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Pacific Region

Proceedings of the Pacific regional peer review on evaluation of methods for identification of early detection monitoring sites for invasive European Green Crab in the Salish Sea, British Columbia

Meeting dates: January 31 – February 2, 2022
Location: Virtual Meeting

Chairperson: Sophie Foster
Editor: Jill Campbell

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

July 2022

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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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on January 31 – February 2, 2022 via the online meeting platform Zoom. The working paper presented for peer review focused on developing a multi-model ensemble to identify priority sites for invasive European Green Crab (EGC) early detection/monitoring in Canadian waters of the Salish Sea.

Due to the COVID-19 pandemic, in-person gatherings have been restricted and a virtual format for this meeting was adopted. Participation included DFO Science, Fisheries Management, and Aquatic Invasive Species Management staff as well as representatives with relevant expertise from First Nation governments, environmental non-governmental organizations, and academia.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to the DFO Aquatic Invasive Species Management program to inform EGC management in the Salish Sea and contribute to DFO's international commitment related to the Bilateral EGC Action Plan.

The Science Advisory Report, Proceedings and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat website.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) was held on January 31 – February 2, 2022 via the online meeting platform Zoom to review the working paper on developing a multi-model ensemble to identify priority sites for European Green Crab (EGC) early detection/monitoring in Canadian waters of the Salish Sea.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from the DFO Aquatic Invasive Species Management program. Invitations to the science review and conditions for participation were sent to DFO Science and Fisheries Management staff as well as representatives with relevant expertise from First Nation governments and organizations (Pacheedaht First Nation, Maanulth First Nations, Toquaht First Nation, Council of the Haida Nation, and Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations, and Q'ul-lhanumutsun Aquatic Resources Society), Parks Canada, Province of BC, environmental non-governmental organizations, and academia.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting (working paper abstract provided in Appendix B):

> Howard, B.R., Davis, A., Gale, K.S.P., Lyons, D.A, DiBacco, C., Grason, E., McDonald, P.S., Green, S., and Therriault, T.W. Evaluation of Methods for Identification of Early Detection Monitoring Sites for Invasive European Green Crab in the Salish Sea, British Columbia. CSAS Working Paper [2018FFHPP02]

The meeting Chair, Sophie Foster, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report, Proceedings, and Research Document), and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working paper, written reviews, and agenda.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying Jill Campbell as the Rapporteur for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 21 people participated in the RPR (Appendix D).

Participants were informed that Cynthia McKenzie (Fisheries and Oceans Canada) and Nicola Smith (University of British Columbia) had been asked before the meeting to provide detailed written reviews for the working paper to facilitate the peer-review process.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to the DFO Aquatic Invasive Species Management program to inform EGC management in the Salish Sea and contribute to DFO's international commitment related to the Bilateral EGC Action Plan. The Science Advisory Report, Proceedings and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat website.

GENERAL DISCUSSION

Following a presentation by the authors, the reviewers, Cynthia McKenzie (Fisheries and Oceans Canada) and Nicola Smith (University of British Columbia), shared their comments and questions on the working paper. The authors were given time to respond to the reviewers before the discussion was opened to all participants. This proceedings document summarizes the discussions that took place by topic, where points of clarification presented by the authors in their presentations and questions and comments raised by the reviewers and participants are captured within the appropriate topics.

INTRODUCTION TOPICS

Paper title

Participants requested the title of the paper be altered to emphasize that these models were evaluated based on habitat suitability only rather than the various vectors of EGC invasion. The authors will change the title to “Evaluation of Methods for Identification of Early Detection Monitoring Sites *based on Habitat Suitability* for Invasive European Green Crab in the Salish Sea, British Columbia”.

Additional background information

Participants requested additional information on the various invasion dynamics, mechanisms, and vectors including information on locations of potential source populations. The authors will add brief context on invasion vectors, but will clarify that these models and applications are exposure-independent (i.e., the mechanism of invasion/transport is not relevant).

Participants requested background information on the impact of native predator species on the colonization of EGC. The authors will add text to address this, including information on habitat use (e.g., salinity preferences) of native crab species and EGC.

A participant suggested using information on the distribution of indicator species to identify suitable locations of EGC. The authors indicated that there was limited data on the distribution of these other species and that this ask is out of the scope of this work. Another participant indicated that the Washington Sea Grant volunteers do collect data on other species and additional habitat elements.

