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Proceedings of the Pacific regional peer review on Canary Rockfish (*Sebastes pinniger*) stock assessment for British Columbia in 2022

September 7-8, 2022
Virtual Meeting

Chairperson: Ben Davis
Editor: Yvonne Muirhead-Vert

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Pacific Biological Station
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Foreword

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

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on September 7-8, 2022 via the online meeting platform Zoom. The working paper presented for peer review focused on the Canary Rockfish (*Sebastes pinniger*) (CAR) stock assessment for British Columbia in 2022.

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 (Groundfish, Quantitative Assessment, and retired DFO staff), Fisheries Management staff; and external participants from the David Suzuki Foundation, Halibut Advisory Board, Interface Fisheries Consulting, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), National Oceanic and Atmospheric Administration (NOAA), Groundfish Trawl Advisory Committee (GTAC), Oceana, Pacific Halibut Management Association, Canadian Groundfish Research Conservation Society, and the Council of the Haida Nation.

The meeting participants agreed the working paper met all of 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) to inform fisheries management decisions to establish catch levels for the species and to inform and supplement decisions external to DFO.

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 September 7-8, 2022 via the online meeting platform Zoom to review the working paper entitled, "Canary Rockfish (*Sebastes pinniger*) stock assessment for British Columbia in 2022", authored by Paul Starr (independent consultant) and Rowan Haigh (DFO Groundfish Science).

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Fisheries Management. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from DFO Science and Fisheries Management staff as well as representatives with relevant expertise from First Nations, National Oceanic and Atmospheric Association (NOAA), Committee on the Status of Endangered Wildlife in Canada (COSEWIC), commercial and recreational fishing sectors, and environmental non-governmental organizations.

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

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 to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, 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, highlighting the objectives and identifying Yvonne Muirhead-Vert as the Rapporteur from the Centre for Science Advice Pacific (CSAP) office for the meeting. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The virtual meeting was held on the platform Zoom, where audio and text conversations were conducted and recorded. Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 21 people participated in the Regional Peer Review (RPR; Appendix E).

Prior to the meeting, Aaron Berger (NOAA) and Kendra Holt (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 provided in the form of a Science Advisory Report to DFO Fisheries Management to inform fisheries management decisions to establish catch levels for the species. This work will also inform and supplement decisions external to DFO, specifically COSEWIC. 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, Aaron Berger (NOAA) and Kendra Holt (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. This proceedings document summarizes the discussions that took place by topic, where points of clarification presented by the authors in their presentations and questions and comments raised by the reviewers and participants are captured within the appropriate topics. Both reviewers agreed that the paper met the TOR objectives; reviewers' formal submissions are located in Appendix C.

TERMS OF REFERENCE OBJECTIVE ONE

Reference Points: While it is standard to use the default 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, the authors presented a number of alternative reference points to satisfy the objective. One of the participants suggested that only one set of reference points (i.e., Maximum Sustainable Yield (MSY)-based) should be presented in the Science Advisory Report (SAR) so that the options are clear to Fisheries Managers. If alternative reference points are presented and there is a scientific reason not to use them, then it should be stated clearly in the document.

The group determined that it would be beneficial to include the other sets of reference points in the revised working paper since other groups such as COSEWIC and some First Nations use B_0. The latter point was used as a reason to include some B_0-based reference points in the SAR.

A participant referred to the following paper, "Protecting our coast for everyone's future: Indigenous and scientific knowledge support marine spatial protections proposed by Central Coast First Nations in Pacific Canada" for supporting information on how some Indigenous organizations look at the reference points.

A participant noted that the revised working paper could take up to a year to publish as a Research Document, unlike the SAR which will be available sooner. Therefore, if some information (e.g., decision table probabilities) was considered important, the SAR should contain that information. The SAR should include information and advice to inform managers (rather than present all options as equally important).

TERMS OF REFERENCE OBJECTIVE TWO

The working paper addressed the issue of only having one stock of Canary Rockfish for the coast of British Columbia (BC). The biology and distribution did not support the separation of this species into spatially distinct stocks. Additionally, lack of data also limited stock separation conclusions. As was determined in the previous Canary Rockfish stock assessment in 2009, this stock assessment adopted a single coastwide stock.

TERMS OF REFERENCE OBJECTIVE THREE

A comprehensive suite of analyses were completed that evaluated the consequences of a range of harvest policies on projected biomass. All runs indicated that there was no probability that the female spawning stock biomass (SSB) would descend into the cautious or critical zones. Ten year projections using a constant catch of 750 tonnes/year indicated that, at the beginning of 2033, the SSB had probabilities of 1 of being above the Limit Reference Point, 1 of being above the Upper Stock Reference Point and 1 that the u_{2032} will be less than the u_{MSY} reference point.

A participant questioned how well the model fit the relative abundance indices in the model. The authors indicated that each index value (survey or catch per unit effort [CPUE]) had an associated error which allowed the model some freedom when matching the indices. Each series only had one or possibly two index values where the model population trajectory fell outside of the index error bars. They also noted that when the CPUE was excluded from the analysis, the model estimates of stock status were similar to the base run.

TERMS OF REFERENCE OBJECTIVE FOUR

The authors indicated that since the stock was in the Healthy zone (and projections indicated that it will remain there for the next 10 years), that a rebuilding plan does not apply.

TERMS OF REFERENCE OBJECTIVE FIVE

Parameters: One trawl fishery was modelled. In future, midwater and bottom trawl fisheries may need to be modelled separately due to possible differences in selectivity. However, adequate data were not available at the time of the 2022 stock assessment to estimate separate selectivities for these two fisheries.

A Bayesian approach was used to address uncertainties in the estimated parameters, with credibility intervals and probabilities provided for all quantities of interest.

Fourteen sensitivity runs, all taken to the Markov chain Monte Carlo (MCMC) level, explored plausible alternatives to the assumptions made in the base run. None of the sensitivity runs contradicted the base run conclusion that the BC Canary Rockfish (CAR) stock was well above the USR in the Healthy zone. Furthermore, the MCMC uncertainty associated with the base run included much of the MCMC uncertainty estimated for the sensitivity runs.

Natural mortality (*M*) was identified as a key uncertainty, especially as it differed between sexes because, while there were many older (> age 60) males in the population, females older than age 40 were rare. The authors, through two sensitivity runs that were made in addition to the base run, explored three potential hypotheses to explain this observation. First was a differential in the male and female *M*, with the model estimating separate values for this parameter by sex (base run). The second hypothesis was similar to the approach adopted by the previous 2007 and 2009 CAR stock assessments, in that both males and females had the same *M* up to age 14, followed by an increase in the female *M* while the male *M* stayed similar to the initial *M* (run S01). Finally, the third hypothesis explored the possibility that females became less vulnerable to the fishery as they got older by allowing the right-hand limb of the selectivity function to descend (run S09). The authors noted that all three hypotheses fit the data well and estimated that the population was firmly in the Healthy zone, with the base run hypothesis (one *M* per sex) being the most parsimonious (needing the fewest parameters) and returning the lowest stock status estimate among the three runs.

