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Proceedings of the Pacific regional peer review on Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-Origin Taku River Coho Stock Aggregate

November 3-4, 2014
Nanaimo, B.C.

Chairperson: Dr. Jeffrey Lemieux
Editor: Louise de Mestral Bezanson

Fisheries and Oceans Canada
Science Branch
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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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TABLE OF CONTENTS

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 November 3rd and 4th, 2014, at the Nanaimo Conference Centre in Nanaimo, B.C.. One working paper focusing on estimates of spawning goals and benchmarks for Canadian-origin Taku River Coho Salmon was presented for peer review.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science (Yukon, Lower Mainland and North Coast offices), US Governmental representatives (Alaska Department of Fish and Game), First Nations groups and representatives (Taku River Tlingit First Nation, Lower Fraser Fisheries Alliance, Fraser River Aboriginal Fisheries Secretariat), as well as consultants (Solv Consulting, Vancouver).

The conclusions and advice resulting from this review will be provided in the form of one Science Advisory Report (SAR) providing advice to the Transboundary Panel (Canada and USA) formed under the Pacific Salmon Treaty to inform fisheries management decisions influencing spawner abundances. As well, the SAR will provide advice on data requirements for possible assessment of Taku River Coho Salmon under the Canadian Wild Salmon Policy.

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

Compte rendu d'un examen par les pairs de la région du Pacifique sur l'élaboration d'un objectif en matière d'échappées fondé sur des données biologiques sur le saumon coho de la rivière Taku

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et des conclusions de la réunion régionale de consultation du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada qui a eu lieu les 3 et 4 novembre 2014 au Nanaimo Conference Centre, en Colombie-Britannique. Un document de travail portant sur les estimations des objectifs et des points de référence en matière de frai pour le saumon coho d'origine canadienne de la rivière Taku a été présenté aux fins d'examen par les pairs.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, il y avait des employés du Secteur des sciences (bureaux du Yukon, du Lower Mainland et de la côte nord) de Pêches et Océans Canada (MPO), des représentants du gouvernement des États-Unis (Alaska Department of Fish and Game), des représentants et des groupes autochtones (Première Nation Tlingit de la rivière Taku, Lower Fraser Fisheries Alliance, Fraser River Aboriginal Fisheries Secretariat) ainsi que des experts-conseils (Solv Consulting, Vancouver).

Les conclusions et l'avis découlant de cet examen seront fournis au moyen d'un avis scientifique offrant des conseils au Conseil transfrontalier (Canada et États-Unis) créé en vertu Traité sur le saumon du Pacifique de façon à orienter les décisions sur la gestion des pêches ayant une influence sur l'abondance des reproducteurs. De plus, l'avis scientifique présentera des conseils sur les exigences en matière de données pour l'évaluation éventuelle du saumon coho de la rivière Taku en vertu de la Politique concernant le saumon sauvage du Canada.

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur le site Web du calendrier des avis scientifiques du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on November 3rd and 4th, 2014, at the Nanaimo Conference Centre in Nanaimo B.C. to review estimates of biological benchmarks for spawner abundances of Taku River Coho Salmon.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Fisheries Management and the Transboundary Panel, which oversees the cooperative management of Taku River Coho Salmon by the Canadian and US governments under provisions specified in the Pacific Salmon Treaty. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations groups and representatives, DFO Science, and US Alaska Department of Fish and Game (ADFG).

The following working paper was prepared and made available to meeting participants prior to the meeting (working paper abstract provided in Appendix E*): Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-Origin Taku River Coho Stock Aggregate* (CSAP 2014/15 SAL01).

The meeting Chair, Jeffrey Lemieux, 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 and working paper.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteur, Louise de Mestral Bezanson. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a public consultation. The room was equipped with microphones to allow web-based participation, and in-person attendees were reminded to address comments and questions so they could be heard by those online.

Participants were reminded that everyone at the meeting had equal standing 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, 20 people participated in the RPR (Appendix D).

Participants were informed that Mike Bradford and Bob Clark 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 also informed of the attendance and conclusions from a pre-review conference call that had been held October 30, 2014 between the lead author of the working paper, the two reviewers, the Chair, as well as a working group member from DFO. The objective of the pre-review meeting was to discuss the reviews and suggested changes to facilitate an efficient discussion at the peer-review meeting.

The conclusions and advice resulting from this review will be provided in the form of Science Advisory Report to the Transboundary Panel (Canada and USA) formed under the Pacific Salmon Treaty to inform fisheries management decisions influencing spawner abundances. As well, the SAR will provide advice on data requirements for possible assessment of Taku River Coho Salmon under the Canadian Wild Salmon Policy. The Science Advisory Report and

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

REVIEW

Working Paper: Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-Origin Taku River Coho Stock Aggregate. WP 2014/15 SAL01

Rapporteur: Louise de Mestral Bezanson

Presenter: Gottfried Pestal

PRE-REVIEW MEETING BETWEEN AUTHORS AND REVIEWERS

The Chair provided a summary of the discussion that occurred at the pre-review meeting between authors and reviewers. There was discussion of the appropriate level of population aggregation at which to conduct the analysis. It was concluded that that the authors' analysis at the aggregate level (i.e. one population of Taku River Coho Salmon) was defensible. In addition, it was concluded in the meeting that the authors would present additional information about observation errors in the spawner-recruit data, as well as comments on how this source of uncertainty might affect recommendations in the working paper.

