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Proceedings of the Pacific regional peer review on the Coastwide Evaluation and Classification of Pacific Region Estuaries based on Anthropogenic Activities and Significant Fish Habitat

April 12-13, 2023
Sidney, British Columbia with Hybrid Option

Chairpersons: Katie Gale and Laura Sitter
Editor: Yvonne Muirhead-Vert

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Foreword

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

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on April 12-13, 2023 at the Institute of Ocean Sciences (IOS) in Sidney, British Columbia. Virtual participants attended using the online meeting platform Zoom. The working paper presented for the peer review focused on the coastwide evaluation and classification of Pacific region estuaries based on anthropogenic activities and significant fish habitat.

Due to the COVID-19 pandemic, the number of in-person gatherings has been restricted. With the relaxing of regional health orders and mandates, it was decided a hybrid meeting format would be adopted for this meeting to strengthen partnerships. Participation included DFO Science, Fish and Fish Habitat Protection Program (FFHPP), and external participants from the Pacific Salmon Foundation, Ducks Unlimited Canada, Parks Canada, Environment and Climate Change Canada - Canadian Wildlife Service, Coastal First Nations, A-Tlegay Fisheries Society, and an independent subject matter expert.

The meeting participants agreed the working paper met all of the Terms of Reference objectives and was accepted with minor revisions. The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) will assist managers in developing management and conservation actions appropriate to estuaries and other marine spatial planning initiatives along the Pacific coast.

The Science Advisory Report and the supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting entitled “Coastwide Evaluation and Classification of Pacific Region Estuaries based on Anthropogenic Activities and Significant Fish Habitat” was held on April 12-13, 2023 at the Institute of Ocean Sciences (IOS) in Sidney, British Columbia (BC). Virtual participants attended using the online meeting platform Zoom. The working paper (listed below) was reviewed during the RPR meeting.

The Terms of Reference (TOR) (Appendix A) for the science review were developed in response to a request for advice from DFO’s Fish and Fish Habitat Protection Program (FFHPP). Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from DFO Science, DFO FFHPP, First Nations, non-profit organizations, academia, and other government organizations.

The working paper (WP) was prepared and made available to meeting participants prior to the meeting (the working paper abstract is provided in Appendix B). The paper will be developed into a Research Document and posted on the CSAS website.

C.K. Robb, P.L. Thompson, J. Cristiani, K.H. Bannar-Martin, B. Proudfoot, and Rubidge, E.M. Coastwide evaluation and classification of Pacific Region estuaries based on anthropogenic activities and significant fish habitat. 2023. CSAP Working Paper 2021FFHPP07.

The meeting Chairs, Katie Gale and Laura Sitter, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chairs 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 Chairs reviewed the agenda and the Terms of Reference for the meeting, highlighting the objectives and identifying Yvonne Muirhead-Vert as the Rapporteur for the meeting. The Chairs agreed to record the proposed revisions to the working paper for the authors. The Chairs then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The hybrid meeting was held in-person and on the meeting platform Zoom, where audio and text conversations were conducted and recorded. 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, 24 people participated in the Regional Peer Review (Appendix D) over the two-day meeting.

Prior to the meeting, Marc Porter (Pacific Salmon Foundation) and Cliff Robinson (DFO Science, Pacific Region) were asked to provide detailed written reviews of the working paper to assist everyone attending the peer review meeting. Participants were provided with copies of their written reviews ahead of the meeting.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to assist managers in developing management and conservation actions appropriate to estuaries and other marine spatial planning initiatives along the Pacific coast. The Science Advisory Report and supporting Research Documents will be made publicly available on the Canadian Science Advisory Secretariat website.

GENERAL DISCUSSION

Following a presentation by the authors, the two reviewers, Marc Porter (Pacific Salmon Foundation) and Cliff Robinson (DFO Science, Pacific Region), 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. Both reviewers' formal submissions are located in Appendix C.

TERMS OF REFERENCE OBJECTIVE ONE

Review the current anthropogenic activities and environmental impacts to estuaries in the Pacific Region.

Anthropogenic and environmental impacts: The reviewers agreed with the level of detail from the literature review of the activities and stressors that could affect estuaries along the coast. However, one reviewer did feel that the activities were limited in temporal scope because it was for articles from 2010 to 2022 only. A discussion about the activity/stressor flow diagram regarding the difference between activities and stressors and how climate change should be included also occurred. The authors agreed with the participants that the language in the figure and figure caption could be clearer, and that human population should be omitted.

Activities not associated with clusters: The authors identified activities that are not associated with the clusters but should be also considered. For example, floating homes and lodges are not significantly associated with any one cluster, but if this activity is deemed important, then managers will need to look the estuaries on an individual basis. A reviewer recommended that a focus needs to be placed on more present-day activities (as opposed to longer term activities), such as geese grubbing, which was not identified as an activity in the literature review or analysis, though it was acknowledged that spatial data for geese grubbing may be limited.

TERMS OF REFERENCE OBJECTIVE TWO

Map the key ecological and anthropogenic features within Pacific Region estuaries, including:

a. *Anthropogenic activities and environmental impacts (including climate change); and*
b. *Significant fish species and sensitive fish habitat.*

Spatial Data: Spatial datasets were compiled, evaluated, and assembled to map anthropogenic activities in estuaries along the coast. The underlying data for this assessment was a deliverable to the client as this process is the first step to prioritize estuaries along the coast. The reviewers and participants suggested a few datasets that could be used to supplement or update the spatial datasets used in the cluster analyses and the authors agreed to incorporate them, where possible (e.g., additional datasets of roads, culverts, European Green Crab).

Climate change: While all estuaries will be impacted by human-induced climate change to some extent, this assessment looked at the following four stressors: sea level rise, precipitation change, air temperature change, and stream temperature change. A participant mentioned that the climate change variables should be included as background information since some of the impacts of climate change are predicted to take place in the far future (i.e., the projection for sea level rise extends to 2099). The authors and most participants wanted to keep the climate change stressors within the body of the working paper to factor in long-term planning for long-

term threats (i.e., sea level rise) and for these threats to be incorporated into future restoration or integrative management plans.

