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Proceedings of the National Peer Review of Screening-Level Risk Assessment Protocols for Freshwater Non-indigenous Species

March 19-21, 2013
Burlington, Ontario

Co-Chairpersons: Gilles Olivier and Sophie Foster
Editor: Sherry Walker

Fisheries and Oceans Canada
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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A national peer review science advisory process was held to provide science advice on a screening-level risk assessment (SLRA) prioritization protocol(s) for aquatic non-indigenous species (NIS). This process consists of at least two peer-review meetings. Part 1 was held in Montreal, Quebec in November 22-24, 2011 and resulted in a background document which reviewed and evaluated various risk assessment protocols for screening and prioritization of aquatic invasive species (Snyder et al. 2013) and the proceedings (DFO 2012). For Part 1, participants examined the methodological review section of the protocol and developed a framework for an SLRA protocol for aquatic NIS. Part 2, which these proceedings address, was held in Burlington, Ontario on March 19-21, 2013, to evaluate and apply SLRA protocols for freshwater NIS currently in trade within Canada across multiple taxa (freshwater fishes, molluscs and aquatic plants). Additional meetings will be required in the future to evaluate SLRA protocols for marine NIS and to assess the ability to prioritize all NIS using the chosen SLRA protocols. Three working papers on SLRA Protocols for freshwater NIS were reviewed. Recommendations were made for protocols that are suitable for SLRA prioritization in Canada, and these protocols were applied to develop lists of priority species for regulatory consideration and other management actions. Existing protocols for aquatic plants (Gordon et al. 2012) and molluscs (Keller et al. 2007) were used to screen species. For freshwater fishes, five protocols were evaluated and compared with the aim of applying one or more to screen freshwater fish species in trade in Canada. Participants of this process included Fisheries and Ocean Canada biologists, provincial biologists, academics from Canada and the United States, and a biologist from Canadian Food Inspection Agency. The resulting publications from Part 2 of this process include a Science Advisory Report, three Research Documents, and these Proceedings.

SOMMAIRE

Un processus consultatif scientifique d'examen national par des pairs a eu lieu pour fournir un avis scientifique sur des protocoles d'évaluation préalable des risques (ÉPR) et de priorisation pour les espèces aquatiques non indigènes (EANI). Ce processus consultatif comprend au moins deux réunions d'examen par des pairs. La première partie de la consultation (partie 1) s'est tenue à Montréal, au Québec, du 22 au 24 novembre 2011; elle a donné lieu à la rédaction d'un document d'information dans lequel on analysait et examinait différents protocoles d'ÉPR et de priorisation pour les espèces aquatiques envahissantes (Snyder *et al*. 2013). Un compte rendu a également été produit (MPO 2012). Durant cette première partie de la consultation, les participants ont examiné la section du protocole portant sur l'examen méthodologique et élaboré le cadre d'un protocole d'ÉPR pour les EANI. La deuxième partie de la consultation (partie 2), sur laquelle porte le présent compte rendu, s'est tenue à Burlington, en Ontario, du 19 au 21 mars 2013; consistait à évaluer et à appliquer des protocoles d'ÉPR pour des espèces d'eau douce non indigènes apparaissant actuellement dans le commerce au Canada à plusieurs taxons (poissons d'eau douce, mollusques et plantes aquatiques). D'autres réunions seront nécessaires à l'avenir pour évaluer les protocoles d'ÉPR pour des espèces marines non indigènes ainsi que la capacité d'établir un ordre de priorité parmi toutes les espèces non indigènes à l'aide des protocoles d'ÉPR choisis. Trois documents de travail portant sur des protocoles d'ÉPR pour des espèces d'eau douce non indigènes ont été étudiés. Des recommandations ont été formulées concernant les protocoles qui ont été jugés adéquats pour établir des priorités parmi les espèces grâce à l'ÉPR au Canada; ces protocoles ont été utilisés pour dresser des listes des espèces qui doivent être visées en priorité par l'examen réglementaire et faire l'objet d'autres mesures de gestion. Des protocoles existants pour les plantes aquatiques (Gordon *et al.* 2012) et les mollusques (Keller *et al.* 2007) ont été utilisés pour effectuer une évaluation préalable des espèces. En ce qui concerne les poissons d'eau douce, cinq protocoles ont été évalués et comparés dans le but d'en retenir un ou plusieurs pour l'évaluation préalable des espèces de poissons d'eau douce apparaissant dans le commerce au Canada. Parmi les participants à ce processus figuraient des biologistes de Pêches et Océans Canada, des biologistes provinciaux, des universitaires canadiens et américains et une biologiste de l'Agence canadienne d'inspection des aliments. Les publications qui ont découlé de la deuxième partie de ce processus consistent en un avis scientifique, trois documents de recherche et le présent compte rendu.

INTRODUCTION

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). The national ranking of aquatic NIS, based on the biological risk they pose to Canadian aquatic ecosystems, is necessary to prioritize the allocation of funds and other resources for national and regional aquatic NIS activities. DFO's Legislative and Regulatory Affairs, also a client for this process, has requested science advice to support the development of a national regulatory proposal for addressing aquatic NIS. DFO's Centre of Expertise for Aquatic Risk Assessment (CEARA) leads a national program to assess the risk associated with potential aquatic invasive species. CEARA was tasked with reviewing existing tools used by other governments and recommending a system for use that best met the client's needs.

