Stock Assessment Review (STAR) Panel Report
for Aurora Rockfish

Northwest Fisheries Science Center Auditorium
Montlake Blvd, Seattle, Washington
8-12 July 2013

STAR Panel Members

David Sampson (Chair)   Oregon State University, PFMC Scientific & Statistical Committee
Chris Francis   Center for Independent Experts
John Field   NMFS, Southwest Fisheries Science Center
Yan Jiao   Center for Independent Experts

Pacific Fishery Management Council (PFMC) Advisors

John DeVore   PFMC Staff
Colby Brady   NMFS Northwest Region, PFMC Groundfish Management Team
Gerry Richter   PFMC Groundfish Advisory Subpanel

Stock Assessment Team (STAT)

Owen Hamel   NMFS, Northwest Fisheries Science Center (NWFSC)
Jason Cope   NMFS, NWFSC
Sean Matson   NMFS, Northwest Regional Office

Summary of the STAR Panel Meeting

Overview

During 8-12 July 2013 a Stock Assessment Review (STAR) Panel met in Seattle, Washington to review a draft stock assessment document for aurora rockfish (Hamel et. al, 2013) that had been prepared by Hamel and Cope of the Northwest Fisheries Science Center and Matson of the Northwest Regional Office. The Panel operated under the Pacific Fishery Management Council's (PFMC) Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment and Review Process for 2013-2014 (PFMC 2012). This same panel also reviewed a draft assessment for rougheye rockfish.

Aurora rockfish (*Sebastes aurora*) is a long-lived, deep-dwelling rockfish ranging from the Queen Charlotte Islands in northern British Columbia to the mid-peninsula of Baja California, Mexico. The fish of this species found off the US West Coast are assumed to be a self-sustaining unit stock. This stock, which has been managed since 2000 as part of the minor slope rockfish complex, has not previously been assessed. Its high score in the Council's productivity and susceptibility analysis (PSA) indicated that it was vulnerable to becoming overfished (Cope et al, 2013).

The draft assessment document and other background materials were made available on the Council's ftp site on 06/25/2013, and the STAR Panelists all had adequate time to review the assessment document in advance of the meeting. The slide presentations prepared by the STAT were also made available from the ftp site, which greatly facilitated the panel's review and subsequent preparation of this STAR Panel report.

Results for the base model developed during the STAR Panel are summarized as follows. The assessment estimates that the spawning stock biomass of aurora rockfish at the start of 2013 was 1673 metric tons and was depleted to 64% of its unfished level. There is very little chance that the stock's spawning biomass has ever been below the Council's target level (40% of unfished), let alone the minimum stock size threshold (25% of unfished).

The STAR Panel commends the STAT members for their excellent presentations and complete and well-written documentation. Their willingness to respond to STAR Panel requests and to engage in productive discussions greatly contributed to the collegial atmosphere of the STAR meeting. The STAR Panel also extends its thanks to the NWFSC and PFMC staff who provided administrative support and hosted the meeting.

The STAR Panel recommends that the assessment for aurora rockfish constitutes the best available scientific information on the current status of the stock and that the assessment provides a suitable basis for management decisions.

Summary of the Assessment Data and Model

The assessment, which was conducted using the Stock Synthesis software (SS3 version 3.24o), was structured as a single coastwide region with removals taken from 1916 through 2012. The model as configured for the draft assessment had three fishing fleets, but during the STAR Panel meeting the non-trawl fleet, which accounted for a relatively small amount of the cumulative landings, was combined with the trawl fleet into a trawl + non-trawl fleet. There were discard data associated with the trawl fleet and its landings. The other fleet, which was assumed to

produce no discards, accounted for removals by the historic foreign trawl fishery, by the at-sea hake fishery, and by research surveys.

Natural mortality rates (separate by sex, constant by age and time) were fixed at the median values of the prior distributions. The steepness parameter for the recruitment versus spawning biomass function was fixed at the mean of its prior distribution. Growth was estimated separately by sex. Fishery selection was length-based and fishery selectivity curves were assumed to be asymptotic. An asymptotic retention curve was estimated for the combined domestic trawl + non-trawl fleet.

The assessment considers biomass indices from four trawl surveys: the Triennial shelf survey; the Alaska Fishery Science Center slope survey; the Northwest Fisheries Science Center (NWFSC) slope survey; and the NWFSC shelf-slope survey. Survey length composition data were available for all but NWFSC slope survey. Conditional age-at-length composition data were available for the NWFSC shelf-slope survey.

Fishery length composition data were available for the combined trawl + non-trawl fleet but very little and variable amounts of data were available for the non-trawl portion of the fleet, so the composition data included in the model were exclusively from the trawl portion of the fleet. Limited amounts of conditional age-at-length composition data were available from the trawl fleet for three years near the end of the time series. Discard data included observed discard rates, length compositions of discards, and mean body weight observations of discarded fish.

Analyses Requested by the STAR and the STAT's Responses

Because the assessments for aurora rockfish and rougheye rockfish were based on similar data sources, the efficiency of the review process was greatly enhanced. Several Panel requests for more detailed background information were common to both assessment reviews (e.g., Requests 1, 2 and 3, below), but unique aspects of each assessment required special probing.

