove the potential for other types of marine fuel oils or bulk oil shipments to spill and impact Arctic waters. Many of the issues raised in this study bear consideration even after an HFO ban takes effect.

6.2.1 Building Arctic Oil Spill Response Capacity and Enhancing Prevention Measures

The oil spill response capacity currently in place in the Canadian Arctic is inadequate to mitigate a marine oil spill. The Coast Guard is the lead response agency for all oil spills north of the 60th parallel, and while there are significant efforts underway to expand Arctic spill response capacity, the reality is that if an oil spill occurred today, there would be very little equipment and virtually no trained personnel available for immediate response.

Because oil spill containment and recovery is a race against time, building a distributed response capacity across the Canadian Arctic would provide the best opportunity to mitigate the impacts of marine oil spill. Understanding the limits to existing spill response technologies and implementing additional prevention measures to account for gaps in response viability would also mitigate spill risks and potential impacts.

6.2.2 Creative Funding Mechanisms to Cover Arctic Marine Fuel Oil Spill Mitigation

Liability limits for bunker fuel spills in Canada are not adequate to cover the magnitude of cost impacts that could result from a fuel oil spill. The obvious solution is to require additional financial security for operators, which would require changes to the liability limits under the Marine Liability Act. In addition to changing the national framework for fuel oil spill liability, specific measures could be adopted that recognize the unique risks and potential impacts of an Arctic oil spill, at least until an Arctic HFO ban takes effect.

A recent study that considers the Canadian permitting context for Arctic tour operators points to a complex permitting system and regulatory disincentives as potentially stifling to tourism growth. While that particular study advocates streamlining permitting for tourism, it also highlights the practice of charging a premium for operating in Arctic waters to defer the high costs of resource protection. Several of the required permits include user fees to support, for example, wildlife management agencies that aim to preserve populations and support long-term wildlife viewing opportunities (Dawson et al., 2017).

Along the same lines, as Arctic adventure tourism has grown in popularity, private insurance companies have begun to offer policies to cover evacuation and rescue for polar expeditions (Douglas, 2016). This reflects the high cost of emergency response in these remote regions.

While permitting and adventure insurance policies may seem unrelated, both point to the precedent of paying to access the Arctic. Tour operators seeking to enter certain areas must pay for access to parks, heritage sites, and other attractions. Adventure tourists who undertake Arctic wilderness expeditions pay for coverage that will increase the likelihood of rescue in the event of an emergency or disaster. A similar model could be developed and applied to Arctic shipping routes, to allocate some of the costs of preparing for and responding to heavy fuel oil spills directly to the operators who are creating a spill risk in this fragile environment. This should include the growing recreational boating and cruise ship industries.

The Government of Canada could also implement a penalty system for vessels that discharge oil or other pollutants in Arctic waters. The assessment of civil and/or criminal penalties for marine pollution is a well-established practice across many Arctic nations, and can provide an incentive for safe operating procedures and spill prevention measures.

6.3 Oil Spill Costs

6.3.1 Creating Cost Incentives to Prevent or Avoid Spills

It is nearly impossible to associate dollar values with spill damages, as the impacts of a spill are experienced subjectively, and when resources such as subsistence are factored in, it is hard to find a currency-based proxy for their value as food and cultural integrity. Models that compare costs of HFO and distillate spills estimate that HFO spills could cost two times, ten times, or even more, than distillate spills. Still, from the perspective of a vessel owner who may never experience an oil spill, the comparative cost of avoiding an HFO spill by switching to distillate fuel is not a compelling economic argument. The Canadian system caps a ship owner's liability regardless of the type of fuel used, and the cap for a fuel oil spill is relatively low; this is another disincentive for a ship owner to switch to less polluting fuels.

The parties that benefit most from avoiding an HFO spill are the potentially impacted people and resources, not the ship operators. The fact that so many of the costs of an oil spill are borne by government and society makes the cost/benefit equation more complex, and worth considering through a different lens. Incentives that reward risk-reduction and spill prevention measures could be created to offset additional fuel costs associated with the HFO ban.

