Gopher/Black and Yellow Rockfish
Stock Assessment Review (STAR) Panel Report

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July 22-26, 2019

Participants

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Overview

The Stock Assessment Review (STAR) Panel met in Santa Cruz, California during the 22nd-26th of July 2019 to review a draft stock assessment of the gopher and black-and-yellow rockfish complex (GBYR, Sebastes *carnatus*/Sebastes *chrysomelas*) in California waters from Cape Mendocino to the U.S./Mexico border, prepared by the gopher and black-and-yellow rockfish stock assessment team (STAT). Dr. Owen Hamel (Panel Chair) welcomed participants, reviewed the Pacific Fishery Management Council's (PFMC) *Terms of Reference for Groundfish and Coastal Pelagic Species Stock Assessments* (PFMC 2019), and discussed logistics for the meeting.

The draft assessment document and extensive background material (previous assessments, previous STAR Panel reports, etc.) were provided (via the PFMC FTP site) to the Panel two weeks in advance of the Panel meeting. The FTP site was also used for common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Gopher and black-and-yellow rockfish are morphologically and genetically nearly indistinct. They are differentiated by their coloration; and where they co-occur, they have different but overlapping depth ranges (gopher: 0-80 m, most common 9-37 m; black-and-yellow 0-40 m; most common 0-18 m). Both are common between Point Arena and Point Conception on the California coast, while gopher is also common south of Point Conception. Growth patterns appear to be similar, though there is a lack of age data for small gopher rockfish. Catch histories are confounded, with periods within the commercial catch history where only one or the other of the two species was reported in landings.

The GBYR stock assessment was conducted using Stock Synthesis 3 (version 3.30.13.09), with the model time period beginning in 1916 and ending in 2018. The model is based on the implicit assumption of a single distinct stock in the waters off of California, from the U.S. - Mexico border to Cape Mendocino, although the STAT very clearly recognizes that the stock assumption is violated due to the two (though very closely related) species with different densities by depth and latitude, and to some extent due to some degree of connectivity to stocks off Mexico. The STAR recommends the gopher and black-and-yellow rockfish stock assessment as the best available science, and that it provides a suitable basis for management decisions. The Panel commends the STAT for their excellent presentations, well-written and complete documentation, their willingness to respond to the Panel's requests for additional analyses, and their dedication in finding possible solutions to difficult assessment problems.

Summary of Data and Assessment Models

The STAT provided detailed presentations on available data and the main assessment approach. There were a number of clarification points and discussion which included issues related to sources of age data, modelling choices and assumptions, and data quality.

The pre-STAR draft assessment included three fisheries (commercial and recreational, with the latter split into areas north and south of Point Conception) and seven indices of abundance based on fishery- dependent and fishery-independent surveys, including two each from the recreational onboard and recreational dockside sampling programs, each split at Point Conception.

Historical catch data were based on the California catch reconstruction (Ralston et al. 2010; commercial through 1968 and recreational through 1980). Length data were available from each of the fisheries, including the 1988-1998 Commercial Passenger Fishing Vessel Onboard Observer survey, and the two fishery-independent surveys. Conditional age at length data were available (intermittently) from the recreational north fishery, the CCFRP hook-and line survey and from a variety of other sources, which were combined into a single dummy fleet for the purposes of including conditional-length-at-age data.

The pre-STAR base model included a high correlation in recruitment among years with relatively little data to inform such auto-correlation.

Requests by the STAR Panel and Responses by the STAT

The pre-STAR draft assessment document was very complete and the STAT's opening presentations to the panel were very comprehensive. The requests by the panel are listed below based on the order, of the request, although minor modifications to previous requests are often included as sub-requests, even if made on a later date. Responses from the STAT team are given below each request. Figures documenting many of the more significant results from the response to requests are also included.

1. Develop catch curves from age data as appropriate during different periods of fishing intensity according to the model.
   Rationale: To obtain an independent estimate of total mortality to better gauge natural mortality given the model uncertainty.

   STAT response: The STAT created two catch curves using the available age data for gopher and black-and-yellow rockfish, one for the time period pre-2000 (629 available ages) and the second from 2000-2018 (1,791 available ages). The pre-2000 plot used fish aged eight and older, while the 2000-2018 plot used fish aged 13 and older. The estimate of total mortality (*Z*) was not very different between the two time periods, 0.37 for the earlier period and 0.36 for the later years (Figure 1). If restricted to the same ages (13 and older), the earlier period would have a steeper decline supporting higher mortality rates in the earlier period and suggesting estimates of M are reasonable.