The purpose of this national process was to peer review three working papers on Screening-Level Risk Assessment (SLRA) Protocols for Freshwater NIS, recommend the protocols that are suitable for SLRA prioritization in Canada, and apply these protocols to recommend lists of priority species for regulatory consideration and other management actions. Existing protocols for aquatic plants (Gordon et al. 2012) and molluscs (Keller et al. 2007) were used to screen species. For freshwater fishes, five protocols were evaluated and compared with the aim of applying one or more to screen Canadian freshwater fish species in trade in Canada. For molluscs and aquatic plants, existing tools were selected as there were recently published protocols available in literature, these protocols had been previously peer reviewed, there were limited resources available, and there was a tight timeline to provide the science advice.

The co-chairs welcomed participants, provided introductory remarks, and reviewed the agenda and terms of reference (Appendix 1). They reminded participants that the purpose of this meeting was to review the science and, as such, economic factors are not considered in this science peer-review process.

Background for Request and Overview of Outcome from Part 1

Presenter – Sophie Foster

The context for the advice requested in this national peer-review science advisory process was provided. The original context was external reviews of the program by the Office of the Auditor General of Canada and an internal DFO evaluation, both in 2008, to prioritize NIS in order to focus resources and efforts. Subsequently, there was a request from the regulatory policy group to provide science advice to support regulatory development and develop or recommend a protocol or protocols that could be used to determine the risk of NIS. A national peer review meeting was convened in Montreal November 2011 to peer review a research document that identified a pool of existing screening-level risk assessments used by other governments around the world (80) that were then classified and scored, creating a sub-group that were retained for further evaluation (13). Criteria were defined and applied to the sub-group and protocols were ranked that best served the identified objectives. Based on this evaluation, the Alberta Risk Assessment Tool and the Freshwater Fish Invasiveness Screening Kit (FISK) scored the highest based on the identified needs of the client's at the time. As FISK is specific to freshwater fishes, it was recommended that related protocols developed for other taxa, for example the MISK (marine fishes) and the MI-ISK (marine invertebrates), be evaluated for marine species. At the meeting, participants agreed that the recommended tools needed to be evaluated further for different taxa in Canada.

Overview of Canadian Science Advisory Secretariat (CSAS) National Peer-Review and Advisory Process for Part 2

The co-chairs gave a presentation on the CSAS National Peer Review and Advisory Process including the principle of consensus, the role of participants, and timelines for submission of documents. Finally, all participants were requested to respect the process.

PRESENTATION OF WORKING PAPERS

Application of a Freshwater Plant Risk Assessment to Non-indigenous Organisms in Trade in Canada

C. Gantz (University of Notre Dame)

Summary

The economic and ecological costs associated with invasive species in North America are high, with some estimates reaching $150-170 billion/year (Pimentel et al. 2000; Colautti et al 2006). Ecological risk assessment tools that prevent the import of invasive species are one way to significantly reduce these costs. For plants, we evaluated a questionnaire-style risk assessment developed by Biosecurity New Zealand and tested previously at the University of Florida and the University of Notre Dame (Gordon et al. 2012). This assessment distinguished a sample of not established and established species in the United States with high accuracy. We modified the Gordon 2012 risk assessment so that all of the questions are relevant to Canada, and evaluated the species from that paper with the modified assessment. We applied a climate screen and excluded any species that did not have a United States Department of Agriculture (USDA) hardiness zone match with Canada. The risk assessment worked well at categorizing this sample of established and not established species in Canada. An additional sample of species in trade was assessed, with high accuracy for not established species, but low accuracy for established species (although the established sample size was small: 4 species). Developing a separate risk assessment model for Canada will take more research on establishment and impact of non-native species, and also, introduction dates to account for lag time. Use of the modified tool developed in the United States. will be a viable alternative for Canada.

Questions of Clarification

The following questions were raised following the presentation:

- It was questioned if guidance is available from DFO on what constitutes an acceptable risk? The response noted that this is a management decision.
- Is the 30-year establishment a surrogate for propagule pressure? It was noted that this is the best available information since we do not have trade volume data.
- Were the Ontario data provided represented as species in trade or plants of concern? It was noted that this is a large database and, whereas, some are designated as in trade, others are included for which there is concern.

Expert Peer Review Presentation

Karen Castro (Canadian Food Inspection Agency) presented her review of the working paper (Appendix 3). She congratulated the authors and noted that she liked the idea of sharing a common approach with the United States. The fact that the approach is used by several countries and is previously peer reviewed adds credibility. Recommendations included

clarification of terminology used in the paper. There were concerns noted regarding Canada's colder climate and whether this requires special attention although she agreed that plant hardiness zones is the best that we have to work. She noted that while the 2007 plant hardiness zone map is used in the document, there is a 2012 map available that shows substantial changes. There were questions regarding the *a priori* categories used in the methodology as well as confirmation of Canadian species. Several literature and database sources were recommended to the authors.

Discussion

It was agreed that there is a lot of work involved in figuring out the *a priori* categories for Canada. In lieu of that, this tool is already available and the goal is to get that best tool available for screening plants that can be applied across Canada.

There was a discussion regarding how long the protocol takes to apply per species on average. When working in batches of 15-20, on average it takes 6-8 hours per species.

It was agreed that with aquatic plants, we are starting from square one and this is a great first step to assess and understand species of concern. It was agreed that this approach was valuable and it could be used with modifications. Participants also liked the fact that the authors have developed guidance for the tool. It was noted that most previous work has focused on fishes and invertebrates, whereas, little work has been done on aquatic plants.

Provincial participants were questioned if other jurisdictions in Canada would have different or similar needs to Ontario. In response, it was noted that, whereas difficult to speak for other provinces, they thought that other jurisdictions would see value in this tool.

