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Pacific Region

Proceedings of the Pacific regional peer review on Methodologies and guidelines for developing Limit Reference Points for Pacific Salmon in British Columbia

March 2-4, 2022
Virtual Meeting

Chairperson: Steven Schut
Editor: Jill Campbell

Fisheries and Oceans Canada
Science Branch
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Nanaimo, BC V9T 6N7

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Canada

Foreword

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

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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 March 2-4, 2022 via the online meeting platform Zoom. The two working papers presented for peer review focused on providing analytical methods for developing Limit Reference Points (LRP) for Pacific salmon stock management units, including guidelines for when they are or are not appropriate given data availability and characteristics of the population. Meeting participants agreed the working papers satisfied all Terms of Reference objectives. The working papers were accepted with minor revisions.

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, Stock Assessment, Fisheries and Resource Management, Salmon Enhancement Program staff and external participants from First Nations and First Nation organizations, National Oceanic and Atmospheric Administration, commercial and recreational fisheries, 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 DFO Science to inform the development of LRPs for stock management units of Pacific salmon across Pacific region to meet national obligations under the Fish Stocks provisions of the revised *Fisheries Act*.

The Science Advisory Report, Proceedings and two supporting Research Documents 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 March 2-4, 2022 via the online meeting platform Zoom to review the two working papers on providing analytical methods for developing Limit Reference Points (LRP) for Pacific salmon stock management units, including guidelines for when they are or are not appropriate given data availability and characteristics of the population.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Science. Invitations to the science review and conditions for participation were sent to DFO Science and Fisheries Management staff, and external participants from First Nations, National Oceanic and Atmospheric Administration, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia.

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

Working Paper #1: Holt, C., Holt, K., Warkentin L., and Wor, C. 2022. Guidelines for Defining Limit Reference Points for Pacific Salmon Stock Management Units. CSAP Working Paper 2019SCI04a.

Working Paper #2: Holt, K., Holt C., Warkentin L., and Wor, C. 2022. Case Study Applications of Limit Reference Point Estimation Methods to Pacific Salmon Stock Management Units. CSAP Working Paper 2019SCI04b.

The meeting Chair, Steven Schut, 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, 47 people participated in the RPR (Appendix D).

Participants were informed that Will Atlas (Wild Salmon Centre) and Mike Bradford (DFO Science) had been asked before the meeting to provide detailed written reviews for the working papers 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 DFO Science to inform the development of LRPs for stock management units of Pacific salmon across Pacific region to meet national obligations under the Fish Stocks provisions of the revised *Fisheries Act*. The Science Advisory Report, Proceedings and two supporting Research Documents will be made publicly available on the Canadian Science Advisory Secretariat website.

GENERAL DISCUSSION

Following a presentation by the authors, the reviewers, Will Atlas (Wild Salmon Centre) and Mike Bradford (DFO Science), 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.

TERMINOLOGY

Serious Harm: A reviewer asked the authors to more clearly describe how 'serious harm' has been interpreted in this work and indicate how the metrics outlined indicate levels above serious harm, which the authors agreed to address. A participant wondered if declining size and age at maturity would constitute serious harm as these parameters are used in estimating Limit Reference Points (LRPs) and serious harm delineations. Future work is needed around this topic.

Stock Management Unit: The term Stock Management Unit (SMU) is a new way of looking at salmon stocks under the Fish Stock Provisions (FSP) and is not yet well understood by all participants. A reviewer asked the authors to include more background information on how SMUs were developed and how the LRPs developed here apply at the SMU level, as LRPs can be developed for multiple uses under various policies. The authors agreed to include a DFO link defining Stock Management Units, describe their composition of one or more Conservation Units (CUs), and the differences in the average number of component CUs by species.

Stock: A reviewer pointed out that the term 'stock' is not used in the Wild Salmon Policy (WSP). The authors will ensure their use of this term is consistent with the policy being discussed.

SPATIAL SCALES

Spatial scales of salmon and management

A reviewer indicated that the guidelines presented here are very precautionary when determining SMU status and that many SMUs may be evaluated to be in the Red zone. Some participants were concerned that as soon as a SMU is evaluated to be in the Red zone that a rebuilding plan would be triggered which would result in a series of management responses that may impact the fisheries. There was concern that whole SMUs may be closed to fisheries when some CUs within that SMU could sustain a fishery.

The size of CUs differ among species of salmon because of varying levels of adaptive diversity they contain. For example, CUs are defined at a relatively fine spatial scale for Sockeye Salmon because of their relatively strict homing behaviour and adaptions that have developed to lakes where they spawn. In comparison, CUs are defined at a coarser scale for Chum Salmon because of higher rates of straying among spawning sites and less localized adaptations. One participant suggested that CUs are sometimes identified at different spatial scales within species, depending on historically available data and input provided during the expert elicitation process used by Holtby and Ciruna (2007).