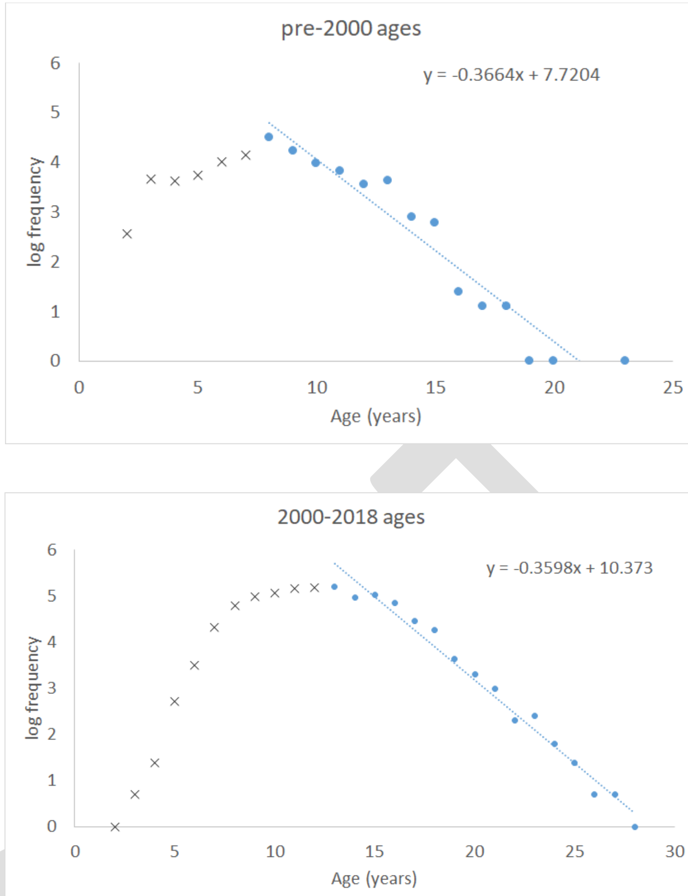


Figure 1. Catch curve analysis for age data prior to 2000 and for 2000-2018.

The following requests are sequential and cumulative:

2. Remove the indices from the Southern fleets 4 and 11 from the model.
   Rationale: These cover a small portion of the population and would not be expected to have the same trends as the majority of the population are in conflict with the northern trends, and there is no straightforward way to combine indices from the two separate regions.

   STAT response: The STAT removed the two fishery-dependent indices representing the portion of the stock south of Pt. Conception, the CDFW MRFSS-era dockside survey and the CDFW CRFS-era onboard observer survey index. There were minor changes to the model, with the total log-likelihood going from 515 to 511 and the estimate of natural mortality going from 0.212 to 0.219 (Figure 2).

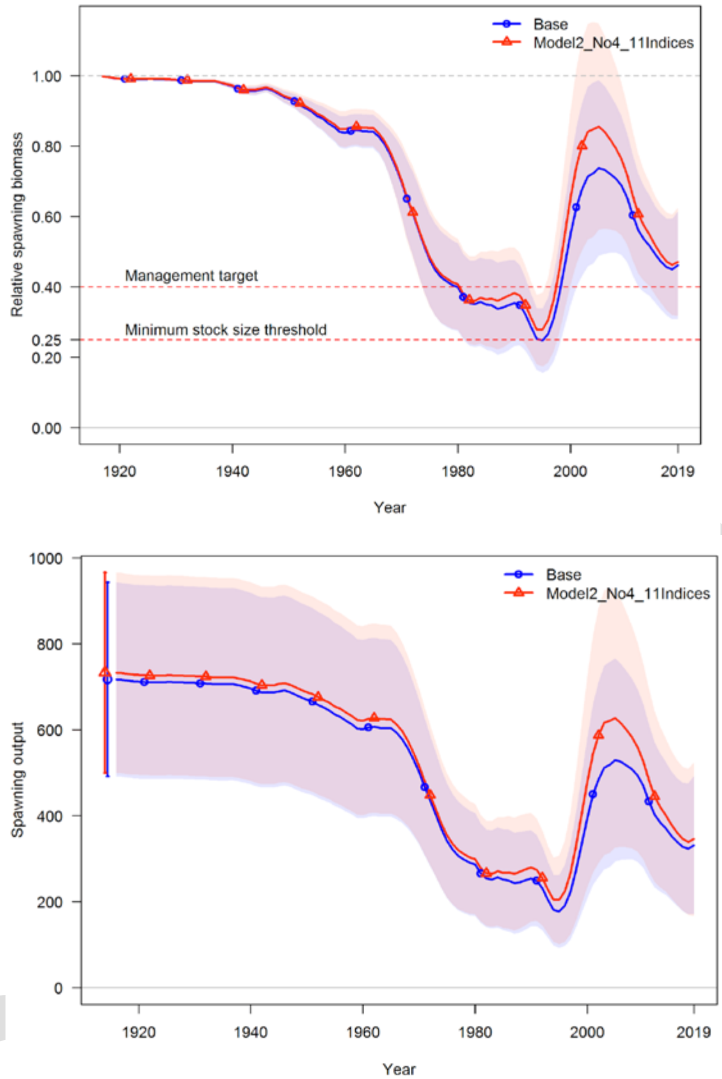


Figure 2. Comparison of time series of relative and absolute spawning output from pre-STAR base model and the model from request 2 removing southern indices.

