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 2023/036

Pacific Region

Proceedings of the Pacific regional peer review on the Application of the Management Procedure Framework for Inside Quillback Rockfish in British Columbia in 2021

December 6-7, 2022
Virtual Meeting

Chairperson: Ben Davis
Editor: Yvonne Muirhead-Vert

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

August 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 978-0-660-49882-9 Cat. No. Fs70-4/2023-036E-PDF

Correct citation for this publication:

DFO. 2023. Proceedings of the Pacific regional peer review on the Application of the Management Procedure Framework for Inside Quillback Rockfish in British Columbia in 2021; December 6-7, 2022. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2023/036.

Aussi disponible en français :

MPO. 2023. Compte rendu de l'examen par les pairs de la région du Pacifique sur l'application du cadre des procédures de gestion du sébaste à dos épineux interne en Colombie-Britannique en 2021; du 6 au 7 décembre 2022. Secr. can. des avis sci. du MPO. Compte rendu 2023/036.

TABLE OF CONTENTS

SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on December 6-7, 2022 via the online meeting platform Zoom. The working paper presented for peer review is to provide scientific advice to support management of Inside Quillback Rockfish (*Sebastes maliger*), which applied the Management Procedure (MP) Framework (Anderson et al. 2021) to evaluate the performance of index-based and constant catch MPs to meet policy and fishery objectives.

Due to the COVID-19 pandemic, in-person gatherings have been restricted and a virtual format for this meeting was adopted. Participation included DFO Science, Fisheries Management, and external participants from Blue Matter Science Ltd., National Oceanic and Atmospheric Administration (NOAA), and Oceana Canada.

The meeting participants agreed the working paper met the Terms of Reference objectives and was accepted with minor revisions. The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) providing advice to the Groundfish Management Unit (GMU) to inform harvest advice for the Inside Quillback Rockfish fishery in accordance with the DFO Precautionary Approach (DFO 2009), and the legislated Fish Stock Provisions of the *Fisheries Act*. The advice will also inform the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reassessment of Quillback Rockfish status. 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 (RPR) meeting was held on December 6-7, 2022 via the online meeting platform Zoom to review the working paper entitled "Application of the Management Procedure Framework for Inside Quillback Rockfish (*Sebastes maliger*) in British Columbia in 2021".

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Fisheries Management Branch. Invitations to the science review and conditions for participation were sent to DFO Science, Fisheries Management staff, and external participants from First Nations, National Oceanic and Atmospheric Administration (NOAA), the commercial and recreational fishing sectors, environmental non-governmental organizations, and consultants.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting (working paper abstract provided in Appendix B). It will be developed into a Research Document and posted on the CSAS website.

Huynh, Q., Siegle, M.R., and Haggarty, D.R. Application of the Management Procedure Framework for Inside Quillback Rockfish (*Sebastes maliger*) in British Columbia in 2021. 2022. CSAP Working Paper 2016GRF02a.

The meeting Chair, Ben Davis, 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, 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, the working paper, and the two formal reviews (Appendix C).

The Chair reviewed the Agenda (Appendix D) and the Terms of Reference (Appendix A) for the meeting, highlighted the objectives and identified Yvonne Muirhead-Vert as the Rapporteur for the review. Lindsay Davidson was identified as the Rapporteur for the revisions table. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. 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 relevant information or questions. In total, 24 people participated in the Regional Peer Review (RPR; Appendix E).

Prior to the meeting, Brian Langseth (NOAA) and Mackenzie Mazur (DFO Science) were asked to provide detailed written reviews of the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of their written reviews ahead of the meeting.

The conclusions and advice resulting from this review will be used to inform fisheries managers on harvest advice for the Inside Quillback Rockfish fishery in accordance with the DFO Precautionary Approach (DFO 2009), and the legislated Fish Stock Provisions of the *Fisheries Act*. The Inside Quillback Rockfish assessment will be used in conjunction with Outside Quillback Rockfish assessment to inform the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reassessment of Quillback Rockfish status. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

GENERAL DISCUSSION

Following a presentation by the authors, the two reviewers, Brian Langseth (NOAA) and Mackenzie Mazur (DFO Science), shared their comments and questions on the working paper. The authors were given time to respond to the reviewers before the discussion was opened to all participants. The proceedings document summarizes the discussions that took place by topic, including points of clarification by the authors; questions and comments raised by the reviewers and participants are captured within the appropriate topics. The formal reviews by the reviewers are located in Appendix C.

TERMS OF REFERENCE OBJECTIVE ONE

Convert the high level strategic objectives identified at the 2021 workshop (Haggarty et al. 2022) into quantitative objectives so that their achievement can be evaluated with performance metrics.

A couple of participants mentioned that the strategic objectives identified in the 2021 workshop (Haggarty et al. 2022) were not clearly linked to the quantitative objectives in the WP. The authors have agreed to add some more text in Section 3.1 of the WP.

A participant suggested that inter-annual catch stability could be a qualified objective for continued access to the fishery. The authors indicated calculated annual changes in catch performance measures are difficult to interpret, so it was not calculated for this assessment since they saw no major changes in the catch advice given the projections. The authors explained that they reviewed the performance of the index MPs and none triggered a 50% cut-off that would result in a drop in catches.

TERMS OF REFERENCE OBJECTIVE TWO

Develop and assess a suite of operating models (OMs) and describe the uncertainties the OMs are meant to address.

Operating Models (OMs): The authors presented a total of five operating models that were developed for Inside Quillback to the group. The reference set included mean natural mortality scenarios (M=0.067, 0.055, and 0.088), whereas the robustness set looked at alternative historical depletion and future productivity. The authors noted that the robustness OMs assumed low recruitment in the future and excluded the jig survey data.

Inside Hard Bottom Longline (HBLL): The Inside Hard Bottom Longline (HBLL) survey for Inside Rockfish fishery occurs in Area 4B. Age composition samples were collected for years 2013-2019. The authors identified gaps in the survey data due to limited ship time in 2006 and 2017, and COVID-19 in 2020. They noted that samples collected in 2021 were not processed in time to be included for this assessment. Data from both the HBLL survey and jig survey provide the abundance index for Inside Quillback.

Jig Survey: The jig survey is one component of the fishery-independent catch data used to construct the abundance index that informs our understanding of Inside Quillback population dynamics. The data from the jig survey were used in both this assessment as well as the 2011 assessment. There is a focus on the Area 12 jig survey since the authors have more confidence with the data as they were collected using a standard survey methodology. Declining trends in catch rates in Area 12 are consistent with trends reported in the jig surveys throughout 4B.

