Sablefish
Stock Assessment Review (STAR) Panel Report

University of Washington School of Aquatic & Fishery Sciences
Room 203
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Seattle, WA 98105

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Overview

The Stock Assessment Review (STAR) Panel for sablefish (*Anoplopoma fimbria*) along the U.S. West Coast was held at the University of Washington School of Aquatic and Fishery Sciences in Seattle, WA on July 14-18, 2025. The meeting was hosted by the Pacific Fishery Management Council (PFMC) and followed the Terms of Reference for the Groundfish Stock Assessment Review Process for 2025-2026 (TOR) and Accepted Practices Guidelines for Groundfish Stock Assessments in 2025 and 2026. Sablefish are retained primarily in commercial fisheries, including bottom trawl, hook-and-line, and pot fisheries, and the stock is an important target throughout nearly all depths and latitudes along the U.S. West Coast. The PFMC manages the U.S. West Coast fishery for sablefish as single stock with two management units north and south of 36° N. lat.

The 2025 full (benchmark) assessment was conducted by Chantel R. Wetzel (NWFSC), Aaron M. Berger (NWFSC), Cheryl Barnes (OSU), Joshua A. Zahner (University of Alaska Fairbanks), Nick Tolimieri (NWFSC), Eric Ward (NWFSC), and Melissa Head (NWFSC). The stock has been assessed many times, with the most recent benchmark in 2019 (Haltuch et al. 2019) and the most recent update being a "limited scope" update in 2023 (Johnson et al. 2023). The 2025 model estimates that the stock has been below the biomass target level of 40% of unfished for several decades, but is currently above the minimum stock size threshold (MSST) of 25% and is rapidly increasing in response to a suite of large year classes over the last decade. General trends and recruitment variability are similar to those of recent assessments, although the relative stock status is considerably more pessimistic.

Discussions during the STAR Panel centered around the STATs efforts to address a number of key challenges identified during the 2019 benchmark assessment review, particularly as related to strong tension between age and length composition data, considerable spatial and temporal variability in growth and size at age, and unusually influential data in commercial discards (which were then modeled with a retention curve). The current assessment addresses these (and other) issues by relying primarily on age data to inform demographic structure and fishing mortality, excluding length data and including empirical weight at age data. The model was considerably more stable and robust to sensitivity analyses than the 2019 model (and associated updates), and the Northwest Fishery Science Center (NWFSC) West Coast Groundfish Bottom Trawl Survey (WCGBTS) data were considered to be highly informative and influential. The STAR Panel and STAT agreed that the original draft base model represents the best scientific information available, and the Panel identified several key areas for future research.

Summary of Data and Assessment Model

Data

The model used landings data from various historical landings reconstructions, historical foreign fishery catch datasets, commercial domestic landings from PacFIN, at-sea Pacific hake fishery catches, and recreational landings from RecFIN. Gear-specific discard rates and discard mortality rates were assembled from multiple sources. The resulting catch data were assigned to six fishery fleets representing retention and discard fleets for trawl, pot, and hook-and-line gears.

The model used model-based indices of relative abundance based on: (1) the NWFSC WCGBTS from 2003-2024; (2) the Alaska Fishery Science Center (AFSC)/NWFSC Triennial Shelf Survey, split into early (1980-1992) and late (1995-2004) periods; and (3) the NWFSC Slope Survey from 1998-2002. All four indices were estimated using a hurdle model with spatial and spatiotemporal random effects in *sdmTMB*. The WCGBTS is the only continuing survey and represents the primary source of information on the stock's trend. The model also used an environmentally driven recruitment index, which was a composite of several oceanographic indicators, to inform the most recent five years of recruitment (2020-2024).

The model used age composition data from all six fishery fleets and all four survey fleets. Scientists at the NWFSC and at the Cooperative Ageing Program (CAP) laboratory have developed a machine learning model to predict ages from the spectral properties of otolith scans generated through Fournier Transform Near Infrared Spectroscopy (FT-NIRS). Although FT-NIRS scans have been produced for otoliths collected from the commercial fishery between 2018 and 2024 that do not have traditional ages, the predicted ages for these otoliths were not used given performance issues with the machine learning model, especially for recent years (2023, 2024).

Because of the historical tension between age and length data, the assessment does not use length composition data, but rather relies on age data accompanied by an empirical weight-at-age modelling approach.

Assessment Model

- The model was implemented in Stock Synthesis (3.30.23) as an integrated age-structured, single area, two-sex model.
- There was a full bridging analysis from the 2023 assessment. This included, sequentially:
    - Removing the sea surface height recruitment index.
    - Reprocessing mortality, discard rate, age and index data, and adding recent data.
    - Adding additional historical ages, which was found to be influential.
    - Splitting the fixed gear fleet into two separate fleets, a hook-and-line fleet and a pot fleet. Selectivity was mirrored between the two fleets in the base model.
    - Refining the blocking for selectivity (and retention).
    - Updating maturity, ageing error, and the priors for natural mortality (*M*).
- Important structural changes were also made to the model:
    - Refined approach to the estimation of annual recruitment deviations (the early recruitment deviations were removed).
    - Removed the AFSC slope survey from the model and split the Triennial shelf survey into two indices (1980-1992 and 1995-2004).
    - Replaced model-estimated retention with gear-based discard fleets.
    - Updated parameters for the WCGBTS selectivity, natural mortality (female and male *M* estimated as a single parameter at 0.088 yr^{-1} and the Beverton-Holt steepness (*h*) which was fixed at 0.75.
    - Switched to time-varying empirical weight-at-age.
    - Added a new, short, environmental recruitment index and estimating recruitment deviations as simple deviations.

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

The base model showed generally good fits to the data. Several recent years (particularly 2019, 2022 and 2023) in the most important of the abundance indices, the WCGBTS index, were not well fitted. The Triennial shelf survey was probably overfitted due to splitting the time series. The recruitment index was also well fitted but is short and not influential in the model. Both survey and commercial age composition data were relatively well fitted.

Results showed a slow decline in abundance and status from the 1890s to the late 1970s, followed by a steep decline to about 2000, and an increase from about 2010 to 2025. Projections suggest the stock will continue to increase due to above average recruitment at the end of the time series.

Key base model outputs included trajectories of biomass, stock status, and fishing intensity:

- Age 3+ biomass, with an estimated value of 246,667 mt in 2025.
- Relative spawning output (B/B_0), estimated as 33.9% in 2025.
- Fishing intensity in 2024 was lower than the reference point threshold, indicative that overfishing is not occurring.

The STAT reported on a wide range of sensitivity model runs in the Pre-STAR assessment report this included sensitivities to data and parameters (and other model structure assumptions). Additional sensitivity runs were added to the final assessment report based on requests made during the review.

Data sensitivities:

- Removal of each of the fisheries-independent indices – little impact.
- Estimating time-invariant, sex-specific growth – lower scale, same status.
- There was no retrospective pattern seen as data were peeled back through time.
- Changing assumptions about recruitment – historic change in biomass and status but not in recent years.

Parameter sensitivities:

- Assuming a higher M – higher biomass, lower terminal status.
- Assuming a lower M – lower biomass, higher terminal status.
- Increasing or decreasing the value of the Beverton-Holt slope, h, – modest impact on biomass but little impact on status.
- Increasing or decreasing the value of R_0 – higher biomass and somewhat lower status.

Additional sensitivities were requested by the Panel, as described in the Requests and Responses. These included:

- Reduced and zero survival of discarded fish – little impact.
- Using the Triennial shelf survey as a single time series – little impact.
- More alignment of the timing the selectivity blocks – little impact.
- A substantial reduction (90%) in the effective sample sizes for the age composition data – this led to a modest reduction in stock status and better fit to recent WCGBTS data.
- A 50% increase in historic catches made before 1969, pro-rata across gear types – little

impact.

- Replacing time varying, annual weight-at-age with overall average weight-at -age – little impact.
- Applying a 25% increase and then a 25% decrease in the ageing error – increased stock status with reduced ageing error, and reduced stock abundance with increased aging error.

Collectively, this range of sensitivities represents a fairly comprehensive exploration and description of the uncertainty associated with the base model and included all of the more important contributors to that uncertainty, whether due to data or parameters.

Technical Merits of the Assessment

The Panel found a number of merits to the assessment:

- Model is highly stable and robust to extensive sensitivity analysis
- Model performance against standard diagnostics, particularly the retrospective analysis, was acceptable.
- Many of the recommendations from the 2019 review panel were implemented, including:
    - Development and usage of empirical weight-at-age data to remove the tension between length and age data.
    - Moving away from a model-based retention curve and adding discard fleets with informed catches.
- The WCGBTS continues to be informative, particularly with respect to incoming year classes and is a key data input to this assessment.
- The assessment evaluated regional differences in growth and maturity, and used an appropriate biomass weighted average approach to applying those estimates in the model.
- Although it exerted low influence on the model results, the assessment used an oceanographic recruitment index to estimate recent recruitment deviations.

Technical Deficiencies of the Assessment

The Panel found no technical deficiencies in the assessment modeling. However, the Panel did identify some deficiencies in data, data treatment, and model configuration that, if addressed, could improve future assessments.

- The spatial extent of the key survey does not cover the full depth distribution of the stock.
- Possible overweighting of the composition data (see research recommendations).
- Sablefish are known to be difficult to age and this assessment includes large ageing error, particularly for older fish (e.g., ± 12 years for the oldest sablefish).
- There are some mismatches between retention and discard fleet selectivity blocks for which the basis for the mismatch is unclear. However, these do not appear to be influential to the model result.
- The assessment struggled to fit two recent datapoints from the WCGBTS index, which were both high.
- Some of the earlier fishery-independent indices were not very informative and could be removed to increase parsimony.

Recommended Sigma Value

The Panel recommends a Category 1b designation for this assessment (default sigma = 0.5). The age-structured model includes compositional data that sufficiently resolve year-class strength, variability in growth is accounted for by the use of mean weight at age data, and trends are well informed by the WCGBTS indices. The model estimates sigma at 0.12 (log scale) for the 2025 OFL. This is less than the default sigma for a Category 1b stock, thus the recommended sigma is 0.5.

Recommended Next Assessment Type

The panel considers that the next assessment should be an update, especially given the intentionally developed stability in this assessment approach.

Areas of Disagreement Regarding STAR Panel Recommendations

There were no disagreements within the Panel or between the Panel and the STAT.

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

A considerable number of structural changes were made to the 2025 model compared to the 2019 model, many of which were based on requests from the 2019 STAR panel. The GMT and GAP appreciate that many of these improvements to the model were designed with a goal of more stability across re-runs in any potential future updates, which is particularly important for a highly valuable target species that receives frequent update and catch-only update assessments.

The GMT expressed interest in the reason for different selectivity time blocks for the retention and discard fleets across the same gear type, as we would expect the timing of changes for retention vs. discard selectivities in the same fleet to be aligned. The STAT explained that there was not sufficient discard data to inform the same time blocks as the respective retention fleets, and the GMT was satisfied with this answer.

There was discussion amongst the Panel about the 50% trawl and 20% non-trawl discard mortality rates (DMRs), which were applied to the entire time series in the assessment. The GMT provided the STAT and Panel with background on the GMT's literature review conducted in 2017 to inform the adoption of those DMRs for survival credits in the Individual Fishing Quota (IFQ) fishery in 2019 (Agenda Item I.2.a, GMT Report 1, March 2017). Several studies exploring the survival rate of discarded sablefish were used to inform PFMC adoption of the 50% and 20% rates. They were also adopted by the SSC as best scientific information available for use in stock assessments and have been used by the Fishery Observer Program for many years when estimating sablefish discard mortality. However, more research is still needed to evaluate the confidence in those values and whether it is appropriate to apply them for the entire time series in an assessment. For example, GAP input indicated that the fixed gear fishery switched from straight hooks to circle hooks in the 1980s, and straight hooks are known to cause more damage and higher mortality than circle hooks.

The STAT split the fixed gear fishery used in the 2023 assessment into separate hook-and-line and pot fleets to allow for flexibility in the selectivity curves for those two gear-specific fleets. The

GMT and GAP advisors noted that there are some differences between the two gear types that would result in different size selectivities to an extent, but the STAT indicated that the model was more parsimonious when the hook-and-line and pot fleet selectivities were mirrored for the retention fleet (i.e., the selectivities for the discard fleet for the hook-and-line and pot gears were estimated separately). The GMT and GAP were satisfied with the STAT's response but also see merit in further exploring the gear-specific selectivity differences in the fixed gear fishery and what implications those differences might have for the model.

The GMT also supports future research efforts to better understand the potential drivers of increasing proportional biomass north of 36° N. lat. and whether this trend is expected to continue into the future.

Unresolved Problems and Major Uncertainties

The biological stock structure is likely to be at a larger scale (e.g., throughout most or all of the Northeast Pacific Ocean) than assumed in this assessment, with movement and dispersal patterns that are neither well understood nor explicitly accounted for within the model. Additionally, sablefish occur in waters deeper than those sampled by both surveys and fisheries.

Survey data suggest a northward shift in the center of gravity of biomass (~2º north) in recent years, which has implications for the fisheries. The mechanisms for this shift seem to be related to recent strong recruitments being more strongly observed north of 42º N. lat. The likelihood of the trend either continuing or reversing represents a significant uncertainty.

Both life history dynamics (growth, maturity) and fisheries (particularly fixed gear) show regional differences, particularly north and south of 36º N. lat. This complicates estimations of life history parameters, and assumptions about the unit stock. Although this was addressed by the STAT through the implementation of biomass-weighted life history parameters, and a more robust resolution would likely be overly complex (e.g., an area model), this does reflect a non-trivial source of uncertainty.

The move to an age-based model is very positive, however, the future model will be very reliant on high quality, representative age data, which is more time-consuming and expensive to develop. Uncertainties regarding the sustainability of recent levels of both data collection and ageing effort may challenge future assessments.

Ageing error is significant for this long-lived species, and no formal age validation has been done. There are also uncertainties regarding age estimates, particularly for older individuals that reside in very deep waters where seasonality is limited (e.g., Pearson and Shaw 2004). It may also be beneficial to re-age some of the age structures from the 1980s, particularly those added to the 2025 model, to ensure consistency between ages and ageing error from those early estimates.

Recruitment is highly variable for this stock. There is some research to understand recruitment dynamics and mechanisms, which are reflected in the recruitment index and associated analysis, but there are still uncertainties regarding longer-term, low frequency variability (e.g., regime-like behavior, which may be suggested by the observation that the five largest estimated recruitment events have taken place between 2013 and 2023) and underlying stock productivity. These uncertainties extend to stocks in other regions of the North Pacific as well.

