Yelloweye Rockfish

Stock Assessment Review (STAR) Panel Report

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Overview

The STAR panel reviewed a new benchmark stock assessment of yelloweye rockfish over the course of a five-day meeting in Seattle, WA. While the stock is distributed from the western Gulf of Alaska to Baja, California, the assessment region covers the U.S. west coast ranging from the U.S.-Mexico border to the U.S.-Canada border. No linkages with yelloweye rockfish in Canadian waters are considered in this assessment. In 2011, the stock was modelled as a single stock with three explicit spatial areas (California, Oregon, and Washington). For this new benchmark, the species is again modeled as a single stock, but with two explicit spatial areas: waters off California and waters off Oregon and Washington. This revision is in response to the recognition that accurate assignment of catches and associated length and age data to the state level between Oregon and Washington is not possible, as there are considerable landings to either state by vessels from the other. Each area has its own unique catch history and fishing fleets (commercial and recreational), but the areas are linked by a common stock-recruit relationship.

The previous benchmark in 2009, updated in 2011, estimated steepness and natural mortality, but not recruitment. This new benchmark estimates recruitment but using fixed steepness and natural mortality. Despite these changes, the 2011 model and the current model show close correspondence. The model result is highly sensitive to the assumed value for natural mortality.

Changes during the STAR to the pre-STAR model are limited to a number of small "house-keeping" items. The pre-STAR model was well presented by the STAT which had undertaken extensive pre-STAR analyses to investigate data influences and model specification sensitivities. This provided a sound starting place and an excellent foundation for clear explorations and decisions during the review.

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

Summary of Data and Assessment Models

The assessment uses the Stock Synthesis modeling framework (version 3.30.04.02, released June 2, 2017).

Yelloweye rockfish has a sedentary life history, exhibit no clear ontogenetic migration by depth, and exploitation rates among areas have been different over time. These factors could in combination have contributed to different trends in abundance among areas and localized depletion. While modeled as a single stock, the assessment therefore keeps track of the separate areas (California and Oregon-Washington). Oregon vessels, particularly those from northern ports, frequently fish in waters off Washington but return to Oregon to land their catch. The same is true to some degree for Washington vessels as well. This issue has become more apparent in recent years, as larger, inter-agency catch reconstruction efforts have been developed. It is infeasible at present to consistently assign removals and biological data landed in Oregon and Washington to area of catch (i.e. Oregon or Washington) with acceptable precision.

The assessment period begins in 1889, when the very first catch records are available for the stock, with the assumption that previously the stock was in an unfished equilibrium condition. Data types used in the model include catch, and length and age frequency data from seven commercial and recreational fishing fleets. Fishery-dependent biological data used in the assessment are from both port-based and on-board observer sampling programs. Recreational observer data from Oregon and California were used to construct indices of relative abundance. Yelloweye rockfish catch in the International Pacific Halibut Commission's (IPHC) long-line survey is also included *via* an index of relative abundance for Washington and Oregon; IPHC length and age frequency data are also used. Relative biomass indices and information from biological sampling from trawl surveys were also included; these trawl surveys were conducted by the Northwest Fisheries Science Center (NWFSC) and the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS). The STAR Panel and STAT discussed removal of indices for the final reference model but agreed to leave all in the final model; none have any significant influence on model results.

The model is primarily informed by length and age composition data (with a plus group at age 65) from a number of commercial and recreational fleets, as well as from the AFSC Triennial survey, the NWFSC Trawl survey, and the IPHC longline survey. Growth is assumed to follow the von Bertalanffy growth model, and the assessment explicitly estimates all parameters describing somatic growth. Estimates of growth parameters did not differ between sexes and the model therefore combines males and females. Selectivity by fleet was explored with allowance for domed forms. For all fleets, however, asymptotic selectivity was fit. Recruitment deviations are estimated (which was not the case in the 2011 model), with sigma R iterated to be close to 0.50. The resulting recruitment estimates look plausible in that general patterns appear to be similar or comparable to those for other rockfish stocks.

Externally estimated life history parameters, including those defining the length-weight relationship, female fecundity and maturity schedule were revised for this assessment to incorporate all new information. Recruitment dynamics are assumed to follow the Beverton-Holt stock-recruit function, and recruitment deviations are estimated. Natural mortality (0.044) and stock-recruitment steepness (0.718) are fixed at the values generated from meta-analytical studies, although the base model results are highly sensitive to both of these parameters, particularly natural mortality (M). When estimated with the prior, the model estimates a slightly higher natural mortality rate. Likelihood profiles indicate that age data are better fit with a lower M, length and index data tend to be better fit with a higher M. There was a similar pattern in the likelihoods with steepness, h, such that age data were better fit with a lower h, length and index data with a higher h.

Requests by the STAR Panel and Responses by the STAT

Three sets of requests were made by the STAR Panel following presentation and consideration of the pre-STAR draft. The STAT responded fully to all items.

