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 2023/046

Pacific Region

Proceedings of the regional peer review evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18

January 10-11, 2017
Nanaimo, British Columbia

Chairperson: John Holmes
Editors: Melissa Nottingham and John Holmes

Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

December 2023

Canada

Foreword

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

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
ISBN 978-0-660-69066-7 Cat. No. Fs70-4/2023-046E-PDF

Correct citation for this publication:

DFO. 2023. Proceedings of the regional peer review evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18; January 10, 2017. DFO. Can. Sci. Advis. Sec. Proceed. Ser. 2023/046.

Aussi disponible en français :

*MPO. 2023. Compte rendu de l'examen régional par les pairs de l'évaluation de la solidité des procédures de gestion pour la pêche à la morue charbonnière (*Anoplopoma fimbria*) en Colombie-Britannique, Canada, 2017-2018; le 10 janvier 2017. Secr. can. des avis. sci. du MPO. Compte rendu 2023/046.*

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 held on January 10, 2017 at the Pacific Biological Station in Nanaimo, British Columbia (BC). A working paper evaluating the performance of the current Sablefish (*Anoplopoma fimbria*) management procedure (MP) and nine alternative MPs against a revised operating model structure was reviewed. The working paper tested MP robustness against three plausible operating model scenarios that represented alternative hypotheses about Sablefish stock productivity. These three scenarios were expanded to five scenarios as a result of the review in order to better represent uncertainty in combinations of productivity and spawning biomass in 2016.

In-person and web-based participation included DFO staff from Science and Fisheries and Aquatic Management Sectors, and external participants from First Nations, the commercial fishing industry, and academia.

DFO and the BC Sablefish fishing industry collaborate on a management strategy evaluation (MSE) process intended to develop and implement a transparent and sustainable harvest strategy. Sustainability of harvest strategies is determined by simulation testing alternative MPs against operating models (OM) that represent a range of hypotheses about Sablefish stock and fishery dynamics. Performance of MPs used in these tests is measured against pre-agreed conservation and catch objectives for the stock and fishery. The Sablefish operating model was revised in 2016 (DFO 2016a, b) to include several structural changes that improved model fit to the data and resulting estimates of historical recruitment relative to the previous operating model. Tests of the current and alternative MPs for robustness to uncertain stock and fishery dynamics described in the working paper that use the revised operating model are expected to result in advice that is compliant with both the “DFO Sustainable Fisheries Framework” (SFF) and “A fishery decision-making framework incorporating the Precautionary Approach” (PA) policies.

The conclusions and advice resulting from this review will be published in the form of a Science Advisory Report (SAR) to inform management planning for the 2017-18 fishing year.

The Science Advisory Report and 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 meeting was held on January 10, 2017 at the Pacific Biological Station in Nanaimo, British Columbia (BC), to review the performance of the current and nine alternative management procedures (MPs) for the BC Sablefish (*Anoplopoma fimbria*) fishery. Performance of the candidate MPs is measured by comparing trade-offs between statistics related to conservation and catch objectives. Robustness of the MPs was assessed against five plausible hypotheses concerning combinations of stock productivity and 2016 female spawning biomass.

The Terms of Reference (TOR) for the science peer review (Appendix A) were developed in response to a DFO Fisheries Management request to DFO Science to provide advice to inform management planning for 2017-18 that is compliant with both the "DFO Sustainable Fisheries Framework" (SFF) policy and "A fishery decision-making framework incorporating the Precautionary Approach" (PA) policy. Notifications of the science review and conditions for participation were sent to external participants with relevant expertise from First Nations, commercial and recreational fishing sectors, and academia. A total of 23 people participated in person or via webinar (Appendix B).

The meeting was chaired by John Holmes, who reviewed the role of CSAS in the provision of peer-reviewed advice, and provided a general overview of the CSAS process. He then discussed the role of participants, the purpose of the resulting meeting publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. The Chair noted that the purpose of the meeting was a science review and not a consultation, and then reviewed the Terms of Reference for the peer review (Appendix A), highlighting the objectives to be achieved. Although the review was scheduled for two days, a revised one-day agenda (Appendix C) was developed by the Chair and adopted. Melissa Nottingham was identified as the Rapporteur for the peer review meeting.

The following working paper (WP) was prepared for review (see summary in Appendix D):

Cox, S., Holt, K., and Johnson, S. Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18. CSAP Working Paper 2014GRF08.

Dr. William Clark (International Pacific Halibut Commission, retired) and Brooke Davis (DFO Science) were asked to provide written reviews of the working paper to inform, but not limit, discussion by participants attending the meeting. Their reviews are in Appendix E.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) to Fisheries Management to inform Sablefish fishery planning. The SAR and supporting research document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

PRESENTATION OF WORKING PAPER

Working Paper: Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18. CSAP Working Paper 2014GRF08.

