Yellowtail Rockfish North of 40° 10' N. lat.
Stock Assessment Review (STAR) Panel Report

Watertown Hotel
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Overview

The Pacific Fishery Management Council (PFMC) manages the U.S. fishery for yellowtail rockfish (*Sebastes flavidus*) as two stocks separated at Cape Mendocino, California (40°10' N. lat.). The Stock Assessment Team (STAT) assessed the stock north of 40°10' N. lat. to the U.S./Canada border due to genetic structure at Cape Mendocino (Hess 2011) as well as greater relative commercial importance and availability of data. The assessment was conducted in Stock Synthesis version 3.30.23.1 and included three fishery fleets (commercial, at-sea hake, recreational) with catch time series beginning in 1889, with length data after 1972 and ages in the later period as well three traditional surveys and one recruitment index.

Catches declined during the 1990s and 2000s due to depth restrictions, area closures, and trip limits with increasingly restrictive management since 2002 to rebuild co-occurring rockfish species. The abundance of yellowtail rockfish increased through this period of stronger recruitment and reduced catch. The catch remained extremely low until implementation of the individual fishing quota (IFQ) system in 2011, followed by an increase in catch through the 2020s. An Exempted Fishing Permit for midwater trawl gear was implemented in 2013 allowing resumed access to shelf habitat over rocky reef habitat where yellowtail rockfish are predominantly found, without impacts on the still rebuilding demersal yelloweye rockfish stock leading to increasing catch. Yellowtail rockfish was last assessed in 2017 and was prioritized in part as a result of resumed access to the primary depth distribution of yellowtail rockfish using midwater trawl gear in 2013, with increasing catch after the rebuilding of co-occurring species, canary and widow rockfish in 2015, leading in an increase in catch limits in 2017. With increasing catches, the abundance of yellowtail rockfish began to decrease toward the target of biomass of 40% after 2017 when the stock was at 69.8% of historical spawning stock biomass.

The 2025 base model is primarily informed by compositional data, though indices of abundance were incorporated as well. The base model did not change during the course of the review, though requests were made to further evaluate modeling decisions and uncertainties. The panel finds the assessment to be the best scientific information available (BSIA) on the current status of the stock to inform management. The STAR Panel recommends the 2025 assessment be designated a Category 1b assessment with a sigma of 0.5. The current status of the stock is healthy in 2025 at 62.5% of unfished spawning stock biomass. The scale of the assessment has decreased compared to the 2017 assessment, reducing the overfishing limit (OFL) from 6662 mt in 2026 to 5051 mt in 2027. While the presumed annual catch limit (ACL) in 2026 is 6023 mt and would decrease to 4723 mt in 2027, the total catch has remained well below the management limits and harvest specifications in recent years averaging just over 3000 mt since 2017. The panel recommends that the next assessment be an update unless the next assessment can be conducted as a transboundary assessment in collaboration with Canada, in which case a full assessment would be preferred.

Summary of Data and Assessment Model

Data

The yellowtail stock assessment was data rich with over 130 years of catch data from three fisheries, more than 180,000 ages and 480,000 lengths, and indices derived from 3 adult surveys and one young-of-the-year (YOY) survey. Fisheries-dependent data include catch, age and length data from three different fleets (Figure 1).

1. Commercial: Shoreside commercial landings derived from a mix of Pacific Fisheries Information Network (PacFIN) and state-specific reconstructions. Catch data spans from 1889 to 2024, while length and age composition data was collected starting in the 1970s.

2. At-Sea Hake: Landings of yellowtail in the at-sea hake fishery (motherships and catcher-processors, but not shoreside vessels) extracted from the North Pacific Database Program (NORPAC). Catch and length data extends from 1976 to 2023, while some limited age data is available in 2019 and 2023.

3. Recreational: Recreational landings aggregated from a mix of the Recreational Fisheries Information Network (RecFIN), Marine Recreational Fisheries Statistics Survey (MRFSS), and state reconstructions. Catch extends back to the 1920's while length data first became available in 1980 and age data in 1997.

The majority of total catch can be attributed to the commercial fishery, with a substantial increase in the 1940s when a US wartime shortage of red meat resulted in the creation of the trawl fishery infrastructure (Figure 2). A second increase in catch occurred in the 1980s when intensive midwater trawling began.

Canary and widow rockfish were declared overfished around 2000, resulting in a collapse in yellowtail catch due to increased regulation. Fishing opportunities gradually increased starting in 2011 and jumped substantially in 2017 after canary and widow rockfish were declared rebuilt.

The at-sea hake bycatch of yellowtail rockfish peaked in the 1980s and 1990s, while the recreational fishery contributed a very small percentage of total catch throughout the length of the series. Age and length composition data were similar for the commercial and at-sea hake fishery, while the recreational fishery tended to catch younger fish.

Fisheries-independent data consisted of four indices along with age and length data (Figure 1).

1. WCGBTS: Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCGBTS). Data from annual hauls from 2003 to 2024 arranged in a random-grid design were developed into an abundance index using geostatistical models.

2. Triennial: The Alaska Fisheries Science Center and Northwest Fisheries Science Center's triennial survey, conducted every third year between 1980 and 2004 using evenly spaced east to west transects and developed into an abundance index using geostatistical modeling.

3. H&L Survey: Hook and line survey data collected in nearshore rocky reef habitat in Washington and at four marine reserves in Oregon. A model-based abundance index for 2010-2024 was developed using year, month, survey and drift depth.

4. SMURF: A young-of-the-year index based on standard monitoring units for the recruitment of fishes (SMURF) deployed in and around Oregon Marine Reserves. These devices were monitored approximately every 2 weeks during the settlement season (April

- September). A model-based index for 2014-2024 was constructed based on year, region, and cumulative degree days 16 days prior to SMURF recovery.

Length data was collected in the WCGBTS, Triennial, and H&L surveys, while age was collected as well for a subset of fish in the WCGBTS and Triennial surveys. Age and length data from the WCGBTS survey were combined to create conditional age at length data to inform the growth functions in the model.

Additional indices were considered but not included in the model. These included four additional YOY/Recruitment indices, and two fishery dependent indices. The SMURF index was chosen over the other YOY/Recruitment indices because it directly measured settlement, identified fish to the species level, sampling occurred throughout the settlement season, it included temperature exposure, and it was developed with agency and university partners. The fishery dependent indices were excluded due to difficulty in accounting for changes in fleet behavior over time and the resulting variability in catchability (see Request No. 9).

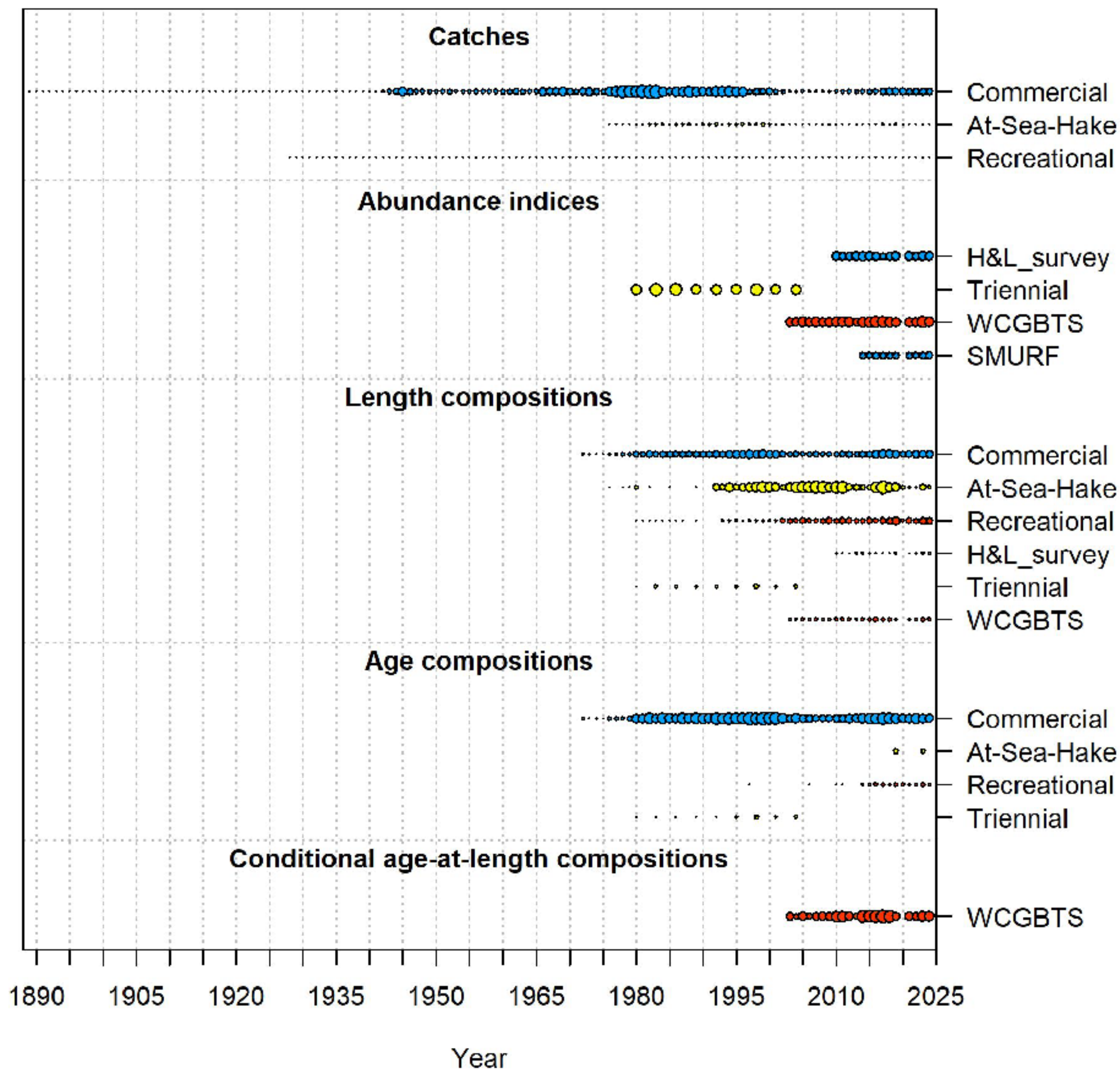

Figure 1. (Figure 7 from the pre-STAR assessment): Data presence by year for each fleet, where circle area is relative within a data type. Circles are proportional to total catch for catches; to precision for indices, discards, and mean body weight observations; and to total sample size for compositions and mean weight- or length-at-age observations.

