SPINY DOGFISH

STAR Panel Report

July 11-15, 2011

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Overview

A draft assessment of the Spiny dogfish (*Squalus suckleyi*) off the U.S. west coast was reviewed by the STAR Panel during July 11-15, 2011. This is the first stock assessment conducted for spiny dogfish stock off the US west coast. The spiny dogfish is one of the most widely distributed sharks. On the US west coast, it is found in inshore and offshore areas to depths of at least 1200 m. Dogfish are frequently observed as solitary individuals though they also form large, localized schools. Life history traits of slow growth, late maturation, and low fecundity make the species susceptible to rapid overfishing and slow recovery from stock depletion.

This new stock assessment focuses on the area between the U.S.-Canada border and U.S.-Mexico border. Although spiny dogfish are known to be distributed further north and south, the assessed stock is assumed to be discrete. Within the assessment model, removals of dogfish were divided into eight fisheries – bottom trawl, bottom trawl discard, midwater trawl, hook-and-line, hook-and line discard, others (primarily nets), recreational, and at-sea hake bycatch. The pre-STAR and agreed base case assessments use Stock Synthesis (version 3.21f) and incorporate a variety of fisheries-dependent and -independent data sources.

The STAR Panel concluded that the base case assessment developed during STAR Panel constitutes the best available scientific information on the status of dogfish off the U.S. west coast and recommends that it be used for status determination and management decisions in the Council process. Results of the base case assessment indicate that depletion of the spiny dogfish stock is at 63% (95% CI: 44%-82%, CV=0.15), which is above the Council's target for groundfish (40%) and that recent fishery removals are below the potential yield. The STAR Panel notes that the $SB_{40\%}$ reference point is consistent with the MSY estimate from the STAT base case, but the overfishing reference point proxy of $F_{45\%}$ caused higher fishing mortality than the MSY estimate ($F_{79\%}$), and that setting of the reference point should be revisited by the SSC.

The STAR panel thanks the STAT team members for their hard work and willingness to respond to panel requests. The quality of their document and presentation are exceptional.

Analysis requested by the STAR Panel

Day 1 Requests and Responses

After seeing the presentation and questioning the analysts during the presentation, the Panel decided on a number of different runs for the STAT to undertake. Many of these runs were designed to explore model behavior. The runs requested, the rationales, and the responses are listed below. After discussion of these runs during the second day, the STAT presented a proposed "New Base" model which incorporated all of the Panels suggestions.

1. **Explore newly found historical data source on 1941-1944 spiny dogfish landings.**
<u>Rationale:</u> During the discussion, one Panel member indicated that there was a memo from the 1950's which suggested much higher catches and landings of dogfish than used in the pre-STAR model formulation. Because these much higher values would have a large influence on B_0 estimation, the Panel asked for the STAT to fully examine the validity of this new-found

information

<u>Response:</u> After conferring with the Panel member who brought up the issue, and after double checking the data sources of the current formation, it was found that the data in this new data source is consistent with the time-series of landings/catch used in the assessment. As such the issue was resolved.

2. Conduct a model run with age composition data removed (and growth parameters fixed at the values as estimated in pre-STAR base run.

<u>Rationale:</u> The Panel noted a significant uncertainty in the ageing of spiny dogfish associated with statistical extrapolation of the unreadable annuli on the worn part of the spines for both ageing methods explored within the assessment. In the pre-STAR model, age data were down-weighted to 0.1 in the likelihood (compared to values of 1.0 for the other data sources). Panel members requested a run with the age data removed and with growth fixed at the values estimated in the pre-STAR base model. The panel had noted (from likelihood profiles on *M*) the tension between age and length data in the pre-STAR model and apparent alternate ridge on the likelihood surface; removing age data was an obvious way of mitigating this problem.

<u>Response:</u> The STAT performed this run as requested. Results indicated a better fit to the length compositions, as well as improving other diagnostics. The Panel and STAT agreed the run with age data removed (instead of largely down-weighted) and with growth parameters fixed was a more reasonable base case. This run resulted in a very similar trend but slightly higher spawning output and a less depleted stock than the original formulation (depletion of about 65% versus 53% in the original base model). The Panel also noted that the growth parameters fixed in the model were similar to those calculated, and explained in a presentation, by Yuk Cheng (WDFW) during Day 2 of the meeting.

