Stock Assessment Review (STAR) Panel Report
For California Scorpionfish

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110 McAllister Way
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Overview

The STAR Panel reviewed a full assessment of California scorpionfish (*Scorpaena guttata*) 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 Point Conception. Although the range of the species extends further south into Mexican waters, the lack of assessment information precluded assessment of the component of the species south of the U.S.-Mexico border. The first full assessment of California scorpionfish was conducted in 2005, and a catch-only update was done in 2015.

Based on our review, which included requests for additional analyses and model runs, the STAR Panel recommends that the assessment for California scorpionfish constitutes the best available scientific information on the current status of the stock and that the assessment provides a suitable basis for management decisions provided adequate account is taken of uncertainty.

Summary of Data and Assessment Models

The assessment uses a recent version of Stock Synthesis 3 (3.30.03.06). The population model in the assessment extends from 1916 to 2016, and two sexes are modeled allowing separate growth and mortality parameters. The main sources of information in the assessment include:

- Catch and length composition from six fisheries: combined commercial fishery (primarily hook-and-line), commercial gillnet fishery, commercial trawl fishery, recreation charter fishery, recreational private vessel fishery, and a recreational "discard" fishery that represents the discard for both the recreational charter and private vessel fisheries.
- Biological information including maturity at length and length at age.
- Fishery-dependent relative abundance (CPUE) indices for the recreational fisheries in southern California. A total of four indices were derived from recreational fishery data, including indices charter and private fleet based on dockside data collections (charter 1980-2016, private 2004-2016), and indices for retained catch and discards based on onboard observer data (2002-2016).
- Fishery-independent indices for the Publicly Owned Treatment Works (POTW) trawl survey, the NWFSC shelf-slope survey, a gillnet survey in southern California, and the Southern California Bight trawl survey. Size composition from the Southern California power plant (impingement) data was used, but no index was developed for this data set.
- New age data for the NWFSC shelf-slope survey.

Key model features include:

- Abundance indices used in the assessment were obtained using delta-GLM, negative binomial, or VAST modeling approaches.
- Growth was estimated within the model.
- A Beverton-Holt stock recruit relationship was assumed and recruitment deviations were estimated.

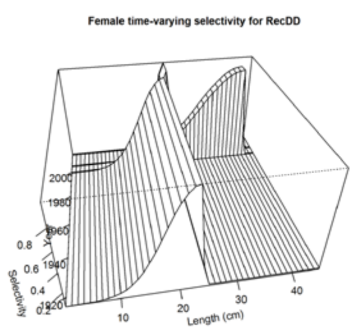
- Prior distributions for steepness (Thorson pers. com.) and natural mortality (Hamel 2015) were used. Steepness was fixed at the mean of the prior for rockfish, and the pre-STAR model fixed female natural mortality at the median of the prior, and the offset for males was estimated
- Length-based selectivity curves were estimated for all surveys and fisheries. Selectivity patterns were assumed to be asymptotic except for recreational discard, which was modeled as a separate fishery with a dome-shaped selectivity pattern.
- Age data were modeled as conditional age given length in the assessment.
- Additional variance terms were estimated for all abundance indices, and length composition and conditional age at length data were reweighted using the Francis method.

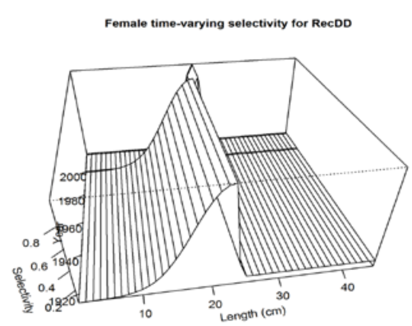
Requests by the STAR Panel and Responses by the STAT

Request 1: Add time blocks (-1999, 2000-2005, 2006-2017) for the recreational dead discard fleet same as for the recreational retained fleets.

Rationale: Changes in selectivity of retained fish likely reflect changes in the retention of discarded fish.

STAT Response: The model was run with the 3 requested blocks, or with only two (-1999 and 2000-2017). The second block encompassing 6 years has only 3 years of data (2003-2005) on which to estimate selectivity. The three blocks reflected the changes in management better (the closed years 2000-2006 show a selectivity reflective of the retained catch in other years) than two blocks and fit the data better (1 to 2 blocks change of 8.7 log likelihood units, 2 to 3 blocks change of 5.7 units). Overall, the total biomass in 2017 changed by less than 0.1% and depletion changed from 0.574 to 0.582 with the addition of the two extra time blocks.