METHOD CONCERNS

MaxEnt model

A reviewer asked for clarification on the location of the sea surface temperature (SST) and salinity observations in relation to the sites. They were concerned that these observations were coming from some distance away from the shore and therefore may not accurately reflect the conditions at each specific site. The authors indicated that these observations are collected within 1km of each site and are considered relatively accurate. The authors will clarify this in the paper. A reviewer was also concerned with how the coast-wide SST and salinity rasters in the MaxEnt model were applied at the site level. The authors indicated that the MaxEnt raster values (calculated over a 100m scale) were averaged over the site polygons (which vary in size). The authors will clarify this in the paper and emphasize the potential concern over differences in scale between MaxEnt model inputs and site size. Additionally, a reviewer was unclear why a 100 meter depth limit was used to calculate the rasters since EGC are considered to inhabit primarily intertidal habitats. The authors said they used this model domain

to ensure they did not exclude habitat, and that EGC have been found down to 10m depths. The authors will clarify the rationale for the model domain depth boundary in the paper.

A reviewer indicated that salinity impacts the life stages and sexes of EGC differently and was concerned that the model is not accounting for this. The authors responded that the model was designed to predict for established adult EGC populations. The authors will add background context regarding the impact of salinity on life history and male and female habitat suitability and use.

Reviewers indicated that multiple genetic lineages have complicated the ability to monitor the invasion of EGC in other regions and wondered if that was a concern in the Pacific. The authors indicated that genetic testing has been done often and it appears there is only one lineage on the West Coast. The authors will clarify this in the paper and indicate a potential uncertainty is the emergence of other lineages, potentially rendering the models unable to predict suitable habitat accurately in this region.

Participants asked for clarification around how the MaxEnt model is discussed with respect to accurately identifying sites with EGC detections. They noted that the MaxEnt model indicates the Salish Sea is poor habitat for the establishment of EGC as it is too fresh and warm. A participant proposed that if the MaxEnt model indicates EGC will be unlikely to establish at certain sites, that there is little justification in monitoring for them there, even if detections occur. The authors indicated there is still value in monitoring for EGC at sites not identified as high likelihood in the MaxEnt model and participants added that they often observe crabs in areas of low salinity. The addition of text in the introduction discussing EGC salinity tolerances over their life history and the relationship between EGC and native crab predators in the Salish Sea will add clarity. As well, an author indicated that the lower rank quantiles may identify sites where EGC are anticipated to invade, but not necessarily establish. The authors will add text to clarify that combining the five independent methods represents multiple stages of colonization.

Gradient boosted regression tree models (BRT)

The inputs into the BRT models were unclear. This information is captured in Table 5, but was not correctly referenced in the methods section text for this model. The authors will ensure this table is properly referenced.

The authors used the term ‘hyper-abundant’ to refer to sites in the training data with high abundances of EGC. A reviewer was unclear about what this term meant and how many crabs it was referring to. The authors will remove this term.

Rapid site selection tool (RSS)

A reviewer was concerned with the approach of removing sites that are not close to freshwater inputs as EGC are sometimes found in areas with no freshwater inputs. The authors will clarify the purpose of this filtering step is to remove any obviously unsuitable sites.

Washington Sea Grant site selection tool (WSG)

A participant was concerned that this tool has an element of assessor subjectivity. The authors indicated that the tool was developed for use by an expert or by someone trained to apply the tool following standard protocols (e.g., volunteers, other practitioners). The authors will clarify that only one person assessed the 447 Salish Sea sites so the amount of inter-assessor variability was reduced in this application, however this is a factor that will need to be taken into account for any future applications.

Method validation

The participants requested clarity around how each of the five independent methods was validated. The authors clarified the process for each method, indicating that once the derived methods were generated or ensemble approaches were taken that no further validation steps were conducted. The authors will clarify how each method was validated in the text and will add subheadings under each method description to make the validation approaches clear.

