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Proceedings of the National Risk Assessment of Zebra Mussel, Quagga Mussel and Dark Falsemussel

March 27-28, 2012
Winnipeg, Manitoba

Chairperson: Marten Koops

Editor: Sherry Walker

200 Kent Street
Fisheries and Oceans Canada
Ottawa, Ontario, Canada K1A 0E6

May 2013

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

In freshwater and some estuarine ecosystems, the Zebra Mussel (*Dreissena polymorpha)* and Quagga Mussel (*D. rostriformis bugenis)*, both native to the Ponto-Caspian Region of Eastern Europe, have a long history of invasion in aquatic ecosystems in both Europe and North America. These two species were introduced to the Great Lakes in the mid-1980s as a result of ballast water discharge from ships. These mussels have rapidly dispersed throughout the Great Lakes region into river systems and smaller lakes. As well, a closely related dreissenid mussel species, the Dark Falsemussel (*Mytilopsis leucophaeta)*, was identified on a boat being trailered across western Canada, raising concerns that this species could also pose a risk to Canadian freshwater ecosystems and was also evaluated in this risk assessment. Dreissenid Mussels have had significant environmental and socio-economic impacts due to their ability for rapid dispersal, resulting in severe negative impacts on food webs and nutrient processing. As a result of the significant impacts associated with these mussels as well as a steady movement west, several western provinces requested Fisheries and Oceans (DFO) (through Canada's Centre of Expertise in Risk Assessment, CEARA) to conduct a risk assessment for Zebra, Quagga and Dark FalseMussels. This risk assessment considered probabilities of survival (habitat suitability) and arrival to 108 Canadian sub-drainages and the ecological impacts associated with these species. The ecological risk posed by these species was determined using an established Risk Matrix. This risk assessment was peer reviewed as the key scientific working paper in a CSAS National Peer Review Process held on March 27 and 28, 2012 at the DFO Freshwater Institute in Winnipeg, Manitoba. The results are presented in the science advisory report and research document for this CSAS national peer review process.

SOMMAIRE

Présentes dans les écosystèmes d'eau douce et certains écosystèmes estuariens, la moule zébrée (*Dreissena polymorpha)* et la moule quagga (*D. rostriformis bugenis),* qui sont toutes deux originaires de la région pontocaspienne, en Europe orientale, sont des espèces envahissantes de longue date en Europe et en Amérique du Nord. Les deux espèces ont été introduites dans les Grands Lacs vers le milieu des années 1980 par l'entremise de l'eau de ballast déversée par les navires. Ces moules se sont rapidement dispersées dans l'ensemble de la région des Grands Lacs, dans les réseaux hydrographiques et les petits lacs. Une autre espèce de moule de la famille des dreissénidés, la moule d'Amérique (*Mytilopsis leucophaeta)*, a également été trouvée à bord d'un bateau qui était remorqué dans l'Ouest canadien. Cette découverte fait craindre que cette moule présente elle aussi un risque pour les écosystèmes d'eau douce au Canada. Cette espèce a également été incluse dans la présente évaluation des risques. En raison de leur capacité de dispersion rapide, les moules dreissénidées ont eu des impacts environnementaux et socio-économiques importants sur les réseaux trophiques et la transformation des éléments nutritifs. Étant donné les impacts importants de ces moules et leur déplacement continu vers l'Ouest, plusieurs provinces de l'Ouest ont demandé à Pêches et Océans Canada (MPO) (par l'intermédiaire du centre d'expertise pour l'analyse des risques aquatiques [CEARA]) d'entreprendre une évaluation du risque pour les moules zébrée, quagga et d'Amérique. La présente évaluation des risques s'est penchée sur les probabilités de survie (habitats propices) et d'arrivée de ces espèces dans 108 sous-bassins versants ainsi que leurs impacts écologiques. Les risques écologiques posés par ces espèces a été établi au moyen d'une matrice des risques. La présente évaluation des risques constituait le principal document scientifique de travail d'un examen par les pairs tenu dans le cadre d'un processus national du SCCS qui s'est déroulé les 27 et 28 mars 2012 à l'Institut des eaux douces du MPO de Winnipeg (Manitoba). Les résultats sont présentés dans l'avis scientifique et le document de recherche de ce processus du SCCS.

