APPENDIX 8B-4

RISK ASSESSMENTS
BALLAST WATER AND HULL BIOFOULING

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Risk Assessment for the Potential Introduction of Aquatic Nonindigenous Species through Ballast Water Discharge at Milne Port

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1.0 INTRODUCTION

Baffinland Iron Mines Corporation ("Baffinland" or "the Company") has been approved to develop an open-pit iron ore mine in northern Baffin Island, Nunavut Territory. The Mary River Project (the Project) will extract iron ore from Deposit No. 1, located in the Qikiqtaaluk Region of Nunavut. Reserves consist of approximately 365 million tonnes (Mt) of direct shipping iron ore at an average grade of 64 % (Mary River Project 2012). In addition to this, Baffinland has proposed an Early Revenue Phase (ERP) whereby 3.5 Mt per annum will be shipped through Milne Inlet during the open water season via an upgraded tote road. It is anticipated that, during ERP operations, shipping will occur annually through Milne Inlet over a period of 90 days between July 15 and October 15. Chartered Supramax (Ice class 1C), Panamax and Post Panamax vessels (55,000, 70,000 and 110,000 DWT respectively) will be retained by Baffinland depending on availability. With a fleet of approximately 18 chartered vessels (6 Supramax; 10 Panamax, 2 Post Panamax), an estimated 55 trips will occur at a voyage time of 26 days. Over the 90 day shipping period, each chartered vessel will make one to three round trips. All vessels are anticipated to ship the iron ore to a European port such as Rotterdam.

During the review of the Draft Mary River Project Environmental Impact Statement, Fisheries and Oceans Canada (DFO) requested that Baffinland "*provide a risk assessment to assess whether accumulating ballast water discharges would significantly increase the potential for species introduction*". The purpose of this document is to present the results of the requested risk assessment of the potential for ballast water exchange at Milne Port to result in the unintended introduction of invasive species to the marine environment.

A fully quantitative risk assessment is not possible at this stage of design for the Early Revenue Phase, nor is it a requirement of the regulatory process (Ballast Water Control and Management Regulations). It has, however proven possible to complete a semi-quantitative risk assessment consistent with the methodology employed by DFO (Chan *et al*., 2012) in which the authors considered the potential for introduction of aquatic nonindigenous species to ports in the Canadian Arctic, including Milne Port. This exercise was carried out by DFO in their role as expert advisor to Transport Canada with regards to ballast water issues.

The study by Chan *et al*. covered Canadian waters north of 60° as well as other Northern locations - Ungava Bay, Hudson Bay, and James Bay. All harbour zones and wharfs that received vessel traffic between 2005 and 2008 in the Northern Canada Vessel Traffic Services (NORDREG) Zone were included in the analysis. The top ten ports in terms of international merchant vessel traffic and ballast water discharge were determined to be Churchill MB, Milne Port NU, Deception Bay QC, Iqaluit NU, Aupaluk QC, Kangiqsujuaq (George River) QC, Quaqtaq (Koartak) QC, Tasiujaq QC, Wakeham Bay/Kangiqsualujjuaq/Maricourt QC, and Arviat/Eskimo Point NU.

The Mary River Project Early Revenue Phase (ERP) will be subject to Section 6(1) of the Canadian Ballast Water Control and Management Regulations and as per the International Maritime Organization (IMO) Ballast Water Convention Regulation D-1. These regulations require that transoceanic vessels travelling to Canadian ports carry out a mid-ocean exchange of ballast water. Such an exchange must occur 200 nautical miles from shore where water depth is at least 2,000 m.

Upon arrival at Milne Port, the charter ships will discharge the exchanged ballast water and load ore. As no icebreaking activities will be required, only a partial load of ballast water will be required. Vessels will carry approximately 25 to 30 % ballast water on board. This amounts to 12,000 to 14,000 tonnes for 55,000 DWT vessels, 15 000 to 17,000 tonnes for the 70 000 DWT vessels and 22 000 to 27 000 tonnes for the 90 000 DWT vessels. Vessels in transit to Milne Port will discharge approximately 20 % of their ballast water prior to docking. At the dock vessels will discharge approximately 9,600 to 21,600 tonnes of ballast water.

The discharge rate of vessels is estimated to be 1,000 tonnes per hour at an average discharge volume of 12,500 tonnes. Discharge will occur over a 12 hour period and occur an estimated 53 times at Milne Port. This equates to an approximate total discharge of 662,000 tonnes of ballast water each shipping season.

2.0 METHODS

This document has applied the methods described by Chan *et al*. (2012) in a manner which allows for comparison of the risks to Milne Port in relation to the risk at the three Canadian Arctic ports assessed by these authors with regards to international merchant vessels.

