

# SPINY LOBSTER

## Technical Review Panel Report

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Southwest Fisheries Science Center  
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### **Technical Review Panel (TRP)**

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## Overview

The technical review panel (TRP) reviewed the draft document and presentations regarding the assessment of the spiny lobster (*Panulirus interruptus*) in California, USA. Only the U.S. portion of the stock was considered, with a northern boundary at Point Conception, thus it includes the whole Southern California Bight (SCB). The major center of distribution is central Baja California. One stock was assumed for the whole SCB, so no local dynamics were followed or described. Environmental considerations regarding temperature and salinity, conditions under which spiny lobster are sensitive, were not explored. Commercial and recreational fisheries were considered, with a time series of removals constructed back to 1916 for commercial fisheries. The recreational fishery was reconstructed back to 1965, with gear-switching documented to the present time. Details of management changes were also described throughout the history of the fishery.

This stock is data-limited, with only catch records and some measure of commercial effort provided. There are no biological data (size or age compositions) available SCB-wide, nor any fishery-independent measures of abundance. A fishery-dependent measure of commercial catch-per-unit-effort (CPUE) was provided using the raw landings per trap pulls, but showed very little contrast. This lack of contrast prohibited the use of surplus production models (formulations presented by both the AT and the TRP). Depletion models were also considered, but did not provide a consistent linear trend for analysis. The FISMO model was presented as the most reasonable use of the provided information.

The TRP reviewed the application of FISMO to the spiny lobster and found many places where improvements were needed before application to fishery management was recommended. The biggest issue the TRP flagged was the low fishing mortality ( $F$ ) estimates with consequent modeled catch in larger size classes that are not found in the fishery. The TRP provided several recommendations to improve and test FISMO for application to the spiny lobster resource. The TRP provided an additional analysis based on the depletion-corrected average catch (DCAC; MacCall 2009, <http://nft.nefsc.noaa.gov/DCAC.html>) that produced a distribution of sustainable catch levels with a median of 335 mt (5%-95% C.I. of 296-386 mt; Appendix). This compares to an estimate of ~375mt from FISMO, suggesting robust yield estimates despite discrepancies in the scale of biomass and magnitude of  $F$ . Future applications of FISMO that incorporate data-fitting techniques may help better resolve these scale issues.

The TRP concurs with the AT that currently, and based on limited information, the spiny lobster fishery appears to be sustainable, though it may be approaching the upper end of recommended sustainable catches under an approximately asymptotic yield curve (i.e., with little or no projected decline in yield at higher fishing effort). The fast-growing recreational fishery, in particular, needs better monitoring. The TRP also recommends consideration of alternative management reference and trigger points based on catch levels that may be useful to guide spiny lobster management action.

The TRP thanks the AT for all of their work and willingness to respond to all requests, recommendations and suggestions.

## Summary of model scenarios reviewed

The TRP reviewed results from the Leslie depletion and FISMO models. ASPIC model results were discussed, but were not formally reviewed because they did not produce viable results. The AT presented the depletion models as having limited utility because of assumption violations; the TRP concurred. FISMO was presented as having the most potential for management application, but several levels of uncertainty and unexpected model behavior led the TRP to examine the model more closely and recommend significant changes to model structure before recommendation for management to spiny lobster. No best model was identified, but the base case was recognized as having a robust estimate of sustainable yield. This yield estimate was compared to an application of DCAC (Appendix) and found to be consistent.