For CUs that are inherently small because of limited habitat availability, the carrying capacity may be less than or equal to absolute abundance thresholds used under the Wild Salmon Policy to indicate Red Status. The authors argued that CUs with small capacity are inherently at higher risk of extirpation due to random demographic events and would be considered Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The way in which these LRPs are applied could have implications for Food, Social, and Ceremonial (FSC) or local sustainable harvests that often occur at fine scales where status of populations within CUs is important. Additionally, a participant mentioned that the Big Bar landslide response faced similar challenges of having to rehabilitate at below-CU levels. Other participants also highlighted the need to manage at smaller, not larger, scales.

In addition, it was noted that the scale of SMUs (application of 'major stocks' for Pacific salmon under the FSPs) is not the same scale at which recovery or management strategies are undertaken for Pacific salmon. Developing rebuilding plans and management actions takes time and management occurs at various scales and with various levers in collaboration with First Nations and stakeholders. The Regulations under the FSPs are still being finalized and there will be timelines and requirements for rebuilding plans stipulated therein. The authors and other participants reminded the group that managers take many socio-economic factors into consideration, not just the science, when determining appropriate management actions. Managers will still have the flexibility to manage at scales smaller than the SMU level. The consequences of this work for management actions is outside of the TOR scope. The CU-status based LRP method does help to address this issue of scale by allowing aggregation of status estimates to the SMU scale or disaggregation to the CU scale. There is a peer-review step within the guidelines that could incorporate local and Traditional Indigenous Knowledge when assessing CU and SMU status (e.g., considering the spatial distribution of spawning among populations within CUs).

There was some concern amongst participants that the requirements under the FSPs for LRPs at the SMU-level and the requirements under the WSP to conserve biodiversity at the CU-level are perhaps at odds, which could cause difficulties for managers. They suggested text be added to the SAR to indicate how LRPs relate to these two policies. Other participants and the authors indicated that discussing the decision making process is out of the scope of this work.

A reviewer suggested including a diagram outlining the spatial hierarchy of SMUs, CUs, and individual spawning sites in relation to management strategies that act at those various scales (e.g., marine fisheries, ocean management, hatcheries, local fisheries, habitat restoration, etc.). The authors will add this figure as it may help readers understand the ways various management strategies act over the spatial hierarchy of the science advice.

A participant noted that the methods described here could be applied at any level, not just the SMU level as the way CUs are grouped can be changed. Participants found this point helpful, as SMU designations are often difficult for salmon CUs to conform to. There is the ability to scale up or down when using the methodology outlined in this work. When working under the WSP, CUs are rigidly defined and there is limited scalability, however the CU assessment methodology allows for fine scale consideration of the distribution of spawning within, which could be informed by Indigenous Knowledge. These guidelines could also be applied to other species that do not have SMUs.

First Nation territories and rights

A participant highlighted a problem with SMU level assessments is that they do not align with Canada's fiduciary responsibilities to First Nations (FN). Many FNs have rights and title on watersheds or streams, a much smaller area than SMUs. They were concerned that management decisions would be made at a SMU or CU level without consideration of each individual salmon population or the FN community needs. They highlighted the need to manage salmon at the population level so as to align with FN community needs and rights. The Chair reminded participants that the methodology being evaluated in this meeting can be detached from how the overarching scale is defined. The political and management implications of this

work are out of scope, however management does have many options at many different levels to enact management decisions, not solely at the SMU level.

METHODS

Pacific Salmon Status Scanner

The Pacific Salmon Status Scanner has not yet been peer reviewed. However, it will be going through a CSAP Science Response process in April 2022 and two technical reports will also be published, one outlining the decision tree/algorithm developed to determine CU-level WSP status and the second paper will highlight case studies of CUs that have not yet been assessed. Participants that are developing these papers indicated that longer-term plans to implement the Salmon Scanner to individual CUs will also require expert review on a case-by-case basis, which will include First Nations, to ground-truth results. Additional text will be added in the Research Document to indicate briefly how the Salmon Scanner functions and how it was used to support this work. The authors anticipate that the Science Response and technical reports will be published prior to the Research Document and proper citations of the Salmon Scanner work will be included.

It was also noted that the use of the Salmon Scanner is not essential to produce the LRPs as defined by this work. The Salmon Scanner is only one method of inputting the data into the models using a multi-dimensional approach. The authors will ensure the text is clear that the Salmon Scanner is a useful tool for completing this analysis, but is not essential for the LRP methodologies presented here.

Names of Proportional and Aggregate Abundance LRPs

A reviewer emphasized that the CU-status based method is preferred for defining LRPs under the FSPs and that aggregate abundance methods are supplementary or proxies which may have use in fisheries management processes. It was agreed that the original label of proportional LRPs be renamed to CU-status based LRP for increased clarity. The aggregate abundance LRPs will be referred to as supplemental LRPs and the authors will indicate that these should be considered approximations of CU status-based LRPs.