The jig survey in Area 12 shows truncation in age structure over the 1986-2004 time period, in comparison to the age structure in the HBLL survey which has been more consistent since

2003. The variability in the surveys led to some of the uncertainty in the data as well as the OMs.

Fishery Data: The catch data are inclusive of the commercial, recreational, and a portion of food, social and ceremonial (FSC) catch. For the commercial catch data, the estimation of data before 2005 was generated by a reconstructive algorithm. The rest of the data came from the groundfish database for years 2006-2021. Age composition data came from the hook and line fishery (1984-2001).

The Internet Recreational Effort and Catch (iREC) data are based on a coastwide internet survey of tidal water license holders. These data were not included in this analysis since the results of the survey calibration, with creel survey data, were not available in time. The data from the creel survey (2002-2021) were used instead. The authors mentioned that they are currently comparing the creel survey to the iREC with a contractor and this work will be completed in the near future. Data used from the creel survey included some length data but did not contain any age data.

Although the FSC catch was not explicitly included in the models, it was partially included as dual-fishing events that are part of the commercial catch and effort estimates from creel overflight surveys used to expand the recreational effort. A “dual fishing” trip is when fishing for commercial and FSC purposes is done on the same trip and all of the catch is landed and weighed at the dock. The FSC portion of these trips is included in the commercial catch record in this paper. The authors explained more collaboration with First Nations will be needed to quantify the contemporary and historical FSC catch within Area 4B to reduce the uncertainty of the FSC catch for Inside Quillback.

It was mentioned that a large amount of the catch appears to be coming out of Area 12, but catch data only goes back to 2005-06. A question was raised on the amount of catch from 1975 to 2000 coming from Area 12. Participants were curious if this was a plausible assumption and if so, what is the impact on the population in Area 12 looking at the 2004 survey point. The authors noted that a proportion of catch from Area 12 is from the Groundfish Fisheries Operations System (GFFOS) system, whereas in the 1980-90s the data came from the PAC Harvest database. Prior to integration of the data, historic fishing data were less reliable. The information is from a period of time when there was less oversight of the fisheries. The authors noted that they did not have a lot of confidence in species identification and location from the fishing log books. Despite the described uncertainties, the authors have confidence in the data from 2006 onwards when the electronic monitoring came into effect.

Allocation of Catch: A participant questioned the allocation of FSC catch between outside and inside stocks. On dual fishing trips, commercial and FSC catches are unloaded on the dock and mixed together by trip. If a trip was fishing in inside and outside waters, it was hard to determine which area to include the catch in and they needed to make decisions. For example, if greater than 70% of the trips were completed on the inside of Vancouver Island then it was considered to be an “inside” catch (i.e., Area 4B). This approach to allocate catch was also used for Inside Yelloweye Rockfish (*Sebastes ruberrimus*).

Rockfish Conservation Strategy (RCS): An author mentioned that the 2004 data point from the jig survey is consistent with what was occurring in the 1990s and early 2000s for the inshore rockfish. The work conducted before the RCS identified declines in the stock, supported by declines in catch per unit effort (CPUE) in the commercial fishery, and in the jig surveys that were being conducted at the time. Commercial fishers also voiced their concern to the Department about the declines they were observing in the stock. The culmination of this work resulted in the announcement of the Rockfish Conservation Strategy in 2001. This strategy led to the implementation of 164 Rockfish Conservation Areas (RCAs), the development of HBLL

survey, major catch reductions were put in place, and the development of catch reporting (i.e., electronic monitoring and at-sea observers) for rockfish in all fisheries. The authors suggested that they could cite some of the papers and provide information in the WP to characterize this time period. They agreed to include an explanation on why robustness OM A is in the robustness set instead of being viewed as a more realistic scenario to include as a reference OM.

Another author presented a slide on the commercial catch by sector which shows the high commercial catch of rockfish in the mid-1980s which could provide some context on why the stock had declined by the early 2000s. The authors believe this is another piece of evidence on why the low abundance observed in the 2004 jig survey is a realistic data point.

Weighting of Reference OMs: The weighting across the three OMs was equal (1/3 each) since it was the simplest to use. The authors preferred M=0.067 since the value is based on the best predictor using life history traits including maximum observed age. A reviewer suggested that the decision should be made beforehand on the weighting of the OM before the models are run.

The authors would like more discussion and guidance on OM weighting, as there could be equally scientifically defensible justifications for different weighting schemes. Values and non-scientific justifications will also need to play a role in selecting an OM weighting scheme. Inside Quillback is a test case for this approach and the approach needs further exploration and discussion.

There is a possible philosophical mismatch when OMs are weighted to convey greater credibility within the reference set, where projections may come across as a forecast instead of an evaluation of MPs across uncertainties. A participant did not like the idea of weighting the OM and preferred to have a probability of model approach and do it empirically. They suggested evaluating the models individually so MP performance can be shown across the different uncertainties represented in the OMs.

It is difficult to determine stock status from individual OMs. The MP framework is designed to avoid the question of determining stock status. Participants suggested in previous stock assessments on other species that a MP approach is better for taking into account uncertainties compared to traditional stock assessment approaches. However, the group is still tasked with deciding how to use the OMs in order to generate a single stock status for reporting purposes.

There was a question on how to decide which OM(s) to use for reporting purposes. A participant suggested that fit of data could be used to compare the index fit and weight the models accordingly. There is a guidance document coming out of Ottawa in the near future that suggests the use of equal weighting across OMs. Decision of weighting should occur before the results are known.

Data Weighting: The authors proceeded with re-weighting the indices of abundance, which in most cases down-weighted the jig index. An alternative distribution (multivariate logistic distribution) for the age composition, following the iSCAM model, was tried and the data did not fit as well since it picked out a single cohort from the jig survey that was not apparent in the HBLL survey. It appears that the 2004 data point has a large effect in the Area 12 jig survey. A Francis weighting was tried and it down-weighted the variance of mean age. A participant suggested that there are alternative weighting methods that could be included in the WP, however it was deemed unnecessary for this work

Steepness (h) of the Stock Recruit Relationship: With 200 replicates, the estimated mean steepness was calculated to be 0.71 with a standard deviation (SD) of 0.15. The steepness value has a wide range of values and Figure 32 of the WP shows that the value of steepness influences the estimated status of the population. The OM with no jig survey data provided the

most optimistic scenario of the estimated stock status compared to the other OMs by showing the majority of the replicates in the Healthy zone.

Dogfish Survey: The dogfish index was not included for the Inside Quillback assessment. A hook comparison study of j to circle hooks was conducted in 2004 to compare the two hook type used on the dogfish survey but no Quillback were caught during the comparison because the study purposely fished in deeper depths to avoid catching Yelloweye and Quillback species. The dogfish survey was completed every 3-5 years and includes differences in gear, season and bait. Calibration/comparison survey work between the Dogfish and HBLL surveys was completed in 2019, 2022, and is planned for 2023. This comparison work may include a comparison between circle hooks and j hooks (which are no longer used by industry or in our surveys).