PRESENTATION OF WORKING PAPER

Gottfried Pestal, the lead author of the working paper, gave a presentation that closely followed the contents of the working paper (see Appendix E).

WRITTEN REVIEWS

MIKE BRADFORD

Mike Bradford (MB) provided a summary of his written review (see Appendix B) as well as several additional comments.

Overall, he found the working paper to be well done, and the analysis techniques applied to be appropriate.

MB raised a question of model selection. He questioned whether Ricker Models are appropriate for Coho Salmon due to the possible lack of a biological mechanism causing overcompensation at high abundances. While density-dependence, or overcompensation, is observed for Pink and Sockeye Salmon, it needs to be demonstrated for Coho Salmon. Reduced productivity at higher spawner abundances is a key assumption of Ricker spawner-recruit models, thus incorrectly assuming its existence could affect conclusions drawn from these models.

MB suggested including a description of age structure, which could be used to develop a time series of smolt-to-adult survival rates. This could help to address the issue of whether changes in productivity are due to environmental (e.g. marine) or density-dependent effects. A recommendation to include this type of analysis in the working paper was not made due to the substantial amount of additional work it would require; however, this was discussed as an important issue that should be addressed at some point.

A discussion of fish ageing techniques occurred, which involved the observation that the majority of the stock sampled via fish wheel switched from being dominated by '2-check' (two

year old) smolts to ‘1-check’ (one year old) smolts in the late 1990’s. It was questioned whether this change could be due to changes in stock composition, and whether this could be responsible for changes in productivity.

The authors of the working paper noted that observations of a relatively recent increase in the early run (adult migration timing) component of the population support the idea of a change in stock composition. However, they were of the opinion that changes in productivity due to stock change were unlikely.

MB suggested that guidance should be provided on which of the many model results should be presented to management. This was generally supported, and an explanation of which results to include in the SAR is provided below. See Appendix B for written comments provided from MB, reflecting his review.

BOB CLARK

Bob Clark (BC) found the working paper to be an interesting, well-analysed view of production dynamics. The purpose was clearly stated, and the data and analytical methods were adequate to support the conclusion. He suggested that an inclusion of error bars representing observation error (e.g. coefficients of variance, confidence intervals) on abundance data could be helpful in exploring the impact of uncertainty on spawner-recruit model fits. BC suggested that including uncertainty in spawner estimates would not likely change results, but would provide better support for conclusions.

BC found that the authors did a good job of addressing both DFO and ADFG’s assessment needs. He did caution however, that it is important to be ‘policy neutral’ when presenting results. For example, the choice of probability levels for each metric presented was a subjective decision, and authors should stress that presented levels are meant to be illustrative and not prescriptive. BC also suggested that it would be helpful to present metrics generated for both countries on one plot.

BC found that a major strength of the work was robustness of results across the multiple datasets used and types of models fitted. He observed that a model averaging approach would likely yield similar results. See Appendix B for written comments provided from BC, reflecting his review.

GENERAL DISCUSSION

CONSERVATION UNITS

Taku River Coho Salmon are currently assessed and managed as a single aggregate (i.e. ADFG assessments at Canyon Island, Canadian test fisheries, Transboundary Panel harvest planning). However, unpublished analyses indicated that there may be up to three distinct Conservation Units (CUs) identified in a future formal WSP status assessment. The working paper analysed the population at the current single management unit. Discussion took place over the appropriateness of providing science advice based on the aggregate assessment. It was concluded that the current analysis was sufficient under the TOR. As well, juvenile and adult data collection is at the level of the entire population, and if analysis at a smaller CU level is required, it is likely that insufficient data would be available for an analysis similar in scale to that undertaken for the aggregate.

DATA OBSERVATION ERROR

Inclusion of observation error in juvenile and adult assessment data in analyses and presentation of data was discussed. It was concluded that it would be helpful to convey estimates of observation error (e.g. coefficients of variance, confidence intervals) in presented plots of spawner abundance and recruits, for example, in the SAR and the working paper. It was also concluded that a formal incorporation of observation error through a Bayesian run reconstruction would be an interesting extension of the work, but is beyond the scope of this project and likely wouldn't change the results much, given the observed robustness across alternative assumptions (e.g. different age compositions).

MODEL SELECTION

Because several models were each fit to multiple data sets, producing many sets of parameter estimates, model selection criteria were developed by the working group to determine which results would be recommended for management use. The model types were three versions of the Ricker stock-recruit model: 1) standard Ricker model; 2) Ricker model correcting for autocorrelation in residuals; 3) Ricker model incorporating changing productivity over time (Kalman-filtered Ricker). The multiple datasets consisted of data based on two age structure estimations as well as spawner and recruit data for males and females combined, as well as just females.

