Center for Independent Experts (CIE) Independent Report on the Stock Assessment Review (STAR) Panel #3 for Petrale Sole and Canary Rockfish, 24–28 July, 2023, in Seattle, Washington State, USA

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Executive Summary

This review considered stock assessment models two important US west coast fish stocks, Petrale Sole (*Eopsetta jordani*) and Canary Rockfish (*Sebastes pinniger*). Both models are relatively data-rich and include (or could include) fishery-independent biomass indices, fishery-independent surveys of recruits or pre-recruits, and extensive age and length composition data. Neither includes commercial CPUE indices. Both stock assessments were implemented by skilled and experienced teams using Stock Synthesis 3 and r4ss, both thoroughly tried-and-tested software packages. Both stocks have been severely depleted in the past, but both now appear to be in reasonably good shape, Petrale Sole above its management target of 25% of unfished spawning output and Canary Rockfish below its management target of 40% of spawning output but probably above the minimum stock size threshold of 25%. These conclusions appear robust to a wide range of assumptions and modelling choices, although a "low state of nature" sensitivity run for Canary Rockfish estimated the current status to be very close to the minimum stock size threshold. No technical deficiencies were identified in either stock assessment although some data deficiencies and data omissions were identified (the latter being corrected just before the STAR panel met). Both stock assessments have uncertainties, especially the treatment of natural mortality, M, and stock-recruit steepness, h. The assessment for Canary Rockfish is more uncertain than that for Petrale Sole, but no plausible weighting procedures for the base treatment of female M could be found that would support an inference that the Canary Rockfish stock is currently below the minimum stock size threshold. Uncertainty was assessed using a combination of maximum likelihood error estimates within models and sensitivity analyses to characterise model uncertainty. I believe within-model uncertainty would be better characterised using fully Bayesian methods (including MCMC simulations) and this should be explored more rigorously in future assessments. Sensitivity assessment would still be required, of course. Notwithstanding the uncertainties, I am confident that both stock assessments represent the best scientific information available for managing these stocks in 2023.

1. Background

The US National Marine Fisheries Service (NMFS) and Pacific Fishery Management Council (PFMC) held three stock assessment review (STAR) panels in 2023 to evaluate and review new draft benchmark assessments for a number of Pacific coast groundfish stocks. The goals and objectives of the groundfish STAR process are to:

1) ensure that stock assessments represent the best available scientific information and facilitate the use of this information by the Council to adopt Overfishing Limits (OFLs), Allowable Biological Catches (ABCs), Annual Catch Limits (ACLs), Harvest Guidelines (HGs), and Annual Catch Targets (ACTs);
2) meet the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3) follow a detailed calendar and fulfil explicit responsibilities for all participants to produce required reports and outcomes;
4) provide an independent external review of stock assessments;
5) increase understanding and acceptance of stock assessments and peer reviews by all members of the Council family;
6) identify research needed to improve assessments, reviews, and fishery management in the future; and
7) use assessment and review resources effectively and efficiently.

I participated in the third of these panel reviews, for Petrale Sole (*Eopsetta jordani*) and Canary Rockfish (*Sebastes pinniger*).

Petrale Sole are found from the Gulf of Alaska to northern Baja California, preferring soft substrates in waters up to ~550 m depth. Most commercial catches are taken in depths of 70–220 m, except for the winter spawning season when they area caught somewhat deeper, 290–440 m. The maximum observed age for this species is 34 years. A single coastwide stock is assumed. The stock was declared overfished in 2009, resulting in implementation of a rebuilding plan and catch restrictions, and was declared rebuilt based on the results of the 2015 update stock assessment. Spawning stock biomass was estimated at 31% of the unfished level in 2015, rising to 39% in 2019, both above the target level of 25%. The 2023 stock assessment for Petrale Sole is a full (benchmark) quantitative assessment and seeks to update the estimated status.

Canary rockfish have a similar geographical spread but prefer rockier substrates than Petrale Sole. Adults are generally found shallower than 300 m, whereas juveniles are found in shallow and intertidal areas. Canary Rockfish are long-lived, with a maximum observed age of 84 years. Catches were strongly restrained in 2000 when the stock was first declared overfished. Assessments in 2002, 2005, and 2007 confirmed the overfished status, but a 2015 assessment suggested that the stock had rebuilt to a spawning stock biomass of 56% of the unfished level, compared with a management target of 40%. The 2023 stock assessment for Canary Rockfish is a full (benchmark) quantitative assessment and seeks to update the estimated status.

The panel review took place between 24 and 28 July, 2023, at the Northwest Fisheries Science Center in Seattle, WA. Each day included formal meetings between 08:30 and 17:30, including presentations from the stock assessment teams (STATs), clarifications and questions from the STAR panel, formalising requests for additional analyses or plots, and report-writing sessions. Interaction with the STATs, council representatives, and a small number of other interested parties was face-to-face, but public transparency and participation was also provided through virtual meetings whenever the panel was convened (but not in writing sessions).

The specific responsibilities of the STAR panels were specified in the Terms of Reference appended to the Performance Work Statement (PWS):

1. Become familiar with the draft stock assessment documents, data inputs, and analytical models along with other pertinent information (e.g., previous assessments and STAR panel report when available), and the Pacific Fisheries Management Council Terms of Reference for the Groundfish Stock Assessment Review Process for 2023-2024 prior to review panel meeting;
2. Discuss the technical merits and deficiencies of the input data and analytical methods during the open review panel meeting;
3. Evaluate model assumptions, estimates, and major sources of uncertainty;
4. Provide constructive suggestions for current improvements if technical deficiencies or major sources of uncertainty are identified;
5. Determine whether the science reviewed is considered to be the best scientific information available;
6. When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time frame; and
7. Provide a brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

I cover each of these in turn in the Summary of Findings section of this report, dealing with ToRs 2–6 under separate sub-section headings for each stock assessment and ToRs 1 and 7 at a higher level.

2. Description of Role in the Review

I was notified on 1 June 2023 that I had been selected for this review and I confirmed my availability that same day. I had already done some background reading on the species and their stock assessments beforehand, but initial formal documentation for review was provided to me on 11 July 2023, including:

- PFMC's Terms of Reference for the Groundfish Stock Assessment Review Process for 2023-2024;
- PFMC's Scientific and Statistical Committee's (SSC) Accepted Practices Guidelines for Groundfish Stock Assessments in 2023 and 2024;
- The proposed agenda and location for the review;
- Draft assessment reports for Petrale Sole and Canary Rockfish, together with supporting information from the stock assessment models;
- Reports from two 2023 pre-assessment data workshops covering the stocks under review;
- Background information on the modelling platform (Stock Synthesis 3); and a link to a very useful archive website for Groundfish Stock Assessment Documents.

Details of these documents, together with others provided during the review, can be found in the Bibliography section of this report. In the 2 weeks before the review meeting, I read the draft (pre-STAR) stock assessment reports and the terms of reference for the review in detail and made notes (both on the PDF files and by hand) on issues that occurred to me based on the documentation. I made sure I was sufficiently *au fait* with all the other documents to know where to look for historical background material, stock assessment model technicalities, or other information relevant to the reviews if I needed these. I left Nelson, New Zealand on 22 July and arrived in Seattle on the afternoon of 23 July (both local time; there is a 5-hour difference between the two cities).

The panel convened on the morning of 24 July 2023 well before the timetabled start time for the first day's meeting. Chair John Field and PFMC representative Marlene Bellman ran through procedural and administrative arrangements then panel members agreed focus roles to spread the workload of report drafting as the reviews developed. My focus was on recording the requests for additional work or presentations from the Canary Rockfish STAT and the responses to these requests. Other panel members worked on documenting the two stock assessments or on requests and responses for Petrale Sole. Working documents for the purposes of documenting the meeting and drafting the panel's report were hosted on Google Drive and edited using Google Docs.

All members of the panel asked questions of the stock assessment team and participated in the development of requests for additional analyses, tables or graphics to increase understanding of the behaviour, sensitivity and reliability of the stock assessment model and its predictions. I made sure to bring up all the issues I had noted before the review meeting, but other issues arose too. Periodically during the week, the panel worked collaboratively to review and finalise blocks of text describing the stock assessments, their respective strengths and weaknesses, additional work sought and delivered, and the panel's discussions and conclusions. In the afternoon of 28 July 2023, the panel agreed a process and deadlines for collaboratively finalising the report using Google Docs after the panel adjourned.

