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Proceedings of the Pacific regional peer review on Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook (Stikine River Drainage)

November 12 to 13, 2015
Nanaimo, British Columbia

Chairperson: Bruce Patten
Editor: Nicholas Komick

Fisheries and Oceans Canada
Science Branch
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October 2016

Foreword

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

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of November 12 and 13, 2015 at the Pacific Biological Station in Nanaimo, B.C. A working paper focusing on "Estimates of a Biologically-Based Spawning Goal and Biological Benchmark for Little Tahltan Chinook Salmon" was presented for peer review.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science staff; and external participants from First Nations organizations and Alaska Department of Fish and Game.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to the Canadian caucus of the Transboundary River Panel of the Pacific Salmon Commission to explore specifically the development of quantitative estimates of reference points which can be used as the basis for a biological spawning goal. Though the analysis presented could not address the objective of an escapement goal for the Little Tahltan River, it provided valuable information about the limitations of the data and would be informative to future work.

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

Compte rendu de l’examen par les pairs de la région du Pacifique sur l’Estimation du but concernant le frai fondé sur les paramètres biologiques et les indices de références biologiques pour le saumon quinnat de Little Tahltan (bassin de la rivière Stikine)

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et conclusions de la réunion régionale d'examen par des pairs de Pêches et Océans Canada (MPO) et du Secrétariat canadien de consultation scientifique (SCCS) qui s'est tenue les 12 et 13 avril 2015 à la Station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail portant sur « un objectif de frai fondé sur des données biologiques et points de référence biologiques pour le saumon quinnat de la rivière Little Tahlan » a été présenté aux fins d'examen par les pairs.

Au nombre des participants en personne ou par conférence Web, il y avait des employés du secteur des Sciences de Pêches et Océans Canada (MPO), des participants externes provenant d'organisations des Premières Nations et des représentants de l'Alaska Department of Fish and Game [ministère de la pêche et de la chasse de l'Alaska].

Les conclusions et avis découlant de cet examen seront présentés sous la forme d'un avis scientifique fournissant des conseils au caucus canadien du Conseil des rivières transfrontalières de la Commission du saumon du Pacifique afin de procéder à des estimations quantitatives des points de référence qui pourront servir de fondement à un objectif de frai reposant sur des paramètres biologiques. L'analyse présentée n'a pas abordé la question d'un objectif pour le taux de remonte dans la rivière Little Tahltan, mais elle a fourni des renseignements précieux sur les limites des données et elle pourrait éclairer les futurs travaux.

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur le site Web 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 12 and 13, 2015 at the Pacific Biological Station in Nanaimo to review the development of escapement goals for the Little Tahltan River.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from the Canadian caucus of the Transboundary River Panel of the Pacific Salmon Commission. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations and United States government agencies.

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

> Estimates of Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook Salmon by Gottfried Pestal et al. (CSAP Working Paper 2014SAL08)

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 draft Science Advisory Report (SAR).

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteur. 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 those online.

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, 20 people participated in the RPR (Appendix D). Nicholas Komick was identified as the Rapporteur for the meeting.

Participants were informed that Robert Clark and Mike Bradford had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting. Similarly, Chuck Parken provided written reviews of the working paper. Participants were provided with copies of the three written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to the Canadian caucus of the Transboundary River Panel of the Pacific Salmon Commission to inform salmon fishery planning for the above-noted stocks. The SAR 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 Little Tahltan Chinook Salmon

Rapporteur: Nicholas Komick

Presenter(s): Gottfried Pestal

PRESENTATION OF WORKING PAPER

The presentation of the working paper began with Gottfried Pestal providing background information of the spatial relationship between the Little Tahltan River to the Tahltan and Stikine Rivers. This included why Little Tahltan was selected for the focus of this analysis. The Little Tahltan was believed to be the most data rich site to use as an indicator stock and certain data were scaled to represent the Little Tahltan River. Furthermore, the Little Tahltan represented a significant component of the Stikine River Chinook spawner population in earlier years.

As further background, information about the May 2014 rock slide on the Tahltan River and its potential to be a barrier to fish migration was presented. Visual surveys in 2014 and telemetry data from 2015, presented at the meeting, showed there was migration of fish past the rock slide and into the upper reaches of the Tahltan River. However, the same telemetry data showed only a small proportion migrating past the weir.

Subsequent to the background information, the main results of the assessment and associated stock-recruit model results were presented. In addition to the Beverton-Holt and two forms of the Ricker stock recruit models, the authors presented results based on a power model that was identified in Chuck Parken's review. Although there is some disagreement regarding escapement goals estimated by the various stock-recruit models presented, all of the estimated escapement goal estimates are higher then what is currently observed at the weir.

When looking at trends in age composition data from the weir, they were consistent with the Bernard et al. (2000) analysis of the Stikine River and similar to age composition data provided from other river systems in the area for this presentation. In more recent years the Little Tahltan River weir age composition data have shown a trend towards Chinook returning at younger ages and Chinook within an age class returning at smaller body sizes.

Some of the reviewers found that the working paper mixed the definitions of jacks with smaller Chinook (< 660 mm). The authors noted that most of the analysis was structured around the relationship between smaller and larger Chinook and not the stricter definition of jacks (i.e. precocious males). The authors would improve the papers by more explicitly referring to smaller or jack Chinook where appropriate.

In response to reviewer comments, a comparison of reconstructed Little Tahltan exploitation rates (ER) from the working paper to the total Stikine ER from the Pacific Salmon Commission Chinook Technical Committee (CTC) analysis was presented. The time series from the two sources of exploitation rates show consistent patterns, with the working paper ER have slightly higher values. These ER differences are possibly related to catch in the upper portions of the Stikine River, and a one year lag between the two times series, potentially resulting from a fish age analysis issue.

REVIEWER PRESENTATIONS

MIKE BRADFORD

The first review, provided by Mike Bradford, identified that although there appears to a shift in the relationship between spawners and recruits after the year 2000, all of the analysis was carried out with full time series. Any Maximum Sustainable Yield (MSY) provided by the analysis from this system would fall outside of the range of conditions observed in either of the two dominate observed productivity conditions and may not be very informative to the TOR objectives.

Furthermore, there was no discussion regarding carrying capacity and its possible impact on the spawning success of smaller Chinook. If the system is constrained in terms of carrying capacity, then it is expected that the spawning success of smaller Chinook would be much lower than if the Little Tahltan had much higher carrying capacity. The analysis would be strengthened with habitat and carrying capacity assessments.

Finally, the TOR identified that the benchmarks used should be related to Wild Salmon Policy (WSP) benchmarks. Although there was reference to WSP benchmarks in the working paper, it is suggested that results related to WSP have a more prominent role in establishing escapement goals.

ROBERT A. CLARK

The second review was provided by Robert A. Clark and focused on answering questions posed by the review guidelines provided by CSAS office. Although the paper was aligned to the TOR, the data and methods were not adequate to support the conclusions. In particular there is a possible concern with the weir totals, as there is a wide range of estimated recruit values but a narrow range of spawners.

A couple of issues with the underlying data set raised concerns about estimating escapement goals from this analysis. Because of the limited range of observed spawner abundance over a wide range of recruit estimates; the stock recruit analysis is driven by earlier years. The more recent years, with greater variability in spawner abundance, have limited influence on the resulting stock recruit model.

