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Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2022/013

National Capital Region

Proceedings of the National Advisory Meeting on Biofouling as a Vector for Aquatic Invasive Species Introduction

January 11–14, 2022
Virtual Meeting

Chairperson: Karen Smokorowski
Editor: Alex Tuen and Tessa Brinklow

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

May 2023

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

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ISSN 1701-1280
ISBN 978-0-660-48340-5 Cat. No. Fs70-4/2023-013E-PDF

Correct citation for this publication:

DFO. 2023. Proceedings of the National Advisory Meeting on Biofouling as a Vector for Aquatic Invasive Species Introduction; January 11–14, 2022. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2022/013.

Aussi disponible en français :

MPO. 2023. Compte rendu de la réunion sur les avis scientifiques national de L'encrassement biologique comme vecteur à l'introduction d'espèces aquatiques envahissantes; du 11 au 14 janvier 2022. Secr. can. des avis sci. du MPO. Compte rendu 2022/013.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from the Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) National Advisory Review Meeting to assess biofouling as a vector for nonindigenous species (NIS) introduction. This meeting was held virtually January 11–14, 2022. The science advice will inform Transport Canada's development of commercial ship biofouling management policies that will better protect Canadian marine and aquatic ecosystems against aquatic invasive species (AIS).

The conclusions and advice resulting from this meeting are provided in the form of a Science Advisory Report which is available on the CSAS website. The supporting Research Document reviewed and discussed at the meeting is also available on the CSAS website.

INTRODUCTION AND CONTEXT

A Canadian Science Advisory Secretariat (CSAS) National Peer Review Meeting was held virtually January 11–14, 2022 to assess biofouling as a vector for nonindigenous species (NIS) introduction. This meeting provided science advice on the risk assessment model and results used to estimate the risk of biofouling of commercial vessels for the introduction of NIS in Canadian waters.

The Chair provided an overview of the CSAS policies, reviewed the Terms of Reference (Appendix 1) that served as the foundation for this CSAS process, and reviewed the Agenda (Appendix 2). Participants included experts from Fisheries and Oceans Canada (DFO), Transport Canada (TC), academia, and industry members from Canada and the United States of America (Appendix 3).

Transport Canada (the client) provided context for this CSAS process. Under section 190 of the *Canada Shipping Act, 2001*, TC has a mandate to prevent the introduction and spread of aquatic invasive species (AIS) from marine transportation. TC currently fulfills this mandate through its Ballast Water Program (which is well under way with an international convention and domestic regulations) and policy development work on biofouling of vessels over 24 metres (which is in its infancy). Biofouling of vessels 24 meters and under is regulated by DFO under their *Aquatic Invasive Species Regulations*. Presently, measures on the control and management of biofouling of large vessels remain voluntary under the International Maritime Organization's (IMO) 2011 Biofouling Guidelines. There are currently three major gaps that need to be filled to address the issue of biofouling of vessels over 24 metres in Canada:

1. There is currently a lack of domestic policies and measures.
2. Internationally, there is a low level of implementation and awareness of the IMO's biofouling guidelines.
3. There remain significant scientific knowledge gaps, especially in the Canadian context.

TC needs to develop options for a long-term national approach on the control and management of biofouling. In the short-term, TC needs to address scientific knowledge gaps that are limiting its ability to develop and implement evidence-based policies and measures.

As part of TC’s work to fill scientific knowledge gaps on biofouling, TC submitted a CSAS request for science advice in December 2019 with the objective of building on DFO's previous regional risk assessments and recreational boating risk assessment conducted in 2012, 2014, and 2017 to create a national biofouling risk assessment.

Publications resulting from this process will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

EVALUATING BIOFOULING AS A VECTOR FOR NONINDIGENOUS SPECIES INTRODUCTIONS IN CANADA

ARRIVAL STEP – METHODS AND DATA

Presenter: Tessa Brinklow

This presentation provided a general overview of biofouling terminology, and described the risk assessment and model framework. Explanation was given for the various steps of the arrival portion of the model, in terms of ship arrival data and biological data, and the methods used to obtain estimates of organism arrival on ships entering Canadian waters.

