SCIENCE ADVICE FOR SCREENING-LEVEL RISK ASSESSMENT PROTOCOLS FOR NONINDIGENOUS FRESHWATER ORGANISMS IN TRADE IN CANADA

Figure 1. Department of Fisheries and Oceans' (DFO) six administrative regions.

Context:

Aquatic invasive species (AIS) threaten global biodiversity and are the second leading cause for the decline of Canadian freshwater species at risk. The establishment of AIS can reduce the abundance or productivity of sport, commercial, or culturally important species and can cause habitat alteration. Therefore, preventing the arrival, establishment, and spread of AIS is an important step to protecting aquatic environments. Fisheries and Oceans Canada's (DFO) Aquatic Invasive Species Program has been tasked by both the office of the Auditor General and an internal evaluation to establish a protocol that would provide a scientifically defensible and relatively quick way of screening and prioritizing aquatic non-indigenous species (NIS). DFO's Legislative and Regulatory Affairs (LRA) has also requested science advice to support the development of a national regulatory proposal for addressing aquatic NIS. AIS are introduced into Canadian fresh waters through various vectors and pathways, some of which are associated with the live trade pathway. An increasingly large number of aquatic plants, molluscs and fishes are imported into North America every year for sale in the aquarium and garden trades. These trades pose a potential risk of introducing into, and/or spreading non-indigenous species within, Canadian freshwater ecosystems through accidental or deliberate unauthorized release.

Given the potential that NIS have to exert substantial negative impacts on Canadian ecosystems, DFO's Centre of Expertise for Aquatic Risk Assessment (CEARA) was tasked to complete a review of the screening-level risk assessment protocols available to identify the risk posed by freshwater organisms in trade in Canada. This process included an evaluation of five screening-level risk assessment tools available for freshwater fishes as well as the application of previously published peer reviewed screening-level risk assessment tools for molluscs and aquatic plants in trade in Canada. The overall risk posed by these species was assessed using these tools.

This Science Advisory Report is from the national peer review meeting on the Screening-level risk assessment prioritization protocol for aquatic non-indigenous species (Part 2) held on March 19-21, 2013 in Burlington, Ontario. Additional publications from this process will be posted on the [DFO Science Advisory Schedule](#) as they become available.

SUMMARY

- Biological risk assessment protocols provide science advice to identify high risk aquatic invasive species. Screening-level risk assessments provide relatively fast advice, based on the best available information, and can be used to evaluate organisms that are currently in trade to determine level of risk.
- Existing screening-level risk assessment protocols were evaluated and used to screen freshwater nonindigenous species in trade in Canada.
- Five tools were evaluated for freshwater fishes and three tools were chosen for application to fish in trade in Canada based on performance and potential for low user bias (Montreal Risk Assessment Tool, Great Lakes Nonindigenous Species Information System, and the Notre Dame Statistical Risk Assessment Tool). Following family- and species-level climate match analysis, 12 species in 6 families (Appendix 1) were identified for screening using these three selected tools.
- For freshwater plants, the US Aquatic Weed Risk Assessment (USAqWRA) tool, which is a previously published peer-reviewed screening-level risk assessment tool developed by Gordon et al. (2012) was deemed suitable for application to freshwater plants in trade in Canada. A total of 20 freshwater plant species in trade in Canada were screened using this tool and identified as high or low risk, depending on the risk threshold selected (Appendix 2).
- For freshwater molluscs, Keller et al. (2007) statistical screening-level risk assessment tool, which predicts invasiveness based on fecundity level, was deemed suitable for mollusc species in trade in Canada. A list of 15 mollusc species not known to be established in Canada, screened in as nuisance species is provided in Appendix 3.
- Climatch, which is a climate-matching tool for fishes, and USDA Global Plant Hardiness Zones for molluscs and plants were found to be suitable to assess the climate match of species to survive under Canadian environmental conditions.
- The key sources of uncertainty identified are the potential for user bias for questionnaire-type tools (which could be reduced through the development of further guidance) and the use of climate matching for plants and molluscs as a surrogate for habitat matching.
- The level of impact that would justify a regulatory response is a management decision. Before the tools presented here are applied to Canadian ecosystems, managers need to define what constitutes a species that poses unacceptable risks.

INTRODUCTION

Non-indigenous species (NIS) pose an enormous risk to native biodiversity and ecosystem function, especially biodiversity. The ability to identify the highest-risk invaders and focus limited resources on these species is critical for resource managers.

Biological risk assessment protocols provide science advice to identify high risk invaders. DFO’s Centre of Expertise for Aquatic Risk Assessment (CEARA) is developing a three-stage biological risk assessment process for aquatic NIS. The three stages include: a) *rapid assessment process* (RAP) to assess a species within a few days using minimal information; (b) *screening-level risk assessment* (SLRA) to assess and prioritize a species in about a week using additional information that is readily available; and, (c) *detailed-level risk assessment* (DLRA) to assess a species within several months using detailed information (Mandrak *et al.* 2012). Depending on the goal, increasingly more detailed risk assessments can be undertaken with the detailed-level risk assessment providing the strongest defensible advice with the least amount of uncertainty.

