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Proceedings of the Pacific regional peer review on the Evaluation of Management Procedures for the Inside Population of Yelloweye Rockfish Rebuilding Plan

June 10-11, 2020
Virtual Meeting

Chairperson: Steven Schut
Editor: Jillian Campbell

Fisheries and Oceans Canada
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Canada

Foreword

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

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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 June 10-11, 2020 via the online meeting platform Zoom to review the implementation of the Management Procedure (MP) Framework for rebuilding the inside population of Yelloweye Rockfish.

Due to the COVID-19 pandemic, in person gatherings had been restricted and a virtual format for this meeting was adopted. Web-based participation included DFO Science and Fisheries Management Sectors staff, and external participants from First Nations organizations, commercial and recreational fishing sectors, environmental non-governmental organizations, academia, as well as the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Washington Department of Fish and Wildlife (WDFW) and the National Oceanic and Atmospheric Administration (NOAA Fisheries).

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) providing advice to DFO Fisheries Management to inform them on the Inside Yelloweye Rockfish rebuilding management plans.

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 June 10-11, 2020 via the online meeting platform Zoom to review the implementation of the Management Procedure (MP) Framework for rebuilding the inside population of Yelloweye Rockfish.

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

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

Evaluation of potential rebuilding strategies for Inside Yelloweye Rockfish (*Sebastes ruberrimus*) in British Columbia by Haggarty, D.R., Huynh, Q.C., Forrest, R.E., Anderson, S.C., Bresch, M.J., Keppel, E.A. CSAS Working Paper [2019GRF01]

The meeting Chair, Steven Schut, 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 of and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working paper, and draft SAR.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference, highlighting the objectives and identifying the Rapporteur (Jillian Campbell, DFO Science, Groundfish). 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 meeting was held via Zoom and consisted of both audio and text conversations. Video was only used by presenters during formal presentations.

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, 45 people were in attendance at the RPR (Appendix D).

Participants were informed that Dayv Lowry (WDFW) and Kendra Holt (DFO Science) had been asked before the meeting to provide detailed written reviews for the working paper. This was a departure from previous CSAS RPR meetings and was an attempt to streamline the virtual meeting. Given the amount of time between the receipt of the working paper and the date of the meeting (postponed due to COVID), reviewer comments were incorporated into the working paper prior to the meeting and the revised document was made available to meeting participants in advance. Participants were also provided copies of the written reviews and the authors comments to those reviews (Appendix E). (Note: a Zoom poll showed that 90% of participants agreed that this streamline approach benefitted the process).

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to the DFO Fisheries Management Branch to inform the rebuilding management plan for the inside population of Yelloweye Rockfish. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

REVIEW

Working Paper:	Evaluation of potential rebuilding strategies for Inside Yelloweye Rockfish (*Sebastes ruberrimus*) in British Columbia by Haggarty, D.R., Huynh, Q.C., Forrest, R.E., Anderson, S.C., Bresch, M.J., Keppel, E.A. [2019GRF01]
Rapporteur:	Jillian Campbell
Presenter(s):	Dana Haggarty, Robyn Forrest, and Quang Huynh

PRESENTATION OF THE WORKING PAPER

The Management Procedure (MP) Framework used in this paper was developed and described in a CSAS RPR meeting held June 8-9, 2020. The WP was reviewed and accepted.

Anderson, S.C., Forrest, R.E., Huynh, Q.C., Keppel, E.A. 2020. A management procedure framework for groundfish in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/nnn. vi + 141 p.

To aid in understanding the aims and methods of this management approach, the abstract from the MP Framework paper is included here as Appendix F. The abstract for this WP, which represents the first application of the framework, is included as Appendix B.

The authors began by presenting the key pieces of the recently accepted MP Framework. The framework has two components: Operating Models (OMs) and MPs. The framework uses a closed-loop simulation design that includes feedback between the OMs and MPs. Through this, the dynamics of stocks and fishing fleets, observation error, and implementation errors can be modeled. The OMs simulate data and these data are used to develop MPs (which might be stock assessment models or adjustments to the Total Allowable Catch [TAC]). This process is simulated over 100 years. Objectives must be stated before-hand and performance metrics are established. Multiple MPs can be simulated, and by evaluating the performance metrics and conducting a satisficing step the MPs can be ranked. The authors outlined six best-practice steps for MP approaches:

1. defining the decision context;
2. setting objectives and performance metrics;
3. specifying OMs;
4. selecting candidate MPs;
5. conducting closed-loop simulations; and
6. presenting results to evaluate trade-offs.

Engagement from all interested parties is important during this process. As with other Management Strategy Evaluations (MSE), the selection of the MP(s) to be implemented is the role of Fisheries Management.

The authors then outlined how the MP Framework best-practice steps were applied to the inside Yelloweye Rockfish (YE) stock.

1. Decision Context – The boundaries of the management area (4B), versus the Designatable Unit (near Sointula Island to the Victoria Sill), versus the genetically different Inside and Outside stocks were defined. In 2008, COSEWIC defined inside YE as “at risk” and the 2011 stock assessment projected the stock to be in the critical zone. A rebuilding plan was established, and it is now time to re-evaluate the stock. This stock will also be reassessed by COSEWIC soon and the advice provided through this CSAS review and the final WP will help with their decision-making process.
2. Setting Objectives and Performance Metrics – The objectives required for rebuilding plans and COSEWIC metrics are specific and guided this process. Generation times and age at 50% maturity are uncertain and imprecise parameters were estimated from the literature and available data.

OBJECTIVES

1. Rebuild the stock above the Limit Reference Point (LRP) over 56 years (1.5 generations) with at least 95% [19 times out of 20] probability of success.
2. Rebuild the stock above the Upper Stock Reference (USR) over 56 years (1.5 generations).
3. Rebuild the stock above the LRP over 38 years (1 generation).
4. Given the above conservation objectives are achieved, maintain an average target catch in the short and long term.
5. Given the above conservation objectives are achieved, minimize variability in fisheries catch from year to year.
6. Achieve positive biomass trends within each 10-year period for as long as the stock remains below the LRP.

PERFORMANCE METRICS

1. LRP 1.5GT: P(B > 0.4 B_{MSY}) after 1.5 GT (in 2075, year 56 of the projection period)
2. USR 1.5GT: P(B > 0.8 B_{MSY}) after 1.5 GT (in 2075, year 56 of the projection period)
3. LRP 1GT: P(B > 0.4 B_{MSY}) after 1 GT (in 2057, year 38 of the projection period)
4. ST C10: P(average catch > 10 t) during 2020–2029, years 1–10 of the projection period
5. ST C15: P(average catch > 15 t) during 2020–2029, years 1–10 of the projection period
6. LT C20: P(average catch > 20 t) after 1 GT (in 2057, year 38 of the projection period)
7. ST AADC: P($\mathrm{AADC}_{2020–2029}$ < $\mathrm{AADC}_{2012–2019}$)

Specifying OMs – The data used included recreational catch; commercial catch; commercial CPUE; Food, Social, and Ceremonial (FSC) catch; and limited age-composition data, as well as two fishery-independent data sets from the Hard Bottom Longline (HBLL) survey and the Dogfish survey.

Performance Metrics 2 - 6 were discussed more specifically and at length.

The OMs have four subcomponents: stock estimates, fishery selectivity estimates, observation error (bias or imprecision in survey or age composition data), and implementation error (+ or – TAC). The R package DLMTool creates the OM models using estimates of natural mortality (M) and steepness (h), which were sampled 250 times from distributions obtained in the 2011 assessment. The R package MSEtool used a Stock Reduction Analysis (SRA) model to fit the OM models to the historic data. The conditioned OMs were then passed back to DLMtool to undergo the closed-loop simulations to generate stock projections for the next 100 years.

Four reference set OMs were created to encompass the most important uncertainties thought to impact the performance of the OMs: base model, low historic catch model, episodic recruitment once per generation, and HBLL selectivity estimated. Two robustness set OMs were created to represent less plausible but potentially important uncertainties: low *M* (Log-normal [0.025, 0.2]), and higher HBLL coefficients of variation (CVs). The low M scenario was intended to mimic the stock status estimates from the 2011 stock assessment, which used an SP model.

The Base OM had difficulties fitting to the data. To achieve a good model fit and minimal retrospective bias in spawning biomass the HBLL selectivity was set to 22 years based on the outside YE stock (since selectivity data for the inside stock is limited) and the dogfish survey was upweighted. All data indices were used to condition the OMs.

All four reference set OMs and the high HBLL CV OM show high probability of the spawning stock biomass being above the LRP in 2019. The low *M* OM projects SSB as falling below the LRP and USR in 2019.

A suite of 44 MPs were tested, including: constant-catch (at 5, 10, and 15 tonnes), index-based, surplus production with harvest control rules, no fishing removals, fishing at Maximum Sustainable Yield (MSY), and fishing at 75% MSY. Each model was also tested to see how it performed with annual or 5-year cycle TAC updates.

Closed-loop simulations were conducted on a 100-year timescale (to satisfy COSEWIC metrics) and performance metrics were calculated by averaging across the reference set OMs. To reduce the suite of MPs to be assessed, a satisficing step was conducted to eliminate MPs that did not meet minimum conservation criteria (the biomass after 1.5 generations has a probability > 0.95 of remaining above the LRP) and harvest criteria (minimum of 10 tonnes of catch in the short term with a probability > 0.50).

All MPs met the conservation criteria and five MPs met the harvest criteria. When the robustness set OMs were used to evaluate the same five MPs the criteria were not necessarily met and there were some trade-offs, especially under the low *M* scenario.

Key uncertainties are *M*, historical catch (recreational, commercial, and FSC catches), and selectivity-at-age (inside YE set to match outside YE despite uncertainty about this assumption and HBLL and dogfish survey selectivity is matched despite substrate and hook-size differences).

COSEWIC metrics (A and E) were also evaluated and presented. YE is scheduled for reconsideration by COSEWIC and their meeting has been delayed to include this information in their assessment.

PRESENTATION TAKE AWAY

Out of all the reference and robustness set OMs explored in this analysis, only the low *M* scenario estimated median spawning biomass to be below the LRP in 2019. After screening out MPs that did not meet the satisficing criteria of LRP 1.5GT > 0.95 and ST C10 > 0.5, 5 MPs remained. Despite uncertainty about stock status, there did not appear to be capacity to support higher catches using alternative MPs evaluated here compared to the current MP. Under the more pessimistic scenario, even current catch levels may be too high.