Request 1: Report additional diagnostics from the GLMMs, including predictions for model covariates. We would also like to see summarized model predictions of the distinct GLMM components (positive model and binomial model).

Rationale: Given the potential for trends in the random vessel effects over time, it is important to feel confident that the estimated effects are plausible. Strong effects may also have implications with respect to how length expansions are developed.

Response: There were no obvious unusual patterns observed in the time-series plots, for two latitude strata, of the binomial and positive catch-rate indices for the triennial survey. However, the AFSC slope survey plots appeared to be the same as the triennial survey plots, probably due to a plotting error. The NWFSC slope survey time-series plots were provided for four latitude strata. Plots of possible *Vessel* effects were not provided.

During discussion Melissa Haltuch (NWFSC) reported that the symbols shown in the standard plots of *Vessel* x *Year* effects don't uniquely identify each survey vessel. Further discussion of the issue of *Vessel x Year* effects was tabled until later in the meeting when Jim Thorson (NWFSC) was available to explain and interpret the random effect plots of the NWFSC shelf/slope survey results for rougheye rockfish.

The STAT began their presentation of responses with an admission that they had mistakenly used an incorrect specification for the recruitment deviations in their base model, as presented in the draft assessment document. Instead of specifying in the SS3 control file that the model should have a standard "dev-vector", the STAT had specified that the model have "simple" recruitment deviations, which are not constrained to sum to zero. The STAT and STAR Panel agreed that the base model going forward should use the dev-vector configuration.

The simple dev-vector approach had some surprising effects. It produced much wider uncertainty bounds surrounding the estimates of spawning biomass, increased the scale of the spawning biomass, and resulted in the stock being less depleted (see below). It is rather alarming that such a subtle and easily overlooked change in the SS3 model specification could have such a significant impact on the assessment results.

Base model with "simple" recruitment deviations versus configured with a dev-vector.
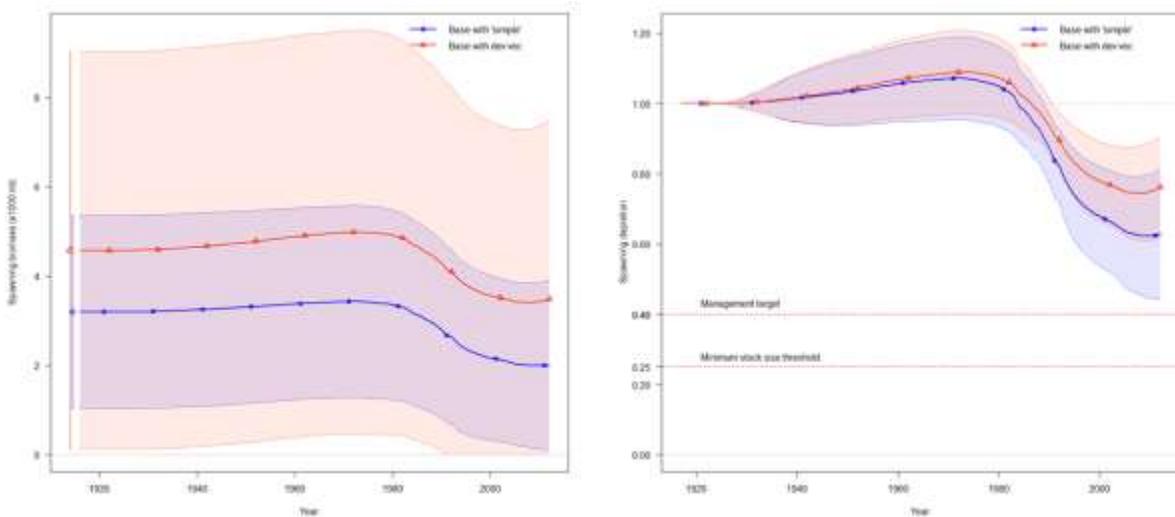
Request 2: Explore alternative effective sample size iteration methods. Based on the Francis (2011) approach, a new set of effective sample sizes can be jointly developed by the STAR Panel (Francis) and STAT. Do new runs with these re-weighted compositional data (as a sensitivity analysis to the current base model).

Rationale: The observation that there are strong autocorrelations in residuals indicates that correlations in the data are not accounted for in estimates of effective sample size. This re-weighting process may need to be done separately for the discard data.

Response: Because Chris Francis developed this relatively new method and R software to implement it, and worked with the STAT to develop the new estimates of effective sample size, he took the lead in presenting the response to this request. To illustrate the problem of autocorrelation leading to underestimates of variability, Chris presented an example (below) from a Chilean hake assessment, which shows several observed average values for which the predicted values do not overlap with the confidence limits based on the data.