There was significant discussion around how the MaxEnt and BRT models were validated using the very limited and spatially clumped Salish Sea EGC observation data set. The purpose of this validation was to determine if the MaxEnt and BRT models could predict the locations where EGC have been observed, had these models been developed prior to the invasion. However, these models focus on predicting where established populations are likely to occur and their utility in predicting locations of early invasions was questioned. Participants were concerned that the invasion is in the early stages in the Canadian side of the Salish Sea and some of the observations do not represent established populations, just stochastic observations. Therefore, this data set is uninformative for model validation. Many thought this section was given too much weight in the paper. Various solutions were discussed, such as: changing the term ‘validation’ to ‘test’, adding more cautionary language around what this validation does and does not inform, adding data from the West Coast of Vancouver Island, Kyuquot Sound, Haida Gwaii, and/or the Washington side of the Salish Sea to increase the number of observations, or adjusting some of the figures (Figs 18 to 20) to address some of the caveats of the validation data. However, the authors indicated there is no truly independent data set with available data layers for all the methods. As well, there is no good way to test the methods until the invasion is complete. The challenge with the validation of the MaxEnt and BRT models is also complicated by the fact that these models predict possible locations of established populations, while the RSS and WSG tools predict sites that have suitable habitat to support initial invasions. The group decided the best course of action is to remove the validation section that used the Salish Sea observations entirely. The authors will indicate that model validation is important future work, and that if data layers are available for other areas (e.g., Haida Gwaii or Central Coast) that the MaxEnt and BRT models may be tested there, however, some of the underlying challenges will remain and ultimately this work is out of scope. The authors will add a column to Table 5 indicating model resolution and the time scale these methods are calculated over (e.g., beach width is likely to change over much longer time scales than temperature).

Isolation terminology

The term isolation refers to different things in the BRT models versus the WSG tool which caused confusion among participants. The authors will change this term to ‘inlet length’ in the BRT model description and to ‘refuge’ in the WSG tool description. Under the linear BRT model, longer inlet lengths tend to concentrate EGC abundances, under the logistic BRT model, longer inlet lengths make it more difficult for EGC to access and invade, and in the WSG, refuge refers to restricted oceanographic connectivity, less predators, and higher larval retention. The WSG tool was designed to be used in Puget Sound and the habitat types there differ from those found on the Canadian side of the Salish Sea. Additional references may be needed to put these terms into context. Further clarification will be added to the paper to discuss these points.

Site size

A participant indicated that the size of the sites varies and that this may have implications for how managers choose to monitor those sites. The authors will add text to the paper to indicate this concern.

Derived methods

A participant was unsure how the derived methods were calculated and what the output of the derived methods means in biological terms. The authors indicated that the outputs from the five individual methods were multiplied and that the outputs from some of the derived methods do not have a biological basis or interpretation. There were additional concerns on the utility of these methods as the derived methods did not appear to improve the results compared to the independent methods. The derived methods will remain in the paper, however, they will be removed from the ensemble approach.

Ensemble approach

The authors will clarify the terms individual methods, derived methods, and ensemble approach in the paper.

A reviewer indicated that the correlation plot, Figure 17, is overly confusing and that Table 6 is just as useful in telling the story that each model is predicting different things, which then leads into the discussion about the purpose behind the ensemble approach. The authors will remove the correlation plot and will clarify the text to better emphasize why an ensemble approach was taken.

In the working paper, the authors present three ensemble approaches, combining the outputs of the individual and derived methods using a Mode, Union, or Intersect approach. As discussed above, the derived methods will be removed from the ensemble approach. A participant indicated that each ensemble approach would have management implications. The Union approach would be the most inclusive, potentially including sites that have less agreement among the five individual methods in terms of identifying suitable habitat. Whereas the Intersect approach may be too limiting of potentially suitable sites if not all individual five methods agree on habitat suitability. The Mode was decided to be better option of the three. This approach encourages agreement among individual methods with respect to site habitat suitability, but will not generate an overly large list of sites that may be difficult for managers to monitor. The authors will address the utility of the Union and Intersect approaches in the text, but will not provide the results from those ensemble approaches.

The 80^{th} and 60^{th} percentiles (ranks) will be used in the Mode ensemble approach to generate lists of sites. This will allow managers to adjust the level of risk to suit their monitoring objectives.

