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Proceedings of the national peer review of the National Risk Assessment of Recreational Boating as a Vector for Aquatic Invasive Species

December 8-11, 2015
Montreal, Quebec

Chairperson: Gilles Olivier
Editor: Lauren Ellis

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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

These proceedings summarize the relevant presentations and discussions of the national science advisory meeting held on 8-11 December 2015 at the Marriott Chateau Champlain in Montreal, Quebec. The conclusions and advice resulting from this meeting will be provided in the form of a Science Advisory Report that will be made publicly available on the CSAS website. Meeting participants included experts from various sectors and regions of Fisheries and Oceans Canada, as well as external participants from the University of Toronto, North Pacific Marine Science Organization (PICES), Massachusetts Institute of Technology (MIT), the Nature Conservancy, the Smithsonian Institute, McGill University, the Government of Newfoundland and Labrador, and the National Aquatic Invasive Species Committee. Three working papers were distributed prior to the meeting in addition to a list of several reference documents. The purpose of this meeting was to collect and provide scientific advice on the risk that recreational boating, as a vector for the introduction and spread of aquatic invasive species (AIS), poses to Canadian fresh and marine waters. This topic was broken down into three distinct papers.

1. **National Risk Assessment of Recreational Boating as a Vector for Marine Non-indigenous Species**

This working paper used a variety of variables to estimate the relative risk of non-indigenous species (NIS) due to boating in different Canadian marine ecoregions. It characterized the movement patterns of recreational boats in marine waters within and between ecoregions and considered 3 variables in its calculation of risk: vessel characteristics/movements, environmental similarity, and NIS sources.

2. **Ecological Risk Assessment of Recreational Boating as a Pathway for The Secondary Spread of Aquatic Invasive Species in the Great Lakes Basin**

A model-based assessment was conducted to estimate the ecological risk of recreational boating activity as a pathway for the secondary spread of AIS in the Great Lakes Basin. The model assessed the relative probabilities of AIS spread and establishment among different ports/marinas supporting boating activity. Furthermore, it calculated the potential difference in the rate of spread between AIS transported by recreational boating and natural drift.

3. **Overland Spread of Aquatic Invasive Species Among Freshwater Ecosystems Due to Recreational Boating in Canada**

A literature review was undertaken to summarize the risk of spreading AIS through the overland movements of recreational boats between freshwater ecosystems in Canada. Only primary literature from North America was considered in the review. A model was developed to analyse the potential risk of an AIS introduction event in Canada and the effectiveness of the vector at spreading AIS.

SOMMAIRE

Le présent compte rendu résume les présentations et les discussions pertinentes de la réunion de consultation scientifique nationale qui s'est tenue du 8 au 11 décembre 2015 à l'hôtel Mariott Château Champlain à Montréal (Québec). Les conclusions et avis découlant de cette réunion seront présentés sous la forme d'un avis scientifique qui sera rendu public sur le site Web du Secrétariat canadien de consultation scientifique (SCCS). Parmi les participants à la réunion, on compte des spécialistes de divers secteurs et diverses régions de Pêches et Océans Canada (MPO), ainsi que des participants externes venus de l'Université de Toronto, de l'Organisation des sciences de la mer pour le Pacifique Nord (PICES), du Massachusetts Institute of Technology des États-Unis, de Conservation de la nature Canada, du Smithsonian Institute des États-Unis, de l'Université McGill, du gouvernement de Terre-Neuve-et-Labrador et du Comité national de travail sur les espèces aquatiques envahissantes (CNEAE). Outre plusieurs documents de référence, trois documents de travail ont été distribués avant la réunion. L'objectif de cette réunion était de recueillir et de fournir un avis scientifique sur les risques associés à la navigation de plaisance, comme vecteur d'introduction et de propagation d'espèces aquatiques envahissantes (EAE), pour les eaux douces et marines canadiennes. Le sujet a été divisé en trois documents distincts.

1. **Évaluation nationale des risques posés par la navigation de plaisance comme vecteur de propagation d'espèces aquatiques non indigènes**

Ce document de travail présente de nombreuses variables permettant d'estimer le risque relatif de propagation d'espèces non indigènes associé à la navigation dans diverses écorégions marines du Canada. Les auteurs y présentent les profils de déplacement des bateaux de plaisance dans les eaux marines, au sein des écorégions et entre ces dernières, ainsi que trois variables de calcul du risque : les caractéristiques des bateaux et leurs déplacements, les similitudes entre les milieux et les sources d'espèces non indigènes.

2. **Évaluation des risques écologiques associés à la navigation de plaisance comme voie de propagation secondaire d'espèces aquatiques envahissantes dans le bassin des Grands Lacs**

Ce document de travail présente l'évaluation fondée sur un modèle ayant permis d'estimer les risques associés aux activités liées à la navigation de plaisance comme voie de propagation secondaire d'espèces aquatiques envahissantes dans le bassin des Grands Lacs. Grâce au modèle, les auteurs ont pu évaluer les probabilités relatives de propagation et d'établissement de ces espèces entre les multiples ports et marinas qui accueillent des activités nautiques. Le document présente par ailleurs le calcul des différences de potentiel en matière de vitesse de propagation, selon que les espèces aquatiques envahissantes sont transportées par l'intermédiaire de la navigation de plaisance ou par dérive naturelle.

3. **Propagation par voie terrestre d'espèces aquatiques envahissantes entre des écosystèmes d'eau douce par l'intermédiaire de la navigation de plaisance au Canada**

Une analyse documentaire a permis de récapituler les risques de propagation d'espèces aquatiques envahissantes entre les écosystèmes d'eau douce au Canada, associés aux déplacements par voie terrestre de bateaux de plaisance. Cette analyse n'a porté que sur la documentation spécialisée publiée en Amérique du Nord. Grâce à un modèle, les auteurs ont pu analyser le risque potentiel d'introduction d'espèces aquatiques envahissantes au Canada, ainsi que l'efficacité du vecteur de propagation de ces espèces.

INTRODUCTION

Gilles Olivier (chair) opened the meeting by welcoming the participants, providing a brief overview of the CSAS peer-review process, and requesting that everyone consider, throughout the course of the meeting, whether there are any common aspects or connections between the papers and how science advice can be extracted from the discussions of the meeting. The Terms of Reference (Appendix 1) indicate that the purpose of the meeting was to collect and provide scientific advice on the risk that recreational boating, as a vector for the introduction and spread of aquatic invasive species (AIS), poses to Canadian fresh and marine waters. In order to accomplish this, three papers were reviewed that assessed this risk in; marine waters on the Pacific and Atlantic coasts, the Great Lakes Basin, and via overland movement of recreational boats among inland freshwater lakes. Each participant was introduced as there was representation from a variety of divisions of Fisheries and Oceans Canada (DFO), as well as the University of Toronto, North Pacific Marine Science Organization (PICES), Massachusetts Institute of Technology (MIT), the Nature Conservancy, the Smithsonian Institute, McGill University, the Government of Newfoundland and Labrador, and the National Aquatic Invasive Species Committee (Appendix 2). The Chair reviewed the agenda (Appendix 3), discussed deadlines for the expected publications, and verbally determined that there was consensus for the Terms of Reference.