I left Seattle on the afternoon of 29 July and arrived back in Nelson in the early afternoon of 31 July (both local time). In the 2 weeks following my return to New Zealand, I provided editorial suggestions for the post-STAR drafts of two stock assessment reports, participated, as agreed, in the finalisation of the panel's report, and drafted this report.

3. Summary of Findings

3.1. Draft stock assessments, data, models, PFMC Terms of Reference (ToR 1)

The key stock assessments for both stocks and supporting documents were provided by PFMC in good time before the meeting and links to PFMC websites provided easy access other documents, including ToRs for the stock assessment process, pre-assessment workshop reports for the two stocks, and historical papers and reports. In general, both stock assessment reports were comprehensive and well-written, making it straightforward to read and review the material in the context of PFMC's stock assessment and review process before the STAR panel convened. Documentation for the modelling platform, Stock Synthesis 3, was also provided for those unfamiliar with the software. Control and output files for the model were also provided which would allow re-running and testing of the model by a reviewer if they felt that to be necessary.

3.2. Petrale Sole stock assessment

3.2.1. Technical merits and deficiencies of data and analytical methods (ToR 2)

The west coast USA stock of Petrale Sole (*Eopsetta jordani*) was assessed (Taylor et al. 2023a) using an age-structured, two-sex, single area, two-fleet model implemented in Stock Synthesis 3 (SS3, version 3.30.21, Methot and Wetzel 2013, Methot et al. 2023). SS3 is a well-established and well-regarded package for conducting fisheries stock assessments and most of its functions are well-understood. The 2023 model for Petrale Sole updates and slightly simplifies a previous full assessment model developed in 2013, most recently updated in 2019. The model is relatively data-rich, having fishery-independent biomass indices since 1980 and substantial length and age information to inform it. However, most of these data were collected after the stock had been depleted, which I believe might limit the model's ability to reconstruct the entire trajectory.

Based on a substantial number of sensitivity runs and other diagnostics presented by the STAT, some of which were requested by the STAR panel, the assessment and its conclusions appears to be quite robust. I particularly liked the comprehensive bridging analysis wherein the effects of each change (compared with the 2019 model) to the model structure, assumptions and data was explored. These explorations were shown graphically in the draft stock assessment report and in the initial presentations, but were also taken further to show the effect of each change on the inferred productivity of the stock (as equilibrium MSY) as part of the additional analyses sought by the STAR panel. This analysis suggested that the biggest change to the model's estimate of stock productivity came from updating the historical catch for Washington State. Re-weighting the data inputs and updating the selectivity blocks also had some impact. These are important findings because stakeholders will need to understand why the perceived productivity of the stock is now somewhat lower than it was in 2019 and why catches might need to be reduced even with the stock probably being above its biomass target. It would be helpful in this context if the process and assumptions used to update the Washington State catch history could be documented more fully; only limited documentation was available to the STAR panel.

I also appreciated the many diagnostic plots provided by the STAT and it seems that these can be routinely generated from the SS3 output files using the R-package *r4ss* (Taylor et al. 2021). The likelihood profiles on key fixed and variable parameters (overall scale R_0, stock-recruit steepness h, natural mortality M, and recruitment variability σ_R) were very informative, allowing the panel to judge the "preference" of each data set for different values of important model parameters. I also found it useful and informative that the span of the likelihood profiles was also presented graphically on plots of key quantities of interest for managers and stakeholders, initial spawning biomass, current spawning biomass, and spawning fraction (depletion). Broadly speaking, these profiles show the types of conflict between data sets that are common to such assessments, but also reassuringly showed that biomass trends were largely driven by the indices and estimates of productivity by the compositions. However, constraining the variability of recruitment between years (using an assumed value of σ_R) and "priors" (particularly on M) were also shown to be influential at times.

Uncertainty around estimates was presented consistently throughout the draft stock assessment report and the presentations and was estimated from the Hessian matrix generated by SS3. These asymptotic estimates do not include uncertainty associated with parameters that were fixed in the model (steepness, recruitment variability, weight at length, fecundity, some selectivity parameters, etc.) or structural choices (stock boundaries, fleet structure, selectivity time blocks, etc.). Because some of these uncertainties can be considerable, they were assessed by the STAT using sensitivity runs of the model using different settings, and also as part of the process whereby the stock assessment results are communicated to fisheries managers using an "axis of uncertainty" to bracket results.

I was a little surprised that neither this stock assessment or that for Canary Rockfish (considered by the same STAR panel, see section 3.3 in this report) had made their model fully Bayesian using MCMC (Markov Chain Monte Carlo) simulations to estimate uncertainty and characterise posterior distributions. This makes the model penalised maximum likelihood rather than Bayesian, even though some language (especially "prior") is used that many would interpret to be Bayesian. This is not a deficiency as such, even though I think it would be better if MCMCs could have been run and the traces and posterior distributions of estimated parameters could have been explored. Both STATs say they explored MCMC runs, as suggested by their Accepted Practices Guidelines, but none was successful. This too surprised me because, in my experience, mostly in New Zealand, and mostly using CASAL (Bull et al. 2012) rather than SS3, it is routine to run very complex fully Bayesian stock assessment models and to explore the Bayesian outputs as diagnostics. Typically, to save on computing time, model development and sensitivity testing is conducted using runs at MPD (Mode of the joint Posterior Distribution, essentially penalised maximum likelihood), and MCMC chains are run only for a base case model or a few competing alternatives. Three very different recent examples from New Zealand using three different packages are: McGregor et al. (2022) for hoki (*Macruronus novaezelandiae*) where two models were taken to MCMC using CASAL; Rudd et al. (2023) for rock lobster (*Jasus edwardsii*) where eight models were taken to MCMC using LSD (Webber et al. 2023); and Langley (2022) for tarakihi (*Nemadactylus macropterus*) where seven models were taken to MCMC using SS3 (version 3.30.17.00). If run time is a significant issue, Monnahan et al. (2019) identified steps that can be taken to run MCMC chains 50–50 000 times faster, including for typical west coast US stock assessments, such as simplification of models as has already been conducted in this assessment. Of course, Bayesian models still estimate uncertainty that is conditional on any structural assumptions so sensitivity testing and "axis of uncertainty" choices would still be required.

The STAR panel did not identify any technical deficiencies in the modelling in the course of a week working with the STAT and none of the potential issues and points of clarification that I raised turned out to be a significant issue. As is often the case with fish stock assessments, deficiencies in the input data were highlighted during discussions, as was the need to assume (fix) some parameters in the model (especially steepness, h). A sensitivity run showed that estimating steepness did not greatly affect the stock's estimated trajectory, but fitting it led to somewhat less plausible estimates for other productivity parameters. I think the choice of fixing steepness at the value of the prior for pleuronectid flatfish was a good one because three very strong year classes at low stock size (2006–2008) will likely lead to estimated steepness that is unreasonably high for a stock like this one.

3.2.2. Model assumptions, estimates, and major sources of uncertainty (ToR 3)

Petrale Sole is modelled as a single US coastwide stock, although spatial aspects of the population are represented in the model using data sets and fleets separated geographically (generally by state). There seems to be at least some indication (e.g., from biomass indices) of similar dynamics in Canadian Pacific waters, suggesting to me that the stock may be broader than the three US states included in this model, and this is a focus for future collaborative work.

The assumed catch history for Petrale Sole was reconsidered for this assessment and significantly modified for fish landed in Washington State before 1980 (work by Washington Department of Fish and Wildlife) and for fish discarded. These changes were large enough to significantly affect the estimated productivity of this stock. Seasonal structure in the 2019 assessment was removed for the 2023 assessment, somewhat simplifying the model (although some new structure was also introduced).

Growth in the model follows a von Bertalanffy curve with all parameters estimated inside the model. Natural mortality is also estimated inside the model for the sexes separately, guided by a meta-analytical prior (based on all pleuronectid flatfish). Other life history parameters are fixed in the model based on external analyses: those defining the length-weight relationship; fecundity; and maturity schedule. All were revised for the 2023 assessment to include new information. The 2019 model used recruited biomass as a measure of stock size; this was changed to spawning output (egg production) in the 2023 model.