NIS are introduced into Canadian fresh waters through various vectors and pathways, some of which are associated with the live trade pathway. A large number of live fishes are imported into Canada every year through stocking, live fish markets, aquarium and baitfish trade, biological supply for research/aquaculture, and garden centres). Freshwater molluscs are primarily found in the ballast water, live food, aquarium, and water garden industries, and an increasingly large number of aquatic plants are imported into North America every year for sale in the aquarium and garden trades. These trades pose a potential risk of introducing into, and/or spreading non-indigenous organisms within, Canadian freshwater ecosystems through accidental or deliberate unauthorized release.

The science advice presented here is part of a national CSAS peer-review process to evaluate available SLRA protocols for their suitability of application to freshwater NIS in Canada and applied to screen freshwater fishes, aquatic plants, and molluscs in trade in order to prioritize species. This advice is provided for managers and/or policy makers for application of these tools for risk management of freshwater aquatic invasive species.

Background

Fisheries and Oceans Canada's (DFO) Aquatic Invasive Species Program has been tasked by both the Office of the Auditor General and an internal evaluation to establish a protocol that would provide a scientifically defensible and relatively quick way of screening and prioritizing aquatic NIS. DFO's Legislative and Regulatory Affairs (LRA) has also requested science advice to support the development of a national regulatory proposal for addressing aquatic NIS. Screening-level risk assessment was identified as the appropriate level to support the development of regulations and to respond to the evaluations of the program. Screening species that have not yet been introduced to Canada was identified as a priority. Therefore, species currently in trade within Canada were screened in this study but NIS already present in some regions of Canada and species that have already been considered by detailed-level risk assessments are not included in this process. The following provides science advice on SLRA tools to evaluate non-indigenous freshwater fishes, molluscs, and plants**.** Additional advice will be required to evaluate SLRA protocols for marine NIS, to assess the ability to prioritize all NIS using the chosen SLRA protocols, and to screen NIS already present in some regions of Canada.

ASSESSMENT

Types of tools for SLRA

Both questionnaire and statistical tools are evaluated and applied in this national peer-review process. Questionnaire tools are developed by experts with taxa and regional considerations. These experts develop a list of qualities that might be linked to invasiveness and then develop a series of questions and a corresponding scoring system. Questionnaire tools generally perform well and can be adjusted to improve fit but may be influenced by bias of the scorers. Statistical tool development begins in a similar way - experts develop a list of qualities that might be linked to invasiveness and develop a method to quantify these qualities, statistical discrimination tools are then used to define which traits, or factors are most important in discriminating between invaders and non-invaders.

Fishes

Following a review of available screening and prioritization risk assessment protocols (Snyder et al. 2013), five SLRA tools were identified and included for further consideration: 1) the Freshwater Fish Invasiveness Scoring Kit Protocol (FISK, v1.19 Calibrated) (Vilizzi et al. 2007); 2) a modified Alberta Risk Assessment Tool (RAT) (Snyder et al. unpubl. data); (3) the Montreal RAT (DFO 2012); (4) the Great Lakes Nonindigenous Species Information System (GLANSIS) risk assessment tool (Sturtevant and Rutherford 2010); and, (5) the Notre Dame statistical RAT (J. Howeth, University of Alabama, pers. comm.).

The first 4 tools are questionnaire-type tools while the Notre Dame tool is a statistical tool. The questionnaire tools each have a different number of weighted questions pertaining to the life history, ecology, climate tolerance, and invasion history of each species. The weighting, overall score, and how uncertainty is addressed in the responses varies among the tools. The Notre Dame statistical RAT identified ecological, life history, and phylogenetic traits as potentially important predictors of invasiveness in freshwater fishes. Classification and Regression Tree (CART) statistical analysis determined that climate match is the most important trait predicting establishment and that trophic guild and fecundity are the best predictors of impact. Further details of the tools can be found in Mandrak et al. (2013).

These protocols were tested using a validation dataset of known successful (n=37) and failed (n=28) NIS in the Great Lakes basin based primarily on Mandrak and Cudmore (2010). Ecological impact was determined using a questionnaire distributed to Great Lakes academics, scientists, and managers to establish the validation dataset (J. Howeth, University of Alabama, pers. comm.). For each established NIS in the region, 27 experts were asked to rank the ecological impact and their confidence in the response. To evaluate the performance of the five SLRA protocols, each of the 65 species was scored using each of the SLRA protocols. For each of the five SLRA protocols, statistical tools (Receiver-Operating Characteristic (ROC) curve analysis and Area Under the Curve (AUC)) were used to determine how closely the protocols matched the expert rank according to the identified thresholds for establishment and impact.