The following steps compose the discussed and agreed-upon model selection criteria:

1. Juvenile results were not recommended because they had consistently worse model fits based on a standard statistical criterion and use of these results would be better fitted to the objective of maximising smolt abundance rather than adult recruits.
2. Kalman-filtered Ricker model results were not recommended because they incorporated annual variation in S_{MSY}, thus their use would require an annual productivity forecast from the last available brood year. It is likely problematic for fisheries management to use an annually changing goal.
3. Results using only female spawners expanded to adult equivalents were not recommended because these results are likely not useful for management purposes. Management occurs at the level of total spawners.
4. Results for the alternative recruit time series based on age composition in the Canadian commercial and test fisheries were not recommended, because the age composition data from the Canyon Island survey is considered more reliable due to its longer time span and use of samples from a less size-biased sampling method.
5. Results from the standard Ricker results were not recommended because the strong observed autocorrelation in residual plots and the formal Durbin-Watson tests indicate that the Ricker model incorporating autocorrelation of residuals is most appropriate.

It was recommended that this rationale for recommending one of the eighteen alternative model-data combinations be included in the SAR as well as the working paper.

DISCUSSION OF POLICY IMPLICATIONS

The authors included discussion of the results in terms of possible implications for potential assessments of the population, under the WSP for example. It was felt that while this discussion was useful, it exceeded the bounds of the Terms of Reference for the advisory process, and should not be reflected as formal recommendation. The suggestion to move this material from the recommendations section to general discussion was upheld.

CONCLUSIONS

WORKING PAPER

Overall the working paper was found to be very well written, the techniques employed appropriate, and the analyses conducted thoroughly. Several edits were suggested by the group (described above) and the working paper was accepted with minor revisions. The author requested that these revisions be reviewed by the Taku Coho working group before publication, and the RPR participants agreed that this is sufficient (i.e. the paper does not have to be reviewed again by all participants).

It was concluded that all objectives of the TOR were met, with only some additional work being required for the second objective (inclusion of observation error, see above).

MODEL SELECTION

Based on statistical and practical considerations, the results for the Ricker model incorporating autocorrelation of residuals fitted to estimates of total spawners and adult recruits using age composition data from the Canyon Island survey is recommended to provide advice for the establishment of management goals for Taku River Coho Salmon.

COMPARISON OF ESTIMATED BENCHMARK TO MANAGEMENT SPAWNING GOALS

All model-data combinations analysed, estimates of S_{MSY} were higher than the spawning goal range of 27,500 to 35,000 fish used under the Transboundary Panel through to 2012. However, the current interim minimum goal of 70,000 fish, recommended by the Panel for 2013 and 2014 is essentially equal to the median S_{MSY} for the recommended model-data combination (69,000 spawners, Table 1).

CONSERVATION UNITS

Taku River Coho Salmon are currently delineated as a single CU under Canada's Wild Salmon Policy (DFO 2005). Estimates are provided at this level of aggregation.

RECOMMENDATIONS & ADVICE

BENCHMARK ESTIMATES

The benchmark and parameter estimates in Table 1 are recommended for inclusion in the SAR. These are based on the analysis of the Taku Coho Salmon population aggregate, for which the available data was sufficient. If it is determined that there are multiple constituent CUs, a similar analysis may not be possible for each CU given current data availability.

Table 1. Biological benchmarks based on data for the 1987-2009 brood years using the recommended model-data combination. Values listed are the median with 10th and 90th percentiles in square brackets.

Parameter	Benchmark definition	Estimated benchmark value
S_{MSY}	spawner level supporting maximum sustainable yield	69,000 [59,000-89,000]
S_{max}	spawner level that maximizes adult recruits	107,000 [82,000-154,000]
S_{eq}	equilibrium spawner level in the absence of fishing	183,000 [158,000-226,000]
Upper benchmark	90% probability of meeting or exceeding 80% of SMSY	71,000
Lower benchmark	90% probability of rebuilding to S_{MSY} in one generation in the absence of fishing	23,000

ANALYSIS RECOMMENDATIONS

The lead author of the working paper made several observations and recommendations concerning the analysis that could be helpful to those conducting similar analyses in the future.

- Inclusion of R code in previously published reports (e.g. Holt and Ogden 2013) was very helpful. Including code in appendices is encouraged when possible.
- During the scoping phase of this project the authors encountered enough variation in methods between ADFG and DFO to warrant considerations for a bilateral process that resolves them. For example, the large variety of alternative summaries is intended to anticipate the likely suite of variations that participants in multiple subsequent planning processes might want to have available for their deliberations, based on recent working papers from the two agencies. However, if clear bilateral guidelines were available, the results presented in future Transboundary analyses could be streamlined to these agreed-upon pieces of information.
- A document summarizing guidelines for the development of biological benchmarks and management reference points for Canada/US Transboundary stocks could be based on recent practice by both agencies and include the following components:
    - Reconcile the 2 agency frames of reference into a single Transboundary policy statement (i.e. a “rosetta stone” for policy jargon, building on our brief comparison in Section 1.3);
    - Build a decision tree for choosing among approaches for developing reference ranges (e.g. under which circumstances to use the percentile method, smolt-capacity method, or stock-recruit (SR)-based benchmarks);
    - Compile best practices for estimating SR-based benchmarks (e.g. when to use bias correction on productivity parameter, determine a standard suite of alternative models to test, identify the minimum scope of sensitivity analyses, map out an updating process for reviewing and incorporating new approaches);

- Compile a manual for implementing and reporting MCMC. A common checklist and implementation handbook would increase the consistency of future analyses.
- Agree on a standard set of reference ranges and summary plots to be presented.

