

BOCACCIO

STAR Panel Report
Northwest Fisheries Science Center
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STAR Panel Members:

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Bocaccio STAR Panel Report

Overview

The STAR Panel reviewed the draft assessment report by the STAT Team for the Bocaccio resource. The review took place during the week of April 15-19, 2002 at the Montlake Laboratory of NMFS Northwest Fisheries Science Center in Seattle, Washington. The STAT Team provided the STAR Panel members with a partial draft report in advance of the STAR workshop. Dr. Alec MacCall, the sole member of the STAT team, was present during the week. On the first day MacCall summarized his draft document including descriptions of the fishery, the biology of canary rockfish, and available data. The relevant features of his stock synthesis model and assumptions, and initial results of alternative modeling scenarios were reviewed. Considerable discussion followed over the week concerning the quality of the data, appropriateness of model assumptions, base model configurations, potential alternative configurations, and interpretation of results. The Panel requested additional alternative model analyses to examine sensitivity of assessment results focusing on areas of data uncertainties and configuration assumptions. Concern was expressed that the early trawl catch numbers used in the analysis maybe too high in Southern California. Before 1978 an arbitrary allocation was made between the hook and line and trawl fishery on total rock fish catch. As well as allocation to gear, the allocation to species may also be uncertain. It was assumed to be 40% Bocaccio. Some late information suggested between 1962-1963 that bocaccio landings could be as high 60%. The reference points based on unexploited biomass were sensitive to this issue. The reference points based on unexploited biomass were sensitive to this issue.

The STAR panel and STAT team discussions resulted in developing a new baseline model that treated the Bocaccio resource off southern and central California as one stock. The STAR panel accepts a single stock model with separate selectivities for all gears split between central and southern California and $M=0.2 \text{ year}^{-1}$ as the base model, and is satisfied that this assessment provides the best scientific management advice available. There is no evidence that central and southern California belong to separate stocks, but greater accuracy in the assessment might be obtained in the future from modeling the spatial differences between management areas explicitly. However, the single population model remains the most robust for providing advice at this time.

Using the average SPR 68-95 rather than SPR 55-95 to calculate the relative sustainable SPR gives estimates suggesting that the southern California management area is unable to sustain even very small levels of fishing, which is clearly incorrect. The time series 1955-1967 is important in producing a realistic assessment. The magnitude of the early catches also affects the results. There is an unrealistically high recruitment event estimated for 1963. This estimate contaminates the recruits-per-spawner estimate which would be used to simulate rebuilding times. Direct observations for recruitment indices exist for 1972 onwards and this probably represents the most reliable period to draw recruitment estimates from for the projection. Alternatives to this base case could be used for the decision table, for example, using all 1955-2001 recruits as opposed to using only the more recent recruitments (e.g. 1980-2001). However, an assessment based on only the most recent recruitments, may indicate that the stock is not able to recover even with no fishing. Some strong recruitments, as seen before 1980, may be a necessary prerequisite for any recovery.

Two decision tables, one projecting the two separate management areas and the other considering the consequences of high and low average recruitment around the base model for the whole stock were suggested. The latter was thought the best to take forward to provide

management advice as it would capture the essential uncertainty of the assessment. Although the STAR Panel has had only limited opportunity to review these latter results, we conclude that Alec's approach to addressing range of uncertainty is appropriate, is presented in a format that should be helpful to the Council decision process, and captures the range of uncertainty.

The Team and the Panel agreed on the base line model to be used in the assessment although a review of the base line model and associated results was not available in time to be included in the STAR panel review report. Even though the final draft STAT document was not available, the new assessment offers a much greater insight into the bocaccio stock and its structure. The Panel anticipates the final results to very useful in directing Council action of managing for the recovery of the Bocaccio stock. The STAR Panel commends the STAT team on their hard work during the STAR panel meeting and the Team's co-operation with the requests of the Panel.