To address the issue of climate change, it was agreed that a qualifier would be added that if one wanted to consider future climate scenarios, then the steps to follow would be outlined in the paper.

There was a discussion concerning zone 10, which is in southwestern British Columbia. In this zone, lakes never freeze and temperatures are rarely close to 0. It was agreed that adjustments may be needed to address the conditions for this small area but the national process should not be held up because of this.

There was a discussion regarding the application of hardiness zones for the three reports and it was agreed that some consistency amongst the three reports would be an improvement. It was also agreed that the application of the maps in the different reports needs to be clearly explained in the research documents.

There were some suggestions to improve the report including: clearly stating the assumptions; wording changes regarding the three thresholds used in the classification curves; and, a suggestion to include examples of species for the different categories.

The participants reviewed how the list was generated. It was noted that the authors started with the list used by Gordon et al. (2012) but screened out those that were deemed not to survive under Canadian climatic conditions.

It was agreed that the report should not state that the list is comprehensive but rather that it is a large sample of the species in live trade in Canada. It was suggested that this be identified as a knowledge gap in the report.

There was an error noted on Figure 2 and 3.

This working paper was accepted as a research document, pending revisions.

Application of a Freshwater Mollusc Risk Assessment to Non-indigenous Organisms in Trade in Canada

B. Schroeder, N.E. Mandrak (presenter), B. Cudmore

Summary

The economic and ecological costs associated with invasive species in North America are high, with some estimates reaching $150-170 billion/year (Pimentel et al. 2000; Colautti et al 2006). Ecological risk assessment tools that prevent the import of invasive species are one way to significantly reduce these costs. For freshwater molluscs, we evaluated a risk assessment tool developed by Keller et al. (2007) that had previously been peer reviewed and exists in the primary literature. This assessment tool successfully identified a number of species of freshwater molluscs available through the live trade industry that had previously become established in Canada and also identified additional species of concern to Canadian ecosystems. It was determined by Keller et al. (2007) that fecundity was the single most important factor for predicting invasiveness and successful establishment in a non-native environment. Climate matching was conducted between the native environment and all climate categories found in Canada that included zones 1-10 and excluded any species that did not have a USDA hardiness zone match with Canada. Categorical and regression tree (CART) methodology indicated a threshold level of annual fecundity of 162 to determine likelihood of invasiveness. The risk assessment worked well at categorizing this sample of established and not established species in Canada. A total of 73 freshwater mollusc species were identified as being available in the live trade pathway and capable of becoming established in Canadian fresh waters including 15 potential species that demonstrate the biological attributes to be considered a nuisance species. Of the 27 mollusc species already introduced to Canada, 14 are considered nuisance species, such as Zebra Mussel or New Zealand Mud Snail, known to have negative impacts on native species.

Expert Peer Review Presentation

Gerry Mackie (University of Guelph – emeritus professor) presented his review of the working paper. He disagreed with some of the numbers regarding the hardiness zones, noting that not many molluscs can live in hardiness zone 2. The author noted that all hardiness zones were referenced but indicated that where species occurred in several zones, the author picked the most conservative. Dr. Mackie questioned how the fecundity numbers were selected in Keller's original paper. In response, it was noted that, for most species, it was straight forward although sometimes the authors combined fecundity from several sources or looked at the highest reliable estimate. Many corrections to the appendix were noted by reviewer Gerry Mackie and recorded by the author. After going through the changes, it was noted that the numbers in the document will need to be adjusted. Dr. Mackie also provided additional fecundity data for a number of molluscs for the authors to include in their assessment.

Discussion

The application of this approach to other jurisdictions (Great Lakes, United States, and now Canada) was discussed. The evidence shows that the approach seems to work, although it was noted that the species tested are similar for the three jurisdictions.

It was questioned if some of the species could be binned. In response, it was noted that this is dependent on the different development stages.

It was noted that of all the families of bivalves, the only family that is not represented by an invasive species is the Unioniidae.

There was a discussion of the opportunities for invasion and parasitism, which could result in very high impacts even if the species has low fecundity. As such, this needs to be considered in the future.

There was a discussion about the risk assessor/risk manager dichotomy and the level of misclassifications with respect to the threshold of 162. It was noted that the analysis supported 162 as the split based on fecundity. The relative costs of false positives and false negatives were not included in the analysis and it was indicated that the CART analysis puts equal weight on both errors. It was suggested that the range of uncertainty (119-190) surrounding the statistical tool be included.

It was agreed that the assumptions needed to be clarified in the paper.

There was a comment that the fact that the paper addressed hitchhiker species was very good and it was suggested that this could also be adopted in the plant tool.

It was agreed that it should be noted in the paper that the model is based on data for which there are knowledge gaps that need to be filled.

It was agreed to:

- add hardiness zone in the caption for Appendix A;
- add a note that when several fecundity values were found, the highest was used; and,
- clarify that some native species are traded and could be associated with other inputs.

This working paper was accepted as a research document, pending revisions.

