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Proceedings of the Pacific Regional Peer Review on Recovery Potential Assessment – Interior Fraser Coho (*Oncorhynchus kisutch*)

May 22-24, 2019
Nanaimo, British Columbia

Chairperson: Bruce Patten
Editor: Kayleigh Gillespie

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

September 2021

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 (RPR) meeting on May 22-24, 2019 at the Pacific Biological Station in Nanaimo, B.C. One working paper focusing on the recovery potential assessment of the Interior Fraser Coho Designatable Unit was presented for peer review and was accepted with minor revisions.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science and Ecosystems Management sectors staff; and external participants from First Nations organizations, the Province of BC, the fishing sector, US agency and environmental non-governmental organizations.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to future *Species at Risk Act* (SARA) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) processes to inform the recovery potential of the Interior Fraser Coho Designatable Unit.

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

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on May 22-24, 2019 at the Pacific Biological Station in Nanaimo to discuss a Recovery Potential Assessment (RPA) of the Interior Fraser Coho (IFC) Designatable Unit (DU).

The Terms of Reference for the science review (Appendix A) were developed in response to a request for advice from the DFO Species at Risk Program. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations, the Province of BC, the fishing sector, academia and environmental non-governmental organizations.

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

> Interior Fraser Coho Salmon Recovery Potential Assessment by Arbeider, M., Ritchie, L., Braun, D., Jenewein, B., Rickards, K., Dionne, K., Holt, C., Labelle, M., Nicklin, P., Mozin, P., Grant, P., Parken, C., Bailey, R. CSAS Working Paper 2015SAR10.

The meeting Chair, Bruce Patten, 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, and written reviews.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying 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. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by all attendees.

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, 42 people participated in the RPR (Appendix D). Kayleigh Gillespie was identified as the Rapporteur for the meeting.

Participants were informed that Mike Bradford and Matt Falcy had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews in advance.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to the Species at Risk Program and may be used for the development of a recovery strategy and action plan, and to support decision making with regards to the issuance of permits or agreements. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

PRESENTATION OF WORKING PAPER

Richard Bailey gave an introductory presentation of the early elements of the working paper which included some background information on the history of the IFC status, the motivation for the current work, and a brief overview of the life history of IFC. Michael Arbeider, with support from co-authors, continued the presentation of the working paper which included additional description of the threats faced by IFC, and an in-depth description of the analysis undertaken and resulting models used to project future success of population given recovery strategies. After each element of the working paper was presented, the chair gave participants the chance to ask clarifying questions.

PRESENTATION OF WRITTEN REVIEWS

MIKE BRADFORD

Mike Bradford provided a written review (Appendix B) in advance but was unavailable to attend the meeting so Mary Thiess presented a summary of this review at the meeting.

MATT FALCY

Matt Falcy provided a written review (Appendix B) in advance and presented a summary at the meeting.

GENERAL DISCUSSION

The following section summarizes the general discussion that followed the reviewer presentations. Since certain issues came up several times in discussion they have been grouped by subject matter rather than presented in the chronological order discussed.

THREATS RANKING TABLE

There were numerous questions from participants following the presentation of the working paper that led authors to make some changes and add content to Table 8 of the WP to improve clarity on how threats were chosen and ranked. It was suggested that there be a more clear connection made between the COSEWIC threats calculator, and how it was adapted to create Table 8. Greater explanation in the document as to how the threats were ranked was requested for the final version. The threat from fisheries to IFC's recovery was unable to be calculated as separate threats for commercial, recreational and food, social and ceremonial fisheries, and was changed to be represented as a combined threat from all fisheries. Another request by participants was made to better link the narrative portion of the document and the content that Table 8 is presenting.

Discussion arose while participants reviewed Table 8 to determine what definition of introduced genetic material should be used and if the inclusion of hatchery fish as a proportion of the recovered population is appropriate. There were two different definitions identified for natural-origin versus wild fish. Based on the lack of concern for introduced genetic material being of major impact on this DU it was left without a decision on the definition of fish included in a recovered population. It was suggested that there may need to be a decision made on which definition to use in the future, that is, whether hatchery-origin fish spawning in the wild are eligible for inclusion in recovered population calculations that will occur in future salmon RPAs.

Regarding upcoming Sockeye and Chinook RPAs, participants expressed concern that some effort be made to find a more inclusive process when applying the threats calculator. It was

noted that the somewhat closed approach taken for this RPA might be less suitable for the upcoming assessments.

MODEL SELECTION AND WEIGHTING

Participants focussed discussion on the authors decision to use multiple stock-recruit models and the choice of model weighting approach. The working paper presented three stock-recruit models: the Ricker, Ricker-Priorcap, and Ricker-Dep models. A participant raised that a single model should be chosen, and that it should be the model of best fit. Authors disagreed that a single model needed to be chosen, and that model averaging has been used in the past. It was suggested that Ricker-PriorCap and Ricker-Dep models were providing similar results and that these models should be grouped as each contributing 25% of model weight, and 50% should be contributed by the Ricker model. With additional model results provided by authors it was determined by participants that each model was equally probable, and to avoid emphasising one model that could provide incorrect projections with such a data-limited stock, each model should receive equal weighting, as the authors had originally reported.