Rapporteur: Melissa Nottingham

Presenter(s): Kendra Holt and Sean Cox

Sean Cox began the presentation of the working paper by providing a background description of the MSE process applied to Sablefish in BC. He outlined revisions made to the operating model in 2016 and the five fishery management objectives currently in use.

The author described each of the 10 candidate management procedures, including MP1, the current management procedure. Differences among the 10 MPs included the maximum harvest rate applied within a harvest control rule, the total allowable catch (TAC) floor, the phase-in period for a new MP, and whether full retention of Sablefish was specified regardless of fish size (Sablefish in BC currently have a 55 cm fork length minimum size limit by regulation).

Kendra Holt continued the presentation by discussing the perceptions of stock status and productivity that resulted from each of the OM scenarios, as well as the performance outcomes when compared to conservation and fishery objectives. MP performance was quantified for each of the OM scenarios, as well as weighted across operating model scenarios.

The working paper originally documented three scenarios to capture uncertainty about stock productivity (i.e., stock recruitment steepness) based on the 10th (loProd), mean (expProd), and 90th (hiProd) percentiles of the marginal posterior distribution for steepness and assigned weights based on their perceived plausibility of 10%, 80%, and 10%, respectively. Because these scenarios only capture uncertainty about recruitment, the authors introduced an alternative scheme during their presentation in which five OM scenarios were used to capture uncertainty about *both* productivity and current female spawning biomass ($fSSB_{2016}$). The base case scenario that represented the most plausible hypothesis for both productivity and $fSSB_{2016}$. The remaining four scenarios were selected by fitting a multivariate normal distribution to the joint Markov chain Monte Carlo (MCMC) posterior sample distribution for these two variables, and selecting four points on the ellipse capturing the central 80th percentiles in each dimension. The four alternatives to the base case represented the following combinations:

1. high productivity, mean fSSB2016 (hiProd/expSSB);
2. low productivity, mean fSSB2016 (loProd/expSSB);
3. mean productivity, high fSSB2016 (expProd/hiSSB); and
4. mean productivity, low fSSB2016 (expProd/loSSB).

Weights were assigned to these scenarios based on normalized probability densities at each associated productivity-$fSSB_{2016}$ point on the joint posterior distribution, which resulted in a 36% probability to the base case scenario and probabilities of 16%, 16%, 15%, and 17% to the hiProd/expSSB, loProd/expSSB, expProd/hi SSB, and expProd/loSSB scenarios, respectively.

The current MP (DFO 2014) did not meet the three conservation objectives under any of the five productivity-biomass OM scenarios using the revised operating model, and was consistently ranked last in management performance. Full retention of Sablefish less than 55 cm fork length resulted in female spawning biomass growing to B_{MSY} in two Sablefish generations (i.e., 36 years) with a 50% probability. Without full retention, female spawning biomass is projected to increase toward B_{MSY}, but fails to reach it with 50% probability. Longer phase-in periods

decreased the probability of reaching B_{MSY} in the long term, but catch increased in the short term.

The authors also discussed limitations of the revised operating model. While the revised model is more complex than earlier versions, it does not account for large scale processes that could impact Sablefish (e.g., a closed BC Sablefish population is assumed, impacts of Hake distribution on Sablefish dynamics are not considered). In addition, steepness of the stock-recruit relationship and natural mortality parameters require informed prior distributions in order to fit the operating model to the data. While this requirement is common for modern statistical catch-at-age assessment models, the prior distributions selected when fitting the operating model are a source of uncertainty. Future research to determine the sensitivity of model outputs to these prior distributions as well as exploration of the variance/covariance structure between these parameters would be informative. Finally, the approach to setting up OM scenarios may under-estimate total variation in forecast performance and the production model assessment in all management procedures can show retrospective patterns during stock decline.

Results relative to fishery management objectives were discussed for each scenario and then a weighted set of outcomes was produced.

The authors concluded that the change in operating model structure gives significantly different performance forecasts for MP1, the current management procedure, compared to the previous operating model. Phase-in to a management plan with a lower target harvest rate and no TAC floor provides transition time. The lower target harvest rate helps improve the performance of the MP relative to stock and fishery objectives. The authors identified several management procedures that could meet fishery management objectives 1 and 2, but none were able to meet conservation objectives 3a and 3b without extending the phase-in period. The authors concluded that the lower productivity estimates of the revised OM resulted in MP1 not meeting the objectives whereas it did when tested against the OM used in 2011. Conclusions were similar for the expanded operating model set of five scenarios that were chosen to better represent joint uncertainty in productivity and current female spawning biomass. The authors finished with suggestions for future research.