INTRODUCTION

The chair, Marten Koops (DFO – Central & Arctic Region) opened the meeting and welcomed the participants. He explained that the purpose of the meeting was to review a working paper and develop science advice on the Risk Assessment for Three Dreissenid Mussels (*Dreissena polymorpha, Dreissena rostriformis bugensis* and *Mytilopsis leucophaeata)* in Canadian Freshwater Ecosystems. He noted that the CSAS process requires high standards of technical evaluation. He reviewed the CSAS guidelines and policies, the Science Advice for Government Effectiveness (SAGE) principles, role of participants, ground rules, terms of reference including the objectives (Appendix 1), and agenda for the meeting. Participants were provided an opportunity to introduce themselves via a round table (Appendix 2). The chair provided an overview of Canada's Centre of Expertise for Aquatic Risk Assessment (CEARA) and the organizations' responsibilities for risk assessment. The rapporteurs for the meeting were Bethany Schroeder (DFO – Central & Arctic Region) and Sherry Walker (DFO – CSAS).

PRESENTATIONS

INTRODUCTION TO BIOLOGICAL RISK ASSESSMENT METHODS USED FOR DREISSENID MUSSELS

(Presenter – Tom Therriault, DFO – Pacific Region)

Abstract

Both Zebra Mussel and Quagga Mussel have extensive invasion histories in both Europe and Eastern North America but the potential risk to Western Canada has not been assessed. The Dark Falsemussel has been detected in the recreational boating pathway in Western Canada and was included here. Although this assessment was initially requested by the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba, subsequent interest and data provided by Ontario and Quebec allowed the risk to be assessed for these provinces as well. This risk assessment used data provided by the six provinces allowing 108 Canadian sub-drainages to be assessed. In addition, updated distribution data for both Zebra Mussel and Quagga Mussel were obtained from the USGS website and presented to participants to ensure the distribution was as up to date as possible. The risk assessment methodology was presented in three major components. The first component was to determine habitat suitability. This was computed using calcium values as the primary determinant of invasion success, corrected for temperature limitations noted for Zebra Mussel (but not Quagga Mussel). The second component was to determine the probability of an introduction and was determined using a Human Footprint Index as a measure of vector pressure and proximity to invaded habitats as potential source of propagules for each assessment area. These two scores were combined to determine the potential for an invasion. To determine the risk to the environment, the potential for invasion was combined with data compiled on dreissenid impacts on the environment from literature meta-analyses, using a Risk Matrix.

Discussion

It was requested that an example and additional details be provided of the risk assessment methodology to understand how the risk was calculated. The authors re-explained the

methodology using a figure and further explained the calculations and formulas used in the assessment.

There was a comment that the terminology used was inconsistent with a DFO protocol. It was agreed that the terminology would be adjusted to avoid potential confusion but the authors noted the terminology was consistent with scientific literature on dreissenid invasions and that some terminology was selected specifically for this taxon that differs from previous DFO risk assessments for other species. Revised terminology was presented by the authors on Day 2 and agreed to by meeting participants.

It was noted that CEARA does not consider positive impacts of aquatic invasive species so it was suggested that positive impacts be removed from the table. The authors agreed to make this change but noted that for some specific ecological endpoints, dreissenid invasions in Europe and North America have resulted in positive impacts.

It was questioned how risk considers issues such as cottage country, which is affected by traffic, and consequently, can influence dispersal of the mussels. The authors noted that this information for specific watersheds is not available. There was a discussion about the human footprint index and how it would be evaluated. It was argued that if there is susceptible habitat and someone can get their boat to that location, then the distance between watersheds is less relevant and thus proximity may not be the best measure. It was noted that recreational boating is likely driving all movement of the mussels. The author noted that the human footprint index considers not only density but also proximity to roads, boat launches etc. For the purposes of the assessment, the Human Footprint Index was used and participants agreed it was the best proxy for human-mediated movements.

It was noted that the risk of arrival can be reduced by boat washing and monitoring at marinas. The authors responded that this would be included as a potential recommendation in the report to lower the risk of arrival.

There was discussion about the calcium concentrations and it was suggested that the 75th percentile rather than the average be used as a more precautionary approach. It was noted that in the absence of weighting that the percentile is used. It was agreed that this change would be made.

There was discussion concerning the accuracy of the water temperature data and how this might affect risk at a local scale. It was agreed that the recommendations need to note that local conditions will “trump” the regional scale as this assessment is at a broad scale since it is national in scope.

