Panel Report: California Sheephead Stock Assessment

Submitted by the Stock Assessment Review Panel:

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Reviewed by the STAT and presented to California Department of Fish and Game on August 06, 2004

Overview

The Review Panel met with the Stock Assessment Team (STAT) on July 8-9th, 2004 at the National Marine Fisheries Service (NMFS) Lab at Santa Cruz, California to review the California Sheephead stock assessment. The stock assessment was prepared by the STAT for use by the California Department of Fish and Game (CDFG) and the California Fish and Game Commission for use in assessing stock status and developing management measures for California Sheephead.

The meeting was moderated by Dr. Marc Mangel (University of California Santa Cruz). Prior to the review meeting, the Review Panel was provided (via mail) with the following documents: 1) a Terms of Reference for the review panel meeting (attached), 2) a draft meeting agenda (attached), and 3) a draft stock assessment document. The draft assessment document was well written, thorough, substantially complete, and was provided early enough to the Review Panel to allow for sufficient review prior to the meeting.

A unique aspect of this assessment is sequential sex change from female to male (protogynous hermaphroditism), which leads to a decrease in egg production as individuals change gender to males. A dome-shaped egg production at age curve is required for modeling, using a modified version of the Stock Synthesis program developed by Methot.

Over the two-day meeting, the STAT and Review Panel members had ample time to discuss and modify the model. Discussions were amiable and constructive, leading to a consensus on appropriate parameterization and interpretation of results. This Panel agrees that the California Sheephead Stock Assessment represents the best available science on this species and is sufficient to serve as a basis for management.

Nevertheless, as with all modeling exercises, there are critical unknowns that affect model results. Uncertainty in assessment results cannot be fully quantified, but should not be ignored when deriving management advice from the assessment. In particular, natural mortality rates have a large effect on the estimates of unfished biomass and spawning potential ratio, which affect our assessment of whether the stock is depleted. The available larval index and fishery catch per unit effort (CPUE) time series are not ideal measures of the stock trends. The appropriate thresholds for status assessment of hermaphrodites have not been established. In addition to recommendations for modifications to model runs and the assessment report, we identified several research needs to improve future assessments.

Minutes of the Panel Meeting at National Marine Fisheries Service Lab in Santa Cruz, CA

Day 1 (8 July)

Overview of biology, data, and model construction by STAT members

Members of the STAT reviewed the biological information given in the assessment and the sources of life history information. Two primary sources of information were used to parameterize natural mortality (M), growth curves and transition to male probability: Warner's (1975) study at Catalina Island and Guadalupe Island, and Cowen's (1990) study at 6 sites in Mexico and California. There are no sex-specific data on mortality or growth rates. Although wide ranges in life history parameters exist among study sites, suggesting local adaptation or plasticity, details on the mechanisms behind these differences are not available.

Fishery data include catch records for commercial and recreational fisheries dating back to 1916, with the most detailed information on CPUE and length frequency data for years 1980 to 2003. CPUE estimates based on commercial passenger fishing vessel (CPFV) logs (recreational fishery) occur in 3 stanzas, due to changes in reported units: 1947-1961, 1960-1981, and 1980-2003. For the most recent stanza, the CPUE standardization is improved by the availability of spatially explicit information on catch rates by statistical fishing block. Length frequencies from the recreational fishery, which targets a wide size range of fish, date back to 1975. Length frequencies are also available for recent years for commercial fisheries, allowing the model to include fishery-specific selectivity-at-length relationships.

Sheephead larvae occur in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) ichthyoplankton survey. A generalized linear model was applied to these data to derive a time series of larval production, which was used in the model as a measure of the spawning biomass that produced these larvae.

Dr. Suzanne Alonzo reviewed the model construction and analyses described in the Assessment with minor clarifications. The sensitivity analyses performed on this model were extensive, and revealed important information about model behavior. The CPFV logbook survey data from 1980-2003 show a trend that is consistent with the trend in the CalCOFI larval index and have the largest influence on the the model result. Length distributions from the recreational and trap fisheries have the largest influence of the four fishery data sets.