Rapid Conditioning Model (RCM): Four of the operating models conditioned using RCM showed that most declines occurred prior to the index series of the observer long line survey. Clarification was sought on what RCM was estimating since it was not clear. They wondered if the model was estimating F and recruitment or biomass and abundance. The authors agreed to add more text in the WP to explain this.

Age Structure: There were two reasons to highlight the estimation of age structure in these analyses. In contrast to the 2011 assessment, an age-structured model was employed (as opposed to a surplus production model which was used in 2011) to compare observed age structure to equilibrium age structure at different biomass levels (i.e., how does the observed age structure compare to the predicted equilibrium age structure if biomass is at the limit reference point).

TERMS OF REFERENCE OBJECTIVE THREE

Consider environmental conditions that may affect the stock as presented in the Guidelines for Implementing the Fish Stocks Provisions in the Fisheries Act.

Fish Stock Provisions: There was a lengthy discussion on whether or not the stock was in the Healthy or Cautious zone since there is an estimated 52% probability that the stock is above the upper stock reference (USR) of 80% B_{MSY}. The authors felt that they should err on the side of caution since the stock could be above or below the USR.

A participant noted that the domestic fish policy indicates that the stock >50% would be moderately high so the stock would be considered to be in the Healthy zone. After reviewing both policies, the group decided not to provide stock status to management for Inside Quillback but provide the probabilities based on the lower reference point and USR instead.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Quillback Rockfish has been assessed as “Threatened” and requires a reassessment every 10 years (COSEWIC 2009). A reference MP was generated to provide an example of “no fishing” to estimate stock biomass in the absence of fishing. The findings from this Research Document may be used to inform COSEWIC’s next assessment.

TERMS OF REFERENCE OBJECTIVE FOUR

Recommend candidate reference points including a limit reference point (LRP) and upper stock reference point (USR) consistent with the DFO Precautionary Approach. Additionally, characterize the stock status relative to the LRP, USR, and if possible, B_{MSY} and B_0.

Reference points: The provisional DFO limit reference point (LRP) of $0.4B_{MSY}$ and the upper stock reference (USR) of $0.8B_{MSY,}$ as recommended by the DFO Precautionary Approach policy were used for this assessment.

The client requested a table to be provided for reporting on significant estimates coming out of the model and values for biomass harvest rate similar to a table that was generated in a recent CSAS Sablefish assessment[1]. The requested values for the table were provided to the authors.

An assumption of this assessment is that there is only one stock for Inside Quillback, which may not be supported by population genetic structure. A genetic study is currently underway to determine if the inside and outside stocks are genetically distinct.

TERMS OF REFERENCE OBJECTIVE FIVE

Propose a set of candidate management procedures (MPs) and test the candidate MPs across the suite of OMs using a closed-loop simulation.

MPs: The authors presented a suite of constant catch MPs, index-based MPs, and reference MPs (no fishing removals and F_{MSY} reference) that were developed and explored for this assessment. All candidate MPs met the satisficing criterion of being above the LRP after 1.5 generations with a probability at or above 75% when averaged across the reference OMs.

Constant Catch: A reviewer asked what makes the 2012-2019 status quo conditions in the WP. The authors indicated that 33 tonnes was the average catch during 2012-2019, which was used to derive a fishery catch objective. It was suggested that more text could be added to the WP to explain this as well as providing text on the uncertainty in the historical catches. The suggestion was made to explore the effects on the historical catch (known imprecisely for most years prior to 2006) in the WP by using ratios to bound uncertainty, draw from a distribution of catches similar for steepness and mortality, and consider alterative values of the catch.

F-Based MP: Science advice to Fisheries Management is typically in the form of decision tables. A reviewer asked if it would be beneficial to include the results of an F-based MP to provide advice on the commercial total allowable catch (TAC) and recreational multispecies bag limit. The authors noted that F-based MPs were not explored except for F=0 and $F=F_{MSY}$ and noted that the adjusted effort base would be difficult to translate to the MPs. The index based MPs can adjust to catch but may not make large changes in the catch. A target harvest rate was not identified in this assessment.

F_{MSY}: The authors provided a slide on a F_{MSY} REF MP showing how it adjusts perfectly to stay above the LRP. One of the challenges with this reference MP is communicating these results, as the MP includes perfect information and perfect implementation, which is not feasible in any real-world context. The authors suggested that the index MP is what can be implemented in reality when determining annual catch.

The authors explained that fishing cannot be expected to occur according to the F_{MSY} REF MP since it is a 'perfect world' scenario, including perfect information and perfect implementation, for each separate operating model. It was suggested that the information regarding F_{MSY} could assist with the leveraging of more resources to conduct more surveys and collecting biological sampling to reduce uncertainties.

[1] Johnson, S.D.N., Cox, S.P., Holt, K.R., Lacko, L.C., Kronlund, A.R., and Rooper, C.N. In prep. Stock status and management procedure performance for the BC Sablefish (*Anoplopoma fimbria*) fishery for 2022/2023. DFO. Can. Sci. Advis. Sec. Res. Doc.

The group agreed that the calculations and plots containing the F_{MSY} REF MP should be removed from the body of the research document in the MP comparison table and inserted into an appendix. The topic of F_{MSY} REF MP will not be discussed in the SAR, since there are some concerns around misinterpreting this MP.

Spatiotemporal Modelling: A participant asked if the Akaike information criterion (AIC) values could be compared across models. The authors indicated that they could not be since they have different random effects structures.

TERMS OF REFERENCE OBJECTIVE SIX

Review the simulation results and demonstrate potential trade-offs between achieving different objectives under different MPs, including catch and index-based MPs.

MP Tradeoffs: There are a number of tradeoffs among MPs. A participant wondered why the results were only plotted for a subset of the MPs in the trajectory plots. The authors mentioned that the tradeoff plots that contained all MPs were cluttered. A suggestion was made to add a comprehensive appendix for all MPs and show why the subset of MPs were chosen in the research document. Similarities across MPs could also be stated within the appendix.

Index-based MPs: A participant asked if the calculation of the index includes an autoregressive term. They suggested looking at diagnostic plots individually and together. They also wondered how the index reflects the true biomass. The authors indicated that there was high autoregression in the observation error, as informed by the residuals from the operating model conditioning. Thus, MPs were evaluated against a relatively imprecise index. There also was not a lot of variance in index trajectory among candidate MPs.

HBLL: For the projected biomass and HBLL index, it may be better to show the median instead of the outcomes of two simulations since the selectivity is right-shifted and some of the mature biomass is not selected. A question was raised about the observation error in the projections. The authors indicated that there is autocorrelation carried over and it is possible to view the different trends in the biomass over the index.