Furthermore, the constant stock proportion used to estimate exploitation of Little Tahltan Chinook in relation to total Stikine River exploitation is a concern with this analysis. With a fixed proportion to the Stikine River, the stock is not allowed to vary independently. Because of both the limited range of observed values in the weir data and the limited information relating Little Tahltan stock to the total Stikine spawner abundance, the recommendation is not to draw any escapement goals from the working paper analysis.

In terms of working paper improvements, incorporation of past aerial overflight data may be informative to the analysis of the working paper. Past spawner abundance estimates before the installation of the weir may provide a broader range of conditions to inform future stock recruit analysis.

CHUCK PARKEN

The final reviewer, Chuck Parken, highlighted issues of relating this work to Wild Salmon Policy approaches. This analysis focused on the Little Tahltan River, which is a tributary of the Tahltan River that drains into the Stikine River. With the whole Stikine River system split into two Conservation Units (CU) based on run timing, the focus on a specific tributary within the system may not be informative to developing escapement goals for the CUs. It may not be appropriate to treat Little Tahltan River Chinook as a distinct population as it is unclear if spawners disperse to the main stem Tahltan or other tributaries. The presence of the weir alone may increase the potential for dispersal to other streams. Based on past experience, weirs on snow-dominated hydrology have had mixed results and may cause some fish to move to other habitat.

In addition to concerns around treating Little Tahltan River Chinook as a distinct population, some issues with historic data treatment were identified. In particular, using a fixed proportion of Little Tahltan River to Total Stikine catch in the marine and lower river fisheries before 1996 is an issue when comparing early year recruitment estimates with later estimates. Furthermore, the impacts of the fisheries were limited to Coded Wire Tag (CWT) recoveries and did not factor in other fishery impacts, such as release mortality. Also, there were CWT data from the 1970s and early 1980s that were excluded from analysis. The paper should mention why these data were excluded. Finally, there was limited discussion regarding the bias correction, which would warrant further discussion in the paper.

Some of these data issues may be addressed by using results from the cohort analysis carried out by the CTC. This analysis would more fully represent fishery impacts, such as incidental mortality, and would also be carried out in adult equivalents. Furthermore, it would include fisheries that are not represented in the working paper analysis, such as a small component of Northern British Columbia catch of Stikine River stocks.

The complete exclusion of smaller fish, as representing jacks, may be underestimating the total number of potential spawners within the analysis. Based on scientific literature, jacks have been shown to contribute a measurable component to the effective spawner and resulting recruitment population. This potential impact is ignored within the working paper.

The representation of environmental variables was somewhat limited within the analysis, particularly the constraints of habitat and incorporation of marine survival into the stock-recruit model. To strengthen the working paper, the Bayesian model priors could be better informed to represent the habitat. Further habitat-based assessment would be informative to this analysis and the potential identification of escapement goals. Furthermore, the stock-recruit models may better represent environmental variability by incorporating a marine survival coefficient and incorporating a dummy variable may support handling the two periods within the analysis.

GENERAL DISCUSSION

The following section summarizes the general discussion that occurred subsequent to the formal reviewer presentations. Below are the major points from the discussion. These points are followed by more detailed descriptions.

HISTORIC AERIAL FLIGHT DATA

The working paper discusses the history of monitoring on the Little Tahltan River, with aerial surveys carried out from 1977 to 1984 and the weir being installed in 1985. Data presented were limited to the years that the weir was present and excluded the aerial survey data. There earlier aerial survey data may be informative to understanding the dynamics of spawner abundance in the Little Tahltan River in the absence of the weir. It is recommended that these historic data should be included in the working paper to provide more historic context of river spawner abundance.

WEIR OPERATIONAL CHARACTERISTICS

Upon discussing the operation characteristics of the Little Tahltan weir, some further details were identified, such as how night operations differ from day and the mitigation of bear issues through installation of an electric fence. As identified by the participants, bears are known to demonstrate sex selectivity towards females when preying on salmon. So, dynamics around when mitigation measures were put into place and how effective they were may be significant to understanding the possible impacts of bears or other operational characteristics on spawner behaviour and dynamics in stock recruit models. It was recommended that more of these weir operational details be included in the paper.

WEIR INFLUENCE ON SPAWNER BEHAVIOR

The review participants further discussed the possible influence of the weir on spawner behaviour. A weir in the area was taken out from another river system because fish wouldn't pass it (Nahlin River in the Taku drainage, removed in 2001). Also weirs have been taken out from the interior Fraser River, as they changed spawner behaviour. There is a possibility that the weir is influencing spawner behaviour in the Little Tahltan River, as well. Other indicators, such as telemetry data, suggest that fish are in the Tahltan River, which is at odds with the suggested production failure in the Little Tahltan from the working paper.

When looking at the influence of the weir on spawner presence in the Little Tahltan, the flow rates over the weir may be informative. However, there are not much data on flow rates directly on the Little Tahltan. It is unclear if flow rates influence the weir's impact on spawner behaviour.

As the weir may be influencing spawner behaviour into the Little Tahltan River, it was suggested that passive techniques be used to monitor spawner abundance into the river. This may include using SONAR or tower counts in conjunction with aerial surveys. Furthermore, it was suggested that assessment may be expanded to the Tahltan River.

WILD SALMON POLICY

In relation to Wild Salmon Policy, the Stikine River basin is divided into two CUs based on run timing. It was unclear if CWTs are applied representatively to the maturation rates and timing of the two CUs. Discussion included whether Stikine River basin warranted splitting into two CUs based on observed data. Definitions of the two CUs have not been reviewed since their initial delineation (Holtby and Ciruna, 2007). Furthermore, there is some mixing of populations with Taku River fish observed in the Stikine River based on CWT data. Future work may review the split in CUs in the Stikine River basin and if the split is warranted based on recent data.

AGE COMPOSITION

The shifting age composition towards younger fish, as identified in the working paper, is echoed in other northern Chinook populations, such as the increasing maturation of age 4/5 fish within the Taku River basin. These changes in maturations rates over time are inconsistent with the assumption of a constant maturation rate used within components of the analysis. Future model work should look at age specific variable maturation rates to be more representative of the temporal dynamics of the spawner population. This work may not improve the overall results, but will provide a more complete scientific analysis.

Analysis of age composition was an important part of this working paper. However, the participants noted that there potential data quality issues when reading Chinook scales ages in freshwater. Several potential issues where discussed by the participants, but there was no discussion in the working paper around these issues or how they were possibly assessed. With the significance of aging data to the analysis, the participants recommended that potential data quality issues with scale aging be discussed in the working paper.

SUGGESTED PRODUCTIVITY SHIFT

As identified by different reviewers, there appears to be two distinct productivity regimes in the data, with the second regime beginning in 2001. No significant human impacts to spawning habitat were identified that could account for the changes in productivity suggested by the stock-recruit analysis. Although a shift in marine survival for transboundary Chinook, including Little Tahltan River, has been observed in more recent years, assessing whether there has been a productivity shift is confounded by the potential that the weir is influencing spawner behaviour.

Irrespective of the possible presence or causes of the potential productivity shift, the potential for non-constant productivity violates an important assumption in the stock-recruit models. Furthermore, adding more years of data to the analysis will likely have little influence over analysis results, since the analysis was driven by the earlier larger recruitment estimates.

CONCLUSIONS

The participants' consensus was that the paper should be accepted with revisions. Even though the analysis could not address the objective of an escapement goal for the Little Tahltan River, it provided valuable information about the limitations of the data and would be informative to future work. Following the meeting, the authors reported that some of the planned revisions could not be accomplished. These mainly involved some data treatments and additional analyses that could not be performed since the necessary data were not available. None of these would impact the conclusions of the paper; therefore, the chair accepted the omission of the revisions.