## List of analyses requested by the Panel and the outcomes

### DAY 1

- Request #1: Scatter plot between spawning stock biomass (SSB) and numbers of adults (N). Response: AT produced the requested plot. There is little contrast between SSB and N, demonstrating that the current formulation of the Beverton-Holt relationship in FISMO is not gaining anything over the traditional Beverton-Holt reparameterization using steepness.
- Request #2: Estimate  $k$  using  $L_{\infty}$  and using an annual 6 mm size increment at the age of recruitment to the fishery. Response: Completed by AT, with an estimated value of  $k$  is 0.1147. The FISMO  $k$  was 0.1133 for 26 years and  $k = 0.0604$  for 50 years. This confirms that the value of  $k$  is consistent with our knowledge of growth, and is independent of the use of this invariant relationship.
- Request #3: Plot VBGF growth model prediction vs. growth curve predicted using the size increment of 6 mm CL. Response: AT provided a plot showing the significant difference between these two realizations of growth. Any interpretation that assumes 6 mm constant growth across all ages will be different than assuming the Von Bertalanffy growth function, and will tend to underestimate age at length.
- Request #4: Depletion analysis: CPUE versus cumulative catch for each year. Response: AT provided the requested plot. The curved relationship suggests two phases: an initial straight depletion of vulnerable individuals and a subsequent removal phase that catches lobsters as they diffuse out from a less vulnerable state (habitat and behavior). Stock biomass is believed much larger than that estimated from the Leslie depletion approach and cannot be quantified by this approach.
- Request #5 (request based on the results of Request #4): Provide harvest rates and subsequent  $F$ s based on the Leslie depletion estimate and total catch. This provides a harvest rate to compare to FISMO. Response: Harvest rates were shown to be  $>0.7$ , which is much higher than FISMO  $F$  and is consistent with levels typical of lobster fisheries around the world.
- Request #6: Summary of catch at age estimated from FISMO for each year. Response: AT provided the TRP the catch at age matrix from the EXCEL FISMO run so they could

consider this request. There is almost a 50-50 split of lobster catch of size classes greater than those appearing in the fisheries, indicating FISMO estimation of fishing mortality is not matching the intensity of the fishery based on observed harvest rates from request #5 (i.e., there are too many large-sized individuals in the FISMO-derived catch).

- Request #7: Further explore surplus production model (catch versus CPUE) by providing data to the TRP. Response: Data were taken from the ASPIC runs and provided to the technical panel. Attempts by the TRP to apply this data to alternative surplus-production models did not yield viable results.
- Request #8: Plot SSB versus CPUE (normal and log transformed). Response: The AT provided the requested plot. There is no apparent relationship between SSB provided by FISMO and CPUE used in the depletion models.

## DAY 2

- Compare  $F$ s estimated from FISMO and depletion model. Response: The  $F$  values estimated by FISMO are much smaller than the  $F$ s from the depletion model (and those implied by catch curves). If FISMO could include a tuning to age compositions, it would be more useful for this fishery.
- Several follow-up FISMO model runs were requested to try and increase the level of  $F$ . Response: Changes to assume constant recruitment and larger growth rates were explored, which did increase  $F$  (maximum around 0.35), but not to the extent expected ( $>0.7$ ).

### **Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.**

The AT explored several models including production models and an age-structured model (FISMO) that has previously been applied to Baja California lobster fisheries (Chavez, 2005). The TRP agreed with the AT's reluctance to use equilibrium production models due to their known misspecification. The AT explored use of a standard production model (ASPIC) and was unable to obtain a reliable fit; the TRP independently fitted a simple production model and similarly concluded that the lack of contrast in the catch and CPUE data severely hindered a production model approach.

FISMO shows promise in assisting management decisions in data-limited situations such as the present case of spiny lobster. The TRP suggested some modifications to improve its suitability for application to the southern California spiny lobster fishery. Alternative formulations of growth and stock-recruitment relationships, as well as decoupling growth from natural mortality will make the model more flexible and are recommended. Allowing for sex-specific parameterization and fleet-specific selectivities should be useful when future monitoring provides sex- and fleet-specific catches and growth parameters. Including the ability to incorporate uncertainty (for instance, using Monte Carlo simulations) in input parameters is needed to characterize the uncertainty in derived assessment quantities. Finally, tuning FISMO to data such as indices of abundance or proportions of catch at size or nominal age may allow more

realistic estimates of fishing mortality while removing the large sensitivity to the initial average catch and stock-recruitment production parameter.

**Unresolved problems and major uncertainties (e.g., any special issues that complicate scientific assessment; questions about the best model scenario).**