200 Simulations: A participant asked if the 200 iterations were enough. The authors mentioned that after 150 simulations the performance measure related to the LRP stabilized. A participant suggested including the failed simulations and projections within an appendix.

A reviewer asked if any of the satisficing requirements were removed to meet the 75% requirement for MPs to maintain the stock above the LRP. The authors indicated that the probability was calculated using all 200 simulations, and no MPs were removed.

Generation Time: The generation time (GT) for Quillback was calculated to be 24 years for this assessment, which is slightly less compared to the 2011 assessment that used 28.5 years. The GT is based on the natural mortality value of 0.067 and 50% maturity at 8.7 years. The projections were generated from for 72 years or three generations for Inside Quillback.

Future Research

Collaborators: It was recommended that DFO continues to work with commercial fishers, recreational fishers, and First Nations to collect catch and biological data.

Ecosystem Considerations: Environmental variables (such as temperature and oxygen) changing within the ecosystem due to climate change impacts or productivity regime shifts could cause rapid change within the food web structure for Inside Quillback. It is important to continue monitoring trends in population productivity and re-assess MPs if survey indices show a large change.

Predators: Predation could have an effect on the estimates of natural mortality. The abundance of predators such as pinnipeds and Lingcod may be evaluated in Area 4B at some point, but the proportion of Quillback being preyed upon is currently unknown.

Rockfish Conservation Areas (RCAs): It is recommended that data from the Remotely Operated Vehicle (ROV) survey in 2018 and the development of a monitoring plan for marine spatial planning be incorporated into stock assessments and OMs.

OM Development: Continue OM development to evaluate how to weight future models and review the robustness of the OM by using a range of steepness and time varying M. It was suggested that the CPUE from the recreation fishery could be included as an OM.

Dogfish Survey Calibration: There was discussion of a hook comparison experiment to standardize the dogfish data from 1986/1989 to calibrate the survey for Quillback Rockfish.

TERMS OF REFERENCE OBJECTIVE SEVEN

Recommend an appropriate assessment frequency and any conditions for exceptional circumstances that warrant reevaluating the OMs.

Reassessment Frequency: It was suggested that a CSAS Science Response process could be used to provide advice on updated MPs in two years. This allows for inclusion of survey information for both the south and north regions, which are surveyed in alternating years.

It was recommended that the OM and stock status should be re-evaluated in five to six years through the CSAS Regional Peer Review process since Quillback is a long-lived species that recruits late at an older age. Based on the discussions at the 2021 workshop, participants suggested that a reassessment should occur every 7-8 years, which happens to correspond to the age of 50% maturity. Using a 5-6 year timeframe would enable new recruits to enter the fishery and have some turnover within the population. Another participant added that the 5-6 year time frame would be appropriate in the context of rapidly changing environmental conditions due to the effects of climate change on shorter time scales.

Triggers for Reassessment: Exceptional circumstances detection protocols to trigger a re-evaluation of MP performance were reviewed. Possible triggers could be a change in the observed index of abundance and mean weight from the HBLL or through informal evaluation procedures (i.e., a comparison of observed versus projected data). There was recognition of the importance of re-evaluating the MP and OMs on a regular basis to ensure they reflect our current understanding of the fishery and the population.

CONCLUSIONS

Meeting participants agreed the working paper satisfied the Terms of Reference objectives, and the working paper was accepted with minor revisions. The group was shown the revisions table listing the revisions agreed upon by the authors.

RECOMMENDATIONS AND ADVICE

DRAFTING OF THE SCIENCE ADVISORY REPORT

One of the authors agreed to track changes on the draft Science Advisory Report (SAR) while it was being discussed with participants during the meeting. The SAR was discussed at length and participants had the opportunity to contribute to key sections. At the end of the meeting, a draft of the SAR bullet points was completed. The meeting Chair worked with the authors to

finalize the draft SAR. Once completed, the Centre for Science Advice Pacific (CSAP) office will circulate the draft SAR and draft proceedings to all participants for final review and input.

ACKNOWLEDGEMENTS

The Centre for Science Advice Pacific (CSAP) congratulates the authors on a successful paper and appreciates the contribution from all participants. Thanks are extended to the formal reviewers, Brian Langseth (NOAA) and Mackenzie Mazur (DFO Science) for their time and expertise for providing their formal reviews of the working paper and to Ben Davis for chairing the meeting.

REFERENCES CITED

Anderson, S.C., Forrest, R.E., Huynh, Q.C., and Keppel, E.A. 2021. A management procedure framework for groundfish in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/007. vi + 139 p.

DFO. 2009. A fishery decision-making framework incorporating the precautionary approach.

Haggarty, D.R., Siegle, M.R., Litt, M.A., and Huynh, Q. 2022. Quillback Rockfish Fishery and Conservation Objectives Workshop Summary Report. Can. Tech. Rep. Fish. Aquat. Sci. 3488: viii + 56 p.

APPENDIX A: TERMS OF REFERENCE

Application of the Management Procedure Framework for Inside Quillback Rockfish in British Columbia in 2021

Regional Peer Review – Pacific Region

December 6-7, 2022
Virtual Meeting

Chairperson: Ben Davis

Context

Quillback Rockfish (*Sebastes maliger*) are a wide-spread marine fish that occur in all British Columbia's (BC's) coastal waters. Quillback Rockfish are targeted in hook and line commercial fisheries, Food Social and Ceremonial (FSC) fisheries, and recreational fisheries.

Fisheries and Oceans Canada (DFO) manages two Quillback stocks: an inside stock that occupies the waters in Queen Charlotte Strait, the Broughton Archipelago and the Salish Sea, and an outside stock that corresponds to all other waters in BC. In 2009, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Quillback Rockfish as a single coastwide species, comprised of both inside and outside stocks, and designated it as Threatened. While a decision by Governor in Council to list this species under the *Species at Risk Act* (SARA) is still pending, COSEWIC is still required to review the classification of each species at risk every 10 years (s.24 of SARA). In order to support implementation of SARA, updated scientific information and advice on the current status of these two stocks is required.

DFO Fisheries Management (Groundfish Management Unit; GMU) has requested that Science Branch review existing fishery, biological and survey data to recommend candidate reference points for inside Quillback Rockfish, and, if possible, to provide guidance and rationale on alternative reference points to the provisional MSY (maximum sustainable yield)-based reference points. The analysis, and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR), will be used by GMU to inform harvest advice for the inside Quillback Rockfish fishery in accordance with the DFO Precautionary Approach (DFO 2009), and the legislated Fish Stock Provisions of the *Fisheries Act*. Outside Quillback Rockfish will be covered in a subsequent CSAS process, which, together with this Inside Quillback Rockfish assessment will inform the COSEWIC reassessment of Quillback Rockfish status.

