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Proceedings of the Pacific regional peer review on An Evaluation of West Coast Vancouver Island Chinook Salmon Visual Spawning Escapement Estimation Methods

July 8, 2014
Nanaimo, British Columbia

Chair and Editor: Lesley MacDougall

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

August 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

Canada assesses the escapement of West Coast Vancouver Island (WCVI) Pacific Salmon Treaty (PST) extensive indicator stocks relative to escapement goals annually and estimate the abundance for the entire WCVI Chinook salmon management unit as part of the implementation of the Chinook Salmon Annex of the PST and meet other domestic management needs under the Wild Salmon Policy.

Mark recapture studies and/or fence counts are conducted for other Chinook Salmon systems under the terms of the Chinook Salmon Annex of the Pacific Salmon Treaty (PST) but are considered infeasible for WCVI Chinook Salmon systems. Instead, escapement estimates for WCVI Chinook Salmon systems are determined using periodic visual surveys and an Area Under the Curve (AUC) estimation procedure. To address concerns regarding the potential bias of the AUC procedure and the difficulties associated with identifying uncertainty in AUC estimates, Fisheries and Aquaculture Management requested the evaluation of alternate visual survey escapement estimation methodologies relative to information gained from independent studies and simulation modelling. A Maximum Likelihood (ML) method has been developed and explored.

These Proceedings summarize the relevant discussions and key conclusions that resulted from the Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of July 8, 2014 at the Pacific Biological Station in Nanaimo, B.C. One working paper focused on Chinook Salmon Escapement Estimation and Stock Aggregation Procedures was presented for peer review, to provide advice respecting the applicability of the new approach for escapement estimation of WCVI Chinook Salmon index stocks. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science Branch, DFO Fisheries and Aquaculture Management, members of the Chinook Technical Committee (Pacific Salmon Treaty [PST]) and Sentinel Stock Committee (PST), representatives from the Alaska Department of Fish and Game, Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, and the National Oceanic and Atmospheric Administration, First Nations, Academia and Non-Government Experts.

The discussions during this review, and the subsequent editorial review of revisions, resulted in the rejection of this Working Paper.

Compte rendu de l'examen par les pairs de la région du Pacifique sur l'Évaluation des méthodes d'estimation visuelle des échappées de saumons quinnats reproducteurs sur la côte ouest de l'île de Vancouver

SOMMAIRE

Dans le cadre de la mise en œuvre des dispositions du Traité sur le saumon du Pacifique (TSP) qui se rapportent au saumon quinnat et pour répondre aux autres besoins nationaux en matière de gestion en vertu de la Politique concernant le saumon sauvage, le Canada évalue, chaque année, les échappées des stocks indicateurs étendus de la côte ouest de l'île de Vancouver (COIV) définis par le TSP par rapport aux objectifs d'échappée. Il doit également évaluer l'abondance de l'espèce dans l'ensemble de la zone de gestion du saumon quinnat de cette région.

Conformément aux dispositions du TSP qui se rapportent au saumon quinnat, des études par marquage et recapture ou par comptage aux barrières de dénombrement sont menées dans les réseaux hydrographiques occupés par le saumon quinnat. On estime toutefois que ces études sont impossibles à réaliser dans les réseaux hydrographiques occupés par le saumon quinnat de la COIV. Les estimations des échappées sont plutôt déterminées au moyen de relevés visuels périodiques et d'une procédure d'estimation d'après la surface sous la courbe (SSC). Pour répondre aux préoccupations concernant le risque de biais de la procédure de SSC et les difficultés liées à la détermination de l'incertitude dans les estimations d'après la SSC, la Direction de la gestion des pêches et de l'aquaculture a demandé l'évaluation des autres méthodes d'estimation visuelle des échappées et l'étude de l'information obtenue au moyen d'études indépendantes et d'une modélisation par simulation. Une méthode de maximum de vraisemblance a été élaborée et examinée.

Le présent compte rendu résume les discussions et les principales 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 a eu lieu le 8 juillet 2014 à la station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail portant sur les procédures d'estimation des échappées de saumon quinnat et de regroupement des stocks a été présenté aux fins d'examen par les pairs, afin de formuler un avis concernant l'applicabilité de la nouvelle démarche à l'estimation des échappées des stocks indicateurs de saumon quinnat de la COIV. Toute autre publication découlant de cette réunion sera publiée, lorsqu'elle sera disponible, sur le calendrier des avis scientifiques de Pêches et Océans Canada.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, on comptait des représentants du Secteur des sciences et de la Direction de la gestion des pêches et de l'aquaculture de Pêches et Océans Canada (MPO), des membres du Comité technique sur le saumon quinnat (Traité sur le saumon du Pacifique [TSP] et Programme de surveillance des stocks), des représentants de l'Alaska Department of Fish and Game, de l'Oregon Department of Fish and Wildlife, du Washington Department of Fish and Wildlife, de la National Oceanic and Atmospheric Administration, des Premières Nations, des universités, ainsi que des experts non gouvernementaux.

Les discussions au cours de cet examen et la révision rédactionnelle ont entraîné le rejet de ce document de travail.

INTRODUCTION

Since 1995, escapement estimates for the extensive indicator stocks monitored for WCVI Chinook have been mainly generated using periodic visual surveys of spawners expanded for observation efficiency and average 'survey life' (the period which Chinook are present in the survey area) of fish using the trapezoidal Area-Under-the-Curve (AUC) method. The use of the AUC method to date has not included an evaluation of the statistical uncertainty of the estimates, the application of the survey and analytical methods, or the assumptions used to apply the AUC method.

A Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) workshop was held June 18-19, 2013 to evaluate the escapement estimate methodology and recommend methods for estimating an annual aggregate escapement or appropriate surrogate for the entire management unit. Several sources of uncertainty and bias were identified, including the estimation of observer efficiency, survey life, the frequency of site visits, and where surveys coincided with the temporal peak of the abundance. Approaches for investigating the sensitivity of the estimates of escapement to these biases, as well as approaches for the evaluation of the bias and the development of correction factors were identified. Specifically, an analysis to compare and verify the modeled estimates (AUC/ML) of escapement with independent estimates of escapement from tagging or other studies was recommended.

A CSAS RPR meeting was held on July 8, 2014 at the Pacific Biological Station in Nanaimo to evaluate the Maximum Likelihood (ML) model developed to estimate spawning abundance of WCVI Chinook Salmon in index streams using periodic visual survey data; and compare performance and accuracy of the ML approach to the previously used AUC approach.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Science Branch. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from members of the Chinook Technical Committee (Pacific Salmon Treaty [PST]) and Sentinel Stock Committee (PST), representatives from the Alaska Department of Fish and Game, Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the National Oceanic and Atmospheric Administration, First Nations, Academia and Non-Government Experts.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting:

> *Investigation of Chinook escapement survey and estimation methods for West Coast Vancouver Island (WCVI) streams* by Marc Labelle and Diana McHugh. CSAP Working Paper 2014/15 SAL11.

The meeting Chair, Lesley MacDougall, 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, and reviews.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteur for the meeting, Diana Dobson. 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, 27 people participated in the RPR (Appendix D).

Participants were informed that Dan Rawding and Antonio Velez-Espino had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews (Appendix B); summaries of each review are found below.

REVIEW

Working Paper:	*Investigation of Chinook escapement survey and estimation methods for West Coast Vancouver Island (WCVI) streams* by Marc Labelle and Diana McHugh. CSAP Working Paper 2014/15 SAL11.
Rappoteur:	Diana Dobson
Presenter(s):	Marc Labelle, Diana McHugh

PRESENTATION OF WORKING PAPER

The authors reviewed the derivation of the Maximum Likelihood Estimation (MLE) Model that was employed for this working paper. This model is derived from one initially developed by R. Hillborn. The authors clarified the scaling factor used in the MLE model to account for Observation Efficiency (OE) – a key point is that this model does not use OE in the same sense as traditional Area Under the Curve (AUC) models. This model uses OE as more of a nuisance factor.

Several points of clarification were requested regarding which parameters in the model were constrained and bounded. The authors presented the program interface and described the rationale for how bounds were set. Bounds were set for escapement, arrival mean, arrival standard deviation, Stream Life mean and Observation Error. Discussion regarding the parameters and bounding is described in greater detail in General Discussion below.

WRITTEN REVIEWS

DAN RAWDING

- Reviewer 1, Dan Rawding, Washington Department of Fish and Game, presented his review via teleconference (Appendix B).
- The reviewer felt the MLE model presented is an improvement over the work presented last year and provides important insights. However, Mr. Rawding expressed concerns regarding whether or not the work addresses all of the objectives of the Terms of Reference, specifically with respect to comparison of the estimates to independent estimates of escapement and sensitivity analyses. The author indicated that reviewing some of the independent data may be useful but that there would be a need for a detailed examination of how the independent studies have been conducted, how the data has been collected and reported for validation.

