Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2020/027

Pacific Region

Proceedings of the Pacific regional peer review of the Evaluation of Management Procedures for Pacific Herring (*Clupea pallasii*) in the Strait of Georgia and the West Coast of Vancouver Island Management Areas of British Columbia

July 25-26, 2018
Nanaimo, British Columbia

Chairperson: Bruce A. Patten
Editor: Brooke Davis

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

December 2020

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280

Correct citation for this publication:

DFO. 2020. Proceedings of the Pacific regional peer review of the Evaluation of Management Procedures for Pacific Herring (*Clupea pallasii*) in the Strait of Georgia and the West Coast of Vancouver Island Management Areas of British Columbia; July 25-26, 2018. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2020/027.

Aussi disponible en français :

*MPO. 2020. Compte rendu de l’examen par les pairs de la région du Pacifique sur l’évaluation des procédures de gestion du hareng du Pacifique (*Clupea pallasii*) dans le détroit de Georgie et sur la côte ouest de l’île de Vancouver dans les zones de gestion de la Colombie-Britannique; du 25 au 26 juillet 2018. Secr. can. de consult. sci. du MPO, Compte rendu 2020/027.*

TABLE OF CONTENTS

SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of July 25-26, 2018 at the Pacific Biological Station in Nanaimo, B.C. A working paper evaluating the performance of management procedures for British Columbia Pacific Herring was presented for peer review

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science and Fisheries and Aquatic Management Sectors staff; and external participants from First Nations organizations, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia.

This paper focuses on the simulation testing of management procedures for two of the five stock management areas of Pacific Herring in BC; West Coast of Vancouver Island (WCVI) and Strait of Georgia (SOG). This work is part of a larger MSE process that has included the previous development of a population dynamics operating model for Pacific Herring in BC, consultation with stakeholders to develop objectives, and finally, the testing of plausible management procedures, and their ability to reach conservation and management objectives. Three alternative operating models were used that represent alternative hypotheses describing stock-specific rates of natural mortality (*M*) over time. Candidate management procedures were run through each operating model, and performance measures (to measure performance against objectives) were reported. For the SOG stocks, all MPs were able to meet the main conservation objective with at least 75% probability, while other objectives were not always met in all scenarios. For the WCVI the conservation objective was not met in all cases with at least 75% probability. MPs that included catch caps were found to better maintain spawning biomass and limit the impact of assessment errors. Despite the current operating model being found suitable for simulation testing candidate management procedures, a number of key uncertainties remain, some of which will be explored in future iterations of this MSE process.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to Fisheries Management to inform herring fishery planning and subsequent management strategy evaluation activities.

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

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on July 25-26, 2018 at the Pacific Biological Station in Nanaimo to review the performance of management procedures for West Coast Vancouver Island (WCVI) and Strait of Georgia (SOG) Herring populations, which were simulation-tested using a management strategy evaluation (MSE) approach.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Fisheries Management. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations, the commercial fishing sector, non-governmental organizations and academia.

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

> Performance of management procedures for British Columbia Pacific Herring (*Clupea pallasii*) in the presence of model uncertainty: closing the gap between precautionary fisheries theory and practice by Benson, A.J., Cleary, J.S., Cox, S.P., Johnson, S., Grinnell, M.H. CSAS Working Paper 2015PEL02.

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 papers, and written reviews.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteur for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by 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, 43 people participated in the RPR (Appendix D). Brooke Davis was identified as the Rapporteur for the meeting.

Participants were informed that Trevor Branch and Paul Regular 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.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to Fisheries Management to inform herring fishery planning for the above-noted stocks. The Science Advisory Report (SAR) and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

PRESENTATION OF WORKING PAPER

Jaclyn Cleary gave a presentation which included some background information on the history of the Herring MSE process, the motivation for the current work, and a brief overview of the work undertaken. Sean Cox gave a second presentation which included additional description of the MSE process, and an in-depth description of the analysis undertaken. After each presentation, the chair gave participants the chance to ask clarifying questions.

PRESENTATION OF WRITTEN REVIEW(S)

TREVOR BRANCH

Trevor Branch provided a written review (Appendix E) in advance and presented a summary of this written review at the meeting.

PAUL REGULAR

Paul Regular provided a written review (Appendix E) in advance and presented a summary of this written review at the meeting.

GENERAL DISCUSSION

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

Choices of Objectives/Reference Points

A question was posed about how the probabilities associated with the biomass objectives were selected. For the Limit Reference Point (LRP) the probabilities of 75-95% were chosen based on the definition of “high probability” given in the Precautionary Approach (PA) framework (DFO), 2009. The reason for giving a range, rather than a single value, is because the attainable level of certainty for a given stock will depend on the inherent level of variability the stock exhibits. Giving a range allows managers to interpret results with this in mind. For the Upper Stock Reference (USR) point there isn’t currently a guiding policy, so values for SOG were chosen somewhat arbitrarily, whereas probabilities for WCVI were chosen in consultation with the Nuu-chah-nulth First Nation.