The STAR Panel and STAT agreed to include the change from one to three time blocks for this fleet in the final base model.

Request 2: Combine retained and discarded catches in the recreational index (use the number of California scorpionfish encountered per angler hour as the CPUE metric). Include retained and discarded catches and length compositions in this new fleet with appropriate weights. Make the CPFV logbook index a survey.

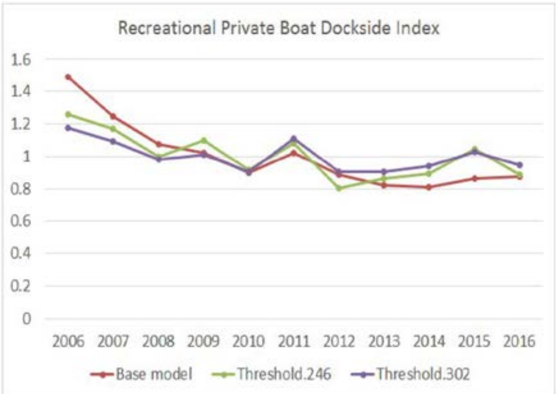
Rationale: The STAR Panel was concerned with modeling discards as a separate fleet, and wanted to compare this approach with an alternative approach.

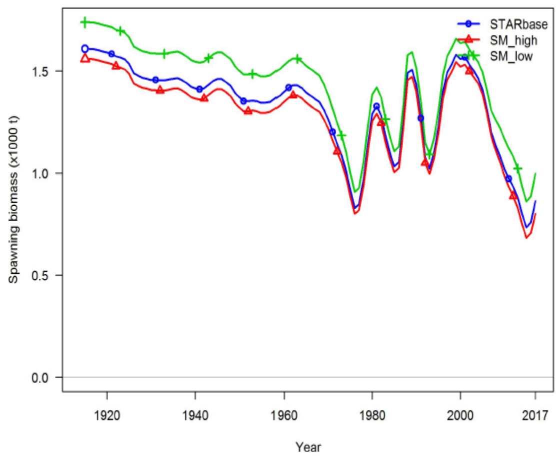
STAT Response: This turned out to be more difficult than the STAR Panel anticipated—the "discard" fleet includes discard amounts from two fisheries, but only one has composition data associated with it. So while one fleet could combine the retained and discarded in the compositions with appropriate weighting, the other would still only be based on the retained compositions (or "borrow" information from the other fleet). Given the small amounts of dead discard overall and the finding of virtually no impact of Request 1 on the model (while fitting the discard compositions better), this request was dropped by the STAR Panel.

Request 3: Explore the sensitivity of the recreational dockside private mode index to the thresholds in the Stephens-MacCall filtering procedure by halving the false positives and alternatively halving the false negatives. Retain the true and false positives in each of these runs.

Rationale: The current thresholds are ad hoc.

STAT Response: The original cutoff used for Stephens-MacCall filtering was a rounded value of 0.17 for the probability of catching California scorpionfish in a trip. This resulted in about 2300 each of false negatives and false positives. Halving these values was achieved by using probabilities of 0.1407 and 0.2308 respectively. The changes had relatively minor effects on the index, but moderate effect on the overall stock size, especially for the lower probability which included many more false positives, adding ~1600 points to the CPUE standardization set, which resulted in a model with nearly 10% more spawning biomass (both unfished and current) than the base. However, the overall pattern was unchanged.





Since it is not clear which data set is most appropriate, there was no recommendation arising from this analysis for the current assessment. Rather this highlights the need for more research into this topic.

Request 4: Do a sensitivity to the relationship between weight and fecundity. Use a generic rockfish relationship from Dick et al. 2017.

Rationale: There is a lack of information on this relationship in the assessment and the sensitivity of the model to this relationship needs to be understood.

STAT Response: The base model assumes that fecundity as proportional to weight. The model was run with an alternative where fecundity is proportional to length to the power 4.043. This model had a slightly lower depletion level (0.531 vs. 0.579, measured in spawning output rather than spawning biomass) and a slightly higher unfished equilibrium biomass estimate (by about 1%). While more research into this topic is warranted, its effect on the model outcome will likely be moderate.

Request 5: Evaluate the selectivity for the impingement index by allowing for a normal descending selectivity pattern.

Rationale: There is a strong residual pattern in the fits to length composition data, suggesting an different selectivity pattern may be appropriate for this index.