NATIONAL RISK ASSESSMENT OF RECREATIONAL BOATING AS A VECTOR FOR MARINE NON-INDIGENOUS SPECIES

PRESENTATION - BACKGROUND AND GENERAL APPROACH

Presenter: Chris McKindsey, DFO Quebec / Demersal and Benthic Science Branch

Synopsis of Presentation

The objectives, as they are stated in the Terms of Reference, were presented. A brief overview of the data collection process that was used to obtain a complete dataset across the country was given. For comparison purposes each coast was divided into regions, designated as ecoregions, based on their similarity of environmental characteristics.

Discussion

A participant requested clarification on the criteria used to determine the location for the division between Canadian and American waters. It was indicated that the different coastal currents that exist in each country create differences in habitats and species assemblages.

Clarification was requested on the use of the term “recreational boats”. The authors segregated “recreational boats” into 3 distinct categories, sailboats, powerboats, and fishing boats. This will be better explained in the paper so the variables of the model are better defined.

A concern arose about identifying the risk that other vectors of non-indigenous species (NIS) transportation pose, outside of hull fouling. The authors admitted that sufficient data could not be collected on the other vectors, across both the east and west coasts, and that hull fouling had been evaluated in the past as having the highest risk of spreading NIS. However, the authors do have sufficient data for assessing the risk of other vectors on the Pacific coast alone and will add this analysis to the paper.

PRESENTATION – METHODS: BOAT FOULING PROBABILITY

Presenters: Nathalie Simard, DFO Quebec / Demersal and Benthic Science Branch;
Cathryn Clarke Murray, North Pacific Marine Science Organization (PICES)

Synopsis of Presentation

An overview of the risk assessment model was given and the first of four steps was presented. Methods included deploying PVC settlement plates at approximately 172 sites on the Atlantic coast and 106 sites on the Pacific coast between 2006 and 2014. Species diversity was assessed on the Pacific coast (ranging between 0-7 species) while percent cover of each species was assessed on the Atlantic coast. Boater questionnaires were distributed at marinas, workshops, and events in order to determine travel history and consistency of antifouling practices. Some boaters permitted SCUBA surveys to be conducted on their boats to check for hull fouling. These results were used in boat fouling predictive models to estimate trends and patterns for a larger population.

Discussion

Concern arose about using the predictive models to estimate the number of boats that are fouled. On the Atlantic coast there was very little accuracy between the values obtained from the predictive model and the true values observed in the field. On the Pacific coast, however, the values were more accurate. It was suggested that the true values be used alone even though that would result in a small sample size. The authors acknowledged that they did not have enough data in certain ecoregions and used the predictive model to extrapolate across larger populations. They also indicated that there were differences in the methods used between coasts. For example, on the Atlantic coast, boaters were surveyed only in marinas, while on the Pacific coast boaters were surveyed in a variety of locations, including boat shows. In order to effectively use the predictive models to estimate the proportion of boats fouled, this discrepancy in the methods between coasts needed to be clearly outlined in the paper. It was suggested that all the assumptions associated with the models be identified up front and the uncertainties be described at each stage.

One suggestion was to evaluate the proportion of NIS versus native species fouling boat hulls. Unfortunately, the authors found that the SCUBA surveys were only able to identify functional groups of species and could not distinguish between NIS and native species. This data was sufficient however, since a boat that is fouled with native species can just as easily be a vector for NIS. A list of species observed in the study was suggested, however, a lack of detail in the SCUBA surveys was noted.

The authors indicated that they had to create their own database of marinas as this compilation did not exist before.

A participant inquired as to whether the species accumulation curves were studied to identify saturation. It was verified that saturation was obtained on the PVC settlement plates in the Pacific, however, some expected species were not observed using this method (e.g., *Didemnum sp.*, although known to foul boats in the Pacific, did not grow on the settlement plates used in this study).

PRESENTATION – METHODS: INTRODUCTION POTENTIAL, NIS NOVELTY, AND INVASION RISK

Presenters: Nathalie Simard, DFO Quebec / Demersal and Benthic Science Branch;
Chris McKindsey, DFO Quebec / Demersal and Benthic Science Branch

Synopsis of Presentation

The overview of the risk assessment model was continued with step two and three out of four. The boater questionnaires were used to determine the number of nights a boat spent away from the home marina and the number of destinations it visited. These variables were used to calculate the probability that an NIS was introduced to a marina. The environmental differences between two marinas were considered to have an effect on the survivability of an introduced NIS. Salinity and climate were the two characteristics used to quantify environmental differences, such that high variability among the marinas would result in a low potential for survival. Another variable considered in the risk assessment model was NIS novelty, defined as an NIS that was new to a marina. This variable resulted in the ranking of boats where boats from nearby marinas had a low probability of introducing novel NIS. NIS novelty was used to evaluate the impact of introduction events.

Discussion

Clarification was requested regarding how values were assigned to boats based on their distances travelled. It was determined that an individual score is developed for each boat to synthesize the number of marinas visited and the number of nights spent in an ecoregion.

A participant suggested that all data limitations or gaps should be clearly outlined in the paper to provide stronger support for the predicted values used in the risk assessment model. One of these limitations was that NIS diversity data and percent cover data were collected on the Atlantic coast while only NIS diversity data was collected on the Pacific coast. It was agreed that only one metric (NIS diversity) would be used for both coasts for consistency.

There was a lengthy discussion about the use of the risk assessment model and how each variable could be better applied. Participants and authors agreed on a set of changes that would be applied to this model:

1. The variables would be multiplied all the way through the equation as opposed to the current use of addition in some places.
2. The NIS novelty variable and associated issues were discussed at length. In the end, it was agreed that the NIS novelty variable was not adequately evaluating what the authors intended and that the model would be better structured if NIS novelty was removed.
3. The data that was categorized into bins created by the authors would become standardized instead (0-1). Each standardized value was increased by 1 to prevent the lowest score of 0 from being multiplied through the model and skewing the data.
4. The data would be kept native (raw) for as long as possible throughout the model. Bins could be used at the end in order to categorize the risk associated with each boat.
5. The 3 bins used for the newly standardized (0-1) salinity and climate variables became 0.2, 0.6, and 1.0. Furthermore, it was agreed that if either climate or salinity indicated a low probability of survival (e.g., a boat travelling from a polar marina to a tropical marina) then, regardless of the probability of survival as assessed by the other variable, the lowest bin would be used.
6. The annual traffic variable, identifying the number of boats a marina receives in a year, would be multiplied at the end of the equation for each boat score.

A participant noted that with the removal of the NIS novelty variable, risk was no longer being assessed in the sense of a traditional risk assessment (in terms of impact) and suggested that the title of the paper should be changed to indicate a hazard assessment instead.