A summary of conclusions from the review participants is provided below.

- Analysis does not inform escapement goals beyond Bernard et al. (2000)
- Significant data quality concerns confound the results of analysis and make the development of an escapement goal scientifically indefensible
- Stock recruit temporal discontinuity makes fitting a stock recruit model inappropriate
- Stock recruit temporal discontinuity is possibly related to different productivity periods or population behaviour changes related to the weir
- Future escapement goal development should be based on the Stikine River basin to inform Wild Salmon Policy

RECOMMENDATIONS & ADVICE

- Future work should incorporate habitat and carrying capacity assessment
- Monitoring methods should be changed to passive techniques to eliminate possibly influence of the weir on spawner behavior
- Monitoring may be broadened to monitor the Tahltan River.
- Future work should review the appropriateness of Conservation Unit definitions within the Stikine River drainage basin
- Assessment of escapement goals should incorporate exploitation rate data provided by the Pacific Salmon Commission Chinook Technical Committee to represent fisheries impacts

- Future analysis should expand on the representation of the multiple age classes by including the possible productivity of smaller (< 660 mm) Chinook and allow for age specific maturation rate variability in the model

ACKNOWLEDGEMENTS

The Chair thanks the reviewers for their expertise in reviewing the working paper, and all of the participants for their constructive engagement in the science review process at this meeting. Nicholas Komick is thanked for being the meeting rapporteur and editor of the proceedings document. Lesley MacDougall's and Ann Mariscak's assistance in providing CSAS meeting support is greatly appreciated.

REFERENCES

Bernard, D.R., S.A. McPherson, K.A. Pahlke, and P. Etherton. 2000. Optimal production of Chinook salmon from the Stikine River. Alaska Department of Fish and Game, Fishery Manuscript No. 00-1, Anchorage. (Accessed August 2, 2016)

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

APPENDIX A: TERMS OF REFERENCE

Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook (Stikine River Drainage)

Regional Peer Review Process – Pacific Region

November 12-13, 2015
Nanaimo, British Columbia

Chairperson: Bruce Patten

Context

The Little Tahltan River drains an area of approximately 314 km2 and flows into the Tahltan River, a major tributary of the Stikine River. The confluence of the Little Tahltan and Tahltan Rivers is approximately 32 km northwest of the community of Telegraph Creek, British Columbia (BC). Little Tahltan Chinook stocks contribute to U.S. approach and in-river fisheries, and in Canada to commercial, First Nation, and sport fisheries.

The Pacific Salmon Treaty (PST) obliges the Parties to use a bilaterally agreed-to, maximum sustainable yield (MSY) based escapement goal for use in managing large Stikine River Chinook salmon (i.e. Chinook salmon greater than 659 mm mid-eye to fork length). A drainage-wide large Chinook salmon spawning goal currently exists; however, there are concerns over a recent decline in the number of Little Tahltan River Chinook, which historically have been a major contributor to the total Stikine production. This concern has generated an interest within the PST process to explore an escapement goal specific to Little Tahltan large Chinook. In Alaska, for an escapement goal to be formally recognized, it needs to be biologically based, to provide sustained yield and be approved by the directors of Commercial Fisheries and Sport Fish divisions. In Canada, advice is sought through a Canadian Science Advisory Secretariat (CSAS) process.

In addition to the above PST obligations, and 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. There are two Chinook Conservation Units (CU) identified for the Stikine River; early and late-run Chinook. Little Tahltan Chinook are considered part of the early-run CU and have served as an abundance index since 1975. Benchmarks have not yet been identified for Stikine River CUs.

DFO Fisheries Management Branch has requested that Science Branch provide advice respecting estimates of WSP biological benchmarks, including a biologically-based spawning goal specifically for Little Tahltan Chinook Salmon as a component of the early-run CU.

This assessment will attempt to estimate the lower WSP benchmark (S_{gen}) of the abundance metric for the Little Tahltan Chinook. The upper WSP benchmark for abundance is 85% S_{MSY} and follows from the estimate of the spawning goal. 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 considered by Canadian and United States management in the development of an integrated management plan for Stikine River Chinook Salmon, and may potentially affect calculations of Total Allowable Catch (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.P., Boyce, I., Etherton, P., Richards, P. and Jaecks, T. Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook (Stikine River Drainage). CSAP Working Paper 2014SAL04

The specific objectives of this review are to:

1. Review Chinook production and escapement data for the Little Tahltan River.
2. Develop biological benchmarks, including the number of spawning adults that would produce a maximum sustainable yield of Chinook Salmon using various models.
3. Examine and identify uncertainties in the data and methods.
4. Examine the models presented in the working paper and provide recommendations on applicability.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science, Fisheries Management sectors)
- Alaska Department of Fish and Game
- Pacific Salmon Treaty Transboundary Technical Committee Members
- Aboriginal communities/organizations: Tahltan/Iskut First Nation

References

Bernard, D.R., McPherson, S. A., Pahlke, K. A., and Etherton, P. 2000. Optimal Production of Chinook Salmon from the Stikine River. Alaska Department of Fish and Game, Fishery Manuscript No. 00-1, Anchorage. iv + 39 p

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

APPENDIX B: WORKING PAPER REVIEWS

Date: November 4, 2015

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

CSAS Working Paper: 2014SAL08

Working Paper Title: *Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook Salmon*

My review focused on addressing the questions posed by Mr. Patten:

- **Is the purpose of the working paper clearly stated and aligned to the Terms of Reference for this CSAS Review (attached)?** Yes. The purpose of this paper is to review available data and provide supporting analyses for developing a spawning goal and biological benchmarks for Little Tahltan Chinook salmon. The paper does attempt to review the data, perform analyses, and guide recommendations for developing a spawning (escapement) goal and possible benchmarks for Little Tahltan Chinook salmon as a portion of the Stikine River stock of Chinook salmon. As such, the paper is aligned to the Terms of Reference (TOR) in that it attempts to address the four objectives listed in the TOR.
- **Are the data and methods adequate to support the conclusions?** No. There are at least two major reasons that the data and one major reason that the methods are inadequate to support the conclusions of the working paper. A successful run reconstruction and stock-recruit analysis requires that production data be collected so that accurate, precise, and internally consistent estimates of escapement and subsequent recruitment can be made. This is especially true for this type of run reconstruction, where mixed-population harvests are resolved to the stock by using information from the escapements made at a single population tributary. There are indications from the data collection and assumptions made in the analysis that this did not occur as described below.

Assumption that Weir Counts and Composition Data are Accurate

The working paper tacitly stated the assumption that counts of all sizes of Chinook salmon were accurately made at the Little Tahltan weir. Similarly the working paper assumes that estimates of age and size composition of Chinook salmon at the Little Tahltan weir are reasonable estimates of the age and size composition of all fish that escaped past the weir. Albeit central to the reconstruction of the entire run (escapement plus harvest), neither of these assumptions can be adequately tested, especially for the time period from 1985 through 1999 when no size information was collected from the escapements.

