Yellowtail Rockfish

Stock Assessment Review (STAR) Panel Report

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Overview

The stock assessment team (STAT) endeavored to assess the status of the Yellowtail Rockfish (*Sebastes flavidus*) resource in U.S. waters off the coast of the California, Oregon, and Washington using data through 2016. The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks separated at Cape Mendocino, California (40°10' N. lat.) at Cape Mendocino. This is consistent with a recent genetic analysis that suggested stock structure north and south of Cape Mendocino. The northern region has long been assessed independently of the southern region, due to the greater relative commercial importance and availability of data. Yellowtail in the southern region is managed as part of the "Minor Shelf Rockfish" complex, and has not been previously assessed, despite being a relatively important component of commercial and recreational fisheries. The assessment analyzed each region/stock independently, with Cape Mendocino as the boundary between the two stocks, with the southern stock extending southward to the U.S./Mexico border and the northern stock extending northward to the U.S./Canada border.

Yellowtail rockfish north of Cape Mendocino (40°10' N. lat.) was most recently assessed as part of a 2013 data-moderate stock assessment (Cope et al. 2013) that did not include any length or age data. The northern stock was previously assessed in 2000 (Tagart et al. 2000) with that assessment updated in 2003 and 2005 (Lai et al. 2003, Wallace and Lai 2005). The stock south of 40°10' N. lat. has never been assessed beyond data-poor methods (DB-SRA), in part due to a lack of data in this area.

This assessment uses Stock Synthesis version 3.3. Both the northern and southern model begin in 1889, the first year of the available catch data. Catches from the Northern stock were divided into four categories: commercial catch, bycatch in the at-sea hake fishery, recreational catch in Oregon and California (north of 40°10' N. lat.), and recreational catch in Washington. Catches declined significantly in the late 1990s and early 2000s, and although they have been increasing over the past 10 years, they remain well below the peak catch due to management measures, included lower catch limits and area closures.

The STAT team was able to develop a base model for the northern assessment area. The model recommended for management did change substantively during the review. The final base model is heavily reliant on compositional data, although fishery independent survey indices are somewhat informative. The base model indicates that the stock is above target biomass levels, with recent harvest rates well below the limits estimated by the base model. Harvest rates in the northern model were estimated to have been greater than the current SPR-based rates in the 1980s and early 1990s, although the stock is not estimated to have ever declined below the minimum stock size threshold (MSST) of 25% of the unfished spawning output. Harvest rates since the late 1990s have been well below target levels. The decision table provided by the STAT in consultation with the STAR panel reflects natural mortality as the major axis of uncertainty and examines various levels of potential harvest from the average catch in the last five years, catch levels approximating catch in the 1990s prior to regulations limiting take in the recent period and harvest approximating the base model ACL.

Despite efforts by the STAT team to develop a model for the Southern assessment area, the uncertainty in the results were too great to provide results for use in management. The Southern stock is managed as part of a stock complex, under catch limits applied at the complex level. However, the fishing intensity is estimated to have remained well below allocable catches for that complex in recent years. While the various models evaluated over the review period gave no rise to concern regarding the status of the stock, the lack of robust abundance indices coupled with the very low availability of age and length data, particularly over the past 15 years, complicated the ability to develop a base model. Developing age estimates for those age structures that are available in recent years and additional data collection efforts would greatly increase the chances successfully completing a full age structured integrated assessment of the Southern stock in the future.

The STAR Panel considers that the new assessment for northern yellowtail rockfish constitutes the best available scientific information on the current status of the stock and that it provides a suitable basis for management decisions. A suitable base model could not be developed for the southern yellowtail rockfish stock. The STAT was of the opinion that the challenges associated with improving data availability and developing a suitable southern base model precluded consideration of a revised model at the "mop up" STAR panel for the 2017 assessment cycle.

Summary of Data and Assessment Models

Yellowtail rockfish was previously modeled in three age-structured assessments north of 40°10' N., and historically has not been assessed (other than using data-poor methods) to the south. An analysis by Hess et al. (2011) indicated two genetically distinct stocks separated at Cape Mendocino (approximately 40°10'N), and the assessment modeled these two regions separately. The Northern stock assessment area extends from Cape Mendocino, California to the U.S./Canada border and the Southern stock assessment area extends from Cape Mendocino, California to the U.S./Mexican border.

The STAT team used Stock Synthesis Version 3.30.03.05 (Methot 2015) for both models, and sensitivity tests conducted with more recent versions of SS produced identical results. Initial sample sizes of commercial and survey length composition and marginal age composition were weighted according to the method of Ian Stewart, while conditional-age-at-length (CAAL) samples were unweighted assuming each fish was an independent sample. Weighting among fleets used the Francis method (Francis 2011), fitting the model to the mean length or age relative to the expected variability for a given input sample size. One exception was the age data from the Southern model Hook and Line survey, which was tuned using the McAllister- Ianelli harmonic mean method (McAllister and Ianelli 1997), as only a single year of ages were available for that series and the Francis method could not be used. Both models also began in 1889, although in the northern model catches were negligible until the 1940s.

The northern model fleet structure included a commercial fishery (primarily trawl), an at-sea hake fishery, a California and Oregon recreational fishery, a Washington recreational fishery, as well as the Triennial trawl survey and the NWFSC combined trawl survey as fishery independent surveys. Both the fisheries and the surveys included significant amounts of length and age data; including over 130,000 age estimates from commercial fisheries alone over the past 40 years. Due to the greater computational time necessary to use age data as conditional age-at-length

(CAAL) data, age data were treated as marginal for the fisheries and triennial survey, and CAAL (to inform growth estimates) from the NWFSC survey.

In the Northern model 123 parameters were estimated including unfished recruitment, 85 recruitment deviations (1932-2016), two natural mortality parameters, eight growth parameters (von Bertalanffy growth equations and CV as a function of length), extra standard deviation parameters, 13 selectivity parameters and 13 retention parameters. Selectivity for all fleets was estimated with 4-parameter double normal models and where the estimated patterns were asymptotic, the parameters related to the dome were fixed, leaving only the position of the peak and the ascending slope estimated. Selectivity in both models is asymptotic with the exception of the OR-CA MRFSS recreational fleet in the Northern model, and the onboard recreational fleet in both models, although domed shaped selectivities were evaluated for all indices. Two fishery-dependent indices included in the draft model were dropped during the review, fisheries dependent indices from recreational fisheries (both dockside/intercept data and onboard observer data) remained in both models.

For the Southern model, the fleet structure included a commercial fleet (in which hook and line and trawl gear catches were pooled), a recreational fleet, and two fishery-independent surveys, the NWFSC hook and line survey in the Southern California Bight, and the SWFSC pelagic juvenile survey (recruitment index). The estimated parameters include unfished recruitment, 72 recruitment deviations (1945 to 2016), all eight growth parameters, an extra standard deviation parameter for one index and 15 selectivity parameters were estimated. Age and length composition data were available, but less so than available for the Northern model (just over 8,000 age observations, relative to nearly 150,000 for the Northern model), and were particularly sparse for both commercial and recreational fisheries in the post-2002 period.

For both models, informative priors for natural mortality were developed based on Hamel (2015), based on the 99th percentile of age observations. These ages were 35 for females and 45 for males in the north, 30 for females and 40 for females in the south, corresponding to natural mortality point estimates in the prior of 0.15 and 0.13 for females and males in the north, and 0.18 and 0.135 in the south. A point estimate of 0.15 for females with an offset for males resulting in an M= 0.13 in the northern model compared to 0.18 for females and 0.135 for males in the Southern model. It was not clear what might be the reason for the considerable difference in natural mortality between males and females. Model estimates of M with these priors were typically higher, and varied in response to changes made in the model both prior to and during the review. In both models, steepness was fixed at the prior of 0.718.

