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Proceedings of the National Peer Review on the Risk Assessment for ship-mediated introductions of aquatic nonindigenous species to Canada (Part 1 and 2)

March 25-27, 2013 (Part 1) and
June 19-21, 2013 (Part 2)
Burlington, Ontario

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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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TABLE OF CONTENTS

SUMMARY

A national risk assessment for introduction of aquatic nonindigenous species to Canada by ballast water was held March 25-27 and June 19-21, 2013 in Burlington, Ontario. This national peer review process, under the auspices of the Department of Fisheries and Ocean's Centre of Expertise on Aquatic Risk Assessment (CEARA), was held to provide science advice to Transport Canada in support of revisions to current *Ballast Water Control and Management Regulations.* The specific questions posed by Transport Canada were:

- What is the level of risk posed by ships transiting to, or from, Arctic ports for the introduction of aquatic invasive species (AIS) to Canadian waters;
- What is the level of risk posed by ships operating within the ballast water exchange exemption zones on the East and West Coasts;
- What level of risk is posed by domestic shipping activities within Canadian waters; and
- Whether current ballast water management regulations provide sufficient protection against ship-mediated AIS introductions.

This national risk assessment process was the final in a series of three processes to address the above questions. The first two peer review meetings were held March 2011 and March 2012 to address questions with respect to the Arctic and Great Lakes as well as Pacific and Atlantic Regions of Canada, respectively. The national risk assessment focused on pathways whereas the regional risk assessments were port-based. Participants at this meeting included DFO Science, Transport Canada experts from Marine Safety and Policy, academia and industry. Publications resulting from this process include a Science Advisory Report, a Research Document and these proceedings.

SOMMAIRE

A Une évaluation nationale du risque de l'introduction au Canada d'espèces aquatiques non indigènes par les eaux de ballast a eu lieu du 25 au 27 mars et du 19 au 21 juin 2013 à Burlington, en Ontario. Ce processus national d'examen par les pairs, réalisé sous l'égide du Centre d'expertise pour analyse des risques aquatiques (CEARA) de Pêches et Océans Canada, visait à formuler un avis scientifique à l'intention de Transports Canada à l'appui des modifications apportées au *Règlement sur le contrôle et la gestion de l'eau de ballast*. Voici les questions précises posées par Transports Canada :

- Quel est le niveau de risque posé par les navires qui transitent par les ports de l'Arctique concernant l'introduction d'espèces aquatiques envahissantes (EAE) dans les eaux canadiennes?
- Quel est le niveau de risque posé par les activités des navires opérant dans les zones exemptés de l’échange de l'eau de ballast le long des côtes est et ouest?
- Quel est le niveau de risque posé par les activités du transport maritime intérieur dans les eaux canadiennes?
- Le règlement actuel sur la gestion de l’eau de ballast offre-t-il une protection suffisante contre l'introduction d'EAE par les navires?

Ce processus national d'évaluation du risque est le dernier d'une série de trois processus visant à répondre aux questions ci-dessus. Les deux premières réunions d'examen par les pairs ont eu lieu en mars 2011 et en mars 2012 afin de répondre aux questions concernant l'Arctique et les Grands Lacs ainsi que les régions canadiennes du Pacifique et de l'Atlantique respectivement. L'évaluation nationale du risque était axée sur les voies d'introduction, tandis que les évaluations régionales du risque portaient principalement sur les ports. Parmi les participants à cette réunion, on retrouve des représentants du Secteur des sciences du MPO, des spécialistes de Transports Canada en matière de sécurité maritime et de politiques, ainsi que des représentants du milieu universitaire et de l'industrie. Les publications qui ont découlé de ce processus consistent en un avis scientifique, un document de recherche et le présent compte rendu.

INTRODUCTION

Transport Canada (Marine Safety) is tasked with managing a regulatory program to set ships' procedures to reduce the risk of ship-mediated transfer of invasive species. Current *Ballast Water Control and Management Regulations* are being revised and Transport Canada has submitted a formal request to Fisheries and Oceans Canada (DFO) for science advice on the level of risk posed by the commercial shipping vector to Canadian waters. The specific questions posed by Transport Canada to DFO Science were:

- What is the level of risk posed by ships transiting to, or from, Arctic ports for the introduction of aquatic invasive species (AIS) to Canadian waters;
- What is the level of risk posed by ships operating within the ballast water exchange (BWE) exemption zones on the East and West Coasts;
- What level of risk is posed by domestic shipping activities within Canadian waters;
- Whether current ballast water management regulations provide sufficient protection against ship-mediated AIS introductions.

These questions were addressed in two previous peer-review meetings held in Burlington, Ontario in March, 2011(Arctic and Great Lakes; DFO 2012 a, b) and March, 2012 (Atlantic and Pacific). Part 1 of the national peer review process was held on March 25-27, 2013 in Burlington, Ontario on the national risk assessment of ballast water introductions of Aquatic nonindigenous species (NIS), which was undertaken by the DFO's Centre of Expertise on Aquatic Risk Assessment (CEARA). This national risk assessment process used a pathway approach rather than a port-based approach followed in the two previous meetings (in 2011 and 2012). A second meeting (Part 2) was held on June 19-21, 2013 to allow the authors address revisions to the methodology agreed to during Part 1 held in March, 2013.

PART I - PROCEEDINGS OF PEER REVIEW MEETING MARCH 25-27, 2013

Introduction

The Co-chairs of the meeting welcomed participants to the science advisory meeting and reminded participants of the Canadian Science Advisory Secretariat (CSAS) peer review process. The meeting co-Chairs explained that the purpose of the meeting was to review a working paper and develop science advice regarding the national risk assessment for ballast water introductions of aquatic NIS to Canada. It was noted that the CSAS process requires high standards of technical evaluation. A review of 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 were provided. Participants were provided an opportunity to introduce themselves via a round table (Appendix 2). The Chair provided an overview of Fisheries and Oceans 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 and Arctic Region) and Jennifer Adams (DFO –Central and Arctic Region).

The client (Transport Canada) provided a brief presentation as to how the results of the risk assessment would be incorporated into management decisions and policy development. The

client reiterated that the request was for robust, defensible, data-driven, evidence-based assessment of the risk that ballast water plays in the introduction of aquatic NIS to Canadian waters. A review of the four questions asked by Transport Canada was presented to participants to guide the subsequent discussions. It was confirmed that this process will provide science advice to the client and will not provide guidance on risk tolerance.

General Overview of the National Shipping Risk Assessment

Presenter: Sarah Bailey (DFO-Central and Arctic Region)

A general review was provided on the work conducted in the regional risk assessments for each of the four regions: St. Lawrence/Great Lakes, Arctic, Atlantic and Pacific regions of Canada. A review of the questions in the request for science advice was also provided.

It was noted that the national risk assessment, in contrast to the regional risk assessments already completed, focuses solely on ballast water as a pathway for introduction of nonindigenous species. The risk assessment does not examine the role of hull fouling as an additional pathway for introduction as there are insufficient data and too much uncertainty to provide science advice on this pathway at this time. The title on the working paper has been updated to reflect this change.

Some concern was noted that individual pathway relevance to risk varies strongly between regions. It was discussed that in providing information on risk at a national level, regional-specific information and details may be lost. Similarly, concern was noted that variation in levels of regulation, enforcement or lack thereof within specific regions may be missed. In response, it was clarified that regional documents capture regional specific issues and that the national risk assessment provides relative risk among regions based on pathway of introduction.

