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Proceedings of the Pacific regional peer review on Yellowmouth Rockfish (*Sebastes reedi*) stock assessment for British Columbia in 2021

September 8-9, 2021
Virtual Meeting

Chairperson: Greg Workman
Editor: Jill Campbell

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

January 2022

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 8-9, 2021 via the online meeting platform Zoom. The working paper presented a Yellowmouth Rockfish (*Sebastes reedi*, YMR) stock assessment for peer review.

Due to the COVID-19 pandemic, in-person gatherings have been restricted and a virtual format for this meeting was adopted. Web-based participation included DFO Science and Fisheries Management staff, and external representatives from First Nations, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), commercial fishery sectors, and environmental non-governmental organizations.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to Fisheries Management to inform fisheries management decisions when establishing catch levels for the species. This work will also inform decisions external to DFO, specifically COSEWIC.

The Science Advisory Report and detailed Research Document will be made publicly available on the CSAS website.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on September 8-9, 2021 via the online meeting platform Zoom to review the working paper on a Yellowmouth Rockfish (*Sebastes reedi*, YMR) stock assessment.

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 DFO Science and Fisheries Management staff as well as representatives with relevant expertise from First Nations, the province of British Columbia, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), commercial and recreational fishing sectors, the National Oceanic and Atmospheric Administration, and environmental non-governmental organizations.

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

Starr, P.J. and Haigh, R. 2021. Yellowmouth Rockfish (*Sebastes reedi*) stock assessment for British Columbia in 2021. CSAP Working Paper 2019GRF02.

The meeting Chair, Greg Workman, 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 (Research Document, Science Advisory Report, and Proceedings), and the definition and process around achieving decisions and advice through consensus. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working paper, and draft SAR.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying Jill Campbell as the Rapporteur for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The 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, 20 people participated in the RPR (Appendix D).

Participants were informed that Bob Rogers (DFO Science, Newfoundland and Labrador) and Andrew Edwards (DFO Science, Pacific) had been asked before the meeting to provide written reviews for the working paper. Participants were provided with copies of the written reviews prior to 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 technical Research Document will be made publicly available on the Canadian Science Advisory Secretariat website.

REVIEW

Working Papers: Starr, P.J. and Haigh, R. 2021. Yellowmouth Rockfish (*Sebastes reedi*) stock assessment for British Columbia in 2021. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/nnn. vi + 262 p.

Rapporteur: Jill Campbell

Presenters: Paul J. Starr and Rowan Haigh

GENERAL DISCUSSION

Following a presentation by the authors, the two reviewers, Bob Rogers (DFO, Newfoundland and Labrador) and Andrew Edwards (DFO, Pacific), 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 summarises 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.

Prior to the meeting, the authors provided an updated WP Appendix F to all participants. They realized an incorrect value for the West Coast Vancouver Island (WCVI) synoptic survey selectivity prior (μ): μ_3 = 12.2 was used instead of the intended value of 15.4. The base case runs were updated in the revised appendix but not the sensitivity runs. The authors indicated that the updated base case model runs only resulted in minor differences to parameter estimates and maximum sustainable yield (MSY) quantities, and that base component run 5, natural mortality (M) = 0.06, had an improved fit. The authors indicated that a run using M=0.065 did not have acceptable Markov Chain Monte Carlo (MCMC) diagnostics to be considered part of the composite base case. The authors will re-run the sensitivity analyses with the correct selectivity prior for the Research Document.