Evaluation of Five Freshwater Fish SLRA Protocols and Application to Non-Indigenous Organisms in Trade in Canada

N.E. Mandrak (presenter), C. Gantz, L.A. Jones, D. Marson, and B. Cudmore

Part 1: Identify and Evaluate Five SLRA Protocols for Screening Fishes in Live Trade in Canada

Summary

Identification and prioritization SLRA of aquatic non-indigenous species (NIS) in trade that pose a potential risk to Canada's aquatic ecosystems is an integral component of the risk assessment process. DFO has identified fishes in live trade (i.e., aquarium, live food, biological supply and water garden trades) in Canada, but not yet present in Canadian waters, as a priority for screening. Using a validation dataset on establishment and impact of non-indigenous fishes in the Great Lakes Basin, we evaluated five SLRA protocols that were previously identified to be suitable for screening of freshwater fishes currently in trade in Canada: FISK; Modified Alberta Risk Assessment Tool (RAT); Montreal RAT; Great Lakes Nonindigenous Species Information System (GLANSIS); and, Notre Dame (ND) Statistical RAT. All tools performed well but, following evaluation, two questionnaire-based SLRA protocols (Montreal RAT and GLANSIS) and one statistical-based protocol (ND Statistical RAT) were selected and applied to a list of freshwater fishes in live trade in Canada. The list of 12 freshwater fishes identified for screening was generated by filtering a master list of fishes in trade in Canada (1648 fish species in 185 families) through habitat (freshwater, euryhaline or marine) and climate matching criteria at the family and species level. Climate matching was conducted between the species' contemporary distribution and Canada using *Climatch*; only families and species with at least 20% of scores at level 6 or higher were included for further analysis. Screening assessment using GLANSIS was not possible for 5 of the 12 species, but for those that were successfully screened, GLANSIS

identified fewer species to be invasive than did the Montreal RAT. The ND RAT predicted all 12 species to establish and 10 of these species would have an impact. Two species, *Silurus glanis* and *Ctenopharyngodon idella* (diploid), were assessed similarly regardless of threshold or SLRA protocol, as being able to establish and have a high impact.

Questions of Clarification

It was questioned why there is such a difference in the threshold values between GLANSIS and the Montreal RAT. In response, it was noted that there are a different number of questions for these two tools and the threshold is based on the questions.

It was questioned what the difference is among the protocols in terms of time and effort to apply. It was noted that the statistical tool takes very little time to apply. The climate match component takes some time depending on how readily available are the distribution data.

There was a discussion to clarify the different impact analysis.

Expert Peer-Reviewer Presentation

Reuben Keller (Loyola University, Chicago) presented his expert peer review (Appendix 4). He noted that he was impressed with the work that had been done. He indicated that the comparison of five different SLRA tools for fishes is academically novel and, as such, an important contribution to the literature that should provide a good basis for DFO to select and recommend a tool for future use. Reuben Keller provided an explanation of how questionnaire tools are developed versus statistical tools. Some further considerations that he recommended were: the time required to apply each tool; the number of questions; and, the geographical constraint of the tool since a tool that performs well in one region of Canada may not perform well in another region. Another point that was brought up was the expertise of the assessors, in particular, for the questionnaire assessments as a potential source of bias. Overall, he noted that the work was impressive, pushes forward our understanding of how risk assessment tools work, it is academically novel, and the report is well written. He recommended the three considerations indicated above be addressed.

Discussion

There was a question regarding whether climate was the only input required to run the model. The author indicated that the model was built using 16 variables and the climate match score was found to be the most important for establishment noting that there are two statistical models – establishment and impact. Additional traits are used to determine the impact component of the model.

There was a discussion concerning whether it was necessary to recalibrate the models for the rest of Canada since the model had been calibrated for the Great Lakes region. It was noted that this was unnecessary since the request for science advice was such that if a species could survive in any part of Canada, it would be considered for blacklisting. It was noted that it would be beneficial to develop calibration statistics for southern BC but currently there are not enough data on failed attempts of species to establish in this region.

The CART analysis and the method used to calculate the area under the curve (AUC), which is the rate for misclassification, was discussed.

It was questioned if there was some way to control the potential bias in the questionnaire methodologies. It was noted that one way to avoid bias is to add guidelines to the questions.

It was agreed to mention that the time needed to do each assessment to the paper as this should be taken into consideration at the next step of the process (which could also consider cost).

Two of the four questionnaire models along with the statistical model are recommended for further testing based on the AUC, but it was noted that all scores are pretty good.

While the statistical risk assessment performed fairly well, it was questioned if something could be adjusted in the model to improve its reflection of reality. In response, the model developer noted that that model had been worked over and the developers believe that this is the best possible outcome.

Part II – Screening Freshwater Fishes in Live Trade in Canada

Presenter – Nick Mandrak

Summary

See abstract under Part I.

Questions of Clarification

It was noted that three of the species presented were used to train the Notre Dame model and they should not be included in the screening. Those species were assessed originally and so the results were used to select the traits. For this reason, the species should be removed from the analysis.

There was further explanation provided of the thresholds used as these are dependent on the number of questions.

Discussion

There was a discussion concerning situations where the family is screened out but the species should have been screened in (e.g., Snakehead, Tilapia). It was acknowledged that this is possible with the approach used where the family is primarily tropical but a species of the family in a temperate area could be a problem. As such, there is a problem of "hidden" species that may have climate match but were inadvertently screened out.

It was noted that it was beyond the scope of the project to provide guidance for specific tools but that could be a recommendation that a user manual be created for specific tools for which guidance has not been developed previously.

There is a good correlation among the models and the table showing the comparison of tools was noted as an important component, although 5 out of 12 species could not be assessed because of lack of information.

It was agreed that clarification is needed in the paper regarding the initial dataset and that this should be included in the sources of uncertainty.

It was recommended that a carefully worded statement be added under recommendations that better knowledge of the data would reduce the sources of uncertainty.

