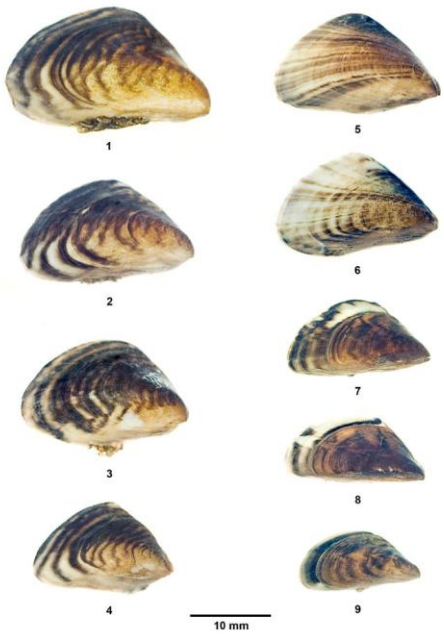
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
National Capital Region
Canadian Science Advisory Secretariat
Science Advisory Report 2012/082

SCIENCE ADVICE FROM THE RISK ASSESSMENT OF THREE DREISSENID MUSSELS (*Dreissena polymorpha, Dreissena rostriformis bugensis, and Mytilopsis leucophaeata*) IN CANADIAN FRESHWATER ECOSYSTEMS

a)



b)

Figure 1. a) Quagga Mussels (Dreissena rostriformis bugensis) (1-6) and Zebra Mussels (Dreissena polymorpha) (7-9) collected from the River Main (Germany). From: Van der Velde, G. and Platvoet, D. 2007. b) Comparison of Zebra Mussel (upper) and Dark Falsemussel (lower) shells. From: Verween, A., Vincx, M. and Degraer, S. 2010.

Context:

*In freshwater and some estuarine ecosystems, two prominent dreissenid mussels, the Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena rostriformis bugensis*), both native to the Ponto-Caspian region, have a long history of invasion in both Europe and North America. Further, a related dreissenid mussel species, the Dark Falsemussel (also known as Conrad's Falsemussel) (*Mytilopsis leucopheata*), has expanded its range to brackish water habitats across Europe and North America. Dreissenid mussels have had disproportionately large economic and ecological impacts due to their ability for rapid dispersal within and across continents, resulting in severe negative impacts on food webs and nutrient processing. Given the potential for non-indigenous species to have substantial negative impacts on Canadian ecosystems as well as the steady migration west, several western provinces requested Fisheries and Oceans Canada (through the Centre of Expertise for Aquatic Risk Assessment (CEARA)) to undertake a national risk assessment to determine the potential risk posed by three species of dreissenid mussels to Canadian aquatic ecosystems. This risk assessment considered probabilities of survival (habitat suitability) and arrival to 108 Canadian sub-drainages and the ecological impacts associated with these species. The ecological risk posed by these species was decided at a workshop meeting based on a draft risk assessment using an established Risk Matrix that combines the probability*

of invasion and the impacts on the environment. This risk assessment provides science-based guidance to resource managers for the development and implementation of management options.

This Science Advisory Report is from the Peer Review meeting on the National Risk Assessment of Zebra Mussel, Quagga Mussel and Dark Falsemussel held on March 27-28, 2012 in Winnipeg, Manitoba. Additional publications from this process, including the Research Document (Therriault et al. 2013) on which the Science Advisory Report is based, will be posted as they become available on the DFO Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

SUMMARY

- Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena rostriformis bugensis*) pose a high risk to most regions of western Canada (Prairie region and BC) and the Laurentian Great Lakes. The assessment did not include the Maritime, Newfoundland/Labrador or Arctic regions of Canada.
- Risk of Dark Falsemussel (*Mytilopsis leucophaeata*) for freshwater ecosystems in Canada has been assessed as low. However, assessment of risk for brackish/estuarine systems is beyond the scope of this document and should be captured in a separate risk assessment.
- The probability of survival (habitat suitability) was determined primarily based on calcium concentrations which indicated that most watersheds in the prairies and Laurentian Great Lakes regions were highly suitable for survival and establishment of Zebra Mussel and Quagga Mussel.
- The probability of survival (habitat suitability) for Quebec and central/northwest Ontario (on the Canadian Shield) was determined to be low, as habitat is not suitable for Zebra Mussel or Quagga Mussel based on very low calcium levels.
- Probability of arrival was assessed using a Human Footprint Index and proximity to invaded habitats.
- This risk assessment was conducted at the spatial scale of Canadian sub-drainages and not for individual waterbodies. Thus, risk may differ at smaller spatial scales where conditions could be more (or less) favourable. Other considerations could include cottage traffic to some watersheds and differences between large lakes and large river systems within sub-drainages.
- Impacts of Zebra Mussel and Quagga Mussel establishment have been shown to have significant, irreversible ecological impacts to freshwater ecosystems. Though not included in this assessment, ecological impacts also have socioeconomic implications and have been well documented in Canada and elsewhere.
- Human-mediated dispersal, specifically recreational boating activities including overland transport of boat trailers and water-based equipment, are important vectors contributing to the spread of Zebra Mussel and Quagga Mussel in Canadian freshwaters.
- Natural dispersal downstream in major river systems can occur rapidly over large distances.
- Due to the well documented impacts associated with Zebra Mussel and Quagga Mussel invasions, the uncertainty of this risk assessment is very low. Uncertainties exist in data limitation associated with human-mediated dispersal of dreissenid mussels in Canada.
- An effort should be made to consolidate geo-referenced water quality data at the national level, which would improve future risk assessments.

INTRODUCTION

Non-indigenous species (NIS) pose an enormous risk to native biodiversity and ecosystem function, especially biodiversity (e.g., Sala *et al*. 2000). Having the ability to identify the highest risk invaders and focus limited resources on these species is critical for resource managers. Human-mediated dispersal of non-indigenous species is so pervasive throughout the world's terrestrial, marine, and freshwater ecosystems that their cumulative impacts are amongst the most important drivers of global change. However, not all non-indigenous species are equivalent in terms of their ecological impacts.

In freshwater and some estuarine ecosystems, two prominent dreissenid mussels, the Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena rostriformis bugensis*), both native to the Ponto-Caspian region have a long history of invasion in both Europe and North America. Further, a related dreissenid mussel species, the Dark Falsemussel (also known as Conrad's Falsemussel, *Mytilopsis leucopheata*), has expanded its range to brackish water habitats across Europe and North America. Whether or not a non-indigenous species becomes invasive depends not only on its ability to establish populations outside its native range but also on its impacts to native ecosystems and society. The Government of Canada (2004) defines invasive alien species as "those harmful alien species whose introduction or spread threatens the environment, the economy or society, including human health". To guide management actions, a risk assessment can be used to identify higher risk invaders, the important vectors for introduction and/or spread, and the potential impacts if introduced.