Stock-Recruit models

A reviewer noted that the choice of stock-recruit (SR) model influences the model outputs, and may be impacted by temporal variability in carrying capacity. The reviewer will provide the authors with some references to discuss this further in the Research Document.

HATCHERIES

Both reviewers were concerned with how hatchery fish were handled in this study and in relation to SMU definitions. One reviewer suggested that excluding hatchery-influenced populations from spawner abundances limits our ability to detect changes in population dynamics and associated fishery opportunities. That reviewer recommended future work be done to develop aggregate abundance LRPs that include hatchery fish (e.g., including hatchery-origin SMUs), though the second reviewer noted that focusing on ‘wild salmon’ only is consistent with the Wild Salmon Policy, and therefore the TOR for these working papers. Both reviewers suggested that more work is needed to determine how to standardize the various population assessments in regards to the contribution of hatchery-origin fish. The authors indicated that hatchery influenced populations are challenging to address within the context of their work given conflicting

approaches that have been used in previous assessments. It was agreed that there needs to be flexibility in how hatchery influenced populations are considered as methods evolve over time.

A participant from the Salmon Enhancement Program (SEP) indicated that enhancement plans are being developed for new hatcheries so that biological and proportionate natural influence (PNI) objectives are defined. These plans are created in discussions with the fisheries and First Nations. Ideally, SEP would like to use PNI as a metric to identify stocks that need production levels changed to achieve biological objectives for wild salmon.

Withler et al. (2018) suggests that integrated hatchery populations with a PNI ≥ 0.5 can (at least provisionally) be included in the WSP assessments, however there is not always sufficient monitoring to assess this for some populations. A participant indicated that the Pacific Salmon Strategy Initiative will work to develop more monitoring programs to address this gap. As well, an integrated habitat, harvest, and hatchery plan that integrates objectives and management actions across sectors is required to effectively manage stocks, but this is also future work. Another participant suggested more work needs to be done to account for hatchery production and reduced reproductive success of hatchery-origin fish in SR models.

GUIDELINES

Upper Stock Reference Points

A reviewer asked why the boundary between Healthy (green) and Cautious (yellow) seems to vary between assessments. In Holt et al. (2009) 80% of the spawner abundance associated with maximum sustainable yield, S_{MSY}, was recommended as the Upper Stock Reference (USR). This aligned with the DFO Precautionary Approach (PA) Policy recommendation of 80% of the biomass associated with MSY and B_{MSY}, as a default USR. The authors stated that USR benchmarks are out of the scope of this work and are determined by management as they consider various socio-economic factors.

Frequency of SMU and CU evaluation

A reviewer asked if CU status needs to be stable over a certain period of time before it can influence SMU status. The peer review process of CU status assessments (Step 6) helps reduce annual variability in CU status due to noise alone when derived from the Salmon Scanner, reducing the probability of SMUs dropping below the LRP when statuses of component CUs are above the Red zone. The authors suggested that this step allows for ground-truthing of the SMU designation using expert knowledge.

CASE STUDY WORKING PAPER

Interior Fraser River Coho case study

A participant highlighted the working paper result that the choice of SR model (Ricker vs Ricker-cap) has an impact on the model results. A discussion about how the SR model uncertainty was handled followed. Specific advice on which of these two SR relationships to use was not provided (beyond the scope of the Working Papers). The authors will add text to the Case Study Research Document to highlight previous published guidance on when to apply model averaging among model formulations and when to keep models and resulting LRPs separate. The authors will not provide any new guidance on this, but will reference literature that speaks to this topic.

A reviewer was uncertain as to why the LRP was higher in the projection when compared to the proportional and logistic regression results. The authors responded that the projection accounts

for more uncertainties and therefore calculates a higher LRP, however this is just one example and may not be a general rule as to how these models perform. The authors will mention this finding in the Case Study Research Document.

A reviewer and participant were uncertain why the confidence intervals on the logistic regression curves (see Figure 2 in the Guidelines WP for an example) were so wide at both high and low abundances. They thought that there would be greater confidence that CUs would not be meeting their benchmarks when abundances were low and conversely, when the abundances are high, they thought there would be greater confidence that the CUs would meet the benchmarks. However, the authors said that since there are often few observations at both low and high abundances, the model predicts wide confidence intervals for those areas of the graph. This results in greater uncertainty in the logistic regression model fits.

A reviewer highlighted the result mentioned in the Working Papers about the limited utility of the logistic regression method, as the assumptions will be difficult to meet for many SMUs. This method may be difficult (or not possible) to estimate when population dynamics are asynchronous among CUs within an SMU. As well, one reviewer noted that, in general, high levels of asynchrony within SMUs can be associated with portfolio effects which stabilize aggregate abundances. This would increase the probability of SMU-level persistence, but this asynchrony is associated with a relatively high, or precautionary, logistic regression LRP. In contrast, SMUs with synchronous dynamics tend to have lower logistic regression LRPs. Although initially counter intuitive, the lower LRP results from reduced risk at any individual CU deviating from other CUs and being Red status under current or recent historical management regime because of synchronous dynamics. The authors agreed to highlight this initially counter intuitive result in the Working Paper.

