3. Assessment of the Sablefish Stock in Alaska

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November 2026

This report may be cited as:

Goethel, D.R. and Cheng, M.L.H. 2026. Assessment of the sablefish stock in Alaska. North Pacific Fishery Management Council, Anchorage, AK. Available from: https://www.npfmc.org/library/safe-reports/

The following appendices accompany this document:

Appendix 3A. The Spatial Population over Regional Components (SPoRC) Model: Technical Description of the Assessment Model for Sablefish
Appendix 3B. Model Building and Bridging Exercise for the Sablefish Single Region Models (Bridging from Model *25.12* to *26.1_1Reg*)
Appendix 3C. Development of a Fleets-as-Areas (FAA) Stock Assessment Model for Alaska Sablefish (*Model 26.2_FAA*)
Appendix 3D. Results of Spatial Stock Assessment Models for Alaska Sablefish
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Executive Summary

Summary of Changes to the Assessment

In 2024, there was an update assessment for sablefish (*Anoplopoma fimbria*) using Model *23.5*. A full assessment was scheduled for 2025 with model changes implemented (Model *25.12*), then reviewed and approved at the North Pacific Fisheries Management Council's (NPFMC) fall Groundfish Joint Plan Team (JPT) and Science and Statistical Committee (SSC) meetings. However, an operational assessment was not performed in 2025 due to the US government shutdown. An important change in Model *25.12* was the update to the natural mortality (*M*) prior (i.e., the mean value was reduced from 0.1 to 0.085), which aimed to ensure that estimates of *M* were better aligned with biological expectations. Model *23.5 M* estimates had been increasing over time and were deemed too high (~0.11) for a species that lives > 100 years. Because *M* acts as an important population scalar, the resulting Model *25.12* acceptable biological catch (ABC) was 20% less than that from Model *23.5*. For 2026, Model *25.12* is considered the continuity model, since it was the last accepted model by the SSC.

For 2026, Model *26.2_FAA*, which utilizes a spatially implicit fleets-as-areas (FAA) structure, is the author recommended model. Transition to the FAA modeling framework is the evolution of a long-term process to address the known sablefish spatial structure. In particular, the lack of a synoptic survey across the entire Alaska range of sablefish (i.e., since NOAA began operating the Longline Survey in the 1990s) presents a particularly salient problem for assessing this widely distributed species. The issue has become more pronounced since the 2025 survey redesign, because large portions of the sablefish resource (~50%) are not being surveyed each year. Single region assessments require an assumption that data inputs are representative of the entire population in the model domain. Thus, when only partially surveying the population in each year and varying the survey footprint both historically (i.e., surveying the AI in even years and the BS in odd years) and recently (i.e., surveying the GOA in odd years and the BS and AI in even years), the assessment has required a suboptimal kluge (i.e., index interpolation for non-surveyed regions) to ensure a consistent annual population scaling. The sudden change in survey design starting in 2025 made the interpolation assumption fully untenable moving forward, but it is important to emphasize that this approach was never ideal. The AFSC has long recognized that the single region model was not the best approach, which is why extensive resources have been devoted over the last decade to the development of a spatial sablefish assessment (see results from the current tag-integrated version in Appendices 3D and 3K). However, the spatial model is more complex and needs refinement before it can be used operationally.

The first step in the 2026 model development process was to update the single region model with new interpolation methods that would be feasible with the 2025 survey redesign, given that the old approach (i.e., using the annual change in the GOA indices to scale unsurveyed regions) can no longer be implemented. Thus, Model *26.1_1Reg* builds off Model *25.12* by using a new 'carryover' interpolation for the NOAA Longline Survey index, which holds index values steady at their last value when a region is not surveyed in the current year. As part of the single region model update a number of moderate refinements were also integrated to better align with assessment good practices and reduce model tension (e.g., estimating sex-specific natural mortality, *M*, removing catch-per-unit effort, CPUE, data, removing length compositions for fleets with age compositions, and updating growth and weight estimates). A full model bridging analysis and description of the final updated single region model is provided in Appendix 3B.

Next, a spatially implicit FAA model was explored to better address spatial dynamics and avoid using interpolated index data. The FAA model structure is a commonly used approach for species and fisheries with extensive spatial structure, but which lack the data or ecological knowledge to implement full spatial models. In other words, FAA models are a step towards a spatial assessment, while providing a fundamentally more robust tool for addressing underlying biological or data spatial structure. However, performance varies on a case-by-case basis and should be simulation tested before implementation (see the

summary of tradeoffs across model structures in the following table; Lee et al., 2017; Punt et al., 2017). A two stage spatially explicit simulation analysis (conditioned on the five-region spatial assessment model) was undertaken to identify whether FAA models were likely to perform better than naïve single region models under the specific spatial dynamics and survey data availability conditions extant for sablefish. First, traditional simulation cross testing was done to identify a suite of FAA models with varying parametrizations that were likely to provide robust population estimates. Next, a closed loop simulation analysis was performed to understand performance of the various model structures (i.e., single region, FAA, and three region spatial models; Appendix 3E). The simulation experiment helped guide model building, particularly the structure of the FAA model, and provided insight on expected assessment performance in terms of potential bias and stability. Simulation results clearly demonstrated that naïve single region assessments were exceedingly risk prone due to the tendency to overestimate spawning biomass, likely due to the use of interpolated data. Moreover, spatial assessments were highly unstable and sensitive to model parametrizations. Conversely, FAA models demonstrated the least assessment bias, were robust across an array of parametrization assumptions (particularly selectivity), and provided more stable estimation due to their reduced model complexity compared to full spatial assessments.

Based on the simulation results, development of the final FAA model proceeded from the parametrization of Model *26.1_1Reg* by adding incremental complexity. Ultimately, the author recommended Model *26.2_FAA* settled on a relatively parsimonious structure, which only included regional disaggregation of the NOAA longline survey into three total fleets (BS, AI, and GOA -- instead of a single aggregate fleet as in Model *26.1_1Reg*). The three-fleet structure allowed the observed indices to be fit directly without any need for interpolation and ensured that signals from regional age compositions were no longer masked by aggregation (i.e., the BS and AI signals of recruitment were not inundated by the higher sample sizes in GOA data). Each regional fleet was modeled with its own estimated selectivity function and catchability parameter, q, by fitting to regionally disaggregated indices and age composition data. Although hundreds of FAA model parametrizations were explored, many of which included domed selectivity and disaggregation of the fixed gear fishery, the added complexity of these models was not deemed necessary nor worth the instability tradeoff (i.e., given limited age composition sample sizes by region especially in the fishery data). Moreover, dome-shaped selectivity was not strongly supported by the data and the low level of BS fishery removals suggests that the shape of the selectivity function does not influence model interpretations (i.e., doming does not lead to cryptic biomass). The full model development process for the FAA models, including model runs with three fixed gear fleets, are presented in Appendix 3C.

In June 2026, a Center for Independent Experts (CIE) peer review of the sablefish assessment occurred where all aspects of the modeling approach were reviewed in a three-day meeting. The reviewers dissected Model 2*6.2_FAA* and Model *26.1_1Reg* along with numerous sensitivity runs (as highlighted in Appendices 3A – 3F, including an off cycle SAFE document that included results from both models). For the provision of sablefish management advice, the independent panel concluded that Model *26.2_FAA* was the most appropriate and scientifically defensible of the models explored (CIE reviewer reports are available in Appendices 3H – 3J and are summarized in the 2026 September JPT sablefish Report, Appendix 3G).

Thus, for 2026, the author recommended model is Model *26.2_FAA*, which uses the same assumptions and data inputs as Model *26.1_1Reg* except that the NOAA Longline Survey is disaggregated by region and no data interpolation is needed. Model *26.2_FAA* is believed to be a more robust model compared to the single region alternative because it better addresses underlying spatial structure and fits only observed (not interpolated) survey data. Moreover, the Model *26.2_FAA* structure is robust to not only the historical and current survey design, but also any future redesigns given that the survey data is fit on the regional scale.

All model files including input data files, R scripts for running the model and associated diagnostics, and all model outputs can be found at the 2026 sablefish SAFE GitHub repo (here).

- *26.2_FAA* (the author recommended FAA model; results available here)

Model Structure Tradeoffs

Model	*Benefits*	*Issues*	*Sablefish Closed Loop Simulation Conclusions*	*Tradeoffs*
Single Region Model (1Reg)	High sample sizes. Low model complexity. Intuitive and transparent results.	Requires fitting extrapolated data for the Longline Survey Index. Implicit historical over-weighting of GOA composition data during aggregation or high interannual variability recently (GOA then BS/AI). Little signal from BS/AI compositions, because GOA given higher weight (RPNs or catch) in data aggregation. Ignores spatial structure.	Moderate SSB bias due to the survey extrapolation and aggregated composition data, with high model stability.	Higher sample sizes and improved stability but requires fitting the extrapolated longline survey index and primarily represents the recruitment signals from the GOA due to data aggregation assumptions.
Fleets-as-Areas (FAA)	Only fitting observed Longline Survey index data. Fitting disaggregated survey compositions. Better accounts for signals from BS/AI compositions on recent year class strength. Implicitly accounts for ontogenetic movement dynamics	Low sample sizes and sparse data for BS/AI compositions. Increased complexity (estimating extra *q* and selectivity parameters for 'regional' survey fleets and/or extra *F* and selectivity parameters for fishery fleets). Non-intuitive estimates that are difficult to interpret (e.g., due to using multiple fleets that are interacting with a single underlying population). Selectivity needs to be flexible to address ontogenetic dynamics. High inertia towards moving away from status quo assessment methodology.	Low SSB bias with improved performance over other structures when survey is not synoptic, but adequate flexibility in selectivity parametrizations is likely needed to ensure good performance while increased complexity increases model instability.	No interpolation of longline survey indices required, but sample size limitations may prevent more complex selectivity parametrization due to model instability.
Spatial (3 or 5 Region)	Fit data at the regional scale. Better account for signals from each region. More intuitive than FAA. Explicitly account for ontogenetic movement dynamics.	Increased sample size limitations. Increased parametrization decisions related to spatial processes. Lack of best practices for fitting tagging data (e.g., dealing with tag mixing issues and data weighting). Increased parameter correlation, particularly between regional recruitment parameters and movement. Diagnostics can be difficult to interpret. Increased instability.	High instability due to overparameterization and low sample sizes but best represents localized dynamics.	Best represents spatial dynamics but suffers from high model instability due to data sparsity that requires extremely careful parametrization, while appropriate handling of tagging data is difficult and potentially subjective.

Alternative Models

For 2026, the SSC has requested that three alternative models be brought forth in addition to the author recommended Model *26.2_FAA*, including:

- Model *25.12* (the continuity model; results available here)
- *26.1_1Reg* (the updated single region model; results available here)
- *26.2_FAA_3LLF_LLS_BS_Dome_DN* (the SSC requested FAA alternative with regionally disaggregated fixed gear fishery fleets and domed selectivity in BS fleets; results available here).

Model *25.12* is described in the sablefish 2025 September JPT report and represents an update of Model *23.5*, including a transition from AD Model Builder to the RTMB based Stochastic Populations Over Regional Components (SPoRC) assessment platform (Cheng et al., 2026). Additionally, updates focused on integrating assessment good practices for likelihood and prior formulations, removing contradictory and uninformative data (i.e., length compositions when age compositions are available, the NOAA GOA Trawl Survey), and updating the prior on natural mortality to ensure estimates better align with biological knowledge. Model *26.1_1Reg* builds upon Model *25.12* as noted previously, while *26.2_FAA* disaggregates the NOAA Longline Survey (LLS) into regional fleets as described above. Finally, Model *26.2_FAA_3LLF_LLS_BS_Dome_DN* disaggregates the fixed gear fishery into regional fleets along with the LLS fleets and estimates dome-shaped selectivity in the BS fishery and survey fleets using a double normal selectivity function (see the Supplemental Material section 'SSC Requested Models' for a description of this model and analysis of results).

Additionally, the five-region spatial model is once again updated (Appendices 3D and 3K):

- *26.3_Spat_5reg* (a spatially explicit model that integrates tagging data and estimates movement among the five management regions; results available here).

Per the SAFE guidelines, this document focuses on the analytical framework, results, and outputs of the author recommended model (Model *26.2_FAA*). For full descriptions and outputs of the other models, see the documents noted above and the sablefish GitHub repo (here). The Supplemental Material to this document also includes full Executive Summary and Biologically-Informed Recommended Distribution (BRD) tables for each of the three additional models requested by the SSC. However, care should be taken when interpreting results from these models as each utilizes suboptimal assumptions (data interpolation) or has high instability (domed selectivity models). An additional ~20 sensitivity model runs are also provided, each of which addresses a specific SSC request or explores a critical uncertainty in the model structure (see the table below). These models are briefly described and compared in the 'Sensitivity Runs' section.

Model Runs for the Final SAFE

Model_Names	Model_Group	Model_Description
26.2_FAA	Base (Author Recommended FAA)	The author recommended model for 2026 (fleets-as-areas for the LLS, no interpolated data; see Appendix 3C)
25.12	Base (1Reg Continuity)	The 2025 model accepted for management advice updated with data through 2026 (fits CPUE and historical LLS+LLF lengths, uses GOA interpolation for LLS through 2023)
26.1_1Reg	Base (1Reg Updated)	The updated single region model using the carryover interpolation for the LLS (see Appendix 3B)
26.2_FAA_3LLF_LLS_BS_Dome_DN	Base (SSC Requested FAA)	The FAA model with 3 LLF fleets and a dome in the BS LLF and LLS selectivity estimated using a double normal function
26.1_1Reg_REMA	REMA (1Reg)	The updated single region model with LLS index values interpolated using REMA
26.2_FAA_LLS_BS_Dome_DN	Dome (LLS BS Dome DN)	The FAA model with a dome in the BS LLS selectivity estimated using a double normal function
26.2_FAA_LLS_BS_Dome_Gam	Dome (LLS BS Dome Gamma)	The FAA model with a dome in the BS LLS selectivity estimated using a gamma function
26.2_FAA_3LLF_BS_Dome_DN	Dome (3LLF BS Dome DN)	The FAA model with 3 LLF fleets and a dome in the BS LLF selectivity estimated using a double normal function
26.2_FAA_3LLF_BS_Dome_Gam	Dome (3LLF BS Dome Gamma)	The FAA model with 3 LLF fleets and a dome in the BS LLF selectivity estimated using a gamma function
26.2_FAA_3LLF_LLS_BS_Dome_Gam	Dome (3LLF+LLS BS Dome Gamma)	The FAA model with 3 LLF fleets and a dome in the BS LLF and LLS selectivity estimated using a gamma function
26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q	Dome (3LLF+LLS BS Dome TV q)	The FAA model with 3 LLF fleets, process error (time-varying) on LLS q, and a dome in the BS LLF and LLS selectivity estimated using a double normal function
26.2_FAA_REMA	REMA (FAA)	The FAA model with LLS index values interpolated using REMA
26.2_FAA_CPUE	Index (CPUE)	The FAA model with CPUE data fit (through the last year of available CPUE data -- 2022)
26.2_FAA_TS	Index (Trawl Survey)	The FAA model with GOA Trawl Survey data fit
26.2_FAA_TS_CPUE	Index (CPUE and Trawl Survey)	The FAA model with GOA Trawl Survey and CPUE data fit
26.2_FAA_M_Pr_0.065	M Prior (Lower)	The FAA model with an M prior mean = 0.065
26.2_FAA_M_Pr_0.075	M Prior (Lower)	The FAA model with an M prior mean = 0.075
26.2_FAA_M_Pr_0.095	M Prior (Higher)	The FAA model with an M prior mean = 0.095
26.2_FAA_M_Pr_0.105	M Prior (Higher)	The FAA model with an M prior mean = 0.105
26.2_FAA_M_Pr_0.115	M Prior (Higher)	The FAA model with an M prior mean = 0.115
26.2_FAA_M_1Reg	M Prior (Fixed M)	The FAA model with the M value fixed at the single region model M estimate
26.2_FAA_Est_M	M Prior (Diffuse Prior)	The FAA model with M estimated with a diffuse prior (sd = 0.75)
26.2_FAA_TV_Selex_LLS	Dome (TV LLS Selectivity)	The FAA model with continuous, semi-parametric, time-varying survey selectivity (see Appendix 3C)
26.3_Spat_5Reg	Spatial (5 Regions)	The 5 region spatial model that fits tagging data and estimates age-varying, but time-invariant movement (See Appendix 3D)
26.4_Spat_3Reg	Spatial (3 Regions)	The 3 region spatial model that fits tagging data and estimates age-varying, but time-invariant movement (See Appendix 3D)

Changes to the Input Data

Newly available data since the 2024 assessment that were used in the assessment model for 2026 (Table 3.3), include:

- Length data from the trawl fisheries for 2024 and 2025.
- Age composition data from the fixed gear fishery for 2024 and 2025.
- All compositional data was disaggregated by sex.
- Finalized catch for 2024 and 2025 as well as initial and imputed catch for 2026.
- The NOAA Longline Survey abundance indices for 2025 in the GOA and 2026 in the BS and AI.
- The NOAA Longline Survey age composition data for 2025 in the GOA.
- Updated length- and weight-at-age estimates using survey age-length-weight data through 2025.
- The input sample size (ISS) for composition data utilizes a relative scaling within gears/surveys to maintain information on sampling across years (previously a static ISS was used for each gear).

Data that were removed from the proposed assessment models for 2026 compared to the 2024 assessment, include:

- The fixed gear fishery CPUE index, including the historical Japanese CPUE (1964 – 1981) and the domestic CPUE (1995 – 2022).
- The fixed gear fishery length composition data for all years.
- The NOAA Longline Survey length composition data for all years.
- For the NOAA Longline Survey index, western AI extrapolated stations (these stations have never been surveyed by the NOAA Longline Survey) relative population numbers (RPNs) were removed from the index and apportionment.

Changes to the Assessment Methodology

Changes from the 2024 Model *23.5*, included:

- Transitioning to the SPoRC stock assessment package (reviewed in Model *25.12*).
- Removing legacy coding errors and implementing appropriate likelihood functions (reviewed in Model *25.12*).
- Removing all selectivity parameter linkages (reviewed in Model *25.12*).
- Updating the selectivity parameter priors.
- Removing the fixed gear fishery early/pre-IFQ (1960 -- 1994) time block to improve stability.
- Updating the M prior to be more biologically realistic: $\sim N(\ln(0.085), 0.1^2)$ (reviewed in Model *25.12*).
- Estimating sex-specific M (reviewed in Model *25.12*).
- Assuming logistic selectivity for the trawl fishery (instead of domed) to account for bimodal distribution and catch of large/old fish.
- Moving to the spatially-implicit FAA structure where the NOAA Longline Survey was disaggregated into three regional fleets (BS, AI, and GOA), each of which had an independently estimated set of selectivity parameters and q values that were estimated by fitting the corresponding disaggregated indices (without any carryover or extrapolation approaches applied) and age compositions.

Summary of Results

Summary of Model Results for the 4 SSC Requested Options

Model Type	*Model Name*	*Major Changes*	*Rationale*	*Conclusion*
1 Region Continuity Model (*Cont*)	*25.12*	• None.	The last accepted assessment model for sablefish (not used operationally due to the 2025 government shutdown).	• *M* estimates are more biologically reasonable, but population undergoes moderate downward scaling. • The GOA interpolation method is no longer feasible given longline survey design changes. • Continued model instability exists due to conflicting signals among age and length data as well as among the various indices.
Updated 1 Region Model (*1Reg*)	*26.1_1Reg*	• (*25.12+*) Implements the 'carryover' index interpolation. • Drops western AI extrapolated LLS stations. • Refines selectivity priors. • Updates growth parameters. • Estimates sex-specific *M*. • Drops historical length data for data sources with age compositions (except Japanese LLS). • Removes CPUE index.	An updated version of the single region model that addresses major parametrization issues, data conflicts, and implements assessment good practices.	• Still relies on a suboptimal kluge to interpolate (using carryover method) ~50% of the NOAA Longline Survey index in a given year for non-surveyed regions. • GOA composition data are implicitly upweighted during data aggregation due to higher sampling and catch, which likely under-represents recruitment signals from the BS and AI. • A stable model that provides good fits to the NOAA Longline Survey index. • Mediocre fits to age compositions. • Concern that using interpolated index data (without associated composition data) leads to inflated model scaling.
Spatially- Implicit Fleets-as- Areas (FAA, *Author Recommended Model*)	***26.2_FAA***	• (26.1+) Disaggregates the NOAA Longline Survey into 3 independently modeled fleets. • Fits LLS survey and age compositions by region. • Estimates unique longline survey parameters for each region (*q*, selectivity).	The FAA provides a fundamentally more robust framework for assessing sablefish due to its ability to implicitly account for spatial dynamics and not require the use of interpolated survey data regardless of how the survey was conducted historically and moving forward.	• Stable model that demonstrates adequate fits to the disaggregated NOAA Longline Survey indices. • Similar tension as 26.1_*1Reg* model associated with simultaneously fitting age compositions and indices. • GOA NOAA Longline Survey selectivity becomes less steep, reflecting the need for the model to alias regional availability through selectivity. • Recruitment trends better reflect signals from BS and AI as evidenced by increasing estimates of 2014/2017 year classes and decreases in the 2016 year class. • Moderate downward scaling of SSB due to decreasing estimates of *M* and R_0, likely reflecting the removal of interpolated index data.

SSC Requested FAA Alternative (*Domed*)	*26.2_FAA_ 3LLF_LLS_ BS_Dome_DN*	• (*26.2+*) Disaggregates the fixed gear fishery into 3 independently modeled fleets • Unique parameters (*F*, selectivity) are estimated for each fishery fleet. • Fishery time blocks are removed to aid model stability. • Domed selectivity is modeled in the BS for both the fishery and the longline survey using a double normal selectivity function.	Further parse out recruitment signals from BS and AI by disaggregating fishery fleets, while potentially better accounting for known ontogenetic movement patterns by allowing domed selectivity in the BS fleets.	• Data sparsity issues for BS and AI fishery age compositions. • Difficulty estimating regional fishery fleet selectivity (given sample size limitations) and domed selectivity. • Poor diagnostics (e.g., jitter and MCMC) indicate that the model has trouble converging to a unique, reliable solution. • Minor downward scaling of SSB compared to Model *26.2_FAA*, but generally little difference in MLE estimates. • Composition data only support minor doming in the BS while BS fixed gear catch is low, so the impacts of allowing domed selectivity are minimal but the added complexity greatly increases instability.

Data and Population Trends

The new NOAA Longline Survey design was implemented for the first time in 2025, where the GOA was sampled followed by the BS and AI in 2026. For the first time since the early to mid 2010s, divergent trends were observed across regions, where the AI increased strongly (26% increase since 2022), the GOA increased minimally (4% increase since 2023), and the BS decreased moderately (14% decline since 2023; Figure 3.8). Thus, the index trends suggest that abundance may be leveling off. However, the 2025 survey and fishery age compositions indicate that the 2020 and perhaps the 2022 (though more uncertain) year classes were likely above average. Catch has remained relatively steady for the last three years (Figure 3.1) and remains well below ABC, with the proportion of the quota utilized ~50% in 2025 and 2026. However, utilization rates of the BRDs vary widely across regions where the GOA is often around ~80 – 90% whereas the BS and AI are less than 25% utilized.

Data fits demonstrates similar issues as single region models, where NOAA Longline Survey indices are well fit at the expense of composition data, primarily due to the Francis reweighting approach. Although residual patterns in the composition data remain, the aggregated fits are adequate given model tension (a long-standing issue with the sablefish assessment; Goethel and Cheng, 2024). Interestingly, the model demonstrates regional tradeoffs in fitting Longline Survey indices versus compositions. In the GOA, age compositions suggest more rapid growth than the index, whereas in the BS and AI the indices demonstrate more rapid growth than indicated from the compositional data. Although there are similar patterns in the single region models, the FAA model clearly demonstrates that the model tension caused from attempting to fit the index and compositions simultaneously reflects a more nuanced regional divergence and not just a simple AK-wide data conflict. Thus, there is further evidence of the need for utilizing a spatial modeling framework that can more explicitly handle the underlying spatial drivers of such data conflicts.

Compared to single region assessments, fits to the fixed gear fishery age compositions (particularly for males) have degraded. Conversely, fits to the regional Longline Survey compositions, particularly the AI, are adequate, albeit with important time and cohort trends. Tradeoffs in fit to the various compositional data sources are a result of competing signals on strong recruitment cohorts across regions where the Francis reweighting is likely upweighting data sources (e.g., AI age compositions) that best balance and reflect competing signals across all data sources. The AI provides a mixture of recruitment signals (strong 2014, 2016, and 2017 year classes) that balances those in the BS (strong 2014 and 2016 and very strong 2017 year classes) and GOA (strong 2014 and very strong 2016 year classes). No major diagnostic issues were identified based on retrospective analysis, profile likelihoods, MCMC, and jitter analysis. Thus, Model *26.2_FAA* appears to be a robust and stable model for interpreting sablefish population dynamics.

The model estimates that most year classes (aside from 2018 and 2019) since 2014 have been at or well above the time series average (Figure 3.62). Although recruitment since 2019 has been lower than the 2014-2017 levels, indications are that the 2020 and 2022 cohorts are large. Analysis of Eastern Bering Sea (EBS) trawl fishery length data (typically an early indicator of strong recruitment) indicates the 2022 year class is likely above average, but does not suggest large year classes in 2023 or 2024 (Appendix 3M). Estimated population growth in total biomass has slowed and did not change from 2025 to 2026, which follows a more than 350% increase in the population from a time series low of 128,000 t in 2015 to 592,000 t in 2026 (Figure 3.60). Conversely, spawning stock biomass (SSB) continues to increase with a 10% growth in 2026, representing a more than 375% increase in the spawning population from the time series low of 45,000 t in 2014 to 214,000 t in 2026 (Figure 3.59). Thus, the sablefish population continues to grow rapidly, where total biomass and SSB are approaching time series highs. Currently, the SSB in 2026 is at 64% of the unfished SSB (i.e., $B_{100\%}$).

Additionally, the sablefish age structure continues to gradually expand as the recent large year classes (e.g., 2014 – 2017) begin to enter ages that are nearing full maturity. For instance, the 2014 year class is now

fully mature, while the larger 2016 and 2017 year classes are 90% and 81% mature, respectively. The abundance of the 2014—2019 cohorts remain high as they age, which is a positive sign for the sablefish population and fishery. Retaining a diverse age structure in the coming years will be important as the fishery harvests these higher value large fish, given that the 2014 – 2022 year classes comprise ~90% of the 2027 projected SSB (i.e., there is little spawning contribution of fish > 13 years of age; Figure 3.64).

Model *26.2_FAA* results in a moderate downward scaling of SSB and catch advice compared to single region alternatives (i.e., Model *25.12* and Model *26.1_1Reg*; Figure 3.82), which is primarily attributed to disaggregation of the age composition data. However, general population dynamics and current stock status remain consistent across models. On the other hand, the phase-plane for Model *26.2_FAA* suggests a more pessimistic interpretation of the population trajectory throughout the early 2000s (Figure 3.70). More recently, Model *26.2_FAA* suggest that the population has been growing more rapidly than in the single region alternatives, further emphasizing that the stock condition is extremely healthy and continuing to grow.

The sablefish assessment model does not demonstrate any strong diagnostic issues, but moderate data concerns are worth monitoring. Poor market conditions led to the 2024 NOAA Longline Survey being cancelled, which has led to increased uncertainty in assessment estimates of recent year class strength. The change in survey footprint and the lack of any survey data from 2024 is further exacerbated by declining collection and reading of fishery otoliths. In 2025, no sablefish targeting trips were observed or otoliths collected in the AI (see Supplemental Material section 'Summary of Fixed Gear Fishery Observer Sampling'), while AFSC aging capacity limitations led to a 50% reduction in the number of fishery otoliths that were read. Conversely, no major population dynamic concerns exist as sablefish remain in a very healthy state, though initial indications suggest that recruitment may be declining to more average conditions. Environmental and ecosystem conditions for sablefish remain generally near average conditions, while no fishery performance metrics indicate any biological concerns for the resource (see the 'Ecosystem and Socioeconomic Profile'). **Thus, there are no elevated risk table concerns for sablefish.**

It is worth noting that when catches have exceeded ~30 kt for multiple years, SSB has demonstrated subsequent strong declines (also associated with transitions from high to low recruitment levels; Figure 3.65). Yet, despite ABCs being above 40 kt for the last three years, catch has yet to exceed 30 kt, primarily due to ABC utilization rates remaining low (~50% but with regional variation where the GOA is ~80 – 90% utilized). Concomitantly, the lack of a 2024 survey and the reduction in survey footprint beginning in 2025 have inherently increased uncertainty regarding regional biomass distributions, especially given that the GOA and BS/AI are no longer surveyed simultaneously. Given the panmictic and highly mobile nature of sablefish, the current apportionment rationale emphasized that apportionment values should not deviate *too* far from survey based regional biomass proportions (Goethel et al., 2020). Considering current ABC utilization rates as well as increased apportionment uncertainty, short-term deviations from survey apportionment values are unlikely to cause biological harm (see 'Spatial Apportionment: BRD' section).

Sablefish are managed under Tier 3 of the NPFMC harvest control rule, which aims to maintain the population at $B_{40\%}$. Since projected female spawning biomass (combined areas) for 2027 is equivalent to $B_{68\%}$, sablefish is in sub-tier "a" of Tier 3. Spawning biomass is projected to continue increasing in the near-term, and the maximum permissible value of F_{ABC} under Tier 3a is 0.08, which translates into **a Tier 3a maximum permissible 2027 ABC (combined areas) of 37,567 t**. **After adjusting for whale depredation, the final author recommended ABC_w is 37,436 t** (a 20% decline from the 2026 ABC of 47,008 t; the enacted ABC represented a 5% reduction from the 2026 author recommended ABC of 49,482 t). The OFL fishing mortality rate is 0.09, which translates into a 2027 OFL (combined areas) of 44,464 t, and results in a whale depredation adjusted OFL_w of 44,333 t. The current model projections indicate that the Alaskan sablefish stock is not subject to overfishing, not overfished, and not approaching an overfished condition.

Summary Table (Author Recommended)

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *26.2_FAA*:	
	2025	2026*	2027	2028**
M Female (estimated)[#]	0.11		0.09	
M Male (estimated)	--		0.09	
Average Recruitment (millions)	26		19	
Tier	3a		3a	
Projected Total Biomass (Age 2+; t)	704,713	695,681	588,629	586,855
Projected Female Spawning Biomass (t)	219,714	241,217	226,595	237,749
$B_{100\%}$ (t)	302,672	302,672	334,913	334,913
$B_{40\%}$ (t)	121,069	121,069	133,965	133,965
$B_{35\%}$ (t)	105,935	105,935	117,220	117,220
F_{OFL}	0.10	0.10	0.09	0.09
$maxF_{ABC}$	0.09	0.09	0.08	0.08
Whale Depredation (t)	171	169	131	131
OFL (t)	58,731	57,993	44,464	44,696
OFL_w (t)^	58,532	57,797	**44,333**	**44,565**
max ABC (t)	50,283	49,651	37,567	37,767
ABC (t)[#]	47,605	47,008	37,567	37,767
ABC_w (t)^	**50,111**	**49,482**	**37,436**	**37,636**
Status	As determined *last* year for:		As determined *this* year for:	
	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 t in 2025 (a yield ratio of 0.49 was assumed). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.

**The 2026 SAFE Model *26.2_FAA* projections were based on specified catch of 21,000 t in 2027 (a yield ratio of 0.53 was assumed based on the three-year average of catch to ABC from completed fishing years, 2023 – 2025).

[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.

^ABC_w and OFL_w are the final author recommended ABCs and OFLs after accounting for whale depredation.

[#]ABCs for 2025 and 2026 are the final NPFMC approved values, which included a 5% reduction from the author recommended values due to the SSC recommending a Level 2 concern for the assessment category of the risk table.

Summary tables (and associated apportionment) for all SSC requested alternative models are available in the Supplemental Material under 'Summary Tables and BRDs for Alternative Models'.

Accounting for Whale Depredation

For the final recommended ABC (ABC_w) or OFL (OFL_w), sperm and killer whale depredation in the fixed gear fishery is accounted for by reducing the maximum ABC by the three-year average of depredation by region. By accounting for whale depredation in the assessment and associated catch projections, the approach does not create additional regulations or burden for in-season management. Beginning in 2023, whale depredation estimates have been held constant at the 2022 levels, per SSC recommendations. Thus, ABC and OFL are now reduced by a fixed value of 131 t annually.

Spatial Catch Apportionment: Biologically-informed Recommended Distributions (BRDs)

A five-year moving average of the NOAA Longline Survey regional biomass proportions are used to

apportion catch to management area, as a means to ensure regional catch is in relative proportion to regional biomass and balanced harvest across the population and age structure (i.e., avoiding only harvesting large or small fish). The apportionment is updated yearly as new survey data are collected. Given the lack of a synoptic survey in any year, survey-based apportionment has always used interpolation for unsurveyed regions. Due to the 2025 change in survey design, the previous apportionment method that used an interpolation based on change in the GOA RPNs is no longer feasible. The static *GOA_Fix* approach from 2024 is provided, but static apportionment approaches are not recommended given the dynamic distribution of sablefish across regions. Thus, four alternatives are provided that include the 'carryover' interpolation (as used in Model *26.1_1Reg*), using REMA to smooth and interpolate, and each of these combined with either including or excluding extrapolated western AI (wAI) Longline Survey stations (which have never been surveyed by NOAA). The REMA approach interpolates unsurveyed regional RPN values prior to the terminal assessment year but uses a carryover value for the terminal year. Thus, the REMA apportionment method replaces the terminal value from the previous assessment with a new interpolated value when calculating the five-year averages. The carryover interpolation assumes RPNs for unsurveyed regions are held constant at the previous level for that region. Removing the wAI stations has the largest influence on apportionment, whereas the choice of survey interpolation method has limited impact (Figure 3.92). For 2026, the author recommended approach is the 'carryover' interpolation with wAI stations removed (bolded in the tables below).

It is worth noting that the lack of a 2024 survey and the reduction in survey footprint beginning in 2025 have inherently increased uncertainty regarding regional biomass distributions, especially given that the GOA and BS/AI are no longer surveyed simultaneously. Given the panmictic and highly mobile nature of sablefish, the current apportionment rationale emphasized that apportionment values should not deviate *too* far from survey based regional biomass proportions (Goethel et al., 2020). Considering current ABC utilization rates as well as increased apportionment uncertainty, short-term deviations from survey apportionment values are unlikely to cause biological harm (see 'Spatial Apportionment: BRD' section).

Regional Apportionment Values by Apportionment Method

Apportionment Approach	BS	AI	WGOA	CGOA	WY	SEO
Carryover_No_wAI	**0.3**	**0.2**	**0.11**	**0.21**	**0.06**	**0.12**
REMA_LLS_No_wAI	0.28	0.23	0.1	0.21	0.06	0.12
Carryover	0.27	0.26	0.1	0.2	0.06	0.11
REMA_LLS	0.26	0.3	0.09	0.19	0.05	0.11
GOA_Fix	0.3	0.24	0.09	0.2	0.05	0.12

BRDs by Apportionment Method

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	13,037	11,421	22,550	4,687	9,622	2,652	5,589	47,008
2027	***Carryover_No_wAI***	**11,231**	**7,487**	**18,718**	**4,118**	**7,862**	**2,246**	**4,492**	**37,436**
2027	*REMA_LLS_No_wAI*	10,482	8,610	18,344	3,744	7,862	2,246	4,492	37,436
2027	*Carryover*	10,108	9,733	17,595	3,744	7,487	2,246	4,118	37,436
2027	*REMA_LLS*	9,733	11,231	16,472	3,369	7,113	1,872	4,118	37,436
2027	*GOA_Fix*	11,231	8,985	17,221	3,369	7,487	1,872	4,492	37,436
2028	***Carryover_No_wAI***	**11,291**	**7,527**	**18,818**	**4,140**	**7,904**	**2,258**	**4,516**	**37,636**
2028	*REMA_LLS_No_wAI*	10,538	8,656	18,442	3,764	7,904	2,258	4,516	37,636
2028	*Carryover*	10,162	9,785	17,689	3,764	7,527	2,258	4,140	37,636
2028	*REMA_LLS*	9,785	11,291	16,560	3,387	7,151	1,882	4,140	37,636
2028	*GOA_Fix*	11,291	9,033	17,313	3,387	7,527	1,882	4,516	37,636

Percent Change in BRD by Apportionment Method

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	0%	0%	0%	0%	0%	0%	0%	0%
2027	*Carryover_No_wAI*	-14%	-34%	-17%	-12%	-18%	-15%	-20%	-20%
2027	*REMA_LLS_No_wAI*	-20%	-25%	-19%	-20%	-18%	-15%	-20%	-20%
2027	*Carryover*	-22%	-15%	-22%	-20%	-22%	-15%	-26%	-20%
2027	*REMA_LLS*	-25%	-2%	-27%	-28%	-26%	-29%	-26%	-20%
2027	*GOA_Fix*	-14%	-21%	-24%	-28%	-22%	-29%	-20%	-20%
2028	*Carryover_No_wAI*	-13%	-34%	-17%	-12%	-18%	-15%	-19%	-20%
2028	*REMA_LLS_No_wAI*	-19%	-24%	-18%	-20%	-18%	-15%	-19%	-20%
2028	*Carryover*	-22%	-14%	-22%	-20%	-22%	-15%	-26%	-20%
2028	*REMA_LLS*	-25%	-1%	-27%	-28%	-26%	-29%	-26%	-20%
2028	*GOA_Fix*	-13%	-21%	-23%	-28%	-22%	-29%	-19%	-20%

Groundfish Plan Team Summary Table by Region

Area	Year	Biomass (4+)*	OFL**	BRDs#	TAC	Catch^
GOA	2025	305,000	--	22,836	22,836	18,387
	2026	299,000	--	22,550	22,550	18,191
	2027	254,727	--	18,718	--	--
	2028	252,024	--	18,818	--	--
BS	2025	175,000	--	13,203	8,496	3,909
	2026	172,000	--	13,037	8,996	3,339
	2027	139,483	--	11,231	--	--
	2028	138,002	--	11,291	--	--
AI	2025	153,000	--	11,566	7,940	948
	2026	151,000	--	11,421	7,440	632
	2027	153,559	--	7,487	--	--
	2028	151,929	--	7,527	--	--

*Biomass represents the value projected by the model used to determine the ABC in that year assuming specified catch (not the full ABC), while regional biomass is determined by multiplying the total age-4 biomass by the longline survey proportions by region in the terminal year of the associated model (but note that apportionment is based on five-year average proportions).
**The OFL is set for the entire Alaska management region, so no area specific OFLs are provided.
#The ABC for 2025 and 2026 was based on Model *23.5*, but with a 5% reduction enacted by the NPFMC. The 2027 and 2028 values are based on Model *26.2_FAA*.
^As of October 15, 2026 Alaska Fisheries Information Network, (www.akfin.org) and not including extrapolated catch for 2026.

Author Recommended BRDs and Whale Adjusted Catch Tables by Region

Year	2026				2027		2028	
Region	OFL_w**	ABCs***	TAC	Catch*	OFL_w**	BRDs**	OFL_w**	BRDs**
BS	--	13,037	8,996	3,339	--	11,231	--	11,291
AI	--	11,421	7,440	632	--	7,487	--	7,527
GOA	--	22,550	22,550	18,191	--	18,718	--	18,818
WGOA	--	4,687	4,687	3,458	--	4,118	--	4,140
CGOA	--	9,622	9,622	7,597	--	7,862	--	7,904
WY	--	2,652	2,652	2,271	--	2,246	--	2,258
SEO	--	5,589	5,589	4,865	--	4,492	--	4,516
Total	57,797	47,008	38,986	22,161	44,333	37,436	44,565	37,636

* As of October 15, 2026 Alaska Fisheries Information Network, (www.akfin.org).
** After whale depredation methods described above
*** Note the terminology change in 2027 from regional ABCs to Biologically-Informed Recommended Distributions (BRDs).

Sablefish Summary

2026 Alaskan Sablefish SAFE (*Anoplopoma fimbria*)

Data and Stock Assessment Model

- Longline survey indices suggest population growth is slowing, where 2025 GOA indices increased by 4%, while 2026 BS indices declined by 14% and AI indices increased by 26%.
- A new fleets-as-areas (FAA) model structure was developed and approved during the 2026 CIE review, which uses the same assumptions and data inputs as Model *26.1_1Reg*, but disaggregates the NOAA Longline Survey by region, does not require data interpolation, is able to implicitly handle sablefish spatial structure, and is robust to historic, current, and future survey designs.

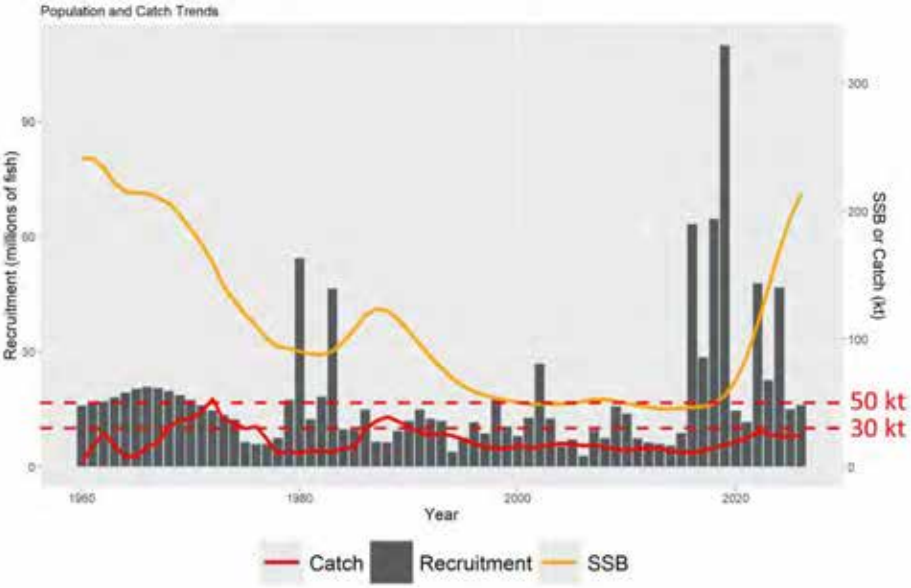
2026 Trends

SSB (kt) ↑

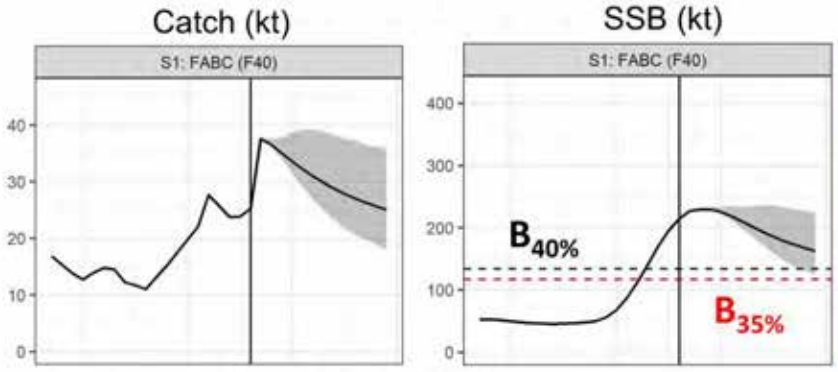
Catch (kt) →

Recruitment (millions) ↓

Age-2+ Biomass (kt) →



Stock Status and ABC Recommendations



Quantity	2026 SAFE (Projections for 2027)
$B_{100\%}$	334,913
$B_{40\%}$	133,965
SSB_{2027}	226,595
$SSB_{2027}/B_{100\%}$	68%
$F_{ABC\ 2027}$	0.08
$ABC_{w\ 2027}$	37,436
$OFL_{w\ 2027}$	44,333

- The resource is *not overfished* and *overfishing is not occurring.*
- Recent ABCs have not been fully utilized with catch averaging < 50% of the ABC over the last 3 years, though regional utilization varies from ~25% in the BS/AI to ~90% in the GOA.
- The ABC decreased due to a rescaling of the population when interpolated index values were removed in the new model structure.

Responses to SSC and Plan Team Comments

SSC Concerns Specific to the Sablefish Assessment

This section lists new or outstanding SSC comments specific to the previous Alaskan sablefish assessment and any model updates presented during the fall meetings. SSC comments are provided in italics with responses to each comment directly following.

December 2024 SSC Report

The SSC agrees with the author and JGPT that exploring additional sex-specific dynamics, in particular disaggregating age data by sex, should be a priority. This may help address troublesome patterns in (sex-aggregated) age composition residuals and (sex-disaggregated) length composition residuals, which may reflect some combination of time-varying (e.g. density-dependent) growth, time-varying selectivity, differences in M between sexes, deviations from a 50:50 sex ratio, and aging errors.

The 2025 model updates as integrated into Model *25.12* aimed to better model sex-specific dynamics, primarily through fitting sex-disaggregated composition data. Moreover, all models presented in 2026 fit sex-disaggregated compositions and estimate sex-specific natural mortality.

The SSC further suggests explorations of models that allow for variations in growth over time, given the results from Cheng et al. (2024) that provide strong evidence of density-dependent growth. Variability in growth could result in the residual patterns noted above.

Sensitivity models were presented in both 2025 and 2026 that explore time-varying growth and weight-at-age as estimated in Cheng et al. (2025a). Although these models provide interesting insight and have important impacts on SSB, they do not improve model performance or reduce residual patterns. Moreover, there is considerable uncertainty in the time-varying growth estimates, given sample size limitations. Thus, these models are not put forward as the basis of management advice.

The SSC supports the plan team recommendation to explore the use of time-varying selectivity in the model to address the poor fit to the fishery CPUE index and fishery catch-at-age data.

Multiple approaches to time-varying selectivity were presented as sensitivity runs in 2025 and 2026. Although representing a promising avenue of research, continuous time-varying selectivity formulations do not greatly improve fits to the age compositions and often result in degraded fits to the longline survey indices. Moreover, they tend to cause model instability, given the number of model partitions included for sablefish (i.e., sex, age/length, fleet, year). The CIE reviewers recommended maintaining the status quo for selectivity parametrization, which includes two time blocks for the fishery and survey. Moreover, the CIE reviewers recommended that continuous time-varying selectivity should not be utilized at this time. Thus, the time blocked selectivity approach has been maintained for all 2026 models.

The SSC re-iterates a recommendation from last year to explore the Hulson and Williams (2024) bootstrapping approach for determining appropriate input sample sizes for compositional data.

The Hulson and Williams (2024) ISS approach has not been fully developed for longline survey data nor has it been fully developed for fishery compositions. Until these methods are resolved for all data sources, it was not deemed appropriate to implement as it may introduce model issues (i.e., when only one type of composition data uses a bootstrapped ISS but others do not). To address these concerns, a new time-varying ISS approach was introduced that scaled ISS relative to the number of samples in a given year and fleet (see Appendix 3B). However, regardless of approach for setting ISS, the ISS likely has limited impact on model outputs or performance given the degree of rescaling from ISS to ESS that occurs with the Francis reweighting.

The SSC appreciates the clarification of how the recruitment bias correction is currently handled in the model but encourages further explorations regarding the treatment of recruitment variances. As noted last

year: "The SSC encourages the use of an appropriate sigma constraining recruitment but notes that the maximum likelihood estimate of a random effects variance is negatively biased. This can be avoided by iteratively tuning in a maximum likelihood framework (per the approach of Methot and Taylor) or by using a full Bayesian analysis such that the recruitment deviations are integrated out."

The iterative tuning method of Methot and Taylor was integrated and used to determine the recruitment bias correction parameters, but had little impact on values. Work is ongoing to move towards treatment of recruitment as random effects, given that the RTMB SPoRC model is capable of handling random effects.

The SSC shares PT concerns over the loss of logbook data and supports the PT recommendation to consider developing a standardized fishery CPUE index using observer data only, especially if the longline survey cannot be conducted each year.

Investigations of the observer data suggest that the sample sizes are likely not sufficient to develop a robust CPUE index and are often extremely limited in certain regions (e.g., the AI in 2025 had no observed sablefish targeting trips).

The SSC encourages further work on skip spawning to assess its potential impact on reproductive potential, perhaps through the development of an index for the ESP.

Skip spawning likely has impacts on reproductive potential and has been previously observed in sablefish. The authors are unaware of any current/ongoing research on this topic. Sablefish maturity observations during the spawning period (winter) would benefit this topic.

The SSC encourages assessment authors to seek out local knowledge regarding fishery CPUE, in particular regarding any issues with the performance of slinky pots that may affect CPUE.

The sablefish IFQ fishery has undergone dramatic changes in response to the development of slinky pots and fishing being allowed in the GOA. Additional information specific to gear type is now being collected by observers and some limited research has been conducted. We will continue to discuss fishing practices with stakeholders.

October 2025 SSC Report

The SSC also recommends including biennial survey impacts on extrapolation in the 2026 CIE review.

The LLS design changes were a primary focus of the CIE review, where the impacts were investigated using closed loop simulations (Appendix 3E).

Document Francis reweighting and effective sample sizes across datasets.

A table is now included for all model runs that provides the SE for indices and the mean ISS and ESS (after Francis reweighting) for compositional data sets (Table 3.8).

Compare empirical length and weight-at-age directly with model estimates.

Comparison of the external estimates of growth and WAA with empirical values has not been undertaken, but is a topic that will be explored in the future. However, empirical WAA values are likely to be noisy given the relatively low level of weight samples (compared to length samples) taken on the LLS. Model sensitivity runs with time-varying growth and weight-at-age using the methods of Cheng et al. (2025a) are presented in Appendices 3B and 3C.

Continue evaluation of flexible fishery selectivity and alternative composition likelihoods.

See responses to similar comments above.

Continue development of spatial models and sex-specific mortality.

The spatial models were updated for 2026 and sex-specific natural mortality is estimated in all new models put forward in 2026.

Continue exploring approaches for using fishery composition data to inform removals only rather than population structure or recruitment.

It is unclear how this would be accomplished as composition data inherently reflects the age structure of the population along with recruitment, as modified through availability and gear selectivity. Further guidance is requested on how this might be achieved.

Explore inclusion of environmental covariates in R-TMB/SPoRC.

Although environmental covariates are possible to include in SPoRC, there are no reliable covariates that have been identified for sablefish.

Model proportions of age-groups by area using spatial approaches.

The spatial assessment explicitly models compositions by region.

Clarifying the likelihood for the prior on M on the scale of M, not logM, and the other likelihood component.

Natural mortality is estimated with a lognormal prior centered on log(0.085), with a standard deviation set to 0.1.

Avoid using an ad hoc approach to down weighting anomalous size comp data points.

The only downweighting used in the sablefish assessment is Francis reweighting, which is a well-established method used by other NPFMC stocks for data weighting.

Consider the reduced survey frequency in the risk tables

For 2026, survey frequency and footprint are specifically addressed in the risk table.

October 2026 SSC Report

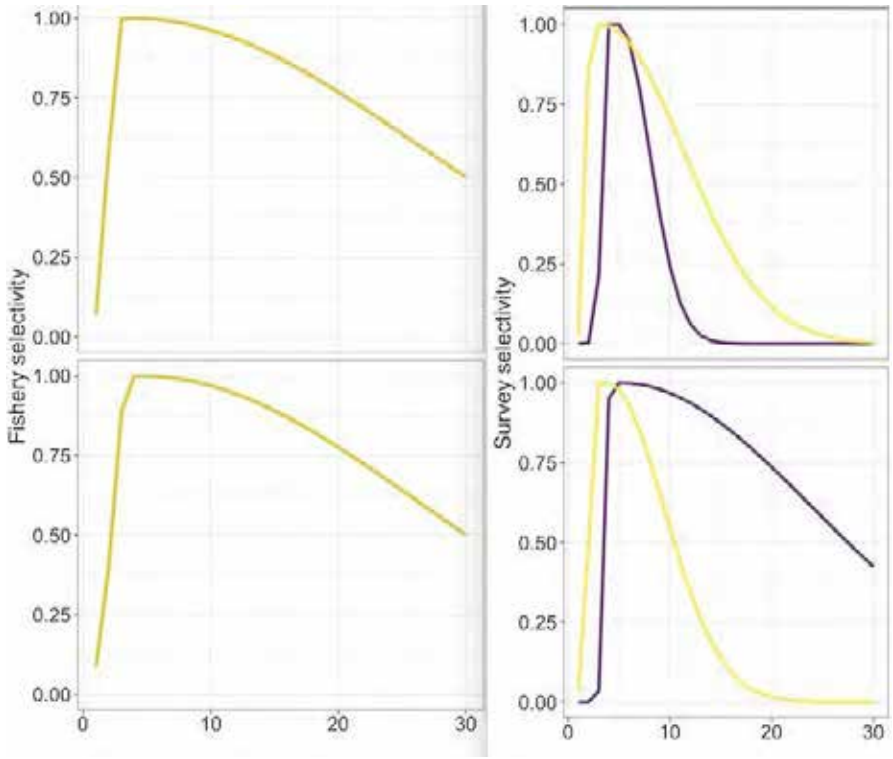
The SSC supports bringing forward the JGPT's proposed models for December, including Model 25.12, the continuity model, Model 26.1_1Reg, and Model 26.2_FAA.

These models have been brought forward in the final SAFE document, as requested. The executive summary and associated BRD tables are provided for alternative models in the Supplemental Material, while all model diagnostics and outputs for each alternative model are provided on the sablefish GitHub repo (here). The SSC requested domed selectivity model (*26.2_FAA_3LLF_LLS_BS_Dome_DN*), which disaggregates the fixed gear fishery into 3 regional fleets and allows for domed selectivity in the BS fishery and survey fleets, is also included. The SAFE document focuses on the results of the author recommended Model *26.2_FAA*, per SAFE guidelines.

Domed-shaped selectivity should be evaluated using more flexible curves such as the double normal that are already implemented in SPoRC. The gamma function is not often used for modeling selectivity because the ascending and descending portions of the curve are linked.

Multiple forms of domed selectivity were explored for the CIE review, including gamma and double normal, and are run again for the 2026 SAFE (see the 'Sensitivity Runs' section). Given the sparsity of data, the gamma function has been the default option for sablefish in the past (i.e., for the trawl fishery) and is routinely used in other AFSC assessments because it only requires 2 parameters to estimate, despite its inflexibility. Conversely, the double normal requires 6 parameters and, in many cases, necessitates fixing several parameters to achieve convergence. Given the pros and cons of each, the gamma was chosen for earlier work (though double normal options had been explored). Regardless of functional form, results and conclusions drawn from these models are similar, where models assuming dome-shaped selectivity remain

unstable and are not recommended for management advice. We refer the reviewers to the Supplemental Material section 'SSC Requested Models' for a full analysis of the 8 alternative models with dome-shaped selectivity.



Estimated double normal selectivity curves for Model 26.2_FAA_3LLF_LLS_BS_Dome_DN for the Bering Sea fixed gear fishery (left column) and longline survey (right column) by sex (top panel is females and bottom panel is males). Colors represent the estimated selectivity curve for different time blocks (yellow indicates the recent block while purple indicates the historical block). The time blocks in the fixed gear fishery were removed to improve stability.

The SSC requests that an additional FAA model be provided for the final assessment in December that allows for selectivity for Bering Sea fisheries and surveys to be dome-shaped.

As noted above, the SSC requested domed selectivity model (*26.2_FAA_3LLF_LLS_BS_Dome_DN*), which disaggregates the fixed gear fishery into 3 regional fleets and allows for domed selectivity in the BS fishery and survey fleets, is included as an alternative model. Full model outputs are available on the GitHub repo (here) and time series comparisons are provided in the 'Sensitivity Runs' section. The authors note, as discussed in Appendix 3C, that domed selectivity FAA models for sablefish are extremely unstable and demonstrate poor model diagnostics (e.g., degraded survey index fits, unstable jitters, non-converged MCMCs, and increased retrospective patterns).

Use the 5-region operating model to evaluate emergent empirical selectivities for regional fisheries and surveys by comparing survey and fishery age composition sampled regionally with abundance at the population level.

At the start of FAA model development process, the authors derived the selectivity curves that an FAA model would need in order to reproduce the catch and survey dynamics generated by the spatial model, following Waterhouse et al. (2014). This analysis directly evaluates the implications of the spatial model

for FAA selectivity and demonstrates that alternative assumptions about BS survey selectivity have negligible effects on estimated SSB. The underlying issue was discussed during the CIE review and is summarized below.

Following Waterhouse et al. (2014), we used the five-region spatial model (Model *26.3_Spat_5Reg*) to derive the selectivity curves that a fleets-as-areas (FAA) model would need to reproduce its catch and survey dynamics. Spatial regions were grouped into the FAA areas (BS, AI, and GOA, with the western, central, and eastern GOA combined). For the fishery, the spatial model's fixed-gear catch-at-age in each area r was set equal to the catch-at-age obtained by applying an area-specific fishing mortality-at-age, $F'_{a,r}$, to the stock-wide numbers-at-age:

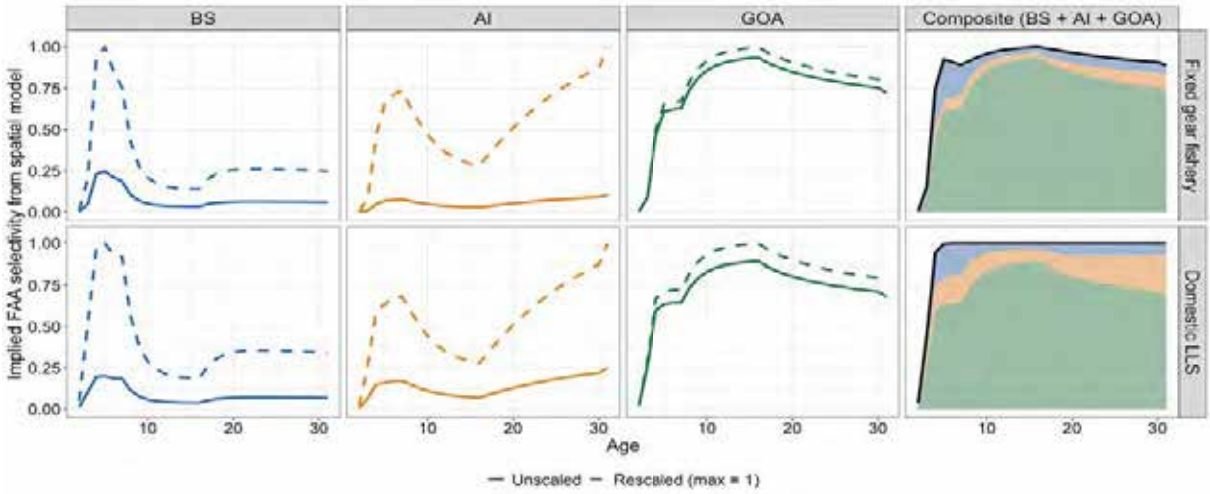
$$C_{a,r} = \left(\sum_r N_{a,r}\right) \frac{F'_{a,r}}{M + \sum_r F'_{a,r}} \left[1 - exp\left(-M - \sum_r F'_{a,r}\right)\right]$$

and solved for $F'_{a,r}$ using Newton's method. The same approach was applied to the domestic longline survey, setting the spatial model's predicted survey index-at-age in each area equal to the stock-wide numbers-at-age at the time of the survey multiplied by an area-specific catchability (selectivity times catchability), $S'_{a,r}$:

$$I_{a,r} = \left(\sum_r N_{a,r}\right) S'_{a,r}$$

Curves were solved for each year and sex, scaled relative to the composite (the sum across areas, representing a single fleet spanning all areas), averaged across years with data (fishery: 1960–2026; survey: 1990–2026), and rescaled so the composite peaks at one.

The composite fishery selectivity was approximately logistic, within ~10% of full selection from age 5 onward. This is because the majority of the fixed-gear fishery occurs in the GOA, which also contains most of the older, larger fish. The composite is therefore dominated by the GOA curve, and a single fixed-gear fishery fleet with logistic selectivity is generally appropriate. When the survey is split by area, there is evidence of doming: the implied BS selectivity peaks at ages 5–7 and declines at older ages, and the AI curve is U-shaped. However, the composite survey selectivity is fully logistic, and the area-specific doming has little influence on stock-wide dynamics. Older fish make up a minority of the population (27% of numbers at ages 10 and older from 1990–2026), and only about 5% of these occur in the BS, so the BS contributes a small percentage to the composite survey signal at ages 10 and older and relative catch in the BS is small compared to the GOA. Thus, allowing for doming in the BS survey and/or fishery has limited impact on estimates, because there is not a large implied 'cryptic biomass' as might otherwise occur if a large portion of the population was older than the age where the descending limb of the domed selectivity curve begins. Consistent with this, estimated spawning stock biomass differed negligibly between FAA configurations assuming logistic and dome-shaped BS survey or fishery selectivity.



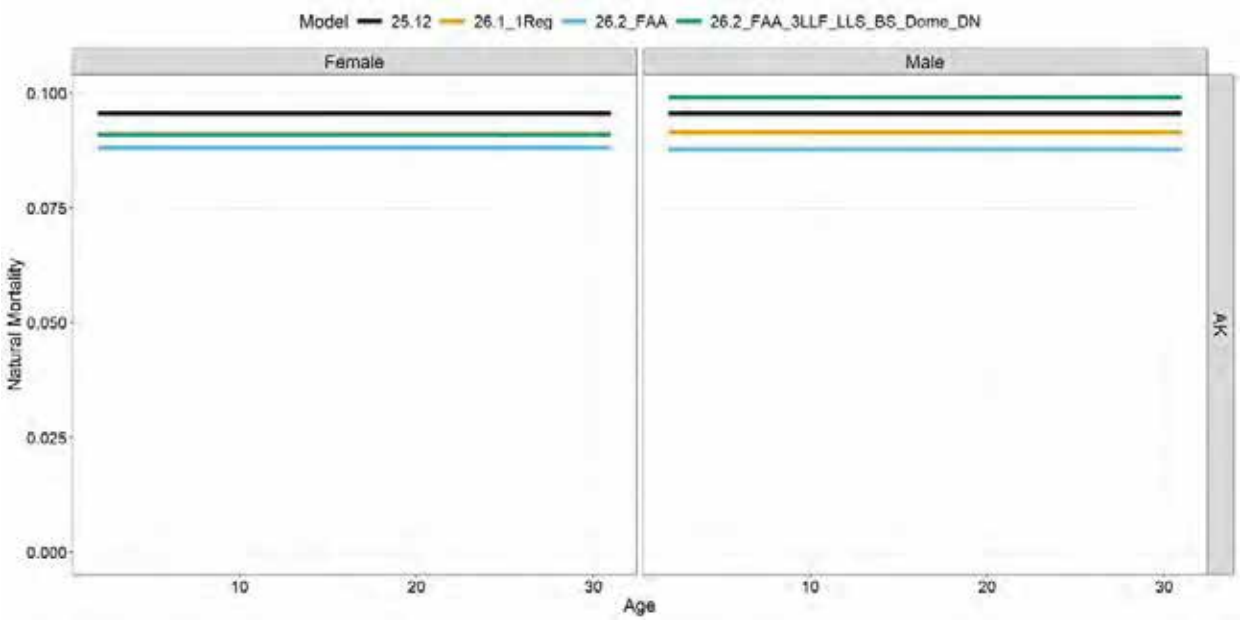
Implied FAA selectivity from the five-region spatial model for the fixed-gear fishery (top) and domestic longline survey (bottom), females. Solid lines are unscaled area curves, which sum to the composite selectivity across all areas (right column, shaded by area contribution); dashed lines are the same curves rescaled to a maximum of one.

The SSC requests that full model diagnostics be provided for models 26.1_1Reg, 26.2_FAA, and the SSC's proposed additional model with dome-shaped selectivity.

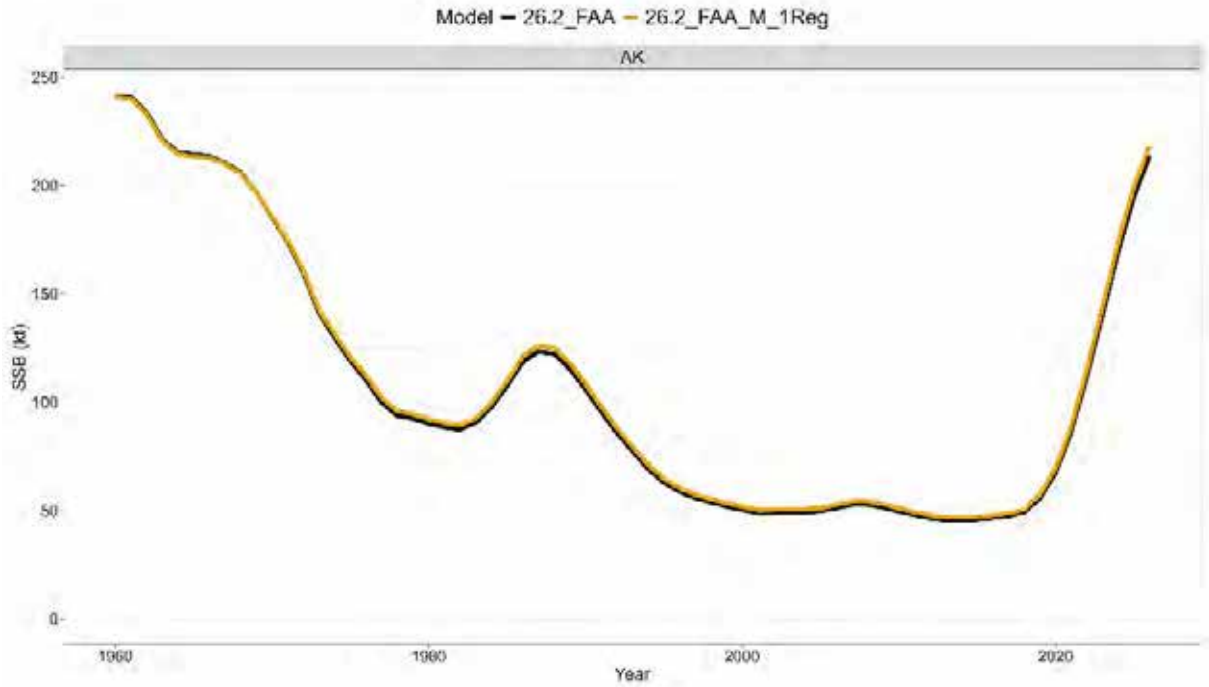
As noted above, all model diagnostics for these model runs and other explorations are available on the sablefish assessment GitHub repo (here).

The SSC requests that a sensitivity model run be done where the natural mortality estimated in Model 26.1_1Reg is included as fixed values in Model 26.2_FAA to evaluate the impact of the re-estimated natural mortality values in Model 26.2_FAA on model results.

A full analysis of model sensitivity to natural mortality estimates was undertaken for the CIE. Because sablefish are long-lived, the model is extremely sensitive to *M* values and *M* remains extremely difficult to estimate. As a fundamental population scalar in assessment models, higher assumed/estimated *M* values increase population scaling. The *M* in the single region model is slightly higher (but remains similar to the FAA model given the use of a strong prior). Thus, when using the single region model *M* in the FAA model, as done for the sensitivity run provided below, the FAA model is scaled slightly higher. It should be noted that the *M* estimates from either model are uncertain and tend to be on the high end for a species that lives to be older than 100. A sensitivity analysis to the *M* prior in Model *26.2_FAA* is provided in the 'Sensitivity Run' section, and the results are provided in the figures below.



Comparison of estimated natural mortality (M) values for each sex across primary models. Note that the single region and FAA models estimate similar M values, while the FAA model estimates the lowest and more realistic M value (~0.088 yr^{-1}) for such a long-lived species.

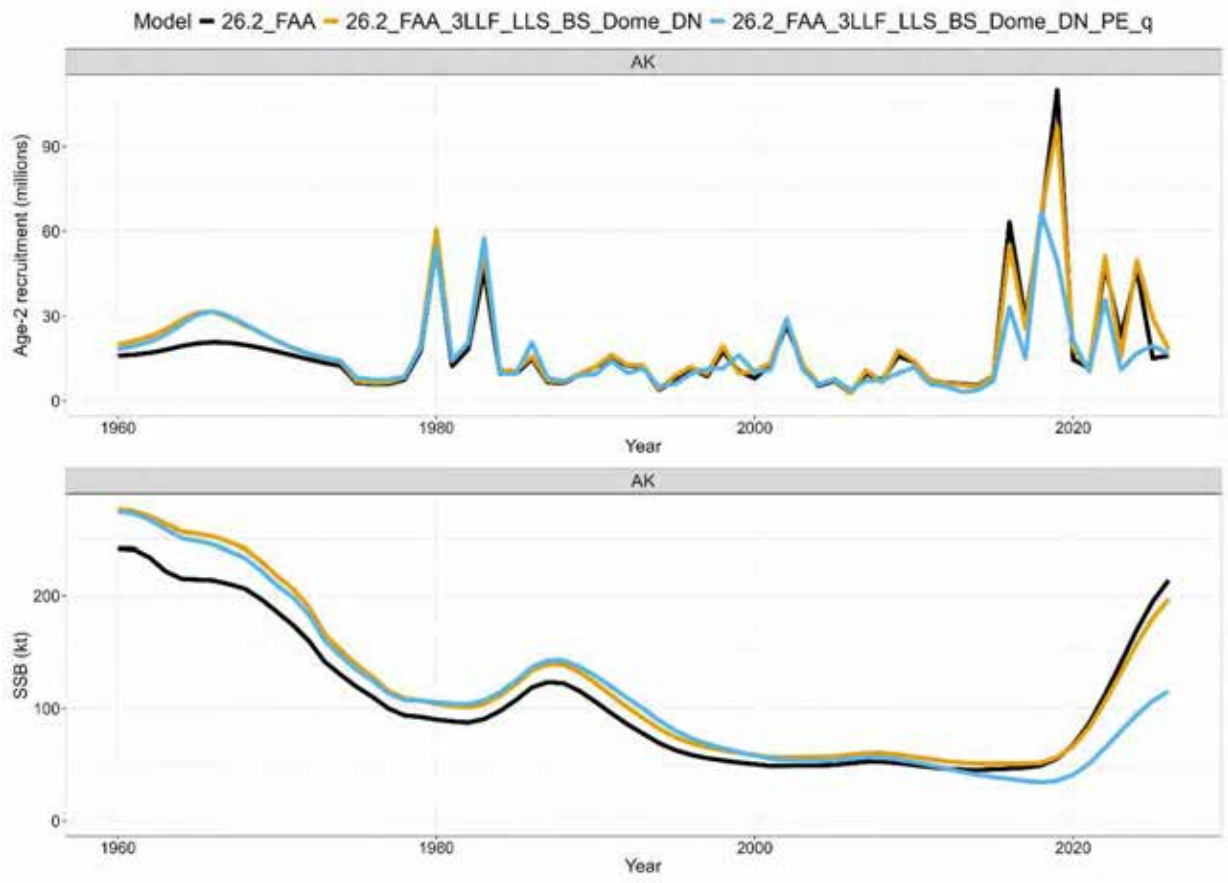


Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	97.67	0.64	213.67	333.97	1.66	0.05	0.08	0.68
26.2_FAA_M_1Reg	99.27	0.66	218.40	331.62	1.66	0.05	0.08	0.65

Trends in SSB (kt) for the recommended model (26.2_FAA; black line) and the same model with M fixed at the values from Model 26.1_1Reg (26.2_FAA_M_1Reg; orange line).

If the FAA approach becomes the preferred approach for sablefish, the SSC recommends that process error in survey catchability be evaluated to account for density dependence and range expansion.

Allowing for time-varying catchability does not appear biologically plausible for sablefish because there is no indication of a change in availability of fish to the survey in a specific region that would suggest redistribution. Conversely, there is indication of a change in availability by depth and age in each region, which was the impetus for instituting a time-block on selectivity (age availability) in models since 2021 (see the 2021 SAFE for further details on why the selectivity time block but not a catchability time block was implemented). Allowing for time-varying catchability implicitly assumes that recent increases in recruitment are actually due to increases in availability to the survey gear. Thus, the model assumes that recruitment is much more moderate in recent years and that population increases are less dramatic. With the added flexibility the model is better able to fit the indices and some age compositions, but results in a strong positive retrospective pattern (Mohn's rho = 0.32 in SSB). The ABC decreases substantially to 19 kt. For a more complete description of this model run please see the Supplemental Material section 'SSC Requested Models'.



Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_3LLF_LLS_BS_Dome_DN	36.21	0.61	197.18	129.87	1.52	0.06	0.08	0.71
26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q	18.83	0.39	114.98	116.51	0.99	0.10	0.08	1.32

Trends in recruitment (top panel) and SSB (bottom panel) for the recommended model (26.2_FAA; black line), a model with 3 regionally disaggregated fixed gear fishery fleets and domed selectivity in the BS fishery and survey fleets (26.2_FAA_3LLF_LLS_BS_Dome_DN ; orange line), and the same model with process error (time-varying) in catchability (q; 26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q; blue line).

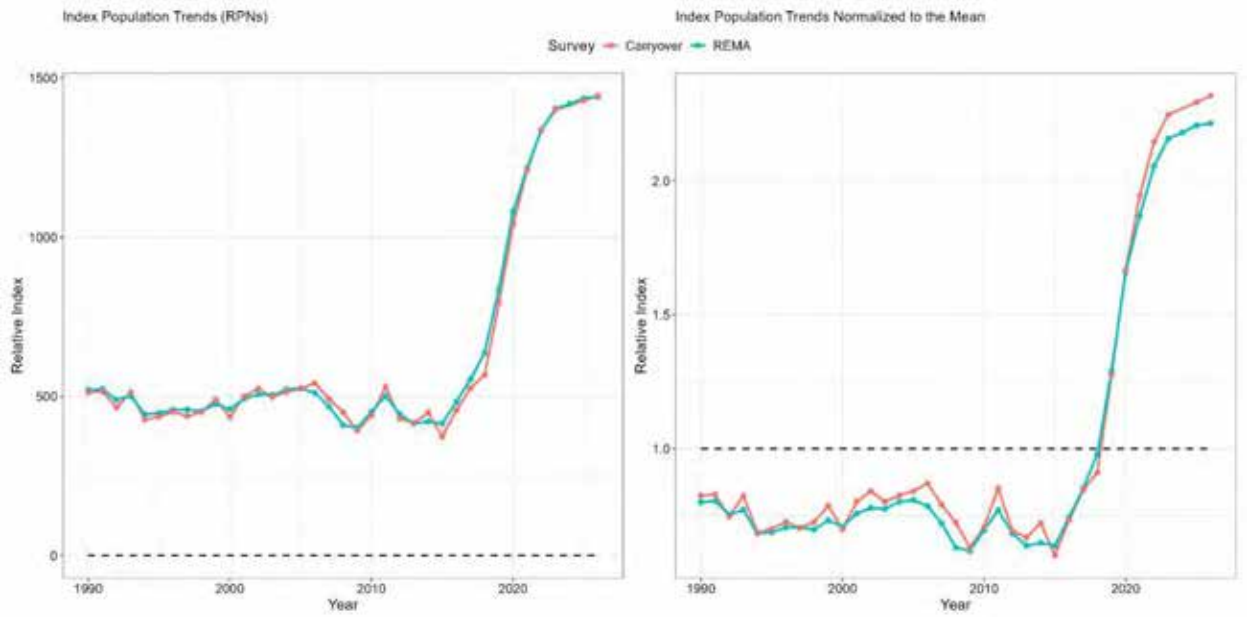
The SSC recommends evaluation of spatial-temporal models for the longline surveys that deal appropriately with missing regional surveys to develop an overall estimate of abundance. In addition, the SSC supports the plan team's recommendation to explore REMA models to estimate biomass distribution.

This issue was discussed extensively during the Groundfish Plan Team as well as during the CIE review. Unfortunately, a spatiotemporal model cannot fully address sparse survey coverage. A Gaussian Markov random field (GMRF; or a spatial tensor spline) cannot recover information that the survey never collected. Because the BS/AI and GOA have never been sampled concurrently under the domestic longline survey, there is fairly minimal information on how their annual abundance trends relate to one another. A GMRF can fill in the missing regional indices, but the reliability of such abundance estimates is low. Thus, the missing information is replaced by assumptions about spatiotemporal covariance and cannot be reliably recovered through statistical sophistication. Under the revised survey design, approximately half of the regional index information would be missing and interpolated in any given year. The problem extends to age composition as well. Regional age compositions differ, so imputing an unobserved region's composition from another region requires additional assumptions about how those compositions relate. If those assumptions are wrong, the resulting bias is not addressed or fixed by using a spatio-temporal model.

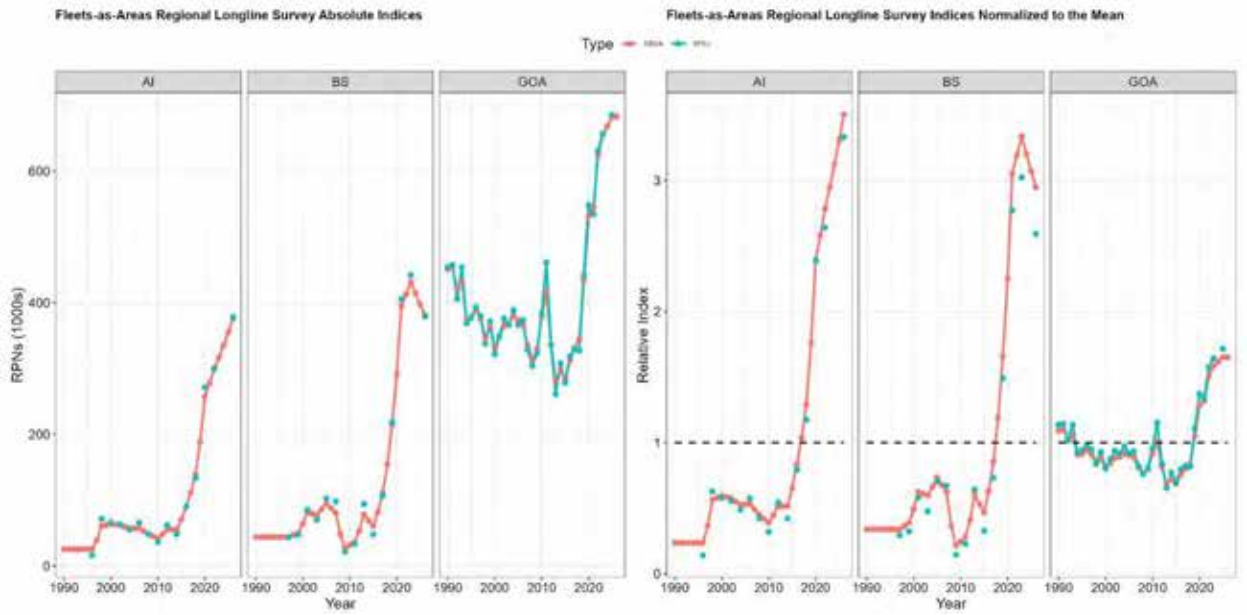
We agree that REMA may be useful for estimating biomass distributions. However, we also note that under REMA's current random walk formulation, in years when a region is not surveyed, its projected biomass distribution is effectively carried forward from the previous year's estimate (i.e., this year's value is last year's value, a well-known statistical property of random walk models), effectively mimicking the "carryover" approach presented. Perhaps more importantly, REMA does not have a method to interpolate/fill in regional composition data in missing survey years.

The assessment team used REMA to interpolate the regional indices, then summed the interpolated RPNs to the Alaska-wide or 3 region spatial structure. Running REMA on the LLS survey does not lead to indices that differ substantially from the carryover approach (in the single region case) or the observed values (in the regional case), aside from interpolating between values and assuming carryover values for unsurveyed regions in the terminal year. When fitting these indices in the single region assessment, the results are essentially unaltered, albeit with a slight decrease in SSB and ABC in the terminal years. For the FAA implementation, using the REMA model and fitting interpolated values as observations leads to a similar upward scaling as with the 'carryover' FAA example in Appendix 3C (Figure 3C.12). The assessment team does not recommend fitting interpolated data of any form in the assessment. For 2026, we have also provided a REMA based apportionment option, as requested.

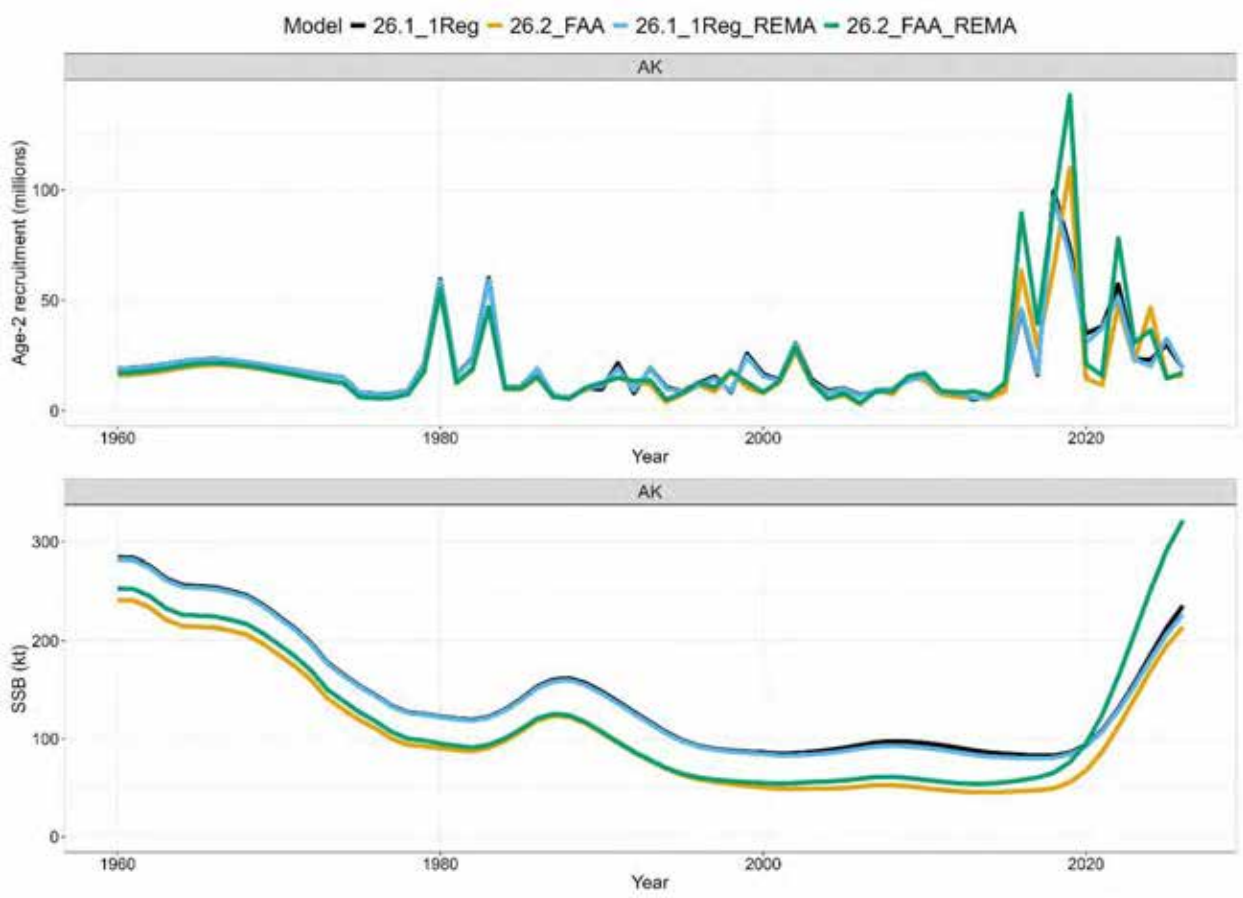
Ultimately, the decision to move to a FAA approach was explicitly to move away from suboptimal approaches for calculating an Alaska-wide index value, and the implicit assumption that GOA LLS age compositions (which dominate the catch-weighted compositions) are representative of the entire population (especially given the relatively lower recruitment observed in the GOA compared to the BS and AI). Thus, we believe that using *only* the observed data, as is done in the FAA, is the best method.



Comparison of the Alaska-wide longline survey index under the assumption of the carryover interpolation (red line) and using the REMA model to interpolate the regional indices (summed to the Alaska-wide population; blue line).



Comparison of the observed regional longline survey indices as used in the FAA models (blue line) and the resulting interpolated regional indices from the REMA model (red line).



Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.1_1Reg	40.18	0.65	235.70	141.83	1.66	0.04	0.07	0.62
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.1_1Reg_REMA	38.52	0.65	227.06	138.72	1.64	0.05	0.07	0.65
26.2_FAA_REMA	55.14	0.83	321.69	154.48	2.08	0.04	0.08	0.45

Trends in recruitment (top panel) and SSB (bottom panel) for the recommended model (26.2_FAA; orange line), the single region model (26.1_1Reg; black line), and versions of each that fit a REMA interpolated index summed to the structure of the longline survey in either model (blue and green lines for single region and FAA versions, respectively).

The SSC supports carrying forward the full range of apportionment options into the final assessment. In addition, the SSC recommends use of REMA models with the longline survey data to estimate regional biomass distribution.

All five approaches, including the use of REMA to smooth and interpolate the regional indices, are presented in the 2026 SAFE. The authors note that REMA mimics the carryover interpolation in the terminal year for non-surveyed regions (i.e., it carries forward the previous value for a given region). One consideration for using REMA is that the current terminal year value will be replaced in the next assessment year by an interpolated value, such that the values going into the apportionment calculation will inherently change with every update. Given the lack of consistency from year to year when using REMA for apportionment, the author recommended apportionment approach is the '*Carryover_No_wAI*' method as presented at the 2026 September JPT meeting. However, aside from the inclusion/exclusion of extrapolated

western AI stations in the apportionment method, there is little variation in regional apportionment values across methods.

Plan Team Concerns Specific to the Sablefish Assessment

This section lists new or outstanding PT comments specific to the previous Alaskan sablefish assessment and any model updates presented during the fall meetings. PT comments are provided in italics with responses to each comment directly following.

November 2024 JPT Report

The Teams recommended the author explore the potential impact of time-varying selectivity, either by directly modeling it as a time-varying process or by mitigating its impact on other parameters, such as by exploring changes in the set of ages over which the age-length comps are fitted. The Teams recommended exploration of data-weighting methods that can be estimated jointly with changes in the variance of the time-varying selectivity parameters.

See response to SSC comment above regarding time-varying selectivity. For 2026, continuous selectivity parametrizations were also combined with the self-weighting Dirichlet-Multinomial likelihood for composition data. The resulting model tended to overfit the composition data at the expense of the LLS index data, resulting in extremely volatile recruitment estimates. The CIE reviewers noted that time-varying selectivity and the DM likelihood were not recommendations for sablefish at this time. As such, the models put forward for 2026 do not utilize either methodology.

The Teams recommended that the author perform a runs test of randomness to test autocorrelation in the fits to the indices.

We now output and report an index runs test as a residual diagnostic for all model runs.

If there are sufficient data, the Teams recommended exploring ways to update the standardized fishery CPUE index using only observer data.

See response to similar SSC comment above. Observer data is insufficient to produce a reliable CPUE index that adequately represents trends across all management regions.

September 2025 JPT Report

The Teams recommended clarifying and documenting the results of Francis reweighting and include tables of input sample sizes and final effective sample sizes. This also extends to the indices since multipliers appear to remain in use (i.e., "lambdas"; it is better to report the variance or CVs implied).

As noted in the SSC comments above, these tables are now provided for all model runs.

The Teams recommended comparing empirical length and weight-at-age directly with modeled estimates.

As noted in SSC comments above, this is a research priority but has not yet been addressed.

The Teams recommended testing approaches where fishery composition data inform removals only rather than population structure or recruitment.

As noted in the SSC comments above, it is unclear exactly how this would be undertaken and further guidance is requested.

September 2026 JPT Report

The Teams recommended Model 26.2_FAA as the candidate model for 2026 management advice. For November, the Teams recommended bringing forward Model 26.2_FAA, the updated single region Model 26.1_1Reg, and the continuity/base Model 25.12_1Reg_Cont. Models 26.1_1Reg and 25.12_1Reg_Cont should be presented for comparison only; full diagnostic results are needed only for Model 26.2_FAA.

Results and diagnostics from all models (and many others, as requested by the SSC) are available on the GitHub repo (here). The SAFE only includes a comprehensive description of Model *26.2_FAA*, as requested.

Introduction

For a full description of the sablefish (*Anoplopoma fimbria*) resource and fishery dynamics, see Goethel et al. (2021; available at https://www.fisheries.noaa.gov/resource/data/2021-assessment-sablefish-stock-alaska).

Sablefish are found from northern Mexico to the Gulf of Alaska (GOA), westward to the Aleutian Islands (AI), northward in the Bering Sea (BS), and into the northwestern Pacific Ocean off the Siberian coast of Russia and the Kuril Islands in Japan (Wolotira et al. 1993). Genetic analysis has found no population sub-structure throughout their range along the US West Coast to Alaska and suggested that observed differences in growth and maturation rates may be due to phenotypic plasticity or are environmentally driven (Jasonowicz et al., 2017; Kapur et al., 2020; Timm et al., 2024). Sablefish are assessed as a single, homogeneous population in Federal waters off Alaska, because of their high movement rates and panmictic stock structure. However, management is by discrete regions to distribute exploitation throughout their wide geographical range, including the Bering Sea (BS), Aleutian Islands (AI), Western GOA (WG), Central GOA (CG), and Eastern GOA (EG) (composed of West Yakutat, WY, and Southeast Outside, SEO; Figure 3.1).

Adult sablefish live at depths greater than 200 m and are highly mobile, though, exact movement patterns and drivers are not well understood (Hanselman et al., 2015). Recently, results of a spatially explicit tag-integrated assessment model (Cheng et al., 2025d) demonstrated support for historical hypotheses of a clockwise ontogenetic movement pattern (Heifetz and Fujioka, 1991), wherein immature fish tend to move towards and reside in western regions (WG, BS, AI) and then move eastward as they mature with high residency of older fish in the CG and EG. Spawning occurs in winter at depths of 300 - 500 m near the edges of the continental slope (Mason et al. 1983). Juvenile sablefish spend their first two to three years on the continental shelf of the GOA and the southeast BS. After their second summer, they begin moving offshore to deeper water, typically reaching their adult habitat, the upper continental slope, at 4 to 5 years of age. This corresponds to the age range when sablefish start becoming reproductively viable (Mason et al. 1983, Rodgveller et al. 2016).

Drivers of recruitment dynamics for sablefish are not well understood, but, unlike other Alaska groundfish species, they appear to have responded positively to recent large marine heatwaves in the North Pacific potentially due to their rapid growth (Callahan et al., 2021). Although young, immature sablefish are found throughout Alaska federal waters, recent extremely large year classes have been more concentrated in western regions, especially the eastern Bering Sea (EBS) shelf (Cheng et al., 2025d). Thus, the EBS may act as a nursery ground during periods of high recruitment and may represent recolonization of a pre-industrial fishing population center (Sasaki, 1985). For further information on sablefish life history dynamics and ecosystem drivers see the Sablefish Ecosystem and Socioeconomic Profile (ESP).

Fishery

Sablefish have been exploited since the end of the 19th century with rapid fishery expansion in the 1960s when Japanese longliners began operations in the EBS (Table 3.1, Figures 3.1 -- 3.4). As the fishing grounds in the EBS were preempted by expanding Japanese trawl fisheries, the Japanese longline fleet expanded to the AI and the GOA in the 1970s (Figure 3.1). Heavy fishing by foreign vessels resulted in a peak in total catch at 53,000 t in 1972, which led to a substantial population decline and implementation of fishery regulations in Alaska. The U.S. longline fishery began expanding in 1982 in the GOA and by 1988 the U.S. harvested all sablefish taken in Alaska, primarily by hook-and-line gear in the eastern and central GOA. Over the last two decades, the EG and CG have constituted the bulk of sablefish landings (~4 – 8kt each), followed by the WG (~1 – 3kt), and BS and AI (0.2 – 2kt each), although catch in the BS has increased over the last decade ranging between 1 and 6 kt. From 2010 to 2015, the AI experienced slightly higher catch than the BS, which corresponded with a period of high catch rates of old, large fish (e.g., from 2010 to 2016 ~20 – 70% of the AI age compositions were composed of fish older than age-30 leading to an unrealistically large plus group in the population level age compositions during that period; Figure 3C.42). Catch and effort in the AI has decreased drastically since 2023 (likely due to poor sablefish markets and the high cost of fishing given the distance to fishing grounds in the AI). In 2025, there were no observed trips or biological sampling from the AI due to a combination of low fishing effort and the sampling design of observer deployment (see Supplemental Material section 'Summary of Fixed Gear Fishery Observer Sampling').

From a year round fishery in 1983, the fishing season shrank to 10 days in 1994, warranting the "derby" fishery label. In 1995, Individual Fishing Quotas (IFQ) were implemented for hook-and-line vessels along with an 8-month season. The IFQ Program is a catch share fishery that issued quota shares to individuals based on sablefish and halibut landings made from 1988 -- 1990. Since the implementation of IFQs, the number of longline vessels with sablefish IFQ experienced a substantial and anticipated decline from 616 in 1995 to 362 in 2011, which was expected as shareholders consolidated their holdings and fished fewer vessels to reduce costs (Fina, 2011). The season dates have varied by several weeks since 1995, but the monthly pattern has been from March to November with the majority of landings occurring in May to June. IFQ management increased fishery catch rates and decreased the harvest of immature fish after implementation (Sigler and Lunsford 2001).

In response to consistent sperm whale depredation on hook and line gear, the NPFMC passed a regulation in 2015 to allow pot fishing in the GOA starting in 2017. In 2017, pot fishing made up a small proportion of the fixed gear catch (~15%). However, since 2021 the majority of removals by the fixed gear fleet was taken by pot gear (Table 3.1, Figures 3.2 -- 3.3). The transition to pot gear was extremely rapid and primarily driven by the increasing popularity of collapsible 'slinky' pots that are easier to store on smaller vessels while effectively eliminating whale depredation that has been rampant on hook and line gear (Figure 3.5; Peterson and Carothers, 2013; Peterson and Hanselman, 2017; Cheng et al., 2024a).

Sablefish are also caught during trawl fisheries for other species groups such as rockfish and deep-water flatfish, and more recently walleye pollock. Allocation of the Total Allowable Catch (TAC) by gear group varies by management region and influences the amount of catch in each region. Allocation percentages by area are: 80% to fixed gear and 20% to trawl in the Western and Central GOA; 95% to fixed gear and 5% to trawl in the Eastern GOA (i.e., 5% to trawl in WY, given trawling bans in the SEO management area); 50% to fixed gear and 50% to trawl in the eastern BS; and 75% to fixed gear and 25% to trawl gear in the Aleutian Islands. For much of the last twenty years, trawl gear has constituted around 10% of total sablefish catch, but this proportion increased rapidly starting around 2016 and reaching a peak of 39% in 2020 (Table 3.1; Figure 3.4). Recent increases in trawl fishery sablefish catch are predominantly from the BS due to the increased prevalence of small sablefish from recent strong year classes on the primary fishing grounds in the EBS (Figures 3.3). Although most sablefish catch in trawl gears are incidental, haul-specific targeting

of sablefish has risen, particularly in the CG and WG, as part of other directed bottom trawl fisheries likely due to the increasing prevalence of sablefish. Over the last two decades, the majority of sablefish catch in trawl gears has occurred in the CG (0.5 – 2kt), but since 2018 catch in the BS has increased rapidly (~1 – 5kt) as has the catch in the AI (~0.5 – 1.25kt). The increase in the BS and AI is attributable to the rapid increase in small sablefish due to strong recruitment since 2016, which have typically been first encountered in the BS and AI (see Appendix 3D), particularly in the pelagic trawl fisheries on the EBS shelf (Appendix 3M).

Five State of Alaska fisheries land sablefish outside the IFQ program, including those in Prince William Sound, Chatham Strait, and Clarence Strait with minor fisheries in the northern GOA and AI. The minor state fisheries were established by the State of Alaska in 1995 at the same time that the Federal Government established the IFQ fishery, primarily to provide open-access fisheries to fishermen who could not participate in the IFQ fishery. State catch from the northern GOA and AI minor fisheries are included in the current assessment, because they are reported using the area code of the adjacent Federal waters in the Alaska Regional Office Catch Accounting System (CAS), the source of the catch data used in the assessment. Major state fisheries in the Northern Southeast Inside (NSEI) or Southern Southeast Inside (SSEI) waters are managed and assessed by the ADFG and catch associated with these fisheries are not included in the model.

Further details on the Alaskan sablefish fisheries can be found in the 2024 SAFE (Appendices 3D – 3F) as well as the sablefish Ecosystem and Socioeconomic Profile (ESP), which includes summaries of various fishery socioeconomic metrics.

Management Measures and Bycatch

A summary of historical catch and management measures pertinent to sablefish in Alaska are provided in Table 3.2. As noted, the sablefish fixed gear fishery transitioned to IFQs in 1995 to avoid the growing derby-style fishery dynamics. Recently, the legalization of pot gear in the GOA in 2017 has had a monumental shift on gear usage, leading to a rapid transition from a predominantly hook-and-line fixed gear fishery to one composed primarily of longline pots since 2021 (Cheng et al., 2024a). Under current regulations, release of any sablefish by the sablefish IFQ fishery is prohibited, as long as there is remaining IFQ for persons onboard the fishing vessel. Following recent extreme recruitment of sablefish starting around 2014, markets for sablefish have become flooded causing socioeconomic downturns and resulting in upwards of 50% of the Alaska sablefish quota being left unharvested in recent years (Goethel et al., 2025). The NPFMC is currently exploring options to loosen full retention requirements based on requests from stakeholders to be able to release small, low value fish (NPFMC, 2024; Goethel et al., 2025; https://shinyfin.psmfc.org/small_sablefish/).

Sablefish discards in groundfish target fisheries are dominated by trawl fisheries in recent years, primarily in the BSAI due to an influx of recent large year classes in the BS, but discards have declined substantially starting in 2023 albeit with a slight uptick in the GOA trawl fisheries in 2026 (Table SM3.3). Bycatch of federally managed groundfish species in the sablefish target fishery has primarily been composed of shortspine thornyhead, arrowtooth flounder, halibut, skates, and shortraker and rougheye rockfish (Table SM3.4). Amounts of incidental catch increased drastically (by upwards of three-fold) in 2024 for many flounder and rockfish species, but have since returned to low levels. In terms of non-target bycatch, grenadiers are consistently the primary species encountered in the target sablefish fishery (Table SM3.5). The predominant prohibited species catch (PSC) in both the BSAI and GOA sablefish target fisheries is golden king crab and Tanner crab (Table SM3.6). The numbers of king crab caught by pot gear in the GOA and BSAI have increased drastically since 2025.

Data

A variety of data sources are included in the assessment and were updated for 2026 (as available; Table 3.3), including fishery catch (Figure 3.4; Table 3.1), fishery and survey compositional data (Tables 3.4 – 3.5), and various indices of abundance and biomass (Figures 3.6 – 3.11; Table 3.6). All data is pulled directly from the Alaska Fisheries Information Network (AKFIN) database, which maintains and hosts fishery catch, observer, and survey data for the Alaska region. All data is QA/QC'd by the collection agency prior to uploading to the AKFIN database. For further information on data collection protocols, estimation procedures, and quality assurance measures see the associated documents and webpages (e.g., Alaska Regional Office Catch Accounting System for fishery catch, North Pacific Observer Program for fishery biological samples, the NOAA Longline Survey for fishery independent indices and biological samples, and the AFSC Age and Growth Program for otolith age determination).

Data Used in the Assessment

Fixed Gear and Trawl Fishery Catch and Compositions

For all fishery data, data streams for two fleets are created: fixed gear and trawl gear (Figure 3.4). The fixed gear fleet represents a combination of the historic Japanese fleet and the current U.S. domestic fleet combining both hook-and-line and pot longline gear. Given the lack of reliable historic composition data to estimate selectivity, the Japanese fleet cannot be independently partitioned. Conversely, because the recent transition from hook-and-line to longline pot occurred so rapidly (<5 years) and the apparent similarity in selectivity between these gear types, combining hook and pot gear into a single fixed gear fleet has been deemed adequate (Cheng et al., 2024a,b). Similarly, given the lack of age data and limited length frequency sample sizes, all trawl gears (i.e., bottom and pelagic) are combined into a single trawl fleet.

Length, catch, and effort data were historically collected from the Japanese and U.S. fixed gear and trawl fisheries, and are now collected from U.S. fixed gear and trawl fisheries. The Japanese data were collected by fishermen trained by Japanese scientists. The U.S. fishery length and age data are collected by at-sea and plant observers. No otoliths were collected from the fisheries until 1999, because of the difficulty of obtaining representative samples from the fishery, and otoliths are only routinely collected from the directed fixed gear fishery (not the trawl fishery). Observer coverage, and resulting biological sampling, varies by region due to the level of fishing effort, sampling strata of associated vessels, and the amount of electronic monitoring (EM) in the region and sampling strata (e.g., EM coverage is much higher for fixed gear vessels in the CG and EG; see summary of fishery data collection in Appendix 3F of the 2024 Sablefish SAFE).

The catch used in this assessment (Table 3.1) represents total catch (landings plus bycatch or discards -- which are minimal in the fixed gear IFQ fishery -- assuming 100% mortality), and includes catch from minor state-managed fisheries (i.e., these are reported by federal statistical areas and directly incorporated into the NOAA catch accounting system) in the northern GOA and in the AI region (constituting about 1% of the average total catch). Additionally, all non-commercial sablefish removals (see Table 3.1) are integrated into the fixed gear fishery catch, including research catches and Alaska state sport fishery removals not associated with the NSEI or SSEI waters fisheries, as well as estimates of whale depredation from hook-and-line gear (see next section). Trawl fishery catch is summed across all trawl gear types (e.g., bottom and pelagic) with widely differing distributions and targeting. For instance, pelagic trawls primarily catch smaller sablefish as bycatch in the EBS pollock fishery, whereas bottom trawls catch larger sablefish across the Alaska region occasionally during targeted hauls. For the assessment, terminal year catch is interpolated through the end of the terminal year (to account for catch from October 1st through the December 31st) based on the three year average (for complete fishing years) ratio of catch from October 1st through December 31st compared to the rest of the year.

Age compositions from the U.S. fixed gear fishery are available since 1999 with relatively consistent

sample sizes (~1,200 otoliths aged yearly; Tables 3.4 and 3.5), and sex and length data recorded for each otolith. However, due to AFSC capacity limitations, the number of sablefish fishery otoliths aged has declined in recent years (e.g., only 600 otoliths were read in 2025), and it is unclear how many sablefish otoliths will be aged annually moving forward. Aged sablefish otoliths are available the year following collection (i.e., there is a one year lag for use in the assessment), and the total number of aged otoliths varies slightly due to otolith damage or issues during the age reading process (Table 3.5). To ensure representative composition data for the entire population, a random sampling protocol (e.g., across size, sex, and haul) is first used to identify which fishery otoliths to age in a given year. The goal is to choose ~200 otoliths from each of the six management regions, where regional allocations are adjusted slightly when any given region does not have the requisite number of samples. Next, a weighted mean is used to determine the population aggregate, sex-specific age compositions to ensure a representative estimate of catch-at-age by sex. The regional age proportions are calculated across both sexes and weighted by total catch in numbers by region (to better reflect recruitment as opposed to older fish – as is the case when weighting by catch in biomass). Because the joint approach to fitting compositions is used for all models (Cheng et al., 2025c), a single vector of compositions that sums to one across both sexes and all ages is calculated each year, hence this single vector for each region is weighted by total regional catch and not sex-specific catch. Finally, the weighted average (by catch in numbers) is taken across all regions to provide the final vector of population age compositions across both sexes. The two-stage protocol ensures adequate samples from across Alaska, such that differences in composition data by region are taken into account, while simultaneously avoiding over-weighting regions with lower catch. For models that disaggregate regions or fleets as regions (e.g., spatially explicit or implicit models, see Appendix 3C and 3D), weighted averages are no longer needed as the raw age compositions from a given region can be used directly (except when modeling the GOA as a single unit, then the same weighted average approach is used but just for regions within the GOA). Length compositions from the fixed gear fishery are collected but not used in the assessment models.

Only length data is available from the trawl fishery and sample sizes are generally much lower than in the directed fisheries, representing a mixture of lower sablefish catch and different observer protocols in non-directed fisheries (Tables 3.4 and 3.5). To obtain representative catch-at-length, the same approach using regional catch (in numbers) weighted averages as the fixed gear fishery age compositions is used to construct a single vector of population level trawl length compositions across sexes. As with fixed gear fishery age compositions, trawl fishery length compositions are available to the assessment on a one year lag from data collection. Only years with at least 300 length samples are used in the assessment.

Whale Depredation

Whale depredation on hook-and-line gear has been pervasive in the fishery, so a general additive modeling (GAM) approach for estimating fixed gear fishery whale depredation was developed (Peterson and Hanselman, 2017) and the model estimates were updated in 2022 (Goethel et al., 2022). The two-step modeling approach estimates total fishery depredation based on observer and high-resolution catch data (i.e., in 1/3° by 1/3° bins). First, the impact on depredated sets (i.e., a CPUE reduction factor) is estimated using a Generalized Additive Mixed Model (GAMM). Next, a Generalized Additive Model (GAM) with a zero-inflated Poisson distribution is used to determine the proportion of sets in an area depredated by whales. The total depredation is then determined based on the number of sets depredated per grid, the reduction in catch per depredated set, and the total catch per grid. Estimated depredation has generally been below 1,000 t per annum, often composing less than 1% of the total catch in recent years. Despite low overall impact relative to total catch, depredation varies by area and species with orca depredation higher in western regions (primarily the WG) and sperm whale depredation more significant in the CG and EG (Figure 3.5). Whale depredation estimates are added to the fixed gear catch and accounted for in associated catch projections (i.e., in the final whale-depredated catch recommendation values). Since 2023, fishery whale depredation values have been held constant at 2022 levels (131 t), per SSC recommendations (i.e., the depredation model is no longer updated annually).

NOAA and Japanese Longline Survey Indices and Compositions

Japan and the U.S. conducted a cooperative fixed station Alaska-wide longline survey for sablefish annually from 1978 (the first year was experimental and not included in indices) to 1994 (herein termed the 'Japanese Longline Survey'; Sasaki 1985; Sigler and Fujioka 1988). In 1988, NOAA instigated a domestic longline survey for sablefish (herein termed the 'NOAA Longline Survey') that has been conducted annually in the GOA with the aim of continuing the Japanese Longline Survey methodology, and was expanded to biennial sampling of the AI starting in 1996 and biennial sampling of the eastern BS starting in 1997. Catch, effort, age (since 1996 and sporadically on the Japanese survey), length, and weight (since 1996) have been collected annually. Relative population abundance in numbers (RPNs) are computed using survey catch rates scaled to management area sizes, except for initial survey years (i.e., the RPN time series begins in 1990; Kimura and Zenger, 1997).

The NOAA Longline Survey operates on a cost-recovery basis, where the sale of the catch offsets the cost of the survey. Due to market conditions and vessel availability, the longline survey was cancelled in 2024. Starting in 2025, a new survey contract led to a shortened schedule, resulting in an unforeseen change in experimental design. The GOA is now sampled in odd-numbered years and the BS and AI are sampled in even-numbered years. Details on the survey operations and recent trends can be found in Siwicke and Malecha (2026).

Longline gear is unable to estimate absolute population numbers or biomass, but it can provide a relative index, in this case a relative population number (RPN). Catch per unit effort (CPUE, $\hat{\theta}_{i,j,k}$) from station (*i*), depth strata (*j*), and geographic area (*k*) is calculated as

$$\hat{\theta}_{i,j,k} = \frac{n_fish_{i,j,k}}{n_skate_{i,j,k}},$$

where $n_fish_{i,j,k}$ is the number of fish caught and $n_skate_{i,j,k}$ is the number of skates of gear at station *i*, depth stratum *j*, and geographic area *k*, after filtering out skates of gear with > 5 ineffective hooks and adjusting the number of fish to a standard 45-hook skate. These are used to get an estimate of the mean CPUE for depth stratum *j* and geographic area *k*

$$\mathrm{E}\left[\bar{\theta}_{j,k}\right] = \frac{\sum_i \hat{\theta}_{i,j,k}}{n_{j,k}},$$

where $n_{j,k}$ is the number of station-level CPUE observations within depth stratum *j* and geographic area *k*. The associated sample variance of CPUE by depth stratum *j* and geographic area *k* is

$$\hat{V}\left[\bar{\theta}_{j,k}\right] = \frac{\sum_i (\hat{\theta}_{i,j,k} - \bar{\theta}_{j,k})^2}{n_{j,k}}.$$

Each depth stratum within a geographic region has an area weight ($w_{j,k}$) which is used to scale the CPUE to an RPN ($\bar{\psi}_{j,k}$) for each depth stratum *j* and area *k*

$$\mathrm{E}\left[\bar{\psi}_{j,k}\right] = \bar{\theta}_{j,k} w_{j,k},$$

These RPNs can then be summed across depth strata and geographic areas to provide regional or management area RPNs for areas sampled. Area sizes were refined in 2014 (Echave et al., 2013). The total

RPN variance of an area ($\hat{V}[\hat{\psi}_k]$) combines sample variance of CPUE and area sizes with covariance of CPUE among depth stratum:

$$\hat{V}[\hat{\psi}_k] = \sum_j w_{j,k}^2 \hat{V}\left[\bar{\theta}_{j,k}\right] + 2\sum_j \sum_{m \neq j} cov\left[\bar{\theta}_{j,k}, \bar{\theta}_{m,k}\right],$$

where *j* and *m* are different depth strata in the same region. These variances can be summed with the associated RPNs to regional or management areas.

For use in single region assessment model (this does not apply to Model *26.2_FAA*), an interpolation is necessary for unsurveyed regions in a given year. The interpolation ensures that the resulting index represents the entire Alaska-wide population in a given year, avoiding annual fluctuations due to differences in survey coverage in even and odd years. By creating a single consistently scaled index, the assessment model can assume a time-invariant catchability (*q*) scalar instead of trying to estimate time-varying catchability and implicitly losing information on population trends and scale. In past assessments, for years when the BS and AI were being biennially sampled, estimates for RPNs in off-years (*y*) for a given region were interpolated from the previous year RPN in that region based on an assumption of a proportional change as the annually sampled GOA:

$$RPN_{AI,y} = RPN_{AI,y-1}\frac{RPN_{GOA,y} - RPN_{GOA,y-1}}{RPN_{GOA,y-1}},$$
$$RPN_{BS,y} = RPN_{BS,y-1}\frac{RPN_{GOA,y} - RPN_{GOA,y-1}}{RPN_{GOA,y-1}}.$$

Interpolating the BS or AI based on the GOA trends (termed 'GOA_Extrap') generally aligns with the assumption of a single population across Alaska, which is supported by the high mobility of sablefish and cross-region movement (see tagging section below). However, it ignores potential depth-based shifts in demographics that may differ among these large regions, as well as recent differences in RPN trends for the AI and BS which have increased more rapidly than the GOA (Figures 3.8 – 3.9).

With the 2025 survey redesign, the GOA interpolation approach is no longer feasible as the GOA is only surveyed in odd years. Thus, a new approach was implemented termed the 'carryover' interpolation, where holdover RPN values from the last time a given region (*k*) was surveyed (*y-1*) are used for interim years (*y*) between survey sampling events:

$$RPN_{k,y} = RPN_{k,y-1}$$

The carryover interpolation ensures a consistent scaling similar to the previous GOA interpolation method, but relies solely on an assumption of steady-state regional dynamics. Ultimately, the population trends between the GOA and carryover interpolation approaches remain similar, but the GOA interpolation approach predicts more rapid recent growth with higher interannual variability (Figure 3.7).

For Model *26.2_FAA*, no interpolation is required and regional NOAA Longline Survey indices are constructed based solely on the observed data in a given year. Regional indices were constructed for the BS, AI, and GOA by summing RPNs from stations within the associated regions. Thus, the regional indices represent only the 'observed' survey data and, when summed across regions, are less than the single region interpolated indices by the amount of the interpolation in a given year (Figure 3.7).

Historically, the NOAA Longline Survey indices have also utilized an extrapolation within the AI region to account for a decrease in survey coverage of western AI stations between the Japanese and NOAA Longline Surveys. Mainly, the NOAA Longline survey has not sampled the northwestern or southwestern

AI, given logistical constraints and associated costs with sampling remote regions of Alaska. Thus, extrapolations have been used to estimate the unsampled western AI RPNs in even-numbered years based on ratios between the western and eastern AI from the Japanese survey from 1983 to 1994. The northwestern AI is extrapolated from the observed northeastern AI RPNs based on a fixed ratio of 0.1820, while the southwestern AI is extrapolated from the southeastern AI RPNs based on a fixed ratio of 0.6581. The western AI extrapolation implicitly assumes a proportional, time-invariant linkage in regional population trends between the northwest or southwest AI with the northeast or southeast AI, respectively. However, the extrapolation methods do not account for numerous quantitative and experimental design changes that have occurred in the 30+ years since they were calculated (e.g., changes in area sizes). Therefore, given the low reliability of these extrapolation methods, the lack of observed data from the western AI, and the rapid changes in Alaska-wide sablefish population dynamics, it was deemed appropriate to remove the western AI extrapolated stations from the AI RPNs for 2026.

Finally, whale depredation on the NOAA Longline Survey is accounted for by removing stations or adjusting area-RPNs depending on the form of depredation. Sets impacted by killer whale depredation are removed from calculations, because of the significant and variable impacts killer whales can have on catch rates. For sets impacted by sperm whale depredation, which is more difficult to detect, catch rates are inflated (i.e., an inflation factor of 1.18 or 1/0.85) based on depredation estimates from an area-wide Generalized Linear Mixed Model (GLMM) using year, depth strata, station, management area, and total number of effective hooks as explanatory variables (Hanselman et al., 2018a). The standard error and covariance of this estimate is included in the total variance of the RPNs. Because sperm whale depredation only occurs on a subset of the stations, the overall increase in the RPN index is modest, ranging from 1 - 5 % over time (Figure 3.10). The correction by area is minimal, but generally most impactful in EG stations.

The lowest RPN values in the NOAA Longline Survey time series occurred in 2013 for the GOA (Table 3.6), but have increased rapidly with new time series highs continually being reached each year (Figures 3.6 – 3.8; aside from the BS in 2026). However, population growth appears to be leveling off, with GOA index undergoing a slight 4% increase in 2025 (Figure 3.8). Conversely, in 2026 the AI underwent a 26% increase compared to 2022, whereas the BS saw a 14% decline compared to 2023. This represents the first time since the early 2010s that regional indices have demonstrated opposing trends or declined by a significant margin. Overall, the survey abundance and biomass remains nearly evenly distributed between the GOA and the BS/AI (Figures 3.8 – 3.9). For SSC requested sensitivity runs and alternative apportionment options, REMA was also applied to the regional Longline Survey data to smooth and interpolate indices as an alternative to the carryover interpolation. Not surprisingly, the resulting indices did not differ widely from the regional or AK-wide indices (Figure 3.11).

Since 1996, a random sample of otoliths has been collected and aged (~1,200 per year; Tables 3.4 – 3.5) from the NOAA Longline Survey, where survey protocols require otoliths be taken if a sablefish is caught on the first hook of a skate (Siwicke and Malecha, 2026). A similar two stage method as is used for the fixed gear fishery age compositions is used for the Japanese and NOAA Longline Survey age compositions, where a random selection of otoliths are aged, then regional compositions are weighted by regional RPNs to determine a weighted average population level survey age compositions. For the random sampling, there is a goal of aging ~900 otoliths from RPN stations (i.e., those that are used in the assessment) and 300 from gully (not included in the RPN index) stations. Of the 900 otoliths from RPN stations, there was an annual target of 600 from the GOA and 300 from either the BS or AI (depending on which region was surveyed). Historically, the number of GOA RPN otoliths that were aged was ~700 due to insufficient otoliths from other strata (Table 3.5). With survey changes in 2025, new targets include ~900 aged otoliths from the GOA and 300 from gully (non-RPN) stations in odd years, then 600 each from the BS and AI in even years. As noted, the regional age compositions are weighted by RPNs in each region to obtain a representative estimate of survey catch-at-age. For models that fit to regional data, the weighted average only needs to be applied within regions with multiple areas (i.e., the GOA). Age compositions are available to the assessment

on a one year lag from data collection. Length data are collected from the NOAA Longline Survey, but not used in the assessment model.

From 1979 – 1994 otolith collections from the Japanese Longline Survey were length-stratified and only aged sporadically (approximately biennially; Table 3.4). Length compositions were collected annually and used in the assessment to enable stable estimation of survey selectivity parameters. As with other composition data sources, the regional Japanese Longline Survey age and length compositions were weighted by regional RPNs to achieve a representative population level survey catch-at-age.

Biological Inputs

Because the assessment model is age-structured, but length data from the Japanese Longline Survey and trawl fishery must be fit, a size-age transition matrix must be constructed based on mean length estimates (with uncertainty) from a growth curve. Two time blocks (pre- and post-1996) of growth are assumed in the assessment to account for potential changes in growth between historical and recent periods, and address changes in data collection protocols on the NOAA Longline Survey. For instance, before 1996 otolith collection was length-stratified and no weights were collected, while random otolith collection and weight sampling began in 1996. Age-length pairs from the Japanese Longline Survey are utilized to estimate pre-1996 growth parameters, based on bias-corrected age-length pairs (Echave, 2021). Thus, these growth parameter estimates remain unchanged from previous assessments (see Goethel et al., 2021). For the post-1996 time block, growth schedules (length-at-age and weight-at-age) were re-estimated using the NOAA Longline Survey age and length data from 1996 through 2025, with estimation assuming a von Bertalanffy growth function. Estimation of growth followed the methods established and approved in previous assessments (Echave, 2021). Sablefish growth exhibits strong sexual dimorphism with males reaching a much smaller maximum size, despite similar growth over the first ~5 years of life (Figure 3.12). In general, updated growth estimates were largely consistent with prior values (Table SM3.7). However, growth rates among younger individuals declined across both sexes, likely attributable to the influence of decreased growth rates of recent cohorts due to density dependence from extreme recruitment events (Cheng et al. 2025a). Size-age transition matrices were constructed using the re-estimated growth curves with normal error fit to the standard deviations of the collected lengths-at-age, which generally aligned across time blocks and with previous estimates (Figure 3.13).

Given the larger maximum sizes achieved by females, the resulting maximum weights achieved are also much higher (Figure 3.14). Not surprisingly, the associated weight-at-age for females is higher, especially as males approach their asymptotic maximum size starting around age-15 (Figure 3.15). Sablefish maturity schedules were developed based on histological data using an age-based logistic regression (Table SM3.7; see Williams and Rodgveller, 2021).

Sablefish are difficult to age, especially those older than eight years (Kimura and Lyons 1991). To compensate, an ageing error matrix based on known-age otoliths collected from tagged young-of-the-year fish is used (Heifetz et al. 1999; Hanselman et al. 2012). The ageing error matrix is directly incorporated into the assessment to account for uncertainty in the ageing process.

Sablefish first appear on the upper continental slope, where the longline survey and longline fishery occur, at age-2, with a fork length of about 45 cm. A higher proportion of young fish are susceptible to trawl gear compared to fixed gear. Trawl fisheries usually occur on the continental shelf and shelf break inhabited by younger fish. The transition towards pot gear in the fixed gear fishery may allow a higher proportion of small fish to be selected, but the location of fixed gear fishing activities (e.g., size-based targeting of more valuable larger fish) and the optional use of escape rings may limit the number of small sablefish retained by pots. Given these considerations, recruitment in the assessment occurs at age-2, which is when fish

primarily become susceptible to the various gears. Based on analysis of NOAA Longline Survey sex-specific age data, a 50:50 sex ratio is assumed at the age of recruitment (i.e., age-2).

Sablefish are a relatively long-lived species with a maximum observed age in Alaska of 94 years (Kimura et al., 1998). However, relatively few fish older than age-31 are seen within the age composition data, aside from a few years of high catch rates of particularly old fish in the AI during the 2010s (SM3C.42). Thus, based on the age composition data, a maximum age of 31 (modeled as a plus group) is assumed. Given the complex and sex-specific population dynamics, estimating natural mortality (M) within the assessment is difficult. Thus, a prior for M is required. The M prior was updated in 2025 [$\sim N(\ln(0.085), 0.1^2)$] based on estimates of natural mortality from previous tagging models (0.0852 from Hanselman et al., 2018b), while also considering realistic average longevity values and estimates of sablefish natural mortality from assessments on the US west coast and British Columbia (See Goethel and Cheng, 2025). In terms of longevity, a mean of 0.085 corresponds to a maximum age of ~65 years (Hamel and Cope, 2022), which was deemed appropriate, on average, because there are only 6 fish >70 years in the survey age compositions. The US west coast trawl survey observes slightly more older sablefish, and the associated longevity based prior in the west coast sablefish assessment was based on a maximum age of 75 resulting in a prior of $\sim N(0.072, 0.31^2)$. The final estimate of natural mortality from the west coast sablefish assessment was 0.088 (Wetzel et al., 2025). For British Columbia, sex-specific natural mortality is estimated as part of the management procedure process, where female M is ~0.094 and male M is ~0.05 (DFO, 2023).

Data Input Changes for 2026

Newly available data since the 2024 assessment that were used in the assessment model for 2026 (Table 3.3), include:

- Length data from the trawl fisheries for 2024 and 2025.
- Age composition data from the fixed gear fishery for 2024 and 2025.
- All compositional data by sex are disaggregated.
- Finalized catch for 2024 and 2025 as well as initial and imputed catch for 2026.
- The NOAA Longline Survey abundance indices for 2025 in the GOA and 2026 in the BS and AI.
- The NOAA Longline Survey age composition data for 2025.
- Updated length- and weight-at-age estimates using survey age-length-weight data through 2025.
- The input sample size (ISS) for composition data utilized a relative scaling within gears/surveys to maintain information on sampling across years (previously a static ISS was used for each gear).

Data that were removed from the proposed assessment models for 2026 compared to the 2024 assessment, include:

- The fixed gear fishery CPUE index, including the historical Japanese CPUE (1964 – 1981) and the domestic CPUE (1995 – 2022).
- The fixed gear fishery length composition data for all years.
- The NOAA Longline Survey length composition data for all years.
- For the NOAA Longline Survey index, western AI extrapolated station (these stations have never been surveyed by the NOAA Longline Survey) relative population numbers (RPNs) were removed from the index and apportionment.

Available Data Not Used in the Assessment

NOAA Gulf of Alaska Trawl Survey

Since 1984, NOAA has conducted triennial or biennial multispecies trawl surveys in the GOA on the upper continental slope to 500 m depth. GOA trawl survey biomass indices were not used in the assessment model prior to 2007, because they were not considered good indicators of the relative biomass of adult sablefish

since the full range of sablefish habitat is not sampled and sablefish may also outswim the net. Beginning in 2007, trawl survey indices were integrated into the assessment, primarily as an index of juvenile sablefish biomass. However, recent evidence suggests that the NOAA Longline Survey provides an adequate indicator of incoming recruitment strength, while signals regarding recent cohort strength in the longline survey data have countered those observed in the trawl survey, and the indices themselves strongly diverged in 2023 (Figure 3.6). Thus, the trawl survey index was again removed from the assessment in 2025 (See Goethel and Cheng, 2025). The GOA trawl survey index was at its lowest level of the time series in 2013, more than quadrupled until 2021, then declined precipitously by ~50% in 2023 and remained relatively stable in 2025 (Figure 3.6; Table 3.6). Lengths are sampled during each survey year (Table 3.4). AI and BS trawl survey biomass estimates are also available, but not used in the assessment model given their relatively low sablefish biomass estimates, high sampling error, and relatively short time series, especially in the BS.

Fixed Gear Fishery Catch-per-Unit Effort Index

Based on Japanese longline fishery catch rate data, a nominal index of historical CPUE was previously included in the assessment from 1964 – 1981 (Table 3.6). For the domestic fixed gear fishery, records of catch weight and effort for vessels that target sablefish are collected by observers and also reported by vessel captains in voluntary and required logbooks. A combined gear (i.e., including data from both hook-and-line and pot gear) standardized fixed gear CPUE index was developed (Cheng et al., 2023) and used in previous assessments (Table 3.6; Goethel and Cheng, 2024). However, the logbook data needed to produce the standardized index is no longer available to NOAA, and the last year of the CPUE index is 2022. Although the CPUE index generally matches trends in the NOAA Longline Survey relative population weights (RPWs), the CPUE index generally lags the RPWs by several years (likely due to the fishery targeting larger fish and CPUE better representing mature biomass, whereas the RPWs better reflect total biomass; Figure 3.6). Given that the CPUE index can no longer be updated and the likely issues with standardizing for management and gear changes, the CPUE index was removed from the assessment in 2026 (See Appendix 3B). Likewise, the Japanese CPUE index was removed, since it cannot be standardized and given the lack of information on the provenance of the underlying data.

NOAA Longline Survey and Fixed Gear Fishery Length Compositions

Extensive length data from the NOAA Longline survey and fixed gear fishery are available, where survey length data are available in the year of collection while fishery length data is available on a one-year lag. Length data were randomly collected for all years since 1990 for both the survey and fishery. Given the difficulties in adequately addressing assumptions for fitting length data in an age-structured assessment (e.g., accounting for time-varying growth and seasonal growth dynamics), length data has been removed for all data sources that otherwise have age data from which selectivity can be estimated (i.e., the Japanese Longline Survey and trawl fishery are the only fleets for which length data is retained and fit in the model; see Appendix 3B; Goethel and Cheng, 2025).

Tagging Data

The spatial distribution and movement of sablefish have been studied by the Alaska Fisheries Science Center (AFSC) through various forms of tagging data, including traditional anchor tags, electronic archival tags, and pop off satellite tags. Tagging occurs on the NOAA Longline Survey and approximately 5% of the longline survey catch of sablefish are tagged and released each year, which generally equals about 3,000 – 3,500 fish per year. Since 1972, approximately 413,000 sablefish have been tagged in Alaska waters, of which over 38,500 have been recovered. The AFSC sablefish tag program has one of the longest time series of groundfish tag data in the nation. These data have been used to examine movement patterns, evaluate areal apportionment strategies of annual catch quotas, validate ageing methods, examine growth and

mortality, and develop spatially explicit tagging and assessment models. Additionally, the AFSC conducts a GOA juvenile tagging program that has released 42,625 juvenile sablefish with conventional tags and 1,082 electronic archival tags have been implanted, with 2,630 conventional tag returns and 41 electronic tag returns. Because of the known-age (age-1) of juvenile sablefish, this tagging program provides valuable information that differs from the tagging of adults on the NOAA Longline Survey. Tagging of known-age juveniles before they leave coastal areas offers an opportunity to document age-specific movement, that is, recoveries of known-age fish provides information on the age at which fish become available to the fisheries (Maloney and Sigler 2008). Recoveries of known-age fish can also provide evaluation of ageing methods, such as otolith reading, enabling the development of ageing error matrices (Heifetz et al. 1999; Hanselman et al. 2012).

Recovered tags from both programs are either physically returned to the Auke Bay Laboratory with a prepaid business reply envelope or are reported with the tag reporting application that can be downloaded for free to a mobile or tablet device. Typical information given by the respondent and collected is: (1) tag number, (2) date of capture, (3) location, (4) size of fish, (5) sex, (6) depth of capture and (7) gear type. In recent years, as many as 500 to 1,000 tag recoveries have been submitted per year. The number of individuals returning tags varies widely. Many fishers and processors associate the tagging programs with the NMFS observer program and utilize observers onboard fishing vessels and in processing plants to collect and return all tags from that particular vessel or plant. The usual number of non-NOAA people participating ranges between 300 and 400 annually.

Existing data sets are used to match recovery and release information for each tag submitted. With each tag recovery, a small reward (hat) is offered along with a brief letter describing the history of the fish in terms of movement and growth. Additionally, an annual tag reward lottery drawing is held in which all tags recovered in the past year are entered into a drawing for a monetary reward. These incentives are to encourage participation and improve tag recovery rates.

Further information on the tagging program and the data can be found in the most recent report to industry on the sablefish tag program (Echave et al., 2013) and at the AFSC groundfish tag website found at https://apps-afsc.fisheries.noaa.gov/maps/tagmap/tagmap-v2/combined.php. The tagging data has been analyzed extensively via tagging studies (e.g., Maloney and Sigler, 2008; Hanselman et al., 2015; Kapur et al., 2025) and is integrated directly into the spatially explicit model recently developed for sablefish (Cheng et al., 2025d; See Appendices 3D and 3K).

Population Trends in Nearby Regions Not Incorporated in the Assessment Model

Alaska Northern Southeast and Southern Southeast Inside Waters

Sablefish in the Northern Southeast Inside (NSEI) Subdistrict waters and Southern Southeast Inside (SSEI) Subdistrict waters of Alaska are treated as separate stocks from the federal population, but some migration into and out of Alaska federal and state waters has been confirmed with tagging studies (Hanselman et al. 2015). NSEI sablefish continue to demonstrate similar population trends as the federal stock with strong recent recruitment observed, particularly the 2016-year class, which is now over 50% mature and comprises approximately 32% of the biomass (Figure 3.16). The NSEI longline survey CPUE has remained substantially above the long term mean since 2020 with minimal variation over the last three years. However, estimates from the 2023 stock assessment suggest sablefish spawning stock biomass remains at lower levels than estimated during the 1980s and 1990s. In SSEI waters, the longline survey CPUE showed a 40% increase from 2022 to 2023 (Figure 3.16). The SSEI pot fishery CPUE increased 10% from 2022 to 2023 while the SSEI longline fishery CPUE decreased in recent years, most likely due to a substantial shift from longline gear to pot gear. Alaska state fisheries are seeing a similar rapid transition from hook-and-line gear to pot gear as the federal fishery.

Canada

The estimated biomass trend for the British Columbia (BC) stock of sablefish is similar to that in Alaska federal waters, with strong increases in the mid-2010s due to above average recruitment in 2016 – 2017. Spawning stock biomass has shown consistent increases in recent years (Figure 3.17). The survey index value in 2023 was 10% less than the 2022 value, but still in line with the above-average levels seen since 2018. Total allowable catches (TACs) for the BC Sablefish stock are determined using a surplus production model implemented as part of a management procedure approach chosen through management strategy evaluation (Kendra Holt, pers. comm.).

United States West Coast (Washington, Oregon, and California)

The United States West Coast stock of sablefish was most recently assessed by NOAA's Northwest Fisheries Science Center in 2025. At the beginning of 2025, spawning output (i.e., the biomass of mature females) was estimated at 74,409 metric tons (t), corresponding to a stock status of 33.9% relative to unfished conditions. The population declined rapidly from the mid-1970s to levels below the minimum stock size threshold (MSST) by the mid-1990s. From 2000 to 2020, spawning output remained relatively stable but below the MSST. Since 2020, however, the population has increased steadily, reaching its highest spawning output since 1989 (Figure 3.18). This recent increase is driven by several above-average recruitment years since 2013, including strong cohorts in 2013, 2016, 2020, 2021, and 2023 (Figure 3.18). Recruitment estimates for 2024 remain highly uncertain at the time of the assessment. Stock size and status are projected to continue increasing over the next several years, with spawning output expected to surpass the management target ($B_{40\%}$) by 2027, even under projected catches that are considerably higher than the recent average (5,651 t per year over the last five years).

Pacific Sablefish Transboundary Assessment Team (PSTAT)

Concurrent sablefish trends seen in Alaska, Canada, and the West Coast highlight the need to better understand the contribution to Alaska sablefish productivity from other areas and vice versa. A Pacific Sablefish Transboundary Assessment Team (PSTAT) consisting of scientists from the U.S. (west coast and Alaska regions, including both federal and state scientists) and Canada has been working to better understand the dynamics, population trends, and biology of sablefish across the eastern Pacific Ocean (https://www.pacificsablefishscience.org/). The PSTAT has engaged in a multi-year research endeavor that produced three key products: 1) a tagging model estimating movement across the northeastern Pacific (Kapur et al., 2025); 2) a spatially structured, data-conditioned operating model (OM), and 3) the development of an MSE for the transboundary sablefish stock, with seven management strategies explored (Kapur et al., 2024). No future meetings are scheduled due to lack of future funding for PSTAT work.

Analytic approach

Model Structure

Model *26.2_FAA* is the author recommended model for 2026. A Center for Independent Experts (CIE) peer review of the sablefish assessment occurred in June 2026, where all aspects of the modeling approach were reviewed over the course of a three day in person meeting. The reviewers dissected both Model 2*6.2_FAA* and Model *26.1_1Reg* along with numerous alternatives and sensitivity runs (as highlighted in Appendices 3A – 3F, including an off cycle SAFE document that included results from both models). For the provision of sablefish management advice, the independent panel concluded that Model *26.2_FAA* was the most appropriate and scientifically defensible of the models explored (CIE reviewer reports are available in Appendices 3H – 3J and are summarized in the 2026 September JPT Sablefish Report in Appendix 3G).

The assessment model is implemented in the generalized RTMB based Stochastic Populations over Regional Components (SPoRC) stock assessment R package (Cheng et al., 2026; https://chengmatt.github.io/SPoRC/index.html), which utilizes the integrated analysis paradigm (Maunder and Punt, 2013). Model *26.2_FAA* utilizes a spatially implicit fleets-as-areas (FAA) configuration, where the NOAA Longline Survey is disaggregated into BS, AI, and GOA fleets with each fleet having a unique index and set of age compositions. Separate catchability and selectivity parameters are then estimated for each regional survey fleet. A complete description of the general SPoRC assessment model structure as it pertains to the sablefish application is available in Appendix 3A.

All model files including input data files, R scripts for running the model and associated diagnostics, and all model outputs can be found at the 2026 sablefish SAFE GitHub repo (here).

- *26.2_FAA* (the author recommended FAA model; results available here)

Information on model bridging from previous AD Model Builder applications to SPoRC as well as recent assessment model changes and rationale is available in the 2025 model development document (Goethel and Cheng, 2025). Bridging from Model *25.12* to Model *26.1_1Reg* is provided in Appendix 3B, while development of Model *26.2_FAA* is provided in Appendix 3C. A research-oriented spatially explicit model has also been developed and is described in Appendices 3D and 3K, but not discussed further here.

Spatial Structure

The assessment model assumes a single Alaska-wide sablefish population. In Model *26.2_FAA*, the FAA configuration uses selectivity and catchability assumptions to implicitly account for spatial heterogeneity. The FAA model assumes that the 'regional' survey trends in indices and compositions represent the dynamics from a single underlying population, where survey-specific catchability (q) and selectivity estimates are used to implicitly account for varying age-specific availability (e.g., due to the survey footprint being smaller than the distribution of the population of inference or caused by ontogenetic or seasonal migration patterns; Berger et al., 2012; Waterhouse et al., 2014). Interpreting the dynamics of FAA models can be less intuitive, because each fleet is still operating on a single, homogeneous population, such that variability in indices and compositions can only be interpreted as changes in availability to a given fleet. Thus, when signals in the data (e.g., survey indices or compositions) differ for fundamental population processes (e.g., recruitment) across space, the model must attempt to rectify these differences primarily through selectivity differences, potentially leading to non-intuitive predictions (e.g., predicted survey abundance trends). The FAA model foregoes the need for using any interpolated survey data and can fit regionally disaggregated data, but may overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high). In particular, given the need for a sex-specific model for sablefish, data sparsity is of concern as compositions are partitioned by sex and region.

Age and Recruitment Dynamics

An age structured statistical catch-at-age (SCAA) framework was utilized, which tracks population numbers-at-age by sex. Sex-specific modeling was required to address sexually dimorphic growth and associated selectivity (Cheng et al., 2025b). Equilibrium age structure in 1960 (model start year) was initialized assuming exponential decay from the mean recruitment based on natural mortality and an assumption that fixed gear fishing mortality is at 10% of the mean fishing mortality. Estimated age deviations were then applied to the equilibrium age structure to define the final initial age structure.

Recruitment at age-2 is estimated based on lognormal deviations about a mean recruitment parameter. As described in Methot and Taylor (2011), a bias correction term was implemented in the stock-recruit relationship and recruitment penalty term in the objective function to ensure that recruitment estimates were

mean unbiased. The correction term was scaled linearly from 0 in data poor years (when there was little information to inform recruitment) to 0.9 in recent data rich years (when there was extensive information to inform recruitment), but then declined near the terminal year to account for lack of information on the most recent year classes. The values of the bias correction terms were iteratively tuned as described in Methot and Taylor (2011). For sablefish, the break points for the bias correction term included a start year of 1968 (i.e., start of the increasing linear ramp), a max of 0.9 starting in 1984, and a subsequent decline (i.e., start of the declining linear ramp) starting in 2023 to account for limited information in the compositional data for recent recruitment events. To ensure adequate flexibility to estimate extreme, spasmodic recruitment events the recruitment variance term (σ_R) was fixed at 0.9 for the recent period (since 1975), while historical recruitment was constrained with a value of 0.4 to aid model stability in years with no composition data.

The population was then projected forward from the initial age structure and annual age-2 recruitment assuming age-based dynamics that tracked fish from age-2 to age-31+, where the terminal age was a plus group. Exponential cohort decay was modeled via total instantaneous mortality composed of natural and fishing mortality.

Demographic Parameters

Primary demographic parameters were estimated outside the model and treated as fixed inputs, including maturity- (single time block), length- (two time blocks, pre- and post-1996), and weight-at-age (single time block; see Table SM3.7 for age-based values for all inputs). To allow fitting length data directly (i.e., in the trawl fishery and Japanese Longline Survey), predicted age compositions were converted to length compositions using input size-age transition matrices. Because sablefish can be difficult to age, an ageing error matrix was directly integrated into the assessment based on known-age otoliths (Hanselman et al., 2012). Sex-specific natural mortality is estimated with a prior [$\sim N(\ln(0.085), 0.1^2)$].

Fishery Dynamics

The model assumes two primary fishing fleets (i.e., the directed fixed gear fishery, including both pot and hook-and-line gear, and the combined trawl gear fishery) each with independent dynamics, including unique fishing mortality and fishery selectivity parameters. Each fleet had an estimated mean fishing mortality parameter and annual lognormal deviations. Selectivity was estimated by sex and fishery using a two-parameter (i.e., age at 50% selectivity, $a_{50\%}$, and the slope of the curve, k) logistic selectivity function estimated with priors [$\sim N(\ln(4),1.5^2)$, estimated in log-space]. Two selectivity time blocks were assumed for the fixed-gear fishery (1960 – 2015 and 2016 – present), roughly corresponding to the transition point between gear types from a primarily hook-and-line fishery to a primarily pot fishery (Cheng et al., 2024a,b). The trawl fishery had a single time block.

Survey Structure

Four fishery-independent survey fleets were modeled, including three regional NOAA Longline Survey and one Alaska-wide Japanese Longline Survey fleets. Each survey fleet was modeled by estimating a single catchability parameter and sex-specific logistic survey parameters (parametrized in the same way as the fishery selectivity functions), where selectivity parameters were estimated with priors [$\sim N(\ln(3),1.5^2)$, estimated in log-space]. A single selectivity and catchability time block was assumed for the Japanese Longline Survey, while the NOAA Longline Survey was modeled with two selectivity time blocks (1990 – 2015 and 2016 -- present), to address apparent changes in age-specific availability by depth and region in recent years and a single catchability time block. The NOAA Longline Survey indices were disaggregated as regional (BS, AI, and GOA) fleets. Each regional NOAA Longline Survey fleet was modeled with unique, estimated catchability and sex-specific logistic selectivity parameters (with two selectivity time

blocks).

Observation Models and Estimated Parameters

Each of the data sources (i.e., fishery catch by fleet, fixed gear fishery age compositions, trawl fishery length compositions, NOAA and Japanese Longline Survey indices, NOAA Longline Survey age compositions, and Japanese Longline Survey age and length compositions; Figure 3.19; Table 3.3) are fit directly in the model. Indices and catch utilized a lognormal error structure with yearly standard errors (SEs; See Table 3.6 for the yearly SE values). For the compositional data, a multinomial error distribution was assumed. To account for interannual variability in composition data, a scaled input sample size (ISS) was utilized that proportionately scaled the ISS within a fleet based on the actual number of samples collected. Relative ISS values were assigned using a linear scaling based on the minimum and maximum samples taken across all years and the fleet-specific maximum ISS (see the maximum ISS values for each in Table 3.5) and a minimum ISS of 20. Generally, to better represent expected information content and representativeness of the data sources, age data was given a relatively higher maximum ISS than length data, survey data was given a higher value than fishery data, and the NOAA Longline Survey a higher value than the Japanese Longline Survey data, while also accounting for the increased number of fleets within the FAA model (e.g., the aggregated fishery had an maximum ISS of 150 whereas each disaggregated Longline Survey fleet had a maximum ISS of 100 to help ensure that each regional fleet was weighted less than aggregated fleets and the Longline Survey data did not overwhelm signals from other data sources).

A statistical maximum likelihood estimation (MLE) framework enabled estimation of key parameters, using a penalized likelihood approach that included normal penalty functions [i.e., recruitment deviations from mean recruitment, $\sim N(0, \sigma_R^2)$, and fishing mortality deviations from mean fishing mortality, $\sim N(0, 0.75^2)$] and lognormal priors (i.e., natural mortality and selectivity parameters). In total, 274 parameters were estimated in Model *26.2_FAA*, which represented the addition of 2 catchability parameters and 16 survey selectivity parameters compared to the single region model to enable fitting the regional NOAA Longline Survey data in the FAA model (Table 3.7).

To ensure appropriate data weighting and avoid overfitting compositional data, the two-stage Francis iterative reweighting method was applied to 'right-weight' the compositional data and account for correlation among composition bins (Francis, 2011, 2017). In Stage 1, the model was run with equal input compositional data weights (i.e., all sources of age and length composition data fit in the model were given a weight, λ, of 1.0; exploratory runs demonstrated that final weights were insensitive to initial weights). Then, the compositional data weights were adjusted following Method TA1.8 and weighting assumption T3.4 of Francis (2011, Appendix Table A1, therein; i.e., using the assumption of a multinomial distribution and accounting for correlations among ages or length bins). In Stage 2, the model was then rerun with the new weights. The weights were iteratively adjusted until the difference between the current weights and the revised weights was minimal (i.e., the weights converged; for sablefish this usually took less than 10 iterations). The final 'effective' sample sizes after Francis reweighting were determined by multiplying the ISS by the data weights (See Table 3.8 for mean SE, ISS, and ESS for each data source fit in the model). It is worth noting that self-weighting Dirichlet multinomial likelihoods for the composition data were explored (See 'Sensitivity Runs' in Appendices 3B and 3C) to circumvent the need for data reweighting procedures, but fits to indices were greatly degraded and the approach was not recommended by the CIE reviewers.

Definitions

Throughout the document mass (i.e., for spawning stock biomass, SSB, biomass, and catch) is reported in metric tons (abbreviated t; equivalent to a tonne) or kilotons (kt; equivalent to 1,000 metric tons). Recruitment was the estimated number of age-2 sablefish (in millions of fish). Total biomass (in kilotons)

was the abundance of all sablefish age-2 and older multiplied by sex-specific input weight-at-age. Spawning stock biomass (SSB) was the mass of mature (based on input age-based maturity) females (in kilotons). Summary fishing mortality was fully selected *F*, which is the instantaneous mortality at the age of maximum fishery selectivity, summed across fleets.

Model Alternatives and Justification

For 2026, the author recommended model is Model *26.2_FAA*, which uses the same assumptions and data inputs as single region alternatives except that the NOAA Longline Survey is disaggregated by region. Model *26.2_FAA* is believed to be a more robust model compared to the single region alternative because it better addresses underlying spatial structure and fits only observed (not interpolated) survey data. Moreover, Model *26.2_FAA* structure is robust to not only the historical and current survey design, but also any future redesigns given that the data is fit on the regional scale. The new FAA structure was vetted through extensive simulation testing and based on an extensive model development process that explored > 100 variations of the FAA parametrization, including model variants with domed selectivity and disaggregation of the fixed gear fishery into a similar regional fleet structure (see Appendix 3C). Ultimately, the FAA structure was demonstrated to be less biased than the single region alternatives (Appendix 3E), and the parsimonious FAA parametrization (i.e., only disaggregating the Longline Survey fleets and not assuming domed selectivity) provided a more reliable and stable framework than more complex FAA models.

For 2026, the SSC has requested that three alternative models be brought forth in addition to the author recommended Model *26.2_FAA*, and each are available from the sablefish GitHub repo (here):

- Model *25.12* (the continuity model; results available here)
- *26.1_1Reg* (the updated single region model; results available here)
- *26.2_FAA_3LLF_LLS_BS_Dome_DN* (the SSC requested FAA alternative with regionally disaggregated fixed gear fishery fleets and domed selectivity in BS fleets; results available here).

Model *25.12* is described in the sablefish 2025 September JPT report and represents an update of Model *23.5*, including a transition from AD Model Builder to SPoRC (Cheng et al., 2026). Additionally, updates focused on integrating assessment good practices for likelihood and prior formulations, removing contradictory and uninformative data (i.e., length compositions when age compositions are available, the NOAA GOA Trawl Survey), and updating the prior on natural mortality to ensure estimates better align with biological knowledge. Model *26.1_1Reg* builds upon Model *25.12* as noted previously, while *26.2_FAA* disaggregates the NOAA Longline Survey (LLS) into regional fleets as described above. Finally, Model *26.2_FAA_3LLF_LLS_BS_Dome_DN* disaggregates the fixed gear fishery into regional fleets along with the LLS fleets and estimates dome-shaped selectivity in the BS fishery and survey fleets using a double normal selectivity function (see the Supplemental Material section 'SSC Requested Models' for a description of this model and analysis of results).

Additionally, the five region spatial model is once again updated (Appendices 3D and 3K):

- *26.3_Spat_5reg* (a spatially explicit model that integrates tagging data and estimates movement among the five management regions; results available here).

Per the SAFE guidelines, this document focuses on the analytical framework, results, and outputs of the author recommended model (Model *26.2_FAA*). For full descriptions and results of the other models see the documents noted above and the sablefish GitHub repo (here). The Supplemental Material to this document also includes full Executive Summary and BRD tables for each of the three additional models requested by the SSC. However, care should be taken when interpreting results from these models as each

utilizes suboptimal assumptions (data interpolation) or has high instability (domed selectivity models). These models are briefly described and compared in the 'Sensitivity Runs' section.

Model Bridging and Final Model Development

Model Bridging

To provide a thorough bridge to the last approved assessment (Model *25.12* in 2025), Model *25.12* was implemented with 2024, 2025, and 2026 terminal years. Similarly, Model *26.2_FAA* was implemented with 2025 and 2026 terminal years. Comparisons were made across key outputs including recruitment and SSB. For a complete description of the stepwise development of Model *26.2_FAA* from Model *25.12* and Model *26.1_1Reg* see Appendices 3B, 3C, and 3E.

Incremental Influence of New Data

A data addition analysis was conducted with the final author recommended Model *26.2_FAA* to demonstrate how new data affected model estimates (e.g., the magnitude of the most recent estimated year classes). Model *26.2_FAA* was first fit to the data available through 2025. Each new data source for 2026 was then added sequentially in a stepwise fashion: 1) 2026 catch for the fixed gear and trawl fishery fleets; 2) 2025 fixed gear fishery age compositions; 3) 2025 trawl fishery length compositions; 4) 2026 BS and AI NOAA LLS indices; and 5) 2025 GOA NOAA LLS age compositions. The final step represents the final 2026 Model *26.2_FAA*.

Final Data Weighting

The first step in model development after adding the new data for 2026 was to perform Francis data reweighting (i.e., accounting for correlations among ages or length bins in the compositional data; Francis, 2017) to adjust data weights to account for the addition of the 2026 data. The data weights (lambdas) used for each data source before and after Francis reweighting along with the input sample sizes for the compositional data are available in Table 3.8.

Model Evaluation

Convergence Criteria

Model convergence was identified through successful inversion of the Hessian matrix, a maximum gradient component of less than 1e-4, reasonable estimates of uncertainty (SE), and limited parameter correlation. Finally, time series estimates of population trends were explored to ensure these were consistent with observations from the resource and general expert judgement regarding temporal dynamics.

Jitter Analysis

A jitter analysis was implemented to identify whether altering the starting parameter values led to an improved fit to the observed data, which would indicate that the model did not find a global minimum and suggest model instability. For the jitter analysis, Model *26.2_FAA* was rerun 200 times with new starting parameter values. These new values were determined by adding a random deviation selected from a standard normal distribution, $\sim N(0, 1^2)$, to each estimated parameter at its maximum likelihood estimate. A jitter run was considered converged if it had a positive-definite Hessian and a maximum gradient component of less than 1e-4.

Goodness of Fit

Model performance and goodness of fit were determined by examining joint negative log-likelihood components, visual fits to the data (including indices of abundance and age and length composition data), runs tests for index data, and residual analysis of both Pearson and one step ahead (OSA) residuals (to identify potential age or time trends in residuals; for OSA residuals the first age or length bin was dropped). Evaluating compositional model fits using Pearson residuals has the potential to result in spurious conclusions regarding lack of fit and/or independence, because correlated observations are retained. OSA residuals, which decorrelate observations arising from multinomial distributions, are increasingly being recommended as best practice for interpreting stock assessment model fits (Trijoulet et al., 2023). The overall interpretation of OSA and Pearson residuals is similar: large magnitude (e.g., greater than three) or systematic trends in residuals could indicate model misspecification.

Uncertainty

Two forms of uncertainty were evaluated, including the Hessian approximations from the MLEs and the posterior distributions from Markov Chain Monte Carlo (MCMC) simulations. The SparseNUTS package (https://github.com/noaa-afsc/SparseNUTS/) was utilized for MCMC with 4 chains, each with 500 warmup iterations followed by 20,000 iterations. We report key diagnostics, including the maximum Rhat and the minimum effective sample size (ESS).

Model Diagnostic Analyses

Retrospective Analysis

Retrospective analysis is the examination of the consistency among successive estimates of the same parameters obtained as new data are sequentially removed from a model. Two types of retrospective analyses were undertaken. First, a typical 'model' retrospective demonstrated consistency among successive model runs as data are systematically removed ('peeled') one year at a time. A seven-year retrospective analysis (i.e., terminal years 2019 through 2026) was undertaken to examine whether any significant time trends in estimates of spawning biomass or recruitment were present. Because the recent fishery and survey selectivity time blocks begin in 2016, peels before 2019 preclude informative retrospective analysis due to model instability when attempting to estimate selectivity parameters with only a few years of data. 'Mohn's rho' (ρ), a measure of overall retrospective bias, was calculated as the mean of the relative 'bias' across all retrospective peels. The second type of retrospective, here termed a 'data' retrospective, informs more on the expected performance of the model in any given year by providing the exact types of data that would be available at the time of a past assessment. Mainly, the one-year time lag for inclusion in the assessment between collection and availability of compositional data (i.e., age and length frequency) is explicitly accounted for by running the model retrospective, but ensuring the compositional data is available only through the model terminal year – 1.

Historical Assessment Retrospective Analysis

An historical assessment retrospective analysis addresses consistency across successive stock assessment model structures with the actual data available in the terminal model year. An 'all model' historical retrospective was undertaken, which compared the actual assessment outputs from the model used as the basis of management advice for a given SAFE year (i.e., going back to the 2018 SAFE; this included successive applications of models *16.5*, *21.12*, *23.5*, *25.12*, and Model *26.2_FAA*).

Profile Likelihoods

Likelihood profiles allow exploration of how the likelihood response surface varies for different values of

a given parameter and highlight potential tension between data sources for estimation of key parameters. Likelihood profiles were developed for the primary scaling parameters, natural mortality (*M*) and mean recruitment (R_0). For each profile, the parameter was fixed at a range of values around the MLE (in increments of 0.05 and 0.1 in log space for *M* and R_0, respectively), while all other parameters were re-estimated.

Model Sensitivity Runs

An array of sensitivity runs were performed and are briefly discussed (see 'Model Runs for the Final SAFE' in the Executive Summary for a summary of each model), where the models are placed into six groupings. The 'Base' grouping includes the four models requested by the SSC (*25.12*, *26.1_1Reg*, *26.2_FAA*, and *26.2_FAA_3LLF_LLS_BS_Dome_DN* – which disaggregates the fixed gear fishery by region and allows domed selectivity in the BS fishery and survey fleets). These models illustrate the impact of moving from interpolated data in the single region models to the FAA structure along with impacts of assuming dome shaped selectivity in the FAA models. The 'Dome' grouping then further explores domed selectivity in the FAA models by allowing for doming only in the LLS (*26.2_FAA_LLS_BS_Dome*), only in the fixed gear fishery (*26.2_FAA_LLF_BS_Dome*) and both (*26.2_FAA_3LLF_LLS_BS_Dome*) and whether the dome is modeled with a double normal (*_DN*) or a gamma (*_Gam*) function. A model with continuous time-varying semi-parametric selectivity (*26.2_FAA_TV_Selex_LLS*) is also included. The parametrization and results of these models are discussed in more detail in the Supplemental Material section 'SSC Requested Models'.

The 'Index' grouping explores the impact of including alternative biomass indices, including the fixed gear fishery CPUE through 2022 (*26.2_FAA_CPUE*), the GOA trawl survey (*26.2_FAA_TS*), and both simultaneously (*26.2_FAA_TS_CPUE*). The '*M* Prior' grouping demonstrates the influence of the natural mortality prior by rerunning Model *26.2_FAA* with an updated mean value in the prior ranging from 0.065 to 0.115 in 0.01 increments (*26.2_FAA_M_Pr_XX* – where XX is the value of the prior mean). Two other models related to *M* are also included: the SSC requested run using the single region estimate of *M* in the FAA model (*26.2_FAA_M_1Reg*); and a model that attempts to estimate *M* with a very diffuse prior (*26.2_FAA_Est_M*; this model failed to converge and is not shown in the results). The 'REMA' sensitivity utilizes the REMA smoothed and interpolated regional indices and fits them in either the single region (*26.1_1Reg_REMA*) or FAA model (*26.2_FAA_REMA*) to demonstrate the impact of using an alternative interpolation approach. Finally, the single region, FAA, and spatial (*26.3_Spat_5reg*) models are compared in terms of overall population SSB scale (*26.4_Spat_3Reg* was also updated but not discussed further here (see Appendix 3K).

Extensive model sensitivity runs were also performed for both Model *26.1_1Reg* (Appendix 3B) and Model *26.2_FAA* (Appendix 3C) as part of the model bridging and model development process.

Results

Model Bridging and Final Model

Model Bridge

As was noted during the model development process (Appendices 3B and 3C), Model *26.2_FAA* demonstrated moderate differences in interpretation of recent recruitment, while providing a strong downward scaling in SSB compared to Model *25.12* (Figures 3.20 – 3.21). Alterations in recruitment are likely due to the age composition aggregation in the single region model, which primarily reflects the GOA dynamics despite recent recruitment primarily being observed first in the BS and AI. Because Model *26.2_FAA* better reflects recruitment trends in the BS and AI, there are slight shifts in the dominant year classes (e.g., 2017 compared to 2016). Moreover, Model *26.2_FAA* appears relatively more consistent with

itself, demonstrating less retrospective adjustment of recruitment estimates. Not surprisingly, both models have a strong increase in the 2020 year class, which reflects the increased uncertainty caused by the lack of a 2024 survey and the addition of survey age composition data for the first time since 2024 (see next section). Changes in overall population SSB scale likely stem from the removal of interpolated index data, which was demonstrated to lead to inflated population estimates during closed loop simulation analysis (see Appendix 3E).

Incremental Influence of New Data

Adding the 2026 data led to no strong changes in model dynamics or population trajectories, and historical estimates of SSB and recruitment were nearly identical across all steps (Figures 3.22 – 3.23). The new catch and fishery composition data had minor impacts, aside from the 2025 trawl fishery length compositions, which modestly increased the 2020 and 2022 year classes. As in previous assessments, the biggest differences as new data were added was the magnitude of recent recruitment, which was driven primarily by the NOAA LLS data. The 2026 BS and AI LLS indices suggested a large 2022 year class and led to moderate increases in recent SSB (< 10%) and average recruitment (~10%). Adding the 2025 GOA LLS age compositions then reduced the 2022 year class by approximately half and doubled the 2020 year class. Estimates of the dominant 2016 and 2017 year classes were stable across all data additions. The final Model *26.2_FAA* balances these data sources, but highlights the uncertainty in recent recruitment estimates. As has been noted in past assessments, the regional age compositions provide important and, at times, unique signals on the size of recent year classes. Thus, signals on recruitment trends from the BS and AI, where much of the recent recruitment is first observed, are often downweighted in the single region models where the GOA compositions are likely overweighted in the aggregate compositions. Moreover, the impact of the loss of the 2024 LLS is clearly demonstrated in this analysis, because the other data sources were unable to provide early indications to the model on the size of the 2020 and 2022 cohorts. The 2025 implementation of Model *26.2_FAA* essentially reverted to mean recruitment for these year classes, which were then revised upward considerably when the 2025 LLS age compositions became available. Thus, the analysis clearly shows the detrimental impacts of reduced survey frequency, footprint, and/or age reading capacity for sablefish.

Data Reweighting

As expected, Francis reweighting significantly downweighted the composition data to ensure adequate fit to the indices (Table 3.8). Not surprisingly, the NOAA Longline Survey age compositions retained the highest final ESS, likely because these data most closely reflect the trends in the indices. However, the significant downweighting of the compositions further exemplifies the internal model tension between fitting the trends represented in the NOAA Longline Survey index compared to age compositions. Despite similar signals of rapid population growth since 2015, the model interprets the magnitude of the recent year classes differently between indices and compositions, where these interpretations also differ across regions (see 'Goodness of Fit' section). The fit to the mean age or length clearly demonstrates the difficulty fitting the rapid transition to a smaller, younger population since 2015. The mean age in the fishery has dropped from nearly 15 to less than 5 in ~7 years with a similar drop in the NOAA Longline Survey from a mean age of 10 to 5 in ~5 years (Figure 3.24). Moreover, reduction in mean age in the NOAA Longline Survey appears strongly driven by the BS and AI, as seen in the fit to mean age from the regional age compositions in Model *26.2_FAA*. Given that the AI age compositions receive moderate upweighting relative to other age composition data in the FAA model (Table 3.8), it is likely that the AI compositions better align with the trends in the indices, such that the Francis reweighting upweights the AI because it allows simultaneously good fit to the indices.

Model Evaluation

Model *26.2_FAA* passed all convergence criteria. It had a positive-definite Hessian, a small maximum gradient component (4.9e -12), and no major parameter correlation, indicating (when also accounting for the jitter analysis results) that the model converged to a robust solution. However, a number of parameters demonstrate high uncertainty, including historical recruitment deviations defining the initial age structure (given lack of compositional data at the start of the model), recent recruitment deviations (due to elevated uncertainty associated with limited data on incoming year classes), and a handful of selectivity parameters (likely caused by the number of model partitions resulting from sex-specific dynamics; Table SM3.8). The objective function values by data source indicated that the compositional data, particularly the NOAA longline survey ages, and catch data had the largest absolute contributions (Figure 3.25).

Jitter Analysis

All jitter runs converged and no run attained a lower joint negative log-likelihood (jnLL) than the MLE solution for Model *26.2_FAA* (Figures 3.26 – 3.27). The large majority of runs (~90%) returned to the same solution, with essentially identical jnLL values and SSB and recruitment time series. The remaining runs converged to a small number of local minima with much poorer fits (jnLL values more than 10 units higher than the final model) and implausibly high population scale (i.e., terminal SSB values ranging from ~ 10% -- 140% higher) driven by inflated recent cohort estimates. These local minima were easily distinguished by their poor fits, and none improved on the MLE, suggesting that Model *26.2_FAA* likely converged to a minimum solution.

Goodness of Fit

Generally, the survey indices are well fit at the expense of composition data, primarily due to the Francis reweighting. Residual patterns in the composition data remain, but the aggregated fits appear adequate, albeit with moderate cohort and time trends. Interestingly, the model demonstrates regional fleet tradeoffs in fitting Longline Survey indices versus compositions. In the GOA, age compositions suggest more rapid growth than the index, whereas in the BS and AI the indices demonstrate more rapid growth than indicated from the compositional data. The tradeoff becomes apparent when comparing Model *26.2_FAA* (that tends to better fit the indices) to sensitivity runs that include time-varying survey selectivity and alternative compositional likelihoods (e.g., Dirichlet Multinomial – which demonstrate clearly better fit to compositional data at the expense of the indices; see Appendix 3C). Essentially, when Longline Survey age compositions are better fit in the GOA, the index is overestimated, while the opposite is true in the BS and AI (Figure 3C.38). Although the single region models have demonstrated similar patterns in the past, the FAA model clearly demonstrates that the model tension caused from attempting to fit the index and compositions simultaneously reflects a more nuanced regional divergence and not just a simple AK-wide data conflict. Thus, there is further evidence of the need for utilizing a spatial modeling framework that can more explicitly handle the underlying spatial drivers of such data conflicts.

Fit to the catch data was good, given the low assumed standard error (Figure 3.28). The regionally disaggregated NOAA Longline Survey indices demonstrate general agreement on long-term population trends across regions, with all indicating rapid population growth since 2015, albeit with a moderate decline in the BS in 2026 (Figure 3.29). Model *26.2_FAA* provided adequate fit to each index, given the slight discrepancies in signals. However, differences in the shape of the survey selectivity curves across regional fleets (i.e., much steeper in BS and AI compared to GOA; Figure 3.68) leads to a divergent trend in the last few years in the predicted indices. The BS and AI predicted indices are nearly level since 2020, while the GOA continues to increase (Figure 3.29). The reason for the divergence across regions is due to the tradeoff between survey selectivity, cohort mortality, and reductions in estimated year class sizes since the 2017 year class. Mainly, for the BS and AI survey indices, maximum selectivity occurs around age-4, so a cohort's maximum contribution to RPNs will decline after this age due to ongoing mortality (i.e., the size of the cohort can only decline). Conversely, in the GOA, survey selectivity is maximum around age-20, so

there is a tradeoff between slowly increasing selectivity and increasing cohort mortality across the lifespan, such that maximum contributions to RPNs likely occur at intermediate ages (but much later than in the BS and AI). Because the 2017 year class has reached full selection in the BS and AI surveys, it is the largest cohort in the time series, and subsequent cohorts have been much smaller, the model predicts a levelling off in BS and AI RPNs starting around 2020 -2022 (i.e., when the cohort reaches age-5). For the GOA, the predicted survey index continues to increase because the tipping point between mortality and selectivity has not yet been reached. The index runs test indicated moderate non-randomness in the fit to the GOA NOAA Longline Survey index, particularly associated with the early data (prior to 2000; Figure 3.30).

As noted, fits to the composition data remain mediocre due to tension between fitting the index and age composition data. The fits to the composition data can partially be attributed to the Francis reweighting approach (Francis, 2011), which prioritizes fit to the abundance indices. Fits to the NOAA Longline Survey age compositions by region were adequate, with a tendency to overestimate at age-2 (demonstrably worse for the GOA compositions) and underestimate the peak of cohort abundance around ages 5-7, then slightly overestimate again between ages 10 through 20 (Figures 3.31 – 3.42). Residual patterns indicate underestimation of recent large cohorts as they enter the population (e.g., since 2016; Figure 3.37), as the model has trouble fitting the massive recent cohorts (e.g., 2014, 2016, and 2017) when they begin to appear in the composition data at age-3. Fits to the BS and AI NOAA Longline Survey age compositions tend to be adequate for Model *26.2_FAA*, especially considering the relatively lower sample sizes and increased sparsity across ages (Figures 3.37 and 3.41). The AI age data tends to be fit slightly better, given the relatively higher data weight (ESS).

Similar patterns are observed in the fixed gear fishery age compositions, though recent recruitment events tend to be first observed at a slightly later age (e.g., age-4 or age-5; Figures 3.43 – 3.46). However, expected values are much higher than observed for ages 4 – 6 for males, and the predicted size of the plus group is greatly underestimated compared to the observed proportions (Figure 3.45), which has been an ongoing concern for the assessment (Goethel and Cheng, 2024). The large plus group is due to an inordinate catch of large, old fish in the AI during the early 2010s (20 – 70% of catch from the AI was older than age-30 during these years; Appendix 3C, Figure SM3C.42), and fitting these data is not possible with realistic population dynamics (and application of a spatial model does not resolve the issue either, See Appendix 3D). The relative downweighting of the fishery age compositions relative to the multiple NOAA Longline Survey age composition data sets is a primary factor in the poorer fit to the fishery age compositions.

Japanese Longline Survey age compositions are noisy but adequately fit (Figures 3.47 – 3.50), while fit to the associated length compositions are mediocre (Figures 3.51 – 3.54). Trawl fishery length compositions are also relatively noisy and, at times, bimodal (representing the aggregation across diverse trawl fleets; Figures 3.55 – 3.56). However, fit to the mean proportions is reasonable and balances fitting the catch of small fish from the pelagic trawls with catch of larger females in bottom trawls (Figures 3.57 – 3.58).

Time Series Results

Estimated sablefish abundance and biomass dropped throughout much of the 1960s and 1970s (Table 3.9, Figures 3.59 – 3.60), as the population began to be heavily exploited, with catches peaking at 53,000 t in 1972 (Table 3.1, Figure 3.1). The population recovered in the mid-1980s due to a series of strong year classes in the late 1970s and early 1980s (Figures 3.59 – 3.63). The population subsequently declined as these strong year classes were removed, with a slight rebound in the early 2000s due to a handful of above average year classes in the late 1990s, then declined to a time series low in the mid 2010s (Figures 3.59 – 3.60). Associated with a series of extremely large recruitment events since 2014, age-2+ biomass has increased by approximately 350% since 2015, which represents historically high sablefish population levels despite a stagnation in growth in 2026. The population age structure is slowly expanding as recent year classes begin to enter more fully mature age classes, but the number of fish greater than age-12 still remains

low compared to historical levels (Figure 3.61; see Tables SM3.9 for numbers-at-age by sex). However, over the course of the next decade, it is expected that the large 2014, 2016, and 2017 year classes will continue to help expand the age structure, as these age classes remain at time series high abundance for their given current ages (Figure 3.61). SSB typically lags behind biomass with less pronounced extremes and, aside from a ten-year upswing in the 1980s, had been on a general downward trajectory for the entire time series (Table 3.9; Figures 3.59). However, SSB has increased by more than 375% from the time series low in 2014 and after an approximately 10% growth in 2026 is now on par with levels estimated in the mid-1960s.

Sablefish are characterized by highly spasmodic recruitment events with periodic year classes that are well above average, then prolonged periods of depressed recruitment (Figures 3.62 – 3.63). Moreover, no apparent relationship between SSB and subsequent recruitment exists, with many of the larger cohorts being spawned from relatively low SSB (Figure 3.63). However, the large recruitment events in the late 1970s and early 1980s were associated with a more balanced age structure, which may indicate a potential age diversity and spawning portfolio effect on recruitment success (e.g., Griffiths et al., 2023). The largest historical recruitment event was the 1978 year class followed by the 1981 year class, but below average recruitment events then occurred throughout much of the 1980s and early 1990s (Table 3.9, Figure 3.62). The 2014, 2016, and 2017 year classes are three of the largest cohorts in the time series (Figures 3.62). Recruitment since 2019 has been lower than the 2014 – 2017 levels, but the 2020 and 2022 cohorts remain above the time series average. Analysis of Eastern Bering Sea (EBS) trawl fishery length data (typically an early indicator of strong recruitment) indicates the 2022 year class is likely above average, but does not suggest large year classes in 2023 or 2024 (Appendix 3M) which is further supported by recent declines in the BS LLS index.

Overall, the sablefish age structure continues to gradually expand as the recent large year classes (e.g., 2014 – 2017) begin to enter ages that are nearing full maturity. For instance, the 2014 year class is now fully mature, while the larger 2016 and 2017 year classes are 90% and 81% mature, respectively. The abundance of the 2014—2019 cohorts remain high as they age, which is a positive sign for the sablefish population and fishery. Retaining a diverse age structure in the coming years will be important as the fishery begins to exploit these high value large fish, given that the 2014 – 2022 year classes comprise ~90% of the 2027 projected SSB (i.e., there is little spawning contribution of fish > 13 years of age; Figure 3.64). Specifically, it is worth noting that when catches have exceeded ~30 kt for multiple years, SSB has demonstrated subsequent strong declines (also associated with transitions from high to low recruitment levels; Figure 3.65).

Estimates of natural mortality generally align for males and females (i.e., ~0.09; Figure 3.66). Generally, estimated selectivity has shifted towards higher selection of age-2 and age-3, but lower selection of intermediate ages in the fixed gear fishery over time (Figure 3.67). Compared to the fixed gear, younger fish are more vulnerable to trawl gear, reflecting the preponderance of pelagic trawl gear data (that primarily interacts with small sablefish on the EBS shelf) in the aggregate trawl fishery length compositions (Figure 3.67). For the longline survey, the BS and AI surveys have seen a shift towards younger fish, whereas the GOA survey has seen in increase an age-2 selectivity but a large decrease in all other ages (Figures 3.68). Moreover, survey selectivity for the GOA becomes much less steep in the recent time block. The GOA selectivity shape reflects the model assuming that the younger age classes (< age-20 and aside from age-2) were less available to the GOA survey, and is required by the model to avoid overestimating the GOA survey index (i.e., it reflects the FAA model's need to alias spatial availability through selectivity; see Appendix 3C). The Japanese Longline Survey selectivity closely reflects the historical time block in the NOAA Longline Survey (Figure 3.68). Males tend to be selected at an older age than females in all fleets, likely because they are smaller at a given age.

Fishing mortality was estimated to be high in the 1970s, relatively low in the early 1980s, then increased in the 1990s before undergoing a recent decline between 2017 and 2020 (Figure 3.69). Over the last five years, fishing mortality has steadily declined and is on par with the low levels of the early 1980s. Fishing mortality from the trawl fleet is generally less than half that of the fishing mortality in the fixed gear fleet. Recent management has generally constrained fishing mortality to below limit reference point values, while biomass is above limit reference point values (Figures 3.70). However, recent low fishing mortality is primarily associated with low ABC utilization in recent years (~50% in 2025 and 2026). Interestingly, the phase-plane suggests that the population was likely below the minimum stock size threshold (MSST) for much of the 2000s, until large recent recruitment events began entering the population and ABC utilization rates declined (Figure 3.70).

Comparison to Last Assessment Model

Generally, the population trends from the 2024 SAFE (Model *23.5*) are similar to Model *26.2_FAA*, though population scale and average recruitment have declined considerably (Table 3.10).

Uncertainty

MCMC diagnostics indicated that the chains converged and adequately explored the posterior (Rhat < 1.01 and ESS > 400 for all parameters), where the MLE and MCMC estimates remained generally similar. For the primary scaling parameters (mean recruitment, sex-specific *M*, and the regional LLS catchabilities), posterior means were similar to the MLE, and the marginal posterior histograms generally aligned with the asymptotic normal distributions from the inverse Hessian (Table 3.11; Figure 3.71). Posterior standard deviations also closely matched the MLE standard errors for most parameters (Figure 3.72). No major pairwise correlations were noted aside from the expected moderate correlations among the primary scaling parameters (Figure 3.73). The MCMC median SSB and biomass were similar to the MLE throughout the time series, and the MLE fell well within the 95% credible intervals (Figure 3.59). As expected, recent recruitment was the most uncertain, with wide credible intervals for year classes since 2020 and slight divergence between the MLE and MCMC estimates for the 2022 cohort (Figure 3.62).

Model Diagnostic Analyses

Retrospective Analysis

The retrospective analysis indicated that the model was quite consistent, demonstrating a slight tendency to overestimate population scale and terminal SSB (Mohn's ρ = 0.025 for SSB; Figure 3.74). Variability exists in the estimates of recent year class strength, particularly associated with the lack of 2024 survey age composition data. Moreover, large recruitment year classes are often initially underestimated, but estimates tend to stabilize within ~5 years (Figure 3.75). Aside from potentially conflicting signals within the age compositions themselves, there is likely also a year-data interaction, given the historical odd-even year survey design for the BS and AI regions, respectively. Therefore, the retrospective patterns partially reflect a data availability issue, where initial recruitment signals are probably dominated by patterns in the GOA, then shift slightly towards the BS and AI signals as those data become available. However, uncertainty in recruitment estimates and associated recruitment retrospective patterns do not lead to retrospective patterns in SSB, because by the time a year class begins to significantly contribute to the SSB (e.g., by around age-5) the estimate of year class strength has already stabilized.

The 'data' retrospective which integrates the one-year time lag in the availability of compositional data, demonstrates generally similar patterns as the normal model retrospective, albeit with slightly stronger patterning (Mohn's ρ = 0.056 for SSB; Figure 3.76). Not surprisingly, the time lag leads to higher uncertainty and variability in recruitment estimates, resulting in stronger initial underestimation and a

longer time until stabilization (Figure 3.77). Analysis of ABC projections from the 'data' retrospective demonstrated that the lack of a 2024 survey was a primary factor in the 2025 implementation of Model *26.2_FAA* recommending a comparatively low quota. Essentially, without the survey age compositions from 2024, the model reverted to mean recruitment for the 2020 and 2022 year classes, which caused a leveling off of the quota recommendation compared to 2024. When the 2025 Longline Survey age compositions became available, these year class estimates increased greatly resulting in a strong jump in the ABC recommendation.

Historical Assessment Retrospective Analysis

Most recent models have been highly consistent from one year to the next and with each other (i.e., based on the 'all model' historical retrospective; Figure 3.78). Model *26.2_FAA* demonstrates a significant downward scaling of population biomass, but trends remain similar to previous models, albeit with a moderately higher rate of population growth since 2018.

Profile Likelihoods

The likelihood profiles for female M, male M, and R_0 demonstrated well-defined minima in the jnLL at the MLE (Figures 3.79 – 3.81). However, the shape of the jnLL was largely driven by the priors and penalties (the 'Other' component), particularly for M, where the profile was dominated by the M prior, while the data components changed comparatively little across the profiled values. As in previous assessments, tension exists among data sources, where the age composition data (i.e., the primary source of information on recruitment and M) supported lower values of M (minima near $M \approx 0.06$ for both sexes, compared to MLEs of ~0.09) and R_0, while the indices, length compositions, and catch data supported higher values.

Sensitivity Runs

Across the four SSC-requested models (the "Base" grouping), time series trends were generally similar, although population scale was moderately lower in the FAA variants than in the single-region models (Figure 3.82). The domed selectivity variant (*26.2_FAA_3LLF_LLS_BS_Dome_DN*) exhibited greater depletion over the time series than Model *26.2_FAA*, along with substantial stability and convergence issues. Within the "Dome" grouping, most models produced population trends and catch advice similar to Model *26.2_FAA* (Figure 3.83). Exceptions included the BS LLS gamma variants, which compensated for extreme doming estimated in the BS LLS by inflating survey catchability and scaling down population size. The time-varying selectivity model (*26.2_FAA_TV_Selex_LLS*), which allowed selectivity to decline at older ages if supported by the data, instead estimated essentially asymptotic LLS selectivity at older ages across fleets and years (Figure SM3.5), suggesting the available data provide little information to support dome-shaped selectivity. Collectively, these results suggest that population scale was driven more by assumptions about the shape of dome-shaped selectivity than by information in the data. All dome models exhibited diagnostic issues, including jitter runs identifying lower nLL solutions, failure of MCMC to converge, and poorer retrospective performance than Model *26.2_FAA*. Consequently, none of the dome models are recommended for management advice (see the Supplemental Material section 'SSC Requested Models' for a full description and comparison).

Including the CPUE index had little impact on model performance, whereas addition of the GOA trawl survey significantly reduced recruitment estimates and terminal SSB ('Index' grouping; Figure 3.84). As expected, scaling the M prior up or down had a proportional impact on total population SSB scale, since M is a fundamental model scalar that is poorly informed by the available data ('M Prior' grouping; Figure 3.85). Using the REMA outputs had little influence on the single region model, but greatly increased recruitment and population growth estimates in the FAA model ('REMA' grouping; Figure 3.86). This likely occurs because interpolating the index adds observations in years without surveys, mainly in the BS

and AI, which gives the index more weight relative to the age compositions. Moreover, in the interpolated years the model has index values but no age compositions, so it must infer the age structure behind the index from the surrounding years that were sampled. As a result, we hypothesize that the model provides more weight to the increasing index signal in the BS and AI and inflates estimates of recent recruitment events. This behavior is similar to the carryover approach explored previously, in which missing BS and AI survey years were filled with the most recent observation, which likewise inflated recent recruitment estimates (Appendix 3C, Fig. 3C.12). In general, interpolating index data without a robust approach for interpolating the associated compositional data is not recommended.

Finally, the spatial model (*26.3_Spat_5Reg*) demonstrated mixed trends between the single region and FAA models with increased depletion estimates compared to Model *26.1_1Reg*, but with a higher overall scale than Model *26.2_FAA* ('Spatial' grouping; Figure 3.87). Recent population growth in the spatial model was more extreme than either of the other models, suggesting the population is at an even higher terminal SSB. However, the results of the spatial model should be interpreted with care until robust tag data weighting methods can be developed and time-varying movement can be reliably estimated (see Appendices 3D and 3K).

Harvest Recommendations

Population Projections

A standard set of seven projections is required for each stock managed under Tiers 1, 2, or 3 by the NPFMC. For sablefish, projections were run using the SPoRCv1.2 reference point and projection functions. For all projections, yearly recruitment is simulated as an inverse Gaussian distribution parameterized using historical recruitment estimates (1979 – 2025; average recruitment was 19 million). A common random number seed is used across projection scenarios to ensure a common time series of recruitment across all 1,000 simulations. Projections start from the terminal year numbers-at-age and all projection parameters (e.g., selectivity, natural mortality, and biological inputs) are taken from the estimated or assumed values from the terminal year of the assessment. As with the assessment model, terminal year catch is interpolated through the end of the year (to account for catch from October 1st through the December 31st) based on the three year average (of complete fishing years) ratio of catch from October 1st through December 31st compared to the rest of the year. The relative fishing mortality among fishing fleets in the terminal year is used to assign future fleet-specific fishing mortality (associated with projection specific catch). The same assumptions are used to define biological reference points using spawning biomass per-recruit calculations. For NPFMC Tier 3 stocks, F_{ABC} is defined as $F_{40\%}$ and F_{OFL} is defined as $F_{35\%}$, except when reduced by the NPFMC threshold/sloped HCR due to SSB falling below SSB_{ABC} ($B_{40\%}$) and SSB_{OFL} ($B_{35\%}$), respectively. For scenarios 1, 2, 6, and 7, the NPFMC threshold HCR is used to reduce specified fishing mortality when the SSB goes below the specified limit reference point ($B_{35\%}$; See Figure 3.70). In Scenario 2 (Specified Catch), the specified catches are used to increase the accuracy of the short-term projections. For catch projections in the two years following the assessment terminal year, the ratio of the three-year average (for complete fishing years, 2023 – 2025) of catch to ABC is used to determine the fraction of F_{ABC} to be applied. This method results in slightly higher future ABCs due to the lower removals in the initial projection years.

The seven projection scenarios are ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC}):

- *Scenario 1*: In all future years, *F* is set equal to *max* F_{ABC}.
- *Scenario 2*: In 2027 and 2028, *F* is multiplied by the yield ratio (0.53), which is the three year average proportion of the ABC that was harvested (from complete fishing years, 2023 – 2025). For the remainder of the future years, maximum permissible ABC is used. Specified catch in 2027 was 21,000 t in 2027 and 2028.
- *Scenario 3*: In all future years, *F* is set equal to the 2021 – 2025 (i.e., five year) average *F*.

- *Scenario 4*: In all future years, F is set equal to 50% of max F_{ABC}.
- *Scenario 5*: In all future years, F is set equal to zero.
- *Scenario 6*: In all future years, F is set equal to F_{OFL}. This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its B_{MSY} level in 2027, or 2) above ½ of its B_{MSY} level in 2027 and above its B_{MSY} level in 2036 under this scenario, then the stock is not overfished.
- *Scenario 7*: In 2027 and 2028, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its B_{MSY} level in 2028, or 2) above 1/2 of its B_{MSY} level in 2027 and expected to be above its B_{MSY} level in 2038 under this scenario, then the stock is not approaching an overfished condition.

Spawning biomass, fishing mortality, and yield are tabulated for the seven standard projection scenarios (Table 3.12). Figures of projected values including uncertainty are provided for SSB (Figure 3.88) and catch (Figure 3.89).

Status Determination

For the purpose of ABC and OFL reporting, the specified catch projections (Scenario 2) are used and reported in the executive summary. Under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition?

The official catch estimate for the most recent complete year (2025) is 23,600 t, which is less than the 2025 OFL of 58,500 t. Therefore, the stock is not being subjected to overfishing. Because 2026 SSB is at $B_{64\%}$ (i.e., above $B_{35\%}$), sablefish are not overfished. Similarly, given that the 2028 SSB is projected to be at $B_{71\%}$ (i.e., above $B_{35\%}$), sablefish are not approaching an overfished condition (Table 3.12).

Thus, **overfishing is not occurring** on Alaskan sablefish and the stock **is not overfished nor is it approaching an overfished condition.**

Acceptable Biological Catches (ABCs) and Overfishing Limits (OFLs)

Sablefish are managed under Tier 3 of the NPFMC harvest control rule, which aims to maintain the population at $B_{40\%}$. The updated point estimate of $B_{40\%}$ is 134,000 t. Since projected female spawning biomass (combined areas) for 2027 is 227,000 t (equivalent to $B_{68\%}$), sablefish is in sub-tier "a" of Tier 3. The updated point estimates of $F_{40\%}$, and $F_{35\%}$ from this assessment are 0.08 and 0.09, respectively. Thus, the maximum permissible value of F_{ABC} under Tier 3a is 0.08, which translates into a 2027 ABC (combined areas, before whale adjustments) of 37,567 t. The OFL fishing mortality rate is 0.09, which translates into a 2027 OFL (combined areas) of 44,464 t. **After adjusting for whale depredation, the final author recommended ABC_w is 37,436 t in 2027 and 37,636 t in 2028. The whale adjusted OFL_w is 44,333 t in 2027 and 44,565 t in 2028.**

Fishing Mortality to Achieve Previous Year's OFL

The NOAA Species Information System (SIS) requires reporting the fishing mortality rate from the current model that would have produced a catch for the previous year equivalent to the previous year's OFL. The OFL for last year (2025) was 58,532 t. The fishing mortality rate required to harvest the OFL would have been 0.13 based on the 2026 model.

Alternate Population Forecasts

To demonstrate how sablefish might respond under different future recruitment scenarios, alternate projections using different mean recruitment values were undertaken. Mean recruitment values from different historical and recent stanzas were used (Figure 3.90, top panel). Under each alternate future recruitment assumption, the NPFMC threshold $F_{40\%}$ HCR was applied (i.e., Scenario 1 from the base projection scenarios). Not surprisingly, the alternate projections indicate that if recruitment remains at recent high levels, then catch and SSB are likely to remain at current high levels or even continue to increase, with catch remaining above 35 kt (Figure 3.90). Conversely, if recruitment returns to historical norms, then SSB is likely to decline more rapidly than under the base projections and catch will need to be decreased appropriately.

A final set of projections was then implemented to illustrate the potential outcomes of introducing a total harvest cap on the sablefish ABC. Over the last three years, work on the sablefish management strategy evaluation (MSE) tool has demonstrated the potential utility of harvest caps for sablefish, including increasing the long-term harvest value, reducing interannual catch variability, and stabilizing long-term sablefish biomass trends (i.e., reducing cyclical trends as the resource transitions between high and low recruitment levels; Zahner et al. 2025, 2026). Thus, for these projection scenarios the NPFMC threshold $F_{40\%}$ HCR was implemented, but with a total ABC cap ranging from 20 to 40 kt. Results indicate that lower harvest caps (20 – 25 kt) could produce consistent long-term catch (i.e., reduce quota creep and subsequent declines), reduce ABC variability, and maintain SSB at relatively high levels (Figure 3.91). Under average recruitment conditions and current stock sizes, intermediate caps would only get implemented for a handful of years, while high caps would see limited implementation and simply revert to the $F_{40\%}$ rule. Overall, harvest caps may be useful if reducing interannual catch variability is of interest to stakeholders.

Each of these alternate forecasts is presented for informational purposes only and are not meant for the basis of management advice.

Risk Table ABC Considerations

The risk table approach is used to highlight externalities to the assessment across four categories (i.e., assessment, population dynamics, environmental and ecosystem, and fishery performance) that may indicate potential issues that should be considered when managers are determining future ABC recommendations. In particular, high risk table scores can be used to justify setting an ABC below the maximum permissible ABC.

Assessment Related Considerations

The sablefish assessment is data-rich and the quality of the data that goes into the model is generally considered to be high. However, the lack of a 2024 Longline Survey and the recent survey redesign have increased uncertainty in recent assessment estimates of recruitment. Moreover, continued reductions in age reading capacity, particularly for sablefish fishery ages, has further increased assessment uncertainty. Despite some data conflicts between fitting the survey indices and age compositions, the suite of diagnostic analyses implemented demonstrate that the author recommended sablefish assessment is robust and consistent. Fits to the compositional data are mediocre but adequate. No strong retrospective patterns exist, though SSB tends to be slightly underestimated as new data are added to the model. The primary assessment uncertainty is the magnitude of recent recruitment events, but catch projections are generally robust to this uncertainty. **Therefore, the assessment related concern is 'level 1 – Normal'.**

Population Dynamics Considerations

Sablefish productivity remains high and the SSB continues to grow rapidly. However, the lack of sablefish greater than 12 years of age, especially compared to historic levels of older and larger fish, is worth monitoring. The diversity of ages contributing to the overall SSB is relatively low (Figure 3.64). The model projects that age classes from 2014 onwards will comprise over 90% of total SSB in 2027. If the recent increase in productivity is associated with transient environmental or ecosystem conditions, then it is likely that the sablefish resource and fishery will be reliant on these handful of year classes for a decade or more. For instance, the sudden appearance of numerous large year classes starting in 2014 occurred at historically low SSB levels, which suggests that these recruitment events may be environmentally driven. Because the exact drivers are not known, a transition to more average recruitment levels (as has typically happened following periods of high recruitment) may occur at any time (Figure 3.65). The 2020 and 2022 year classes remain above average, but early indications suggest that incoming year classes may be smaller. Overall, though, population trends are extremely positive and indicate continued growth of the population. **Hence, the population dynamics related concern is a 'level 1 – Normal'.**

Environmental and Ecosystem Considerations

In 2026, environmental conditions were moderate for survival and growth of larvae in the eastern GOA (warm, productive, low larval transport), average to above average for YOY/juvenile sablefish in the GOA, and average/unknown for adult slope habitat in the GOA, EBS, and AI. Foraging opportunities for juvenile and pre-recruit sablefish were likely sufficient, given average to above average zooplankton and forage fish prey base in 2026. Predation by other groundfish likely remains below average in EBS and western GOA but above average in eastern GOA, and low in the AI due to decreasing apex groundfish predators despite the increase of Pacific cod. Competition for zooplankton prey is moderate, due to low returns of pink salmon in the GOA, but relatively higher biomass of pollock (EBS & GOA) and Pacific ocean perch (GOA). Overlap competition based on incidental catch of sablefish in the arrowtooth flounder fishery increased to high levels in the GOA. The GOA's response to the 2027 strong El Niño is expected to include warmer winter and spring surface temperatures and potentially stronger circulation and eddy strength, benefiting survival of the 2027 sablefish year class if adequate prey resources are available. Based on the ecosystem information related to Alaskan sablefish provided in the 2026 EBS, GOA, and AI Ecosystem Status Reports along with the sablefish Ecosystem and Socioeconomic Profile, **the environmental and ecosystem related concern is a 'level 1 – Normal'.**

Fishery Performance Considerations

Currently, there is no updated CPUE index (terminal year is 2022) to inform fishery performance considerations. The lack of ABC utilization is likely driven by socioeconomic considerations and is unlikely related to population dynamics. Similarly, the lack of fishing effort (or associated observer biological samples) in the AI is likely associated with prohibitive costs to fishing in the region and not associated with biological trends. **Thus, the fishery performance concern is a 'level 1 – Normal'.**

Risk Table Summary

For the 2026 sablefish risk table, all scores were a 'level 1 – Normal'. Given the lack of major concerns for sablefish, no additional reductions in ABC are being recommended (though deductions for whale depredation are still incorporated). It is worth noting that when catches have exceeded ~30 kt for multiple years, SSB has demonstrated subsequent strong declines (also associated with transitions from high to low recruitment levels; Figure 3.65). Although catch levels have yet to exceed 30 kt in recent years, future full utilization of ABCs would exceed this threshold and the population response would be worth monitoring closely, especially if recruitment signals indicate a transition back towards more average conditions.

However, the population is nearing all-time highs in SSB and biomass with the maturation of the historical 2014 – 2017 year classes, while recruitment remains strong in 2022 and 2024. Under continued above average recruitment conditions (e.g., the 'Recent Average, 2021 – 2024' projection scenario), current SSB would be maintained in the near-term at relatively high catch levels (Figure 3.90). Moreover, utilization rates over the last ~5 years have declined rapidly as the quota has increased, dropping to ~50% in recent years. In 2026, utilization was ~5% in the AI, ~25% in the BS, and averaged ~80% across the GOA (ranging from ~70% in the WG to ~90% in the SEO). Thus, effective buffers have resulted that have ensured continued population growth, aided by periodic above average recruitment.

Assessment-related considerations	*Population dynamics considerations*	*Ecosystem considerations*	*Fishery Performance considerations related to health of the stock*
Level 1: Normal	Level 1: Normal	Level 1: Normal	Level 1: Normal

Spatial Apportionment: Biologically-informed Recommended Distributions (BRDs)

An apportionment method that tracks regional biomass, or a proxy thereof, is likely the best defense against localized depletion or other conservation concerns (e.g., disproportionately targeting spawners in only a handful of regions or population strongholds), and ensures balanced harvest across the population and age structure (i.e., avoiding only harvesting large or small fish). Based on a biological perspective, the five-year average survey apportionment method was recommended by the SSC in 2020, because it tracks biomass across management regions to the best of our current ability (i.e., by using estimates of regional biomass from the yearly longline survey that targets sablefish in primary adult habitat). Because a moving five-year average is used, the apportionment values are updated each year as new survey data is added into the calculation. Given that sablefish are assumed to be panmictic and represent a single population across the GOA and BSAI (Jasonowicz et al., 2017), area-specific OFLs are not implemented. Explorations with the spatial model (Appendices 3D and 3E) concluded that the area apportionment based on survey biomass generally matched recommended regional harvest levels from the spatial assessment (Cheng et al., 2025d).

Given the lack of a synoptic survey in any year, survey-based apportionment has always used some form of interpolation for unsurveyed regions. Due to the 2025 change in survey design, the previous apportionment method that used an interpolation based on change in the GOA RPNs is no longer feasible. The static *GOA_Fix* approach from 2024 is provided, but static apportionment approaches are not recommended given the dynamic distribution of sablefish across regions. Thus, four alternatives are provided that include the 'carryover' interpolation (as used in Model *26.1_1Reg*), using REMA to smooth and interpolate, and each of these combined with either including or excluding extrapolated western AI (wAI) Longline Survey stations (which have never been surveyed by NOAA). The REMA approach interpolates unsurveyed regional RPN values prior to the terminal assessment year but uses a carryover value for the terminal year. Thus, the REMA apportionment method replaces the terminal value from the previous assessment with a new interpolated value when calculating the five-year averages. The carryover interpolation assumes RPNs for unsurveyed regions are held constant at the previous level for that region. Removing the wAI stations has the largest influence on apportionment, whereas the choice of survey interpolation method has limited impact (Figure 3.92). For 2026, the author recommended apportionment approach is the 'carryover' interpolation that removes the wAI stations from the indices.

It is worth noting that the lack of a 2024 survey and the reduction in survey footprint beginning in 2025 have inherently increased uncertainty regarding regional biomass distributions, especially given that the GOA and BS/AI are no longer surveyed simultaneously. Given the panmictic and highly mobile nature of sablefish, the current apportionment rationale emphasized that apportionment values should not deviate *too* far from survey based regional biomass proportions (Goethel et al., 2020). Considering current ABC

utilization rates as well as increased apportionment uncertainty, short-term deviations from survey apportionment values are unlikely to cause biological harm.

Data Gaps and Research Priorities

In terms of the assessment model and general knowledge of sablefish dynamics, the following research is being considered (priority level is given in parentheses):

- Continue exploring the parametrization of fleet structure and selectivity in the FAA model, particularly whether or not to disaggregate the fixed gear fishery by region or allow for domed selectivity in the various fleets (e.g., BS and AI) to address ontogenetic movement patterns; improved regional age composition sample sizes are likely required in the future to enable more complex FAA parametrizations (high).
- Continue to explore the use of self-weighting likelihoods in combination with time-varying selectivity formulations (medium).
- Explore use of bootstrapping methods to determine appropriate input sample sizes for compositional data using the methods of Hulson and Williams (2024), when available for longline survey and fishery data simultaneously (high).
- Integrate age-varying natural mortality and robust natural mortality priors into the assessment (medium).
- Refine the spatial model and identify good practices for data-weighting with tagging data as well as implementation of a robust and parsimonious approach for estimating time-varying movement (high).
- Expand the spatial model to get a better understanding of juvenile distribution, spawning locations, and habitat utilization (e.g., using electronic and satellite tagging) through integration of a high-resolution tagging and movement model (low).
- Allow for time-varying growth (estimated internally or externally) to address the potential for declines in growth due to recent extreme year classes and explore the incorporation of tagging data to inform growth processes (medium).
- Update the aging error matrix (low).
- Explore expanding the age-structure (i.e., set the plus group to age-41+ or age-51+) to reduce the size of the plus group and better represent the age-structured dynamics (low).
- Pending NPFMC action on small sablefish release motions, explore methods for handling discards in the assessment model (high).
- Expand the spatial model into a full life cycle model that incorporates larval individual-based modeling outputs to inform connectivity during early life history stages and ecosystem drivers of settlement success (low).
- Continue work on the sablefish MSE tool to identify robust harvest control rules that account for age structure and fishery performance metrics (high).

