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Proceedings of the National Peer Review of the Risk Assessment for Ship-Mediated Introductions of Aquatic Nonindigenous Species to the Atlantic and Pacific Regions of Canada

**March 6-7, 2012
Burlington, ON**

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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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SUMMARY

Draft research documents were developed to evaluate the biological risk associated with ship-mediated introductions of aquatic nonindigenous species to the Atlantic and Pacific regions of Canada. A meeting was held to peer review these draft documents according to the Canadian Science Advisory Secretariat (CSAS) peer review process. The meeting was held March 6-7, 2012, in Burlington, Ontario. There were a total of 26 participants including the Centre of Expertise for Aquatic Risk Assessment (CEARA) Directorate, the ship-mediated risk assessment team leader and team members, and other individuals (from within and outside DFO Science) with relevant expertise in ship-mediated aquatic nonindigenous species, marine invasive species or the shipping industry in these regions. This document summarizes the discussions that took place during the workshop.

The peer review process resulted in changes to the risk assessment documents by adding a 'Recommendations' section which clearly relates results back to management objectives, and by removing information on secondary spread from top ports to an Appendix. It was also recommended that the 'relative' nature of the risk assessments needed to be emphasized and frequently acknowledged throughout the documents. The methods for assigning uncertainty were clarified, and some changes were made to uncertainty values. Additional changes were raised for consideration in the development of the national level risk assessment which is scheduled to be completed in 2013.

SOMMAIRE

Les ébauches des documents de recherche ont été préparées pour évaluer le risque biologique lié à l'introduction d'espèces aquatiques non indigènes par les navires dans les régions canadiennes de l'Atlantique et du Pacifique. Une réunion a eu lieu les 6 et 7 mars 2012 à Burlington, en Ontario, afin de les soumettre au processus d'examen par les pairs du Secrétariat canadien de consultation scientifique (SCCS). Parmi les 26 participants, on comptait des membres de la direction du Centre d'expertise pour l'analyse des risques aquatiques (CEARA), le chef et les membres de l'équipe d'évaluation du risque d'introduction par les navires ainsi que d'autres intervenants (internes ou externes au Secteur des sciences du MPO) possédant une expertise pertinente en matière d'introduction d'espèces aquatiques non indigènes par les navires, d'espèces marines envahissantes ou du secteur de la marine marchande de ces régions. Le présent compte rendu résume les discussions qui ont eu lieu durant cet atelier.

Le processus d'examen par les pairs a entraîné des changements aux documents relatifs à l'évaluation du risque, notamment l'ajout d'une section « Recommandations », qui rapproche clairement les résultats des objectifs de gestion, et le regroupement dans une annexe des données sur la propagation secondaire provenant des ports principaux. Il a aussi été recommandé d'insister sur la nature « relative » des évaluations du risque, et de la mentionner fréquemment dans les documents. Les méthodes utilisées pour définir le degré d'incertitude ont été clarifiées et certains changements ont été apportés aux valeurs de l'incertitude. D'autres changements à prendre en compte dans la préparation de l'évaluation du risque à l'échelle nationale, qui doit être terminée en 2013, ont été suggérés.

INTRODUCTION

BACKGROUND

Many of the science issues facing Fisheries and Oceans Canada (DFO) are associated with significant knowledge gaps and uncertainties. This, however, does not relieve the department of the need to make decisions on these issues. Under these conditions, decisions must balance the risks and uncertainties while ensuring the sustainability of Canada's aquatic ecosystems. Risk assessment is the process of estimating the risk presented by a hazard, in either qualitative or quantitative terms, to aquatic ecosystems, fisheries resources, fish habitat, and aquaculture that DFO is mandated to manage and protect. DFO currently faces hazards from nonindigenous species (NIS), climate change, and fish habitat alteration, with the potential for any or all of these hazards to impact species at risk (SAR), biodiversity, aquaculture, or fisheries resources.

The *National Code on Introductions and Transfers of Aquatic Organisms* (DFO, 2003a) identifies risk assessment as central to the process of assessing proposals to move aquatic organisms. The *Canadian Action Plan to Address the Threat of Aquatic Invasive Species* (DFO, 2003b) identifies risk assessment as one of the implementation strategies to deal with the threat of NIS. By forming the Centre of Expertise for Aquatic Risk Assessment (CEARA), DFO has developed expertise in risk assessment. To this end, one of the mandates and objectives of CEARA is to coordinate and give advice on biological risk assessments conducted on priority aquatic nonindigenous species (NIS) of concern and different pathways for introduction of NIS. One pathway known to introduce NIS is the ship-mediated pathway.