Discussion section

A participant pointed out that if CU statuses within a SMU covary and they are assessed as being in the Red zone, then that should be more cause for alarm than if only one CU is assessed as being in the Red zone. The additional context of the number of CUs in the Red zone would be helpful. The authors agreed that future work exploring how the SMU status is defined is valuable for informing recovery potential analyses and rebuilding plans. Another participant said that the focus of the Wild Salmon Policy is on conserving adaptive capacity, which includes CUs or populations that respond differently to similar environmental conditions. Therefore it may be realistic to expect asynchronous dynamics among CUs. The authors agreed that alternative models to the logistical model that can harness covariance among CUs should be considered for future work.

FUTURE RESEARCH

Time-varying productivity and population dynamics

In general, time-varying parameters of the SR relationship (productivity and capacity) impact estimates of CU-level benchmarks and status against LRPs. Evaluating the extent and impact of time-varying parameters is an area of ongoing research. A reviewer noted that many stocks had been declining in size and age at maturity, which may impact population productivity.

A reviewer mentioned that while habitat based benchmarks for Chinook salmon were included in the Working Paper (as part of the Case Study on WCVI Chinook), habitat-based models used to inform benchmarks for Sockeye and Coho salmon were not mentioned despite strong indications that habitat constrains capacity for these species. As well, since all CUs are being

impacted by climate change, understanding changes in productivity and capacity of spawning habitat is key gap. The authors indicated this is important future work.

As well, considering LRP estimates in a life cycle framework would allow researchers and managers to better understand the role of freshwater and marine habitats on population dynamics, which would allow for more targeted management strategies. One reviewer suggested further work using coded wire tag data to help better understand freshwater and marine threats. The authors said there is often limited data to determine differences in smolt or adult survival in each habitat, however this is valuable future work.

Ecosystem consideration

A participant raised the point that salmon are valuable to many other Peoples (e.g., plants and animals) in the ecosystem and for nutrient cycling, not just for human consumption. However, this is rarely taken into account. Including other ecosystem considerations is valuable future work. Text on the importance of salmon for the ecosystem will be added to the Working Paper and SAR.

CONCLUSIONS

Meeting participants agreed the working paper satisfied all Terms of Reference objectives. The working paper was accepted with minor revisions (see Appendix E for a list of agreed upon revisions).

ACKNOWLEDGEMENTS

We appreciate the time contributed to the RPR process by all participants. In particular, we thank the reviewers Will Atlas (Wild Salmon Centre) and Mike Bradford (DFO Science) for their time and expertise. We also thank Steven Schut as Chair of the meeting and Jill Campbell as the Rapporteur.

REFERENCES CITED

Holt, C.A., Cass, A., Holtby, B., and Riddell, B. 2009. Indicators of Status and Benchmarks for Conservation Units in Canada's Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/058: viii + 74 p.

Holtby, L.B. and Ciruna, K.A. 2007. Conservation Units for Pacific Salmon under the Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/070: viii + 350 p.

Withler, R.E., Bradford, M.J., Willis, D.M., and Holt, C.A. 2018. Genetically Based Targets for Enhanced Contributions to Canadian Pacific Chinook Salmon Populations. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/019. xii + 88 p.

APPENDIX A: TERMS OF REFERENCE

METHODOLOGIES AND GUIDELINES FOR DEVELOPING LIMIT REFERENCE POINTS FOR PACIFIC SALMON IN BRITISH COLUMBIA

Regional Peer Review – Pacific Region

March 2-4, 2022
Virtual Meeting

Chairperson: Steven Schut

Context

Canada's revised *Fisheries Act* (2019) includes Fish Stocks provisions that introduce legal requirements to promote sustainability, avoid Limit Reference Points (LRPs) and implement rebuilding plans for depleted stocks. Compliance with the Fish Stocks provisions is being interpreted nationally through the application of DFO's Sustainable Fisheries Framework (SFF), and in particular the Fishery Decision-Making Framework Incorporating the Precautionary Approach (PA Framework, DFO 2009). LRPs that represent the stock level below which serious harm is occurring will be required for major fish stocks prescribed in the proposed regulation. LRPs define the trigger below which rebuilding plans will be required.

For Pacific salmon in Canadian waters (Pacific region) there are over 60 stock management units (SMUs), where the proposed functional definition of an SMU is a group of one or more Wild Salmon Policy Conservation Units (CUs) that are managed together with the objective of achieving a joint status and would be considered a major fish stocks under the Fish Stocks Provisions of the *Fisheries Act*. Guidance is required on how to develop LRPs for Pacific Salmon SMUs that are aligned with both (i) the intent of the Wild Salmon Policy to restore and maintain biodiversity and ecosystem integrity at the level of the Conservation Unit, CU (DFO 2005) and (ii) previously developed methods for CU assessments under the WSP (Holt et al.2009)[1].