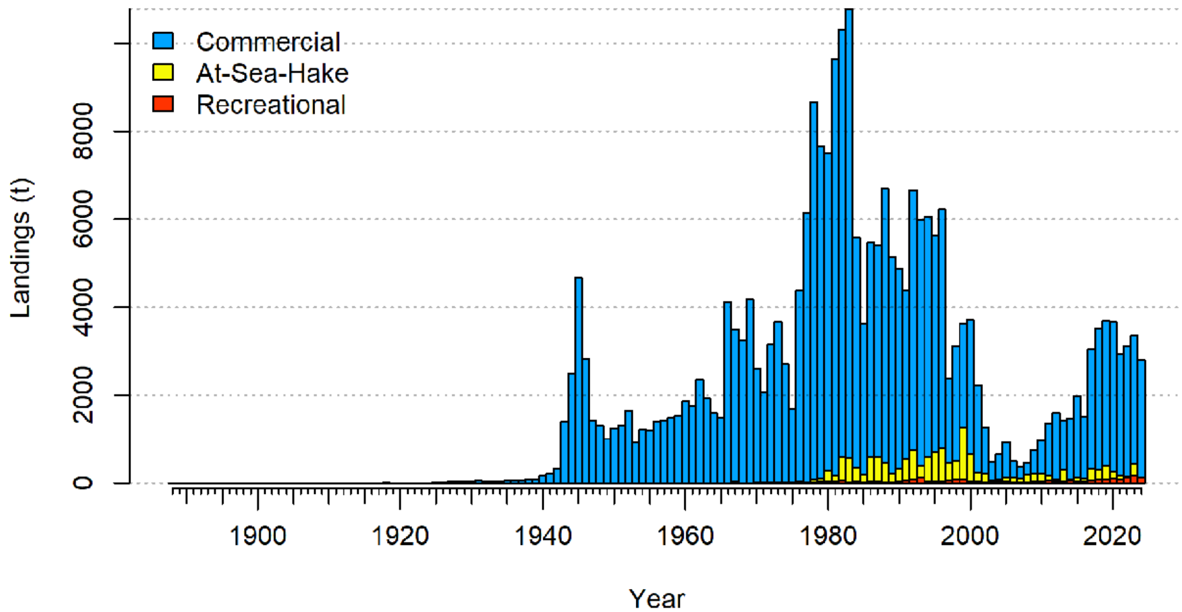

Figure 2. (Figure 8 in the pre-STAR assessment): Total catch (mt) by fleet (including discards) used in the base model.

Assessment Model

The yellowtail rockfish assessment model, implemented in Stock Synthesis version 3.30.23.1, is age and sex structured with 140 estimated parameters (Table 1), most of which are recruitment deviations (105).

Population dynamics: The model starts in 1889 when the population abundance and age structure are assumed to be at unfished equilibria. Each year age 0 fish are recruited into the population using a Beverton-Holt stock-recruitment relationship, parameterized with unfished recruitment (R_0, estimated as ~37 million recruits), steepness (h, fixed at 0.718), and the standard deviation of log-recruitment deviations (σ_R, fixed at 0.5). In each subsequent year sex-specific natural mortality is applied to the cohort (M, estimated as 0.157 for females and 0.136 for males), where natural mortality is assumed to be constant across ages and years.

Growth: Growth is assumed to follow a sex-specific von Bertalanffy relationship. Parameters include mean length at maximum age (L_∞, estimated as 54.5 cm for females and 46.3 cm for males), the growth coefficient (K, estimated as 0.143 for females and 0.203 for males), the length at age 2 (L_{min}, estimated as a single parameter for both sexes as 14 cm), the CV at young ages (estimated as a single parameter for both sexes as 0.113) and the CV at older ages (estimated as 0.0406 for females and 0.0537 for males).

Selectivity: Catch is apportioned to ages using fishery- and survey-specific length based selectivity functions (the double normal model). Asymptotic selectivity (shared by sex) was assumed for the commercial fishery, at-sea hake fishery, triennial survey, and WCGBTS, while dome-shaped selectivity was applied to the hook and line survey (shared by sex) and recreational fleet (sex specific). To account for changes in the fisheries, parameters were estimated for two time blocks in the at-sea hake fishery and three time blocks in the recreational fishery.

Reproduction: The number of eggs feeding into the stock-recruitment function is derived by estimating the number of females that are mature at each age, translating these to lengths using the growth function, and applying a length-fecundity relationship. The parameters for the age at maturity, and fecundity relationships are estimated outside of the assessment model.

Likelihood: The likelihood included terms for the survey-based indices and the survey and fishery specific age, length and age at length data. Sample size for the commercial fishery age and length data was based on the equation $N_{trips} + 0.138 \times N_{fish}$ (if $N_{fish}/N_{trips} < 44$), otherwise $7.06 \times N_{trips}$. For the at-sea hake fishery sample size was set to the number of hauls, and number of fish was used in the recreational fishery. For the WCGBTS age at length and hook and line length data, the number of fish in each composition vector was used as sample size, and other survey-based age and length data sample sizes were set to 2.43*tows. In addition to these adjustments to sample sizes, the different data sources were reweighted using the Francis method. Data weighting played an important role in this assessment and received significant attention in the assessment report and the STAR panel review process (see Requests, 3, 7 and 12).

Table 1. (Table 24 in the pre-STAR assessment): Estimated parameters in the model.

Type	Count
Natural Mortality (M)	2
Growth mean	5
Growth variability	3
Stock-recruit	1
Rec. dev. time series	93
Rec. dev. Forecast	12
Index	4
Size selectivity	14
Size selectivity time-variation	6

Requests by the STAR Panel and Responses by the STAT

The panel made the following requests of the STAT to further evaluate the model and trends observed. Requests 1, 2, 6, 10 and 11 were in part posed to address public comment using the available data, and helped test hypotheses related to the distribution, abundance and model fits. Figure references in request narrative are noted from the pre-STAR assessment document; STAT response Figures are incorporated sequentially within this report.

Request No. 1: Compare length and age composition by sex between the midwater trawl fishery since resumed access to deeper depths (for 2017 and onward) and the West Coast Groundfish Bottom Trawl Survey (WCGBTS) composition as in Figure 42 and Figure 20.

Rationale: Determine whether the fish presumably encountered over rocky reef between data sources are of comparable size and age to the fish sampled by the WCGBTS. This will help resolve whether there might be some hidden biomass over rocky reef observed in the midwater fishery that the WCGBTS cannot access with bottom trawl gear.

STAT Response: Length and age distributions are generally similar between the bottom trawl survey and midwater trawl gear used in the commercial fishery. This is consistent with the similarity between a comparison of bottom trawl gear and midwater trawl gear in the commercial sector.

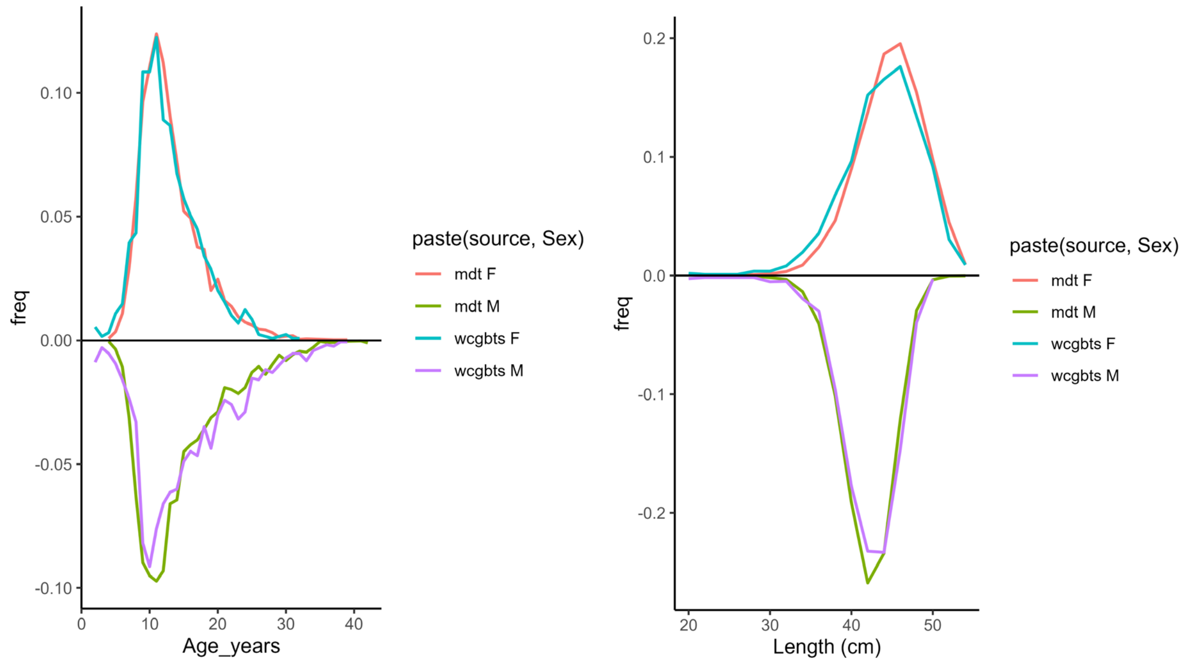

Figure 3. Frequency distribution of males (bottom) and females (top) in the WCGBTS (all years) and midwater trawl commercial fishery (2017-2024) for ages (left) and lengths (right). Distributions are normalized independently for males and females, so not representative of sex ratios.

Panel Conclusion: The lack of consistently larger fish in the fishery would indicate that they are also available to the WCGBTS.

Request No. 2: Implement an alternative time blocking on selectivity for the commercial fleet with three time blocks; prior to 2000 or 2003 (depending on shifts in composition observed) with asymptotic selectivity, 2000 or 2003-2016 (with domed and asymptotic selectivity), and 2017 to present with asymptotic selectivity.

Rationale: The time blocking may improve the fit to the length and age composition data source over time. In 2000, vessels using bottom trawl footrope >8 inches were prohibited from retaining shelf rockfish species (which included yellowtail rockfish). In 2002, the trawl Rockfish Conservation Areas (RCAs) were established off all three states (Washington, Oregon, and California). However, there were some allowances for midwater trawl vessels to fish within the "no trawl" Darkblotched Conservation Area (DBCA) for midwater rockfish such as yellowtail and widow. In 2017, the trawl gear Experimental Fishing Permit (EFP) went into effect to monitor and minimize salmon bycatch when vessels target rockfish in the Individual Fishing Quota (IFQ) fishery. This was expanded in 2018 to include year-round midwater trawl targeting midwater stocks. Additionally, the canary rockfish (a co-occurring species) ACL increased in 2017 following the 2015 canary rockfish stock assessment.