Round 1 of Requests (Tuesday, July 11th)

Request one: *(1) One round of changes:*

- o *Include a ramp-up on CA non-trawl catches from 1889 to 1916.*
- o *Add newest maturity ogive.*
- o *Include mid 1940s-1960s catches off OR landed in CA.*
- o *Interpolate missing WA recreational catches.*
- o *Reconsider the inclusion of those recreational CPUE indices with poor diagnostics.*
- o *Compare r4ss outputs of original base case and the new base case.*

Rationale: *These were noted gaps in this assessment. These changes are expected to be part of the new base case model.*

Response: The STAT made the suggested changes and provided plots of the results. The panel noted the changes requested are small and for house-keeping purposes. Plots showing the revised base case and pre-STAR base case spawning output and depletion (plus MLE estimates of uncertainty) clearly show the small changes do not impact the model fit or results. The STAT chose to include all of the indices, including those with somewhat concerning diagnostics, as they had little influence in this model but could potentially be informative or improved upon in future updates. The model with house-keeping changes ess adopted as the new base case .

Request two: *Provide an M estimate using the 99th percentile of ages.*

Rationale: *This M estimation approach may be helpful in designing a decision table.*

Response: The 99th percentile of all age estimates used in the assessment was age 97, which was associated with a natural mortality rate of 0.056 with the Hamel prior (Hamel 2015). It was noted that when the model estimates M with the prior, the estimate is 0.058. All selectivities become asymptotic. Given the large number of age estimates well beyond the 99th percentile, it was agreed that the STAT's approach for determining the maximum age was appropriate. More relevant discussion followed on the result from request three.

Request three: Provide age distributions from all data sources in density plots by ageing institution and combined.

Rationale: *This may lend focus on true maximum age given ageing error.*

Response: The STAT provided the graph shown below (Figure 1), as well as the result of a catch curve using the best available set of age data (from the IHPC survey) for a variety of ending ages to evaluate the inferred total mortality estimates (Figure 2).
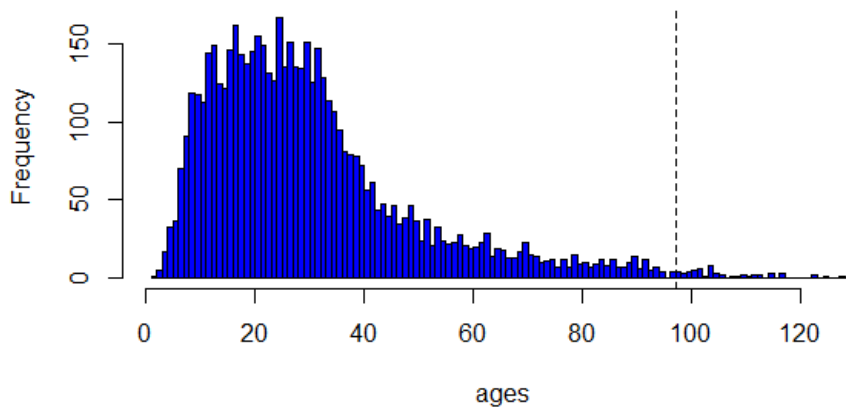
Figure 1: Frequency distribution of all ages used in the base Yelloweye rockfish stock assessment. Dotted line represents the 99th percentile of ages.
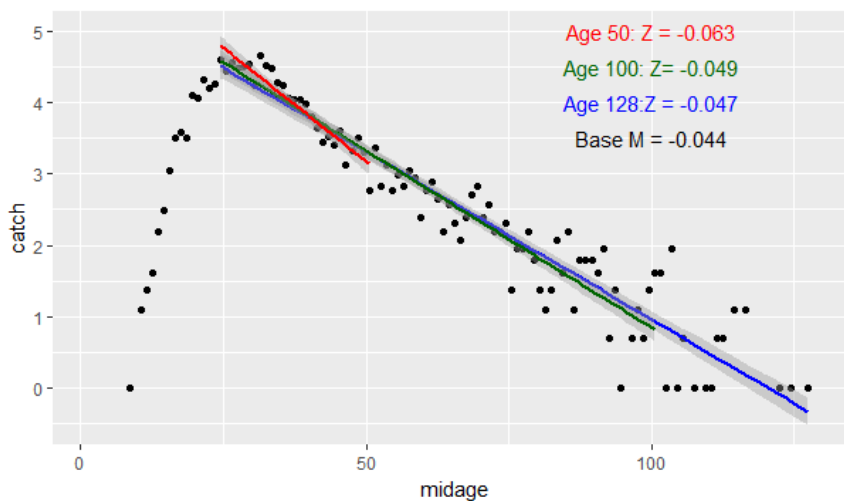

Figure 2: Catch curve analysis of the IPHC survey data for Yelloweye Rockfish. Note that the estimate of F at $SPR_{50\%}$ in the base model is 0.022.