In addition to the four climate change stressors listed above, the timing and volume of spring/summertime snowpack melt could impact some estuaries with increased freshwater flow. The discharge and flow for estuaries connected to mainland rivers are driven by snow melt, whereas precipitation is the primary influence in watersheds located in the Salish Sea.

A reviewer commented that this assessment highlighted a subset of estuaries that are particularly vulnerable to the projected climate change stressors (i.e., estuaries within fjords will experience higher temperatures) and may be candidates for enhanced management or mitigation. It may be possible to remove or reduce the number of anthropogenic stressors for those estuaries that have multiple activities. Estuaries experiencing fewer climate change stressors could potentially be refuges.

Significant fish species and sensitive fish habitat: Both reviewers noted that mapping of the ecological data was limited in the WP and there appeared to be limited data on population and the distribution of forage fish species. A participant noted that additional disparate datasets are available and may be important in future, finer-scale work. Maps of the fish and fish habitat data were shown at the review meeting and the authors have agreed to include the maps in the working paper. The authors have suggested that an interactive map could be developed in the future so the activities and fish/fish habitat data relevant to each estuary could be reviewed based on the variable of choice.

TERMS OF REFERENCE OBJECTIVE THREE

Review and apply approach for estuary assessment based on anthropogenic activities, where data are available.

Cluster analysis: The authors used hierarchical clustering to categorize the anthropogenic activities and identify distinct groups of BC estuaries based on the type and intensity of activities. The cluster method is hierarchical and provides the opportunity to group activities so estuaries with similar activities can be compared. The principal components analysis (PCA) clustering approach is one way of looking at estuary data and this approach has been used in the past. The authors have agreed to add some more text and citations to the WP to explain why they decided to use this method.

An author noted that different estuaries may not have the same suite of activities within the same cluster. One advantage of using the cluster analyses is that it shows the magnitude of the impact within the cluster. A participant requested that they would like to see more specific information in the discussion on described activities in the two main clusters.

Based on one reviewer's comments, the authors presented a reduced set of activities under FFHPP management, which resulted in an output with five clusters. The results were largely consistent and gave the same overall picture as the initial results using eight clusters. The group agreed that the analysis will be updated using recommendations for spatial datasets provided by participants and reviewers and the updated analysis will be presented in the published research document. The authors will use a descriptor along with colour coding for each cluster in maps and tables to assist with accessibility for the reader.

The group agreed to create a new table (Table 1: activity data per marine, terrestrial and climate zones) to present the estuaries categories (characteristic activities), the count (N) of estuaries, a column to address climate highlights, and a column to provide an example of a species or biological data highlight. It was also suggested that a column labelled bioregion be included in the estuary activity tables in the appendix so individual estuaries can be identified by bioregion.

The group suggested that the authors include an example estuary for each cluster in the write-up of the paper. Some text or an appendix table could be included to compare counts of activities by ecological data (i.e., species by species) based on the scatter plots or summary statistics to highlight where some of the data gaps occur. The group left this addition to the authors' discretion, with the chairs having final approval.

Cumulative impact mapping: The cumulative impact map scores from Murray et al. (in prep.)[1] corresponds well when compared to all estuaries in this analysis. The highest value of the scores compared to the estuaries in cluster one that had a lot of activities in the marine and terrestrial environments. It was noted that this analysis was not a cumulative impact assessment which would require ranking of the activities.

Ranking of activities: There was some discussion on the ranking of estuaries within this assessment. One participant wanted to provide the client with a ranking of activities and stressors on habitat in relation to fish. The paper could rank the activities that are most detrimental to fish. Another participant expressed concern with the ranking of estuaries for this assessment since it was not in the request and would start to become a cumulative impact mapping assessment. To rank estuaries, a vulnerability assessment and/or a sensitivity risk assessment would need to be conducted. They thought the assembly of the spatial data and maps could be useful to show the current activities happening in the estuaries for management planning.

For the categories of estuaries, a participant suggested that it may be more important to look at the count of activities (Figure 4) per estuary, although it was noted that not all activities have equal impact. The count of activities identifies the activity whereas the cluster analysis represents a suite of activities occurring in the estuary. The authors have agreed to add some text in the published research document. If a manager is looking at a specific activity, then they will need to look at the underlying data presented in the maps and supplementary tables in addition to the cluster analysis. The group agreed that some summary statistics about individual activities within the estuaries would be helpful to compare individual estuaries.

Correlation matrix: A question was asked regarding how the cluster analysis compares to the correlation matrix presented in the authors' overview presentation in response to a question from one of the reviewers. The authors indicated that the cluster analysis distinguishes groups of estuaries with similar activities whereas the correlation matrix shows how the activities are correlated across all estuaries.

Linkages between activities and associated stressors: A reviewer suggested that there were some inconsistencies in the framing of the activities and their associated linkages since the stressor diagram was limited to the literature review. For example, literature showing the stressors associated with fishing or forestry activities may be from earlier decades. Another example in the stressor diagram lists boating as an activity but it is not linked to noise as a stressor because relevant references were not identified by the search terms of the literature review. They felt linkages with other activities could be connected to noise as well. A reviewer also noted that there were some inconsistencies in how activities and stressors were categorized. For example, population should not be listed as an activity in Figure 2 (anthropogenic activities and stressors with documented impacts on estuary systems) of the WP. They indicated that the effects of population could be captured under pollution or human density instead. The correlation matrix showed that the data layer for human density and

[1] Murray, C.C., Kelly, N.E., Nelson, J.C., Murphy, G.E.P., and Agbayani, S. In prep. Cumulative impact mapping and vulnerability of Canadian marine ecosystems to anthropogenic activities and stressors. DFO Can. Sci. Advis. Sec. Res. Doc.

watershed development is highly correlated. It was also noted that some activities (e.g., the different commercial fishing activities) could be combined but other participants preferred the specificity. Following the discussion, the authors agreed to revise specific portions of the figure and clarify the colours in the graphic.