ALLOWABLE HARM ASSESSMENT

The final working paper revision request made as a result of the peer-review process was to increase the content in the Allowable Harm section. The working paper focused on recovering the IFC DU given the known threats that affect the recruitment and productivity of this population. It was noted by the authors in the working paper that reducing the exploitation rate of IFC was one option to improve the stocks recovery. Participants agreed that this is one method of assisting IFC recovery; but it was noted that the exploitation rate of IFC is already very low and not entirely within the control of Canada so unlikely to decrease significantly. Other factors influencing smolt-to-adult survival were discussed; however, without habitat-based analyses, there is great uncertainty in the impact other factors are having on the DU.

CONCLUSIONS

The participants' consensus was that the paper should be accepted with revisions. The paper succeeded in addressing all of the objectives presented in the Terms of Reference, although it was noted that data deficiency of this DU makes for high uncertainty in the conclusions reached through the working paper. The authors were able to create three equally probable models that produce reasonable outcomes, and were chosen in combination to reduce the chance of bias from a less realistic model.

RECOMMENDATIONS & ADVICE

During the course of the paper review, it was mentioned that IFC is a data-deficient DU and there were many recommendations made to set priorities to advance recovery of this DU in the future given proposed research. Recommendations for future work included:

- Improve estimates of exploitation rates, fishing encounters, post-release mortality, and the uncertainty around estimates.
- Analyses should include compounding uncertainty in the data (i.e. escapement and recruitment) so that the true uncertainty in the model may be representative. The application of an errors-in-variables model may also be beneficial if measurement error was quantified for either exploitation rate (ER) or escapement. (It is not always possible to quantify measurement error for catch or escapement; so an expert panel approach may be required to develop hypothesized levels of error.)

- Investigate additional or alternative covariates to describe unexplained variability, issues associated with the use of time series data, and trends in productivity.
- Invest in additional habitat analysis work to define the usable area and the accompanying known barriers for IFC habitat.
- Explore parentage-based tagging (PBT) for improved estimation of ER; there is no uniform PBT for the region of study.
- Greater participant inclusion in future threats calculator discussions to get ahead of the upcoming salmon RPA CSAS processes.
- Additional work required to define natural-origin spawner; confusion came up in the meeting in differences between SARA and Wild Salmon Policy (WSP) definitions and whether inclusion of hatchery-origin fish in what constitutes a recovered population is appropriate.

ACKNOWLEDGEMENTS

We thank Mike Bradford and Matt Falcy for sharing their time and expertise in reviewing the working paper, and all of the participants for their constructive engagement in the RPR process. We thank John Candy, Lisa Christensen and Ann Mariscak for providing CSAS meeting support.

APPENDIX A: TERMS OF REFERENCE

Recovery Potential Assessment – Interior Fraser Coho (*Oncorhynchus kisutch)*

Regional Peer Review – Pacific Region

May 22-24, 2019
Nanaimo, British Columbia

Chairperson: Bruce Patten

Context

After the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses an aquatic species as Threatened, Endangered or Extirpated, Fisheries and Oceans Canada (DFO) undertakes a number of actions required to support implementation of the *Species at Risk Act* (SARA). Many of these actions require scientific information on the current status of the wildlife species, threats to its survival and recovery, and the feasibility of recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment. This timing allows for consideration of peer-reviewed scientific analyses into SARA processes, including recovery planning.

The Interior Fraser population of Coho (*Oncorhynchus kisutch*) was designated as Endangered in May 2002 by COSEWIC based on population declines in excess of 60%. The status was re-examined and designated Threatened in November 2016, as the population increased in abundance from 2005 to 2012, but recent escapement and marine survival were very low and were suspected to cause reductions in numbers exceeding 30% over three generations.

DFO Science has been asked to undertake a Recovery Potential Assessment (RPA), based upon the national RPA Guidance. The advice in the RPA may be used to inform both scientific and socio-economic aspects of the listing decision, development of a recovery strategy and action plan, and to support decision making with regards to the issuance of permits or agreements, and the formulation of exemptions and related conditions, as per sections 73, 74, 75, 77, 78 and 83(4) of the *Species at Risk Act* (SARA 2002). The advice in the RPA may also be used to prepare for the reporting requirements of SARA section 55. The advice generated via this process will update and/or consolidate any existing advice regarding the Interior Fraser population of Coho.

Objective

To provide up-to-date information, and associated uncertainties, to address the following elements:

Biology, Abundance, Distribution and Life History Parameters

Element 1: Summarize the biology of the Interior Fraser population of Coho.

Element 2: Evaluate the recent species trajectory for abundance, distribution and number of populations.

Element 3: Estimate the current or recent life-history parameters for the Interior Fraser population of Coho.