Recruitment dynamics in the model follow a Beverton-Holt stock-recruit curve with estimated annual recruitment deviations. The steepness parameter for the stock-recruit curve was fixed in the model at 0.80, the mean of the meta-analytical prior for all pleuronectid flatfish. There is reasonable evidence (Tolimieri et al. 2023) that recruitment of Petrale Sole is at least partly environmentally-driven. A sensitivity run was conducted including an environmental index of recruitment but there is broad agreement that this index still needs some work before it should be included in a base model. In general, the model with the environmental index of recruitment suggested stronger recent recruitment than the base model. Clearly, more reliable estimates of recent recruitment would be useful for stock projections.

The STAR panel concluded that all these structural assumptions were reasonable and accepted the pre-STAR model as the one to recommend for developing management advice. I agree with that assessment.

The accepted base model estimated M to be 0.142 (SD = 0.0115) for females and 0.155 (SD = 0.0133) for males (both somewhat lower than their respective priors), and unfished recruitment (natural

logarithm) to be 9.64 (SD = 0.128). Current "summary biomass" (ages 3 and older) was estimated to be 15 803 t compared with an estimated equilibrium unfished biomass of 42 198 t, equivalent to an estimated depletion of 0.374. In terms of spawning output, the base model estimated current output to be 7.7 trillion eggs compared with an estimated unfished spawning stock output of 22.9 trillion eggs, equivalent to an estimated depletion of 0.336. The model estimated the stock's nadir at a depletion of 0.057 in 1993 and a peak of 0.415 in 2017 following good recruitment in 2006–2008. The stock is estimated to be declining in 2023 following lower recruitment in recent years.

For reference (largely reproduced from Taylor et al. 2023a), the management biomass target for Petrale Sole is defined as 25% of the unfished spawning output ($B_{25\%}$), estimated by the base model to be 5.7 trillion eggs (4.5–6.9 trillion), which corresponds to an equilibrium exploitation rate (catch / 3+ biomass) of 0.18. This harvest rate provides an equilibrium yield of 2 481 t at $B_{25\%}$ (2 120–2 841 t). Catch limits are determined by an SPR = 30% reference point associated with equilibrium exploitation rate of 0.17. The model estimate of MSY is 2 482 t (2 121–2 842 t) where estimated spawning stock output is 5.5 trillion eggs (4.3–6.7 trillion). The exploitation rate corresponding to the estimated F_{MSY} proxy of SPR = 29% is 0.18.

The model therefore estimates the current stock size to be slightly above the MSY-compatible reference points but declining from the 2017 peak in the wake of relatively poor recruitment in recent years (although the model including the environmental index suggests slightly higher recent recruitment than the base model estimates).

The adopted base model and its estimates appeared robust to most of the changes tested in sensitivity runs. However, like all stock assessments, there remain some uncertainties. I believe key of these for this assessment include the catch history (which would benefit from better documentation of recent reconstructions for Washington and, perhaps, the discard fraction) and the productivity parameters M and h. These are not unusual uncertainties for stock assessments. Slightly less run of the mill for this assessment was the availability of an environmental index for recruitment; this has the potential to provide more reliable estimates of recent recruitment which would be especially useful for informing projections.

3.2.3. Suggestions for improvements in the current assessment (ToR 4)

At the end of its week-long review and exploration of a wide range of sensitivity runs and additional analyses, the STAR panel concluded that the pre-STAR base model should be adopted as the base model to recommend for informing management decisions. I agree with that conclusion and I have no suggestions for improvements to the stock assessment model for Petrale Sole that I believe should be made before it is used to inform management decisions.

3.2.4. Judgement on best scientific information available (ToR 5)

After reading the draft stock assessment report and discussing this model over the course of a whole week with the STAR panel and the stock assessment team, I am confident that the modelling results for Petrale Sole represent the best scientific information available to inform the management of this stock.

3.2.5. Suggestions for future improvements in data, analysis or modeling (ToR 6)

The Petrale Sole assessment model is relatively data rich and robust to many modelling choices, even though the great bulk of the data have been collected since the fishery became depleted. This is a

happy state to be in, but uncertainties around key productivity inputs (catch, discards) and parameters (M, h) suggest that research and data collection should continue. Continued trawl surveys to develop biomass indices is clearly important, but I would suggest that the reasons for seemingly unusual indices in 2004 (triennial survey) and 2018 and 2019 (WCGBTS) for this species should be explored. In addition, however, I would have thought that a periodic assessment of the potential for using commercial CPUE time series would be worthwhile to augment the trawl surveys or replace them if they become unaffordable or missed in some years (as during the Covid-19 pandemic, for instance). Similarly, sampling for age, length, and discard proportion should continue throughout the commercial fleets, also age-length sampling on research voyages. Accumulating such data should eventually resolve the issue of higher than model-predicted proportions of large, old fish, especially in the south. Finally, I believe an environmental index of recruitment for this stock shows great promise and should be pursued. I would like to see a variety of methods of introducing the index into the stock assessment explored, including as a simple index (as in the sensitivity run explored for this assessment) but also potentially as part of a complex S/R relationship involving both spawning output and environmental drivers. I'm not sure if this is possible in SS3. I do not disagree with any of the research and development ideas put forward by the STAT or the STAR panel, the ideas in this paragraph are those that I see as priorities for future data collection.

3.3. Canary Rockfish stock assessment

3.3.1. Technical merits and deficiencies of data and analytical methods (ToR 2)

The west coast USA stock of Canary Rockfish (*Sebastes pinniger*) was assessed (Langseth et al. 2023a) using an age-structured, two-sex, single area, multi-fleet model implemented in Stock Synthesis 3 (SS3, version 3.30.21, Methot and Wetzel 2013, Methot et al. 2023). SS3 is a well-established and well-regarded package for conducting fisheries stock assessments and most of its functions are well-understood. The 2023 model for Canary Rockfish updates and improves a previous full assessment model developed in 2015, most recently updated (incorporating updated catches and corrections to historical catch history time series) in 2021. The model is relatively data-rich, having fishery-independent biomass indices since 1980, a pre-recruit index since 1983 (not including all years), and substantial length and age information to inform it. However, most of these data were collected after the stock had been depleted, which I believe might limit the model's ability to reconstruct the entire trajectory.

After the pre-STAR stock assessment report had been circulated and only days before the STAR panel convened, the STAT discovered that they had inadvertently omitted from their pre-STAR base model a substantial number of age reads for Oregon and California commercial fleets (both trawl and non-trawl). The missing data represented ~50% of available California age data, ~9% of Oregon data, and ~8% of all commercial age data. The STAT were very forthright about this mistake and presented some initial model runs that suggested that the omission did not result in a dramatically different trajectory or status for Canary Rockfish. They suggested that, based on this similarity, they continue to present the results of model runs, explorations, and sensitivity analyses based on their original pre-STAR base model. The STAR panel agreed with this suggestion, as did I, in order to progress the review as quickly as possible. I greatly appreciated the STAT's candour about the omission and the additional work they had put in to provide the STAR team with at least some assurance that the review could continue fruitfully. I was, however, a little surprised that such a significant omission had slipped though checking procedures by both the STAT and the pre-assessment online workshop conducted in January/February 2023 (where length and age data were discussed in some detail, see PFMC 2023a and Langseth et al.

2023h). Fortunately, the omission of much of the recent age data did not greatly impact the assessment and the initial explorations, and some conducted at the request of the STAR panel during the review, were all useful in understanding the model's behaviour.

Based on sensitivity runs and other diagnostics presented by the STAT using the original pre-STAR model, the assessment and its conclusions appears to be broadly robust but the details are quite sensitive to the treatment of natural mortality for females (a long-standing issue for this species) and data weighting choices. As for Petrale Sole, I particularly liked the comprehensive bridging analysis wherein the effects of each change to the model structure, assumptions and data (compared with the 2021 model and the 2015 model structure) was explored. These explorations were shown graphically in the draft stock assessment report and in the initial presentations. This analysis suggested that the biggest changes to the model's estimate of stock trajectory and status came from structural assumptions about female mortality and selectivity, and from data weighting choices (especially differences between weighting conducted in 2023 compared with in 2015). I had noticed the sensitivity to data weighting in the pre-STAR assessment report (wherein I thought the sensitivity was given strangely little emphasis) and made a point of following this up at the review meeting.