There is indirect evidence of bias in estimation of jacks in the escapement. In reviewing the data, the working paper reports that jacks were determined at the weir through visual inspection (all years) and that no size samples were taken during 1985-1999 (Table A1 of the working paper). Age composition was taken during the entire time period relevant to the analysis, but no mention is made of how the age samples were taken, especially during the time period when no size data were taken (1985-1999). A comparison of estimates of jacks based on size composition in the escapement during 2000-2013 shows that visual determinations were substantially biased low. Similarly estimates of jacks based on size at age during 2000-2013 showed bias that varied considerably by year. As a means of comparison, estimates of the proportion of jacks (using age 1.2 fish for comparison) at two other long term weir projects in Alaska are as follows:

Table 1. Estimates of the proportion of jacks (using age 1.2 fish for comparison) at two other long term weir projects.

Weir site	Years	Avg. % 1.2	Range % 1.2	Years <10%	Years >30%
Deshka	1995-2015	30%	9% to 67%	1 of 21	7 of 21
Situk	1995-2015	25%	6% to 48%	1 of 21	9 of 21
Little Tahltan	1995-2013*	11%	2% to 27%	10 of 19	0 of 19

*Landslide years excluded.

From this information, it is reasonable to assume that bias in visual determination and age-based determination of the proportion of jacks in the escapement was occurring during 1985-1999. Bias in determining the proportion of jacks in the escapement is problematic, but not insurmountable if the actual counts of fish at the weir are of all fish and all fish are counted in all years.

There is also indirect evidence that weir counts may not have been complete counts of all fish in all years, especially during the time period when no size data were taken (1985-1999). Escapements during 1985-1999 varied much less than in the proceeding brood years (2000-2007; Table A1). However recruitment from the 1985-1999 brood years varied much more than during 2000-2007 brood years (e.g., first panel of Figure 9). When looking at the production data, it is implausible that weir counts (and jack percentage) remained fairly stable during an extended time period (1985-1999) when harvest rates were fairly low so that strong year classes with more abundant jacks should have been seen at the weir (see Plot 1 below with the earlier years in red). It is as if the earlier data were taken from a completely different stock assessment program or the distribution of fish above and below the weir that are attributable to the Little Tahltan River has changed over time. We cannot test to see if overall Stikine River abundances were actually higher during this time period since the independent mark-recapture estimates of in-river abundance did not exist until 1996. Moreover, estimated escapements are more variable during 2000-2014 when mark-recapture estimates are available for comparison. It is possible that both biases (age composition and counts) were occurring during 1985-1999.

Assumption That Harvest Rates Are Equal

The second reason that the data are not adequate to support the conclusions of the working paper are that stock-specific harvests are calculated indirectly from relationships to escapements that were based on weir counts and size composition. This assumes that harvest rates are equal among all populations in the Stikine River, including those produced from the Little Tahltan River. Even if the weir counts and age compositions are 100% accurate, the assumption that stock-specific harvests can be estimated from the relationship to spawning escapements is not directly testable. Simple differences in run timing of different populations and the timing of fisheries would likely invalidate this assumption. This assumption also invalidates the need for a separate escapement goal or biological benchmark for Little Tahltan Chinook salmon because harvest rates on all populations within the Stikine River would be the same and management to achieve the current Stikine River Chinook salmon escapement goal would provide sufficient management for all populations within the Stikine River drainage. To test this assumption would require direct estimation of the stock-specific harvests in the mixed population and mixed-stock fisheries that harvest Little Tahltan Chinook salmon as is done for the entire Stikine River stock.

Methods Ignore Time Series Bias

There is also one major reason that the methods utilized are not adequate to support the conclusions of the working paper. This is related to the direct mathematical relationship between weir counts used as escapements, estimation of stock-specific harvests, and calculation of recruitments used to reconstruct the run. The method used to apportion harvests into stock-specific harvests and subsequent recruitment creates increased serial dependence in the stock-recruit data across years, especially when harvest rates are low to moderate. This type of run reconstruction can seriously bias a stock-recruit analysis and the reference points estimated based on the independence of stock and subsequent recruitments (Walters 1985, Korman et al. 1995) as is assumed in the methods of the working paper. A partial remedy to this problem would be to develop a state-space model that links recruitments back to subsequent escapements (e.g., the 'R-S linkage' as described in Fleischman et al. 2014). However, a model of this type would need at least a few years of estimates of stock-specific harvest of Little Tahltan Chinook salmon that are independent of the weir counts (escapements), which are not available.

Finally, escapement goals used in the Pacific Salmon Treaty (PST) process must be MSY-based. For the Alaska Department of Fish and Game to utilize an escapement goal on the Little Tahltan River as part of the PST process it must by definition be a BEG, which must be based on a reliable and scientifically defensible estimate of S_{MSY}. Based on the evidence provided above, the estimates of S_{MSY} in the working paper are not defensible given the problems with the data and inability to test important assumptions regarding harvest rates, and counting and sampling at the weir.

- **Are the data and methods explained in sufficient detail to properly evaluate the conclusions?** No. Although the authors go to considerable lengths to address the problem of weir counts with visual counts of jacks and perhaps incomplete or biased age composition data, there is no recourse for potentially biased sampling during 1985-1999. Either the weir counts and/or the age compositions are biased to some degree. Potential bias in escapements that are also used to estimate recruitments and an inability to test assumptions about the methods of run reconstruction clouds the ability to evaluate the conclusions and make a recommendation on an escapement goal or biological benchmarks.
- **If the document presents advice to decision-makers, is the advice and/or recommendations aligned to the objectives in Terms of Reference and in a useable form?** No. Aside from the problems with biased escapement data and untested assumptions concerning harvest rates, the working paper does not discuss the implications of attempting to manage for an escapement goal or biological benchmark on a small tributary of a larger river with most fisheries targeting mixed populations from that larger river. Moreover, the assumption of equal harvest rates in the analysis leads one to believe that management of the Stikine River stock for its escapement goal will provide for sustainable escapements to the Little Tahltan River without the need for an escapement goal specific to this population.
- **Does the advice reflect the uncertainty in the data, analysis or process?** Not completely. The authors did attempt to address model structural uncertainty by presenting several stock-recruit models. They also attempted to address bias in estimation of escapement through sensitivity analyses. However, all of the stock-recruit models they present accept the stock and recruitment data pairs as 100% accurate and independent of one another. Untestable assumptions regarding the accuracy of escapements and equality of harvest rates among populations within the Stikine River prevent reliable estimation of stock-recruit parameters and biological benchmarks.

Are there additional areas of research that are needed to improve the quality of or the ability to provide advice and recommendations related to the stated objectives? Yes. Although it appears that better assessments of total weir counts and representative sampling of age and size compositions is occurring, an assessment of whether all fish that enter the Little Tahltan River are actually ascending above the weir would be helpful. I also recommend continuation of telemetric studies of the distribution of Chinook salmon in the Stikine River drainage. While this information would be useful, I doubt that genetic or other methods of deriving an independent estimate of stock-specific harvests of Little Tahltan Chinook salmon are available at this time.

In closing, I also had some comments on analyses that were not performed, but may have been helpful.

- I see that the Parken method (Parken et al. 2004, Liermann et al.2010) was not used for this analysis. It would have been useful to see an estimate of carrying capacity or S_{MSY} that is independent of the assessment data. The Stikine River data were one set of results used in this model, with a reasonable fit so the proportion of the accessible drainage contained in the Little Tahltan River could be used to provide an independent estimate of carrying capacity and S_{MSY}.
- Use of the entire Stikine River stock-recruit data set might have provided better insights into this analysis. This would alleviate the problem of indirect estimation of stock-specific harvests.
- I was curious why the aerial survey expansions were not used? Perhaps they are also fraught with bias, but could be used to corroborate or refute assumptions made about the weir data.
- Although not part of the analysis, I would note that numbers of aged fish relative to sample sizes (Table A4) at the weir appear to have dropped appreciably since 2006 (see also sample size determinations described on page 9 in Section 2.1.1.2). Why not age more of the samples that were taken, especially in years of low runs? Moreover why were sample size goals not met in many years since 2006 even though there were sufficient fish at the weir to sample?