COMMERCIAL TRAWL DATA

- A reviewer (BR) indicated that since the midwater trawl data show size and age structure differences from the bottom trawl data, and that the midwater trawl landings contribute 16% of total landings, it might be useful to use a two-fishery model. The authors indicated that there were insufficient data to reliably support a two-fishery model but agreed that a separate midwater fishery in the model would be an improvement. A participant noted that the Pacific groundfish sampling protocols were being reviewed to determine where sampling effort should be directed in the future, which may result in more data being available for future YMR stock assessments. An author pointed out that the midwater trawl YMR catch appeared to be increasing and may constitute a higher proportion of landings in the future. For the next assessment, a two-fishery model should be explored if the data are available.
- A reviewer was concerned that the commercial trawl CPUE analysis may be driven by fewer and fewer vessels over time, which may have biased the index (see Figures C2 and C9). The authors responded that while this was an insightful point, they did not consider it to be a problem. Most of the vessels that remained in the fishery had been active for the entire 25-year time series, and they covered a broad range of catch rates. These vessels provided continuity to the analysis and confidence in the results.
- A reviewer was concerned that the commercial and survey weight data were different due to differing selectivities and this difference may have been affecting age frequency proportions through time (Section D.1.1). The authors indicated that each fleet had its own selectivity

function, which was based on the observed age distributions for that fleet. Thus differences in weight or length were not an issue in this model.

- A reviewer questioned why a 2021 catch was included in the model inputs when the RPR was only halfway through the year. The authors indicated they had consulted with representatives from the commercial trawl industry who agreed that the estimate of 1057 t for the 2021 catch was reasonable, if not an overestimate. Queries to the DFO groundfish database (GFFOS) indicated that the trawl fleet had only landed ~300 tonnes by the end of June 2021, a lower amount than usual (possibly due to COVID-19 restrictions and reduced market demand). The authors noted that by June the fishery typically had caught 40-60% of their total catch, and therefore estimating the 2021 catch at 1057 tonnes could be an overestimate for total landings in 2021. The 5-year average catch was 1272 tonnes, so the estimate for 2021 catch was only 200 t lower. The authors also noted that it was not unusual for stock assessments to include the catch for the current year in order to provide up-to-date advice.

  In response to the comment by reviewer AE, the authors ran an additional sensitivity with the 2021 catch doubled to 2114 tonnes. The model results were similar to the central run (which was used as the base for all sensitivity runs), with the current stock status being only 2% lower. This sensitivity run will be included in the Research Document (and SAR) along with a discussion of its results and implications for advice to managers.

SYNOPTIC SURVEY DATA

- The authors noted in the presentation of the working paper that, because the research surveys provided very imprecise indices for YMR, the surveys contributed little information to the model on biomass trends. Furthermore, the surveys were concentrated in the summer to early autumn, resulting in biological data that were necessarily confined to these months. Because YMR appears to spawn during the winter, the authors combined the available commercial observer-collected data with the synoptic survey data to more fully cover the maturity observations. However, it is likely that observers on commercial vessels would be less trained than survey personnel, resulting in some variability in the visual recording of maturity states (i.e., resting and mature stages can look similar to inexperienced observers).
- Reviewer BR asked whether the different survey vessels could be standardized among the surveys, suggesting that catchability may vary between vessels (due to differences in vessel power, mechanical noise, and net lifting speed) and that the surveys may not be sampling consistent portions of the stock. These issues may explain the poor fit to the data by the model. Participants and authors indicated that the gear and procedures were standardized as much as possible among vessels in order to minimise this problem. However, existing differences among skippers are more difficult to standardize. The random depth-stratified design, which targets a broad range of species, and the aggregating nature of many rockfish species potentially had a larger impact on sampling and data quality than differences among vessels. Reviewer BR accepted that the relative errors of the YMR survey data were high due to aggregating behaviour by this species and swimming off bottom, and that vessel standardization would not be sufficient to reduce the observed error.

DIFFERENCES BETWEEN AWATEA AND SS MODEL PLATFORMS

In 2011, the authors used a model variant of Coleraine called ‘Awatea’. In this stock assessment, the authors used the National Oceanic and Atmospheric Administration’s (NOAA’s) Stock Synthesis 3 (SS) model, version 3.30.17.01 (2021-06-15).