The base case model uses M of 0.044, based on an observed, third oldest aged fish of 123 years known to be from the California-Oregon-Washington region. The oldest from the region is 128 and oldest yelloweye from the literature is 147 (Love 2011), thought possibly to be from Alaska. The distribution of ages has a 99th percentile of 97 years. The catch curve analysis was indicative of the potential for M to be lower than assumed in the base model, but was not considered conclusive, particularly in light of discussions related to the potential for aging bias among different aging labs. Discussion focused on the most appropriate fixed value for M (and possible sensitivity tests on). When taking into account of all information provided by the STAT, the Panel agreed that the base model use of a fixed M of 0.044 was appropriate. These results and

consideration of M derived from the Hamel meta-analytically derived prior are also considered at Request (7).

Request four: *Sensitivity on recruitment distribution between the two areas. Fix the recruitment distribution parameter at 20S:80N. If the model is sensitive to this change, explore other scenarios. Provide an explanation of how this parameter affects model results and the basis for the choice of the original distribution.*

Rationale: *To understand how this parameter may affect model results.*

Response: The model estimate of the distributional fraction (60% OR-WA; 40% CA) is highly specified. The likelihood profile pattern is strong, with the length data providing the greatest influence (Figure 3), with good overall support coming from several length components (Figure 4). Estimates of the corresponding stock biomass and stock status are provided in Figures 5-6.

The panel had concerns regarding how the redistribution of recruitment relates to underlying stock distribution and the degree to which the model and results are sensitive to its specification. The likelihood profiles provided clearly demonstrate that the length composition data, especially from Oregon and California recreational fisheries, strongly suggest an average recruitment redistribution as used in the base case model. Changes in the redistribution ratio in either direction lead to much higher spawner output and relative spawning biomass results. While recognizing further work could be done to investigate how recruitment redistribution is modeled might be warranted the panel agreed with the STAT that the base case model should continue to use the 60:40 (WA:OR and CA) redistribution ratio.

In a supplementary analysis, the STAT provided an estimate of the time series of spawning output by area relative to the fixed ratio of recruitment distribution (Figure 7). This led to some discussion regarding the dispersal and distribution processes that could be necessary to justify the way the model treats this distribution and the resulting distribution of recruits (which are unlinked to the area spawning output), as the inference is that the population could be heavily depleted in one area and be sustained by high recruitment in another (less exploited) area. In sensitivity analyses, the STAT did explore a model structure with a single area, for which results did not diverge substantially from the two-area base model.
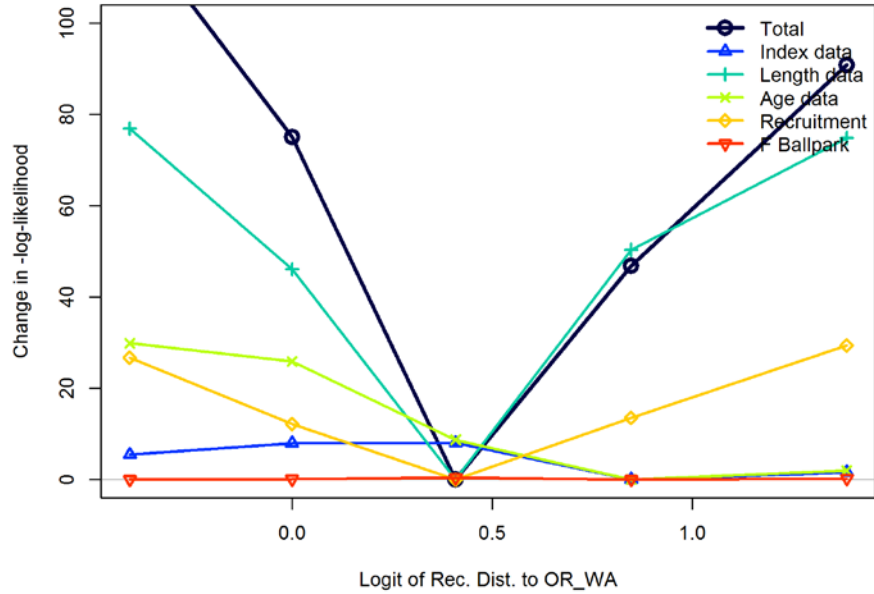
Figure 3. Likelihood profile for each data component and in total given different values of area specific recruit distribution parameter. The values are given in the logit transformation, but can be translated as, from left to right, as 80% ORWA: 20% CA; 70% ORWA: 30% CA; 60% ORWA: 40% CA; 50% ORWA: 50% CA; 40% ORWA: 60% CA.
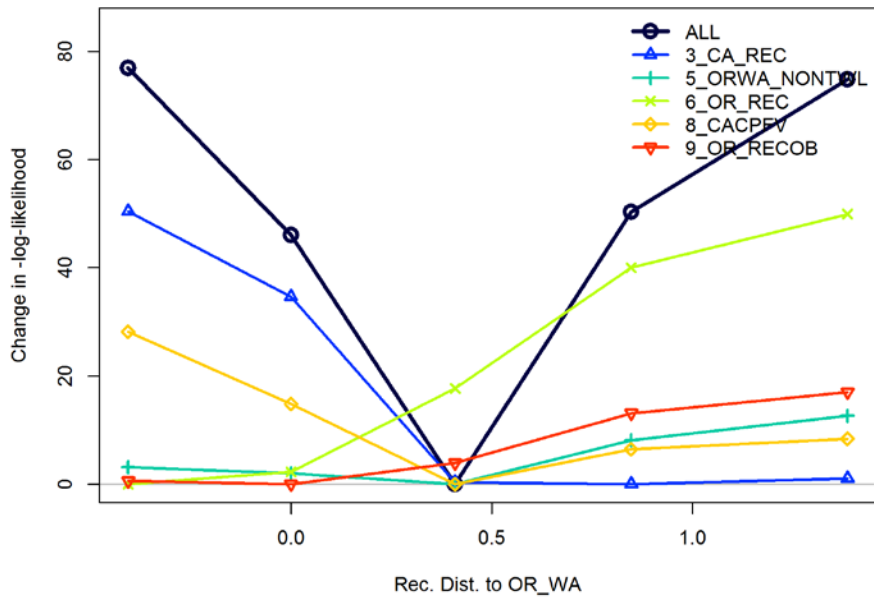