Literature cited

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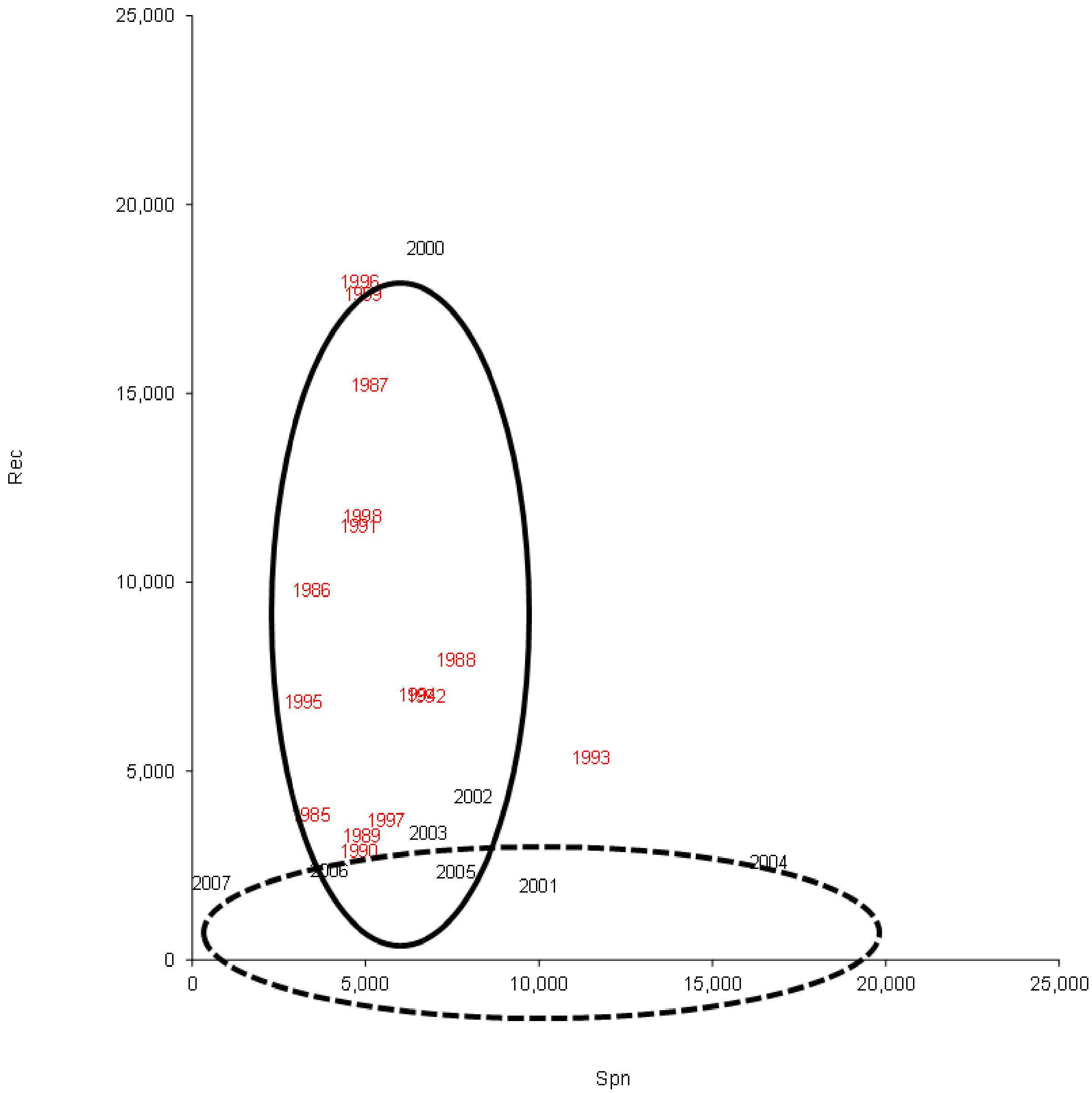
Liermann, M.C., R. Sharma, C.K. Parken. 2010. Using accessible watershed size to predict management parameters for Chinook salmon, *Oncorhynchus tshawytscha*, populations with little or no spawner-recruit data: a Bayesian hierarchical approach. Fisheries Management and Ecology 17: 40-51.

Parken, C.K., R.E. McNichol, and J.R. Irvine. 2004. Habitat-based methods to estimate escapement goals for data limited Chinook salmon stocks in British Columbia. Fisheries and Oceans Canada, Pacific Biological Station Nanaimo BC, Salmon Subcommittee Working Group Paper S2004-05.

Walters, C.J. 1985. Bias in the estimation of functional relationships from time series data. Canadian Journal of Fisheries and Aquatic Sciences 42: 147-149.



Plot 1. Production graph for Little Tahltan Chinook salmon with brood years indicated. Earlier brood years (except 1993) are in red text and encircled by a solid line oval and later brood years (except 2000) are in black text and encircled by a dashed line oval.

Date: November 2 2015

Reviewer: Mike Bradford DFO Science

CSAS Working Paper: 2014SAL08

Working Paper Title: *Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook Salmon*

This is a well presented body of work. The data are clearly presented and the analysis appears thorough and is within current practise for this type of project. I have only a few comments and a couple of items that need to be considered by the committee.

My most significant concern is whether conclusions derived from the statistical modelling are consistent with inferences that can be drawn from examination of the data.

From the beginning of the record to 2005 spawning escapement showed little trend and averaged in excess of 5,000 fish. At that time the exploitation rate was relatively constant at 20-30%. Exploitation increased in 2005 to over 60% for three years which coincided with an extended period of below replacement productivities ($R/S < 1$, Fig 2) resulting in a dramatic decline in both run size and spawning escapement. Thus the data can be divided into 2 periods: 1985-2000 broods of higher though variable productivity, and 2001-2007, the recent period of sustained low productivity.

It is informative to plot these periods separately as they reveal different patterns of production (see figure 1 below). If we allow for two regimes it is clear there is no S_{MSY} for the current period as the population is largely unable to sustain itself. For the earlier period, visual examination of the data suggests the largest yields would likely result from escapement in the 4000-6000 range, although considerable variation would be expected. This is similar to the estimate of S_{MSY} obtained using data through to 2000 in the retrospective analyses (Figure 17).

In this light it may be appropriate to consider regime-based analyses to estimate production parameters and benchmarks for regimes where there is a reasonable expectation of $R/S>1$. The information to do that is found within the report but it appears as a consideration after the detailed analysis of the whole dataset.

Finally, the terms of reference clearly state that the analysis should generate the WSP benchmarks of S_{gen} and $85\%S_{MSY}$ as is used in the WSP and that the previously devised methods should be used. The authors of the working paper have similar, but not identical benchmarks and it would be of value to provide the metrics as defined by the WSP, particularly in the abstract or conclusions of the paper.