One participant raised that the working paper does not capture secondary spread or transfers between Canadian ports. Participants and authors agreed that this will be further clarified in the working paper. Participants also commented that further description of data and methods used was needed. Specifically, requests were made for the addition of details on scaling calculations on fouling data (to the entire ship hull), and how fouling was distributed on the ships (as it is difficult to quantify colonial species into abundance data). Authors later presented the detailed abundance calculations, which accounted for patchiness of biofouling. Authors stated this would be added to the working paper to clarify this step.

The Arctic data was the only data source used to calculate the proportion of nonindigenous species, which was concerning for many participants, as organisms that survive in the Arctic are different from those in other regions. The authors acknowledged this and responded that they would investigate other data sources to obtain a better representation of nonindigenous biofouling species. Authors stated that they will investigate the Canadian Aquatic Invasive Species Network (CAISN) data further to see if they can be used for calculating proportions on a regional-basis, if the methods were the same as the Arctic data.

Many participants raised concerns over how the Species Abundance Distributions (SADs) were created, stating that the use of zooplankton data were not a good proxy for biofouling species. The authors argued that ecological patterns remained the same across different biological communities, regardless of the taxa, and that SADs for biofouling communities would be similar with few abundant and many rare species. The participants were not convinced this would be true, and that biofouling communities would be different. It was decided that alternate methods would be investigated to construct SADs representative of biofouling communities. These alternate methods included investigating the use of a generic SAD (where sensitivity analyses could be conducted on its parameters), as well as exploring data from fouling plates and source ports. The authors stated they would investigate fouling data for use in the analysis to inform generic SADs.

Tunicates were not well characterized in the available data. Alternate data from other sources were not used because they did not quantify colonial species in terms of abundance, and conversion is difficult. The authors offered to include the seachest data for the species that were counted, and to mention that colonial species have been excluded from the analysis. Another uncertainty acknowledged was a limitation in available taxonomic expertise in species identification data.

Participants were concerned that data were pooled across regions to create probability distributions for organism abundance and proportion of NIS. Authors stated that pooling was not ideal but that sample sizes were very low when separating by regions. Authors presented additional plots that showed the regional separation of fouling abundance data with a box and whisker plot. The plots were created from data with low sample sizes, and justify why the data were originally pooled for the analysis. It was agreed that these plots were to be added to the working paper, and that the data would continue to be pooled for the main analysis.

SURVIVAL STEP – METHODS AND DATA

Presenters: Tessa Brinklow and Mohammed Etemad

This presentation provided an overview of the survival step and described the process for environmental matching and environmental distance calculations. The differences were emphasized between the processes used in the survival step for ballast water compared to biofouling. Explanation was given for the methods and results of the feature selection process used to determine the relative importance of ships' prior ports-of-call, which was used to select the last two ports-of-call for the future steps. The presentation concluded with the remainder of

the steps used to assess nonindigenous species survival based on environmental distance from the prior two ports-of-call to the destination.

The authors explained that if the environmental distance between ports-of-call is high, species would have low probability to survive. The authors considered the differential effects that may occur when the last port pair has a high environmental match but the previous pair has low environmental match, and vice versa. Therefore, when there is both low and high match, the survival probability for 50% of species is predicted by the low match, and 50% by the high match. This does not infer the species came from only the last two ports, but that the environmental match with the last two ports can be used to determine the survival of the species assemblage at the recipient Canadian port. This will be clarified in the working paper.

One participant wanted to know the relative contributions of the temperature variables (minimum, mean, and maximum) for calculating environmental distances. They stated that seasonal averages are more predictive than annual averages. The authors agreed to investigate individual variable contribution, and to make adjustments if one variable is not contributing any differences to the environmental distance and probability of survival. Further explanation was given on how both temperature and salinity influence both survival and establishment, but needed to be separated in the model as was done in prior studies. This will be clarified in the working paper as well.