ACKNOWLEDGEMENTS

Gottfried Pestal and Sandy Johnston authored the working paper, and contributed to these proceedings. Louise de Mestral Bezanson was the rapporteur, and took meeting minutes and compiled the proceedings. Bob Clark and Mike Bradford provided written reviews of the working paper.

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APPENDIX A: TERMS OF REFERENCE

Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-origin Taku River Coho Stock Aggregate

Regional Peer Review Process – Pacific Region

November 3-4, 2014
Nanaimo, BC

Chairperson: Jeffrey Lemieux

Context

The Taku River is a large, trans-boundary river in northwestern British Columbia with approximately 90% of the 19,000 km^2 drainage area occurring in B.C. The drainage is ecologically and physiographically diverse characterized by three dominant aquatic regions, based primarily on geomorphological features: the dynamic, highly braided and glacially influenced streams and Taku mainstem in the lower river; the lake dominated and glacially influenced streams on the eastern slopes of the Boundary Ranges; and, the high elevation streams and small lakes of the Stikine Plateau.

With the signing of the Pacific Salmon Treaty (PST) (Canada 1985) bilateral investigations into the Chinook, Coho and Sockeye Salmon of the Taku drainage were begun. Estimation of Coho Salmon escapement began in 1987 and smolt enumeration and coded-wire tagging was begun in 1991. The annual total run size of Coho Salmon originating from the Canadian portion of the Taku River drainage over the past decade has been in excess of 185,000 fish with an average exploitation rate of roughly 49%. Most of the harvest (approximately 89%) is taken by the US primarily in marine troll and net fisheries; the remainder is harvested in a small in-river commercial gillnet fishery in Canada. Coho rear and spawn throughout the drainage and likely are diverse in their utilization of habitat. The diverse ecotypology of the drainage underlies the three Coho Conservation Units for this system.

Taku River Coho salmon are managed in the aggregate under provisions of Chapter 1, Annex IV of the PST. The most recent provisions of the Pacific Salmon Treaty call for the development of a bilaterally-agreed spawning goal for Canadian-origin Taku River Coho salmon set at S_{MSY}. The aim was to have this in place for the 2010 fishing season. Considerable work in this regard was undertaken and presented in an exploratory draft to CSAP in the fall of 2010. Reviewers of the paper acknowledged the complexity of the work undertaken, but provided feedback that the work should be more focused on the spawner-recruitment and smolt-recruitment relationships, and less focused on separating the analyses into apparent productivity regimes. Due to changes in personnel, the work was not completed or accepted for publication.

In addition to the above PST obligations, as part of implementing Strategy 1 of the Wild Salmon Policy (WSP), Fisheries and Oceans Canada (DFO) is required to identify biological benchmarks to assess the status of WSP Conservation Units (CUs) for Pacific salmon. Benchmarks have not been estimated for Taku River Coho CUs, and this work cannot be completed at this time because of data deficiencies at the CU level.

Fisheries Management Branch has requested that Science Branch provide advice respecting a biologically-based spawning goal for Taku River Coho Salmon and the estimate of WSP biological benchmarks.

This assessment will attempt to estimate the lower WSP benchmark (S_{gen}) of the abundance metric for the aggregate of the three Taku Coho CUs. The upper WSP benchmark for

abundance is 85% S_{MSY} and follows from the estimate of the spawning goal. Note, however, that this Working Paper will not present the other WSP status metrics (trends, distribution), and will not comment on the status of Taku Coho CUs. Also note that the Working Paper will only estimate the spawning goal given the current definition in the PST, and not evaluate the implications of this management approach (e.g. expected trajectory relative to the WSP benchmarks). Methods utilized to estimate biological benchmarks will be based on the approaches and criteria previously developed and applied for other Pacific Salmon CUs (Holt 2009a, Holt 2009b, Grant 2011).

Results of the assessment, and advice arising from this Regional Peer Review process, will be used by Canadian and United States management to develop a revised integrated management plan for Taku Coho Salmon and may potentially affect calculations of TAC which could change harvest levels of the Parties. Advice respecting WSP biological benchmarks will contribute to a future assessment of status to meet WSP commitments.

Objectives

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

Pestal, G. and Johnston, S. Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-origin Taku River Coho Stock Aggregate. *CSAP Working Paper 2014-15/SAL01*

The specific objectives of this review are to:

1. Review Coho production, escapement and fry abundance data for the Taku River;
2. Develop biological benchmarks at the aggregate level including the number of spawning adults that would produce a maximum sustainable yield of Coho Salmon using various models;
3. Examine and identify uncertainties in the data and methods;
4. Comment on future data needs and considerations which would allow development of biological benchmarks at the CU level.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document(s)

Participation

- Fisheries and Oceans Canada (DFO) (Science, Fisheries Management)
- Alaska Department of Fish and Game
- Taku River Tlingit FN
- Academia

References

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APPENDIX B: WORKING PAPER REVIEWS

REVIEW #1

Reviewer: Mike Bradford

CSAS Working Paper: 2014/15 SAL01

Working Paper Title: *Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-Origin Taku River Coho Stock Aggregate (Gottfried Pestal and Sandy Johnston).*

Overall summary

This is an extremely well written paper that presents sophisticated analyses to estimate SR parameters for the Taku Coho salmon aggregate. However, the paper does not closely follow the TOR and it is unclear to me whether the paper contains sufficient analysis with respect to the stated objectives for the client's needs. If that is not the case there may be a need for a significant revision to meet those objectives.