Annual reassessments of TAC are suggested if an index-based MP is selected, otherwise three-year updates are suggested, as is recommended for rebuilding plans.

Possible triggers for reassessment are observed index of abundance falling outside the 90% range, “exceptional circumstances,” informal evaluation procedures via feedback from stakeholders, or differences in the visual comparison of observed data vs. projected data.

Future areas of research are to improve collection of catch and biological data from commercial, recreational, and First Nation fleets, explore ecosystem considerations such as changes in predator abundance and other potential impacts on natural mortality, determine effect of rockfish conservation areas (RCAs) on rebuilding, develop RCA monitoring plans, and include the data from the RCA ROV survey in 2019.

PRESENTATION OF THE WRITTEN REVIEWS

DAYV LOWRY, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

- The document achieves its goals well and will prove valuable during re-evaluation of the rebuilding plan. The conclusions reached are defensible.
- The authors responded well to the comments and the COVID-related delays that allowed for the incorporation of the comments improved the document.
- Comment 1: Generation time (GT) estimates could be better justified in the paper. Potentially add an MP with 2 generations.
    - The authors have expanded the discussion on GTs and found that 2 GTs did not alter MP performance metrics considerably.
- Comment 2: Episodic recruitment could be more frequent than once per generation; more justification is required.
    - The authors have expanded their discussion of episodic recruitment and see no evidence in the data for more frequent recruitment events in YE, although the spatiotemporal rigor of this data set is less than desired.
- Comment 3: The justification for OM B (increasing HBLL CV) is unclear. As YE recover and increase in abundance they will occupy more habitat at higher density and the encounter rate should increase in the survey, which would increase estimate precision and lower CVs. Was this included to account for potential reductions in survey effort?
    - The authors have expanded their discussion. This scenario was included as a conservative effort as the survey is biennial over the north and south regions, which have different catches. A spatiotemporal model has been used to account for the temporal irregularities in the data. As well, some years of the index show large CVs and this scenario was aimed at capturing this.
- Comment 4: There is not enough discussion on the selectivity differences between the dogfish and HBLL surveys.
    - The authors have expanded their discussion and spoke more about the data limitations.
- Comment 5: Request removal of the mention of the Fox model as it is unnecessary.
    - Authors removed the sentence.
- Comment 6: Direct comparison to the previously used surplus production (SP) model requested to benefit stakeholder understanding of the benefits of using the new SRA models.
    - Authors were deliberate in their decision to not speak to previous model “correctness” and instead focused on the ability of the MP Framework to integrate across the inherent uncertainties for this stock and other long-lived species.
    - The reviewer requested additional language be added to indicate the trade-offs between the SP and SRA models or language that the models are not comparable.

- Comment 7: The radar plots can be useful in evaluating multiple criteria, but changes to how the graphics are displayed may improve their value.
  - The authors included the radar plots more as a point of discussion for the RPR and do not want to spend additional time configuring them.
- Comment 8: The discussion of predation on YE is primarily targeted towards adults and should be expanded to include all life stages.
  - The authors have expanded their discussion to include additional predators.
- Comment 9: The reviewer suggested that the knowledge provided by the First Nations or by specific members of those Nations be more accurately attributed.
  - The authors added text to clarify that the traditional ecological knowledge received comes from fishery biologists who work for the Nations but are not representatives of the Nations. The authors also acknowledged that more collaborative work is needed to better quantify historic and contemporary FSC catch.
  - A fishery biologist who works with numerous Nations added that the knowledge he shared was not from one Nation in particular, but of his observations overall.

KENDRA HOLT, DFO SCIENCE, QUANTITATIVE ASSESSMENT

- The authors did a great job, the rationale for their decisions was well justified and documented. This MP Framework approach is suitable for data-limited species. The geostatistical spatiotemporal models to standardize the dogfish and HBLL surveys are useful.
- Comment 1: The Base OM and Episodic Recruitment OM have similar results and are weighted similarly in the final averaged results, which may be skewing the performance metrics.
  - The authors added Figure 35 showing how the models differ in recruitment deviations and added more discussion to explain how the episodic recruitment model has high and low years, which average out to be similar to the base OM recruitment estimates. Since recruitment is a key uncertainty the authors kept this model as it warranted discussion.
- Comment 2: More discussion and inclusion in the models of implementation error is warranted.
  - The authors did not include implementation error as an OM scenario as more discussion is needed with commercial, recreational, and First Nation stakeholders to determine the direction of this error. Implementation was partially captured by the range of TACs in the MP models.
- Comment 3: The previously used SP model predicted a very different trajectory than the SRA models did. While the bridging analysis was useful and some discussion was provided, more discussion as to what specifically was driving this difference is important.
  - The authors have expanded their discussion and note that the way the stock parameters are dealt with in the SP model differs from the SRA model, which may contribute to the different trajectories. They note that more simulation testing of productivity and the performance of the SP versus SRA models would be useful.
- The reviewer declined to go into further detail on the remaining 9 comments as they were specific and the authors addressed them well.

GENERAL DISCUSSION

FIRST NATION INVOLVEMENT

- First Nation collaborators can contribute valuable knowledge on historic and contemporary FSC, help frame objections, and help establish the decision context. It is best to include First Nation collaborators from the outset.
- For other stock assessments, First Nation collaboration included co-authorship. This is a preferable process. First Nations and other stakeholders would like to have more involvement as opposed to a Science-only approach.
- The authors noted that there was no First Nation involvement in the project as the timeline was very tight. They hope to expand in this area and build those relationships for future work. They were glad to see First Nation representatives in the RPR.
- A participant noted that a harvest database was provided to DFO, and information down to species level could be provided from 2017 onwards, possibly earlier.
- The northern boundary of the DU is challenging, especially since First Nations do not share the same boundary or necessarily note which management area the catch is coming from.
- **Outcome:** More language in the paper was requested around collaborating with First Nations for sources of data, knowledge, and involvement.

MP FRAMEWORK OBJECTIVES

- It was noted that in the list of objectives there were redundancies. If objective 2 or 3 were completed it also meant that objective 1 was completed. Objectives 4 and 5 indicate that objectives 1-3 must be met first.
- The authors responded by saying that under the original rebuilding plan only objective 1 was required, with a 56% probability of success. Under the TOR, a new set of objectives was requested. The MP Framework and MSE processes were followed to develop these objectives. Objective 2 speaks to moving out of a rebuilding plan and may be useful for managers. Objective 6 was taken from the original rebuilding plan and intended to ensure long-term rebuilding. It acknowledges the fact that the stock cannot increase indefinitely.
- The authors also noted that the hierarchy of the objectives may not be clear but that objective 1 is the most important. More language will be added to clarify the hierarchy, however there is text in Section 3.1 that speaks to the objective hierarchy and that objectives 2-5 are used to evaluate trade-offs when evaluating the MPs.
- The time frame of the rebuilding above the LRP and USR were not considered explicitly in this application of the MP Framework and, therefore, are the same.
- Probabilities of meeting objectives 2 and 3 were not set in the technical committee meetings as meeting objective 1 was the priority for rebuilding the stock. In the satisficing step a 50% threshold was set for objective 4.
- There was concern that the wording may lead readers to think that the work is done once the stock is rebuilt above the LRP and this may result in confusion should the rebuilding targets and regulatory amendments be updated.
- Objectives 1-3 have been achieved under this modeling framework.
- **Outcome:** Authors will determine if further clarification around the objective rankings is required in the paper.

SURPLUS PRODUCTION VS STOCK REDUCTION ANALYSIS MODELS

- The stock reduction analysis (SRA) models used in the MP Framework are more robust than the previously used surplus production (SP) models (Yamanaka et al. 2011) in that the new framework assesses against multiple potential states of nature or multiple functional assumptions via the OMs. As well, the SP models were not suited for assessing long-lived species with lags in recruitment. Since selectivity of YE is a key uncertainty, age-structured OMs better capture stock dynamics. There is more flexibility in the MP Framework to tune the parameters and better explore the uncertainties than under the SP models. An author noted that the SRA MPs had a tendency to underestimate biomass from the OMs and, therefore, may be giving conservative results.
- However, there was concern about there being sufficient proof to move forward with this new methodology given the contrasting outlook from the 2011 stock assessment. Participants were concerned that OM model fitting to the high and low stock periods and index weighting may not be adequate. It was stated that the authors have addressed these concerns, but that more justification about why the SRA approach was used is required.
- There was some confusion about how the SRA models are being implemented as opposed to the SP models. In the MP Framework, the SRA models are being used to tune the OM models, which are then used to determine the results of the MPs. Comparing the models directly is challenging but more language is required to make this more clear.
- An author noted there is text in the paper about how the SP and SRA models deal with productivity differences, especially with respect to recruitment time lags. The low *M* OM was specifically included in the robustness set as a safety net to help inform decision making.
- A participant suggested using an SP model directly in the robustness OM set rather than the low *M* SRA model to mimic the SP model. It was noted that the OMs are age-structured and cannot accommodate the SP model parameters. The SRA models are able to recreate recruitment and growth and construct spawning stock biomass whereas the SP models are not able to do this.
- An author pointed out that only *r* could be changed under the SP. With the SRA models, growth, *M*, and *h* can be adjusted and OMs can be created to explore how those parameters influence the results.
- These stocks have been subject to very little harvest for over a decade and the low *M* model that mimics the SP model, which used a very low value for *M*, shows no change in the stock projection, which is unexpected.
- **Outcome:** The authors will add more text to the methods section to further justify why the SRA models were used (e.g., to depict more detailed dynamics and a broader range of hypotheses, using OMs to explore selectivity and data quality/quantity issues). As well, more text will be added to the discussion as to why the models generated conflicting results.

MODEL FIT TO THE DOGFISH SURVEY

- The drivers of the positive biomass trajectories evident in the four reference set OM's and robustness set B were questioned. There was no indication in the age composition data, nor any indication of a recruitment signal, to result in an increase in biomass and it was not immediately apparent what was driving that trend.
- It was noted that the last two data points in the dogfish survey may be leading the increase in biomass and these data were only collected in the southern portion of 4B. Further, this survey is not intended to target rockfish. This survey has also changed hook sizes and has

large interannual variation in biomass, which is difficult to reconcile. The dogfish survey was upweighted in the models and the justification for that was questioned, as was its inclusion as a survey index for rockfish. There was concern that removing the upweighting on the dogfish survey would result in projections of flat biomass and of the stock not moving out of the critical zone.

