External Independent Peer Review
for the
Center for Independent Experts (CIE)
Stock Assessment Review (STAR) Panel 3
of
Canary Rockfish and Petrale Sole
July 24-28, 2023
Northwest Fisheries Science Center
2725 Montlake Boulevard E
Seattle, WA 98112

by
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Executive Summary

i. Assessments of Canary Rockfish and Petrale Sole stocks were reviewed during a formal, public meeting of fishery stock assessment experts from 24-28 July 2023. Two Center for Independent Experts (CIE) reviewers were included in the Review Panel. Both stocks were assumed to occur within US waters off the coasts of Washington, Oregon and California.

ii. The Canary Rockfish assessment uses an areas-as-fleets approach to account for different sizes and ages of fish available in each state, but returns to a coastwide population model configuration. The assessment model is a two-sex, age-structured including updated catches from five fleets (commercial trawl, non-trawl, foreign, and at-sea hake, and recreational), each of which is divided across three states; fishery-independent indices from the NWFSC West Coast Groundfish Bottom Trawl Survey, AFSC/NWFSC West Coast Triennial Shelf Survey, and a pre-recruit survey. Additionally, age and length data from the fishery and the Trawl and Triennial Surveys are available. Parameters for sex-specific von Bertalanffy growth and recruitment deviations were estimated. The assumed recruitment model was Beverton-Holt stock-recruit function with a fixed steepness (h=0.72) and sigmaR=0.5. In addition, this assessment includes an updated maturity curve based on newly analyzed ovaries and updated biological relationships for fecundity. Natural mortality was modeled as age-invariant, with male M fixed at the prior (as in the previous assessment) and female estimated. The model estimated selectivities by sex within time blocks thought appropriate for each fleet. A final reference model was developed which differed from the original by alternative weighting of the Triennial survey versus time blocks of selectivity, as recommended by the STAR Panel.

iii. The Petrale Sole fishery is almost entirely comprised of commercial trawl effort and landings. Historical catch estimates for California and Oregon were essentially unchanged between the last benchmark and this assessment, although historical catch estimates for the Washington fishery changed substantially, to considerably lower levels. The 2023 petrale sole assessment was a fully integrated age-structured bench-mark assessment using catch, length, age, and index data from fishery dependent and independent sources. Natural mortality, growth and recruitment were estimated, while steepness (h)was fixed at 0.80. Sex-specific selectivity with time blocks based on important management changes and milestones are a key model feature. Although previous models distinguished summer fisheries from winter fisheries, the 2023 model combined previous seasonal fisheries into a single annual fleet, reducing model complexity and number of parameters to estimate. The 2023 assessment continued the approach of having separate bottom trawl fisheries north and south of the California/Oregon border. Fishery length and age composition data are extensive for the northern fleet. Survey data from the historical Triennial Survey and the West Coast Groundfish Bottom Trawl Survey (WCGBTS) were key model inputs. One significant change from the previous model was the treatment of the triennial survey index as a single time series, rather than distinct early and late time series. After considering exploration of model structure and parameter sensitivities, the STAR

Panel recommended that the reference model remain unchanged from that originally presented.

iv. These assessment models represent the best science available given the existing data as the assessment goes forward to the final model runs for the SSC.

v. The need for more aging, size samples and expanded surveys are ubiquitous in these assessments. As opposed to assessments of other stocks around the world, the current WA, OR, CA indices are not very informative.

vi. Implicit within all these assessments is that migration at pre- or post-recruitment time periods are not important to the dynamics (i.e. that the stock-delineation is correct). While it is important to augment research on stock identification, it is also important to explore management procedures which are robust to stock-id mis-specifications.

vii. Usually, the axes of uncertainty are focused on natural mortality and steepness. There is a need for simulation research on best practices regarding the joint choice of h, M and SigmaR in the stock recruitment relationship including statistical structure of the sigmas (alternatives to lognormal, shifting SigmaR with spawning output, etc).

viii. The review meeting was constructive and productive with effective excellent co-operation from the STAT teams. Meeting facilities were good, and the local staff provided great support to the reviewers. There were no major disagreements between Panel members or the STATs.

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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.

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; and 7) use assessment and review resources effectively and efficiently.

This report addresses the 3rd of the STAR reviews which met July 24-28, 2023, in-person at the Northwest Fisheries Science Center , Seattle with a remote participation option to facilitate public comment and participation. The Panel full reviewed full benchmark assessments for two stocks: Canary rockfish off the coast of Washington, Oregon and California and Petrale Sole off of the coast of Washington, Oregon and California. The panel operated under the Pacific Fishery Management Council's (PFMC) Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2023-2024. This document will be referred to as the PFMC_ToRs in the remainder of this document.

Description of the Individual Reviewer's Role in the Review Activities

The STAR Panel for the July 24-28 review was comprised of John Fields (National Marine Fisheries Service, Southwest Fisheries Science Center (Chair)), Kristin Marshall (National Marine Fisheries Service, Northwest Fisheries Science Center), Martin Cryer (CIE) and myself, also as a designate of the CIE. Additionally, I was designated as the "common" CIE reviewer for

the three STAR Panel groundfish reviews that were conducted in June-July 2023. The Panel's (and, thus, my) responsibilities were to examine the documentation provided prior to the meeting and then to interact within the meeting to evaluate details of the assessments, suggest alternatives to the base model if appropriate and provide feedback on possible improvements in modeling, research and data, both short- and long-term.