There is evidence of intraspecific competition (e.g., density dependence) resulting from recent large recruitments, as seen in reduced weights-at-age in recent years. While this is appropriately included in the assessment, it does introduce a significant uncertainty for the future.

Discard mortality rates, both historical and contemporary, have some influence on the model scaling and additional research into gear-specific rates best supported by data would be beneficial. Recent discard rates have been showing some modest increase.

Recommendations for Future Research and Data Collection

- Consider developing a full Bayesian (MCMC) assessment to enhance estimates of model uncertainty, ascertain direct probability statements for management, and/or as a diagnostic tool.
- Consider exploring whether a spatially explicit model might help to address ongoing uncertainties associated with spatially varying life-history parameters or otherwise improve a benchmark assessment. However, in recent years there has been very limited otolith collection south of 36° N. lat. which would severely challenge the ability to develop a spatially explicit age-based model for sablefish. Both to improve the current model, as well as to support future explorations of a spatially explicit model, otolith collection in southern California needs to be increased.
- Consider a more general review of the approach to weighting the composition data, which may be somewhat overweighted in this assessment. This should include considering bootstrapping approaches (Hulson et al. 2023; Hulson and Williams 2024). This work would improve all future groundfish assessments.
- Study cross-boundary dispersal or movements of all life stages to inform on stock structure and to specifically determine the scale and importance of emigration and immigration for the assessed stock.
- Periodically collect representative biological information from discarded fish to inform the various discard fleets. This should include lengths, otoliths, weights, and sex.
- Ensure more consistent biological sampling, especially for age structures and weight, across the relevant different State and Federal agencies. Consider re-ageing some of the age structures from the 1980s, particularly those added to the 2025 model, to ensure consistency between ages and ageing error from those early estimates.
- Continue to develop the (or a more appropriate) environmentally-derived recruitment index with reduced uncertainty, particularly as this index may be especially important during periods in which other, currently more informative, recruitment information may be lacking (e.g., WCGBTS).

- The ability to produce age information more efficiently, by using advanced analytical methods such as Fourier Transform Near-Infrared Spectroscopy (FT-NIRS) and AI-informed ageing should continue to be explored.
- Review the implications of the WCGBTS accessing newly opened Cowcod Conservation Areas (CCAs) within the assessment.
- Exploration of alternative data weighting or model structure approaches that help to improve the fit to recent WCGBTS data points.
- Consider incorporating a change-point analysis to quantitatively analyze the need for selectivity blocks.
- Convene a workshop to guide practices for using and specifying selectivity blocks, including gear changes and fisher behavior changes. Consider such evaluations prior to either a future full or update assessment. Such discussions and recommendations are likely to be helpful across multiple assessments.
- Consider the utility of the early survey data (Triennial shelf, slope surveys), including their potential removal from future models to increase parsimony. Also consider the tradeoffs associated with treating the historical Triennial survey data as a single versus two separate time series. These issues are not limited to this stock.
- Size-dependent fecundity has not been documented for this species, and some research has indicated that there is little evidence for this, but other research (Del Colletti et al., unpublished data) has suggested that there may be some modest increased relative fecundity (e.g., eggs per gram of spawning female) with size, as there is for many other West Coast groundfish. A closer look at this aspect of reproductive ecology would be helpful and may be important.
- More discussion and guidance (and potentially workshops) about how best to develop risk tables would be helpful (broad relevance to many assessments), especially for developing consistency between assessments.

Acknowledgements

The STAR Panel thanks the public attendees, STAT, GMT, GAP, and Council representatives. The Panel also thanks Council staff for providing technical support and NWFSC staff for providing hospitality.

References

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SABLEFISH Requests, Rationale, and Responses

1 - Request

Add model sensitivity runs with (1) zero post-release survival for discards for all fleets and (2) 25% post-release survival for trawl discards and 40% post-release survival for hook and line / pot discards. Add additional text to the final assessment document to explain the 50% and 20% discard mortality rates assumed for the trawl and hook and line / pot fisheries, respectively. Show plots of population trajectories and fits to age data and abundance indices.

1 - Rationale

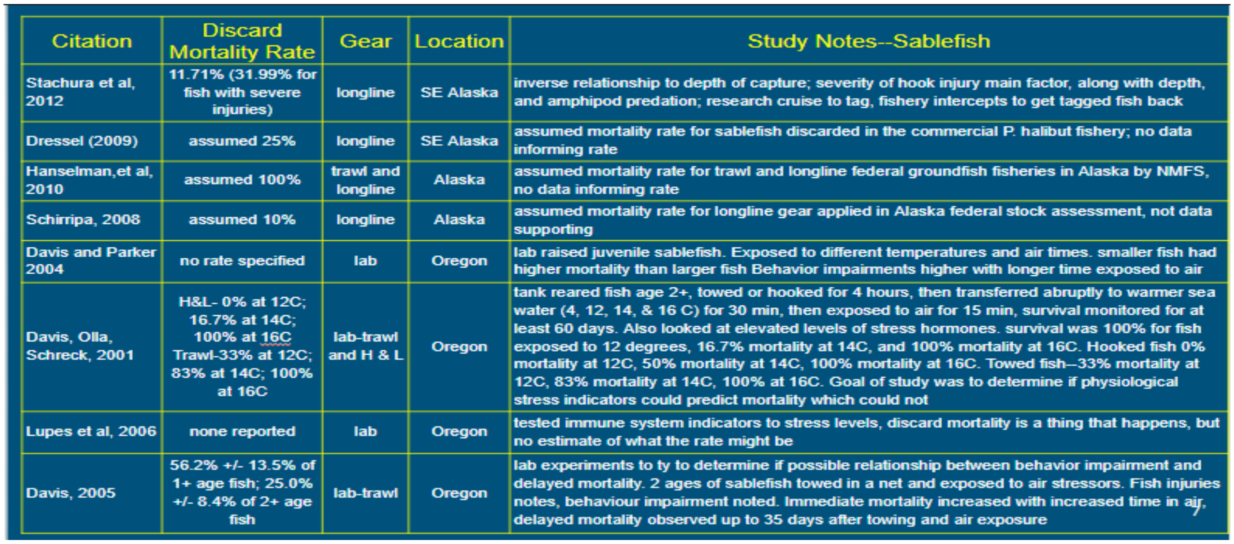
There appears to be some considerable uncertainty about post-release survival for some gear types (trawl - tow length, handling; HKL – changes in hook type); this would explore the impact of the worst case post-release survival.

1 - STAT Response

The two sensitivity runs resulted in expected directional changes in stock size given the overall changes assumed for discard mortality (Fig. 1A). Differences in stock status between model runs was negligible (Fig. 1A). Fits to the age data and the WCGBTS survey were largely insensitive to the imposed changes in discard mortality (Fig. 1B and Fig. 1C, respectively). Whitney Roberts, GMT representative, provided the following GMT and SSC statements that were considered by the Council when adopting the current discard mortality rates; GMT report, March 2017, GMT report, June 2017, GMT report on Trawl Catch Share Review, June 2017, and SSC report, June 2017.

The STAT will add additional text to the final assessment document to better describe how the assumed discard mortality rates used in the base model were developed.

Table 1A. Discard mortality studies for sablefish mortality (based on a GMT literature review).



Citation	Discard Mortality Rate	Gear	Location	Study Notes--Sablefish
Stachura et al, 2012	11.71% (31.99% for fish with severe injuries)	longline	SE Alaska	inverse relationship to depth of capture; severity of hook injury main factor, along with depth, and amphipod predation; research cruise to tag, fishery intercepts to get tagged fish back
Dressel (2009)	assumed 25%	longline	SE Alaska	assumed mortality rate for sablefish discarded in the commercial P. halibut fishery; no data informing rate
Hanselman,et al, 2010	assumed 100%	trawl and longline	Alaska	assumed mortality rate for trawl and longline federal groundfish fisheries in Alaska by NMFS, no data informing rate
Schirripa, 2008	assumed 10%	longline	Alaska	assumed mortality rate for longline gear applied in Alaska federal stock assessment, not data supporting
Davis and Parker 2004	no rate specified	lab	Oregon	lab raised juvenile sablefish. Exposed to different temperatures and air times. smaller fish had higher mortality than larger fish Behavior impairments higher with longer time exposed to air
Davis, Olla, Schreck, 2001	H&L- 0% at 12C; 16.7% at 14C; 100% at 16C Trawl-33% at 12C; 83% at 14C; 100% at 16C	lab-trawl and H & L	Oregon	tank reared fish age 2+, towed or hooked for 4 hours, then transferred abruptly to warmer sea water (4, 12, 14, & 16 C) for 30 min, then exposed to air for 15 min, survival monitored for at least 60 days. Also looked at elevated levels of stress hormones. survival was 100% for fish exposed to 12 degrees, 16.7% mortality at 14C, and 100% mortality at 16C. Hooked fish 0% mortality at 12C, 50% mortality at 14C, 100% mortality at 16C. Towed fish--33% mortality at 12C, 83% mortality at 14C, 100% at 16C. Goal of study was to determine if physiological stress indicators could predict mortality which could not
Lupes et al, 2006	none reported	lab	Oregon	tested immune system indicators to stress levels, discard mortality is a thing that happens, but no estimate of what the rate might be
Davis, 2005	56.2% +/- 13.5% of 1+ age fish; 25.0% +/- 8.4% of 2+ age fish	lab-trawl	Oregon	lab experiments to ty to determine if possible relationship between behavior impairment and delayed mortality. 2 ages of sablefish towed in a net and exposed to air stressors. Fish injuries notes, behaviour impairment noted. Immediate mortality increased with increased time in air, delayed mortality observed up to 35 days after towing and air exposure

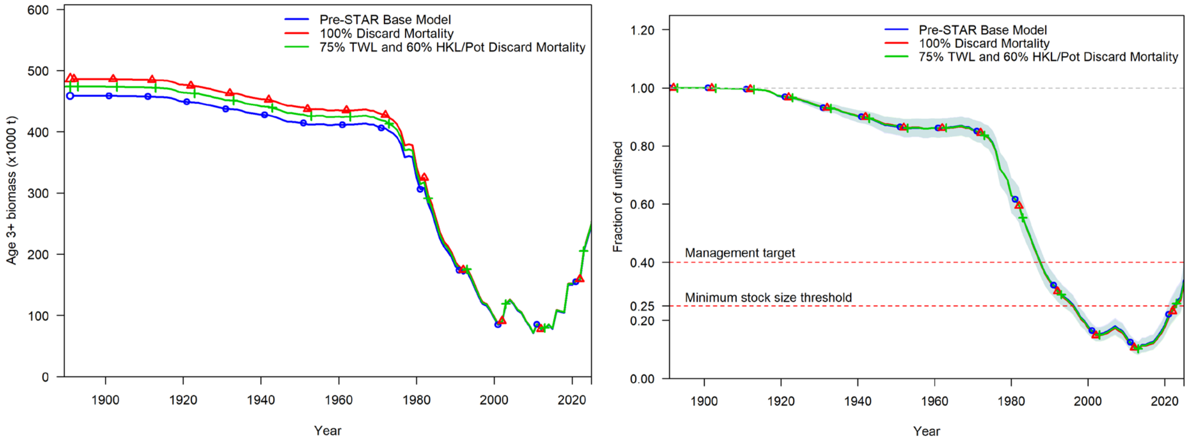


Figure 1A. Population trajectories for the pre-STAR base model and sensitivities related to discard mortality.

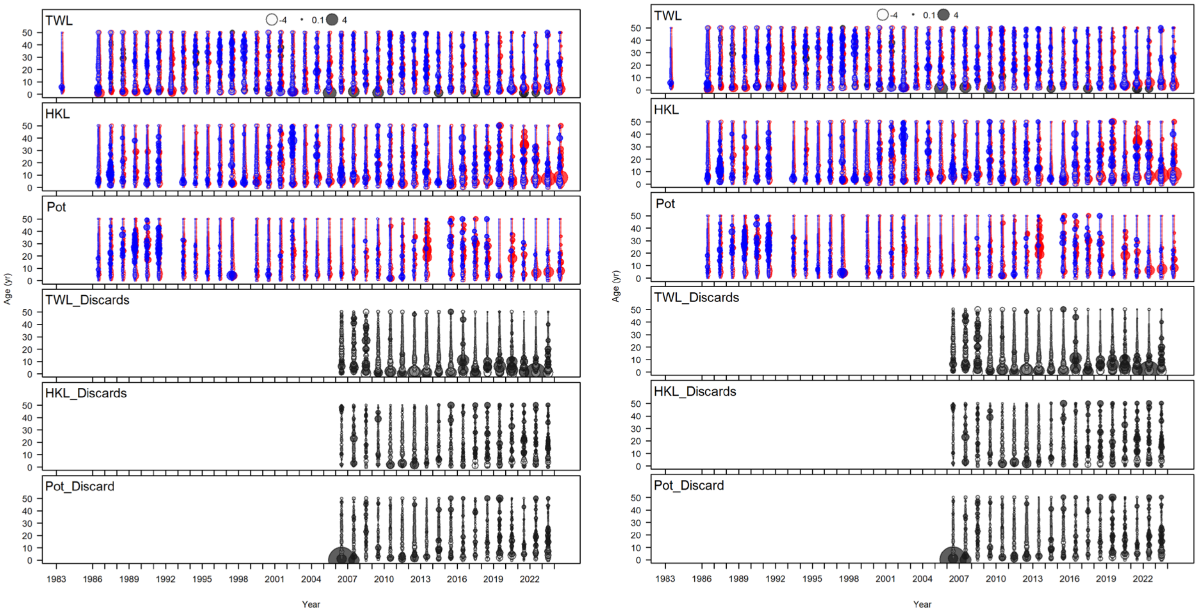
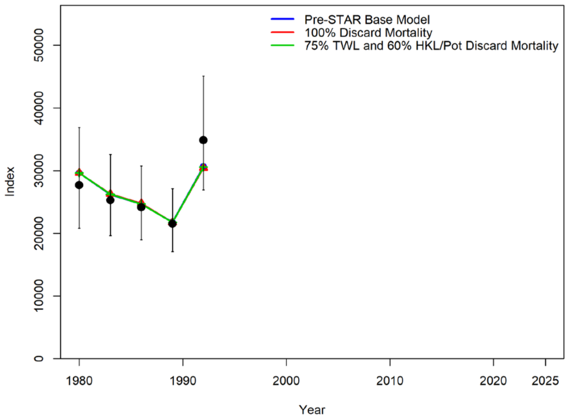
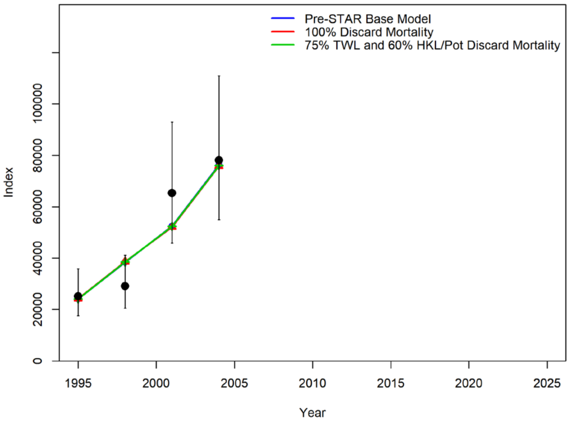
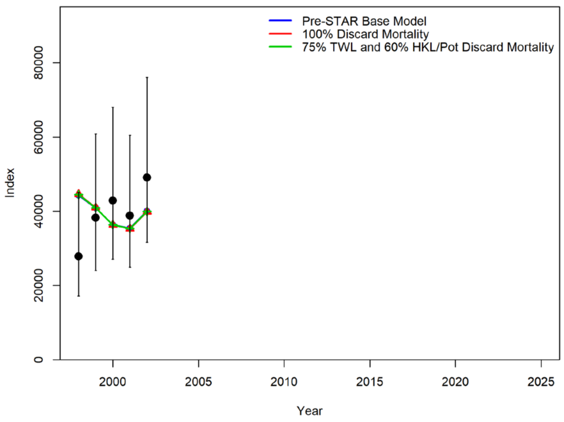


Figure 1B. Pearson residuals between the pre-STAR base model and the sensitivity run that assumed 100% discard mortality (left: pre-STAR base model, right: sensitivity run with full discard mortality).