To provide fishery managers with the best available advice, DFO Science will be following the Management Procedure (MP) Framework for groundfish species (Anderson et al. 2021). The MP Framework uses closed-loop simulation to evaluate the robustness of management procedures to achieve fishery and conservation objectives across plausible states of nature. This approach is particularly well-suited for data limited stocks with major uncertainties in stock dynamics, such as inside Quillback Rockfish. As part of the MP Framework, fishery and conservation objectives and performance measures were previously identified in a workshop series in March 2021 (Haggarty et al. 2022a) with DFO scientists and managers, Indigenous representatives and knowledge-holders, commercial and public fishing representatives, non-governmental organizations, and scientists.

Objectives

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

Quang Huynh, Matthew R. Siegle, Dana R. Haggarty. Management Procedure Framework for Inside Quillback Rockfish (*Sebastes maliger*) in British Columbia in 2021. 2022. CSAP Working Paper 2016GRF02a.

The specific objectives of this review are to:

1. Convert the high level strategic objectives identified at the 2021 workshop (Haggarty et al. 2022a) into quantitative objectives so that their achievement can be evaluated with performance metrics.
2. Develop and assess a suite of operating models (OMs) and describe the uncertainties the OMs are meant to address.
3. Consider environmental conditions that may affect the stock as presented in the Guidelines for Implementing the Fish Stocks Provisions in the *Fisheries Act*.
4. Recommend candidate reference points including a limit reference point (LRP) and upper stock reference point (USR) consistent with the DFO Precautionary Approach. Additionally, characterize the stock status relative to the LRP, USR, and if possible, B_{MSY} and B_0.
5. Propose a set of candidate management procedures (MPs) and test the candidate MPs across the suite of OMs using a closed-loop simulation.
6. Review the simulation results and demonstrate potential trade-offs between achieving different objectives under different MPs, including catch and index-based MPs.
7. Recommend an appropriate assessment frequency and any conditions for exceptional circumstances that warrant reevaluating the OMs.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, Fisheries Management)
- Academia (e.g., Simon Fraser University)
- Indigenous communities and organizations (e.g., A-Tlegay Fisheries Society, Cowichan Tribes, Island Marine Aquatic Working Group, Tlowitisis First Nation Guardian Program, Tla'amin Nation, shíshálh Nation)
- Industry (e.g., Sport Fishery Advisory Board, Pacific Halibut Management Association, BC Dogfish Hook & Line Industry Association, Commercial Industry Caucus)
- Environmental non-government organizations (e.g., David Suzuki Foundation, Oceana)
- Consultants (e.g., Blue Matter Science Ltd., Landmark Fisheries, LGL)

References

Anderson, S.C., Forrest, R.E., Huynh, Q.C., and Keppel, E.A. 2021. A management procedure framework for groundfish in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/007. vi + 139 p.

DFO. 2009. A fishery decision-making framework incorporating the precautionary approach.

Haggarty, D.R., Siegle, M.R., Litt, M.A., and Huynh, Q. 2022a. Quillback Rockfish Fishery and Conservation Objectives Workshop Summary Report. Can. Tech. Rep. Fish. Aquat. Sci. 3488: viii + 56 p.

APPENDIX B: ABSTRACT OF WORKING PAPER

The purpose of this project is to provide scientific advice to support management of Inside Quillback Rockfish (*Sebastes maliger*). The stock is expected to be prescribed as a major fishstock, at which time its sustainable management will be legislated under the Fish Stocks Provisions of the Fisheries Act. This analysis applied the Management Procedure (MP) Framework, recently developed for BC groundfishes, to evaluate the performance of index-based and constant catch MPs, with respect to meeting policy and fishery objectives.

To account for uncertainty in underlying population dynamics and data sources, we developed five alternative operating model (OM) scenarios, which differed with respect to specific model and data assumptions. Operating models were conditioned on historical catches, indices of abundance, and age composition. Three reference OMs varied on the assumption of the natural mortality value for Inside Quillback Rockfish. Two additional robustness OMs were developed, with one developed by excluding a historical jig survey in Area 12, and another that modeled lower than average recruitment in the projection. The reference OMs indicated the stock was above the LRP (0.4 BMSY) with at least 50% probability in 2021.

Two fixed catch MPs of 33 tonnes (the average catch during 2012-2019) and 41 tonnes (125% of the 2012-2019 mean) and eight index-based MPs that adjust the catch based on the recent trend in the index of abundance from the inside hard-bottom longline (HBLL) survey were tested in the closed-loop simulations. In the reference set, all MPs passed the proposed satisficing criterion with the stock exceeding the LRP with at least 75% probability after one generation (24 years). The satisficing criterion was also met in both robustness operating models.

Visualizations present trade-offs in tabular and graphical formats to support the process of selecting the final MP. There is a trade-off between biomass and fishery catches after one generation. Tradeoffs in short-term and long-term catch were evident only when evaluating over longer time scales (after one vs. three generations or after 24 vs. 72 years).

We propose operating models to be identified in the reference set when used to identify stock status. We also provide future research recommendations regarding commercial fishery biological sampling and Food, Social, and Ceremonial (FSC) catch. We make recommendations to use the HBLL index of abundance and HBLL mean weight to identify triggers for future re-assessment.

APPENDIX C: WORKING PAPER REVIEWS

WRITTEN REVIEW

Date: November 23, 2022

Reviewer: Dr. Brian Langseth, NOAA Fisheries, Northwest Fisheries Science Center, Seattle WA.

CSAS Working Paper: 2016GRF02a

Working Paper Title: Application of the Management Procedure Framework for Inside Quillback Rockfish in British Columbia in 2021

Preface

This document is my review of "the working paper" (Huynh et al. 2022) describing the management procedure framework for Inside Quillback Rockfish in British Columbia in 2021. I divide this review into two parts. The first part contains direct answers to the questions in the review template. The second part emulates my approach to reviewing journal articles, and contains my thoughts on the elements of the working paper, organized with major comments first, followed by minor comments. I include recommendations along with my major comments. These two parts are at times complementary, and at times distinct, but are meant to be viewed together to reflect the full scope of my review.

To enhance transparency in this review, the following are documents I read in their entirety:

1. Huynh, Q.C., Siegle, M.R., and Haggarty, D.R. 2022. Application of the management procedure framework for Inside Quillback Rockfish (*Sebastes maliger*) in British Columbia in 2021. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/nnn. iv + 151 p.
2. The Terms of Reference
3. DFO. 2009. A fishery decision-making framework incorporating the precautionary approach.

