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Proceedings of the National Peer Review of Ballast Water Exchange Plus Treatment Protocol

February 27–28, 2018
Burlington, Ontario

Chairperson: Gilles Olivier
Editors: Dawson Ogilvie and Sarah Bailey

Fisheries and Oceans Canada
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, Ontario L7S 1A1

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Canada

Foreword

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

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TABLE OF CONTENTS

SUMMARY

In 2010, the Government of Canada proposed that a multidimensional ballast water management strategy, which targets multiple stages of the invasion process by utilizing both ballast water exchange and onboard ballast water management systems, may provide superior protection against the introduction of aquatic invasive species than either strategy could alone in certain aquatic environments. Studies examining this unique invasive species management strategy have shown promising results in freshwater environments, but its effectiveness at a national scale or across different habitats has not yet been evaluated, which is an important step in determining if this strategy should be implemented in Canada.

A draft research document was developed to examine the efficacy of different ballast water management strategies for different shipping pathways across Canada. The objective of this meeting, held February 27-28, 2018, in Burlington, Ontario, was to peer review the research document according to the Canadian Science Advisory Secretariat (CSAS) peer review process and to develop science advice to inform Canadian national shipping regulations. The participants at this peer review meeting included experts from Fisheries and Oceans Canada, Transport Canada, industry, and academia. This document summarizes the discussions that took place during that meeting.

INTRODUCTION

The peer review of the Assessment of the Ballast Water Exchange Plus Treatment Protocol took place in Burlington, Ontario on February 27 and 28, 2018, and provided science advice on a risk assessment model to compare the effectiveness of ballast water exchange plus treatment to conventional ballast water management strategies in Canada.

The peer review meeting commenced with Gilles Oliver, the Chairperson, welcoming the participants and providing an overview of the CSAS peer-review process, guidelines and policies, and the agenda for the first day. Gilles described the terms of reference (Appendix 1), wherein the purpose of the meeting was to provide advice on the performance of exchange plus treatment as a management strategy to prevent the introduction and establishment of aquatic non-native (or harmful) species attributed to ballast water discharge in Canada, by assessing the working research document and drafting a science advisory report. Meeting participants included experts from Fisheries and Oceans Canada (DFO), Transport Canada, Saint Lawrence Seaway Development Corporation, U.S. Environmental Protection Agency, FedNav Ltd., Shipping Federation of Canada and University of Michigan (Appendix 2). The meeting followed the agenda in Appendix 3.

Additional publications from this process will be posted on the DFO Canadian Science Advisory Secretariat website as they become available.

ASSESSMENT OF THE EXCHANGE PLUS TREATMENT PROTOCOL

GENERAL OVERVIEW OF BALLAST WATER MANAGEMENT STRATEGIES

Presenter: Sarah Bailey

Sarah Bailey provided context for the study, describing the significance of ballast water discharge as a pathway of introduction for invasive species and described the invasive species management strategies of ballast water exchange (BWE) and onboard ballast water management systems (BWMS), including their advantages and disadvantages for protecting aquatic ecosystems. Sarah introduced the exchange plus treatment strategy and the logic behind its potential application to prevent ballast water mediated invasions in Canada.

During the general overview, Sarah described two protocols used to perform exchange plus treatment (i.e., exchange-treatment and treatment-exchange-treatment). It was noted by a participant that an additional benefit of the treatment-exchange-treatment protocol is that potentially viable invasive species are not released into mid-ocean ecosystems during ballast water exchange. Furthermore, it was suggested that any preference of ship owners to conduct either of the two protocols should not be assumed.

OBJECTIVE AND METHODS

Presenter: Andrew Drake

Andrew Drake presented the objective of the study, which was to determine the species invasion rate in the event that the exchange plus treatment strategy is implemented in Canada in comparison to other ballast water management strategies. Andrew explained the study area, management scenarios, and shipping pathways used in the study. Then, he provided a general overview of the steps in the risk assessment model used to forecast species establishment rates, including the critical components of the invasion process such as propagule pressure, surviving the environmental conditions upon release in the recipient locality, and establishing a

viable population through adequate reproduction. The role and purpose of each step in the model was also described, followed by the sources of data.

One of the assessed management scenarios applied Regulation D-2 – the ballast water organism discharge limit defined by the International Maritime Organization's 2004 Ballast Water Management Convention – on 50% of ship-trips as a theoretical example of incomplete compliance. A question was raised by one participant regarding how this percentage of ship-trips was chosen. The authors responded by clarifying that this was the observed percentage of voyages where ballast water discharged after treatment by a BWMS did not meet the D-2 standard during preliminary studies conducted by DFO during June–October 2017. The group agreed that the working paper should provide an explanation for the choice of compliance percentage applied. The authors acknowledged that compliance rates may improve in the future as experience is gained with the operation and maintenance of BWMS, and with advancements in associated technologies.