The risk of an invasion from an aquatic nonindigenous species was estimated using a three-step process (Figure 1).

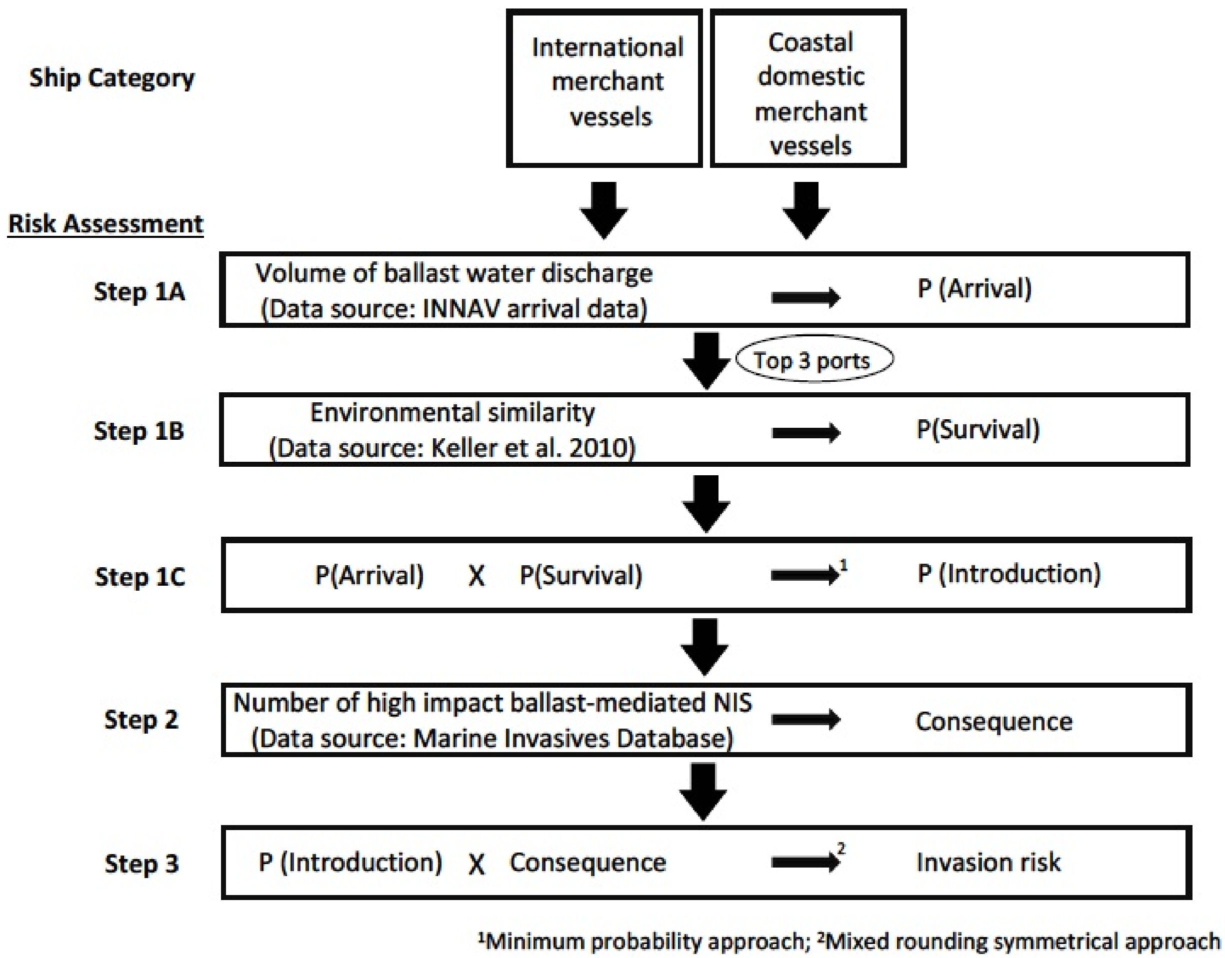

Figure 1 Flow Chart Illustrating Steps for Risk Assessment (taken from Chan et al., 2012)

Step 1 - Probability

Two aspects related to probability were examined – Probability of Arrival and Probability of Survival. In total, these two factors combine to create a Probability of Introduction.

