Bocaccio
Stock Assessment Review (STAR) Panel Report

NMFS, Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, CA 95060

July 6-10, 2015

STAR Panel Members

Dr. Martin Dorn, National Marine Fisheries Service, Alaska Fisheries Science Center, SSC (Chair)
Dr. Neil Klaer, Center for Independent Experts
Dr. Noel Cadigan, Center for Independent Experts
Mr. Paul Nitschke, National Marine Fisheries Service, Northeast Fisheries Science Center

Stock Assessment Team (STAT) Members

Dr. Xi He, National Marine Fisheries Service Southwest Fisheries Science Center, STAT Lead
Dr. John Field, National Marine Fisheries Service Southwest Fisheries Science Center, SSC
Mr. Don Pearson, National Marine Fisheries Service Southwest Fisheries Science Center
Ms. Lyndsey Lefebvre, National Marine Fisheries Service Southwest Fisheries Science Center
Dr. Steve Lindley, National Marine Fisheries Service Southwest Fisheries Science Center

STAR Panel Advisors

Mr. Gerry Richter, Pt. Conception Groundfish Fishermen’s Association, GAP
Mr. John Budrick, California Department of Fish and Wildlife, GMT
Mr. John DeVore, Pacific Fishery Management Council

Overview

The STAR Panel reviewed a full assessment of bocaccio rockfish (*Sebastes paucispinis*) off the west coast of the United States during a five-day meeting in Santa Cruz, CA. The assessed area extended from the U.S.-Mexico border to Cape Blanco, Oregon (Conception, Monterey and Eureka INPFC areas). Although the range of the species extends further north, there is evidence that there are two population centers of bocaccio rockfish, one in southern California and another off the west coast of British Columbia, with a relative scarcity of bocaccio in the region between Cape Mendocino and the mouth of the Columbia River. The last full assessment of bocaccio rockfish was done in 2009, and was subsequently updated in 2011 and 2013.

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

Summary of Data and Assessment Models

This assessment used Stock Synthesis 3 (v3.24U). Data inputs and model structure generally followed those of the 2009 assessment with the important exception that age data for bocaccio were included for the first time. The main sources of information in the assessment include:

1) Catch and length composition from six fisheries: two trawl fisheries (north and south of 38º N), hook-and-line fishery, set net (gillnet) fishery and two recreational fisheries (south and north of Point Conception).
2) Biological information including maturity at length and fecundity at weight.
3) Fishery-dependent relative abundance (CPUE) indices for the trawl fishery and the two recreational fisheries (Southern and Central California). A total of five indices are provided based on recreational data, including indices based on dockside data collections (1980-early 2000s in each region) and indices based on onboard observer data (1988-1998 in Central California only, 2003-2014 for both Southern and Central California).
4) Fishery-independent indices for the CalCOFI larval abundance survey, the triennial trawl survey, the NWFSC shelf-slope survey, the NWFSC Southern California Bight hook-and-line survey, the Southern California power plant (impingement) index, and the coastwide pelagic juvenile survey.
5) New age data for the trawl, hook and line, and setnet fisheries, as well as the NWFSC shelf-slope survey.

The key model features include:

1) Fisheries were split north and south to implicitly incorporate spatial structure in the assessment.
2) Abundance indices used in the assessment were obtained using delta-GLM modeling approaches.
3) Growth was estimated within the model.