Fisheries and Oceans Canada (DFO) Science has requested that Science Branch provide analytical methods for developing Limit Reference Points for Pacific salmon SMUs, including guidelines for when they are or are not appropriate given data availability and characteristics of the population. A full evaluation of LRPs is beyond the scope of this review process.

The assessment and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) will be used to inform the development of LRPs for stock management units of Pacific salmon across Pacific region to meet national obligations under the Fish Stocks provisions of the revised *Fisheries Act*.

Objectives

The following two working papers will be reviewed and provide the basis for discussion and advice based on the objectives outlined below. The working papers will complement each other,

[1] For example, as applied by DFO's State of the Salmon Program's Pacific Salmon Status Scanner, Pestal, G., MacDonald, B, Grant, S, and Holt, C., in prep. Rapid Status Approximations from Integrated Expert Assessments Under Canada's Wild Salmon Policy. Can. Tech. Rep. Fish. Aquat. Sci.

with the guidelines provided in the first paper being supported by the detailed case study applications provided in the second paper.

Working Paper #1: Holt, C., Holt, K., Warkentin L., and Wor, C. 2022. Guidelines for Defining Limit Reference Points for Pacific Salmon Stock Management Units. CSAP Working Paper 2019SCI04a.

Working Paper #2: Holt, K., Holt C., Warkentin L., and Wor, C. 2022. Case Study Applications of Limit Reference Point Estimation Methods to Pacific Salmon Stock Management Units. CSAP Working Paper 2019SCI04b.

The specific objectives are:

1. Working Paper #1:
    a. Develop candidate methods for identifying SMU-level LRPs for Pacific salmon that are consistent with the Wild Salmon Policy objective of conserving biodiversity by maintaining CUs above lower biological benchmarks. These candidate methods will include LRPs based on the status of component CUs and aggregate abundance over multiple CUs, where CU assessments can be developed using a multidimensional or single-metric approach, as appropriate.
    b. Document candidate methods for developing LRPs at the SMU-level, including data requirements and assumptions.
    c. Document key uncertainties that affect LRP estimates for each method considered, including uncertainties arising from inadequate CU-level data.
    d. Provide guidance and recommendations on the application of candidate methods over a range of data types and availability.
2. Working Paper #2:
    a. Apply proposed methods to Pacific Salmon case studies over a range of data types and availabilities.
    b. For case studies, evaluate methods for developing LRPs using a combination of sensitivity analyses to key parameters and assumptions, and where possible retrospective analyses.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Documents

Expected Participation

- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science and Ecosystems and Fisheries Management sectors)
- Indigenous groups
- Academia
- Non-Government organizations
- Stakeholder Groups

References

DFO. 2005. Canada's Policy for the Conservation of Wild Pacific Salmon. Vancouver, British Columbia.

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APPENDIX B: WORKING PAPER ABSTRACT

WORKING PAPER #1 ABSTRACT

Limit reference points, LRPs, define the stock status below which serious harm is expected to occur to a stock. LRPs are required for major fish stocks, or Stock Management Units (SMUs) that are prescribed by regulation under amendments to the Canadian *Fisheries Act* (2019). Pacific salmon are unique among marine fish stocks due to their high levels of intraspecific diversity which gives rise to a large range in data availability, considerations, and approaches for assessments and LRP development. In this paper, we identify six principles for developing LRPs for Pacific salmon that are adapted from principles used more broadly among marine species. One principle unique to Pacific salmon is that LRPs should be aligned with Canada's Wild Salmon Policy (WSP) objective of preserving biodiversity of salmon at the scale of Conservation Units (CUs), which are often nested within SMUs. We developed methods for calculating LRPs, and established guidelines on how to implement them including under which conditions they should or should not be applied. We propose that LRPs be identified from the proportion of CUs that have status above the Red zone for WSP status assessments, as a default approach. This provides some consistency with status assessments already produced under the WSP, and can inform management decisions for harvest, habitat and hatcheries that often occur at finer, CU scales. To supplement the default approach, we provide LRPs based on metrics of aggregate abundances for the entire SMU, which may be required for fisheries management purposes in some cases. These latter LRPs are derived to have a desired probability of all component CUs being above Red status given an assumed relationship between aggregate abundance and the probability that all CUs will be above Red status. We identify uncertainties associated with each approach, and describe how they can be applied across a range of data types, qualities and quantities. Analyses to support our development of guidelines has been informed by three cases studies: Interior Fraser Coho Salmon Oncorhynchus kisutch, West Coast Vancouver Island Chinook Salmon, O. tshawytscha, and Inside South Coast Chum Salmon, O. keta, excluding the Fraser River.