- The sensitivity analysis that was provided is satisfactory in terms of understanding how the model operates. However, the sensitivity analysis could be improved by testing how well model performs as various data limitations are introduced (e.g. what is the effect of missing surveys, and consequently missing the peak). The author agreed that an expanded sensitivity analysis could be completed.
- Mr. Rawding concluded, by reconstructing the model, that the model does not provide information regarding observer efficiency, and has questions regarding whether or not the model can accurately estimate OE and SL from the included observations. The author responded by identifying that the model does not use a lognormal error structure such that the replication of the MLE model may have produced different results.
- Mr. Rawding identified that some of the observations may be outside the current model bounds. The author indicated that the bounds could be relaxed to be more representative, but cautioned that the bounds were set on the estimates, not the data.

ANTONIO VELEZ-ESPINO

- Reviewer 2, Antonio Velez-Espino, DFO Science, PBS, presented his review in person (Appendix B).
- The reviewer agreed with Mr. Rawding's suggestion that the sensitivity analyses were too narrow, and that the model description should also be expanded to provide more detail regarding the steps taken to adapt Hillborn's model.
- The reviewer also expressed concerns regarding the influence of bias of the Observer Efficiency and Stream Life on escapement estimates, and identified a potential concern of over-parameterization where so few data points are available.
- Mr. Velez-Espino recognized the contributions of this paper in terms of improved methodologies, expanded modelled estimates that can be used for comparative purposes or trend analysis, and suggested that the introduction and objectives of the paper should be rewritten to reflect the terms of reference and the values of this paper.
- Mr. Velez-Espino also recommended that the method by which the model configuration was chosen (unimodal vs. bi-modal) should be more clearley explained in the paper.

GENERAL DISCUSSION

Potential advantages to the Maximum Likelihood Estimate model, in comparison with the Area Under the Curve model include:

- MLE does not require "0" counts at the start and end of a survey, although they are still desirable.
- MLE does not require empirical estimates of OE/SL – OE and SL generated by the model is not ideal, but can be useful to analyze historical records when OE and SL values were not measured, and are instead based on 'surveyor opinions'
- MLE models can provide measures of uncertainty more explicitly than AUC models.
- MLE does not require 'peak' counts as AUC models do (although still desirable).
- MLE model has more conditions to comply with than AUC models (limits on SL for instance, desired survey periodicity, etc.).

CONCLUSIONS

The working paper was **conditionally** accepted subject to major revisions and a second review by an editorial board selected from the participants of the July 8, 2014 Regional Peer Review. The subsequent revisions and review did not yield an acceptable final paper; thus the working paper was **ultimately rejected** as a Research Document. Details are included in the “Summary and Closing” section below.

While it was noted that there were critical revisions required to address concerns raised during discussion, there was also acknowledgement that this working paper represents a successful exploratory investigation of an alternate model. The preliminary estimates generated with the Maximum Likelihood Estimation model illustrate that there are parameter sensitivities that need to be explored in a sensitivity analysis as future work.

Two important contributions in this working paper are the adaptations to the Hillborn model that enable the incorporation of a bimodal pulse and the development of key model software.

While the MLE model does provide a measure of partial uncertainty, the group was unable to conclude the MLE is a superior approach compared to the AUC approach based on the results presented so far. The superior performance of the MLE estimator may remain a matter of conjecture until rigorous comparisons can be made using very reliable escapement enumeration records.

The recommended working paper revisions are summarized below:

- Simulation expansion: assess the sensitivity of the escapement estimate from the model to stochastic variation in some parameters, and violations of the some underlying assumptions. Using simulated datasets, priorities include:
- Provide additional guidance regarding how to address odd data sets, what results to check, what to do if the results are unrealistic, etc: “Model Applicability and Limitations”.
- Introduction, discussion and conclusions to be clarified to highlight the key contributions of the paper, and identify how the paper meets the objectives.
- Model selection process to be explained more clearly.
- Use of equation 8 to be explained more clearly.
- Adaptations to Hillborn’s model to be explained more clearly.
- Include independent survey data (from Burman river) in a separate table for comparison.
- Include figure from the presentation that compared reported OE vs. measured OE.

Participants noted that it is an improvement to have an estimate of partial uncertainty, and the use of ancillary data, and allowance for additional process error may help improve the confidence interval of the MLE estimates. Participants noted that additional information from complementary surveys would help determine if the nuisance parameter estimates match those from field investigations.

Complete and reliable escapement enumeration data are needed to assess the performance of this model, and the accuracy of the main non-nuisance estimate of interest, namely total escapement.

SUMMARY AND CLOSING

As noted above, a second review of the significant changes and further sensitivity analyses was recommended by participants, and was a condition of approval of the working paper. The revised working paper was reviewed, secretarially, by the selected editorial board in January 2015, and again in June 2015 after further edits. Final responses from editorial board members were submitted in July, 2015 – the editorial board concluded that the revised working paper did not fully address the key changes that had been requested by reviewers in the first assessment of the working paper. The members of the editorial board recommended that the revised working paper be rejected. A series of internal follow up meetings were unsuccessful in identifying a path forward for the further revision of the working paper; thus the decision was made in May 2016 to reject the working paper and conclude the peer review process.

ACKNOWLEDGEMENTS

We wish to acknowledge the considerable efforts provided by our reviewers, Dan Rawding and Antonio Velez-Espino, as well as editorial board member John Clark, and Rapporteur Diana Dobson.

APPENDIX A: TERMS OF REFERENCE

An Evaluation of West Coast Vancouver Island Chinook Salmon Visual Spawning Escapement Estimation Methods

Regional Peer Review - Pacific Region

July 8, 2014
Nanaimo, BC

Chairperson: Lesley MacDougall

Context

As part of the implementation of the Chinook Salmon Annex of the Pacific Salmon Treaty (PST), Canada is required to assess the escapement of West Coast Vancouver Island (WCVI) PST Chinook Salmon index stocks relative to escapement goals annually. Domestically, assessments of individual stocks are required to implement Canada's Wild Salmon Policy, and meet other domestic management needs, such as managing and evaluating terminal fisheries in the WCVI area.

Given the geomorphology, remoteness and available resources, it is has not been feasible to conduct either mark recapture studies or fence counts on WCVI Chinook Salmon systems, as are done other Chinook Salmon systems that fall under the terms of the Chinook Salmon Annex of the PST. Instead, periodic visual surveys are conducted and these observations have been used with an Area Under the Curve (AUC) estimation procedures to produce an estimate of escapement for WCVI Chinook Salmon index stock. Concern has been raised by the Chinook Technical Committee of the PST that this method may have unacceptable bias and does not adequately estimate uncertainty. To address these concerns, an investigation into an alternate analytical method had been developed and studies, funded under PST Sentinel Stocks Program, have been conducted.

The objective of this review is to evaluate the alternate visual survey escapement estimation methodology and consider information gained from the independent studies and simulation modelling to provide advice respecting the applicability of the new approach for escapement estimation of WCVI Chinook Salmon index stocks. Advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review Process will be provided to DFO Fisheries Management, the Pacific Salmon Commission and the Chinook Technical Committee (CTC) established under the Pacific Salmon Treaty.

Objectives

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

> *Labelle, M. and McHugh, D. An Investigation of West Coast Vancouver Island Chinook Salmon Visual Spawning Escapement Estimation Methods. CSAP Working Paper 2014-15/SAL01.*

1. Evaluate the Maximum Likelihood (ML) model developed to estimate spawning abundance of WCVI Chinook Salmon in *index streams using periodic visual survey data,* including*:*
    a. Quantification of uncertainty of the abundance estimates; and,
    b. Identifying sources of bias in the survey and estimation method.

2. Compare performance of the ML approach to the previously used AUC approach and in relaton to information gained through the independent studies with respect to accuracy.

Expected publications

- CSAS Research Document
- CSAS Proceedings

Participation

- DFO Science Branch
- Members of the Pacific Salmon Treaty, Chinook Technical Committee (PST) and Sentinel Stock Committee (PST)
- Representatives from the Alaska Department of Fish and Game, Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, and the National Oceanic and Atmospheric Administration
- Representatives from the Nuu-chah-nulth Tribal Council
- Academia and Non-Government Experts

References

DFO. 2014. Proceedings of the Regional Peer Review on the West Coast Vancouver Island Chinook Salmon Escapement Estimation and Stock Aggregation Procedures. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2014/025 In press.

DFO. 2014. West Coast Vancouver Island Chinook Salmon Escapement Estimation and Stock Aggregation Procedures. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/038. In press.