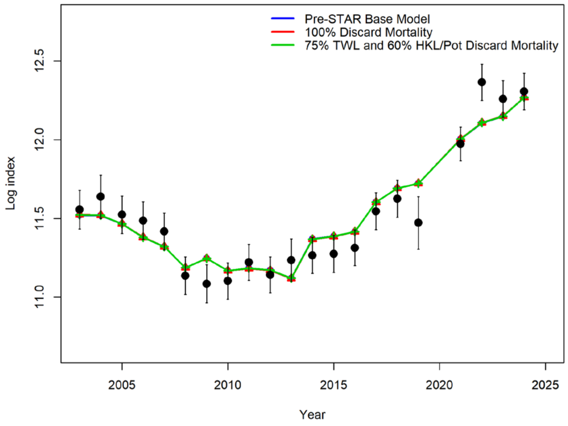


Figure 1C. Model fits to the survey indices (top panel left; Early Triennial Survey, top panel right; Late Triennial Survey, bottom panel left; NWFSC Slope Survey, bottom panel right; WCGBTS).

1 - Panel Conclusion

The results are intuitive with respect to the direction and scale change in the biomass and depletion estimates, and fits to indices are virtually unchanged. The STAT provided information from a GMT-led literature review that provided additional context with respect to the origins of the current assumptions for discard mortality rates.

2 - Request

Add a model sensitivity run using a reworked index of abundance based on the Triennial survey filtered to a common depth range in which the index is treated as a single time series. Conduct another sensitivity in which that reworked index is split into early and late time series and compare both of these to the base model. Show plots of population trajectories and fits to age data and abundance indices.

2 - Rationale

Splitting the Triennial survey into two separate index periods may reduce the influence of this survey in the assessment. This is a potential alternative to splitting the triennial survey into early and late periods with separate indices of abundance for each period.

2 - STAT Response

Reworking the index of abundance from the Triennial survey into a single time series and then splitting that time series into early and late periods had minimal effects on summary biomass and fraction unfished (Fig. 2A). Model fits to mean ages were worse when treating the Triennial survey as a single time series (Fig. 2B) compared to treating the index as a single time series and then separating it into early and late periods (Fig. 2C). Model fits to the Triennial index of abundance were worse when treating the Triennial survey as a single time series (Fig. 2D) compared to treating the index as a single time series and then separating it into early and late periods (Fig. 2E). Overall, the Triennial survey across various treatments (e.g., two separately estimated indices, a single index, etc.) has limited influence in the model estimates. Additionally, estimating two separate indices, early and late, allows the pre-STAR base model to fit the late Triennial Survey index with lower added variance (e.g., 0.14) compared to sensitivity that used the single index but fit via two fleets (e.g., added variance of 0.22 for the late Triennial Survey).

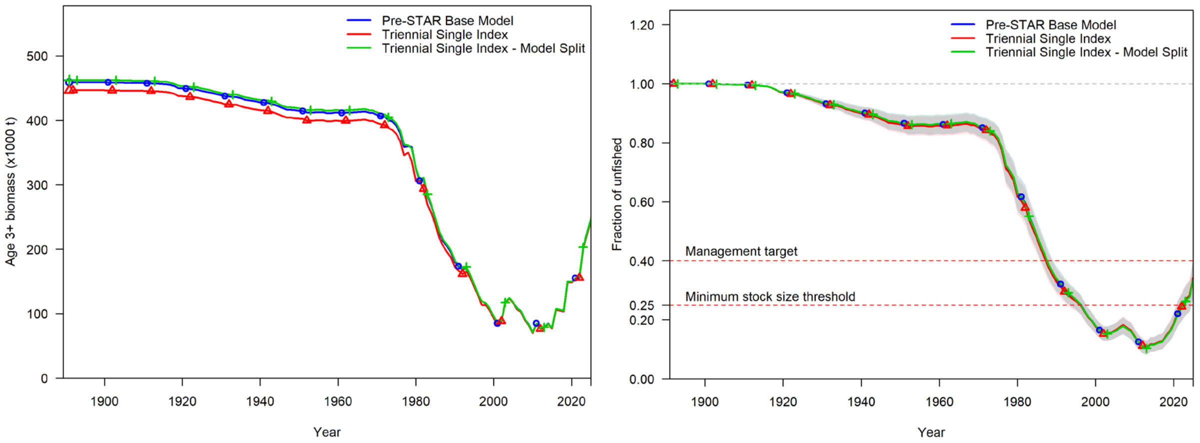


Figure 2A. Summary biomass (left) and fraction unfished (right) for the pre-STAR base model and runs with the reworked Triennial survey index (a single index with the full time series and the single time series split into early and late periods).

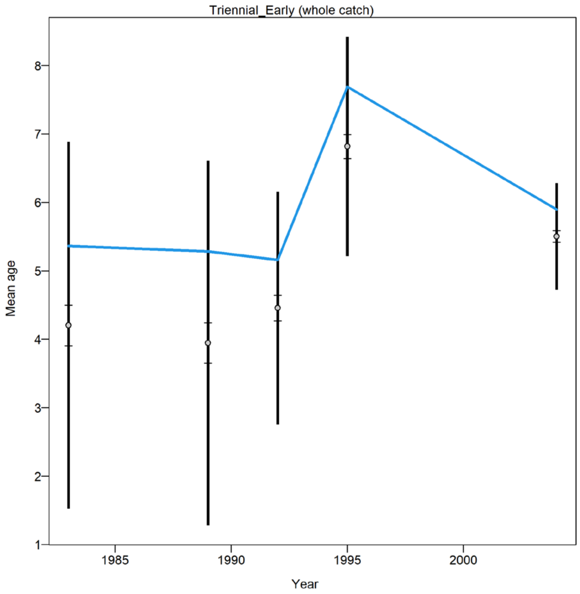


Figure 2B. Model fits to mean ages when treating the Triennial survey index as a single index.

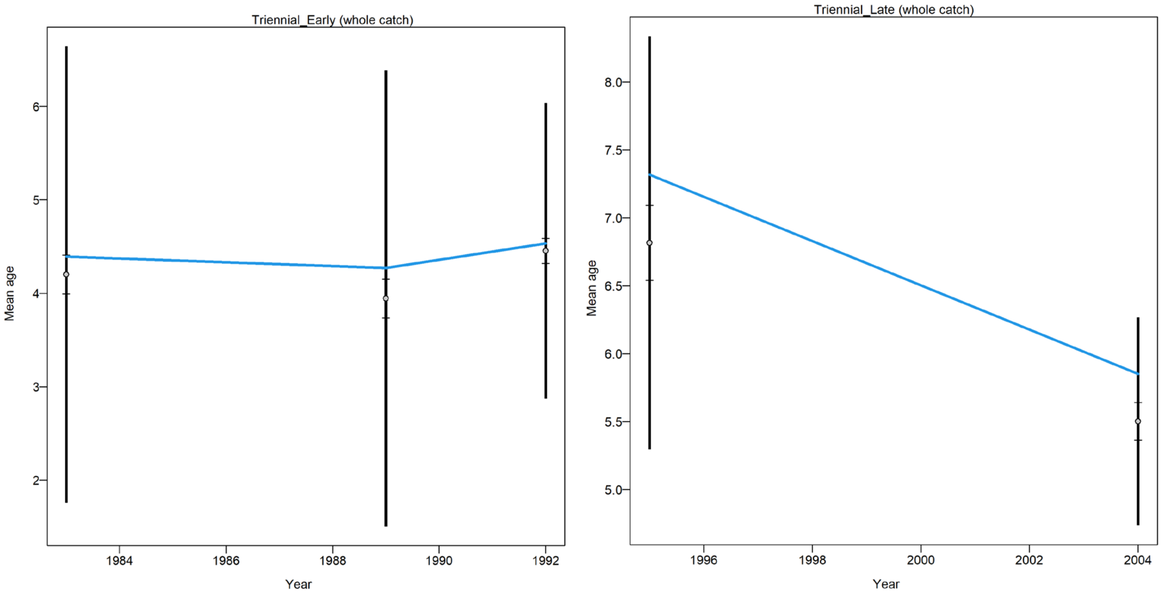


Figure 2C. Model fits to mean ages when treating the Triennial survey index as a single time series and then separating the time series into early (left) and late (right) periods.

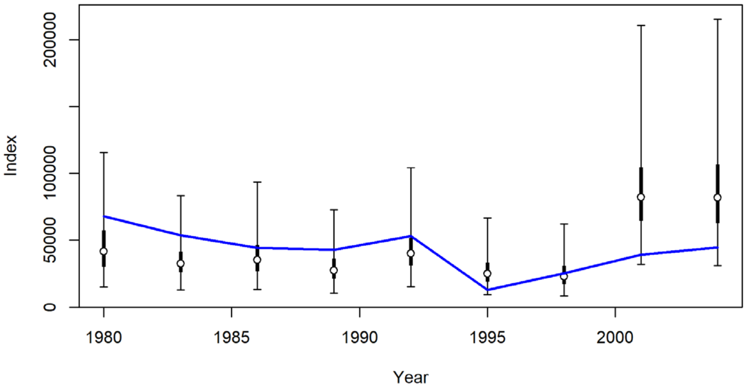


Figure 2D. Model fits to the Triennial survey index when treated as a single time series. The estimated added variance for the index was 0.36.

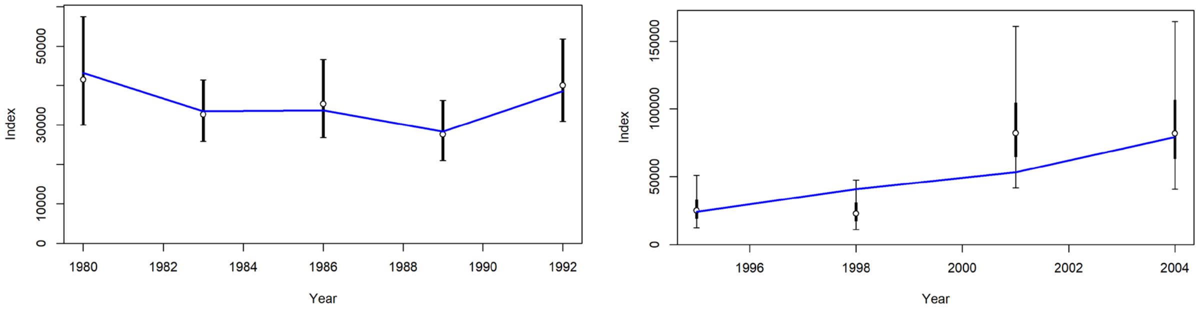


Figure 2E. Model fits to the Triennial survey index when estimated as a single index and then separated into early (left) and late (right) periods within the model. The estimated added variance for the late period was 0.22.

2 - Panel Conclusion

There are not large differences in the model result, the model is able to fit the single index reasonably well, although the added variance is greater and the fit is a little degraded. The degradation in fit to the age data is intuitive given that the later time period sampled greater depths, and thus a different size and age composition than the early time period. The results may prove helpful for considering how to treat this index in the future (or perhaps even whether to use it), but do not suggest that there should be changes to the base model.

3 - Request

Align the retention and discard fleet time blocks, timing of blocks to be at the STAT's discretion. Show the estimated curves. Compare this run to the base model and to the model run with no time blocks. Provide justification into the use of different selectivity time blocks for the landings and discards fleets for the base model.

3 - Rationale

The Panel is concerned both about the use of time blocking in selectivity functions and about the potential impact of having unaligned temporal blocks between what are essentially two versions of the same fishing fleets (retention and discard). This request will provide the ability to better understand the influence of the time blocks on the model.

3 - STAT Response

There are several reasons that prevent use of identical time blocks for all fleets and associated discards. The STAT maximized similarity in time blocking by increasing the number of time blocks for the trawl (TWL), hook-and-line (HKL), and pot fleets to more closely match the finer scale time blocks for discards. This involved separating the 2002-2024 TWL fleet time block into 2002-2010, 2011-2018, and 2019-2024 blocks (Table 3A). This also involved removing the 2019-2024 time block for HKL discards and separating the 2002-2024 time block for HKL and Pot fleets into 2002-2010 and 2011-2024 time blocks (Table 3B). Time blocking (pre-STAR base model, revised time blocks as shown in Tables 3A and 3B, and no time blocks) had negligible effects on summary biomass and fraction unfished (Fig. 3A) as well as recruitment deviations (Fig. 3B). Selectivities for the various time blocks were provided (Fig. 3C). A comparison of the negative log-likelihoods between the pre-STAR base model and the model with no selectivity time blocks and consistent selectivity time blocks, pre- and post-data weighted, are shown in Table 3C.