TERMS OF REFERENCE OBJECTIVE SIX

It was recommended that the next assessment for this stock occur no later than 2032. To complete the quantitative analyses, it is required to commence ageing otoliths collected over the intervening period approximately one year in advance. Priority for age requests from stock assessment personnel depends on various factors like stock status. Given that the Canary Rockfish population is in the Healthy zone, it is unlikely to see a trigger that will prompt an early assessment for this species.

TERMS OF REFERENCE OBJECTIVE SEVEN

DFO groundfish fisheries managers have worked in consultation with science, industry and non-government organizations to implement measures in the commercial trawl fishery to protect bottom habitat, foster biodiversity, and ensure that these fisheries remain sustainable. Few, if any, reliable quantitative analyses of environmental effects have been incorporated into BC stock assessments for advice to managers to date. However, this is an area of work that is actively being explored by ecologists and assessment scientists.

Sensitivity Runs: A participant asked where the signal for recruitment was coming from within the models. The authors responded that these models vary the estimated recruitment deviation for each recruiting year class as it enters the model in order to fit the age proportions for that year class in successive years. It is the consistency in the age frequency data over time that allows the model to set a single initial deviation to fit successive observations of the same year class. The resulting recruitment deviation is then converted to recruitment in numbers of fish, mediated through the stock-recruitment function.

Data weighting: A participant asked how the age data were reweighted. The authors indicated that the Dirichlet-Multinomial (DM) distribution was used which estimated the weights for each age frequency data set. They noted that these estimated weights for recalculating effective sample size only ranged from 0 to 1. This meant that effective sample sizes could not increase above those originally supplied; that is, they could not be upweighted. The fits to the DM were such that the model did not change sample sizes significantly (keeping them close to their original values). This is one of the possible disadvantages to the reweighting scheme but the authors noted that they used the number of tows to set the initial weights while a lot of stock assessments use the number of fish aged, which would be a much larger value. This observation could be the reason that the DM theta estimates did not downweight the age frequency data very much for this stock assessment. An additional sensitivity run (S14) was added using Francis mean-age reweighting to explore the impact of the DM restriction.

A reviewer mentioned that the DM log(theta) parameters estimated in this stock assessment were approaching the upper bound. Hence, sensitivity run S14 (as noted above) was made to see how the alternative Francis mean-age reweighting would have an impact the results. MCMC diagnostics for this sensitivity run were good. Estimated B_0 was 12% lower and estimated M was higher than the corresponding base run estimates; however, S14 provided similar estimates with respect to stock status ($B_{2023}/B_{\mathrm{MSY}}$) and depletion ($B_{2023}/B_0$) compared to the base run.

Growth: The estimation of growth was calculated outside of the stock assessment model and used as input to that model.

Recruitment: The authors indicated that age frequency data, beginning in the late 1970s, were available to the model. Given the maximum age for this species used in the stock assessment (up to age 60 y), recruitments were being estimated as far back as the 1950s. It was speculated by some participants that there were likely to have been regime shifts over the long estimation period for the recruitment time series. The group suggested that some text could be added to the revised working paper raising the possibility of regime shifts over the period of recruitment estimation and that regime shifts could be identified in the next stock assessment. At the time of the RPR meeting, there was no consensus on how to deal with this issue.

Selectivity: The selectivity priors for the surveys were derived from the commercial selectivity parameter estimates from the 2007 Canary Rockfish stock assessment. Selectivity parameters for surveys without age frequency (AF) data were fixed to these prior means.

Sampling: The group noted that biological sampling of the commercial fishery had declined, beginning from about 2015. There were no commercial age samples available for the model after 2017. Electronic monitoring (EM) was implemented in early 2020, replacing the onboard observers who were not available during the pandemic. While EM adequately monitors catch, a new bio-sampling protocol needs to be developed and implemented. Staffing challenges are a constraint to expanding the bio-sampling.

A participant asked about the analytical *q* values (catchability) estimated for each survey, primarily to ensure that they looked reasonable and made sense. The authors did not routinely check these *q* values as part of the their diagnostic investigation of model results; however, these estimated analytical *q* values were all low. This was an expected result because the model population covers all of the BC coast while each survey only covers a fraction of the total coast.

Trawl fishery CPUE: The authors were queried whether commercial CPUE was a reliable signal of abundance. One reviewer asked the authors if it was justified to keep CPUE in the base run. The authors believed that the CPUE helped anchor the assessment because the series contained values for every year beginning in 1996 and that the associated error values tended to be lower than the equivalent values used for the survey indices. The authors had also used CPUE in many past assessments, and have found the approach to work well. In the case of Canary, the authors believed that the CPUE index was credible and strengthened the model fits compared to leaving it out. It was noted that if the RPR required the base run to be changed (e.g., drop CPUE), then all the sensitivity analyses would need to be rerun. The reviewer recommended that commercial CPUE indices should not be used in the base run of future Canary Rockfish stock assessments but agreed that the current assessment could retain it, provided that more justification be included in the text on why it was retained. A participant noted that the results from this stock assessment are consistent with what the commercial fishermen are seeing on the ground.

Delta model versus Tweedie model: One of the reviewers asked why the Delta-lognormal model was used in this assessment since the Tweedie model had been shown to avoid some of the problems of Delta models and has been adopted by most of the DFO groundfish stock assessment scientists. The authors believe that the two models are equally good at fitting the data. Thorson (2017) outlined problems with delta models but concluded that better alternatives (which model encounter probabilities using more robust statistical methods) do not increase the information available to stock assessments when used to estimate abundance indices. The Delta-lognormal model has been used by the authors for many years; they are familiar with it (and its diagnostics) and have confidence in it.

The authors noted that there have been issues running the current DFO Tweedie code, which relies on the plotting routine ‘gfplot’. The latter relied on a package called INLA (Integrated Nested Laplace Approximation), which in turn relied on 57 packages.

Another issue for the authors regarding the Tweedie model was the lack of diagnostics for goodness of fit compared to those available for the Delta component models that make up the delta-lognormal.

Comparison on Markov Chain Monte Carlo (MCMC): A participant wanted some additional clarification regarding the base run MCMC diagnostic descriptors (what does ‘acceptable’ mean?) and why the single-*M* hypothesis was chosen over the split-*M* and female dome selectivity hypotheses.

A reviewer suggested improving the description of the MCMC diagnostics in the revised working paper so that these MCMCs can be evaluated relative to those of the sensitivity runs.

