Spiny Dogfish
Stock Assessment Review (STAR) Panel Report

Virtual Online Meeting
May 3-7, 2021

Participants

STAR Panel Members

Tien-Shui Tsou, Washington Department of Fish and Wildlife (Chair)
Fabio Caltabellotta, Oregon State University
Matt Cieri, Center for Independent Experts
Noel Cadigan, Center for Independent Experts

Stock Assessment Team (STAT) Members

Vladlena Gertseva, National Marine Fisheries Service Northwest Fisheries Science Center
Ian Taylor, National Marine Fisheries Service Northwest Fisheries Science Center
John Wallace, National Marine Fisheries Service Northwest Fisheries Science Center
Sean E. Matson, National Marine Fisheries Service West Coast Region

STAR Panel Advisors

Whitney Roberts, Washington Department of Fish and Wildlife, Groundfish Management Team representative
Gerry Richter, B&G Seafoods, Groundfish Advisory Subpanel representative
John DeVore, Pacific Fishery Management Council representative

Overview

A Stock Assessment Review (STAR) panel met virtually on May 3-7, 2021 through the RingCentral platform to review a draft stock assessment of Pacific Spiny Dogfish (*Squalus suckleyi*) prepared by a stock assessment team (STAT) led by Dr. Vladlena Gertseva. The panel operated under the Pacific Fishery Management Council's (PFMC) Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2021-2022 (PFMC, December 2020). This same panel also reviewed a draft assessment for Dover Sole (*Microstomus pacificus*).

The Spiny Dogfish is one of the most widely distributed sharks that is generally found in inshore and offshore areas to depths of at least 1,200 m. They 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. In North America, dogfish occur from the Gulf of Alaska to southern Baja California and are extremely abundant in waters of British Columbia and Washington state. As in the most recent previous assessment conducted in 2011 (Gertseva and Taylor, 2012), the current draft assessment assumes that dogfish off the U.S. West Coast, bounded by the US-Canada border and US-Mexico border, consist of a single coastwide stock whose dynamics are independent of dogfish populations off Canada and Mexico.

This draft stock assessment was conducted with Stock Synthesis version 3.30.16 (released in September 2020). Data were compiled into eight fishing fleets and five indices of relative abundance. The eight fishing fleets include 1) bottom trawl landings, 2) bottom trawl discard, 2) midwater trawl catches, 4) bycatch in at-sea Pacific hake fishery, 5) non-trawl landings, 6) non-trawl discard, 7) non-trawl catches during the historical Vitamin A fishery, and 8) recreational removals. The indices of relative abundance used in the model include data from four bottom trawl surveys conducted by the National Marine Fisheries Service (NMFS) (the Alaska Fisheries Science Center (AFSC) Triennial, the AFSC slope, the Northwest Fisheries Science Center (NWFSC) slope, and the West Coast Groundfish Bottom Trawl Survey (WCGBTS)), and one setline survey conducted by the International Pacific Halibut Commission (IPHC). As Spiny Dogfish shark exhibit dimorphic growth by sex, the assessment model was structured to have two sexes. The model started from an unfished equilibrium state in 1916 with no annual recruitment deviations estimated.

Important changes made since the 2011 assessment include: updated fisheries- and survey-related data; abundance indices estimated using the vector auotregressive spatial temporal (VAST) modeling approach; revised historical discard estimates; updated selectivity assumptions from asymptotic to dome-shaped with sex-specific offset; updated biological parameters, and updated tuning for age data. The magnitude of historical discard remains one of the main concerns in assessment data. Age determination is another unresolved issue for female dogfish, which has impacts on the growth parameters and the assumed natural mortality rate. Despite these concerns, the panel considered the new approaches used in the draft assessment improvements and encouraged further investigation.

Results from the base model indicate that the stock status was at 34% of the unfished spawning output level at the beginning of 2021. This is above the overfished threshold of $SB_{25\%}$ but below the management target of $SB_{40\%}$ of unfished spawning output. Based on the sensitivity analysis provided in the draft assessment and further exploration during the review, the status of the population was relatively well estimated, while the scale of the population was not. The panel noted the STAT's recommendation to evaluate the current proxy harvest rate for spiny dogfish due to the stock's extremely low productivity and other reproductive characteristics. Fishing at the target of SPR 50% does not appear sustainable.

The STAR panel recommended the Spiny Dogfish stock assessment as the best available science and considered it a suitable basis for management decisions. The assessment is a Category 2 assessment because recruitment deviations were not estimated. Based on concerns raised during the review (highlighted in this report under the "Technical Deficiencies" and the "Unresolved Problems and Major Uncertainties" sections), the STAR panel recommended the next assessment be a full assessment.

The panel appreciates the many data challenges in this assessment and the STAT's effort in conducting research to address issues identified in the 2011 assessment. The panel thanks the STAT for their hard work, openness, and responsiveness during the review.

Summary of Data and Assessment Models

Stock structure, fleet structure and surveys included in the model were the same as in the 2011 assessment. Associated data were updated accordingly. No retention curves were estimated in the model because discards were included as separate fleets in the model.

The only age data included in the model were collected by the WCGBTS, which were incorporated into the model as conditional ages-at-length. Sex-specific growth parameters were estimated within the model; however, females larger than 80 cm were excluded due to uncertain age determinations for larger/older females. No fishery-dependent age data were included in the model. Length compositions collected by the fishing fleets and surveys were included if available.

Maturity parameters were unchanged from the 2011 assessment while fecundity parameters were half of the values used in the 2011 assessment to account for the 2-year (22-24 months) gestation period. Natural mortality (M) was fixed at 0.065 for both sexes, which is similar to the value

(0.064) used in the 2011 base model.

The spawner-recruit relationship was modeled in terms of pre-recruit survival between the stage during which embryos can be counted in pregnant females and their recruitment as age-0 dogfish. The parameters of this survival-based relationship (*zfrac* = 0.4 and $\beta = 1.0$) were the same as the values used in the 2011 assessment. Recruitment deviations were not estimated.

A double-normal selectivity function was used for all fleets to allow consideration of both dome-shaped and asymptotic patterns. However, the selectivity of the non-trawl landing fleet and the IPHC survey was fixed to be asymptotic. A sex-specific offset to selectivity in each fleet was also estimated.

Separate catchability parameters were estimated for the WCGBTS and AFSC Triennial Survey indices of biomass, while catchability parameters for the AFSC Slope, NWFSC Slope and IPHC Surveys were solved analytically. WCGBTS catchability was estimated at 0.586 then fixed for all model diagnostics because the model has little information for this parameter based on the likelihood profile analysis.

The Francis data weighting method was used to adjust effective sample sizes for all composition data, except for the age composition. Due to the limitation of sample size, the age composition was tuned using the McAllister-Ianelli harmonic mean method.

A bridging analysis was conducted with data updates and parameter changes added sequentially to the 2011 assessment model. Results indicated that updated WCGBTS length data and fecundity parameters have the biggest impacts on final estimates of population scale and status.

Requests by the STAR Panel and Responses by the STAT

Request No. 1: Provide a time series plot of the residuals of the total catch relationship between Sablefish and Spiny Dogfish from the observer data.

Rationale: The relationship is assumed to not vary by year and this needs to be checked.

STAT Response:
The STAT provided Figures 1 and 2 as requested. Figure 2 demonstrates that there is no pattern or bias in the residuals and only one year had an outlier.

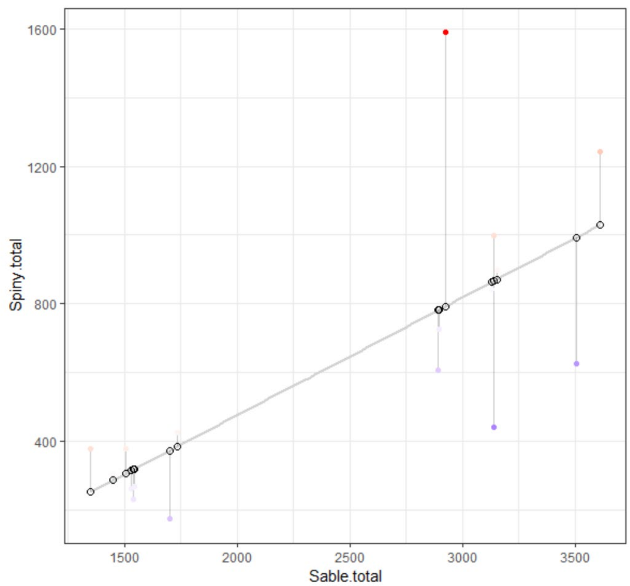

Figure 1. Residuals against the linear relationship between catches by bottom trawl of Spiny Dogfish and Sablefish.

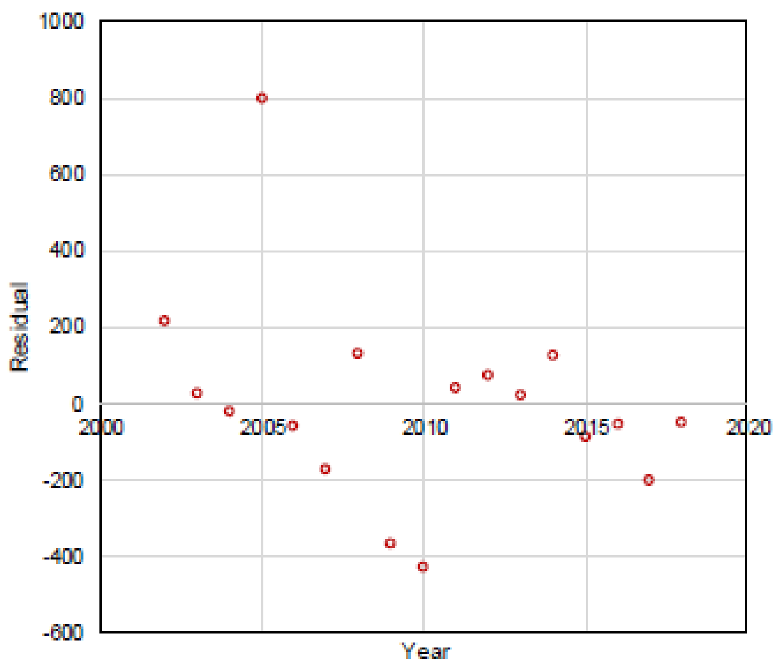

Figure 2. Residuals of the linear relationship between catches by bottom trawl of Spiny Dogfish and Sablefish by year.

Additionally, the STAT examined using just Sablefish landings, as opposed to catch (both landings and estimated discards of Sablefish), to estimate dogfish discards. As shown in Figure 3, the predictive value of Sablefish landings was rather poor.

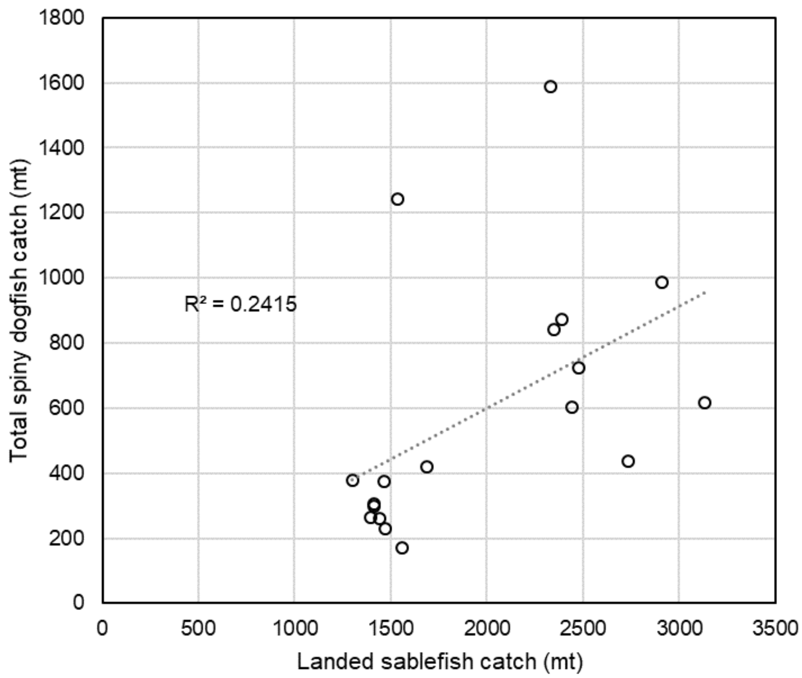

Figure 3. Relationship between catches of Spiny Dogfish and landings of sablefish by bottom trawl.