The Probability of Arrival is based on the corrected ballast water volume that will be discharged. A correction factor was applied to the total annual volume of ballast water to be discharged due to the fact that the ERP will apply mandatory management activities (mid-ocean exchange). This correction factor is employed in order to determine the discharged volume of water that may contain founding individuals of aquatic nonindigenous species, also known as propagules, after a mid-ocean exchange. This correction factor is based on exchange efficiency rates as determined by total zooplankton abundance which was determined to be 90 % for saline water (Ruiz and Smith, 2005). Based on this efficiency rate, a correction factor of 0.1 was applied by Chan *et al*. where mid-ocean exchange could be assumed.

The Probability of Survival is based on the concept of "environmental distance", a calculation developed from four parameters:

1. Average Annual Salinity
2. Average Annual Water Temperature
3. Average Water Temperature of Warmest Month
4. Average Water Temperature of Coldest Month

These parameters were standardized using a z-transformation (standard score formula) in order to ensure that each parameter had equal weight. The formula for the environmental distance calculation is based on Euclidean distance in four dimensional space. The formula is as follows:

Aquatic Nuisance Species Task Force and Commission for Environmental Cooperation Risk Assessment Guidelines).

Step 2 - Consequences

The severity of consequences was established by considering the number of high impact aquatic nonindigenous species that may be introduced into the receiving port. The number of harmful nonindigenous species that could potentially be introduced from connected ecoregions is available from two sources - the Marine Invasive Database of the Nature Conservancy (Molnar *et al.*, 2008) and a database available online at www.conserveonline.org/workspaces/global.invasive.assessment. Given the destination of ERP ore carriers the listings for the North Sea ecoregion were used in the calculation.

Step 3 - Risk

The Risk associated with the subject port was determined by combining Probability and Consequences. Probability of Introduction and Consequences as determined by the approach described above, were combined in a symmetrical mixed-rounding matrix as shown in Table 1 (from Chan *et al.*, 2012). Three levels (lower, intermediate and higher) of risk ranking are assigned as a conclusion to the assessment.

Table 1 Matrix used to combine Probability of Introduction and Magnitude of Consequences into Final Risk Rankings[1] (taken from Chan *et al*. 2012)

		P (Introduction)				
		Lowest	Lower	Intermediate	Higher	Highest
Consequence	Highest	Yellow	Yellow	Red	Red	Red
	Higher	Yellow	Yellow	Yellow	Red	Red
	Intermediate	Green	Yellow	Yellow	Yellow	Red
	Lower	Green	Green	Yellow	Yellow	Yellow
	Lowest	Green	Green	Green	Yellow	Yellow

Green = lower risk, Yellow = intermediate risk and Red = higher risk

As this study is semi-quantitative, there exists a certain level of uncertainty to this study. While the uncertainty does not directly apply to the methods, it is important to ensure that uncertainty is characterized in a standardized way, and as such, levels of uncertainty were assigned based on the quality of data available for analysis. These levels range from very high to very low. Table 2 below provides a description of the levels of uncertainty.

Table 2 Description of Uncertainty Levels (taken from Chan *et al*., 2012)

Levels of Uncertainty	Description
Very High	Little or scientific information; no supporting data
High	Limited scientific information; circumstantial evidence
Moderate	Moderate levels of scientific information; first hand, unsystematic observations
Low	Substantial scientific information; expert opinion
Very Low	Extensive scientific/systematic information; peer-reviewed data sources/information

3.0 RESULTS

3.1 Probability

As noted, the estimation of probability combines two considerations – Probability of Arrival and Probability of Survival. The indicator of Probability of Arrival is the total volume of ballast water. The Probability of Survival is based on an indicator that reflects the environmental similarity of the “donor” and “recipient” environments.

3.1.1 Arrival Probability

Upon arrival at Milne Port, the charter ships will discharge the exchanged ballast water to allow for the loading of ore and this will occur and expected 53 times per year. At the dock vessels will discharge approximately 9,600 to 21,600 tonnes of ballast water, with the average ballast water load for the chartered vessels being approximately 12,500 tonnes. Other vessels such as tugs, fuel tankers, and cargo vessels are not anticipated to discharge ballast water at Milne Port and as such are not included in this analysis. A total of approximately 662,000 tonnes of ballast water is anticipated to be discharged into Milne Port during the shipping season each year (Table 3).

Chan *et al.* (2012) use a correction factor of 0.1 for marine ballast water in order to estimate the propagule supply. Bailey *et al*. (2011, as cited in Chan *et al*. 2012) noted that mid-ocean exchange of ballast water drastically reduces the potential propagule supply to Canadian ports. As well Chan *et al*. discuss that with mid-ocean exchange occurring in international merchant vessels, these vessels may no longer play a prominent role in the introduction of aquatic nonindigenous species.