WRITTEN REVIEWS AND DISCUSSION

REVIEW BY BROOKE DAVIS

The reviewer provided general comments acknowledging the years of work that went into the working paper supporting documents and background. She requested increased clarification of table headings, definition of terms used within the paper and a reference to previous data used.

The reviewer questioned the use of a simple surplus production model considering the reduced complexity from the current operating model. The authors responded that the requirement of a successful MP is that it has been simulation tested to provide a reasonable expectation of delivering an acceptable trade-off of management outcomes relative to objectives. If a simple assessment method is adequate for that purpose, then it has the advantage of being based on data that are likely to be available in the future. In addition, the existing procedure, and alternatives presented in the working paper, were initially motivated by industry desire to adopt a transparent procedure to providing harvest advice. The other models were considered, but would require additional simulated data, which can be difficult to simulate with realistic amounts of observation error (e.g., age-structured data). The surplus production model chosen for the existing and alternative procedures has the advantage of requiring only landings (retained catch) and a survey index for application.

The reviewer also asked for an explanation of why higher estimates of exploitation were considered more realistic. The authors noted that improved fitting to the at-sea release data resulted in a higher estimated exploitation rate on sub-legal Sablefish. They consider the updated model more reliable because of the improved fits to age composition data, improved fits to at-sea-release data, and a reduction in unrealistic levels of autocorrelation in recruitment residuals (compared to US assessment model estimates). The revised operating model also produced higher estimates of sub-legal exploitations rates, but this was not the rational for believing the revised operating model was an improvement. Instead, the higher estimates of sub-legal mortality were seen as a rationale for revisiting scenarios related to full retention. The authors agreed to clarify this distinction in the revised working paper.

The reviewer asked that the source of observational error be included in the working paper and why it was manually partitioned. The author responded that simulated data are produced with observation error, with the total error in the survey assumed to be 95% observational and 5% process error and this is considered the most stable configuration. The authors agreed to add this description to the working paper.

The reviewer and authors discussed the prior distributions applied to F_{MSY} and MSY parameters in the surplus production model used within management procedures. The reviewer noted that MP2 - MP10 used a tighter, more precise prior distribution for these parameters to reflect the corresponding reductions in these values for the updated operating model. In comparison, MP1 used tuning that was previously used. The reviewer suggested that this approach made an unfair comparison between MP1 and the nine alternative MPs. The authors replied that they had done this because the currMP is meant to be the exact procedure that we have implemented over the past 5 years, but noted that they had done some runs in which the new tuning was applied to MP1.

In response to this comment, the authors agreed to add a discussion of this sensitivity analysis of parameter tuning for MP1 to the revised working paper.

REVIEW BY WILLIAM G. (BILL) CLARK

The reviewer began by defining his scope as the review of the scenarios described in the working paper and judging if they are a reliable test of the robustness of candidate management procedures. He discussed the Markov chain Monte Carlo (MCMC) sample used to approximate the Bayes Posterior Distribution and the degree to which unlikely values were included in simulations, implying that there should be more effort to include less probable sets of parameter values in the simulations. The reviewer and author discussed choosing MCMC samples at random in the neighbourhood of the target point. This would allow for the incorporation of variability, but would keep the results in the desired neighbourhood of each OM scenario. The Chair clarified that this suggestion should be considered an avenue for future research. The Chair called for comments from the room and seeing as there were none the meeting moved on to general discussion.

GENERAL DISCUSSION

It was noted that the Sablefish stock and fishery objectives have been applied in a sequential manner, i.e., an acceptable management procedure (MP) must achieve Conservation objectives 1 and 2 before the other objectives are considered, i.e., the objectives are applied as a pass/fail sequence. None of the MPs achieved either Conservation objective 3a or 3b as defined. The only way to meet objective 3b is by application of MPs that incorporate full retention or a reduction in harvest rate. Even for MPs with these features, the target level is only reached at

the end of two generations (36 years) rather than in 50% of the years over a two generation period. Discussion focused on what kind of target was achievable and the choice of time period over which the objective is to be achieved. Two fish generations was determined in the case of Sablefish by interpretation of the DFO PA policy. It was suggested that reasonable time frames could also be identified by calculating the expected time to attain an objective in the absence of fishing.

It was noted that in comparison to the original three OM scenarios presented in the WP, two additional management procedures (MPs) for a total of four MPs failed to achieve objectives 1 and 2 for the weighted results over the five OM scenarios.