The choice of USR was questioned, and some participants felt that of the three candidates for USR, $0.6B_0$ received too much focus, and should have been considered equally to the other presented USRs. The authors justified using $0.6B_0$ in that it was a convenient choice, as it was twice the LRP. The authors also explained that there were four USRs calculated in last year’s stock assessment, but they chose not to present B_0, as the other three seemed to be sufficiently high. Another participant felt strongly that $0.4B_0$ should have been considered for the USR. The authors agreed to add this value to result tables in the Research Document. This discussion resulted in a slight change in the categorization of objectives, with the LRP objective being described as a “conservation objective” and the three USR objectives now being described as “biomass objectives”. These changes will be reflected in the Research Document and SAR.

Some participants felt that yield objectives did not receive enough focus- in the working paper. The authors agreed to include more discussion of the trade-offs between biomass and yield that occur once a population is above the LRP in the Research Document.

Choice of Management Procedures

The authors were questioned on why harvest rates below 10% were not considered, given that for WCVI, and the constant mortality model, no management procedure was able to reach 75% probability of being above the LRP. Other participants suggested that exploring the trade-offs between setting lower harvest rates, and imposing catch caps would have been an informative exercise. The authors stated that they weren't necessarily "chasing" a 75% value, since it would be up to fisheries managers to decide what would be considered an acceptably high probability. It was also brought up that the goal of the process was not to find the optimal management procedure, but rather to assess the utility of the current one. The authors also stated that they couldn't start to explore better harvest control rules (HCR) until more clear guidance was received from stakeholders as far as the hierarchy of objectives. Until this consultation takes place, the authors chose to prioritize the conservation objectives laid out in the PA policy, without focusing on a specific probability (although 75% was used as a convenient cut-off).

Trend criterion were suggested as a possible basis for HCRs. The authors explained that they chose target-based reference points because they are more straight-forward, and require fewer choices to be made in terms of the time-frame to consider and levels of significance to use as cut-offs. The authors described an alternative "slow-up" management procedure that they had developed as an alternative that doesn't just use hard targets. It was debated whether this should be included in the Research Document, and decided that if the group couldn't see these results during the meeting, it should not be in the Research Document. Additionally, it was re-enforced that the goal of the process was not to find an optimal HCR for these stocks, but rather to test the effectiveness and risks associated with the current management approach. It was agreed that some wording should be added to the Research Document to indicate the scope of the current work does not include finding the "best" management procedure. It was also agreed that alternative management procedures that include a "slow-up" or trend approach be flagged as a recommendation for future work.

Modelling Fisheries

A participant expressed concern that the current simulation model does not represent spawn on kelp (SOK) fisheries well. The authors explained that in this iteration of the modelling process, they had added fleet dynamics to reflect the three main gear types, and decided to leave SOK fisheries out because there weren't specific objectives related to this type of harvest, and they were unsure on how to approach the issue from the current, aggregated, scale. The authors expressed that mortality associated with SOK fisheries is still not fully understood, and that it had been flagged as a topic for future work. They hoped that future iterations of the model would include characteristics of different types of fleets including timing of the fishery, and what type of harvest (SOK or other) was being simulated. This topic was flagged as one to be added to the SAR as a recommendation for future work.

A clarifying question was asked about the 135 tons allocated yearly to Food, Social, and Ceremonial (FSC) fisheries for WCVI. The authors explained that this is the current allocation in the Integrated Fisheries Management Plan, and this will be clarified in the Research Document. It was also pointed out that this value might actually over-estimate catch, since abundances have been too low in recent years to allow for fishing opportunities.

Density-Dependent (Depensatory) Procedure

Following comments from Trevor Branch's review, the authors decided to change the name of the "density dependent" procedure to "depensatory" as it provides a clearer description of the ecological phenomena being imposed on the population at low abundance. A participant questioned how the choice was made for depensation to be simulated as a 150% spike in mortality in 6% of years, when the population is below the LRP. The authors revealed that these levels were chosen based on an informal analysis where time-varying mortality was estimated and it was observed that spikes in mortality occurred in about 6% of the years, and generally increased mortality by about 50%.The choice to enforce this additional depensatory mortality below the LRP (rather than at some other level) was chosen to give the LRP some ecological importance.

A suggestion was made to fit a density-dependent relationship between biomass and mortality, but the authors replied that it is very hard to separate natural mortality and biomass fluctuations, and therefore hard to identify a functional relationship between the two. It was also indicated that the current assessment model being used limits the breadth of scenarios that can be run, especially since relationships between co-varying parameters (like biomass and mortality) may just be an artifact of the assessment model structure.