I also appreciated the many diagnostic plots provided by the STAT and it seems that these can be routinely generated from the SS3 output files using the R-package *r4ss* (Taylor et al. 2021). The likelihood profiles on key fixed and variable parameters (overall scale R_0, stock-recruit steepness h, natural mortality M, and recruitment variability σ_R) were very informative, allowing the panel to judge the "preference" of each data set for different values of important model parameters. I also found it useful and informative that the span of the likelihood profiles was also presented graphically on plots of the associated biomass trajectories and key quantities of interest for managers and stakeholders, initial spawning biomass, current spawning biomass, and spawning fraction (depletion). Broadly speaking, these profiles show the types of conflict between data sets that are common to such assessments, but also reassuringly showed that biomass trends were largely driven by the indices and estimates of productivity by the compositions. However, constraining the variability of recruitment between years (using an assumed value of σ_R) and "priors" (particularly on M) were also shown to be influential at times.

Uncertainty around estimates was presented consistently throughout the draft stock assessment report and the presentations and was estimated from the Hessian matrix generated by SS3. These asymptotic estimates do not include uncertainty associated with parameters that were fixed in the model (steepness, recruitment variability, weight at length, fecundity, some selectivity parameters, etc.) or structural choices (stock boundaries, fleet structure, selectivity time blocks, etc.). Because some of these uncertainties can be considerable, they were assessed by the STAT using sensitivity runs of the model using different settings, and also as part of the process whereby the stock assessment results are communicated to fisheries managers using an "axis of uncertainty" to bracket results. An obvious candidate for an axis of uncertainty for Canary Rockfish is the structural treatment of M for females, given the substantial preponderance of males in older age classes and the sensitivity of results to the alternatives. Different approaches have been used over time, and the STAT made it very clear that the choice of modelling approach matters.

I was a little surprised that neither this stock assessment or that for Petrale Sole (considered by the same STAR panel, see section 3.2 in this report) had made their model fully Bayesian using MCMC (Markov Chain Monte Carlo) simulations to estimate uncertainty and characterise posterior distributions. This makes the model penalised maximum likelihood rather than Bayesian, even though

some language (especially “prior”) is used that many would interpret to be Bayesian. This is not a deficiency as such, even though I think it would be better if MCMCs could have been run and the traces and posterior distributions of estimated parameters could have been explored. Both STATs say they explored MCMC runs, as suggested by their Accepted Practices Guidelines, but none was successful. This too surprised me because, in my experience, mostly in New Zealand, and using CASAL (Bull et al. 2012) rather than SS3, it is routine to run very complex fully Bayesian stock assessment models and to explore the Bayesian outputs as diagnostics. Typically, to save on computing time, model development and sensitivity testing is conducted using runs at MPD (Mode of the joint Posterior Distribution, essentially penalised maximum likelihood), and MCMC chains are run only for a base case model or a few competing alternatives. Three very different recent examples from New Zealand using three different packages are: McGregor et al. (2022) for hoki (*Macruronus novaezelandiae*) where two models were taken to MCMC using CASAL; Rudd et al. (2023) for rock lobster (*Jasus edwardsii*) where eight models were taken to MCMC using LSD (Webber et al. 2023); and Langley (2022) for tarakihi (*Nemadactylus macropterus*) where seven models were taken to MCMC using SS3 (version 3.30.17.00). If run time is a significant issue, Monnahan et al. (2019) identified steps that can be taken to run MCMC chains 50–50 000 times faster, including for typical west coast US stock assessments, such as simplification of models as has already been conducted in the Canary Rockfish assessment. Of course, Bayesian models still estimate uncertainty that is conditional on any structural assumptions so sensitivity testing and “axis of uncertainty” choices would still be required.

The STAR panel did not identify any technical deficiencies in the modelling in the course of a week working with the STAT, although the omission of a substantial amount of recent age data and inadvertently mirroring early and late selectivity blocks for the CA non-trawl fishery were clearly mistakes (both of which were identified and remedied by the STAT). Of the potential issues and points of clarification that I raised, only the change in data weighting approaches compared with that used in 2015 turned out to be a significant issue. This was highlighted more strongly by the STAT in their presentations than it had been in their pre-STAR report. As is often the case with fish stock assessments, deficiencies in the input data were highlighted during discussions, as was the need to assume (fix) some parameters in the model (especially steepness, h). A sensitivity run showed that estimating steepness did not affect the stock’s estimated trajectory as much as changing the structure of female M, although it did lead, unsurprisingly, to a faster estimated recovery from the stock’s nadir. The estimated value was h = 0.835 which seems high for a long-lived rockfish so I think the choice of fixing steepness at the value of the prior for rockfishes was a good one.

3.3.2. Model assumptions, estimates, and major sources of uncertainty (ToR 3)

Canary Rockfish is modelled as a single US coastwide stock, although spatial aspects of the population are represented in the model using data sets and multiple fleets separated geographically (generally by state). There seems to be at least some indication (e.g., from similar life history and population nadir) of similar dynamics in Canadian Pacific waters (especially southern British Columbia), suggesting to me that the stock may be broader than the three US states included in this model, and I believe this is a focus for future collaborative work.

The assumed catch history for Canary Rockfish was reconsidered for this assessment based on reconstructions of historical catch by States and other new information. Assessing historical catch is complicated by the use of general reporting groups for rockfish at times, and by incomplete information on the location of catches (as opposed to port of landing). It appears that reconstructions have been done carefully, but assumptions had to be made and there will always be some uncertainty

about the actual catches. I could not find any documentation of the magnitude of changes to the catch history in the pre-STAR assessment report but the bridging analysis shows that these changes increased the estimated scale of the assessment slightly. Estimated depletion was less affected but slightly more favourable in recent years. Catch came from 15 different fleets (five methods by three areas) leading to a lot of selectivity parameters for the model to estimate. Discards were included in the assumed catches and not estimated in the model.

Based on the STAR panel's desire to understand whether changing the catch histories was introducing more conflict into the model, one of its requests was for runs that allowed the model to estimate different catches from the input values before 1980, using catch SEs of 0.1 and 0.2 for these years. The results were entirely unexpected in that the model did not use the extra flexibility to change its estimates of early catch at all, but the resulting biomass trajectories were very different from the base model's, with lower likelihoods. It was clear from this analysis that changing the catch SE settings introduced some numerical instability and neither the STAT nor the STAR panel knew precisely how the catch SE function in SS3 worked, if indeed it was working properly at all during these runs. It seems clear that better documentation is required.

Growth in the model follows a von Bertalanffy curve with all parameters estimated inside the model. Age invariant natural mortality of both sexes is assumed, a departure from many previous assessments where female mortality has been assumed to "ramp up" from a specified age. Female M is estimated inside the model, guided by a log-normal prior with a mean of 0.064, based on observed longevity (84 years) for this species. Male M was fixed at the mean of the prior. Other life history parameters are fixed in the model based on external analyses: those defining the length-weight relationship; fecundity (using a meta-analysis for rockfishes); and maturity schedule. These were reviewed for the 2023 assessment and any new information included. The 2021 model used recruited biomass as a measure of stock size; this was changed to spawning output (egg production) in the 2023 model. Recruitment dynamics in the model follow a Beverton-Holt stock-recruit curve with estimated annual recruitment deviations guided by a plankton-based pre-recruit index (as well as the compositions). The steepness parameter for the stock-recruit curve was fixed in the model at 0.72, the mean of a published meta-analytical prior for rockfishes.

The inadvertent omission of some age data and the slightly later discovery that early and late selectivity blocks for the CA non-trawl fishery had been inadvertently mirrored led to some model development and testing during the STAR review meeting. That model testing focused on the sensitivity to data weighting choices and structural choices about female M, methods of reducing the very high correlations in estimated selectivity parameters, and constraints on recruitment variability. These explorations led to a new base model that included the missing age data, had separately-estimated selectivity parameters for CA non-trawl fisheries, and mirrored recent and early selectivity parameters for OR non-trawl and WA recreational fisheries, reweighted using current standard practice. The STAR panel concluded that these structural assumptions were reasonable, based on the evidence available, and accepted this revised model as the one to recommend for developing management advice. I agree with that assessment.

The revised base model was shown to be sensitive to the change in weighting procedures between 2021 and 2023 (i.e., the imposition of standard weighting procedures), to strong weighting choices in 2023 (omitting data sets or giving them 10-fold additional weight), and to the structural treatment of female M. The same conclusions would be drawn from the pre-STAR model and the revised, post-STAR model. I had been particularly interested in the impact of weighting choices on estimates of current

stock status, given the results shown in the pre-STAR assessment, and it was reassuring to see that the only weighting scenario that led to a very poor stock status was complete exclusion of the entire triennial trawl survey series (1980–2004). I see no reason to exclude this time series, and I, therefore, agree with the STAR panel that there are no plausible data weighting scenarios that would lead to point estimates of current depletion below the minimum stock size threshold.