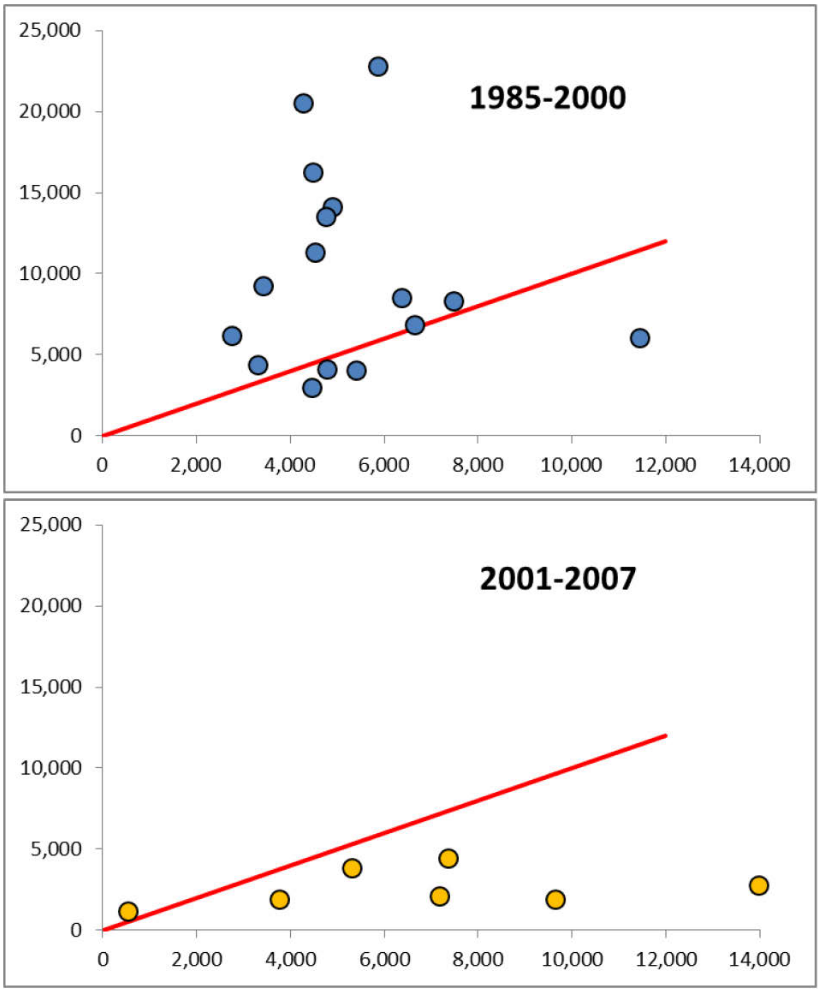


Figure 1. Baseline stock-recruit data (with 1:1 replacement line) for 2 time periods for Little Tahltan chinook salmon. Data from Table 3.

Comments relative to objectives stated in the Terms of Reference:

1. Review Chinook production and escapement data for the Little Tahltan River.

A detailed description of the data sources are provided in the report. It is noted there are number of steps where ratios are used to estimate components of recruitment including infills for missing data that will contribute to some uncertainty about the annual estimates.

2. Develop biological benchmarks, including the number of spawning adults that would produce a maximum sustainable yield of Chinook Salmon using various models.

The methodologies employed here are similar to those reviewed in the Taku coho project and I have no concern about them, with the exception of providing the WSP metrics as was requested.

The committee will need to discuss the appropriateness of using a single model for the whole time series (which generates an S_{MSY} of <3000 spawners) given the non-stationarity in production parameters that seems evident from Figure 1. The alternative is to use a reduced dataset (to 2000), which represents the regime where there is a harvestable surplus. Based on

Figure 17 I expect the benchmarks for this period will be significantly higher than when the whole database is employed.

3. Examine and identify uncertainties in the data and methods.

While the escapement data are of high quality, the catch data are the result of a number of simplifications involving indirect ratios, derived from basin-wide estimates. There is only a minimal treatment and discussion of the potential significance of these uncertainties. I cannot comment on the quality of these data but I did note the use of a basin scale mark-recapture method to estimate total spawner abundance. In light of recent research on the effects of handling and tagging on adult there is potential for the mark-recapture estimates to be biased high due to the loss of tagged fish. How this effects the recruitment estimates is unknown and may be relatively minor given the exploitation rates are relatively low in most years. With the weir it would seem a genetic-based approach could avoid some of these handling issues.

I do not believe the short paragraph on page 30 is sufficient for objective 3 with respect to data uncertainties.

Uncertainty in the outputs given the data as presented is well captured by the analyses and summaries provided by the authors.

4. Examine the models presented in the working paper and provide recommendations on applicability.

The examination of models under this objective could be expanded though this may be beyond the normal scope of work for such a project. Essentially, the authors have followed tradition and used the Ricker and Beverton Holt models. Neither fits the data particularly well as they are unable to account for large interannual variation as well as non-stationarity in population processes.

The Ricker models is difficult to justify based on knowledge of the freshwater biology of the species, and growing number of freshwater smolt-spawner relations for stream-chinook salmon that do not show “over compensation” at large spawner abundances. See Bradford et al. 2009 (Am. Fish. Soc. 70) for a discussion.

The Beverton-Holt model avoids the issue of overcompensation but its formulation usually results in the prediction of higher productivity and lower S_{MSY} values compared to the Ricker model when fit to the same data. This model can generate unrealistic productivity parameter values when used for salmon.

It seems that neither model is ideal, and there is a need to expand the suite of models that should be considered in such an analysis. Since model choice is really a key step that is fraught with uncertainty and requires careful deliberation (and sometimes has the largest impact on the outcomes) greater emphasis should be placed on this phase.

Date: November 3 2015

Reviewer: Chuck Parken, DFO

CSAS Working Paper: 2014SAL08

Working Paper Title: *Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook Salmon*

Is Little Tahltan a biological stock, or independent population, of salmon or just an opportunistic location to count a fraction of a group of salmon that share biological production characteristics and exchange individuals among generations?

- Confidence in the appropriateness of the reports analysis and its findings depend on the evidence that the Little Tahltan is an independent population of Chinook salmon in the Stikine watershed. If it is part of a meta- or larger population, then the analysis will need to be repeated with a larger set of information. It wasn't clear why the stock-recruitment analysis was not conducted at the Conservation Unit level, which would enable the results to contribute to Wild Salmon Policy implementation. A case could be made to conduct the SR analysis at the scale of the CU, since the CU is a biological unit that shares population dynamics characteristics.
- Little Tahltan are perhaps 1 of 3 or 4 possible spawning areas in the Tahltan watershed, based on the locations of fixed site telemetry receivers in the 2007 study and Figure 1 (Little Tahltan, Tahltan, Beatty, Johnny Tashoots). What evidence is there that Little Tahltan is independent of the other spawning groups (e.g. low correlation among spawners)?
- Are there life history differences that distinguish Little Tahltan from the other tributaries in the Tahltan and Stikine (e.g. maturation patterns, migration timing, spawn timing (2007 telemetry indicated similar migration timing for Tahltan and Little Tahltan)? Are there productive characteristics that lead the authors to believe that it is independent? Are there genetic differences between the spawning groups, or low genetic migration rates between them? What happens to fish that do not pass the Little Tahltan counting fence (do they die unspawned below the fence, migrate to other locations, spawn downstream below the fence?)? When the rock slide occurred and affected the 2014 return, where did the returning Little Tahltan fish spawn elsewhere, die trying to pass the obstruction, or was there a recruitment failure that coincided with the return year affected by the slide?
- How was this Chinook salmon monitoring location chosen? Was it hand-selected based on logistics, convenience, was it a known spawning location with productive habitat that had lots of Chinook? Was it randomly selected from a sampling frame to develop an inference about a stock that it is part of?
- Perhaps the rationale for using a single location in the Tahltan River can be explained further in the context of why the analysis was not conducted at the scale of the Conservation Unit (CU) or the Tahltan watershed. Is the stock-recruitment relationship based only on the Little Tahltan stronger than the relationship based on the Tahltan watershed or the CU.
- What happened to the fish that could not pass the rockslide in 2014? Did they spawn elsewhere in the Tahltan? Are there any signals in the escapement data for the other spawning areas in the Tahltan?