Projections: Two participants expressed concern that the estimated stock trajectory was essentially impervious to any of the sensitivity runs, which suggests we may not completely understand what is driving stock performance, i.e., perturbation of some parameters or data should produce some changes in the estimated trajectory or we are either not perturbing things enough or not looking at appropriate data or parameters for sensitivity.

Environmental Variables: Correlation between the recruitment deviation time series and the Pacific Decadal Oscillation (PDO) data looked good during the latter years of the series (from 2000 on, r=0.655), but selectively looking at a piece of each series was considered arbitrary. The overall correlation of the PDO with the base run recruitment deviations was low (r=0.174) from 1950 on. PDO was relatively higher in the 1980s and early 1990s than it was in the 2000s while the opposite was true for the base run recruitment estimates. There was clearly a conflict between the PDO series with the recruitment estimates based on the age frequency data, leading to making a choice between one or the other. It is also possible that the PDO was not the most appropriate environmental index series to use in this context, requiring the need to seek expert advice when selecting the best series to use in this type of analysis for the future.

A participant asked why the PDO index was included since there was no apparent linkage to Canary Rockfish life history. Did previous work identify PDO as a variable related to Canary Rockfish recruitment or productivity, or was this a general exploratory analysis? The authors indicated that the hypothesised linkage was with sea surface temperatures (SST), which may have an effect on recruitment.

A participant referred the following paper, "Climate forcing and the California Current ecosystem" during the discussion. It was noted that negative PDO values indicate cooler SST, which is associated with higher productivity, usually from the upwelling of cool, nutrient-rich water.

Survey Data: A participant asked how the survey data were generated for the stock assessment. Another participant, who was a member of the DFO surveys group, described four synoptic bottom trawl surveys: west coast Vancouver Island (WCVI), Hecate Strait (HS), Queen Charlotte Sound (QCS), and west coast Haida Gwaii (WCHG). The participant noted that the details of the surveys and trends for the various species collected could be found in the following Science Response, "A data synopsis for British Columbia groundfish: 2021 data update". The report presents relative biomass series for the four synoptic surveys mentioned above, the Outside Hard Bottom Longline (HBLL) surveys (north and south), and the International Pacific Halibut Commission (IPHC) Fishery Independent Setline surveys.

It was noted that the longline and trawl surveys are conducted in different geographic areas along the BC coast. The longline survey data appear to be missing small and large fish. The lack of small fish collected was due to the large hook size used, while larger fish were not caught because the species moves into deeper habitat as they get older and therefore are absent from nearshore areas covered by the HBLL surveys.

The authors stated that they did not perform a CPUE analysis on the commercial longline data because the available data were sparse. The stock assessment had one sensitivity run which used the survey indices from the HBLL surveys, The authors stated they would make the recommendation that the next stock assessment should explore the use of the HBLL surveys in the base run, using a descending right-hand selectivity.

REQUESTED REVISIONS

One of the reviewers expressed an interest in the authors adding geospatial and environmental data to the time series in a future stock assessment and suggested that this be a research recommendation.

The authors agreed to recommend that analysts who have a better understanding of the available environmental data should be consulted when implementing this recommendation.

The authors agreed to make the following changes in the revised working paper:

- Replace instances of "composite run" to "base run" and remove any mention of component runs.
- Include a table outlining the sensitivity runs in the main document.

CONCLUSIONS

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

RECOMMENDATIONS AND ADVICE

DRAFTING OF THE SCIENCE ADVISORY REPORT

The meeting Chair used track changes on the draft Science Advisory Report (SAR) to document changes while it was being discussed with participants. The SAR was discussed at length and participants had the opportunity to contribute to key sections. At the end of the meeting, a draft SAR was completed. The meeting Chair will work 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 PRO 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. We thank the formal reviewers, Aaron Berger (NOAA) and Kendra Holt (DFO Science) for their time and expertise for providing their formal reviews of the working paper. We would also like to thank Ben Davis for his support throughout the process and as Chair of the meeting.

REFERENCES CITED

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

DFO. 2010. Stock assessment update for British Columbia Canary Rockfish. DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/019.

APPENDIX A: TERMS OF REFERENCE

CANARY ROCKFISH *(SEBASTES PINNIGER*) STOCK ASSESSMENT FOR BRITISH COLUMBIA IN 2022

Regional Peer Review – Pacific Region

September 7-8, 2022
Virtual Meeting

Chairperson: Ben Davis

Context

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Canary Rockfish in British Columbia (BC) as "Threatened" in November 2007 due to a population decline[1]. COSEWIC identified fishing as the primary threat to this species. Canary Rockfish are targeted by commercial trawl (~98% of total BC catch, 5-yr average 2017-2021) and hook and line fisheries. A small amount of catch, often non-directed, is taken in the First Nations fisheries, recreational fisheries and commercial salmon troll fisheries.

The COSEWIC designation led to a Canary Rockfish stock assessment in 2007 (Stanley et al. 2009), followed by a stock assessment update (DFO 2009a). In 2011, a decision was made by the Minister of the Environment to not list Canary Rockfish in Schedule 1 of the *Species at Risk Act* (SARA), and that Fisheries and Oceans Canada (DFO) would continue to manage this species under the *Fisheries Act*. In response to the 2007/2009 stock assessments, the trawl total allowable catch was reduced twice but has since been increased to 965 t, which is 81 t below the 2007 level.

The 2007 and 2009 stock assessments depicted a coastwide Canary Rockfish stock that had reached low levels in the mid-2000s but was now increasing slowly. The 2009 update estimated that the population was most likely in the Healthy zone (DFO 2009b); an improvement from the previous assessment which estimated the stock to be in the Cautious zone. The management objective for this species is to keep the population in the Healthy zone.

The bulk of the BC population of Canary Rockfish is found off the west coast of Vancouver Island and in Queen Charlotte Sound (central BC coast), largely in association with the three main gullies – Goose Island, Mitchell's, and Moresby. There are a few 'hotspots' near Langara Spit and in Dixon Entrance (north of Graham Island, Haida Gwaii); however, catch in the northern regions is dwarfed by that from further south. Preliminary analyses in 2021 showed no strong evidence for stock separation along the BC coast based on growth and size frequencies; therefore, the coastwide population will continue to be assessed as one unit.

Data for Canary Rockfish are adequate (in terms of biomass index series and available age structures) to conduct a statistical catch-at-age analysis. In 2007 and 2009, the authors used a model variant of Coleraine called 'Awatea'. In this proposed assessment, the authors will use the National Oceanic and Atmospheric Administration's (NOAA's) Stock Synthesis (SS3) model, which has been adopted by many United States assessment scientists in the Pacific region and was used to assess the Canary population off the lower west coast of the United States

[1] Canary Rockfish range from the Gulf of Alaska to northern Baja California. The Puget Sound/Georgia Basin population of Canary Rockfish was listed as threatened under the US *Endangered Species Act* (April 2010), although the US population has been increasing since fishing effort was reduced in 1999.