WORKING PAPER #2 ABSTRACT

The revised *Fisheries Act* requires that Limit Reference Points (LRPs) be identified for all major fish stocks. For Pacific salmon, major fish stocks are represented by stock management units (SMUs). An SMU is composed of one or more salmon conservation units (CUs), which are the assessment units under the Wild Salmon Policy, WSP. We introduce methods to estimate LRPs at the SMU level that integrate statuses derived under the WSP at the CU level. We demonstrate and evaluate the LRPs for three case study SMUs: Interior Fraser Coho (*Oncorhynchus kisutch*), West Coast Vancouver Island (WCVI) Chinook (*O. tshawytscha*), and Inside South Coast Chum (*O. keta*) - excluding Fraser River. Methods are divided into two categories: proportional LRPs and aggregate abundance LRPs. Proportional LRPs are recommended as the default method, and are based on the proportion of CUs above levels associated with increased risk of extinction (above 'Red' status) under the WSP. Aggregate abundance methods may be used supplementally to meet specific fisheries management requirements. Aggregate abundance LRPs are subdivided into logistic regression LRPs and projection LRPs. Both types of aggregate abundance LRPs are defined at the SMU-level abundances associated with a desired probability of all component CUs being above Red status, but they differ in that logistic regression LRPs are determined directly from historical data and projection LRPs are determined from projections of CU-level population dynamics. We discuss suitability and requirements for the application of the various LRP estimation methods, drawing from the range of data and information availability among the case studies. In general, the application of aggregate abundance LRPs may be limited to SMUs where the CU-level

populations covary, as demonstrated for the Interior Fraser Coho case study, and where covariance has not changed over time or, for projection LRPs, those changes can be parameterized.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

AGENDA

Guidelines for Defining Limit Reference Points for Salmon Stock Management Units

March 2-4, 2022
Virtual
Chair: Steve Schut

DAY 1 – Wednesday, March 2

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0930	Presentation of Working Paper (Overview)	Authors
1030	***Break***	
1045	Continuation of Presentation of Working Paper (Overview), Written Reviews and Authors Response	Chair + Reviewers & Authors
12:00	***Lunch Break***	
1300	Completion of discussion of Written Reviews	Chair + Reviewers & Authors
1400	Identification & Discussion of Issues	RPR Participants
1430	***Break***	
1445	Identification & Discussion of Issues	RPR Participants
1600	**Adjourn for the Day**	

DAY 2 - Thursday, March 3

Time	Subject	Presenter
0900	Review Status of Day 1 (*As Necessary*)	Chair
0915	Discussion & Resolution of Issues	RPR Participants
1030	***Break***	
1045	Discussion & Resolution of Issues	RPR Participants
1200	***Lunch Break***	
1300	Discussion & Resolution of Issues	RPR Participants
1445	***Break***	
1500	Discussion & Resolution of Issues	RPR Participants
1600	***Adjourn for the day***	

DAY 3 - Thursday, September 24

Time	Subject	Presenter
0900	Review Status of Day 2 (*As Necessary*)	Chair
0915	Consensus on the acceptability of the working paper (Review Revisions Table + TOR objectives)	Chair & Participants
1030	***Break***	
1045	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Summary Bullets • Results & Conclusions • Sources of Uncertainty • Tables & Figures Additional advice to Management (as warranted)	RPR Participants
1200	***Lunch Break***	
1300	*Science Advisory Report (SAR) cont'd*	RPR Participants
1445	***Break***	
1500	SAR/ Finalization • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (as necessary) Other Business arising from the review	Chair & Participants
1600	***Adjourn the Regional Peer Review Meeting***	

APPENDIX D: PARTICIPANT LIST

Last Name	First Name	Affiliation
Arbeider	Michael	DFO Stock Assessment
Ashton	Chris	Commercial Salmon Advisory Board
Atlas	Will	Wild Salmon Centre
Bocking	Bob	Maa-nulth First Nations
Bradford	Mike	DFO Science
Campbell	Jill	DFO Science, Centre for Science Advice Pacific
Campbell	Kelsey	A-Tlegay Fisheries
Carr-Harris	Charmaine	DFO Science
Christensen	Lisa	DFO Science, Centre for Science Advice Pacific
Connors	Brendan	DFO Stock Assessment
Crowley	Sabrina	Nuu-chah-nulth Tribal Council
Dobson	Diana	DFO Science
Frederickson	Nicole	Island Marine Aquatic Working Group
Grant	Sue	DFO Stock Assessment
Hague	Merran	Pacific Salmon Commission
Hawkshaw	Mike	DFO Science, Big Bar Slide
Hertz	Eric	Pacific Salmon Foundation
Holt	Carrie	DFO Science
Holt	Kendra	DFO Science
Huang	Ann-Marie	DFO Science
Ings	Danny	DFO Science
Jenewein	Brittany	DFO Resource Management- Fraser
Johnston	Diane	DFO Science, Canadian Science Advisory Secretariat
Kanno	Roger	DFO Sustainable Fisheries Framework
Ladell	Jason	DFO Science, National Capital Region
Lewis	Dawn	DFO Stock Assessment
Marentette	Julie	DFO Science
Maxwell	Marla	DFO Fisheries Management
May	Chelsea	DFO Stock Assessment
Mazur	Mackenzie	DFO Science
McDuffee	Misty	Raincoast Conservation Foundation/Marine Conservation Caucus
McHugh	Diana	DFO Stock Assessment
Nicklin	Pete	Upper Fraser Fisheries Conservation Alliance
Parken	Chuck	DFO Stock Assessment
Pestal	Gottfried	Solv contracting
Radford	Jeff	DFO Resource Management
Ramshaw	Brock	DFO Salmon Enhancement Program
Rogers	Luke	DFO Science
Rosenberger	Andy	Coastland Research