Recruitment Estimation

- Use CTC cohort analysis results
    - o includes all salmon fisheries via CTC: current report (e.g. section 1.2.4, 1.2.5, 2.1.1.5) completely missed exploitation in NBC troll and NBC sport based on actual CWT recoveries. There are just a few recoveries in these fisheries, but they should be included.
    - o total mortality (line 568): current report completely ignored accounting for incidental mortality from releases in large Southeast Alaska (SEAK) troll non-retention fisheries, and drop-out in terminal net and other fisheries.
    - o enables recruitment estimation by age (hence brood year): this is a major error in the current report in that age-specific ERs were not used; terminal net gear for sockeye vs chinook will exploit ages differently, size limits in ocean fisheries affect age-specific IM, recreational fisheries often select for older fish. Age specific reconstruction also address a concern that small chinook contribute to fishery catch (e.g. one of the Canadian fishery CWT recoveries was age 3). This will also avoid the need to assume that the age composition of the little Tahltan is represented by the age compositions of Stikine CWTs (which assumes a constant marked fraction and identical age composition as Little Tahltan which implies that Little Tahltan is not an independent stock or population).
    - o enables recruitment estimates in terms of adult equivalents.

- Timeframe for recruitment estimation
    - o CWT results began with BY 1999 (but see later CWT comments). Only natural production years with concurrent CWT cohorts should be used in the stock-recruitment analysis. This reduces the time series available, but will enable better representation of current production dynamics (see WSP). If contrast is low, then apply Bayesian methods described by Lierman et al. 2010. Accurate recruitment data are essential for the report objectives and a statistical basis for the ER estimates was not presented for the years without CWTs.
    - o Table B 2 reports the same catch values from 1981-2002/2003 for age 1.3 and age 1.4 fish. This assumption makes no sense considering the results for recent years in Figure b 2 . The fisheries in SEAK experienced very different management regimes in the AABM area at least: ceiling management from 85-98, abundance-based Harvest Rate Index management from 1999-2008, reduction in HRI management ceilings in 2009+. There isn't a basis to assume catch levels would be exactly the same when the fisheries experienced major changes in harvest rates and the length of chinook non-retention fisheries. Also, by design the harvest rates post 98 were reduced relative to the 79-82 period, and the SEAK HRI relationship leads to different HRI depending on the aggregate abundance. Also the cohort abundance changes, so a fixed catch is inappropriate.

Efforts to remove jacks

- Contrary to the authors belief in lines 333-4, jacks contribute substantially to production. Literature reports that 20% of chinook production sired by jacks. Age x.1 and age x.2 chinook contribute to ocean fisheries also. They contribute to the terminal net fisheries, but age data were not provided for them: I found age-3 and -4 CWT recoveries in the RMIS data.

- Jacks are not defined correctly in report. Literature defines biological jacks as males that return at an age that is one year younger than the youngest females. Thus, they are not based on size as stated in report. For Little Tahltan, jacks are age x.1, but I could not double check this as sex-specific age information was not provided. Considerable effort was taken in the report to remove small males and examine the influence of different treatments, but no effort was spent to evaluate if these efforts were necessary. Why are they necessary?

- The efforts to remove jacks are unnecessary because they are estimated accurately and precisely. For Chinook salmon, jack spawners are excluded from estimates of production during stock-recruitment analyses when their abundance is estimated poorly: this is not the case with Little Tahltan (unless the counting fence is not 'tight' for small Chinook). Much of the report was spent on removing small Chinook and developing alternate stock-recruitment data sets and analyses, but no attention was given to the primary data series.

CWT Program

- Section 2.1.1.4 states that the CWT program began in 2000, but RMIS indicates tagging began with brood year 1976. Tagging occurred for brood years 1976, 1979, and 1980. There was no mention of this in the report, which makes the report appear incomplete or not fully developed. Could any of these data be used to corroborate assumptions in table a 2.

Accuracy of scale ages

- No mention or assessment. Paired scale and CWT data should be available to evaluate the accuracy of the scale ages and to correct for aging errors. This is a very normal part of CWT indicator stock programs to collect the CWT information to correct for scale aging errors. McNicol and MacLellan 2010 demonstrated the extent of aging error for Chinook salmon adults in a very comprehensive study. For the two northern stocks in the study, Kincolith and Kitsumkalum, all 5 readers had errors in the scale ages, showing an under-aging bias. In addition, resorption causes under-aging bias when scales are used for Chinook salmon sampled near the spawning grounds (Murray 1994).
- Table A 3 provides a couple of examples which raise concern about aging error and data management. There are several situations where a fraction (ranging from 1-100%) of the fish with 3 ocean annuli have lengths in the jack size category. This leads to concerns about the accuracy of scale ages, or perhaps the accuracy with which data are managed from collection in the field to entry into the database. There was no information provided about the Quality Control/Quality Assurance with the sample collections and data management-is there none? What evidence can you present to convince readers that samples were not mixed up along the way or that lengths were recorded correctly for the fish that was scale sampled.

Bias in escapement estimate

- There was no mention of spawners downstream of the weir. What happened to the fish that were not corralled into the trap? Where do they go to spawn?
- It wasn't clear if the weir count was a size-biased under-estimate of escapement? Can small fish swim through the fence?
- There is evidence that counting fences can cause a bias in escapement estimates based only on counts at the fence. What information can be shared that demonstrates the estimates are unbiased.
    - o Counting fences in rivers with snow-dominated hydrology can lead to some Chinook choosing to not migrate passed the fence.

- This observation occurred at several of the interior Fraser locations which led to counting weirs not being used for the purpose of estimating Chinook escapement there.
- At Kitwanga River (Skeena), the counting weir caused some Chinook to spawn immediately downstream of the weir, where spawning had not been observed previously or only very rarely.
- At Kwinageese River (Nass), the fence diverts fish to pass through an opening where migration is monitored by video and the design has not altered spawning distribution.

Percentile Method

- The last sentence of the abstract is false Are there any examples of use for PSC assessment? There are none in the PSC Chinook Technical Committee reports. None of the Canadian chinook stocks use this approach to my knowledge.
- Unclear why the habitat based approach wasn't used (in Bayesian analysis as described by Lierman et al. 2010). Even simpler Parken et al. (2006) approach could be used, but only if the stock unit is identified correctly (probably at scale of Tahltan watershed based on info from 2007 telemetry report).

85% SMSY as upper benchmark (Brown et al. SBC Chinook WSP status assessment)

- In the Brown et al. CSAS report on the WSP status of Southern BC Chinook salmon the upper benchmark was 85% of S_{MSY} to align with reference points used in the PST Agreement. The 85% value should be used in this report instead of the 80% value for consistency within the species and with the PST agreement. Another issue is that Little Tahltan is not a CU, and perhaps the generation of upper and lower benchmarks is not appropriate for a component of the CU.