- Both reviewers and some participants expressed concerns over the large biomass trajectory differences between the 2011 assessment (Edwards et al. 2012) and the 2021 assessment. One reviewer pointed out that the historical recruitment estimates had changed considerably between assessments, but much of the input data were the same. In response to these comments, the authors prepared a presentation after running additional model runs in Awatea to explore the differences between the Awatea platform (used in 2011) and the currently used SS platform.
- A major difference between the two models was the error distributions used to fit the age frequency data. In Awatea, a robust normal distribution was used; however, this option was not available in SS and so a multinomial distribution was used. In Awatea, any standardised residuals over 3 were downweighted, while under SS, the fitting method did not downweight large residuals. This difference in handling residuals allowed SS to generate large stock sizes resulting from non-credible (very high) estimates of R_0.
- Model fits to the age data appeared to be better in this assessment over the model fits using Awatea, especially for the older ages. Year-of-birth residuals were also lower using the multinomial distribution in SS.
- The estimated recruitment patterns were similar under the two model platforms. While the mode of posterior density (MPD) for both models found the same years of high recruitment, the early recruitment spike in 1952 was larger in SS. The MCMC search in the Awatea model lost the clarity of the 1952 recruitment spike. Without ageing error, both models spread the recruitment events into adjacent years. Such a pattern is atypical of deepwater *Sebastes*, a group of finfish which typically have episodic recruitment confined to a single year.
- The spawning biomass trajectories after 1980 were similar between the model platforms, as were the current (beginning year 2022) biomass estimates.
- The authors indicated that the model platforms appeared to be functioning similarly, but differed in how they interpreted the early recruitment pulses. This difference in the early recruitment estimates resulted in a higher estimate of B_0 for the 2012 assessment (and an analagous 2021 Awatea run) compared with the SS model fits. However, the ratios of B_{MSY}/B_0 were similar between the two platforms (around 0.28) as were the current biomass estimates. However, since B_0 was lower under SS, B_{MSY} was also lower, and consequently, the ratio of B_{2022}/B_{MSY} (current stock status) was higher in SS than it was in Awatea.
- The authors will include a ‘bridging’ analysis to compare the model results from Awatea and SS using the updated dataset. They will keep as many assumptions the same between platforms as possible (i.e., age frequency distributions and ageing error). The authors will highlight how the ratio of B_{MSY}/B_0 is similar between models even though B_0 has changed.
- The SS model did not result in a credible stock assessment while estimating M. Estimating steepness (h) was not attempted. The multinomial error distribution allowed unrealistically high estimates of R_0, resulting in long tails on the upper end. The authors revisited the Awatea platform which was capable of estimating M and h with the updated data and found the results had good MCMC diagnostics and were similar to those from the 2012 assessment.
- Text will be added to the SAR to indicate that (i) the survey data were not very informative and (ii) there were no definitive reasons for choosing one age frequency distribution and model platform over the other; therefore the 2021 results from SS should be interpreted with a degree of caution. The authors noted that both stock assessment platforms estimated the

YMR population to be well above the USR, residing safely in the Healthy zone, so these differences did not result in substantially altered advice.

AGEING ERROR

- The 2011 assessment did not use ageing error in the models, which would contribute to some of the observed differences between the 2011 and 2021 assessments as shown in a sensitivity analysis presented by the authors. As well, Awatea and SS incorporate ageing error differently, which could also contribute to some the observed differences when the 2021 data were entered into the Awatea model.
- The procedure used in the 2021 stock assessment included ageing error calculated from coefficients of variation (CV) of observed length-at-age, which were then applied to each age to derive a standard deviation by age. A second method, proposed by a participant and explored in previous rockfish assessments, calculated the CVs at age from the variation reported by otolith readers who read the same otolith, and applying the observed range of age precision to estimate CVs at age. Applying both methods in separate models showed that the first method resulted in two single-year recruitment spikes before 1980 while the second method resulted in recruitments spread over adjacent years (although the ages covered were somewhat narrower that those without ageing error). A participant thought that the method used in the stock assessment represented compound error (in length and age), and preferred the second method because the error was only in age. However, the second method relied on fewer observations in the older ages than the length method, yielding a vector of standard deviations that showed greater variation compared with that from lengths and which may have underestimated the error in older ages. Both methods indicated that the standard deviation increased as age increased (i.e., CVs remain fairly constant), but the length methods provided a more consistent signal while the CVs estimated by the age method were irregular after about age 40.
- The authors compared three model runs to better understand the effect of the ageing error (AE) assumptions: (i) the central run (R75) using the CVs of length-at-age, (ii) S11 (R88) with no ageing error, and (iii) a new run (R93) with AE based on CVs calculated from otolith readers' estimated ageing precision. Both R88 and R93 had broad historical recruitment pulses, where good recruitment was spread across adjacent years. The authors commented that the area under these recruitment pulses would be similar to that for the central run, although the total recruitment was probably greater for R88 and R93 because the B_0 estimate for these models was larger than that for R75. The problem in this comparison was that the biomass data were not very informative and it appeared that the underlying assumptions were driving the differences in the outputs. This is a concern since B_0 and its derivatives are the primary reference levels used to determine stock status.
- The authors will add more explanation of how the ageing error is used to influence the proportion at age and the likelihood calculations in WP Appendix E.
- The authors will include Run 93 (reader ageing error) as an additional sensitivity run in the Research Document (and in the SAR).
- The authors will add text to the paper describing the differences between model platforms and will indicate that there is no single reason to use either platform or ageing error assumption over the other. The authors will also add text to indicate that when the CVs of observed length-at-age are used as the ageing error, the recruitment pulses have distinct peaks, which is more closely aligned with deepwater YMR biology.