The accepted revised base model estimated female M to be 0.078 (SD = 0.0018), somewhat higher than the prior of 0.064 (unsurprisingly, given the preponderance of males in older age groups). Unfished recruitment (natural logarithm) was 8.22 (SD = 0.057). Current spawning output was estimated to be about 0.35 of the unfished level compared with the management target of 0.40 and the minimum stock size threshold of 0.25. The model estimated the stock's nadir at a depletion of 0.057 to have been in the late 1990s. The stock is estimated to be relatively stable in 2023 following lower than average recruitment in recent years. The model therefore estimates the current stock size to be slightly below the management target and not likely to increase much at current levels of catch in the wake of relatively poor recruitment in recent years. These conclusions are sensitive to the treatment of female M: assuming the same M for males and females (not a particularly credible assumption in my opinion) results in current spawning output being at or slightly below the minimum stock size threshold and stable; whereas all tested variants of a break or a ramp formulation for female M resulted in the current spawning output being slightly above the management target and increasing (albeit slowly). Thus, one structural assumption in the model, leaving all other assumptions and data unchanged, leads to the stock status being assessed anywhere between the minimum stock size threshold and the management target. Removing sex-specific selectivity from the model resulted in an even more extreme result and led to the current spawning output being estimated well above the management target and increasing rapidly. As suggested by the STAT, I see this sensitivity to structural choices as a major uncertainty in the stock assessment and one that appears quite difficult to resolve.

3.3.3. Suggestions for improvements in the current assessment (ToR 4)

At the end of its week-long review and exploration of a wide range of sensitivity runs and additional analyses, the STAR panel concluded that the pre-STAR base model modified to include all available composition data and with some selectivity assumptions modified (and all data sets re-weighted using current standard procedures) should be adopted as the base model to recommend for informing management decisions. I agree with that conclusion and I have no suggestions for improvements to the stock assessment model for Canary Rockfish that I believe should be made before it is used to inform management decisions.

3.3.4. Judgement on best scientific information available (ToR 5)

After reading the draft stock assessment report and discussing this model over the course of a whole week with the STAR panel and the stock assessment team, I am confident that the modelling results for Canary Rockfish represent the best scientific information available to inform the management of this stock.

3.3.5. Suggestions for future improvements in data, analysis or modeling (ToR 6)

The Canary Rockfish assessment model is relatively data rich and reasonably robust to some modelling choices, even though the great bulk of the data have been collected since the fishery became depleted and the model appears quite sensitive to structural choices about M. This is a happy state to be in, but uncertainties around key productivity assumptions (especially the structural treatment of female M and sex-specific selectivity, as well as steepness, h) suggest that research and data collection should

continue. Particularly important, I would have thought, would be research to understand the reasons for the preponderance of males in older age classes and to identify the most appropriate formulation for M in stock assessment models. Sampling for age, length, and discard proportion should continue throughout the numerous fleets specified in the current model, also age-length sampling on research voyages; these might eventually help resolve the issues around female M especially if higher proportions of old females continue to be observed. Continued trawl surveys to develop biomass indices is clearly important, especially given the model's sensitivity to excluding the triennial survey and the relatively low precision of annual estimates for Canary Rockfish. Given the use of mixed codes for reporting rockfishes historically, I doubt that a useful commercial CPUE time series could be developed for the full historical period, but one for some more recent years might be explored to augment the trawl surveys or replace them if they become unaffordable or missed in some years (as during the covid-19 pandemic, for instance). Given the large number of selectivity curves estimated in the current model, it is not very surprising that some very high correlations between parameters arise, but I think it would be useful to explore a variety of approaches to reducing corelations and/or simplifying the structure. I do not disagree with any of the research and development ideas put forward by the STAT or the STAR panel, the ideas in this paragraph are those that I see as priorities for future data collection.

3.4. Thoughts on panel review proceedings (ToR 7)

I enjoyed participating in this review and I think it was a useful contribution to quality assurance for stock assessments that will contribute to management of two important stocks of the US west coast. I liked the structure of having an initial stock assessment tabled then discussed in detail by a panel in an open forum before passing to the next stage in the process. I wasn't sure whether the development of the initial models was done entirely by the stock assessment teams (STATs) working together, or whether some sort of standing working group had guided the development, advising on structural choices and data treatments along the way. Either approach works, perhaps with the preference laying slightly more with standing working groups as the complexity of the model and/or the level of contention around the assessment increase.

It was very helpful to have the draft documents and stock assessment files well in advance of the review meeting, giving me plenty of time to read the material and to "sleep on" some issues that arose for me. I was also grateful that the reports were both very well written and included lots of graphics. The packages used for these assessments (SS3 and r4ss) seem very well set up for generating a wide range of standard graphics and diagnostics.

During the review meetings, there was a consistently collegial and constructive atmosphere and I thought the panel was very well-informed and the chairing was excellent. The STATs were very open and keen to engage and provide additional analyses; I know such review meetings can be very stressful for them so I thank them for that enthusiasm and candour. There was also useful and thoughtful support from PFMC representatives and from others in the room or online at the meetings; sometimes it's invaluable to hear about the management context or the industry perspective or from research partners directly from those involved.

I was surprised that the omission of some age data from the Canary Rockfish assessment had not been captured earlier in the process. Age and length compositions were discussed at a pre-assessment workshop in late January (including graphics that seemed, to me, to show some of the gaps) and a workshop like that should have been the ideal time to identify the issue. I have no specific

recommendation on how to reduce the chances of this happening again other than to look for "loopholes" in the processes and protocols and to maintain diligence in checking and double-checking. It is easier for an analyst or reviewer to spot such omissions if they have excellent working knowledge of the data sets in question. This familiarity may be lost if each stock assessment for a given species is done by a different STAT (although changing STATs does have the advantage of bringing fresh eyes and different experiences to each set of problems periodically).

The STAR panel had extensive discussions, especially concerning Canary Rockfish, on the choice of low and high states of nature that might be used to populate the decision tables for fisheries managers. The guidance in the PFMC ToR and the accepted practice guidelines had several choices of possible approaches, none of which seemed ideal. In hindsight, perhaps the key statement in the PFMC ToR is that the ratio of probabilities for the low and high states of nature and the base model should be 25:50:25, but this would be very difficult to comply with precisely when much of the uncertainty lies in structural and weighting choices rather than in model-based estimates of precision for estimated or derived parameters (as for Canary Rockfish). Strictly speaking, and acknowledging the long run times for MCMC chains, if model-based estimates of uncertainty are used to assign probabilities, Bayesian approaches should be preferred to penalised maximum likelihood. The ToR allow for expert judgement as well as quantitative methods and this STAR panel selected that approach to define states of nature for Canary Rockfish, based on runs with different structural choices for the treatment of female mortality in the model. This approach led to low and high states of nature spanning only about a 50% confidence range for current spawning output, which seems too tight, but well over a 95% confidence range for relative spawning output / depletion, which seems much wider than the 25:50:25 ratio would imply (and also suggesting stock status could be anywhere between the minimum stock size threshold and the management target). I think the guidance on choosing states of nature needs more thought. It's clearly a good idea to require that stock assessment results are bracketed for decision makers in this way, but I think the STATs and STAR panels would benefit from a bit more guidance in their ToR and other guidelines on how to operationalise it.

The STAR panel review concluded by agreeing a process for finalising the panel report collaboratively using Google Docs. I was new to this software, which I think I demonstrated conclusively during the meetings, but this approach seemed to work much better and is timelier and more interactive than the "old" way of circulating multiple drafts by email.