Figure 4. Likelihood profile for each data source of the length likelihood component given different values of area specific recruit distribution parameter. The values are given in the logit transformation, but can be translated as, from left to right, as 80% ORWA: 20% CA; 70% ORWA: 30% CA; 60% ORWA: 40% CA; 50% ORWA: 50% CA; 40% ORWA: 60% CA.
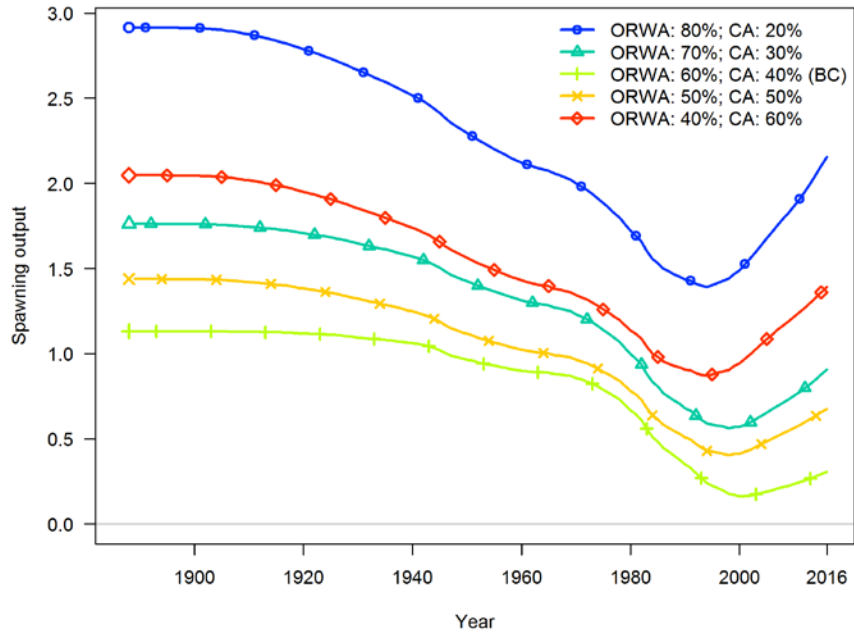
Figure 5: Model likelihood profile of the length composition components to the recruitment distribution parameter. BC refers to the base case reference model.
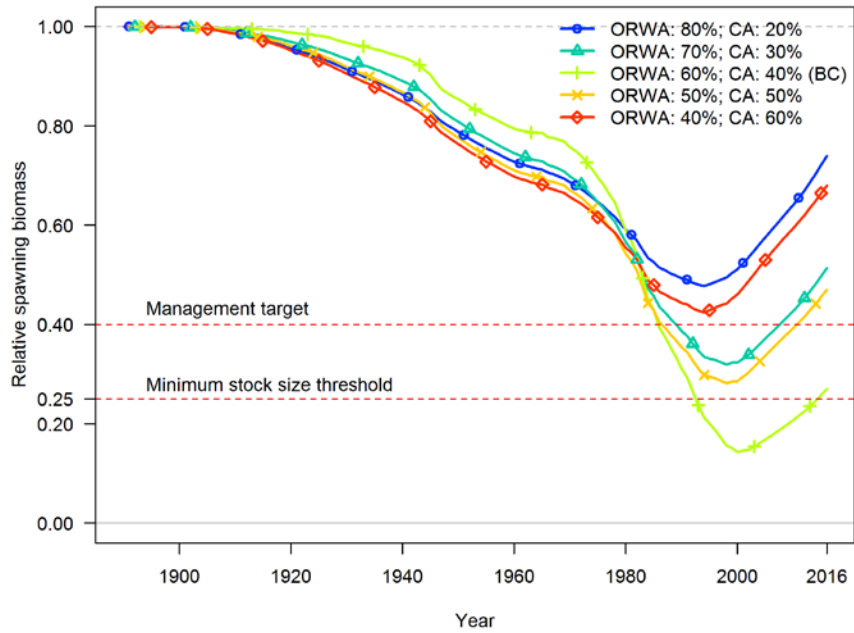