Acknowledgments

The authors wish to acknowledge the many additional contributors that help make this sablefish assessment possible each year. The feedback we receive from industry participants is vital in aiding our understanding of patterns in the fishery and the stock. The careful data collection by fishery observers and survey biologists is greatly appreciated and form the backbone of all our assessments. Finally, we thank our excellent AFSC Age and Growth program.

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Tables

Table 3.1. Alaska sablefish total catch (t). Eastern GOA includes West Yakutat (WY) and Southeast Outside (SEO). Catch is as of October 15, 2026 (from www.akfin.org). The values in this table are not adjusted for whale depredation. Abbreviations are: Bering Sea (BS), Aleutian Islands (AI), Western Gulf of Alaska (WGOA), Central Gulf of Alaska (CGOA), Eastern Gulf of Alaska (EGOA), West Yakutat (WY), Southeast Outside (SEO), non-commercial (Non-Comm.), Hook and Line (HAL). Note that the total column is the sum of the gear-specific catch columns and may not reflect the sum of the area-specific columns due to minor discrepancies in area-specific catch reporting.

		By Area								By Gear		
Year	Total	BS	AI	WGOA	CGOA	EGOA	WY	SEO	Non-Comm.	HAL	Pot	Trawl	% Trawl
1960	3,100	1,861	-	-	-	1,193	-	-	-	3,100	-	-	0
1961	16,100	15,627	-	-	-	451	-	-	-	16,100	-	-	0
1962	26,400	25,989	-	-	-	390	-	-	-	26,400	-	-	0
1963	16,900	13,706	664	266	1,324	941	-	-	-	10,600	-	6,300	37
1964	7,300	3,545	1,541	92	955	1,140	-	-	-	3,300	-	4,000	55
1965	8,700	4,838	1,249	764	1,449	433	-	-	-	900	-	7,800	90
1966	15,600	9,505	1,341	1,093	2,632	1,012	-	-	-	3,800	-	11,800	76
1967	19,200	11,698	1,652	523	1,955	3,368	-	-	-	3,900	-	15,300	80
1968	31,000	14,374	1,673	297	1,658	12,938	-	-	-	11,200	-	19,800	64
1969	36,800	16,009	1,673	836	4,214	14,099	-	-	-	15,400	-	21,400	58
1970	37,800	11,737	1,248	1,566	6,703	16,604	-	-	-	22,700	-	15,100	40
1971	43,500	15,106	2,936	2,047	6,996	16,382	-	-	-	22,900	-	20,600	47
1972	53,000	12,758	3,531	3,857	11,599	21,320	-	-	-	28,500	-	24,500	46
1973	36,900	5,957	2,902	3,962	9,629	14,439	-	-	-	23,200	-	13,700	37
1974	34,600	4,258	2,477	4,207	7,590	16,006	-	-	-	25,500	-	9,100	26
1975	29,900	2,766	1,747	4,240	6,566	14,659	-	-	-	23,300	-	6,600	22
1976	31,700	2,923	1,659	4,837	6,479	15,782	-	-	-	25,400	-	6,300	20
1977	21,403	2,718	1,897	2,968	4,270	9,543	-	-	3	18,900	-	2,500	12
1978	10,414	1,193	821	1,419	3,090	3,870	-	-	14	9,200	-	1,200	12
1979	12,031	1,376	782	999	3,189	5,391	-	-	131	10,400	-	1,500	12
1980	10,584	2,205	275	1,450	3,027	3,461	-	-	184	8,400	-	2,000	19
1981	12,838	2,605	533	1,595	3,425	4,425	-	-	238	11,000	-	1,600	12
1982	12,348	3,238	964	1,489	2,885	3,457	-	-	348	10,200	-	1,800	15
1983	12,082	2,712	684	1,496	2,970	3,818	-	-	282	10,200	-	1,600	13
1984	14,511	3,336	1,061	1,326	3,463	4,618	-	-	411	10,300	-	3,800	26
1985	15,076	2,454	1,551	2,152	4,209	4,098	-	-	576	13,000	-	1,500	10
1986	29,419	4,184	3,285	4,067	9,105	8,175	-	-	519	21,600	-	7,300	25
1987	35,666	4,904	4,112	4,141	11,505	10,500	-	-	466	27,600	-	7,600	21
1988	39,107	4,006	3,616	3,789	14,505	12,473	-	-	707	29,300	-	9,100	23
1989	35,564	1,516	3,704	4,533	13,224	11,852	-	-	764	27,500	-	7,300	21
1990	30,880	2,330	2,120	1,993	12,066	11,707	-	-	664	25,532	-	4,684	15
1991	27,092	1,209	2,190	1,931	11,178	9,938	4,069	5,869	645	23,349	-	3,097	11
1992	24,574	613	1,553	2,221	10,355	9,158	4,408	4,750	674	20,977	13	2,910	12
1993	26,099	669	2,078	740	11,955	9,976	4,620	5,356	682	22,912	0	2,506	10
1994	24,174	694	1,727	539	9,377	11,243	4,493	6,750	594	20,614	29	2,938	12
1995	21,080	930	1,119	1,747	7,673	9,223	3,872	5,352	388	18,062	18	2,613	12
1996	17,834	648	764	1,649	6,773	7,558	2,899	4,659	441	15,147	59	2,187	12
1997	14,951	552	781	1,374	6,234	5,666	1,930	3,735	344	12,975	1	1,632	11
1998	14,242	563	535	1,432	5,922	5,422	1,956	3,467	368	12,386	1	1,487	10
1999	13,977	675	683	1,488	5,874	4,867	1,709	3,159	390	11,566	37	1,985	14
2000	15,894	742	1,049	1,587	6,173	6,020	2,066	3,953	324	13,402	149	2,019	13
2001	14,435	864	1,074	1,588	5,518	5,021	1,737	3,284	370	12,057	225	1,783	12
2002	15,205	1,144	1,118	1,865	6,180	4,441	1,550	2,891	457	11,993	512	2,243	15
2003	16,797	1,012	1,118	2,118	6,994	5,170	1,822	3,347	386	13,671	680	2,060	12
2004	17,896	1,041	955	2,173	7,310	6,041	2,241	3,801	376	15,042	822	1,656	9
2005	16,951	1,070	1,481	1,930	6,706	5,399	1,824	3,575	366	13,741	1,288	1,556	9
2006	15,904	1,078	1,151	2,151	5,921	5,251	1,889	3,362	353	13,218	1,087	1,246	8
2007	16,284	1,182	1,169	2,101	6,004	5,502	2,074	3,429	326	13,087	1,636	1,235	8
2008	14,857	1,141	899	1,679	5,495	5,337	2,016	3,321	305	12,490	940	1,122	8
2009	13,364	916	1,100	1,423	4,967	4,656	1,831	2,825	302	11,370	635	1,057	8
2010	12,275	752	1,048	1,354	4,512	4,270	1,579	2,692	339	10,422	510	1,005	8
2011	13,328	707	1,027	1,395	4,922	4,936	1,902	3,034	341	11,251	556	1,180	9
2012	14,144	744	1,205	1,352	5,328	5,243	2,033	3,210	272	12,259	511	1,102	8
2013	13,851	635	1,082	1,358	5,187	5,349	2,102	3,246	240	12,134	439	1,037	7
2014	11,806	314	813	1,194	4,736	4,489	1,671	2,817	259	10,195	326	1,025	9

2015	11,179	210	422	998	4,626	4,677	1,866	2,811	246	9,721	122	1,090	10
2016	10,472	531	340	1,052	4,195	4,106	1,651	2,455	248	8,701	187	1,336	13
2017	12,552	1,150	588	1,181	4,838	4,510	1,694	2,816	285	8,464	1,531	2,272	18
2018	14,494	1,536	664	1,389	5,778	4,881	1,861	3,019	246	8,690	1,778	3,780	26
2019	16,911	3,162	663	1,533	6,280	4,914	1,802	3,112	360	8,268	3,130	5,154	30
2020	19,416	5,329	1,232	1,462	6,041	4,971	1,835	3,137	381	5,813	5,730	7,493	39
2021	21,747	4,168	1,578	1,994	7,325	6,201	2,329	3,872	481	4,644	11,771	4,852	22
2022	27,420	5,514	2,230	3,028	8,165	7,972	2,750	5,222	512	4,057	17,486	5,366	20
2023	25,512	6,132	2,488	2,788	6,458	7,149	2,452	4,697	498	3,310	16,103	5,602	22
2024	23,513	4,904	1,430	2,783	7,317	6,976	2,390	4,586	105	3,406	14,497	5,506	23
2025	23,649	3,909	948	3,136	7,710	7,541	2,294	5,247	405	2,818	16,320	4,105	17
2026	22,374	3,339	632	3,458	7,597	7,135	2,271	4,865	212	1,904	16,695	3,562	16

Table 3.2. Summary of management measures with time series of catch, ABC, OFL, and TAC. All values are in metric tons (t). Catch is as of October 15, 2026 (from www.akfin.org). Catch does not include non-commercial catch (i.e., as opposed to Table 3.1).

Year	Catch	OFL	ABC	TAC	Management measure
1980	10,400			18,000	Amendment 8 to the Gulf of Alaska Fishery Management Plan established the West and East Yakutat (now SEO) management areas for sablefish.
1981	12,600			19,300	
1982	12,000			17,300	
1983	11,800			14,500	
1984	14,100			14,800	
1985	14,500			13,500	Amendment 14 of the GOA FMP allocated sablefish quota by gear type: 80% to fixed gear and 20% to trawl gear in WGOA and CGOA and 95% fixed to 5% trawl in the EGOA.
1986	28,900			21,400	Pot fishing banned in Eastern GOA.
1987	35,200			27,700	Pot fishing banned in Central GOA.
1988	38,400		44,200	36,400	
1989	34,800		37,100	32,200	Pot fishing banned in Western GOA.
1990	30,200		33,400	33,200	Amendment 15 of the BSAI FMP allocated sablefish quota by gear type: 50% to fixed gear and 50% to trawl in the EBS, and 75% fixed to 25% trawl in the Aleutian Islands.
1991	26,400		28,800	28,800	
1992	23,900	34,100	25,200	25,200	Pot fishing banned in Bering Sea (57 FR 37906).
1993	25,400	33,200	25,000	25,000	
1994	23,600	35,900	28,800	28,800	
1995	20,700	25,700	25,300	25,300	Amendment 20 to the Gulf of Alaska Fishery Management Plan and 15 to the Bering Sea/Aleutian Islands Fishery Management Plan established IFQ management for sablefish beginning in 1995. These amendments also allocated 20% of the fixed gear allocation of sablefish to a CDQ reserve for the Bering Sea and Aleutian Islands.
1996	17,400	22,800	19,600	19,400	Pot fishing ban was repealed in Bering Sea except from June 1-30.
1997	14,600	45,600	17,200	16,800	Maximum retainable allowances for sablefish were revised in the Gulf of Alaska. The percentage depends on the basis species.
1998	13,900	27,800	16,800	16,800	
1999	13,600	24,700	15,900	15,400	
2000	15,600	21,500	17,200	17,200	
2001	14,100	20,700	16,900	16,900	
2002	14,700	26,100	17,300	17,300	
2003	16,400	28,900	20,900	20,900	
2004	17,500	30,800	23,000	22,600	
2005	16,600	25,400	21,000	21,000	
2006	15,600	25,300	21,000	20,700	
2007	16,000	23,700	20,100	20,100	
2008	14,600	21,300	18,000	18,000	Pot fishing ban repealed in Bering Sea for June 1-30 (74 FR 28733).
2009	13,100	19,000	16,100	16,100	
2010	11,900	18,000	15,200	15,200	
2011	13,000	19,000	16,000	16,000	
2012	13,900	20,400	17,200	17,200	
2013	13,600	19,200	16,200	16,200	
2014	11,500	16,200	13,700	13,700	
2015	10,900	16,100	13,700	13,700	NPFMC passes Amendment 101 to allow pot fishing in the GOA.
2016	10,200	13,400	11,800	11,800	Whale depredation accounted for in survey and fishery.
2017	12,300	15,400	13,100	13,100	Pot fishing begins in the GOA.
2018	14,200	29,500	15,000	15,000	
2019	16,600	32,800	15,100	15,100	
2020	19,000	50,500	22,000	18,300	OFL changed to Alaska-wide. TAC set below ABC based on AP recommendation.
2021	21,300	60,400	29,600	26,100	
2022	26,900	40,400	34,500	34,500	
2023	25,000	47,400	40,500	39,600	
2024	23,400	55,100	47,100	39,000	
2025	23,200	58,500	47,600	39,300	
2026	22,200	57,800	47,000	39,000	

Table 3.3. Data used in the 2026 Model *26.2_FAA*. Years in **bold** are data new to this assessment.

Source	Data	Years
Fixed Gear Fisheries	Catch	1960 – **2025+2026**
Trawl Fisheries	Catch	1960 – **2025+2026**
Non-Commercial Catch	Catch	1977 – **2025+2026**
U.S. Fixed Gear Fisheries	Age	1999 – **2024+2025**
U.S. Trawl Fisheries	Length	1990,1991,1999, 2005 – **2024+2025**
Japan-U.S. Cooperative Longline Survey	RPNs, Length	1979 – 1994
	Age	1981, 1985, 1987, 1989, 1991, 1993
Aleutian Islands NOAA Domestic Longline Survey	RPNs	1996 – 2022 (even years), **2026**
	Age	1996 – 2022 (even years)
Bering Sea NOAA Domestic Longline Survey	RPNs	1997 – 2023 (odd years), **2026**
	Age	1997 – 2023 (odd years)
Gulf of Alaska NOAA Domestic Longline Survey	RPNs	1990 – 2023, **2025**
	Age	1996 – 2023, **2025**

Table 3.4. Sample sizes for age and length data for all available data (not all data is used in the assessment). Japanese fishery data are from Sasaki (1985), U.S. fishery data are from the observer databases, and NOAA survey data are from AFSC databases.

	Age Samples			Length Samples				
Year	Japanese LL Survey	NOAA LL Survey	Fixed Gear Fishery	Japanese LL Survey	NOAA LL Survey	NOAA Trawl Survey	Fixed Gear Fishery	Trawl Gear Fishery
1979	-	-	-	18,673	-	-	-	-
1980	-	-	-	26,568	-	-	-	-
1981	490	-	-	32,789	-	-	-	-
1982	-	-	-	62,241	-	-	-	-
1983	-	-	-	65,759	-	-	-	-
1984	-	-	-	98,077	-	-	-	-
1985	1,294	-	-	120,453	-	-	-	-
1986	-	-	-	121,834	-	-	-	-
1987	1,211	-	-	98,246	-	-	-	-
1988	-	-	-	108,695	-	-	-	-
1989	2,069	-	-	105,575	-	-	-	-
1990	-	-	-	71,858	86,960	4,954	32,936	1,204
1991	797	-	-	64,052	81,747	-	28,182	655
1992	-	-	-	73,075	90,725	-	20,929	-
1993	1,718	-	-	74,402	82,033	7,015	21,943	-
1994	-	-	-	69,020	62,714	-	11,914	386
1995	-	-	-	-	80,652	-	17,735	87
1996	-	957	-	-	72,720	4,299	14,416	170
1997	-	1,126	-	-	73,694	-	20,330	-
1998	-	912	-	-	48,094	-	8,932	37
1999	-	791	1,141	-	62,812	3,968	28,070	447
2000	-	911	1,148	-	52,556	-	32,208	471
2001	-	889	1,003	-	64,448	-	30,315	422
2002	-	901	1,059	-	60,004	-	33,719	527
2003	-	872	1,185	-	62,972	4,839	36,077	463
2004	-	949	1,145	-	69,977	-	31,199	717
2005	-	976	1,114	-	62,514	4,643	36,213	2,541
2006	-	949	1,154	-	66,060	-	32,497	898
2007	-	905	1,115	-	59,425	3,690	29,854	2,142
2008	-	947	1,164	-	56,830	-	23,414	2,268
2009	-	963	1,126	-	55,637	3,455	24,674	1,897
2010	-	940	1,159	-	62,820	-	24,530	1,634
2011	-	954	1,190	-	73,063	2,064	22,659	1,877
2012	-	947	1,165	-	53,514	-	22,203	2,533
2013	-	957	1,157	-	43,230	1,206	16,093	2,674
2014	-	1,010	1,126	-	46,885	-	19,524	2,210
2015	-	1,098	1,176	-	44,150	2,023	20,056	2,320
2016	-	990	1,169	-	60,353	-	12,857	1,630
2017	-	975	1,190	-	61,616	2,860	12,345	2,625
2018	-	976	1,174	-	63,287	-	13,269	3,306
2019	-	946	1,140	-	84,705	7,555	13,537	2,620
2020	-	972	1,188	-	91,432	-	9,122	9,421
2021	-	963	1,183	-	76,162	8,208	15,762	7,681
2022	-	972	1,174	-	66,850	-	16,152	6,485
2023	-	993	991	-	61,037	2,795	17,993	6,732
2024	-	-	1,180	-	-	-	12,178	6,383
2025	-	1,194	598	-	93,164	2,249	8,300	9,231
2026	-	-	-	-	19,396	-	-	-

Table 3.5. The actual number of samples and associated Input Sample Size (ISS) by year for age and length composition data used in the assessment model (Model *26.2_FAA*). ISS is calculated using a relative linear scaling within each gear based on the maximum and minimum number of samples (see text). The fleets-as-areas (FAA) model uses the 'AK' row for all data sources except the NOAA Longline Survey (i.e., regional ISS are used for each regional fleet).

		Age Samples						Length Samples			
		Japanese LL Survey		NOAA LL Survey		Fixed Gear Fishery		Japanese LL Survey		Trawl Fishery	
Year	Reg	#	ISS	#	ISS	#	ISS	#	ISS	#	ISS
1979	AK	-	-	-	-	-	-	18,673	29	-	-
1980	AK	-	-	-	-	-	-	26,568	32	-	-
1981	AK	490	43	-	-	-	-	32,789	35	-	-
1982	AK	-	-	-	-	-	-	62,241	49	-	-
1983	AK	-	-	-	-	-	-	65,759	50	-	-
1984	AK	-	-	-	-	-	-	98,077	65	-	-
1985	AK	1,294	85	-	-	-	-	120,453	75	-	-
1986	AK	-	-	-	-	-	-	121,834	75	-	-
1987	AK	1,211	81	-	-	-	-	98,246	65	-	-
1988	AK	-	-	-	-	-	-	108,695	70	-	-
1989	AK	2,069	125	-	-	-	-	105,575	68	-	-
1990	AK	-	-	-	-	-	-	71,858	53	1,204	28
1991	AK	797	59	-	-	-	-	64,052	49	655	24
1992	AK	-	-	-	-	-	-	73,075	53	-	-
1993	AK	1,718	107	-	-	-	-	74,402	54	-	-
1994	AK	-	-	-	-	-	-	69,020	52	-	-
1995	AK	-	-	-	-	-	-	-	-	-	-
1996	AI	-	-	204	31	-	-	-	-	-	-
1996	AK	-	-	-	-	-	-	-	-	-	-
1996	GOA	-	-	753	70	-	-	-	-	-	-
1997	AK	-	-	-	-	-	-	-	-	-	-
1997	BS	-	-	223	33	-	-	-	-	-	-
1997	GOA	-	-	903	80	-	-	-	-	-	-
1998	AI	-	-	323	40	-	-	-	-	-	-
1998	AK	-	-	-	-	-	-	-	-	-	-
1998	GOA	-	-	589	58	-	-	-	-	-	-
1999	AK	-	-	-	-	1,141	145	-	-	447	22
1999	BS	-	-	192	30	-	-	-	-	-	-
1999	GOA	-	-	599	59	-	-	-	-	-	-
2000	AI	-	-	281	37	-	-	-	-	-	-
2000	AK	-	-	-	-	1,148	146	-	-	471	22
2000	GOA	-	-	630	61	-	-	-	-	-	-
2001	AK	-	-	-	-	1,003	129	-	-	422	22
2001	BS	-	-	315	39	-	-	-	-	-	-
2001	GOA	-	-	574	57	-	-	-	-	-	-
2002	AI	-	-	248	34	-	-	-	-	-	-
2002	AK	-	-	-	-	1,059	136	-	-	527	22
2002	GOA	-	-	653	63	-	-	-	-	-	-
2003	AK	-	-	-	-	1,185	150	-	-	463	22
2003	BS	-	-	166	29	-	-	-	-	-	-
2003	GOA	-	-	706	66	-	-	-	-	-	-
2004	AI	-	-	282	37	-	-	-	-	-	-
2004	AK	-	-	-	-	1,145	145	-	-	717	24
2004	GOA	-	-	667	64	-	-	-	-	-	-
2005	AK	-	-	-	-	1,114	142	-	-	2,541	40
2005	BS	-	-	301	38	-	-	-	-	-	-
2005	GOA	-	-	675	64	-	-	-	-	-	-
2006	AI	-	-	295	38	-	-	-	-	-	-
2006	AK	-	-	-	-	1,154	146	-	-	898	26
2006	GOA	-	-	654	63	-	-	-	-	-	-
2007	AK	-	-	-	-	1,115	142	-	-	2,142	37

2007	BS	-	-	286	37	-	-	-	-	-	-
2007	GOA	-	-	619	60	-	-	-	-	-	-
2008	AI	-	-	265	36	-	-	-	-	-	-
2008	AK	-	-	-	-	1,164	148	-	-	2,268	38
2008	GOA	-	-	682	65	-	-	-	-	-	-
2009	AK	-	-	-	-	1,126	143	-	-	1,897	35
2009	BS	-	-	189	30	-	-	-	-	-	-
2009	GOA	-	-	774	71	-	-	-	-	-	-
2010	AI	-	-	156	28	-	-	-	-	-	-
2010	AK	-	-	-	-	1,159	147	-	-	1,634	32
2010	GOA	-	-	784	72	-	-	-	-	-	-
2011	AK	-	-	-	-	1,190	150	-	-	1,877	34
2011	BS	-	-	171	29	-	-	-	-	-	-
2011	GOA	-	-	783	72	-	-	-	-	-	-
2012	AI	-	-	242	34	-	-	-	-	-	-
2012	AK	-	-	-	-	1,165	148	-	-	2,533	40
2012	GOA	-	-	705	66	-	-	-	-	-	-
2013	AK	-	-	-	-	1,157	147	-	-	2,674	41
2013	BS	-	-	237	34	-	-	-	-	-	-
2013	GOA	-	-	720	67	-	-	-	-	-	-
2014	AI	-	-	198	31	-	-	-	-	-	-
2014	AK	-	-	-	-	1,126	143	-	-	2,210	37
2014	GOA	-	-	812	74	-	-	-	-	-	-
2015	AK	-	-	-	-	1,176	149	-	-	2,320	38
2015	BS	-	-	132	26	-	-	-	-	-	-
2015	GOA	-	-	966	85	-	-	-	-	-	-
2016	AI	-	-	304	38	-	-	-	-	-	-
2016	AK	-	-	-	-	1,169	148	-	-	1,630	32
2016	GOA	-	-	686	65	-	-	-	-	-	-
2017	AK	-	-	-	-	1,190	150	-	-	2,625	41
2017	BS	-	-	300	38	-	-	-	-	-	-
2017	GOA	-	-	675	64	-	-	-	-	-	-
2018	AI	-	-	297	38	-	-	-	-	-	-
2018	AK	-	-	-	-	1,174	149	-	-	3,306	47
2018	GOA	-	-	679	64	-	-	-	-	-	-
2019	AK	-	-	-	-	1,140	145	-	-	2,620	41
2019	BS	-	-	299	38	-	-	-	-	-	-
2019	GOA	-	-	647	62	-	-	-	-	-	-
2020	AI	-	-	296	38	-	-	-	-	-	-
2020	AK	-	-	-	-	1,188	150	-	-	9,421	100
2020	GOA	-	-	676	64	-	-	-	-	-	-
2021	AK	-	-	-	-	1,183	150	-	-	7,681	85
2021	BS	-	-	300	38	-	-	-	-	-	-
2021	GOA	-	-	663	63	-	-	-	-	-	-
2022	AI	-	-	298	38	-	-	-	-	-	-
2022	AK	-	-	-	-	1,174	149	-	-	6,485	75
2022	GOA	-	-	674	64	-	-	-	-	-	-
2023	AK	-	-	-	-	991	128	-	-	6,732	77
2023	BS	-	-	300	38	-	-	-	-	-	-
2023	GOA	-	-	693	65	-	-	-	-	-	-
2024	AK	-	-	-	-	1,180	149	-	-	6,383	74
2025	AK	-	-	-	-	598	83	-	-	9,231	99
2025	GOA	-	-	1,194	100	-	-	-	-	-	-

Table 3.6. Sablefish abundance or biomass index values (only the NOAA Longline Survey and Japanese Longline Survey RPNs are used in the assessment model) along with associated standard errors (SEs). Relative population number (RPN; in 1000s of fish) equals CPUE in numbers weighted by respective strata areas. Relative population weight (RPW; in kilotons) equals CPUE in weight multiplied by strata areas. NMFS trawl survey biomass estimates (kilotons) are from the Gulf of Alaska only at depths < 500 m. The fleets-as-areas (FAA) model uses the 'AK' row for all data sources except the NOAA Longline Survey (i.e., regional RPNs are used for each regional fleet).

		Relative Population Numbers (RPNS)				Relative Population Weights (RPWs) or Biomass									
		NOAA LL Survey*		Japanese LL Survey		NOAA LL Survey*		Japanese LL Survey		NOAA Trawl Survey		Japanese Fishery CPUE		Fixed Gear Fishery CPUE	
Year	Reg	RPN	SE	RPN	SE	RPW	SE	RPW	SE	RPW	SE	RPW	SE	RPW	SE
1964	AK	-	-	-	-	-	-	-	-	-	-	1,452	0.2	-	-
1965	AK	-	-	-	-	-	-	-	-	-	-	1,806	0.2	-	-
1966	AK	-	-	-	-	-	-	-	-	-	-	2,462	0.2	-	-
1967	AK	-	-	-	-	-	-	-	-	-	-	2,855	0.2	-	-
1968	AK	-	-	-	-	-	-	-	-	-	-	2,336	0.2	-	-
1969	AK	-	-	-	-	-	-	-	-	-	-	2,443	0.2	-	-
1970	AK	-	-	-	-	-	-	-	-	-	-	2,912	0.2	-	-
1971	AK	-	-	-	-	-	-	-	-	-	-	2,401	0.2	-	-
1972	AK	-	-	-	-	-	-	-	-	-	-	2,247	0.2	-	-
1973	AK	-	-	-	-	-	-	-	-	-	-	2,318	0.2	-	-
1974	AK	-	-	-	-	-	-	-	-	-	-	2,295	0.2	-	-
1975	AK	-	-	-	-	-	-	-	-	-	-	1,953	0.2	-	-
1976	AK	-	-	-	-	-	-	-	-	-	-	1,780	0.2	-	-
1977	AK	-	-	-	-	-	-	-	-	-	-	1,511	0.2	-	-
1978	AK	-	-	-	-	-	-	-	-	-	-	942	0.2	-	-
1979	AK	-	-	413	0.06	-	-	1,075	0.08	-	-	809	0.2	-	-
1980	AK	-	-	387	0.07	-	-	968	0.07	-	-	1,040	0.2	-	-
1981	AK	-	-	458	0.05	-	-	1,146	0.04	-	-	1,343	0.2	-	-
1982	AK	-	-	613	0.06	-	-	1,572	0.04	-	-	-	-	-	-
1983	AK	-	-	621	0.06	-	-	1,632	0.04	-	-	-	-	-	-
1984	AK	-	-	685	0.07	-	-	1,804	0.06	-	-	-	-	-	-
1985	AK	-	-	903	0.06	-	-	2,569	0.06	-	-	-	-	-	-
1986	AK	-	-	838	0.06	-	-	2,456	0.06	-	-	-	-	-	-
1987	AK	-	-	667	0.06	-	-	2,068	0.06	-	-	-	-	-	-
1988	AK	-	-	707	0.06	-	-	2,088	0.05	-	-	-	-	-	-
1989	AK	-	-	661	0.1	-	-	2,177	0.1	-	-	-	-	-	-
1990	GOA	455	0.06	-	-	1,553	0.06	-	-	-	-	-	-	-	-
1990	AK	-	-	449	0.08	-	-	1,454	0.09	213	0.3	-	-	-	-
1991	GOA	457	0.06	-	-	1,625	0.06	-	-	-	-	-	-	-	-
1991	AK	-	-	386	0.11	-	-	1,321	0.1	-	-	-	-	-	-
1992	GOA	406	0.06	-	-	1,416	0.05	-	-	-	-	-	-	-	-
1992	AK	-	-	402	0.06	-	-	1,390	0.07	-	-	-	-	-	-
1993	GOA	454	0.07	-	-	1,573	0.07	-	-	-	-	-	-	-	-
1993	AK	-	-	395	0.06	-	-	1,318	0.06	248	0.2	-	-	-	-
1994	GOA	368	0.06	-	-	1,455	0.06	-	-	-	-	-	-	-	-
1994	AK	-	-	366	0.09	-	-	1,288	0.09	-	-	-	-	-	-
1995	GOA	377	0.07	-	-	1,384	0.06	-	-	-	-	-	-	-	-
1995	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.07
1996	AI	16	0.32	-	-	50	0.32	-	-	-	-	-	-	-	-
1996	GOA	394	0.06	-	-	1,583	0.06	-	-	-	-	-	-	-	-
1996	AK	-	-	-	-	-	-	-	-	144	0.3	-	-	0.3	0.07
1997	BS	43	0.17	-	-	157	0.17	-	-	-	-	-	-	-	-
1997	GOA	379	0.07	-	-	1,396	0.07	-	-	-	-	-	-	-	-
1997	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.4	0.07
1998	AI	71	0.2	-	-	217	0.2	-	-	-	-	-	-	-	-
1998	GOA	338	0.08	-	-	1,238	0.08	-	-	-	-	-	-	-	-
1998	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.07
1999	BS	47	0.19	-	-	125	0.19	-	-	-	-	-	-	-	-
1999	GOA	371	0.07	-	-	1,338	0.07	-	-	-	-	-	-	-	-
1999	AK	-	-	-	-	-	-	-	-	103	0.2	-	-	0.3	0.07
2000	AI	66	0.27	-	-	188	0.27	-	-	-	-	-	-	-	-
2000	GOA	322	0.09	-	-	1,202	0.09	-	-	-	-	-	-	-	-
2000	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.07

2001	BS	85	0.14	-	-	255	0.13	-	-	-	-	-	-	-	-
2001	GOA	349	0.08	-	-	1,252	0.08	-	-	-	-	-	-	-	-
2001	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.06
2002	AI	63	0.26	-	-	209	0.26	-	-	-	-	-	-	-	-
2002	GOA	376	0.1	-	-	1,344	0.1	-	-	-	-	-	-	-	-
2002	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.06
2003	BS	70	0.28	-	-	219	0.27	-	-	-	-	-	-	-	-
2003	GOA	367	0.09	-	-	1,236	0.09	-	-	-	-	-	-	-	-
2003	AK	-	-	-	-	-	-	-	-	187	0.2	-	-	0.3	0.07
2004	AI	55	0.21	-	-	142	0.21	-	-	-	-	-	-	-	-
2004	GOA	389	0.09	-	-	1,243	0.1	-	-	-	-	-	-	-	-
2004	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.07
2005	BS	103	0.2	-	-	260	0.2	-	-	-	-	-	-	-	-
2005	GOA	366	0.1	-	-	1,202	0.1	-	-	-	-	-	-	-	-
2005	AK	-	-	-	-	-	-	-	-	178	0.2	-	-	0.4	0.07
2006	AI	65	0.38	-	-	181	0.37	-	-	-	-	-	-	-	-
2006	GOA	374	0.09	-	-	1,304	0.09	-	-	-	-	-	-	-	-
2006	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.06
2007	BS	98	0.2	-	-	286	0.2	-	-	-	-	-	-	-	-
2007	GOA	329	0.09	-	-	1,120	0.09	-	-	-	-	-	-	-	-
2007	AK	-	-	-	-	-	-	-	-	110	0.2	-	-	0.3	0.06
2008	AI	48	0.22	-	-	148	0.23	-	-	-	-	-	-	-	-
2008	GOA	304	0.08	-	-	1,052	0.09	-	-	-	-	-	-	-	-
2008	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.06
2009	BS	21	0.2	-	-	71	0.19	-	-	-	-	-	-	-	-
2009	GOA	323	0.11	-	-	1,108	0.11	-	-	-	-	-	-	-	-
2009	AK	-	-	-	-	-	-	-	-	105	0.2	-	-	0.3	0.06
2010	AI	36	0.25	-	-	119	0.25	-	-	-	-	-	-	-	-
2010	GOA	383	0.1	-	-	1,279	0.1	-	-	-	-	-	-	-	-
2010	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.05
2011	BS	33	0.17	-	-	91	0.17	-	-	-	-	-	-	-	-
2011	GOA	461	0.1	-	-	1,406	0.1	-	-	-	-	-	-	-	-
2011	AK	-	-	-	-	-	-	-	-	84	0.3	-	-	0.3	0.05
2012	AI	62	0.28	-	-	145	0.28	-	-	-	-	-	-	-	-
2012	GOA	336	0.09	-	-	1,029	0.09	-	-	-	-	-	-	-	-
2012	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.05
2013	BS	94	0.19	-	-	254	0.18	-	-	-	-	-	-	-	-
2013	GOA	261	0.09	-	-	870	0.09	-	-	-	-	-	-	-	-
2013	AK	-	-	-	-	-	-	-	-	58	0.3	-	-	0.2	0.04
2014	AI	48	0.24	-	-	136	0.24	-	-	-	-	-	-	-	-
2014	GOA	308	0.08	-	-	989	0.08	-	-	-	-	-	-	-	-
2014	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.04
2015	BS	48	0.23	-	-	135	0.23	-	-	-	-	-	-	-	-
2015	GOA	279	0.09	-	-	894	0.09	-	-	-	-	-	-	-	-
2015	AK	-	-	-	-	-	-	-	-	65	0.1	-	-	0.2	0.04
2016	AI	90	0.2	-	-	217	0.19	-	-	-	-	-	-	-	-
2016	GOA	319	0.08	-	-	933	0.08	-	-	-	-	-	-	-	-
2016	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.03
2017	BS	107	0.35	-	-	181	0.33	-	-	-	-	-	-	-	-
2017	GOA	329	0.07	-	-	923	0.07	-	-	-	-	-	-	-	-
2017	AK	-	-	-	-	-	-	-	-	118	0.3	-	-	0.2	0.04
2018	AI	134	0.2	-	-	253	0.2	-	-	-	-	-	-	-	-
2018	GOA	327	0.07	-	-	770	0.07	-	-	-	-	-	-	-	-
2018	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.03
2019	BS	218	0.27	-	-	426	0.26	-	-	-	-	-	-	-	-
2019	GOA	442	0.08	-	-	952	0.08	-	-	-	-	-	-	-	-
2019	AK	-	-	-	-	-	-	-	-	210	0.1	-	-	0.2	0.04
2020	AI	271	0.15	-	-	496	0.15	-	-	-	-	-	-	-	-
2020	GOA	549	0.08	-	-	1,339	0.08	-	-	-	-	-	-	-	-
2020	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.04
2021	BS	406	0.1	-	-	916	0.09	-	-	-	-	-	-	-	-
2021	GOA	535	0.07	-	-	1,311	0.07	-	-	-	-	-	-	-	-
2021	AK	-	-	-	-	-	-	-	-	290	0.2	-	-	0.3	0.05
2022	AI	300	0.13	-	-	632	0.13	-	-	-	-	-	-	-	-
2022	GOA	631	0.06	-	-	1,600	0.05	-	-	-	-	-	-	-	-
2022	AK	-	-	-	-	-	-	-	-	-	-	-	-	0.4	0.07
2023	BS	442	0.17	-	-	962	0.16	-	-	-	-	-	-	-	-
2023	GOA	657	0.09	-	-	1,548	0.09	-	-	-	-	-	-	-	-
2023	AK	-	-	-	-	-	-	-	-	140	0.2	-	-	-	-
2024	AK	-	-	-	-	-	-	-	-	-	-	-	-	-	-

2025	GOA	686	0.07	-	-	1,750	0.07	-	-	-	-	-	-	-	-
2025	AK	-	-	-	-	-	-	-	-	153	0.2	-	-	-	-
2026	AI	379	0.1	-	-	1,055	0.1	-	-	-	-	-	-	-	-
2026	BS	379	0.12	-	-	958	0.12	-	-	-	-	-	-	-	-
2026	AK	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.7. Summary of the parameters estimated within the assessment model, where Model *26.2_FAA* is the author recommended model.

Parameter Name	*25.12_1Reg_Cont*	*26.1_1Reg*	*26.2_FAA*	*26.2_FAA_3LLF_ LLS_BS_Dome_DN*
Catchability	5	2	4	4
Mean recruitment	1	1	1	1
Natural Mortality	1	2	2	2
Initial Deviations	28	28	28	28
Recruitment Deviations	66	66	66	66
Mean Fishing Mortality	2	2	2	4
Fishing Mortality Deviations	131	131	131	262
Fishery Selectivity	14	12	12	18
Survey Selectivity	11	12	28	32
Total	259	256	274	417

Table 3.8. The assumed error terms for each data source that are used in the final assessment model. Fit to catch and survey data assumed lognormal error with an associated assumed standard error (SE). Fit to composition data (ages and lengths) assumed a multinomial distribution with associated sample sizes (input sample size, ISS, and final 'effective' sample size, ESS). The model used Francis data reweighting to 'right-weight' the composition data relative to the indices (Francis, 2011), which resulted in a weighting factor (λ, Data Wt) used to scale the ISS to achieve the final ESS. Values represent the mean across all years of associated data, where the yearly SE can be found in Table 3.6 and the yearly ISS can be found in Table 3.5 (associated yearly ESS can be calculated by multiplying the ISS by the respective Data_Wt for the given data source).

Data Source	*26.2_FAA*			
	SE	**Data Wt**	**ISS**	**ESS**
Fixed Gear Catch	0.05	--	--	--
Trawl Catch	0.05	--	--	--
NOAA Longline Survey RPN BS	0.2	1	-	-
NOAA Longline Survey RPN AI	0.23	1	-	-
NOAA Longline Survey RPN GOA	0.08	1	-	-
Japanese Longline Survey RPN	0.07	1	-	-
Fixed Gear Age Composition	-	0.04	142.85	5.86
NOAA Longline Survey Age Composition BS	-	0.62	34.07	20.96
NOAA Longline Survey Age Composition AI	-	2.01	35.57	71.37
NOAA Longline Survey Age Composition GOA	-	0.36	67.17	24.5
Japanese Longline Survey Age Composition	-	0.2	83.33	16.3
Japanese Longline Survey Size Composition	-	0.32	54.62	17.35
Trawl Fishery Size Composition	-	0.09	47.62	4.16

Table 3.9. Assessment estimates (MLE mean and MCMC median) of recruitment (millions of age-2 fish), spawning biomass (kt), and total biomass (kt) with lower and upper 95% MCMC credible intervals.

	Recruits (millions)				*SSB (kt)*				*Biomass (kt)*			
Year	**MLE**	**MCMC Median**	**2.5% CI**	**97.5% CI**	**MLE**	**MCMC Median**	**2.5% CI**	**97.5% CI**	**MLE**	**MCMC Median**	**2.5% CI**	**97.5% CI**
1960	16	15	7	32	241	247	201	299	516	526	446	623
1961	16	15	7	34	241	246	201	298	517	527	448	624
1962	17	16	7	35	234	239	194	290	507	517	437	609
1963	18	17	7	38	222	227	182	276	488	497	418	588
1964	19	18	8	42	215	220	177	269	481	491	413	577
1965	20	18	8	43	214	219	177	267	486	496	420	582
1966	21	19	8	45	214	219	177	266	492	501	428	583
1967	21	18	8	43	210	215	174	262	491	500	429	579
1968	20	18	8	43	206	211	172	257	486	495	427	571
1969	19	17	8	38	197	202	164	245	469	478	413	549
1970	17	16	7	35	186	191	154	231	445	453	392	521
1971	16	15	7	33	174	179	144	217	419	427	370	490
1972	15	14	6	28	160	165	132	201	386	394	342	456
1973	13	13	6	26	141	146	116	179	343	351	302	409
1974	12	12	6	23	130	135	106	166	316	324	278	378
1975	6	5	1	16	119	124	97	153	286	293	250	342
1976	6	5	1	14	110	115	91	142	259	265	225	311
1977	6	5	1	14	100	104	82	130	229	234	198	277
1978	8	6	1	19	94	98	77	123	212	216	183	255
1979	17	16	3	51	92	96	77	120	216	222	188	264
1980	54	52	14	83	90	94	76	116	261	264	226	308
1981	12	11	2	42	88	92	75	112	273	276	240	321
1982	18	19	3	61	87	90	75	109	288	295	255	346
1983	46	43	7	72	91	93	79	111	333	335	293	387
1984	10	9	2	30	98	100	86	117	344	347	307	398
1985	10	10	2	27	107	110	95	127	349	353	315	403
1986	15	13	3	28	119	121	106	140	354	358	321	406
1987	7	6	1	16	123	126	110	146	334	338	303	383
1988	6	6	1	15	122	125	109	145	304	308	276	350
1989	9	9	2	19	115	118	102	138	272	276	246	315
1990	12	10	2	23	106	109	93	128	246	249	221	285
1991	15	16	4	28	96	99	84	117	229	232	205	266
1992	13	12	3	25	86	89	75	106	215	218	194	250
1993	12	12	4	20	77	80	68	97	204	207	185	236
1994	4	4	1	9	69	72	61	86	184	188	167	215
1995	8	7	2	13	63	65	55	79	169	172	152	197
1996	12	12	6	18	59	61	51	73	160	163	144	188
1997	9	8	3	16	56	58	49	69	153	155	137	180
1998	18	17	10	26	54	56	47	67	158	160	141	185
1999	11	11	3	19	52	54	46	65	158	160	142	185
2000	8	8	2	16	50	52	45	63	156	159	140	183
2001	13	12	4	22	49	51	43	61	156	158	139	182
2002	27	28	17	38	49	51	43	61	173	176	155	202
2003	13	12	4	21	49	51	44	61	178	180	161	207
2004	5	5	2	12	49	51	44	61	173	176	156	201
2005	7	7	2	12	50	52	44	61	166	168	150	193
2006	3	3	1	7	51	53	45	63	154	158	139	181
2007	10	9	3	15	53	54	47	64	149	151	133	174
2008	7	8	3	17	53	54	47	65	141	144	126	168
2009	16	15	6	24	51	53	45	64	144	146	128	170
2010	14	14	6	23	50	51	44	62	148	151	132	175
2011	7	7	2	15	48	50	42	60	147	150	132	173
2012	6	6	2	12	46	48	41	58	143	146	128	169
2013	6	6	2	12	46	47	40	57	137	140	122	163
2014	6	5	2	12	45	47	40	57	130	133	115	157
2015	9	9	3	19	46	48	40	57	128	133	113	158
2016	63	63	44	88	47	48	41	59	186	190	158	231
2017	29	29	12	51	47	49	41	60	219	225	186	276
2018	65	65	37	99	49	52	43	63	291	298	243	366
2019	110	112	75	156	56	59	48	72	418	427	350	527
2020	15	14	3	41	68	71	57	88	457	469	384	578

2021	12	11	2	36	87	91	72	113	481	495	403	612
2022	48	44	10	86	112	117	93	146	530	541	437	673
2023	23	23	3	84	141	146	115	184	547	565	452	706
2024	47	33	3	92	170	176	138	223	585	594	478	736
2025	15	13	2	62	195	202	158	257	592	603	490	744
2026	16	16	13	20	214	222	173	283	592	603	489	743

Table 3.10. Comparison of the 2024 SAFE model (*23.5*; last published sablefish assessment) estimates and the 2026 assessment outputs (Model *26.2_FAA*) for recruitment (millions of fish) and spawning stock biomass (SSB; kt) including the % change from the 2024 SAFE estimates (Diff %). Note that terminal year recruitment estimates are not included for either model since they are fixed at the long-term mean and not estimated.

	Recruitment (millions)			SSB (kt)		
Year	**2024 SAFE**	**2026 *26.2_FAA***	**Diff (%)**	**2024 SAFE**	**2026 *26.2_FAA***	**Diff (%)**
1960	28	16	-44	283	241	-15
1961	30	16	-46	282	241	-15
1962	32	17	-47	275	234	-15
1963	34	18	-47	264	222	-16
1964	36	19	-45	259	215	-17
1965	36	20	-43	261	214	-18
1966	34	21	-39	263	214	-19
1967	32	21	-35	264	210	-20
1968	29	20	-31	264	206	-22
1969	26	19	-28	259	197	-24
1970	24	17	-27	251	186	-26
1971	22	16	-26	241	174	-28
1972	20	15	-27	227	160	-30
1973	19	13	-30	207	141	-32
1974	19	12	-34	194	130	-33
1975	9	6	-27	180	119	-34
1976	10	6	-42	167	110	-34
1977	11	6	-45	153	100	-35
1978	14	8	-46	144	94	-35
1979	83	17	-79	141	92	-34
1980	46	54	18	137	90	-34
1981	23	12	-46	136	88	-35
1982	69	18	-74	138	87	-37
1983	40	46	17	147	91	-38
1984	14	10	-31	161	98	-39
1985	16	10	-38	179	107	-40
1986	26	15	-42	196	119	-39
1987	10	7	-33	205	123	-40
1988	7	6	-7	205	122	-40
1989	8	9	21	197	115	-41
1990	12	12	-2	184	106	-42
1991	24	15	-37	170	96	-44
1992	8	13	67	157	86	-45
1993	26	12	-53	144	77	-46
1994	7	4	-44	130	69	-47
1995	8	8	1	119	63	-47
1996	13	12	-8	112	59	-48
1997	21	9	-58	107	56	-48
1998	10	18	84	103	54	-48
1999	37	11	-72	99	52	-48
2000	16	8	-51	96	50	-47
2001	16	13	-19	93	49	-47
2002	44	27	-39	93	49	-47
2003	13	13	-5	94	49	-48
2004	10	5	-47	96	49	-49
2005	12	7	-42	98	50	-49
2006	8	3	-62	102	51	-50
2007	11	10	-9	104	53	-49
2008	10	7	-25	105	53	-50
2009	16	16	-1	103	51	-50
2010	22	14	-36	101	50	-51
2011	10	7	-27	97	48	-51
2012	12	6	-45	93	46	-50
2013	4	6	33	89	46	-49
2014	8	6	-27	86	45	-47
2015	14	9	-38	85	46	-46
2016	50	63	27	84	47	-45
2017	22	29	33	83	47	-43
2018	96	65	-33	83	49	-41

2019	94	110	17	86	56	-35
2020	43	15	-66	95	68	-29
2021	82	12	-86	110	87	-21
2022	25	48	91	133	112	-16
2023	28	23	-19	161	141	-13
2024	-	47	-	191	170	-11
2025	-	15	-	-	195	-
2026	-	-	-	-	214	-

Table 3.11. Key scaling parameter estimates along with their uncertainty, including 95% credible intervals from MCMC analysis for each model. Recruitment is in millions of fish. All parameter estimates are in ln-space.

Model	Parameter	Mean (MCMC)	Median (MCMC)	SD (MCMC)	2.5% CI	97.5% CI	Mean (MLE)	SD (MLE)
26.2_FAA	*ln_Mean_Recruit*	2.78	2.78	0.11	2.60	2.97	2.78	0.11
	ln_M_Female	-2.44	-2.44	0.07	-2.56	-2.32	-2.43	0.07
	ln_M_Male	-2.45	-2.45	0.08	-2.58	-2.32	-2.43	0.08
	ln_q NOAA Longline Survey BS	0.54	0.54	0.10	0.38	0.70	0.58	0.10
	ln_q NOAA Longline Survey AI	0.40	0.40	0.10	0.24	0.56	0.42	0.10
	ln_q NOAA Longline Survey GOA	2.19	2.19	0.08	2.05	2.32	2.22	0.08
	ln_q Japanese Longline Survey	2.06	2.06	0.09	1.92	2.21	2.08	0.08

Table 3.12. Sablefish spawning biomass (kilotons), fishing mortality, and yield (kilotons) for the seven projection harvest scenarios (columns) outlined in the 'Population Projections' section for Model *26.2_FAA*. 'Specified Catch' (Scenario 2) uses the three year average proportion of the ABC utilized in 2023 – 2025 (~53%) to set the realized yield for 2027 and 2028. SSB and yield are in kilotons.

Year	Scenario 1: Maximum Permissible F	Scenario 2: Author's F (Specified Catches)	Scenario 3: 5-year Average F	Scenario 4: Half Max F	Scenario 5: No Fishing	Scenario 6: Overfished	Scenario 7: Approaching Overfished
Spawning biomass (kt)							
2026	214	214	214	214	214	214	214
2027	227	227	227	227	227	227	227
2028	230	238	233	238	248	226	230
2029	229	245	237	247	266	222	229
2030	225	241	236	252	281	216	222
2031	218	233	233	253	293	206	212
2032	210	223	227	251	301	196	201
2033	201	213	221	248	307	186	190
2034	193	204	214	245	311	176	180
2035	185	195	208	241	315	168	171
2036	179	187	202	237	318	160	163
2037	172	180	197	234	321	154	157
2038	167	173	192	230	323	148	151
2039	162	168	188	227	324	144	145
Fishing mortality							
2026	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2027	0.08	0.04	0.06	0.04	0	0.09	0.08
2028	0.08	0.04	0.06	0.04	0	0.09	0.08
2029	0.08	0.08	0.06	0.04	0	0.09	0.09
2030	0.08	0.08	0.06	0.04	0	0.09	0.09
2031	0.08	0.08	0.06	0.04	0	0.09	0.09
2032	0.08	0.08	0.06	0.04	0	0.09	0.09
2033	0.08	0.08	0.06	0.04	0	0.09	0.09
2034	0.08	0.08	0.06	0.04	0	0.09	0.09
2035	0.08	0.08	0.06	0.04	0	0.09	0.09
2036	0.08	0.08	0.06	0.04	0	0.09	0.09
2037	0.08	0.08	0.06	0.04	0	0.09	0.09
2038	0.08	0.08	0.06	0.04	0	0.09	0.09
2039	0.08	0.08	0.06	0.04	0	0.09	0.09
Yield (kt)							
2026	25.3	25.3	25.3	25.3	25.3	25.3	25.3
2027	37.6	20.5	29.6	19.1	0.0	44.5	37.6
2028	36.5	20.6	29.2	19.3	0.0	42.7	36.5
2029	35.1	37.4	28.5	19.2	0.0	40.4	41.5
2030	33.6	35.7	27.7	18.9	0.0	38.2	39.2
2031	32.2	34.1	26.9	18.7	0.0	36.3	37.1
2032	31.0	32.6	26.1	18.5	0.0	34.5	35.3
2033	29.8	31.3	25.4	18.2	0.0	33.0	33.6
2034	28.8	30.0	24.7	18.0	0.0	31.6	32.1
2035	27.9	29.0	24.1	17.7	0.0	30.4	30.9
2036	27.1	28.0	23.6	17.5	0.0	29.3	29.7
2037	26.3	27.1	23.1	17.3	0.0	28.4	28.8
2038	25.7	26.4	22.6	17.0	0.0	27.7	27.9
2039	25.1	25.7	22.2	16.8	0.0	26.9	27.2

Figures

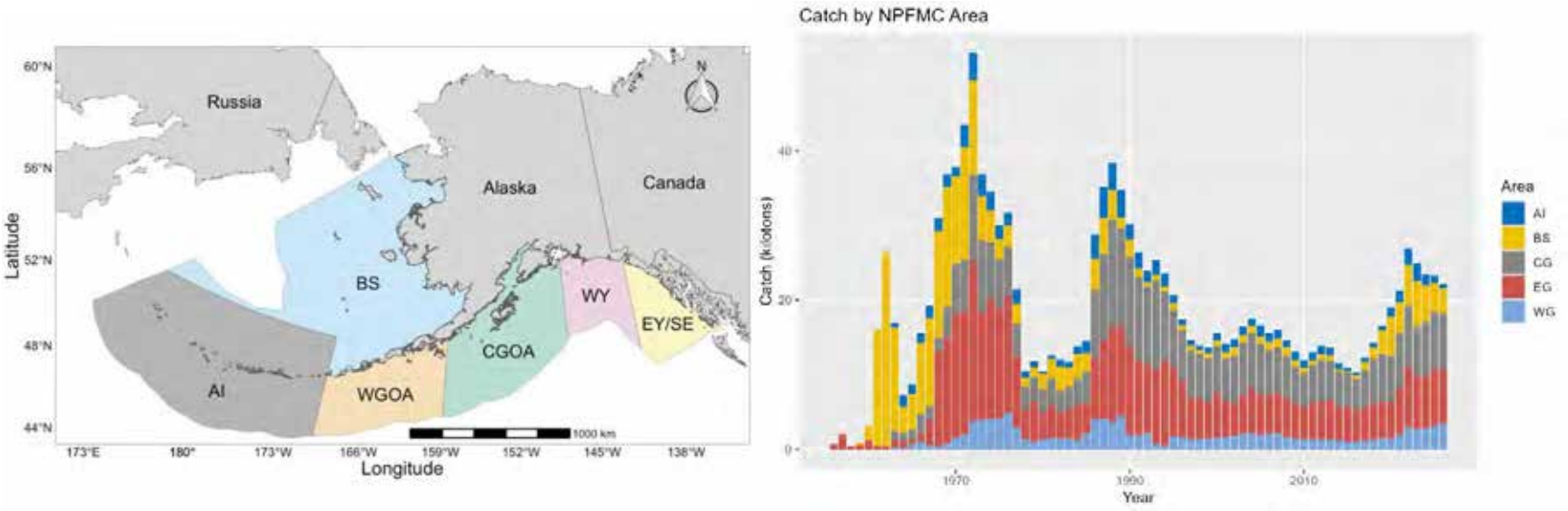


Figure 3.1. Sablefish North Pacific Fishery Management Council management areas and total catch (kt) summed across all fleets by management area (the EGOA includes WY and SEO). Catch is as of October 15, 2026.

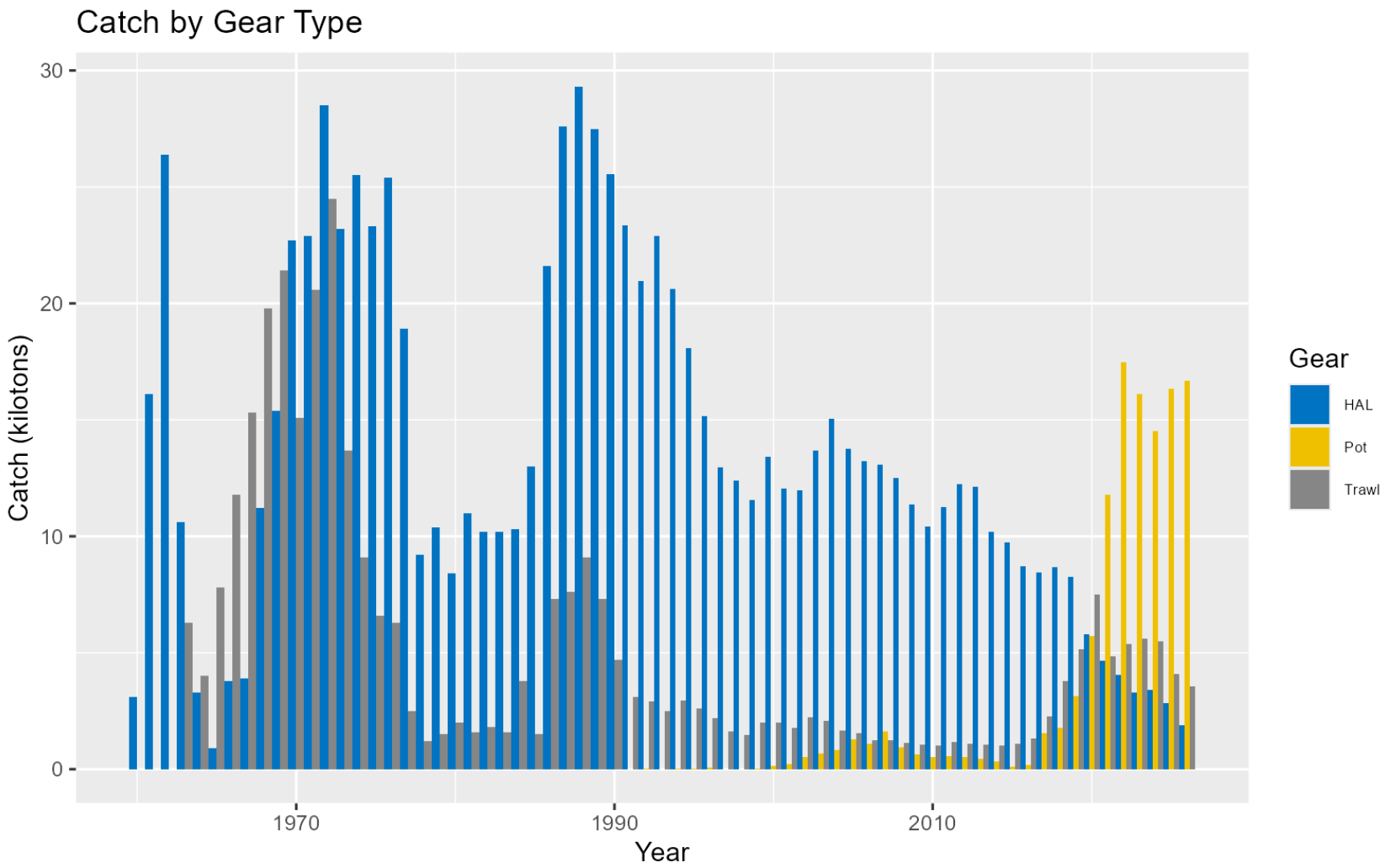


Figure 3.2. Sablefish catch (kt) by gear type. Note that hook and line (HAL) and pot gear catch are combined into a single 'fixed gear' fleet in the model. Catch is as of October 15, 2026.

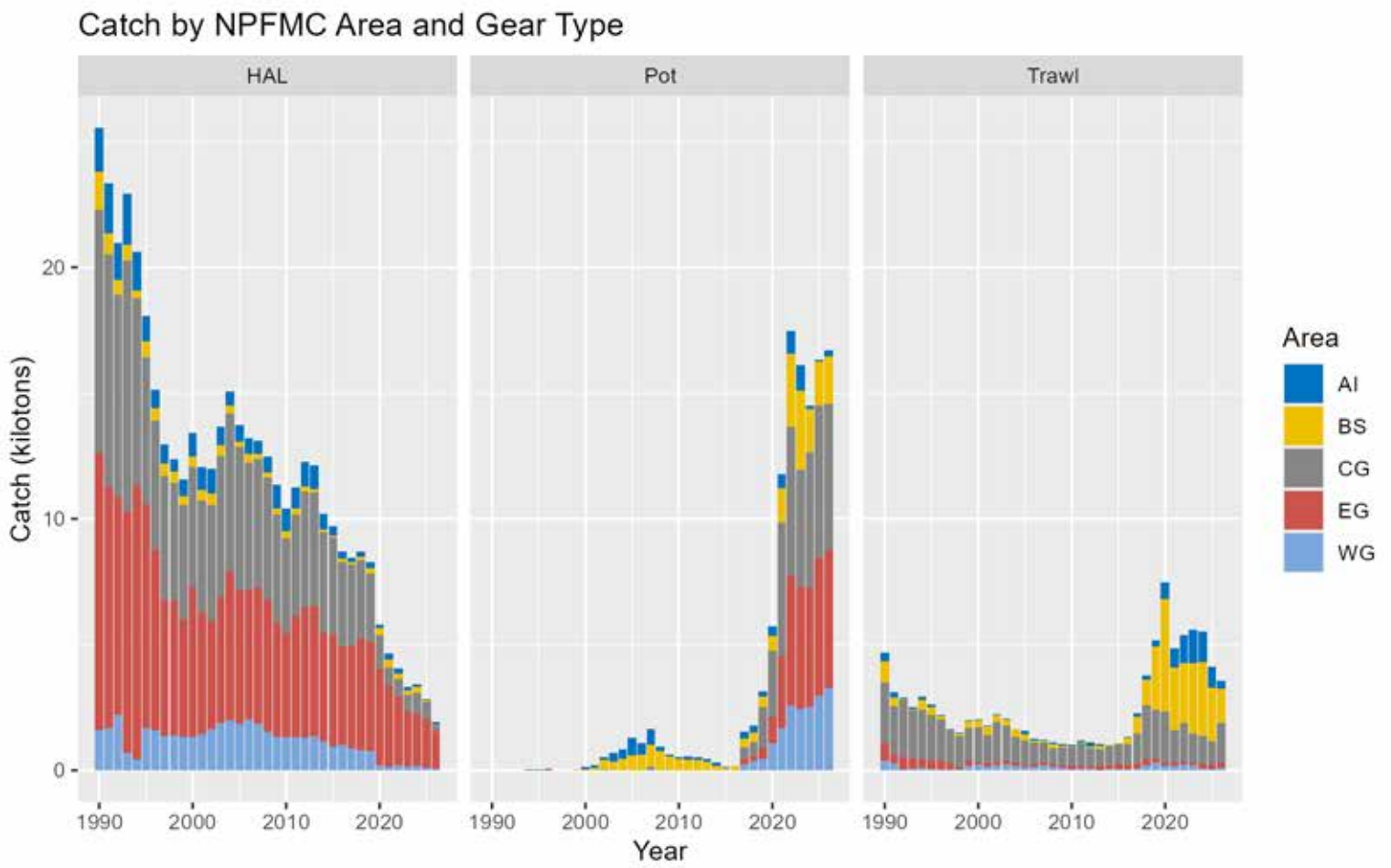


Figure 3.3. Sablefish catch (kt) by fleet (facet) and North Pacific Fishery Management Council area (colored bars). EGOA includes WY and SEO. Catch is as of October 15, 2026.

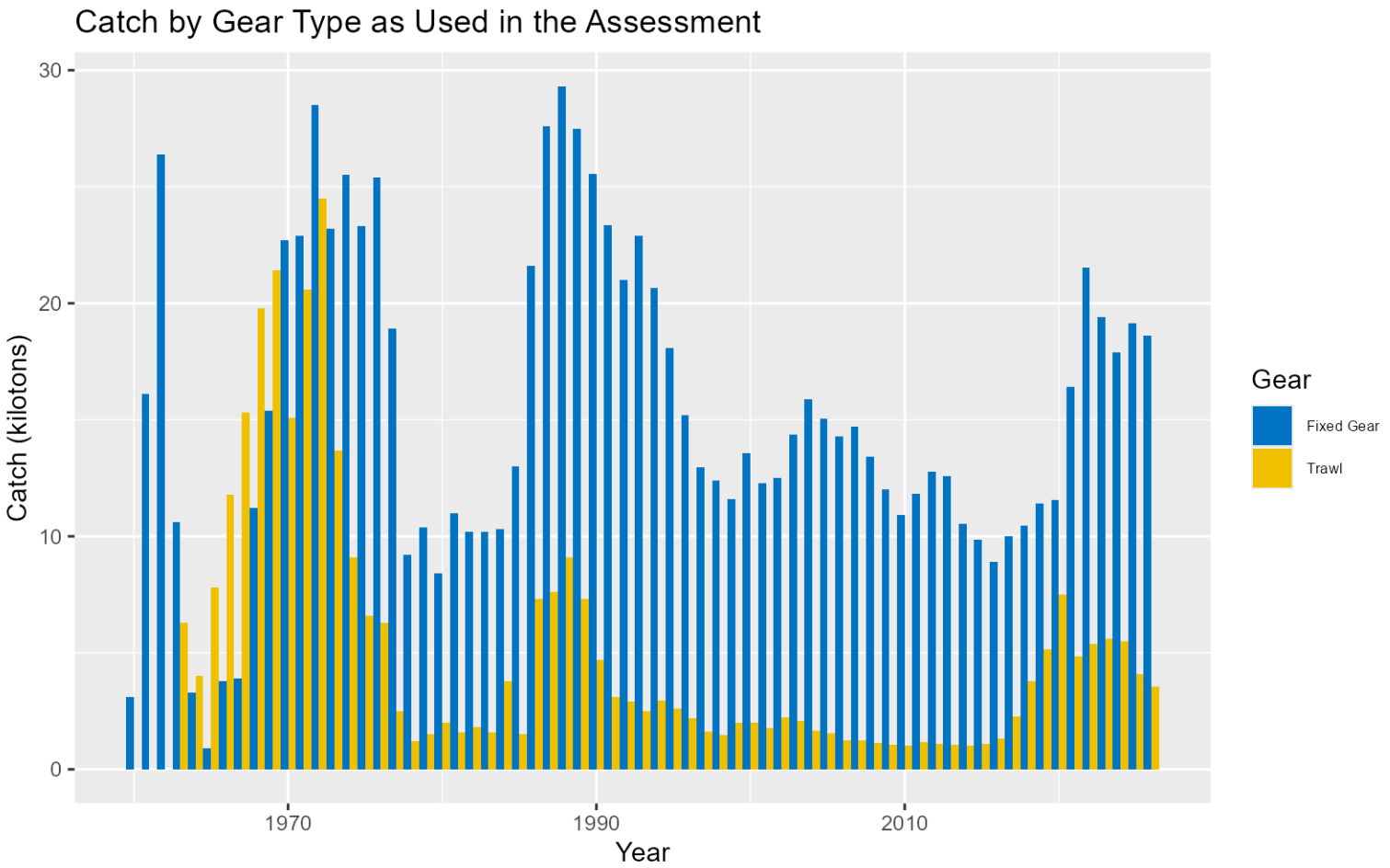


Figure 3.4. Sablefish total catch (kt) by fleet as used in the assessment model. Note the fixed gear fleet includes hook-and-line and pot gear. Catch is as of October 15, 2026.

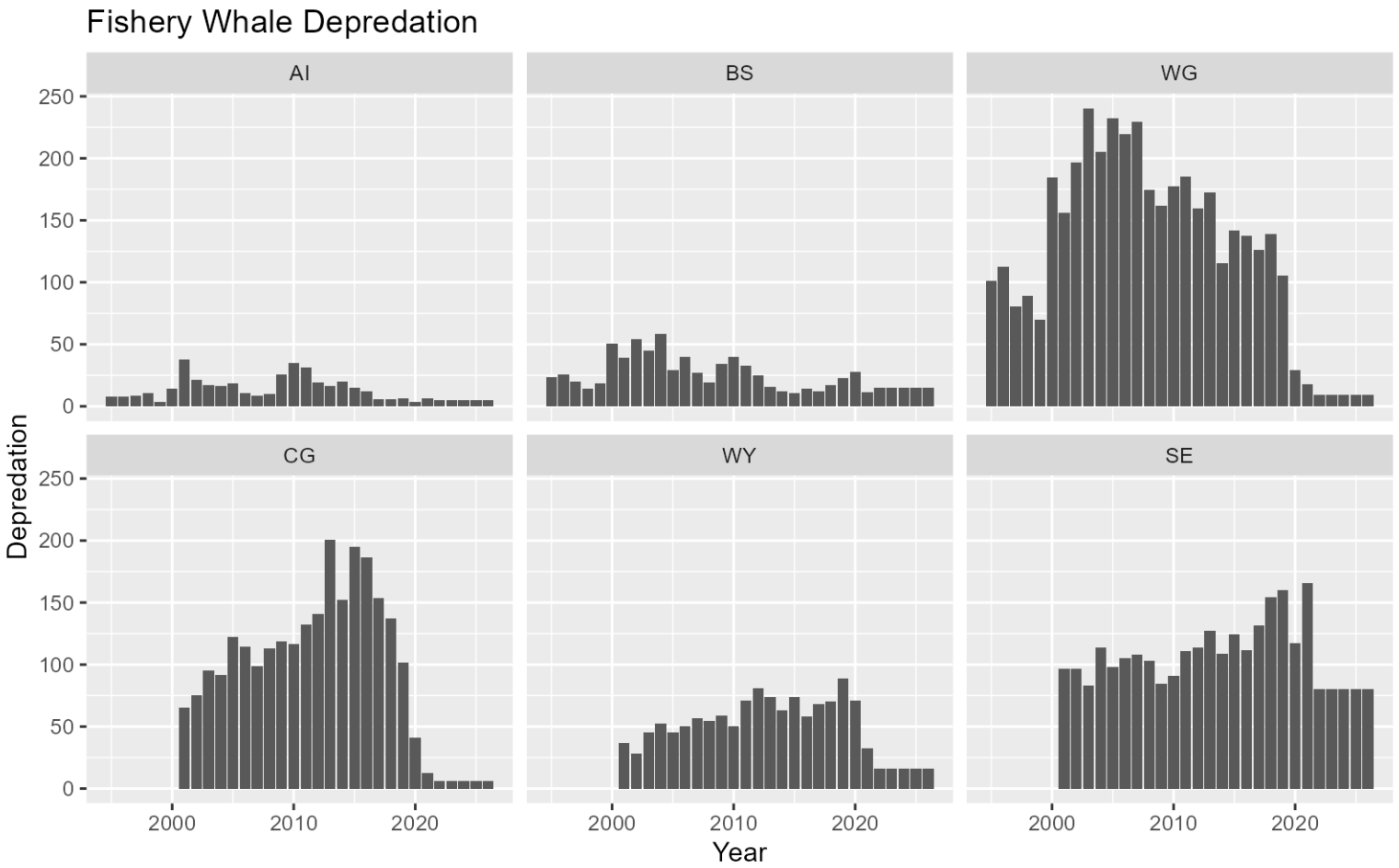


Figure 3.5. Estimated whale depredation in the sablefish fixed gear fishery as used in the assessment model. Depredation estimates reflect catch removals (metric tons, t) by region (panel) – western regions only experience orca depredation (top row) and eastern regions only undergo sperm whale depredation (bottom row). Starting in 2023 estimates were held constant at 2022 values, given the strong reduction in depredation due to the largescale switch to pot gear.

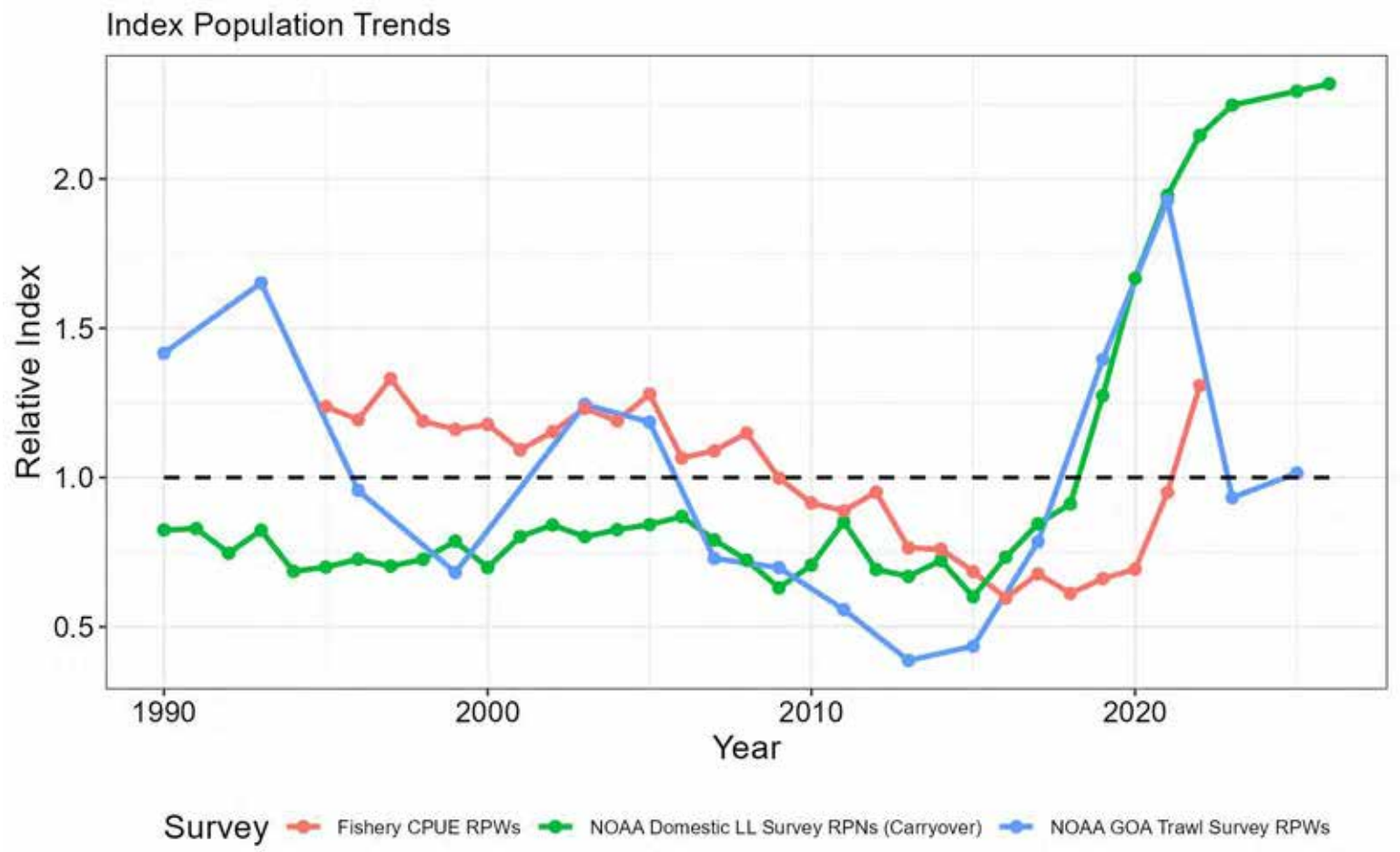


Figure 3.6. Comparison of the three abundance and biomass indices for sablefish, including the NOAA Longline Survey relative population numbers (RPNs), the fixed gear fishery standardized CPUE (in weight), and the NOAA Gulf of Alaska (stations < 500m depth) Trawl Survey relative population weights (RPWs). Each index is relativized to the associated mean value for the time series. Note that only the NOAA Longline Survey index is currently used in the assessment, but is disaggregated by region and only uses actual survey observations. The LLS index presented here to provide an indication of AK-wide trends uses the 'carryover' interpolation. There was no NOAA Longline Survey in 2024.

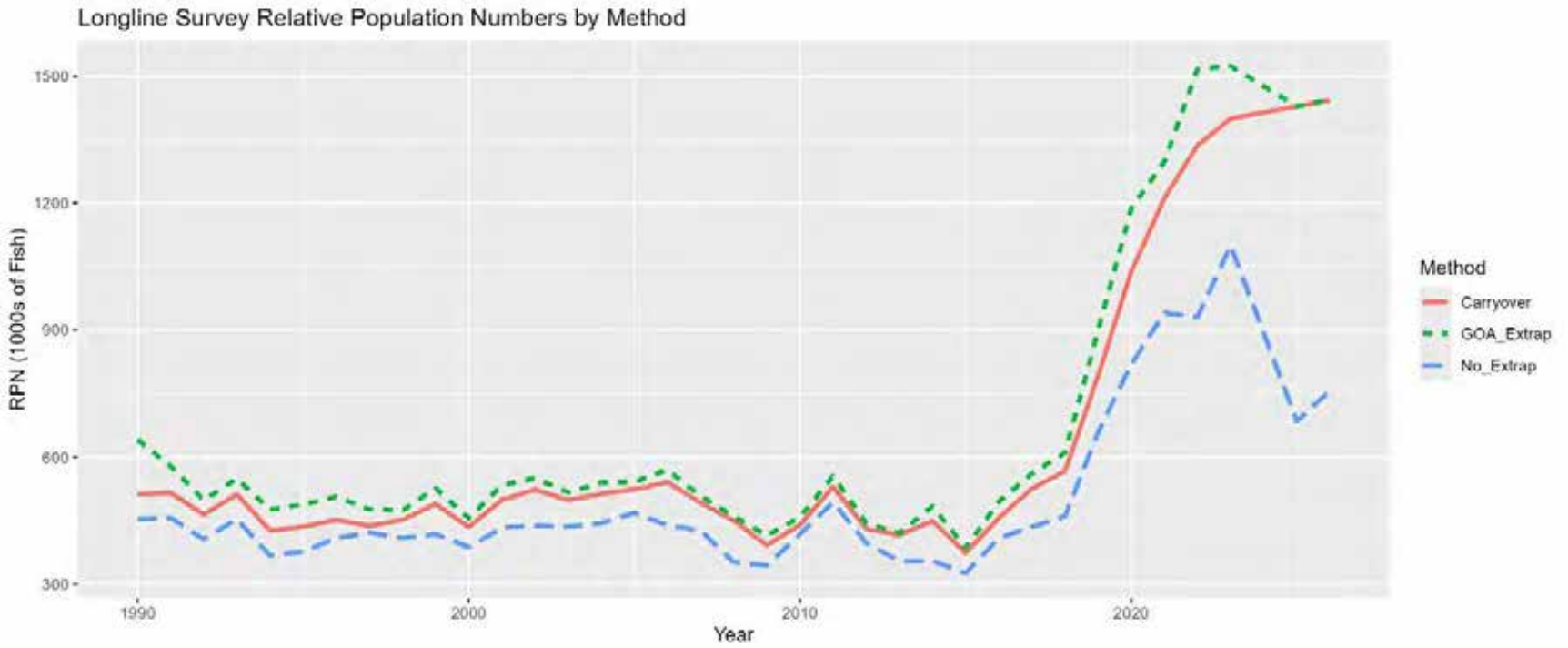


Figure 3.7. Comparison of three versions of the AK-wide NOAA Longline Survey abundance index for sablefish (relative population numbers, RPNs) demonstrating different interpolation methods and station inclusion. The *GOA_Extrap* index (used in Model *25.12*) represents the traditional approach of interpolating the BS/AI in unsurveyed years based on the year-over-year change in the GOA, but then switches to the 'carryover' interpolation in 2025. This method includes the extrapolated western Aleutian Island (AI) stations in the index. The *Carryover* index (used in Model *26.1_1Reg*) represents a new interpolation method for all years, where holdover RPNs for unsurveyed regions are used based on the RPN from that region the last time it was surveyed. This method excludes western AI extrapolated stations. The *No_Extrap* index represents the sum of the area-specific RPNs without any interpolation (i.e., including only RPNs from stations actually surveyed in a given year) and excludes western AI extrapolated stations – this index represents the sum of the regional indices as used in Model *26.2_FAA.*

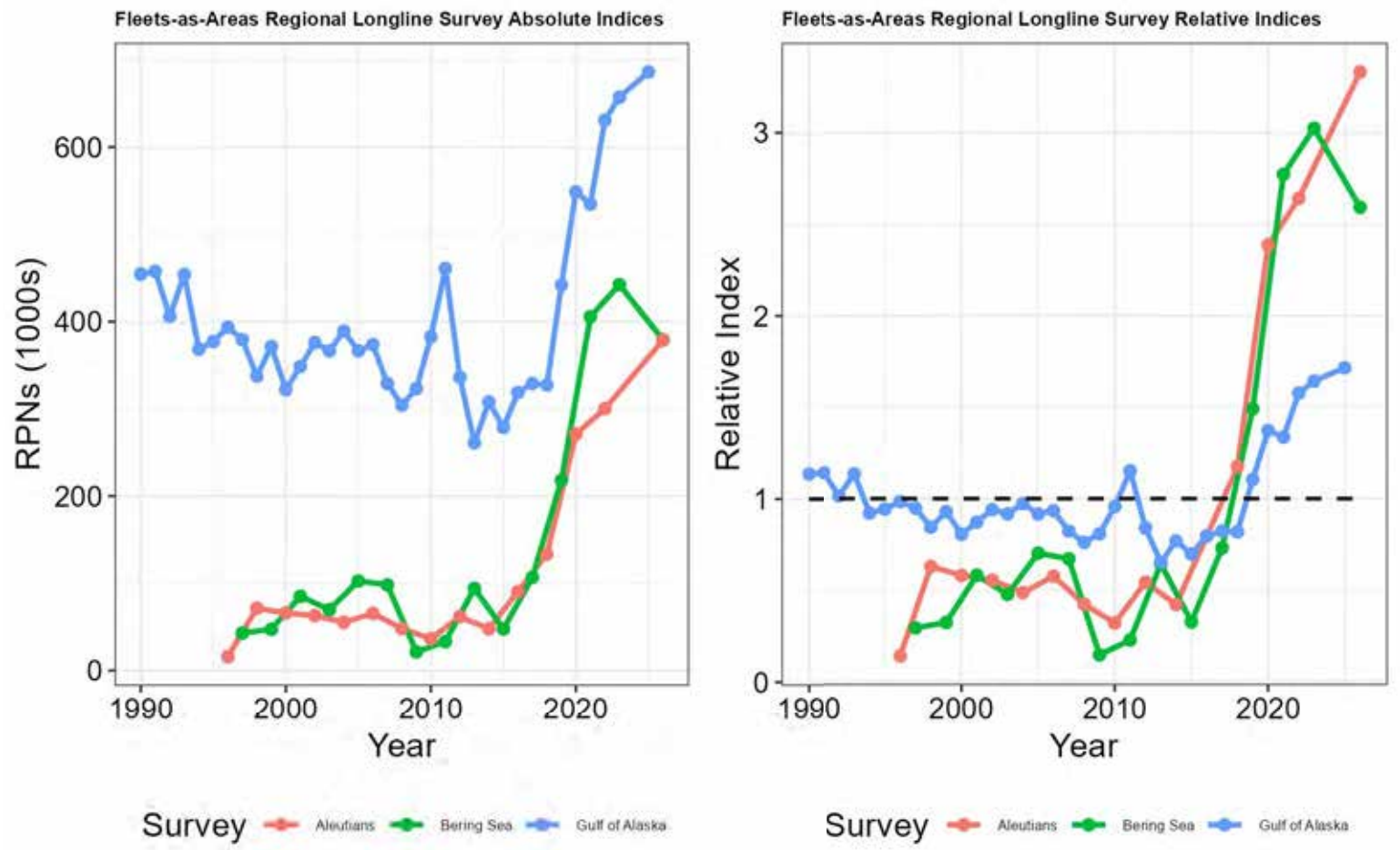


Figure 3.8. The regional NOAA Longline Survey indices as used in Model *26.2_FAA*, which do not include any extrapolation or western AI extrapolated stations. The left panel shows the absolute relative population numbers (RPNs, 1000s) for each region, whereas the right panel shows each index relativized to the associated mean value for the time series. Note that the Bering Sea was historically surveyed in odd years and the Aleutian Islands in even years (i.e., sampling occurred every other year in these regions) and there was no survey in 2024. With the survey redesign, starting in 2025 only the GOA is surveyed in odd years and the BS and AI in even years.

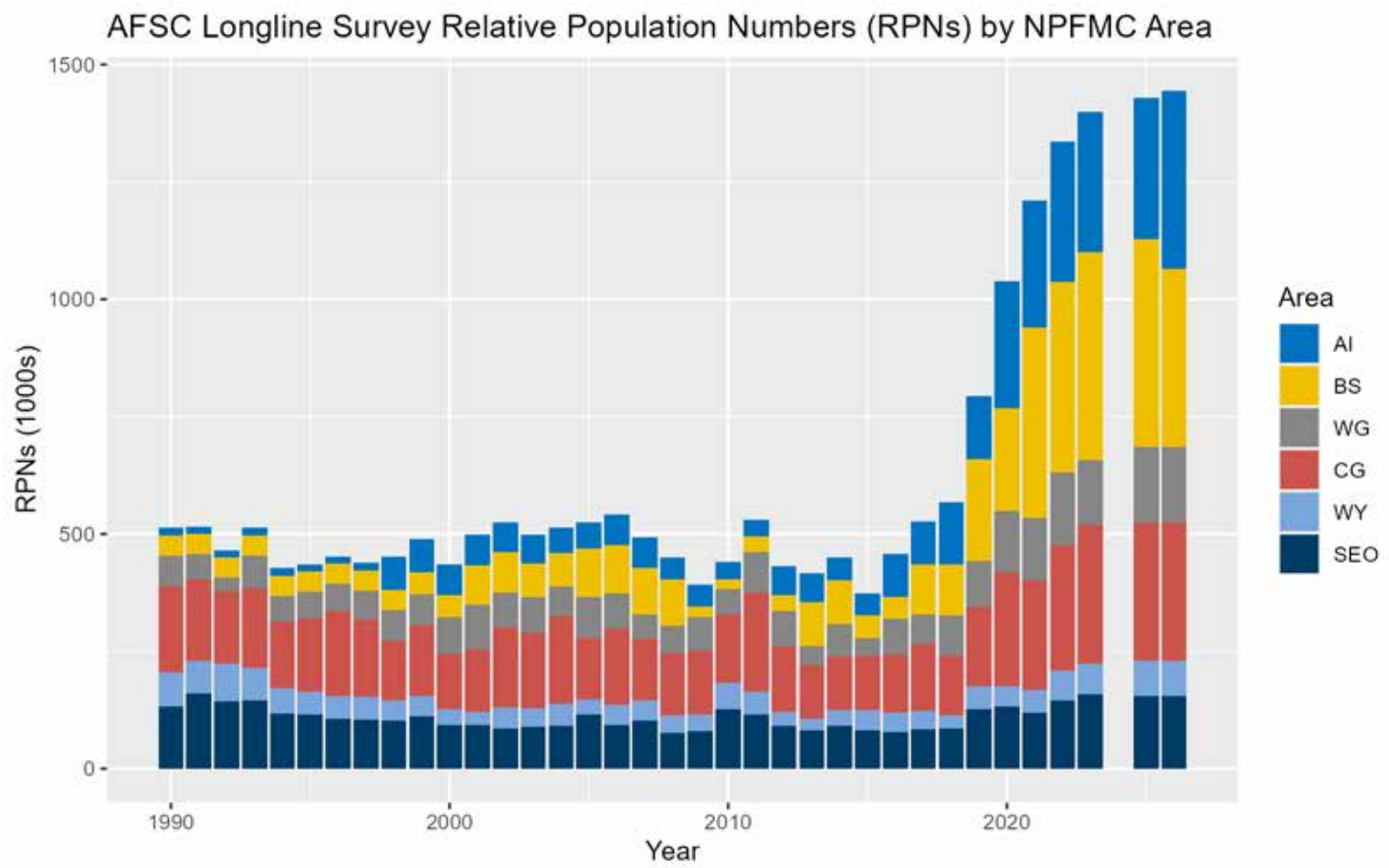


Figure 3.9. Relative abundance (relative population numbers, RPNs, in thousands) by region from the NOAA domestic longline survey utilizing the carryover interpolation for non-surveyed regions, which matches the author recommended apportionment approach. The regional trends for non-surveyed regions are interpolated by using holdover values from the last time the given region was surveyed. There was no survey in 2024.

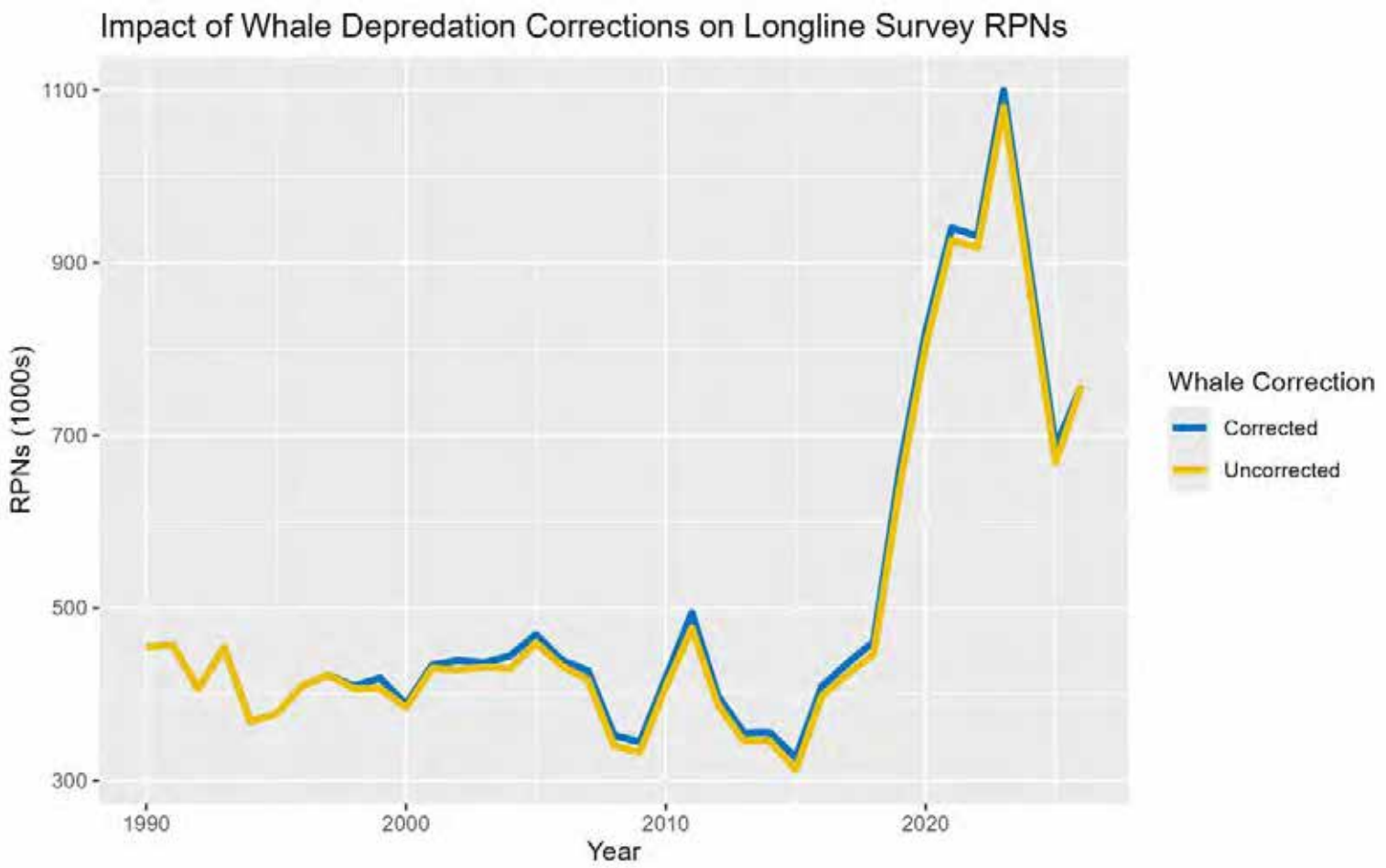


Figure 3.10. NOAA Longline Survey relative population numbers (RPNs, 1000s of fish) with (blue line) and without (yellow line) corrections for sperm whale depredation. Note that these are the summed regional RPN values that do not include interpolations for regions not surveyed in the given year, which matches the summed regional indices used in Model *26.2_FAA*.

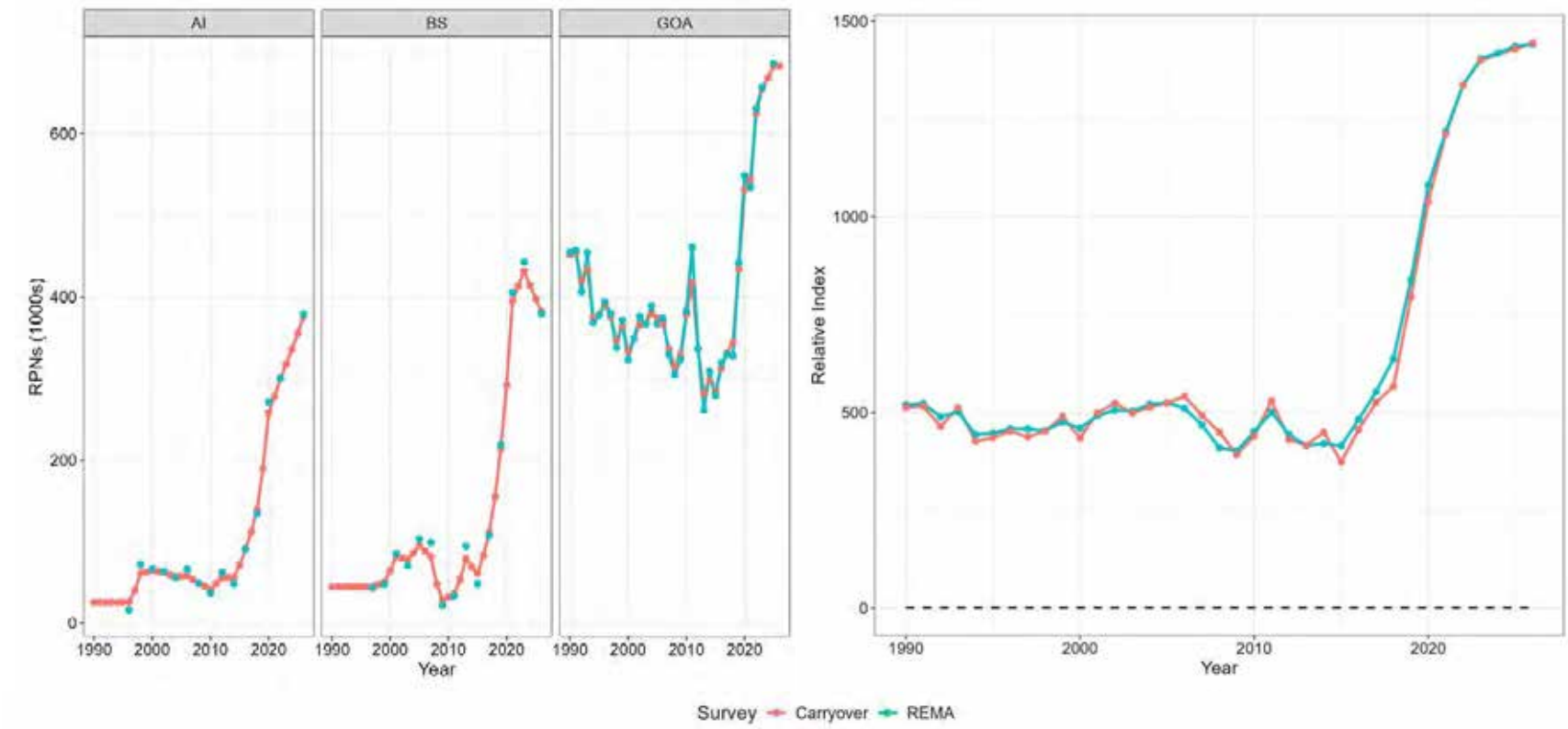


Figure 3.11. Comparison of the NOAA Longline Survey relative population numbers (RPNs, 1000s of fish; blue dots and lines) by region (left) and Alaska-wide (right) to smoothed and interpolated values from the REMA model (red dots and lines). The smoothed outputs from REMA are used in the associated sensitivity runs with the single region and FAA models.

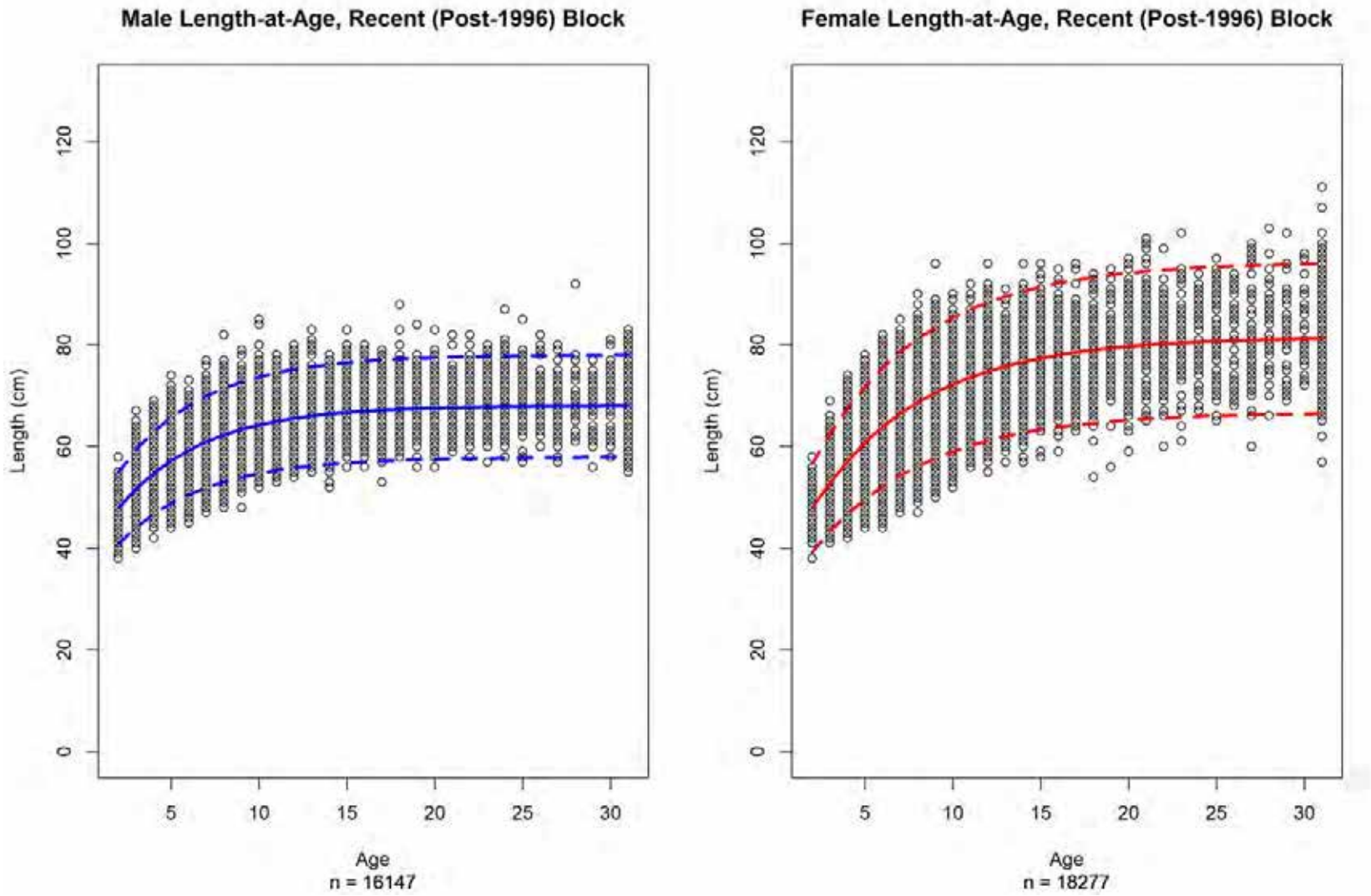


Figure 3.12. Observed (open circles) age-length pairs from the NOAA Longline Survey from 1996 – 2025 and predicted (colored lines) von Bertalanffy growth curves with associated 95% confidence intervals (dashed lines) for males (left panel) and females (right panel). Sex-specific sample sizes (*n*) are listed under each plot.

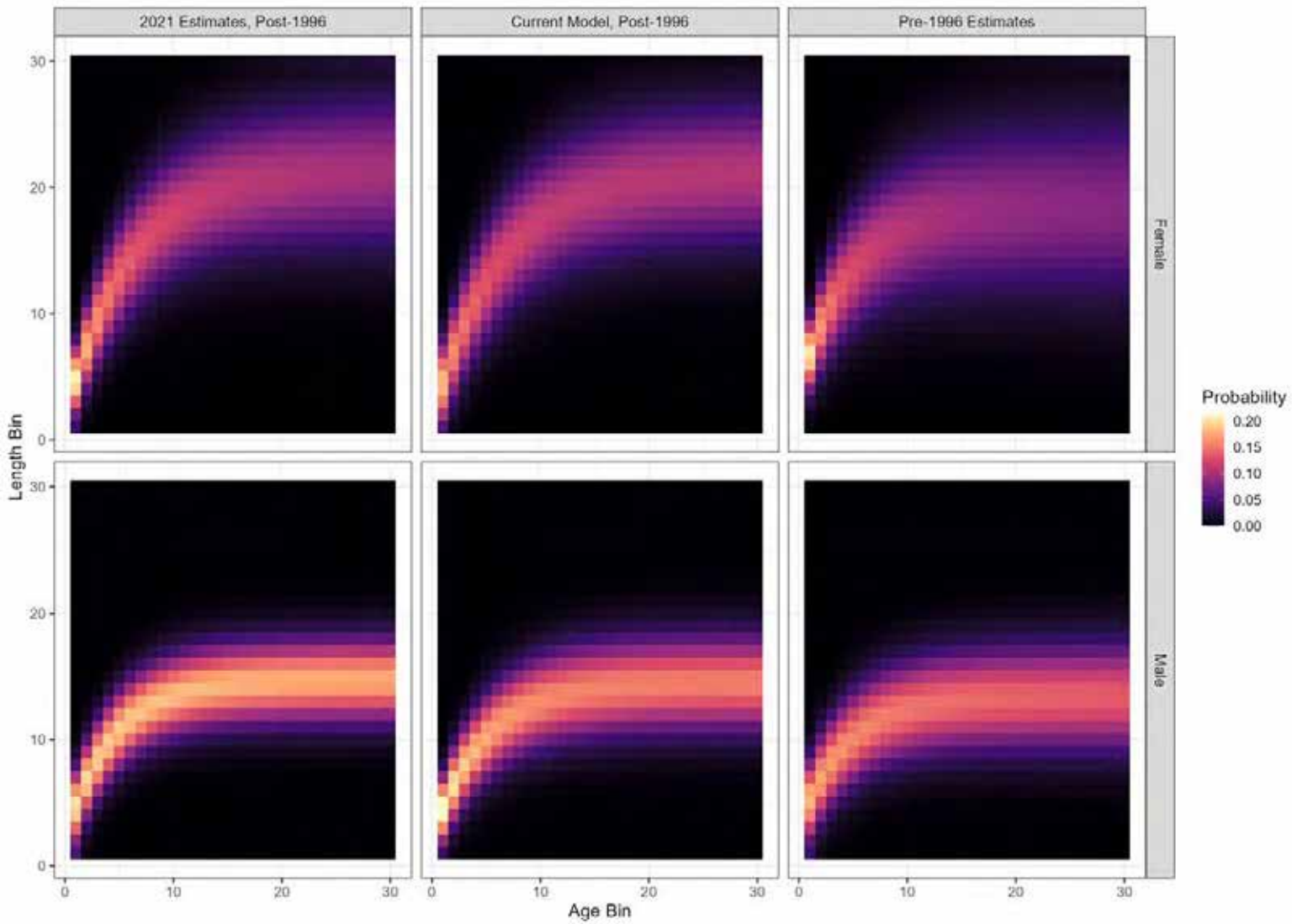


Figure 3.13. Comparison of size-age transition matrices from the previous SAFE (as estimated in 2021, 2021 Estimates) and as estimated in 2026 (2026 Estimates) with all NOAA Longline Survey data from 1996 – 2025, as well as the pre-1996 size-ag transitions estimated previously using the bias-corrected NOAA Longline Survey data prior to 1996 (see Echave, 2021).

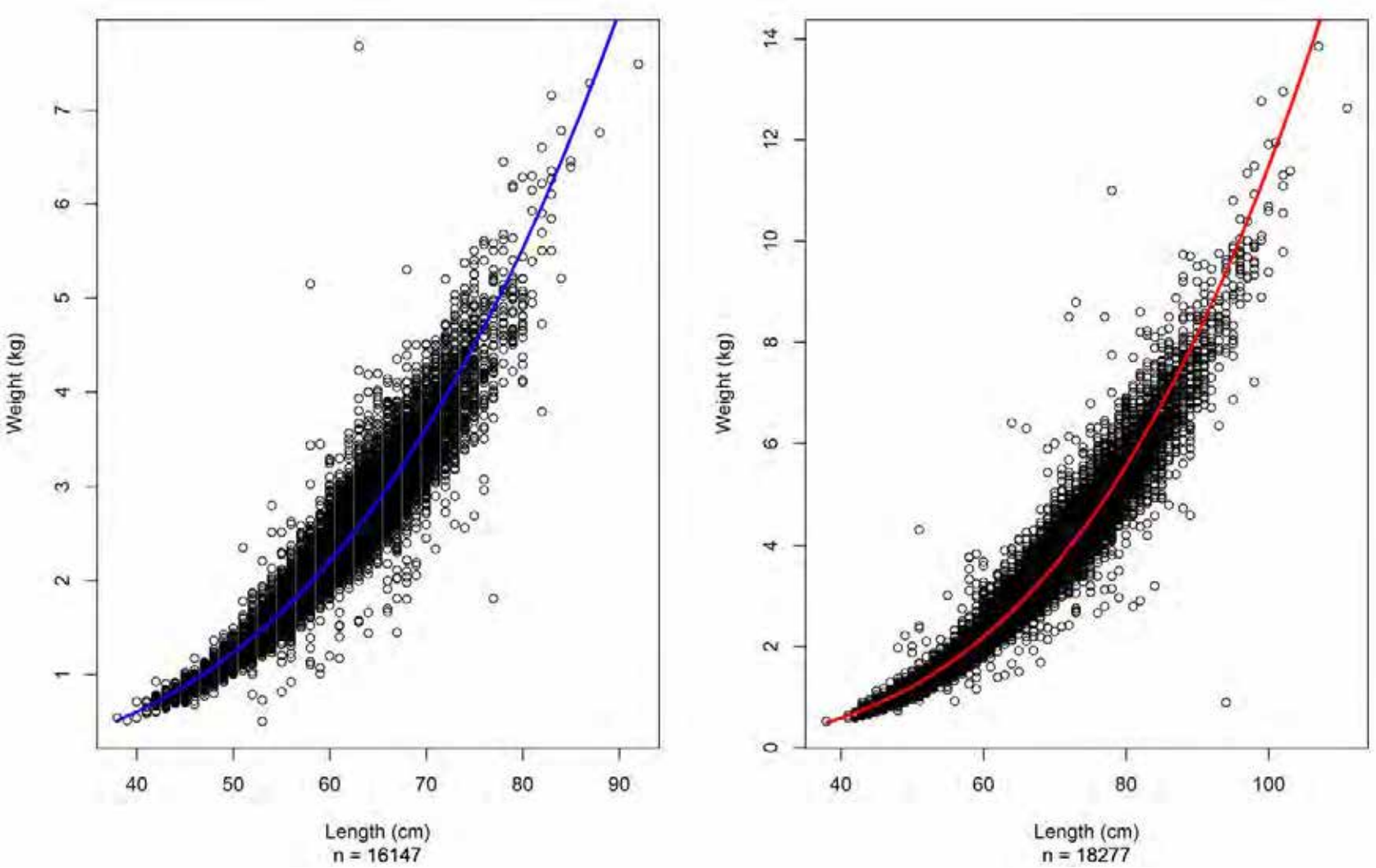


Figure 3.14. Observed (open circles) weight-length pairs from the NOAA Longline Survey from 1996 – 2025 and predicted (colored lines) weight-length curves for males (left panel) and females (right panel). Note the difference in y-axis scale across sexes.

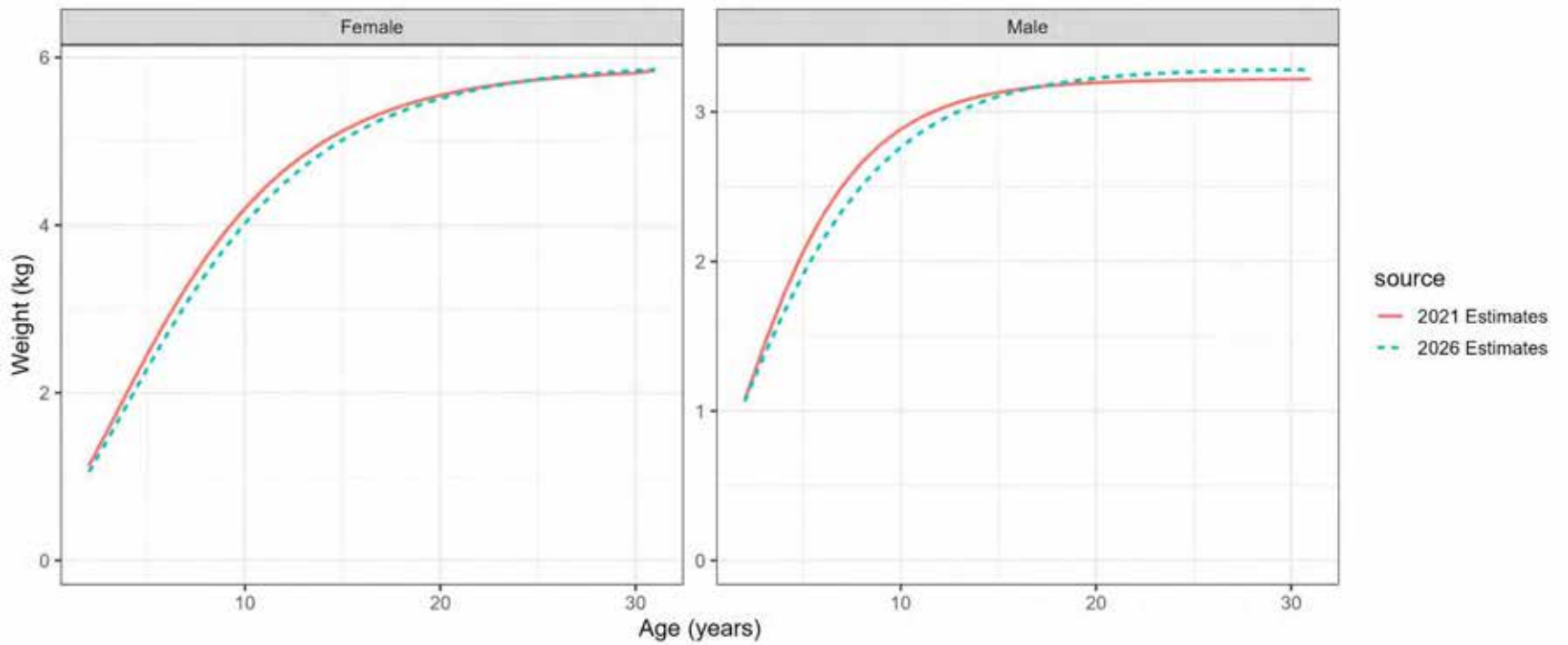


Figure 3.15. Comparison of weight-at-age estimates from the previous SAFE (as estimated in 2021, 2021 Estimates) and as estimated in 2026 (2026 Estimates) with all NOAA Longline Survey data from 1996 – 2025. The estimated weight-at-age is based on the estimate length-weight parameters and mean length from the von Bertalanffy growth curve estimates. Note the difference in y-axis scale across sexes.

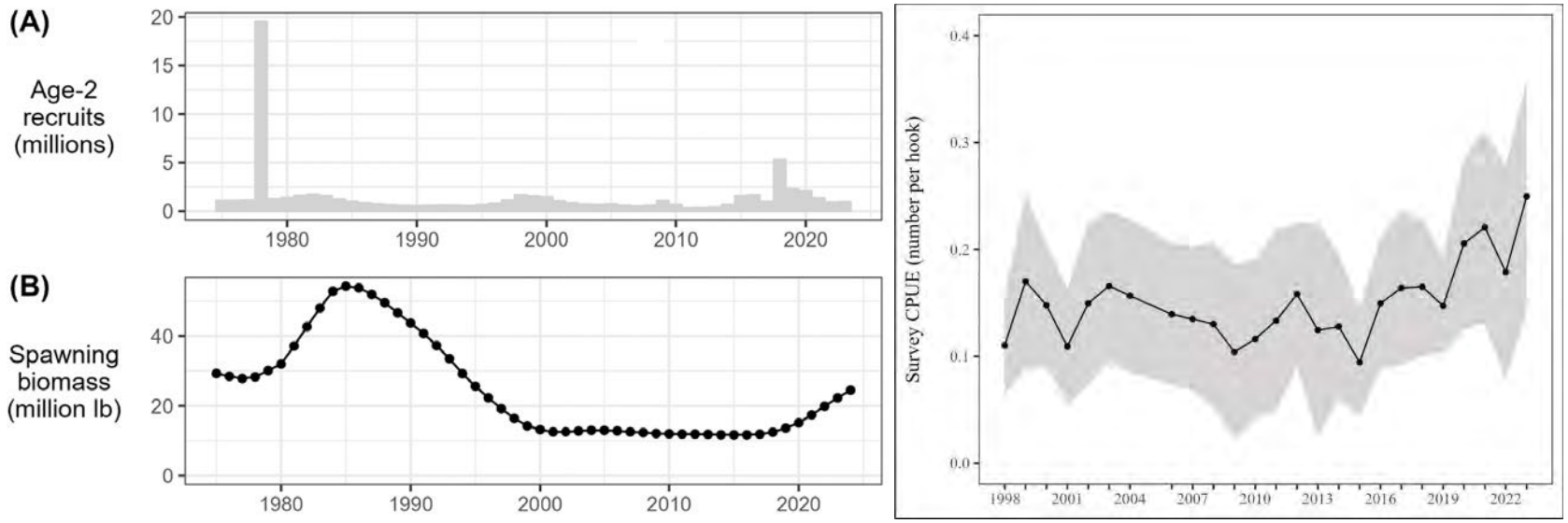


Figure 3.16. Model predictions for the ADFG Northern Southeast Inside (NSEI) sablefish stock assessment (left panels; reproduced here with permission from Rhea Ehresmann, pers. comm., https://github.com/commfish/seak_sablefish) of age-2 recruitment (millions; top) and female spawning stock biomass (million pounds; bottom). Southern Southeast Inside (SSEI) sablefish longline survey catch-per-unit-effort (CPUE) in individuals per hook (right panel) from 1998 to 2023 (except 2005; reproduced here with permission from Rhea Ehresmann, pers. Comm.).

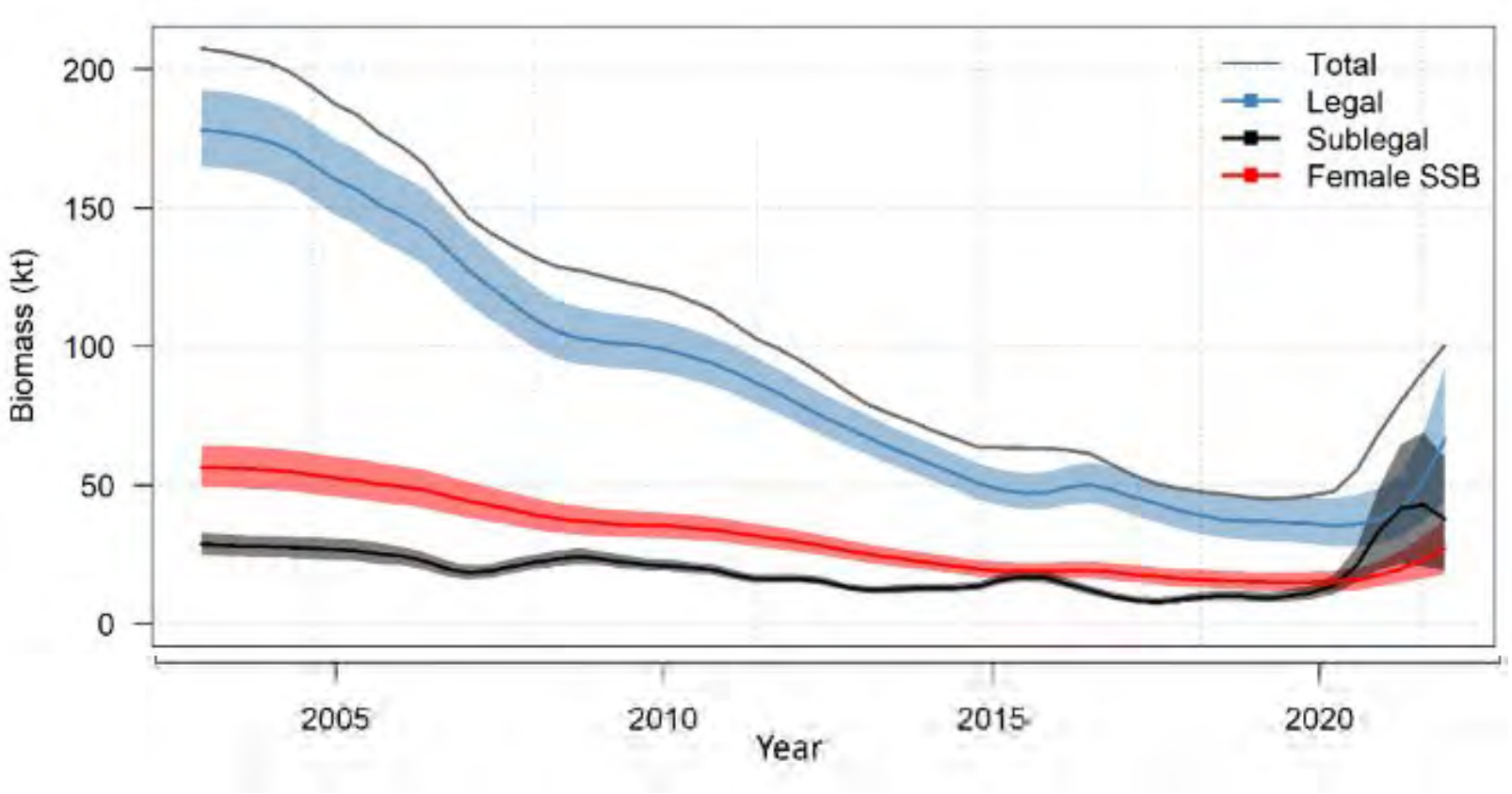


Figure 3.17. Time series of total biomass, legal-sized biomass, sub-legal-sized biomass, and female spawning biomass (SSB) estimates for the British Columbia stock of sablefish based on weighted averages over the five OM scenarios used in 2022. Note that total, legal, and sub-legal biomass estimates include both female and male fish, while SSB is shown for only female Sablefish (reproduced here with permission from Kendra Holt, DFO Canada, pers. comm.).

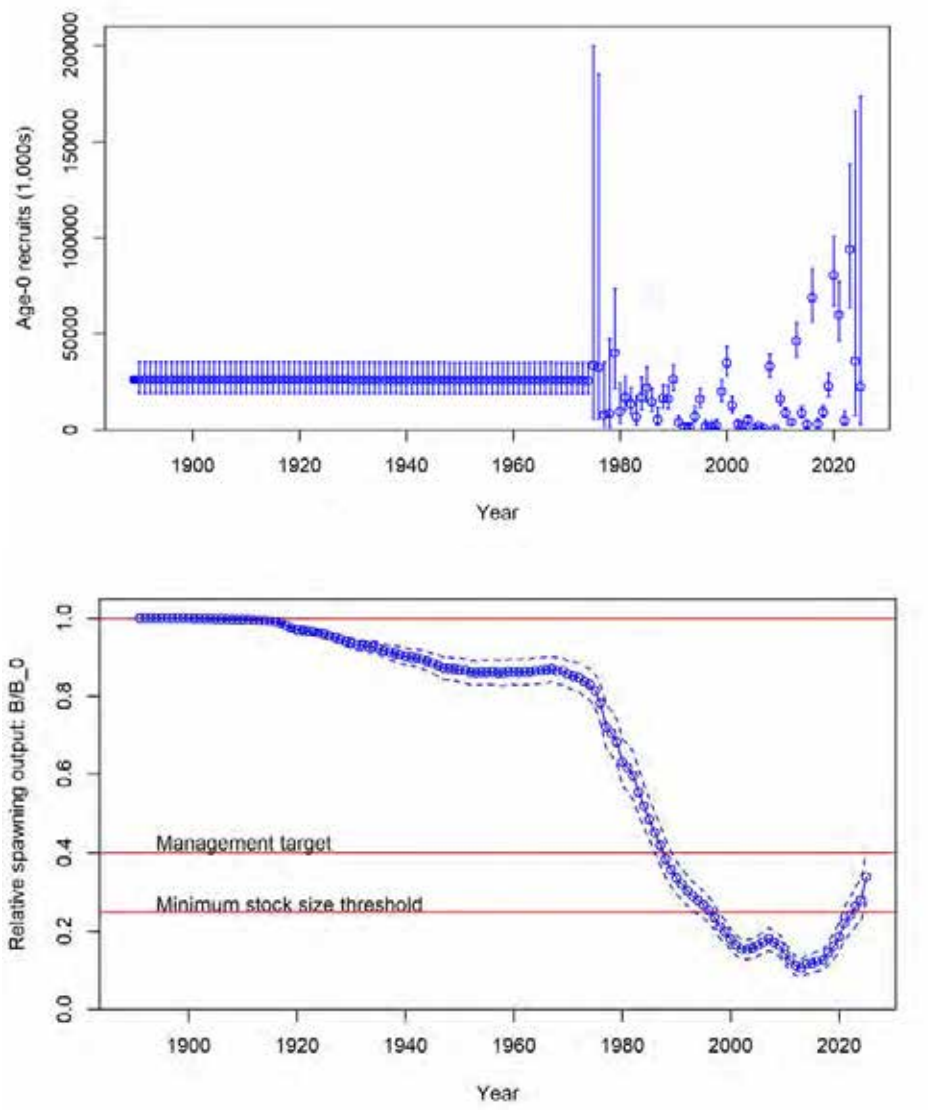


Figure 3.18. Time series (dots) of recruitment (1000s of age-0 fish, top panel) and relative spawning output (bottom panel) with associated 95% confidence intervals (bars or dashed lines) for west coast USA sablefish (reproduced here with permission from Wetzel et al. 2025).

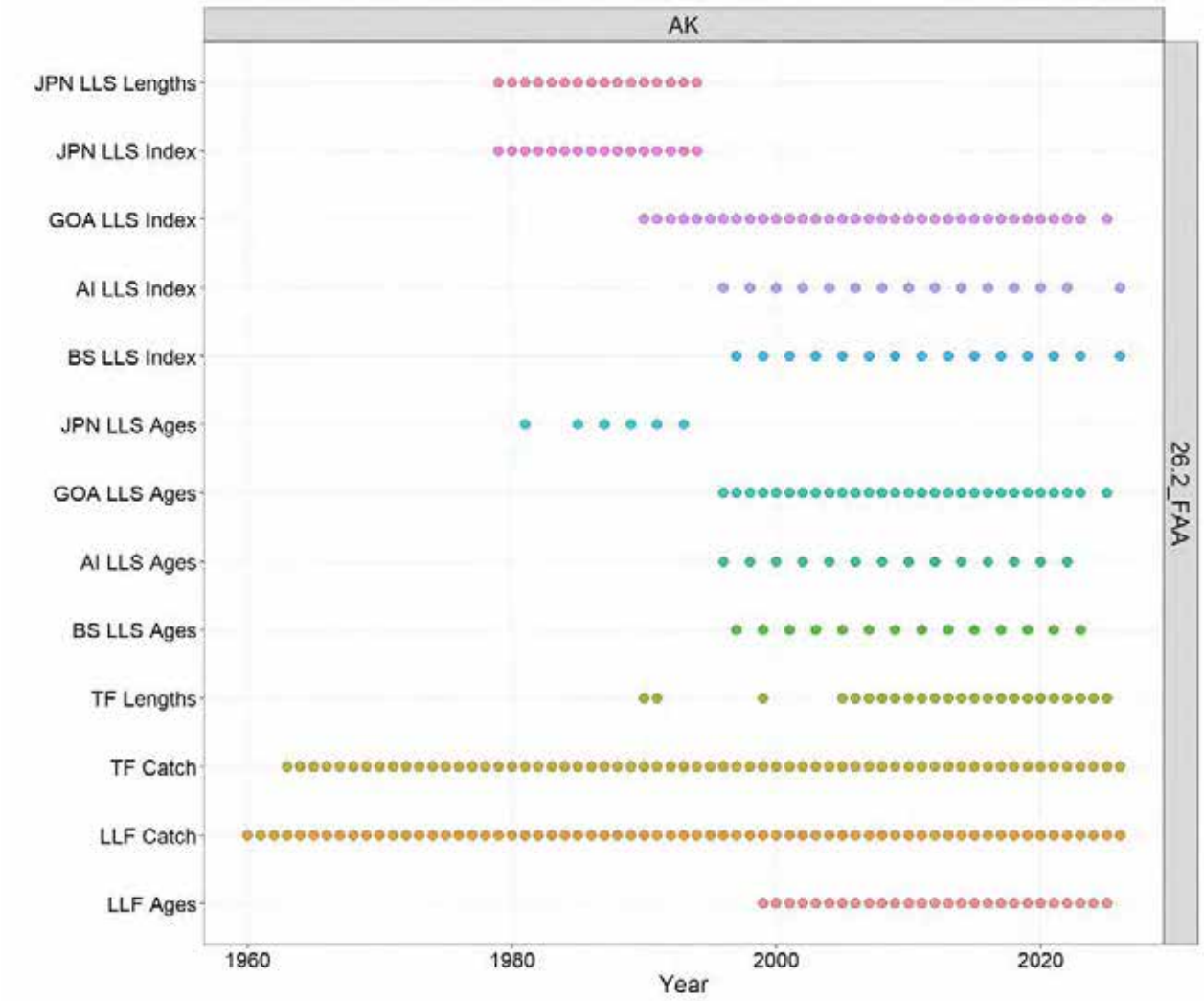


Figure 3.19. Data inputs fit in the assessment model.

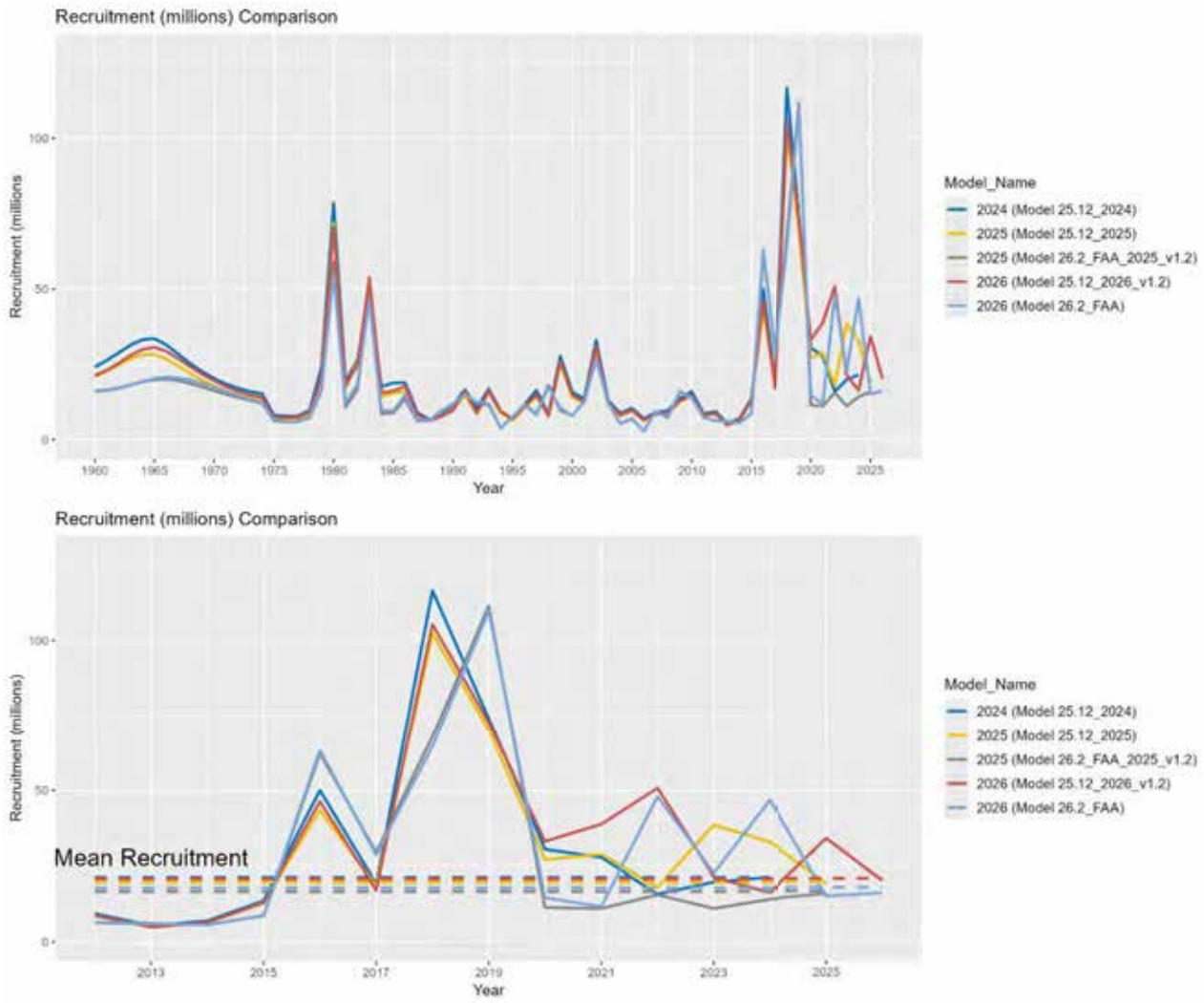


Figure 3.20. Results of the model bridging exercise in terms of recruitment (millions of age-2 fish) demonstrating the transition of model estimates from the continuity Model *25.12* to the author recommended Model *26.2_FAA*. Model *25.12_1Reg_Cont* (medium blue and yellow lines) is the continuity model. Model *26.1_1Reg* (grey and light blue lines) is the updated single region model (shown for comparison). Model *26.2_FAA* (red and dark blue lines) is the final fleets-as-areas author recommended model.

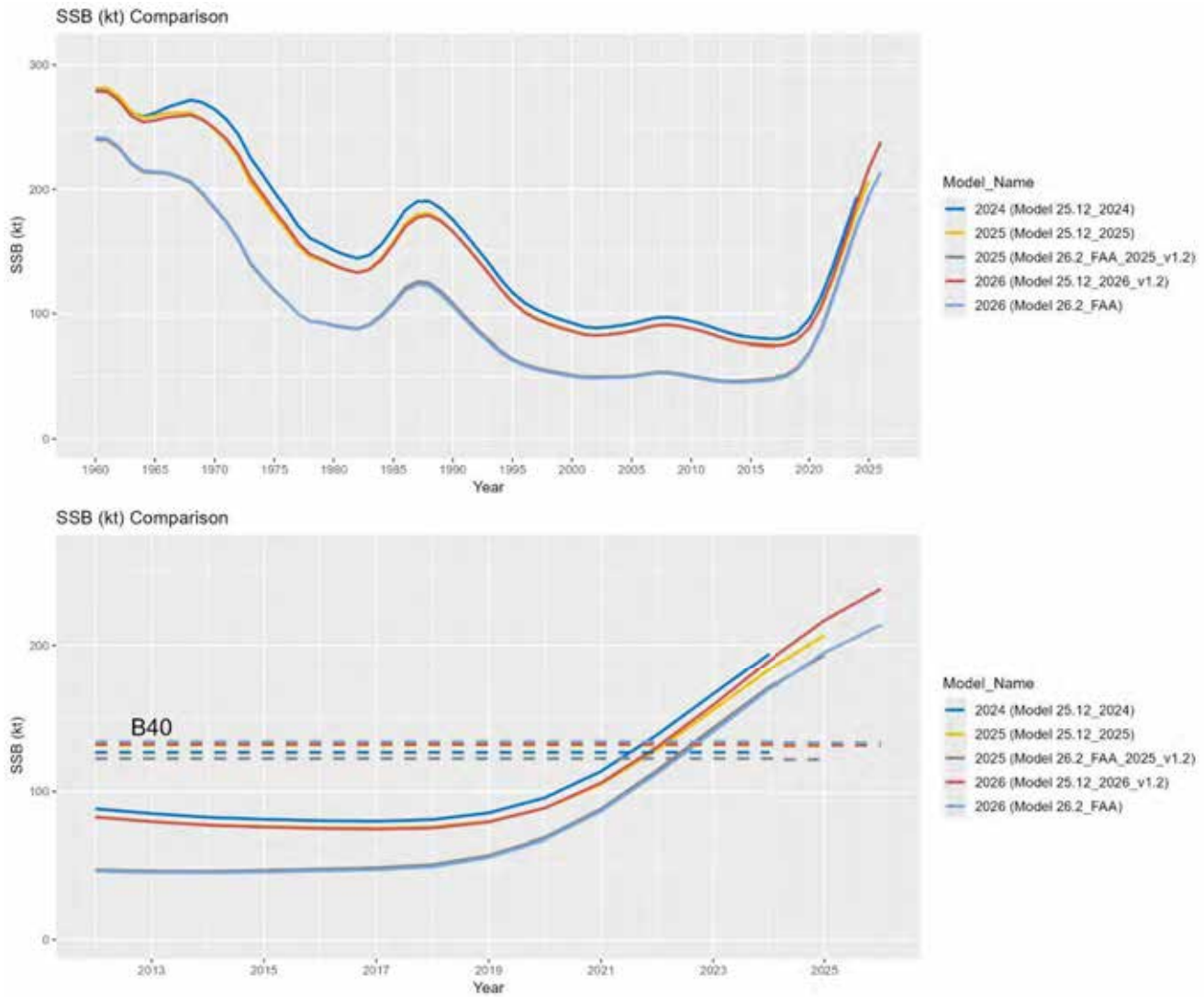


Figure 3.21. Results of the model bridging exercise in terms of spawning stock biomass (kt; solid lines) with associated biomass reference points (dashed lines) demonstrating the transition of modele estimates from the continuity Model *25.12* to the author recommended Model *26.2_FAA*. Model *25.12_1Reg_Cont* (medium blue and yellow lines) is the continuity model. Model *26.1_1Reg* (grey and light blue lines) is the updated single region model (shown for comparison). Model *26.2_FAA* (red and dark blue lines) is the final fleets-as-areas author recommended model.

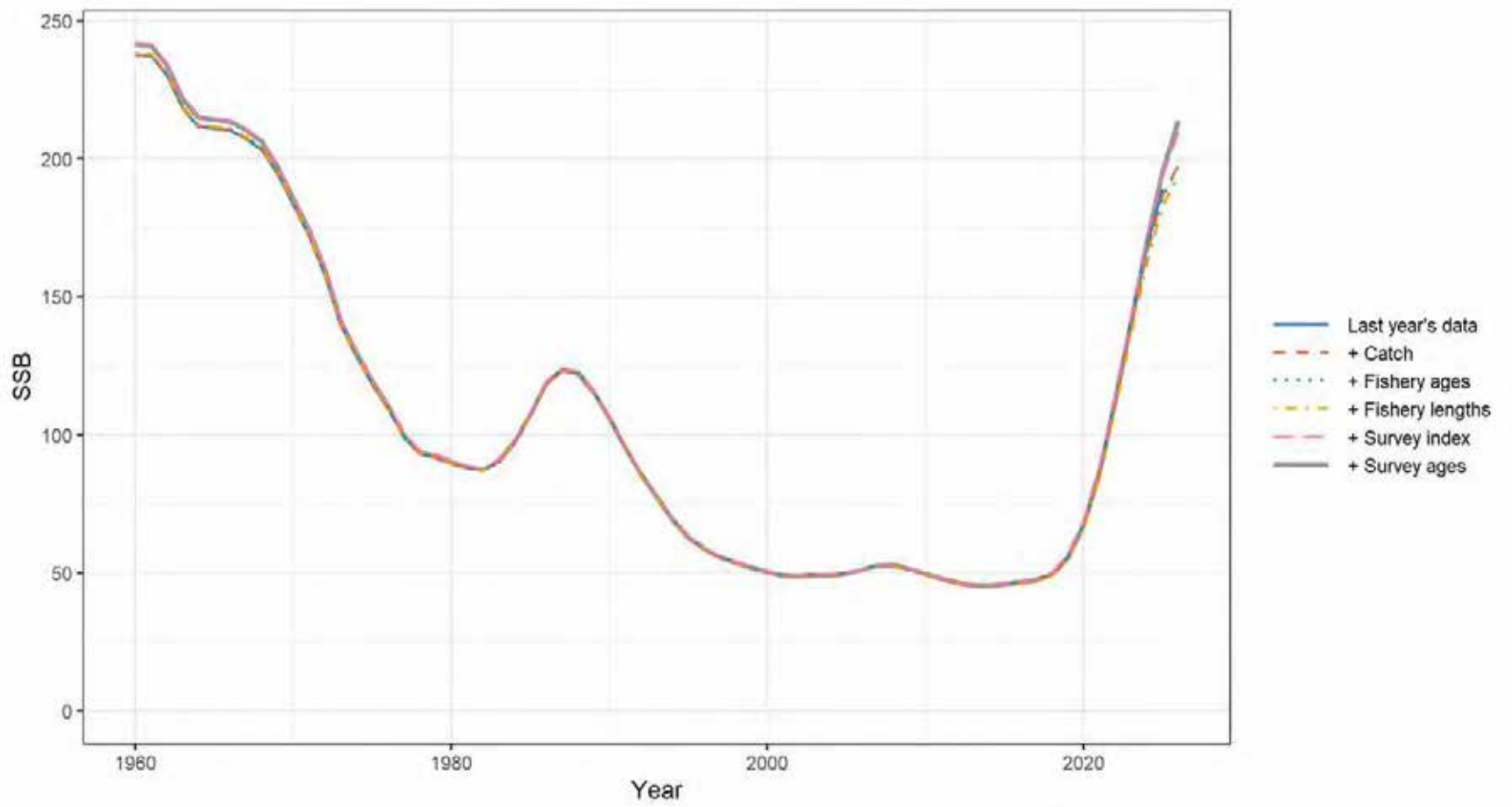


Figure 3.22. Results of an incremental data addition exercise for Model *26.2_FAA* in terms of SSB (kt), where each new data source for 2026 is added in a cumulative, stepwise fashion. 'Last year's data' denotes the model fit to the data available through 2025, while '+ Survey ages' denotes the final Model *26.2_FAA*.

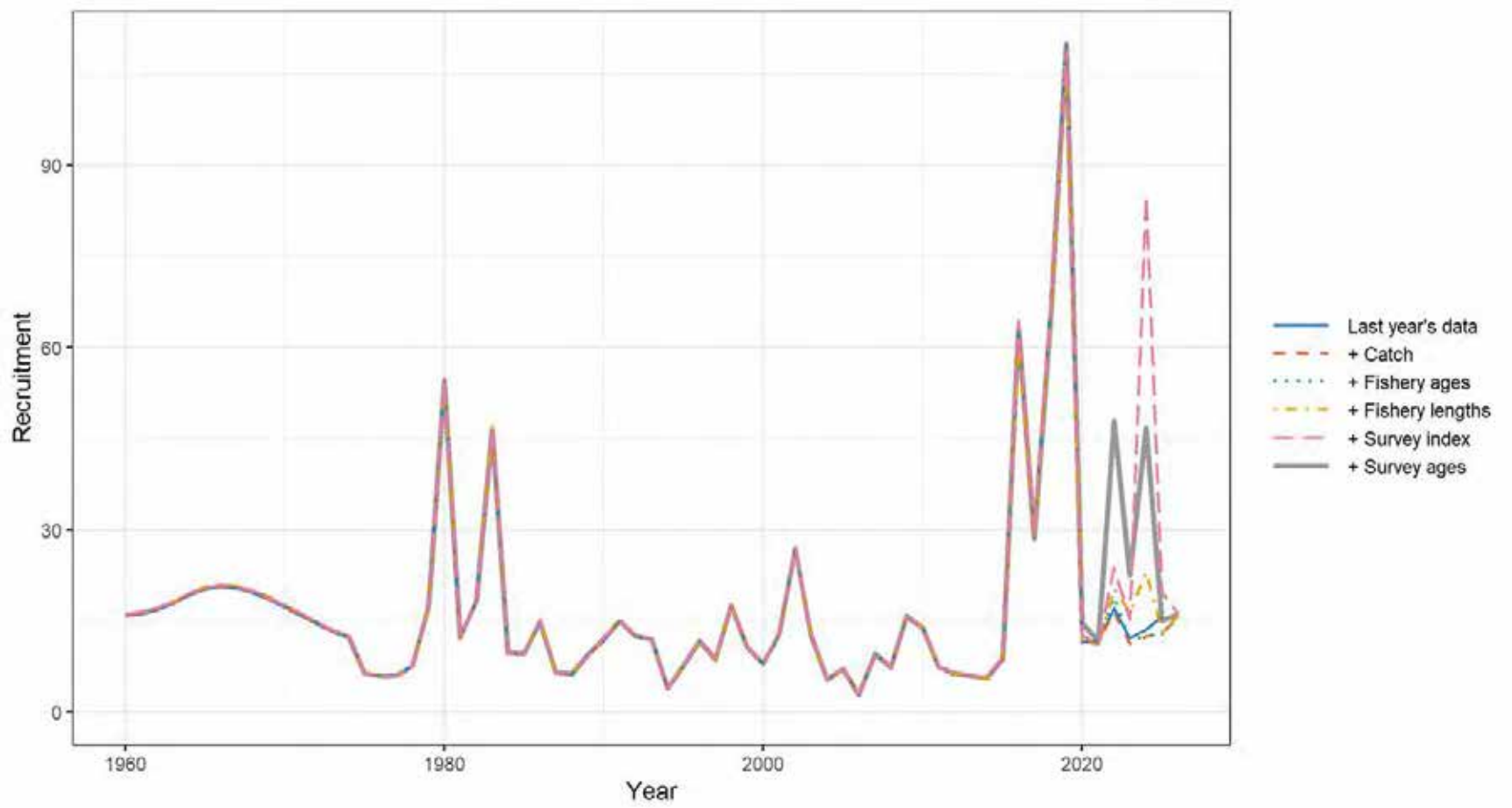


Figure 3.23. Results of an incremental data addition exercise for Model *26.2_FAA* in terms of recruitment (millions of age-2 fish) by recruitment year, where each new data source for 2026 is added in a cumulative, stepwise fashion. 'Last year's data' denotes the model fit to the data available through 2025, while '+ Survey ages' denotes the final *Model 26.2_FAA*.

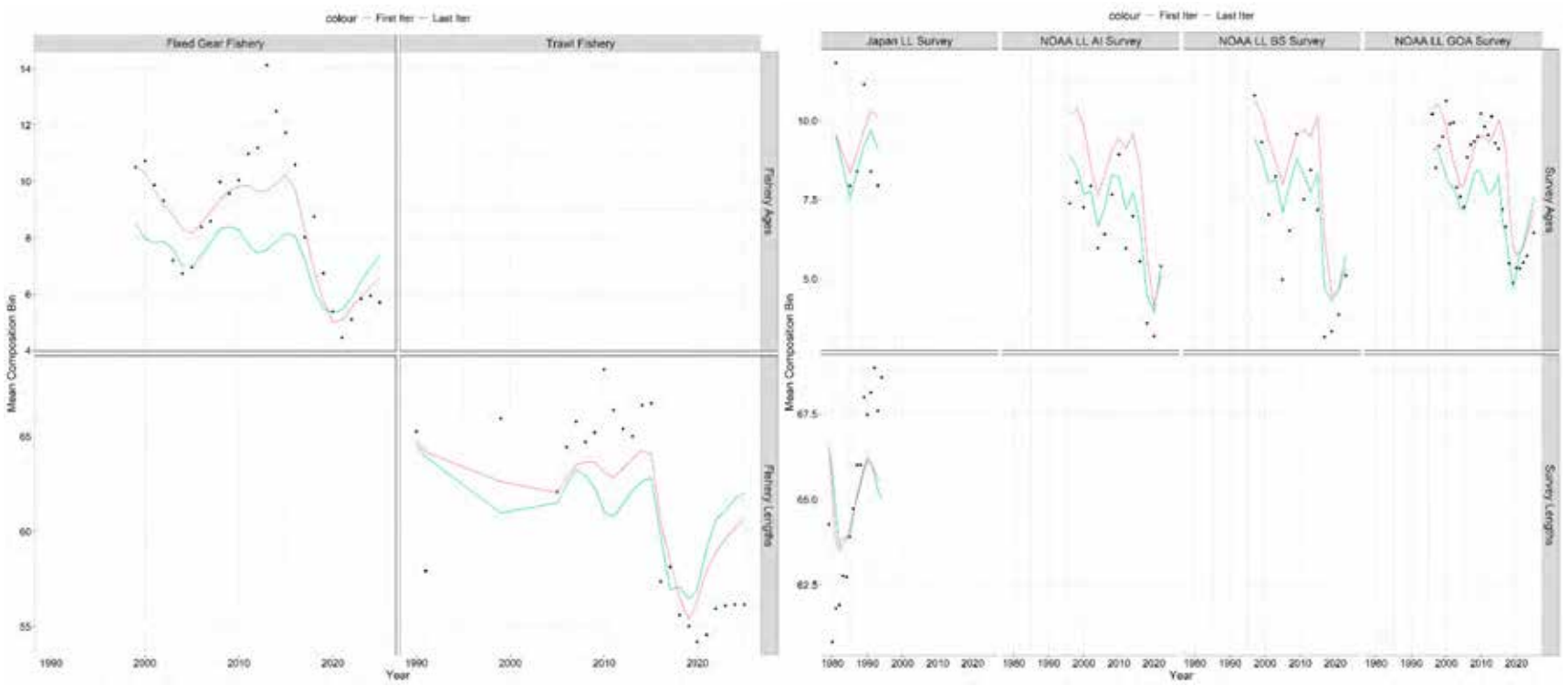


Figure 3.24. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.2_FAA*.

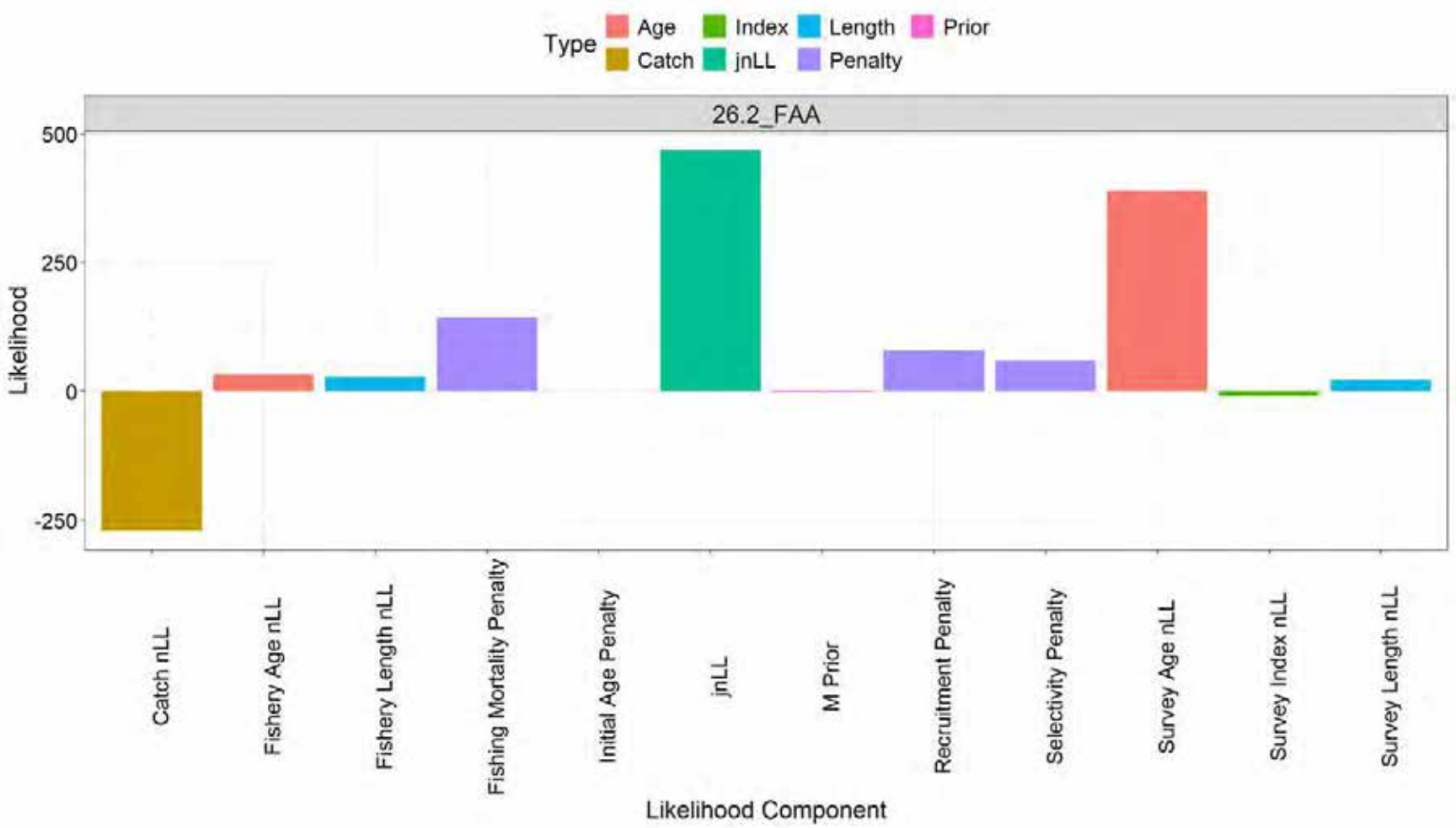


Figure 3.25. Joint negative log-likelihood (jnLL) components from Model *26.2_FAA* where different colors represent the various data sets and priors or penalty terms.

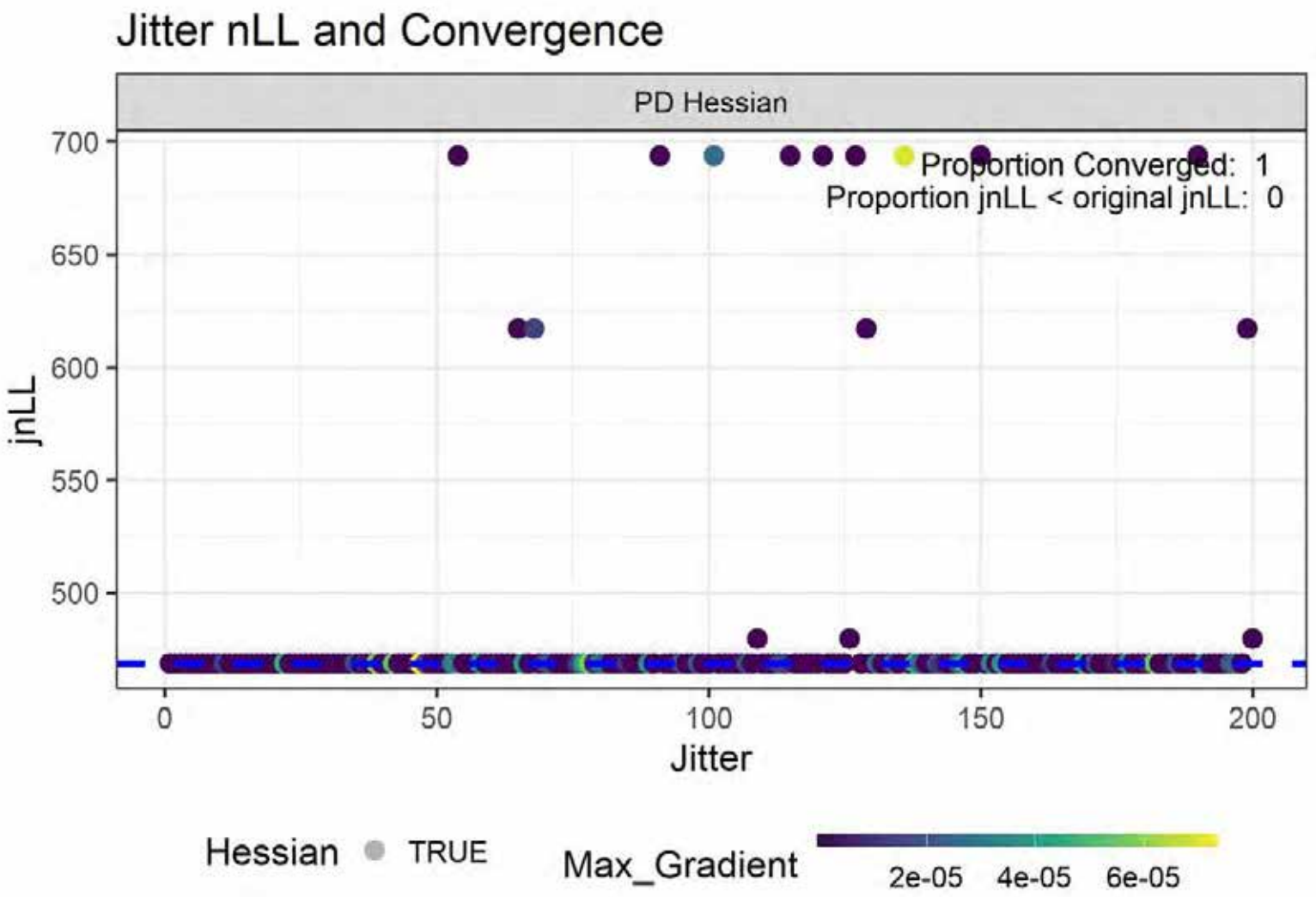


Figure 3.26. Results of the jitter analysis in terms of total joint negative log-likelihood (jnLL) values for Model *26.2_FAA*. The starting parameter values were randomly jittered by adding ~$N(0, 1^2)$ deviations to the MLE parameter estimates. All 200 jitter runs are shown (colored by maximum gradient component) and the dashed blue line denotes the jnLL of the final model.

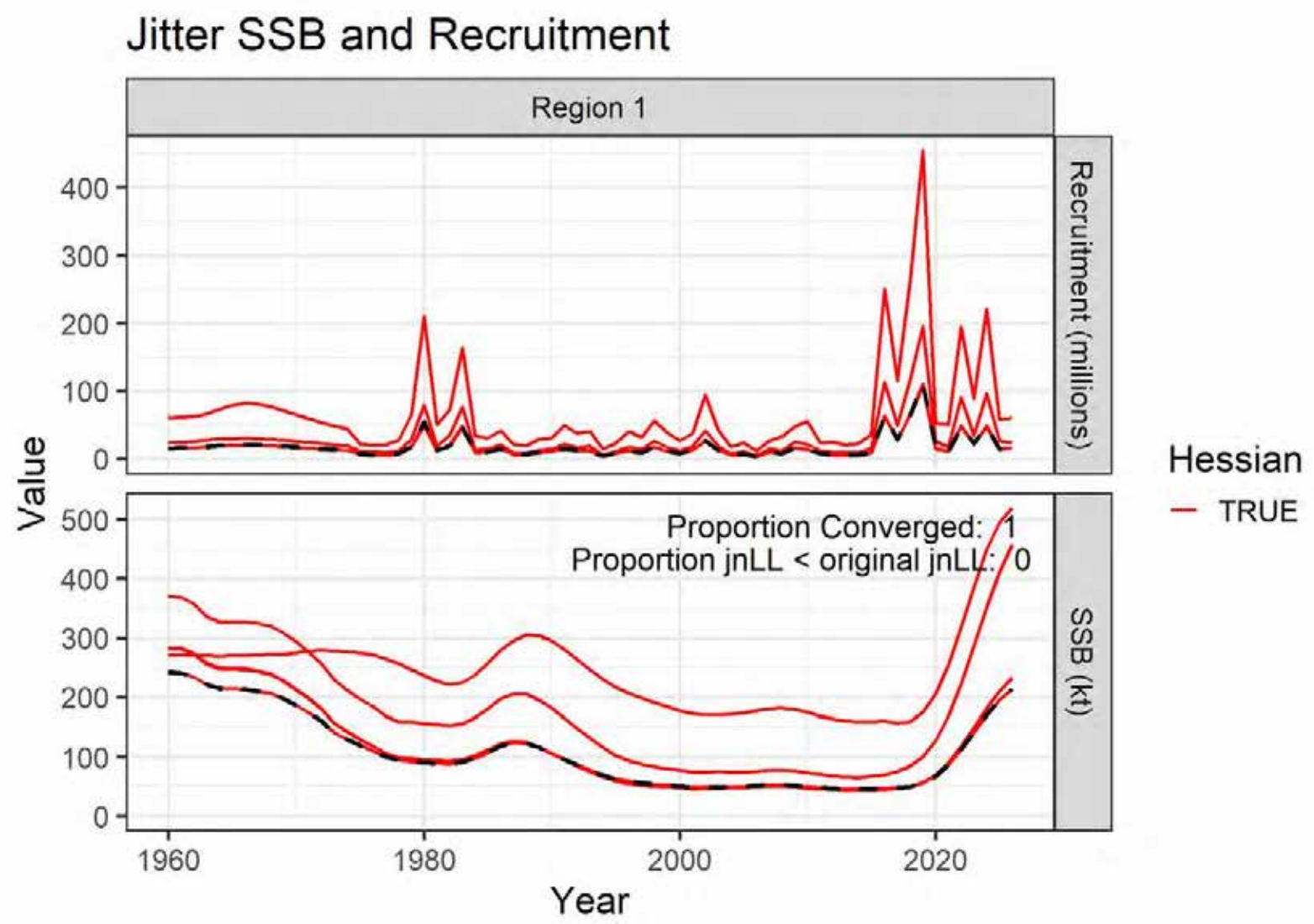


Figure 3.27. Results of the jitter analysis showing recruitment (millions of age-2 fish; top panel) and SSB (kt; bottom panel) for each jitter iteration (red lines) compared to the final (MLE) model (black dashed line) for Model *26.2_FAA*. The starting parameter values were randomly jittered by adding ~$N(0,1)$ deviations to the MLE parameter estimates, and all 200 jitter runs are shown.

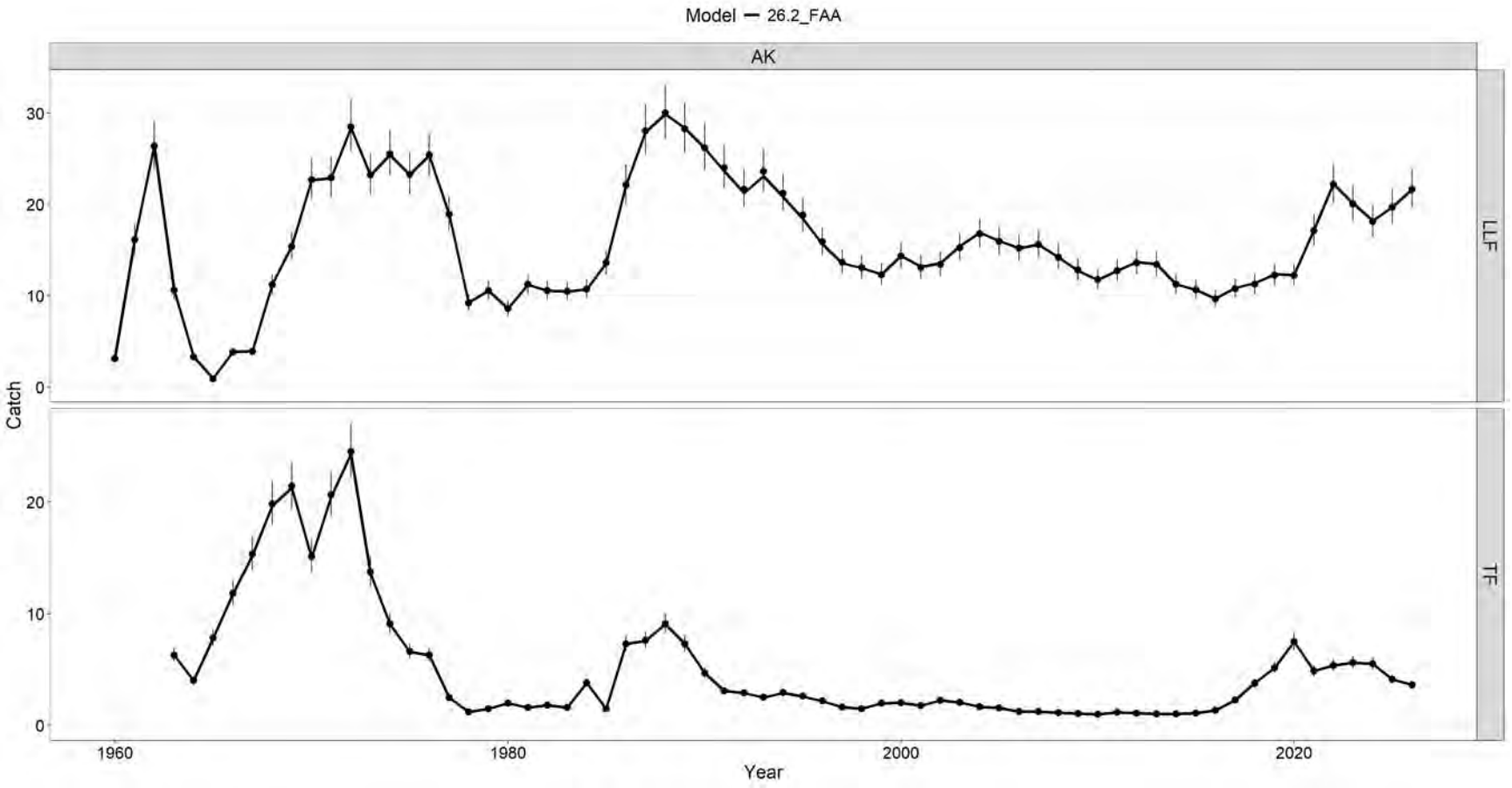


Figure 3.28. Fit to the catch data (black dots with 95% confidence intervals) by fleet (LLF is the fixed gear fishery and TF is the trawl fleet) for Model *26.2_FAA* (black line). Note the varying y-axis scales.

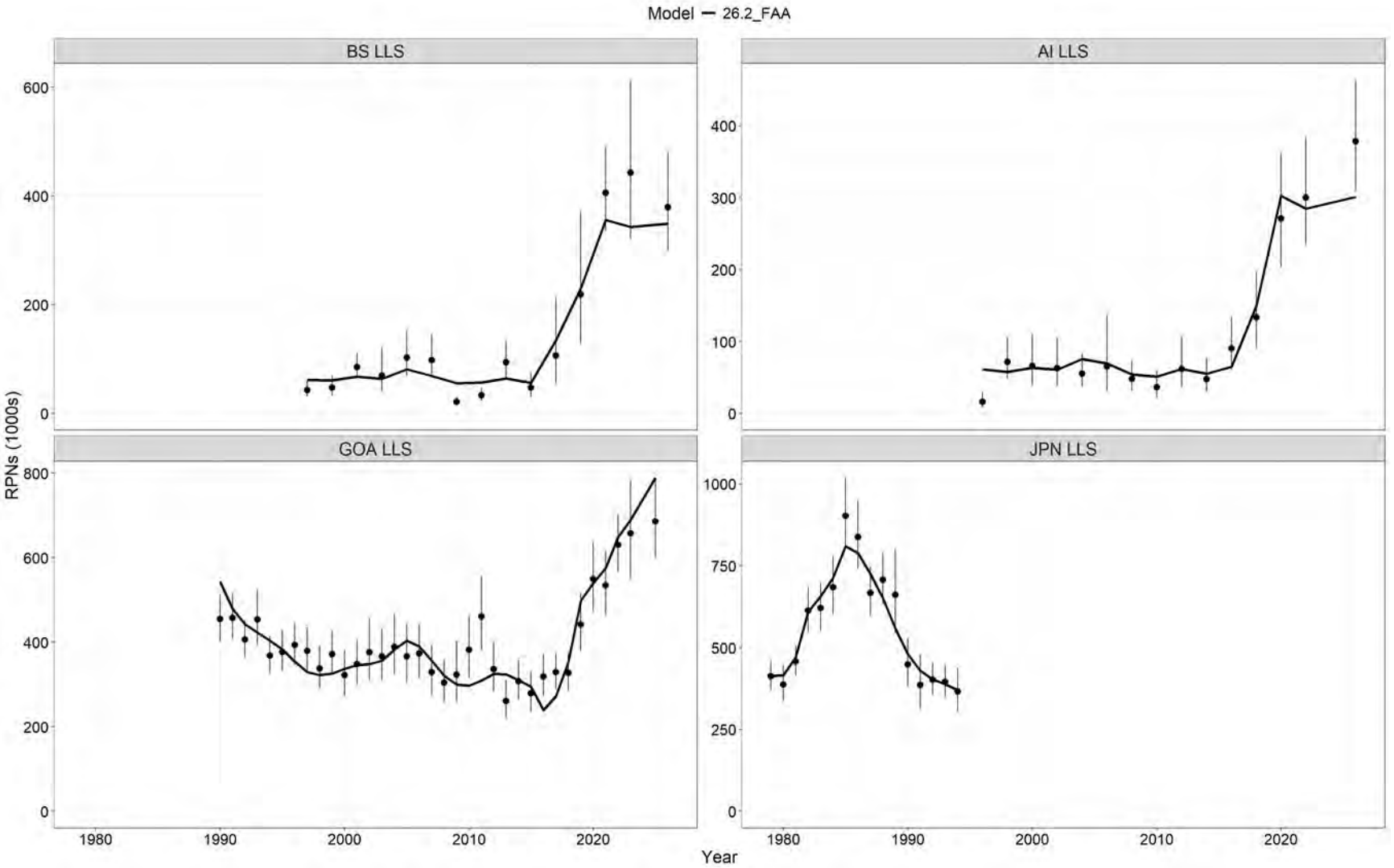


Figure 3.29. Model *26.2_FAA* fit (black lines) to observed indices of abundance (black points with 95% confidence intervals), including the NOAA Longline Survey (by region) and the Japanese Longline Survey (AK-wide) RPNs (1000s of fish).

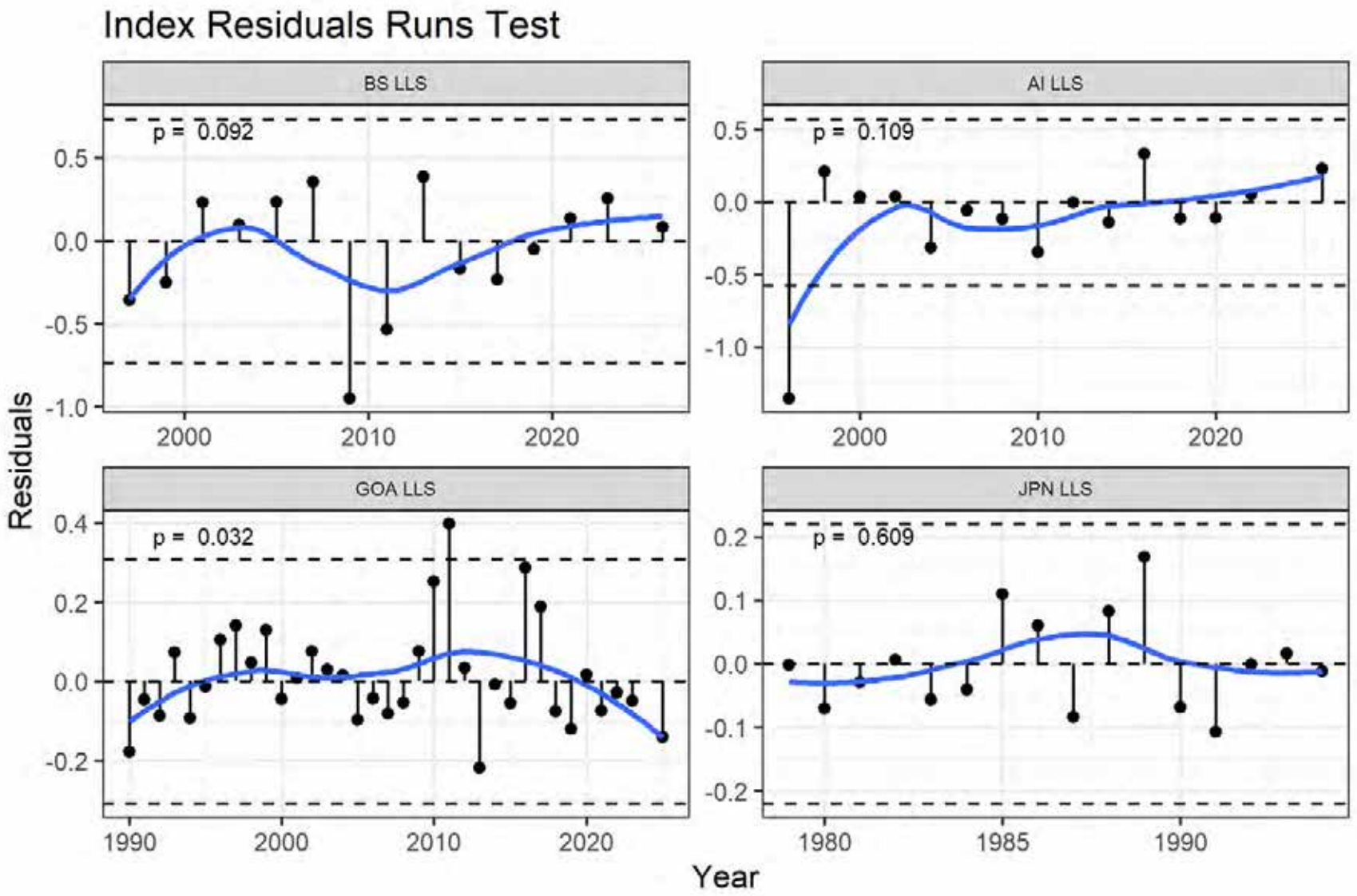


Figure 3.30. Results of an index residuals runs test for Model *26.2_FAA*, where the black dots are the residual values, the blue lines represent a LOESS smoother across years, and the dashed lines represent the 95% confidence intervals.

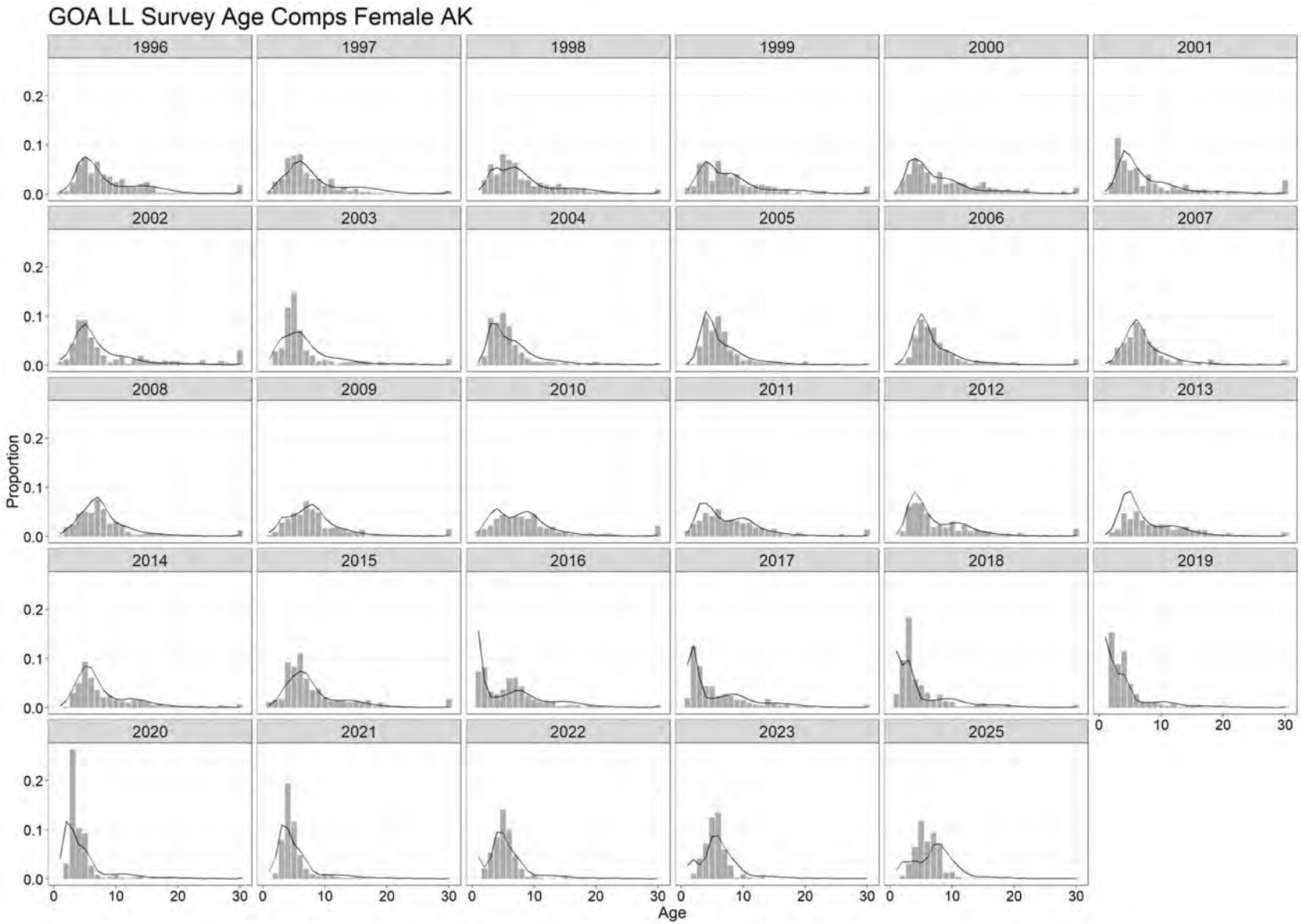


Figure 3.31. Fits to GOA NOAA Longline Survey age composition data by year for females.

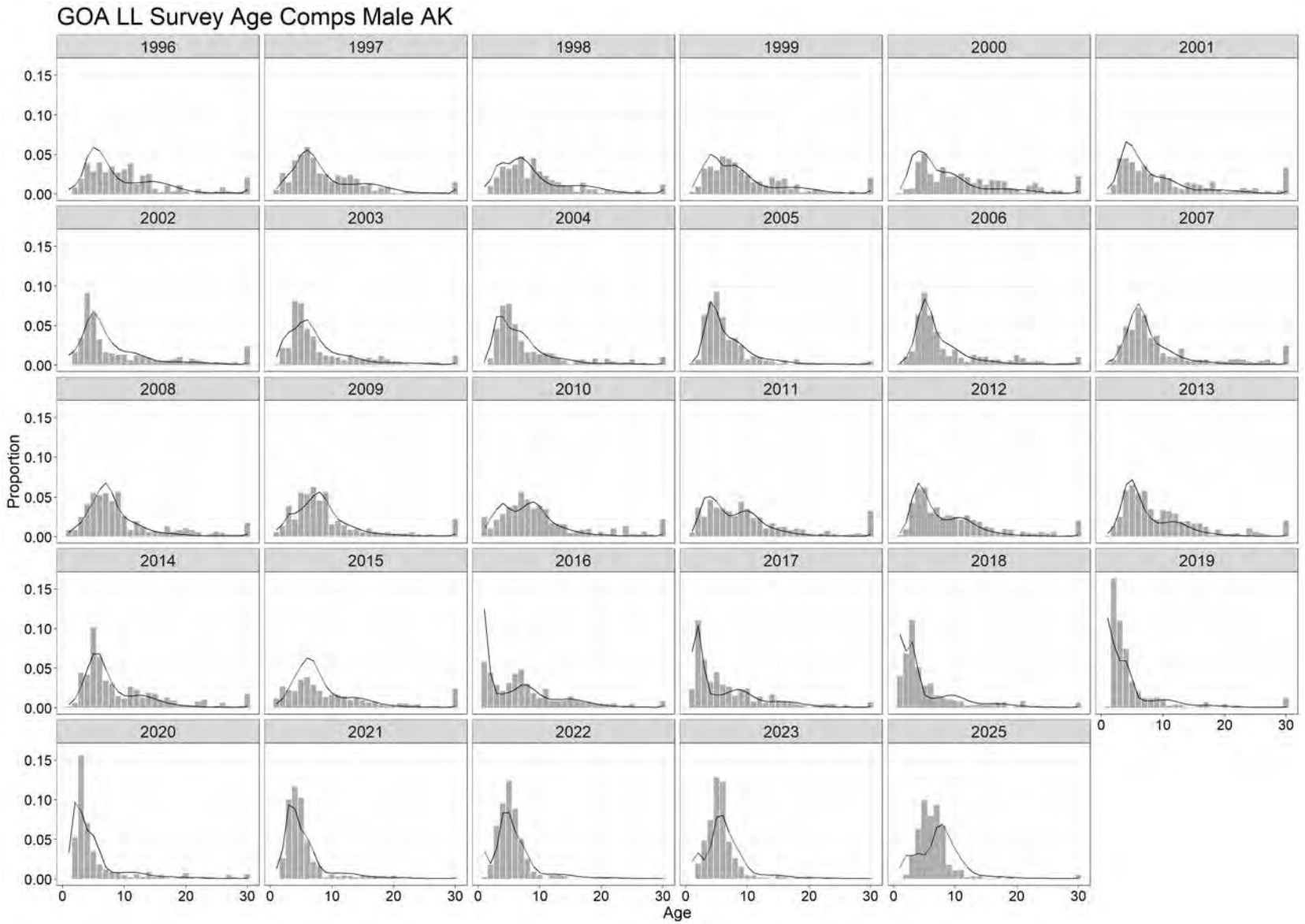


Figure 3.32. Fits to GOA NOAA Longline Survey age composition data by year for males.

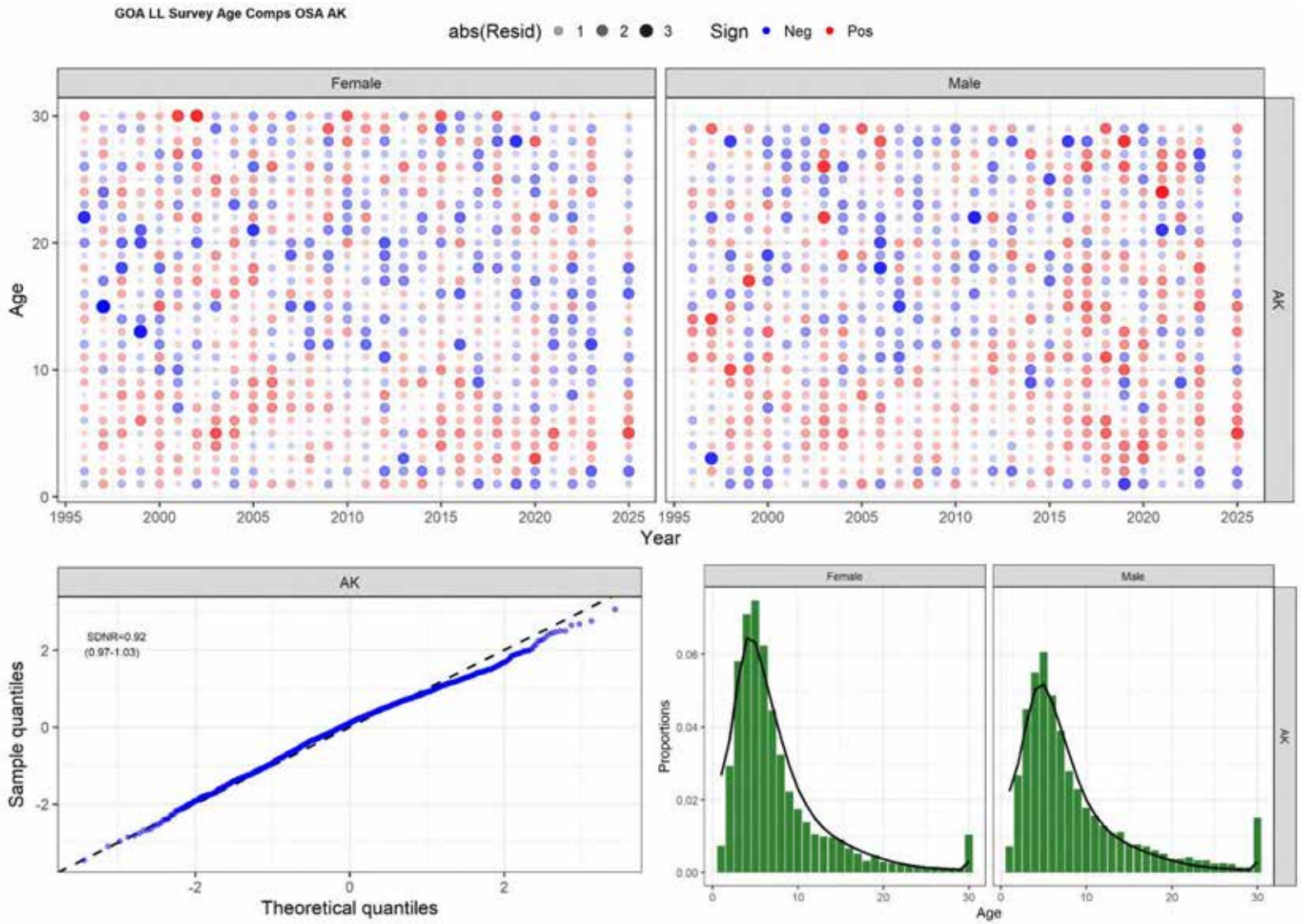


Figure 3.33. Fits to GOA NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

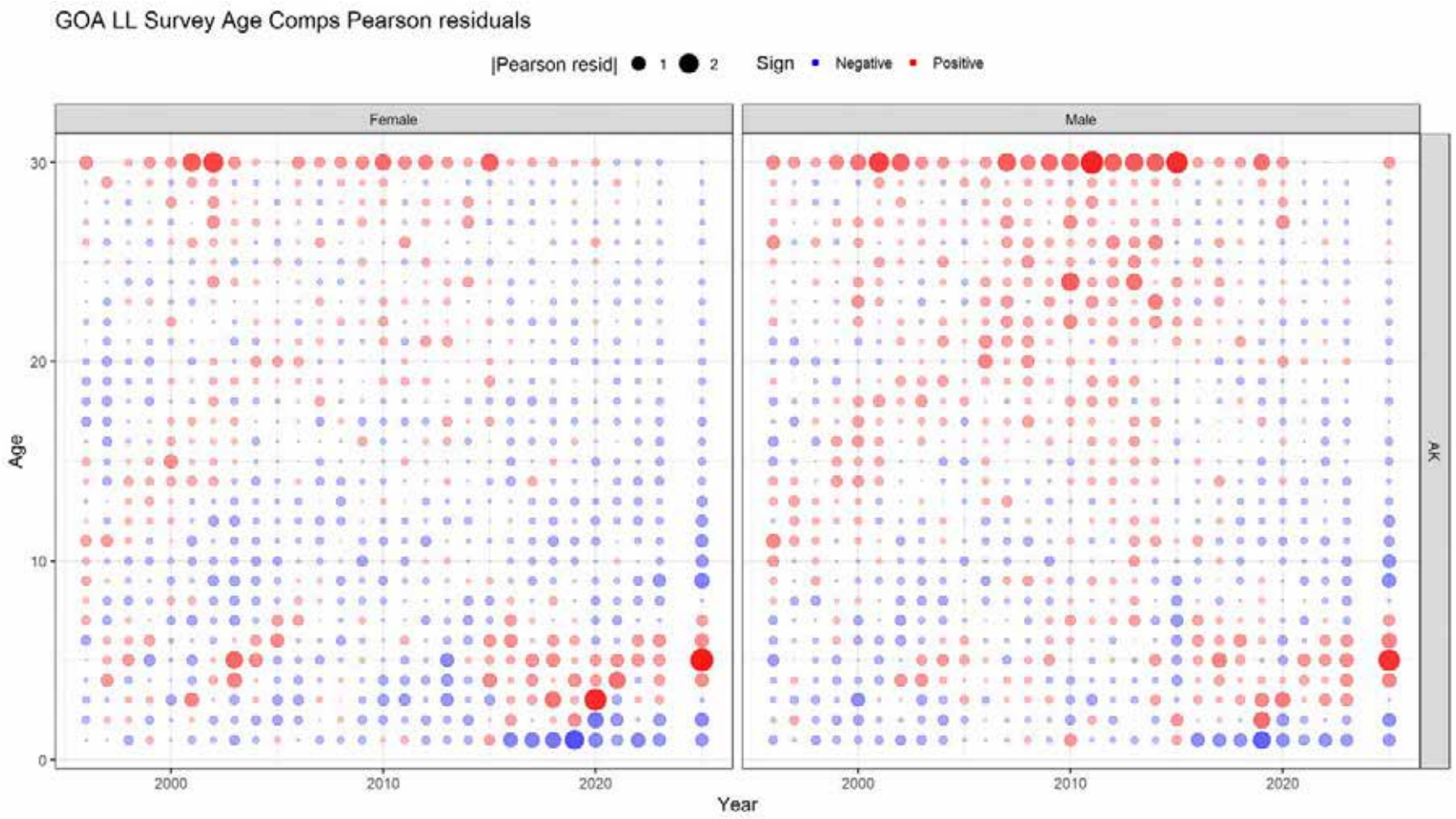


Figure 3.34. Fits to GOA NOAA Longline Survey age composition data based on Pearson residuals.

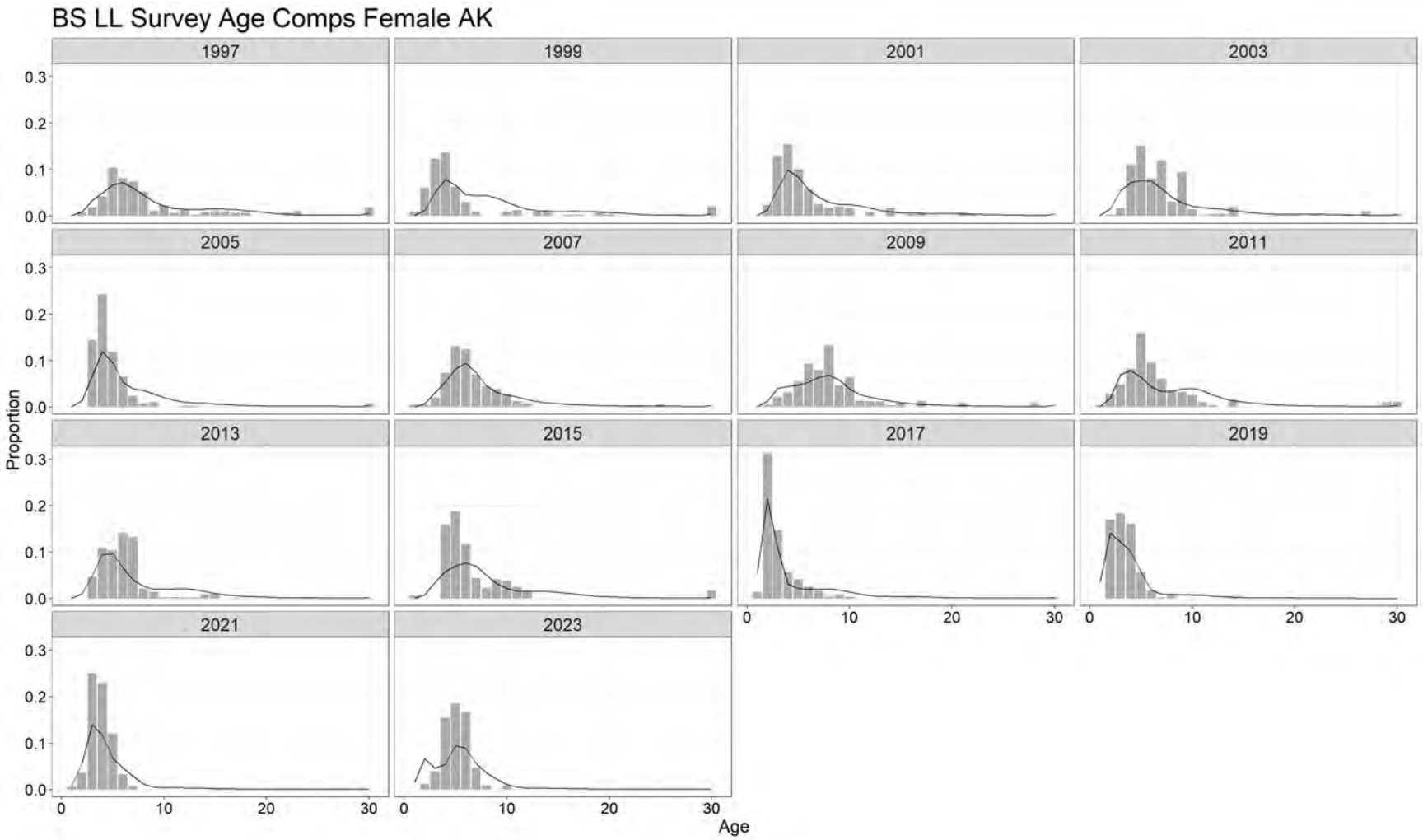


Figure 3.35. Fits to BS NOAA Longline Survey age composition data by year for females.

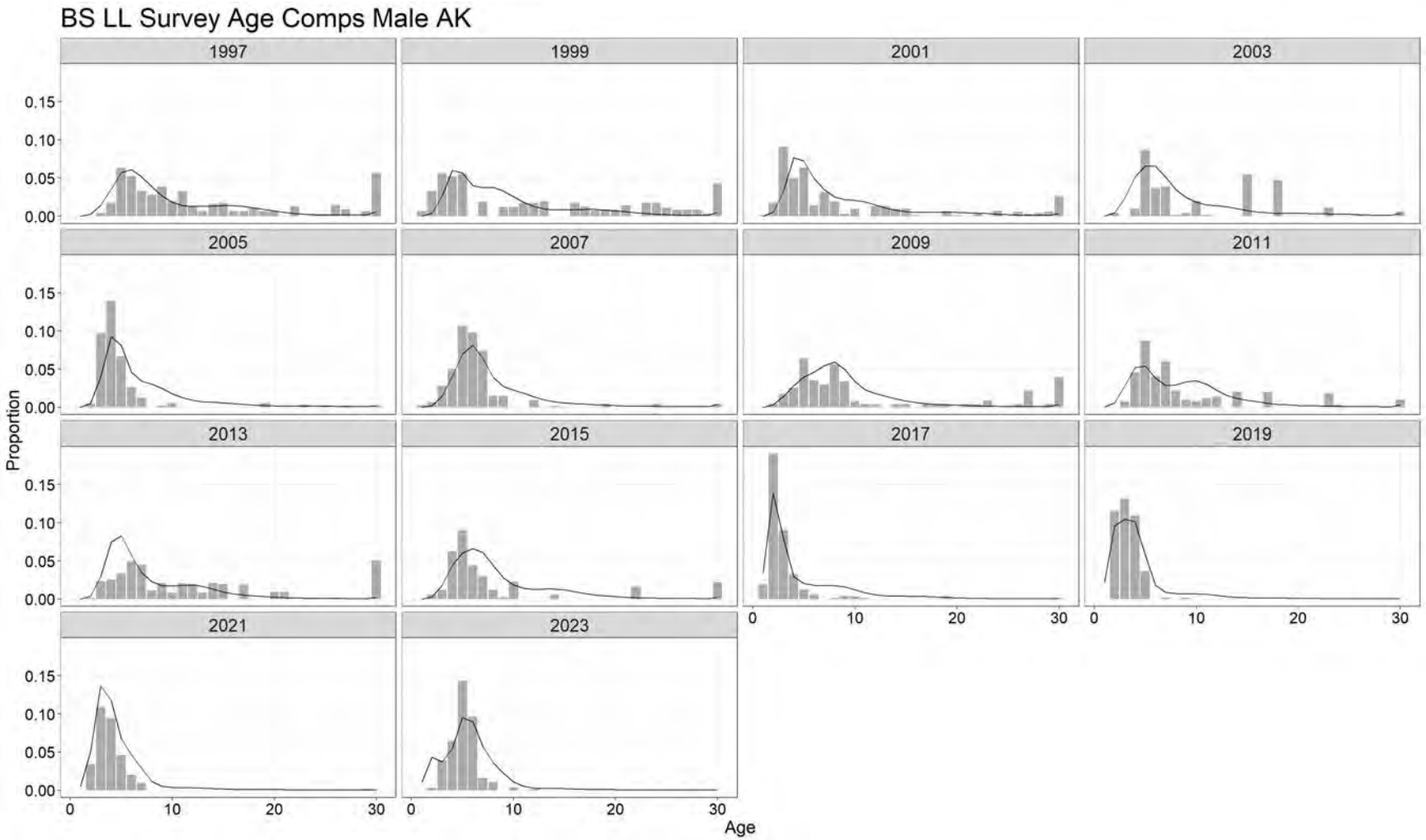


Figure 3.36. Fits to BS NOAA Longline Survey age composition data by year for males.