Discussion of the OM scenarios led to the conclusion by meeting participants that the five scenarios and weighting scheme were more appropriate for simulation testing in terms of capturing the range of uncertainty concerning stock productivity and 2016 female spawning biomass. Meeting participants recommended that the authors revise the WP to include the five scenarios and weighting scheme and that the Science Advisory Report reflect the five scenarios.

There was brief discussion on the equilibrium assumption used for initialization of the OM, i.e., equilibrium is assumed in 1965. No conclusions were reached on validity of this approach, but it was agreed that alternatives should be explored in future efforts.

The closed population and the form of the stock recruitment relationship are key uncertainties in the analysis. A coastwide view of the stock is needed, as there is ample evidence of movements between BC, Alaska, and the west coast United States based on tag release-recovery data (e.g., DFO 2014).

It was recommended that future MSE analyses conduct robustness testing on the prior distributions for steepness and natural mortality.

Noting that the WP was well written and comments of the reviewers were handled well by the authors, meeting participants accepted the WP with minor revisions (Appendix F).

POST-MEETING REVISIONS

An error in the code used to weight MP performance relative to objectives over the updated five OM scenarios was discovered two weeks after the meeting. This error did not apply to the individual scenario performance tables, or to the three scenarios originally presented in the working paper; it was specific to weighting across the five productivity-OM scenarios. This error was corrected for the weighted performance indicator tables provided in the SAR and the final research document resulting from this meeting.

ACKNOWLEDGEMENTS

The authors provided a well written and clearly argued working paper and Drs. Brooke Davis (DFO Science) and William Clark (Seattle, Washington) provided thorough written reviews of the working paper. The efforts of the authors, reviewers and meeting participants contributed to a smooth experience and are much appreciated. The Chair thanks Melissa Nottingham for Rapporteuring during this Regional Peer Review meeting.

REFERENCES CITED

DFO. 2014. Performance of a revised management procedure for Sablefish in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/025.

DFO. 2016a. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

DFO. 2016b. Proceedings of the Pacific regional peer review on A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada; January 20, 2016. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2016/027.

APPENDIX A: TERMS OF REFERENCE

Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18

Regional Peer Review - Pacific Region

January 10-11, 2017
Nanaimo, British Columbia

Chairperson: John Holmes

Context

Fisheries and Oceans Canada (DFO) and the British Columbia (BC) Sablefish fishing industry collaborate on a management strategy evaluation (MSE) process intended to develop and implement a transparent and sustainable harvest strategy. Sustainability of harvest strategies is determined by simulation testing alternative management procedures against operating models that represent a range of hypotheses about uncertain Sablefish stock and fishery dynamics. Performance of management procedures used in these tests is measured against pre-agreed conservation and catch objectives for the stock and fishery (Cox et al. 2011, DFO 2014).

A revised Sablefish operating model was developed in January 2016 (DFO 2016) that implements a two-sex/age-structured model to account for differences in growth, mortality, and maturation of male and female Sablefish, adjusted model age-proportions via an ageing error matrix, and revised the multivariate-logistic age composition likelihood to reduce model sensitivity to small age proportions. Structural revisions to the operating model provide a better fit to age-composition and at-sea release data that were not well-fit by the previous operating model. Accounting for ageing errors improved the time-series estimates of age-1 Sablefish recruitment by reducing the unrealistic auto-correlation present in the previous model results. Sablefish begin to appear in commercial fisheries at 2-3 years of age, but are required to be released by regulation when measuring less than 55 cm fork length. The improved recruitment estimates derived from the operating model help to explain the temporal pattern of at-sea releases. As a consequence, it may be possible to improve the evaluation of potential impacts of these at-sea releases on exploitable Sablefish biomass and productivity by Cox et al. (2011). If post-release estimates are determined to be more significant than previously determined, management procedures such as full retention, avoidance, or catch limits on sub-legal Sablefish by one or more gear types may be required to reduce post-release mortality effects that compromise performance of the Sablefish management system.

Fisheries Management has requested advice from Science to inform planning for the 2017-18 fishing year that incorporates the improvements to the Sablefish operating model and tests the existing and alternative management procedures for robustness to uncertain stock and fishery dynamics. It is expected that advice will be compliant with both the "*DFO Sustainable Fisheries Framework*" (SFF) policy and "*A fishery decision-making framework incorporating the Precautionary Approach*" (PA) policy.

Objectives

Guided by the DFO Sustainable Fisheries Framework, particularly the Fishery Decision-making Framework Incorporating the Precautionary Approach (DFO 2009), meeting participants will review the working paper:

Evaluating the robustness of management procedures for the Sablefish (Anoplopoma fimbria) fishery in British Columbia, Canada for 2017-18. Cox, S.P., Holt, K., and Johnson, S. CSAS Working Paper 2014GRF08.