Habitat and Residence Requirements

Element 4: Describe the habitat properties that the Interior Fraser population of Coho needs for successful completion of all life-history stages. Describe the function(s), feature(s), and attribute(s) of the habitat, and quantify by how much the biological function(s) that specific

habitat feature(s) provides varies with the state or amount of habitat, including carrying capacity limits, if any.

Element 5: Provide information on the spatial extent of the areas in distribution that are likely to have these habitat properties.

Element 6: Quantify the presence and extent of spatial configuration constraints, if any, such as connectivity, barriers to access, etc.

Element 7: Evaluate to what extent the concept of residence applies to the species, and if so, describe the species' residence.

Threats and Limiting Factors to the Survival and Recovery of the Interior Fraser population of Coho

Element 8: Assess and prioritize the threats to the survival and recovery of the Interior Fraser population of Coho.

Element 9: Identify the activities most likely to threaten (i.e., damage or destroy) the habitat properties identified in elements 4-5 and provide information on the extent and consequences of these activities.

Element 10: Assess any natural factors that will limit the survival and recovery of the Interior Fraser population of Coho.

Element 11: Discuss the potential ecological impacts of the threats identified in element 8 to the target species and other co-occurring species. List the possible benefits and disadvantages to the target species and other co-occurring species that may occur if the threats are abated. Identify existing monitoring efforts for the target species and other co-occurring species associated with each of the threats, and identify any knowledge gaps.

Recovery Targets

Element 12: Propose candidate abundance and distribution target(s) for recovery.

Element 13: Project expected population trajectories over a scientifically reasonable time frame (minimum of 10 years), and trajectories over time to the potential recovery target(s), given current population dynamics parameters.

Element 14: Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present and when the species reaches the potential recovery target(s) identified in element 12.

Element 15: Assess the probability that the potential recovery target(s) can be achieved under current rates of population dynamics parameters, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.

Scenarios for Mitigation of Threats and Alternatives to Activities

Element 16: Develop an inventory of feasible mitigation measures and reasonable alternatives to the activities that are threats to the species and its habitat (as identified in elements 8 and 10).

Element 17: Develop an inventory of activities that could increase the productivity or survivorship parameters (as identified in elements 3 and 15).

Element 18: If current habitat supply may be insufficient to achieve recovery targets (see element 14), provide advice on the feasibility of restoring the habitat to higher values. Advice must be provided in the context of all available options for achieving abundance and distribution targets.

Element 19: Estimate the reduction in mortality rate expected by each of the mitigation measures or alternatives in element 16 and the increase in productivity or survivorship associated with each measure in element 17.

Element 20: Project expected population trajectory (and uncertainties) over a scientifically reasonable time frame and to the time of reaching recovery targets, given mortality rates and productivities associated with the specific measures identified for exploration in element 19. Include those that provide as high a probability of survivorship and recovery as possible for biologically realistic parameter values.

Element 21: Recommend parameter values for population productivity and starting mortality rates and, where necessary, specialized features of population models that would be required to allow exploration of additional scenarios as part of the assessment of economic, social, and cultural impacts in support of the listing process.

Allowable Harm Assessment

Element 22: Evaluate maximum human-induced mortality and habitat destruction that the species can sustain without jeopardizing its survival or recovery.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, and Ecosystems and Fisheries Management sectors)
- Province of BC
- Academia
- First Nations
- Industry
- Environmental non-governmental organizations

References

COSEWIC. 2016. COSEWIC assessment and status report on the Coho Salmon *Oncorhynchus kisutch*, Interior Fraser population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 50 pp.

APPENDIX B: WORKING PAPER REVIEWS

REVIEWER: MIKE BRADFORD, FISHERIES AND OCEANS CANADA

This is a thorough and well-written document that builds on previous work conducted on the same stock group. This RPA has the elements needed to provide advice for the listing decision, although the length of the document will mean a carefully crafted SAR will be needed as a succinct summary.

This population was re-assessed from endangered to threatened in 2016. The roadmap for recovery is often based on the “reasons for designation” in the COSEWIC assessment but unfortunately the reasons are somewhat difficult to interpret. In my view it is worth attempting to predict the conditions that would lead to a de-listing decision as this will affect the recovery potential and the approaches taken to it. For example, one could ask that if the aggregate was managed to a level of 35K spawners and all else was left unchanged, would it be designated as “not at risk”?

In my review I first provide a number of larger issues, and follow with editorial and smaller comments intended to improve the document.