The following revisions were agreed to:

- separate the three species that were used to help develop the model in the table from the other species screened;
- add a recommendation that species between 10 and 20% climate match be looked at to identify match in a subsequent process such as a Science Response Process since the 20% threshold may have been too high for family the family match may have screened out some species that should have been screened in;
- add a sentence that detailed-level risk assessments are available for several species in Canada under the background section of the Science Advisory Report;

- add table in research document of the species that have already been identified as high risk;
- add description or explanation of thresholds;
- a simpler table will be included in the Science Advisory Report of species that are high / low risk but to also highlight the species for which there was not enough data; and,
- add to recommendations that Characidae should be assessed in the future for southwest BC because of the climate match.

The participants agreed to accept the paper, with revisions.

DRAFTING OF SCIENCE ADVISORY REPORT

A draft of the science advisory report was presented and discussed at the meeting. Participants discussed and proposed additions/revisions to the results, sources of uncertainty, conclusions and recommendations sections of the report.

CONCLUDING REMARKS

The co-chairs thanked participants and it was agreed that the Science Advisory Report and proceedings would be circulated to participants for comment in April. For the three research documents, the co-chairs will confirm that all revisions agreed to are met prior to approval. The meeting was adjourned.

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APPENDIX 1. TERMS OF REFERENCE

Screening-Level Risk Assessment Prioritization Protocol for Aquatic Non-Indigenous Species

National Peer Review Process Meeting – National Capital Region

March 19-21, 2013
Burlington, Ontario

Co-Chairperson: Gilles Olivier and Sophie Foster

Context

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). The national ranking of aquatic NIS, based on the biological risk they pose to Canadian aquatic ecosystems, is necessary to prioritise the allocation of funds and other resources for national and regional aquatic NIS activities.

As a result, DFO's Centre of Expertise for Aquatic Risk Assessment (CEARA) undertook the development of a screening-level risk assessment (SLRA) prioritization protocol for aquatic NIS. This protocol will allow the ranking of aquatic NIS for national priorities. As well, it will be used as a biological screening tool for aquatic NIS to determine (in a short time frame) if more detailed-level risk assessment or a risk management evaluation is required based on existing information.

DFO's Legislative and Regulatory Affairs (LRA), also a client for this process, has requested science advice to support the development of a national regulatory proposal for addressing aquatic NIS. Specifically, they have requested to include in the regulatory proposal: 1) a protocol to prioritise aquatic NIS; and, 2) a list of high risk aquatic NIS including those NIS already present in Canada whose transport into "non-infected" areas in Canada should be limited.

A national Canadian Science Advisory Secretariat (CSAS) science advisory process will be held to provide science advice on the SLRA prioritization protocol for aquatic NIS. This process will consist of at least two peer-review meetings. Part 1 was held in Montreal, Québec on November 22-24, 2011. For Part 1, participants examined the methodological review section of the protocol and developed a framework for a SLRA protocol for aquatic. It was concluded that different SLRA protocols may be required for different aquatic NIS taxa and, hence, prioritization using a single protocol may not be possible. Part 2 will be held in Burlington, Ontario on March 19-21, 2013 and will evaluate and apply SLRA protocols for freshwater NIS. SLRA protocols will be evaluated and applied to freshwater NIS currently in trade within Canada across multiple taxa (including freshwater fishes, molluscs, and plants). The most appropriate SLRA protocols for freshwater NIS fish taxa will be identified, and previously peer-reviewed and published SLRA protocols for molluscs and plants will be used to screen freshwater NIS currently in trade within Canada. Additional meetings, not yet scheduled, will be required in the future to evaluate SLRA protocols for marine NIS and to assess the ability to prioritize all NIS using the chosen SLRA protocols.

Working papers

Part 2 - Peer-review SLRA prioritization protocol for aquatic NIS

There will be **three working papers (WP)** for Part 2 of this process. A separate working paper will be produced for the evaluation and application of the SLRA protocols used for each of the specific freshwater NIS taxa (fishes (WP1), molluscs (WP2, plants (WP3)).

Objectives

Based on the working papers presented at the meeting, meeting participants will be asked to fulfill the following objectives:

1. Review the SLRA protocol for freshwater molluscs to identify potential invasive mollusc species in Canada. If deemed suitable, review the list of freshwater mollusc species screened using the SLRA protocol.
2. Review the SLRA protocol for freshwater plants to identify potential plant invasive species in Canada. If deemed suitable, review the list of freshwater plant species screened using the SLRA protocol.
3. Review the evaluation of five SLRA protocols for freshwater fishes. Determine the suitability of the recommended SLRA protocol for freshwater fish to identify potential invasive fish species in Canada. If deemed suitable, review the list of freshwater fish species screened using the SLRA protocol.

Expected Publications

- Science Advisory Report(s)
- Proceedings
- DFO Research Documents

Participation

- DFO Science, Legislative and Regulatory Affairs, and other sectors
- Experts from other federal and provincial government departments
- Academics

References

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APPENDIX 2. LIST OF PARTICIPANTS

Name	Affiliation	19-Mar	20-Mar
Gilles Olivier	DFO	x	x
Nick Mandrak	DFO	x	x
Crysta Gantz	University of Notre Dame	x	x
Becky Cudmore	DFO	x	
Bethany Schroeder	DFO	x	x
Sherry Walker	DFO	x	x
Sophie Foster	DFO	x	x
Reuben Keller	Loyola University	x	x
Karen Castro	CFIA	x	x
Andrew Drake	DFO	x	x
Mike Bradford	DFO	x	x
Lisa Jones	DFO	x	x
Gerry Mackie	University of Guelph (emeritus)	x	x
Sophie Monfette	Ontario Federation of Anglers and Hunters	x	
Francine MacDonald	Ontario Ministry of Natural Resources	x	
Jeff Brinsmead	Ontario Ministry of Natural Resources	x	x
Todd Morris	DFO	x	x
Lynn Bouvier	DFO	x	x
Wendy Michaud	DFO (rapporteur)	x	x
Sara Venskaitis	DFO (rapporteur)	x	x