Given the extremely data-limited nature of the spiny lobster fishery, major uncertainties were recognized in all major inputs to the models. The only available information came in the form of commercial catch and effort data, all of which remained highly uncertain as to how it relates to abundance. The commercial and recreational catches lacked biological information of landed catch, unreported harvest, and survival of discarded sublegal lobsters. The recreational fishery was particularly uncertain and relied upon a reasonable, but major assumption of the proportion of recreational harvest to commercial harvest. The very low reporting rates of the recreational report cards and limited creel sampling of apportionment among recreational gear types was a source of imprecision. Life history traits were almost completely unknown, with major uncertainties in longevity, growth, and natural mortality at both regional and local scales. Spatial variability in key fisheries and life history parameters were not evaluated. A lack of contrast in the commercially-derived CPUE data rendered surplus-production models inappropriate for application. FISMO was applied, but uncertain scaling of the input parameters and resultant population dynamics demonstrated large sensitivity in derived model output, particularly estimates of  $F$  and biomass. Consequently, values of  $F$  and biomass and their related management reference points of  $F_{MSY}$  and  $B_{MSY}$  could not be obtained from existing data. However, this may not be a serious problem to spiny lobster management, and the TRP has suggested alternative approaches to management such as use of a proxy SPR once FISMO's performance is deemed adequate via simulation testing (see recommendations).

Given the lack of reliable stock abundance index and biological information, the application of a statistically-based size-structured stock assessment is not practical for this fishery at this time. This suggests that an accurate quantification of stock dynamics and reference points will not be made available for management decision making until data collection is improved.

**Explanation of areas of disagreement regarding Panel recommendations:**

There were no areas of disagreement among TRP members, or between the TRP and AT.

**Recommendations for changes to stock status summary**

The models and analyses of spiny lobster failed to provide conventional information on stock status. The TRP emphasized available data support the conclusion that the fishery is relatively stable, and there is a low risk of overexploitation in the near future. The rapidly developing recreational fishery and latent commercial effort though could pose a challenge to future management of spiny lobster if removals continue to increase. Time is thus available to improve data collection and assessment methods. At this time, reference points based on removals are sufficient to inform spiny lobster fisheries management.

## **Prioritized recommendations for future research and data collection.**

### High Priority

- Simulation test FISMO. Use an operating model (e.g., POPSIM from the NOAA toolbox (<http://nft.nefsc.noaa.gov/POPSIM.html>) or FLR in R (<http://flr-project.org/>) to generate known population dynamics based on known life history values and catch. FISMO can be applied to assess these dynamics simulated deterministically and with process (recruitment, life history) and observational (catch) errors. Use performance measures (e.g., relative error in  $F$  and  $F_{max}$  or other important quantities) to evaluate FISMO's ability to retrieve the built-in population dynamics.. Peck (2004; provided to the AT by the TRP) offers a nice overview of simulation testing. Cope and Punt (2011; provided to AT by the TRP) demonstrate the application of performance measures in simulation testing. Chen et al. (2005; provided to AT by the TRP) demonstrate the use of simulation test to evaluate the performance of a length-structured model for the Gulf of Maine American lobster.
- Further develop FISMO so it will be more flexible. Specifically, allow the option of alternative growth and stock-recruitment functions. Relax the requirement of the invariant relationships between  $k$  and  $M$  so that they can be defined separately (though retain the invariant approach as an option). Allow for sex-specific biological parameters and for the ability to define selectivity outside of the knife-edge assumption. Including tuning parameters (e.g., CPUE or fits to assumed proportion at age in the catch or population) will allow FISMO to fit parameters to data rather than just account for individuals given catch and life history assumptions. Incorporating parameter uncertainty (e.g., Monte Carlo, Bayesian, or Delta Method approaches) to characterize model output uncertainty is also recommended.
- Evaluate the spatial variability in life history traits. Growth, maturity, mortality, and other life history traits are likely to vary by area and environmental regime. Documenting the variability in these traits via literature review and lab and/or field experiments would help parameterize models at regional scales, while offering a way to characterize variability on larger scales in stock assessments.
- Analyze size increment data collected from mark-recapture programs conducted in different areas to estimate yearly size increments and evaluating spatial variability in the size increments to yield information on spatial variability in lobster growth.
- Estimate the proportion of recreational catch that is taken from areas shared with the commercial fishery and from areas only available to the recreational fishery. This information is needed to obtain the correct mixture of commercial and recreational catch for use in the Leslie depletion model. It is also useful for understanding the relationships between the two fisheries, including competition and impacts on stock spawning potential.
- Localized dynamics should be accounted for, incorporating localized studies on catch or growth rates. Rather than a single southern California assessment, separate regional

assessments could capture more of the local information and variability. One possibility would be to divide the region into three areas, a northern area from Santa Monica Bay to Point Conception, a middle region from Santa Monica Bay south to Dana Point (and including the southern islands), and a southern region from Dana Point to the border.