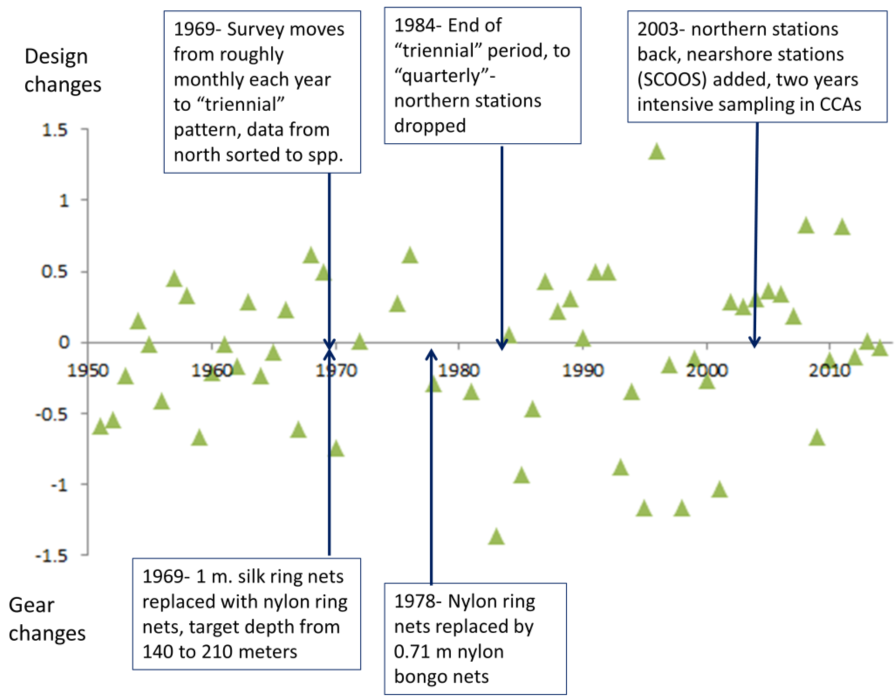
4) A Beverton-Holt stock recruit relationship was assumed and recruitment deviations were estimated.
5) Prior distributions for steepness (Thorson pers. com.) and natural mortality (Hamel 2015) were used.
6) Length-based selectivity curves were estimated for all surveys and fisheries. Most selectivity patterns were dome-shaped.
7) Age data were modeled as conditional age given length in the assessment.
8) Input data were reweighted using several approaches. Additional variance terms were estimated for index data; length composition data were reweighted using the Francis method; and the harmonic mean of effective sample size was used to reweight the conditional age at length data.

Requests by the STAR Panel and Responses by the STAT

Request No. 1: Develop a prioritized list of significant changes to the CalCOFI index over time to compare the residual pattern in fits to the survey with respect to these changes.

Rationale: There have been a number of changes in survey design and gear. These changes may affect the comparability of the index over time. It is useful to be aware of these and examine if model residuals are associated with these changes.

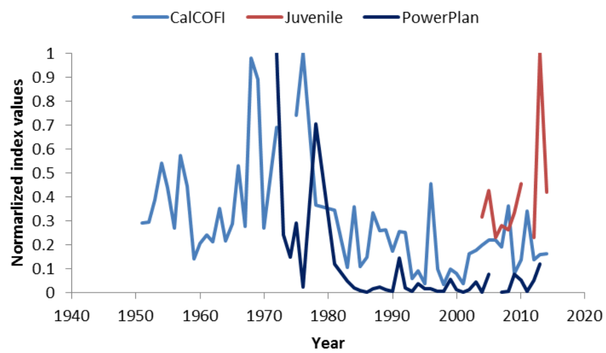
STAT Response: The STAT provided a detailed summary of changes in survey design that occurred in 1969, 1978, 1984, and 2003 (below). These changes were shown in time-series plots of survey indices and model residuals. There was little pattern in residuals during these periods, suggesting that modeling changes in survey catchability is not warranted.

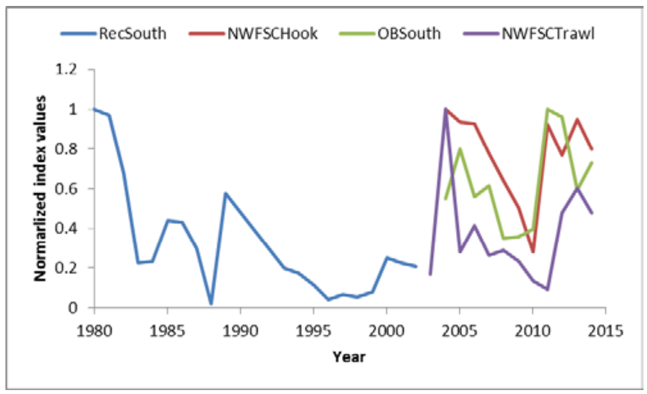


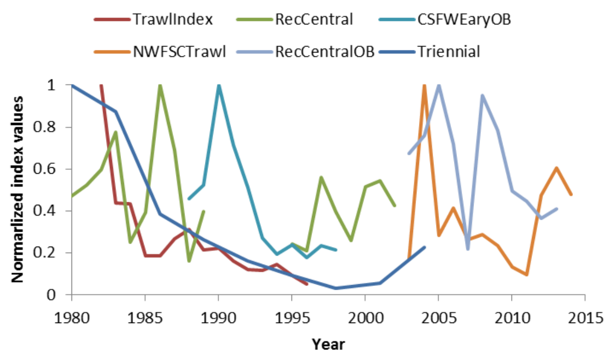
Request No. 2: Normalize all indices and provide time series plots in which groups of comparable indices are plotted together.