Requests by the STAR Panel and Responses by the STAT

Round 1 of Requests (Monday, July 10th)

Request No. 1 (northern model): *Compare the geospatial GLMMs for the NWFSC Combo survey conducted in VAST to the delta-GLMM version of the VAST with the geo-spatial switches turned off and to the designed-based estimates. Include a table with the number of hauls, positives, and number of fish and/or length observations in the north and the south.*

Rationale: *This is strongly encouraged in the SSC's Accepted Practices guide. The data were too sparse to model a survey index independently in the southern region.*

Response: The STAT provided a figure comparing the requested alternative indices (Figure 1). All of them provided similar general trends, including relatively high values in the most recent years in the time series, with the design-based estimate providing a considerably higher 2016 value. The model was not able to fit the recent increasing trend well. Diagnostics generally indicated that the algorithm was behaving as expected, generating appropriate results. As the geospatial approach is perceived to better account for regional hot spots of abundance, and there was some evidence of a north-south trend in the Pearson residuals for encounter probability in the non-spatial model, the Panel agreed that use of the VAST method with the spatial algorithm would be preferable.

The STAT presented tables of the average number of positive tows and the percent positive tows for the triennial trawl and NWFSC survey (included in assessment document). There was a reasonably high proportion of positive hauls north of 40°10' N (26.6% and 10.9% for triennial NWFSC, respectively, without accounting for depth strata), and far fewer in the south (5.6% and 1.5% for triennial and NWFSC, respectively). This is consistent with the STAT's conclusion that the trawl surveys are not able to provide an informative index of abundance for the Southern assessment. There was some discussion regarding these apparent differences in vulnerability to the survey, with potential causes including differential distribution of yellowtail rockfish in shallower rocky reef in the south. Future research should be conducted to explore this issue in greater detail.

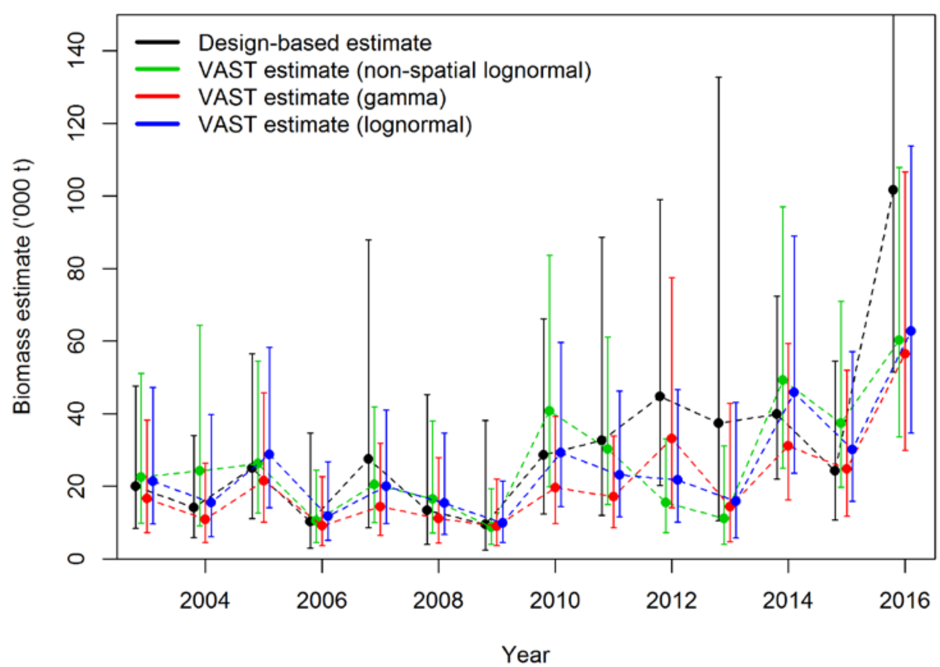

Figure 1. Comparison of trends in the geospatial GLMMs for the NWFSC Combo survey conducted in VAST to the delta-GLMM version of the VAST with the geo-spatial switches turned on and off as well as the results of the design-based delta-GLMMs.

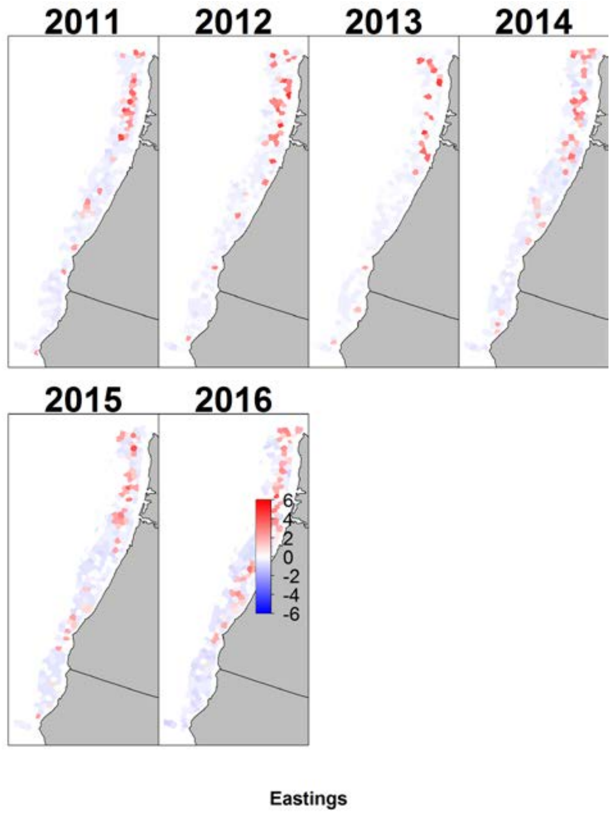

Figure 2. Pearson residuals for encounter probability in non-spatial model.

Request 2 (both models): *Provide the numbers of fish north and south of 40°10' N lat. that were used for the ageing error matrix and show the results of the cross-reads.*

Rationale: *To see if there is greater uncertainty and/or bias from samples collected in only one area.*

Response: There were an insufficient number of otoliths from each area for a comparison of cross-lab reads. Cross-reads between WDFW and NWFSC within-lab comparison for the northern area alone showed a minor deviation from the one to one line for the 121 samples compared (Figure 3). There were 1085 otoliths from the northern area and only 88 fish from south (collected in the NWFSC Trawl survey) that were double read by the NWFSC in within-lab comparisons. There were few deviations from the one to one line for within-lab double reads by the NWFSC in either area (Figure 3). The R-square values were 0.9198 and 0.9515 for northern or southern areas, respectively showing no discernable difference in the accuracy of reads between areas for the within-lab reads. Future research comparing cross-lab and within-lab reads in the north and the south with larger sample sizes may be advantageous in further evaluating the potential for differential bias or imprecision in ageing with latitude.

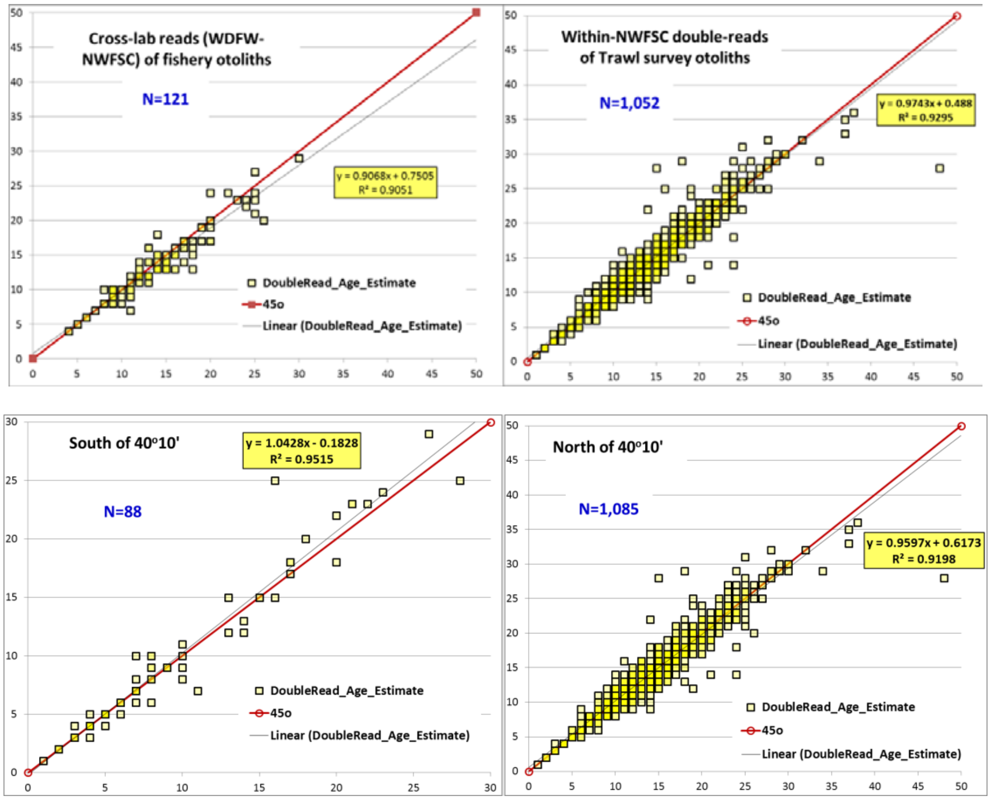

Figure 3. Comparison of yellowtail rockfish age determination double reads across aging laboratories (upper left) and within-lab (survey age structures) in each area.