The working paper will be used to provide advice with respect to the following objectives:

1. Provide the results of fitting (conditioning) a range of operating model configurations that represent hypotheses about uncertain Sablefish dynamics to updated stock monitoring and fishery data.
2. Characterise Sablefish stock status relative to outcomes specified in conservation and fishery objectives for each of the operating model configurations.
3. Quantify and rank the relative performance of candidate management procedures against the objectives. Procedures may include:
   a. the original procedure implemented in 2011 (Cox et al. 2011);
   b. the current procedure that incorporates a catch floor (DFO 2014);
   c. a new procedure that adds a catch ceiling to the current procedure; and
   d. modifications of (a-c) that implement full retention, avoidance, and/or sub-legal catch limits.
4. Evaluate whether mortality attributable to at-sea releases across all fishery sectors compromises the achievement of fishery objectives related to conservation and growth of the stock.

Expected Publications

- Science Advisory Report
- Research Document
- Proceedings

Participation

- Fisheries and Oceans Canada (DFO) (Science, Fisheries Management sectors)
- Academics
- Aboriginal communities/organizations
- Industry (groundfish commercial fishing industry)

References Cited

Cox, S.P., Kronlund, A.R., Lacko, L. 2011. Management procedures for the multi-gear Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/063. viii + 45 p.

DFO. 2009. A Fishery Decision-making Framework Incorporating the Precautionary Approach.

DFO. 2014. Performance of a revised management procedure for Sablefish in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/025.

DFO. 2016. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

APPENDIX B: MEETING PARTICIPANTS

Last Name	First Name	Affiliation
Anderson	Kristina	DFO Science
Bassett	Sandra	DFO Science
Bocking	Bob	Maa-nulth Fisheries Committee
Christensen	Lisa	DFO Science, Centre for Science Advice Pacific
Cox	Sean	Simon Fraser University
Davis	Brooke	DFO Science
Fenske	Kari	National Ocean and Atmospheric Administration (NOAA)
Forrest	Robyn	DFO Science
Holmes	John	DFO Science
Holt	Kendra	DFO Science, Groundfish Section
Keizer	Adam	DFO Fisheries Management, Groundfish
Kronlund	Allen	DFO Science, Groundfish Section
MacDougall	Lesley	DFO Science, Centre for Science Advice Pacific
Nottingham	Melissa	DFO Science, Groundfish Section
Surry	Maria	DFO Science, Groundfish Section
Williams	Daniel	DFO Science, Groundfish Section
Wyeth	Malcolm	DFO Science, Groundfish Section
Mose	Brian	Deep Sea Trawlers Association of BC
Tadey	Rob	DFO Fisheries Management, Groundfish

APPENDIX C: REVISED AGENDA

Time	Subject	Presenter
09:30	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
09:45	Review Terms of Reference	Chair
10:00	Presentation of Working Paper	Authors
10:45	***Break***	
11:00	Presentation of Written Reviews + Author Responses	Reviewers & Authors
12:00	***Lunch Break***	
13:00	Presentation of Written Reviews + Author Responses	Reviewers & Authors
13:15	Identification of Key Issues for Discussion	RPR Participants
13:30	Discussion and Resolution of Key Issues	RPR Participants
14:00	Develop Consensus on Paper Acceptability & Revisions	RPR Participants
14:30	***Break***	
14:45	*Science Advisory Report* (SAR) Develop consensus on the following for inclusion: • Results and Conclusions • Key advice to Managers • Sources of Uncertainty • Additional advice to Management (as warranted)	RPR Participants
16:15	Next Steps • SAR review/approval process and timelines • Research Document & Proceedings timelines	Chair
16:30	***Adjourn***	