STAT Response: Allowing for a descending selectivity pattern resulted in a reduction in the residual pattern. The run conducted, however, did not estimate the size at the “peak” selectivity (representing here where the start of the downturn would be) and the downward slope was quite steep. Estimating this value resulted in a change from about 20 to 17 cm for this value and better overall fit of the model the length and age composition data (by about 5 log likelihood points apiece vs. the constant selectivity assumption). The scale of the population increased by approximately 15% and the 2017 depletion increased to 0.598 (vs. 0.579). The resulting selectivity pattern is close to an inverse logistic with a non-zero lower asymptote. The STAR Panel and STAT agreed that this pattern is more realistic and fits the data better than the model with full selectivity at all ages and sizes, and should be included in the final base model.

Request 6: Investigate the commercial net length data sources to see if they are representative of the different mesh sizes used. For a sensitivity analysis, turn off the mirroring of selectivity to the hook and line fleet and estimate a fleet-specific selectivity pattern. An additional sensitivity analysis, remove the length composition data from this fleet and continue to mirror the selectivity of the hook and line fleet.

Rationale: These lengths do not fit well in the current model. It is not clear if the length composition data are tracking the temporal changes in allowable mesh sizes.

STAT Response: When estimated independently for the commercial net fleet, the selectivity pattern moved far to the right of that for the hook and line fleet. Depletion (0.575 vs 0.579) and stock size decreased slightly with this change, and the fit to length composition data improved by 20 log likelihood points. Since there is relatively little length data from the commercial net fishery, dropping that length data and continuing to mirror selectivity made little change from the base model, but the resulting model does not accurately reflect the apparent selectivity of the net fleet. The STAR Panel and STAT agreed that the independently estimated selectivity for the net fleet is more realistic and fits the data better, and should be included in the final base model. Since the peak value parameter hit the upper bound, it should be fixed in the final model.

Request 7: Turn off the mirroring of the gillnet survey to the POTW survey selectivity and allow the model to estimate a survey-specific selectivity.

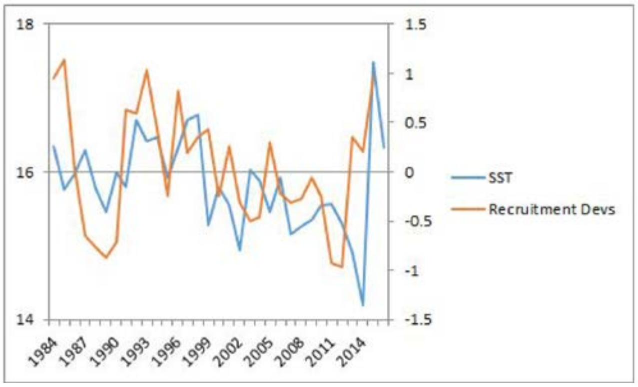
Rationale: The length composition data do not fit well in the current model.

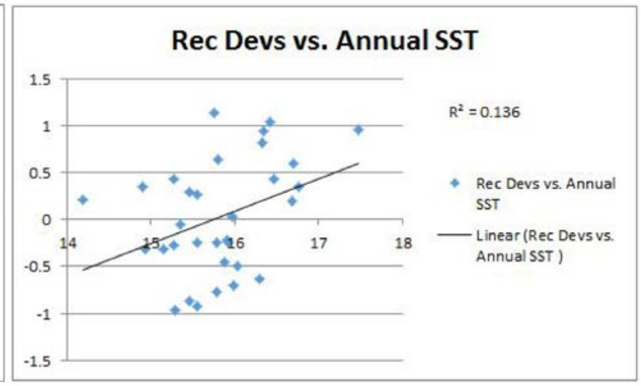
STAT Response: The model run following this change did result in a very different selectivity pattern (nearly a straight diagonal line up from zero to the 40 cm), however, the Hessian did not converge. Dropping the gillnet data altogether had very little impact on the model. It was agreed to drop this fleet from the final base model, and recommend further investigation of this data for future use.

Request 8: Plot the CalCOFI sea surface temperature index for Pacific sardine with the estimated California scorpionfish recruitment deviations.

Rationale: To investigate the hypothesis of warmer water influencing positive recruitment.

STAT Response: The annual CalCOFI sea surface temperature index was correlated with the model estimated recruitment deviations. This helps explain the pattern of alternating periods of positive and negative recruitment deviations in the model. The Panel recommends further investigation of possible predictors with the goal of finding a better indicator of California scorpionfish recruitment to be considered for use within a model and for forecasting.