3. Use selectivity curves of bottom trawl discard and hook-and-line discard fleets to describe selectivity of bottom trawl and hook-and line fleets respectively during the time of vitamin A fishery. Mirror selectivity of the “Other” gear fleet to the selectivity of hook-and-line discard (instead of hook-and-line). Mirror selectivity of IPHC longline survey to that of hook-and-line discard fleet (instead of hook-and-line fleet).

<u>Rational:</u> During the high value fishery for livers (as a source of oil and vitamin A) in the 1940's it was likely there was little discarding and fish of all sizes were retained. Selectivity for the trawl and hook-and-line fisheries during that time should therefore be more similar to discard selectivity in more recent trawl and hook-and-line fisheries. The Panel suggested a further refinement to the longline survey selectivity. In the presented run the STAT used a selectivity identical to hook and line fishery landings. The Panel suggested using a selectivity which was similar to the hook and line fishery discards. The Panel suggested that such a change would reflect the true selectivity as the survey did not discard fish.

<u>Response:</u> The STAT performed this run and presented it the following day. Although the effect on the model was not very large, they found the change to be more logical then their initial selectivity and the Panel and STAT agreed the change should be incorporated into a new Base Case model.

4. Perform a run with mid-water and at-sea hake fishery discard selectivities fixed asymptotic.
Rationale: During the presentation it was noticed that the selectivity for the midwater trawl fishery was dome-shaped rather than asymptotic. Given the discussion on widow rockfish (RFERE STAR 2011 widow rockfish report), Panel members felt that a run examining an asymptotic selectivity would be useful.

Response: The STAT performed this run as requested. The results deteriorated the models fit to the data. The STAT also provided a set of reasons why a domed selectivity should be expected in this fishery. These included the fact that multiple sources suggest younger fish are found in pelagic waters, while older fish are more demersal and thus unavailable to midwater trawl gear. Also, if dome-shape is available for mid-water trawl gear, the model estimates dome-shape selectivity. The Panel and STAT agreed on the use of a dome-shaped selectivity curve in this fishery.

5. Conduct a run with a minimum threshold discard set for the period of 1950-1975.
Rationale: Given the lack of historical discard data (particularly for the 1950-1974 period), an alternative assumption about 1950-1975 discard was explored. The minimum threshold for historical discard was applied, this minimum threshold was calculated as an average of the 1950-1974 discard values (as estimated in the base model).This run was conducted in addition to exploring uncertainty in historical removals (landings and discard) by increasing the entire time-series of removal by 50% and decreasing by 25%.

Response: The STAT performed this run as requested. The explored changes made very little difference to model fits or estimates. Further modeling did not assume any minimum catch levels.

Day 2 Requests and Responses

In addition to receiving the STAT presentation addressing the request from Day 1, the Panel also discussed additional runs to be examined during Day 3. These runs were to explore the new Base Case configuration, and probe the models behavior. Because most of the new requested analyses were standard diagnostics, a common response section (below) is more convenient then detailing each individually.

6. Show time series of spawning stock biomass or some other measure of biomass
Rationale: While reproductive output is the measure used in reference points; measures of abundance or biomass can reveal issues in the model without the confounding additional calculations of fecundity and maturity at length.

7. Retrospective runs (2 or 3 years)
Rationale: A standard diagnostic test. Given the fact that much of the age and length data for this assessment were derived in the last few years, it was expected that there could be strong retrospective patterns in quantities of interest to management.

8. Length fits for fishery-dependent and -independent data
Rationale: A standard diagnostic test. The Panel members were interested in seeing if the new Base Case out-performed the old base case model with respect to fitting the length compositions. This was especially interesting given the removal of age-based input data from the new Base Case runs.

9. Likelihood profiles focusing on *M*
Rationale: The Panel was interested in seeing how sensitive the new Base Case was to changes in *M*. This likelihood profile would show each of those recommendations from the Day 1 runs and test what effect those would have on how the model fit the rest of the input data.

10. Standard diagnostics for the other estimated parameters
Rationale: Again, these are standard diagnostics used to test how well the new Base Case assessment performs.