ASSESSMENT

An ecological risk assessment was conducted to evaluate the risk posed by three non-indigenous dreissenid mussels to Canadian freshwaters and contains information for 108 Canadian sub-drainage basins within the Arctic Ocean, Atlantic Ocean, Gulf of Mexico, Hudson Bay, and Pacific Ocean freshwater drainages. This risk assessment considered probabilities of survival (habitat suitability) and arrival to each sub-drainage and the ecological impacts associated with these species. The ecological risk posed by these species was assessed using an established Risk Matrix that combines both the probability of invasion and the potential impacts on the environment. Non-ecological impacts (e.g. economic, human health) were not included in this assessment of risk, but have been considered in other studies. (Higgins and VanderZanden, 2010). The ecological risk for Zebra Mussel and Quagga Mussel were identified and reported at the Canadian sub-drainage scale.

Biology

The dreissenid mussels assessed in this study exhibit a similar morphology, and despite differences in size (13 -35 mm), are characterized as being mytiliform bivalves with variable patterns of white banding against a black or dark brown shell. Variation in morphology is observed in the ventral and dorsal margins of the shells as well as the overall degree of concavity. Additional morphological variability as "ecomorphs" has been observed in Quagga Mussel and is determined environmentally, rather than genetically, to reflect occupation of either shallow or deep-water habitats. The deep-water morphotypes are more dorso-ventrally compressed with an ovate profile and more pointed ventral surface. *M. leucophaeata* can be distinguished from members of the genus *Dreissena* by the presence of a small tooth (called an apophysis) located near the umbo that serves as the origin of anterior retractor muscles. All species have both inhalant and exhalant siphons which are used for feeding and can ingest

small particles (0.07 – 1.0 µm in diameter). Common prey includes planktonic algae and zooplankton such as tintinnids, rotifers, copepods, and cladocerans. Due to their grazing on small zooplankton and phytoplankton, adult dreissenid mussels compete with larger zooplankton, collectively depressing microzooplankton populations and impacting ecosystem structure and function. As Zebra Mussel and Quagga Mussel have similar diets, the larger size of Quagga Mussel may confer a competitive advantage over co-occurring dreissenid mussels; however, this advantage may be offset by the more fragile shells of Quagga Mussel that render it more vulnerable to fish predation.

Dreissenid mussels are r-strategists, exhibiting a short maturation time (1-2 years), high fecundity (>1 million eggs per female for each spawning event) and a capacity for dispersal aided by a planktonic veliger stage as well as the ability for juveniles and adults to attach to hard surfaces (e.g., boats, trailers, hard shelled animals) which are often transported between different ecosystems. Shell growth occurs at 6 – 8°C, reaching 1.5 – 2.0 cm per year during maturation. Although all dreissenid mussel shell growth is temperature dependent, higher temperatures appear to enhance shell growth rates in Zebra Mussel to a greater extent than is observed in Quagga Mussel. Multiple cohorts can coexist within a population. Dreissenid mussels exhibit a variable life span, Zebra Mussel and Quagga Mussel can survive up to 6 – 9 years (generally 3 – 4 years); whereas 2 - 4 years has been cited as average lifespan of the Dark Falsemussel. Lifespan of dreissenid mussels has been linked to general ambient temperatures, where lifespans tend to be shorter in warmer lakes. Dreissenid mussels can reach very high densities (exceeding 1,000,000 individuals m^{-2}) in localized areas when conditions are favorable. Egg sizes of the Dark Falsemussel generally are smaller compared to the other species included in this assessment, but as with the other dreissenids, fertilization occurs externally and larvae are produced within 24 hours.

Zebra Mussel and Quagga Mussel primarily inhabit freshwater ecosystems but are also found in brackish environments due to their ability for osmoregulation (0 to 8-12 ppt for adults, 0 to 6 ppt for embryos). These species are typically found in lakes, rivers, canals, and estuaries attached to a wide variety of substrates such as rocks, shellfish, aquatic plants; however, the Quagga Mussel has a greater tolerance for cooler temperatures and softer substrates, enabling colonization of deeper, benthic substrates in lakes. The ability of Quagga Mussel to use a broader range of habitats for colonization has been suggested as a fitness advantage over Zebra Mussel. Zebra Mussel typically settle at moderate depths (4-7m) and tend to be very rare in the profundal zone (>50m) due to the finer sediments and cold (~4 °C) temperatures. Zebra Mussel are known to be negatively phototaxic. The Dark Falsemussel is the most euryhaline and eurythermal of the three dreissenid mussel species considered here. Typically characterized as an estuarine species, the Dark Falsemussel is well adapted to environments with high sediment loading due to its long incurrent siphon and ability to close the valves around the byssus. It is typically found under oligo- or mesohaline conditions (e.g., 0.5-5 ppt to 6-18 ppt).

As with other bivalves, a significant quantity of calcium is required for shell development and calcium concentrations are considered a major factor in the potential for invasion and development of large populations to become established. The calcium thresholds for Zebra Mussel and Quagga Mussel are reported in Table 1. The range of pH tolerance spans 7.4-9.4 with the optimum at 8.5.

*Table 1. Calcium suitability for Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena rostriformis bugensis*) based on literature accounts (Cohen and Weinstein (2001), Cohen et al. (2001), Cohen (2007), Mackie and Claudi (2010), Whittier et al. (2008), Benson et al. (2012a; 2012b)).*

Category	Definition	Zebra Mussel Ca (mg/L)	Quagga Mussel Ca (mg/L)
Very Low	No adult survival	< 12	< 12
Moderate	Evidence that both adult survival AND reproduction are supported at a minimum level	12 -19	N/A
High	Evidence that good sized populations are supported in terms of both survival and reproduction	20 - 25	12 - 32
Very High	Very close to or at optimal range for all stages of the mussel life history; usually supports high to very high level of infestation	> 25	> 32

Potential Routes of Introduction and Vectors of Secondary Dispersal

Zebra Mussel began expanding their range throughout Europe over 200 years ago, substantially earlier than their establishment in the Laurentian Great Lakes of North America, and genetic data indicates that the Baltic Sea was the probable origin for these populations. Comparatively, it is suggested that Quagga Mussel populations in North America originated from native populations found in estuarine regions of the Southern Bug and Dnieper Rivers from the Black Sea. Dark Falsemussel originates from the eastern coast of North America, in the United States and Mexico, but is fairly rare throughout its native range.

The Zebra Mussel and Quagga Mussel are thought to have arrived to the Laurentian Great Lakes, via ballast water of trans-Atlantic shipping vessels, in the mid-to-late1980's. Subsequently, the Zebra Mussel dispersed rapidly to lakes and rivers in eastern North America and, by 2007, had crossed the continental divide into western North America. Following its introduction and establishment throughout the Laurentian Great Lakes, the Quagga Mussel has remained much more geographically restricted than the Zebra Mussel, but by 2007 this species had also invaded freshwaters of several western states in the USA. Dark Falsemussel has also spread along the eastern coast of North America and has invaded various non-native regions of the United States, Brazil and Europe. The principal vectors for its introduction into new areas are associated with the industrial shipping pathway. Larvae and adults are transported via ballast water and hull fouling respectively.

Many potential vectors of secondary introduction/spread have been identified for dreissenid mussels, most notably associated with recreational boating (attached to watercraft/trailers or entrained in live-well/bilge/lines). However, dreissenid mussels can spread via natural dispersal (e.g., drift, attachment to wildlife) or other human-mediated activities (e.g., intra-basin ballast water discharge, canal creation, waterway operations, and scientific expeditions).