The following are documents I read only partially or on an as needed basis:

a. Anderson, S.C., Forrest, R.E., Huynh, Q.C., and Keppel, E.A. 2021. A management procedure framework for groundfish in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/007. vi + 139 p.
b. Haggarty, D.R., Siegle, M.R., Litt, M.A., and Huynh, Q. 2022a. Quillback Rockfish Fishery and Conservation Objectives Workshop Summary Report. Can. Tech. Rep. Fish. Aquat. Sci. 3488: viii + 56 p.
c. Guidelines for Implementing the Fish Stocks Provisions in the *Fisheries Act*

Also to enhance transparency, the reason I accepted this review is because I have experience conducting domestic (to the United States) and international stock assessments, including the most recent stock assessments for quillback rockfish along the west coast of the United States, which is cited in the working paper.

Part 1 – Answers to questions from review template

1. Is the purpose of the working paper(s) clearly stated?

Answer: Yes. The purpose of the working paper is stated in the abstract and is "…to provide scientific advice to support management…". I believe the working paper does that.

2. Has the working paper fulfilled the Terms of Reference objectives?

Answer: Overall, yes. My response to each objective from the terms of reference are below.

a. Convert the high level strategic objectives identified at the 2021 workshop (Haggarty et al. 2022a) into quantitative objectives so that their achievement can be evaluated with performance metrics.

Answer: Yes, but can be improved. There are no strategic objectives listed in Haggarty et al. (2022a) so I am assuming the objectives are described under the "Key considerations for the stock assessment" section of Haggarty et al. (2022a). Four quantitative objectives were provided in section 3.1 of the working paper. I believe these capture the first consideration that "stocks should be ecological, economic, and culturally sustainable", which is the broadest goal listed. Key considerations #2 and #4 were fleet specific, and results by fleet were not provided in the working paper. Im not actually sure whether this can be done in the current framework given a single aggregated fleet is projected into the future. Similarly, the key considerations around "protect peak fecundity" and "concern over the accuracy of removal estimates" were also not addressed, with the later being fairly easy to incorporate by either setting implementation error to not be 1 for future values or exploring alternative historical catch streams for past values (see my major comment 3 in Part 2).

b. Develop and assess a suite of operating models (OMs) and describe the uncertainties the OMs are meant to address.

Answer: Yes. Uncertainties in natural mortality (M), an uncertain yet important parameter, form the basis of the reference OMs. Robustness OMs address uncertainties around the jig survey, and the magnitude of future recruitment. Steepness also varied for each model run. Uncertainties not addressed that could also be considered are uncertainty around historical catch (though I appreciate the effort to account for known omissions), and alternative choices for sample sizes (i.e. weighting) of the respective composition sources.

c. Consider environmental conditions that may affect the stock as presented in the Guidelines for Implementing the Fish Stocks Provisions in the *Fisheries Act*.

Answer: Yes. The authors include alternative values for M that are implicitly linked to predation mortality. The authors also describe an alternative recruitment condition, which more explicitly accounts for changes in the environment.

d. Recommend candidate reference points including a limit reference point (LRP) and upper stock reference point (USR) consistent with the DFO Precautionary Approach. Additionally, characterize the stock status relative to the LRP, USR, and if possible, BMSY and B0.

Answer: Yes. Reference points are clearly defined in section 3.2. Stock status is clearly described in section 7.3 with respect to BMSY. Status with respect to B0 is also provided in Figures 29, 31, 33, 34.

e. Propose a set of candidate management procedures (MPs) and test the candidate MPs across the suite of OMs using a closed-loop simulation.

Answer: Yes. MPs are described in section 5. Im not clear why fishing mortality based MPs were not also explored. The reference MPs provide this to an extent but other policies could have been considered. See more in major comment 2 of Part 2, below.

f. Review the simulation results and demonstrate potential trade-offs between achieving different objectives under different MPs, including catch and index-based MPs.

Answer: Yes, in Figures 39-46. See my minor comments 3 in Part 2, below, about making these figures more understandable.

g. Recommend an appropriate assessment frequency and any conditions for exceptional circumstances that warrant reevaluating the OMs.

Answer: Yes, in section 7.6

3. Are the data and methods adequate to support the conclusions, and explained in sufficient detail?

Answer: Yes. The working paper is well organized. The data are described adequately, and I appreciate seeing the fits to data during model conditioning. The methodology seems to have been approved, and is described extensively elsewhere.

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

Answer: Yes, but could be improved. The document provides guidance for decision-makers and provides tradeoffs between differing performance metrics across varying time periods. I offer improvements to better reflect uncertainty in Part 2, major comment 1a and 1b, below.

5. Can you suggest additional areas of research that are needed to improve the working paper?

Answer: Please see recommendations in the major comment section in Part 2, below.

Part 2 - Open ended comments and recommendations

I commend the authors for providing materials that are understandable and easy to navigate, which make my role in reviewing easier. It is apparent that a lot of work has gone into this working paper and the supporting documentation. Additionally, management frameworks require work beyond those writing working papers. Setting up objectives, metrics to gauge progress towards objectives, and defining management procedures are crucial steps for closed-loop management frameworks. I commend workshop participants for engaging in this effort.

Major comments:

1. I am concerned that conditioning of the observation model using the RCM may be heavily influenced by the assumption in weighting the HBLL age composition data relative to other data sources, and by the value of the jig survey in 2004. a. Weighting: The authors used a maximum sample size of 100 in fitting the HBLL age composition data to the multinomial distribution. This is higher than the 50 used for the jig survey, the fishing events for the commercial age compositions, and the PFMA areas for the recreational length compositions. Composition data is often down-weighted to preferentially fit indices when both data sources are available. I understand that a value must be selected, and acknowledge the range selected is typical, but statistical methods are available (e.g. McAllister and Ianelli 1997; Francis 2011) and could be used to explore the implications of the authors choices. I see no exploration of alternative weighting either among the composition data, nor between the

composition data and the indices. The poor fit to the indices (Figures 5-6) indicate composition data are driving the conditioning of the OM. The fits to the respective compositions are harder to compare (bubble plots would be more informative). The HBLL age composition varies very little based on Figure 38, and thus weighting the HBLL data heavily, even though I understand why, has the potential to set the model in a certain state that other data sources may provide less evidence for.