Thresholds were identified by plotting the classification accuracy by score for each of the analysis types identified in Table 1 (the intersection of the two categories, for example established and not established, determined the threshold). Several different types of analyses were identified including an establishment analysis (established or not established) and four different impact analyses (Table 1). The four impact analyses chosen vary in the consideration of what species are considered “invasive”, with some of the impact analyses more conservative than others. For each SLRA protocol, this provided a single threshold for establishment and a range of thresholds for impact dependent upon the definition of impact.

Table 1. Establishment and impact analyses for the SLRA protocol evaluation.

Analysis type	Definition
Establishment	Established (37) or failed invaders (28)
Impact 1	Upper 1/3 of established species (12 high impact) vs all other species (11 intermediate impact, 12 low impact, 28 failed)
Impact 2	Upper 2/3 of established species (12 high impact and 11 intermediate impact) vs lower 1/3 (12 low impact) + failed invaders (28)
Impact 3	Upper 1/3 of established species (12 high impact) vs lower 1/3 (12 low impact) + failed invaders (28)
Impact 4	Top (12 high impact) vs bottom 1/3 (12 low impact) of established species only

Prior to screening freshwater fishes in trade in Canada with the selected SLRA, a series of steps were taken to reduce the initial list of fish species that was compiled from a variety of sources. Only freshwater or euryhaline species were retained for further consideration (habitat matching). Next, fish families whose native range is a climate match to Canada were retained (family-level climate matching), followed by an evaluation of species whose native and established introduced range is a climate match to Canada (species-level climate matching) (Figure 2). The chosen SLRA was then applied to the remaining species.

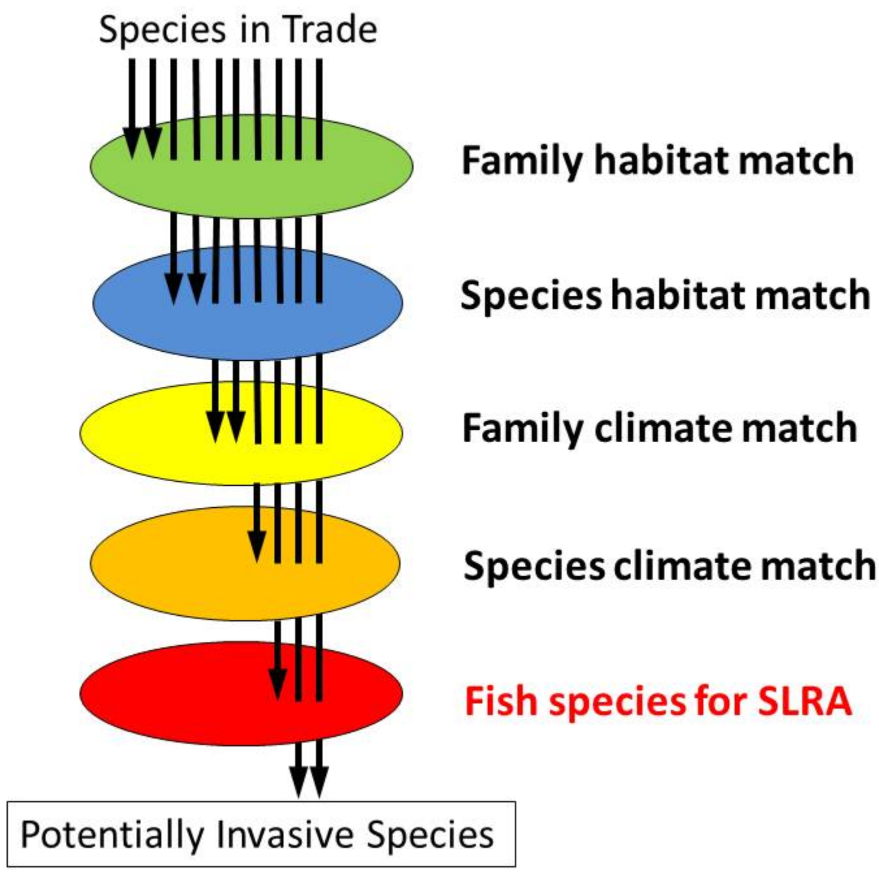

Figure 2. A schematic diagram representing the steps to reduce the initial list of fish species.

Plants

A list of freshwater plant species known in North American or Canadian trade was established using species previously screened in the US by Gordon et al. (2012) and additional species identified through water garden surveys in the Greater Toronto Area (OMNR unpubl. data) and online (Marson et al. 2009a,b). Species that have a climate match for Canada were identified and retained for screening. The US Aquatic Weed Risk Assessment (USAqWRA), a recently published, peer-reviewed questionnaire SLRA protocol (Gordon et al. 2012), was applied and assessed to determine its accuracy to screen freshwater plants in trade within Canada. This tool is composed of 38 questions pertaining to the life history, ecology, climate tolerance, and invasion history of each species. To answer default questions in the USAqWRA, a species must have been in the global trade for at least 30 years. For the current screening, it was assumed that this is the case.