It was suggested that marinas located in the North Atlantic could be of greater concern than identified in the paper. These marinas could be used as stepping stones for species invasions due to the environmental similarities with international ports. It was agreed that text would be added to the paper to specify that stepping stone transfers were not included in the risk assessment.

The authors indicated that they did not collect sufficient data to allow for differentiation between the risks associated with different boat types in the analysis.

PRESENTATION – RISK ASSESSMENT RESULTS

Presenters: Nathalie Simard, DFO Quebec / Demersal and Benthic Science Branch;
Cathryn Clarke Murray, North Pacific Marine Science Organization (PICES)

Synopsis of Presentation

The results indicated that many sites held either low NIS diversity or no NIS at all. Certain locations, like the Scotian Shelf and Bay of Fundy appear to be the most infested with NIS. Furthermore, it was determined that the fishing boat category, as defined in the paper, was the most frequent boat type found in the Newfoundland Shelf, Laurentian Channel, and Bay of Fundy. There was a notable distinction in the boat storage trends between coasts, likely due to differences in seasonality and ice-free time among the coasts. In addition to climatic variances, boaters on the Atlantic coast tended to apply antifouling paint more often than their Pacific counterparts. The risk assessment model indicated that three ecoregions on the Pacific coast had a high risk of invasion, relative to the other ecoregions assessed, as a result of high boat traffic and environmental similarity with other marinas.

An overview of the assumptions and considerations followed:

- Fouling species were the focus of this paper and mobile species were not always considered.
- The authors do not have a high level of confidence in the species distribution data as NIS were only recorded sporadically on the Atlantic coast. NIS populations may be underestimated in this study as there were sites where NIS were expected but not found.
- No information was collected about the routes that vessels took before arriving at a marina within the study area.
- High risk activities may not be captured in the paper, such as the sale of moored boats, as they were not docked at a marina and were therefore not surveyed.
- The Arctic region cannot be included in this analysis as there are too many data gaps.

Discussion

Clarification on the definition and division of ecoregions was requested. The authors made a note to provide extra detail in a revised version of the paper regarding the choice of ecoregions. There were discussions throughout the meeting to determine the reason behind selecting ecoregions at all. Some argued that it would have been better to compare marinas directly instead of grouping them. The authors felt that the results categorized by ecoregions sent a stronger message about the risk of invasion across different marine ecosystems.

Throughout the meeting participants brought up terms that required clarification or better definition. It was agreed that more comprehensive explanations would be given in the revised paper for the following concepts: number of invasive species in an ecoregion, potential of boats to be fouled, and NIS diversity.

One participant requested that the paper clearly identify that the boats surveyed at marinas were likely left in the water longer as they had a docking location. The longer a boat is left in the water the greater the degree of fouling. The authors explained that the boater questionnaires, on the Pacific coast, were not only handed to boaters docked at marinas but also those trailering and removing their boats from the water. On the Atlantic coast, the majority of boater questionnaires were given to boaters docked at the marina. This difference in methods between coasts could have resulted in the discrepancy observed in the predicted numbers of fouled boats on the Atlantic coast. It was agreed that this bias would be noted in the revised paper.

The authors were asked to draw out inferences and key conclusions at each stage of their risk assessment model. It was emphasized that this model gave a relative risk and was not directly comparable to any other studies conducted in this field. It was agreed that this was important to be appropriately captured in the paper.

A request was made to add a section of text to the discussion to identify hubs or areas that would be sensitive to an invasion. One participant indicated that although this paper draws conclusions across ecoregions, marinas within each ecoregion could be identified as having a higher or lower risk of invasion. Additionally, it was suggested to include an overview of the dangers of introducing an NIS because of the speed at which it can be dispersed through secondary spread via recreational boating.

ECOLOGICAL RISK ASSESSMENT OF RECREATIONAL BOATING AS A PATHWAY FOR THE SECONDARY SPREAD OF AQUATIC INVASIVE SPECIES IN THE GREAT LAKES BASIN

PRESENTATION – SCOPE OF THE MODEL-BASED RISK ASSESSMENT

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The purpose of the paper was to evaluate the risk of secondary spread due to recreational boating after an AIS was introduced into the Great Lakes Basin (GLB). Since all the lakes were fairly connected, the risk was quantified as a function of the probability that spread, due to boater activity, would surpass AIS rates of natural dispersal. Meaning, that a higher risk value would result if an AIS transported from one lake in the GLB to another, via recreational boating, occurred faster than natural dispersal by seven or more years. The results were applicable to other freshwater lakes in Canada as well. Valleyfield, Quebec represented the eastern boundary of this study and the Welland locks were considered an impassable section between Lake Erie and Lake Ontario. Species were categorized into different functional groups based on how they could be transported by boaters:

1. Potential for uptake into the engine cooling system or bilge (phytoplankton, zooplankton).
2. Direct attachment to the hull (molluscs).
3. Indirect attachment, such as entanglement on trailer hitches or anchors (macrophytes).

The model showed a high level of certainty even when a 25% change in all parameters was simulated. The model assumed that each invaded site became a source the following year. The application of this assumption resulted in the prediction of the extent of spread after 10 years. The predicted extent of spread after 10 years was recalculated using the model 10 times in order to obtain a reasonable sample size to show patterns and probabilities.

Discussion

A participant argued that it is difficult to identify the rate at which AIS spread because they are not monitored until a single observation is made, which is often too late. An example of this includes an invasive species of shrimp, which was not observed or sampled until it had reached a substantial population size. It was suspected that this species was introduced to the GLB through the shipping vector. As soon as this species was observed in the GLB, various sites were sampled to determine the extent of spread. By that time the species had already invaded every site sampled, including sites not associated with shipping. It was agreed that the model used in this paper would provide a good estimate of the rate of invasion and spread as a result of recreational boating.

Confusion was described about one of the figures that showed the spread timelines of a group of organisms. Bars in the bar graph represented the probability that the organism would spread to a neighbouring lake after each consecutive year, except for one of the bars (black) which represented the probability that an organism would fail to invade another lake within 10 years. After further discussion it was agreed that, given sufficient time (greater than 10 years), an organism could invade any lake. The authors agreed to move this black bar to a more logical location along the x-axis of the graph.

Several participants requested that the timelines, used to predict the probability that an organism would invade another lake, surpass 10 years. The authors explained that the model was very time consuming to run and with the time allotted for the completion of the study, it was impossible to run it for more than 10 years. 10 years at 10 iterations, was considered to result in a sufficient sample size for robust statistical analyses.

A question arose about whether the paper considered bait transfers from fisherman as vectors for transporting AIS. The authors responded that they had sufficient information on invasive species introductions as a result of bait transfers but this was not represented in the paper. However, it was noted that by including data on species that foul fishing boats, this information may already be captured in the model.