I. Analyses Requested by the STAR Panel

- 1) Carry out a sensitivity analysis for the different sources by weighting (de-emphasizing each survey in turn).** It was found that the triennial composition conflicts with the recruitment index. The CalCOFI index also shows some conflict with the size composition data and models.
- 2) Plot all abundance indices, with appropriate lag and scale, on the same graph for direct comparison.** The trends in the indices were similar within and between the two areas. This should raise confidence in the estimate of the current state of the stock.
- 3) Produce a likelihood profile for natural mortality.** A comparison between the low (0.15), base (0.2) and high (0.25) for Southern and Central California was undertaken. For Southern California, there was little to choose statistically between the levels of natural mortality. For Central California, 0.25 year⁻¹ was inconsistent with the data, and no realistic fit could be found. There was little to choose between natural mortality of 0.15 and 0.2 year⁻¹.
- 4) Carry out a retrospective analysis for each stock assessment.** For Southern California, the estimates for the spawning output and total biomass remain stable. The analysis of Central California suggests slight systematic overestimation of the same indices, but the bias applies to the whole series rather than just the most recent values.
- 5) Apply a uniform selectivity curve for the triennial survey.** The triennial age composition was found to be inconsistent with other size and age compositions when a uniform selectivity was forced. It was generally felt that the triennial survey selectivity pattern was implausible, but there is no clear way to improve it. However, this problem largely disappeared when combining the areas into a single population assessment. The selectivity parameters for the two-stock model may have been trapped at a local optimum.
- 6) Apply an asymptotic selectivity curve for the commercial trawl fishery.** Commercial trawl selectivity changes other selectivity curves, suggesting it is very informative on the size/age structure. Although the asymptotic selectivity curve was a simpler model and could be justified using a statistical test (Akaike criterion, +15.4 log-likelihood on 9 degrees of freedom; there was uncertainty about the error degrees

of freedom), a domed selectivity was more plausible from what is known of the species and gear. Therefore, although there was little improvement in the fit, the domed selectivity was kept in as the base model.

- 7) **Conduct a sensitivity analysis on historical 1951-1977 and 1979 catches for Southern California apportioning between trawl and hook and line.** All catches were allocated to hook and line and 1979 catch was estimated through linear interpolation between 1978 and 1980. This appears to have little impact on the results, although it was generally agreed that the allocation to hook and line was probably closer to reality.
- 8) **Carry out a sensitivity analysis on historical 1950-1977 and 1979 catches for Southern California changing the proportion of the total rockfish catch which is being allocated to bocaccio.** The results suggested that the model fits lower catches worse than higher catches. Increasing catches has little effect on the current SSB relative to 1951. However, the ratio of the average 1951-1975 spawning output to the estimated unexploited spawning output is very sensitive to the initial catches assumption. The current exploitation rate is not sustainable if the 1951-1977 catches are reduced to 25%, and sustainable if the catches are 125% of those used in the base model. It was decided to use two scenarios with 40% (base) and 20% allocation of the total rockfish landings to bocaccio. Subsequently, information became available that suggests that in some cases as much as 60% of rockfish landings were bocaccio, so clearly more research is required on this issue.
- 9) **As well as the two-stock model, carry out a single-stock assessment.** Fit a single population model, but different selectivities (i.e. fisheries remain separate) for northern and southern fisheries to accommodate differences in commercial gear. The single stock assessment fitted the data less well, although many fewer recruitment parameters were required. In particular, the recreational and trawl size compositions, and recruitment indices fit less well for the combined population model. The single stock model was preferred as the base model despite fitting the data less well because all available evidence suggests that bocaccio in central and southern California belong to the same stock. Managers may define northern and southern management areas but this question was not in the scope of the assessment.
- 10) **Present a single stock model assessment, but with the north and south fisheries with the same selectivity curves.** The results were similar to the combined model with separate selectivity except the set net and hook and line size compositions fitted less well. A formal test (Akaike) suggests this model should be rejected in favor of the model with separate selectivity.