(Thorson and Wetzel 2016). This stock assessment software has more flexibility in fitting data and provides some useful diagnostics (e.g., retrospective analysis) that are not available in Awatea. The authors plan to make use of the flexibility afforded by this software platform to explore a wider range of stock hypotheses that could not be run on the previous platform. This includes the capacity to explore the possible impact of environmental effects.

Fisheries and Oceans Canada (DFO) Fisheries Management has requested that DFO Science Branch provide advice regarding the assessment of this stock relative to reference points that are consistent with the DFO's *Fishery Decision-Making Framework Incorporating the Precautionary Approach* (DFO 2009b), including the implications of various harvest strategies on expected stock status. The advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) will be used to inform fisheries management decisions to establish catch levels for the species. This work will also inform and supplement decisions external to DFO, specifically COSEWIC.

Objectives

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

Paul J. Starr and Rowan Haigh. 2022. Canary Rockfish (Sebastes pinniger) stock assessment for British Columbia in 2022. CSAP Working Paper 2015GRF04

The specific objectives of this science response are to:

1. Recommend reference points consistent with the DFO Precautionary Approach (PA), including the biological considerations and rationale used to make such a determination. If possible, these should include the default DFO limit reference point (LRP) of $0.4B_{MSY}$ and the upper stock reference (USR) of $0.8B_{MSY}$, or historical reference points (e.g., B_{min}). The following additional reference points will be presented: B_{MSY}, u_{MSY}, $0.1B_0$, $0.2B_0$, and $0.4B_0$. The choice of reference points is often determined by the complexity of the population model, which, in turn, depends on the quality of the input data.
2. Assess the current status of Canary Rockfish in BC waters relative to the selected reference points. If necessary, provide evidence to support the separation of this species into spatially distinct stocks, and if required, provide advice on the status of these stocks.
3. Using probabilistic decision tables, evaluate the consequences of a range of harvest policies on projected biomass (and exploitation rate) relative to the reference points and provide additional stock metrics.
4. Provide guidance, if needed, to be used by a management rebuilding plan under the DFO PA framework for Canary Rockfish to satisfy recent legislation (Bill C-68). Provide probabilistic decision tables that demonstrate a high probability of the stock growing out of the Critical Zone (i.e., above the LRP) within a reasonable timeframe (1.5-2 generations) if the stock is assessed to be in the Critical Zone.
5. Describe sources of uncertainty related to the model (e.g., model parameter estimates, assumptions regarding catch, productivity, carrying capacity, and population status).
6. Recommend an appropriate interval between formal stock assessments, indicators used to characterize stock status in the intervening years, and/or triggers of an earlier than scheduled assessment (DFO 2016). Provide a rationale if indicators and triggers cannot be identified.

7. Explore environmental effects on the stock assessment with the understanding that their incorporation at this point is exploratory. There is no proven functional system that can be used in population reconstruction and there is very limited ability to interact with black-box platforms like Stock Synthesis. At best, environmental indices might exhibit correlations with population components (e.g., recruitment, growth, natural mortality); however, these correlations can only be explored as sensitivity analyses and should not be used for primary harvest advice.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science and Fisheries Management)
- Commercial and Recreational Fishing Representatives
- Environmental Non-government Organizations
- First Nations
- Province of BC
- USA Government Agencies (National Oceanic and Atmospheric Administration, Alaska Fish and Game)

References

DFO. 2009a. Stock assessment update for British Columbia Canary Rockfish. DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/019.

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

DFO. 2016. Guidelines for providing interim-year updates and science advice for multi-year assessments. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/020. 10 p.

Stanley, R.D., Starr, P. and Olsen, N. 2009. Stock assessment for Canary Rockfish (*Sebastes pinniger*) in British Columbia waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/013. xxii + 198 p.

Thorson, J.T. and Wetzel, C. 2016. The status of canary rockfish (*Sebastes pinniger*) in the California Current in 2015. PFMC groundfish stock assessment documents 2016/05. iv + 678 p.

APPENDIX B: WORKING PAPER ABSTRACT

ABSTRACT

Canary Rockfish (*Sebastes pinniger*, CAR) ranges from the Gulf of Alaska southward to northern Baja California. In BC, the apparent area of highest concentration occurs on the west coast of Vancouver Island and at the heads of the three gullies in Queen Charlotte Sound. This species occurs along the west coast of Graham Island and in the western sections of Dixon Entrance, but the apparent abundance is lower.

In 2007, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the coastal population of CAR in British Columbia as ‘Threatened’, based on an analysis of survey indices and the threat from commercial fishing. As a result, the species was considered for legal listing under the *Species at Risk Act* (SARA). A 2007 stock assessment (also acting as a recovery potential assessment) by Stanley et al. (2009) estimated that CAR was in the ‘Cautious Zone’ in the DFO Sustainable Fisheries Framework (DFO 2009) but an update to that assessment conducted in 2009 concluded that CAR was in the ‘Healthy Zone’ when using a credible steepness value. In 2011, a decision was made not to list Canary Rockfish under Schedule 1 of the SARA. In 2019, Bill-C-68 was enacted to amend the Fisheries Act with the Fish Stocks provisions, prompting a national review of the approximately 180 stocks using Sustainability Surveys with the aim to include the majority of those stocks in regulation over the next five years. Canary Rockfish is one of 18 groundfish stocks in the Pacific Region being considered for inclusion. The purpose of this CAR stock assessment is to evaluate the current stock status and provide advice suitable for input to a sustainable fisheries management plan.

This stock assessment evaluates a BC coastwide population harvested by two fisheries: a combined bottom and midwater trawl fishery accounting for over 95% of the catch and an ‘other’ fishery which combines a range of capture methods but is mostly longline. Midwater trawl catches of CAR were combined with bottom trawl for the purposes of this stock assessment. Analyses of biology and distribution did not support separate regional stocks for CAR. A single coastwide stock was also assumed by Stanley et al. (2009) and the subsequent update.

We use an annual catch-at-age model tuned to six fishery-independent trawl survey series, a bottom trawl CPUE series, annual estimates of commercial catch since 1935, and age composition data from survey series (23 years of data from three surveys) and the commercial fishery (37 years of data). The model starts from an assumed equilibrium state in 1935, the survey data cover the period 1967 to 2021 (although not all years are represented) and the CPUE series provides an annual index from 1996 to 2021.