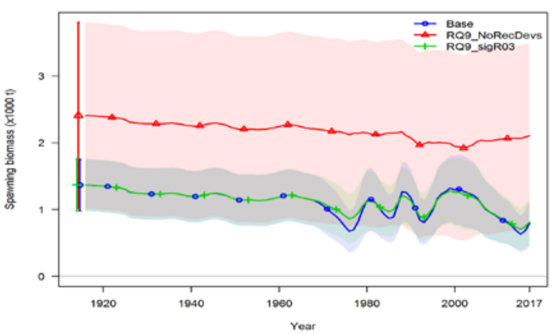


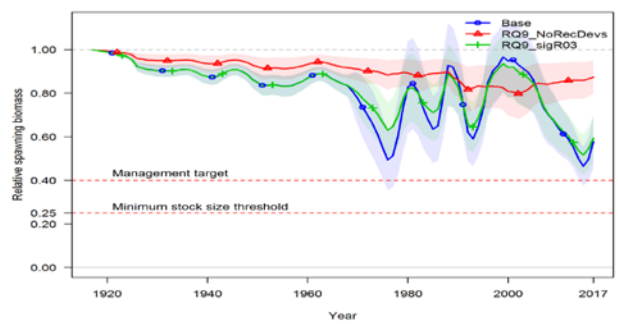


Request 9: Provide a model run where recruitment deviations are not estimated. Also, provide a model run with a lower sigma-r (0.3).

Rationale: There is concern that the higher recruitment deviations are not realistic and they sustain the trends we see in stock size regardless of removals.

STAT Response: A run with no recruitment deviations resulted in a higher unfished equilibrium biomass, but did not fit the data nearly as well (by over 110 log likelihood units). With half the sigma-r value (0.3), the overall scale of the stock did not change from the base, but the variation over time was suppressed somewhat. Since the results of Request 8 indicated potential underlying environmental drivers for the recruitment patterns in the base model, it was agreed that the original sigma-r (0.6) was reasonable.





Request 10: Prepare a new base model that changes July 26 base model as follows:

- Model the commercial net fishery with its own selectivity curve with two selectivity blocks matching the other commercial fisheries. Peak selectivity parameter needs to be fixed (not estimated);
- Model the impingement data with a descending selectivity pattern, including estimation of the peak parameter;
- Drop the gillnet survey from the model;

- Fix M for both sexes combined based on a max. age of 23 years (M = 0.235) (determined by averaging the third oldest estimated ages of each sex);
- Retune and jitter; and
- Evaluate diagnostics to ensure this is a sound model.

Rationale: These changes were agreed to by the STAT and STAR Panel.

STAT response: The requested model run was provided. Model diagnostics indicated that this was an acceptable model.

Request 11: Building on the new base model, prepare bracketing runs on natural mortality that use the 12.5% (M = 0.164) and 87.5% (M = 0.335) quantiles of the Hamel prior distribution.

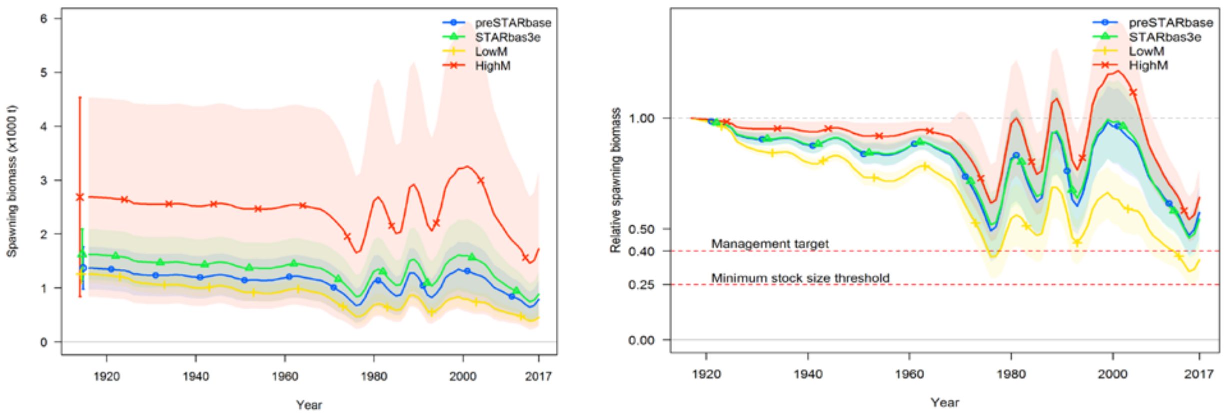
Rationale: To consider for a decision table.