APPENDIX 3 – EXPERT REVIEW BY KAREN CASTRO (CANADIAN FOOD INSPECTION AGENCY) OF "APPLICATION OF AN AQUATIC PLANT RISK ASSESSMENT TO NON-INDIGENOUS FRESHWATER PLANTS IN TRADE IN CANADA"

General comments

My overall impression of the document is very positive, and the authors should be congratulated for their work. Harmonizing screening approaches between the United States and Canada is an excellent idea considering that we share a border and many of the same invasive species. Although I was rather surprised at the adoption of the United States Aquatic Weed Risk Assessment (USAqWRA) for freshwater aquatic plants, which was a significant change from the Montreal discussions on the Alberta Risk Assessment Tool for all aquatic species, the fact this new tool has been tested in several countries, validated for the United States, and published in a peer-reviewed journal all serve to provide good reasons for choosing it. I hope the authors find my comments helpful for strengthening the document.

Terms and definitions

The use of the word "screen" is confusing in all three documents because it is used for two different types of exercises. At top of page 4, "Species in Gordon et al. (2012) were first screened for climate match in Canada and those screened in were then screened by USAqWRA", the word "screen" is used for climate matching and also for the use of the risk assessment tool. I would suggest reserving the word "screen" for the second case, but finding an alternate word for the first, to avoid confusion about what screening means. I think you could use something more generic for climate matching, e.g., "Species…were first assessed for climate match."

The term "native" is used for some species "native" to the United States but not present in Canada. I would not consider those species to be "native" to Canada, so this term is a bit confusing when discussing native vs. non-native species in Canada.

In Gordon et al. (2012), aquatic plants were categorised as attached-floating, erect emergent, free-floating, sprawling emergent, or submerged freshwater macrophytes. Wetland and riparian species were not included in the Gordon et al. (2012) analysis. It would be helpful to include the definitions of the various types of aquatic plants in the present document. Also, some guidance on how to draw the line between aquatic and terrestrial plants would be helpful to determine which tool to use (i.e., terrestrial or aquatic plant screening tool).

In Table 3 and Appendix 1, the tool is called the "CanadaAqWRA", suggesting it has been modified for Canada. However, the text does not mention any specific modifications, so it should be the same as the USAqWRA. The switch from "USAqWRA'" to "CanadaAqWRA" is a bit misleading.

Concerns about climate

Canada has a colder climate than anywhere else where the New Zealand screening tool (NZAqWRA) or modified forms of it has been tested (New Zealand, Australia, Micronesia, United States). With respect to adapting a tool for Canada, our climate may require some special consideration. This was the experience of my unit when we tested the Australian WRA for terrestrial plants in Canada.

On page 4, it is acknowledged that the USDA Global Plant Hardiness Zones are based on air, not water, temperatures, and do not account for insulating effects of water or snow or for reproductive structures to survive winter temperatures. What could be the implications of this? I don't think anyone currently has the answer, and I agree that plant hardiness zones are probably the best you have to work with, but this should be further explored and ever present in mind as you go forth with this tool. It might be that the zones are too conservative for aquatic plants.

Some aquatic species can survive further north than expected from a typical climate match. My unit did a comprehensive risk assessment on *Cabomba caroliniana* (fanwort) a few years ago, and we were surprised that it could survive and do well in south-central Ontario, which is probably its most northerly location in the world. It has shown that it is capable of thriving well outside the range of the warm, humid climates it is said to prefer in the literature (described as average annual temperatures of 15-18ºC). It is very difficult to predict how much more of Canada might be climatically suitable for this species. Its range is still expanding and its northern limits have not yet been established.

Some other species of real concern can produce over-wintering buds, or turions (e.g. Potamageton, Myriophyllum) that sink to the bottom of the water in winter where they never freeze. If such a species were to grow in an area of one of the colder plant hardiness zones (e.g., zone 3 or 4), those overwintering structures would not experience the temperatures associated with that hardiness zone because they're in the water.

The NCSU/APHIS Plant Pest Forecast (NAPPFAST) map produced in 2007 was used for hardiness zone matching in this document. A new NAPPFAST map became available in 2012, based on an improved and more recent dataset. The new ten-year NAPPFAST map shows zone 10 for the first time in Canada, on Vancouver Island. Therefore, you may want to consider screening species hardy to zone 10 in addition to those already screened from zones 1-9.

Methodology

In the Gordon et al. (2012) paper, which describes the adaptation of the NZAqWRA tool into the USAqWRA, the US tool was tested for accuracy using 130 introduced aquatic plants that had the opportunity for at least 30 years to become established in the United States. It was then validated with an additional 20 species.

Roughly the same structure is apparent in the research document for Canada, although the methods section (page 3) indicates the US tool is to be used to "screen" two lists of aquatic plants for Canada and doesn't explicitly state that the tool is to be tested and validated.

To test the tool for Canada, a priori categories are required for the species lists. I don't think a priori categories can be made for the Gordon et al. (2012) list when applied to Canada, because one would have to assume that the species are in trade in Canada and that they have been in trade for at least 30 years (to be consistent with Gordon et al. (2012)). This history of trade was known for the US, but not for Canada. Without evidence of a history of trade in Canada, it is not known if these species have ever had a chance to establish in Canada, and so the a priori category "not established" is not meaningful. This has implications for the accuracy assessment, in which the screening tool outcomes are compared to the a priori categories. To deal with this issue, additional information on history of trade in Canada should be sought. It may be necessary to reduce the number of species included in the analysis, based on the availability of this type of information.