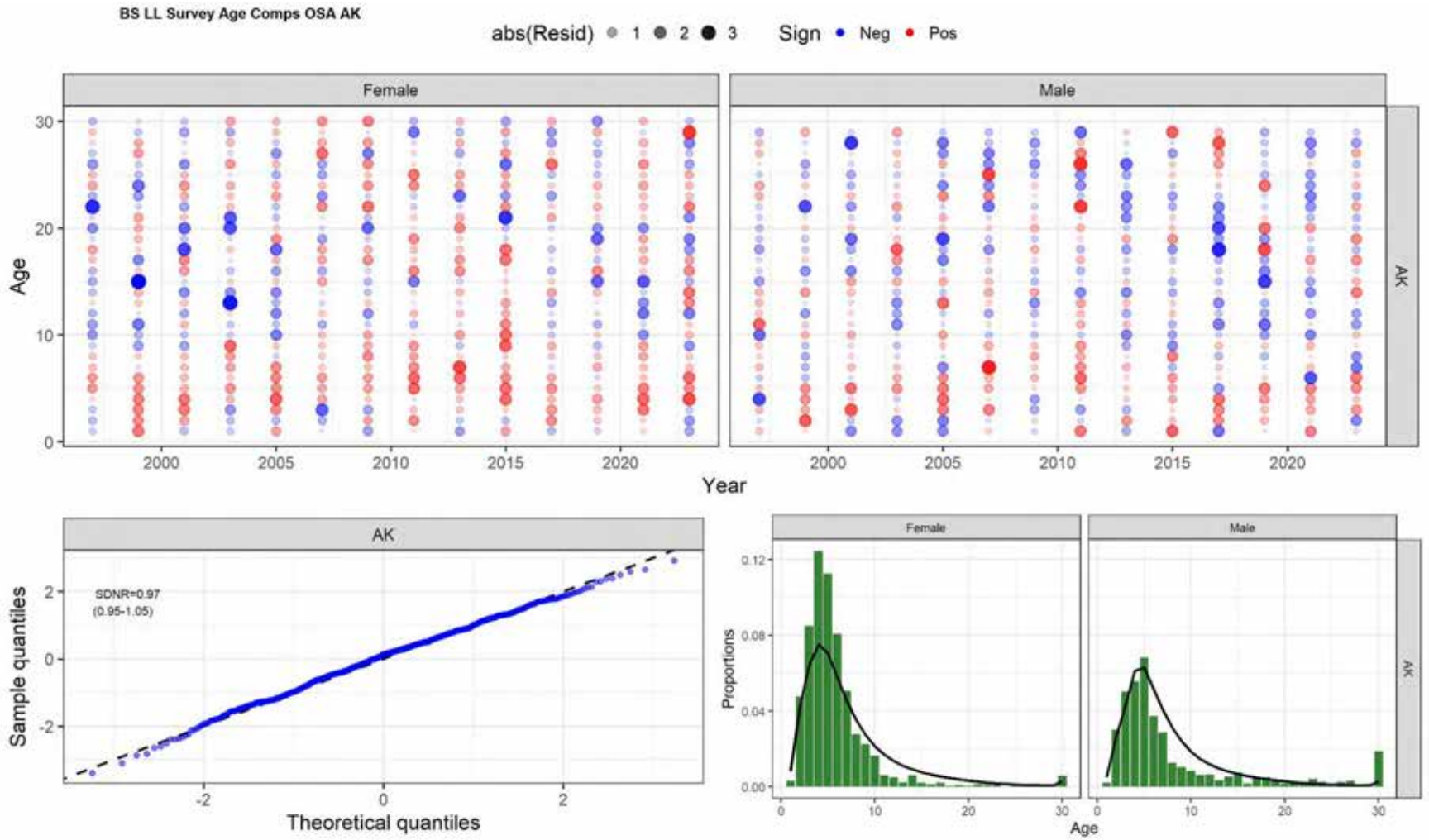


Figure 3.37. Fits to BS NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

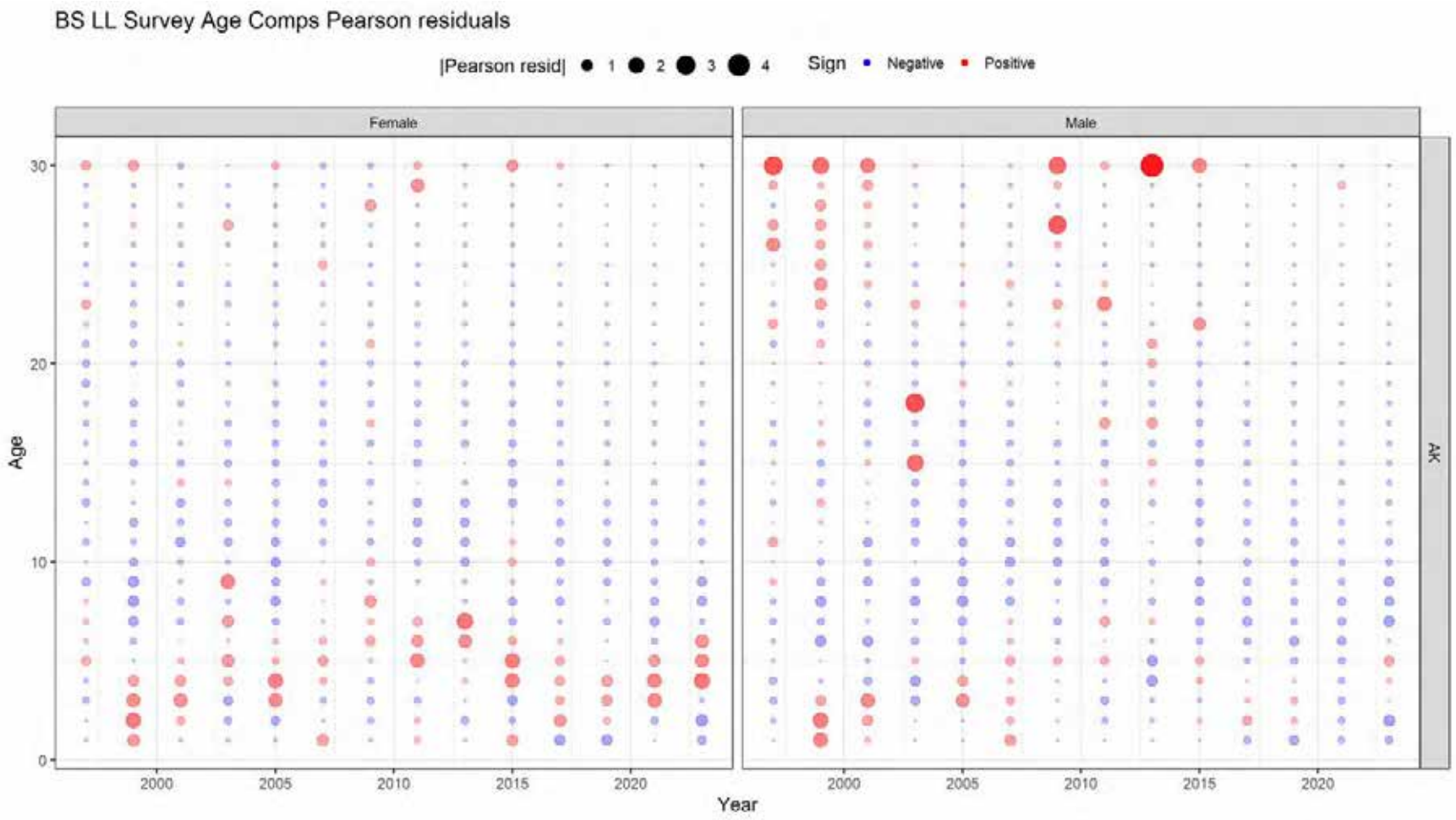


Figure 3.38. Fits to BS NOAA Longline Survey age composition data based on Pearson residuals.

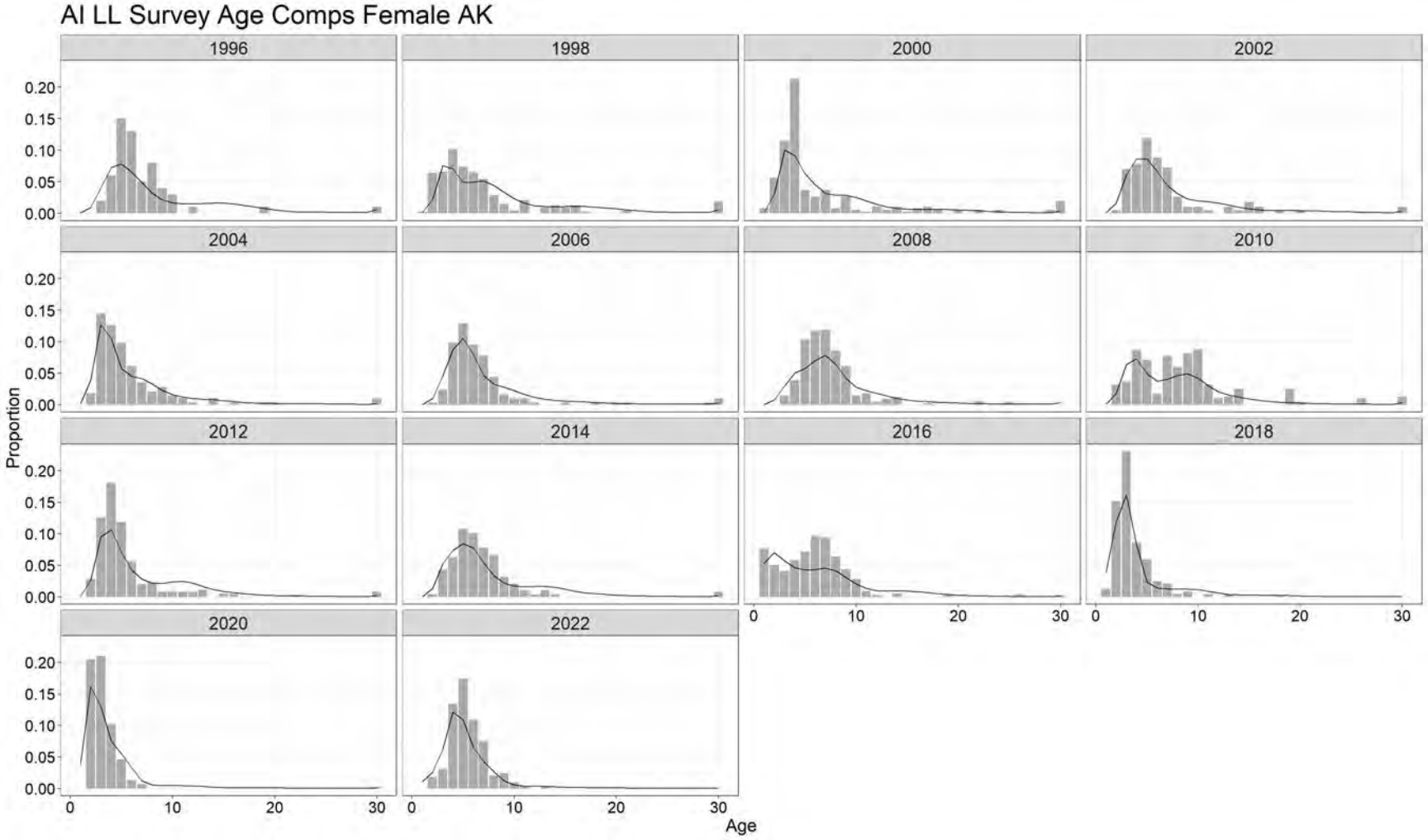


Figure 3.39. Fits to AI NOAA Longline Survey age composition data by year for females.

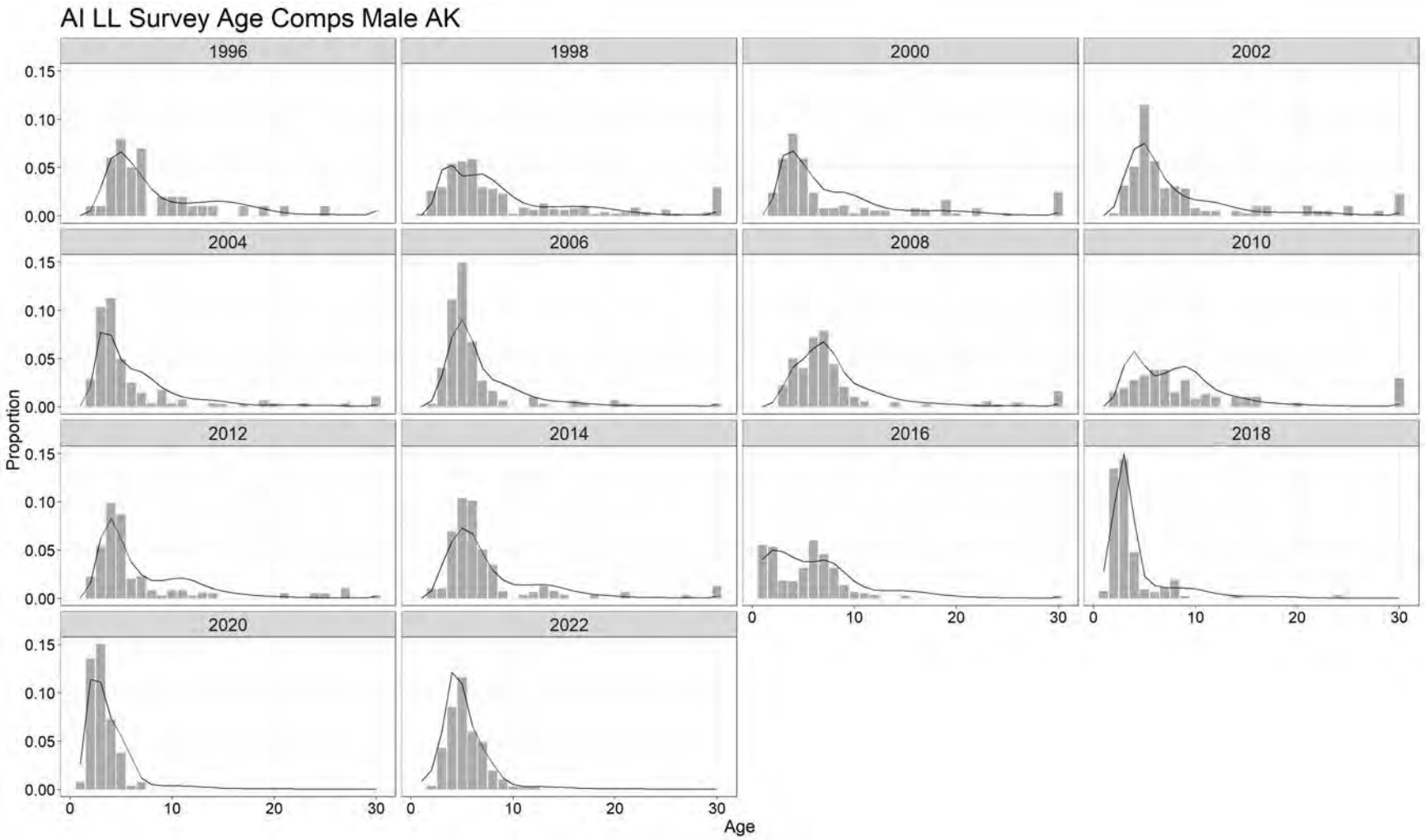


Figure 3.40. Fits to AI NOAA Longline Survey age composition data by year for males.

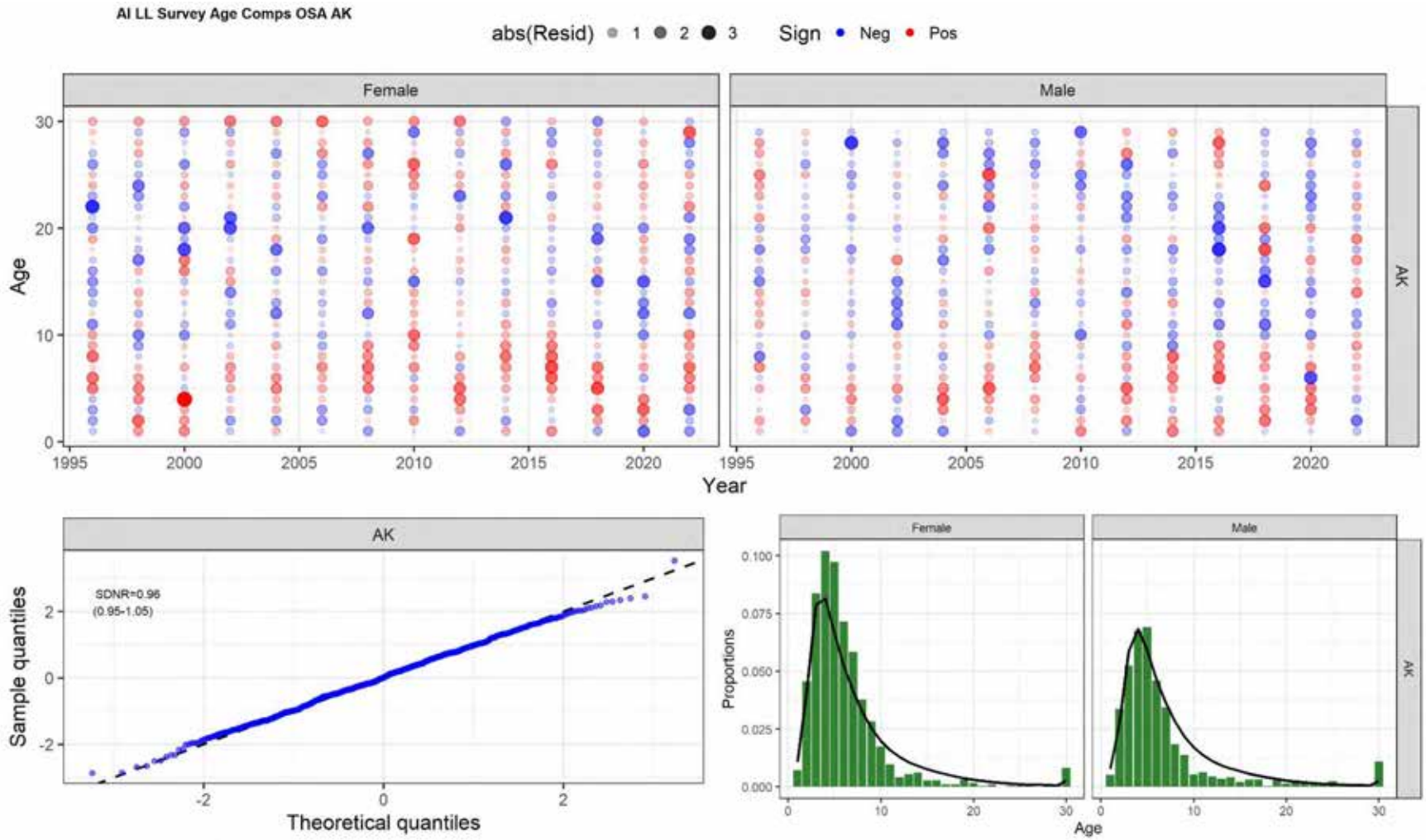


Figure 3.41. Fits to AI NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

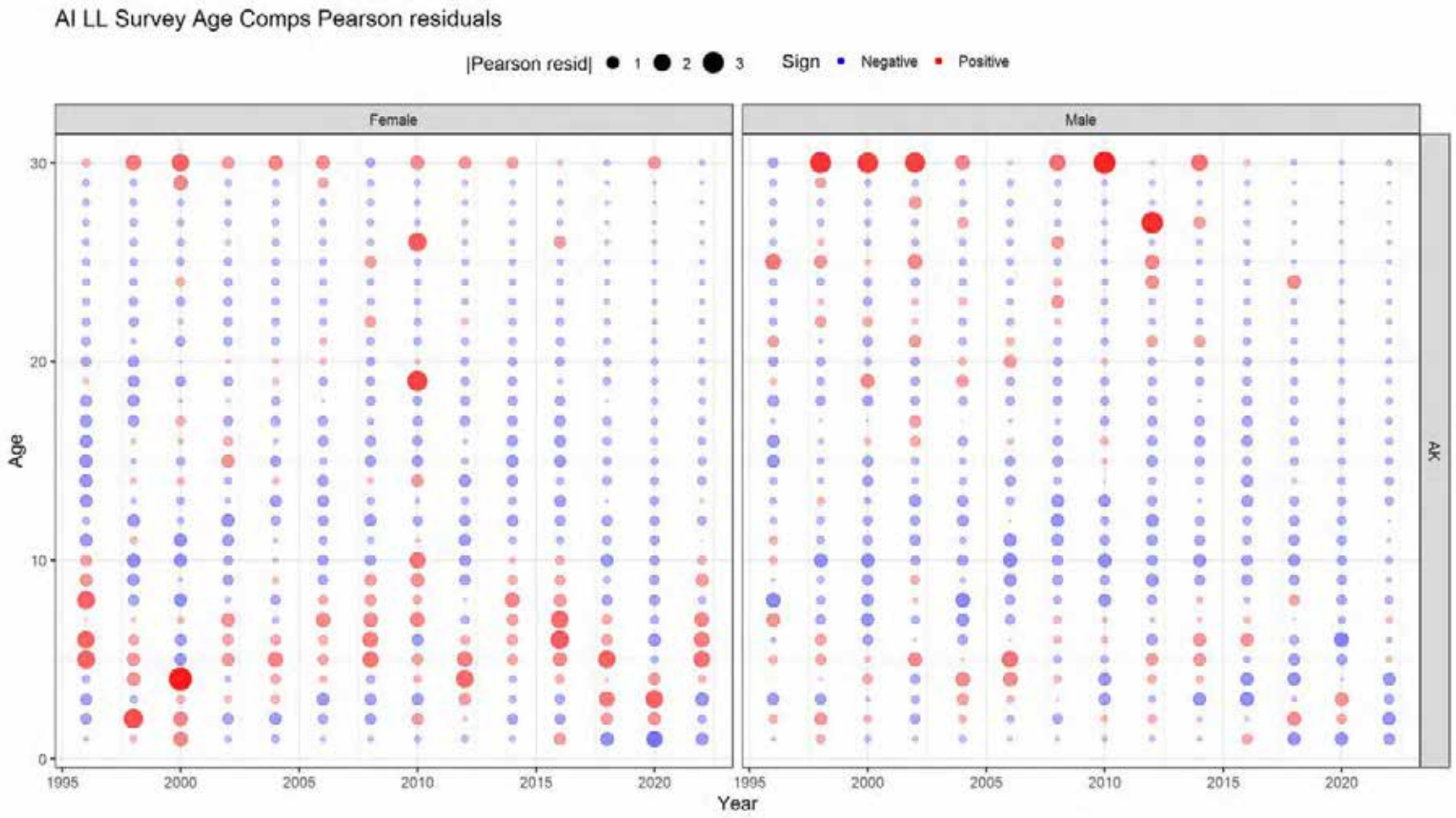


Figure 3.42. Fits to AI NOAA longline survey age composition data based on Pearson residuals.

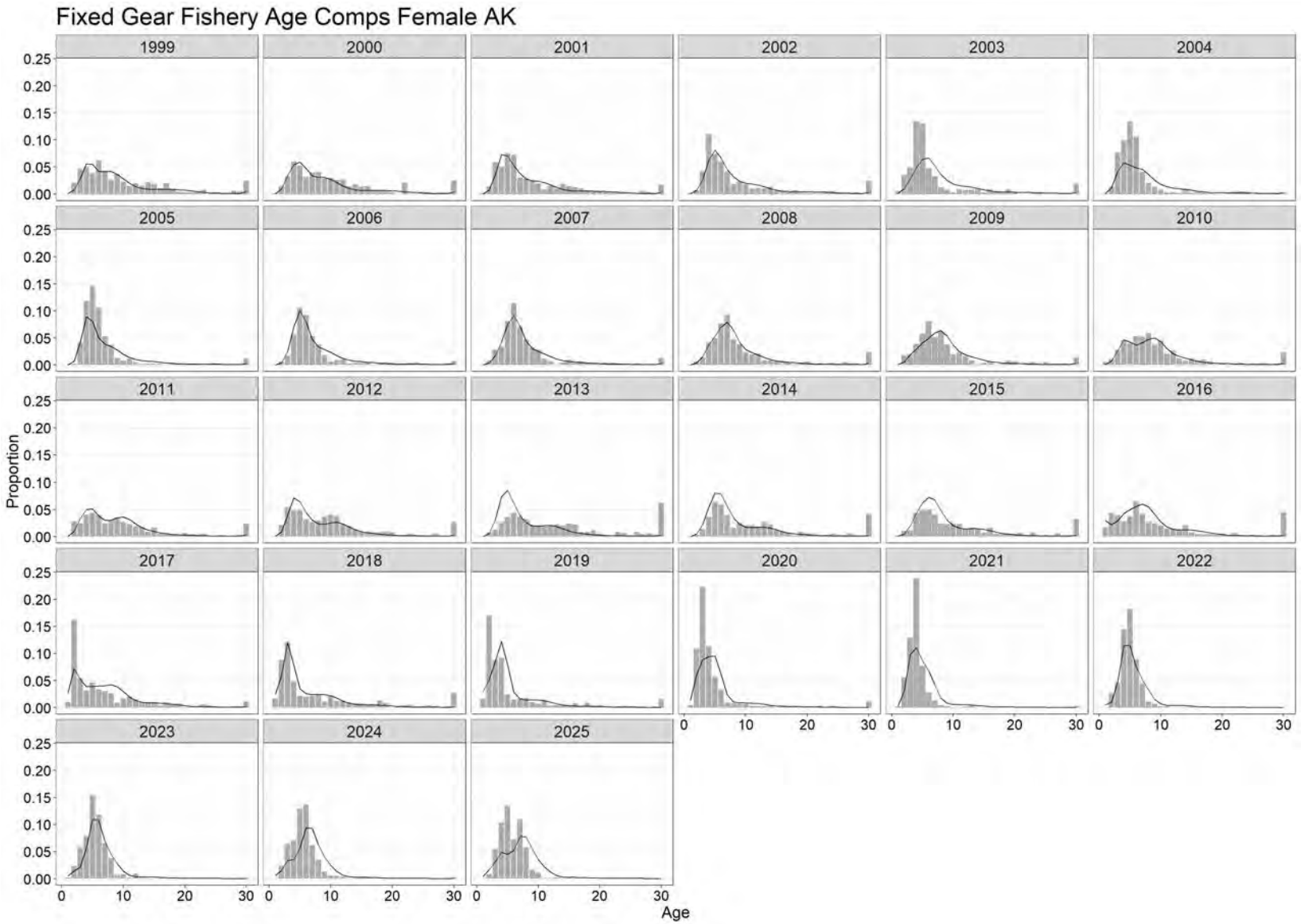


Figure 3.43. Fits to fixed gear fishery age composition data by year for females.

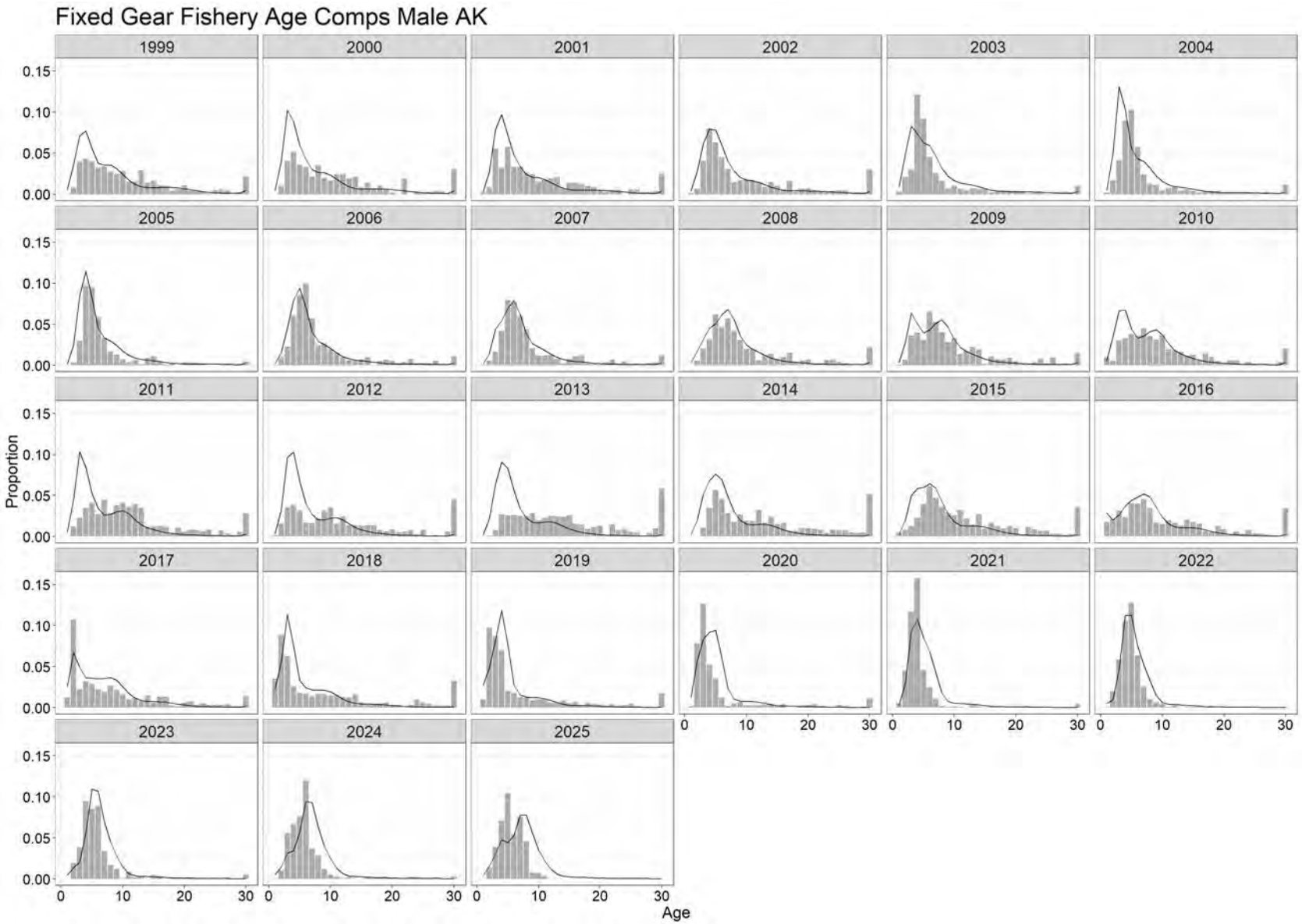


Figure 3.44. Fits to fixed gear fishery age composition data by year for males.

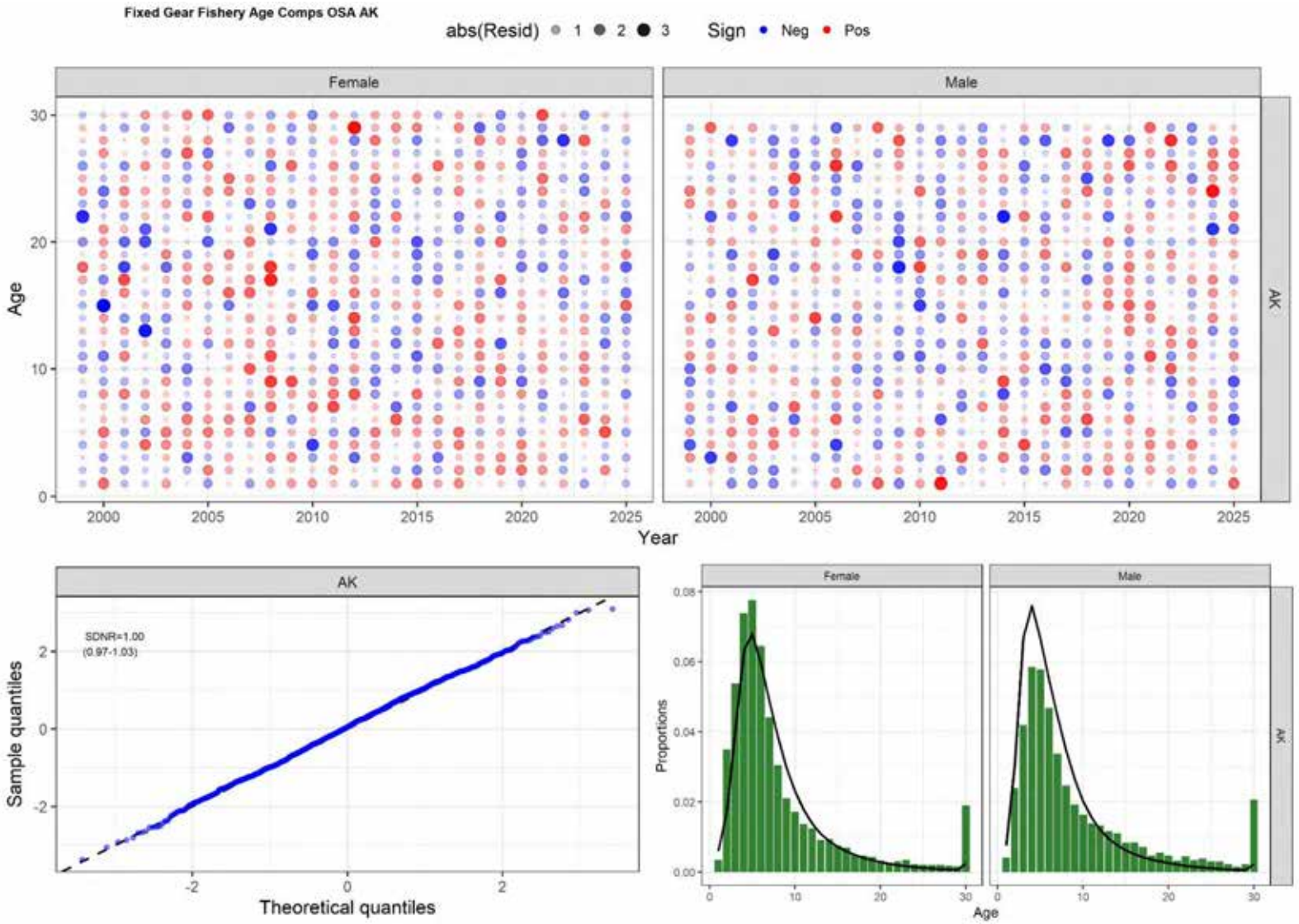


Figure 3.45. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

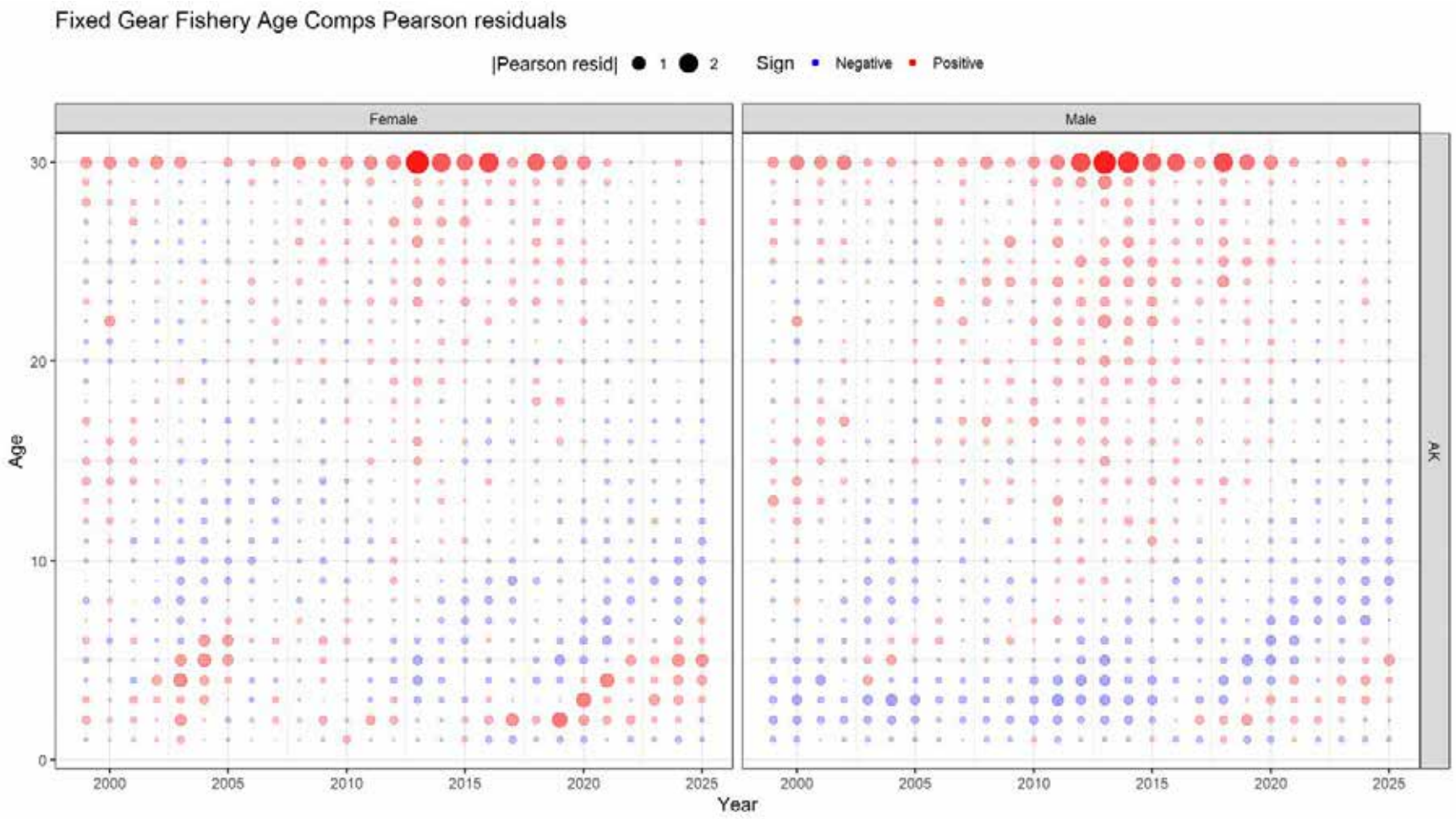


Figure 3.46. Fits to the fixed gear fishery age composition data based on Pearson residuals.

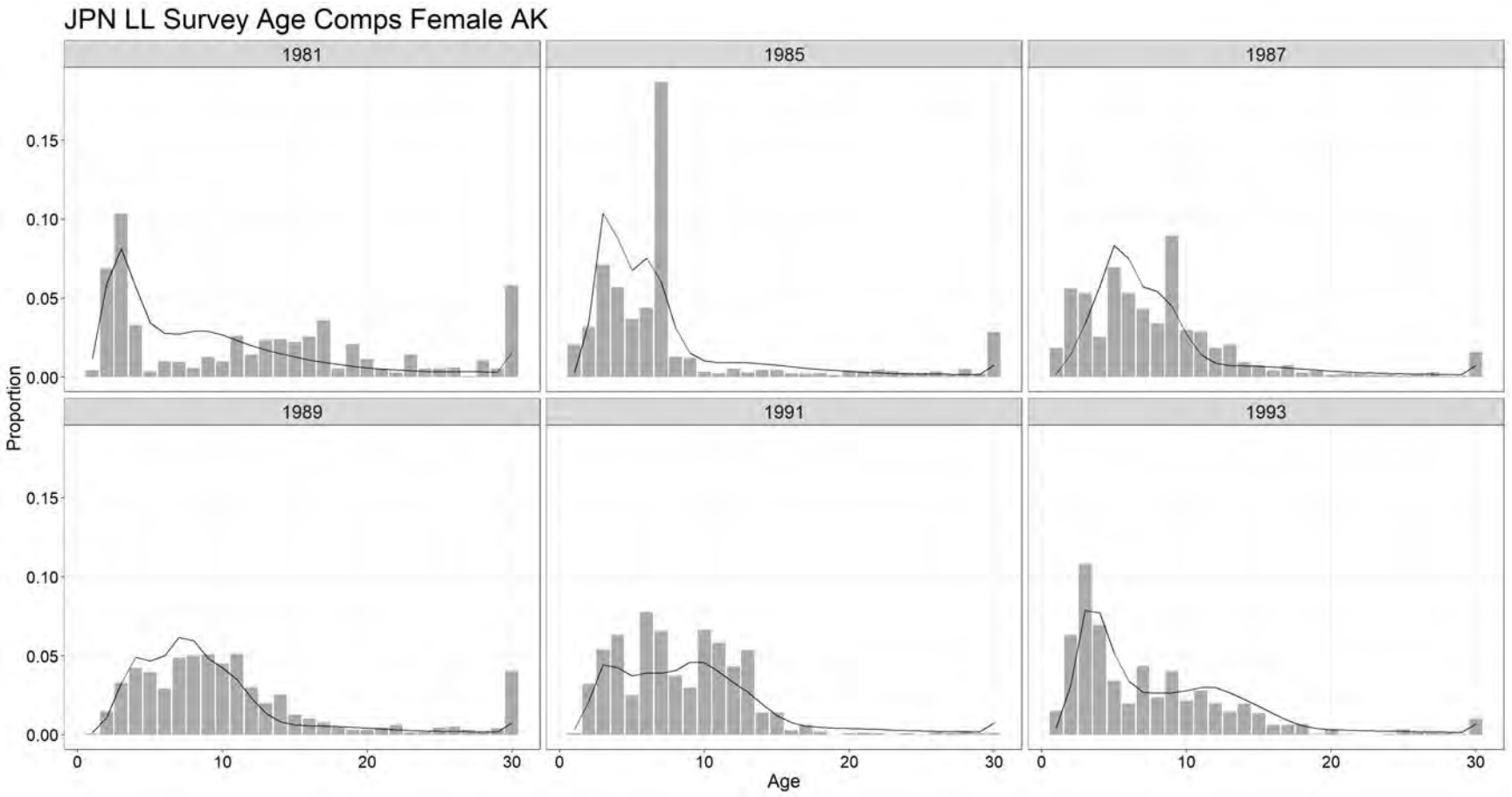


Figure 3.47. Fits to Japanese Longline Survey age composition data by year for females.

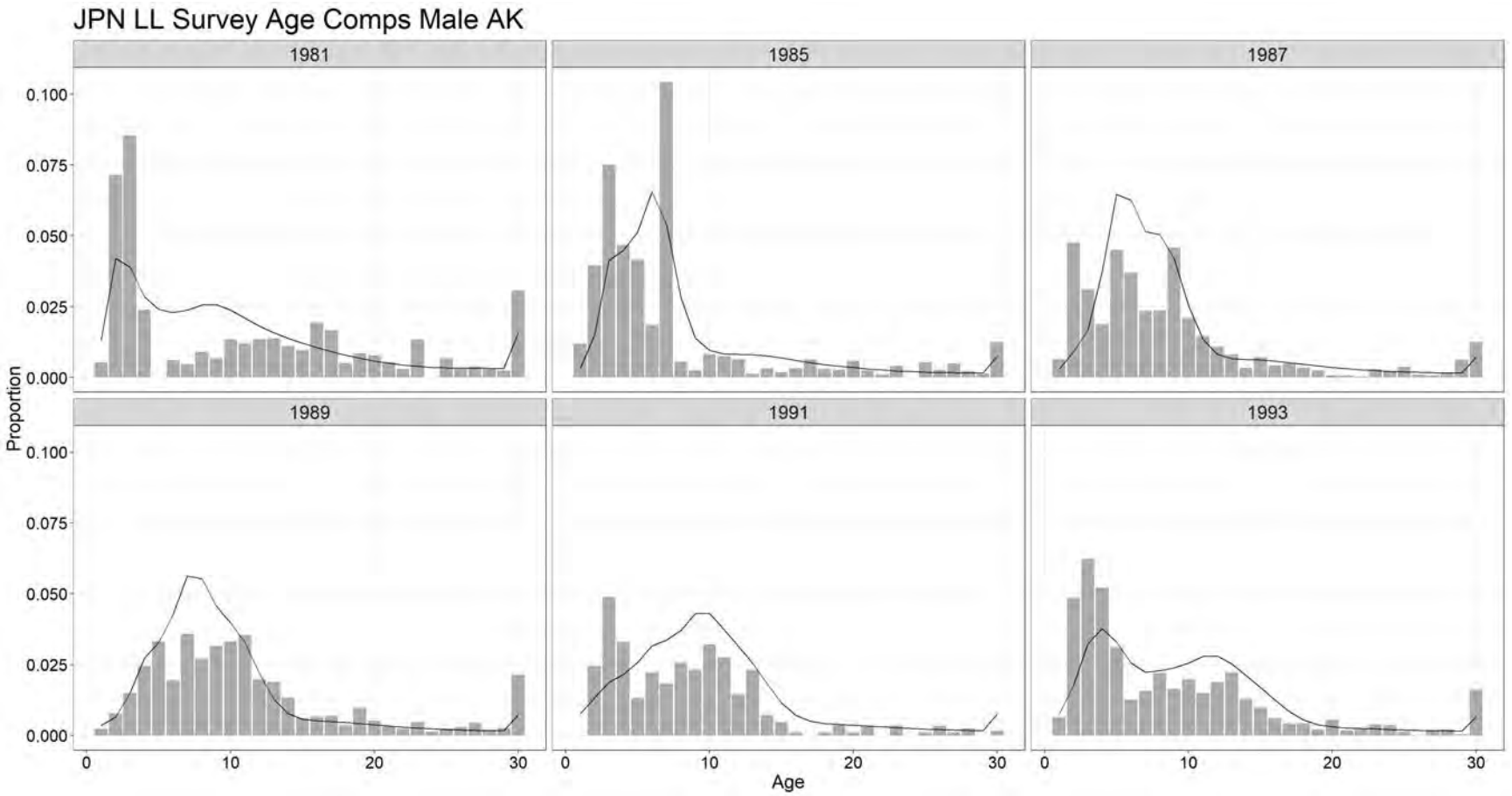


Figure 3.48. Fits to Japanese Longline Survey age composition data by year for males.

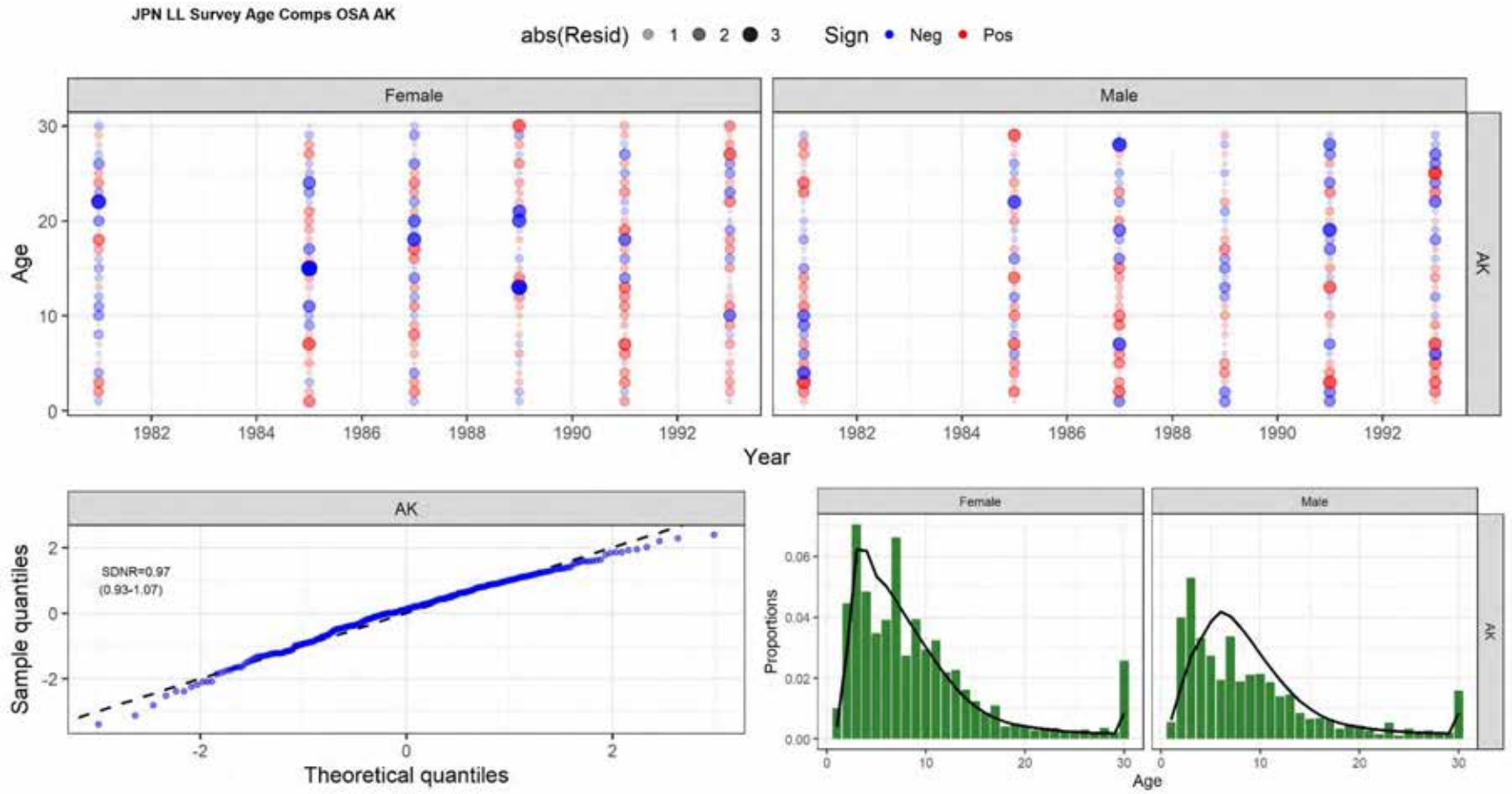


Figure 3.49. Fits to Japanese Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

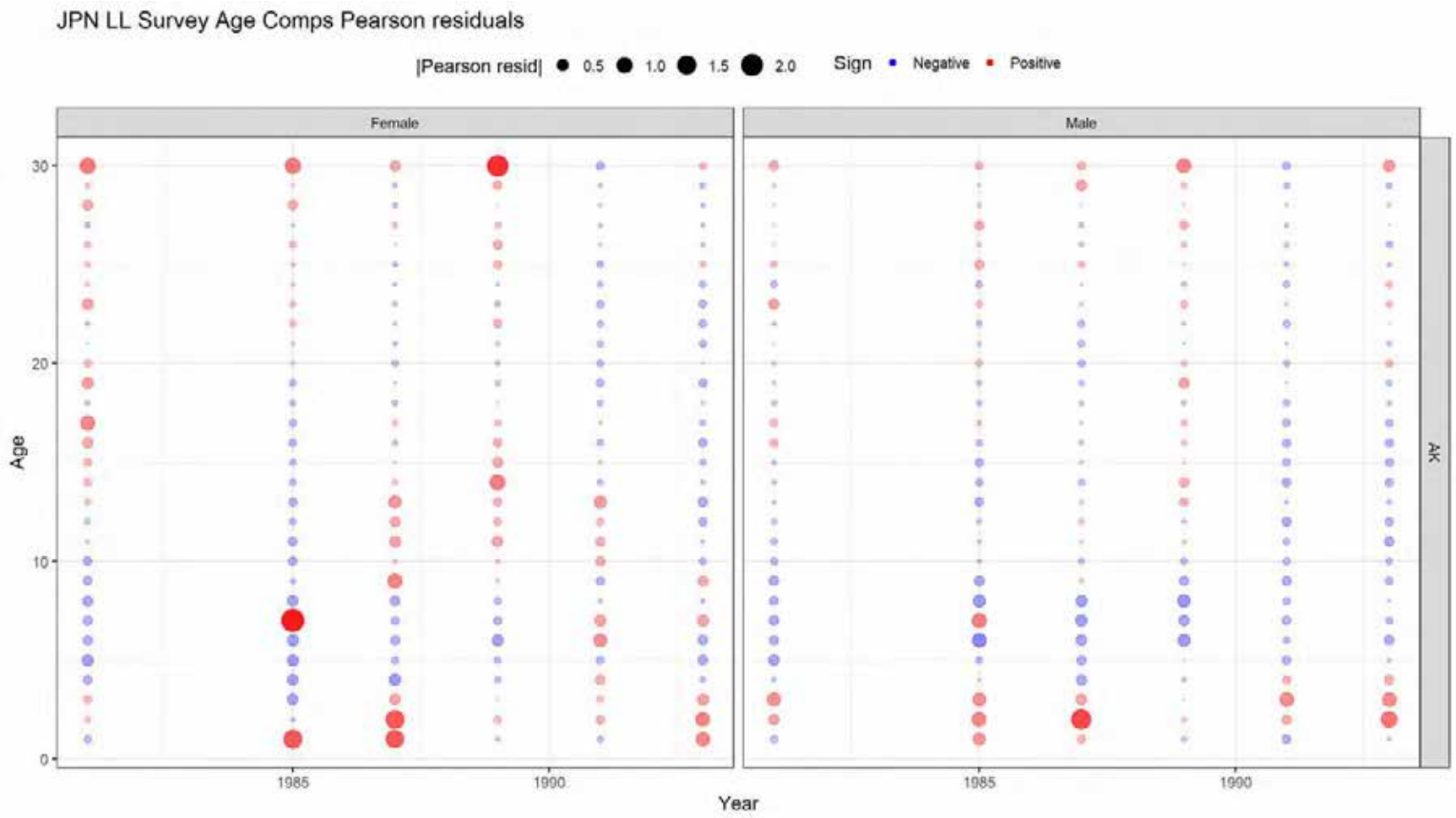


Figure 3.50. Fits to the Japanese Longline Survey age composition data based on Pearson residuals.

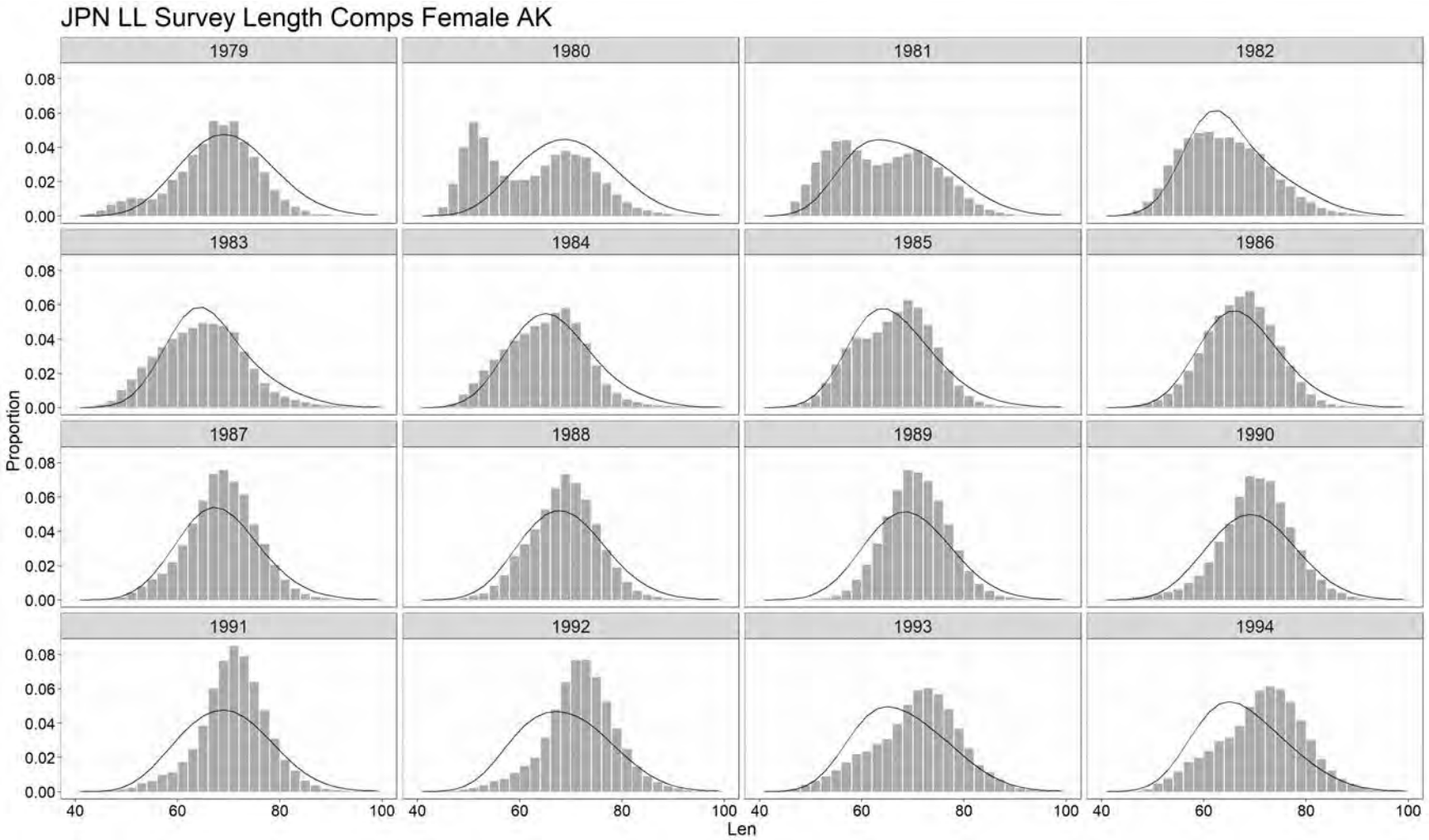


Figure 3.51. Fits to Japanese Longline Survey length composition data by year for females.

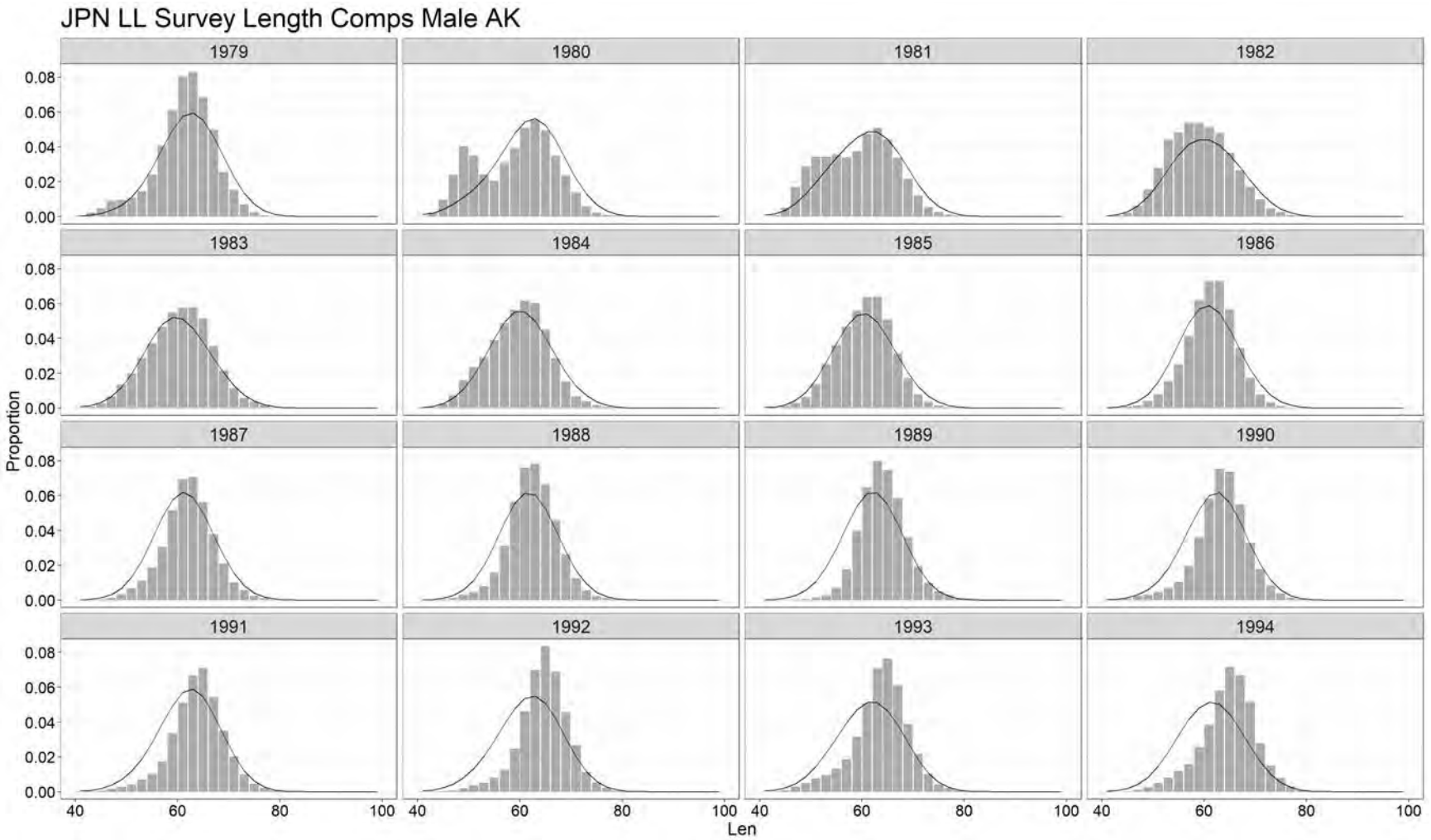


Figure 3.52. Fits to Japanese Longline Survey length composition data by year for males.

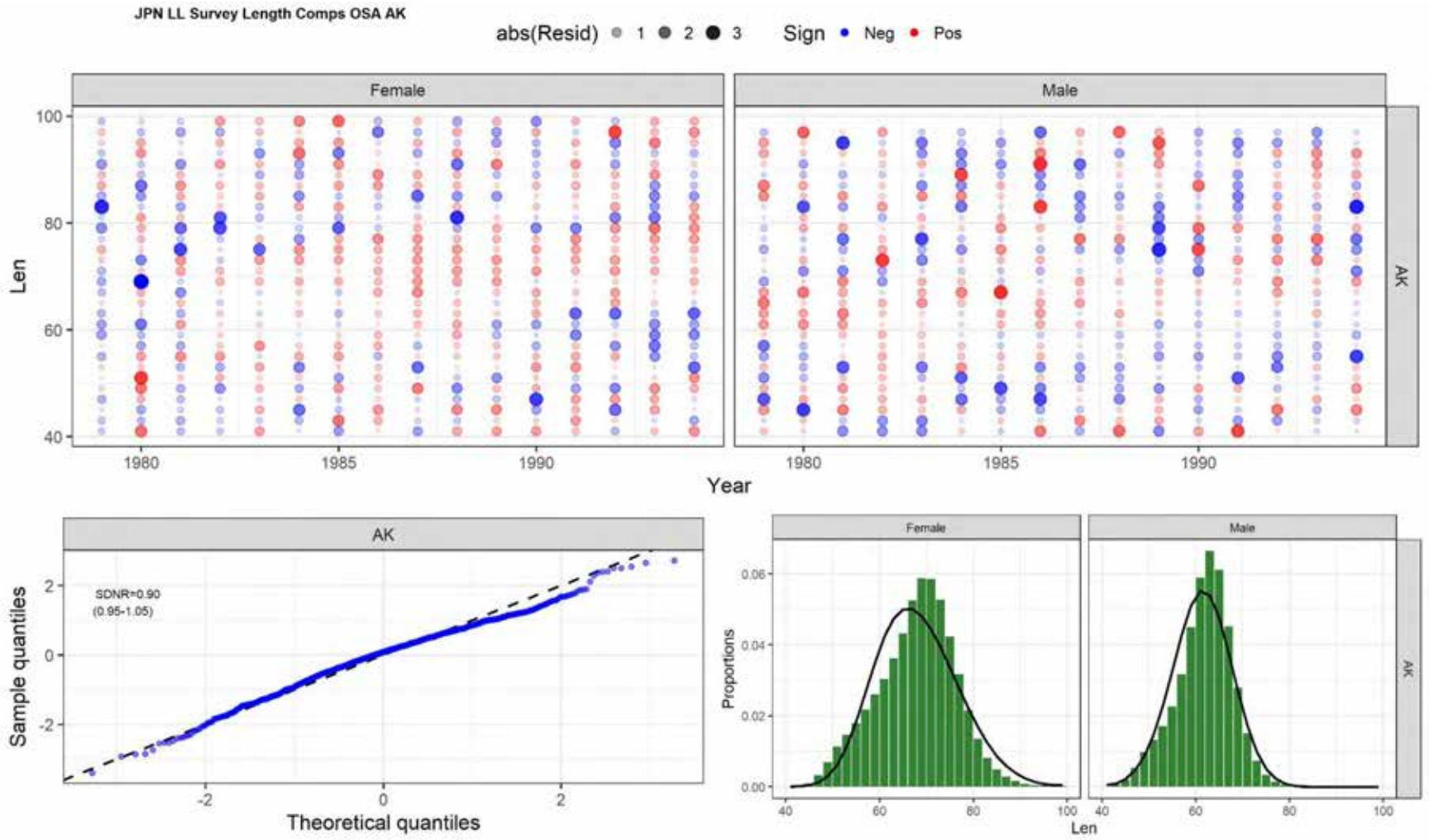


Figure 3.53. Fits to Japanese Longline Survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

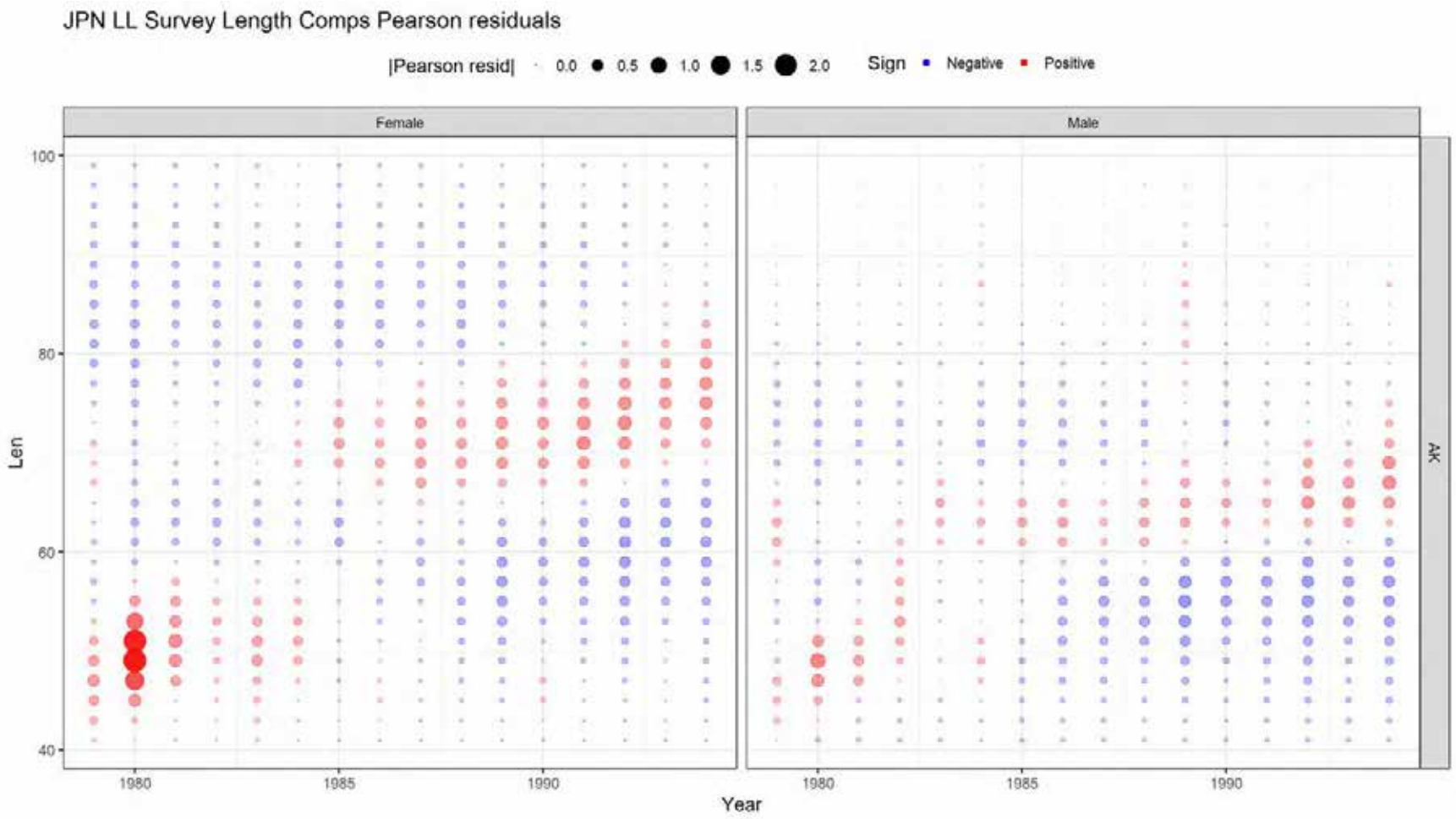


Figure 3.54. Fits to the Japanese Longline Survey length composition data based on Pearson residuals.

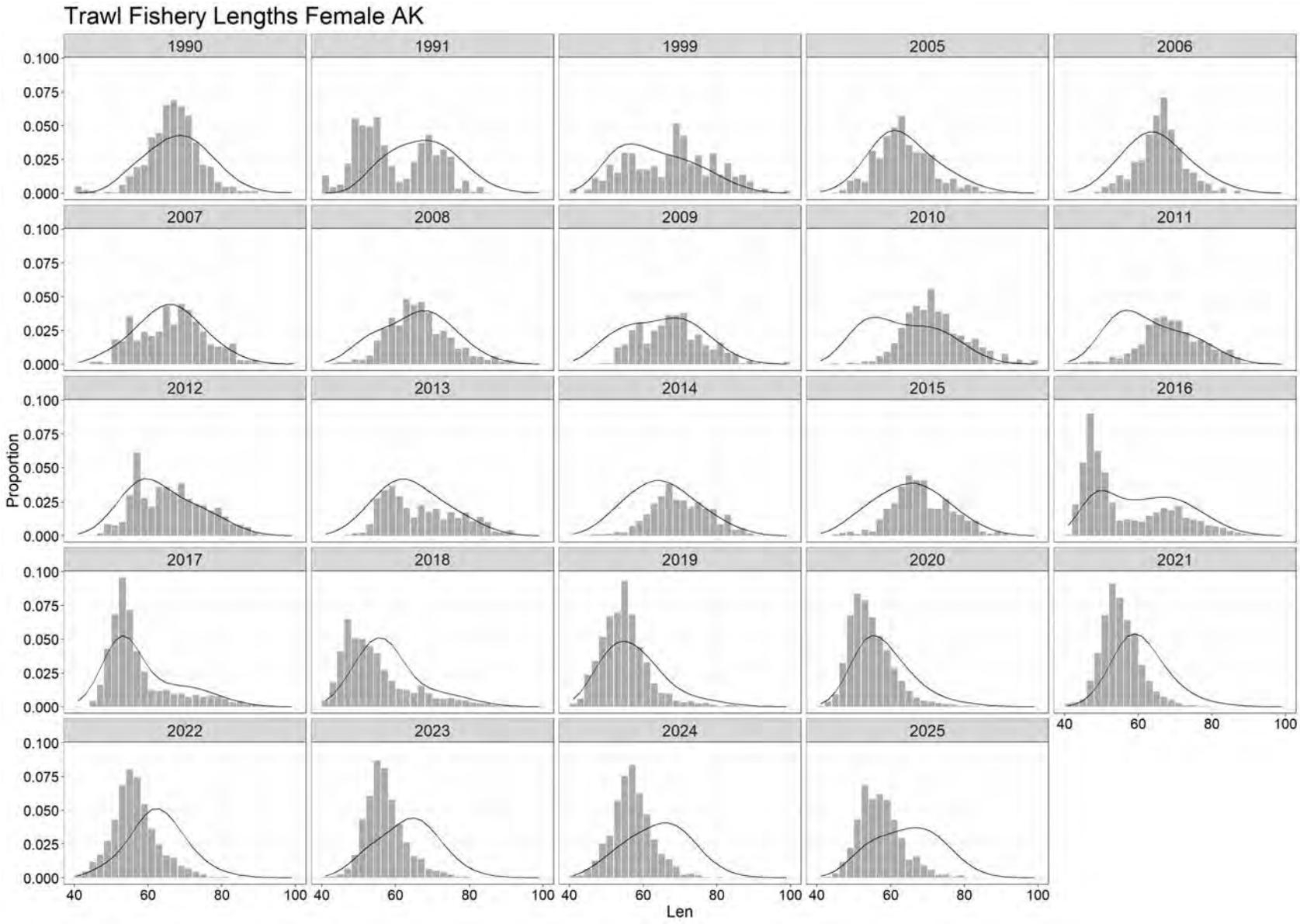


Figure 3.55. Fits to the trawl fishery length composition data by year for females.

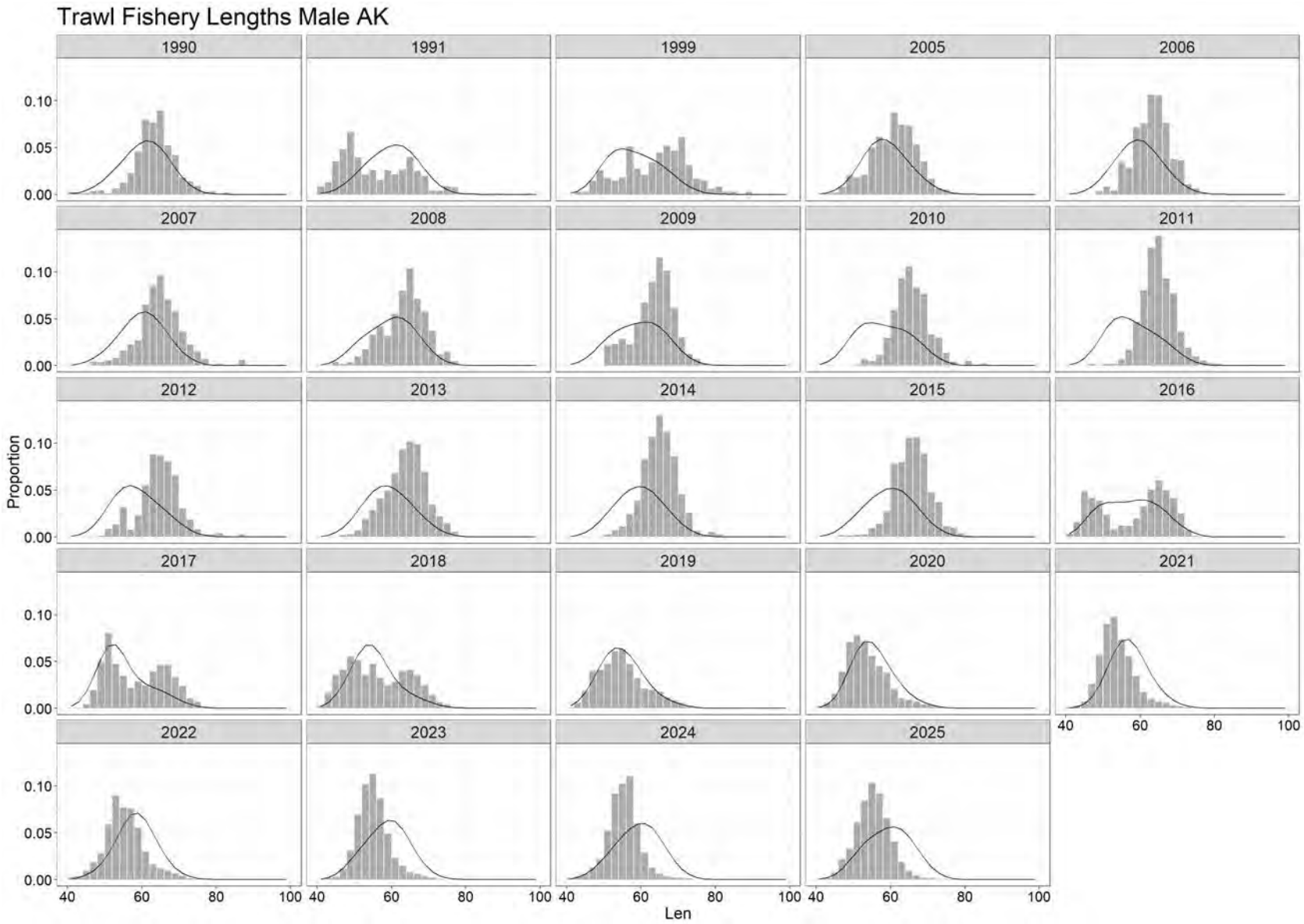


Figure 3.56. Fits to the trawl fishery length composition data by year for males.

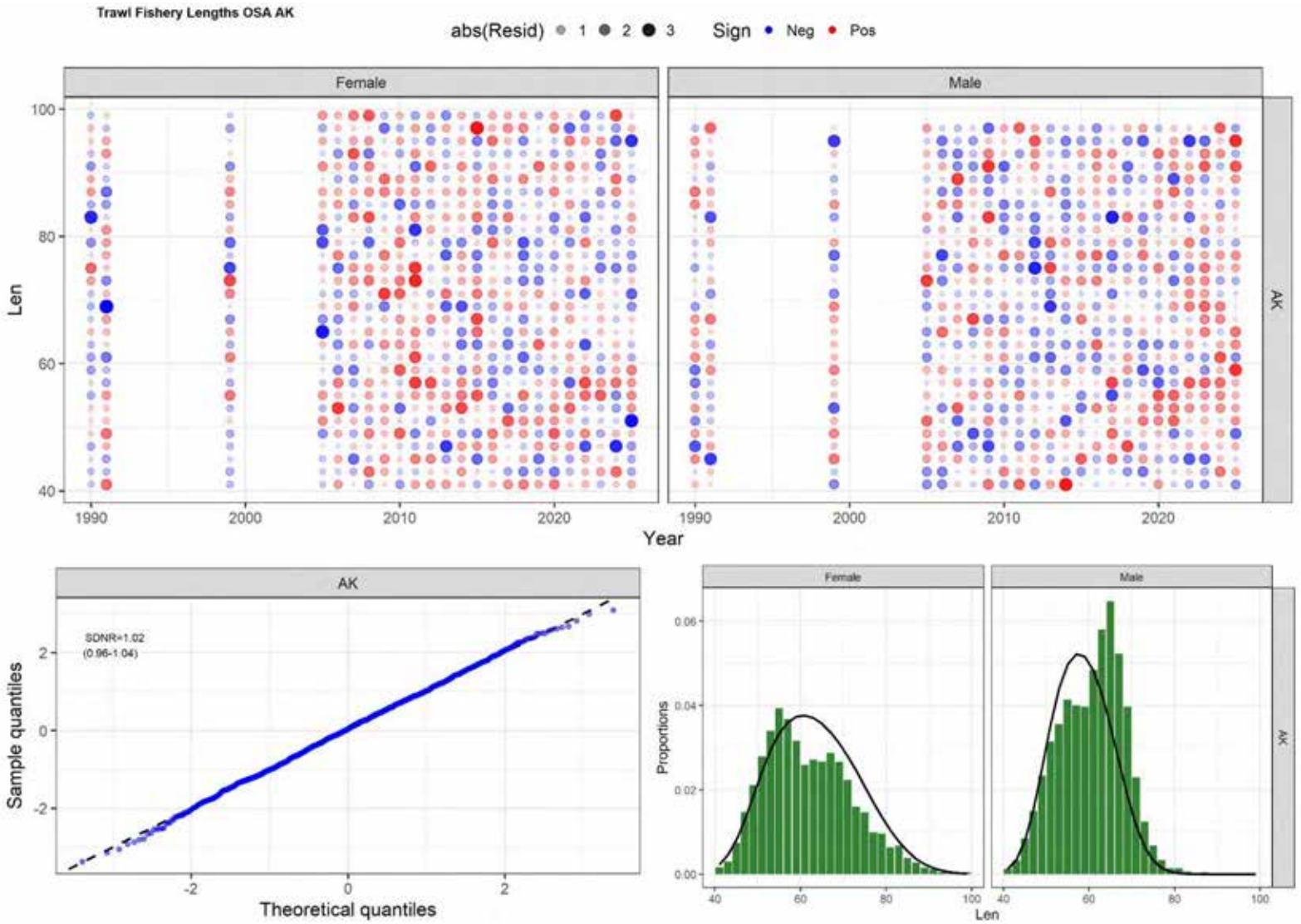


Figure 3.57. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions).

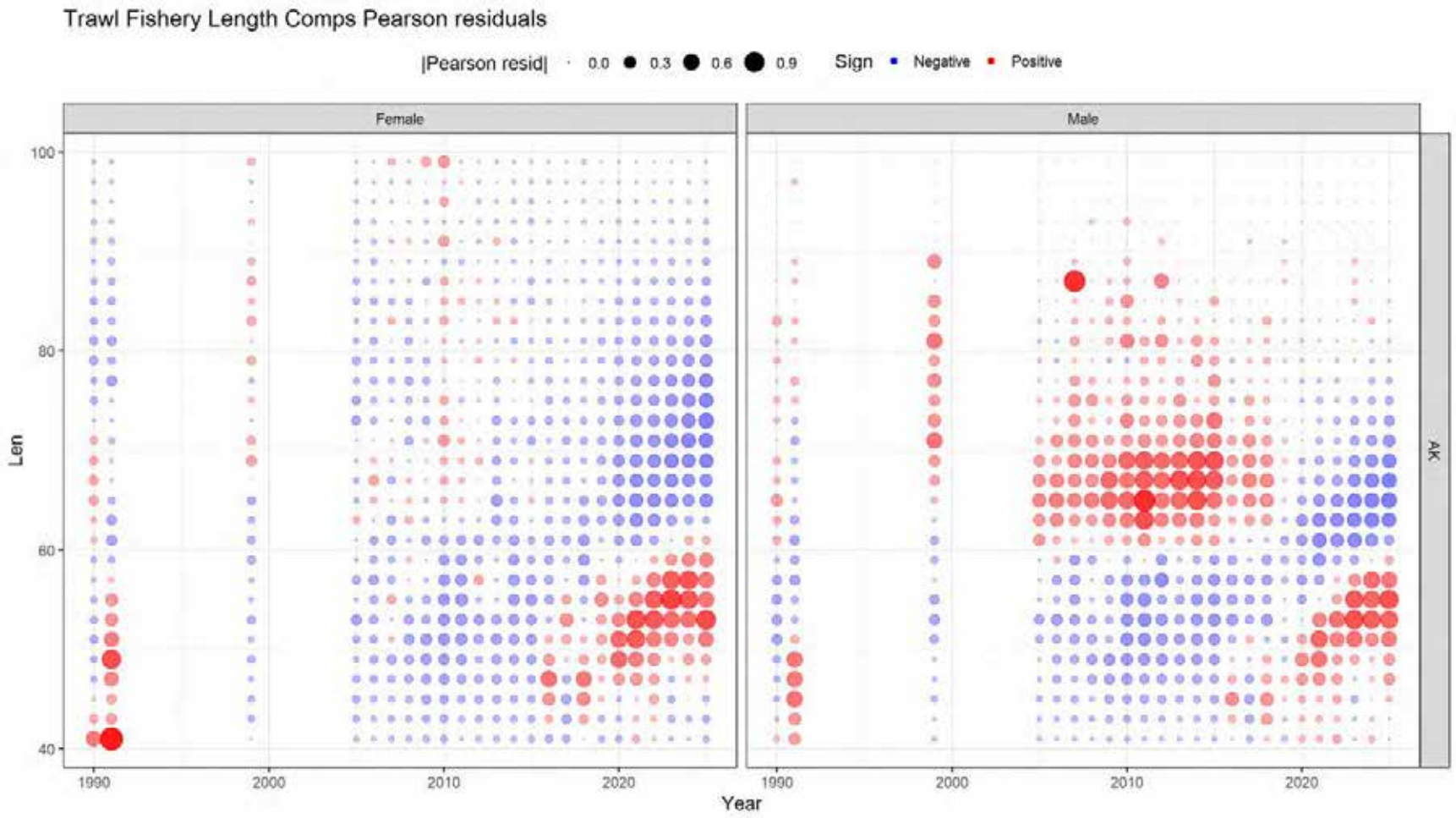


Figure 3.58. Fits to the trawl fishery length composition data based on Pearson residuals.

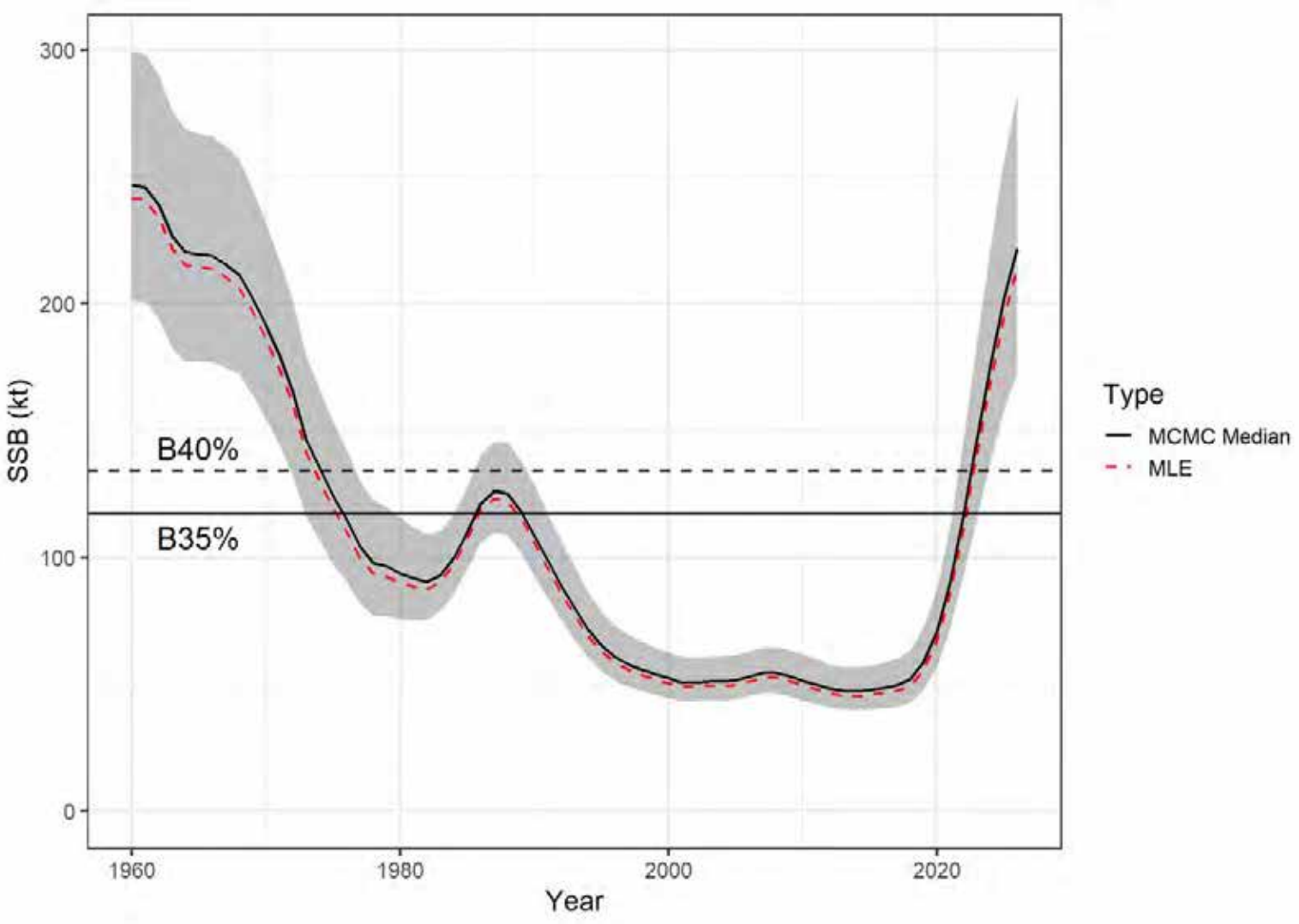


Figure 3.59. Estimated sablefish MCMC median (black line) and MLE mean (red line) spawning biomass (kt) with 95% MCMC credible intervals (grey fill). The associated biological reference points are illustrated by the horizontal lines, including $B_{35\%}$ (solid line) and $B_{40\%}$ (dashed line).

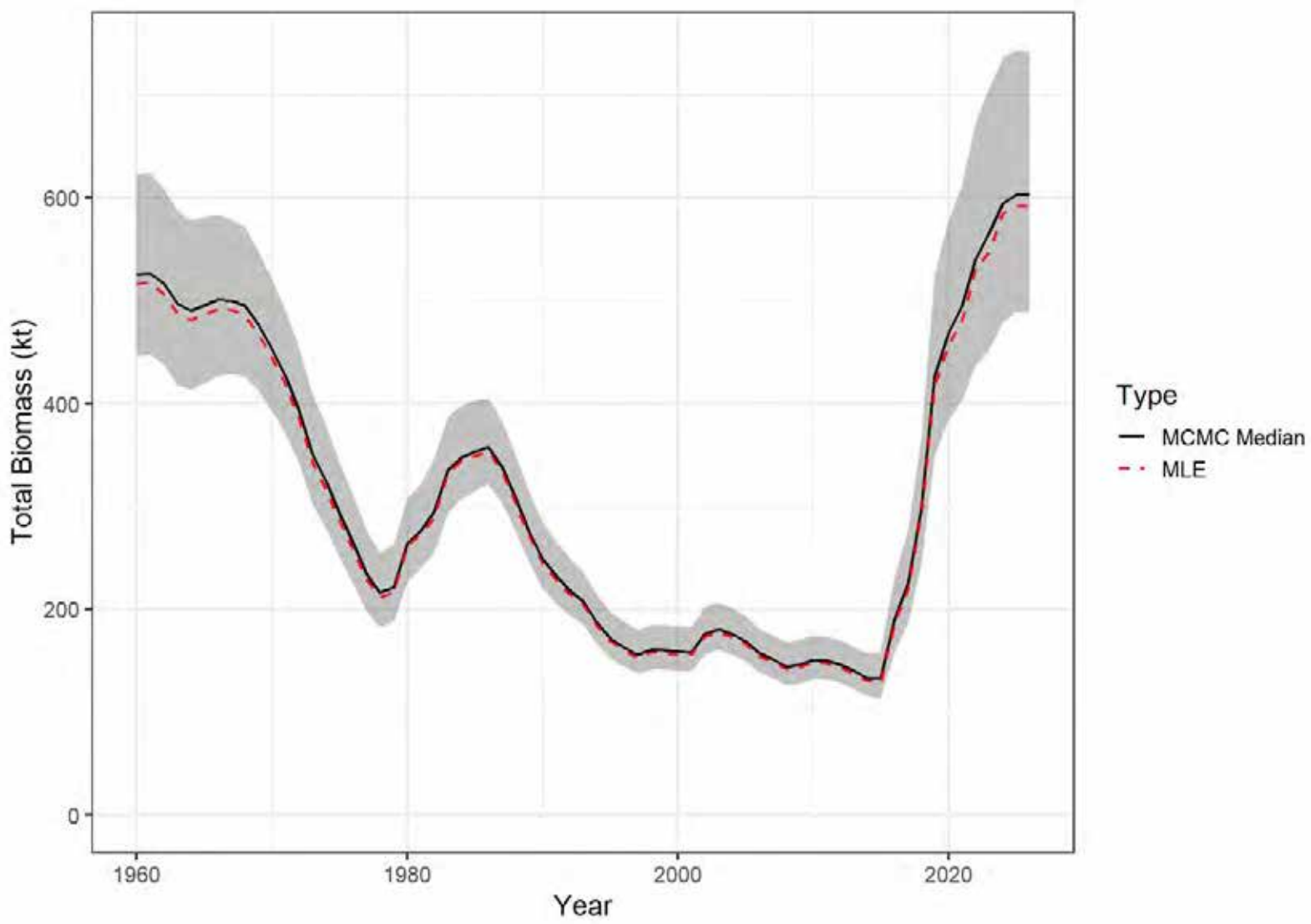


Figure 3.60. Estimated sablefish MCMC median (black line) and MLE mean (red line) total age-2+ biomass (kt) with 95% MCMC credible intervals (grey fill).

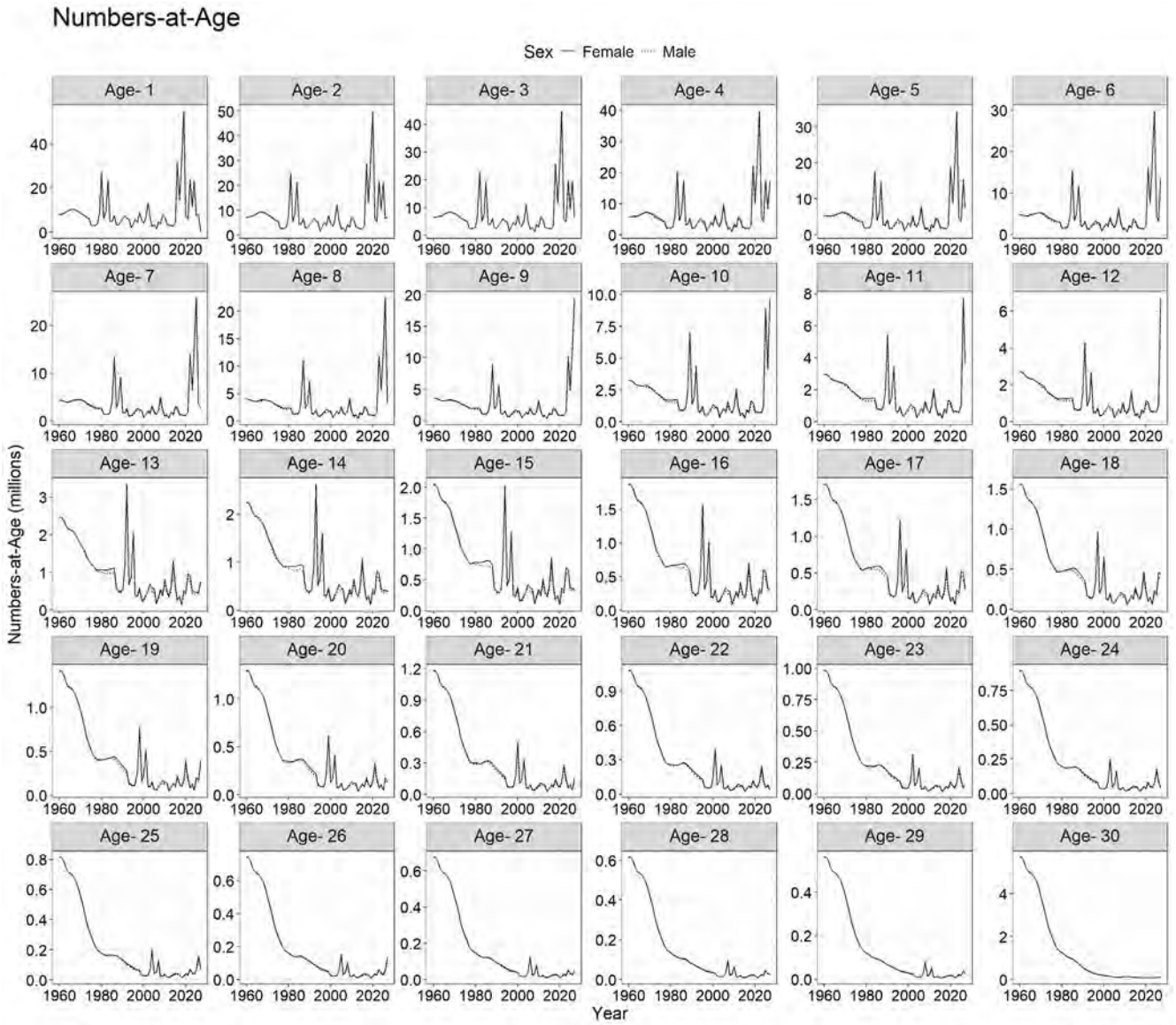


Figure 3.61. Estimated population numbers (millions of fish) by sex (line type), age (facet; true ages are model ages shown here + 1), and year (x-axis). Females are solid lines and males are dashed lines.

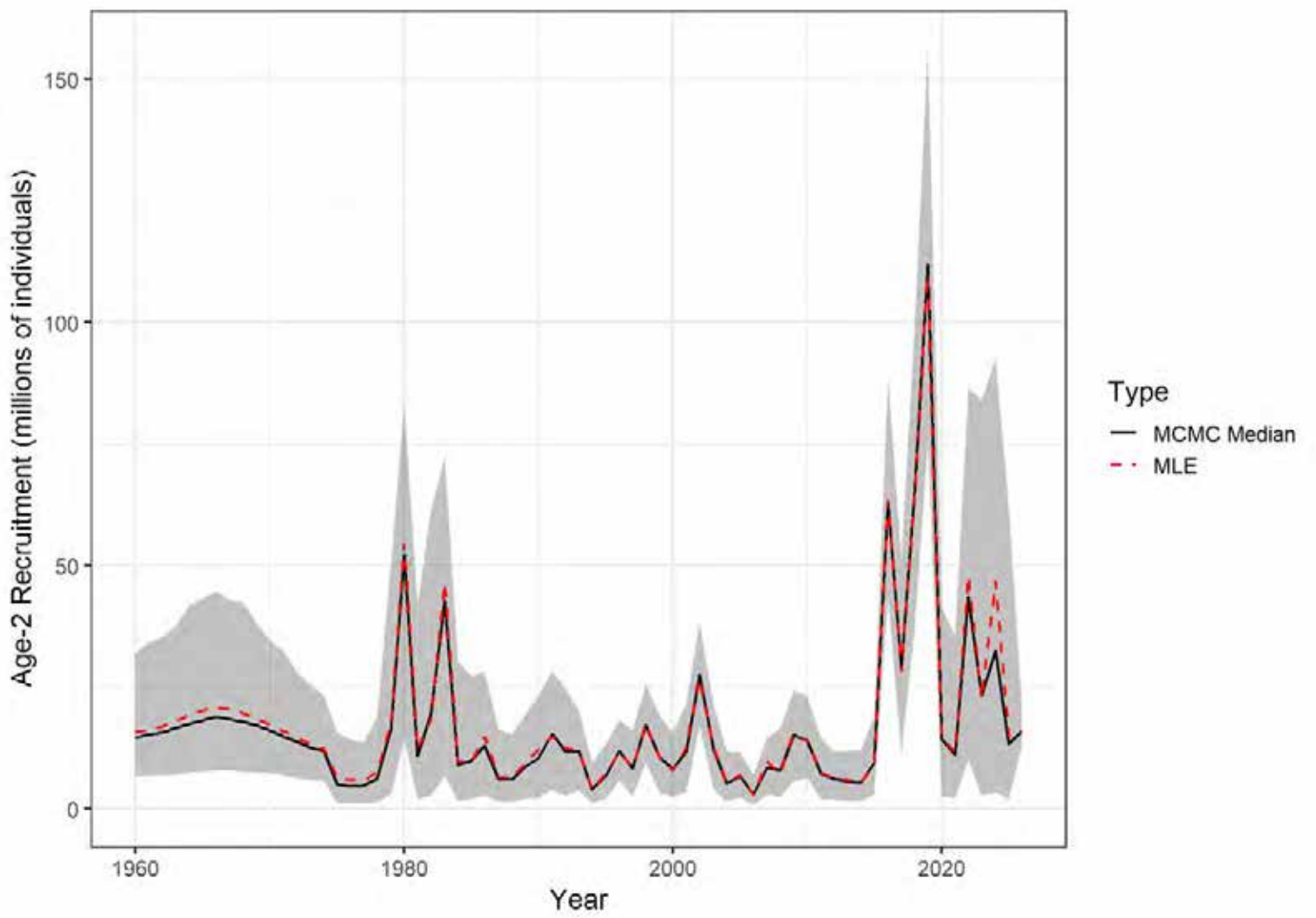


Figure 3.62. Estimated MCMC median (black line) and MLE mean (red dashed line) recruitment of age-2 sablefish (millions of fish) with MCMC 95% credible intervals (grey fill) by recruitment year. The estimate for the 2026 recruitment is fixed at the mean recruitment with no deviation parameter estimated.

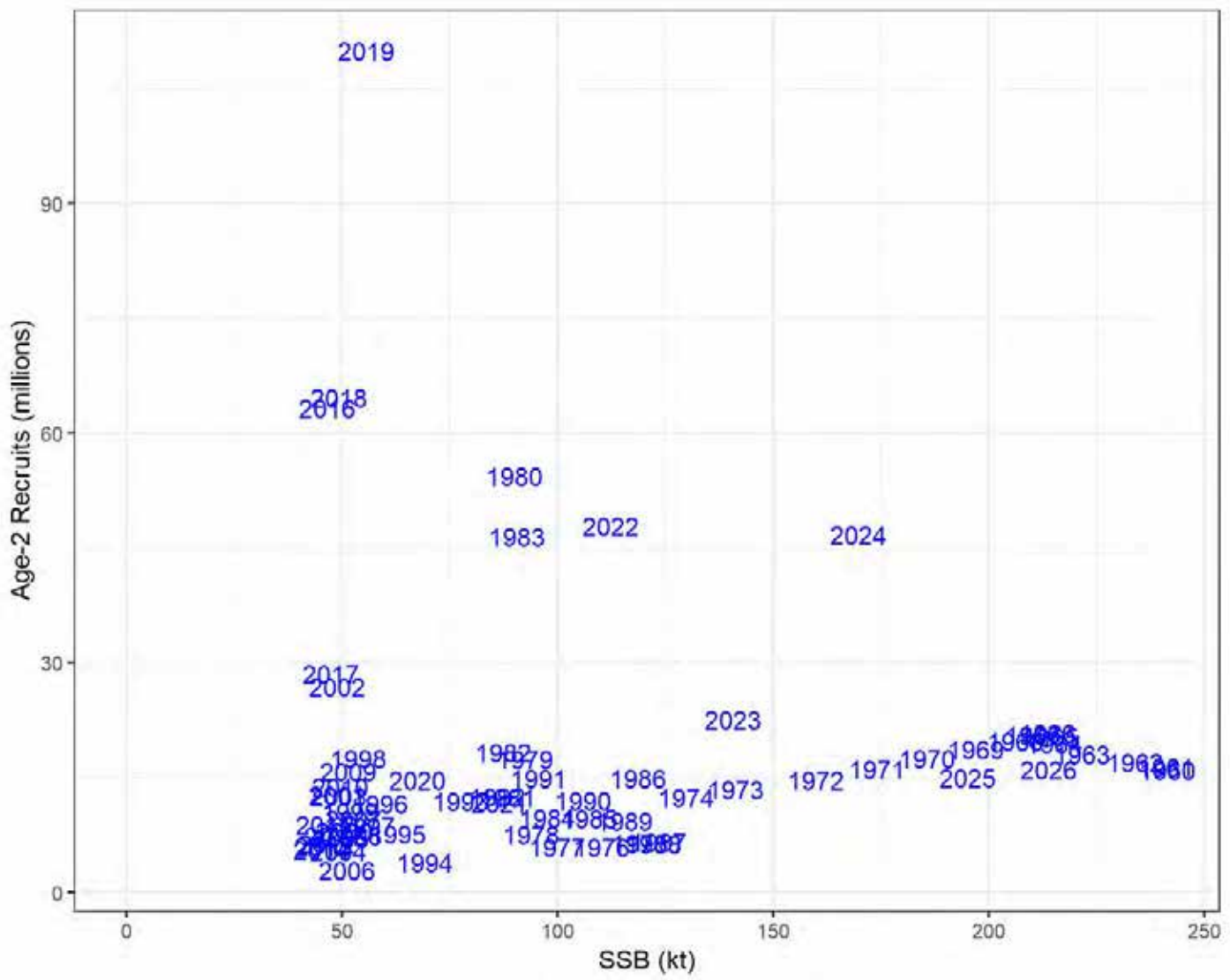


Figure 3.63. Age-2 recruits (millions of fish) and corresponding spawning stock biomass (kilotons) that produced the given recruitment event (i.e., lagged by two years from year of birth; identified by plotted year text).

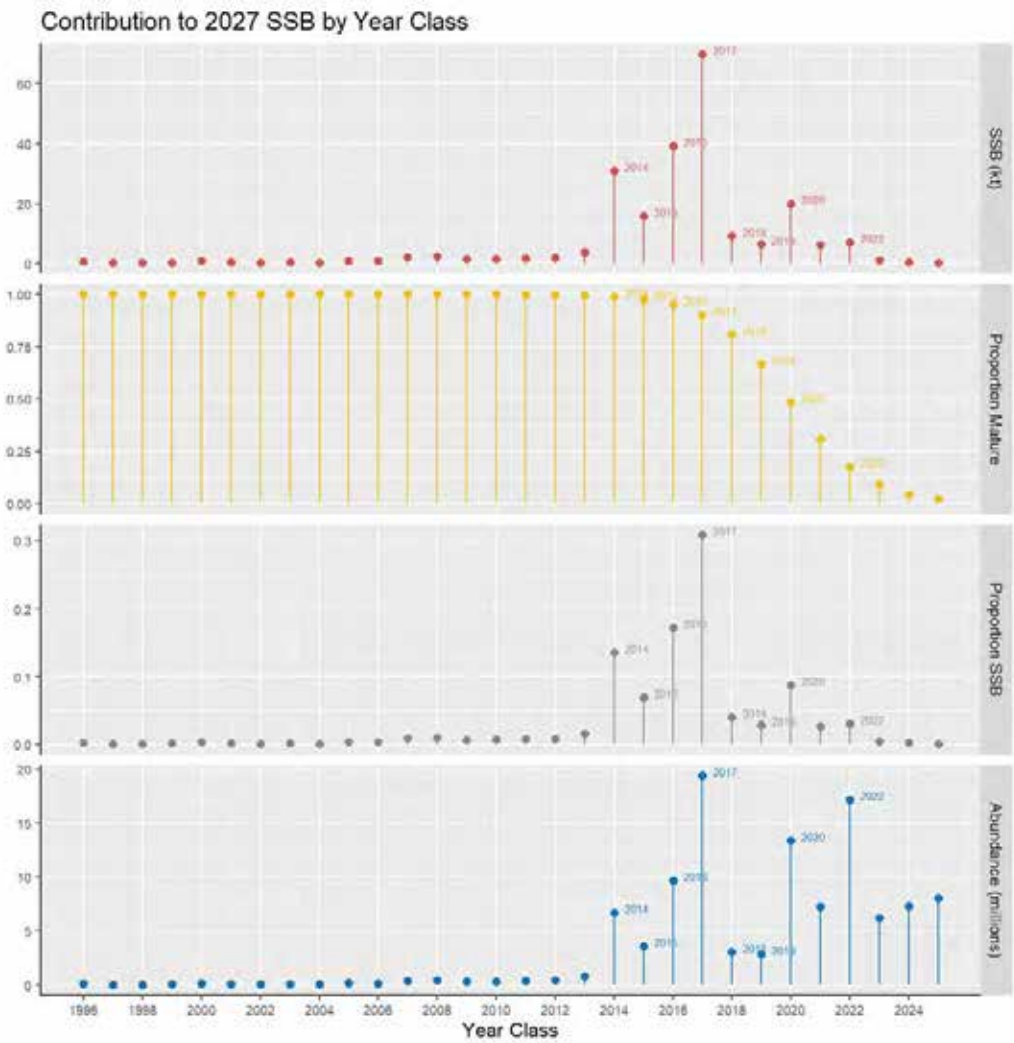


Figure 3.64. For each of the last 30 cohorts, the contribution to projected 2027 spawning stock biomass (kilotons; top row), proportion mature (2nd row), proportional contribution to 2027 spawning stock biomass (3rd row), and projected 2027 female (assuming a 50:50 sex ratio) abundance (millions of fish; 4th row). Note that the 1996 year class represents all contributions from all earlier year classes (i.e., fish in the plus group age). Abundance of the 2024 and 2025 year classes are based on mean recruitment, because these year classes have not yet been estimated in the 2026 assessment model.

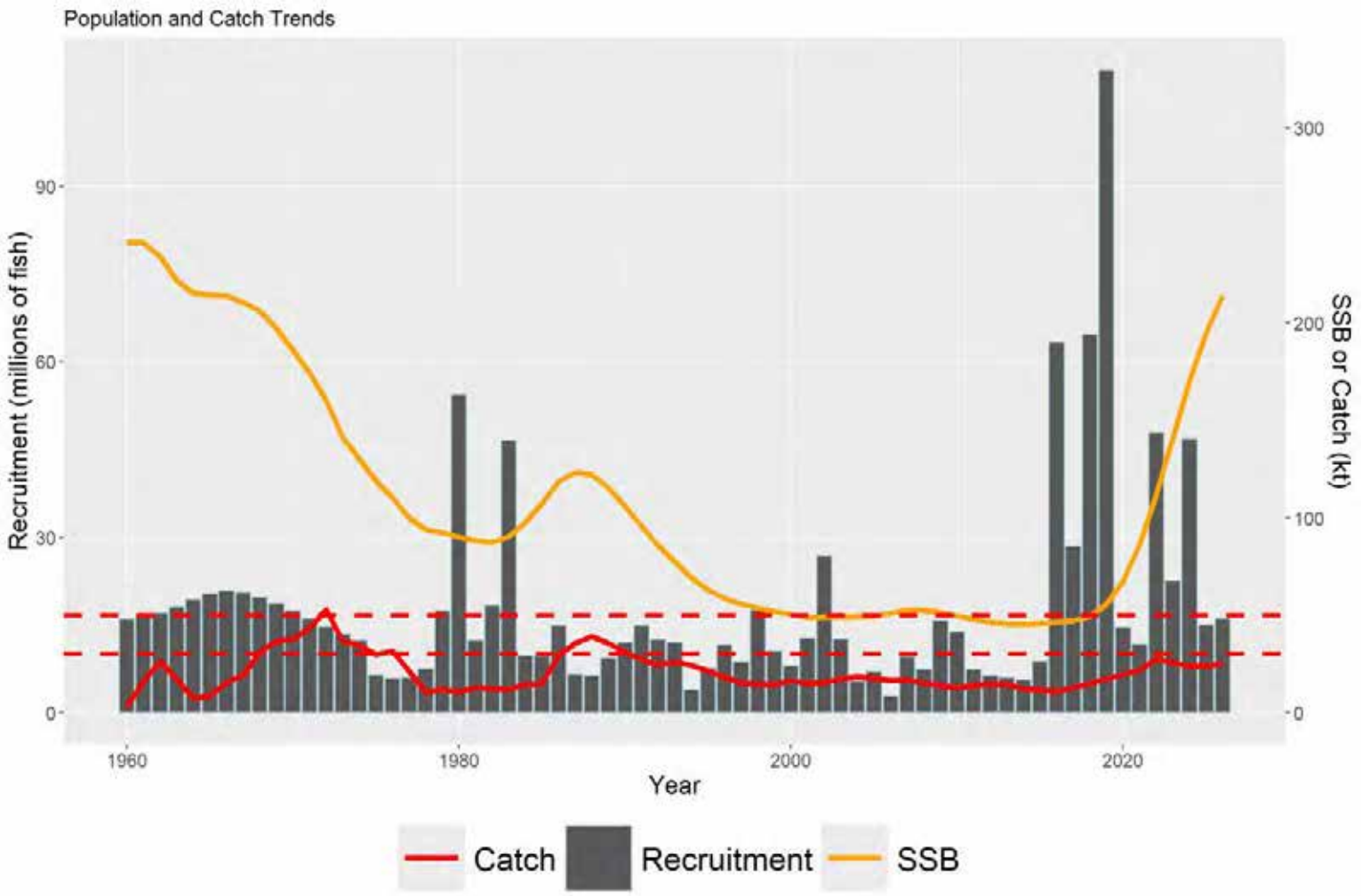


Figure 3.65. Time series of sablefish spawning stock biomass (kt, orange line), catch (kt, red line), and recruitment (millions of fish; grey bars). Catch levels between 30 kt and 50 kt are demarcated by the horizontal dashed red lines. Note the cyclical dynamics associated with spasmodic recruitment. Transitory increases in SSB subsequent to periods of strong recruitment are often followed by a persistent downward time series trend. Catches often rapidly increase following high recruitment periods, while recruitment reverts back towards average levels. Catch levels exceeding 30 kt are often associated with subsequent rapid declines in spawning biomass, but spawning biomass declines are also linked with recruitment reverting back to more average levels.

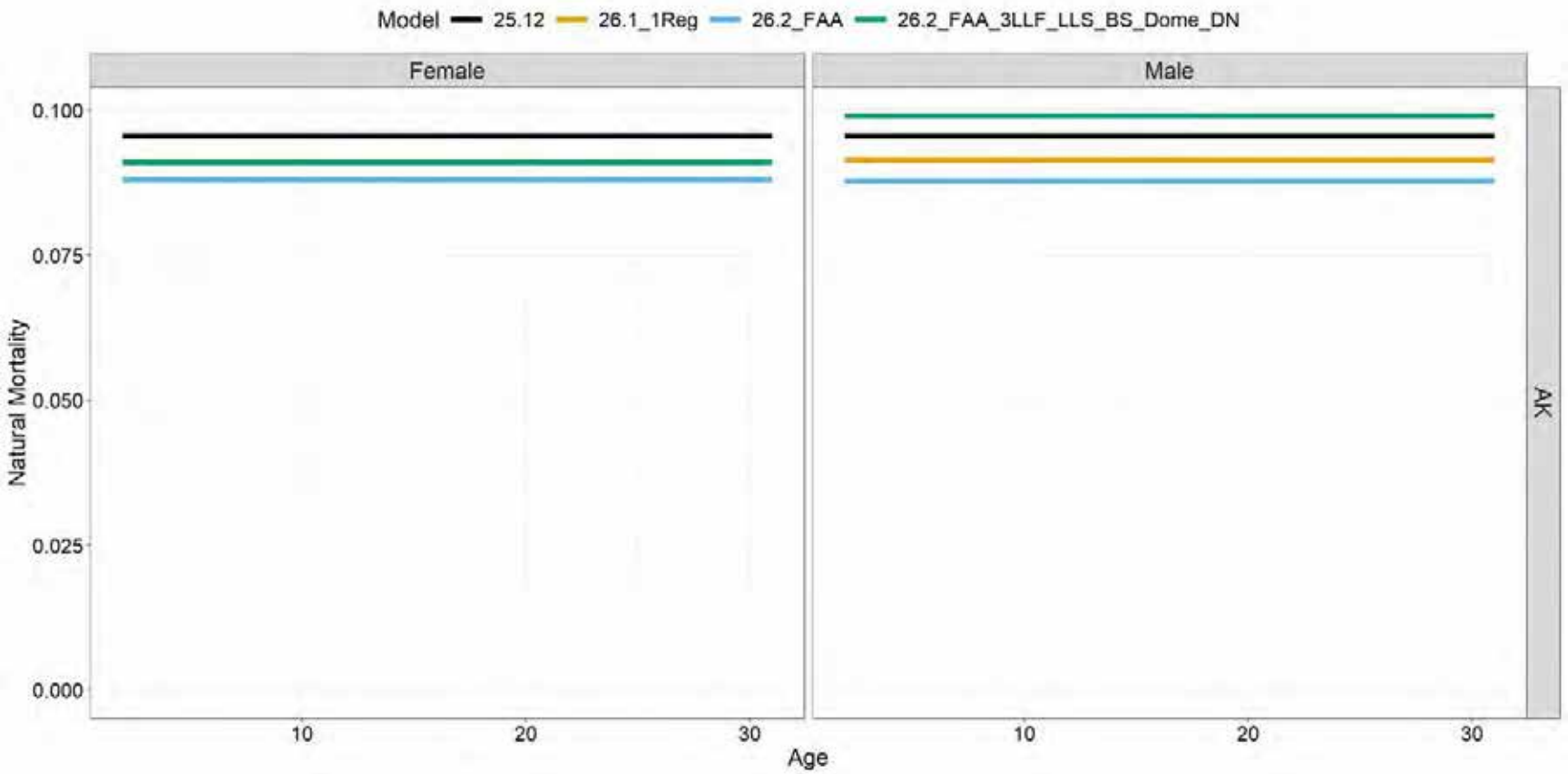


Figure 3.66. Natural mortality estimates by sex for each of the models (colored lines). Author recommended Model *26.2_FAA* is represented by the light blue line.

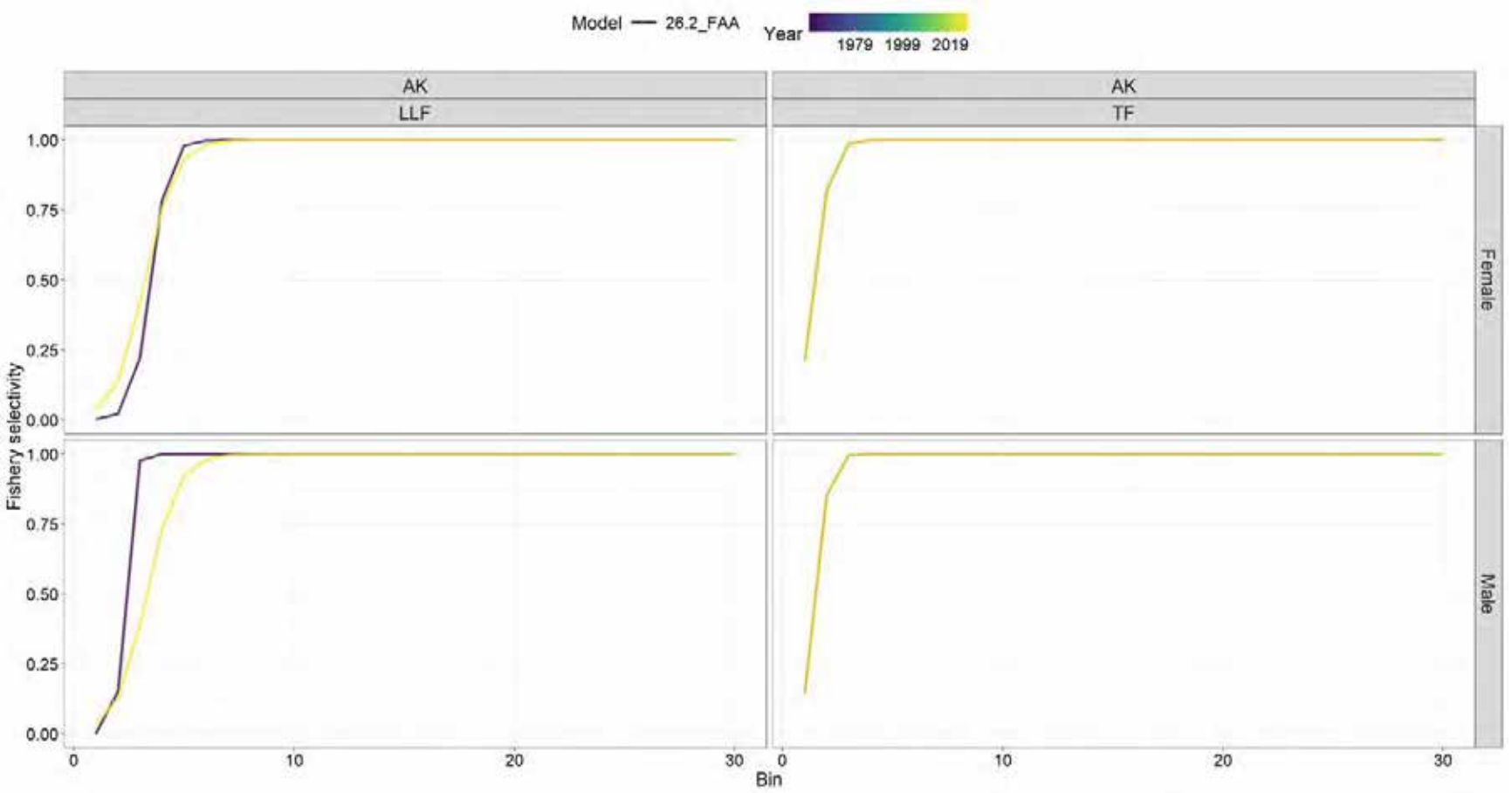


Figure 3.67. Fishery selectivity estimates by fleet and sex where colors represent the different time blocks (purple is the pre-2016 time block and yellow is the post-2016 time block). LLF is the fixed gear fishery and TF is the trawl fishery, which has only a single time block.

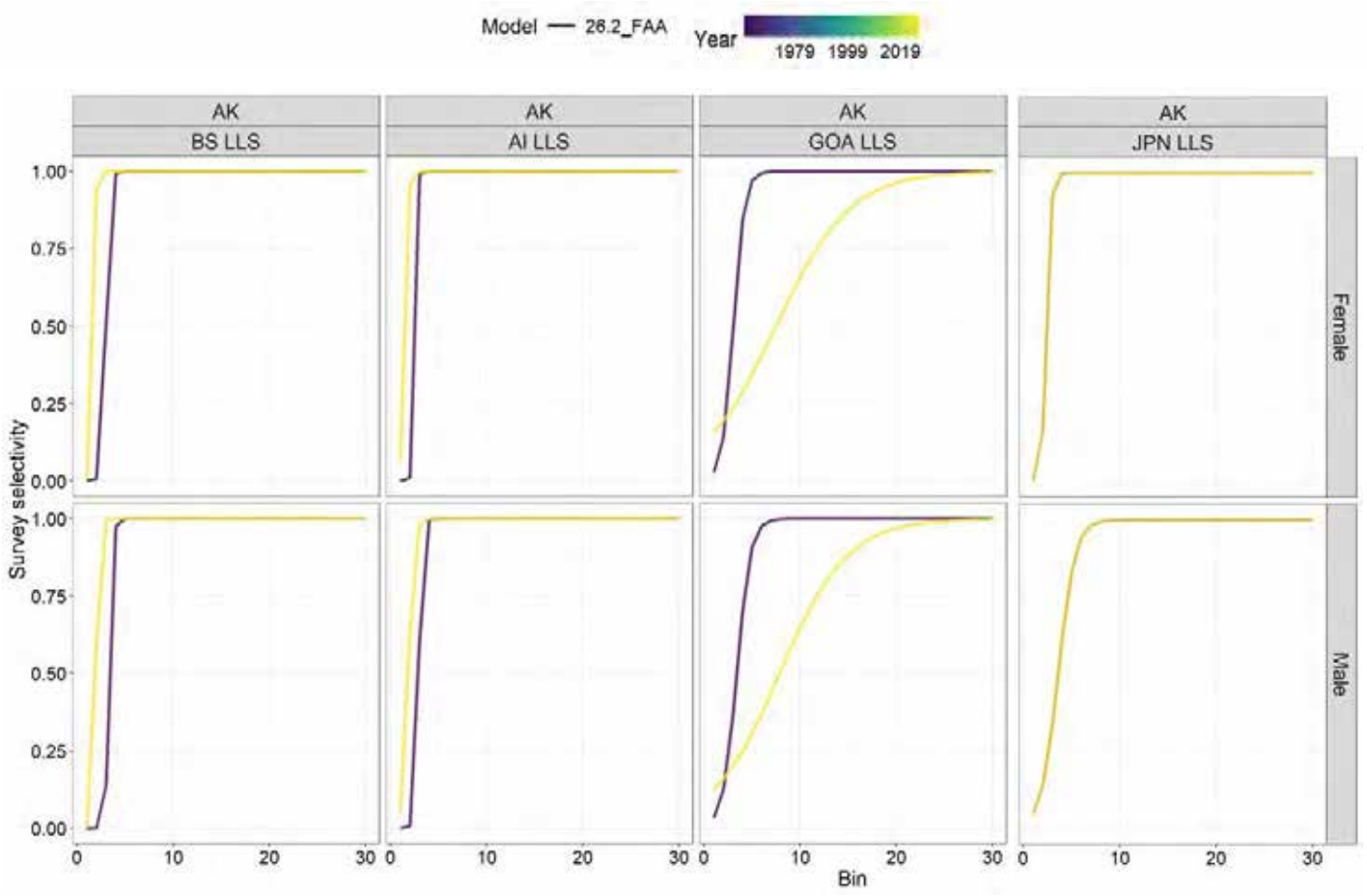


Figure 3.68. Survey selectivity estimates by sex and fleet where colors represent the different time blocks (purple is the pre-2016 time block and yellow is the post-2016 time block). The Japanese Longline Survey (JPN LLS) only has a single time block.

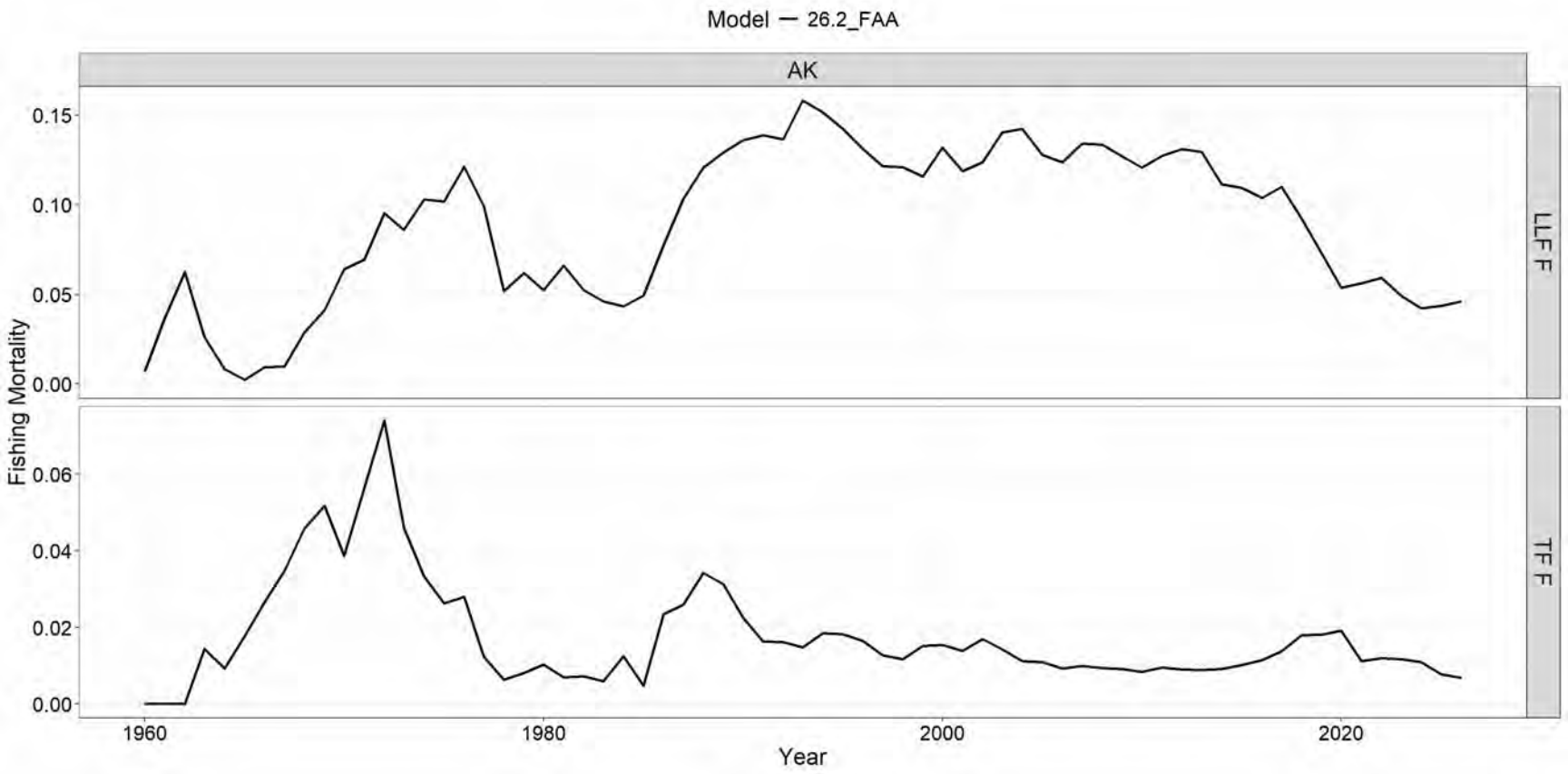


Figure 3.69. Time series estimates of fishing mortality (yr^{-1}) by fleet, where LLF is the fixed gear fishery and TF is the trawl fishery.

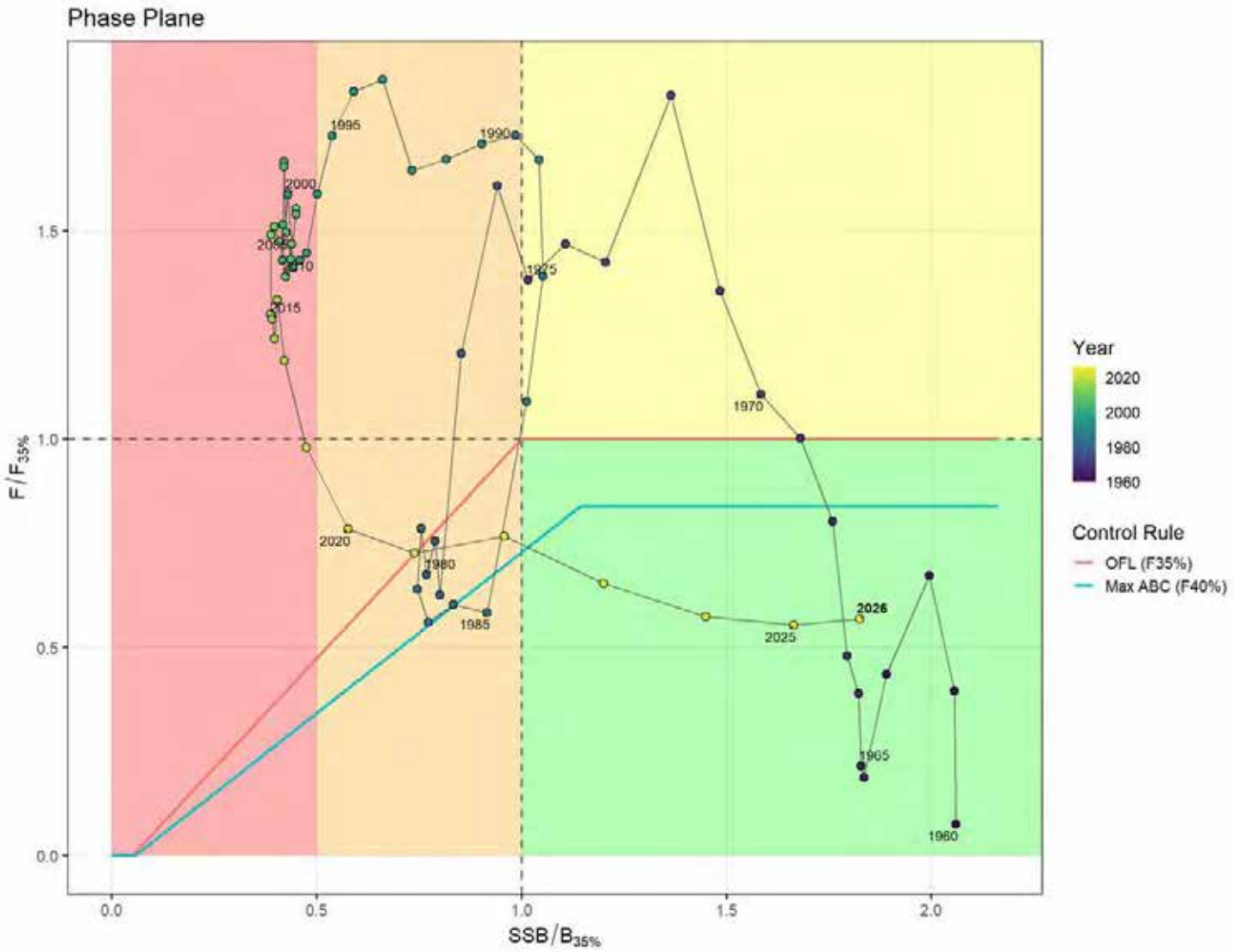


Figure 3.70. Phase-plane diagram illustrating the time series of sablefish estimated spawning biomass relative to the level at $B_{35\%}$ and fishing mortality relative to $F_{35\%}$ (equal to F_{OFL}). F_{ABC} for the max ABC is equivalent to $F_{40\%}$ and the associated threshold HCR is demonstrated by the blue line. The red line represents a threshold HCR associated with fishing at F_{OFL}. Note that status is based on static reference points from the 2026 model.

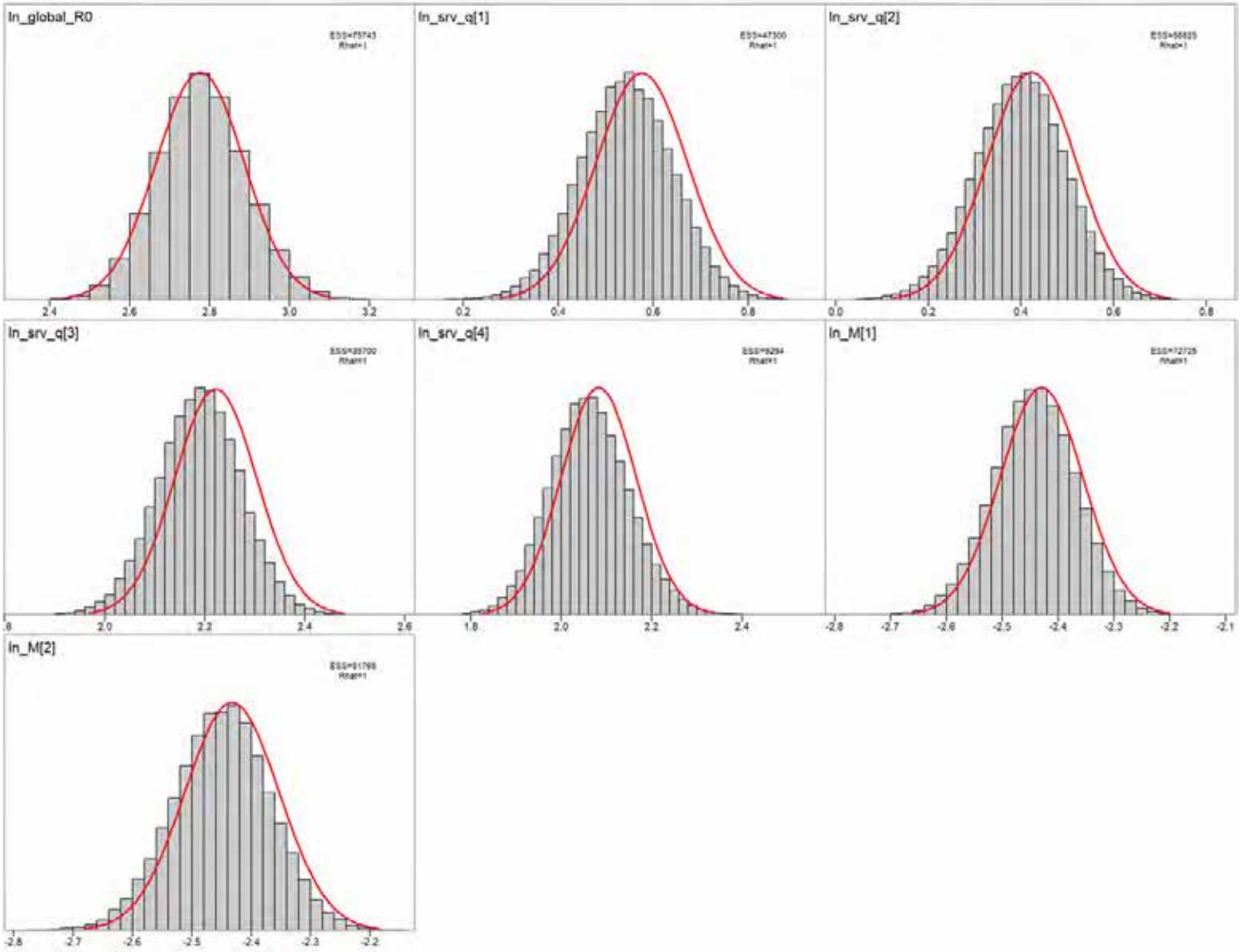


Figure 3.71. Key parameter marginal posterior histograms from MCMC and asymptotic normal distributions (red line) from the inverse Hessian (MLE). MCMC effective sample size (ESS) and R-hat estimates are printed in the top right corner.

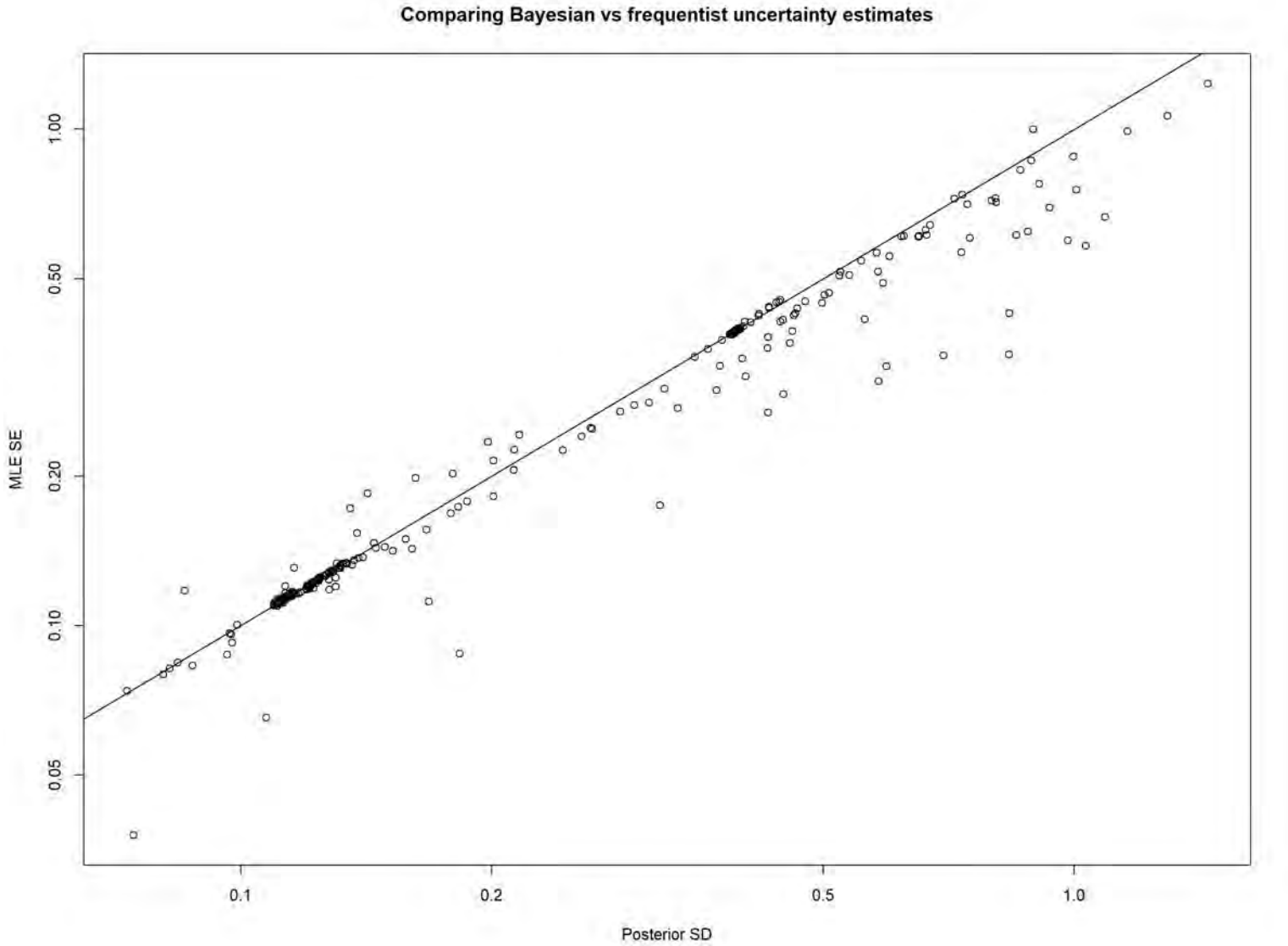


Figure 3.72. Comparison of posterior standard deviations from MCMC and standard errors from the inverse Hessian (MLE) for all estimated parameters in Model 26.2_FAA, where the solid line denotes the 1:1 line.

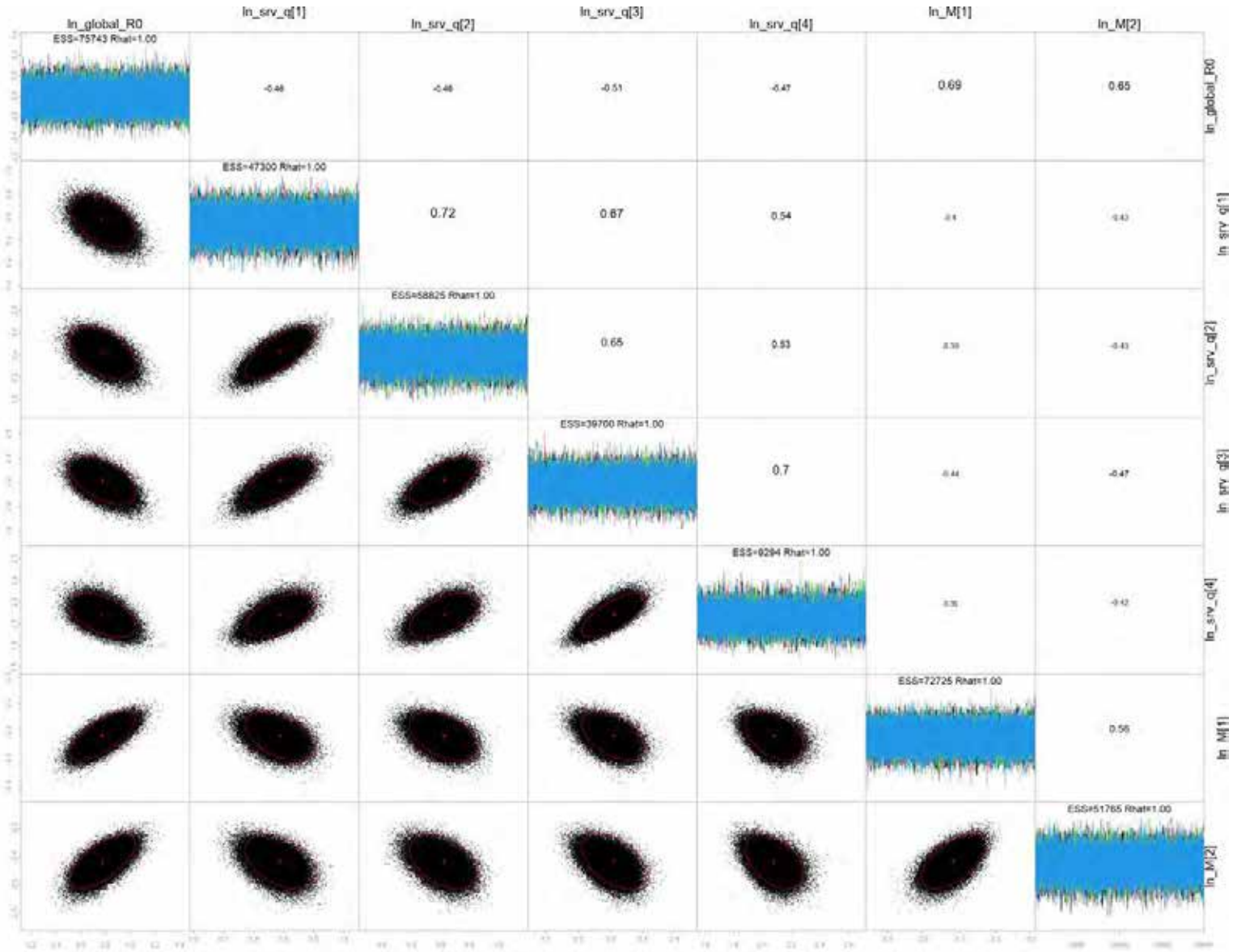


Figure 3.73. MCMC pairwise correlation plots among key model parameters for Model *26.2_FAA*, where trace plots with ESS and Rhat are shown along the diagonal and parameter correlations are shown in the upper right quadrant.

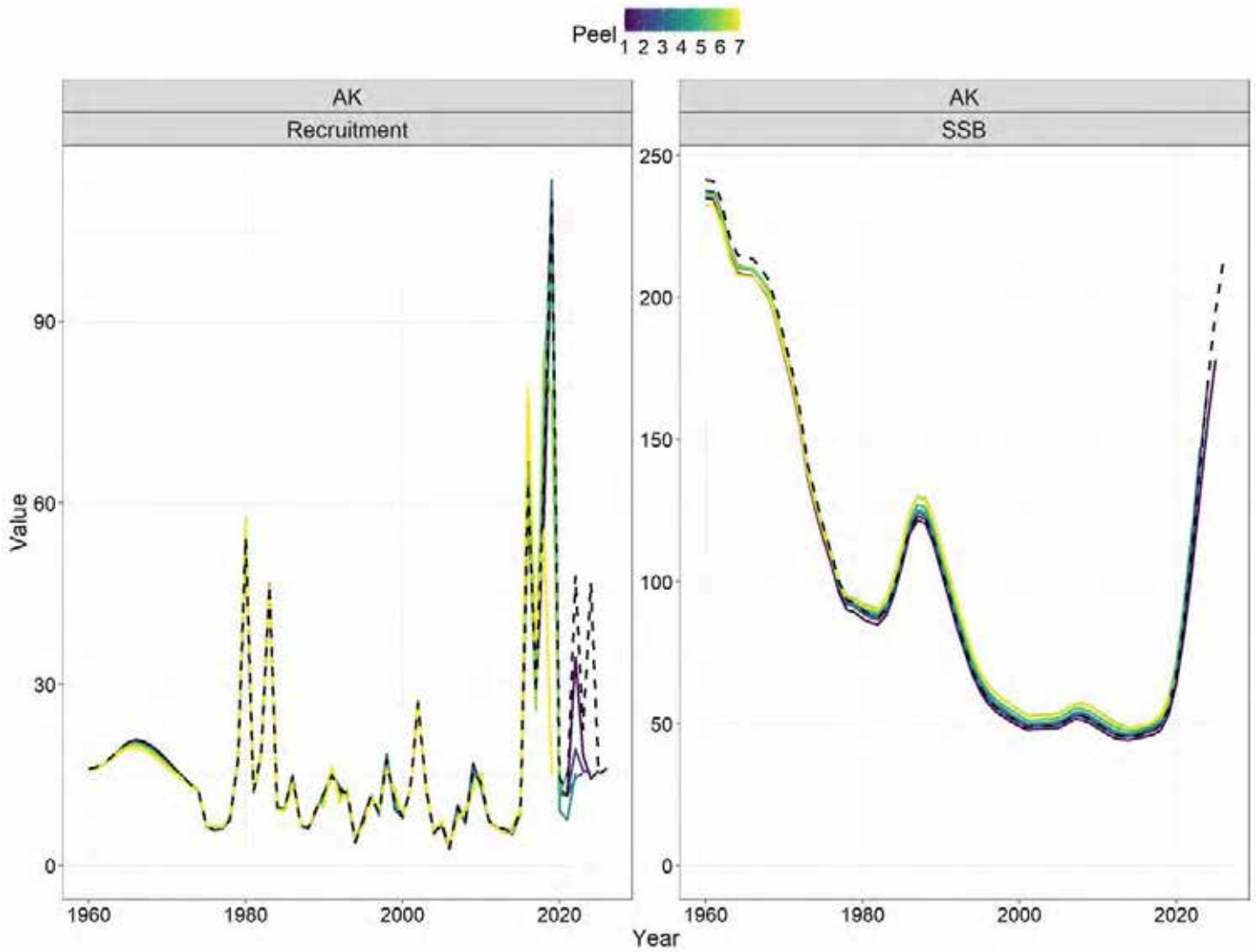


Figure 3.74. Comparison of recruitment (millions of fish; left panel) and spawning stock biomass (SSB; right panel) time series estimates from a seven-year retrospective analysis. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.025.

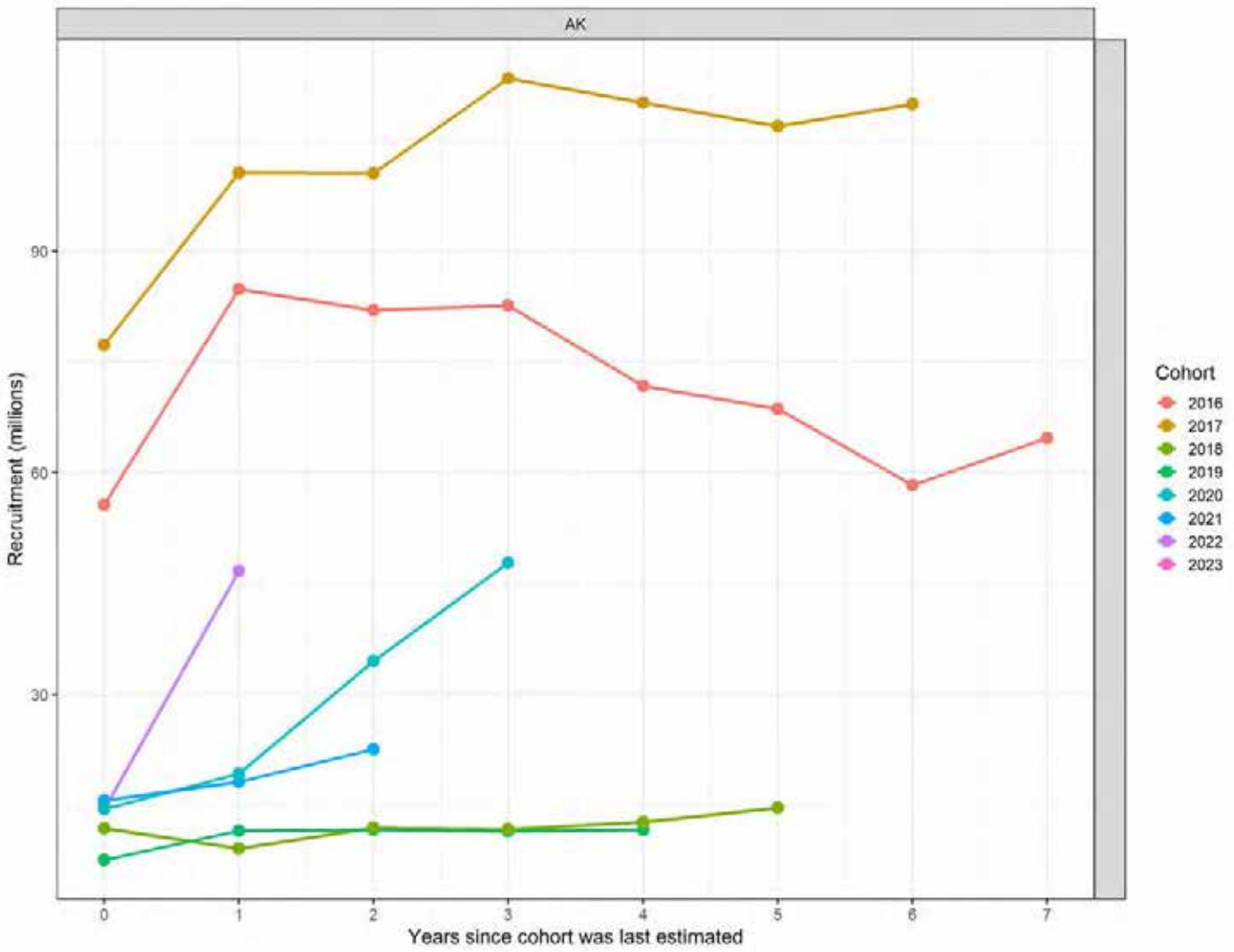


Figure 3.75. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation.

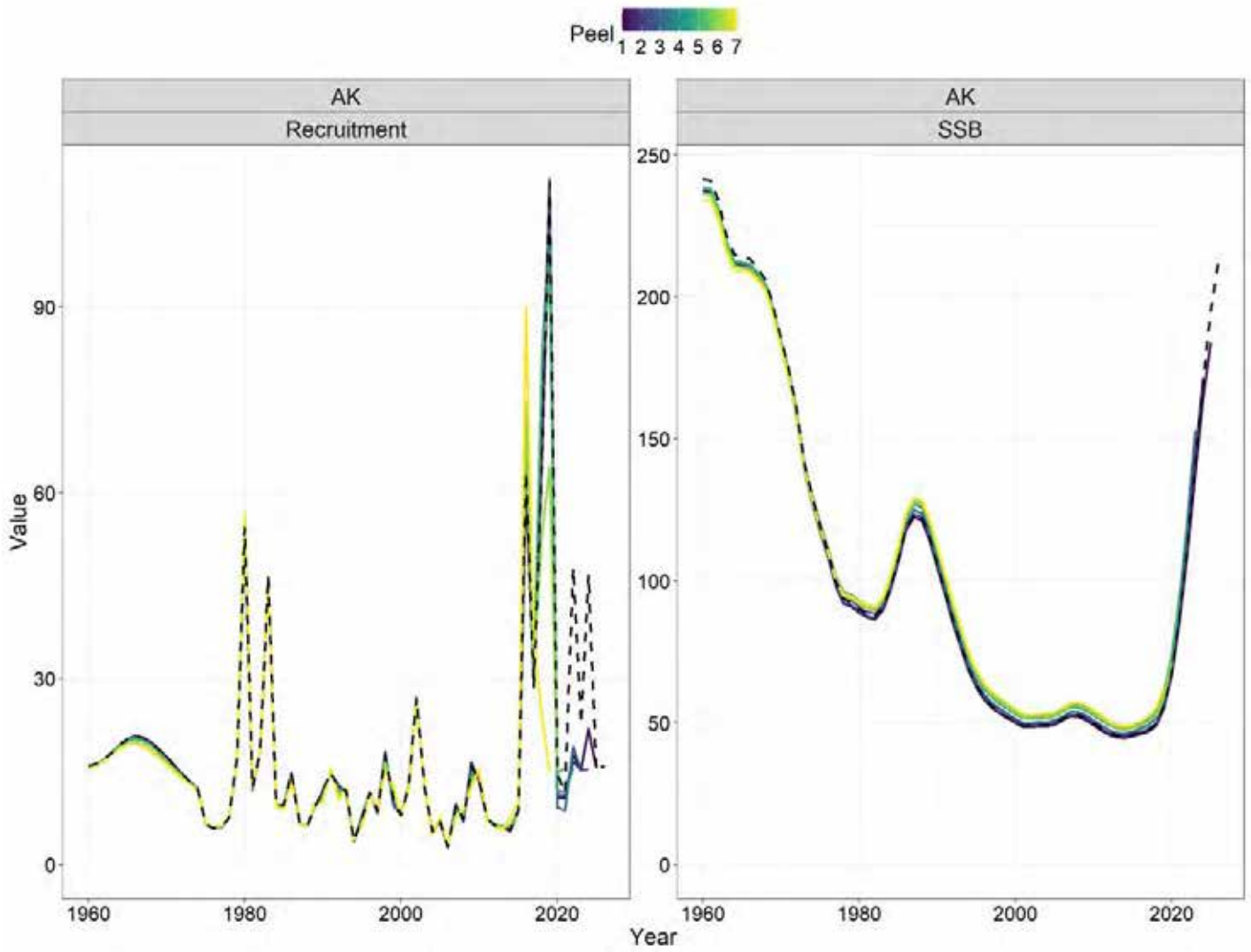


Figure 3.76. Comparison of recruitment (millions of fish; left panel) and spawning stock biomass (SSB; right panel) time series estimates from a seven-year retrospective analysis that explicitly accounts for real-world data lags (i.e., the 1-year lag between age composition collection and availability for the assessment). Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.056.

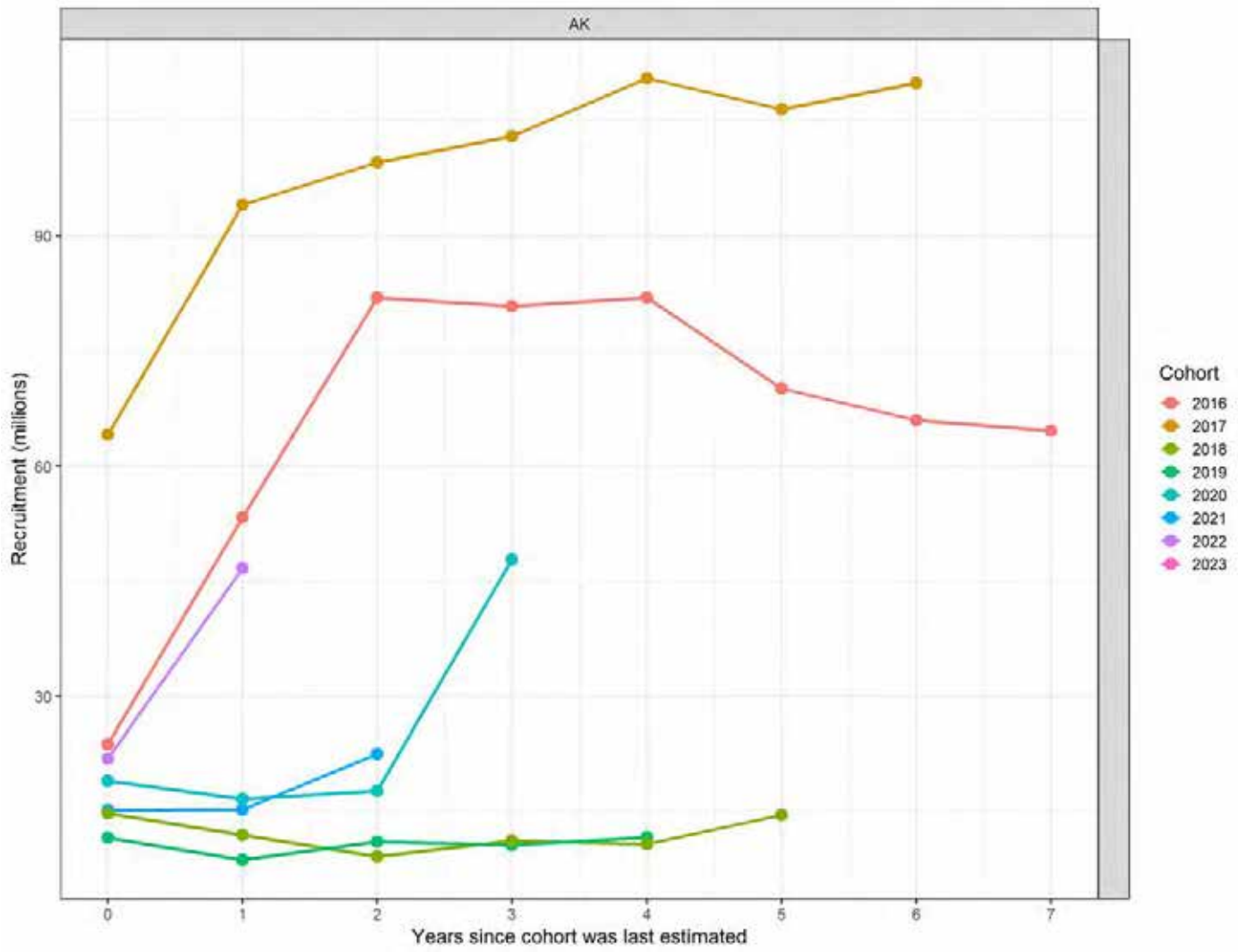


Figure 3.77. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis that explicitly accounts for real-world data lags (i.e., the 1-year lag between age composition collection and availability for the assessment). Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation.

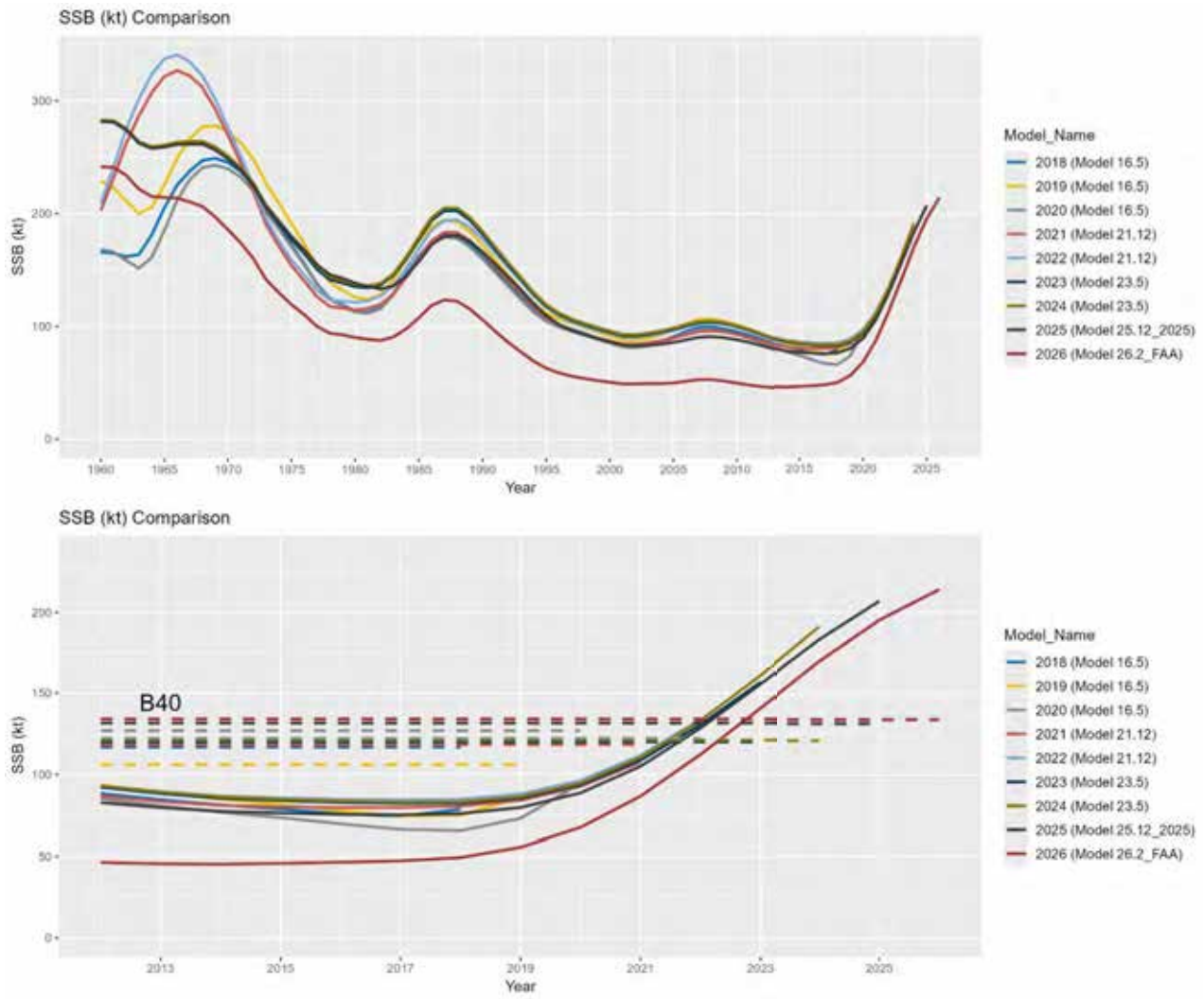


Figure 3.78. Results of the 'all model' historical retrospective illustrating estimated spawning stock biomass (in kilotons). Results are based on the accepted model in each terminal model year, including application of Model *25.12* for 2025 (although there was no SAFE), Model *23.5* for 2023 and 2024, Model *21.12* for 2021 and 2022, and Model *16.5* model for earlier model years. The top panel shows the entire time series of SSB from each assessment model, while the bottom panel shows the same results since 2010 overlaid with corresponding estimates of $B_{40\%}$.

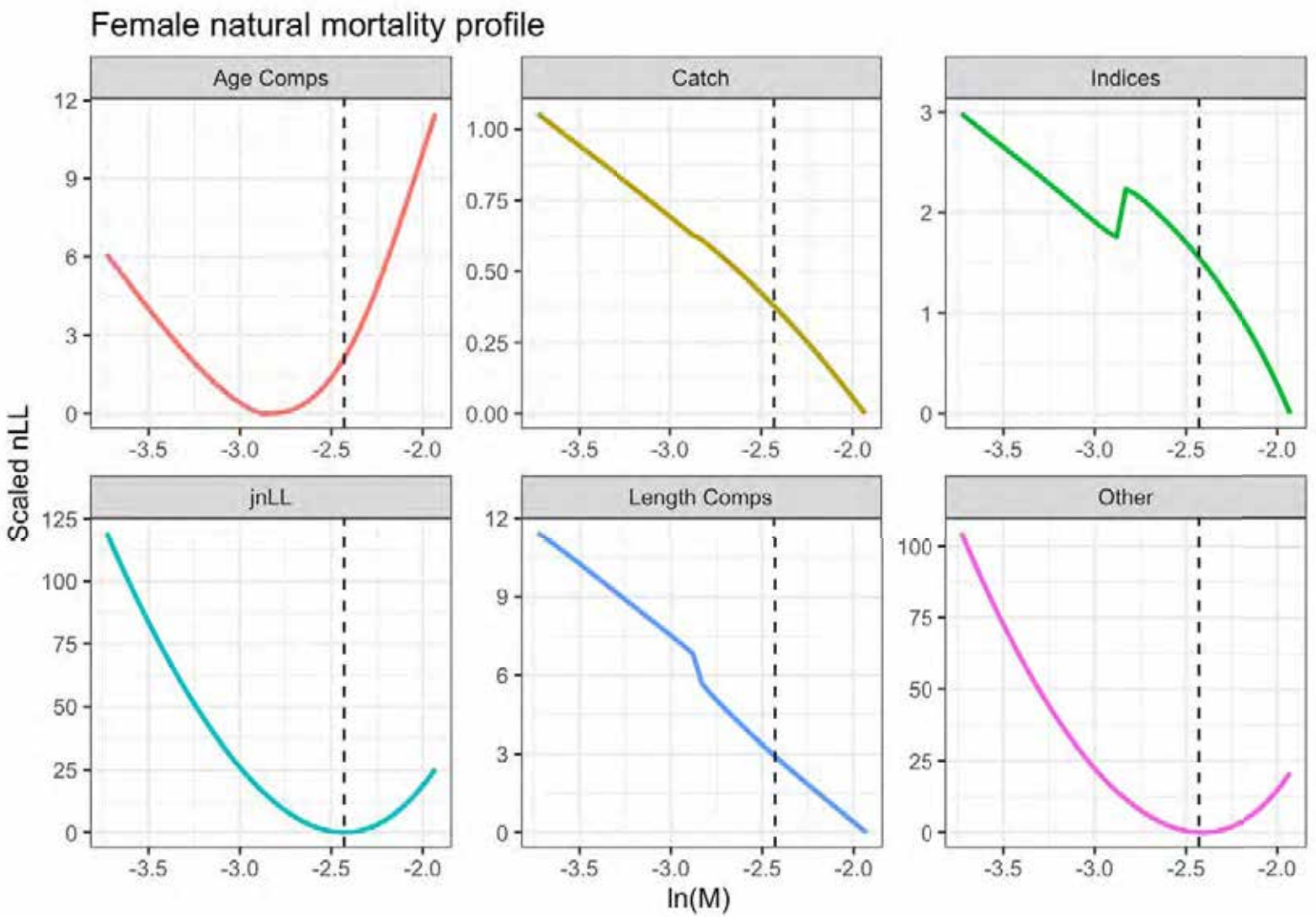


Figure 3.79. Likelihood profile for female natural mortality (*M*), where male *M* was estimated at each profile step. Panels represent the profile for each data type used in the model and the total joint negative log-likelihood (jnLL), each scaled to a minimum of zero. The 'Other' category represents the priors and penalties, which is dominated by the *M* prior. The dashed line denotes the MLE.

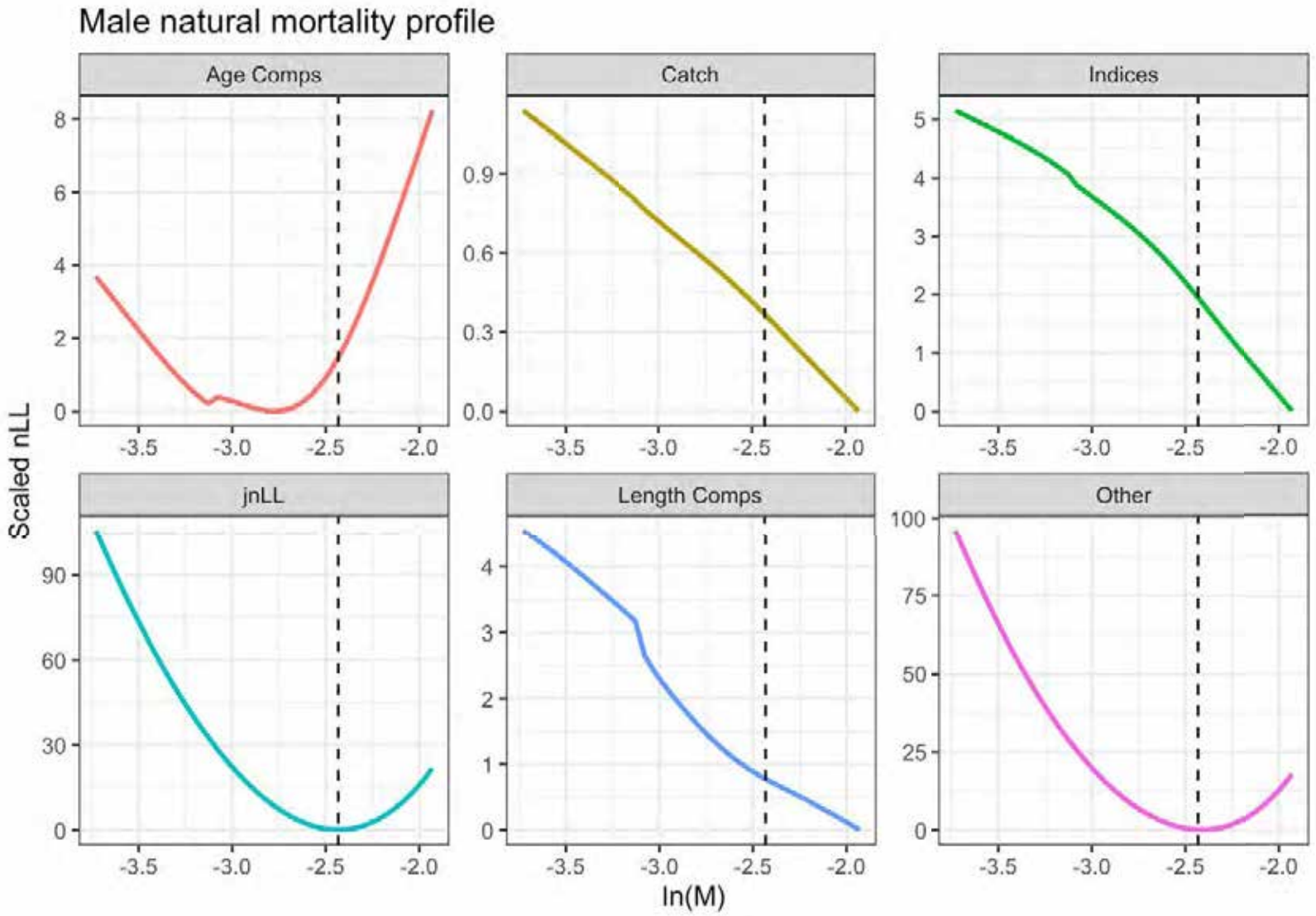


Figure 3.80. Likelihood profile for the male natural mortality (*M*), where female *M* was estimated at each profile step. Panels represent the profile for each data type used in the model and the total joint negative log-likelihood (jnLL), each scaled to a minimum of zero. The 'Other' category represents the priors and penalties, which is dominated by the *M* prior. The dashed line denotes the MLE.

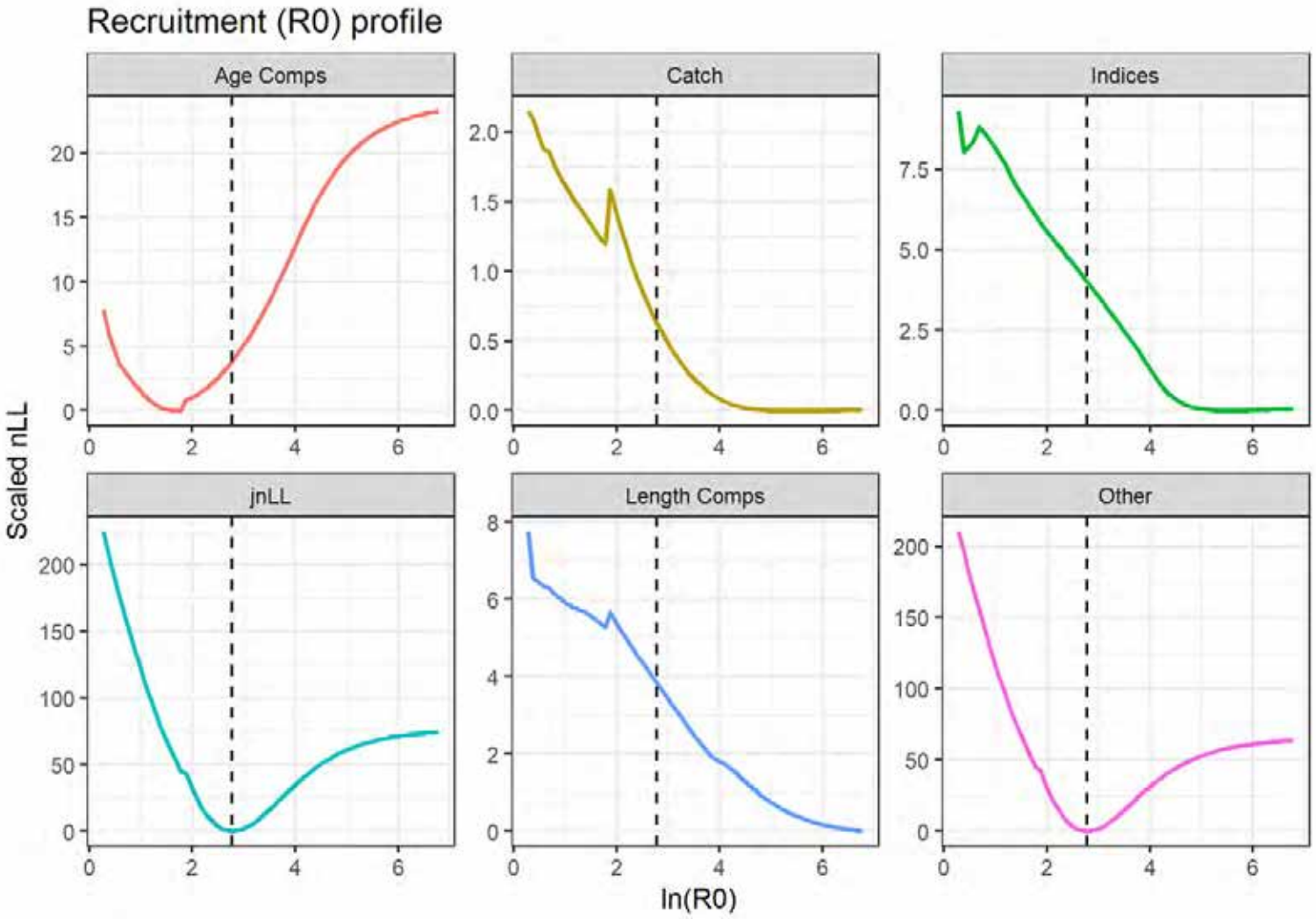
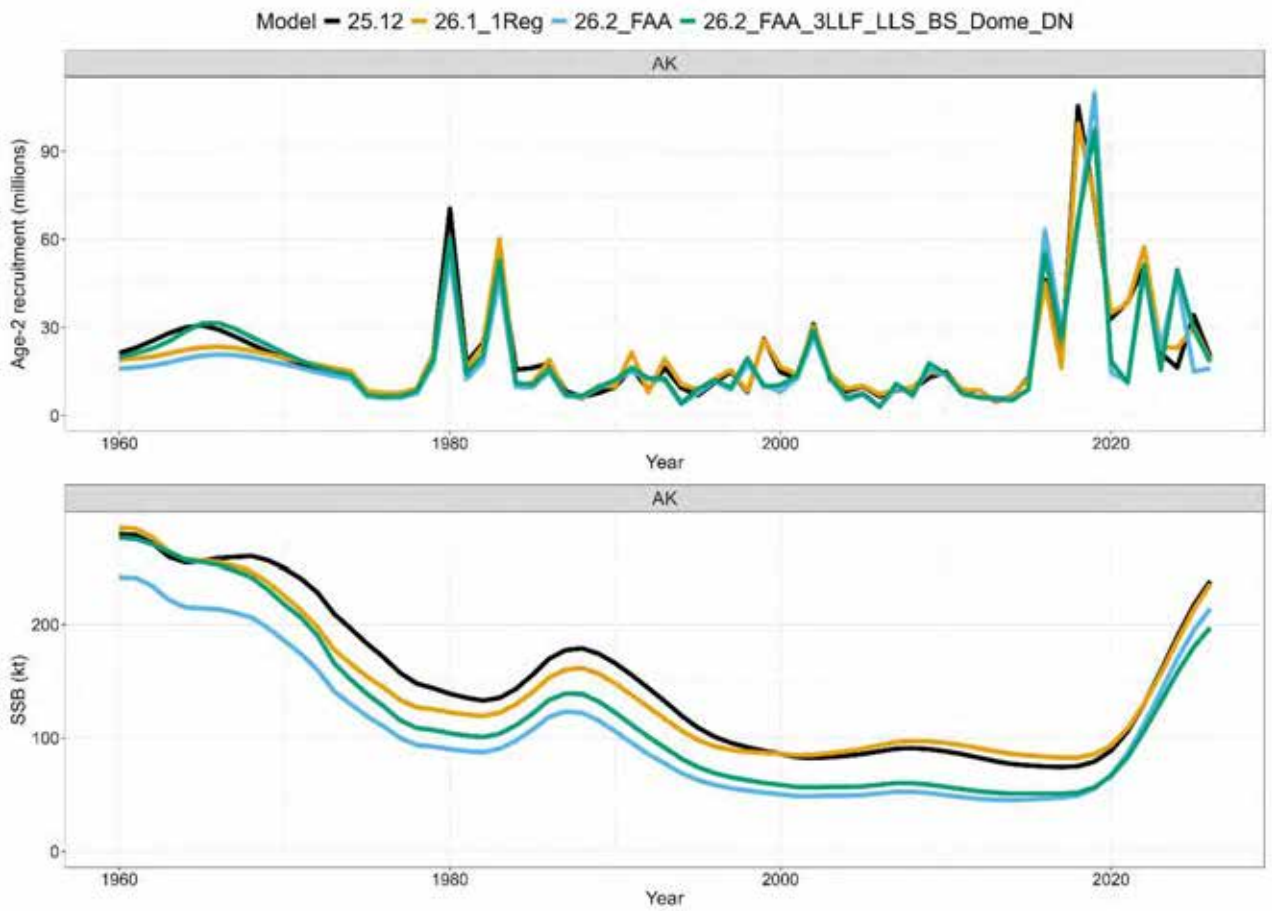
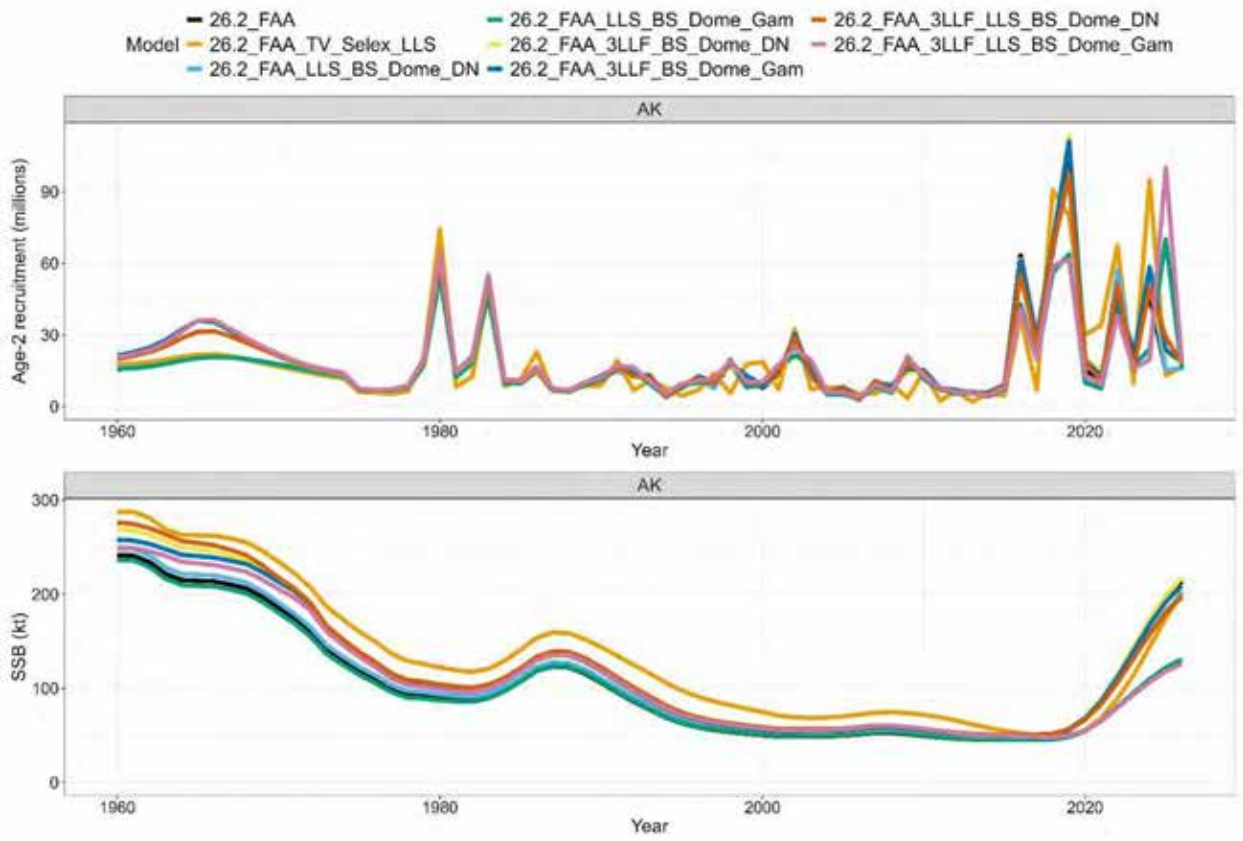


Figure 3.81. Likelihood profile for mean recruitment (R_0). Panels represent the profile for each data type used in the model and the total joint negative log-likelihood (jnLL), each scaled to a minimum of zero. The 'Other' category represents the priors and penalties. The dashed line denotes the MLE.



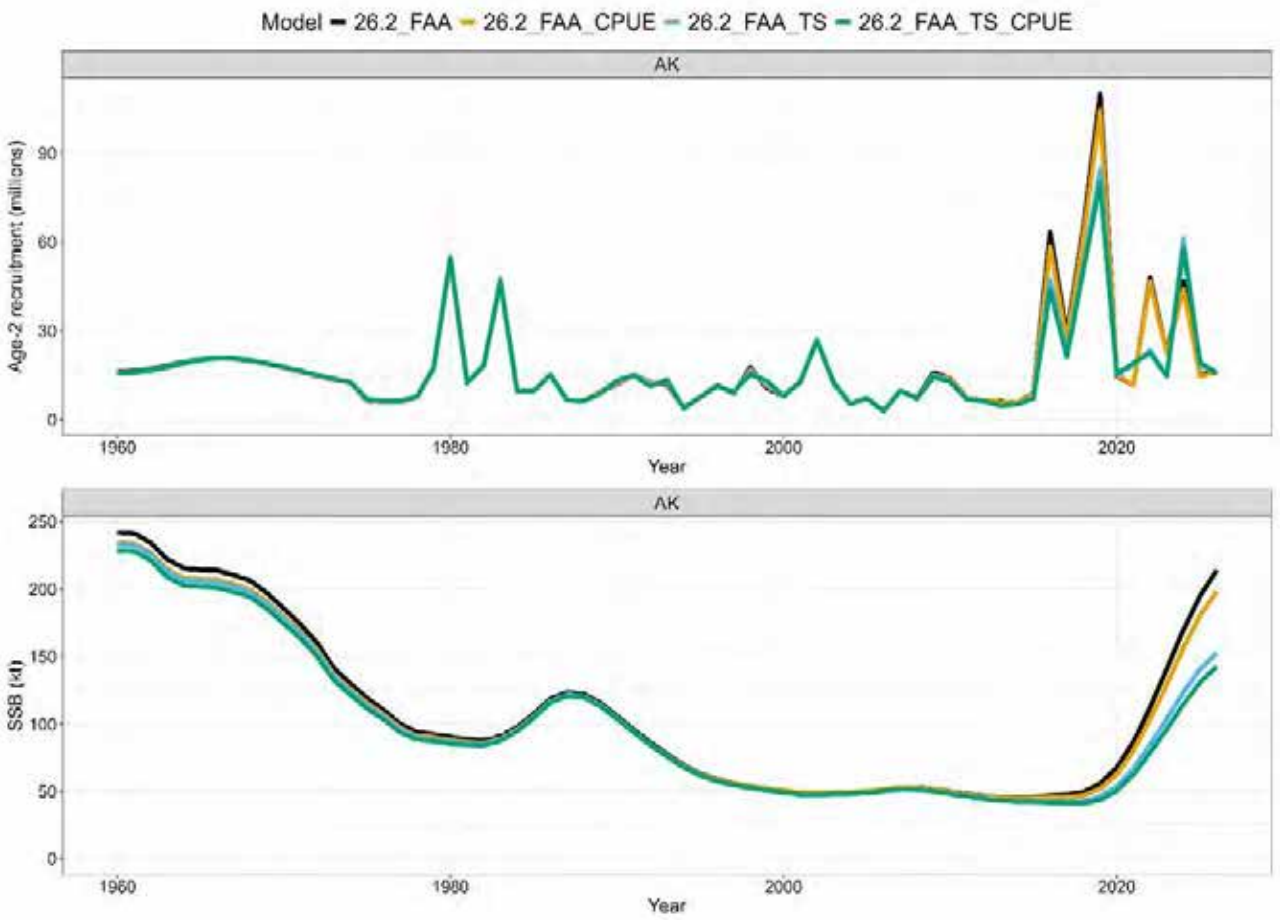
Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
25.12	43.06	0.72	238.34	132.17	1.80	0.05	0.08	0.57
26.1_1Reg	40.18	0.66	235.70	141.83	1.66	0.04	0.07	0.62
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_3LLF_LLS_BS_Dome_DN	36.21	0.61	197.18	129.87	1.52	0.06	0.08	0.71

Figure 3.82. Results of the 'Base' sensitivity run grouping showing recruitment (millions of fish; top panel) and spawning stock biomass (kt; middle panel) along with max ABC estimates ('Catch_Advice') and stock status ('B_Status') relative to associated $B_{100\%}$ estimates. Other reference points are based on $B_{40\%}$ and $F_{40\%}$ (e.g., 'B_Ref_Pt', 'F_Ref_Pt'). The 'Base' grouping includes the 4 SSC requested models (see text).



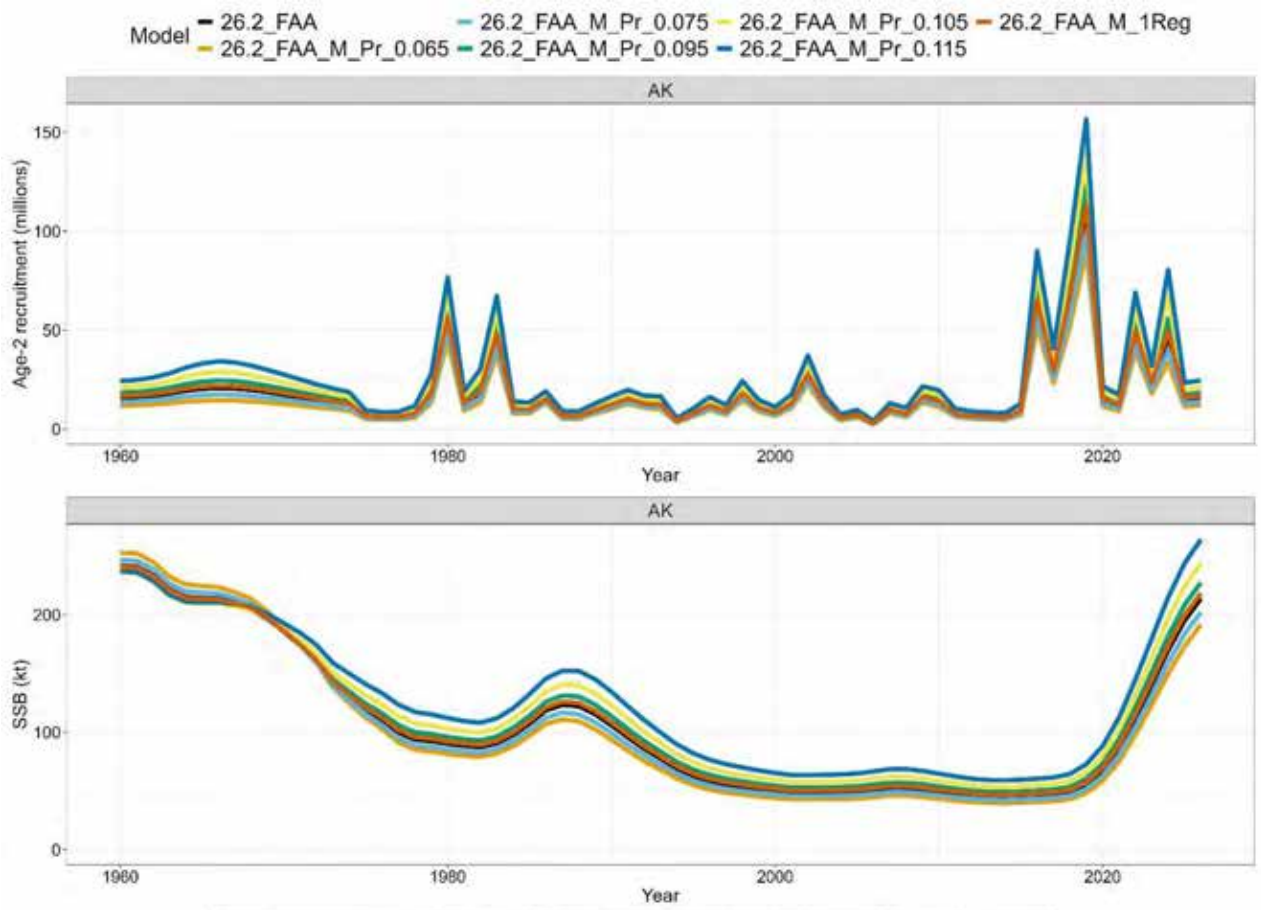
Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_TV_Selex_LLS	39.84	0.53	202.98	154.65	1.31	0.04	0.07	0.65
26.2_FAA_LLS_BS_Dome_DN	35.35	0.59	200.05	136.28	1.47	0.05	0.08	0.73
26.2_FAA_LLS_BS_Dome_Gam	26.02	0.46	131.02	114.88	1.14	0.08	0.07	1.07
26.2_FAA_3LLF_BS_Dome_DN	39.58	0.67	217.44	130.17	1.67	0.05	0.08	0.64
26.2_FAA_3LLF_BS_Dome_Gam	39.85	0.66	209.11	126.28	1.66	0.06	0.09	0.64
26.2_FAA_3LLF_LLS_BS_Dome_DN	36.21	0.61	197.18	129.87	1.52	0.06	0.08	0.71
26.2_FAA_3LLF_LLS_BS_Dome_Gam	27.91	0.47	126.10	106.94	1.18	0.09	0.09	1.02

Figure 3.83. Results of the ‘Dome’ sensitivity run grouping showing recruitment (millions of fish; top panel) and spawning stock biomass (kt; middle panel) along with max ABC estimates (‘Catch_Advice’) and stock status (‘B_Status’) relative to associated $B_{100\%}$ estimates. Other reference points are based on $B_{40\%}$ and $F_{40\%}$ (e.g., ‘B_Ref_Pt’, ‘F_Ref_Pt’). The ‘Dome’ grouping includes variations on the SSC requested domed selectivity model (see text and Supplemental Material section ‘SSC Requested Models’).



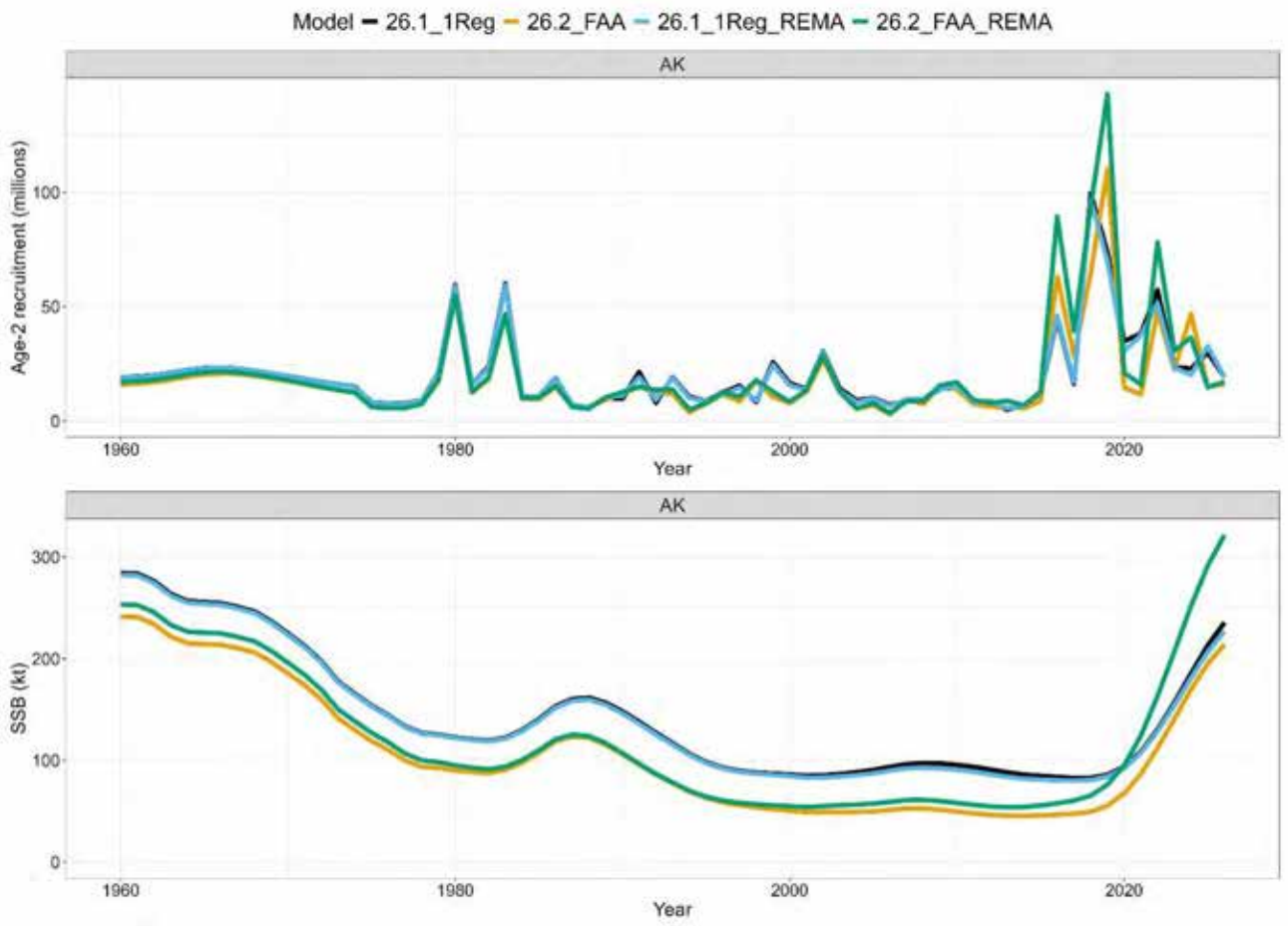
Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_CPUE	36.01	0.61	198.41	129.44	1.53	0.07	0.09	0.72
26.2_FAA_TS	28.94	0.51	152.55	120.35	1.27	0.07	0.08	0.91
26.2_FAA_TS_CPUE	27.03	0.48	142.52	117.55	1.21	0.06	0.09	0.96

Figure 3.84. Results of the 'Index' sensitivity run grouping showing recruitment (millions of fish; top panel) and spawning stock biomass (kt; middle panel) along with max ABC estimates ('Catch_Advice') and stock status ('B_Status') relative to associated $B_{100\%}$ estimates. Other reference points are based on $B_{40\%}$ and $F_{40\%}$ (e.g., 'B_Ref_Pt', 'F_Ref_Pt'). The 'Index' grouping includes variations on Model *26.2_FAA* that fit the CPUE and NOAA GOA trawl survey biomass indices (see text).



Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_M_Pr_0.065	28.15	0.48	191.71	158.36	1.21	0.06	0.07	0.92
26.2_FAA_M_Pr_0.075	32.64	0.56	202.07	144.20	1.40	0.06	0.07	0.78
26.2_FAA_M_Pr_0.095	43.09	0.72	227.52	126.68	1.80	0.05	0.08	0.59
26.2_FAA_M_Pr_0.105	49.43	0.80	243.76	121.85	2.00	0.05	0.09	0.51
26.2_FAA_M_Pr_0.115	57.02	0.88	264.13	119.38	2.21	0.04	0.09	0.44
26.2_FAA_M_1Reg	39.27	0.66	218.40	131.62	1.66	0.05	0.08	0.65

Figure 3.85. Results of the '*M* Prior' sensitivity run grouping showing recruitment (millions of fish; top panel) and spawning stock biomass (kt; middle panel) along with max ABC estimates ('Catch_Advice') and stock status ('B_Status') relative to associated $B_{100\%}$ estimates. Other reference points are based on $B_{40\%}$ and $F_{40\%}$ (e.g., 'B_Ref_Pt', 'F_Ref_Pt'). The '*M* Prior' grouping includes variations on Model *26.2_FAA* with alternative natural mortality priors (see text).



Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.1_1Reg	40.18	0.66	235.70	141.83	1.66	0.04	0.07	0.62
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.1_1Reg_REMA	38.52	0.65	227.06	138.72	1.64	0.05	0.07	0.65
26.2_FAA_REMA	55.14	0.83	321.69	154.48	2.08	0.04	0.08	0.45

Figure 3.86. Results of the 'REMA' sensitivity run grouping showing recruitment (millions of fish; top panel) and spawning stock biomass (kt; middle panel) along with max ABC estimates ('Catch_Advice') and stock status ('B_Status') relative to associated $B_{100\%}$ estimates. Other reference points are based on $B_{40\%}$ and $F_{40\%}$ (e.g., 'B_Ref_Pt', 'F_Ref_Pt'). The 'REMA' grouping includes variations on Model *26.1_1Reg* and Model *26.2_FAA* that use REMA to smooth and interpolate the regional NOAA Longline Survey indices (see text).

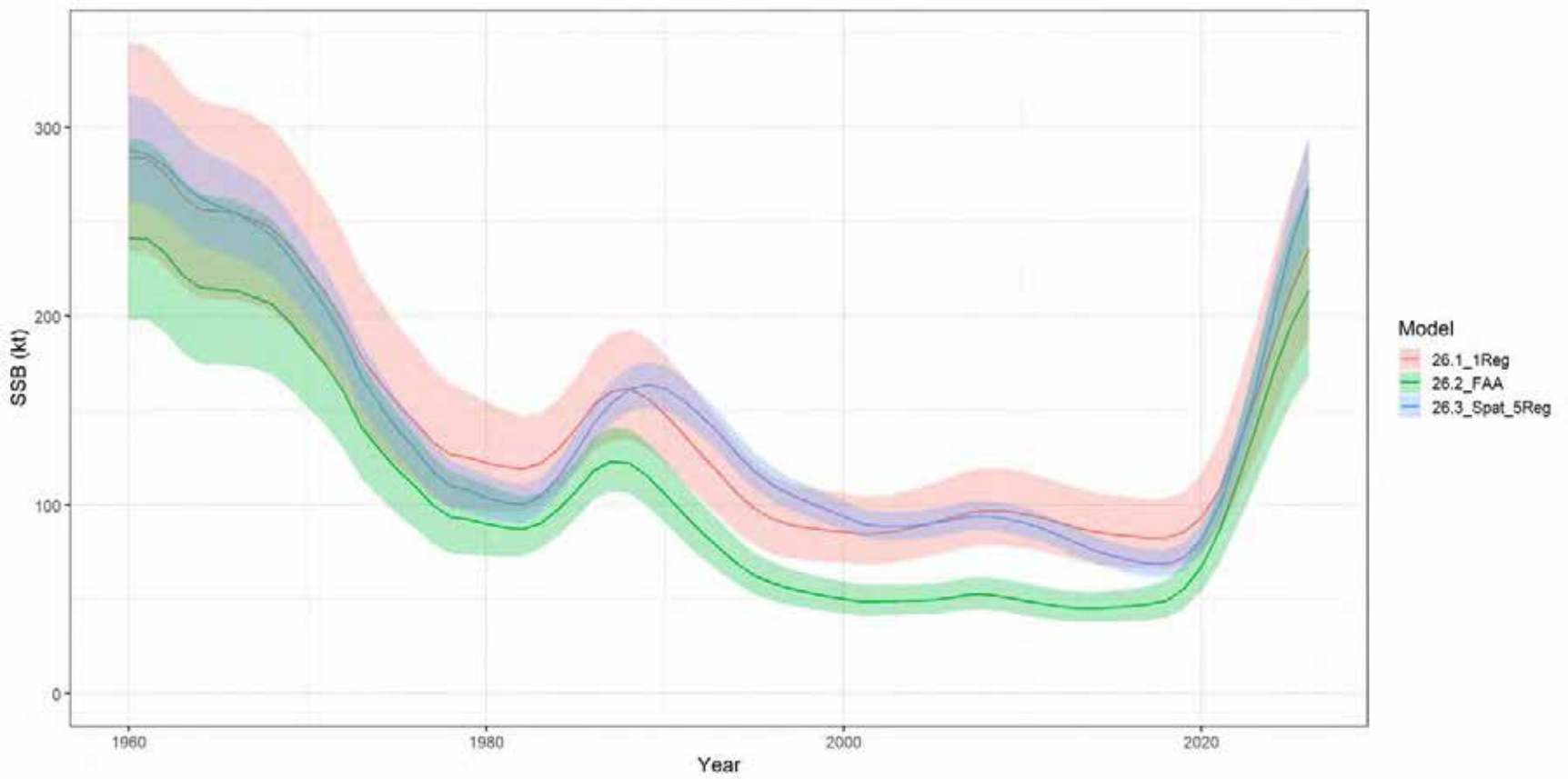


Figure 3.87. Results of the 'Spatial' sensitivity run grouping showing AK-wide spawning stock biomass (kt) with 95% confidence intervals for the author recommended FAA Model *26.2_FAA* (green line), the updated single region Model *26.1_1Reg* (red line), and the five region spatial Model *26.3_Spat_5Reg* (blue line). Full results from the updated spatial model are available in Appendix K.

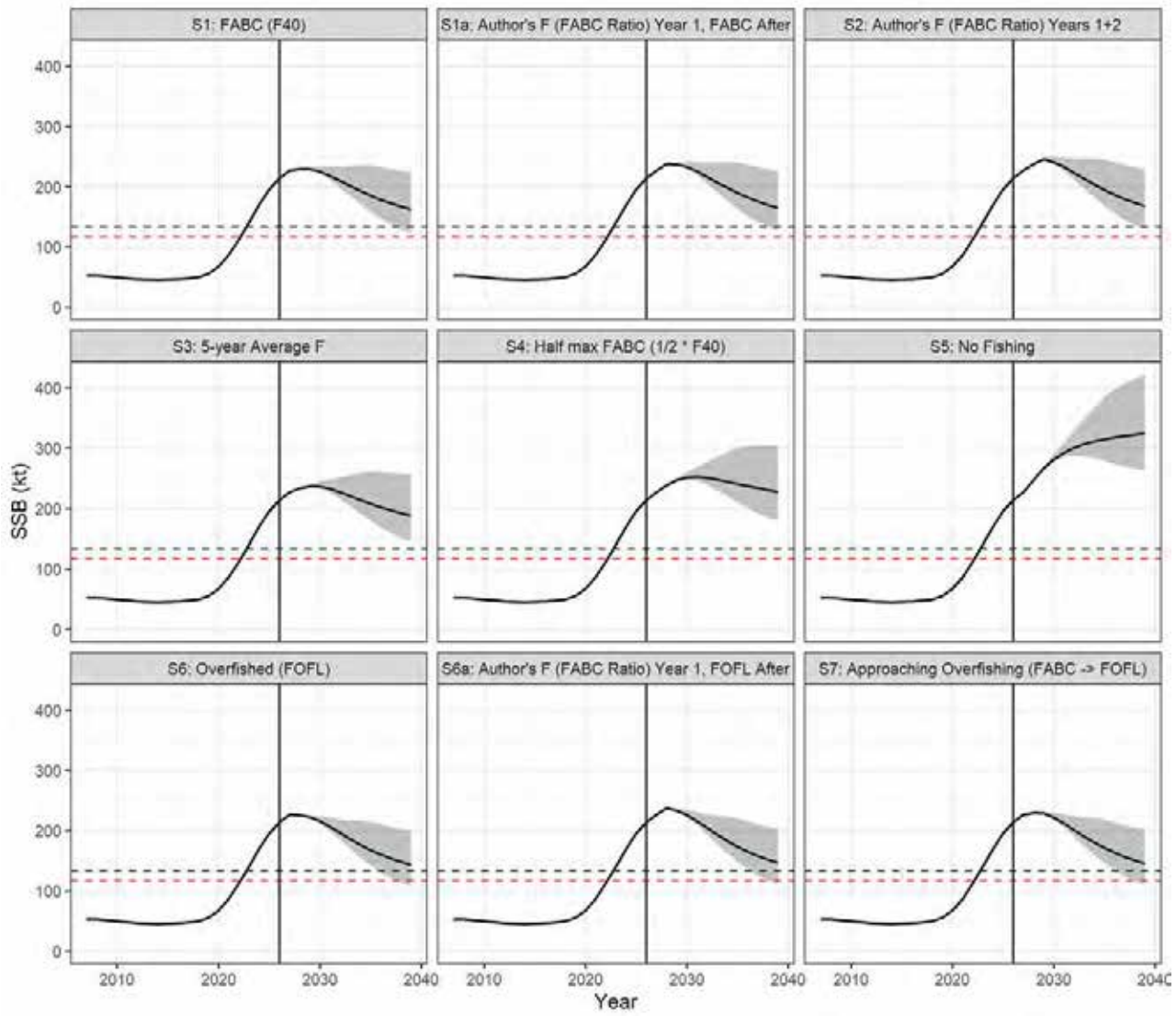


Figure 3.88. Estimated and projected (mean) spawning stock biomass (kt; black line) with 95% simulation intervals (grey shading) for the various base projection scenarios along with estimates of $B_{35\%}$ (red dashed line) and $B_{40\%}$ (black dashed line). The black vertical line in 2026 separates model estimates (left side) from projected values (right side).

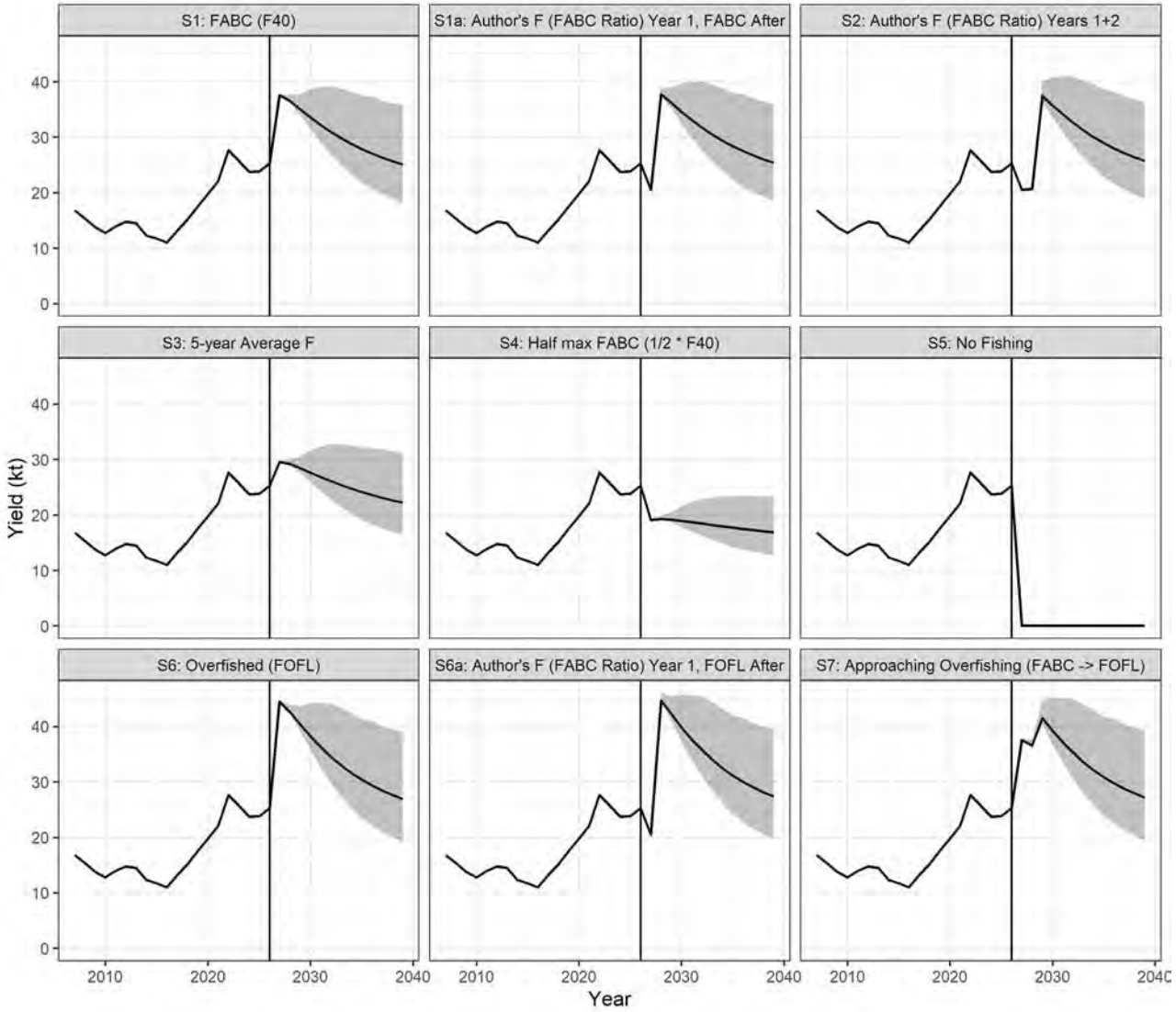


Figure 3.89. Observed and projected (mean) catch (kt; black line) with 95% simulation intervals (grey shading) for the various base projection scenarios. The black vertical line in 2026 separates observed catch (left side) from projected catch under each projection scenario (right side).

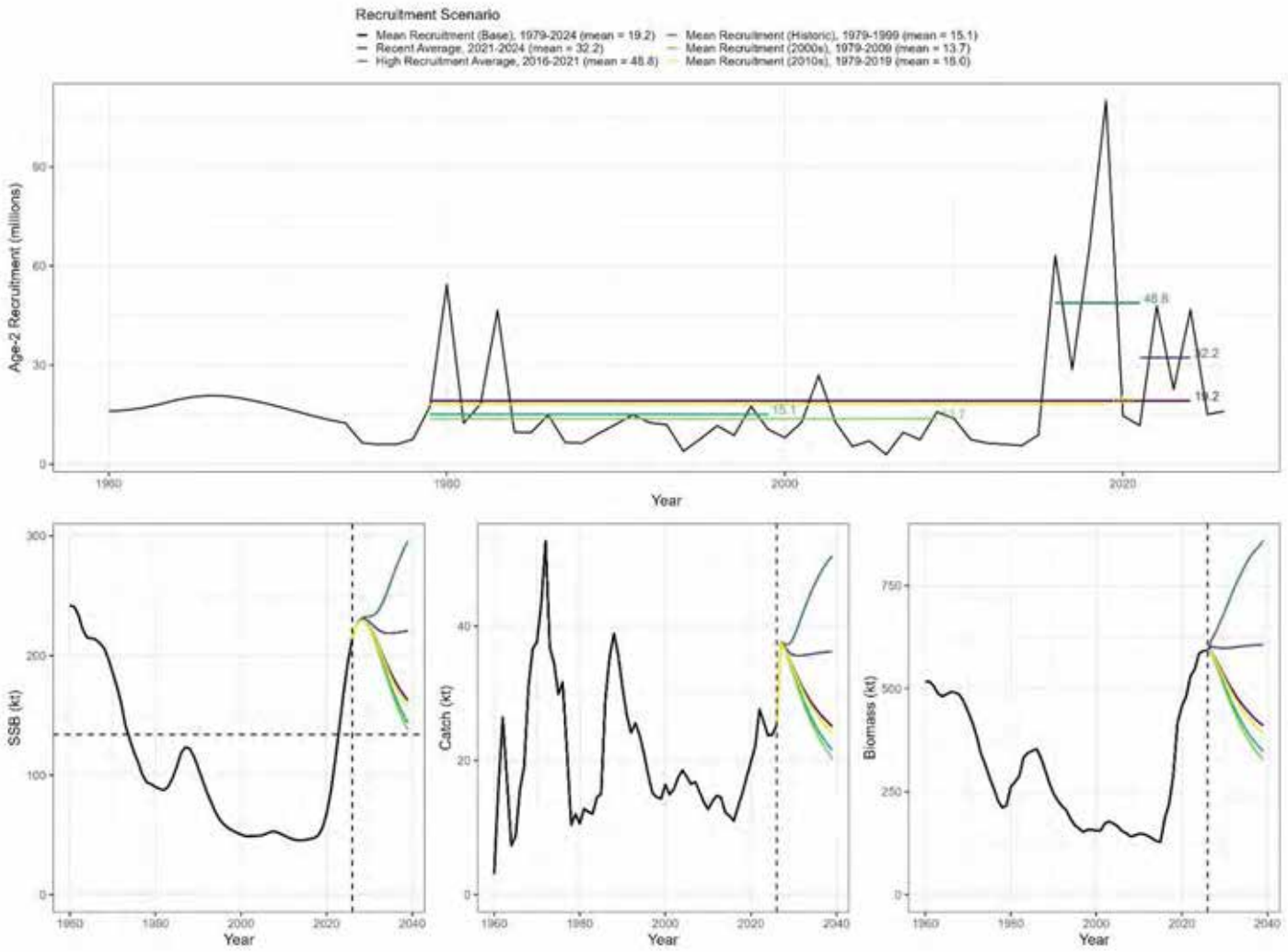


Figure 3.90. Model estimated recruitment (millions of fish; black line) and various mean recruitment assumptions (see text, colored lines) for the alternate recruitment projections scenarios (top panel) assuming the NPFMC threshold $F_{40\%}$ HCR. The second row illustrates model estimated (black line) and projected (mean; colored lines which represent each recruitment scenario) spawning stock biomass (kt; left column), catch (kt, middle column), and total age-2+ biomass (kt, right column). The black vertical dashed line in 2026 separates model estimated values (left side) from projected values (right side).

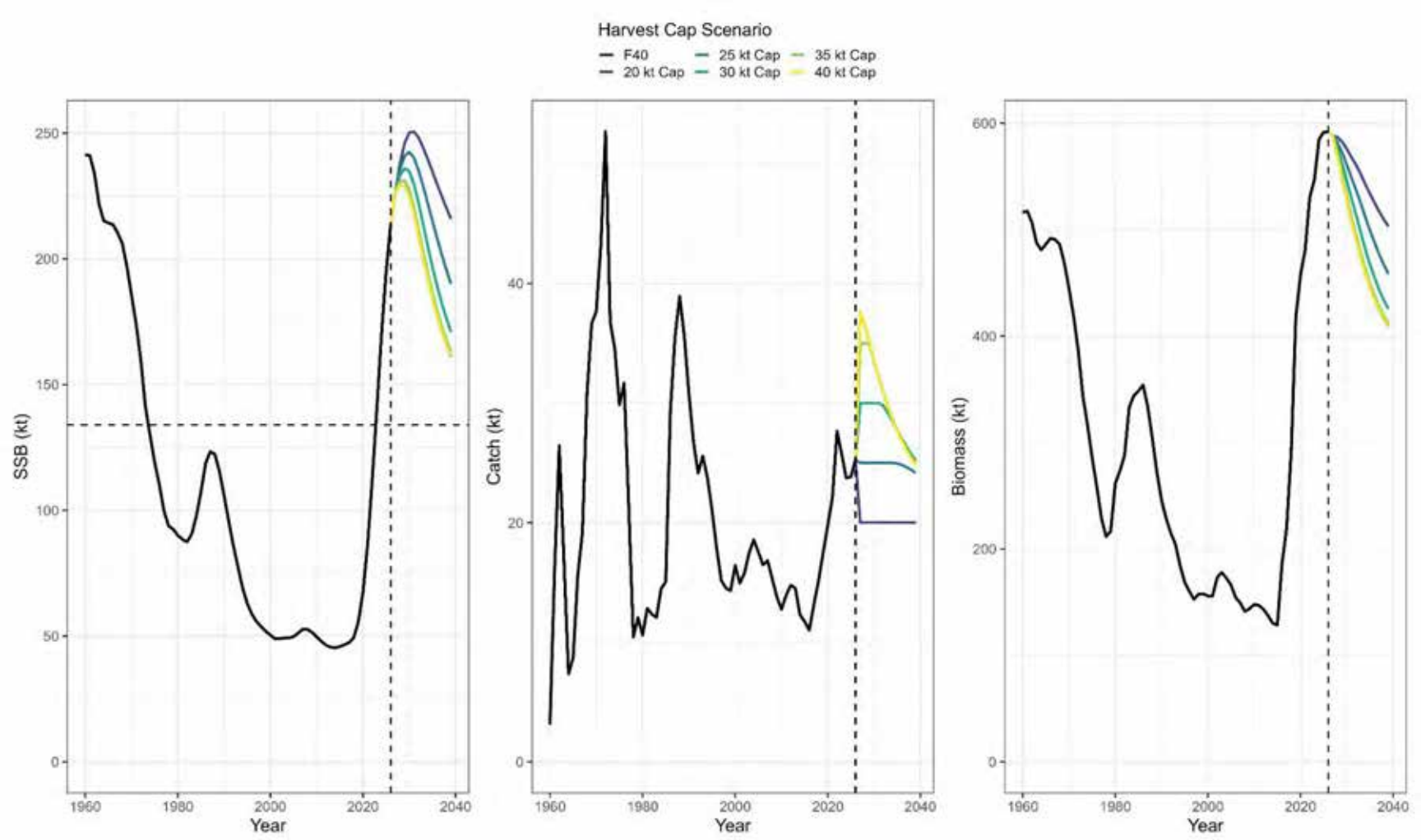


Figure 3.91. For the alternate harvest cap projection scenarios (see text), the model estimated (black line) and projected (mean; colored lines which represent each HCR scenario) spawning stock biomass (kt; left column), catch (kt, middle column), and total age-2+ biomass (kt, right column). The black vertical dashed line in 2026 separates model estimated values (left side) from projected values (right side).

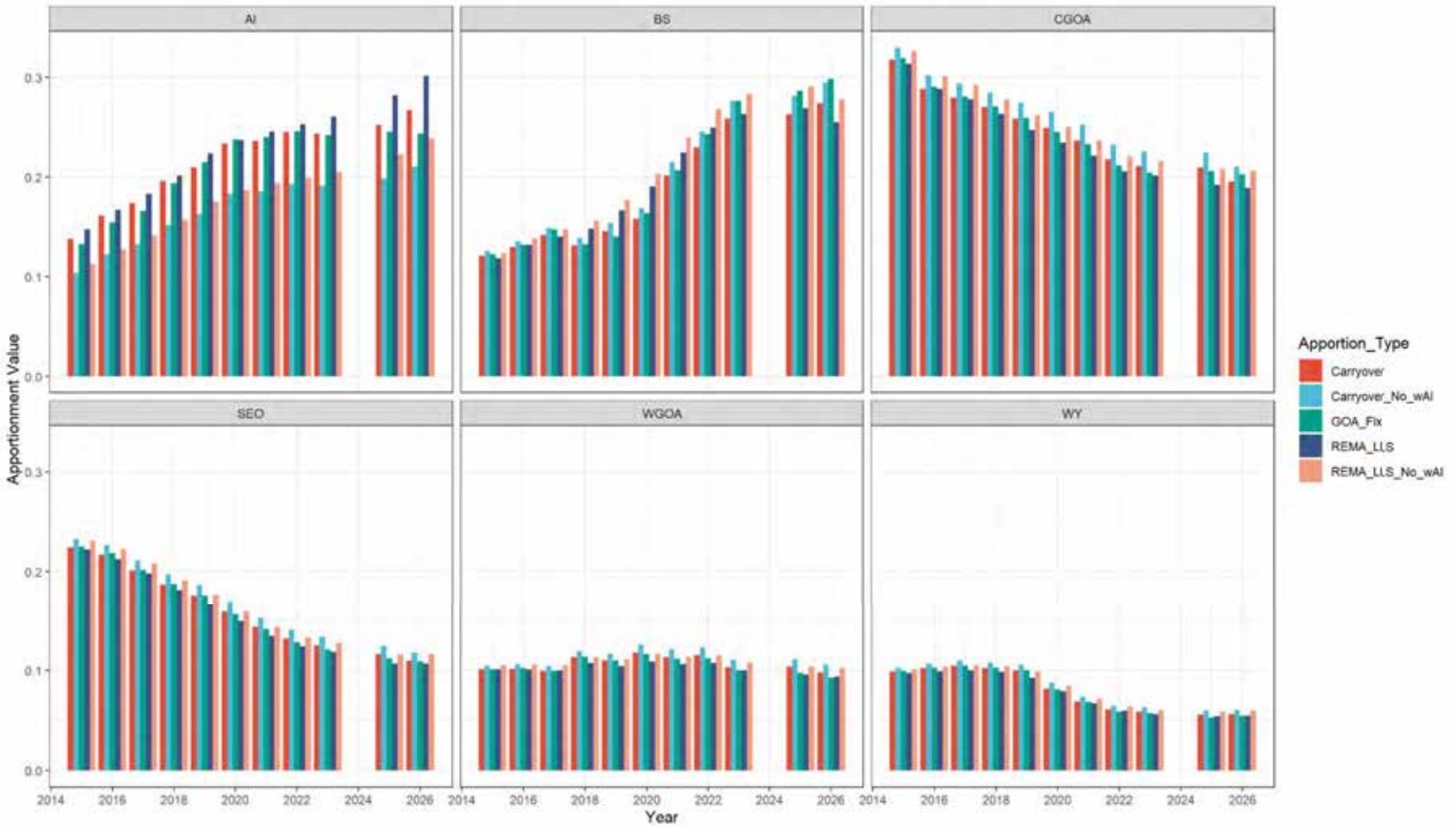


Figure 3.92. Comparison of apportionment values by region (facet) and year for each of the apportionment methods described in the text. The '*Carryover_No_wAI*' method is the author recommended apportionment. Each method uses an alternative approach to interpolation for unsurveyed regions in a given year. All methods utilize a 5-year moving average of regional biomass proportions to determine apportionment in a given year.

Supplemental Material

Sablefish Longline Survey Fishery and Whale Interactions

NMFS has requested the fishing fleet avoid longline survey stations by at least five nm for 7 days before and 3 days after planned sampling dates (3 days allows for survey delays). Survey calendars are available online (https://www.fisheries.noaa.gov/resource/document/alaska-sablefish-longline-survey-station-schedule). While the survey is being conducted, the skipper of the vessel makes radio announcements detailing the planned set locations for the upcoming days. Vessels encountered near survey stations are contacted by the survey vessel captain and interviewed to determine potential effects on survey catches. Typically, vessels are aware of the survey and have not been fishing close to survey locations. Even with communication, there are some instances where survey gear is fished nearby commercial fishing gear or where commercial fishing has recently occurred (Table SM3.1). In 2025, there were four instances of vessel interactions that may have impacted survey catch or required the survey vessel to move the day's sets from their originally intended locations (1 in WGOA, 1 in CGOA, 2 in EGOA). In 2026, there were five vessel interactions at 4 stations (2 in BS, 2 in AI). The number of sets impacted by orca and sperm whales is also tallied (Table SM3.2). Sets depredated by orcas are removed from index calculations; catch data from sets depredated by sperm whales are inflated using a survey whale inflation factor (see 'Whale Depredation Estimation' section). In 2025, orca whales depredated at two stations each in the WGOA and the CGOA; sperm whales depredated at 4 stations in the CGOA and 2 in WY. In 2026, orca whales depredated at 9 stations in the BS; sperm whale depredation was not observed. No longline survey was conducted in 2024.

Table SM3.1. Count of longline survey and fishery vessel interactions by area, fishery gear type, and year.

	Longline		Trawl		Pot		Total	
Year	Stations	Vessels	Stations	Vessels	Stations	Vessels	Stations	Vessels
1995	8	7	9	15	0	0	17	22
1996	11	18	15	17	0	0	26	35
1997	8	8	8	7	0	0	16	15
1998	10	9	0	0	0	0	10	9
1999	4	4	2	6	0	0	6	10
2000	10	10	0	0	0	0	10	10
2001	1	1	1	1	0	0	2	2
2002	3	3	0	0	0	0	3	3
2003	4	4	2	2	0	0	6	6
2004	5	5	0	0	1	1	6	6
2005	1	1	1	1	0	0	2	2
2006	6	6	1	2	0	0	7	8
2007	8	6	2	2	0	0	10	8
2008	2	2	2	2	0	0	4	4
2009	3	3	0	0	0	0	3	3
2010	2	2	1	1	0	0	3	3
2011	3	3	0	0	0	0	3	3
2012	5	5	0	0	0	0	5	5
2013	5	5	0	0	0	0	5	5
2014	2	2	0	0	0	0	2	2
2015	3	3	1	1	0	0	6	6
2016	5	5	1	1	0	0	6	6
2017	8	10	3	3	3	3	13	16
2018	9	9	3	3	0	0	12	12
2019	4	4	1	1	4	4	9	9
2020	1	1	1	1	3	3	5	5
2021	0	0	0	0	4	4	4	4
2022	1	1	0	0	7	7	8	8
2023	2	3	0	0	4	5	6	8
2025	3	3	0	0	1	1	4	4
2026	0	0	2	3	2	2	4	5

Table SM3.2. Count of stations where sperm (S) or killer whale (K) depredation occurred and the number of stations sampled (in parentheses) by management area. Only stations used for RPN calculations are included. Areas not surveyed in a given year are left blank. If there were no whale depredation data taken, it is denoted with an "n/a". Killer whale depredation did not always occur on all skates of gear, and only those skates with depredation were removed from calculations of RPNs and RPWs.

	BS (16)		AI (14)		WG (10)		CG (16)		WY (8)		SEO (17)	
Year	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**
1996	-	-	-	1	-	0	-	0	-	0	n/a	0
1997	-	2	-	-	-	0	-	0	-	0	n/a	0
1998	-	-	0	1	0	0	0	0	4	0	0	0
1999	0	7	-	-	0	0	3	0	6	0	4	0
2000	-	-	0	1	0	1	0	0	4	0	2	0
2001	0	5	-	-	0	0	3	0	0	0	2	0
2002	-	-	0	1	0	4	3	0	4	0	2	0
2003	0	7	-	-	0	3	2	0	1	0	2	0
2004	-	-	0	0	0	4	3	0	4	0	6	0
2005	0	2	-	-	0	4	0	0	2	0	8	0
2006	-	-	0	1	0	3	2	1	4	0	2	0
2007	0	7	-	-	0	5	1	1	5	0	6	0
2008	-	-	0	3	0	2	2	0	8	0	9	0
2009	0	10	-	-	0	2	5	1	3	0	2	0
2010	-	-	0	3	0	1	2	1	2	0	6	0
2011	0	7	-	-	0	5	1	1	4	0	9	0
2012	-	-	1	5	1	5	2	0	4	0	3	0
2013	0	11	-	-	0	2	2	2	3	0	7	0
2014	-	-	1	3	0	4	4	0	6	0	4	0
2015	0	9	-	-	0	5	4	0	6	0	7	0
2016	-	-	1	0	0	3	3	2	5	0	6	0
2017	0	11	-	-	1	2	4	0	3	0	9	0
2018	-	-	0	2	0	3	3	0	7	0	9	0
2019	0	10	-	-	1	4	6	3	6	0	4	0
2020	-	-	0	7	1	5	3	1	4	0	6	0
2021	0	10	-	-	0	1	5	0	1	0	2	0
2022	-	-	0	1	0	4	2	0	1	0	5	0
2023	0	12	-	-	0	3	2	1	2	0	8	0
2025	-	-	-	-	0	2	4	2	2	0	0	0
2026	0	9	0	0	-	-	-	-	-	-	-	-

* Beginning in 2025, 15 stations sampled in the CGOA and 16 stations sampled in SEO in odd-numbered years.

Supplemental Catch Data

In order to address NS1 total accounting requirements, discards (Table SM3.3), FMP bycatch (Table SM3.4), nontarget bycatch (Table SM3.5), and prohibited species catch (PSC; Table SM3.6) are reported in this appendix. Note that all non-commercial catch is now accounted for in the assessment model catch, so no additional table is provided for these sources of removal.

Table SM3.3. Retained and discarded catch of sablefish (t) by year, fleet, and management (FMP) region. Abbreviations are: HAL = hook-and-line; POT = pot; TRW = trawl; and JIG = jig fishery. Source: NMFS Alaskan Regional Office Catch Accounting System via AKFIN (www.akfin.org), accessed on October 29, 2026. Discards are included in the assessment model catch assuming 100% mortality.

		Gulf of Alaska		Bering Sea/Aleutian Islands	
Year	**Gear Type**	**Retained**	**Discarded**	**Retained**	**Discarded**
2022	HAL	3,234	401	200	222
	POT	13,493	156	3,781	55
	TRW	1,354	527	2,209	1,276
2023	HAL	2,655	332	188	135
	POT	11,850	90	4,155	9
	TRW	1,173	296	3,648	485
2024	HAL	2,734	333	114	225
	POT	12,568	79	1,830	22
	TRW	1,108	254	4,096	48
2025	HAL	2,355	373	33	57
	POT	14,214	282	1,818	6
	TRW	998	164	2,900	42
2026	HAL	1,534	265	115	26
	POT	14,738	200	2,148	20
	TRW	1,222	673	1,685	20

Table SM3.4. Bycatch (t) of FMP groundfish species by year in the targeted sablefish fishery. Source: NMFS Alaskan Regional Office Catch Accounting System via AKFIN (www.akfin.org), accessed on October 29, 2026.

	2022		2023		2024		2025		2026	
Species	**R**	**D**	**R**	**D**	**R**	**D**	**R**	**D**	**R**	**D**
Arrowtooth Flounder	38.5	435.0	170.5	238.6	440.8	333.1	119.7	144.9	218.7	166.9
Atka Mackerel	0.0	0.4	66.6	0.9	8.3	0.7	1.6	0.1	0.0	0.4
BSAI Kamchatka Flounder	60.3	18.9	235.6	26.4	501.0	18.2	260.4	6.5	186.1	17.6
BSAI Other Flatfish	22.4	14.6	133.8	6.3	383.0	23.5	205.8	15.8	154.7	7.0
BSAI Shortraker Rockfish	6.4	2.3	16.9	2.3	13.9	7.4	0.5	2.8	0.2	0.6
BSAI Skate and GOA Skate, Other	0.6	71.9	4.4	214.2	28.3	120.9	2.0	101.7	0.0	32.8
Flathead Sole	31.4	5.3	79.8	3.1	262.8	8.7	135.3	3.2	109.1	1.1
GOA Deep Water Flatfish	2.0	19.9	0.1	14.0	1.3	15.0	1.0	10.0	3.5	18.5
GOA Demersal Shelf Rockfish	20.7	2.2	17.9	0.5	23.4	0.6	25.6	4.5	30.1	1.4
GOA Rex Sole	0.7	3.3	2.1	1.0	4.1	5.5	0.0	0.9	1.0	8.5
GOA Shallow Water Flatfish	0.0	6.3	4.7	4.2	0.3	1.4	1.2	3.4	0.0	0.3
GOA Skate, Longnose	4.7	212.8	4.6	91.7	3.5	118.8	0.0	48.3	1.1	44.4
GOA Thornyhead Rockfish	76.3	11.5	60.3	6.4	56.9	6.2	36.5	15.6	37.7	30.4
Greenland Turbot	91.3	7.2	117.9	22.7	229.6	6.9	126.5	2.4	57.4	5.9
Halibut	663.5	299.0	548.8	284.3	545.2	192.1	355.8	73.0	422.0	59.8
Northern Rockfish	1.4	-	1.1	1.0	0.9	0.5	0.7	0.0	0.0	2.6
Octopus	0.2	2.1	0.2	25.1	0.4	5.4	0.1	13.3	0.1	6.9
Other Rockfish	119.6	26.1	106.6	52.8	370.7	100.8	115.6	13.1	73.8	10.2
Pacific Cod	23.6	13.2	44.3	4.4	138.2	23.9	50.0	30.3	9.3	99.5
Pacific Ocean Perch	40.7	12.4	104.7	18.0	196.3	11.5	162.3	2.4	19.7	6.3
Pollock	26.3	13.0	139.0	15.4	325.7	32.9	247.3	10.7	210.4	130.4
Rock Sole	0.6	0.4	0.7	0.6	52.0	0.9	1.1	0.1	4.4	1.6
Rougheye Rockfish	98.7	35.2	105.2	18.9	78.7	17.7	56.0	12.9	40.0	21.7
Shortraker Rockfish	56.9	35.6	58.6	18.8	45.2	25.9	31.5	1.3	26.7	14.2

Table SM3.5. Bycatch of nontarget species and HAPC biota in the targeted sablefish fishery. Source: NMFS AKRO Blend/Catch Accounting System via AKFIN, October 29, 2026.

Species Group	2022	2023	2024	2025	2026
Eelpouts	10	20	80	69	32
Giant Grenadier	589	964	856	230	498
Grenadier - Rattail Grenadier Unidentified	143	147	47	23	28
Misc crabs	5	9	13	13	12
Misc fish	72	38	40	16	15
Sculpin	7	172	46	8	9
Sea anemone unidentified	4	9	17	11	6
Sea star	17	33	61	15	9
Snails	7	20	3	3	4
Squid	10	24	59	23	45
urchins dollars cucumbers	1	6	32	5	0

Table SM3.6. Prohibited Species Catch (PSC) estimates (in metric tons for halibut and numbers of animals for crab and salmon) by year and management (FMP) region for the sablefish target fishery. HAL is hook and line gear; POT is pot gear; and TRW is trawl gear. Source: NMFS Alaska Regional Office Catch Accounting System PSCNQ via AKFIN (www.akfin.org), accessed on October 29, 2026.

Gulf of Alaska

Species	Gear Type	2022	2023	2024	2025	2026
	HAL	16	29	16	-	-
Bairdi Tanner Crab	POT	481	71	25	-	200
	TRW	1,554	250	-	12	-
	HAL	-	-	-	-	-
Blue King Crab	POT	-	-	-	-	24
	TRW	-	-	-	-	-
	HAL	-	-	-	-	-
Chinook Salmon	POT	-	-	-	-	-
	TRW	-	-	-	1	-
	HAL	30	5	-	-	-
Golden (Brown) King Crab	POT	187	1,470	1,554	23,951	11,333
	TRW	-	16	-	12	659
	HAL	116	33	32	8	2
Halibut	POT	78	376	29	39	41
	TRW	18	4	77	5	5
	HAL	-	-	-	-	-
Herring	POT	-	-	-	-	-
	TRW	-	-	-	-	-
	HAL	11	-	-	-	-
Non-Chinook Salmon	POT	-	-	-	6	-
	TRW	-	-	-	1	-
	HAL	-	-	-	-	-
Opilio Tanner (Snow) Crab	POT	-	-	-	-	195
	TRW	-	-	-	-	-
	HAL	-	-	-	-	-
Red King Crab	POT	-	-	-	-	30
	TRW	-	-	-	-	-

Bering Sea/Aleutian Islands

Species	Gear Type	2022	2023	2024	2025	2026
	HAL	14	49	-	11	28
Bairdi Tanner Crab	POT	1,288	121	756	1,888	12
	TRW	69	1,223	2,054	572	2,795
	HAL	9	6	-	1	1
Blue King Crab	POT	-	-	-	-	-
	TRW	-	-	-	-	-
	HAL	-	-	-	-	-
Chinook Salmon	POT	-	-	-	-	-
	TRW	-	-	-	-	-
	HAL	2	1	46	-	7
Golden (Brown) King Crab	POT	10,341	22,668	13,307	-	63,893
	TRW	618	2,510	1,039	1,126	1,520
	HAL	-	-	-	-	4
Halibut	POT	13	8	15	8	20
	TRW	7	29	43	25	23
	HAL	-	-	-	-	-
Herring	POT	-	-	-	-	-
	TRW	-	-	1	1	4
	HAL	-	1	-	0	0
Non-Chinook Salmon	POT	-	-	-	-	-
	TRW	-	-	-	-	57
	HAL	44	204	7	11	25
Opilio Tanner (Snow) Crab	POT	1,675	1,167	2,244	652	17
	TRW	171	212	67	354	135
	HAL	2	3	-	8	2
Red King Crab	POT	-	25	2,483	-	-
	TRW	-	-	76	-	-

Additional Assessment Inputs and Outputs

Table SM3.7. Estimates of fork length (cm), weight (kg), and proportion mature by age and sex (bottom panel). The 2021 values represent estimates used in previous assessments as estimated in Echave (2021). The 2026 estimates represent the updated growth and weight estimates using all NOAA Longline Survey data from 1996 through 2025.

	Fork Length (cm)				Round Weight (kg)				Maturity
Age	**2021 Male**	**2026 Male**	**2021 Female**	**2026 Female**	**2021 Male**	**2026 Male**	**2021 Female**	**2026 Female**	**Female**
2	47.9	48.0	48.0	47.9	1.1	1.1	1.1	1.1	0.02
3	52.0	51.7	53.2	52.9	1.4	1.4	1.6	1.5	0.05
4	55.3	54.8	57.6	57.1	1.8	1.7	2.0	1.9	0.09
5	57.9	57.3	61.3	60.8	2.1	1.9	2.5	2.3	0.18
6	60.0	59.3	64.4	63.8	2.3	2.1	2.9	2.7	0.31
7	61.6	60.9	67.0	66.5	2.5	2.3	3.3	3.1	0.49
8	62.9	62.3	69.2	68.7	2.7	2.5	3.6	3.4	0.67
9	64.0	63.3	71.1	70.6	2.8	2.6	3.9	3.7	0.81
10	64.8	64.2	72.7	72.2	2.9	2.7	4.2	4.0	0.90
11	65.4	64.9	74.0	73.6	3.0	2.8	4.4	4.3	0.95
12	66.0	65.5	75.1	74.8	3.0	2.9	4.7	4.5	0.98
13	66.4	66.0	76.1	75.8	3.1	3.0	4.8	4.7	0.99
14	66.7	66.4	76.9	76.6	3.1	3.0	5.0	4.9	0.99
15	66.9	66.7	77.6	77.4	3.1	3.1	5.1	5.0	1.00
16	67.1	66.9	78.1	78.0	3.2	3.1	5.2	5.1	1.00
17	67.3	67.1	78.6	78.5	3.2	3.2	5.3	5.2	1.00
18	67.4	67.3	79.0	79.0	3.2	3.2	5.4	5.3	1.00
19	67.5	67.4	79.4	79.4	3.2	3.2	5.5	5.4	1.00
20	67.6	67.6	79.7	79.7	3.2	3.2	5.5	5.5	1.00
21	67.7	67.6	79.9	80.0	3.2	3.2	5.6	5.6	1.00
22	67.7	67.7	80.1	80.2	3.2	3.2	5.6	5.6	1.00
23	67.8	67.8	80.3	80.4	3.2	3.3	5.7	5.7	1.00
24	67.8	67.8	80.4	80.6	3.2	3.3	5.7	5.7	1.00
25	67.8	67.9	80.6	80.7	3.2	3.3	5.7	5.7	1.00
26	67.9	67.9	80.7	80.9	3.2	3.3	5.8	5.8	1.00
27	67.9	67.9	80.8	81.0	3.2	3.3	5.8	5.8	1.00
28	67.9	67.9	80.8	81.1	3.2	3.3	5.8	5.8	1.00
29	67.9	68.0	80.9	81.1	3.2	3.3	5.8	5.8	1.00
30	67.9	68.0	80.9	81.2	3.2	3.3	5.8	5.9	1.00
31+	67.9	68.0	81.0	81.3	3.2	3.3	5.8	5.9	1.00

Table SM3.8. Maximum likelihood estimation parameter values and standard errors from the inverse of the Hessian for all estimated parameters for Model *26.2_FAA*.

Parameter	Estimate	Std. Error
ln_global_R0	2.78	0.11
ln_InitDevs	-0.02	0.39
ln_InitDevs.1	-0.05	0.39
ln_InitDevs.2	-0.07	0.39
ln_InitDevs.3	-0.07	0.39
ln_InitDevs.4	-0.07	0.39
ln_InitDevs.5	-0.07	0.39
ln_InitDevs.6	-0.07	0.39
ln_InitDevs.7	-0.07	0.39
ln_InitDevs.8	-0.07	0.39
ln_InitDevs.9	-0.06	0.39
ln_InitDevs.10	-0.06	0.39
ln_InitDevs.11	-0.06	0.39
ln_InitDevs.12	-0.05	0.39
ln_InitDevs.13	-0.05	0.39
ln_InitDevs.14	-0.05	0.39
ln_InitDevs.15	-0.04	0.39
ln_InitDevs.16	-0.04	0.39
ln_InitDevs.17	-0.04	0.39
ln_InitDevs.18	-0.03	0.39
ln_InitDevs.19	-0.03	0.39
ln_InitDevs.20	-0.03	0.39
ln_InitDevs.21	-0.03	0.39
ln_InitDevs.22	-0.02	0.40
ln_InitDevs.23	-0.02	0.40
ln_InitDevs.24	-0.02	0.40
ln_InitDevs.25	-0.02	0.40
ln_InitDevs.26	-0.02	0.40
ln_InitDevs.27	-0.02	0.40
ln_RecDevs	0.00	0.40
ln_RecDevs.1	0.02	0.40
ln_RecDevs.2	0.06	0.41
ln_RecDevs.3	0.12	0.42
ln_RecDevs.4	0.19	0.44
ln_RecDevs.5	0.24	0.45
ln_RecDevs.6	0.26	0.45
ln_RecDevs.7	0.25	0.45
ln_RecDevs.8	0.21	0.44
ln_RecDevs.9	0.15	0.42
ln_RecDevs.10	0.08	0.41

ln_RecDevs.11	0.00	0.39
ln_RecDevs.12	-0.09	0.38
ln_RecDevs.13	-0.18	0.36
ln_RecDevs.14	-0.26	0.35
ln_RecDevs.15	-0.91	0.63
ln_RecDevs.16	-1.00	0.61
ln_RecDevs.17	-0.99	0.61
ln_RecDevs.18	-0.75	0.61
ln_RecDevs.19	0.08	0.57
ln_RecDevs.20	1.22	0.27
ln_RecDevs.21	-0.26	0.72
ln_RecDevs.22	0.13	0.71
ln_RecDevs.23	1.06	0.31
ln_RecDevs.24	-0.50	0.71
ln_RecDevs.25	-0.51	0.64
ln_RecDevs.26	-0.07	0.49
ln_RecDevs.27	-0.89	0.61
ln_RecDevs.28	-0.93	0.61
ln_RecDevs.29	-0.54	0.56
ln_RecDevs.30	-0.29	0.55
ln_RecDevs.31	-0.07	0.46
ln_RecDevs.32	-0.25	0.52
ln_RecDevs.33	-0.29	0.38
ln_RecDevs.34	-1.42	0.54
ln_RecDevs.35	-0.75	0.39
ln_RecDevs.36	-0.32	0.27
ln_RecDevs.37	-0.61	0.43
ln_RecDevs.38	0.09	0.25
ln_RecDevs.39	-0.42	0.41
ln_RecDevs.40	-0.70	0.44
ln_RecDevs.41	-0.23	0.37
ln_RecDevs.42	0.52	0.21
ln_RecDevs.43	-0.24	0.36
ln_RecDevs.44	-1.10	0.51
ln_RecDevs.45	-0.82	0.35
ln_RecDevs.46	-1.72	0.52
ln_RecDevs.47	-0.51	0.32
ln_RecDevs.48	-0.77	0.45
ln_RecDevs.49	-0.02	0.30
ln_RecDevs.50	-0.15	0.30
ln_RecDevs.51	-0.77	0.45
ln_RecDevs.52	-0.93	0.41
ln_RecDevs.53	-0.98	0.47
ln_RecDevs.54	-1.06	0.51

ln_RecDevs.55	-0.60	0.42
ln_RecDevs.56	1.37	0.17
ln_RecDevs.57	0.58	0.33
ln_RecDevs.58	1.39	0.23
ln_RecDevs.59	1.92	0.18
ln_RecDevs.60	-0.09	0.74
ln_RecDevs.61	-0.32	0.73
ln_RecDevs.62	1.09	0.41
ln_RecDevs.63	0.34	1.00
ln_RecDevs.64	1.07	0.61
ln_RecDevs.65	-0.07	0.87
ln_M	-2.43	0.07
ln_M.1	-2.43	0.08
ln_F_mean	-2.63	0.11
ln_F_mean.1	-4.20	0.12
ln_F_devs	-2.32	0.13
ln_F_devs.1	-0.67	0.13
ln_F_devs.2	-0.14	0.13
ln_F_devs.3	-1.01	0.13
ln_F_devs.4	-2.16	0.13
ln_F_devs.5	-3.46	0.13
ln_F_devs.6	-2.02	0.13
ln_F_devs.7	-1.99	0.13
ln_F_devs.8	-0.92	0.13
ln_F_devs.9	-0.56	0.13
ln_F_devs.10	-0.11	0.13
ln_F_devs.11	-0.03	0.13
ln_F_devs.12	0.28	0.12
ln_F_devs.13	0.18	0.13
ln_F_devs.14	0.36	0.12
ln_F_devs.15	0.35	0.12
ln_F_devs.16	0.53	0.12
ln_F_devs.17	0.33	0.12
ln_F_devs.18	-0.33	0.12
ln_F_devs.19	-0.15	0.12
ln_F_devs.20	-0.32	0.12
ln_F_devs.21	-0.08	0.13
ln_F_devs.22	-0.32	0.12
ln_F_devs.23	-0.44	0.12
ln_F_devs.24	-0.50	0.12
ln_F_devs.25	-0.37	0.12
ln_F_devs.26	0.08	0.12
ln_F_devs.27	0.36	0.11
ln_F_devs.28	0.52	0.11

ln_F_devs.29	0.59	0.11
ln_F_devs.30	0.64	0.11
ln_F_devs.31	0.66	0.11
ln_F_devs.32	0.64	0.11
ln_F_devs.33	0.79	0.11
ln_F_devs.34	0.75	0.11
ln_F_devs.35	0.68	0.11
ln_F_devs.36	0.60	0.11
ln_F_devs.37	0.53	0.11
ln_F_devs.38	0.52	0.11
ln_F_devs.39	0.48	0.11
ln_F_devs.40	0.61	0.11
ln_F_devs.41	0.50	0.11
ln_F_devs.42	0.54	0.11
ln_F_devs.43	0.67	0.12
ln_F_devs.44	0.68	0.12
ln_F_devs.45	0.58	0.12
ln_F_devs.46	0.54	0.11
ln_F_devs.47	0.63	0.11
ln_F_devs.48	0.62	0.11
ln_F_devs.49	0.57	0.11
ln_F_devs.50	0.52	0.12
ln_F_devs.51	0.57	0.12
ln_F_devs.52	0.60	0.12
ln_F_devs.53	0.59	0.12
ln_F_devs.54	0.44	0.12
ln_F_devs.55	0.42	0.12
ln_F_devs.56	0.37	0.12
ln_F_devs.57	0.43	0.14
ln_F_devs.58	0.25	0.22
ln_F_devs.59	0.02	0.23
ln_F_devs.60	-0.29	0.23
ln_F_devs.61	-0.24	0.24
ln_F_devs.62	-0.19	0.20
ln_F_devs.63	-0.38	0.15
ln_F_devs.64	-0.53	0.14
ln_F_devs.65	-0.50	0.14
ln_F_devs.66	-0.44	0.14
ln_F_devs.67	-0.04	0.14
ln_F_devs.68	-0.49	0.14
ln_F_devs.69	0.17	0.13
ln_F_devs.70	0.57	0.13
ln_F_devs.71	0.84	0.13
ln_F_devs.72	1.12	0.13

ln_F_devs.73	1.24	0.12
ln_F_devs.74	0.95	0.12
ln_F_devs.75	1.33	0.12
ln_F_devs.76	1.60	0.12
ln_F_devs.77	1.12	0.12
ln_F_devs.78	0.80	0.12
ln_F_devs.79	0.56	0.12
ln_F_devs.80	0.62	0.12
ln_F_devs.81	-0.19	0.12
ln_F_devs.82	-0.86	0.12
ln_F_devs.83	-0.61	0.12
ln_F_devs.84	-0.38	0.12
ln_F_devs.85	-0.78	0.13
ln_F_devs.86	-0.73	0.11
ln_F_devs.87	-0.92	0.12
ln_F_devs.88	-0.18	0.12
ln_F_devs.89	-1.14	0.11
ln_F_devs.90	0.45	0.11
ln_F_devs.91	0.54	0.11
ln_F_devs.92	0.83	0.11
ln_F_devs.93	0.74	0.11
ln_F_devs.94	0.41	0.11
ln_F_devs.95	0.08	0.11
ln_F_devs.96	0.07	0.11
ln_F_devs.97	-0.02	0.11
ln_F_devs.98	0.21	0.11
ln_F_devs.99	0.19	0.11
ln_F_devs.100	0.09	0.11
ln_F_devs.101	-0.17	0.11
ln_F_devs.102	-0.25	0.11
ln_F_devs.103	0.01	0.11
ln_F_devs.104	0.02	0.11
ln_F_devs.105	-0.08	0.11
ln_F_devs.106	0.12	0.11
ln_F_devs.107	-0.05	0.12
ln_F_devs.108	-0.29	0.11
ln_F_devs.109	-0.32	0.11
ln_F_devs.110	-0.49	0.11
ln_F_devs.111	-0.42	0.11
ln_F_devs.112	-0.46	0.11
ln_F_devs.113	-0.50	0.11
ln_F_devs.114	-0.58	0.11
ln_F_devs.115	-0.46	0.11
ln_F_devs.116	-0.51	0.11

ln_F_devs.117	-0.53	0.11
ln_F_devs.118	-0.50	0.11
ln_F_devs.119	-0.40	0.11
ln_F_devs.120	-0.27	0.14
ln_F_devs.121	-0.09	0.17
ln_F_devs.122	0.18	0.13
ln_F_devs.123	0.18	0.15
ln_F_devs.124	0.24	0.15
ln_F_devs.125	-0.29	0.12
ln_F_devs.126	-0.23	0.13
ln_F_devs.127	-0.25	0.13
ln_F_devs.128	-0.31	0.13
ln_F_devs.129	-0.66	0.13
ln_F_devs.130	-0.80	0.13
fish_fixed_sel_pars	1.25	0.10
fish_fixed_sel_pars.1	0.94	0.58
fish_fixed_sel_pars.2	1.17	0.25
fish_fixed_sel_pars.3	0.39	0.60
fish_fixed_sel_pars.4	0.84	0.17
fish_fixed_sel_pars.5	1.69	0.99
fish_fixed_sel_pars.6	1.20	0.28
fish_fixed_sel_pars.7	0.38	0.67
fish_fixed_sel_pars.8	0.38	0.35
fish_fixed_sel_pars.9	1.04	1.24
fish_fixed_sel_pars.10	0.41	0.33
fish_fixed_sel_pars.11	1.26	1.06
srv_fixed_sel_pars	1.10	0.07
srv_fixed_sel_pars.1	1.61	0.78
srv_fixed_sel_pars.2	0.50	0.20
srv_fixed_sel_pars.3	2.12	0.70
srv_fixed_sel_pars.4	1.20	0.08
srv_fixed_sel_pars.5	1.69	0.88
srv_fixed_sel_pars.6	0.66	0.09
srv_fixed_sel_pars.7	1.76	0.76
srv_fixed_sel_pars.8	0.91	0.12
srv_fixed_sel_pars.9	2.25	0.62
srv_fixed_sel_pars.10	0.38	0.18
srv_fixed_sel_pars.11	1.75	0.60
srv_fixed_sel_pars.12	1.07	0.04
srv_fixed_sel_pars.13	1.67	0.73

Table SM3.9. Number (in millions of fish) of sablefish estimated by Model *26.2_FAA* by age and year. Columns are age with age-31+ being the plus group. The terminal year plus one (2027) numbers are incremented based on the terminal year (2026) mortality and recruitment is set at 0.

Year	Sex	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31+
1960	Female	8.0	7.2	6.4	5.8	5.2	4.7	4.3	3.9	3.6	3.3	3.0	2.7	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.7
1961	Female	8.2	7.3	6.6	5.9	5.2	4.7	4.3	3.9	3.6	3.2	3.0	2.7	2.5	2.2	2.0	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.7
1962	Female	8.5	7.5	6.7	6.0	5.2	4.6	4.2	3.8	3.4	3.1	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	5.5
1963	Female	9.0	7.8	6.8	6.0	5.2	4.5	4.0	3.6	3.3	3.0	2.7	2.5	2.2	2.0	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	5.2
1964	Female	9.7	8.2	7.0	6.1	5.3	4.6	3.9	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.5	5.0
1965	Female	10.2	8.9	7.5	6.4	5.5	4.8	4.1	3.6	3.2	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	5.0
1966	Female	10.4	9.3	8.0	6.7	5.7	5.0	4.3	3.7	3.2	2.8	2.6	2.3	2.1	1.9	1.7	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	4.9
1967	Female	10.3	9.5	8.3	7.1	6.0	5.1	4.4	3.8	3.3	2.8	2.5	2.3	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	4.8
1968	Female	9.9	9.3	8.4	7.3	6.3	5.2	4.4	3.8	3.3	2.9	2.5	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	4.6
1969	Female	9.4	9.0	8.2	7.3	6.3	5.3	4.4	3.8	3.3	2.8	2.4	2.1	1.9	1.7	1.5	1.4	1.3	1.2	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	4.3
1970	Female	8.7	8.5	7.9	7.1	6.2	5.2	4.4	3.7	3.1	2.7	2.4	2.0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	3.9
1971	Female	8.1	7.9	7.5	6.8	5.9	5.1	4.3	3.7	3.1	2.6	2.3	2.0	1.7	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.3	3.6
1972	Female	7.3	7.3	6.9	6.4	5.6	4.8	4.1	3.5	3.0	2.5	2.1	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	3.2
1973	Female	6.7	6.6	6.3	5.8	5.1	4.3	3.7	3.2	2.7	2.3	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	2.7
1974	Female	6.2	6.1	5.8	5.4	4.7	4.1	3.5	3.0	2.6	2.2	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	2.4
1975	Female	3.2	5.6	5.4	5.1	4.4	3.8	3.2	2.8	2.4	2.0	1.7	1.5	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	2.1
1976	Female	3.0	2.9	5.0	4.7	4.2	3.5	3.0	2.6	2.2	1.9	1.6	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.8
1977	Female	3.0	2.7	2.6	4.4	3.8	3.3	2.8	2.4	2.1	1.8	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	1.6
1978	Female	3.8	2.7	2.4	2.3	3.7	3.1	2.7	2.3	2.0	1.7	1.4	1.2	1.1	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	1.4
1979	Female	8.7	3.5	2.5	2.2	2.0	3.2	2.7	2.3	2.0	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	1.3
1980	Female	27.2	8.0	3.1	2.2	1.9	1.7	2.7	2.3	2.0	1.7	1.4	1.2	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.3
1981	Female	6.2	24.8	7.2	2.8	1.9	1.6	1.5	2.3	2.0	1.7	1.5	1.2	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2
1982	Female	9.1	5.7	22.6	6.5	2.4	1.6	1.4	1.3	2.0	1.7	1.5	1.2	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1983	Female	23.2	8.3	5.1	20.3	5.7	2.1	1.4	1.2	1.1	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1984	Female	4.9	21.3	7.6	4.6	17.8	4.9	1.8	1.2	1.0	0.9	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1985	Female	4.8	4.4	19.2	6.8	4.1	15.4	4.3	1.6	1.1	0.9	0.8	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1986	Female	7.5	4.4	4.0	17.4	6.0	3.5	13.4	3.7	1.4	0.9	0.8	0.7	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.9
1987	Female	3.3	6.8	3.9	3.6	14.6	4.9	2.9	11.1	3.1	1.1	0.8	0.6	0.6	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.8
1988	Female	3.2	3.0	6.1	3.4	2.9	11.8	4.0	2.3	8.9	2.5	0.9	0.6	0.5	0.5	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1989	Female	4.7	2.9	2.7	5.2	2.8	2.3	9.2	3.1	1.8	7.0	1.9	0.7	0.5	0.4	0.4	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1990	Female	6.0	4.2	2.6	2.3	4.2	2.2	1.8	7.2	2.4	1.4	5.5	1.5	0.6	0.4	0.3	0.3	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1991	Female	7.5	5.5	3.8	2.2	1.8	3.3	1.7	1.4	5.6	1.9	1.1	4.3	1.2	0.4	0.3	0.2	0.2	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.5
1992	Female	6.3	6.8	4.9	3.3	1.8	1.4	2.6	1.3	1.1	4.4	1.5	0.9	3.3	0.9	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1993	Female	6.0	5.7	6.1	4.3	2.7	1.4	1.1	2.0	1.0	0.9	3.5	1.2	0.7	2.6	0.7	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1994	Female	1.9	5.5	5.1	5.4	3.4	2.1	1.1	0.9	1.6	0.8	0.7	2.7	0.9	0.5	2.0	0.6	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1995	Female	3.8	1.8	4.9	4.5	4.3	2.7	1.6	0.8	0.7	1.2	0.6	0.5	2.1	0.7	0.4	1.6	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1996	Female	5.8	3.5	1.6	4.3	3.6	3.3	2.1	1.3	0.7	0.5	0.9	0.5	0.4	1.6	0.5	0.3	1.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.3
1997	Female	4.4	5.3	3.1	1.4	3.5	2.9	2.6	1.6	1.0	0.5	0.4	0.7	0.4	0.3	1.3	0.4	0.3	1.0	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2
1998	Female	8.8	4.0	4.8	2.8	1.1	2.8	2.3	2.1	1.3	0.8	0.4	0.3	0.6	0.3	0.3	1.0	0.3	0.2	0.8	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2
1999	Female	5.3	8.0	3.6	4.2	2.3	0.9	2.2	1.8	1.7	1.1	0.6	0.3	0.3	0.5	0.2	0.2	0.8	0.3	0.2	0.6	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
2000	Female	4.0	4.8	7.2	3.2	3.5	1.8	0.7	1.8	1.5	1.4	0.8	0.5	0.3	0.2	0.4	0.2	0.2	0.7	0.2	0.1	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2001	Female	6.4	3.6	4.3	6.3	2.6	2.8	1.4	0.6	1.4	1.2	1.1	0.7	0.4	0.2	0.2	0.3	0.2	0.1	0.5	0.2	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2002	Female	13.4	5.8	3.3	3.8	5.2	2.1	2.2	1.2	0.5	1.1	0.9	0.9	0.5	0.3	0.2	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2
2003	Female	6.3	12.3	5.2	2.9	3.1	4.1	1.6	1.8	0.9	0.4	0.9	0.7	0.7	0.4	0.3	0.1	0.1	0.2	0.1	0.1	0.3	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.2
2004	Female	2.7	5.8	11.1	4.6	2.3	2.5	3.3	1.3	1.4	0.7	0.3	0.7	0.6	0.5	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.1
2005	Female	3.5	2.4	5.2	9.7	3.7	1.8	1.9	2.6	1.0	1.1	0.6	0.2	0.6	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.1
2006	Female	1.4	3.2	2.2	4.6	7.9	3.0	1.5	1.5	2.0	0.8	0.9	0.5	0.2	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.1
2007	Female	4.8	1.3	2.9	1.9	3.8	6.4	2.4	1.2	1.2	1.6	0.6	0.7	0.4	0.1	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
2008	Female	3.7	4.4	1.2	2.6	1.6	3.0	5.1	1.9	0.9	1.0	1.3	0.5	0.5	0.3	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1
2009	Female	7.9	3.4	4.0	1.1	2.1	1.3	2.4	4.0	1.5	0.7	0.8	1.0	0.4	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
2010	Female	6.9	7.2	3.1	3.5	0.9	1.7	1.0	1.9	3.2	1.2	0.6	0.6	0.8	0.3	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
2011	Female	3.7	6.3	6.5	2.7	2.9	0.7	1.4	0.8	1.5	2.6	1.0	0.5	0.5	0.7	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
2012	Female	3.2	3.4	5.7	5.8	2.2	2.3	0.6	1.1	0.7	1.2	2.1	0.8	0.4	0.4	0.5	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2013	Female	3.0	2.9	3.1	5.0	4.7	1.8	1.8	0.4	0.9	0.5	1.0	1.6	0.6	0.3	0.3	0.4	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	Female	2.8	2.7	2.6	2.7	4.1	3.8	1.4	1.5	0.4	0.7	0.4	0.8	1.3	0.5	0.2	0.3	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2015	Female	4.4	2.5	2.5	2.3	2.2	3.4	3.1	1.1	1.2	0.3	0.6	0.3	0.6	1.1	0.4	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2016	Female	31.6	4.0	2.3	2.2	1.9	1.8	2.7	2.5	0.9	1.0	0.2	0.5	0.3	0.5	0.9	0.3	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2017	Female	14.3	28.8	3.6	2.0	1.8	1.6	1.5	2.2	2.0	0.8	0.8	0.2	0.4	0.2	0.4	0.7	0.3	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2018	Female	32.3	13.0	25.7	3.1	1.7	1.5	1.3	1.2	1.8	1.6	0.6	0.6	0.2	0.3	0.2	0.3	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2019	Female	55.0	29.4	11.6	22.2	2.6	1.4	1.2	1.1	1.0	1.5	1.4	0.5	0.5	0.1	0.2	0.1	0.3	0.5	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1

2020	Female	7.3	50.0	26.3	10.1	18.9	2.2	1.1	1.0	0.9	0.8	1.2	1.1	0.4	0.4	0.1	0.2	0.1	0.2	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2021	Female	5.8	6.7	44.8	23.1	8.7	16.2	1.9	1.0	0.9	0.8	0.7	1.1	1.0	0.4	0.4	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2022	Female	23.9	5.3	6.0	39.6	20.0	7.5	13.8	1.6	0.8	0.8	0.6	0.6	0.9	0.8	0.3	0.3	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
2023	Female	11.3	21.8	4.8	5.3	34.3	17.2	6.4	11.8	1.4	0.7	0.6	0.5	0.5	0.8	0.7	0.3	0.3	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
2024	Female	23.4	10.3	19.7	4.2	4.6	29.6	14.8	5.5	10.2	1.2	0.6	0.6	0.5	0.4	0.7	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.1
2025	Female	7.5	21.3	9.3	17.5	3.7	4.0	25.7	12.8	4.8	8.8	1.0	0.5	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1
2026	Female	8.0	6.9	19.3	8.3	15.4	3.2	3.5	22.4	11.2	4.2	7.7	0.9	0.5	0.4	0.4	0.3	0.5	0.5	0.2	0.2	0.0	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.1
2027	Female	0.0	7.3	6.2	17.2	7.3	13.4	2.8	3.0	19.5	9.7	3.6	6.7	0.8	0.4	0.4	0.3	0.3	0.4	0.4	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1
1960	Male	8.0	7.2	6.4	5.7	5.2	4.7	4.3	3.9	3.5	3.2	2.9	2.7	2.5	2.2	2.0	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.7
1961	Male	8.2	7.3	6.6	5.8	5.2	4.7	4.3	3.9	3.5	3.2	2.9	2.7	2.4	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.7
1962	Male	8.5	7.5	6.7	5.8	5.1	4.6	4.2	3.8	3.4	3.1	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	5.5
1963	Male	9.0	7.8	6.8	5.7	5.0	4.4	4.0	3.6	3.2	3.0	2.7	2.4	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	5.2
1964	Male	9.7	8.3	7.0	6.0	5.0	4.4	3.9	3.5	3.1	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.5	5.0
1965	Male	10.2	8.9	7.5	6.3	5.4	4.5	4.0	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	5.0
1966	Male	10.4	9.3	8.0	6.7	5.7	4.8	4.1	3.5	3.1	2.8	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	4.9
1967	Male	10.3	9.5	8.3	7.1	5.9	5.0	4.3	3.6	3.1	2.8	2.5	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	4.8
1968	Male	9.9	9.4	8.4	7.3	6.2	5.2	4.4	3.7	3.2	2.7	2.4	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	4.6
1969	Male	9.4	9.0	8.2	7.2	6.2	5.3	4.4	3.7	3.2	2.7	2.3	2.1	1.9	1.7	1.5	1.4	1.3	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	4.3
1970	Male	8.7	8.5	7.8	6.9	6.0	5.2	4.4	3.7	3.1	2.7	2.2	1.9	1.7	1.5	1.4	1.3	1.2	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	3.9
1971	Male	8.1	8.0	7.5	6.5	5.7	4.9	4.3	3.6	3.1	2.6	2.2	1.9	1.6	1.4	1.3	1.2	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.3	3.6
1972	Male	7.3	7.3	6.9	6.0	5.2	4.6	4.0	3.4	2.9	2.5	2.1	1.8	1.5	1.3	1.2	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	3.2
1973	Male	6.7	6.7	6.2	5.3	4.7	4.1	3.5	3.1	2.7	2.3	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	2.7
1974	Male	6.2	6.1	5.8	5.0	4.3	3.7	3.3	2.8	2.5	2.1	1.8	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	2.4
1975	Male	3.2	5.6	5.4	4.6	4.0	3.4	3.0	2.6	2.3	2.0	1.7	1.5	1.2	1.0	0.9	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	2.1
1976	Male	3.0	2.9	5.0	4.3	3.7	3.2	2.8	2.4	2.1	1.8	1.6	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.8
1977	Male	3.0	2.7	2.6	3.9	3.4	2.9	2.5	2.2	1.9	1.7	1.4	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	1.6
1978	Male	3.8	2.7	2.4	2.1	3.2	2.8	2.4	2.1	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	1.4
1979	Male	8.7	3.5	2.5	2.1	1.8	2.8	2.4	2.1	1.8	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	1.3
1980	Male	27.2	8.0	3.1	2.1	1.8	1.6	2.4	2.1	1.8	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.3
1981	Male	6.2	24.9	7.2	2.7	1.8	1.5	1.3	2.0	1.8	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2
1982	Male	9.1	5.7	22.4	6.1	2.3	1.5	1.3	1.1	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1983	Male	23.2	8.4	5.1	19.4	5.3	2.0	1.3	1.1	1.0	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1984	Male	4.9	21.3	7.6	4.5	16.8	4.6	1.7	1.2	1.0	0.9	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1985	Male	4.8	4.4	19.1	6.6	3.9	14.6	4.0	1.5	1.0	0.8	0.7	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1986	Male	7.5	4.4	4.0	16.6	5.7	3.3	12.7	3.5	1.3	0.9	0.7	0.6	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.9
1987	Male	3.3	6.8	3.9	3.3	13.8	4.7	2.8	10.5	2.9	1.1	0.7	0.6	0.5	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.8
1988	Male	3.2	3.0	6.0	3.2	2.7	11.1	3.8	2.2	8.4	2.3	0.9	0.6	0.5	0.4	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1989	Male	4.7	2.9	2.6	4.7	2.5	2.1	8.7	3.0	1.8	6.6	1.8	0.7	0.5	0.4	0.3	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1990	Male	6.0	4.3	2.5	2.0	3.7	1.9	1.6	6.8	2.3	1.4	5.2	1.4	0.5	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.6
1991	Male	7.5	5.5	3.7	2.0	1.6	2.9	1.5	1.3	5.3	1.8	1.1	4.0	1.1	0.4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.5
1992	Male	6.3	6.8	4.9	2.9	1.6	1.3	2.3	1.2	1.0	4.2	1.4	0.8	3.2	0.9	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1993	Male	6.0	5.7	6.0	3.8	2.3	1.2	1.0	1.8	0.9	0.8	3.3	1.1	0.7	2.5	0.7	0.3	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1994	Male	1.9	5.5	5.0	4.7	3.0	1.8	0.9	0.8	1.4	0.7	0.6	2.5	0.9	0.5	1.9	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1995	Male	3.8	1.8	4.8	3.9	3.6	2.3	1.4	0.7	0.6	1.1	0.6	0.5	1.9	0.7	0.4	1.5	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.3
1996	Male	5.8	3.5	1.6	3.8	3.1	2.8	1.8	1.1	0.6	0.5	0.8	0.4	0.4	1.5	0.5	0.3	1.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.3
1997	Male	4.4	5.3	3.1	1.2	3.0	2.4	2.2	1.4	0.9	0.4	0.4	0.7	0.3	0.3	1.2	0.4	0.2	0.9	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.2
1998	Male	8.8	4.0	4.7	2.5	1.0	2.4	1.9	1.8	1.1	0.7	0.4	0.3	0.5	0.3	0.2	1.0	0.3	0.2	0.7	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
1999	Male	5.3	8.0	3.5	3.8	2.0	0.8	1.9	1.6	1.4	0.9	0.5	0.3	0.2	0.4	0.2	0.2	0.8	0.3	0.2	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2000	Male	4.0	4.8	7.1	2.9	3.1	1.6	0.6	1.5	1.2	1.1	0.7	0.4	0.2	0.2	0.3	0.2	0.2	0.6	0.2	0.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2001	Male	6.4	3.6	4.3	5.6	2.3	2.4	1.3	0.5	1.2	1.0	0.9	0.6	0.3	0.2	0.1	0.3	0.1	0.1	0.5	0.2	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2002	Male	13.4	5.8	3.2	3.4	4.5	1.8	1.9	1.0	0.4	1.0	0.8	0.7	0.5	0.3	0.1	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2
2003	Male	6.3	12.3	5.2	2.6	2.7	3.6	1.4	1.5	0.8	0.3	0.8	0.6	0.6	0.4	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1
2004	Male	2.7	5.8	10.9	4.1	2.0	2.1	2.8	1.1	1.2	0.6	0.3	0.6	0.5	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.1
2005	Male	3.5	2.4	5.1	8.6	3.2	1.6	1.7	2.2	0.9	1.0	0.5	0.2	0.5	0.4	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1
2006	Male	1.4	3.2	2.2	4.1	6.8	2.5	1.3	1.3	1.8	0.7	0.8	0.4	0.2	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.1
2007	Male	4.8	1.3	2.9	1.7	3.3	5.5	2.0	1.0	1.1	1.4	0.6	0.6	0.3	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
2008	Male	3.7	4.4	1.2	2.3	1.4	2.6	4.3	1.6	0.8	0.9	1.1	0.5	0.5	0.3	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1
2009	Male	7.9	3.4	3.9	0.9	1.8	1.1	2.1	3.4	1.3	0.6	0.7	0.9	0.4	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
2010	Male	6.9	7.2	3.0	3.1	0.7	1.5	0.9	1.7	2.8	1.0	0.5	0.5	0.7	0.3	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
2011	Male	3.7	6.3	6.4	2.4	2.5	0.6	1.2	0.7	1.3	2.2	0.8	0.4	0.4	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2012	Male	3.2	3.4	5.6	5.2	1.9	2.0	0.5	0.9	0.6	1.1	1.8	0.7	0.3	0.3	0.5	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2013	Male	3.0	2.9	3.0	4.5	4.1	1.5	1.6	0.4	0.7	0.5	0.8	1.4	0.5	0.3	0.3	0.4	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	Male	2.8	2.7	2.6	2.4	3.6	3.3	1.2	1.3	0.3	0.6	0.4	0.7	1.1	0.4	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2015	Male	4.4	2.5	2.5	2.1	2.0	2.9	2.7	1.0	1.0	0.2	0.5	0.3	0.5	0.9	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2016	Male	31.6	4.0	2.3	2.0	1.7	1.6	2.4	2.2	0.8	0.8	0.2	0.4	0.2	0.4	0.7	0.3	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2017	Male	14.3	28.8	3.6	2.0	1.7	1.4	1.3	1.9	1.8	0.7	0.7	0.2	0.3	0.2	0.4	0.6	0.2	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2018	Male	32.3	13.0	25.7	3.1	1.6	1.4	1.1	1.1	1.6	1.4	0.5	0.6	0.1	0.3	0.2	0.3	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1

2019	Male	55.0	29.5	11.6	22.3	2.6	1.4	1.1	0.9	0.9	1.3	1.2	0.4	0.5	0.1	0.2	0.1	0.2	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2020	Male	7.3	50.1	26.3	10.1	19.0	2.2	1.1	0.9	0.8	0.7	1.1	1.0	0.4	0.4	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2021	Male	5.8	6.7	44.8	23.2	8.8	16.3	1.9	1.0	0.8	0.7	0.6	0.9	0.8	0.3	0.3	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
2022	Male	23.9	5.3	6.0	39.7	20.1	7.5	14.0	1.6	0.8	0.7	0.6	0.5	0.8	0.7	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1
2023	Male	11.3	21.8	4.8	5.3	34.4	17.3	6.4	11.9	1.4	0.7	0.6	0.5	0.5	0.7	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.1
2024	Male	23.4	10.3	19.7	4.3	4.6	29.8	14.9	5.5	10.3	1.2	0.6	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1
2025	Male	7.5	21.3	9.3	17.5	3.7	4.0	25.9	12.9	4.8	8.9	1.0	0.5	0.4	0.4	0.3	0.5	0.5	0.2	0.2	0.0	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.1
2026	Male	8.0	6.9	19.3	8.3	15.4	3.3	3.5	22.5	11.2	4.2	7.8	0.9	0.5	0.4	0.3	0.3	0.4	0.4	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1
2027	Male	0.0	7.3	6.2	17.3	7.3	13.5	2.8	3.1	19.6	9.8	3.6	6.7	0.8	0.4	0.3	0.3	0.3	0.4	0.3	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1

Summary Tables and BRDs for Alternative Models: Model *25.12*

Table SM3.10. Summary table for Model *25.12*.

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *25.12*:	
	2025	2026*	2027	2028^
M Female (estimated)[#]	0.11		0.10	
M Male (estimated)	--		0.10	
Average Recruitment (millions)	26		21	
Tier	3a		3a	
Projected Total Biomass (Age 2+; t)	704,713	695,681	651,327	642,525
Projected Female Spawning Biomass (t)	219,714	241,217	252,158	260,404
$B_{100\%}$ (t)	302,672	302,672	330,434	330,434
$B_{40\%}$ (t)	121,069	121,069	132,173	132,173
$B_{35\%}$ (t)	105,935	105,935	115,652	115,652
F_{OFL}	0.10	0.10	0.10	0.10
$maxF_{ABC}$	0.09	0.09	0.08	0.08
Whale Depredation (t)	171	169	131	131
OFL (t)	58,731	57,993	50,570	49,907
OFL_w (t)* **	58,532	57,797	50,439	49,776
max ABC (t)	50,283	49,651	43,057	42,492
ABC (t)	47,605	47,008	43,057	42,492
ABC_w (t)* **	**50,111**	**49,482**	42,926	42,361
Status	As determined *last* year for:		As determined *this* year for:	
	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 t in 2025 (a yield ratio of 0.49 was assumed). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.
**The 2026 SAFE Model *25.12* projections were based on specified catch of 24,000 t in 2027 (a yield ratio of 0.53 was assumed based on the three-year average of catch to ABC from completed fishing years, 2023 – 2025).
[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.
***ABC_w and OFL_w are the final author recommended ABCs and OFLs after accounting for whale depredation.

Table SM3.11. BRDs by apportionment method for Model *25.12*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	13,037	11,421	22,550	4,687	9,622	2,652	5,589	47,008
2027	*Carryover_No_wAI*	12,878	8,585	21,463	4,722	9,014	2,576	5,151	42,926
2027	*REMA_LLS_No_wAI*	12,019	9,873	21,034	4,293	9,014	2,576	5,151	42,926
2027	*Carryover*	11,590	11,160	20,175	4,293	8,585	2,576	4,722	42,926
2027	*REMA_LLS*	11,161	12,878	18,887	3,863	8,156	2,146	4,722	42,926
2027	*GOA_Fix*	12,878	10,302	19,746	3,863	8,585	2,146	5,152	42,926
2028	*Carryover_No_wAI*	12,708	8,472	21,181	4,660	8,896	2,542	5,083	42,361
2028	*REMA_LLS_No_wAI*	11,861	9,743	20,757	4,236	8,896	2,542	5,083	42,361
2028	*Carryover*	11,437	11,014	19,910	4,236	8,472	2,542	4,660	42,361
2028	*REMA_LLS*	11,014	12,708	18,639	3,812	8,049	2,118	4,660	42,361
2028	*GOA_Fix*	12,708	10,167	19,486	3,812	8,472	2,118	5,084	42,361

Table SM3.12. Percent Change in BRDs by apportionment method for Model *25.12*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	0%	0%	0%	0%	0%	0%	0%	0%
2027	*Carryover_No_wAI*	-1%	-25%	-5%	1%	-6%	-3%	-8%	-9%
2027	*REMA_LLS_No_wAI*	-8%	-14%	-7%	-8%	-6%	-3%	-8%	-9%
2027	*Carryover*	-11%	-2%	-11%	-8%	-11%	-3%	-16%	-9%
2027	*REMA_LLS*	-14%	13%	-16%	-18%	-15%	-19%	-16%	-9%
2027	*GOA_Fix*	-1%	-10%	-12%	-18%	-11%	-19%	-8%	-9%
2028	*Carryover_No_wAI*	-3%	-26%	-6%	-1%	-8%	-4%	-9%	-10%
2028	*REMA_LLS_No_wAI*	-9%	-15%	-8%	-10%	-8%	-4%	-9%	-10%
2028	*Carryover*	-12%	-4%	-12%	-10%	-12%	-4%	-17%	-10%
2028	*REMA_LLS*	-16%	11%	-17%	-19%	-16%	-20%	-17%	-10%
2028	*GOA_Fix*	-3%	-11%	-14%	-19%	-12%	-20%	-9%	-10%

Summary Tables and BRDs for Alternative Models: Model *26.1_1Reg*

Table SM3.13. Summary table for Model *26.1_1Reg*.

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *26.1_1Reg*:	
	2025	2026*	2027	2028^
M Female (estimated)[#]	0.11		0.09	
M Male (estimated)	--		0.09	
Average Recruitment (millions)	26		21	
Tier	3a		3a	
Projected Total Biomass (Age 2+; t)	704,713	695,681	647,221	643,401
Projected Female Spawning Biomass (t)	219,714	241,217	251,836	263,641
$B_{100\%}$ (t)	302,672	302,672	354,569	354,569
$B_{40\%}$ (t)	121,069	121,069	141,828	141,828
$B_{35\%}$ (t)	105,935	105,935	124,099	124,099
F_{OFL}	0.10	0.10	0.09	0.09
$maxF_{ABC}$	0.09	0.09	0.07	0.07
Whale Depredation (t)	171	169	131	131
OFL (t)	58,731	57,993	47,250	46,922
OFL_w (t)* **	58,532	57,797	47,119	46,791
max ABC (t)	50,283	49,651	40,173	39,895
ABC (t)	47,605	47,008	40,173	39,895
ABC_w (t)* **	**50,111**	**49,482**	40,042	39,764
Status	As determined *last* year for:		As determined *this* year for:	
	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 t in 2025 (a yield ratio of 0.49 was assumed). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.

**The 2026 SAFE Model *26.1_1Reg* projections were based on specified catch of 22,000 t in 2027 (a yield ratio of 0.53 was assumed based on the three-year average of catch to ABC from completed fishing years, 2023 – 2025).

[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.

***ABC_w and OFL_w are the final author recommended ABCs and OFLs after accounting for whale depredation.

Table SM3.14. BRDs by apportionment method for Model *26.1_1Reg*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	13,037	11,421	22,550	4,687	9,622	2,652	5,589	47,008
2027	*Carryover_No_wAI*	12,013	8,007	20,021	4,405	8,409	2,403	4,805	40,042
2027	*REMA_LLS_No_wAI*	11,212	9,209	19,621	4,004	8,409	2,403	4,805	40,042
2027	*Carryover*	10,811	10,411	18,820	4,004	8,008	2,403	4,405	40,042
2027	*REMA_LLS*	10,411	12,012	17,618	3,604	7,608	2,002	4,405	40,042
2027	*GOA_Fix*	12,013	9,610	18,419	3,604	8,008	2,002	4,805	40,042
2028	*Carryover_No_wAI*	11,929	7,953	19,882	4,374	8,350	2,386	4,772	39,764
2028	*REMA_LLS_No_wAI*	11,134	9,146	19,484	3,976	8,350	2,386	4,772	39,764
2028	*Carryover*	10,736	10,339	18,689	3,976	7,953	2,386	4,374	39,764
2028	*REMA_LLS*	10,339	11,929	17,496	3,579	7,555	1,988	4,374	39,764
2028	*GOA_Fix*	11,929	9,543	18,291	3,579	7,953	1,988	4,772	39,764

Table SM3.15. Percent Change in BRDs by apportionment method for Model *26.1_1Reg*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	0%	0%	0%	0%	0%	0%	0%	0%
2027	*Carryover_No_wAI*	-8%	-30%	-11%	-6%	-13%	-9%	-14%	-15%
2027	*REMA_LLS_No_wAI*	-14%	-19%	-13%	-15%	-13%	-9%	-14%	-15%
2027	*Carryover*	-17%	-9%	-17%	-15%	-17%	-9%	-21%	-15%
2027	*REMA_LLS*	-20%	5%	-22%	-23%	-21%	-25%	-21%	-15%
2027	*GOA_Fix*	-8%	-16%	-18%	-23%	-17%	-25%	-14%	-15%
2028	*Carryover_No_wAI*	-8%	-30%	-12%	-7%	-13%	-10%	-15%	-15%
2028	*REMA_LLS_No_wAI*	-15%	-20%	-14%	-15%	-13%	-10%	-15%	-15%
2028	*Carryover*	-18%	-9%	-17%	-15%	-17%	-10%	-22%	-15%
2028	*REMA_LLS*	-21%	4%	-22%	-24%	-21%	-25%	-22%	-15%
2028	*GOA_Fix*	-8%	-16%	-19%	-24%	-17%	-25%	-15%	-15%

Summary Tables and BRDs for Alternative Models: Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*

Table SM3.16. Summary table for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*. Note that the instability in this model makes it unsuitable for the basis of management advice.

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*:	
	2025	2026*	2027	2028^
M Female (estimated)[#]	0.11		0.09	
M Male (estimated)	--		0.10	
Average Recruitment (millions)	26		20	
Tier	3a		3a	
Projected Total Biomass (Age 2+; t)	704,713	695,681	557,786	557,903
Projected Female Spawning Biomass (t)	219,714	241,217	209,117	220,794
$B_{100\%}$ (t)	302,672	302,672	324,670	324,670
$B_{40\%}$ (t)	121,069	121,069	129,868	129,868
$B_{35\%}$ (t)	105,935	105,935	113,634	113,634
F_{OFL}	0.10	0.10	0.10	0.10
$maxF_{ABC}$	0.09	0.09	0.08	0.08
Whale Depredation (t)	171	169	131	131
OFL (t)	58,731	57,993	42,796	43,381
OFL_w (t)* **	58,532	57,797	42,665	43,250
max ABC (t)	50,283	49,651	36,212	36,710
ABC (t)	47,605	47,008	36,212	36,710
ABC_w (t)* **	**50,111**	**49,482**	36,081	36,579
Status	As determined *last* year for:		As determined *this* year for:	
	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 t in 2025 (a yield ratio of 0.49 was assumed). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.

**The 2026 SAFE Model *26.2_FAA_3LLF_LLS_BS_Dome_DN* projections were based on specified catch of 20,000 t in 2027 (a yield ratio of 0.53 was assumed based on the three-year average of catch to ABC from completed fishing years, 2023 – 2025).

[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.

***ABC_w and OFL_w are the final author recommended ABCs and OFLs after accounting for whale depredation.

Table SM3.17. BRDs by apportionment method for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	13,037	11,421	22,550	4,687	9,622	2,652	5,589	47,008
2027	*Carryover_No_wAI*	10,824	7,216	18,041	3,969	7,577	2,165	4,330	36,081
2027	*REMA_LLS_No_wAI*	10,103	8,298	17,680	3,608	7,577	2,165	4,330	36,081
2027	*Carryover*	9,742	9,381	16,958	3,608	7,216	2,165	3,969	36,081
2027	*REMA_LLS*	9,381	10,824	15,876	3,247	6,855	1,804	3,970	36,081
2027	*GOA_Fix*	10,824	8,659	16,597	3,247	7,216	1,804	4,331	36,081
2028	*Carryover_No_wAI*	10,974	7,315	18,290	4,024	7,682	2,195	4,389	36,579
2028	*REMA_LLS_No_wAI*	10,242	8,413	17,924	3,658	7,682	2,195	4,389	36,579
2028	*Carryover*	9,876	9,510	17,192	3,658	7,316	2,195	4,024	36,579
2028	*REMA_LLS*	9,511	10,973	16,095	3,292	6,950	1,829	4,024	36,579
2028	*GOA_Fix*	10,974	8,779	16,826	3,292	7,316	1,829	4,389	36,579

Table SM3.18. Percent Change in BRDs by apportionment method for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*.

Year	Apportionment Approach	BS	AI	GOA	WGOA	CGOA	WY	SEO	ABCw
2026	*GOA_Fix (Model 23.5)*	0%	0%	0%	0%	0%	0%	0%	0%
2027	*Carryover_No_wAI*	-17%	-37%	-20%	-15%	-21%	-18%	-23%	-23%
2027	*REMA_LLS_No_wAI*	-23%	-27%	-22%	-23%	-21%	-18%	-23%	-23%
2027	*Carryover*	-25%	-18%	-25%	-23%	-25%	-18%	-29%	-23%
2027	*REMA_LLS*	-28%	-5%	-30%	-31%	-29%	-32%	-29%	-23%
2027	*GOA_Fix*	-17%	-24%	-26%	-31%	-25%	-32%	-23%	-23%
2028	*Carryover_No_wAI*	-16%	-36%	-19%	-14%	-20%	-17%	-21%	-22%
2028	*REMA_LLS_No_wAI*	-21%	-26%	-21%	-22%	-20%	-17%	-21%	-22%
2028	*Carryover*	-24%	-17%	-24%	-22%	-24%	-17%	-28%	-22%
2028	*REMA_LLS*	-27%	-4%	-29%	-30%	-28%	-31%	-28%	-22%
2028	*GOA_Fix*	-16%	-23%	-25%	-30%	-24%	-31%	-21%	-22%

SSC Requested Models

In response to SSC requests, six alternative FAA models were developed that allowed for dome-shaped selectivity in the Bering Sea (BS) fleets as well as two further sensitivity runs that were used to better understand whether time-varying survey catchability and dome-shaped selectivity are supported by the available data. Many of these alternatives were previously explored and were deemed unstable, and, thus, were not brought forward for further evaluation in September. Nonetheless, these alternatives are discussed here to further document the rationale for not integrating more complexity in the author recommended Model *26.2_FAA*. The six alternatives varied in several components, including: differences in fishery fleet structure (a single fixed gear fishery fleet as in Model *26.2_FAA* or three regional fixed gear fleets for the BS, AI, and GOA -- denoted with "3LLF"); which BS fleet was domed (the BS fixed gear fishery, the BS NOAA Longline Survey, LLS, or both), and the functional form of the dome (gamma or double normal) where logistic selectivity was retained for all other fleets. The gamma selectivity function requires only two parameters to be estimated (age at maximum selectivity and width) but links the ascending and descending limbs of the curve. The double normal is more flexible, but is traditionally parameterized with six parameters, such that a reduced form with three estimated parameters per sex was used here to improve convergence (described below). The gamma variants with a dome in the BS LLS (Models *26.2_FAA_LLS_BS_Dome_Gam* and *26.2_FAA_3LLF_LLS_BS_Dome_Gam*) led to similar conclusions as the double normal variants, such that the diagnostics below focus primarily on the double normal models. We note that the 3LLF configuration with domes in both the BS fishery and survey mirrors the cross-testing configuration with the smallest median SSB bias (Figure SM3.1; see Appendix 3E), though, as noted in documents provided in September, this model alternative proved to be unstable when confronted with real world data.

The first sensitivity implemented continuous semi-parametric (i.e., age- and year-specific) deviations around logistic selectivity for each regional LLS fleet (Model *26.2_FAA_TV_Selex_LLS*), which allowed selectivity to decline at older ages if supported by the data (this is the same as Model *26.2_FAA_ContTVSel* described in Appendix 3C). Given runtime and memory constraints, these deviations were estimated as iid and as penalized fixed effects rather than random effects, with the standard deviation of these penalized effects fixed at 0.3. The second sensitivity was a 3LLF configuration with domes in both the BS fishery and survey, but with *iid* annual process error estimated as random effects for the regional LLS catchabilities, as also requested by the SSC (Model *26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q*). These sensitivity runs were not intended as candidate models for management advice, but rather were used to better understand the extent to which time-varying survey catchability and dome-shaped selectivity are supported by the available data, and are thus discussed below but not included in the comparison of management quantities.

Full model outputs and diagnostics for all runs are available on the GitHub (here), while the extensive explorations of domed selectivity undertaken during FAA model development are described in Appendix 3C.

Methods

For the double normal selectivity function, selectivity at age b is constructed from the combination of an ascending Gaussian limb, a plateau, and a descending Gaussian limb, which are all joined by smooth logistic switches. Six quantities $\hat{p}_1$ to $\hat{p}_6$ are estimated and transformed as follows, where w denotes the bin width and $\max(b)$ is the oldest age:

$$p_1 = \hat{p}_1, \qquad p_2 = p_1 + w + \frac{0.99 \cdot \max(b) - p_1 - w}{1 + \exp(-\hat{p}_2)}, \qquad p_3 = \exp(\hat{p}_3), \qquad p_4 = \exp(\hat{p}_4),$$

$$p_5 = \frac{1}{1 + \exp(-\hat{p}_5)}, \qquad p_6 = \frac{1}{1 + \exp(-\hat{p}_6)}.$$

Here, p_1 is the age at the start of the plateau (the peak), p_2 the age at the end of the plateau, p_3 and p_4 the ascending and descending widths, and p_5 and p_6 represent the selectivity at the first and last age. The two Gaussian limbs and their respective values at the ends of the age range can then be given by:

$$\text{asc}_b = \exp\left(-\frac{(b-p_1)^2}{p_3}\right), \qquad \text{asc}_{\min} = \exp\left(-\frac{(\min(b)-p_1)^2}{p_3}\right),$$

$$\text{desc}_b = \exp\left(-\frac{(b-p_2)^2}{p_4}\right), \qquad \text{desc}_{\min} = \exp\left(-\frac{(\max(b)-p_2)^2}{p_4}\right).$$

In the traditional parameterization of the double normal, the raw limbs are rescaled such that selectivity equals p_5 at the first age and p_6 at the last age:

$$\text{asc}_b^{\text{scaled}} = p_5 + (1-p_5)\cdot\frac{\text{asc}_b - \text{asc}_{\min}}{1-\text{asc}_{\min}}, \qquad \text{desc}_b^{\text{scaled}} = 1 + (p_6-1)\cdot\frac{\text{desc}_b - 1}{\text{desc}_{\min}-1}.$$

Logistic joiners switch from the ascending limb to the plateau at p_1 and from the plateau to the descending limb at p_2:

$$j_b^{(1)} = \frac{1}{1+\exp\left(-20\cdot\frac{b-p_1}{1+|b-p_1|}\right)}, \qquad j_b^{(2)} = \frac{1}{1+\exp\left(-20\cdot\frac{b-p_2}{1+|b-p_2|}\right)},$$

$$\text{Sel}_b = \text{asc}_b^{\text{scaled}}\cdot\left(1-j_b^{(1)}\right) + j_b^{(1)}\cdot\left[\left(1-j_b^{(2)}\right) + \text{desc}_b^{\text{scaled}}\cdot j_b^{(2)}\right].$$

For the alternatives presented, we instead parameterized the double normal as raw Gaussian limbs rather than rescaled to the end-age parameters (i.e., p_5 and p_6) to improve model convergence. This parameterization simply replaces $\text{asc}_b^{\text{scaled}}$ and $\text{desc}_b^{\text{scaled}}$ with asc_b and desc_b above, so p_5 and p_6 are not estimated for this form. Moreover, the plateau was also constrained to a single age ($\hat{p}_2 = -10$, so $p_2 \approx p_1 + 1$), therefore leaving three estimated parameters per sex: the peak age p_1 and the log widths $\hat{p}_3$ and $\hat{p}_4$.

Results

Consistent with Appendix 3C presented in September, models with domed selectivity were generally unstable and did not meaningfully improve upon the performance of Model *26.2_FAA*. In particular, models with dome-shaped selectivity in the BS LLS were the most unstable, where models *26.2_FAA_LLS_BS_Dome_DN* and *26.2_FAA_3LLF_LLS_BS_Dome_DN* estimated a strong dome in the BS LLS, with selectivity declining to near zero at the oldest ages, which was offset by a higher BS LLS catchability. For these models, about 10% of jitter runs converged to solutions with a lower nLL than the MLE, indicating that a global minimum was not attained, whereas no jitter runs for Model *26.2_FAA* converged to a lower nLL. We note that simply adopting these lower nLL solutions would not resolve the underlying issue, as the dependence of the solution on starting values indicates a likelihood surface that is difficult to traverse, which is better addressed through reparameterization or simplification of the model than by tuning starting values (which would need to be revisited, and may not hold, with each annual update). While MCMC results are not directly used for management purposes, as diagnostics they provide useful insights that were alluded to in the September documents. In particular, MCMC failed to converge for every dome model where it was run (Models *26.2_FAA_LLS_BS_Dome_DN*, *26.2_FAA_3LLF_BS_Dome_DN*, and *26.2_FAA_3LLF_LLS_BS_Dome_DN*), with selectivity and catchability parameters poorly sampled (minimum effective sample sizes of 7 - 25 and maximum Rhat values of 1.12 - 1.61 across parameters, compared to 842 and 1.00, respectively, for Model *26.2_FAA*).

Moreover, for the BS LLS dome models, the posterior median of terminal SSB was about 20% lower than the MLE, a pattern that was not present for Model *26.2_FAA* (Figure SM3.2). Retrospective patterns were also degraded for every dome model when compared to Model *26.2_FAA* (Figure SM3.3). Fits were slightly improved for the BS LLS index, largely because the dome effectively converts the BS LLS into an index of young fish, while fits to the AI LLS index degraded (see the GitHub repo for full diagnostic outputs).

Of all the dome-shaped alternatives, Model *26.2_FAA_3LLF_BS_Dome_Gam* (gamma-based dome in the BS fixed gear fishery only) was the most stable in the MLE context, with no jitter runs converging to a lower nLL and nearly all returning to the MLE (comparable to Model *26.2_FAA*), followed by Model *26.2_FAA_3LLF_BS_Dome_DN*. However, both models exhibited slightly degraded fits to the LLS indices, worse retrospective patterns than Model *26.2_FAA* (Mohn's rho for SSB of 0.08 – 0.10 compared to 0.02; Figure SM3.4), and severe convergence problems in the MCMC context. Importantly, the 3LLF structure adds ~140 fleet-specific fishing mortality and selectivity parameters (a total of 400 model parameters compared to 274 for Model *26.2_FAA*) informed by sparse BS and AI fishery age compositions. Moreover, in the sensitivity run where selectivity was allowed to vary semi-parametrically by age and year (Model *26.2_FAA_TV_Selex_LLS*), regional LLS selectivity at older ages remained essentially asymptotic in all years with large deviations largely confined to the youngest ages, suggesting that the data contain little information on selectivity at older ages and that the domes estimated in the parametric models are largely driven by the assumed functional form (Figure SM3.5). Moreover, this added flexibility also resulted in a considerably worse retrospective pattern and degraded fits to the BS and AI LLS indices relative to Model *26.2_FAA*. Lastly, the sensitivity run with annual process error in the LLS catchabilities (Model *26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q*) performed poorly, where it fit the indices nearly perfectly (i.e., overfit) by interpreting recent BS and AI recruitment as increased availability to the survey, which is not biologically supported for sablefish (see Responses to SSC Comments). It also estimated implausible selectivity for the AI fixed gear fishery (i.e., males essentially unselected until the plus group), resulted in the worst retrospective pattern of all models (Mohn's rho for SSB of 0.33; Figure SM3.6), and led to an implausibly strong downward scaling of SSB (terminal SSB of 115 kt, just below B40%).

With respect to management quantities, Models *26.2_FAA_3LLF_BS_Dome_Gam* and *26.2_FAA_3LLF_BS_Dome_DN* produced results nearly identical to Model *26.2_FAA* (terminal SSB of 209 – 217 kt compared to 214 kt and ABCs of 39.6 – 39.9 kt compared to 37.6 kt; Figure SM3.7), even though the gamma variant estimated a considerably stronger dome in the BS fixed gear fishery. This is consistent with the analysis evaluating the implied FAA selectivity curves (see Responses to SSC Comments), given that relatively little catch is removed in the BS and few older fish are present in the population (i.e., there is minimal cryptic biomass to be gained by adding a dome in the BS fishery). As such, even the most stable dome-shaped alternative provided essentially the same management advice as Model *26.2_FAA*, but with ~140 additional parameters and worse retrospective patterns. Likewise, models *26.2_FAA_LLS_BS_Dome_DN* and *26.2_FAA_3LLF_LLS_BS_Dome_DN* produced MLEs of SSB and ABC similar to Model *26.2_FAA* (SSB of 197 – 200 kt and ABCs of 35.3 – 36.2 kt). Conversely, the BS LLS gamma variants (Models *26.2_FAA_LLS_BS_Dome_Gam* and *26.2_FAA_3LLF_LLS_BS_Dome_Gam*) estimated a population scale much lower than the other alternatives (SSB of 126 – 131 kt and ABCs of 26.0 – 27.9 kt). This was likely driven by the extreme BS LLS domes, which the model offset by inflating BS LLS catchability (roughly three times that of Model *26.2_FAA*), such that fewer fish were needed to explain the observed BS LLS index, thereby scaling the population down. That is, for the same fleet structure, the scale of the population depended largely on the assumed functional form of the BS LLS dome, consistent with the domes being driven by the functional form rather than information in the data.

The findings from the dome-shaped alternatives are consistent with the cross-testing simulations presented in Appendix 3E, wherein the more plausible FAA configurations (i.e., a single fixed gear fishery fleet with logistic selectivity, or three regional fixed gear fleets with dome-shaped selectivity in the BS) yielded similar estimates of SSB, such that the choice among most of these configurations mattered little with

respect to management quantities (Figure SM3.7). Notably, the cross-testing simulations demonstrated that the simplest FAA configuration (i.e., the Model *26.2_FAA* structure) produced essentially the same SSB bias as the domed configurations, with median errors of similar magnitude and largely overlapping simulation intervals. However, Model 26.2_FAA also demonstrated the least bias in the terminal years (Figure SM3.1). In other words, adding dome-shaped selectivity in the BS provided no meaningful reduction in bias relative to the more parsimonious Model *26.2_FAA* structure. Moreover, the closed-loop simulations indicated that FAA models tended to demonstrate the least bias when confronted with spatial dynamics (Figure SM3.8).

Thus, considering the instability of FAA models that assume dome-shaped selectivity, the limited improvement and oftentimes degradations in data fit, and added complexity, the authors continue to reiterate the conclusions from the documents provided in September (Appendix 3C) -- models with dome-shaped selectivity are not presently appropriate for operational management advice. As such, none of the dome-shaped selectivity models presented herein (including the gamma variants) are recommended for use as the basis of management advice. Dome-shaped selectivity models will continue to be explored in the future as more BS and AI age composition data become available.

Figures

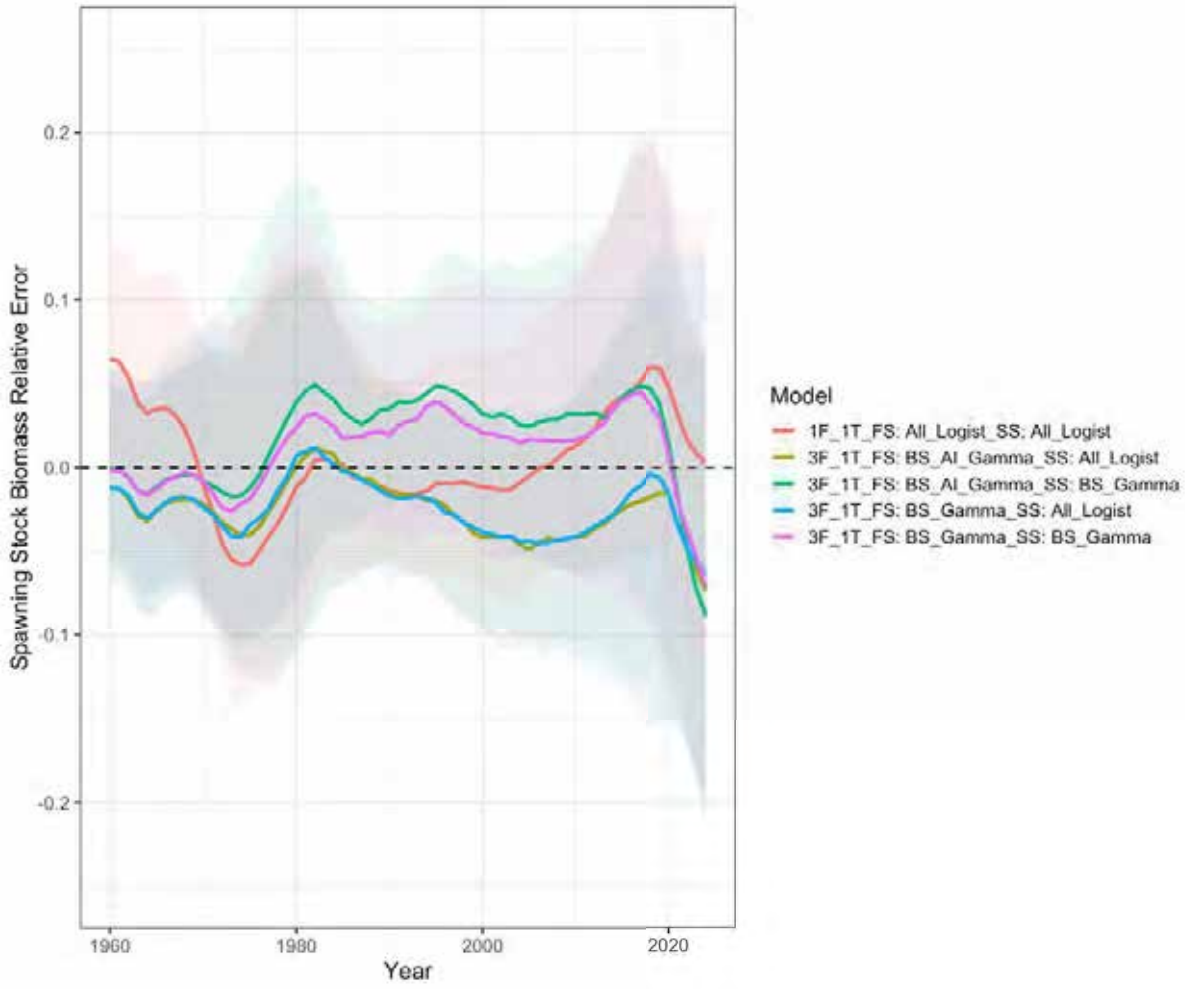


Figure SM3.1. Time-series of relative error in SSB for select FAA configurations evaluated in the cross-testing simulations (from Appendix 3E, Figure 3E.4). *1F_1T* represents a single fixed gear fishery fleet and a single trawl fleet (i.e., the Model *26.2_FAA* structure) and *3F_1T* represents three fixed gear fishery fleets (BS, AI, and GOA) and one trawl fleet. FS and SS denote fishery and survey selectivity, where *All_Logist* denotes logistic selectivity for all fleets, *BS_Gamma* denotes gamma selectivity for the BS fleets, and *BS_AI_Gamma* denotes gamma selectivity for the BS and AI fleets (logistic elsewhere). Solid lines denote the median and shaded regions represent 95% simulation intervals.

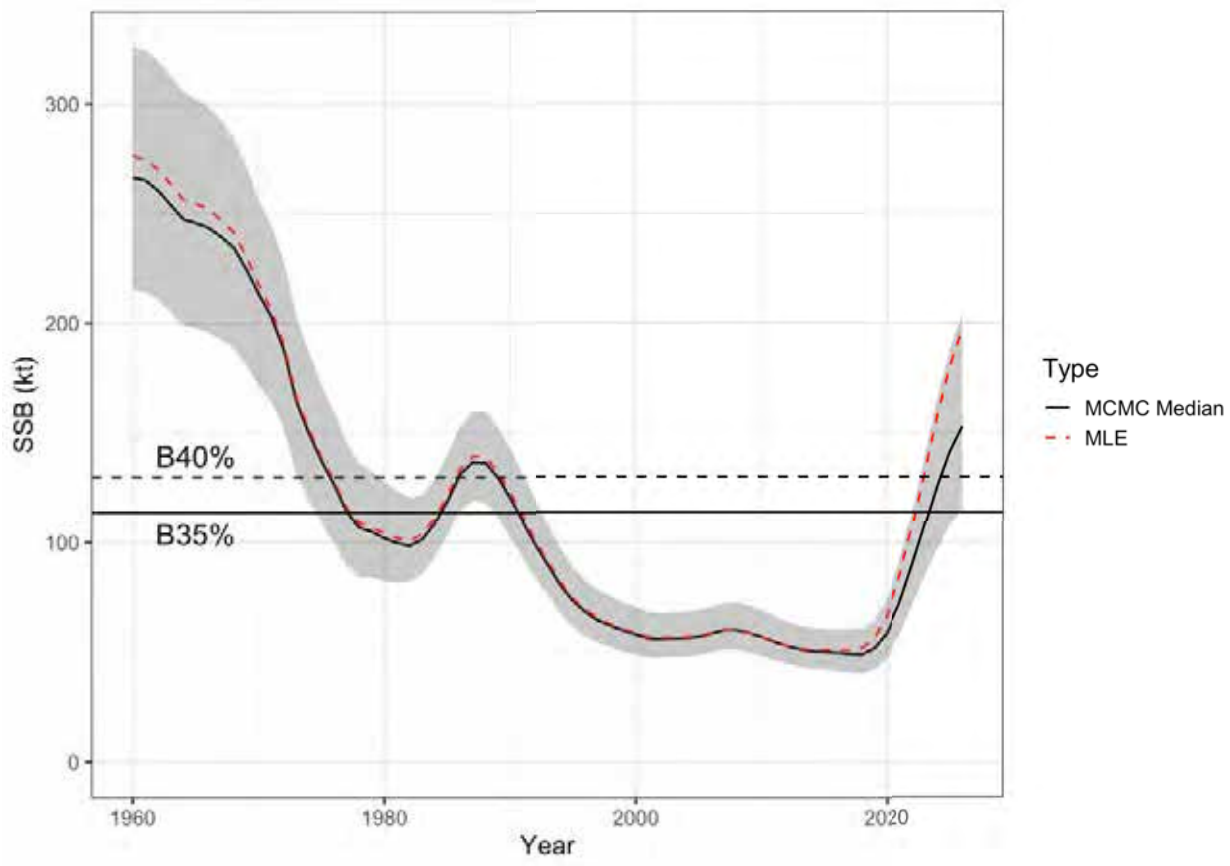


Figure SM3.2. Comparison of SSB (kt) between the MLE (red dashed line) and the MCMC posterior median (black line; shaded region represents the 95% credible interval) for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*. MCMC results for the other models are available from the GitHub repo.

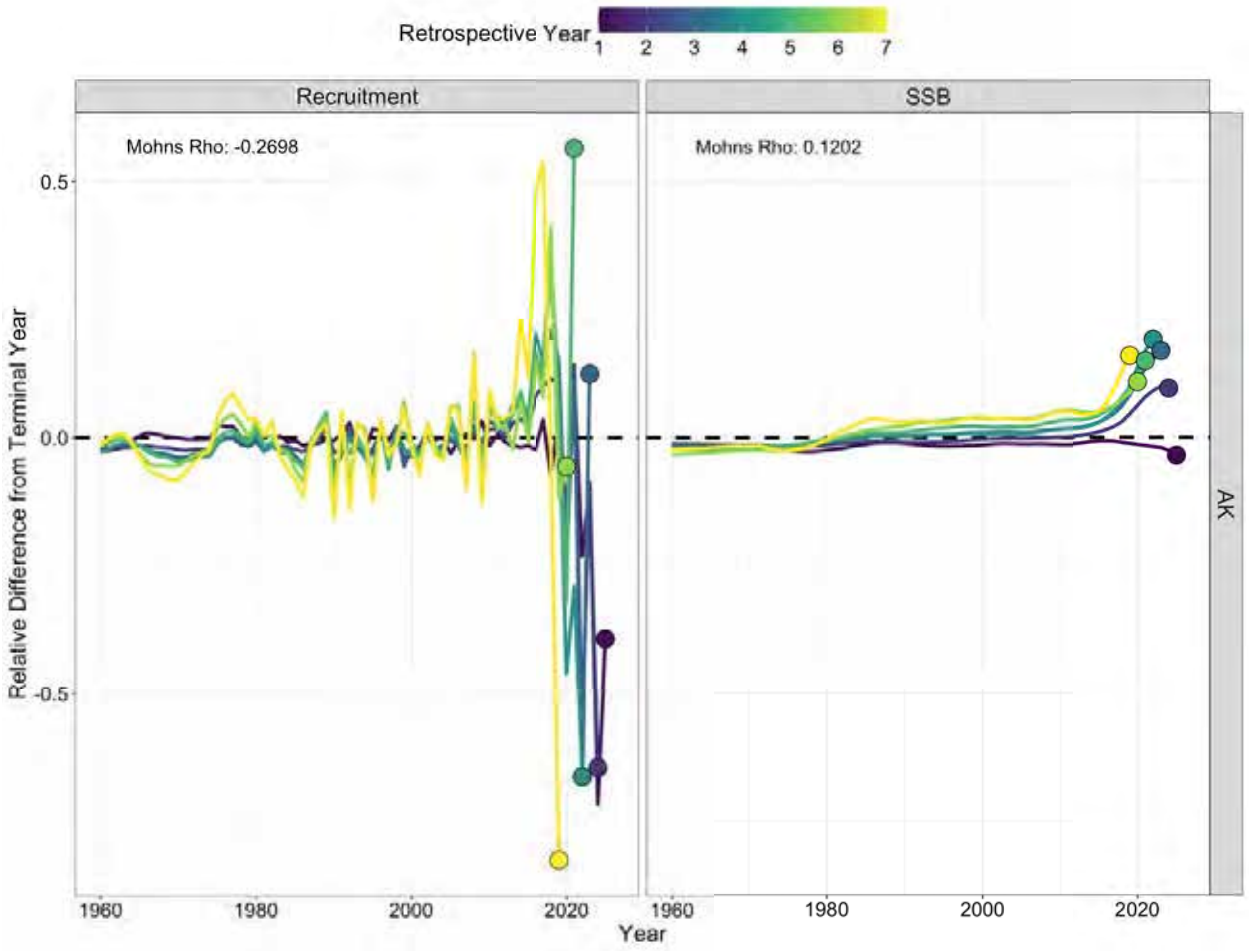


Figure SM3.3. Seven-year retrospective analysis of recruitment (left) and SSB (right) for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN*, shown as the relative difference from the terminal year model. Colors denote the retrospective peel and Mohn's rho is shown for each quantity. Retrospective analyses for all other models are available from the GitHub repo.

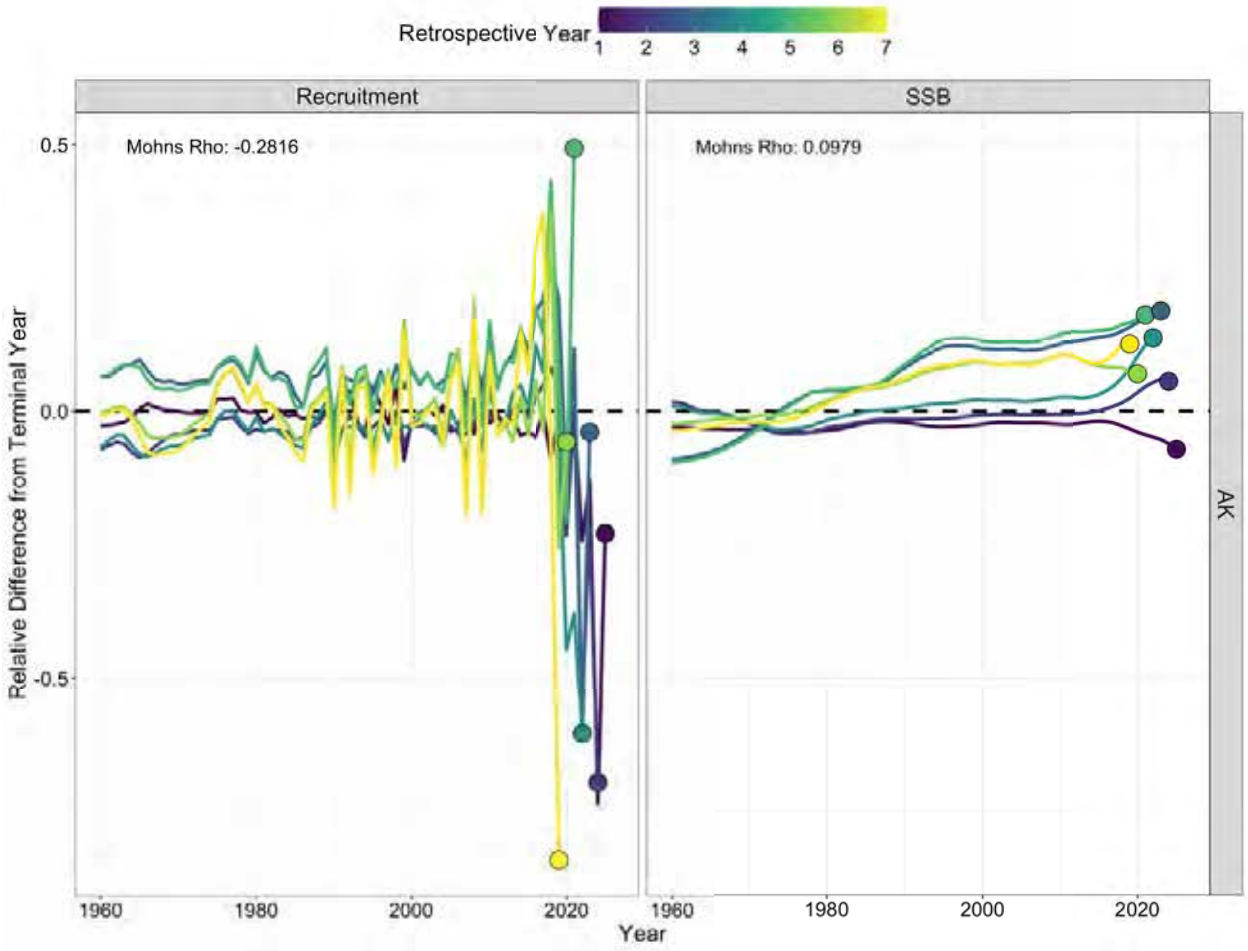


Figure SM3.4. Seven-year retrospective analysis of recruitment (left) and SSB (right) for Model *26.2_FAA_3LLF_BS_Dome_Gam*, shown as the relative difference from the terminal year model. Colors denote the retrospective peel and Mohn's rho is shown for each quantity. Retrospective analyses for all other models are available from the GitHub repo.

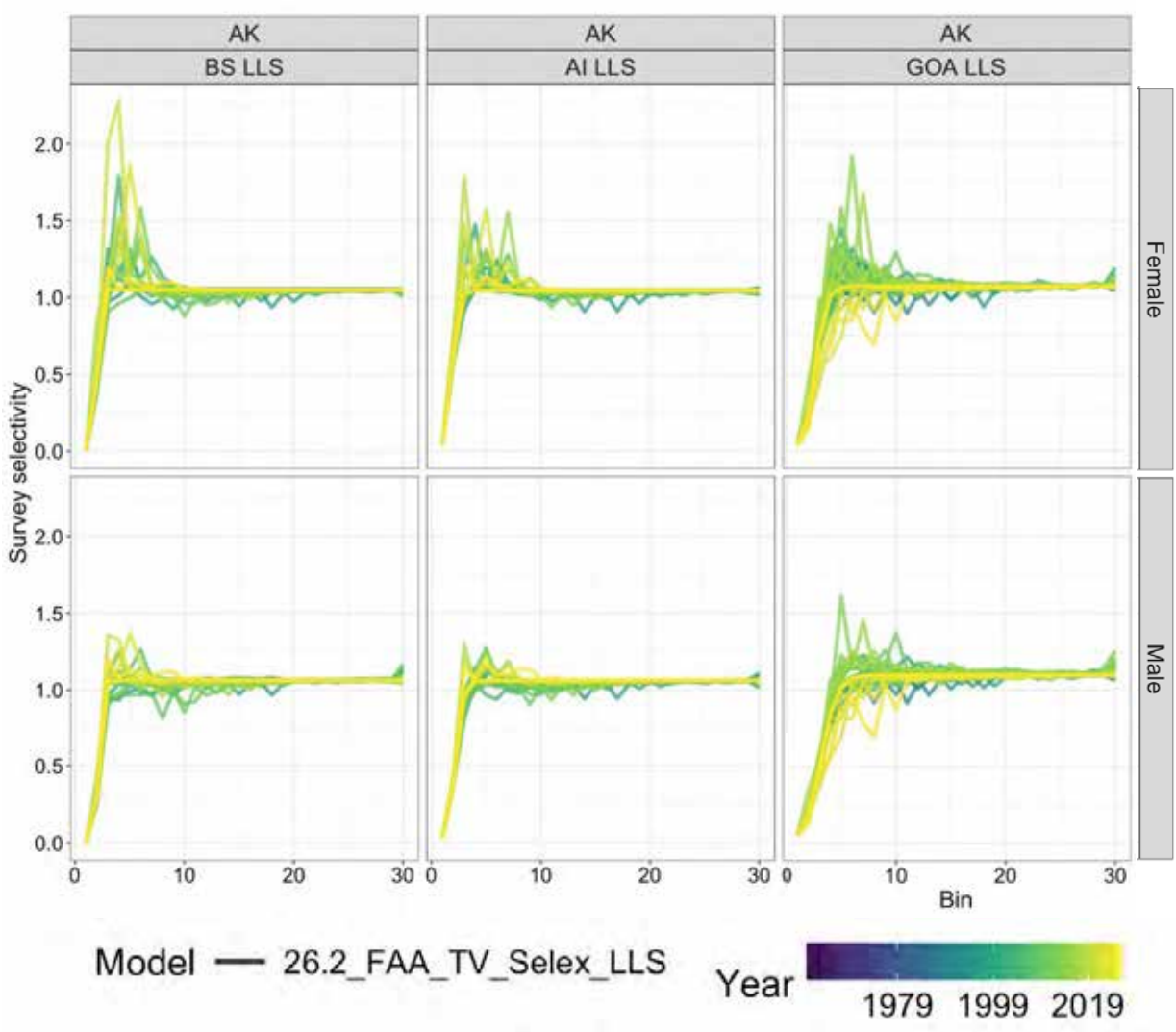


Figure SM3.5. Survey selectivity estimates from Model *26.2_FAA_TV_Selex_LLS*.

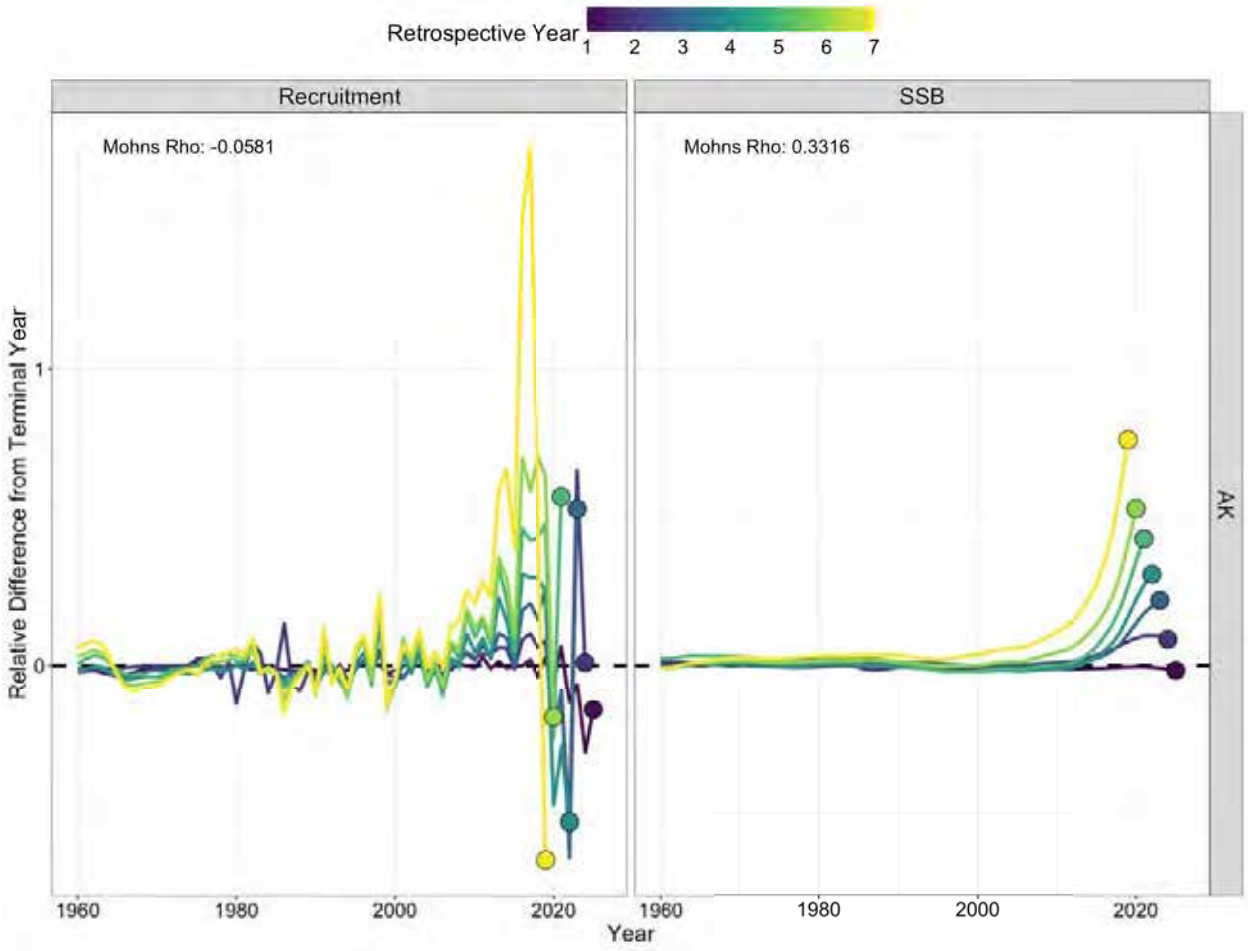
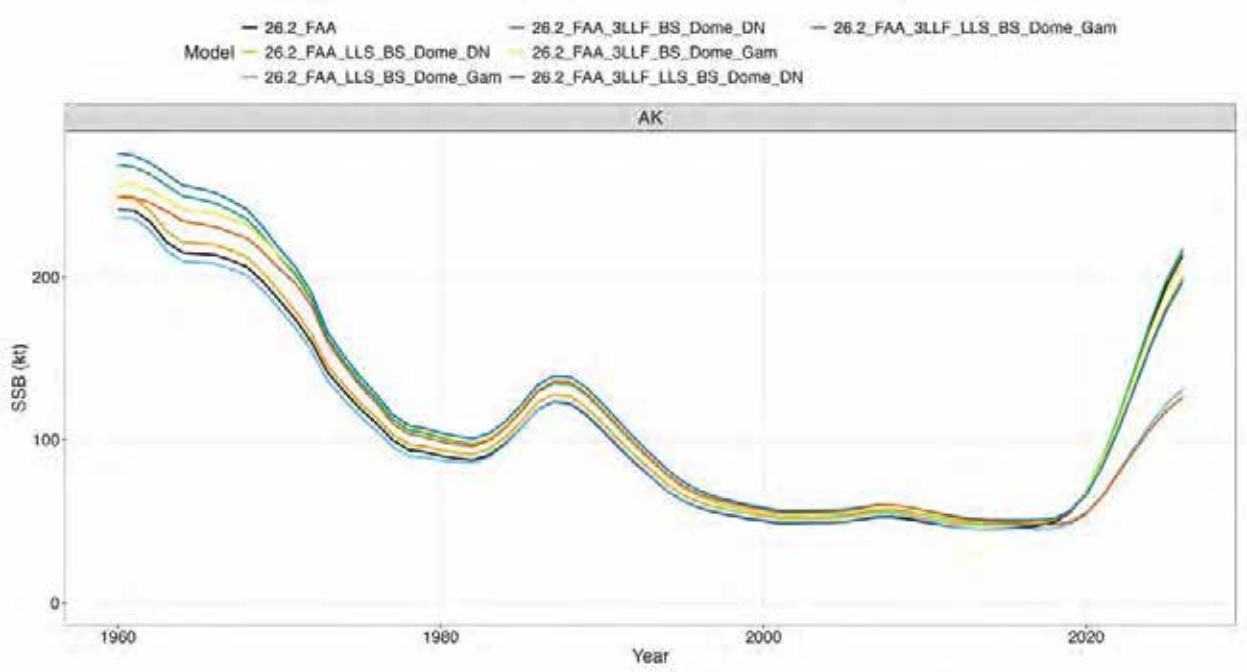


Figure SM3.6. Seven-year retrospective analysis of recruitment (left) and SSB (right) for Model *26.2_FAA_3LLF_LLS_BS_Dome_DN_PE_q*, shown as the relative difference from the terminal year model. Colors denote the retrospective peel and Mohn's rho is shown for each quantity. Retrospective analyses for all other models are available from the GitHub repo.



Model	Catch_Advice	B_Status	Terminal_SSB	B_Ref_Pt	B_over_B_Ref	Terminal_F	F_Ref_Pt	F_over_F_Ref
26.2_FAA	37.57	0.64	213.87	133.97	1.60	0.05	0.08	0.68
26.2_FAA_LLS_BS_Dome_DN	35.35	0.59	200.05	136.28	1.47	0.05	0.08	0.73
26.2_FAA_LLS_BS_Dome_Gam	26.02	0.46	131.02	114.88	1.14	0.08	0.07	1.07
26.2_FAA_3LLF_BS_Dome_DN	39.58	0.67	217.44	130.17	1.67	0.05	0.08	0.64
26.2_FAA_3LLF_BS_Dome_Gam	39.85	0.66	209.11	126.28	1.66	0.06	0.09	0.64
26.2_FAA_3LLF_LLS_BS_Dome_DN	36.21	0.61	197.18	129.87	1.52	0.06	0.08	0.71
26.2_FAA_3LLF_LLS_BS_Dome_Gam	27.91	0.47	126.10	106.94	1.18	0.09	0.09	1.02

Figure SM3.7. Comparison of SSB (kt) for Model *26.2_FAA* and the six dome-shaped alternatives (top), along with associated management quantities (bottom), where Catch_Advice is the ABC (kt), B_Ref_Pt is $B_{40\%}$ (kt), and B_over_B_Ref is SSB relative to $B_{40\%}$.

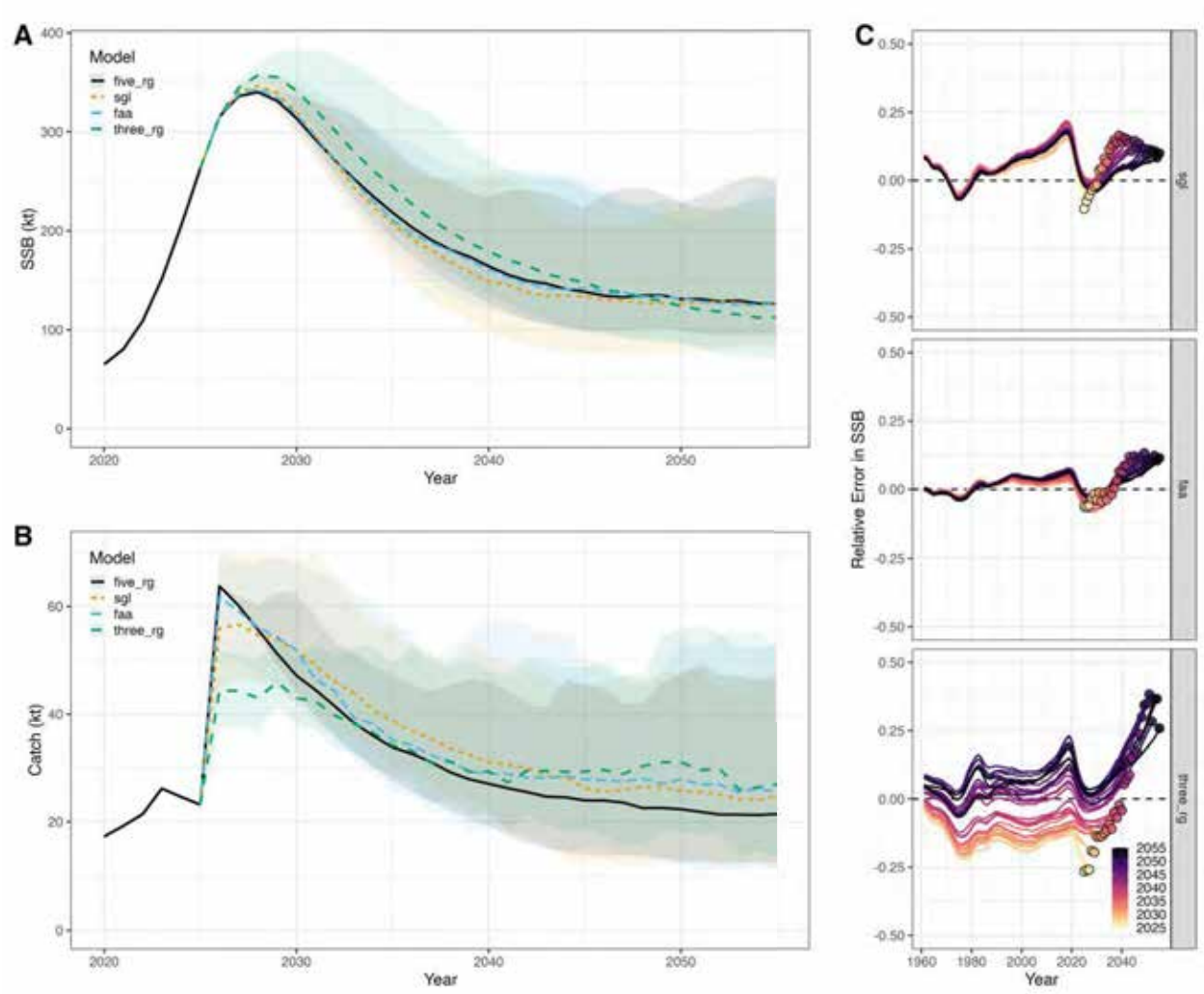


Figure SM3.8. Summary of results from the closed-loop simulations (from Appendix 3E; Figure 3E.9). Panels A and B depict trajectories and associated 95% simulation intervals of Alaska-wide SSB and catch resulting from the single region (*sgl*), FAA (*faa*; three fixed gear fishery fleets with BS dome-shaped selectivity), and three-region (*three_rg*) estimation models compared to the five-region reference model (*five_rg*). Panel C shows the median relative error in SSB for each estimation model (row panels) by closed-loop projection year (colors), where the terminal year of each projection is indicated by a colored point.

Summary of Fixed Gear Fishery Observer Sampling

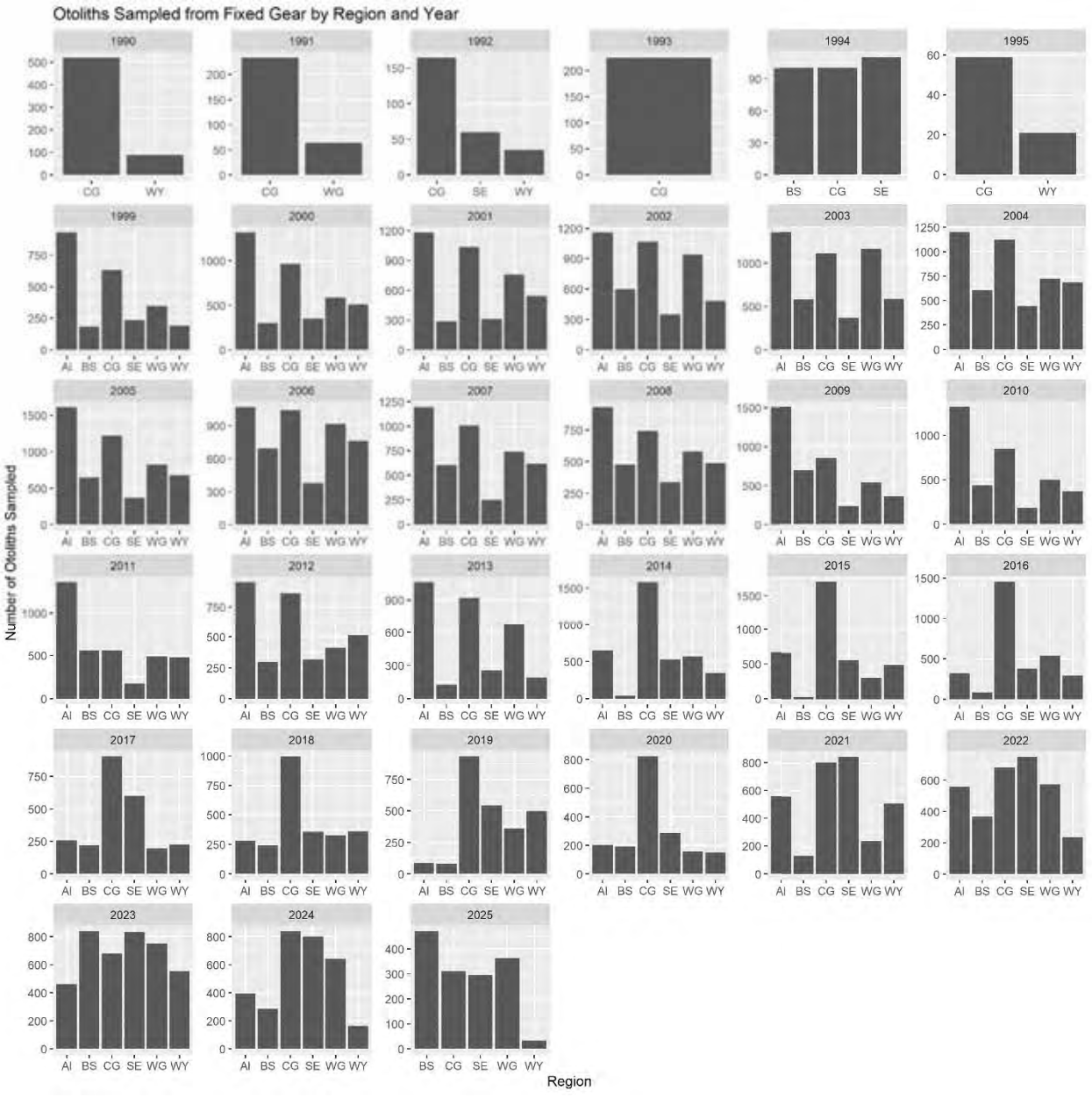


Figure SM3.8. The number of otoliths sampled by observers on sablefish targeting trips in the fixed gear fishery by year and management region. Note that no otoliths were collected in the AI (low effort and no observed hauls) and few otoliths were sampled in WY (increasing use of EM in the EGOA fixed gear fleet).

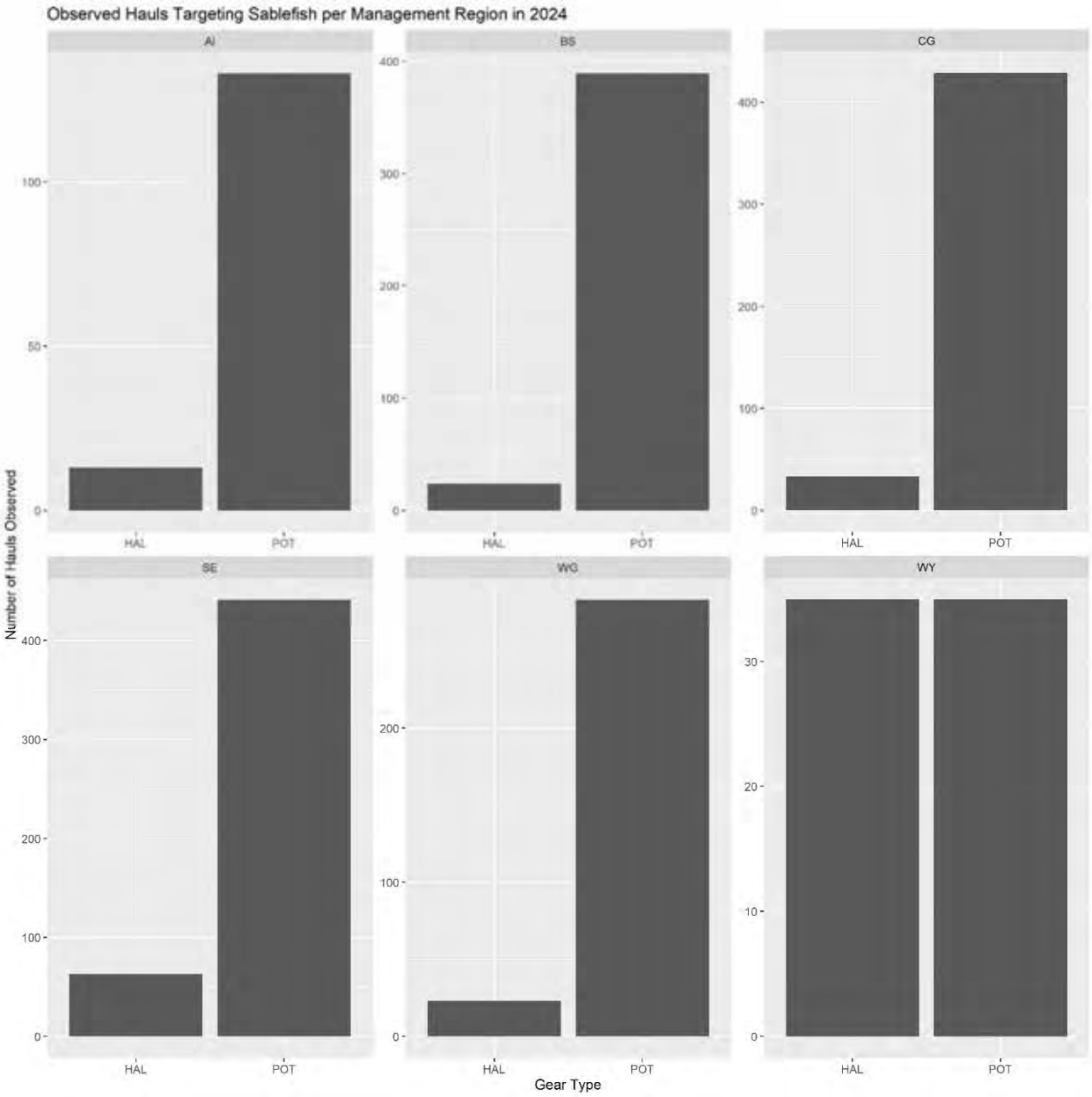


Figure SM3.9. The number of sablefish targeting hauls in the fixed gear fishery that were observed by onboard fishery observers in 2024 by management region and gear type.

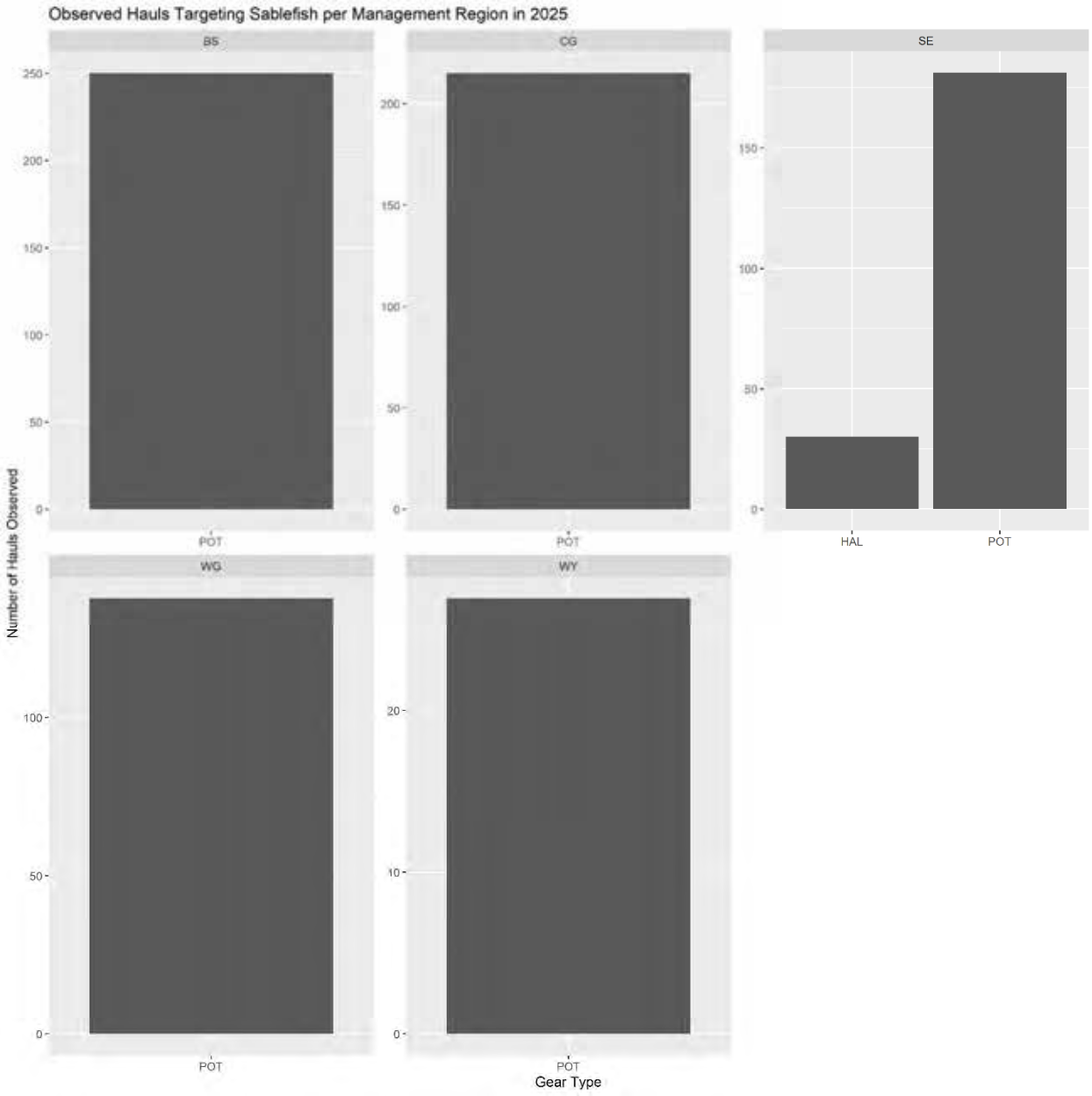


Figure SM3.10. The number of sablefish targeting hauls by the fixed gear fleet that were observed by onboard fishery observers in 2025 by management region and gear type. Note the near complete transition to pot gear coverage and the lack of any observed hauls in the AI.

Appendix 3A: The Spatial Population over Regional Components (SPoRC) Model: Technical Description of the Assessment Model for Sablefish

The 2026 SAFE for Alaskan sablefish uses the SPoRC package, which supports single-region, fleets-as-areas (FAA), and spatial models. The sections below outline the generalized model structure used across these assessment configurations, as well as any specific mathematical configurations pertinent to the models presented throughout. Additional details on model descriptions can also be found at https://chengmatt.github.io/SPoRC/articles/c_model_equations.html.

Population dynamics follow an annual time step, which proceed in the following sequence:

1. Recruitment and tag releases initially occur (tag releases only occur if tagging data are used),
2. Markovian movement of individuals then follow (movement only occurs in the spatial model), and
3. Total mortality, chronic tag loss (if applicable), and ageing processes occur.

These processes are modeled across four main partitions: region (r), year (y), age (a and a_+, where a_+ is the plus group), and sex (s). In single-region models, most equations reduce by setting $r = 1$.

Process Equations

Population Initialization

Initialization of equilibrium abundance differs between the single-region and spatial models due to the need to incorporate movement dynamics in the latter. In the single-region model, the initial equilibrium population is computed as:

$$N'_{r=1,a,s} = \mu^{\text{Rec}} \exp\left(-(a-1)\cdot\left(Z'_{r=1,a,s}\right)\right)\psi_s, \quad \text{for } 2 \leq a < a_+$$

$$Z'_{r=1,a,s} = \text{Natmort}_{r=1,y=1,a,s} + \mu^{\text{Fsh}}_{r=1,f=1}\text{Fmort}^{\text{InitProp}}\text{Sel}^{\text{Fsh}}_{r=1,y=1,a,s,f=1}$$

where $N'_{r=1,a,s}$ are the equilibrium numbers-at-age, μ^{Rec} is a global recruitment parameter, $Z'_{r=1,a,s}$ is the initial instantaneous total mortality rate, $\text{Natmort}_{r=1,y=1,a,s}$ is the instantaneous natural mortality rate, $\mu^{\text{Fsh}}_{r=1,f=1}$ is the mean fishing mortality rate from the longline fleet (f denotes fishery fleet), $\text{Fmort}^{\text{InitProp}}$ is the proportion of the mean fishing mortality from the longline fleet applied during the initialization stage, $\text{Sel}^{\text{Fsh}}_{r=1,y=1,a,s,f=1}$ is the fishery selectivity-at-age for the longline fleet, ψ_s is the sex ratio of the equilibrium population (fixed at 50:50).

The plus group (a_+) of the initial population is then derived by solving for a geometric series:

$$N'_{r,a,s} = \mu^{\text{Rec}} \frac{\exp\left(-(a_+ - 1)\cdot\left(Z'_{r=1,a=a_+,s}\right)\right)}{1 - \exp\left(Z'_{r=1,a=a_+,s}\right)}\psi_s$$

By contrast, the initial population abundance for the spatial model using the solution to a matrix geometric series to appropriately account for movement dynamics in equilibrium:

$$\boldsymbol{N'}_{a_+,s} = \left[\mathbf{I} - \mathbf{O}_{a_+}\right]^{-1}\mathbf{O}_{a_+-1}\boldsymbol{N'}_{a_+-1,s}$$

where $\mathbf{O}_a$ is a matrix representing the proportion of individuals surviving and moving among regions. $\mathbf{O}_a$ is defined as the matrix product of a diagonal survival matrix $\exp[\mathrm{diag}(-\mathbf{Z}_a)]$ and a movement rate matrix $\mathbf{M}_{y=1,a,s}$.

Following the definition of equilibrium age structure for both the single-region and spatial model, initial age deviations are applied:

$$N_{r,y=1,a\notin 2,s} = N'_{r,a\notin 2,s}\exp\left(\epsilon_{r,i}^{\mathrm{Init}}\right)$$

$N_{r,y=1,a\notin 2,s}$ are the stochastic numbers-at-age in the first year, and initial age deviations ($\epsilon_{r,i}$) are constrained by a lognormal distribution.

Recruitment Processes

In both model types, recruitment is estimated based on lognormal deviations about a mean recruitment parameter:

$$N_{r,y,a=2,s} = \mu^{\mathrm{Rec}}\exp\left(\epsilon_{r,y}^{\mathrm{Rec}} - \frac{\sigma_{\mathrm{Rec}}^2}{2}b_y\right)\psi_s\zeta_r$$

Here, $\epsilon_{r,y}$ are annual, lognormally distributed recruitment deviations with a lognormal bias correction term ($\frac{\sigma_{\mathrm{Rec}}^2}{2}b_y$).

Population Projection

Following recruitment processes, the population can then be projected forward. In the context of the spatial model, Markovian movement dynamics are first applied:

$$\mathbf{N}_{y,a,s} = \left(\mathbf{N}_{y,a,s}\right)^{\mathrm{T}}\mathbf{M}_{y,a,s}$$

After the population undergoes movement, individuals experience mortality and ageing processes via an exponential mortality model:

$$N_{r,y+1,a+1,s} = N_{r,y,a,s}\exp\left(-Z_{r,y,a,s}\right), \quad \text{for } 2 \le a < a_+$$
$$N_{r,y+1,a,s} = N_{r,y,a-1,s}\exp\left(-Z_{r,y,a-1,s}\right) + N_{r,y,a,s}\exp\left(-Z_{r,y,a,s}\right), \quad \text{for } a = a_+$$

$Z_{r,y,a,s}$ denotes the annual total instantaneous mortality rate and is defined as:

$$Z_{r,y,a,s} = \text{Natmort}_{r,y,a,s} + \sum_{f} \text{Sel}^{\text{Fsh}}_{r,y,a,s,f}\, \text{Fmort}_{r,y,f}$$

$\text{Fmort}_{r,y,f}$ is the annual instantaneous fishing mortality rate parameterized based on lognormal deviations about a mean fishing mortality parameter for a given fishery fleet:

$$\text{Fmort}_{r,y,f} = \mu^{\text{Fsh}}_{r,f} \exp\left(\epsilon^{\text{Fsh}}_{r,y,f}\right).$$

Observation Equations

Fishery Observation Model

The fishery observation model describes the expected catch-at-age, catch-at-length, catch (in units of biomass), and fishery indices. In cases where the fishery is defined as a FAA model, the f index simply extends and the following equations can be generalized. Expected catch-at-age ($C^{a}_{r,y,a,s,f}$) is computed using Baranov's catch equation:

$$C^{a}_{r,y,a,s,f} = \frac{\text{Fmort}_{r,y,f} \text{Sel}^{\text{Fsh}}_{r,y,a,s,f}}{Z_{r,y,a,s}} N_{r,y,a,s}\left[1 - \exp\left(-Z_{r,y,a,s}\right)\right]$$

Catch-at-length ($C^{l}_{r,y,l,s,f}$) can then be derived using the following equation:

$$C^{l}_{r,y,l,s,f} = \left(\mathbf{A}^{l}_{r,y,s}\right)^{\mathrm{T}} \mathbf{C^{a}}_{r,y,s,f}$$

where $\mathbf{A}^{l}_{r,y,s}$ is the size-age transition matrix. Expected catch ($\text{Catch}_{r,y,f}$) is then computed summation of the expected catch-at-age across ages and sexes, multiplied by their respective weights-at-age ($W_{r,y,a,s}$):

$$\text{Catch}_{r,y,f} = \sum_{a}^{a_+} \sum_{s}^{n_s} C^{a}_{r,y,a,s,f}\, W_{r,y,a,s}$$

The expected fishery index ($\text{FshIdx}_{r,y,f}$) is computed as:

$$\text{FshIdx}_{r,y,f} = q^{\text{Fsh}}_{r,y,f} \sum_{a}^{a_+} \sum_{s}^{n_s} N_{r,y,a,s} \exp\left(-Z_{r,y,a,s} 0.5\right) \text{Sel}^{\text{Fsh}}_{r,y,a,s,f} W_{r,y,a,s}$$

where $q^{\text{Fsh}}_{r,y,f}$ is the catchability coefficient for a given fishery fleet.

Survey Observation Model

Similarly, the survey observation model describes the expected survey catch-at-age, survey catch-at-length, and survey indices. Moreover, if surveys are defined as an FAA model, the *sf* index

similarly extends, and the following equations can also be generalized. Expected survey catch-at-age ($I^{a}_{r,y,a,s,sf}$) is calculated as follows:

$$I^{a}_{r,y,a,s,sf} = N_{r,y,a,s}\exp\left(-Z_{r,y,a,s}0.5\right)\mathrm{Sel}^{\mathrm{Srv}}_{r,y,a,s,sf}$$

where subscript sf denotes a given survey fleet and $\mathrm{Sel}^{\mathrm{Srv}}_{r,y,a,s,sf}$ is the survey selectivity-at-age pattern. Expected survey catch-at-length ($I^{l}_{r,y,l,s,sf}$) is given by:

$$I^{l}_{r,y,l,s,sf} = \left(\mathbf{A}^{l}_{r,y,s}\right)^{\mathrm{T}}\mathbf{I^{a}}_{r,y,s,f}$$

Survey indices ($\mathrm{SrvIdx}_{r,y,sf}$) is computed as either abundance-based or biomass-based. Abundance-based survey indices are calculated as:

$$\mathrm{SrvIdx}_{r,y,sf} = q^{\mathrm{Srv}}_{r,y,sf}\sum_{a}^{a_+}\sum_{s}^{n_s} I^{a}_{r,y,a,s,sf}$$

while biomass-based indices are computed as:

$$\mathrm{SrvIdx}_{r,y,sf} = q^{\mathrm{Srv}}_{r,y,sf}\sum_{a}^{a_+}\sum_{s}^{n_s} I^{a}_{r,y,a,s,sf}\,W_{r,y,a,s}$$

In both equations, $q^{\mathrm{Srv}}_{r,y,sf}$ represents the survey catchability coefficient.

Selectivity Models

Several parameterizations of both fishery and survey selectivity are used throughout. In general, most fleets assume logistic selectivity, which is parameterized as:

$$\mathrm{Sel}_{a} = \frac{1}{1+\exp(-k(a-a_{50\%}))}$$

where k is the slope of the logistic function and $a_{50\%}$ denotes the age in which 50% of individuals are selected.

The other common selectivity form specified for certain model formulations presented includes a dome-shaped gamma selectivity form:

$$p = 0.5\left[\sqrt{a^{max}+4\gamma^{2}} - a^{max}\right]$$

$$\text{Sel}_a = \left(\frac{a}{a^{max}}\right)^{\frac{a^{max}}{p}} \exp\left(\frac{a^{max} - b}{p}\right)$$

In this parameterization, p is a derived power parameter, γ is the shape parameter that describes the steepness of the descending limb, and a^{max} describes the age-at-maximum selection.

As part of sensitivity analyses presented for both single-region and FAA models, certain models also specified continuous semi-parametric time-varying selectivity in attempts to address time-varying changes in availability. These models assumed logistic selectivity as the parametric form, with independent and identically distributed (iid) semi-parametric lognormal deviations by age $\left(\epsilon_{y,a}^{Sel}\right)$from the base parametric form and were configured as:

$$\text{Sel}'_{y,a} = \frac{1}{1 + \exp(-k(a - a_{50\%}))} \exp\left(\epsilon_{y,a}^{\text{Sel}}\right)$$

$$\text{Sel}_{y,a} = \frac{\text{Sel}'_{y,a}}{\text{mean}(\mathbf{Sel}')}$$

where deviations were applied about the underlying parametric logistic form and selectivity values were mean-standardized to improve interpretability and maintain identifiability among years. Sex- and fleet-specific subscripts were also estimated for selectivity deviations, but are omitted from the notation herein for brevity. Additional smoothing penalties were imposed to maintain identifiability and prevent large year-to-year and age-to-age changes in selectivity values, thereby encouraging gradual temporal and age transitions in selectivity patterns (additional details are provided in the Likelihoods section).

Tagging Observation Model

The tagging observation model tracks tag cohorts ($T_{r,y,a,s}^{k}$) by the combination of release region and release year (k) and follows a Brownie tag attrition framework. Tag cohorts are tracked for a pre-defined maximum duration (maximum tag liberty; n_L), after which calculations for the tag cohort are no longer computed. This is done to help with computation time. Additionally, tag cohorts also have the option to undergo a fraction of mortality in the year of release, such that if a given cohort is released during the middle of the year, mortality processes are discounted. If mortality discounting is specified, movement does not occur in the year of release. In general, the process dynamics for the tagged cohort mimics those specified for the overall population.

Immediately following release, tag cohorts are decremented by an initial tag-induced mortality rate:

$$T_{r,y,a,s}^{k} = T_{r,y,a,s}^{k} \exp(-\tau)$$

where τ is the initial tag-induced mortality rate. If tagged cohorts are released at the beginning of a calendar year, Markovian movement occurs (movement does not occur otherwise):

$$\mathbf{T}^{k}_{y,a,s} = \left(\mathbf{T}^{k}_{y,a,s}\right)^{\mathrm{T}}\mathbf{M}_{y,a,s}$$

Mortality and ageing of the tagged cohort then occur:

$$T^{k}_{r,y+1,a+1,s} = T^{k}_{r,y,a,s}\exp\left(-Z^{\mathrm{Tag}}_{r,y,a,s}\right), \quad \text{for } 2 \leq a < a_{+}$$
$$T^{k}_{r,y+1,a,s} = T^{k}_{r,y,a-1,s}\exp\left(-Z^{\mathrm{Tag}}_{r,y,a-1,s}\right) + T^{k}_{r,y,a,s}\exp\left(-Z^{\mathrm{Tag}}_{r,y,a,s}\right), \quad \text{for } a = a_{+}$$

where tagged cohorts follow an exponential mortality model, with accumulation of individuals in the plus-group. Total mortality for the tagged cohort ($Z^{\mathrm{Tag}}_{r,y,a,s}$) is specified as:

$$Z^{\mathrm{Tag}}_{r,y,a,s} = \left(\kappa + \mathrm{NatMort}_{r,y,a,s} + \sum_{f} \mathrm{Sel}^{\mathrm{Fsh}}_{r,y,a,s,f}\,\mathrm{Fmort}_{r,y,f}\right)$$

where κ is a parameter describing chronic tag loss (i.e., annual tag shedding). Similar to computations for catch-at-age, tag recaptures are calculated using a modified version of Baranov's catch equation:

$$\mathrm{Recap}^{k}_{r,y,a,s} = \beta_{r,y}\frac{\sum_{f}\mathrm{Sel}^{\mathrm{Fsh}}_{r,y,a,s,f}}{Z^{\mathrm{Tag}}_{r,y,a,s}}T^{k}_{r,y,a,s}\left[1 - \exp\left(-Z^{\mathrm{Tag}}_{r,y,a,s}\right)\right]$$

$\beta_{r,y}$ represents a tag reporting rate parameter that can vary across space and time, and is estimated in logit space such that it is constrained between $[0,1]$.

Likelihoods

The model incorporates likelihood components for the following data sources:

1. fishery catches,
2. fishery indices,
3. fishery age compositions,
4. fishery length compositions,
5. survey indices,
6. survey age compositions,
7. survey length compositions, and
8. tagging data.

The total likelihood is the sum of the individual likelihood contributions from these sources, along with penalties and priors. This total is minimized using a non-linear optimization algorithm to estimate model parameters.

Observation Likelihoods

Fishery catches are fit using a lognormal likelihood. The log-likelihood for observed catch, $L\left(\log\left(\text{ObsCatch}_{r,y,f}\right)\right)$, is defined as:

$$L\left(\log\left(\text{ObsCatch}_{r,y,f}\right)\right) = \lambda_{\text{ObsCatch}_{r,y,f}} \cdot \frac{1}{\sqrt{2\pi}\,\sigma_{\text{ObsCatch}_{r,y,f}}} \exp\left(-\frac{\left[\log\left(\text{ObsCatch}_{r,y,f}\right) - \log\left(\text{Catch}_{r,y,f}\right)\right]^2}{2\sigma^2_{\text{ObsCatch}_{r,y,f}}}\right)$$

Here, $\lambda_{\text{ObsCatch}_{r,y,f}}$ is the likelihood weight, $\text{ObsCatch}_{r,y,f}$ is the observed catch, $\text{Catch}_{r,y,f}$ is the predicted catch, and $\sigma^2_{\text{ObsCatch}_{r,y,f}}$ is the variance on the log scale.

Fishery indices are also fit using a lognormal likelihood. The log-likelihood for observed indices is:

$$L\left(\log\left(\text{ObsFshIdx}_{r,y,f}\right)\right) = \lambda_{\text{ObsFshIdx}_{r,y,f}} \cdot \frac{1}{\sqrt{2\pi}\,\sigma_{\text{ObsFshIdx}_{r,y,f}}} \exp\left(-\frac{\left[\log\left(\text{ObsFshIdx}_{r,y,f}\right) - \log\left(\text{FshIdx}_{r,y,f}\right)\right]^2}{2\sigma^2_{\text{ObsFshIdx}_{r,y,f}}}\right)$$

The parameter $\lambda_{\text{ObsFshIdx}_{r,y,f}}$ controls the weight of fishery indices to the objective function. $\text{ObsFshIdx}_{r,y,f}$ represents the observed fishery indices, and $\sigma^2_{\text{ObsFshIdx}_{r,y,f}}$ denotes the variance of the index.

Similarly, survey indices are fit to assuming a lognormal likelihood, which is given by:

$$L\left(\log\left(\text{ObsSrvIdx}_{r,y,sf}\right)\right) = \lambda_{\text{ObsSrvIdx}_{r,y,sf}} \cdot \frac{1}{\sqrt{2\pi}\,\sigma_{\text{ObsSrvIdx}_{r,y,sf}}} \exp\left(-\frac{\left[\log\left(\text{ObsSrvIdx}_{r,y,sf}\right) - \log\left(\text{SrvIdx}_{r,y,sf}\right)\right]^2}{2\sigma^2_{\text{ObsSrvIdx}_{r,y,sf}}}\right)$$

Again, $\lambda_{\text{ObsSrvIdx}_{r,y,sf}}$ is the likelihood weight applied to survey indices, $\text{ObsSrvIdx}_{r,y,sf}$ are the observed survey indices, and $\sigma^2_{\text{ObsSrvIdx}_{r,y,sf}}$ indicates the variance of the index.

Several formulations of composition likelihoods were explored throughout. Across most models, both fishery and survey compositions were generally fitted assuming a multinomial likelihood, which is given by:

$$L(\left(\text{ObsCompositionData}_{r,y,j}\right) = \lambda_{\text{ObsCompositionData}_{r,y,j}} \cdot \text{ISS}_{r,y,j} \cdot \prod_{b=1}^{n_b} E_{r,y,b,j}^{O_{r,y,b,j}}$$

where subscript j is used to indicate a fishery or survey fleet. $\lambda_{\text{ObsCompositionData}_{r,y,j}}$ are likelihood weights applied to composition data (can be derived using iterative weighting methods), $ISS_{r,y,j}$ is the input sample size, the b subscript generically indicates a bin number, $E_{r,y,b,j}$ denotes the expected composition proportions, and $O_{r,y,b,j}$ are the observed composition proportions.

In some cases, the Dirichlet-multinomial was also employed to better understand the impact of self-weighting likelihoods on model results, and was parameterized as:

$$L\left(\text{ObsCompositionData}_{r,y,j}\right) =$$
$$\lambda_{\text{ObsCompositionData}_{r,y,j}} \cdot \frac{\Gamma\left(\text{ISS}_{r,y,j}+1\right)}{\text{ISS}_{r,y,j} \cdot O_{r,y,b,j}+1} \cdot \frac{\Gamma\left(\text{ISS}_{r,y,j}\theta_{r,j}\right)}{\Gamma(\text{ISS}_{r,y,j}+\text{ISS}_{r,y,j}\theta_{r,j})} \cdot$$
$$\prod_{b=1}^{n_b} \frac{\Gamma(\text{ISS}_{r,y,j}O_{r,y,b,j} + \text{ISS}_{r,y,j}\theta_{r,j}E_{r,y,b,j})}{\text{ISS}_{r,y,j}\theta_{r,j}E_{r,y,b,j}}$$

Here, $\theta_{r,j}$ is the overdispersion parameter of the Dirichlet-multinomial that adjusts the input sample size. The effective sample size ($\text{ESS}_{r,y,j}$) can then be derived as:

$$\text{ESS}_{r,y,j} = \frac{1}{1+\theta_{r,j}} + \text{ISS}_{r,y,j}\frac{\theta_{r,j}}{1+\theta_{r,j}}$$

Therefore, if $\theta_{r,j}$ was large such that $\theta_{r,j} \gg \text{ISS}_{r,y,j}$, then $\text{ESS}_{r,y,j} \rightarrow \text{ISS}_{r,y,j}$. By contrast, if $\theta_{r,j}$ was estimated at a small value such that $\theta_{r,j} \ll \text{ISS}_{r,y,j}$, then $\theta_{r,j}$ approximates the ratio of $\text{ESS}_{r,y,j}$ and $\text{ISS}_{r,y,j}$.

Within the SPoRC framework, compositions can be arranged to be split by sex or joint by sex. For brevity, we will describe the joint by sex approach, which is the author recommended approach (i.e., models 25.7 +). Here, composition proportions are assumed to sum to one jointly across both ages and sexes. Thus, for the expected fishery age compositions, this is computed as:

$$E_{r,y,b,j} = \frac{\left[C^a_{r,y,a,s=1,f},\ C^a_{r,y,a,s=2,f}\right]}{\sum_a \sum_s C^a_{r,y,a,s,f}}$$

with $b \in \{1, \ldots, n_a \cdot n_s\}$. The expected survey age compositions are computed similarly as:

$$E_{r,y,b,j} = \frac{\left[I^a_{r,y,a,s=1,sf},\ I^a_{r,y,a,s=2,sf}\right]}{\sum_a \sum_s I^a_{r,y,a,s,sf}}$$

For expected fishery length compositions, this is given by:

$$E_{r,y,b,j} = \frac{\left[C^{l}_{r,y,l,s=1,f},\ C^{l}_{r,y,l,s=2,f}\right]}{\sum_l \sum_s C^{a}_{r,y,l,s,f}}$$

where $b \in \{1, \ldots, n_l \cdot n_s\}$. Expected survey length compositions follow in a similar fashion:

$$E_{r,y,b,j} = \frac{\left[I^{l}_{r,y,l,s=1,f},\ I^{l}_{r,y,l,s=2,f}\right]}{\sum_l \sum_s I^{a}_{r,y,l,s,f}}$$

To fit tagging data, a multinomial release-conditioned likelihood is assumed, which describes both recaptured and non-recaptured states. The observed and expected recapture proportions are defined as:

$$\begin{aligned}
\text{PropRecap}^{k}_{r,y,a,s} &= \frac{\text{Recap}^{k}_{r,y,a,s}}{\text{InitTag}^{k}} \\
\text{ObsPropRecap}^{k}_{r,y,a,s} &= \frac{\text{ObsRecap}^{k}_{r,y,a,s}}{\text{InitTag}^{k}}
\end{aligned}$$

where InitTag^{k} is the total number of tags released for tag cohort k.

The corresponding non-recapture proportions are computed as:

$$\begin{aligned}
\text{PropNonRecap}^{k} &= 1 - \sum_r \sum_y \sum_a \sum_s \text{PropRecap}^{k}_{r,y,a,s} \\
\text{ObsPropNonRecap}^{k} &= 1 - \sum_r \sum_y \sum_a \sum_s \text{ObsPropRecap}^{k}_{r,y,a,s}
\end{aligned}$$

Expected and observed tagging outcomes are represented by the following vectors:

$$\begin{aligned}
\mathbf{O}^{k}_{\text{Tagging}} &= \left\{\text{ObsPropRecap}^{k}_{r,y,a,s},\ \text{ObsPropNonRecap}^{k}\right\} \\
\mathbf{E}^{k}_{\text{Tagging}} &= \left\{\text{PropRecap}^{k}_{r,y,a,s},\ \text{PropNonRecap}^{k}\right\}
\end{aligned}$$

A multinomial likelihood is then used to evaluate tagging data:

$$L^{k}_{\text{Tagging}} = \lambda_{\text{Tagging}} \cdot \text{InitTag}^{k} \prod_i \left(E^{k}_{i,\text{Tagging}}\right)^{O^{k}_{i,\text{Tagging}}}$$

Here, λ_{Tagging} is the likelihood weight, and i indexes elements of the observed and expected tagging proportion vectors.

Several priors and penalties are applied to constrain, stabilize, and inform parameter estimation. Specifically, priors are used for natural mortality, selectivity, movement, recruitment proportions,

and tag reporting rates. The last three parameter types are only applicable for the spatial model. Additionally, penalties are used to constrain the estimation of parameters associated with deviations, which include: initial ages, recruitment, and fishing mortality.

In the case of natural mortality, a lognormal prior is utilized:

$$P\big(\log(\text{NatMort}_s)\big) = \frac{1}{\sqrt{2\pi}\,\sigma_{\text{NatMort}}} \exp\left(-\frac{[\log(\text{NatMort}_s) - \log(\mu_s^{\text{NatMort}})]^2}{2\sigma_{\text{NatMort}}^2}\right)$$

The variance of the prior is given by $\sigma_{\text{NatMort}}^2$, and μ_s^{NatMort} denotes the prior mean.

Selectivity priors are also utilized which serve as regularizing priors to facilitate stable parameter estimation. These priors are assumed to be lognormal and are applied to the selectivity parameters themselves:

$$P\big(\chi_{r,p,t,s,j}\big) = \frac{1}{\chi_{r,p,t,s,j}\sqrt{2\pi}\,\sigma_{r,p,t,s,j}^{\text{Sel}}} \exp\left(-\frac{\big[\ln\big(\chi_{r,p,t,s,j}\big) - \ln\big(\mu_{r,p,t,s,j}^{\text{Sel}}\big)\big]^2}{2\big(\sigma_{r,p,t,s,j}^{\text{Sel}}\big)^2}\right)$$

where $\chi_{r,p,t,s,j}$ is the selectivity parameter for region r, parameter p, time period t, sex s, and fleet j (fishery or survey). $\mu_{r,p,t,s,j}^{\text{Sel}}$ is the prior mean, while $\big(\sigma_{r,p,t,s,j}^{\text{Sel}}\big)^2$ is the prior variance.

Priors on movement values are assumed to arise from a Dirichlet process:

$$P\big(\mathbf{M}_{k,y,a,s}\big) = \frac{\Gamma\big(n_r \cdot \alpha_{y,a,s}\big)}{\big[\Gamma\big(\alpha_{y,a,s}\big)\big]^{n_r}} \prod_{r=1}^{n_r} M_{k,r,y,a,s}^{\alpha_{y,a,s}-1}$$

where $\mathbf{M}_{k,y,a,s} = \{M_{k,1,y,a,s}, \ldots, M_{k,n_r,y,a,s}\}$ is the vector of movement probabilities from region k to all regions, and $\alpha_{y,a,s}$ is the concentration parameter controlling the strength of the prior for year y, age a, and sex s.

Regional recruitment is derived by apportioning a global recruitment parameter using regional recruitment proportions (i.e., $\mu^{\text{Rec}} \cdot \zeta_r$). Here, ζ_r is derived via a multinomial logit transformation and Dirichlet priors are used to help constrain estimation:

$$P(\boldsymbol{\zeta}) = \frac{\Gamma(n_r \cdot c)}{[\Gamma(c)]^{n_r}} \prod_{r=1}^{n_r} \zeta_r^{c-1}$$

$\boldsymbol{\zeta} = \{\zeta_1, \zeta_2, \ldots, \zeta_{n_r}\}$ are the estimated recruitment proportions across regions, and c is a shared concentration parameter governing the spread of the Dirichlet distribution.

To facilitate the estimation of tag reporting rates, a symmetric beta distribution is applied:

$$P(\beta_{r,y}) = (\beta_{r,y} + 1e-4)^{\beta_{\text{PriorScale}}}(1 - \beta_{r,y} + 1e-4)^{\beta_{\text{PriorScale}}}$$

$\beta_{\text{PriorScale}}$ determines the scale of the tag reporting parameter and determines how strongly to penalize estimates when they approach the bounds of [0,1].

Estimation of initial age deviations $\epsilon_{r,i}^{\text{Init}}$ is constrained by the following normal likelihood:

$$L(\epsilon_{r,i}^{\text{Init}}) = \frac{1}{\sqrt{2\pi}\,\sigma_{\text{Init}}} \exp\left(-\frac{(\epsilon_{r,i}^{\text{Init}})^2}{2\sigma_{\text{Init}}^2}\right)$$

with a mean of 0 and a variance determined by σ_{Init}^2.

Similarly, estimation of recruitment deviations is also constrained by a normal likelihood with a mean of 0 and a variance of σ_{Rec}^2. This is given by:

$$L(\epsilon_{r,y}^{\text{Rec}}) = \frac{1}{\sqrt{2\pi}\,\sigma_{\text{Rec}}} \exp\left(-\frac{(\epsilon_{r,y}^{\text{Rec}})^2}{2\sigma_{\text{Rec}}^2}\right)$$

Estimation of fishing mortality deviations is also constrained by a normal likelihood. Fishing mortality deviations are then assumed to have a mean of 0 and a variance of σ_{Fsh}^2:

$$L(\epsilon_{r,y,f}^{\text{Fsh}}) = \frac{1}{\sqrt{2\pi}\,\sigma_{\text{Fsh}}} \exp\left(-\frac{(\epsilon_{r,y,f}^{\text{Fsh}})^2}{2\sigma_{\text{Fsh}}^2}\right)$$

In model configurations where semi-parametric time-varying selectivity is specified, estimation of semi-parametric deviations is also constrained by a normal likelihood. Semi-parametric deviations are assumed to then have a mean of 0 and a variance of σ_{Sel}^2:

$$L(\epsilon_{r,y,a}^{\text{Sel}}) = \frac{1}{\sqrt{2\pi}\,\sigma_{\text{Sel}}} \exp\left(-\frac{(\epsilon_{r,y,a}^{\text{Sel}})^2}{2\sigma_{\text{Sel}}^2}\right)$$

Additionally, second-order smoothing penalties are also imposed to ensure that selectivity values do not drastically vary by temporally or across ages:

$$P_{\text{SelBinCurve}_r} = \sum_{y=1}^{n_y}\sum_{b=2}^{n_b-1}\left(\log(\text{Sel}_{r,y,a+1}) - 2\log(\text{Sel}_{r,y,a})\log(Sel_{r,y,a-1})\right)^2$$

$$P_{\text{SelYrCurve}_r} = \sum_{y=2}^{n_y-1}\sum_{b=1}^{n_b}\left(\log(\text{Sel}_{r,y+1,a}) - 2\log(\text{Sel}_{r,y,a})\log(\text{Sel}_{r,y-1,a})\right)^2$$

The penalties associated with selectivity also include sex- and fleet-specific subscripts, although these are omitted from the notation herein for brevity.

Lastly, the joint likelihood to be minimized represents the sum of all observational likelihood components, priors, and penalties defined above:

$$\text{Joint Likelihood} = \sum\text{Observation Likelihoods} + \sum\text{Priors} + \sum\text{Penalties}$$

Note that some of these components may be zero depending on the configuration of the model (e.g., tagging likelihood would equal 0 in a single-region model).

Appendix 3B: Model Building and Bridging Exercise for the Sablefish Single Region Models (Bridging from Model *25.12* to *26.1*)

Daniel Goethel and Matt Cheng

June 2026 Sablefish Center for Independent Experts (CIE) Review

Executive Summary

The model building exercise focused on three general areas of refinement to the sablefish assessment (Table 3B.1): model parametrization (primarily aimed at improving stability), biology (focused on updating biological inputs and sex-specific modeling), and data usage (emphasizing reducing model tension, removing uncertain data, and developing a consistent approach for constructing the NOAA longline survey abundance index due to survey design changes). In addition, a number of sensitivity runs were also undertaken (Table 3B.4), but were not included in the final single region model. Sensitivity runs primarily focused on improving fits to compositional data (via time-varying selectivity), using self-weighting likelihoods (Dirichlet-multinomial) to avoid potentially overfitting the indices, and exploring time-varying growth to better represent recent declines in size and weight.

Despite minor rescaling of spawning stock biomass (SSB) across model building runs, the suite of models retained strong agreement in population trends, particularly recruitment (Figures 3B.4 – 3B.5). The differences in SSB scale can be attributed to changes in natural mortality (M) estimates (Figure 3B.6), because small changes in M have long-term impacts on SSB for a long-lived species, such as sablefish. Estimating sex-specific M values reduced estimates and helped stabilize estimation, likely reducing correlation among other scaling parameters (e.g., R_0). Updating the growth curve and length-weight parameter estimates also had a downward impact on scaling, as expected, given the decline in size- and weight-at-age of younger fish in recent years (Figure 3B.7). The changes to the input data had important impacts on scale, as well. The removal of length compositions for data sets that had age compositions (i.e., the NOAA Longline Survey and fixed gear fishery) reduced M and SSB scale, while switching to a 'carryover' approach for NOAA Longline Survey index construction had the opposite effect, particularly leading to a more rapid increase in SSB in recent years. Removal of extrapolated NOAA Longline Survey stations for the western Aleutian Islands, which are not surveyed and assume a fixed extrapolation proportion, scaled the survey and population downward at the end of the time series. The final survey index appears biologically reasonable with more gradual and consistent increases during the recent (since 2016) population growth and slightly lower overall scale (Figure 3B.3). The combination of the new index construction and removal of the fixed gear fishery Catch-per-Unit Effort (CPUE) index led to minor improvements in fitting the NOAA Longline Survey index. Similarly, dropping the length compositions led to very minor improvements in the age composition fits, but greatly improved model stability.

Despite the tranche of model changes, the general consistency across models in parameter estimates, population trends, and catch advice as well as the lack of any strong retrospective patterns within each model suggests a strong degree of viscosity towards alternative interpretations of the available data (even as different data types were added or removed). However, the continued

mediocre fits to the composition data (exhibiting age and cohort residual patterns) highlights a fundamental tension between fitting the indices and the compositions. Part of the consistency across models along with mediocre fits to the composition data can be attributed to the use of the Francis reweighting approach (Francis, 2011), which aims to 'right-weight' the data by prioritizing the abundance indices and accounting for correlations in composition data, typically resulting in lower weights for the compositions. The sensitivity runs explored alternative approaches for dealing with inherent process error when fitting composition data, including self-weighting likelihoods and/or time-varying selectivity. Although these approaches modestly improved the fit to the composition data, it often occurred at the expense of poorer fits to the NOAA Longline Survey index, and led to moderate retrospective patterns in SSB (due to overfitting compositions leading to consistent overestimation of recruitment relative to the terminal assessment). The proposed changes, as implemented in Model *26.1_1Reg*, balance fit across data sources (e.g., age compositions and indices) and model complexity, while providing a much more stable model with reduced tension caused by uncertain and potentially uninformative data (e.g., by dropping length compositions and fixed gear fishery CPUE). The sensitivity models provided potentially useful functionality that might be considered in future sablefish assessments, but diagnostics and performance did not indicate that any of the explorations led to substantially improved models at this time.

The following document summarizes model performance and results of select model runs from the stepwise model building process, primarily in comparison to the continuity model (*25.12_1Reg_Cont*). However, full model results and diagnostics are available at the Alaska sablefish assessment CIE review GitHub site, where individual folders are provided for every model run produced for the CIE Review. Folders contain SPoRC input and output R files along with PDFs of results (folders for single region model runs are available here). Full model outputs for the continuity model (*25.12_1Reg_Cont*) and the final single region model (*26.1_1Reg*) are provided in the Supplementary Material (SM3B).

1. Model Building

Introduction

In 2025, the custom sablefish assessment model implemented in AD Model Builder (ADMB) was transitioned into the R-TMB generalized Spatial Populations over Regional Components (SPoRC) stock assessment R package (Cheng et al., 2026; https://chengmatt.github.io/SPoRC/index.html). After demonstrating an exact match to the ADMB model (Figures 3B.1 – 3B.2), major modeling changes to the stock assessment were undertaken, which aimed to address model stability, better align parametrizations with stock assessment good practices, and refine data inputs (Goethel and Cheng, 2025). The final model for 2025 (Model *25.12*) was reviewed and approved at the September North Pacific Fisheries Management Council (NPFMC) Groundfish Plan Team (GPT) and October Science and Statistical Committee (SSC) meetings. However, an operational assessment was never undertaken due to the US government shutdown in the fall of 2025 (the last operational assessment was in 2024; Goethel and Cheng, 2024). With the goal of providing the 'best scientific information available' for review by the CIE and to further address GPT and SSC recommendations provided in 2025, the authors underwent another round of model building with the sablefish assessment for the CIE review resulting in the final single region model for review, Model *26.1_1Reg*.

The model building exercise focused on three general areas of refinement to the sablefish assessment (Table 3B.1): model parametrization (primarily aimed at improving stability), biology (focused on updating biological inputs and sex-specific modeling), and data usage (emphasizing reducing model tension, removing uncertain data, and developing a consistent approach for constructing the NOAA longline survey abundance index). Sablefish exhibit sexually dimorphic growth, which manifests as differences in selectivity-at-age by sex in the age-structured assessment model. A key source of model instability is the estimation of selectivity, given the increase in model parameters due to integrating a sex partition. The first step in model building was to remove selectivity parameter linkages and implement more realistic priors on the selectivity parameters, which aimed to improve model stability.

The next set of big changes aimed to improve the general portrayal of sablefish biology, which involved updating length and weight estimates as well as estimating sex-specific *M*. Given that sablefish appear to be undergoing density-dependent growth and reaching smaller sizes and weights, especially at younger ages (Cheng et al., 2024), the growth curves and length-weight parameters were reestimated (externally) with all available data through 2025 to better reflect recent changes. Then, sex-specific natural mortality was estimated to better reflect good practices for sex-specific assessments (Cheng et al., 2025a).

Next, the data inputs were revised to better address model tension and improve data inputs (e.g., the construction of the NOAA Longline Survey index). Historically, the sablefish assessment has fit both age and length composition data despite inherent tension and potential misspecification (e.g., due to lack of time-varying growth parameters when fitting length compositions). The decision to fit both types of data likely stemmed from the limited age composition data available when the sablefish assessment began using an age-structured integrated analysis paradigm in the 2000s. Moreover, certain data sources (e.g., the trawl fishery) only have length composition data available. In Model *25.12_1Reg_Cont*, length compositions were removed in years when age

compositions were available for a given data source. However, extensive tension remained between fitting age and length compositions for a given data source (as observed in the likelihood profiles; Goethel and Cheng, 2025), which could be due to continued model misspecification and/or varying signals in the data. In particular, the general lack of strong signals of recruitment in length compositions due to multiple cohorts contributing to a given length bin is likely to cause tension across fitting age and length compositions simultaneously, which is common for long-lived species. Generally, age compositions provide more direct indications of year class strength and cohort mortality compared to length data. The benefit of simultaneously fitting age and length data in an integrated assessment is an open area of research (Ono et al., 2015), but fitting length data is not recommended when growth is misspecified (i.e., if time-varying growth cannot be adequately replicated in the model; Minte-Vera et al., 2017). Given that sablefish demonstrate density-dependent growth that is not captured in the assessment (Cheng et al., 2024), there likely is model tension between age and length data, particularly for recent cohorts. Thus, the remaining length data from the fixed gear fishery (1990 – 1998) and NOAA Longline Survey (1990 – 1995) were deemed likely to be providing low signal to noise ratio and causing tension with fitting the more reliable age composition data.

Similarly, the fixed gear fishery standardized CPUE index (Cheng et al., 2023) has greater uncertainty compared to the NOAA Longline Survey index, given that the latter is a dedicated sablefish survey that historically covers a large proportion of the sablefish distribution in Alaska. Moreover, since 2022, the CPUE index can no longer be updated, given lack of important input data streams (i.e., logbooks) for creation of the index. Ultimately, NOAA Longline Survey and fixed gear fishery length compositions and the CPUE index were removed following the general principle of data quality over quantity (Payne et al., 2009), with the aim of reducing data conflict and model tension and instability.

Finally, alternative methods for index calculation of the NOAA Longline Survey relative population numbers (RPNs) were explored to provide a more consistent and reliable index. Historically, because the survey was conducted every other year in the Bering Sea (odd years, BS) and Aleutian Islands (even years, AI), an extrapolation was required for non-surveyed region RPNs to ensure a consistent scale of the index at the Alaska-wide level. The traditional approach was to use the population growth in the GOA (surveyed annually) to extrapolate abundance (from the previous RPN value) in either the BS or AI for years where a given region was not surveyed (Siwicke and Malecha, 2026). In 2025, the longline survey design was changed due to market conditions (given it is a cooperative research cost recovery survey), where only the GOA is now surveyed in odd years and only the BS and AI are surveyed in even years. The new design precludes use of the GOA extrapolation method (since it is no longer surveyed annually), so the ‘carryover’ approach was introduced in 2025 wherein hold-over values for non-surveyed regions were used (i.e., the last survey RPN value for a given region was used if the region was not surveyed). Although simple analysis indicated that the ‘carryover’ approach was likely sufficient (Goethel and Cheng, 2025), the new survey design necessitates extrapolating ~50% of sablefish abundance in a given year.

Thus, to ensure consistency across the index time series, the ‘carryover’ index was calculated and fit for all years (instead of using the GOA extrapolation until 2023 and switching to the carryover approach in 2025, as was done in Model *25.12_1Reg_Cont*). As part of the update to the index,

the longline survey team noted that the historical extrapolation of western AI stations (that are no longer sampled) based on eastern AI station RPNs and a fixed extrapolation ratio (estimated from Japanese survey data) was likely not appropriate (K. Siwicke, Personal Communication). Due to the rapid increase in the AI RPNs in recent years, the extrapolation was likely leading to overestimation of population growth. Thus, the final NOAA Longline Survey index utilized the carryover approach and removed western AI stations from the index (Figure 3B.3).

The three groupings of model changes, as implemented in Model *26.1_1Reg*, are expected to provide a more robust modeling framework that improves stability and biological realism of the sablefish stock assessment.

Methods

A stepwise model development process was undertaken wherein model changes were first implemented as single, one-off changes from Model *25.12* (see the sablefish CIE project GitHub for all results), then an incremental model building approach was undertaken. Each step implemented a single primary change from the previous step in the build towards the final Model *26.1_1Reg*, and the order of steps was done within the broad groupings and generally aimed to build from smaller to larger impact changes (aside from the first update, Model *26.1a*, which aimed to greatly increase stability). For all model runs in this document, the final data through the end of 2025 were utilized as would have been available for the 2025 operational assessment. All models underwent Francis reweighting to 'right-weight' the compositional data and account for correlation among composition bins (Francis, 2011, 2017).

The choice of the final model (Model *26.1_1Reg*) was made based on a combination of whether a model led to improved data fits or diagnostics, reduced model tension among data sets, increased model stability, and/or improved biological realism. In many instances, results and diagnostics were similar across model runs, which required the use of expert judgment to identify which models were likely to be more robust to the primary uncertainties associated with sablefish population dynamics while providing consistent management advice. The results focus on stepwise runs that had large impacts in comparison to the continuity model (*25.12_1Reg_Cont*), but primarily describe impacts from the full suite of changes (Model *26.1_1Reg*).

See Table 3B.1 for a full list of models with associated rationale for each and Table 3B.2 for a summary of results. Further model explorations that were deemed mostly exploratory for 2025 are then provided as sensitivity runs (Table 3B.4; see Section 2: Sensitivity Runs). A full mathematical description of the underlying SPoRC assessment framework is provided in Appendix 3A, while additional figures comparing the continuity model (*25.12_1Reg_Cont*) with the 2026 final single region model (*26.1_1Reg*) is provided in the supplement to this document (SM3B).

Primary model updates included:

- *25.12_1Reg_Cont*:
    - The final 2025 operational model with no changes except updated data through 2025.

- *26.1a_1Reg_Cont_Upd*:
    - Remove linkages among selectivity parameters (mainly sharing of parameters across sexes or time blocks, such that each selectivity parameter is estimated independently for each sex and time block).
    - Update the selectivity parameter to be more realistic (estimated in log-space) priors to ~$N(\ln(4),1.5^2)$ for the fishery and ~$N(\ln(3),1.5^2)$ for the survey.
    - Reduce the assumed survey standard error from 2*Obs_SE to 1.5*Obs_SE to reflect relative information content of the index.

- *26.1b_1Reg_Cont_Upd_ISS*:
    - Implement scaled input sample sizes (ISS) across years within a gear to better represent interannual variability in sampling, which are scaled to fleet/composition specific minimum and maximum values (e.g., age data are provided a higher max ISS than length data; formerly a time-invariant sample size of 20 was assumed for all composition data).

- *26.1c_1Reg_Cont_Upd_TF_log*:
    - Assume logistic selectivity for the trawl fishery (formerly domed selectivity was assumed estimated with a gamma function) to better reflect catch of bigger female fish and to improve model stability.

- *26.1d_1Reg_Cont_Upd_Upd_Bio*:
    - Externally re-estimate and update the growth curve and length-weight parameters using the methods outlined in Echave (2021) using all available NOAA Longline Survey age-length-weight data (1996 – 2025) and input the new size-age transition matrix and weight-at-age curve into the assessment model.

- *26.1e_1Reg_Cont_Upd_Sex_M*:
    - Estimate sex-specific *M* as independent parameters, but sharing the same prior as in Model *25.12_1Reg_Cont*.

- *26.1f_1Reg_Cont_Upd_No_CPUE:*
    - Remove the fixed gear fishery CPUE index from the assessment, including the historical Japanese CPUE (1964 – 1981) and the domestic CPUE (1995 – 2022), noting that these data are unavailable starting from 2023 onwards.

- *26.1g_1Reg_Cont_Upd_No_Len_2_Blks_F:*
    - Remove the length data for the fixed gear fishery (1990 – 1998) and the NOAA Longline Survey (1990 – 1995) and remove the early fixed gear fishery selectivity time block (given that there is no longer composition data available to estimate it).

- *26.1h_1Reg_Cont_Upd_LLS_Carry:*
    - Implement the ‘carryover’ method for constructing the NOAA Longline Survey RPN index for all years.

- *26.1i_1Reg_Cont_Upd_No_wAI_LLS:*
    - Remove the extrapolated western AI stations from the NOAA Longline Survey RPN index for all years.