STAT Response: Using three selectivity blocks (start to 2001, 2002 to 2016, 2017 to 2024) slightly improved fits to commercial age and length data (8.2 units of negative log-likelihood improvement in the age data and 5.3 for the length data). The unfished spawning output and terminal spawning output are nearly identical, though the trajectories are slightly different. The middle time block selects slightly larger fish, but selectivity in the first and third block is nearly identical. Overall differences in selectivity among blocks are more muted than they were for the selectivity blocks in the candidate base model (recreational and at-sea hake fleets only).

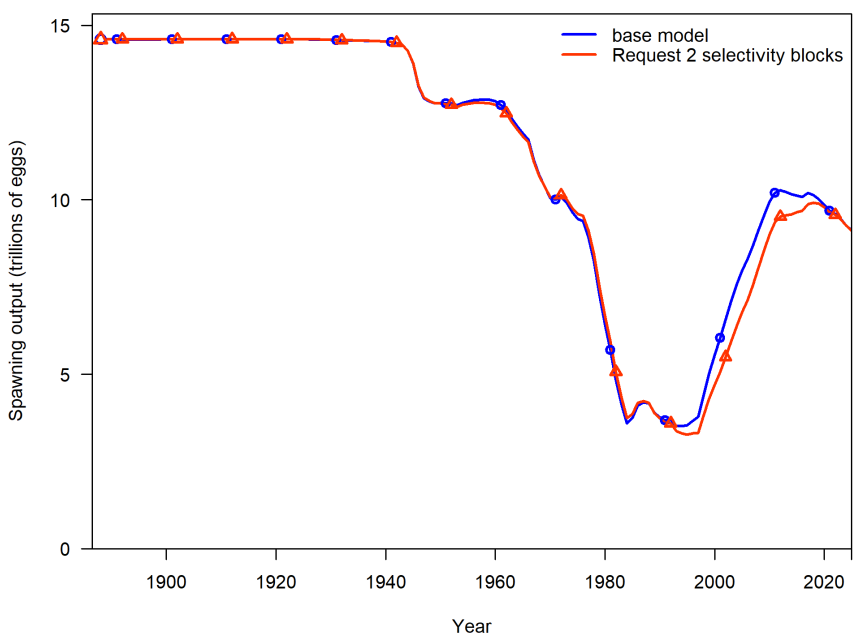

Figure 4. Spawning output time series for base model (blue) and model with updated commercial selectivity blocks (red).

Panel Conclusion: The lack of improved fit to composition data or implications for spawning output indicates the model is not substantively improved by time blocking, while adding parameters. In the interest of parsimony, the time block is not essential to include.

Request No. 3: For the base model, the model with fishery length data removed, and the model with survey indices removed, provide a table of input sample size, data weight, and adjusted input sample size. Also provide time series of spawning output and relative spawning depletion. We are requesting more detail to be presented on the adjusted input sample sizes for the composition data, as a way to check on whether the composition data are appropriately weighted. This should also include any details on model runs that have dropped length composition data and/or age composition data and how this affected fits and outcomes.

Rationale: The assessment shows a substantial increase in abundance after about 2000 over a period when none of the abundance indices show material increases. This implies that the model is drawing abundance information from elsewhere, possibly from the composition data, which would not necessarily be appropriate.

STAT Response: For the base model, this information is in Table 26 of the draft report. Reweighting the two sensitivity models only results in slight changes to adjusted sample sizes. Removing the two data sources leads to some changes in spawning output and relative spawning output.

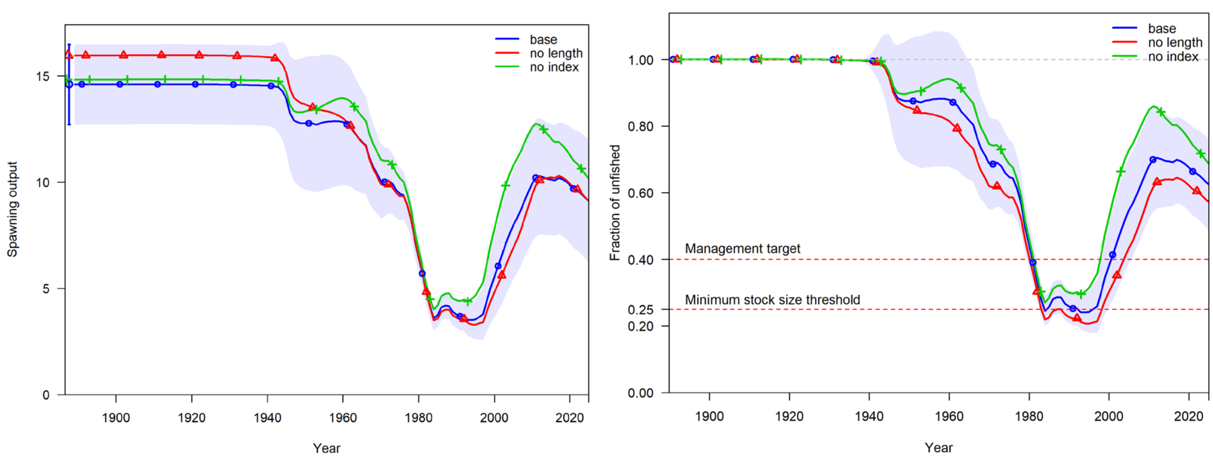

Figure 5. Spawning output (left) and relative spawning output (right) time series for base model (blue), model with no commercial length data (red), and model with no indices (green). Uncertainty interval is for the base model.

Panel Conclusion: The removal of the abundance indices from the base run has only a limited impact on the assessment outcome, with a similar trajectory but a slightly higher stock status in later years. Removal of the length compositional data similarly has a limited impact on the assessment outcome, with a similar trajectory but a slightly lower stock status in later years.

This suggests that the model is insensitive to both the abundance index data and the large quantity of length data used in the base run. The model is therefore relying on either the age data alone, the model assumptions alone, or a combination of the age data and model assumptions.

Request No. 4: Present a comparison of the Canadian recruitment and trawl survey index for discussion.

Rationale: This was not discussed during the presentation and it would be good to see how well they compare.

STAT Response: Comparisons to Canadian time series from their most recent assessment (Canadian Science Advisory Secretariat, 2025) and recruitment are in Figure 72 of the pre-STAR assessment document (Oken et al., 2025). Canadian catches have been consistently around 4000 mt (more than the U.S. fishery) since the mid-1980s. The Canadian trawl survey index is fairly flat and does not contain the same increase and decrease as the U.S. trawl index.

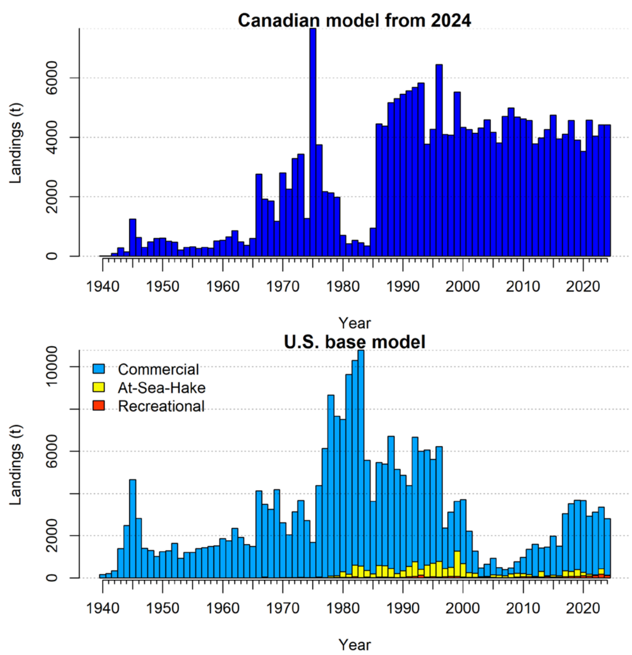

Figure 6. Catches for the Canadian model (top) and U.S. model (bottom).

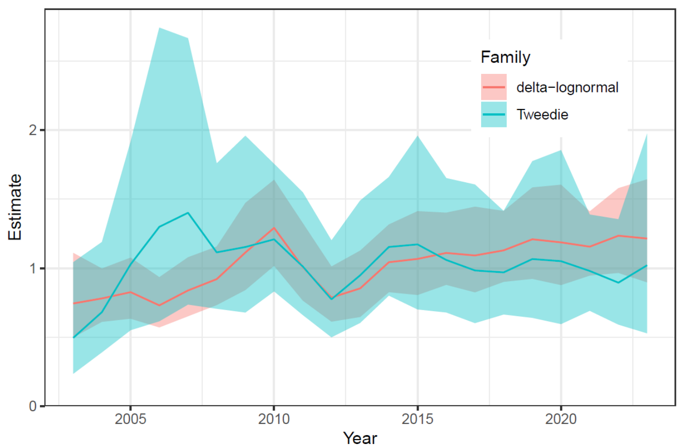

Figure 7. Model-based index for Canadian trawl survey. The delta-lognormal model (blue) is preferred based on diagnostics.

Panel Conclusion: Similar trends were observed between the U.S. and Canadian recruitment and fraction of unfished biomass, with a decline in the 1970s and 80s, and an increase in the 2000s. The fraction unfished biomass was lower in Canada, never dropping below 50%. Since 1986 the Canadian catch has remained consistently high and their fraction unfished biomass has remained relatively stable.

Request No. 5: What evidence exists pertaining to stock structure, including for yellowtail rockfish in Canadian waters and the Gulf of Alaska?

Rationale: The current assessment makes a strong assumption of the spatial extent of the stock. This is supported by evidence from the southern boundary but not for the northern boundary. This is key to understanding aspects of the uncertainty of the assessment, particularly if the assessment is of a partial biological population, etc.

STAT Response: The main source on genetic differentiation in yellowtail rockfish Hess et al. (2011) does not indicate any break near the U.S.-Canada border.