Transport Canada is tasked with managing a regulatory program that sets shipping procedures in order to reduce the risk of ship-mediated transfer of NIS. While in the process of updating these regulations, Transport Canada submitted a request for science advice of DFO that posed the following questions:

1. What level of risk do ships transiting to, or from, Arctic ports pose for introduction of NIS to Canadian waters?
2. What level of risk is 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?
4. Do the current ballast water management regulations (and future International Maritime Organization discharge standards) provide sufficient protection against ship-mediated NIS introductions to all Canadian waters?

These questions will be answered through a risk assessment (RA) for each of the main shipping regions in Canada (East and West coasts, Arctic and Great Lakes). An overall RA that combines information from the regions into a national context will be the final step to answering the questions posed.

Risk assessments have been drafted for the ship-mediated introduction of aquatic NIS to the Atlantic and Pacific regions of Canada (Adams et al. 2012 and Linley et al. 2012). A peer review meeting of 26 experts on ship-mediated introductions of aquatic NIS, aquatic invasive species, Canadian shipping or risk assessment was held on March 6-7 2012, in Burlington, Ontario. The purpose of the peer review meeting is to discuss and provide comments on the draft risk assessments in a face-to-face forum.

Overviews of presentations and discussions at the peer review meeting are presented here.

CSAS GUIDELINES, CODE OF CONDUCT AND INTRODUCTION TO CEARA

The Chairperson, Dr. Nicholas Mandrak, Research Scientist, DFO, Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS), Burlington, ON, presented:

- Guiding principles for this CSAS process
- Terms of Reference (Appendix A).

The objective of the meeting is to peer review the draft RA's for ship-mediated introduction of NIS to the Atlantic and Pacific regions of Canada (Adams et al. 2012 and Linley et al. 2012).

Expected deliverables are:

- A Proceedings document, recording discussions and opinions of those present. It is also a record of the presentations and information presented.
- The risk assessment Research Documents, which are finalized versions of the drafts presented at the meeting.
- Science Advisory Reports, which will summarize the risk assessment documents.

The resulting documents will be publicly available, transparent and can be used by any client. The formal science advice produced by this meeting will be used in future management activities (for example, for use in policy or other sectors, departments or agencies).

Transport Canada was the client for this science advice (they posed the questions). Transport Canada is in the process of reviewing their regulations and will use this advice when drafting new regulations.

It was indicated that there will be a similar meeting in approximately one year, to evaluate the national risk assessment document.

Participants introduced themselves (see Appendix B for participants) and there was a brief overview of the Agenda (Appendix C).

OVERVIEW OF BIOLOGICAL INVASION THEORY AND SHIPPING AS A PATHWAY IN THE INVASION PROCESS

A presentation was made by Dr. Sarah Bailey, Research Scientist, DFO, GLLFAS, Burlington, ON.

- Terms such as biological invasion, invasive species, nonindigenous species, pathways (geographic mode, e.g., shipping), vectors (e.g., ballast water, hull fouling) were defined.
- Stages of invasion were described including: arrival, survival, establishment, and spread.
- It was stated that prevention is the key strategy to reduce invasion risk through Risk Assessment and Vector Management, since early detection is difficult, eradication is virtually impossible and impacts are unpredictable.
- Map of distribution of NIS in Canada was presented, with limitations acknowledged (e.g., biases in research effort and taxonomic expertise).
- Ships were presented as most important pathway of aquatic NIS introductions in Great Lakes, while the presenter questioned if aquaculture and small vessels may be more important to Canadian coasts.
- It was stated, however, that shipping is a more important pathway of NIS to US coasts compared to aquaculture or commercial fishing, so the same trend may occur in coastal Canada.

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- It was stated that ballast water has been a very important vector of aquatic NIS to Canada, while sediments are less important and hull fouling is negligible for freshwater ports.

Questions/comments

- It was commented that species counts for the Atlantic coast of Canada have increased from 83 to 112 marine species (not including phytoplankton), and 8 - 10 freshwater species.
- It was commented that ballast water is the most important vector for AIS on the east coast of Canada and is responsible for 49% of Atlantic AIS, while accidental/deliberate release and hull fouling is responsible for 24% and 9% respectively.
- A participant commented that higher numbers for ballast water are coming in from the Atlantic and Pacific, which may reflect the recent increase in research effort for the coasts.
- Another participant commented that there are over 97 NIS in the west coast (not including phytoplankton). It was suggested that if more recent data is available that the data should be sent to the AIS database so that the figure presented can be updated.

REVIEW OF BALLAST WATER/HULL FOULING REGULATIONS IN CANADA

The review was presented by Dr. Bailey.