Response to requests 6-10: The STAT performed all requests. Overall, the model diagnostics suggested better stability and a better fit to the data, when compared to the pre-STAR run proposed on Day 1. The retrospective pattern was quite large. While this will create some uncertainty in the final status determination of the stock, the results are in-line with expectations. Many of the length data are from the most recent years; removing even a few years of data will impact the selectivity estimates and hence estimates of derived parameters. In some cases, slight changes in selectivity produce dramatic changes in derived parameters. Slight changes in selectivities were observed for selected fleets in some of the retrospective runs; these changes, when put together, could be translated into changes in overall dynamics and model output. Also, the index from the IPHC longline survey showed a general decline over the years 1999-2006 which has not continued in subsequent years. Likewise, the first two years of the NWFSC shelf-slope survey showed the highest abundance. All these factors contribute to the retrospectives with the most data removed producing estimates of a more depleted stock with greater recent declines in abundance.

Description of base case model and alternative models to bracket uncertainty
One-area sex-specific model; start year=1916; eight fisheries; discards estimated externally; *M*=0.064 for both sexes; growth estimated externally using ages estimated by Ketchen's method; stock-recruitment relationship with pre-recruit mortality.

Fisheries:
- Bottom trawl and discard
- Midwater trawl
- At-sea hake bycatch
- Hook-and-line and discard
- Recreational
- Others

Abundance indices:
- AFSC triennial survey
- AFSC slope survey

- NWFSC shelf-slope survey
- NWFSC slope survey
- IPHC survey

Size composition:

- Bottom trawl and discard
- Midwater trawl
- At-sea hake bycatch
- Hook-and-line and discard
- Recreational
- AFSC triennial survey
- AFSC slope survey
- NWFSC shelf-slope survey

Specification of the states of nature for a decision table is necessarily ad hoc but the Panel attempted to follow STAR Terms of reference and to develop scenarios representing roughly 25%, 50% and 25% probabilities. After discussion with the STAT, the Panel specified a decision table to complete the work on this stock. Low and high states of nature were chosen in an attempt to jointly capture the two main dimensions of uncertainty (catch history and *M*). For the low state of nature, using a catch 25% below the base case, *M* was chosen such that estimated spawning output was one standard deviation below that estimated in the low catch run. The high state of nature was similarly calculated but using catch history 50% above the base case and selecting *M* that matched a spawning output one standard deviation above that estimated in the high catch run. The catch options specified for the 12-year forecast included $SPR_{45\%}$ (current management target), $SPR_{77\%}$ (SPR level identified by the model as associated with $SB_{40\%}$ target biomass) and 1,584 mt. The value of 1,584 mt is the 2011 ACL-based catch value provided by the Groundfish Management Team (GMT) and calculated as 28.4% of the total Other Fish ACL (the percentage is derived from the dogfish contribution to Other Fish OFL).

Technical merits of the assessment

The New Base model uses catch, indices, and other data sources in line with standard methods of fishery stock assessment. However, the lack of reliable aging data precluded the use of growth within the model structure. Another major source of uncertainty included the use of a new stock-recruitment relationship. As such, the full properties of this relationship have not been tested and more explicit testing should be completed prior to the next assessment cycle. In both the new and prior formations of the stock-recruitment relationship, levels of steepness have to be assumed, rather than estimated within the model.

Additionally, the spawning stock biomass (SSB) trend declined over the entire period assessment. This results in the model not having a lot of contrast and therefore it has a higher degree of uncertainty in scale rather than in the trajectory of depletion.

Overall the retrospective pattern (Figure 1a, below) seen in the model diagnostics also indicate a further source of uncertainty not captured in the confidence intervals of the final base model

(Figure 1b). It was noted that while there are considerable uncertainties in the input data, the model seemed to reliably handle these uncertainties as expected.

a) b)