Hess et al. 95

Fig. 3. Individual assignment values from the Structure analysis using microsatellite data and a cluster setting of $K = 2$. The collections are depicted on the *x* axis and posterior probabilities along the *y* axis. The location of Cape Mendocino is indicated between collections 8 and 9.

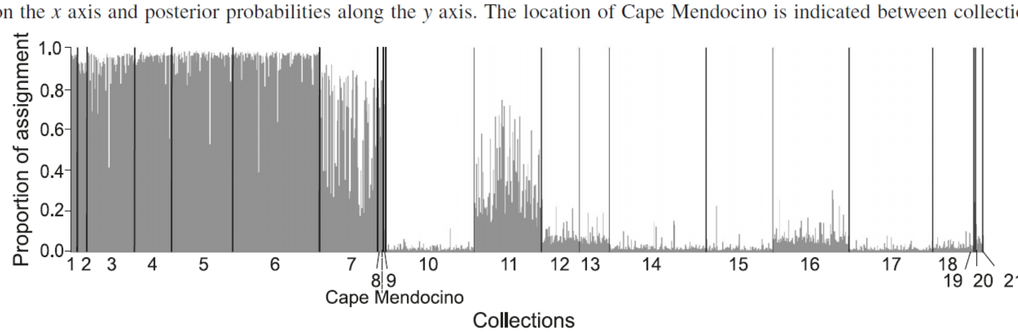

Fig. 8. Figure 3 from Hess et al. (2011) illustrating genetic break of yellowtail rockfish at Cape Mendocino, and lake of genetic differentiation near the U.S.-Canada border.

Panel Conclusion: There does not appear to be genetic structure across the U.S./Canadian border. This suggests a transboundary stock may be present and would support a transboundary stock assessment in the future.

Request No. 6: Implement an alternative time blocking on selectivity for the commercial fleet with three time blocks; prior to 2002 (depending on shifts in composition observed) with asymptotic selectivity, 2002-2010 (with domed and asymptotic selectivity), and 2011 to present with asymptotic selectivity.

Rationale: The time blocking may improve the fit to the length and age composition data source over time. In 2002, the trawl Rockfish Conservation Areas (RCAs) were established off all three states (Washington, Oregon, and California). However, there were some allowances for midwater trawl vessels to fish within the "no trawl" Darkblotched Conservation Area (DBCA) for midwater rockfish such as yellowtail and widow. In 2011, the Individual Fishing Quota (IFQ) trawl fishery was established. This change in the time block will also encompass the midwater rockfish trawl fishery that started to catch more yellowtail rockfish in 2013 due to an increased widow rockfish Annual Catch Limit (ACL). This increase in yellowtail rockfish catch across the U.S. West Coast (including south of 40° 10' North Latitude) by commercial sector across time is shown in Figure 1. While this figure includes catch from outside the scope of this stock assessment, the midwater rockfish targeting occurred in Washington and Oregon, so the increases in the Midwater Rockfish and Midwater Rockfish - Electronic Monitoring (EM) sectors shown in Figure 1 are relevant to this stock assessment.

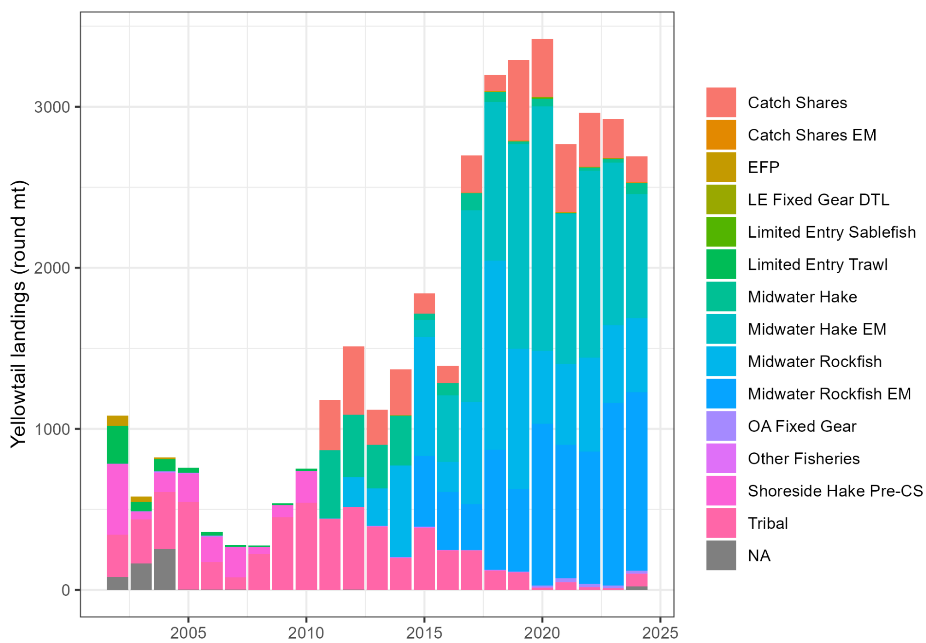

Figure 9. Yellowtail rockfish commercial landings from 2002-2024 in metric tonnes broken out by sector using Fishery Observation Science (FOS) sector codes. Note that this includes yellowtail rockfish catch from south of 40° 10’ North Latitude, which is not in the scope of this stock assessment.

STAT Response: While the population trajectory was more sensitive to this time blocking than the time blocking for request 2, request 2 had a better fit to the data as measured by the likelihood (e.g. index fit was better by 1.5 units of negative log-likelihood in request 2 and worse by 0.2 units in request 5).

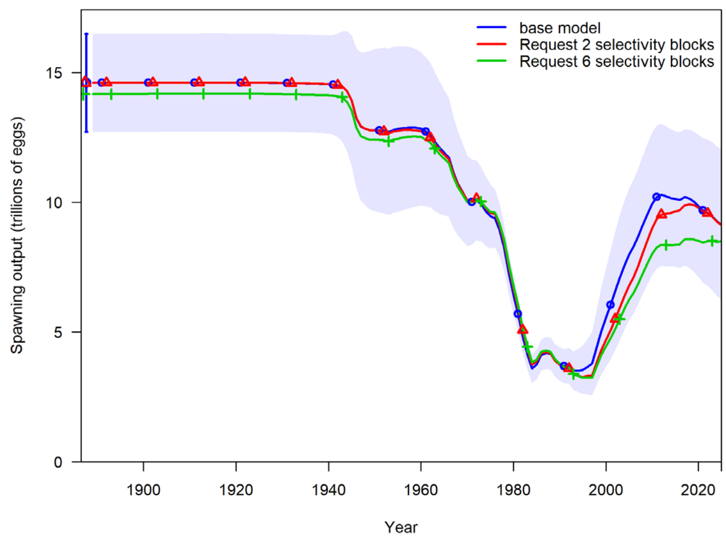

Figure 10. Spawning output time series for base model (blue) and models with commercial selectivity blocks based on Request 2 (red) and this Request (green). Uncertainty interval is based on the base model.

Panel Conclusion: The fit to the commercial length data was not appreciably improved by time blocking, thus the base model is preferred.

Request No. 7: For the base model, reduce all composition weights by a large amount (e.g., 90%). Show model fits to indices and composition data, and spawning output and spawning depletion time series**.**

Rationale: Desire to explore potential conflicts between the indices and compositional data, and the impacts on quality of fit and stock trajectory.

STAT Response: Down-weighting composition data by 90% leads to a slightly increased unfished spawning output, lower terminal spawning output, and a more substantial decrease in terminal relative spawning output. Fits to the survey likelihood improved, but not visibly so. Fits to composition data are visibly similar. Also included in this comparison is the sensitivity upweighting the WCGBTS (CV set to 0.05) which resulted in more dramatic changes to the trajectory in a similar direction as downweighting composition data. Terminal spawning depletion is near the minimum stock size threshold. The fits to the trawl survey index are visibly improved, but still miss the magnitude of the increase in the late 2010s.

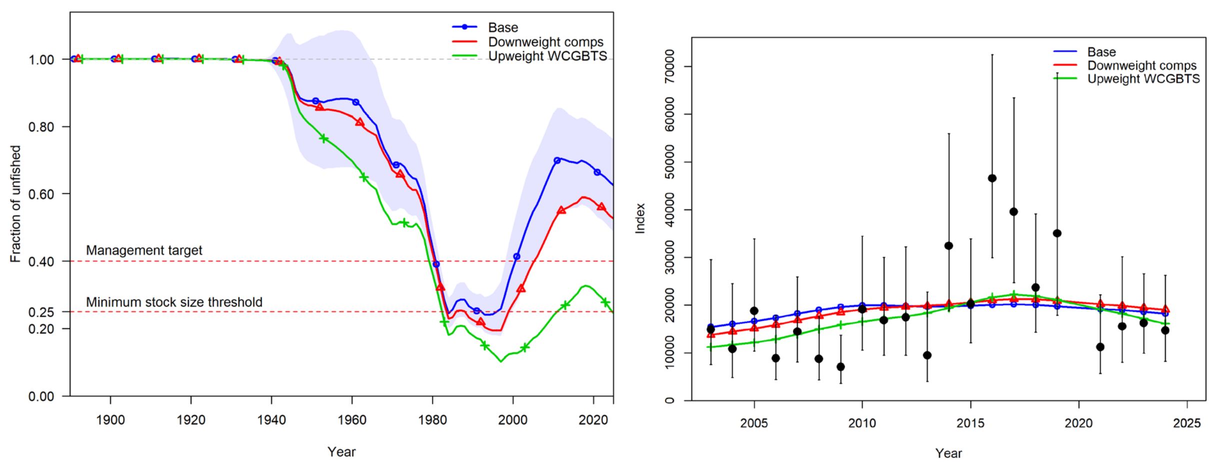

Figure 11. Left: relative spawning output for the base model (blue), model with all composition data downweighted 90% (red), and model with log standard errors (SEs) for the WCGBTS reduced to 0.05, effectively upweighting the survey (green). Right: Fits to the WCGBTS index (with 95% intervals based on base model input SEs) for the same three models.

Panel Conclusion: The alternative weighting did not lead to a material degradation in the fits to the composition data, suggestive that the base model does overweight the composition data. This did not improve the fit to the high CPUE values from the WCGBTS. Though the likelihood of the model improved with Request 7, the nature of the survey is a bottom trawl unable to access rocky reef making representation of the stock uncertain, thus the base model result was retained rather than downweighting the composition data or upweighting of the survey. The result also supports the view that there is limited information in the survey on yellowtail rockfish biomass. Future research should investigate the environmental drivers that may be affecting interannual variation in the index values affecting catchability given conflicts with the composition data.