3. Add discard to commercial catch data in terms of both catch and compositions (by weighting comps by the number of fish discarded or retained), and remove selectivity time block. Apply discard rate back in time.
   Rationale: Simpler to have a single fleet for all commercial catch and the model is likely to better reflect the actual dynamics.

3a. Remove commercial length comp data from 2000-2003 in addition to request 3.
Rationale: Length limit imposed in 2000 but length discards not available until 2004. Therefore, comp data from these years are not representative of total removals.

STAT response: The STAT combined the catches from the commercial retained and commercial discard fleets, to create one commercial fleet representing both catch streams. The length composition data from the two fleets from 2004-2017 were combined by weighting the length compositions by the catches from each fleet. Compared to the pre-STAR base, the model run for request 3a, reduced the number of estimated parameters by 10, and resulted in a decrease in natural mortality to 0.195 (Figure 3). The overall model output did not change from the base model or the changes made from Request #2. Nevertheless, the more appropriate treatment of the data in terms of the processes reflected in the model was deemed to be an improvement and was used in subsequent requests as the base model.

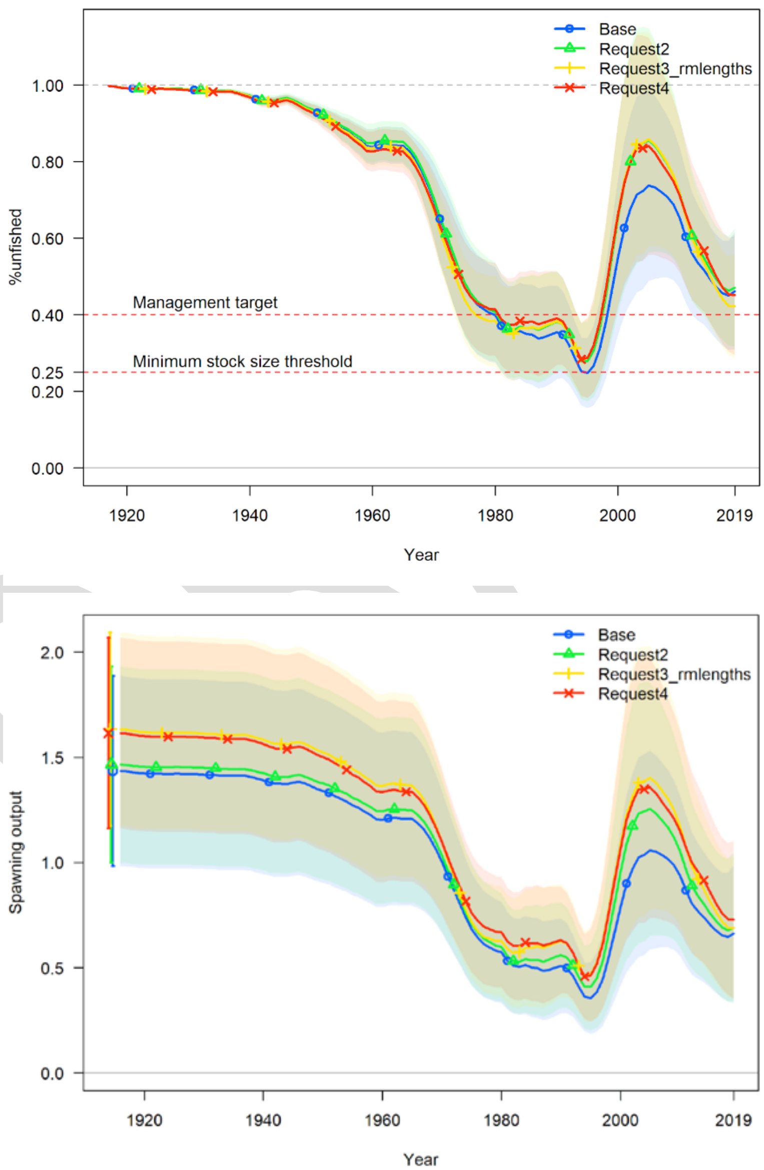


Figure 3. Comparison of time series of relative and absolute spawning output from pre-STAR base model and models from requests 2, 3a and 4.

4. Split PISCO survey such that the 0-age fish (4 and 5 cm) are in one survey and the 15 cm+ fish are in the other. Fix age selectivity to age-0 only for the first fleet and use a logistic selectivity for the second fleet.
   Rationale: To separate out the recruitment index in the survey and to simplify the selectivity assumptions for this fleet.