- Develop fishery-dependent monitoring program (e.g., sampling-at-sea and/or port sampling programs) to collect key biological information on the fishery such as catch (both shorts and legal-sized) size composition, CPUE, sex ratio, and shell condition. This can be done by developing a study fishing fleet consisting of typical fishing boats in the fishery.
- Develop fishery-independent monitoring program to collect information on stock abundance and key stock parameters such as size composition, sex ratio, maturation, fecundity, and shell condition and to develop a reliable abundance index.
- Evaluate biological reference points and harvest control rules used in other lobster/crab fisheries in the world and developing biological reference points from analyses such as egg/SSB per recruit analysis (e.g.,  $F_{10\%}$ ). Catch-based BRP (not just F-based) should also be considered as potential reference points. Develop a management strategy evaluation (MSE) framework and identify data gaps in applying MSE in the spiny lobster fishery management. Develop a simulation study based on the spiny lobster fishery to evaluate the performance of the biological reference points and harvest control rules in achieving the management objectives defined for the spiny lobster fishery.
- Evaluate and identify multiple indicators for monitoring the status of the fishery (e.g., temporal and spatial variability in CPUE and catch, temporal and fishing effort, catch size composition, short discard rate, time duration to reach 80% of the total catch in a season) and develop decision rules including trigger points and associated management regulations.
- Increase the return compliance of report cards in the recreational fishery. The current low reporting rates requires too much extrapolation. The increasing contribution of the recreational fishery warrants increased scrutiny via reported catches. Efforts to increase this ability to characterize recreational removals is important to interpreting total removals of spiny lobsters and its relationship to critical management reference/decision points.

#### Lower priority

- Evaluate if lobster spatial distribution is size-dependent and identify key environmental factors (e.g., depth, bottom type, and bottom temperature) that significantly affect spatial distribution of lobster.
- Regress yearly catch versus discards of previous years and consider temperature effects on discards. The pattern of discard rates suggests that location and year effects may be separable. A GLM model, possibly with temperature covariates, would be worth exploring. One hypothetical source of annual recruitment variability is that it may be

partially due to variable growth rates of pre-recruits. Warmer years may give the appearance of higher recruitment if more individuals grow to minimum size, while growth may be retarded in cooler years.

- Develop CPUE series based on fishermen who are in the fishery for the whole season (80% of total catch defined as whole) each year, and ideally for multiple years, and develop precision estimates. This would provide a more consistent CPUE. Individual fishermen could possibly be calibrated by use of a GLM, producing a more comparable time series across years.
- Evaluate population dynamic models used in other lobster fisheries in the world, and identify 1-2 potential models other than FISMO that fit the biology and history of the spiny lobster fishery, identifying data gaps needed in these selected models. Develop models (e.g., a two-stage GAM model) to quantify the relationship between lobster abundance and environmental variables (e.g., temperature, location, salinity, bottom type, etc.) and then using the model developed to project the spatial distribution of lobster based on the environmental variables (e.g., temperature and salinity field, bottom map, etc.).
- Develop a coupled circulation and biological model to project spatial dynamics of pelagic larval lobster and spatial distribution of settlers.
- Develop a notching study for discards. Notching has been used successfully in other lobster fisheries (notches may last after the first molt), and could provide useful information on growth and recapture rates of pre-recruit lobsters. Indication of a high fishing rate suggests that pre-recruits are probably being caught and discarded multiple times. A notching program could help to quantify this, potentially allowing discard rates to be used as a pre-recruitment abundance indicator (possibly combined with the location and temperature regression study described above).
- Better understanding of the catch apportionment in the recreational fishery, particularly the extent of gear switching from diving to hoopnets. In order to properly interpret the gear usage proportion over time, it is important to understand if fishers have switched gears (mainly from diving to hoopnets), maintained their original gear choice, or use both gear types. This resolution would offer a better extrapolation of removals in the recreational fishery.
- Investigate fishing effort distribution by season and year to improve our understanding of the spatial dynamics of fishing fleet and observed CPUE.



## References

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**Appendix. DCAC Input (.dat) file**

# File Version 2.0

CASpinyLobster

76562500

10000

0.15 0.5

5.3 0.2 2

0 0.1 1 0 0

11038 0.0

33

0.1 0.05 1.0 0.0