6.3.2 Response vs. Cleanup

Much of the emphasis in evaluating spill costs is on the direct cost of spill response. Cleanup cost analyses typically aggregate the costs of removing oil from the sea surface and cleaning up oil off the shoreline. However, oil recovery and removal at sea often occurs before sensitive resources are impacted, while shoreline cleanup nearly always occurs after initial damage has been sustained.

Real-world experience responding to HFO spills has demonstrated that in most cases, very little oil is recovered before it reaches the shoreline – meaning that all of the remediation occurs post-impact. The 2004 *Selendang Ayu* oil spill in the Aleutian Islands illustrates this point. Of the 1,200 tonnes of IFO 380 spilled, not a drop was recovered from the marine environment. All of the cleanup was beach cleanup to remove the sticky, tarry oil that had washed ashore. The majority of the oil spilled was not recovered – it broke into tar balls and tar patties and either washed ashore or eventually submerged or sank in the Bering Sea.

This is an important – if unpleasant – distinction to make when contemplating fuel oil spills in the Arctic. "Spill response" is often limited to cleaning shoreline after it has already been fouled by the oil. Working from the reasonable assumption that very little, possibly none, of the spilled oil is going to get recovered before it impacts the shoreline or the ice edge, the behavior and fate of the spilled oil becomes a key consideration, and one where the distinction between HFO and distillate fuels becomes particularly relevant. HFO will literally "stick around" for a very long time, particularly in Arctic conditions. Distillate fuels may be acutely toxic in the short term, but the harmful components are volatile, and they will dissipate more readily. In the first 48 hours, up to half of the volume of an MGO or MDO spill – in cold conditions – may evaporate. If there is enough sea energy, the total volume can evaporate within about a week. Returning to the site of an untreated diesel spill two years later, it would difficult to find evidence of the oil in the environment; conversely, if it had been an HFO spill, it is more likely that the shoreline would still have some lingering oil or tar coating present.

6.4 Issues for Further Consideration

6.4.1 Categorization of Low Sulphur Residual Blends and Hybrid Fuels in the Context of an Arctic HFO Ban

It is unclear whether residual fuel blends or hybrid fuels will be captured under the pending Arctic HFO ban. Theoretically, these oils could be blended to fall below the HFO density and viscosity thresholds established under MARPOL. Yet, they are substantially similar to HFO from a spill risk and response perspective. If an Arctic HFO ban were to go into effect, this might create an incentive for refineries to keep the viscosity of these products below 900 (MARPOL threshold for HFO); however, an LSFO with a density of 899 will still behave more like HFO when spilled than it would like a distillate fuel – so the oil spill risk/impacts are not equivalent to a distillate fuel. This issue could be resolved by refining the HFO ban language and definitions.

6.4.2 Risk Tolerance

The ability to anticipate the potential impacts – ecological, sociocultural, or economic – of an Arctic oil spill is limited by a lack of data and a lack of reliable models. Additional work could be done to evaluate the potential impacts of an HFO fuel spill to the Arctic ecosystem and the communities that rely on its health and integrity, but it is virtually impossible to try to quantitatively estimate the potential impacts of a persistent fuel spill into the Arctic Ocean. Ultimately, the issue becomes one of risk tolerance, and of determining whether the potential benefits of continuing to allow HFO to be transported through Arctic waters merits the risks of a potential Arctic HFO spill. The liability discussion and cost analyses presented in this report provide some insight into how risks and impacts are borne differently by communities, shipping companies, and governments.

6.4.3 Impacts of the 2020 Sulphur Cap on Marine Fuel Costs

Shipping companies are already contemplating how to comply with the phase out of high sulphur heavy fuel oils. Most analysts agree that the changing regulatory framework for ship bunkers will result in changes to fuel costs, and potentially to the cost spread between residual and distillate fuels. The Montreal fuel price data presented in Section 3 shows that recent

MGO prices have actually been lower than past IFO 380 prices, indicating that shipping companies have been able to continue with Arctic community resupply against wide fluctuations in heavy fuel oil costs, and are therefore able to adapt to an HFO ban. Continuous evaluation of fuel costs and differentials is a necessary component of an adaptive approach to implementing the HFO ban. It is possible that in the long-term, HFO and MGO prices could equalize or that HFO could eventually become more expensive due to reduced demand in the marine sector.