Terms of Reference: The terms of reference for this paper are somewhat ambiguous as to the requirements for this paper. In the text on the second page of the TOR there is a request for the upper abundance-based WSP benchmark (normally 80% of Smsy), as well as the corresponding lower benchmark for the aggregate of the 3 CUs. It is noted that the paper will not comment on WSP status or management implications. The authors are directed to use approaches previously reviewed for WSP application.

However, there is also a slightly different list of objectives (paraphrased here):

1. Review the data
2. Develop "biological benchmarks" at the aggregate level including Smsy
3. Examine and identify uncertainties in data and methods
4. Comment on future needs that would allow development of biological benchmarks at the CU level.

While the manuscript to varying degrees addresses these objectives, the development of science advice would have been greatly assisted by organization of material aligned with the 4 objectives, particularly with respect to recommendations and conclusions. In retrospect it appears that authors could have paid closer attention to the TOR in preparing the working paper. In particular section 4.3 contains discussion of harvest, policy, and WSP implications that are expressly identified TOR as not being part of the working paper. The authors did a lot more work estimating Smsy than was probably necessary given the TOR, although the report now serves as a standard that should facilitate simplify the task of others conducting similar analyses.

My comments are aligned to the objectives:

1. Data review

The sources of data are briefly summarized in the report but the material presented could not be considered a critical review as inferred in Objectives 1 and 3). Perhaps this is probably outside the reasonable scope of work of the authors. However, there are many assumptions with mark-recapture estimates of adult and smolt abundance and no information is provided here on the robustness of the estimates. Recent experience with the Dawson fishwheel program suggests there is reason for concern.

At a minimum the report could contain some summary statement about the estimated uncertainty about the smolt and spawner estimates to give the reader some sense of precision. Some of these are shown in Figure 2 but not details are provided. Comments on potential bias in the estimates and the implications for benchmarks may be useful.

2. Biological benchmarks

This is the heart of the paper and the authors have conducted a thorough analysis of stock-recruit models and a couple of alternative approaches.

Percentile method: It is difficult to recommend this method as I don't believe the methods have been reviewed by CSAS or integrated into the WSP assessment process. As I understand the brief description, the SEG is based on historical data, and essential maintains the status quo (and probably is best suited to stable, moderately productive fisheries that are exploited at sustainable raters). In any event, and as noted by the authors, the Taku Coho salmon aggregate is not a "data-poor" stock, and there is little need to rely on a method that does not use all available data or tools.

Smolt method: If I recall this is a method based for coastal Coho streams and is probably as not applicable to a large basin such as the Taku.

SR models

This section contains considerable analysis of the Ricker SR model applied to the Taku aggregate data. A variety of model variants and approaches are used, all of which yield very similar results from a practical perspective.

There are 2 components to such an analysis— model selection, and parameter estimation. With respect to models selection, the primary challenge is that the data provide very little information about the appropriate choice of model as most of the variation in the data results from annual deviations, and measurement error. In this case, I would characterize model selection as being guided by tradition- and the common observation that the Ricker model generally leads to lower productivity estimates and this is considered a risk adverse approach compared to the usual alternative, the B-H model.

While the consequences of defaulting to the Ricker model are likely not severe for representing the dynamics at the lower end of abundances, the tendency of the Ricker model to predict the presence of strong density dependence is significant for the interpretation of the effect of spawners > Smsy.

Model selection should proceed (in the absence of information from the data) on the basis on knowledge of the biology of Coho salmon, and in particular, the density-dependent processes that regulate abundance, and an understanding and interpretation of the effects of aggregating many populations that are likely different in size and productivity. While outside the scope of current work, it would be useful to evaluate and compare population dynamics of Coho salmon from other large watersheds to establish the appropriateness of the Ricker function relative to alternatives.

Having selected the Ricker model and its variants, the authors should be commended for the depth of the parameter estimation component. It is reassuring that most methods yield very similar results and the details of implementation do not yield meaningful differences in the outputs. I concur with the Authors that the Kalman-Ricker method is not ideal for benchmark estimation, as re-assessment on an annual basis is unlikely.

Finally, it would be useful if the authors recommended a single Smsy value (or preferred approach) for the aggregate among the many computations they document to assist managers in interpreting the information presented.

3. Examine and identify uncertainties in data and methods.

It is difficult to extract conclusions and recommendations for this objective. Considerable effort is placed on the estimation of parameters and associated uncertainty under the assumption that the data is accurate and precise. However, it is unclear from the report whether there are deficiencies in the data. There is little discussion of model selection as well, and the implications of alternative approaches are not addressed. It could very well be that the data and methods are entirely appropriate for the goal of estimating Smsy for the aggregate but the evidence in support of this assertion needs to be identified

4. Comment on the data needs and considerations which would allow development of biological benchmarks at the CU level.

I find no material to address this objective. The TOR (text in paragraph) mentioned estimates of Sgen for the aggregate but this seems not to have been attempted either. This is obviously a significant challenge in a large remote watershed but clearly the clients of this paper requested advice on how to proceed with this step.