1. Limits of Knowledge: I found at times there were inferences or assertions made in the document that were either not supported by any cited information or were based on first principles or knowledge of Coho salmon from other parts of its range. Clearly there is a lack of information for IF Coho for many aspects of life history and habitat use. This lack of knowledge should emerge as a key point because it can potentially inform studies and actions that may be listed within the recovery plan, if listing on Schedule 1 is the result of this process. Some of the sections (particularly those related to habitat and habitat-based threats) could do with an opening statement such as “no information is available for IFC so the following is based on…..”. In other places general concepts should be separated from what is actually known about IFC or the Interior Fraser region. A few examples are provided in the detailed comments.
2. Element/Section 2 Trends: This section is an opportunity to update the trend assessments conducted by COSEWIC. The authors have done that, but comparisons are not explicitly made. In COSEWIC (2016) the reasons for listing are not particularly clear as 10-year trends, the primary statistic, are positive for all CUs, which seems to conflict with the explanation given in the “reasons for designation”. Some narrative that describes the potential implications of the addition of the 3 years of data on the trend statistics is needed. At first glance it appears that the rates of change have generally declined. As noted below, a figure of untransformed raw escapement data (see Figure 8 of COSEWIC (2016)) would be helpful for communicating any changes that have occurred as a result of the new data.
3. Element 12- Recovery Targets: Recovery targets approach set out in the RPA Guidelines seem intended for populations that are obviously well below desirable levels of abundance. However, in some cases the reasons for designation may not be the result of low abundance. One case is endemic populations of small habitats. More relevant for IFC is an interpretation of the reasons for designation that is based more on ongoing threats than actual abundance levels. In this case, a recovery target within the range of recent abundances (as proposed here) is reasonable under the assumption that recovery (resulting in a change in assessed status) can occur if threats can be managed or mitigated.

   Although one can infer the relation between the proposed recovery target and some recent abundances from Figure 3 a figure that compares the target to the full time series of recent abundance would be helpful to understand the magnitude of “recovery” and the scope of

recovery measures that is implied by the proposed target. A statement like the aggregate has exceeded the target in X% of years since 1992 would be useful.

I should think the authors should also take some latitude from the Guidelines by proposing other aspects of recovery (related to threats) that would address some of COSEWIC's other reasons for designation. Some of the concepts from IFCRT objective 2 may be relevant here.

4. Habitat-Based Elements

   The report provides a broad-based review of habitat threats to IFC largely based on the general salmon and habitat literature, but does not provide sufficient site-specific detail from which one can draw advice, or provide direction to a list of potential studies that could address knowledge gaps. Perhaps the authors should have drawn more from the IFCRT (2006) report that attempted, at the watershed level, to assess the significance of various potential stressors. Not all of the stressors are equally relevant in all DUs and there may be a way of providing some direction on priorities given current populations trends in each DU, and the potential of actions designed to mitigate stressors in the landscapes relevant to each DU to change the status of each DU.

   It is difficult to draw science advice from Section 6.1.7, Conclusions around mitigations relevant to the recovery of IFC in the context of a SARA listing. Are there specific habitat actions than can be taken in the RPA timeline (~10 years) that will contribute to delisting?

5. Hatchery Production as a Mitigation Measure

   The report is silent on the use of hatcheries as a mitigation measure. Hatcheries are present in the IFC region and there may be potential for hatchery production to assist in recovery under certain circumstances. It is likely there are parties interested in the use of hatcheries to assist recovery or to enhance use opportunities. This should be addressed. The guidance provided by Withler et al. (2018) for WSP considerations should be appropriate in the COSEWIC/SARA context.

Specific Comments

L21,29 The use of "adult mortality" interchangeably with fishing mortality adds a level of ambiguity as there is also natural adult mortality. I would suggest being explicit about fishing mortality (line 29).

L86- the Korman paper is now published on the CSAS website as 2019/01

L103- this first sentence is awkward. Perhaps "In response to the decline in abundance and productivity, reductions in exploitation rates were instituted beginning in xx". Were there corresponding reductions in US fisheries that may have intercepted IFC?

L208- the issue of "straying" is key to thinking about metapopulation processes both within and among CUs. Is the 5% rate mentioned here generic or specific to IFC? Is this likely for adjacent watershed (defined as CUs)? I suspect this rate of interchange would eliminate the genetic differentiation noted in Figure 2. It may be more appropriate for the exchange among spawning sites. But in any event, it should be clarified if this knowledge about IFC coho or a general rate from the literature.

L244 Arbeider 2018 not in references. The UBC thesis of A.L. Macdonald (1984?) suggests coho smolts do not remain in the estuary for any length of time.

L251- The 88% is too low, as only the age 1.0 (jacks) do not spend one and half years in the ocean. Should be closer to 99%.

L265- to end of page. Important to note that these observations are for coho in general as there are no specific citations for IFC.

L323 “Spawners” is missing after IFC

Figure 3. It is always good to show the raw spawner data, perhaps as a multipanel (5 CUs, I DU). Line 405 -“Data *are*”

L427 missing word.

Line 426- it should be noted the purpose of element 2 is to provide updates if there are significant new data and comment on whether a COSEWIC reassessment is warranted. I assume that you only have a few new years of data since the assessment. It would be useful to spell out what COSEWIC did, and then update the previous analysis. It appears that estimates of trends of pre-fishery returns were not part of the COSEWIC assessment and should either be removed or identified as such.

There should be a comment on whether the new data warrant a reassessment, as per the RPA guidelines.

Tables 4&5 and further- put page breaks in to keep tables together on one page.

L 514- some aspects of this section are also found in section 2.1, and perhaps 2.1 can be reduced as more of an overview to avoid duplication.