- Meeting participants requested that additional analyses be conducted to either weight the dogfish index to nothing, do sequential removal of data, or conduct a sensitivity analysis.
- The authors responded by saying reconciling the initial data fits to the Base OM was challenging and that solving one problem appeared to create another. The authors agreed to conduct a conditioning run of the OMs without the upweighting and they presented those data on the second day of the meeting.
    - The authors tried up-weighting, down-weighting, and excluding the 2019 data from the dogfish survey. The biomass still trended upwards.
    - The authors also looked at changing the weighting of the age composition data or removing that index entirely. The biomass still trended upwards.
    - The authors also looked at lowering *M* to 0.02 and *h* to 0.4. This configuration produced the best fit to the indices but conflicted with the age composition data. This model resulted in flat growth trends. There was concern that the value selected for *M* in the low *M* OM scenario was too low, but the authors pointed to other studies that have estimated similarly low *M* values.
- The authors believe the upward biomass trend is being driven by fish entering the spawning population. The reduction in commercial catch over the last two decades may be contributing to the increases in recruitment that is driving the upward trend. A participant thought the trend should be more gradual, but the authors pointed out that YE are thought to start maturing at age 7 and have 50% maturity at 17-18, and this fits in with the timeline of reduced commercial catches in 4B. The selectivity curve is to the right of the maturity curve, so the OMs capture the population that is spawning before it becomes vulnerable to the fishery. When the curves were reversed, the biomass did decline.
- While there was an OM that estimated the HBLL selectivity, there was concern about how selectivity and *M* interact. It was suggested that if the selectivity curve was dome-shaped instead of asymptotic there would be evidence of attrition in the age composition data, but for the last 20 years of data that trend was not evident. More data from years when the catch was higher would be needed to confirm this trend.
- A participant suggested a short paragraph be added to highlight the need for future analysis to explore selectivity. Length-based vs. age-based selectivity is not well characterized and appears to be inconsistent with the catch data, yet this relationship is driving the low biomass trajectory in the low *M* OM scenario.
- There was discussion around how the performance metrics are weighted across the range of OMs. It was suggested that for data-limited stocks local, traditional, and expert knowledge could be used to determine the performance metric weighting.
- It was suggested that a stronger emphasis be placed on the low *M* OM scenario in the paper. Management stated it needs MPs that include the low *M* OM to evaluate all plausible and pessimistic scenarios.
- **Outcome:** Authors will include the details of the OM conditioning analyses done for the RPR in the paper. Authors will place more emphasis on the results of the low *M* OM scenario in the paper. A paragraph will be added discussing the need for future work on establishing the

selectivity of YE in the HBLL survey. Future work with MPs should establish how the OMs will be weighted prior to the analysis being conducted.

IMPLEMENTATION OF THIS MP FRAMEWORK

- Managers expressed concern that they are unsure what the five chosen MPs mean for harvest advice for 2021 and how to best establish the TAC.
- Managers expressed concern that the MP Framework seems to be a miniature stock assessment and were unsure if they should be treating the OMs as such.
- There was concern that moving from a rebuilding mindset focusing on the worst-case scenario to a management mindset focusing on sustainability has not been fully explored. It was suggested that perhaps the OMs be weighted to reflect this inflection point by having the base OM and the worst-case OM each weighted at 50%.
- It was suggested that the reference set be used to find MPs that meet the criteria, then use the robustness set OMs to rank the MPs and establish exceptional circumstances to provide a safety net. Ranking in the robustness set may be more important in data-limited situations since those exceptional circumstances may in fact be reality.
- **Outcome:** No specific actions need to be taken by the authors. It is the role of Fisheries Management to decide how to best implement the advice from Science. However, for future MP Framework projects, more work needs to be done during the decision context phase to help managers interpret and implement the Science advice.

COMMERCIAL CATCH DATA CONCERNS

- It was noted that most of the commercial catch for the inside YE population comes from Area 12 and very little catch is taken from within the Strait of Georgia (however, historically there were commercial catches from the southern Strait). Since there is no way to break down the catch into finer management areas it is all attributed to 4B. This led to concern that the commercial data are not representative of the conditions in the entirety of 4B.
- There is concern of serial depletion in Area 12 that is not being properly captured in the models and should be a risk that managers are being made aware of. The authors noted that there are spatial differences in YE abundances, and the sedentary nature of rockfish can result in serial depletion. The RCAs were created to help reduce that risk by protecting ~20% of their habitat. Wording will be added to the paper in the RCA section to address the risk of serial depletion. The authors also noted that the HBLL surveys cover most of 4B, although not in any single year, so there are data on the whole Management Area.
- Historic YE catch was reconstructed from the catch and discard ratios for other rockfish but the post-2006 data is expected to be accurate. The authors have provided a chronology of management measures in the WP (Table C4 and C5). It was noted that in other assessments the SP models are not sensitive to historic catch data.
- A participant wanted to know if there was any size or age comparison done between the commercial mid-water trawl data and the recreational catch data. The commercial mid-water trawl comprises a small portion of YE mortality and the only length data came from one commercial longline trip in the 1980s. No comparisons between these data could be made.
- **Outcome:** Authors will add text to the paper indicating that the RCAs can address some of the serial depletion concerns. However, management may need to act to account for the potential of serial depletion in area 12.

RECREATIONAL CATCH DATA CONCERNS

- There was discussion around length-based vs. age-based selectivity curves in the recreational catch data modeling. The creel surveyors do not have a protocol when collecting samples and selection is thought to be biased towards larger fish. Representing lengths in an age structure model is difficult for rockfish as they experience asymptotic growth quickly in their life-history and become difficult to age. Therefore, length-based selectivity curves were not used in these models.
- There is concern that the recreational catch data near the northern DU boundary are not being accurately captured. The DU boundary bisects Area 12. As well, many fishers may fish in Areas 10 or 11 but encounter creel observers in Port Hardy, therefore it is difficult to determine if the fish being caught are from the inside or outside stock. The 2011 assessment used a ratio to establish catch between Area 12 and Groundfish Management Area 4B and a participant inquired if this ratio of 1.09 in Area 12 to the rest of 4B may need to be checked against current data.
- There is also concern about inaccurate species identification on the iREC platform. SARA has released a new identification guide that may help. However, vermilion and canary, which would be mis-identified as YE and vice-versa, are not common in 4B, so this risk is assumed to be low.
- There was also concern that the changes to retention regulations in 2019 (no retention and mandatory descending devices) are not being incorporated in the models. Authors responded that released fish are assumed to have 100% mortality as there is limited data on the efficacy of the descending devices, however retention did decline in the data. In addition, the total catch is used in the entire recreational time series (retained plus released Yelloweye Rockfish).
- **Outcome:** Authors will provide more language to indicate a CPUE index for the recreational fishery could not be derived due to active avoidance of YE.

FIRST NATION FSC CATCH DATA CONCERNS

- Historical and contemporary FSC catch is uncertain. Due to the short time frame for this project, FSC catch documentation and inclusion was not fully developed. However, more work needs to be done as many people are using YE and the spatial component of YE catch and boundaries are complex.
- The authors of the 2011 stock assessment (Yamanaka et al. 2011) used a consumption rate applied to the population over time to estimate FSC catch, which the authors thought was an incorrect assumption, so no estimation of FSC catch was conducted. It was determined that FSC catch may be captured in the creel overflight surveys especially in the South of 4B and that these data are not captured in the dockside surveys. In the North of 4B, FSC catch may be included in dual commercial-FSC trips and some of these trips occurred both inside and outside 4B. If sets were > 50% inside 4B they were included in the data, if they were ≤ 50% they were excluded. More text will be added to explain how these data were treated.
- A participant suggested expanding the discussion to include more text around how the FSC catch was treated as well as the magnitude of uncertainty (anywhere from 0 – 30% of commercial landings) surrounding the volume of FSC catch and how that might affect the results. However, it was noted that determining the TAC for FSC catch is a management decision and does not alter how the models perform.

- **Outcome:** Authors will include more text on how the dual commercial-FSC catch was treated as well as text on the magnitude of uncertainty surrounding FSC catch. More collaboration with First Nations could help resolve some of these data uncertainties.

COSEWIC METRICS

- Metrics required by COSEWIC were asked to be included in the SAR as COSEWIC will be re-evaluating the status of YE soon and the SAR will be published ahead of the WP.
- It was noted that the probability of decline metrics in the WP and in the text in the presentation were backwards to how COSEWIC requires them. It should be presented as the probability that decline is less than 30, 50, and 70% of 1918 biomass. The figure in the presentation was correct.
- Extinction risk metrics, while rarely used for marine fish, were able to be developed using this model framework. COSEWIC representatives were happy with this and found it useful. This will be included in the SAR along with additional text to aid interpretation.
- **Outcome:** Authors will reword the probability of decline text and figures in the working paper to reflect how COSEWIC uses that information.

CONCLUSIONS

The TOR objectives were deemed to be reached and the working paper was accepted. Multiple minor additions to the text of the paper were requested, in addition to those already made in response to the formal reviews, to further justify some of the choices made by the authors.

The following “Draft Summary Bullets” and “Draft Conclusions and Advice” sections were presented and/or discussed at the meeting. The Chair and Authors were directed to further clarify these components and recommendations in the final SAR. While the substantive recommendations contained in the following draft sections remain the same in the final advice, the wording in the SAR may have changed.