Final comments

The Taku River drains a relatively large catchment and apparently contains a number of different Coho salmon “populations” in a variety of ecoregions; this diversity has led to the identification of 3 CUs in the Canadian range. The data are collected at the scale of the catchment, and the analyses performed here use methods originally designed for single, homogenous populations. The SR data reflect the sum of the dynamics of each population, and chance events that may cause components of the aggregate to vary in abundance over the time.

There are risks to managing a large and potentially diverse aggregate using Smsy or similar approaches if there is a desire to sustain the diversity within the aggregate. The recent Interior Fraser Coho salmon review suggests that Smsy is fairly close to levels of abundance that cause a reduction in population diversity within the aggregate. It would be useful for the working paper to address this risk more fully than the bullet at line 1190. That discussion might include non-yield benefits of escapements>Smsy, and the role that the choice of SR model plays in the shape of the yield functions (Fig. 10). I believe there could be a fuller accounting of risks and benefits of various levels of escapement that greater reflects the diversity of this population complex as well as those that arise from the extreme simplification of population processes that is implied by the use aggregate level approach.

REVIEW #2

Reviewer: Robert A. Clark, Alaska Department of Fish and Game

CSAS Working Paper: 2014/15 SAL01

Working Paper Title: *Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-Origin Taku River Coho Stock Aggregate (Gottfried Pestal and Sandy Johnston).*

First, to address the questions that Dr. Lemieux asked:

- *Is the purpose of the working paper clearly stated?*

Yes, the purpose of the working paper is clearly stated and is evident from the title of the work. The paper describes methods for development of a spawning goal, the data used in development of the goal along with uncertainties that exist, and discusses the advantages and disadvantages of each analytical method.

- *Are the data and methods adequate to support the conclusions?*

  The data and methods are adequate to support the conclusions, although there exist analytical methods to better incorporate uncertainty into the chosen production model. These methods may not produce recommendations for a biological goal that differ from the authors, but are more scientifically defensible given the data used to model production.

- *Are the data and methods explained in sufficient detail to properly evaluate the conclusions?*

  The data and methods are explained in sufficient detail to evaluate the conclusions. However, estimates of uncertainty (i.e., measurement error) should be provided for each of the data sources and at a minimum these uncertainties should be discussed in light of the analytical findings that ignore these uncertainties.

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

  The analysis of production data is very straightforward and focused on estimation of S_{MSY}. However, due to differences in policies and management objectives of the two countries and the Pacific Salmon Commission, choice of a spawning goal is not straightforward. Although the recommendations provided are relative clear, repeatable, and usable, they are arbitrary in terms of the probabilities of achieving a percentage of S_{MSY} or MSY as well as the percentage of S_{MSY} or MSY to achieve. Management objectives should have been agreed upon prior to the analysis so that the variety and arbitrariness of recommendations could have been reduced. In my opinion, the best possible comparison of spawning goal ranges based on differing policies would be to develop these range directly from: 1) ADF&G-style 70-90% of MSY yield profiles for the Alaska policy; and, 2) estimating and profiling S_{GEN} and 80% of S_{MSY} for the Canadian policy choice. These profiles could possibly be overlaid to permit a graphical comparison as is done for overfishing and yield profiles in Alaska spawning goal analyses (Bernard and Jones 2011). To further clarify the choice of spawning goal, the most appropriate model for the data and management approach should also be employed. In the case of Taku River Coho salmon the Ricker AR1 model (for the Spn2Ad data set) provides the best fit without the added complexity of a time-varying estimate of S_{MSY} from the Ricker K that can vary substantially from year to year.

- *Can you suggest additional areas of research that are needed to improve our assessment abilities?*

  As stated earlier, the analytical methods could be improved to more formally incorporate uncertainty in source data into model. While this would likely not result in a substantially

different set of spawning goal recommendations, the results would be more scientifically defensible.

What follows are my specific comments on various aspects of the analysis, by section and line number:

- Section 1.1.1., Lines 18-20 – The genesis of this report is stated through the Pacific Salmon Treaty as an "...MSY goal..." While this could be construed as either a goal to achieve S_{MSY} or MSY, the implication from the term MSY is that the spawning goal should be used to produce MSY. While the report does provide recommendations that are based on producing MSY, other recommendations are based on achieving or exceeding S_{MSY} or some other objectives (e.g., maximizing smolt production or maintaining spawning abundance within the range of observed abundances). Perhaps this is outside the purposes of the report, but clarity is needed on which objective or objectives are being sought. If there are multiple objectives, a clear statement of how they should be evaluated needs to be made. For example, would it be acceptable to develop an MSY-based spawning goal and biological benchmarks that differ or do all the objectives need to be addressed in a single spawning goal range?
- Section 1.1.2, Lines 47-48 – The report cites examples of Bayesian MCMC approaches to analyzing production data, although use of the citation of Eggers and Bernard (2011) does not match the methods used in the report. Eggers and Bernard (2011), as well as others (e.g., Fleischman et al. 2012; Su and Peterman 2012) incorporate uncertainties (i.e., measurement error) of the run reconstruction into the production model, whereas the report does not.
- Section 1.2.2, Line 117 – Use of the term "CU" is undefined at this point in the report. It is subsequently defined on line 161. The definition should be moved up to this first use of the term.
- Section 1.3.5, Line 308-309 and Table 2 – The definition of Alaska's "yield concern" is inaccurate. A yield concern occurs when the spawning goal has been met, but yields have been curtailed or eliminated by management actions so that the average yields in the fishery have chronically not been met. Exceeding the upper bound of the spawning goal is not part of the definition of a "yield concern."
- Section 2.2.1 in general – Estimates of measurement error should be provided for all of the source data. Either coefficients of variation (CVs) or standard errors (SEs) should be given in the tables.
- Section 2.5, Line 654-661 – The yield profiles were developed differently than those used by ADF&G. The authors' approach ignores uncertainty in the estimate of S_{MSY} by fixing the yield comparison to the yield from the median S_{MSY} estimate. Although potentially useful for selecting a spawning goal, an Alaskan reader of this analysis would be better served by seeing yield profiles that are similar to what has been used for ADF&G analyses so they have a frame of reference for understanding the yield characteristics of a particular spawning goal range.
- Section 2.5, Line 693-694 – No rationale is provided for use of an arbitrary 60% probability for the alternative PGY90 spawning goal ranges. The ADF&G-style yield profiles provide all the information needed to evaluate differing spawning goal ranges for a wide range of probabilities. If a probability needs to be selected for tabularizing the results, the table should provide the 50% probability (i.e., the median estimate) as a starting point for comparing outcomes from the analyses.