Scatter plots: On the second day of the meeting, one of the authors presented the group with a scatter plot and dendrogram of the cluster analysis outputs with population and the climate variables removed. The figures showed that population was playing a larger role than previously thought.

The scatter plots have the number of activities that are non-zero on the x-axis and on the y-axis, an ecological or climate variable like temperature change that is log-transformed and then plotted. Each point on the scatterplot represents an individual estuary and the user could see the intensity for each estuary experiencing for a variable like temperature change. Estuary points were distinguished by colour and shape to show which cluster each belongs to.

The group wanted to include interactive maps in the published research document but a “Shiny app” will not be developed before the document is published. The authors have agreed to add scatter plots for the ecological variables (fish and fish habitat) and the four climate variables (air temperature change, stream temperature change, change in precipitation, and sea level rise) to the paper. With the addition of the scatter plots, the group decided to remove the climate change variables from the cluster analysis.

Boundaries of estuaries: A reviewer suggested that there needs to be more clarity in the methods section around the estuary boundary delineation since the extent of freshwater influence is quite dynamic. They were also curious about how the cutoffs were handled when the outflow of two rivers mixes, since it appeared that the subtidal and freshwater plume boundaries of the estuary were unclear. The reviewer discussed with the group how another paper has dealt with the boundaries of estuaries and has agreed to forward the paper to the authors for their review. In response, the authors described how the estuaries were defined and that the boundaries used were those defined by the Pacific Birds Habitat Joint Venture (PBHJV) Technical Team (2020). The authors noted that there are set distances and the decision-making was extensive and documented.

A participant suggested that the environmental gradients encountered within an estuary (i.e., sedimentation, nutrient loading) due to freshwater in-flow/marine mixing needs to be added.

Fraser and Skeena rivers: A member of the group suggested that the discussion of the estuary assessment for the Fraser and Skeena rivers could be included earlier in the Context/Background Section 1.2.3, instead of the Discussion Section 5.0. There was a recommendation that more information is required in the Spatial Data Section 4.1.1. to link the results to specific estuaries and their level of activity.

Members of the group noted that it is difficult to compare the level of activity of the Skeena River to the Fraser River since the Skeena River has fewer obstructions and no dams, even though they are in the same cluster. The freshwater obstructions such as culverts are underrepresented in the databases (i.e., FFHHP’s Program Activity Tracking for Habitat (PATH) dataset and BC dataset that include culverts, bridges and dams) that were used and it was challenging to group these activities. The Skeena River estuary is more complex than the other estuaries since it includes a number of islands, and it is difficult to know how far the intertidal zone extends. One participant provided the group with the Skeena River Estuary Synthesis Report and indicated that there is a lot of data and peer reviewed papers published from 2014 onwards. The boundaries for the Skeena River could be updated and the synthesis report cited. The authors have agreed to add some text on the Skeena and Fraser rivers to describe why these two rivers are coming out similar since it would help with interpretation of this assessment.

Another participant wondered if the scaling of the data distorted the industrial activity level between the Skeena and Fraser rivers to make these two rivers appear similar in scaled values in the estuary threats table in Appendix G2. The authors suggested that the raw data could be included in the appendix tables before the data is standardized and scaled. The authors standardized the data by summing the polygon data for the terrestrial activities in the watershed and dividing it by the watershed area. The log transformed data enables the two watersheds (Skeena and Fraser) with different activities to be compared. The authors will review the input datasets, assess recommendations for additional freshwater obstruction data, and include information in the discussion on why the scaled values came out so high for the Skeena River.

Smaller and lesser-known estuaries: A member of the group suggested that the paper should focus on the clusters of smaller, lesser-known estuaries. The inclusion of some of the smaller estuaries may provide management opportunities for conservation and restoration that could provide good value with limited funding sources.

TERMS OF REFERENCE OBJECTIVE FOUR

Identify estuaries of importance to salmon and other significant fish species (e.g., herring spawning areas), and presence of sensitive fish habitats (e.g., eelgrass), where data are available.

Invertebrates: A participant noted that invertebrates were not included in this analysis. The authors have agreed to extract Dungeness Crab data from the DFO Shellfish Database and add it to the paper. In addition, they will add some text on other invertebrates such as bivalves.

Fish and fish habitat: A participant suggested that more information could be included on how fish use the estuary as well as emphasize to managers how important estuaries are to fish. The WP identified a major data gap for the assessment of fish and fish habitat and a participant suggested some text could be added for clarification.

Salmon: A reviewer commented that the literature review for Section 2 seemed to be providing good information for linking anthropogenic activities and salmon. This information will be useful to assist with the management of salmon.

Salmon escapement biomass: A reviewer suggested that additional explanation is needed in the report on the average maximum escapement biomass metric for describing salmon use of estuaries. They wondered if biomass was the final metric. A breakdown by species for the salmon species that use estuaries longer would also be helpful as well. The cluster analyses showed that the estuaries with the highest amount of development also had the highest amount of salmon biomass and richness. A reviewer requested more text be provided on salmon escapement data and richness. It would be helpful to provide summaries of the conservation unit statuses given that current salmon biomass may not align with historic values.

Case studies: It was suggested that the authors highlight a few estuaries (e.g., data-rich, data-poor, large size, small size, heavy activities, and estuaries with a few activities) to show the diversity of estuaries along the coast and to broaden focus from the assessment on the Skeena and Fraser rivers. The authors have agreed to summarize data, provide more tables, some summary statistics, and provide inset maps of these example estuaries.

Historical vs present data: The client (FFHPP) was asked what kind of questions they wanted to have answered from this assessment to determine the type of salmon escapement data (i.e., historical or present) that would be required to answer the questions. They said that they wanted both types of data, but the present data for salmon would be most applicable. FFHPP wants the current data to improve fish abundance within the estuaries. The authors expressed some concern regarding completeness of the historical data since the data were moved from a

different platform. They have agreed to add some text that more data would need to be reviewed to identify historic levels of salmon within estuaries.

TERMS OF REFERENCE OBJECTIVE FIVE

Examine and identify uncertainties in the data and methods.