Please also discuss the difference between the a priori categories used in Gordon et al. (2012) for the US (non-invader, minor invader, major invader) and the a priori categories used for

Canada (not established, established), and the implications of those differences. Establishment in Canada appears to be equated with high risk, which is questionable (e.g., in the last sentence of p.8, “Of the 30 species established in Canada, 73% were correctly screened as high risk at a threshold of 40…”).

There are some discrepancies between the list of species in Gordon et al. (2012) and the list in Appendix 1 of this document, which was supposed to come from Gordon et al. (2012). For example, *Phragmites australis* and *Cabomba caroliniana* do not appear in Gordon et al. (2012) but are included in Appendix 1 of this document. These should have been the same lists, with some species from Gordon et al. (2012) excluded from Appendix 1 if they did not match climate for Canada.

For the second list of aquatic plants, described on page 5, it is stated that “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 was the case”. What might the effect of this assumption be on the screening tool scores?

There is a large percentage (29%) of species that fall in between the two risk thresholds and may require further evaluation. Do the authors have any preliminary thoughts on a protocol for the “evaluate further” category? Are these the species that will go on to DLRA?

Other comments

In the methods section (page 3), it is stated that comprehensive data are not available on the introduction, establishment, and invasiveness status of freshwater NIS in Canada. This type of information may be available for at least a modest set of species. To what extent was this type of information sought? Scoggan’s Flora of Canada was published in 1979 and could provide evidence of a 30-yr history in Canada for some species. There are also comprehensive accounts of a few aquatic plants in the Canadian Journal of Plant Science, Biology of Canadian Weeds and/or Biology of Invasive Plants in Canada series. It might be more difficult to find information on species in trade that have not established in Canada. This is a comment for consideration only, for possible future work.

Please also note that there are also a couple of good online Canadian databases that could be used for double-checking evidence of establishment in Canada, in addition to the USDA PLANTS database used in the research document. These include VASCAN and the Plants of Canada database.

Paragraph 4. Some of the percentages are incorrect (they add up to more than 100%).

Guidance for questions 11.1-11.6 in Gordon et al. (2012) is confusing.

Can you comment on the amount of overlap in the list of aquatic plants from Gordon et al. (2012) and the list provided by E. Snyder? Were overlapping species then removed from the second list?

APPENDIX 4. EXPERT REVIEW BY REUBEN KELLER OF "EVALUATION OF FIVE FRESHWATER FISH SCREENING-LEVEL RISK ASSESSMENT PROTOCOLS AND APPLICATION TO NON-INDIGENOUS ORGANISMS IN TRADE IN CANADA".

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Background

The document under review has been put together as part of a DFO/CEARA effort to develop a three-stage approach to risk assessment for invasive freshwater species. The final goal is to have a rapid assessment (takes a few days to complete per species), a screening-level risk assessment (SLRA; takes about a week to complete per species), and a detailed-level risk assessment (DLRA; takes several months to complete). The report being reviewed here describes the results of a DFO program to evaluate five existing approaches to SLRA for fishes. SLRA has been identified as the appropriate risk assessment stage for screening and prioritizing non-native fish species. It is anticipated that SLRA results would provide DFO with scientifically defensible grounds to act on the risks posed by each species. The potential management actions pursued for different risk levels are not addressed in the report.

Overview Comments

This report covers several steps in a proposed process for assessing the biological risk of fish species to Canada. These steps are outlined in the following, and the numbering system is used throughout this review.

1. The report takes five existing SLRA tools and tests them by assessing the range of species that have been introduced to the Great Lakes. Performance of the tools is estimated by how well they assign these species to the known outcome from introduction (established or not, impact or not).
2. The report develops and presents a list of all fish species currently known to be in trade in Canada (n=1649).
3. The report applies a new four level 'pre-screening' hierarchy to remove from this total list any species that are not freshwater, or that are unlikely to survive in Canadian climates.
4. The report assesses the remaining 12 species using three of the SLRA tools.

In recent years a large number of risk assessment tools have been developed for a range of taxa in a range of regions. Most of these tools fit approximately within the paradigm of SLRA; i.e., take 1-5 days per species to conduct. One notable omission from the growing literature on risk assessment is any rigorous comparison of different tools. This has, I believe, hampered further development within the field. It has also encouraged the profusion of many risk assessment tools, many of questionable quality, because there are not results from general comparisons that can be used as consistent guidelines for developing new tools.

The work presented in this report is just the second project (of which I am aware) that compares the performance of multiple risk assessment tools. Importantly, these tools come from both statistical and questionnaire approaches to risk assessment tool development. In general, questionnaire risk assessment tools have been developed by management agencies, while statistical risk assessment tools have been developed by academics. There are reasons to favor each, and it is notable that (to the best of my knowledge) there are no statistical risk assessment tools currently being used to support policy. In contrast, several nations, states and regions have implemented questionnaire risk assessment tools.

Regardless of the SLRA tool chosen, it needs to be remembered that any risk assessment can be time consuming (=expensive). This means that there is great value in excluding (e.g., based on being extremely unlikely to establish in Canada even if released) any species from SLRA. This report presents a novel hierarchy for doing this, beginning with family and then species habitat match, followed by family and species climate match (see Figure 2). Only those species making it through these four preliminary screens are subject to SLRA. This approach reduced the list of 1649 'potential' invaders in Canada to just 12 species requiring SLRA. This is an enormous savings in terms of time and resources.