APPENDIX B: WORKING PAPER REVIEWS

Date: July 3, 2014

Reviewer: Dan Rawding, Washington Department of Fish and Wildlife

CSAS Working Paper: 2014/15 SAL01

Working Paper Title: Investigation of chinook escapement survey and estimation methods for West Coast Vancouver Island (WCVI) streams by Labelle and McHugh

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Thank you for the opportunity to review the Chinook escapement survey and methods for WCVI streams presented in Labelle and McHugh (2014[1]). An earlier version of this paper was included for the June 2013 CSAS meeting (Dobson et al. 2013[2]). [DFO] (2014) published the proceedings from this meeting. In the executive summary it is state that: "A working paper on the methodology used to estimate escapement of WCVI index stocks was reviewed as part of objective 1. The summary of the working paper, the reviews and the main points for the review discussions are summarized in these Proceedings. Participants and reviewers recommended that more work be conducted, including further model development, sensitively analysis and calibration with empirical data. The paper was not accepted in its current form."

The objective of this review, as stated in the TOR, is "to evaluate the alternate visual survey escapement estimation methodology and consider information gained from the independent studies and simulation modelling to provide advice respecting the applicability of the new approach for escapement estimation of WCVI Chinook Salmon index stocks". Labelle and McHugh (2014) have provided an updated paper based on the 2013 recommendations from the CSAS meeting. The manuscript provides a description of surveys and procedures, review of possible models based on live counts, a description of the proposed model, sensitivity analysis, comparison to a limited set of independent estimates, evaluates new information from studies designed to estimate stream life and observer efficiency, and updated the escapement time series through 2013. This manuscript is an improvement from Dobson et al. (2013) but does not adequately address the TOR and I have significant concerns with the application of the model, sensitivity analysis, and comparison with independent estimates, which are discuss below.

Model

This paper reviews live count method to estimate salmon escapement and proposes the use of parametric model based on arrival, mortality, observer efficiency, and residence time initially developed by Quinn and Gates (1997) and extended by Hilborn et al. (1999) using maximum likelihood methods, which are implemented in a MS Excel spreadsheet. They propose escapements be evaluated using uni-modal and bi-modal normal arrival times with a log likelihood ratio function with a correction factor for zero counts that can be used for model selection, goodness of fit tests, and to estimate uncertainty in escapement using likelihood profile methods. In addition, they use prior information to bound the parameter estimates into a

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[1] Labelle, M. and McHugh, D. 2014.An Investigation of West Coast Vancouver Island Chinook Salmon Visual Spawning Escapement Estimation Methods. Unpublished CSAS Working Paper 2014 15/SAL01.

[2] Dobson, D., M. Labelle, D. McHugh and E. Porszt. 2013. Evaluation of escapement monitoring program and escapement estimates for WCVI Chinook (*Oncorhynchus tshawytscha*) extensive indicator stocks. Unpublished CSAS Working Paper 2013/P57.

suitable range based on professional judgment, which in Bayesian context is referred to as a uniform prior. The authors mention methods used by Hilborn et al. (1999) and Su et al. (2001) to more formally incorporate prior information into this model but they are presented and not assessed. They also constrain the CV, mean arrival time, and limit the difference in observed and expected counts, which may help with convergence, confounding, unrealistic parameter estimates, and unexpected counts.

The proposed model is very similar to that described in Dobson et al. (2013). However, the authors did add an addition section that more fully explores the incorporation of observer efficiency from the Tranquil and Marble rivers in 2012 and 2013 into the abundance estimate. This was accomplished by exploring different relationships between observer efficiency and environmental covariates (Korman et al. 2002, 2007). The results suggest that Labelle's model based estimates of observer efficiency are greater (mean 1.5, range 1.1 to 1.9) than those determined from regression analysis and the observed data.

Comments

The authors present two models in the paper; for the first model equations 1-4 from Hilborn et al. (1999) are used to estimate abundance along with assumptions on the range of stream life and observer efficiency but in the second model the authors provide an alternate set of equations (5-8) to estimate the number of salmon in the stream (N_t) based on Korman et al. (2002, 2007). Therefore, equations 3 and 8 are equivalent but the authors should clarify the specific equations used in their model. The authors propose a model that is statistically defensible and has been used to estimate salmon escapements for numerous populations. They provided a short summary of the rationale in choosing the model and provide the symbols, notation, and model structure (equations), fitting procedure, model selection, the possibility to more directly incorporate prior information.

I offer the following comments on the model. First, the some of the observed data are outside the parameter bounds used in the model. While it appears that the bounds may be realistic under most conditions, the observer efficiency estimates are not (Figure 6 & 9). This could be remedied by decreasing the lower bound on observer efficiency. Although, I believe it is not appropriate for this model to estimate observer efficiency (see comments below and in appendix). Second given the variable environmental conditions (Figure 9), it is likely there is considerable bias in escapement estimates using an average observer efficiency. This could be improved allowing observer efficiency to vary by survey, which was shown on pages 14-15. Although this data is limited, the authors suggest additional studies in the discussion, which is I believe is warranted.

Third, the only model inputs are the Chinook counts and the model estimates the all the parameters including survey life, observer efficiency, and escapement (page 5). I believe the model structure proposed in this paper is trying to optimize all parameters given the bounds and constraints of the model. If this is the case optimization will lead to the lowest negative log likelihood by through adjustment of all parameters but not necessarily provide and unbiased estimate of escapement. The desired approach is to use data for counts, observer efficiency, and stream life because these data are needed to estimate abundance, mean date of arrival and standard deviation of arrival (e.g. Hilborn et al. 1999). I believe the authors are treating observer efficiency and stream life as nuisance parameters (page 15). There was considerable discussion in the June 2013 CSAS meeting, in which some participants believed, they are nuisance parameters but need to be estimated based on the data. I believe the authors have constructed a parameter redundant or near parameter redundant model for which it is not possible to estimate all the parameters in the model because the resulting model is not identifiable (Catchpole et al. 1997, 1998, 2001). In the Bayesian context, this is referred to weak identifiablity, when the there is little data to estimate the posterior distribution of the parameter, so the posterior is strongly influence by the prior distribution (Gimenez et al. 2009). In this case the recommended solution is to provide observer efficiency and survey life as inputs to the model, not parameters to be estimated, which consistent with recommendations from Hilborn et al. (1999) and many participants in the 2013 CSAS meeting. For example, in the comparison of estimate and modeled observer efficiency (page 14-15), the model observer efficiency is 1.5 times higher, which would lead to a 50% increase in the population size. Therefore, the current estimates produced from the model will be biased low due to near redundancy or weak identifiability. See the appendix for a formal analysis of this concern and the resulting bias on abundance when the methods presented in Labelle and McHugh (2014) are used.

Fourth, the authors have constrained estimates of the mean date of arrival in the second period to be greater than the first, CV, and constrained limits of the differences in observed and expected counts. While this constraining may help with fitting the model, the difference between observed and expected counts especially at low abundance may lead to reduced uncertainty in the escapement estimates. This constrain was not listed in the last version of the paper and it would help if the authors provided the need for this constraint and the CV constraint, and result on model performance. The constraint on the mean date of arrival is typically used in bi-modal models with sparse data. My final model comment is that is survey frequency remains low on WCVI has been reduced and currently is low, and independent estimates of stream life and observer efficiency are limited. Pursuing Bayesian hierarchical approaches may lead to reduced bias and improved precision (Su et al. 2001), and may be more defensible than the use of constraints. For example, one could pursue annual entry timing of streams with similar size and within a geographic area because it entry appears to be correlated with flow. The exchangeability assumption may also be justified regarding observer efficiency and stream life within years or possibly streams.

Sensitivity

The authors provide a sensitivity analysis based on the models (uni-modal and bimodal), escapement (500 and 2000), observer efficiency (0.80±0.05 and 0.90±0.05), and survey frequency (every 3, 6, and 9 days). Run timing and average stream life were fixed based on reported figures. Relative error and point estimates were reported for each simulation. The authors summarized results indicating relative error was generally small (<10%), and the relative errors are less with higher escapements, more surveys, and higher observer efficiency for the uni-model model. When run timing is bi-modal, when survey frequency and observer efficiency is high and suggested some factors that may contribute to this. They conclude that observe efficiency can be more difficult to estimate with uncertainty than stream life when there are few surveys or when using the bimodal model.