Figure 6: Model estimated depletion with alternative values of the recruitment distribution parameter.
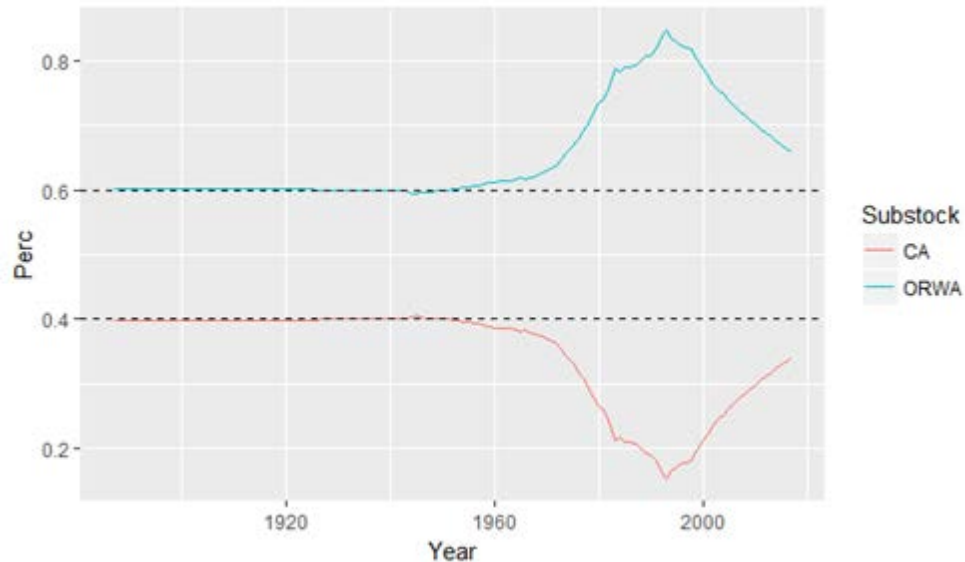
Figure 7: Spawning output ratio time series relative to the fixed ratio of recruitment distribution to each area, such that the solid lines indicate the spawning output (SO) ratio (SOarea/SOtotal), and broken lines are the fixed proportion of distributed recruits (40% CA, 60% ORWA).

Request 5: *Provide a model run with only the Washington Recreational Dockside CPUE index; keep all the other compositional data in the model. The specification in the request was for a single run with very different distribution.*

Rationale*: This index had a different trend than the others. We want to understand the sensitivity to this index.*

Results: The pre-STAR sensitivity/influence tests showed little influence for any individual index. However, because the WA recreational dockside index shows a slight upward trend and no other index does, the panel asked for a model run with only that index included. The results shown above are consistent with the pre-STAR influence/sensitivity exploration suggesting minimal influence of the index data (Figure 8). The panel and STAT agreed to continue with the base case model including all indices.
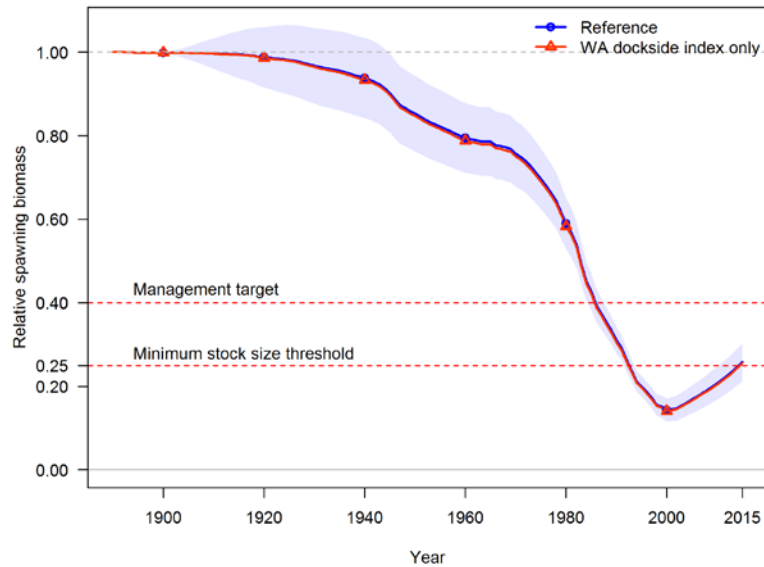
Figure 8: Base model contrasted with model that included only the Washington dockside fishery index.