Thus, as a CIE reviewer, I am to submit a report addressing the Terms of Reference for this CIE review as noted in the Performance Work Statement (Appendix 2). The report herein is my evaluation addressing the third of the STAR Panel meetings.

Summary of Findings for each TOR in which the weaknesses and strengths are described

The **Terms of Reference (TORs)** for this CIE review include the specific responsibilities of the STAR Panels, as well as additional tasks assigned to the CIE reviewers. These are listed below. My response to each **TOR** is provided after each item in the list. This item-by-item response to each **TOR** is required by the CIE Performance Work Statement (Appendix 2). However, several of these **TORs** are fairly generic (for example "become familiar", "discuss … during the open meeting", etc). Therefore, my responses to those items were that those events did, indeed, occur. Hence, my technical comments and discussions are mostly grouped under **TORs 3, 4** and **6**. Additionally, **TOR 5** is a response to the best available science question. Discussions and conclusions that support that response are included in the other **TOR**s.

Terms of Reference for CIE Reviewers

TOR 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 PFMC_ToRs ***prior to review panel meeting***

(Note, the PFMC_ToRs *are terms of reference for the scope and details of the assessments, not to be confused with the CIE Terms of Reference for this review*).

Background documentation as listed in Appendix 1 were provided two weeks prior to the STAR 3 Panel meeting, as well as the PFMC's guidelines for conducting assessments and reviews of those assessments for the 2023-2024 STAR cycle. These were reviewed prior to the meeting. Note that I received the STAR 3 materials while I was participating in the STAR 2 Panel review meeting. Nevertheless, I became familiar with the assessment approaches, data inputs and basic STAR Panel requirements.

TOR 2. Discuss the technical merits and deficiencies of the input data and analytical methods during the open review panel meeting.

I participated in the STAR Panel 3 discussions during the meeting. Those discussions covered the technical merits, limitations of input data and analytical methods. The results of those discussions are summarized in the above **Executive Summary** and in **TOR 7** below. The technical details of those discussions and my thoughts on those issues are contained in responses to **TORs 3**, **4** and **6**.

TOR 3. Evaluate model assumptions, estimates, and major sources of uncertainty.

Model assumptions, estimates and major sources of uncertainty were examined at the July 24-28 meeting by the Panel making requests of the STAT to conduct short-term analyses on the four stocks being evaluated. The results of these analyses provided Panel members (including CIE reviewers) further understanding of the implications of assumptions, model structure and uncertainty estimates (or ranges). The scope of those requests and outcomes are summarized for each stock assessment, below.

Canary Rockfish

The status of canary rockfish off the U.S. coast of Washington, Oregon and California was assessed assuming a single coast-wide stock. While canary rockfish were modeled as a single population, spatial aspects were addressed through geographic separation of data sources/fleets where possible.

Canary rockfish are caught in both commercial and recreational fisheries off the U.S. coast of Washington, Oregon and California, with the majority of catches coming from commercial sources. The trawl fishery peaked for canary rockfish in the early 1980s and subsequently decreased after the establishment of strict management restrictions starting in the mid-1990s. Beginning in the 2000s the recreational and non-trawl fisheries took a larger proportion of total catch of canary rockfish. In 2015, catches of canary rockfish increased somewhat due to relaxation of regulations where current catches are predominantly trawl, though there is a sizable recreational component of landings, as well.

Canary rockfish was most recently assessed in 2015 using an age-structured population model that allowed for spatial differences in recruitment deviations and depletion by state. The current assessment uses an areas-as-fleets approach to account for different sizes and ages of fish available in each state, but returns to a coastwide population model configuration. The assessment model is a two-sex age-structured model operating on an annual time step covering the period 1892 to 2022 assuming an unfished equilibrium population prior to 1892. The current assessment included updated catches from five fleets (commercial trawl, non-trawl, foreign, and at-sea hake, and recreational), each of which is divided across three states; fishery-independent indices from the NWFSC West Coast Groundfish Bottom Trawl Survey (WCGBTS), AFSC/NWFSC West Coast

Triennial Shelf Survey (Triennial Survey), and a pre-recruit survey; and age and length data from the fishery and the WCGBTS and Triennial Survey. It extended all of these data sets from the previous assessment through 2022, and also included any updates to previously used data.

Parameters for sex-specific von Bertalanffy growth and recruitment deviations are estimated. The assumed recruitment model was Beverton-Holt stock-recruit function with a fixed steepness (h=0.72) and SigmaR=0.5. In addition, this assessment includes an updated maturity curve based on newly analyzed ovaries and updated biological relationships for fecundity. Natural mortality was modeled as age-invariant, with male M fixed at the prior (as in the previous assessment) and female estimated. The model estimated selectivities by sex within time blocks thought appropriate for each fleet.

The Panel investigated a number of sensitivities and alternative model structures in order to understand the relationships associated with parameter estimates and sources of uncertainty. Most of the additional analyses focused on the area-specific indices, their selectivities, time-blocking of selectivities, dropping indices one by one, mirroring selectivity of selected indices, reweighting indices, alternative historical catch scenarios, the stability of the estimates through jittering, adding inadvertently omitted age data, the relationship of fixed M with estimated selectivities. These analyses and the jittering showed that there were several selected models with similar likelihoods which estimated plausible parameters not approaching bounds.