Determining Probability of Survival (Habitat Suitability)

The probability of survival (habitat suitability) primarily was determined using calcium concentration thresholds (see Table 1). Although several environmental variables (e.g., temperature, pH, dissolved oxygen, calcium) may limit successful mollusc invasions (e.g., Mackie and Claudi 2010), Whittier et al. (2008) and Neary and Leach (1992) each used calcium

concentration as the primary factor for determining Zebra Mussel and Quagga Mussel risk. The minimum levels of calcium varied depending on the associated levels of pH, alkalinity and conductivity, but in general a calcium concentration of 12 mg/L was needed to support adult establishment.

In addition to calcium limitation, scientific literature suggests that water temperature may limit Zebra Mussel populations but does not influence Quagga Mussel populations. Accordingly, a temperature based correction factor was applied to calcium concentration scores (Limiting: $<10^{o}C$ (probability of survival was reduced by 1 category) and Potentially or Not Limiting: $>10^{o}C$ (probability of survival was not changed).

Determining Probability of Arrival

Probability of arrival was defined as a function of propagule pressure as determined using a Human Footprint Index and proximity to an invaded habitat. The inclusion of propagule pressure incorporates the understanding that the transport of dreissenid mussels between habitats is associated with human-mediated activities (e.g. recreational boating). A human footprint index was used (Therriault et al. 2013, Appendix A3), which integrates land use, urbanization, and other human activities as a proxy for vector pressure (see Sanderson et al. 2002). In order to estimate propagule pressure per sub-drainage, mean scores of the Human Footprint Index were binned according to their natural (Jenks) data breaks into five categories ranging from very low to very high

Risk Posed to Regions of Canada

The results of the risk assessment indicate that the ecological risk posed to Canadian freshwater ecosystems by both Zebra Mussel and Quagga Mussel is high, with the exception of sub-drainages on the Canadian Shield where calcium concentrations are too low to support large dreissenid mussel populations. In contrast, the risk posed by Dark Falsemussel to freshwater sub-drainages, due to its brackish/marine life history requirements, is low.

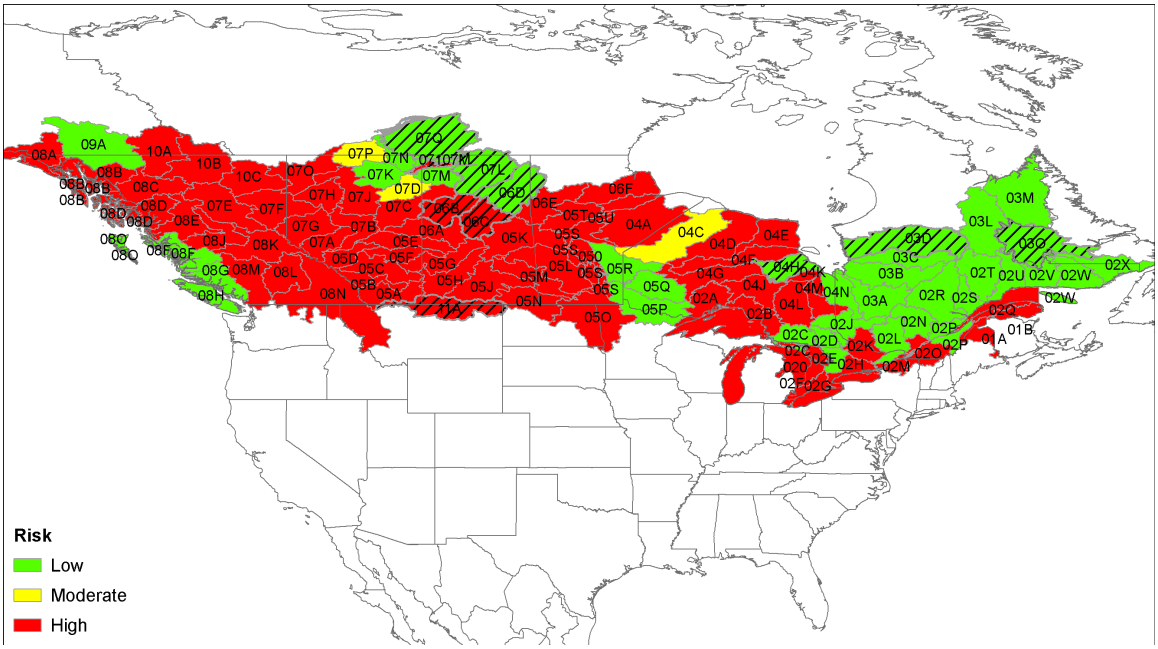


Figure 2. Zebra Mussel (D. polymorpha) ecological risk per sub-drainage, ranging from low to high. Risk is based on probability of invasion and impact on the environment. Hatched watersheds had less than 5 sampling sites.

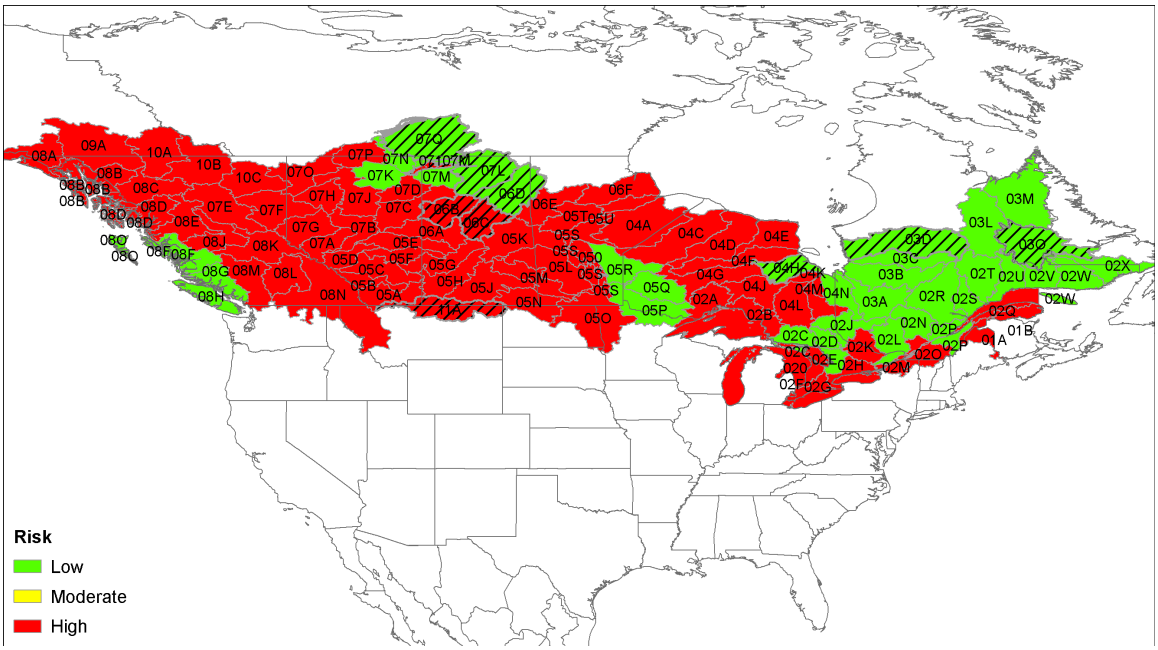


Figure 3. Quagga Mussel (D. rostriformis bugensis) ecological risk per sub-drainage, ranging from low to high. Risk is based on probability of invasion and impact on the environment. Hatched watersheds had less than 5 sampling.