- Ballast water management regulations have been in force since 2006 (ballast water management was voluntary since 2000). Current regulations require ballast water exchange (of full or partly filled tanks which will be discharged) and tank flushing (tanks with only residuals).
- Regulations apply to vessels ≥ 50 m long and with ≥ 8 m³ ballast capacity, arriving from outside of the Canadian exclusive economic zone, with a few exceptions.
- It was stated that exchange/flushing works by purging organisms and sediment from tanks and reducing fitness by salinity shock
- Efficacy of exchange/flushing is influenced/limited by a variety of factors, and thought to be lower for brackish/marine ports than for freshwater ports.
- Regulations also include reporting requirements, however, it was stated that enforcement activities are high only for the Great Lakes
- It was acknowledged that new regulations were enacted in 2011. Changes were mainly house-keeping issues relating to the Canada Shipping Act 2001 being proclaimed.
- There are currently no regulations in Canada that address bio-fouling of ship hulls.

OBJECTIVES AND METHODOLOGY OF THE RISK ASSESSMENT

The objectives were presented by Dr. Bailey.

- The main objective of this Risk Assessment is to provide Transport Canada with science-based advice to reduce invasion risk of aquatic NIS.
- The results of the regional data analyses will form the basis of the National Risk Assessment to follow.
- The regional assessments will focus on data collection and analysis while the national assessment will link directly back to questions posed by Transport Canada.

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- A biological risk assessment includes the relative likelihood of introduction and potential ecological impacts of aquatic NIS to Canadian Atlantic and Pacific ports, as well as uncertainty.
 - The CEARA methodology was adjusted from a species-specific assessment to an invasion pathway assessment that considers multiple species within a pathway.
 - It was stated that the approach used does not assess survival and establishment independently.
 - It was stated that results of the risk assessments can inform research, monitoring, early detection, rapid response and prevention activities, as well as inform decision-making.

Questions/comments

- An issue was raised regarding ranking sensitivity since many observed invasions occur in locations not in the shipping traffic results. It was noted that the shipping risk assessment will not reflect patterns of invasions by other pathways.
- It was suggested that clarification should be added to the document regarding which regulations influence which vector/vessel/pathway. It was also suggested that the location of the alternate exchange zones for ballast water be included to demonstrate which zone is in each region.

OVERVIEW OF OUTCOMES/RECOMMENDATIONS FROM 2011 PEER REVIEW MEETING FOR ARCTIC AND GREAT LAKES REGIONS

A review of outcomes and recommendations from the 2011 Peer Review Meeting, which had significant impact on methods, were presented by Dr. Bailey.

- It was stated that the methodology used for the Arctic and Great Lakes regions was also used for the Atlantic and Pacific regions to ensure consistency in methodology, facilitating the future National Risk Assessment.
- It was decided that $p(\text{establishment})$ should be removed from the risk assessment due to the large number of taxa to consider with regards to environmental tolerance, life history characteristics, dispersal ability etc.
- It was decided that $p(\text{spread})$ should be removed since aquatic NIS can be spread by multiple pathways and vectors. Data on spread by shipping is included in the Research Documents, but not incorporated into the assessment of risk.
- It was decided to use a linear approach for ranking, consistent with scientific literature on invasion theory.
- The assessment of risk is limited to the top three ports for each ship category due to time and money constraints.
- A correction factor was considered to adjust $p(\text{arrival})$ for ballast water, using estimates of propagule pressure from biological sampling surveys; however, such data was not available across regions/pathways. The inclusion of biological data will be reconsidered for inclusion in the national risk assessment.
- A correction factor was considered to adjust $p(\text{arrival})$ for hull fouling according to hull size and ship type; however, it was determined that vessel size and type were poor correlates of fouling and data was not available to account for strong correlates (e.g. ship speed, mooring time, time since last dry-docking).
- It was decided that salinity and temperature be the only environmental variables used to assess similarity between source and recipient ports in the assessment of $p(\text{survival})$.

These two variables are indicated as most important in the scientific literature, while adding additional variables would increase 'noise' and be difficult to incorporate on a global scale.

- It was decided that p(survival) for hull fouling would be 'lowest risk' for ships arriving to freshwater ports after sailing in euhaline saltwater, and highest risk otherwise, since data for other risk factors (e.g. time since last dry-dock) was not available.

Questions/comments

- Annual fluctuation in regional shipping activity was discussed. One participant questioned if one year of data (Pacific) was sufficient for analyses considering the recent economic downturn. It was stated that the 2008 data used should reflect normal activity before Pacific shipping declined in 2009.
- A participant suggested that a seasonal correction factor might be important for assessment of risk if ports open year-round are at greater risk than ports that have most traffic in the summer.
- A participant asked how to move from relative rankings to absolute risk, and what approach would be used for the national document? It was stated that data to produce quantitative risk assessments is lacking and that the method of ranking for the national risk assessment has not been determined, but the goal is to have a broad comparative view across the regions. The current regional methods are the result of long discussion.