A question was asked about identifying regional differences in regulations to be applied. It was discussed if regional differences were the most important information to be identified, or if regional differences should be nested within the risk matrix as seen in the document. It was acknowledged that there was concern from the steering committee that important regional differences may be lost if regions became merged and also if kept independent. It was discussed that risk from BWE does not represent a single, national level of risk, but rather is region-specific as is reflected in the research document. It was noted that regulations are federal (national), thus, it was agreed that a national approach was the most appropriate.

Methods

Estimating Probability(Arrival)

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

The presentation included a description of the methodology and information systems/databases used to generate an assessment of the likelihood of arrival by each of the regional pathways. Data limitations and use of proxies were discussed and arrival metrics were presented for both annual and per-event situations.

It was acknowledged that under current regulations, approximately half of all ships would meet International Maritime Organization (IMO) standards for phytoplankton discharge without treatment.

Clarification was requested, with respect to Canadian Aquatic Invasive Species Network (CAISN) data (biological density of organisms per tank), were all species considered, only NIS, or only risky species? The authors confirmed that the biological data considered in the risk assessment included all those species previously identified by CAISN as “risky”.

Clarification was requested on how NIS were being defined for different regions, specifically those where a proxy was used to replace biological data which were unavailable. The authors indicated that, for example, Atlantic transoceanic biological data were used as a proxy for Arctic transoceanic biological data due to the similarity of the two pathways. It was recommended that numbers of NIS be estimated specifically according to the recipient region, as different species will be NIS in the Arctic than in the Atlantic region. Two participants were identified at the meeting as regional specialists who were to assist with this revision. Accordingly, the level of uncertainty was increased for pathways which relied on proxy data. It was noted that wording in the Science Advisory Report (SAR) will reflect this uncertainty for pathways which relied on proxy data.

Clarification was requested on the difference between risky and NIS terminology used in the working paper. The authors clarified that NIS included all non-native species and was the terminology used in P(Arrival) calculations. Risky species implies high-impact consequences (as defined by the Nature Conservancy) and was the terminology used in the calculations of Magnitude of Consequences.

It was clarified that species currently identified as non-risky NIS could become risky NIS in the future under climate change projections etc.

It was suggested that some headings in Table 8 from the research document be clarified in the final document.

Concern was raised regarding the small sample size for some pathways, specifically concerning high variability in the number of organisms per ship in pathways that only had a few replicates, especially when used as a proxy.

Significant discussion was held regarding the grouping of pathways and post-hoc analysis and the overlap in statistical grouping letters in Figure 8. Similar concerns existed for the figures associated with P(Arrival). Questions were asked regarding the ability to assign different levels of risk when post-hoc analyses indicate overlap. It was suggested that pathways which cannot be unequivocally attributed to a single bin remain unsorted. The authors indicated that when a pathway couldn’t be resolved, it was placed in the highest category of risk to reflect the most conservative approach. Some participants objected to this approach, indicating that this wouldn’t truly answer the questions posed in the risk assessment and wouldn’t illustrate the true distribution of the data. Alternatively, participants suggested that one or two risk categories could be eliminated without compromising resolution and that confidence levels could be altered within the statistical programming used to generate this figure. It was noted by the authors that a statistical approach (as was used in the research document) provides the most unbiased method to identify groupings.

It was requested that the authors provide additional details in the text of the research document regarding the methods of categorical assignment that was used. Additionally, clarification was requested on the use of abundance of organisms as a multiplier for calculations of P(Arrival). As well, a brief clarification in the text was requested explaining why both “per event” and “annual” values were calculated for each pathway.

Questions were raised regarding the log transformation applied in Figure 8. It was clarified by the authors that the data were not log transformed for analysis, only for the visual effect in the figure provided. The authors agreed to clarify in the text and figure caption that log-transformed data are visually represented whereas in the text, non-transformed data were analyzed.

It was suggested by a participant that the confidence level in the statistical analysis program used could be changed to 0.1 or other to provide more resolution in the figure and subsequent analysis.

Significant discussion was held to determine whether certain pathways/regional pathways should be merged. In light of the very limited data available for certain smaller pathways, consensus was reached to retain Atlantic and Pacific exemption zones separately for regulatory and information purposes; whereas, Great Lakes and Atlantic Lakers were merged into a single “Lakers” pathway as well as the Great Lakes, Atlantic and Atlantic Coastal Domestic pathways becoming merged under a single “Eastern Coastal Domestic”, which resulted in 11 new regional pathways rather than 14 as originally proposed.

Some participants felt that untransformed data should be shown in Figure 9. The authors provided clarification that the bars in the figure relate to the 25^{th} and 75^{th} quartiles of data distribution and are not error bars.

Significant discussion was held regarding the grouping of data by ports prior to analysis as well as a number of aspects of the methodology used in the research document. The authors provided additional details regarding the methodology for conducting the groupings as currently presented. It was emphasized that the methods used in the national level risk assessment were the methods which had previously been peer reviewed in the regional processes. After extensive discussion from participants and authors, a new methodology was proposed and discussed. Consensus was achieved and the authors agreed to re-analyze the data within the new methodology for presentation at a subsequent meeting.

Revised methods for P(Arrival) as decided by participants:

1. Re-assemble database of ship arrivals in Canada. Each row in database will be single ship arrival with ballast water source, discharge volume, arrival port.
2. Reassess pathway labels for each of those ship arrivals, condense from 14 to 11 new pathways as decided by participants, each ship labelled with the pathway it belongs to. Combine Great Lakes/Atlantic Lakers into single “Lakers” pathway. Great Lakes/Atlantic/Atlantic Coastal Domestic into single “Eastern Coastal Domestic” pathway.
3. Apply biological sampling results (CAISN and DFO data), review suggestion of not using CAISN definitions of pathways. Re-evaluate shipping traffic and biological data to determine to which pathway data fits best. Consult CAISN researchers who are most familiar with biological data to ensure the pathways are applied correctly. Some biological data may be appropriate for multiple pathways.

4. Use ballast volume and biological data to create probability distributions of numbers of NIS per ballast discharge event (reporting zooplankton and phytoplankton numbers separately) within each pathway.
    a. A standard number of random draws (100) will be taken for each pathway to look at P(Arrival) "per event" (new Figures 10, 11).
    b. A separate analysis will be used to assess "annual" P(Arrival), where the number of ship arrivals within each pathway is taken into consideration. Monte Carlo simulation will be used to draw biological data for each arrival within each pathway. This will capture the higher risk, although less likely events so as not to underestimate overall risk as may be done using mean abundance values. The data will be summed annually, and the multiple simulations will be used to generate mean and error for statistical analysis (new Figures 8, 9).

Cautionary text within the document will be needed to describe the small biological sample size used to generate the distributions. Sensitivity analyses will be conducted to better understand the uncertainty associated with sample size for each distribution and the overall outcome.

1. Consider using bar graphs instead of box plots.
2. Complete pairwise comparisons, should be stronger with more data points going into analysis.
3. Complete groupings using statistical methods. Assess multiple methods as required (mean, max, min, 75^{th} percentile, confidence value).

Probability(Survival)

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

The use of environmental similarity (climate and salinity) between paired source and recipient ports as a method to calculate the likelihood of survival of NIS following a successful arrival to a new location was presented. It was emphasized that this method examines port similarity and not biological tolerances.