DRAFT SUMMARY BULLETS

- The inside stock of Yelloweye Rockfish (*Sebastes ruberrimus*, Inside Yelloweye Rockfish) is a data-limited stock, occurring in Groundfish Management Area 4B (Queen Charlotte Strait, Strait of Georgia, and Strait of Juan de Fuca) in British Columbia (BC).
- The stock was assessed as being below the LRP in 2010, resulting in a published rebuilding plan.
- This project provides scientific advice through application of a new management strategy evaluation framework recently developed for BC groundfishes (the Management Procedure [MP] Framework; Anderson et al 2020, in prep). It evaluates the performance of alternative data-limited MPs to support re-evaluation of the current rebuilding plan for Inside Yelloweye Rockfish.
- An MP framework differs from a conventional assessment in two key ways: (1) reference points and stock status are calculated in the Operating Models (OM) and are built into the performance metrics rather than reported explicitly; and (2) objectives defined by probabilities of breaching reference points must be made explicit at the beginning of the process in order to establish performance metrics and satisficing criteria.
- The MP Framework was used to evaluate the ability of 34 data-limited MPs to meet the proposed principal objective of rebuilding the stock above the Lower Reference Point (LRP,

0.4 B_{MSY}) over 1.5 generations (56yrs) with at least a 95% (19 times out of 20) probability of success.

- Performance of MPs was also evaluated for two additional conservation metrics based on LRP=0.4B_{MSY} and Upper Stock Reference (USR)=0.8B_{MSY}, four average-catch objectives, and one catch-variability objective.
- Natural mortality, selectivity, and historic catch were identified as sources of uncertainty. Reasonable estimates were made for these, and more importantly the impact of these sources of uncertainty was reduced by evaluating performance of MPs across six alternative OM scenarios based on different model and data assumptions. Four were based on normal expectations (reference sets) and 2 were designed to test extreme parameters (robustness sets).
- None of the reference set OMs estimated the stock to be below the LRP in 2020. Closed-loop simulation was used to screen out MPs that did not meet basic performance criteria, resulting in five remaining candidate MPs: two annual constant-catch MPs (10 and 15 tonnes), and three MPs that adjust the TAC based on a survey index of abundance. All five final MPs met the principle objective with greater than 0.98 probability (49 times out of 50), across all four OM reference set scenarios.
- Because all the MPs met the principle objective under the reference set scenarios, there were no strong trade-offs between conservation and catch objectives.
- Trade-offs were most apparent under the lower productivity robustness scenario (Low M) where none of the 5 MPs evaluated were able to achieve the primary objective of rebuilding the stock above the LRP over 1.5 generations with at least 95% probability. The highest ranking MP for this scenario (a constant catch of 10t) resulted in a 90% probability of rebuilding the stock to above the LRP over 1.5 generations.
- Evaluation of the OMs used suggest that the differences in estimates of Inside Yelloweye Rockfish stock status between the current and previous assessments may be attributable to model structure choices. Given the limited data available, reliable estimation of biological reference points and stock status is not possible, highlighting the importance of methods such as the MP Framework applied in this project.
- When employing this MP Framework going forward, recommendations for assessment frequency are predicated on the choice of Management Procedure; annual updates for index-based MPs and a maximum of three years between re-evaluations. In line with MSE best practice, it is recommended to establish formal “exceptional circumstance” detection protocols to trigger earlier reassessment, reasonable examples can be found in the literature.
- The flexibility of the MP Framework to inform different information needs was demonstrated using results structured to allow evaluation of two alternative assessment criteria (Metric A and E) for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).
- Preliminary advice for use of candidate MPs related to the problem of setting TAC
- Recommendation for more work on implementation

DRAFT CONCLUSIONS AND ADVICE

We applied a new MP Framework for Pacific groundfishes (Anderson et al. 2020b) to evaluate the ability of alternative MPs to meet rebuilding objectives for Inside Yelloweye Rockfish. This is the first application of the MP Framework for decision-making purposes.

This MP Framework, and all MSE processes, differ from conventional stock assessments in the way science advice is delivered (Anderson et al. 2020b). In most BC groundfish stock assessments (e.g., Yamanaka et al. 2011; Starr and Haigh 2017; Forrest et al. 2019), catch advice is presented in the form of decision tables, where probabilities of breaching reference points (e.g., probability of the stock falling below the LRP) are presented over a range of possible future TAC levels. This approach places consideration of risk at the final step of the decision-making process and may not always be transparent or related to pre-agreed objectives.

MP frameworks differ from conventional assessments in two key ways: (1) reference points and stock status are not necessarily explicitly reported; and (2) objectives related to the probability of breaching reference points must be agreed upon at the beginning of the process, (i.e., Step 2 of the best practices). Reference points and stock status are therefore still an integral component of the framework, but they are calculated in the OMs and are built into the performance metrics. Critically, agreement on acceptable risk (e.g., acceptable probabilities of breaching reference points) must be reached at the beginning of the process so that performance metrics and satisficing criteria can be established.

For many stocks, especially data-limited stocks, it is not possible to reliably estimate biological reference points or estimate stock status. MP frameworks such as this one may be especially important for these stocks. The Sustainable Fisheries Framework and the Fish Stocks provisions of the *Fisheries Act* require that fish stocks be maintained at sustainable levels, and particularly above the LRP. This framework implicitly preserves the intent of these policies despite the fact that reference points and stock status are not explicitly emphasized.

We evaluated the performance of 31 data-limited MPs (and three reference MPs) with respect to meeting the objectives described in Section 3. We screened out MPs that did not meet both satisficing criteria LRP 1.5GT > 0.9 and ST C10 > 0.50 across the OM reference set scenarios, resulting in five remaining MPs (CC_10t, CC_15t, Islope_10_lambda04, Islope_10_lambda08, and Islope_5_lambda04). All remaining MPs achieved the conservation metrics LRP 1.5 GT, USR 1.5GT and LRP 1GT with greater than 0.98 probability (49 times out of 50) across all four OM reference set scenarios. This was largely because none of the reference set OMs estimated the stock to be in the critical zone in 2020—the start of the projection period.

Within the two OM robustness set scenarios, OM Scenario (B), which simulated higher variability in the future HBLL survey, performed similarly to the OM reference set scenarios. However, under OM Scenario (A), the Low M scenario, the probabilities of meeting the performance metric LRP 1.5GT ranged from 0.75 (75 times out of 100) to 0.9 (nine times out of 10), with the current MP (CC_15t) having the lowest probability in this range.

Whereas the rebuilding plan guidance (DFO 2013) only describes objectives related to rebuilding, we also evaluated performance of MPs with respect to three average-catch objectives and one catch-variability objective. The CC_10t and CC_15t MPs, by definition, met their respective ST C10 and ST C15 performance metrics. The Islope MPs showed some contrast across MPs within the reference set for ST C10 and ST C15, depending on the MP configuration and the OM scenario. The OM robustness set scenarios generally produced lower probabilities of meeting the ST C10 metric.

Explicit discussion of tradeoffs: Generally there were no significant trade-offs apparent between conservation and catch objectives for the different Management Procedures in the reference set OMs. In the most challenging Low M robustness set none of the MPs could achieve the primary conservation objective for the stock. In this scenario the closest result was achieved by a 10 tonne constant catch MP, however at an unacceptably low likelihood of 90% probability. (any recommendation relative to selecting an MP?)

Evidence for exceptional circumstances, occurring within the recommended assessment interval, would trigger a review of the OM(s) and MP, possibly resulting in a new OM, or an adjustment to the selected MP (Carruthers and Hordyk 2018b). Satisficed MPs in the current analyses included constant catch MPs and annual Islope MPs. All of the index-based MPs were also evaluated at five-year intervals. While all of these MPs met the LRP 1.5GT criteria, none of them met the ST C10 criteria. Therefore, if an index-based MP is selected, we recommend annual updates. In line with guidance for rebuilding plans in Canada (DFO 2013), we recommend re-evaluation of the performance of the selected MP at least every three years.

LESSONS LEARNED

- It was noted that since this is a new process issues such as those encountered here are to be anticipated, but for future assessments using this framework more emphasis should be placed on including more stakeholders and planning the implementation steps during the decision context phase. This is particularly important when the objectives are not limited to the rebuilding context.
- First Nations and other stakeholders should have a larger role during the decision context phase.
- A participant highlighted three concerns surrounding implementation: (a) a need for elaboration of the decision context; (b) a lack of thorough consideration regarding the definition of exceptional circumstances; and (c) the need to improve information support so that we don't have the same discussion in a few years time. More work should be done to address these before the next MP Framework project is started.
- The decision context needs to highlight how the OMs will be weighted, how the final MPs will be selected, and how that MP will be implemented.
- It was noted that there is not a clear method to transition from choosing an MP to operationalizing it. The decision context should address how to transition out of a rebuilding phase into a management phase and what the new objectives should be.
- It was suggested that for future MP Framework work, managers should include specific text in the TOR that outlines how they want results presented to suit their methods of selecting an MP.
- Management suggested including input controls on FSC and recreational fishery into the decision context to aid in determining TACs.
- Monitoring for exceptional circumstance has little accountability through the SARs and there is a mix of roles and responsibilities. This should be addressed in a broader Management-Science context.
- The CSAS process deals mainly with Science process in stock assessments, but little is done to reflect on the decision-making and management processes. Yet under the MP Framework science and management are intertwined in the decision-making environment resulting in management-oriented work.
- **Outcome:** No specific actions need to be taken by the authors. Broader discussions between Fisheries Management and Science should be had prior to the next MP Framework project.

ACKNOWLEDGEMENTS

We appreciate the time contributed to the RPR process by all participants. In particular, we thank the reviewers, Dayv Lowry and Kendra Holt, for their time and expertise. The CSAP office thanks Steven Schut as Chair and Jill Campbell as Rapporteur.

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APPENDIX A: TERMS OF REFERENCE

EVALUATION OF MANAGEMENT PROCEDURES FOR THE INSIDE POPULATION OF YELLOWEYE ROCKFISH REBUILDING PLAN

Regional Peer Review – Pacific Region

June 10-11, 2020
Nanaimo, British Columbia

Chairperson: Steven Schut

Context

As part of the Sustainable Fisheries Framework, Fisheries and Oceans Canada (DFO) has developed "*A Fisheries Decision-Making Framework Incorporating the Precautionary Approach*" (DFO 2009), and "*Guidance for the Development of Rebuilding Plans under the Precautionary Approach Framework" (*DFO 2013). These documents outline the departmental policy and guidelines for applying the precautionary approach (PA) to Canadian fisheries. A key component of the PA Policy requires that when a stock has reached or fallen below a Limit Reference Point (LRP), a rebuilding plan must be in place with the aim of having a high probability of the stock growing above the LRP within a specified timeframe.

Canadian fish stocks that have been assessed as being below the LRP require a rebuilding plan to rebuild the stock out of the Critical Zone. The Department's guidance document for the development of rebuilding plans (DFO 2013) states that rebuilding plans should include short- and long-term objectives. Rebuilding plans should also include planned management measures, milestone objectives and undergo regular (no more than three years) performance reviews, in addition to annual monitoring and evaluation.

The inside population of Yelloweye Rockfish (*Sebastes ruberrimus*), situated within Groundfish Management Area 4B, is a data-limited stock caught primarily in the hook and line commercial groundfish fisheries, Food Social and Ceremonial fisheries, and recreational fisheries. The population was last assessed in 2011 as being below the LRP (Yamanaka et al. 2011, DFO 2012). A rebuilding plan for the population was developed and published in Appendix 9 of the Pacific Region Integrated Fishery Management Plan (IFMP) for Groundfish (DFO 2018).