II Comments on the Assessment

- 1) The STAR panel accepts the single stock model with separate selectivities for all gears split between central and southern California and $M=0.2 \text{ year}^{-1}$ as the base model, and is satisfied that this assessment provides the best scientific management advice available. There is no evidence that central and southern California belong to separate stocks, but greater accuracy in the assessment might be obtained in the future from modeling the spatial differences between management areas explicitly. However, the single population model remains the most robust for providing advice at this time.

- 2) For many of the indices, the delta lognormal was used. This is a mixture model between a presence-absence probability (binomial with $n=1$) and lognormal distributions. The probability that a cell is greater than zero is estimated by a logit model. The mean value, given it is positive, is estimated by the lognormal. This avoids a linear transformation (adding an arbitrary constant) before taking logs to remove problems with zero values. While theoretically better, it was pointed out that this model has had problems in other assessments and has attracted substantial criticism in the recent scientific literature. The problem stems from using the log-normal, which down-weights higher values, may be a poor approximation to small discrete values (such as size-specific survey trawl catches) and may introduce significant bias. Alternative probability models, such as quasi-likelihood Poisson, negative binomial or an alternative mixture model (e.g. replacing the log-normal in the above model with the normal) were suggested as alternatives. The problems caused by a high frequency of zero cells are more likely to occur in overexploited stocks which are recovering, as in this case.
- 3) The assessment assuming two separate stocks suggests growth and recruitment is very similar between the areas. Previous research also suggests that they are very similar genetically. Only recruits-per-spawner and the level of depletion were different, but these apparent differences might be due to estimation error. However, these differences may be better explained by a migration model between two connected populations rather than separate stocks. The main implication for the current assessment is that uncertainty about migration increases the uncertainty of unexploited biomass estimate, which in turn makes the target biomass for the rebuilding program less certain.
- 4) The problem of modeling two management areas was considered appropriate for further research. In particular, it would be most useful to parameterise migration or connectedness between the areas rather than having separate models which represent the extremes of what is probably a continuum. It should be noted that if the stock is split, there may be further implications for the way it is managed.
- 5) It was suggested that the central California population is probably towards the edge of the California stock range (Pt. Arena) and therefore may be less resilient to climatic effects and exploitation. Recovery in the central area may take longer than Southern California and may be difficult to predict.
- 6) Retrospective analysis suggests predictions and estimates of state of the resource are stable as new data were added for Southern California. Central California indicates the estimate of spawning falls as data are added. Spawning may be overestimated although it will make little difference to the final results as it is very low already. This bias may be due to the abundance index series, which are short (with the exception of the CalCOFI) for the Central region and will probably disappear as data are accumulated.
- 7) Concern was expressed that the early trawl catch numbers used in the analysis maybe too high in Southern California. No facilities for landing trawl-caught bocaccio existed before 1977 and therefore the trawl fishery was not well developed. Before 1978 an arbitrary allocation was made between the hook and line and trawl fishery on total rock fish catch. As well as allocation to gear, the allocation to species may also be uncertain. It was assumed to be 40% bocaccio. Some late information suggested between 1962-1963 that bocaccio landings could be as high 60%. The reference points based on unexploited biomass were sensitive to this issue.