STEEPNESS

- In response to comments from a participant, the authors conducted an additional sensitivity run to determine the impact of setting steepness (*h*) to 0.5 (instead of *h*=0.7 used in the base case runs) on the model outputs. Since the stock is at a high biomass (> 50% B_0), steepness was not thought to be a driving factor. The sensitivity run resulted in biomass and stock status estimates that were very similar to the central run, with the exception that B_{MSY} was higher and F_{MSY} was lower because the steepness assumption altered the apparent productivity.
- This sensitivity run will be included in the Research Document (and SAR) along with a discussion of its results and implications for advice to managers.
- A participant asked if sensitivity runs could be conducted where multiple assumptions are altered to determine the impact on the stock status (e.g., lower *h* and using otolith reader ageing error). The authors were reluctant because the opportunities for sensitivity scenarios would be numerous and time-consuming if this suggestion were accommodated. As well, the value of *h* used in the base case runs was similar to that estimated in Awatea (0.82 [0.62, 0.96]) and to the meta analysis produced by Forrest et al. (2010) in which estimated *h*=0.67, SD=0.17 for Beverton-Holt recruitment. The value of *h* can be estimated in SS, but the authors did not have time to explore that for this assessment, assuming that *h* was not influential in a healthy population. The recent recruitment spikes were estimated at similar levels under the various sensitivity runs and it is these spikes that will drive the biomass projections for the next 10 years. The participant was concerned that the paper may be too optimistic. The authors will add text indicating that there may be concerns with the value selected for *h* when discussing the differences between the central run and the newly added *h* = 0.5 sensitivity run. In future assessments, the authors will estimate *h*, if possible.

BIOMASS PROJECTION TIMELINE

- Projections for YMR were only calculated for ten years, until 2032, rather than for three generations which is used by COSEWIC for the application of some status criteria. In species with unpredictable, sporadic recruitment events, the mean recruitment over the time series does not provide realistic future recruitment scenarios. Also, at constant catch greater than MSY, the population will decline towards 0 under these unrealistic recruitment assumptions. Meeting participants agreed that 10-year projections were reasonable and useful for this species. As well, 10-year projections are dominated by recruitments that had been estimated during the stock reconstruction. Randomly drawn recruitments will have little impact because it takes 10-11 years for a cohort to be fully selected by the commercial fishery, based on the estimated selectivity function. The authors indicated that it may be more appropriate to project using a constant harvest rate rather than a constant catch, but that approach would still be using an unrealistic recruitment scenario. The SS development team is developing more realistic recruitment distributions for rockfish species that may be available for future assessments.
- COSEWIC was comfortable with the probability of B_t > 0.5B_0 and > 0.7B_0 decision tables that had been provided in Appendix F and agreed that projecting out three generations was not useful for this species. There was some discussion on whether a one generation (30-year) projection would be more useful than the 10-year projection, but meeting participants agreed that the 30-year projection was not likely to be credible given that recruitment pulses cannot be predicted.