   4a. Include all years of the recruitment index developed above.
   Rationale: Years with low numbers of 4 and 5 cm fish indicate low recruitment and provide contrast to years with large numbers of those fish.

   STAT response: The STAT developed an index of abundance using only fish that were 5 cm or less and re-developed the length composition data for the PISCO survey representing fish 15 cm and larger. The effect of splitting the PISCO index into two indices, one for young of the year and one representing older fish resulted in dampening of the age-0 recruits seen in the previous models (Figure 4). This was seen as a weakness in the model due to high uncertainty in the estimates due to limited compositional evidence of such an extended period of improved recruitment. The appropriateness of the size cutoff was investigated further in Request 8.

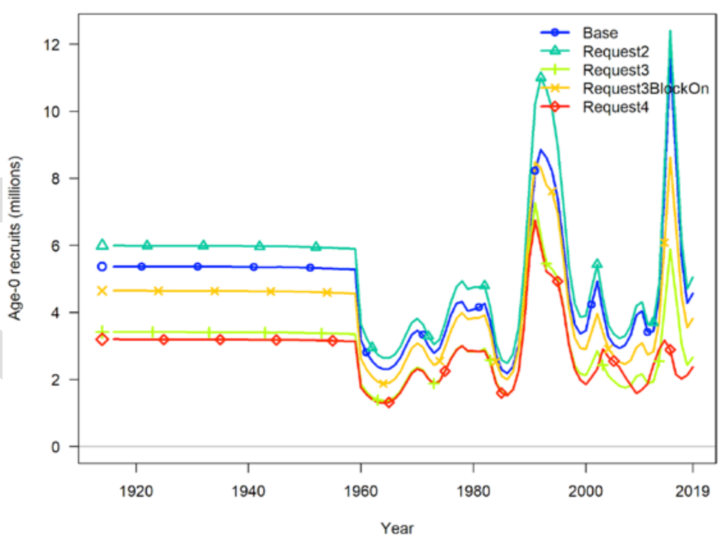


Figure 4. Comparison of time series of recruits from pre-STAR base model and models from requests 2, 3a and 4a.

5. Remove the autocorrelation in recruitment.
   Rationale: Given the sensitivity run presented, autocorrelation didn't make much of a difference in model results, and there was not adequate evidence in the data for autocorrelation.

STAT response: Removing the autocorrelation in recruitment resulted in no significant change to the model output. There was little evidence for autocorrelation in recruitment in the stock or that it provided much in the way of stability to the model, it was therefore decided that the assessment should not implement this option.

6. 1) Start recruit deviations in 1978 as main recruit deviations. 2) Start these in 2001. Turn off all early recruit deviations in both cases.
   Rationale: The composition data does not seem to be informing the estimates of the recruitment deviations but maybe driven by the artifacts in the catch data. The early recruit deviations are uninformed and all in one direction. Recruitment indices start in 2001.

   STAT response: Starting the recruitment deviations in 2001 did not produce a reasonable recruitment signal. Starting the recruitment deviations in 1978 provided reasonable recruitment deviations and is a more appropriate starting year given the lack of sufficient length data prior to this period.

7. Start from model shown at request 6(1). Fix M at 0.193 and let the model estimate k. Change the recruitment bias-correction ramp to estimated level with an up ramp from 1978 to 1979. Provide all appropriate diagnostics
   Rationale: STAT and STAR agree 6(1) was an improvement over the original base model and the request refers to adjusting the ramp value and M treatment consistent with the way these were dealt with in the original the pre-STAR-base model given the new settings.

   STAT response: Requests 7 and 8 were conducted for comparison and the plots comparing the two requests are below Request 8. Fixing natural mortality at the mean of the prior results in an increase in the growth parameter *k* from 0.145 to 0.147 from Request #6 due to the decrease in the modeled natural mortality rate and the observed correlation between estimated M and k values.

8. Determine if 6 cm or larger fish should be included in PISCO recruitment index. If so, update the PISCO index and include the updated index in the model from request #7 (above).
   Rationale: Better to use all appropriate data for the recruitment index. The panel felt the splitting of the PISCO index had advantages based on the results from Request 4, but given the temporal variability in the survey over time wanted to ensure that the size cutoff included the majority of 0-group fish while minimizing the potential to include 1-group individuals.