Sources of Uncertainty

A combination of probability of survival (habitat suitability) and probability of arrival was used in this document to determine the probability of invasion. However, given the frequency with which dreissenid mussels have used long distance jump dispersal to reach new environments, probability of arrival based on propagule pressure and proximity to invaded locations may be underestimated. Thus, managers should refer to the habitat suitability information when considering the risk posed to specific waterbodies under their purview, especially if detailed water quality data are available.

There is considerable variation in the literature reporting environmental tolerances of dreissenids, in part due to variability in observations over a significant geographic range due to the widespread nature of these invaders and in part due to a number of laboratory studies that do not necessarily reflect actual field conditions. It is important to note that at the scale of the risk assessment conducted here there can be considerable intra-sub-drainage variability. This variability is the greatest source of uncertainty when projecting habitat suitability to the sub-drainage spatial scale used in this risk assessment. Human-mediated transport of Zebra Mussel and Quagga Mussel, especially by recreational boaters and long distance transport by commercial boat haulers, are likely the most significant vectors contributing to the redistribution of these species in North America. Further research to better characterize recreational boater movements both within Canada and between Canada and the United States would significantly advance our understanding of this currently unregulated vector.

CONCLUSIONS AND ADVICE

Conclusions:

The ecological risk posed to Canadian freshwater ecosystems by both Zebra Mussel and Quagga Mussel is high. In contrast, the ecological risk posed by Dark Falsemussel to freshwater sub-drainages is considered low.

The risk to various ecological endpoints was not equal; the most significant risk appears to be on Canadian unionid mussels, several of which are identified as at some level of risk by COSEWIC.

Recommendations:

Based on the results of the risk assessment, Zebra Mussel and Quagga Mussel were identified as high risk invaders to Canadian freshwaters and further research may be required to fully identify habitats and environmental variables contributing to risk at smaller spatial scales.

The ecological risk posed by Dark Falsemussel to freshwater sub-drainages is considered low largely due to the salinity requirements for successful establishment. A separate risk assessment should be considered for estuarine waters that were beyond the scope of this process.

Probability of survival (habitat suitability) was determined using the 75^{th} percentile calcium value at the sub-drainage level; however, spatial variation in suitability should not be overlooked, as

some lakes or rivers may exist which exhibit sufficient calcium concentrations for the establishment of these species.

A geo-referenced Canadian database of environmental variables is much needed. Although literature exists on the environmental tolerances of dreissenid mussels, insufficient data is available for many additional variables, and virtually none at the spatial scales required for modeling. Such a database would prove invaluable not only for predicting the potential distribution of aquatic invasive species but also to better understand how potential climate variable could affect Canadian biota.

Increased monitoring is necessary to determine the extent of species' distributions and spread. Veliger sampling for Zebra Mussel and Quagga Mussel has proven very successful in the United States and is a key component of effective monitoring projects.

Recreational boating has been identified as a key vector in the spread of dreissenid mussels. Managers should consider education efforts to raise the awareness about potential inadvertent transport of these mussels (e.g., signage at boat launches) or consider proactive intervention (e.g., boat wash stations).

Commercial shipping has been identified as the vector responsible for the introduction of Zebra Mussel and Quagga Mussel to North America and Dark Falsemussel to Europe. Environmental data for ports receiving international vessels or those connected by domestic vessels would enhance understanding of higher risk locations for primary introduction from foreign populations.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 27-28, 2012 National risk assessment of Zebra Mussel, Quagga Mussel and Dark Falsemussel. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule as they become available.

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Whittier, T.R., Ringold, R.L., Herlihy, A.T., and Pierson, S.M. 2008. A calcium-based invasion risk assessment for Zebra and Quagga Mussels (*Dreissena* spp). Front. Ecol. Environ. 6:180-184.

APPENDIX 1: Probability of Zebra Mussel Arrival, Survival, and Invasion per Sub-Drainage

The probability of invasion is based on the probability of survival (calcium suitability corrected for temperature) and probability of arrival (propagule pressure corrected for proximity to an invaded watershed). The risk to the environment is based on the probability of invasion and impacts to the environment.

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
AB	05F	Battle	Very high	0	Very high	High	0	High	Very high	High
AB	06A	Beaver (Alta.-Sask.)	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	05B	Bow	Very high	0	Very high	High	0	High	Very high	High
AB	07C	Central Athabasca - Lower	Very high	0	Very high	Low	0	Low	High	High
AB	07B	Central Athabasca - Upper	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	05E	Central North Saskatchewan	Very high	0	Very high	High	0	High	Very high	High
AB	07J	Central Peace - Lower	Very high	0	Very high	Low	0	Low	High	High
AB	07H	Central Peace - Upper	Very high	0	Very high	Low	0	Low	High	High
AB	08N	Columbia - U.S.A.	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	10C	Fort Nelson	Very high	0	Very high	Low	0	Low	High	High
AB	07Q	Great Slave Lake - East Arm South Shore	Very low	0	Very low	Very low	0	Very low	Very low	Low
AB	07O	Hay	Very high	0	Very high	Low	0	Low	High	High
AB	71	Lake Athabasca	High	0	High	Very low	0	Very low	Moderate	High
AB	07M	Lake Athabasca - Shores	Very low	0	Very low	Very low	0	Very low	Very low	Low
AB	07D	Lower Athabasca	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate
AB	05G	Lower North Saskatchewan	High	0	High	High	0	High	High	High
AB	07K	Lower Peace	Very low	0	Very low	Very low	0	Very low	Very low	Low
AB	05H	Lower South Saskatchewan	Very high	0	Very high	High	0	High	Very high	High
AB	11A	Missouri	Very high	0	Very high	Moderate	1	High	Very high	High
AB	05C	Red Deer	Very high	0	Very high	High	0	High	Very high	High
AB	07N	Slave	Very low	0	Very low	Low	0	Low	Very low	Low
AB	07G	Smoky	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	07P	Southern Great Slave Lake	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate
AB	07A	Upper Athabasca	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	06B	Upper Churchill (Man.)	Very high	0	Very high	Very low	0	Very low	Moderate	High
AB	08K	Upper Fraser	Very high	0	Very high	Low	0	Low	High	High
AB	05D	Upper North Saskatchewan	Very high	0	Very high	Moderate	0	Moderate	High	High
AB	07F	Upper Peace	Very high	0	Very high	Moderate	0	Moderate	High	High