Further clarification of the feature selection process to determine which ports-of-call were most important was given. Participants were not familiar with the methods and wanted additional explanation of the determination that only the last two ports-of-call were important. Authors agreed to add more categories into Figure 5 in the working paper, and expand on the explanation.

There was discussion around the turnover of biofouling from port-to-port, and authors stated that biofouling tends to accumulate cumulatively over time, except when there may be mass die-offs when the ship enters inhospitable environments (such as freshwater). The participant was concerned that if one port was different, then there may be different implications for what can survive long enough and arrive at the destination port. The authors responded that this would be dependent on the organism type, as hard-bodied organisms are more resilient, and duration of stay at the port, and assumptions on duration of stay could not be accounted for. A participant mentioned that new data were available for the ability of soft-bodied and hard-bodied organisms to tolerate and survive in harsh conditions, which will be investigated by the authors.

ESTABLISHMENT AND FINAL PROBABILITY OF INTRODUCTION STEPS – METHODS AND DATA

Presenter: Tessa Brinklow

The term “Introduction” used in the original presentation title was switched to “Establishment” going forward, as agreed on by participants and authors.

This presentation explained the establishment step in the model, including an overview of the establishment equation and salinity matching using environmental data. The final probability of establishment summarized how the model used repeated simulations to generate mean values estimating nonindigenous species establishment.

One participant pointed out that the reason that the biofouling establishment rate in this study is much higher than the establishment rate seen in ballast water risk assessments is because whole ship propagule pressure is used. Prior studies estimated alpha values (the independent probability for a single propagule to establish) using density-based propagule pressure, which aligned with the 2009 mesocosm publication. The authors were careful to acknowledge that the

lack of information has downstream effects on the model. Another participant stated that there is no relationship between propagule pressure and establishment, and it is a difficult relationship to parameterize. It was pointed out that this risk assessment is relative and should not be compared to ballast water, and authors agreed to investigate the effects of using whole ship propagule pressure instead of density-based propagule pressure in the model sensitivity analysis. The Science Advisory Report will include an uncertainty about how biofouling accumulation is more complex than ballast water introductions because of diverse life history stages.

The authors agreed with a suggestion that the salinity match information, which is available as text in the working paper, will also be presented in table form. One participant was unclear about the use of values for freshwater salinity. The authors clarified that the freshwater salinity value of 5.0g/kg used in this study was based on that used in the CSAS National Advisory Meeting on the Evaluation of Existing Risk Assessment Methods for Granting Ballast Water Management Exemptions.

A participant brought up that the Royal Canadian Navy (RCN) data may be useful. With higher level classification, higher level commonality can be used. Authors agreed to investigate this data source to potentially supplement the data used in the model.

RESULTS

Presenter: Tessa Brinklow

This presentation provided the main results of the working paper by showing figures and explaining main findings. The results were summarized in terms of main differences across regions, ship types, and hull and niche areas. Main results were presented using number of unique species establishments per decade (SpPD) metric, which scaled up the yearly number of species establishments to ten years.

Further discussion on scaling and the species establishments per decade metric took place. Participants felt that scaling one year to a decade was unreasonable. Authors stated that this was done to keep consistent with the CSAS National Advisory Meeting on the Evaluation of Existing Risk Assessment Methods for Granting Ballast Water Management Exemptions, and for visual clarity purposes. Authors and participants agreed that scaling up to ten years would not be done, and that species establishments would be kept on a per-year basis in the results, while stating that 2018 was the representative year.

Confusion was voiced over whether or not species identity was used in the analysis. Authors confirmed that species identities were not used, only the number of species and their relative abundances. Concern was raised that the number of species arriving to a port may be overestimated, as repeat species may arrive when ships bring in the same species to a port as prior visiting ships, or that the source pool of species might be used up. The authors stated that the pool of species could be considered infinite, and that the analysis had an identifier where species were tracked. They agreed to clarify this in the working paper, along with assumptions.