Table 3 Annual Ballast Water Discharge at Milne Port

Port	Number of Discharges (per year)	Total Ballast Water Discharged per year (m^3)	Corrected Foreign Exchange (X0.1) (m^3)	P(Arrival)
Milne	53	662,000	66,200	Highest

The value calculated for Milne Port lies outside the range of values calculated for the ports considered by Chan *et al*. (2012). Thus, for the purposes of this evaluation, the scale of rankings was modified.

The modified range was applied to top three ports for international merchant vessels- Churchill, Deception Bay and Milne Port. Table 4 shows the results of the revised range, with Milne Port ranked highest.

Table 4 Ranking for Probability of Arrival (modified from Chan *et al.*, 2012)

Mean annual corrected volume of ballast water discharged (m^3)	P(Arrival)	Ranking
0 – 13,240	Lowest	Deception Bay
13,241 – 26,480	Lower	
26,481 – 39,720	Intermediate	Churchill
39,721 – 52,960	Higher	
52,961 – 66,200	Highest	Milne Port

Due to the unconfirmed number of vessel that will be deployed for the shipping of ore, the level of uncertainty is ranked high.

3.1.2 Survival Probability

Data for Rotterdam were collected from Joyce (2006) and the data ranges from 1970 to 2004. Data for Milne Port was available from baseline studies completed for the Mary River Project Environmental Impact Assessment (see Rabinovich and Fine, 2010). Water and salinity data was based on a depth of 30 m. Depth was not described in Chan *et al*. and it did not appear to be taken into consideration.

$$\sqrt{\left((-0.041-0.933)^2+\left(0.102-(-2.260)\right)^2+(0.239-(-3.832)^2+\left(0.331-(-2.102)\right)^2\right)}$$

√29.02

Environmental Distance = 5.39

The value calculated for Milne Port occurs within the ranges calculated in Chan *et al*. (2012). Comparing the environmental distance of Milne to Rotterdam to the environmental distance of Churchill to Rotterdam (2.70, from Chan *et al*. 2012) and Deception Bay to Aarhus (2.81, from Chan *et al*. 2012), the Milne to Rotterdam shipping route has a vastly larger environmental distance and as such has a lower probability for survival for nonindigenous species (see Table 5). While Chan *et al*. did not compare the route of Deception Bay to Rotterdam, Aarhus (located in Denmark) is a port located within the North Sea and as such is considered to be a viable comparison for the purpose of this study.

Table 5 Ranking System for Probability of Survival

Environmental Distance	P(Survival)	Ranking
0.00 – 1.40	Highest	
1.41 – 2.80	Higher	Churchill
2.81 – 4.20	Intermediate	Deception Bay
4.21 – 5.60	Lower	Milne Port
5.61 – 7.00	Lowest	

In comparison with the other top ranked locations, the probability of survival is ranked <u>lower</u> for Milne Port.

The uncertainty of this determination has been ranked high based on the limited studies have been conducted on nonindigenous species in Arctic ports.

3.1.3 Introduction Probability

While there is a very high probability of nonindigenous species arriving at Milne Port, there is low probability of their survival. The drastic differences in the two ports (Port of Rotterdam vs. Milne Port) equates to a potentially lethal environment for nonindigenous species coming from the North Sea ecoregion. While nonindigenous species may arrive at Milne Port, they are unlikely to survive and as such the Probability of Introduction is ranked as <u>lower</u>. Consequently, as shown in Table 6, the Milne Port ranking is lower than that of Churchill and is one tier above Deception Bay.

Table 6 Ranking System for Probability of Introduction

Port	Probability of Arrival	Probability of Survival	Probability of Introduction
Milne	Highest	Lower	Lower
Churchill	Intermediate	Higher	Intermediate
Deception Bay	Lowest	Intermediate	Lowest

The level of uncertainty is rated high due to retaining the highest level of uncertainty as well as limited studies have been conducted on nonindigenous species in Arctic ports.

3.2 Consequences

With respect to Milne Port, a total of 51 potentially harmful nonindigenous species are reported as present in the originating waters of the North Sea ecoregion, and it is assumed that all 51 species could potentially be introduced. In comparison with the other ports considered by Chan *et al.*, (2012), this value achieves a rank of lowest (Table 7). This does not take into account high impact species that are native to the North Sea ecoregion, or species that may cause high impacts at Milne Port despite having a low or negligible impact on the North Sea ecoregion.