Panel Conclusions:

The panel agreed with the STAT that there appeared to be little bias and no time pattern in the residuals that could indicate a change in the relationship between Sablefish catch and Spiny Dogfish catch. While there were some concerns about using Sablefish catch as a predictor of dogfish catch during 1960-2002 given the seasonal differences in occurrence between these two species, overall, the panel concluded that the proposed procedure was an improvement compared to the 2011 assessment which assumed a static catch to discard ratio.

Request No. 2: Provide a sensitivity of the gamma vs. log-normal error distribution of the VAST.

Rationale: There is a need to explore alternative assumptions.

STAT Response:

The STAT provided Figures 4 and 5 that compared gamma and log-normal error distributions for runs with fixed and estimated catchability (q).

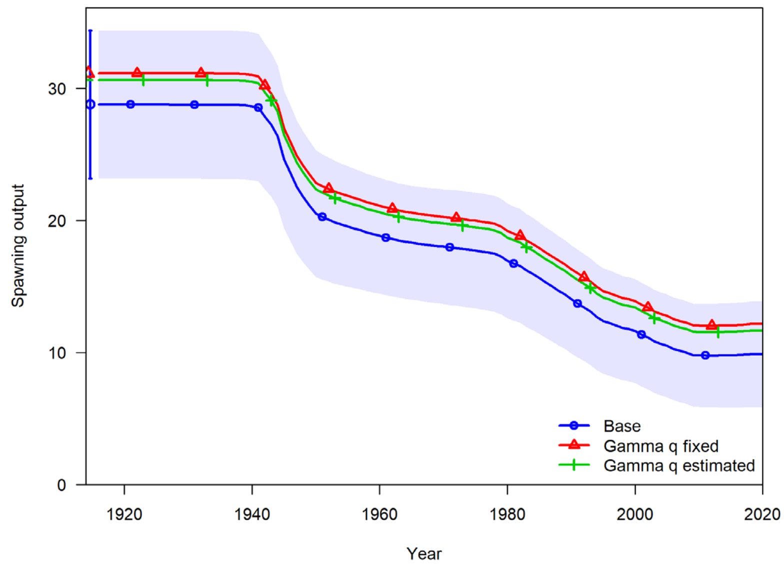

Figure 4. Time series of spawning output (in millions of pups) associated with abundance indices estimated by using a lognormal (base) vs. a gamma error assumption in the VAST model.

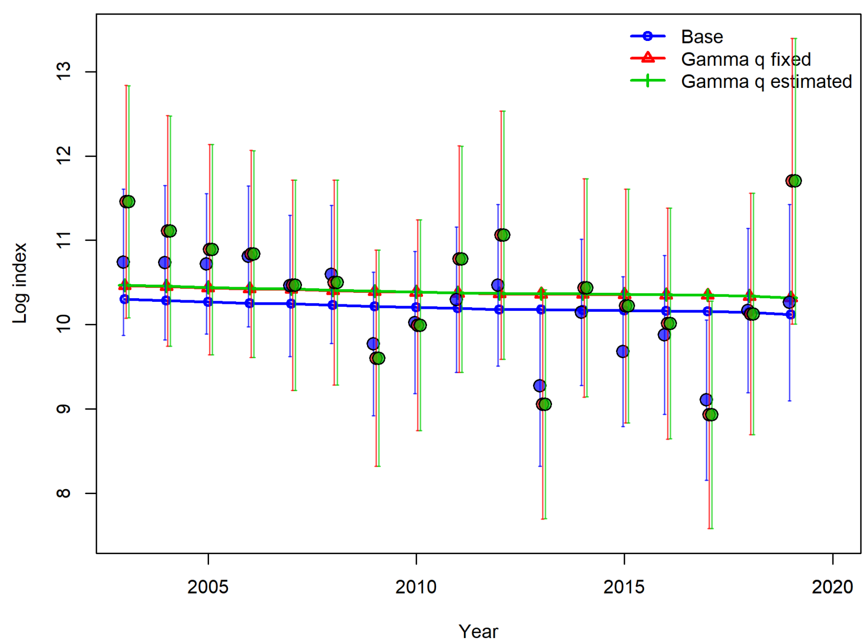

Figure 5. Comparison of fit to the WCGBTS index by using a lognormal (base) vs. a gamma error assumption in the VAST model.

As can be seen in the Figures, switching to a gamma error structure did not change the results of the model by much, nor were the estimated *q's* for the WCGBTS very different (0.59 for the base model vs. 0.6 for the VAST using a Gamma error distribution). Additionally, the assessment model fit the WCGBTS index with the VAST lognormal error structure indices slightly better than with the gamma error structure.

Panel Conclusions:
The panel agreed with the STAT's conclusion to use the lognormal error distribution in the VAST for developing the WCGBTS index.

Request No. 3: Provide a justification for the 80 cm cutoff in the growth function.
Rationale: To better understand the model selection decisions.

STAT Response:
The STAT reminded the panel that the length at 50% maturity was 88.2 cm, and also noted that the proportion mature was approximately 12.5% at the base model's 80 cm cutoff. Reducing the cutoff to 70 cm had no effect on the model output as shown in Figure 6. Additionally, the L_{inf} estimated from the alternative run with a 70 cm cutoff was identical to the base run using an 80 cm cutoff.

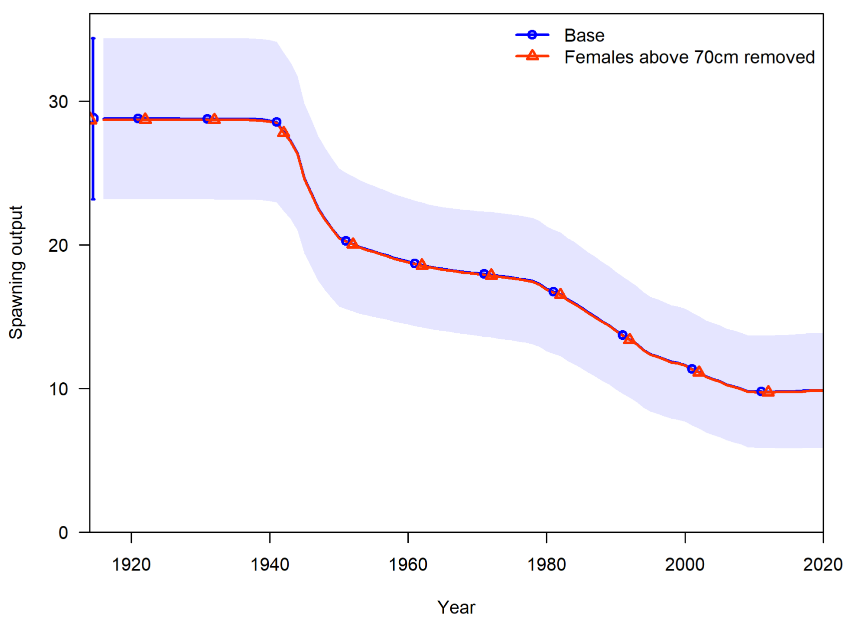

Figure 6. Time series of spawning output (in millions of pups) associated with growth parameters estimated with females above 70 cm or 80 cm.

Panel Conclusions:
The panel was satisfied with the STAT's response to the request and agreed that an 80 cm cutoff was justified.

Request No. 4: Provide the uncertainty intervals of the Spiny Dogfish historical discard estimation.

Rationale: To better understand the realistic bounds of historical dogfish removals. A sensitivity of these bounds may be requested later if the model is sensitive to these assumptions.

STAT Response:

The STAT provided estimates of uncertainty in the discarded fraction from 1960 to 2002 as shown in Figure 7. The methods for how this uncertainty was calculated appears in the STAT's response to Request 6.

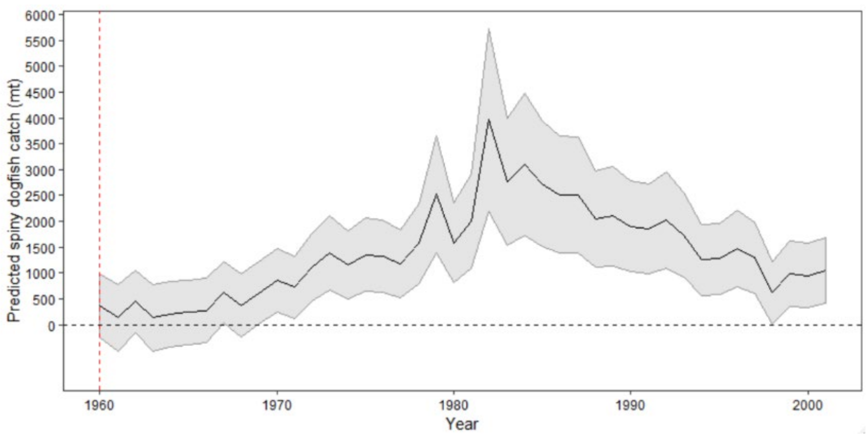

Figure 7.Reconstructed time series of spiny dogfish total catch within bottom trawl fleet, based on sablefish catch, with predicted intervals.

Runs were conducted at both the upper and lower bounds in addition to the base model. Results suggested some difference in the initial biomass estimated and a corresponding difference in the estimated depletion (Figures 8 and 9). Despite this rather large uncertainty in the discards during this time period, the model estimates of stock status and current biomass didn't appear to be very sensitive to the discard assumption during this period.

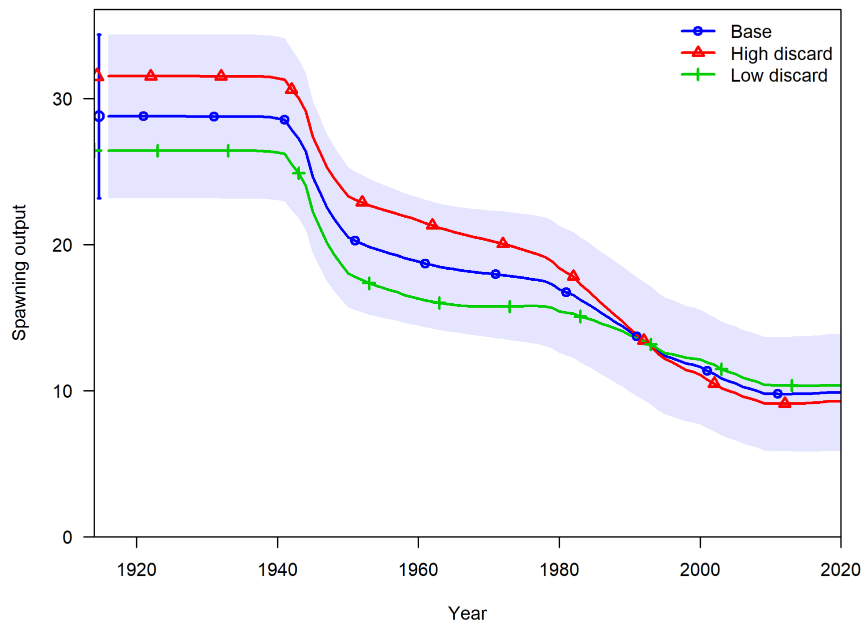

Figure 8. Time series of spawning output (in millions of pups) associated with different levels of discards. Shaded area represents 95% confidence interval of the proposed base model.