Request No. 8: Provide more information on the relative abundance in the WCGBTS by year north and south of the Columbia River.

Rationale: To begin an evaluation of variability in relative abundance across time in the respective strata given the apparent variation in distribution of the stock within the assessment area.

STAT Response: The WCGBTS used for yellowtail rockfish has spatial blocks north and south of Cape Mendocino, California. For multi-region models, indices are not interpretable other than the split used in the model. To investigate the variation in distribution of the stock relative to the

Columbia River, we fit a new sdmTMB model to the WCGBTS data that had state-specific blocks in order to compare the temporal variability of the index north and south of the Columbia River. The index of abundance for Washington is approximately 90% of the total Oregon and Washington abundance. The two indices were more synchronous than anticipated, both state indices had an increasing trend from 2008 - 2015 and a decreasing trend from 2017 - 2024. Over these time periods, the index for Oregpm increased and decreased steeper than Washington. Given the observations shared during the public comment on day 1, we expected there may be an increase in abundance in Washington relative to Oregon reflecting fish migrating north as they age, as a possible explanation for the increases observed in Washington not represented in the WCGBTS. This evaluation of state-specific abundance based on WCGBTS did not support this hypothesis, and instead indicated that changes in abundance were actually similar in Washington compared to Oregon, although fish are more abundant in Washington.

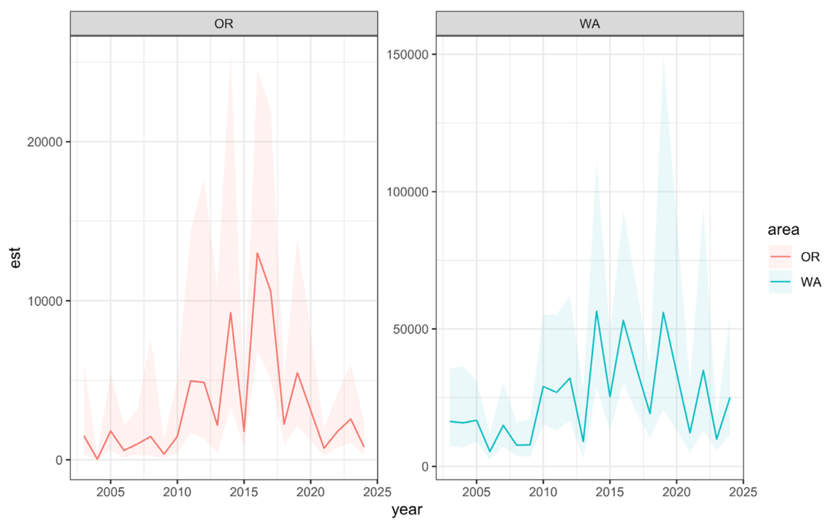

Figure 12. WCGBTS state-specific index of abundance for Oregon and Washington. Note the y-axis for both indices represent different scales.

Panel Conclusion: The Washington area had much higher CPUE, but both reflected similar trends of increase and decrease over time, although the scale of change in Oregon was relatively much greater than that seen for Washington.

Request No. 9: Provide more information on the approaches used to develop a midwater (and other) commercial CPUE time series.

Rationale: The panel is seeking to explore the availability of alternative indices that may be more informative than the current fishery-independent indices.

STAT Response: The data included and the standardization procedure are described in Section 2.1.4.1 of the draft pre-STAR assessment document. Alternative indices considered under this request include 1) a model fit for a subset of vessels that more frequently encounter yellowtail rockfish, which includes a vessel specific spline for Julian day (common boats), 2) a model that only includes tows in Washington where vessels are more likely to be targeting yellowtail rockfish, 3) a model that only includes tows in September-December when fishermen say they are more likely to be targeting yellowtail (fall), and 4) a model that includes an effect for before or after constraints on widow and canary rockfish were lifted in 2017 (2017 flag). The indices are variable, but generally align with the increase and decrease from the WCGBTS index. The index with the flag for before or after 2017 is least variable. However, this model also has year modeled as a hierarchical random effect rather than a fixed effect, because the fixed effects are confounded with the 2017 flag and cannot all be estimated. Thus, less interannual variability would be expected from the index based on the model with the 2017 flag.

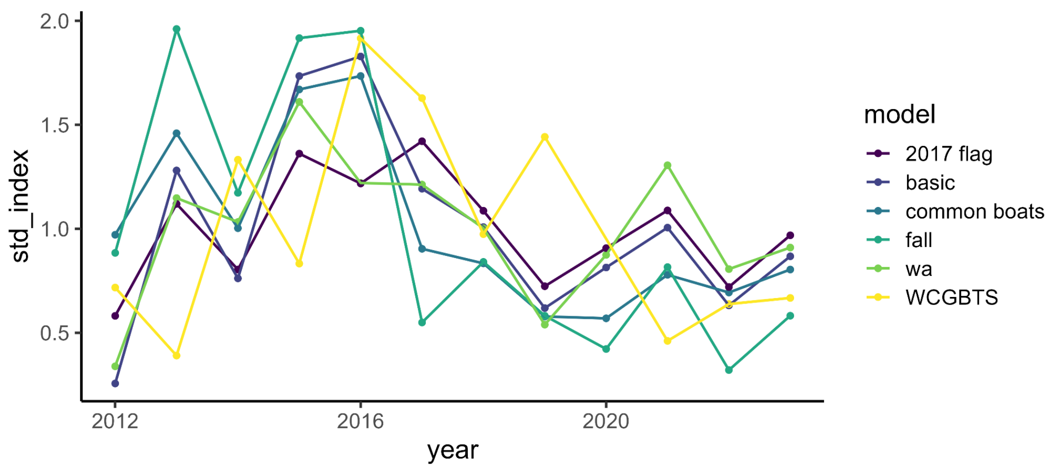

Figure 13. Candidate commercial midwater rockfish CPUE indices for various model-based indices (lines are described in text).

Panel Conclusion: The trends in this midwater commercial CPUE time series are similar to those of the WCGBTS, thus the same considerations concerning fit to high values are likely to apply if the WCGBTS was supplanted by the midwater commercial CPUE index. The conflicts with length data in attempting to fit either survey may not be resolved.

Request No. 10: Plot, for each year, the cumulative proportion of the catch limit attained across the year for bottom trawl and midwater trawl trips.

Rationale: To see if fish are easier to catch in different years to evaluate consistency with the observations of fishermen provided in public comment.

STAT Response: The rate of attainment varies through the year but there are no notable patterns. Attainment has been higher overall since 2017, likely a management effect. The rate of attainment through the year is consistent with the Julian day spline estimated in the CPUE standardization, which implies that CPUE is highest in the summer (day 200 is July 19).

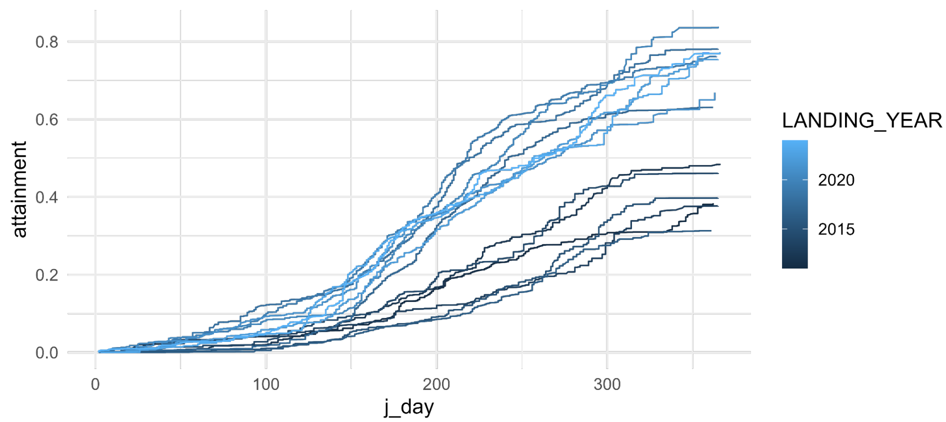

Figure 14. Attainment of the total annual ITQ allocation through the year by Julian day (j_day). Catches include both targeted (e.g., midwater rockfish) and non-targeted (e.g., shoreside hake, bottom trawl) trips.

Panel Conclusion: Though there is a shift to higher rates of accumulation of catch in 2017 with the liberalization of catch limits for constraining co-occurring species canary and widow rockfish that recently rebuilt, in recent years the rates of accumulation have not increased as would be expected if the biomass were increasing in the last few years as noted in public comment.

Request No. 11: Rerun the model with the commercial CPUE index in place of the WCGBTS. Show the fit to the commercial index and pertinent diagnostics.

Rationale: The model was unable to fit high CPUE values from the WCGBTS and although they have a similar trend, investigation of the ability of the model to fit this trend in the commercial index can be explored.

STAT Response: The model had similar fits to both the CPUE index and the WCGBTS. Both indices produced similar estimates of spawning output. Both the CPUE index and WCGBTS indicated an above average period in 2014 - 2018 (see Request 9 response) and the model had poor fits to this period for both indices. We note the uncertainty for the CPUE index in that period was greater, and the fits were in the 95% confidence interval for 2015 - 2017.

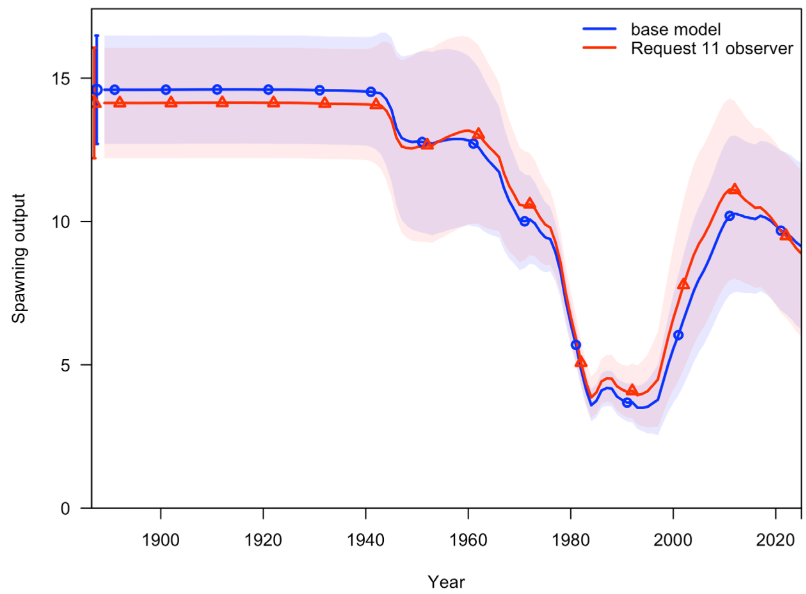

Figure 15. Time series of spawning output for the base model (blue) and the model replacing the WCGBTS index with the commercial CPUE index (red).