2nd Set of Requests to the Yelloweye STAT

Request 6: *Jitter the new base model.*

Rationale: *Final check for a global minimum.*

Response: Jitter runs either recovered the base model or found solutions outside of -2 log likelihood units. These results support that the current reference model is at the global minimum.

Request 7: *Decision table explorations:*
o   *Provide projections assuming a range of M values from 0.037 to 0.056 as a possible axis of uncertainty for a decision table.*
o   *Provide projections assuming a range of h values from 0.509 to 0.894 as a possible axis of uncertainty for a decision table.*

Rationale: *To explore possible axes of uncertainty.*

Response: The panel discussed axes for states of nature and appropriate trial parameterization for natural mortality (M) and steepness (*h*). The M values are chosen based on the oldest ever estimated age of 147 (possibly for a fish from Alaska) and the 99th percentile of all aged samples. It was decided not to use 12.5 and 87.5 percentiles from the Hamel meta-analytically derived prior (being 0.031 and 0.063) as these are very wide, with the lower value corresponding to a maximum age of 175 years. This is generally regarded as unreasonable. The *h* values chosen, however, are the 12.5 and 87.5 percentiles of the prior on steepness. The values for investigation were chosen after extensive discussion with all present for the review. Discussion included consideration of model precision and model specification uncertainty. The M and *h* values

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chosen to span states of nature are considered to account for model specification error and are larger than uncertainty just associated with the base case run.

The STAT provided graphical results and full model results for all models covering the 5 states of nature (see Figure 9). The low M and low h model runs are very similar while the high h model shows results within the base case model uncertainty. The panel and STAT agreed that the low and high M models provided sufficient coverage of states of nature to be used in Decision Tables. These became the basis for Request (8).
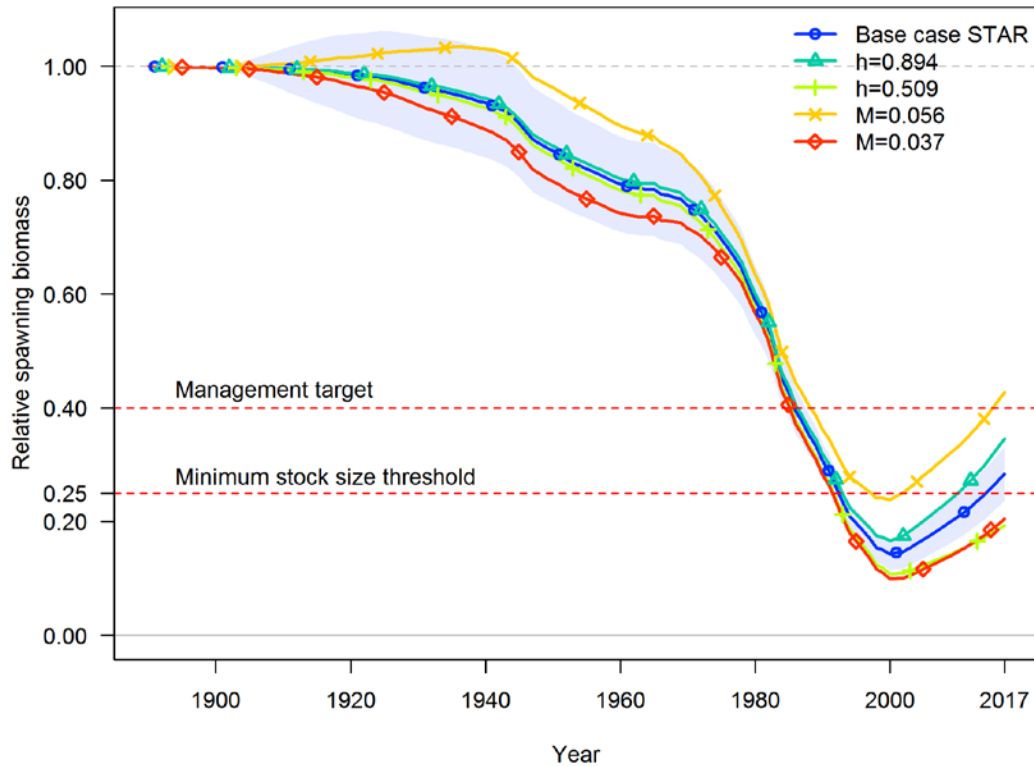

Figure 9: Sensitivity runs to support Decision Table exploration

3rd Set of Requests to the Yelloweye STAT

Request 8: Based on the previous explorations, M provides a reasonable contrast for the major axis of uncertainty. The range of values of M are: low state: 0.037, base: 0.044, high state: 0.056. Provide a draft Decision table with the following catch streams under those states of nature:

- *60% of the rebuilding ACL under an SPR of 76%.*
- *100% of the rebuilding ACL under an SPR of 76%.*

Rationale: Final check of the decision table.

Response: The STAT provided Decision Tables as requested using the catch streams specified by the GMT/GAP. After one iteration to correct an error in the catch streams, the Panel, STAT,

and GAP/GMT representatives accepted the Decision Tables provided.