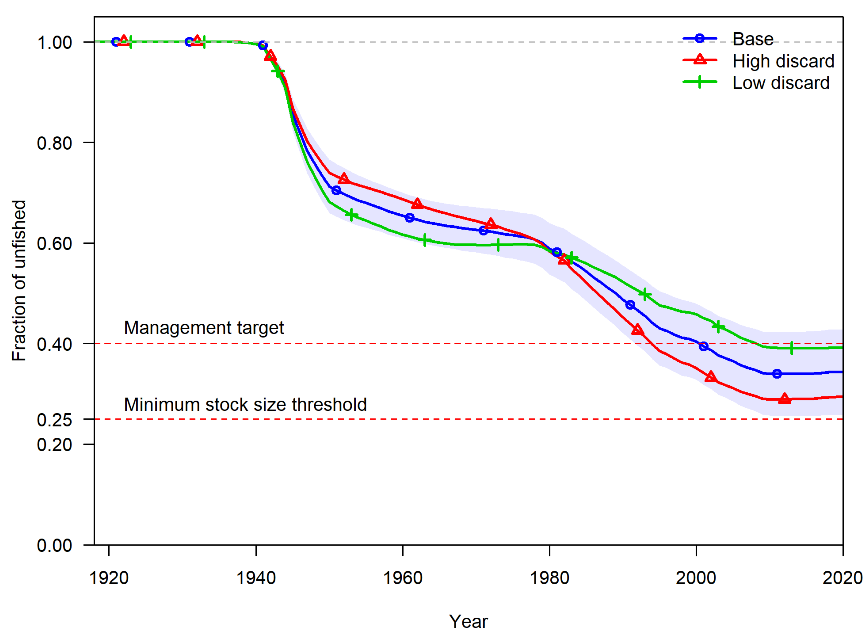

Figure 9. Time series of spawning depletion associated with different levels of discards. Shaded area represents 95% confidence interval of the proposed base model.

Panel Conclusions:

The panel was satisfied with the STAT's response to the request. While the resulting spawning outputs and stock status did not appear to be sensitive to the estimates of historical discards, this issue remains uncertain and unresolved. Estimates of stock status were similar whether q was estimated or fixed. Further research recommendations on this issue appear below.

Request No. 5: Provide the discard rates applied to trawl and non-trawl landings.

Rationale: To better understand these rates.

STAT Response:

The STAT provided Figure 10 and indicated that a table of these rates would be added to the assessment document.

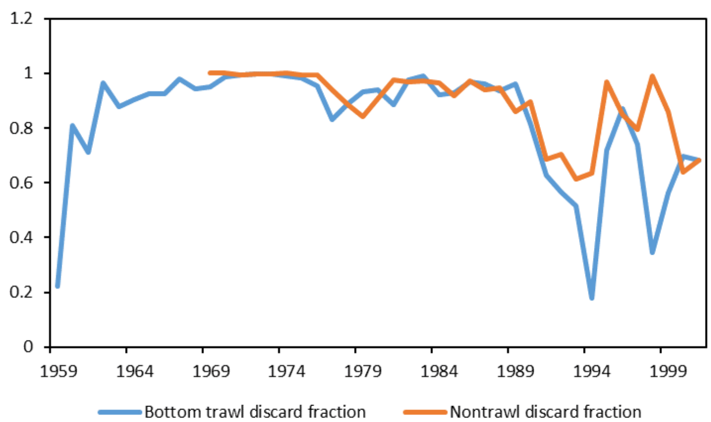

Figure 10. Historical bottom trawl and non-trawl discard rates.

The STAT also noted that the higher discard rates for the 1980s were supported by the Pikitch et al. (1988), while the lower rates in the 1990s were supported by the Enhanced Data Collection Project (EDCP) administered by Oregon Department of Fish and Wildlife in late 1990s.

Panel Conclusions:
The panel was satisfied with the STAT's response to the request. The STAT also clarified that model-estimated discard amounts used for each sector after 2002 are listed in the draft assessment document.

Request No. 6: Provide details on calculating the prediction intervals for the historical bottom trawl discards and provide the catch streams for the low and high alternative runs (from request #4).

Rationale: To understand how the prediction intervals were calculated, including how the negative values were considered in the low run.

STAT Response:
The STAT indicated that the 95% prediction intervals were calculated using the predict function in base R (https://rpubs.com/aaronsc32/regression-confidence-prediction-intervals) and that a full write-up of these methods including equations would be added to the assessment document. The full time series of discards is shown in Figure 11 with the base, lower, and upper bounds to frame the uncertainty.

.

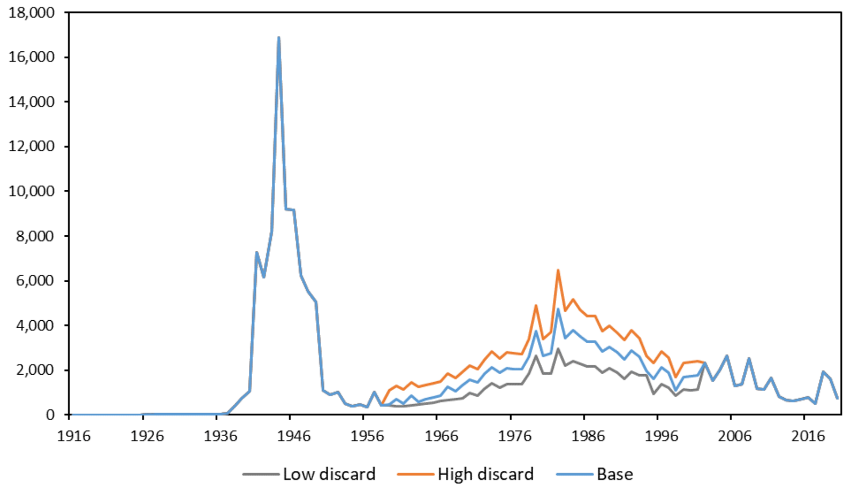

Figure 11. The full time series of catch streams with low and high historical discard rates.

Panel Conclusions:
The panel was satisfied with the STAT's response to the request. A particular issue was the negative confidence intervals near the start of the estimated time period. While these were dropped by the STAT, a better method for this estimation could be conducted. This issue of estimating the historical discards remains an area of uncertainty as outlined in Request 4. The full write-up of the analysis used for dogfish including the above figure should be included in the draft assessment report appendix.

Request No. 7: Show the sensitivities from slide #56 (from the day 1 presentation) with the WCGBTS q estimated and a supplemental table displaying the estimated q's for these sensitivities.

Rationale: To understand the behavior of these sensitivities when *q* is estimated and to see if the *q* estimates are realistic.

STAT Response:
As shown below, the STAT produced the required figures and table.

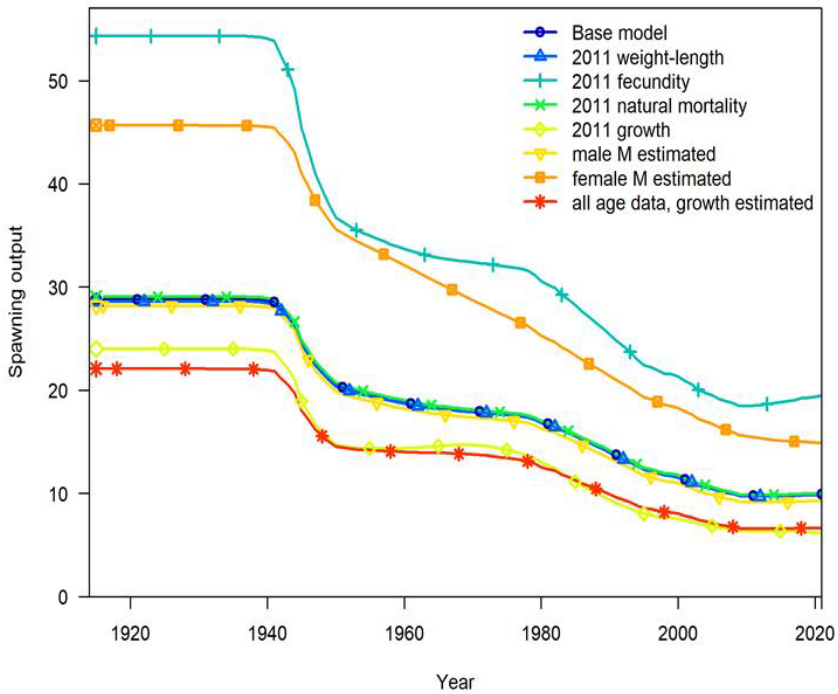

Figure 12. Sensitivity runs with WCGBTS *q* fixed.

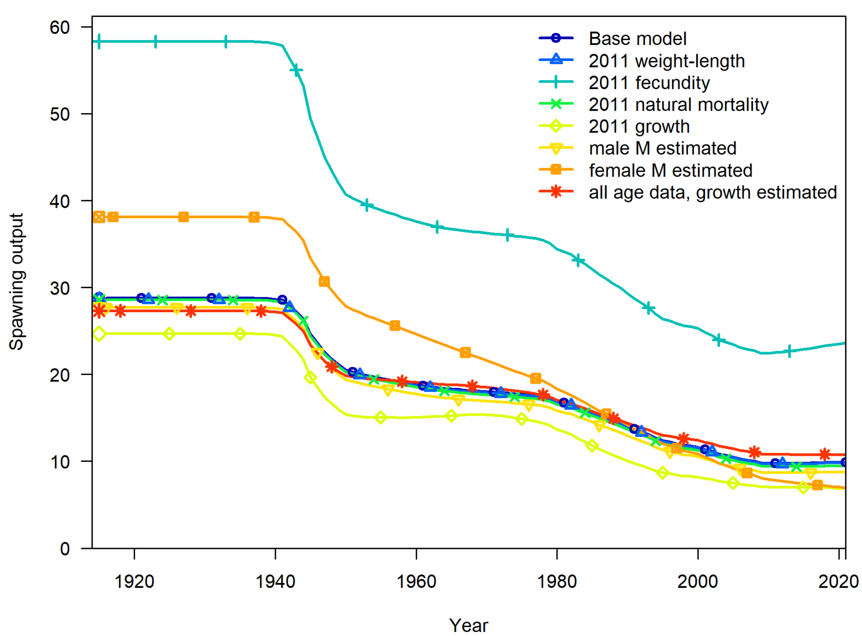

Figure 13. Sensitivity runs with WCGBTS *q* estimated.

Table 1. Estimated q for the WCGBTS.

	Base model	2011 WL	2011 fecundity	2011 M	2011 growth	Male M estimated	Female M estimated	All age data
WCGBTS q	0.59	0.59	0.49	0.62	0.53	0.61	1.36	0.39

Table 2. Summary for sensitivities comparing the base model with a run which estimated the q for the WCGBTS.

Label	Base model	2011 WL	2011 fecundity	2011 M	2011 growth	Male M estimated	Female M estimated	All age data, growth estimated
TOTAL Likelihood	418.93	418.93	420.138	418.708	454.956	418.891	408.524	703.726
Survey Likelihood Components	-5.21814	-5.2187	-3.92766	-5.24066	-6.3733	-5.41917	-3.91443	-5.31925
Length Likelihood Components	381.387	381.39	381.281	381.194	397.497	381.559	368.102	380.901
Age Likelihood Components	42.7391	42.739	42.7616	42.7318	63.8046	42.7294	42.8571	328.11
Natural mortality females	0.065	0.065	0.065	0.064	0.065	0.065	0.0307681	0.065
Natural mortality males	0.065	0.065	0.065	0.064	0.065	0.0631745	0.026988813	0.065
L1 females	22.064	22.063	22.101	22.040	25.246	22.066	21.460	25.821
Linf females	118.954	118.952	119.912	118.575	109.100	119.058	107.833	122.857
L1 males	22.064	22.063	22.101	22.040	25.246	22.066	21.460	25.821
Linf males	98.680	98.679	99.457	98.417	86.123	98.302	90.048	109.202
von Bertalanffy k females	0.028	0.028	0.027	0.028	0.026	0.028	0.034	0.020
von Bertalanffy k males	0.040	0.040	0.039	0.040	0.052	0.040	0.049	0.025
LnQ_base_WCGBTS(11)	-0.53364	-0.533	-0.717794	-0.482637	-0.6431	-0.489487	0.309194	-0.952754
WCGBTS q	0.59	0.59	0.49	0.62	0.53	0.61	1.36	0.39
SOVirgin (millions of fish)	28.778	28.586	58.323	28.562	24.682	27.706	38.104	27.319
SO 2021 (millions of fish)	9.895	9.829	23.616	9.494	6.849	8.781	6.969	10.733
B ratio_2021	0.343834	0.3438	0.404912	0.332397	0.2775	0.316923	0.182885	0.39289
SPR ratio 2020	0.282184	0.2823	0.230211	0.296184	0.3568	0.311266	0.701907	0.225196

Panel Conclusions:

The panel was satisfied with the STAT's response to the request. The panel noted that when both *M* and q were allowed to be estimated, the model tended to settle on the same scaling of biomass; especially in the most recent years. The panel expressed some reservations that q was estimated implausibly high (1.36) when *M* for females was also estimated.