4. Conclusions and Recommendations

4.1. Overall conclusions

This review for two important US west coast stocks considered relatively data-rich stock assessments implemented by two skilled and experienced teams using thoroughly tried-and-tested software packages. Both stocks have been severely depleted in the past, but both now appear to be in reasonably good shape and relatively close to their respective management targets (although in the low state of nature Canary Rockfish is close to the minimum stock size threshold). These conclusions seem robust to a wide range of modelling choices, especially for Petrale Sole. No technical deficiencies were identified in either stock assessment, although the stock assessment team for Canary Rockfish identified (and remedied) their omission of some important data and the inadvertent confusion of some selectivity blocks either just before or during the review. To an extent, correcting these errors and testing candidate base models during the STAR review meeting would have restricted the types of options that could be explored, but I think the revised base model is a defensible choice and gives very

similar overall results, in terms of current stock status, to the original pre-STAR model. Both stock assessments have uncertainties, of course, and the treatment of natural mortality and stock-recruit steepness are key among these (more so for Canary Rockfish than for Petrale Sole). The Pacific Fisheries Management Council has guidelines on how such uncertainty should be assessed and communicated to fisheries managers using decision tables, but this panel took some time to decide how to accomplish this, especially for Canary Rockfish. Notwithstanding the uncertainties, I am confident that both stock assessments represent the best scientific information available for managing these stocks in 2023.

4.2. Recommendations

In general, I found the stock assessments and the process for reviewing them to be well-designed and fit for purpose. I did have a few suggestions, of course, although I will not repeat all of the suggestions for future data collection and research covered in other sections and concentrate on "higher-level" ideas:

1. To increase transparency, any catch reconstructions that lead to modifications of catch histories in stock assessments should be documented more fully and those reports made publicly available;

2. To reduce the risk of inadvertent data omissions, data selection and checking protocols for stock assessments should be explored and updated if "loopholes" are found. This might include the remit of the pre-assessment workshops;

3. I think it would be beneficial for a range of reasons if fully Bayesian models using MCMC simulation could be implemented for candidate and final base cases. Run times can be long for complex models but ways of reducing these are available and MCMC simulation is routine in some other jurisdictions;

4. To provide more concrete guidance and rationale to STAR review panels on choosing low and high states of nature, it would be useful to review the PFMC Terms of Reference and guidelines as these relate to states of nature.

Appendix 1: Bibliography of materials provided for review and other cited works

Material provided for review

The following documents and presentations were provided to the panel (including CIE reviewers) before or during the STAR Panel meeting:

Alverson, DL; Chatwin, BM (1957). Results from tagging experiments on a spawning stock of petrale sole, *Eopsetta jordani* (Lockington). *Journal of the Fisheries Board of Canada* **14**: 953–74.

Gertseva, V.; Matson, SE; Cope, J (2017). Spatial growth variability in marine fish: example from Northeast Pacific groundfish. *ICES Journal of Marine Science* **74**: 1602–1613.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023a). Status of Canary Rockfish (*Sebastes pinniger*) along the U.S. West Coast in 2023 (including r4ss files and plots). Pre-STAR Stock Assessment Report, Northwest Fisheries Science Center. 278 p.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023b). 2023 Canary Rockfish Stock Assessment: STAR presentation 1 - Biology, Fisheries, Data. Presentation to STAR Panel, 24 July 2023. 68 slides.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023c). 2023 Canary Rockfish Stock Assessment: STAR presentation 2 - Modeling, performance. Presentation to STAR Panel, 24 July 2023. 74 slides.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023d). 2023 Canary Rockfish Stock Assessment: STAR presentation 3: Day 1 Requests. Presentation to STAR Panel, July 25 2023. 49 slides.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023e). 2023 Canary Rockfish Stock Assessment: STAR presentation 4: Day 2 Requests. Presentation to STAR Panel, July 26 2023. 19 slides.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023f). 2023 Canary Rockfish Stock Assessment: STAR presentation 5: Day 3 Requests. Presentation to STAR Panel, July 27 2023. 19 slides.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S (July 2023g). 2023 Canary Rockfish Stock Assessment: STAR presentation 6: Day 4 Requests. Presentation to STAR Panel, July 28 2023. 7 slides.

Methot Jr, RD; Taylor, IG (2011). Adjusting for bias due to variability of estimated recruitments in fishery assessment models. *Canadian Journal of Fisheries and Aquatic Sciences* **68**: 1744–1760.

Methot Jr, RD; Wetzel, CR; Taylor, IG; Doering, KL; Johnson, KF (February 2023). Stock Synthesis User Manual Version 3.30.21. Downloaded from https://github.com/nmfs-stock-synthesis/stock-synthesis/releases/tag/v3.30.21.

Methot Jr, RD; Wetzel, CR (2013). Stock synthesis: a biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research* **142**: 86–99.

Miller, S; Stephens, A; Whitmire, C; Hastie, J; Wetzel, C (July 2023). Overview of West Coast Groundfish Fishery-Independent Surveys. Northwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, USA.

Pacific Fishery Management Council (June 2022). Terms of Reference for the Groundfish Stock Assessment Review Process for 2023-2024. 64 p.

Pacific Fishery Management Council Scientific & Statistical Committee (March 2023). Accepted Practices Guidelines for Groundfish Stock Assessments in 2023 and 2024. 11 p.

Pacific Fishery Management Council (February 2023a). Report of the Pre-Assessment Workshop for 2023 Groundfish Stock Assessments of Copper Rockfish, Canary Rockfish and Black Rockfish. Report from online workshop held on 31 January and 1 February 2023. 14 p.

Pacific Fishery Management Council (March 2023b). Report of the Pre-Assessment Workshop for a Full Assessment of Petrale Sole and Data-Moderate Assessments of Shortspine, Thornyhead and Rex Sole in 2023. Report from online workshop held on 20 March 2023. 7 p.

Taylor, IG; Gertseva, V; Tolimieri N (July 2023a). Status of petrale sole (*Eopsetta jordani*) along the U.S. West Coast in 2023 (including r4ss files and plots). Pre-STAR Stock Assessment Report, Northwest Fisheries Science Center. 155 p.

Taylor, IG; Gertseva, V; Tolimieri N (July 2023b). Stock Assessment for Petrale Sole – Introduction and Data. Presentation to STAR Panel, 24 July 2023. 33 slides.

Taylor, IG; Gertseva, V; Tolimieri N (July 2023c). Stock Assessment for Petrale Sole – Model. Presentation to STAR Panel, 25 July 2023. 50 slides.

Taylor, IG; Gertseva, V; Tolimieri N (July 2023d). Stock Assessment for Petrale Sole – Responses to requests 1–12. Presentation to STAR Panel, 25–28 July 2023. 54 slides.

Tolimieri N (July 2023). Appendix A: Environmental indices of petrale recruitment, and estimates of the abundance spatial distribution of juveniles. Appendix to pre-STAR stock assessment report by Taylor et al. (2023a). 32 p.

Ward, D; Robinson, R; Nye, G; Reed, D (1969). Fisheries statistical report. Olympia. Washington Department of Fisheries. 92 p (not all pages were included in the PDF provided).

Other works cited

Bull, B; Francis, RICC; Dunn, A; McKenzie, A; Gilbert, DJ; Smith, MH.; Bian, R; Fu, D (2012). CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30–2012/03/21, *NIWA Technical Report* 135. 280 p. https://niwa.co.nz/fisheries/tools-resources/casal-2-niwas-next-generation-fisheries-population-modelling-software.

Langley, AD (2022). A stock assessment of eastern tarakihi for 2021. New Zealand Fisheries Assessment Report 2022/07. 68 p. https://www.mpi.govt.nz/dmsdocument/50305/direct.

Langseth, BJ; Oken, KL; Whitman, AD; Budrick, JE; Tsou, T-S; Hinton, K (January 2023h). 2023 Canary Rockfish Stock Assessment: Pre-assessment Data Workshop. Presentation to Pre-Assessment Workshop for 2023 Groundfish Stock Assessments of Copper Rockfish, Canary Rockfish and Black Rockfish. Pacific Fishery Management Council Online Meeting, January 31 and February 1, 2023. 93 slides.

McGregor, VL; Dunn, MR; Langley, AD; Dunn, A (2022). Assessment of hoki (*Macruronus novaezelandiae*) in 2021. *New Zealand Fisheries Assessment Report* 2022/43. 247p. https://fs.fish.govt.nz/Doc/25292/FAR-2022-43-Hoki-Assessment-2021-4240.pdf.ashx.

Monnahan, CC; Branch, TA; Thorson, JT; Stewart, IJ; Szuwalski, CS (2019). Overcoming long Bayesian run times in integrated fisheries stock assessments. *ICES Journal of Marine Science*, doi:10.1093/icesjms/fsz059.