Participants requested further breakdown of the results to be included in the working paper, such as the establishment of ship type per region. This information was available to be presented so authors agreed to add it to the paper. Additional information on datasets used in each step was to be added, as well as exploring using different plots for results to give further information on the distribution of the data and to determine if the data were skewed (for example, box plots or violin plots).

Biofouling of both hull and niche areas was acknowledged as serious. The hull had a larger wetted surface area and was more important if commercial vessels travel to the Arctic. Niche

areas were protected and more fouled. The authors agreed to include extra explanations about observations in niche areas and recognize that biofouling can be patchy.

There were further questions around the survival and establishment steps, with a participant wanting to separate the port importance and selection step. Authors explained that these steps are merged in the biological invasion process and they happen at the same time in real life, but that these two steps were separated in the analysis due to the mechanics of the model. The separation of steps in the model would be clarified to avoid confusion with the biological invasion process, as well as separating the explanation of the port selection process.

Questions were raised on the results of the Great Lakes region, where species establishments per year was fairly high, but participants expected these numbers to be relatively lower (compared to coastal regions) based on previous biological studies. The authors acknowledged that this issue had been flagged, and explained that this could be due to the way certain steps were modeled and potentially because of abundance data being pooled across regions. This will be verified when authors examine the differences of separating data by region. They also stated that the abundances were not extremely low in samples from the Great Lakes, and the number will not be zero. They agreed to expand on the discussion to address this, and potentially adjust alpha values more for freshwater recipient ports.

There was further discussion on the use of the last two ports-of-call and importance of the transit between the two ports having an impact on survival. Participants believed that it was important to reflect the biological reality of what biofouling communities are exposed to during the marine transit, so that freshwater to freshwater trips would have poor survival because of the marine transoceanic voyage in between. The authors clarified that there are two types of duration, first at the port of call, and second during transit. The data used in the analysis was incomplete for addition of a duration component to the model, and there was uncertainty on what can inform a short duration compared to a long duration. The participants further asked if transit times can be included for freshwater-marine-freshwater trips. The authors offered to change alpha to reflect transit duration, but were uncertain about changing the resistance and survival factor since the magnitude of change is unknown. The authors offered for this to be incorporated into the sensitivity analysis to explore a measure of resistance to acknowledge variability, but argued that there is not enough information to justify it being added to the main analysis. Participants agreed with this approach.

SENSITIVITY ANALYSIS

Presenter: Tessa Brinklow

This presentation provided an overview of the methods and results of the sensitivity analysis, in terms of the parameters that were altered and the resulting changes to the model. Patterns of changes in certain regions in response to altering certain parameters were indicated in the results table. Overall, parameter changes resulted in very small changes to model results.

Participants felt that a specific species resistance factor should be included in the sensitivity analysis to describe how certain species can endure harsh conditions during short periods. Another recommended factor to include in the sensitivity analysis was the effects of changing the alpha and salinity adjustment, which the authors stated they would address in the working paper and include if there were differences in values.

There was a recommendation to consider transit time in the sensitivity analysis, where alpha would be adjusted for freshwater Canadian receiving ports. This would be done according to the duration of transit as best as it can be addressed, to ensure establishment reflects current knowledge of transits.

FUTURE SCENARIO (OBJECTIVE 2)

Presenter: Jiban Deb

This presentation provided an overview of the methods used to address Objective 2 in the Terms of Reference and described the reasons of not achieving the Objective due to data gaps. Objective 2 originally sought to determine the effect of future changes in shipping activity and temperature on NIS establishment probability via biofouling in Canada, with particular consideration to the Arctic region where greater changes are expected. The suggestions on how to address the Objective were discussed with the known sources of data.