Last Name	First Name	Affiliation
Satterthwaite	Will	National Oceanic and Atmospheric Administration
Schut	Steven	DFO Science
Staley	Mike	Fraser Salmon Management Council
Walsh	Michelle	Shuswap Nation Tribal Council
Warkentin	Luke	DFO Science
Weir	Lauren	DFO Stock Assessment
Wilson	Kyle	Central Coast Indigenous Resource Alliance
Wor	Catarina	DFO Science

APPENDIX E: AGREED UPON REVISIONS TO THE WORKING PAPER

Working Paper	Section	Topic	Revision
Guidelines	Introduction	Serious harm	Define clearly (maybe a grey box)
Guidelines	Introduction	Include definition of SMU (including # of CUs)	Add citation (DFO link) for Stock Management Units, and mention average number of component CUs (to give an idea of scale) which differs among species (more for Sockeye)
Guidelines	Introduction (Scope)	Pacific Salmon Status Scanner	Add text mentioning that the Salmon Scanner will be reviewed by CSAS in 2022.
Guidelines	Subsection on spatial scales	Spatial scales of salmon and management	Add figure as suggested by Bradford with nested scales of salmon population structure and management, including human dimension (e.g., some First Nations rely on small streams)
Guidelines	Introduction (and spatial scale subsection)	First Nations territories / rights at different scale from CUs (often smaller than CUs)	Add text acknowledging that First Nations rely on finer scale spatial units within CUs and SMUs, which is not captured in the development of LRPs. This issue is also related to the biological values of the distribution of spawning within a CU, captured below.
Guidelines	Introduction (spatial scale subsection)	Integrated Management Process	Could mention the need for Integrated Management Process (following previous recommendations, e.g., in Withler et al 2018), that integrates over these different spatial scales. This Integrated Management Process can adaptively respond to abundances with routine assessments and have clear objectives, including those related to biodiversity and hatcheries
Guidelines	Section on Hatcheries	Removal of hatchery-origin spawners from biological assessments in hatchery	Suggestion to recommend flexibility in addressing hatchery influenced populations in assessments, because there is uncertainty about how to process hatchery fish and this will evolve over time. Highlight the inconsistency with Withler et al.

Working Paper	Section	Topic	Revision
		influenced populations where natural spawning predominates	(2018), who recommend including all spawners in biological assessments when natural spawning predominates (PNI>0.5). The approach used in the paper is consistent with existing published integrated assessments, on which our analysis relied. Developing new time-series and CU assessments was beyond the scope of our WPs.
Guidelines	Section on Hatcheries	Designating populations with respect to enhancement outcomes (as in HSRG, and Withler et al. 2018)	Highlight that Enhancement Plans are being developed for hatchery populations (by SEP in integrated processes), with objectives and triggers. Objectives can include those related to PNI. These Enhancement Plans can inform rebuilding plans. This needs to be integrated with habitat and hatcheries in an integrated process.
Guidelines	Section on Hatcheries	Hatcheries for rebuilding, where PNI is currently <0.5	Suggest regular evaluation of PNI value and their inclusion in LRP determination
Guidelines	Table 2, Section on CU assessments	Include evidence of how benchmarks relate to serious harm	Show through literature citations how benchmarks (e.g., Sgen, percentile and absolute threshold) are linked to serious harm and extinction risk, by expanding Table 2 in the Guidelines WP
Guidelines	CU methods	habitat-based priors for Coho and Sockeye	Mention these in methods for CU assessments (e.g., Atlas et al. 2020)
Guidelines	CU methods	Salmon Scanner	Add a few more sentences describing the Salmon Scanner (taken from the Case Study WP methods and/or contributions from Sue and Gottfried in Day 1 of the meeting)
Guidelines	LRP Methods-Proportional LRPs	Different number of CUs among species and implications for status against LRPs (esp. for Sockeye)	Add sentence highlighting that species with more (smaller) CUs, like Sockeye will likely have more LRP breaches