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
AB	05A	Upper South Saskatchewan	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	08A	Alsek	Very high	-1	High	Low	0	Low	Moderate	High
BC	05B	Bow	Very high	0	Very high	High	0	High	Very high	High
BC	08F	Central Coastal Waters of B.C.	Very low	0	Very low	Low	0	Low	Very low	Low
BC	10B	Central Liard	Very high	0	Very high	Very low	0	Very low	Moderate	High
BC	08N	Columbia - U.S.A.	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	10C	Fort Nelson	Very high	0	Very high	Low	0	Low	High	High
BC	07O	Hay	Very high	0	Very high	Low	0	Low	High	High
BC	09A	Headwaters Yukon	Moderate	-1	Low	Low	0	Low	Low	Low
BC	08M	Lower Fraser	High	0	High	Moderate	0	Moderate	High	High
BC	08D	Nass - Coast	Moderate	0	Moderate	Low	0	Low	Moderate	High
BC	08J	Nechako	Moderate	0	Moderate	Low	0	Low	Moderate	High
BC	08B	Northern Coastal Waters of B.C.	High	-1	Moderate	Low	0	Low	Moderate	High
BC	08O	Queen Charlotte Islands	Very low	0	Very low	Moderate	0	Moderate	Very low	Low
BC	08E	Skeena - Coast	Moderate	0	Moderate	Low	0	Low	Moderate	High
BC	07G	Smoky	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	08G	Southern Coastal Waters of B.C.	Very low	0	Very low	Low	0	Low	Very low	Low
BC	08C	Stikine - Coast	High	-1	Moderate	Low	0	Low	Moderate	High
BC	08L	Thompson	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	07A	Upper Athabasca	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	08K	Upper Fraser	Very high	0	Very high	Low	0	Low	High	High
BC	10A	Upper Liard	Very high	-1	High	Low	0	Low	Moderate	High
BC	05D	Upper North Saskatchewan	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	07F	Upper Peace	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	05A	Upper South Saskatchewan	Very high	0	Very high	Moderate	0	Moderate	High	High
BC	08H	Vancouver Island	Very low	0	Very low	Moderate	0	Moderate	Very low	Low
BC	07E	Williston Lake	Very high	0	Very high	Low	0	Low	High	High
MB	05M	Assiniboine	Very high	0	Very high	High	1	Very high	Very high	High
MB	06E	Central Churchill (Man.) - Lower	Very high	0	Very high	Very low	0	Very low	Moderate	High
MB	05R	Eastern Lake Winnipeg	Very low	0	Very low	Very low	1	Low	Very low	Low
MB	05T	Grass and Burntwood	Moderate	0	Moderate	Low	0	Low	Moderate	High
MB	04A	Hayes (Man.)	High	0	High	Very low	0	Very low	Moderate	High
MB	50	Lake Winnipeg	Very high	0	Very high	Low	1	Very high	Very high	High

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
MB	05L	Lake Winnipegosis and Lake Manitoba	Very high	0	Very high	Moderate	1	High	Very high	High
MB	06F	Lower Churchill (Man.)	High	0	High	Very low	0	Very low	Moderate	High
MB	05U	Nelson	Very high	0	Very high	Very low	1	Very high	Very high	High
MB	05J	Qu'Appelle	Very high	0	Very high	High	1	Very high	Very high	High
MB	05O	Red	Very high	0	Very high	High	1	Very high	Very high	High
MB	06D	Reindeer	Very low	0	Very low	Very low	0	Very low	Very low	Low
MB	05K	Saskatchewan	Very high	0	Very high	Moderate	1	High	Very high	High
MB	04C	Severn	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate
MB	05N	Souris	Very high	0	Very high	High	1	Very high	Very high	High
MB	05S	Western Lake Winnipeg	Very high	0	Very high	Moderate	1	High	Very high	High
MB	05P	Winnipeg	Very low	0	Very low	Moderate	1	High	Very low	Low
NL	03L	Caniapiscau	Very low	-1	Very low	Very low	1	Low	Very low	Low
NL	03O	Churchill (Nfld.)	Very low	0	Very low	Low	1	Moderate	Very low	Low
NL	03M	Eastern Ungava Bay	Very low	-1	Very low	Low	0	Low	Very low	Low
NL	02W	Gulf of St. Lawrence - Natashquan	Very low	0	Very low	Low	1	Moderate	Very low	Low
NL	02V	Gulf of St. Lawrence - Romaine	Very low	0	Very low	Very low	1	Low	Very low	Low
NL	02U	Moisie and St. Lawrence Estuary	Very low	0	Very low	Low	1	Moderate	Very low	Low
NL	02X	Petit Mécatina and Strait of Belle Isle	Very low	0	Very low	Low	1	Moderate	Very low	Low
NT	10B	Central Liard	Very high	0	Very high	Very low	0	Very low	Moderate	High
NT	07L	Fond-du-Lac	Very low	0	Very low	Very low	0	Very low	Very low	Low
NT	07Q	Great Slave Lake - East Arm South Shore	Very low	0	Very low	Very low	0	Very low	Very low	Low
NT	07O	Hay	Very high	0	Very high	Low	0	Low	High	High
NT	07N	Slave	Very low	0	Very low	Low	0	Low	Very low	Low
NT	07P	Southern Great Slave Lake	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate
NT	10A	Upper Liard	Very high	-1	High	Low	0	Low	Moderate	High
ON	04M	Abitibi	High	0	High	Moderate	1	High	High	High
ON	04F	Attawapiskat - Coast	Moderate	0	Moderate	Very low	1	Low	Moderate	High
ON	02K	Central Ottawa	Moderate	0	Moderate	Moderate	1	High	High	High
ON	02E	Eastern Georgian Bay	Very low	0	Very low	High	1	Very high	Very low	Low
ON	02F	Eastern Lake Huron	Very high	0	Very high	Very high	1	Very high	Very high	High
ON	05R	Eastern Lake Winnipeg	Very low	0	Very low	Very low	1	Low	Very low	Low