Panel Conclusion: The trends in spawning output resulting from the inclusion of each index do not differ appreciably between the WCGBTS and the mid-water trawl fishery apart from the peak in 2015. This would indicate the survey and fishery are providing similar information to the assessment. Neither index observed substantial increases in abundance in recent years as would be expected if abundance were increasing in recent years. Comparing the index values from WCGBTS and the observer survey over time they both increase during the period 2014-2018, but the model does not fit well to either. The increase in the index values may be the result of the distribution of biomass during the marine heat wave or other systemic changes in availability or random sampling variability as the model is not able to fit the increase given tension with composition data.

Request No. 12: Rerun the model using the fishery-independent index combinations below.

1. WCGBTS, H&L, SMURF
2. Triennial, H&L, SMURF
3. Triennial, WCGBTS, SMURF
4. Triennial, H&L, WCGBTS
5. Triennial
6. WCGBTS
7. H&L

Rationale: This will allow for the testing of the sensitivity of the model to each index.

STAT Response: The impact of removing the indices in different ways was relatively small for each of the combinations requested (figure below left). The biggest changes came from removing the WCGBTS, the next biggest changes came when the Triennial was removed, and third biggest changes came from removing the Hook and Line index. The uncertainty in estimated spawning output increases significantly when both trawl surveys are removed, leaving only the Hook and Line and SMURF indices, or when all indices are removed (figure below right).

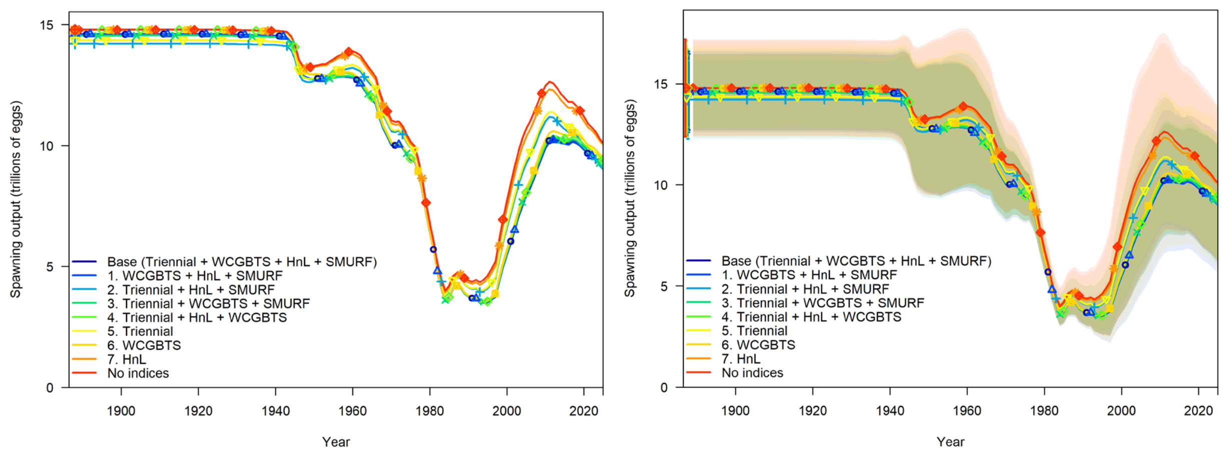

Figure 16. Time series of spawning output without 95% confidence intervals (left) and with intervals (right) for base model (blue) and various permutations of removing indices (other colors).

Panel Conclusion: The results are broadly similar in trajectory and scale, and provide information on how influential the respective indices are on the model. The WCGBTS is a longer time series and is slightly more influential on model results and prevents the model from showing a strong peak then decline in abundance later in the time series in its absence.

Request No. 13: Explore alternative models to inform decision tables such as those based on R_0, natural mortality or data weighting alternatives between the WCGBTS and the composition data, as well as McAllister-Ianelli as opposed to Francis data weighting. Provide the range of spawning output and relative depletion over time. Examine the fits and outputs to ensure the resulting models are feasible.

Rationale: Unfished recruitment (R_0) and natural mortality (M) display a wide range of spawning output of parameter values in explored sensitivities and the alternative weighting provides information on uncertainty from model structure.

STAT Response: Three low and three high candidate states of nature were provided based on the guidance in the Terms of Reference (quoted below).

One method bases uncertainty in management quantities for the decision table on the asymptotic standard deviation for the OFL in the final year of the model from the base model. Specifically, the current year spawning biomass for the high and low states of nature are given by the base model mean plus or minus 1.15 standard deviations (i.e., the 12.5th and 87.5th percentiles). A search across fixed values of log(R_0) are then used to attain the current year spawning biomass values for the high and low states of nature.

The asymptotic standard deviation for the 2025 OFL from the base model was 0.186 and the point estimate of the 2025 OFL was 5440 mt. The associated 12.5th and 87.5th percentiles were 4392 mt and 6739 mt. Model runs from the likelihood profiles for log(R_0) and M were explored to find the steps in the profile for which the OFL values best matched these two values. The resulting models had log(R_0) = 10.25 and 10.75, and M = 0.14 and 0.175. The model with down-weighted composition data from request 7 and the model with up-weighted composition data from the sensitivity analysis where the McAllister-Ianelli data-weighting was applied were also considered as candidate states of nature.

Among the proposed options, the log(R_0) and M states had very similar results (figure below left) while the upweight comps model was higher than the other high-state alternatives. The catches from the default harvest control rule (P* = 0.45, sigma = 0.5) applied to the based model to calculate forecast catches which were input as fixed values to a subset of the candidate states of nature (figure below right, note different colors for same models than the figure at left). The low and high M models were so similar to the low and high log(R_0) models so they were not included in the projections. These projections showed that the projections for the downweight comps converged in the projection years toward the base model, suggesting that this model did not adequately represent the range of uncertainty about the stock status in the near future. Therefore, the STAT proposes the low and high log(R_0) models as the best choice for the alternative states of nature.

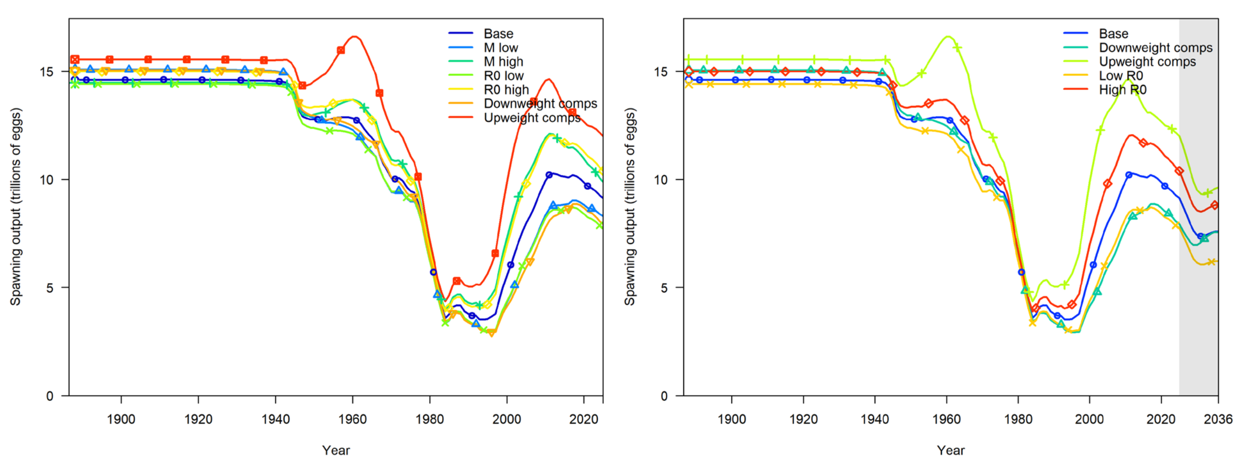

Figure 17. Time series of spawning output without (left) and with (right) forecast period. Forecast period appears in grey. The figure on the right includes a subset of the model runs from the figure on the left.

Label	Base	M low	M high	R0 low	R0 high	Down-weight comps	Upweight comps
Diff. in likelihood from base model							
Total	0	1.7	1.84	1.22	0.92	-963.711	1260.87
Index	0	-1.025	2.418	-0.744	1.531	-5.772	7.13
Length comp	0	1.416	-1.217	0.986	-0.809	-275.869	533.677
Age comp	0	1.962	-1.154	1.578	-1.097	-672.632	712.662
Recruitment	0	-0.46	1.497	-0.425	1.098	-9.657	6.683
Parm priors	0	-0.188	0.312	-0.158	0.194	-0.145	0.46
Estimates of key parameters							
Recruitment unfished	36.63	27.665	50.233	28.282	46.63	30.312	60.869
log(R0)	10.509	10.228	10.824	10.25	10.75	10.319	11.017
M Female	0.157	0.14	0.175	0.144	0.169	0.145	0.182
M Male	0.136	0.122	0.151	0.125	0.146	0.126	0.158
L at Amax Female	52.9	52.9	53	52.9	53	52.9	52.5
L at Amax Male	47.9	47.9	48.0	47.9	48.0	47.9	47.5
Estimates of derived quantities							
Unfished age 4+ bio 1000 mt	135.0	127.7	147.3	124.4	147.5	130.8	158.7
B0 trillions of eggs	14.6	15.1	14.5	14.4	15.0	15.0	15.5
B2025 trillions of eggs	9.13	8.306	9.87	7.754	10.384	7.929	12.005
Fraction unfished 2025	0.626	0.551	0.682	0.538	0.693	0.527	0.773
Fishing intensity 2024	0.638	0.744	0.548	0.762	0.546	0.746	0.45
Catchability for WCGBTS	0.329	0.377	0.288	0.39	0.284	0.411	0.231
OFL mt 2025	5440	4388	6666	4223	6701	4391	8555

Table 2. Comparisons of likelihoods, key parameter estimates, and key derived quantities, for candidate models to bracket states of nature.