Rationale: To assess the comparability of indices prior to incorporation in the assessment model.

STAT Response: The index comparison plots did not indicate good correspondence between spawner and juvenile indices, or between adult indices in the southern or central/northern areas (below). The Panel found this comparison to be valuable and recommends that it be included as routine part of stock synthesis output plots.



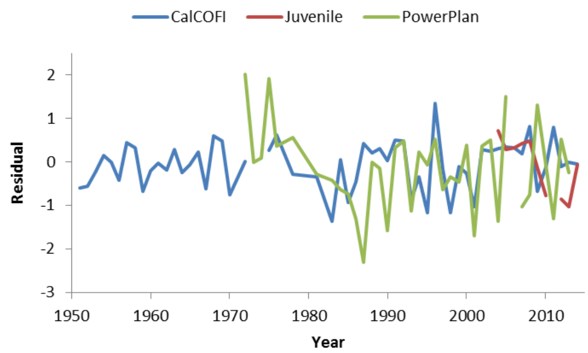


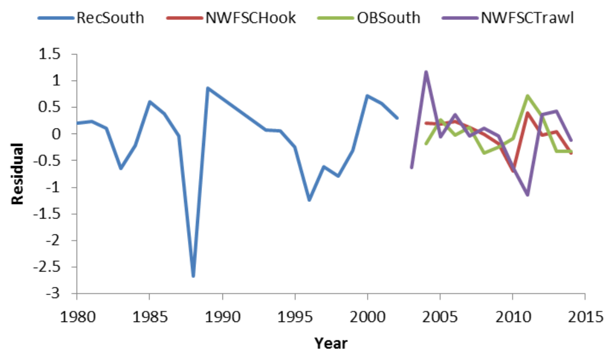


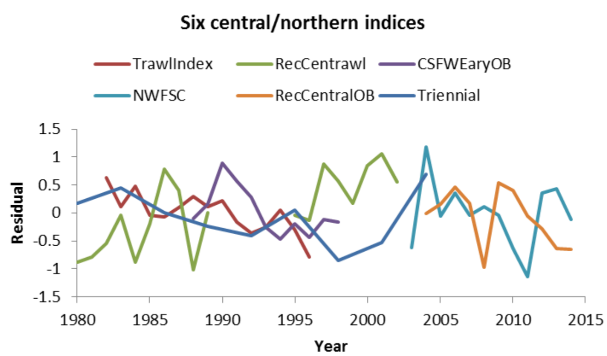
Request No. 3: Provide time series plots in which groups of comparable index residuals are plotted together.

Rationale: Runs of positive or negative residuals that are consistent across indices may indicate changes in stock productivity or some other factor that consistently affects catchability for multiple indices.

STAT Response: Residuals patterns, while variable, were not consistent across indices (below). This result suggests that changes in productivity or catchability did not occur.







Request No. 4: Provide a comparison of mean catch rates inside and outside the Cowcod Conservation Areas (CCA) for the NWFSC hook and line survey in years the survey was conducted in the CCAs. Also provide a time series of mean catch rates and compare to the derived GLM index. Alternatively, if a GLM model has been run with the area inside the CCAs with a region effect, provide estimates of regional effects inside and outside the CCAs.

Rationale: Provide some indication of how much of the stock is inside of the area closed to the fisheries and most surveys.

STAT Response: Responses were provided by NWFSC staff, who noted that data were only available inside the CCAs for the 2014 survey year (but are expected to be available in 2015 and future years). Catch rates were about double inside the closed area compared to outside, suggesting that there may be a closed area effect on bocaccio rockfish abundance. Depth patterns in CPUE suggested that the effect was larger at shallower depths. If smaller fish are found at shallower depths, then this is consistent with a domed selectivity in fisheries that are excluded from the CCAs.