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
ON	04E	Ekwan - Coast	High	0	High	Very low	0	Very low	Moderate	High
ON	05Q	English	Very low	0	Very low	Low	1	Moderate	Very low	Low
ON	20	Great Lakes and St. Lawrence	Very high	0	Very high	Very high	1	Very high	Very high	High
ON	04N	Harricanaw - Coast	Very low	0	Very low	Low	1	Moderate	Very low	Low
ON	04A	Hayes (Man.)	High	0	High	Very low	0	Very low	Moderate	High
ON	04J	Kenogami	Very high	0	Very high	Low	1	Moderate	High	High
ON	02H	Lake Ontario and Niagara Peninsula	High	0	High	Very high	1	Very high	Very high	High
ON	04H	Lower Albany - Coast	Very low	0	Very low	Very low	1	Low	Very low	Low
ON	02L	Lower Ottawa	Very low	0	Very low	High	1	Very high	Very low	Low
ON	04L	Missinaibi-Mattagami	Moderate	0	Moderate	Moderate	1	High	High	High
ON	04K	Moose (Ont.)	Moderate	0	Moderate	Very low	1	Low	Moderate	High
ON	02B	Northeastern Lake Superior	Moderate	0	Moderate	Low	1	Moderate	Moderate	High
ON	02G	Northern Lake Erie	Very high	0	Very high	Very high	1	Very high	Very high	High
ON	02C	Northern Lake Huron	Very low	0	Very low	Moderate	1	High	Very low	Low
ON	02A	Northwestern Lake Superior	Moderate	0	Moderate	Moderate	1	High	High	High
ON	04C	Severn	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate
ON	04G	Upper Albany	Moderate	0	Moderate	Very low	1	Low	Moderate	High
ON	02J	Upper Ottawa	Very low	0	Very low	Moderate	1	High	Very low	Low
ON	02M	Upper St. Lawrence	Very high	0	Very high	High	1	Very high	Very high	High
ON	02D	Wanipitai and French (Ont.)	Very low	0	Very low	Moderate	1	High	Very low	Low
ON	04D	Winisk - Coast	Moderate	0	Moderate	Very low	1	Low	Moderate	High
ON	05P	Winnipeg	Very low	0	Very low	Moderate	1	High	Very low	Low
QC	04M	Abitibi	High	0	High	Moderate	1	High	High	High
QC	02S	Betsiamites - Coast	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	03B	Broadback and Rupert	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	03L	Caniapiscau	Very low	-1	Very low	Very low	1	Low	Very low	Low
QC	02K	Central Ottawa	Moderate	0	Moderate	Moderate	1	High	High	High
QC	02O	Central St. Lawrence	Moderate	0	Moderate	Very high	1	Very high	High	High
QC	03O	Churchill (Nfld.)	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	03M	Eastern Ungava Bay	Very low	-1	Very low	Low	0	Low	Very low	Low
QC	03C	Eastmain	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	20	Great Lakes and St. Lawrence	Very high	0	Very high	Very high	1	Very high	Very high	High
QC	02W	Gulf of St. Lawrence - Natashquan	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02V	Gulf of St. Lawrence -	Very low	0	Very low	Very low	1	Low	Very low	Low

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
		Romaine								
QC	01B	Gulf of St. Lawrence and Northern Bay of Fundy (N.B.)	Very high	0	Very high	High	1	Very high	Very high	High
QC	04N	Harricanaw - Coast	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	03D	La Grande - Coast	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02L	Lower Ottawa	Very low	0	Very low	High	1	Very high	Very low	Low
QC	02P	Lower St. Lawrence	Very low	0	Very low	High	1	Very high	Very low	Low
QC	02T	Manicouagan and aux Outardes	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02U	Moisie and St. Lawrence Estuary	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02Q	Northern Gaspé Peninsula	Very high	0	Very high	High	1	Very high	Very high	High
QC	03A	Nottaway - Coast	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02X	Petit Mécatina and Strait of Belle Isle	Very low	0	Very low	Low	1	Moderate	Very low	Low
QC	02R	Saguenay	Very low	0	Very low	Moderate	1	High	Very low	Low
QC	01A	Saint John and Southern Bay of Fundy (N.B.)	High	0	High	High	1	Very high	Very high	High
QC	02N	Saint-Maurice	Very low	0	Very low	Moderate	1	High	Very low	Low
QC	02J	Upper Ottawa	Very low	0	Very low	Moderate	1	High	Very low	Low
QC	02M	Upper St. Lawrence	Very high	0	Very high	High	1	Very high	Very high	High
SK	05M	Assiniboine	Very high	0	Very high	High	1	Very high	Very high	High
SK	05F	Battle	Very high	0	Very high	High	0	High	Very high	High
SK	06A	Beaver (Alta.-Sask.)	Very high	0	Very high	Moderate	0	Moderate	High	High
SK	07C	Central Athabasca - Lower	Very high	0	Very high	Low	0	Low	High	High
SK	06E	Central Churchill (Man.) - Lower	Very high	0	Very high	Very low	0	Very low	Moderate	High
SK	06C	Central Churchill (Man.) - Upper	Moderate	0	Moderate	Low	0	Low	Moderate	High
SK	05E	Central North Saskatchewan	Very high	0	Very high	High	0	High	Very high	High
SK	07L	Fond-du-Lac	Very low	0	Very low	Very low	0	Very low	Very low	Low
SK	07Q	Great Slave Lake - East Arm South Shore	Very low	0	Very low	Very low	0	Very low	Very low	Low
SK	71	Lake Athabasca	High	0	High	Very low	0	Very low	Moderate	High
SK	07M	Lake Athabasca - Shores	Very low	0	Very low	Very low	0	Very low	Very low	Low
SK	05L	Lake Winnipegosis and Lake Manitoba	Very high	0	Very high	Moderate	1	High	Very high	High
SK	07D	Lower Athabasca	Moderate	0	Moderate	Very low	0	Very low	Low	Moderate

Prov.	ID	Sub-drainage	Calcium Suitability	Temp corr.	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
SK	05G	Lower North Saskatchewan	High	0	High	High	0	High	High	High
SK	05H	Lower South Saskatchewan	Very high	0	Very high	High	0	High	Very high	High
SK	11A	Missouri	Very high	0	Very high	Moderate	1	High	Very high	High
SK	05J	Qu'Appelle	Very high	0	Very high	High	1	Very high	Very high	High
SK	05C	Red Deer	Very high	0	Very high	High	0	High	Very high	High
SK	06D	Reindeer	Very low	0	Very low	Very low	0	Very low	Very low	Low
SK	05K	Saskatchewan	Very high	0	Very high	Moderate	1	High	Very high	High
SK	05N	Souris	Very high	0	Very high	High	1	Very high	Very high	High
SK	06B	Upper Churchill (Man.)	Very high	0	Very high	Very low	0	Very low	Moderate	High
SK	05A	Upper South Saskatchewan	Very high	0	Very high	Moderate	0	Moderate	High	High
YT	08A	Alsek	Very high	-1	High	Low	0	Low	Moderate	High
YT	10B	Central Liard	Very high	0	Very high	Very low	0	Very low	Moderate	High
YT	09A	Headwaters Yukon	Moderate	-1	Low	Low	0	Low	Low	Low
YT	10A	Upper Liard	Very high	-1	High	Low	0	Low	Moderate	High

APPENDIX 2: Probability of Quagga Mussel Arrival, Survival, and Invasion per Sub-Drainage

The probability of invasion is based on the probability of survival (calcium suitability) and probability of arrival (propagule pressure corrected for proximity to an invaded watershed). The risk to the environment is based on the probability of invasion and impacts to the environment.