Working Paper	Section	Topic	Revision
Guidelines	LRP Methods section	Metrics on which LRPs are identified	For marine species, harvestable biomass is typically the metric assessed. For salmon, natural origin spawners are typically assessed (as is convention for Pacific salmon assessments under WSP). Explicitly identify this disconnect in the WP.
Guidelines	Guidelines section	Frequency of SMU and CU evaluation	Expand on current text on 'current' status (within last generation), to provide recommendation on frequency of assessment is generationally
Guidelines or Case Study WP	Guidelines section	Projection LRPs	Model evaluation for projection LRPs are more subjective than for logistic regression LRPs, due to added assumptions and analytical decisions it requires. Evaluation of logistic regression LRP is more objective and repeatable
Guidelines	Guidelines section	Asynchronous dynamics results in higher LRP and vice versa	Mention this in Guidelines Step 8 when describing the impacts of covariation in dynamics on logistic regression and projection LRPs. But for mixed-stock fisheries, less correlation reduces fisheries risk, so perhaps not counterintuitive
Guidelines	Uncertainties	Lack of monitoring of hatchery influence	Lack of monitoring of hatchery-origin fish in many cases, and recognition of this as a gap
Guidelines	Future research	Time-varying productivity / population dynamics	Add time-varying capacity in the discussion of time-varying parameters with productivity, and challenges detecting both given negative correlation in productivity and capacity. Also include mention that change in population demographics are also likely to influence benchmarks.
Guidelines	Future research	Changes in population demographics, ecosystem and	Mention demographic, environmental and ecosystem changes and their impacts on status assessments (metrics and benchmarks) in the future research section. Include this as a

Working Paper	Section	Topic	Revision
		environment may affect biological status	gap in WSP assessment methods and resulting LRP, citing e.g., Czorlich et al. 2022 (Science 10.1126/science.abg5980), Staton et al. 2021
Guidelines	Future research	Indigenous Knowledge	Suggestion to engage and collaborate with Indigenous Peoples about how best to reconcile Indigenous Knowledge with LRPs.
Guidelines	Future Research	Consideration of distribution with a CU	Future research priority: Identifying robust metrics and benchmarks on distribution within WSP assessments (this is mentioned earlier in the text, and can be brought into the Future Research section). In addition, mention that consideration of population structure below the CU level may be required for biological and management purposes, acknowledging that First Nations sometimes rely on specific areas that are smaller than SMUs/ CUs.
Guidelines	Future Research	Ecosystem consideration	Add mention of marine-derived nutrients, and ecosystem components that rely on them
Guidelines	LRP Methods-Proportional LRPs	CU status-based LRP fig	Add code for figure (I'm guessing we want this new fig in the Guidelines paper?)
Case Study	IFR Coho case study	Possible use of life cycle models to parse out marine/freshwater life cycles, recognizing that there are more management options for freshwater habitat	Note that life cycle models are an alternative to adult-adult SR models that could be explored in the future citing previous examples (Ohlberger et al. 2018 and Bradford 1998)

Working Paper	Section	Topic	Revision
Case Study	IFR Coho case study	Differential productivity of hatchery- vs natural-origin spawners	Future analyses: When accounting for hatchery origin spawners in stock-recruitment modelling, future analyses could include differential productivity of hatchery-origin spawners relative natural-origin spawners (but beyond scope of this project). Cite Falcy and Suring (2019)
Case Study	IFR Coho case study	Projection LRP higher than logistic-regression LRP	Identify this, possibly because projection LRPs account for more sources of uncertainty than logistic regression LRPs, though this is not necessarily a general rule as it is demonstrated only for this case study.
Case Study	IFR Coho case study	-	When to model average and when to keep separate, accounting for the plausibility: add guidance from literature
Case Study	Chum case study	-	Logistic regression did not fail, but the logistic regression LRPs are not supported
Case Study	Lessons learned (lesson 4)	Use of logistic regression aggregate abundance method for stocks with cyclic dynamics	Mention that the method is likely not applicable for stocks with cyclic dynamics, which is supported by preliminary analyses on sockeye data.
Case Study	Discussion; lessons learned	Consideration of distribution with a CU	Highlight ways in which distribution of spawning abundances were considered within our case studies, and note that distributional metrics do not yet have quantitative benchmarks defined, but that this should be an area of future research.
Case Study	-	Uncertainties in proportional LRP due to underling uncertainties	How to handle false negatives/positives in Salmon Scanner: handled at the expert review stage.
Case Study	Discussion	Number of CUs in the Red zone	Can mention that historical plots can be expanded to include number of CUs in the Red zone to inform Rebuilding

Working Paper	Section	Topic	Revision
both	throughout	Naming of aggregate abundances LRPs	Include both as 'supplemental', but mention that these are proxies or 'approximate" CU status-based LRPs (proportional LRPs)
both	throughout	Naming of proportional LRPs	Proposed name change to ‘CU status-based LRPs’. Ensure that name is changed in all text, figure labels, tables and captions.
both	throughout	Stock is not used by the WSP	Remove the use of "stock" when referring to CU or streams in both working papers.
both	Introduction	Stock management unit	Include text explaining that the delineation of "Stock Management Units" for Pacific salmon was in part a response to the national-level requirement for delineating "Major Stocks" for Pacific salmon under FSPs.