Request No. 8: Provide a sensitivity to the estimated female k values by fixing k at 0.065; estimate male k as an offset.

Rationale: The *M/k* ratio is atypical for elasmobranchs; a ratio of 1 - 2 is more typical and a fixed k at 0.065 provides a 1.0 *M/k* ratio.

STAT Response:

The STAT provided the requested runs (see below). The STAT noted that while female growth parameters changed, those for males did not.

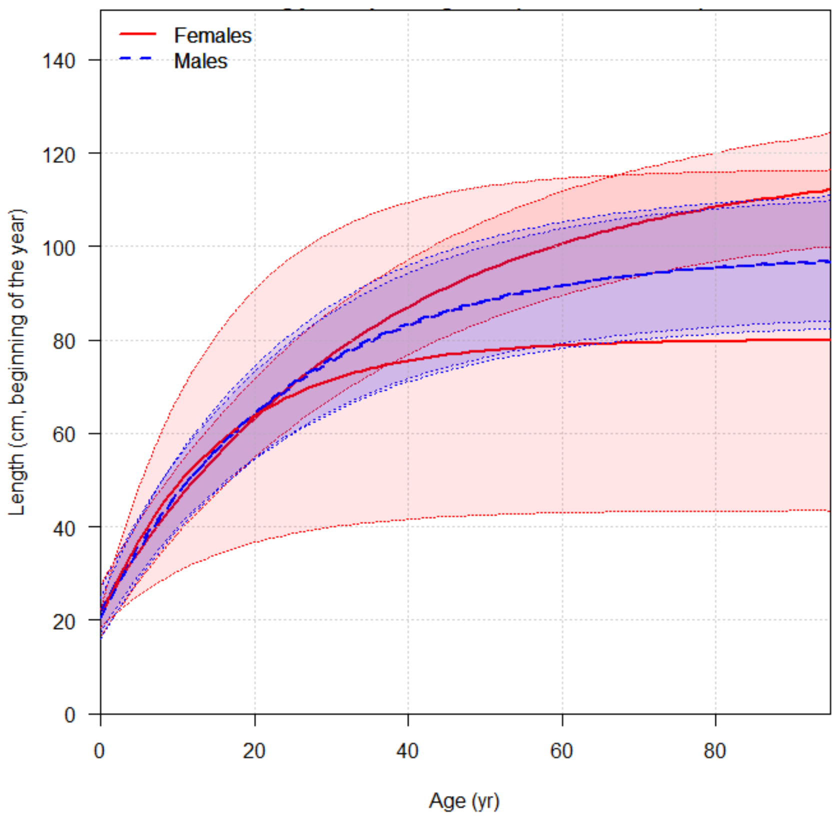

Figure 14. Growth curves for males and females when fixing female *k* at 0.065 and estimating male *k* as an offset.

Moreover, this change in female growth parameters was not consistent with the observed biology of dogfish; as this run resulted in females attaining a lower size than males. Additionally, the requested run had an effect on the resulting scale of the model, but little effect on the overall depletion (see below).

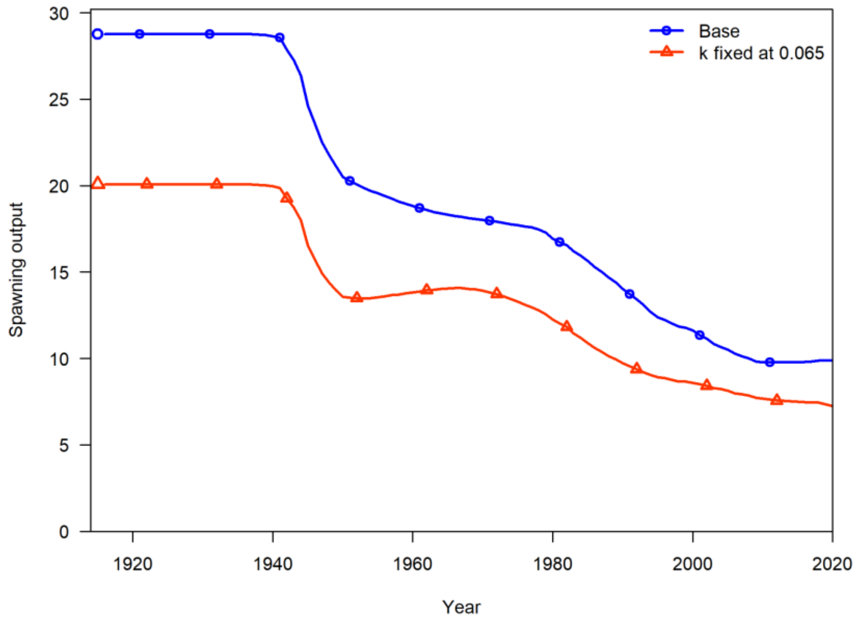

Figure 15. Time series of spawning output (in millions of pups) associated with different *k* values.

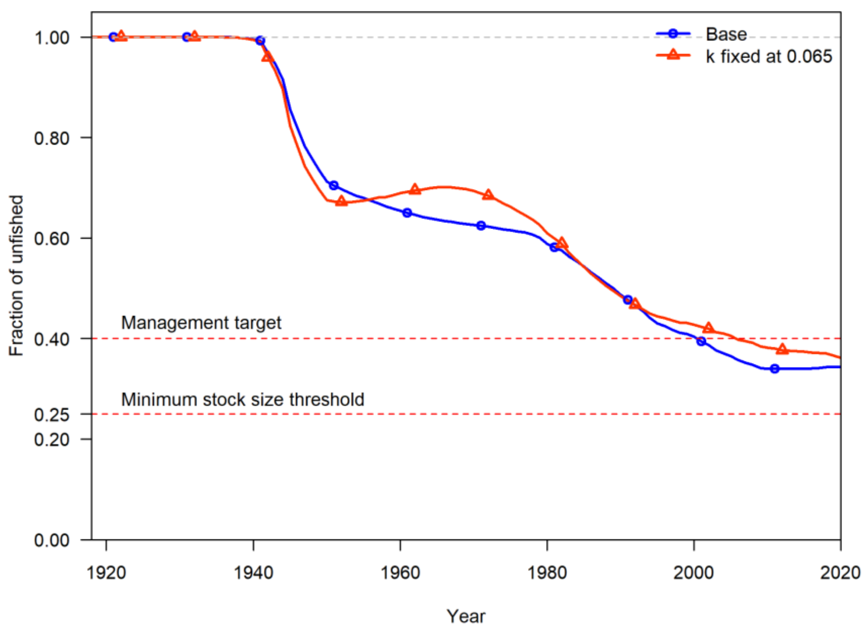

Figure 16. Time series of spawning depletion associated with different *k* values.

Panel Conclusions:

The panel was satisfied with the STAT's response to the request. Moreover, the panel agreed with the conclusion that fixing female *k* at 0.065 and estimating male *k* as an offset was not an improvement to the base model.

Request No. 9: Provide runs where female M is estimated and WCGBTS q is estimated and fixed. Provide fits and other diagnostics for these runs.

Rationale: We need better rationale for the choice of female *M* and why model fits appear to improve with lower *M*.

STAT Response:

The STAT provided the requested runs. Results indicated a higher scaling of the model when female *M* was estimated and when both female *M* and *q* from the WCGBTS were estimated , as shown in Figure 17.

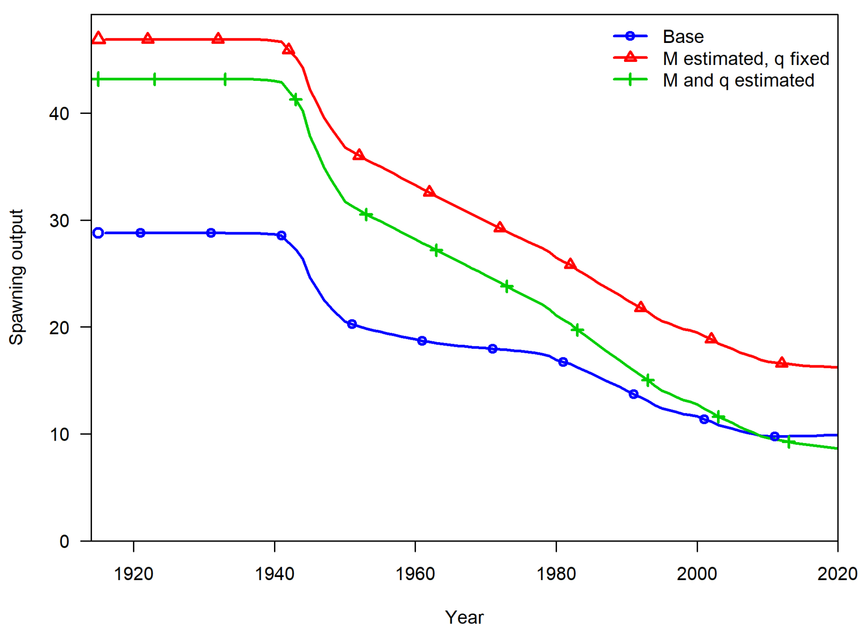

Figure 17. Time series of spawning output (millions of pups) estimated by the base model compared with alternative treatments of *M* and WCGBTS *q*.

Table 3. Likelihood of the Base model and alternative models with *M* estimated and *q* fixed, and both *M* and *q* estimated.

Label	Base model	M estimated	M and q estimated
TOTAL Likelihood	418.93	415.30	409.90
Survey Likelihood Components	-5.22	-2.86	-4.19
Length Likelihood Components	381.39	373.93	369.49
Age Likelihood Components	42.74	43.08	42.86
Priors Likelihood Components	0.00	1.14	1.72
Natural mortality females	0.065	0.034	0.029
Natural mortality males	0.065	0.034	0.029
L1 females	22.06	21.67	21.54
Linf females	118.95	109.34	107.46
L1 males	22.06	21.67	21.54
Linf males	98.68	90.01	90.89
von Bertalanffy k females	0.03	0.03	0.03
von Bertalanffy k males	0.04	0.05	0.05
LnQ_base_WCGBTS(11)	-0.53	-0.53	0.30
WCGBTS q	0.586	0.586	1.356
SOVirgin (millions of fish)	28.78	46.90	43.18
SO 2021 (millions of fish)	9.90	16.20	8.55
B ratio_2021	34%	35%	20%
SPR ratio 2020	0.56	0.38	0.67

Likelihood profiles showed a contrast in the data where the most recent surveys (WCGBTS and IPHC) fit best with higher *M*, while two sources of length comps. (non-trawl landings and the IPHC survey) are best fit with lower *M* (Figures 18 and 19).