Clarification was given on how the 3 sets of locks were dealt with. The model considered these locations to have slower rates of spread as they were points of constriction. It would have been an arduous task for either a boat or an organism to transit across these points. Additionally, an argument was made for using Valleyfield, Quebec as the eastern most boundary for this paper. Valleyfield is the point of inspection for commercial ships entering the GLB, and it was difficult to locate all launching areas, including private beaches, beyond this point.

A request was made to add a flow chart to the paper that illustrated the steps of the model for clarity. The authors agreed to this and also considered highlighting the assumptions at each step.

Participants pointed out that the naming convention for the functional groups of organisms was too specific. It was recommended that the titles be general enough to include all species based on their vessel attachment behavior. For example, “entanglers and hitchhikers”, could be used as a group name in place of “macrophytes”. The name macrophytes may exclude some non-plant species that may be transported by entanglement or hitchhiking, such as snails.

A participant requested that the text indicate that upstream movement occurs when the model outcomes identify spread by recreational boats as being faster than natural dispersal. The majority of these results occurred where AIS were spread to the lake upstream of the hypothetically inoculated one. The authors agreed that the text would appropriately identify upstream movement and indicated that the model only considered natural dispersal as drift.

Therefore the model was based on the assumption that no natural dispersal could occur upstream.

One question arose about whether the model considered actual distributions of AIS. The authors indicated that the model was created without any assumptions on AIS distribution and that it strictly identified the risk of spread from a single inoculation in the GLB. This allowed the model to be flexible in terms of new species, which could show up at any location by any vector.

It was clarified that the model could not be calibrated with historical records of invasions as the nature of AIS makes it difficult to ascertain the vector used for spread. Furthermore, there were gaps in the data as a result of delayed species monitoring. Typically, population monitoring for AIS is deferred until an individual has been discovered in the ecosystem, which is usually after spread has already occurred.

A participant requested that several examples of rates of natural dispersal be added to the paper. This would allow the reader to get a sense of what regularly occurs in nature. It was agreed that the paper would benefit from having more background information on true dispersal estimates.

As a group, it was agreed that the model was measuring “consequence” as opposed to “impact”. This change in wording would be reflected in the tables and figures in the paper.

Participants offered data, collected from eastern parts of the St. Lawrence, to expand the paper. However, it was noted that there may be a lower risk of spread from the St. Lawrence ports given the way the dispersal kernel works and this addition would require a significant amount of extra work for a small gain. It was agreed that the paper adequately covers the GLB.

A question arose as to why larval fish, which could be transferred by vessels in the same way as plankton, weren’t being considered in the analysis as potential invaders. The authors indicated that no references had discussed entrapment of larval fish in vessels but the model does not explicitly exclude larval fish. The invasion potential for larval fish was already captured in the model via the planktonic functional group.

Clarification was obtained for the term “high invasiveness” used in the paper. The definition was explained as the potential of an organism to establish from a very small population size, such as 1-10 individuals. This term will be clarified further in the text of the paper.

PRESENTATION – PROPAGULE PRESSURE FROM FRESHWATER RECREATIONAL BOATERS TRIPS WITHIN THE GREAT LAKES BASIN

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The model measured the potential for propagule pressure by quantifying recreational boating in the GLB, types of vessels owned, and travel distances and destinations. Questionnaires were distributed at marinas to collect data on boating behaviours. The average boater took 8.8 trips per year in the GLB.

Assumptions made to develop the model included:

- The 235th boater could have used the Soo or Welland locks systems. All surveyed boaters (234 individuals) indicated that they did not use either locks systems.
- The proportion of boat owners in the United States (US) that entered the GLB in a single year was used to predict the Canadian population that entered the GLB. The GLB received a total of 11.8 million boat trips per year from the US and Canada.

- Each launch site was visited an equal number of times, resulting in 7800 trips per year at each site.
- Plankton contamination was quantified based on the density found in surface waters and the assumption that all propagules will survive transport through an engine cooling system. Manual boats, like kayaks were assumed to carry 10% less than the densities found in surface waters.
- Mollusc contamination on boats stored on land (transient boats) was quantified as 0.11 times the density of organisms found in surface waters.
- Macrophyte contamination was quantified as a 0.0033 reduction of the density found in the surrounding benthos. This assumption is based on a study that found that 2 out of 58 boats transported at least one viable macrophyte fragment.

Discussion

A participant asked if a variety of dispersal kernels were used in the model since different boat types travel different distances. The authors responded that for simplicity, only one dispersal kernel was used. This likely overestimated the distances that manually powered boats, like canoes and kayaks, travelled. However, manually powered boats represent a small proportion of the total number of boats using the GLB per year. The authors agreed to add this clarification to the paper.

The assumption that all launch sites were visited an equal number of times was disputed. One participant asked if postal codes could be used to identify the number of boaters that reside near a particular launch site. The authors indicated that this type of analysis may have a large number of data gaps and that the uncertainty of the current method used is clearly identified in the paper.

The group agreed that the paper needed to clarify the term “transient boat” as it was used with a different meaning in the previously presented paper.

A concern arose about underestimating the number of sail boats in the GLB. Sail boats are stored in water more often than power boats, and are therefore more likely to be fouled. An underestimate of sail boats could result in a lower evaluation of risk. The authors indicated that the total number of boats would remain the same and if the number of sail boats entered in the model was increased, the number of power boats would decrease. The authors suspected that the underestimation of sail boats was small. It was suggested that Google Earth could be used to better quantify the proportion of sailboats to power boats in a small sample of marinas.

One participant suggested improving the questionnaire by inquiring as to whether boaters had released the plug to drain the boat prior to leaving the launch site.

The assumption that all propagules will survive transport through an engine cooling system was disputed. This survival rate was likely an overestimate because water is constantly flushing through the system, not allowing sufficient time for propagules to attach. Alternatively, there may be niche areas within the engine that provide acceptable attachment or containment sites. The authors indicated that the sensitivity analysis will identify key variables, like this, that need to be adjusted or carefully observed. Overall basic assumptions were used throughout the model and when data was unavailable then an assumption resulting in an overestimation was implemented in order to give the worst case scenario.

One participant indicated that different species of zooplankton may have varying densities in the environment. Furthermore, the proportion of propagules that are transported by a vessel may differ from the densities found in the surrounding environment. For example, some species could swim away from vessel suctions while others occur in patchy distributions. The authors acknowledged that these examples are good reasons to further explore the sensitivity of the model and that the highest possible density was assumed to attach or survive as a worst case scenario.

A participant suggested that the model may underestimate the amount of fouling on boats. As an example, it was explained that zebra mussels were so contagious in Lake Winnipeg that they were found on every vessel that entered the environment. It was added that zebra mussels also have the ability to survive 5 days of desiccation. The authors indicated that the data showed some boats do not wait 5 days between trips. It was clarified that the model works on the assumption that boats stored in the GLB will contain a high density of fouling propagules.

A point was brought up that the movement potential between sail boats and power boats was considered the same in the model, but the differing structures of these boat types leads to different attachment potential.