L523—how do you know “overall abundance of spawning habitat is not generally limiting”? Is this for coho in general, or IFC?

L570- how many lakes have been surveyed? Is there an absence of use, or absence of information?

L589- After one *or sometimes two* years in freshwater

L632—is there any direct support for impacts of Hells Gate? Is this being inferred from pink salmon, for example?

L848—for completeness there is a gas pipeline that runs down from Prince George and crosses into the Coldwater basin and then to Vancouver. See the NEB online mapping tool.

L898 Korman et al. 2019.

L971 perhaps replace “new thinking” with “adjustments for underestimates of fishing mortality from..”

L984 redds

L1077: I am not sure that new IPP projects are “likely” in the range of IFC given provincial energy policy.

L1111: This paragraph is not well supported. Is forestry extensive or pervasive? Can specific statistics be cited or studies reviewed? If not, then that should be stated as a difficult to

quantify risk. Similarly the next few paragraphs provide a narrative that could benefit from some specifics, or an appropriate statement about uncertainty in the IFC context.

L1302. I believe that nearly all IFC hatchery production is based on local-origin broodstock and is conducted in a manner consistent with integrated hatchery programs and genetic guidelines (but check with SEP). In that sense the risk associated with “introduced genetic material” would seem small.

1719: This refers to the Eagle? What is the recent hatchery component? Earlier it is stated that spawning areas are not limiting populations. Of course there are risks if the hatchery component is larger and more productive than the wild (See Withler et al. 2017 CSAS review of hatchery genetics).

L1815, this is repeated earlier. It should be noted the time yolk-sac larvae spend in the gravel is significant and they are more sensitive to environmental conditions than eggs.

L1819 See Bradford et al. 2000 where we provide evidence for a lack of compensation for the egg-fry stage. However, those data are for coastal populations.

L1909. Like most stream-rearing salmonids there is likely competition at one or more freshwater stages that leads to some form of inverse relation between Rec/Spawner and abundance as is shown in Figure 3. For smaller coastal streams there is abundant evidence of this in the form of a limiting life stage, sometimes low flow period in summer, sometimes in winter, that sets a broad upper limit on smolt production (See Bradford et al. 2000). The situation is likely more complex for IFC due to the indeterminate life history and habitat use, but perhaps the best parallel examples come from interior stream-type chinook salmon that have a similarly diverse life history. In any case, while strict “small stream” territoriality may not be common in some of these larger habitats, behavioral interactions leading to mortality or displacement is undoubtedly important.

2045- it is unclear why the recovery goal is based on analysis of 1998-2016 when earlier in the document reference is made to the “recent” period of 1991-2017. It would be useful to assess the role of an apparent outlier (0,32K) on the target and if there is anything unusual about that year in terms of data collection or otherwise. The addition of more years may help reduce the influence of one year.

2049- it should be clearly stated here whether the target is for one year, or 3-year based on some averaging method as in Table 11.

2078- a condition that is not mentioned here is that hatchery production is assumed to be “turned off”. Are hatchery fish spawning in the wild included in the “spawners” of the stock recruit analysis? Were they part of the seed years for the simulations?

2424- Not clear to me why you would model ER as a statistical distribution when it is a management decision (with some uncertainty in implementation).

2359—I like the list, but would suggest that a deeper understanding of biology and how these metapopulations work is important to inform the key decision about model structure. For 4 of 5 CUs the data are the aggregate of many different sized populations that use different spawning habitats at different levels of abundance and environmental conditions and have likely variable, but unknown juvenile dynamics. What is the implication of aggregating all this information in a single stock-recruit model?

2460- curious that extirpation is modelled but not included as a performance measure.

2570- The conclusion about the sensitivity of marine survival and ER is partly a function of how each is framed. If ER is converted to survival through the fishery the dashed lines in Figure 19 span 82-94%, compared to 0.7-1.6% for marine survival. Thus variation in marine survival will have a larger impact because the proportional range is much greater.

2579: suggest “they are representative of the recent past, and are assumed to be reasonable for the immediate future..”

2867: In certain circumstances hatchery production can accelerate trends in abundance, particularly if there are transient or mitigatable threats (that have a finite time frame). I was surprised that no consideration is given to hatchery production, given that it is currently in place and has been present throughout the period of study. The potential for hatchery production to enhance recovery will be a question the Department will be faced with and some commentary is needed here (and it is listed prominently in Table 1).