   STAT response: After and email discussion with Mark Carr, Dan Malone (UCSC PISCO) and Darren Johnson (CSU Long Beach) it was decided that fish of length 6 cm at the end of the year of birth would still all be young of the year fish during the months in which the PISCO survey is conducted. Additional research could serve to verify the appropriate lengths to include, perhaps by month. The PISCO age-0 index developed for this request (including all fish size 4, 5, and 6 cm) resulted in a decrease in the recruitment index in the early 2000s, and an increase in the recruitment index in 2010 and from 2014-2018 relative to include only 4 and 5 cm individuals (Figure 5). The effects on spawning output of the revised PISCO age-0 index of abundance (8b), and a fix to an issue in the selectivity mirroring, and an additional correction that fixes the last year of bias adjustment to 2019 and not 2020 (8c) are shown in Figure 6. With natural mortality fixed at 0.193, the growth parameter *k* is estimated at 0.114. The estimate of length at age-2 (L1) is 13.37, similar to the external estimates.

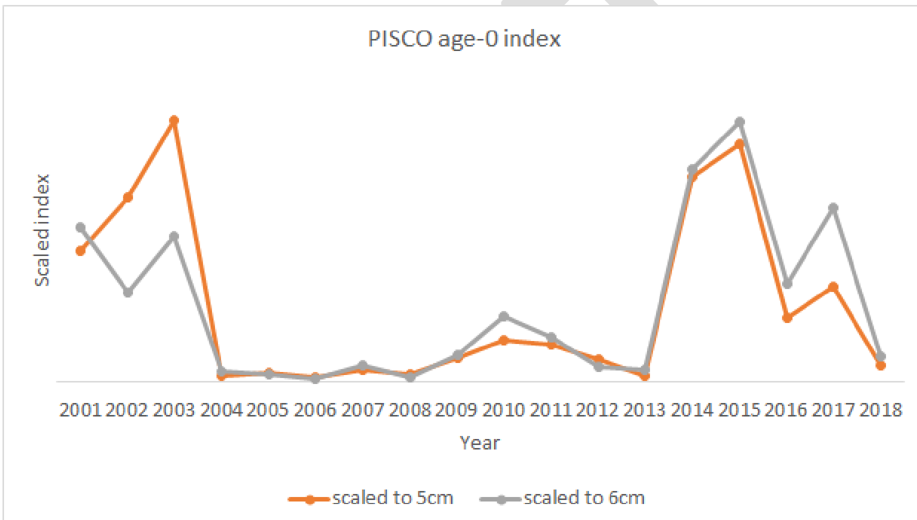


Figure 5. The PISCO recruitment index based upon observed individuals of 4 and 5 cm ("scaled to 5cm") or 4, 5a and 6 cm ("scaled to 6 cm).