The authors elaborated that the information used was projected from BioORACLE 2.1 layers. The layers were only for marine, and at one coarse resolution (five square kilometers) suitable for working at a global scale. Fine resolution was needed for salinity. The coarse resolution meant that a grid cell with a marine port of interest may include the land adjacent to that port. One solution suggested was to select the nearest all-water grid and acknowledge this choice in the text. However, this would not resolve the river ports. Riverine data could be rebuilt the same way, but it is a big job to do meaningfully. There was no proposed solution to address freshwater ports. There were discussions around the validity of using air temperature or land temperature, but there was uncertainty around these metrics as they do not relate to benthic water temperature.

MODELLING FUTURE DISTRIBUTIONS OF SHIP-MEDIATED AQUATIC INVASIVE SPECIES

Presenters: Kim Howland, Jesica Goldsmit

This presentation covered the potential future risks associated with ship-mediated biofouling species with a focus on the Arctic region. Traffic in the Arctic is affected by sea ice, increased resource extraction, and tourism. This provided some additional context for Objective 2 in the Terms of Reference.

Brief discussion centered around how to respond to Objective 2 based on current knowledge, and what work could be conducted in the future to address Objective 2.

EXPECTED PUBLICATIONS AND NEXT STEPS

Participants collaborated in real time on the draft Summary Bullets for the Science Advisory Report. A Bullet was created to accurately capture the inability to currently achieve Objective 2 in this CSAS process and what could be done in the future to address this Objective. Participants expressed consensus on all Bullets.

Participants had been asked to provide their comments on the draft uncertainties and other considerations. The comments were compiled and further refined collaboratively in real time, and will be captured in the Science Advisory Report.

The methods workflow was presented again, this time noting the changes that had been proposed and discussed during the CSAS process. The workflow will be included in the working paper. Participants agreed to upgrade the working paper to a Research Document.

The Science Advisory Report and working paper will be finalized based on participants' feedback during this CSAS process. The model will be revised and presented in these documents so participants can review the updated draft documents against the Summary Bullets that received consensus during this CSAS process. The authors sought to provide the participants with the updated drafts around the end of March 2022.

APPENDIX 1: TERMS OF REFERENCE

Biofouling as a Vector for Aquatic Invasive Species Introduction

National Advisory Meeting – National Capital Region

January 11-14, 2022
Virtual Meeting

Chairperson: Karen Smokorowski

Context

A series of regional risk assessments conducted by Fisheries and Oceans Canada (DFO) between 2012 and 2014 identified biofouling (i.e., the accumulation of living biological material on underwater ship surfaces) as a vector for the introduction of aquatic nonindigenous species (NIS), posing a threat to Canadian marine and freshwater ecosystems. Fisheries and Oceans Canada is mandated under the *Fisheries Act* to protect fish and fish habitat, including the prevention and management of aquatic nonindigenous species (i.e., species not native to the receiving water body) and invasive species (i.e., those NIS likely to cause harm). Meanwhile, Transport Canada (TC) regulates shipping activities under the *Canada Shipping Act, 2001* and is responsible for preventing the introduction and spread of aquatic invasive species (AIS) by ships (i.e., through ships' ballast water and biofouling). During the last 15 years, TC has worked collaboratively with DFO to develop science-based policies and regulations to effectively manage ballast water. More recently, these efforts have expanded to include ship biofouling. To support these regulatory efforts, DFO research often focuses on examining the probability of establishment of species that are nonindigenous to the receiving environment, since the magnitude of impact or invasiveness may be unknown or difficult to predict, particularly when hundreds to thousands of species may be transported.