- 8) Mexico may have CalCOFI data which could be included. This had already been considered. There may be some by-catch of bocaccio in Mexico, but it is probably small.
- 9) Some correction may be required to the CalCOFI data allocation between the southern and central areas, as there was a geographical boundary change during the series.
- 10) Bocaccio spawns more than once per year and the spawning season extends beyond that assumed in the development of the spawning index. Some concern was expressed as to whether this would affect the index. It was argued that the index used data from the mid-season period, so it probably represented the whole season adequately, but multiple spawning was not taken into account. The index could overestimate the number of spawners or recruits per spawner depending on how and where multiple spawning occurs. Conversely recruitment may be underestimated with a second recruitment not included in the index. Multiple spawning is more likely in the south and may also explain the higher recruits per spawner estimate.
- 11) Overall, the results are moderately sensitive to the assumed natural mortality rate. Natural mortality cannot be estimated as it is confounded with the growth rate parameter (among others) in the assessment, and therefore must be supplied as a known value. There was a slight improvement in fit with lower natural mortality for the assessments split between regions. There was significant improvement with higher M for the combined model, but this improvement continued on to unrealistic values for natural mortality. Abundance relative to the unexploited biomass remained unchanged, although absolute abundance increased with natural mortality in Southern California. Natural mortality affects the estimate of the sustainable exploitation rate and other important indicators from the assessment.
- 12) Using the average SPR 68-95 rather than SPR 55-95 to calculate the relative sustainable SPR gives estimates suggesting that the southern California management area is unable to sustain even very small levels of fishing, which is clearly incorrect. The time series 1955-1967 is important in producing a realistic assessment. The magnitude of the early catches also affects the results. A reduction in early catches lowers the productivity of the assessment area, but also makes it less depleted. These two factors cancel each other out to some extent, so the time to rebuild the stock is less affected than might be expected. Nevertheless, the estimates of the unexploited biomass are dependent the early catch time series, which needs to be reassessed. One member of the STAR panel suggested that spawner-recruit and productivity calculations for a portion of the stock (i.e. a management area) were not meaningful because neither spawners nor recruits were measured for the whole stock.
- 13) There is an unrealistically high recruitment event estimated for 1963. This estimate contaminates the recruits-per-spawner estimate which would be used to simulate rebuilding times. Direct observations for recruitment indices exist for 1972 onwards and this probably represents the most reliable period to draw recruitment estimates from for the projection. Alternatives to this base case could be used for the decision table, for example, using all 1955-2001 recruits as opposed to using only the more recent recruitments (e.g. 1980-2001). However, an assessment based on only the most recent recruitments, may indicate that the stock is not able to recover even with no fishing. Some strong recruitments, as seen before 1980, may be a necessary prerequisite for any recovery.

- 14) For projecting recruitment, the average recruit-per-spawner 1955-95 and its observed coefficient of variation should be used. Average recruitment is an important source of uncertainty as it affects both the target and current status. It was suggested that the rebuilding projections should use high and low mean recruitment as a source of uncertainty (± 1 SE). Also, the target could be based on median (from simulations) rather than mean SSB. The median may be a more robust target than that based on the mean and should be considered as an alternative for future research.
- 15) Sensitivity analyses using random initial parameter estimates were carried out during and after the STAR panel meeting. Results suggest that likelihood surfaces for the bocaccio model were complex, which made identification of the global maximum likelihood estimates uncertain. It seems possible that the model for bocaccio was sensitive to noise in the length or age composition data. A simpler model or different parameterization might be used in the next assessment.
- 16) Most of the model runs examined at and after the STAR panel meeting suggest that the triennial survey is basically a young fish survey for bocaccio because estimated selectivity patterns declined with size. It is not clear if the estimated selectivity patterns were reasonable, given the type of gear, areas surveyed and biology of bocaccio rockfish. The hypothesis that triennial survey data could be used to derive a recruitment index for bocaccio rockfish should be addressed in the next assessment.
- 17) Two decision tables, one projecting the two separate management areas and the other considering the consequences of high and low average recruitment around the base model for the whole stock were suggested. The latter was thought the best to take forward to provide management advice as it would capture the essential uncertainty of the assessment.

III Explanation of Areas of Disagreement Regarding STAR Panel Recommendations

There were no areas of disagreement among STAR panel members or between the STAR panel and the STAT team. It is the consensus conclusion of the review panel that the assessment represents the best available scientific information regarding the status of the Boccacio stock.