RECOMMENDATION: Consider statistical analysis for weighting data to explore uncertainties in the assumptions made by the authors around sample size and explore possible tradeoffs in the data.

b. Jig survey: I consider the jig survey to be an index between two points; the values in the 1980s and 1990s, and the value in 2004. Catches were high between these time periods, and the age data in 2004 show some compression towards younger fish. Those pieces of evidence combined with a decline in the index support the general decline in the population as shown by the conditioned OM, and the lack of decline when the jig survey is removed (Figure 29). The jig survey is included in the reference set, which I think it should be, in part because it is conservative to the stock, and the authors appropriately include a robustness case of an OM without the jig survey. However, Im concerned that the reference OMs may be largely driven by the single value of the index in 2004, which according to Section B.2 is based on sampling ten sites over two days, and according to

   Table B.3 had the highest proportion of zeros. Moreover, the pattern of the dogfish survey appears to show an opposite pattern to that of the jig index (Figure B.17). The authors provide performance metrics for the robustness OMs in Figure 40 for managers to consider, but do not convey results in other performance figures (Figures 41-46).

   RECOMMENDATION: Additional data showing a similar decline in the population prior to 2004 as observed in the jig index would mitigate against a seemingly strong reliance on a single datum.

   FUTURE RESEARCH RECOMMENDATION: Would it be possible to conduct a hook comparison experiment in the dogfish survey using two sizes of hooks, those in recent years and those in 1986 and 1989? One would have to assume the population structure is the same, which is likely not the case, but it could provide evidence that the low values in 1986 and 1989 are indeed due to differences in hook size and not due to a smaller population size than in the 2000s.

2. Im unclear why F-based management procedures were not explored? These are well studied and provide alternatives to catch-based management procedures, many of which appear to have similar performance metrics. The authors use Fmsy for the reference procedure but I don't see why a procedure between 0 (the other reference procedure) and Fmsy can't be applied. The authors state in line 555 of the working paper that "The MP Framework currently only considers MPs that make catch recommendations, because most groundfish stocks are managed by quotas and commercial TACs" however I do not see how that precludes an F-based procedure. Catch can be set to match a fishing mortality rate, and the Fmsy performance measure the authors use shows me that F and Fmsy are reported.

   My rationale for this is that the probability that the population is above 40% and 80% of Bmsy is usually high at the end of the projection periods, and thus constant catch policies are forgoing potential yield. I understand there are other objectives than catch (e.g. stability of catch), but excluding F-based policies precludes consideration of those tradeoffs.

   RECOMMENDATION: Consider F-based policies or describe more clearly in the working paper why these policies are not considered.

3. Extensive work was done to estimate historical catches. I commend the authors for accounting for unknown aggregate catches as well as unreported catches. While I commend the authors efforts, uncertainty in historical catch (as well as the magnitude of FCS) could be included in robustness OMs. Simple assumptions such as a ratio to increase or decrease catch in historical years could provide a measure to decision-makers of the importance of uncertainty in historical catch. I acknowledge the magnitude of the effect would depend on the ratio selected, but the purpose would be to explore the ranges of uncertainty, and therefore I believe could be informative.

   RECOMMENDATION: Consider alternative values for historical catch to bound the possible range of uncertainty on performance metrics.

4. The authors are inconsistent in their treatment of the assumed uncertainty around natural mortality (M). In section D.1.2 of the working paper the authors indicate a clear preference for M = 0.067. I agree with this preference given the expected form of heteroscedasticity in M (Hamel 2015). In contrast to this assumption however, the authors weight each reference OM equally. If the authors prefer a certain value for M, why weight each reference OM equally? Only one performance metric figure presents results for each reference OM separately (Figure 39) while the others (Figures 41-46) aggregate across reference OMs. Decision-makers are therefore provided results averaged over OMs and are not able to weigh tradeoffs across values of M. A consistent treatment on the belief in M should be applied. Alternatively, the value of M most supported by the data could be determined based on the value producing the lowest negative log likelihood during OM conditioning.

   RECOMMENDATION: Use weightings for the reference OMs that are consistent throughout the working paper. Either adjust weightings for the reference OMs or make it clear in the working paper that the three values for M were equally likely.

Minor comments:

1. The values of steepness (Figure D.2) effectively covered all possible values for the parameter. Was a more constrained (to nearer to the mean) range of values around the mean considered, perhaps based on meta analyses? I acknowledge that a normal distribution with mean 0.67 and sd 0.17 generally matches the beta distribution used, but I have a hard time believing quillback rockfish have steepness values much above 0.9 or below 0.5.
2. Can you explain why in figure 28, the ratio of B/Bmsy for the OM with M = 0.067 is nearly equal to the USR (0.8BMSY)? I understand it could be coincidence but perhaps something is fixed during conditioning.
3. I recommend that additional explanation be provided for the performance metrics figures (Figures 39-46). These figures are important for the public and decision makers to understand the work done. I had difficulty interpreting them. Specifically, I recommend colors be consistent across performance metrics (it appears the colors are specific to their columns), and that a legend be provided to understand the values of coloring. The legend is not as necessary for performance metrics with probabilities but is helpful for interpreting the catch based metrics, which the caption says represent probabilities but which appear to represent catch instead.
4. I would have liked to see more rationale for why a lower recruitment robustness OM was used. Figure 35 suggests recruitment has been low in recent years, and therefore I can guess the rationale but I would rather have it articulated in the working paper.

References:

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68(6): 1124–1138.

McAllister, M.K., and Ianelli, J.N. 1997. Bayesian stock assessment using catch-age data and the sampling - importance resampling algorithm. Canadian Journal of Fisheries and Aquatic Sciences 54: 284–300.

Hamel, O.S. 2015. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science: Journal du Conseil 72(1): 62–69.

WRITTEN REVIEW

Date: November 24, 2022

Reviewer: Mackenzie Mazur, DFO

CSAS Working Paper: 2016GRF02a

Working Paper Title: Application of the Management Procedure Framework for Inside Quillback Rockfish in British Columbia in 2021

1. Is the purpose of the working paper(s) clearly stated?

The purpose of the working paper is clearly stated in the Introduction section. The purpose is to "provide scientific advice to support management of the inside stock of Quillback Rockfish".

2. Has the working paper fulfilled the Terms of Reference objectives?

The paper has fulfilled the TOR objectives. However, some clarification would be helpful to assess the degree to which the TOR objectives have been fulfilled.

TOR 1: The strategic objectives identified at the 2021 workshop were converted into quantitative objectives. However, its not clear what the strategic objectives were from the working paper. It would be helpful if the strategic objectives that link to the quantified objectives in Section 3.1. were briefly described. It also seems that not only catch but catch stability (i.e. interannual variability in catch) could be an important quantified objective given the strategic objective for continued access for the fishery.

TOR 2: A suite of OMs (reference and robustness OMs) were developed and assessed and the uncertainties that the OMs address are described.

TOR 3: Environmental conditions that may affect the stock were considered indirectly in the OMs. OMs considered a variety of natural mortality and recruitment assumptions which would be impacted by environmental variables.

TOR 4: Candidate reference points are recommended. The LPR and USR are consistent with the definitions in the PA Framework and the 2011 stock assessment. Stock status is characterized relative to reference points.