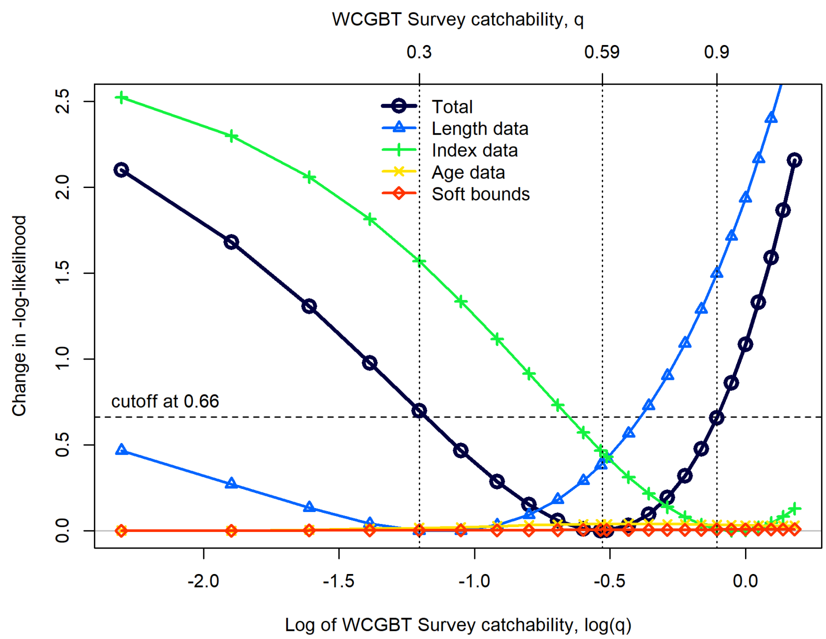

Figure 18. Likelihood profile over WCGBTS q.

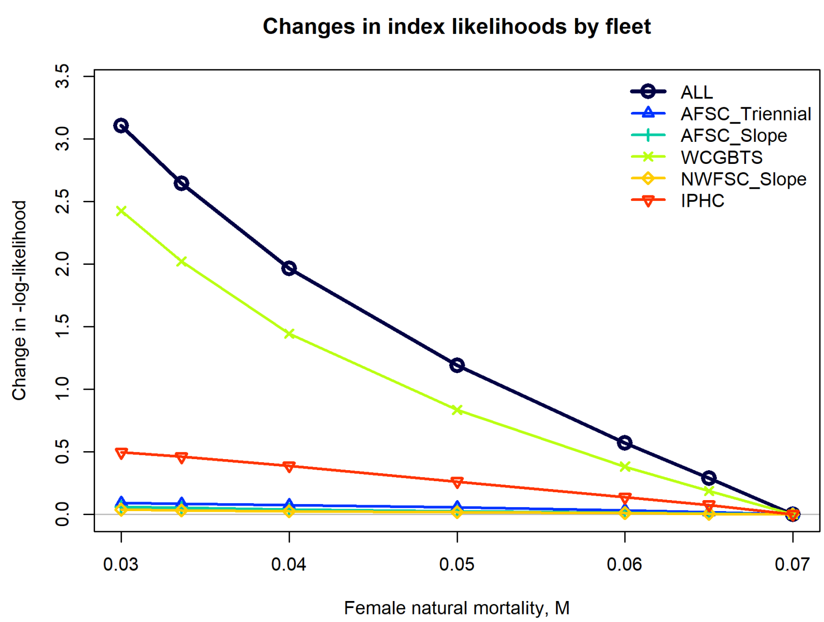

Figure 19. Likelihood profile over M by survey.

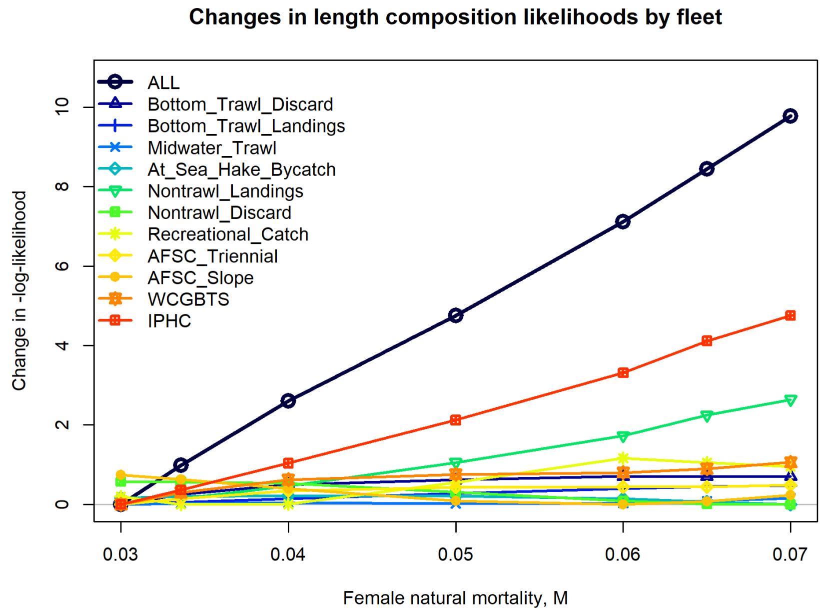

Figure 20. Likelihood profile over *M* by fishing fleet and survey.

Overall, changing *M* did have a large effect on the scale of the model, but it had little effect on stock status, as shown in Figures 21 and 22.

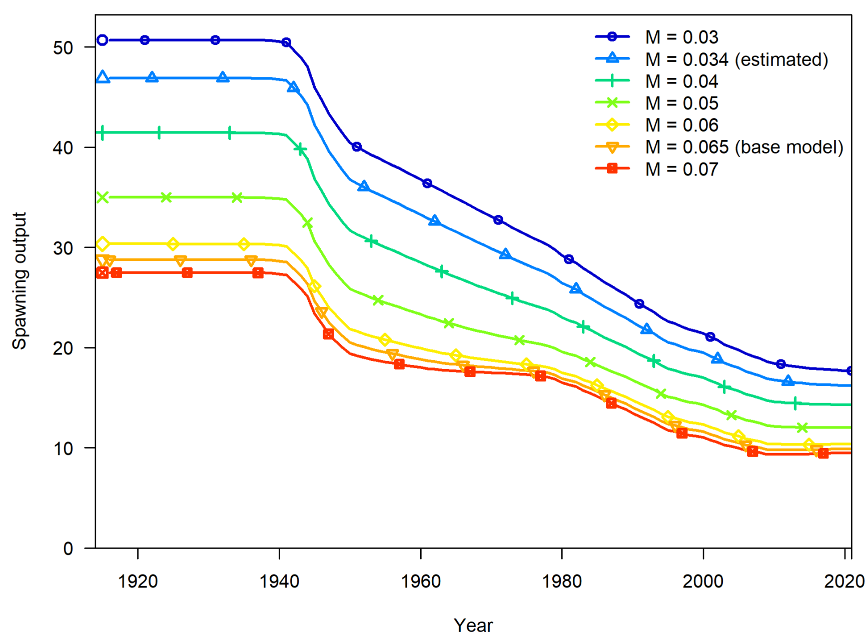

Figure 21. Time series of spawning output (millions of pups) associated with different values of natural mortality (*M*).

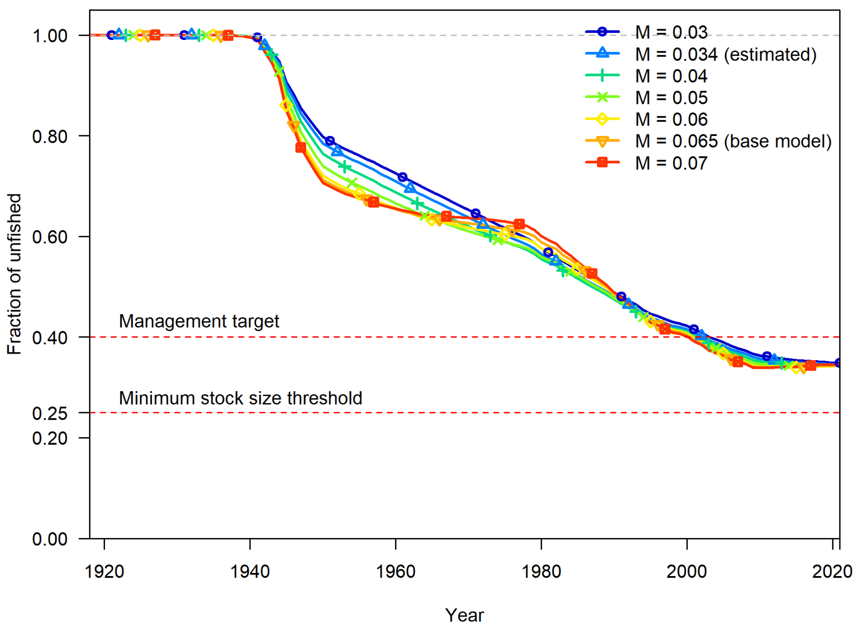

Figure 22. Time series of spawning depletion associated with different values of natural mortality (M).

Panel Conclusions:
The panel was satisfied with the STAT's response to the request. The panel agreed with the STAT's conclusion that the index abundance and the index lengths were pulling the M estimates in different directions. This is also shown in the response to Request 10.

Given that the model's scale is sensitive to changes in M, the panel concluded that this is an unresolved issue worthy of further investigation.

Request No. 10: Provide runs with WCGBTS q values of 0.3 and 0.9 with an accompanying likelihood profile.

Rationale: To explore potential values and states of nature for the proposed axis of uncertainty in the decision table.

STAT Response:
The STAT provided the requested runs, displayed below in Figure 23.

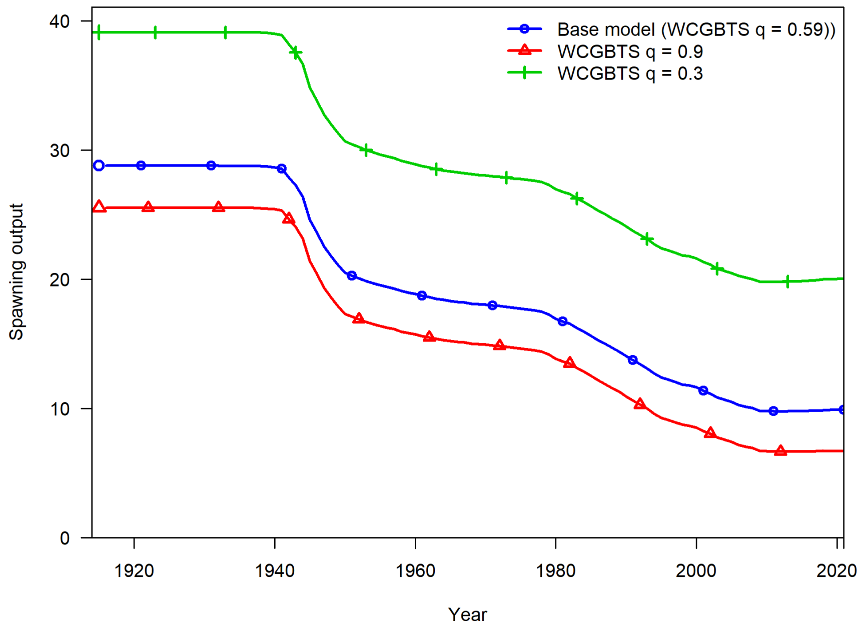

Figure 23. Time series of spawning output (in millions of pups) associated with different values of WCGBTS q.

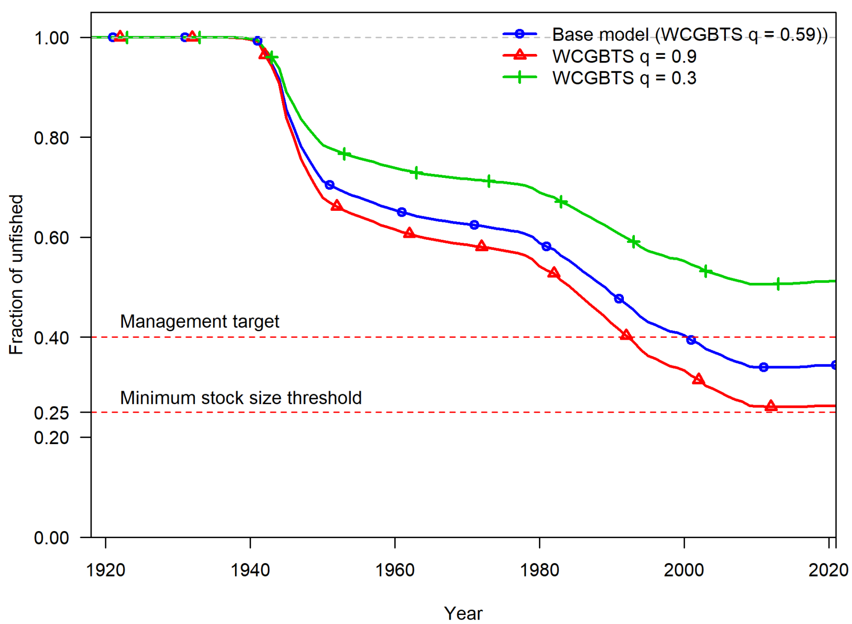

Figure 24. Time series of spawning depletion associated with different values of WCGBTS q.