A two-sex model, which estimated M for each sex and the stock-recruitment steepness parameter, was implemented in a Bayesian framework, using the Markov Chain Monte Carlo (MCMC) ‘No U-Turn Sampling’ (NUTS) procedure. In addition to natural mortality and steepness, the parameters estimated by this model included average recruitment over the period 1950–2012, and selectivity for the three surveys with age frequency (AF) data and the commercial trawl fleet. The survey and CPUE scaling coefficients (q) were determined analytically. Thirteen sensitivity analyses evaluated with MCMC were conducted relative to the base run to test the effect of alternative model assumptions. A further three runs were made with an environment PDO index series to evaluate the effect of this series on the estimated recruitment trajectory. These models were also evaluated with MCMC.

The base run estimated the CAR female spawning population biomass at the end of 2022 (median with 0.05 and 0.95 quantiles) to be 0.78 (0.57, 1.0) relative to B_0 and to be 3.0 (1.9, 4.9) relative to B_{MSY}. This latter result suggests that the CAR spawning population currently lies well in the Healthy zone (with a probability >0.99). Projections predicted that the stock will remain in

the Healthy zone up to the end of 2032 at all evaluated catch levels up to 2,000 t/y. However, these projections also predicted that the stock would decline at catch levels greater than 750 t/y, under the assumption that recruitment will be average over that time period.

Older female CAR are absent from the AF data (females older than age 40 are rare) while the male CAR AF data extend to above age 60. The previous CAR stock assessment assumed a fixed M = 0.06 for all males and for females up to age 13; females age 14 and older had M = 0.12. This stock assessment approached this problem in three ways: 1) estimating a separate M for males and females to get the best fit to the AF data; 2) estimating separate M values for males and females up to age 13 and then estimating new M values for both sexes from age 14 and higher; 3) while estimating single M values for each age, allowing the female selectivity to the commercial fishery and the six surveys to decline with older ages, creating a cryptic population of female spawners. This assessment found that all three models could fit the data credibly, with the first option being the most parsimonious so it was selected as the base run. The other two options were more optimistic relative to B_0 and B_{MSY} than was the base run.

The median estimates by the 13 sensitivity runs for B_{2023}/B_0 ranged from 0.62 to 0.97 and for B_{2023}/B_{MSY} ranged from 2.40 to 3.22, indicating that all 13 sensitivity runs lay well in the Healthy zone. These analyses included, higher and lower pre-1996 catch histories, higher and lower recruitment standard deviation (σ_R) assumptions, adding the two HBLL survey series, dropping the CPUE series, substituting an alternative CPUE series, omitting ageing error, adding AF data from the HS and WCHG synoptic surveys, and using two alternative ageing error functions in addition to the treatments of female natural mortality described above.

Incorporating the environmental PDO index series into the stock assessment resulted in an unsatisfactory conclusion: the degree to which the index series was able to influence the recruitment pattern was dependent on the weight given to the index series. Choosing the weight was arbitrary and higher weights resulted in a deterioration of the fit to the fishery data. This procedure is effectively a correlation analysis because there is no functional link between the index series with the population dynamics.

APPENDIX C: WORKING PAPER REVIEWS

Fisheries and Oceans Canada

Canadian Science Advisory Secretariat (CSAS)

Regional Peer Review Process - Pacific

Written Review

Date: August 26, 2022

Reviewer: Aaron Berger

CSAP RSIA: 2015GRF04

Working Paper Title: Canary Rockfish (*Sebastes pinniger*) stock assessment for British Columbia in 2022

I structured my review by first answering the five posed questions at a very high, summary-style level. I then follow with Specific Comments and a few general very Minor Editorial Notes. The Specific Comments section is where much of my remarks about the authors' methodology, interpretations, and recommendations are located.

In general, the stock assessment is well put together, comprehensive, defensible, and thus should be considered best available science for Canary Rockfish in British Columbia. I do have several comments that I would like some further discussion on during the review, though most of those will fall under providing additional 'supporting information', clarifications, and thoughts on future research.

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

Yes, the purpose of the working paper is clearly outlined, including sufficient background information and context in order to interpret the methods, results, and recommendations in a sufficient manner. I thank the authors for producing such a well-structured document with flow and structure that was conducive to comprehension given its length.

Are the data and methods adequate to support the conclusions?

Yes, the data and methods are adequate to support the conclusions. The Bayesian analytical approach taken to assess the stock is considered (in my opinion) to be a 'gold standard' for incorporating data and other information into the stock assessment directly into the estimation procedure. Please see the Specific Comments section below for discussion consideration during the review meeting.

Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

Yes, the data and methods are explained in great detail and were properly explained to evaluate the validity of the conclusions. The authors should be commended for their comprehensive and exhaustive efforts. The level of detail and background information provided in this assessment should be considered a standard for others to follow. Please see the Specific Comments section below for discussion consideration during the review meeting.

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?

Overall, I believe the document does a good job of providing useable information for managing this stock, including adequate descriptions of central tendencies and probability distributions to capture uncertainty for an array of metrics specific to DFO management as well as those to evaluate stock assessment best practices in general. The use of a Bayesian framework along with the use of alternative model explorations via sensitivity analyses provides a solid foundation within which to interpret uncertainty. The fact that the authors conducted nearly all model comparisons within a Bayesian framework is commendable. Please see the Specific Comments section below for discussion consideration during the review meeting.

Can you suggest additional areas of research that are needed to improve our assessment abilities?

While this assessment is very comprehensive, there are always areas for additional exploratory work (many of which were highlighted in the assessment document itself, which I agree with). I have mentioned a few more in the Specific Comments section below.

Specific Comments (and questions)

> [Reviewer caveat: there is a chance that some of my comments are already addressed in the document itself. Given it's comprehensive and lengthy structure, I may have missed some aspects upon aggregating my final comments here. If so, please excuse my oversight. I'm happy to be pointed to text that references my comment.]

Combining (or mirroring) the 'other' fleet selectivity with the combined trawl (bottom/midwater) fleet selectivity – so this effectively means that there was one modeled fleet (i.e. one F that was then filtered through the one fleet selectivity pattern to get F-at-ages by fleet)? What is the potential impact of this assumption? Is it large enough that this assessment should note it such that future age samples be collected? Did the authors consider the pros/cons of considering the midwater trawl separate from the bottom trawl by using length information for the midwater and a length-age key?

Combining bottom and midwater trawl fleets: what are the caveats that should be considered given that the nets are likely quite different, no? I do note that the age comp fits didn't look too bad.

Were discards assumed negligible and not included in the removals, or where they estimated as a constant (no trend through time) and added in with the catch as effectively a constant multiplier on the landed catch?

Now that it is later in the year, does the industry projection of a 780 t catch still seem to be a good assumption?

M: Hide them/Kill them; "the most parsimonious" mentioned is kill them – how defined? I do note that it also is the most risk averse assumption given other approaches were more optimistic.