The time blocks assumed in the pre-STAR base model were selected based upon the following justifications. The trawl, hook-and-line, and pot gears had time blocks between 1890–2001 and 2002–2024 to account for the implementation of the RCAs that eliminated fishing in select depth ranges across the coast. It is important to note that many RCAs were opened for groundfish fishing in 2024, but with only one year of data, an additional time block starting in 2024 was not included in the base model. Future updates to this model should explore adding a time block starting in 2024 to determine if there were changes in selectivity arising from the opening of RCAs. The trawl and hook-and-line discard fleets assumed three time blocks: 1890–2010, 2011–2018, and 2019–2024 to account for implementation of the IFQ system in 2011 and the change by management to credit quota accounts in the IFQ fishery for discarded sablefish that were assumed to have survived based upon discard mortality rates which led to changes in discarding practices. The pot discard fleet assumed two time blocks: 1890–2010 and 2011–2024, with early model development determining that an additional block for 2019–2024 had little to no impact on the model fits to the age data for this fleet.

The selectivity blocking in the pre-STAR base model was simplified considerably compared to the blocking assumed in the 2019 assessment which had the following blocks by gear type: fixed gear length-based retention: 1890-1941, 1942-1946, 1947-1996, 1997-2010, 2011-2018, and 2019+; trawl length-based retention: 1890-1941, 1942-1946, 1947-1981, 1982-2010, 2011-2018, and 2019+; fixed gear selectivity: 1890-1996, 1997-2002, 2003-2010, and 2011+; and trawl selectivity: 1982-2002, 2003-2010, and 2011+.

Overall, the pre-STAR base model balances the trade-off between fits to the age data by fleet, model parameters, and applying time blocks where management action may have been expected to change fishing behaviour (e.g., discarding, fishing areas).

Table 3A. Modified selectivity time blocks for the trawl (TWL) and trawl discard fleets to maximize similarity between the two given the available age data.

Fleet	Block 1	Block 2	Block 3	Block 4
TWL	1890-2001	2002-2010	2011-2018	2019-2024
TWL Discards	1890-2010		2011-2018	2019-2024

Table 3B. Modified selectivity time blocks for the hook-and-line (HKL), pot, hook-and-line discard, and pot discard fleets to maximize similarity between given the available age data.

Fleet	Block 1	Block 2	Block 3
HKL-Pot	1890-2001	2002-2010	2011-2024
HKL Discards	1890-2010		2011-2024
Pot Discards	1890-2010		2011-2024

Table 3C. A comparison of likelihood components and total model parameters across model runs that “align” or remove selectivity blocks compared to the pre-STAR base model. Model versions that were not reweighted are directly comparable to the pre-STAR base model.

	Same Data Weights				Model-Specific Data Weights	
Model Metric	pre-STAR Base Model	No Selectivity Blocks	Selectivity Blocks Consistent		No Selectivity Blocks	Selectivity Blocks Consistent
Total Parameters	99	94	104		94	104
Total Likelihood (NLL)	1335.77	1412.62	1353.23		1278.97	1328.79
Survey	-43.51	-37.82	-41.59		-41.55	-41.97
Age Comp	1341.49	1412.86	1357.14		1283.06	1333.08
Recruitment	37.52	37.38	37.45		37.26	37.45
Priors	0.20	0.11	0.15		0.12	0.15

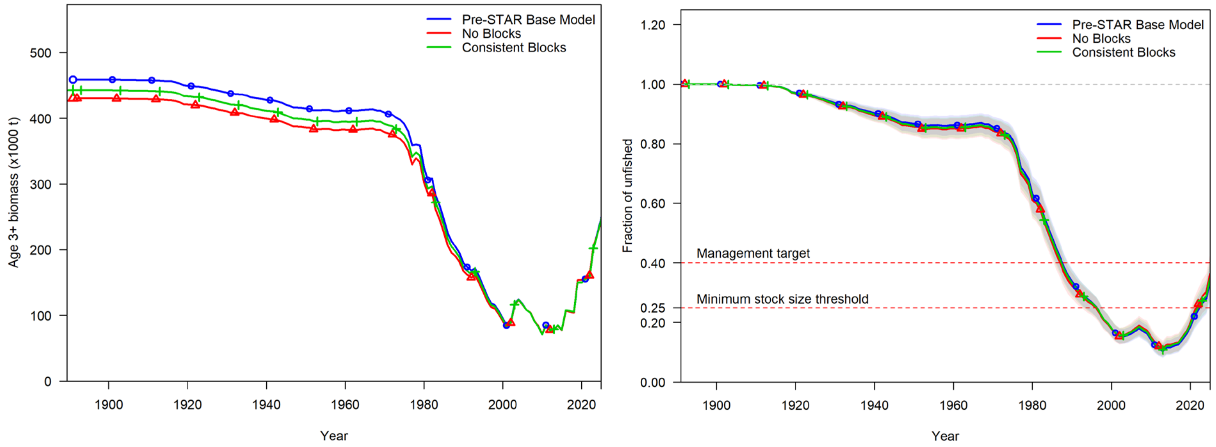


Figure 3A. Population trajectories for the pre-STAR base model, a run with no time blocks, and a run with more consistent blocks between the retention and discard fleet for each gear type (based on Table 3A and Table 3B).

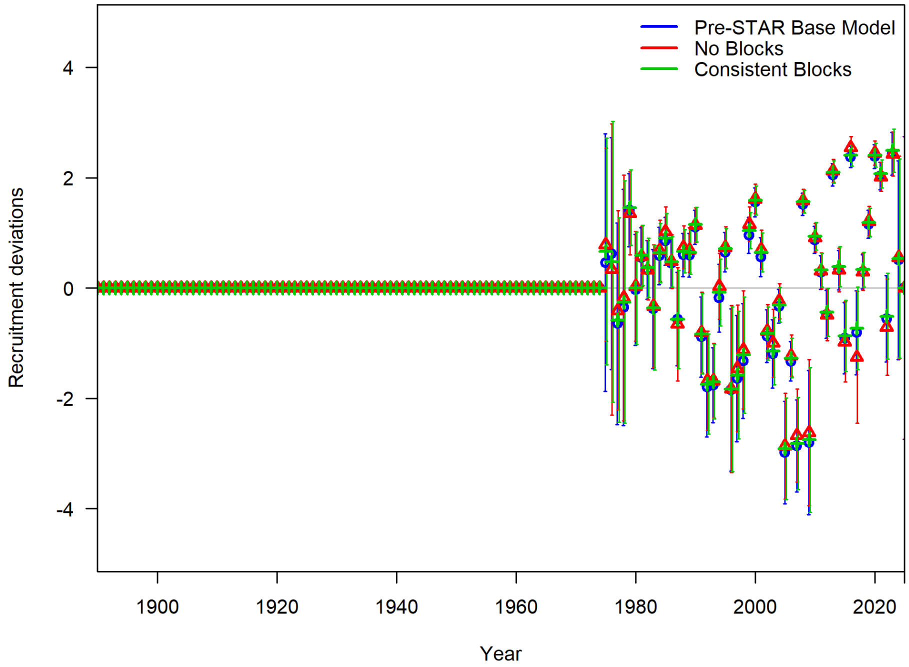


Figure 3B. Recruitment deviations for the pre-STAR base model, a run with no time blocks, and a run with more consistent blocks between the retention and discard fleet for each gear type (based on Table 3A and Table 3B).

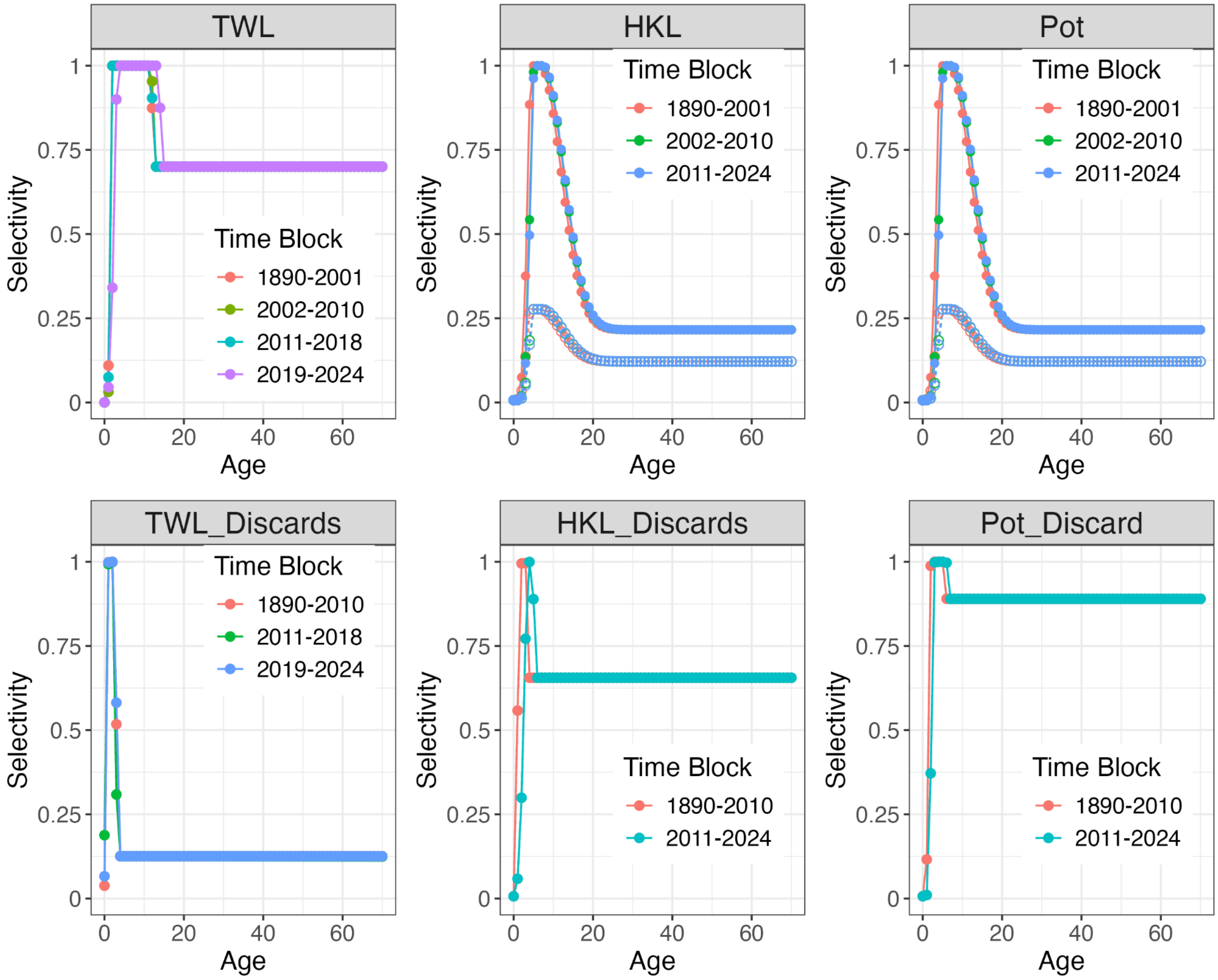


Figure 3C. Selectivities for the trawl (TWL), hook-and-line (HKL), and pot fleets and discards using modified time blocks to maximize similarity among them.

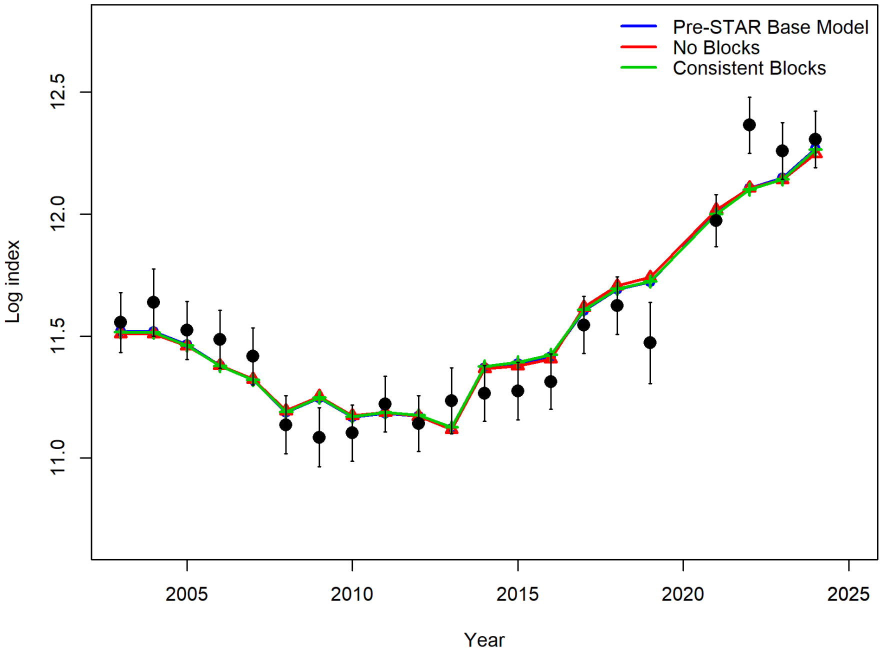


Figure 3D. Fit to the WCGBTS between the pre-STAR base model, the model with no selectivity time blocks, and the model with consistent selectivity time blocks.

3 - Panel Conclusion: Selectivity blocks do not seem to have a substantive influence on the model results. It might be worth thinking about other causes of shifting selectivity patterns, such as gear type shifts, spatial shifts in the fishery removals or environmental changes. The panel noted that the fit to the data actually degraded with the addition of more parameters, although the blocks were not "nested" so this is not a concern. There may be benefits to providing more evaluations or developing additional guidance regarding time blocking for selectivity.

4 - Request

Run a sensitivity with the effective sample sizes of the age composition data reduced by 90%. Show population trajectories and fits to age data and abundance indices, including Pearson residuals, where informative. Tables of effective sample sizes please.

4 - Rationale

A test of whether the large amount of age data are overweighted in the model.