It was pointed out that the Terms of Reference (TOR) focus on effectiveness of LRPs and the current management procedure, not the complicated relationship between biomass and mortality. However, there seemed to be concern that the paper might not adequately assess risks associated with management procedures if the depensatory scenario wasn't close enough to being a "worst case scenario". The authors insisted that the most important factor in whether a management procedure reached objectives was the harvest rate, and the modelled depensatory effect had only a small effect, and that they were confident it wouldn't change outcomes very much even if made much more "severe" (higher mortality, more often).

In response to this discussion the authors re-ran simulations with a more severe version of the depensatory scenario, where spikes in natural mortality occurred in 75% of years (instead of 6%) where the population abundance dipped below the LRP, and these pulses were twice the average natural mortality (instead of 1.5-times). They presented the results during the second day of the meeting. The results showed that this change does not cause additional failures in the LRP objective, but did reduce the probability of staying above the LRP by about 2%. This showed that depensatory effects at small population sizes are not that important to stock dynamics, and the primary difference between the two model scenarios is due to differences in natural mortality caused by using more recent mortality values (for the time-varying mortality model) versus using historical mortality values (constant mortality model).

Choice of Operating Models

The choice to not use the AM1 model (a model using estimated survey catchability, q, rather than q=1) as a candidate operating model was brought up several times in discussion. Some participants felt strongly that it should have been included. Concerns were mainly based around the validity of the assumption that q=1, and whether the uncertainty in q was properly captured. The authors described how the model with estimated q was not able to estimate q, and would generally just return the model prior given for q back as the posterior. Such model behaviour indicates that there isn't enough information in the data to guide the model in estimating that particular parameter. They viewed the decision to set q=1 as being conservative, since the model then uses the survey value as the "minimum biomass" rather than estimating how much larger the biomass might be. They also justified this choice because the fixed-q model (AM2) is the current model used for management, and the TOR is mainly concerned with testing the current management approach. Adding the AM1 model as an operating model would have "opened the floodgates" to numerous model formulations that the data simply cannot support.

After some discussion a consensus was reached that the root of the problem is actually the model's inability to track changes in survey quality over time. There was discussion about the possibility of measuring survey uncertainty outside of the model, but this work has no yet been done. The fact that the model cannot track changes in the survey over time was decided to be flagged as a key uncertainty, rather than including AM1 as an additional operating model. Additionally, it was decided that the discussion of the AM1 model was unnecessary in the working paper, and that it will be omitted from the Research Document, to be replaced with discussion of uncertainties associated with the survey.

Some concern was expressed about the formulation of the forward simulations associated with the time-varying mortality model. Going forward, the model initiates a random walk for natural mortality, but restricts the model to always end up at the mean value for natural mortality. This results in less variability in mortality, compared to a random walk that is initiated, and allowed to “wander off” to any value. There was some concern that this was overly optimistic – given that it increases the model certainty in mortality, and also restrains the model from ever-increasing mortality values. The authors explained that their motivation for this choice was the assumption that the future would behave similar to the recent past, and they didn’t want the model to wander off towards unrealistic values of natural mortality.

The choice to use a spline (data smoothing) approach to estimate time-varying mortality in the assessment model, but not in projections was questioned. The authors clarified that they did not want future mortality fluctuations to be smooth, since they aren’t in real life. The smoothing tool is one used for data analysis only, and it wouldn’t make sense to simulate data and then smooth it.

A participant enquired about whether changes in weight-at-age had been considered. The authors said that there had been some previous work looking at changes in growth, but they found that the effect of these changes were small when compared to the effects of natural mortality. The authors stated that they were confident that changes in weight-at-age wouldn’t affect the assessment model enough to affect the outcomes of the tested management procedures.

A participant enquired about whether the effect of changes in age structure would be reflected in the operating model, and whether the generation time would still be accurate. They were concerned that different management procedures could affect the age structure of the population (for example, if there is no fishing, fish will survive to older ages). The authors explained that since the model is age-structured, these sorts of effects would show up in the model. Since generation time depends on age at maturity and natural mortality rates, it would only be altered by a change in age structure if there was a developmental response to fishing or abundance, which changed maturity or mortality rates.

Accounting for the Spatial Structure of Populations

The fact that objectives, assessments, and management procedures can act at different scales, presents a challenge for this MSE process. There was discussion about whether TOR Objective 4, to evaluate a proxy to address spatially explicit objectives that utilizes records of Pacific Herring spawn, had been addressed in the model. The authors described their decision to not include an explicit proxy for this, rather to include information on the spatial structure in appendix A of the working paper. In a separate simulation analysis they found that complex interactions between population and fleet dynamics made it impossible to apply a simple proxy. They concluded that a more complex operating model would likely be required to address the issue. A participant suggested that the authors describe other studies that have found that more conservative HCRs are required when trying to meet finer-scale objectives with a coarser-scale analysis. The authors expressed the idea that precautionary management doesn’t just hinge on a HCR chosen in a single MSE iteration – it is a framework to be used to test possible population scenarios and management procedures. The authors also stated that the reality of Herring management isn't as simple as choosing a HCR tested in an MSE, there are in-season and finer-scale decisions made to protect finer spatial scale objectives. The authors recognized that the current model is a simplification of reality, but that there is still value in continuing the MSE process iteratively, until more realistic simulations can be developed. A spatial operating model was identified as an important area of research going forward.