STAT Response: While the low value for natural mortality produced a reasonable result, the high value resulted in an incredibly large biomass. This request was modified below.

Request 12. For the high state of nature, explore a natural mortality such that the ratio of ending SSB in the high state of nature to the base case is equal to that ratio from the base case (M = 0.235) to the low state of nature (M = 0.164).

Rationale: The first exploration of a high state of nature in a potential decision table provided unrealistic results, and a follow-up run with narrower range for natural mortality did not provide adequate contrast between states of nature.

STAT Response: The high value of natural mortality which meets the above criteria was found to be 0.2745. This, along with the low value (M = 0.164) results in a reasonable bracketing of the uncertainty.



Request 13: Provide a draft decision table with the 3 states of nature assuming the following harvest control rule for a catch stream: ACL = ABC, P*=0.45, sigma = 0.36; ABC buffer = 4.4% (i.e., ABC is 0.956*OFL).

Rationale: This is a reasonable catch stream to demonstrate the outcomes of a potential decision table.

STAT Response: The STAT provided the following table.

		LOW		BASE		HIGH	
Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	Depletion
2017	150.032	451.55	0.3599	882.45	0.54323	1725.8	0.64251
2018	150.01	496.18	0.39548	1017.5	0.62641	2032.5	0.75671
2019	323.26	516.62	0.41177	1085.4	0.66822	2185.3	0.8136
2020	318.23	430.93	0.34347	1023	0.62978	2164	0.80564
2021	302.65	349.03	0.27819	954.29	0.58746	2116.4	0.78794
2022	286.11	285.62	0.22765	897.23	0.55233	2069.7	0.77055
2023	272.41	239.31	0.19074	855.16	0.52644	2032.8	0.7568
2024	261.94	202.63	0.1615	825.32	0.50807	2006.3	0.74695
2025	254.09	170.36	0.13578	804.05	0.49497	1988.4	0.74029
2026	248.19	140.86	0.11227	788.57	0.48544	1976.9	0.73598
2027	243.72	113.76	0.09067	777.06	0.47836	1969.8	0.73334
2028	240.31	88.485	0.07052	768.39	0.47302	1965.8	0.73186

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

Several changes were made to the pre-STAR base model during the STAR Panel review:

- The recreational discard fleet was modeled with three selectivity blocks in the same way as the recreational retained fleets.
- The commercial net fishery was modeled with its own selectivity curve with two selectivity blocks that matched the selectivity blocks used for other commercial fisheries;
- The power plant impingement data was modeled with a descending selectivity pattern;
- The gillnet survey data was dropped from the model;
- Natural mortality was assumed to be the same for males and female and fixed at median of the Hamel prior based on a maximum age of 23 years (M = 0.235) (determined by averaging the third oldest estimated ages of each sex).

Alternative Models for Bracketing Uncertainty

The high and low biomass scenarios were identified by considering uncertainty in natural mortality. The low biomass scenario was defined by the 12.5% quantile (M = 0.164) of the Hamel prior distribution. An extremely high biomass that was considered implausible by the STAR Panel was produced when the 87.5% quantile (M = 0.335) of the Hamel prior distribution was used. Therefore an alternative approach was used for the high biomass scenario by selecting a natural mortality such that the ratio of ending spawning biomass the high state of nature to the base case is equal to that ratio from the base case (M = 0.235) to the low state of nature (M = 0.164).

Technical Merits of the Assessment

- This is a very thorough assessment with extensive exploration of sensitivity runs to evaluate model assumptions.
- The assessment benefits from several long time-series of abundance indices, including the POTW survey and the recreational charter CPUE indices. The survey indices used in the assessment, while noisy, were reasonably consistent with each other.
- The parameterization of the assessment model seems appropriate given the data available and the stock's exploitation history. Natural mortality and steepness were fixed and selectivity curves were assumed to be asymptotic.
- The assessment model appears to be mature and stable enough for an update assessment the next time that it is assessed.