The DFO Fisheries Management Branch has requested that Science Branch develop advice to inform a rebuilding plan consistent with the DFO (2013) guidance document. This advice will include a review and updating of rebuilding objectives for the inside Yelloweye Rockfish population and fisheries, and development of an analytical framework for evaluating candidate management procedures against the rebuilding objectives.

The advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR), will be used to revise the rebuilding plan for the inside population of Yelloweye Rockfish. The inside population of Yelloweye Rockfish is listed under the *Species at Risk Act* (SARA) as Special Concern, and is anticipated to be reassessed by COSEWIC in 2020 (Keppel and Olsen 2019). A SARA Management Plan is currently under development. Results of this rebuilding plan may inform a COSEWIC reassessment, a SARA Recovery Potential Assessment, and a possible SARA listing decision for the Inside Population.

Objectives

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

Forrest, R.E., Haggarty, D.R, Bresch, M., Anderson, S. and Huynh, Q. 2020. Evaluation of Management Procedures for the Inside Population of Yelloweye Rockfish Rebuilding Plan. CSAP Working Paper 2019GRF01.

The specific objectives of this paper and review are to:

1. Develop a set of candidate management objectives and corresponding performance metrics for the Inside Yelloweye Rockfish population and fisheries, in support of the development of a rebuilding plan under the Sustainable Fisheries Framework policies, a COSEWIC Recovery Potential Analysis, and a possible SARA listing decision.
2. Develop one or more Operating Model(s) (OM) using the software DLMtool (Carruthers and Hordyk 2018) to represent alternative hypotheses for the structure and dynamics of the Inside Yelloweye Rockfish stock and fishery (e.g., processes determining annual stock biomass, recruitment, fishing mortality, and biological reference points).
3. Recommend biological reference points, as built into the performance metrics, that are scientifically defensible and appropriate given the available data and management needs.
4. Develop a closed-loop simulation approach using the software DLMtool (Carruthers and Hordyk 2018) to evaluate the performance of candidate management procedures (MPs) with respect to achieving objectives developed in (#1). MPs may include a variety of methods for determining removals including fixed Total Allowable Catches (TACs), data-limited methods or simple models (e.g., surplus production models).
5. Recommend an appropriate interval between formal stock assessments and/or triggers of an earlier than scheduled assessment. Provide a rationale if indicators and triggers cannot be identified.
6. Examine, identify, and report on uncertainties in the data and methods.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, Species at Risk, and Fisheries Management sectors)
- Province of British Columbia
- Academics
- Indigenous organizations
- Industry (commercial fishing industry)
- NOAA/Washington Department of Fish and Wildlife

References

Carruthers, T.R., and Hordyk, A.R. 2018. The Data-Limited Methods Toolkit (DLMtool): An R package for informing management of data-limited populations. Methods in Ecology and Evolution 9(12): 2388–2395. doi:10.1111/2041-210X.13081.

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APPENDIX B: ABSTRACT OF THE WORKING PAPER

Under Canadian policy and legislation, fish stocks that have been assessed as being below the Limit Reference Point (LRP) require a rebuilding plan to grow the stock above the LRP. Rebuilding plans should be based upon objectives characterised by (1) a target, (2) a desired time to reach the target, (3) and an acceptable probability of reaching the target. Rebuilding plans should also include planned management measures or management procedures (MPs), milestone objectives, and should undergo regular evaluation.

The inside stock of Yelloweye Rockfish (*Sebastes ruberrimus*, Inside Yelloweye Rockfish) is a data-limited stock, occurring in Groundfish Management Area 4B (Queen Charlotte Strait, Strait of Georgia, and Strait of Juan de Fuca) in British Columbia (BC). The stock was assessed as being below the LRP in 2010, resulting in a published rebuilding plan. It is also listed under the Species at Risk Act (SARA) as a Species of Special Concern. The current MP for rebuilding is a fixed annual total allowable catch (TAC) of 15 metric tonnes, which has not been re-evaluated since the last assessment.

The purpose of this project is to provide scientific advice to support re-evaluation of the rebuilding plan for Inside Yelloweye Rockfish. We apply a new management strategy evaluation (MSE) framework (the MP Framework), recently developed for BC groundfishes, to evaluate the performance of alternative data-limited MPs, with respect to meeting rebuilding objectives. The MP Framework follows six best-practice steps for MSE: (1) defining the decision context, (2) setting objectives and performance metrics, (3) specifying operating models (OMs) to represent the underlying system and calculate performance metrics, (4) selecting candidate MPs, (5) conducting closed-loop simulations to evaluate performance of the MPs, and (6) presenting results to facilitate evaluation of trade-offs.

We followed this framework to evaluate the performance of 34 data-limited MPs with respect to meeting the principal objective, which is to rebuild the stock above the LRP over 1.5 generations with at least 95% [19 times out of 20] probability of success. We also evaluated performance of MPs with respect to two additional conservation metrics, four average-catch objectives, and one catch-variability objective. To account for uncertainty in underlying population dynamics and data sources, we developed six alternative OM scenarios, which differed with respect to specific model and data assumptions. These OM scenarios were divided into a “reference set” (four OMs) and a “robustness set” (two OMs). We conditioned all OMs on observed catch data, indices of abundance, and available age composition data. We used closed-loop simulation to evaluate the performance of the MPs and screened out MPs that did not meet a basic set of criteria, resulting in five remaining candidate MPs: annual constant-catch MPs of 10 tonnes or 15 tonnes, and three MPs that adjust the TAC based on the relative slope of the inside hard-bottom longline (HBLL) survey index of abundance.

All five final MPs met the principle objective with greater than 0.98 probability (49 times out of 50), across all four OM reference set scenarios. This was largely because none of the reference set OMs estimated the stock to be below the LRP in 2020. Within the two OM robustness set scenarios, the scenario that simulated higher variability in the future HBLL survey performed similarly to the reference set scenarios. However, under the scenario that assumed a lower rate of natural mortality for the stock (“Low M”), all MPs had lower probabilities of meeting the principle objective, with the lowest probability achieved by the current MP (constant catch of 15 t).

We present a number of visualizations to show trade-offs among conservation and catch objectives for the different MPs across alternative OM scenarios. The visualizations present tradeoffs in tabular and graphical formats, intended to support the process of selecting the final

MP. Because all the MPs met the principle objective under the reference set scenarios, there were no strong trade-offs between conservation and catch objectives. Of the two OM robustness set scenarios, trade-offs were most apparent under the Low M scenario, where the probability of meeting the principle objective decreased as the probability of achieving an average short-term catch of 10 t increased.

We discuss major uncertainties, including uncertainty in natural mortality, selectivity, and historical catches, noting that we attempted to account for these uncertainties by evaluating performance of MPs across multiple OMs. We highlight issues regarding estimates of current stock status for Inside Yelloweye Rockfish, and the role of reference points in the MP Framework. We make recommendations for assessment frequency and suggest triggers for re-assessment. Performance of MPs with respect to meeting two alternative assessment criteria for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are also evaluated.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Evaluation of Management Procedures for the Inside Population of Yelloweye Rockfish Rebuilding Plan

June 10-11, 2020
Virtual Platform on Zoom

Chair: Steven Schut
Rapporteur: Jill Campbell

DAY 1 – Wednesday, June 10, 2020

Time	Subject	Presenter
0900	Introductions and overview of virtual platform Review Agenda CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper (Background)	Dana Haggarty
1000	***5 minute Break***	
1005	Presentation of Working Paper *cont'd* (OMs and Results)	Quang Huynh
1100	***5 minute Break***	
1105	Overview of Written Reviews	Chair + Reviewers & Authors
12:00	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	Group
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, June 11, 2020

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
1530	Other follow up commitments (as necessary)	Chair + Participants
1600	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Ahern	Pat	Sport Fishing Advisory Board
Anderson	Sean	DFO Science, Groundfish
Ashcroft	Chuck	Sport Fishing Advisory Board
Bates	George	Sport Fishing Advisory Board
Benson	Ashleen	Landmark Fisheries
Bocking	Bob	Tla'amin First Nation
Bresch	Midoli	DFO, Science, Groundfish
Campbell	Jill	DFO, Science, Groundfish
Carruthers	Tom	University of British Columbia
Christensen	Lisa	DFO Science, CSAP
Claytor	Ross	COSEWIC
Cope	Jason	NOAA Fisheries
Cornthwaite	Maria	DFO Science, Groundfish
Edwards	Andrew	DFO Science, Quantitative Assessment
English	Philina	DFO Science, Groundfish
Forrest	Robyn	DFO Science, Quantitative Assessment
Freshwater	Cameron	DFO Science, Quantitative Assessment
Frid	Alejandro	Central Coast Indigenous Resource Alliance
Gardner	Lindsay	DFO Fisheries Management, SARA
George	Layla	Tla'amin First Nation
George	Larry	Cowichan Tribes
Grandin	Chris	DFO Science, Groundfish
Grant	Paul	DFO, Science, SARA
Guo	Chuanbo	DFO, Post Doctoral
Haggarty	Dana	DFO Science, Groundfish
Haigh	Rowan	DFO Science, Groundfish
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Holt	Carrie	DFO Science, Quantitative Assessment
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Olmstead	Melissa	DFO Science, NHQ advisor

Last Name	First Name	Affiliation
Rusel	Christa	A'Tlegay Fisheries Society
Schut	Steven	DFO Science, Spatial Data Unit
Sporer	Chris	Pacific Halibut Management Association (PHMA)
Weckworth	Erin	Quatsino FN Fisheries Coordinator
Workman	Greg	DFO Science, Groundfish

APPENDIX E: WORKING PAPER REVIEWS AND AUTHOR RESPONSE

Due to the amount of time offered to the authors between receiving the reviews and the CSAS meeting, reviewer comments were incorporated into the working paper prior to it being submitted to the RPR. Author comments are indented in italics in the following reviews.

DAYV LOWRY, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE, SENIOR RESEARCH SCIENTIST

Date: 8 May 2020

General Comments:

The working paper is well written, follows a clear logical structure from purpose to goal, and lays a solid groundwork for future efforts to apply the newly developed Management Procedures (MP) Framework to groundfishes throughout British Columbia's waters. The paper clearly details the policy and science need for Management Strategy Evaluation (MSE) in the face of limited biological and fishery data and systematically responds to the best practice guidance set forth in the MP Framework in a way that is well justified and largely accessible. Given the rebuilding objectives and performance metrics identified, the data available, the structure of the operating model, and the analytical processes applied, the conclusions reached are largely defensible, though modifications to some model parameters may be warranted (see specific comments below). Though the paper stops short of recommending a specific MP for use by managers (which was not one of the objectives), it supplies a suite of visualization tools that will allow stakeholders and decision makers to understand and weigh trade-offs, and tailor MP selection to socioeconomic, and other, factors that play into conservation and fishery management. All told, the document achieves its goals well and will prove valuable during reevaluation of the rebuilding plan for Inside Yelloweye Rockfish.