One participant commented that the modelled efficiency of BWE was not explicitly stated in the working paper. The authors agreed to clarify that within the model, it was assumed that BWE was 100% efficient at purging source port organisms and that the total organism abundance in ballast tanks did not change due to exchange.

There were various comments regarding the need to provide more detailed explanations of the shipping pathways used in the study and the rationale to consider only domestic voyages for the Arctic region. The authors stated that domestic voyages were not considered for the other Canadian regions due to operational limitations (e.g., inability to perform BWE during nearshore domestic transits) and that this will be clarified in the research document.

It was requested that a geographical map be provided in the research document that identifies the Canadian regions and ports used in this study; this map should include the four geographical regions as defined in this study (i.e., Pacific Coast, Atlantic Coast, Great Lakes-St Lawrence River, and Arctic regions), and the Canadian ports included in the assessment.

During the overview of the steps in the risk assessment model, comments were made with regards to the difficulty in understanding steps two to five – determination of propagule pressure and identification of the proportion of non-native (or harmful) species on a given trip – especially given the limited explanation about how population densities were determined and species abundance distributions were created. The authors agreed to address these concerns by providing a more detailed explanation of the steps in the research document.

There was also concern that the species abundance distribution was based on proportional data of adults and does not take into account the larval stages which typically cannot be identified to the species level. The authors responded to this concern by stating that this would only affect the study results if the abundance of larval species varies across pathways and agreed to provide an explanation in the research document addressing this issue.

A final question was raised concerning the age of the environmental data used in this study, and the authors agreed to confirm the timeframe of data used in the study.

Statistical distributions of propagule pressure

Presenter: Andrew Drake

Andrew presented an in-depth explanation about how propagule pressure was quantified using statistical distributions and shipping and ballast water sample data.

Multiple questions were raised regarding the data used in this study. First, the source of shipping data was questioned as the number of ship transits for the Arctic pathways appeared

too low, especially for the Arctic domestic pathway; recent Arctic shipping data was offered to be made available to the authors. Second, there were concerns regarding the accurate representation of phytoplankton in this study, due to the inaccessibility and thus exclusion of existing diatom data; help was offered to acquire the missing diatom data. Considering both these concerns, the group questioned if rerunning the model was necessary as it was unlikely that a different outcome would be achieved. It was left to the authors' discretion to address each issue appropriately whether by rerunning the model or acknowledging data gaps. Additionally, dinoflagellate data for the Arctic domestic pathway was also offered to be made available to the authors, but the group decided not to incorporate this data due to the small amount of data that would be added. There was high uncertainty whether the extra effort required would produce meaningful differences in the results.

Environmental distance and survival probability

Presenter: Andrew Drake

Andrew explained how an environmental distance curve was used to determine the probability of survival for each species based on the degree of environmental similarity between ballast source and recipient locations (i.e., water temperature and salinity).

A suggestion was made to change the language for this step in the model, considering that the environmental distance curve reflects species establishment, as well as survival. The authors agreed to make necessary clarifications in the research document.

A further question was raised concerning domestic shipping in the Arctic region, asking how the study addresses the effect of BWE for this pathway since international ships on domestic transits to the Arctic region currently do not perform BWE, while domestic ships do perform voluntary BWE. The authors agreed to confirm how BWE was evaluated for domestic voyages to the Arctic and clarify this in the research document.

Probability of establishment

Presenter: Andrew Drake

The methodology to assess the probability of each species becoming established was explained. Andrew described how the probability that one species becomes established was determined, with the upper limit being set by data from parthenogenetic species, as the first step in quantifying establishment. Then, subsequent steps in the model that consider propagule pressure and shipping activity are used to determine the two metrics of species establishment rates: number of species establishing per year and probability of at least one species establishing per trip.

A participant inquired how the lower limits of the alpha and beta distributions were determined for the probability that a species establishes a viable population. It was explained that the lower limit of establishment for a single species is unknown and, therefore, the worst-case scenario was used as the starting point (i.e., parthenogenetic species). Then, the establishment rates were grounded against data from the Great Lakes, where the values were adjusted through an iterative process to determine the best fit of the distribution. The authors agreed to provide more detailed explanation within the methods of the working paper.