OVERVIEW OF METHODS USED TO EVALUATE SHIP-MEDIATED RISK

A general overview of methods used for the draft risk assessments was presented by Ms. Jennifer Adams, Research Technician, DFO, GLLFAS, Burlington, ON.

- Slightly different methodologies were used to assess hull-mediated and ballast-mediated invasions.
- **Step 1A:** Estimate probability of arrival to a port using the number of arrivals of ships (for hull-mediated species) or the volume of ballast water discharged (for species carried in ballast water).
- **Step 1B:** Estimate probability of survival at a port. For ballast water, environmental similarity between source-recipient port-pairs was calculated using temperature and salinity. Hull-mediated species survival was estimated based on salinity of the recipient port and geographic pathway of the vessel.
- **Step 1C:** Combine results of 1A and 1B using the minimum probability approach.
- **Step 2:** Estimate the magnitude of consequences, using data from the Nature Conservancy's Marine Invasive Database (Molnar *et al.* 2008). The number of AIS potentially transported on hulls or in ballast water from each source port was tallied. The authors assume that each connected port may be a donor of all high impact AIS in that ecoregion.
- **Step 3:** Combine the probability of introduction and magnitude of consequences using the mixed rounding symmetrical approach.
- Probability of NIS spread from top ports to other Canadian ports was estimated based on the number of vessel departures (hull fouling) or ballast loading events. This data was included for information only and was not factored into the risk assessment.
- A level of uncertainty was assigned to each invasion component and the final risk rating, based on the quality of data.

Questions/comments/clarification

- Alternate methods to combine probabilities were thoroughly discussed (e.g., averaging, multiply probabilities). The CEARA method used was upheld as the most conservative and suitable method for vector-based assessment.
- It was suggested that the document clarify that combining probabilities is done on a port-by-port basis rather than ship category.
- A question was asked about the rationale for the symmetrical risk matrix. It was explained that multiple risk matrices were evaluated at the 2011 Peer Review Meeting and that the balanced model was considered most appropriate by the experts at the first meeting.
- It was commented that the draft documents appeared to focus on port-specific results, whereas broader pathway-based information would be more beneficial to inform management. Point was noted and held for later discussion.

RISK ASSESSMENT FOR ATLANTIC REGION

HISTORY AND SPECIAL CONSIDERATIONS OF NONINDIGENOUS SPECIES IN THE ATLANTIC REGION

An overview of the history and special considerations associated with NIS in the East Coast of Canada was presented by Dr. Cynthia McKenzie, Research Scientist, Northwest Atlantic Fisheries Centre, St. John's, NL.

- 112 marine NIS are reported from Atlantic Canada
- Hull fouling is an issue of concern, being an important vector for tunicate invasions
- Shipping, and especially ballast water, is the likely vector >50% of marine NIS to Atlantic Canada
- Domestic vessel traffic, including non-ballast vessels (fishing, aquaculture, recreational, tourism), are an additional concern.

Questions/comments

- A participant asked why is there a discrepancy between the relative importance of hull fouling vs. ballast water in Canadian and US data (hull fouling more important in the US). It was explained that phytoplankton is included in Canadian, but not US data, thus leading to a larger number of ballast-mediated species for Canada.

DETERMINATION OF PROBABILITY OF ARRIVAL IN THE ATLANTIC REGION

Ms. Adams presented results for the probability of arrival in the Atlantic region. Results were presented separately for hull fouling and for ballast water.

- Concern was raised about the ranking system used for p(arrival) across all vessel types, ports and pathways. A participant expressed that there should be more discriminating power at the lower risk levels. After lengthy discussion of possible alternate approaches (e.g. natural breaks), it was decided that the linear approach was most appropriate and consistent. The approach may be re-evaluated for the national assessment.
- A concern was raised that ferry traffic could be inflating specific ports that may otherwise be low risk due to local traffic only.
- The terms "arrival" and "spread" were discussed and differentiated. Additional clarification in the text is recommended to define arrival and spread since it can be different based on

the scale of perspective. It was further suggested that the text include differences from species-specific risk assessments and state that vessels less than 24m are not included in this assessment.

- There was discussion about the correction factor used to account for reduced risk as a result of ballast water exchange.
- There was further discussion about ballast water exchange concerning rates of non-compliance, since the year of assessment for the Atlantic region was also the year that regulations became mandatory (mid-2006). It was decided that compliance rates should be included, but they should be presented pre- and post- regulations, or other appropriate cautionary wording should be included.
- Concern was raised regarding the moderate level of uncertainty for hull fouling arrivals given the number of factors that could not be incorporated into the analyses. Uncertainty is estimated by the quality of data in the document, but could also be the appropriateness of the measure used as a proxy. After much discussion, it was decided to revisit this issue later in the meeting.