In order to refine the reference model, the analysis was rerun with the missing age data and the best jittered model (after mirroring recent OR Non-Trawl & WA Recreational selectivities to the early period, and reweighting) with CA Non-Trawl early and late period not combined and applying one additional iteration of reweighting. This modification was accepted by the STAR Panel as an appropriate adjustment to the draft base model and thus, this updated base model is to be carried forward in the subsequent post-STAR assessment. Additionally, the M, h and SigmaR likelihood profiles for this model were examined.

Similar to other rockfish assessments, the STAR Panel recommended that the upper and lower states of nature be defined based on the uncertainty in natural mortality. That range in uncertainty was centered on the point estimate of the reference model and with the lower end of the range being defined by a model run with the single M over both sexes set at the prior and the upper end of the range from a model run with a ramp for female M between age 6 and age 14, The upper end scenario mimics the M vector used in the 2015 assessment. The lower end scenario, a single M for both sexes, reflects a low productivity state of nature for this stock. This was recommended as an appropriate approach for designing "axes of uncertainty" required by the PFMC_ToRs. I, as a Panel member, concurred.

Petrale Sole

The fishery is almost entirely comprised of commercial trawl effort and landings. Landings data extend to at least 1900 in California waters, and fisheries extended north to

Oregon and Washington waters during the 1930s. Historical catch estimates for California and Oregon were essentially unchanged between the last benchmark and this assessment, although historical catch estimates for the Washington fishery changed substantially, to considerably lower levels, as a result of a more comprehensive catch reconstruction developed by WDFW. Discards have been low both historically and recently for most years of the fishery.

The 2023 petrale sole assessment was a fully integrated age-structured bench-mark assessment using catch, length, age, and index data from fishery dependent and independent sources. Natural mortality, growth and recruitment were estimated, while steepness (h)was fixed at 0.80. Sex-specific selectivity with time blocks based on important management changes and milestones are a key model feature.

Although previous models distinguished summer fisheries from winter fisheries (in which winter fisheries targeted spawning ground), the 2023 model combined previous seasonal fisheries into a single annual fleet. This reduced the model complexity and number of parameters needed to inform separate selectivity curves, while providing results highly comparable to earlier models. The 2023 assessment continued the approach of having separate bottom trawl fisheries north and south of the California/Oregon border. Fishery length and age composition data are extensive for the northern fleet, with some (generally limited) data available historically to the 1940s and 1950s, although age composition data are fairly sparse for the southern (California) fishery. A fishery-dependent CPUE index that was included in earlier models was excluded from the 2023 model, as the influence of the index was minimal and survey data are considered to be considerably more robust and reliable.

Survey data from the historical triennial bottom trawl survey, as well as the West Coast Groundfish Bottom Trawl Survey (WCGBTS) are key model inputs. One significant change from the previous model was the treatment of the triennial survey index as a single time series, rather than distinct early and late time series. Another key change in the 2023 model is the removal of the fishery dependent CPUE index that was used in earlier models. Reasons for this include concerns over the hyperstability of catch rates when fishing on spawning grounds and the fact that the nearly 20-year time series of survey data from the WCGBTS provide robust estimates of abundance. Age composition data are available only from WCGBTS, and treated as conditional-age-at-length to better inform estimates of growth internally.

Given this background the STAR Panel 3 explored sensitivities and model structure by examining: the effects of the WA reconstruction of historical catch; examining index fits to the WCGBTS including various weightings and additional variance; shifting recent time blocks of commercial selectivity to test possible fishery pattern effects; exploring the use of an environmental index as a mechanism to inform recent recruitment; model runs with M from previous assessment; and alternative weighting of northern vs southern size data; profiles over SigmaR.

The base assessment provides a somewhat different scale from the previous, thus, the

Panel asked for estimates of equilibrium maximum sustainable yield for each step of the bridging analysis. The current assessment has a more comprehensive analysis of discards and is an improvement over the previous assessment. Multiple contributing factors are reinforcing perceptions of stock productivity and the scale of the population. From the responses prepared by the STAT, the Panel concluded that changes in spawning output were more attributed to catches than parameter changes (M and h). The most influential factors contributing to updated catches were the new WA catch reconstruction and changes to discard estimates.
In the end, the reference model was unchanged from the pre-STAR 3 assessment model described above. The alternative models chosen to bracket uncertainty are based on alternative values of female natural mortality (M), as estimated based on the likelihood profiles using the methods described in the PFMC_ToRs.. Natural mortality values in general had the greatest influence on the perception of stock status and productivity for this model. This approach led to female M values of 0.072 (low productivity state of nature) and 0.219 (high productivity state of nature), respectively. The associated ending year depletion estimates were 0.336 (above target level of 0.25) for the base model, 0.195 for the low productivity scenario (within the precautionary zone), and 0.528 (well above target levels) for the high productivity scenario. This was recommended as an appropriate approach for designing "axes of uncertainty" required by the PFMC_ToRs. I, as a Panel member, concurred.

TOR 4. Provide constructive suggestions for current improvements if technical deficiencies or major sources of uncertainty are identified.