CPUE indices – why were the synoptic surveys not aggregated, and then evaluated at the design-based versus spatiotemporal method? They seem to largely only be different due to location, or are there other critical factors? The year and space differences could be accounted for with the geostatistical, spatiotemporal approach. Perhaps the analyses presented in this assessment provides a good basis to recommend that approach in the future. True? Unless the spatial structure approach changes (in the future) from a single area one fleet model to a fleets-as-areas style of assessment, it seems that developing a single spatiotemporal index would be a future improvement or at least research evaluation.

Canary seem to be relatively ubiquitous across BC for LL fishing depths (Figure A1). This seems to be somewhat counter to the general statement that the LL surveys are outside of the main area of concentration for Canary. The younger age distributions seem like a real advantage for estimating growth. Was there an attempt to estimate growth within the model while including these data? Was growth estimation attempted during model development of the base model? Fixing growth in the assessment model based on 'outside the model' estimates is certainly a reasonable thing to do in many cases; however, it would be beneficial to acknowledge that overall uncertainty may be under-represented in the base model (such is the case with almost all assessment models of course, but explicitly mentioning growth here).

M: Was there consideration of increasing the SD on the prior for female M? I was initially thinking that the prior may have been constraining the female M estimate, although the likelihood profile seem to indicate that it may not have been, at least not drastically. An experimental run that artificially increases the SD on the prior for female M would be a diagnostic to see whether the prior played a large role.

Selectivity: The commercial trawl fishery and the 3 surveys with AF data estimated selectivity with informed priors from the 2007 assessment. However, it sounds like the parameters for the other surveys with no age data were fixed at the 2007 estimates. Is this true? Or were they subsequently fixed at the new selectivity estimates (this assessment) for the 3 surveys with AF data (i.e. estimate those that can be estimated and then fix those at this assessment estimates via mirroring fleets)? It seems like fixing those at the 2007 prior mean does not use all the available data to update that mean. Since the selectivity estimates did not update much from previous assessment (correct?), perhaps it makes little difference.

Did r4SS diagnostics (if used) for alternative values of sigmaR agree with the 0.9 value used in the assessment?

The male shift parameter for selectivity did not move much from the initial prior mean. Is that due to the fact that the prior is the only information available, and/or that the prior mean was a good prior (i.e., there was information about the male shift parameter, but it just matched the prior mean)? One way to test this would be to adjust the prior mean and see if the model just tracks this change or if it wants to stay near the -0.4 estimate. This helps determine how influential that prior assumption is for this assessment.

Recruitment: were the recruitment deviations specified to sum to zero (i.e., sum to zero constraint)?

Recruitment deviations for the main recruitment period go to 2012. This seems early to me. Is there a belief that it takes 10 years before any data are informative on recruitment? Did the r4SS diagnostic about early, main, and late periods suggest anything different when running in MPD mode (if the authors are aware of that)? Are there other indications in the data about recruitment strength over the last 10 years that would suggest average, below average, or above average? Given that 50% mature occurs at approximately age 10, there would be SSB coming into the population prior to year 10 that may or may not be in line with 'average' and thus impact stock status.

DM parameters appear to be on (or near) the bound - log(theta). If you get a log(theta) of 5 you are at a 0.993 weighting; a value of 3 is 0.953; and a value of 7 is 0.999; do you think input sample sizes were too high (i.e., the DM parameter is bounding because it wants to upweight but DM approach only allows no weight or down-weight)? My concern is that the DM data weighting really didn't do anything such that the data were essentially not reweighted against one another. Was the Francis and/or McAllister-Ianelli approaches examined to see if results led to similar findings?

The authors note that two of the sensitivity runs (add HBLL survey and Tweedie CPUE) resulted in plausible alternative interpretations to the base model. Do the authors have any sort of qualitatively-based remarks (noting the differences in data inputs halts traditionally model selection procedures) on a relative weight of these models compared to the base model? Are there particular reasons that these were not chosen for the base model (in addition to those stated abut the HBLL surveys, see my comments on that earlier; and the comments that the Tweedie probably handles zero catch observations better)? My initial impression is that the HBLL survey is an informative survey that may bring about useful information on juveniles/young adults, which could improve recent recruitment estimates and subsequent management advice. The HBLL survey could be a configured as dome-shaped selectivity to capture the apparent targeting of younger individuals.

Environmental index: Did previous work identify PDO as a variable related to Canary (or Rockfish) recruitment or productivity, or was this a general exploratory analysis? Did the estimated Rec Devs correlate well with the PDO index in the base model?

Figure 13 (and others) show a considerable trend in the recruitment deviates (or stock-recruitment residuals). Other figures (F.14 and F.15) almost indicate two recruitment regimes, with one being pre-1995ish and one being post 1995ish. Are there reasons to believe that fundamental productivity changes in this region for this stock and that S/R parameters may be time-varying (or using 2 blocks of time)? I acknowledge that this would be a big assumption, but are there explanations for that pattern in recruitment? A change in productivity would have implications for reference points and stock status potentially.

It would be useful to provide a single figure of all the survey indices and the CPUE index on one plot to ease trend comparisons among them.

Were there any explorations on the sensitivity to data filtering rules when formulating the CPUE index? Were there correlations among the spatial variables “DFO locality”, “Latitude bands”, and “PFMC major area” in the standardization model? It sounds like they may be attempting to account for the same process (positive model and binomial model components).

The west coast Haida Gwaii synoptic survey possibly has an extreme catch event in its time series. Future research may consider methods that account for extreme events (e.g., Thorson).

Sex ratios are skewed in the observations, but the population starts out at 50:50 sex ratio. Does the difference in natural mortality estimates correspond to observed sex ratios?

Is there any justifications for years where the fitted population trend drastically misses survey data points (see Figure F.2)?

The lack of fit for age data appears most prominent at the youngest ages (did the sensitivity with the HBLL help that?), and with older males (did the cryptic biomass run help that?).

MCMC diagnostics: I find it useful to report the number of divergences, which with NUTs gives an indication of ‘sampling’ success (akin to Metropolis-Hastings sample rate sufficiency).

Was there any attempt to estimate added variance for the CPUE index as a way to supplement that the external approach (added process error) was sufficient?

Minor Editorial Notes

There are many examples of sentences that have two complete thoughts (subject and verb) separated by a conjunction (and, but, because, etc.), but do not include a comma. Sentences that have two complete thoughts should include a comma.

Fisheries and Oceans Canada

Canadian Science Advisory Secretariat (CSAS)

Regional Peer Review Process - Pacific

Written Review

Date: August 30, 2022

Reviewer: Kendra Holt

CSAP RSIA: 2015GRF04

Working Paper Title: Canary Rockfish (*Sebastes pinniger*) stock assessment for British Columbia in 2022

This stock assessment for Canary Rockfish uses a two-sex statistical catch-at-age model to estimate stock status at the start of 2023 relative to reference points. The model includes several updates from the last assessment in 2009, including the switch to a different modelling platform (Stock Synthesis), the use of an updated reconstruction of the historical catch series, the ability to fully estimate natural mortality, and some changes in the fishery-independent survey series deemed appropriate for Canary Rockfish.