Clarification was requested regarding the use of surface layer parameters for environmental conditions when assessing port similarity. Some participants felt that a deeper profile may be more representative of characteristics of entire port. The authors clarified that "surface" is defined as the upper 10m of water column and that average depth of many ports assessed is <10 m; and this same data used for determining P(Survival) in the regional documents was deemed sufficient previously. In the regional documents, environmental matching was conducted using Euclidean distance; however, some participants in the regional processes felt uncomfortable with that approach which is why the current matrix method was used. More explanation was requested of the methodology for estimating survival in the text of research document.

It was confirmed that P(Survival) values will be modified, as required, as a result of the changes recommended for P(Arrival).

A participant suggested that under "Future Probability", reference should be made to increased/changing risk levels due to patterns of climate change (specifically as noted in the Pacific region), changes in shipping traffic/routes due to increased accessibility (e.g., increased development in Arctic region, increased access via the Panama Canal, direct routing to Europe

etc.). The authors have already addressed these comments in the “considerations” section of the research document. These will also be highlighted in the Science Advisory Report.

Probability(Introduction)

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

The calculation incorporating P(Arrival) and P(Survival) into P(Introduction) was presented, as was the method for retaining the highest level of uncertainty. It was clarified that where two values are reported for a single pathway, this indicates a difference in risk level between zooplankton and phytoplankton (reported as zooplankton/phytoplankton).

Some participants raised concern regarding the treatment of phytoplankton in the research document, specifically due to the low percentage (5%) of a population needed to establish and the use of the minimum probability method.

Concern was raised by a participant of the lower risk categorization result of the Pacific International pathway. The participant felt it should be higher. The authors agreed to double check the calculations to ensure all results were accurate in the final document.

Significant discussion was held regarding the use of terminology P(Introduction) versus P(Establishment). Some participants felt that the use of the term “introduction” may not be representative of what is occurring at this stage. The Co-chairs of the meeting resolved the discussion by indicating that the terminology will remain as initially indicated for consistency with the guidelines; however, more clarifications will be included in the text of the research document (e.g., section on the Biological Invasion process).

Discussion was also held regarding expected outcome of the risk assessment in relation to findings in pre-existing scientific literature. Participants were reminded by the Co-chairs of the meeting that, although the findings may differ from those in previously published peer-reviewed literature, the analysis and methodology will not be adjusted to achieve different results. In cases where results differ from expected outcomes, findings will be discussed with caveats or additional considerations in the text of the risk assessment or the Science Advisory Report.

Magnitude of Consequences

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

A brief presentation was provided describing how the number of high impact NIS in source ecoregions was used to estimate consequences, the method of grouping the results according to pathways, as well as categorical ranking of each pathway using the percentile bin method as was used in the arrivals section.

A participant requested confirmation regarding definition of “events”. It was confirmed by the authors that the results of the risk assessment are based on individual transits by an individual vessel.

It was requested that the terminology of “9-29,215” be defined as (number of AIS) x (number of events).

The group discussed Appendix 1 of the working paper and the inclusion of a number of species as NIS which are not appropriate for this purpose (i.e., *Branta canadensis*). Concerns were noted that an artificial inflation of risk may be present if species are misidentified as is common with larval forms of a number of species. Additional concern was expressed about removing species from the list simply because they do not currently represent a risk. It was decided that participants at the meeting with considerable expertise in a number of the species from the list, in consultation with other regional specialists, would review and edit the list to remove inappropriate species and update nomenclature. The new list will be included in the final version of the risk assessment. Consensus was reached against adding any species to the list as too many uncertainties exist regarding global distribution and lack of a consistent process for listing species as NIS. The Appendix will only be updated to remove species which are misidentified or in direct contrast to expert regional knowledge (i.e., tunicates no risk for the Great Lakes region).

A question was asked regarding the process for selecting species to be considered for the Great Lakes region. The authors confirmed that they consulted multiple DFO experts from the Great Lakes region and applied the same ranking methodology as was used by Molnar et al. (2008).

Participants preferred the use of aquatic invasive species (AIS) terminology in the heading of Appendix 1 as compared to NIS. The authors agreed to make the change.

Consensus was reached to include farmed/cultured species on the Appendix 1 listing of AIS as species are most often farmed in a given location, are often shown to be invasive elsewhere and are not native. A question was asked by a participant regarding the ability to identify a species as being native to one region but not to another. Consensus was reached by the committee who will be revising the Appendix of AIS to also compose a brief explanation for inclusion in the text of the risk assessment document. It was noted that the text should have a description of which species from the Appendix were included in the analysis as well as any concerns from science.

Final relative invasion risk

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

The methods and results of the final invasion risk were presented. Assessment of invasion risk incorporates P(Introduction) and the magnitude of consequences along with the highest level of uncertainty.

Discussion followed regarding the anchoring of the final risk matrix.

A participant suggested that the authors provide a summation in the text of the risk for pathways across regions for the purpose of regulatory advice and possibly to synthesize risks in a final table of overall invasion risk. It was suggested that regional differences be retained but that a combined risk may also be useful. The authors declined this suggestion, stating that the risk assessment has many uses beyond the application for IMO D2 regulations and cautioned against over-synthesizing/summarizing data.

Clarification of Table 8 was requested and suggestions were made to include appropriate units as well as a definition of “source”.

Clarification of Table 13 was requested and it was suggested that units for zooplankton abundance be incorporated.

A suggestion was made to include a discussion on some of the characteristics of receiving waters and the impacts on NIS being discharged there.

General group discussion

Presenter: Sarah Bailey (DFO-Central and Arctic Region)

The authors of the working paper attempted to complete the P(Arrival) re-analysis within the timeframe of the meeting, but found that the task was too large to be completed in such a short timeframe. The authors presented a subset of new results using the new methodology recommended by participants. Reanalysis of three Pacific International pathways were conducted and when compared with Figure 10 in the risk assessment document, the results did appear to be different.

Consensus was reached among participants that the proposed new methodology is correct and addresses concerns regarding data limitations and procedural approach. The authors were instructed to continue with reanalysis and reconvene the group in future to review final revised results. The authors estimated that a minimum of 4 weeks would be required to complete the reanalysis and incorporate the results into the risk assessment document. The group reviewed the earlier decision to collapse overlapping regional pathways. It was confirmed that the re-analysis will be conducted using 11 pathways based on the type of advice needed.

The group discussed the treatment of biological data. Consensus was reached among participants that Monte Carlo simulations would be the most appropriate method despite having certain pathways with low numbers of replicates. It was agreed that sensitivity analysis would be conducted to examine the influence of low sample size.

The group discussed the possible exclusion of pathways with low numbers of replicates (i.e., low number of transits in Pacific International Exempt) from pairwise comparisons. It was suggested that perhaps certain pathways could be excluded from statistical analysis and incorporated by eye for comparison. The group agreed that the authors could select statistical/optical grouping methods as appropriate for the final dataset, once assembled.

It was noted that it would be useful to include a statement in the text to reflect that phytoplankton abundance is not as critical as zooplankton abundance when determining invasion risk since significantly fewer phytoplankton are required for propagation. This is due to their clonal life history and ability to reproduce rapidly following a small inoculation. It was discussed that habitat matching and suitability may provide a more accurate measure of relative risk for phytoplankton as opposed to abundance.

It was suggested that clarification be provided to accurately describe the data deficiencies and the imbalance of research and reporting consistencies among regions and across taxa, which directly influence the accuracy of modelling used in the research document.

It was noted that microbes such as bacteria and viruses were not included in this study and may present a risk for introductions of NIS to Canada via ballast water.