Scores from the USAqWRA were categorized by outcome (high or low risk) based upon two sets of thresholds (Gantz et al. 2013). The threshold is the score where classification accuracy is maximized for each group being compared (e.g., established vs. not established species). One threshold (score ≥40) represents the statistical grouping of “Established, not invasive” species with “Not established” species. The other threshold (score ≥24,29,31; all have equivalent classification accuracy) groups “Established , not invasive” and “Established, invasive” species resulting in a lower score threshold and more species screened as “high risk” The range of possible thresholds represents the range of risk tolerance (Table 2).

Table 2. Definitions of establishment and invasiveness (after Gordon et al. 2012) and category of risk for the different thresholds.

Term	Definition	Establishment threshold (score ≥ 40) category of risk	Impact threshold (score ≥24, 29, 31) category of risk
Established, invasive	Forming reproducing, self-sustaining populations; documented ecological impacts	High	High
Established, not invasive	Forming reproducing, self-sustaining populations; no documented ecological impacts	High	Low
Not established	Not established, but in the trade for at least 30 years	Low	Low

Molluscs

A list of freshwater mollusc species known to occur in North American or Canadian trade was compiled. Species from that list were then assessed for a climate match in Canada. Species that had climate match were screened using the Keller et al. (2007) statistical SLRA tool. Keller et al. (2007) examined a number of life-history characteristics to develop a screening tool for freshwater molluscs and determined through Classification and Regression Tree (CART) statistical analysis that fecundity was the best predictor of invasiveness. Nuisance species had fecundities of >162 offspring/female/year and benign species had fecundities of <162 (Keller et al. 2007). The evaluation and refinement of a similar tool specific to Canada is not currently possible as comprehensive data are not available on the introduction, establishment, and invasiveness status of freshwater mollusc NIS in Canada. Therefore, the Keller et al. (2007) tool was used to screen freshwater mollusc NIS known, or potentially in, Canadian trade.

Freshwater molluscs currently in trade in North America were identified through a series of literature searches, online searches of aquarist, water garden, biological supply, and live bait websites as well as supplemented with existing surveys. The resulting list of freshwater mollosc species was then screened based on climate tolerance for Canada, as described below. The species identified to have a suitable climate tolerance for Canada were subsequently screened for invasiveness using Keller et al. (2007). Although only fecundity is required for the Keller et al. (2007) protocol, additional data, potentially beneficial for management needs were compiled including invasion history, parasite or pathogen burden, alkalinity, environmental calcium, and temperature thresholds.

Climate matching

For freshwater fishes, climate matching was conducted using *Climatch*, a climate-matching tool, which provides regional climatic scores from a global climate database consisting of information from over 9,000 weather stations around the world (Bureau of Rural Sciences 2008). *Climatch* determines the climatic similarity between a source region (e.g., fish family or species distribution) and a target region (e.g., Canada). The climate-match scores range from 10 for the highest level match to zero for the poorest match. Family- and species-level climate matching was defined by a minimum threshold of 20% of the *Climatch* scores at level 6 or higher (Bomford et al. 2010).

For molluscs and plants, USDA Global Plant Hardiness Zones, which range from 1 to 13, were used for climate matching (Figure 3). The system is based upon average minimum temperatures in geographically defined areas (i.e. zones), which is a major indicator of survival for plants and molluscs. Hardiness zones for individual species of plants and molluscs were identified based on available literature from native and established introduced ranges. All hardiness zone matching was conducted based upon recent climate data (2002-2011) and did not incorporate climate change projections.

Under current climate conditions, hardiness zones 1 to 10 are present in Canada; most of Canada is in hardiness zones 1 to 5 with the warmer zones occurring in southwestern British Columbia (especially Vancouver Island) (Figure 1). Species tolerant of hardiness zones 1 to 10 were screened for invasiveness.