Prov.	ID	Sub-drainage	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
AB	05F	Battle	High	High	0	High	High	High
AB	06A	Beaver (Alta.-Sask.)	High	Moderate	0	Moderate	High	High
AB	05B	Bow	Very high	High	0	High	Very high	High
AB	07C	Central Athabasca - Lower	High	Low	0	Low	Moderate	High
AB	07B	Central Athabasca - Upper	High	Moderate	0	Moderate	High	High
AB	05E	Central North Saskatchewan	Very high	High	0	High	Very high	High
AB	07J	Central Peace - Lower	High	Low	0	Low	Moderate	High
AB	07H	Central Peace - Upper	Very high	Low	0	Low	High	High
AB	08N	Columbia - U.S.A.	Very high	Moderate	0	Moderate	High	High
AB	10C	Fort Nelson	Very high	Low	0	Low	High	High
AB	07Q	Great Slave Lake - East Arm South Shore	Very low	Very low	0	Very low	Very low	Low
AB	07O	Hay	Very high	Low	0	Low	High	High
AB	71	Lake Athabasca	High	Very low	0	Very low	Moderate	High
AB	07M	Lake Athabasca - Shores	Very low	Very low	0	Very low	Very low	Low
AB	07D	Lower Athabasca	High	Very low	0	Very low	Moderate	High
AB	05G	Lower North Saskatchewan	High	High	0	High	High	High
AB	07K	Lower Peace	Very low	Very low	0	Very low	Very low	Low
AB	05H	Lower South Saskatchewan	Very high	High	0	High	Very high	High
AB	11A	Missouri	Very high	Moderate	0	Moderate	High	High
AB	05C	Red Deer	Very high	High	0	High	Very high	High
AB	07N	Slave	Very low	Low	0	Low	Very low	Low
AB	07G	Smoky	Very high	Moderate	0	Moderate	High	High
AB	07P	Southern Great Slave Lake	High	Very low	0	Very low	Moderate	High
AB	07A	Upper Athabasca	Very high	Moderate	0	Moderate	High	High
AB	06B	Upper Churchill (Man.)	High	Very low	0	Very low	Moderate	High
AB	08K	Upper Fraser	Very high	Low	0	Low	High	High
AB	05D	Upper North Saskatchewan	High	Moderate	0	Moderate	High	High
AB	07F	Upper Peace	Very high	Moderate	0	Moderate	High	High
AB	05A	Upper South Saskatchewan	Very high	Moderate	0	Moderate	High	High

Prov.	ID	Sub-drainage	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
BC	08A	Alsek	Very high	Low	0	Low	High	High
BC	05B	Bow	Very high	High	0	High	Very high	High
BC	08F	Central Coastal Waters of B.C.	Very low	Low	0	Low	Very low	Low
BC	10B	Central Liard	High	Very low	0	Very low	Moderate	High
BC	08N	Columbia - U.S.A.	Very high	Moderate	0	Moderate	High	High
BC	10C	Fort Nelson	Very high	Low	0	Low	High	High
BC	07O	Hay	Very high	Low	0	Low	High	High
BC	09A	Headwaters Yukon	High	Low	0	Low	Moderate	High
BC	08M	Lower Fraser	High	Moderate	0	Moderate	High	High
BC	08D	Nass - Coast	High	Low	0	Low	Moderate	High
BC	08J	Nechako	High	Low	0	Low	Moderate	High
BC	08B	Northern Coastal Waters of B.C.	High	Low	0	Low	Moderate	High
BC	08O	Queen Charlotte Islands	Very low	Moderate	0	Moderate	Very low	Low
BC	08E	Skeena - Coast	High	Low	0	Low	Moderate	High
BC	07G	Smoky	Very high	Moderate	0	Moderate	High	High
BC	08G	Southern Coastal Waters of B.C.	Very low	Low	0	Low	Very low	Low
BC	08C	Stikine - Coast	High	Low	0	Low	Moderate	High
BC	08L	Thompson	Very high	Moderate	0	Moderate	High	High
BC	07A	Upper Athabasca	Very high	Moderate	0	Moderate	High	High
BC	08K	Upper Fraser	Very high	Low	0	Low	High	High
BC	10A	Upper Liard	High	Low	0	Low	Moderate	High
BC	05D	Upper North Saskatchewan	High	Moderate	0	Moderate	High	High
BC	07F	Upper Peace	Very high	Moderate	0	Moderate	High	High
BC	05A	Upper South Saskatchewan	Very high	Moderate	0	Moderate	High	High
BC	08H	Vancouver Island	Very low	Moderate	0	Moderate	Very low	Low
BC	07E	Williston Lake	High	Low	0	Low	Moderate	High
MB	05M	Assiniboine	Very high	High	0	High	Very high	High
MB	06E	Central Churchill (Man.) - Lower	Very high	Very low	0	Very low	Moderate	High
MB	05R	Eastern Lake Winnipeg	Very low	Very low	1	Low	Very low	Low
MB	05T	Grass and Burntwood	High	Low	0	Low	Moderate	High
MB	04A	Hayes (Man.)	High	Very low	0	Very low	Moderate	High
MB	50	Lake Winnipeg	Very high	Low	0	Low	High	High
MB	05L	Lake Winnipegosis and Lake Manitoba	Very high	Moderate	0	Moderate	High	High
MB	06F	Lower Churchill (Man.)	High	Very low	0	Very low	Moderate	High
MB	05U	Nelson	Very high	Very low	0	Very low	Moderate	High
MB	05J	Qu'Appelle	Very high	High	0	High	Very high	High

Prov.	ID	Sub-drainage	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
MB	05O	Red	Very high	High	1	Very high	Very high	High
MB	06D	Reindeer	Very low	Very low	0	Very low	Very low	Low
MB	05K	Saskatchewan	Very high	Moderate	0	Moderate	High	High
MB	04C	Severn	High	Very low	0	Very low	Moderate	High
MB	05N	Souris	Very high	High	0	High	Very high	High
MB	05S	Western Lake Winnipeg	Very high	Moderate	1	High	Very high	High
MB	05P	Winnipeg	Very low	Moderate	1	High	Very low	Low
NL	03L	Caniapiscau	Very low	Very low	1	Low	Very low	Low
NL	03O	Churchill (Nfld.)	Very low	Low	1	Moderate	Very low	Low
NL	03M	Eastern Ungava Bay	Very low	Low	0	Low	Very low	Low
NL	02W	Gulf of St. Lawrence - Natashquan	Very low	Low	1	Moderate	Very low	Low
NL	02V	Gulf of St. Lawrence - Romaine	Very low	Very low	1	Low	Very low	Low
NL	02U	Moisie and St. Lawrence Estuary	Very low	Low	1	Moderate	Very low	Low
NL	02X	Petit Mécatina and Strait of Belle Isle	Very low	Low	0	Low	Very low	Low
NT	10B	Central Liard	High	Very low	0	Very low	Moderate	High
NT	07L	Fond-du-Lac	Very low	Very low	0	Very low	Very low	Low
NT	07Q	Great Slave Lake - East Arm South Shore	Very low	Very low	0	Very low	Very low	Low
NT	07O	Hay	Very high	Low	0	Low	High	High
NT	07N	Slave	Very low	Low	0	Low	Very low	Low
NT	07P	Southern Great Slave Lake	High	Very low	0	Very low	Moderate	High
NT	10A	Upper Liard	High	Low	0	Low	Moderate	High
ON	04M	Abitibi	High	Moderate	1	High	High	High
ON	04F	Attawapiskat - Coast	High	Very low	0	Very low	Moderate	High
ON	02K	Central Ottawa	High	Moderate	1	High	High	High
ON	02E	Eastern Georgian Bay	Very low	High	1	Very high	Very low	Low
ON	02F	Eastern Lake Huron	Very high	Very high	1	Very high	Very high	High
ON	05R	Eastern Lake Winnipeg	Very low	Very low	1	Low	Very low	Low
ON	04E	Ekwan - Coast	High	Very low	0	Very low	Moderate	High
ON	05Q	English	Very low	Low	1	Moderate	Very low	Low
ON	20	Great Lakes and St. Lawrence	Very high	Very high	1	Very high	Very high	High
ON	04N	Harricanaw - Coast	Very low	Low	1	Moderate	Very low	Low
ON	04A	Hayes (Man.)	High	Very low	0	Very low	Moderate	High
ON	04J	Kenogami	High	Low	1	Moderate	High	High
ON	02H	Lake Ontario and Niagara Peninsula	High	Very high	1	Very high	Very high	High
ON	04H	Lower Albany - Coast	Very low	Very low	0	Very low	Very low	Low
ON	02L	Lower Ottawa	Very low	High	1	Very high	Very low	Low