Questions, comments and discussion

The primary issues brought up by the panel can be divided into three categories: general ecology, data uncertainty, and model parameters and structure. Irresolvable unknowns are detailed more extensively in the Critical Uncertainties section, below.

- There was considerable discussion on the role of larval transport from Mexico and the relative importance of fish caught in Mexico and landed in the US, which were included in the analyses.

- Sex change may be related to density or sex ratio and highly plastic, which will make extrapolations for local to regional assessments difficult. The age-length data suggest a bimodal growth curve, which might be expected as females change into males.
- There is no empirical information or accepted theory to set sex-specific spawning potential ratios (SPR = current spawning stock biomass per recruit/unfished spawning stock biomass per recruit) for hermaphrodites. The currently accepted SPR threshold of 50% may be acceptable for females, but does not assure an adequate sex ratio. The optimal or minimum adult sex ratios for adequate fertilization success are unknown.
- Although the model results suggest relatively high variance in recruitment (age 1 fish), visual examination of the length frequency data and residuals of model length frequency estimations by year and fishery do not show evidence of strong year classes. However, strong year classes may be difficult to detect in the time series, which are length-based.
- CPUE time series do not account for technological changes in fishing effort and may not be proportional to stock abundance.
- An increase in model predicted biomass sometime between 1958 and 1960 could be due to a switch in CPUE units between the first two stanzas of available data, rather than an actual increase in recruitment. The jump in biomass occurs in the model fits for some levels of natural mortality, but not others. Final model runs were stabilized in this regard by linking the initial equilibrium biomass to the mean recruitment level.
- As with many assessments, the model is highly sensitive to the natural mortality rate. Mortality rates from field populations, which likely included some level of fishing mortality, were not age-specific and were based on limited samples of aged fish.
- There was some discussion of the stock-recruit relationship and a suggestion by Dr. Xi He (NMFS) to run a simpler model without estimating recruitment variability. It was agreed that a range of weighting levels on the spawner recruit parameters should be examined.

Request for additional analyses and data discussion (Panel and STAT)

The Panel asked the STAT to recheck the log-likelihood results for one part of the sensitivity analysis, which seemed abnormally high. An error in the estimation of variability in length-at-age was corrected. There was also a request to plot the total catch time series with and without landings from Mexico. There was a request to add additional size bins to the model structure in order to examine the dynamics within the 50+ cm size range.

New model runs included: change in natural mortality to a base M of 0.2, a fixed coefficient of variation (CV) of 0.11 for size-at-age, allowing the model to freely estimate recruitment for most years in the time series with a small emphasis on deviations from the mean recruitment level, including a constant recruitment run.

Day 2 (9 July)

Presentation and discussion of results from new baseline models

The data input checks included an update of the age-length relationship and correction of some of the log-likelihood graphs from the sensitivity analysis. The Panel and STAT agreed that the new graphs were an improvement. Removing the landings from Mexico proved problematic

because it required multiple assumptions about the distribution of Mexican fish in the landings for years without data. The consensus was to leave the landings in the time series, in part because they represented an increase of less than 5% for those years since 1970. Natural mortality rates less than 0.2 gave poor model fits. It was suggested that a probability distribution for natural mortality could be developed, but the present data and model structure are not well-suited for such an analysis. A re-analysis of the raw age-at-length data from Warner and Cowen would be necessary, but still probably not sufficient to provide definitive results.

Additional length bins altered some model outputs. The model predicted a descending selectivity gradient with age for recreational and trap fisheries, but there was minimal improvement of model fit so, in the interest of parsimony, the subsequent runs were restricted to an ascending selectivity curve. More length bins allowed the model to "retain" big, old fish, which had some effect on biomass. Overall, however, biomass estimates were lower for the new runs because of the reduced natural mortality rate (M = 0.2 instead of 0.35).

The model fits to surveys were variable for early years, but trajectories consistently showed a decline for recent years. Further examination of the model results showed a dependency on the early years of CalCOFI larval index data, which were thought to be zero for the years 1951-1960. A recheck of CalCOFI Atlas 32 revealed that these were not true zeros because Sheephead were not enumerated by species during those survey years, so subsequent analyses eliminated CalCOFI "data" prior to 1961.