Data: The data used in this assessment was limited to the confines of the literature review search terms for anthropogenic activities and environmental impacts including climate change. The authors have acknowledged that the list of papers used in this assessment is not an exhaustive list of the information and data available on estuaries.

Some important stressors such as geese grubbing, some aquatic invasive species (i.e., European Green Crab), algal blooms, and noise were identified but were not included in the literature review, or were not linked to all activities through the literature review, and may be considered in future work. The authors have agreed to add some text about the inclusion of the green crab to the assessment even though the species did not come up in the literature review search of key words.

The authors also agreed to include a recommendation to do a secondary literature review for a future assessment. The information could be included for European Green Crab, geese, algal blooms, and noise disturbance. One of the reviewers suggested that they could have a look for potential data sources for the impacts geese have on estuaries and share with the authors. They identified that geese are considered to be a nuisance species and it would be helpful to include their activities into future assessments since it may be more impactful than some of the other stressors identified in this assessment.

Tidal marsh: It was noted that there is a data gap along the coast for tidal marsh which is an important habitat for fish. A participant indicated that data is available for the Fraser River but not well mapped for the Skeena River. It was suggested that the Fraser River could be used as a data rich example in the paper.

Spatial datasets: For this assessment, mixed GIS data types (point, line, or polygon data) were used. Variable temporal coverage and differences in resolution produced some data quality concerns (e.g., overlap of gridded commercial fisheries data with estuary boundaries). The authors documented their assumptions and decisions when grouping the data and activities from multiple sources. They found that the data limitations were more prevalent for biological data than for anthropogenic activities. Where intensity values were not available for anthropogenic activities such as aquaculture data, percent overlap was used.

The authors noted that the mining tenure data seemed to be incomplete and they could use some guidance on how to use the data. There were also questions on the Pollutants Affecting Whales and their Prey Inventory Tool (PAWPIT) and how it differed from the BC Waste Discharge Authorization database. The authors questioned the accuracy of the data since some of the shoreline zone appears within the watershed boundaries that are not actually part of the watershed. A participant requested some clarification on the wastewater structures to be added.

Scale of data: For this assessment, only coastwide data were used, and finer scale data with limited spatial extents were not reviewed or incorporated. It was suggested that local finer scale datasets of fish and fish habitat could potentially be incorporated into the broader datasets in the future to assist with the assessment of estuaries facing multiple threats.

It was noted that when managers are assessing activities for a specific estuary that they would require a finer scale analysis of the area to be used in conjunction with this assessment. More local data would need to be acquired.

Biological datasets: A major limitation of this assessment was due to the lack of coastwide biological datasets. The authors found there were a number of data gaps for non-commercial species such as sand lance outside of the Strait of Georgia, tidal marsh habitats, and Shiner Perch.

A member of the group mentioned that the Pacific Salmon Foundation has a good green crab database and other data sources for invasive species could be used.[2] The absence of broad scale, spatial ecological datasets, especially for aquatic invasive species, is likely due to the area not being surveyed coastwide rather than a known presence or absence of invasive species.

Limitation of the cluster analysis: It was noted that the use of the cluster analysis and activity count is just one way of looking at estuary data. There are many ways and/or applications to look at estuary data and the method used in this assessment is only one way of looking at the data. There was agreement to focus less on the clusters within the research document.

Assessment limitations: This assessment was limited to estuaries that intersected with the coast and were greater than a 4th order stream. A total of 439 estuaries were identified. Other estuaries intersecting with the coast and stream order less than 4 have not yet been mapped comprehensively and therefore could not be included in this assessment so the total number of estuaries along coast is underestimated.

The authors acknowledged that Indigenous Knowledge and information on Indigenous uses within estuaries were not included in this assessment and is an important next step.

The mapping of ecological impacts and human activities can inform future risk assessments or vulnerability frameworks. The scope of the paper was limited to the identification of human activities. This paper is not an impact analysis or a risk assessment since it does not rank the intensity of the activities.

Activities: Activities identified in this assessment should be not considered to be equivalent or have the same intensity between estuaries. It was noted that the number of activities within each estuary in a cluster is not the same and each activity is not uniformly distributed throughout the estuary.

NEXT STEPS

Working group formation: Meeting participants recommended that a coastwide working group be formed to advance estuarine prioritization as well as build partnerships along the coast. The working group would include representatives from Indigenous partners, local experts, managers and other knowledge holders.

Estuary prioritization: A participant suggested that ground truthing needs to be conducted to assist managers with the prioritization of estuaries for conservation and management. The next step of this process would enable management to rank estuaries and determine where to allocate resources. It was suggested that a table could be provided to the client to rank the most important estuaries or provide a list of the top ten estuaries to consider based on factors such as: high activities and high importance could have conflict management; estuaries of medium and moderate number of activities could be restored; low activities and high importance could be protected; high activities and low importance would require further discussion to determine if the estuaries are degraded and are worth restoring; and estuaries with low activity and low

[2] After the RPR meeting, it was found that the green crab data being referred to was held in a different database. The authors were able to obtain the data from FFHPP instead of querying the Pacific Salmon Foundation database.

importance could be left alone or conserved. However, the group agreed that this would be beyond the scope and better suited to future work.

Cumulative effects: This assessment does not look at the cumulative effects, however future analysis could combine the outputs from this work with vulnerability scores of individual estuarine species to quantify an overall risk to each estuary. Participants noted that work on cumulative impact mapping is underway in marine and freshwater systems.

CONCLUSIONS

The group was shown the revision table with all revisions agreed upon by the authors. Meeting participants agreed the working paper satisfied all Terms of Reference objectives and the paper was accepted with minor revisions.

RECOMMENDATIONS AND ADVICE

DRAFTING OF THE SCIENCE ADVISORY REPORT

Participants were provided with a draft Science Advisory Report (SAR) that was prepared in advance of the meeting. During the meeting, one of the Chairs used track changes on the draft SAR to document changes during discussions. The SAR was discussed and participants had the opportunity to contribute to key sections and identify the included tables and figures. At the end of the meeting, a draft SAR was completed. The meeting Chairs will work with the authors to finalize the draft SAR. Once completed, the Centre for Science Advice Pacific (CSAP) office will circulate the draft SAR and draft Proceedings (PRO) to all participants for final review and input.