DETERMINATION OF PROBABILITY OF SURVIVAL (HULL FOULING AND BALLAST WATER) IN THE ATLANTIC REGION

Ms. Farrah Chan, PhD. Candidate, University of Windsor, Windsor, ON, presented results for probability of survival of NIS in the Atlantic region. Results were presented separately for hull fouling and for ballast water.

- A concern was raised about the use of annual average surface salinity to estimate environmental similarity between ports, when salinity can differ according to depth or season. After discussion, it was decided that data and resource limitations prohibited any changes to the regional assessments, but that seasonal influences could be considered in the national assessment.
- A participant requested clarification on the definition of "environmental distance" and recommended additional information be provided in the text. It was also suggested that more variables be included to estimate environmental distance. It was clarified that increasing the number of variables can also increase error, as important variables for one species may not be important for others. Scientific literature recommends salinity and temperature as robust, truly predictive variables.
- It was verified that annual discharge data for Sept-Iles, QC is correct, and it was stated that Sept-Iles receives a large amount of ballast water.
- A participant asked why environmental similarity between Sept-Iles and Port Cartier, QC was 'high' rather than 'highest'. It was decided that the authors would double check the raw data to confirm the results.
- Discussion returned to the issue of uncertainty, and its assignment based on data quality or based on appropriateness of the measure.

DETERMINATION OF PROBABILITY OF INTRODUCTION IN THE ATLANTIC REGION

Ms. Adams presented results for the probability of introduction of NIS in the Atlantic region. Results were presented separately for hull fouling and for ballast water.

- Concern was raised about the relative ranking system used. Lowest relative volume may be misinterpreted as low volume and provide a misconception that the volume is negligible

when in fact it is a large amount of water being exchanged. It was stated that this methodology follows a linear logistic model. It was accepted that the methodology should remain as it is, so that methodology is consistent across regions for later comparisons in the national risk assessment.

- There was extensive discussion regarding ranking number of arrivals for merchant and non-merchant vessels separately, as ferry traffic to ports such as Black's Harbor is overwhelming results for merchant vessels.

DETERMINATION OF MAGNITUDE OF CONSEQUENCES IN THE ATLANTIC REGION

Ms. Adams presented results for the magnitude of consequences in the Atlantic region. Results were presented separately for hull fouling and for ballast water.

- The use of equal binning of NIS was raised as a concern. Clarification in text must be made to ensure that data and results are viewed as relative.
- A participant expressed concern that the number of NIS at each port is more applicable to the risk of introduction rather than magnitude of consequences due to repeat inoculations. It was clarified that multiple populations could affect consequence through differences in tolerance (genetics).
- Uncertainty for magnitude of consequence was discussed. It was stated that moderate uncertainty was too low considering the methods used to translate AIS to rank did not account for repeat introductions.
- Participants identified errors in the draft Appendix L, with 4 species listed as NIS that are native to some Atlantic Canadian ports. The authors asked relevant experts in the group to review the draft appendix and report back so that any errors and subsequent analyses can be corrected.

DETERMINATION OF OVERALL LEVEL OF RISK IN THE ATLANTIC REGION

Ms. Adams presented results for the overall level of risk to the Atlantic region. Results were presented separately for hull fouling and for ballast water.

- After extensive discussion about the use of five equal bins for ranking, the authors were asked to experiment with log transformation of data before binning, and examine effects on ranking results. The authors presented the results of these exploratory methodology changes.
- Some participants expressed a preference for the log-transformed method since it reduces the effect of outliers and the results more accurately reflect a priori expectations of risk at ports.
- Some participants expressed a strong objection against changing the methods because the results did not line up with expectations. Logged results indicate 80-90% of ships are a concern, which does not reflect reality, and is not useful for management decisions.
- A number of considerations were raised in the discussion that followed. In the end it was agreed to retain the existing methods. It was reiterated that the text should clearly state that results are "relative" risks. It was suggested that a 'Recommendations' section be added to the document to ensure the results are not mis-interpreted (i.e. that 'lower' risk does not mean 'no' risk).

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- A participant suggested that the document should be revised to focus more on the categories of ships (pathways) rather than on specific ports, since that is the way that management is applied.

RISK ASSESSMENT FOR PACIFIC REGION

HISTORY AND SPECIAL CONSIDERATIONS OF NONINDIGENOUS SPECIES IN THE PACIFIC REGION

An overview of the history and special considerations associated with NIS in the west coast of Canada was presented by Dr. Terri Sutherland, Research Scientist, Centre for Aquaculture and Environmental Research, West Vancouver, BC.