Results

Generally, none of the models in the model building exercise led to significant changes to the data fits or interpretation of population dynamics (Figures 3B4 – 3B.5; Table 3B.3). Moderate scaling changes in SSB resulted across runs due to changes in the biological inputs (Figure 3B.6), estimates of *M* (Figure 3B.7), NOAA Longline Survey index construction (Figure 3B.8), and selectivity assumptions (i.e., removing the dome for the trawl fishery selectivity; Figures 3B.8 – 3B.9). Although relative stock status and catch advice (Acceptable Biological Catch, based on fishing at $F_{40\%}$) remained consistent from Model *25.12_1Reg_Cont* to Model *26.1_1Reg* (same as Model *26.1i_1Reg_Cont_Upd_No_wAI_LLS*), the stepwise progression involved moderate upward and downward scaling across various model updates. Upward scaling of SSB and catch advice in Models *26.1a_1Reg_Cont_Upd*, *26.1f_1Reg_Cont_Upd_No_CPUE*, and *26.1h_1Reg_Cont_Upd_LLS_Carry* was primarily associated with closer fits to the NOAA Longline Survey index (increased assumed standard error in the first, removal of contradictory CPUE signals in the second, and a more steady and consistent index in the third). Downward scaling was then associated with updating the biology (reduced growth and weight; Model *26.1d_1Reg_Cont_Upd_Upd_Bio*), estimating sex-specific *M* (reduced *M* estimates; Model *26.1e_1Reg_Cont_Upd_Sex_M*), removing length compositions (reduction in male *M* estimates; Model *26.1g_1Reg_Cont_Upd_No_Len_2_Blks_F*), and removal of extrapolated survey stations (reductions in total NOAA Longline Survey RPNs; Model *26.1i_1Reg_Cont_Upd_No_wAI_LLS*).

Notable changes in model dynamics included:

- *25.12_1Reg_Cont* (full results here):
    - Adding a new year of data led to important changes in the shape of the trawl fishery selectivity, highlighting the lack of stability in the gamma function parameters (comparison here).
    - *M* decreased moderately (likely correlated to the change in the shape of the trawl fishery dome selectivity), leading to a slight decrease in SSB across the time series.
    - Catch advice (Acceptable Biological Catch, ABC, based on the $F_{40\%}$ harvest control rule) did not change given similar relative stock status due to the increase in $B_{40\%}$.

- *26.1a_1Reg_Cont_Upd* (full results here):
    - Assuming a lower standard error for the NOAA Longline Survey index led to minor improvements to the index fit, but no appreciable changes to fits in other data.
    - *M* increased moderately (Figure 3B.7) leading to an increase in overall scale of SSB and moderate increase in catch advice (Table 3B.4), which is due to the higher terminal SSB (Figure 3B.3) caused by a closer fit to the terminal NOAA Longline Survey index value.
    - Selectivity only changes slightly despite removing parameter linkages and updating priors, but estimates are more stable demonstrating lower correlation.

- *26.1b_1Reg_Cont_Upd_ISS* (full results here):
  - Despite higher mean Input Sample Size (ISS), final mean Effective Sample Size (ESS) values across data sources after Francis reweighting remain consistent with the previous model that assumed a time-invariant ISS.
  - Minor improvements in yearly compositional fits and residual patterns result due to better representation of interannual variability in sampling.
  - No appreciable changes in population trajectories or catch advice.

- *26.1c_1Reg_Cont_Upd_TF_log* (full results here):
  - Assuming logistic trawl fishery selectivity leads to subtle improvements in fit to the mean length by year and minor differences in length composition fits and residual patterns, as well as an important change in the shape of the ascending limb of the selectivity function for females.
  - There were no appreciable changes in population trajectories or catch advice, but trawl fishery selectivity parameters are much more stable.

- *26.1d_1Reg_Cont_Upd_Upd_Bio* (full results here):
  - Updating growth and weight parameters caused the mean weight of younger fish to decrease slightly (Figure 3B.6) reflecting decreases in average size and weight for recent cohorts, but there were similar increases in mean weight for older aged fish.
  - The scale of SSB and biomass are scaled down slightly while $B_{40\%}$ increases slightly (due to an increase in weight for older fish) resulting in a moderate decline in catch advice (Table 3B.3).

- *26.1e_1Reg_Cont_Upd_Sex_M* (full results here):
  - Allowing sex-specific *M* to be estimated leads to a downward scaling of *M* for both sexes (Figure 3B.7), though estimates remain similar (likely given the use of the same prior).
  - Reductions in *M* resulted in an upward shift in *F* and $B_{40\%}$, and a concomitant downward shift in SSB across the time series, all of which resulted in a moderate decrease in catch advice (Table 3B.3).

- *26.1f_1Reg_Cont_Upd_No_CPUE* (full results here):
  - Removing the fixed gear fishery CPUE index allows the NOAA Longline Survey index to be better fit, especially in recent years.
  - SSB demonstrates a more rapid decrease historically (due to removal of the historical Japanese CPUE) and a more rapid increase since ~2016 (more in line with the NOAA Longline Survey index trends).

- *26.1g_1Reg_Cont_Upd_No_Len_2_Blks_F* (full results here):
  - Removing the remaining fixed gear fishery and NOAA Longline Survey length compositions led to minor improvements in the fit and residual patterning in the associated age compositions (including improved fits to mean age).

    - Removal of potentially conflicting signals in the data resulted in a reduction in male *M* (Figure 3B.7), average recruitment (Figure 3B.5), and the scale of SSB (Figure 3B.4).
    - The combined effect of changes in *M* and recruitment was to reduce $B_{40\%}$ and associated catch advice moderately (Table 3B.3).
    - Model stability improved with slightly lower maximum gradients and reduced parameter correlation.

- *26.1h_1Reg_Cont_Upd_LLS_Carry* (full results here):
    - Using the 'carryover' method to calculate the NOAA Longline Survey index led to a more gradual and consistent increase in RPNs over the last decade, which allowed the model to better fit the index (Figure 3B.8).
    - By fitting the index more closely, the population scale increases similar to Model *26.1f_1Reg_Cont_Upd_No_CPUE* including catch advice (Table 3B.3).

- *26.1i_1Reg_Cont_Upd_No_wAI_LLS* (a.k.a. *26.1_1Reg*; full results here):
    - Dropping extrapolated stations from the western AI from the NOAA Longline Survey index reduces the scale of the index and the recent rate of increase in the index (Figure 3B.8).
    - SSB scale is reduced slightly in the recent period resulting in a small decline in catch advice (Table 3B.3).

Each model building step helped improve model stability as diagnosed via various convergence diagnostics (e.g., maximum gradient values, number and degree of parameter correlations, jitter analysis, and profile likelihoods). The resulting end model for this first segment (Model *26.1_1Reg*) has much more stable selectivity parameters, which has been an ongoing concern for the sablefish assessment, often requiring linking parameters across sexes. Moreover, improving biological realism by estimating sex-specific *M* has helped stabilize the estimates and move them towards more realistic, lower values. Similarly, removal of length compositions (for fleets where age compositions exist) has further reduced model tension, providing better alignment in scaling parameters among the age composition data and the indices (Figures SM3B.61 – SM3B.64).

Compared to *Model 25.12_ 1Reg_Cont, Model 26.1_1Reg* provides a slight improvement in fit to the age composition data, while also improving fit to the NOAA Longline Survey index (see Figures in SM3B). By improving model parametrization, reducing model tension from uncertain data sources, and improving biological realism, the resulting Model *26.1_1Reg* appears to provide a more robust assessment of the sablefish population. Although conflicting signals remain between the age compositions and the NOAA Longline Survey index in terms of magnitude of recent year classes and the associated rate of population growth, these conflicts appear to be reduced with the suite of model updates. Moreover, the assessment continues to produce extremely good retrospective diagnostics, showing essentially no over- or under-estimation of SSB and only moderate initial underestimation of the recent, large year classes (Figures SM3B.57 – SM3B.60).

Conclusion

Model *26.1_1Reg* provides improved parametrization and removal of uncertain and potentially contradictory data sets, greatly improves model stability, provides updates to the NOAA Longline Survey index construction that improve consistency and better reflect observed dynamics, and utilizes improved biological inputs and parametrization that likely help to better reflect sex-specific sablefish dynamics. Despite important model and data changes across the range of updates explored, SSB and recruitment trajectories are generally consistent across model runs and mostly fall within the 95% confidence intervals of the continuity Model *25.12_1Reg_Cont* (Figures 3B.5 – 3B.6). Although stock status has not changed drastically across models, important model rescaling (e.g., in SSB) due to changes in estimates of natural mortality and associated changes in survivorship have occurred, yet catch advice in Model *26.1_1Reg* remains consistent to that from Model *25.12_1Reg_Cont* (Table 3B.3).

Data fits have improved slightly, but fits to the composition data remain mediocre due to tension between the index and age composition data. The poorer fits to the composition data can partially be attributed to the Francis reweighting approach (Francis, 2011), which aims to 'right-weight' the data by prioritizing the abundance indices and accounting for correlations in composition data, typically resulting in lower weights for the compositions. Thus, the sensitivity runs were designed to explore alternative approaches to Francis reweighting for dealing with inherent process error when fitting composition data, including self-weighting likelihoods and/or time-varying selectivity (See Section 2: Sensitivity Runs). Although these approaches modestly improved the fit to the composition data, it often occurred at the expense of poorer fits to the NOAA Longline Survey index and led to moderate retrospective patterns in SSB (due to overfitting compositions leading to overestimation of recruitment). Thus, the proposed changes, as implemented in Model *26.1_1Reg*, were deemed best able to balance fit across data sources (e.g., age compositions and indices) and model complexity, while providing a much more stable model with reduced tension caused by uncertain and potentially uninformative data (e.g., by dropping length compositions and CPUE).

However, a fundamental issue for the sablefish assessment is how to handle the NOAA Longline Survey index construction and data fitting. Mainly, whether it is better to perform extrapolations for non-surveyed regions and aggregate composition data across regions (as is done in Model *26.1_1Reg*, and all associated single region models in Appendix 3B), disaggregate the indices and compositions by region (i.e., fitting the regional RPNs without any extrapolation) and use a fleets-as-areas model (see Appendix 3C), or implement a spatially explicit assessment (see Appendix 3D). All of these options maintain tradeoffs between sample size limitations, complexity, and stability. However, the impact on overall assessment bias and performance for provision of robust management advice may be relatively negligible, given the results of a sablefish-conditioned management strategy evaluation that showed essentially the same management outcomes across assessment structures (see Appendix 3E). Ultimately, as with all assessments, Model *26.1_1Reg* is not perfect and ongoing work will continue to try and better inform sex-specific dynamics and address model tension among data inputs. However, it appears to be a robust and consistent modeling framework for the provision of management advice for sablefish.

Tables

Table 3B.1. Model runs undertaken as part of the 2026 sablefish single region assessment model building process. Model development proceeded in a stepwise manner with a single change from the previous model (and including all updates from previous models). Each update was also implemented as a single, one-off change from the continuity model (*25.12*), but the results are not discussed herein.

Model Group	*Model Name*	*Major Changes*	*Rationale*
Continuity Model	*25.12_1Reg_Cont*	(*25.12*) None.	2025 continuity model.
Model Parametrization (Section 1)	*26.1a_1Reg_Cont_Upd*	(*25.12+*) Remove selectivity links, update selectivity priors, update recruit bias correction, and reduce survey CV.	Improve stability and selectivity estimation by using more realistic selectivity priors, removing selectivity parameter links (across sexes), and reducing the assumed survey CV (~7.5%) to reflect observed variance (formerly CV ~ 10%).
	26.1b_1Reg _ISS	(*26.1a+*) Implement relative scaled input sample size (ISS) across years.	Account for interannual variability in composition data (ages and lengths) by using a relative (within gears) scaling of the ISS (formerly time-invariant).
	26.1c_1Reg_TF_log	(*26.1b+*) Implement logistic selectivity for the trawl fishery.	Improve stability and account for catch of large females in the trawl fishery by using a logistic selectivity function (formerly domed gamma function).
Biology (Section 2)	*26.1d_1Reg_Upd_Bio*	(*26.1c+*) Utilize updated length and weight parameters.	Integrate recent changes in growth by updating estimates of growth and weight curves with all available data through 2025.
	26.1e_1Reg_Upd_Sex_M	(*26.1d+*) Estimate sex-specific natural mortality (*M*).	Implement best practices for sex-specific models by estimating *M* for both sexes using the same prior (formerly single *M* value shared across sexes).
Data Usage (Section 3)	*26.1f_1Reg_No_CPUE*	(*26.1e+*) Remove the fishery CPUE index.	The CPUE index is difficult to standardize given rapidly changing management and fishery practices, it is no longer able to be updated, and at times gives contradictory signals in population trends compared to the LLS; removing CPUE reduces model tension with the primary index of abundance.
	26.1g_1Reg_No_Len_2_Blks_F	(*26.1f+*) Drop fixed gear fishery and NOAA LLS lengths along with associated early fishery selectivity time block.	Historical length data for the fixed gear fishery (pre-1999) and NOAA LLS (pre-1996) is likely to be uncertain; removing this data (and pre-1995 fishery selectivity time block) reduces model tension with age comps and increases stability.
	26.1h_1Reg_LLS_Carry	(*26.1g+*) Implement 'carryover' approach for NOAA LLS calculation in all years.	The NOAA LLS extrapolation approach for non-surveyed regions in a given year (i.e., formerly using GOA growth to extrapolate for the BS or AI) is no longer feasible or defensible, so using the carryover method (i.e., for non-surveyed regions assume the same index value as the last time it was surveyed) for all years is more appropriate.
	26.1i_1Reg_No_wAI_LLS	(*26.1h+*) Drop extrapolated western AI stations from the NOAA LLS index.	Using historical extrapolations (based on the Japanese LLS) from surveyed eastern AI to non-surveyed western AI stations is no longer defensible, so remove these extrapolated station values from the index.
Final 1 Region Model	***26.1_1Reg***	(*26.1i*) None.	The 2026 final proposed single region model with all updates implemented.

Table 3B.2. Summary of results for the single region model building and bridging exercise.

Model Group	*Model Name*	*Major Changes*	*Conclusions*
Continuity Model	*25.12_1Reg_Cont*	(*25.12*) None.	The continuity model retains minor instability due to selectivity parametrizations and conflicting signals among age and length data as well as the various indices; further model updates are warranted to improve performance and increase stability.
Model Parametrization (Section 1)	*26.1a_1Reg_Cont_Upd*	(*25.12+*) Remove selectivity links, update selectivity priors, and reduce survey CV.	Improved selectivity parametrization greatly improved model stability, while decreased survey CV led to minor improvements in fit to LLS index; moderate rescaling resulted from an increase in the *M* estimate that led to increases in SSB and catch advice.
	26.1b_1Reg _ISS	(*26.1a+*) Implement relative scaled input sample size (ISS) across years.	The scaled ISS had minimal impact on estimates (e.g., selectivity) but led to minor improvements in fits to composition data and mean age.
	26.1c_1Reg_TF_log	(*26.1b+*) Implement logistic selectivity for the trawl fishery.	Implementing the logistic function for trawl fishery selectivity improved model stability and led to minimal improvements to trawl fishery length composition fits, particularly larger females.
Biology (Section 2)	*26.1d_1Reg_Upd_Bio*	(*26.1c+*) Utilize updated length and weight parameters.	Led to minor scaling changes in biomass due to slight decrease in mean weight of fish under 15 years of age.
	26.1e_1Reg_Upd_Sex_M	(*26.1d+*) Estimate sex-specific natural mortality (*M*).	Caused moderate reduction in *M* estimates across ages, which led to increases in *F* along with reductions in SSB and catch advice.
	26.1f_1Reg_No_CPUE	(*26.1e+*) Remove the fishery CPUE index.	Resulted in minor improvements in fit to the LLS index and changes to estimates of fishery selectivity (particularly in the pre-1995 block).
Data Usage (Section 3)	*26.1g_1Reg_No_Len_2_Blks_F*	(*26.1f+*) Drop fixed gear fishery and NOAA LLS lengths along with associated early fishery time block.	Improved model stability considerably and led to minor changes to fishery selectivity and male *M*, leading to increases in *F* and downward scaling of SSB and catch advice; fits to early age compositions improved slightly.
	26.1h_1Reg_LLS_Carry	(*26.1g+*) Implement 'carryover' approach for NOAA LLS calculation in all years.	The 'carryover' LLS index construction approach leads to a slightly different index trajectory that is more steadily increasing in recent years, while the model is better able to fit this trend; the lower initial index values and steady recent increases lead to an upward scaling of SSB and catch advice.
	26.1i_1Reg_No_wAI_LLS	(*26.1h+*) Drop extrapolated western AI stations from the NOAA LLS index.	Removal of the extrapolated western AI stations causes the LLS index to be scaled downwards and tampers the rate of increase in recent years (given that the increasing catch rates in the AI cause the extrapolation to have a stronger impact), which results in a minor reduction in recent SSB and catch advice.
Final 1 Region Model	***26.1_1Reg***	(*26.1i*) None.	Improved parametrization and removal of uncertain and potentially contradictory data sets greatly improved model stability; updates to the LLS index construction improve consistency and better reflect observed dynamics; and improved biological inputs and parametrization likely help to better reflect sex-specific sablefish dynamics.

Table 3B.3. Key management quantity outputs. SSB is in kt, B_Ref_Pt is the associated $B_{40\%}$ reference point in kt, and F_Ref_Pt is the associated $F_{40\%}$. The catch advice is the 2026 Acceptable Biological Catch (ABC) resulting from fishing at $F_{40\%}$. See Table 3B.1 for a summary of model changes and Table 3B.2 for a summary of results. Note that Model *26.1i_1Reg_No_wAI_LLS* represents the final single region model (Model *26.1_1Reg*).

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
25.12_1Reg_Cont	1	206.6999	357.0208	0.04784668	39.55138	131.4549	0.07875	1.57240	0.57896	0.60758
26.1a_1Reg_Cont_Upd	1	236.8887	374.7811	0.04088599	48.47894	134.3321	0.08233	1.76346	0.63207	0.49659
26.1b_1Reg_Cont_Upd_ISS	1	236.7808	372.1708	0.04010794	49.30014	134.0740	0.08287	1.76605	0.63622	0.48397
26.1c_1Reg_Cont_Upd_TF_log	1	239.0244	374.6549	0.04057036	49.03881	135.6938	0.08350	1.76150	0.63799	0.48589
26.1d_1Reg_Cont_Upd_Bio	1	236.9829	378.2417	0.04239512	46.94926	138.3195	0.08301	1.71330	0.62654	0.51072
26.1e_1Reg_Cont_Upd_Sex_M	1	219.4031	373.0349	0.04583853	41.16434	140.1182	0.07836	1.56584	0.58816	0.58497
26.1f_1Reg_Cont_Upd_No_CPUE	1	230.2295	384.2490	0.04435560	42.49986	143.0228	0.07854	1.60974	0.59917	0.56478
26.1g_1Reg_Cont_Upd_No_Len_2_Blks_F	1	204.7788	360.0882	0.04872276	38.40136	135.5328	0.07778	1.51092	0.56869	0.62644
26.1h_1Reg_Cont_Upd_LLS_Carry	1	230.4754	382.9105	0.04375466	43.52004	142.4181	0.07947	1.61830	0.60190	0.55056
26.1i_1Reg_Cont_Upd_No_wAI_LLS	1	216.4521	369.6689	0.04642913	40.85173	139.0172	0.07903	1.55702	0.58553	0.58749

Figures

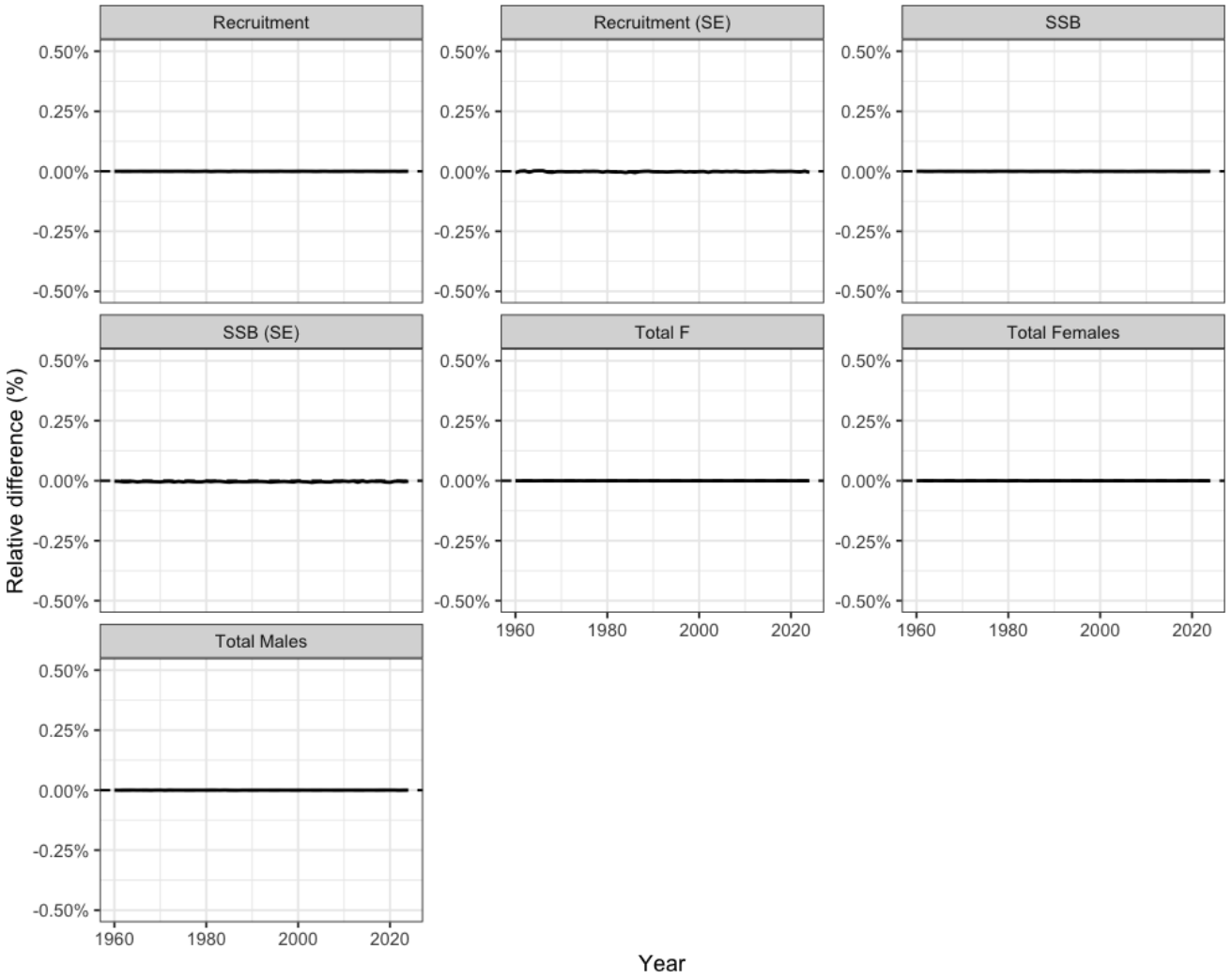


Figure 3B.1. Results of the 2025 model-bridging exercise moving the sablefish assessment from ADMB to SPoRC (R-TMB), which demonstrates the post-optimization relative percent difference ((ADMB - R-TMB) / ADMB) in time-series quantities. The black dashed horizontal line indicates 0% difference between models.

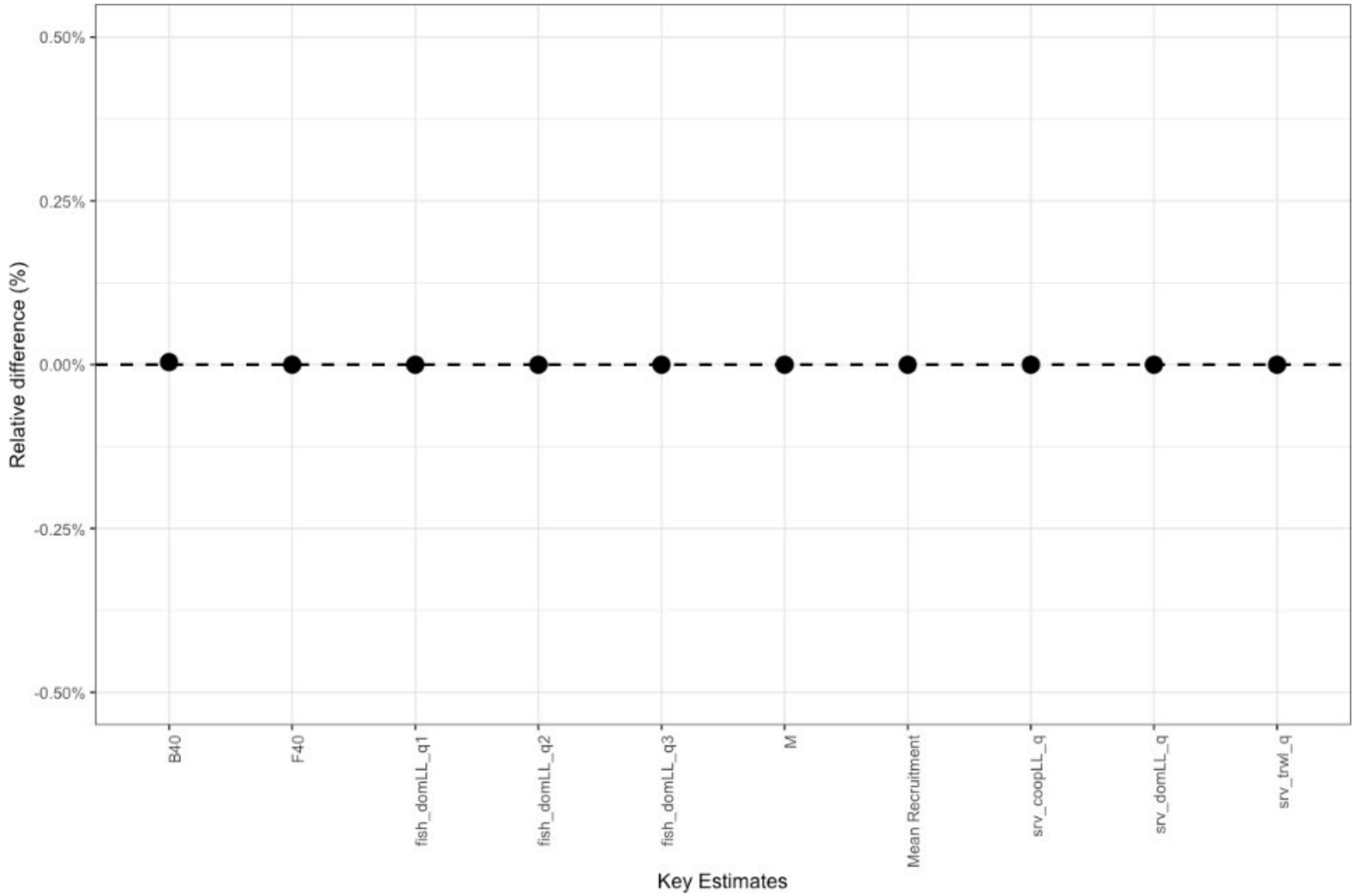


Figure 3B.2. Results of the 2025 model-bridging exercise moving the sablefish assessment from ADMB to SPoRC (R-TMB), which demonstrates the post-optimization relative percent difference ((ADMB - R-TMB) / ADMB) key parameter estimates. The black dashed horizontal line indicates 0% difference between models.

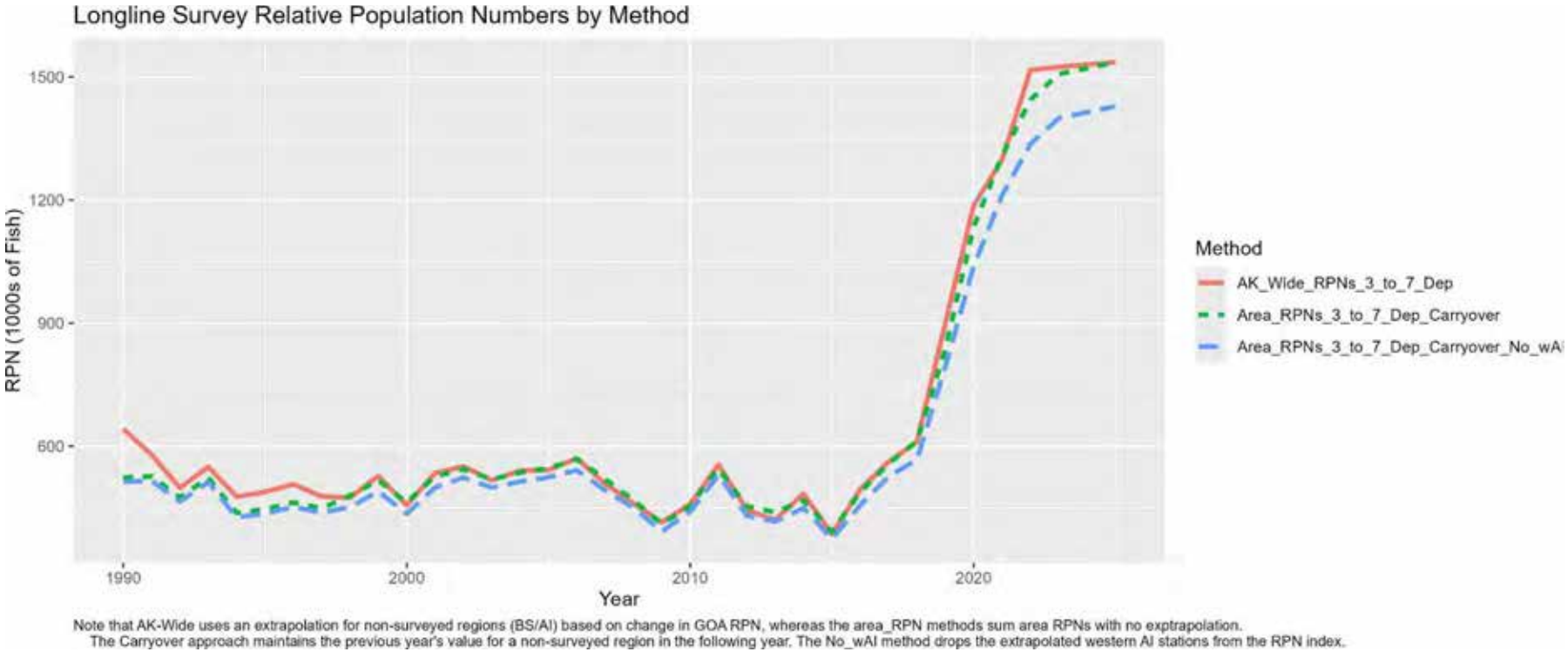


Figure 3B.3. Comparison of NOAA Longline Survey indices (relative population numbers, RPNs) resulting from different approaches for calculating the index. The 'AK_Wide_RPNs' method (red line) uses the growth in the GOA to extrapolate RPNs for non-surveyed regions (BS or AI) in off years, but switched to the 'carryover' method in 2025 (since it cannot be continued in the future given the new survey design). The 'Area_RPNs_Carryover' method (green line) uses the last survey RPN value for a non-surveyed region in off years as a carryover value. The 'Area_RPN_Carryover_No_wAI' method (blue line) uses the carryover approach, but drops the extrapolated (not surveyed in all years) western AI stations from the index. All models through Model *26.1g* (including Model *25.12_1Reg_Cont*) utilize the 'AK_Wide' method, Model *26.1h* uses the 'Area_RPNs_Carryover' method, and Model *26.1i* (including Model *26.1_1Reg*) uses the 'Area_RPN_Carryover_No_wAI' method.

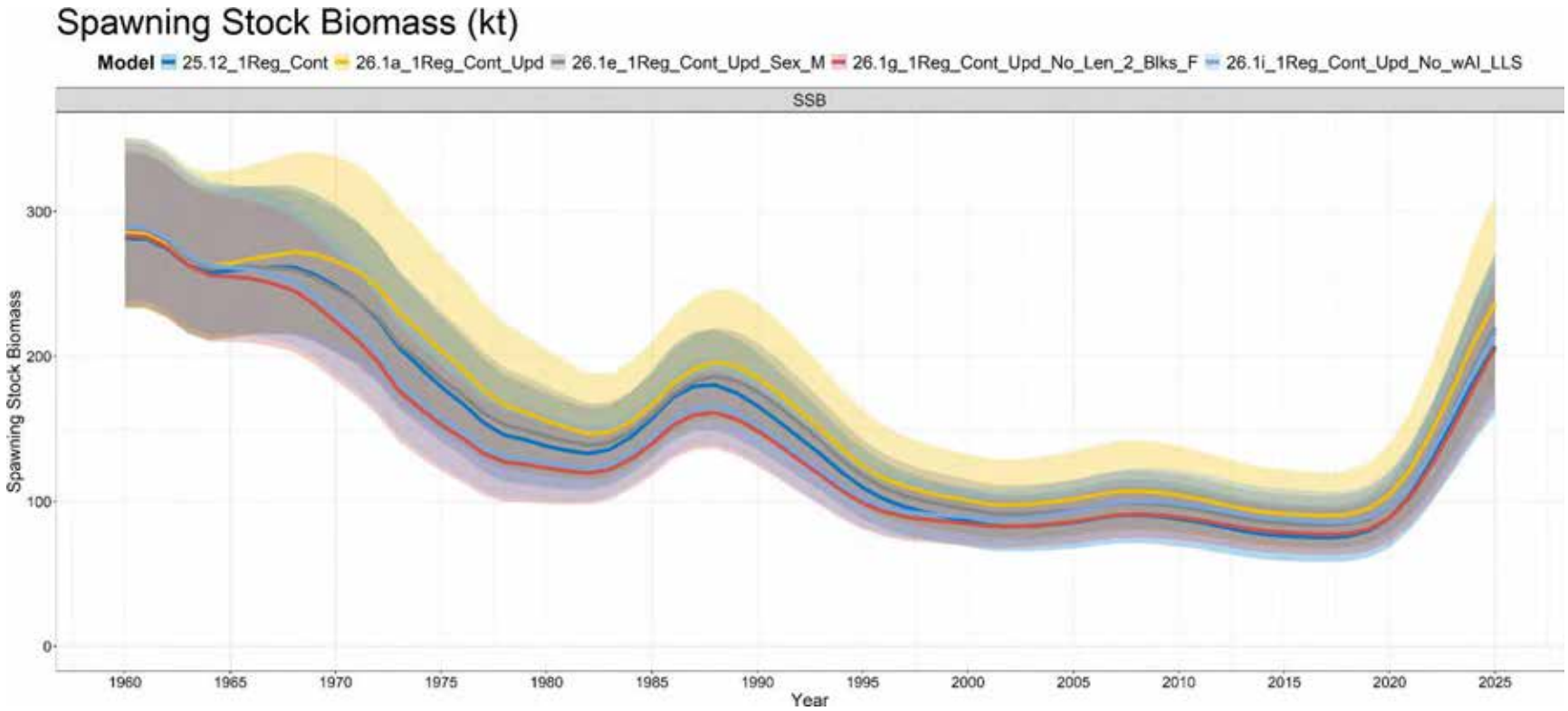


Figure 3B.4. Comparison of spawning stock biomass (SSB, in kilotons) across select model runs representing each grouping, where shaded regions represent the 95% confidence intervals.

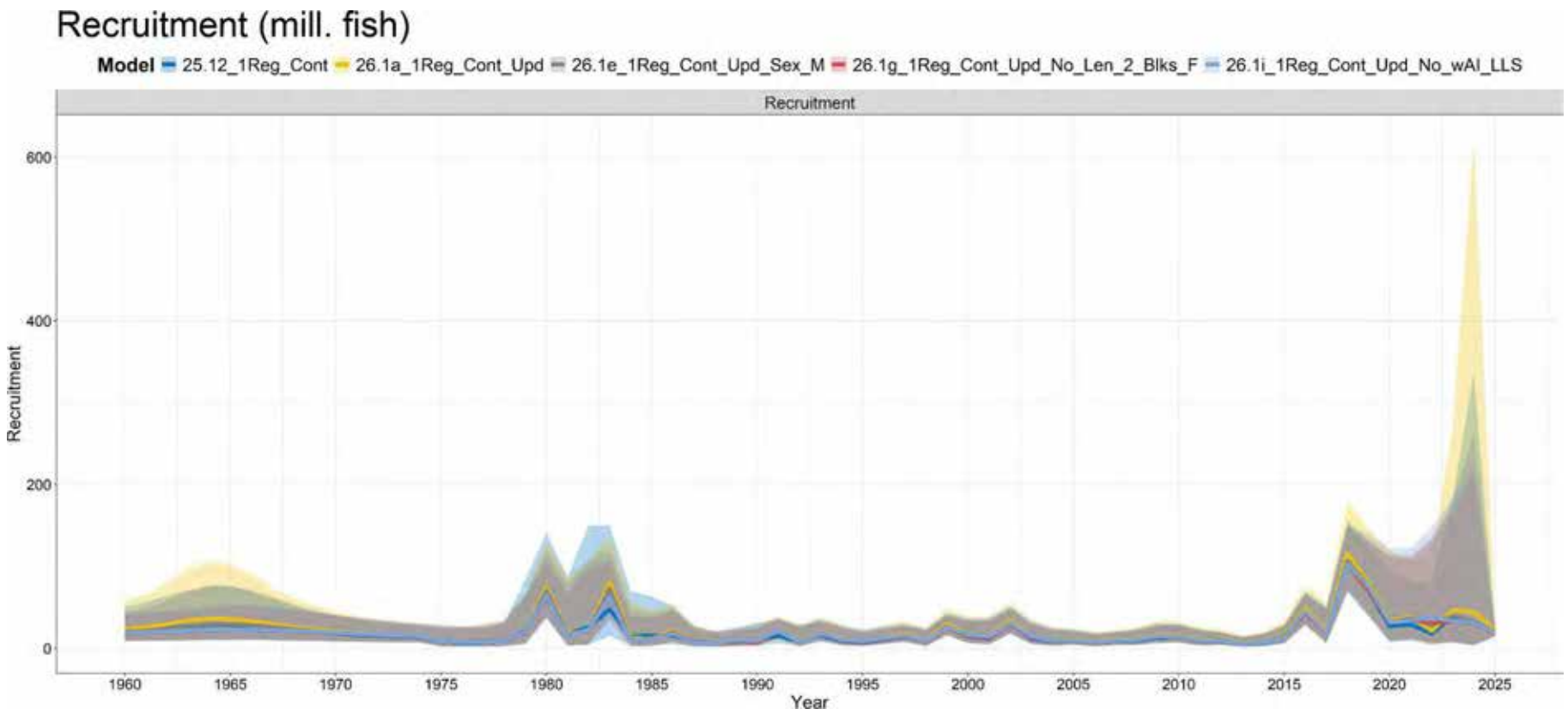


Figure 3B.5. Comparison of recruitment (in millions of fish) across select model runs representing each grouping, where shaded regions represent the 95% confidence intervals.

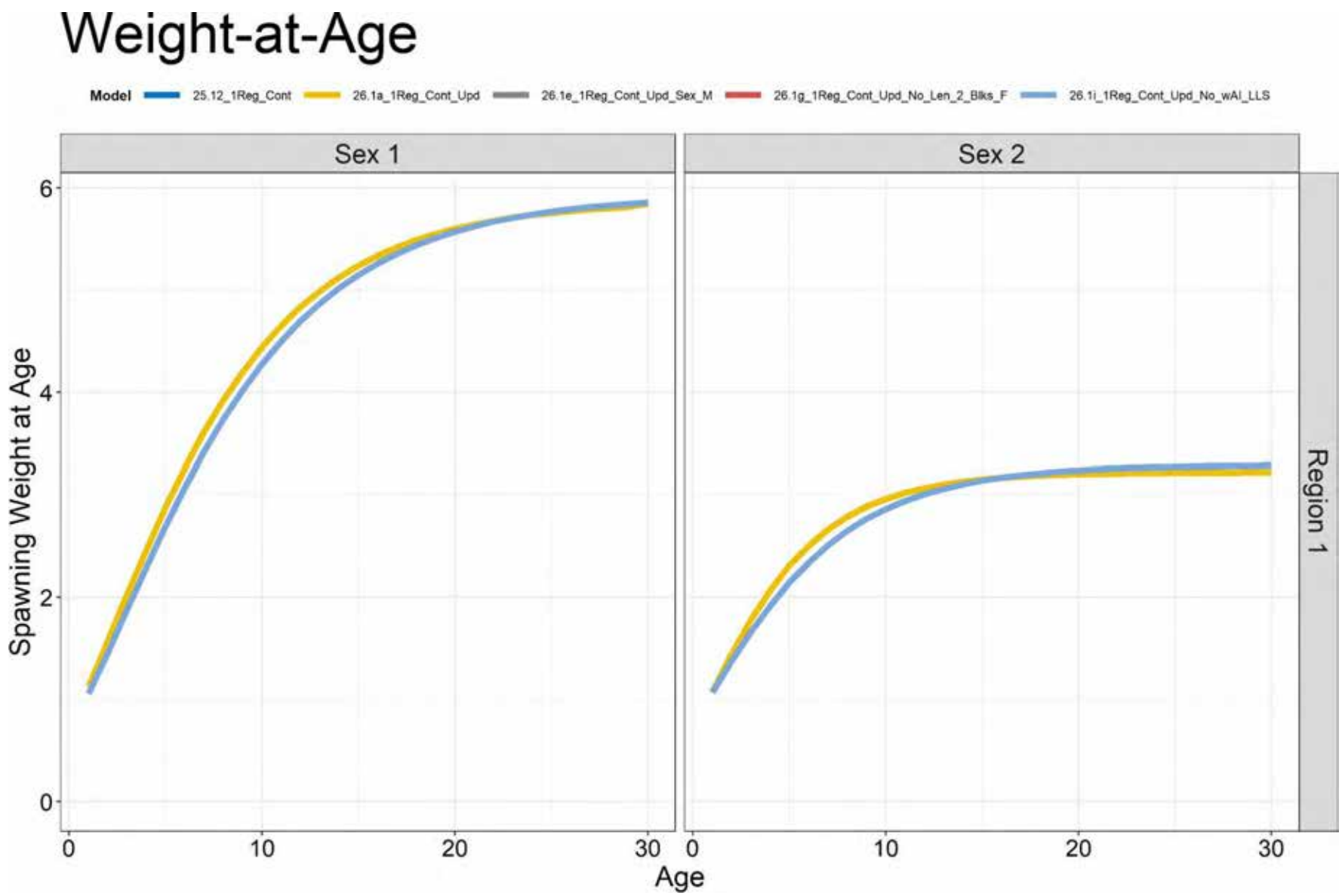


Figure 3B.6. Comparison of weight-at-age across select model runs representing each grouping with yellow line indicating original growth parameters and blue-line represents updated biological data. All models from Model *26.1d* onward use updated growth and weight-at-age (blue line). Sex 1 is females and sex 2 is males.

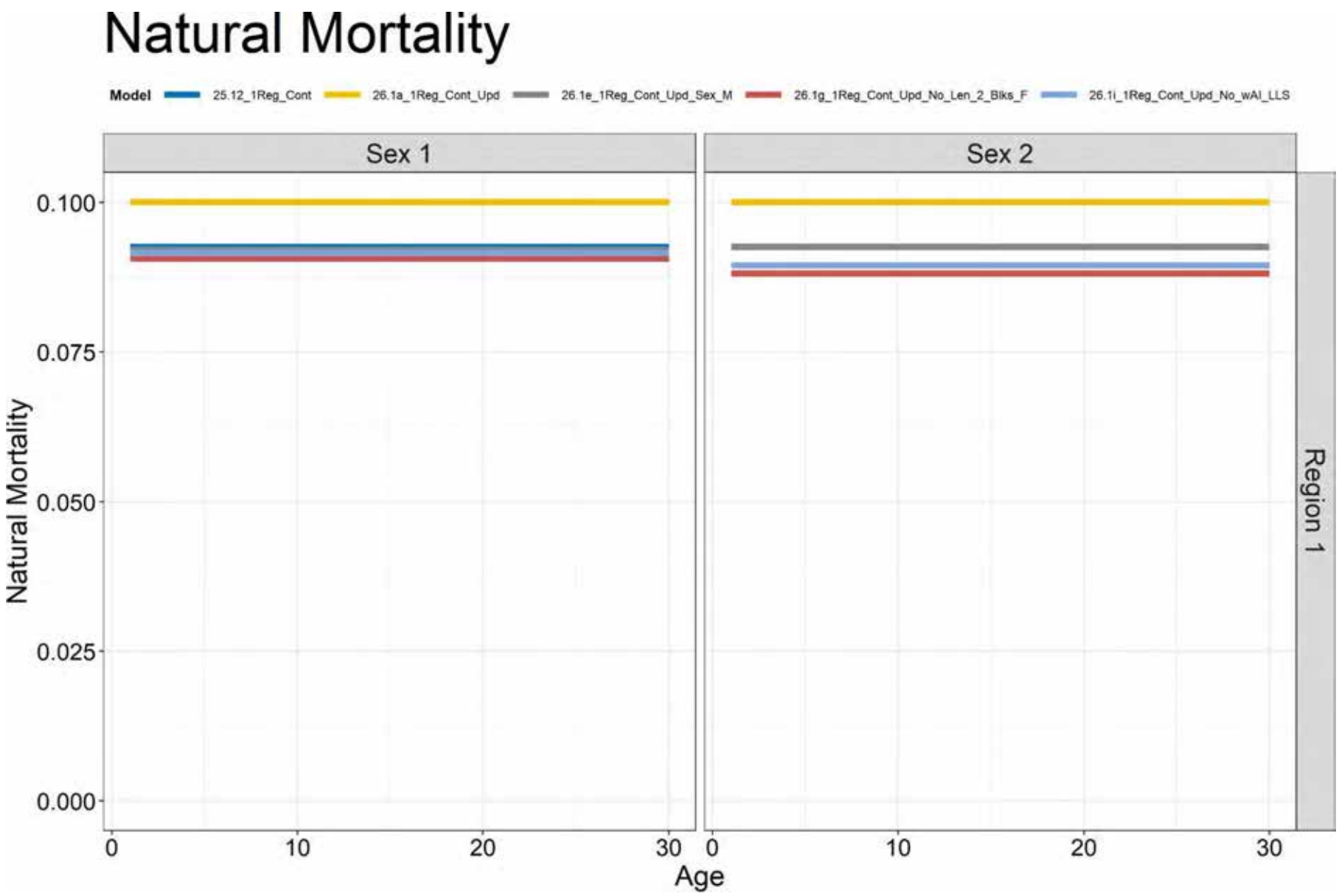


Figure 3B.7. Comparison of natural mortality estimates across select model runs representing each grouping. All models from Model *26.1e* onward use estimate sex-specific *M*. Sex 1 is females and sex 2 is males.

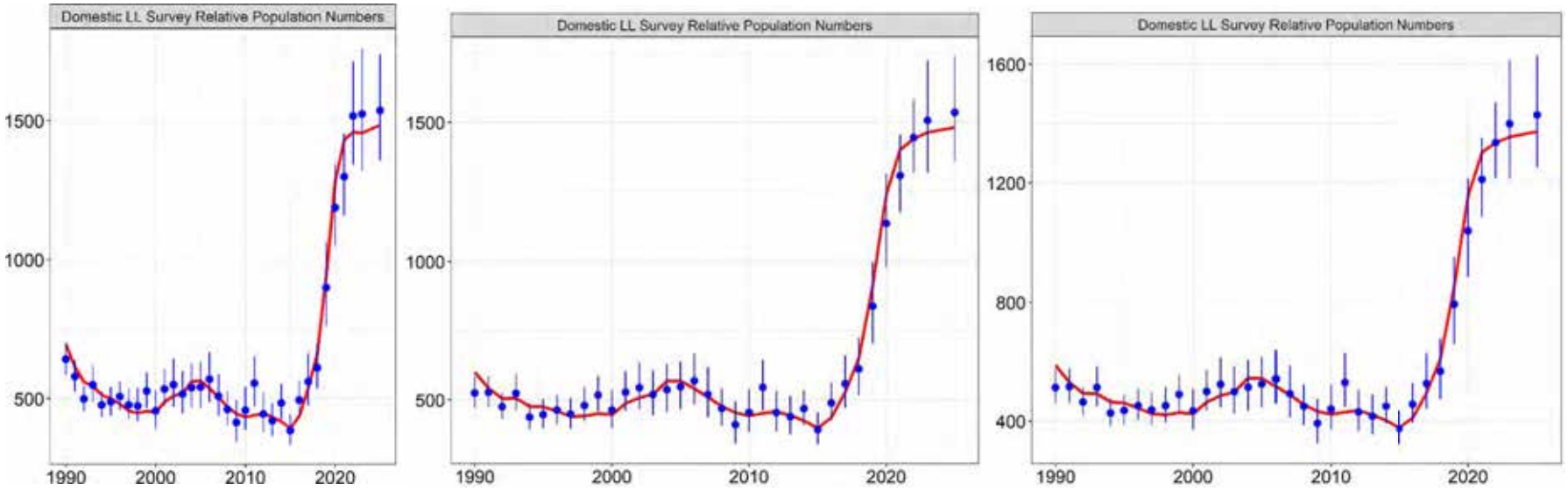


Figure 3B.8. Fits (red lines) to the NOAA Longline Survey abundance indices in relative population numbers (RPNs – 1000s of fish; blue dots with vertical lines represent 95% confidence intervals) for models with various methods of construction (see text and Figure 3B.3). The left panel is Model *26.1e*, which uses the traditional 'AK_Wide' index using an extrapolation for non-surveyed regions based on GOA growth, and still fits to the fixed gear fishery CPUE index (see text). The center panel is Model *26.1h*, which uses the 'carryover' index using an extrapolation for non-surveyed regions based on a carryover value from the last time that region was surveyed, and does not fit to the fixed gear fishery CPUE index. The right panel is Model *26.1i*, which is the same as Model *26.1h* except that extrapolations for non-surveyed western AI stations are removed from the index. Note the difference in y-axis (RPN) scaling across panels.

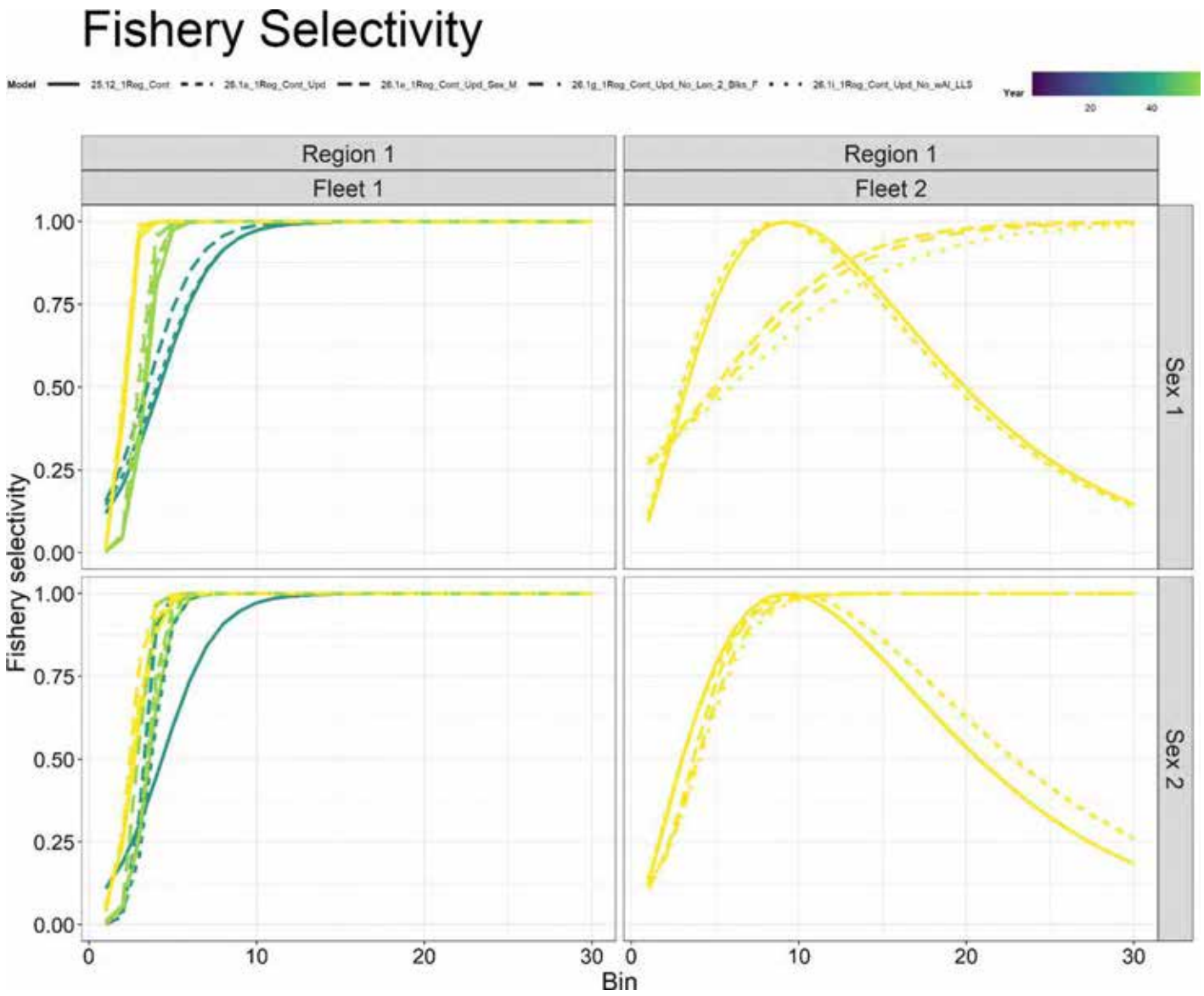


Figure 3B.9. Comparison of fishery selectivity across for select model runs representing each grouping. All models from Model *26.1c* onward assume a logistic (instead of dome) selectivity for the trawl fishery. Sex 1 is females and sex 2 is males. Fleet 1 is the fixed gear fishery and Fleet 2 is the trawl fishery.

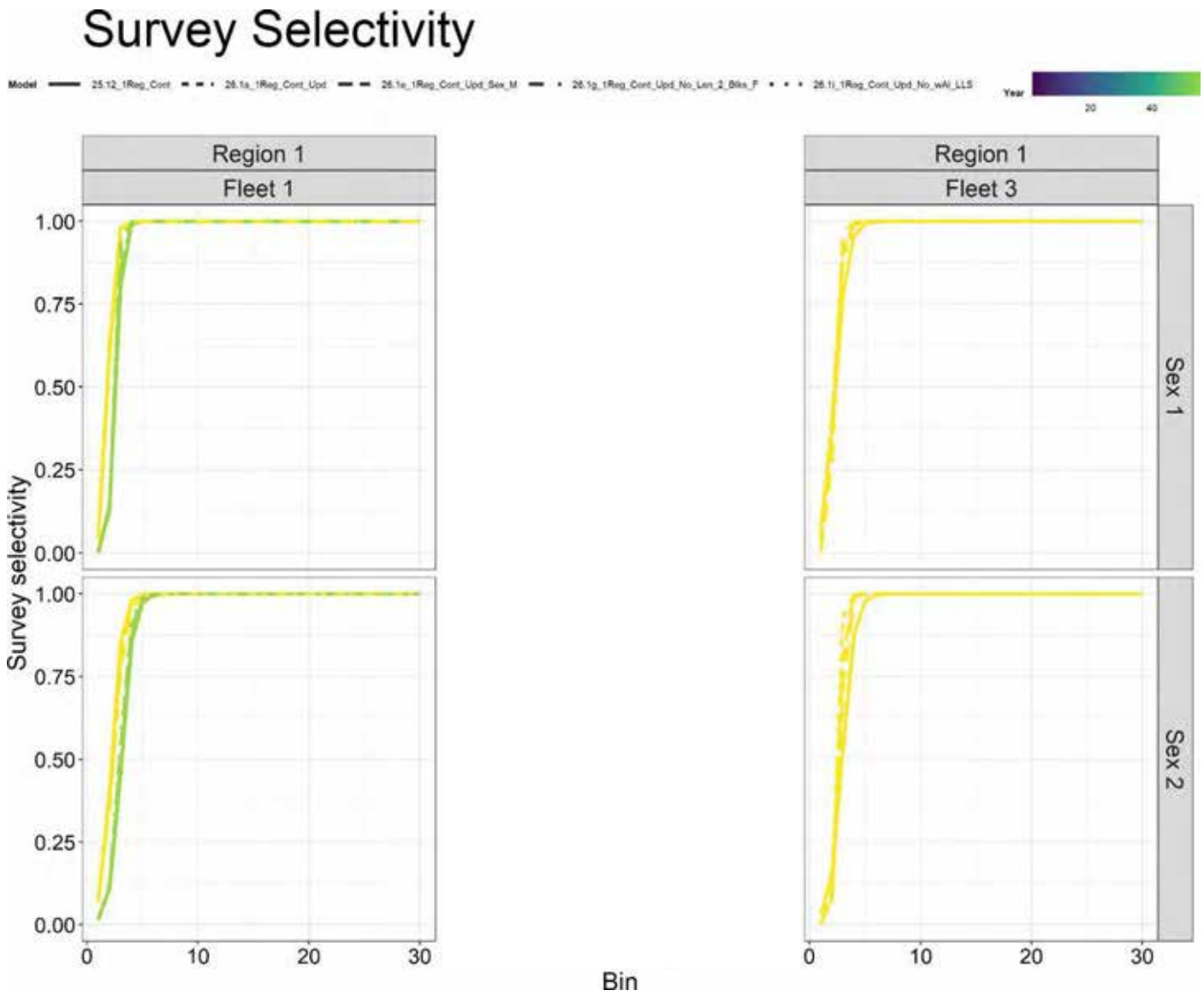


Figure 3B.10. Comparison of survey selectivity across for select model runs representing each grouping. Sex 1 is females and sex 2 is males. Fleet 1 is the NOAA Longline Survey and Fleet 3 is the Japanese Longline Survey.

2. Sensitivity Runs

Introduction

Based on previous research on sablefish dynamics, as well as insights gained from the model-building exercise conducted for the single-region model, several sensitivity runs were developed. The first sensitivity model explored the use of time-varying, empirical weight-at-age (EWAA) to account for density-dependent growth associated with recent large year classes (*26.1_1Reg_TVWAA*; Cheng et al. 2024), with the objective of better reflecting the biological characteristics of Alaska sablefish. A second sensitivity model implemented continuous semi-parametric time-varying survey selectivity for the NOAA longline survey to evaluate whether a more flexible selectivity formulation could better capture temporal changes in survey availability (*26.1_1Reg_ContTVSel*). In particular, this approach was intended to represent the spatial progression of large recruitment events originating in western regions and subsequent ontogenetic movement toward eastern regions (see Appendix 3D), while also reducing tension between composition data and abundance indices. Although a similar approach could also be considered for the longline fishery, additional exploration was not pursued because: 1) previous analyses indicated relatively limited evidence for substantial temporal variation in fishery selectivity, and 2) the fixed-gear fishery is primarily concentrated in the GOA, where large-scale shifts in availability to the fishery are less likely to occur. For similar reasons, an additional sensitivity model implementing the Dirichlet-multinomial likelihood for composition data was explored to evaluate whether model tension arising from unaccounted-for process error could be better accommodated relative to the Francis re-weighting approach (*26.1_1Reg_DM*). In particular, the Francis method has the potential to substantially downweight composition data, whereas the Dirichlet-multinomial likelihood provides an alternative framework for accounting for overdispersion in composition data. The final sensitivity run explored the combined effects of continuous semi-parametric time-varying survey selectivity, and the Dirichlet-multinomial likelihood for composition data (*26.1_1Reg_ContTVSel_DM*). This combined sensitivity model was intended to evaluate the extent to which time-varying selectivity and the Dirichlet-multinomial jointly interacted.

Methods

The sensitivity model runs follow the parameterization of Model *26.1_1Reg* with updates as noted below, and results are compared to that model. Francis reweighting was only utilized for model *26.1_1Reg_TVWAA*. This was done because Francis reweighting is known to substantially upweight composition data when time-varying selectivity is specified (Xu *et al.* 2019), and because the Dirichlet-multinomial formulation inherently accounts for overdispersion in composition data and therefore does not require additional composition re-weighting.

The configuration of sensitivity model runs was as follows:

- *26.1_1Reg_TVWAA*:
    - Time-varying EWAA was incorporated into the model following the methods from Cheng et al. (2024). Specifically, annual weight-at-age values were estimated external to the assessment model. An initial set of EWAA estimates was first derived using bootstrapping, after which a model-based smoothing framework was applied to account for correlations among age, year, and cohort effects.

- *26.1_1Reg_ContTVSel*:
    - The NOAA Longline Survey selectivity was parameterized to exhibit continuous semi-parametric time-varying selectivity. The parametric form assumed a logistic shape, while semi-parametric lognormal deviations were specified for each age to be independent and identically distributed (iid) random variables following a normal distribution. These deviations were estimated within a penalized likelihood framework, with the standard deviation fixed at 0.5.

- *26.1_1Reg_DM*:
    - Composition likelihoods were specified assuming the linear parameterization of a Dirichlet-multinomial distribution (Thorson *et al.*, 2017). The Dirichlet-multinomial likelihood was applied to all composition datasets except those associated with the Japanese longline survey length compositions. Owing to the sparse nature of the Japanese longline survey data, and the resulting difficulty in estimating overdispersion parameters for this dataset during initial model explorations, a multinomial likelihood was instead assumed for these observations.

- *26.1_1Reg_ ContTVSel_DM*:
    - It is generally recommended to explore the use of continuous time-varying selectivity and self-weighting likelihoods in tandem (Xu *et al.* 2020). Accordingly, this model configuration combined the attributes of Models *26.1_1Reg_ContTVSel* and *26.1_1Reg_DM*, such that time-varying survey selectivity and Dirichlet-multinomial likelihoods were implemented simultaneously.

Results

- *26.1_1Reg_TVWAA* (full results here):
    - Similar to the results from Cheng et al. (2024), recent declines in weight-at-age were apparent particularly for young to intermediate-aged individuals, likely attributed to density dependent effects from recent large recruitment events (Fig. 3B.11).
    - Potentially unrealistic increases in weight-at-age were observed for older females, likely reflecting parameter correlation between the intrinsic growth rate and asymptotic length parameters, exacerbated by limited data availability for older ages (Fig. 3B.11).
    - Incorporation of EWAA into the assessment yielded intuitive results, where recent declines in weight-at-age coincided with declines in *SSB*, along with a downward revision in population scale relative to Model *26.1_1Reg* (Fig. 3B.12). Data fits remained largely unchanged (because indices were based on abundance rather than biomass) and estimates of stock status also maintained similar levels (Fig. 3B.13).

- *26.1_1Reg_ContTVSel* (full results here):
    - Specifying continuous semi-parametric time-varying survey selectivity for the NOAA longline survey did not lead to substantiative improvements in model fits to composition data nor abundance indices relative to model *26.1_1Reg* (Fig. 3B.14

– 3B.19). Moreover, aggregate fits to young individuals appeared somewhat degraded for *26.1_1Reg_ContTVSel*.

- Moderate variability in survey selectivity estimates was detected, with recent years exhibiting some degree of doming, likely reflecting the influence of large recruitment events. The magnitude of this variability was partly attributable to the subjective specification of a standard deviation of 0.5 within the penalized likelihood framework (chosen based on initial explorations attempting to balance composition and index fits). Attempts to estimate time-variation in a state-space framework were attempted, but proved computationally challenging (i.e., convergence issues were encountered) (Fig. 3B.20).
- The introduction of additional variability in survey selectivity led to degraded retrospective performance, resulting in moderate and consistent overestimation of *SSB* relative to the terminal assessment (Fig. 3B.21).
- In general, while moderate variability in survey selectivity was detected, no substantial differences in model fit, estimated stock status, or interpretation of population dynamics were observed compared to model *26.1_1Reg* (Fig. 3B.22 – 3B.23). Moreover, moderate retrospective patterns were evident, likely driven by continual revision of recruitment and survey selectivity estimates as cohorts progressively entered the observed population. These dynamics introduce instability in retrospective performance, making this model difficult to recommend as a viable option for assessment use.

- *26.1_1Reg_DM* (full results here):
  - The use of a Dirichlet-multinomial likelihood resulted in slightly degraded fits to the abundance index. Relative to Francis reweighting, composition data were generally upweighted, which contributed to the slight deterioration in fit to the abundance index (Fig. 3B.24). Despite this upweighting, improvements in fits to composition data were limited (Fig. 3B.25 – 3B.29).
  - The introduction of additional overdispersion parameters resulted in slightly degraded retrospective patterns compared to *26.1_1Reg*, particularly with respect to recruitment estimates of large year classes being often underestimated relative to the terminal assessment. *SSB* retrospective patterns remained small (Mohn's rho of ~0.02; Fig. 3B.30).
  - Recruitment estimates became more variable compared to model *26.1_1Reg*, with an upward revision in overall population scale (Fig. 3B.31 – 3B.32). Presumably, the upward revision in population scale is due to upweighting composition data relative to the Francis re-weighting approach, where the model then attempts to increase the number of recruits in the population to better fit the composition data. The increase in the number of recruits then increases population scale in order to adequately fit to catch data (i.e., to remove the "correct" amount of individuals from the population).
  - Although the Dirichlet-multinomial likelihood is more statistically rigorous than Francis reweighting, the model was generally unable to provide an adequate trade-off between fit to composition and indices simultaneously.

- *26.1_1Reg_ContTVSel_DM* (full results here):

- Combining continuous time-varying survey selectivity with a Dirichlet-multinomial likelihood for composition data generally improved model fits. However, fits to composition data still remained moderately overdispersed and showed little substantive change in interpretation relative to *26.1_1Reg* (Fig. 3B.33 – 3B.38).
- Strong retrospective patterns persisted, likely driven by constant revision of recruitment estimates as cohorts aged into the population given the more flexible survey selectivity parameterization (estimates were largely similar to *26.1_1Reg_ContTVSel*; Fig. 3B.20, 3B.39). Nonetheless, interpretation of population dynamics remained similar, although some differences in recruitment estimates were detected towards the end of the time-series (Fig. 3B.41 – 3B.42). Given the increased retrospective instability and the lack of meaningful improvement in model fit, this configuration does not appear to offer substantive improvement over Model *26.1_1Reg*.

Conclusions

The sensitivity models illustrate both the potential benefits and limitations of more complex model parameterizations. In general, none of the sensitivity runs led to substantial changes in the interpretation of population dynamics, nor did they meaningfully improve model fits as compared to Model *26.1_1Reg*. Moreover, none of the sensitivity runs appear to address the issue of extrapolating for unsampled survey regions for the NOAA Longline Survey indices. Incorporating EWAA appears to be a potentially useful option; however, several issues remain that warrant attention, particularly regarding the realism of estimates at older ages. These may be addressed through the application of smoothing penalties as well as by incorporating EWAA directly within the assessment model itself. Moreover, the inclusion of time-varying survey selectivity or self-weighting likelihoods did not consistently improve fits to the data and, in some cases, resulted in degraded retrospective performance. Collectively, the sensitivity runs provide a useful foundation for exploring alternative model parameterizations in future assessments, but further investigation is required to better understand their performance and stability before they could be recommended as the basis for operational management advice.

Tables

Table 3B.4. Summary of sensitivity model runs and associated results.

Model Group	Model Name	Major Changes	Rationale	Conclusions
Sensitivity Runs	*26.1_1Reg_TVWAA*	(*26.1_1Reg+*) Incorporate time-varying empirical weight-at-age.	Large recruitment events in recent years likely resulted in density-dependent declines in weight-at-age. Incorporating time-varying weight-at-age is expected to improve the biological realism of the model.	Declines in weight-at-age were evident in recent years. However, unrealistic increases in weight-at-age for older females were detected, likely due to sparse data at older ages. Further investigation and potential smoothing are required before operational use.
	26.1_1Reg_ContTVSel	(*26.1_1Reg +*) Specify continuous semi-parametric time-varying survey selectivity for the domestic NOAA longline survey.	Intended to better capture temporal changes in survey selectivity and associated changes in availability due to recruitment and ontogenetic movement.	No substantive improvements in fit to composition data or abundance indices were observed relative to *26.1_1Reg*. Moderate variability in selectivity was detected, but retrospective performance was degraded.
	26.1_1Reg_DM	(*26.1_1Reg +*) Specify Dirichlet-multinomial likelihoods for composition data.	Designed to account for overdispersion in composition data and provide a more flexible statistical treatment than Francis reweighting.	Fits to abundance indices were slightly degraded, and composition data were upweighted relative to indices. Retrospective performance of recruitment degraded, with an increase in recruitment variability.
	26.1_1Reg_ContTVSel_DM	(*26.1_1Reg +*) Combines *26.1_1Reg_ContTVSel* and *26.1_1Reg_DM* and specifies continuous semi-parametric time-varying survey selectivity alongside Dirichlet-multinomial likelihoods for composition data.	Time-varying selectivity and self-weighting likelihoods likely interact. This model is intended to address the concerns of both *26.1_1Reg_ContTVSel* and *26.1_1Reg_DM*.	Some reconciliation of misfit was observed (relative to *26.1_1Reg_ContTVSel* and *26.1_1Reg_DM*) when combining approaches; however, composition data remained overdispersed and overall interpretation changed little relative to *26.1_1Reg*. Strong retrospective instability persisted, and no meaningful improvement in fit was achieved.

Table 3B.5. Key management quantity outputs for sensitivity runs. SSB is in kt, B_Ref_Pt is the associated $B_{40\%}$ reference point in kt, and F_Ref_Pt is the associated $F_{40\%}$.

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
26.1i_1Reg_Cont_Upd_No_wAI_LLS	1	215.8208	369.2842	0.04654268	40.71033	139.1895	0.07907	1.55055	0.58443	0.58864
26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel	1	240.1340	405.2891	0.04234058	44.32321	152.7854	0.07810	1.57171	0.59250	0.54212
26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel_DM	1	221.8317	389.8287	0.04638192	44.66541	153.8605	0.08404	1.44177	0.56905	0.55192
26.1i_1Reg_Cont_Upd_No_wAI_LLS_DM	1	303.2590	441.4774	0.03691477	63.00107	155.6534	0.09728	1.94830	0.68692	0.37946
26.1i_1Reg_Cont_Upd_No_wAI_LLS_TVWAA	1	165.3681	312.4824	0.05666288	30.36136	117.3838	0.07249	1.40878	0.52921	0.78162

Figures

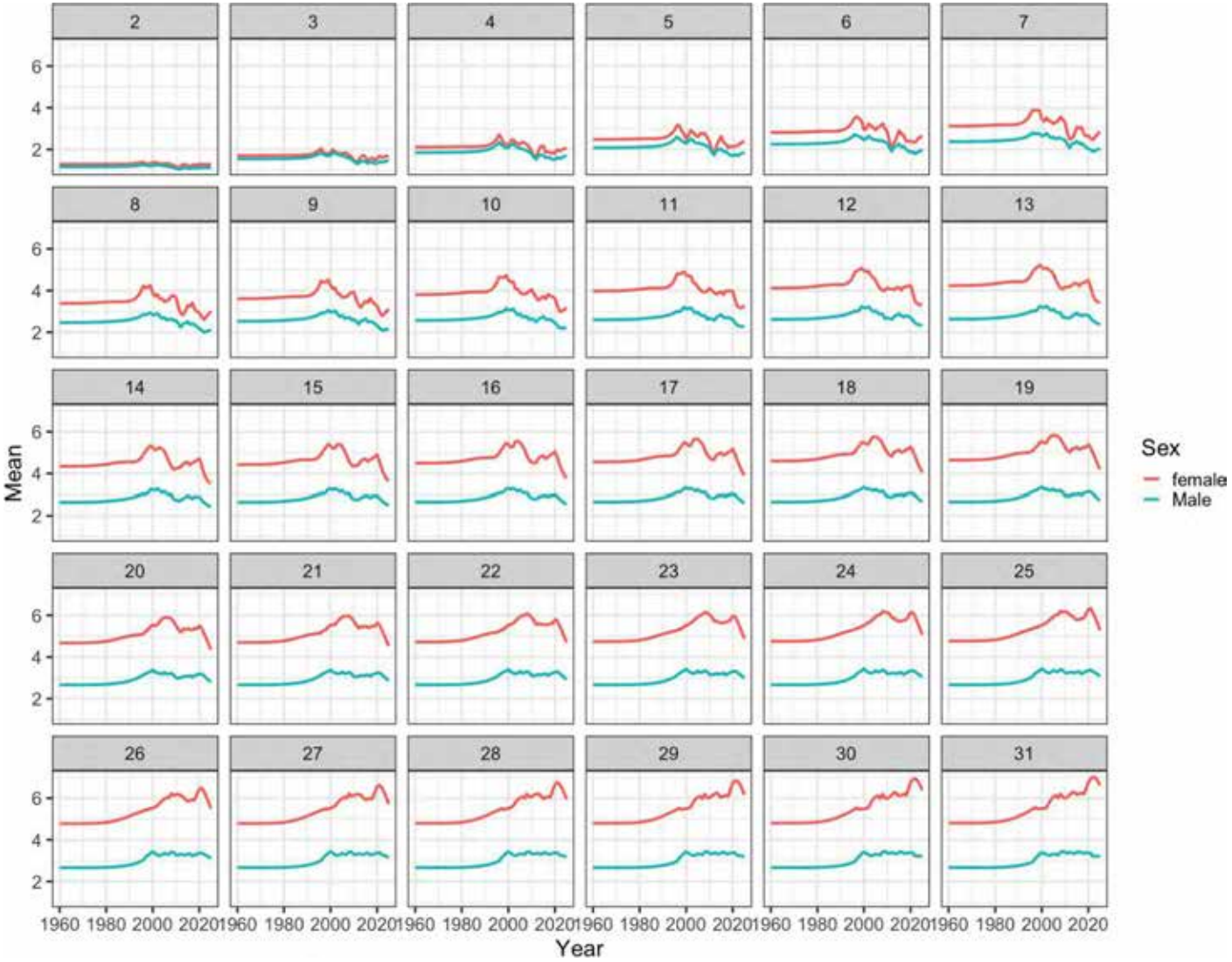


Figure 3B.11. Empirical weight-at-age estimates used in model *26.1_1Reg_TVWAA*. Panels represent different ages, while colored lines represent sexes. Estimates were derived following similar methods as Cheng et al. 2024.

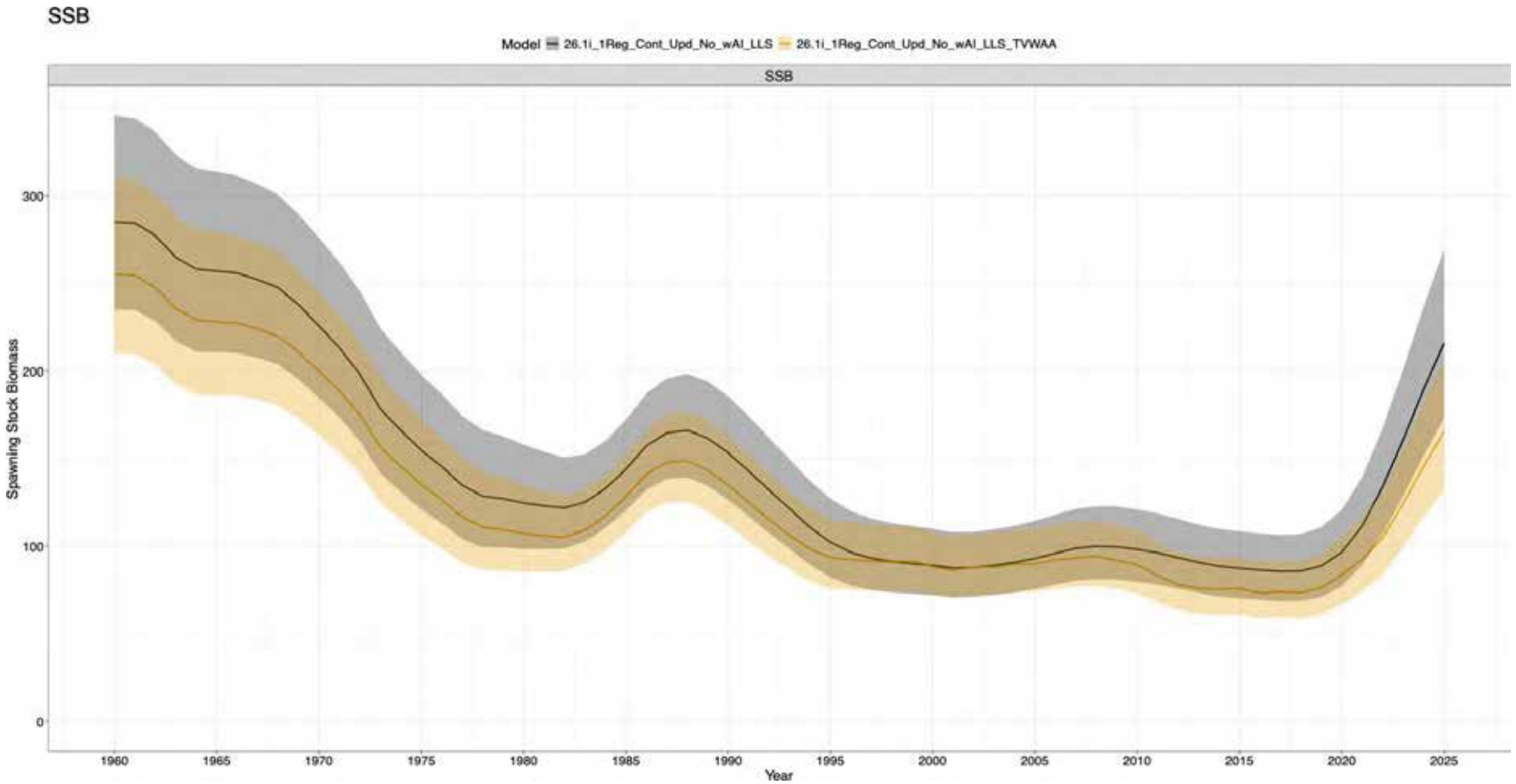


Figure 3B.12. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates time-varying empirical weight-at-age (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_TVWAA; yellow line*). Shaded regions represent the 95% confidence intervals.

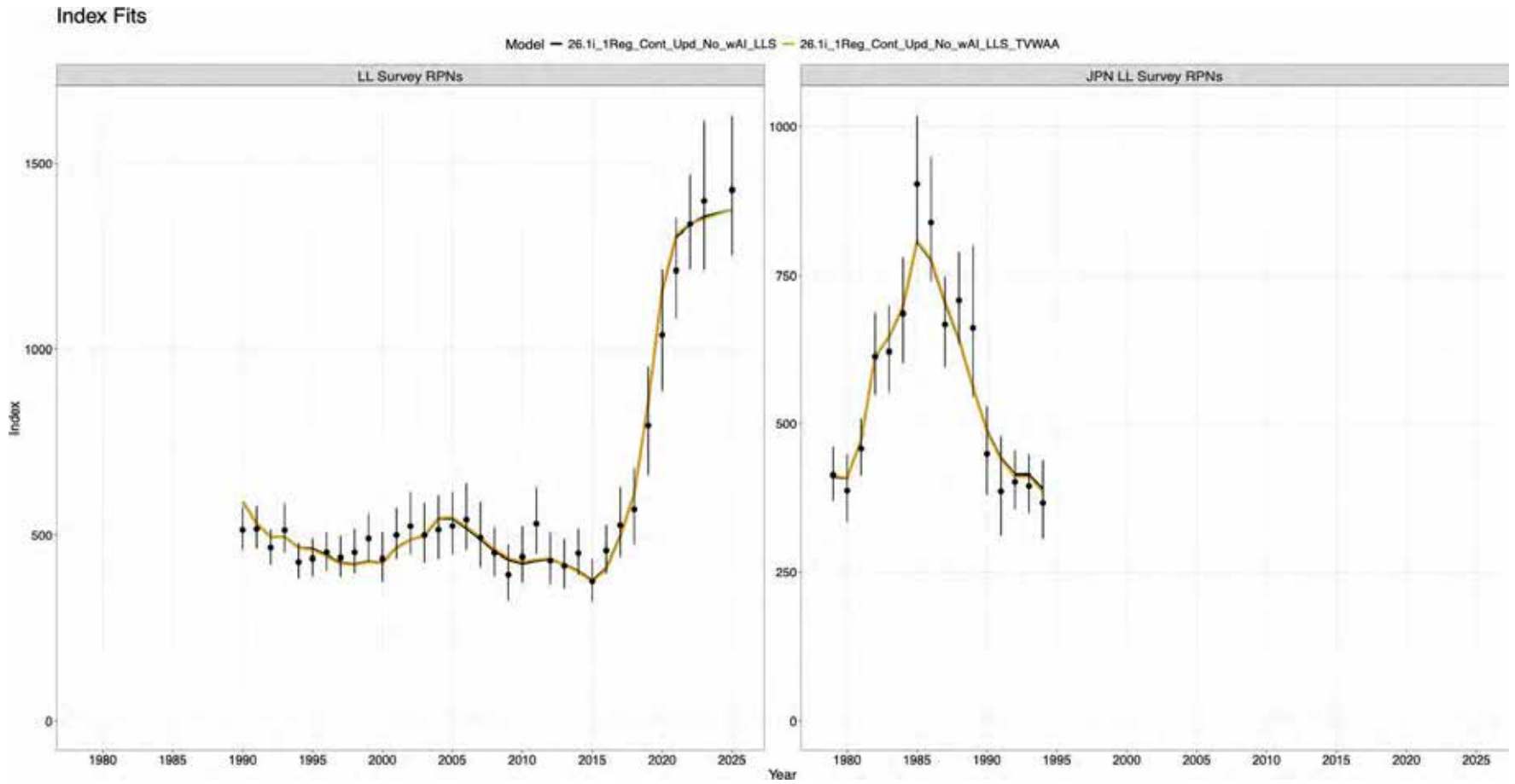


Figure 3B.13. Model fits to survey abundance indices between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates time-varying empirical weight-at-age (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_TVWAA; yellow line*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

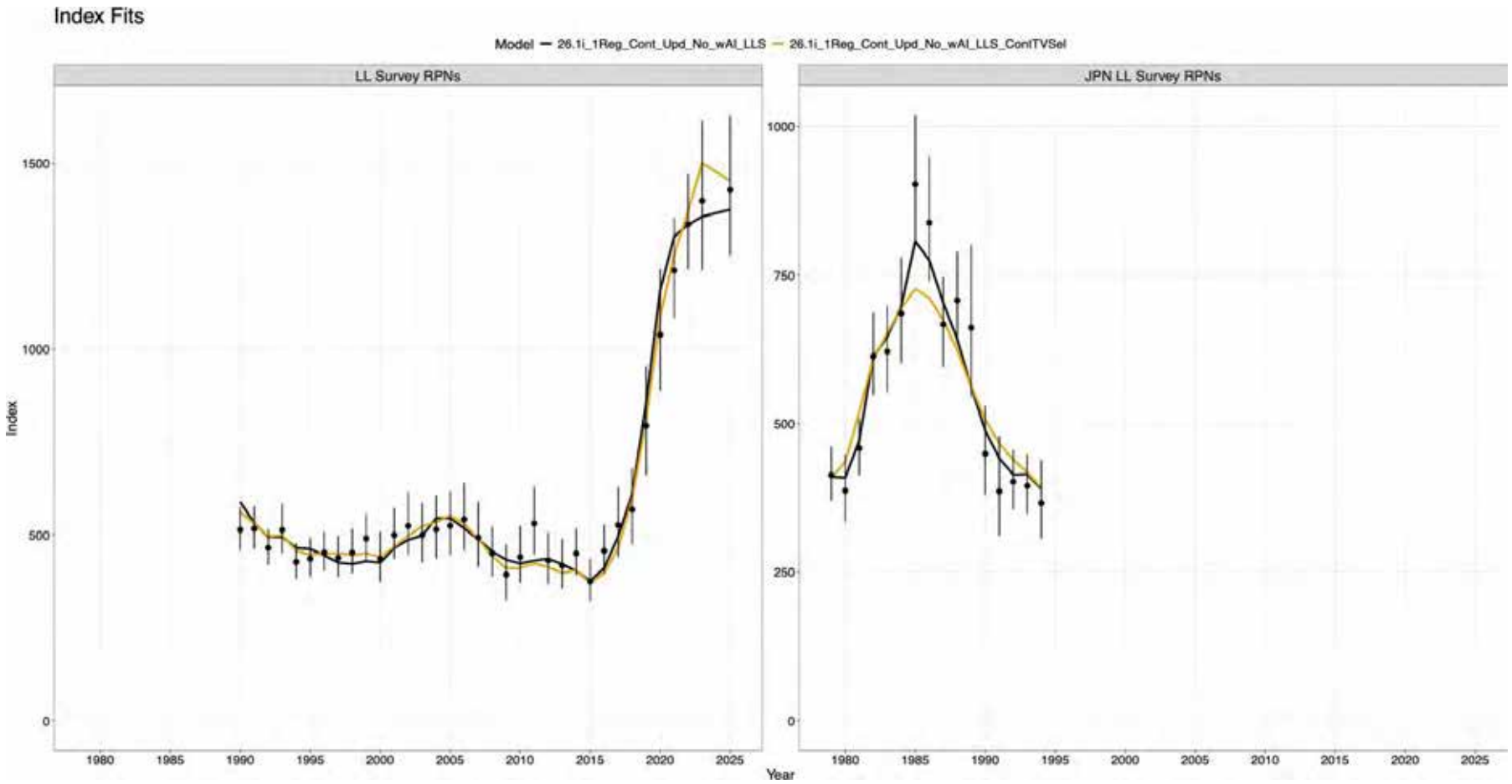


Figure 3B.14. Model fits to survey abundance indices between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous semi-parametric time-varying survey selectivity (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel; yellow line*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

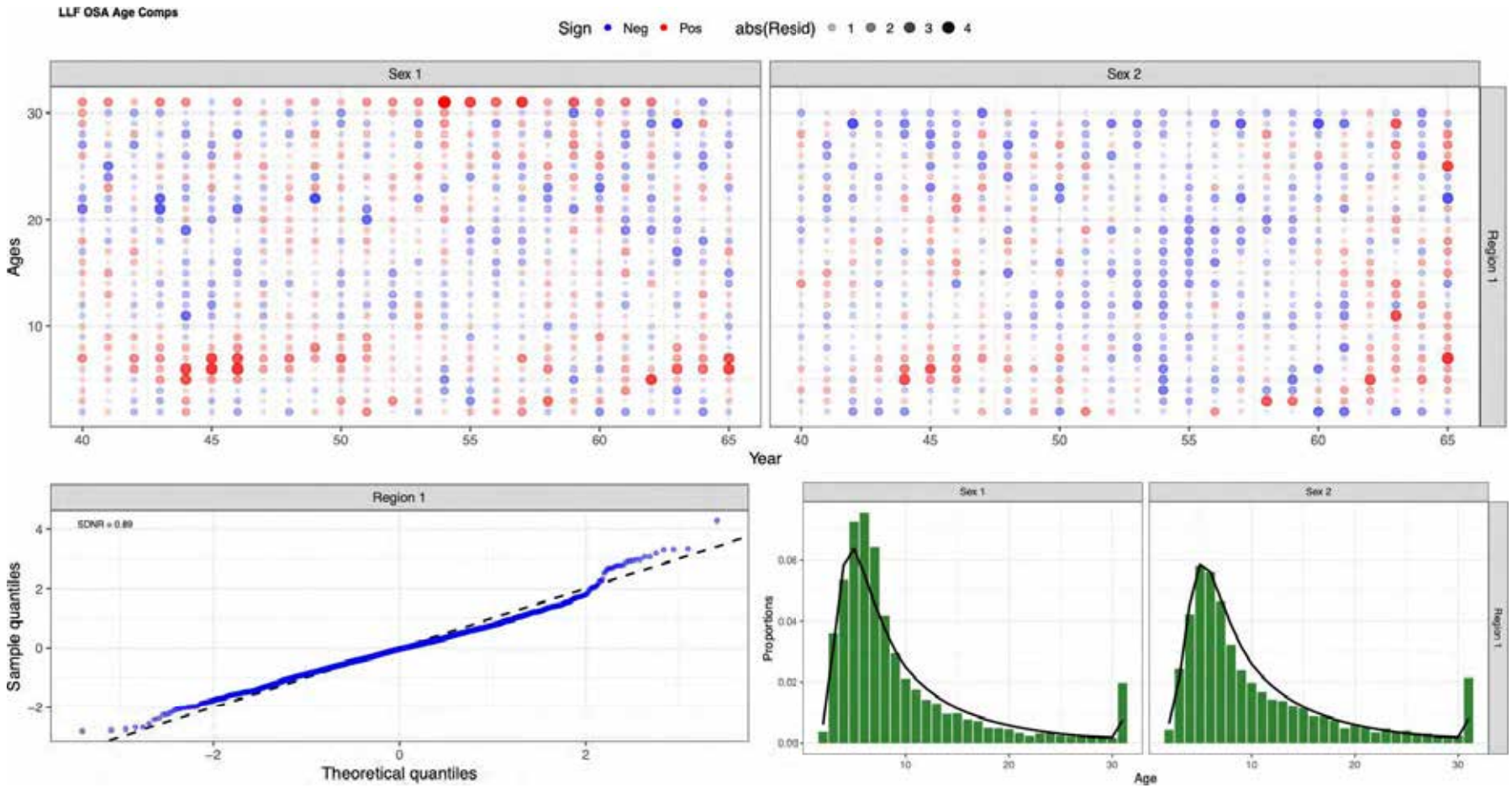


Figure 3B.15. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel*.

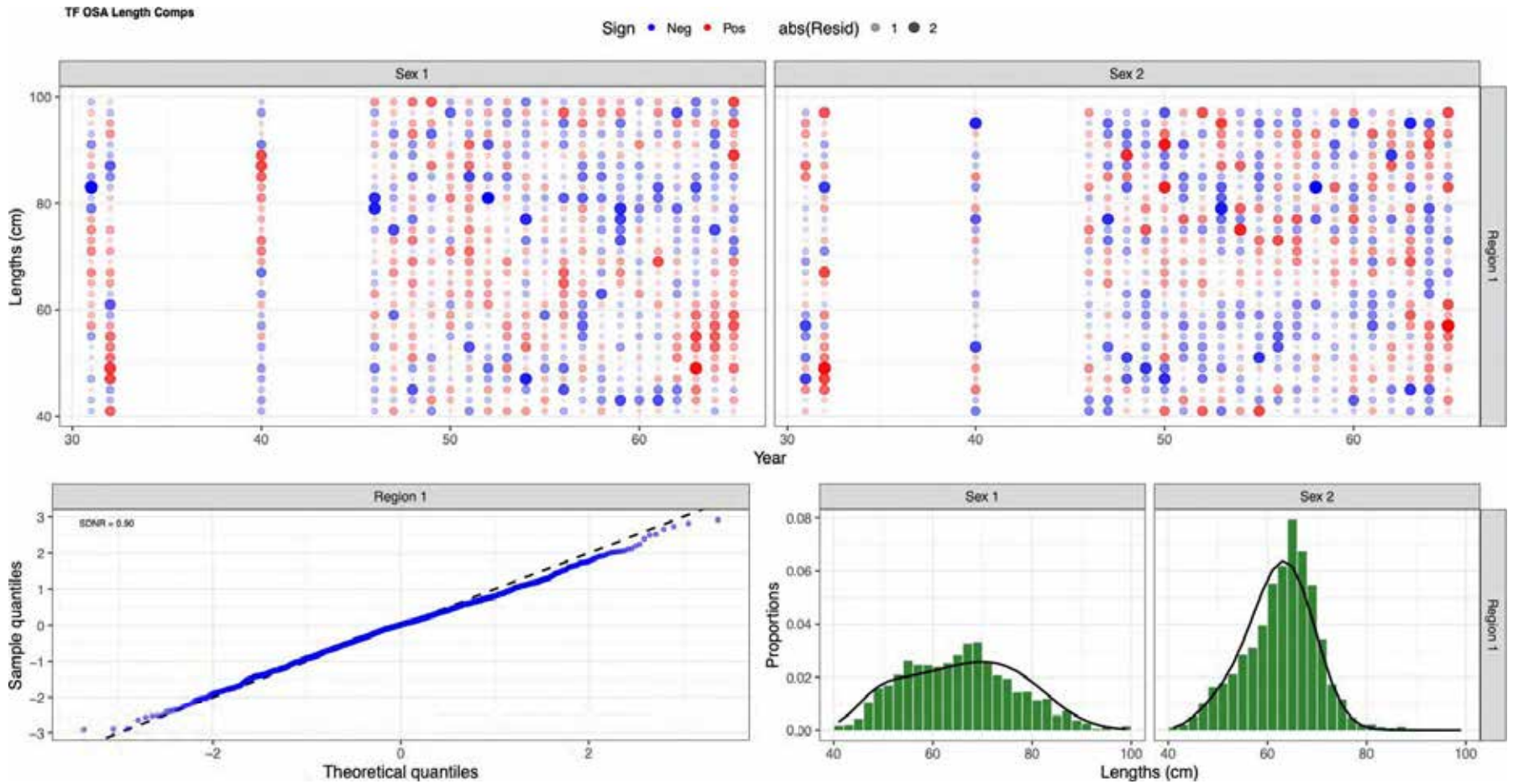


Figure 3B.16. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel*.

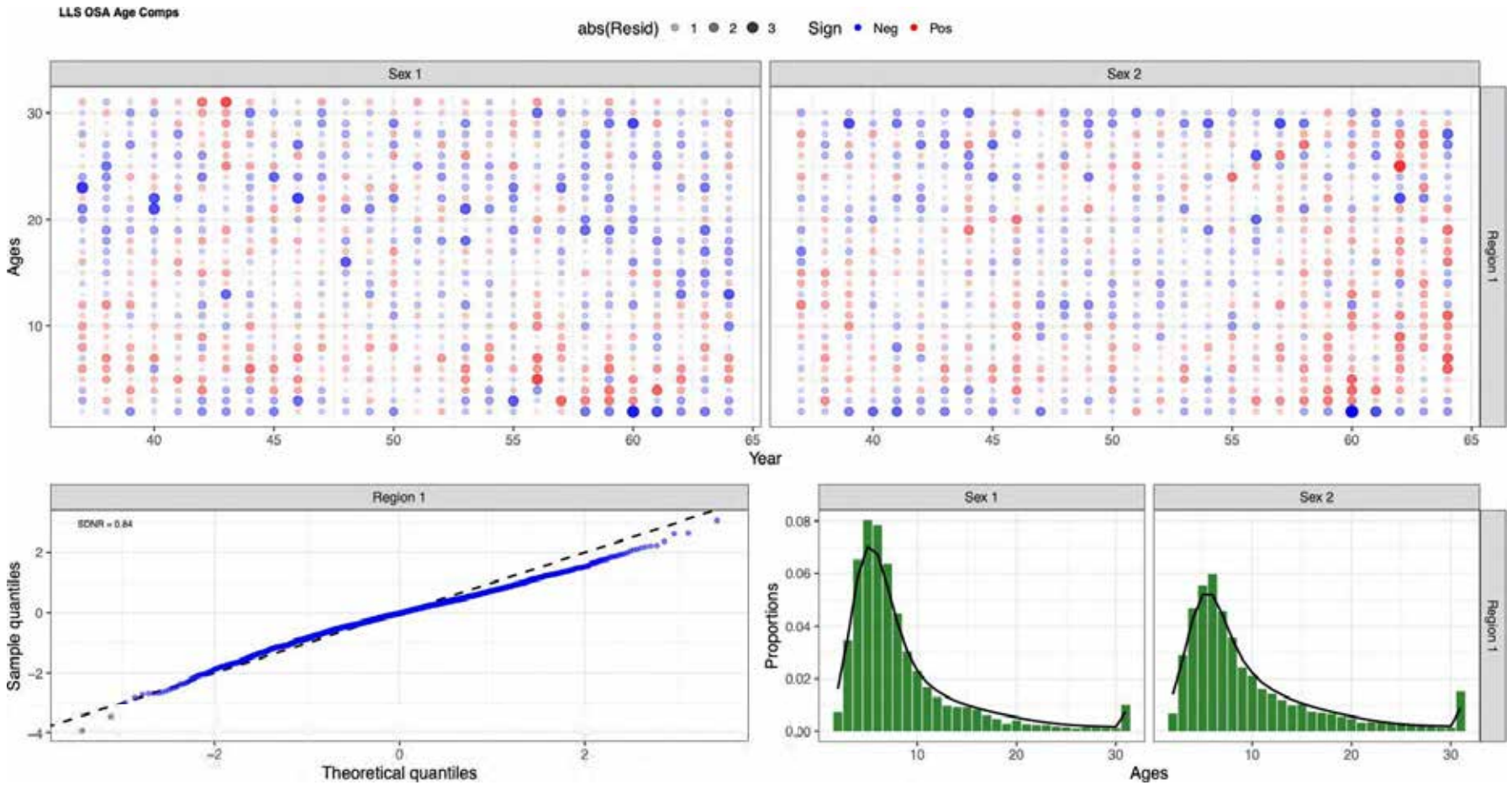


Figure 3B.17. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel*.

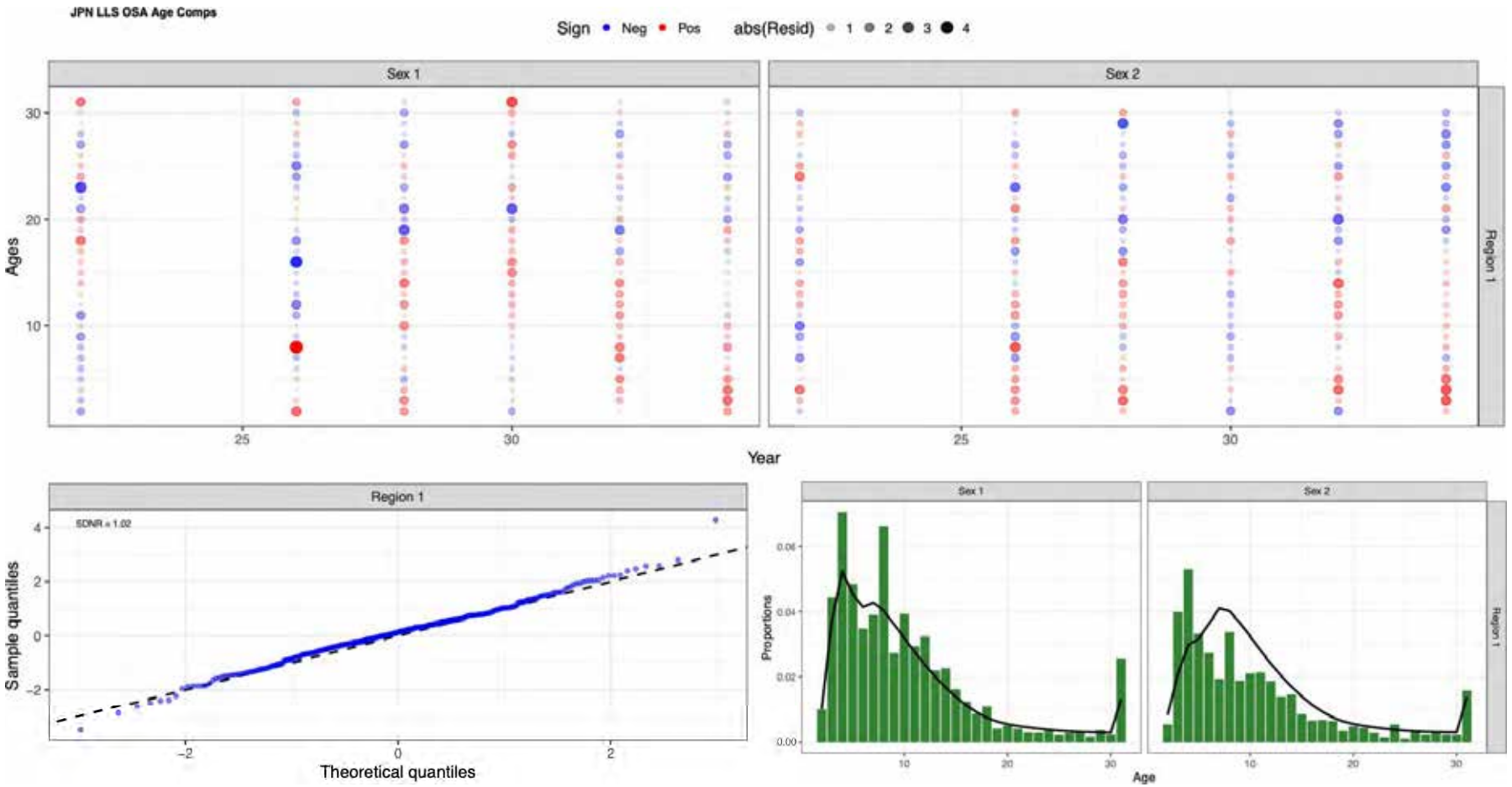


Figure 3B.18. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel*.

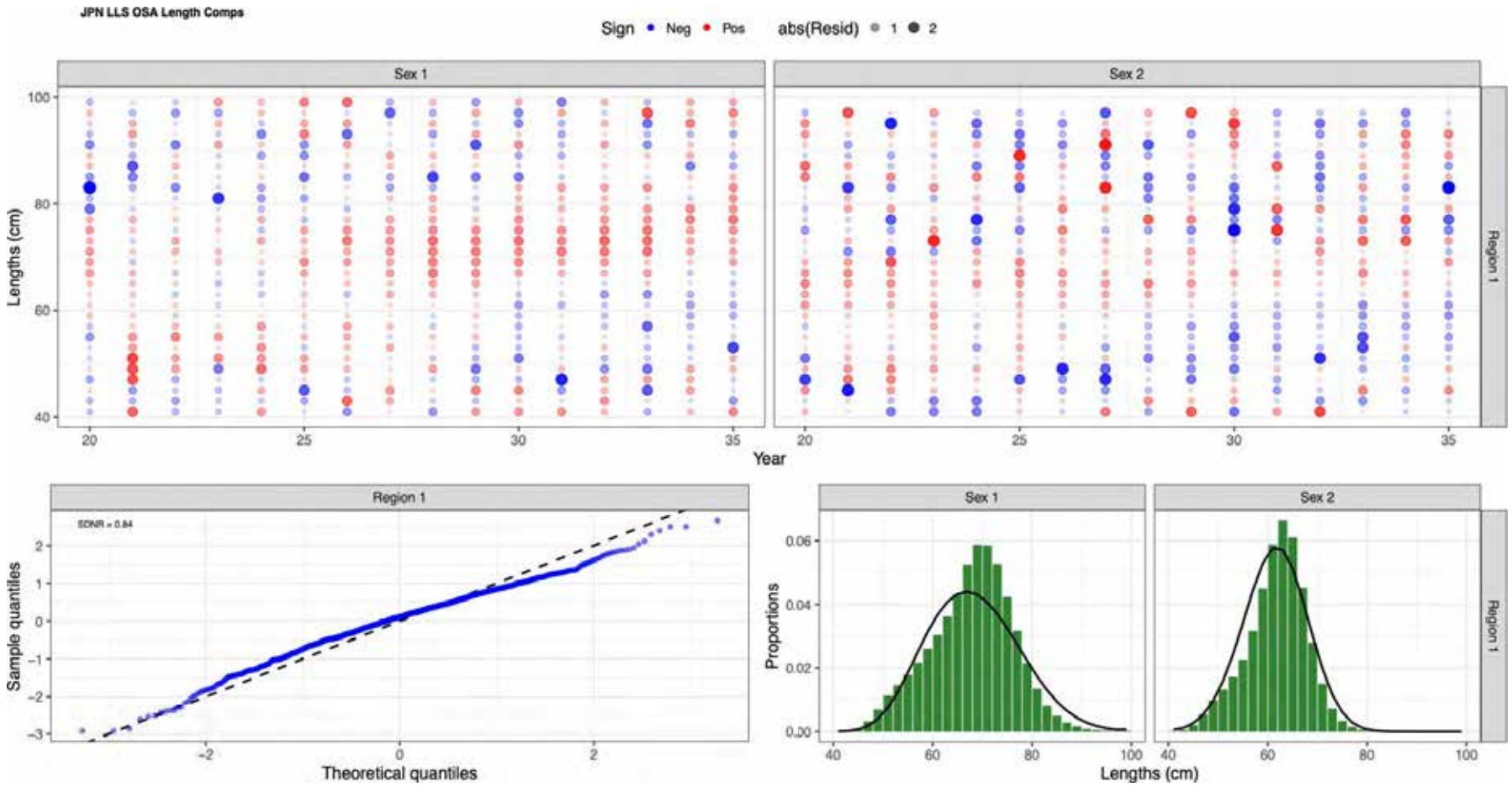


Figure 3B.19. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel*.

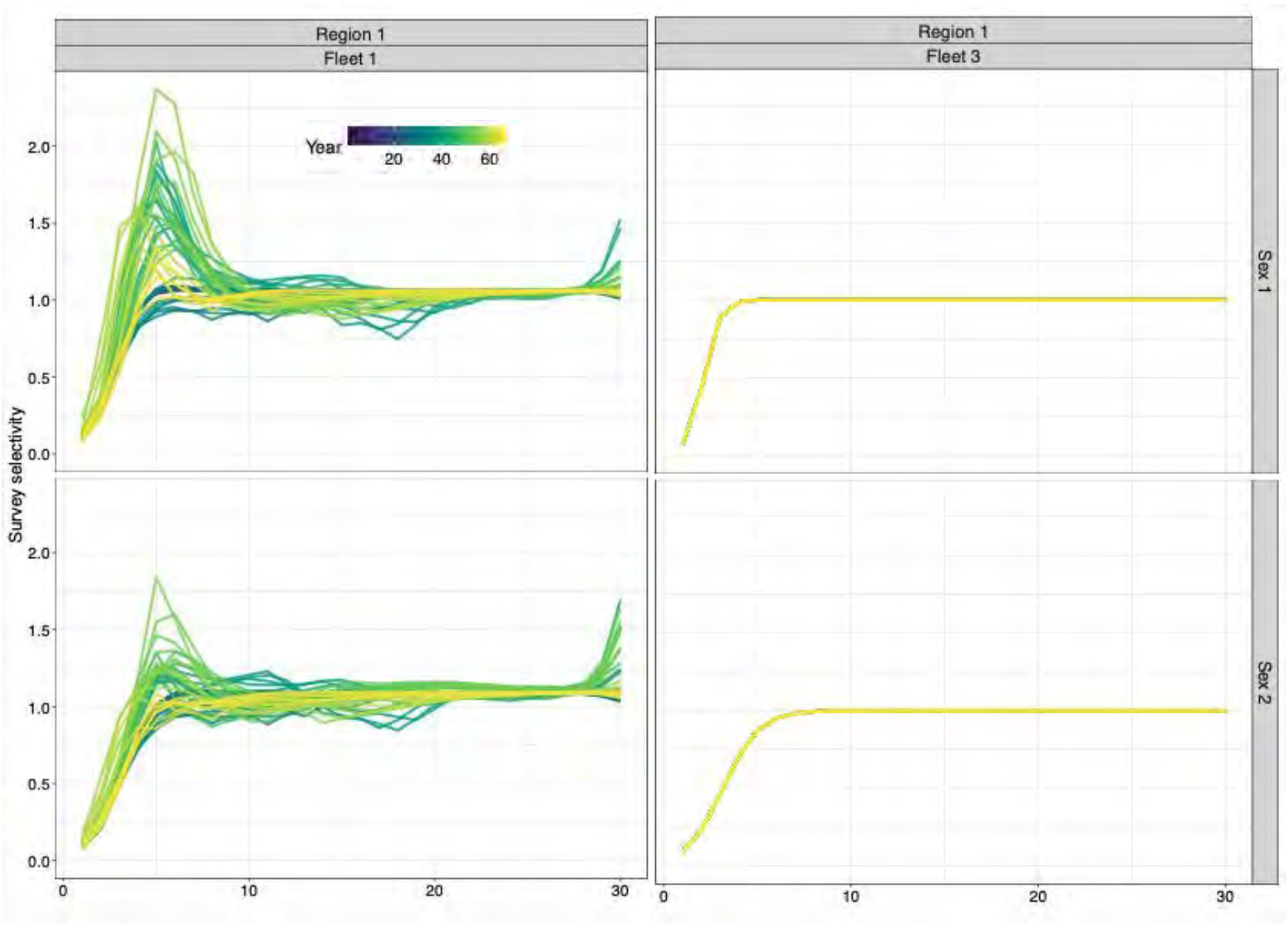


Figure 3B.20. Survey selectivity estimates from Model *26.1_1Reg_ContTVSel*. Fleet 1 is the domestic longline survey fleet and fleet 2 is the Japanese longline survey fleet. Sex 1 is females and sex 2 is males.

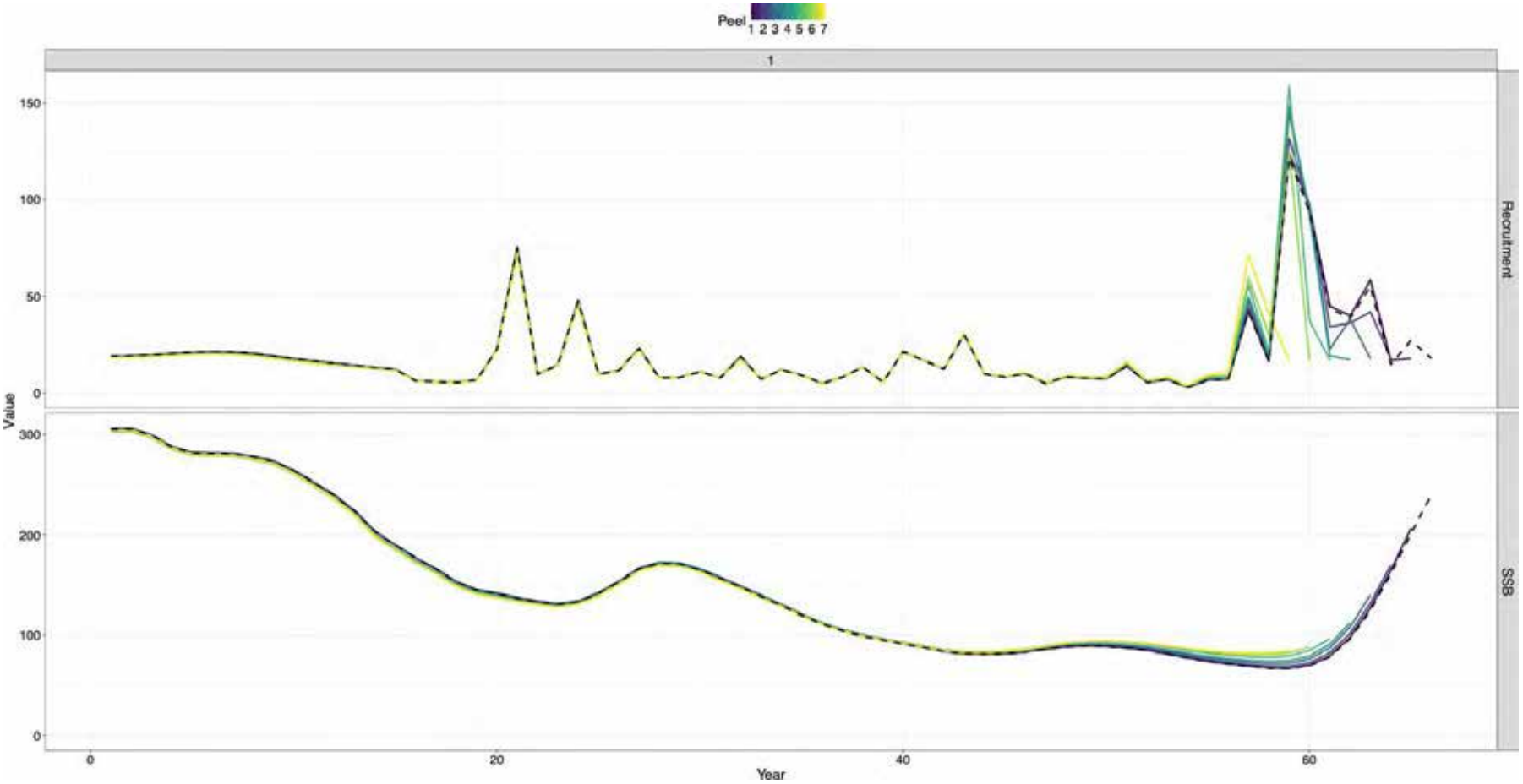


Figure 3B.21. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg_ContTVSel*. Mohn's rho for SSB was 0.161.

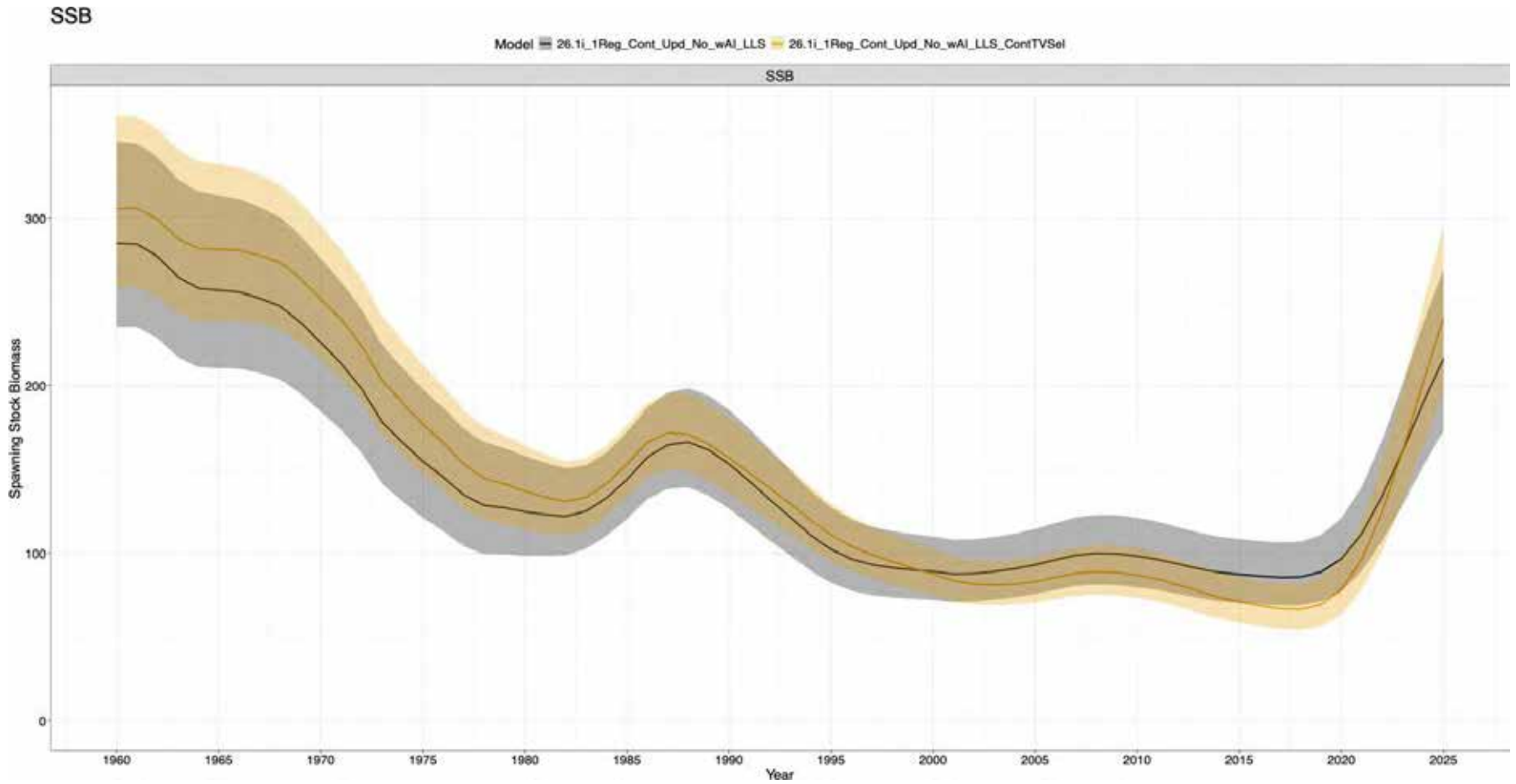


Figure 3B.22. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel; yellow line*). Shaded regions represent the 95% confidence intervals.

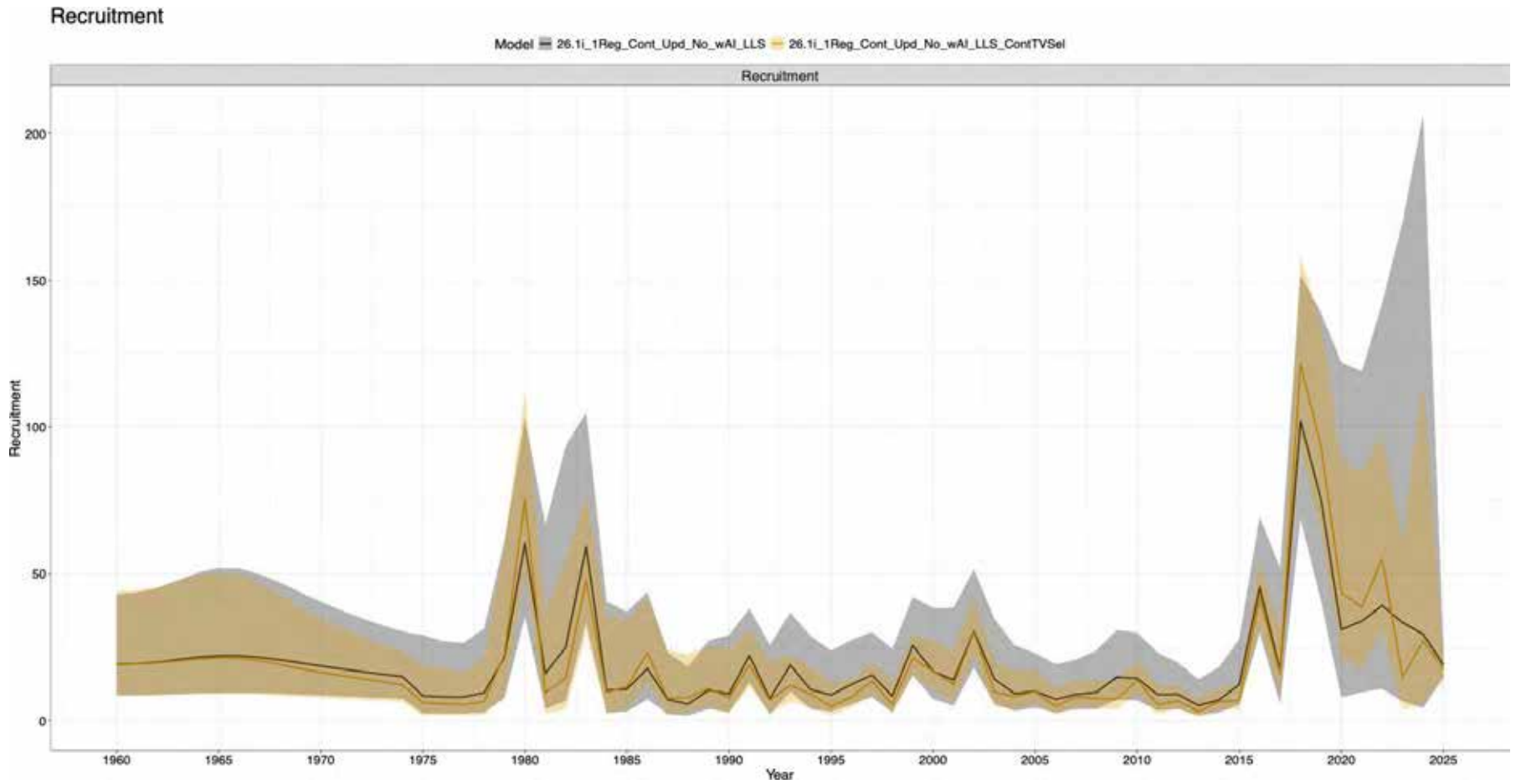


Figure 3B.23. Comparison of age-2 recruitment (in millions of individuals) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel; yellow line*). Shaded regions represent the 95% confidence intervals.

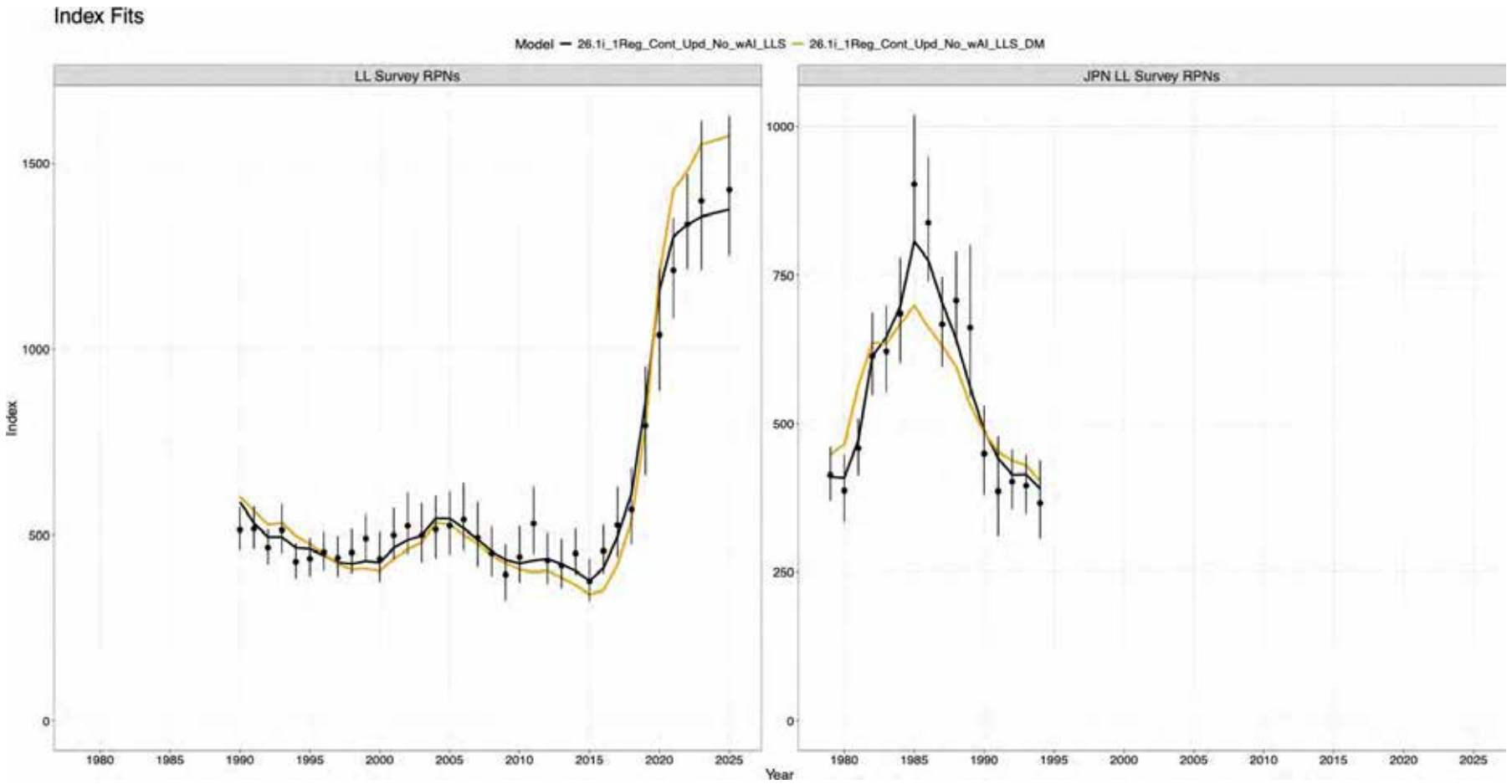


Figure 3B.24. Model fits to survey abundance indices between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_DM; yellow line*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

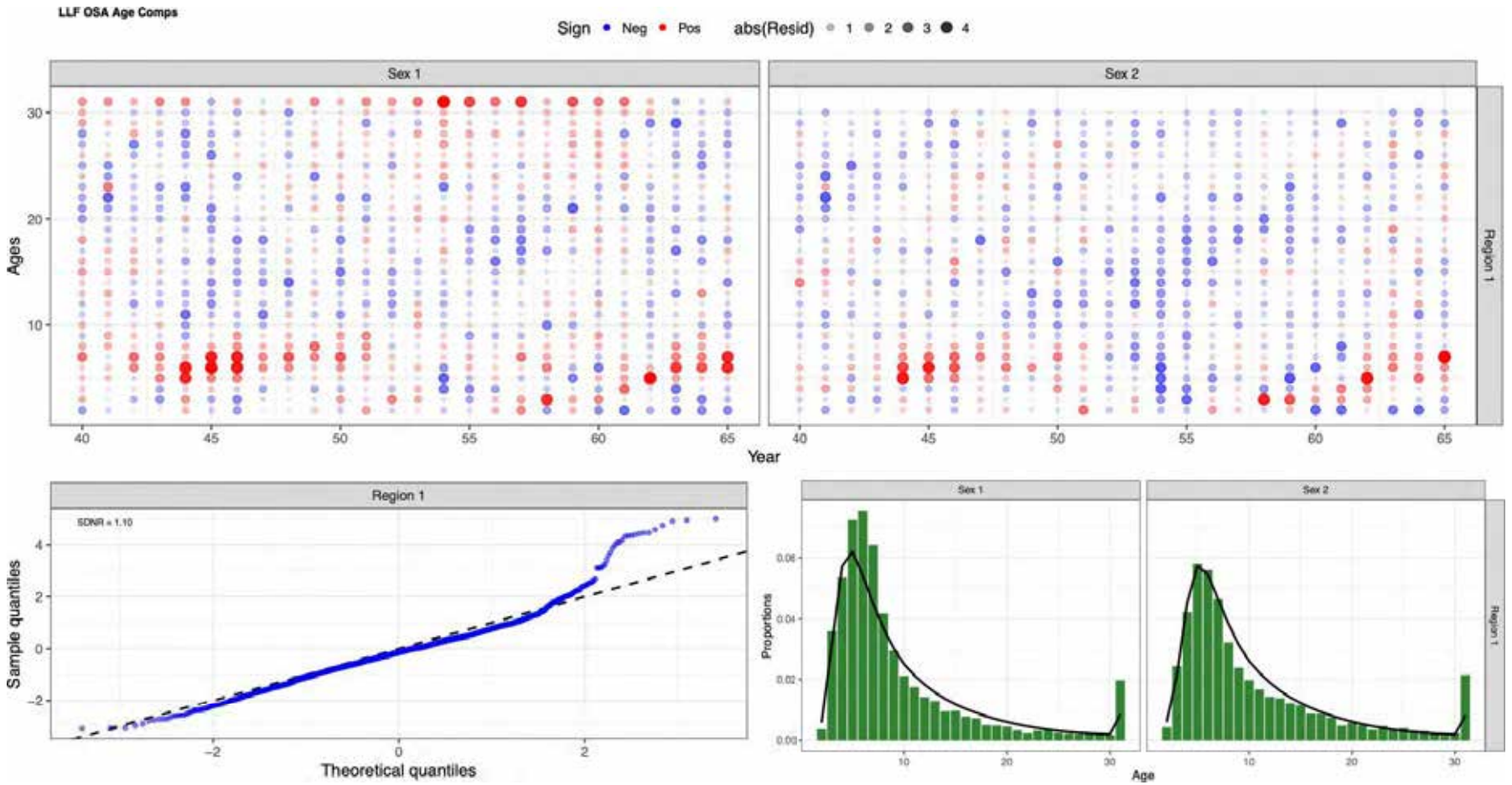


Figure 3B.25. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

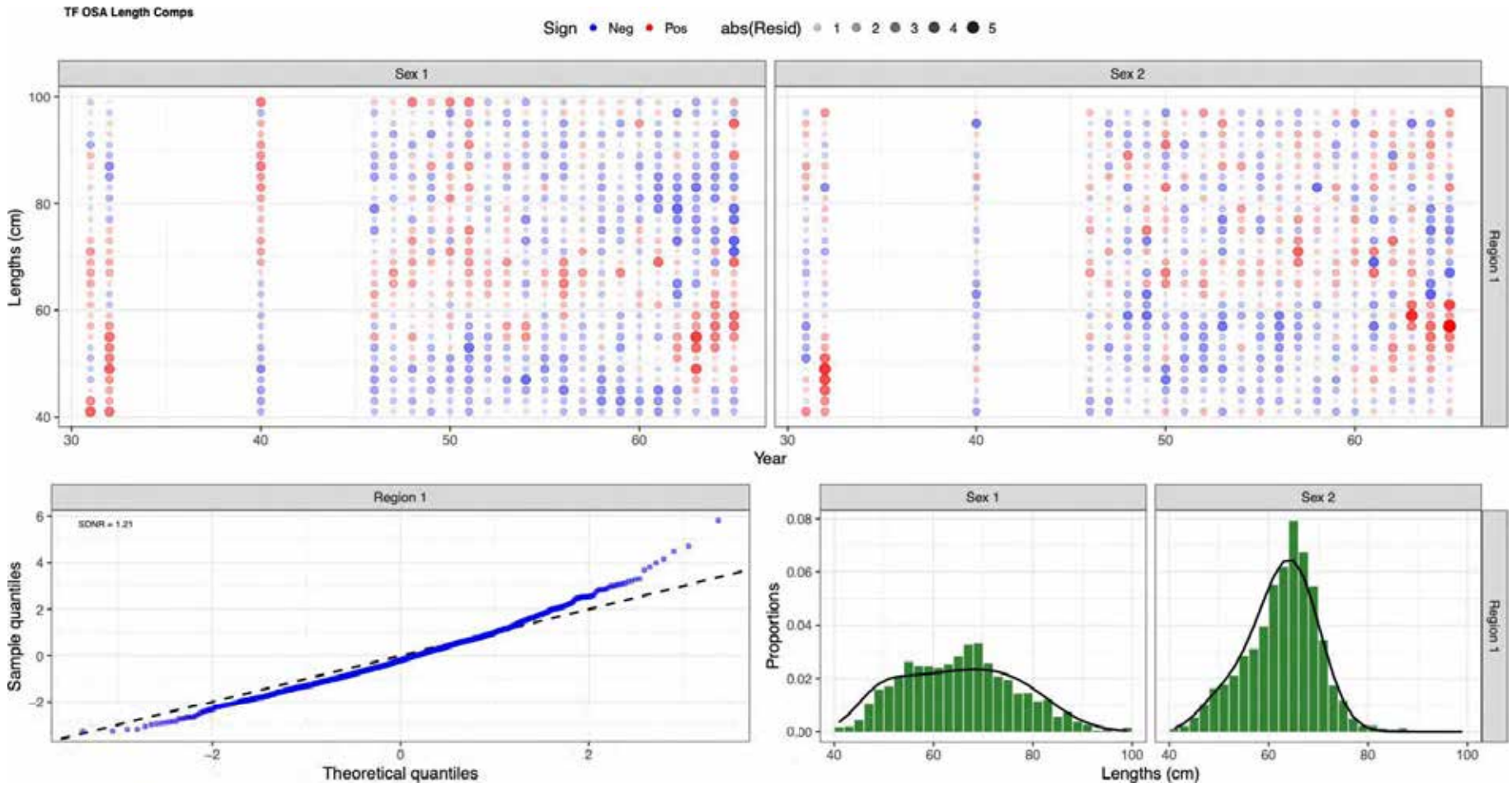


Figure 3B.26. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

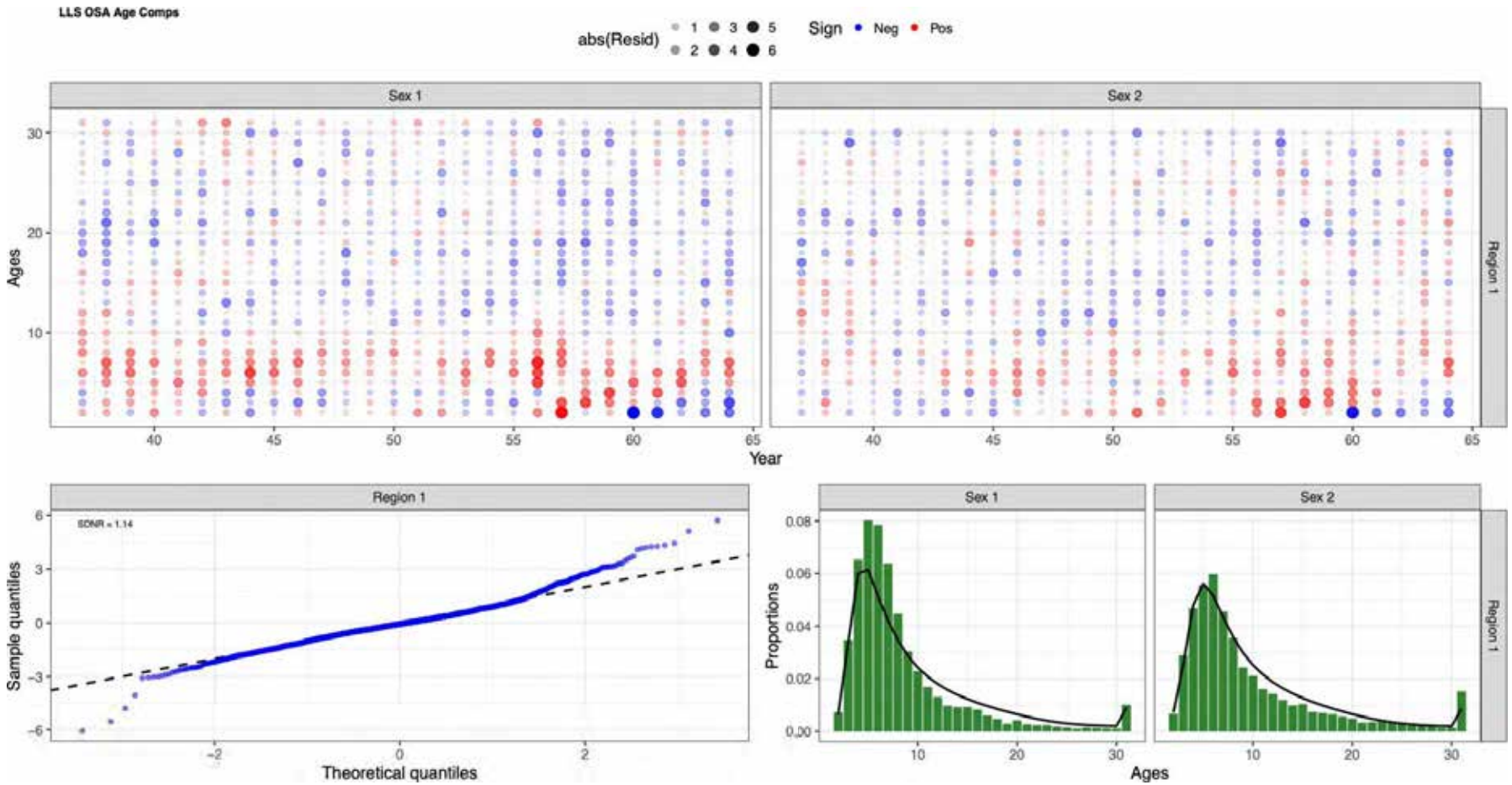


Figure 3B.27. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

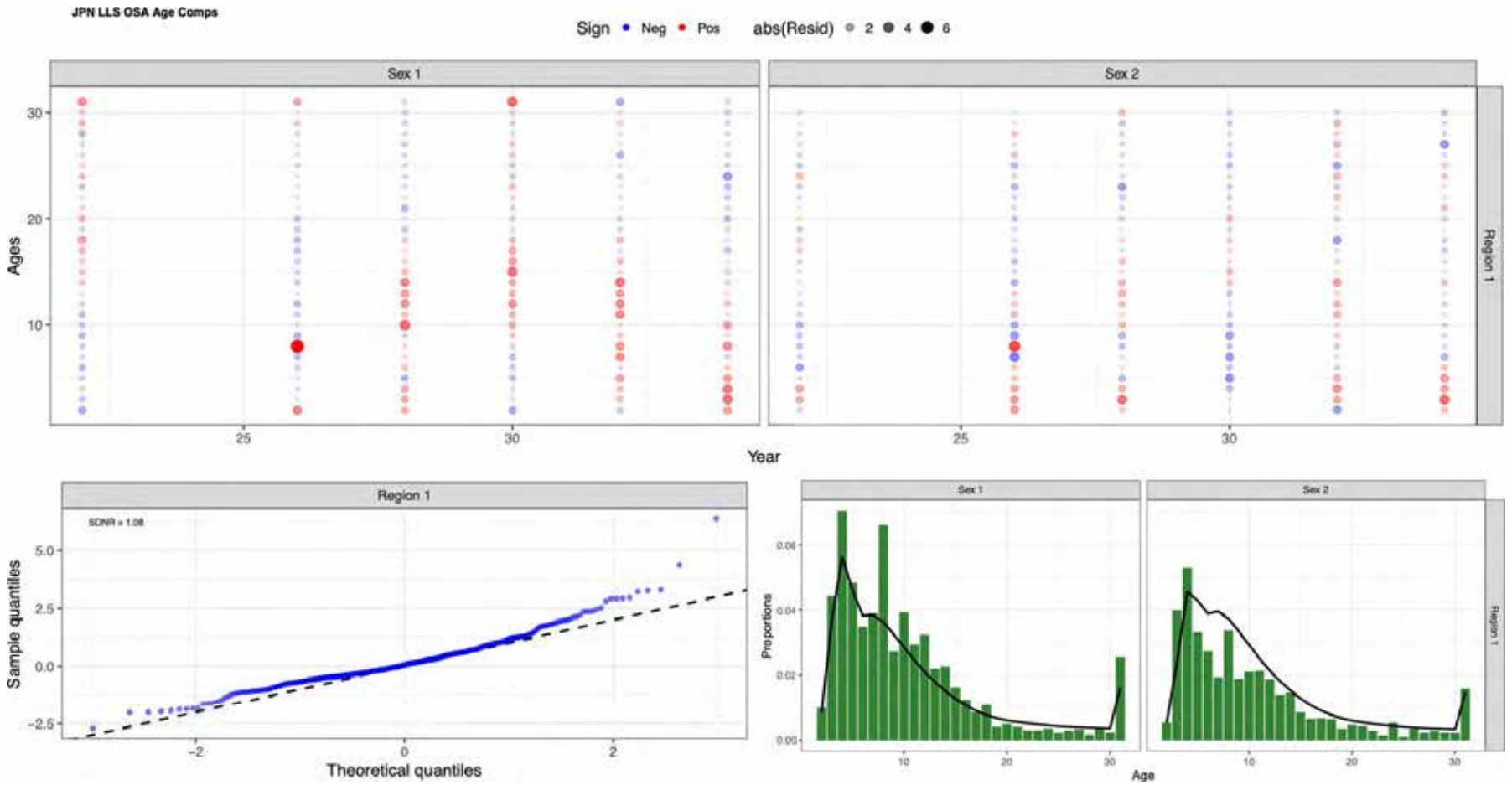


Figure 3B.28. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

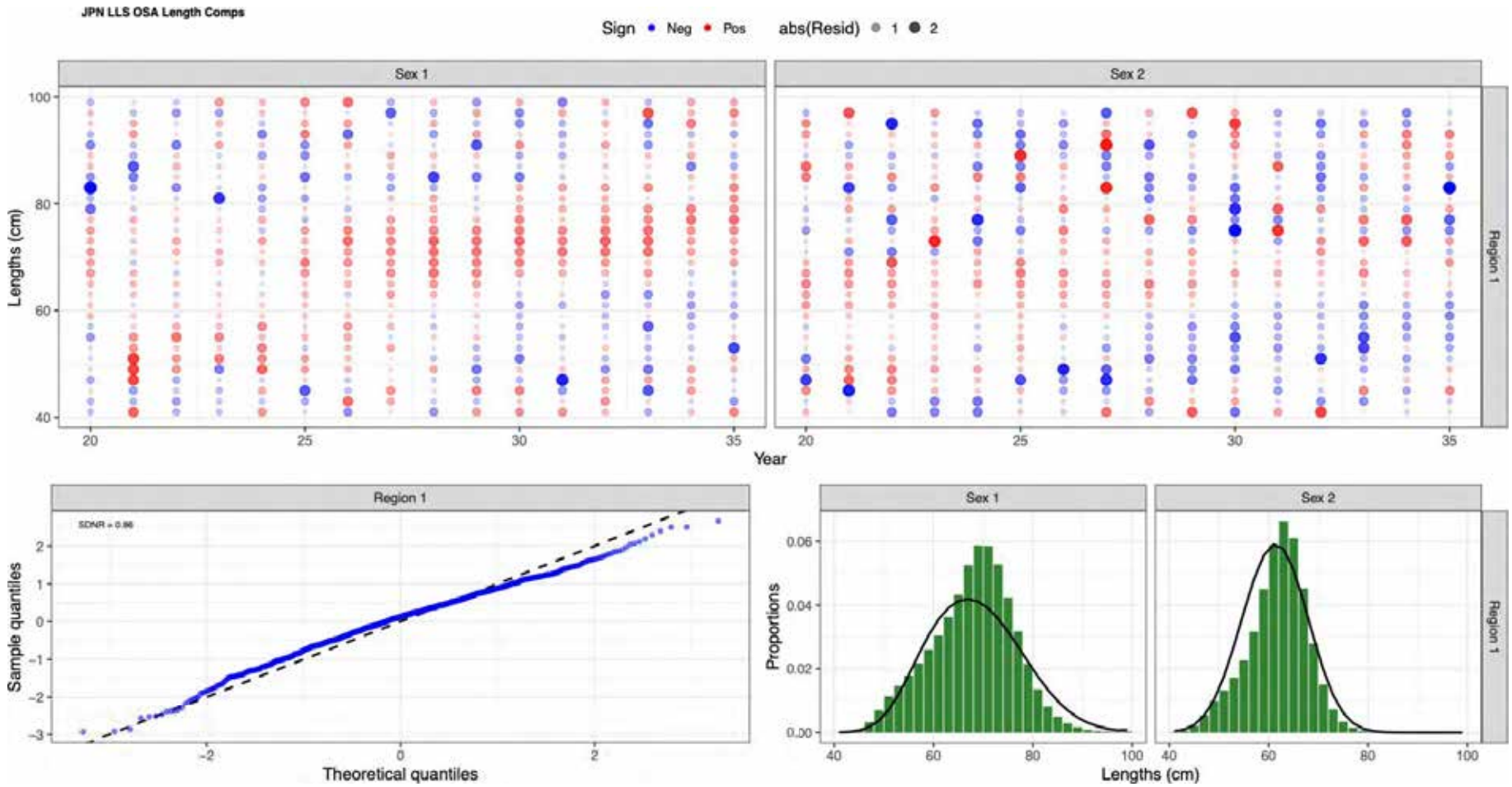


Figure 3B.29. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

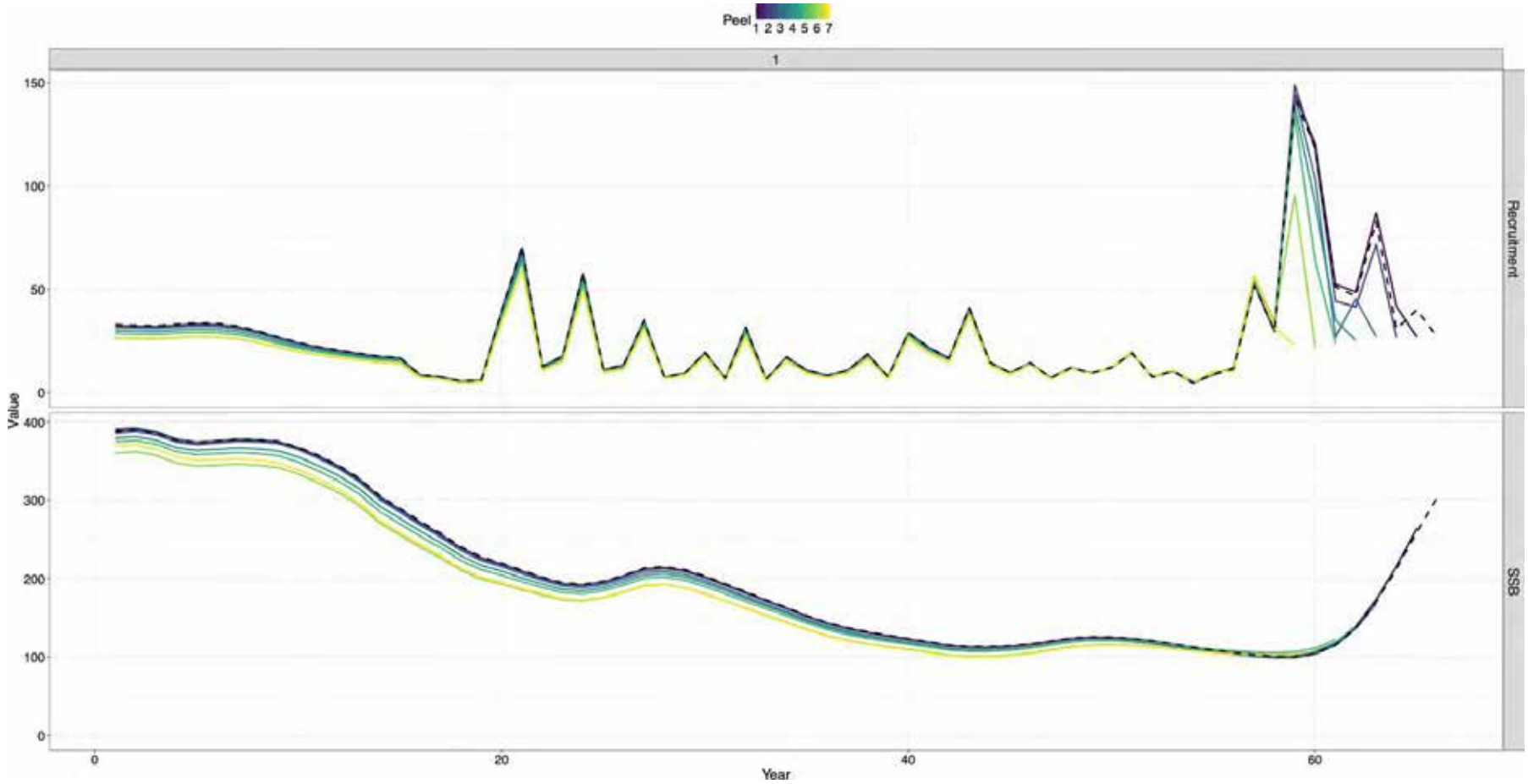


Figure 3B.30. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg_DM*. Mohn's rho for SSB was 0.022.

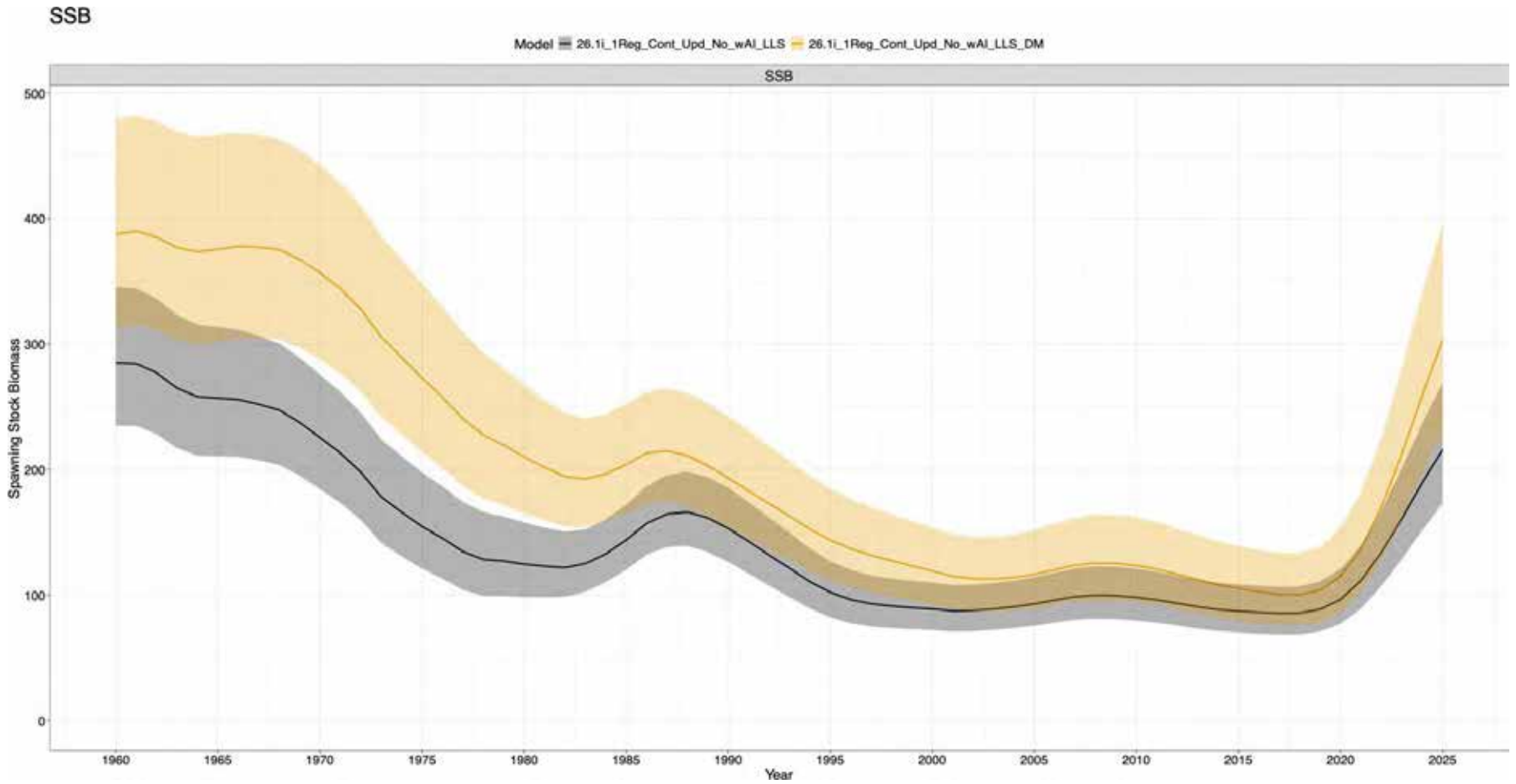


Figure 3B.31. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_DM; yellow line*). Shaded regions represent the 95% confidence intervals.

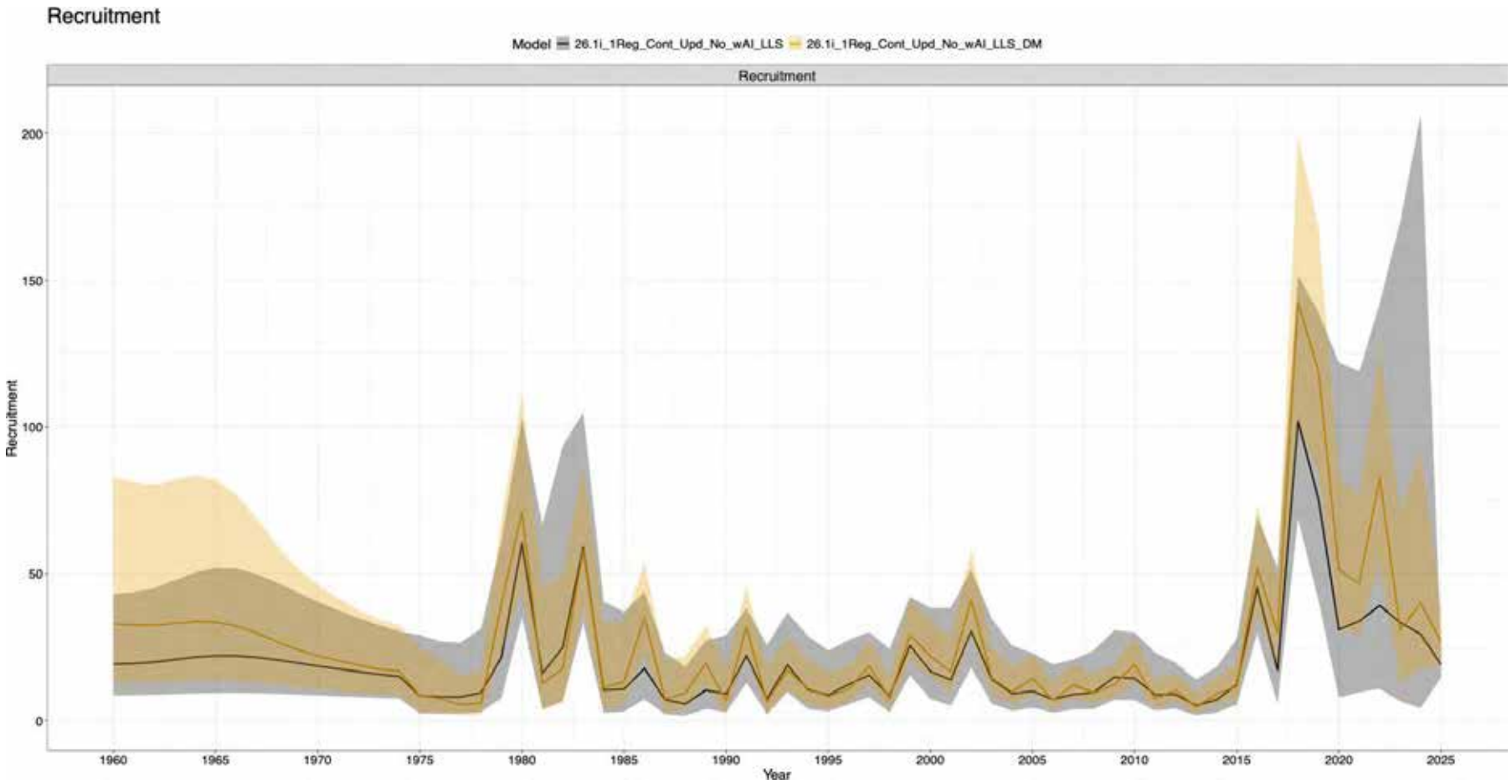


Figure 3B.32. Comparison of age-2 recruitment (millions of individuals) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_DM; yellow line*). Shaded regions represent the 95% confidence intervals.

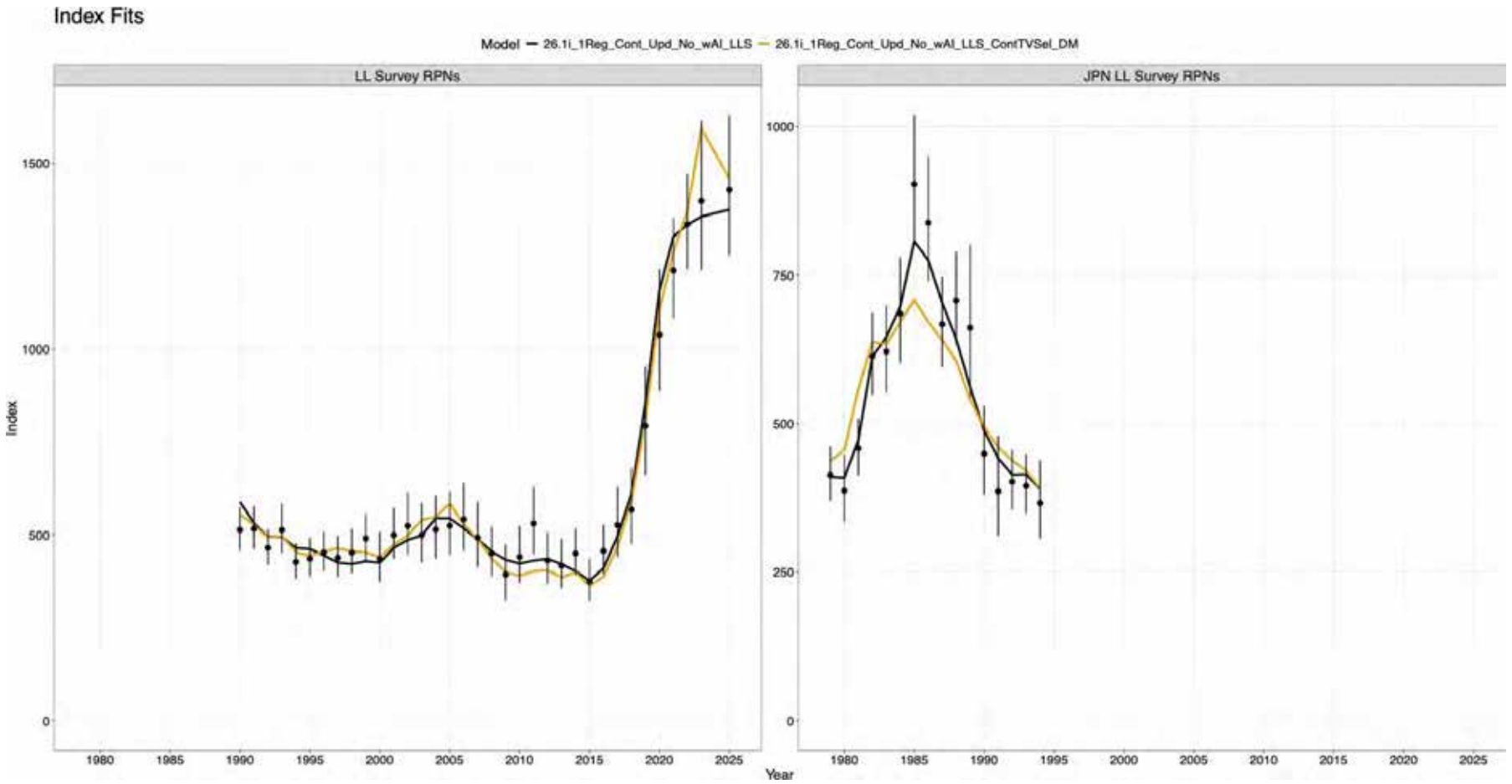


Figure 3B.33. Model fits to survey abundance indices between Model *26.1_1Reg*) also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous semi-parametric time-varying survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel_DM; yellow line*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

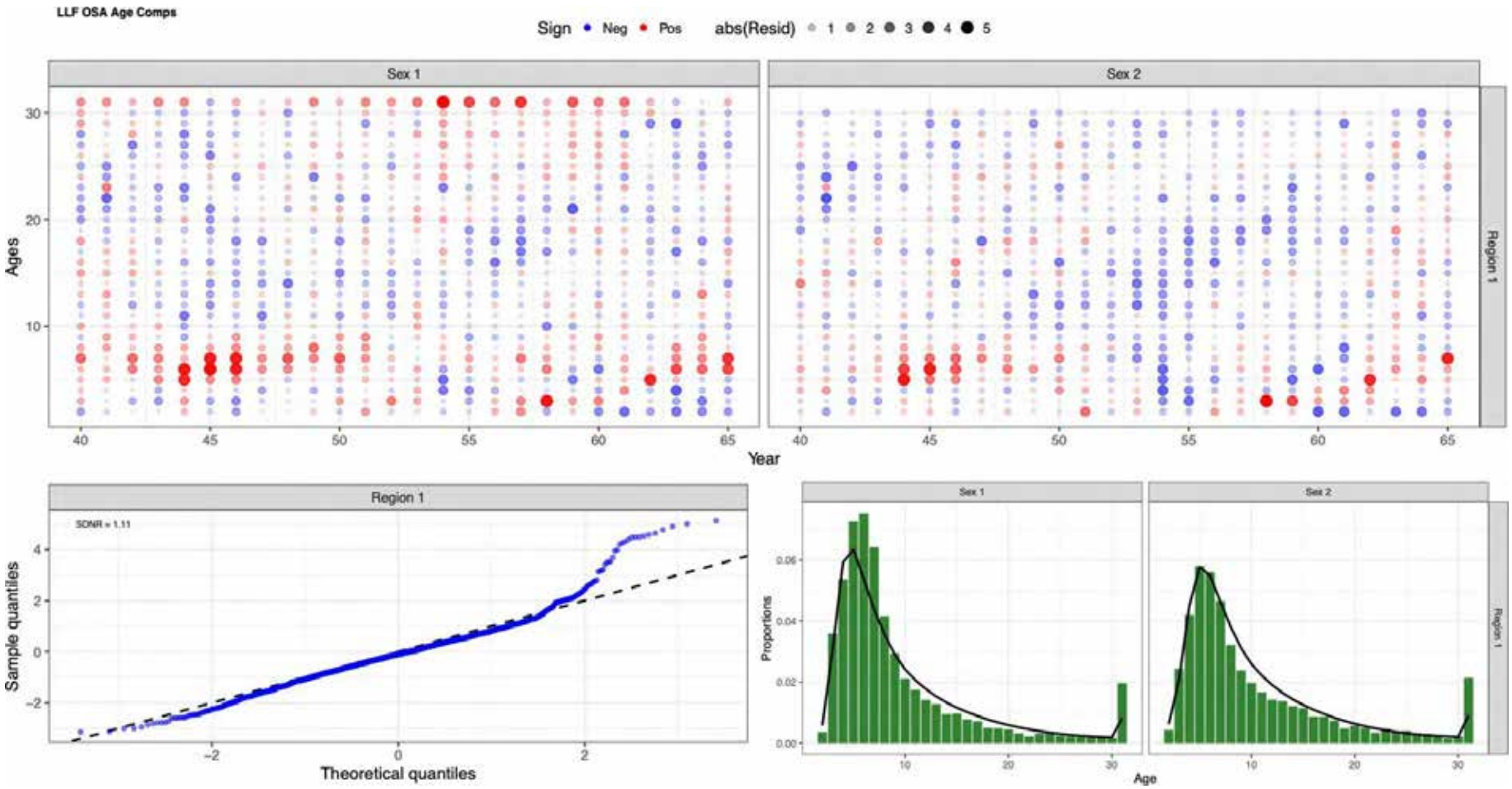


Figure 3B.34. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel_DM*.

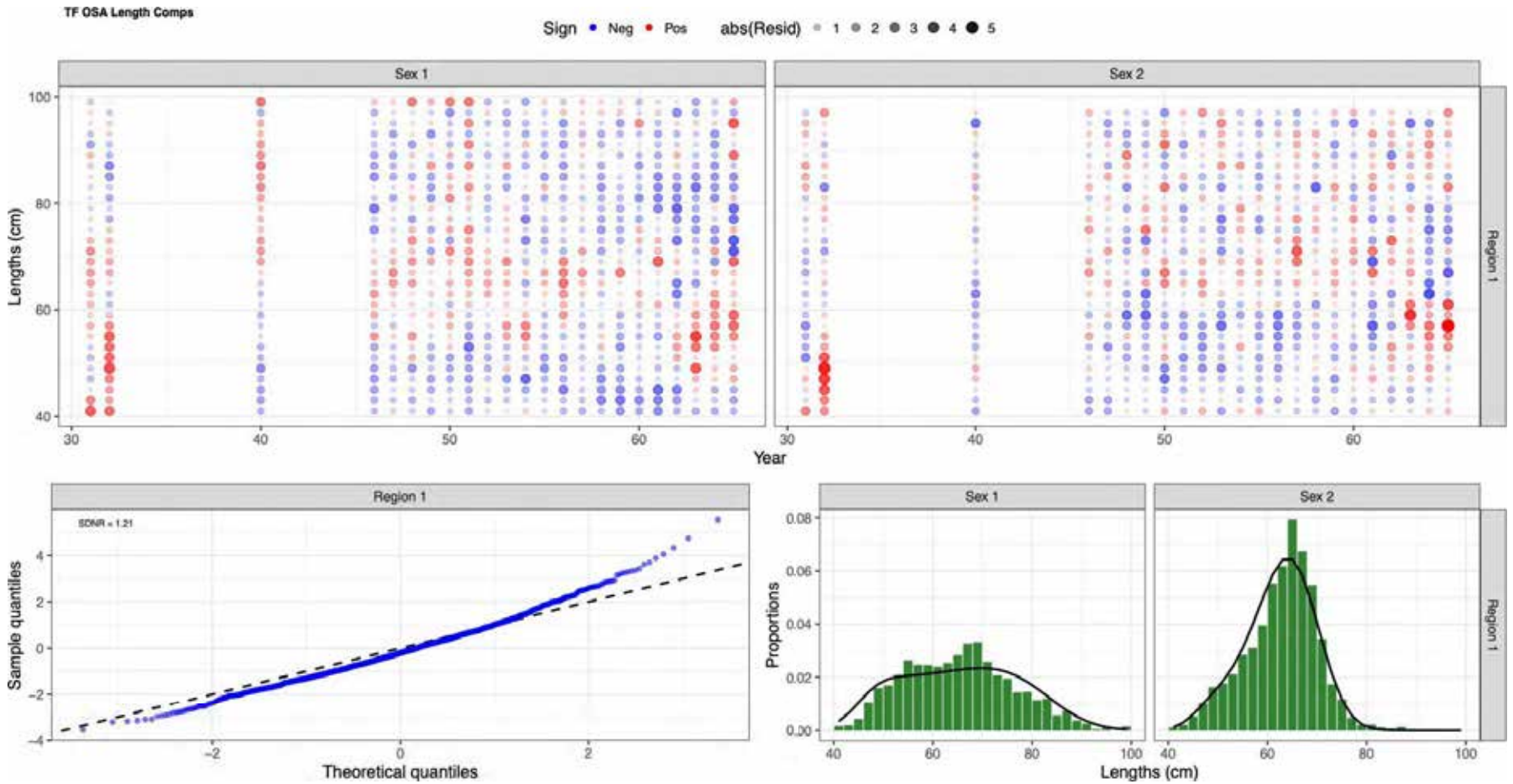


Figure 3B.35. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_DM*.

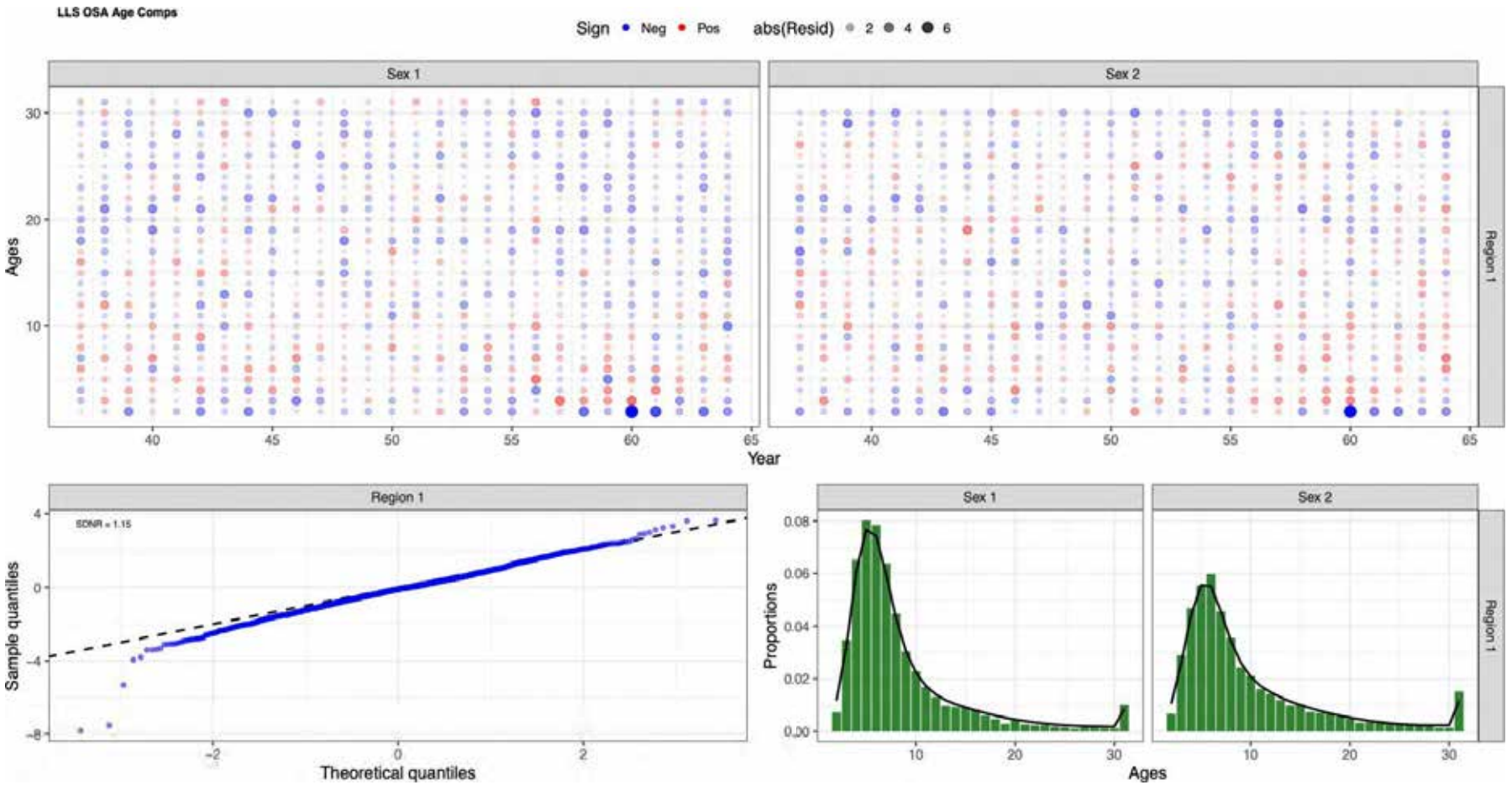


Figure 3B.36. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel_DM*.

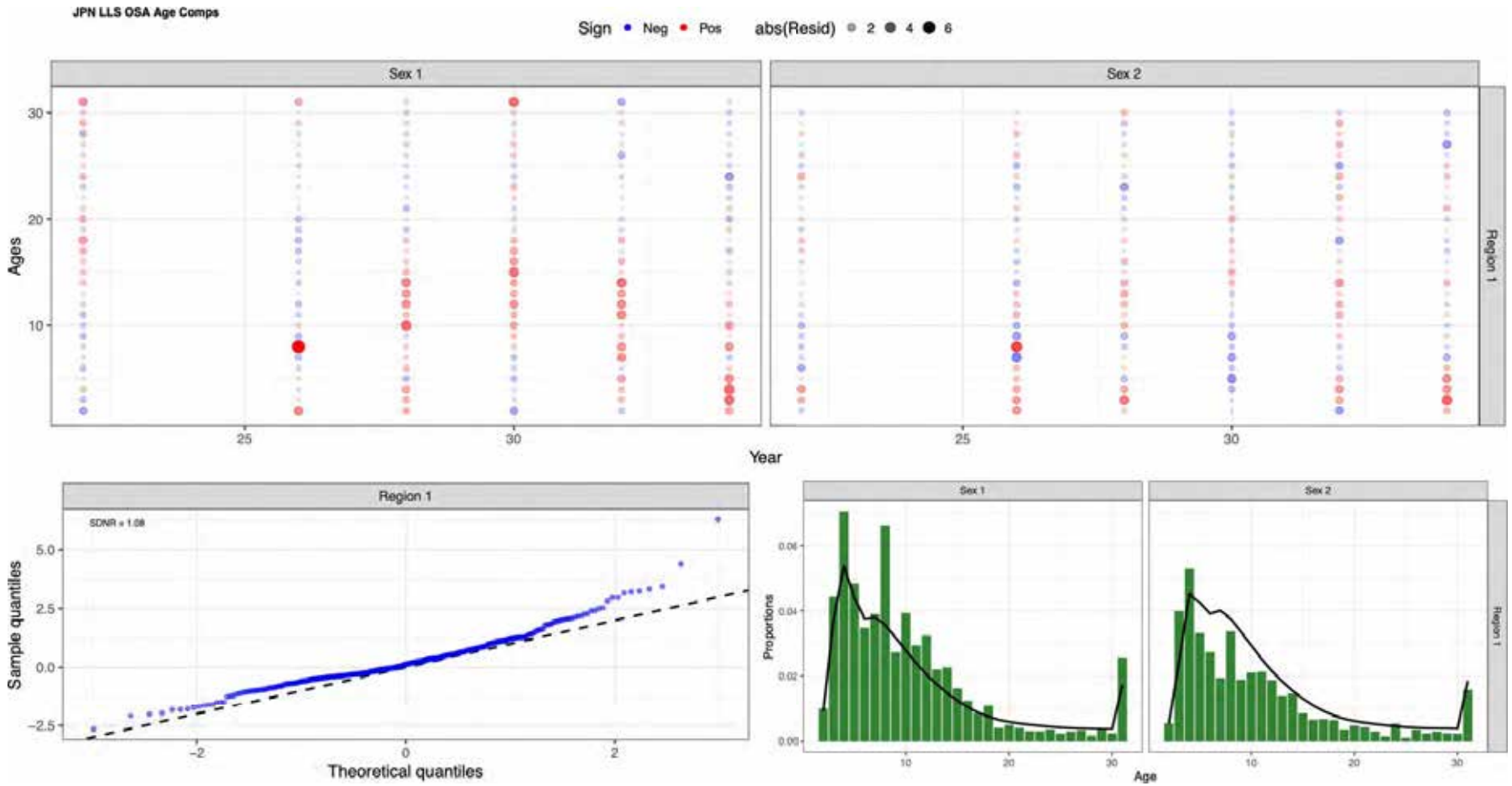


Figure 3B.37. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel_DM*.

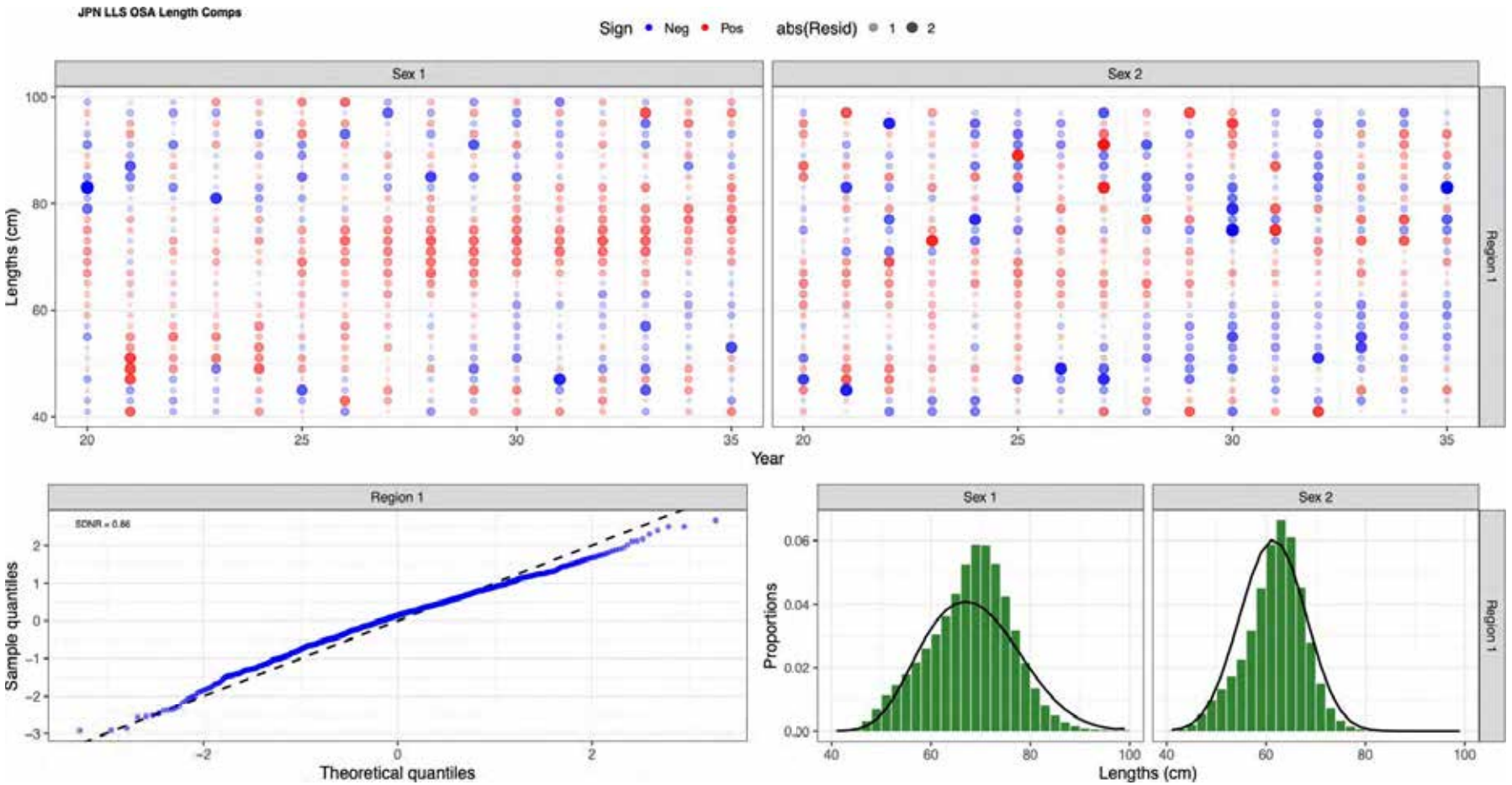


Figure 3B.38. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg_ContTVSel_DM*.

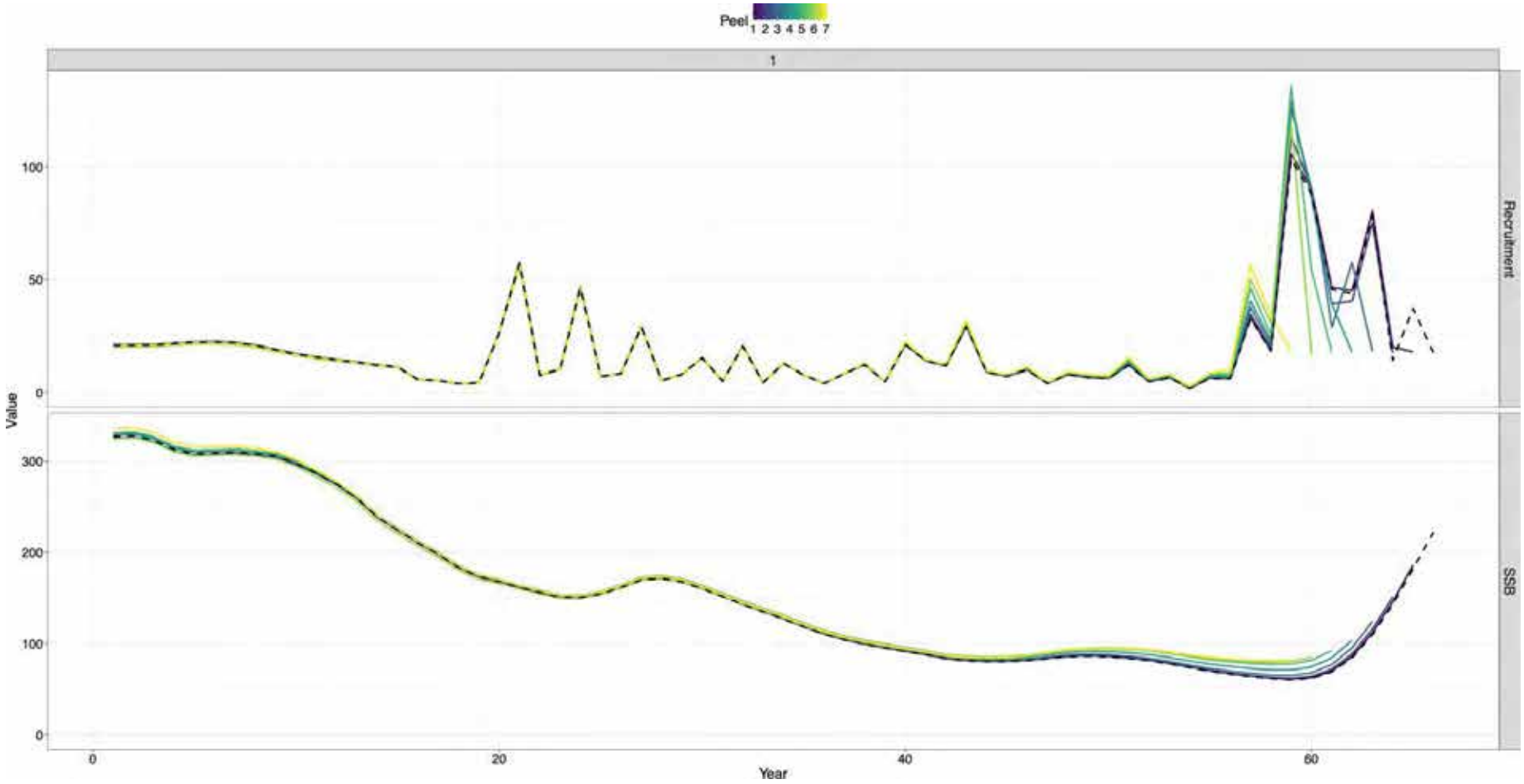


Figure 3B.39. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg_ContTVSel_DM*. Mohn's rho for SSB was 0.217.

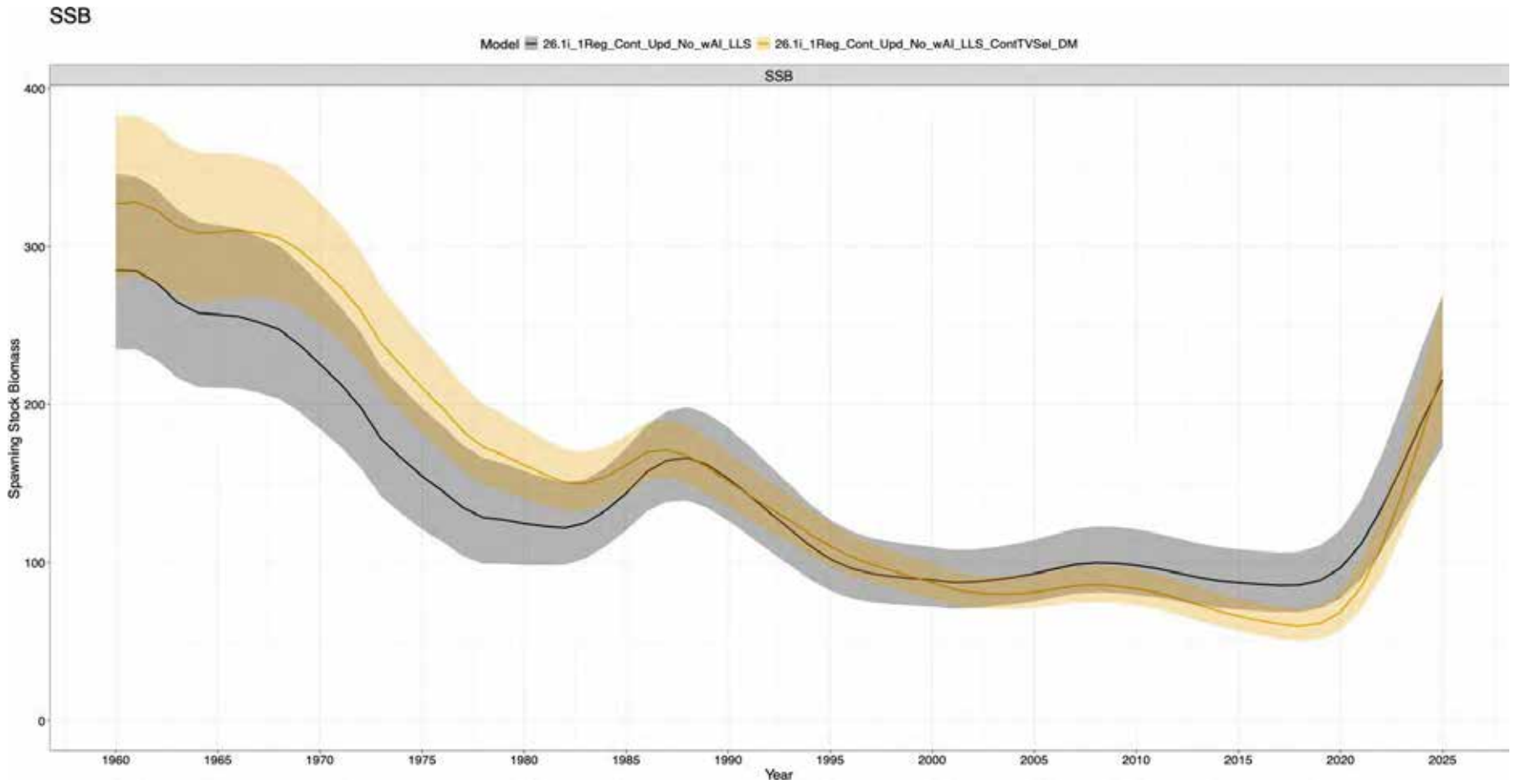


Figure 3B.40. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel_DM; yellow line*). Shaded regions represent the 95% confidence intervals.

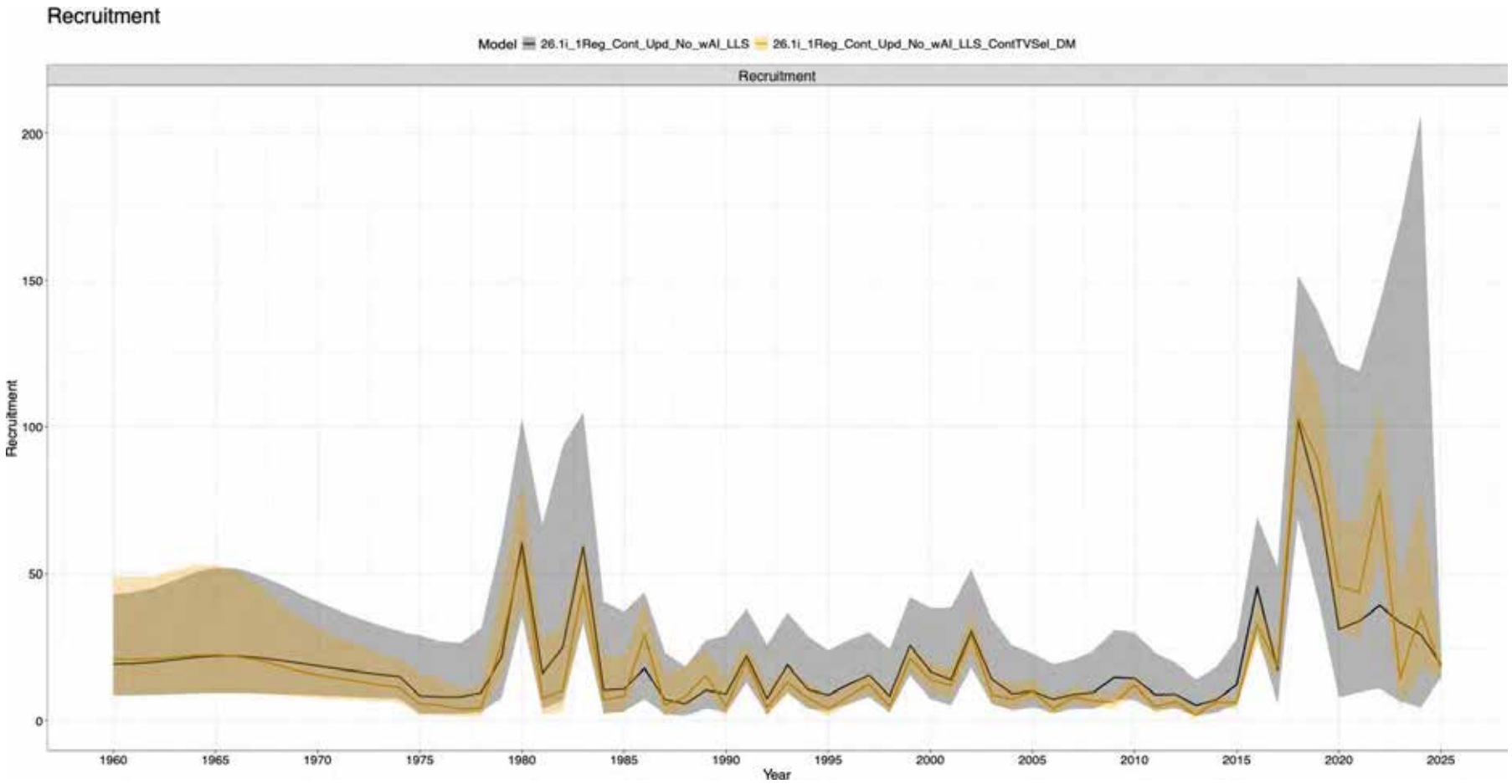


Figure 3B.41. Comparison of age-2 recruitment (millions of fish) between Model *26.1_1Reg* (also termed *26.1i_1Reg_Cont_Upd_No_wAI_LLS; black line*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.1i_1Reg_Cont_Upd_No_wAI_LLS_ContTVSel_DM; yellow line*). Shaded regions represent the 95% confidence intervals.

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4. Supplemental Material 3B: Additional Figures

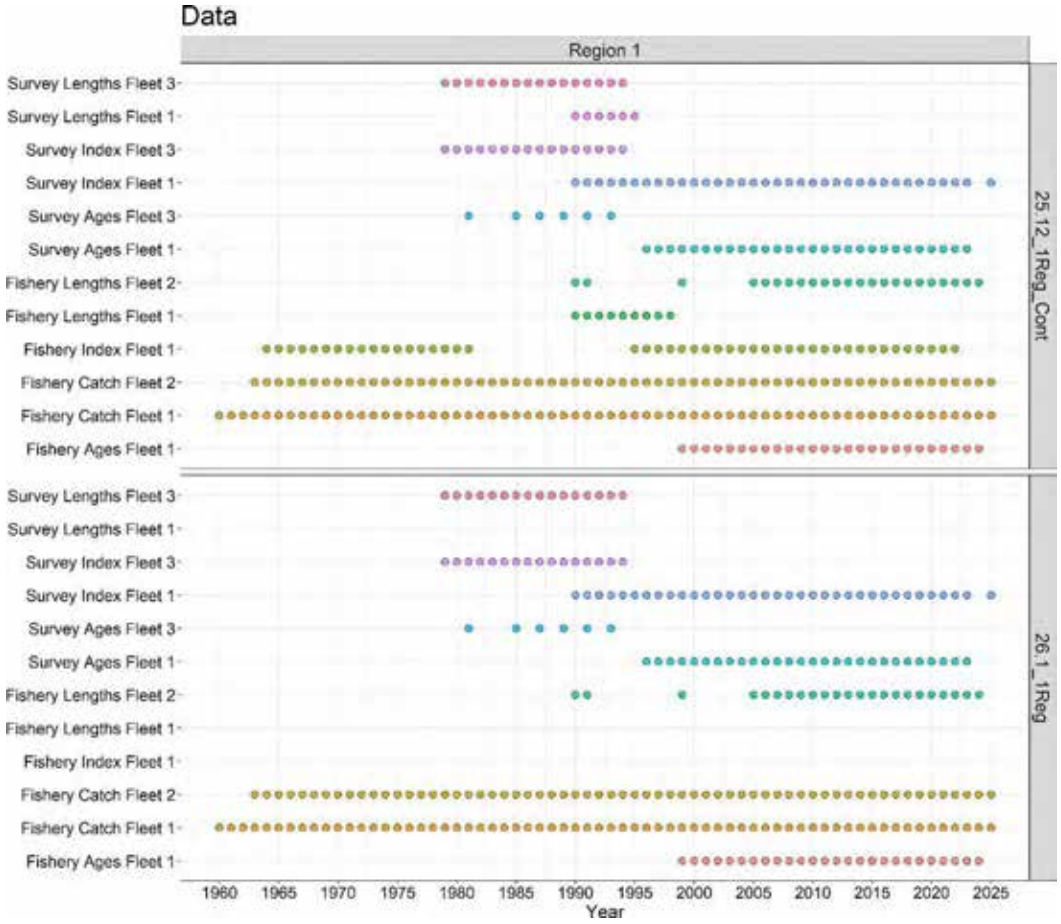

Figure SM3B.1. Data inputs used by Model *25.12_1Reg_Cont* and Model *26.1_1Reg*. Note that Fishery Fleet 1 is the fixed gear fleet, Fishery Fleet 2 is the trawl fleet, Survey Fleet 1 is the NOAA Longline Survey, and survey Fleet 3 is the Japanese Longline Survey. Primary differences in data usage are that Model *26.1_1Reg* no longer fits to fixed gear fishery lengths or the associated CPUE index (including the historical Japanese fishery CPUE and the recent domestic fishery CPUE) as well as not fitting NOAA Longline Survey lengths.

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
25.12_1Reg_Cont	1	206.6999	357.0208	0.04784668	39.55138	131.4549	0.07875	1.57240	0.57896	0.60758
26.1_1Reg	1	216.4521	369.6689	0.04642913	40.85173	139.0172	0.07903	1.55702	0.58553	0.58749

Figure SM3B.2. Key management quantity outputs from Model *25.12_1Reg_Cont* and Model *26.1_1Reg*. SSB is in kt, B_Ref_Pt is the associated $B_{40\%}$ reference point in kt, and F_Ref_Pt is the associated $F_{40\%}$.

Source	SE	Eff_SE	Data_Wt	ISS	ESS
LL Survey Index	0.09	0.09	1.00	NA	NA
JPN LL Survey Index	0.09	0.09	1.00	NA	NA
Fixed Gear Fishery CPUE	0.20	0.20	1.00	NA	NA
Fixed Gear Fish Ages	NA	NA	0.80	20	16.00
LL Survey Ages	NA	NA	3.54	20	70.75
JPN LL Survey Ages	NA	NA	0.64	20	12.87
Fixed Gear Fish Lengths	NA	NA	3.48	20	69.54
Trawl Fish Lengths	NA	NA	0.35	20	6.99
LL Survey Lengths	NA	NA	2.29	20	45.75
JPN LL Survey Lengths	NA	NA	1.03	20	20.56

Source	SE	Eff_SE	Data_Wt	ISS	ESS
LL Survey Index	0.07	0.07	1.00	NA	NA
JPN LL Survey Index	0.07	0.07	1.00	NA	NA
Fixed Gear Fish Ages	NA	NA	0.12	145.15	17.69
LL Survey Ages	NA	NA	0.28	171.43	47.31
JPN LL Survey Ages	NA	NA	0.17	83.33	14.45
Trawl Fish Lengths	NA	NA	0.25	45.39	11.51
JPN LL Survey Lengths	NA	NA	0.34	54.62	18.84

Figure SM3B.3. Assumed mean (across years) statistical distribution variance terms for each data source defined in terms of standard error (SE) for indices or input sample size (ISS) for compositional data for Model *25.12_1Reg_Cont* (left) and Model *26.1_1Reg* (right). The compositional data weights (λ, Data_Wt) are calculated using the Francis reweighting method (Francis, 2011). The effective values (Eff_SE or effective sample size, ESS) represent the input values multiplied by the data weights and are the final variance terms used to fit the data in the assessment likelihoods. All compositional data are fit using the 'joint' approach (Cheng et al., 2025b), so only a single ISS/ESS or weighting term is provided across both sexes. Note that Model *25.12_1Reg_Cont* assumes a SE for indices of 2x's the observed value, while Model *26.1_1Reg* assumes a SE for indices of 1.5x's the observed value.