The authors undertook a re-formulation of the Human footprint index during the break and presented the revised results as a proposal for consensus by the participants. The scores were binned according to their natural (Jenks) data breaks into five categories ranging from very low to very high. This was essentially the same index but re-grouped and re-scored differently. The participants agreed that this was a better representation but noted that there are some limitations. For example, how proximity is used still needs to be re-considered. A concern was also expressed that the representation around Vancouver seemed low.

There was a discussion of switching the proximity correction factor to a two-tailed argument. It was suggested that the correction factor should be increased by a factor of 1. As such, this would increase the probability of introduction if close proximity and decrease if far. It was

questioned if the distance is two watersheds away, would +1 still be used. The response indicated that the probability would decrease if more than two watersheds away. It was affirmed that this would represent Manitoba better.

There was a discussion of the relationship between the differences in risk of dispersal spread from downstream as opposed to upstream areas. It was proposed that there needs to be some type of correction factor. For example, the Red River is upstream from Manitoba and it would make sense to have this secondary dispersal included in the assessment. It was suggested that the recommendations highlight that this species has a high potential for downstream dispersal. The authors agreed to make revisions to the text to reflect this argument.

BIOLOGICAL AND ECOLOGICAL SYNOPSIS OF THREE DREISSENID MUSSEL SPECIES: *DREISSENA POLYMORPHA*, *D. ROSTRIFORMIS BUGENSIS*, AND *MYTILOPSIS LEUCOPHAEATA*

(Presenter – Scott Higgins, DFO – Central & Arctic)

Abstract

The three mussel species share a common subfamily (Dreisseninae), and Zebra Mussels and Quagga Mussels (*D. polymorpha*, and *D. rostriformis bugensis* respectively) share a common genus (*Dreissena*). The species share many common morphological characteristics and can be mischaracterized by untrained personnel. As the Dark Falsemussel (*Mytilopsis*) is a brackish water species, the majority of the presentation focused on the two remaining species. These species are capable of achieving very high densities (>500,000 m^2), and as filter feeders can exert considerable control over phytoplankton biomass (mean -40% to -80% of pre-dreissenid biomass depending on habitat type). Despite large overall declines in biomass, there are a growing number of documented reports of increases in a toxin producing phytoplankton species called Microcystis, and concentrations of its hepatotoxin microcystin, within invaded waters. Dreissenid effects on zooplankton biomass appear proportional to effects on total phytoplankton biomass, with mean declines of -45% to -75% (dependant on habitat type) of pre-dreissenid levels. In response to dreissenid filtration of seston (phytoplankton + other suspended particulates), water clarity (secchi depth) increased from 30% to 70% depending on habitat type. In general, strongest impacts were found in rivers, followed by shallow non-stratified lakes, then large stratified lakes. Increases in water clarity and nutrients from dreissenid excretion at the sediment water interface increased benthic algal biomass and macrophyte coverage (both +175% of pre-dreissenid conditions), and the total biomass of native benthic invertebrates in the littoral zone (+60 %). In the lower Laurentian Great Lakes (Lake Erie, Lake Ontario, Lake Michigan) dreissenid invasion has led to dramatic shoreline blooms of a filamentous green alga known as *Cladophora glomerata*, which was associated with a number of negative ecological consequences (e.g., increased anoxia, high bacterial counts including toxic strains, beach fouling). Two important taxa (Unionid Mussels and Sphaerrid Mussels) showed significant declines in abundance following dreissenid invasion. Unionid Mussels, already imperiled fauna in North America, generally declines in abundance by 90% within 10 years of dreissenid invasion with localized declines in species richness. Effects on the fish community are less well understood due to logistical and methodological problems (e.g., long life spans, errors associated with population estimates); however several case studies suggest that strongest effects are found on planktonic and deepwater benthivore species that are unable to efficiently switch resource use to benthivores. For example, in Lake Huron dreissenids appear to have caused a collapse in an important food resource; a deepwater amphipod known as diporeia. In addition to strong top down pressure by predators, the collapse in dipoeria

caused a collapse in pelagic forage fish (Alewife and Lake Whitefish), followed by a collapse of Pacific Salmon populations. A time series analysis on key ecosystem indicators (secchi depth, phytoplankton biomass, zooplankton biomass) indicated the dreissenid effects are prolonged, with no evidence of declining impacts within 20 years of dreissenid invasion. Due to the widespread impacts on the physical, chemical, and biota within all trophic levels the overall ecological risk of *D. polymorpha* and *D. rostriformis bugensis* were considered very high.