Specific Comments:

Reviewer 1 Comment 1. Line 308 – The estimated generation time applied here needs further justification/consideration. The 2008 COSEWIC estimates for generation time were 66 yrs for Outside Yelloweye and 70 yrs for Inside Yelloweye. While Cox et al. 2011 used the average modeled age of the unfished stock to produce an estimate of 38 yrs for Outside Yelloweye, simply transferring this value to the inside stock ignores documented biological variation between modeled unfished populations of the two stocks. The justification on line 1362 that aligning rebuilding timeframes between the Inside and Outside populations is desirable falls flat if it ignores biological variance.

A potentially larger issue is that the two stocks have different fishery histories and are affected by very different population stressors/drivers. Using a generation time based on the unfished state ignores the biological reality of Inside fish, especially those in the southern portion of the DU, currently residing in a highly modified ecosystem relative to the early 1900s. Assuming that the demographic processes underlying reproductive success are unaffected by these factors and that the population will continue to "function normally" seems risky. Larval survival is likely lower in some areas due to toxic contaminants, juvenile survival may be lower due to enhanced predation, and reproductive output may be compromised by prey shortages and bioaccumulation of toxins.

Given that the MP Framework allows for objectives to be set using 1.5-2 generations I would at least suggest that the core conservation objective be set to occur over 72 years (2 generations) to allow for unaccounted variation in generation time, if an alternative value cannot be generated.

We expanded the discussion on generation time considerably. We felt that the most appropriate place to elaborate on generation time is in the Biological Appendix (A.3) devoted to generation time. We refer the reader to this appendix in Section 3.1.

In Appendix A.3, we explain that the previous estimates of generation time presented in COSEWIC and Pre-COSEWIC documents used in the past, were based on the formula GT=age at 50% maturity + 1/M). In 2008, a natural mortality rate of 0.02 and age at 50% maturity for females in the inside stock of 37.5 years were used to estimate generation time at 70 years, which is now thought to be higher than it probably is. Keppel and Olsen (2019) revised GT to be 40.5 to 45.0 years using a natural mortality of 0.038 and age at 50% maturity of 14.2 to 18.7 years, estimated using commercial and research data, respectively.

Had we used this formula and the median estimate of natural mortality used in our baseline OM, 0.045, and the inside 50% maturity, the generation time would be 36 for females and 40 for males, which is remarkably similar to the estimate of 38 years that we borrowed from the Outside Yelloweye Rockfish rebuilding analysis.

We also discussed the great uncertainty around estimating generation time given the uncertainties involved in natural mortality, and imprecision associated with maturity classification and ageing. When writing this discussion, we also realized that we could present data on the ageing precision of the inside Yelloweye Stock. We added a figure to Appendix A.1 (Figure A.2. Ageing precision plot for inside Yelloweye Rockfish).

Although it is possible to present our results over 2 GT rather than 1.5GT, we note that there is a higher probability of achieving rebuilding over the longer time frame. In terms of selecting MPs, using the longer timeframe of 2GT is not necessarily more conservative. We did re-run the results with 2GT and the results did not appreciably change with the longer time frame since: a) probabilities of rebuilding were already in the high 90s over 1.5 GT; and b) the other satisficing performance metric, STC, is unaffected by choice of generation time, therefore resulting in the same set of satisficed MPs.

Reviewer 1 Comment 2. Line 482 – Why was the expected frequency of extreme recruitment events set to once per generation? This seems arbitrary and fails to account for environmental drivers of such events. Given that variation in parameters like water temperature and upwelling indices occur on seasonal to decadal cycles, it seems that conditions could be ripe for “jackpot” recruitment events on a much more frequent basis. In Puget Sound extreme recruitment was observed in 2006, 2012, and 2019 for a broad suite of rockfish species. At the least, the paper should provide some basis for this assumption. It might also be worthwhile to create an OM where extreme events are tied to a known or suspected environmental driver with a higher frequency of occurrence to see how this affects performance metrics.

Although it is true that rockfish recruitment events may become more frequent and there is evidence of recent large recruitment events in BC, such as for Bocaccio (Haigh and Starr 2020), as well as Atlantic redfish (Licando et al. 2020), we have no evidence to support that this will be the case for Yelloweye Rockfish, a species known to have episodic recruitment. In our dataset, it appears as though the Outside Yelloweye Rockfish have had recruitment events in 1948 and 1978, so we decided to use once per generation to model episodic recruitment events. Furthermore, Yelloweye Rockfish are examples of species that display the storage effect (Warner and Chesson 1985) where strong recruitment events are stored in the adult population and are capable of contributing to reproduction, sometimes significantly, when favorable conditions return. Longevity in rockfish is thought to have evolved as a strategy for weathering un-

favorable conditions. Therefore, assuming that one strong recruitment event occurs per generation is based in life history theory.

In Section 4.1.4, we expanded on our justification to use one recruitment event per generation:

"We assume that an extreme recruitment event is expected to occur once every generation (38 years), based on the observation that strong recruitment events in Outside Yelloweye Rockfish were present in 1948 and 1970. Although recent environmental conditions may be favorable for some species of rockfishes (Haigh and Starr 2020; Licandeo et al 2020), we don't yet have any evidence of recent strong recruitment events for Inside Yelloweye Rockfish that might indicate more frequent episodic or spasmodic recruitment events."

We also expanded on rockfish life history by adding these sentences earlier in Section 4.1.4:

"This life history strategy is sometimes called the storage effect (Warner and Chesson 1985) because strong recruitment events are stored in the adult population and are capable of contributing to reproduction, sometimes significantly, when favourable conditions return. Longevity in rockfish is thought to have evolved as a strategy for weathering un-favourable conditions."

Reviewer 1 Comment 3. Line 500 – I am unclear on the justification for including an OM that assumes a higher CV for the HBLL survey in the future. As Inside Yelloweye recover and occur at higher densities and/or over a broader array of habitats the encounter rate in the survey should go up. This should increase precision of the estimates, lowering CV. Is this scenario included as a conservative effort to account for possible reductions in funding/staffing, survey frequency, etc. that could compromise data utility?

Yes, this scenario is in part included as a conservative effort. However, the current design of the survey, which is actually two surveys, a north and a south survey, means that the combined index bounces around with the region that is sampled, with catches being lower in the southern region. We have used the spatio-temporal model to try to deal with this seesawing as well as several sampling irregularities over time which affect the index, but the combined index does still fluctuate depending on the region sampled. The surveyed counts are real data, but we also have to consider whether the operating model can explain why the survey leaped from one year to the next. We also have several years of fairly large residuals in the HBLL survey in the OM. The higher CV scenario was intended to get at this.

We also hope to extend this spatio-temporal modeling work to try to improve the survey design, but there is always uncertainty in what may happen in the future in terms of budgets, personnel, ship-time availability and their effects on survey effort.

Reviewer 1 Comment 4. Line 536 – Neither here nor in Appendix B are details provided about hook size in the dogfish and HBLL surveys or seasonality of survey efforts, despite these being potentially major factor determining selectivity. While Appendix B does note that locations and depths vary between the two surveys, I think more emphasis could be placed both in the appendix and in the description of the base model on the fact that the dogfish survey samples largely over "soft" bottoms and that the HBLL survey very intentionally does not. Sampling over different substrates and different depth ranges, and potentially at different times of year with dissimilar hook sizes, makes the assumption that selectivity is comparable between the two methods suspect as you are sampling different segments of the population.

There are a number of factors that increase uncertainty in estimating selectivity for the Dogfish survey e.g. the absence of biological data from this survey, and changes in fishing operations and hook type that occurred in 2004 (Appendix B.2). There are also several differences between the HBLL and Dogfish longline surveys (Appendix B.3), but, for the reasons mentioned, we cannot reliably estimate the selectivity for the Dogfish survey. Out of necessity, selectivity in the Dogfish survey was set to mirror selectivity in the HBLL survey, whether it was estimated (Scenario (4) or fixed (all other scenarios).

We did add the following explanation of the differences between the two surveys In the appendix (Appendix B.3):

The Dogfish survey is not designed to index rockfish, so there are several important differences between the inside HBLL and Dogfish survey designs. Perhaps the most significant difference is that the HBLL specifically targets habitats suitable for rockfish (i.e. hard bottom), whereas the Dogfish survey visits sites that were important in the commercial fishery that have mainly soft sediment bottoms. The Dogfish survey also uses slightly larger circle hooks (14/0) than the HBLL survey (13/0); herring bait instead of squid; fishes 300 hooks per set instead of 225; and the hooks are spaced 1.8m apart instead of 2.4m. We use the Dogfish survey in this analysis because it provides the longest time series of fishery independent data for inside Yelloweye Rockfish and because it was used in the previous assessment in 2011. In August of 2019, we also initiated research to compare the Dogfish and HBLL surveys by fishing at some of the northern Dogfish Survey sites with both survey gear types. These data have not yet been analyzed and we anticipate needing to collect additional data for a proper comparison. Also in 2019, we began to collect full biological data and otoliths on rockfish species on the Dogfish Survey so that future work will have better estimates of selectivity. The otoliths have not yet been aged. We added this information to Section 8.4.1.

Reviewer 1 Comment 5. Line 650 – Mention of the Fox model here is unnecessary and it adds nothing. You don’t mention it anywhere else in the document and so no context is available. Remove this brief mention.

We have removed this sentence.

Reviewer 1 Comment 6. Line 662 – The comparison of the past SP model runs with your runs incorporating new data is compelling but it begs two questions: 1) was the old model necessarily ‘wrong’ (i.e., was rebuilding unnecessary?); and 2) how is your current OM necessarily a ‘better’ interpretation of stock status than the SP model? While I think these questions are answered implicitly by subsequent analyses, and addressed to some degree on line 912, it could benefit stakeholders if you are explicit about the improvements here so that they don’t construe this as a government entity failing to acknowledge a shortcoming in their methods and setting out to correct them.