Technical Deficiencies of the Assessment

- The stock likely extends south of southern boundary of the assessment at the US/Mexico border.
- The maturity estimates that were used in the assessment are dated and cannot be reproduced. No studies have been done of the relationship between fish weight and reproductive output.
- Ageing samples come only from the NWFSC shelf-slope survey NW slope shelf survey, which does not survey shallower than 55 m, and thus does not cover the depth distribution of the stock. The maximum age from this data set could be biased.
- The assessment used estimates of discard mortality of a distantly related species (lingcod) in a different ecological setting.
- Steepness in the assessment was based on the Thorson prior, which is only strictly appropriate for West Coast rockfish (*Sebastes spp.*).

Areas of Disagreement Regarding STAR Panel Recommendations

Among STAR Panel members (including GAP, GMT, and PFMC representatives):

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

Between the STAR Panel and the STAT Team:

There were no areas of disagreement between the STAT and 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 GAP representative provided extensive information regarding the recreational fishery for California scorpionfish that greatly assisted the STAR Panel in its review. The GMT representative did not raise any data or management issues regarding the California scorpionfish assessment.

Unresolved Problems and Major Uncertainties

- The stock likely extends south of southern boundary of the assessment at the US/Mexico border. An assessment that covers the range of the stock was not possible because of a lack of assessment data from Mexican waters.
- The natural mortality for California scorpionfish is highly uncertain and the model is sensitive to the assumed value.
- Recruitment is highly variable presumably due to environmental factors, leading to fluctuations stock abundance. It is not known which environmental factors are forcing recruitment variability.
- Fishery-independent surveys are highly variable, and none cover the full spatial extent of the stock.
- Recreational CPUE indices used in the assessment can provide a misleading signal about true population abundance trends.

Recommendations for Future Research and Data Collection

1. A reproductive biology study of California scorpionfish is needed. The maturity estimates that were used in the assessment are dated and cannot be reproduced. No studies have been done of the relationship between weight and reproductive output. Scorpionfish have a different reproductive strategy than rockfish, and seasonal protection of spawning areas may help maintain reproductive capacity of the stock.

2. Although the overall discard California scorpionfish is relatively low, the assessment used estimates of discard mortality of a distantly related species (lingcod) in a different ecological setting. Studies of discard mortality are needed to more accurately parametrize the assessment model.

3. The relationship between environmental conditions and recruitment for scorpionfish should be further explored. Preliminary exploration using CalCOFI temperature data suggested that a relationship existed, but other time series may correlate more strongly given that scorpionfish are a nearshore species. Scorpionfish appear to be a relatively hardy and adaptable species and may expand northward in a warming climate.

4. Ad hoc criteria are used to identify a threshold when applying the Stephens and MacCall method of selecting records for CPUE index development. Further research is needed to determine whether threshold selection criteria can be optimized.

5. Modeling discard as a separate fleet, as was done for California scorpionfish, is a simple and intuitive approach, but the strengths and weaknesses of this approach are unclear. This method should be compared to the more standard approach of modeling discard with retention curves to ensure the model results are not strongly affected by the method used.

6. The Markov chain Monte Carlo (MCMC) method implemented in Stock Synthesis is not reliable in many cases. Characterizing uncertainty of the final assessment model is important, and MCMC offers advantages over asymptotic approximations using the Hessian or likelihood profiles.

7. Several alternative approaches were used this year to construct decision tables and some approaches may be better than others. The stock assessment TOR should outline the various methods that can be used, and provide recommendations if possible on preferred approaches.

8. Additional biological information (sex, otoliths, depth distribution) should be collected for California scorpionfish during the Publicly Owned Treatment Works (POTWs) trawl

survey and the Southern California Bight Regional Monitoring Project (SCCWRP) trawl survey.

9. An age validation study is needed for California scorpionfish.

10. CalCOFI ichthyoplankton surveys in southern California do not currently identify scorpionfish eggs to species, though it is possible to do so in southern California waters. Species-specific identification of scorpionfish eggs is recommended to develop spawning output index for use in the next stock assessment.

11. A meta-analysis of steepness should be done for species with the same reproductive strategy as scorpionfish.

12. Aggregative behavior in both spawning and non-spawning seasons of California scorpionfish is not well understood. Studies are needed to evaluate the environmental or ecological conditions that govern this behavior.

13. The natural mortality estimate used the assessment was based on maximum age. It may be possible to evaluate mortality by quantifying predation by major predators of scorpionfish, such as octopus.

14. A tagging study to estimate natural mortality for scorpionfish should be considered. This project could be designed as a cooperative research project with the charter fleet in southern California.

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 review process. The STAR Panel also thanks SWFSC staff at the Santa Cruz Lab for hosting the meeting and providing administrative support.

References

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