ACKNOWLEDGEMENTS

The Centre for Science Advice Pacific (CSAP) congratulates the authors on the successful paper and appreciates the contributions from all participants. We thank the formal reviewers, Marc Porter (Pacific Salmon Foundation) and Cliff Robinson (DFO Science) for their time, expertise, and providing their formal written reviews of the working paper. We would also like to thank Katie Gale and Laura Sitter for their support throughout the process and as Chairs of the meeting.

REFERENCES CITED

PBHJV (Pacific Birds Habitat Joint Venture) Technical Team. 2020. Pacific Estuary Conservation Program Identified Estuaries of British Columbia Mapping and Ranking Project: 2019 Update.

Sharpe, C., Moore, J.W., Carr-Harris, C., and Butts, K. 2021. Skeena River Estuary Synthesis Report. Simon Fraser University, Vancouver, BC.

APPENDIX A: TERMS OF REFERENCE

Coastwide Evaluation and Classification of Pacific Region Estuaries based on Anthropogenic Activities and Significant Fish Habitat

Regional Peer Review – Pacific Region

April 12-13, 2023
Sidney, British Columbia with Hybrid Option

Chairpersons: Katie Gale and Laura Sitter

Context

Estuaries are highly productive ecosystems that support a high diversity of habitats, including eelgrass beds, saltmarshes, and mudflats. Found at the intersection of terrestrial, freshwater, and marine environments, estuaries are a geographic and life history bottleneck where anadromous fish have been shown to aggregate and are areas important for juvenile salmon (Levings 2016; Chalifour et al. 2019). As such, estuaries were identified as ecologically and biologically significant areas (EBSAs, Clarke and Jamieson 2006). More recently, estuaries were reassessed against the suite of EBSA criteria and found to score either high (aggregation, biological diversity, special importance for life history stage, and productivity) or medium (vulnerability, uniqueness, and importance for threatened species) (Rubidge et al. 2020). The final EBSA criterion, naturalness, was considered variable for estuaries because the analysis did not assess threats facing individual estuaries. Estuaries are however the site of many anthropogenic activities and the fish species and habitats within are threatened by multiple factors, including habitat degradation and modification, pollution, invasive species, overexploitation of fish, and climate change. Estuarine activities in the Pacific Region have been reviewed in other assessments (Hodgson et al. 2020; Robb 2014) which supports the need to expand/continue this research.

Canada's *Oceans Act* provides the legislative framework for an integrated approach to managing Canada's estuarine, coastal, and marine waters. The Fish and Fish Habitat Protection Program (FFHPP) at Fisheries and Oceans Canada (DFO) is responsible for estuary and coastal management planning for fish and fish habitat. As such, FFHPP has requested that Science Branch provide a coastwide evaluation of Pacific Region estuaries for activities that may impact fish and fish habitat and help to identify the importance of the estuaries to salmon, other significant fish species (e.g., herring), and the presence of sensitive fish habitat (e.g., eelgrass). This work will build on past research and analyses, including the systematic mapping of 439 estuaries in the Pacific Region (Pacific Birds Habitat Joint Venture [PBHJV] Technical Team 2020; Ryder et al. 2007), an assessment of Pacific Region estuaries (Robb 2014), and recent assessments of salmon biomass in Pacific estuaries[3]. The analyses will be completed at a coastwide scale, though will identify activities and environmental impacts relevant to individual estuaries. The work will not incorporate the full ecosystem risk assessment framework (ERAF, O et al. 2015).

The assessment, and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR), will assist managers in developing management and conservation actions appropriate to estuaries along the Pacific coast. Using the described methods, the analyses for evaluating estuaries can be updated iteratively as new spatial datasets become available. The information may also contribute to the identification of areas of

[3] Robb, C.K., Proudfoot, B., Thompson, P.L., and Rubidge, E.M. In review. Salmon biomass and richness – implications for the relative importance of estuaries in British Columbia, Canada.

high conservation value for marine spatial planning (MSP) initiatives on the coast of British Columbia, as well as the identification of at-risk areas that can help to guide emergency response programs.

Objectives

The following working paper will be reviewed and provide the basis for discussion and advice on the specific objectives outlined below.

C.K. Robb, P.L. Thompson, J. Cristiani, B. Proudfoot, and Rubidge, E.M. Coastwide evaluation and classification of Pacific Region estuaries based on anthropogenic activities and significant fish habitat. 2023. CSAP Working Paper 2021FFHPP07.

The specific objectives of this working paper are to:

1. Review the current anthropogenic activities and environmental impacts to estuaries in the Pacific Region.
2. Map the key ecological and anthropogenic features within Pacific Region estuaries, including:
    a. Anthropogenic activities and environmental impacts (including climate change); and
    b. Significant fish species and sensitive fish habitat.
3. Review and apply approach for estuary assessment based on anthropogenic activities, where data are available.
4. Identify estuaries of importance to salmon and other significant fish species (e.g., herring spawning areas), and presence of sensitive fish habitats (e.g. eelgrass), where data are available.
5. Examine and identify uncertainties in the data and methods.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science, Fish and Fish Habitat Protection Program, Ecosystem Management)
- A-Tlegay Fisheries Society
- BC Parks
- Central Coast Indigenous Resource Alliance
- Coastal First Nations
- Council of the Haida Nation
- Cowichan Tribes
- Ducks Unlimited Canada
- Environment and Climate Change Canada
- First Nations Fisheries Council of British Columbia
- Lower Fraser Fisheries Alliance
- North Coast-Skeena First Nations Stewardship Society

- Nuu-chah-nulth Tribal Council
- Pacific Salmon Foundation
- Parks Canada
- Province of British Columbia
- Simon Fraser University
- University of British Columbia
- University of Victoria

References

Chalifour, L., Scott, D.C., MacDuffee, M., Iacarella, J.C., Martin, T.G., and Baum, J.K. 2019. Habitat use by juvenile salmon, other migratory fish, and resident fish species underscores the importance of estuarine habitat mosaics. Marine Ecology Progress Series, 625: 145-162.