- Areas of high productivity, high biodiversity and cultural significance, which may be sensitive to effects of ship-mediated NIS, were briefly described.
- The Vancouver and Fraser Port groupings were identified as areas of concern due to high shipping activity.
- The Fraser Surrey Docks were identified as an area of concern for freshwater NIS.
- Information was presented about the Pacific distribution of four tunicate species and the green crab, as well as the prevalence of nonindigenous zooplankton in ballast water arriving to Pacific ports.
- Coastal shipping traffic was identified as an issue of concern due to short voyage length, potential for high environmental similarity between ports, and ballast water exchange being conducted 50, rather than 200, nautical miles from shore.

Questions/comments

- A participant stated that the low sampling effort north of California may lead to an underestimate of the true number of NIS in the Pacific region.

DETERMINATION OF PROBABILITY OF ARRIVAL IN THE PACIFIC REGION

Dr. Bailey presented results for the probability of arrival in the Pacific Region. Results were presented separately for hull fouling and for ballast water.

- It was stated that there were issues surrounding data availability since the Pacific region utilized a different vessel traffic system (VTOSS) than the rest of Canada, prior to 2011. Since VTOSS does not provide information on cargo or ballast activities, the authors were unable to fill in ballast water data gaps, as was done for the other regions.
- Although three data sources were used for the Pacific region, there was minimal overlap in the data, making it difficult to cross reference and verify the data. As a result, there is less confidence in the quality of data used to estimate p(arrival) for the Pacific region.
- It was noted that resources were not available to include non-merchant vessels in the analysis, but that the high level of non-merchant vessel traffic is a concern in the Pacific region.
- It was also noted that enforcement records were poor concerning 'international-exempt' vessels. There appears to be a potential risk posed by this vessel category due to extremely liberal application of exemptions by Inspectors, although documented evidence is very limited. If exemptions are applied based on last port-of-call, rather than the longer history of the vessel, then untreated residual ballast water could pose a risk; however, 2008 U.S. state requirements for management of residual ballast have decreased this risk.

Questions/comments

- A participant asked whether the ratio of missing ballast declaration forms was similar among regions. It appears to the authors that the Pacific region has more gaps in ballast water data (189 forms missing, not including exempt vessels).
- It was confirmed that the Pacific region appears to have more missing data than other regions. Explanations for missing data include:
 1. Ship did not discharge ballast water
 2. Ship was given an exemption
 3. Ship reported discharge, but data was not entered into the database.
- It was clarified that a correction factor was only applied to ships that declared a ballast water exchange (BWE), and the correction factor was only applied to the exchanged volume. It was further explained that ships that operate exclusively in the exemption zone are not required to perform BWE.
- Discharge volume was speculated to be under-reported in the West Coast. The authors agreed to verify if any additional data has been added to the ballast water database prior to finalizing the West Coast assessment. Even with additional data, it was suggested that the top three ports for international vessel arrivals would likely not change.
- A discrepancy was identified in data reported in draft Tables 3 and Table 9. The authors agreed to verify the data in Tables 3, 4, and 9.

DETERMINATION OF PROBABILITY OF SURVIVAL IN THE PACIFIC REGION

Ms. Chan presented results for the probability of survival in the Pacific region. Results were presented separately for hull fouling and for ballast water.

- A concern was raised regarding potential for freshwater to freshwater transfer of organisms (especially unionids) by hull fouling from Columbia River to Fraser River. After much discussion, it was decided to add the specific example to the text of the document, and to again clarify that 'lower' risk does not mean 'no risk'. The authors also agreed to examine the dataset to determine if any vessels do transit directly between the two freshwater rivers.
- It was clarified that vessel categories were assigned according to the vessel's operational profile over the entire year of data. It was recommended to make this clarification in the final document as well.
- The author noted the following errors in the draft document that will be corrected in the final version:
 1. Figure 12: colour of circles are opposite of what they should be
 2. Tables 25, 28: tables mislabelled international coastal and exempt
 3. Fraser-Surrey environmental similarity map missing from document
 4. Remove 'high risk' terminology from environmental similarity maps as decided earlier in the meeting.

DETERMINATION OF PROBABILITY OF INTRODUCTION IN THE PACIFIC REGION

Dr. Bailey presented results for the probability of introduction in the Pacific region. Results were presented separately for hull fouling and for ballast water.

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- A participant expressed concern that Vancouver and Island ports occupy the same water body (Strait of Georgia) and thus NIS will quickly spread among all ports in the area. It was clarified that some ports in close proximity to each other were grouped for analysis, but these ports were kept separate due to different traffic patterns.