Model fits for low natural mortality rates were abandoned due to poor model fits and agreement among the Panel and STAT that there are no empirical data to support them.

Further discussion of model results and most reasonable parameter inputs went through the morning, punctuated by new runs. A consensus on the appropriate baseline model and range of natural mortality rates was reached.

Final consensus on model inputs and structure

The Review Panel agreed with the final baseline model structure proposed by the STAT, which provided model stability without heavy reliance on stock recruitment assumptions. In the final baseline model, year-specific recruitment values were lightly constrained by setting the spawner-recruit emphasis at 0.01, variability in recruitment was fixed at a CV of 0.80, spawner-recruit steepness was fixed at 0.99 (equivalent to setting the spawner-recruitment relationship equal to the mean recruitment), and the mean recruitment level was used as the initial equilibrium recruitment level prior to 1947. The age structure of the population at the beginning of the modeled era is assumed to be in equilibrium with a catch level of 55 mt. The most recent recruitments (2001-2003) were determined from the spawner-recruit relationship.

Models run prior to the review explored a range of values for the variability around the growth curve. The panel recommended that the size composition data were not sufficient to enable the assessment model to estimate this parameter. Further examination of the published size-at-age information produced an estimate of growth CV of 0.11 that was used in all subsequent model runs.

Another change from the draft stock assessment involved the bin structure of the length composition input data. In the draft stock assessment, the bins were in 2 cm increments with an accumulator bin at 50+ cm. In the final baseline model, the bins were in 2cm increments from 18-78 cm. This change was made to more fully incorporate the population dynamics of the older portion of the population age structure.

Due to uncertainty in the true value of natural mortality, the final baseline model was profiled over the values of M of 0.15, 0.20, and 0.30.

Recommendations for final assessment document

- Add "mature spawning stock" to the SPR analysis. In the absence of better theory or analysis, we suggest the 50% level be maintained as a threshold for status assessment. Combining the sexes into a mature biomass category may also account for plasticity in age at sex change.
- Life history differences among sites and their effects on model outputs are interesting and may be important for local assessments. However, the growth curves should be rechecked due to inconsistencies in length at age and age at maturation between the curves and empirical data.
- In the Introduction, provide more information on plasticity in life history parameters and the potential effects of density and sex ratio on sex change probability and lifetime reproductive success. This leads to an important caveat: local dynamics may be important drivers of abundance and stock status.
- Discuss why CPUE is declining, whether it matters, and what we should expect to see in the future if removals are reduced. A set of yield projections should be produced under the CDFG-recommended fishing mortality rate.
- Discuss results of sensitivity analysis and what they mean.

Critical uncertainties

The data available for this assessment lacked age and sex composition. A lack of fishery-independent estimates of length distributions and a less than ideal fishery-independent abundance indicator reduced our ability to eliminate alternative hypotheses for observed declines in CPUE. However, relative to many assessments, this one is not particularly data poor: a long time series of CPUE is available through logbook records, length compositions are available for multiple fisheries, basic biological information is available through detailed biological studies of Warner and Cowen, and fishery-independent information is available in the form of CalCOFI larval indices.

Stock Structure

The southern boundary of the assessment area is the US-Mexico border. Although the assessment includes a small amount of catch that is taken in Mexican waters and landed in the U.S., all other catch and stock trend data are from the U.S. zone. There are no trend data from Mexico. Limited information on catch landed in Mexico indicates a lower level than in the U.S., and life history data from the south-central Mexican zone is different than comparable life history data from the U.S. Therefore, because Sheephead are largely sedentary as adults, the assessment results for stock abundance and fishing mortality are reasonably ascribed to the U.S. portion of the Sheephead population. However, it is not assured that the U.S. stock is completely independent of the Mexican stock. There could be cross-border movement of larvae, juveniles or adults; and the north-south connections are probably influenced by environmental events such as el Niño. Sheephead are at the northern edge of their range in the U.S. zone, so it is very possible that recruitment in the U.S. zone is partially dependent on spawning off Mexico.

The assessment necessarily analyzes the U.S. stock as if it is a unit stock with enough dispersion so that fishing mortality is dispersed across the entire stock. However, the sedentary nature of the adults means that localized depletion is possible if the fishery is allowed to

concentrate too much into a limited portion of the range. Without information on particularly important spawning or nursery sites, it is not possible to provide further guidance on area-specific management of Sheephead.