I am interpreting suggestions for "current" improvements to be those improvements that were made to the final reference model and supporting information to be presented to the SSC and subsequently to the Council. Therefore, current improvements are the changes to the reference model recommended by the Panel (and by me as a Panel member). Those modifications were noted in **TOR 3** and highlighted here. Research improvements (both analytical and data) discussed in **TOR 6**,

Canary Rockfish

In order to refine the reference model, the analysis was rerun with the missing age data and the best jittered model (after mirroring recent OR Non-Trawl & WA Recreational selectivities to the early period, and reweighting) with CA Non-Trawl early and late period not combined and applying one additional iteration of reweighting. This modification was accepted by the STAR Panel as an appropriate adjustment to the draft reference model and thus, this updated reference model is to be carried forward in the subsequent post-STAR assessment.

Petrale Sole

After considerable exploration (**TOR 3**) the Panel recommended the pre-STAR 2 reference model as described above remain the reference model is to be carried forward in the subsequent post-STAR assessment.

TOR 5. Determine whether the science reviewed is considered to be the best scientific information available.

Canary Rockfish

In my scientific opinion the science reviewed at the July 24-28 meeting and the recommended modifications to the reference model given in the Summary Report (and noted in TOR4) represent the best scientific information available on Canary Rockfish to go forward to the SSC.

Petrale Sole

In my scientific opinion the science reviewed at the July 24-28 meeting and the recommended reference model given in the Summary Report (and noted in TOR4) represents the best scientific information available on Petrale Sole to go forward to the SSC.

TOR 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.

Following are lists of research suggestions made by the STATs and the Panel. I have assigned each a designation of short-term or longer-term. Note the time frame assignments are my opinions and not necessarily those of the Panel, at large. At the end of the response to TOR 6, I include a more detailed discussion about future modeling research including some analytical support. These are my opinions, independent of the Panel.

Canary Rockfish

STATs recommendations: a) continued research into the mechanism leading to skewed sex ratios and empirical studies to estimate natural mortality rates. This remains a critical uncertainty for canary rockfish assessments, as well as other species of rockfish along the U.S. West Coast. Further research to understand the mechanism by which skewed sex ratios occur would be beneficial for understanding the potential of canary rockfish recovery (**longer-term**); b) the WCGBTS has low encounter rates with canary rockfish in part because it has limited access to rocky habitat. There is a need for non-trawl coast-wide fishery-independent surveys to improve abundance indices by expansion of the Hook and Line Survey into more northern waters (**longer-term**), or taking advantage of developments in model-based index standardization to integrate multiple similar overlapping fishery-independent non-trawl sampling programs that have occurred over smaller spatial and temporal scales than the WCGBTS (**short-term**); c) update biological relationships of fecundity (**short-term**); d) explore ecosystem or climate change effects highly vulnerable canary rockfish including relationship with British Columbia stock(s) (**longer-term**); doing this research in a multispecies manner across groundfish species, particularly those with similar life histories, may lead to more statistical power to gain new insight (**short-term**); e) further exploration of differences in

spatial and non-spatial modeling structure, stability, and results. The structure of canary rockfish stock assessments has varied over time. The 2015 assessment added population structure so as to more explicitly describe potential regional differences in depletion. For this assessment we return to a coastwide model for reasons explained previously (**short-term**); f) research to inform understanding of movement rates for a spatial model, as well as improve estimates of natural mortality. Large scale movement patterns for canary rockfish are generally unknown (**longer-term**); and g) update ageing error matrices (**short-term**)

Additionally, the STAR panel recommends: a) explore selectivity parameterization using asymptotic selectivity at length and domed selectivity at age to potentially capture dynamics related to male-skewed sex-ratio and sex dependent selectivity. b) given large changes in biomass of known or likely predators of canary rockfish (e.g., lingcod, hake), there is a need to explore possible predatory changes in M. This could be initially explored using existing databases and published information (**short-term**); c) consider a comprehensive literature review and/or additional development of models to explore the potential mechanisms for greater mortality with age (or simply higher natural mortality more generally) for female canary rockfish be initiated. This could include an evaluation of bioenergetics models or state dependent models to better understand and quantify the trade-offs between growth and reproduction for rockfish (**short-term**); d) consider whether additional sampling or potentially cooperative research with the Washington or Oregon fixed gear fleets to better sample age structure for canary rockfish could be informative and evaluate and explore additional sources of relative abundance information from either commercial fixed gear fisheries or other fixed gear surveys in the California Current (**short-term**); e) if available, historical age structures (otoliths) that were surface read and not used in this assessment might be read using contemporary methods to better inform historical population structure within the model (**short-term**); and f) given the uncertainty and apparent declines in Canary recruitment deviations in recent years, monitoring of the pre-recruit survey index in between assessments for Canary rockfish is recommended. Additional explorations of how best to incorporate the pre-recruit index into rockfish stock assessments should be done (**short-term**).

Petrale Sole

STATs recommendations: a) the development of environmental indices that could be used to better inform estimates of recruitment and cohort strength in recent model years; more validation would be helpful prior to formally including the index into the base model (**short-term**); b) pending or complementing (a) the potential use of an index in a future assessment model, the Panel also encourages continued consideration of a risk table to inform managers with respect to environmental trends would be useful (**short-term**); c) additional research into both spatial and temporal variability of productivity processes such as growth, recruitment and maturity would help identify the extent to which such processes could or should be explicitly modeled in future assessments (**longer-term**); d) encourage continued discussion and research with Canadian researchers to exchange data and ideas regarding index trends, demographic structure, movement patterns, dispersal, and recruitment dynamics (**short-term, but ongoing**); e) exploration of the mechanisms that could explain sex-specific differences in selectivity patterns would be helpful, such as

sex-specific spatial distributions or behavioral patterns and f) the analytical solution for catchability in the WCGBTS was considerably greater than 1 in the base model; further research into the effects of herding or other responses to survey gear is needed (**longer-term**).