Request 3 (southern model): *Model the southern onboard recreational CPFV survey data for separate time periods pre- and post-1999 using a delta-GLMM modeling approach. Present the results of the delta-GLMM approach including the factors, CVs, and other diagnostics. Show the results of the Southern model with the new indices compared to the old indices as a sensitivity analysis.*

Rationale: *The indices were inappropriately inputted as averages rather than model results. The blocking after 1999 is supported by the CVs and the change in the sampling programs.*

Response: Melissa Monk of the SWFSC provided two indices using the delta-GLMM both with and without spatial information. The onboard survey early and late have very different results providing a domed shaped selectivity for the late period when the whole state was sampled as compared to the early period when only the central California was sampled for which there was an asymptotic selectivity. The index values for the early onboard survey were still not well fit by the model. The model was able to fit the late survey well, which may in part have been a consequence of the new domed shaped selectivity reflecting more limited access to the primary depth distribution of the species due to depth restrictions. Some members of the panel noted that there may be benefit from considering the availability at a finer spatial resolution, as depth restriction vary over the assessed area.

Comparison of the original base model to the model with the separate time periods for the onboard survey indicated that the separate time periods resulted in reduced uncertainty in the spawning output. These changes were retained as changes to the proposed base model. The domed shaped selectivity was also retained in the proposed base model.

Request 4 (southern model): *If time allows, run the model without the 1982 recreational catch spike (assume the average of 1981 and 1983).*

Rationale: *To understand the influence of this catch, which is suspiciously large.*

Response: Changing 1982 recreational catch to the average of the preceding and following year had little impact on model results. There was a 1.3% reduction in total removals from reducing this value. Though the value is suspect, it was retained since it had little impact on the model results and further examination of the underlying causes of this outlier estimate is justified before making ad-hoc changes to the recreational catch time series. While the panel does not recommend an adhoc removal of the original value given the lack of impact on the outcomes of the assessment, they recommend that the cause of the extreme value be evaluated before modeling to determine whether they are erroneous and should be addressed prior to modeling.

Request 5 (northern model): *Provide a table of species that occur in each state trawl logbook program. Confirm the model is using nominal retained catch from the original logbook data.*

Rationale: *There may be different logbook reporting requirements by state that might influence construction of CPUE indices using these data.*

Response: The STAT provided a table (Appendix A) detailing the data that were used for the original analysis. The STAT initiated a new analysis based on discussions during day one which used 22 market categories that occurred in the dataset along the west coast, such that each of them had to occur at least 50 times in each of the three areas (WA, OR and NCA) to be included. The team indicated that they used the nominal catches from the logbooks. The STAT and others participating at the meeting did highlight some limitations of this dataset. For example, the Washington area has the least resolution in their market category designations in their reporting so, any analysis that tries to relate encounter of yellowtail to other species will be limited by the detail in species recorded from WA.

Request 6 (northern model): Recalculate the trawl logbook CPUE index to catch/tow hour rather than catch/tow.

Rationale: *This is the appropriate metric for this index.*

Response: The STAT were able to generate an index based on a new set of covariate species (with a minimum of 50 occurrences in each of the 3 states) and using lbs per tow-hour as the response variable. However, due to computational issues that could not be resolved in the time available for this meeting, they were unable to produce estimates of uncertainty. The following figure shows a comparison of the previous index (orange) and the new index (blue) indicating relatively little change in the resulting index.

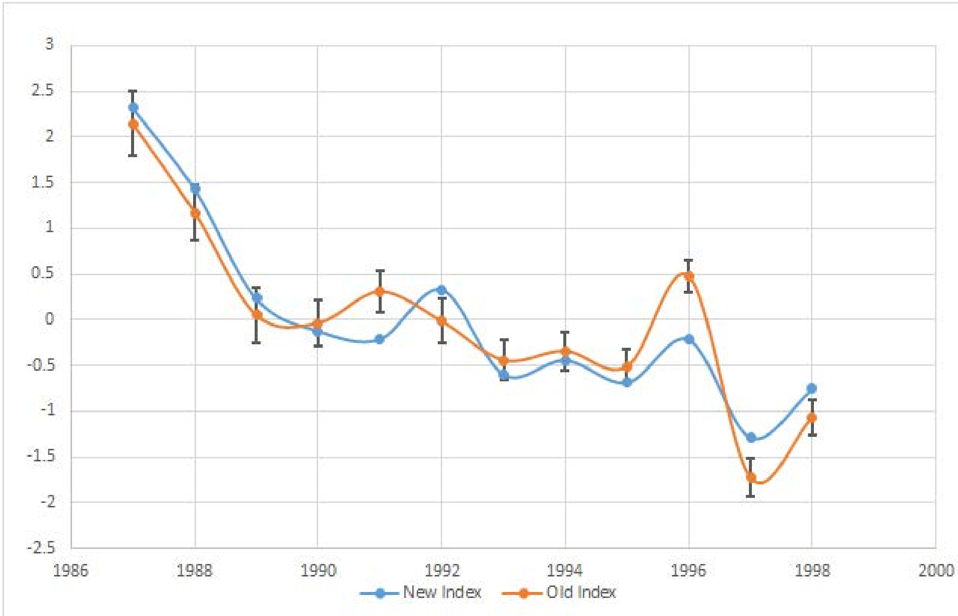

Figure 4: Original and revised trawl CPUE index upon standardizing data to catch per tow hour and refining the list of co-occurring species for the filtering model.

The team indicated that information about the nature and quality of the commercial data that were used for this index, communicated during the meeting, eroded confidence in the commercial logbook CPUE index. Further, they evaluated the performance of this index and the hake bycatch index in the Northern model, and concluded that "*neither of these was ever well fit by any version of the model.*" Because of this and other considerations detailed below, they stated that it was best to leave these indices out of the northern base model:

- Logbook Index: The states did not routinely identify market categories in the same way during the period this index covers, and that causes concerns that the index may be biased.
- Hake bycatch: This index is developed from a fishery with different ships and different fisheries (domestic/foreign). The estimation of changes in catchability based on comparison of a hake index with the estimated hake biomass from the hake assessment requires numerous assumptions. The results of the hake bycatch index is dependent on the distribution of the target species relative to yellowtail rockfish, as well as constraints associated with managing overfished rockfish species which led to avoidance and depth restrictions. As such it may not provide a suitably consistent measure of the abundance of yellowtail rockfish over time.

- Both indices: The use of fishery CPUE was introduced to Yellowtail assessments in the 1990s, during a period when there were relatively few years of observations from the triennial survey and limited length and age data. The STAT argued that the current model had enough information from other sources to provide reasonable estimates of population dynamics without requiring the use of a fishery-dependent CPUE index.

The STAT indicated that although there was value in trying to reanalyze the logbook data, including filtering and understanding the origin and reporting procedures of the data, they had concerns regarding whether a representative index could be created during the time remaining in the review. The STAR Panel noted that although the indices were not well fit in the model, they were influential, with non-trivial changes to model estimates resulting from their exclusion. This is discussed in greater detail in the response to request 10.