APPENDIX D: WORKING PAPER SUMMARY

Fisheries and Oceans Canada (DFO) and the British Columbia Sablefish (*Anoplopoma fimbria*) fishing industry have collaborated on a management strategy evaluation (MSE) process since 2009. This process is used to develop and implement a transparent and sustainable harvest strategy for the multi-gear Sablefish fishery. The underlying operating model used to generate hypotheses about Sablefish stock and fishery dynamics as part of the MSE was recently updated to include several structural changes that improved model fit to data and resulting estimates of historical recruitment. This paper updates the Sablefish MSE by incorporating these improvements to the operating model, and then tests the existing and alternative management procedures for robustness to uncertain stock dynamics. The current management procedure (MP) uses a harvest control rule with a maximum harvest rate set at the estimated harvest rate at maximum sustainable yield (U_{MSY}), as well as a minimum TAC floor of 1,992 tonnes and a minimum size limit of 55 cm fork length. Nine alternative MPs were also evaluated that differed in their use of TAC floors, maximum harvest rates within the harvest control rule, phase-in periods to a new MP, and sub-legal release regulations. Three operating model scenarios were originally developed in the WP to capture uncertainty about stock productivity based on differences in the stock recruitment steepness parameter (low, mean, high). Because these scenarios only capture uncertainty about recruitment, an alternative scheme was introduced during the meeting in which five OM scenarios were used to capture uncertainty about both productivity and current female spawning biomass (fSSB2016). MP performance was ranked within scenarios, as well as weighted across operating model scenarios. Our results show that the current MP was unable to meet conservation objectives under any of the productivity levels. MPs with floors combined with a maximum harvest rate of 5.5% were able to meet conservation objectives under the expected and high productivity scenarios; however, poor performance for these MPs in the low productivity scenario meant that when performance was weighted across all three scenarios, none of the MPs with floors were able to meet conservation objectives unless combined with full retention of all Sablefish < 55 cm in length. In the absence of both TAC floors and full retention, an MP with 5-year phased-in period to a new maximum target harvest rate of 5.5% was able to meet the two highest-level conservation objectives while providing 10-year average catch near the current TAC.

APPENDIX E: WORKING PAPER REVIEWS

BROOKE DAVIS
DFO Science
Date: January 3, 2017

This paper is the culmination of many years of work, and much rigorous quantitative analysis – which can be hard to summarize in a single document. Overall, the authors have done a commendable job at compiling many years of iterative research on Sablefish population dynamics and management. The document comprehensively carries out the objectives laid out in the Terms of Reference. It presents a high quality MSE, in which objectives have been clearly laid out, and performance across these objectives explicitly measured across simulated scenarios. It presents a sophisticated operating model to capture sablefish population dynamics, which has been recently improved. Many of my comments below call for further explanation of certain choices made in the construction of the close-looped simulation, which may be contained in previous documents. Some calls for further explanation could likely be confronted with more comprehensive citation of previous work, but some may require adding explanation to the body of the document. Some clarity could be gained by including some of the information contained in the appendices in the main body – but this tends to be a matter of personal style. There are opportunities to make notation of model parameters more consistent, scenario names and codings more readable, and figures more reader-friendly. The document represents an impressive, ongoing, research process, and I am appreciative to have been given the opportunity to learn a great deal about sablefish population dynamics and management in reviewing it.

1. In the introduction you mention the “wide range of management approaches” evaluated in past work, and various operating model scenarios considered in past work, but the choice of which scenarios show up in this analysis doesn’t seem to be discussed further. After reading this introduction I was expecting to see some of these different assessment models compared -- for example surplus production vs. catch-at-age assessment models. I was left wondering why a simple surplus production model was used as the assessment model – and there doesn’t seem to be any justification for this choice.
2. It would be helpful if the fishery objectives were each named, I found myself constantly referring back to see which numbered objective was being discussed. It might be worth considering first describing objectives 1-3 without any equations, and later presenting how these objectives are measured. I think that maybe the actual equations used to implement the objectives would be better placed in the “Performance measures” section.
3. Objective 2 is a bit confusing in its current description. It says that the probability of decline changed when the population is between 0.4 and 0.8 B_{MSY}, but also that the scale on which it changes is between the LRP and B_{MSY}. I’m assuming that 0.4 B_{MSY} is the LRP, but unsure if it changed linearly from 5 to 50% probability between that value and 0.8B_{MSY} , or that value and B_{MSY}.
4. There seems to be some inconsistencies in notation and variable names throughout the document. The first time we are introduced to female spawning stock biomass in the description for objective 1, it is symbolized by SSB, where elsewhere it is referred to as fSSB. There is also inconsistency with the definition of the “healthy zone”, LRP, B_{lower}, B_{upper} (in table 2). There are also some cases where some variables are named without the symbol, named with the symbol, or only the symbol is used. It would be best if the name and symbol are both used consistently.