Stationarity of Life History Parameters

Ecological studies of Sheephead by Warner and Cowen have found life history differences between sites in U.S. and Mexican waters. Some of these differences have been ascribed to differences in Sheephead local densities, but confounding by latitudinal environmental conditions is possible also. These differences in life history make it difficult to determine the best set of growth, maturity, gender change, and natural mortality parameters to use in the assessment. Further information on life history characteristics at more sites and over time is needed to resolve these issues.

CPUE Standardization

The assessment uses two sources of information on trends in Sheephead abundance. One is the CalCOFI larval survey as an index of the spawning biomass that produced these larvae. The other is the catch per unit effort (CPUE) from three eras of the recreational fishery. Neither is ideal as an indicator of the trend in Sheephead abundance. The CalCOFI survey does not capture many Sheephead larvae, so the index is highly variable, and there is a possibility of contamination by larvae spawned off Mexico, especially during el Niño climate conditions. The CPUE indexes are based upon various measures of angler effort, none of which are standardized to the degree that fishery-independent surveys are standardized, so there is a potential for an unknown degree of drift in the relationship between CPUE and abundance of the fishable biomass. The CalCOFI and CPUE indices have been used in a reasonable and customary way in this assessment, but a more confident result depends upon a more focused measure of Sheephead abundance.

Natural Mortality

One of the most influential life history parameters is the level of natural mortality. Certainly time- and age-dependent values are not available, and even an average value for all ages and times is not well known. A value near 0.29-0.35 is obtained from the work by Cowen and Warner, a value near 0.20 is consistent with the maximum ages near 20, and lower values of natural mortality are consistent with the possibility that these other estimates contain some level of fishing mortality. In addition, life history studies from sites in south-central Mexico indicate even higher values, near 0.5. Further resolution of the actual natural mortality value is not possible without a substantial investment in field studies. The Committee recommends that the ramification of using values between 0.15 and 0.30 be presented to managers and that an intermediate value is more probable than either extreme.

Recruitment

After much fruitful discussion between the review and assessment teams, the final model configuration estimated year-specific recruitment values that were lightly constrained to not

deviate too far from the mean recruitment level and the mean recruitment level was used as the initial equilibrium recruitment level prior to 1947. Other, more flexible model configurations were explored but there are insufficient data to provide stable model results from such configurations. The long-term trend in recruitment is sufficiently well-determined by the final model configuration, but year-specific recruitment estimates should not be interpreted too literally. Without age composition data or distinct progression of modes in the size composition data, the estimated year-specific recruitments may not represent actual recruitment events or failures.

Recommendations

management

- monitor catch by sex as well as length
- collect some area-specific age information
- determine whether TAC should include fish caught in Mexico

future models, assessments

- develop a two-sex assessment model to monitor changes in sex ratio
- explore how changes in F distribution among fisheries may affect stock in future
- determine the ramifications of occasional "seeding" through larval transport from Mexico

research

- assess age- and sex-specific mortality rates in several California locations, including marine reserves
- study behavior and mating system – is there compensatory sex change?
- examine larval retention and transport variability and its relationship to ocean conditions
- determine stock structure and dispersal
- develop new theory – what should threshold SPR be?
- examine the relationship between ocean conditions and recruitment patterns

Terms of Reference for the California Sheephead Review Panel Meeting

NOAA Fisheries Laboratory
Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, California.

July 8-9, 2004

The principal responsibility of the Review Panel is to carry out the following terms of reference. The Panel's work includes:

1. reviewing draft stock assessment documents and any other pertinent information;
2. working with STAT (Stock Assessment Team) to ensure the assessment is reviewed;
3. documenting meeting discussions; and
4. reviewing summaries of stock status (prepared by STAT Teams) for use by CDFG and the Fish and Game Commission in developing management measures.