Discussion

There was a discussion regarding the correct species name for Quagga mussel. It was verified that *Dreissenia rostriformis bugensis* is now consistently used in the scientific literature.

There was a question regarding whether there was any attempt to look at differences in mussel population density to determine relative impact. It was noted that the magnitude of impact is related to population density and ability to filter the water column. Within a year, the density can change by an order of magnitude. The authors noted that Table 1 in the Research Document shows that population abundance was used in determining the probability of survival and, in turn, the overall risk.

It was questioned whether short term impacts were considered as well as long term. The authors noted that these were combined under one rating.

CALCIUM THRESHOLD AND PREDICTING SUITABLE FRESHWATER ECOSYSTEMS IN CANADA

(Presenter – Tom Therriault)

Abstract

The invasion success of a non-indigenous species depends on its ability to arrive, survive and ultimately establish in new locations. Further, successful invaders often spread from their initial area of introduction. In our risk assessment, we first assessed the habitat suitability for Dreissenids. Although several environmental variables such as temperature, pH, dissolved oxygen, substrate size, etc., may limit successful mollusc invasions, we used calcium as the primary factor to determine invasion risk. Calcium is considered as a key limiting factor, required for basic metabolic function and shell building. The average calcium concentration from the most recent year was extracted for each sampling site from the datasets acquired for British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec. The mean calcium concentration was then calculated for all assessed sub-drainages. Five probability categories, ranging from very low to very high, were defined. Since published literature suggests that temperature might limit Zebra Mussel populations, a temperature correction factor was applied to the calcium scores to calculate habitat suitability. In addition to suitable habitat, potential invaders must have a mechanism to reach the risk assessment area and potentially be redistributed within it. Here, we considered the potential for arrival and spread to be a function of vector pressure and the proximity to potential source populations. The potential for invasion is thus a function of habitat suitability and probability of introduction. When this is further combined with ecological impacts, an overall level of risk can be determined. Overall, there was a moderate to high risk to freshwater environments associated with both Zebra Mussel and Quagga Mussel invasion across the western provinces, Ontario, and Quebec. The ecological

risk associated with Dark Falsemussel was considered very low in all freshwater environments of Canada as this brackish water species requires a relatively high salinity for reproduction.

Discussion

There was a discussion of using an approach other than the mean calcium concentration in order to provide a more precautionary approach to the watershed. There was a decision to use the 75th percentile of the calcium concentrations.

Comments had been submitted in writing by a participant who could not attend the meeting (Appendix 3). The chair provided these comments to the authors and read one pertinent comment at the meeting as follows:

> Regarding page 29, 3rd paragraph:
>
> ''For example, the Great Lakes and St. Lawrence represent a single drainage with median calcium concentrations that are moderate for zebra mussel (Figure 12). However, even under moderate conditions the impacts of zebra and quagga mussels in this system have been immense."
>
> "The above statement is very true and thus a word of caution on the model or variables used to determine the risk assessment here. In the case of the Zebra and Quagga Mussels, the size of the water bodies plays a role – not just calcium levels. These dreissenids dwell in large bodies of water; it is as if large lakes or large bodies of water allow for the larval life cycle to be more easily completed."

ZEBRA MUSSEL DISTRIBUTION IN RELATION TO BUFFER VARIABLES IN ONTARIO LAKES – A 2011 UPDATE (G. L. Mackie, R. Claudi, K. Prescott)

(Presenter – Gerrie Mackie, University of Guelph)

Abstract

A total of 32 lakes with calcium levels ranging from 2.7 to 75 mg Ca/L were evaluated for the ability to support Zebra Mussel establishment. The lakes were selected from the Invasives Tracking System (ITS) web site (http://www.comap.ca/its/index.php) based on the presence of veliger larvae but adult establishment was unknown; these lakes were surveyed in June 2011 to determine if adult Zebra Mussels had established themselves. Another 54 lakes were selected based on their known establishment of adult Zebra Mussels. The data were analyzed to determine the minimum levels of pH, calcium, alkalinity and conductivity that would support establishment of adult Zebra Mussels. The minimum levels of calcium varied depending on the associated levels of pH, alkalinity and conductivity, but in general a calcium level of 14 mg/L was needed to support adult Zebra Mussel establishment.

Discussion

It was noted that, in general, these findings support the working paper. It was suggested that some of the differences are variation amongst studies and locations where studies were conducted.