Panel Conclusion: Natural mortality is not the most uncertain parameter and others may provide a more reasoned axis of uncertainty. While *M* and R_0 provide similar ranges of values in spawning output and are correlated parameters, *M* is expected to be more consistent than R_0. Downweighting and upweighting composition data provides a range of spawning output reflective of the structural differences in the assessment. The R_0 provides the broadest range of spawning output. Downweighting of comps is similar to low R_0 but the downweighting composition converges with the base model in projections of spawning output, therefore R_0 may provide a more reasoned basis for the primary axis of uncertainty. Alternative means of estimation the range of values from the TOR from the axis of uncertainty provides a narrower range than provided by the presented range for R_0 and remains the preferred basis for the axis of uncertainty. The results for R_0 captures a similar range of spawning output observed from upweighting and downweighting of composition, and can be more easily derived as described in the TOR, further supporting its use as the preferred basis for the axis of uncertainty.

Request No. 14: Compare the trends in the WCGBTS index for yellowtail rockfish to those for canary and widow rockfish stratified at 40°10' N. lat..

Rationale: The comparison may provide an indication as to whether there may be environmental influences contributing to the increased index values in the mid 2000s.

STAT Response: We find similar trends across the three midwater species (yellowtail, canary and widow rockfish) with elevated indices of abundance during the 2014 - 2019 time period, this was observed in both a coastwide and N. of Cape Mendocino indices. This increase was most dramatic for yellowtail, but present across all three species. This indicates there may be some environmental or ecological driver increasing the catchability of midwater species during this period which may explain the differences between the index and composition data. More research is necessary to understand what is driving this variability to justify accounting for this in the model.

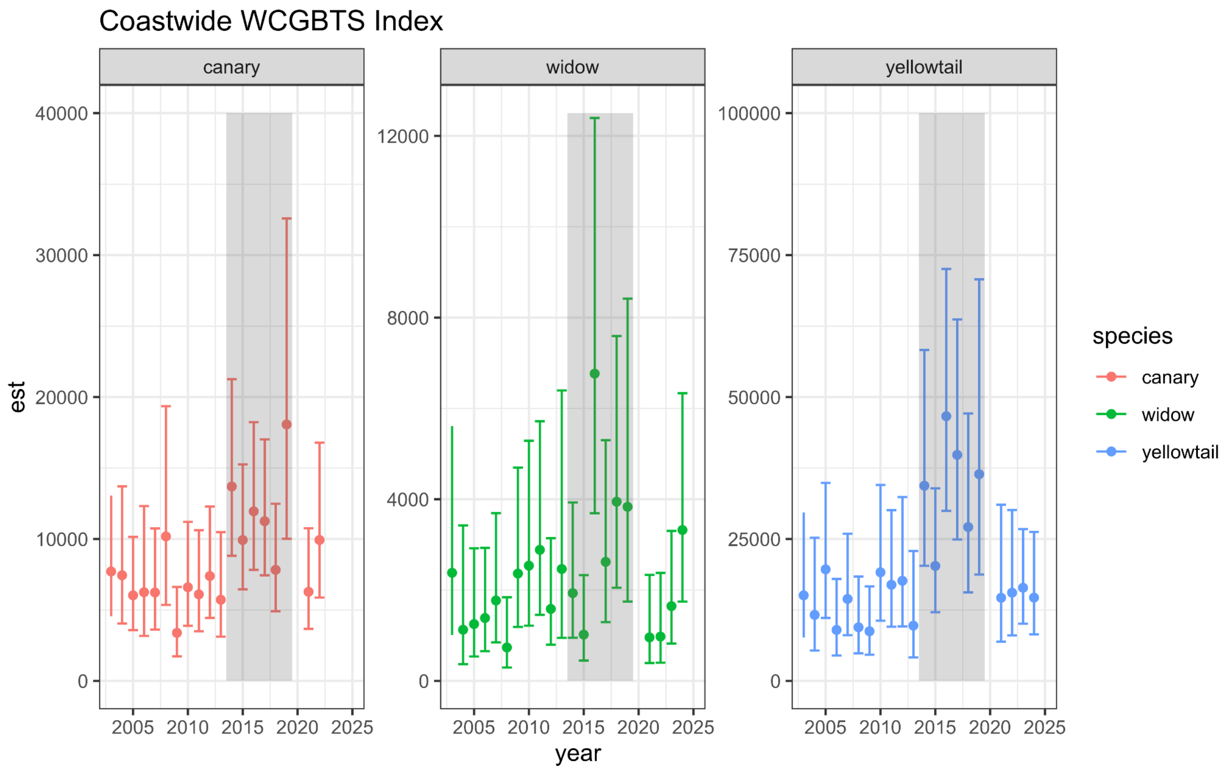

Figure 18. Coastwide WCGBTS indices for canary, widow, and yellowtail rockfish. The gray box covers the period of elevated index values for yellowtail rockfish that also coincides with a marine heat wave. Note that the canary rockfish time series is from the 2023 canary stock assessment, and ends in 2022. Widow and yellowtail indices go through 2024. Y-axis scales vary by panel.

Panel Conclusion: There is a consistent pattern of elevated index values among species. This suggests further research into the potential cause should be added to the research and data needs. Alternative methods to fit the elevated values through time blocking on catchability or accounting for environmental drivers as a variable in the model if the driver is identified may be pursued in the future to develop a generalized approach to improving the fit to the index during this time period.

Request No. 15: Provide a decision table using R_0 as the primary axis of uncertainty based on the catch time series reflecting full attainment as required by the TOR, as well as alternative catch projections based on recent catch and attainment to bracket the range of catch alternatives in the decision table.

Rationale: This will help compose the basis for the catch time series in the decision table.

STAT Response: A decision table showing two catch streams calculated from the base model and applied to the low and high states of nature was presented to the panel. The alternative catch stream proposed by the GMT representative was 55% attainment of the default harvest control rule ACL. The percentage is approximately equal to the average attainment over both the 2022-2024 period and a slightly longer range covering 2020-2024. Figures showing the projections were also provided (full attainment of ACL at left, 55% attainment at right).

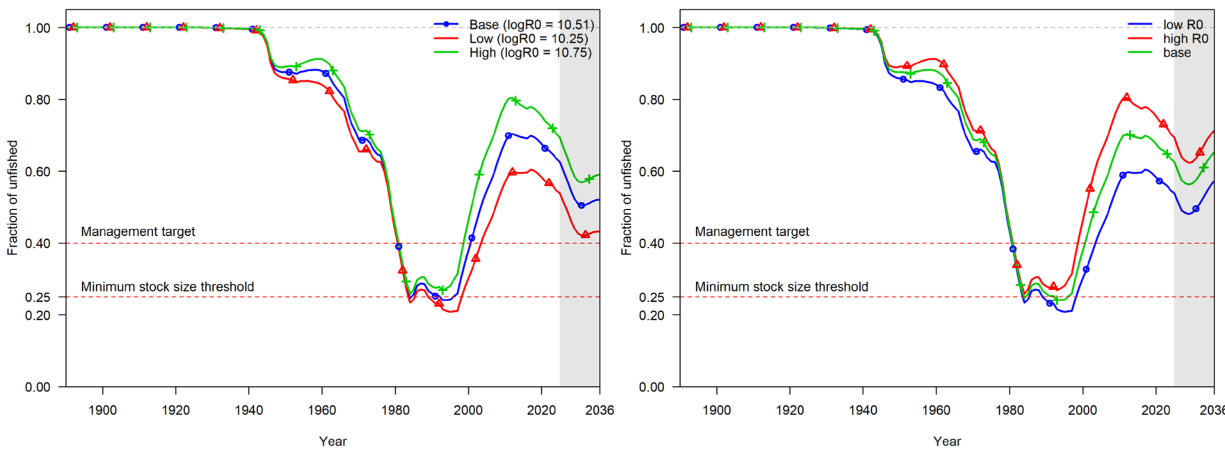

Figure 19. Time series of fraction of unfished spawning output assuming full attainment of the ACL (left) and 55% attainment (right) for the base model and high and low states of nature.

Panel Conclusion: The use of R_0 as the basis for the primary axis of uncertainty provides an adequate range of results to inform decision tables.

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

The base model proposed by the STAT was developed in Stock Synthesis (v 3.30.23.1) and, after some testing of alternative and sensitivity runs, was agreed by the Panel. Spawning output was the key population measure estimated, with 1-SPR equivalent to *F*.

The base model included the following:

<u>Structure:</u>

- One area, North of 40° 10' N. to the US-Canada border.
- Two sex.
- Three fleets (commercial, at-sea hake, recreational).
- Model starts in 1889, with an assumed unfished population and equilibrium age structure.

- Model end 2024.
- Maximum age 40 years.
- Population 1 cm length bins, 1 to 65cm.
- One season.
- One growth pattern.
- Data lengths 2 cm bins, 20 cm-56 cm.
- Age data were annual, with years 1 to 30.
- Maturity was age-based, a change from the 2017 assessment where this was length-based.

Parameters:

- Fixed Beverton & Holt steepness, *h*, = 0.718, the same value as used in the 2017 assessment.
- Sex-specific, fixed (i.e. constant) values for *M*, were estimated. Judging from the likelihood profiles, the information about *M* in the data is more informative than the prior.
- Fecundity was also the same as applied in the 2017 assessment, and used the relationship from Dick et al. (2017), with spawning output in trillions of eggs (10^9) for an individual estimated at 1.1185×10^{-11} *$\text{length}^{4.59}$.
- Von Bertalanffy growth was assumed, supported by adequate data.
- Fourteen size selectivities for fleets and surveys were used, with some time-varying.

Data:

- Four fishery-independent abundance indices:.
  - West coast groundfish bottom trawl survey (WCGBTS) for 2003–2024.
  - Triennial bottom trawl survey for 1980–2004.
  - SMURF index, used as a recruitment index for 2014–2024.
  - Combined areas (Oregon and Washington) hook and line survey (numbers of fish) for 2010–2024.
- Catch data for the area from 40° N. lat. to the US-Canada border from 1989 to 2024. Catch data were composed of reported commercial landings plus discards data, and estimates from the recreational fishery. Discard data were estimated from various sources and added to the catch reports. Discards were added to catch rather than modelled using retention.
- Age composition data from the target commercial fishery from 1972 to 2024, the recreational fishery from 1997-2024, the at-sea hake fishery in 2019 and 2023, and from the Triennial survey.
- Age-at-length composition data from the WCGBTS.
- Length composition data from the fisheries were available from 1972-2024 (commercial fleet), 1977-2024 (at-sea hake), and 1980-2024 (recreational), as well as from three surveys: WCGBTS, Triennial, and hook and line. Composition data were reweighted using the Francis methodology.