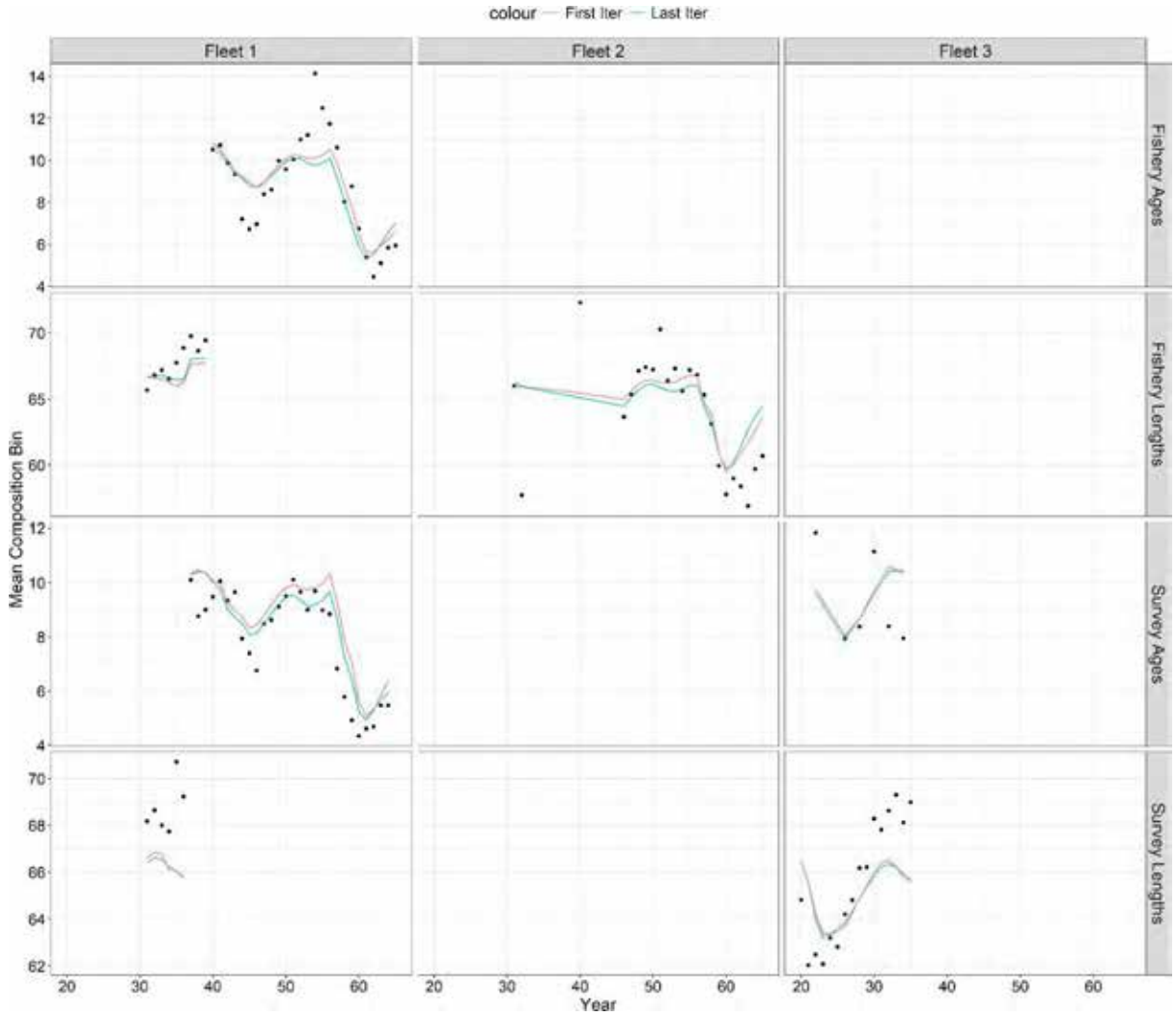

Figure SM3B.4. Fits to the mean age or mean length by year for each compositional data source at the start (red line) and end (blue lines) of the Francis reweighting method (Francis, 2011) for Model *25.12_1Reg_Cont*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey fleet 1 is the NOAA longline survey and fleet 3 is the Japanese longline survey.

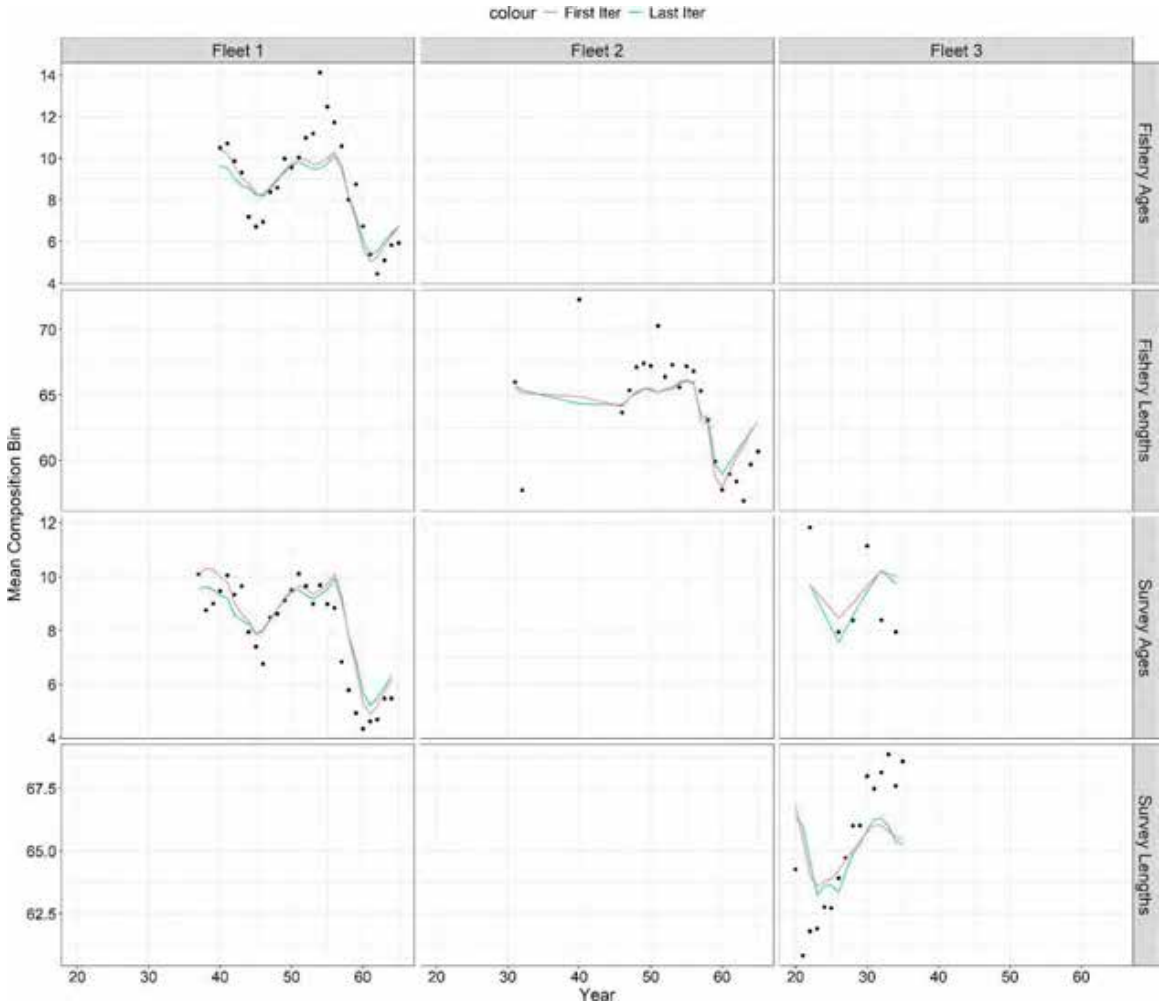

Figure SM3B.5. Fits to the mean age or mean length by year for each compositional data source at the start (red line) and end (blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.1_1Reg*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey fleet 1 is the NOAA longline survey and fleet 3 is the Japanese longline survey.

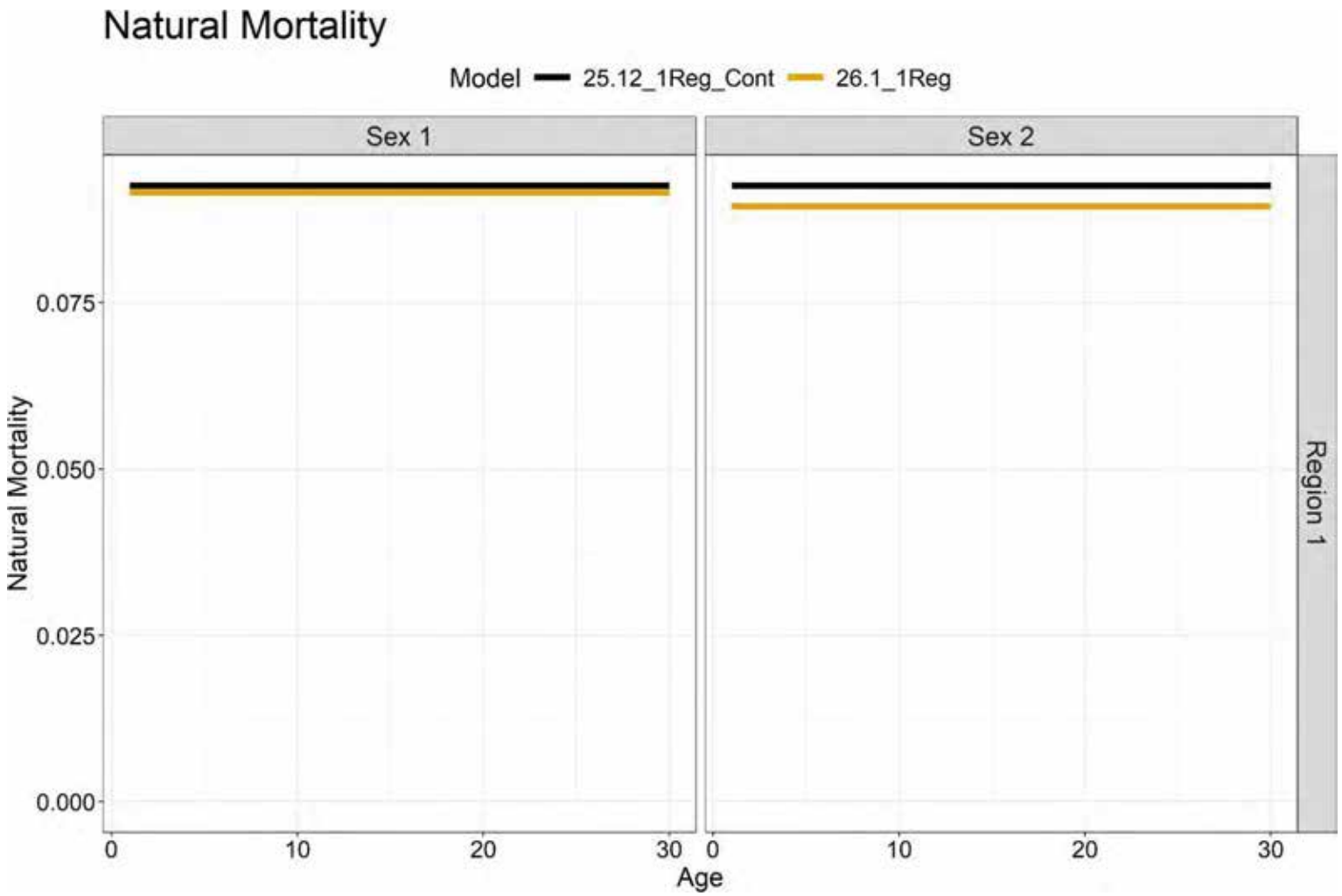

Figure SM3B.6. Natural mortality estimates from Model *25.12_1Reg_Cont* (black line) and Model *26.1_1Reg* (orange line). Sex 1 is females and sex 2 is males.

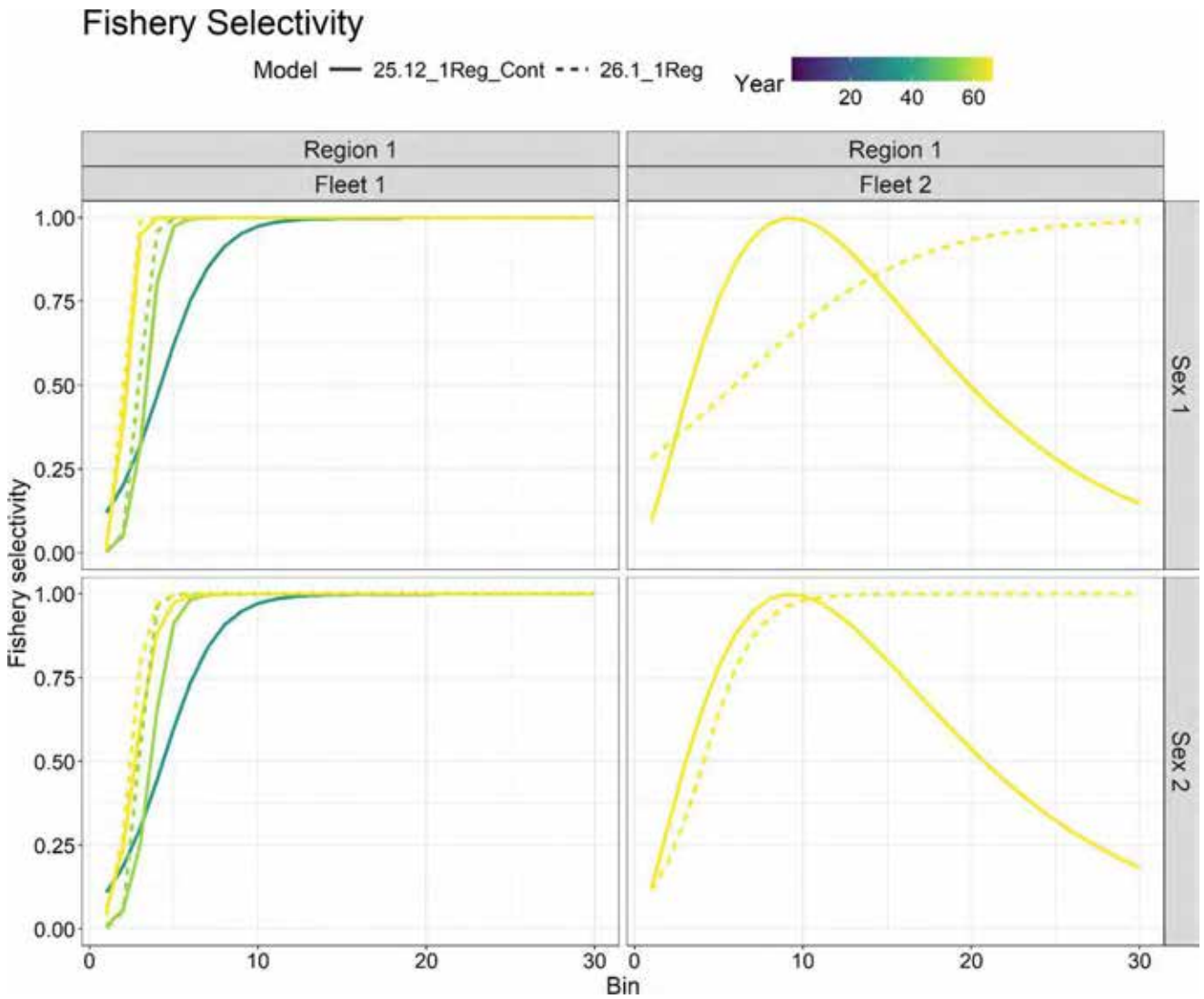

Figure SM3B.7. Fishery selectivity estimates from Model *25.12_1Reg_Cont* (solid lines) and Model *26.1_1Reg* (dashed lines) where different colors represent the different time blocks. Fleet 1 is the fixed gear fleet and fleet 2 is the trawl fleet. Sex 1 is females and sex 2 is males.

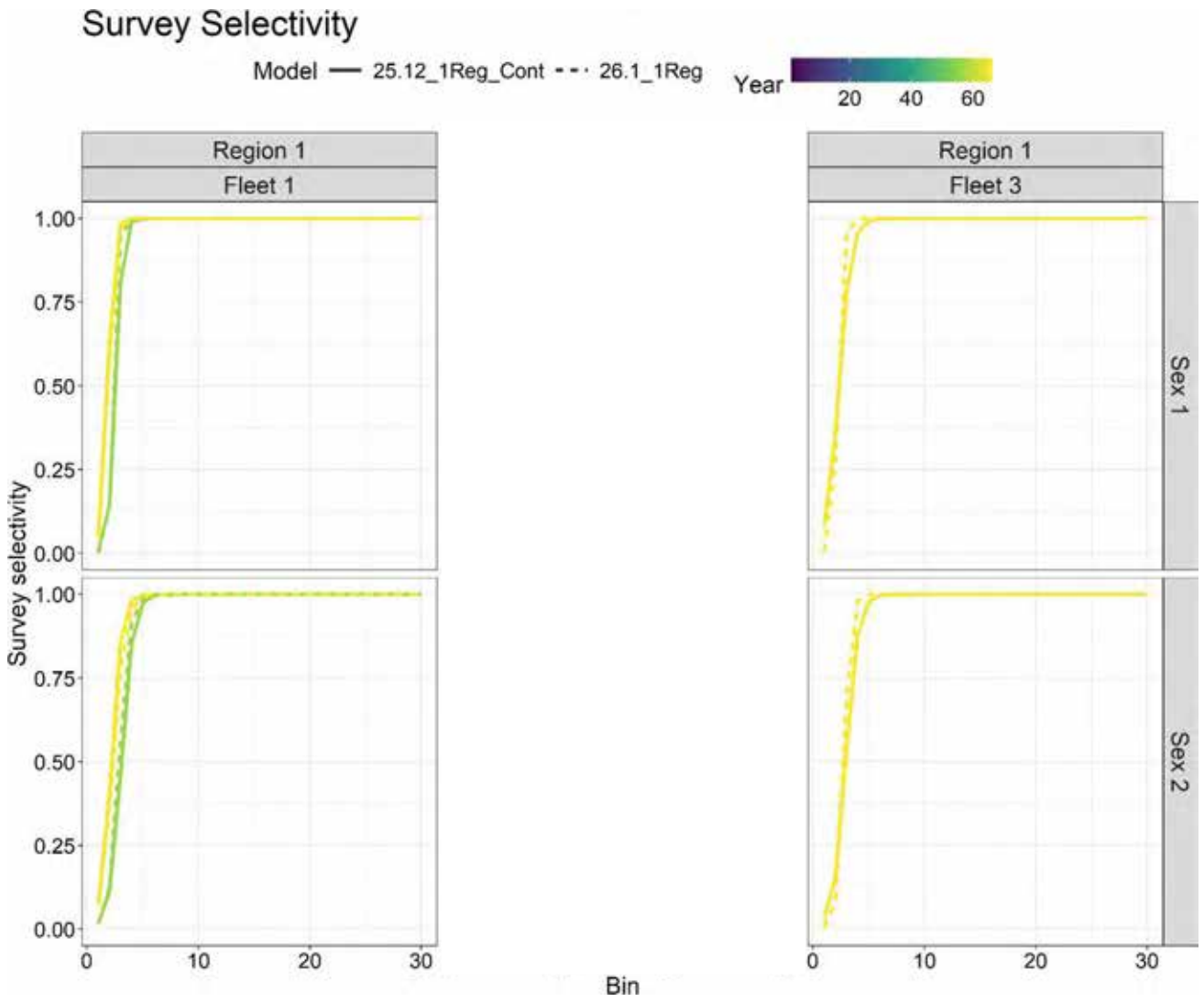

Figure SM3B.8. Survey selectivity estimates from Model *25.12_1Reg_Cont* (solid lines) and Model *26.1_1Reg* (dashed lines) where different colors represent the different time blocks. Fleet 1 is the NOAA Longline Survey and fleet 3 is the Japanese Longline Survey. Sex 1 is females and sex 2 is males.

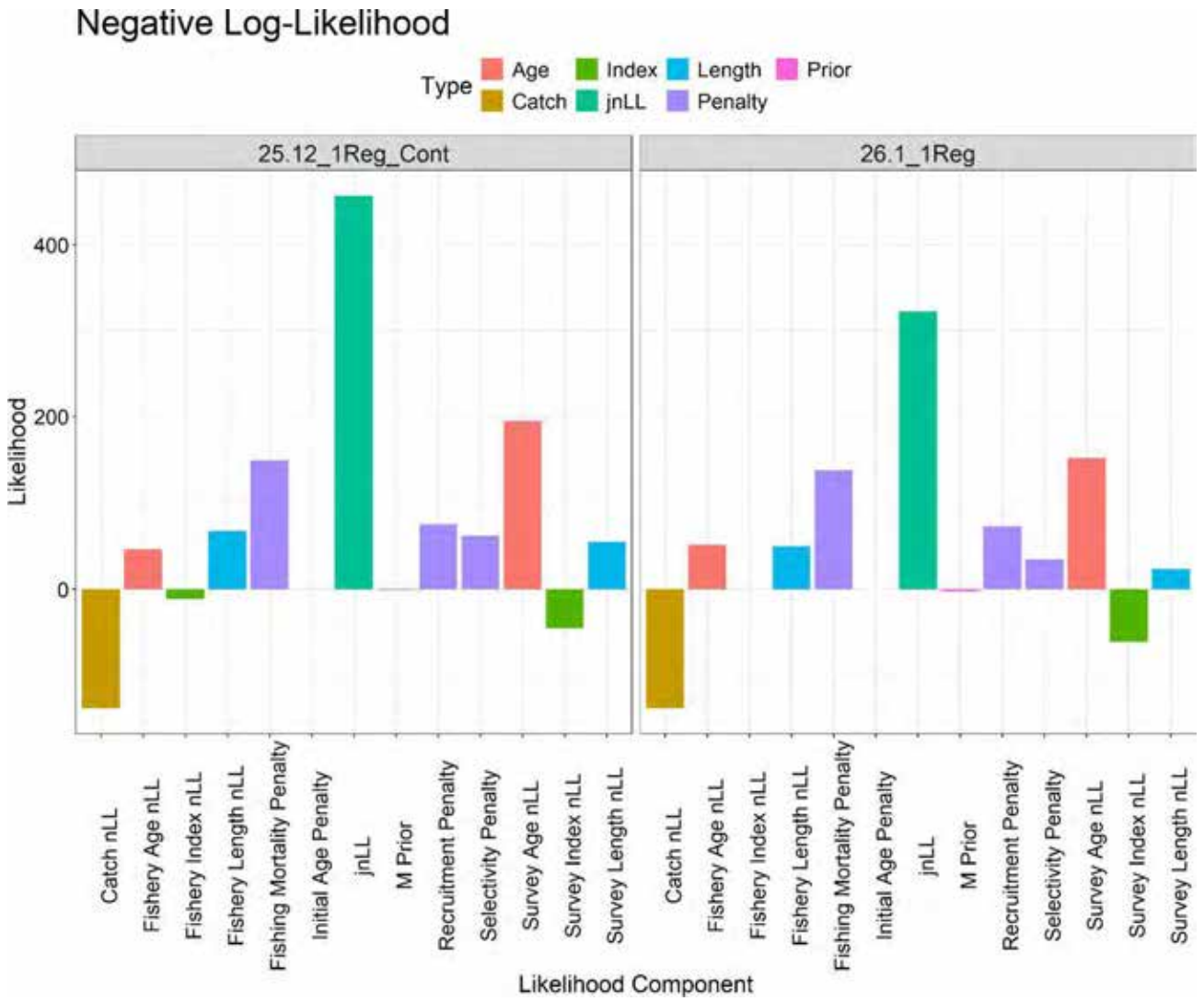

Figure SM3B.9. Joint negative log-likelihood (jnLL) components from Model *25.12_1Reg_Cont* and Model *26.1_1Reg* where different colors represent the various data sets and priors or penalty terms. Note that due to differences in data and priors or penalties used in each model, these figures are not directly comparable across models.

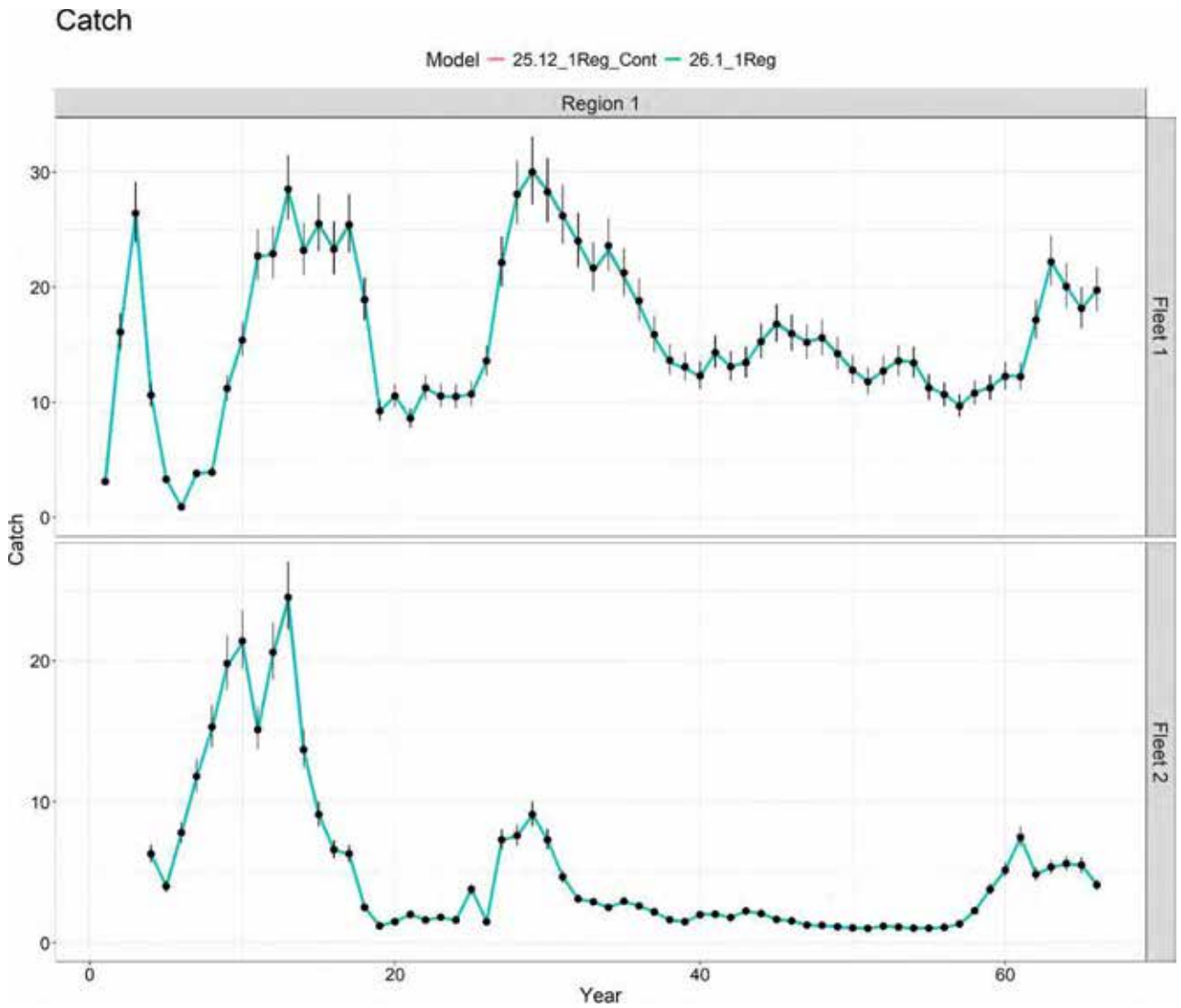

Figure SM3B.10. Fit to the catch data (black dots with 95% confidence intervals) by fleet (fleet 1 is the fixed gear fishery and fleet 2 is the trawl fleet) for Model *25.12_1Reg_Cont* (red line) and model *26.1_1Reg* (blue line).

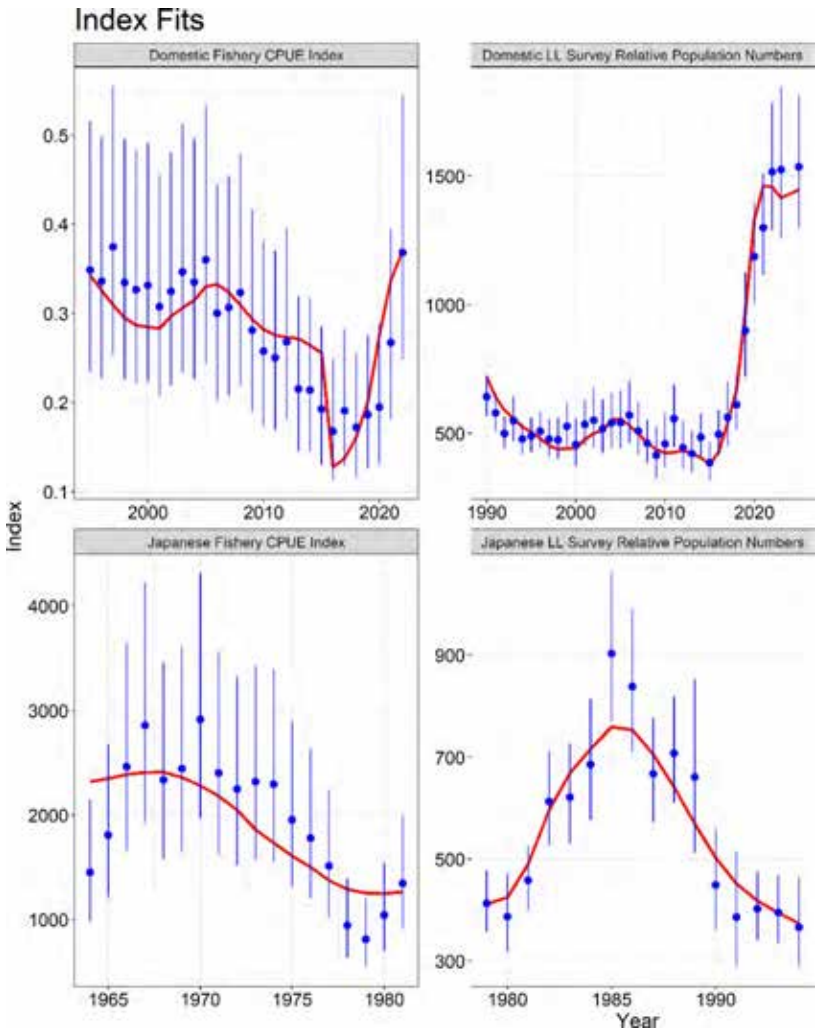

Figure SM3B.11. Model *25.12_1Reg_Cont* fit to indices, including the domestic fishery CPUE (top left), Japanese fishery CPUE (bottom left), NOAA Longline Survey RPNs (top right), and Japanese Longline Survey RPNs (bottom right). Red lines are model predicted values and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

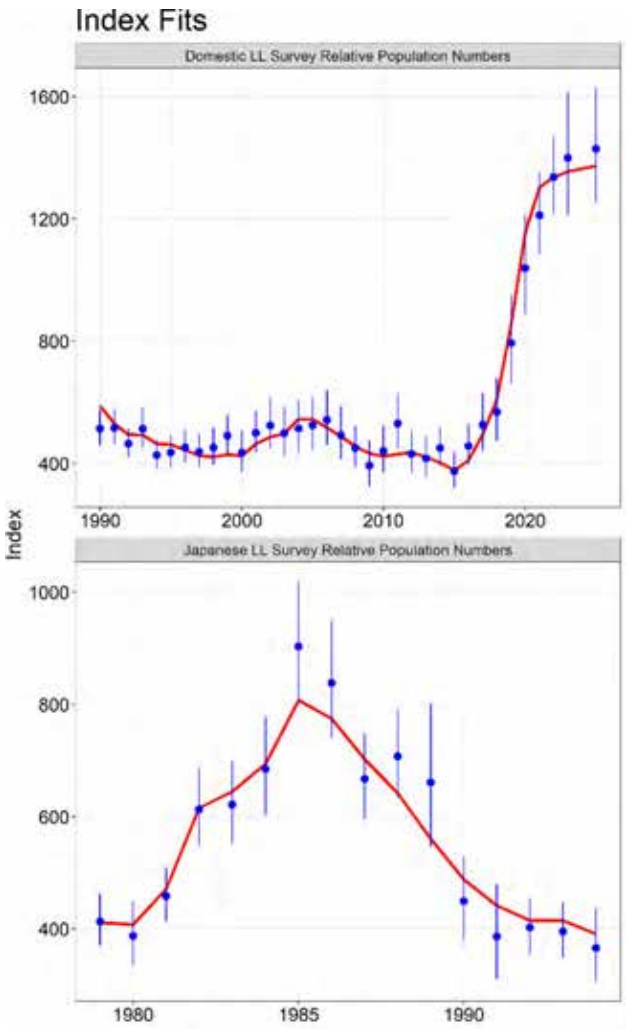

Figure SM3B.12. Model *26.1_1Reg* fit to indices, including the NOAA Longline Survey RPNs (top) and Japanese Longline Survey RPNs (bottom). Red lines are model predicted values and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors). Note the changes in the NOAA Longline Survey index from Model *25.12_1Reg_Cont* due to the use of the carryover method and removal of extrapolated western AI stations (see Figure 3B.3).

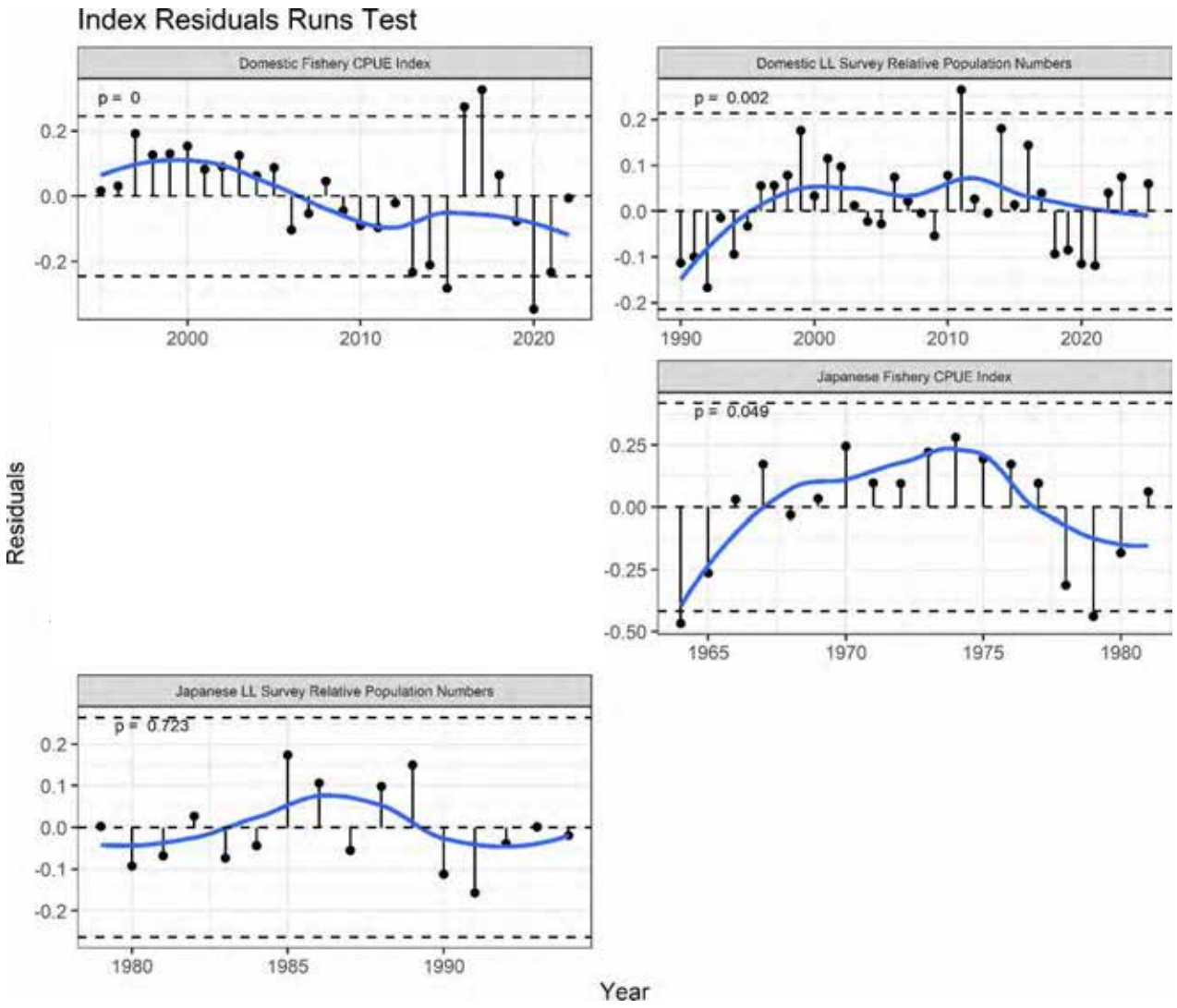

Figure SM3B.13. Results of an index residuals runs test for Model *25.12_1Reg_Cont*.

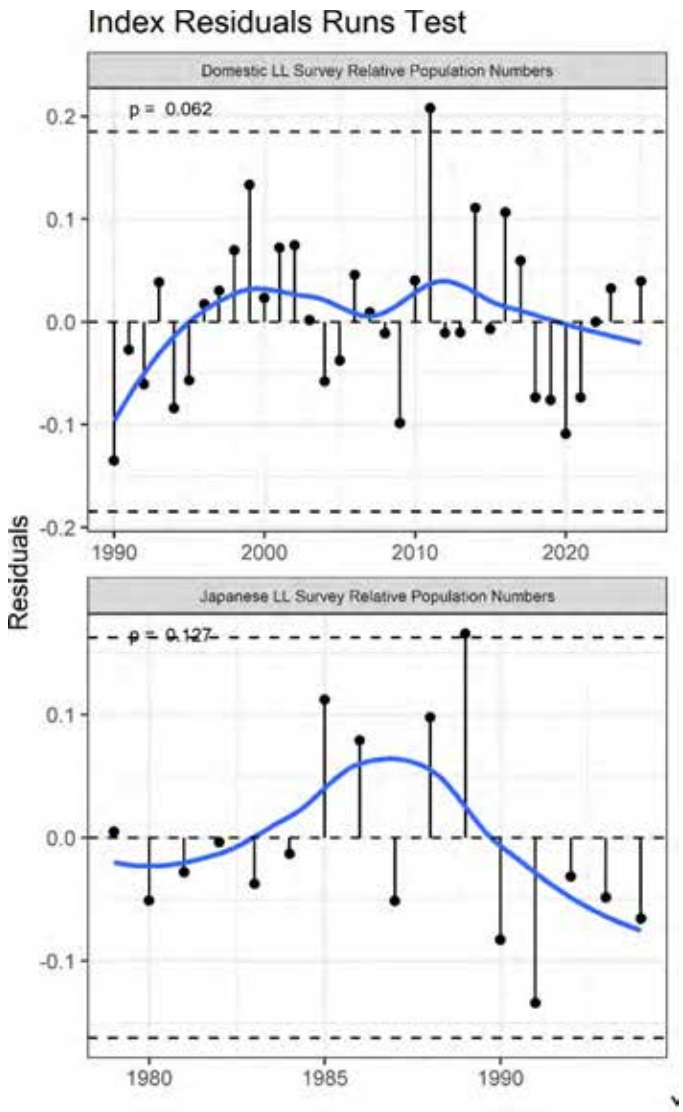

Figure SM3B.14. Results of an index residuals runs test for Model *26.1_1Reg*.

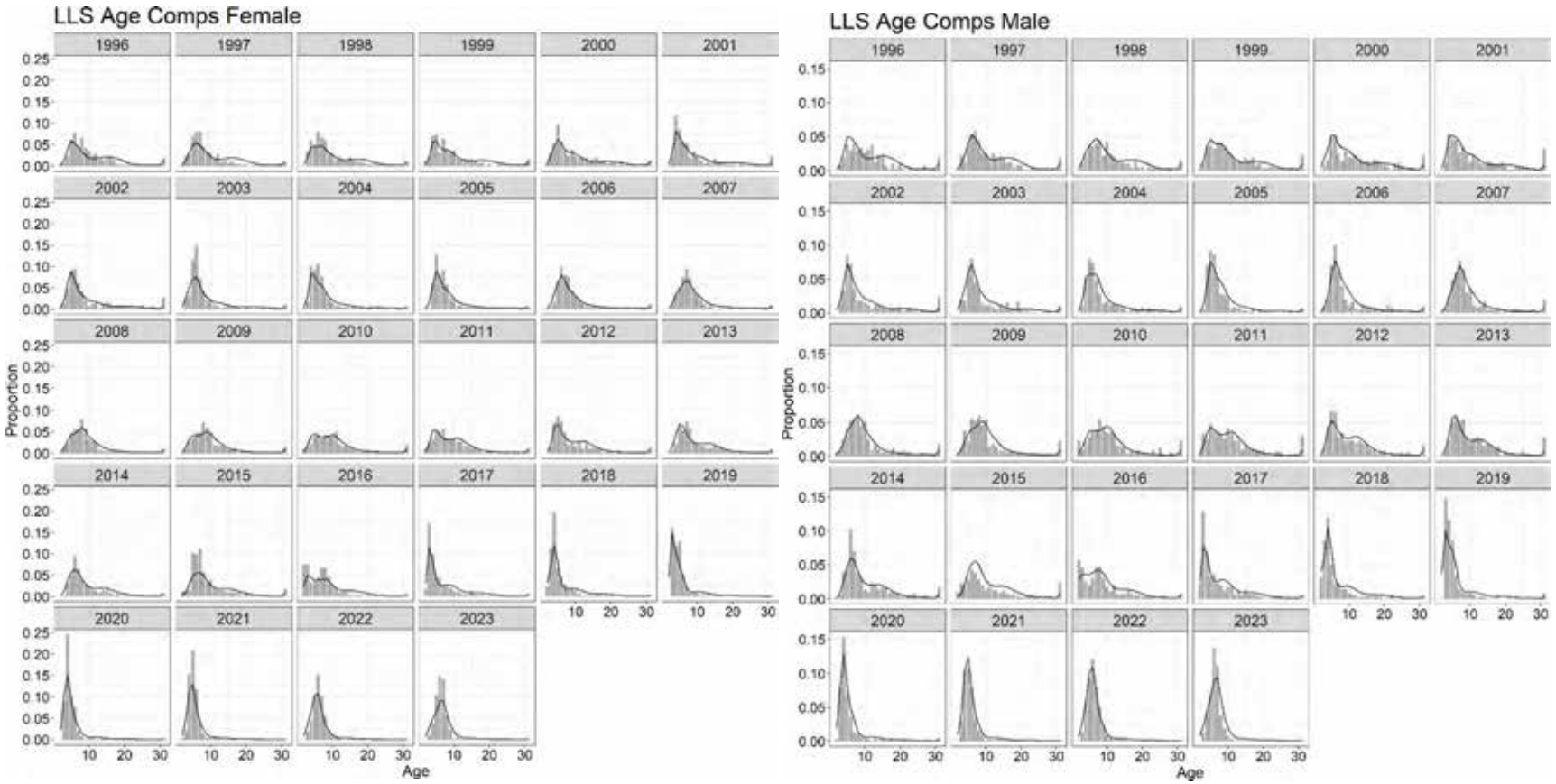

Figure SM3B.15. Fits to NOAA longline survey age composition data by year and sex (females left and males right) for model *25.12_1Reg_Cont.*

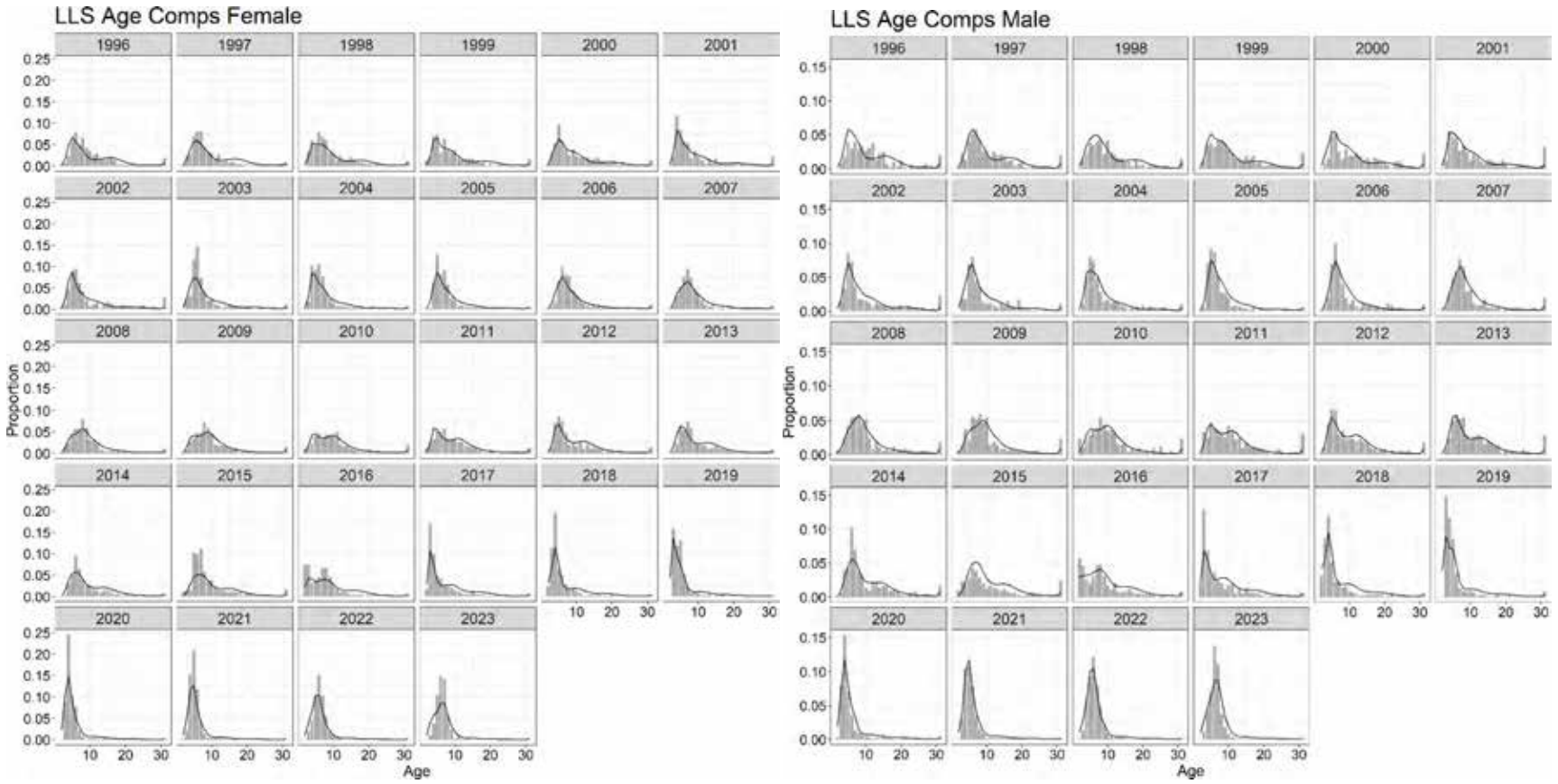

Figure SM3B.16. Fits to NOAA longline survey age composition data by year and sex (females left and males right) for model *26.16_1Reg*.

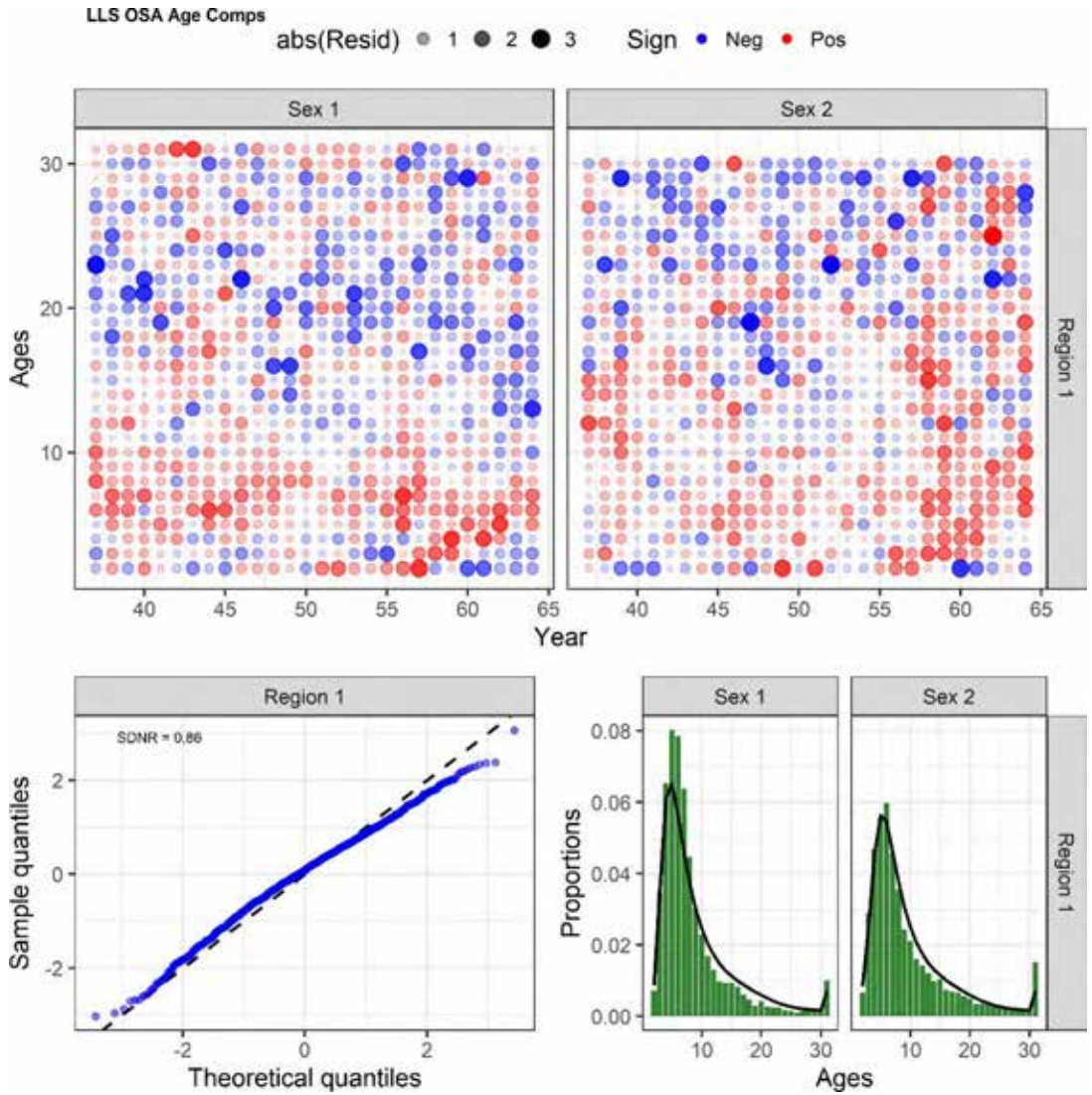

Figure SM3B.17. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

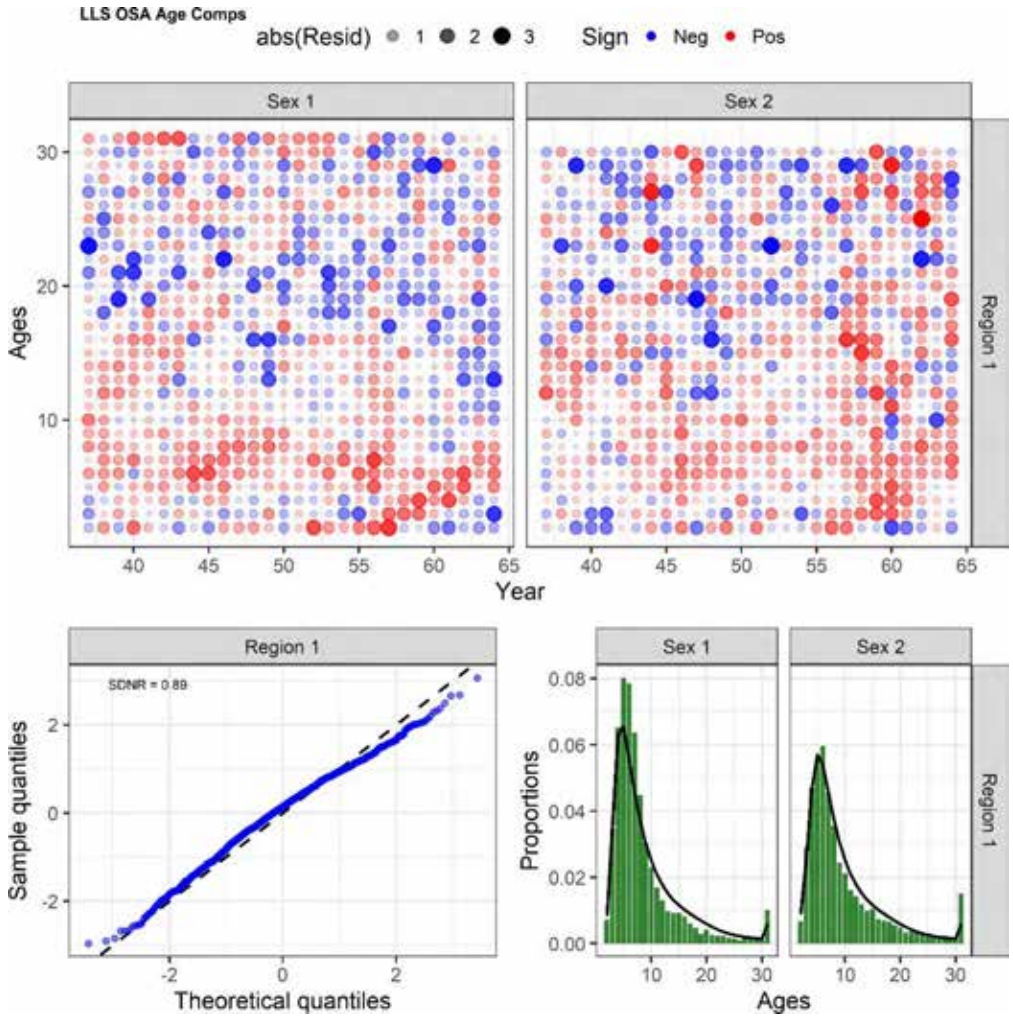

Figure SM3B.18. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*

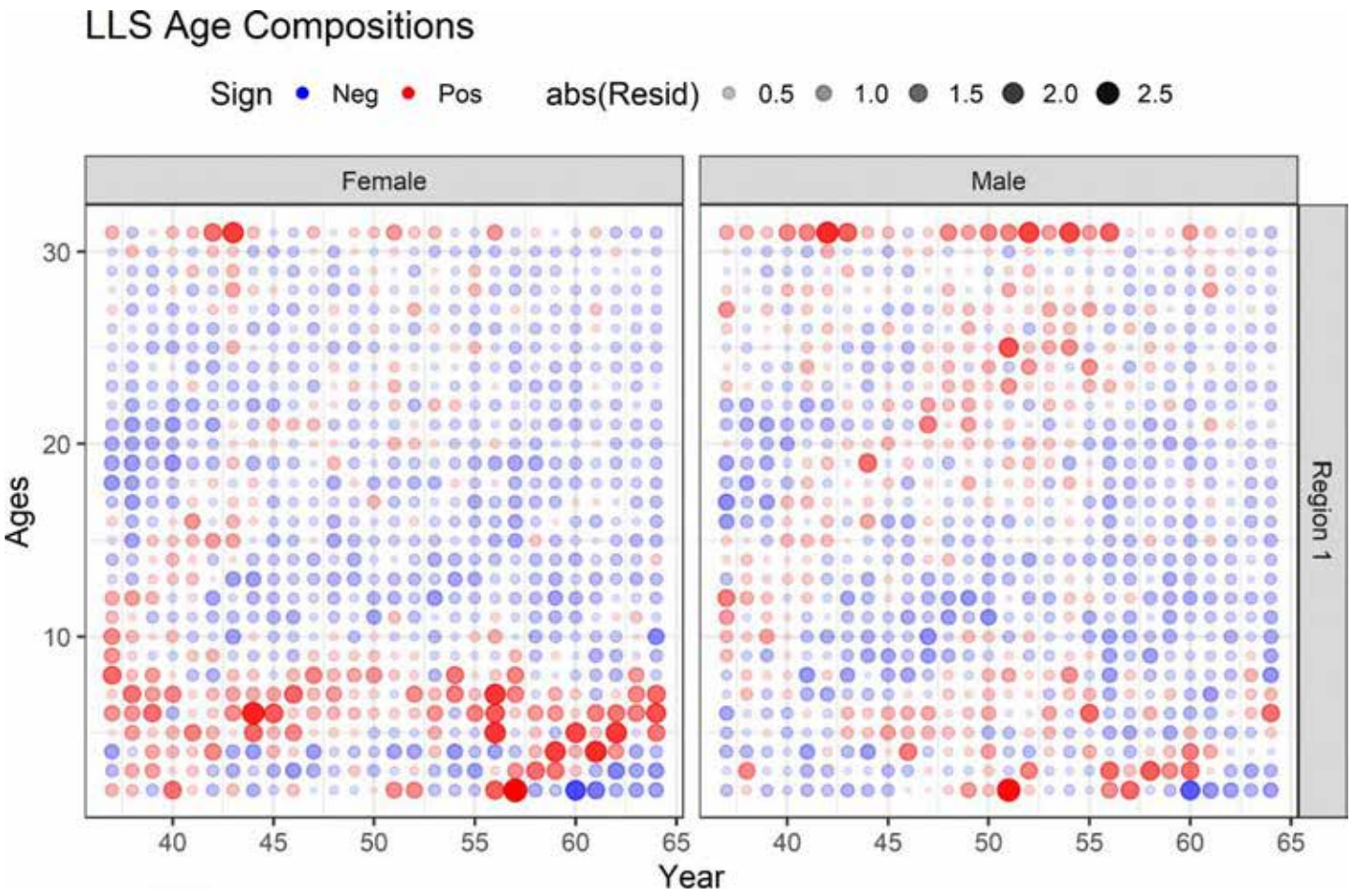

Figure SM3B.19. Fits to NOAA longline survey age composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

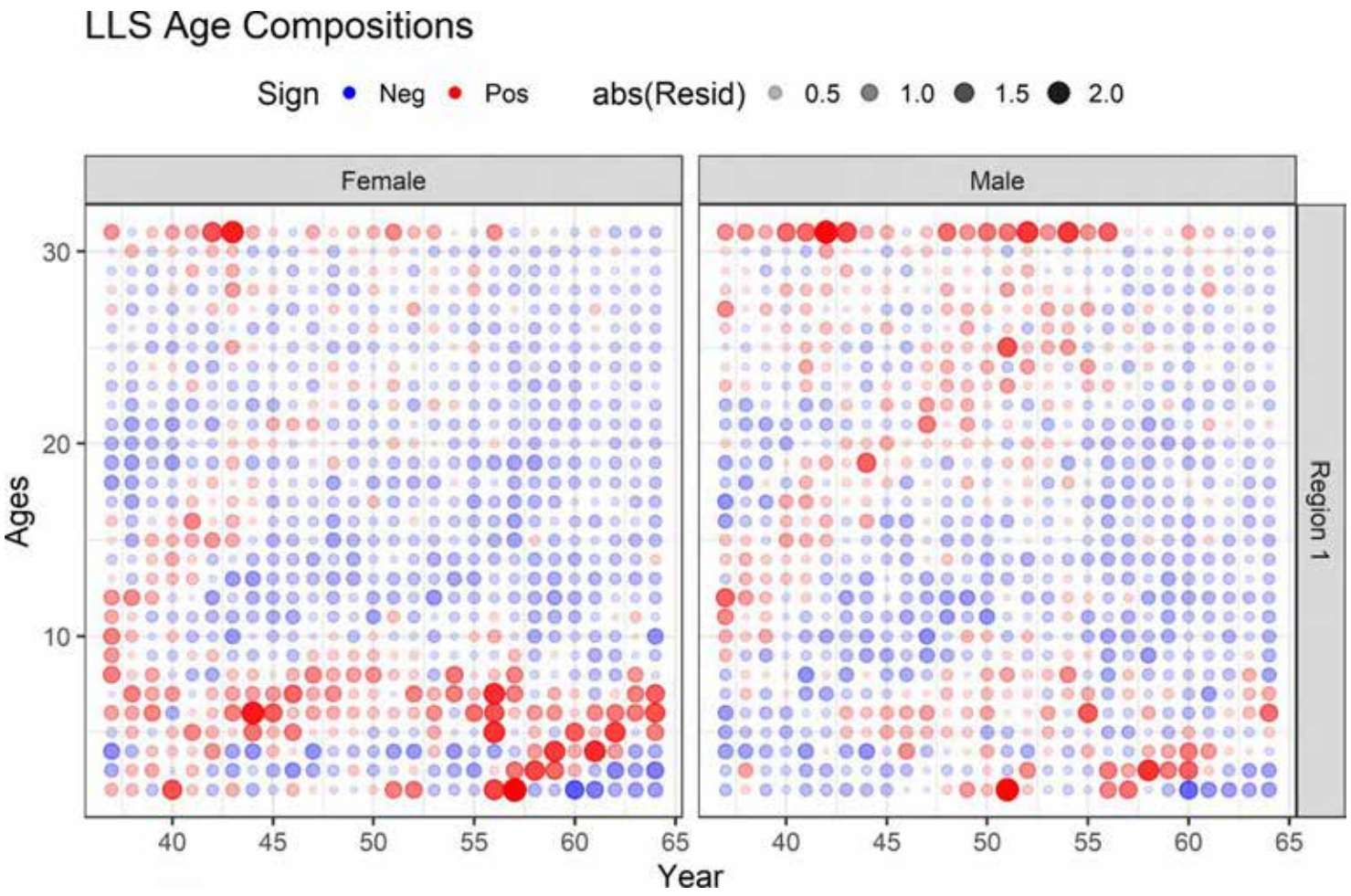

Figure SM3B.20. Fits to NOAA longline survey age composition data based on Pearson residuals for model *26.1_1Reg*.

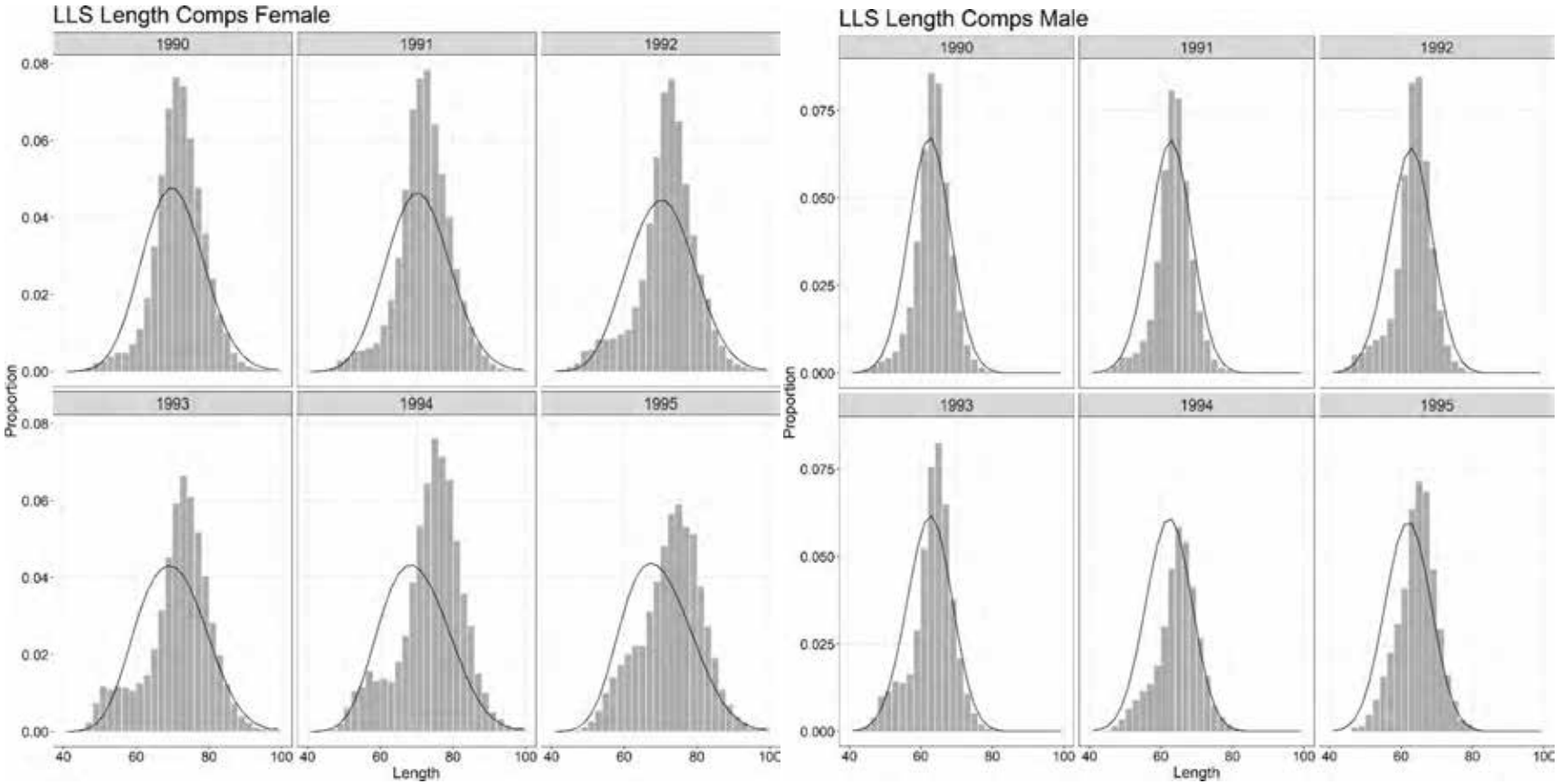

Figure SM3B.21. Fits to NOAA longline survey length composition data by year and sex (females left and males right) for Model *25.12_1Reg_Cont*.

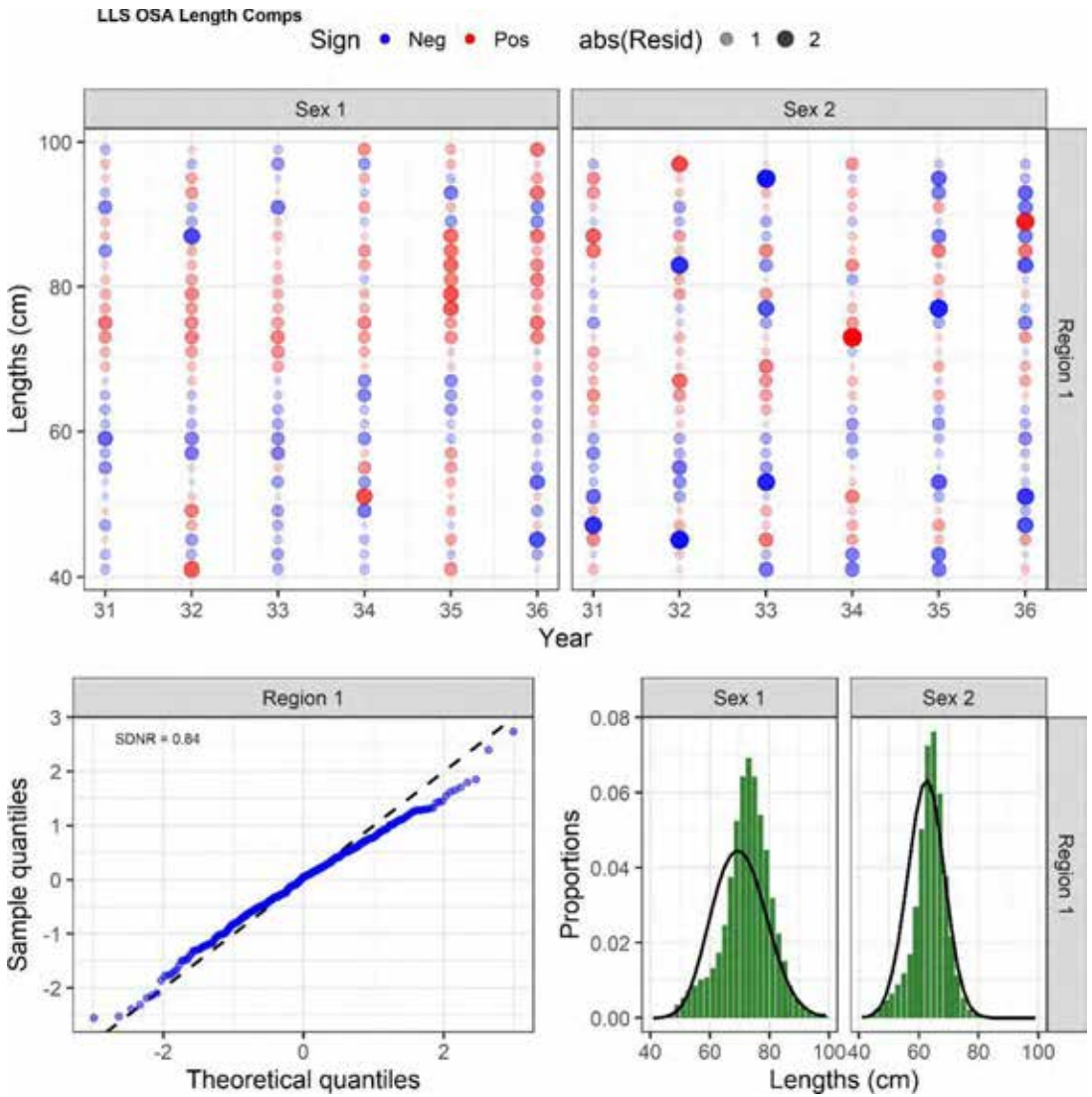

Figure SM3B.22. Fits to NOAA longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

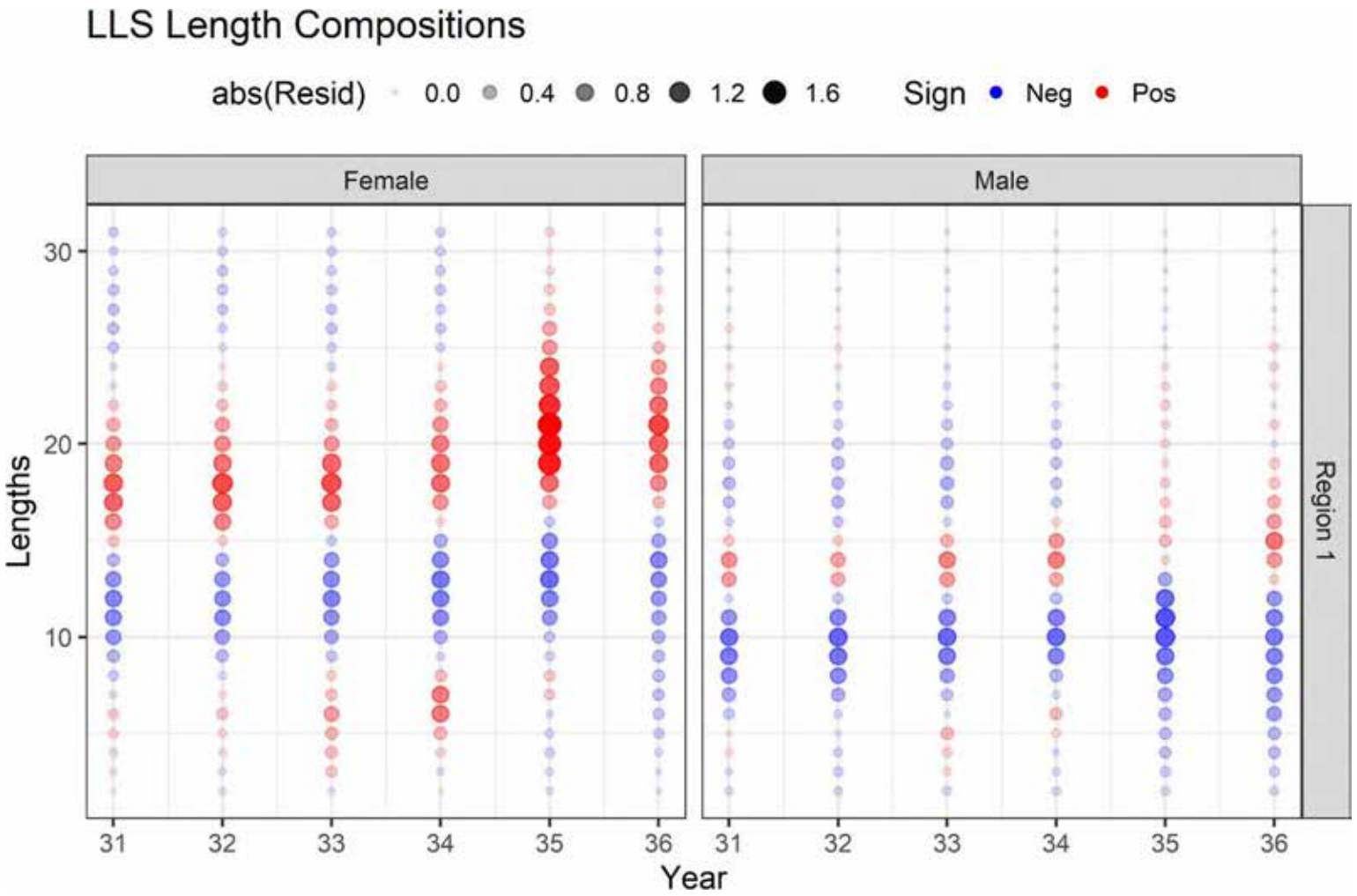

Figure SM3B.23. Fits to NOAA longline survey length composition data based on Pearson residuals for Model *25.12_1Reg_Cont*.

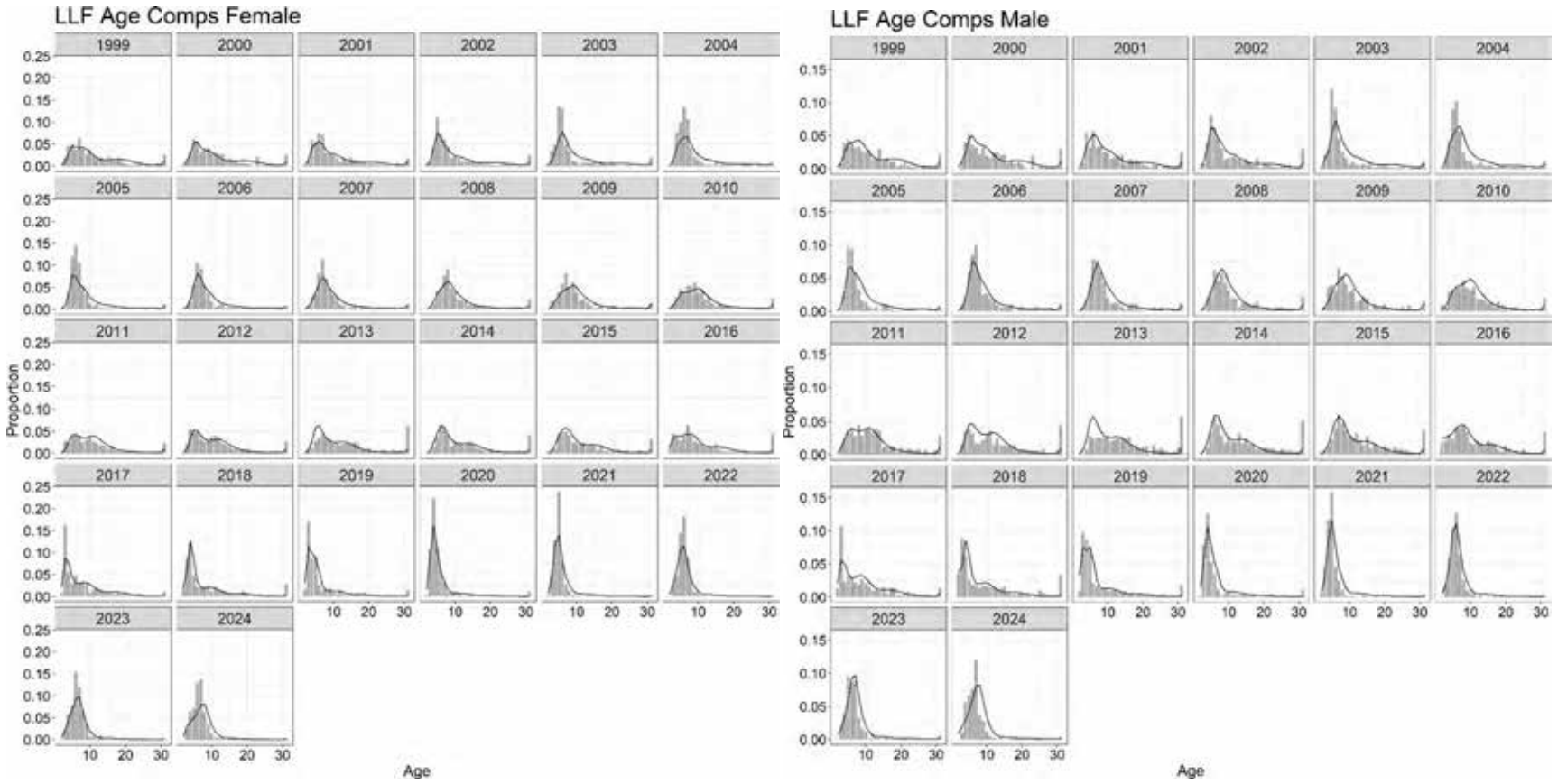

Figure SM3B.24. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for model *25.12_1Reg_Cont.*

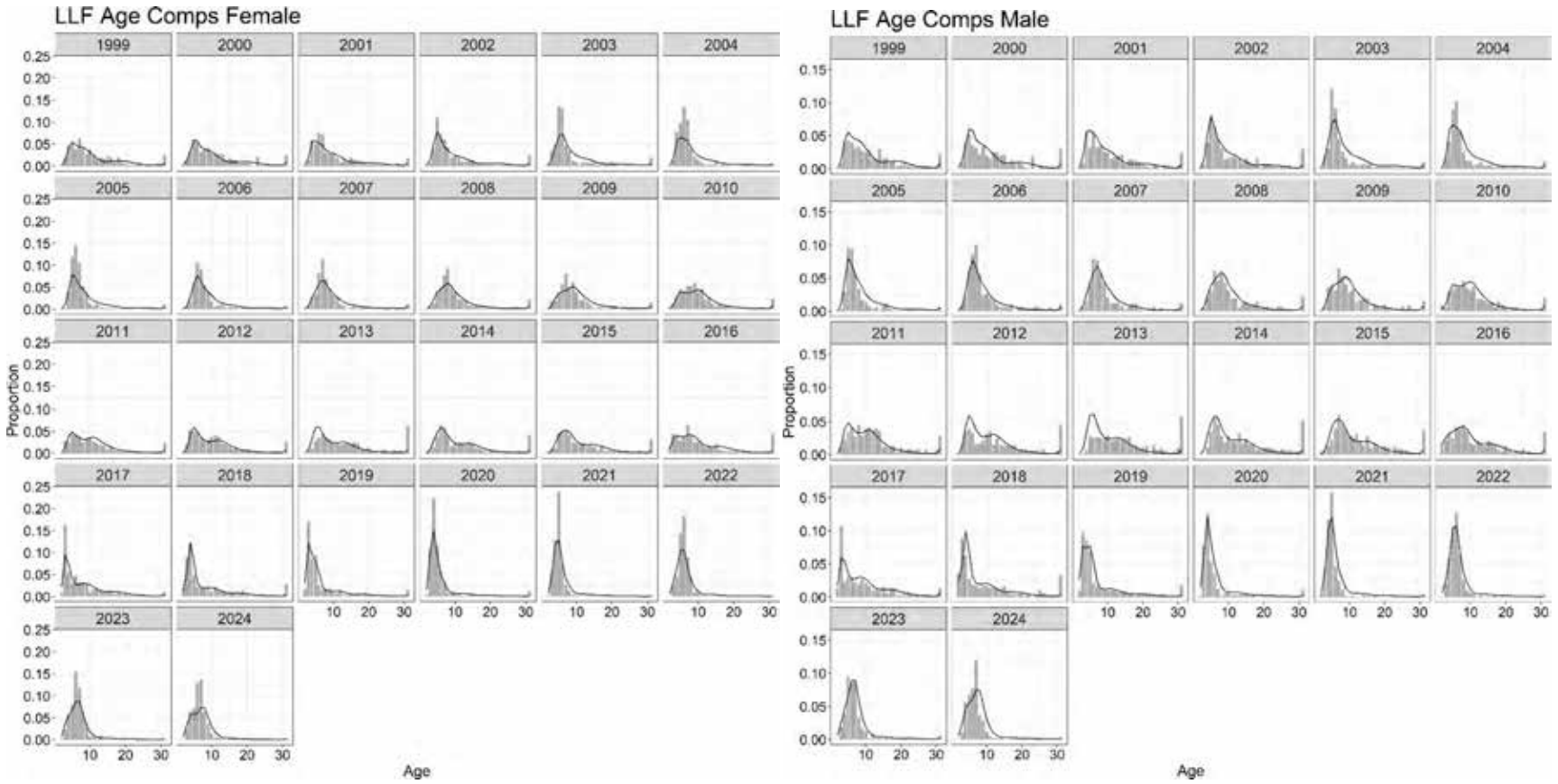

Figure SM3B.25. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for model *26.1_1Reg*.

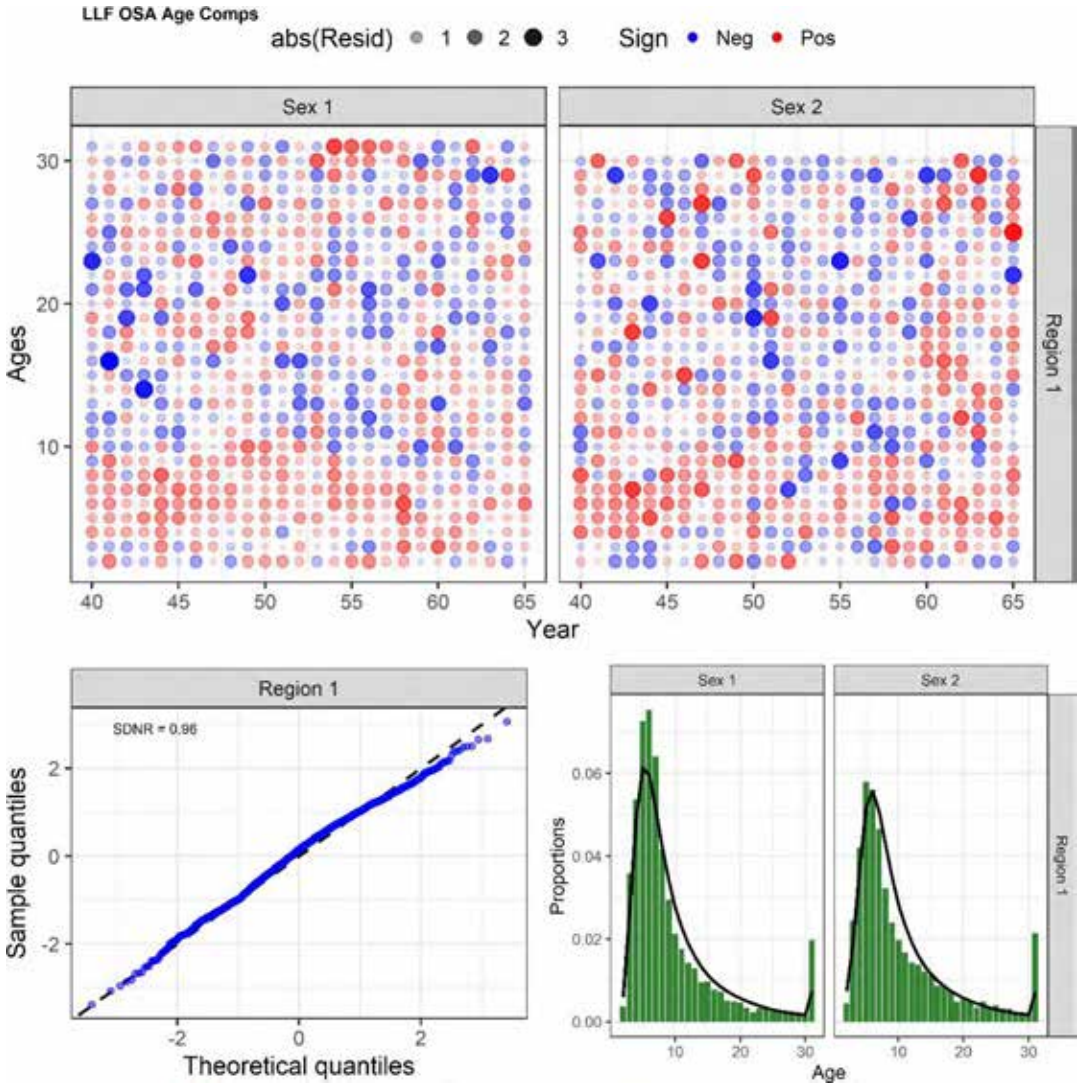

Figure SM3B.26. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

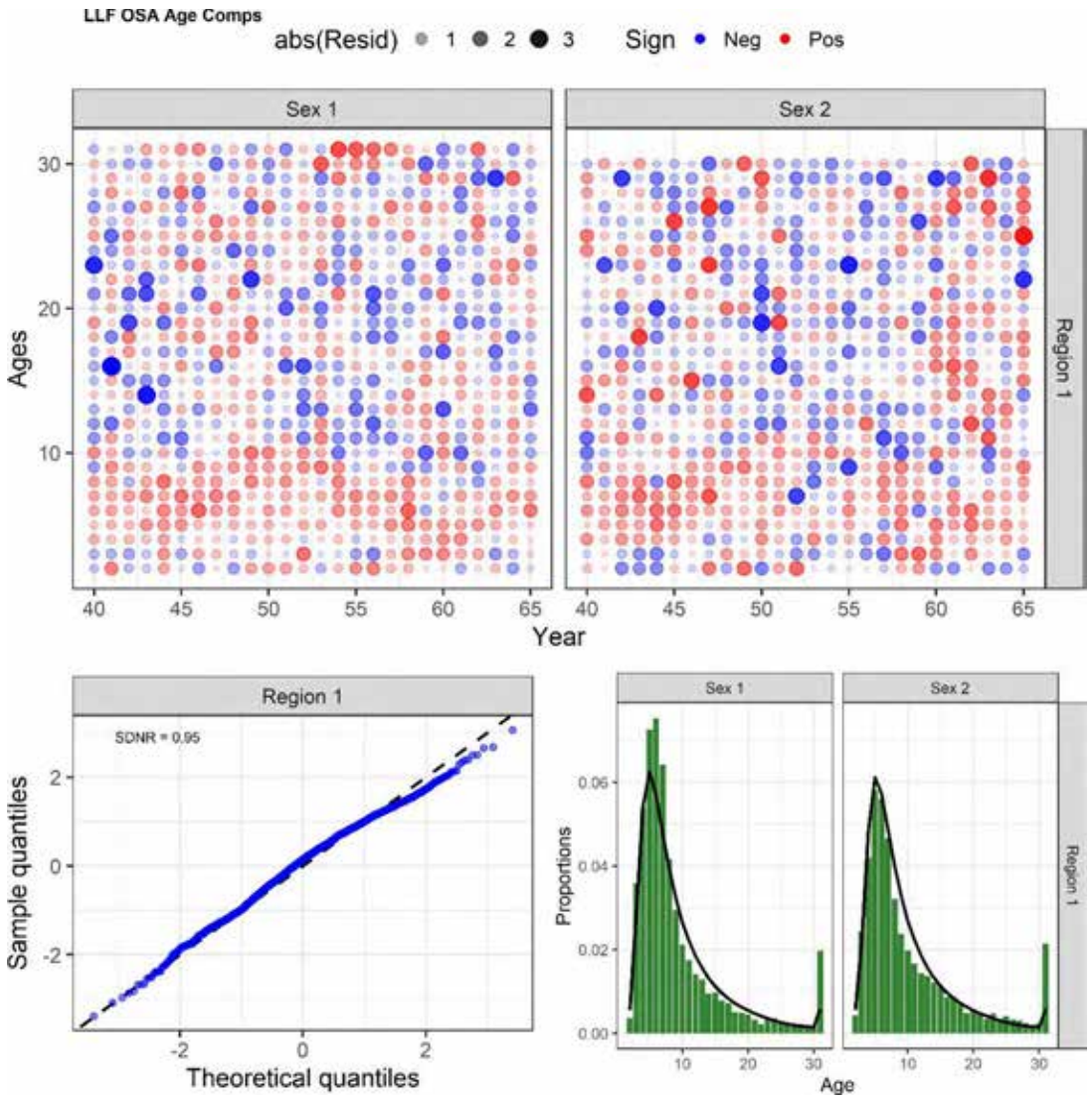

Figure SM3B.27. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

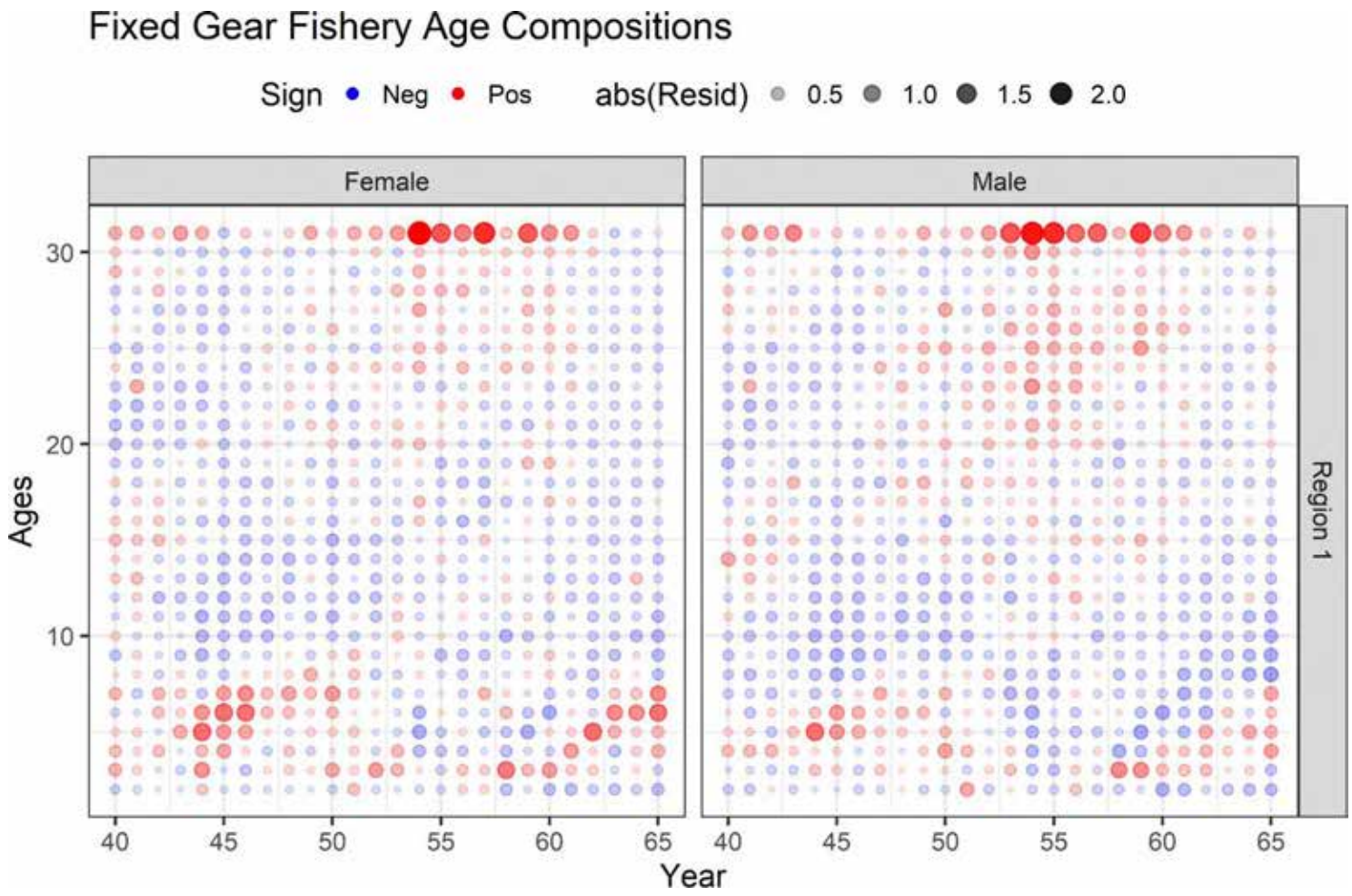

Figure SM3B.28. Fits to the fixed gear fishery age composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

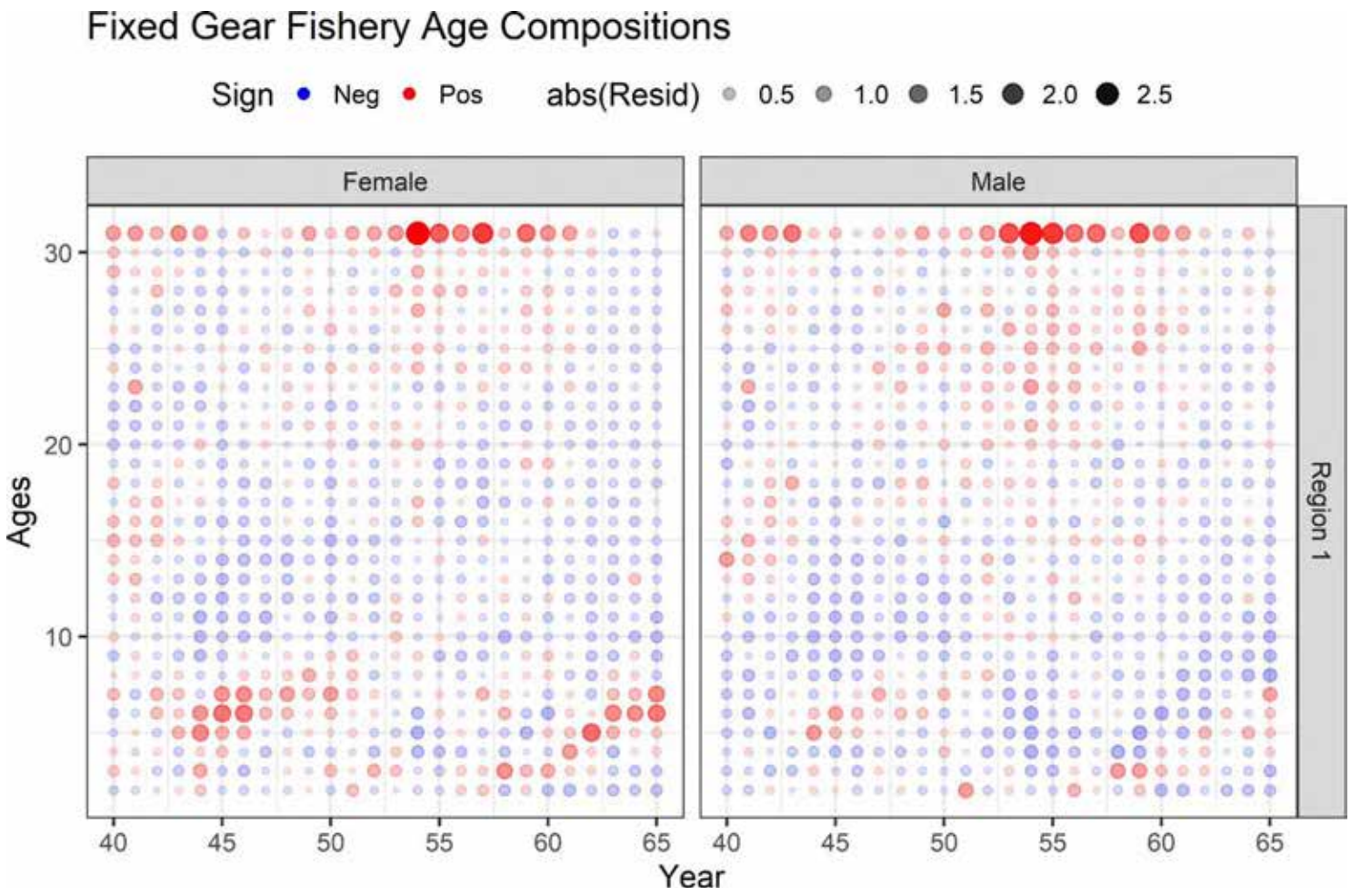

Figure SM3B.29. Fits to the fixed gear fishery age composition data based on Pearson residuals for model *26.1_1Reg*.

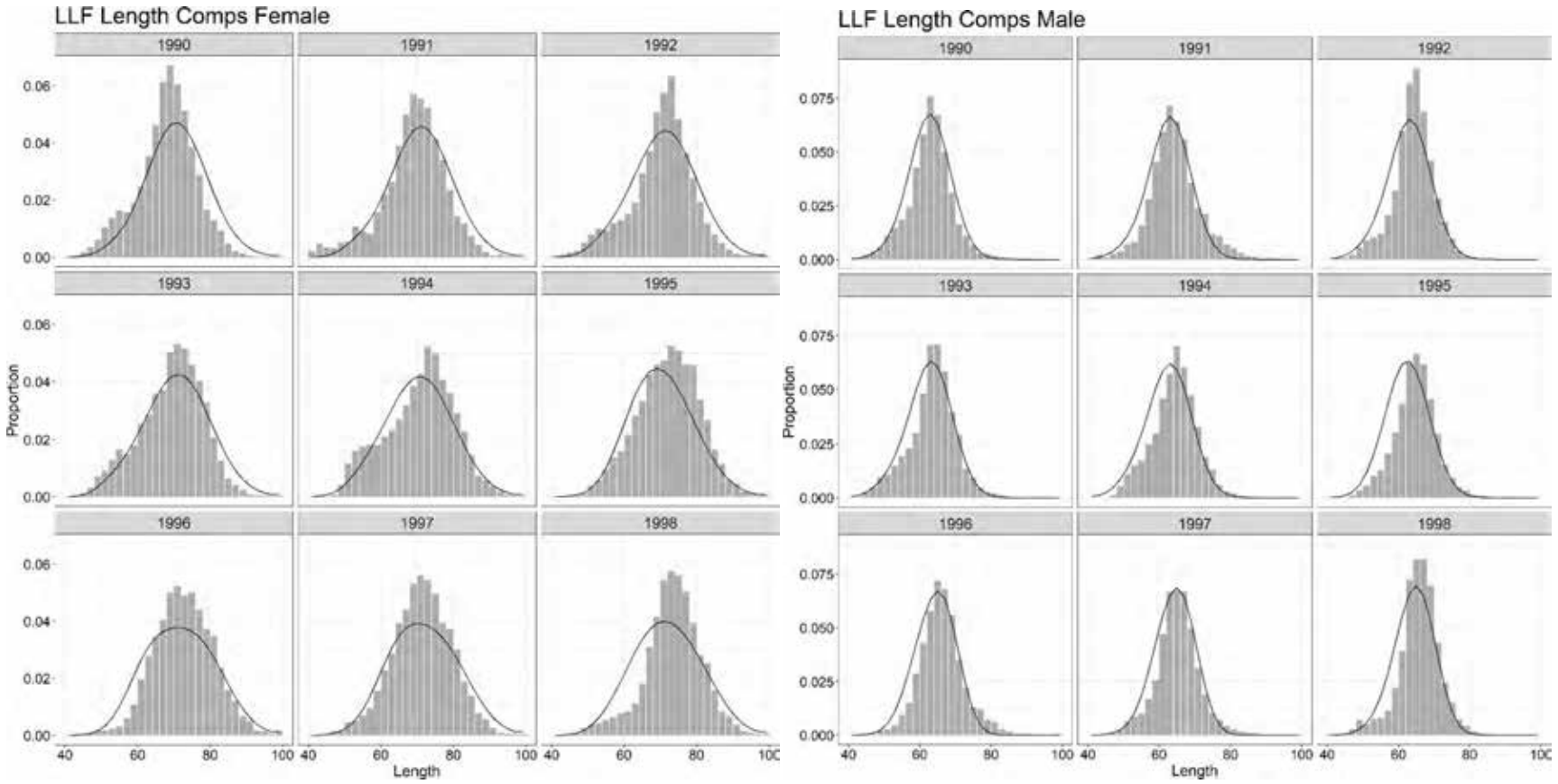

Figure SM3B.30. Fits to fixed gear fishery length composition data by year and sex (females left and males right) for model *25.12_1Reg_Cont*.

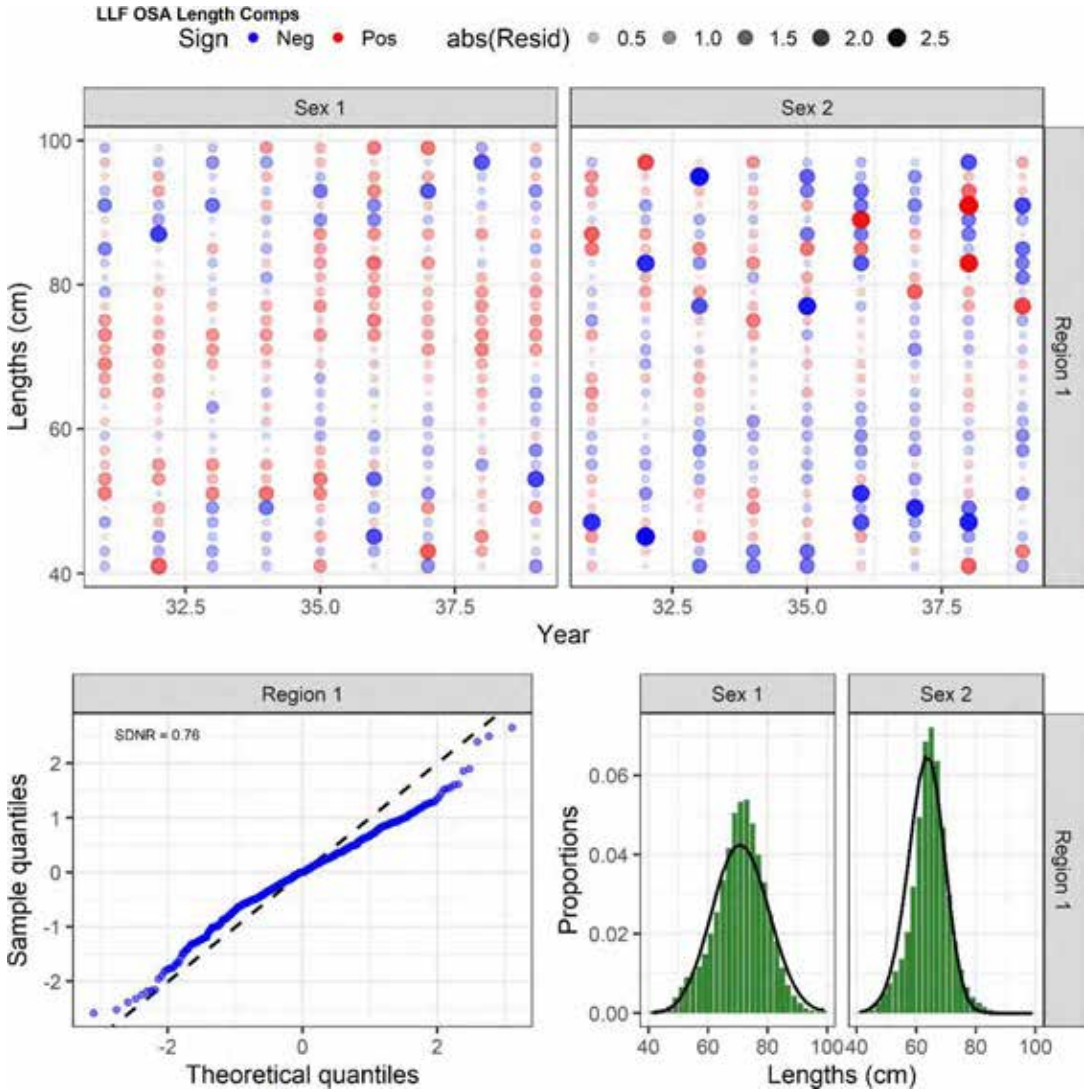

Figure SM3B.31. Fits to fixed gear fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

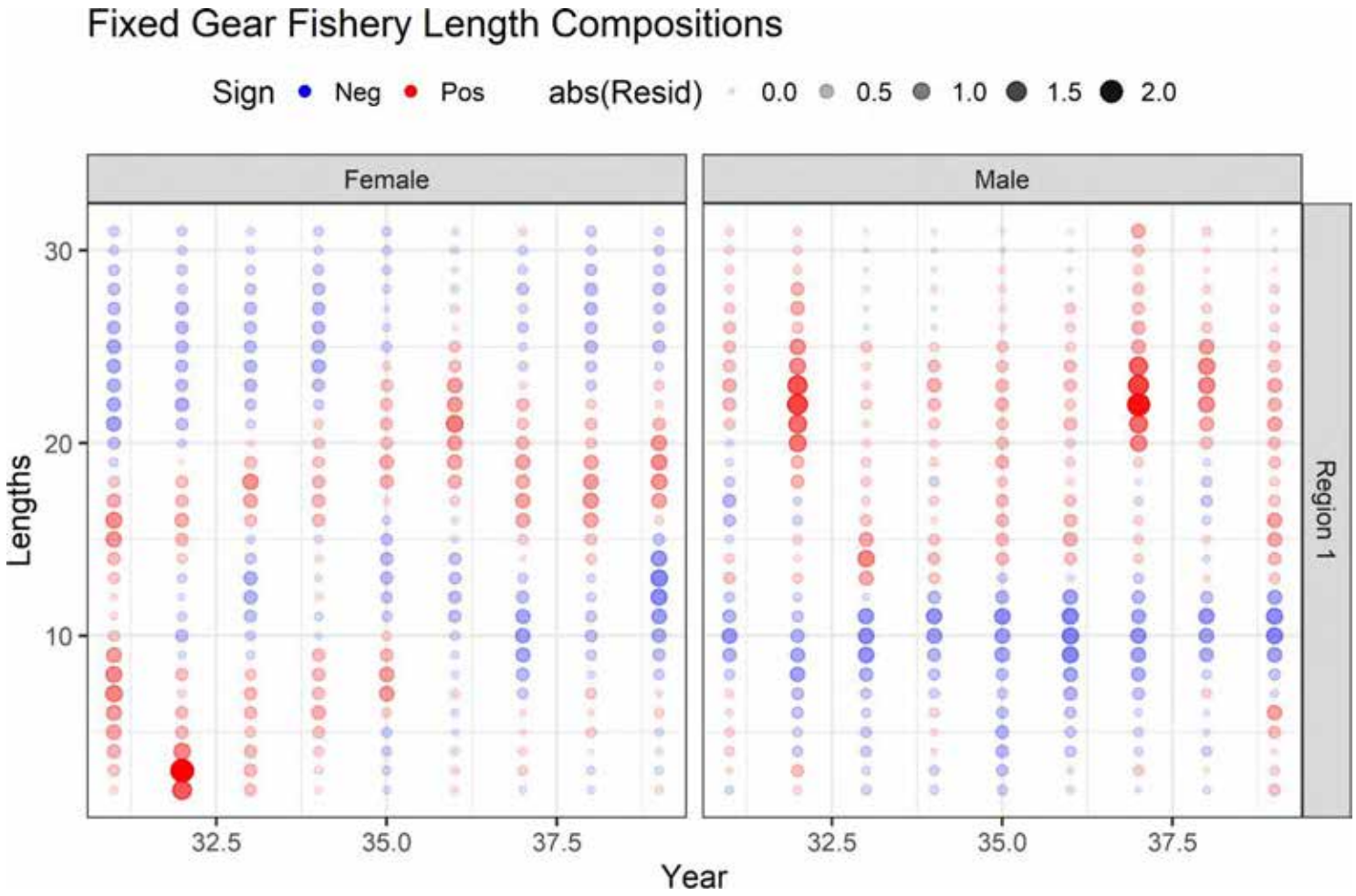

Figure SM3B.32. Fits to the fixed gear fishery length composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

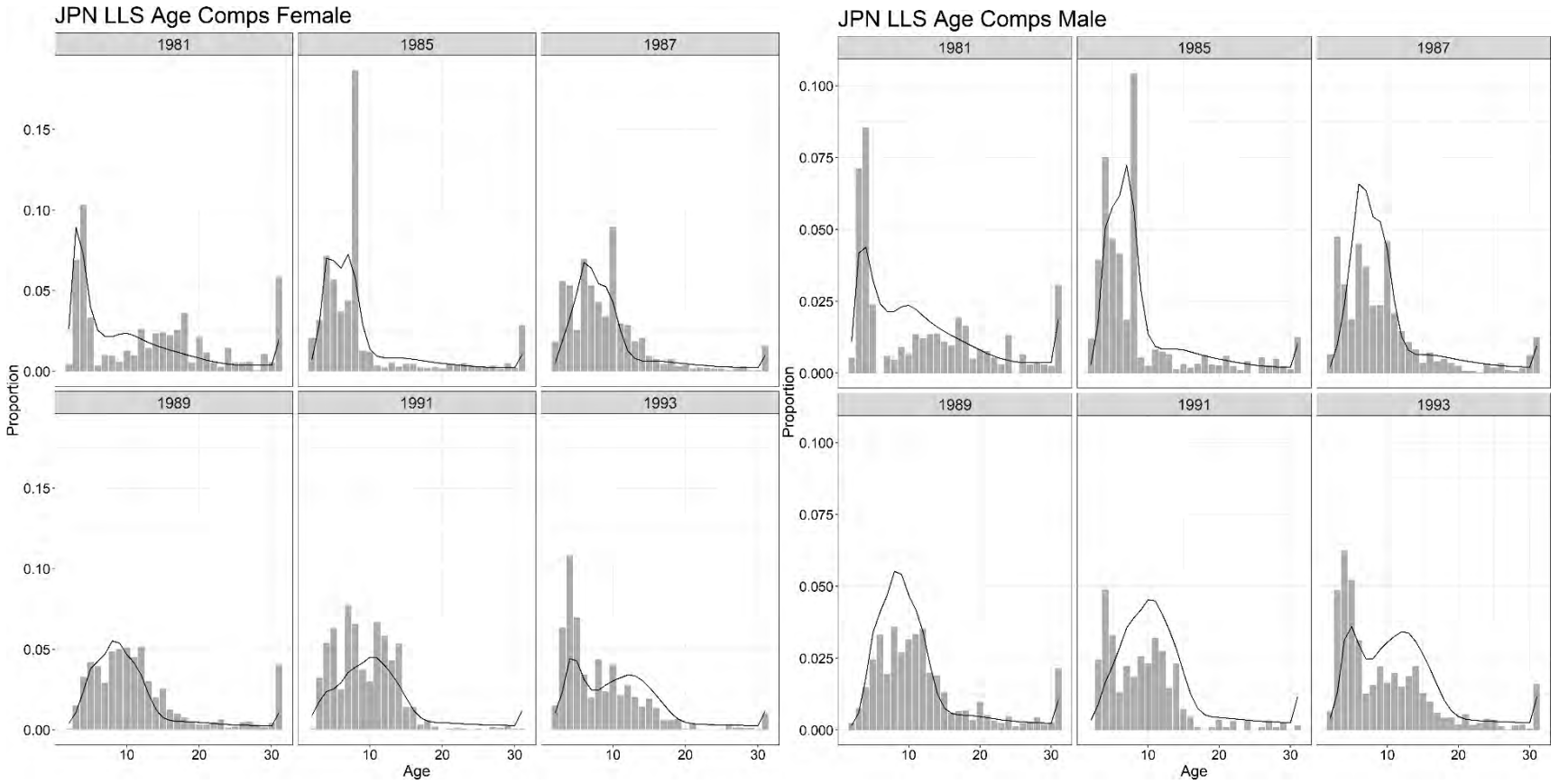

Figure SM3B.33. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *25.12_1Reg_Cont.*

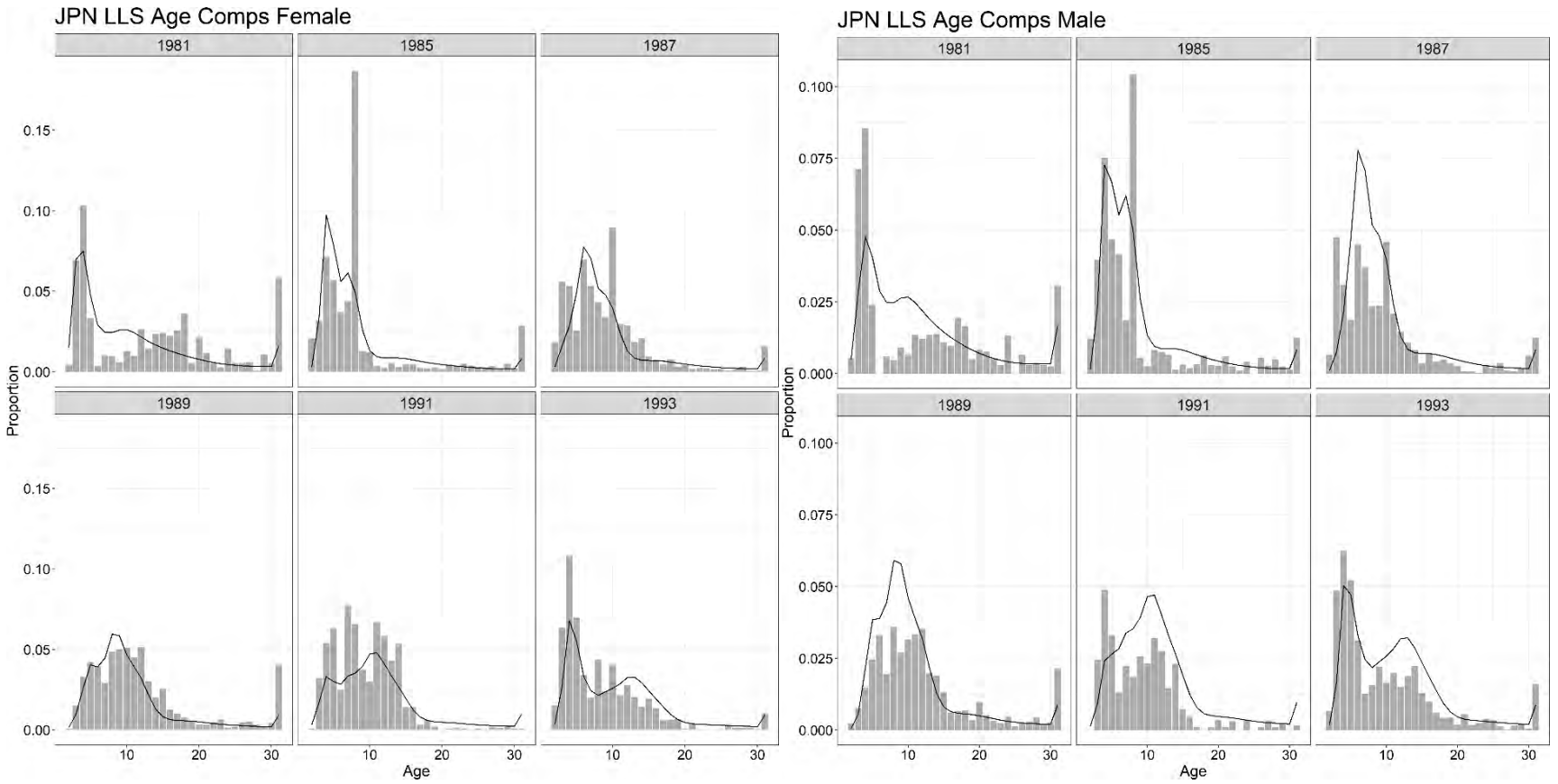

Figure SM3B.34. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *26.1_1Reg*.

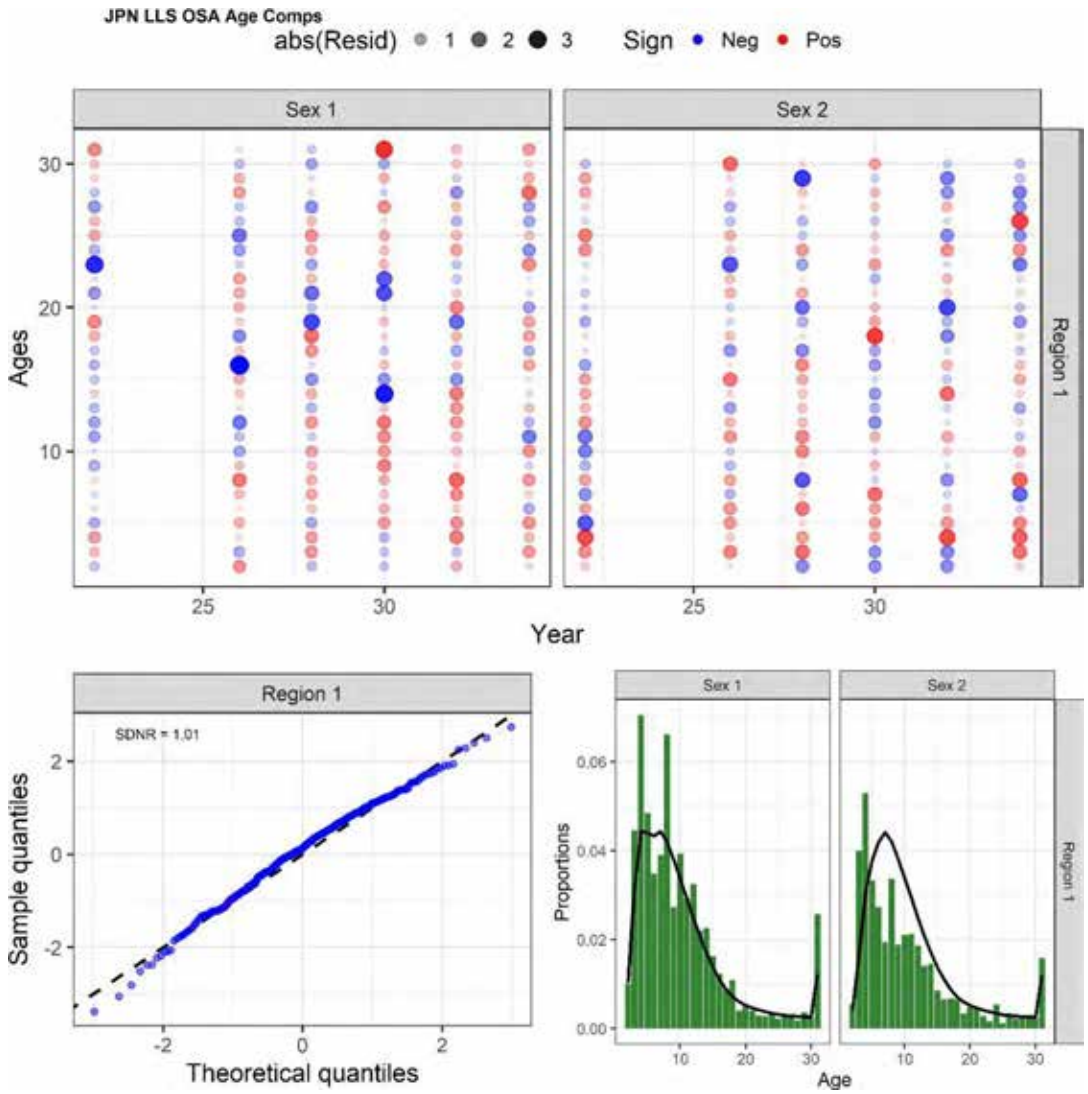

Figure SM3B.35. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

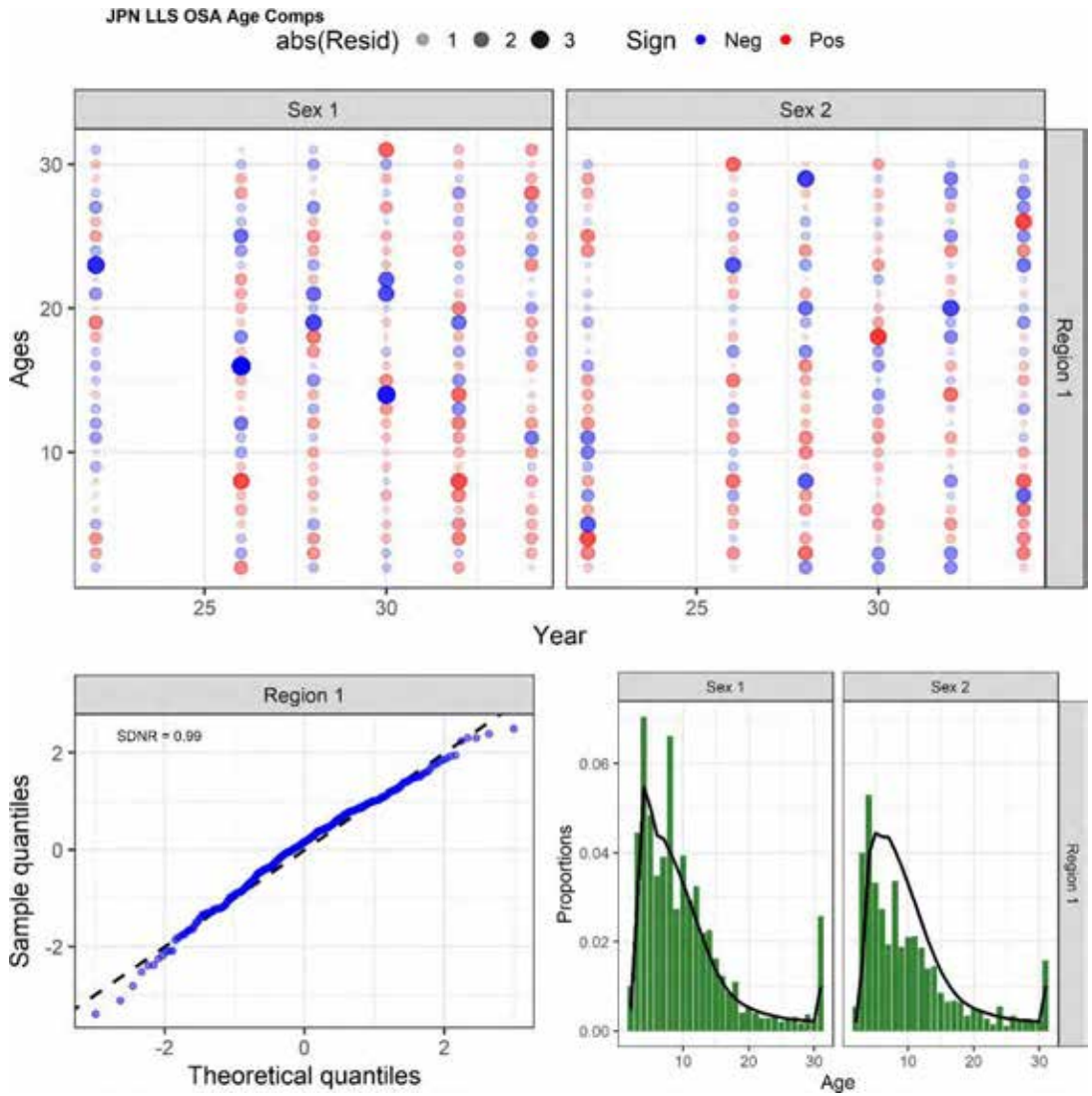

Figure SM3B.36. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

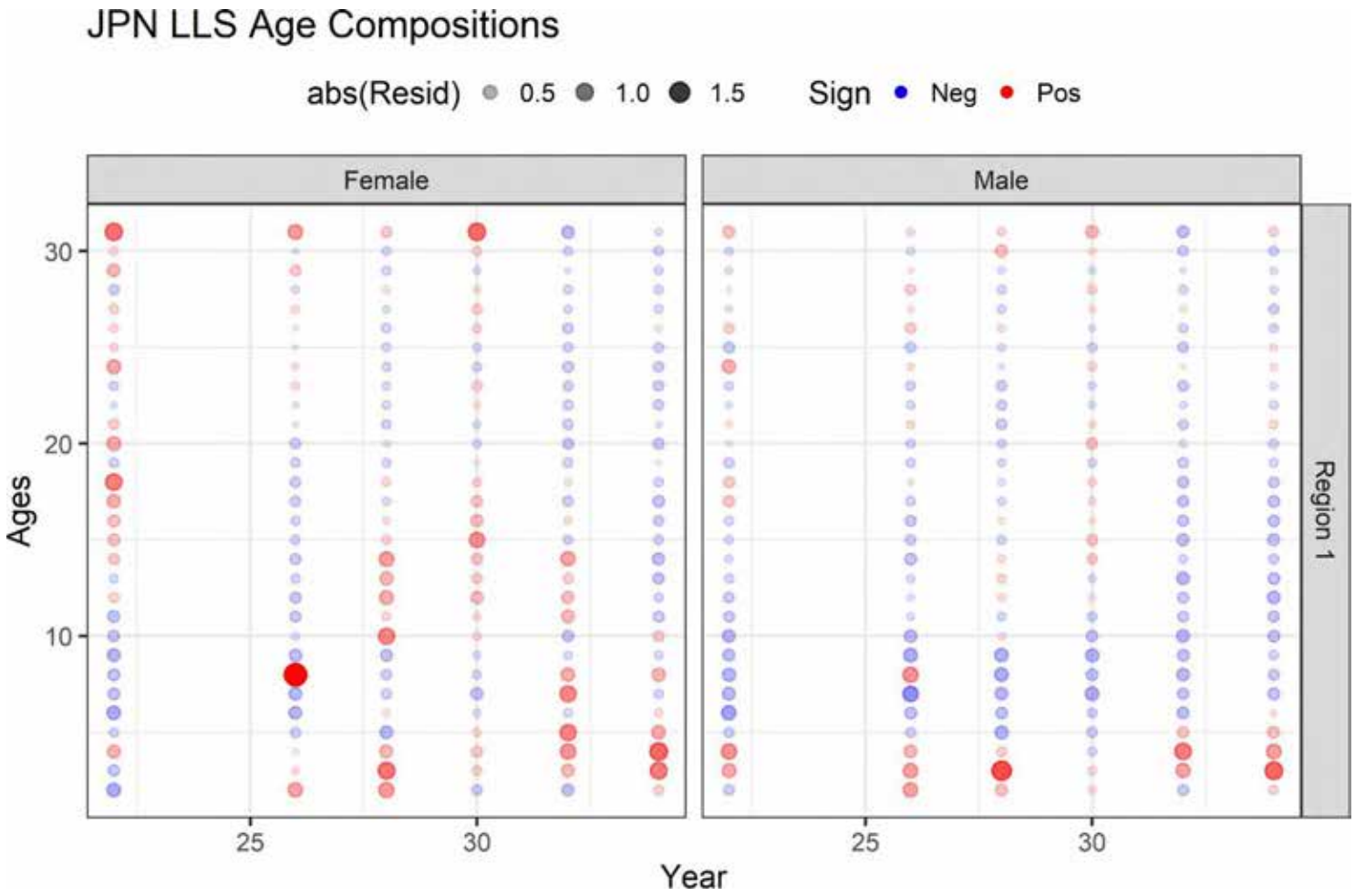

Figure SM3B.37. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

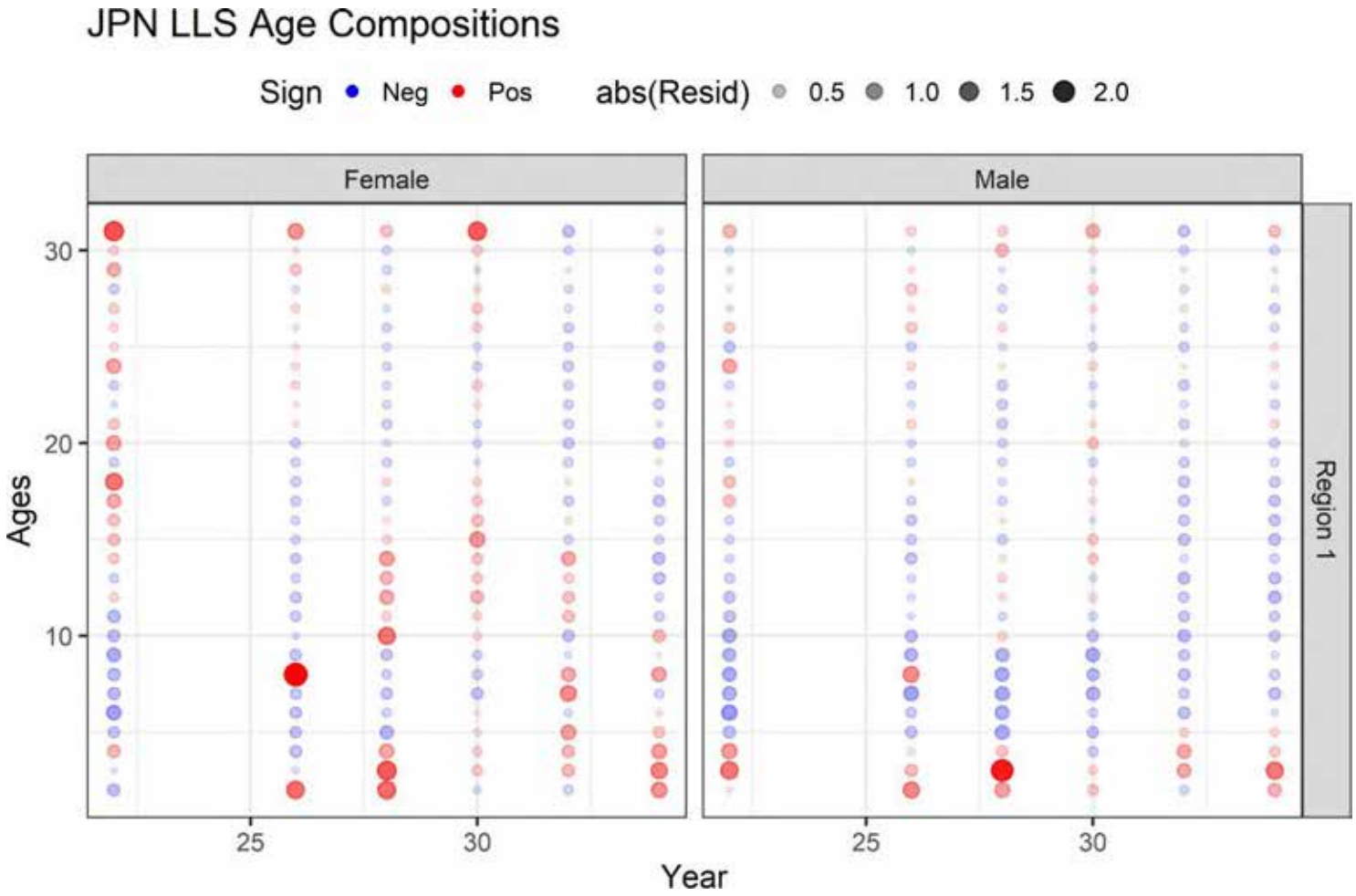

Figure SM3B.38. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for model *26.1_1Reg*.

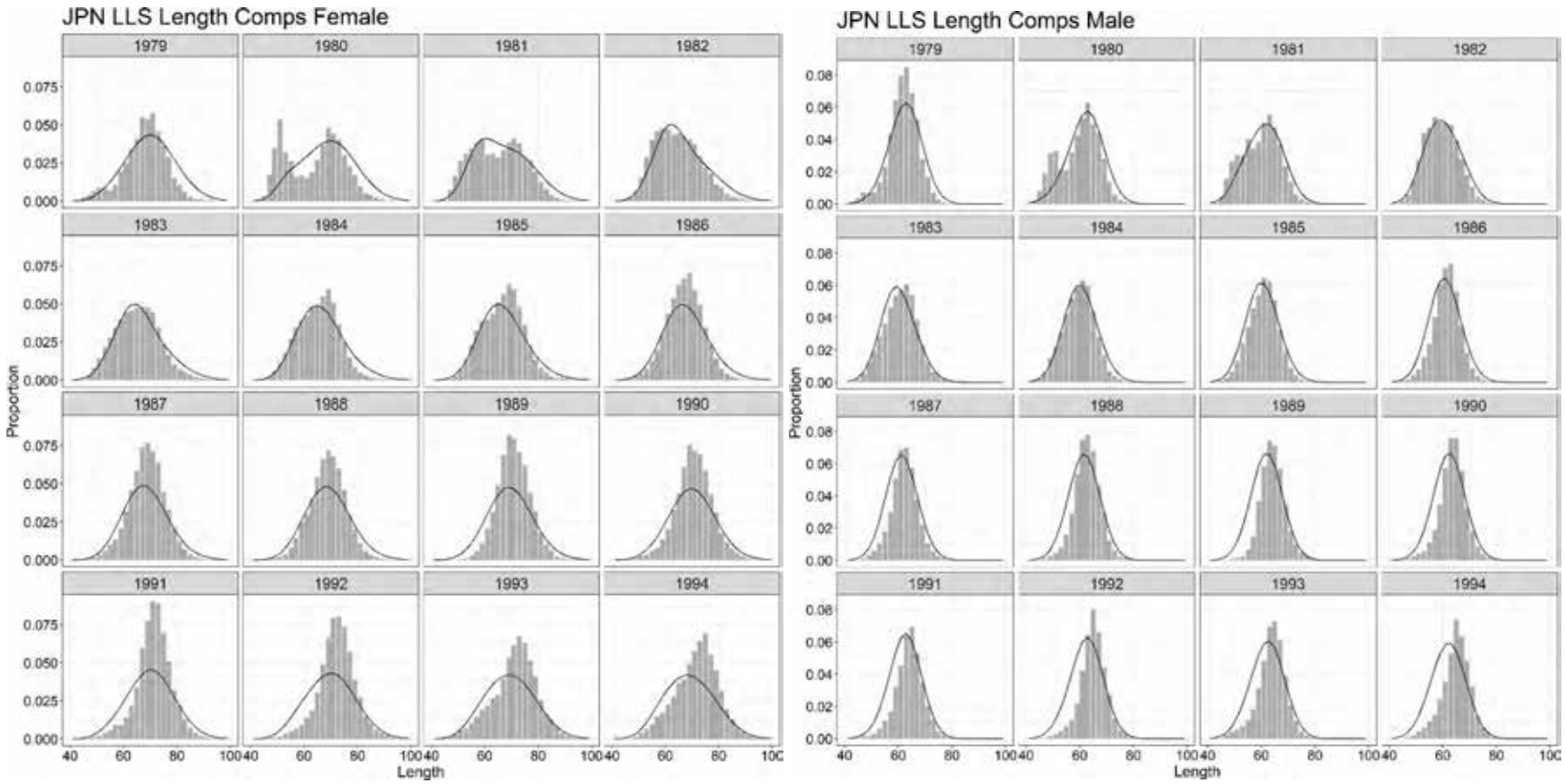

Figure SM3B.39. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *25.12_1Reg_Cont*.

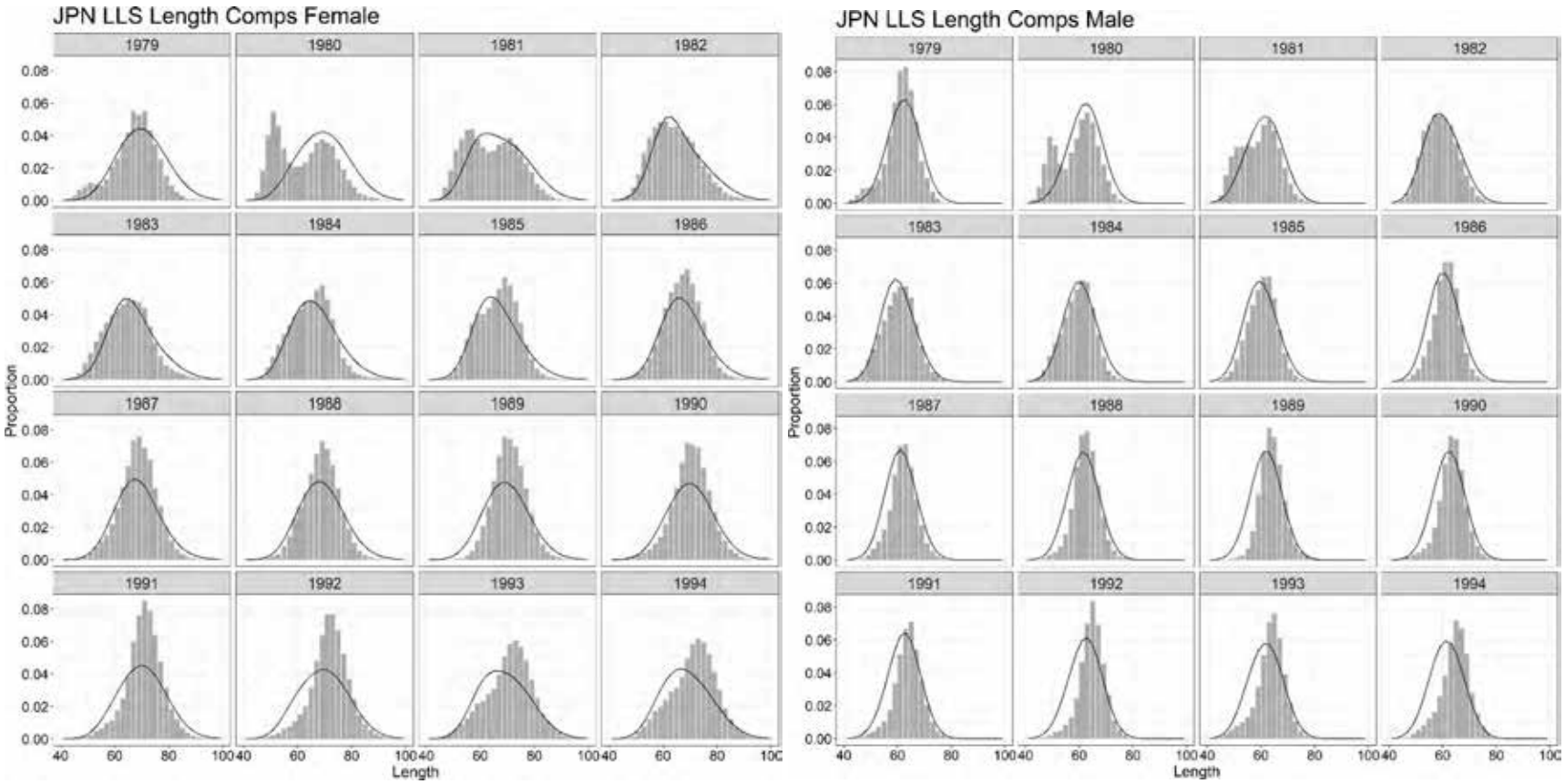

Figure SM3B.40. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

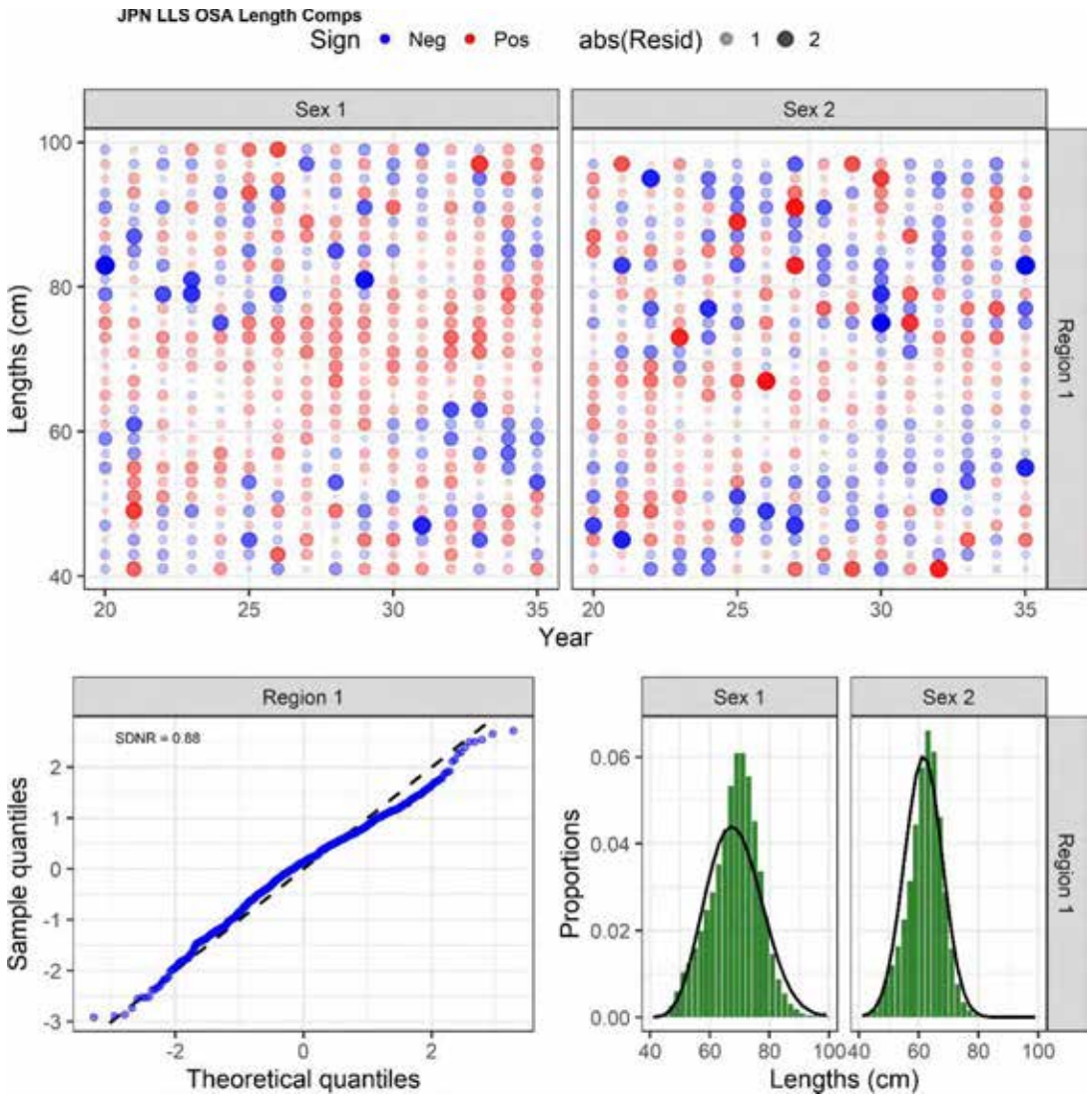

Figure SM3B.41. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

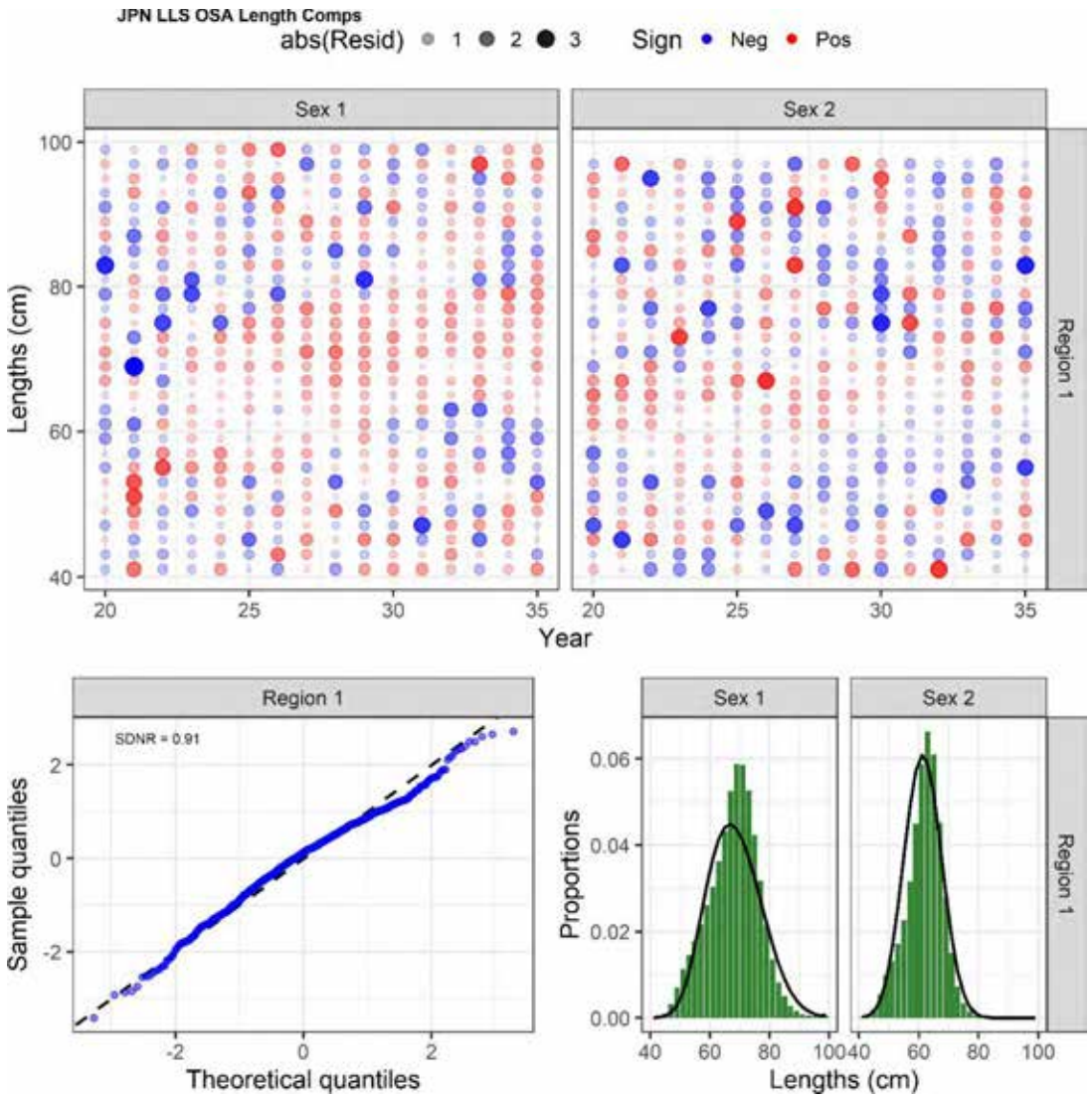

Figure SM3B.42. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

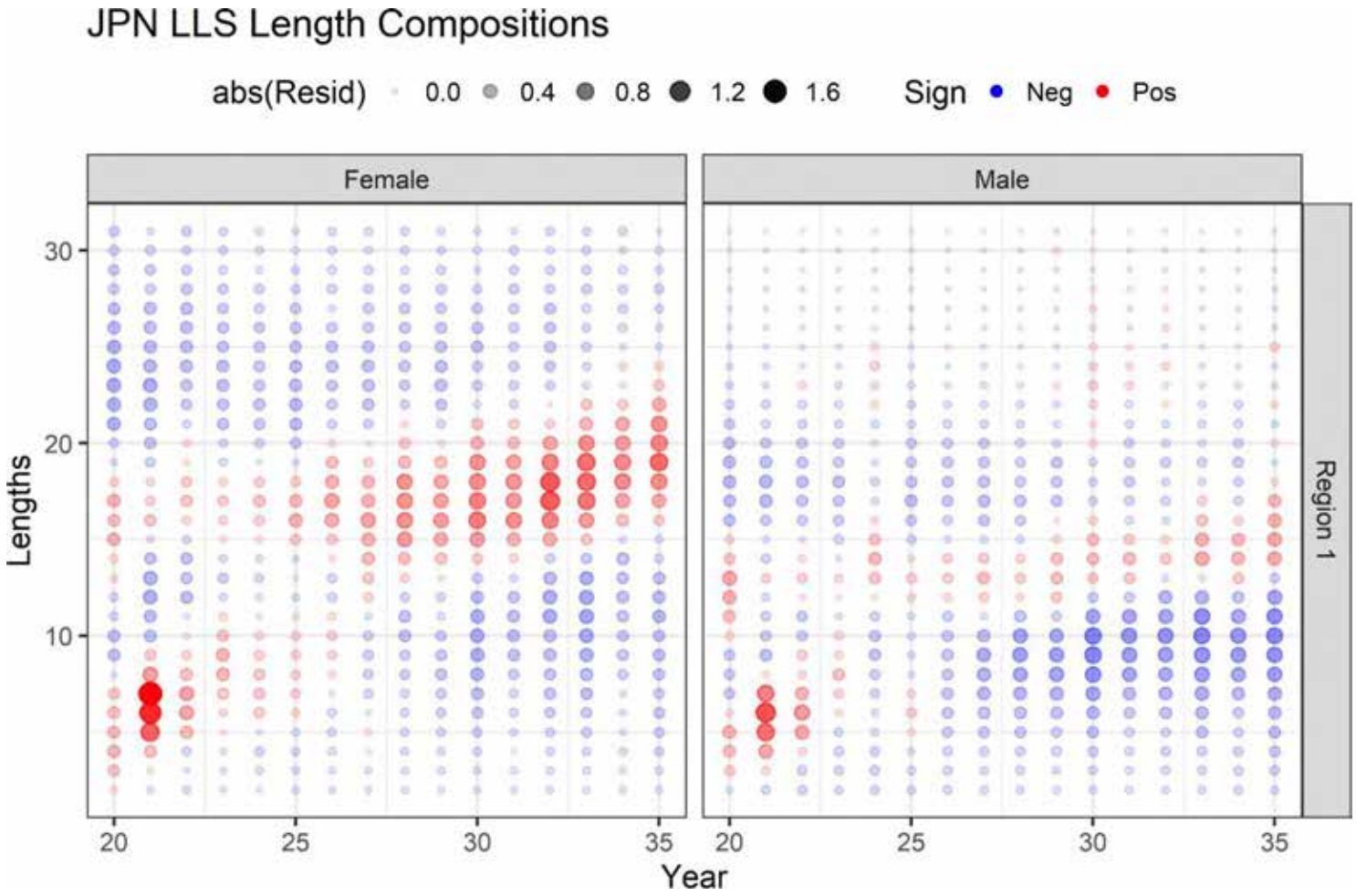

Figure SM3B.43. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

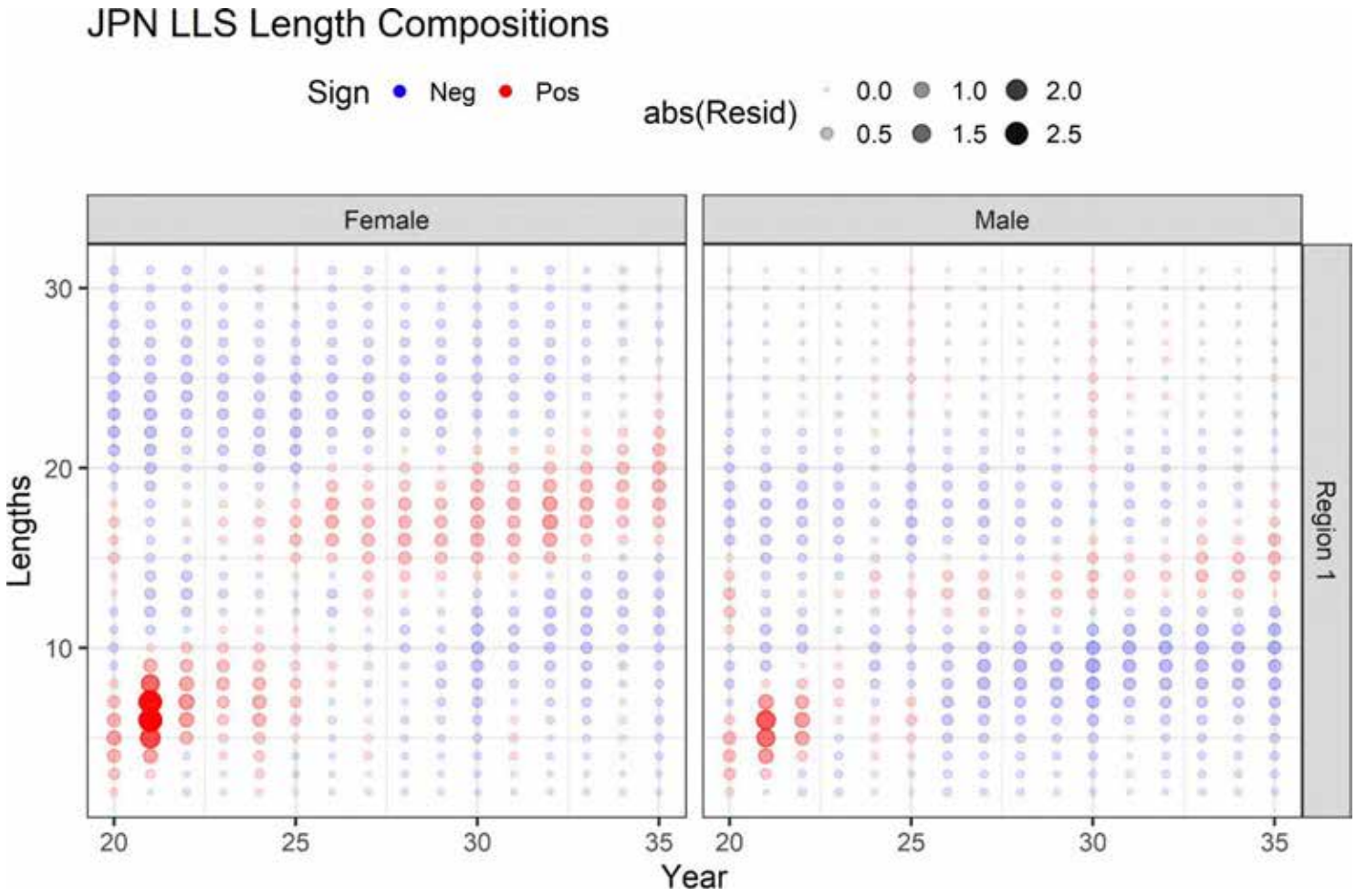

Figure SM3B.44. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.1_1Reg*.

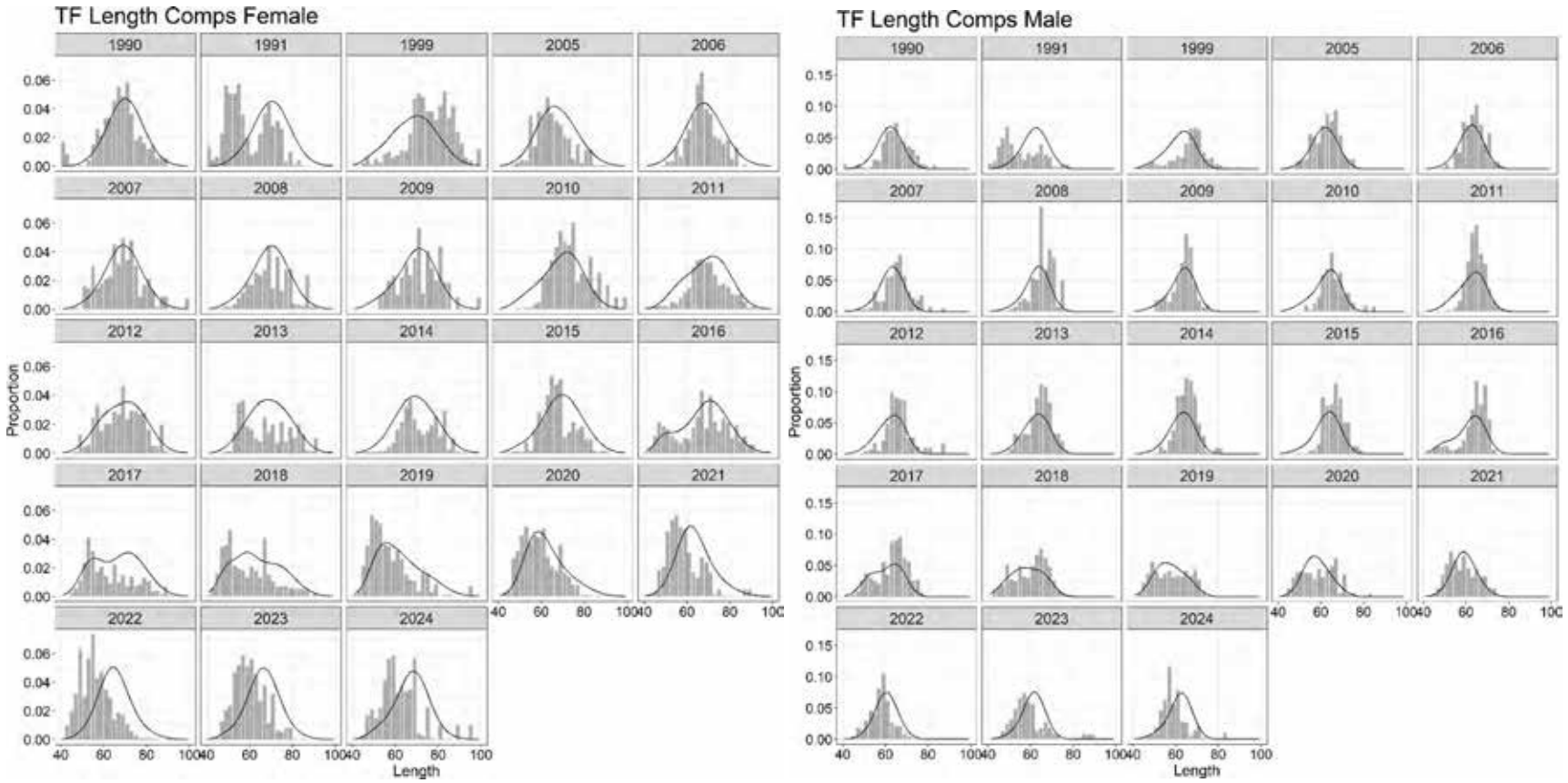

Figure SM3B.45. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *25.12_1Reg_Cont*.

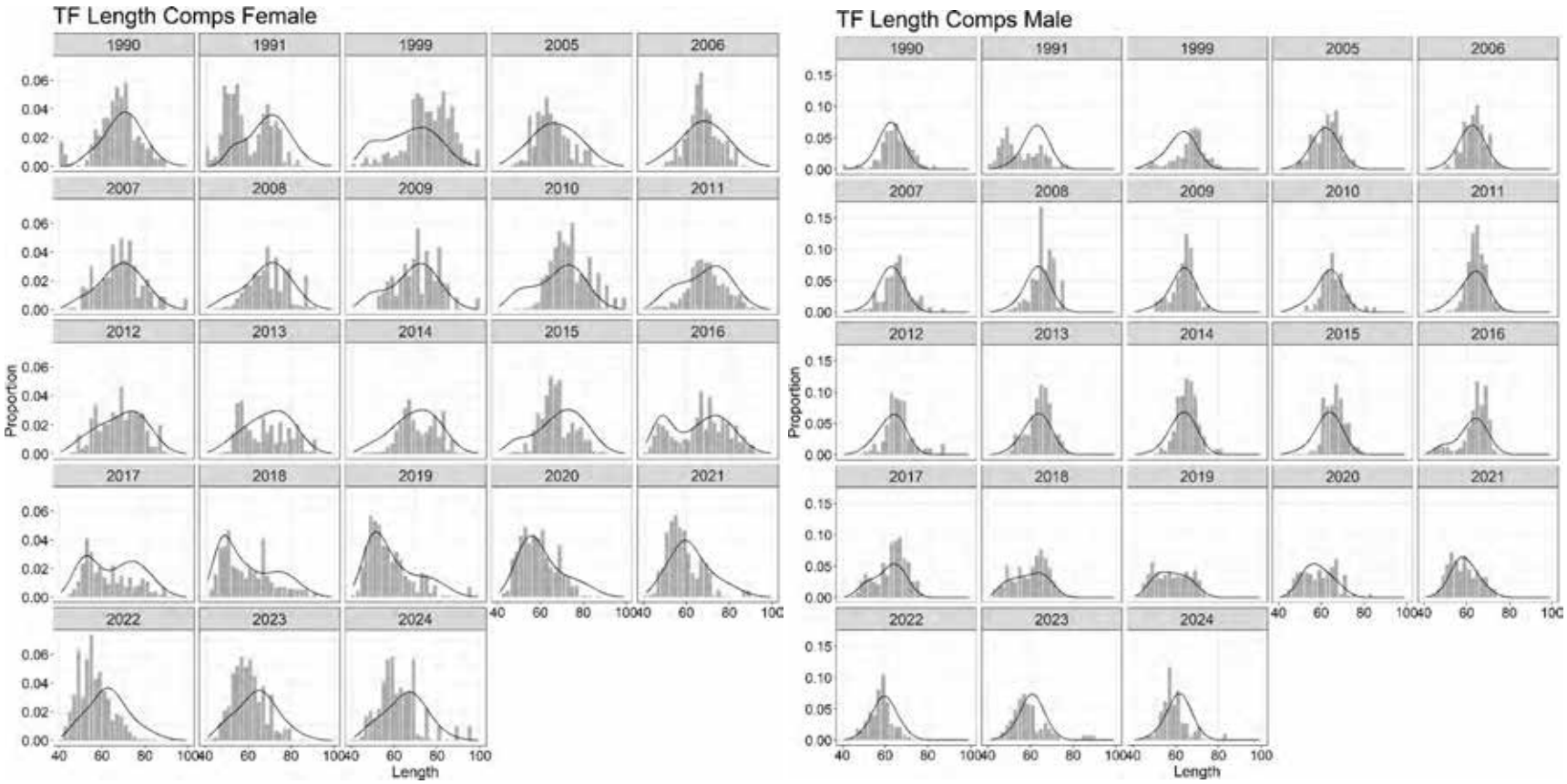

Figure SM3B.46. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

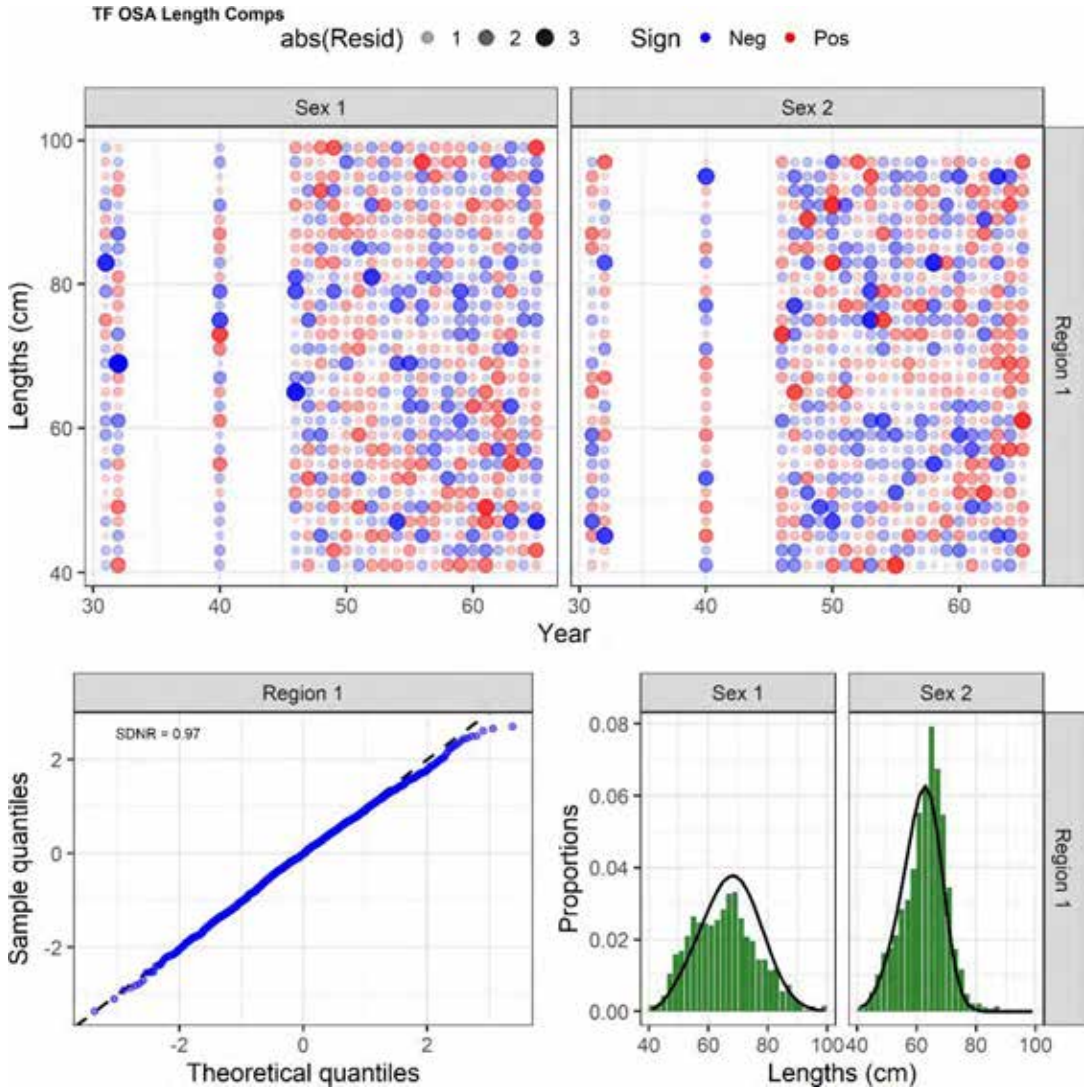

Figure SM3B.47. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *25.12_1Reg_Cont*.

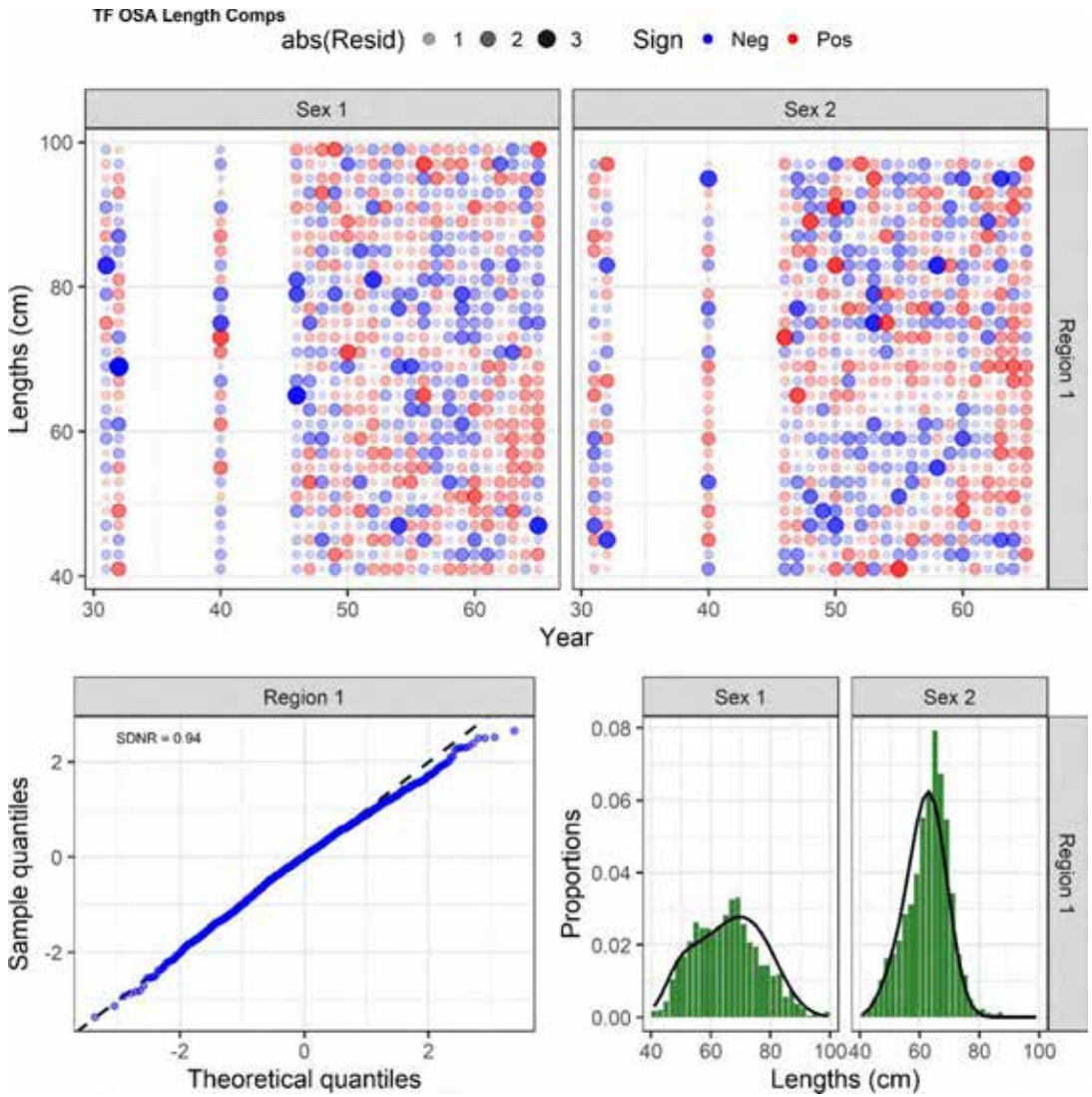

Figure SM3B.48. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

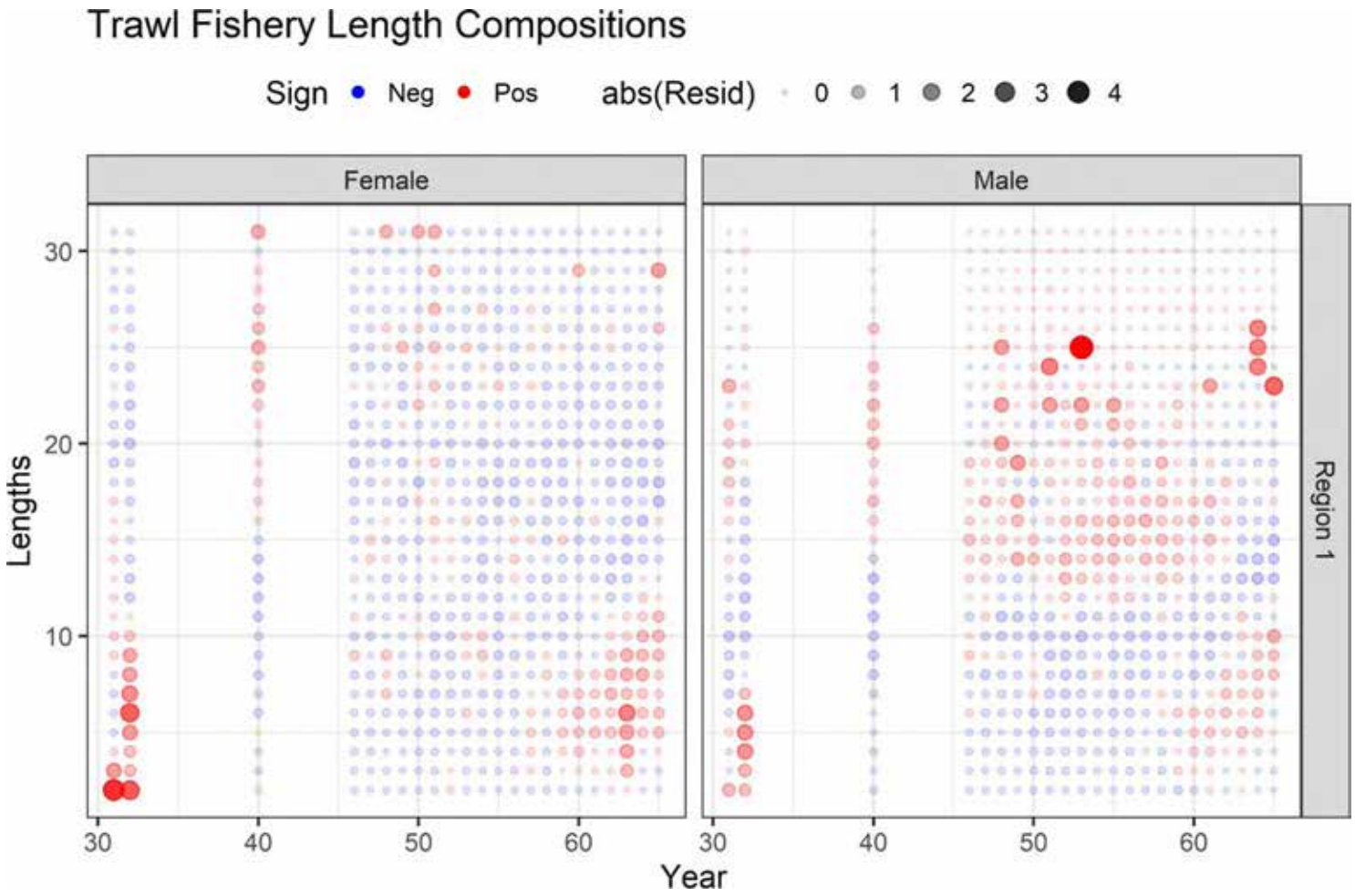

Figure SM3B.49. Fits to the trawl fishery length composition data based on Pearson residuals for model *25.12_1Reg_Cont*.

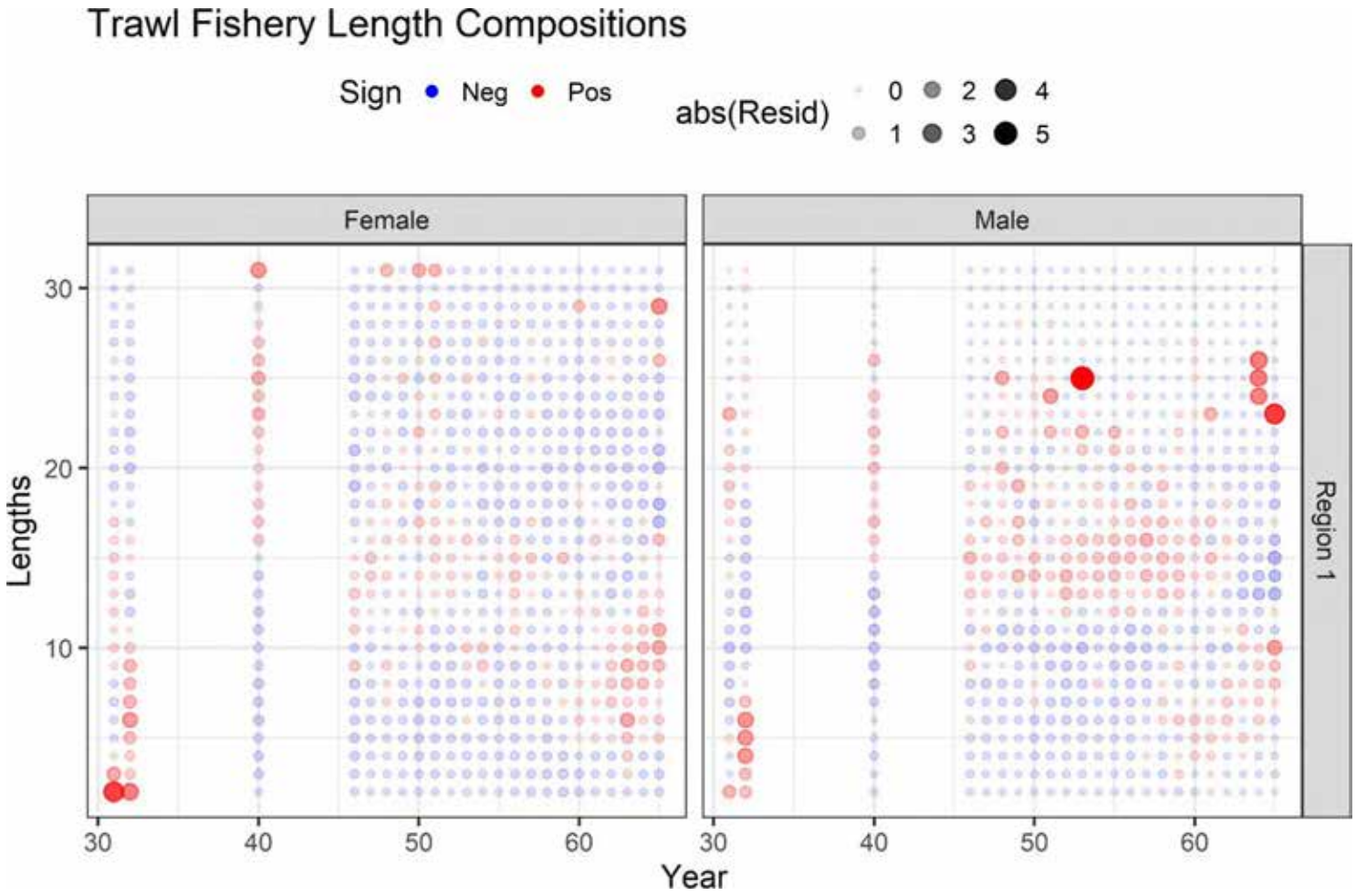

Figure SM3B.50. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.1_1Reg*.

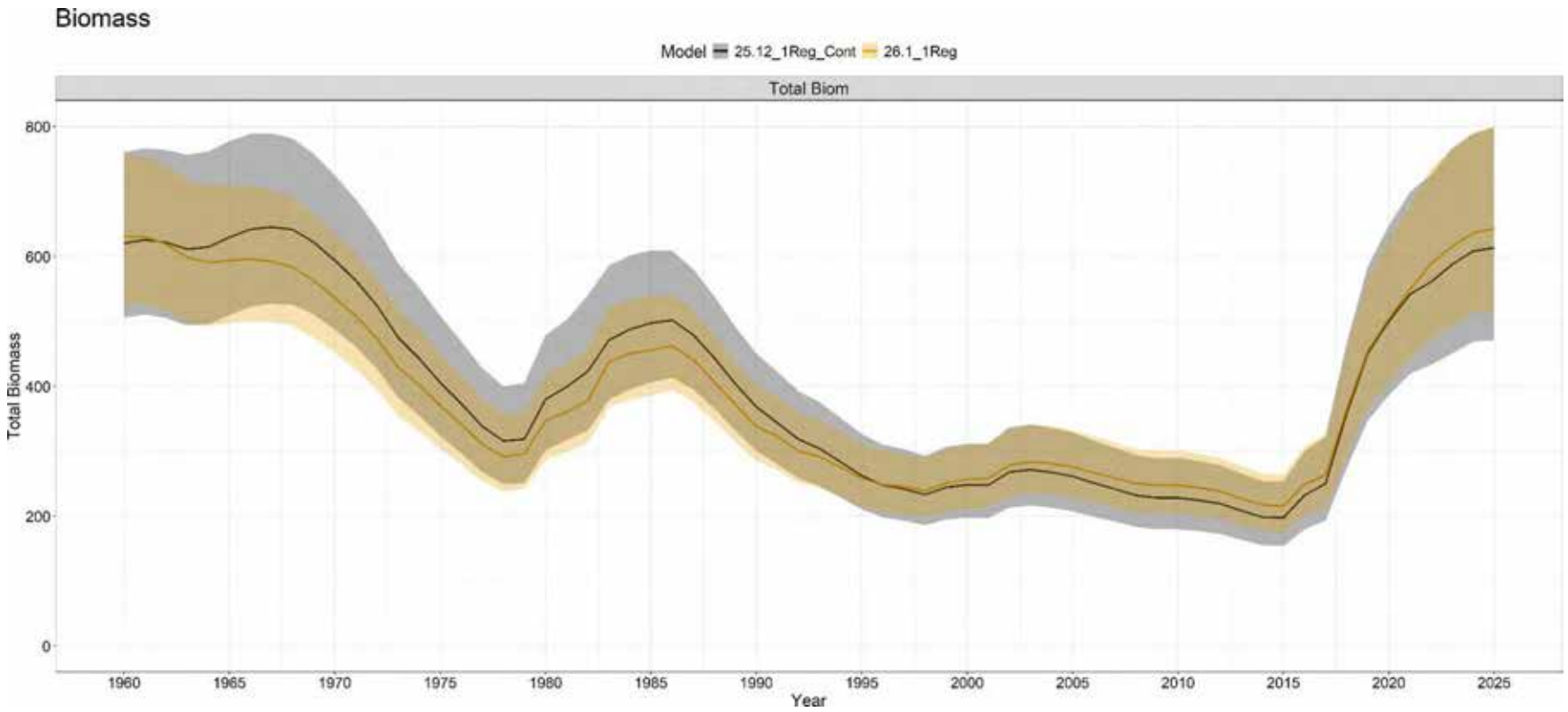

Figure SM3B.51. Time series estimates of total biomass (kt) for model *25.12_1Reg_Cont* and Model *26.1_1Reg*.

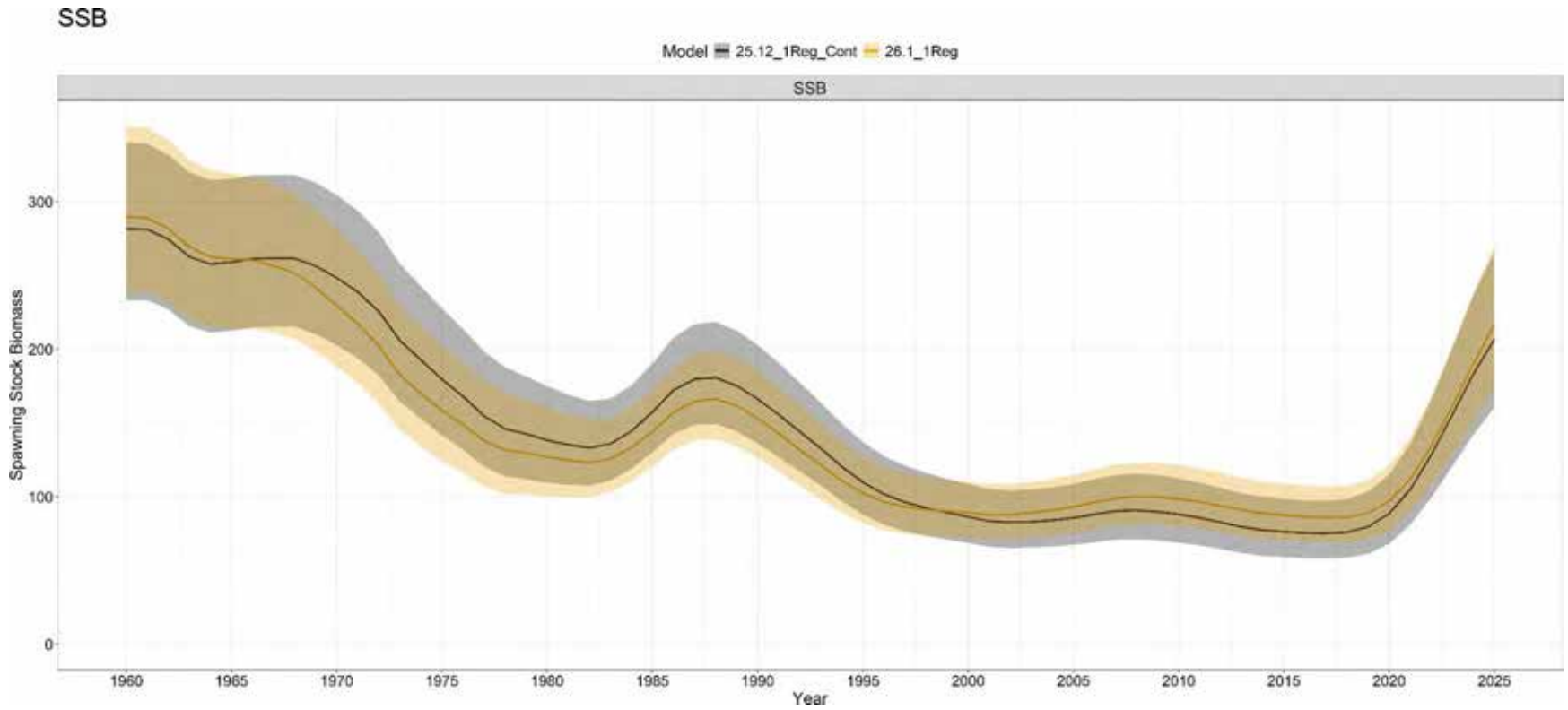

Figure SM3B.52. Time series estimates of spawning stock biomass (kt) for model *25.12_1Reg_Cont* and Model *26.1_1Reg*.

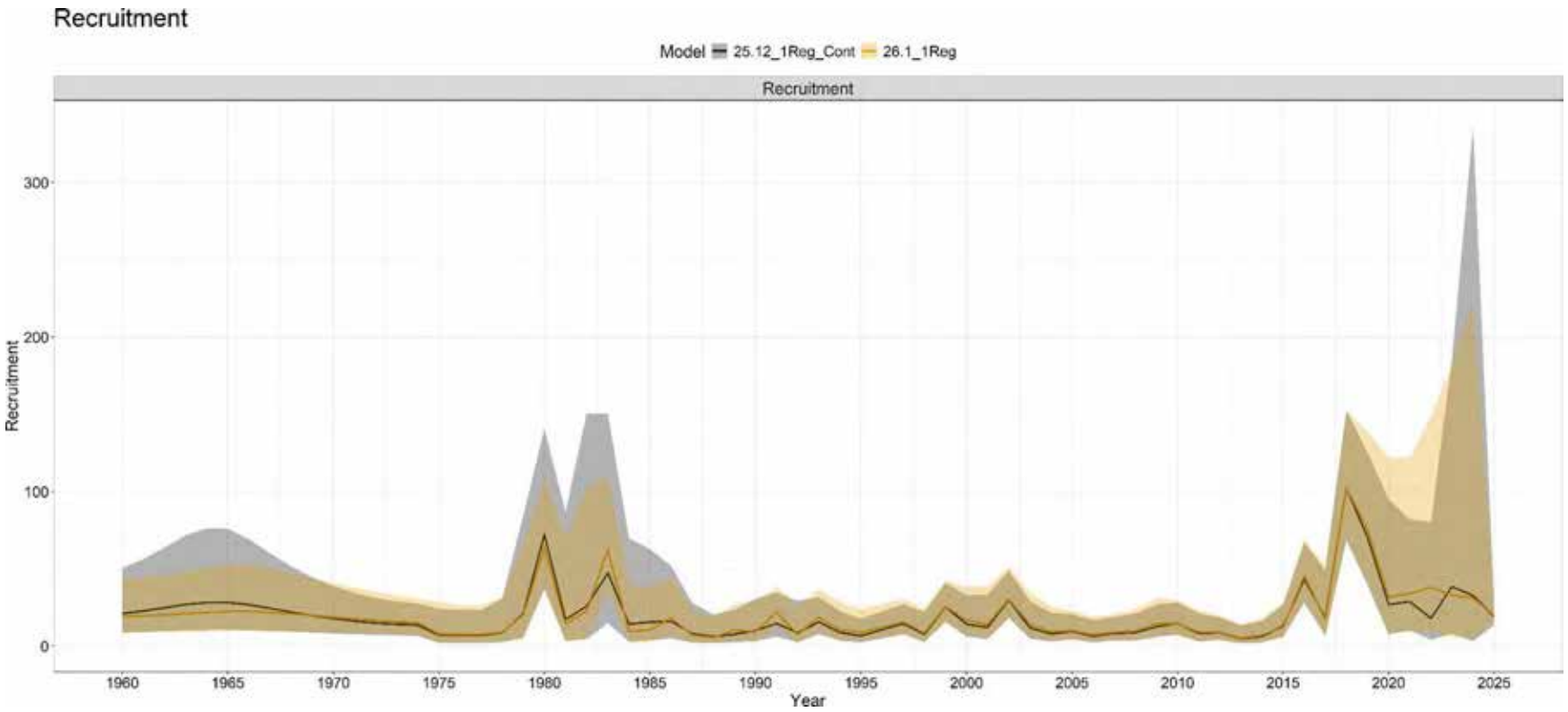

Figure SM3B.53. Time series estimates of recruitment (millions of fish) for model *25.12_1Reg_Cont* and Model *26.1_1Reg*.

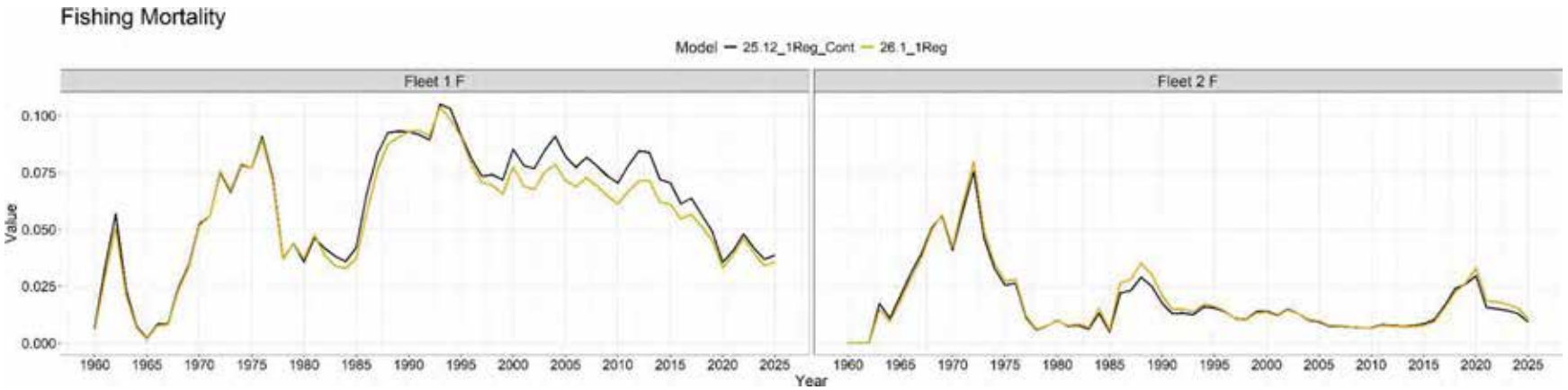

Figure SM3B.54. Time series estimates of fishing mortality (yr^{-1}) for model *25.12_1Reg_Cont* and Model *26.1_1Reg*. Fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery.

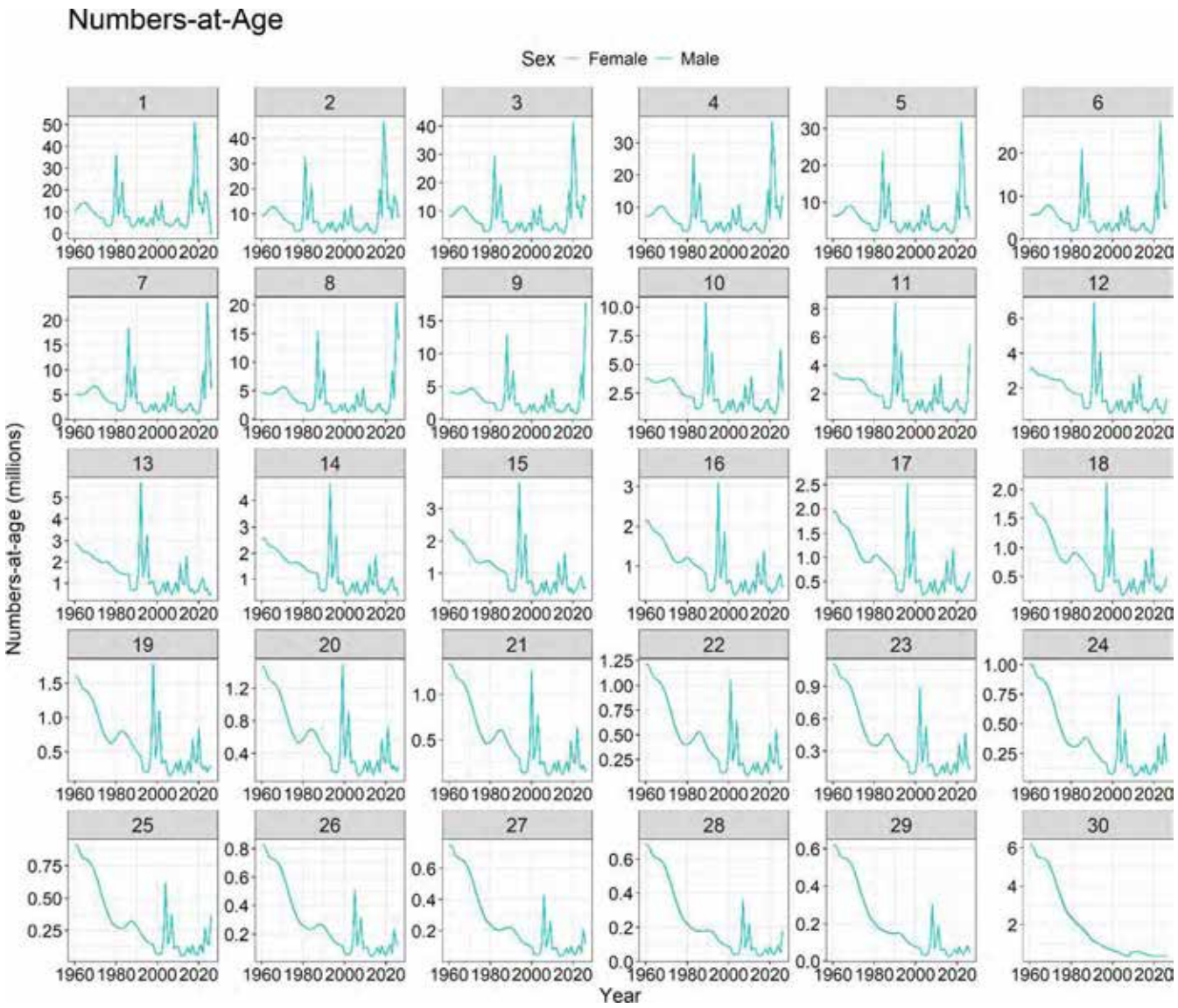

Figure SM3B.55. Time series estimates of numbers-at-age (millions of fish) by sex for model *25.12_1Reg_Cont*.