Clarke, C.L., and Jamieson, G.S. 2006. Identification of ecologically and biologically significant areas in the Pacific North Coast Integrated Management Area: Phase II - Final report. Can. Tech. Rep. Fish. Aquat. Sci. 2686.

Hodgson, E.E., Wilson, S.M., and Moore, J.W. 2020. Changing estuaries and impacts on juvenile salmon: A systematic review. Global Change Biology, 26: 1986-2001.

Levings, C.D. 2016. Ecology of salmonids in estuaries around the world: Adaptations, habitats, and conservation. University of British Columbia Press, Vancouver.

O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J. and Patton, S. 2015. An Ecological Risk Assessment Framework (ERAF) for Ecosystem-based Oceans Management in the Pacific Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/072.vii + 59 p.

Pacific Birds Habitat Joint Venture (PBHJV) Technical Team. 2020. Pacific Estuary Conservation Program Identified Estuaries of British Columbia Mapping and Ranking Project: 2019 Update. 44p.

Robb, C.K. 2014. Assessing the impact of human activities on British Columbia's estuaries. PLoS One 9(6): e99578.

Rubidge, E., Jeffery, S., Gregr, E.J., Gale, K.S.P., and Frid, A. 2020. Assessment of nearshore features in the Northern Shelf Bioregion against criteria for determining Ecologically and Biologically Significant Areas (EBSAs). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/023. vii + 63 p.

Ryder, J.L., Kenyon, J.K., Buffett, D., Moore, K., Ceh, M., and Stipec, K. 2007. An integrated biophysical assessment of estuarine habitats in British Columbia to assist regional conservation planning. Technical Report Series No. 476. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

APPENDIX B: WORKING PAPER ABSTRACT

Estuaries are highly productive and diverse ecosystems that represent a geographic bottleneck between marine and freshwater systems. Estuaries have been identified as ecologically and biologically significant areas (EBSAs) in Canada's Pacific Region because of their importance for the aggregation, productivity, and fitness of anadromous fishes, including Pacific salmon. However, estuaries are also the site of many anthropogenic activities and degradation of estuarine habitats such as eelgrass beds has had corresponding impacts on many species of ecological, economic, and cultural importance. A coastwide classification of estuaries based on anthropogenic activities was completed to support a regional request for information to aid integrated coastal planning. Anthropogenic activities and associated stressors related to estuaries were identified through a literature review and used to guide the compilation of spatial datasets, which were then used in a cluster analysis that identified estuaries that share similar activity types and levels of use. In addition, ecological information was compiled and mapped to highlight estuarine fishes and fish habitats considered significant or sensitive and compared to the individual estuaries and results of the clustering analysis. This broad-scale analysis represents an initial assessment of BC's estuaries that can help guide localized efforts and identify opportunities for management efficiencies among estuaries that face similar activities and stressors. Research needs for future evaluations at a finer-scale scale are detailed, as are linkages with projects underway within specific estuaries, to highlight opportunities for collaboration as priority estuaries are identified for management and conservation action.

APPENDIX C: WORKING PAPER REVIEWS

WRITTEN REVIEW

Date: 04/04/2023

Reviewer: Marc Porter, Senior Analyst, Pacific Salmon Foundation (PSF)

CSAS Working Paper #: 2021FFHPP07

Working Paper Title: Coastwide evaluation and classification of Pacific Region estuaries based on anthropogenic activities and significant fish habitat

The following five questions provide general guidance for your review:

1. Is the purpose of the working paper(s) clearly stated?

Yes, the authors do a good job of providing useful context and clearly presenting the intended multi-objectives for the working paper i.e., reviewing and mapping activities that could affect BC estuaries, mapping out occurrences of significant fish species and their habitats in BC estuaries, developing and applying a classification system for BC estuaries based on threats from human activities, and also highlighting estuaries of particular importance of key fish species and sensitive fish habitat.

2. Has the working paper fulfilled the Terms of Reference objectives?

The TOR objectives identified for the working paper were:

1. *Review the current anthropogenic activities and environmental impacts to estuaries in the Pacific Region.*
    - The authors have developed an exceptionally thorough literature review of activities and stressors that could impact environmental conditions in BC estuaries.

2. *Map the key ecological and anthropogenic features within Pacific Region estuaries, including:*

    a. Anthropogenic activities and environmental impacts (including climate change); and

    b. Significant fish species and sensitive fish habitat.
    - For a. the authors have done a very good job of using available datasets (both from direct observation and modeled) to define and map the known or predicted occurrences and extent of different activities and environmental impacts, including climate change-related impacts, across BC estuaries.
    - For b. while there has been an excellent effort in the working paper to pull in information on a suite of datasets on fish and fish habitats that could be used to identify estuaries of key importance this part of the paper is not developed as fully as would be hoped due to existing inconsistencies in available datasets as identified by the authors.

3. *Review and apply approach for estuary assessment based on anthropogenic activities, where data are available.*
    - The authors have done an excellent job of developing a principle component (PC)-based clustering approach for classifying BC estuaries based on similarities in the types and intensities of anthropogenic impacts they are experiencing (noting that the intent of the analysis is not to provide a quantitative ranking of anthropogenic activity intensity for each estuary). While there will be some questions as to PC interpretation

and the most meaningful splitting/clumping of cluster groups in such analyses the approach has merit and provides a data-based foundation for estuary classification based on activity patterns.

4. *Identify estuaries of importance to salmon and other significant fish species (e.g., herring spawning areas), and presence of sensitive fish habitats (e.g. eelgrass), where data are available.*
    - The authors note significant existing gaps in data coverage for various spatial datasets informing fish habitat and occurrences of significant fish species that will need to filled in the future to better develop this part of the analysis. But it would have been good to see more of the elements within this theme that are broadly interpretable/mappable at this time across BC estuaries and included with the working paper as possible.
5. *Examine and identify uncertainties in the data and methods.*
    - The authors do a very thorough job in identifying the various datasets used for the analyses, and have done a great job pulling in relevant datasets relating to quantification of terrestrial, marine, and climate-related disturbances the could affect estuaries. Uncertainties with these activity/stressors datasets obtained for the report, with the underlying understanding of how some of these activities/stressors may actually interact with estuary habitat and/or fish populations, and with associated statistical analyses undertaken in the working paper are well described by the authors.