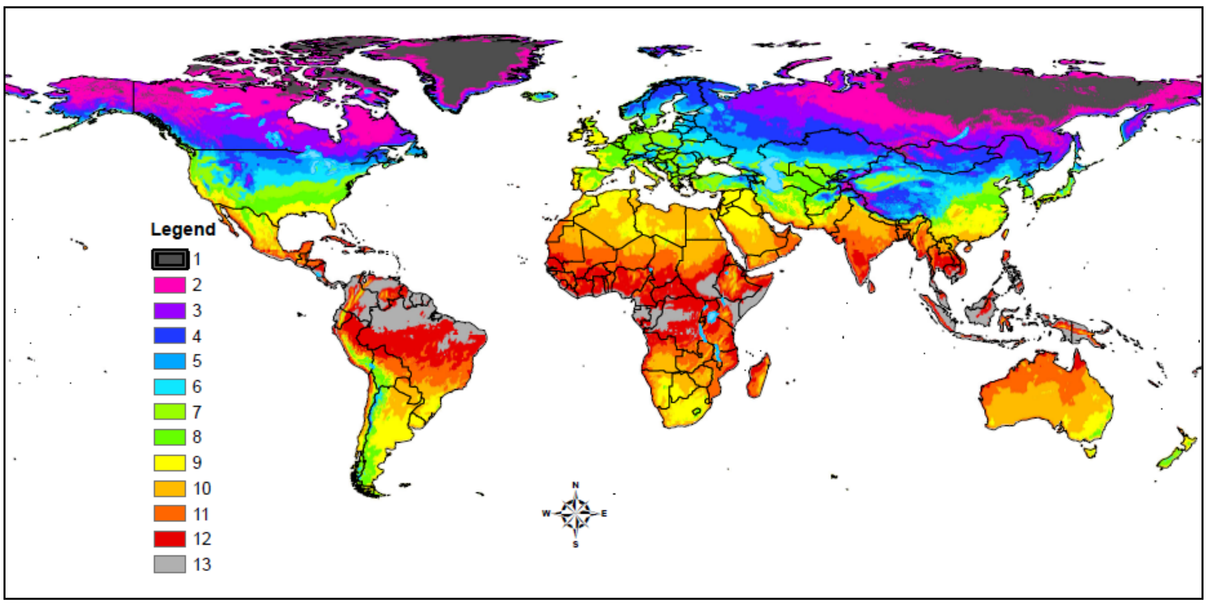

Figure 3. USDA Global Plant Hardiness Zones based on 2002-2011 climate data used to determine climate suitability of plants and molluscs in trade in Canada.

Results

Fishes

All of the five SLRA tools tested performed well in distinguishing either established species from failed invaders or high impact from low impact species. Alberta RAT, GLANSIS, and Montreal RAT performed best based on establishment. Montreal RAT and GLANSIS performed best based on the impact analyses and were retained for screening. The Notre Dame Statistical RAT, however, still performed well and was retained for further use, as the statistical methodology on which this tool is based allows for less variability and user bias in the results.

For the Montreal RAT, the threshold for establishment was a score of 22, and ranged from 24 to 31 for impact, depending on the definition of impact (Table 3). For the GLANSIS protocol, the threshold for establishment was a score of 79, and ranged from 88 to 99 for impact, depending on the definition of impact (Table 3). Threshold scores are based on the total number of questions and the weighting of those questions.

Table 3. Thresholds for establishment and impact were identified by plotting the classification accuracy by score for each of the analysis types.

Analysis type	Definition	Montreal RAT	GLANSIS
Establishment	Established or failed	22	79
Impact 1	Upper 1/3 of established vs all other species	31	99
Impact 2	Upper 2/3 of established species vs lower 1/3 + failed invaders	24,25	88
Impact 3	Upper 1/3 of established species vs lower 1/3 + failed invaders	29,30,31	97
Impact 4	Top + bottom 1/3 of established species only	29,30,31	92-99

The GLANSIS, Montreal RAT, and Notre Dame Statistical RAT were chosen to screen a list of fishes in trade that were a habitat and climate match to Canada. This list was generated from a master list of 1648 species in 185 families identified to be in trade in Canada. Of these families, 106 were considered a habitat match resulting in 825 species within these families that were freshwater or euryhaline. Following family- and species-level climate-match analysis, a final list of 12 species in 6 families (Appendix 1) was identified for screening using the selected tools.

Plants

A total of 129 freshwater plant species were identified as a Canadian climate match and screened as low and high risk categories at two threshold levels using the U.S. AqWRA. At a threshold of 40, 91% (49 of 54) of the not established species were correctly identified as low risk. Twenty–seven of the species are established in Canada. 75% of the species established in Canada were correctly identified as high risk.

All of the species (100%) established in Canada were correctly identified as “high risk” at thresholds 24/29/31 whereas 74% of the not established species were correctly classified as low risk.

An additional 20 freshwater plant species in trade in Canada were identified and screened using USAqWRA (Appendix 2). All of the not established species were correctly classified at threshold 40; however, only 25% of the established species correctly had high risk outcomes. At the second threshold of 24/29/31, the not established species were correctly classified 67% of the time whereas the established species were correctly classified 25% of the time.

Molluscs

Of the 87 freshwater mollusc species identified in North American or Canadian trade, 73 had climate tolerances to hardiness zones 1-10, including 32 species that had climate tolerances to hardiness zones 8-10, found only on southern Vancouver Island. Information on hardiness zones could not be found for three species. Of those species not already established in Canada, 15 species had fecundities greater than 162, including 11 tolerant only of hardiness zones 8-10 (Table 5, Appendix 3); these species would be screened in as nuisance species. The results would not change at thresholds of 119 and 189, which were identified as the range in which error may occur in the classification (Keller et al. 2007). Information on the fecundity of 31 of the 87 species could not be found.

Table 5. Number of molluscs, not established in Canada, screened in as nuisance species at three fecundity thresholds by hardiness zone tolerance.