Transport Canada is requesting science advice from DFO to inform the development of commercial ship biofouling management policies that will better protect Canadian marine and aquatic ecosystems against AIS. Specifically, DFO is asked to conduct an updated national assessment of the probability of NIS introduction through biofouling, incorporating methods advanced during the last decade for assessment of ballast water risk. Throughout this assessment, probability of NIS introduction is used as a measure of potential 'risk', as species may be introduced that are yet to be identified as AIS. The term introduction is used to define the end-result of a species that has successfully arrived, survived, and established in Canadian waters. This assessment will include an examination of the potential for introduction of NIS through biofouling along domestic and international commercial shipping pathways, across Canadian freshwater and marine ports.

Objectives

The objective of this science advisory process is to build on previous DFO regional risk assessments for ship-mediated introductions of aquatic NIS conducted in 2012 and 2014 (Bailey et al. 2012; Chan et al. 2012; Adams et al. 2014; Linley et al. 2014), in view of creating a comprehensive National Biofouling Risk Assessment using best available science. This process will advance the national risk assessment by incorporating new data and modeling methods, to determine:

1. What are the probabilities of arrival, survival, and establishment of biofouling NIS posed by domestic and international commercial ships at freshwater and marine ports and anchorages, considering different operational and/or route characteristics (e.g., long stay vs. short stay) and additional factors identified in the scientific literature that could be used to predict probability of introduction of NIS by biofouling; and

2. What effect will forecasted changes in shipping activity (as provided by TC) and temperature (as predicted by climate change model(s)) have on the probability of introduction of NIS by biofouling to freshwater and marine ecosystems of Canada (in particular, to the Arctic and other waterways where greater changes are expected)?

Expected Publications

- Research Document
- Science Advisory Report
- Proceedings Document

Expected Participation

- Fisheries and Oceans Canada
- Transport Canada
- Department of National Defence
- Industry
- Academia
- International Experts

References

Adams, J.K., Ellis, S.M., Chan, F.T., Bronnenhuber, A.G. Doolittle, J.E., Simard, N., McKenzie, C.H, Martin, J.L., and Bailey, S.A. 2014. Relative risk assessment for ship-mediated introductions of aquatic nonindigenous species to the Atlantic Region of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/116. v + 403 p.

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Linley, R.D., Doolittle, A.G., Chan, F.T., O'Neill, J., Sutherland, T. and Bailey, S.A. 2014. Relative Risk Assessment for ship-mediated introductions of aquatic nonindigenous species to the Pacific Region of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/043. v + 208 p.

APPENDIX 2: AGENDA

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

Biofouling as a Vector for Aquatic Invasive Species Introduction

AGENDA

MS Teams: January 11-14, 2022, 10:30 a.m. - 12:30 p.m. and 1:30 - 3:30 p.m. daily EST.

Chairperson: Dr. Karen Smokorowski

DAY 1		
Time	**Tuesday January 11, 2022**	**Lead**
10:30-11:10	○ Introduction of participants ○ Housekeeping notes ○ Introduction to the CSAS advisory process	Chair and All
11:10-11:25	○ Transport Canada - context for the request for science advice	Marie-Claude Lanouette
11:25-11:30	Review Terms of Reference including the overview of goals and objectives of meeting Objectives: 1) What are the probabilities of arrival, survival, and establishment of biofouling NIS posed by domestic and international commercial ships at freshwater and marine ports and anchorages, considering different operational and/or route characteristics (e.g., long stay vs. short stay) and additional factors identified in the scientific literature that could be used to predict probability of introduction of NIS by biofouling; and 2) What effect will forecasted changes in shipping activity (as provided by TC) and temperature (as predicted by climate change model(s)) have on the probability of introduction of NIS by biofouling to freshwater and marine ecosystems of Canada (in particular, to the Arctic and other waterways where greater changes are expected)?	
11:30-11:35	5 minute health break	
11:35-11:50	○ *Presentation: Arrival step - methods and data*	Tessa Brinklow
11:50-12:30	○ Discussion	All