Table 7 Ranking System for Magnitude of Consequence (taken from Chan *et al*., 2012)

Cumulative number of high impact ballast-mediated nonindigenous species	Magnitude of consequence	Ranking
701 - 875	Highest	Churchill
526 - 700	Higher	
351 - 525	Intermediate	
176 - 350	Lower	
0 - 175	Lowest	Milne Port, Deception Bay

3.3 Invasion Risk (Combining Probability and Consequences)

For Milne Port the Probability of Introduction was estimated to be lower, and the magnitude of Consequences was estimated to be lowest. Consequently, the Invasion Risk for a nonindigenous species to invade Milne Port is rated as "Lower" (Table 8). It is notable that the level of uncertainty of this ranking is high, in large measure because of the limited experience with shipping from Milne Port. Nevertheless, it is somewhat reassuring to reach a “Lower Risk” conclusion employing accepted risk assessment methods.

Table 8 Relative Invasion Risk of Top Artic Ports (as determined in Chan *et al*. 2012) and Milne Port by Ballast-mediated Nonindigenous Species for International Merchant Vessels Ballast Water Discharges

Port	P(Arrival)		P(Survival)		P(Introduction)		Magnitude of consequences		Invasion Risk	
	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty
Milne Port, NU	Highest	Moderate	Lower	High	Lower	High	Lowest	High	Lower	High
Churchill, MB	Intermediate	Moderate	Higher	Moderate	Intermediate	Moderate	Highest	Moderate	Higher	Moderate
Deception Bay, QC	Lowest	Low	Intermediate	Moderate	Lowest	Moderate	Lowest	Moderate	Lower	Moderate

4.0 CONCLUSION

This semi-quantitative risk assessment of ballast water concludes that ore shipping operations at Milne Port (as per the Early Revenue Phase proposal) is ranked "Lower" with regards to the potential for an aquatic nonindigenous species invasion. This outcome confirms that the Early Revenue Phase of the Mary River Project is unlikely to significantly increase the potential for species introduction as a consequence of ballast water discharges at Milne Port.

5.0 REFERENCES

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May 1, 2013

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1.0 INTRODUCTION

Baffinland Iron Mines Corporation ("Baffinland" or "the Company") has been approved to develop an open-pit iron ore mine in northern Baffin Island, Nunavut Territory. The Mary River Project (the Project) will extract iron ore from Deposit No. 1, located in the Qikiqtaaluk Region of Nunavut. Reserves consist of approximately 365 million tonnes (Mt) of direct shipping iron ore at an average grade of 64 % (Mary River Project 2012). In addition to this, Baffinland has proposed an Early Revenue Phase (ERP) whereby 3.5 Mt per annum will be shipped through Milne Inlet during the open water season via an upgraded tote road. It is anticipated that, during ERP operations, shipping will occur annually through Milne Inlet over a period of 90 days between July 15 and October 15. Chartered Supramax (Ice class 1C), Panamax and Post Panamax vessels (55,000, 70,000 and 110,000 DWT respectively) will be retained by Baffinland depending on availability. With a fleet of approximately 18 chartered vessels (6 Supramax; 10 Panamax, 2 Post Panamax), an estimated 55 trips will occur at a voyage time of 26 days. Over the 90 day shipping period, each chartered vessel will make one to three round trips. All vessels are anticipated to ship the iron ore to a European port such as Rotterdam.

The study by Chan *et al*. covered Canadian waters north of 60° as well as other Northern locations - Ungava Bay, Hudson Bay, and James Bay. All harbour zones and wharfs that received vessel traffic between 2005 and 2008 in the Northern Canada Vessel Traffic Services (NORDREG) Zone were included in the analysis. The top ten Canadian Arctic ports for arrival of international merchant vessels were determined to be Churchill MB, Iqaluit NU, Deception Bay QC, Salluit (Saglouc) QC, Kuujjuaq (Fort Chimo) NU, Tasiujaq QC, Puvimituq QC, Aupaluk QC, Wakeham Bay/Kangiqsujuaq/Maricourt QC, and Kangiqsualujjuaq (George River) QC.

The purpose of this report is to complete a risk assessment to address the potential for the Mary River Project to result in the introduction of aquatic nonindigenous species through hull fouling at Milne Port. This risk assessment follows the methodology provided by DFO (Chan *et al*., 2012) where a semi-quantitative risk assessment was conducted on the introduction of aquatic nonindigenous species to the Canadian Arctic.

A fully quantitative risk assessment is not possible at this stage of design for the Early Revenue Project, nor is it a requirement of the regulatory process (Regulations for the Prevention of

Pollution from Ships and for Dangerous Chemicals). It has, however proven possible to complete a semi-quantitative risk assessment consistent with the methodology employed by DFO (Chan *et al*., 2012) in which the authors considered the potential for introduction of aquatic nonindigenous species to ports in the Canadian Arctic. This exercise was carried out by DFO in their role as expert advisor to Transport Canada.