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Appendix A: Data

Table A-1 presents monthly fuel price data for Montreal from November 2013 through December 2017 as calculated based on daily price data provided by Bunkerworld (November 2013-December 2015) and Ship and Bunker (January 2016-Decemeber 2017) subscription services.

Table A-1. Average monthly fuel price data

Month	Price by Fuel Type ($U.S./tonne)		Spread	
	MGO	IFO 380	By price	By %
Nov-13	1058	654	404	62%
Dec-13	1097	652	445	68%
Jan-14	1116	637	479	75%
Feb-14	1170	648	522	81%
Mar-14	1133	641	492	77%
Apr-14	1123	632	491	78%
May-14	1087	637	450	71%
Jun-14	1070	649	421	65%
Jul-14	1055	637	418	66%
Aug-14	1040	617	423	69%
Sept-14	1003	592	411	69%
Oct-14	956	547	409	75%
Nov-14	932	475	457	96%
Dec-14	879	384	495	129%
Jan-15	777	321	456	143%
Feb-15	788	346	443	129%
Mar-15	818	345	474	137%
Apr-15	782	348	434	125%
May-15	777	376	401	107%
Jun-15	747	364	383	105%
Jul-15	683	319	365	115%
Aug-15	608	266	342	129%
Sep-15	616	257	359	140%
Oct-15	618	243	375	155%
Nov-15	636	242	395	164%
Dec-15	595	187	408	222%
Jan-16	526	152	374	247%
Feb-16	526	161	365	227%
Mar-16	562	183	379	208%
Apr-16	557	193	364	189%

Month	Price by Fuel Type ($U.S./tonne)		Spread	
	MGO	IFO 380	By price	By %
May-16	582	239	344	146%
Jun-16	613	261	352	135%
Jul-16	594	267	328	123%
Aug-16	568	271	297	110%
Sep-16	539	272	268	98%
Oct-16	575	299	276	92%
Nov-16	640	269	372	148%
Dec-16	634	266	368	148%
Jan-17	627	263	365	149%
Feb-17	602	249	354	153%
Mar-17	618	258	359	149%
Apr-17	592	240	352	157%
May-17	603	249	354	153%
Jun-17	592	240	352	156%
Jul-17	590	238	352	159%
Aug-17	592	239	353	158%
Sep-17	587	238	349	158%
Oct-17	587	238	349	158%
Nov-17	587	240	347	155%
Dec-17	592	248	344	148%

Appendix B: Acronyms and Abbreviations

C	Celcius
CARB	California Air Resource Board
CPI	Consumer price index
DMA	Abbreviation for a form of marine diesel oil
DMB	Abbreviation for a form of marine diesel oil
DMX	Abbreviation for a form of marine diesel oil
ECA	Emission control area
EEZ	Exclusive economic zone
EPPR	Emergency Prevention, Preparedness and Response (Arctic Council)
g	Gram
GT	Gross tons
HFO	Heavy fuel oil
ICCT	International Council on Clean Transportation
IFO	Intermediate fuel oil
IMO	International Maritime Organization
INAC	Indigenous and Northern Affairs Canada
ISO	International Standards Organization
kg	Kilogram
LDO	Abbreviation for a form of marine diesel oil
LLC	Limited Liability Company
LNG	Liquefied natural gas
LSMFO	Low sulphur marine fuel oil
M	Million
m^3	Cubic meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environmental Protection Committee (IMO)
MDO	Marine diesel oil
MDC	Abbreviation for a form of marine gas oil
MGO	Marine gas oil

mm^2	Square millimeter
NBS	Nunavut Bureau of Statistics
NDT	Net deadweight tons
NEI	Northern Economics, INC
NNC	Nutrition North Canada
SOPF	Ship-Source Oil Pollution Fund
t	Tonne
UK	United Kingdom
UNCTAD	United Nations Council on Trade and Development
US	United States
USEIA	United States Energy Information Agency