We deliberately stopped short of saying the old model was right or wrong, and we rarely do this when a new stock assessment model is introduced. In a regular stock assessment process we might do a bridging analysis, changing individual data and model components one at a time to understand differences, although this is more challenging when switching from a SPM to an age structured model. However, as noted, we did fit a SPM to the observed data to check whether it produced more similar results to the previous assessment. In Section 8.3, as noted, we attempted to list some features of the SRA that might lend it to better characterize a long-lived stock such as Yelloweye Rockfish, but we do not suggest it is necessarily “better” since assumptions about selectivity, natural mortality and recruitment introduce new elements of uncertainty.

Instead we ended with a paragraph suggesting that the MP Framework provides an approach to integrate across the inherent uncertainties prevalent for this stock. We did add a minor edit to the last paragraph to improve readability.

Reviewer 1 Comment 7. Line 760 – Regarding the radar plots, I see how they can become cluttered but I find them useful in simultaneously evaluating several criteria at once. I agree that no more than six spokes should be added to any one plot, and wonder if in addition to arranging the performance metrics in order of stated goal importance you might also experiment with bolding the spoke, label, or both for the primary metric.

We agree that some tweaks such as bolded spokes or labels might make the radar plots slightly more interpretable. On balance though, we think that once the radar plots get to the point where there are enough spokes that some need to be bolded for emphasis that the radar plots have probably exceeded the number of spokes at which they are interpretable. We cite a number of papers that show the downfalls of this type of visualization. One of the major downfalls is how sensitive their interpretation is to the arrangement of the spokes. They may seem to tell one story, but arrange the spokes differently and they tell a different story. For these reasons, along with those mentioned in the report, we would rather not spend more time polishing these plots.

Reviewer 1 Comment 8. Line 860 – The discussion of predation on yelloweye here is incomplete and seems to be focused only on adults. Larval rockfishes, including yelloweye, are consumed by a wide variety of organisms, and juvenile yelloweye are cannibalized by adults, eaten by lingcod and other piscine predators, consumed by birds, and picked off by harbor seals and other marine mammals. If the focus here is on adults only, state that, but if it's on the species as a whole – including natural mortality at all stages – it must include mention of other predators.

We have added two additional predators of Yelloweye Rockfish, Pacific Halibut and Lingcod. Although we can assume that Lingcod are predators of juvenile Yelloweye Rockfish, the scientific literature is actually quite lacking in predators (and many other juvenile life history information) of juvenile Yelloweye Rockfish. We can, however, assume that some of the "unidentified rockfish" noted in Lingcod stomach contents may be juvenile Yelloweye. Interestingly, the Strait of Georgia Lingcod population has also gone through major declines and is beginning to recover, so this strengthens our argument that time-varying mortality be investigated in future work. We added the following at the end of Section 8.1:

Pacific Halibut have also been observed preying on Yelloweye Rockfish in the Gulf of Alaska (Livingston at al 2017); however, Pacific Halibut are not very abundant in inside waters (see data for 2018 IPHC survey in Anderson et al. 2019). Lingcod are likely predators of juvenile Yelloweye Rockfish as they are known predators of rockfish species. However, stomach content studies are often not able to resolve rockfish species beyond unidentified rockfish (i.e. Beaudreau and Essington 2007, Livingston at al 2017). Lingcod in the Strait of Georgia also suffered major population declines and were thought to have been fished down to 2% of historic levels in 1990 but the population has increased since (Logan et al 2005; Holt et al 2016).

Reviewer 1 Comment 9. Line 960 – In the MP Framework First Nations are noted as key partners in evaluating and committing to rebuilding strategies. Here, FSC catch is essentially rolled up with commercial and recreational harvest and not given specific consideration or treatment. While it is noted that First Nation representatives were contacted, only consultants are acknowledged at the end of the document. I am not sure of the cultural traditions in Canada in this regard, but in Washington we recognize specific Tribal knowledge holders by name, and state their Tribal affiliation, when they share information with us. If this is appropriate, ensure you do so in the final version of the document.

Thank you for pointing out the lack of clarity in our phrasing. The consultants that we spoke to are Fisheries Biologists who work for or consult with local First Nations, and though they are often sent to science meetings to represent the views of the Nations they work with, they are not representatives. We changed the text to better reflect our intent. "After discussions with Fisheries Biologists who work with local First Nations in the northern and southern portions of Area 4B…"

We would also like to reiterate that we acknowledge the limitations of our approach to the treatment of FSC catch and noted in Section 8.4.2: "Future applications of the MP Framework for this stock would benefit from more detailed collaborative work with First Nations to quantify contemporary and historical FSC catch in Area 4B."

REVIEWER: KENDRA HOLT, DFO SCIENCE

Date: May 14, 2019

This working paper provides science advice that is intended to support an upcoming re-evaluation of DFO's rebuilding plan for Inside Yelloweye Rockfish (IYE). The advice is provided using a new simulation-based management strategy evaluation framework that has recently been developed for B.C. groundfish stocks, with the current Inside Yelloweye analysis being the first application of the framework in support management advice. An MSE approach is well-suited for this analysis given data limitations and associated biological uncertainties for this stock, and I think the development of this project was well worth the effort. I support acceptance of the framework for management advice linked to the current rebuilding plan efforts, and note that the framework can be used to provide ongoing science support for IYE in the coming years in a consistent and transparent manner (with revisions made the framework over time as required). The development of geostatical spatiotemporal models to standardize the Inside Hard Bottom Longline survey and the Dogfish survey, including simulation testing of the former, also appear to be a significant improvement to the data treatment for this stock, and I commend the authors for undertaking these analyses.

The paper is well-written and laid out, with the main body of the document structured according to six steps in an MSE. The authors have drawn extensively from established best practices in the MSE literature, including the identification of clearly articulated objectives and linked performance measures, the development of reference and robustness operating model scenarios, the use of reference management procedures for comparison purposes (e.g., the no fishing scenario), and well thought-out visualizations of results. In general, the decisions made throughout the analysis, such as the selection of objectives, performance measures (including those of interest to COSEWIC) and operating model scenarios, are well justified and documented.

In this review, I provide some general comments that I think could be addressed in the working paper, as well as some suggested changes to figures that I think will improve clarity. I have also included a section on some minor comments. I don't consider any of my comments to require major revisions to the analyses presented in the working paper.

Overall Comments:

Reviewer 2 Comment 1 Given that both the conditioning and projection results for the episodic recruitment OM appear identical to the base model, I am surprised that both OMs were used as part of the reference set. Including the episodic recruitment OM does not add anything to the range of plausible outcomes represented in the reference set. Removing it would have simplified the results presentation. I suggest highlighting the near identical results between the base and episodic recruitment OM, as well as the rationale for the decision to retain both in the reference set. The authors could also consider making a recommendation about whether future iterations of this framework for Inside Yelloweye should continue to explore / use the episodic recruitment OM.

This is a good question and invites the broader question in MSE of whether results should be removed if they do not provide contrast in results. The MP Framework working paper makes the case that choice of robustness set scenarios should in part be based on whether they provide contrast. In light of other review questions about the episodic recruitment scenario (Reviewer 1 Comment 2), we are leaving it in the working paper to invite further discussion of this scenario. We have added text to Section 7.1 to note the near identical results. We have also included a plot of the recruitment deviations (new Figure 35), which shows that the episodic recruitment scenario also produced very low recruitment events in some years. This is probably the reason that the average results were the same as for the Base case. Low recruitments are needed because if we only add large recruitment events in the extreme scenario, then the stock in essence becomes more productive. Instead, we wanted to change the pattern in recruitment deviates while maintaining the same level of mean productivity. There are alternative distributions that could have been used to model episodic recruitment (e.g., skewed or heavytailed distributions) and we recommend these be explored and simulation-tested in the future, as this will become an important topic as accounting for environmental considerations become a more prominent component of our work.

Reviewer 2 Comment 2 Was an OM scenario with implementation uncertainty considered for the current evaluation? Should it be in the future? For example, could implementation error be parameterized based on the difference between the TAC and realized catch in recent years (e.g., since the total 15t TAC has been in place)? There is currently no discussion of implementation error in the document. However, the presence of an implementation error submodel in the MP framework lends itself to these types of considerations in the future, and likely warrants a mention in this document.

The authors did discuss implementation uncertainty but we did not include a scenario. We felt that parameterizing a scenario would require more discussions with commercial and recreational stakeholders and First Nations, as we are uncertain even about the likely direction of any implementation error. We also felt that a range of TACs were considered among the MPs (including three constant catch MPs) that should have adequately covered the range of likely outcomes. With more consultation, we could include an implementation uncertainty scenario in future applications.

Reviewer 2 Comment 3 Section 4.3. I appreciate that this working paper included a bridging analysis with the previous 2011 assessment. The 2011 assessment used a different model structure (surplus production) and reached a different conclusion about stock status relative to the LRP that the current paper. By approximating the 2011 assessment's surplus production analysis with updated data, the authors are able to provide insight into why results differ among approaches. The SRA approach used in the current assessment predicts an increasing trend in biomass since 2000 while the surplus production model predicts a stable trend since 2000 (i.e., no sign of rebuilding). While the authors note in the discussion section that age-structured models such as the SRA allow for better representation of lags in recruitment to surveys than surplus production models, I think more details could be provided about what model assumptions lead to this difference in this specific case. For example, what assumptions in the SRA model lead to estimated increases in recruitment even though there are no recent upward trends in survey indices? Is it simply a function of selectivity assumptions combined with reduced catch? Does recruitment information from the age composition data inform this trend?

It is always difficult to isolate a "smoking gun" when trying to compare results from structurally different models. There was a slight upward trend in the HBLL index after 2009 and the recruitment anomalies seem to track this, albeit with autocorrelation. There is also a slight uptick in the dogfish survey at the end of the time series.

The SPM estimates a less productive population, indicated by a lower estimate of FMSY and higher BMSY than all the SRA models except Scenario (A), Low M. Age-structured maturity and selectivity may confer some resilience on the population as modeled by the SRA. The stock-recruit function, and incorporation of density dependence via steepness also contributes to possible greater productivity. Even though the prior for the intrinsic rate of increase parameter, r, in the SPM was conditioned on steepness, this may not translate to the same emergent productivity as in the SRA. For example, selectivity affects FMSY in the SRA but the SPM makes no explicit assumption about selectivity. We have updated the Discussion (Section 8.3) but we have tried not to speculate too much. We expect that these types of issues will continue to emerge as we gain experience with data-limited methods. It may be useful in the future to do more simulation testing of productivity and performance of SPMs vs age-structured models.