DETERMINATION OF MAGNITUDE OF CONSEQUENCES IN THE PACIFIC REGION

Dr. Bailey presented results for the magnitude of consequences in the Pacific region. Results were presented separately for hull fouling and for ballast water.

- Errors in draft Tables 8 and 13 were noted. The authors agreed to make corrections for the final document.
- There was discussion about NIS that may be "high risk" to the Pacific region which were not identified in the species list (Molnar et al. 2008) used to assess magnitude of potential consequences. It was agreed that examples of Asian species that became problematic to the Canadian West Coast, despite not becoming problematic elsewhere, would be added to the text to demonstrate difficulties in identifying potential invaders.

DETERMINATION OF OVERALL LEVEL OF RISK IN THE PACIFIC REGION

Dr. Bailey presented results of the overall level of risk of NIS to the Pacific region. Results were presented separately for hull fouling and for ballast water.

- A participant expressed concern that non-merchant traffic, especially ferries, was included in the Atlantic assessment but not in the Pacific assessment. It was asked if the discrepancy would create problems for the national document. It was agreed to consider this issue when developing the national assessment.

GENERAL DISCUSSION AND CONCLUSIONS/RECOMMENDATIONS

There was a group discussion on unresolved topics, general conclusions, and a review of recommendations.

- The topic of assigning uncertainty was revisited. Two types of uncertainty were discussed: error and mismatch. Error was defined as the difference between the measured and true values of the data. Mismatch was defined as the suitability of the selected measure as a proxy for the variable of interest. In the draft document, error was the basis for the table of definitions, but mismatch was described in the text. The final uncertainty was assigned based on both, but the process was not clear.
- It was decided to revise the text to make the uncertainty methodology more clear. The group then reviewed the assigned uncertainty values, and made changes to some values which will be reflected in the final document.
- The topic of spread was revisited. Concerns were raised about the conclusions drawn about spread, when spread was not included in the risk assessment. There was also confusion as to whether some aspects of spread were already included in p(arrival) component. It was decided to change terminology for spread away from definitive terms like 'risk' and 'probability' to 'potential'. It was also decided to remove the spread information from the main body of the document and place it into an Appendix since it is useful but does not address project objectives.
- It was reiterated that emphasis will be made throughout the text to explain the "relative" nature of the risk assessments.

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- It was decided to retain methods for binning of p(arrival), but provide caveats indicating alternate methods for binning exist that would require extensive evaluation and calibration. The authors will consider and address the concern that p(arrival) is dictating final invasion risk when developing the national document.
 - Finally, it was suggested that the recommendations resulting from the assessments must be presented more clearly, and more specifically related back to vessel pathways.

NEXT STEPS

1. Authors will revise and recirculate the Research Documents.
2. One Proceedings document will be produced and circulated.
3. Two Science Advisory Reports will be produced and circulated.
4. Participants will review above documents for clarity and to ensure decisions at this meeting have been incorporated. No new methodological changes or information can be introduced.
5. If wording/clarity needs further discussion following reviews, a follow-up conference call will be arranged.

ACKNOWLEDGEMENTS

Workshop participants were acknowledged for their time and contributions to this process.

Becky Cudmore, Bethany Schroeder and Johannie Duhaime for taking notes of the discussions and decisions.

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APPENDIX A. TERMS OF REFERENCE

Risk Assessment for ship-mediated introductions of aquatic nonindigenous species to the Atlantic and Pacific regions of Canada

National Peer Review – National Capital Region

March 6-7 2012

Burlington, Ontario

Chairperson: Nicholas Mandrak

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 (CEARA) has developed risk evaluation guidelines that have been used to create risk assessments addressing:

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;
2. The level of risk posed by ships operating within the ballast water exchange exemption zones on the East and West Coasts;
3. The level of risk posed by domestic shipping activities;
4. If 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. This second meeting will address items 2 and 3 for the Atlantic and Pacific regions. The 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?

EXPECTED PUBLICATIONS

- Science Advisory Reports
- Proceedings
- Research Documents

PARTICIPATION

- Fisheries and Oceans Canada (DFO) experts from Ecosystems and Oceans Science, and Ecosystem and Fisheries Management sectors
- Transport Canada experts from Marine Safety and Policy
- Province of British Columbia
- Province of Quebec
- Academia
- Industry