Age designation format

- Two formats are used in the report: European and Gilbert-Rich
  - Suggest sticking with one format to reduce confusion.
  - Gilbert-Rich (1927) format appears incorrect. E.g. the report writes 5.2 but it should be 5_2.
  - The European format is commonly used in the literature (e.g. Hess et al. 2014; Murray 1994) and easy to explain, which may improve communication.
  - Table B 2 has the GR and EU designations switched (e.g. EU 5.2)

Alternative Stock Recruit models

- The report indicated that the rationale for the Beverton-Holt model was poor and not appropriate. None of the stock-recruitment analyses that I came across when I did the meta-analysis of Chinook stock-recruitment studies (Parken et al 2006) used a BH model.
- It seems like the BH model was included only because the computer code had been developed for the Taku coho, which have much different biology than Chinook.
- There are several other types of stock recruitment models and it wasn't clear why these were not considered (e.g. power model, Quinn-Deriso model, Schnute model, Ricker model with smolt-adult survival covariate(or an environmental covariate))
- The BH analysis can be removed completely from the report and the authors can explain in the methods why that type of production model was not reported.
- The residual diagnostics should be part of the report. Were there any patterns? There is text in the report (e.g. Fig. 20 caption) that talks about Ricker AR1 correcting the residual

pattern. Is there a before and after plot? If there is a significant pattern, then AR1 has more support. Are the residuals correlated with the CWT survival indices?

Bias Correction

- The report could explain this more and consider other CSAP approaches for Chinook and for WSP assessments.
  - Bias correction was used for Cowichan, Harrison, and habitat model (meta-analysis) Chinook stock recruitment studies. The correction is because of the lognormal distribution for the error term. Correction for the bias gives the expected value, which is the mean.
  - The median has been used for the WSP assessments to my knowledge.

Conclusions

- The conclusions should be succinct and align with the objectives. Recommend data requirements should be a recommendations section.
- This section needs revamping.
  - New materials are introduced in the conclusions that are not part of the main report (e.g. Status of Little Tahltan).
  - The process of model selection should be in the discussion. The conclusion would simply identify the best model.
  - The CWT vs DNA catch estimate comparison is out of the blue, and none of the methods and supporting information were in the rest of the report. Among 10 comparisons, one of them had estimates with non-overlapping confidence intervals. How were genetic misidentification errors treated in the estimate of the stock-specific catches? There appears to be a lot of uncertainty in the catch estimates as indicated by the standard errors.

Data

- There should be a table with the escapements by age and annual exploitation by age
- There should be a table summarizing the stock-recruitment parameters for the different models (alpha, beta, theta, sigma, S_{MSY}, S_{rep}). Provide the values (no need to round).
- It was unclear why the marine catches in table 1 were incomplete 2014

APPENDIX C: AGENDA

Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for Little Tahltan Chinook (Stikine River Drainage)

November 12-13, 2015

Pacific Biological Station, Nanaimo, BC

Chair: Bruce Patten

DAY 1- Thursday, November, 12

Time	Subject	Presenter
1200	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Bruce Patten
1215	Review Terms of Reference	Bruce Patten
1230	Presentation of Working Paper	Gottfried Pestal
1330	Overview of Written Review #1	Mike Bradford
1430	***Break***	
1445	Overview of Written Review #2	Bob Clark
1545	Identification of Key Issues for Group Discussion	RPR Participants
1600	Discussion & Resolution of Technical Issues Distribute rough draft Science Advisory Report (SAR)	Bruce Patten
1700	***Adjourn for the Day***	

DAY 2 – Friday, November, 13

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Review Status of Day 1	Bruce Patten
0915	Discussion & Resolution of Technical Issues	RPR Participants
1030	***Break***	
1045	Discussion & Resolution of Technical Issues	RPR Participants
1145	Develop Consensus on Paper Acceptability & Agreed-Upon Revisions	RPR Participants
1200	***Lunch Break***	
1300	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Results & Conclusions • Sources of Uncertainty • Additional advice to Management (*as warranted*)	RPR Participants
1430	***Break***	
1450	*Science Advisory Report (SAR)* • Continued	RPR Participants
1600	Next Steps – Chair to outline: • SAR review/approval process and timelines • Timelines for other documents • Other follow-up or commitments required	RPR Participants
1645	Concluding Remarks • Other business arising from the review	Chair & RPR Participants
1700	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Bailey	Richard	DFO Science Fraser
Boyce	Ian	DFO Science Yukon/Transboundary
Bradford	Mike	DFO Science SAFE*
Brown	Gayle	DFO Science SAFE
Clark	Bob	Alaska Fish and Game
Erhardt	Richard	Tahltan First Nation
Heinl	Steve	Alaska Fish and Game
Holt	Carrie	DFO Science SAFE
Jones	Ed	Alaska Fish and Game
Komick	Nicholas	DFO Science SAFE
Lemieux	Jeffrey	DFO Science SAFE
Lewis	Dawn	DFO Science SAFE
MacDougall	Lesley	DFO Centre for Science Advice Pacific
Parken	Chuck	DFO Science Fraser
Patten	Bruce	DFO Science SAFE
Pestal	Gottfried	Solv Consulting
Richards	Philip	Alaska Fish and Game
Smith	Steve	DFO Science Yukon/Transboundary
Tompkins	Arlene	DFO Science SAFE
Winther	Ivan	DFO Science North Coast

*SAFE = Salmon and Freshwater Ecosystems

APPENDIX E: ABSTRACT OF WORKING PAPER

This paper builds a quantitative basis for establishing a biological frame of reference for spawner abundances of Chinook Salmon (*Oncorhynchus tshawytscha*) in the Little Tahltan River, which is tributary of the Stikine River in northwestern British Columbia. Stikine River Chinook Salmon are a transboundary stock aggregate, and are managed cooperatively by Canada and the US under the Pacific Salmon Treaty. The project focused on fitting various Spawner-Recruit (SR) models and estimating biological benchmarks for each model. Spawner data for Little Tahltan Chinook are of high quality with absolute counts available from 1985 to 2014. Recruitment estimates were reconstructed for 1985 to 2007 broods based on annual catch and escapement. In-river catch estimates are also of high quality, given the scale of the fisheries. However, marine catch estimates are more uncertain, due to the challenge of identifying Stikine-origin fish in the mixed-stock fisheries. The two major marine fisheries in terms of harvest rate are the SEAK troll fishery and the fisheries inside District 108. Estimates of biological benchmarks and summary reference points are robust across many alternative assumptions and sensitivity tests (e.g. age composition, dropping individual data points), but show a clear pattern over time in the retrospective test and a pronounced difference between alternative SR model forms (Ricker vs. Beverton-Holt). For example, current estimates of the number of spawners that maximizes sustainable yield under long-term average conditions (S_{MSY}) range from 2,700 to 3,100 across Ricker variations, and from 1,900 to 2,000 for Beverton-Holt variations. However, estimates using only data up to brood year 2000 or earlier are roughly 35% higher (around 4,000 for Ricker fits and around 2,700 for Beverton-Holt fits). The full suite of results needs to be considered in subsequent planning processes. In addition, we present various reference points derived from the SR model fits to address policy considerations under Canada's Wild Salmon Policy (e.g. upper and lower benchmarks for the relative abundance metric in a status assessment) and Alaska's Sustainable Salmon Policy (e.g. range of spawner abundance with given probability of achieving some specified proportion of maximum sustainable yield). As a consistency check, we also applied a common approximate goal range based on percentiles of observed spawner abundance. These are more widely applicable to data-poor systems and account for the majority of spawning goals for Pacific Salmon currently in use by DFO and ADFG [Alaska Department of Fish & Game].