REVIEWER: MATT FALCY, OREGON DEPARTMENT OF FISH AND WILDLIFE

General Comments

1. The clarity of thought in Chapters 1-5 is excellent.
2. The organization of the Assessment is very good. Any document of this complexity will require the reader to flip between sections. The Assessment is very good at referencing itself.
3. The depth of discussion of the overall biological context given in chapters 1-4 is very good, and includes a very good literature review.
4. A description of how the raw data were used to estimate spawning escapement could be improved. The Assessment references an unpublished report that appears relevant, but more could be done to describe the abundance estimation methods, including strengths and weaknesses of whatever field protocols and analytics were used. How were counts made at specific places and times used to infer the abundance at the level of an entire population and run year? The abundance of hatchery-origin spawners in the assessment data (Appendix 4) is not described, and presents a technical concern blow.
5. The modeling performed in Chapters 5 is generally very good and reflects considerable technical expertise. The exposition (English, math, figures) is very clear. Assumptions are clearly described and documented. The assessment of the sensitivity to priors is good. See the technical comments below for specific concerns that were seemingly not addressed within the Assessment.
6. Chapter 6 (scenarios for mitigation of threats and alternatives to activities) is relatively weak. It is difficult to do scenario-gaming without a detailed life-cycle model, which would require data that are presumably unavailable. Still, this chapter is less authoritative and precise. For example, recommending monitoring of AIS eradication activities (L2740) ignores the more complex issue of how to optimally allocate limited budgets across multiple objectives. This section should seemingly provide a road-map for doing adaptive management, management strategy evaluation, and/or bio-financial optimization. Are the current data collection methods best or should different kinds of data be collected? Decision points should be described more crisply, with details on how new information can be used to make better decisions. The concept of expected value of perfect information could be introduced and used as an organizing principle for this section.

7. More broadly, I believe the Assessment would benefit from a more explicit attempt at structured decision making. What is the ultimate purpose of a target or goal? What actions will be taken when a goal or target is attained? Which uncertainties are irrelevant to deciding among potential actions? Should science and monitoring focus on future status assessments or resolve uncertainty around specific actions? Bureaucratic processes are always very complex, but I would hope that this complexity does not prevent individuals or teams from trying to define goals and decision points in a manner that better serves both society and salmon.

Technical Comments

1. L2192. I realize that Beverton-Holt can produce extreme values for intrinsic productivity, and so I am sympathetic to the adoption of the Ricker model. However, most salmon datasets do not contain clear evidence to discriminate between a BH with high intrinsic productivity, and a Ricker with much lower intrinsic productivity. What is the nature of the evidence referenced here? How might uncertainty in model choice affect big-picture prognostications?
2. L2219-2222. I believe the language will mislead most readers. In this model, reducing HSASI will cause recruit abundance to decline across all possible levels of spawner abundance.
3. L2309. Overall, the Assessment is quite commendable for exploring sensitivity to priors, and I am generally satisfied. However, the authors may wish to explore placing a uniform prior the standard deviation of the normal distribution (Gelman, 2006. Bayesian Analysis 1: 515-533). The lognormal prior on beta is nice for disallowing negative values, but the selected values may influence the posterior more than a uniform distribution.
4. L2365. "Hatchery contribution." There could be an important issue here that deserves more explicit attention in this Assessment. It appears that the proportion of hatchery- origin fish was 60% of escapements in 1998-2000 (L1341). The data used in the Assessment begin in 2001 (L2135). I presume that hatchery-origin fish remained abundant in the beginning of the time series and then declined to the current level of 3.4% (L1348). If so, there are important implications for estimating the productivity of natural-origin spawners…. If the relative reproductive success of hatchery-origin fish is less than natural-origin spawners (Christie, Ford, and Blouin [2014] Evolutionary Applications), then the recruits will be more likely to be offspring of natural-origin fish. This means that the productivity of natural-origin fish will be underestimated when "spawners" is a simple enumeration of all hatchery and natural-origin fish. There are implications here for trends in productivity.
5. L2382. The alpha presented in this table is not on the same scale as alpha in Eq (2) and Eq (4). In Table 4, we must be seeing the result of taking the natural log of the alpha depicted in Eqs. 2 and 4. I appreciate seeing alpha back-transformed as in Table 4. I simply recommend clarifying the transformations to ease understanding. This could be done in the table legend.
6. L2397. It appears that the simulations assumed stationarity in the sense that trends in residuals (Appendix 11) were not incorporated. This could be an egregious assumption for a declining population (Fraser Canyon, Figure 27).
7. L2406. I understand that variable mortality will induce variation in spawner age composition. Is the ratio of simulated 3yo and 4yo fish similar to the observed ratio? If not, the covariate may be inadequate or there could be temporal variation in maturation propensity.

8. L2410. I believe it would make more sense to hold constant the values of alpha, beta, and gamma across time. To incorporate parameter uncertainty, the values of alpha, beta, and gamma can be sampled from the joint posterior across the 500 Monte-Carlo trials.
9. L2422. What is the rationale for truncating simulated values HSASI? I appreciate using the more recent years (L2417-2419). The mean and variance computed from this period (without truncation) seemingly provides the best depiction of the near future.
10. L2464. The proportion of positive trajectories will be 0.5 because the forward projection model does not incorporate any form of trend in the parameters or covariates. Finding this "result" (L2482) is really just a restatement of the assumptions, and thus does not represent any new knowledge. Indeed, I think the assumption of stationarity needs to be more explicit when discussing the results and purpose of these simulations. Connect back to Figure 4 (L465) with a compare/contrast discussion and official position of what the data (Figure 4) and the modeling (Figures 19 & 20) mean.
11. L2516. I appreciate that marine survival and exploitation rate dominate this section because the effects of these variables can be quantified and explored with modeling. However, something new in this section could discuss the implications of egg survival varying anywhere from 0-74% (L214).
12. L2570. The result of the sensitivity analysis would be easier to interpret if % change in the response variable (proportion of positive trajectories) is reported in terms of standard deviations instead of the arbitrary step sizes. Note that there are more steps within one standard deviation of Exploitation Rate than steps within Marine Survival. Do Marine Survival and Exploitation Rate covary?