TRIGGER FOR NEXT ASSESSMENT

- Given that the survey biomass indicators were relatively uninformative and no environmental or ecosystem indices were used in this stock assessment, the authors and participants agreed that the next assessment should be conducted no later than 10 years from this assessment. However, a reassessment could occur earlier if there is evidence of a recruitment pulse or if catches exceeded 2500 tonnes/year. Abundance indices can be monitored using updates of the groundfish synopsis report (Anderson et al. 2019).

REQUESTED REVISIONS TO THE WORKING PAPER

- A participant provided the authors with updated wording on Bill-C68 now that it has been accepted and is part of the *Fisheries Act*. The authors agreed to update the abstract and the appropriate lines in the Main document.
- Reviewer BR asked to have wording in the Main document to clarify how the abundance and composition data were reweighted. While the information was presented in Appendix E, it was unclear from the main body of the paper how this was done. The authors agreed to add a short description of the reweighting methodology in the Main document.
- Reviewer BR asked that the authors provide better support for their Section 3 statement that there were no sustainability issues for YMR. In particular, he asked for interpretation of the exploitation rates and stock status ratios that underlie this assertion. The authors indicated that 'sustainable' might have a different meaning for rockfish species which are anticipated to experience declining biomass in between large, sporadic recruitment events. The authors agreed to add additional wording in this section, after noting that the exploitation rate for YMR was low relative to M, a simple measure often indicative of sustainability.
- Reviewer BR asked for additional clarification as to why the length-weight and growth parameters were derived solely from the survey data instead of using the commercial data, given that the commercial data appear to be driving the stock assessment. The authors indicated in their presentation of the working paper that the commercial trawl fishery uses coarser codends in their nets to reduce or eliminate the catch of small fish. Consequently, biological data derived from this fishery do not provide adequate data to represent young small fish, resulting in potentially biased growth and length-weight functions. The authors will add text to clarify this (Section 6.3).
- Reviewer BR questioned why fecundity was mentioned in Section 6.4 of the Main document as the reference seemed out of place. The authors indicated that this stock assessment implicitly assumes that fecundity is proportional to weight. They will add text to explain the underlying fecundity assumption used in the stock assessment.
- Reviewer BR inquired as to why dome-shaped selectivity was not explored. The authors responded that they generally don't allow cryptic biomass (reduced selectivity at older ages) in models. However, when they did try to estimate such a selectivity, the data did not support a declining right-hand limb. An attempt was also made to force dome-shaped selectivity but there was no improvement to model fits. Furthermore, the estimated recruitments are confounded with the descending right-hand limb. For this reason, these models can estimate only one of these categories while holding the other constant. The authors will add a sentence to indicate this in Section 7.
- Reviewer BR requested the authors look for possible shifts in maturity over time as well as providing a male maturity ogive by age (see Figure D.6). In response to this request, the authors presented maturity ogives in five 5-year blocks which yielded little variability among

the time blocks except for some differences in the first two time blocks (1996-2000, 2001-2005). They also indicated that male maturity was very similar to the female maturity ogive, and they noted that, since spawning males are not tracked by the assessment model, there was no need to include the male ogive. The reviewer commented that there is more to understand in stock assessments than only model outputs and that biological changes in the stock are important to understand. As well, it is a good standard to set for stock assessments, especially if there are changes over time. The authors agreed to include a figure of the male maturity ogive.

- Reviewer AE requested that the authors include a catch time series figure from Appendix A into Section 2 of the main document and in the SAR.
- Reviewer AE suggested moving the text in Section 8.1.1 (central run MPD fits to the data) to Appendix F, or possibly moving some of the figures from Appendix F up to Section 8.1.1. The authors were reluctant to move the text to the Appendix F as information about the model fits to the data are important.
- A participant asked for an equation (or clarification) to be added to Appendix E indicating how the ageing error vector informs the likelihood.