Description of the Base Model and Alternative Models used to Bracket Uncertainty

The base/reference model uses all fishery-dependent and -independent indices and all composition data as in the pre-STAR model. Only small house-keeping changes have been made, as in request (1). The model is regarded as a good representation of the overall stock status and, although it is differently configured to the previous benchmark model and estimates recruitment instead of h and M (as previously), it shows good continuity with that previous model. However, it should be noted that the current base case model estimates higher productivity, largely as a consequence of the value used for steepness (h), and indications of recent strong recruitment. Resulting yield estimates are therefore larger than previously estimated.

Uncertainty as represented by the approximate 95% asymptotic confidence limits within the base case model is not large given the use of fixed parameters and model specification error is regarded as the main source of uncertainty. While the base case is the best available information to guide decision-making, uncertainty associated with it is not perceived to be symmetrical, as there appears to be a higher likelihood of the stock having a higher, rather than a lower, natural mortality rate. This is driven by the length and index data in the base model, as the age data tend to fit better with a lower M based on likelihood profiles. Uncertainty related to less productivity can be captured equally through M and h specification while uncertainty associated with potential higher productivity is best captured by variation in M. The base model has a fixed h of 0.718 and M of 0.044. The models used to represent alternative states of nature use M values of 0.037 and 0.057.

Technical Merits of the Assessment

The assessment used the latest version of SS3 and made good use of the available data. The rationale for the single stock-two area model was well articulated as were reasons for moving from a model that estimates h and M to one fixing them while estimating recruitment. The STAT provided a very thorough analysis of data influence and specification sensitivity which provided an excellent basis for discussion and agreement on a base case model and axes of uncertainty including natural mortality, steepness and the shape of the selectivities employed (Figure 10). Full diagnostics were made available. The STAT was very responsive to requests from the panel.
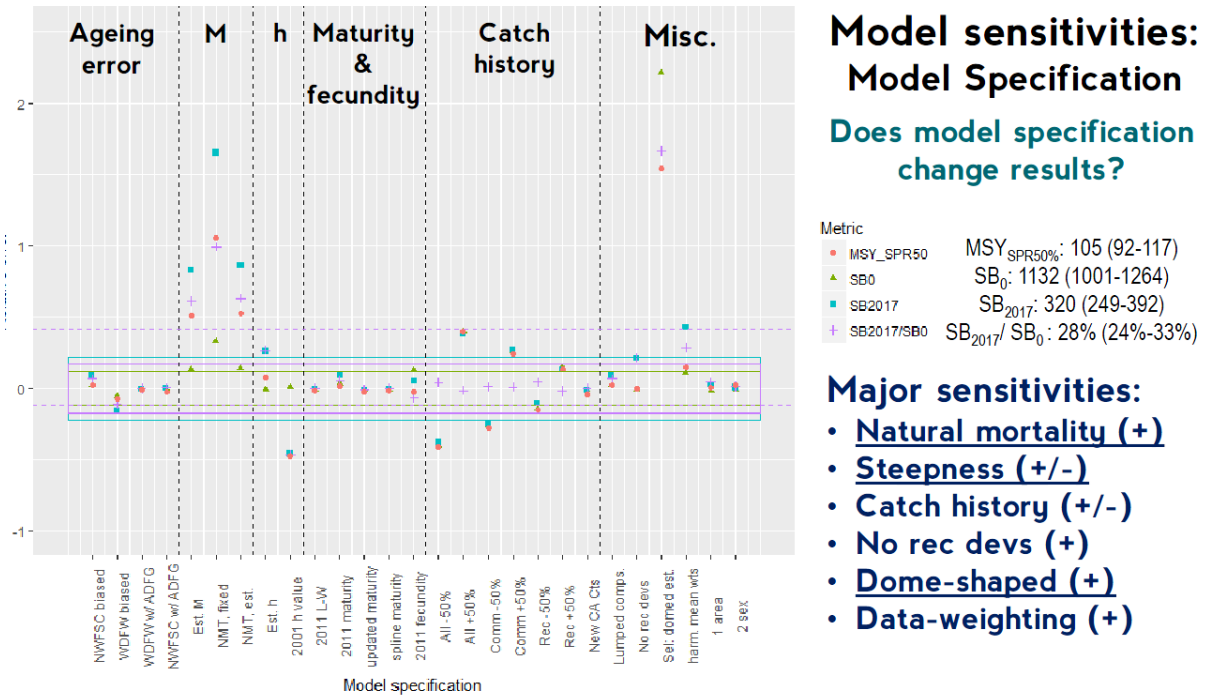
Figure 10: Example of sensitivity analysis provided by the STAT to help guide STAR Panel discussions.