A participant questioned whether the information/data currently available could be used to address questions regarding increased development and shipping in the Arctic and associated risk to be included in the research document. The Co-chairs of the meeting declined to pursue this additional analysis and stated that the comments addressing this as an area of potential future significance and research is sufficient for this research document. It was acknowledged by participants that this could be a separate project and that results produced by this risk assessment could be used to justify the need for future research.

Discussion was held regarding salinity concentrations in the marine environment and that compliance with BWE cannot be determined by salinity concentrations of ballast water alone, in cases where the source ballast water's salinity exceeds 30 ppt. It was stated that 30 ppt ballast salinity is not the only measure of compliance but that vessels also report the location of ballast exchange procedures for each ballast tank. An issue with moving species around from mid-ocean to coastal environments was discussed and consensus was reached that this should be addressed in the Science Advisory Report.

The group discussed changes in reporting of salinity units; the authors agreed to check for standard practices and revise units as required.

A question was asked regarding an alternate regulatory scenario for the Great Lakes/St. Lawrence region: if international pathways are regulated under D-2 standards, but not domestic pathways, will the risks of NIS/AIS decrease? It was asked if the authors could address this scenario in the document. The authors determined that each alternate scenario would require an additional one or two weeks of analysis. It was suggested that this could be a separate project to be addressed following the completion of the existing working paper; results could be expedited if a previously peer-reviewed methodology was available. It was determined that the additional analysis requested was beyond the scope of the current risk assessment at this time.

It was determined that a follow up meeting would be held in approximately 8-12 weeks to review the results of the new peer-reviewed methodology. CSAS would be responsible for coordinating the follow up discussion.

PART II - PROCEEDINGS OF PEER REVIEW MEETING JUNE 19-21, 2013

Introduction

The Co-chairs of the meeting welcomed participants to the science advisory meeting and reminded participants of the Canadian Science Advisory Secretariat (CSAS) peer review process. The meeting Co-chairs explained that the purpose of the meeting was to review significant changes to methodology and reanalysis of data as determined in Part 1 of this CSAS process. Changes to the working paper and the associated development of science advice regarding the national risk assessment for ballast water introductions of aquatic NIS to Canada is the expected outcome of this process. It was noted that the CSAS process requires high standards of technical evaluation. A review of 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 were provided. Participants were provided an opportunity to introduce themselves via a round table (Appendix 2). The Chair provided an overview of Fisheries and Oceans Canada's (DFO) Centre of Expertise for Aquatic Risk Assessment (CEARA) and the organization's responsibilities for

risk assessment. The rapporteurs for the meeting were Bethany Schroeder (DFO –Central and Arctic Region), Jennifer Adams (DFO –Central and Arctic Region) and Sherry Walker (DFO-CSAS).

A general overview and recap from the previous peer-review meeting was provided by the Co-chairs. It was confirmed that this meeting will conclude this CSAS peer-review process, that the Science Advisory Report will be drafted by participants, and that the working paper will be finalized by the authors representing the best-available science.

Methods

P(Arrival)

Presenter: Oscar Casas-Monroy, Andrew Drake (DFO-Central and Arctic Region)

The revised methodology was reviewed and results from the Monte Carlo simulations and fitting distributions were presented. Zooplankton exhibited strong negative binomial distributions whereas phytoplankton exhibited a combination of negative binomial and geometric distributions.

A question was asked regarding the data used and the method of calculating abundance. The authors confirmed that the data for each discharge event was calculated per ship, not per tank, and standardized per cubic meter. It was suggested that this detail be clarified in the text.

Clarification was requested regarding the number of events and discharge volumes. It was noted that between the Atlantic and Pacific coasts, the number of events was fairly similar; however, the volume of discharge is quite different. It was confirmed that this is real data and likely reflects a higher proportion of cruise and container ships on the Pacific coast and that these vessels often do not discharge ballast.

A question was asked why, when multiple years of data were available from regional processes, the authors selected to use the year with the highest number of discharge events and volume discharge. The authors confirmed that most years were quite similar; however, the highest year was chosen to reflect the most conservative approach. Low levels of inter-annual variation were observed in the Great Lakes/ St. Lawrence data whereas increasing frequencies and volumes were observed in the Arctic region but selected to use the most recent year data to determine if this would give a more accurate representation of vessel traffic. It was suggested that the authors include a qualifier regarding the choice of using single year rather than multi-year data and its relative impact on the outcome of the risk assessment. It was suggested that it be clearly stated in the text that this is based on a subset of the data available and to clarify what the numbers actually represent. Participants felt that it should be mentioned that choice of year may influence the results of the risk assessment. The authors responded that inter-annual variability is expected to have little influence on the risk assessment, due to the large magnitude differences in shipping activity among pathways.

A question was asked regarding the Monte Carlo simulations and whether the simulations were run for annual discharge or per event discharges. It was suggested that clarification in the text could be provided to confirm that the distributions which arise from the Monte Carlo simulations are the product of all the possible outcomes being combined.

It was suggested that the text be clarified to reflect the use of box plots and the interpretation of each component of those boxplots. Consensus was reached to plot the median in the box plots rather than the mean, despite using the mean to interpret results. The authors confirmed that using the median in the box plots provides more relevant information and is more representative of the events occurring. Using the mean in the box plots may be skewed by long right tails in the data and may be misleading.

Participants felt that it would be helpful to include a table with a summary of the number of events with discharge volume for each pathway. The authors agreed to add this information to Table 4.

Clarification was requested regarding the comparison of mean and median values in each of the categories and it was suggested that a table which expresses tabular data, including both mean and median, in numerical and graphical form would be useful for increasing clarity of results. The authors felt this was an effective solution and will include such a table/appendix in the final document.

A question was asked whether other methods of ranking/classification were considered. The authors confirmed that multiple methods were considered; however the mean was chosen due to the importance of a large right tail as discussed at the previous meeting.

A question was asked regarding the method of binning data into 5 categories. The authors indicated that the results were based on the output of the Monte Carlo simulations and the entire distribution of values. Thousands of events per pathway were grouped into 20% intervals to produce a 5 category risk matrix.

Clarification was requested in the text regarding the IMO future scenario and the use of raw data. It was suggested that it be made clearer in the text as to how percentiles were obtained.

A question was asked regarding Figures 8 and 9 and the difference between the two points in the highest risk category and whether there might be an overestimation of risk due to the choice of binning? The authors also considered using the lowest and highest value in each percentile but ended up losing all resolution in this method. Extensive discussion was held on this topic. It was acknowledged that the Lakers pathway does drive this pattern. The observations were standardized to an annual volume per event scale to account for differences between size/number of events. The authors confirmed that all pathways were now deemed statistically unique as a result of the increased power of the analysis.

Additional questions were asked about data used in the Monte Carlo simulations. The authors confirmed that raw data were used to generate the distributions.

A question was asked regarding how the differences between pathways were determined to be statistically different. The authors provided additional details and indicated that ANOVA with pairwise comparisons were done to determine statistical significance. It was determined that this will be clarified in the text.

Some participants requested that Table 5 be updated to include additional information from regional specialists and confirmed that AIS are assigned relative to the regions. It was acknowledged that the data set used for the Arctic region was a proxy from the Atlantic region. Consensus was reached to provide additional clarification in the text regarding the use of proxy data and specifically address the limitations of data available for Arctic phytoplankton data.