PRESENTATION – RELATIONSHIP BETWEEN PROPAGULE PRESSURE AND PROBABILITY OF ESTABLISHMENT

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The model included a measure of the probability that an organism would establish a population at a new site. Results from a past mesocosm experiment conducted in Lake Ontario were used to test the lowest population density required for an organism to establish. This experiment duplicated the early stages of spread when few propagules are initially introduced to a site. The model considers a species to have an established population once it reaches 50% of its greatest population growth. Molluscs, for example, take 2-5 years to reach 50% of their greatest population growth, while phytoplankton take 0.5 years. A single viable macrophyte easily establishes at a new site. The model assumed no Allee effects.

Discussion

One participant argued that Eurasian Milfoil, a highly invasive macrophyte, would take only 3 years to reach 50% of its maximum population density. The model had listed all macrophytes as requiring 5 years. It was agreed that the rapid growth of Eurasian Milfoil would be used as the worst case scenario and the variable would be corrected to 3 years.

It was discussed that the density of the organisms released from the vessel should be less than the density initially picked up. Some organisms would remain attached to the boat.

One participant disputed the assumption that climate does not differentially impact the survivability of AIS across the GLB. It was agreed that this assumption resulted in the worst case scenario, but was unrealistic. Environmental conditions differ greatly across the GLB. The authors explained that there were many examples of AIS spread throughout the GLB regardless of environmental differences. A suggestion was made to flag any lakes that were environmentally similar and thus had a higher risk of AIS survival and spread. Furthermore, it was agreed that text would be added to the paper to clarify the assumption that the worst case scenario predicted that the environmental conditions between the lakes were similar enough for AIS survival.

A point was made to explain that the model only took into account boat traffic. Any seasonal variability in propagule reproductive cycles was ignored. In this analysis, if a boat travelled between two sites then it was possible to spread AIS.

A concern arose about propagules being dispersed by water currents prior to settling in locations outside of where they were released. The authors suggested that boat launches, where propagules are assumed to be released, had lower water currents that would facilitate launching and trailering boats. The authors agreed to move all the model assumptions to the front of the paper.

PRESENTATION – OVERALL PROBABILITY OF SPREAD AND MAGNITUDE OF IMPACTS

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The model assessed the rate of spread when a species was introduced at a single access point, at year 0. The following model assumptions were further introduced:

- Half of all boat travel was near shore.
- The probability of releasing a propagule from a vessel was 0.5. The probability could have been lower since propagules were not likely released from every vessel.
- If the model predicted that a vessel would introduce propagules then the density released was a small proportion of the initial fouling density.
- Each new site that was invaded became a source the following year. The populations remaining at previously invaded sites were assumed to grow, after a year, thus increasing the probability that a boat would become fouled.

General results indicated that of the functional groups, phytoplankton spread between lakes the fastest, however, many data gaps were encountered when researching natural dispersal. The sensitivity of the model was checked by doubling and quadrupling the time it took for natural dispersal to occur. Only the quadrupling of these variables impacted the outcome of the model.

It was concluded that recreational boating was a high risk vector for spread to upstream locations that would not naturally be invaded. Spread was aided by interacting or overlapping vessel travel. Recreational boating may have also been responsible for spread to downstream locations but was often conducted at a similar rate to natural dispersal.

Discussion

Clarification was made about the sensitivity analysis. There was confusion about what doubling or quadrupling the rates of natural dispersal in the model meant. An initial interpretation was that this would increase the speed at which an organism naturally drifted to another location thus shortening the time it took to spread. It was clarified that the intended interpretation was that time would be lengthened such that it would take longer for an organism to spread. The model outcomes using these altered parameters could be used to help predict the spread of species that have longer natural dispersal rates.

A participant suggested that the authors consider the results of a recently published paper that indicated slower dispersal rates than originally expected. It was agreed that the rates already calculated in this paper would be sufficient but that text could be added to explain the effect that these new dispersal rates could have.

Results indicated that Canadian boaters did not visit many US launch sites. Similarly, the lakes were so large that it was unlikely for a propagule to naturally disperse across a lake to US launch sites on the other side. However, natural dispersal and establishment would likely occur between US and Canadian launch sites that are adjacently situated.

A comment was made about a figure that portrayed maps of the spread of a single AIS across a 10 year period. In this particular example the model introduced an AIS on the US side which appeared to come close to the Canadian border but never invaded sites across it. The authors explained that this was a function of a single iteration of the model and that other iterations likely crossed the border. Furthermore, it was explained that in this example, the densities at the sites near the Canadian border were not high enough to spread across the border, in every iteration, before the 10th year.

It was clarified that the risk of spread was quantified across each lake as a whole. Meaning that results were concerned with whether a lake was invaded, including a single launch site, or not at all.

Concern arose about unique scenarios of spread that may not have been captured by the model. For example, some sailboats that are moored offshore may be heavily fouled. Unfortunately, the model could not capture all scenarios, so only boats at launch sites were considered.

A participant requested clarification for the term “nearshore” used in the paper. The authors indicated that the term was used to identify a location that could become invaded and act as a new source for spread. Distance from land was not used to define nearshore sites.

It was collectively agreed that the conclusions of the paper should be presented in a way that would be comparable to the marine paper presented earlier. The Lakes could be considered similar to the ecoregion categories from the marine paper and both attempted to measure the risk of spread by recreational boats.

The paper did not identify any hotspots that could result in a higher risk scenario if an introduction occurred.

OVERLAND SPREAD OF AQUATIC INVASIVE SPECIES DUE TO RECREATIONAL BOATING IN CANADA

PRESENTATION – SCOPE OF LITERATURE REVIEW

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The purpose and objectives of the literature review were outlined. Primary literature that discussed overland lake-to-lake movement of AIS via recreational boats was considered. The review provided supporting information, without duplication, for ongoing provincial initiatives, such as the inland GLB research in Ontario. This was the first comprehensive literature review synthesizing a high volume of papers involving overland spread of AIS in North America.

Discussion

A question arose about whether the overland spread of AIS from US into Canadian waters was considered. The authors responded that this was not explicitly considered and that literature was not available to quantify this.

Participants collectively agreed that the term “freshwater” should be added to the title of the paper to provide clarity about the nature of the review. Literature on overland marine to marine movements that could be important for coastal areas was not included.

It was suggested that the term “trailered boats” replace “small craft”. The term “small craft” could include commercial fishing boats, bait collections, agency research vessels, fish guides and charters, and house boats, none of which were included in the analysis. The authors agreed that only the overland movement of trailered boats was being measured and that the term “trailered boats” would be used.

Discussion arose about ongoing provincial initiatives to research and quantify overland spread of AIS. It was decided that several examples would be included in the paper, such as the mandatory roadside inspection programs taking place in Alberta (23,000 boats inspected in 2015) and British Columbia (4,300 boats inspected in 2015). Additional text would be added to explain how these provincial initiatives integrate into the analysis of the paper.

A participant suggested that a map identifying the lakes that have already been invaded in Canada would benefit the paper. Furthermore, it would be useful to add a list of the species that had successfully established.