Overall I am very impressed with the scope of work conducted to prepare this report. It is academically novel and provides a solid foundation from which Canada can select an SLRA tool for application. This does not necessarily mean that the decision of which SLRA to use will be easy, but this report does provide much of the information that will be required to make that decision.

Detailed Comments

1. Comparison of Tools

In this report the statistical approach to SLRA is represented by the Notre Dame tool (ND). The questionnaire approach is represented by the remaining four tools (FISK, Montreal RAT, Alberta RAT and GLANSIS). Statistical tools have been favored by the academic community because they are minimally biased by the people who develop and use them. Statistical tools are created by gathering a large amount of trait data for species that have been introduced and caused known levels of impacts. These data are then analyzed with statistical discrimination algorithms to determine which combinations of traits are associated with different outcomes (e.g., established vs. failed to establish).

In contrast, questionnaire tools are generally developed by assembling a list of questions about species, the answers to which are believed by the developers to be associated with invasiveness. These tools usually contain many questions, and the answers to questions required are often imprecise (e.g., rank species quality X as High, Medium, Low), especially in comparison to the precise data required by statistical tools.

All tools were assessed for their performance across a range of scenarios for determining which species are 'high-' vs. 'low-risk' (see Table 2 of the document). It will be up to DFO to decide what the appropriate scenario is for application as a management tool. This decision should be made without reference to the results presented in this paper (that is, it should come before and be independent of the decision of which tool has the best performance). It should be remembered that choosing any scenario other than 'established vs. failed establishers' implies that DFO is prepared to see more established fish species.

In the assessment presented here the statistical tool was shown to have the lowest performance of all five tools. While this is sobering for those of us who work on statistical tools, I think that more detail is necessary before the statistical approach is discarded. First, the statistical tool

should give the most consistent results. That is, if multiple people use this SLRA to assess the same species I believe that they are more likely to get the same result than if they used a questionnaire result. This is an attractive quality, especially considering that assessments conducted by DFO may be challenged.

Second, the ND tool should be much more rapid to conduct. It requires answers to one question to estimate establishment, and two questions to estimate impact. In contrast, the other tools contain many more questions (FISK = 49, Alberta RAT = 31, Montreal RAT = 17, GLANSIS = 36). Thus, the ND tool should be much cheaper to implement.

These two points suggest two additions to this report that would be very useful. The first is an assessment of consistency, and would require several scientists to assess a group of species. While this would be useful, it would be a large additional project, and may be beyond the scope of this work. Instead, I recommend that the authors insert a paragraph or two explicitly addressing the likely consistencies of each tool. The second addition is a description of how long it took the assessor to assess each species using the five different tools. These data should be available, at least as an estimate, and would help in deciding which tool is most appropriate for application.

An additional consideration is that the ND statistical tool was developed based only on data in the Great Lakes. Thus, it may not be appropriate for adoption at the scale of Canada. The way that statistical tools are developed (i.e., gather data, analyze with a statistical tool to create the model) means that it may require additional testing to determine whether the ND tool is appropriate for implementation at the national scale.

Related to these points, it would be useful to include a more detailed description of how the risk assessments were conducted. Who did the assessments? How many people were involved? What is the expertise of the person/people doing the work? These further details would provide a basis for determining whether the results presented here are likely to be similar to the results that would come from implementing one of these tools as policy. They are also necessary to determine whether any potential biases were introduced by the choice and practices of the assessor(s).

Overall, I recommend that DFO consider the performance metrics presented in this report (Table 4) against the investment required for each SLRA. Additionally, if the SLRA is going to be used in conjunction with stage 1 and stage 3 risk assessment approaches, it may be useful to consider the desired qualities of SLRA in the context of the full three stage process.

2. List of Species Currently in Trade in Canada

This section of the report is explained well and appears to be as comprehensive as possible. Many resources have been consulted to put together the list. I believe that this has been done very well, and I have no suggestions for improvement.

3. Application of a Pre-Screening Hierarchy

SLRA approaches take hours (e.g., ND statistical tool) to days (the remaining tools) to complete. Given that there are at least 1649 species currently in trade, there is strong incentive to screen out any species which pose a very low risk.

The protocol presented for doing this begins by screening out any species from families that do not contain freshwater or euryhaline members. Remaining species are then assessed to determine whether they are freshwater or euryhaline. The authors have put together the information so that this assessment can be conducted on any future species. This level of pre-screen conforms to standard scientific practice in fish risk assessment (i.e., marine species

pose a very low risk to freshwater habitats) and will greatly speed up the screening of many species.

The second step in the pre-screening is to remove species from families that do not have a strong climate match, and then to test the remaining species for a strong climate match. Climate match is a continuous variable, meaning that it is necessary to establish a threshold. In this report the threshold has been developed from previous work by Bomford, and it appears to be a conservative approach. That is, it is unlikely that species screened out are in fact capable of establishing. Despite this, there has been no rigorous assessment of whether this threshold does, in fact, only remove species from the species pool that are incapable of establishing. Thus, this threshold may need to be modified in the future as further results become available.

4. Assessing 12 species

These assessments appear to have been conducted well, and should be useful for providing immediate guidance to DFO for management. The results from a single SLRA could be used if one is chosen, or the results could be combined in several ways. For example, regulators may decide that if any one (or two, three, etc.) of the five tools ranks a species as ‘high-risk’ it will be excluded from trade.