REGIONAL CALCIUM CONCENTRATIONS AND DREISSINID MUSSEL DISTRIBUTIONS IN THE USA

(Presenter - Thom Whittier, Oregon State University)

Abstract

When Zebra Mussels began to invade inland lakes, Whittier et al. (1995; Fisheries 20(6):20-27) presented a Zebra Mussel risk map for eight northeastern USA states based on mapped low alkalinity regions corresponding to calcium levels $\leq$ 12 mg/L and hypothesized that mussels would not invade lakes in those areas. After Quagga Mussels were discovered in Lake Mead, NV in 2007, Whittier et al. (2008; Frontiers in Ecology and the Environment 6:180-184) showed that the low alkalinity areas in the Northeast had not been invaded. They also used calcium data from a national probability survey of streams, assessed at the Omernik level III ecoregion scale, to produce a national risk map. In the four years since that study neither Dreissena species has established in any of the very low and low risk regions, except in a few large rivers and lakes receiving high calcium waters from high risk regions. Very low risk was defined as regions where the 75th percentile of calcium values < 12 mg/L. Low risk was defined as regions with 12 mg/L $\leq$ 75th percentile < 20 mg/L. High risk regions had mean calcium $\geq$ 28 mg/L and 25th percentile > 12 mg/L. All other regions were highly variable, with both low and high concentrations.

Discussion

This study supported the idea of taking the low and very low categories and ranking them as zero since if calcium is low then these species cannot invade since the habitat would be unsuitable.

There was a question if the data would extend into Canada. In response, the presenter noted that there has been some cooperation with Canada to look at the water chemistry data.

PRESENTATION OF NEW REVISED MAPS

(Presenter – Tom Therriault)

Abstract

Revised figures/maps were presented with the new calcium calculation based on the 75th percentile for Zebra Mussel. A new vector pressure map was presented based on the new bins. Revised maps for habitat suitability (now probability of survival), the probability of introduction (now probability of arrival), and the potential for invasion (now probability of invasion) were also presented along with revised terminology.

Discussion

There was a question about the calcium threshold. There was consensus to collapse to 4 categories by combining the low and very low into a single category.

Vector Pressure – Human Footprint Index

The new vector pressure was presented based on the new bins. The participants agreed that this provided a better representation of the vector pressure.

Habitat suitability

There was a discussion regarding the weighting of habitat suitability (now probability of survival) and the probability of introduction (now probability of arrival), which were weighted equally for the purposes of the assessment.

It was decided that if habitat suitability is zero then the potential for invasion (now probability of invasion) drops to low otherwise if habitat is other than 0, the probability of introduction (now probability of arrival) is included to determine the potential for invasion (now probability of invasion). There was consensus to use the average of these two probabilities to determine risk as per the original document.

There was a discussion concerning the temperature correction factor. If temperature is limiting, then -1 is used as a correction factor. For the other two categories (likely limiting, not limiting), no correction factor is applied. There was consensus that this adjustment is only applicable to Zebra Mussel and not Quagga Mussel. It was noted that this will only affect a few watersheds in BC and in the north.

Impacts

The overall magnitude of the impact was noted to be very high (negative) while the uncertainty was very low. There was a discussion of the detail of the impacts included in the table. It was noted that not all impacts are equal but some impacts were considered high to very high and thus significant, widespread and not reversible. It was recommended that the socioeconomic impacts (beach closures, aesthetics) be removed.

There was a discussion concerning whether food web shifts, community disruptions (littoral vs pelagic, benthivorous vs piscivorous fishes) should be included in the summary table of impacts.

There was discussion of ratings and it was suggested that species at risk should be ranked low to high given potential differences among species depending on trophic level and impacts on the Unionid Mussels should be ranked very high given extensive literature on the impact of dreissenid mussels on these native ones.

It was suggested that the level of impact should consider the density or size of the area infected. The author responded that this is considered in the risk assessment as probability of survival explicitly includes a measure of dreissenid abundance.

Discussion of Risk Matrix

Some of the rankings such as impacts on recreational and commercial fisheries were based on the information that was available. It was suggested that there is a need to break down fishes into different categories and discuss the relative effects of each.

There was consensus to change the very low probability of establishment (now probability of invasion) column to all green and to change the low probability of establishment (now probability of invasion) column to yellow for very high impacts on the environment.

New Calcium Map for Zebra Mussel

The new map for Zebra Mussel was presented using the 75th percentile. The participants agreed that this was a better representation and there was consensus to adopt this new figure for the risk assessment.