Request No. 5: Provide a sensitivity run in which the NWFSC hook and line survey selectivity is forced to be asymptotic, and provide fits to the composition data.

Rationale: It is generally good to have at least one index with asymptotic selectivity, for inferences on total mortality rates.

STAT Response: Using asymptotic selectivity resulted in a worse fit to length composition data for the NWFSC hook and line survey. Unfortunately no age data are available for the hook and line survey. This outcome led to a discussion about natural mortality. While it is useful to have a fleet with asymptotic selectivity to estimate M, it is not an absolute requirement, and the northern trawl fishery is estimated to be asymptotic after the selectivity break in 2001. Re-examination of the likelihood profile for M suggested that a plausible estimate could be obtained even with weaker assumptions.

Request No. 6: Explore alternative time blocking for fisheries as follows:

a) Trawl fishery, north and south: explore alternative time blocks in 2000 (CCA and small footrope restrictions implemented) and 2003 (RCA implementation).
b) Recreation fishery: explore an alternative time block in 2003 (RCA implementation).

Rationale: These time blockings are more consistent with changes in management regulations.

STAT Response: The model was not sensitive to these changes in selectivity blocks. However, the length composition data were fit a little better with a time block in 2003. The new blocking is more consistent with regulatory changes so the Panel and the STAT agreed to adopt the new blocking in 2003, subject to examination of impacts on weighting. The effects of this change were minor so the Panel did not need to see full output from this change.

Request No. 7: Provide a run using age-specific pattern of natural mortality recommended by Brodziak et al. (2011). Provide likelihood components, fits to composition data, and estimated selectivity patterns

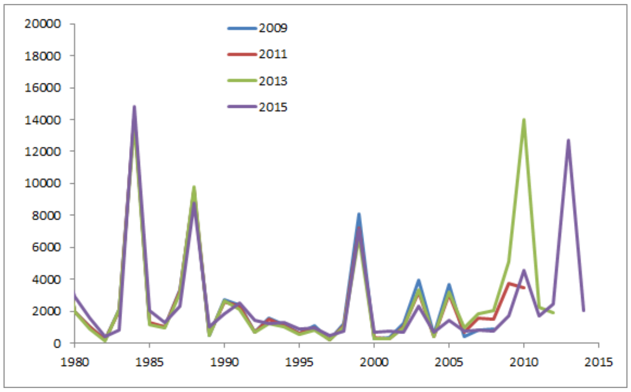
Rationale: Several estimated selectivity patterns are very unusual. The NWFSC trawl survey has a curiously flat selection pattern at young ages, and triennial survey has a strongly peaked selectivity at young ages. Such strong differences in selectivity in surveys using similar sampling gear is suspicious. The Panel wants to explore if this could be the result of using an M that is too low for the young fish.

STAT Response: The largest impact of increasing M on juveniles was to increase R_0, which is an expected result. The additional younger fish are then killed off by the higher M so that there was little impact on model results. The NWFSC trawl survey selectivity for small lengths decreased only a little, and triennial survey retained its very sharp peak. It was suggested to experiment with an even higher juvenile mortality rate, but this seemed best to consider for future assessments. There was no compelling reason to adopt a higher juvenile M in this assessment.

Request No. 8: Compare estimates of year-class strengths from 2009, 2011, and 2013 assessments with the new base case.

Rationale: To evaluate the magnitude of revisions to recent estimates of year class strength that occurred as assessments were updated.

STAT Response: The 2015 assessment resulted in a large revision in the estimated size of the 2010 year class compared to the 2013 assessment (below). The 2015 assessment also indicates a large 2013 year class, but the uncertainty in this estimate is very high, and the initial estimate may be reduced in subsequent assessments. Several factors led to reduction in the estimated magnitude of the 2010 year class. First, application of the Francis method for reweighting the length composition data resulted in lower weights being given to these data. In addition, although several data sources are still consistent with an above average 2010 year class, none of the recent fishery-independent indices show a strong increase in relative abundance that would be expected with a 2010 year class of the magnitude estimated in the 2013 model.



Request No. 9: Provide marginal age composition fits.

Rationale: Examine how well age data are fit.

STAT Response: The fits looked reasonable overall. This did not provide motivation to change the model formulation.