Chilean hake assessment
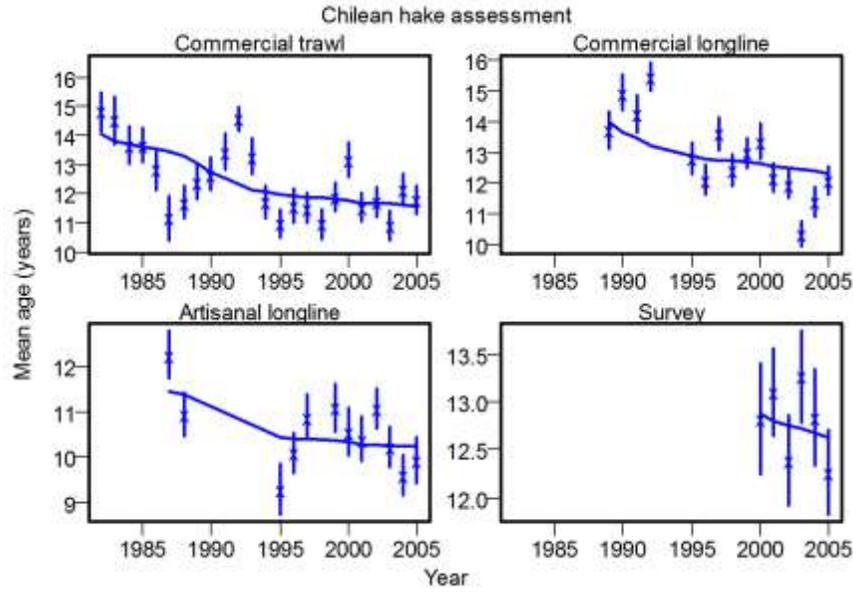
Using the aurora rockfish assessment data, Chris showed that the variance of the estimated mean length can be quite variable for the fishery length and retained data, implying that short series would probably not produce reliable estimates of reweighting factors. He suggested that a combined reweighting factor be applied to all the trawl and nontrawl fisheries data. For survey lengths, because of limited data points in the AFSC shelf and AFSC slope surveys (four data points for each survey), all the surveys were combined and one reweighting factor was estimated. For the trawl age-at-length data, one reweighting factor was estimated. Chris expressed concern that for the fisheries data the residuals indicated some lack of fit in the predicted mean ages-at-length (below). For the survey age-at-length data the fits to the mean age were acceptable, and one reweighting factor was estimated. Chris also computed estimated ranges for the reweighting factors based on bootstrapped estimates for the mean length or mean age-at-length.

Observed and predicted age-at-length for the trawl fishery.
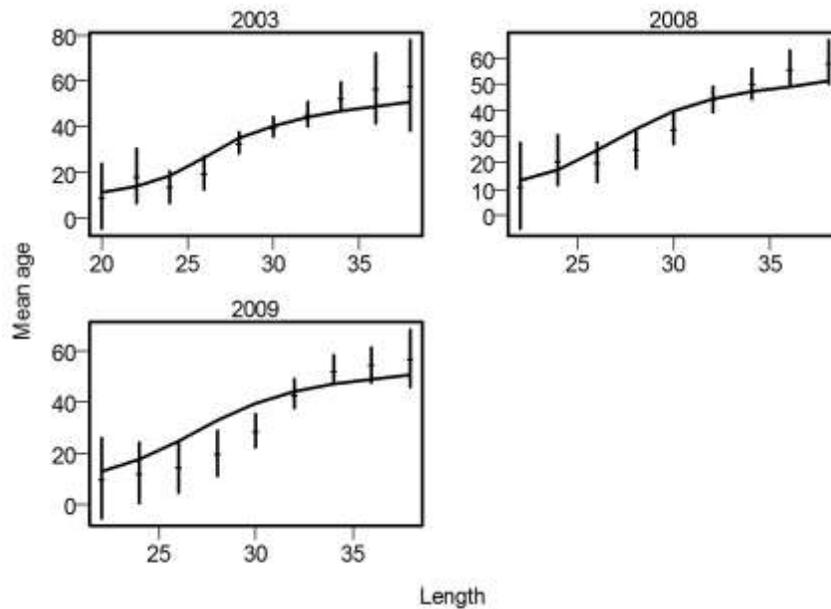
Request 3: Report the temporal trend in the ratio between input and effective sample sizes for each compositional data set.

Rationale: To see whether the calculation of the input N's is consistent over time.

Response: For most of the fleets the ratio of the effective N over the input N showed variability (as expected) but no time-trend. The one exception was the plot for the trawl fishery (below), for which the ratio was higher in the early years of the series. This suggests that the formula for calculating the input N values may need to be reconsidered.

Ratio of the effective N to the input N (Neff/N) for the trawl fishery composition data.
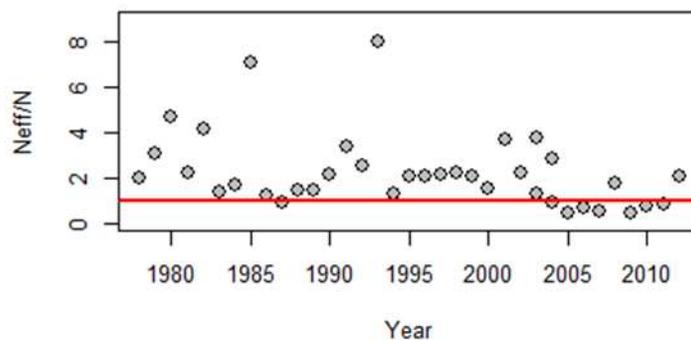

Also, because of differences in how the states collect their fishery samples, the relative number of samples coming from WA or OR may influence the combined length compositions. However, both the STAT and STAR after discussion realized that there was no clear "best approach" for combining the data.