Significant discussion was held regarding the level of uncertainty in P(Arrival). A number of participants felt that since data used were only from a single year, the potential for patchy distribution of phytoplankton in ballast tanks, as well as the Monte Carlo simulations, the level of uncertainty should be increased. Discussion on the level of uncertainty was clarified in the text of the research document on page 13. Other participants felt that the existing level of uncertainty was adequate and reiterated that this risk assessment provides a level of relative risk for the data available. The information is not necessarily relevant to other reports or assessments. This is based on the best available science at the moment and that more is likely known about the data and entire scenario than changing the level of uncertainty to “low” would indicate. It was suggested that the level of uncertainty be kept as is. Consensus was not reached at this point in the meeting and it was agreed that participants would revisit this issue at a later point.

P(Survival)

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

Environmental similarity (climate and salinity) between paired source and recipient ports and survivability of NIS was presented to calculate the likelihood of survival of NIS following a successful arrival to a new location. It was emphasized that this method emphasizes port similarity and not biological tolerances.

A participant was concerned about the use of correspondence analysis and the interpretation in the text based on the results. This method was selected as frequency data were used as these were the only data available. It was confirmed that this method does not take temperature and salinity into consideration and that there may be more appropriate methods to convey this information. The limitations and applicability of this method were discussed at length and alternate methods of analysis were suggested to describe distance with statistical relevance. Many participants felt that Figure 12 was not necessary for the final document, and questioned the usefulness of its inclusion. Consensus was reached to remove the correspondence analysis from the risk assessment, and insert text describing the methodology used.

A question was asked regarding Tables 9 and 10 and differences in sample sizes compared to the earlier version of the working paper. The authors confirmed that additional data points were available for the re-analysis because summary data were used previously. In addition, the authors clarified that they were required to use a broader definition for exempt vessels on the Pacific coast, because no ships met the literal definition as written in regulations.

A participant asked the authors to confirm results in the final document for Arctic salinity rankings as they changed fairly significantly since the last version of the document. One of the authors suggested that there may have been a change in the methods for the BWE correction factor between versions, but was uncertain and had to consult with data files and co-authors. The authors agreed to review the Arctic survival methods/results prior to submission of the final document.

A participant questioned the definitions of climate zones and port groupings into thermal classifications. The authors confirmed that the classifications are based on latitudes and may not necessarily reflect the participant’s expectations of the port’s characteristics. Consensus was achieved to include the definition of the zones in the research document. The authors confirmed that they will review all classifications and groupings.

A question was asked about seasonal salinities and whether annual fluctuation would be more relevant to survival than annual mean salinity. It was clarified that the term “summer” refers to the warmest three consecutive months whereas the term “winter” is the coldest three consecutive months, but that annual values were used for the analysis.

Clarification was requested in the text and Figures 9 and 10 regarding the consolidation of the Great Lakes/St. Lawrence coastal domestic and Atlantic coastal domestic pathways into a single Eastern coastal domestic pathway. The authors agreed to provide additional details regarding the methodology used to group pathways into three categories with respect to the correspondence analysis.

A question was asked regarding the bimodal distribution of categories in Figures 9 and 10 and what future implications this may have. It was suggested this may reflect sub pathways, or that there may be different classes of source ports for this region, and whether future work would be needed to examine highly divergent source ports and whether different environmental similarity measures may be required. It was also acknowledged that until the lowest source port groupings are resolved, this bimodal distribution may not persist; however, other participants felt that recognition of highly divergent source ports was very important.

A question was asked regarding environmental similarity calculations and riverine freshwater ports, with specific reference to the Fraser-Surrey Docks. Clarification was requested whether Fraser port was considered a freshwater or saline port. The authors provided the participant with data/results for that specific location, and reiterated that survival rankings for the pathway of concern were already ranked highest.

Clarification was requested regarding the uncertainty values for P(Survival). It will be ranked as moderate uncertainty as seasonal salinity may not capture daily fluctuations. Annual salinity values were used and this will be clarified in the text.

Clarification was requested to include a matrix which illustrates how climate and salinity were combined to determine environmental similarity and survival potential. The authors agreed to consider this approach and will clarify in the text.

P(Introduction)

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

Introduction potential is dependent upon the sequential occurrence of arrival and survival. The most conservative approach was used and combines the lowest value for arrival or survival and is coupled with the highest degree of uncertainty. P(Introduction) was calculated separately for phytoplankton and zooplankton.

It was confirmed that eastern coastal domestic ships do not travel further south than Cape Cod and are never on transoceanic transits. Due to their limited biogeographic coverage, they are exempt from the *Ballast Water Control and Management Regulations*. It is of some concern that there may be movement along the coast of certain AIS, such as Ascidians; however, this risk is incorporated into the results when addressing magnitude of consequences. This also reflects the benefit of assessing ships by pathways to examine shipping practices within a classification.

Some participants expressed concern regarding deficiencies in phytoplankton data when compared with zooplankton data. It was acknowledged that the phytoplankton data series was not complete and did exhibit a low number of samples; however, there is high level of confidence in the data that were available. Lakers presented one of the more problematic pathways to be addressed in this risk assessment. Consensus was reached that with increased sample size, the risk could be better characterized. It was also acknowledged that Lakers have a limited selection of phytoplankton which are able to be transported within the Great Lakes (fewer than 10 potential AIS phytoplankton in Great Lakes/St. Lawrence region); however, coastal and US pathways exhibit a much greater range of possible AIS. It was also acknowledged that with smaller organisms, it is more difficult to distinguish native species from AIS.

A participant expressed concern in the confidence of the phytoplankton data set. It was indicated that fewer long-term data sets exist for phytoplankton, and that unless sampling occurs on a weekly timeframe, large gaps are present in the data as blooms can happen so quickly. It was acknowledged that taxonomic expertise in phytoplankton is limited and that estimating true risk associated with phytoplankton AIS is difficult in the absence of long-term data sets (required 5-10 years); however, the authors have conducted the assessment using the data currently available at this time. Consensus was reached to provide a caveat in the research document that the quality of the data varies, even within the groups, and accordingly, the uncertainty varies and should be indicated.

A question was asked regarding the Arctic coastal domestic pathway and lack of phytoplankton data. A participant felt that the use of proxy data was not appropriate for this specific case, and that the ranking for arrival potential should be “not available” rather than “lowest”. The proxy data were acceptable for zooplankton, contingent on the reanalysis of NIS status recommended earlier. Consensus was reached to indicate “not assessed” rather than lowest risk for arrival potential; however, this did not change the survival category or have any implications on downstream components of the risk assessment. The modification improves clarity in data limitation/knowledge gaps.

Magnitude of Consequences

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region)

A brief presentation was provided to discuss the methods for determining high impact NIS to each source-recipient port pair, the method of grouping the pathways in each regions as well as categorical ranking of each pathway using the percentile bin method as was used in the arrivals section. Uncertainty was determined to be moderate.

Clarification was requested whether ports in the Great Lakes/St. Lawrence region include US ports. Lakers include all ports and transits operating between Sept-Isles and Thunder Bay. The authors confirmed that this will be clarified in the text. A participant expressed concern that although a limited number of AIS will be moved in this pathway, those species that are present are being moved frequently. The concern is that there is high potential for dispersal across a large region very quickly.

A participant felt that a table which was provided in the presentation to participants was excellent and requested that it be included in the final version of the research document. The authors indicated that the figure wasn’t included in the research document as Figure 13 already

presents this data. To address this request, it was agreed to include means and percentiles in figures for clarity.

A question was asked regarding Figure 13. It was clarified that the boxplots are presented with the median indicated whereas rankings were calculated using the means and were likely influenced by long right tails of the data in the figure indicating a log-normal distribution. It was suggested that clarification be provided in the text to indicate that the mean was used to generate rankings.