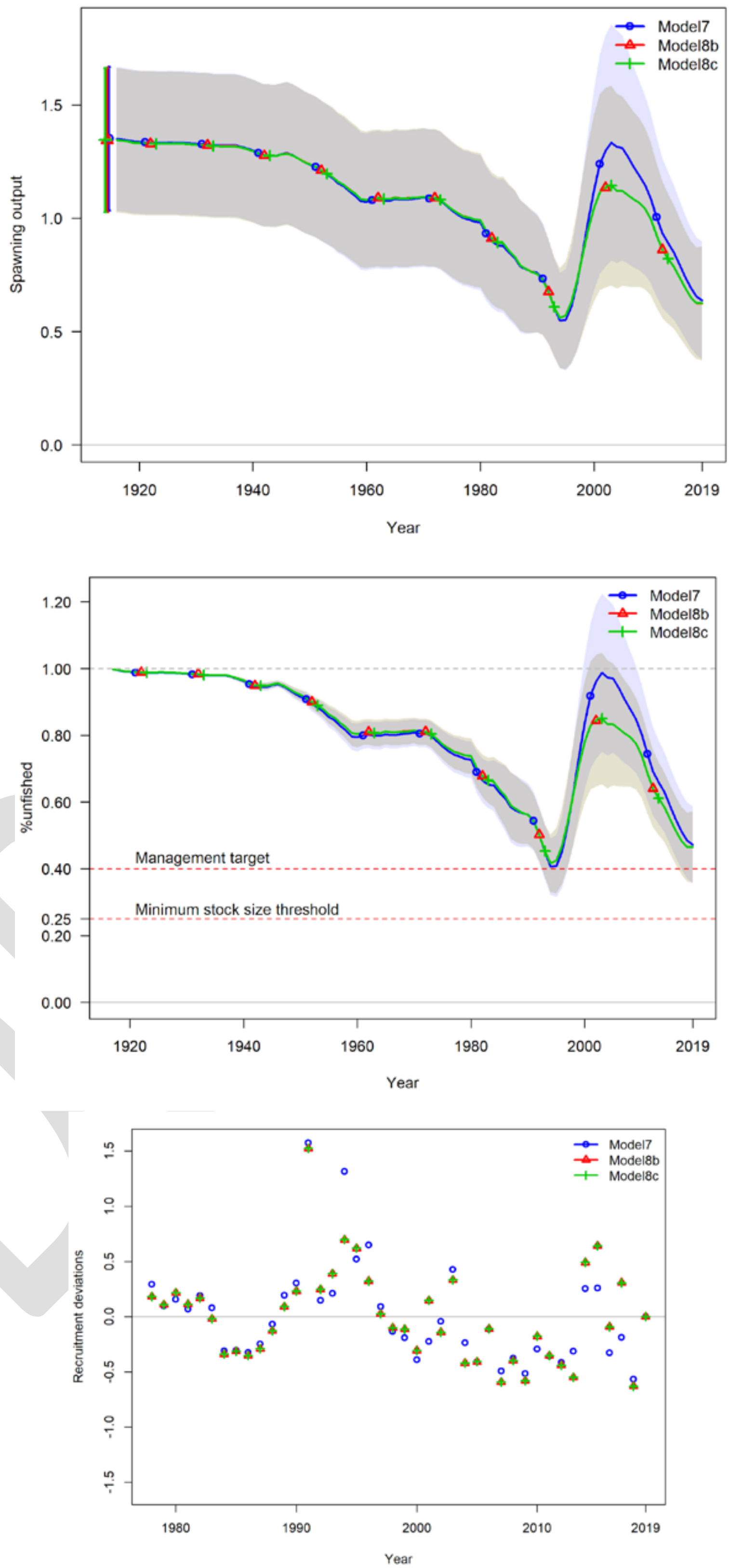


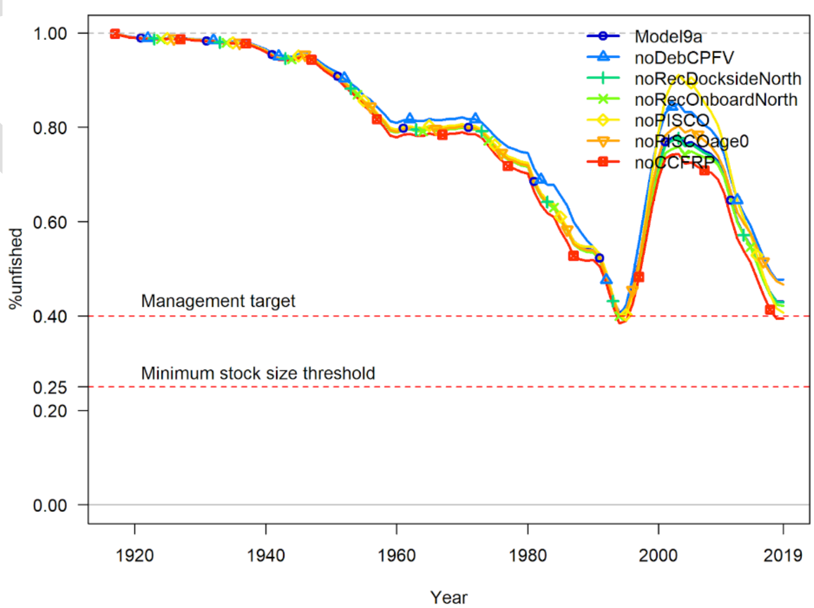
Figure 6. Results of request 7 and 8. Time series of absolute (top) and relative (middle) spawning output and recruitment deviations (now staring in 1978; bottom).

9. Mirror the DebWV_CPFV selectivity to the Recreational North selectivity. Fix the start logit parameter for the adult PISCO selectivity to zero. Investigate appropriate methods for modeling selectivity for CCFRP.
Rationale: These will result in more appropriate and parsimonious treatment of selectivity.

STAT response: The selectivity for the CCFRP index was also mirrored to the Recreational North fleet since the length compositions were not drastically different than the other fleets mirrored to the Recreational North fleet. The STAT could not find a domed selectivity pattern that had reasonable parameter estimates. The STAT also explored fitting asymptotic selectivity to the CCFRP index, but even when fixing the peak parameter to the upper bound, other parameters were not well estimated. Mirroring fleet selectivities was an advantage to the stability of the model.

10. Perform a drop 1 out analysis for the index fleets.
Rationale: To investigate the influence each of these data sets on the model.

STAT response: No single index had a substantial effect on the model output. Each index contributed to the status of the stock, with some indicating a an increase over the base model developed for Request 9, and some estimating a decreased stock status (Figure 7). Depending on which index was dropped, the year(s) of high recruitment predicted in the early 1990s did shift, and was either attributed to a single year, or spread over a few years. The PISCO age-0 index does inform recruitment and age-0 recruitment is dampened in recent years when this index is excluded.