I found the analyses in this assessment to be thorough and well-thought out. The extensive sensitivity analyses covered a wide range of key uncertainties and explored how decisions about which data series to use affected assessment outcome. I founds that these analyses answered most of the questions that arose for me while reading through the assessment. The document was also well-written and easy to read.

Below, I start with some general comments on the assessment approach for consideration by the authors and at the review meeting. These comments are then followed by more minor and editorial suggestions for the authors to follow-up on after the meeting. I also include my responses to the specific questions posed to reviewers by the CSAS office at the end.

Main Comments

Choice to include trawl fishery CPUE as an abundance index in the base run

The assessment would benefit from more justification of the choice to include commercial fishery CPUE in the base case model fit. In Section 5 (pg. 9) of the main body, the authors note general concerns with using fishery-dependent abundance series, but then go on to note that they included it in this assessment because using the trawl fishery CPUE series “provided a more informative abundance signal to the model than did the six survey series”. No details are provided to justify this statement however and support for it is not immediately apparent in the results presented. Model fit for the sensitivity run that omits trawl fishery CPUE appears to be adequate. Some rockfish assessments have avoided using fishery-dependent CPUE series in recent years (e.g., Yellowtail Rockfish – DFO 2015, Pacific Ocean Perch – Haigh et al. 2019), so it is not clear why it is retained for Canary Rockfish here, especially given that it’s value is not demonstrated.

As a related point, if a trawl fishery CPUE series is to be retained, it was not clear why the delta-lognormal GLM model was selected over the Tweedie model for the base run. Anderson et al. (2019) documented the benefits of the Tweedie model over the delta-lognormal approach in their Appendix D (also, see Thorsen 2017 cited within their Appendix D). While I appreciate that the Tweedie model was shown as a sensitivity analysis, the Groundfish Data synopsis tool uses the Tweedie GLM exclusively for standardizing fishery CPUE, so it’s not clear why this assessment wouldn’t also switch to the Tweedie approach.

Comparison of MCMC diagnostics

I liked the identification of criteria for categorizing MCMC diagnostics as good, fair, poor, etc. in Section 8.2.1 (pg. 23) and Appendix F (pg. 210). However, I was unable to find a clear statement that the base run was assessed as having 'good fit'. It is noted on page 233 that the base run had 'acceptable fit', but it is not clear how this lines up with the 'good', 'fair', etc rankings used to assess sensitivity runs.

- I suggest adding a description of the MCMC diagnostics for the base run to the main body so that these can be evaluated relative to the sensitivity runs.
- The authors assess the run that removes the CPUE series entirely (S13) as 'fair' convergence (pg. 252), but it is not immediately clear why this run is ranked as fair while the base run is ranked as 'good' (assuming that this is the case; see above). Given that both S13 and the base run have some differences in the cumulative posteriors for R0 in their split chain analysis and comparable trace plots and autocorrelation (Figures F.29 – F.31), the two runs seems equal to me. (This is obviously linked to my above question about why trawl CPUE was retained for the base model fit).
- It seems to me that a couple of the sensitivity runs (e.g., S04, S11) have better MCMC diagnostics than the base run based on Appendix F. If the authors agree with this assessment, this result should be highlighted and included in a discussion of why the base run was selected.

- **Age Structured Model Description, Environmental Effects. Pg. 15.**
  The two general approaches for including environmental effects into stock synthesis considered for Canary (model effect of environment on recruitment vs treat the environmental effect as data) have been previously considered and simulation-tested (Schirripa et al. 2009; Methot and Wetzel 2013). While Schirripa et al. 2009 found neither method to be superior, they did find overall that the inclusion of environmental data resulted in better estimates of historical stock size and productivity. This research could be cited and compared to the approaches and results for Canary.
-
- **Sensitivity Analysis to PDO Series, Section 8.3.2, pg. 27.**
  When discussing Figure 13, the text reads "The recruitment deviations after 2000 show four distinct peaks, only one of which coincides with the PDO series." I think this is a bit of an understatement. When looking at Figure 13, it seems to me that the base model recruitment deviations and Winter PDO index show very similar patterns in peaks and dips starting around 2003. I am interested to know what the simple correlation coefficient is for this recent time period. Also, it looks to me like Figure 13 only goes to ~2012, so the 2014 peak is not yet apparent (i.e., I think there are only 3 peaks after 2000 shown, not 4)
  - Linked to the above point, I wonder whether the divergence that the authors note in spawning biomass depletion from the PDO sensitivity away from the base run in recent years of Figure 12 is more attributable to a lack of recruitment information for the most recent years than the "conflict between the AF data and the recent observations from the PDO series", as suggested by the authors.

Minor & Editorial Comments

- **Catch data, Section 2, pg. 5.** The sentence "Total annual reconstructed trawl catches are presented in Figure 3 and catches for the reconstructed other fishery are presented in

Figure 4" is incorrect. Both these catch series are on Figure 3. Figure 4 compares 2009 and 2022 catch series.

- **Maturity and fecundity, Section 6.4, pg. 11.** The sentence that starts with "Although it is preferable to use research data to estimate biological functions, this is not always possible for species which mature in the late autumn, winter or early spring months …" could be made more direct by referring specifically to Canary. E.g., "Although it is preferable to use research data to estimate biological functions, this was not possible for Canary Rockfish because they spawn in the …"
- **Maturity and fecundity, Section 6.4, pg. 11.** Some edits / corrections are needed to the description of the maturity ogive.
  - The following sentence from pg. 11 is hard to interpret: "The ogive used in the model assigned proportions mature to zero for ages 1 to 4, then switched to the fitted monotonic function for ages 5 to 40, all forced to 1.0 (fully mature) from age 17 to age 60". I think what you mean to say is that the double normal forced ages above 17 to be 1.0, and that this was carried over to the ogive used here (Mod ma). Is this correct? Also – should upper age be 40 or 60? And did the forcing to 1.0 start at age 17 or age 19?
  - Linked to this, also note that the following on page 161 of Appendix D has an error. It reads: "the maturity ogive used in the stock assessment models (columns marked 'Mod ma' in Table D.6) set proportion mature to zero for ages 1 to 4, then switched to the fitted monotonic function for ages 5 to 16. All ages from 19 were forced to 1 (fully mature)." Should this be corrected to: "… then switched to the fitted monotonic function for ages 5 to 18"?
- **Natural Mortality, Section 6.5, pg. 12.** First paragraph should refer to Table D.7, not D.8
- **Natural Mortality, Section 6.5, pg. 12.** Description of Sensitivity run S01 could be revised to better describe what is meant by 'a stepped M'. Is it a consistent step-wise increase? Or, is it just a jump from one constant value (ages 1-13) to another constant value (ages 14+)?
- **Age Structured Model Description, Section 7, pg. 13**. The Dirichlet-Multinomial approach only applies to age composition data, correct? If so, the second half of the second paragraph in this section could be revised to clarify that it applies to age composition data, not biomass index series.
- **Model Results, Section 8. Table 2 caption.** The caption describes B0 as mature females, but this is the only place I see female-only biomass mentioned. Is this a typo? Or, are all spawning biomass values female-only?
- **Model Results, Section 8, pg. 17.** Reference to Figure F.32 seems incorrect. Was this mean to reference Figure F.28? Or, simply Figure 10?
- **Sensitivity Analyses, Section 8.2.1, pg. 23-24.** About a dozen paragraphs of text comparing sensitivity runs are exact duplicates of the text in Appendix F section F.2.3.0.2. This text only needs to appear once in the document. I suggest removing it from Appendix F so that it remains in the main body.
- The M values for age 14+ fish estimated om the split M sensitivity analysis are only mentioned at the tail end of the main body, in the second paragraph of the 'General comments'. I suggest bringing this up into the results section when discussing the sensitivity analysis. I was interested in knowing this earlier on so that I could compare with the values used in the 2009 assessment.