4 - STAT Response

The age composition data weights that were applied to effective sample sizes for each model are shown in Table 4A. Reducing the ability of the model to fit the age data resulted in an overall change in population scale (increase) and stock status (decrease) relative to the base model (Fig. 4A). This is primarily due to the model being forced to fit the index data (Fig. 4B) in lieu of age data. In the base model, the age data is the main source of information on R_0, as seen in Fig. 117

in the pre-STAR assessment document. Thus, removing the age data considerably increases the uncertainty in population scale (Fig. 4A). Model fits to mean age data and residual patterns in the age composition data are similar between models (Fig. 4C and Fig. 4D, respectively). The change in total residual scale is an artifact of using Pearson residuals because the difference between observed and predicted values is scaled by the standard deviation, which is artificially increased for age composition data with lower assumed effective sample sizes. A sensitivity run comparing using the McAllister-Ianelli harmonic mean method of data weighting is compared to the base model Francis data weighting method in the pre-STAR assessment document (Table 33; Figs. 114-116). There was only a minor effect on population scale as a result of the method chosen to data weight (estimates of stock status were largely unaffected).

Table 4A. Francis data weight multipliers for the base model compared to the sensitivity model that artificially downweighted the effective samples sizes of all age data by 90%. The McAllister-Ianelli harmonic mean data weights sensitivity model presented in the assessment document are also shown for comparison.

Age Data Source	Base Weight (Francis)	Request Run (Artificial Down Weight Francis)	Sensitivity Run (McAllister-Ianelli Weight)
Trawl fleet	0.194052	0.0194052	0.046378
Hook-line fleet	0.318849	0.0318849	0.374517
Pot fleet	0.125632	0.0125632	0.515728
Trawl discard fleet	0.329077	0.0329077	0.066641
Hook-line discard fleet	0.070836	0.0070836	0.140204
Pot discard fleet	0.077003	0.0077003	0.142103
Triennial Early	1.0	0.10	0.972515
Triennial Late	1.0	0.10	0.206457
NWFSC Slope	0.123101	0.0123101	0.286831
WCGBTS	0.053476	0.0053476	0.005456

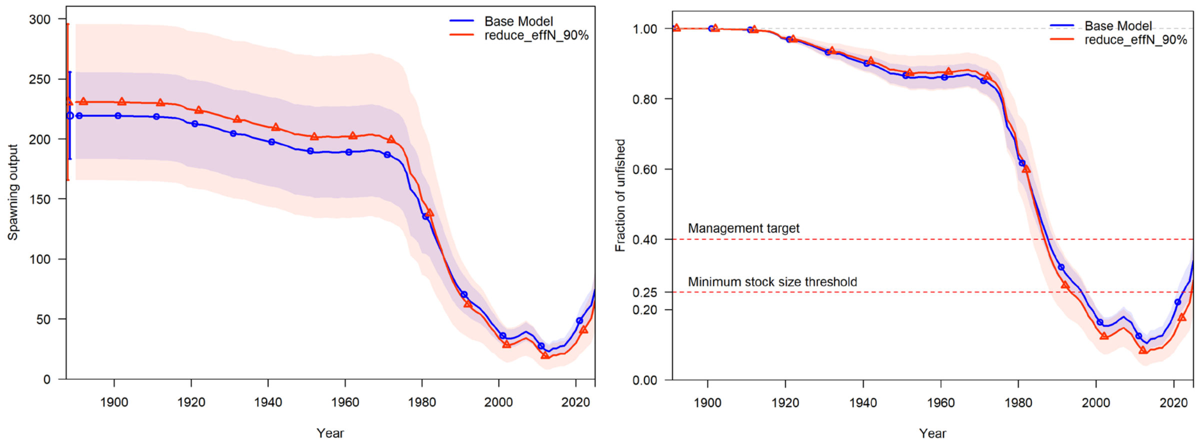


Figure 4A. Population trajectories for the pre-STAR base model and runs with all age data artificially downweighted (effective sample sizes reduced by 90%).

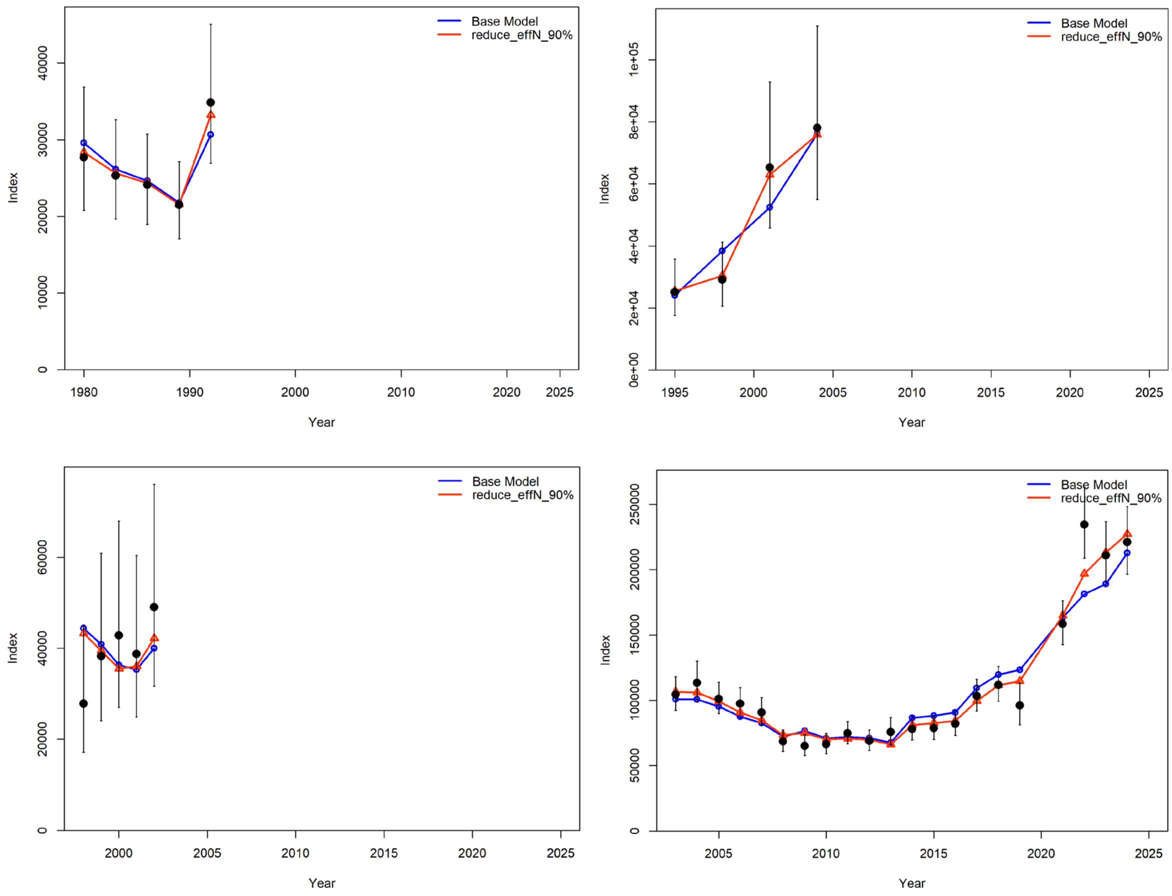


Figure 4B. Model fits to the survey indices (top left: Triennial_Early; top right: Triennial_Late; bottom left: NWFSC_Slope; bottom right: WCGBTS).

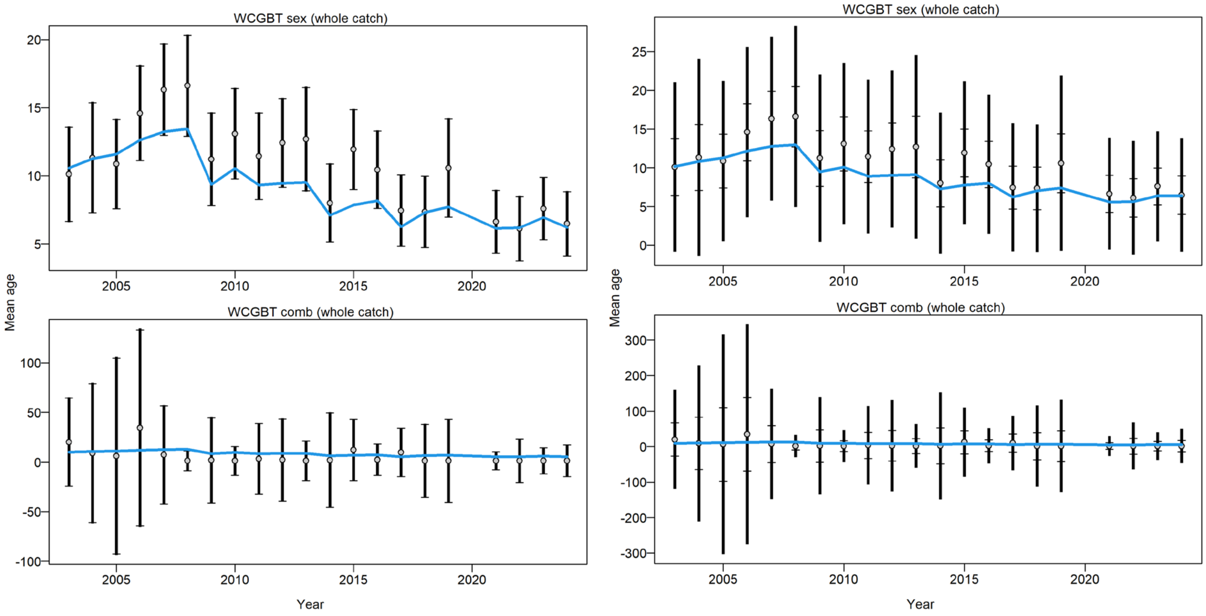


Figure 4C. Model fits to WCGBTS mean ages (left: pre-STAR base model; right: sensitivity run).

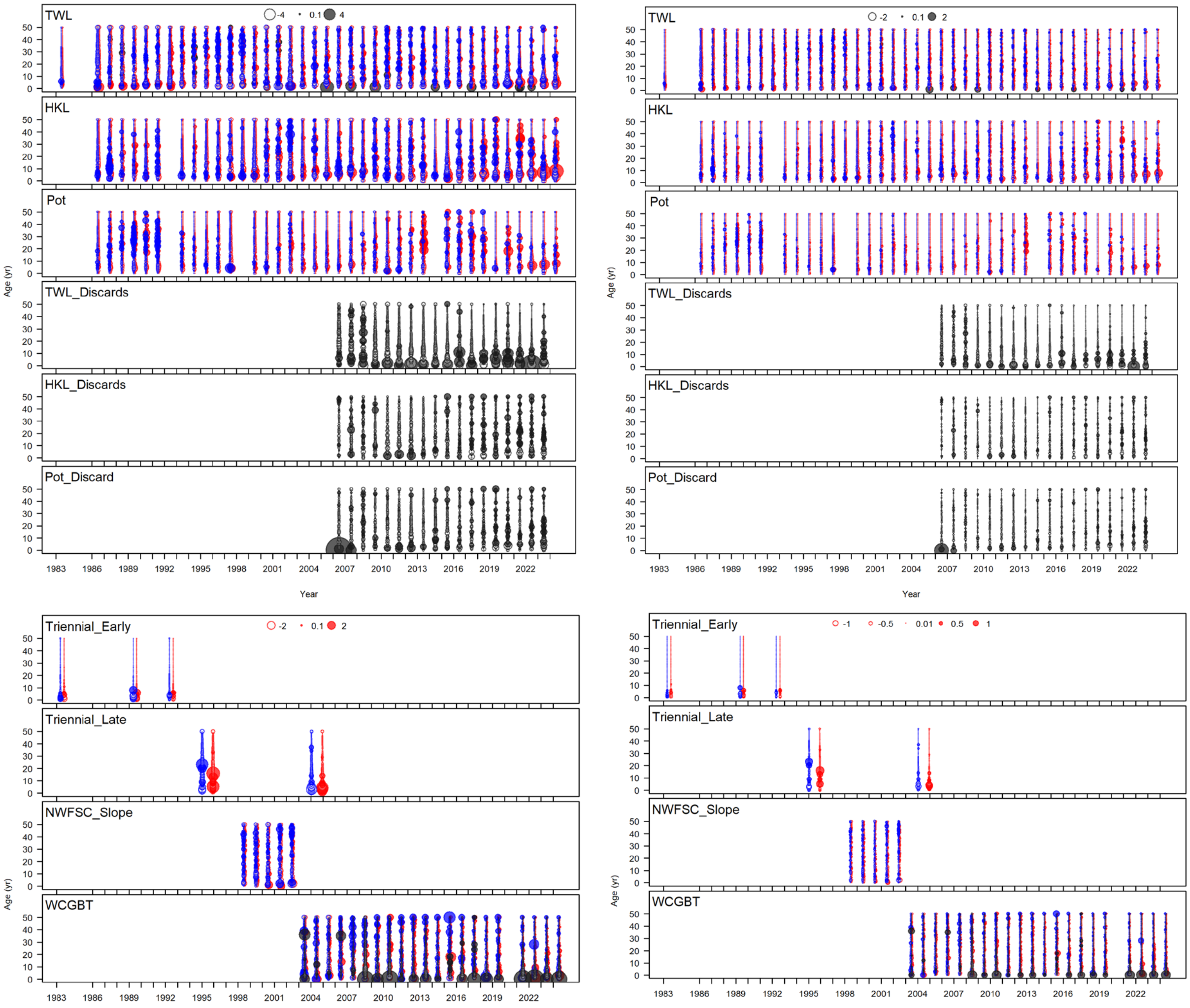


Figure 4D. Pearson residuals (left: pre-STAR base model; right: sensitivity run).

4 - Panel Conclusion

The age data are fairly important in the model, spawning output scales up and the model is slightly more pessimistic with the ages downweighted. Fits to the survey data are improved, particularly the last three years of the WCGBTS, not all of which were well fit. However, the overall uncertainty is considerably greater. The Panel is concerned that the age data may be overweighted in the base model, but recognizes that even a large arbitrary change in weighting resulted in only a moderate change to the model result. The Panel does not recommend additional changes to the weighting of the base model, but does recommend that there be continued exploration and consideration of alternative weighting approaches.

5 - Request

Run a sensitivity using an alternative catch history with catches prior to about 1970 increased by 50% pro rata by gears (STAR to define the most appropriate year). Showing population trajectories and fits to abundance indices.

5 - Rationale

There is some uncertainty in the early catch history, with the potential for higher catches being made than supported by the current data.

5 - STAT Response

Catches for fleets prior to 1969 (TWL, HKL, TWL Discards, HKL Discards) were artificially increased by 50% (Fig. 5A). Overall, population scale and status were not sensitive to this change (Fig. 5B). The effect of increasing historical catches resulted in a slightly more rapid decline in the population from about 1920 to 1980 compared to the base model. After 1980, the dynamics of the population were estimated to be similar across both models. Increasing historical catches had no influence on the fit to any of the survey indices (Fig. 5C).