Request No. 10: Explore alternative weighting for conditional age-at-length data. Alternatives include the 1) input sample size for age composition data, 2) using the Francis weighting method A, and 3) Francis weighting method B (report values of A & B) for the conditional age-at-length with the revised base case. For 2) and 3) continue to use the Francis adjustment for the length composition data.

Rationale: Assessment results are sensitive to weighting and this needs to be explored.

STAT Response: Francis method A resulted in an apparently extreme down-weighting of age composition data. Francis method B was more moderate in down-weighting the age data and was similar to harmonic mean weighting method.

Request No. 11: Revise base case model with a time block in 2003 for the trawl fishery (north and south) and recreational fishery (central and southern) fleets.

Rationale: Follow-up to request No. 6.

STAT Response: This model configuration did not result in much change to model outputs, but was considered the new base model for subsequent evaluation.

Request No. 12: Provide a run where the conditional age-at-length data are reweighted using the harmonic mean method; length composition data should continue to be weighted using the Francis method.

Rationale: Follow-up action to request No. 10. This approach mirrors what was done for the China rockfish, in which the Francis method is used for length composition data, and the harmonic mean weighting method for conditional age composition data.

STAT Response: The impact of this change in model configuration was not large overall; however, it did make a big difference in the size of the 2013 year class. The Francis method was considered an acceptable approach for length composition data, but its application to conditional age-at-length data is less straightforward. The method using the harmonic mean is well-established and based on the properties of the multinomial distribution. The Panel recommended this approach as the new base model for subsequent evaluation.

Request No. 13: Provide likelihood profiles on M with and without asymptotic selectivity on the NWFSC hook and line survey (give the highest priority to the profile without asymptotic selectivity)

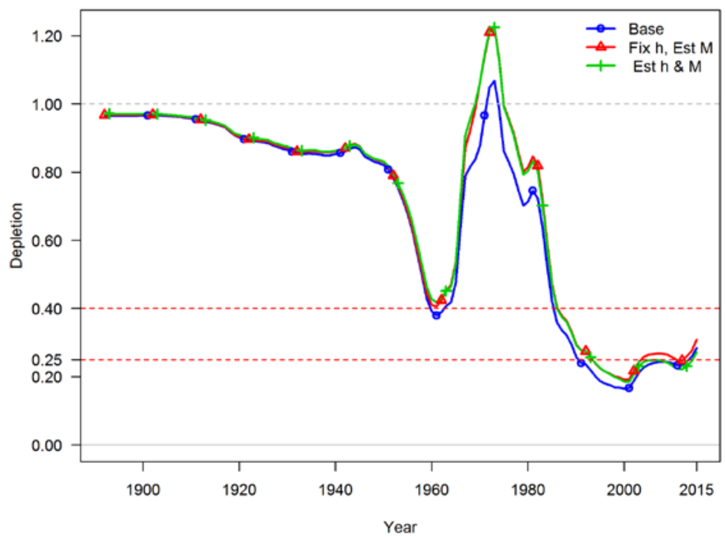
Rationale: To better understand the impacts of this assumption, and to assess the strength of information about M in the assessment.

STAT Response: The M profiles were shifted toward higher M when the NWFSC hook and line survey selectivity was fixed to be asymptotic compared to the modestly domed selectivity that resulted without this constraint. This is to be expected. The M profiles for the asymptotic selectivity configuration indicated less data conflict between length and age composition data than the model configuration that did not use this constraint. However, the M profiles had similar curvatures in both cases. The results based on asymptotic selectivity indicated a worse overall fit, and the estimate of M=0.2 was very different than the prior. Since it is possible that selectivity is lower for the largest fish in this survey, the Panel did not adopt this model formulation. The Panel emphasizes that future data and analysis may lead to a different conclusion.

Request No. 14: Provide model runs as follows: a) steepness (*h*) and *M* estimated using the current priors, b) *h* fixed and *M* estimated using current prior, and c) *M* fixed and *h* estimated using the current prior.

Rationale: To better understand how well are these key parameters estimated.

STAT Response: Although all runs were clustered closely together (below), the Panel concluded M is better estimated than steepness in the model. As a result, the Panel considered it more appropriate to estimate M in the model, and use bracketing runs with different values of steepness to characterize uncertainty, but the Panel needs to see these results with the agreed weighting scheme.