Request 4: Develop a single-sex model.

<u>Rationale:</u> This is done in the interest of parsimony (minimizing the number of parameters), based largely on observation that growth and natural mortality are very similar between the two sexes.

<u>Response:</u> The STAT presented results from three models: (1) the base case model with two sexes plus some unsexed data; (2) a model with a single sex, but which leaves the unsexed data as in the base model; and (3) a model with a single sex that fully combined the sexed and unsexed data. There were surprisingly large differences in the estimated spawning biomass and depletion among the three models (below).

Base model (two sexes + unsexed) versus single sex + unsexed model ("Single Sex") versus model with sexes fully combined ("Single Sex 2").
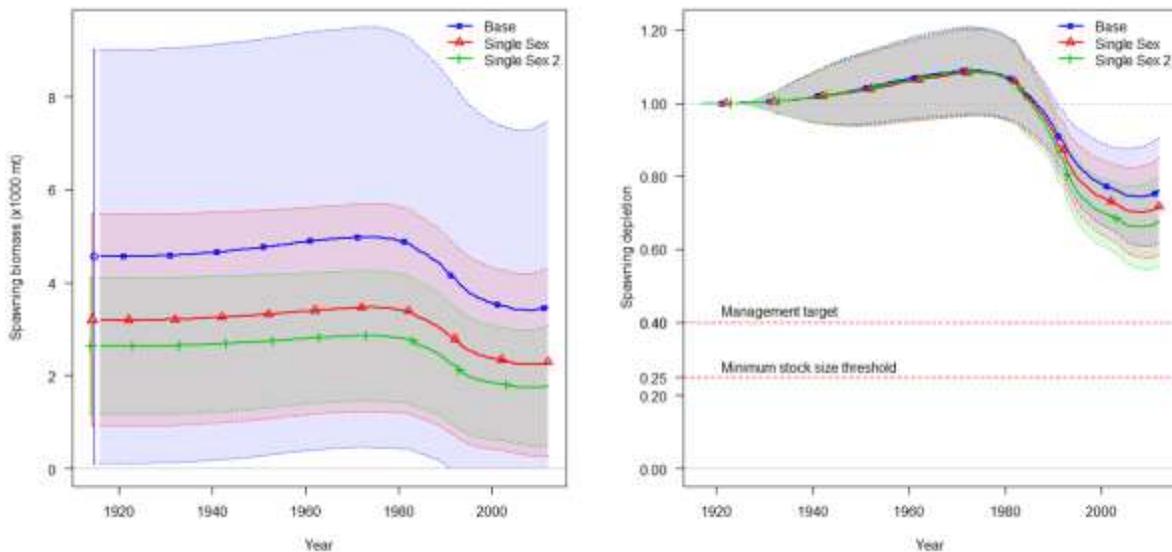
The STAR and STAT agreed that model (a), which maintains the sex-structure as in the original base model, was the structure to go forward with.

Request 5: Develop a two (trawl+non-trawl, full retention) fishery model, in which the non-trawl length frequency data are removed.

<u>Rationale:</u> This is done in the interest of parsimony, and noting that non-trawl catches are very small and that the length frequency data for the non-trawl fishery are very noisy.

<u>Response:</u> This slight revision to the originally proposed base model resulted in slight increase in the scales of spawning biomass and current depletion, but the influence was less pronounced than the sex effect found in the response to Request 4.

Request 6: Develop models that begin around 1970. Start one model without recruitment deviations but with an equilibrium catch for the pre-1970 period, the other with recruitment deviations (estimated numbers at age in 1970) but without an equilibrium catch. Produce a plot of the age structure in 1970 from the base model and from the model that starts in 1970 (estimating age structure in that year).

Rationale: This is done in the interest of parsimony, and noting that catches prior to 1970 are minor. Also, the panel wants to better understand the cause of the unusual and implausible pattern in the estimated recruitment series of the proposed base model.

Response: The STAT showed results for three models: (1) the base model, which starts in 1916 from an unfished equilibrium; (2) a model which starts in 1970 from an unfished, non-equilibrium state; and (3) a model similar to (2) but that has a small historical average annual catch of 2.4 tons. Model (3) produced a sudden drop in spawning biomass that was implausible and taken as an indication that the model had not fully converged. Model (2) produced a spawning biomass trajectory that was essentially a scaled-up version of the spawning biomass trajectory from model (1). All three models produced nearly identical series of recruitment deviations for the period 1970 to 2011.

Request 7: Run the model both with no recruitment deviations (deterministic recruitment) as well as with recruitment deviations beginning later in the model (e.g., start main devs in 1970, 1980, 1990).

Rationale: The recruitment deviation patterns are somewhat unusual, with above average recruitment in the first 40 years of the model, followed by below average recruitment for ~25 years. The panel would like to better understand how these patterns improve the fit to the data, as well as how they affect model results.