- Section 3.2.1, Line 761-768 – No rationale is given for using the 2009 BY for estimating benchmark quantities for the Ricker Kalman filter model except that it is the most recent brood year. Perhaps using a summarized version of the model (e.g., average over all years or the most recent series of 4- 5 years) would be better to depict the long-term production dynamics that choice of a spawning goal could be based. As noted in the report, the minimum and maximum point estimates of S_{MSY} are within four consecutive brood years of each other.
- Section 4.2, Line 943-946 – Estimates of S_{MSY} from a model of juvenile production are actually closer to estimates of S_{MAX} in units of adult production since the maximization of smolt yield theoretically occurs at the number of spawners that maximize adult production, or S_{MAX}. These "S_{MSY}" estimates should not be compared to those resulting from adult-to-adult production models.
- Section 4.3, Line 1083-1089 – I am unsure why the authors chose the Ricker model over the Ricker AR1 or Ricker K models as the base case for choosing a spawning goal. Use of 80% of S_{MSY} as the lower bound for a long-term management target seems arbitrary given the entirety of the results presented in Table 13 where this value is not provided for the other data sets or models.
- Section 4.3, Line 1094-1104 – This method of summarization and discussion of results is not entirely appropriate. Although I do not advocate model averaging in this case, one would probably "weight" the results from the bettering fitting models more heavily than those that fit less well.
- Section 6.1, Line 1193-1195 – Same comment as above for Section 4.2, Line 943-946.
- Section 6.1, Line 1201-1207 – I am in agreement with the idea of probing higher levels of spawning abundance for this stock, given the mixed stock nature of the targeting fisheries and moderate serial correlation in productivity. The upper bound of the spawning goal range should take this into account as a tradeoff with the median estimate of carrying capacity (~185,000 for the Ricker AR1).
- Section 8, Line 1447-1449 – The Peterman et al. 2003 reference is given twice.
- Section 9, Table 2 – This table does not reflect the actual definitions for yield concern. Escapements chronically above the upper bound of the spawning goal range do not constitute a yield concern. See comments made in Section 1.3.5, Line 308-309.
- Section 9, Table 4 – The labels used for models in this table are not the same as those used in the text or other tables (e.g., Table 13).
- Section 9, Table 11 – Please add SEs of estimates of parameters a and b.
- Section 9, Table 12 - This table should be augmented with median and credible intervals (or SEs or CVs) for the model parameters that are given in Table 4 as well as the residual error.
- Section 10, Figure 2 – the y-axis label for the third plot from the top of the page should be "Smolts" not "Spawners."
- Section 10, Figure 5 – These plots would be greatly enhanced by adding the confidence intervals for each of the data points. This would illustrate the variation in uncertainty in production, but importantly the variation in uncertainty in spawning abundance, which can greatly affect the estimates of the Ricker parameters. This is especially true for the most influential values such as the 2002-2004 brood years and the 1993-1994 brood years.

- Section 10, Figure 8 – Same comment as for Figure 5.
- Section 10,Figure 13 – As commented on above, a table of medians, credible intervals and/or SEs or CVs for these quantities would help.
- Section 11, Tables A1 and A2– Where possible, SEs or CVs should be provided for the numerical columns.

Literature cited external to the draft report

Bernard, D. R. and E. L. Jones III. 2010. Optimum escapement goals for Chinook salmon in the Alsek River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 10-02, Anchorage.

Fleischman, S. J., M. J. Catalano, R. A. Clark, and D. R. Bernard. 2012. An age-structured state-space stock-recruit model for Pacific salmon (*Oncorhynchus* spp.). Canadian Journal of Fisheries and Aquatic Sciences 70: 401-414.

Su, Z. and R. M. Peterman 2012. Performance of a Bayesian state-space model of semelparous species for stock-recruitment data subject to measurement error. Ecological Modelling 224: 76-89.