Request 7 (northern model)*: Check the WA composition data to determine the correct units in the length data. Double check on the number of ages from the WA recreational fishery.*

Rationale: *There was a suspicious spike in the time series that may have been due to the wrong units of measurement (cm vs. mm) in the length data. There is also suspicion the age comps used in the model are not consistent with WA records.*

Response: The STAT checked the data and identified two issues; one was that the data were provided with varying units (some lengths in cm, others in mm), which was not properly recognized, or addressed in developing the data files. The second issue was about the sample sizes for the age comps for which there was a copy-and-paste error in Excel, so that the column of sample-sizes was offset by one year in the data. Both lengths and ages for the WA recreational fishery were re-processed. Old (left) and New (right) length compositions are shown below (Figure 5). The correction of the data has removed the spikes at big sizes that were shown in the length composition. There was agreement that the revised data are appropriate to use in the base model.

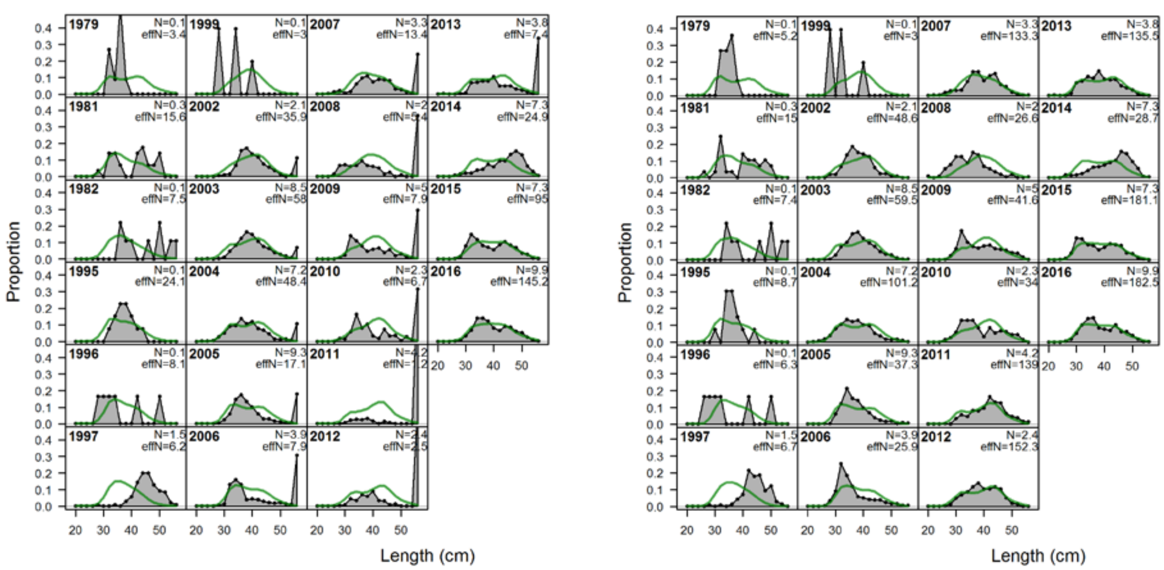

Figure 5: Draft (left) and final (right) model length compositions for the WA recreational fleet when correcting length units and effective starting sample sizes.

Request 8 (northern model): *Put a time block on the recreational selectivity pattern from 2003 onward.*

Rationale: *Implementation of depth restrictions forced fleets into shallower water affecting the size of fish caught. This was evidenced by a poor residual pattern.*

Response: The model estimated selectivity curves changed very little change for the Oregon and Northern California recreational fisheries, but there was a larger change for Washington when the time block was added. The new and original selectivity estimates are shown (Figure 6).

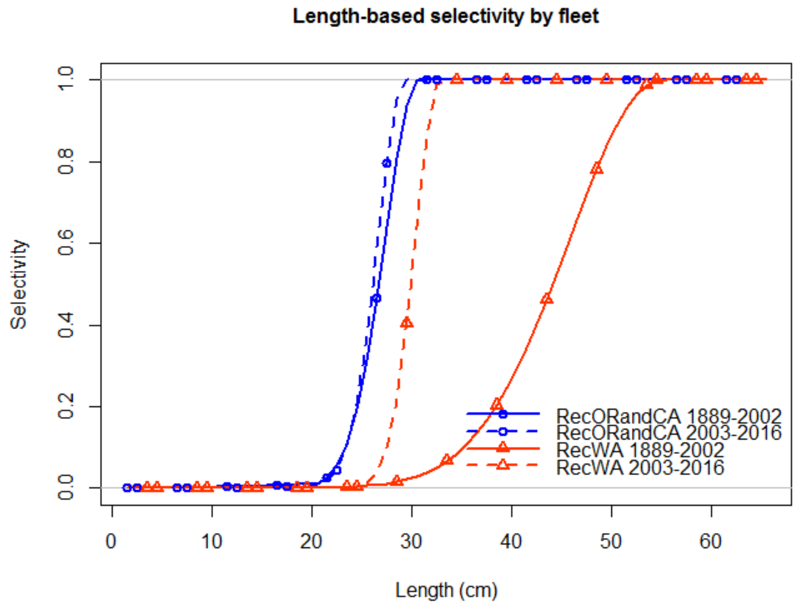

Figure 6: Estimated selectivity curves for northern model recreational fisheries when including a time block to account for regulatory changes.

Note that this analysis was done after the correction in the length and age composition done in response to Request 1.3. The selectivities calculated for the two blocks of time for the Washington recreational fishery are very different, but the change was negligible for the Oregon and California recreational fishery. The next step was to allow the selectivity to be dome shaped, and the result was that both selectivities fit better when dome shaped; the WA has a small dip at the end while the CA+OR are a full domed. The STAT team recommended that both the dome-shaped curve and the time block be incorporated into the base case model, and the Panel concurred with that change.

Request 9 (both models): *If time allows, estimate the added variance parameter for all indices.*

Rationale: *This is standard practice.*

Response: The Northern model estimated additional variances for all indices (plot below showing status-quo commercial logbook CPUE index) highlighting problems with fitting the model to the data.