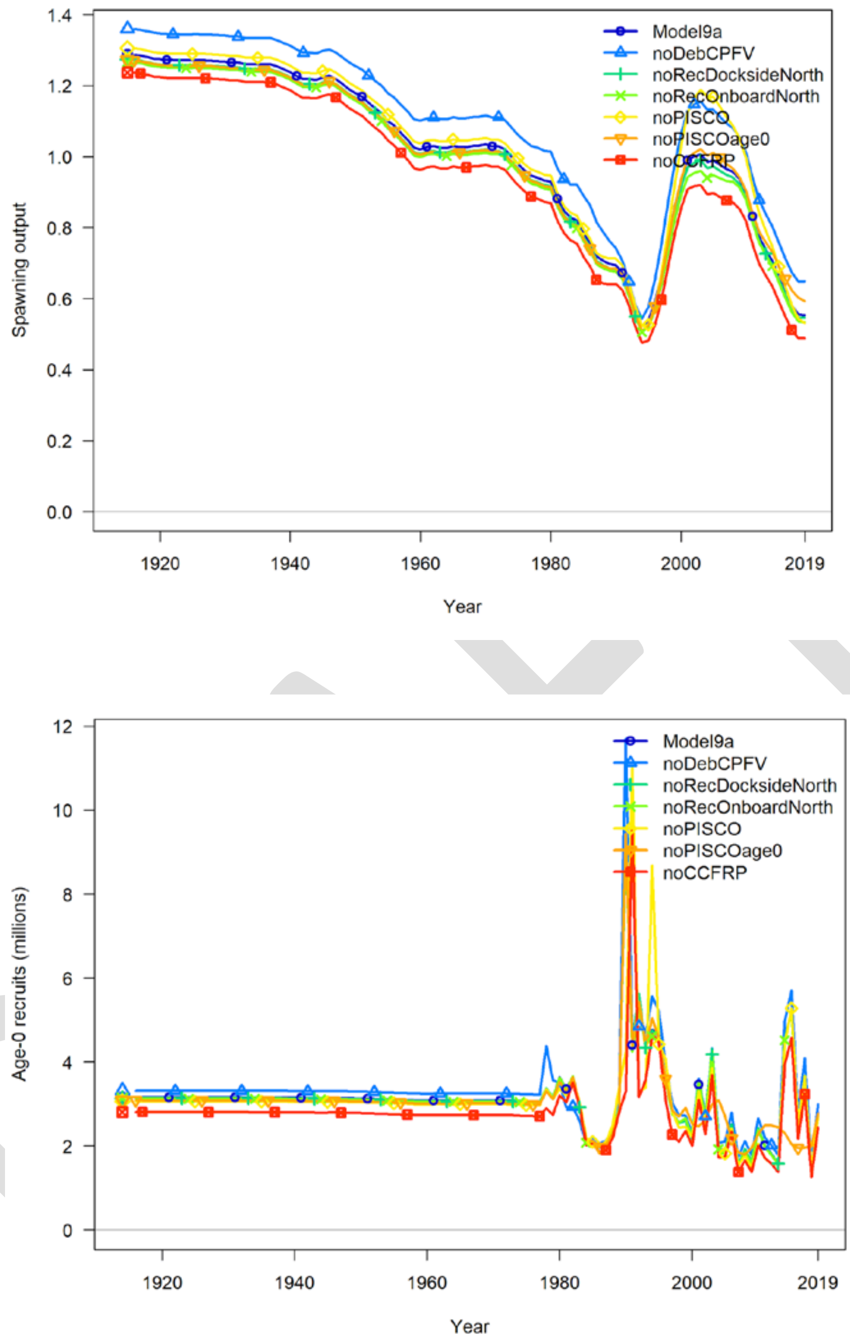


Figure 7. Results of request 10, drop-1-out analysis. Time series of relative (top) and absolute (middle) spawning output and recruitment estimates (now staring in 1978; bottom).

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

The Post-STAR base model included:

1. Three fisheries: A commercial fishery including discard amounts; a north and a south recreational fishery.
2. Six surveys of abundance: The 1988-1998 CPFV onboard observer survey, recreational onboard observer survey and recreational dockside survey, both restricted to north of Point Conception; the CCFRP hook-at-line survey; the "adult" PISCO dive survey including fish of length 15cm and larger; and the age-0 PISCO dive survey recruitment index including fish of size 4, 5 and 6 cm.
3. A "dummy" fleet including multiple sources of conditional age-at-length data for the purposes of including this information in the model for estimation of growth and relative recruitment strength.
4. Length composition data from the commercial and recreational north fisheries and CPFV, CCFRP and adult PISCO surveys.
5. Recruitment deviations starting in 1978, with no autocorrelation in recruitment.
6. Fixed natural mortality rate (0.193) and steepness (0.72), with growth parameters estimated.