	Fecundity >		
Hardiness Zone	119	161	189
1	0	0	0
2	0	0	0
3	0	0	0
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	4	4	4
9	7	7	7
10	0	0	0

Of the 27 freshwater mollusc NIS established in Canada, 14 have fecundities greater than 162. Of those 14 species, three have undergone detailed-level risk assessment. Quagga Mussel and Zebra Mussel were assessed as high risk (Therriault et al. 2013), whereas New Zealand Mudsnail was assessed as moderate risk, to Canadian aquatic ecosystems (Therriault et al. 2011). Although Asian Clam has not been formally assessed, it is known to be an invasive species (Ricciardi 1998; Magara et al. 2001; Cataldo et al. 2012). The European Ear Snail and European Stream Valvata have negatively impacted native gastropods, and the Faucet Snail is thought to be benign (Harman 2000; Haynes et al. 2005). Therefore, six of the 14 species have been assessed, or are thought to be, invasive. The impacts of the three species with fecundities less than 119 are largely unknown although the Chinese Mystery Snail is considered benign, Japanese Mystery Snail a net fouler, and the European Fingernail Clam a parasite host (Mackie 1976; Mackie 2000). These observations largely support the fecundity thresholds of 119-189 to differentiate nuisance from benign species.

Sources of Uncertainty

There was no assessment of potential user bias for the different tools that were assessed. Very limited user guidance is provided for the GLANSIS and Montreal RAT protocols. Questionnaire tools can lead to user bias in that different people may access different literature and interpret questions that may lead to different responses. Statistical tools are less likely to have a user bias. Clear guidelines for a questionnaire SLRA may reduce the uncertainty associated with user bias.

Climate matching is assumed to be a surrogate for habitat matching but climate may not be the only driver of species distribution. Similarly, for fishes, salinity is assumed to be a measure of habitat matching and other factors may be important in determining species distribution.

The method used to filter the master list to the list of fish species screened included several filters including a family-level habitat match and climate match, which may have eliminated some species with more temperate distributions that would be of concern in Canada. Further work is required to identify such species and potentially more appropriate climate-match thresholds.

The USDA Global Plant Hardiness Zones is a system based upon air, not water, temperatures, and does not account for any insulating effects of water or snow. Similarly, it does not take into account the reproductive biology of individual species and their potential ability to survive winter temperatures.

There were data gaps with respect to fecundity information for molluscs.

CONCLUSIONS AND ADVICE

General

Comparison of tools available for SLRA has been done only in a limited number of cases and this is one of the first times various SLRA tools have been compared. It is preferable to test available tools rather than developing new ones, to build on expertise of previous work and to take advantage of previous peer reviewed literature that have been applied in other jurisdictions.

The level of impact that would justify a regulatory response is a management decision. Before the tools presented here are applied to Canadian ecosystems, managers need to define what constitutes a nonindigenous species that poses unacceptable risks.

Screening-level risk assessments are provided to assess non-native organisms in trade. Lists of species of fishes, molluscs, and aquatic plants are provided in Appendices 1, 2 and 3, respectively, to identify species for which further management measures, such as regulations should be considered.

This study considers species currently in trade; trade patterns may change and species may need to be re-evaluated at a later date.

The current study applies to current climate conditions; the assessments may need to be re-done to incorporate future climate scenarios.

Bias and time to apply different tools should be considered when selecting which tool to use. The questionnaire tools used to assess freshwater fishes in trade were applied by an individual with a Master’s degree in biology. The time of applying the statistical tools (Notre Dame statistical tool, Keller et al. 2007 statistical tool for molluscs) takes 1-3 hours per fish species, whereas, questionnaire tools took on average 8 hours per species.

Fishes

The Montreal RAT, GLANSIS and the Notre Dame Statistical RAT were found to be suitable for application to Canada to prioritize freshwater fishes in trade.

Habitat and climate suitability were found to be useful ways in which to filter NIS in trade for SLRA.

Twelve species in six families were identified for screening following family- and species-level habitat- and climate-match analysis (Appendix 1). A detailed-level risk assessment has been previously conducted for one of these species, Grass Carp, *Ctenopharyngodon idella* (Mandrak and Cudmore 2004).

The method used to filter the master list to the list of species screened, which included a family-level climate match and other filters, may have eliminated species that would be of concern in Canada, particularly in southwestern British Columbia, which has the warmest climate in Canada. Further work is required to assess these species.

Although the tools have been tested for the Great Lakes, they have not been tested for the rest of Canada. Lack of data on failed invasions limits the ability to test in other regions of Canada. However, the tools are considered valid for assessing freshwater fishes because the Great Lakes account for 70% of the Canadian fish fauna.

Molluscs

For molluscs, the Keller et al. (2007) SLRA tool was found to be suitable for application to Canada to prioritize aquatic NIS in trade.