Numerous sensitivity runs were conducted, these included:

- Removing all indices
- Removing SMURF index
- Adding the WCGOP commercial CPUE index
- Adding an oceanographic index
- Adding an Oregon recreational CPUE index (ORBS), with varying amounts of SEs
- Adding an RREAS (absolute recruitment) index
- Upweighted WCGBTS index
- Estimated *M* for specific age groups by sex
- Estimated shared *M* for males and females
- No sex selectivity
- Time-varying weight-length relationship for years with WCGBTS data
- Hybrid *F* method (treats *F* as a continuous rate)
- Estimated density-dependent WCGBTS catchability parameter
- Alternative compositional data reweighting (McAllister & Ianelli)
- Remove all lengths from fishery data
- Add unsexed commercial data

The STAR panel also requested some additional sensitivities, which are described in the '*Requests'* by the STAR Panel above.

Technical Merits of the Assessment

The Panel found a number of merits to the assessment:

- The assessment is data-rich, with large amounts of fisheries independent and dependent data.
- There were large numbers of age and length observations, covering shoreside, at-sea, and recreational fishery sectors.
- The age data fit well with simple selectivity assumptions.
- The assessment was informed with two long-term indices – the Triennial and WCGBTS, and two new indices – the H&L and SMURF.
- The assessment benefits from known ecosystem drivers, and data indicates that there is a strong oceanographic recruitment index.
- The risk table provides additional support and context for the assessment, with neutral ecosystem and environmental conditions and favorable data inputs and assessment model fits and structural uncertainty.
- The assessment has good agreement with a recent Canadian assessment for stocks in British Columbia.
- The assessment has well informed sex-specific estimates of natural mortality, unfished

recruitment, and growth.
- There is a good fit to composition data with simple selectivity assumptions and fleet structure.
- The model was highly stable, with most model sensitivity runs within the asymptotic confidence intervals of the base model.
- The estimate of steepness used in the model comes from a substantial meta-analysis from recent *Sebastes* species assessments.

Technical Deficiencies of the Assessment

Overall, the panel only found a few deficiencies, as listed below:

- The model does not show good fits to commercial lengths in some years.
- The fishery-independent indices of abundance are fairly uninformative.
- The use of bottom trawl surveys may not be the most reliable indices for a midwater species.
- The population likely extends into Canadian waters, but the assessment only focuses on US waters.

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 GMT advisor and the STAR panel expressed concern about the poor fit of the commercial length composition data between the years 2009-2015. This time period also encompasses a time when multiple management changes were taking place that affected the commercial bottom trawl and midwater trawl groundfish fisheries. In 2011, the Individual Fishing Quota (IFQ) trawl fishery was established. In 2013, midwater trawl vessels started targeting rockfish since the widow rockfish ACL was increased, so this led to an increase in yellowtail rockfish catch. This trend was further increased in 2017 when the canary rockfish and widow rockfish ACLs were increased following their rebuilt status designation. These increased ACLs allowed for more yellowtail catch in both the bottom trawl and midwater trawl fisheries since these are co-occurring species. To address these management changes, the STAT addressed Requests 2 and 6 with sensitivity time blocks. It was concluded that these time blocks did not substantively improve the fit to the composition length and age data, so the blocks were removed in favor of parsimony.

Members of the midwater trawl fishing fleets expressed concern during the public comment period that the assessment was showing a decrease in the population even though they see large schools of yellowtail rockfish and must modify their fishing behavior if targeting other midwater species such as widow rockfish and Pacific whiting. Participants in the midwater trawl fisheries also expressed concern about the use of the West Coast Groundfish Bottom Trawl Survey (WCGBTS) as an index of abundance within the base model since this survey uses bottom trawl gear and cannot catch yellowtail rockfish in the water column or over rocky areas that are known to be the preferred habitat. These concerns were addressed by the STAT by incorporating the combined Washington and Oregon hook and line survey as an additional index in the base model. The STAT also addressed these concerns through multiple requests by the STAR panel. First, the STAT compared the length and age composition by sex between the midwater trawl fishery and the WCGBTS composition (Request 1). Next, the STAT examined the ACL attainment rates of yellowtail rockfish for midwater and bottom trawl groundfish fisheries to see if fish were easier to catch in recent years (Request 10). The STAR panel concluded that the rates of attainment in recent years did not increase in a way that would indicate an increase in the yellowtail rockfish biomass. Finally, the STAT addressed these concerns by exploring the potential for developing a commercial Catch-Per-Unit-Effort (CPUE) index (Requests 9 and 11). However, it was determined that an accurate commercial CPUE index would require extensive effort and collaboration with the fishing fleet in order to address the complexities of the fishery including management changes, market fluctuations, targeting strategies, and other nuances. Nonetheless, the attempt at a commercial CPUE index that the STAT could develop within the constraints and timeframe of a STAR panel showed similar trends to the WCGBTS survey index. Therefore, the STAR panel concluded that the model fit was not improved by the existing CPUE index.

Unresolved Problems and Major Uncertainties

Major uncertainties:

- **Stock structure:** This 2025 yellowtail rockfish assessment is for a stock of yellowtail rockfish between 40°10' North lat. and the US-Canadian Border. There is genetic evidence that supports a stock split at 40°10' North lat.. There is no such evidence for a stock separation at the US-Canadian border, a perspective also supported by the draft 2025 Canadian yellowtail rockfish assessment (details provided by the STAT). The northern stock boundary is, therefore, a management construct not based on any biological information. The actual stock structure is therefore possibly, or even likely, to be different from the current assumption and represents a major uncertainty in the assessment. While this is noted in the assessment report, no attempt to address this was made in either the 2017 assessment or this one.

  The 2017 STAR Panel noted "*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.*", which remains true today.

- **Data weighting:** There was considerable discussion about key components about data weighting. This focused on the weighting of the composition data. The assessment included large amounts of both length and age composition data, and thus appropriate weighting was important in allowing the key abundance indices to drive the model. The initial exploration of weighting was to consider the development of the effective sample size

(Mean N adj.) and chose an arbitrary reduction in all composition weighting 90% from those used in the base case. Convergence of trajectories in the projection space argued for not including data weighting in the decision table.

- **Unfished recruitment (R_0):** Different model runs generated a range in estimates of R_0 and the range seen was a key factor in selecting R_0 as for inclusion of uncertainty in the decision table.

- **Natural mortality (*M*):** *M* has previously been considered a major uncertainty. This was not so obvious from this assessment, and the panel considered there was insufficient variability to also include *M* as an axis of uncertainty in the decision table development. Also, *M* and R_0 are correlated to some degree so including both was considered to be inappropriate.

- **Indices of abundance:** All of the time series included in the model as indices of abundance appear to have some data quality issues or concerns. For example, the key times series comes from the Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCGBTS) which is a bottom trawl survey seeking to index a predominantly midwater species and as such may have undefined inconsistencies over time and may not be a very reliable or informative index. Preliminary exploration showed that a series of relatively high abundance estimates (2014-2019) were also seen for other midwater rockfish species, suggestive of a possible environmental driver resulting in variable catchability.

Other areas of uncertainty in the assessment were considered, and two of these, the uncertainties associated with both natural mortality (*M*) and Beverton and Holt steepness (*h*) were specifically explored and were not characterized as major uncertainties for this assessment.

Recommendations for Future Research and Data Collection

The following items were identified as research and data collection needs for future assessments, in addition to maintaining the existing data sources.

- Further research into the lack of fit to the WCGBTS and tension between composition and indices.
    - Alternative methods to fit the elevated values through time blocking on catchability or accounting for environmental drivers as a variable within or outside the model if the driver is identified may be pursued in the future to develop a generalized approach to improving the fit to the index during this time period. A meta-analytical approach across midwater rockfish species reflecting an increase in the 2010s (canary, widow and yellowtail rockfish) may better inform potential methods.
    - Evaluate the potential for spatial and vertical compression of the distribution of biomass in the WCGBTS survey area as a result of the environmental drivers such

as the warm blob affecting the distribution and catchability of yellowtail rockfish, thus contributing to increased index values in the mid-2010s.
    - Canary, yellowtail and widow rockfish stocks all showed increased WCGBTS index values between 2014 and 2019 as noted in Request 14, which may be the result of similarly recent strong recruitment patterns among all three species as a result of environmental forcing. Compare the recruitment deviations across other midwater rockfish for each species to see if the patterns of recruitment might drive the observed increase in the index for the survey or whether environmental conditions alone may have altered the distribution of adult biomass of these species relative to the sampling for the survey.
- In constructing a commercial CPUE index, efforts should be made to take into consideration the time of day to filter out trips fishing at night for widow rockfish when they are off the bottom and consider a minimum catch of yellowtail rockfish for the trip as additional filters.
- Consider the potential of acoustic/mid-water trawl surveys to provide data from sampling over rocky reef habitat to directly estimate biomass or provide an index better suited for sampling semi-pelagic rockfish species including widow, canary and yellowtail rockfish. Incorporation of an eDNA index may be of interest in generating a more species-specific index from acoustic data.
- Pursue collaborative research opportunities with industry to provide additional data where beneficial to filling data gaps. These may include socioeconomic data or information that would better inform behavioral responses to market influences or environmental variability directing effort on the fishing grounds, in addition to biological data.
- Consider collecting sex and age data in the recreational sampling in the Oregon Recreational Boat Survey (ORBS) and Oregon Recreational Fisheries Survey (ORFS) to allow sex specific analyses.
- Develop methods for use of research and/or commercial acoustic data collected in association with bottom trawl data to determine whether rockfish can be identified and used to estimate tonnage of ensonified schools to inform a midwater-rockfish abundance index.
- Given the lack of genetic structure north of Cape Mendocino between U.S. and Canadian waters, and scale and importance of the commercial fisheries of both countries reflected in stock assessments conducted on a recurring basis, a transboundary stock assessment could provide a better understanding of stock status and trends in the northern population and the U.S. stock as a whole and account for potential transboundary movements.

Acknowledgements

The STAR panel thanks the public attendees, STAT, GMT, GAP, and Council representatives. The panel also thanks Council staff for providing technical support.

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