Suggested Revisions to Figures:

Reviewer 2 Comment 4 Figure 3. I find the arrow from the "Simulated Data" bubble to the "Performance Metrics" bubble confusing. To me, this implies that performance metrics are calculated based on simulated "observed data". A clearer alternative may be to move the arrow to extend from the outer "Operating Model" box to the "Performance Metrics" bubble.

We agree and have revised the figure so that the arrow goes directly from the operating model box to the performance metrics bubble.

Reviewer 2 Comment 5 Figure 4. Similar comment to above on Figure 3. It seems more logical to show the "Management Strategy Evaluation" data as coming from the operating model (or maybe all of the operating model, simulated data, and management procedure components combined) instead of just coming from the simulated data.

We have also revised this figure in line with the comments about Figure 3. Furthermore, we have also moved Step 1 (definition of the decision context) to encompass the entire process, added a bubble between performance metrics and real data that notes the selection of an MP, changed "Real data" to "Apply MP to real data" (see Comment 9), and made sure that the bracket for Step 6 only includes the relevant bubbles.

Reviewer 2 Comment 6 Figure 25-26: The additional "Reference" variable (True vs. False) added to the legend could be simplified by instead having two sub-headings on the legend: (i) Candidate MPs (showing closed symbols for the 5 satisficing MPs) and (ii) Reference MPs (showing open symbols for NFref, FMSYref, 0.75FMSYref). I initially found having the reference MPs shown as solid fill in the legend confusing. I suggest using "Reference MPs" as a header instead of "Reference" because the latter could easily be interpreted as indicating whether the result was for the Reference set of OMs vs. the Robustness set.

We have revised the figure captions for all the dot plots to clarify the True and False definitions. The legend is automated by the R package ggplot2 and requires mapping specific data columns to aesthetics (here colour and fill type). We have not made a bespoke legend as suggested, as this would make generalising the plot for future applications challenging.

Reviewer 2 Comment 7 Figure 27: I agree with the authors that this figure is hard to interpret; especially when comparing among 7 MPs. I would support removing radar plots from the working paper.

> *We prefer for the radar plot to be shown in this working paper, as it is the first application of the MP Framework and it makes a good example of how radar plots can become problematic.*

Reviewer 2 Comment 8 Figure 33: The figure label could note that the grey vertical dashed lines represent the LRP (0.4Bmsy) and USR (0.8Bmsy).

> *We have revised this figure caption, as well as captions for Figs 34 and 40 (now 41).*

Minor Comments:

Reviewer 2 Comment 9 Figure 4 (line 456). When referencing Figure 4 in the main body, it would be helpful to provide a better description of what is meant by the "Real data" bubble in Figure 4 and how it fits into Step 6 (Presentation of results and selection of a management procedure). In addition, perhaps it could be made clear in the working paper how real data should be used as part of step 6 when providing management advice for Inside Yelloweye.

> *We have revised the figure. See our response to Comment 5. Specifically, this bubble now refers to "Apply MP to real data" instead of just "Real data". We have also added text to the main body when referencing this figure with respect to setting the catch limit "e.g., applying the selected MP algorithm to the observed survey index".*

Reviewer 2 Comment 10 Performance metrics (lines 340-364) : This section would benefit from a definition of the number of projected years near the top of it. This revision would make it more immediately clear when defining a metric as being calculated "after 1.5 GT (56 years)", that it was being calculated over years 57 to 100.

> *We have added a sentence at the end of the first paragraph of Section 3.2 stating the end of the projection period. We have also clarified the years for which performance metrics are calculated in Section 3.2 and Appendix G.*

Reviewer 2 Comment 11 Section 7.2 (line 772): It would be helpful to remind readers at the top of this section what Scenario (A) and Scenario (B) represent.

> *We have added the names of the Scenarios.*

Reviewer 2 Comment 12 Section 8.1 (line 842): It would help to re-state what the low M distribution is here so that it can easily be compared to the baseline M distribution that is referenced on line 845.

> *We have added the distribution of M for Scenario A.*

Responses to Specific Questions Posed to Reviewers:

Is the purpose of the working paper clearly stated?

Yes. The purpose of the working paper is clearly stated at the start of the Introduction (starting on line 142).

Are the data and methods adequate to support the conclusions?

Yes. It appears that all relevant data sets have been considered for this stock and the data treatments used (biological analyses, development of survey indices) are scientifically rigorous. The modelling methods, including the Stock Reduction Analysis used to condition the operating models and the underling closed-loop simulation software (DLMtool), have been peer-reviewed and published in the primary literature.

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

Yes. Detailed descriptions of the data treatments and the model components are provided in appendices. In addition, the rationale for decisions made through this working paper are well described (e.g., the selection of objectives based on DFO policy considerations, the selection of operating model scenarios, the decision to not include pinniped predation scenarios (Appendix F)).

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?

Yes. It seems to me that the trade-off tables and figures linked to relevant rebuilding objectives will be useful for management decisions. The MP framework used explicitly incorporates uncertainties in the analysis into the provision of management advice through the consideration of multiple operating model scenarios. Advice is provided for the reference set of operating models using an ensemble model approach in which structural uncertainties among alternative models are combined trade-off tables.

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

The Anderson et al. working paper “A management procedure framework for groundfish in British Columbia” that is being reviewed preceding this Inside Yelloweye working paper notes that the MP framework could be used to “help build an understanding of the most important data needs and research priorities for reducing uncertainty in stock assessment advice”? Given the considerable data limitations for Inside Yelloweye Rockfish, future iterations of this MP framework should consider evaluating MPs that could inform decisions about how best to prioritize future data collection and research. For example, is there a benefit to increased collection of age composition data to better inform fishery selectivity (including the recreational fishery)?

> *This is very true. During the outside Yelloweye Rockfish Rebuilding RPR we also concluded that recreational, commercial and FSC selectivites be improved through the collection of biological data in the fisheries. We added this recommendation to this work in the “key uncertainties” section on selectivity (8.4.1). We also realized that we hadn’t mentioned that we have begun to collect data that will inform the selectivity of the Dogfish survey and the comparability between it and the HBLL, so we also added this.*

Given that some the key predators cited for Yelloweye rockfish (Killer Whales, Chinook salmon, and Steller Sea Lions) have had drastic changes in abundance over the past couple decades, I agree with the authors suggestion in Section 8.1 (~ line 870) that future iterations of this MP framework could consider OM scenarios representing time varying mortality. If additional diet composition data from these prey species becomes available from ongoing research programs, this information could be used to support these scenarios.

APPENDIX F: ABSTRACT OF MANAGEMENT PROCEDURE FRAMEWORK PAPER

The Pacific Region Groundfish Integrated Fisheries Management Plan lists approximately 80 species-area fish stocks for which annual total allowable catches (TACs) are required, most of which are applied as individual transferable quotas (ITQs) within the British Columbia (BC) integrated groundfish fishery. The majority of fish stocks encountered by the integrated groundfish fishery are considered data-limited, where data-limited stocks are defined as those with insufficient data to reliably estimate stock status or estimate abundance or productivity with conventional stock assessment methods such as statistical catch-at-age models. In recent decades, DFO groundfish stock assessments have focused on data-rich stocks, resulting in a subset of stocks with full stock assessments, while many stocks with less informative data remain unassessed.

The Department of Fisheries and Oceans (DFO) Sustainable Fisheries Framework, legislated via the Fish Stocks provisions in the Fisheries Act, requires that fish stocks be managed at sustainable levels—specifically at biomass levels above the Limit Reference Point (LRP). For data-limited stocks, data are often insufficient to adequately account for uncertainty in the assessment of stock status relative to biological reference points in traditional stock assessments. Instead of focusing on the explicit knowledge of current stock status, we propose a management-oriented approach that emphasizes selecting management procedures (MPs) that have a high likelihood of maintaining fish stocks above implicitly known reference points across multiple plausible states of nature, regardless of the quality and quantity of available data.

Worldwide there has been a movement towards MP (or management strategy evaluation [MSE]) approaches to providing science advice on fish stocks via closed-loop simulation. Closed-loop simulation differs from conventional stock assessment because it simulates feedback between the implementation of MPs and a simulated system representing the fish stock and its environment, described by one or more operating models (OMs). This document presents a methodology for developing appropriate OMs, testing suites of MPs, and identifying MPs that best meet the objectives of fisheries management and stakeholders. We outline six best-practice steps for MP approaches: (1) defining the decision context, (2) setting objectives and performance metrics, (3) specifying OMs, (4) selecting candidate MPs, (5) conducting closed-loop simulations, and (6) presenting results to evaluate trade-offs. We then describe our proposed approach (the “MP Framework”) and how it aims to accomplish each of these best-practice steps. Included in our framework are provisional conservation and fishery objectives and performance metrics based on Sustainable Fisheries Framework policies, a provisional library of data-limited MPs that are appropriate for BC groundfish stocks, and provisional visualizations to help decision-makers evaluate performance of MPs and trade-offs amongst MPs.

We undertake a case study of the Rex Sole (*Glyptocephalus zachirus*) stock in the West Coast Vancouver Island groundfish management area (Area 3CD) to demonstrate an application of the MP Framework. The case study develops six reference-set OMs and two robustness-set OMs. The case study reveals a set of survey-index-based MPs, constant catch, and surplus production- based MPs that achieve > 0.9 probability (9 times out of 10 chance) of maintaining biomass above the LRP in the long term (35–50-years in the future) while maintaining a > 0.8 probability (4 times out of 5 chance) of maintaining catches at or above recent (5-year) average levels in the near future (1–10 years) in the reference-set OMs. We also present performance metrics related to the long-term probability of biomass remaining above the Upper Stock Reference, the long-term probability of fishing below F_{MSY} (fishing mortality at maximum sustainable yield), the long-term probability of maintaining catches above recent average levels, and the probability of catch variability remaining below historical levels. Four of the MPs achieved only slightly lower performance metrics in the robustness OMs, compared to the reference-set OMs, while other MPs were more sensitive to these OM robustness scenarios.

We highlight issues regarding reference points, MP tuning, assessment frequency and triggers, the inclusion of environmental effects, assessing the value of information, and use of this framework as part of stock rebuilding plans. Throughout, our framework emphasizes transparency and reproducibility and to that end we develop an associated package for the statistical software R that facilitates applications of the framework. Overall, we intend this framework to improve the capacity for Pacific DFO Science to provide evidence-based catch advice for more groundfish stocks—regardless of data limitations—in a standardized and transparent manner consistent with the DFO Sustainable Fisheries Framework, the Fish Stocks provisions in the Fisheries Act, and international best practices.