Comments

This appears to be similar to the analysis that was done in Dobson et al. (2013) and did not address concerns raised during the CSAS review. The sensitivity analysis provides some useful conclusion for development of study designs and implementation of this program regarding especially regarding survey frequency. However, it uses some unrealistic scenarios regarding survey frequency and observer efficiency. Observer efficiencies are frequently lower (Figure 9) than the values used in simulation and survey frequencies are less than the 9 day period (Table 2). In addition, Hill (1997) noted that missing the peak can lead to underestimates of abundance using the AUC method. Understanding how missing the peak may be important in the implementation of the study design. The results of the sensitivity analysis may change and provide more useful advice the inputs more accurately reflect field conditions (e.g. observer efficiencies, missed surveys, and the missed peak count). Therefore, I recommend that these realistic scenarios be incorporated into the sensitivity analysis. These realistic scenarios are likely to yield more relevant advice, which is one of the TOR objectives.

Comparison

One of the comments in [DFO] (2014) was for the authors to compare their estimates to known estimates, which they accomplished in this paper. The authors compared estimates to their model based estimates to those in the Tranquil, Tahsis, Leiner, Kaouk, and Marble rivers. The authors note this comparison was made because there were independent estimates available from mark-resight and mark-recapture. The model based estimates were generally higher than the mark-recapture estimates. The authors indicate that the assumptions for the mark-recapture estimates in the populations used for comparison were likely violated, which would result in a biased mark-recapture estimate. So, the comparison of modeled and mark-recapture estimates in the paper is not very informative.

Comments

The Sentinel Stocks Program has funded mark-recapture estimates on the Burman River for the last five years. Open (Jolly-Seber) and closed (pooled Petersen) produced similar estimates and testing detected no bias in key assumptions (Rodger Dunlop, pers. comm.). These escapement estimates met the Chinook Technical Committee standard of an unbiased estimate with a CV of less than 20%. Therefore, a comparison of mark-recapture estimates and those from Labelle and McHugh (2014) on the Burman River should be informative of model performance (Table 1). In four of five years, Labelle's estimates have a negative relative bias of -24% to -70%. For the most recent year, Labelle's estimate was positively biased by 32%. The mean bias over the five years was -32%. These are consistent with the observations that the current analysis of periodic live counts leads to negatively biased abundance estimates (Clark 2013[3]).

Table 1. Comparison of Burman River Chinook salmon estimates based on the Petersen mark-recapture model and Labelle's model.

Year	Petersen Estimate	Petersen CV	Labelle Estimate	Relative Bias
2009	2363	6%	1799	-24%
2010	3543	15%	2393	-32%
2011	5386	14%	1602	-70%
2012	4119	10%	1579	-62%
2013	8275	11%	10905	32%
mean				-31%

In 2012, observer efficiency and stream life were calculated based on radio tags in the Burman River. Independent estimates using the trapezoidal AUC and the Petersen mark-recapture estimates are similar (Rodger Dunlop per. comm.). For 2012, the mean estimate was 11.3 days for stream life in the tagging pool before entry into the survey area, 5.2 days for stream life in the survey area, and 62% for observer efficiency on days DFO surveyed. The weighted

[3] Clark, J.H. 2013. Area-Under-the-Curve estimates of Chinook salmon spawning in rivers along the west coast of Vancouver Island: an approach to interpretation of metrics as reported by the Chinook Technical Committee. 40pp.

average of stream life was 8.0 days in the survey area and 67% for observer efficiency from Labelle and McHugh (2014). The positive bias in Labelle's estimates of survey life and observer efficiency are the likely cause in the negative bias of Labelle's abundance estimate compared to the mark-recapture and AUC estimates for the Burman Chinook salmon in 2012 (see appendix). A detailed comparison with the Burman was recommended in [DFO] (2014) and should be completed to provide valuable insights into model performance.

Summary

Inference in ecology is based on models, which are scientific tools to help us understand a part of the natural environment. The proposed model represents a simplified but realistic depiction of adult salmon entry and mortality, and our ability to observe these fish during their spawning run to estimate the number of spawning salmon. Since all models are wrong but some are useful (Box and Draper 1987), a critical step in understanding the usefulness of any model is validation through simulations (theoretical approach) and comparison to independent estimates (practical approach), which are defined in the TOR. Parametric arrival and mortality models to estimate salmon escapement are credible and provide a statistically sound approach to estimate uncertainty in salmon escapements albeit based on some key assumptions about the distribution model used for arrival, model error structure, and estimates of observer efficiency and stream life (Quinn and Gates 1997, Hilborn et al. 1999). The model proposed by the authors represents a potential improvement to Chinook salmon escapement estimates on the WCVI. However, the manuscript does not adequately address the comments from the last review and the stated purposes of the paper in the TOR "evaluate the alternate visual survey escapement estimation methodology and consider information gained from the independent studies and simulation modelling to provide advice respecting the applicability of the new approach for escapement estimation of WCVI Chinook Salmon index stocks". Therefore, major revisions to the manuscript are required to meet the TOR.

TOR Obj. 1: Evaluate the alternate visual survey escapement estimation methodology.

The authors provided an alternate approach to the traditional AUC estimates based on the modification of Hilborn's model. However, the evaluation of the model was incomplete specifically in testing for parameter redundancy and/or weak identifiablity which could be detected using statistical methods, simulations, and/or known independent abundance estimates. In addition, the model selection section of the paper needs to be strengthened, and be more specific rather than a list of items to consider in model selection. Better use of recent information and graphical data analysis should be explored to help with providing better advice regarding model selection. For example, do environmental covariates improve model selection? Targeted simulations addressing current monitoring could provide better advice regarding model selection and use.

TOR Obj. 2: consider information gained from the independent studies to provide advice for application.

The paper only explored a fraction of the independent data available. They focused on mark-resight data from some systems and indicated they have little confidence in the estimates. This implies there was little benefit in this part of the analysis. In addition, they explored relationships between environmental covariates and observer efficiency. However, the conclusions from this analysis need to be more specific. The authors did not use the independent mark-recapture Chinook salmon estimates for the Burman River from 2009 for comparison. It appears they did not use other Burman data such radio tag information on survey life and observer efficiency. In addition, there is other data on survey life from tag depletion curves and environmental covariates and observe efficiency on the Burman that was not included. Burman data should be included in the paper.

TOR Obj. 3: Simulation modelling to provide advice respecting the application.

The presented sensitivity analysis using simulations focused on the study design given the recommended model. It should also explore an alternative approach which is the usefulness of the model given the data. This may be a more important consideration in face of declining resources. For example simulation using current monitoring (survey frequency, environmental covariates, ranges in observer efficiency and stream life) may provide improved advice regarding application of the model and model selection. For example, how accurate is model selection (uni-modal or bimodal) depending on the number and timing of surveys, observer efficiency with and without covariates, and constant or declining stream life?

In general, more attention to the TOR would improve the organizational structure of the paper. Since the goal of the TOR includes model development, evaluation of recent independent information, and model evaluation and application, I would recommend the authors consider the use of the organization structures presented in Schwarz et al. (1993), Adkison and Su (2001), and Korman et al. (2002) for a template to improve the paper. For example, after defining the purpose and the objectives in the introduction, these authors introduce the model, review the literature on the model variations available, develop and clearly define their statistical models including the probability distribution functions, and model assumptions. They use probability distributions to incorporate uncertainty in the model and use simulations to assess bias and accuracy of models when the assumptions are violated and/or to compare to other models. These authors described the protocols used to collect data, and apply their models to the collected data.

The current discussion section is general and not very focused. It is likely to improve based on the changes in organizational structure recommended above but should also include next steps. If this method is recommended is the current study design adequate? What environmental covariates need to be collected? How will these updated study design recommendations reduce bias and improve the precision of estimates? Finally, what resources (funds) are required to collect the quality and quantity of data needed for the model?

Thank you for the opportunity to review the paper. I appreciate the effort of the authors in development of a model to improve Chinook Salmon escapement estimates on the WCVI. I hope that this review helps them achieve their objectives. Please contact me if you have questions or want to further discuss my comments.

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Appendix

To demonstrate the problem of near parameter redundancy or weak identifiably in Labelle and McHugh (2014) framework, I re-analyzed the Burman 2012 Chinook salmon data in WinBUGS. I added a count of zero for August 15 and used the observed count of seven on November 7. The first model was Hilborn's model, which use equations 1-4 from Labelle and McHugh (2014). In addition the mark-resight data was pooled across the DFO swim surveys to directly estimate observer efficiency, and the 106 estimates of stream life as determined from radio tag data obtained provided by Rodger Dunlop. I used normal error structure rather than the log likelihood ratio function from Labelle and McHugh (2014). For the second (adapted Labelle's) model, I used equations 1-4 from their paper, stream life was a Poisson distribution truncated from 4-25 days, and observer efficiency was a uniform distribution from 0.65 to 0.95.