FUTURE RESEARCH RECOMMENDATIONS

- If sufficient midwater trawl fishery biological data are available, try a two-fishery model.
- Estimate both *M* and *h* in SS.
- Explore using a single sex model: the growth functions differ little by sex.
- Explore how hyperallometry in the length relationship influences fecundity (e.g., exponent greater than 3).
- Investigate using a smoothing function or possibly binning ages to explore how best to incorporate ageing error into this stock assessment.
- Try using constant harvest rates to project farther than 10 years. As well, investigate if more realistic recruitment procedures for rockfish species have been implemented in SS. Such improvements may increase the reliability of the projections.
- Once the authors are more comfortable with the new modelling platform, explore retrospective patterns, fecundity, and parameter options.
- Explore the addition of climate-based variables, which might be especially important for sporadically recruiting species. The authors could address this as a sensitivity analysis for next time. The authors also indicated that SS has the option to include environmental indices as abundance indices.
- Overlay Pacific Decadal Oscillation bands on recruitment trajectories (see Figure F.30.) to see if there are any patterns.

CONCLUSIONS AND ADVICE

Meeting participants agreed the working paper satisfied all Terms of Reference objectives. The working paper was accepted with the above noted revisions. The group agreed to present the composite base case model decision tables as advice to managers.

ECOSYSTEM APPROACH TO FISHERY MANAGEMENT PRESENTATION

Reviewer AE presented a slide deck outlining DFO's plan to move towards an ecosystem approach in single-species stock assessments. The bullets below summarize the participant feedback.

- The framework outlining how an ecosystem approach can be implemented will be finished in 2023, but the presenter was unsure of when this will be required in stock assessments. It is likely to be a gradual introduction.
- A participant noted that there may not be credible links between environmental or ecosystem indices and biomass given the current data available.
- Author PS thought it would be very difficult to use this approach over a long term since correlation does not imply causation. He has noted that such correlative relationships rarely persist over time and that the environmental linkage should be explicitly modelled if it were to have real predictive power. However, this type of additional work is too complex to incorporate well into a stock assessment in terms of time, understanding, and data requirements. Reviewer AE indicated that there were plans to develop a tool-box framework to help stock assessment authors, but such improvements are not yet available.

ACKNOWLEDGEMENTS

We appreciate the time contributed to the RPR process by all participants. In particular, we thank the reviewers, Bob Rogers and Andrew Edwards for their time and expertise. We also thank Greg Workman as Chair of the meeting and Jill Campbell as the Rapporteur.

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APPENDIX A: TERMS OF REFERENCE

YELLOWMOUTH ROCKFISH (*SEBASTES REEDI*) STOCK ASSESSMENT FOR BRITISH COLUMBIA IN 2021

Regional Peer Review – Pacific Region

September 8-9, 2021
Virtual meeting

Chairperson: Greg Workman

Context

In 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the coastal population of Yellowmouth Rockfish (*Sebastes reedi*) in British Columbia (BC) as 'Threatened', based on a decline in abundance and the threat from commercial fishing. As a result, the species was considered for legal listing under the *Species at Risk Act* (SARA). In a 2011 stock assessment (also acting as a recovery potential assessment), Edwards et al. (2012) modelled the biomass of Yellowmouth Rockfish as 0.614 (0.431, 0.829)[1] of the unfished equilibrium spawning biomass (B_0), and 1.606 (2.685, 4.573) of the spawning biomass at maximum sustainable yield (B_{MSY}), which is above the upper stock reference for a healthy stock in the Sustainable Fisheries Framework (DFO 2009).

In 2017, a decision was made not to list Yellowmouth Rockfish under Schedule 1 of the SARA. While DFO will continue to manage this species under the *Fisheries Act*, actions to address conservation concerns were outlined in the order not to list (SI/2017-24 May 3, 2017). In 2019, Bill C-68 was enacted to amend the Fisheries Act, which prompted a review of 57 stocks in BC with the aim to implement sustainable fisheries management plans for the stocks over five years. Bocaccio, Yelloweye Rockfish, and Sablefish were the first groundfish to be assessed in a set of Batch 1 stocks in 2020/21. Yellowmouth Rockfish is slated for Batch 2 assessment in 2021/22.