Response: Several of the runs with short series of recruitment deviations produced implausibly large estimates for the scale of spawning biomass, which was taken as an indication that these models had not converged on the maximum likelihood estimates. The STAR and STAT discussed various hypotheses of the cause of the unusual pattern of recruitment deviations. One plausible hypothesis put forward by the STAT is that the historical fishery in California operated in shallow water, which would have resulted in dome-shaped fishery selectivity for these early removals, but the base model assumed asymptotic fishery selectivity for the entire catch series.

Request 8: Compare the size and age compositions in the northern (WA/OR) and southern regions (CA).

Rationale: The panel wants to better understand whether there are important geographical differences in size and age composition not accounted for in the model.

Response: The STAT produced a figure comparing the overall length frequency compositions from each of the three states. The fish landed in WA tend to be larger than the fished landed in OR, which in turn tend to be larger than the fish landed in CA. Because of the apparent differences in size among the states, there was discussion of whether the overall length frequency compositions for the coastwide fisheries had been generated by pooling the states' length frequency data based on their landing weights or on the estimated numbers of fish.

The STAT also produced a figure comparing the overall age compositions for samples from CA and OR, and similar comparison plots for the three years for which data were available (2003, 2008, and 2009). No age composition data were available from WA. It was evident that the age compositions could be quite different between CA and OR. The STAT commented that fishery selectivity might be changing over time because of changes in fishing patterns, and that retention was also likely to be changing over time.

Request 9: If possible, recalculate fishery length compositions with a numbers-based (rather than weight based) expansion factor, and use these composition data in the two-fleet model from Request 5. Include a comparison of the two runs.

Rationale: Given that length-frequencies are based on the numbers of fish (rather than their weight), and given that there are differences in size composition among states (noted in the response to Request 8), this is an appropriate change for the base model. This will also make the treatment of the fishery composition data consistent with the survey composition data, which supposedly were combined based on the numbers of fish caught rather than their weights.

Response: The fishery length-frequency data in the original base case model run turned out to have been combined based on the estimated numbers of fish. However, in checking out the methods they had used in preparing the data, the STAT found that the survey composition data had been combined according to weight rather than numbers. So, the STAT corrected the survey length composition data.

The STAT produced a spawning biomass trajectory plot that compared the two-fleet model from Request 5 with the same model based on the numbers-based survey length composition data. In the new model the STAT also corrected the discard rates to reflect that the trawl and non-trawl fleets had been combined. There were only minor differences between the spawning biomass trajectories from the two models, with the newer model having a slightly lower scale for the spawning biomass.

Request 10: Provide a comparison of the two-fleet model with tuning as done in the base model, and tuning consistent with Request 2.

Rationale: The rationale is the same as that for Request 2.

Response: The Francis reweighting approach resulted in a drastically higher spawning biomass that is implausible and that indicates a problem with model convergence.

All these models fixed the natural mortality coefficient M at the mean value of the prior distribution (0.0405 y^{-1} for females; 0.0429 y^{-1} for males). The STAT recommended that the M values in the base model should be fixed at the median values of the prior distribution (0.0350 y^{-1} for females; 0.0371 y^{-1} for males) rather than at the mean values. The STAR concurred with this recommendation.

Request 11: Evaluate the differences in likelihoods of the year-specific compositional data (either, or both, age and length compositional data) in the two-fleet model (from Request 5) with full recruitment deviations (as in the original base model) versus a two-fleet model in which recruitment deviations begin in 1970.

Rationale: The STAR want to better understand the unusual recruitment pattern produced by the base model. For example, when recruitment deviations start in 1970 rather than 1916, there are comparable results in both the likelihoods and biomass trajectories, but very different results with respect to equilibrium recruitment. Differences in the likelihood components from the alternative recruitment scenarios may indicate the source of the odd recruitment pattern produced by the base model.

Response: The STAT provided plots by year and data source of individual log-likelihood ratios based on the two different models. It appears that the primary difference between the two models is in how they make the tradeoff between fitting the composition data from the mid-1980s versus fitting the composition data from the end of the time series (see figure below).

Difference in negative log-likelihood for fits to trawl + non-trawl fishery length composition data between the base model and a model that starts recruitment deviations in 1970.
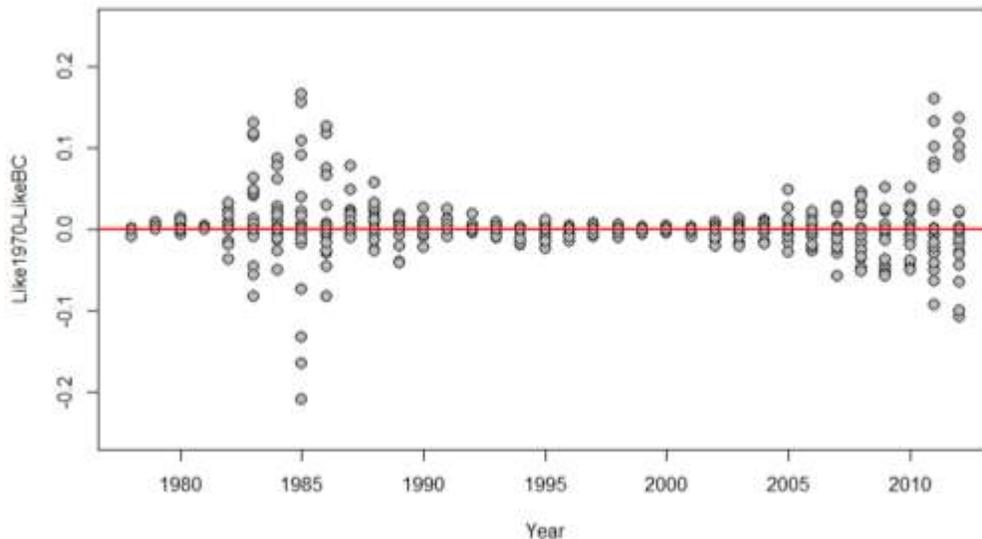
Description of the Base Model