Rudd, MB; Pons, M; Webber, DN; Starr, PJ; Roberts, J; Goeden ZD (2023). The 2022 stock assessment of red rock lobsters (Jasus edwardsii) in CRA 2. New Zealand Fisheries Assessment Report 2023/43. 108 p. https://fs.fish.govt.nz/Doc/25559/FAR-2023-43-The-2022-Stock-Assessment-For-CRA2-Red-Rock-Lobster-4395.pdf.ashx.

Taylor, IG; Doering, KL; Johnson, KF; Wetzel, CR; Stewart, IJ (2021). Beyond visualizing catch-at-age models: Lessons learned from the r4ss package about software to support stock assessments. *Fisheries Research* **239**: 105924. https://doi.org/10.1016/j.fishres.2021.105924.

Webber, DN; Rudd, MB; Starr, PJ; Roberts, J; Pons, M (2023). The lobster stock dynamics (LSD) model. New Zealand Fisheries Assessment Report 2023/11. 28 p. https://www.mpi.govt.nz/dmsdocument/55810-FAR-202311-The-lobster-stock-dynamics-LSD-model.

Appendix 2: CIE Performance Work Statement

Stock Assessment Review (STAR) Panel 3 (CLIN 0003) Petrale Sole and Canary Rockfish

Background
The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Scope:
The National Marine Fisheries Service and the Pacific Fishery Management Council will hold three stock assessment review (STAR) panels and potentially one mop-up panel (if needed), to evaluate and review benchmark assessments of Pacific coast groundfish stocks. The goals and objectives of the groundfish STAR process are to:

1) ensure that stock assessments represent the best available scientific information and facilitate the use of this information by the Council to adopt Overfishing Limits (OFLs), Allowable Biological Catches (ABCs), Annual Catch Limits (ACLs), Harvest Guidelines (HGs), and Annual Catch Targets (ACTs);
2) meet the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3) follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required reports and outcomes;
4) provide an independent external review of stock assessments;
5) increase understanding and acceptance of stock assessments and peer reviews by all members of the Council family;
6) identify research needed to improve assessments, reviews, and fishery management in the future;
7) use assessment and review resources effectively and efficiently.

Benchmark stock assessments will be conducted and reviewed for each of two species: Petrale Sole and Canary Rockfish, which were identified within the top twenty-five rankings for assessment consideration during the Pacific coast groundfish regional stock assessment prioritization process: (https://www.pcouncil.org/documents/2022/05/f-3-attachment-2-nmfs-assessment-prioritization-workbook-electronic-only.xlsx/) which was based on the national stock assessment prioritization framework (http://www.st.nmfs.noaa.gov/Assets/stock/documents/PrioritizingFishStockAssessments_FinalWeb.pdf).

Petrale Sole (*Eopsetta jordani*) is a right-eyed flounder ranging from the western Gulf of Alaska to northern Baja California with a preference for soft substrates at depths ranging from 0-550 meters. Adults are caught in depths

[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

from 18 to 1,280 m off the U.S. West Coast with a majority of the catches of petrale sole being taken between 70-220 m during March through October, and between 290-440 m during November through February, when fishing concentrates on spawning aggregations. The maximum length reported for Petrale Sole is 70 cm, and the maximum observed age is 34 years.

The stock has been assessed as a single-area coastwide stock based on strong evidence of a mixed stock from tagging studies, a lack of genetic studies on stock structure, and a lack of evidence for differences in growth. In 2009 the stock was declared overfished, resulting in implementation of a rebuilding plan and catch restrictions. The stock was declared rebuilt based on the results of the 2015 update stock assessment, which estimated the coastwide biomass at 30.7% of unfished spawning stock biomass. The 2019 assessment estimated spawning biomass to be above the target of 25% of unfished spawning biomass, at 39%.

Canary rockfish (*Sebastes pinniger*) are distributed in the northeastern Pacific Ocean from the western Gulf of Alaska to northern Baja California. Adults are primarily found along the continental shelf shallower than 300 m, although they are occasionally observed in deeper waters. Juvenile canary rockfish are found in shallow and intertidal areas. Canary Rockfish are a medium to large-bodied rockfish, achieving a maximum size of around 70 cm, and are relatively long-lived, with a maximum observed age of 84 years.

Beginning in 2000, when the stock was first declared an overfished species, management guidelines dramatically curtailed harvest. Assessments in 2002, 2005, and 2007 confirmed the overfished status. Canary rockfish were last assessed in 2015, and that assessment indicated the stock was rebuilt with a spawning stock biomass of 56 percent of unfished spawning stock biomass. That assessment treated the U.S. canary rockfish resource from the Mexican border to the Canadian border as a single coast-wide stock, but explicitly tracked population- and fleet-structure in each of three spatial strata, equivalent to the three state (WA, OR, and CA) boundaries, in order to account for differences in exploitation history among the states.

Assessments for these stocks will provide the basis for the management of the groundfish fisheries off the West Coast of the U.S., including providing scientific basis for setting OFLs and ABCs as mandated by the Magnuson-Stevens Act. The technical review will take place during a formal, public, multiple-day virtual meeting of fishery stock assessment experts. Participation of external, independent reviewers is an essential part of the review process. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements:
Two CIE reviewers will participate in the stock assessment review panel. One CIE reviewer, requested herein, shall conduct an impartial and independent peer review of the assessments described above and in accordance with the Performance Work Statement (PWS) and ToRs herein. Additionally, one "common" CIE reviewer will participate in all STAR panels held in 2023 and the PWS and ToRs for the "common" CIE reviewer are included in **Attachment A**.

The CIE reviewers shall be active and engaged participants throughout panel discussions and able to voice concerns, suggestions, and improvements, while respectfully interacting with other review panel members, advisors, stock assessment technical teams, and other participants. The CIE reviewers shall have excellent communication skills in addition to working knowledge and recent experience in fish population dynamics; with experience in the integrated-analysis modeling approach, using age- and size- (and possibly spatially-) structured models, and methods for quantifying uncertainty. Familiarity with environmental, ecosystem and climatic effects on population dynamics and distribution may also be beneficial. The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Tasks for Reviewers:
The CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the NMFS Contracting Officer Representative (COR), who forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the PWS and ToRs to the CIE reviewer. The NMFS Project Contact is responsible for providing the CIE reviewer with

the background documents, reports, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the PWS in advance of the panel review meeting. Any changes to the PWS or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at a File Transfer Protocol (FTP) site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein. The CIE reviewer shall read all documents in preparation for the peer review.

Documents to be provided to the CIE reviewers prior to the STAR Panel meeting include:

- The current draft stock assessment reports;
- Previous stock assessments and STAR Panel reports for the assessments to be reviewed;
- The Pacific Fishery Management Council's Scientific and Statistical Committee's Terms of Reference for Stock Assessments and STAR Panel Reviews;
- Stock Synthesis (SS) Documentation;
- Additional supporting documents as available;
- An electronic copy of the data, the parameters, and the model used for the assessments (if requested by reviewer).

Panel Review Meeting: The CIE reviewer shall conduct the independent peer review in accordance with the PWS and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the PWS and ToRs cannot be made during the peer review, and any PWS or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the review panel's virtual meeting, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., video or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements. The agenda will be made available two weeks prior to the start of the Panel Review Meeting.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewer shall complete an independent peer review report in accordance with the PWS. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. The CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**.

Other Tasks – Contribution to Summary Report: The CIE reviewer should assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. The Chair is not provided by the CIE under this contract. A CIE reviewer is not required to reach a consensus with other members of the Panel, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Place of Performance:
The CIE reviewers shall conduct an independent peer review during the panel review meeting scheduled for the dates of July 24-28, 2023. The meeting shall take place in Seattle, Washington. In the event that conditions at the time warrant, this meeting will be conducted instead as a virtual meeting, with technical assistance provided by staff from the Pacific Fishery Management Council.

Period of Performance:
The period of performance shall be from the time of award through **September 2023**. The CIE reviewers' duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables:

CIE shall complete the tasks and deliverables described in this PWS in accordance with the following schedule. Within two weeks of the award	Contractor selects and confirms reviewers. This information is sent to the COR, who then transmits this to the NMFS Project Contact
Approximately two weeks later	Contractor provides the pre-review documents to the CIE reviewers
July 24-28, 2023	**Panel Review Meeting, Seattle, Washington**
Approximately two weeks later	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final CIE independent peer review reports to the COR

Note: The Chair's Summary Report shall not be submitted to, reviewed, or approved by the Contractor.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content; (2) The reports shall address each TOR as specified; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel:

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $11,000.00.