Errata

1. L2. Add "(DU)"
2. L255. "1%" conflicts with "10%" given on L4015.
3. L323. Note the reference problem. Use search functions to find other instances.
4. L506. Two periods.
5. L712. "… of for…"
6. L1636. Use of "modelled" is awkward.
7. L1640. "increase increase"
8. L1645. Delete "While"
9. L1716. Delete "is"
10. L2022. Inconsistent underlining of Target Names.
11. L2053. Reference Figure 12 in the main text. I like this.
12. L2085. Not just alpha', but also beta and Neq.
13. L2112. Replace "to" with "about"
14. L2186. The sentence is a fragment.
15. L2216. Insert "be"
16. L2185. The sentence should be revised for clarity.
17. L2216. The word "be" is missing.

18. L2348. Carrying capacities (Neq) should be reported in a table.
19. L2402. "…where the performance metrics were stable (standard error ≤ 3%)" . The word "where" made this difficult for me to understand. Perhaps add a sentence stating that 500 trials is sufficient to capture expectations and uncertainties in performance metrics that are relatively unfettered by simulation sample size.
20. L2613-2617. Is this alleging that synergy among threats is more likely to occur at the DU level than the population level? Perhaps rewrite to improve clarity.
21. L2619-2621. This could come before the paragraph above it.
22. L2623. "nature" is vague, and "plastic" should not be used like this because it does not match the technical usage of "plasticity" understood by geneticists and eco-evolutionary biologists.
23. L2631. Instead of "This document", I suggest repeating "Corker et al." to avoid confusion with the Assessment.
24. In Chapter 6, replace "which" for "that" unless preceded by a comma.
25. L2698. Complete the sentence.
26. L2711. "our" is a shift into first person.
27. L2711-2714. Poor sentence structure. Everything between "with" and "would" is an insertion that would be better off in a follow-up sentence beginning with "For example,…"
28. L2817-2821. This sentence seems to combine several ideas that could potentially be explained more clearly in several sentences.
29. L2824-2828. Again, lots of ideas packed into a single sentence. Instead of merely saying that these things need to be "reconsidered," it would be helpful to provide a glimpse of what that looks like in terms of decision points and tradeoffs.
30. L2831. "will need to improve" seems like impossible advice to follow since extraction is "unmonitorable and hence unmonitored."
31. L2856. Don't start a paragraph with "This". A new paragraph implies a change in topic, but "this" does not.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific
Regional Peer Review Meeting (RPR)

Recovery Potential Assessment – Interior Fraser Coho (*Oncorhynchus kisutch*)

May 22-24, 2019
Nanaimo, British Columbia

Chair: Bruce Patten

Day 1 - Wednesday, May 22, 2019

Time	Subject	Presenter
0900	Introductions, Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Overview of Recovery Potential Assessment Approach	Sean MacConnachie
0930	Review Terms of Reference	Chair
0940	*Biology, Abundance, Distribution and Life History Parameters*: Presentation of Working Paper & Written Reviews	Authors & Reviewers
1030	***Break***	
1050	*Habitat and Residence Requirements*: Presentation of Working Paper & Written Reviews	Authors & Reviewers
1200	***Lunch Break***	
1300	*Threats and Limiting Factors to Survival and Recovery:* Presentation of Working Paper & Written Reviews	Authors & Reviewers
1445	***Break***	
1500	*Recovery Targets:* Presentation of Working Paper & Written Reviews	Authors & Reviewers
1630	Identification of Key Issues from Day 1 for Group Discussion (during Day 2)	RPR Participants
1700	***Adjourn for the Day***	

Day 2 - Thursday, May 23, 2019

Time	Subject	Presenter
0900	Introductions, Review Agenda & Housekeeping Review Status of Day 1	Chair
0915	*Scenarios for Mitigation of Threats and Alternatives to Activities*: Presentation of Working Paper & Written Reviews	Authors & Reviewers
1030	***Break***	
1050	*Allowable Harm Assessment*: Presentation of Working Paper & Written Reviews	Authors & Reviewers
1200	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	Chair
1330	Discussion & Resolution of Technical Issues	RPR Participants
1445	***Break***	
1500	Discussion & Resolution of Technical Issues • Continued	RPR Participants
1600	Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1700	***Adjourn for the Day***	