Canada regulates the use of anti-fouling systems by a prohibition on the use of organotin compounds (tributyl tin [TBT]) as an anti-fouling agent as per IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships ("Convention") of which Canada is a co-signer. Annex 1 of the Convention states that ships shall not apply or re-apply organotin compounds which act as a biocide (IMO, 2001).

2.0 METHODS

This document has applied the methods described by Chan *et al*. and has been completed so as to provide a definition of the risk associated with hull mediated fouling at Milne Port as a result of the Operation of the Early Revenue Phase of the Project. Thus the results can be compared against the ports assessed by Chan *et al*. for international merchant vessels.

The risk assessment followed a three-step process by which the risk of an invasion from an aquatic nonindigenous species was estimated (Figure 1).

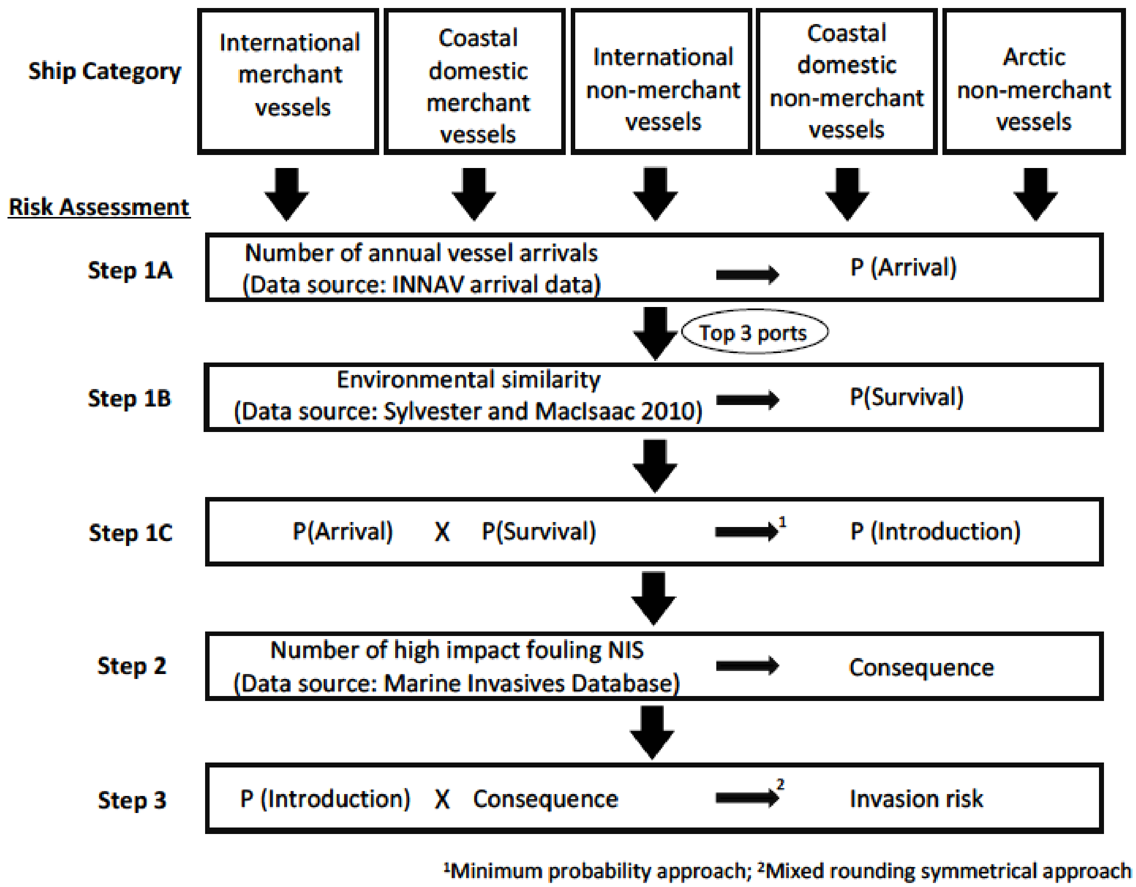


Figure 1 Flow Chart Illustrating Steps for Risk Assessment (taken from Chan *et al.*, 2012)

Step 1 - Probability

Two aspects related to probability were examined – Probability of Arrival and Probability of Survival. In total, these two factors combine to create a Probability of Introduction.

The Probability of Arrival is based on the number of vessels arriving at the port. Data limitations with regards to sailing speed, port layover time, anti-fouling management and voyage history prevented these factors from being incorporated into the assessment.