APPENDIX C: AGENDA

Regional Peer Review Meeting (RPR)

Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-origin Taku River Coho Stock Aggregate

November 3-4, 2014

Vancouver Island Conference Centre
Nanaimo, British Columbia

Chair: Dr. Jeffrey Lemieux

Time	Subject	Presenter
DAY 1	**Monday, November 3, 2014**	
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper	Author
1030	***Break***	
1050	Overview Written Reviews	Chair + Reviewers & Authors
1200	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	Group
1330	Discussion & Resolution of Technical Issues	RPR Participants
1445	***Break***	
1500	Discussion & Resolution of Results & Conclusions	RPR Participants
1630	Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1700	Adjourn for the Day	

Time	Subject	Presenter
Day 2	**Tuesday, November 4, 2014**	
0830	Introductions Review Agenda & Housekeeping Review Status of Day 1	Chair
0845	*(As Necessary)* Carry forward outstanding issues from Day 1	RPR Participants
0930	<u>Science Advisory Report (SAR)</u> Develop consensus on the following for inclusion: • Results & Conclusions • Sources of Uncertainty • Additional advice to Management (*as warranted*)	RPR Participants
1030	***Break***	
1050	<u>Science Advisory Report (SAR)</u> • Continued	RPR Participants
1130	Next Steps – Chair to review • SAR review/approval process 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
DFO		
Boyce	Ian	DFO Science Yukon
Bradford	Mike	DFO Science Fraser R.
Cox-Rogers	Steve	DFO Science North Coast
de Mestral Bezanson	Louise	DFO Science SAFE
Grant	Sue	DFO Science Fraser R.
Hargreaves	Marilyn	DFO Science CSAP
Huebschwerlen	Bonnie	DFO Science Yukon
Lemieux	Jeffrey	DFO Science SAFE
MacDougall	Lesley	DFO Science CSAP
Parken	Chuck	DFO Science Fraser R.
Patten	Bruce	DFO Science SAFE Core
Sawada	Joel	DFO Science SAFE Core
Smith	Steve	DFO Science Yukon
Thiess	Mary	DFO Science SAFE Core
Tompkins	Arlene	DFO Science SAFE Core
Waugh	Bill	DFO Science Yukon
External		
Clark	John	Alaska Fish and Game
Clark	Bob	Alaska Fish and Game
Erhardt	Richard	Taku River Tlingit First Nation
Heinl	Steve	Alaska Fish and Game
Jones	Ed	Alaska Fish and Game
Ned	Murray	Lower Fraser Fisheries Alliance (LFFA)
Pestal	Gottfried	Solv Consulting
Staley	Mike	Fraser River Aboriginal Fisheries Sec.

APPENDIX E: ABSTRACT OF WORKING PAPER

The purpose of this paper is to establish a biological frame of reference for spawner abundances of the Taku River Coho salmon (*Oncorhynchus kisutch*) stock aggregate, which can then be used to evaluate status and set management goals. Taku Coho are a transboundary stock managed jointly by Canada and the US under the Pacific Salmon Treaty (PST). Therefore, the analysis is set up to cover the range of approaches applied in recent work published by Fisheries & Oceans Canada (DFO) and the Alaska Department of Fish & Game (ADFG).

We apply 3 alternative approaches to establish a reference range for spawner abundance: (1) *Percentile Method:* Based on some percentiles of observed spawner abundance (2) *Smolt Capacity Method*: Based on average smolt abundance observed for large brood years, divided by regional average for smolt per spawner at S_{MSY} (3) *SR Model Method*: Based on fitting spawner-recruit (SR) models and estimating biological benchmarks for each model (S_{MSY}, S_{max}, S_{gen}, S_{eq}). We test each approach through extensive sensitivity analyses (e.g. retrospective evaluations, alternative assumptions, and alternative model forms).

Averaging across two versions of the percentile method results in a *Sustainable Escapement Goal* (SEG) range of roughly 60-125 thousand, centered on the long-term median of 90 thousand, which is basically the same as the range covered by 80% of the posterior for S_{MSY} derived from the basic Ricker fit for the base case data set. Other model fits and other adult data sets had similar or lower S_{MSY} estimates, so that the percentile method produced a cautionary approximation of S_{MSY}.

As a contrast, the smolt capacity method is highly sensitive to the productivity assumption. Published regional reference values resulted in an S_{MSY} estimate of approximately 50,000 spawners, which is substantially lower than most of the alternative estimates resulting from SR model fits. Conversely, using observed productivity of Taku Coho more than doubles the mid-point of the approximate S_{MSY} range, highlighting that even simple approximate methods can be highly sensitive to underlying assumptions, and can produce results that widely miss the mark.

S_{MSY} estimates for Taku River Coho are remarkably consistent across alternative models for the base case data set and all available years of data (1987 -2009 brood years). Median estimates range from 62,000 to 79,000, differing by less than 30% from each other.

SR model fits based on smolt data were much poorer than the adult fits. Setting aside the juvenile data sets, we identified the following reference ranges for Taku Coho across 4 alternative data assumptions and 3 variations of the Ricker SR model:

- 23,000 to 40,000 = Spawner abundance with 90% of rebuilding to S_{MSY} in 1 generation in the absence of fishing
- 57,000 to 106,000 = Spawner abundance with 90% of meeting or exceeding 80% of S_{MSY}.
- 51,000 to 71,000 = Lower bound of the spawner range with 90% probability of pretty good yield (i.e. 70% of MSY).
- 82,000 to 101,000 = Upper bound of the spawner range with 90% probability of pretty good yield (i.e. 70% of MSY).