ADVICE TO MANAGERS

Presentation of advice

In the working paper, the authors presented a framework for managers to use to identify sites based on the number of sites managers have the capacity to monitor. Participants found this framework to be confusing and not overly informative. It was unclear which combination of methods should be used to identify sites, which sites should be monitored, and which sites had the highest likelihood of EGC invasion. The authors indicated that it is difficult to determine the top priority sites since each individual method produces output based on different aspects of EGC physiology and habitat usage. The authors did not want to be prescriptive in their advice, however it was determined that the advice they provided in the working paper did not go far enough to support managers in interpreting the ensemble approach outputs. Various options were discussed to improve the framework. A reviewer suggested managers assess their level of risk (the quantile's included in the ensemble approach) first, rather than the number of sites they would like to monitor. The group decided to present the ensemble approach using the Mode of

combinations of 5, 4, and 3 of the individual methods for both the 80th and 60th percentile ranks. Since the advice to managers is now more focused, the framework will be removed from the paper.

Clarification on model results

Participants indicated more clarity was needed on what the five individual methods and ensemble approach results do and do not address and what factors were not included in the methods. Some of the factors raised were extreme events (e.g., heat waves), seasonality, and invasion or spread mechanisms. The authors addressed some of these concerns in their presentation and this information will be added to the paper.

Alternative factors for site selection

Participants identified a suite of factors other than EGC habitat suitability that may need to be considered when choosing sites to monitor. These factors included site accessibility and site size, ecological, economic, and cultural factors, local knowledge, presence of prey/absence of predators, and sources of potential anthropogenic introductions. Consideration of these factors in site selection is outside of the scope of this work, however authors will indicate in the paper that managers may choose to prioritize or add sites based on these or other factors.

A participant was concerned that managers may need to evaluate the model outputs of all the 447 sites, but was unclear if this output would be included in the paper. They were concerned that if they had inquiries into the value of sampling at a site not identified in the Mode ensemble site list, that they would not have the information they need. The authors indicated that the appendix will list each site with each model output. The authors did indicate, however, that if the site was not one of the 447 Salish Sea sites, there would be no model outputs for that location.

Future applications

Based on participant feedback, the authors will add a section to the paper that will guide managers on how to apply this methodology in future applications. The authors will indicate the type of data inputs required for each individual method and how to develop these methods if the data do not already exist for their area of interest. The authors will indicate that if managers do not have the data to support all five independent methods, that they will still be able to go through an ensemble approach using fewer methods (i.e., whichever is available). The authors will include a table indicating the pros and cons of each model type to assist managers in developing their application of this work.

FUTURE WORK RECOMMENDATIONS

Participants identified the impact of anthropogenic vectors (e.g., vessels, gear, harbours, etc.) on EGC establishment be considered. The authors indicated that this is out of scope, however they do not think human-mediated invasions are the primary source of the observations in the Salish Sea data set, rather that EGC larvae are coming from the West Coast of Vancouver Island or potentially from Puget Sound. Anthropogenic vectors are factors managers can consider when filtering sites identified by the ensemble approach. As more data become available, anthropogenic vectors may be addressed in future work.

Climate change, heat waves, interannual variation, and their impacts on EGC establishment and colonization were also identified as areas of important future work. It appears that short term stochastic events may facilitate invasions into new areas and as climate change progresses, these types of events are anticipated to occur more frequently. Climactic variation is likely to affect the MaxEnt model more than the other four methods. The authors indicated work is

currently being done on interannual climactic variability which may make MaxEnt models more informative in the future. The authors also indicated that predicting EGC abiotic suitability using extreme year conditions was not done due to time constraints, but may be valuable future work.

Developing methods to properly validate the MaxEnt and BRT models would be valuable future work, provided the data are available to do so.

CONCLUSIONS

Meeting participants agreed the working paper satisfied the Terms of Reference. Recommended monitoring sites identified in objective 3 were based on an integrated assessment of habitat suitability for EGC as evaluated in objective 1. Although beyond the scope of the current study, it is important to note that other factors such as propagule pressure should be considered when identifying specific monitoring sites. Discussion of this at the meeting led to the change in title of the study to specify "based on habitat suitability". The working paper was accepted with minor revisions.

ACKNOWLEDGEMENTS

We appreciate the time contributed to the RPR process by all participants. In particular, we thank the reviewers, Cynthia McKenzie (Fisheries and Oceans Canada) and Nicola Smith (University of British Columbia) for their time and expertise. We also thank Sophie Foster as Chair of the meeting and Jill Campbell as the Rapporteur.