As noted the model is fit based on a normal error structure, $x_t \sim$ Normal(c_t, prec). Comparison of x_t (observed counts) to posterior distribution of c_t (expected counts) by day suggests that both models fit the data (Figure 1 and 2). Specifically, the observed count (x_t), the vertical bar is in the middle of the estimates counts (c_t) for both models. This indicates that model fit based on normal error structure is the same for both models. However, the models lead to very different estimates of escapement (Figure 3). Hilborn's model using observer efficiency and stream life based on radio tags yields and this model abundance estimate is slightly biased compared to the mark-recapture estimates (upper panel in Figure 2). However, the adapted Labelle model (lower panel in Figure 3) underestimate abundance. Note the mode in the lower graph is similar to the estimate of 1579 (Labelle and McHugh 2014, page 28).

Since both models fit the data equally well, I examined the observer efficiency. The estimates observer efficiency was (0.62) based on mark-resight using radio tags on the day of the survey, with surveys pooled across the season (Figure 4, upper panel). The estimated observer efficiency is not within the bound used by Labelle (Figure 4, lower panel). Since $c_t = vN_t$, there is no information to estimate observer efficiency (*v*), which resulted in a posterior distribution for observer efficiency within the bounds specified by Labelle and McHugh (2014) (0.65-0.95). Therefore, the posterior distribution of *v* in the adapted Labelle model is the same as the prior distribution, which in the Bayesian paradigm is referred to as weak identifiability (Gimenez et al. 2009) or in the maximum likelihood frame work as near parameter redundancy (Catchpole et al. 2001), which result in biased model estimates for these parameters and other parameters that use these parameters.

The examination of stream life provided similar results. The estimate of stream life from radio tagging data was 5.2 and I assumed this followed a Poisson distribution based on Labelle and McHugh (2014) (Figure 5, upper panel). The estimate of stream life from the adapted Labelle model is uniform except there is consider mass above the lower bound of 4, without this bound the estimate would be uniform from 0-15, with little support for values above 15. The median estimate from the adapted Labelle model is 8.0 days, which is similar to the estimate of the weight stream life of 8.0 days from Labelle and McHugh (2014). Since stream life (*s*) is used to adjust the departure curve (equation 2) and ultimately N_t because $N_t = A_t - D_{t-}$, there is no information to estimate stream life as shown in the flat posterior distribution of s, which also indicates weak identifiability.

I believed it was most straight forward to demonstrate this using example data collected in the Burman River during 2012. For those interested in a more technical understanding and diagnosing parameter redundancy in the Kent University School of Mathematics, Statistics, and Actuarial Science webpage has additional information and references. The second purpose in examining the actual data was to demonstrate that bias occurs from not using stream life and observer efficiency data and rely on the model to estimate these parameters. The analysis in this appendix also suggest that because it is not appropriate to rely on the model to estimate stream life and observer efficiency, WCVI salmon biologists and researchers need to consider more comprehensive analysis of historical data on stream life and observer efficiency if they plan to use these models. In addition, they should pursue for opportunities to continue to collection this information for use of their models to estimate abundance.

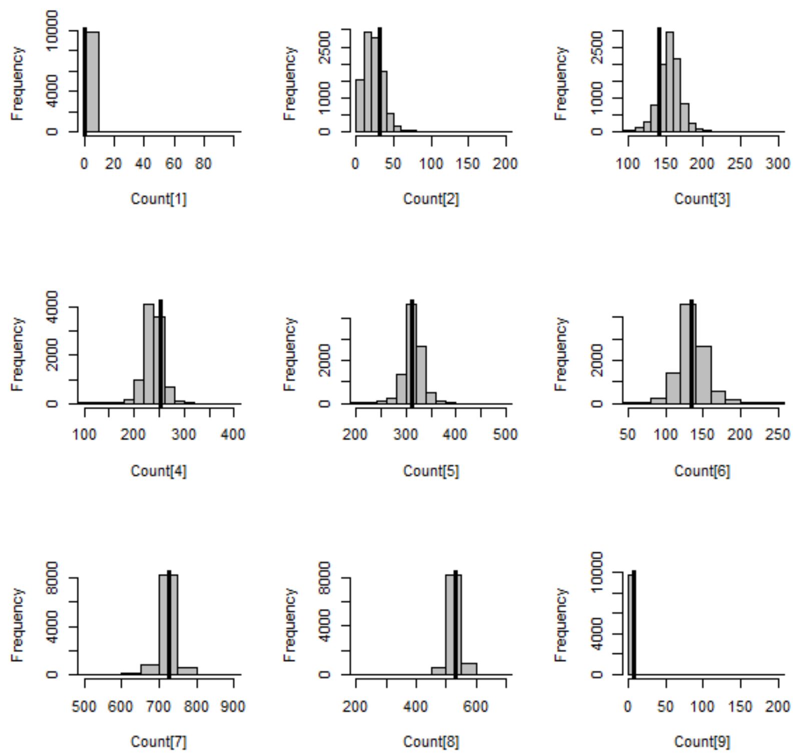

Figure 1. Comparison of estimated Burman Chinook salmon counts (grey histogram) with the observed count (black vertical line) using Hilborn's model, where observer efficiency and stream life are estimated from the radio tagging.

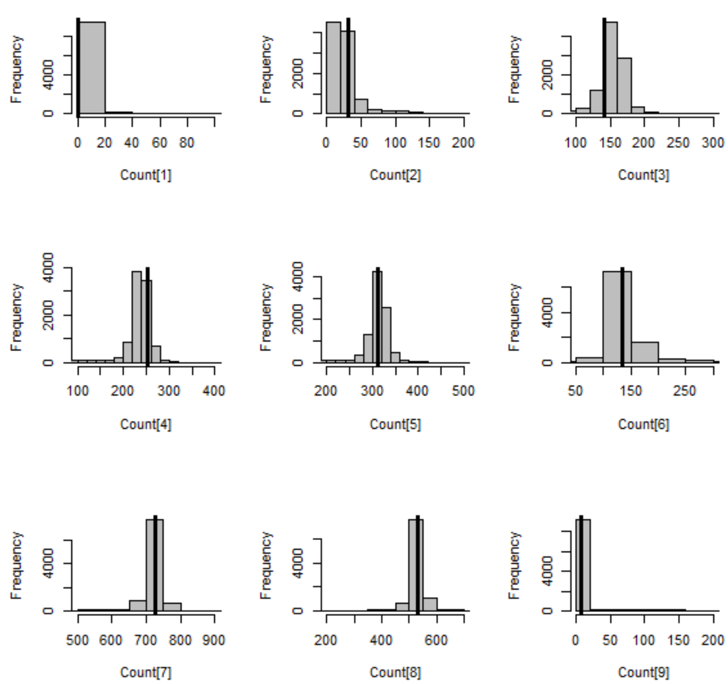

Figure 2. Comparison of estimated Burman Chinook salmon counts (grey histogram) with the observed count (black vertical line) using an adaptation of Labelle's model, where observer efficiency and stream life are estimated from the Chinook count data.