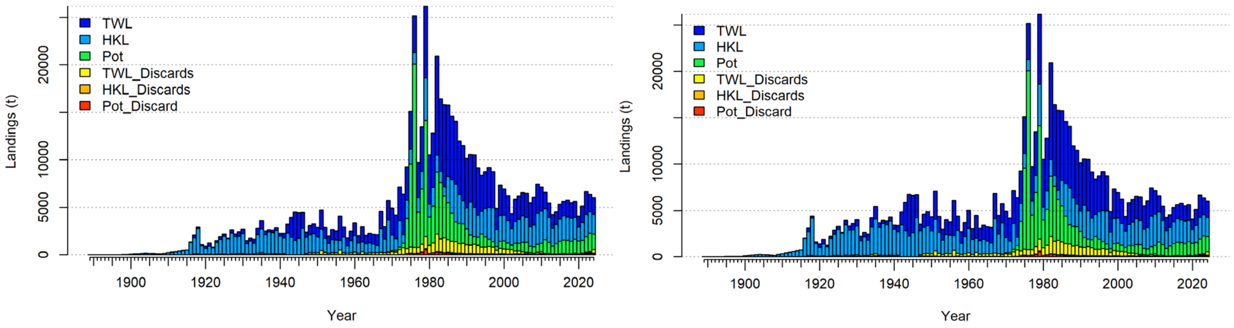


Figure 5A. Catch history used in the base model (left) and the model with the catch history artificially increased by 50% prior to 1969 (right).

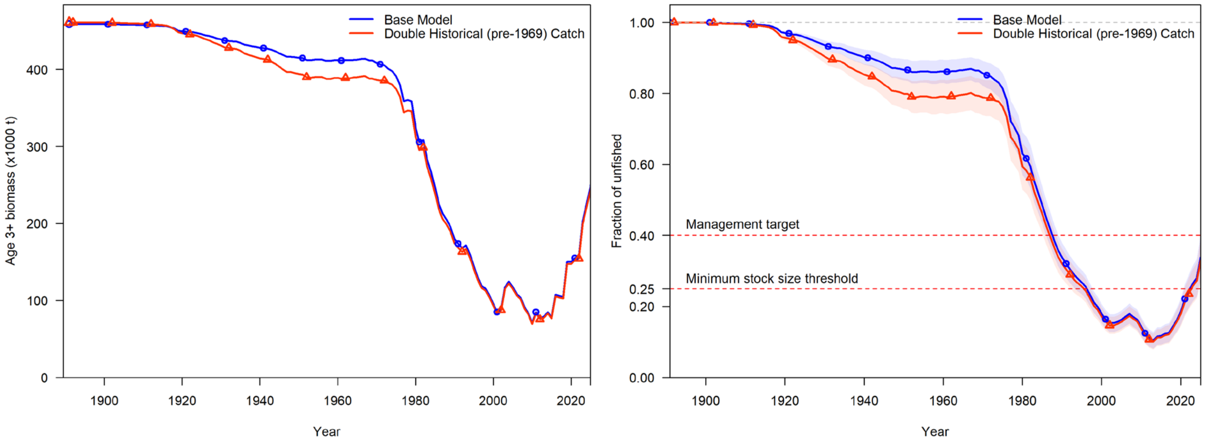


Figure 5B. Summary biomass (left) and fraction unfished (right) for the pre-STAR base model and a run with an alternative catch history increased by 50% prior to 1969.

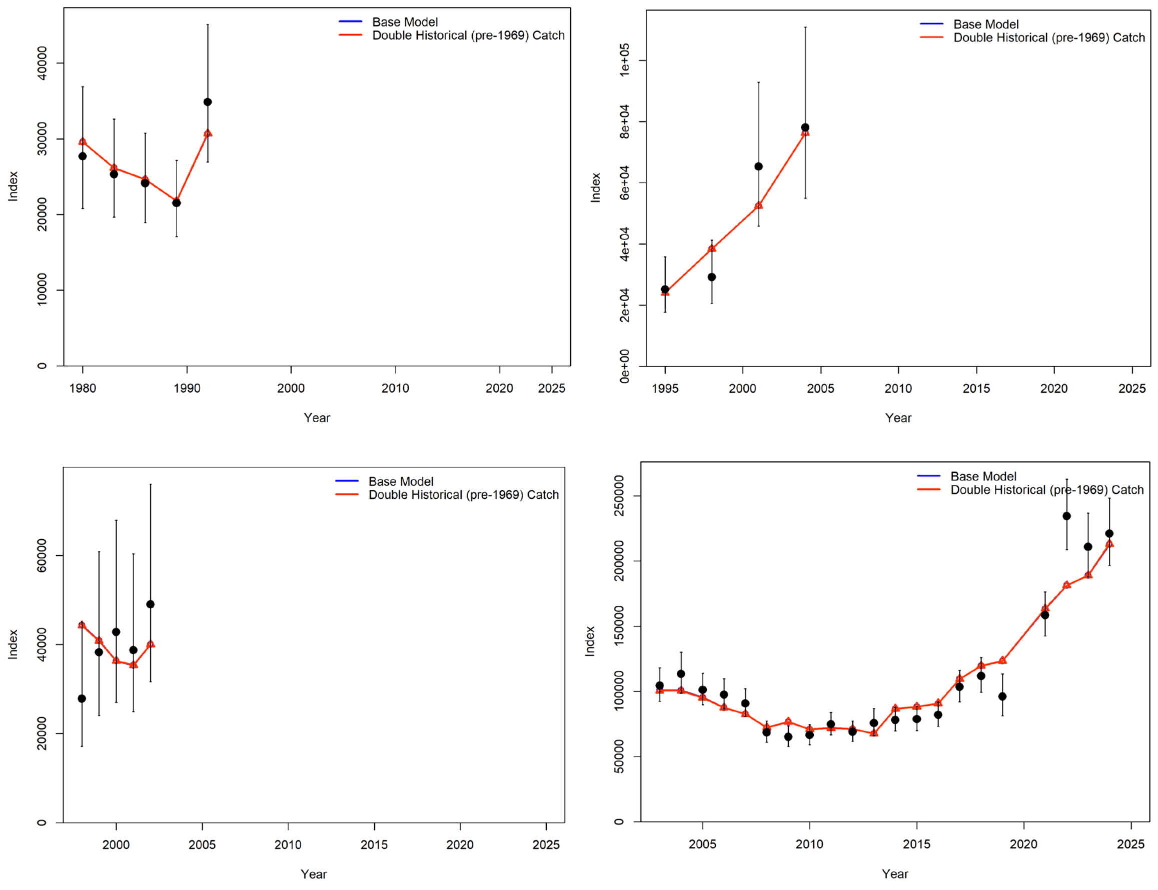


Figure 5C. Model fits to the survey indices (top left: Triennial_Early; top right: Triennial_Late; bottom left: NWFSC_Slope; bottom right: WCGBTS). Note that fits for both models shown are on top of each other.

5 - Panel Conclusion

Results indicated that any difference in model trajectory associated with changes in the estimated historical catch was limited to the early time period, with no discernible change in unfished spawning output or more recent stock trajectories. Both this and the discard mortality requests indicate that the unfished stock size (and spawning output) are relatively insensitive to changes in historical mortality assumptions.

6 - Request

Plot commercial fishery age frequency distribution data with and without the data that were added to the current assessment but not included in the 2019 assessment. Summarize these using whichever fishery and year combinations makes the most sense to the STAT.

6 - Rationale

The model is fairly sensitive to the addition of these data, it would be helpful to understand the extent to which this may be a consequence of a shift in the estimated age structure relative to just an increase in effective sample size.

6 - STAT Response

Recovered ages (i.e., ages without an ageing method assigned and samples that were collected as part of a special project) were sourced from all three commercial fleets (TWL: trawl, HKL: hook-and-line, POT: pot) but were primarily restricted to Oregon in the 1980s and 1990s (Fig. 6A). Age distributions did not differ when including data that were filtered out during the previous assessment Fig. 6B).

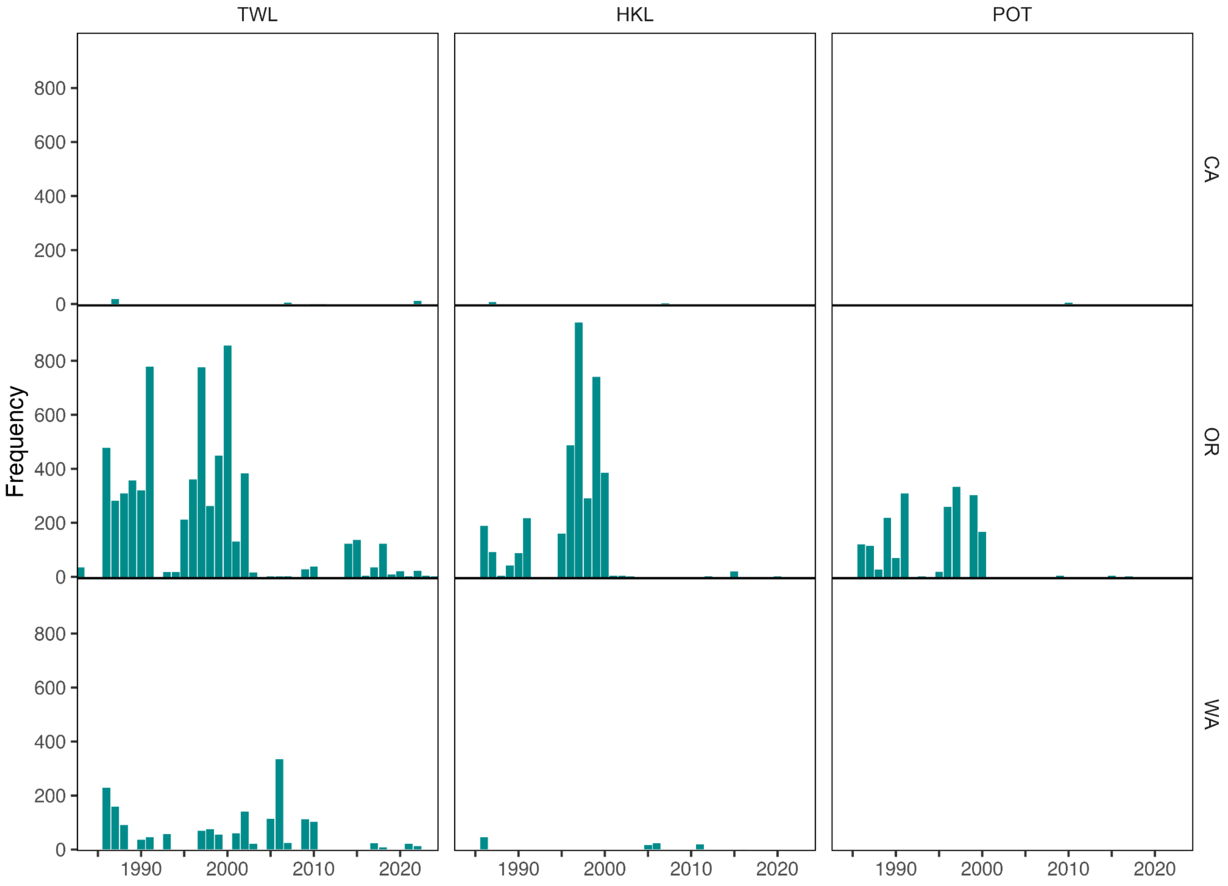


Figure 6A. Frequency distribution of recovered ages (i.e., those that were previously removed because they did not have an ageing method assigned and the structures were collected as part of special projects). Frequencies are shown by gear type (TWL: trawl, HKL: hook-and-line, POT: pot) and state.

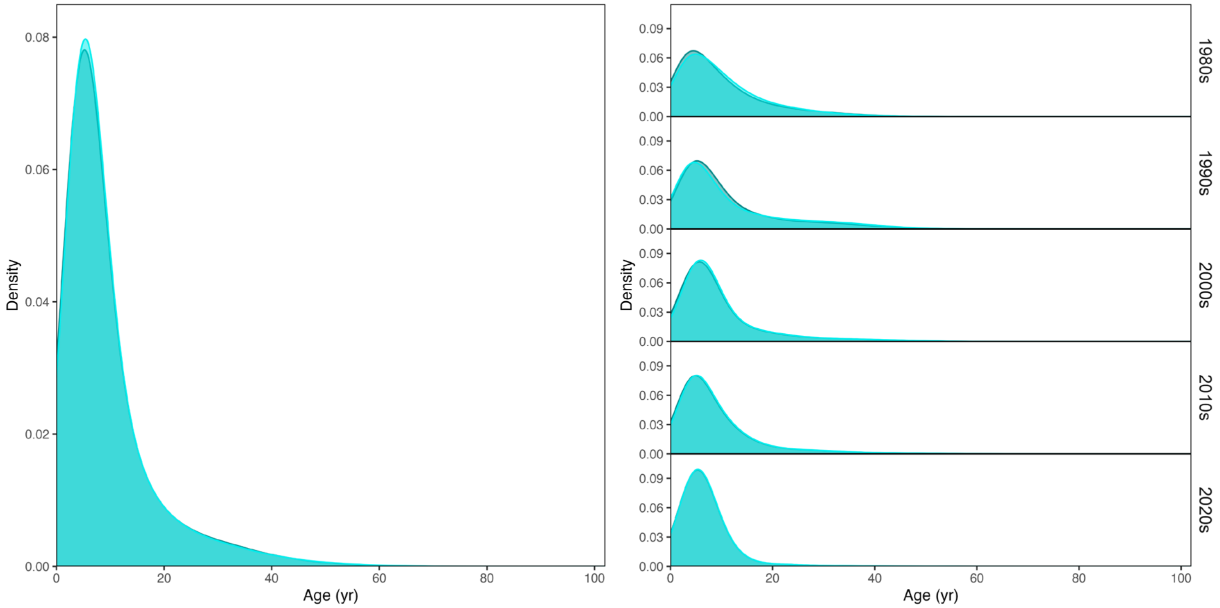


Figure 6B. Distribution of ages before (dark color) and after (light color) removing samples without an ageing method assigned and those collected as part of special projects. Age distributions are shown for the entire time series (left) and by decade (right).