Additionally, the STAR panel recommends: a) there is an apparent pattern of above average abundance estimates for not only petrale sole, but many other flatfish and skate species in the final year (2004) of the triennial survey; vessel or skipper effects might be evaluated using location data associated with 2004 trawls relative to those from earlier years (**short-term**); b) there remains a paucity of age data for the southern (California) area relative to northern fleets. In addition to better informing the model, age structure data from this region would improve the ability to better evaluate spatial differences in growth, productivity and population dynamics (**longer-term**); c) the forecast values derived from Stock Synthesis suggested some minor discrepancies when control rule buffers were applied to OFLs to arrive at ACLs, such that some ACLs were greater than the ABCs after application of the harvest control rule. Improvements to Stock Synthesis to avoid this inconsistency should be implemented (**short-term**),

General Comments and Recommendations on Assessment Research.

Note: I am the "common" CIE reviewer for all three STAR Panels of 2023 covering 10 stocks that were reviewed during the June-July 2023 period. What I realize is that there are some generic issues, especially for the rockfishes, that reoccur. Thus, I find myself repeating myself on some recommendations in my STAR 1, 2 and 3 CIE Reports. Perhaps, that is a good thing, in that it emphasizes my opinions.

Targets

Following is the equilibrium yield= equilibrium dB/dt plot taken from the draft executive summary of the pre-STAR 3 Canary rockfish document. However, note that only the y-axis and the "current S/S0" are a result of the assessment. Everything else is a result of the assumption of steepness imposed by the PFMC_ToRs. This figure (Figure 1) has shown up throughout the STAR process for other rockfish stocks, where h=0.72 was used.

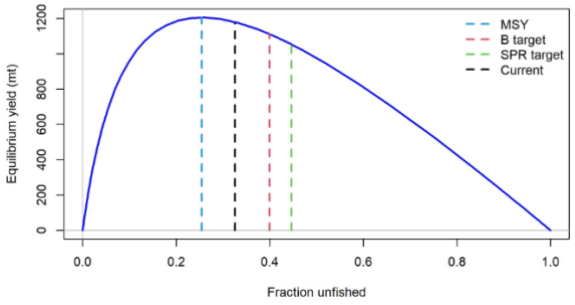

Figure 1: Equilibrium yield vs. fraction unfished.

The equilibrium results from the Beverton-Holt relationships:

$$\frac{S}{S_0} = \frac{SPR - ((1-h)/(4h))}{1 - ((1-h)/(4h))} \; and \; SPR_{MSY} \cong SPR_{Max\ Excess\ Rec} = \sqrt{(1-h)/(4h)}$$

Examination of this figure tells us 1) that all the equilibrium "targets" are more than 1.5 times the spawning output at msy (Smsy); and 2) a depleted stock (S<Smsy) has the potential for a fairly rapid recovery to Smsy (the slope of the curve on the left is more steep than the right. All of this comes from the specification of h without an assessment. I only mention this because it is unclear to me what the various "targets" are trying to achieve and how they are folded into a control rule and how consistent they are with the h or Smsy/S0 specification.