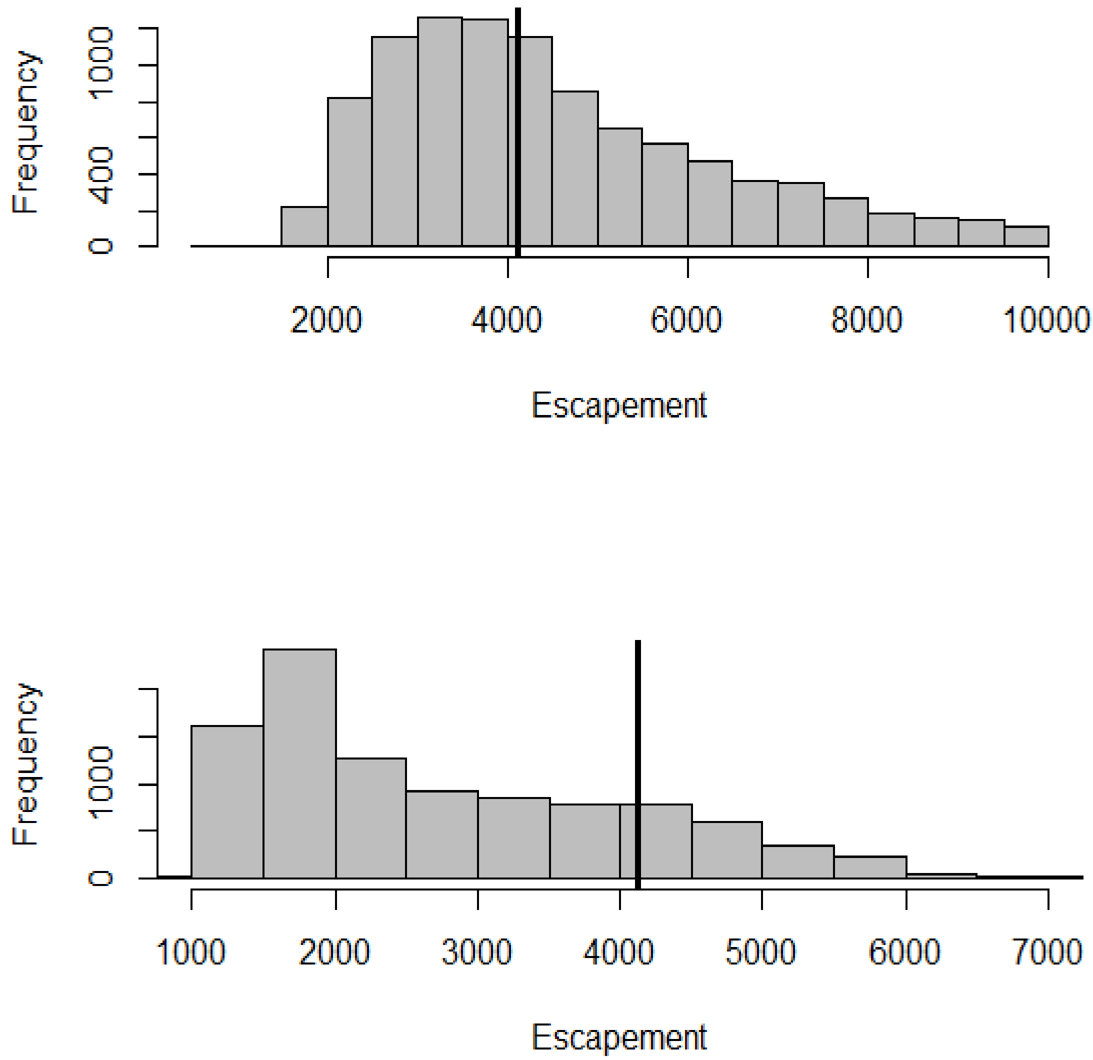

Figure 3. Comparison of Hilborn's (upper panel) and the adapted Labelle model (lower panel) estimates with the known estimate from mark-recapture (black vertical line). The mode in in the lower panels is similar to the escapement estimate of 1579 from Labelle and McHugh (2014).

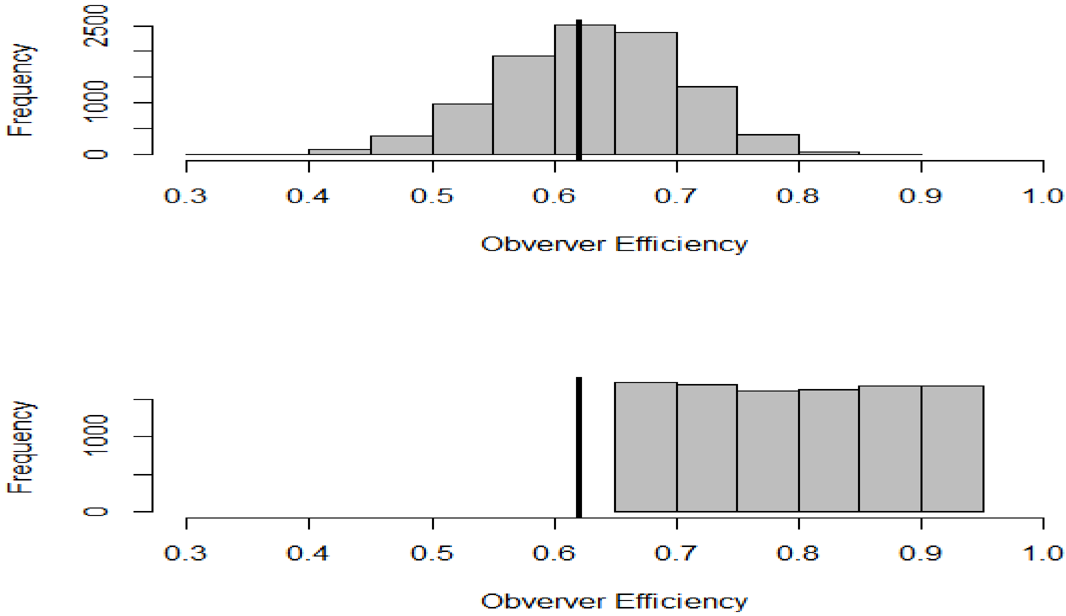

Figure 4. Estimates of observed efficiency from radio tagging data (upper panel), which is used as data in Hilborn's model and those from the adapted Labelle model (lower panel). Black vertical line is the estimate from mark-resight surveys. Note that in the adapted Labelle model the estimate the observer efficiency is uniform over the sample space.

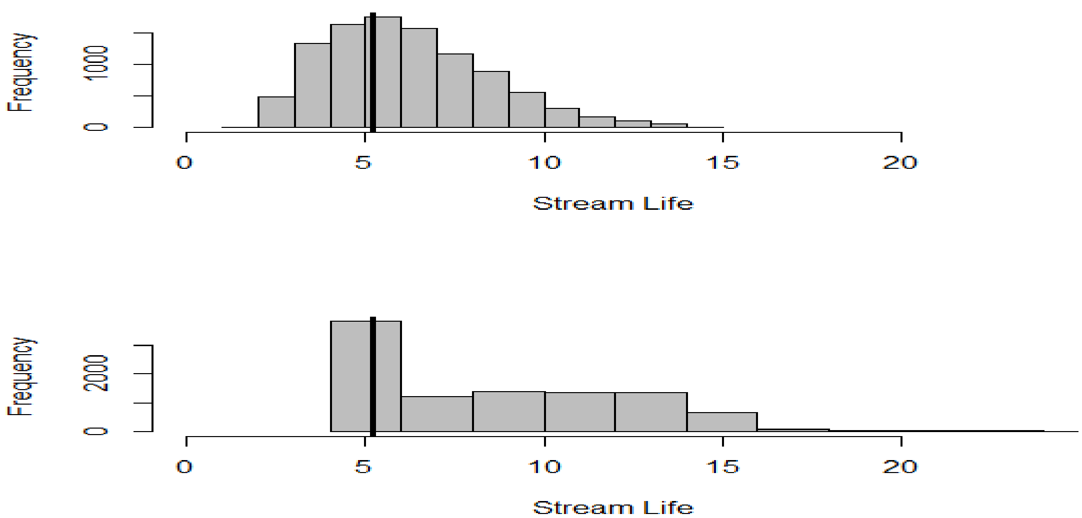

Figure 5. Estimates of stream life from radio tagging data (upper panel), which is used as data in Hilborn's model and those from the adapted Labelle model (lower panel). Black vertical line is the stream life estimate from radio tags. Note that in the adapted Labelle model the estimate the stream life is uniform over the sample space accept above the constraint at 4. Without the constraint if would be distribution would be uniform.

Date: July 4, 2014

Reviewer: Antonio Velez-Espino, Fisheries and Oceans Canada

CSAS Working Paper: 2014-15/SAL01

Working Paper Title: *Labelle, M. and McHugh, D. An Investigation of West Coast Vancouver Island Chinook Salmon Visual Spawning Escapement Estimation Methods. CSAP Working Paper*

Thank you so much for the opportunity to review this paper. I hope the following comments are useful and help the authors to make improvements to this working paper.

A great effort has been placed in this investigation and numerous analyses have been undertaken mostly following high quantitative standards. The authors have undertaken a literature review of escapement estimation methods based on visual surveys and identified some that could be potentially used to estimate escapement of West Coast Vancouver Island (WCVI) Chinook salmon. Among the escapement estimation methods considered, Hilborn et al.'s (1999) method characterized by a maximum-likelihood approach to the area-under-the curve (AUC) conceptual framework was selected for in-depth investigation given its suitability to integrate the data available for Chinook salmon returning to WCVI streams and its ability to incorporate uncertainty in stream life (*s*) and observer efficiency (*v*), both crucial variables for AUC estimation. The authors developed a new formulation of the Hilborn et al.'s (1999) method by characterizing *s* as a Poisson-distributed variable (instead of normally-distributed as in Hilborn et al.) and enabling the representation of two up-migration periods. The latter required the development of a bi-modal version of the model in addition to the standard uni-modal version developed by Hilborn et al. (1999). The two versions of the model (uni-modal and bi-modal) were fitted to stream-year specific survey data and a qualitative model selection was undertaken based on specified criteria. Likelihood ratio tests were also used to assist the model selection process. Lastly, the authors compared the results of their models with those of alternative AUC models, including applications of the Hilborn et al.'s (1999) method, and non-AUC models (e.g., mark-recapture models) applied to specific WCVI Chinook salmon populations. A sensitivity analysis was also undertaken with simulated data attempting to quantify the influence of survey periodicity and observer efficiency on escapement estimates.