The bulk of the BC population of Yellowmouth Rockfish is centred in Queen Charlotte Sound (central BC coast), specifically in association with the three main gullies – Goose Island, Mitchell's, and Moresby. There are also density 'hotspots' off the southwest coast of Haida Gwaii (near Cape St. James), off Rennell Sound, off the northwest coast of Haida Gwaii, and off the northwest coast of Vancouver Island. Densities of Yellowmouth Rockfish appear to be low off the west coast of Vancouver Island south of Brooks Peninsula. Preliminary analyses showed no strong evidence for stock separation along the BC coast based on growth and size frequency; therefore, the coastwide population will be assessed, as it was in 2011.

Data for Yellowmouth Rockfish are sufficient (index series and age structures) to conduct a statistical catch-at-age analysis. In 2011, 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 (SS) model, which has been adopted by many United States assessment scientists in the Pacific region. 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 will also provide a bridging

[1]denoting median and 0.05 and 0.95 quantiles of the Bayesian posterior distribution

analysis comparing fits to the data using Awatea and SS during this transition between modeling platforms.

In the absence of updated science advice, there is uncertainty about the risks posed to the BC Yellowmouth Rockfish stock by current levels of catch. 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 2009), 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. 2021. Yellowmouth Rockfish (*Sebastes reedi*) stock assessment for British Columbia in 2021. CSAP Working Paper 2019GRF02

The specific objectives of this review 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 provisional DFO limit reference point (LRP) of $0.4B_{\text{MSY}}$ and the upper stock reference (USR) of $0.8B_{\text{MSY}}$, or historical reference points (e.g., B_{min}). The following additional reference points will be presented: B_{MSY}, u_{MSY}, $0.2B_0$, 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 Yellowmouth Rockfish in BC waters relative to the 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. If the data are insufficient to quantitatively evaluate BC Yellowmouth Rockfish in terms of the selected reference points and decision tables, summarise what is known about the status of this species, and discuss the implications for harvest advice.
4. Provide guidance, if needed, to be used by a management rebuilding plan under the DFO PA framework for Yellowmouth 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).
5. Provide probabilistic decision tables to inform a COSEWIC assessment or a subsequent DFO Recovery Potential Assessment. This includes projections up to 3 generations to address COSEWIC's assessment criteria (indicators A1 and A2) using probability tables of future population status (with respect to the reference criteria) at various catch levels, as well as estimates of the time taken to attain them (with different levels of confidence).
6. Describe sources of uncertainty related to the model (e.g., model parameter estimates, assumptions regarding catch, productivity, carrying capacity, and population status).

7. 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.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participants

- 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 & Game)

References

DFO. 2009. 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.

Edwards, A.M., Haigh, R. and Starr, P.J. 2012. Stock assessment and recovery potential assessment for Yellowmouth Rockfish (*Sebastes reedi*) along the Pacific coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/095. iv + 188 p.

APPENDIX B: WORKING PAPER ABSTRACT

Yellowmouth Rockfish (*Sebastes reedi*, YMR) ranges from the Gulf of Alaska southward to northern California near San Francisco. In BC, the apparent area of highest concentration occurs in Queen Charlotte Sound with isolated hotspots west of Haida Gwaii and at the northern end of Vancouver Island. This species occurs along the west coast of Vancouver Island, but its density appears to be low south of Brooks Peninsula.