Following the STAT's presentation of their response to Request 11 the STAT presented slides (below) that compared the spawning biomass and depletion trajectories of three candidate models that could be considered for use as the base model: (1) the model configuration that the STAT presented in their response to Request 9 (two sexes; two fleets, including combined discard data; full set of recruitment deviations; and M values - female M separate from male M - fixed at the means of the prior distribution); (2) the same configuration as in (1) but with the M values fixed at the medians of the prior distribution; and (3) the same configuration as in (2) but with the data reweighted using the Francis method. After discussion the STAT and STAR agreed that model (3) should be used as the final base model for the assessment and that the natural mortality rates (female M, male M) should form the major axis of uncertainty for constructing the decision table.

Candidate models (1-3, see text) considered for use as the new base model.
Model (1) = BC_Thurs; (2) = BC_Thurs_MMed; (3) = BC_Thurs_MMedfw.
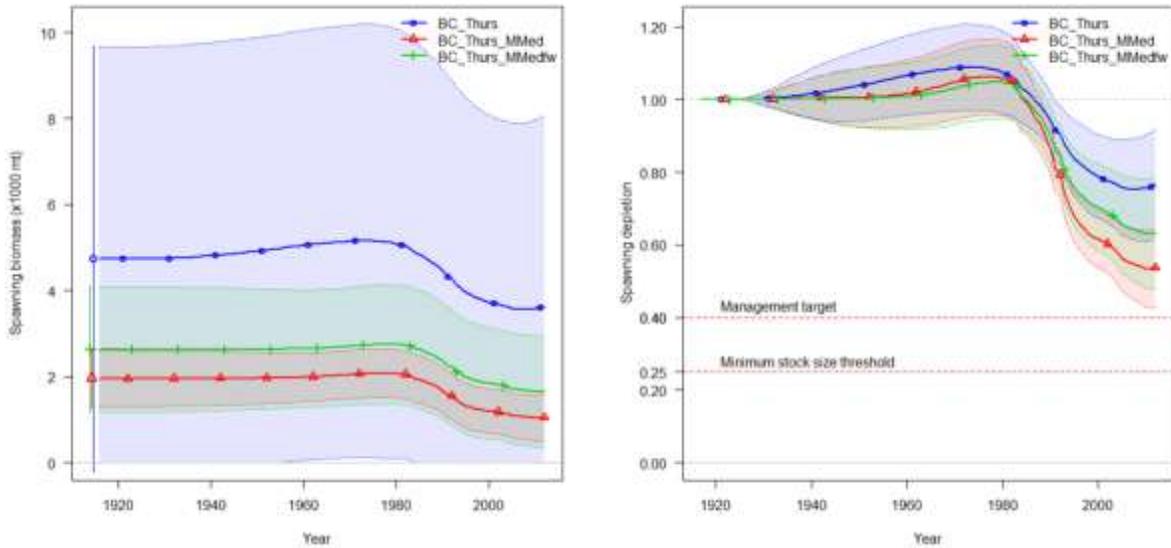
The base model has the following structural characteristics.

- The stock is contained in one area, has no seasonality, and is modeled as having two sexes.

- The stock is at unfished equilibrium in 1915 and recruitment deviations start in 1916.

- The rate of natural mortality (M) is fixed at 0.035 y^{-1} for females and 0.0371 y^{-1} for males, based on the median values of the prior probability distributions.

- The steepness parameter (h) for the stock-recruitment function is fixed at the mean value (0.779) of the most recent version of the steepness prior probability distribution for rockfish. The recruitment variability parameter (*sigma-R*) is assumed to be 0.5.

- All parameters for the von Bertalanffy growth model are estimated freely. The parameters controlling variability in length-at-age for the males are assumed to be the same as those estimated for the females.

- There are two fishing fleets operating coastwide. One is conducted primarily with bottom trawl gear and is modeled as having discards. It includes some landings from a mixture of minor fisheries conducted primarily with hook-and-line gear (commercial and recreational). The other is a combination of two fisheries that are assumed to have produced no discards: the foreign fishery for Pacific ocean perch, the at-sea fishery for Pacific hake, and some research catches.

- Selectivity for both fleets is length-based, has a simple asymptotic form, and is assumed to be time-invariant. There is a single selectivity curve for both fleets, but the trawl + non-trawl fleet has a length-based logistic retention function for which the asymptote is estimated for 11 time-blocks (one block for 1916-1998, another for 1999-2001, annual blocks for 2002-2010, and a final block for 2011-2012).