The group unanimously agreed that, given the proper resources, a national database of AIS would assist further research in this field.

After some discussion, it was agreed that text would be added to the paper to adequately describe the purpose and scope of the literature review. Further details were required for clarity.

PRESENTATION – HISTORY AND SCALE OF INLAND LAKE INVASIONS DUE TO OVERLAND MOVEMENT OF RECREATIONAL VESSELS

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

Historically, publications predicted the spread of zebra mussels by estimating aggregate boater movements. In 2007, it was confirmed that overland spread was a prominent risk when a lake (Lake Mead, Nevada) 1500 km from any source was invaded by Zebra Mussels. In Canada, overland recreational boating movement has been the suspected vector for the spread of Zebra Mussels, macrophytes, species of zooplankton, the Fish Hook Waterflea, the Spiny Waterflea and many others.

There was a lack of data on the number of boaters that entered freshwater environments, outside of the GLB. Thus, as a first step, the model used the proportion of Ontario boaters that used the GLB exclusively to help predict the number of boats that use marine environments in coastal regions. Assuming boaters are either freshwater or marine enthusiasts, this number was subtracted from the total number of Ontario boaters to estimate the proportion of freshwater boaters, in Ontario. This proportion was then used to predict the number of freshwater boaters in other provinces, and ultimately the number of overland freshwater trips across Canada. Trip distances, cleaning behaviours, and boat fouling were additional variables considered in the model.

Discussion

A lengthy discussion ensued about the variables used to estimate the number of overland freshwater trips across Canada. Due to the differences in numbers and locations of bodies of freshwater between provinces, an extrapolation of data from Ontario was argued to be too imprecise. Other suggested approaches included analyzing the number of angler licenses distributed, or boat/trailer registrations, however, it was determined that none of these would provide a better alternative. It was then agreed that the Ontario data would be used to predict the proportion of freshwater overland trips across Canada as a whole, rather than breaking down the estimate into individual provincial values first. This change would result in an order of magnitude estimate at the national level and would highlight data deficiencies at local levels. This discussion also resulted in the removal of a table that displayed the estimated values by provinces.

A participant inquired as to whether the model could distinguish between AIS introductions from large-scale overland movements versus localized secondary spread. The authors indicated that the long distance overland movements were well predicted by the gravity model but localized secondary spread was difficult to predict. Localized spread involved many small-scale effects including transport of AIS by other vectors. It was agreed that text would be added to the paper to explicitly describe the difference between long distance movements versus the more numerous, shorter trips and explain what scenarios could be quantified by the model.

Fishing guides were identified as having conducted the majority of local boat trips and small-scale overland movements. Unfortunately, there was no historical data to determine whether fishing guides practiced more consistent boat cleaning behaviours, particularly when moving between bodies of water.

Concern was vocalised about the use of *Dydymosphenia geminata* (Didymo), a species of algae, as an example of AIS spread through boater mediated vectors. This species has yet to be confirmed as non-indigenous to Canada and may be spread through other vectors, such as contaminated hip-waders. Additionally, it was requested that the authors include a discussion on the movement of native species to lakes where they are considered “invasive”.

Participants offered a variety of information on marine vectors of AIS spread that could have been added to the paper. It was collectively agreed that the research document continue to be focused on freshwater vectors alone.

A participant inquired whether the data could identify a functional group of species that were spread more rapidly by recreational boat movements than the rate at which natural spread might occur. The authors agreed to add text to the paper to discuss this analysis.

PRESENTATION – MANAGEMENT IMPLICATIONS SPECIFIC TO OVERLAND SPREAD

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

The literature collected for the review fell into 4 main subject categories:

1. 10% - Contamination of vessels with freshwater fauna.
2. 32% - Survival of species during overland transport.
3. 40% - Forecasting sites at greatest risk of invasion due to overland boating activity.
4. 18% - Role of inspection stations, the link between boater behaviour and educational campaigns and their role in spread management.

There were several variables that increased the probability of an AIS being introduced by recreational boating. A small proportion of boaters were recorded visiting 2 different bodies of water before the boat had sufficient time to dry. Many overland boater trips were short distances (less than 150 km) but occasionally some overland trips exceeded 300 km. The functional groups considered in this paper had different survivorship periods ranging from 12 hours to 42 days of drying time and only a small proportion of the boater population practiced some form of boat cleaning.

Discussion

A participant requested that a figure be added to the paper to plot the relationship between trip frequency and maximum or average trip length.

Clarification was needed on the differences between landscape level variables. The authors agreed to add text describing the important distinctions between measuring risk among few lakes separated by great distances versus many small lakes in close proximity to one another.

A small discussion was conducted on the various boater categories considered in the paper. The authors indicated that the contrast in boat structure (e.g., niche areas for attachment) and boat maintenance (e.g., cleaning frequency, boat storage) between these categories could result in different risk evaluations. It was further identified that sub groups of recreational boaters such as guides or anglers could also result in different risk evaluations. It was agreed that these distinctions should be better described in the paper.

PRESENTATION – SUMMARY OF LITERATURE REVIEW AND DISCUSSION OF OUTSTANDING KNOWLEDGE GAPS

Presenter: Andrew Drake, University of Toronto

Synopsis of Presentation

An overview of the model used in the overland analysis was given in which the probability of AIS introduction in Canada was calculated. This probability helped to illustrate mechanisms of rarity and justify ongoing provincial research initiatives. The probability was a function of whether an AIS was spread given 10, 100, or 1000 introduction events within a year.

The conclusions indicated that overland boater-mediated spread provided effective transport of AIS. Risk was confined to a subset of boaters with specific behavioural and trip characteristics. The spread of AIS through the overland movement of recreational boats greatly surpassed the rate at which natural dispersal would occur. The most effective management strategy was controlling outbound trips during the early stages of the spread process. Appendices were included in the paper that summarized literature on observed AIS contamination as well as decontamination strategies.

Discussion

There were a large number of data gaps identified through this research. It was agreed that a section at the end of the paper be added to address all of the known gaps at once. Topics for this section included the overland movement of invasive species between the US and Canada as well as within the Maritime provinces, and AIS movement in watersheds that flow from the US into Canada. Additionally, it was recommended that the purposeful exclusion of AIS spread through marine ecosystems should be clearly stated in this section as well.