In 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the coastal population of YMR in British Columbia as 'Threatened', based on a decline in abundance and the threat from commercial fishing. As a result, the species was considered for legal listing under the *Species at Risk Act* (SARA). In a 2011 stock assessment (also acting as a recovery potential assessment), Edwards et al. (2012a) put forward two base case runs ('Estimate *M*' and *M*=0.047), which both estimated that the B_{2011} stock status was well above the upper stock reference level for a healthy stock in the DFO Sustainable Fisheries Framework (DFO 2009). In 2017, a decision was made not to list Yellowmouth Rockfish under Schedule 1 of the SARA. In 2019, Bill C-68 was enacted to amend the Fisheries Act, which prompted a review of 57 stocks in BC with the aim to implement sustainable fisheries management plans for the stocks over the next five years. The purpose of this YMR 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 a single fishery dominated by bottom trawl. Midwater trawl catches of YMR were combined with bottom trawl for the purposes of this stock assessment. YMR catches by capture methods other than trawl were negligible, averaging less than 1% over the period 1996 to 2020. Analyses of biology and distribution did not support separate regional stocks for YMR. A single coastwide stock was also assumed by Edwards et al. (2012a).

We use an annual catch-at-age model tuned to four fishery-independent trawl survey series, a bottom trawl CPUE series, annual estimates of commercial catch since 1935, and age composition data from survey series (25 years of data from four surveys) and the commercial fishery (28 years of data). The model starts from an assumed equilibrium state in 1935, the survey data cover the period 1967 to 2020 (although not all years are represented) and the CPUE series provides an annual index from 1996 to 2020.

A two-sex model was implemented in a Bayesian framework (using the Markov Chain Monte Carlo 'No U-Turn Sampling' procedure) to estimate models which fixed natural mortality to one of five levels (0.04, 0.045, 0.05, 0.055, 0.06), spanning a range that was considered plausible and which returned acceptable MCMC diagnostics. The parameters estimated by these models included average recruitment over the period 1950–2012, and selectivity for the four surveys and the commercial trawl fleet. The survey and CPUE scaling coefficients (*q*) were determined analytically. These five model runs were combined into a composite base case which explored the major axis of parameter uncertainty in this stock assessment. Eleven sensitivity analyses were performed relative to the central (*M*=0.05) run of the composite base case to test the effect of alternative model assumptions.

The composite base case estimated the YMR female spawning population biomass at the end of 2021 to be 0.69 (0.44, 1.08) relative to B_0 and to be 2.4 (1.5, 3.7) relative to B_{MSY}. This latter result suggests that the YMR 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 2031 at all evaluated catch levels up to 3000 t/y. However, these projections also predicted that the stock will decline at all catch levels, under the assumption that recruitment will be average over that time period. None of the eleven sensitivity analyses changed this conclusion.

These analyses included, estimating M, higher and lower pre-1996 catch histories, higher and lower recruitment standard deviation (σ_R) assumptions, dropping the CPUE series and substituting an alternative CPUE series, omitting ageing error, restricting the period over which recruitments were estimated to 1970–2012, and upweighting the age frequency data for the Queen Charlotte Sound synoptic survey. The most pessimistic sensitivity run was the one which omitted the ageing error, an option that we consider unrealistic.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Yellowmouth Rockfish stock assessment for British Columbia in 2021

September 8-9, 2021
Virtual Platform on Zoom

Chair: Greg Workman

DAY 1 – Wednesday, September 8, 2021

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 9, 2021

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***	
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 D: PARTICIPANTS

Last Name	First Name	Affiliation
Anderson	Sean	DFO Science
Campbell	Jill	DFO Science, Centre for Science Advice Pacific
Christensen	Lisa	DFO Science, Centre for Science Advice Pacific
Edwards	Andrew	DFO Science
Finn	Deirdre	DFO Resource Management
Gardner	Lindsay	DFO Resource Management
Haigh	Rowan	DFO Science
Jubinville	Isabelle	Oceana
Kronlund	Rob	Interface Fisheries Consulting
Leaman	Bruce	COSEWIC
Mose	Brian	Groundfish Trawl Advisory Committee
Olmstead	Melissa	DFO Science, National Headquarters
Rogers	Luke	DFO Science
Rogers	Bob	DFO Science, Newfoundland and Labrador
Sporer	Chris	Pacific Halibut Management Association
Starr	Paul	Canadian Groundfish and Research Conservation Society
Tadey	Rob	DFO Resource Management
Turris	Bruce	Canadian Groundfish and Research Conservation Society
Wilson	Kyle	Central Coast Indigenous Resource Alliance
Workman	Greg	DFO Science