The STAT proposes these two models (WCGBTS q = 0.3 and 0.9) as alternative states of nature with q as the axis of uncertainty.

Overall, the likelihood profiles (below) again showed the contrasting signal of the length and index data in this assessment.

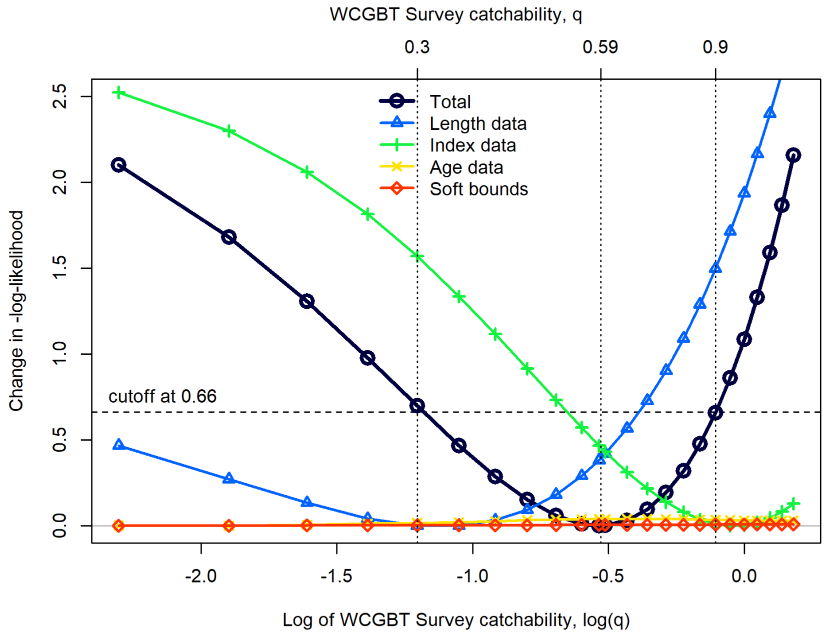

Figure 25. Likelihood profile over WCGBTS q by data type.

Panel Conclusions:

The panel was satisfied with the STAT's response to the request. It also noted that q is a major uncertainty in this model formulation and, in particular, one that greatly affects the overall scale of the model. The tension between length and index data pulling q in opposite directions is an unresolved issue worthy of further research. The panel further noted that different length data were also in conflict with each other. After discussion, the panel formulated Request 11 to, in part, attempt to decide if q or R_0 would be best to capture this scaling uncertainty.

During the meeting, the panel also evaluated length composition likelihood contributions by data source (Piner plots), as well as Francis weighting fits to the mean lengths by year. WCGBTS exhibits the increasing mean length, which along with declining index suggests a potential decline in recruitment (consistent with a decline in spawning females), which could also explain why that data source is best fit at higher catchability values associated with lower stock sizes as shown in the likelihood profiles. Increasing trends in both observed and expected values of mean length from composition data is also observed for bottom trawl discards, are shown in Figures 26-28.

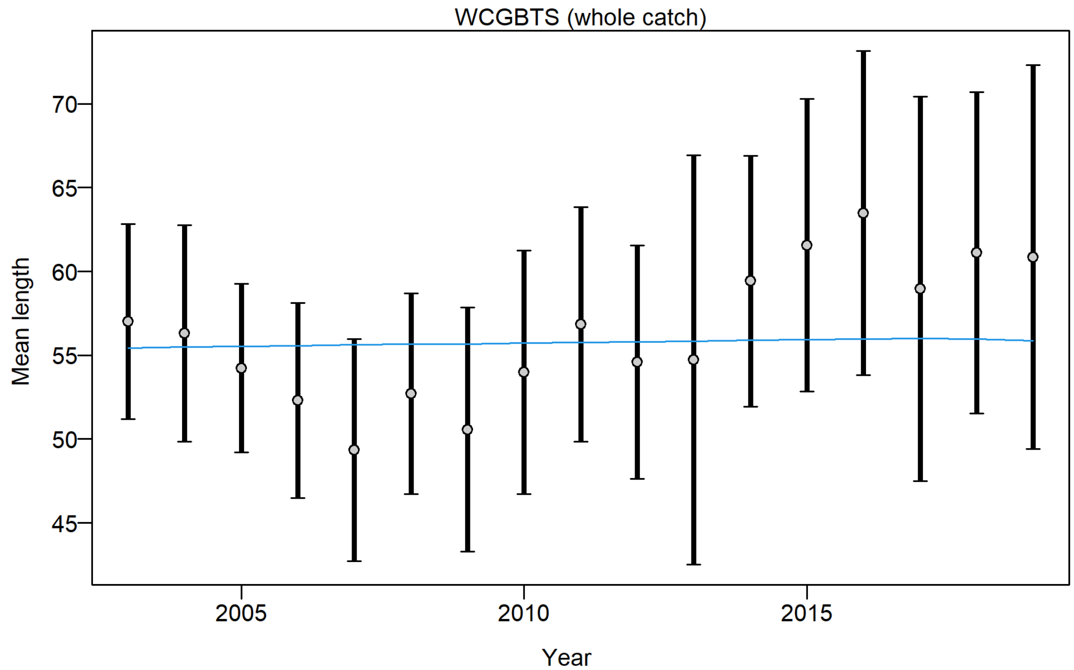

Figure 26. Francis weighting fits to the mean lengths by year for the WCGBTS. Vertical lines are 95% confidence intervals.

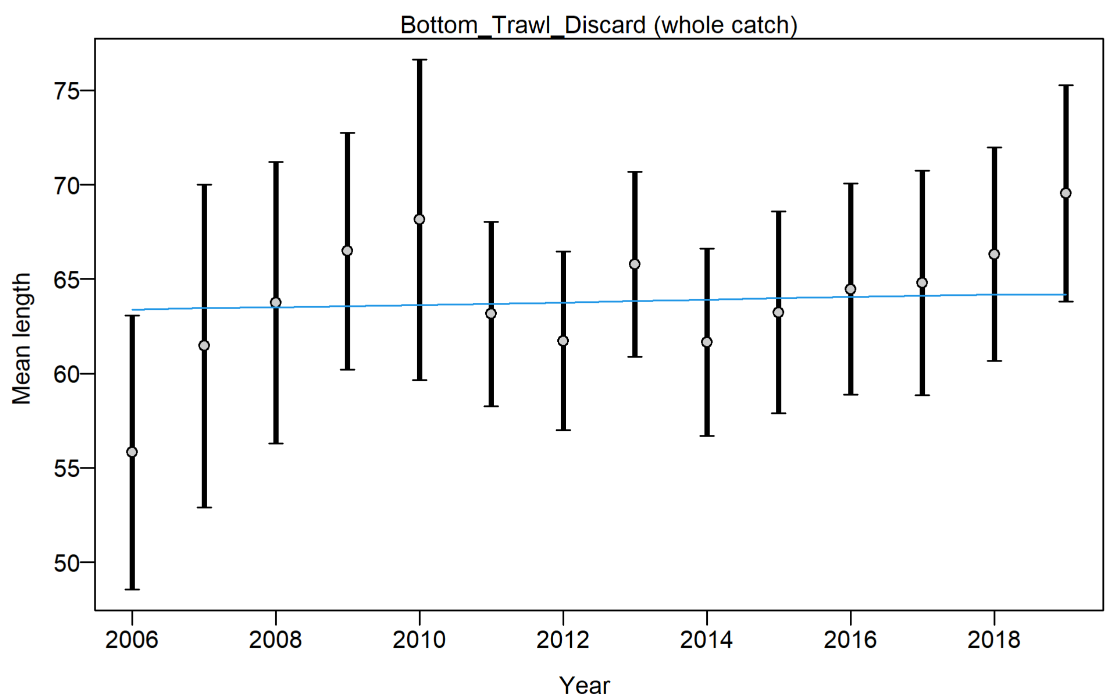

Figure 27. Francis weighting fits to the mean lengths by year for the bottom trawl discards. Vertical lines are 95% confidence intervals.

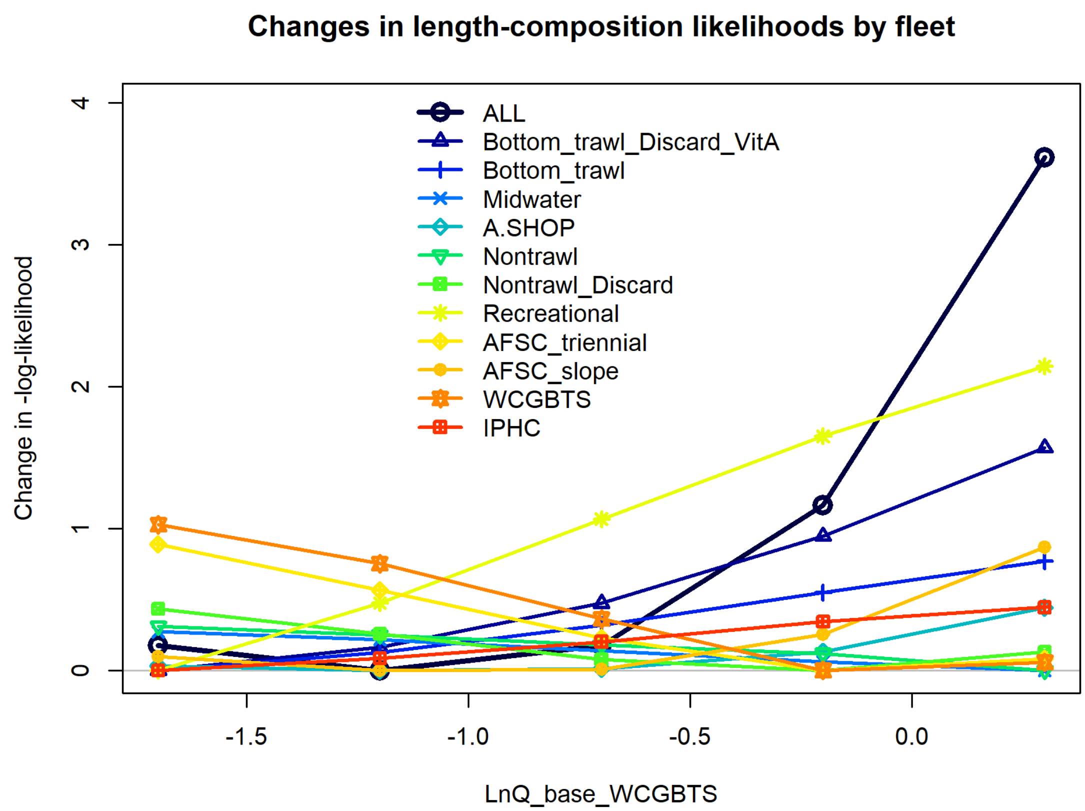

Figure 28. Likelihood profile over WCGBTS q values by fleet.

Request No. 11: Provide runs where ln(R0) is the axis of uncertainty with WCGBTS q estimated with an accompanying likelihood profile.

Rationale: To explore potential values and states of nature for the axis of uncertainty in the decision table.

STAT Response:
The STAT provided the requested runs. They noted that the initial profiles with q fixed resulted in a very narrow range of alternative models. With q estimated, models with $\log(R_0) = 9.6$ and 10.05 were close to the 0.66 cutoff typically used. Alternative values of q associated with these runs are very similar to the proposed alternative states of nature based on q as shown in Figures 29-31.