The Panel is responsible for determining if a stock assessment is sufficiently complete. It is the Panel's responsibility to identify whether the assessment cannot be reviewed or completed for any reason. The Panel's decision that an assessment is complete should be made by consensus. If a Panel cannot reach agreement, then the nature of the disagreement must be described in the Panel's report. The Panel's terms of reference concern technical aspects of stock assessment work. The Panel should strive for a risk neutral approach in its reports and deliberations. Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in the completed stock assessment and the report prepared by the Panel. The Panel should identify model scenarios that are unlikely or have a flawed technical basis.

Recommendations and requests to the STAT for additional or revised analyses must be clear, explicit and preferably in writing. A written summary of discussion on significant technical points and lists of all Panel recommendations and requests to the STAT are appropriate for inclusion in the Panel's report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel's responsibility to carry out any follow-up review work that is required.

Additional analyses required in the stock assessment should be completed during the Panel meeting. If follow-up work by the STAT Team is required after the review meeting, then it is the Panel's responsibility to track STAT progress. In

particular, the chair is responsible for communicating with all Panel members (by phone, email, or any convenient means) to determine if the revised stock assessment and documents are complete and ready to be used by managers. If stock assessments and reviews are not complete at the end of the Panel meeting, then the work must be completed in order to conclude the work of the Panel. The Panel, STAT, and all interested parties are legitimate meeting participants that must be accommodated in discussions. It is the Panel chair's responsibility to manage discussions and public comment so that work can be completed.

The STAT and the Panel may disagree on technical issues. If the Panel and STAT disagree, the Panel must document the areas of disagreement in its report. The Panel may request additional analysis based on alternative approaches. Estimates and projections representing all sides of the disagreement need to be presented in the assessment document, reviewed. It is expected that the Team will make a good faith effort to complete these analyses.

The chair is responsible for providing CDFG with the final version of the Panel's report.

Suggested Template for Panel Report

- Minutes of the Panel meeting, including name and affiliation of Panel members.
- List of analyses requested by the Panel.
- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.
- Explanation of areas of disagreement regarding Panel recommendations:
    - among Panel members (majority and minority reports), and
    - between the Panel and STAT.
- Unresolved problems and major uncertainties, (e.g., any special issues that complicate scientific assessment, questions about the best model scenario).
- Prioritized recommendations for future research and data collection.

DRAFT AGENDA
2004 CDFG California Sheephead Stock Assessment Review Panel

Santa Cruz, CA
July 8-9, 2004

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<tr><th></th><th>8-Jul Thursday</th><th>9-Jul Friday</th></tr>
<tr><td>8:00 AM</td><td>Welcome/Introductions</td><td rowspan="4">Review New Model Runs
Model Refinements
Yield</td></tr>
<tr><td>8:15 AM</td><td>Review TOR</td></tr>
<tr><td>8:30 AM</td><td rowspan="3">Presentation (Part I)
History of the Fishery (Teresa)
Biology of Sheephead (Suzanne)
Data & Initial Analysis (Meisha)</td></tr>
<tr><td>9:00 AM</td></tr>
<tr><td>9:30 AM</td><td></td></tr>
<tr><td>10:00 AM</td><td>Break</td><td>Break</td></tr>
<tr><td>10:30 AM</td><td rowspan="3">Presentation (Part II - Suzanne)
Parameter Estimates
Baseline Model
Management Recommendations</td><td rowspan="2">Primary Areas of Concern</td></tr>
<tr><td>11:00 AM</td></tr>
<tr><td>11:30 AM</td><td>Public Comment</td></tr>
<tr><td>12:00 PM</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td></tr>
<tr><td>12:30 PM</td></tr>
<tr><td>1:00 PM</td><td rowspan="4">Model Evaluation
Discussion Session</td><td rowspan="8">Panel Recommendations
Draft/Review Panel Report</td></tr>
<tr><td>1:30 PM</td></tr>
<tr><td>2:00 PM</td></tr>
<tr><td>2:30 PM</td></tr>
<tr><td>3:00 PM</td><td>Break</td></tr>
<tr><td>3:30 PM</td><td>Public Comment</td></tr>
<tr><td>4:00 PM</td><td rowspan="2">Evening Tasks - (Panel requests for additional runs or new configurations)</td></tr>
<tr><td>4:30 PM</td></tr>
<tr><td>5:00 PM</td><td>Close</td></tr>
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