Dark Falsemussel Risk

There was a concern raised that the Dark Falsemussel is an estuarine species and that to indicate that this species is low risk based on salinity is misleading. There was agreement that for the scope of this risk assessment (freshwater ecosystems) the risk was low since Dark FalseMussel cannot complete its lifecycle in a freshwater ecosystem. However, as noted in the research document, the risk could be completely different in coastal ecosystems, which were not assessed in this risk assessment. It was recommended that caution should be used to extrapolate beyond freshwater systems considered in this risk assessment. It was agreed that a recommendation be added that this species be re-assessed for estuaries at the appropriate scale.

Discussion of Recommendations

There was a discussion that the wording in the risk assessment should not be prescriptive in terms of recommendations for management actions as the assessment and CSAS process only considers science.

REVIEW OF REVISED FIGURES/MAPS

(Presenter – Tom Therriault)

Based on the input from the participants from the first day, the authors had revised the maps and presented these revisions on the second day of the meeting. The maps included the revised calcium and air temperature used to determine habitat suitability, vector pressure – human footprint index, proximity to invaded watersheds and probability of arrival for Zebra Mussel.

The participants agreed that the 75th percentile was more reflective of the watersheds for the calcium.

For the probability of invasion (now probability of arrival), it was agreed that the revised map captured much of the previous day's discussion.

There was a discussion about watersheds that have a low number of data points. It was suggested that a cut off be selected (i.e., 5 data points) and areas below this cut off be represented with "hatched lines". A note of explanation would be added indicating that there is lower confidence in these areas as the data were potentially limiting.

The denotation of Lake Superior as red on the probability of arrival map was questioned. The authors noted that they are not able to distinguish sub-basins even though Zebra Mussels do not establish in Lake Superior.

It was also commented that there is a potential error for Lake Winnipeg. It was suggested that this area should be ranked high or very high because of the cottage factor. The authors' response indicated that the human density measure may miss transient migration (people who travel to site in the summer).

It was noted that the Risk Matrix was modified such that if there was very low probability of invasion then the overall risk is low.

There was consensus that the revised figures for Zebra Mussel made more sense and the authors indicated that they would follow the same approach with Quagga Mussel.

PRESENTATION OF REVISED FIGURES

(Presenter - Andrea Weise)

Abstract

The new revised figures were presented and reviewed for Zebra Mussel (Figures 10 to 17).

Discussion

There was discussion concerning the watershed risk levels in Saskatchewan, Alberta, British Columbia, which decreased a risk level.

There was a discussion of the decision rule and options. It was noted that if a water body is connected downstream to an invaded habitat then the ranking is +1. There was a decision to insert a decision rule that if connected via a large river system that the potential for arrival is very high via downstream dispersal. This decision changed the probability of introduction in Lake Winnipeg to very high.

CLOSING REMARKS

The chair, Marten Koops, provided closing remarks and reviewed the next steps in the process. He indicated that the revised research document, science advisory report and proceedings would be circulated to participants. He requested that any editorial comments be emailed to the authors (with a copy to the chair and coordinator) as soon as possible.

APPENDIX 1. TERMS OF REFERENCE

National Risk Assessment of Zebra Mussel, Quagga Mussel and Dark Falsemussel

National Peer Review – National Capital Region

March 27 - 28, 2012
Winnipeg, Manitoba

Chairperson: Marten Koops

Context

Zebra Mussel (*Dreissena polymorpha*), Quagga Mussel (*D. bugenis*) and Dark Falsemussel (*Mytilopsis leucophaeata*) are aquatic invasive species. The first two species were introduced in the early 1990s initially into the Great Lakes from ballast water discharge from ships from Eastern Europe, where these species are indigenous. These mussels have rapidly dispersed throughout the Great Lakes region into river systems and smaller lakes due to passive drifting at the larval stage and their ability to attach to the hulls of boats. In addition, these mussels are very prolific and can have profound effects on ecosystems by depleting the biomass of phytoplankton communities, which in turn affect the composition of other communities within the ecosystem. Also of concern is a potential invader related to these two mussel species, the Dark Falsemussel.