APPENDIX A: TERMS OF REFERENCE

EVALUATION OF METHODS FOR IDENTIFICATION OF EARLY DETECTION MONITORING SITES FOR INVASIVE EUROPEAN GREEN CRAB IN THE SALISH SEA, BRITISH COLUMBIA

Regional Peer Review – Pacific Region

January 31st to February 2nd, 2022
Virtual meeting

Chairperson: Sophie Foster

Context

The European Green Crab (EGC) is a high risk invader that is listed as a Control Species under the Aquatic Invasive Species (AIS) Regulations in the *Fisheries Act*. EGC can devastate aquatic ecosystems, displacing native species, degrading and disturbing native habitats (including eelgrass), and altering food webs. Thus, early detection is essential to inform AIS management. However, where to focus limited monitoring resources is an ongoing problem, especially for areas where EGC have only recently been detected such as the Salish Sea. EGC populations are well established on the west coast of Vancouver Island and in Sooke Basin but several detections have occurred recently in other parts of British Columbia (BC), including the Salish Sea.

To better understand the incursion of EGC into the Salish Sea, Fisheries and Oceans Canada's (DFO's) Ecosystem Management Branch (EMB) and DFO Science AIS programs worked with the Washington Department of Fish and Wildlife, Washington Sea Grant's Crab Team, and University of Washington to develop a Salish Sea Transboundary Action Plan for Invasive European Green Crab. This plan lays out early detection (monitoring) recommendations but doesn't specify how to identify or prioritize intertidal sites for EGC monitoring. Additionally, DFO's Aquatic Invasive Species National Core Program has been working to develop a monitoring program for the early detection of EGC throughout coastal BC, with a focus on the Salish Sea. Given the extreme spatial extent to be monitored, efforts must involve citizen science and Indigenous groups focusing on sites most likely to have EGC. Thus, prioritized monitoring sites for EGC in Canadian waters of the Salish Sea are urgently needed and the approach could be extended to other coastal areas in the future.

A variety of methods have been implemented by different users to identify suitable habitat for EGC at a range of spatial scales, but the outputs have not been evaluated in the context of EGC management nor for the Canadian portion of the Salish Sea specifically. Habitat suitability models have been developed for EGC along the west coast using MaxEnt, stochastic gradient boosted regression and classification models, and a qualitative site assessment and ranking tool (developed by the Washington Sea Grant Crab Team), all of which rely on different inputs and generate different response variables. Further, DFO Science developed a rapid site selection tool based on beach locations and habitat characteristics believed to be influencing invasion success. Each of these models will be evaluated to provide recommendations for EGC trapping sites in the Salish Sea. This will fulfil a need identified by Fisheries and Oceans Canada (DFO) AIS Management program and the assessment and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) will be used to inform EGC management in the Salish Sea and contribute to DFO's international commitment related to the Bilateral EGC Action Plan.

Objectives

The specific objectives of this review are to:

1. Evaluate the strengths/weaknesses associated with four different methods of assessing habitat suitability for EGC, for the purpose of identifying potential monitoring sites in Canadian waters of the Salish Sea. Specifically reviewing: 1) MaxEnt; 2) Stochastic gradient boosted regression and classification models; 3) Washington Sea Grant's Crab Team's site assessment tool; and 4) DFO Science's rapid site selection tool.
2. Identify uncertainties in each of the tools evaluated in Objective 1.
3. Identify sites for EGC monitoring in Canadian waters of the Salish Sea using the preferred method(s) evaluated in Objective 1.
4. Characterize the feasibility of using the preferred method(s) to identify potential monitoring sites throughout coastal BC in the future.