- There are four fishery-independent trawl surveys: (1) the Triennial shelf survey; (2) the Alaska Fishery Science Center (AFSC) slope survey; (3) the Northwest Fisheries Science

Center (NWFSC) slope survey; and (4) the NWFSC shelf-slope survey. The surveys differ slightly from each other in survey design, survey gear, seasonal timing and geographic coverage.

- Selectivity for the surveys is length-based and is allowed to be dome-shaped (using the double-normal function), and the selection curves are independent of one another except for the NWFSC slope survey and the NWFSC shelf-slope survey, which are assumed to have the same selectivity. No length composition data are available from the NWFSC slope survey.

- The Francis method is used for reweighting the composition data from the different sources.

The base model is informed by the following data sources.

- Annual landings data from the two fishing fleets (trawl + non-trawl versus no-discard) for the period 1916-2012.

- Annual length composition data from the trawl fleet starting in the late 1970s. The length composition data from the non-trawl fleet had been included in the base model of the draft assessment, but were excluded from final base model. They were from limited very sampling and were quite variable.

- Annual conditional age-at-length composition data from the trawl fleet for three years (2003, 2008, and 2009).

- Annual discard biomass rates for the trawl fleet for 1985-1987 and 2002-2011.

- Annual mean weights of discarded fish for the trawl fleet for 2002-2011.

- Annual length compositions of discarded fish from the trawl fleet for 2002-2011.

- Annual biomass indices from the Triennial survey (1995, 1998, 2001, and 2004), the AFSC slope survey (1997, 1999, 2000, and 2001), the NWFSC slope survey (1999, 2000, 2001, and 2002), and the NWFSC shelf-slope survey (2003-2012).

- Annual length composition data from all surveys except the NWFSC slope survey.

- Annual conditional age-at-length composition data from the NWFSC shelf-slope survey (2003, 2005, 2007, and 2009-2012).

Alternative Models for Bracketing Uncertainty

The STAT, in the draft assessment document and in their opening presentation to the STAR, indicated that the results for this assessment were extremely sensitive to the assumed natural mortality coefficient (M). This sensitivity is clearly indicated in the last figure shown above. Changing female M from the mean value of the prior (0.0405 y^{-1}) to the median value (0.0350 y^{-1}) resulted in large changes in both spawning biomass and depletion. There was general agreement that M was the major axis of uncertainty. However, the best approach for quantifying the uncertainty associated with different values of M was not clear. The topic generated much discussion among all the STAR and STAT members. The STAT proposed the following method for selecting M values to characterize the low and high states of nature. The STAR endorsed this approach.

- Use the base model to produce a likelihood profile for M and approximate this profile by a lognormal distribution for M.

- Combine this lognormal distribution with the prior distribution for M based on Hoenig's method, which is also a lognormal distribution.

- Determine the 12.5 and 87.5 percentiles of spawning biomass in 2013 (SB_{2013}) based on this distribution.

- Determine the sets of fixed M values that produce these low (female $M = 0.033$ y^{-1}) and high (female $M = 0.037$ y^{-1}) estimates of SB_{2013}.

One problem with this approach is that it only incorporates the uncertainty associated with the data measurement errors in the base model; the approach does not consider any of the uncertainties associated with the assumed model structure (e.g., the assumptions that steepness $h = 0.779$ and that the data weightings are correct).

Comments on Technical Merits and/or Deficiencies

Technical Merits

This is the first assessment for this stock and as such it provides a significant improvement on the previous data-poor view of the stock's potential productivity and current status. The preliminary concerns, based on the Council's productivity and susceptibility analysis, that the stock might be in poor condition proved to be unfounded.

The STAT produced a good quality assessment document, presented it clearly to the STAR, and was very responsive at addressing the questions and points raised by the STAR.

Technical Deficiencies

Because there were limited age-composition data available and because the stock had not previously been assessed, our state of knowledge regarding this stock is not fully mature. While the natural mortality rate remains the major source of uncertainty regarding this stock, there are several other potential sources of uncertainty that have not yet been fully explored or accounted for (e.g., the catch history and the assumption that fishery selectivity is time-invariant). The current assessment almost certainly underestimates the uncertainty of the stock's status and its ability to support harvest.

Areas of Disagreement

Between the STAR Panel and STAT

There were no areas of disagreement between the STAT and the STAR Panel regarding the technical aspects or results of the assessment.

Among STAR Panel Members

There were no disagreements among the members of the STAR Panel regarding the technical aspects or results of the assessment.

Concerns Raised by the GMT.

The GMT did not raise any concerns regarding the technical aspects of the assessment.

Concerns Raised by the GAP.

The GAP did not raise any concerns regarding the technical aspects of the assessment.

Unresolved Problems and Major Uncertainties

Numerous results presented by the STAT in the draft assessment document and during the review illustrated that the assessment results for aurora rockfish are very sensitive to the values chosen for the female and male natural mortality coefficients. Natural mortality is always a very problematic parameter for stock assessments, but with very long-lived species such as aurora rockfish, the presence of very old individuals in composition data can provide strong information regarding the implausibility of large values for M. Future assessments of this stock would greatly benefit from an increase in the number of conditional age-at-length observations and a validation of the ageing method.