Stratified Random Sampling of the Posterior

Trevor Branch's review questioned the choice to perform stratified random sampling of the joint posteriors of initial mortality (M_0) and unfished biomass (B_0) rather than a straightforward random sample, as is commonly done when carrying out a Bayesian analysis. The authors explained that due to computational limitations, they were limited by the number of replicate draws they were able to take when running Markov chain Monte Carlo (MCMC) sampling. They found that due to this limitation, results were sensitive to the starting seed for each simulation. They found that this stratified sampling (also called "Latin hypercube" sampling) reduced this sensitivity by ensuring that the full range of the posterior is sampled. This approach also ensures that the whole range of variability found in these variables is projected forward. Suggestions were made to provide a citation to add credibility to the method, but the authors weren't able to find a relevant publication where the method was used. It was also suggested to increase the number of simulations used for the final model runs to be presented in the Research Document, pointing out that this "work-around" methods seems like one that should be used in model development only, not for final results. It was agreed that additional wording would be added to the Research Document to justify the choice of this approach. Exploring the effect of this approach on model outcomes was flagged as a possible topic of future work.

Coefficient of Variation Used in Forward Simulations

It was argued by Trevor Branch that the coefficient of variation (CV) used to simulate uncertainty in the survey (which determines biomass) is different depending on the operating model used. Since the time-varying mortality model estimates a lower CV around the survey values, the simulation model going forward will have more "confidence" in given survey values. The argument against this formulation was that the CV of the survey is something inherent in the survey design and annual variability in fish location, and should not be different just because a different operating model was used. If the CV of the survey was known, this value would be the best option, but unfortunately that value is unknown at this point. Some participants argued that the differences in survey CV caused the two alternate projections to not be comparable. Where others believed that each OM should be viewed as an alternate hypothesis, and that this hypothesis needed to be implemented in both the past and future to retain consistency.

In response to this discussion the authors ran some additional simulations for WCVI where the survey CV used in the forward simulation for the time-varying mortality model used a higher CV than estimated. This scenario was examined for depensatory mortality and density-independent mortality. The results were presented during the second day of the meeting. Increasing the survey CV led to a higher probability of meeting the conservation objective for the depensatory scenario and no change for the density-independent scenario under the tested MPs. It was agreed that some discussion of which survey index should be used in forward simulations, and the associated sensitivities in the model, should be included in the Research Document.

Lack of Model Fit

Poor model fit to WCVI data from 1969-1975 and 1986-1990 for the constant mortality model was pointed out by a Trevor Branch. The authors explained that catch was increasing rapidly during both of these periods, so the model needs to drastically increase abundance in order to reconcile the high catches, without decreasing natural mortality (which is held constant in this model). Trevor Branch expressed some concern that the model doesn't lower its estimated recruitment in order to match better with the recruitment data points. It was recognized that the variance around recruitment is estimated at 0.88, which seems like it would be a value that would allow for enough variability in recruitment to allow better fit to data. Inability for the given models to fit could also be attributed to the fact that this modelled population is actually an aggregate of several smaller stocks, functioning at distinct spatial scales. Peaks in catch/abundance could be due to a single stock having one or a few large recruitment events, for example the Vargas stock shows up and disappears when stocks are looked at separately. More work may need to be done on stock-recruitment analysis for this stock to get at the root cause of this lack of fit. It was flagged as a consideration for future iterations of the MSE process.

CONCLUSIONS

The participants' consensus was that the paper should be accepted with revisions. Although the paper could not address all of the objectives presented in the TOR, it provides an important piece of the research. The authors were able to create a model that produces reasonable outcomes, and were able to test the effectiveness of management procedures that closely mimic those currently in place. Although an exhaustive set of operating models, scenarios, and candidate harvest control rules was not tested, the work carried out will be informative for Herring fisheries management. Management strategy evaluation is an iterative framework towards sustainable fisheries management, and the process will continue to move forward and evolve following the publication of this working paper as a Research Document.