TOR 5: A set of candidate MPs are proposed and are tested across the suite of OMs using closed-loop simulation.

TOR 6: Simulation results are presented and trade-offs under different MPs are illustrated. However, more details on the subset of MPs used in trajectory plots would be helpful. Are these the best performing MPs? As the trajectories are an important component of MP evaluation, I suggest more details on the choice of the subset.

TOR 7: An assessment frequency of two years is recommended. Exceptional circumstances that warrant revaluating the OMs are discussed.

3. Are the data and methods adequate to support the conclusions, and explained in sufficient detail?

The data and methods support the conclusions, but some clarification would be beneficial:

It seems like not all the questions are addressed in Section 2: Decision Context: What is the time frame for making the decision? and What are specific roles and responsibilities of parties involved?

Regarding the RCM model, does it estimate F and recruitment or does it also estimate biomass and abundance? This is a little unclear in the text as some sentences state different estimated metrics (Lines 309-311 vs. Lines 448-449).

For OM B, a plot of the recruitment deviation time series (historical and projected) would be helpful for the reader to visualize the magnitude and uncertainty in recruitment in the projection period.

More information on why 2012-2019 reflects status quo conditions would be helpful. Also if 2012-2019 reflect status quo conditions, why not use that those years for a historical period for an index-target MP?

Is 200 iterations enough? Figures 30 and 31, which show somewhat irregular shaped distributions, may suggest more iterations are needed.

Clarification on the results of the spatiotemporal modelling in Appendix B would be helpful. What about the AIC of model 1? Does model 1 have the same issue as model 2 with extrapolating a fixed parameter out of the survey range? Where are the depth data from?

More description of the iRec data would be useful. It seems like it could be valuable information. What calibration is necessary?

In Appendix C.3, it is not clear how it is known if 70% of the total catch is from inside waters if the data is only available at the trip level. Why add 50% of the catch from trips with total catch >70% inside (i.e. how is 50% determined)?

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

Recommendations are provided in a useable form and advice reflects uncertainty. Applying the MP framework especially allows the working paper to reflect uncertainty. The plots (especially Figures 44-46 and Figure 49) are excellent at showing the impacts of alternative OMs, trade-offs among MPs, and reflecting uncertainties.

5. Can you suggest additional areas of research that are needed to improve the working paper?

The authors mentioned future areas of research, which I agree with. However, I do have some thoughts regarding the text on future collaborations with First Nations. Collaborations with First Nations can extend beyond and do not have to focus on resolving uncertainties in FSC catch information. For example, Indigenous Knowledge could be used to inform parameters in OMs. Ultimately this would depend on agreements with the DFO and First Nations.

I also have suggestions for additional areas of research:

It seems like OMs with different levels of steepness would be appropriate robustness OMs. The current working paper discusses and illustrates the effect of steepness so I do not think that new reference OMs need to be developed for this current working paper, but they could be considered in future studies. Figure 32 is a great visual of the effect of steepness along with M. This figure provides more evidence for potential reference OMs with different levels of steepness. A broad range of steepness is covered in the current OMs, but additional insight can be provided if different levels of steepness with a smaller range for each level were used in reference OMs.

Future work could also focus on determining weights for objectives so that a performance across all objectives can be quantified as one metric. Trade-off plots are definitely helpful but

when it comes to selecting an optimal MP, it can be difficult when several MPs have similar performance.

Future work could evaluate a time-varying M. The authors state M could increase due to increased predation by pinnipeds. Although the proportion of Quillback Rockfish consumed by pinnipeds is uncertain, an increase in M OM could be a ‘robustness’ OM.

Using CPUE from the recreational fishery may be an interesting robustness OM. Even though the recreational fishery does not target Quillback rockfish, the CPUE can still be informative, perhaps even more informative since the CPUE would not exhibit hyperstability or hyperdepletion towards Quillback rockfish.

Future studies should evaluate the relationship between EVs and Quillback rockfish. Hypotheses on the relationships between EVs and productivity can be based on relationships found in other rockfish species.

APPENDIX D: AGENDA

DAY 1 – TUESDAY, DECEMBER 6

Time	Subject	Presenter
09:00	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
09:15	Review Terms of Reference	Chair
09:30	Presentation of Working Paper	Authors
10:30	**Break**	
10:45	Presentation of Working Paper continued	Authors
11:30	Overview of Written Review #1	Chair + Reviewers & Authors
12:00	**Lunch Break**	
13:00	Overview Written Reviews #2	Chair + Reviewers & Authors
13:30	Identification of Key Issues for Group Discussion	Group
14:45	**Break**	
15:00	Discussion & Resolution of Technical Issues	RPR Participants
16:30	Discussion & Resolution of Results & Conclusions	RPR Participants
17:00	Adjourn for the Day	

DAY 2 - WEDNESDAY, DECEMBER 7

Time	Subject	Presenter
09:00	Introductions Review Agenda & Housekeeping Review Status of Day 1 (*As Necessary*)	Chair
09:15	Develop Consensus on Paper Acceptability & Agreed upon Revisions (TOR (Terms of Reference) objectives)	RPR Participants
10:30	**Break**	
10:45	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Summary bullets • Sources of Uncertainty	RPR Participants
12:00	**Lunch Break**	
13:00	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Results & Conclusions • Figures/Tables • Additional advice to Management (as warranted)	RPR Participants
14:45	**Break**	
15:00	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
15:45	Other Business arising from the review	Chair & Participants
16:00	**Adjourn meeting**	

APPENDIX E: PARTICIPANT LIST

Last Name	First Name	Affiliation
Acheson	Schon	DFO Science
Anderson	Erika	DFO Centre for Science Advice Pacific
Anderson	Sean	DFO Science
Carruthers	Thomas	Blue Matter Science Ltd.
Cornthwaite	Maria	DFO Science
Davidson	Lindsay	DFO Science
Davis	Ben	DFO Science, Meeting Chair
English	Philina	DFO Science
Ganton	Amy	DFO Fisheries Management
Haggarty	Dana	DFO Science
Haigh	Rowan	DFO Science
Huynh	Quang	Blue Matter Science Ltd.
Langseth	Brian	National Oceanic and Atmospheric Administration
MacInnis	Christine	DFO Fisheries Management
Mazur	Mackenzie	DFO Science
Muirhead-Vert	Yvonne	DFO Centre for Science Advice Pacific
Obradovich	Shannon	DFO Science
Olmstead	Melissa	DFO Science
Olsen	Norm	DFO Science
Rogers	Luke	DFO Science
Schijns	Rebecca	Oceana Canada
Siegle	Matt	DFO Science
Tadey	Rob	DFO Fisheries Management
Walker	Leah	DFO Science