Both draft assessments reviewed by the STAR Panel had used the SS3 estimates of effective sample size to iteratively reweight the different data sources. Although this reweighting approach has become a standard feature of most US West Coast assessments, Francis (2011, and in person at the review) provided compelling evidence that this standard approach resulted in implausible residual patterns for the aurora rockfish assessment and for the rougheye rockfish assessment. The Francis approach to reweighting, in contrast, for the most part eliminated these "bad" residual patterns. The Panel endorsed the use of the Francis approach for both assessments. However, it remains to be determined whether the Francis approach is the "best" general approach for deriving reweighting factors. The STAR Panel recommends that a scientific workshop be sponsored to review the state of the art for reweighting stock assessment data, with the aim of preparing a guide to good practices for future assessments.

The assessment model produced a rather implausible pattern of historical recruitments in which an extended period of positive deviations (roughly for the years 1940-1965) was followed by an extended period of negative deviations (roughly 1966-1987). Possible causes for this unusual pattern are likely related to one or more structural limitations in the model, which created systematic departures from an equilibrium age composition. However, despite attempts by the STAR and STAT to uncover the mechanism(s) that might be responsible (e.g., Requests 7 and 11), the exact cause(s) remain unknown. These structural limitations in the assessment model remain a source of uncertainty that should be explored more fully the next time this stock is assessed.

Another issue that generated considerable discussion amongst the STAR and STAT was how to adequately quantify and balance uncertainty when constructing the decision table. An initial attempt by the STAT conducting the rougheye rockfish assessment used the lognormal prior distribution for M, but this resulted in low and high states of nature that seemed implausibly asymmetric with respect to spawning biomass and projected catches. Future stock assessments and STAR Panels would likely benefit if they were provided with more detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

Issues Raised by the GMT or GAP Representatives

The GMT and GAP did not raise any data or management issues regarding this assessment.

Prioritized Recommendations for Future Research and Data Collection

General (affecting more than one assessment)

1. A workshop should be held to evaluate (a) methods for the iterative reweighting of composition data (e.g., current approach based on SS3 calculation of effective N versus Francis approach) and (b) methods for developing initial weightings (the initial input N values).

2. A workshop should be held to evaluate methods for constructing survey GLMM estimates. Topics that should be explored include: (a) the effect of treating vessels as random when in fact the vessels hardly vary from one year to the next; (b) possible aliasing of the index values with the *Vessel* x *Year* interactions; and (c) using information from the GLMM for combining length composition data collected by different vessels. One goal for the workshop should be to provide adequate documentation of the GLMM methods that will be used to produce survey biomass indices for future assessments and guidelines on how the analyses, including diagnostics, should be presented in stock assessment reports.

3. Port sampling programs should continue their routine collection of otoliths of slope rockfish species. A catalog of historical collections that have not been aged should be developed.

4. The series of historical catches of individual rockfish species, which are important sources of uncertainty in stock assessments of rockfish, should be explored in more detail. The STAR Panel agrees with the statement in the draft assessment document for rougheye rockfish that "*A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for*".

   Furthermore, catch reconstructions should not just develop best estimates of rockfish catch by species, but should also characterize the uncertainty of historical catch estimates by identifying periods of greater and lesser uncertainty. For example, rockfish species compositions taken during early years when there were limited slope fisheries should be very different from species compositions taken during later years when fisheries on the slope were more prevalent.

5. The SSC should develop detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

6. Investigate better fishery-independent data collection methods for slope rockfish and other species living in untrawlable habitats (e.g., surveys using submersibles or remotely operated vehicles).

7. To lessen the potential for confusion in assessment documents and presentations, STATS in the future should be encouraged to develop and use consistent nomenclature for

identifying standard data sets. For example, during the Review the "AFSC triennial shelf survey" was also described as the "triennial survey" and as "AKSHLF".

Specific to aurora rockfish

1. The STAR Panel agrees with the STAT regarding the importance of (a) producing additional age-reading data for use in the next assessment of aurora rockfish and (b) validating the ageing method and age readings.

2. *The STAR Panel agrees with the STAT regarding the importance of collecting additional information on reproductive biology (maturity, fecundity, and mass atresia) in aurora rockfish. This will allow analyses that better establish the relationship between effective fecundity and length, and between effective fecundity and weight.*

3. The STAR Panel agrees with the STAT regarding the need for further development of the meta-analysis for steepness, including "*consideration of fixed and estimated parameters, assumptions, and the quality of the information on maturity and fecundity in the component assessments, as well as correlations in recruitments among assessments due to environmental drivers*".

4. *The STAR Panel agrees with the STAT regarding the need for information on the stock structure of aurora rockfish with the aim of evaluating the assumption that the US West Coast stock is isolated from aurora rockfish off Canada and Mexico.*

5. The STAR Panel agrees with the STAT that there should be exploration of developing an index of larval abundance of aurora rockfish from the CalCOFI surveys.

Suitability for an Update Assessment

Given that this stock had not been previously assessed, and given the sensitivity of the assessment results to small structural changes and additional data, the Panel recommends that the next assessment of this stock be a conducted as a full assessment.

References

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