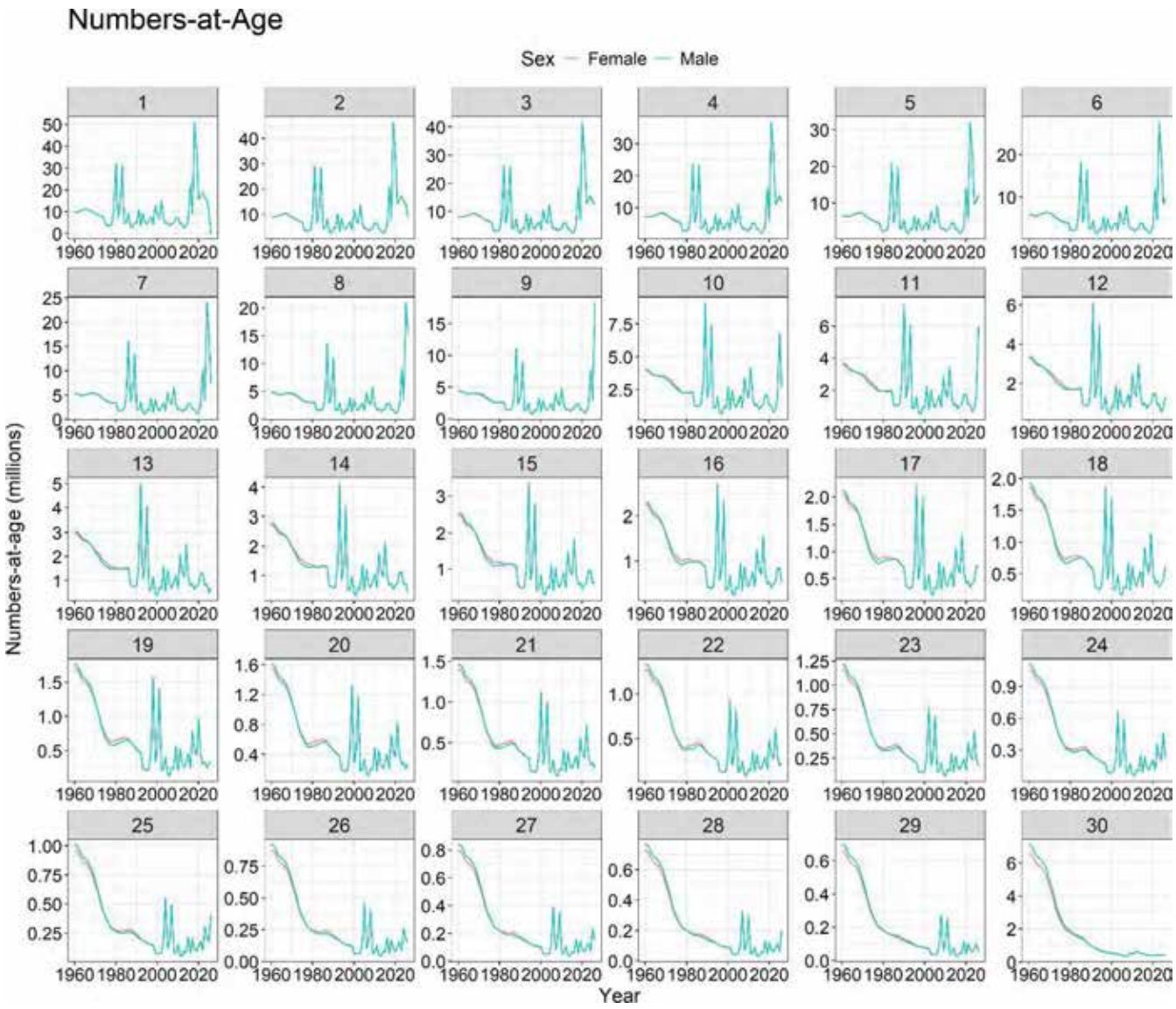

Figure SM3B.56. Time series estimates of numbers-at-age (millions of fish) by sex for model *25.12_1Reg_Cont*.

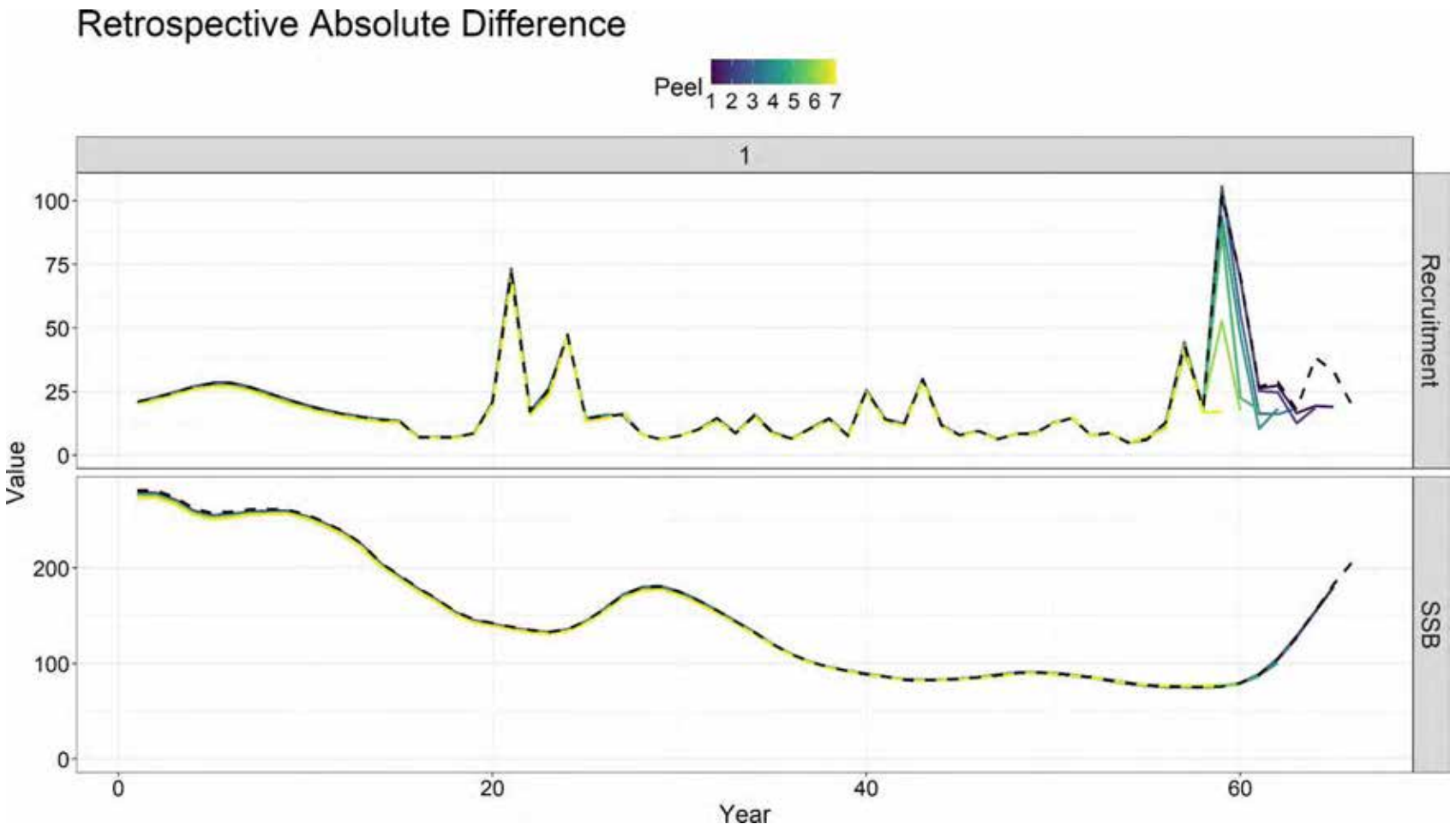

Figure SM3B.57. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year 'true' retrospective analysis for Model *25.12_1Reg_Cont*. Francis reweighting is undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was -0.014.

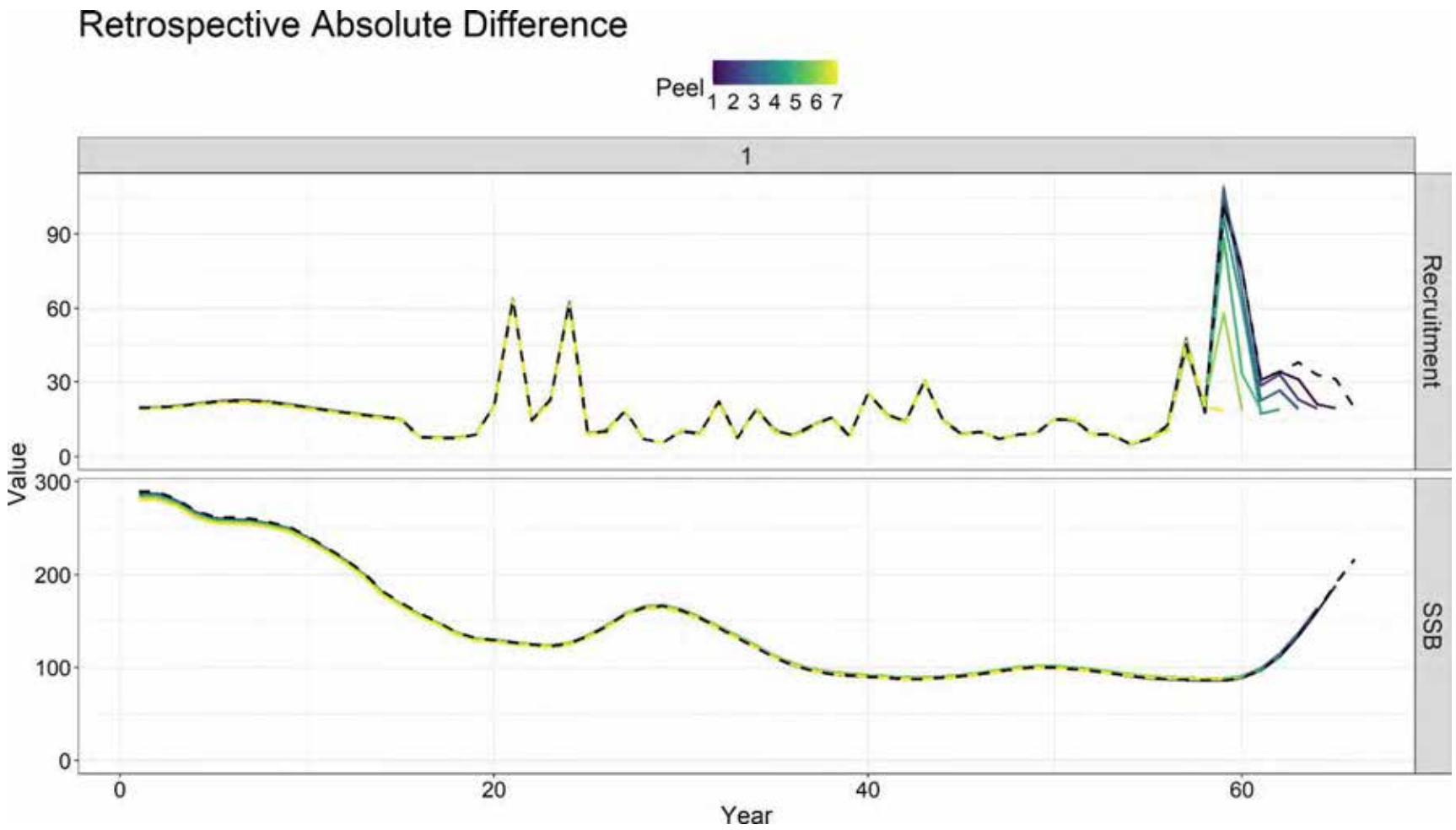

Figure SM3B.58. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year 'true' retrospective analysis for Model *26.1_1Reg*. Francis reweighting is undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.0054.

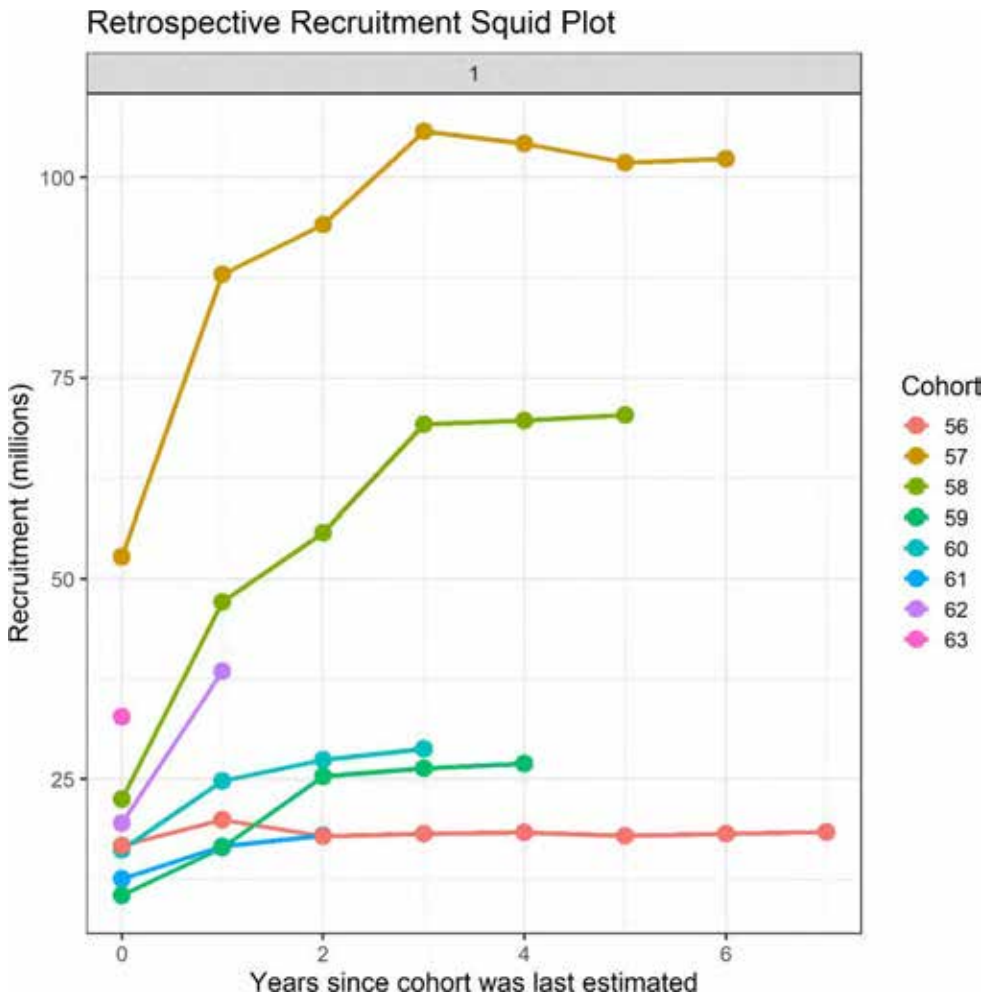

Figure SM3B.59. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven year 'true' retrospective analysis for model *25.12_1Reg_Cont*. The 'true' retrospective analysis removes a year of data for each peel, but also accounts for the lag in availability of compositional data (i.e., fishery ages and lengths as well as longline survey ages become available on a one year lag from associated catch or index data). Francis reweighting is undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation.

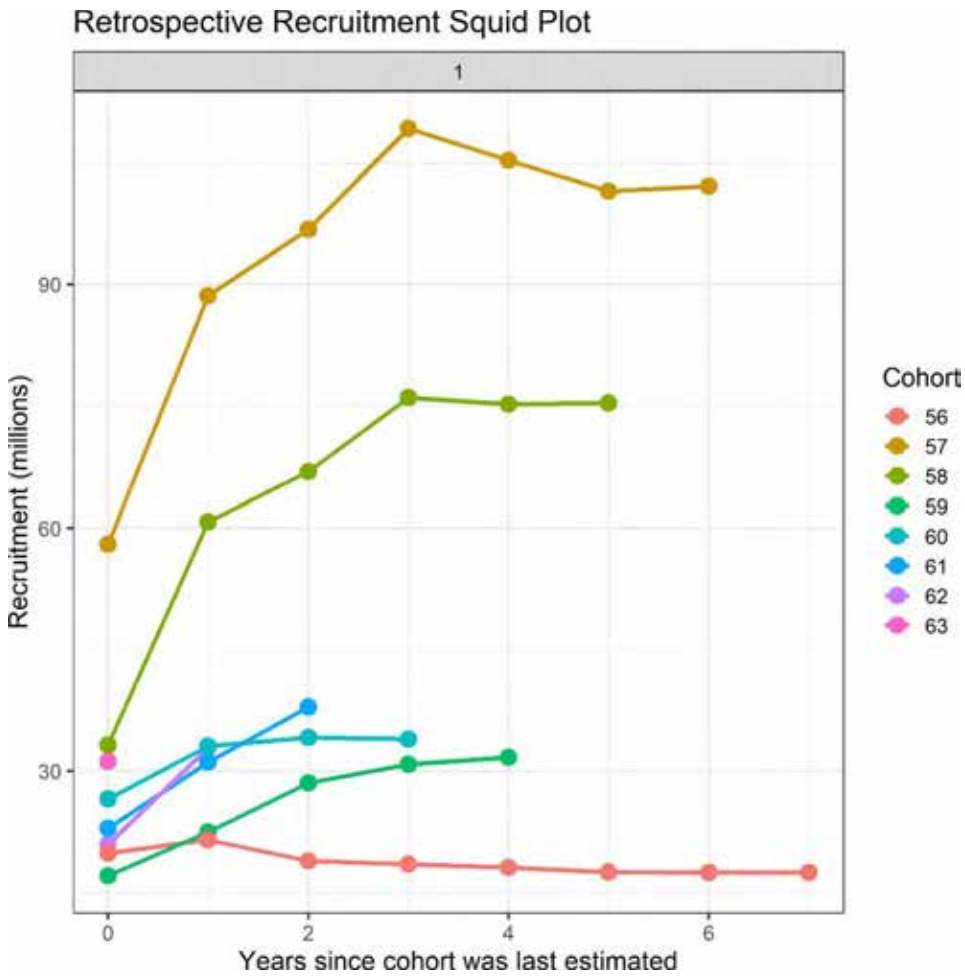

Figure SM3B.60. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven year 'true' retrospective analysis for model *26.1_1Reg*. The 'true' retrospective analysis removes a year of data for each peel, but also accounts for the lag in availability of compositional data (i.e., fishery ages and lengths as well as longline survey ages become available on a one year lag from associated catch or index data). Francis reweighting is undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation.

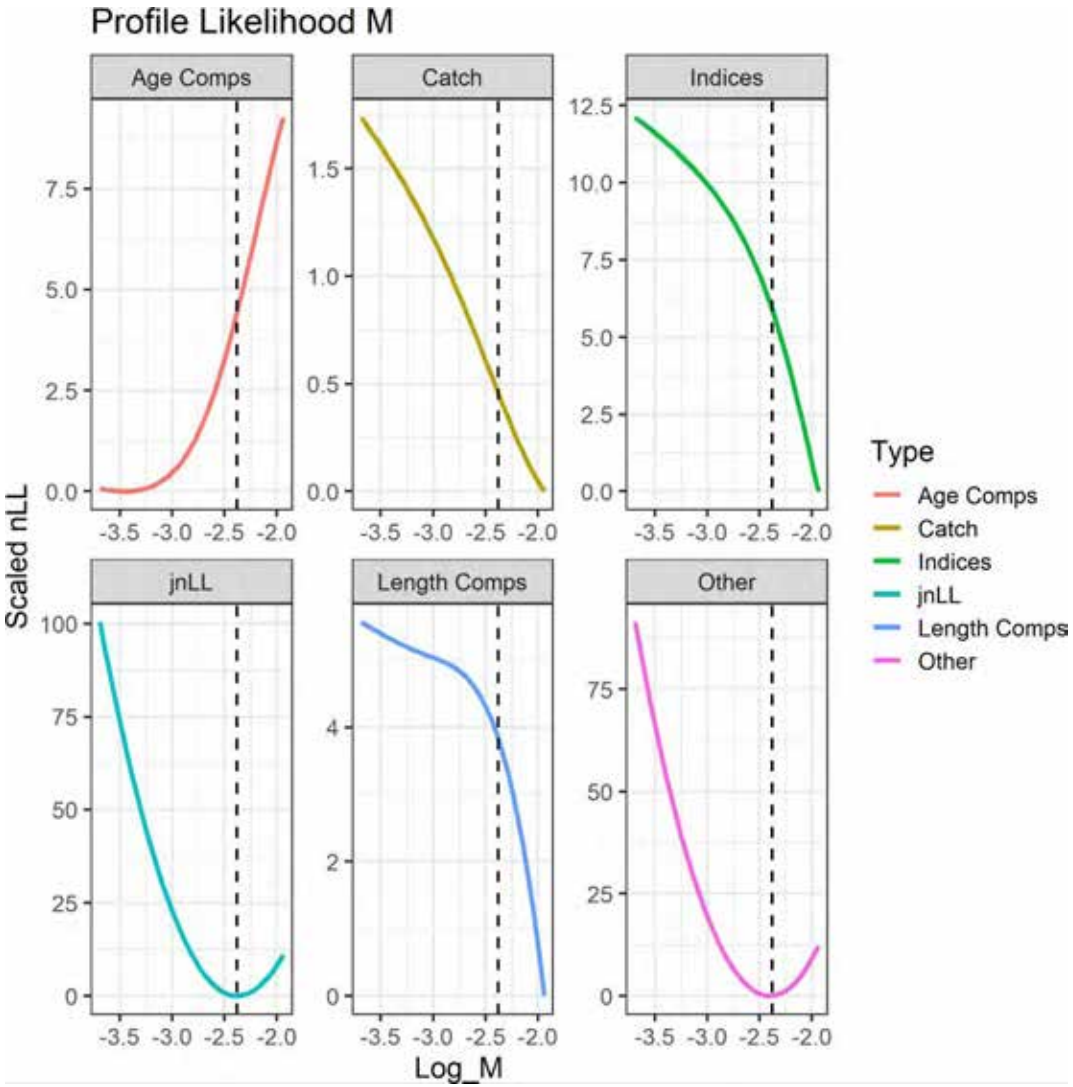

Figure SM3B.61. Likelihood profile for the natural mortality parameter (*M*), where panels represent the profile for each data type used in the model, for Model *25.12_1Reg_Cont*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

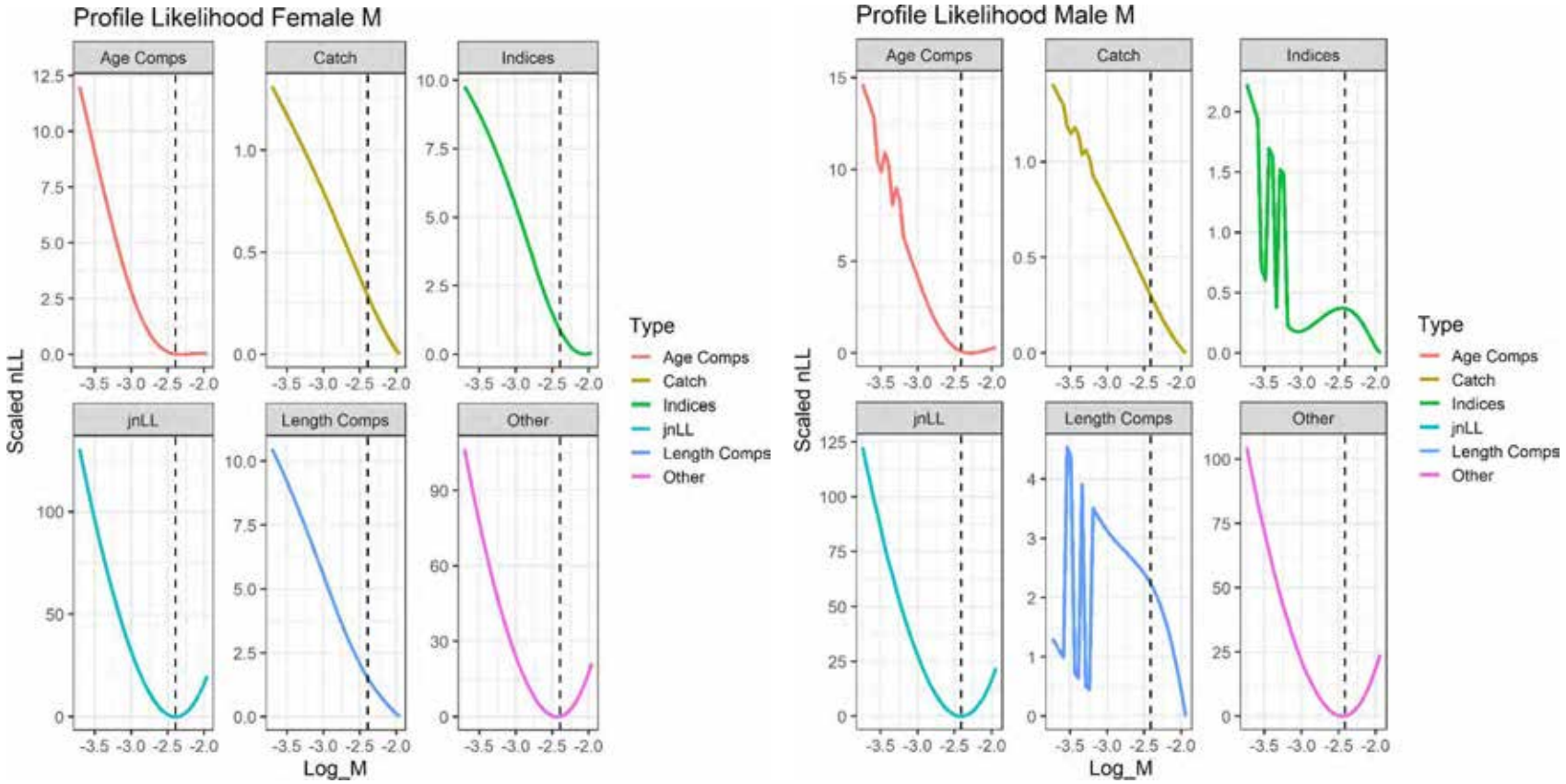

Figure SM3B.62. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for model *26.1_1Reg*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

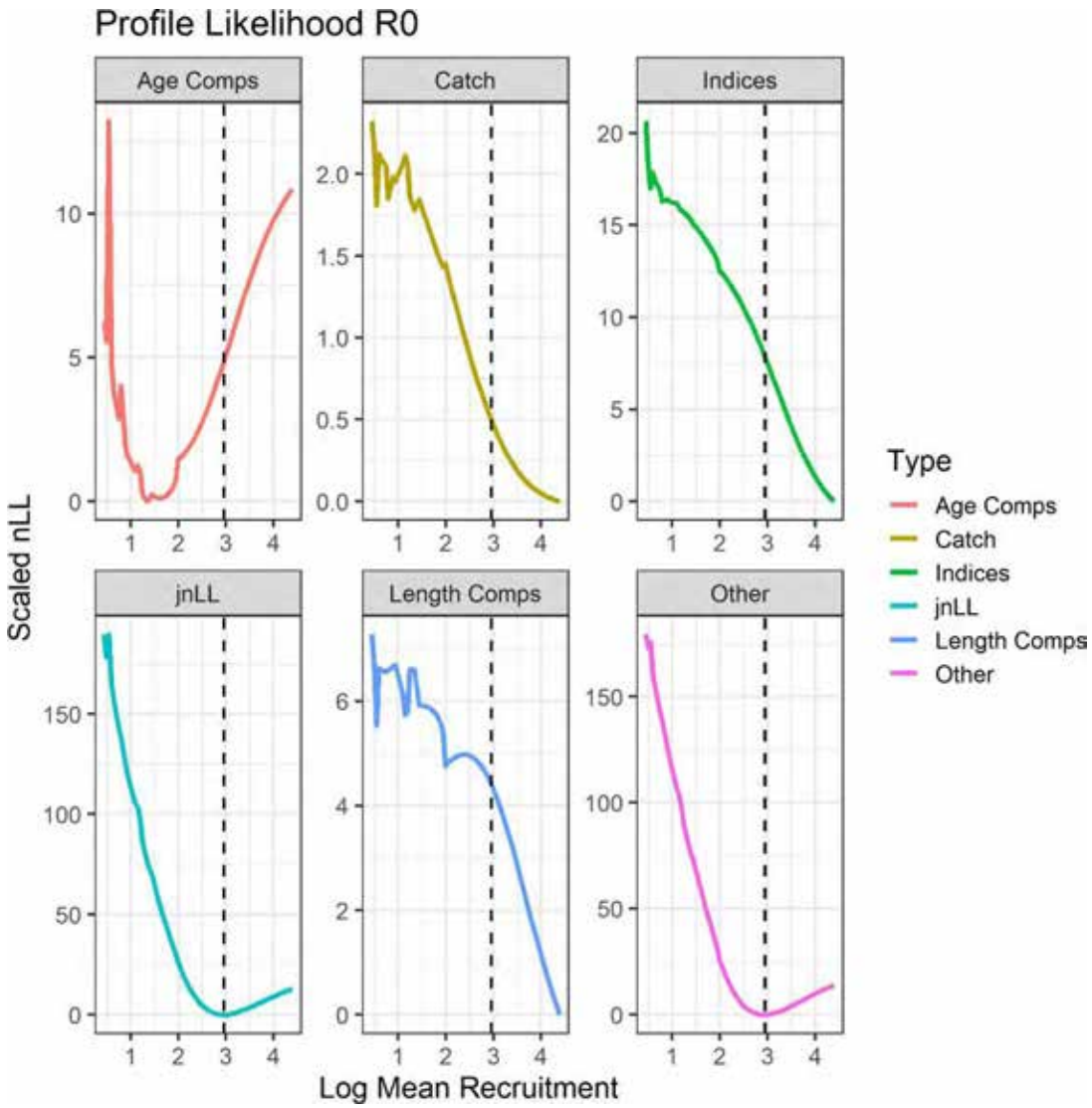

Figure SM3B.63. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for model *25.12_1Reg_Cont*.

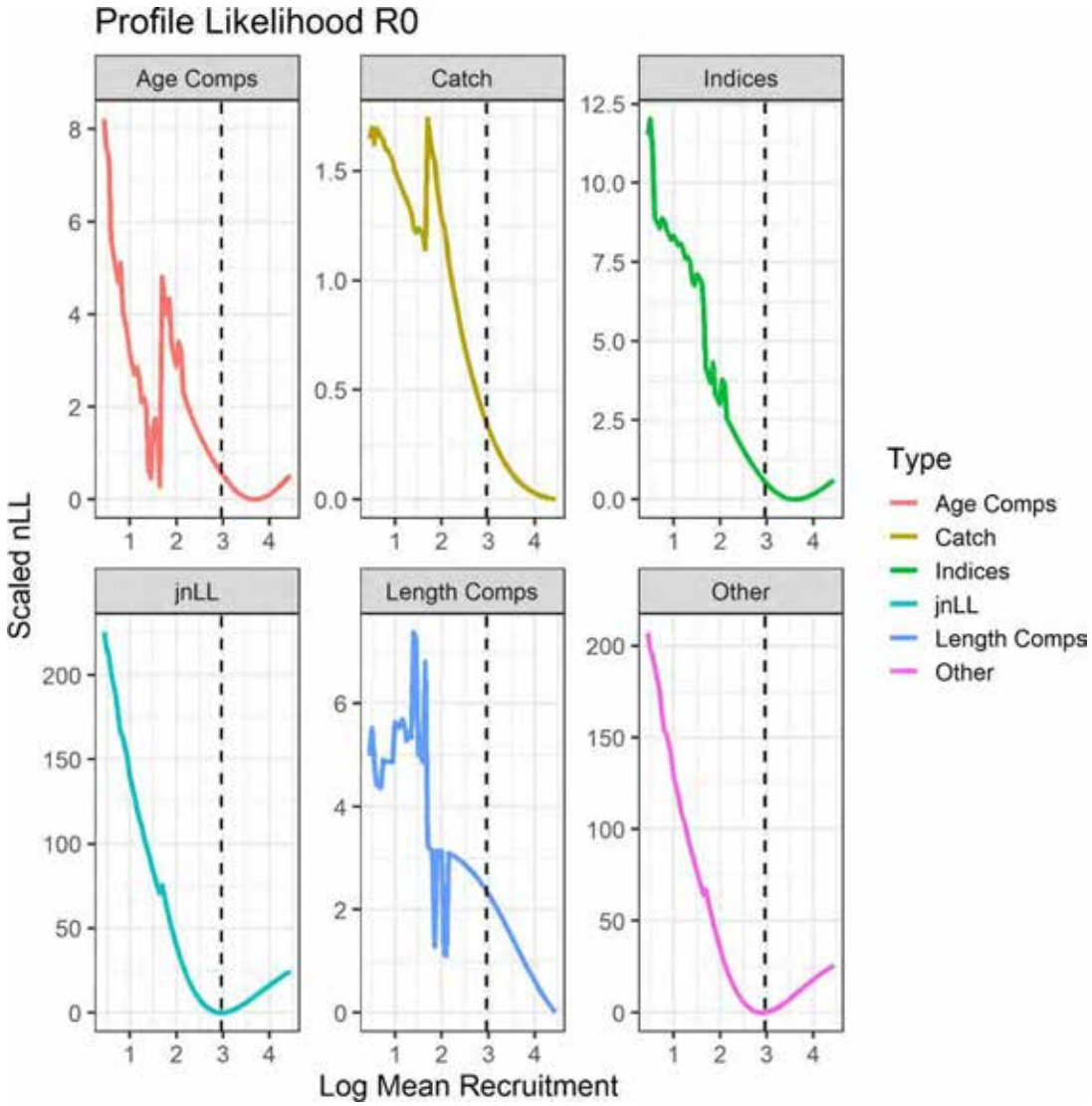

Figure SM3B.64. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for model *26.1_1Reg*.

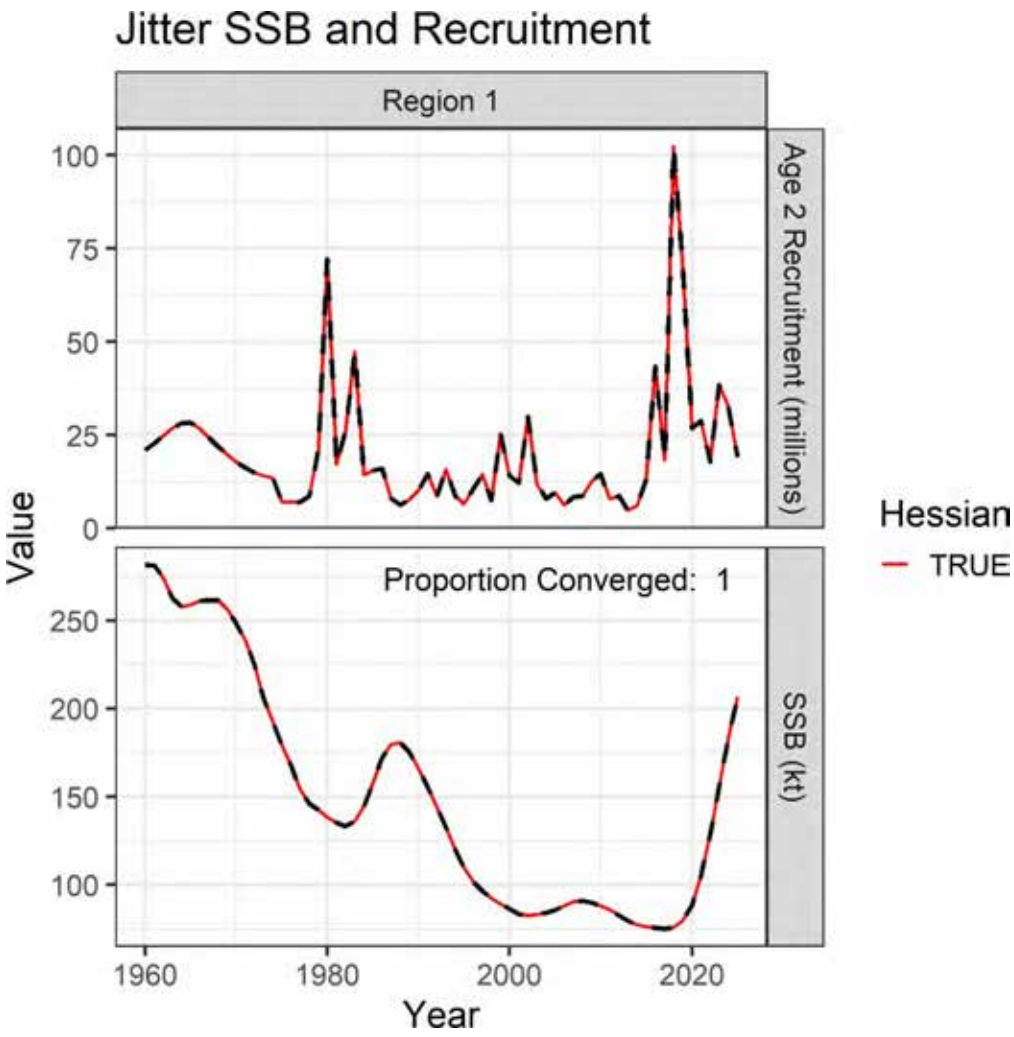

Figure SM3B.65. Results of a jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for model *25.12_1Reg_Cont* (left panel). The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

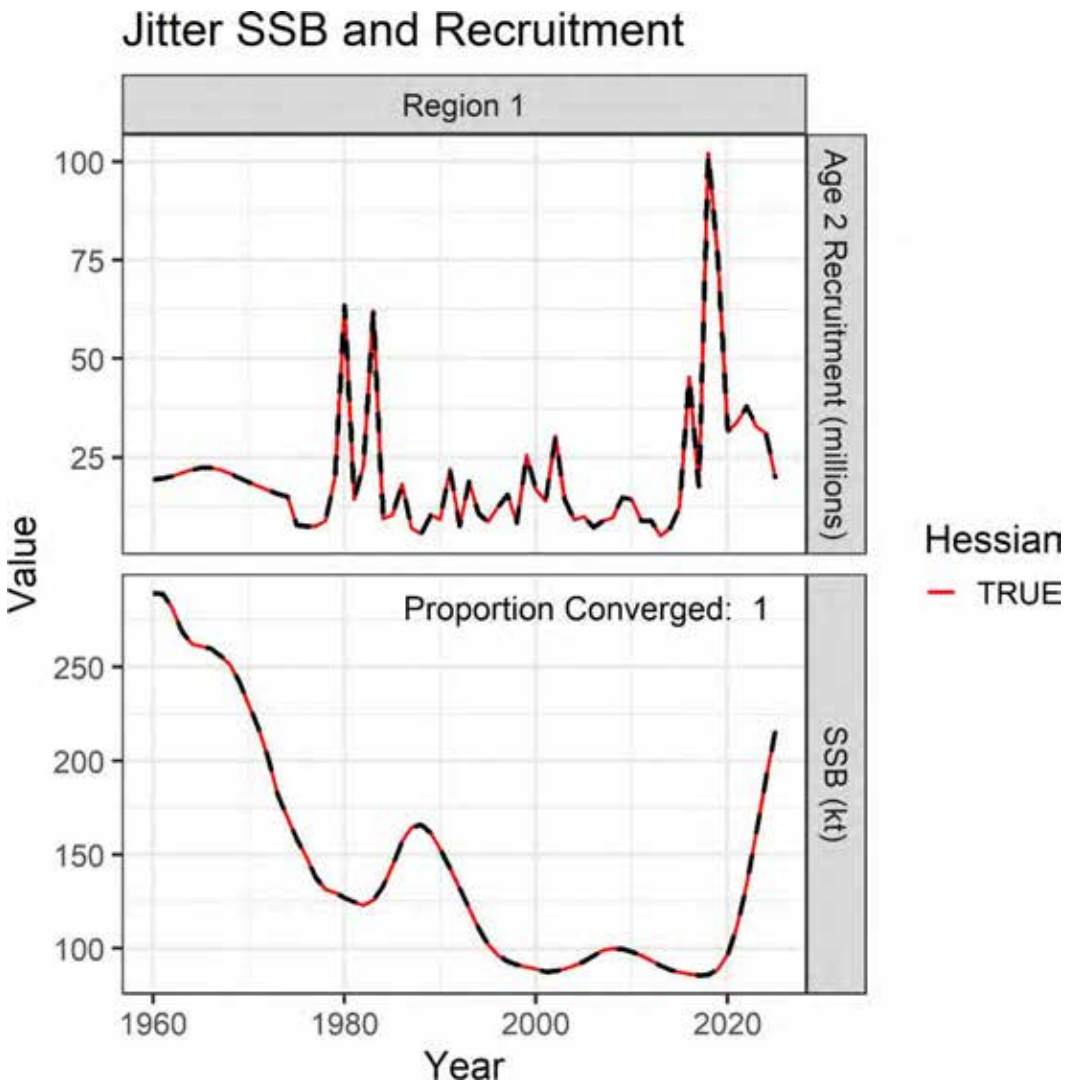

Figure SM3B.65. Results of a jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.1_1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

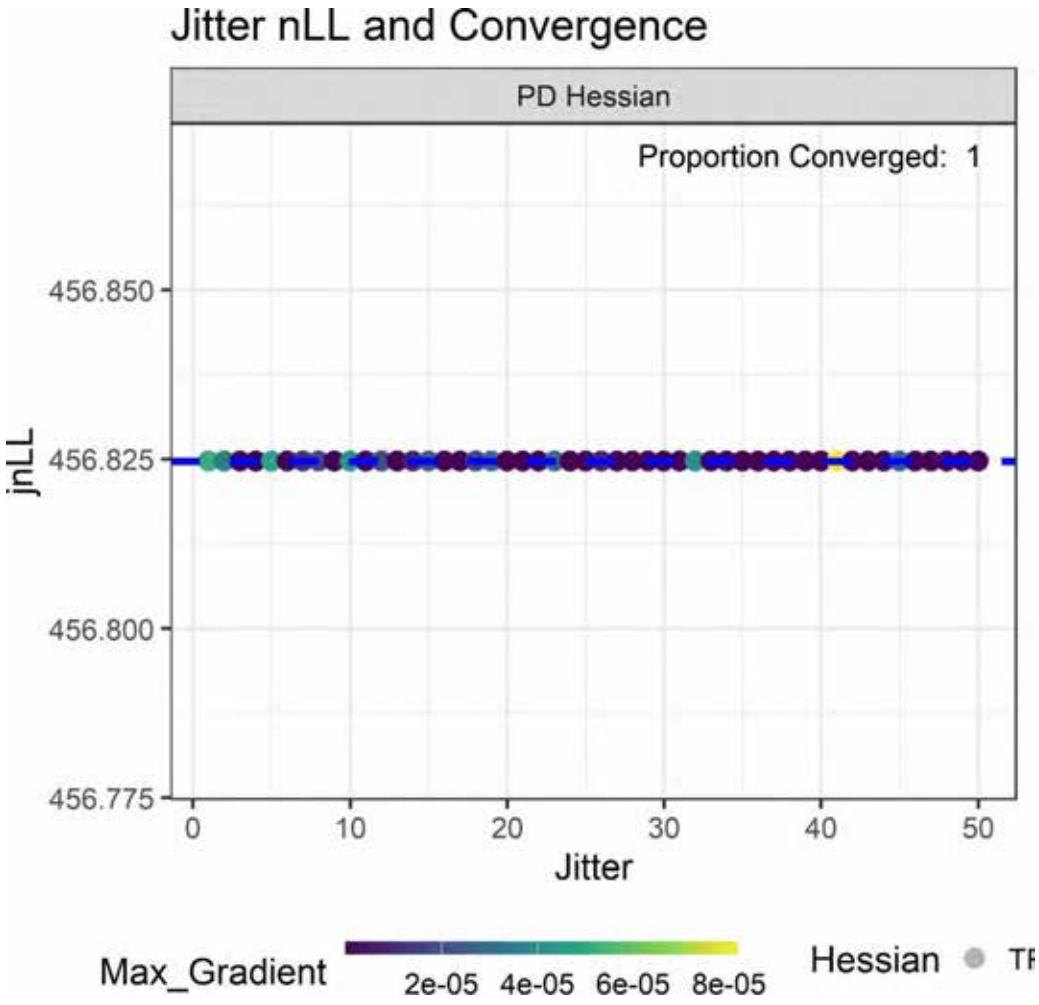

Figure SM3B.66. Results of a jitter analysis showing the joint negative log-likelihood values for converged (Positive Definite, PD, Hessian) and non-converged runs (non-Positive Definite Hessian) for model *25.12_1Reg_Cont*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

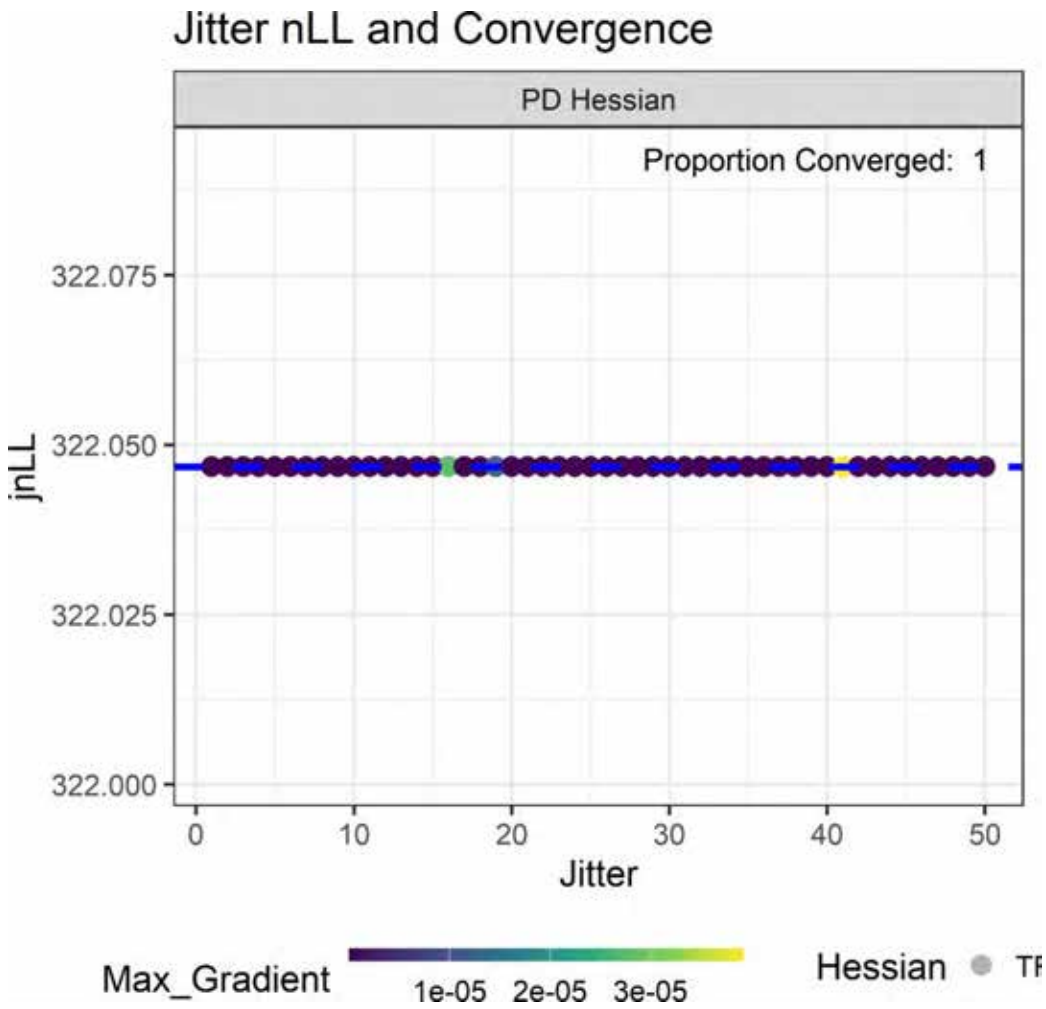

Figure SM3B.67. Results of a jitter analysis showing the joint negative log-likelihood values for converged (Positive Definite, PD, Hessian) and non-converged runs (non-Positive Definite Hessian) for model *26.1_1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

Appendix 3C: Development of a Fleets-as-Areas (FAA) Stock Assessment Model for Alaska Sablefish

Daniel Goethel and Matt Cheng

June 2026 Sablefish Center for Independent Experts (CIE) Review

Executive Summary

Given the complex ontogenetic spatial patterns exhibited by sablefish in Alaska as well as the change in NOAA Longline Survey design in 2025 (where only ~50% of the population is being sampled in a given year), a fleets-as-areas (FAA) model building exercise was undertaken to explore alternatives to current single region assessment models. FAA models disaggregate data by region and use model selectivity and catchability assumptions to alias differential age-based availability across regions to implicitly account for spatial heterogeneity. Thus, an FAA model was identified as a potential suitable structure for sablefish, as it could disaggregate survey data by region and avoid the need for 'carryover' extrapolation as is used in the single region assessment (Model *26.1_1Reg*; to ensure a consistent scaling of the index given inconsistent sampling across years, see Appendix 3B). Ultimately, the choice of model structure for sablefish is a tradeoff between model stability, assessment complexity, and assumed data representativeness (Table 3C.1). Although an FAA model would forego the need for data extrapolation, it may be more unstable and might overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high).

The final FAA model, Model *26.2_FAA*, appears to provide a robust and stable model for interpreting sablefish population dynamics. Although Model *26.2_FAA* leads to a moderate downward scaling of SSB and catch advice, general population dynamics and stock status remain consistent with Model *26.1_1Reg*. Similarly, fits to the available data retain similar issues, where survey indices are well fit at the expense of composition data, primarily due to the Francis reweighting approach of 'right-weighting' the data to ensure adequate fit to the indices. Although residual patterns in the composition data remain, the aggregated fits continue to appear adequate given associated model tension between fitting the NOAA Longline Survey indices versus age compositions. Fundamentally, both the single region and FAA models have trouble reconciling the much larger year classes and population growth suggested by the age composition data compared with the rapid, but more tempered, population growth observed in the survey RPNs. All model diagnostics, including retrospective patterns, indicated that Model *26.2_FAA* is relatively stable and showed no signs of significant misspecification. Although other FAA models were explored, data sparsity issues resulted when attempting to regionally disaggregate the fishery data, suggesting that Model *26.2_FAA* was a suitable model of intermediate complexity.

An exploratory FAA model run using the 'carryover' approach was enlightening as it showed the potential downside of using extrapolated data in the assessment, given that it led to a much more optimistic estimate of stock status and catch advice. Although the sablefish MSE work indicates that the carryover extrapolation is not likely to have a major detrimental impact on management advice from the single region model, it does appear that using extrapolated values in the index should be considered judiciously. Thus, Model *26.2_FAA* may be a good candidate for the

sablefish operational assessment and management, given that it does not rely on any data extrapolation and appears to provide a stable and robust assessment.

Sensitivity runs demonstrated application of the Dirichlet-multinomial likelihood, which effectively upweighted composition data relative to the Francis reweighting approach, as an attempt to provide a more statistically rigorous approach to data weighting (and to better fit the age compositions). However, using the Dirichlet-multinomial likelihood led to degraded fits to abundance indices, more variable recruitment estimates, and inflated population scale. Additionally, the combination of continuous time-varying selectivity and the Dirichlet-multinomial likelihood was explored but failed to reconcile the respective issues encountered when each approach was applied independently, particularly the positive retrospective patterns. Collectively, sensitivity run explorations suggest that none of the alternative configurations examined performed better than Model *26.2_FAA*. However, they provide a useful foundation for future model development and help clarify key areas of model tension and structural sensitivity.

The following document summarizes model performance and results of select FAA model runs, primarily in comparison to the final single region model (*26.1_1Reg*). Full model results and diagnostics are available at the Alaska sablefish assessment CIE review GitHub site, where individual folders are provided for every model run produced for the CIE Review. Folders contain SPoRC input and output R files along with PDFs of results (folders for FAA model runs are available here). Full model outputs for the final FAA model (*26.2_FAA*) and the final single region model (*26.1_1Reg*) are provided in the Supplementary Material (SM3C).

1. Fleets-as-Areas Model Development

Introduction

A change to the design of the NOAA Longline Survey starting in 2025 has led to a situation where approximately only 50% of the sablefish abundance/distribution in a given year is sampled. Since 1990, the Gulf of Alaska (GOA) has been sampled annually, while the Aleutian Islands (AI) were sampled in even years starting in 1996 and the Bering Sea (BS) was sampled in odd years starting in 1997 (Siwicke and Malecha, 2026). Beginning in 2025, only the GOA is being sampled in odd years, and both the BS and AI are being sampled in even years. However, the abundance in the BS and AI appears to be increasing more rapidly than other regions over the last decade (e.g., based on regional NOAA Longline Survey Relative Population Numbers, RPNs; Figure 3C.1), apparently due to extremely large recent year classes primarily recruiting in these regions before moving to other regions as they mature (see the results of the spatial model, Appendix 3D; Figure 3C.2).

To maintain a consistent scaling of the index given the inconsistent survey design, an extrapolation of index RPNs is required for years when a given region is not surveyed -- if the index is to be used in a single region assessment and assumed to be representative of the entire population. Historically, the year over year change in the GOA was used to extrapolate growth in the BS or AI for survey off years (Siwicke and Malecha, 2026). However, that approach is no longer feasible because the GOA is not sampled annually. In 2025, the 'carryover' approach was introduced wherein a constant hold-over value of the RPN from the previous sampled year was used for regions that were not sampled. Regardless of extrapolation approach, around 50% of the index relies on extrapolated values under the new survey design. Concomitantly, aggregated age compositions (using area RPN-weighted average proportions) are either dominated by the GOA historically (given larger summed RPNs across the GOA compared to either the BS or AI in a given year) or undergo strong interannual variability due to the survey switching between the GOA one year and BS and AI the other (where these regions demonstrate strong differences in compositions; see Figures SM3C.18, SM3C.24, and SM3C.31). Thus, resulting single region models are highly reliant on extrapolated data and likely prone to retrospective patterns in recruitment caused by interannual variability in age compositions due to sampling different segments of the population that aren't representative of the entire population on a yearly basis.

An alternative to developing a single index and extrapolating for a region that is not sampled is to develop multiple indices, disaggregated by region, such that the survey footprint is consistent within each region and off years are simply treated as missing data. Similarly, the associated composition data can be aggregated at the same regional scale, ensuring that each regional index has concordant composition data. Within a stock assessment, there are two approaches to fitting regional data: spatially implicit fleets-as-areas (FAA) models or spatially explicit multi-region models. The primary difference in assumptions is that FAA models assume a single population and use 'regional' (modeled as fleets) selectivity to alias spatial processes, while spatial models explicitly model spatial processes such as movement and regional recruitment dynamics (Goethel et al., 2023).

Similar to a single region assessment, an FAA model assumes that the 'regional' trends and compositions represent a single underlying population, where survey-specific catchability (q) and

selectivity (and/or fishing mortality, *F*, and fishery selectivity) estimates are used to implicitly account for varying age-specific availability (e.g., due to the survey footprint being smaller than the distribution of the population of inference or caused by ontogenetic or seasonal migration patterns; Berger et al., 2012; Waterhouse et al., 2014). FAA models tend to perform better than single region models when there are patterns in the composition data due to seasonal or ontogenetic availability that single region models are otherwise unable to explain (since they cannot account for spatial structure; Lee et al., 2017). Conversely, FAA may perform poorly compared to spatial assessments when underlying spatial population structure and complex movement patterns exist (Bosley et al., 2022). Moreover, FAA models may be prone to model instability due to issues estimating selectivity parameters as sample sizes decrease when regional fleets are modeled independently, particularly for lesser sampled regions (e.g., the BS and AI for sablefish, particularly in the fishery data). Interpreting the dynamics of FAA models can also be less intuitive, because each fleet is still operating on a single, homogeneous population, such that variability in indices and compositions can only be interpreted as changes in availability. Thus, when signals in the data (e.g., survey indices or compositions) differ for fundamental population processes (e.g., recruitment) across space, the model must attempt to rectify these differences primarily through selectivity differences, potentially leading to non-intuitive predictions (e.g., predicted survey abundance trends).

When there is complex population structure or spatial processes present, development of a spatially explicit model may be preferred. Spatial models fit the data at regional scales and, unlike FAA models, are better able to differentiate regionally varying data signals as changes in population composition (e.g., age structure or biological differences) or availability across space. In simulation studies, spatial models are often found to be the most robust to complex spatial dynamics (e.g., Lee et al., 2017; Goethel et al., 2021). However, real-world implementation is often difficult as data sparsity may cause severe model instability, parametrization is often complex, and tagging data is typically required to estimate movement yet comes with numerous additional complications (e.g., dealing tag mixing and data weighting; Goethel et al., 2023). A spatial model for sablefish has been developed (Cheng et al., 2025; see Appendix 3D for updated results), but it is primarily a research tool. Ongoing work with the sablefish spatial model has been exploring how best to loosen simplifying model assumptions (e.g., spatially invariant selectivity and time-invariant movement estimates), handle tag mixing, and deal with tag data weighting in relation to other data sources (e.g., indices and compositions). Despite relatively good model convergence and general diagnostics for the spatial model, instability still exists. Therefore, the spatial model requires further refinement and evaluation before being explored for management decision-making.

To better understand the potential tradeoffs among assessment model structures for sablefish, particularly for dealing with the recent survey design changes, a sablefish-conditioned closed loop simulation study was developed (see Appendix 3E). The desktop management strategy evaluation (MSE) utilized a spatially explicit, five region operating model with movement and spatial dynamics matching those estimated by the spatial assessment model (Appendix 3D). Moreover, the study emulated the real-world survey design both historically and moving forward, which enabled thorough evaluation of the expected impacts of survey changes in 2025 on each assessment structure. Three model structures were explored, including: a single region assessment (generally matching Model *26.1_1Reg*) utilizing an extrapolated, carryover longline survey index

(from 2025 onwards), a FAA model (generally matching Model *26.2a_FAA_Fsh+Srvy*) fitting regionally (BS, AI, GOA) disaggregated longline survey indices and comps as well as fixed gear fishery catch and compositions, and a three region spatial assessment (generally matching model *26.3a_Spat_3Reg*) that estimated regionally-varying parameters and movement. Overall, the FAA assessment configuration performed best, especially as survey coverage declined (emulating the real-world survey dynamics; Appendix 3E; Table 1). The single region model tended to demonstrate higher yet moderate SSB bias, associated with using the extrapolated longline survey index and utilizing aggregated survey composition data that did not always equitably reflect dynamics across all regions (e.g., it was over representative of the GOA). The spatial model performed well, on average, but was extremely unstable and prone to unrealistic estimates (e.g., no recruitment in a given region and year). From a management standpoint, all models tended to perform similarly, with low long-term risk to the population or foregone yield, despite potential assessment bias across structures. Thus, the FAA model was generally the 'best' assessment framework from a simulation standpoint, but differences were subtle. Conversely, the simulation study did not likely adequately represent potential regional data sparsity that could have detrimental impacts for the more complex assessment structures (i.e., FAA and spatial models).

Ultimately, the choice of model structure for sablefish is a tradeoff between model stability, assessment complexity, and assumed data representativeness (Table 3C.1). The relatively stable single region model performs adequately but requires extensive extrapolation assumptions and has difficulty simultaneously fitting the indices and composition data (indicating potential model tension and data inconsistencies; see Appendix 3B). An FAA model would forego the need for using any extrapolated data and would be able to fit regionally disaggregated data but may be more unstable and might overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high). Given the need for a sex-specific model for sablefish, data sparsity is of concern as compositions are partitioned by sex and region. A spatial model could better represent spatial dynamics but is more complex and likely much less stable (and is not considered further here).

Given the potential benefits of using a FAA model to address ontogenetic patterns and NOAA Longline Survey design changes, an extensive model development process was undertaken to identify a suitable FAA structure for sablefish. The results of the simulation and MSE work were used to first identify the FAA structures that were likely to perform the best. Then, a suite of FAA models was built and applied to real-world data. Here, the results of the two most robust FAA models are presented in comparison to the final single region assessment (Model *26.1_1Reg*). Although the FAA framework demonstrates promise and is especially appealing since it utilizes the regional survey data without the need for extrapolation, there remain performance issues and uncertainties on par with the single region assessment.

Methods

In addition to the final single region model (*26.1_1Reg*), two FAA models are described, which were winnowed from an extensive model exploration exercise. The results of the sablefish simulation and MSE study (Appendix 3E) were used to guide model exploration and target final model structure (Figure 3C.3). Key findings from the MSE work indicated that FAA models performed relatively better than other structures as survey coverage decreased or data quality declined but required adequate complexity in selectivity parametrization to address ontogenetic

changes in availability across regions (Appendix 3E; Table 3C.1). For instance, domed selectivity in the BS, particularly for the NOAA Longline Survey, often improved bias, while time-varying non-parametric selectivity helped improve simultaneous fits to the regional indices. However, the simulation work also demonstrated that a relatively simple FAA model (i.e., utilizing only FAA structure in the survey while maintaining aggregated fishery fleets) may perform as well as more complex models that disaggregated survey and fishery fleets and/or included domed selectivity (Figure 3C.3, column facet 2/row facet 2 model *1F_1T*).

The minimum criteria for the final choice of FAA model structure was to be able to fit the disaggregated NOAA Longline Survey indices and age compositions by region (BS, AI, GOA), such that no extrapolation for non-surveyed regions would be necessary (see Appendix 3B) and signals of recruitment from the BS and AI regions (where many of the recent large cohorts appear to be originating; Figure 3C.2) would be better represented. Model building explored three primary parametrization options: 1) whether to disaggregate the fixed gear fishery fleets by region (since this is the primary fleet representing a large majority of fishery removals); 2) whether to include domed selectivity in the BS or AI fishery or survey fleets; and 3) how many time blocks to include in the fixed gear fishery.

FAA model building began by adding incremental complexity to Model *26.1_1Reg* until adequate data fits (e.g., residual patterns from fits to indices and composition data), convergence criteria (e.g., maximum gradient, invertible Hessian, and no major parameter correlations), and general diagnostics (e.g., retrospective patterns and likelihood profiles) were obtained. Two FAA base models were identified that generally passed the desired convergence and diagnostic criteria: *26.2_FAA* and *26.2a_FAA_Fsh+Srvy*. Model *26.2_FAA*, which only disaggregated the NOAA Longline Survey index and age compositions, was deemed the minimally complex model necessary to address the primary goals driving the desire for exploring a FAA model. Model *26.2a_FAA_Fsh+Srvy*, which disaggregated the NOAA Longline Survey and fixed gear fishery fleets by region, was then deemed the least complex and most stable model that allowed disaggregating both the survey and fixed gear fleet (but required assuming a single fixed gear fishery time block due to instability in selectivity estimates when assuming two time blocks). Alternatives to these two base models were explored for the three primary parametrization options noted above, including the number of fishery fleets to model (e.g., 1, 2, or 3 fleets), whether to allow for domed selectivity in the BS fleets (fishery or survey), and whether to assume 1 or 2 fishery time blocks. Additionally, time-varying survey selectivity approaches were explored (see Section 2: Sensitivity Runs). However, most alternatives had extensive stability issues (e.g., due to trying to estimate domed selectivity or tradeoffs with sample sizes when fishery time blocks were added), while others portrayed poor diagnostics or data fits, and all were excluded from further consideration (only pertinent and select exploratory results are presented here).

We provide a comparison between the two primary FAA models (Model *26.2_FAA* and Model *26.2a_FAA_Fsh+Srvy*) in terms of data fits and diagnostics, model stability, and biological dynamics (see SM3C for full model outputs from each model). However, the summarized results focus primarily on comparisons of Model *26.2_FAA* to Model *26.1_1Reg*. See Table 3C.2 for a summary of models and results. Further model explorations that were deemed mostly exploratory for 2026 are then provided as sensitivity runs (see Section 2: Sensitivity Runs). A full mathematical description of the underlying SPoRC assessment framework is provided in Appendix 3A.

All models presented here utilize the same parametrization as the final single region model (*26.1_1Reg*; see Appendix 3B), with added complexity solely via fleet structure. For all model runs in this document, the final data through the end of 2025 were utilized as would have been available for the 2025 operational assessment. All models underwent Francis reweighting of compositional data to account for correlation among composition bins (Francis, 2011, 2017). All models are built in the R-TMB based generalized Spatial Populations over Regional Components (SPoRC) stock assessment R package (Cheng et al., 2026; https://chengmatt.github.io/SPoRC/index.html).

Primary model updates included:

- *26.1_1Reg*:
    - The final single region model for 2026 (see Appendix 3B for a full model description).

- *26.2_FAA*:
    - Matches the structure, settings, and data inputs as Model *26.1_1Reg* with adjustments to the NOAA Longline Survey fleet structure, where the fleets are disaggregated by 'region' including the BS, AI, and GOA.
    - Both the NOAA Longline Survey indices and age compositions are disaggregated by region and fit at the same scale.
    - The GOA data streams are aggregated (within the GOA) in the same way as the single region models, where area RPNs are summed across the GOA for the index and age compositions are aggregated using the same RPN-weighted aggregation approach as the single region model.
    - For each NOAA Longline Survey fleet, an independent catchability (q) parameter and two logistic selectivity parameters per sex (a_{50} and a_{95}) for each survey time block are estimated (i.e., compared to Model *26.1_1Reg* two additional q parameters and 16 additional selectivity parameters are estimated).
    - All other fleets (i.e., fixed gear fishery, trawl fishery, and Japanese Longline Survey) are aggregated to a single region matching the structure of Model *26.1_1Reg*.

- *26.2a_FAA_Fsh+Srvy*:
    - Matches the structure, settings, and data inputs as Model *26.2_FAA* with adjustments to the fixed gear fishery fleet structure, where the fleets are disaggregated by 'region' including the BS, AI, and GOA.
    - Both the fixed gear fishery catch and age compositions are disaggregated by region and fit at the same scale.
    - The GOA data streams are aggregated (within the GOA) in the same way as the single region models, where catch is summed across the GOA and age compositions are aggregated using the same catch-weighted (in numbers) aggregation approach as the single region model.

- For the fixed gear fishery, the associated time blocks for selectivity are removed due to stability issues because of reduced sample sizes (especially in the BS and AI) when composition data are disaggregated.
- For each fixed gear fishery fleet, an independent fishing mortality (F) parameter, yearly F deviations, and two logistic selectivity parameters per sex (a_{50} and k) are estimated (i.e., compared to Model *26.1_1Reg* two additional F parameters and four additional selectivity parameters – because a selectivity time block is removed -- along with two additional time series of F deviations are estimated).
- All other fleets (i.e., trawl fishery and Japanese Longline Survey) are aggregated to a single region matching the structure of Model *26.1_1Reg*.

Results

Disaggregating the NOAA Longline Survey indices and age compositions and using an FAA structure (Model *26.2_FAA*), led to moderate downward rescaling in SSB (Figure 3C.4, Table 3C.3) and average recruitment (Figure 3C.5), primarily due to a decline in M estimates (Figure 3C.6) as well as other scaling parameters (Table 3C.4). The result is a strong decline in $B_{40\%}$ and catch advice (Table 3C.3). Generally, the SSB trends remain consistent, though stock rebuilding increases more rapidly since 2018 in Model *26.2_FAA* compared to Model *26.1_1Reg*. The primary difference between models is the interpretation of recent recruitment events, where Model *26.2_FAA* now predicts that the 2017 year class is much larger than the 2016 year class and all subsequent recruitment has been considerably lower than in Model *26.1_1Reg* (Figure 3C.5).

Disaggregating the fixed gear fishery data in Model *26.2a_FAA_Fsh+Srvy* led to minor increases in SSB scaling as well as other scaling parameters (R_0, M; Tables 3C.3 – 3C.4), but results were generally similar to Model *26.2_FAA*. The major difference was that Model *26.2a_FAA_Fsh+Srvy* was very unstable, due to the need to estimate fishing mortality and selectivity parameters for two additional fleets with sparse data (e.g., the BS; Figure SM3C.39) as well as difficult to interpret trends (e.g., the enormous plus group in the AI in the 2010s; Figure SM3C.42). Moreover, Model *26.2a_FAA_Fsh+Srvy* had difficulty with initial scaling, as demonstrated in retrospective (Figure SM3C.91) and jitter (Figures SM3C.102 and SM3C.105) diagnostics. Given model instability, Model *26.2a_FAA_Fsh+Srvy* is not recommended, and the remaining results focus on comparisons between Model *26.2_FAA* and *26.1_1Reg*.

Despite disaggregating the NOAA Longline Survey indices and age comps in Model *26.2_FAA*, the relative data weights after Francis reweighting remain similar to Model *26.1_1Reg* (Table 3C.5). However, the fixed gear fishery age compositions are moderately downweighted, given the comparatively higher weights and increase in number of NOAA Longline Survey age composition data sets (Table 3C.5). Moreover, the AI age compositions receive moderate upweighting relative to other age composition data. It is likely that the AI compositions better align with the trends in the indices, such that the Francis reweighting upweights the AI because it allows simultaneously good fit to the indices compared to other composition data sets. Similarly, the AI appears to provide a mixture of recruitment signals (strong 2014, 2016, and 2017 year classes; Figure SM3C.24) that balances those in the BS (strong 2014 and 2016 and very strong 2017 year classes; Figures SM3C.18) and GOA (strong 2014 and very strong 2016 year classes; Figures SM3C.31), which may serve as a mediary when trying to fit the various composition data. However, there may also

be a data-year interaction related to the timing of the AI survey in even years (potentially matching years when some of the large recent recruitment events have occurred; e.g., 2014 and 2016). The resulting fit to the mean composition bins after reweighting do not drastically change compared to the single region model (Figures SM3C.2 – SM3C.3). However, disaggregation of the NOAA Longline Survey age compositions better elucidates the rapid reduction in mean age in recent years, particularly in the BS and AI, as well as the comparatively higher variation in mean age in these regions compared to the GOA.

The disaggregated NOAA Longline Survey indices demonstrate general agreement in long-term population trends across regions, with all indicating rapid population growth since 2015 (Figure 3C.7). Model *26.2_FAA* provides adequate fits to each index, given the slight discrepancies in signals, tension in fitting indices and age compositions from all three regions simultaneously, and the need to alias availability with catchability and selectivity estimates when assuming a single underlying population in a FAA model. Although fishery selectivity does not alter much (aside from trawl selectivity becoming a bit steeper; Figure 3C.8), survey selectivity for the GOA becomes much less steep (Figure 3C.9). The GOA selectivity shape reflects the model assuming that the younger age classes (< age-20 and aside from age-2) were less available to the GOA survey. Ultimately, the tension between fitting the age compositions and indices, an underlying issue in Model *26.1_1Reg*, remains in Model *26.2_FAA*, because better fit to the age compositions would result in a strong overestimation of GOA survey RPNs in recent years (see Model *26.2_FAA_DM* which effectively upweights composition data leading to overestimation of the GOA index; Figure 3C.27).

It is also worth noting that the strong differences in the shape of the survey selectivity curves across regions (i.e., much steeper in BS and AI compared to GOA) leads to an interesting divergent trend in the last few years in the predicted index. The BS and AI predicted indices begin to decline despite observed RPNs continuing to increase, while the GOA continues to increase and better fits the increasing observed index (Figure 3C.7). The reason for the divergence across regions is due to the tradeoff between survey selectivity, cohort mortality, and reductions in estimated year class sizes since the 2017 year class. Mainly, for the BS and AI survey indices, maximum selectivity occurs around age-4, so a cohort's maximum contribution to RPNs will decline after this age due to ongoing mortality (i.e., the size of the cohort can only decline). Conversely, in the GOA, survey selectivity is maximum around age-20, so there is a tradeoff between slowly increasing selectivity and increasing cohort removals due to mortality across the lifespan, such that maximum contributions to RPNs likely occur at intermediate ages (but much later than in the BS and AI). Because the 2017 year class has reached full selection in the BS and AI surveys, it is the largest cohort in the time series, and subsequent cohorts have been much smaller, the model predicts a decline in BS and AI RPNs starting around 2022 (i.e., when the cohort reaches age-5). For the GOA, the predicted survey index continues to increase because the tipping point between mortality and selectivity has not yet been reached. To verify that this is true, a sensitivity run was undertaken where the GOA NOAA Longline Survey selectivity was fixed at the AI values. As expected, when the GOA survey selectivity was much steeper, the resulting predicted index increased much more rapidly, greatly overestimated the recent observed index, and began to decline after 2023 (Figure 3C.10)

For composition data in Model *26.2_FAA*, fits tend to show similar patterns as Model *26.1_1Reg*, particularly for the spatially aggregated fleets (Figures SM3C.45 – SM3C.46). A notable change is that the fixed gear fishery male age compositions demonstrate a noticeably worse fit for Model *26.2_FAA*, where expected values are much higher than observed for ages 4 – 6 (Figure SM3C.49). The pattern was present in Model *26.1_1Reg* for certain years (e.g., 2012 -- 2013) but has become much more exacerbated in Model *26.2_FAA*. Fixed gear fishery male selectivity in the first time block is estimated to be much steeper in Model *26.2_FAA* (Figure SM3C.6), which is likely driving the overestimation of young male fish. The relative downweighting of the fishery age compositions relative to the multiple NOAA Longline Survey age composition data sets is probably a primary factor in the poorer fit to the fishery age compositions in Model *26.2_FAA* (Table 3C.5).

Given the disaggregation by region of the NOAA Longline Survey age compositions in Model *26.2_FAA*, it is not possible to make a direct comparison to Model *26.1_1Reg* survey composition fits. However, because the GOA compositions are more highly sampled and receive higher relative weight in the aggregation method for the single region model, the GOA compositions in the FAA model are quite similar. Generally, the observed and predicted survey compositions are quite similar (Figures SM3C.30 – SM3C.31), with generally similar residual patterns (Figures SM3C.33 – SM3C.34). A noticeable difference is that Model *26.2_FAA* strongly overestimates age-2 compositions across sexes but has a slightly improved estimate for intermediate ages (e.g., ages 10 to 20). Fits to the BS and AI NOAA Longline Survey age compositions tend to be adequate in Model *26.2_FAA*, especially considering the relatively lower sample sizes and increased sparsity across ages (Figures SM3C.18 and SM3C.24). The AI age data tends to be fit slightly better, given the relatively higher final ESS. Residual patterns tend to reflect the pervasive trend seen in Model *26.1_1Reg* of generally underestimating peak abundance at ages 4 – 6 and overestimating intermediate ages 10 – 20 as well as the plus group (Figures SM3C.20 – SM3C.26). No major changes in the fits to the Japanese Longline Survey or trawl fishery compositions were detected for Model *26.2_FAA* compared to Model *26.1_1Reg* (see the SM3C figures for all plots of compositional fits as well as One Step Ahead, OSA, and Pearson residuals). Given the pervasive tension between simultaneously fitting the indices versus the compositions, and the resulting lower weights given to the composition data, the fits across data sources for Model *26.2_FAA* were deemed adequate and on par with those from Model *26.1_1Reg*.

Similarly, no major changes were noted in the other key model diagnostics. Model *26.2_FAA* demonstrates little retrospective patterning in SSB, with a slight tendency to underestimate SSB as data is removed similar to Model *26.1_1Reg* (Figures SM3C.89- SM3C.90). Similarly, large recruitment year classes are often initially underestimated, but estimates tend to stabilize more quickly for Model *26.2_FAA* (Figures SM3C.92 – SM3C.93). However, the internal tension and difference in recruitment signals across age composition data sources (e.g., the different NOAA Longline Survey regional compositions) for Model *26.2_FAA* is apparent, given the switch between 2016 and 2017 being the dominant year class as more data is integrated over time, as well as the downsizing of the 2014 year class (Figure SM3C.90). As noted, the GOA compositions tend to favor the 2016 year class, whereas the BS favors the 2017 year class and the AI demonstrates strong signals for both. Aside from conflicting signals within the age compositions themselves, there is also a year-data interaction, given the historical odd-even year survey design for the BS and AI regions, respectively. Therefore, the retrospective pattern partially reflects a data

availability issue, where initial recruitment signals are probably dominated by patterns in the GOA, then shift slightly towards the BS and AI signals as those data become available.

Likelihood profiles on key scaling parameters show similar trends across models, although those from Model *26.2_FAA* tend to be more stable and demonstrate a stronger minima for the age composition data (i.e., the primary source of information on recruitment and *M*; Figures SM3C.95 – SM3C.98). Not surprisingly, given the final estimates (Table 3C.4), the age composition data indicate lower values for *M* and R_0 in Model *26.2_FAA*. Jitter diagnostics remain essentially unchanged across models, demonstrating that both have likely found a robust solution and demonstrate strong stability and convergence (Figures SM3C.100 – SM3C.104).

As noted, model building involved hundreds of exploratory runs to understand model performance, identify robust model parametrizations, and better understand key assumptions. Given the results of the simulation study demonstrating that domed selectivity for BS fleets may be warranted to address availability (Figure 3C.1), an exploratory run that assumed domed BS NOAA Longline Survey selectivity for the recent survey time block was developed. Results demonstrated improved fits to BS mean age, compositions, and the associated BS index (Figure 3C.11). However, estimating domed selectivity led to moderate model instability and worse fits to the survey indices for the other regions (Figure 3C.11).

To better understand the impact of using extrapolated ('carryover') NOAA Longline Survey index RPN values for years when a region was not surveyed, an exploratory model was run that used similar assumptions to regional index construction as Model *26.1_1Reg*. Mainly, for a survey off-year in a given region, the previous (carryover) RPN was used for the off-year value (instead of assuming a missing data point, as in Model *26.2_FAA*), such that there were no data gaps in the regional indices (aside from 2024 when there was no survey). Interestingly, the use of extrapolated carryover values led to a strong upward scaling of SSB, particularly since the start of the NOAA Longline Survey in the mid-1990s (Figure 3C.12). The increase in recent scaling is driven primarily by major increases in the estimates of the large year classes (e.g., 2014, 2016, and 2017). Because carryover RPNs are not accompanied by associated age compositions, there is likely a non-intuitive interaction between fitting these static index values for the BS or AI and fitting the survey age compositions for the regions that were surveyed while assuming all these data simultaneously provide signals from a single population. Using carryover values may also implicitly act to upweight each survey data point, by effectively including it twice in a given index (since a given value is repeated in the following year when a region is not sampled). Ultimately, this exploratory run demonstrates the potential downsides of using extrapolated data in the assessment, indicating that Model *26.1_1Reg* (and any single region model for sablefish) could be artificially inflating the resulting recruitment, SSB, and catch advice due to the need for using extrapolated survey values.

Notable changes in model dynamics included (Table 3C.2):

- *26.1_1Reg* (full results here):
    - A stable model that provides good fits to the NOAA Longline Survey index.
    - Mediocre fits to age compositions.

    - Requires extrapolating (using carryover method) ~50% of the NOAA Longline Survey index in a given year (to maintain a consistent scale for the single region assessment) for non-surveyed regions.
    - GOA composition data are implicitly over-represented during data aggregation due to higher sampling and catch which likely under-represents recruitment signals from the BS and AI, resulting in extremely large 2016 year class.

- *26.2_FAA* (full results here):
    - Model remains relatively stable and demonstrates adequate fits to the disaggregated NOAA Longline Survey indices.
    - Shows similar tension as single region model when simultaneously trying to fit indices and age compositions and demonstrates poor fit to the fixed gear fishery male age compositions.
    - GOA NOAA Longline Survey selectivity becomes less steep, reflecting need for model to alias regional availability with selectivity.
    - Recruitment trends better reflect signals from BS and AI as evident by increasing estimates of 2014/2017 year classes and decreases in the 2016 year class.
    - Moderate downward scaling of SSB due to decreasing estimates of M and R_0, likely reflecting the removal of extrapolated index data.
    - Retrospective patterns are minimal for SSB, while continued underestimation of large recruitment events occurs as well as switching between large year classes (2016 vs. 2017) as new data become available.

- *26.2a_FAA_Fsh+Srvy* (full results here):
    - Due to stability issues with selectivity estimation, the fishery time blocks needed to be removed to ensure convergence.
    - Increased stability issues, especially for initial scale and selectivity estimation.
    - Data sparsity issues are present for BS and AI fishery age compositions.
    - There are no major changes in fits to the data, with GOA fixed gear fishery age compositions showing similar overestimation of age 4 to 6 compositions as the fixed gear fishery compositions in Model *26.2_FAA*.
    - Demonstrates a minor upward scaling of SSB, but stock status and catch advice remain similar to Model *26.2_FAA*.
    - Minor retrospective patterns emerge for SSB and recruitment, primarily indicating model instability, particularly with initial scale.
    - Jitter diagnostics indicate a consistent solution was not found, again associated with uncertainties in the initial population scale, further demonstrating model stability issues.

Conclusion

Model *26.2_FAA* appears to provide a robust and stable model for interpreting sablefish population dynamics. Although Model *26.2_FAA* assumes a moderate downward scaling of SSB and catch advice, general population dynamics and stock status remain consistent with Model *26.1_1Reg*. Similarly, fits to the available data retain similar issues, where survey indices are well fit at the

expense of composition data, as a result of the Francis reweighting approach. Although residual patterns in the composition data remain, the aggregated fits continue to appear adequate given associated model tension between fitting the NOAA Longline Survey indices versus age compositions. Fundamentally, both models have trouble reconciling the much larger year classes and population growth suggested by the age composition data compared with the rapid, but more tempered, population growth observed in the survey RPNs. All model diagnostics, including retrospectives, indicated that Model *26.2_FAA* is relatively stable and showed no signs of significant misspecification. Although other FAA models were explored, data sparsity issues resulted when attempting to regionally disaggregate the fishery data, suggesting that Model *26.2_FAA* was a suitable model of intermediate complexity.

Ultimately, the choice of model structure for the sablefish assessment necessitates a tradeoff between data quality and quantity. For instance, utilizing a single region assessment and aggregating data provides improved sample sizes, but requires extrapolating NOAA Longline Survey index values to ensure consistent scaling and may over-represent GOA age compositions. Conversely, disaggregating the NOAA Longline Survey data into regional 'fleets' in an FAA model avoids the need to extrapolate indices, but greatly reduces sample sizes and may increase the noise to signal ratio in the age compositions. There is not a 'silver bullet' solution to this conundrum. However, the exploratory FAA model run using the 'carryover' approach was enlightening as it showed the potential downside of using extrapolated data in the assessment, given that it led to a much more optimistic estimate of stock status and catch advice. Although the sablefish MSE work indicates that the carryover extrapolation is not likely to have a major detrimental impact on management advice from the single region model, it does appear that using extrapolated values in the index should be considered judiciously. Thus, Model *26.2_FAA* should be considered as a good candidate for the sablefish operational assessment and management, given that it does not rely on any data extrapolation and appears to provide a stable and robust assessment.

Tables

Table 3C.1. Summary of tradeoffs between using a single region, Fleets-as-Areas (FAA), and muti-region (spatial) models for sablefish.

Model	*Benefits*	*Issues*	*MSE Conclusions*	*Tradeoffs*
Single Region Model	High sample sizes. Low model complexity. Intuitive and transparent results. High inertia towards moving away from status quo assessment methodology.	Requires fitting extrapolated data for the Longline Survey Index. Implicit historical over-weighting of GOA composition data during aggregation or high interannual variability recently (GOA then BS/AI). Little signal from BS/AI compositions, because GOA given higher weight (RPNs or catch) in data aggregation. Ignores spatial structure.	Moderate SSB bias and moderate instability due to the survey extrapolation and aggregated composition data but impacts on resulting management advice may be negligible.	Higher sample sizes and improved stability but requires fitting the extrapolated longline survey index and primarily represents the recruitment signals from the GOA due to data aggregation assumptions.
Fleets-as-Areas (FAA)	Fitting non-extrapolated Longline Survey index. Fitting disaggregated survey compositions. Better accounts for signals from BS/AI compositions on recent year class strength. Implicitly accounts for ontogenetic movement dynamics	Low sample sizes and sparse data for BS/AI compositions. Increased instability from added complexity (estimating extra *q* and selectivity parameters for 'regional' survey fleets and/or extra *F* and selectivity parameters for fishery fleets). Non-intuitive estimates that are difficult to interpret (e.g., due to using multiple fleets that are interacting with a single underlying population – not multiple populations/regions). Selectivity needs to be flexible to address ontogenetic dynamics.	Low SSB bias and instability with improved performance over other structures when survey coverage decreases, but adequate flexibility in selectivity parametrizations is likely needed to ensure good performance.	Able to fit the regional longline survey indices without aggregation and likely provides more robust outputs when survey coverage decreases, but sample size limitations may prevent adequate selectivity flexibility to address ontogenetic availability issues due to model instability.
Spatial (3 or 5 Region)	Fit data at the regional scale it was collected. Better account for signals from each region. More intuitive than FAA. Explicitly account for ontogenetic movement dynamics.	Increased sample size limitations. Increased parametrization decisions related to spatial processes. Lack of best practices for fitting tagging data (e.g., dealing with tag mixing issues and data weighting). Increased parameter correlation, particularly between regional recruitment parameters and movement. Diagnostics can be difficult to interpret. Increased instability.	High instability due to overparameterization and low sample sizes but best represents localized dynamics.	Best represents spatial dynamics but suffers from high model instability due to data sparsity that requires extremely careful parametrization, while appropriate handling of tagging data is difficult and potentially subjective.

Table 3C.2. Primary FAA model runs, including major differences, rationale, and summary of results.

Model Group	*Model Name*	*Major Changes*	*Rationale*	*Conclusion*
Final 1 Region Model	***26.1_1Reg***	(*26.1i*) None.	The 2026 final proposed single region model with all updates implemented.	• A stable model that provides good fits to the NOAA Longline Survey index. • Mediocre fits to age compositions. • Requires extrapolating (using carryover method) ~50% of the NOAA Longline Survey index in a given year (to maintain a consistent scale for the single region assessment) for non-surveyed regions. • GOA composition data are implicitly upweighted during data aggregation due to higher sampling and catch which likely under-represents recruitment signals from the BS and AI, resulting in extremely large 2016 year class.
Final FAA Model	*26.2_FAA_Srvy*	(*26.1+*) Split NOAA Longline Survey into 3 independently modeled fleets, with unique parameters (*q*, selectivity).	Balance ability to fit regional indices and comps against rapidly increasing complexity from adding fleets.	• Model remains relatively stable and demonstrates adequate fits to the disaggregated NOAA Longline Survey indices. • Continues to show similar tension with simultaneously fitting age compositions, with poor fit to the fixed gear fishery male age compositions. • GOA NOAA Longline Survey selectivity becomes less steep, reflecting need for model to alias regional availability. • Recruitment trends better reflect signals from BS and AI as evident by increasing estimates of 2014/2017 year classes and decreases in the 2016 year class. • Moderate downward scaling of SSB due to decreasing estimates of M and R0, likely reflecting the removal of extrapolated index data.
Alternate FAA	*26.2a_FAA_Fsh+Srvy*	(*26.2+*) Split the fixed gear fishery into 3 independently modeled fleets, with unique parameters (*F*, selectivity) and remove fishery time blocks.	Further parse out recruitment signals from BS and AI by disaggregating fishery fleets.	• Increased stability issues, especially for initial scale. • Data sparsity issues for BS and AI fishery age compositions. • Minor upward scaling of SSB.

Table 3C.3. Key management quantity outputs. SSB is in kt, B_Ref_Pt is the associated $B_{40\%}$ reference point in kt, and F_Ref_Pt is the associated $F_{40\%}$. Catch advice is the 2026 Acceptable Biological Catch (ABC) resulting from fishing at $F_{40\%}$.

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
26.1_1Reg	1	216.4521	369.6689	0.04642913	40.85173	139.0172	0.07903	1.55702	0.58553	0.58749
26.2_FAA	1	193.1500	358.1881	0.05874255	31.69570	122.4267	0.08054	1.57768	0.53924	0.72940
26.2a_FAA_Fsh+Srvy	1	196.3059	353.5244	0.05864900	33.14317	120.4123	0.08484	1.63028	0.55528	0.69129

Table 3C.4. Estimates of primary scaling parameters (e.g., catchability, q, unfished recruitment, R_0, and natural mortality, M) along with associated standard error (SE) estimates from each model. All parameters and associated SE are in natural logarithmic (ln) space. The maximum gradient value across all parameters is also shown as a metric of model convergence.

Parameter	Model *26.1_1Reg*		Model *26.2_FAA*		Model *26.2_FAA_Fsh+Srvy*	
	Estimate	*SE*	*Estimate*	*SE*	*Estimate*	*SE*
ln_R0	2.97	0.13	2.76	0.11	2.88	0.12
ln_M_female	-2.39	0.07	-2.43	0.07	-2.39	0.07
ln_M_male	-2.41	0.07	-2.44	0.08	-2.36	0.08
ln_q_LLS	1.91	0.10	--	--	--	--
ln_q_LLS_BS	--	--	0.55	0.10	0.50	0.10
ln_q_LLS_AI	--	--	0.34	0.10	0.30	0.10
ln_q_LLS_GOA	--	--	2.20	0.08	2.13	0.08
Max. Gradient	2.91 e -10		7.64 e -10		5.86 e -12	

Table 3C.5. Assumed mean (across years) statistical distribution variance terms for each data source defined in terms of standard error (SE) for indices or input sample size (ISS) for compositional data for Model *26.1_1Reg* (left), Model 26.2_FAA (middle), and Model *26.2a_FAA_Fsh+Srvy* (right). The compositional data weights (*λ,* Data_Wt) are calculated using the Francis reweighting method (Francis, 2011). The effective values (Eff_SE or effective sample size, ESS) represent the input values multiplied by the data weights and are the final variance terms used to fit the data in the assessment likelihoods. All compositional data are fit using the 'joint' approach (Cheng et al., 2025b), so only a single ISS/ESS or weighting term is provided across both sexes.

Source	SE	Eff_SE	Data_Wt	ISS	ESS
LL Survey Index	0.07	0.07	1.00	NA	NA
JPN LL Survey Index	0.07	0.07	1.00	NA	NA
Fixed Gear Fish Ages	NA	NA	0.12	145.15	17.69
LL Survey Ages	NA	NA	0.28	171.43	47.31
JPN LL Survey Ages	NA	NA	0.17	83.33	14.45
Trawl Fish Lengths	NA	NA	0.25	45.39	11.51
JPN LL Survey Lengths	NA	NA	0.34	54.62	18.84

Source	SE	Eff_SE	Data_Wt	ISS	ESS
BS LL Survey Index	0.20	0.20	1.00	NA	NA
AI LL Survey Index	0.24	0.24	1.00	NA	NA
GOA LL Survey Index	0.08	0.08	1.00	NA	NA
JPN LL Survey Index	0.07	0.07	1.00	NA	NA
Fixed Gear Fish Ages	NA	NA	0.04	145.15	6.08
BS LL Survey Ages	NA	NA	0.51	37.43	19.15
AI LL Survey Ages	NA	NA	1.91	39.14	74.82
GOA LL Survey Ages	NA	NA	0.29	77.14	22.66
JPN LL Survey Ages	NA	NA	0.18	83.33	15.33
Trawl Fish Lengths	NA	NA	0.14	45.39	6.53
JPN LL Survey Lengths	NA	NA	0.33	54.62	17.98

Source	SE	Eff_SE	Data_Wt	ISS	ESS
BS LL Survey Index	0.20	0.20	1.00	NA	NA
AI LL Survey Index	0.24	0.24	1.00	NA	NA
GOA LL Survey Index	0.08	0.08	1.00	NA	NA
JPN LL Survey Index	0.07	0.07	1.00	NA	NA
BS Fixed Gear Fish Ages	NA	NA	0.33	26.92	8.81
AI Fixed Gear Fish Ages	NA	NA	0.04	29.65	1.14
GOA Fixed Gear Fish Ages	NA	NA	0.11	64.15	6.96
BS LL Survey Ages	NA	NA	0.56	37.43	20.87
AI LL Survey Ages	NA	NA	1.81	39.14	70.68
GOA LL Survey Ages	NA	NA	0.33	77.14	25.84
JPN LL Survey Ages	NA	NA	0.17	83.33	14.56
Trawl Fish Lengths	NA	NA	0.15	45.39	6.73
JPN LL Survey Lengths	NA	NA	0.34	54.62	18.61

Figures

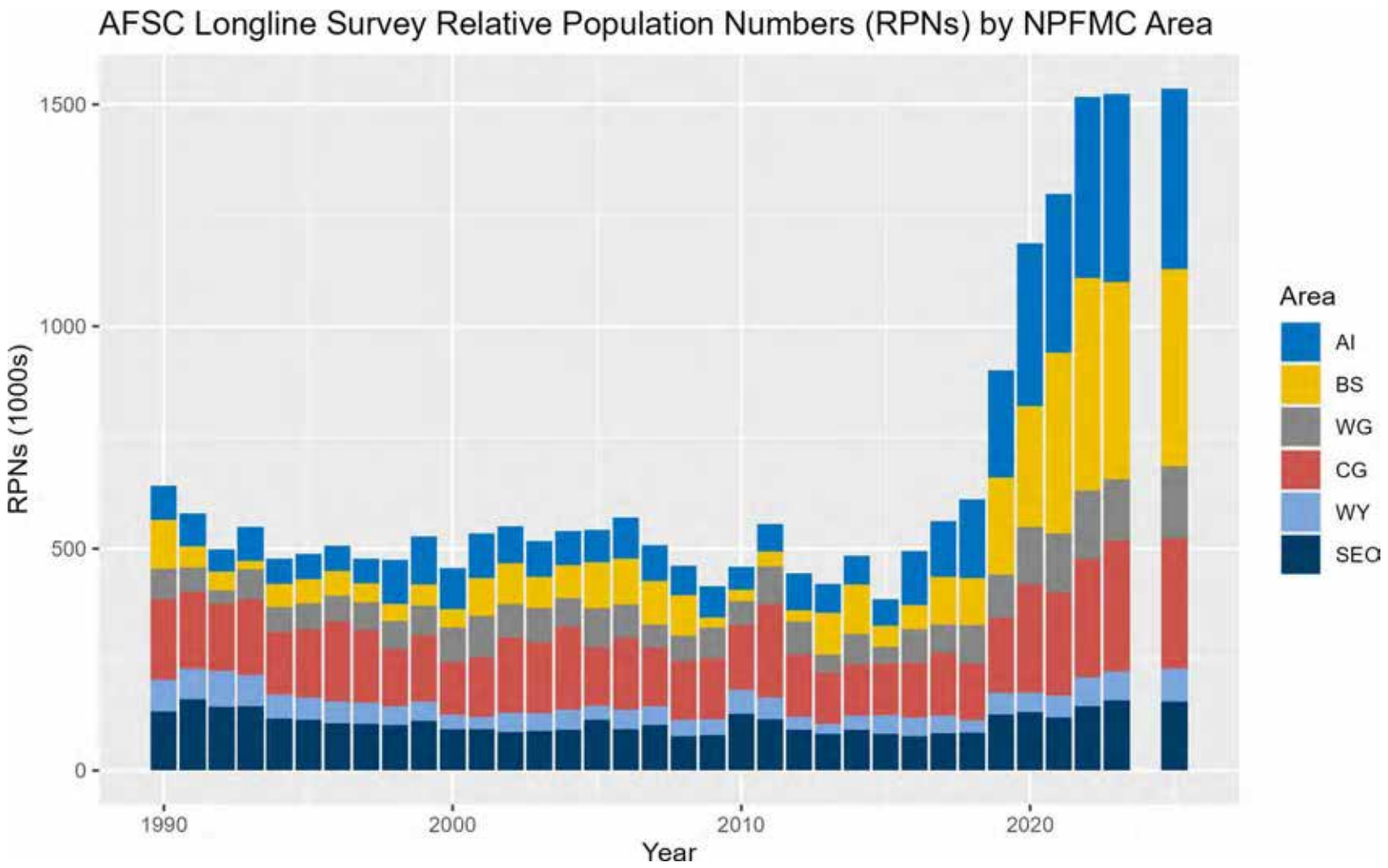

Figure 3C.1. NOAA Longline Survey relative population numbers (RPNs, 1000s of fish) by region. Note that the Western Gulf (WG), Central Gulf (CG), Western Yakutat (WY), and Southeast Outside (SEO) are all part of the Gulf of Alaska (GOA) region.

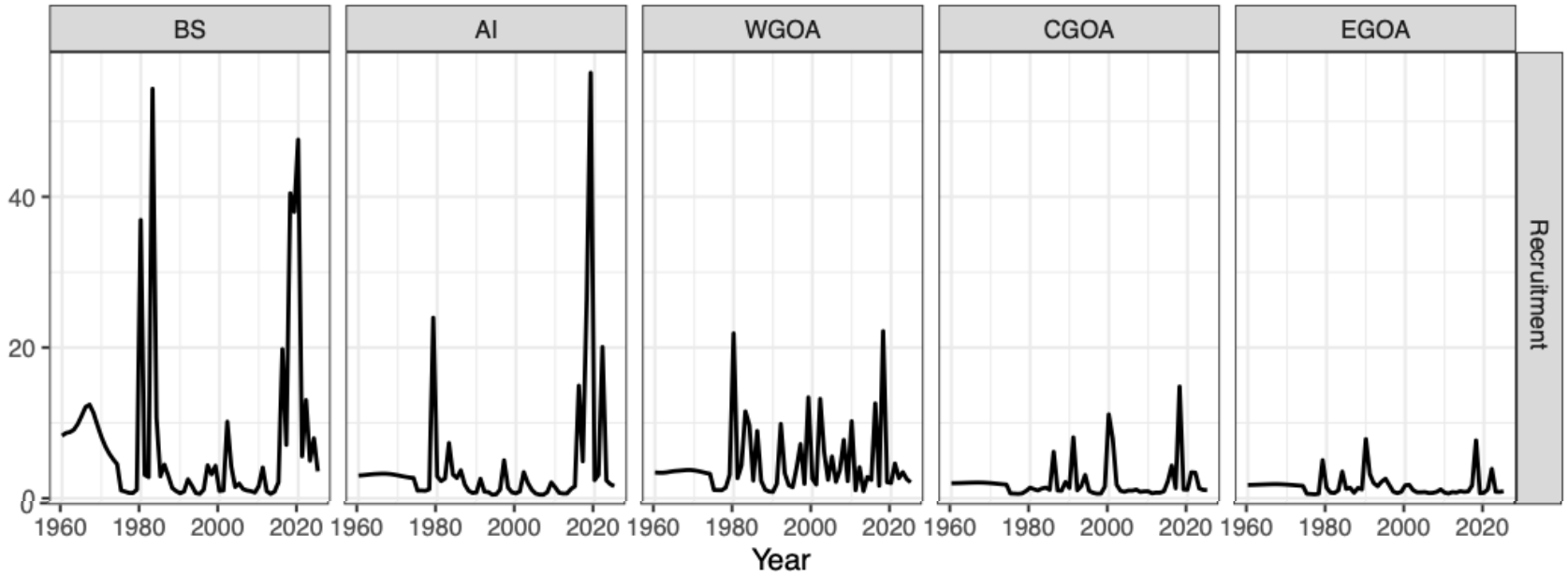

Figure 3C.2. Time-series of recruitment (millions of age-2 fish) by region from the five-region spatial model (See Appendix 3D).

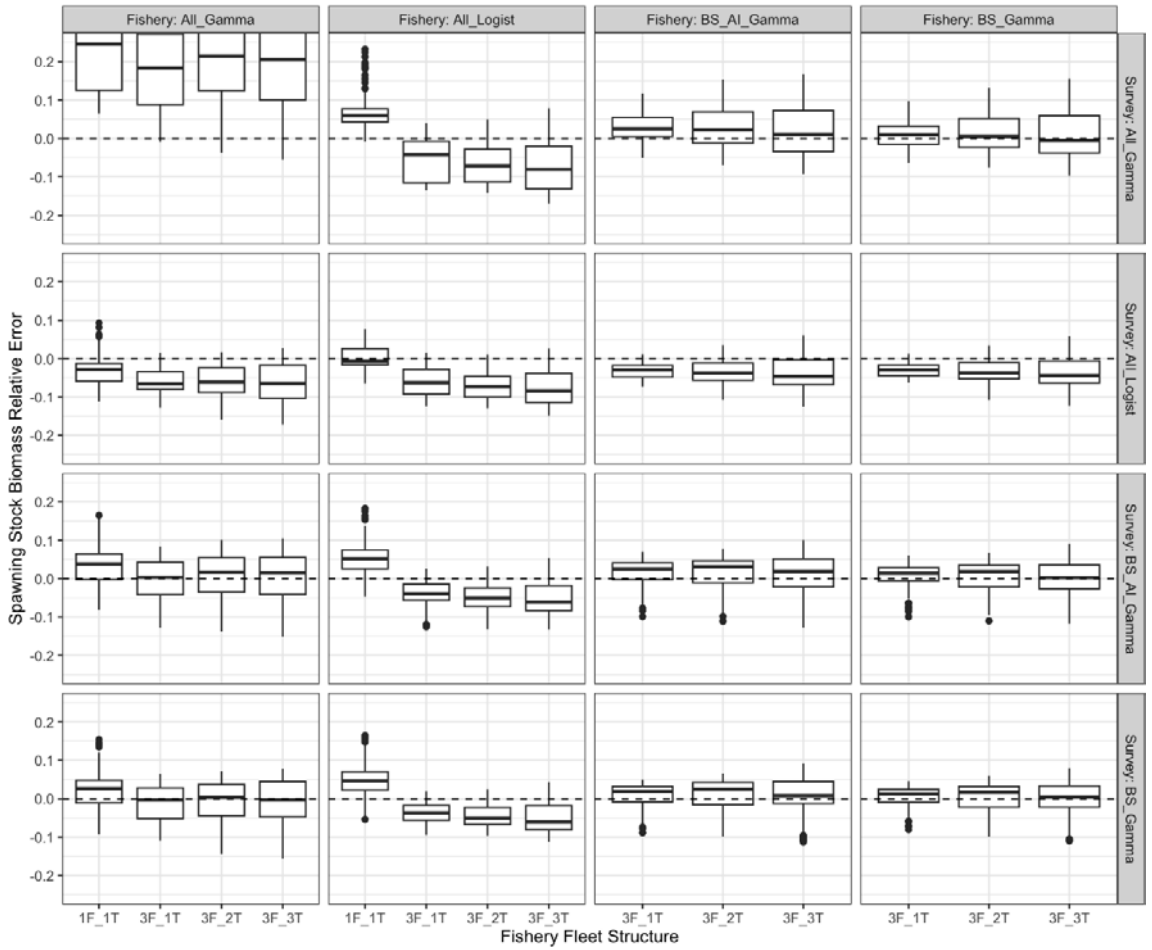

Figure 3C.3. Relative error in estimates of SSB (median across all years) of the simulation experiment that explored assessment bias for different Fleets-as-Areas structures in the fishery (x-axis) as well as selectivity functional forms (fixed gear fishery – column facets; NOAA Longline Survey – row facets). Note that all models assumed three NOAA Longline Survey fleets and a single (aggregated) Japanese Longline Survey fleet. For the x-axis, F stands for fixed gear (longline) fishery, T stands for the trawl fishery and the preceding number is the number of fleets for that fishery (3 means 3 fleets split by region -- BS, AI, and GOA; 2 means 2 fleets split by BS and AI + GOA, and 1 means a single aggregated fleet across all regions). The intersection of the logistic fishery and logistic survey facets provides models matching the FAA models described in this document, where 1F_1T generally matches Model *26.2_FAA* and 3F_1T generally matches model *26.2a_FAA_Fsh+Srvy*. See Appendix 3E for full results.

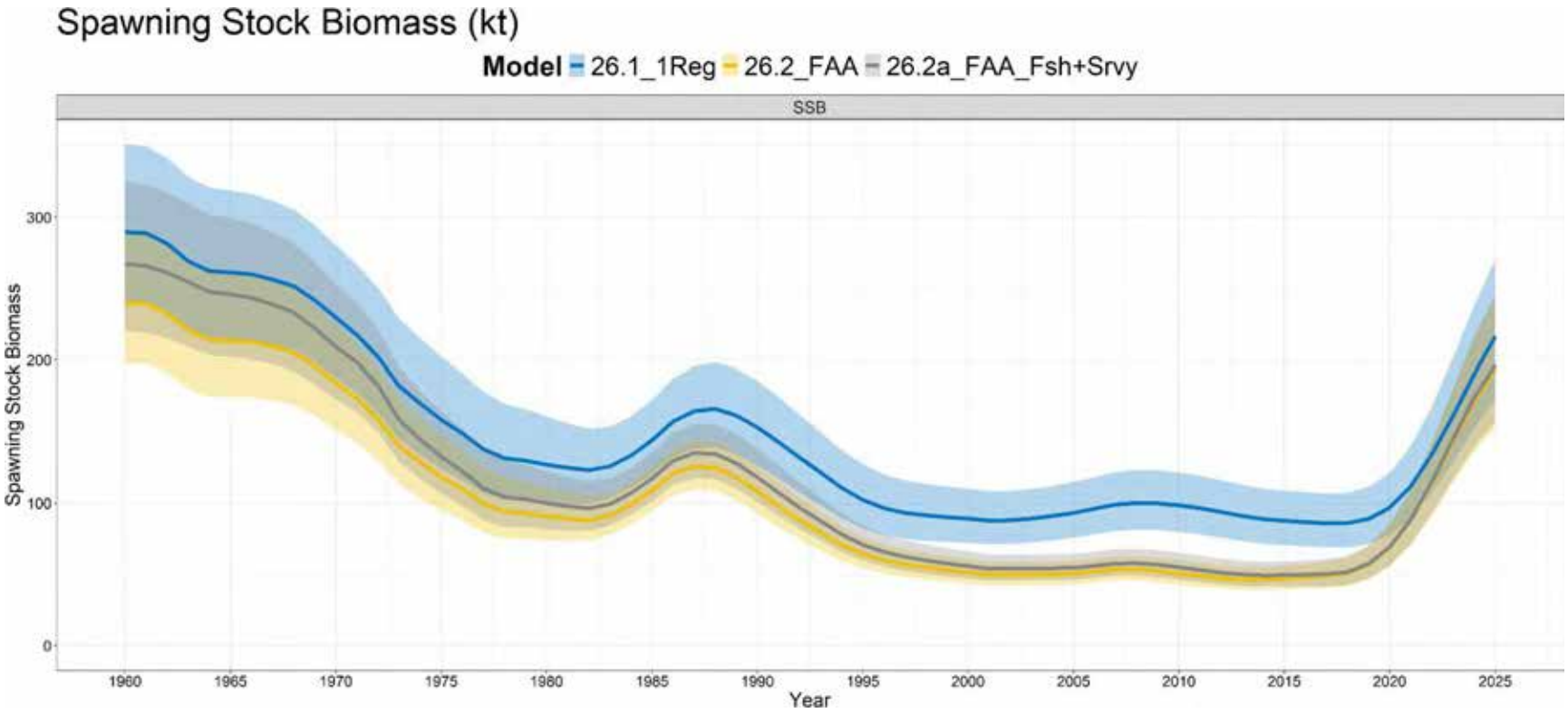

Figure 3C.4. Comparison of spawning stock biomass (SSB, in kilotons) across models, where shaded regions represent the 95% confidence intervals.

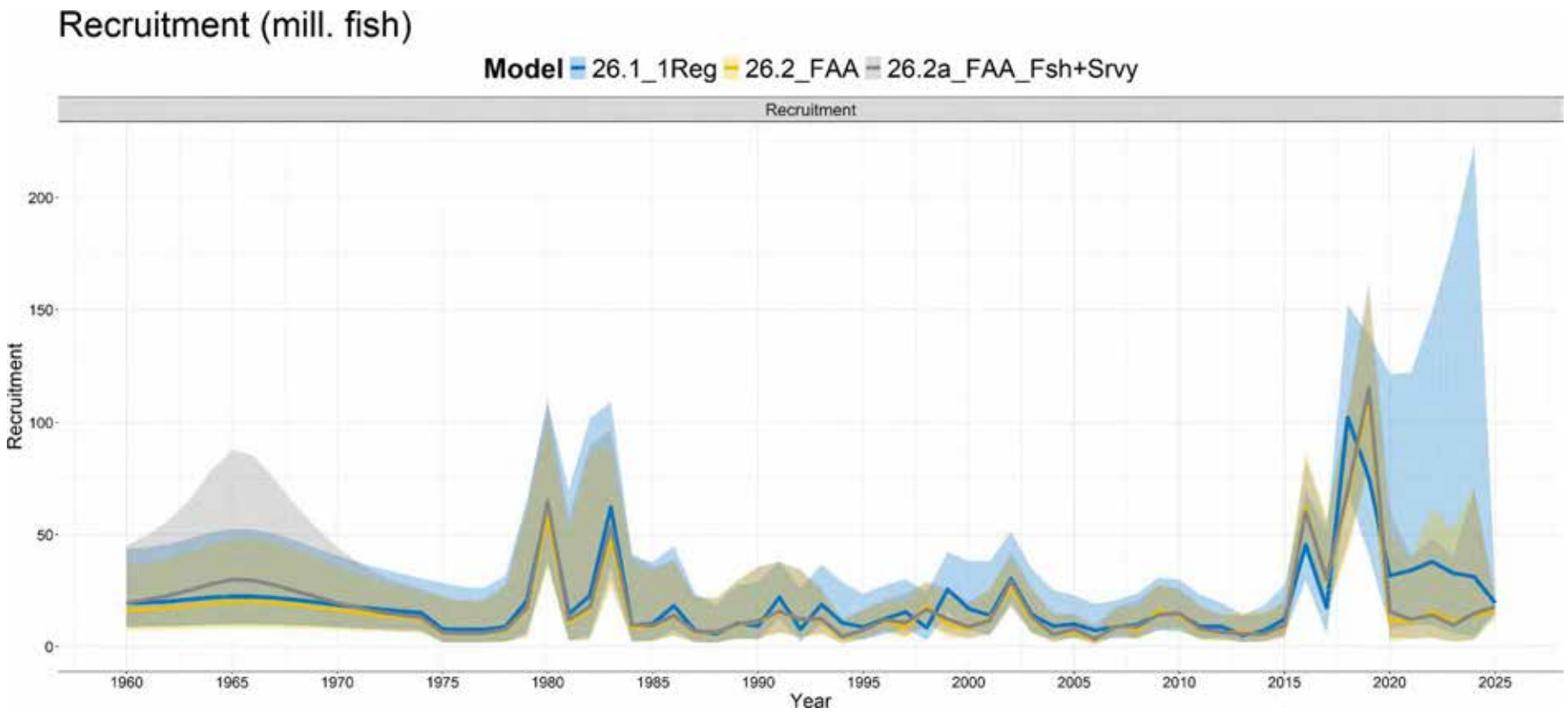

Figure 3C.5. Comparison of recruitment (in millions of fish) across models, where shaded regions represent the 95% confidence intervals.

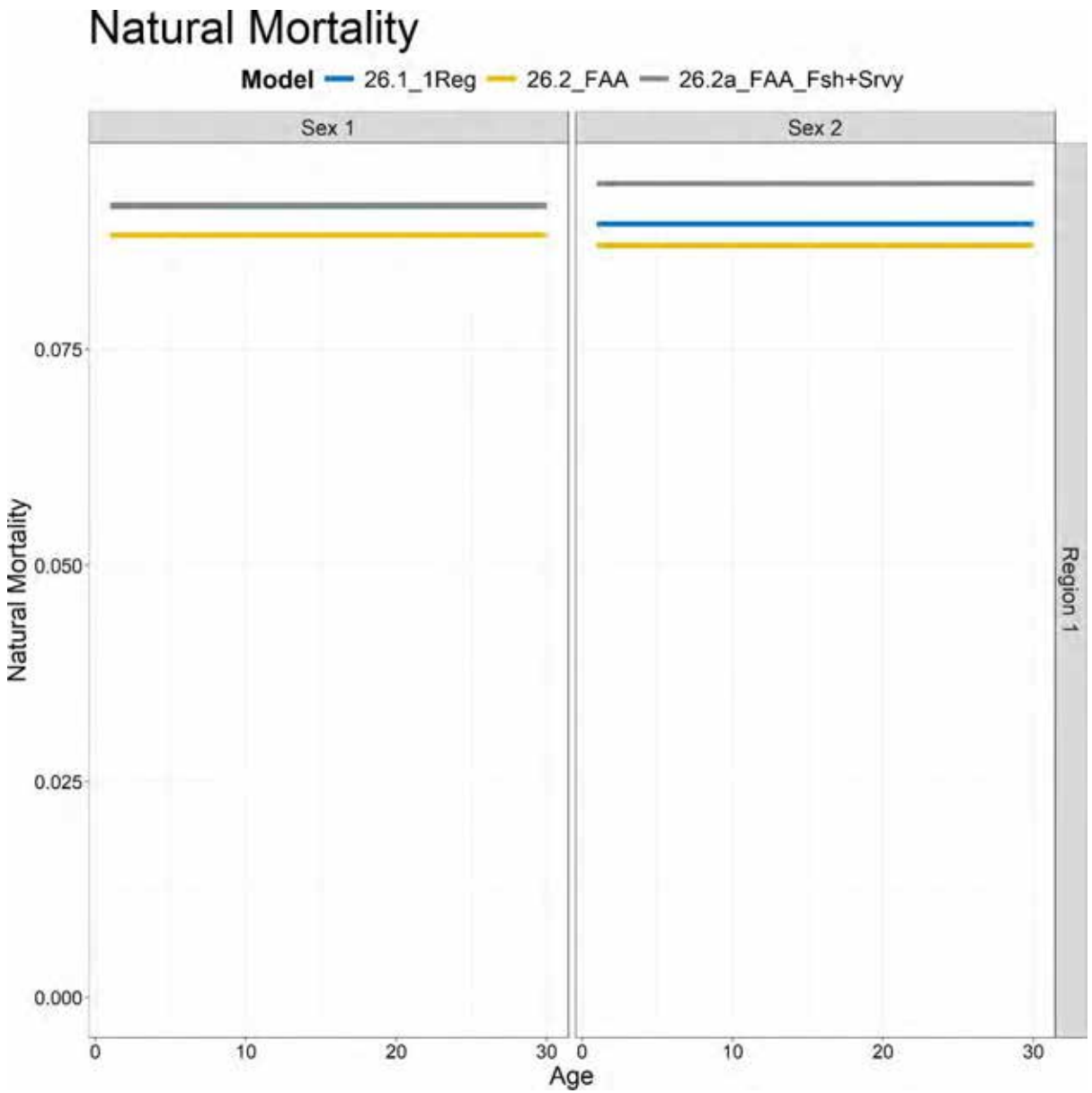

Figure 3C.6. Comparison of natural mortality estimates across models. Sex 1 is females and sex 2 is males.

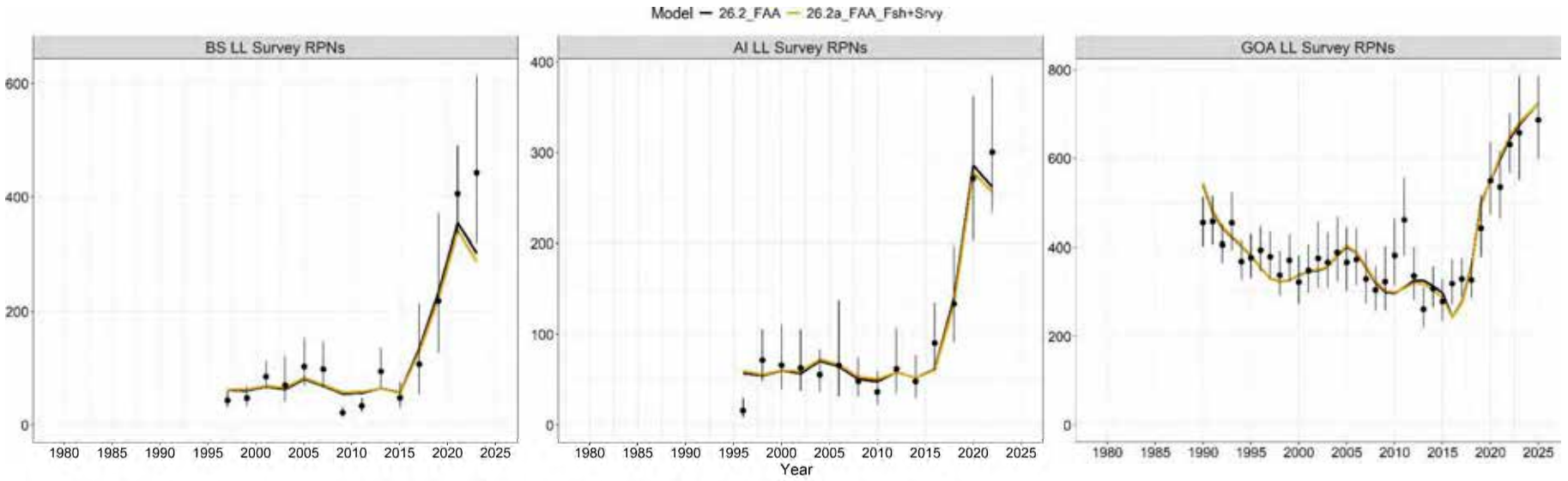

Figure 3C.7. Fits (lines) to the NOAA Longline Survey abundance indices in relative population numbers (RPNs – 1000s of fish, y-axis; black dots with vertical lines representing 95% confidence intervals) for the FAA models.

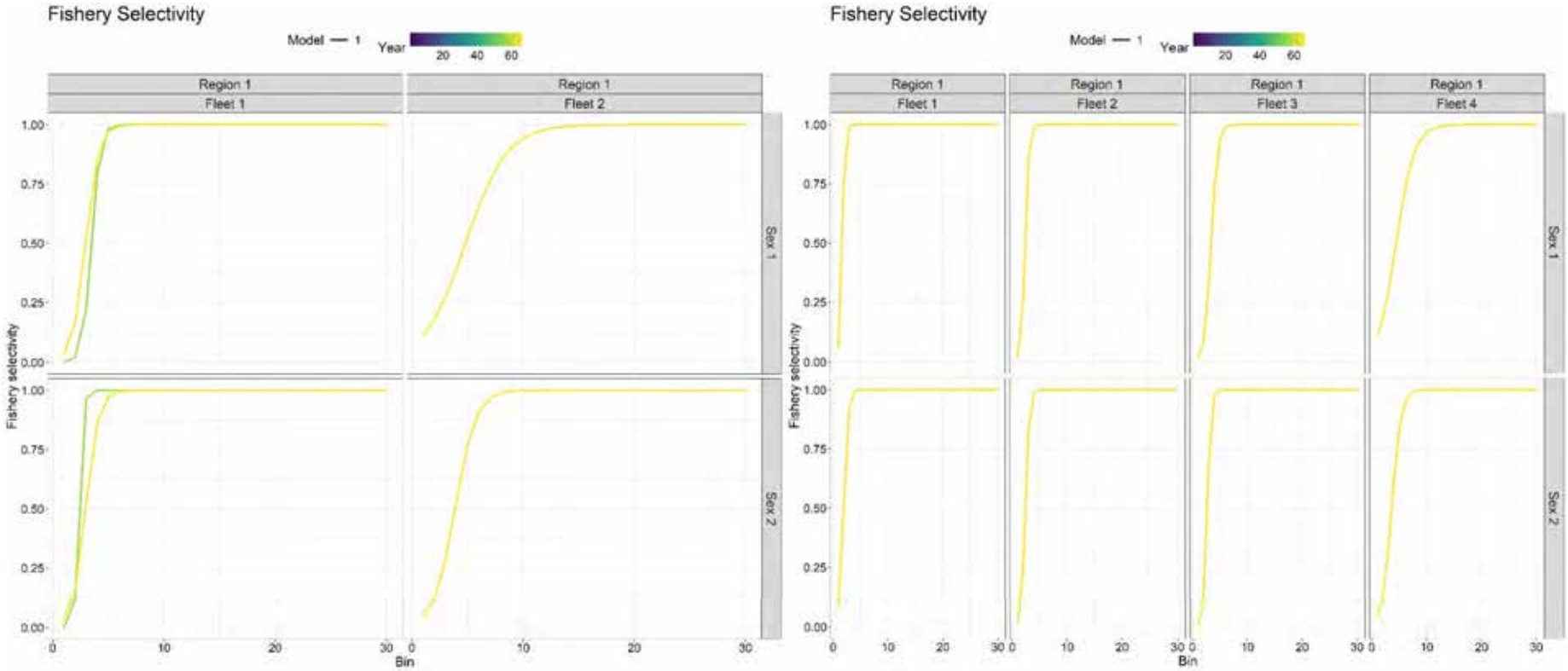

Figure 3C.8. Comparison of fishery selectivity for Model *26.2_FAA* (left panels) and Model *26.2a_FAA_Fsh+Srvy* (right panel). Sex 1 is females and sex 2 is males. For Model *26.2_FAA* Fleet 1 is the fixed gear fishery and Fleet 2 is the trawl fishery. For Model *26.2a_FAA_Fsh+Srvy* Fleet 1 is the Bering Sea fixed gear fishery, Fleet 2 is the Aleutian Islands fixed gear fishery, Fleet 3 is the Gulf of Alaska fixed gear fishery, and Fleet 4 is the trawl fishery. All models assume logistic selectivity for fishery fleets.

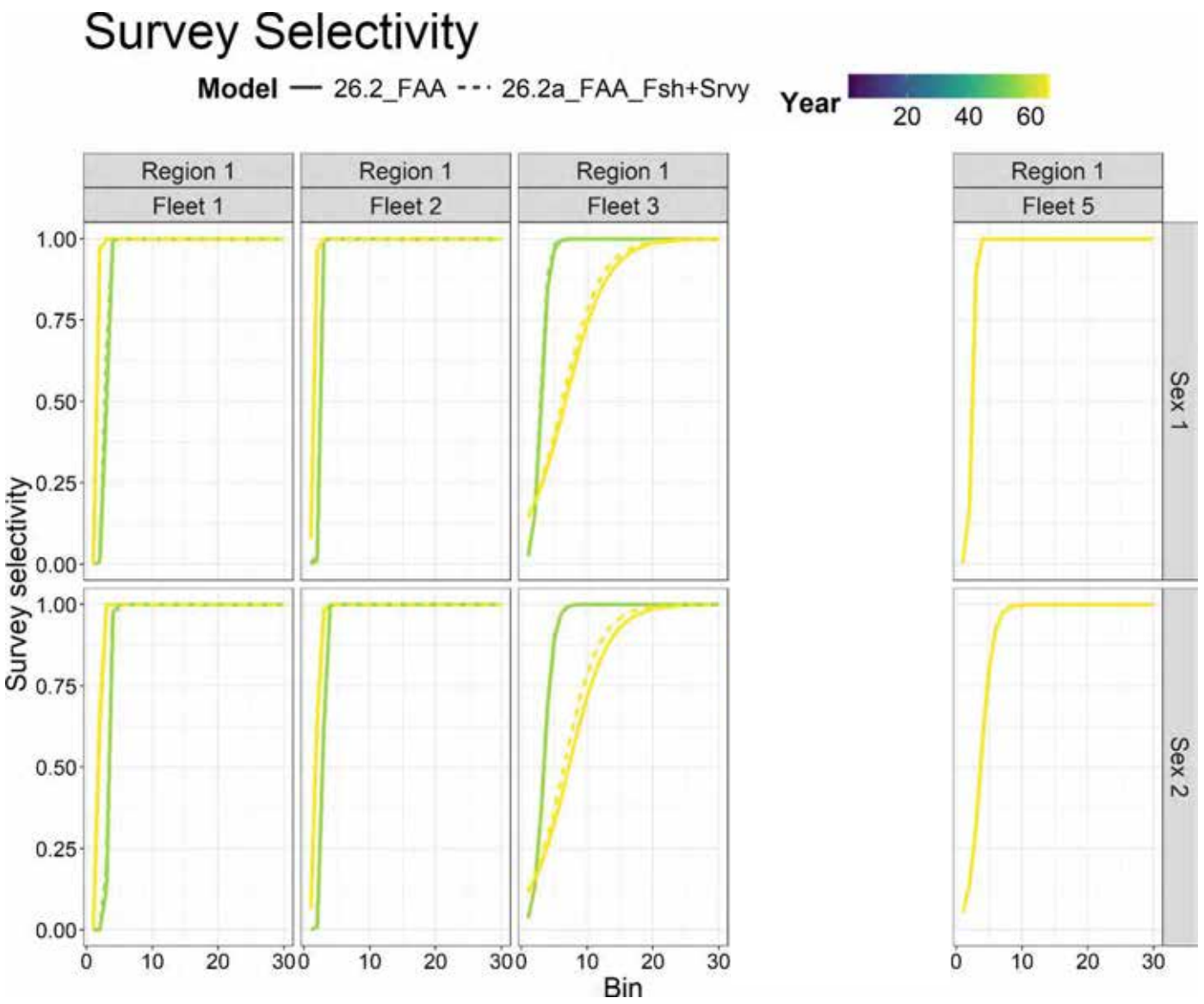

Figure 3C.9. Comparison of survey selectivity for fleets-as-areas (FAA) model runs. Sex 1 is females and sex 2 is males. Fleet 1 is the Bering Sea NOAA Longline Survey, Fleet 2 is the Aleutian Islands NOAA Longline Survey, Fleet 3 is the Gulf of Alaska NOAA Longline Survey, and Fleet 5 is the Japanese Longline Survey.

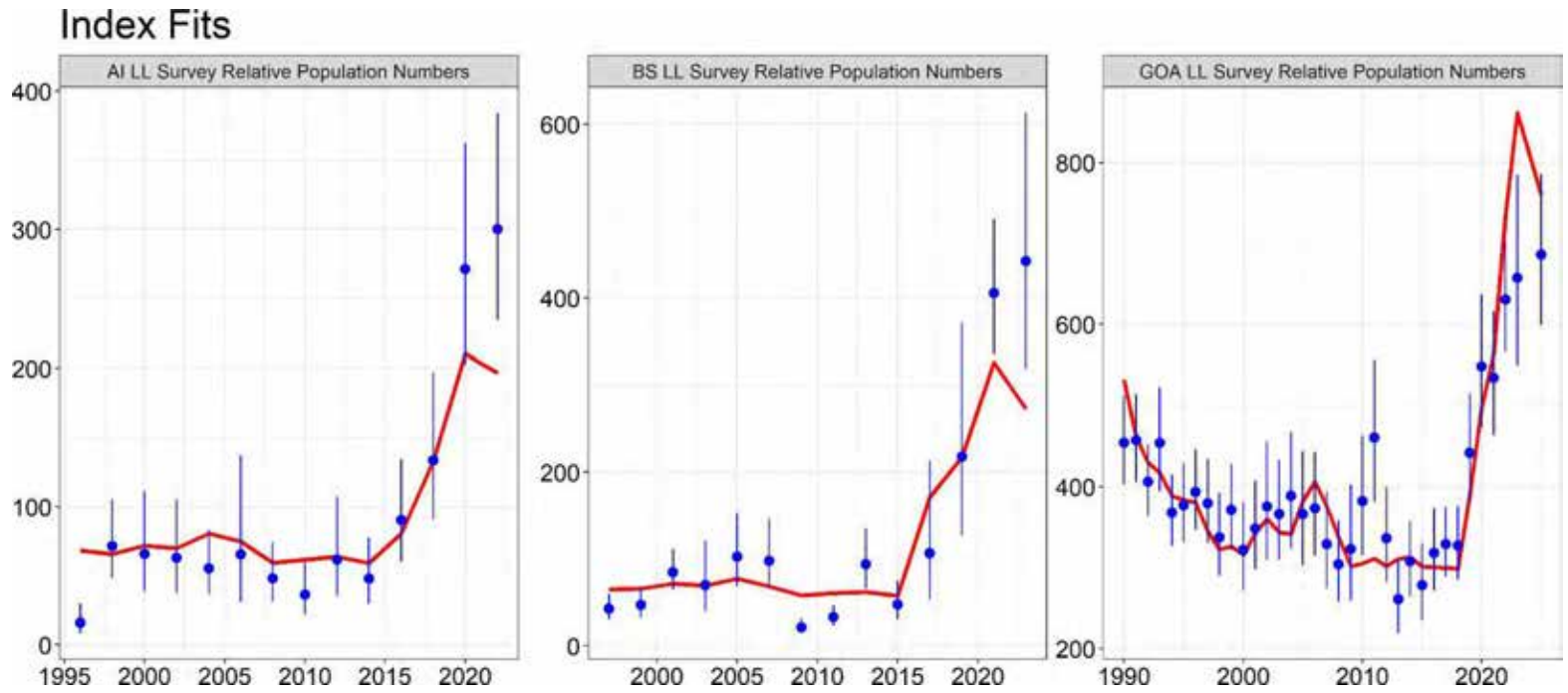

Figure 3C.10. Fits (red lines) to the NOAA Longline Survey abundance indices in relative population numbers (RPNs – 1000s of fish, y-axis; blue dots with vertical lines representing 95% confidence intervals) for an exploratory run matching Model *26.2_FAA*, but fixing the GOA NOAA Longline Survey selectivity at similar values as the BS and AI survey selectivity.

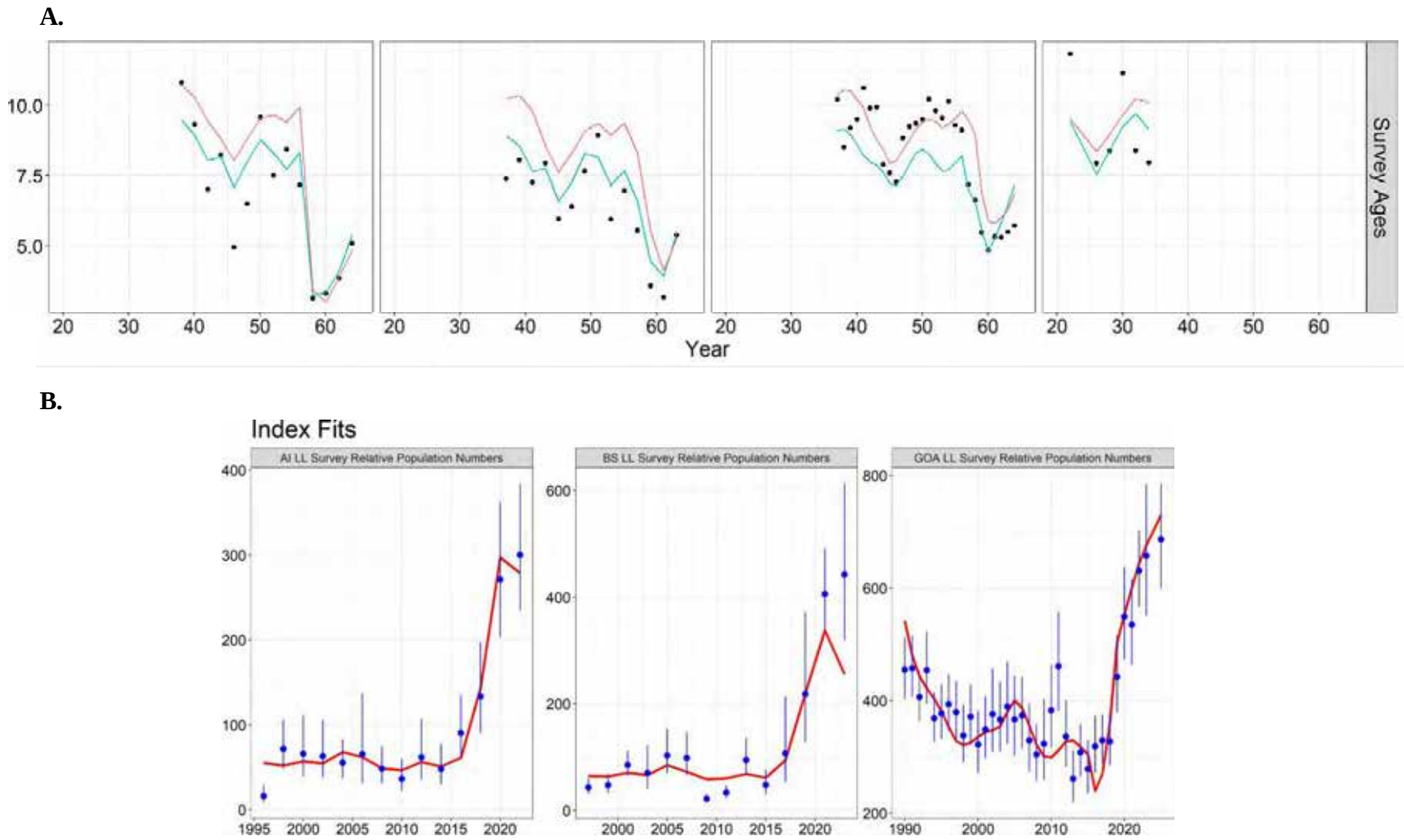

Figure 3C.11. Results from an exploratory model with the same parametrization as Model *26.2_FAA*, but assuming domed BS survey selectivity for the recent time block, including fit to mean survey age (panel A) and NOAA Longline Survey indices (panel B). In Panel A (y-axis is mean age), red lines represent the model fit to the mean age under the assumption of equal weighting (data weights equal to one for all data sources) and the blue lines represent model fit to the mean age after Francis reweighting is complete (and resulting data weights have been applied). In Panel B, red lines are model predicted fits to the NOAA Longline Survey abundance indices in relative population numbers (RPNs – 1000s of fish, y-axis) and blue dots are observed RPNs with vertical lines representing 95% confidence intervals.

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
26.2_FAA	1	193.1500	358.1881	0.05874255	31.6957	122.4267	0.08054	1.57768	0.53924	0.72940
26.2_FAA_Carry	1	301.1013	462.3924	0.03737749	53.9853	145.3347	0.08519	2.07178	0.65118	0.43876

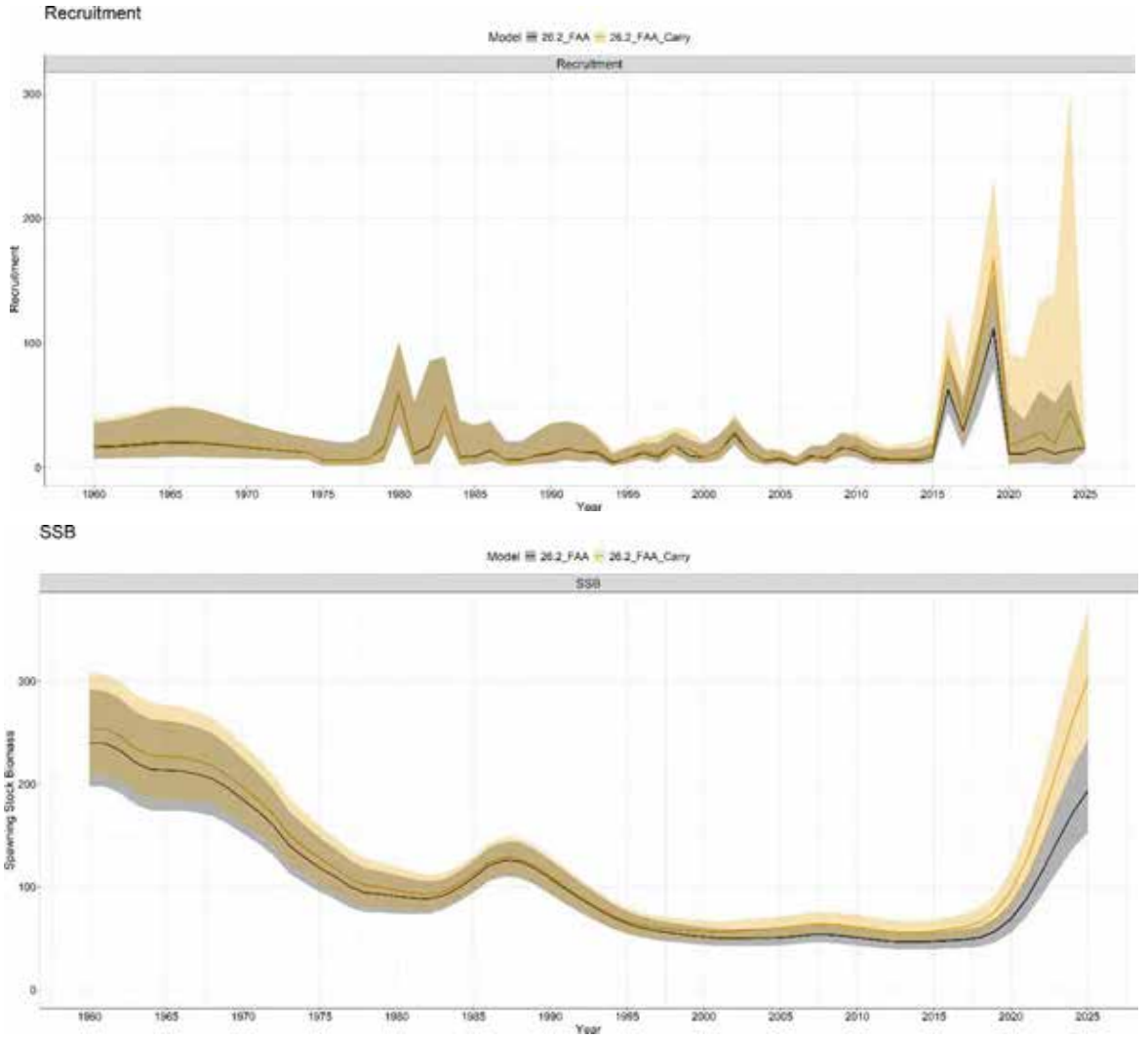

Figure 3C.12. For an exploratory run matching Model *26.2_FAA* but assuming using 'carryover' RPN values for regional indices when a given region is not surveyed, estimates of stock status (top), recruitment (millions of fish, middle), and SSB (kt, bottom).

2. Sensitivity Runs

Introduction

Following similar rationale for single-region models, several analogous sensitivity runs were developed for fleets-as-areas (FAA) models. In particular, the use of empirical weight-at-age (EWAA) was explored to account for potential density-dependent growth associated with recent large year classes (*26.2_FAA_TVWAA*; Cheng et al., 2024). Moreover, while the use of an FAA model theoretically accounts for average differences in availability across regions, there may also be a need to address time-varying availability given the spatial dynamics of sablefish, where large recruitment events often appear in western regions and shift eastward as cohorts mature. Thus, a second sensitivity model implemented continuous semi-parametric time-varying survey selectivity for the NOAA longline survey in the BS, AI, and GOA fleets to evaluate whether a more flexible selectivity formulation could better capture temporal changes in survey availability (*26.2_FAA_ContTVSel*). Likewise, a model exploring the use of the Dirichlet-multinomial likelihood for composition data was developed to evaluate whether model tension arising from unaccounted-for process error, particularly associated with time-varying survey selectivity, could be better accommodated relative to the Francis re-weighting approach (*26.2_FAA_DM*). Lastly, a sensitivity run combining continuous semi-parametric time-varying survey selectivity and the Dirichlet-multinomial likelihood for composition data (*26.2_FAA_ContTVSel_DM*) was explored to evaluate the extent to which these approaches interacted.

Methods

The sensitivity model runs follow the parameterization of *26.2_FAA* with incremental updates as noted below. All results presented herein are compared to *26.2_FAA*. Francis reweighting was only employed for model *26.2_FAA_TVWAA*.

The configuration of sensitivity model runs was as follows:

- *26.2_FAA_TVWAA*:
    - Time-varying EWAA was incorporated into model *26.2_FAA* following the methods from Cheng et al. (2024), where annual weight-at-age values were estimated external to the assessment model. An initial set of EWAA estimates was first derived using bootstrapping, after which a model-based smoothing framework was applied to account for correlations among age, year, and cohort effects in bootstrapped estimates of weight-at-age.

- *26.2_FAA_ContTVSel*:
    - The NOAA domestic survey selectivity for the BS, AI, and GOA fleets was specified with continuous semi-parametric time-varying selectivity. For all fleets, the parametric form assumed a logistic shape, while semi-parametric lognormal deviations were specified for each age to be independent and identically distributed (iid) random variables following a normal distribution. These deviations were estimated within a penalized likelihood framework, with the standard deviation fixed at 0.5 to balance fit to composition data as well as indices (based on initial

explorations). Note that deviations were estimated for all age, sex, and fleet combinations.

- *26.2_FAA_DM*:
    - Model *26.2_FAA* assumes that all composition datasets arise from a Multinomial distribution. To incrementally add to this model, composition likelihoods were specified assuming the linear parameterization of a Dirichlet-multinomial distribution Thorson *et al.* (2017). The Dirichlet-multinomial likelihood was applied to all composition datasets except those associated with the Japanese longline survey length compositions, given the sparse nature of those data. A multinomial likelihood was instead assumed for these observations.

- *26.2_FAA_ ContTVSel_DM*:
    - Continuous time-varying selectivity and self-weighting likelihoods are known to interact, and has been found to provide improved assessment results when jointly considered (Xu *et al.* 2019). Accordingly, model *26.2_FAA_ContTVSel_DM* combines the attributes of models *26.2_FAA_ContTVSel* and *26.2_FAA_DM*, such that time-varying survey selectivity for the BS, AI, and GOA fleets was estimated concurrently with the implementation of Dirichlet-multinomial likelihoods.

Results

- *26.2_TVWAA* (full results here):
    - Recent declines in weight-at-age were notable for young to intermediate-aged individuals, likely reflecting density-dependent effects associated with recent large recruitment events (Appendix 3B, Fig. 3B.11). Potentially unrealistic increases in weight-at-age were also observed for older females, likely attributed to parameter correlation between the intrinsic growth rate and asymptotic length parameters, compounded by limited data availability at older ages (Appendix 3B, Fig. 3B.11).
    - Declines in *SSB* coincided with declines in EWAA, with a reduction in population scale as compared to Model *26.2_FAA* (Fig. 3C.13). However, data fits remained largely unchanged and estimates of stock status also maintained similar levels (although fishing mortality appears to be larger than $F_{40\%}$ in this model configuration) (Fig. 3C.14 and Table 3C.7).

- *26.2_FAA_ContTVSelex* (full results here):
    - Specifying continuous semi-parametric time-varying survey selectivity for the NOAA longline survey did not lead to substantive improvements in model fits to composition data or abundance indices relative to model *26.2_FAA* (and were somewhat degraded despite the added complexity) (Fig. 3C.15). Moreover, aggregate fits to young individuals appeared degraded for *26.2_FAA_ContTVSel*, with young fish consistently overpredicted across all domestic longline survey fleets relative to model *26.2_FAA* (Fig. 3C.16 – 3C.22).
    - Moderate variability in survey selectivity estimates was detected, with recent years exhibiting some degree of doming, likely reflecting the influence of large recruitment events. Dome-shaped selectivity patterns were particularly apparent for

the BS survey fleets, likely driven in part by large recruitment events in the BS, while the AI and GOA survey fleets generally exhibited selectivity patterns more closely resembling a logistic function (Fig. 3C.23). Moreover, GOA survey selectivity appeared to shift towards older ages in recent years, likely attributed to the movement into the GOA region of maturing fish from recent year classes in recent years. Similar to the single-region sensitivity runs, attempts to estimate time-varying selectivity within a state-space framework were also explored, but convergence issues were encountered.

- Implementing continuous time-varying survey selectivity led to degraded retrospective performance, resulting in moderate and consistent overestimation of *SSB* relative to the terminal assessment (likely due to consistent overestimation of large recruitment events in recent years; Mohn's rho of 0.189; Fig. 3C.24).
- Although survey selectivity appeared to vary over time, likely attributed to time-varying availability, model fits for both abundance indices and composition data appeared to worsen. Additionally, comparison of stock status and population dynamics did not appear to substantially differ between model *26.2_FAA* and model *26.2_FAA_ContTVSel* (Fig. 3C.25, 3C.26). Moderate positive retrospective patterns were detected, likely due to year-to-year changes in recruitment and interactions with continuous time-varying selectivity as cohorts aged into the population.

- *26.2_FAA_DM* (full results here):
  - The use of a Dirichlet-multinomial likelihood resulted in substantially poorer fits to abundance indices (Fig. 3C.27). Presumably, this occurred because composition data were effectively upweighted relative to the Francis re-weighting approach (Fig. 3C.28, 3C.34), thereby reducing the model's ability to adequately fit abundance indices simultaneously.
  - The introduction of additional overdispersion parameters resulted in degraded retrospective performance relative to model *26.2_FAA*, where estimates of large recruitment events were frequently overestimated relative to the terminal year, manifesting as a positive SSB retrospective pattern (Mohn's rho of approximately 0.147; Fig. 3C.35). These retrospective patterns may in part reflect conflicting recruitment signals within the composition data arising from spatial heterogeneity in recruitment as new composition data entered the model.
  - Recruitment estimates were substantially more variable relative to model *26.2_FAA*, with an associated upward revision in overall population scale. Presumably, this increase in population scale resulted from the effective upweighting of composition data relative to the Francis re-weighting approach, where the model compensated by increasing recruitment estimates to improve fits to composition data. The increased recruitment estimates then propagated into a larger overall population scale, which was necessary to maintain adequate fits to catch data (Fig. 3C.36, 3C.37).
  - While the Dirichlet-multinomial likelihood is theoretically more statistically rigorous than Francis re-weighting, the model was generally unable to adequately balance simultaneous fits to both composition and abundance index data.

- *26.2_FAA_ContTVSel_DM* (full results here):
    - Combining continuous semi-parametric time-varying survey selectivity with a Dirichlet-multinomial likelihood for composition data continued to produce degraded fits to both abundance indices and composition data (Fig. 3C.38 – 3C.45). Moreover, the combined approach was unable to adequately reconcile the respective model misfits observed when each method was applied independently.
    - Positive retrospective patterns in SSB were detected, likely reflecting the continual revision of recruitment estimates and differing recruitment signals across space as new composition data entered the model and cohorts aged into the population (Fig. 3C.46). These patterns were likely exacerbated by the more flexible survey selectivity parameterizations. Overall interpretation of population dynamics remained generally similar to model *26.2_FAA*, although recruitment estimates were more variable and overall population scale was larger (Fig. 3C.47, 3C.48). Thus, this model configuration does not appear to provide substantive improvement over model *26.2_FAA*.

Conclusions

Sensitivity analyses indicated that Model *26.2_FAA* with Francis reweighting for the composition data likely provided the most balanced and robust performance among the configurations examined. While incorporation of time-varying weight-at-age captured biologically plausible density-dependent growth reductions among younger age classes associated with recent large recruitment events, this approach also resulted in somewhat unrealistic estimates for older ages where data were sparse. Future work could evaluate methods to improve the smoothing of those older ages, as well as refine the bootstrapping procedure to better derive uncertainty of EWAA estimates. In evaluating the use of continuous semi-parametric time-varying survey selectivity, temporally variable selectivity patterns consistent with time-varying availability were detected. However, this approach resulted in degraded fits to both abundance indices and composition data, alongside elevated positive retrospective patterns. Moreover, application of the Dirichlet-multinomial likelihood effectively upweighted composition data relative to the Francis reweighting approach, leading to substantially more variable recruitment estimates, inflated population scale, and degraded fits to abundance indices. Finally, the combination of continuous time-varying selectivity and the Dirichlet-multinomial likelihood failed to reconcile the respective misfits observed under each approach when applied independently, with positive retrospective patterns persisting. Collectively, these results suggest that none of the alternative configurations examined performed better than Model *26.2_FAA*. However, they provide a useful foundation for future model development and help clarify key areas of model tension and structural sensitivity.

Tables

Table 3C.6. Summary of sensitivity model runs and associated results.

Model Group	Model Name	Major Changes	Rationale	Conclusions
Sensitivity Runs	*26.2_FAA_TVWAA*	(*26.2_FAA+*) Incorporate time-varying empirical weight-at-age.	Incorporating time-varying weight-at-age is expected to improve the biological realism of the model.	• Declines in weight-at-age were evident for young to intermediate-aged individuals in recent years, consistent with density-dependent effects. • Potentially unrealistic increases in weight-at-age for older females. • Declines in SSB coincided with declines in empirical weight-at-age. • Fishing mortality exceeded $F_{40\%}$ under this configuration.
	26.2_FAA_ContTVSel	(*26.2_FAA +*) Specify continuous semi-parametric time-varying survey selectivity for the domestic NOAA longline survey.	Better capture temporal changes in survey selectivity and associated changes in availability due to recruitment and ontogenetic movement.	• Fits to abundance indices and composition data were degraded despite added complexity. • Moderate variability in selectivity was detected, with dome-shaped patterns apparent for BS survey fleet and a shift towards older ages in the GOA survey fleet. • Retrospective performance was degraded, with moderate and consistent overestimation of *SSB*.
	26.2_FAA_DM	(*26.2_FAA +*) Specify Dirichlet-multinomial likelihoods for composition data.	Account for overdispersion in composition data and provide a more flexible statistical treatment than Francis reweighting.	• Composition data were effectively upweighted relative to the Francis reweighting approach. • Fits to abundance indices were substantially degraded. • Recruitment estimates were more variable with an associated upward revision in population scale. • Retrospective patterns of overestimating large recruitment events.
	26.2_FAA_ContTVSel_DM	(*26.2_FAA +*) Combines *26.2_FAA_ContTVSel* and *26.2_FAA_DM*.	This model is intended to address the interaction effects of both *26.2_FAA_ContTVSel* and *26.2_FAA_DM*.	• Degraded fits to abundance indices and composition data. • Positive retrospective patterns in SSB were detected, likely reflecting continual revision of recruitment estimates and differing spatial recruitment signals. • Recruitment estimates were more variable, and population scale was larger.

Table 3C.7. Key management quantity outputs for sensitivity runs. SSB is in kt, B_Ref_Pt is the associated $B_{40\%}$ reference point in kt, and F_Ref_Pt is the associated $F_{40\%}$. Catch advice is the 2026 Acceptable Biological Catch (ABC) resulting from fishing at $F_{40\%}$.

Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt	B_over_B_Ref	B_over_DynB_Ref	F_over_F_Ref
26.2b_FAA_3Flt_LLS_Only	1	192.6658	357.5388	0.05878813	31.77084	122.3957	0.08070	1.57412	0.53887	0.72846
26.2b_FAA_3Flt_LLS_Only_DM	1	152.0593	317.7291	0.07041890	28.25891	126.1990	0.08206	1.20492	0.47858	0.85810
26.2b_FAA_3Flt_LLS_Only_ContTVSel	1	188.2890	362.7107	0.05456974	32.82219	141.1775	0.07484	1.33370	0.51912	0.72912
26.2b_FAA_3Flt_LLS_Only_ContTVSel_DM	1	175.5888	353.4455	0.05788491	33.65480	142.1871	0.07873	1.23491	0.49679	0.73524
26.2b_FAA_3Flt_LLS_Only_TVWAA	1	141.2156	296.2604	0.07934650	21.63043	102.7233	0.07571	1.37472	0.47666	1.04796

Figures

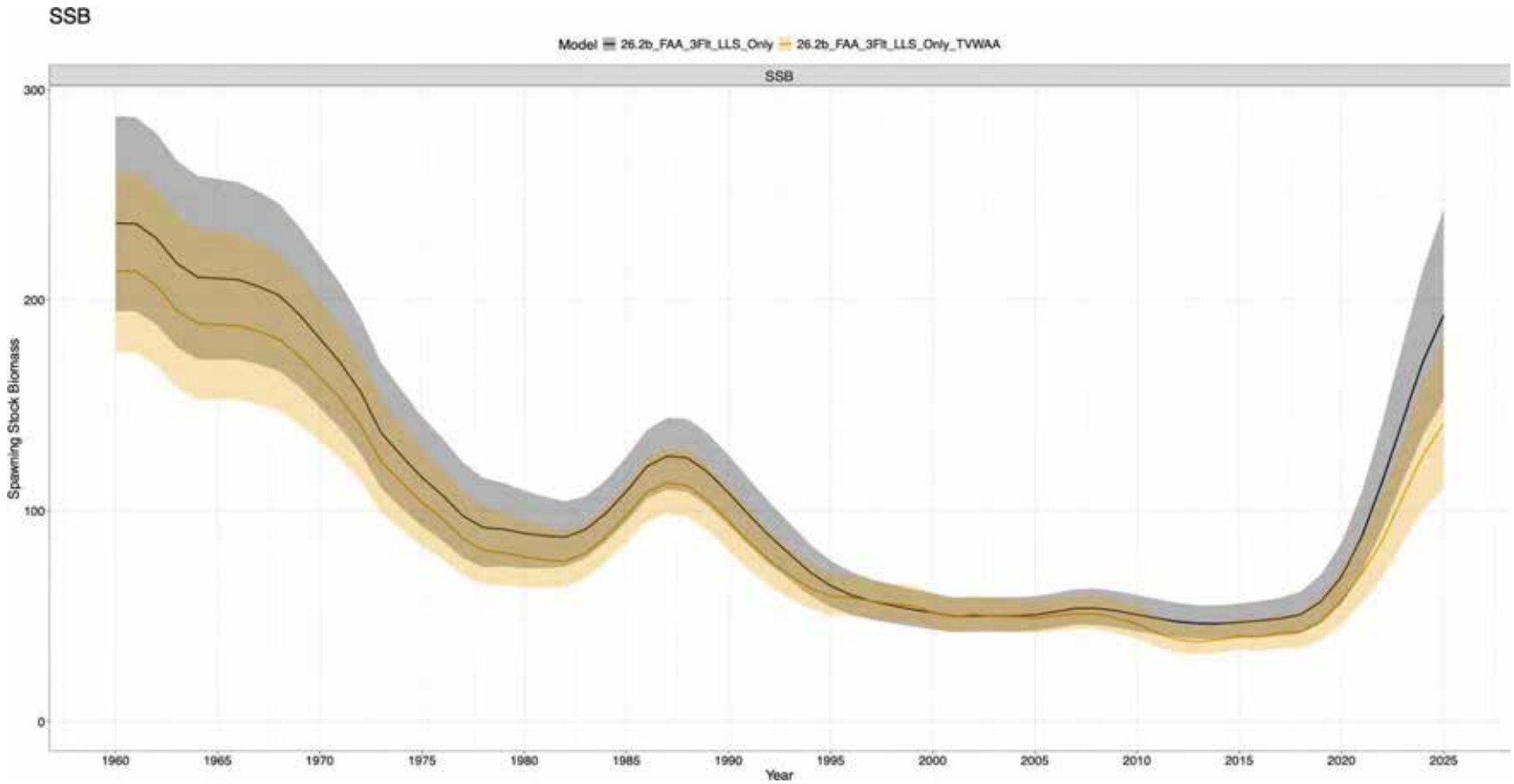

Figure 3C.13. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates time-varying empirical weight-at-age (*26.2b_FAA_3Flt_LLS_Only_TVWAA*). Shaded regions represent the 95% confidence intervals.

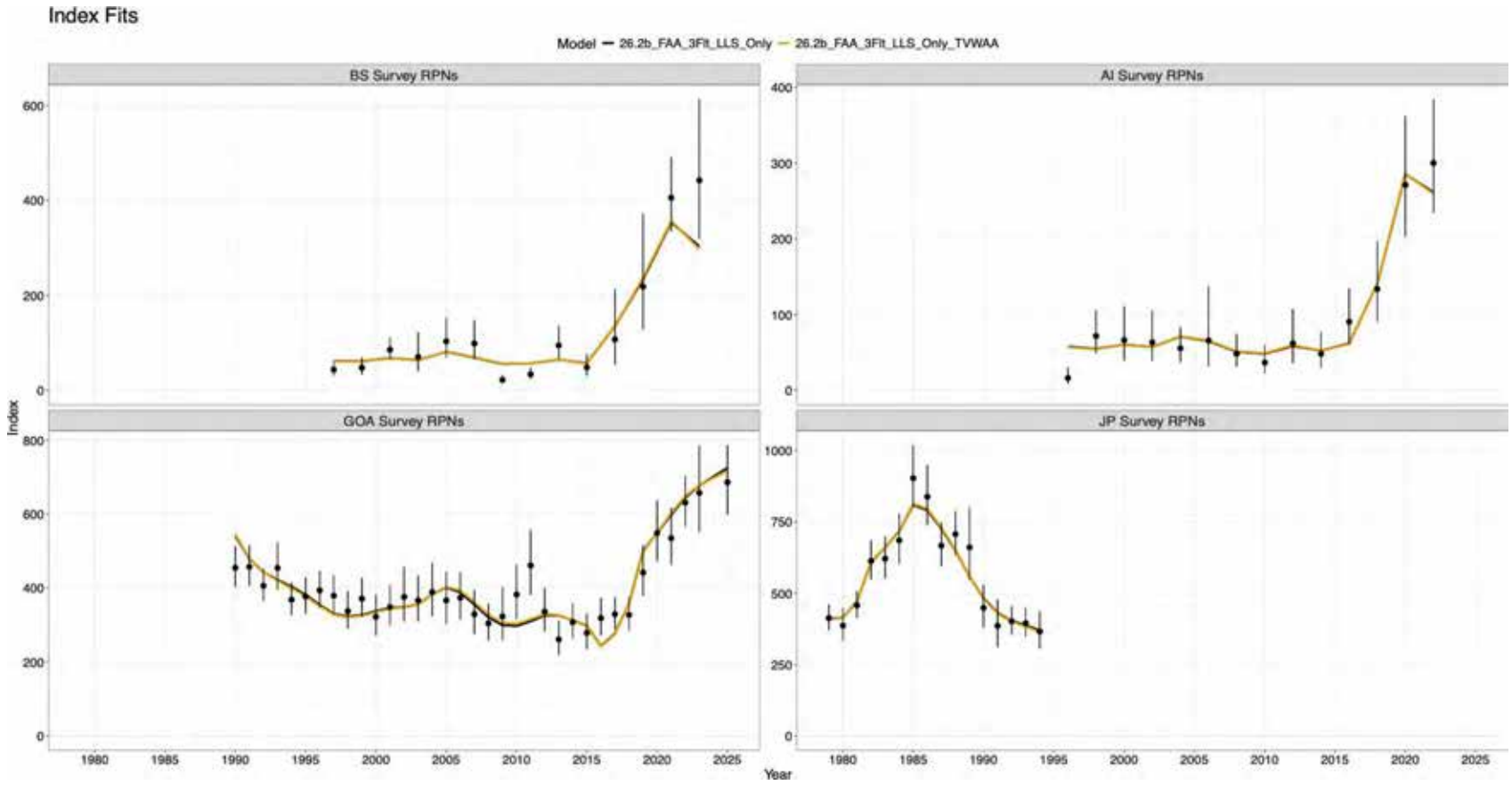

Figure 3C.14. Model fits to survey abundance indices between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates time-varying empirical weight-at-age (*26.2b_FAA_3Flt_LLS_Only_TVWAA*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

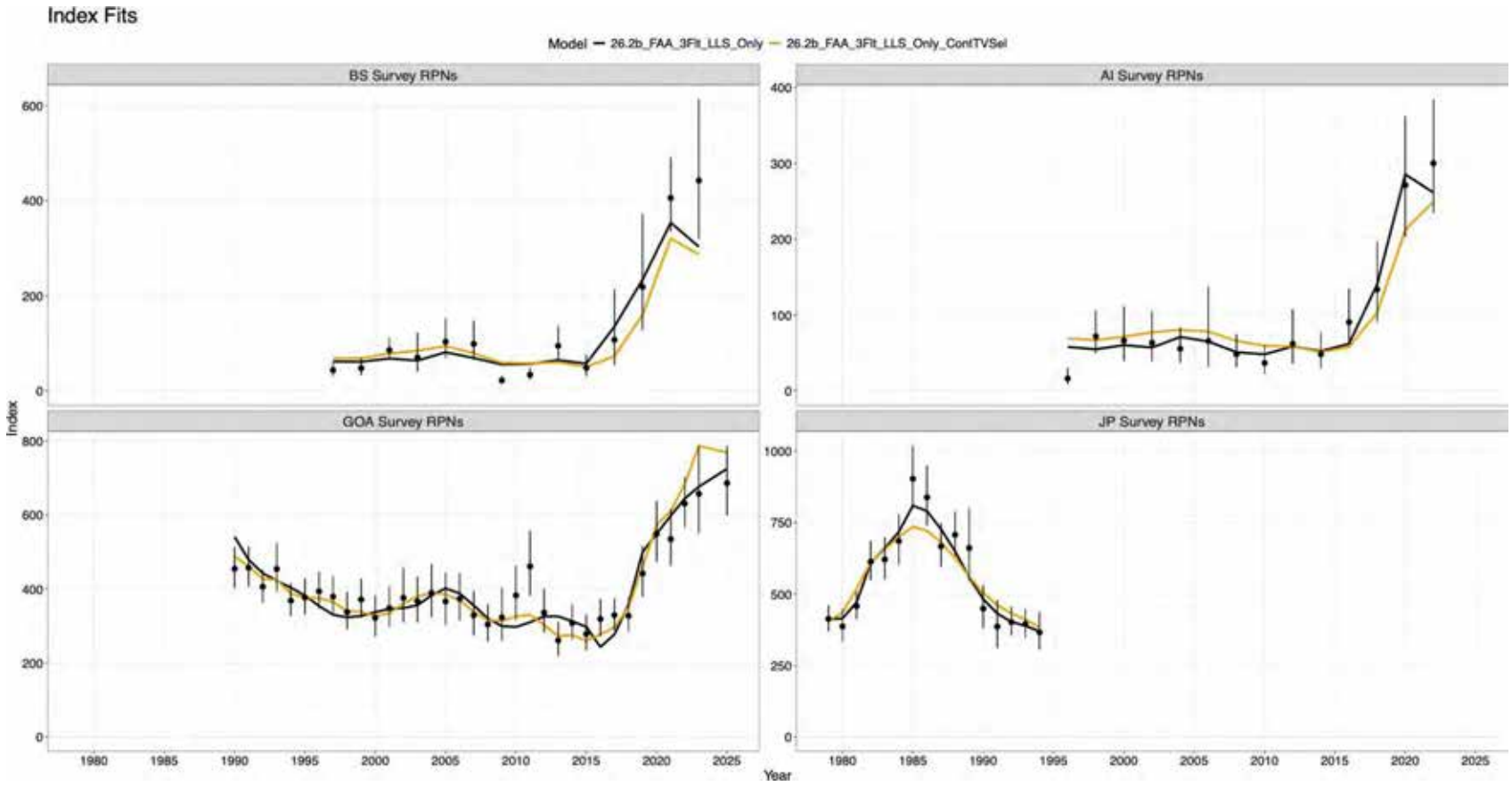

Figure 3C.15. Model fits to survey abundance indices between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous semi-parametric time-varying survey selectivity (*26.2b_FAA_3Flt_LLS_Only_ContTVSel*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

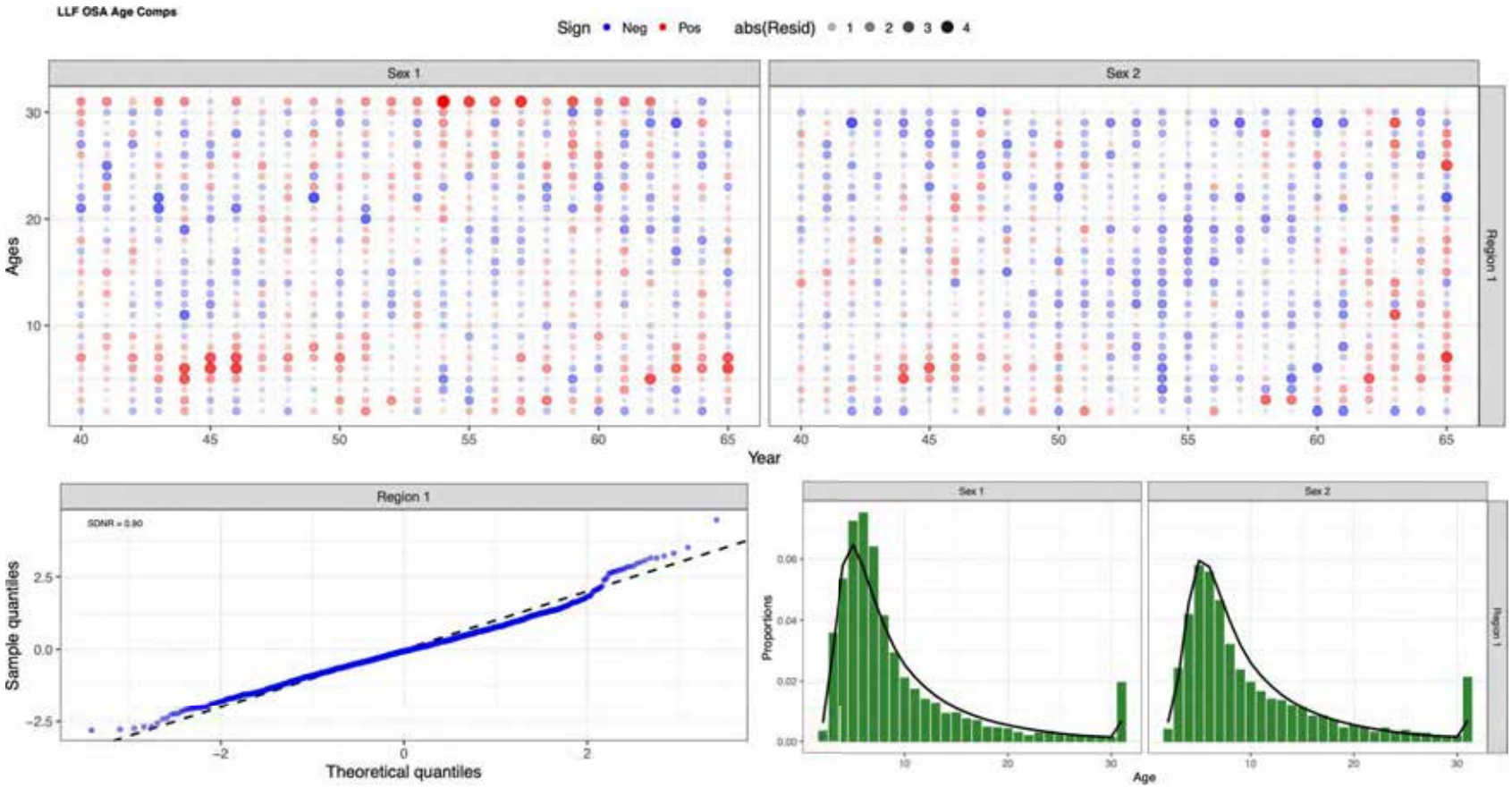

Figure 3C.16. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

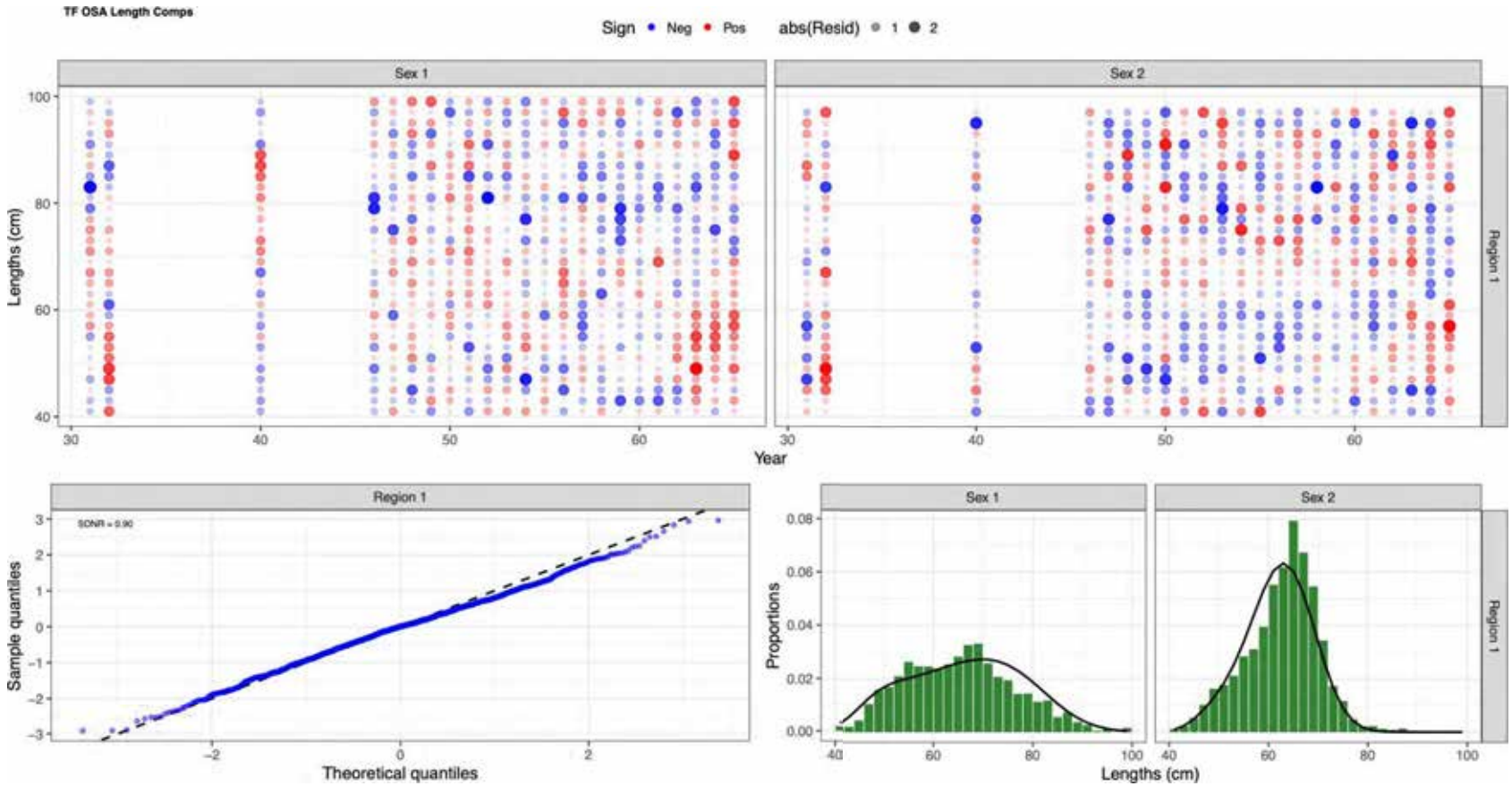

Figure 3C.17. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

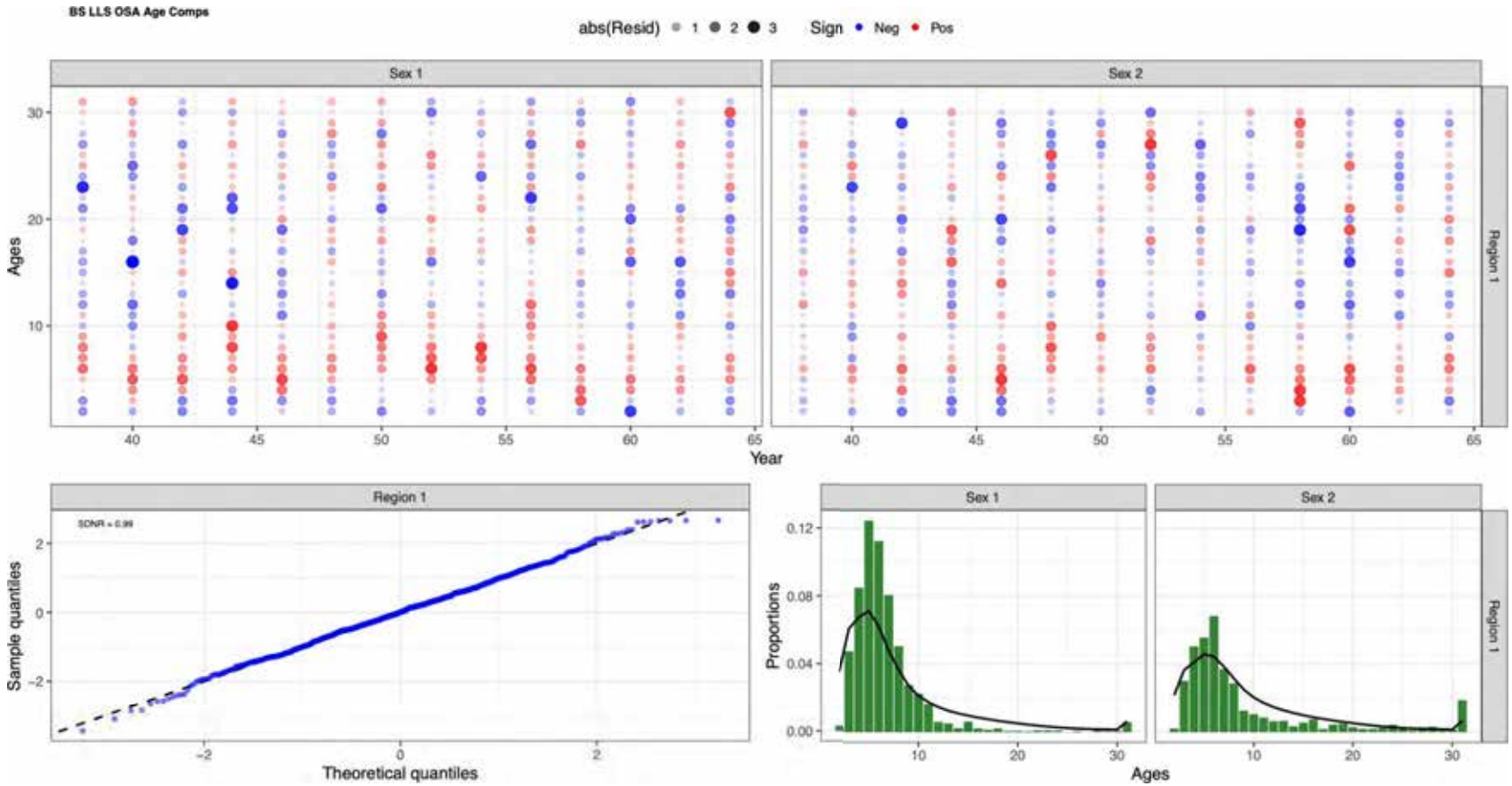

Figure 3C.18. Fits to NOAA longline Bering Sea (BS) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

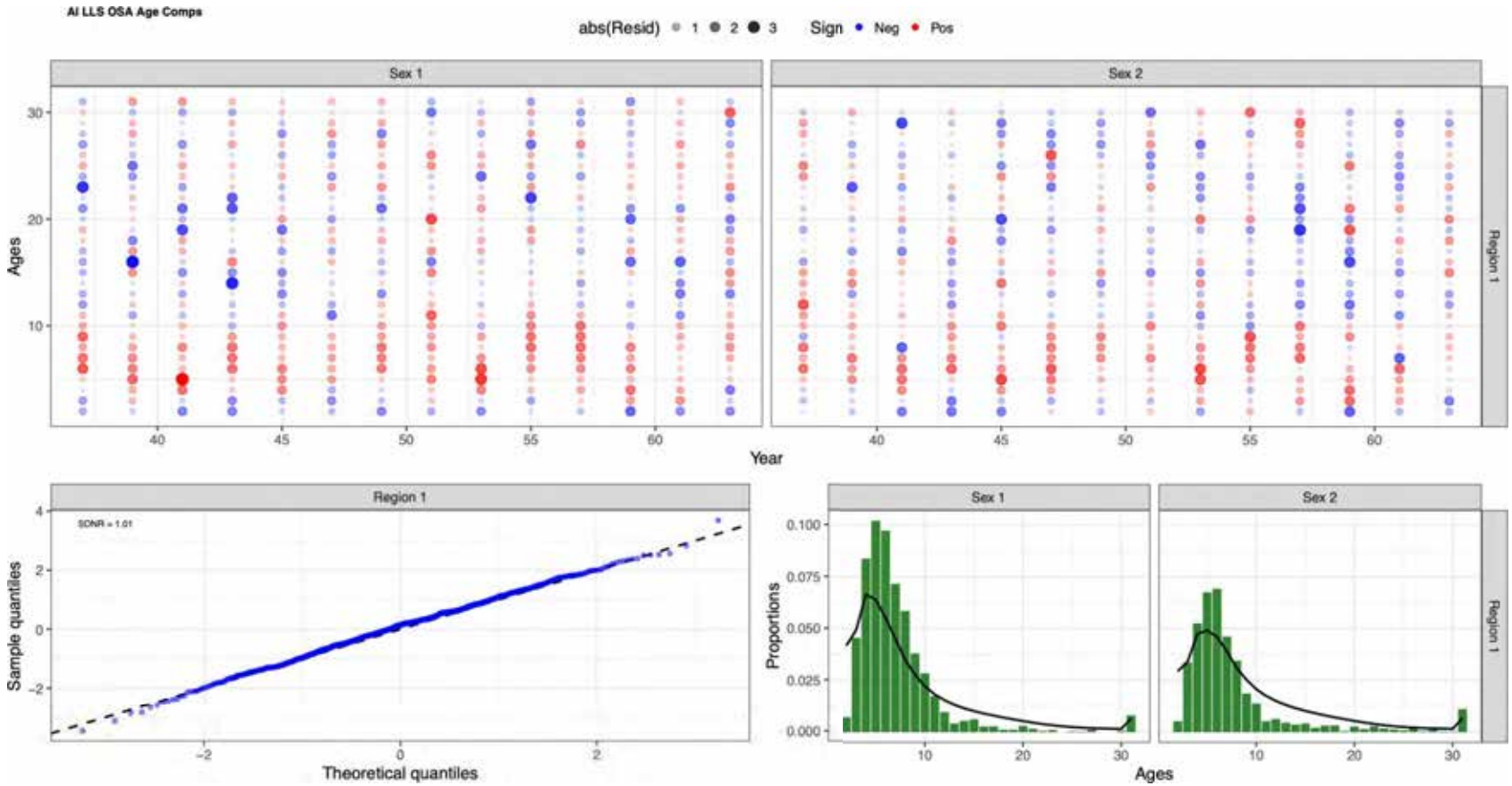

Figure 3C.19. Fits to NOAA longline Aleutian Islands (AI) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

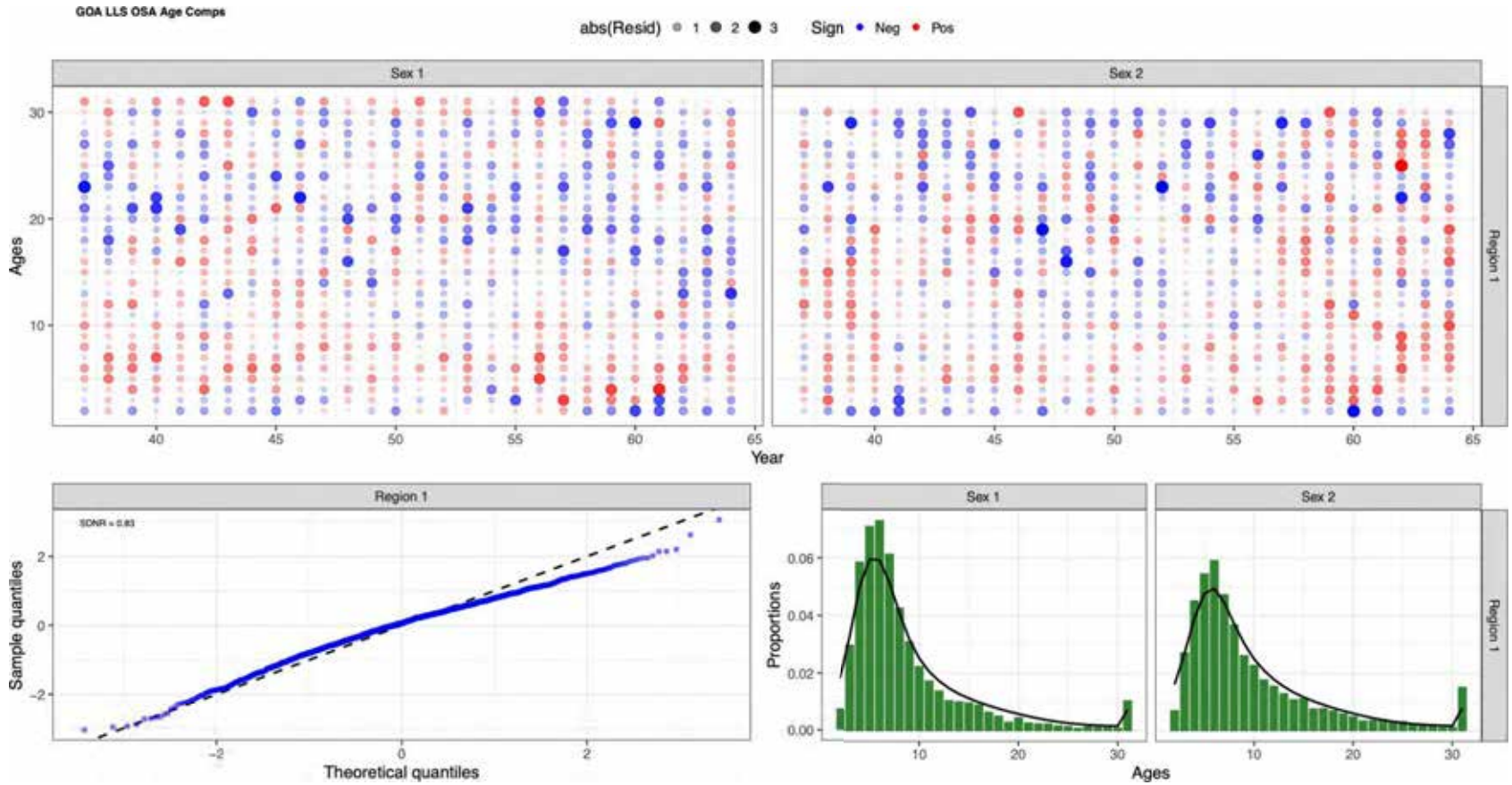

Figure 3C.20. Fits to NOAA longline Gulf of Alaska (GOA) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

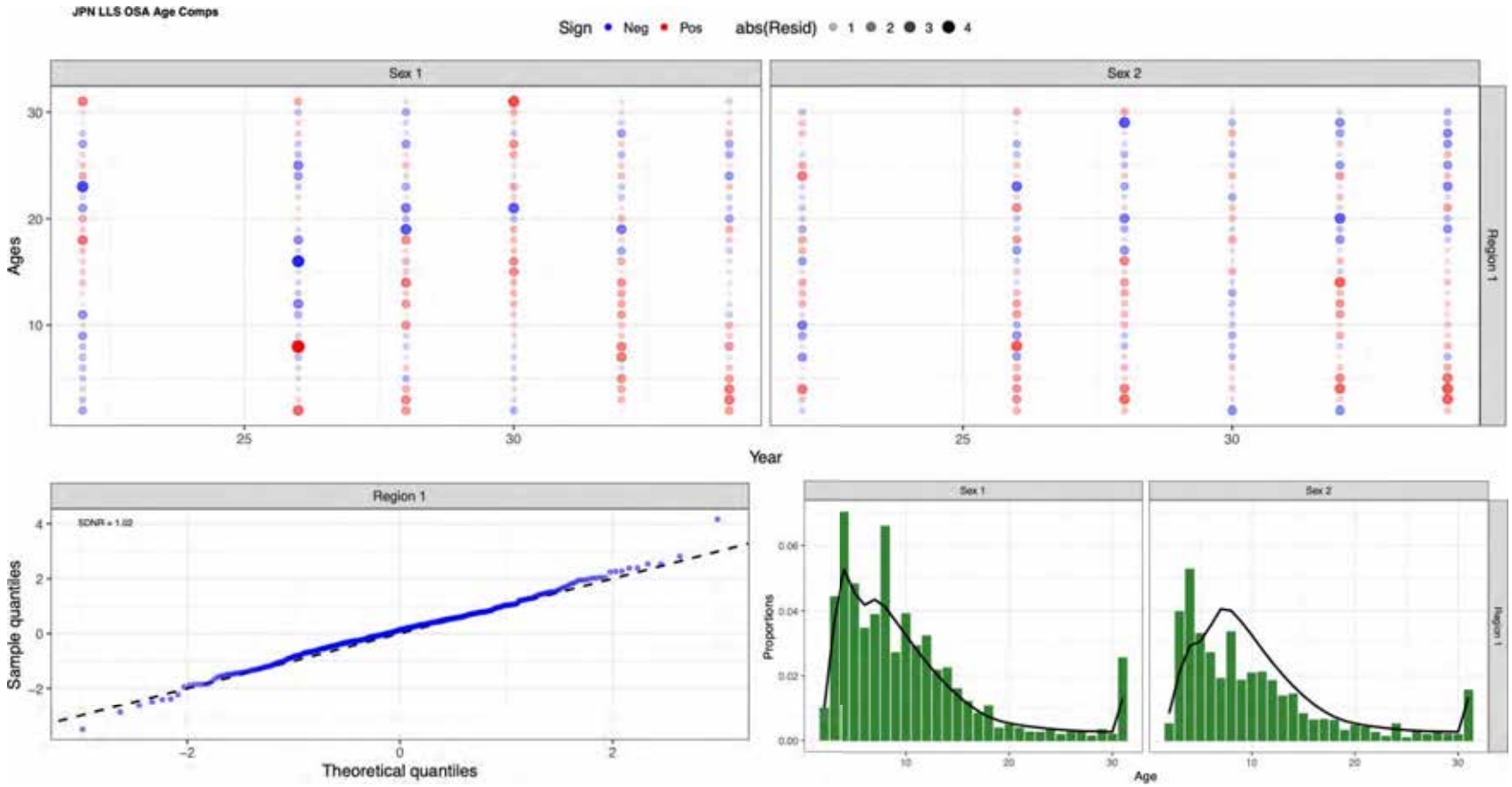

Figure 3C.21. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

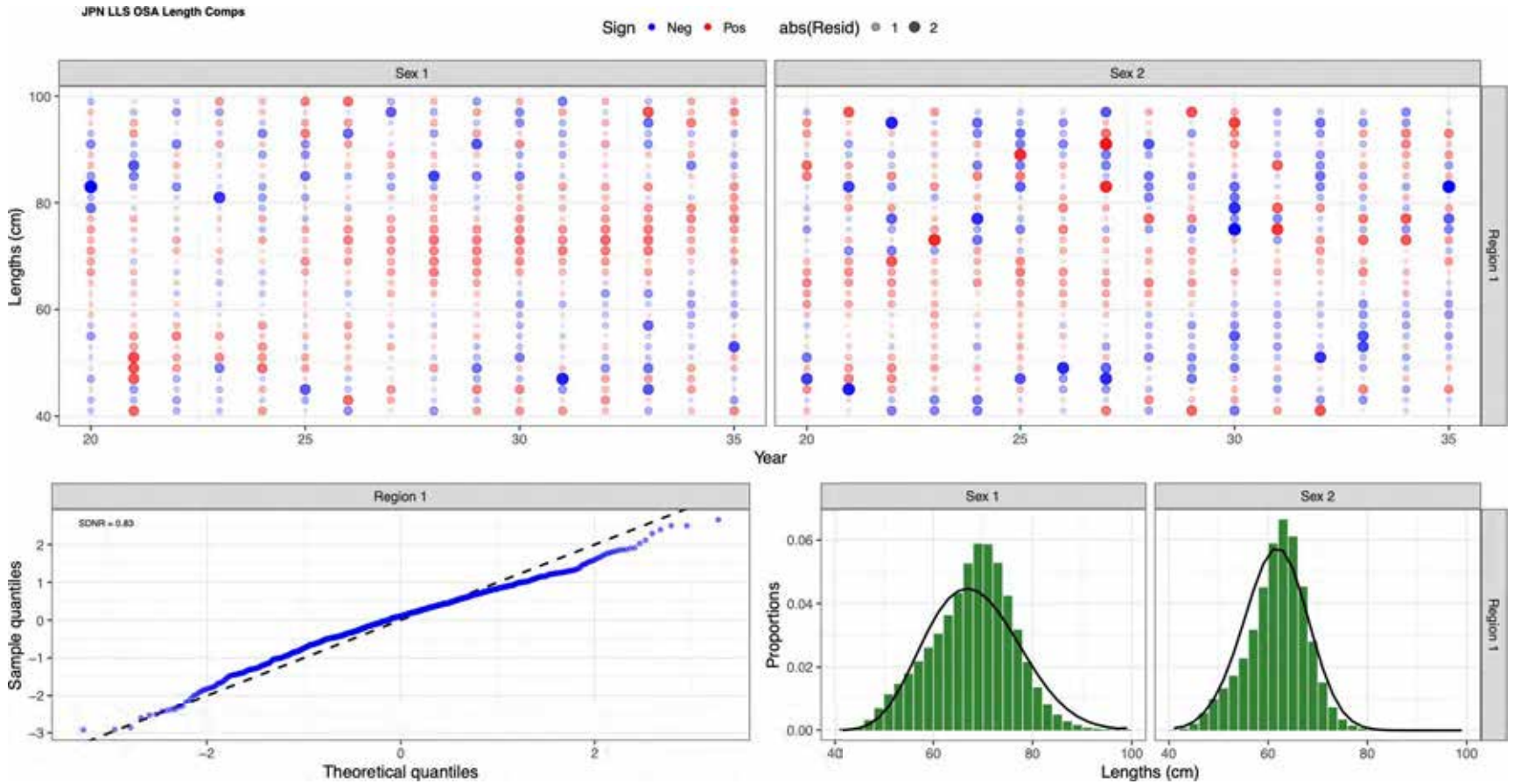

Figure 3C.22. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel*.

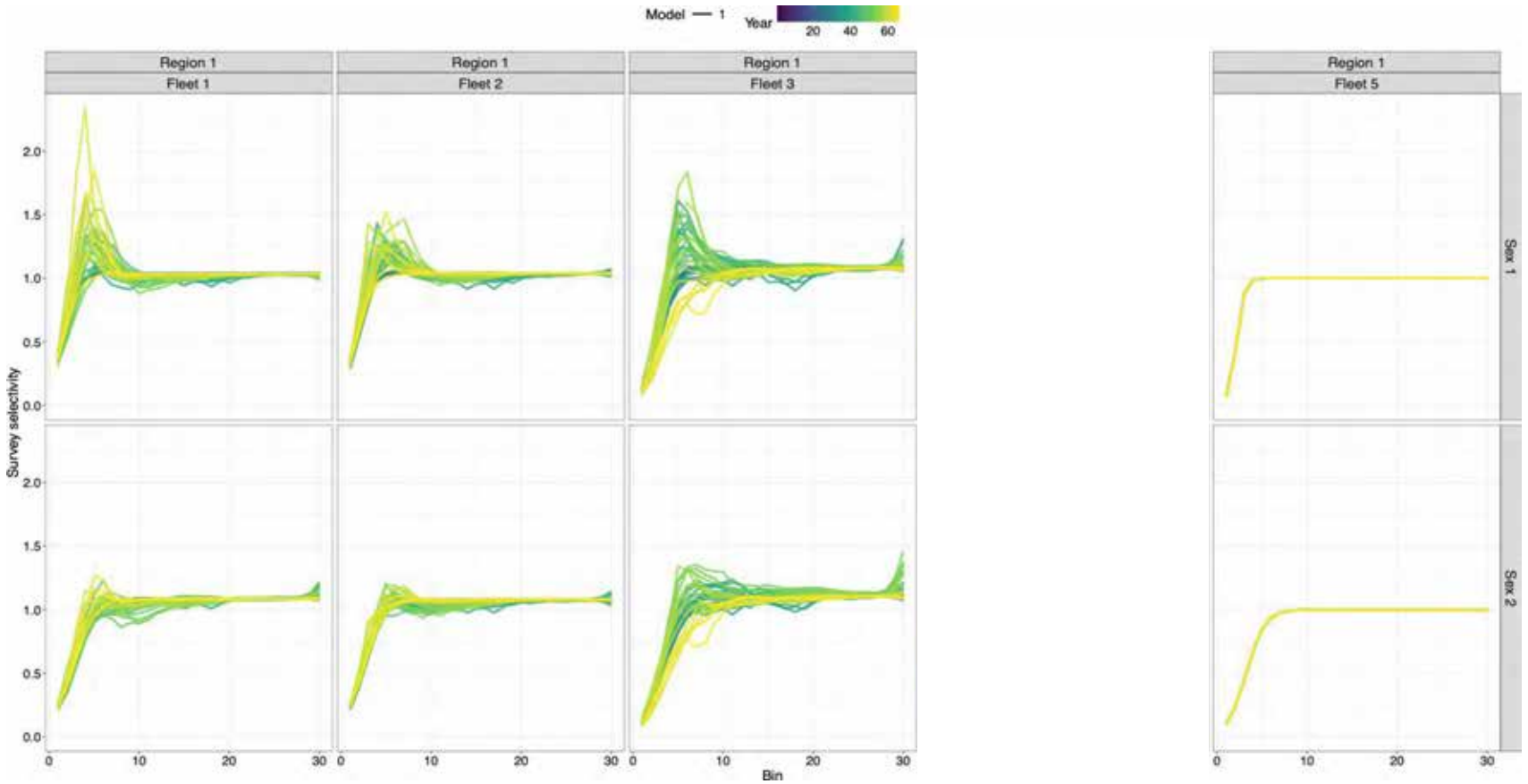

Figure 3C.23. Survey selectivity estimates from Model *26.2_FAA_ContTVSel*. Fleets 1 – 3 represent the Bering Sea, Aleutian Islands, and Gulf of Alaska domestic longline survey fleets. Fleet 5 represents the Japanese longline survey fleet. Sex 1 is females and sex 2 is males.