The Probability of Survival is muddled due to the fact that aquatic nonindigenous species encrusted on a vessel may have accumulated over a large number of ports, and the most recent port-of-call may only represent a small fraction of aquatic nonindigenous species present. The data evaluated in Chan *et al*. (2012) only looked at last port-of-call and as such could only assign Probability of Survival on a very coarse scale.

The Probability of Introduction was estimated based on the minimum probability method when combining the Probability of Arrival and the Probability of Survival. This method retains the value with the lowest rating. This method has been employed in various other risk assessments (e.g., Canadian Food Inspection Agency Weed Risk Assessment Guidelines, Aquatic Nuisance Species Task Force, and Commission for Environmental Cooperation Risk Assessment Guidelines).

Step 2 - Consequences

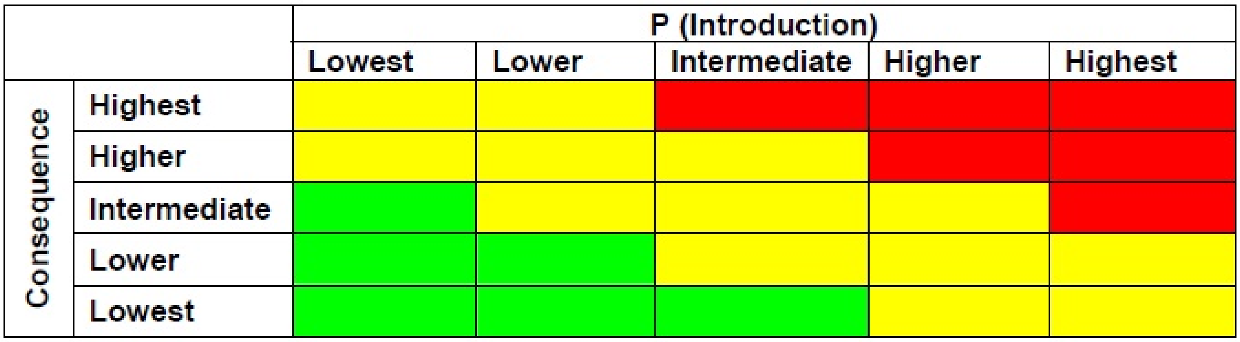
The severity of consequences was established by considering the number of high impact aquatic nonindigenous species that may be introduced into the receiving port. The number of harmful nonindigenous species that could potentially be introduced from connected ecoregions is available from two sources - the Marine Invasive Database of the Nature Conservancy (Molnar *et al.*, 2008) and a database available online at www.conserveonline.org/workspaces/global.invasive.assessment. Given the destination of ERP ore carriers the listings for the North Sea ecoregion were used in the calculation.

Step 3 –Risk

The Risk associated with the subject port was determined by combining Probability and Consequences. Probability of Introduction and Consequences as determined by the approach described above, were then combined in a symmetrical mixed-rounding matrix as shown in

Table 1 (from Chan *et al*., 2012). Three levels (lower, intermediate and higher) of risk ranking are assigned as a conclusion to the assessment.

Table 1 Matrix used to combine Probability of Introduction and Magnitude of Consequences into Final Risk Rankings1 (taken from Chan et al. 2012)



Green = lower risk, Yellow = intermediate risk and Red = higher risk

As this study is semi-quantitative, there exists a certain level of uncertainty to this study. While the uncertainty does not directly apply to the methods, it is important to ensure that uncertainty is characterized in a standardized way, and as such, levels of uncertainty were assigned based on the quality of data available for analysis. These levels range from very high to very low. Table 2 below provides a description of the levels of uncertainty.

Table 2 Description of Uncertainty Levels (taken from Chan et al., 2012)

Levels of Uncertainty	Description
Very High	Little or scientific information; no supporting data
High	Limited scientific information; circumstantial evidence
Moderate	Moderate levels of scientific information; first hand, unsystematic observations
Low	Substantial scientific information; expert opinion
Very Low	Extensive scientific/systematic information; peer-reviewed data sources/information

3.0 RESULTS

3.1 Probability

3.1.1 Arrival Probability

Vessels will arrive at Milne Port an expected total of 53 times per year as part of the Early Revenue Phase of the Project. This value falls outside of the range used by Chan *et al*. (2012) and therefore the ranking for Probability of Arrival must be modified. The modified probabilities for Churchill, Iqaluit and Deception Bay can be found in Table 3 below.