RECOMMENDATIONS & ADVICE

- The Pacific Herring operating model (DFO 2015) is suitable for simulating realistic data derived from alternative hypotheses about stock and fishery dynamics for WCVI and SOG Pacific Herring.
- For Pacific Herring, key uncertainties include: historical and future trends in natural mortality, steepness of the stock-recruitment (SR) relationship and SR functional form, potential changes in survey coverage and sampling, an unknown relationship between herring biomass and spawn survey index (estimated by the parameter *q*), and uncertainty in spatial population dynamics. The three operating model scenarios presented in the working paper only differed structurally in assumptions about natural mortality, and use operating models based on an assumption that there is a direct linear relationship between the spawn survey index and spawning biomass, i.e., q=1 (Assessment Model 2, DFO 2016). This assumption (q=1) reflects the parameterization of the stock assessment model implemented by Fisheries Management for quota decisions since 2015.
- The sensitivity of WCVI results to future trends in natural mortality suggests additional management procedure (MP) modifications may be required such as criteria that the spawning stock is increasing above the cut-off prior to resuming harvest, i.e., a slow-up MP.
- For Pacific Herring, MPs that implement reductions in harvest rates and application of catch caps can mitigate against positive biases in the assessment model, reducing the risk of overharvesting. This finding is applicable to all BC Pacific Herring stocks. However, differences in future trends in abundance presented for WCVI and SOG show the importance of undertaking stock-specific selection of objectives and evaluation of MPs via

simulation. Future MSE cycles are likely to result in area-specific MP design. This contrasts with the historical practice of applying the same MP design to all areas.

- As MSE processes tend to be iterative, several suggestions were made as to what changes to the operating model, management procedures, and performance measures could be made in future iterations. Some of these examples include:
  - Including climate-change scenarios into operating models.
  - Further exploration of the time-varying catchability model (AM1) either using alternative data to inform changes in catchability (q), or testing scenarios that include changes in the value and/or uncertainty of q over time.
  - Including spawn-on-kelp fisheries explicitly in the model.
  - Testing the effects of stratified random sampling of posterior distributions, versus just random sampling.
  - Using juvenile data to validate estimates of mortality, or to help estimate recruitment.
  - Incorporating other ecosystem objectives into the MSE process, such as using predator biomass to explain changes in natural mortality.
  - Looking at finer-scale objectives to help with the planning of individual fisheries.

ACKNOWLEDGEMENTS

We thank Trevor Branch and Paul Regular for sharing their time and expertise in reviewing the working paper, and all of the participants for their constructive engagement in the RPR process. We thank Lisa Christensen and Ann Mariscak for providing CSAS meeting support.

REFERENCES CITED

DFO. 2015. Candidate Limit Reference Points as a basis for choosing among alternative Harvest Control Rules for Pacific Herring (*Clupea pallasii*) in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/062.

DFO. 2016. Stock Assessment and Management Advice for BC Pacific Herring: 2016 Status and 2017 Forecast. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/052.

APPENDIX A: TERMS OF REFERENCE

Evaluation of Management Procedures for Pacific Herring (*Clupea pallasii*) in the Strait of Georgia and the West Coast of Vancouver Island Management Areas of British Columbia

Regional Peer Review Process – Pacific Region

July 25-26, 2018
Nanaimo, BC

Chairperson: Bruce Patten

Context

Fisheries and Oceans Canada (DFO) has committed to renewing the current management framework to address a range of challenges facing Pacific Herring stocks and fisheries in British Columbia. Renewal of the management framework includes conducting a Management Strategy Evaluation (MSE) process to evaluate the performance of candidate management procedures against a range of hypotheses about uncertain stock and fishery dynamics. The purpose of the evaluation is to identify management procedures (combination of data, assessment method and harvest control rule) that provide acceptable outcomes related to conservation and fishery management objectives. Selection of a preferred management procedure for a DFO fisheries management area is an iterative process conducted with the participation of First Nations, the fishing industry, government and non-government organizations.

The DFO Sustainable Fisheries Framework and Precautionary Approach (PA Framework; DFO 2009) calls for the identification of limit reference points (LRPs) to serve as thresholds to undesirable stock states. Limit reference points were presented and approved for the five major Pacific Herring stocks in February 2017 (DFO 2017, Kronlund et al. 2018). Closed-loop feedback simulation testing of candidate management procedures to evaluate the consequences of LRP choice for each stock was recommended as the next step. However, the identification of a preferred management procedure requires a fully specified set of objectives that includes LRPs, upper stock reference (USRs; candidate USRs included in DFO 2018) and target reference points (TRPs). In addition, a number of core fisheries management objectives, proposed by DFO to the Integrated Herring Harvesters Planning Committee in May 2017, as well as stock-specific objectives, proposed by herring users (First Nations and fishing industry) will be included in this first cycle of the MSE process.

Pacific Herring (*Clupea pallasii*) in British Columbia are managed based on five major stock management areas: Haida Gwaii, Prince Rupert District, Central Coast, Strait of Georgia, and West Coast of Vancouver Island, and two minor stock management areas. A full CSAS review of the stock assessment model occurred in October 2017 (Cleary et al. 2018, DFO 2018). This peer review will focus on simulation testing of management procedures for West Coast of Vancouver Island (WCVI) and Strait of Georgia (SoG). These two management areas were chosen for evaluation because they exhibit contrasting stock and fishery states, and a set of conservation and fishery objectives have been identified through workshops with WCVI First Nations and industry participants. Experience with this MSE process will be applied to simulation testing of management procedures for the remaining Pacific Herring stocks following the first MSE cycle.