6 - Panel Conclusion

This was very helpful to confirm that the distribution of the additional ages was highly consistent with the distribution of the ages that were previously in the model. This suggests that the influence of the additional age data on the model result was primarily by increasing the sample size, rather than the data providing a different signal with respect to demographic structure. The Panel recommends that a subset of these early ages be re-aged at some point in the future to ensure that there are no previously unestimated sources of bias or error in the early age data.

7 - Request

Run the base model using overall average weight-at-age rather than year specific weight-at-age. Provide basic model comparisons and diagnostics. If there is time, share any additional results from early explorations with upcoming versions of stock synthesis that better account for time-varying dynamics in projections and reference point estimation.

7 - Rationale

To better understand the influence of variable weight-at-age and presumed density-dependent dynamics on the model result.

7 - STAT Response

Time-varying weight-at-age (as a matrix of input data) used in the pre-STAR base model was replaced with a time-invariant vector of weight-at-age (averaged across all years; Fig. 7A). This restriction on sablefish growth across the time series resulted in small modifications to overall stock size and status (Fig. 7B). This suggests that time-varying weight-at-age is a useful refinement for an important biological process but that refinement does not have a large directional impact on sablefish dynamics because variability in growth is not trending over time. Time-varying weight-at-age results in a slight decrease (0.4%) in equilibrium recruitment ($\ln(R_0)$) and slight increase in recruitment deviations during years with time-varying weight-at-age information (i.e., 2003 onwards; Fig. 7C). In general, fits to the late portion of the Triennial survey slightly degraded and fits to the WCGBTS index slightly improved when assuming time-invariant weight-at-age. Fits to the other surveys were effectively identical. The estimate of natural mortality increased from 0.0877 (pre-STAR base model) to 0.0890 when assuming time-invariant weight-at-age. Changes to resulting reference points (e.g., B_{MSY} and $B_{40\%}$) were minimal (~ 1%).

The pre-STAR base model, when run under the current version of Stock Synthesis (v. 3.30.23.2) and a new pre-release version (v. 3.30.24), results in identical projections of spawning output, depletion, ABC, and OFL by year (Table 7A, 7B). The pre-release model (v. 3.30.24) fixes shortcomings in the calculation of equilibrium reference points that influence reference point outputs in certain situations due to the factors identified in Miller and Brooks (2021) when you have a model with time-varying biology. The pre-release version now provides consistency between these two calculations. The pre-release version can be found online.

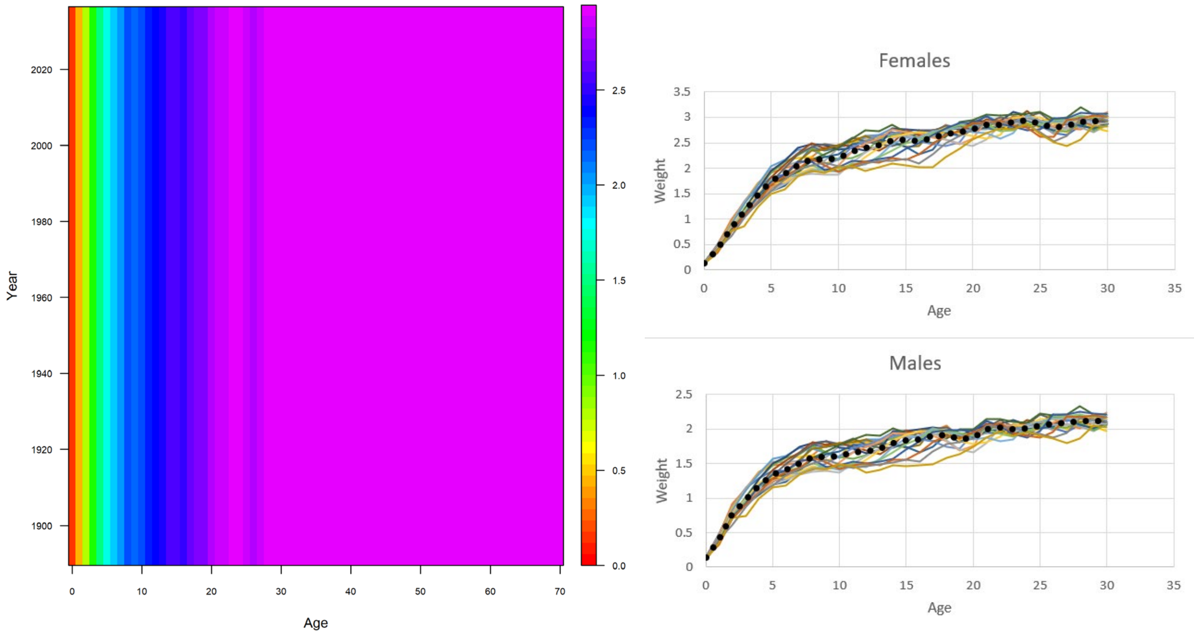


Figure 7A. Time-invariant weight-at-age values used in the sensitivity run (left: females only). Time series of time-varying weight-at-age used in the pre-STAR base model (colored lines) and time-invariant weight-at-age (overall mean; dotted line) are also shown (right; 2003-2024).

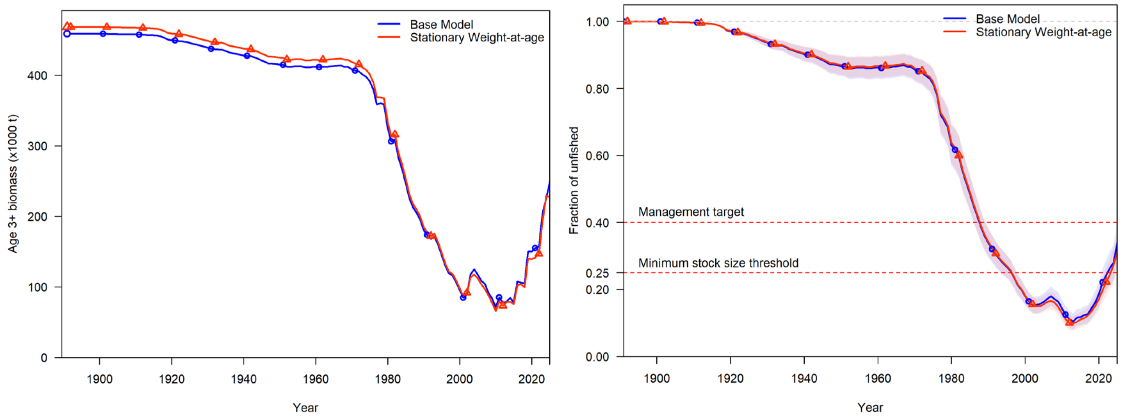


Figure 7B. Comparisons of summary biomass (left) and stock status (right) trajectories between the base model (time-varying weight-at-age) and the model that uses a single vector for weight-at-age across all years (time invariant weight-at-age).

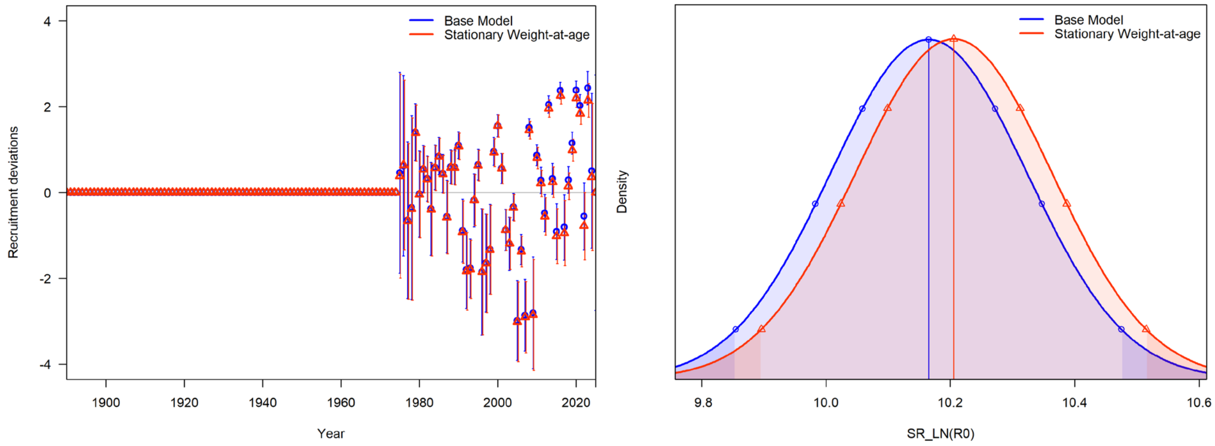


Figure 7C. Comparisons of recruitment deviations (left) and ln(R_0) (right) estimates between the base model (using time-varying weight-at-age data) and the model that uses a single vector for weight-at-age across all years (using time invariant weight-at-age data).

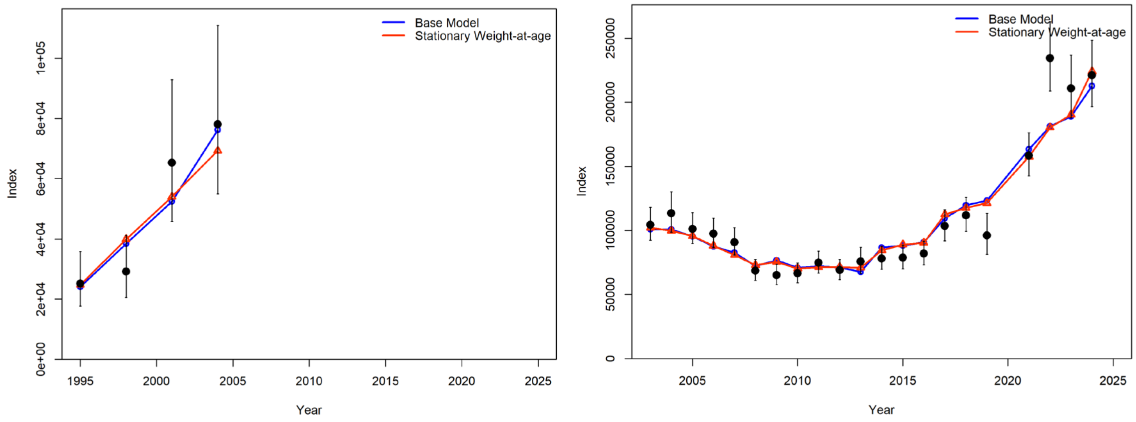


Figure 7D. Comparisons of fits to the Triennial Late survey (left) and the WCGBTS (right) between the base model (using time-varying weight-at-age data) and the model that uses a single vector for weight-at-age across all years (using time invariant weight-at-age data). Fits to the other surveys (not shown) were effectively identical.

7 - Panel Conclusion

This was an informative sensitivity. In general, the small observed changes are broadly in line with expectations, including the slightly improved fit to the last survey index point for the WCGBTS. The panel recommended no change to base model with respect to the implementation of weight-at-age.

8 - Request

Run the pre-STAR base model with an imposed bias on the ageing error matrix, one run in which ages are underestimated by 25%, and another in which ages are overestimated by 25%. Provide model results and diagnostics, including resulting estimates of natural mortality, for each run. If the STAT has additional sensitivities that would be insightful, please include them.

8 - Rationale

There have been discussions about the lack of robust age validation and extent to which large, older fish in deep water may have greater ageing error than currently estimated. Combining ageing error with natural mortality uncertainty may also be helpful in developing a decision table in future requests.

8 - STAT Response

A positive bias for ageing (i.e., overestimating ages by 25%) results in decreased spawning output and similar fraction unfished relative to the pre-STAR base model (Fig. 8A). A negative bias for ageing (i.e., underestimating ages by 25%) results in slightly higher spawning output and fraction unfished relative to the pre-STAR base model (Fig. 8A). A range of ageing biases (± 10% to ± 25%) were also explored (Fig. 8B). Positive ageing bias tends to increase internal estimates of *M* (*M* = 0.106), whereas negative ageing bias tends to decrease internal estimates of *M* (*M* = 0.062) relative to the pre-STAR base model (*M* = 0.088; Table 8A). The potential decision table reflects a greater difference in spawning output between low and high states of nature and relatively similar estimates of depletion among all states of nature (Table 8B).

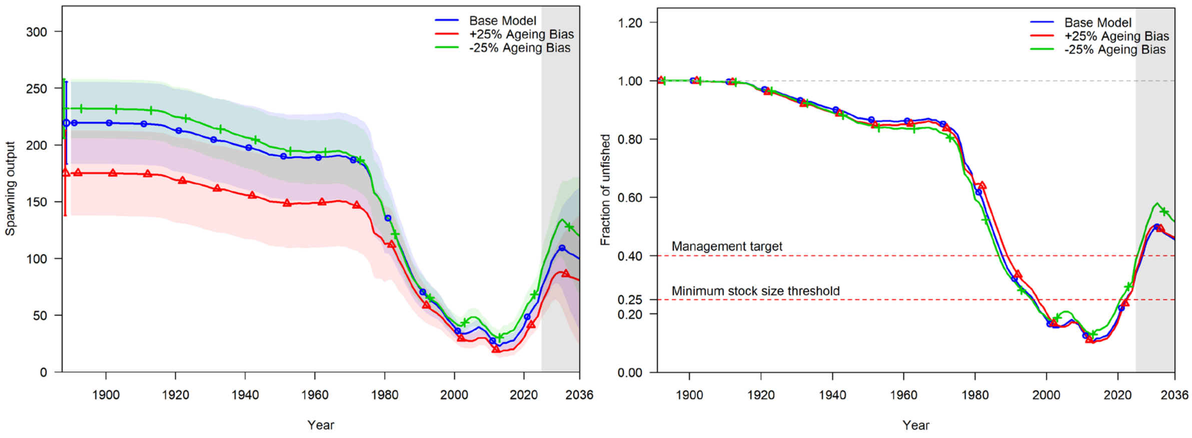


Figure 8A. Estimates of spawning biomass (left) and fraction of unfished (right) between the pre-STAR base model and the sensitivities runs that assume +25% ageing bias (e.g., older true ages than estimated) and -25% ageing bias (e.g., younger true ages than estimated).