The STAT team presented a decision table run where the uncertainty in the von Bertalanffy growth rate parameter, k, was used to bracket uncertainty. The low state of nature set k at 0.046, and estimated L1 and L2, while and the high state of nature fixed growth, with k = 0.248. The proposed high state of nature produced unrealistic estimates of L1 and L2 when estimated. Therefore, it was proposed to fix those parameters at the external estimates: L1 = 13.8, L2 = 28.5, which are nearly identical to the base model estimates (13.4, 28.8). The base model estimates k at 0.107.

The STAR and STAT agreed that creating a decision table based on these values provided the right amount of contrast across stock size, status, and the OFL values to reflect the uncertainty in the assessment.

Technical Merits of the Assessment

The assessment makes use of the latest version of Stock Synthesis (SS3). This modelling framework can make use of a variety of disparate data and is particularly useful when time series data are discontinuous or where there are intermittent observations on length or age. It is therefore an appropriate choice for the assessment.

The assessment applied the full abilities of SS given the data available for the GBYR. The model data and alternative model structures were thoroughly explored and the base model was well justified. Full sets of diagnostics were made available. The STAT was fully responsive to requests from the STAR panel.

Technical Deficiencies of the Assessment

There were no serious technical deficiencies. However, systematic patterns in the residuals for the model fit to abundance indices and the composition data could not be resolved. This lack of fit will undermine the reliability of asymptotic variance estimates for the quantities of interest

Areas of Disagreement Regarding STAR Panel Recommendations

There were no major areas of disagreement among STAR Panel members (including GAP, GMT, and PFMC representatives), nor between the STAR Panel and the STAT.

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

None

Unresolved Problems and Major Uncertainties

1) Structure of complex and contribution of each species to the complex and biological parameters differences. Regional differences within species.

The STAR panel recommends that this assessment be considered a Category 2 assessment for purposes of management.

The STAR panel recommends that the next assessment be a full assessment pending improvements in data and modeling approaches including those outlined below.

Recommendations for Future Research and Data Collection

1) Investigate the structure of complex and contribution of each species to the GBYR complex. Investigate possible spatial differences in biological parameters within a single species and also between the two species. Little biological data for south of Point Conception or north of Point Arena was available for this assessment and is needed to better under biological parameters.
    a. Conduct life history studies.
    b. Conduct research to identify the proportion of each species in population and in catch
2) Take a closer look at the Ralston (2010) historical catch reconstruction for gopher and black-and-yellow rockfishes. The recreational catch reconstruction for gopher rockfish south of Point Conception was an order of magnitude higher than expected when extracted for this assessment.
3) Refine the PISCO survey data and analysis to better identify age-0 fish in each month of the survey. Occasional sampling during all months of the year would better help identify the length distribution of fish classified as age-0. This is the only recruitment index available for gopher and black-and-yellow rockfish.
4) Refine CCFRP survey index to look at different possible model structures, including a hierarchical structure and random effects. It is also strongly recommended to continue the coastwide sampling of the CCFRP program that began in 2017, as well as the collection of

biological samples for nearshore rockfish species. The CCFRP survey is the only fishery-independent survey available for nearshore rockfish sampling the nearshore rocky reef habitats. As of this assessment, only two years of coastwide data are available, and the index was limited to the site in central California that have been monitored since 2007.

5) Collection of length and age data are recommended for both the commercial and recreational fisheries. Very little age data are available from either fishery for gopher rockfish and none for black-and-yellow rockfish.
6) Data collection across Research Recommendations 1-5 is needed to improve the efficacy of data collection and ensure that samples are representative of the data sources and the fisheries. For example, the conditional age-at-length data in the dummy fleet represent a number of sampling techniques, areas sampled, and selectivities. Better coordination of research efforts will allow the age data to be better utilized by the assessment. Sampling of the commercial and recreational fleets by area in proportion to the length distribution of fish observed will also allow the model to better fit selectivity patterns and avoid possible patterns in the length and age composition residuals.
7) Investigate possible environmental drivers/co-variates for biological parameters, and, in particular, recruitment.
8) Examine the CFRS angler interview data for the recreational private/rental model to create a "trip" based identifier for catch and effort. This will enable the creation of an index of abundance for the private/rental mode as well as investigation into whether selectivity for this mode differs from the party/charter mode.
9) Resolve differences between CalCOM and PacFIN expanded length composition data sets.

Acknowledgements

The panel thanks the STAT for their hard work, openness and responsiveness during the review. The panel also thanks John Field and others at the SWFSC for their hospitality during the review.

References

Pacific Fishery Management Council (PFMC). 2019. Terms of reference for the groundfish and coastal pelagic species stock assessment review process for 2019-2020. https://www.pcouncil.org/wp-content/uploads/2019/04/Stock_Assessment_ToR_REVISED_2019-20_APR2019_Final-2.pdf

Ralston, S. D. Pearson, J. Field, and M. Key. 2010. Documentation of the California catch reconstruction project. NOAA Technical Memorandum NMFS 461, 80 p.