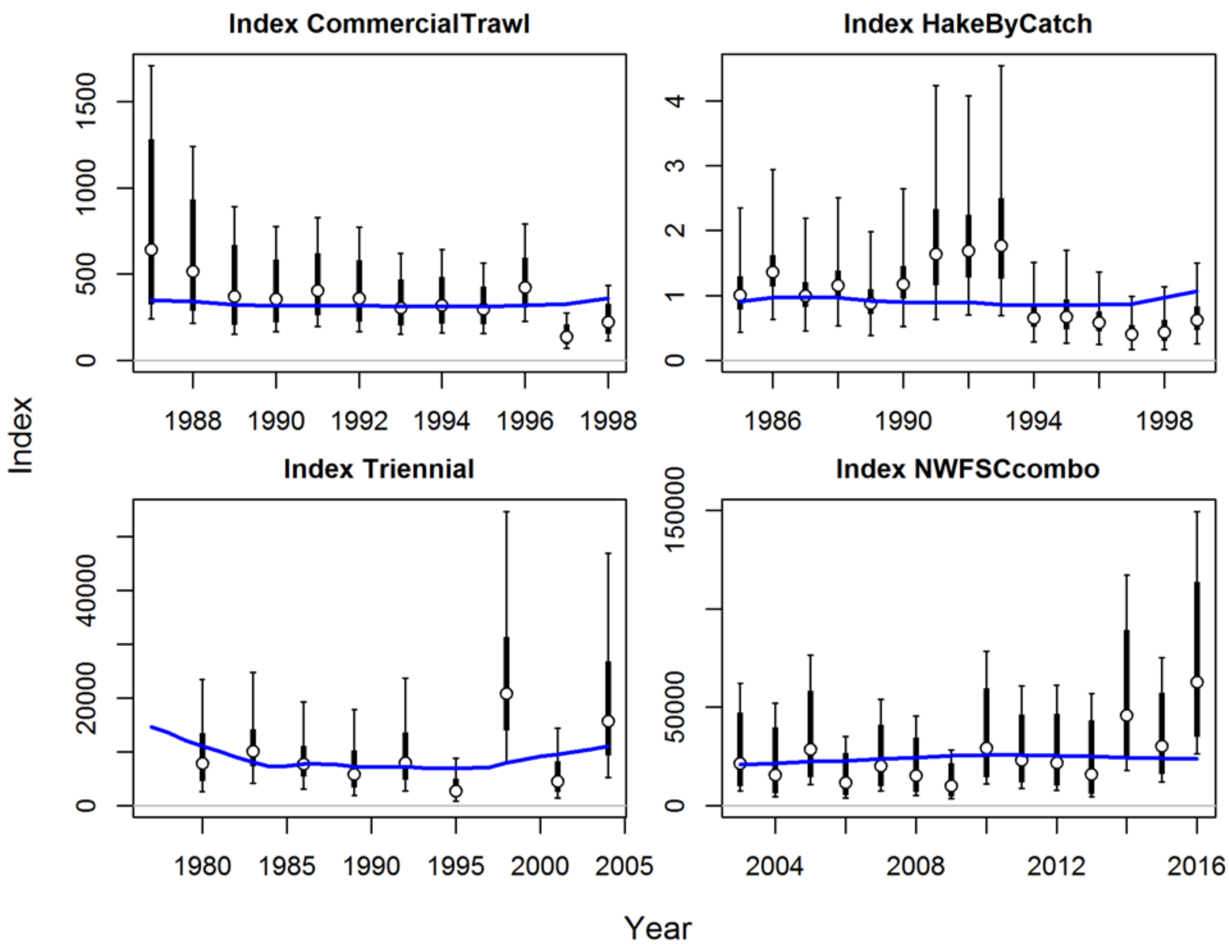

Figure 7: Fits to index data for the Northern Yellowtail model when added variance parameters are estimated.

However, the incorporation of additional variance did not really affect the behavior of the model and therefore, this aspect of the analyses was not explored further but the additional variance was maintained in the model. The STAT team ran the model with the corrections and the correction of the Washington data as well as the transition to domed selectivity for the recreational fisheries (previous requests). These changes resulted in a slightly higher estimate of female natural mortality and a slightly more optimistic depletion level at the end of the time series.

Round 2 of requests (Wednesday, July 12th)

Request 10 (northern model): *Re-tune the new base northern model with the changes agreed on the 1st set of requests (i.e., correct WA comp. data, add extra variance to indices, add time block in 2003 for rec., allow dome-shaped selectivity for rec. in the recent time block).*

***Rationale**: The STAT and STAR Panel agreed these changes were needed to correct errors in the input data and to improve model fits. These changes will be included in the new base model.*

Response: The team ran the model with the corrections and new structure of the model resulted from the first round of requests and presented the new results together with the previous version of the results for comparison. As part of this comparison, new tuned northern model with and without fishery CPUE indices has been produced. The figure below presents those results; the revised model (no fishery CPUE indices) has a slightly higher initial starting point and a higher current stock status than the previous base models, but otherwise is largely similar to previous Northern models.

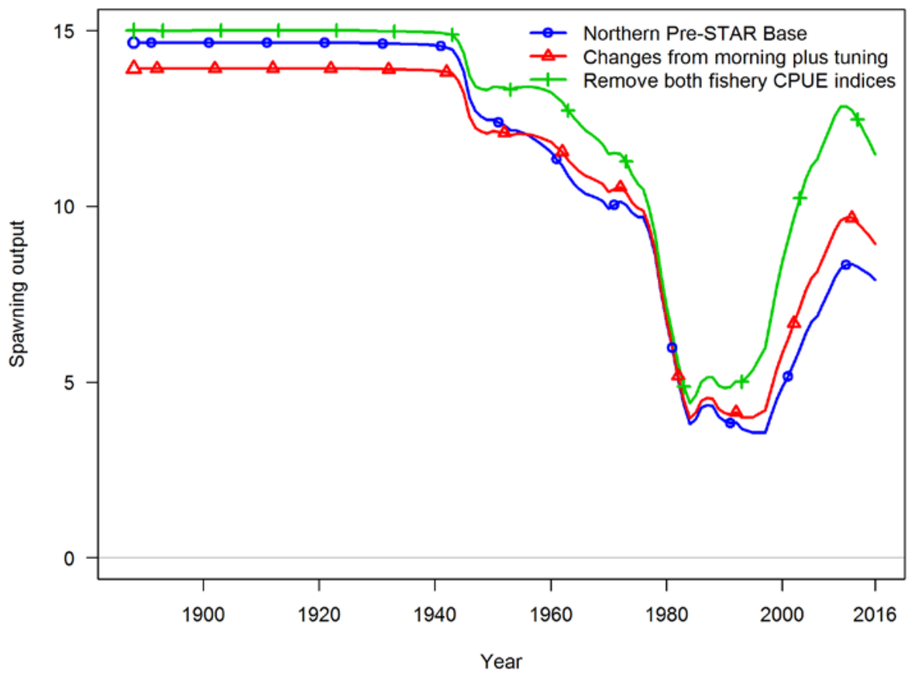

Figure 8: Changes in base model as a result of STAR (earlier requests) and STAT (dropping CPUE indices) recommendations.

However, the natural mortality estimated in northern models has changed with the revised M being greater than the previous ones. The specific values are shown in the Table below. The posterior for M is also shown in the figure below; the posterior is much narrower than the prior supporting a much smaller range of plausible values for M.

Table 1: Pre-STAR, intermediate, and Post-STAR model estimates of natural mortality for northern yellowtail.

	pre-STAR model	adjusted, tuned model	without cpue indices
M (females)	0.145	0.159	0.174
M (males)	0.138	0.138	0.15

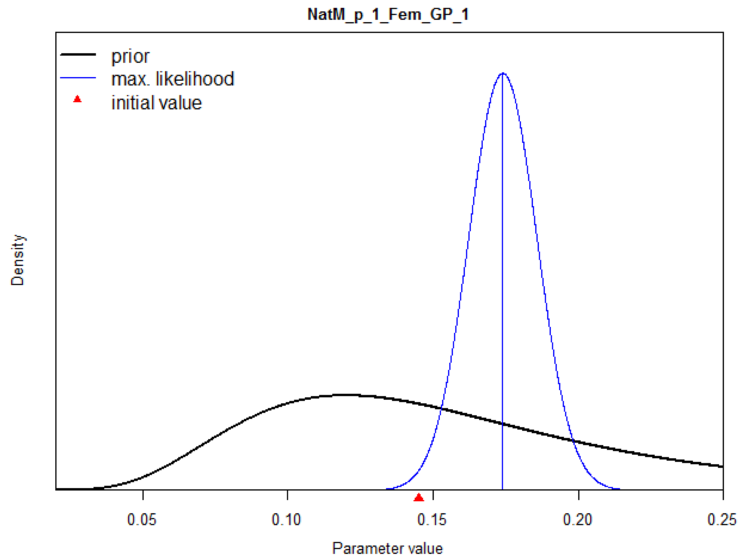

Figure 9: Comparison of prior distribution, model initial value, and posterior for natural mortality (females) as estimated from the Northern base model.

The STAR and STAT discussed these changes in the context of how influential (even if poorly fit) the fishery-dependent CPUE indices were in the model. The STAT expressed their concerns regarding the data used to develop these indices, particularly with respect to concerns raised by Panelists and others during initial discussions of the indices, and proposed exclusion of the indices from their base model. The Panel did not have an objection to the proposed exclusion of the two CPUEs. However, the Panel did note that although the indices were never fit well by the model, they were influential with respect to model estimates of natural mortality, scaling of total biomass and stock dynamics. Following some discussion, the Panel agreed with the STAT that excluding these indices from the base model was reasonable given the concerns that had been raised for each index.