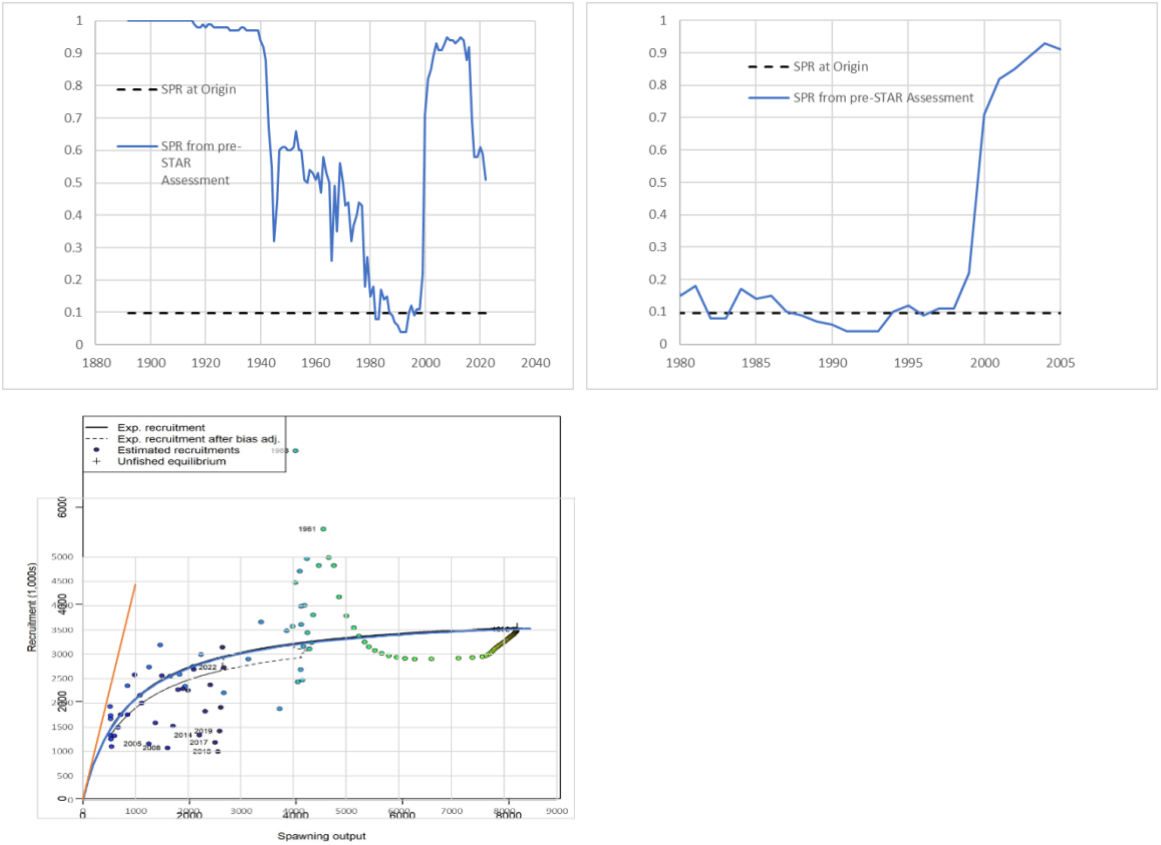

Figure 2: Consequences of h, M and SigmaR specification. SPR and SPR at the origin.

The SPR at the origin of a BH stock-recruitment curve is (1-h)/4h. This says that with a BH SR curve with h=0.72, equilibrium SPRs <=0.0972 will go to extinction. Taking Canary Rockfish as an example (Table 15 of the Pre-STAR 3 assessment report) the above figures shows there were a number of years where SPR<0.0972. Additionally, the SR curve shows that the realized R/S was very close to the slope at the origin (and an SPR of 0.0972). Thus, by the model, not necessarily in reality, the stock was teetering on extinction. This is a reminder that the h specification in the rockfish models can have some unintended influences in the highly constrained parameter space the models are operating in.

That constrained parameter space is demonstrated by a simple production model: dB/dt=aB - bB^p -Y , where a, b and p are parameters B is the biomass and Y is the yield in weight. Specifying h=0.72 gives Smsy/S0=0.238. The value of p that gives the equivalent Bmsy/B0=0.238 is p=0.461. The value of B0 (carrying capacity is taken from the Canary

assessment Table 15. Thus, the simple model becomes dB/dt= B0*b*(1-p)*(B^p)-bB-Y. Taking b=M, we get dB/dt= B0*alpha*(B^p)-MB-Y, where alpha=M*(1-p). I know the M mortality rate in the assessments are in numbers but here it is weight. But it will be seen that it serves an equivalent scaling property in both models. Essentially, what I have done here is create a simple population dynamics model which uses the same basic assumptions that the detailed assessment model uses (B0, h or p and priors on M) and coupled with the observed catches in weight (Y's). Then I numerically solved dB/dt. The resulting dynamics are very similar to the reference model