Day 3 - Friday, May 24, 2019

Time	Subject	Presenter
0900	Introductions, Review Agenda & Housekeeping Review Status of Day 2	Chair
0915	*(As Necessary)* Carry forward outstanding issues from Day 2	RPR Participants
10:00	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Sources of Uncertainty • Results & Conclusions • Additional advice to Management (as warranted)	RPR Participants
1030	***Break***	
1050	*Science Advisory Report (SAR)* • Continued	RPR Participants
1130	Next Steps – Chair to review • SAR review/approval by participants and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1145	Other Business arising from the review	Chair & Participants
1200	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Arbeider	Michael	DFO Science
Bailey	Richard	DFO Science
Braun	Doug	DFO Science
Campbell	Kelsey	Joint Technical Working Group/A-Tlegay Fisheries/Island Marine Aquatic Working Group
Candy	John	DFO Centre for Science Advice Pacific
Christensen	Lisa	DFO Centre for Science Advice Pacific
Dionne	Kaitlyn	DFO Science
Dunlop	Roger	Pacific Salmon Treaty Coho Technical Committee
Falcy	Matt	Oregon Department of Fish and Wildlife
Fisher	Aidan	Lower Fraser Fisheries Alliance
Frederickson	Nicole	Island Marine Aquatic Working Group
Galbraith	Ryan	DFO Salmon Enhancement Program
Gayle	Brown	DFO Science
Gerick	Alyssa	DFO Species at Risk Program
Gillespie	Kayleigh	DFO Science
Hall	Peter	DFO Species at Risk Program
Hawkshaw	Mike	DFO Science
Holt	Carrie	DFO Science
Huang	Ann-Marie	DFO Science
Jantz	Les	DFO Fisheries Management
Jenewein	Brittany	DFO Fisheries Management
Kanno	Roger	DFO Fisheries Management
Labelle	Marc	Okanagan Nation Alliance
Luedke	Wilf	DFO Science
MacConnachie	Sean	DFO Science
Mahoney	Jason	DFO Salmonid Enhancement Program
Maxwell	Marla	DFO Fisheries Management
Maynard	Jeremy	Sport Fishing Advisory Board
McCleary	Rich	Province of BC
McGreer	Madeleine	Central Coast Indigenous Resource Alliance
Mortimer	Matt	DFO Fisheries Management
Nicklin	Pete	Fraser River Aboriginal Fisheries Secretariat
Parken	Chuck	DFO Science
Patten	Bruce	DFO Science
Pearce	Robyn	DFO Species at Risk Program
Pestal	Gottfried	SOLV Consulting
Rickards	Karen	DFO Fisheries Management

Last Name	First Name	Affiliation
Ritchie	Lynda	DFO Science
Sawada	Joel	DFO Science
Staley	Mike	International Analytic Science Ltd.
Thiess	Mary	DFO Science
Van Will	Pieter	DFO Science

APPENDIX E: ABSTRACT OF WORKING PAPER

The Interior Fraser Coho Salmon (IFC) (*Oncorhynchus kisutch*) Designatable Unit was assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2016, and is currently under consideration for addition to Schedule 1 of the *Species at Risk Act* (SARA). This Recovery Potential Assessment (RPA) provides descriptions and status of populations, habitat, threats, and limiting factors, possible recovery targets and population projections, as well as recommendations regarding mitigation and allowable harm. The initial decline in IFC is attributed to decreased marine survival and lagged fisheries management response; however, subsequent management has buffered further decline. The population trajectory since 2005 appears flat, with uncertainty. Quantification of suitable freshwater habitat represents a gap in knowledge for IFC. Threats with the highest ranked risk (modifications to catchment surfaces, linear development, and agricultural and forestry effluent) were associated with landscape-level modifications affecting whole watersheds. As well, threats from both anthropogenic and natural factors will be exaggerated by climate change and cumulative impacts. Recommended mitigation measures were kept broad in scope because a biogeoclimatic, landscape-level approach that may benefit multiple COSEWIC assessed salmonids and freshwater species is likely the most effective approach, and would require a collaborative effort beyond this RPA. The suggested DU-level natural-origin spawner abundance target of a 3-year geometric mean of 36,935 is based on observed abundances that met a distribution goal of 1000 spawners per subpopulation. Population projections of growth to the recovery target under different exploitation (adult mortality) and marine survival (smolt-to-adult survival) regimes was based on a stock-recruit analysis from brood years 1998-2013, but contains several caveats and conditions. Three models, based on different hypothetical population dynamics, were updated from a previous CSAS assessment and their forward projection results were given equal weight and model-averaged. Results indicate that positive population growth and reaching the recovery target under current conditions (average exploitation rate of 12.5% and marine survival of 1.0%) is about as likely as it is not likely. If marine survival continues like current conditions and no further impacts occur, IFC are likely (≥ 66% chance) to have positive population growth at an adult mortality of 6%; however, the risks imposed by climate change and continued anthropogenic development add additional uncertainty. Therefore, it is recommended that only activities in support of the survival and recovery of the species, which may result in possible mortalities (e.g. stock assessment, research, or mitigation activities), be permitted to insure positive population growth.