DFO Fisheries Management has requested that DFO Science evaluate the performance of candidate management procedures for Pacific Herring. The evaluation and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) will support the renewal of Pacific Herring management framework and will be used to support the development of the 2018/19 Pacific Herring Integrated Fisheries Management Plan (IFMP).

Objective

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

Cleary, J.S., Benson, A.J., Cox, S.P., Grinnell, M. Evaluation of Management Procedures for Pacific Herring (Clupea pallasii) in the Strait of Georgia and West Coast Vancouver Island Management Areas of British Columbia. CSAP Working Paper 2015PEL02.

Guided by the DFO Sustainable Fisheries Framework, the following objectives for this advisory process have been established:

1. Evaluate the suitability of the Pacific Herring operating model (modified from Cox et al. unpublished document[1]; DFO 2015) for simulating realistic data derived from alternative hypotheses about stock and fishery dynamics for WCVI and SoG Pacific Herring.
2. Characterize stock status relative to reference points for all operating model configurations.
3. Review the results of applying a hierarchy of stock and fishery objectives in terms of a relative ranking of candidate management procedures by simulated outcomes. Candidate management procedures may include:
4. an approximation of the status quo harvest control rule implemented in 1986
5. alternative procedures that vary the choice of status and fishing rate operational control points specified in a harvest control rule
6. Evaluate a proxy to address spatially explicit objectives that utilizes records of Pacific Herring spawn (fine scale spatial dynamics are not modelled in the current operating model).
7. Recommend acceptable management procedures and evaluate the possibility of applying results from the WCVI and SoG analyses to the Haida Gwaii, Prince Rupert District, and Central Coast stocks.

Expected Publications

- Science Advisory Report
- Research Document
- Proceedings

Expected Participation

- DFO Science and Fisheries Management
- First Nations
- Fishing Industry
- Government Agencies (Province of BC, NOAA)
- Non-government Organizations

[1] Cox, S.P., Benson, A.J., Cleary, J.S., and Taylor, N.G. Candidate Limit Reference Points as a basis for choosing among alternative Harvest Control Rules for Pacific Herring (*Clupea pallasii*) in British Columbia. CSAP Working Paper 2013PEL01.

References

Cleary, J.S., Hawkshaw, S., Grinnell, M.H., and Grandin, C. 2018. Stock Assessment for Pacific Herring (*Clupea pallasii)* in British Columbia in 2017 and forecast for 2018. DFO Can. Sci. Advis. Sec. Res. Doc 2018/028. In press.

DFO 2009. A fishery decision-making framework incorporating the Precautionary Approach.

DFO. 2015. Candidate Limit Reference Points as a basis for choosing among alternative Harvest Control Rules for Pacific Herring (*Clupea pallasii*) in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/062.

DFO. 2017. The Selection and Role of Limit Reference Points for Pacific Herring (*Clupea pallasii*) in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/052.

DFO. 2018. Stock assessment for Pacific Herring (*Clupea pallasii*) in British Columbia in 2017 and forecast for 2018. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/002.

Kronlund, A.R., Forrest, R.E., Cleary, J.S., and Grinnell, M.H. 2018. The Selection and Role of Limit Reference Points for Pacific Herring (*Clupea pallasii*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/009. ix +125 p.

APPENDIX B: WORKING PAPER REVIEWS

TREVOR A. BRANCH, UNIVERSITY OF WASHINGTON

General comments

1. The report is well written, and in places such as the introduction, very well written and a pleasure to read. In other places, the abbreviations and jargon make for quite difficult interpretation of the results. Minor corrections have been sent directly to the authors.

2. The biomass objectives (lines 124-136) are inconsistent. Notably, objective 3 is dominant over objective 2, i.e. whenever (3) is met, (2) will automatically be met since a 75% probability of being >= 0.75B0 automatically implies a 50% probability of being >= 0.6B0. Later in the manuscript this is acknowledged, but it should be noted here at the outset. Perhaps, given that (3) is meant to apply to WCVI only, perhaps preface (2) with “For SOG: …” and (3) with “For WCVI:…”.

3. In lines 236-238 density-dependent M scenario has mortality that is 1.5 times normal mortality, 6% of the years where spawning biomass is 0.3B0, i.e. in other words, occasional surprisingly high natural mortality. But no analysis is presented to justify this frequency of increased mortality. Is there a rationale for this particular level of increased M, or frequency of increased M?

4. In lines 269-285 a procedure is outlined for sampling 100 sets of values from the posterior obtained using MCMC methods, that involves stratifying the R0 and B0 values into centiles. It would have been much simpler, more standard, and more straightforward, to sample 100 sets of values randomly from the MCMC draws, which would automatically preserve correlations among parameters. The authors provide no theoretical justification for their choice of stratifying the draws.