APPENDIX B. PARTICIPANTS

Name	Affiliation
Sarah Bailey	DFO, GLLFAS
Kim Howland	DFO, FWI
Terri Sutherland	DFO, West Vancouver
Jennifer Martin	DFO, St. Andrews
Cynthia Mckenzie	DFO, NAFC, St. John's
Farrah Chan	University of Windsor, GLIER
Jennifer Adams	DFO, GLLFAS
Dallas Linley	DFO, GLLFAS
Becky Cudmore	DFO, GLLFAS
Nick Mandrak	DFO, GLLFAS
Bethany Schroeder	DFO, GLLFAS
Johannie Duhaime	DFO, GLLFAS
Sophie Foster	DFO, Ottawa
Tom Therriault	DFO, PBS
Claudio DiBacco	DFO, BIO
Chris Wiley	Transport Canada, Environmental Issues
Laurent Jean	Transport Canada, Senior Inspector
George Anderson	Transport Canada, Senior Inspector
Caroline Gravel	Shipping Federation of Canada
Mira Hube	Algoma Central Corp
Thomas Landry	DFO, Moncton
Andrea Locke	DFO, Moncton
Tanya Koropatnick	DFO, BIO
Terri Wells	DFO, NAFC, St. John's
Colin Henein	Transport Canada, Policy
Dan McPhee	DFO, Aquaculture Science

APPENDIX C. AGENDA

Risk Assessment for ship-mediated introductions of aquatic non-indigenous species to the Atlantic and Pacific regions of Canada CSAS Peer-Review Meeting

March 6-7, 2012: Burlington, Ontario

Day 1 (Tuesday March 6)

Time	Topic
9:00-9:15	Welcome and Introductions (Nick Mandrak)
9:15-9:30	CSAS Guidelines, Code of Conduct and Introduction to CEARA (Nick Mandrak)
9:30-10:15	Background Overview (Sarah Bailey) <ul style="list-style-type: none">• Biological Invasion Theory and Shipping as a Pathway• Review of Ballast Water/Hull Fouling Regulations in Canada• Objectives of Risk Assessment
10:15-10:30	BREAK
10:30-10:45	Overview of Outcomes/ Recommendations from 2011 Peer Review Meeting for Arctic and Great Lakes regions (Sarah Bailey)
10:45-11:15	Overview of Methods Used to Evaluate Ship-Mediated Risk (Jennifer Adams)
11:15-11:45	History and Special Considerations of Nonindigenous Species in the Atlantic region (Cynthia McKenzie)
11:45-12:45	LUNCH (on own; CCIW cafeteria available)
12:45-1:20	Determination of Probability of Arrival in the Atlantic region (Jennifer Adams)
1:20-1:35	Group Discussion
1:35-2:10	Determination of Probability of Survival in the Atlantic region (Farrah Chan)
2:10-2:25	Group Discussion
2:25-2:40	BREAK
2:40-3:00	Determination of Probability of Introduction in the Atlantic region (Jennifer Adams)
3:00-3:15	Group Discussion
3:15-3:35	Determination of Magnitude of Consequences in the Atlantic region (Jennifer Adams)
3:35-3:50	Group Discussion

Time	Topic
3:50-4:10	Determination of Overall Level of Risk in the Atlantic region (Jennifer Adams)
4:10-4:25	Group Discussion
4:25-4:45	Estimating Potential for Ship-Mediated Secondary Spread (Jennifer Adams)
4:45-5:00	Group Discussion
5:00-5:20	General Discussion and Conclusions/Recommendations for the Atlantic region (Nick Mandrak/Sarah Bailey)
5:20	Adjourn for Day 1

Day 2 (Wednesday March 7)

Time	Topic
9:00-9:45	Welcome Back/General Discussion/Points of Clarification from Day 1 (Nick Mandrak)
9:45-10:15	History and Special Considerations of Nonindigenous Species in the Pacific region (Terri Sutherland)
10:15-10:30	BREAK
10:30-10:55	Determination of Probability of Arrival in the Pacific region (Sarah Bailey)
10:55-11:10	Group Discussion
11:10-11:30	Determination of Probability of Survival in the Pacific region (Farrah Chan)
11:30-11:45	Group Discussion
11:45-12:45	LUNCH (on own; CCIW cafeteria available)
12:45-1:05	Determination of Probability of Introduction in the Pacific region (Sarah Bailey)
1:05-1:20	Group Discussion
1:20-1:40	Determination of Magnitude of Consequences in the Pacific region (Sarah Bailey)
1:40-1:55	Group Discussion
1:55-2:15	Determination of Overall Level of Risk in the Pacific region (Sarah Bailey)
2:15-2:25	Group Discussion
2:25-2:40	BREAK

Time	Topic
2:40-3:00	General Discussion and Conclusions/ Recommendations for the Pacific region (Nick Mandrak / Sarah Bailey)
3:00-3:30	Finalizing Scientific Advice Included in the CSAS Science Advisory Report (Nick Mandrak / Sarah Bailey)
3:30-4:00	Final Discussions of CSAS Documents and Next Steps (Nick Mandrak)
4:00	Adjourn Day 2