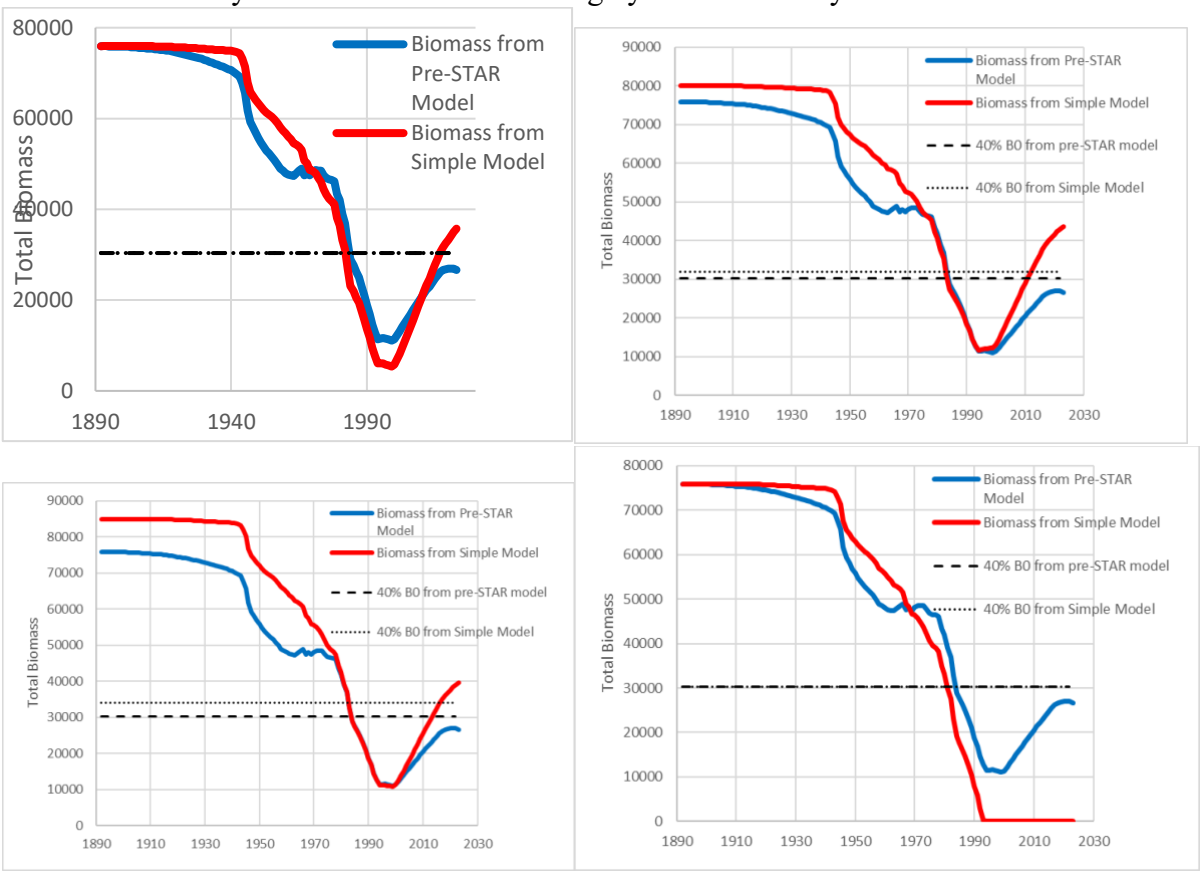

Figure 3: Biomass trajectories (blue lines) from the Canary Rockfish pre-STAR 3 assessment where h=0.72, M estimated at 0.21 and B0=75920 from Table 40. Red lines are the simple production model with parameters p=0.461 (equivalent to h=0.72); Upper left: M =0..076 the same as the estimate from the pre-STAR model and B0 fixed at 75920; Upper Right: M=0.076, B0=80000; Lower Left: M=0.064 the median of the prior used in pre-STAR and B0=85000; and Lower Right: M=0.064, B0=75920. Note Lower Right collapses because the low M is not sufficient to cover history of catches at that B0 (equivalent to SPR at origin issue in the previous figure).

What these graphs in Figure 3 suggest is that 1) the basic dynamics are being driven by the h and M assumptions and the history of catches; 2) since almost all the index and size data other than catches were collected post depletion, those data are estimating recovery and are only weakly related to scale (R0, S0 or B0); 3) the rockfish assessments at h=0.72 and the priors on M are forcing the model into a confined space during the time period 1985-2000 where slight reductions in M would cause stock collapse unless the scale (B0, S0 or R0) is inflated. Therefore, the SS modeling is essentially using aging/size data and limited index data in the later years (post 2000) to modulate what the dynamics imposed by M and h are trying to do. And it is doing this by estimating recruitment deviations since the index data are not very informative.

Most of the rockfishes in all 3 STARs have similar histories of catch, the same specification for h, priors on M and the same SigmaR. This leads me to a generic recommendation for modeling/simulation research:

> **My recommendation from this discussion is that there is a need for simulation research which explores the relationship of h, M and SigmR and the statistical structure of the sigmas (alternatives to lognormal, shifting sigmaR vs S, etc). We usually consider these choices independently from one another, or not at all. This research is beyond the scope of a single assessment and could probably be achieved in 2-4 years.**

Recruitment Timing

This is an issue I brought up in more detail in my report for STAR Panel 1, but I reiterate it here, along with some evolution of my thoughts on the issue over the 3-month time of the STAR series reviews.

The stock-recruitment model is a depiction of a mortality process of eggs to recruits at some specified age. Inherently, the parameters are tied to a time period: what is the duration of the recruitment process? Often, we think of recruitment at the beginning of age 1 and assume that all the density-dependence occurs before that time. Use of the Beverton-Holt curve is pretty forgiving in that we can model sequential period of B-H processes interspersed with density-independent processes as a single B-H process. So as long as there are no catches during the recruitment process, this approach has been acceptable. But when does the S-R process end and when does the imposition of M begin? Or more directly, when does density-dependent mortality become trivial relative to density-independent M?

In SS3 in these assessments, the S-R function is imposed using S (#eggs) at the beginning of the year and the predicted "recruits" from the model are for some unspecified time during year 0. Then an M for an unspecified time period is imposed for what works out to be the rest of year 0. This raises a few issues: 1) for something like Canary Rockfish with a prior on M of ~0.06, would we expect that density-dependence becomes insignificant before age 1? before age 2?; 2) "recruitment" deviations are estimated relative to the unspecified time duration toward the beginning of the year with a SigmaR assuming lognormal process error; but are we measuring recruitment deviations or are M deviations being inherently encompassed into these estimates? Given these questions, I recommend that:

> **Assessments routinely explore models where recruitment (post density-dependence) occurs at a fixed time both less than age 1 and greater depending on life history. This is especially important as assessments move to age-dependent M (e. g. Lorenzen M's). Additionally, the relationship between sigmaR and time of recruitment should be explored and the assumption of lognormality, as well. Finally, software should be developed to implement this process, along with appropriate diagnostics. This research is beyond the scope of a single assessment and could probably be achieved within a year or so.**

Alternative Models

Also, the PFMC_ToRs and the STAR meetings themselves are structured around the SS3 platform. The modeling philosophy is to try to use the data as collected and to derive an accurate model often with the result of estimating high precision (Hessian) that is known to be biased. Often this results from the fixing of important parameters. Then at the end, the assessment defaults to overall uncertainty best practices (sigma). There is a need to expand the modeling to encompass the diversity of model responses to sequential time series of data,

> **Ensemble modeling approaches should be explored since there might be alternative modeling structures that estimate rates better, while others may estimate scale better. How to structure an assessment accordingly and how to weight results would be an important contribution. For example, a simple model might be used for projections as in a management procedure. This research is beyond the scope of a single assessment and could probably be achieved in 2-4 years.**

TOR 7. Provide a brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

The review was conducted in a constructive manner and the STAT teams were responsive to the requests from the Panel for additional analyses with all the essential runs being completed during the meeting. Those issues were referred to in the TOR 3 response.