The authors designed a table to display the overall probability that a single AIS introduction event would occur given a certain number of potential introduction events and probabilities of AIS being transported. A suggestion was made to increase the number of potential introduction events to begin above 10. It was discussed that 10 was too low to be a likely number of potential introduction events in a given year as there are thousands of lakes in Canada.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Gilles Olivier	DFO National Capital Region
Tom Therriault	DFO Pacific / Marine Ecosystems & Aquaculture Division
Gavin Christie	DFO Central & Arctic / Great Lakes Laboratory for Fisheries and Aquatic Science
Doug Watkinson	DFO Central & Arctic / Environmental Science Division
Ashley Kling	DFO National Capital Region / Fish Population Science Branch
Julie Richter	DFO National Capital Region / Fisheries Protection Program
Nathalie Simard	DFO Quebec / Demersal and Benthic Science Branch
Renée Bernier	DFO Gulf / Aquatic Ecosystem Section
Dawn Sephton	DFO Maritimes / Ecosystem Research Division (BIO)
Cynthia McKenzie	DFO Newfoundland & Labrador / Ecological Sciences
Andrew Drake	University of Toronto
Marten Koops	DFO Central & Arctic / Great Lakes Laboratory for Fisheries and Aquatics Sciences
Kim Howland	DFO Central & Arctic / Arctic Aquatic Research Division
Mike Bradford	DFO Pacific / Cooperative Resource Management Institute
Sarah Bailey	DFO Central & Arctic / Great Lakes Laboratory for Fisheries and Aquatics Sciences
Claudio DiBacco	DFO Maritimes / Ecosystem Research Division (BIO)
Chris McKindsey	DFO Quebec / Demersal and Benthic Science Branch
Cathryn Clarke Murray	North Pacific Marine Science Organization (PICES)
Michele Pelletier-Rousseau	Université du Québec à Rimouski (UQAR)
Thomas Landry	DFO Gulf / Aquatic Ecosystems Section
Judith Pederson	Oceans at Massachusetts Institute of Technology (MIT)
Lindsay Chadderton	Nature Conservancy
Jim Muirhead	Smithsonian Institute
Brian Leung	McGill University
Bobbi Rees	Government of Newfoundland and Labrador / National Aquatic Invasive Species Committee (NAISC)
Lauren Ellis	DFO National Capital Region / Canadian Science Advisory Secretariat

APPENDIX 2: MEETING TERMS OF REFERENCE

National Risk Assessment of Recreational Boating as a Vector for Aquatic Invasive Species

National Peer Review – National Capital Region

8-11 December 2015
Montreal, QC

Chairperson: Gilles Olivier

Context

Aquatic invasive species (AIS) pose a significant threat to Canadian fresh, estuarine and marine waters. An important vector for the introduction and spread of AIS into and throughout these waters is recreational boating. This meeting is being held to address a request for science advice from the National Aquatic Invasive Species Committee, a federal-provincial-territorial committee that reports to the Canadian Council of Fisheries and Aquaculture Ministers, to assess the risk that the recreational boating vector poses to both freshwater and marine systems in Canada with respect to the introduction and spread of AIS. Fisheries and Oceans Canada (DFO) has held many species-based risk assessment meetings and a few pathway-based risk assessment meetings (DFO 2012a, DFO 2012b, DFO 2014a). This meeting will assess, for the first time, the risk posed by recreational boating as a vector for AIS in both freshwater and marine systems in Canada and will contribute to the overall body of knowledge of AIS pathways and vectors of concern in Canada. Advice generated from this meeting can be used to inform targeted research, the locations and methodology for boater-specific monitoring activities, communication efforts focused towards high-risk users, potential policy/regulatory changes, and the overall management of this vector.

The marine portion of this risk assessment will address risk for the west and east coasts of Canada. Research was conducted on vessel type, maintenance, pathways, transit and mooring days and AIS transfer potential to determine this risk. The freshwater portion of this risk assessment will address the ecological risk in the Great Lakes Basin, with applicability to other large inland lake systems in Canada that support recreational boating activity (e.g., Lake Winnipeg). Research was conducted on the contamination of freshwater vessels with AIS, the spatiotemporal dynamics of vessel transits in the Great Lakes Basin, and the overall probability of spread in the basin as a result of boating activity. The freshwater component will also summarize and assess the current state of knowledge of recreational boating as a vector for AIS, drawing from Canadian and U.S. literature, with applicability for overland lake-to-lake AIS transfers in Canada.

Objectives

The overarching goal of this meeting is to collect and provide scientific advice on the risk that recreational boating, as a vector for the introduction and spread of AIS, poses to Canadian fresh and marine waters.

To accomplish this, three working papers will be peer reviewed at this meeting to ensure they provide adequate and scientifically defensible information on:

1. The risk posed by recreational boating in Canadian marine waters on both the east and west coasts.
    - Characterization of movement patterns of recreational boats in marine waters within and between ecoregions.

- o Estimate potential risk to marine ecoregions considering vessel characteristics, their movements, environmental similarity, and AIS sources.

2. The ecological risk posed by recreational boating in the Great Lakes Basin.
   - o Quantify the characteristics of AIS spread by recreational boats within and among the Great Lakes proper, including an assessment of the relative probabilities of spread and establishment among different ports/marinas supporting boating activity.
   - o Highlight, wherever possible, how results are applicable elsewhere in Canada.

3. The current state of knowledge about the ecological risk posed by recreational boating as a vector of overland AIS movement between inland lakes in Canada.
   - o Examination of risk based on a summary and meta-analysis of Canadian and U.S. literature pertaining to the overland movement of recreational boats to and from freshwater lakes in North America, highlighting how results are applicable to Canada.

Working papers to be reviewed *(due November 13, 2015)*

- WP 1: R. Bernier, C. Clarke Murray, A. Lacoursière-Roussel, J. Martin, C. McKenzie, C. McKindsey, M. Pelletier-Rousseau, D. Sephton, N. Simard, T. Therriault; Marine recreational boating risk assessment.
- WP 2: A. Drake, S. Bailey, and N. Mandrak; Risk assessment of recreational boating activity in the Great Lakes Basin as a pathway for the introduction and spread of aquatic invasive species.
- WP 3: A. Drake; A review of the overland spread of aquatic invasive species in North America as a result of recreational boating, with emphasis on Canadian ecosystems.

Expected Publications

- Science Advisory Report
- Proceedings Document
- 3 Research Documents

Participation

- Fisheries and Oceans Canada: Ecosystems and Oceans Science and Ecosystem and Fisheries Management Sectors
- Experts from provincial government departments and non-governmental organizations
- Academics

References

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APPENDIX 3: MEETING AGENDA

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat (CSAS)
National Science Advisory Process

National Risk Assessment of Recreational Boating as a Vector for Aquatic Invasive Species

Venue: Montreal Marriott Chateau Champlain (Maisonneuve BC, 36th floor)

1050 de la Gauchetière West, Montreal,
Québec, H3B 4C9, Canada, 1-514-878-9000

December 8-11, 2015

Chairperson: Dr. Gilles Olivier

Note: All times tentative and subject to change depending on progress of discussions.