DAY 1		
Time	**Tuesday January 11, 2022**	**Lead**
12:30-1:30	Break	
1:30-1:45	○ *Presentation: Survival step - methods and data*	Tessa Brinklow, Mohammad Etemad
1:45-2:30	○ Discussion	All
2:30-2:35	5 minute health break	
2:35-2:50	○ *Presentation: Establishment and Final Probability of Introduction steps - methods and data*	Tessa Brinklow
2:50-3:30	○ Discussion	All

DAY 2		
Time	**Wednesday January 12, 2022**	**Lead**
10:30-11:10	○ Re-cap of day 1 ○ Review of SAR bullets captured from Day 1	Chair All
11:10-11:15	5 minute health break	
11:15-11:45	○ *Presentation: Results – Arrival, Survival and Establishment steps (Objective 1)*	Tessa Brinklow
11:45-12:30	○ Discussion	All
12:30-1:30	Break	
1:30-2:00	○ Results discussion continued	All
2:00-2:30	○ *Presentation: Sensitivity analysis* ○ Discussion	Tessa Brinklow All
2:30-2:35	5 minute health break	
2:35-3:30	○ Discussion and drafting SAR bullets, Objective 1	All

DAY 3		
Time	**Thursday January 13, 2022**	**Lead**
10:30-11:00	○ Re-cap of Day 2 ○ Review of SAR bullets captured from Day 1-2	Chair All
11:00-11:15	○ *Presentation: Future scenario (Objective 2)*	Tessa Brinklow, Jiban Deb
11:15-11:20	5 minute health break	
11:20-11:35	○ *Presentation: Modelling future distributions of ship-mediated aquatic invasive species*	Kim Howland, Jessica Goldsmit
11:35-12:30	○ Discussion – How to respond to Objective 2 based on current knowledge?	All
12:30-1:30	Break	
1:30-2:30	○ Discussion – What work could be conducted in the future to address Objective 2?	All
2:30-2:35	○ 5 minute health break	
2:35-3:30	○ Draft SAR bullets from Day 3	All

DAY 4		
Time	**Friday January 14, 2022 (if needed)**	**Lead**
10:30-11:30	○ Re-cap of Day 3 ○ Review of SAR bullets captured from Days 1-3	Chair All
11:30-11:35	○ 5 minute health break	
11:35-12:30	○ Continue drafting Science Advisory Report, including uncertainties and other considerations	All
12:30-1:30	Break	
1:30-3:30	○ Complete drafting Science Advisory Report ○ Wrap Up/Next Steps ○ CSAS meeting ends	All

Note: This meeting was originally scheduled to take place January 10 to 14, 2022, however, the fifth day was not needed, so January 10 was removed from the agenda.

APPENDIX 3: LIST OF PARTICIPANTS

Name	Affiliation
Ashton, Gail	Smithsonian Environmental Research Center
Bailey, Sarah	Fisheries and Oceans Canada
Brinklow, Tessa	Fisheries and Oceans Canada
Deb, Jiban	Fisheries and Oceans Canada
DiBacco, Claudio	Fisheries and Oceans Canada
Drake, Andrew	Fisheries and Oceans Canada
Eliot, Matthew	Transport Canada
Etemad, Mohammad	Fisheries and Oceans Canada
Giroux-Bougard, Katherine	Transport Canada
Goldsmit, Jesica	Fisheries and Oceans Canada
Grey, Erin	University of Maine
Hill, Jaclyn	Fisheries and Oceans Canada
Howland, Kimberly	Fisheries and Oceans Canada
Koops, Marten	Fisheries and Oceans Canada
Lakhal, Ouafae	Transport Canada
Lanouette, Marie-Claude	Transport Canada
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Mckindsey, Chris	Fisheries and Oceans Canada
Michaud, Daniel	Transport Canada
Scianni, Chris	California State Lands Commission
Smokorowski, Karen	Fisheries and Oceans Canada
Tita, Guglielmo	Fisheries and Oceans Canada
Tuen, Alex	Fisheries and Oceans Canada
Valenta, Adam	The Department of National Defence and Canadian Armed Forces