5. In paragraph 3 of section 2.2 (page 3) it is stated “Updated estimates of exploitation rates of sub-legal Sablefish are considerably higher than previous estimates, suggesting that re-evaluation of full retention may yield more realistic effect sizes”. It is unclear to me how estimating higher estimates than the previous model automatically indicates that it has estimated “more realistic” effect sizes. This statement needs further explanation.
6. There is no explanation given for why the assessment model ignores at-sea releases and release mortality. I think a more detailed justification of the chosen assessment model is necessary. As mentioned above: why was such a simple assessment model used, and why weren’t other assessment models were compared in this MSE?
7. There is no mention of observation error in the simulated data used in the assessment model, nor is there any discussion of implementation error in the TAC in the closed-loop simulation.
8. I’m wondering if you tried to estimate observation and process error in the state-space surplus production model, or if it was only fit with the prescribed partitioning of the variance?
9. Many of your leading variables in both your assessment model, and operating model have informative priors placed on them. When this is the case, there should be a discussion of how these priors were determined, and how their sensitivity was analyzed. At the bottom of page 4 you state that tighter and more precise priors were used “to reflect the corresponding reductions in these values for the updated operating model” – why does a reduction in an estimate warrant the tightening of priors? I would also be interested in further discussion of the priors placed on natural mortality and steepness – and the decision to estimate both parameters. Johnson et al. (2015) chose to fix steepness in their assessment of WA sablefish due to data limitations. Is the model only able to estimate steepness and mortality because of the priors placed on them? Were alternative model formulations explored?
10. I understand testing the current management procedure using the old “parameter tuning” but it seems that this method should have also been tested with the same parameterization as the other MP’s as well. Otherwise a fair comparison of the current management method cannot be directly compared to the new MP’s.
11. There should be more discussion of how 0.055 was chosen as a harvest rate – and why procedures that incorporate changes in retention and catch floors were not tested with procedures that use harvest rates informed by U_{MSY}. This seems especially relevant when you are testing performance of MP’s under lower and higher than expected productivity – it seems obvious that is 0.055 was chosen based on expected productivity, it would not perform well when actual productivity is lower. I would be more interested in comparing MP’s that base TAC’s on U_{MSY} under different productivity scenarios.
12. I would like to see more explanation of the “unrealistic autocorrelation” that was present in the previous model estimates. Why was it unrealistic?
13. It might be helpful if the MP’s were given clearer names – I don’t have a good suggestion for how they should look, but the current format was hard for me to remember throughout the document. This becomes especially apparent in figures, especially when these codings are shown in small type, usually with a dashed line running through them. I would suggest having labels outside the plots, which use real words and not codes; each column, which has the same MP would have a label like “Current MP”, “No floor, 0.055 HR”, “No floor, 0.055 HR, Phase 5”, “No Floor, 0.055 HR, Phase 5, Full Ret.”. It would also be helpful if table 5 and 6 had the MP’s numbered, as they are in this description, and in table 3. I think it would also improve readability if codes for different scenarios were not used in the text.

14. You cite your previous report when referencing the data, but I think the same data is also listed in appendix B. I think it is worth mentioning in the text body that although new data is added for 2016, it is extrapolated through the end of the year, and uses the 2015 fishery independent abundance index – which I think is a bit dubious and requires some more justification.
15. There should be justification for the choice of selectivity curves chosen for each gear type, at least by citing references.
16. Figure 3, and the explanation of results written in the first paragraph of page 8 were quite confusing to me. Further explanation of how these plots show these results would be helpful. This could be achieved by drawing the reader's attention to the features of the plot that show these conclusions ("The distance between x and y line displays that.."). There also appears to be some errors in the legend.
17. The clarity of figure 4 could be improved with a legend, and standardized names and symbols for variables, as well as non-coded plot titles. It is confusing that solid red lines represent two different parameters in the top and bottom plots.
18. It seems counter-intuitive to me that full retention models would result in lower overall mortality of small fish (page 8, bottom of paragraph 2). This might be a point worth further discussion, especially when considering how fisher behavior may change with differing management procedures. If full retention is implemented, it could change fisher behavior, such that the age composition of catches could change – which would have implications for the overall productivity of the stock.
19. In the second paragraph of section 4.1 (page 11) you attribute stocks being unable to remain above B_{MSY} past year 18 to "lower than expected productivity". How did you determine that productivity was lower than expected? Lower than expected according to what?
20. Why are MP's with full retention not feasible to implement in 2017/2018? (First paragraph of section 4.2, page 12).
21. Include what Std and StRS symbolize in figure C-3 in caption or plot label. This plot could be made much clearer with better plot labels: for example "Males" and "Females" written at top of plot, and "Trap", "Hook" etc. written down left side of plot, rather than small, individual labels in each plot. You state that selectivity is challenging to estimate, but there are no error bounds shown on figure C-3, which would help to illustrate this point.
22. If the current operating model estimates optimal harvest rates at 4-5% (paragraph 5 of section 4.3, page 13) why was 0.055 chosen for the evaluated MP's?
23. Appendix D and E could easily be merged, such that each of D-1 through D-10 is a 3x3 plot with E-1 through E-10 across the bottom row – which would make for easier comparisons. There is also an opportunity to make these plots much clearer with better labelling (for example "Expected", "High", "Low" written across the top). Add units for retained catch.