DAY 1 - Tuesday December 8, 2015

Time	Topic
8:30am–9:30am	Welcome and Context (15 minutes) Introduction of participants (5 minutes) **Presentation:** Overview of DFO CSAS advisory process Presenter: Gilles Olivier (15 minutes presentation, 15 minutes questions) Review Terms of Reference (5 minutes) **Time: ~60 minutes**
9:30am-9:45am	**Presentation:** (WP1) National Risk Assessment of Recreational Boating as a Vector for Marine Nonindigenous Species – Background and general approach Presenter: Chris McKindsey **Time: ~15 minutes**
9:45am-10:05am	**Presentation:** (WP1) National Risk Assessment of Recreational Boating as a Vector for Marine Nonindigenous Species – Methods: boat fouling probability Presenters: Nathalie Simard and Cathryn Clarke Murray **Time: ~20 minutes**
10:05am-10:30am	Reviewer comments: Judith Pederson and Brian Leung Discussion, questions and answers: All **Time: ~25 minutes**
10:30am–10:45am	Break

Time	Topic
10:45am-11:15am	**Presentation:** (WP1) National Risk Assessment of Recreational Boating as a Vector for Marine Nonindigenous Species – Methods: introduction potential, NIS novelty and invasion risk Presenters: Nathalie Simard and Chris McKindsey **Time: ~30 minutes**
11:15am-12:00pm	Reviewer comments: Judith Pederson and Brian Leung Discussion, questions and answers: All **Time: ~45 minutes**
12:00pm–1:00pm	Lunch Break (lunch not provided)
1:00pm-1:15pm	*If necessary:* Reviewer comments (continued): Judith Pederson and Brian Leung Discussion, questions and answers (continued): All **Time: ~15 minutes**
1:15pm–2:15pm	**Presentation:** (WP1) National Risk Assessment of Recreational Boating as a Vector for Marine Nonindigenous Species – Risk assessment results Presenters: Nathalie Simard and Cathryn Clarke Murray **Time: ~60 minutes**
2:15pm–2:30pm	Reviewer comments: Judith Pederson and Brian Leung **Time: ~15 minutes**
2:30pm–2:50pm	Break
2:50pm-**5:00pm**	Reviewer comments (continued): Judith Pederson and Brian Leung Discussion, questions and answers, and recommendations: All **Time: ~130 minutes**

DAY 2 - Wednesday December 9, 2015

Time	Topic
8:30am–9:15am	*If necessary:* Discussion, questions and answers (continued from yesterday): All **Time: ~45 minutes**

Time	Topic
9:15am- 9:45am	**Review of day 1 key points and outstanding discussion** Discussion, questions and answers: All **Time: ~30 minutes**
9:45am– 9:55am	**Presentation:** (WP2) Ecological Risk Assessment of Recreational Boating as a Pathway for the Secondary Spread of Aquatic Invasive Species in the Great Lakes Basin – Scope of the model-based risk assessment Presenter: Andrew Drake **Time: ~10 minutes**
9:55am- 10:15am	Discussion, questions and answers: All **Time: ~20 minutes**
10:15am- 10:30am	**Presentation:** (WP2) Ecological Risk Assessment of Recreational Boating as a Pathway for the Secondary Spread of Aquatic Invasive Species in the Great Lakes Basin – Propagule pressure from freshwater recreational boaters trips within the Great Lakes Basin Presenter: Andrew Drake **Time: ~15 minutes**
10:30am– 10:45am	Break
10:45am- 11:15am	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~30 minutes**
11:15am– 11:25am	**Presentation:** (WP2) Ecological Risk Assessment of Recreational Boating as a Pathway for the Secondary Spread of Aquatic Invasive Species in the Great Lakes Basin – Relationship between propagule pressure and probability of establishment Presenter: Andrew Drake **Time: ~10 minutes**
11:25am- 12:00pm	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~35 minutes**
12:00pm– 1:00pm	Lunch Break (lunch not provided)

Time	Topic
1:00pm– 1:20pm	**Presentation:** (WP2) Ecological Risk Assessment of Recreational Boating as a Pathway for the Secondary Spread of Aquatic Invasive Species in the Great Lakes Basin – Overall probability of spread and magnitude of impacts Presenter: Andrew Drake **Time: ~20 minutes**
1:20pm- 2:30pm	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~70 minutes**
2:30pm– 2:50pm	Break
2:50pm– **5:00pm**	Discussion, questions and answers (continued) and recommendations: All **Time: ~130 minutes**

DAY 3 - Thursday December 10, 2015

Time	Topic
8:30am– 9:00am	*If necessary:* Discussion, questions and answers (continued from yesterday): All **Time: ~30 minutes**
9:30am- 10:00am	**Review of day 2 key points and outstanding discussion** Discussion, questions and answers: All **Time: ~30 minutes**
10:00am– 10:10am	**Presentation:** (WP3) A review of the overland spread of aquatic invasive species in North America as a result of recreational boating, with emphasis on Canadian ecosystems – Scope of literature review Presenter: Andrew Drake **Time: ~10 minutes**
10:10am- 10:30am	Discussion, questions and answers: All **Time: ~20 minutes**
10:30am– 10:45am	Break

Time	Topic
10:45am- 11:00am	**Presentation:** (WP3) A review of the overland spread of aquatic invasive species in North America as a result of recreational boating, with emphasis on Canadian ecosystems – History and scale of inland lake invasions due to overland movement of recreational vessels Presenter: Andrew Drake **Time: ~15 minutes**
11:00am– 11:30am	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~30 minutes**
11:30am- 11:45am	**Presentation:** (WP3) A review of the overland spread of aquatic invasive species in North America as a result of recreational boating, with emphasis on Canadian ecosystems – Management implications specific to overland spread Presenter: Andrew Drake **Time: ~15 minutes**
11:45am- 12:00pm	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~15 minutes**
12:00pm– 1:00pm	Lunch Break (lunch not provided)
1:00pm– 1:25pm	Reviewer comments (continued): Lindsay Chadderton and Jim Muirhead Discussion, questions and answers (continued): All **Time: ~25 minutes**
1:25pm- 1:35pm	**Presentation:** (WP3) A review of the overland spread of aquatic invasive species in North America as a result of recreational boating, with emphasis on Canadian ecosystems – Summary of literature review and discussion of outstanding knowledge gaps Presenter: Andrew Drake **Time: ~10 minutes**
1:35pm- 2:00pm	Reviewer comments: Lindsay Chadderton and Jim Muirhead Discussion, questions and answers: All **Time: ~25 minutes**
2:00pm– 2:20pm	Break

Time	Topic
2:20pm–2:50pm	**Review of day 3 key points and outstanding discussion** Discussion, questions and answers: All **Time: ~30 minutes**
2:50pm-**5:00pm**	Re-cap of days 1, 2, and 3 Review of Terms of Reference to ensure all questions answered Drafting of Science Advisory Report (SAR) **Time: ~130 minutes**

DAY 4 - Friday December 11, 2015

Time	Topic
8:30am–10:30am	Drafting of SAR (continued) **Time: ~120 minutes**
10:30am–10:45am	Break
10:45am–12:00pm	Drafting of SAR (continued) **Time: ~75 minutes**
12:00pm–1:00pm	Lunch Break (lunch not provided)
1:00pm–2:00pm	Finalize drafting of SAR Review and endorse summary bullets of SAR Next steps to finalize Research Documents **Time: ~60 minutes**
2:00 pm (approx.)	Conclusion (time approximate)