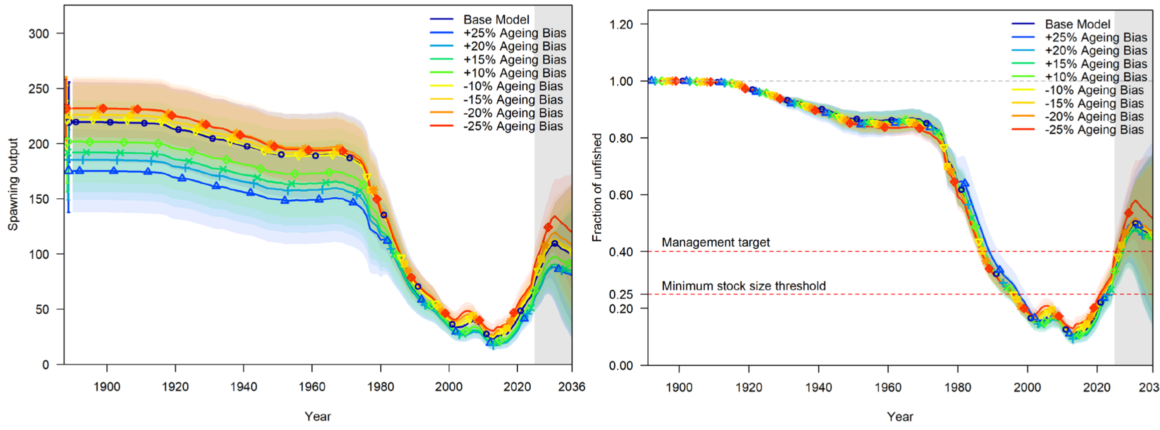
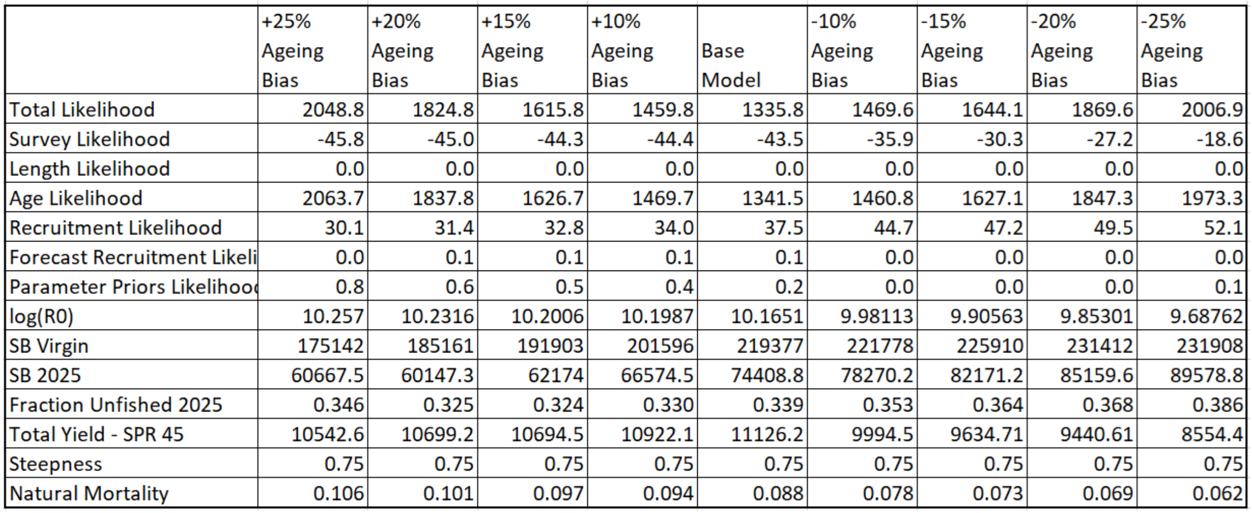


Figure 8B. Estimates of spawning biomass (left) and fraction of unfished (right) for the pre-STAR base model and sensitivity runs that assume a range of ageing error biases.

Year	Catch	Low_SO	Low_depl	SO	Depl	High_SO	High_depl
2025	19114	60668	0.35	74409	0.34	89579	0.39
2026	19082	66681	0.38	80877	0.37	98096	0.42
2027	13965	73614	0.42	88838	0.4	106143	0.46
2028	15103	82271	0.47	98185	0.45	115139	0.5
2029	14720	86799	0.5	103869	0.47	121011	0.52
2030	14095	88076	0.5	107603	0.49	127235	0.55
2031	13437	87667	0.5	109277	0.5	129942	0.56
2032	12755	85083	0.49	107167	0.49	126370	0.54
2033	12172	82094	0.47	104575	0.48	122914	0.53
2034	11749	80236	0.46	103162	0.47	120513	0.52
2035	11274	78430	0.45	101283	0.46	116705	0.5
2036	10918	76804	0.44	99821	0.46	114256	0.49

Table 8A. Model estimates across a range (± 10% to ± 25%) of ageing bias.



	+25% Ageing Bias	+20% Ageing Bias	+15% Ageing Bias	+10% Ageing Bias	Base Model	-10% Ageing Bias	-15% Ageing Bias	-20% Ageing Bias	-25% Ageing Bias
Total Likelihood	2048.8	1824.8	1615.8	1459.8	1335.8	1469.6	1644.1	1869.6	2006.9
Survey Likelihood	-45.8	-45.0	-44.3	-44.4	-43.5	-35.9	-30.3	-27.2	-18.6
Length Likelihood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Age Likelihood	2063.7	1837.8	1626.7	1469.7	1341.5	1460.8	1627.1	1847.3	1973.3
Recruitment Likelihood	30.1	31.4	32.8	34.0	37.5	44.7	47.2	49.5	52.1
Forecast Recruitment Likeli	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Parameter Priors Likelihooc	0.8	0.6	0.5	0.4	0.2	0.0	0.0	0.0	0.1
log(R0)	10.257	10.2316	10.2006	10.1987	10.1651	9.98113	9.90563	9.85301	9.68762
SB Virgin	175142	185161	191903	201596	219377	221778	225910	231412	231908
SB 2025	60667.5	60147.3	62174	66574.5	74408.8	78270.2	82171.2	85159.6	89578.8
Fraction Unfished 2025	0.346	0.325	0.324	0.330	0.339	0.353	0.364	0.368	0.386
Total Yield - SPR 45	10542.6	10699.2	10694.5	10922.1	11126.2	9994.5	9634.71	9440.61	8554.4
Steepness	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Natural Mortality	0.106	0.101	0.097	0.094	0.088	0.078	0.073	0.069	0.062

Table 8B. Potential decision table projections using ± 25% ageing bias with an assumed sigma of 0.5 and P* of 0.45. SO: spawning output; depl: fraction unfished.

8 - Panel Conclusion

The Panel found these to be informative runs. Positive changes (overestimation of true ages) led to a small decrease in spawning output, an increase in the estimated natural mortality rate, but generally unchanged status. Underestimating true ages (negative ageing bias) led to a lower estimated natural mortality rate, a relative modest increase in the scale of spawning output and a modest increase in status that was projected to be greater in the projection period. These were helpful diagnostics for considering a state of nature table. The Panel expressed some concerns about whether the '*M*+emigration' option is really plausible.

Base and 2019 *M* values gave similar outcomes (2019 *M* gave slightly lower biomass). 'M+emigration' gives much larger biomass but broadly similar stock status and continues to increase in projections.

9 - Request

Provide alternative models of states of nature, using natural mortality, *M*, as the main axis of uncertainty. Please use the 12.5% and 87.5% quantiles, or higher if justified, of the likelihood profile of natural mortality. Add additional alternatives to the states of nature as the STAT deems appropriate.

9 - Rationale

To continue to explore alternative decision table structures

9 - STAT Response

Two sets of candidate states of nature were developed for consideration as the basis for the 2025 sablefish assessment decision table. Both candidates are based on deterministic evaluations of the base model (i.e., fix all parameters at the values from the base model except for specific values to create an alternative state), (A) one with alternative fixed natural mortality values (Fig. 9A) and (B) one with alternative recent recruitment deviations from 2016-2023 (Fig. 9B). The potential decision table assuming a sigma of 0.50 and a P* of 0.45 are provided (Table 9A and Table 9B). Overall, the STAT thinks using the alternative values of M in this deterministic manner is the most straightforward manner to create alternative states of nature that would be most informative to management for decision making.

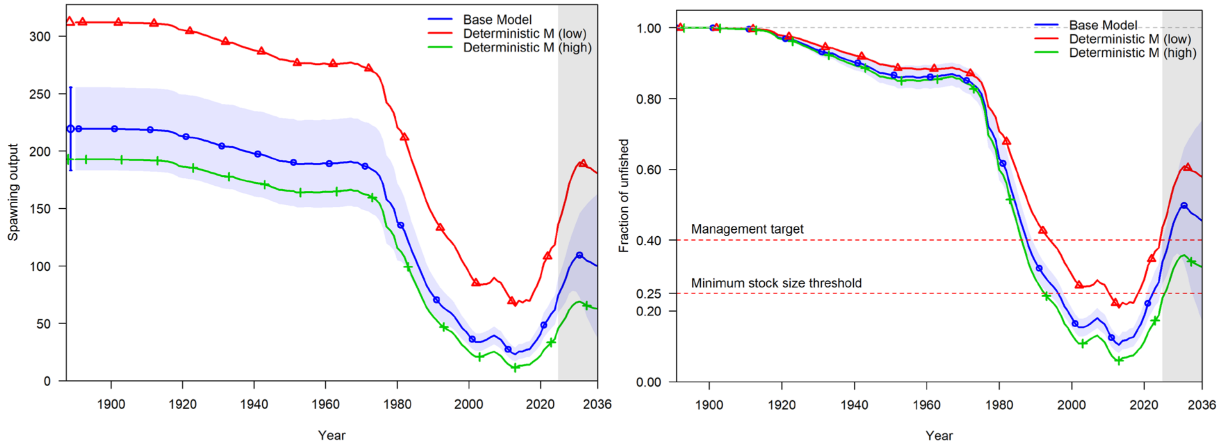


Figure 9A. Spawning stock size (left) and fraction unfished (right) for candidate (A) alternative states of nature based on deterministic model evaluations of the base model with natural mortality fixed at 0.0700 (high state) and 0.0950 (low state). The base model estimates natural mortality at 0.0878.

Table 9A. Candidate decision table when using natural mortality as the basis for alternative states of nature (A).

		Low		Base		High	
Year	Catch	SO	Depletion	SO	Depletion	SO	Depletion
2025	19,114	45,746	0.24	74,409	0.34	136,165	0.44
2026	19,082	49,979	0.26	80,877	0.37	145,453	0.47
2027	13,965	54,904	0.28	88,838	0.40	157,818	0.51
2028	15,103	61,586	0.32	98,185	0.45	171,209	0.55
2029	14,720	65,692	0.34	103,869	0.47	179,879	0.58
2030	14,095	68,210	0.35	107,603	0.49	186,364	0.60
2031	13,437	69,067	0.36	109,277	0.50	190,326	0.61
2032	12,755	67,342	0.35	107,167	0.49	188,697	0.60
2033	12,172	65,405	0.34	104,575	0.48	186,051	0.60
2034	11,749	64,381	0.33	103,162	0.47	185,006	0.59
2035	11,274	63,290	0.33	101,283	0.46	182,588	0.58
2036	10,918	62,613	0.32	99,821	0.46	180,530	0.58

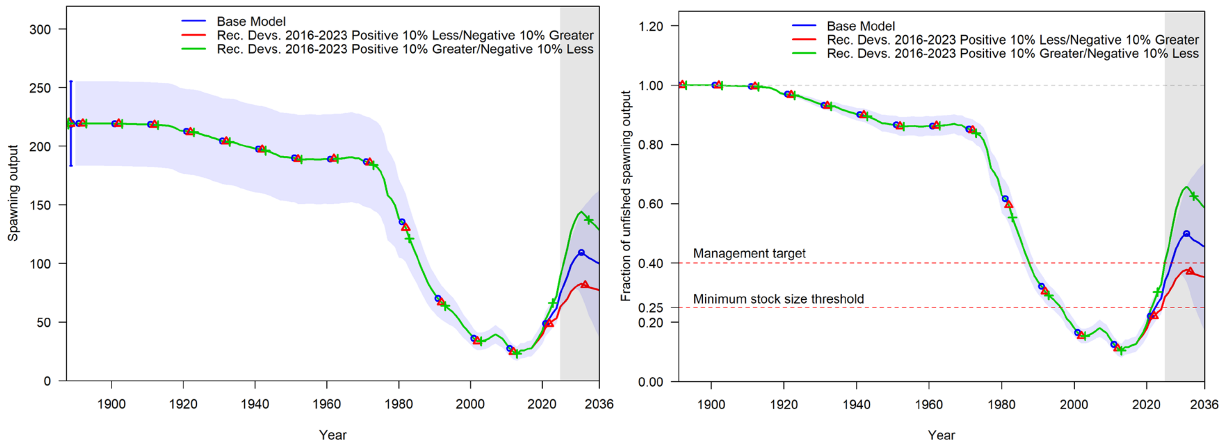


Figure 9B. Spawning stock size (left) and fraction unfished (right) for candidate (B) alternative states of nature based on deterministic model evaluations of the pre-STAR base model with alternative assumptions about recruitment deviations from 2016-2023.

Table 9B. Candidate decision table when using recent recruitment deviations as the basis for alternative states of nature (B).

		Lower		Base		High	
Year	Catch	SO	Depletion	SO	Depletion	SO	Depletion
2025	19,114	62,881	0.287	74,409	0.339	89,012	0.406
2026	19,082	65,987	0.301	80,877	0.369	99,771	0.455
2027	13,965	70,019	0.319	88,838	0.405	112,857	0.514
2028	15,103	75,793	0.345	98,185	0.448	126,977	0.579
2029	14,720	79,241	0.361	103,869	0.473	135,905	0.620
2030	14,095	81,581	0.372	107,603	0.490	141,776	0.646
2031	13,437	82,703	0.377	109,277	0.498	144,315	0.658
2032	12,755	81,379	0.371	107,167	0.489	141,088	0.643
2033	12,172	79,672	0.363	104,575	0.477	137,135	0.625
2034	11,749	78,840	0.359	103,162	0.470	134,712	0.614
2035	11,274	77,829	0.355	101,283	0.462	131,343	0.599
2036	10,918	77,188	0.352	99,821	0.455	128,470	0.586

9 - Panel Conclusion

The panel agreed with the STAT that natural mortality as specified in these elements of the decision table represented an appropriate axis of uncertainty. The GAP and GMT representatives indicated that additional catch stream scenarios would be requested at a later date.

Following completion of the decision table, the STAT and the Panel spent some time discussing various elements of the risk table, particularly with respect to aligning key highlights appropriately among the main column headings (ecosystem and environmental conditions, assessment data inputs and assessment model fits and structural uncertainty). The STAT and the Panel also discussed and agreed on the final level assignments reported in the final assessment.