A question was asked regarding the list of known AIS and how applied to each region or each pathway. Consensus was reached to clarify this list in the text and indicate how the numbers vary depending on the application of the list and that this is not the same list as was used by Molnar et al., (2008). It will be clarified to reflect that the database by Molnar (2008) included 90 AIS which were introduced by the ballast water vector into at least one of the world's 232 coastal ecoregions. Of these 90 AIS, some are AIS in a given Canadian ecoregion. It was suggested that it be included in the methods section that the list is a cumulative grouping of all potential AIS in ballast water, not all species are relevant to each region or pathway.

Clarification was requested about the list of AIS. The number of species on the list should be 101, not 167. A number of species which could not be established in recipient ports were removed from the list (i.e. tunicates). It was also confirmed that a number of species were retained on the list as survivability may be uncertain and the authors wanted to retain the most conservative approach for listing species. The authors did not accept revision to list based on P(Survival) as it was incorporated into a different stage of the risk assessment. Marine phytoplankton was retained in Great Lakes/St. Lawrence region as the authors were concerned that there was no certainty that they would not establish. A number of reviewers felt that marine phytoplankton would never survive in fresh water and could be removed from list. A number of known examples of marine species able to survive in freshwater (e.g. species of marine phytoplankton, blue crab); however, participants felt they did not meet the criteria for "establishment" due to restricted microenvironments. It was determined to keep the listing as previously reviewed. Distributions of species were modified by regional expert advice from the Molnar et al. (2008) list. This will be clarified in the figure caption and in the text.

Discussion was held that the elemental salt composition of a marine environment is not equivalent to localized saline environments in the Great Lakes/St. Lawrence region. The marine species in the Great Lakes region are more likely to be coastal marine species which are tolerant of brackish water conditions as opposed to truly open water marine species. It was suggested that this information be added as a consideration in the text of the research document when discussing localized adaptive conditions/patchy microenvironments.

It was suggested that the caption for the list of AIS species in the appendix indicate "potentially introduced" rather than "potentially arrived". Consensus was reached to change the caption.

It was suggested that a map may be helpful to visualize the various pathways.

It was clarified that Appendix 1 is a summative list of AIS in the ballast water vector and that not every species would be applicable to every transit or event. The number of species applied to each transit would be determined based on port source salinity. Clarification in the table caption should reflect that survival is not expected in each region, rather this listing indicates species which are able to survive the transit and arrival in a recipient port. The group discussed the

differences between introduction and survival. It will be clarified in the text that arrival does not imply survival in the recipient port.

A question was asked regarding obligate marine or freshwater species and whether they should be kept on the Appendix 1 listing for incompatible regions (i.e. retaining obligate marine species on listing for Great Lakes/St. Lawrence region). Consensus was reached that due to uncertainty regarding many marine specie with uncertain/unknown biology, it would be unwise to remove from this list as we cannot exclude risk with absolute certainty. The authors were instructed to update the “Magnitude of Consequences” figure with new data.

Final relative invasion risk

Presenter: Oscar Casas-Monroy (DFO-Central and Arctic Region) and Andrew Drake (DFO-Central and Arctic Region).

P(Introduction) and magnitude of consequences were combined to provide an estimate of final invasion risk. A mixed rounding matrix was used and the highest level of uncertainty was retained. Sensitivity analysis was also presented to participants.

A question was asked if it was likely that biological density was over- or underestimated in ballast tanks. Monte Carlo simulations were conducted based on variable tank distributions (+/-25%). Certain pathways do change (3/22 pathways for zooplankton); however, it was clarified that distributions are largely insensitive to categorical shifts of ships and that the support for the groupings as presented is robust. Where pathways do change between groupings, it was by a single category only, and usually in a decreasing trend (the Great Lakes/St. Lawrence region is the exception).

Clarification was requested if sensitivity analysis was conducted on all events at once? It was confirmed that sensitivity analysis was conducted on individual ships. Other pathways for the event remained unchanged and that only the pathway being examined was increased by 25%. The original method for binning was retained.

A question was asked regarding the decision to use 25% as the variance and how this related to true changes in abundance. The mean value as well as the K value (dispersion) which provides an increase in magnitude of mean by 25% as well as a longer right tail.

It was suggested by participants that a written description of the sensitivity analysis would be beneficial in the text and would provide clarification of the results. The authors originally removed this description from the research document in order to improve the readability of the document for non-technical readers. Consensus was reached to include the summary of sensitivity analysis in the final version of the research document.

Clarification was requested about whether the sensitivity analysis validates the methods used in the risk assessment. The results indicate that given these uncertainties and methods, only two pathways are sensitive to this approach and may warrant additional research in future.

General group discussion and finalization

Presenter: Sarah Bailey (DFO-Central and Arctic Region)

A question was asked regarding the sensitivity analysis and future risk scenario. It was asked whether the 25% increase in tank abundance could be used to estimate the risk associated with increased shipping traffic in the Arctic. It was determined that it could possibly be used as a very coarse proxy. The tank distributions may not change; however, the source waters will vary according to climate change scenarios and future assumptions would be tricky. There is no guarantee that the right tail of the distribution would increase in length with an increase in shipping traffic. More appropriate would be to do sensitivity analysis with a 25% increase in number of events. It was determined that this would be beyond the scope of this document; however, may be useful for other projects.

The group discussed whether increased biological abundance would be observed under changing climate conditions. It was acknowledged that this would be difficult to characterize; however, current composition of water being taken up appears to demonstrate increased numbers of organisms which provides increased risk to Arctic recipient ports.

A discussion was held regarding Table 12 and the per event arrivals. It was determined that the Arctic coastal domestic grouping had the highest arrivals; however, it was determined that the risk is identified as “lower” as most of these vessels are arriving from freshwater ports from Quebec. This likely underestimates the risk as these vessels probably did BWE in marine waters (Belle Isle Strait). Consensus was reached that this fact should be highlighted in the research document.

Discussion was held on increasing development in the Arctic region and the recognition that predictions today may not be relevant under future conditions. It was acknowledged that ongoing and future reassessment under changing climate and trade activities would be necessary.

A participant indicated that the location of BWE in marine environment would potentially introduce more NIS into the Arctic than ballast uptake from a source freshwater port. It was agreed that this would be an excellent follow up project to this work; however, was not within the scope of this research document. It was suggested that the Arctic may require separate management or regulation activities to effectively manage risk.

A participant suggested that a separate statement regarding the limitations of the Arctic region should be included in the research document; specifically acknowledging use of proxies, assumptions, data limitations but also recommendations for how to proceed in future.

Significant discussion was held regarding the final risk matrix and the coloration of the risk boxes. The authors indicated that anchoring the table with the Great Lakes/St. Lawrence International Transoceanic pathway was beneficial for management goals (i.e. this pathway constitutes the reference value to which the other risk values are compared). Alternate colouration patterns were suggested and discussed among participants. Consensus was reached to retain the Great Lakes/St. Lawrence International Transoceanic vessels as the anchor. It was also agreed that the entire first column and entire bottom row will be designated as green (lowest risk). Consensus was reached to enhance the text description for the reasoning for the change in matrix coloration. It was also determined that while Great Lakes/St. Lawrence International Transoceanic vessels are the anchor, it should be noted that there is a

strong management protocol for these vessels in the Great Lakes/St. Lawrence region which is not necessarily true in other regions. The world standard is based on the Great Lakes protocol; therefore, it is felt that it is intuitively obvious to root the matrix on the Great Lakes. The relative risk assessment is based on the anchor point that no reports of new species attributable to ballast water have been reported in the Great Lakes since 2006. Therefore, it must be clarified that this is a relative risk assessment relative to Great Lakes transoceanic vessels.