5. In lines 408-410 it says that constant-M operating models result in higher estimates of survey index CV than varying-M operating models, which is reasonable. However, the true uncertainty in a survey index does not change, only the estimates of the CV of the survey index. Therefore, when projecting forward and generating new future survey indices, you should use the same CV for both operating models. Perhaps a reasonable value is to assume a CV midway between the two estimates of the CVs or maybe sqrt(CVA^2 + CVB^2), thus one will estimate a CV that is lower than the truth, and the other will estimate a CV that is higher than the truth. This allows all of the operating models to be compared directly. Otherwise you are giving the varying-M operating models more information (a more precise survey index) and of course they will perform better.

6. The model fit for Model B WCVI Figure 3 shows a substantial failure to fit from 1969 to 1975, again from 1986 to 1990 and again in the last four years. In each case the model fit is far above the observed indices. There is something odd about this, because the model should just increase recruitment estimates in those years to fit the data.

Overall, I found no major issues with the analysis, which is a good effort to determine which management procedure would meet the objectives for each of the two fisheries, and comes with some practical management advice and recommendations.

PAUL REGULAR, FISHERIES AND OCEANS CANADA

In their working paper, the authors clearly outline the purpose of the performance management procedure performed on British Columbia Pacific Herring (*Clupea pallasii*). It is clear from the document that there is a long and rich history to the management of this stock, and this work represents another critical step in the evolution of the precautionary management of BC herring. The management strategy evaluation (MSE) presented here is an elaborate simulation that aims to test the performance of various management procedures (MPs) applied to the West Coast Vancouver Island (WCVI) and Strait of Georgia (SOG) components of the herring stock. An array of operating models (OMs) are constructed for this simulation to test the robustness of the MPs to different model assumptions (e.g. time-varying or constant rates of natural mortality). Overall, the document is concise and very well constructed; this is surely not an easy feat given the complexities of the stock, OMs and MPs, and the extensive nature of the output. Below I simply outline a few areas that may benefit from additional details and I raise some questions that may help with further analyses or highlight areas that need clarification for a naive reader.

After reading the whole document, it appears that the data and methods are adequate to support the conclusions. The data and methods are also explained in sufficient detail to evaluate the conclusions. Nonetheless, I feel that the document could benefit from more high-level descriptions of the input data and the base-case assessment models in the background section. For instance, it is late into the discussion before the approach used to model time-varying-M in the assessment model was mentioned. Likewise, the distinction between assessment models AM1 and AM2 were not clear to me until after the discussion. It may be useful to put such things into context in the background to help the reader better understand the inputs, the logic behind the tests conducted, and the patterns in the outputs.

The approach presented accounts for many sources of uncertainty and, being an MSE, it is purpose built to evaluate management procedures that satisfy an array of management objectives under a wide range of scenarios. With the current results, the authors make objective recommendations for the future management of the SOG and WCVI herring stocks. Nonetheless, I wonder if some of the performance statistics are overly optimistic given the way natural mortality is projected in the OMs. First, it is unclear why a random walk formulation was used in the projection period of the OMs instead of the cubic-spline approach used in the assessment model. Second, I would have expected the error around natural mortality to propagate in the projection years but, instead, the 95% confidence intervals become more narrow. Third, I would have expected the confidence intervals to be much wider around the constant M scenario given the variation "observed" by the time-varying-M model. Whatever the case, a wider range of future M values may be plausible and the error and trend in M is likely to have an impact on the outcomes. I also wonder if uncertainty around catchability should be addressed using an OM? If the issue is important enough to warrant two assessment models, then perhaps it should be tested in the MSE. While the q assumption may not be as important to test as the M assumption, the consequences of different catchabilities on performance may not be negligible.

As a final remark, I would like to thank the Pacific Region for the invitation to provide a review of this performance management procedure. I have found the work to be very thorough and enlightening, and I hope my comments are helpful for the working paper and for future analyses and testing.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat (CSAS)
Regional Peer Review Meeting (RPR)

Evaluation of Management Procedures for Pacific Herring (*Clupea pallasii*) in the Strait of Georgia and the West Coast of Vancouver Island Management Areas of British Columbia

July 25 & 26, 2018
Nanaimo, British Columbia

Chair: Bruce Patten

DAY 1 - Wednesday, July 25

Time	Subject	Presenter
0900	Introductions, Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper	Authors
1030	***Break***	
1050	Overview Written Reviews	Chair + Reviewers & Authors
1200	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	Group
1330	Discussion & Resolution of Technical Issues	RPR Participants
1430	***Break***	
1450	Discussion & Resolution of Technical Issues	RPR Participants
1600	Check in on progress and confirmation of topics for discussion on Day 2	RPR Participants
1615	Adjourn for the Day	