Request No. 11 (southern model): *Use the preliminary new M estimate from the revised northern model in the revised southern model (new base case after the 1st round of requests). Compare the existing southern base and the new potential base using the new M estimate. Explore other M assumptions in the southern model as deemed appropriate and as time allows.*

Rationale: *The changes to the northern base model will likely affect the estimate of M and consequently would change the assumed M in the southern model.*

Response*:* The pre-STAR model value for M of 0.14 was replaced by the value of 0.175 based on the proposed northern base model (following the first round of requests for the northern model). The higher M resulted in an increase in spawning depletion level across all years and the biomass was higher in the recent time span than the early historical period. Recent recruitment is some of the highest in the entire time series and with the higher M, the sigma R increased. The increased values of M results in very wide confidence intervals for the southern model (Figure 10). There were concerns that these results could be unreliable for management. Upon consideration of these changes and other considerations relating to uncertainties in the southern model, the STAT did not support the resulting base model. No further sensitivities were requested for the southern model, based on the conclusion by the STAT that insufficient time remained during the review to develop a robust model. In discussion the potential for a model to be developed for the "mop-up" panel in late September, the STAT expressed the opinion that there was insufficient time and data to develop a plausible model in that time frame.

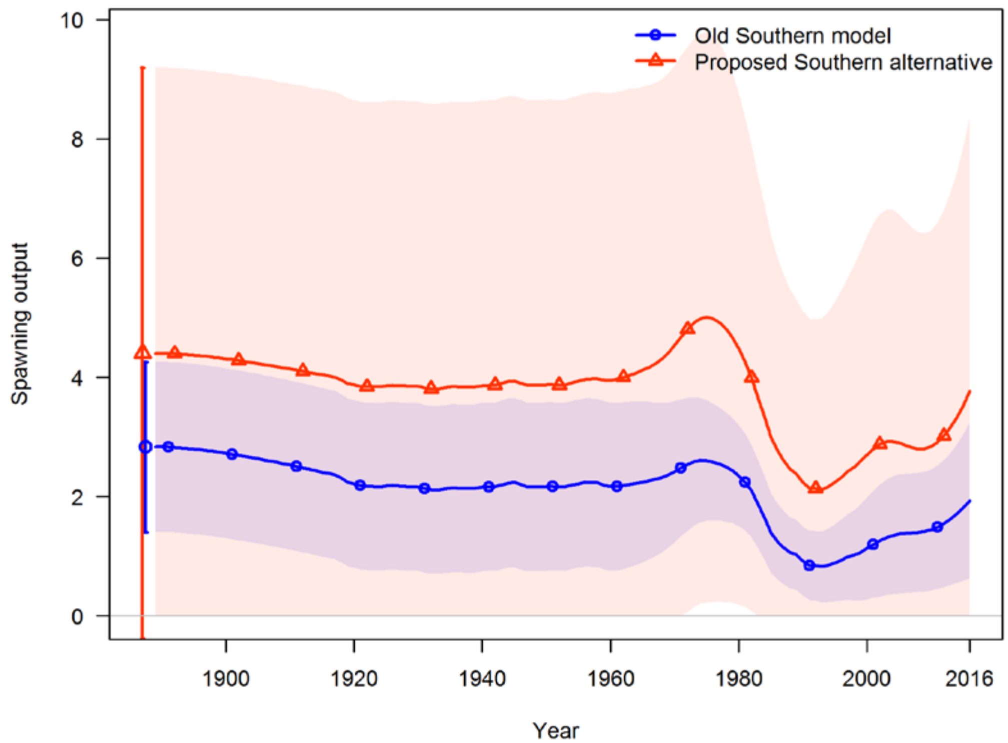

Figure 10. Spawning output and confidence intervals for the yellowtail rockfish southern assessment base model and the alternative model with a higher value of M.

Request 12 (northern model): *As time allows, provide the basis for and documentation of the use of the geospatial GLMMs for the Hake CPUE index conducted in VAST.*

Rationale: *This is needed to understand the basis for how this index is constructed and why there was no sensitivity to the non-spatial analysis.*

Response: Upon greater discussion and evaluation, the STAT no longer felt this index should be included in the base model. The Panel did not request further work on this but noted that future assessments would benefit from further exploration of these series to ascertain its appropriateness and best type of analyses to apply.

Request 13 (northern model): *Jitter the new northern base model.*

Rationale: *Final check for a global minimum*

Response: The result of 100 jitter runs was shown to the panel and indicated that a global minimum had been attained. Those results will be included in the final assessment.

Request 14 (northern model): *Decision table explorations:*

- *Provide projections assuming a range of M values that the STAT considers to be an appropriate approximation of uncertainty for a decision table.*
- *Provide projections assuming a range of R0 values based on the base model uncertainty estimates for R0, including the 87.5 and 12.5 percentiles and other explorations as appropriate, as a possible axis of uncertainty for a decision table.*
- *Provide any additional projections that the STAT determines may be more appropriate for developing the axis of uncertainty for a decision table.*

Rationale: *To explore possible axis of uncertainty*

Response: Likelihood profiles over R0 and M indicated a lower range of spawning output associated with the 12.5% and 87.5% cutoff (change in likelihood of 0.662) than the uncertainty in spawning output estimated for the base model. Thus, the STAT took the 12.5% and 87.5% quantiles of a normal distribution representing 2017 spawning output, for which the base model had an MLE value of 11.28 (trillion eggs) with a standard deviation of 1.823. This resulted in target 2017 spawning output values for the low and high states of nature of 9.17 and 13.38 (trillion eggs). R0 and M profiles using a fine step size (0.01 units of R0 or M) were used to find the best matching values of these two parameters for the low and high cases.

A request to present the results in terms of relevant depletion was made during the presentation of the results as it appeared that depletion could be very similar across the different scenarios. In terms of depletion, the STAT indicated that the range covered was from 57% to about 82% of pre-exploited spawning output but that was clearly smaller than the uncertainty envelope that characterized the base case results. Therefore, the STAT looked to extend the range of values of M that will be used to represent uncertainty.

In order to find the new range of values, the STAT used the prior for M as the shape of the distribution but shifted the distribution so the mean was that estimated in the northern base model, of 0.174. The values that corresponded to 12.5 and 87.5 percentile of that distribution were 0.122 and 0.249.

Request 14 (northern model): *Provide projections based on the base model uncertainty estimates for M, including the 87.5 and 12.5 percentiles of the prior distribution centered around the base model estimate of M (low M = 0.122, base M = 0.174, high M = 0.249) as a possible axis of uncertainty for a decision table.*

For catch stream alternatives, assume full attainment of 2017 and 2018 ACLs; i.e., 6,196 mt and 6,002 mt, respectively. Attribute fleet allocations based on the 2017 and 2018 sector allocations for 2017 and 2018; fleet allocations as per the assessment thereafter, such that the 2019-2028 *catch streams are based on:*

- *Default HCR: ACL = ABC (P* = 0.45)*
- *Constant catch of 4,000 mt (approx. catch level when midwater targeting was occurring in the past; in line with the GMT's 2017-18 spex analysis)*
- *Constant catch of 2,000 mt (marginal increase in recent year average catch)*

Rationale: *To explore possible axis of uncertainty for a decision table*

Response: The STAT produced the requested table, the STAT and the STAR Panel agreed that the results represented an appropriate means of capturing the greatest axis of uncertainty in the northern base model.

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

Northern Yellowtail

The northern yellowtail model went through some revisions during the review, including removal of commercial fishery CPUE indices (from the trawl logbook data as well as the Pacific hake fishery), correction of mis-specified length composition data from the Washington recreational fishery, blocking of selectivity patterns for recreational fisheries, inclusion of additional variance parameters for the fishery-independent and fishery dependent indices that were used in the model, and adding time-blocking and allowing dome-shaped selectivity for recreational fisheries. As a result of these changes, there were changes to the estimate of natural mortality (estimated in the model with the Hamel prior) in the base model, from 0.145 to 0.174 (females), and 0.138 to 0.15 (males), between the pre- and post- STAR panel models (starting values based on the prior were 0.15 and 0.12 for males and females, respectively). Likelihood profiles in the original base model had indicated that length and age composition data has slightly better fits to higher M values, while indices were better fit with lower M values. It was notable that the discrepancy between female and male natural mortality estimates increased in response to changes made in the base model, however the potential mechanisms behind these differences were not investigated or described in detail. Liklihood profiles also indicated that the model preferred higher values of steepness, but there was relatively little information in the data to support estimating a value greater than 0.7.