Of the 87 freshwater mollosc species identified in trade, 73 had climate tolerances to hardiness zones 1-10. Of those species not already established in Canada, 15 species had fecundities greater than threshold of 162 including 11 tolerant of hardiness zones 8-10. These species would be screened in as nuisance species. Of the 27 freshwater mollosc NIS established in Canada, 14 have fecundities greater than 162 of which Zebra and Quagga Mussel have been assessed as high risk (Therriault et al. 2013) and the New Zealand Mudsnail was assessed as a moderate risk (Therriault et al. 2011) based on previous detailed-level risk assessments. This list is deemed to be comprehensive at this time.

Aquatic Plants

For aquatic plants, the USAqWRA was found to be a suitable SLRA tool for application to Canada to prioritize NIS in trade.

A total of 129 species with native and/or introduced ranges in hardiness zones 1-10 were screened using the USAqWRA. A total of 20 freshwater plant species in trade in Canada were screened using the USAqWRA tool at various thresholds.

OTHER CONSIDERATIONS

There are different thresholds considered in this Science Advisory Report including those for establishment and different degrees of impacts. When selecting a threshold, managers should work with the authors to understand the implications of threshold selection.

To improve consistency in application of the questionnaire-type tools and reduce the potential for user bias, appropriate guidance is needed. Guidance material is available for the plant SLRA tool; however, no guidance was available for the Montreal RAT and GLANSIS. For freshwater fish SLRA tools, guidance should be developed for questionnaire tools if they are selected for use to screen species.

The Government of Canada should come up with an improved method of data collecting and sharing of import data.

For fishes, the method used to filter the master list included a family-level climate match that may have eliminated species with a suitable climate match and be of concern in Canada. For example, the Snakehead family was not included, while species in the family have been predicted to have high impacts to Canadian ecosystems. Therefore, the family-level, climate-match thresholds should be reviewed and, if lowered, the additional species should be screened and the new results peer reviewed.

Although the Characidae family, which contains over 100 species currently in North American trade, has a marginal climate match to Canada, it does have a suitable climate match to southern British

Columbia (zone 10). Given the marginal family-level climate match, the characid species in trade were not screened in this study, but should be considered for further screening in British Columbia.

Since the plant industry imports a number of species and is dynamic, a number of species in trade may not have been assessed. This information may be particularly relevant to southwestern British Columbia.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 19-21, 2013 meeting Screening-level risk assessment prioritization protocol for aquatic non-indigenous species (Part 2). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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APPENDICES

Appendix 1

*Results of species screened using GLANSIS, Montreal RAT, and Notre Dame (ND) Statistical RAT SLRA protocols. Thresholds for GLANSIS and Montreal RAT correspond to scores generated from plots of the point of intersection of the two classification accuracy curves for each analysis type described in Table 3. For GLANSIS and Montreal RAT threshold assessment: 0 – not invasive; 1 – invasive; inc – incomplete due to inability to answer the required number of questions (GLANSIS only). For ND Statistical RAT, Establishment (Est): 0 – predicted not to establish; 1 – predicted to become established, Impact: 0 – predicted not to have an impact; 1 – predicted to have an impact. * indicates impact score for GLANSIS is unknown due to lack of information; therefore, final score is incomplete.*

	GLANSIS				Montreal RAT			ND Statistical RAT	
	Score	Screened			Score	Screened		Est	Impact
		In	Out	inc		In	Out		
Carassius carassius	105	5	0	1	32	5	0	1	0
Cobitis taenia	54*	0	0	5	20	0	5	1	0
Danio albolineatus	60*	0	0	5	14	0	5	1	1
Ictalurus furcatus	66*	0	0	5	30	4	1	1	1
Leuciscus idus	87*	1	0	4	26	2	3	1	1
Misgurnus fossilis	58*	0	0	5	18	0	5	1	1
Morone saxatilis x chrysops	93	3	2	1	24	2	3	1	1
Silurus glanis	123	5	0	0	37	5	0	1	1
Siniperca chuatsi	81	1	4	0	33	5	0	1	1
Ctenopharyngodon idella (diploid)	121	5	0	0	35	5	0	1	1
Ctenopharyngodon idella (triploid)	70	0	5	0	35	5	0	1	1
Cyprinella lutrensis	98	4	1	0	31	5	0	1	1
Misgurnus anguillicaudatus	97	4	1	0	29	4	1	1	1

Note: Species highlighted in grey were used to train the ND Statistical RAT. However, based on the fish ecological impact questionnaire disseminated to Great Lakes academics, scientists, and managers, these species were considered to be high impact and were independently included for environmental matching analysis.

Appendix 2

USAqWRA results for freshwater plant species in trade in Canada (n=20).