I commend the authors for their efforts to explore the potential benefits of alternative methods to improve escapement estimation of WCVI Chinook salmon. However, the present document falls short of meeting the terms of reference specified for this CSAS review or the objectives stated in the Introduction to the paper. In addition, the paper could benefit from a streamlined organizational structure and additional methodological details to improve the readability of the document. There are noticeable limitations with some of the analyses involved and I am concerned that important escapement estimates of WCVI Chinook salmon populations, such as those generated from mark-resight studies in the Marble and mark-recapture studies in the Burman, were not considered for comparison in this investigation. My major criticism is that despite the hard work invested in this working paper, it is not clear at the end what are the main contributions of this investigation to the original problem, presented in the Terms of Reference, of finding (developing) robust and feasible methodologies for WCVI Chinook salmon escapement estimation with the ability to incorporate visual-survey data and determining whether the new approach is expected to produce reliable escapement estimates.

Following I provide comments on key issues, analyses, and interpretation of results. I am also attaching to this review an edited version of the document with my detailed comments, questions and edits, hoping these are helpful.

Objectives Unclear and Inconsistent With ToR

The objectives specified in the ToR are more restricted than those specified in the Introduction of the working paper and they seem to better reflect the content of the paper.

The Terms of Reference (ToR) specify the objective of this review is to evaluate the alternate visual survey escapement estimation methodology and consider information gained from the independent studies and simulation modelling to provide advice respecting the applicability of the new approach for escapement estimation of WCVI Chinook Salmon index stocks.

In addition, the following specific objectives in the ToR are expected to be addressed in this working paper:

1. Evaluate the Maximum Likelihood (ML) model developed to estimate spawning abundance of WCVI Chinook Salmon in index streams using periodic visual survey data, including:
   a. Quantification of uncertainty of the abundance estimates; and,
   b. Identifying sources of bias in the survey and estimation method.
2. Compare performance of the ML approach to the previously used AUC approach and in relation to information gained through the independent studies with respect to accuracy.

The objectives specified in the Introduction of the working paper differ from those in the working paper:

1. identifying scientifically defensible procedures to provide escapement estimates to small stream populations surveyed in recent years,
2. determine the potential benefits of conducting complementary surveys for gains in accuracy and precision, and
3. assess the merits of alternative survey designs to determine total escapements to WCVI conservation units (CUs) given the mixture of monitoring procedures used. The paper addressed the first objective by identifying Hilborn et al.'s (1999) method as suitable escapement estimation methodology for WCVI Chinook salmon and developing a variant of this method that was considered an improvement over the original because it accommodates more than one up-migration period, which is commonly observed in Chinook salmon escapement. However, the authors are uncertain about the reliability of the new approach. The authors also used a sensitivity analysis to address the second objective (but see below). Regarding the third objective, this is barely touched in the Introduction and Discussion but no effort was invested to address the topic of survey design and CUs total escapement.

The closing paragraph of the Introduction indicates this report summarizes work conducted on model selection. However, formal, quantitative model selection was not undertaken in this investigation. The study focuses on one approach: a variant of Hilborn et al. 1999 methodology. The selection of this method was based on qualitative criteria.

The tile of the paper does not accurately reflect its content. A title along the lines of "Investigation of a visual escapement survey and estimation method for West Coast Vancouver Island chinook salmon" would be more appropriate for two main reasons. First, despite the cursory review of suitable escapement estimation procedures in the paper (Section 3), the investigation really focuses on a single method with two versions (uni-modal or bi-modal). Second, the methods reviewed in Section 3 are strictly based on visual surveys. The current title is more inclusive than the actual content of the paper. The evaluation of estimation methods not dependent on visual surveys such as mark-recapture studies, for instance, is not included in the paper.

Thus, the specific objectives specified in the ToR are more in line with the content of the working paper, except that the overall objective of implementing simulation modeling to provide advice respecting the applicability of the new approach is not fully developed in the paper. It is really required to revise and clearly state the objectives of the paper. The content of the paper has to reflect these objectives unambiguously.

Observer Efficiency and Stream Life

Observer efficiency and stream life values available for WCVI Chinook salmon are mostly subjective and hypothetical, based on expert opinion, highly uncertain, and have not been rigorously validated. To address these limitations of the available data, the new approach presented in this paper and based on Hilborn et al.'s (1999) method treats observer efficiency and stream life as model parameters, which can bring other issues such as unknown effects of different error structures and parameter distributions on escapement estimates and the possibility of parameter non-identifiability and redundancy, which is a real concern given that the model is fitted only to count data rarely surpassing 15 data points and usually including less than 10. In the bi-modal version of the model, the number of parameters exceeds the number of data points in some cases. These conditions can lead to overdispersion (a.k.a. variance inflation factor), which produces magnification of parameter errors and skewed confidence intervals. The effect of overdispersion can be reduced by the bounds specified in the model fitting procedure but it is not eliminated. The escapement estimation problem when using AUC-based methods does not disappear by making these two variables model parameters and it will remain an issue as long as the values of these two variables and their temporal and spatial variation remain uncertain and/or not validated with empirical data. This is one reason why recommendations were made in the June 2013 CSAS review to implement simulations to quantify the effect that uncertainty in these variables have on precision and accuracy of escapement estimates. It is expected that the magnitude of error in these variables can have different influence on escapement estimation depending on the method used to estimate escapement. It is important to consider that the sensitivity of escapement estimates to uncertainty in model variables and parameters is expected to differ between methods. Some modeling approaches would be more resilient to uncertainty in specific variables than others. This kind of knowledge would be very valuable to guide improvements in WCVI Chinook escapement estimation. In the absence of fence counts or robust mark-recapture escapement estimation, simulations have the potential to quantify the effects of observation error embedded in variables s and v as well as process error derived from different methods on the accuracy and precision of escapement estimates.

Simulations and Sensitivity Analysis

The sensitivity analysis presented in the working paper is a good start to the topic of simulation development for model performance evaluation. However, the process implemented in the working paper has limited capabilities and is not truly stochastic in nature. At the end, this sensitivity analysis provided little benefits to this investigation for it leaves unanswered the question of how good the new method is relative to alternative methods based on visual-survey data. However, the sensitivity analysis provides some insight into the relationship between escapement relative error and factors such as survey periodicity and escapement magnitude for both uni-modal and bi-modal versions of the model, with the latter requiring more surveys for comparable levels of accuracy. The simulation exercise does not address the issue of precision. In addition, it is not clear in the report how the 10 “scenarios” in tables 3-6 were generated. Simulation-estimation results are called “scenarios” in tables 3-6. It is not clear whether each one of these scenarios is the result of single and independent simulation-estimation runs. If so, it is necessary to explain in the text. In my view, each of the combinations of conditions (the attributes in the first column) can be properly referred to as scenarios; each of the 10 estimates is not really a scenario but rather a model run using specific input data. One related question that comes to mind is why the authors did not use bootstrapping to integrate the results of multiple runs and produce confidence intervals as part of escapement estimates? More details are needed in this and other sections of the Methods.

The sensitivity of escapement estimates to changes in observer efficiency and stream life was based on what the authors describe as “realistic conditions” which seem to be in large part based on highly uncertain and not-validated (e.g., expert opinion) available data. As a result, their sensitivity analysis provides limited insights into the effects of potentially wider parameter ranges on escapement estimation, including a limited response of the accuracy and precision of escapement estimates to potentially existing conditions (for instance their range for observer efficiency is 0.75-0.85 and 0.85-0.95) and survey designs. Given the variability in relevant environmental and local attributes of WCVI streams such as turbidity and flow conditions, the ranges used most likely missed important regions of the spectrum for these variables. This is also supported by the wider range of observer-efficiency values from the Tranquil and Marble rivers shown in Figure 9 of the paper. Albeit, the authors recognize “there is substantial spatio-temporal variation in escapement patterns and survey conditions when WCVI chinook stocks are spawning in small coastal streams”. Their restricted sensitivity analysis and the absence of a fully-stochastic process in their simulations prevented the authors from providing solid recommendations on optimum survey designs over a range of environmental conditions (and their interaction with observer efficiency) necessary to support escapement estimates of desirable accuracy and precision.

Another problem of visual surveys not always discussed is that observer efficiency can be more than 100% in cases when counts take place for large fish aggregations in pools where individual fish can be counted more than once and therefore overestimate the number of fish. The authors identified this issue in Section 2 of the working paper but did not consider it in their sensitivity analysis.