The changes made to the northern model had a substantial influence on the base model result, although the scale and trend between the starting model and the final model were generally comparable. The model is well informed by age and length composition data, particularly from commercial fisheries where shifts in age and length structure are apparent throughout the duration of the time series, which leads to some level of confidence in the natural mortality estimates and base model results. The base model indicates that the stock was heavily exploited during the 1980s and early 1990s, with SPR harvest rates above target levels, and spawning output dipping slightly below the target level of 40% unfished spawning output (but staying above the MSST), and spawning output increasing substantially since the late 1990s in response to substantial declines in landings and a number of strong year classes. Ending year depletion is estimated to be just above 75% of the unfished level in 2017.

The primary axis of uncertainty was determined to be the natural mortality rate, which is estimated with an informative prior and is presumed to be fairly well informed by age composition data, but was shown to be sensitive to inclusion of relative abundance indices, fairly influential with respect to stock status, and very influential with respect to scaling of abundance and potential yield. The alternative states of nature were developed based on the 87.5 and 12.5 percentiles of the prior distribution that were re-centered around the base model estimate of M, such that the base model estimate of 0.174 (females) was bracketed by sensitivity runs that had a fixed low (0.122) and high (0.249) value for female natural mortality (with the male offset fixed as a constant value as estimated in the base model). All scenarios estimated the stock to be well above target levels in 2017, with the low M (low productivity) scenario estimating the stock to be 50% unfished spawning output, relative to 75% for the base model and 82% for the high M (high productivity) model.

Southern Yellowtail

There were substantial changes to the southern yellowtail model between receiving the original draft assessment, receiving a revised assessment and model several days prior to the panel (based on addressing and correcting several issues raised in the original draft by the panel), and in response to the first round of requests by the STAR Panel during the review week. Upon consideration of these changes, and with recognition of the general paucity of data for this stock and the very high degree of sensitivity of the southern model to a number of factors and parameters, the STAT and STAR agreed that a plausible model for southern yellowtail could not be developed during the review panel. This acknowledgement came after extensive consideration of model fits to data, diagnostics, the perceived need for some consistency among key parameters (e.g., natural mortality) between northern and southern models, and the extraordinarily wide confidence intervals (Figure 10) resulting from the model reflecting the best efforts of the STAT team upon completion of the first round of requests.

The STAT and STAR panel agreed that additional data for the southern area representing the fishery after 1999 was among the key data needs necessary to develop a robust model for the southern region, particularly given the high degree of sensitivity to the natural mortality estimate (Figure 11). This is particularly true given that demographic data are highly informative in the northern model. The combination of constraining opportunities to access shelf rockfish, along with limited access to landings for port sampling (as allowing port samplers access to landings is voluntary rather than mandatory in California law), has resulted in a limited ability to collect age and length data in California fisheries.

The paucity of fishery-independent indices and data, resulting from the low encounter rates of bottom trawl surveys to yellowtail rockfish south of Cape Mendocino, are also notable challenges. Although one fishery-independent (Southern California Bight) and several fisheries dependent (recreational CPUE time series) indices were available, two of these (the NWFSCO hook and line survey, and the more recent CPFV onboard observer index) were in direct conflict with each other, constraining the ability to develop a plausible model. As the former is limited spatially to the very southern fringe of the range of the southern stock, some closer examination of the robustness of that index as being indicative of trends in the core areas of abundance of the southern stock, which might include more direct comparison with the fishery-dependent data from the southern region, would benefit future assessment efforts.

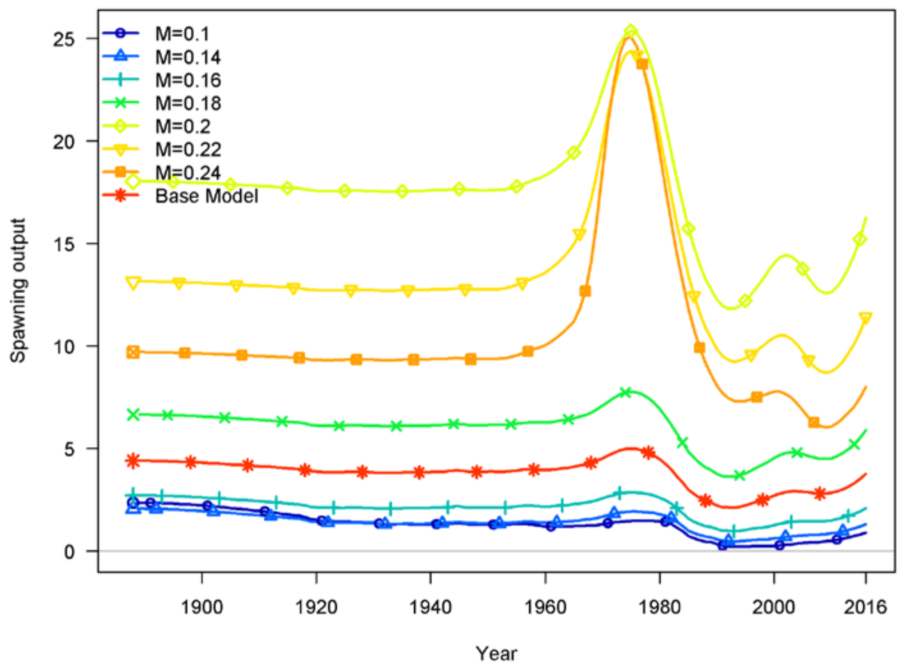

Figure 10. Spawning output for the (unaccepted) final base model (M = 0.175) for the southern assessment area compared to the results of the model with alternative fixed natural mortality rate values.

Technical Merits of the Assessment

The STAT team endeavored to utilize the limited data available from the Southern assessment area, and attempted to inform the model using data from the Northern model area where appropriate. The analysis provided a useful insight into the potential for using a fully age structured model in assessing this stock, and clearly highlighted numerous data needs and research priorities.

Technical Deficiencies of the Assessment

For both models, the draft document provided to the review panel lacked an adequate level of detail regarding many of the data sources and indices, some of which were later found to be modeled or incorporated inappropriately. This can be in part attributed to the workload associated with what ultimately evolved to be two assessments (one in each area), each with unique and very different sources of information and modeling challenges. Ultimately, the lack of robust indices and compositional data from the recent time period were the primary factors constraining the STAT from arriving at a southern yellowtail model suitable for use in management. The level of complexity of the modeling framework chosen may not have reflected the information content of the available data.

Areas of Disagreement Regarding STAR Panel Recommendations

Among STAR Panel members (including GAP, GMT, and PFMC representatives): None.

Between the STAR Panel and the STAT Team: None.

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

The GAP advisor indicated that the At-Sea Hake fishery index, developed and included in the draft assessment for northern yellowtail, could be biased by the distribution of the target species as well as changing constraints posed by bycatch species through time, which in turn drive the distribution of fishing effort. These considerations lead to its removal from the Northern model by the STAT.

Unresolved Problems and Major Uncertainties

The review identified the following unresolved problems and major uncertainties:

The lack of robust indices, as well as age data from the recent period (post 1999) limited the ability of STAT to provide a sufficiently reliable southern model. The uncertainty surrounding the results of the proposed model made it unusable for management. Processing of existing collections of otoliths and additional sampling of commercial and/or recreational fisheries would greatly improve the model, and should be completed prior to attempting another age structured integrated model for the southern stock.

Appropriate estimates of natural mortality for the southern assessment area were a major area of uncertainty and sensitivity. The values were fixed at those determined for the northern model, but the likelihood profiles indicated that a higher value of M was plausible. Examination of higher values than the 0.175 for females from the northern model caused the spawning output to increase to implausible levels. Given that the southern stock has been found to be genetically distinct from the population to the north, further examination of the basis for natural mortality for the southern assessment area is warranted.