IV Unresolved Problems and Major Uncertainties

There were a number of substantial unresolved issues pertaining to details in the standardization of abundance indices for bocaccio rockfish. Use of the delta-lognormal distribution and jackknife variance calculations were chief among these. Southwest Fisheries Science Center Administrative Report LJ-96-06 indicates, for example, that trends in CalCOFI indices for bocaccio rockfish are sensitive to the model used in standardization. Evidence presented suggested that trends in abundance data for bocaccio rockfish were relatively robust and similar. If trends are similar, questions about variance calculations are relatively unimportant. The STAR panel decided to accept the abundance indices for bocaccio as presented. However, they should be carefully evaluated for the next assessment.

An important uncertainty is the method used to model future recruitment. The past recruitment has been much higher than recent recruitment. Recovery will be much slower and may not occur in the central California area, unless there are some strong year classes produced by recruitments similar to the beginning of the series.

If the recruitment is driven by the environment, recruitments more similar to the initial part of the time series are possible. Alternatively, if recruitment is driven by spawning stock size, more recent recruitments may be a better indicator of future recruitments. Which of these two hypotheses is correct cannot be resolved.

The degree to which the central and southern California management areas are connected is unclear. This issue does not affect the assessment of the status of the overall stock much, but may affect the way the stock recovers. The separate stock models fitted the observations better. A model with separate adult populations, parameterised migration and a common recruitment pool distributed proportionally to the recruitment indices could significantly improve future assessments.

The unexploited biomass is inaccurately estimated, as it depends on poorer catch data from the early part of the time series. While this does not put its overfished status in doubt, it will lead to greater uncertainty over when the stock has recovered. This estimate should be improved by further work on the catch series.

V Recommendations for Future Research and Data Collection

- 1) Ichthyo-plankton CALCOFI data from northern and central California (including “Russian” data) from 1970-1982 was missing from the analysis. The CalCOFI ichthyo-plankton samples for the region north of Avila Beach for bocaccio and other *Sebastes* spp. should be traced and worked up into appropriate indices. If of good enough quality, they should be included in future analyses.
- 2) A two area model for the bocaccio stock could be developed which would allow migration between the two main regions. It was suggested that the model might have two separate adult populations, but shared recruitment and other parameters as appropriate. The degree of mixing between the populations could be parameterized, rather than having two different models representing extreme ends of the hypothesis. This model could be used explore the implications of different levels of adult migration between the areas, and choose some reasonable level. This model could form the basis for exploring the issue of how to handle two separate areas in the assessment.
- 3) The assessment is sensitive to the way past rockfish catches are allocated between species and, to a lesser extent, gear. Information on rockfish landings composition may be available for the earlier years which will improve estimates. Also it may be possible to fit a species abundance curve to those years where information on species composition is available. Species abundance curves may improve interpolation and extrapolation of species composition to those years where only total catch is available.
- 4) RecFIN has data missing, which needs to be addressed by the RecFIN committee to provide reasonable estimates for missing values for each species. RecFIN data is becoming increasingly important as recreational catch is becoming the largest proportion of the catch for this species.
- 5) Research on the effect of multiple spawning on the CalCOFI spawning index is required. The number of spawnings may differ between northern and southern California.

- 6) Trawl logbooks from 1950-1980 exist and should be entered into a database to obtain rockfish catch and effort data for this period. This would provide valuable data for many species as well as bocaccio.
- 7) Party logbook data exist and indices for bocaccio should be updated for the next assessment.
- 8) The current reference points may not be robust to the uncertainties in the model. Reference points might be developed based on robust median estimates rather than means for the unexploited SSB.
- 9) Conventional stock assessment model calculations which rely on assumptions about lognormal measurement errors in abundance data are problematic when applied to stocks that are naturally rare or depleted (e.g. bocaccio) because zeroes are common in abundance data and the assumption of lognormal errors is not tenable. The next assessment should explore approaches (e.g. maximum likelihood using the Poisson, negative binomial distributions) that make statistical assumptions about measurement errors that might be more appropriate.