Scientific name	Common name	Lowest hardiness zone found	AqWRA score	Established in Canada &/or U.S.	Threshold 40 (US)	Thresholds 24,29,31 (US)
Nymphaea pygmaea (Salisb.) W. T. Aiton	Water lily	6	15	No	Low	Low
Typha lugdunensis P. Chabert	Cattail	5	15	No	Low	Low
Nymphaea nouchali Burm. f.	Blue lotus	6	16	No	Low	Low
Cyperus exaltatus Retz.	Tall flat-sedge	4	17	No	Low	Low
Sagittaria aginashi Makino	None	5	17	No	Low	Low
Nymphaea alba L.	European white waterlily	3	18	Canada	Low	Low
Trapa bicornis Osbeck	Horn nut	8	18	No	Low	Low
Wolffia brasiliensis Wedd.	Brazilian watermeal	5	21	Canada & U.S. (Native)	Low	Low
Nasturtium ×sterile (Airy Shaw) Oefelein	Sterile Nasturtium hybrid	6	22	Canada & U.S.	Low	Low
Orontium aquaticum L.	Golden-club	6	23	U.S. (Native)	Low	Low
Sagittaria guayanensis Kunth	Arrowhead-lily	8	23	U.S.	Low	Low
Potamogeton schweinfurthii A. Benn.	Pondweed	8	24	No	Low	High
Myriophyllum propinquum A. Cunn.	Common water milfoil	7	25	No	Low	High
Sagittaria subulata (L.) Buchenau	Awl-leaf arrowhead	4	26	U.S. (Native + introduced)	Low	High
Persicaria thunbergii (Siebold & Zucc.) H. Gross	Knoterid	3	27	No	Low	High
Egeria najas Planch.	Narrow leaf elodea	6	29	No	Low	High
Myriophyllum verrucosum Lindl.	Red water-milfoil	8	34	No	Low	High
Najas graminea Delile	Ricefield waternymph	7	38	U.S.	Low	High
Sagittaria platyphylla (Engelm.) J. G. Sm.	Delta arrowhead	7	61	U.S. (Native)	High	High
Myriophyllum heterophyllum Michx.	Broadleaf water-milfoil	5	72	Canada & U.S. (Native & introduced in both countries)	High	High

Appendix 3

Mollusc species, not known to be established in Canada, screened in as nuisance species at a threshold of 162. (Note that there were no species with fecundities between 119 and 162.)

Scientific Name	Common Name	Established in Canada	Hardiness Zone	Annual Fecundity
Biomphalaria alexandrina		Unknown	9	2439
Biomphalaria glabrata	Bloodfluke Planorb	Unknown	8	356
Biomphalaria pfeifferi		No	8	11902
Biomphalaria straminea		No	9	1730
Bulinus truncatus		Unknown	8	1455
Elimia livescens	Liver Elimia	Unknown	5	399
Indoplanorbis exustus		No	9	6132
Lymnaea palustris (Stagnicola palustris)		Unknown	4	310
Lymnaea peregra		Unknown	6	1400
Melanoides tuberculata	Malaysian Trumpet Snail, Red-rimmed Melania	No	9	365
Pomacea bridgesi	Apple Snail, Spiketop Apple Snail, Golden Mystery Snail	No	7	600
Pomacea canaliculata	Golden/Channelled Apple Snail	No	9	4355
Pomacea haustrum	Titan Apple Snail	No	9	236
Pomacea insularum	Island Apple Snail	No	9	700
Tarebia granifera (Thiara granifera)	Quilted Melania	No	8	213

Appendix 4

List of acronyms

AIS : Aquatic Invasive Species

AqWRA: Aquatic Weed Risk Assessment Tool

AUC: Area Under the Curve

AWRA: Australian Weed Risk Assessment

CART: Categorical and Regression Tree

CBSA: Canada Border Services Agency

CEARA : Center of Expertise for Aquatic Risk Assessment

CFIA: Canadian Food Inspection Agency

CSAS : Canadian Science Advisory Secretariat

DFO : Department of Fisheries and Oceans Canada

DLRA: Detailed-level Risk Assessment

FI-FISK: Freshwater Invertebrate Invasiveness Scoring Kit

FISK: Fish Invasiveness Scoring Kit protocol

GLANSIS: Great Lakes Nonindigenous Species Information System

NAPPFAST: NCSU/APHIS Plant Pest Forecast

NCSU: North Carolina State University

NIS : Non-indigenous Species

NZAqWRA: New Zealand Aquatic Weed Risk Assessment Tool

OIE: World Organization for Animal Health

OMNR: Ontario Ministry of Natural Resources

RAP : Rapid Assessment Process

PLANTS: PLANTS online database (http://plants.usda.gov)

RAT, Alberta: modified Alberta Invasive Alien Risk Assessment Tool

RAT, Montreal: Montreal Risk Assessment Tool

RAT, Notre Dame: Notre Dame Statistical Risk Assessment Tool

ROC: Receiver Operating Curve

SLRA : Screening-level Risk Assessment

TROPICOs: online meta-database of horticultural specimens (http://www.tropicos.org)

USAqWRA: United States Aquatic Weed Risk Assessment Tool

USDA: United States Department of Agriculture

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