Request No. 15: Provide model runs where the strength of the 2013 year class varies such that the lower value is at the 12.5 percentile of the uncertainty in the 2013 year class estimate and the upper value is at the 87.5 percentile. Include 10-year forecasts.

Rationale: The size of this year class is likely to have a large impact on stock forecasts.

STAT Response: The STAT developed an approach using a dummy young-of-the-year survey to set the magnitude of the 2013 year class at a specified value. The approach worked well, though estimated recruitments in other years, as well as other productivity parameters, are slightly affected by the choice of recruitment size in 2013. The approach of bracketing 2013 year class captured uncertainty in stock projections, and could form the basis for a decision table.

Request No. 16: Fix steepness at the mean of the prior (h = 0.773) and estimate M; tune the conditional age at length data using the harmonic mean, and length compositions using the Francis method for proposed new base case.

Rationale: Follow-up to request no. 14.

STAT Response: The Panel concluded that this model formulation should be the base configuration for management advice.

Request No. 17: Provide two decision tables that alternatively vary steepness and the magnitude of the 2013 year class as follows:

> Table for steepness: low biomass state of nature h = 0.6 (~12.5 percentile); base case h = prior (0.773); high biomass state of nature h = 0.9 (~87.5 percentile).
>
> Table for 2013 year class magnitude: low biomass state of nature = value at 12.5 percentile, base case = point estimate; high biomass state of nature = value at 87.5 percentile.

Rationale: These are the major sources of uncertainty that were identified during the review. The Panel was considering whether providing two decision table would add value to the stock assessment.

STAT Response: The decision tables were provided. The catch streams used for the tables were based on status quo catches, the rebuilding SPR applied to the base model, and ACL catches as estimated by the base model. The Panel noted that stock projections were not highly sensitive to choices for steepness. This is partly because M was estimated in the three alternatives, but it also suggests that there is not much structural uncertainty in the assessment. The decision table with respect to the 2013 year class was similar to the steepness sensitivity table. The STAT suggested that it would be preferable to combine these two sources of uncertainty into a single decision table.

The Panel agreed, and requested that the estimated M values be reported for the low and high biomass scenarios.

Projected catches from the rebuilding SPR applied to the low biomass scenario were not provided. The Panel requested that these projections be added as a fourth row in the decision table.

Request No. 18: Provide a decision table with the low biomass state of nature defined by low steepness (h = 0.6) and low 2013 recruitment (~12.5 percentile of the uncertainty of the recruitment estimate); high biomass state of nature defined by high steepness (h = 0.9) and high 2013 recruitment (~87.5 percentile of the uncertainty of the recruitment estimate). Use same catch streams as in request no. 17 and add a catch stream associated with the low biomass state of nature assuming SPR = 77.7% (the rebuilding harvest control rule). Include M estimates for both states of nature.

Rationale: To obtain a pair of bracketing runs for the decision table.

STAT Response: These runs were agreed to form a suitable basis for characterizing uncertainty around the base model.

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

The base model developed during STAR panel was similar to the model in the draft document with the following exceptions: breaks in fishery selectivity occurred in 2003 rather than 2001; steepness was fixed at the mean of the prior and natural mortality was estimated (rather than the reverse), and the conditional age-at-length data were re-weighted using the harmonic mean method rather than Frances method A.

Alternative Models for Bracketing Uncertainty

Uncertainty was bracketed by considering both uncertainty in steepness and uncertainty in the magnitude of the 2013 year class. The low biomass scenario was defined by low steepness (h = 0.6) and low 2013 recruitment (~12.5 percentile of uncertainty of estimated recruitment); high biomass scenario was defined by high steepness (h = 0.9) and high 2013 recruitment (~87.5 percentile of uncertainty of estimated recruitment). Natural mortality was estimated in all scenarios subject to a prior (Hamel 2015).

Technical Merits of the Assessment

This was a thorough assessment with good use of recent research results and sensitivity runs to evaluate alternative model assumptions. The assessment benefits from some long time-series of stock trend indices and substantial length composition information. A new and important information source for this assessment was conditional age composition data from several fisheries and surveys.

The occurrence of sporadic large year classes of bocaccio also improves the assessment because these year class provide information on temporal changes in age structure via length composition data. Consequently, natural mortality seems to be well estimated when steepness is fixed. However, as usual, natural mortality is confounded with steepness.