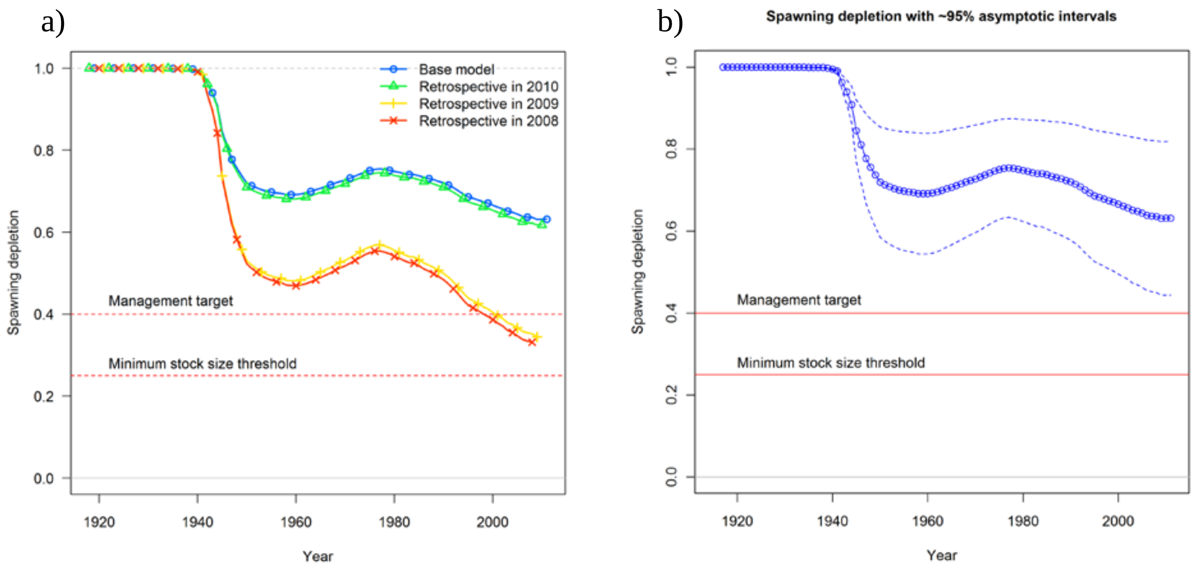

Figure 1. a) Spawning depletion for retrospective analysis; b) time series of the estimated spawning depletion of spiny dogfish with 95% confidence interval.

Explanation of areas of disagreement regarding STAR panel recommendations

A. Among STAR panel members (including concerns raised by GAP and GMT representatives)

There were no areas of disagreement among STAR panel members.

B. Between the STAR panel and the STAT team.

There were no areas of disagreement between the STAR panel and STAT team.

Unresolved problems and major sources uncertainty

- Discard and discard estimations
  It is noted that dogfish is mainly a bycatch species through most of its range off the U.S. Pacific coast, except during the "vitamin A" fishery and the export market in the late 1970s. Current estimation of bycatch centers on the use of extrapolation based on dogfish landings. Typically such extrapolations are conducted using a measure of effort by the fleet with some stratification by area, time, and gear type. However, such was not possible here due to the lack of data. This should be an area for further exploration in the next assessment.

- The stock-recruitment relationship
  This assessment brought forward a new method for determining the stock-recruitment relationship, rather the typical Beverton–Holt formulation. While the relationship as outlined in the STATs pre-panel report seem appropriate, further tests on this method, via sensitivity, analysis , and comparison to the Beverton-Holt formulation, is recommend prior to the next assessment

- Aging interpretation
  Because dogfish lack otoliths, traditional methods of aging are not conducted as in other teleost fishes. Instead, spines are used to determine age. However these spines are subject to wear, which leads to aging errors. To address this problem, two different methods for estimating “missing ages” were used in this assessment. However, both methods showed a high degree of variability and produced variable results in the model. Because the variability and uncertainty surrounding the aging process was high, aging data was not used in the New Base run. Further exploration of both estimation methods, and aging techniques in general should be conducted prior to the next assessment for dogfish.

- Growth modeling
  Partly due to the aging difficulties mentioned above, modeling growth is challenging for dogfish. This is particularity true given the slow growing nature of the species. In the pre-panel report the STAT used the aging data to generate growth parameters within the model. However, with the exclusion of the age data, growth became more difficult to be parameterized. As such, growth is an important aspect which needs further examination prior to the next assessment cycle.

Management, data, or fishery issues raised by the GAP and the GMT representatives

The comments in this section record issues raised through the GMT representative during the meeting and represent issues raised by GMT members present at the meeting. Each of these issues was discussed at length by the STAT and STAR panel during the meeting. The role of the GMT in the STAR Panel does not involve commenting on the merits of the stock assessment as a whole, only management implications. The following comments do not express disagreement with the overall conclusions of the Panel about the suitability of the stock assessment for management or its status as the best available science.