A participant strongly objected to this revision of the matrix and risk categorization. Specifically, the participant objected to the new classification of the Eastern Coastal domestic ranking. It was acknowledged that the sample size (zooplankton, n=37; phytoplankton, n=7) is low given the known volume of traffic in that pathway; however, the Co-Chairs of the meeting reiterated that the advice needs to be based on evidence presented. The matrix provides a green classification indicating lowest risk for this pathway whereas the participant felt that this classification new matrix does not accurately reflect the risk.

Discussion pertaining to each of Transport Canada's original questions and request for advice follows.

1. The level of risk posed by ships transiting to, or from, Arctic ports for the introduction of aquatic invasive species (AIS) to Canadian waters

A participant felt that it was important to note that per event arrivals will increase with increased shipping traffic as is expected in future with increased climate change and increased access. It was noted that a clearly defined statement linking the current results of the risk assessment with the known likelihood of increased events, increased per event arrivals, and a significant increase in risk for the Arctic region needs to be explicitly stated in the research document.

2. The level of risk posed by ships operating within the ballast water exchange exemption zones on the East and West Coasts

A question was asked regarding the use and efficiency of exemption zones. The authors were asked if they would advise Transport Canada to remove exemption zones. The Co-Chairs of the meeting indicated that it wasn't appropriate for DFO-Science to advise on appropriate policy, but rather to provide scientifically defensible information for managers and policy makers to decide the best course of action to manage risk. DFO-Science is able to describe what the effects of removal would be but whether the exemption zones should be removed is Transport Canada's decision. The group discussed the impressions of participants regarding the efficacy of exemption zones. It was identified that the data used in the risk assessment indicates that no ships operate exclusively within the Pacific exemption zone and; therefore, the exemptions should not be applied to any vessels and are effectively moot. A participant suggested that this information be clearly stated in the recommendations of the research document as the information would be relevant to the context of this risk assessment. It was acknowledged that the future of exemption zones may be changing and that it would be helpful to indicate whether they were effective in order to inform other countries who may be considering applying them. Additional discussion was held to discuss changing size of exemption zones or to restrict an area. No resolution was identified as this was beyond the scope of the peer review process.

It was acknowledged that it is not possible for the authors to provide science advice on exemption zones as it appears that the regulations were applied inconsistently for the Pacific

and Atlantic coasts. However, the authors will state that efficiency would be increased if regulations were applied consistently across the country for ease of data interpretation in the future. It was felt that a statement regarding inaccurate reporting/inconsistent inspections led to difficulties in accurately characterizing risk for those vessels.

A question was asked regarding the impact of increased traffic in the Arctic and the risk if exemption zones are applied properly versus the risk if exemption zones were not applied. If exemption zones are removed, will this provide a decreased risk to recipient ports?

It was discussed that within the exemption zones, a vast number of marine eco-regions exist and encompass different biota. It was acknowledged that one of the uncertainties of this risk assessment was that the list of AIS was based on what species were available rather than the species that may actually be in the ports. A high number of NIS from different regions could become AIS in recipient ports. A participant felt that this risk may not be fully explained in the research document and requested additional clarification be made. The authors indicated that the risk of NIS becoming AIS had already been captured in the document in the uncertainty section.

3. The level of risk posed by domestic shipping activities

A brief discussion was held regarding the language used to reflect the certainty of conclusions from the risk assessment. Concern was expressed that the use of “may be” or “might” could dilute the impact of the conclusions of the risk assessment and a participant offered to provide suggestions for clearer text for consideration. A concern was raised regarding the new grouping of “Eastern Coastal domestic” vessels. A participant felt that by modifying the grouping to include port pairs of marine-freshwater rather than exclusively marine-marine, the risk for this grouping has been artificially diluted and is now underestimated. It was suggested that a caveat be added to the text to indicate the lower risk category reflects this combination. A question was asked regarding how many of the port pairs were originally marine-marine (only 5 of 667 events) and it was recognized that the majority of the events were marine-freshwater pairings. Clarification was then provided that the final level of risk is still intermediate and that if changed for P(Arrival) or P(Survival), would still retain the current result of intermediate.

The group discussed the definition of a “relative” risk assessment. Some participants felt that it would be helpful to provide some interpreting information to address the limitations of relative risk assessments. The authors indicated that this was clearly addressed in the text of the research document and felt comfortable that it had been explained.

Clarification was requested on the source of the phytoplankton data used for the Lakers pathway. It was confirmed to be from the a laboratory in the Central and Arctic Region (DFO’s Great Lakes Laboratory for Fisheries and Aquatic Sciences [GLLFAS]). It was suggested that this be identified as a need for future data collection as it is not possible to accurately characterize Laker phytoplankton risk based only on 6 samples (whereas 87 samples were available for zooplankton). Consensus was reached to include this in the recommendations of the research document as well as in the SAR.

A participant commented that 36 new species of phytoplankton have been identified in the Atlantic region and their introduction has been attributed to ballast water.

4. **If current ballast water management regulations provide sufficient protection against ship-mediated AIS introductions.**

It was suggested that the research document emphasize that BWE does not appear to be effective for coastal regions.

General discussion

It was suggested that emphasis be made to indicate the “relativeness” of this risk assessment and reiterate the risks are presented relative to other pathways and should not be compared between documents/existing reports.

It was suggested that the SAR effectively capture the limitations of the data used to inform this risk assessment and that it clearly outlines future directions and knowledge gaps pertaining to data.

In regards to future regulations having a lesser effect on propagule arrival for phytoplankton, clarification should be included to indicate that the risk will not be decreased with treatment plans for phytoplankton as the current IMO standards for phytoplankton densities are higher than any observed current densities in ballast tanks. It can be reiterated that the risk is intermediate in the future and not lower.

Discussion was held among participants and consensus was reached that current regulations are not equally effective for all transoceanic pathways. Specifically, it was noted that International Coastal vessels from both the Pacific and Atlantic coasts should be addressed.

A question was asked regarding compliance with BWE. Transport Canada indicates that every tank on foreign vessels arriving to the Great Lakes from beyond the Exclusive Economic Zone is checked for compliance and that program analysis has determined that the success of BWE is based on it. If there are concerns about the regulatory regime of compliance and enforcement, this must be stated as an assumption in the research document. Recommendations to Transport Canada can include a description that 100% compliance is critical to the success of the BWE program. The authors indicated that issues pertaining to compliance and effectiveness have already been addressed in the methodology.

Two participants also had issues with the new matrix and the risk indicated for Arctic Coastal domestic pathway. Concern was expressed that information is being lost as the risk indicted in the results section is lower than the anchor. Discussion was held regarding “lower” versus “lowest” terminology. This was resolved by agreeing to add clarification that this is a relative risk assessment.

It was requested that a vote be taken to determine if consensus on new matrix coloration. It was noted that five participants objected to the new matrix; however, it will still be included in the research document as the majority-agreed upon colouration pattern. Objections from participants included that the anchor for “no new introductions” is only based on seven years of data and they did not feel that there was sufficient time to convey certainty. It is also of concern that no data was included on phytoplankton. Those participants who objected to the matrix felt that there is no need to compare pathways relative to the Great Lakes and believe that the highest risk categories will remain constant and that there will be minor changes to the low risk categories. These participants felt that they did not want to convey the message of lowering the

risk on pathways, preferred higher risk levels. To address these concerns, the authors will clearly describe the assumptions in the text of the research document.