The mechanisms responsible for the apparent differences in natural mortality rates between the two sexes (in both models) also warrant greater investigation. Likelihood profiles indicate significant tension between compositional (length and age) data and index data in the northern assessment. There is little evidence in the likelihood profiles that steepness can be reliably estimated, consequently fixing steepness at the point estimate of the prior was considered to be appropriate.

Recommendations for Future Research and Data Collection

The age data available for the northern model are strongly indicative of a higher natural mortality rate for female yellowtail rockfish. Yellowtail are one of several rockfish species that demonstrate this apparent difference in sex ratios at age, and historically there has been concern regarding whether differential natural mortality rates throughout the lifespans of populations are reasonable, whether these differences reflect greater mortality rates of older females, or whether these difference reflect some manifestation of dome-shaped age-based selectivity (such that older females are less vulnerable to fisheries or surveys, presumably as a result of habitat associations). These models did not explore alternative explanations for these differences at the level that has been done for other stock assessments (such as Canary and Black Rockfish, where increasing natural mortality rates for females with age, as well as both size- and age-based dome-shaped selectivity have been explored). Given the richness of age data for yellowtail rockfish in the north, additional investigations that better quantify the phenomena, and evaluate potential mechanisms for the observed discontinuities, should be pursued.

The draft northern yellowtail assessment models included indices of relative abundance based on fishery-dependent time series, including a trawl logbook CPUE index and an index of abundance based on yellowtail bycatch in the at-sea Pacific whiting fishery. Upon greater discussion of challenges associated with the development of these indices, particularly with regards to possible differences by state in the resolution of market categories in the logbook data, and how the bycatch rate information was standardized for the whiting fishery bycatch index, the STAT recommended exclusion of both indices in the final base model. However, as the indices were influential with respect to model results, greater exploration of the potential for these data to inform a relative abundance index, particularly for the trawl logbook cpue data, would benefit future assessment efforts.

As yellowtail rockfish is a semipelagic species, it may not always be reliably sampled in bottom trawl surveys, particularly if the depth distribution is sensitive to environmental conditions (for example, for widow rockfish it has been suggested in the past that El Niño years or other periods of low productivity, individuals may have a more benthic, relative to pelagic, distribution and therefore be more vulnerable to bottom trawl surveys). Consideration of alternative survey methods (e.g, acoustic surveys, midwater trawl surveys) and/or the means to account for changes in catchability that may be associated with environmental factors, could improve the ability of survey indices to track stock abundance.

For the southern yellowtail model, the STAT and STAR Panel discussed a number of priorities. Given the importance of age and length compositional data, and the sparseness of such data available for the southern model, developing additional age data from available sources (such as the hook and line survey, and reproductive ecology studies at the SWFSC) should be a fairly high priority. The means to best ensure reasonably comprehensive sampling of commercial, and if possible recreational, fisheries catches with sex and maturity information is also a high priority for this (and other) stocks, particularly to the extent that future management changes enable greater fishing activities and landings for these populations.

Additional efforts to improve recreational and fisheries-independent indices for the southern model should also be undertaken. For example, there were conflicting trends in the onboard observer index (reflecting yellowtail catches throughout all California waters) and the NWFSC hook and line survey (reflecting catches in the northern part of the Southern California Bight). Investigating whether this reflects a fundamental difference in signal, or whether this might reflect regional differences in catch rates, which could be evaluated by subsetting the recent onboard observer data to overlap the spatial scale of the hook and line survey, would be worth greater scrutiny in advance of any future assessment.

As both genetic studies and past assessments have indicated differences in stock structure and life history parameters, greater evaluation of region-specific life history parameters (such as growth, maturity, fecundity) would also likely benefit future assessment efforts both within and between the two assessment areas. For example, as the NWFSC hook and line survey is at the southern extent of the range of the southern stock, this might include potential differences in growth and maturity among different subregions within the southern model range, to evaluate the potential utility of indices and age data from that survey in a future southern base model. Such studies should be feasible based on the relatively rich amount of data available to inform the northern assessment.

It was ultimately not possible to fully evaluate the influence of the pelagic juvenile index on the southern model results during the panel review, however there was some concern that the index could have been overly influential in the model due to the lack of age or length compositional data in the recent time period that might conflict with the juvenile abundance signal. Greater scrutiny regarding the potential utility of this index should be given if the index is to be included in future models

As northern yellowtail presumably 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

The STAR Panel thanks the STAT for their vigorous efforts in improving the northern assessment and in pursuing a plausible assessment for the southern area. The STAR Panel also thanks the NWFSC, particularly Stacey Miller and Jim Hastie, for hosting the panel during the week.

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Appendix A: Trawl logbook market category data that were used for the trawl logbook CPUE analysis, numbers represent the number of positive observations in the 500,000 observations used in the analysis. CAPITALIZED market category IDs are as in original data, lowercase market category IDs are those for which the analyses the STATs team conducted combined the actual and nominal (e.g., “YTRK” and YTR1”) market category codes.

SPID	CA	OR	WA	SPID	CA	OR	WA	SPID	CA	OR	WA
ALBC	0	0	24	LSRK	6	0	0	sbly	37	0	0
bcac	3213	0	0	MEEL	18	0	0	SCLP	0	2	901
blck	71	2320	0	MISC	351	3	3795	scor	13	0	0
blgl	3	0	0	MSC2	4692	2273	1076	SHAD	0	3857	344
blur	2	0	0	MSQD	38	3065	0	SMLT	0	1	0
BRW1	23	0	0	NANC	0	1	0	snos	65	0	0
bskt	14	0	0	OCRB	11	18	0	SPRW	11	0	0
BSOL	596	992	415	OCTP	8316	15648	24146	SQID	260	0	1885
BSRK	5	95	8	OFLT	4	12	3	SQR1	2	0	0
BTCR	181	0	0	OGRN	0	45	0	SRFP	18	0	0
BTRY	1	0	0	ORCK	0	0	7085	ssol	7316	20229	21723
byel	1	0	0	OSRK	26	74	19	SSRK	1220	3756	1965
cbrk	23	0	0	OSRM	0	138	0	stry	6730	18847	23614
cbzn	361	965	0	PCOD	2388	64430	85900	TCOD	86	0	10
CHL1	2312	0	0	pdab	7	17097	0	thds	37243	101081	13049
CHLB	0	324	0	PHLB	0	592	93	TSRK	11	187	65
chna	18	0	0	PHRG	0	856	211	UDAB	15268	0	2915
clpr	62	0	0	PLCK	0	103	3254	UFLT	318	0	2777
CMCK	16	5480	0	POP1	0	67300	0	UHLB	1	0	0
cnry	3494	22648	8624	POP2	0	31830	0	UMCK	17	0	505
copp	7	0	0	PSDN	1	123	0	UPOP	1	0	16908
csol	0	2950	0	PSHP	6	0	0	URCK	25677	110428	66031
CUDA	2	0	0	ptrl	27418	105152	50273	USCU	0	0	7
cwcd	8	0	0	PWHT	3353	12794	2430	USKT	12558	20606	23891
DCRB	1750	11	0	qlbk	4	0	0	USRK	34	88	925
dovr	46760	149199	48901	RATF	0	18	26	USRM	3	0	0
DSRK	95	3420	28348	RCK1	22	0	0	USTG	9	0	0
EELS	16	0	0	RCK2	3	0	0	UTCR	0	35	0
egls	24913	100348	77170	RCK3	5	0	0	UTRB	2561	0	0
FNTS	13	0	0	RCK4	1081	0	0	WCRK	21	0	0
FSOL	0	2206	0	RCK5	16603	0	0	wdow	5914	52786	19241
gphr	7	0	0	RCK6	679	0	0	WEEL	1598	4822	0
GRDR	7500	11219	0	RCK7	7	0	0	WSTG	0	1056	420
gspt	15	0	0	RCRB	0	5	0	yeye	181	0	0
gsrk	113	0	0	rdbd	4	0	0	YLTL	6	0	0

GSTG	0	3487	2534	rex	33540	84955	25796	ytrk	1460	57009	25362
JMCK	97	6241	150	rsol	93	4138	11774				
klpg	25	63	0	rstn	5	0	0				
lcod	19879	91658	49946	SABL	42443	122292	39356				