Expected Publications

- Science Research Document
- Proceedings Document
- Science Advisory Report

Expected Participation

- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science, Ecosystems Management and Fisheries Management)
- Parks Canada
- Province of BC
- Environmental Non-governmental Organizations (Coastal Guardian Watchmen, World Fisheries Trust)
- Academia (University of Alberta, University of Washington, Simon Fraser University)
- Indigenous Organizations: Q'ul-lhanumutsun Aquatic Resources Society, Pacheedaht First Nation, Maanulth First Nations

APPENDIX B: WORKING PAPER ABSTRACT

The European Green Crab (EGC) is a high risk invader that can devastate aquatic ecosystems by displacing native species, degrading and disturbing native habitats (including eelgrass), and altering food webs. Thus, early detection is essential to inform aquatic invasive species (AIS) management. However, where to focus limited monitoring resources is an ongoing problem, especially for areas where EGC have only recently been detected such as the Salish Sea. A variety of methods can be used to identify suitable habitat for EGC at a range of spatial scales, but none have been evaluated in the context of EGC management nor for the Canadian portion of the Salish Sea specifically. Here we evaluate five individual models (MaxEnt, stochastic gradient boosted linear and logistic regression models, a rapid site selection tool, and a qualitative site assessment and ranking tool) and five derived models generated by multiplying the outputs of the individual models. Finally we develop a suite of combination (mode and union) models to identify priority sites for EGC early detection/monitoring in Canadian waters of the Salish Sea. Since each model relied on slightly different input variables believed important to EGC invasion success, either environmental or habitat, it was not possible to identify a single "preferred" model. However, by using a multi-model ensemble, it was possible to increase predictive power by including both environmental and habitat characteristics in predictions. To further aid AIS management we developed a framework to select the model(s) most appropriate for achieving specific management objectives. Finally, we identify how these models, alone or in combination, could be expanded to predict additional sites or into new areas.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Evaluation of Methods for Identification of Early Detection Monitoring Sites for Invasive European Green Crab in the Salish Sea, British Columbia

January 31 – February 2, 2022

Virtual Meeting

Chair: Sophie Foster

DAY 1 – Monday, January 31 (*All times below are in Pacific Standard Time*)

Time	Subject	Presenter
08:00	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
08:15	Review Terms of Reference	Chair
08:30	Presentation of Working Paper	Authors: Brett Howard & Katie Gale
09:30	Questions of Clarification	RPR Participants
10:00	***Break (1 hour)***	
11:00	Overview Written Reviews	Reviewers: Cynthia McKenzie & Nicola Smith
11:30	Discussion of Reviews	Authors & Reviewers
12:30	Identification of Key Issues for Group Discussion	RPR Participants
13:00	Adjourn for the Day	

DAY 2 – Tuesday, February 1, 2022

Time	Subject	Presenter
08:00	Introductions Review Agenda Carry forward outstanding issues	Chair
08:30	Identification of Key Issues cont'd	RPR Participants
09:00	Discussion & Resolution of Technical Issues	RPR Participants
10:00	***Break (1 hour)***	
11:00	Discussion & Resolution of Technical Issues cont'd	RPR Participants
12:00	Develop Consensus on Paper Acceptability/TOR & Agreed-upon Revisions (Revision table)	RPR Participants
13:00	Adjourn for the Day	

DAY 3 – Wednesday, February 2, 2022

Time	Subject	Presenter
08:00	Introductions Review Agenda Carry forward outstanding issues	Chair
08:15	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Summary Bullets • Sources of Uncertainty • Results & Conclusions • Figures/Tables	RPR Participants
10:00	***Break (1 hour)***	
11:00	SAR cont'd	RPR Participants
12:45	Next Steps • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
13:00	***Adjourn meeting***	

APPENDIX D: PARTICIPANT LIST

Last Name	First Name	Affiliation
Anderson	Erika	DFO Centre for Science Advice Pacific
Campbell	Jill	DFO Centre for Science Advice Pacific
Chaves	Lais	Council of the Haida Nation
Christensen	Lisa	DFO Centre for Science Advice Pacific
Davis	Alexandra	University of Alberta
Demers	Andreanne	DFO Aquatic Invasive Species Management
DiBacco	Claudio	DFO Science
Foster	Sophie	DFO Science
Francis	Fiona	DFO Science
Gale	Katie	DFO Science
Grason	Emily	Washington Sea Grant
Greene	Stephanie	University of Alberta
Howard	Brett	DFO Science
Lyons	Devin	DFO Science
McDonald	Sean	University of Washington
McKenzie	Cynthia	DFO Science
Menning	Patty	DFO Fisheries Management
Smith	Nicola	University of British Columbia
Sobey	Timothy	Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations
Talbot	Renny	DFO Aquatic Invasive Species Management
Therriault	Thomas	DFO Science