DAY 2 - Thursday, July 26

Time	Subject	Presenter
0900	Introductions, Review Agenda & Housekeeping Review Status of Day 1	Chair
0915	Discussion & Resolution of Technical Issues (Continued from Day 1)	RPR Participants
1030	***Break***	
1045	Discussion and Resolution of Working Paper Conclusions	RPR Participants
1130	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: • Sources of Uncertainty • Results & Conclusions • Additional advice to Management (as warranted)	RPR Participants
1430	***Break***	
1445	*Science Advisory Report (SAR) (*Continued)	RPR Participants
1630	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1645	Other Business arising from the review	Chair & Participants
1700	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Ashcroft	Chuck	Sport Fishing Advisory Board
Benson	Ashleen	Landmark Fisheries Research
Branch	Trevor	University of Washington
Cass	Al	Herring Industry Advisory Board
Chaves	Lais	Council of the Haida Nation
Christensen	Lisa	DFO Science
Cleary	Jaclyn	DFO Science
Cox	Sean	Simon Fraser University,
Davis	Brooke	DFO Science (rapporteur)
Dorner	Brigitte	Heiltsuk Nation
Forrest	Robyn	DFO Science
Ganton	Amy	DFO Fisheries Management
Goruk	Andrea	DFO Fisheries Management
Grinnell	Matthew	DFO Science
Groves	Steven	DFO Fisheries Management
Guo	Chuanbo	DFO Science
Hawkshaw	Sarah	DFO Science
Jones	Russ	Council of the Haida Nation
Kanno	Roger	DFO Fisheries Management
Kenyon	Alexander	Landmark Fisheries Research
Kronlund	Rob	DFO Science
Kulchyski	Tim	Cowichan Tribes
Laliberte	Bernette	Cowichan Tribes
Lane	Jim	Nuu-chah-nulth Tribal Council
MacDougall	Lesley	DFO Science
Marentette	Julie	DFO Science
Marshall	Kristin	National Oceanic and Atmospheric Administration (USA)
McGreer	Madeleine	Central Coast Indigenous Resource Alliance
Miller	Sara	Alaska Government
Morley	Rob	Canadian Fishing Company
Neuman	Amber	DFO Fisheries Management
Obradovich	Shannon	DFO Science
Ormond	Chad	South Island Nations
Patten	Bruce	DFO Science (chair)
Postlethwaite	Victoria	DFO Fisheries Management
Regular	Paul	DFO Science
Rusch	Bryan	DFO Fisheries Management
Rusel	Christa	A'Tlegay Fisheries Society

Last Name	First Name	Affiliation
Schweigert	Jake	DFO emeritus
Spence	Brenda	DFO Fisheries Management
Starr	Paul	Herring Industry Advisory Board
Swain	Doug	DFO Science
Thomas	Greg	Herring Conservation and Research Society

APPENDIX E: ABSTRACT OF WORKING PAPER

The method of setting catch limits for Pacific Herring (*Clupea pallasii*) fisheries in British Columbia is similar to precautionary harvest policies found elsewhere in the world; however, 3 out of 5 herring fisheries have been closed in most years since 2006 due to persistent low spawning abundances and low productivity. Although the mechanisms underlying declines of these herring stocks remain unknown, temporal variation in natural mortality and stock assessment over-estimation of abundance are potential factors involved in these outcomes. We used closed-loop simulations to evaluate management procedure (MP) performance for West Coast Vancouver Island (WCVI) and Strait of Georgia (SOG) herring fisheries given uncertainties about past and future herring natural mortality and stock assessment estimation errors. This work represents the first phase of management strategy evaluation under Pacific Herring Renewal. We develop three operating models representing hypotheses for how stock-specific natural mortality changes over time. The first model (constant-*M*) assumes that natural mortality has remained constant over the 1951-2017 period, while the alternative model (time-varying-*M*) allows natural mortality to vary over that time. The time-varying-*M* operating model is further divided into two models for projecting future patterns in natural mortality. A density-independent-*M* model assumes that future natural mortality rates will fluctuate randomly around the recent 10-year average, while a density-dependent-*M* model allows random pulses of high natural mortality when spawning biomass is low. We simulated performance of nine feedback harvest control rules (HCRs) given by combinations of maximum harvest rate (20% vs 10%), HCR form (i.e., hockey-stick vs. minimum escapement), operational control points defining biomass cutoffs (25%, 30%, and 50% of B_0) and thresholds below which harvest rates are reduced (none vs 60% of B_0), and absolute catch caps (0 vs 2,000 t for WCVI and 0 vs 30,000 t for SOG). For WCVI, results show that the current MP would fail to meet spawning biomass objectives under most operating models. Reducing the maximum harvest rate from 20% to 10% and capping fishery quotas at a maximum 2,000 t would reduce the effective harvest rate and protect against over-estimates of abundance when they occur, thus providing acceptable performance against biomass objectives for two of three operating models. For SOG herring, the current MP was robust across almost all scenarios and objectives we examined. For both WCVI and SOG herring, the maximum target harvest rate was the most important harvest control rule element controlling management performance compared to the shape and/or operational control points in harvest control rules.