As a result of the spread of the Zebra Mussel to areas beyond the Great Lakes region, including a steady movement west in North America, and the resulting significant environmental and economic problems, several provinces have requested Fisheries and Oceans Canada's (DFO) Centre of Expertise for Aquatic Risk Assessment (CEARA) to conduct a national risk assessment of the Zebra, Quagga, and Dark False- mussels throughout most of Canada. The purpose of this CSAS process is to peer review the risk assessment of these three mussels and provide scientific advice. The advice resulting from this process will be used as the scientific basis to help risk manage these species for managers in both federal and provincial jurisdictions.

Objectives

The objective of the meeting is to collect expert advice on the following aspects of the draft risk assessment documents.

- Are components missing from the draft documents?
- Are the determined risk ratings scientifically sound and defensible?
- Are the limitations of the studies clearly outlined?

Expected publications

- Science Advisory Report
- Proceedings
- Research Documents

Participation

- Fisheries and Oceans Canada (DFO) experts from the Ecosystems and Oceans Science, Ecosystem and Fisheries Management, Policy and Economic Sectors
- Provinces of British Colombia, Alberta, Saskatchewan, Manitoba, Ontario and Quebec
- Academia

APPENDIX 2 - LIST OF PARTICIPANTS

Participant	Affiliation
Marten Koops (chair)	DFO – Science (Central & Arctic)
Tom Therriault	DFO – Science (Pacific)
Scott Higgins	DFO – Science (Central & Arctic)
Andrea Weise	DFO – Science (Quebec)
Becky Cudmore	DFO – Science (Central & Arctic, CEARA)
Bethany Schroeder	DFO – Science (Central & Arctic, CEARA)
Sophie Foster	DFO – Science (NCR)
Todd Morris	DFO – Science (Central & Arctic)
Graham Gillespie	DFO – Science (Pacific)
Doug Watkinson	DFO – Science (Central & Arctic)
Sherry Walker	DFO – Science (CSAS)
Jeff Adam	DFO – Policy & Economics (Central and Arctic)
Salim Hayder	DFO – Policy & Economics (Central & Arctic)
Gerry Mackie	Academic – University of Guelph
Kelly McNichols-O'Rourke	Academic – University of Guelph
Thom Whittier	Academic – University of Oregon
Andre Martel*	Museum of Nature
Leif-Matthias Herborg	BC Ministry of Environment
Justin Shead	Manitoba Conservation and Water Stewardship
Jeff Brinsmead	Ontario Ministry of Natural Resources

* provided written comments but was unable to attend meeting

APPENDIX 3. EXPERT REVIEWER COMMENTS

From: André L. Martel, Canadian Museum of Nature
To: Becky Cudmore, DFO, Burlington, ON

Becky and DFO team: please find, below, some comments on the document entitled:

Risk Assessment for Three Dreissenid Mussels (*Dreissena polymorpha, Dreissena rostriformis bugensis, and Mytilopsis leucophaeata*) in Canadian Freshwater Ecosystems

Thomas W. Therriault, Andrea M. Weise, Scott N. Higgins, Yinuo

Guo*, and Johannie Duhaime

General comment

I read the above risk assessment report and overall find it well prepared, including the literature review. In general I agree with the recommendations made near the end of the report, at pages 32-33. The authors have put in a lot of efforts in pulling this together. I want to congratulate that DFO team for this important report.

The main criticism I have at this point relates to the geographic coverage and completeness of the report. Since this risk assessment report must cover all of Canada, I noticed that there is a significant lack of information regarding calcium levels, habitat suitability, probability of introduction, and other assessed variables, for several Canadian provinces. This is notable for New Brunswick and Nova Scotia. Yet, one of these provinces, New Brunswick in particular, has so much to lose in terms of natural capital, or native species, if Dreissena were to become established in that province (e.g., St. John River unionid fauna). I would strongly recommend completing the geographical coverage of this already impressive report as to ensure that it covers all of Canada's major geographic areas where these dreissenids are likely to be introduced in the near or distant future.

More Specific Comments:

In one of the sections of the report, at page 21, under ''Risk Assessment for zebra mussel. Step 1. Determining the Potential for Invasion. Habitat suitability. Calcium Suitability.'' We read:

'*Many sub-drainages across much of Manitoba, Saskatchewan and Alberta, especially in the southern part of these provinces, have median calcium concentrations that could easily support zebra mussel populations at high to very high levels and thus are considered to have very high habitat suitability based on calcium*

Also, at page 25, under Risk Assessment for quagga mussel. Step 1. Determining the Potential for Invasion. Habitat Suitability. We can read:

''High habitat suitability exists throughout much of British Columbia and the remaining parts of Alberta, Saskatchewan, and Manitoba''

I fully agree with these two above statements. Indeed, western provinces are highly vulnerable to an invasion by Dreissena. Numerous large lakes with the righ physic-chemistry for these invasive bivalves.