3. Are the data and methods adequate to support the conclusions, and explained in sufficient detail?

- Yes, the data and methods are explained in sufficient detail and seem adequate to support the conclusions. There were a few relatively minor elements within the overall methodology I was unclear on and they're documented within my Comments section.

4. If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

- Yes, the information is presented to decision makers in a useable form and does reflect the uncertainty in the analyses and particularly in the data available. Noting that the information from the working paper analysis would only be one part of a decision process. As the authors note while the analyses can help to inform decision makers as to where development activities may have increased the likelihood of estuarine habitat degradation and fragmentation there will be a continuing need to develop improved habitat and biophysical information to better identify and track key concerns and understand on-the-ground impacts of activities across BC estuaries.

5. Can you suggest additional areas of research that are needed to improve the working paper?

- The authors have done a very good job of pulling in some very recent modeling efforts into their analyses and in identifying new research that would be helpful to fill in existing data gaps in the future. I have nothing to add to their summaries in terms of additional research to improve the working paper beyond some potential supporting analyses I have mentioned in my Comments.

Comments:

P4, paragraph 4: recognizing that there is a lot of variation in naming approaches used in the literature for the common names of species I would note that the most recent AFS style guide (2016) for Taxonomic Names recommends that the common names of fish species and subspecies should be capitalized. If you are going with a convention of not capitalizing common names then should be consistent in that regard for chinook (or chinook salmon), as its naming in the paper while mainly non-capitalized has some switches between capitalized and non-capitalized.

P8, paragraph 3: the citation on migratory bird use of the Fraser River is from 1987. Are there no more recent surveys that would indicate if more recent use by birds remains the same or has suffered over time.

P12, paragraph 1 – for the statement: “Additionally, a study on a resilient…” shouldn’t this instead be “Conversely, a study on a resilient…” as it seems rather to counter the previous sentence in the paragraph that indicates a relationship between land use and habitat conditions.

P13, paragraph 6: for the estuary study noted from Abbas et al., 2021) where cordgrass had invaded it would be good to note the location of this particular disturbed estuary for the reader

P15, paragraph 1: if describing the state of Chinook populations in the Puntledge River I would suggest supplementing with information more recent than 2002 as there is an active Puntledge River Watershed Action Plan than should be able to provide information on current salmon productivity and limiting factors.

P16, paragraph 3: should note in the paragraph that introduction of these air-born hydrocarbon contaminants to estuary sediments comes from deposition. That isn’t explicitly stated.

P16, paragraph 3: need to provide some context around the statement about habitat condition changes post Iona, as the reader won’t necessarily know what “Iona” is referring to or why it would have created a difference in the Fraser estuary.

PG 19 , paragraph 2: there are no supporting citations for some of the statements made here about the potential impacts of vessel traffic and dredging.

PG 20, paragraph 5: in you statement about PAH concentrations in Fraser River estuary fish exceeding those of reference areas are you talking about a larger population of fish species or just English sole? If the latter is the only reference species that should be indicated rather than making the broader statement.

PG 22. Section 2.2.3: I’m not sure if calling this theme a Climate Zone is quite the right terminology to use for this, and seems inconsistent with the other themes’ framing of Terrestrial and Marine Zones which have defined spatial contexts. I would suggest renaming this as an Atmospheric Zone instead. This then would better indicate linkage to where direct management could be targeted (i.e.. improving atmospheric chemistry as you would look to improve conditions in the terrestrial or marine environment that affect estuaries)

PG 25, paragraph 3: I don’t understand what the first sentence is referring to in contrasting flood events to extreme drought events – don’t they both equally relate to potential climate change impacts?

PG 28, Figure 2: don’t understand why Commercial and Recreational fishing are identified in the figure as a Climate Zone activity. Shouldn’t those be Marine Zone activities? That would be consistent with their discussion in the report text.

PG 28, Figure 2: think you have the Activities and Stressors reversed for your Aquatic Invasives category. The Activity should be Invasive Introduction, the Stressor should be Aquatic Invasive Species

PG 28, Figure 2: its hard to think of/define Population as an Activity, and also have it linked to only one stressor – Pollution. Also hard to define the identified climate-related factors as Activities (the related activities around this are more things like coal power plants, cars, airplane traffic, ranching, etc.). Could you perhaps make the term you're using for this theme more inclusive and call it Activities and Drivers?

PG 28, Figure 2: the climate Activity, climate Stressor framing is just not consistent with the other themes. Essentially the climate Activities as stated are just the same as the Stressors (e.g. Ocean Acidification links to Acidification, etc.). Feels forced.

PG 32, Paragraph 4: for "recent conditions" it would be good to add the date range for what you are defining as recent for modeling purposes.

PG 33, Table 1: assume you would have buffered the underwater infrastructure lines (submarine cables) but a buffer distance is not indicated.

PG 34, Table 1: for Forestry cutblocks there is no rationale provided for why harvest records quantified are restricted to 2013-2022. Similarly, for burned area polygons. Watershed impacts from forest disturbance can persist long beyond 10 years.

PG 34, Table 1: curious as to why for Sewage and wastewater outflows you did not alternatively or also use the province's waste discharge authorizations database which has information current through 2023. BC Provincial Waste Discharge Authorizations. Is there derived analyses in the ECCC tool that is more informative than this base information on potential discharge sites/volumes?

PG 35, Table 1: for your roads summaries wondering why you used the DRA and Forest Tenure Roads layers for this rather than the province's Integrated Roads layer developed for the BC CE Framework that already combines the DDR and Forest Tenure roads, as well as Mineral Tenure Roads, and is current to 2021: BC Cumulative Effects Framework - Integrated Roads - 2021

PG 35, Table 1: for your representation of mine impacts you have used information on footprint of mine tenures and permitting. That doesn't necessarily mean a mine has been developed and may not reflect legacy of past mines. I would have suggested instead using the province's MinFile database for identifying active and legacy mines: Mineral Inventory - Province of British Columbia; MapPlace2; although recognizing that consistent information across mines is not available within this dataset.