Restricted or Limited Use of Data:

The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contact:

Andi Stephens, NMFS Project Contact
National Marine Fisheries Service,
Newport, OR 97365
Andi.Stephens@noaa.gov, Phone: 843-709-9094

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.
   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.
   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.
   e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.
3. The reviewer report shall include the following appendices:
   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Performance Work Statement
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review
Stock Assessment Review (STAR) Panel 3

The specific responsibilities of the STAR panel are to:

1. Become familiar with the draft stock assessment documents, data inputs, and analytical models along with other pertinent information (e.g., previous assessments and STAR panel report when available), and the Pacific Fisheries Management Council Terms of Reference for the Groundfish Stock Assessment Review Process for 2023-2024 prior to review panel meeting.
2. Discuss the technical merits and deficiencies of the input data and analytical methods during the open review panel meeting.
3. Evaluate model assumptions, estimates, and major sources of uncertainty.
4. Provide constructive suggestions for current improvements if technical deficiencies or major sources of uncertainty are identified.
5. Determine whether the science reviewed is considered to be the best scientific information available.
6. When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time frame.
7. Provide a brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

Appendix 3: Panel Membership and other information

Panel membership and attendance

The panel for the STAR 3 review comprised Dr John Field (Scientific and Statistical Committee (SSC); STAR Panel chair), Dr Kristin Marshall (SSC), and Center for Independent Experts (CIE) reviewers Dr Joe Powers and myself. Also at the table were support and advisory personnel from the Pacific Fishery Management Council (PFMC) and its advisory bodies: Marlene Bellman (PFMC), Whitney Roberts (Groundfish Management Team; Oregon Department of Fish & Wildlife); and Gerry Richter (Groundfish Advisory Subpanel).

Key members of the stock assessment teams were: for Petrale Sole, Dr Ian Taylor and Dr Vladlena Gertseva; and, for Canary Rockfish, Dr Brian Langseth and Dr Kiva Oken, all from the National Oceanic & Atmospheric Administration (NOAA) Northwest Fisheries Science Center.

I do not have a list of all people who attended the meetings in the room or online but it appeared to me that there were up to about 40 people engaged at any given time, more during the earlier part of the week. The working agenda is reproduced below.

Agenda for STAR 3 review panel

Petrale Sole and Canary Rockfish

National Oceanic and Atmospheric Administration
Northwest Fisheries Science Center
Auditorium and Online
2725 Montlake Boulevard E
Seattle, WA 98112
260-860-3200

July 24-28, 2023

This groundfish stock assessment review (STAR) meeting is hosted by the Pacific Fishery Management Council (Council) and the National Oceanic and Atmospheric Administration (NOAA) Northwest Fisheries Science Center (NWFSC) and will follow the Council's Terms of Reference (TOR) for Groundfish Stock Assessment Reviews. This STAR panel will review 2023 stock assessments for petrale sole and canary rockfish. STAR Panel meetings are open to the public and a public comment period is scheduled for each day. Additional public comments and breaks will be taken at the discretion of the Chair.

Dates and times (Pacific Daylight Time) on this agenda are subject to change once the meeting begins. Note that the schedule is intended to be flexible, and the timing of responses to comments and the development of additional requests in particular will be dictated by the complexity of the requests and availability of the analysts; participants should not expect a static schedule.

The meeting will be conducted in person with a web broadcast that provides the opportunity for remote listening and public comment. In the event an outage occurs, or technical issues arise that impact the experience of remote attendees, we will attempt to resolve them but ultimately we cannot guarantee that they will be resolved satisfactorily. Specific meeting information, materials, visitor protocols, and instructions for how to connect to the meeting remotely will be available on the Council's website in advance of the meeting.

Monday, July 24, 2023		
8:30 am	Welcome, Logistics, and Introductions	Field/Hamel/Bellman
8:45 am	Review the Agenda and Discuss Meeting Format Administrative matters, Terms of Reference, etc.	Field/Bellman
9:00 am	Canary rockfish: Stock Assessment Team (STAT) Presentation (Part 1: Biology, Fisheries, and Data)	Langseth/Oken/STAT
10:15 am	BREAK	
10:30 am	Canary rockfish: STAT Presentation (Part 2: Assessment Modeling and Performance)	Langseth/Oken/STAT
12:30 pm	LUNCH	
1:30 pm	STAR Panel Discussion and Requests to the Canary rockfish STAT	Panel/ Canary STAT
2:45 pm	BREAK	
3:00 pm	Petrale sole: STAT Presentation (Part 1: Biology, Fisheries and Data)	Taylor/Gertseva/STAT
5:15 pm	Public Comment	Field
5:30 pm	Adjourn for day	
Tuesday, July 25, 2023		
8:30 am	Review Agenda for the day; STAR Panel Discussion	Field/Panel
8:45 am	Petrale sole: STAT Presentation (Part 2: Assessment Modeling and Performance)	Taylor/Gertseva/STAT
10:15 am	BREAK	
10:30 am	STAR Panel Discussion and Requests to the Petrale sole STAT	Panel/ Petrale STAT
12:30 pm	LUNCH	
1:30 pm	Response to Round 1 Canary rockfish Requests and Discussion	Canary STAT
3:30 pm	BREAK	
3:45 pm	Consideration of Round 2 Requests for Canary rockfish	Panel/ Canary STAT
4:45 pm	Initial Report Writing and Work Session, as needed	Panel
5:15 pm	Public Comment	Field
5:30 pm	Adjourn for day	
Wednesday, July 26, 2023		
8:30 am	Review Agenda for the day; STAR Panel Discussion, Responses to requests (if available), or Report Writing and Work Session, as needed	Field/Panel
10:15 am	BREAK	
10:30 am	Response to Round 1 Petrale sole Requests and Discussion	Petrale STAT
12:30 pm	LUNCH	
1:30 pm	Consideration of Round 2 Requests for Petrale sole	Panel/ Petrale STAT
3:00 pm	BREAK	
3:15 pm	Response to Round 2 Canary rockfish Requests and Discussion	Canary STAT
4:45 pm	Consideration of Round 3 Requests (if any) for Canary rockfish	Panel/ Canary STAT
5:15 pm	Public Comment	Field
5:30 pm	Adjourn for day	
Thursday, July 27, 2023		
8:30 am	Review Agenda for the day; STAR Panel Discussion, Responses to requests (if available), or Report Writing and Work Session, as needed	Field/Panel
10:00 am	BREAK	
10:15 am	Response to Round 2 Petrale sole Requests and Discussion	Petrale sole STAT
12:00 pm	Consideration of Round 3 Requests (if any) for Petrale sole	Panel/ Petrale STAT
12:30 pm	LUNCH	
1:30 pm	Response to Round 3 requests (if any) for Canary rockfish, discussion of base model, consideration of Canary rockfish decision table	Panel/ Canary STAT
3:00 pm	BREAK	
3:15 pm	Response to Round 3 requests (if any) for Petrale sole, discussion of base model, consideration of Petrale sole decision table	Panel/ Petrale STAT
4:45 pm	Initial Report Writing and Work Session, as needed	Panel
5:15 pm	Public Comment	Field
5:30 pm	Adjourn for day	
Friday, July 28, 2023		
8:30 am	Review Agenda for the day; STAR Panel Discussion, Responses to requests (if requested/available), or Report Writing and Work Session, as needed	Field/Panel

8:45 am	Consideration of Remaining Modeling Issues and Decision Table for Canary rockfish	Panel/ Canary STAT
10:00 am	BREAK	
10:15 am	Consideration of Remaining Modeling Issues and Decision Table for Petrale sole	Panel/ Petrale STAT
12:30 pm	LUNCH	
1:30 pm	Review Draft of the STAR Panel Report	Panel
3:00 pm	BREAK	
3:15 pm	Public Comment	Field
3:30 pm	Review Draft of the STAR Panel Report: Panel agrees to process for completing the Final STAR Report for Council's September Meeting Briefing Book (Deadlines: August 9 Advance; August 25 two weeks prior SSC; August 28 Supplemental)	Panel
5:15 pm	Discuss Any Remaining Considerations/Departing Remarks	All
5:30 pm	STAR Panel Adjourns	