Technical Deficiencies of the Assessment

There were no technical deficiencies identified. The approach used was standard except for the two area formulation with recruitment redistribution set constant through time; exploration of the model suggested this was a reasonable approach. Index data are not informative and the model relies heavily on length and age composition data – there are no clear patterns in the residuals for age and length and no indication of a need for further model development (e.g., selectivity blocking).

Areas of Disagreement Regarding STAR Panel Recommendations

Among STAR Panel members (including GAP, GMT, and PFMC representatives): There were no areas of disagreement.

Between the STAR Panel and the STAT: There were no areas of disagreement.

Management, Data, or Fishery Issues raised by the GMT or GAP Representatives during the STAR Panel Meeting

Representatives provided insights and comments on data sources and how management changes might affect, for example, fishery-dependent indices. No major issues were identified.

Unresolved Problems and Major Uncertainties

Key problems and uncertainties for the model include a lack of clearly representative indices of abundance, sparse length and age data, and continued uncertainty over the natural mortality rate and steepness. Nevertheless, the model is regarded as sufficiently robust to provide management advice. The major uncertainty within the existing model is associated with natural mortality, with an indication the model would fit well to higher M. Ageing studies suggest some still-unresolved differences between otolith reading by institutions (see below in research recommendations) which may have implications for the specification of M in future models.

Recommendations for Future Research and Data Collection

Although data are available from a number of sources to inform this model, both index and compositional data to inform this stock remain relatively sparse. Efforts to increase sampling for length and age data would be very beneficial for future assessment efforts.

In evaluating the results of age determination cross-reads between WDFW and NWFSC age estimates, it has become apparent that there may be some bias in age estimation methods by one or another of these laboratories. Specifically, there is some indication that while there was strong agreement on fish up to age 32, age estimates produced by WDFW efforts for older individuals are significantly older than estimates on the same fish produced by both the NWFSC and the Alaska Department of Fish and Game (ADFG). Given the high sensitivity of the model results to the presumed values of natural mortality, which are greatly informed by age distributions, further investigation into the likely causes of these discrepancies would be a very high research priority. Additional research efforts to confirm age estimation results using age validation methods (such as bomb radiocarbon or lead 210 validation) would also be beneficial in resolving such differences.

The IPHC longline survey index is based on a delta-GLMM in which station effects represent the spatial information to inform the model. As most stations do not regularly encounter yelloweye, this approach results in exclusion of nearly half of the positive observations available from this survey to inform the index. Analysis to investigate whether a geostatistical approach, using the VAST package and/or other geostatistical methods, instead of fixed station effects, may improve the information content of this index for future assessments.

A long standing research recommendation for this (and other) stocks has been the development of appropriate surveys (such as some form of hook and line, and/or visual survey) that could lead to indices that might better inform assessments. Selectivity of the surveys was a large source of uncertainty identified in the sensitivity analysis (Figure 9). When selectivity was estimated the model the result was dome shaped for not only the recreational fisheries, but for others as well resulting in depletion of 72.8% and implausible values of spawning biomass in 2017 (2412 mt vs. 323 mt for the base case). While the degree of dome shape resulting from free estimation may not be plausible, estimation of a representative selectivity proved difficult without data to inform what size classes were present yet unobserved. Assuming selectivity is asymptotic results in more conservative estimates of scale and depletion. As the current base model estimated asymptotic selectivity for all fishery independent and fishery-dependent data sources, despite

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some indication that older, larger fish may be more associated with rockier habitat, greater evaluation of data from recent or ongoing visual surveys could be beneficial in helping to inform likely selectivity patterns in future assessments. A closely related observation is that this stock appears to be considerably less vulnerable to the NWFSC bottom trawl survey in California waters relative to those off of Oregon and Washington, a pattern noted for other stocks as well (e.g., yellowtail rockfish). Understanding these possible differences in catchability, as may be associated with habitat preferences or other factors, would be beneficial.

Many historical catch estimates remain highly uncertain and would benefit from greater refinement and improvement, including the potential to develop estimates of uncertainty over time and greater precision with respect to catch versus landing locations, if feasible (note that more explicit recommendations are highlighted in the catch reconstruction workshop report from 2016).

Future work is recommended on the recruitment redistribution process for area-specific models to either support or reject the assumptions behind the spatial recruitment distribution dynamics inherent in stock synthesis. The restriction to a single value across years may be constraining-options to address this could include time blocking or revising the model structure such that it would take the ratio of spawning stock on one or the other side to help inform how recruitment is distributed over time.

As the yelloweye rockfish population at the northern end of the range likely represents a transboundary stock and resource, work towards a combined US/Canadian stock assessment would greatly aid our overall understanding of stock status.

Common documentation of data streams and sources to support fishery independent and fishery dependent indices and compositional data could reduce the burden on assessment analysts to provide details about each data source, and allow reviewers a robust source of information on the most important, common data sources for any given stock assessment cycle.

Acknowledgements

References

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Love, M.S. 2011. Certainly more than you want to know about the fishes of the Pacific Coast: a postmodern experience. Really Big Press.