- **General comments, pg. 35.** The start of the last paragraph reading “The approach used for the base run was the most parsimonious …”. This first sentence should be edited to clarify that this paragraph is only comparing among the M scenarios. E.g., “The approach to modelling M used for the base run …”
- For future working papers, it would be nice to have line numbers on the review copy.

Response to Review Questions

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

Yes. The purpose of the working paper is clearly stated in the last paragraph of the Introduction.

Are the data and methods adequate to support the conclusions?

Yes. The level of ageing data and multiple biomass time series seem to provide relatively stable model fits and management advice. All of the analyses done support the general conclusion that the coastwide BC Canary Rockfish stock is in the Healthy Zone under DFO’s Precautionary Approach to Fisheries Management Policy. I do raise a couple questions about the approach taken to select the ‘base model run’ in my comments above that can be considered by the review committee when deciding whether to support the choice of a base model.

Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

Yes. The data and methods are well documented in the detailed Appendices A - G. Sufficient detail is provided in the main body of the assessment document to provide an overview of the methods, with references made to relevant appendices for more detailed descriptions.

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?

The figures and tables used to present harvest advice are clear and well-described. They are also in the same format that have been used for several previous assessments, so decision-makers will be familiar with them.

The reliance on a single base case for presenting harvest advice means that structural uncertainties are not captured in harvest advice. The authors suggest that this a preferable to previous assessments that have been forced to take a composite model approach given key uncertainties surrounding assumptions about M. While I think this assessment takes a reasonable approach to estimating M, there may still be key uncertainties that could be captured through a composite model (e.g., which biomass indices to include, historic catch level scenarios).

Can you suggest additional areas of research that are needed to improve our assessment abilities?

I thought the author’s list of future research recommendations in Section 11 addressed the major research avenues I would suggest for this species.

Literature Cited

Anderson, S.C., Keppel, E.A., Edwards, A.M. 2019. A reproducible data synopsis for over 100 species of British Columbia groundfish. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/041. vii + 321 p.

DFO. 2015. Yellowtail Rockfish *(Sebastes Flavidus)* Stock Assessment for the Coast of British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/010.

Haigh, R., Starr, P.J., Edwards, A.M., King, J.R., and Lecomte, J.-B. 2019. Stock assessment for Pacific Ocean Perch *(Sebastes alutus)* in Queen Charlotte Sound, British Columbia in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/038. v + 227 p.

Methot, R.D. and Wetzel, C.R. 2013. Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish. Res. 142. 86-99.

Schirripa, M. J., Goodyear, C. P., and Methot, R. M. 2009. Testing different methods of incorporating climate data into the assessment of US West Coast sablefish. ICES Journal of Marine Science, 66: 1605 – 1613.

Thorson, J.T. 2017. Three problems with the conventional delta-model for biomass sampling data, and a computationally efficient alternative. Canadian Journal of Fisheries and Aquatic Sciences. 75: 1369-1382.

APPENDIX D: AGENDA

DAY 1 – WEDNESDAY, SEPTEMBER 7, 2022

Time	Subject	Presenter
0900	Introductions/Overview of virtual platform Review Agenda CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper	Authors
1030	***Break***	
1045	Presentation of Working Paper cont'd	Authors
1115	Overview Written Reviews	Chair + Reviewers & Authors
12:00	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	RPR Participants
1330	Discussion & Resolution of Technical Issues	RPR Participants
1430	***Break***	
1445	Discussion & Resolution of Results & Conclusions	RPR Participants
1530	Develop Consensus on Paper Acceptability & Agreed-upon Revisions (TOR objectives)	RPR Participants
1600	Adjourn for the Day	

DAY 2 - THURSDAY, SEPTEMBER 8, 2022

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Review Status of Day 1 (*As Necessary*)	Chair
0915	Carry forward outstanding issues from Day 1	RPR Participants
1030	***Break***	

Time	Subject	Presenter
1045	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Summary bullets • Sources of Uncertainty • Results & Conclusions • Figures/Tables • Additional advice to Management (as warranted)	RPR Participants
1200	***Lunch Break***	
1300	*Science Advisory Report (SAR) cont'd*	RPR Participants
1430	***Break***	
1445	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1500	Other Business arising from the review	Chair & Participants
1600	***Adjourn meeting***	

APPENDIX E: PARTICIPANTS

Last Name	First Name	Affiliation
Berger	Aaron	NOAA
Christensen	Lisa	DFO Science, Centre for Science Advice Pacific
Davis	Ben	Retired DFO
Driscoll	John	David Suzuki Foundation
Grandin	Chris	DFO Science, Groundfish
Grout	Angus	Halibut Advisory Board
Haggarty	Dana	DFO Science, Groundfish
Haigh	Rowan	DFO Science, Groundfish
Holt	Kendra	DFO Science, Quantitative Assessment
Kronlund	Rob	Interface Fisheries Consulting
Leaman	Bruce	COSEWIC
Mose	Brian	Groundfish Trawl Advisory Committee (GTAC)
Muirhead-Vert	Yvonne	DFO Science, Centre for Science Advice Pacific
Rogers	Luke	DFO Science, Groundfish
Schijns	Rebecca	Oceana
Siegle	Matt	DFO Science, Groundfish
Skil Jáada		Council of the Haida Nation
Sporer	Chris	Pacific Halibut Management Association
Starr	Paul	Canadian Groundfish Research Conservation Society
Tadey	Rob	DFO Fisheries Management, Groundfish
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