The assessment model appears to be mature enough for an update in the next assessment cycle (in 2017). The availability of additional age data may require flexibility in application of the rules for stock assessment updates.

Technical Deficiencies of the Assessment

The model is sensitive to alternative methods for data re-weighting. Best practices for data re-weighing are not well established, and proposed methods need further investigation.

Lack of a spatial model for this stock inhibits better modeling of differences in growth, recruitment, and apparent larval and adult migration.

Several estimated selectivity patterns in the bocaccio assessment are very unusual, and it was not obvious what was causing these patterns.

Some of the abundance indices used in the assessment may not contribute to estimated stock status in a substantive way. An objective procedure is needed for selection of abundance indices based on information content.

Areas of Disagreement Regarding STAR Panel Recommendations

Between the STAR Panel and STAT

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

Among STAR Panel Members

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

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

The GMT and GAP representatives did not raise any data or management issues regarding the bocaccio assessment.

Unresolved Problems and Major Uncertainties

Stock structure is a major uncertainty. The stock likely extends south of southern boundary of the assessment at the US/Mexico border. The relationship between the bocaccio stock off California and populations further north is unknown.

Episodic recruitment of very large year classes is a feature of bocaccio population dynamics. Harvest projections can depend on initial estimates of these year class that are very uncertain, and are subject to revision as additional information becomes available.

Survey indices are often not consistent and may indicate different short-term trends.

Most of the fishing fleets and survey indices have a dome-shaped selectivity patterns that can be confounded with mortality rates.

Recommendations for Future Research and Data Collection

An objective procedure for evaluating the stock boundaries is needed for all rockfish (and potentially other west coast assessments). Such a procedure would more directly point to directions for future research or collaboration across national/international political boundaries.

Explore better ways to model productivity for stocks like bocaccio that exhibit large episodic recruitment patterns. Lognormal distributions are not a good way to model the recruitment variability for such stocks.

The strength of recent recruitments is a major uncertainty for bocaccio. Technical methods for capturing and propagating this uncertainty are needed in stock synthesis (especially for axes of uncertainty), perhaps by an improved procedure to fix particular recent recruitment deviations.

The relationship between stock size and spawning output is critical for interpretation of the CalCOFI index, which is perhaps the most useful index in the bocaccio assessment. Research is needed to better quantify spawning output. This research could include evaluation of environmental correlations of spawning output, and studies of both the prevalence, and the potential demographic and environmental drivers of multiple broods (multiple spawning events by an individual fish within a given spawning season).

The Panel recommends continued processing of historical CalCOFI samples from northern transects in the early 1950s through the late 1960s. These data would add to the index used in the assessment model, and improve understanding of spatial patterns in population dynamics.

A data workshop prior to STAR panel review, perhaps for all rockfish stocks due for assessment, should be scheduled to examine assessment information across a broad range of species. The workshop could document protocols used to compile data sets for stock assessment, establish agreed procedures for standardization of abundance indices, and develop alternative data series that capture uncertainty–particularly for historical catch and discards.

Several estimated selectivity patterns in the bocaccio assessment are very unusual. The NWFSC trawl survey has a curiously flat selection pattern at young ages, and triennial survey has a strongly peaked selectivity at young ages. Research into alternative ways to model the selection pattern of these surveys is needed. Possible approaches include 1) use of age-specific natural mortality, 2) splitting the surveys into separate indices for juveniles (age 0 and/or1) and older fish.

Available information indicates that the CCAs are a center of abundance for bocaccio. Surveying inside the CCA during the NMFSC hook and line surveys should be continued, though several years of data will be required before the information can be used to inform the assessment. Consideration should also be given to extending the NWFSC trawl survey into the CCAs. A simple analysis of potential catch rates of cowcod, and the impact of survey take on stock rebuilding, would allow the benefits of surveying inside CCA to be compared to potential costs.

Age data from the NWFSC hook and line survey would increase the utility of the survey for assessment of bocaccio by better defining the selectivity pattern for large fish.

Acknowledgements

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

References

Brodziak, J., J. Ianelli, K. Lorenzen, and R.D. Methot Jr. (eds). 2011. Estimating natural mortality in stock assessment applications. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-119, 38 p.

Hamel, O. S. 2015. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science 72:62–69.