Model simulations and scenarios

Presenters: Andrew Drake and Sarah Bailey

While each model component was described in general in the preceding discussions, time was taken to describe the model simulations and specific management scenarios examined in this study in detail, including the three main components of the model used to estimate the number of species establishing in Canada: quantifying vessel traffic and propagule pressure; determining the survival of propagules in recipient environments; and, quantifying the number of species establishing. The sensitivity analysis that was conducted on the model was also presented.

There were several concerns that the sensitivity analysis did not adequately evaluate the sensitivity of the model to changes in input parameters, and the sensitivity analysis should include more input parameters than were initially used. The authors agreed to run additional sensitivity analyses with consideration to the abovementioned concerns.

RESULTS

Presenters: Andrew Drake and Sarah Bailey

Figures of the results were presented, categorized by region and by port salinity combinations within each region. The regional results were presented using both metrics of establishment (number of species invasions per year and probability that at least one species establishes per trip), whereas the port salinity combinations were presented using only the per-trip metric of establishment rate.

There were questions regarding how to interpret the results and identify meaningful differences among them. The authors explained that traditional statistics are not used to assess significant differences as the results represent the long-run outcomes from 1000 iterations of the model simulation. They stated that results should be interpreted relative to one another with less focus on the absolute values, as there is greater uncertainty about the values than the trends in the results. Furthermore, given the purpose of the study to provide guidance regarding relative differences in establishment risk among management strategies, it is the management groups' responsibility to determine acceptable levels of risk. The authors agreed to explain how the results should be interpreted in the research document.

There was also discussion regarding the best way to standardize the results. One suggestion to standardize the results was to capture a probability value for the percentage of times that one management strategy yielded better results than another. The authors stated that the per trip metric of evaluating establishment rates may already address this recommendation.

It was suggested that the establishment rates of various strategies could be normalized to the baseline scenario, in order to reduce the effect of the small numbers. The group suggested that the results may be easier to interpret if the metrics of establishment risk are presented as the number of species per decade, and the number of trips until one invasion occurs.

Participants raised a concern that the uncertainty associated with the results was not adequately stated within the text of the working paper. The authors acknowledged this concern and agreed to provide additional explanation regarding the uncertainty associated with the results.

A participant suggested that since BWE is currently used in Canada, the exchange-only scenario should be used as baseline upon which the other management scenarios are compared against, in place of the no-management scenario. The group agreed and appropriate changes will be made to the working paper. There was also discussion about the inclusion of

error bars on the graphs, but the group determined that this was not the best course of action as the focus should remain on the expected values.

A participant's recommendation was noted that since each ship-trip is highly variable in terms of the concentration of organisms and probability of species establishment, it should be stated as such in the working paper.

For the purpose of transparency in the methods of the risk assessment, it was requested to include the ship-trip sample size for each pathway in the research document as well as either a species list or a statement that the biological data could be made available upon request.

APPENDIX 1: TERMS OF REFERENCE

Science Advice on Ballast Water Exchange Plus Treatment

National Peer Review – National Capital Region

February 27–28, 2018
Burlington, Ontario

Chairperson: Gilles Olivier

Context

Transport Canada (TC) regulates the ballast water of ships to address the risk that they will introduce and/or spread aquatic invasive species into Canada's waters. Since 2006, TC has required ships to manage their ballast water through exchange (and flushing of residual ballast water), treatment, disposal to a reception facility, or retention onboard. In 2010, Canada acceded to the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (the Convention), which will require ships to transition from ballast water exchange to ballast water treatment to a defined standard (Regulation D-2).

Between 2010 and 2012, in response to requirements in some U.S. jurisdictions for greater protection than offered by Regulation D-2, TC officials and DFO scientists suggested that combining exchange/flushing with ballast water treatment could theoretically increase protection for the environment using existing approved ballast water management systems (BWMS). In a 2012 discussion paper on bringing the Convention into force in Canada, TC referred to this approach as exchange plus treatment (E+T) and proposed applying it to freshwater regions of Canada.

Since then, a number of Great Lakes states have adopted the requirement, as has the U.S. Environmental Protection Agency for ships voyaging to the Great Lakes. In addition, a number of scientific studies have been undertaken to consider any implications of E+T and whether it is effective in practice. TC requires science advice from DFO in the short term to inform a policy recommendation and draft regulations on whether to include E+T in Canadian regulations as TC brings the Convention into force in Canada.