Methods Require More Detail and A Better Organizational Structure

An outline of the Methods would be very helpful. The use of different data subsets and the assumptions involved in different steps of the methodology make it really challenging to track the Methods sections in the working paper. Currently, there are many information gaps in the description of the Methods. The corresponding sections of the paper would benefit from additional detail. A good example of this is the development of the MS Excel Add-in software used for function minimization, which remains a mystery in the paper. There is no clarification of whether this is an Excel macro, a commercial add-in or something else. This is not a trivial oversight since the last sentence of the Introduction states that “efforts were made to produce a software application based on this escapement estimation model, and use it for evaluation and testing purposes”. In addition, the description of how this software incorporates survey records in the likelihood function, how the bounds and constraints are specified using what the authors call a “user friendly interface table”, how the minimization function is done, and how convergence problems were solved is highly minimalistic. It would be really challenging for a researcher to replicate the analyses presented in the working paper based on the information provided in the Methods.

I have added numerous comments in my edited version of the paper in places that require clarification or additional detail.

Currently, the data subsets used for the various analyses in the methodology are reported in the Results sections. It is also very confusing to track the data sources for each of the analyses. Section 2 (Datasets and Sources) in the working paper is very generic and it does not help understand many of the choices for data subsets in different steps of the methodology. For instance, tables 10-11 present parameter estimates and derived variables for a “randomly chosen subset of WCVI populations by year". There is no explanation of why a subset was needed or how the random selection was implemented. Additional details on data sources for each of the analyses are required. A table seems like a minimum requirement to show the links between data sources, subsets and analyses (and assumptions?). This information should be introduced in the Methods rather than in the Results.

A Weak Discussion and Uninformative Conclusions

The Discussion is currently a weak section of the working paper, addressing general topics and not really emphasizing the main conclusions of the study. Partly due to its not-well defined objectives, the Discussion does not accomplish its role of connecting back to the objectives of the study and providing recommendations based on the new knowledge acquired in this exercise. Some of the main questions around this investigation that could have been addressed in the Discussion are:

How the new method compares in terms of the accuracy and precision of estimates to the traditional trapezoidal AUC?

Is this model variant a better solution to escapement estimation for WCVI Chinook than the original model from Hilborn et al. (1999)?

How often the bi-modal version of the new model is expected to provide better escapement estimates than the uni-modal version?

How biased (if any) can the uni-modal version be in the presence of more than one up-migration pulse?

Under which conditions different methods are appropriate or comparable escapement estimators?

What are the optimum combinations of escapement estimator and number and frequency of surveys under specific environmental conditions and Chinook salmon average run size or for specific streams?

What are the next steps? For instance, how can some of the shortcomings of the study could be addressed in the future, such as developing fully-stochastic simulations and enabling sampling at different rates and error structures, automating the model selection, structuring and formalizing comparisons with non-AUC and potentially more robust escapement estimators (such as mark-recapture experiments), and documenting the characteristics of the software used for function minimization, escapement estimation and model evaluation.

In spite of the numerous analyses and evident hard work behind this investigation, the main conclusions of the study are not very useful for decision making and the main contributions of the investigation remain highly elusive.

Even after consideration of the nature of working papers, I was mystified by the authors conclusion that "Reliance on examination of survey counts or comparisons with crude mark-recapture estimates is not sufficient for evaluation purposes, so the reliability of estimates obtained with this procedure will remain largely a matter of conjecture with no alternative but to gage its benefits using numerical simulation results and ancillary data." This sentence implies that there are no reliable mark-recapture estimates available for evaluation of accuracy of the present model. This is not necessarily true for there are reliable and robust escapement estimates (e.g., Burman and perhaps Kaouk) as well as reliable mark-resight estimates (e.g., Marble) that could serve to evaluate the accuracy and precision and identify critical sources of uncertainty in the application of the new method. In addition, the above sentence suggests the reliability of the estimates generated with the new method is unknown and that the evaluation of its potential would rely on simulations and ancillary data. I see this as problematic and confusing for it is specified in the in the ToR that simulation modelling was going to be used to evaluate the new approach. However, the need for simulations is emphasized in the above sentence in the Discussion of the working paper. A question that comes to mind is whether this investigation was really needed to reach the abovementioned conclusion.

The conclusion that “The simulation results indicate that [on average] relatively unbiased estimates can be obtained under some conditions when the underlying assumptions are met” is not well supported by the study. What are the bases to support this conclusion? It remains a question how estimate accuracy would respond to observer efficiency levels lower than those used in this study. It is likely that observer efficiency levels in the sensitivity analysis are biased high. In addition, the paper fails to categorically identify under which conditions their model is expected to produce unbiased estimates of escapement.

Recommendations

A clear definition of the objectives of the working paper is required. If the only purpose of the working paper is to develop a variant of Hilborn et al.’s (1999) model and compare its escapement estimates with available estimates derived from the trapezoidal-AUC method, this has to be unambiguously stated.

If the working paper is going to include escapement estimation comparisons with other non-AUC based estimates, the comparison should be more inclusive and incorporate relevant escapement estimates derived from mark-recapture studies in the Burman and mark-resight studies in the Marble, just to mention some that were ignored in the present study.

The cursory review of escapement procedures in Section 3 of the working paper could be condensed and included in the Introduction, helping describe the reasons why Hilborn et al.’s (1999) method was considered suitable for estimation of WCVI Chinook salmon escapement over other available methodologies. Based on the content of the working paper, I don’t think one of the primary objectives is to document existing available procedures and therefore dedicating a section to this topic seems out of scope. The ToR do not include this as an objective either. Again, the problem branches from an unclear definition of objectives.

A major re-structure of the paper is required to portray with clarity the analytical components of the methodology. Given the various analyses and their use of different data subsets, I suggest including an outline of the methodology describing the steps involved in the study, a brief reference to the datasets used in each step, and the rationale behind each step. This can be placed at the end of the Introduction, right after the objectives. This would help readers to understand the structure of the Methods and put in perspective the sequence of analyses devised by the authors to address the objectives.

A formal simulation and evaluation of alternative methods is still required. The restricted sensitivity analysis undertaken in the working paper was not a true simulation with the ability to generate data of known attributes, sample at various rates and under different conditions, and therefore evaluate the accuracy and precision of alternative escapement estimators in the presence of errors (i.e., bias) of different magnitude in observer efficiency and stream life. In the absence of perfect information, a simulation exercise with these characteristics could be very useful.

The authors mention that “the model selection has not been automated yet” but do not mention what is the direction they plan to take on this regard. A formal quantitative model-selection process is required to compare the various AUC models. It also remains a mystery to me how the authors were able to implement likelihood-ratio tests but not AIC for model selection.

Relevant escapement estimates generated through mark-recapture and mark-resight studies were not considered for comparison between model-based estimates. There are reliable estimates for Burman for 2009-13. Also, Table 13 indicates that mark-resight estimates for 2012 were not included because the estimate was unrealistic or unreliable. The mark-resight estimate from the best model in 2012 for Marble was 1634 with 95% CIs of 1444-1934, comparable to the other escapement estimates reported in this table for this stream and year.

The study of functional relationships between observer efficiency and visibility-discharge seems promising to constrain potentially large errors in observer efficiency derived from expert opinion only. A formal analysis of these relationships is still required. AIC and the analysis of residuals could be considered for the purpose of identifying the best functional model to describe the relationship between these two variables.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat
Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Investigation of Chinook escapement survey and estimation methods for WCVI streams

July 8, 2014
Pacific Biological Station, Nanaimo, British Columbia

Chair: Lesley MacDougall

Time	Subject	Presenter
09:00	• Introductions • Review Agenda & Housekeeping • CSAS Overview and Procedures • Review Terms of Reference	Lesley MacDougall
09:20	Review of Context and Scope	Lesley MacDougall
09:30	Presentation of Working Paper	Marc Labelle / Diana McHugh
10:30	***Break***	
10:45	Reviewer Presentation and Authors Response	Dan Rawding
11:15	Reviewer Presentation and Authors Response	Antonio Velez-Espino
12:00	***Lunch Break***	
13:00	Group Consensus Building: 1. Are the assessment methods adequately developed and documented? 2. Does the assessment method adequately address uncertainty in the data, analysis or process? 3. Does the paper meet the objectives in the Terms of Reference? 4. Decision on acceptability of working paper.	RPR Participants
13:30	Science Advisory Report (SAR): Develop consensus on • Assessment & Uncertainties • Key findings & conclusions	RPR Participants
14:30	***Break***	
14:45	Science Advisory Report (SAR): Develop consensus on • Recommendations for Working Paper revisions • Recommendations for future work	RPR Participants
15:30	Draft SAR	RPR Participants
16:30	***Adjourn***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Baillie	Steve	DFO Science
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Dunlop	Roger	Nuu chah nulth Tribal Council
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