PG 36, Paragraph 1: it would be helpful to provide a diagnostic figure to allow the reader to evaluate how well the inverse hyperbolic sine (HIS) procedure managed to normalize the activities data.

PG 37, Section 3.3; it would be useful to see a simple correlation matrix here (or in appendix) of the different activities to help evaluate the potential utility of a PCA analysis

PG 39, Paragraph 2: would be useful to know what time period of record was used to calculate average maximum escapement.

PG 39, Paragraph 2: can you clarify better how you define the metric of "average **maximum** escapement"? This isn't clear. Hard to comment fully without being able to better understand how this is derived. In general would suggest using a geometric mean for escapement analyses instead of an arithmetic mean as its considered insensitive to less frequent, higher return years.

PG 39, Paragraph 2: not clear why a biomass calculation for salmon is required or provides additional information beyond escapement numbers. Is there some biomass adjustment incorporated based on average size of the different salmon species? If so it isn't indicated in the text.

PG 42, Paragraph 3: is it appropriate to include these additional eelgrass polygon datasets in the overall comparison across estuaries as I imagine they only exist for a subset of well-studied estuaries. Is this creating a bias in the comparisons? Same comment for the Macroalgae polygon datasets.

PG 41: Paragraph 3: would it be useful to consider supplementing the ShoreZone observations for eelgrass with bathymetry-based modeling of predicted eelgrass polygons as in Developing an algorithm and quantifying eelgrass extent.

PG 41, Section 4.1: I would like to see the raw summary figures by estuary for the Fish and Fish Habitat information (especially for salmon escapement) as you have done for the Activities and Climate Change Stressors in Sections 4.1.1. and 4.1.2. The reader would want to see this information at this level and within a provincial-scale map format, and not summarized within the defined clusters. Is there a reason you have chosen not to have a section 4.1.3 dedicated to this level of visualization for these features?

PG 44, Figure 4: Excellent figure, and is easy to visualize the contrast in marine activities intensity with the light blue shading changing to darker based on number of threats but the shading change doesn't seem clear to me for the terrestrial threats. Seems like more threats is a brighter yellow vs a darker green (i.e. doesn't seem like an increasing green shading as I would have expected from the legend.

PG 47, Section 4.2.1: this will obviously be a point of discussion at the workshop but can be a challenge to generate meaningful interpretations across a eight cluster PC split. The primary split into high and low development clusters as the primary split seens clear and the interpretation around the three high development clusters seems helpful, as does a split of low development estuaries into inner coast (clusters 5 and 6 combined) and outer coast estuaries (clusters 6, 7, 8 combined). Analysis beyond this separation for the low development estuaries definitely becomes more challenging and more difficult to translate into different management priorities.

PG 52, Paragraph 2: surprising not to see some of these activities come into the mix as being significant for any cluster, especially as there are some key perceived threats to estuaries in the mix here that might have been expected to create some differentiation e.g., finfish aquaculture, ports and terminals.

PG 72, Paragraph 2: citation for Nephin et al. 2020 not covered in the working paper's References Cited section.

WRITTEN REVIEW

Date: 3 April 2023

Reviewer: C. Robinson, ESD, DFO

CSAS Working Paper #: 2021FFHPP07

Working Paper Title: Coastwide evaluation and classification of Pacific Region estuaries based on anthropogenic activities and significant fish habitat

The following five questions provide general guidance for your review:

1. **Is the purpose of the working paper(s) clearly stated? Yes.**

From TOR "FFHPP has requested that Science Branch provide a coastwide evaluation of Pacific Region estuaries for activities that may impact fish and fish habitat and help to identify the importance of the estuaries to salmon, other significant fish species (e.g., herring), and the presence of sensitive fish habitat (e.g., eelgrass)."

From WP:

"The purpose of this working paper is to provide a starting point to address this management need and

1) Review and map current anthropogenic activities in Pacific Region estuaries; **completed**

2) Use available data to map significant fish species distributions (**not completed**) and sensitive fish habitat within Pacific Region estuaries (**completed**)

3) Classify estuaries based on common threats from human activities; **completed**

4) Highlight estuaries that are particularly important for key fish species and sensitive fish habitat." **Not obvious**

2. **Has the working paper fulfilled the Terms of Reference objectives?**

1. Review the current anthropogenic activities and environmental impacts to estuaries in the Pacific Region. **Reviewed but limited in temporal scope.**

2. Map the key ecological and anthropogenic features within Pacific Region estuaries, including:

a. Anthropogenic activities and environmental impacts (including climate change); and

Figure 4 mapped the count of marine and terrestrial activities for the whole coast, while Figure 5 mapped climate change stressor values.

b. Significant fish species and sensitive fish habitat. **No mapping included; lack of data.**

3. Review and apply approach for estuary assessment based on anthropogenic activities, where data are available. **A literature review was completed, and where possible spatial data assembled.**

4. Identify estuaries of importance to salmon and other significant fish species (e.g., herring spawning areas), and presence of sensitive fish habitats (e.g. eelgrass), where data are available. **Identified clusters of estuaries but no identification of specific estuaries discussed.**

5. Examine and identify uncertainties in the data and methods. **Yes, well discussed.**

Are the data and methods adequate to support the conclusions, and explained in sufficient detail?

See my attached comments.

3. If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

As it stands the WP does not present specific science advice to decision-makers. I am not convinced that the recommendations are in a 'useable' form. See my attached comments.

4. Can you suggest additional areas of research that are needed to improve the working paper?

The MS addresses some additional research.

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Anderson	Erika	DFO Centre for Science Advice Pacific
Bannar-Martin	Katherine	DFO Science
Carr-Harris	Charmaine	DFO Science
Chalifour	Lia	Independent
Cristiani	John	DFO Science
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Gale	Katie	DFO Science
Harrison	Bruce	Ducks Unlimited Canada
Hoover	Carie	Coastal First Nations
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