Prov.	ID	Sub-drainage	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
ON	04L	Missinaibi-Mattagami	High	Moderate	1	High	High	High
ON	04K	Moose (Ont.)	High	Very low	1	Low	Moderate	High
ON	02B	Northeastern Lake Superior	High	Low	1	Moderate	High	High
ON	02G	Northern Lake Erie	Very high	Very high	1	Very high	Very high	High
ON	02C	Northern Lake Huron	Very low	Moderate	1	High	Very low	Low
ON	02A	Northwestern Lake Superior	High	Moderate	1	High	High	High
ON	04C	Severn	High	Very low	0	Very low	Moderate	High
ON	04G	Upper Albany	High	Very low	1	Low	Moderate	High
ON	02J	Upper Ottawa	Very low	Moderate	1	High	Very low	Low
ON	02M	Upper St. Lawrence	High	High	1	Very high	Very high	High
ON	02D	Wanipitai and French (Ont.)	Very low	Moderate	1	High	Very low	Low
ON	04D	Winisk - Coast	High	Very low	0	Very low	Moderate	High
ON	05P	Winnipeg	Very low	Moderate	1	High	Very low	Low
QC	04M	Abitibi	High	Moderate	1	High	High	High
QC	02S	Betsiamites - Coast	Very low	Low	1	Moderate	Very low	Low
QC	03B	Broadback and Rupert	Very low	Low	1	Moderate	Very low	Low
QC	03L	Caniapiscau	Very low	Very low	1	Low	Very low	Low
QC	02K	Central Ottawa	High	Moderate	1	High	High	High
QC	02O	Central St. Lawrence	High	Very high	1	Very high	Very high	High
QC	03O	Churchill (Nfld.)	Very low	Low	1	Moderate	Very low	Low
QC	03M	Eastern Ungava Bay	Very low	Low	0	Low	Very low	Low
QC	03C	Eastmain	Very low	Low	1	Moderate	Very low	Low
QC	20	Great Lakes and St. Lawrence	Very high	Very high	1	Very high	Very high	High
QC	02W	Gulf of St. Lawrence - Natashquan	Very low	Low	1	Moderate	Very low	Low
QC	02V	Gulf of St. Lawrence - Romaine	Very low	Very low	1	Low	Very low	Low
QC	01B	Gulf of St. Lawrence and Northern Bay of Fundy (N.B.)	High	High	1	Very high	Very high	High
QC	04N	Harricanaw - Coast	Very low	Low	1	Moderate	Very low	Low
QC	03D	La Grande - Coast	Very low	Low	1	Moderate	Very low	Low
QC	02L	Lower Ottawa	Very low	High	1	Very high	Very low	Low
QC	02P	Lower St. Lawrence	Very low	High	1	Very high	Very low	Low
QC	02T	Manicouagan and aux Outardes	Very low	Low	1	Moderate	Very low	Low
QC	02U	Moisie and St. Lawrence Estuary	Very low	Low	1	Moderate	Very low	Low
QC	02Q	Northern Gaspé Peninsula	High	High	1	Very high	Very high	High
QC	03A	Nottaway - Coast	Very low	Low	1	Moderate	Very low	Low
QC	02X	Petit Mécatina and Strait of Belle Isle	Very low	Low	0	Low	Very low	Low

Prov.	ID	Sub-drainage	Probability of Survival	Propagule Pressure	Prox corr.	Probability of Arrival	Probability of Invasion	Risk to Environment
QC	02R	Saguenay	Very low	Moderate	1	High	Very low	Low
QC	01A	Saint John and Southern Bay of Fundy (N.B.)	High	High	1	Very high	Very high	High
QC	02N	Saint-Maurice	Very low	Moderate	1	High	Very low	Low
QC	02J	Upper Ottawa	Very low	Moderate	1	High	Very low	Low
QC	02M	Upper St. Lawrence	High	High	1	Very high	Very high	High
SK	05M	Assiniboine	Very high	High	0	High	Very high	High
SK	05F	Battle	High	High	0	High	High	High
SK	06A	Beaver (Alta.-Sask.)	High	Moderate	0	Moderate	High	High
SK	07C	Central Athabasca - Lower	High	Low	0	Low	Moderate	High
SK	06E	Central Churchill (Man.) - Lower	Very high	Very low	0	Very low	Moderate	High
SK	06C	Central Churchill (Man.) - Upper	High	Low	0	Low	Moderate	High
SK	05E	Central North Saskatchewan	Very high	High	0	High	Very high	High
SK	07L	Fond-du-Lac	Very low	Very low	0	Very low	Very low	Low
SK	07Q	Great Slave Lake - East Arm South Shore	Very low	Very low	0	Very low	Very low	Low
SK	71	Lake Athabasca	High	Very low	0	Very low	Moderate	High
SK	07M	Lake Athabasca - Shores	Very low	Very low	0	Very low	Very low	Low
SK	05L	Lake Winnipegosis and Lake Manitoba	Very high	Moderate	0	Moderate	High	High
SK	07D	Lower Athabasca	High	Very low	0	Very low	Moderate	High
SK	05G	Lower North Saskatchewan	High	High	0	High	High	High
SK	05H	Lower South Saskatchewan	Very high	High	0	High	Very high	High
SK	11A	Missouri	Very high	Moderate	0	Moderate	High	High
SK	05J	Qu'Appelle	Very high	High	0	High	Very high	High
SK	05C	Red Deer	Very high	High	0	High	Very high	High
SK	06D	Reindeer	Very low	Very low	0	Very low	Very low	Low
SK	05K	Saskatchewan	Very high	Moderate	0	Moderate	High	High
SK	05N	Souris	Very high	High	0	High	Very high	High
SK	06B	Upper Churchill (Man.)	High	Very low	0	Very low	Moderate	High
SK	05A	Upper South Saskatchewan	Very high	Moderate	0	Moderate	High	High
YT	08A	Alsek	Very high	Low	0	Low	High	High
YT	10B	Central Liard	High	Very low	0	Very low	Moderate	High
YT	09A	Headwaters Yukon	High	Low	0	Low	Moderate	High
YT	10A	Upper Liard	High	Low	0	Low	Moderate	High

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