In my opinion, this risk assessment report does not provide a sufficient or complete coverage of the impact these dreissenids (especially *D. polymorpha*) would have on native unionid stocks if they were to be introduced to other provinces. The authors should elaborate on this in their report – ref. unionid richness between each province.

At page 27, 3rd parag. I agree, the dark falsemussel is an estuarine species and the risk assessment, as per found in this report, indicates that the overall risk posed is considered low. But, what about the Fraser River estuary?

At page 29, 3rd parag, we read:

‘*’For example, the Great Lakes and St. Lawrence represent a single drainage with median calciumconcentrations that are moderate for zebra mussel (Figure 12). However, even under moderate conditions the impacts of zebra and quagga mussels in this system have been immense”*.

The above statement is very true and thus a word of caution on the model or variables used to determine the risk assessment here. In the case of the Zebra and Quagga mussels, the <u>size of the water bodies</u> plays a role – not just calcium levels. These dreissenids dwell in large bodies of water; it is as if large lakes or large bodies of water allow for the larval life cycle to be more easily completed.

At page 30, 2nd parag, we read:
‘’Human-mediated transport of zebra and quagga mussel, especially by recreationnal boaters, is likely the most significant vector contributing to the redistribution of these species”.

I sure agree with this conclusion.

At page 32, recommendation #3, we read:
‘’A risk assessment for Mytilopsis leucopheata that includes coastal waters would be required to fully address the potential risk posed by this species to Canadian ecosystems.’’

With this note, this brings me back to the potential introduction of the dark falsemussel into large Canadian estuaries such as the Fraser River system. There are also other important estuaries along the west coast where this invasive species could easily be introduced. Moreover, there are, along Canada’s East coast, such as the St. Croix River in the Bay of Fundy ecosystem, estuaries where this dreissenid could be established. The above-mentioned estuary systems are more ‘temperate than other estuarine systems in Canada and are at risk, may be more than others.

At page 32, recommendation #6. We read:

‘’ Recreational boating appears a key vector for dreissenid mussels. Managers should consider education efforts to raise the awareness about potential inadvertent transport of these mussels (e.g., signage at boat launches) or consider proactive intervention (e.g., boat wash stations).”

I could not agree more. In fact, if we act on this item alone, we will make headway towards preventing further introductions (ref. MB, SK, AB, BC, and NB, NS).

As my main critique on the present format of the risk assessment report, I would like to raise a point here regarding the geographical coverage of this report; by and large, information and risk assessment for the province of New Brunswick and Nova Scotia are lacking. May be I missed a part of this document – i.e., there is may be a mention as to why these two provinces are not equally covered. Just thinking of the famous St. John River, in NB, the river with the richest unionid fauna of all Atlantic Canada. At page 89, figure 10, regarding calcium levels, both NB and NS are not covered in the report. The same applies to 'Habitat suitability' found at page 91, Figure 12. Also, regarding the probability of introduction for NB and NS, see page 94, Figure 15, there is nothing for these two provinces. Yet, there are numerous unionid-rich sections in the St. John River (and a number of unique unique unionid species, including one listed by COSEWIC, the Yellow Lampmussel) and the risk of introduction is certainly quite high in that region of Canada, especially considering that recreational boats could be trailered quite easily from the region of Québec City to the region of Fredericton. See Figures 16-22 as well; NB and NS are not involved in the assessment. So, unless I missed something while going through the text, I would recommend the authors complete the present version of the report by properly evaluating the risk assessment for all of Canada's provinces, including NB and NS. If I may at this point, I would like to propose that the authors consult the following paper, which could be of great assistance in the completing the present report (I am attaching a PDF to this mail, for the authors):

Ref. **Martel, A.L.**, McAlpine, D.F., Sabine, D., Madill, J.B., Pulsifer, M.D., and Elderkin, M.F. 2010. Freshwater Mussels (Bivalvia: Margaritiferidae, Unionidae) of the Atlantic Maritime Ecozone. *In*: **Assessment of Species Diversity in the Atlantic Maritime Ecozone**. *Editors*: D.F. McAlpine and I.M. Smith. **NRC Research Press, Ottawa, Canada**. Pages 551-598