Objectives

The science advice objective is to provide answers to the specific questions posed by the client, Transport Canada, i.e.:

1. What is the recommended protocol for ships to undertake E+T and what is its mechanism of action?
2. When compared with the use of a BWMS, to what extent would E+T reduce the risk that non-indigenous species will arrive and survive in Canada, and what would be the expected reduction in the rate of new establishments?
3. Which Canadian ports would benefit most from a requirement for E+T considering the key factors related to efficacy of E+T (i.e., salinity and temperature)?
4. When compared to the use of treatment alone, how would E+T affect the expected rate of new establishments in the case of ballast water that does not meet the standards in Regulation D-2, for example due to a BWMS failure?
5. What circumstances would justify revisiting this advice in the future?

Expected publications

- Proceedings
- Research Document
- Science Advisory Report

Expected participation

A maximum of number 19 participants had been established for taking part to the peer-review meeting. Participants will be affiliated with the following institutions:

- Fisheries and Oceans Canada
- Transport Canada
- Academics
- Industry
- Shipping industry
- Other institutional representatives:
    - U.S. Naval Research Laboratory
    - National Oceanic and Atmospheric Administration
    - U.S. Coast Guard

APPENDIX 2: LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Sarah Bailey	DFO, Science, Central and Arctic Region
Oscar Casas-Monroy	DFO, Science, Central and Arctic Region
Andrew Drake	DFO, Science, Central and Arctic Region
Charles Laliberté	Transport Canada
Chris McKindsey	DFO, Science, Quebec Region
Claudio DiBacco	DFO, Science, Maritimes Region
Colin Henein	Transport Canada
David Reid	Saint Lawrence Seaway Development Corporation
Gilles Olivier	DFO, Science, National Capital Region
Guglielmo Tita	DFO, Science, National Capital Region
John Darling	U.S. Environmental Protection Agency
Keyvan Abedi	Transport Canada
Kim Howland	DFO, Science, Central and Arctic Region
Marc Gagnon	FedNav Ltd.
Nathalie Simard	DFO, Science, Quebec Region
Paul Mudroch	Transport Canada
Sonia Simard	Shipping Federation of Canada
Tom Johengen	University of Michigan

APPENDIX 3: MEETING AGENDA

Canadian Science Advisory Secretariat (CSAS) Peer Review Meeting on the Assessment of the Ballast Water Exchange Plus Treatment Protocol

Canada Centre for Inland Waters
867 Lakeshore Road, Burlington, Ontario

Library Lounge (L231A)

February 27–28, 2018

Day 1 - Tuesday, February 27

8:30-8:50	Welcome and Introductions
8:50-9:00	Review of CSAS Process and Guidelines (Gilles Olivier)
9:00-9:10	Review of Terms of Reference and Agenda for Day One (Gilles)
9:10-9:30	Background /Context for Ballast Water Exchange Plus Treatment (Sarah Bailey)
9:30-10:15	General Overview: Res Doc Objectives and Methods (Andrew Drake)
10:15-10:30	BREAK (coffee/water provided)
10:30-11:00	Methods: Statistical Distributions of Propagule Pressure (Andrew)
11:00-11:30	Questions/Group Discussion
11:30-12:00	Methods: Environmental Distance and Survival Probability (Andrew)
12:00-13:00	LUNCH (provided)
13:00-13:30	Questions/Group Discussion
13:30-14:00	Methods: Probability of Establishment (Andrew)
14:00-14:30	Questions/Group Discussion
14:30-14:45	BREAK (coffee/water provided)
14:45-15:15	Methods: Model Simulations/Scenarios (Andrew/Sarah)
15:15-15:45	Questions/Group Discussion
15:45-16:30	Summary/Wrap-Up of Day One (Gilles)

Day 2 - Wednesday, February 28

8:30-8:45	Review of Agenda for Day Two (Gilles)
8:45-9:15	Results: By Pathway and Salinity Combination (Andrew/Sarah)
9:15-9:45	Questions/Group Discussion
9:45-10:15	Results: Model Validation and Sensitivity (Andrew)
10:15-10:30	BREAK (coffee/water provided)
10:30-10:45	Questions/Group Discussion
10:45-11:15	Discussion and Conclusions in Res Doc (Andrew/Sarah)
11:15-11:45	Questions/Group Discussion

11:45-12:00	Wrap-Up of Research Document
12:00-13:00	LUNCH (provided)
13:00-14:15	Drafting the CSAS Science Advisory Report
14:15-14:30	BREAK (coffee/water provided)
14:40-16:00	Drafting the CSAS Science Advisory Report
16:00-16:30	Summary/Wrap-Up of Day Two (Gilles)