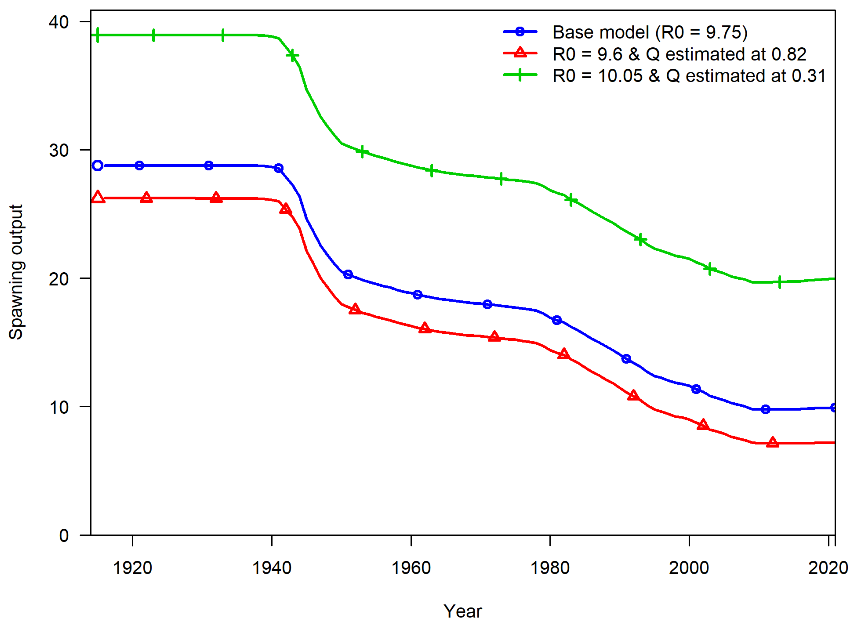

Figure 29. Time series of spawning output (in millions of pups) associated with different values of R0.

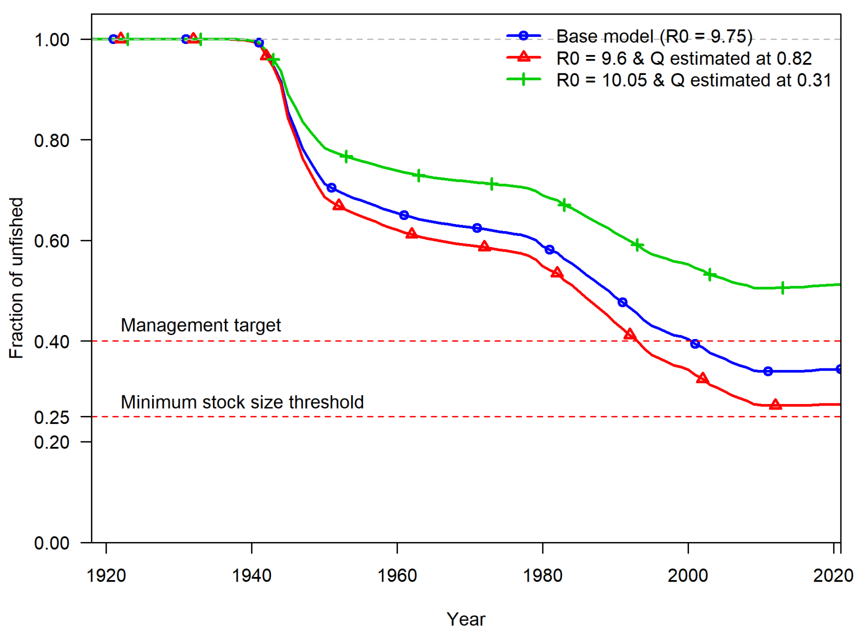

Figure 30. Time series of spawning depletion associated with different values of R_0.

Likewise, the likelihood patterns were very similar to using q as the axis of uncertainty. The STAT felt that q would be a better axis of uncertainty given that it was more explainable to stakeholders and the general public.

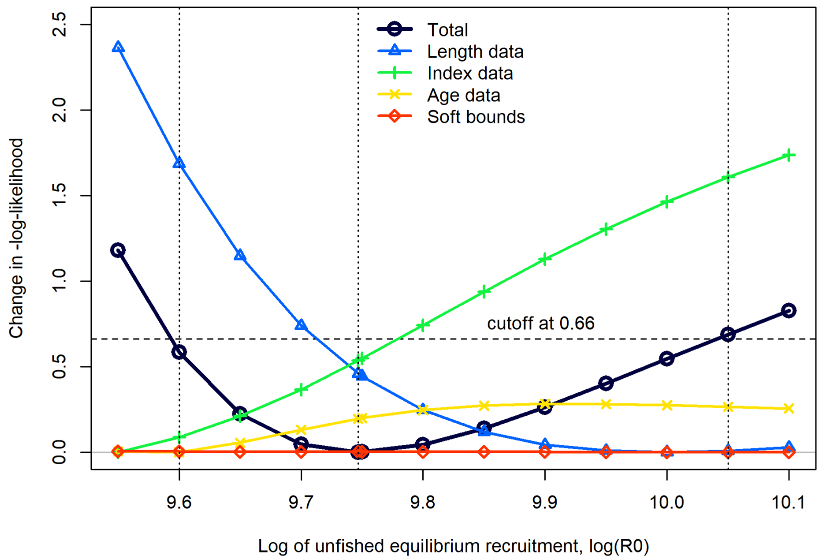

Figure 31. Likelihood profile over log(R_0) by data type.

Panel Conclusions:
The panel was satisfied with the STAT's response to the request. They noted and agreed that using R_0 or *q* is acceptable. They affirmed the recommendation by the STAT that *q* should be the axis of uncertainty at the values specified above.

Request No. 12: Repeat request #4 and evaluate the sensitivity of the historical discard assumptions under each catch stream when WCGBTS *q* is estimated. Reproduce the figures under request #4 with an accompanying table of the *q* values and other model outputs. Also provide the total biomass time series under each of these scenarios.

Rationale: To examine estimated *q* among different historical discard assumptions.

STAT Response:

The STAT produced both estimates with *q* either fixed or allowed to be estimated (Figures 32-35).

With WCGBTS *q* estimated:

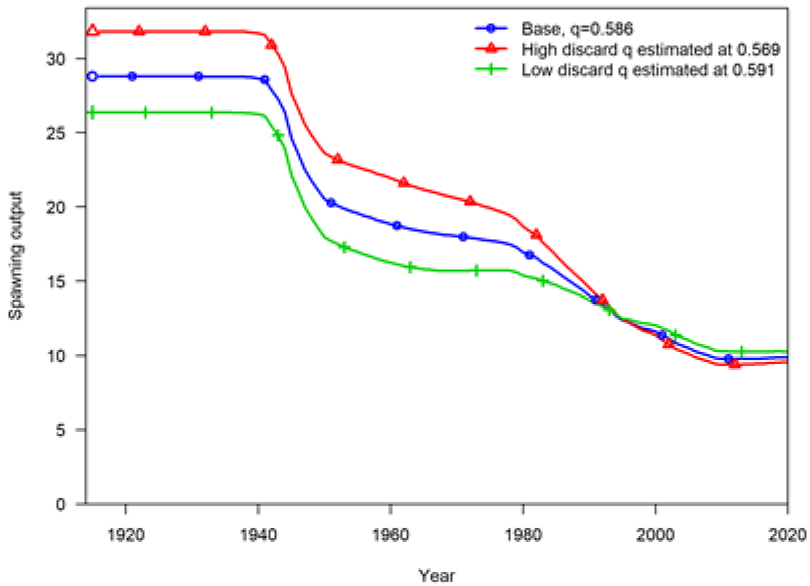

Figure 32. Time series of spawning output (in millions of pups) associated with different discard rates and estimating WCGBTS *q*.

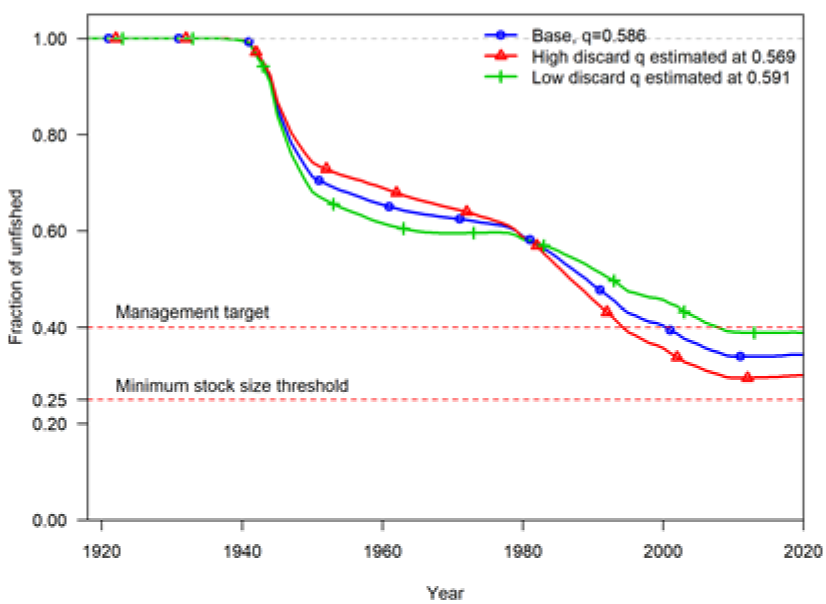

Figure 33. Time series of spawning depletion associated with different discard rates and estimating WCGBTS *q*.

With WCGBTS *q* fixed:

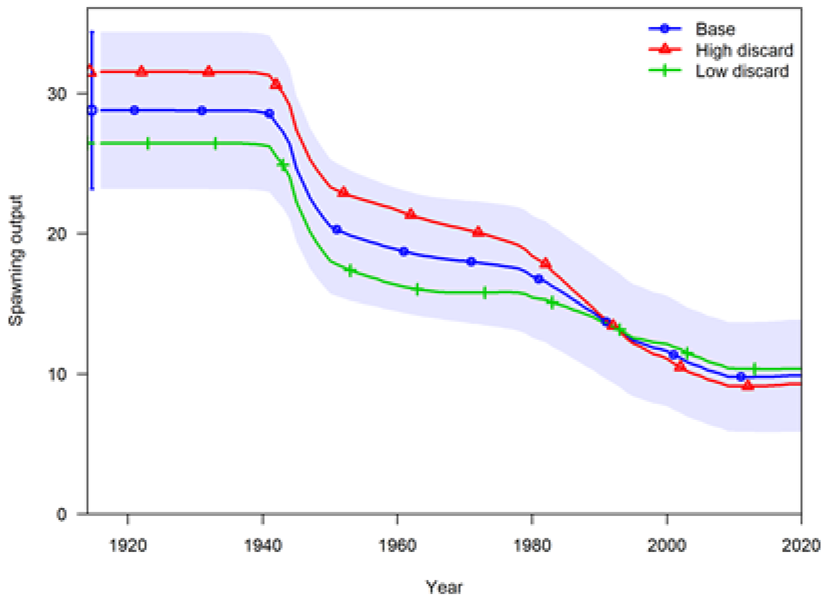

Figure 34. Time series of spawning output (in millions of pups) associated with different discard rates and WCGBTS *q* fixed.

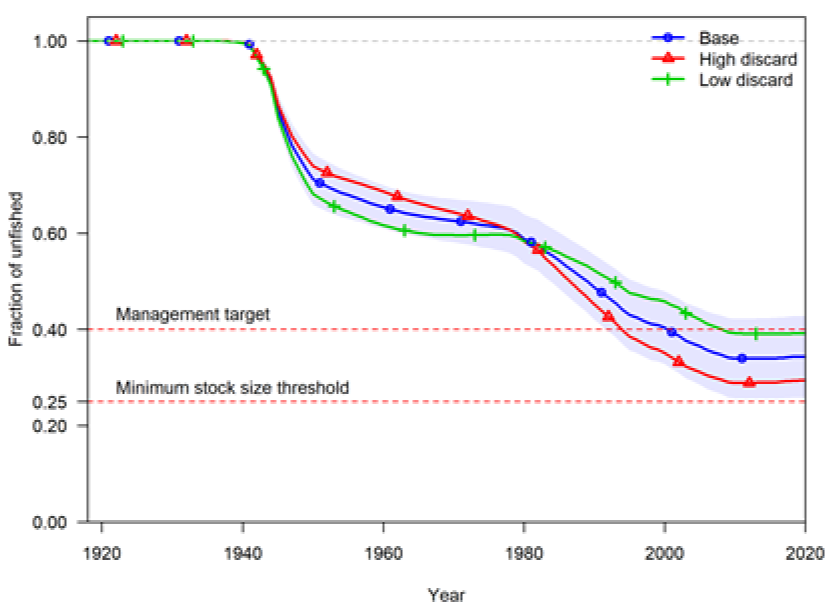

Figure 35. Time series of spawning depletion associated with different discard rates and WCGBTS *q* fixed.