Work Cited

Johnson, K. F., Rudd, M. B., Pons, M., Allen Akselrud, C., Lee, Q., Hurtado-Ferro, F., Haltuch, M. A., and Hamel, O. S. 2015. Status of the U.S. sablefish resource in 2015, 162 pp. *In* Council Meeting Record, 230th Session of the Pacific Fishery Management Council, June 10-16, 2015, Spokane, WA. Agenda D.8, Attach. 8. . Pacific Fishery Management Council, Portland, OR.

WILLIAM G. (BILL) CLARK
International Pacific Halibut Commission (retired)
Date: January 3, 2017

Background

The management system for the sablefish fishery in British Columbia consists of five parts:

1. a set of fishery performance objectives (including conservation requirements) developed by the industry.
2. a set of operating models, which are age-structured models fitted to fishery and survey data, models of the sort used for data-rich stock assessments throughout this region of North America.
3. an assessment model different from any of the operating models, specifically a state-space surplus production model, fitted to fishery and survey data.
4. a management procedure, which is a set of rules for setting a catch limit on the basis of stock size and productivity estimates produced by the assessment model.
5. a management strategy evaluation, in which the robustness of the management procedure is tested by fitting the assessment model to artificial data generated by the various operating models, including projections in which the catches are determined by the management procedure.

The present review focuses on the management strategy evaluation. A previous review considered a new generation of operating models that are now in use. The issue here is therefore whether the simulations reported in the working paper are a reliable test of the management procedure.

Three operating models are run in the simulations. Structurally they are the same model, but each one is tuned (conditioned) to have a prescribed value of steepness representing low, expected, and high stock productivity. The values are the 10%, 50%, and 90% points of the marginal distribution of estimated steepness obtained from MCMC runs of the unconditioned model. The operating models are also conditioned to produce an estimated 2016 spawning biomass that agrees with the overall relationship between steepness and average estimated 2016 spawning biomass in the MCMC samples. The regression of biomass on steepness (Fig. 1a) is almost flat, so this condition amounts to constraining the three operating models to generate a 2016 spawning biomass near the average of MCMC samples of the unconditioned model.

The conditioning of each of the three operating models is achieved by initializing the model parameters to the values of the realized MCMC sample parameter vector closest to the prescribed values of steepness and 2016 spawning biomass. After being thus initialized, the model is run for a number of years with the estimated process and observation variances to produce artificial data to which the management procedure is applied, and the stock trajectory calculated by the operating model is recorded. One hundred replicate runs of each model are done to obtain the distribution of possible outcomes.

Review

The simulations are properly done and certainly serviceable for the intended purpose, which is to predict the performance (in terms of probabilities of achieving the various fishery objectives) of the alternative management procedures considered. The constraint placed on 2016 spawning biomass in the operating models is a strong one, and it raises the question of what the forecasts

would look like without that constraint. And there are other ways in which the results are deliberately influenced, e.g. by tight priors on the assessment model fits. Some measures of this sort are often needed to keep simulation model runs in plausible territory, and the need is greater where the data are questionable or incomplete in some respects, as are the B.C. sablefish data. The incorporation of priors and constraints into the simulations is therefore a matter of judgment, and in this case what has been done appears reasonable.

Recommendations

In principle it would be a good thing to use choose an MCMC sample parameter vector at random to initialize the operating model for each replicate run, because this would introduce the variances and covariances of the parameter estimates into the simulations. The amount of uncertainty added could be controlled by restricting the candidate samples to a larger or smaller neighborhood of the target values of steepness and 2016 spawning biomass.

If an initialization method of that sort is deemed undesirable, it would be worthwhile to consider another alternative to using the closest MCMC sample to do the initialization for all replicates, e.g. the conditional MLE. The problem with using the closest MCMC sample is that it introduces an element of randomness into the initialization of each operating model that could influence the apparent performance, absolute or relative, of the different candidate management procedures.

APPENDIX F: WORKING PAPER REVISIONS

The WP was well written and clear. Meeting participants identified a few minor revisions and the reviewers identified other revisions. The following revisions were recommended for the working paper and future iterations of the Sablefish MP performance evaluations.

- Use five OM scenarios, representing combinations of productivity and female spawning biomass in 2016, and weighting scheme in revised WP;
- Include a discussion of the sensitivity analysis of F_{MSY} and MSY parameter tuning for MP1 to the revised working paper.
- Clearly define what is 80% B_{MSY} and the status zones prescribed by the Precautionary Approach policy.