Significant discussion was held to emphasize that this is a relative risk assessment and that it is not possible to assess absolute risk using these data or methods. This was an exercise in ranking and it is noted and being clarified in the research document that all pathways indicate a level of risk but that absolute risk cannot be determined. The anchoring of the risk matrix on the Great Lakes is a result of it being a well-managed pathway. It was reiterated that “low” risk does not imply “no” risk, rather that it is “low” relative to other pathways.

Additional discussion was held regarding limitations of phytoplankton data and some participants reiterated that additional clarification in the text should be included to describe implications of phytoplankton and lack of information. It is known that phytoplankton is fairly resilient to treatment options; however, it is again reiterated that the IMO standard is high enough that half of all vessels will meet the standard without any treatment option.

A participant felt it may be beneficial to include a description of the inspection process and provide an explanation for different levels of effectiveness on the coast as compared to along the St. Lawrence Seaway.

Other Considerations

It was discussed that hull fouling as a vector was not included in this risk assessment; however, it does present a significant risk for introductions of NIS and must be addressed in future. It has been noted that hull fouling exceeds ballast water as a risk pathway for NIS introductions in some locations. It was acknowledged that it is difficult to quantify P(Introduction) as species may be brought into recipient ports on vessels but may not be deposited.

The group discussed whether Transport Canada should delay action on ballast water to request and await science advice on hull fouling; however, it was determined that it was not worth reducing action on ballast water to gain data on hull fouling. The importance of hull fouling should be noted and further research to address the risk of hull fouling would be valuable for future use. Hull fouling was included in all of the regional risk assessments and can be referenced therein.

It was noted that the economic downturn occurred in 2008; therefore, shipping traffic in 2009 and onwards is likely reduced during this recession and the estimates should be considered conservative.

Uncertainties identified by participants included a lack of multiyear data, small or inconsistent sample size, limited phytoplankton data, seasonal variability in environmental conditions and limited ability/inability to predict P(Establishment) of NIS. Uncertainty also exists regarding the ability to predict consequences.

Recommendations

Participants felt that it would be helpful to provide broad-scale, general considerations about ballast water in Canada. A general statement should be included that the pathway poses significant risk to Canadian waters.

It was suggested that the terminology for AIS be more general, it is known that any species which is introduced may become invasive; therefore more generic wording may be appropriate.

It was suggested that the pathways which had been identified in the sensitivity analysis as potentially moving up or down a risk level due to +/-25% changes in tank abundance be indicated clearly.

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APPENDIX 1: TERMS OF REFERENCE

Risk Assessment for ship-mediated introductions of aquatic nonindigenous species to Canada

National Peer Review – National Capital Region

Part 1: March 25-27, 2013[*]
Part 2: June 19-21, 2013*
Burlington, Ontario

Co-Chairs: Darlene Smith and Patrice Simon*

Context

Transport Canada (Marine Safety) is tasked with managing a regulatory program to set ships' procedures to reduce the risk of ship-mediated transfer of invasive species. Current ballast water regulations are being revised and Transport Canada has submitted a formal request to Fisheries and Oceans Canada (DFO) for science advice on the level of risk posed by the commercial shipping vector to Canadian waters. DFO's Centre of Expertise on Aquatic Risk Assessment has developed risk evaluation guidelines that have been used to create risk assessments to address the questions:

1. What is the level of risk posed by ships transiting to, or from, Arctic ports for the introduction of aquatic invasive species (AIS) to Canadian waters;
2. What is the level of risk posed by ships operating within the ballast water exchange exemption zones on the East and West Coasts;
3. What level of risk is posed by domestic shipping activities within Canadian waters;
4. Whether current ballast water management regulations provide sufficient protection against ship-mediated AIS introductions.

Three meetings are being held to develop the risk assessment advice. The first meeting held in 2011 addressed items 1 and 3 for the Great Lakes and Arctic regions. The second meeting held in 2012 addressed items 2 and 3 for the Atlantic and Pacific regions. This third meeting planned for 2013 will address item 4 with a national context.

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?

[*] Updated June 3, 2013

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) experts from Ecosystems and Oceans Science
- Transport Canada experts from Marine Safety and Policy
- Academia
- Industry

APPENDIX 2: LIST OF PARTICIPANTS

Name	Affiliation
Jennifer Adams	DFO – Central and Arctic Region
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Jeff Cordell	University of Washington
Becky Cudmore	DFO – Central and Arctic Region
Claudio DiBacco	DFO - Maritimes Region
Andrew Drake	DFO – Central and Arctic Region
Sophie Foster	DFO – National Capital Region
Caroline Gravel	Shipping Federation of Canada
Colin Henein	Transport Canada
Kim Howland	DFO – Central and Arctic Region
Marten Koops	DFO – Central and Arctic Region
Robert Lewis-Manning	Canadian Ship Owners Association
Robert (Dallas) Linley (Part 1 only)	DFO – Central and Arctic Region
Andrea Locke	DFO - Gulf Region
Hugh MacIsaac	University of Windsor
Nick Mandrak	DFO – Central and Arctic Region
Jennifer Martin	DFO - Maritimes Region
Cynthia Mckenzie	DFO – Newfoundland and Labrador Region
Chris McKindsey	DFO - Quebec Region
Judy Pederson	Massachusetts Institute of Technology
Bethany Schroeder	DFO – Central and Arctic Region
Nathalie Simard	DFO- Quebec Region
Patrice Simon	DFO – National Capital Region
Darlene Smith	DFO – National Capital Region
Terri Sutherland	DFO - Pacific Region
Tom Therriault	DFO - Pacific Region
Sherry Walker (Part 2 only)	DFO – National Capital Region
Chris Wiley	Transport Canada

APPENDIX 3: COMMENTS FROM EXTERNAL REVIEWER ON TRANSPORT CANADA DISCUSSION PAPER

Submitted comments from Dr. Jeffrey Cordell, University of Washington

Topic 3.2. Ballast Water Performance Standard and Timeline:

The compliance standard of 10 viable organisms per m^3 has been and in my opinion remains problematical from a verification point of view. While researchers have been working on this problem, I am not aware that they have solved the issue of how one (a) reliably detects the 10 organisms in a cubic meter of water and (b) how one determines what constitutes "viable" and then determines whether or not the organisms remaining after treatment meet this criterion.

Topic 3.7.2. Transport Canada's planned approach to compliance and enforcement:

Even if the problems with verification mentioned above are solved, the language in this section does not adequately provide for reliable verification. In my opinion the provision that "other than for scientific purposes, Transport Canada anticipates performing full scale biological sampling of vessel discharges only in cases where there are specific grounds to suspect violation of the Regulations" is lacking. I think that until approved treatment systems are proven to meet discharge standards in real-world regular use while undergoing the rigors of ocean voyages, some kind of random ongoing sampling of treated water across various ship types, routes, and treatment methods should be done. This is the only way that real effectiveness of treatment can be understood. This would also account for variations in the effectiveness of treatment based on ship tank configuration, how and when the system is used, characteristics of the treated water, etc. Relying on "scientific purposes" is no guarantee this longer-term verification will be done, given the vagaries of funding scientific work, and I think that this should be considered for inclusion as a required part of compliance.