As can be seen by Figures 32 & 33 vs. Figures 34 & 35, there was little difference between allowing the catchability to be estimated or fixed. Estimated catchability was 0.6, similar to the fixed value of 0.59

Panel Conclusions:
The panel was satisfied with the STAT's response to the request. After discussion, the panel concluded that this was a non-issue. The STAT reminded the panel that the estimate of discards with high uncertainty was mostly from years 1960-2002, well before the use of the WCGBTS; as such, a change in the effect of catchability would not be likely to occur given the differences in timing of these two data inputs. The panel agreed with this conclusion.

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

The final ***base model*** incorporated the following specifications:

Model strcuture	Base model
Starting year	1916
Population characteristics	
Maximum age	95
Gender	2
Population lengths	10-136 by 2 cm bins
Summary biomass (mt)	Age 1+
Data characteristics	
Data lengths	12-132 by 4 cm bins
Data ages	0-71 ages
Minimum age for growth calculations	0
Maximum age for growth calculations	999
First mature age	1
Fishery characteristics	
Fishing mortality method	Hybrid F
Maximum F	4
Catchability	
AFSC triennial survey	Estimated parameter
AFSC slope survey	Analytical solution
NWFSC slope survey	Analytical solution
WCGBTS	Estimated parameter, Fixed at estimated value
IPHC survey	Analytical solution
Selectivity	
Bottom trawl landings	Double normal, Female offset
Bottom trawl discard	Double normal, Female offset
Midwater trawl	Double normal, Female offset
At-sea hake fishery bycatch	Double normal, Female offset
Nontrawl landings	Double normal, Male offset, Assumed asymptotic
Nontrawl discard	Double normal, Female offset
Nontrawl catch during vitamin A fishery	Mirrored to Nontrawl discard
Recreational catch	Double normal
AFSC triennial survey	Double normal, Female offset
AFSC slope survey	Double normal, Male offset
NWFSC slope survey	Mirrored to AFSC slope survey
WCGBTS	Double normal, Female offset
IPHC survey	Double normal, Male offset, Assumed asymptotic

Alternative models to bracket uncertainty

WCGBTS catchability (q) was used as the axis of uncertainty to define the alternative states of nature. In the base model, q was estimated to be 0.586 and then fixed at the estimated value. To define alternative states of nature, the 12.5% and 87.5% quantiles of the likelihood profile of WCGBTS q was used, as illustrated in Figures 23-25 (the value of 0.66 reflects the chi square distribution with one degree of freedom). Therefore, the models with $q = 0.9$ and $q = 0.3$ were used as the low and high states of nature, respectively.

Technical Merits of the Assessment

- The STAR panel commends the STAT for their systematic and thorough documentation of the assessment data and model specifications, as well as their documentation of assessment model diagnostics and sensitivity analyses. Technical merits of the assessment model can be summarized as a size-structured model that integrates almost all relevant data about the productivity dynamics for the Spiny Dogfish stock as a whole. Model fit diagnostics were good overall, as were model convergence diagnostics.
- Using Sablefish as a proxy of effort for discard estimation was an improvement over assuming a static discard fraction from 1960-2002 as was done in the 2011 assessment.
- The incorporation of the limited and uncertain age data did help to estimate the growth parameters within the model, especially for males.
- The retrospective pattern has improved dramatically since the 2011 assessment.

Technical Deficiencies of the Assessment

- Model scale is very sensitive to assumptions on M and q. Different data streams appear to be pulling the model's scale in different directions.
- Ageing uncertainty of older dogfish, driven by the wearing of dorsal spines as dogfish age, is a significant source of uncertainty. As a consequence, estimates of maximum age and M, as well as female von Bertalanffy parameters are highly uncertain.

Areas of Disagreement Regarding STAR Panel Recommendations

There were no major areas of disagreement between the STAT Team and the STAR panel, nor among the STAR panel members (including GAP, GMT, and PFMC representatives).

Management, Data, or Fishery Issues raised by the GMT or GAP Representatives During the STAR Panel Meeting

The GMT was initially concerned about the application of trawl discard rates to the non-trawl sector to estimate non-trawl discard amounts because of functional differences in operations between the two sectors. However, after review of the non-trawl discard amounts estimated by the base model and how they compared to discards estimated by WCGOP, the GMT is no longer concerned about this method.

The GAP representative raised concerns about the 50% non-trawl discard mortality rate used in the model, because this rate appears to be higher than what industry representatives have experienced or would expect.

Unresolved Problems and Major Uncertainties

Currently the proposed base estimates catchability (q) from the WCGBTS at 0.59; however, there are rather large uncertainties around this estimate. As indicated in the likelihood profiles of base and sensitivity analysis, indices of abundance suggest a larger q (0.9 value), while length data from the same surveys indicates a smaller q (0.3 value). Like with estimates of natural mortality mentioned above, this uncertainty in the q reflects a larger issue of scaling in the assessment. Because of the impact of q on the estimates of scale, the panel recommends a research focus to address this issue.

The base model used a fixed M of 0.065 based on the demographic analysis by Smith et al. (1998); however, there is a possible error with the reference used to set M in the current assessment. The maximum observed age of 70 years used to estimate M in the demographic analysis is below the maximum age of 80 years reported by Saunders and McFarlane (1993), which was the reference used by Smith et al. (1998) to estimate M in the demographic analysis. Additionally, M/k ratio of 2.32 based on the current analysis is large for a longer-lived species (Frisk et al. 2001). In general, longer-lived elasmobranchs tend to have lower M/k ratios. The uncertainty surrounding the aging data could significantly impact the results of the M/k ratio since it is very sensitive to changes in the growth rates, as observed when the STAT used a fixed M rather than an estimated M. There are large uncertainties around this estimate that do not consider the lack of age data for larger females (i.e., > 80 cm TL), which in turn increases the uncertainty of M as it is related to growth. The panel suggests that M could be estimated externally in a Bayesian framework using different M estimators given the data availability (e.g., Charnov et al. 2013 and Hamel 2015).

As outlined in the assessment document and elsewhere in this report, uncertainties in the aging of older, larger females was an unresolved issue in this assessment. This is due in part to the realization that spines from older fish tend to be worn, resulting in age readings that were biased low. This prompted the STAT to discard ages of females greater than 80 cm as they were deemed unreliable. This has a number of effects, chiefly that there is uncertainty in the estimated growth parameters as older and larger fish are not represented well. Additionally, this also impacts the issue of natural mortality, as natural mortality is typically estimated using known maximum age. Because this issue impacts growth, natural mortality, and other biological parameters, the panel suggests that research be conducted to examine this issue.

One area of uncertainty in this assessment that was not resolved was the issue of discards in all fleets between 1960 and 2002. After 2002, at-sea observing captured discards of Spiny Dogfish relatively well; however, prior to that, logbook information was deemed less reliable. In the 2011 assessment, the discards in this period were estimated using a kept-to-discard ratio formulated during the observed period from 2002 on. In the current assessment, the STAT refined the ratio method of the previous assessment by using the catch of Sablefish as a predictor of Spiny Dogfish discards. While this refinement is an improvement, panel members expressed concern that this analysis did not account for the seasonal differences in availability between the two species. Despite stock status not being sensitive to the uncertainty around these estimated discards, the panel indicated that a more thorough analysis should be conducted in the near future. The panel, however, was able to conclude that the use of Sablefish as a predictor of dogfish discards was reasonable; and a more refined analysis of observer data is warranted in the next assessment.

Recommendations for Future Research and Data Collection

Research to be done prior to the next assessment attempt.

The panel also supported the STAT's recommendation that all ongoing data streams used in this assessment be continued or increased including; fishery-dependent and -independent sampling for length, age, and maturity. Fishery-dependent samples should be collected in light of changing fleet dynamics and to fully cover the range of the current fishery.

Additionally, the approaches for informing the historical discards of Spiny Dogfish should be reevaluated, and existing literature reexamined. If the preferred method continues to be examining the total catch of Spiny Dogfish in association with the total catch of Sablefish in recent years of at-sea observations, the Sablefish catch data should be parsed to the portion of the fishery on the shelf where Spiny Dogfish occur by excluding trawl efforts on the slope. This could be done by excluding winter trawl effort for Sablefish or by using a MacCall-Stephens approach of filtering out efforts where Sablefish are caught with Dover Sole and thornyheads, which is indicative of slope targeting.

As also recommended by the STAT, the panel suggests that a vigorous examination of natural mortality via meta-analysis be conducted to help in establishing informative priors for M for future assessments. This analysis should be linked to other parameters such as growth.

Like most other assessments, estimates of catchability (q) is a major source of uncertainty and an unresolved issue for this assessment. This is especially true for dogfish as they appear to be semi-pelagic and may not be consistently available to bottom trawling. As such, both the STAT and the panel recommend future research into the catchability of dogfish in the WCGBTS. These could include depletion studies, video surveillance of trawl operations, or other analyses as appropriate, such as bench-top analysis of co-occurring fishery dependent/independent data.

Given the issue that worn spines of older females produce an aging bias, the panel recommends that research be conducted to examine this issue in detail. The panel suggests a re-examination of existing data, models, and methods used to derive age and growth.

Research needed at some point in the future.

Given the densities of large schools of dogfish adjacent to the US-Canada border, the panel supported the STAT recommendation that the next assessment be conducted jointly with DFO Canada as a potential transboundary assessment. Prior to that, research on tagging might be helpful in either reaffirming the current 5% straying rate or updating it.

As outlined in the assessment report, efforts should be devoted to both improving current ageing techniques based on dogfish spines and developing new methods using other age structures. Ideally, an alternative method of ageing dogfish that does not rely on the estimation of ages missing from worn spines may be necessary. Improvement in ageing would contribute to a better understanding of Spiny Dogfish longevity and would help estimate natural mortality as well as inform growth parameters within the assessment model.

Acknowledgements

The STAR panel thanks the public attendees, STAT, GMT, GAP, and Council representatives. The panel also thanks Jim Hastie for providing guidance on conducting virtual assessment review and Council staff for providing technical support.

References

Charnov, E. L., Gislason, H., and Pope, J. G. (2013). Evolutionary assembly rules for fish life histories. Fish and Fisheries 14, 213–224.

Frisk, M. G., Miller, T. J., and Fogarty, M. J. (2001). Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. Canadian Journal of Fishery Aquatic Sciences 58, 969-981.

Gertseva, V., Taylor, I.G. 2012. Status of the spiny dogfish shark resource off the continental U.S. Pacific Coast in 2011. Pacific Fishery Management Council, Portland, OR.

Hamel, O. S. (2015). A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science 72(1), 62-69.

Pikitch, E.K., Erickson, D.L., Wallace, J.R. 1988. An evaluation of the effectiveness of trip limits as a management tool. Northwest and Alaska Fisheries Center, NWAFC Processed Report, 88-27.

PFMC, December 2020 Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2021-2022.

Saunders, M. W., McFarlane, G. A. 1993. Age and length at maturity of the female spiny dogfish, Squalus acanthias, in the Strait of Georgia, British Columbia, Canada. Environ. Biol. Fishes 38:49-57.

Smith, S. E., Au, D. W., and Show, C. (1998). Intrinsic rebound potentials of 26 species of Pacific sharks. Marine and Freshwater Research 49, 663-678.