Table 3 Ranking for Probability of Arrival (modified from Chan *et al.*, 2012)

Mean Annual Number of Vessel Arrivals	P(Arrival)	Ranking
42.5 - 53	Highest	Milne Port
31.9 – 42.4	Higher	
21.3 – 31.8	Intermediate	
10.7 – 21.2	Lower	Churchill, Iqaluit
0 – 10.6	Lowest	Deception Bay

The modifications applied to Churchill, Iqaluit and Deception Bay saw their rankings change. Churchill went from highest probability of arrival to lower, Iqaluit went from higher probability of arrival to lower and Deception Bay went from intermediate probability of arrival to lowest.

The probability of arrival is ranked highest for Milne Port. Due to the unconfirmed number of vessel that will be deployed for the shipping of ore, the level of uncertainty is ranked high.

3.1.2 Survival Probability

Chan *et al*. discussed how species attached to vessels may derive from any of the ports the vessels may have visited from the time its last drydock and cleaning. Due to the lack of data on all port visits, Probability of Survival can only be assigned at a very coarse level. The risk for fouling in freshwater ports (salinity <2 ppt) is lower compared to all other ports. Based on this information Chan *et al*. concluded that the Probability of Survival for freshwater ports was lowest and all other ports would be ranked as highest. Thus, the Probability of Survival at Milne Port would be ranked highest with a moderate level of uncertainty.

3.1.3 Introduction Probability

With both a high Probability of Arrival and high Probability of Survival at Milne Port, the ranking for Probability of Introduction is highest. Table 4 below compares the ranking of Milne Port to that of Churchill, Iqaluit and Deception Bay.

Table 4 Ranking System for Probability of Introduction

Port	Probability of Arrival	Probability of Survival	Probability of Introduction
Milne	Highest	Highest	Highest
Churchill	Lower	Highest	Lower
Iqaluit	Lower	Highest	Lower
Deception Bay	Lowest	Highest	Lowest

The level of uncertainty is rated high due to retaining the highest level of uncertainty as well as limited studies have been conducted on aquatic nonindigenous species in Arctic ports and there is little experience with shipping to the Arctic at a scale similar to that of the Project.

3.2 Consequences

With respect to Milne Port, a total of 51 harmful nonindigenous species are reported as present in the originating waters of the North Sea ecoregion, and it is assumed that all 51 species could potentially be introduced. In comparison with the other ports considered by Chan *et al.*, (2012), this value achieves a rank of lowest (Table 5). This does not take into account high impact species that are native to the North Sea ecoregion, or species that may cause high impacts at Milne Port despite having a low or negligible impact on the North Sea ecoregion.

Table 5 Ranking system for Magnitude of Consequence (taken from Chan *et al.*, 2012)

Cumulative number of high impact fouling-mediated nonindigenous species	Magnitude of consequence	Ranking
701 - 875	Highest	Churchill
526 - 700	Higher	
351 - 525	Intermediate	
176 - 350	Lower	
0 - 175	Lowest	Iqaluit, Milne Port, Deception Bay

3.3 Invasion Risk (Combining Probability and Consequences)

For Milne Port the Probability of Introduction was estimated to be highest, as was the magnitude of Consequences. Consequently, the Invasion Risk for a nonindigenous species to invade Milne Port through hull fouling is rated as "Intermediate" (Table 6). It is notable that the level of uncertainty of this ranking is high, in large measure due to the limited experience with shipping from Milne Port. Nevertheless, it is somewhat reassuring to reach an "Intermediate" risk conclusion by employing accepted risk assessment methods as the rating of Milne Port ties it with the rating of the Port of Churchill.

Table 6 Relative Invasion Risk of Top Artic Ports (as determined in Chan *et al*. 2012) and Milne Port by Hull Fouling via Internal Merchant Vessels

Port	P(Arrival)		P(Survival)		P(Introduction)		Magnitude of Consequences		Invasion Risk	
	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty
Milne Port, NU	Highest	High	Highest	Moderate	Highest	High	Lowest	High	Intermediate	High
Churchill, MB	Lower	Low	Highest	Moderate	Lower	Moderate	Highest	Moderate	Intermediate	Moderate
Iqaluit, NU	Lower	Low	Highest	Moderate	Lower	Moderate	Lowest	Moderate	Lower	Moderate
Deception Bay, QC	Lowest	Low	Highest	Moderate	Lowest	Moderate	Lowest	Moderate	Lower	Moderate

4.0 CONCLUSION

This semi-quantitative risk assessment for hull fouling concludes that ore shipping operations at Milne Port (as per the Early Revenue Phase proposal) is ranked "Intermediate" with regards to the potential for an aquatic nonindigenous species invasion. This outcome confirms that the Early Revenue Phase of the Mary River Project is unlikely to significantly increase the potential for species introduction as a consequence of hull fouling at Milne Port.

5.0 REFERENCES

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