These included: updates of aging error, maturity models, alternative selectivity assumptions that better explained the observed data, appropriate assumptions on natural mortality, steepness and SigmaR and discussions on the states of nature for decision tables. Overall, there was effective engagement from all members of the Panel, the STATs and the Panel advisors. This led to improvements in the configuration of the base models.

TOR 8. CIE Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

The review process functioned well in that the meeting time was fully utilized, interactions were collegial and productive and important elements of the four assessments were explored. The meeting itself was constructive and productive with effective and excellent co-operation from the STAT teams. Meeting facilities were good, and the local staff provided great support to the reviewers.

In terms of scheduling. the guidance given in the PFMC_ToRs is: *"The number of groundfish assessment models reviewed per panel should ideally be two, except in extraordinary circumstances if the SSC and NMFS agree that it is advisable, feasible, and/or necessary, taking into account multiple area models per species or the potential for also reviewing data-moderate assessments in the STAR panel".* In the present case of STAR Panel 3, two assessments were evaluated within the 5-day meeting. This was in contrast to the STAR 1 and STAR 2 Panels where 4 stocks were evaluated during each meeting. The SSC/NMFS/Council must have considered STAR Panel 3 to be a normal process as opposed to the "extraordinary circumstance"

of STAR Panels 1 and 2. Clearly, the SSC/NMFS/Council is aware of the trade-offs of this type of scheduling, but they bear repeating here. The additional time compared to STAR 1 and 2 allowed more extensive exploration of, for example, the reweighting and model selection leading to the accepted Canary Rockfish reference model. Generally, time limitation forces some issues to be relegated into the research category highlighted in **TOR 6** and in the **Panel Summary Report**. However, this should be kept to a minimum and, thus, I wish support the original guidance in the PFMC_ToRs that the number of assessments for a single STAR Panel meeting should ideally be two.

Conclusions and Recommendations in Accordance with the ToRs

The assessments of the four stocks represent the best science available given the existing data and the guidance imposed by the PFMC_ToRs. The analyses were thorough and considerable work had gone into making good use of data from a variety of sources. The limited amount of age data and lack of informative fishery independent abundance indices means that despite the complexity and detail of the assessments, there remains uncertainty in estimated stock trends. If these stocks are of sufficient importance, the research suggestions in **TOR 6** form a template to address that uncertainty.

As usual, natural mortality and the stock-recruitment relationship (h, M and SigmaR) remain a source of uncertainty. There is a need to examine through simulation the best practices for specifying their relationships.

STATs and other assessment bodies should consider the implications of the duration of recruitment in their assessment models.

SS3 has a wide use and has a large array of options and diagnostics. Some additional thought is needed on the trade-offs of model complexity and the management needs for short-term forecasts of sustainable catches.

The review meeting was constructive and productive with effective excellent co-operation from the STAT teams. Meeting facilities were good, and the local staff provided great support to the reviewers. There were no major disagreements between Panel members or the STAT.

Appendix 1: Bibliography of Materials Provided for Review

Langseth, B.J., K.L. Oken, A.D. Whitman, J.E. Budrick, T.S. Tsou. 2023. Status of Canary Rockfish (*Sebastes pinniger*) along the U.S. West Coast in 2023. Pacific Fishery Management Council, Portland, Oregon. 256p.

Taylor, I.G., V. Gertseva, N. Tolimieri. 2023. Status of petrale sole (*Eopsetta jordani*) along the U.S. West Coast in 2023. . Pacific Fishery Management Council, Portland, Oregon. 155p.

Additionally, zipped files of model runs were provided.

Appendix 2: CIE Performance Work Statement
Stock Assessment Review (STAR) Panel 3 (CLIN 0003)
Canary Rockfish and Petrale Sole

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;

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

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.

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-assessmentprioritization-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 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 fleetstructure 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 or other pertinent information from the panel review meeting.

STAR 3 Panel Members

John Field, National Marine Fisheries Service, Southwest Fisheries Science Center (Chair)
Kristin Marshall, National Marine Fisheries Service, Northwest Fisheries Science Center
Joseph Powers, Center for Independent Experts
Martin Cryer, Center for Independent Experts

Stock Assessment Team (STAT) Members

Canary Rockfish
Brian J. Langseth, National Marine Fisheries Service, Northwest Fisheries Science Center
Kiva L. Oken, National Marine Fisheries Service, Northwest Fisheries Science Center
Alison D. Whitman, Oregon Department of Fish and Wildlife
John E. Budrick, California Department of Fish and Wildlife
Tien-Shui (Theresa) Tsou, Washington Department of Fish and Wildlife

Petrale Sole
Ian G. Taylor, National Marine Fisheries Service Northwest Fisheries Science Center
Vladlena Gertseva, National Marine Fisheries Service Northwest Fisheries Science Center
Nick Tolimieri, National Marine Fisheries Service Northwest Fisheries Science Center

STAR Panel Advisors

Whitney Roberts, Washington Department of Fish and Wildlife,
Groundfish Management Team representative
Gerry Richter, B&G Seafoods, Groundfish Advisory Subpanel representative

Marlene A. Bellman, Pacific Fishery Management Council representative