Per the GMT’s role, the comments focus on certain assumptions about catch and discard of dogfish and the management issues that arise from those assumptions. The purpose is to emphasize the GMT’s concerns so as to give further support to future research needs and to underscore some of the challenges management will face interpreting the results. The GMT representative expresses appreciation to the Panel and the spiny dogfish STAT for exploring the additional model runs that the GMT requested to investigating the management application of this assessment.

One general management issue the dogfish assessment highlights is the interpretation of a risk-neutral base case model when known, but presently unquantifiable, input values are missing in the assessment. This stems directly from the newer management framework that uses reductions in the OFL based on uncertainty in the base case rather than from the decision table. This issue is not unique to the spiny dogfish assessment, but an emerging issue we face in applying stock assessments to management decisions when available information for the assessment is limited. The GMT offers some examples from the spiny dogfish assessment to highlight this bigger issue.

The primary issue in the dogfish assessment is the uncertainty in the removal history of the base case. This uncertainty is largely derived from a lack of available historical discard data in the foreign fishery, midwater vessels targeting rockfish, the pink shrimp fishery, commercial and tribal halibut fisheries, bottom trawl fisheries, as well as any removal issues associated with the transboundary nature of this species. The GMT recognizes that no data is available to quantify the missing information and that the individual contribution of each of these fisheries discards may be low. In addition, the use of dogfish landings to estimate dogfish discard in the historical bottom trawl fishery was particularly notable to some GMT members. The level of spiny dogfish discard and the differences in market incentives and management structure in the current period from which data is available relative to the historical bottom trawl fishery (primarily during the 1950s and early 1970s) may be very different.

The STAT provided individual sensitivity runs to address several of the above bycatch scenarios. These demonstrated little sensitivity in depletion, though biomass scale was sensitive in some cases. Sensitivity runs only provide uncertainty relative to the base case, not for the base case. The base case, though, is what the Council uses to determine future catch. The STAT and the STAR panel addressed the concerns raised above with historical catch uncertainty in the decision table, but this uncertainty is not represented in the base case and thus not translated through to management.

The Council assumes the base case coming from the stock assessment is risk neutral; in such a situation, taking the uncertainty around biomass is a reasonable thing to do. In many groundfish assessments, including spiny dogfish, there is a non-trivial probability of producing a non-risk neutral assessment despite the fact that the base case is appropriately deemed the best use of the available data. Again it is unknown how much this assumption is violated in spiny dogfish. Consideration of the decision table when rendering a decision on biomass uncertainty may be warranted under such conditions (in the case of spiny dogfish, the decision table demonstrates substantial variability in biomass scale). We encourage further dialogue on this issue with the SSC to solicit advice and help determine how best to apply a risk-neutral characterization of uncertainty.

Lastly, the spiny dogfish assessment offers an important example of what appears to be a misspecification of the overfishing proxy. Specifically, the current SPR_{proxy}=0.45 results in removals greater than the calculated SPR_{MSY}=0.77. It was found also that the proxy SPR would lead this population to extinction over a long time scale. In addition to the need for general SSC discussion and advice on catch uncertainty and risk in setting the OFL, the GMT would also like to further discuss the current F_{MSY} proxy harvest control rule compared to estimates of F_{MSY} from the model and how that might influence our understanding of the risk of overfishing in elamsobranchs.

Prioritized recommendations for future research and data collection

1. Improve age estimates and aging methods.
2. Examine the uncertainties regarding the catch data and discard mortalities. In particular bycatch estimations are very important, given that they are larger than the recorded landings over recent years
3. Research on dogfish movement. This would be informative not only in providing a better definition of the unit stock, but also aid addressing # 4 (below)
4. Linkage with fish on Canadian side of the border and exploration of a joint assessment process for this stock
5. Continuation of the commercial catch and bycatch sampling
6. Examination of catchability priors in the New Base model as well as a method for deriving future priors
7. Examination of the Beverton-Holt derivation, as it relates to dogfish, and comparison with new stock-recruitment model used in this report.

Acknowledgements

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