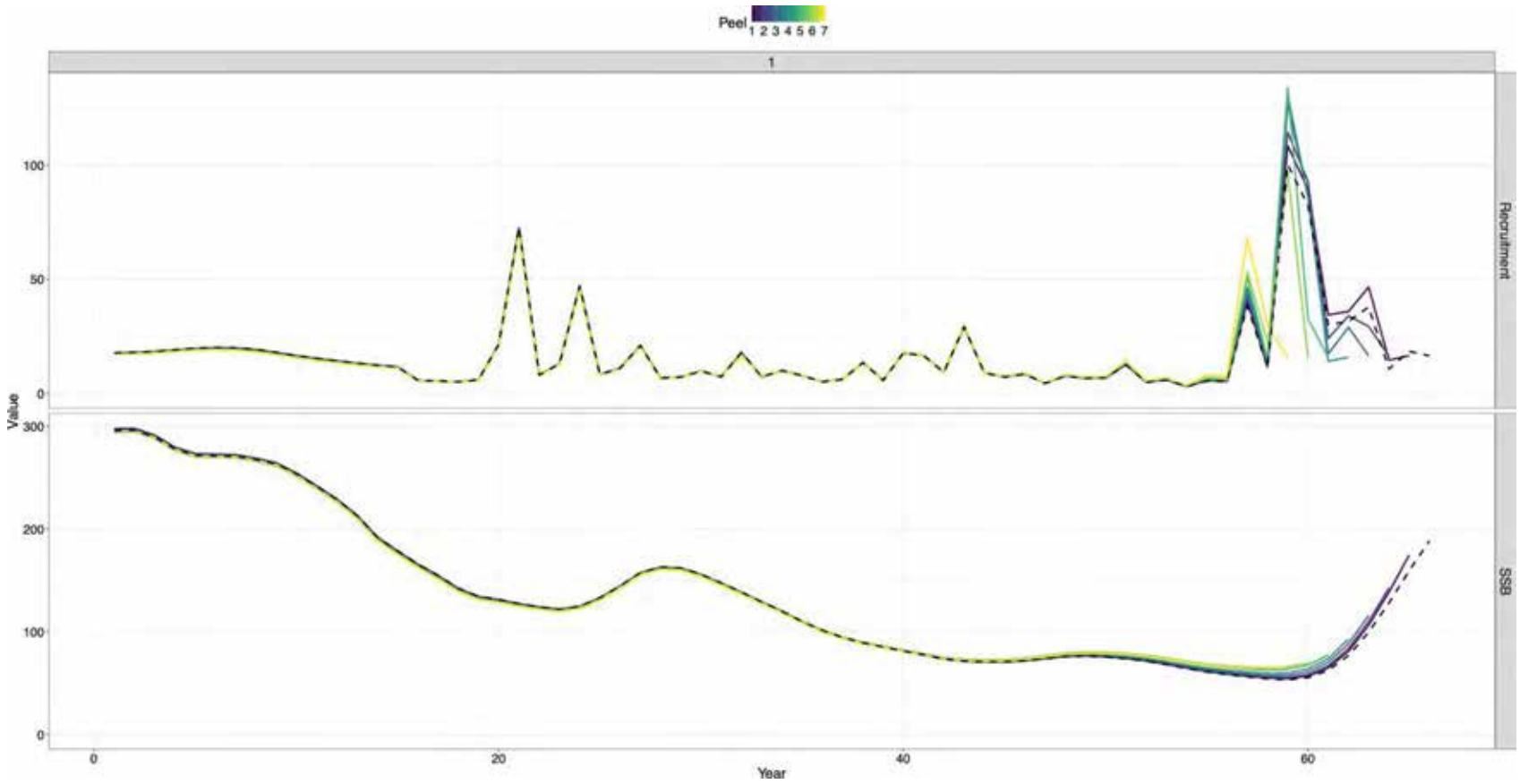

Figure 3C.24. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA_ContTVSel*. Mohn's rho for SSB was 0.189.

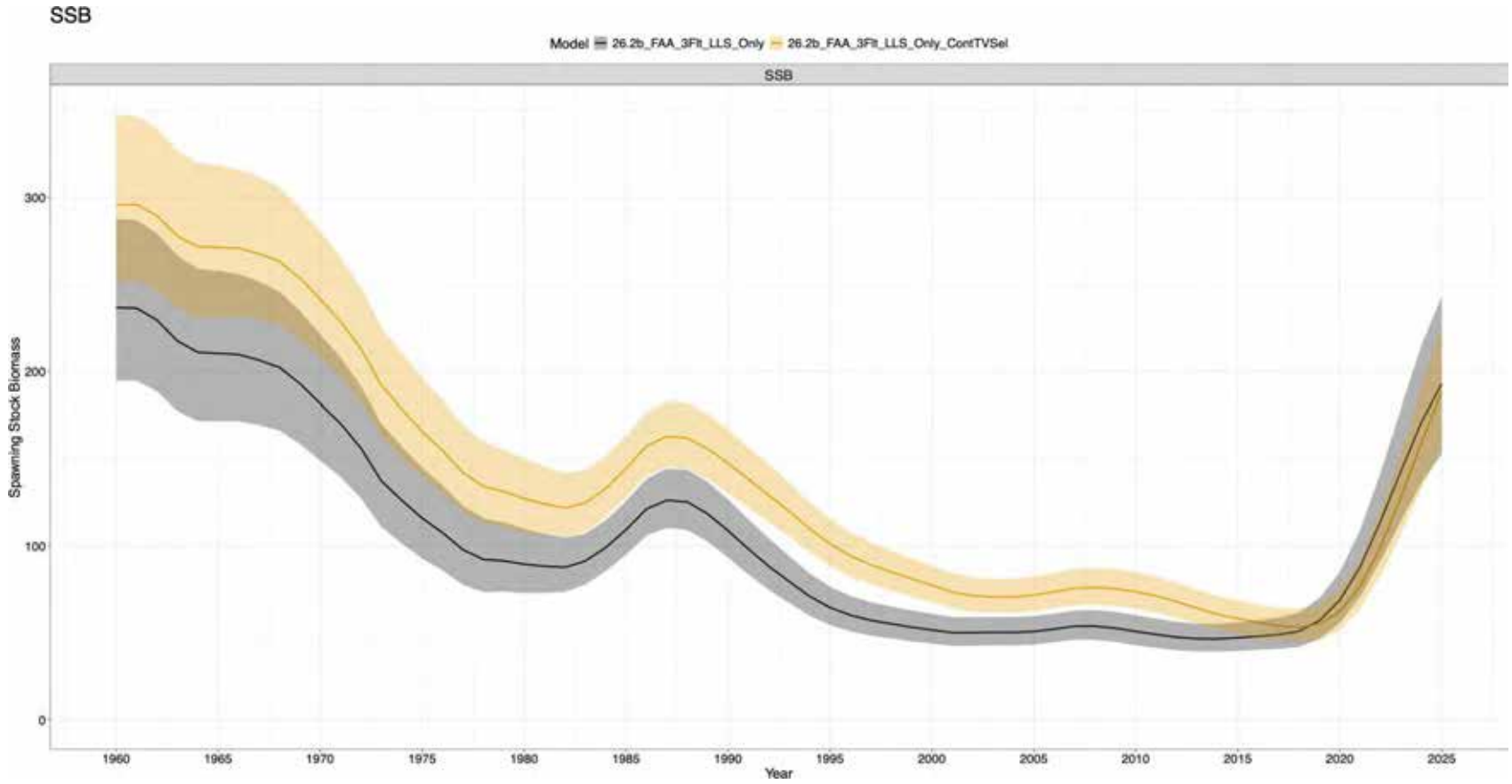

Figure 3C.25. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity (*26.2b_FAA_3Flt_LLS_Only_ContTVSel*). Shaded regions represent the 95% confidence intervals.

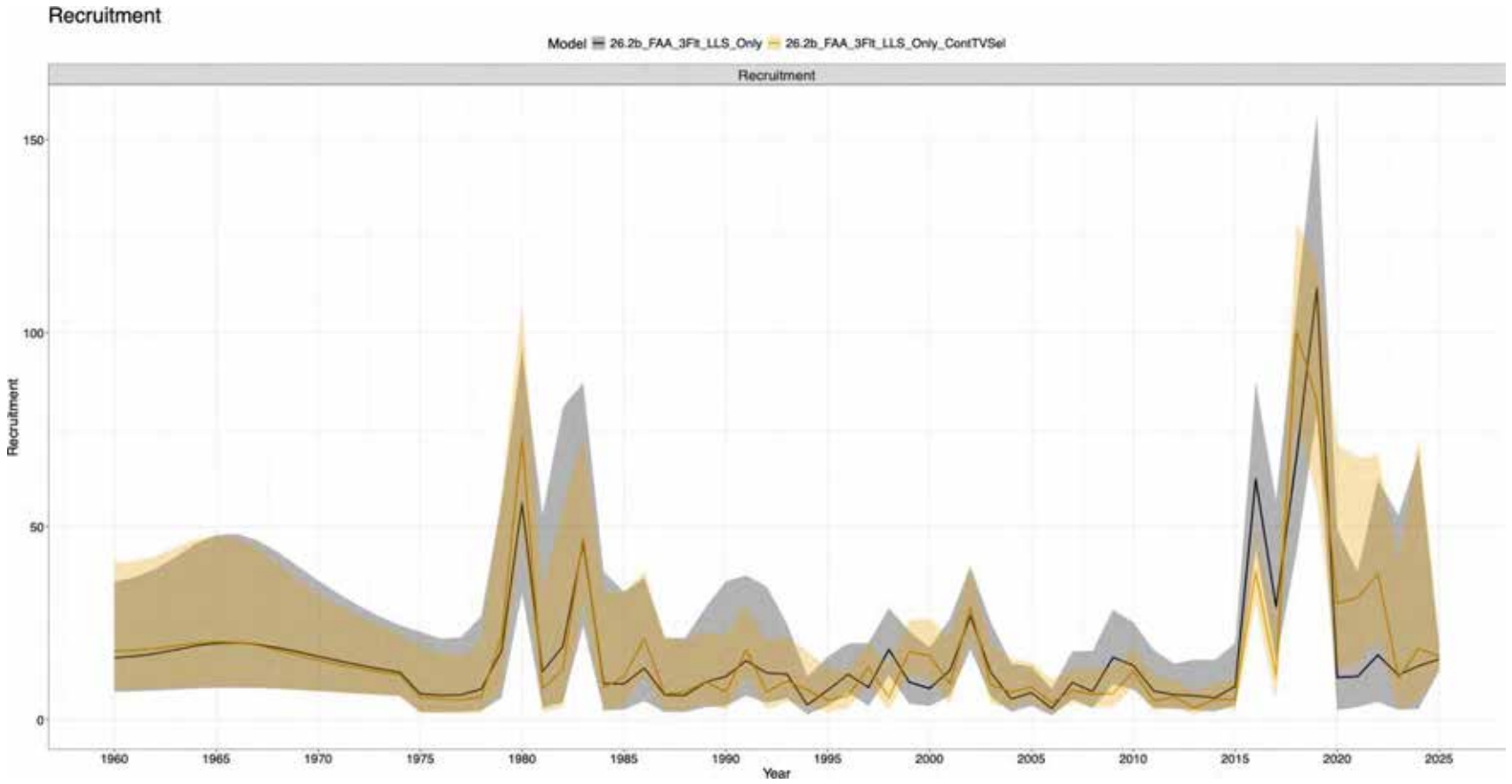

Figure 3C.26. Comparison of age-2 recruitment (in millions of individuals) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity (*26.2b_FAA_3Flt_LLS_Only_ContTVSel*). Shaded regions represent the 95% confidence intervals.

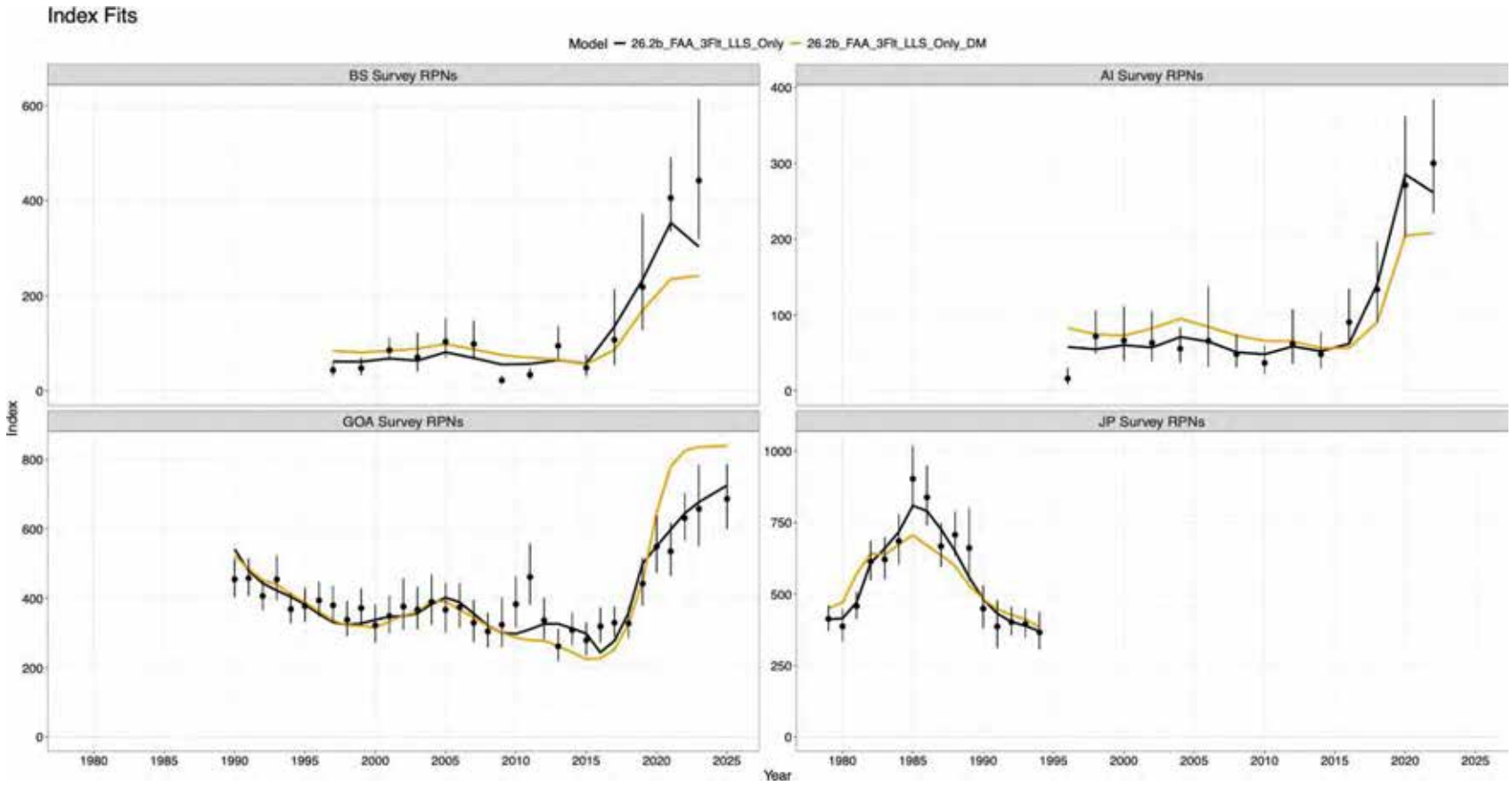

Figure 3C.27. Model fits to survey abundance indices between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.2b_FAA_3Flt_LLS_Only_DM*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

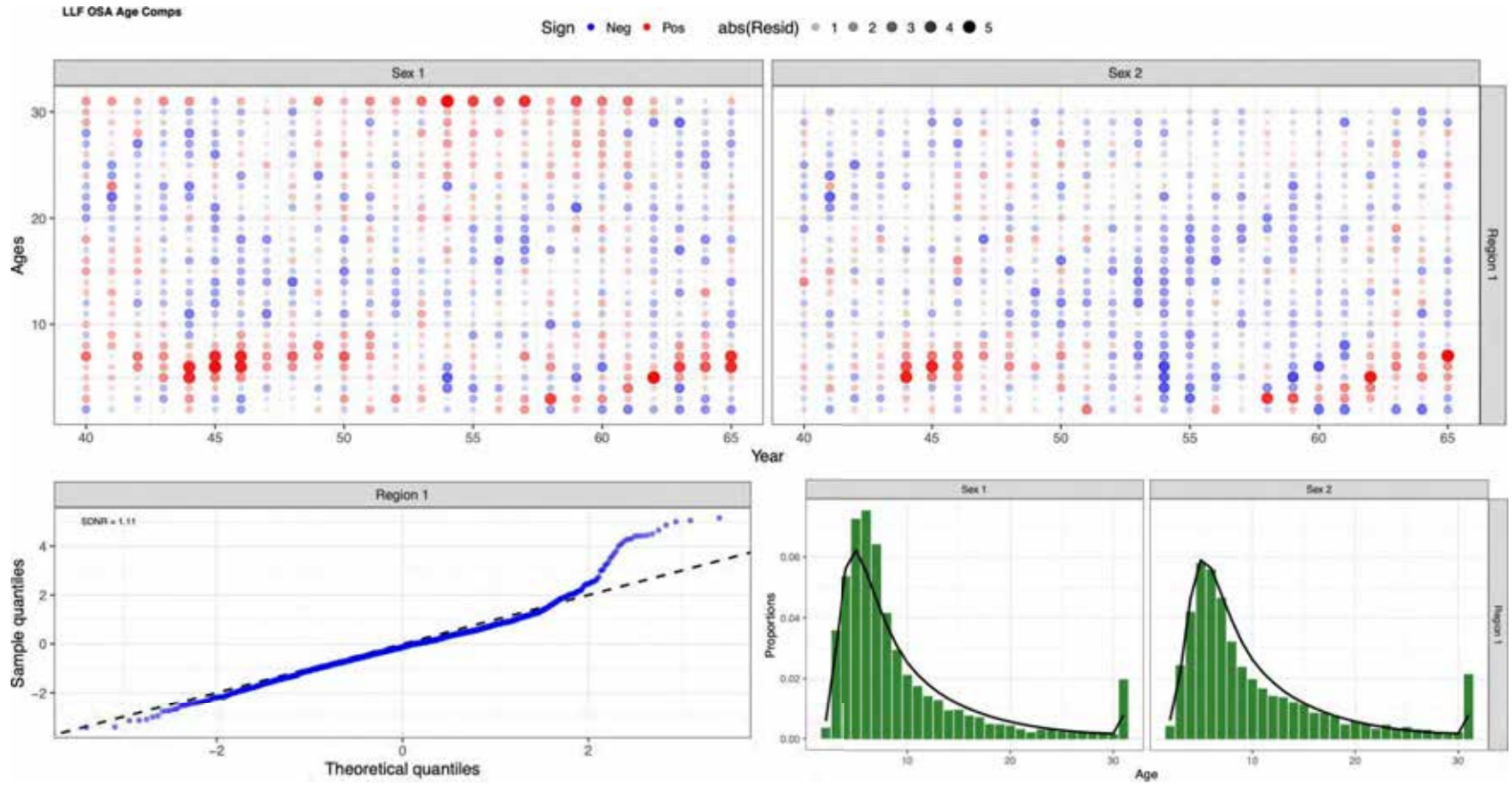

Figure 3C.28. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

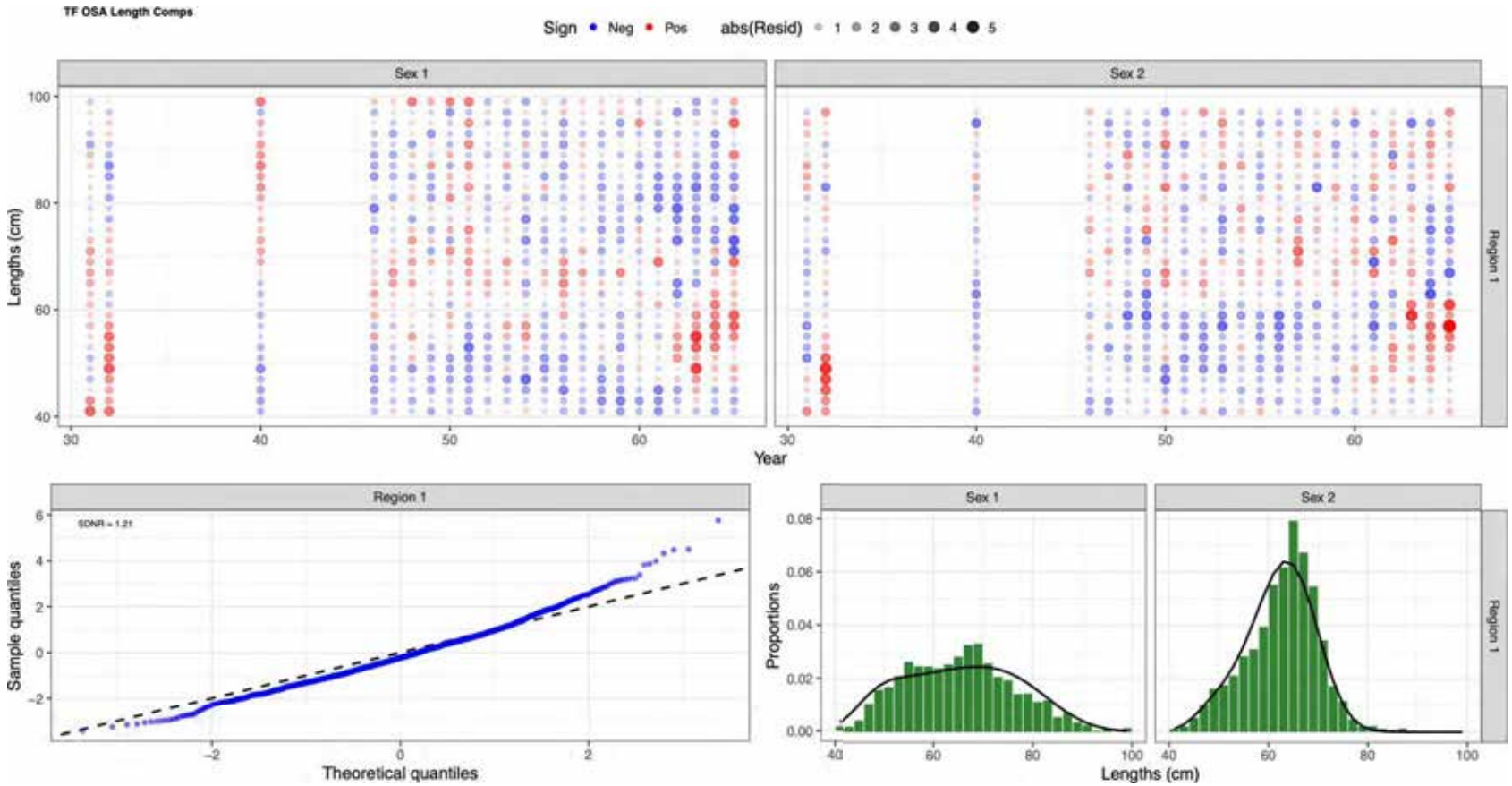

Figure 3C.29. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

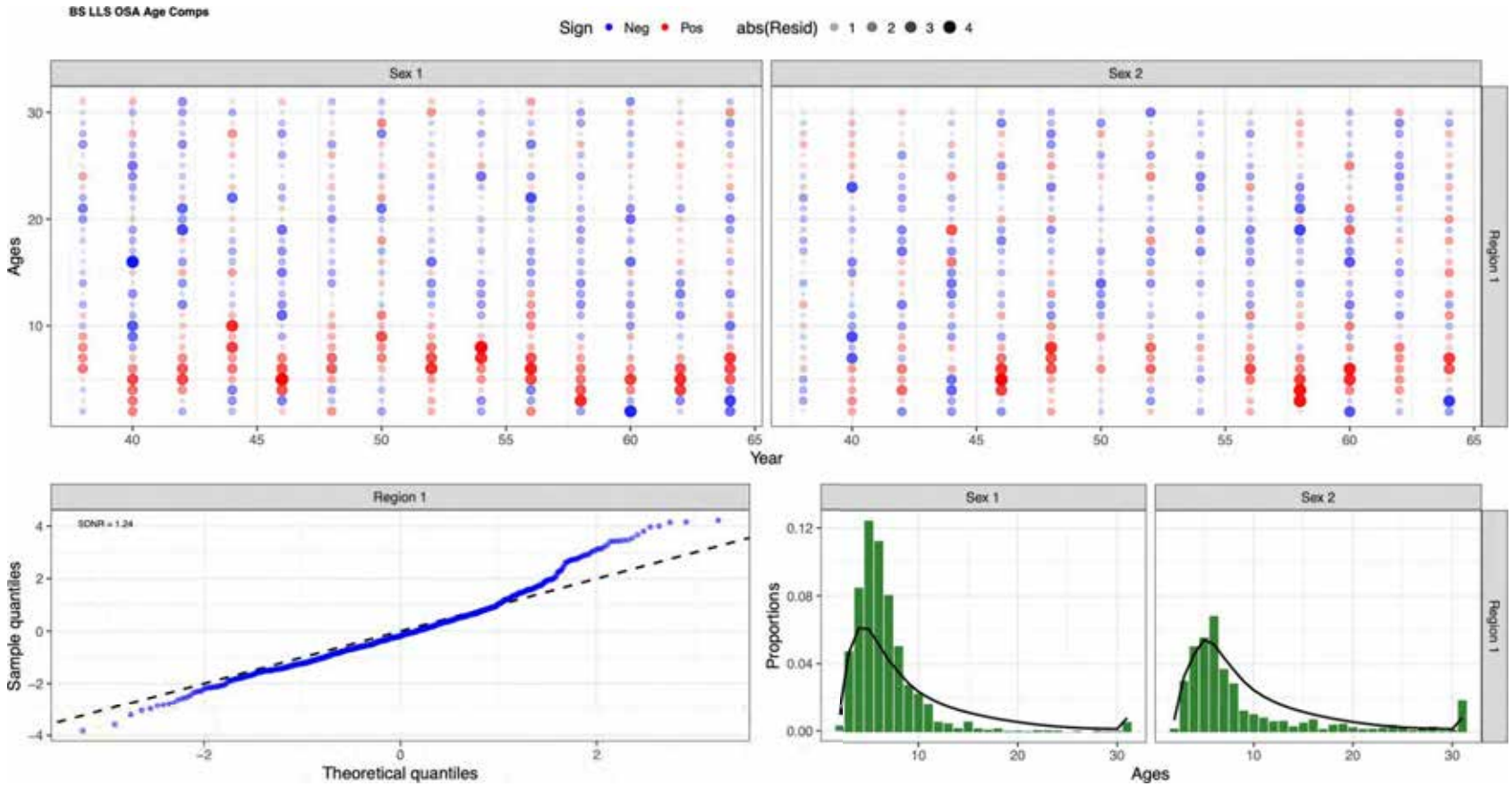

Figure 3C.30. Fits to NOAA longline Bering Sea (BS) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

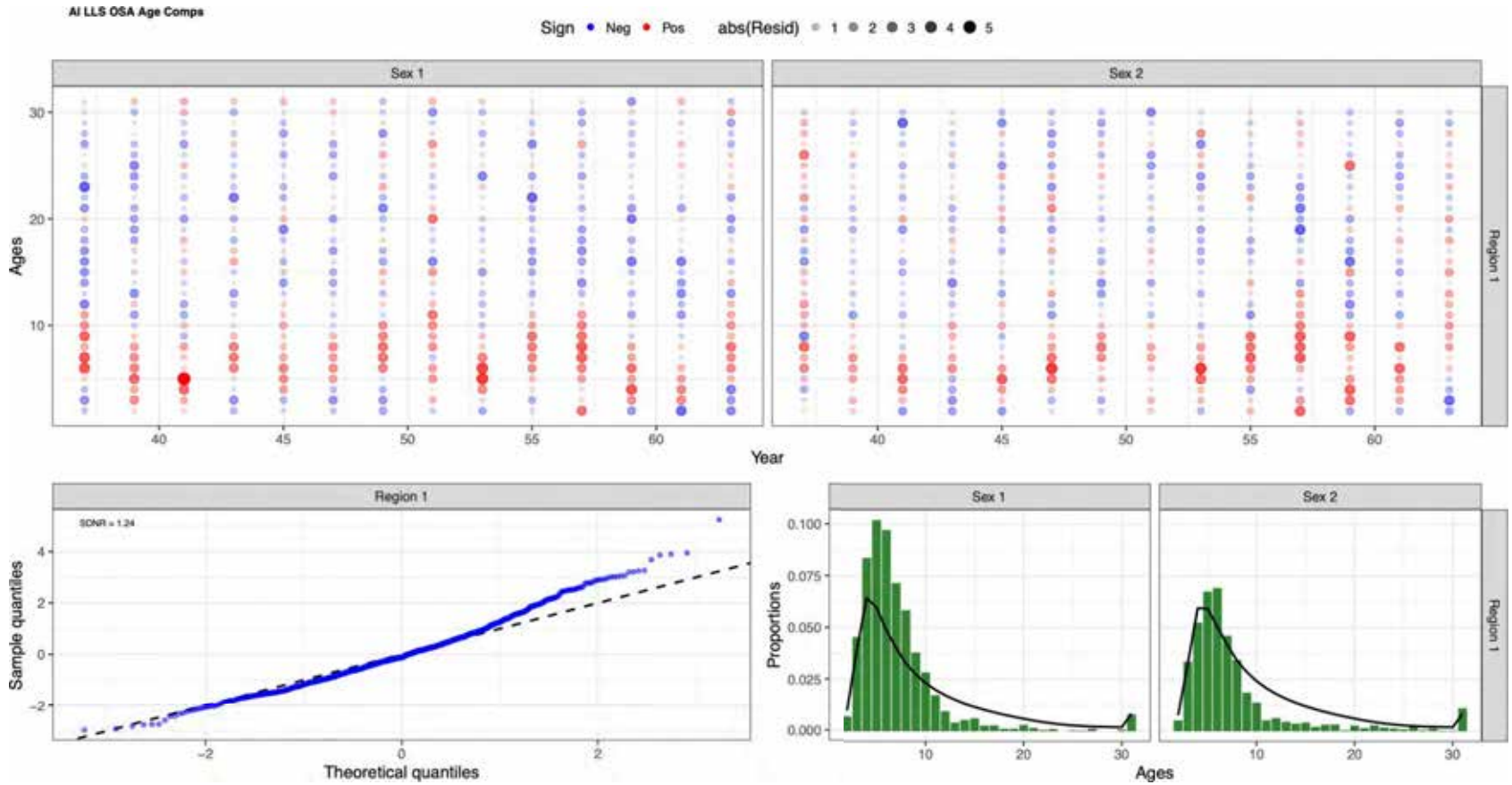

Figure 3C.31. Fits to NOAA longline Aleutian Islands (AI) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

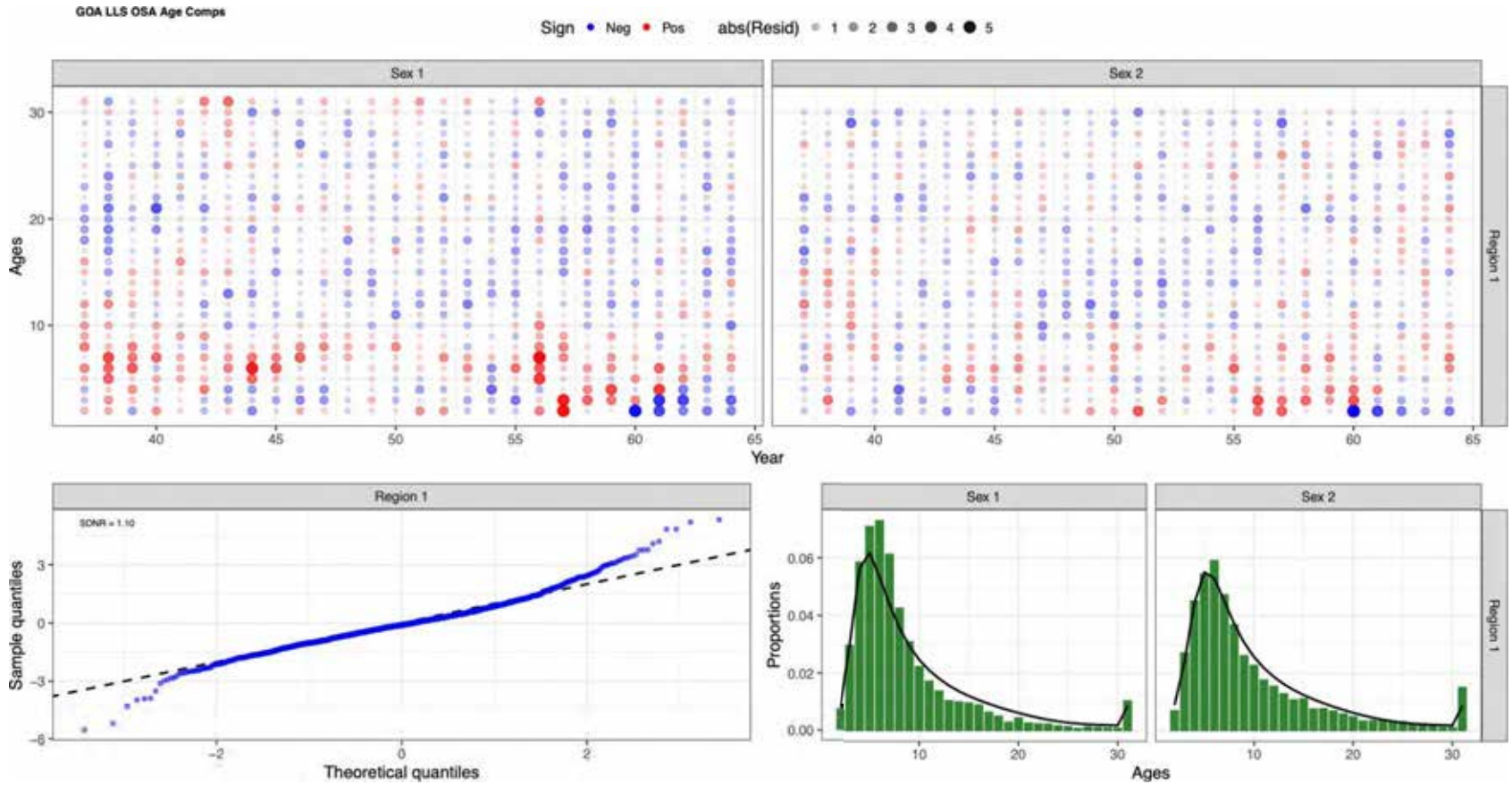

Figure 3C.32. Fits to NOAA longline Gulf of Alaska (GOA) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

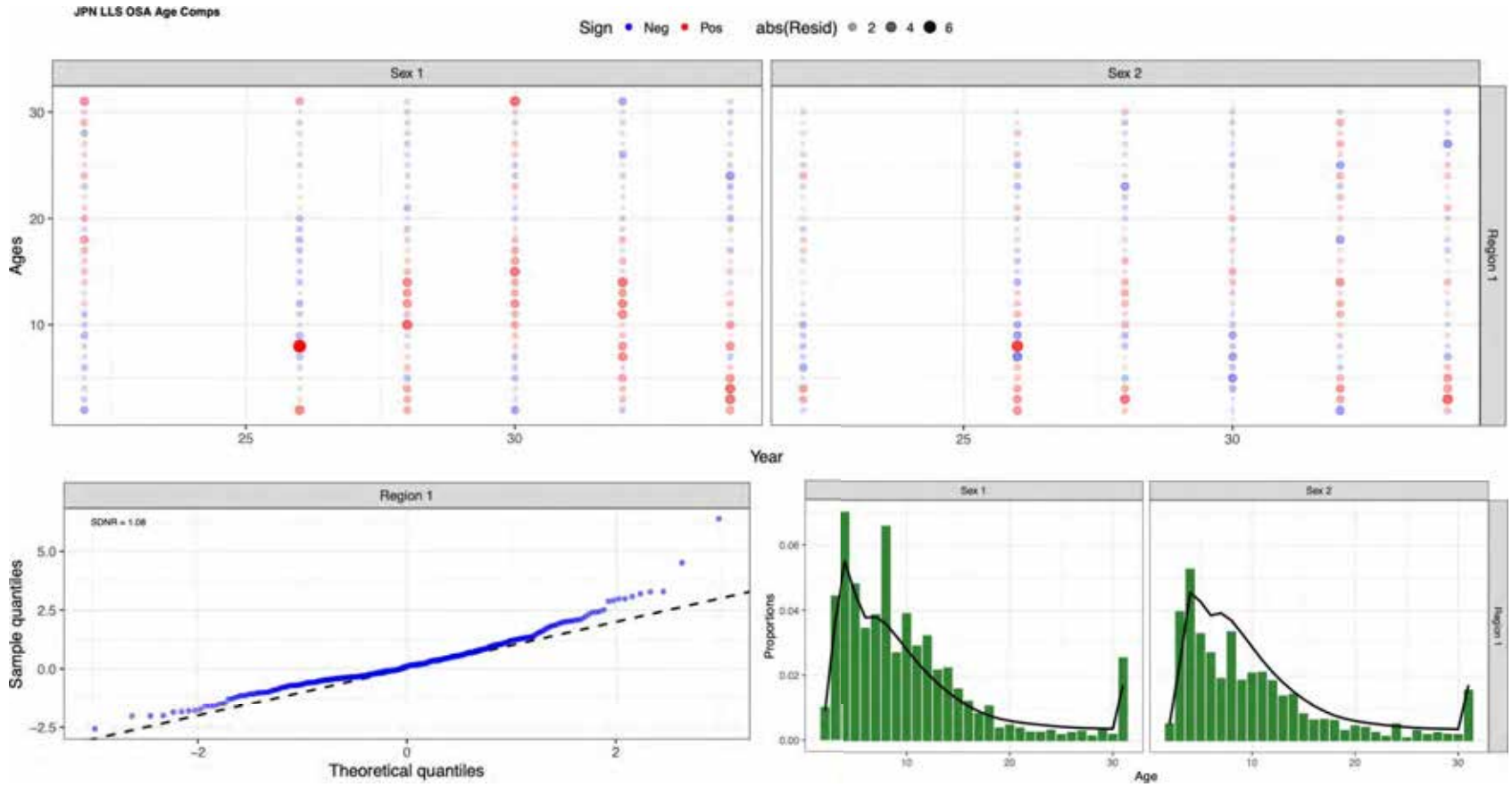

Figure 3C.33. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

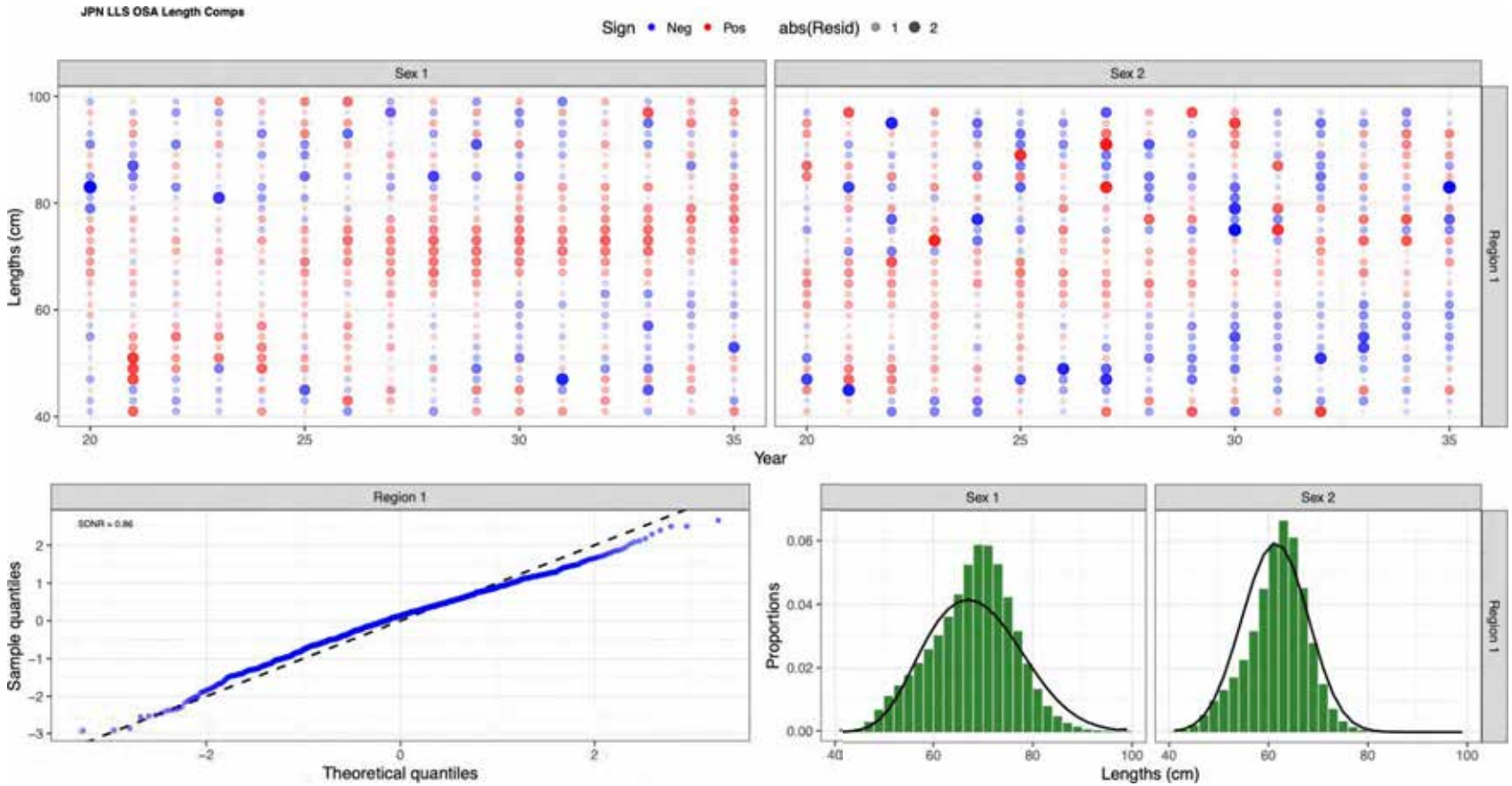

Figure 3C.34. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

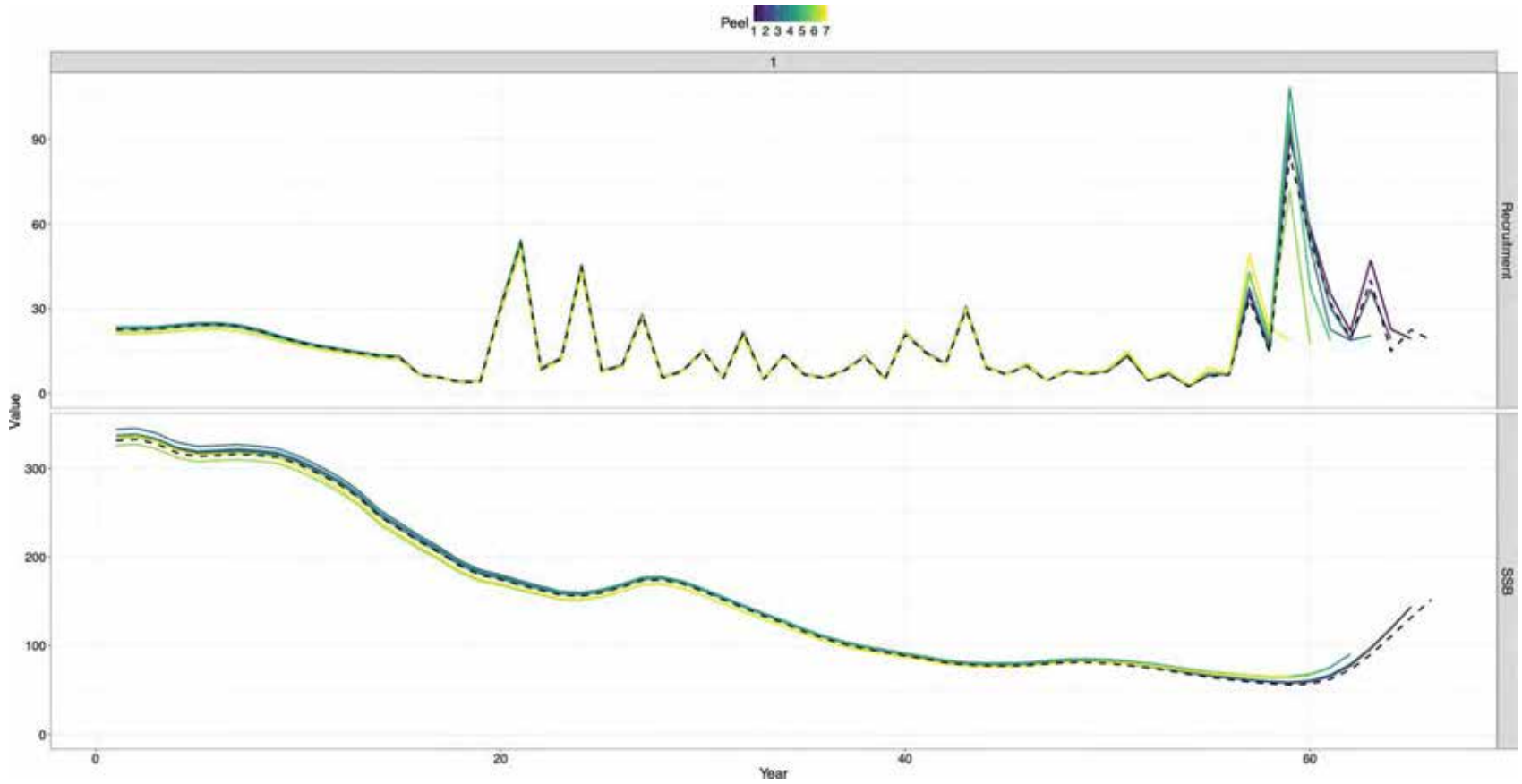

Figure 3C.35. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA_DM*. Mohn's rho for SSB was 0.147.

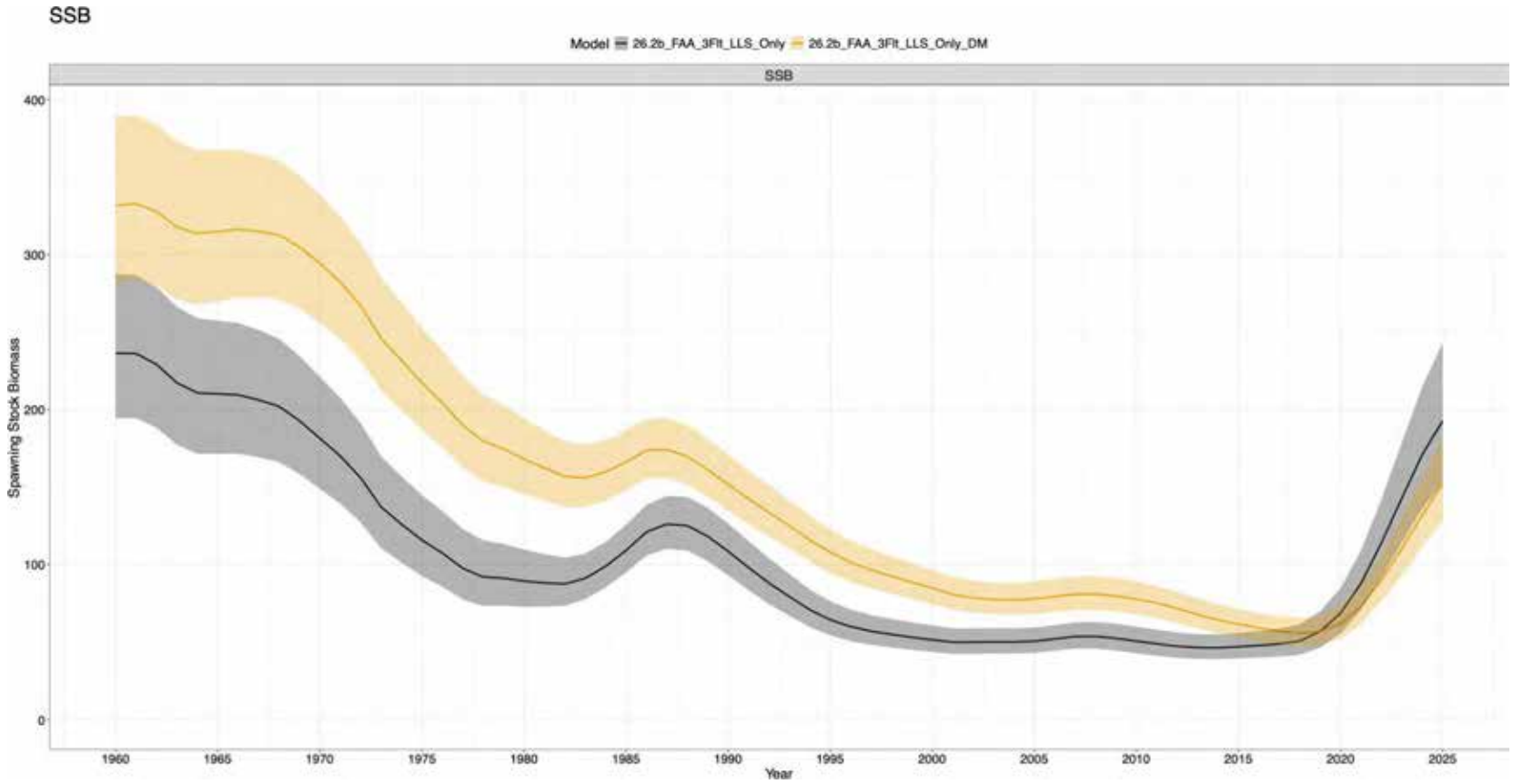

Figure 3C.36. Comparison of spawning stock biomass (SSB, in kilotons) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.2b_FAA_3Flt_LLS_Only_DM*). Shaded regions represent the 95% confidence intervals.

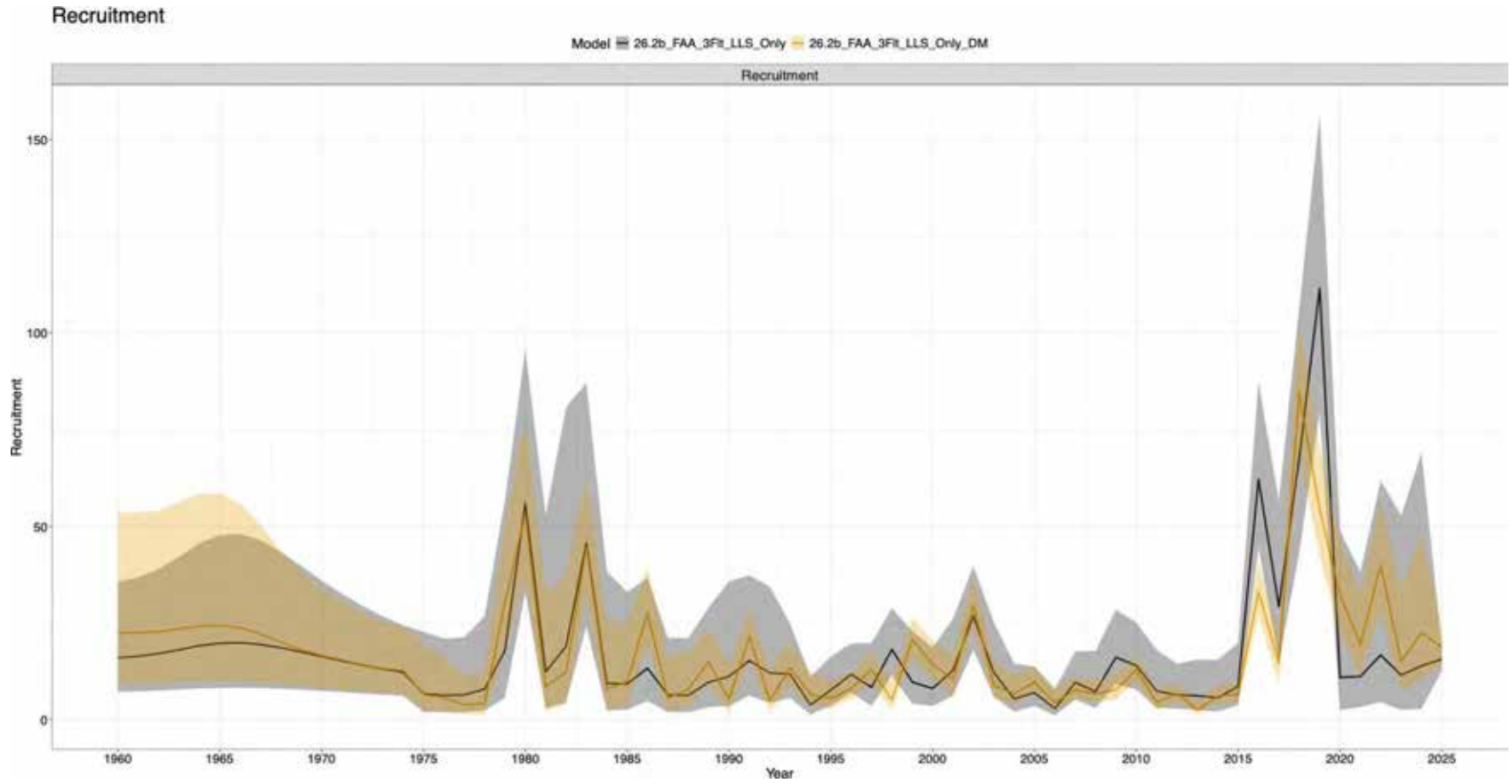

Figure 3C.37. Comparison of age-2 recruitment (millions of individuals) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates the Dirichlet-multinomial likelihood for composition data (*26.2b_FAA_3Flt_LLS_Only_DM*). Shaded regions represent the 95% confidence intervals.

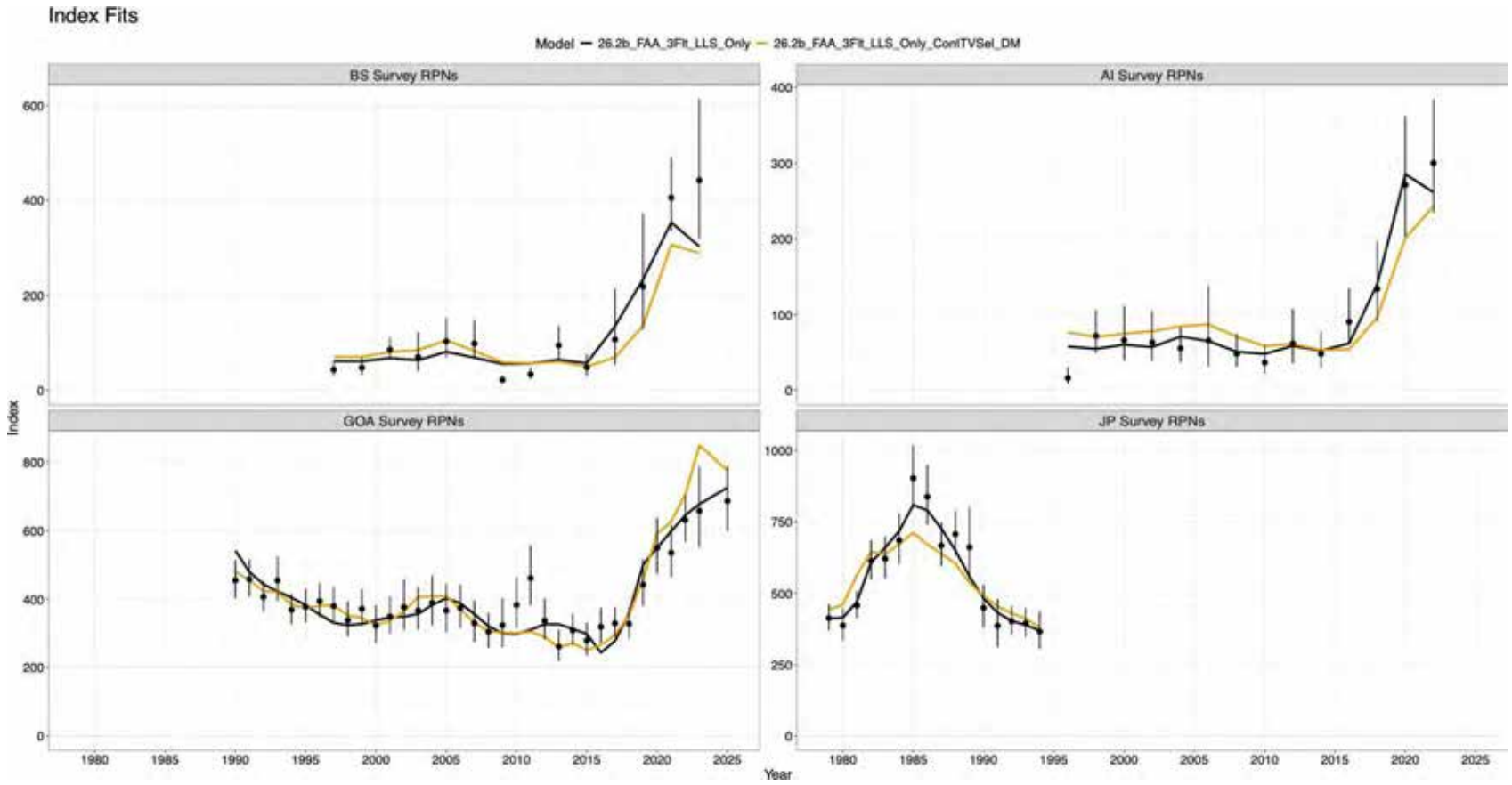

Figure 3C.38. Model fits to survey abundance indices between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous semi-parametric time-varying survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.2b_FAA_3Flt_LLS_Only_ContTVSel_DM*). Point ranges denote observed data and associated 95% confidence intervals. Solid colored lines represent the model expectation.

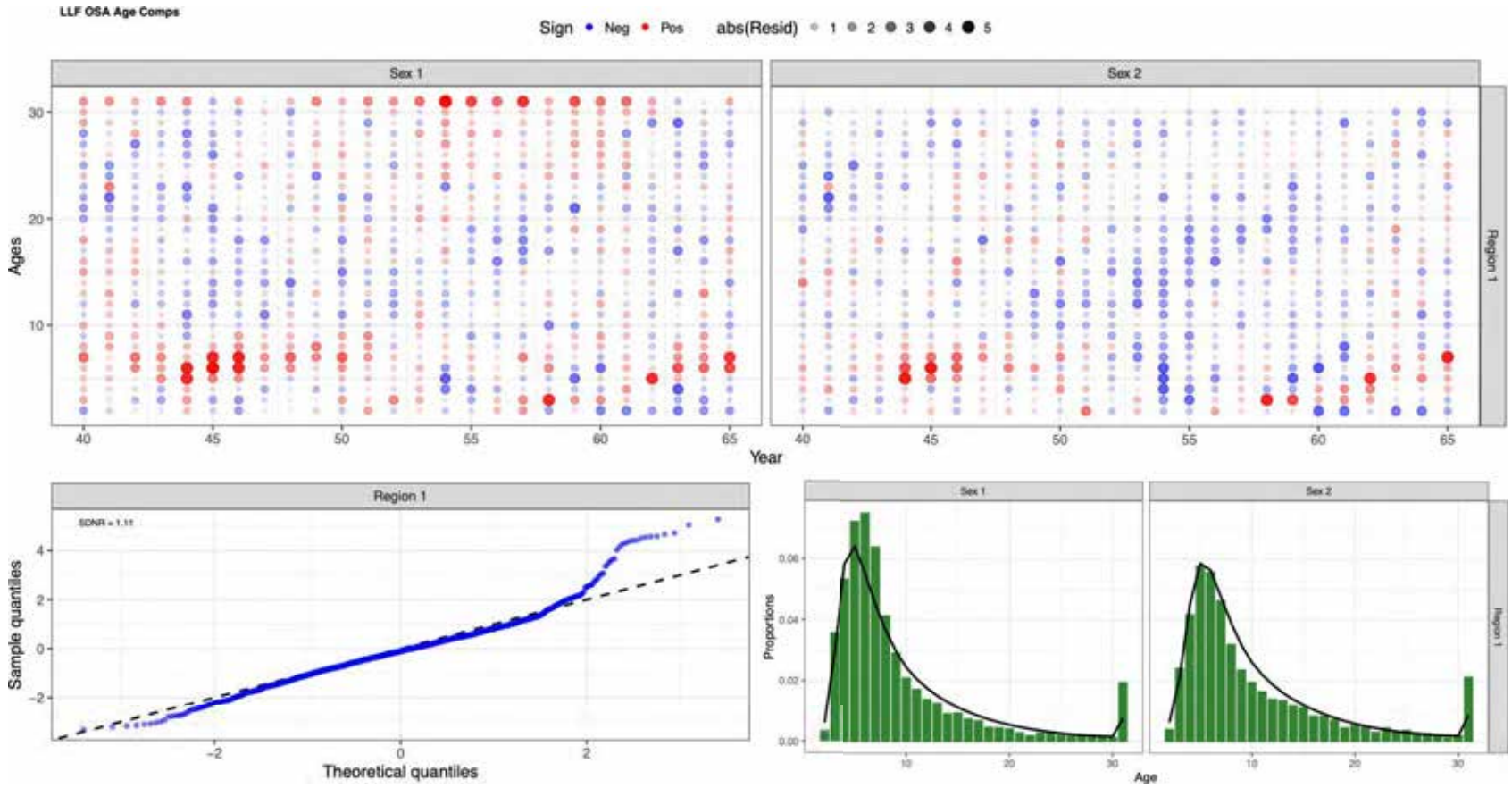

Figure 3C.39. Fits to longline fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

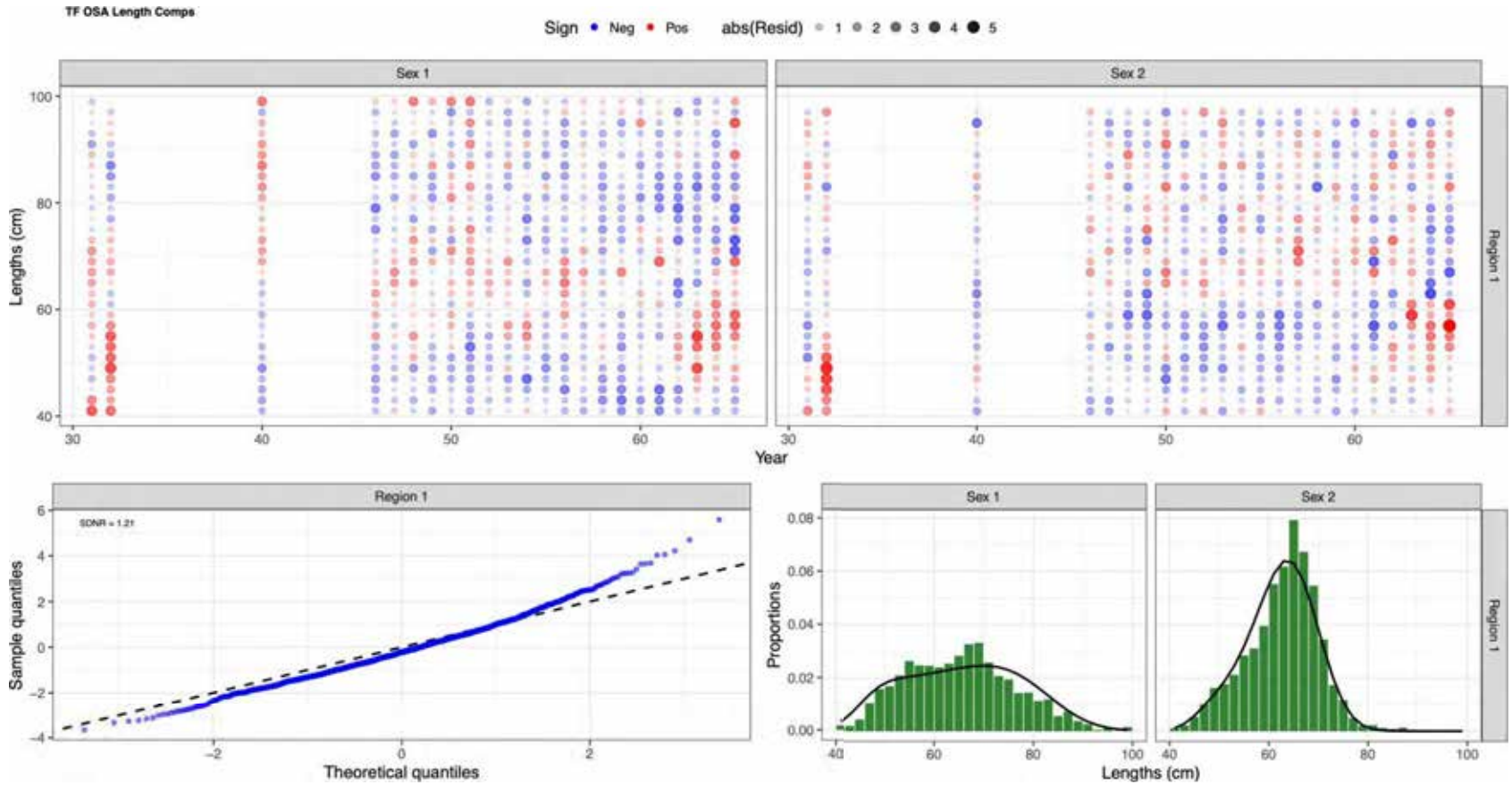

Figure 3C.40. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_DM*.

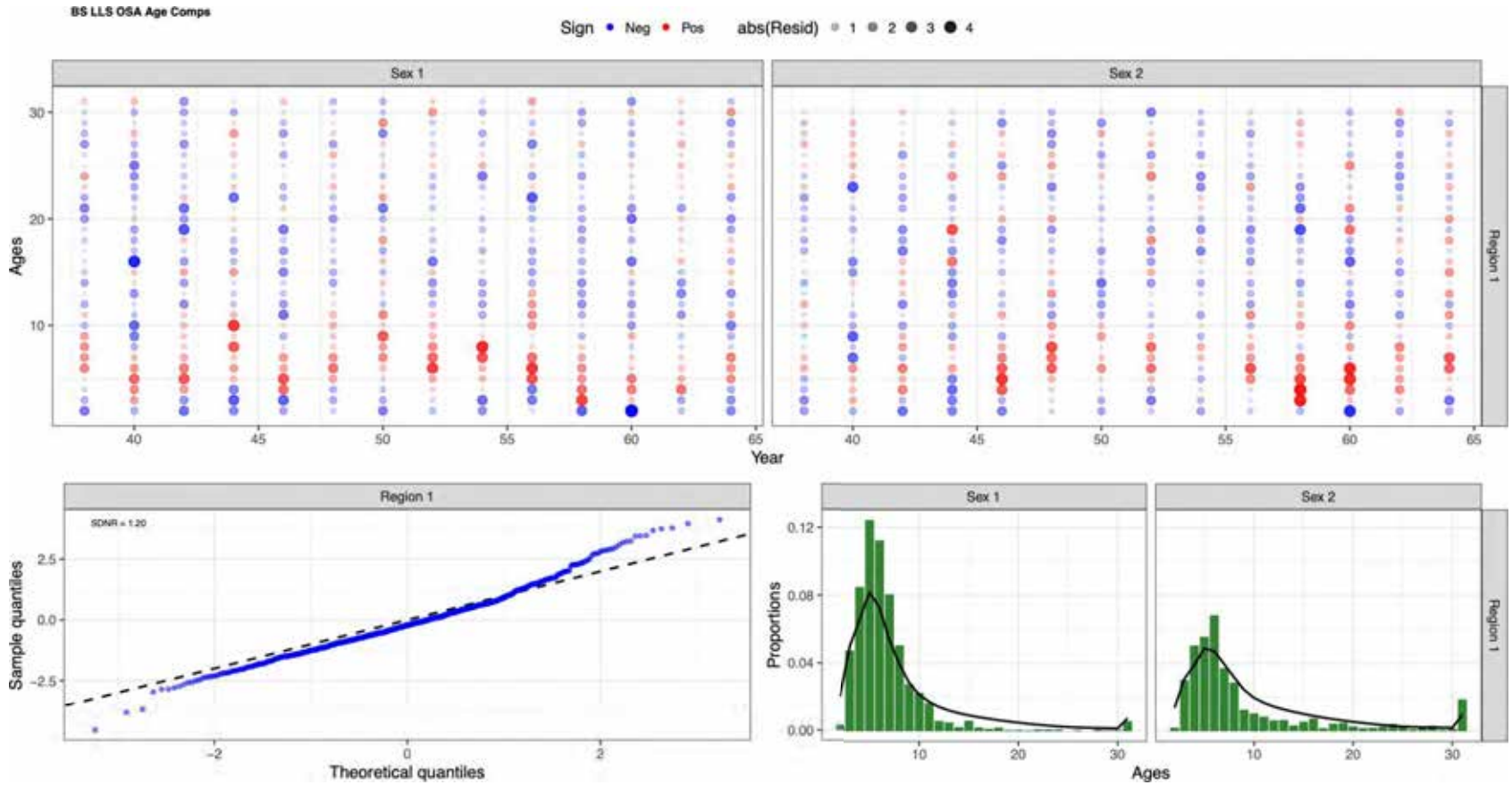

Figure 3C.41. Fits to NOAA longline Bering Sea (BS) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

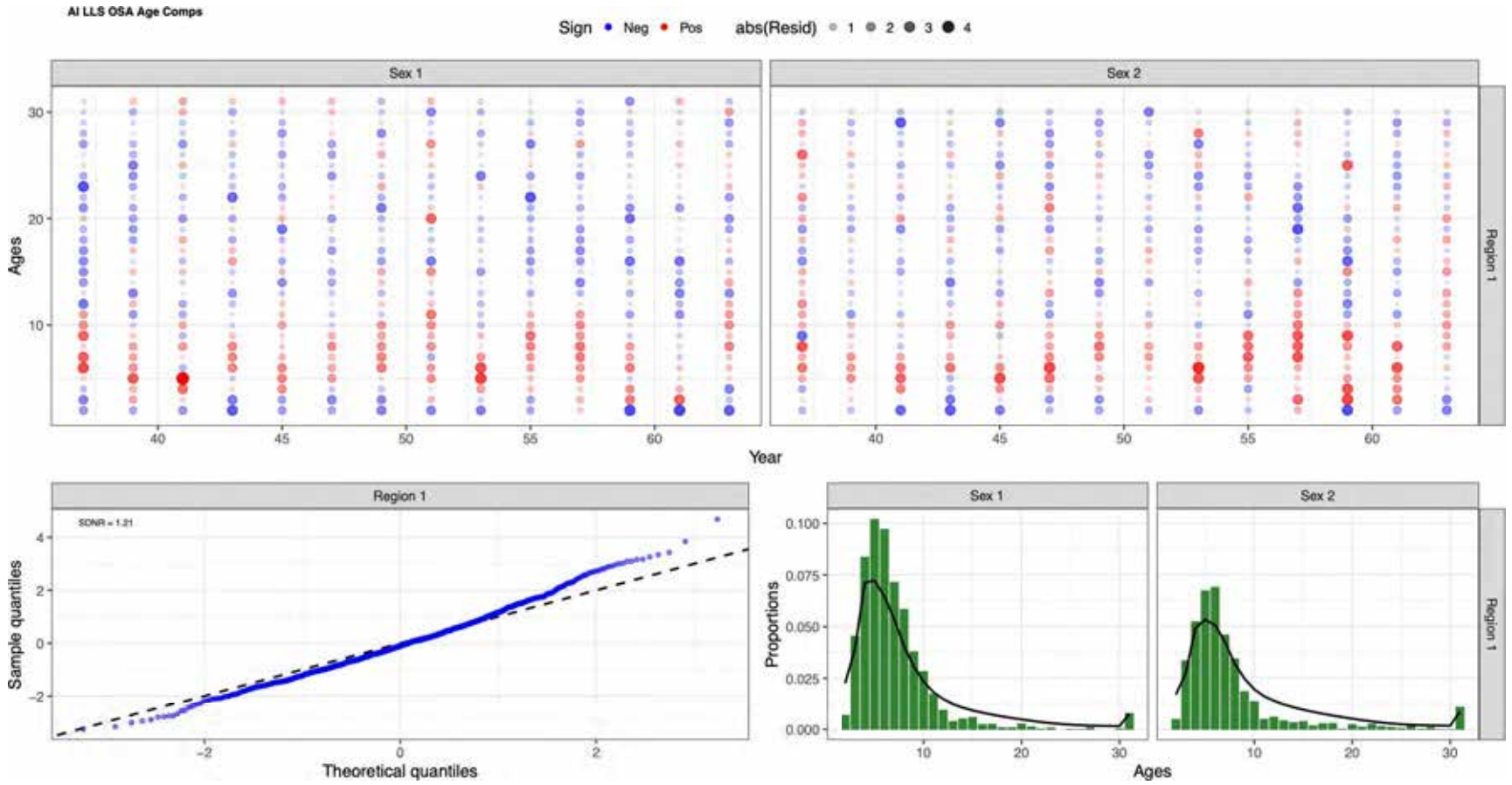

Figure 3C.42. Fits to NOAA longline Aleutian Islands (AI) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

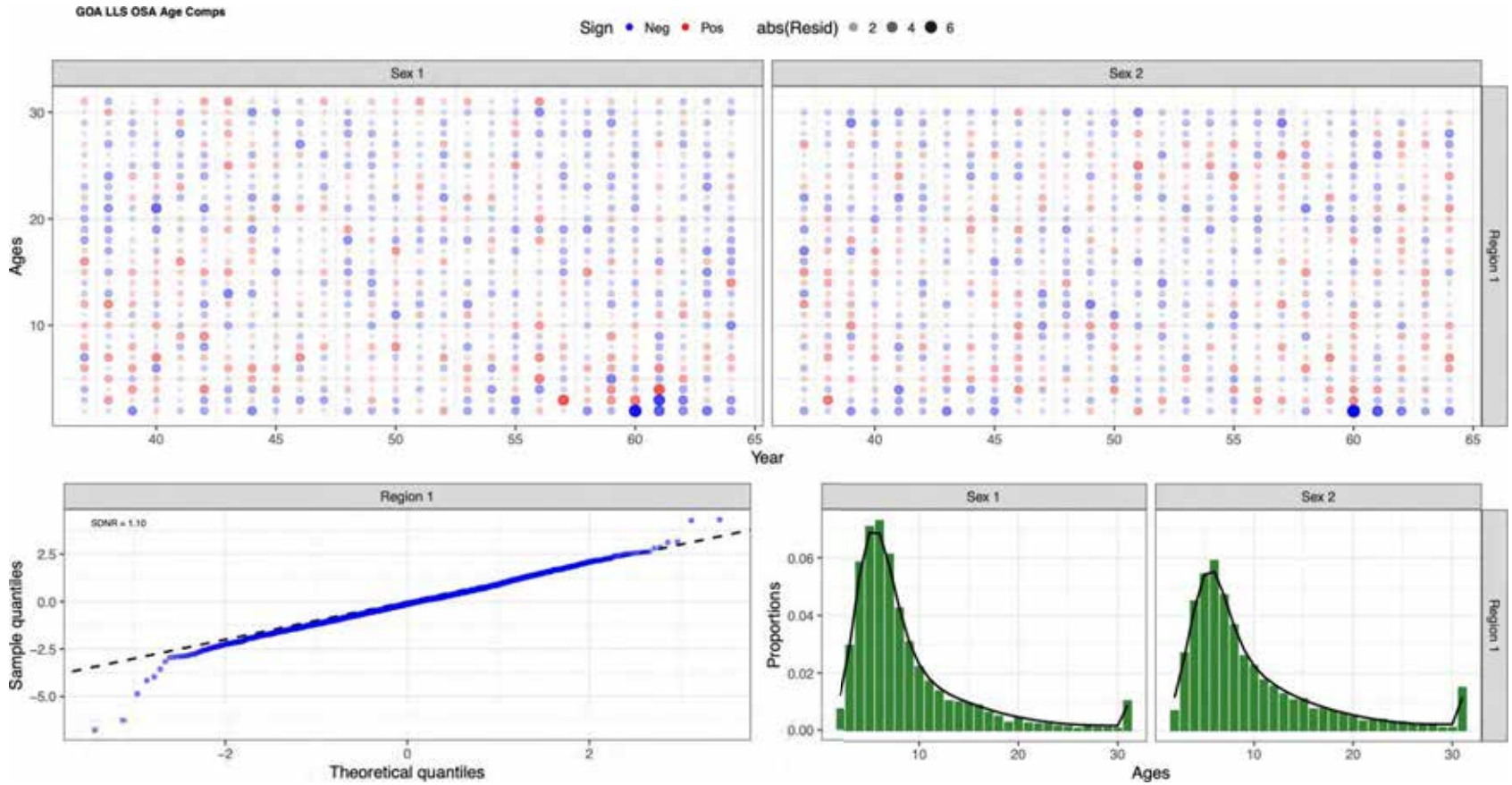

Figure 3C.43. Fits to NOAA longline Gulf of Alaska (GOA) survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

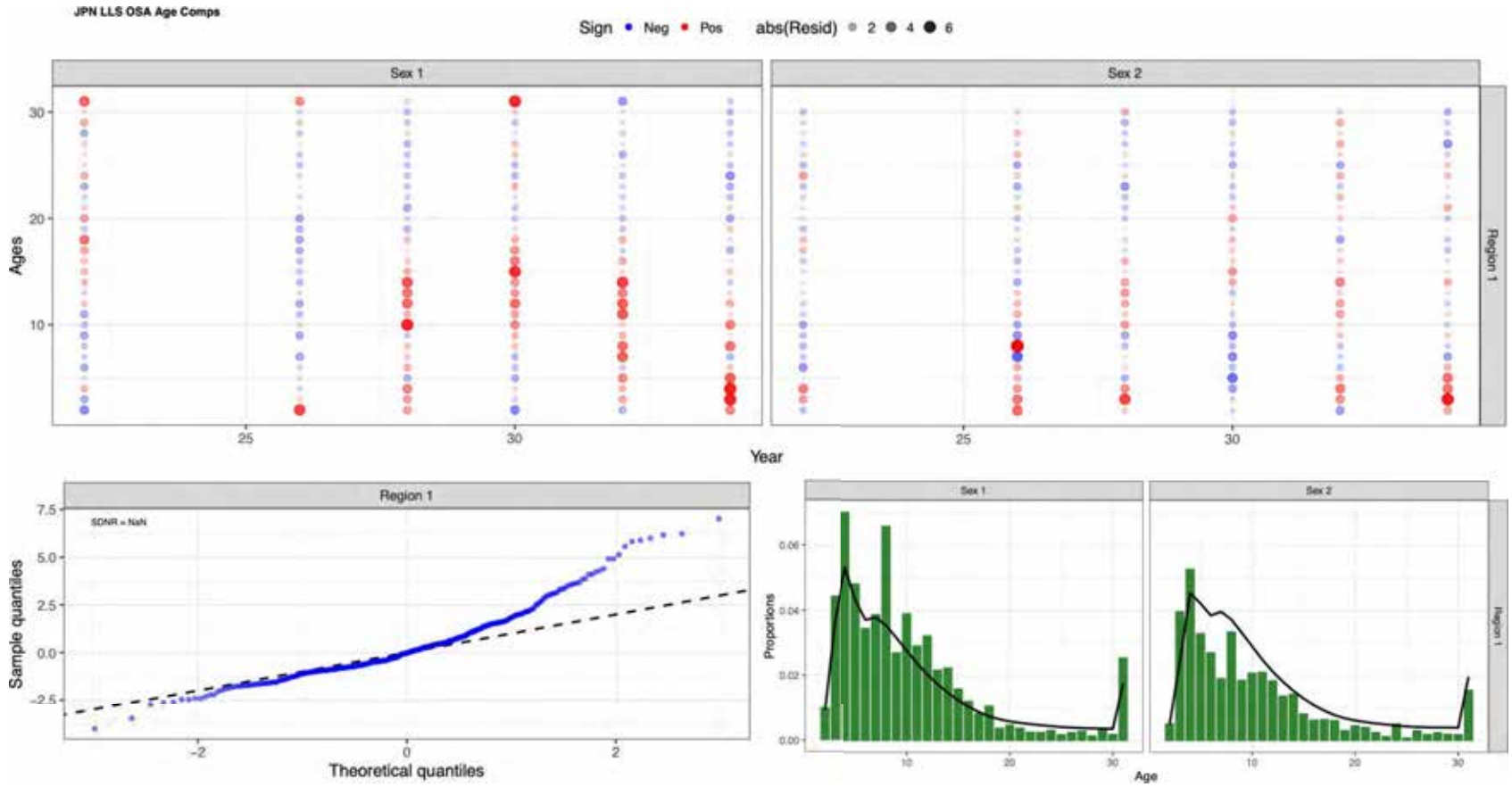

Figure 3C.44. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

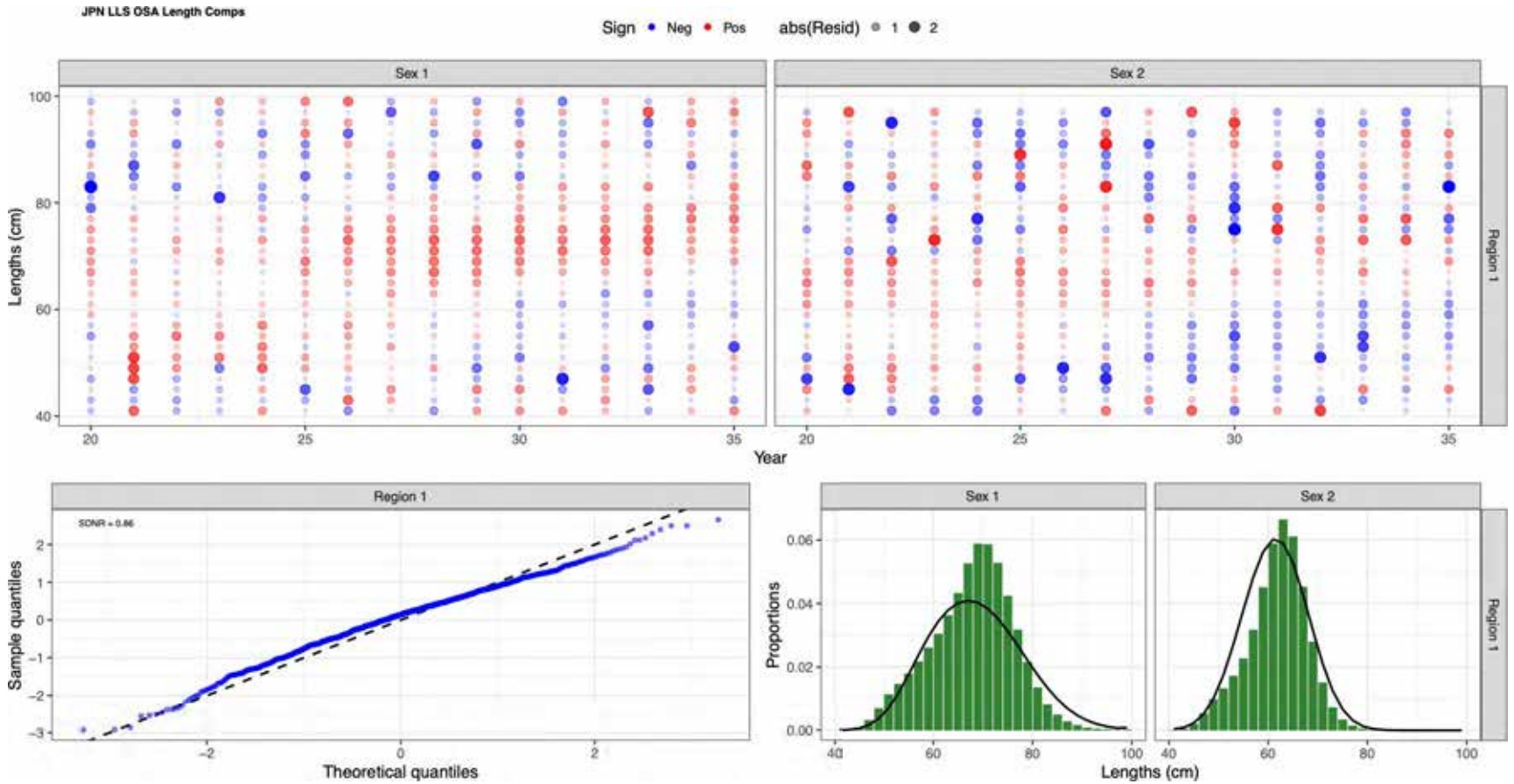

Figure 3C.45. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA_ContTVSel_DM*.

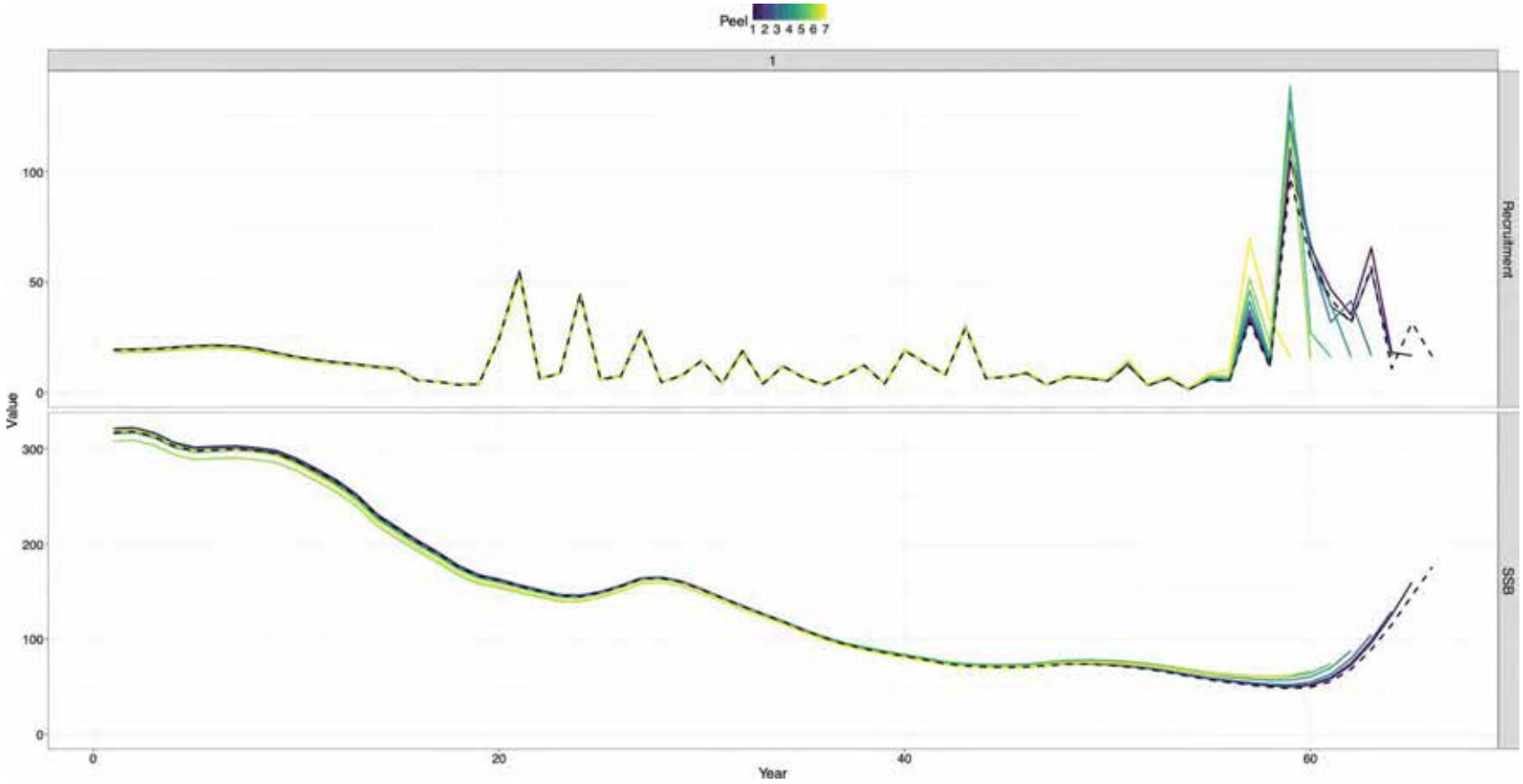

Figure 3C.46. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA_ContTVSel_DM*. Mohn's rho for SSB was 0.234.

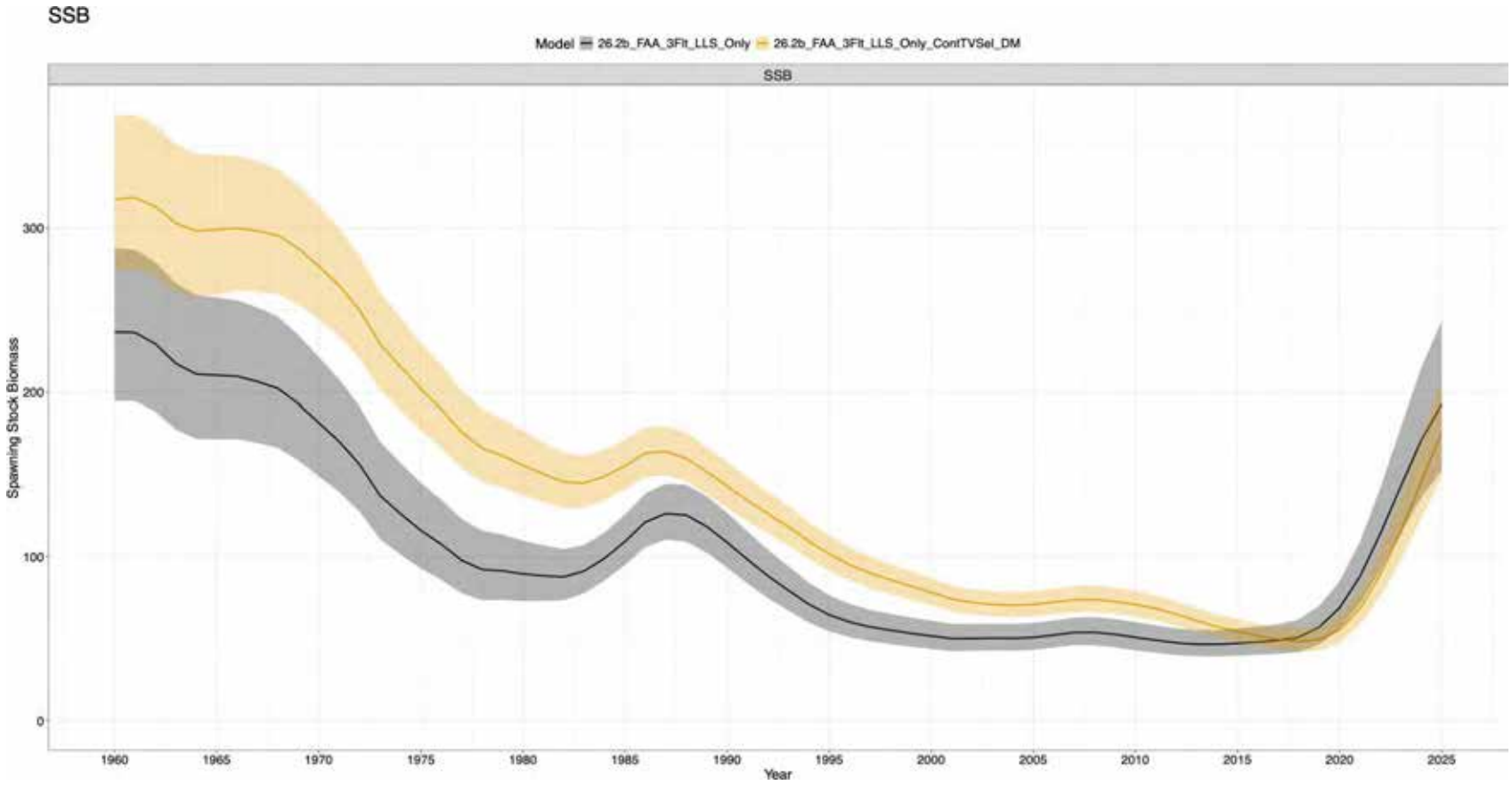

Figure 3C.47. Comparison of spawning stock biomass (SSB, in kilotons) Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.2b_FAA_3Flt_LLS_Only_ContTVSel_DM*). Shaded regions represent the 95% confidence intervals.

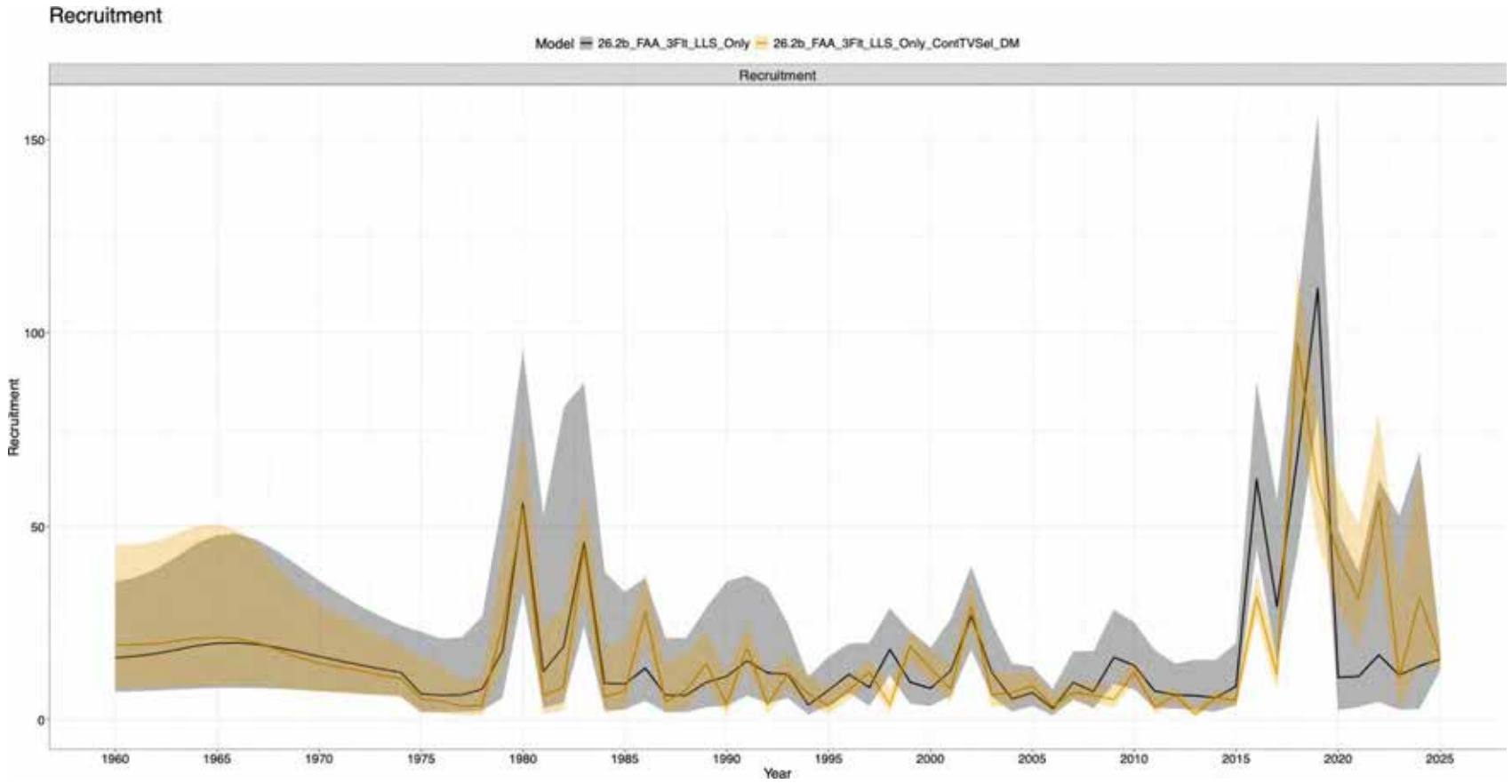

Figure 3C.48. Comparison of age-2 recruitment (millions of fish) between Model *26.2_FAA* (also termed *26.2b_FAA_3Flt_LLS_Only*), along with a configuration that incorporates continuous time-varying semi-parametric survey selectivity and Dirichlet-multinomial likelihoods for composition data (*26.2b_FAA_3Flt_LLS_Only_ContTVSel_DM*). Shaded regions represent the 95% confidence intervals.

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4. Supplemental Material 3C: Additional Figures

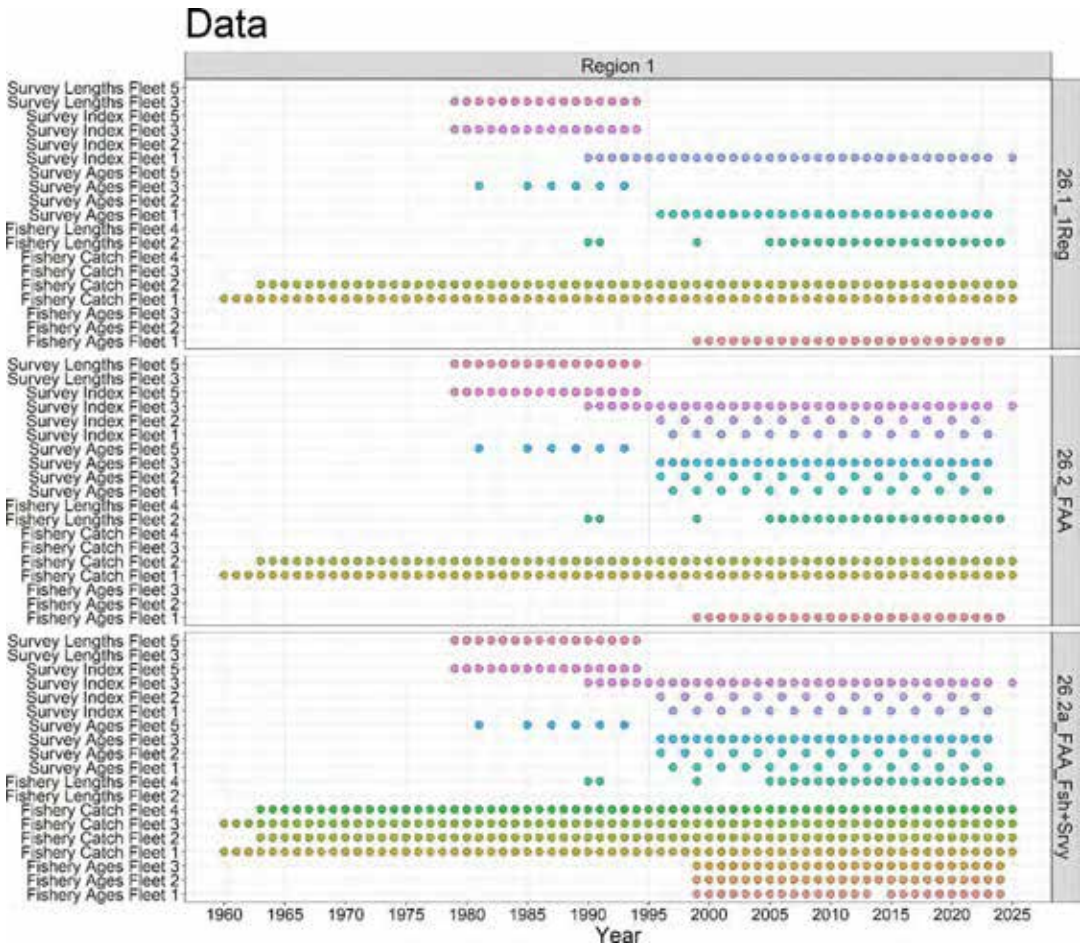

Figure SM3C.1. Data inputs used by each model. Note that fleet numbers vary across models. When fleets are not disaggregated by region then Fishery Fleet 1 is the fixed gear fleet and Fishery Fleet 2 is the trawl fleet, while Survey Fleet 1 is the NOAA Longline Survey and survey Fleet 3 is the Japanese Longline Survey. When fleets are disaggregated by region then Fishery Fleet 1 is the BS fixed gear fleet, Fishery Fleet 2 is the AI fixed gear fleet, Fishery Fleet 3 is the GOA fixed gear fleet, and Fishery Fleet 4 is the trawl fleet, while Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey.

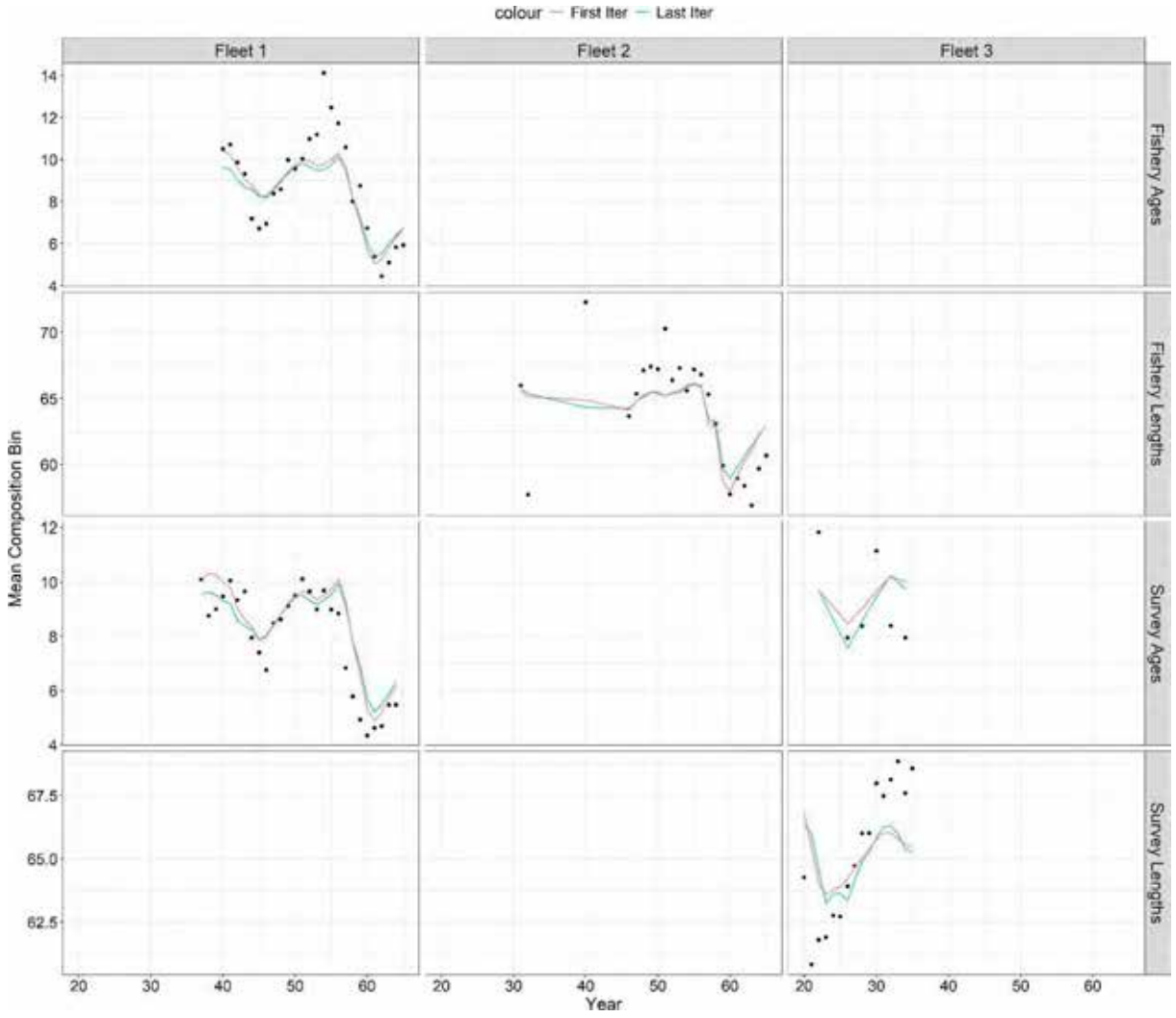

Figure SM3C.2. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.1_1Reg*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey fleet 1 is the NOAA longline survey and fleet 3 is the Japanese longline survey. Year 1 is 1960.

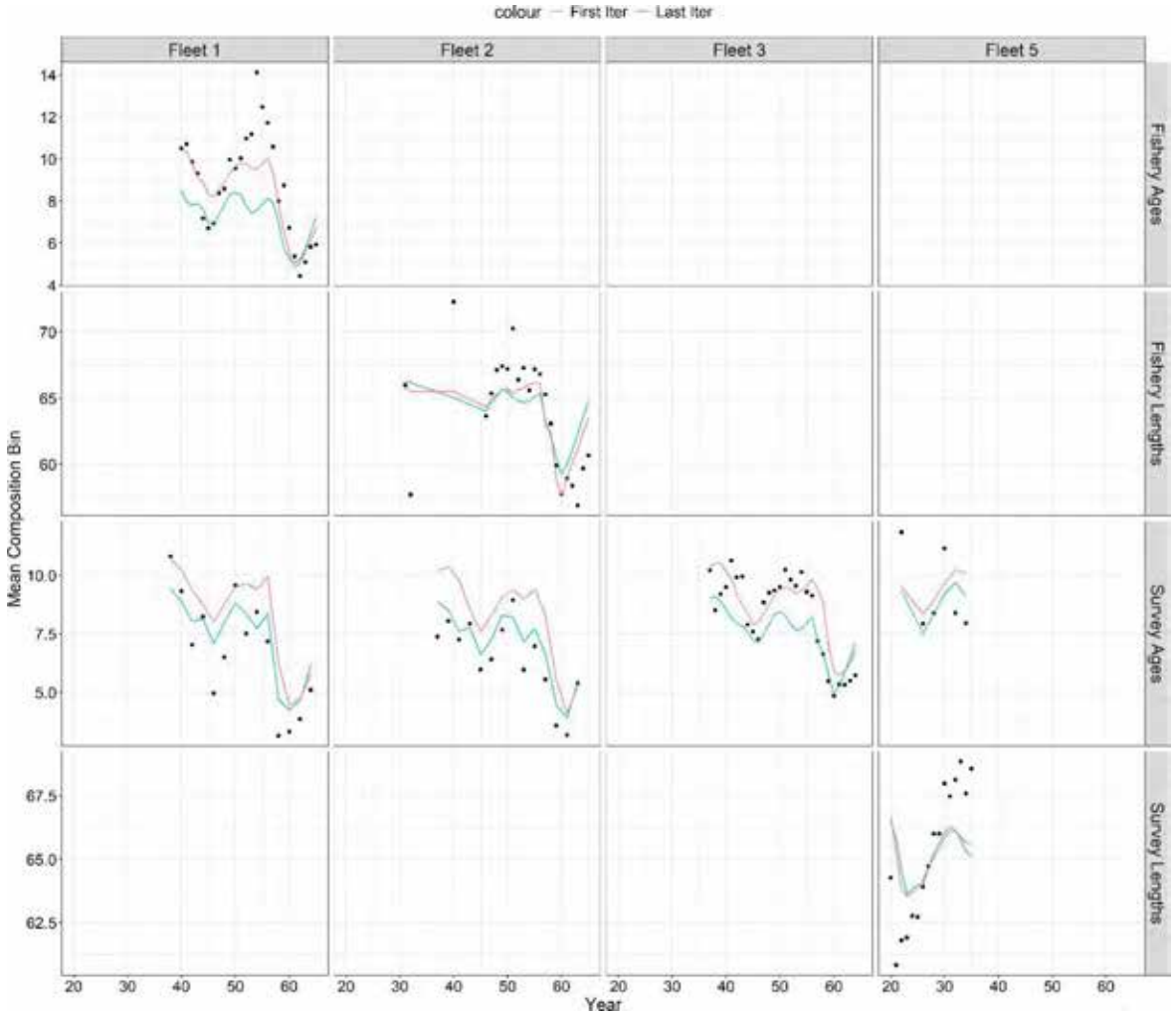

Figure SM3C.3. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.2_FAA*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey. Year 1 is 1960.

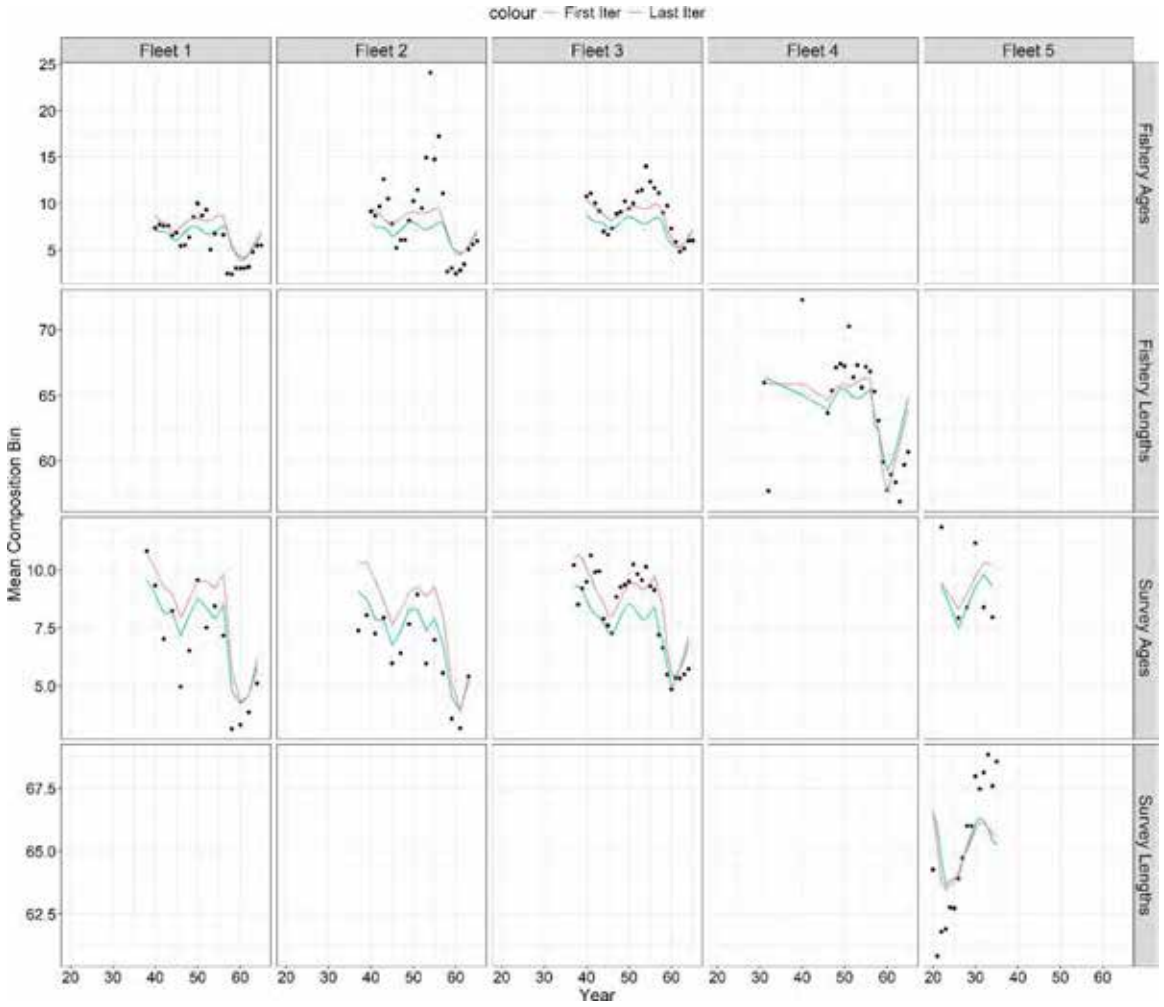

Figure SM3C.4. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.2a_FAA_Fsh+Srvy*. Fishery Fleet 1 is the BS fixed gear fleet, Fishery Fleet 2 is the AI fixed gear fleet, Fishery Fleet 3 is the GOA fixed gear fleet, and Fishery Fleet 4 is the trawl fleet. Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey. Year 1 is 1960.

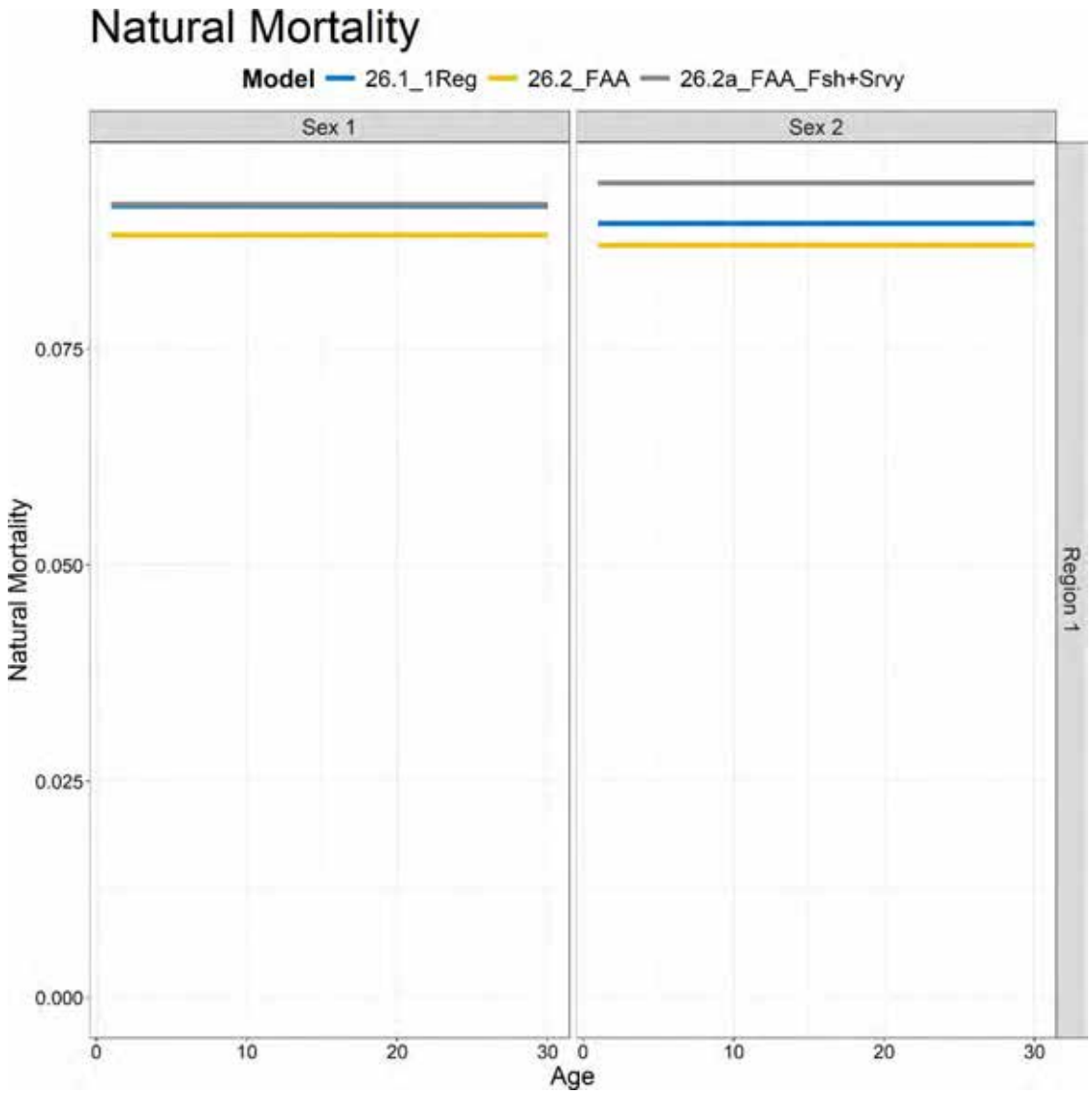

Figure SM3C.5. Natural mortality estimates from Model *25.12_1Reg_Cont* (black line) and Model *26.1_1Reg* (orange line). Sex 1 is females and sex 2 is males.

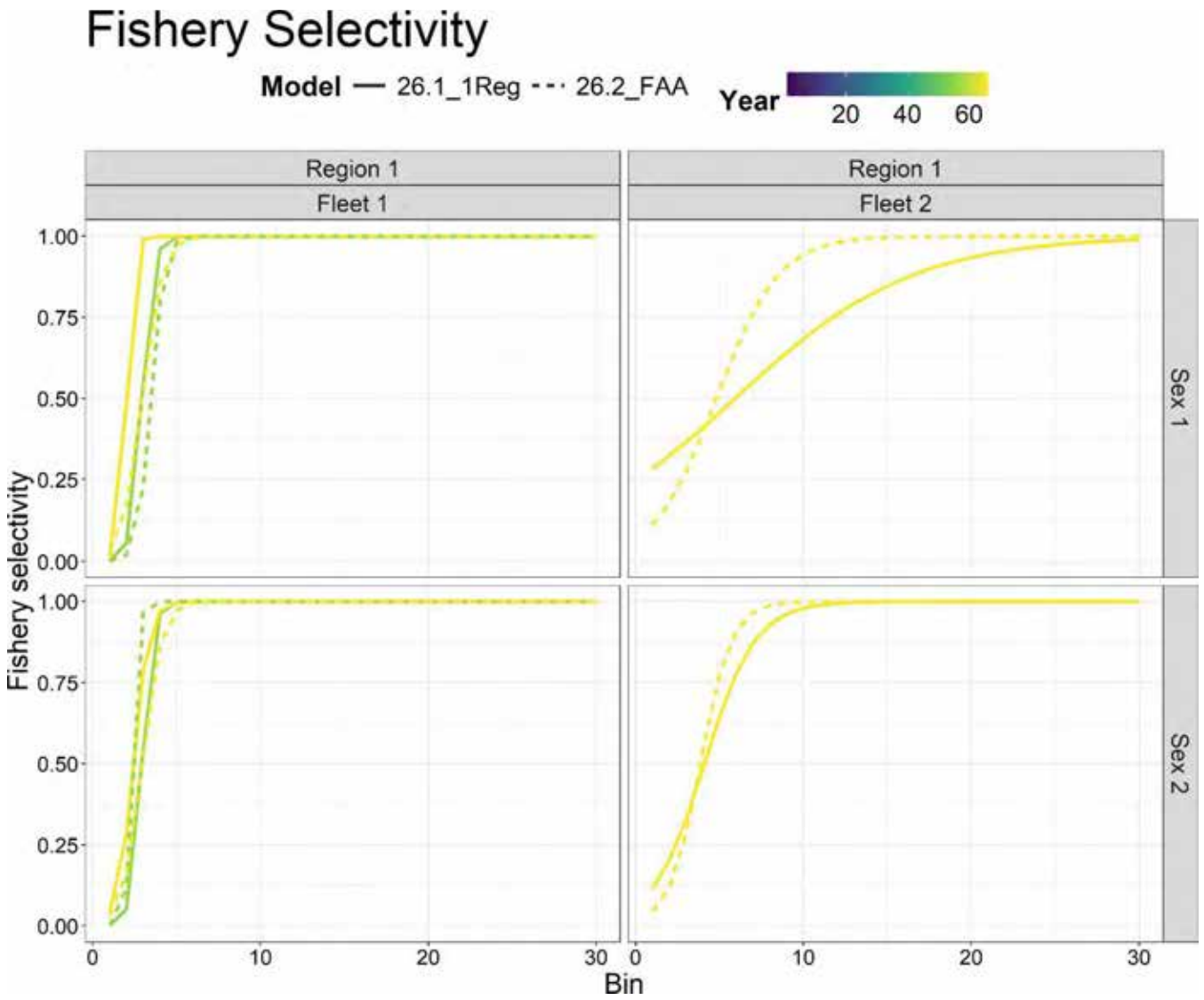

Figure SM3C.6. Fishery selectivity estimates from Model *26.1_1Reg* (solid line) and Model *26.2_FAA* (dashed line) where different colors represent the different time blocks. Fleet 1 is the fixed gear fleet and fleet 2 is the trawl fleet. Sex 1 is females and sex 2 is males.

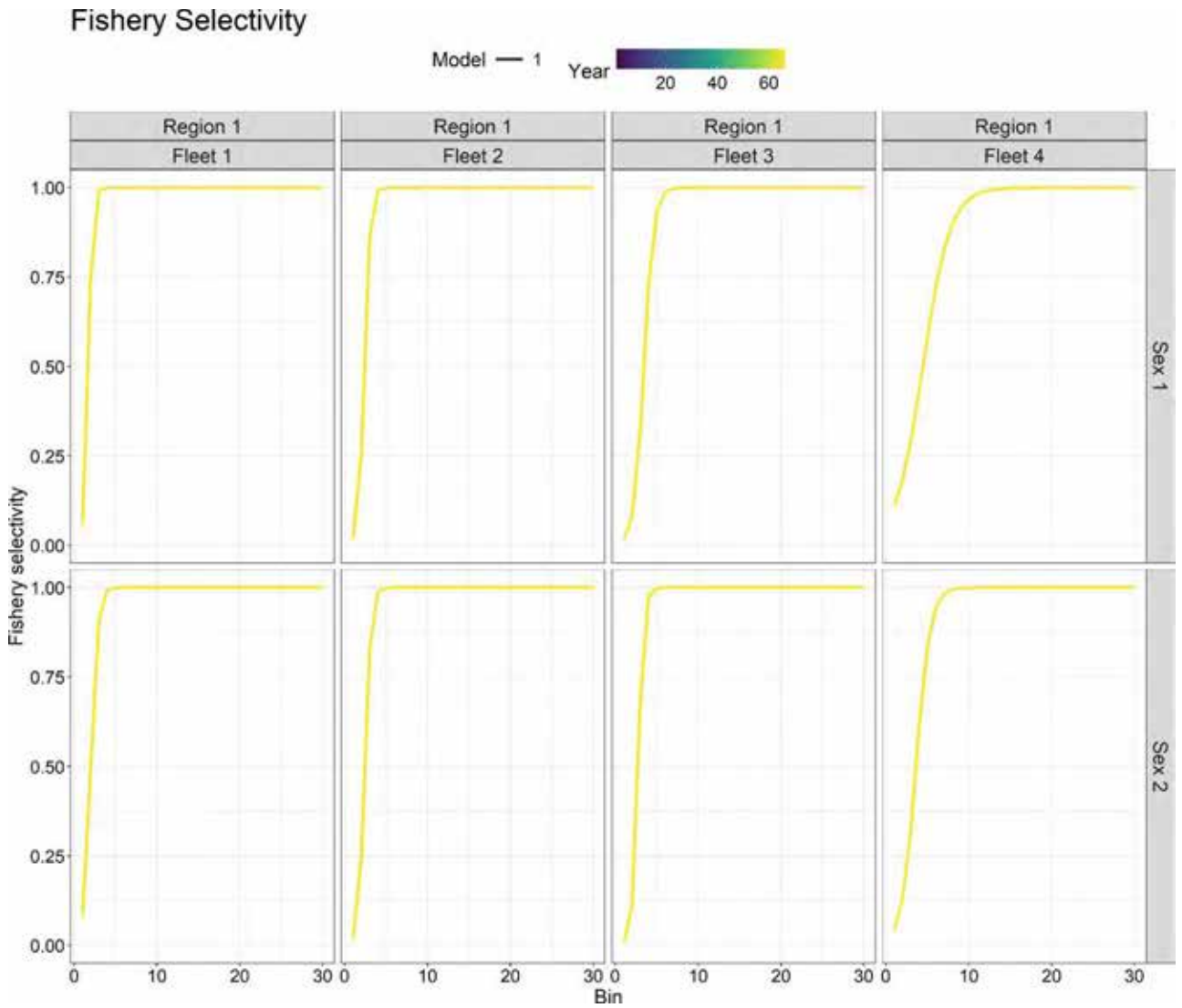

Figure SM3C.7. Fishery selectivity estimates from Model *26.2a_FAA_Fsh+Srvy* where different colors represent the different time blocks. Fishery Fleet 1 is the BS fixed gear fleet, Fishery Fleet 2 is the AI fixed gear fleet, Fishery Fleet 3 is the GOA fixed gear fleet, and Fishery Fleet 4 is the trawl fleet. Sex 1 is females and sex 2 is males.

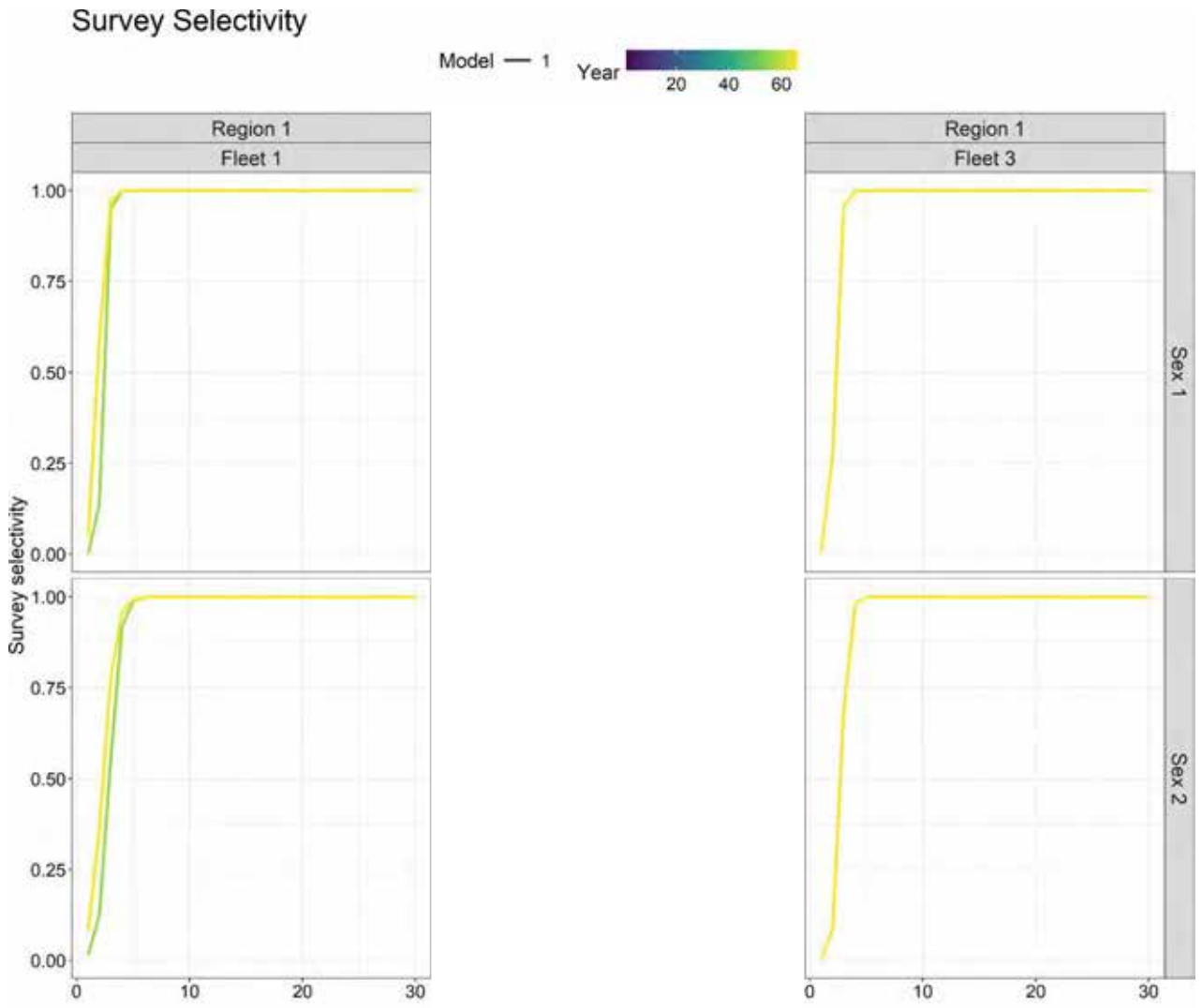

Figure SM3C.8. Survey selectivity estimates from Model *26.1_1Reg* where different colors represent the different time blocks. Fleet 1 is the NOAA Longline Survey and fleet 3 is the Japanese Longline Survey. Sex 1 is females and sex 2 is males.

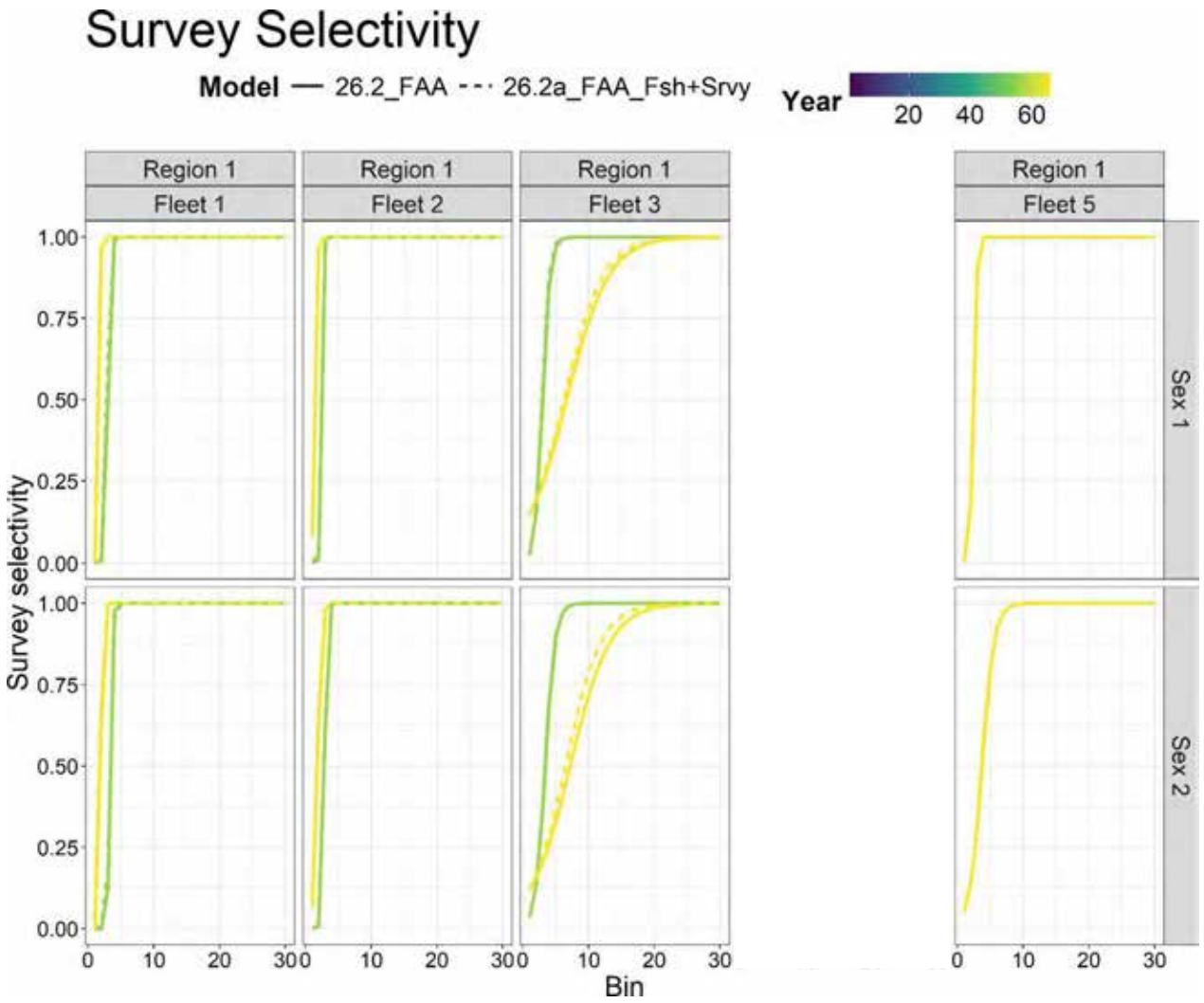

Figure SM3C.9. Survey selectivity estimates from Model *26.2_FAA* (solid lines) and Model *26.2a_FAA_Fsh+Srvy* (dashed lines) where different colors represent the different time blocks. Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey. Sex 1 is females and sex 2 is males.

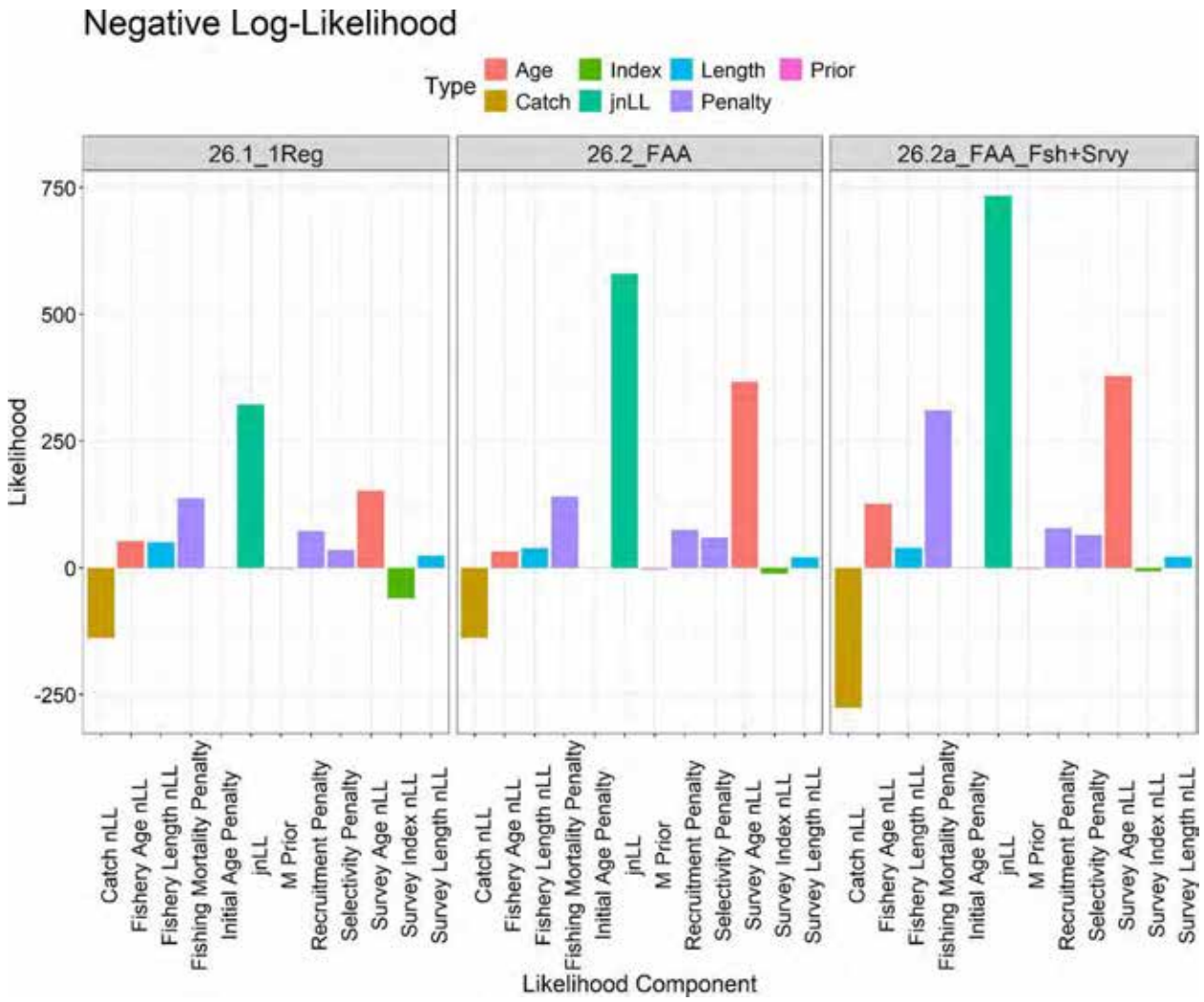

Figure SM3C.10. Joint negative log-likelihood (jnLL) components from Model *26.1_1Reg*, Model *26.2_FAA*, and Model 26.2a_FAA_Fsh+Srvy where different colors represent the various data sets and priors or penalty terms. Note that due to differences in likelihood structures and data inputs (regional disaggregation of fleets) used in each model, these figures are not directly comparable across models.

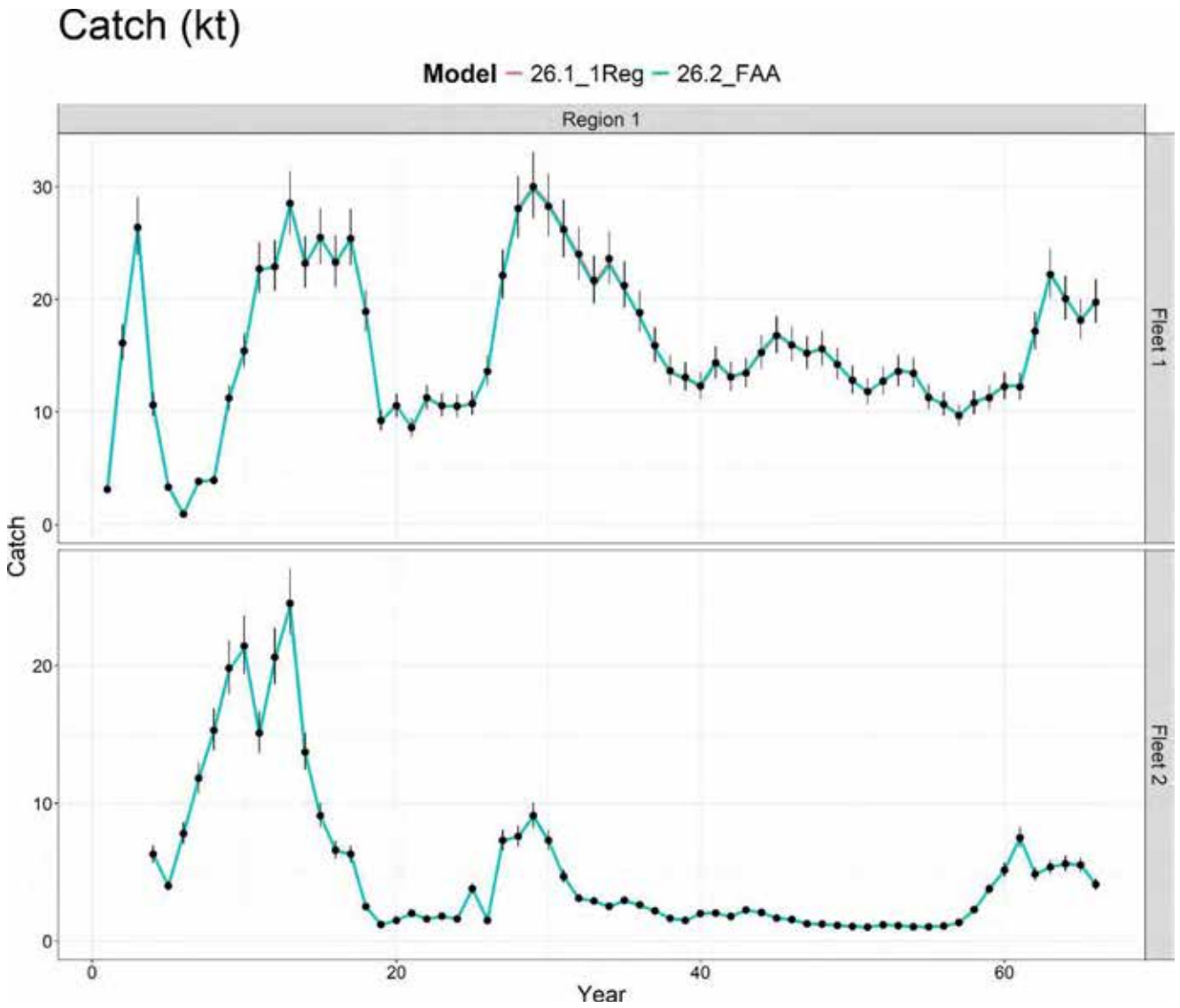

Figure SM3C.11. Fit to the catch data (black dots with 95% confidence intervals) by fleet (fleet 1 is the fixed gear fishery and fleet 2 is the trawl fleet) for Model *26.1_1Reg* (red line) and Model *26.2_FAA* (blue line). Note the varying y-axis scales.

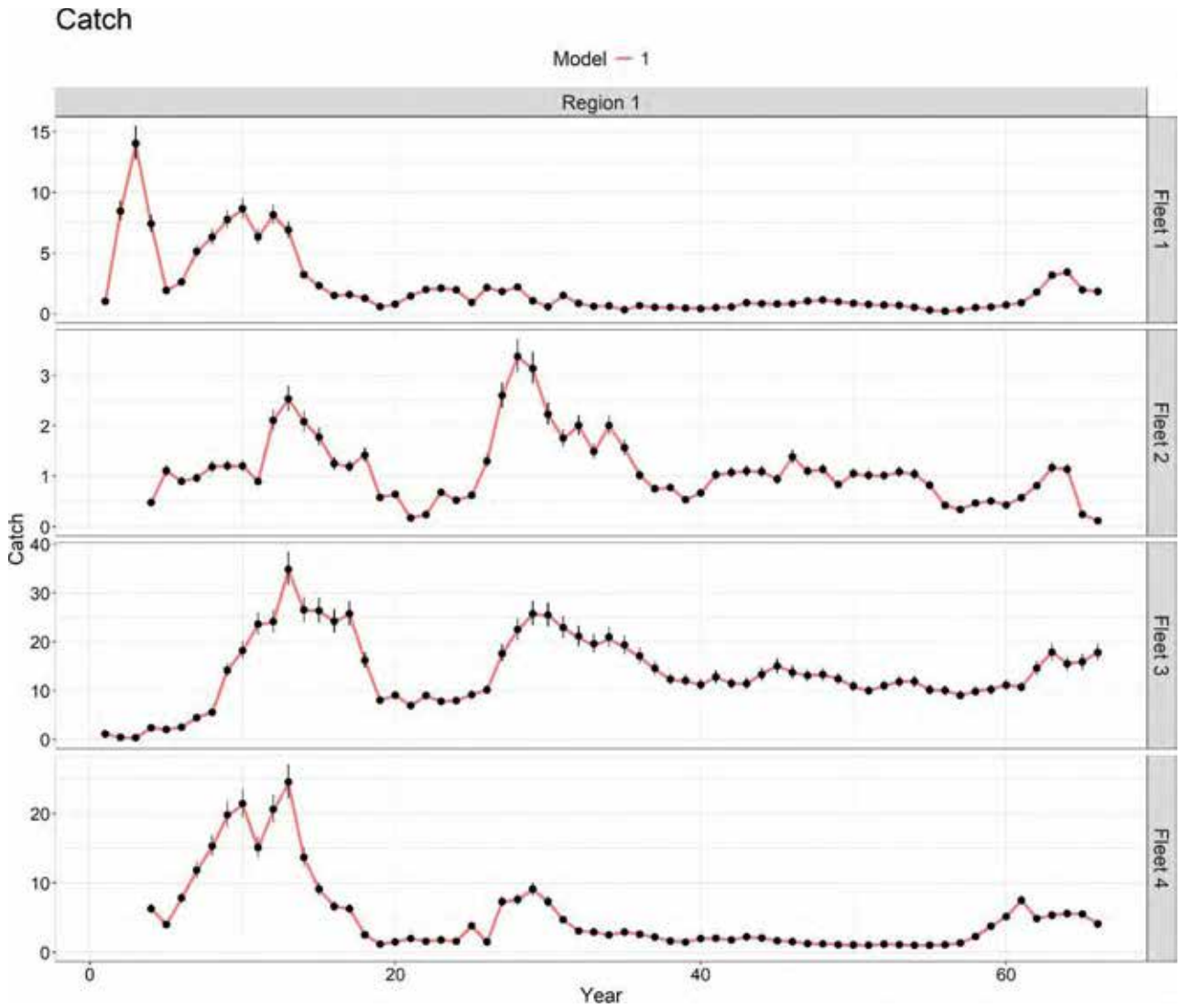

Figure SM3C.12. Fit to the catch data (black dots with 95% confidence intervals) by fleet (Fishery Fleet 1 is the BS fixed gear fleet, Fishery Fleet 2 is the AI fixed gear fleet, Fishery Fleet 3 is the GOA fixed gear fleet, and Fishery Fleet 4 is the trawl fleet) for Model *25.2_FAA_Fsh+Srvy* (red line). Note the varying y-axis scales.

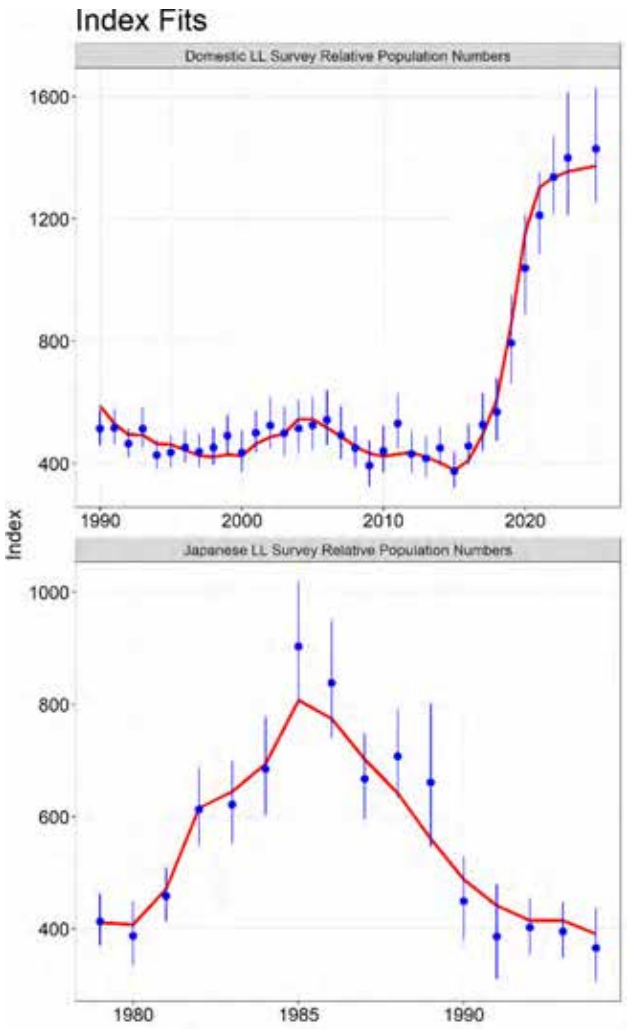

Figure SM3C.13. Model *26.1_1Reg* fit to indices, including the NOAA Longline Survey RPNs (top) and Japanese Longline Survey RPNs (bottom). Red lines are model predicted values, and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

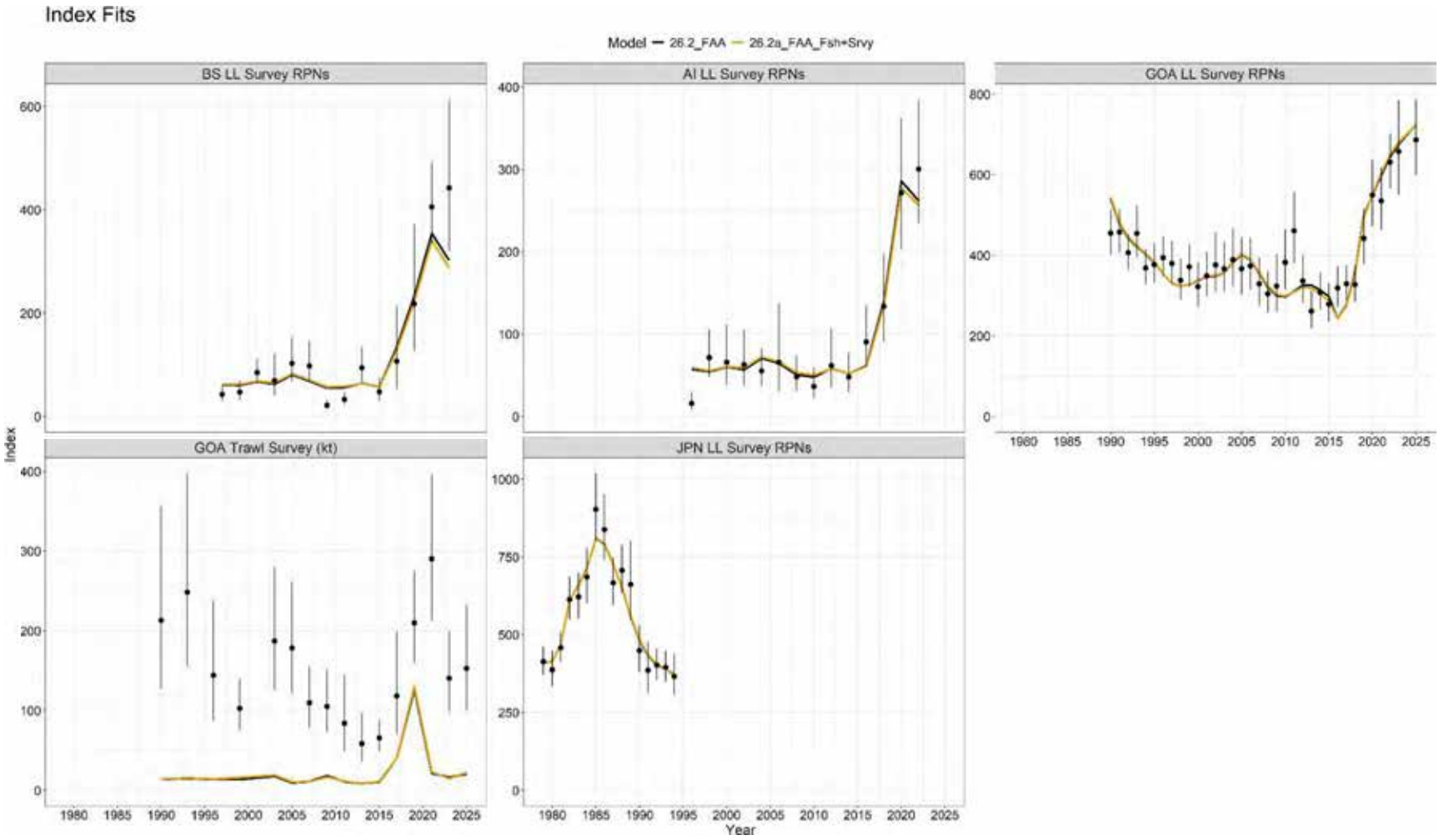

Figure SM3C.14. Model *26.2_FAA* (black line) and Model *26.2a_FAA_Fsh+Srvy* (orange line) fit to indices, including the NOAA Longline Survey RPNs (top panels) and Japanese Longline Survey RPNs (bottom panel). Lines are model predicted values, and black dots are observed values (with 95% confidence intervals based on the assumed standard errors).

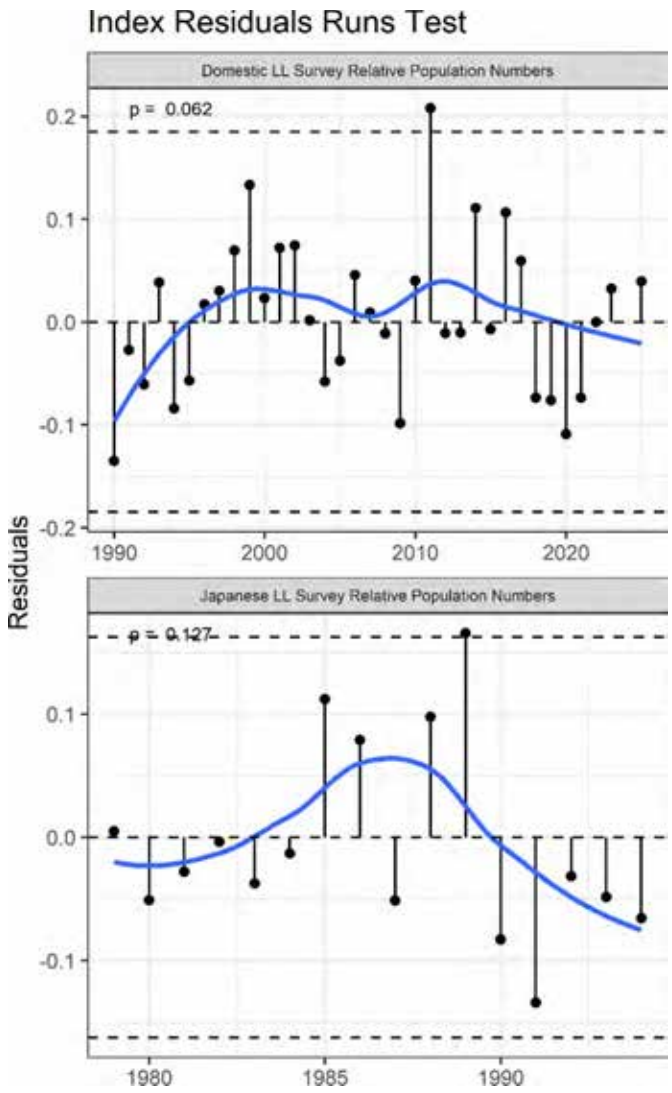

Figure SM3C.15. Results of an index residuals runs test for Model *26.1_1Reg*.

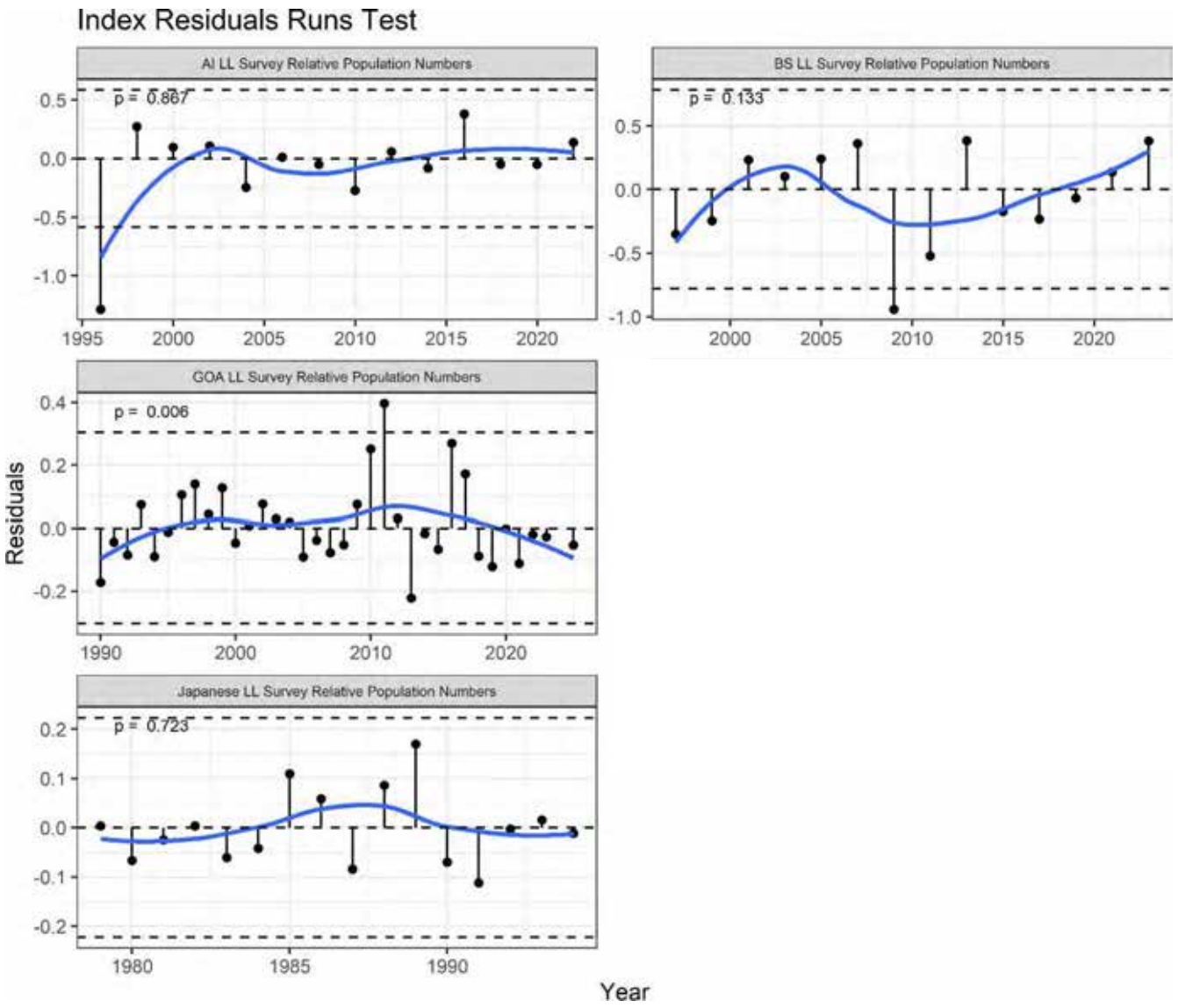

Figure SM3C.16. Results of an index residuals runs test for Model *26.2_FAA*.

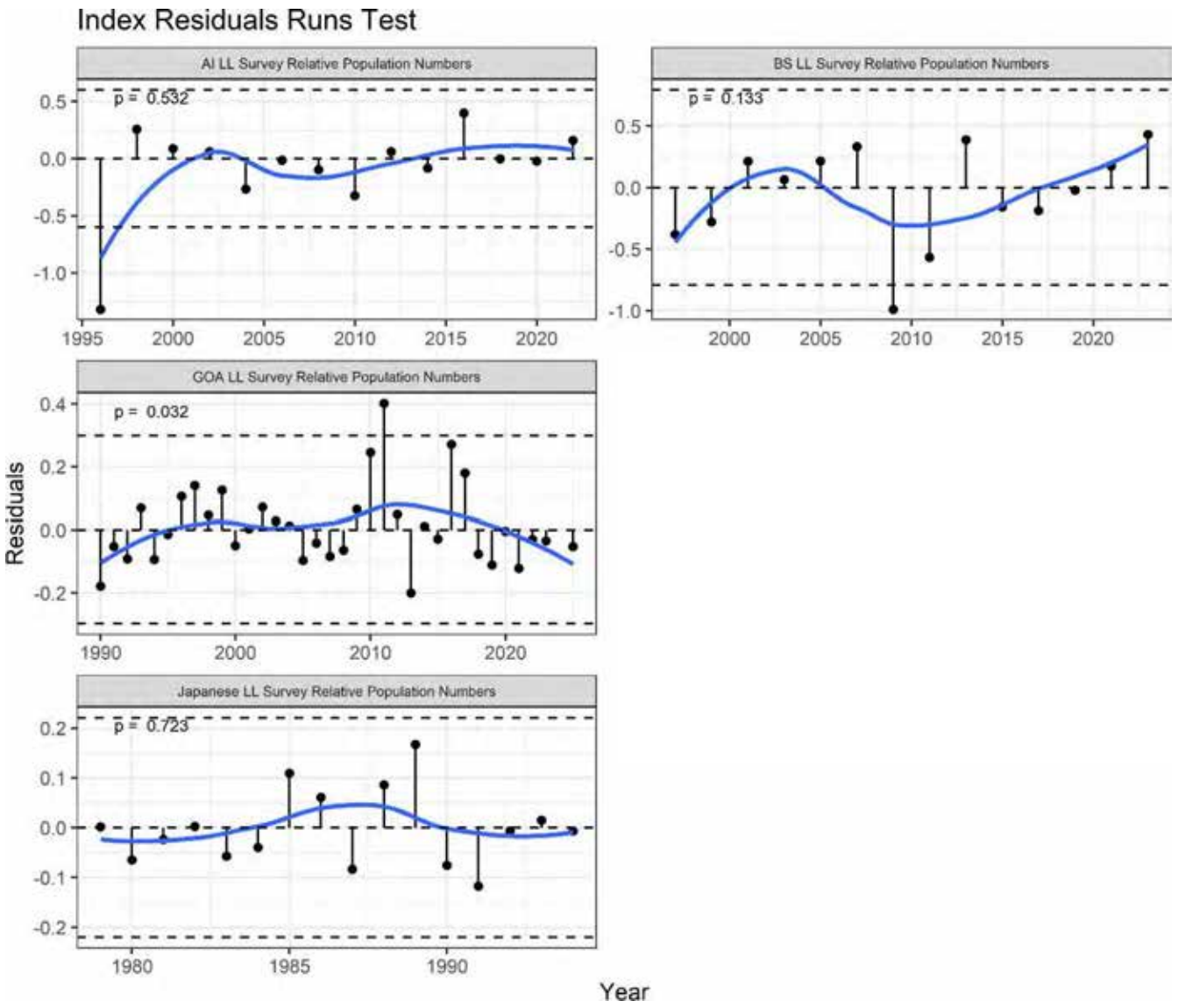

Figure SM3C.17. Results of an index residuals runs test for Model *26.2a_FAA_Fsh+Srvy*.

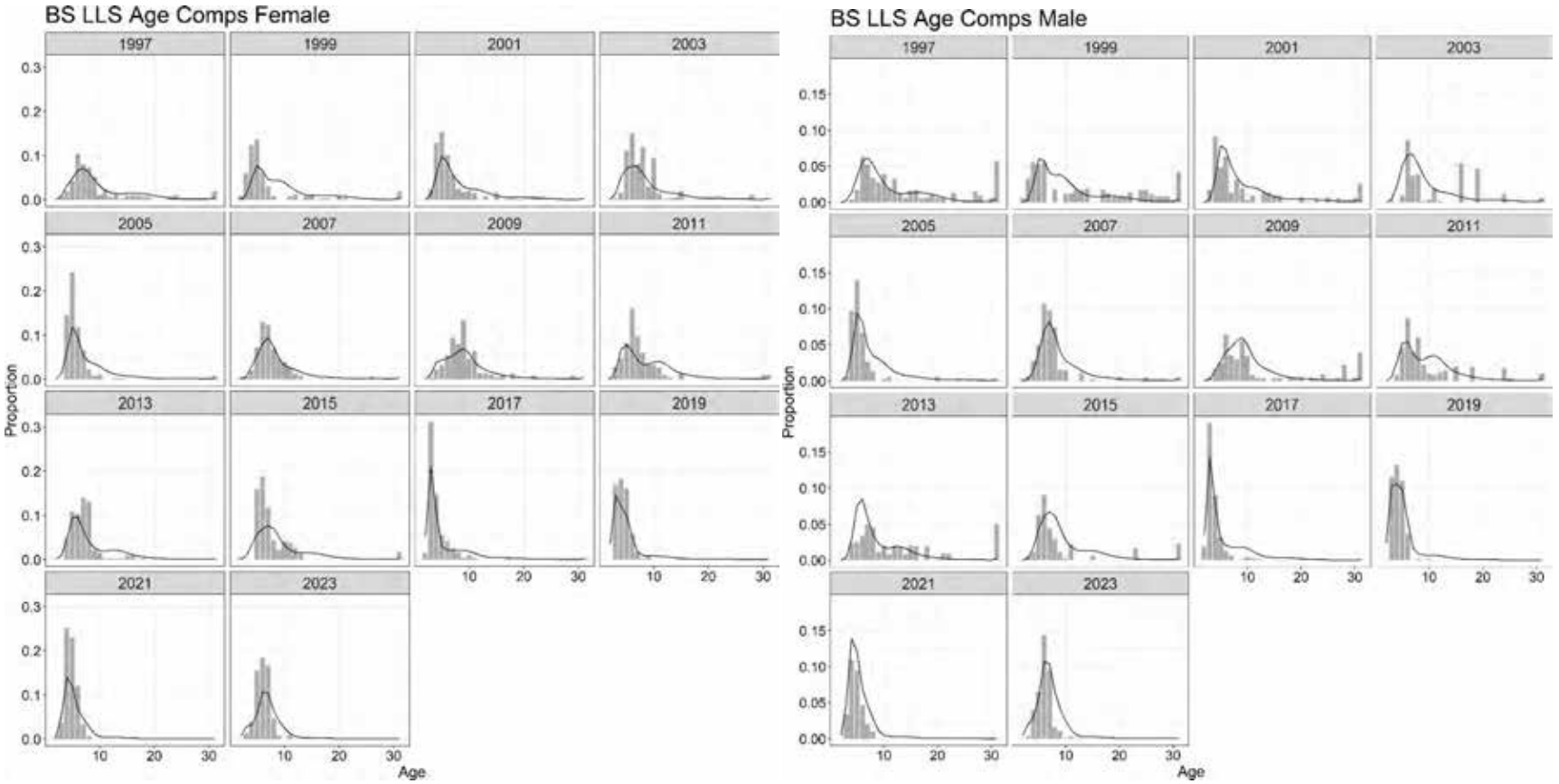

Figure SM3C.18. Fits to BS NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2_FAA.*

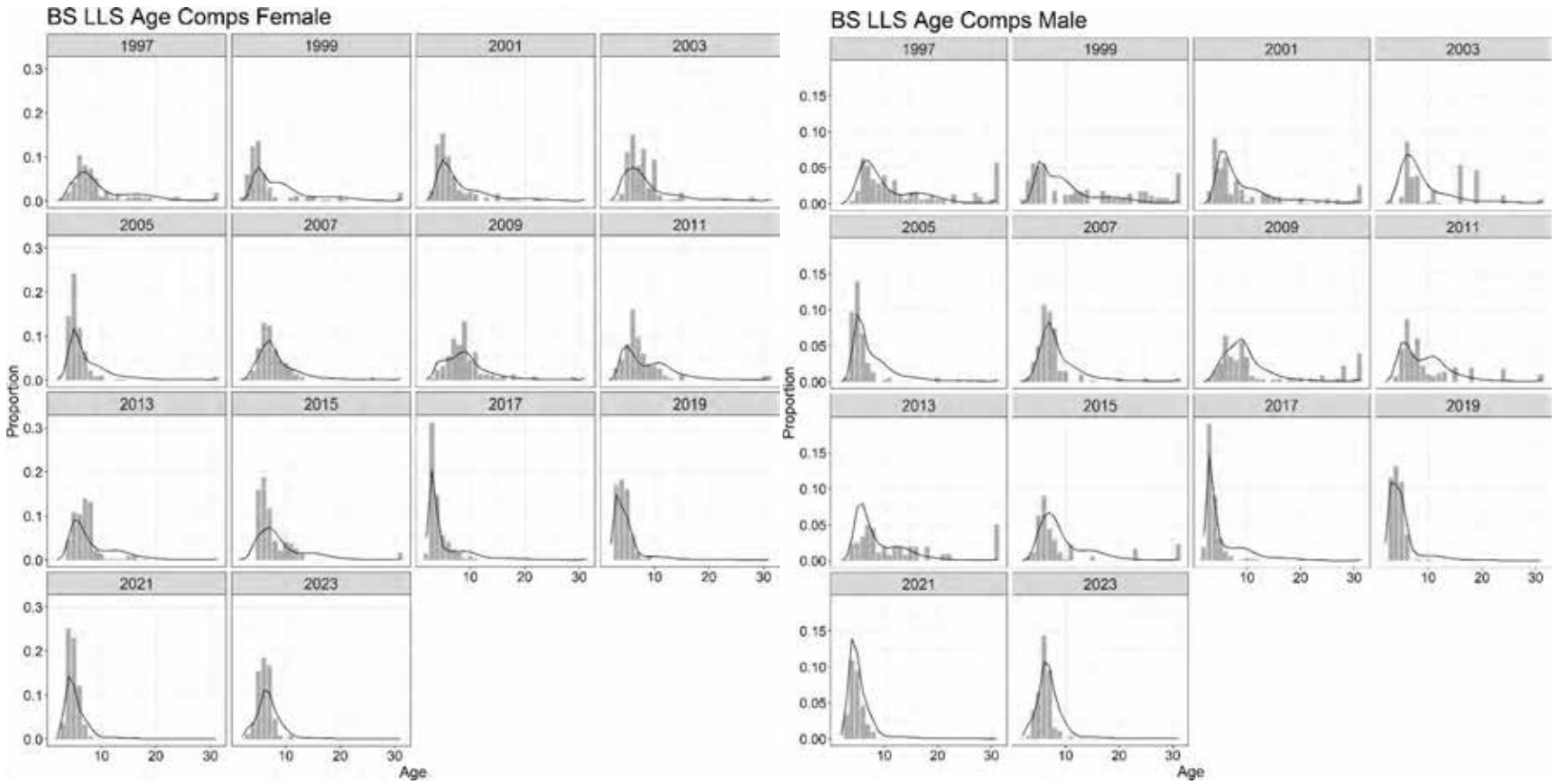

Figure SM3C.19. Fits to BS NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

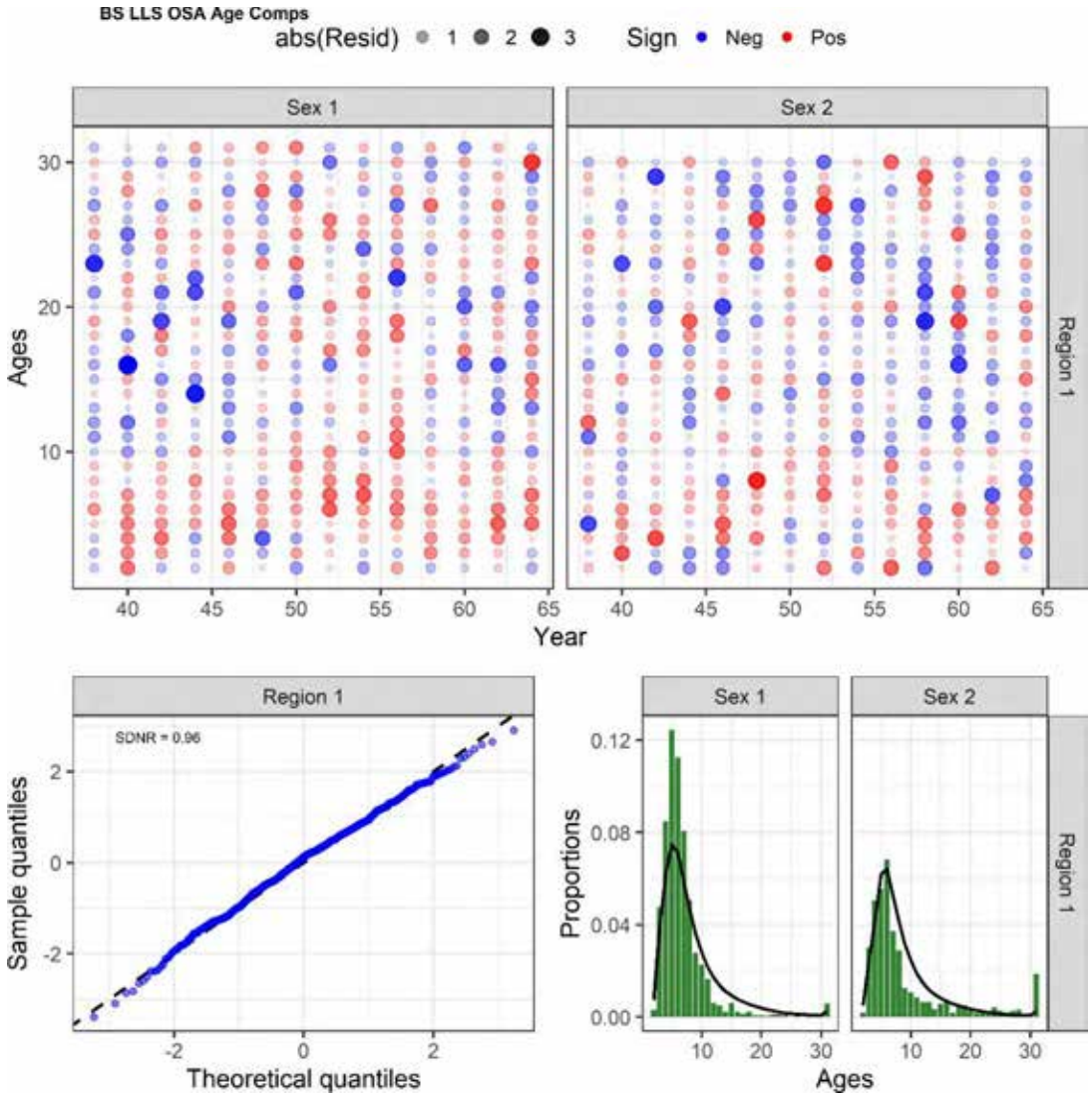

Figure SM3C.20. Fits to BS NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

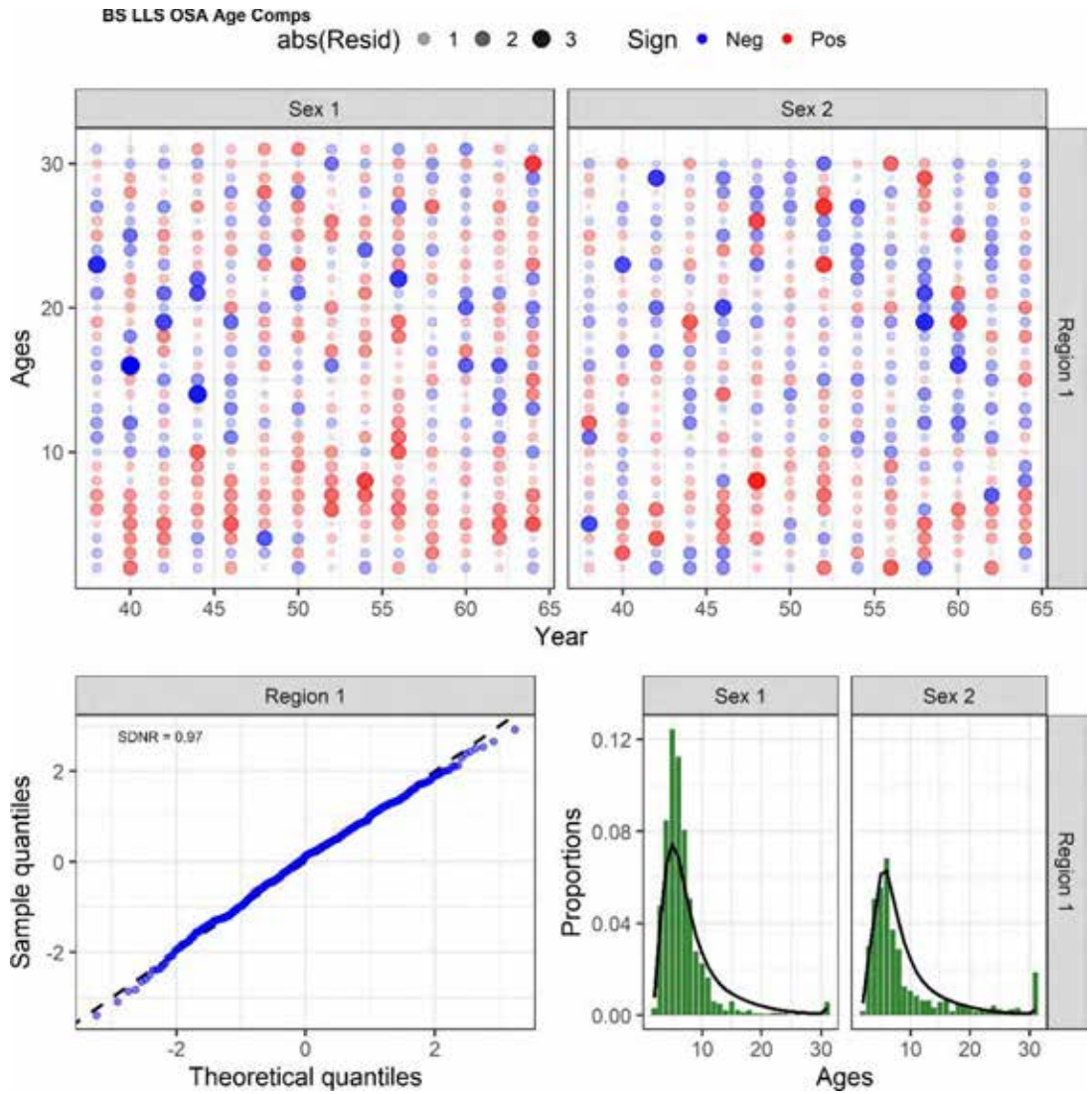

Figure SM3C.21. Fits to BS NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

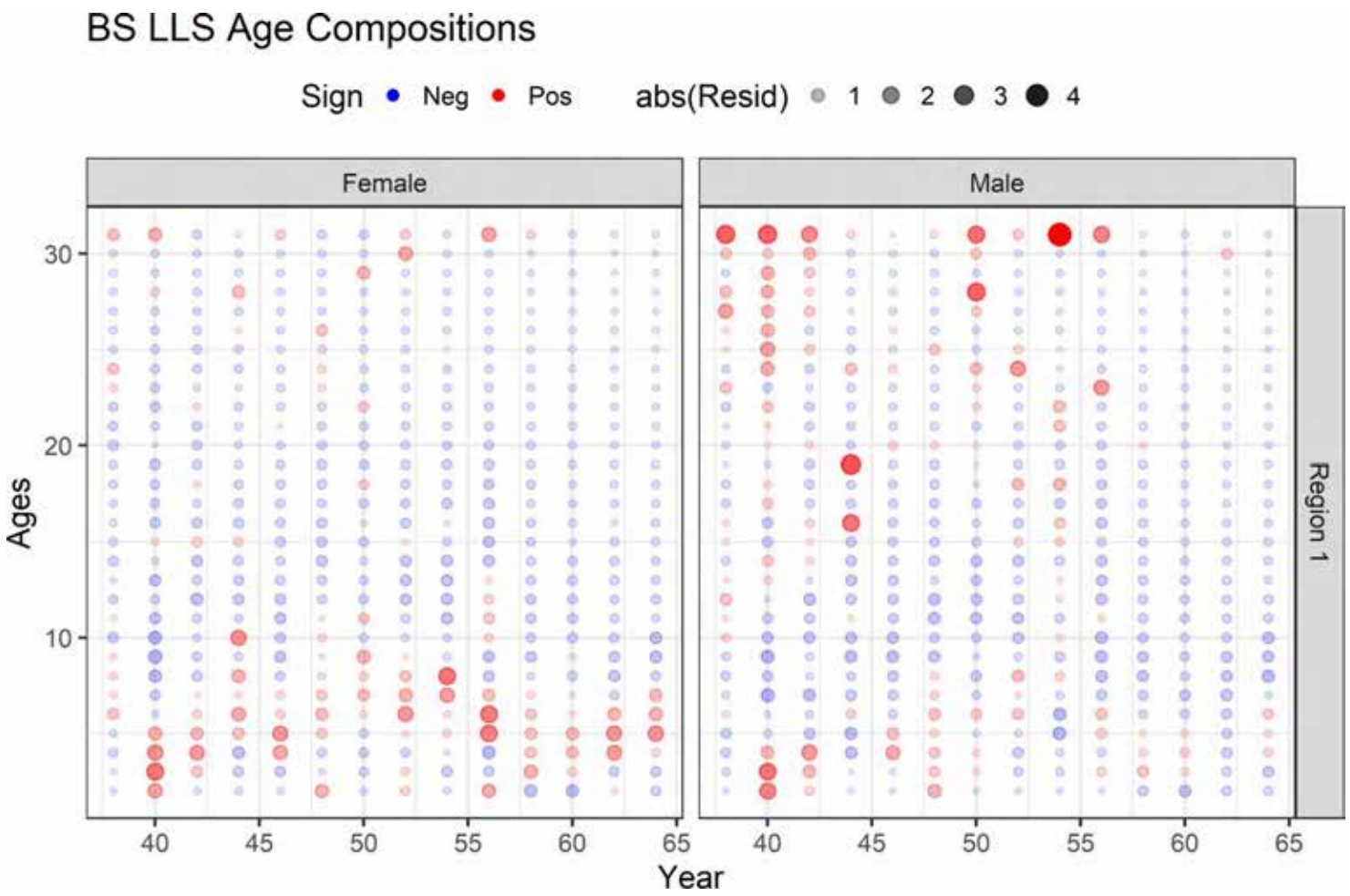

Figure SM3C.22. Fits to BS NOAA longline survey age composition data based on Pearson residuals for model *26.2_FAA*.

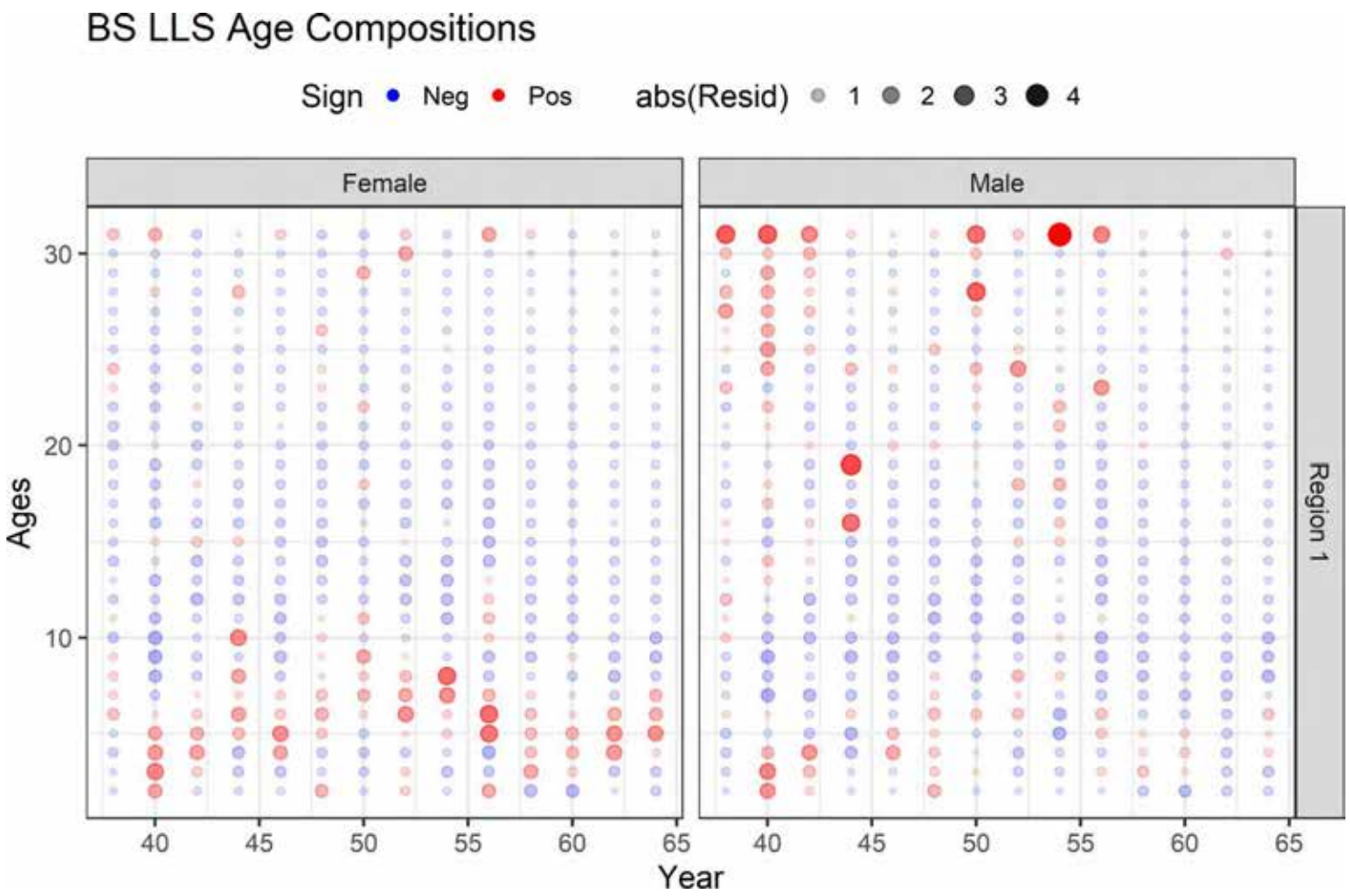

Figure SM3C.23. Fits to BS NOAA longline survey age composition data based on Pearson residuals for model *26.2a_FAA_Fsh+Srvy*.

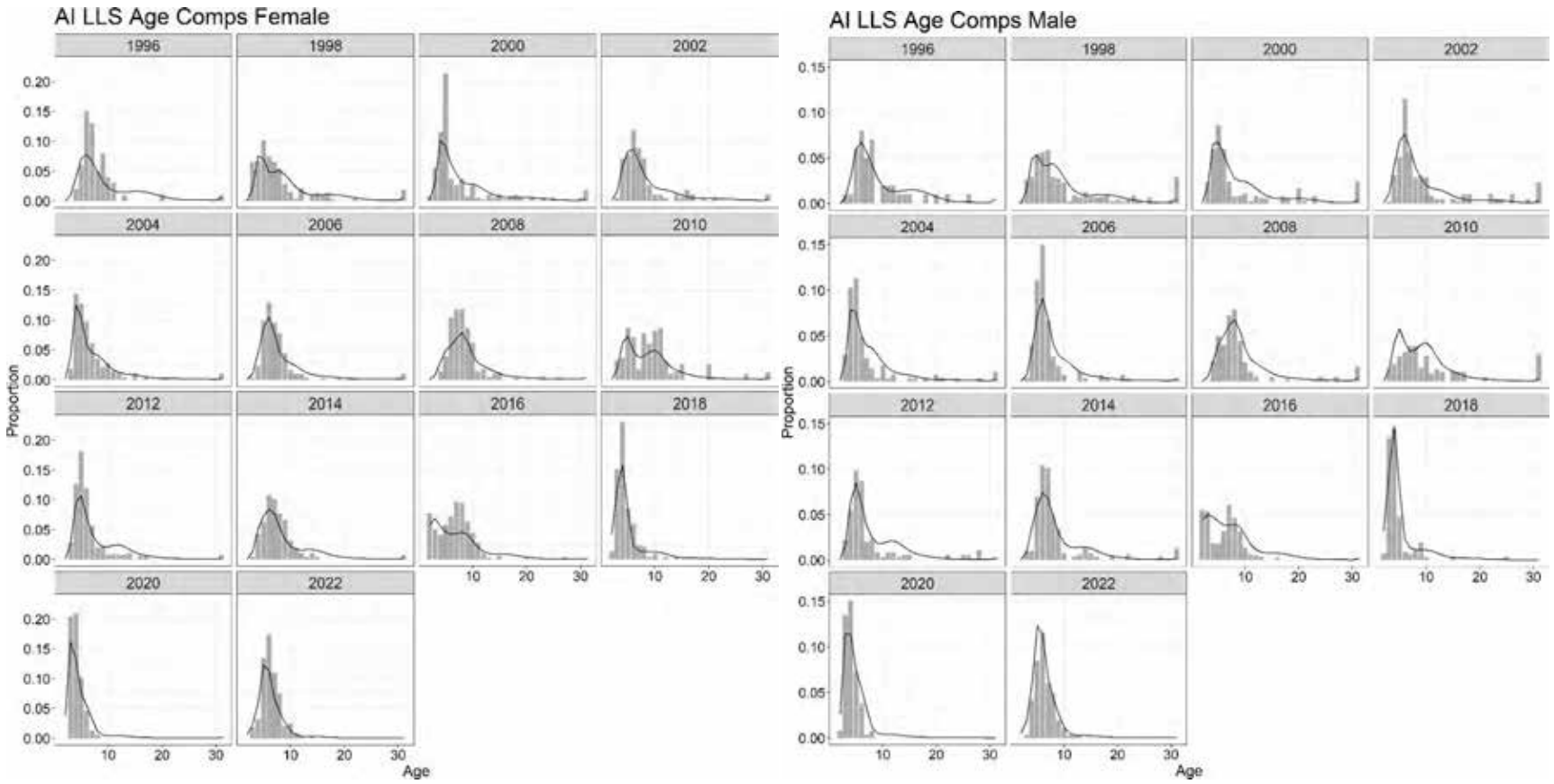

Figure SM3C.24. Fits to AI NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2_FAA.*

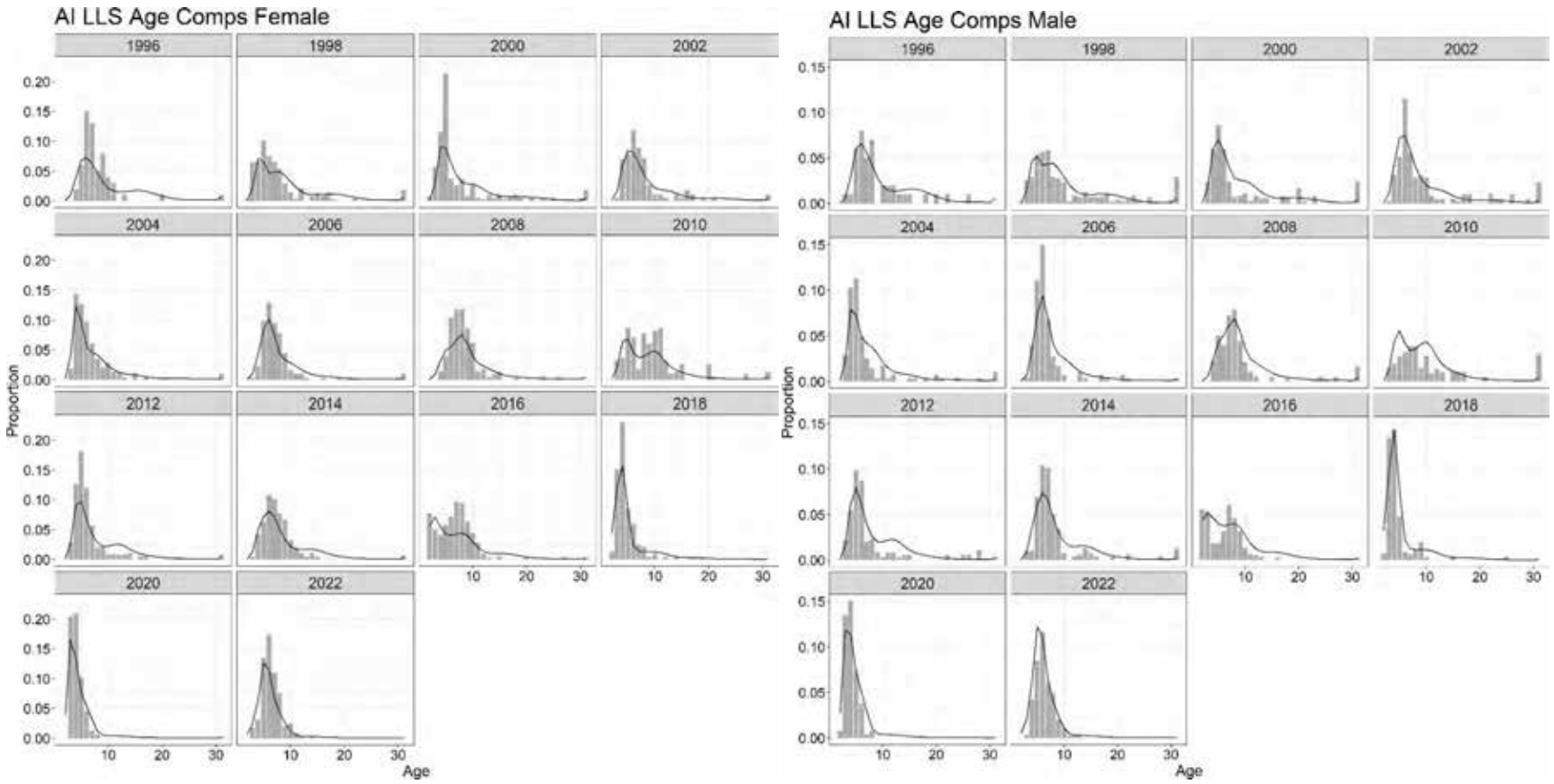

Figure SM3C.25. Fits to AI NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

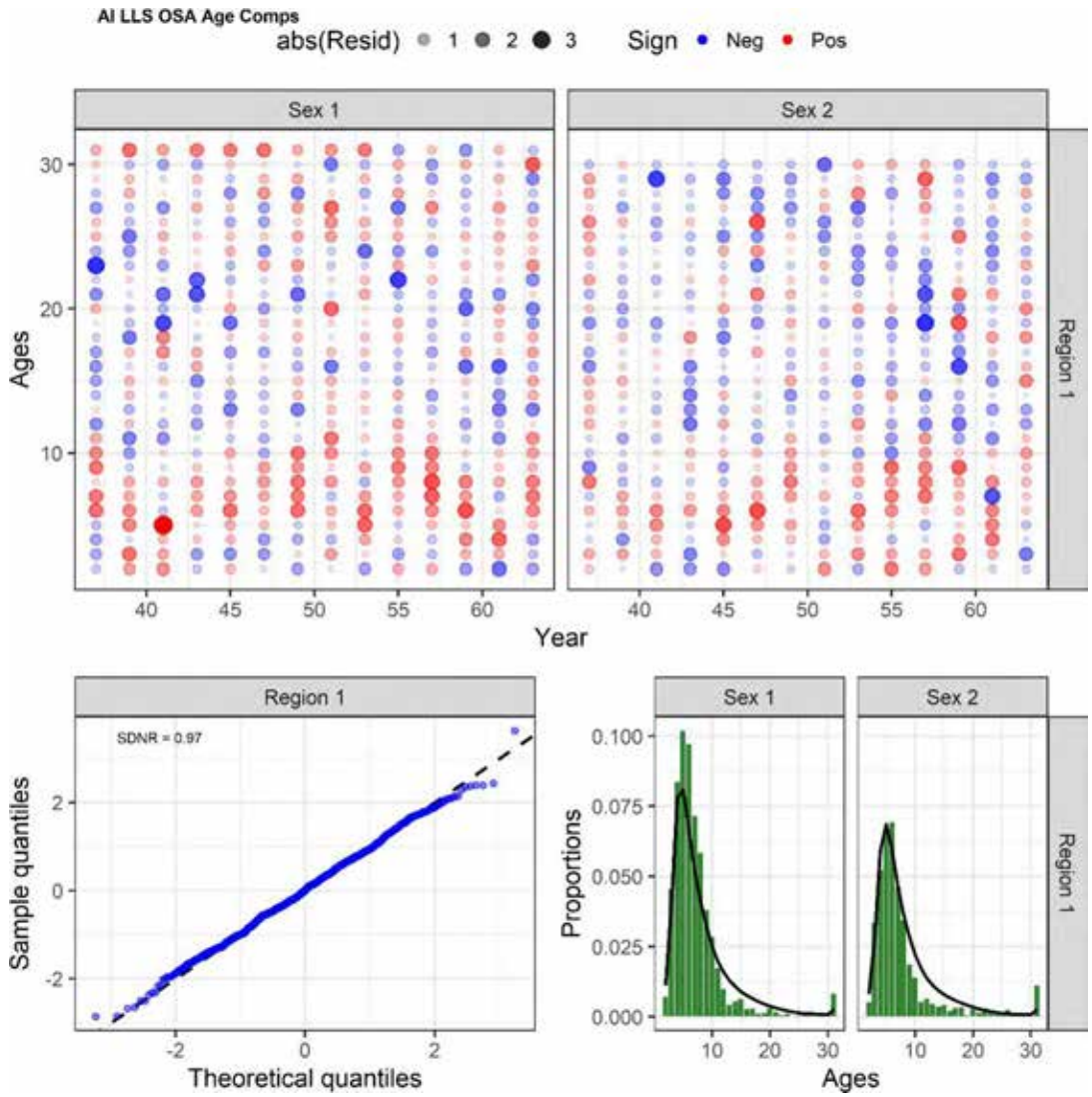

Figure SM3C.26. Fits to AI NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

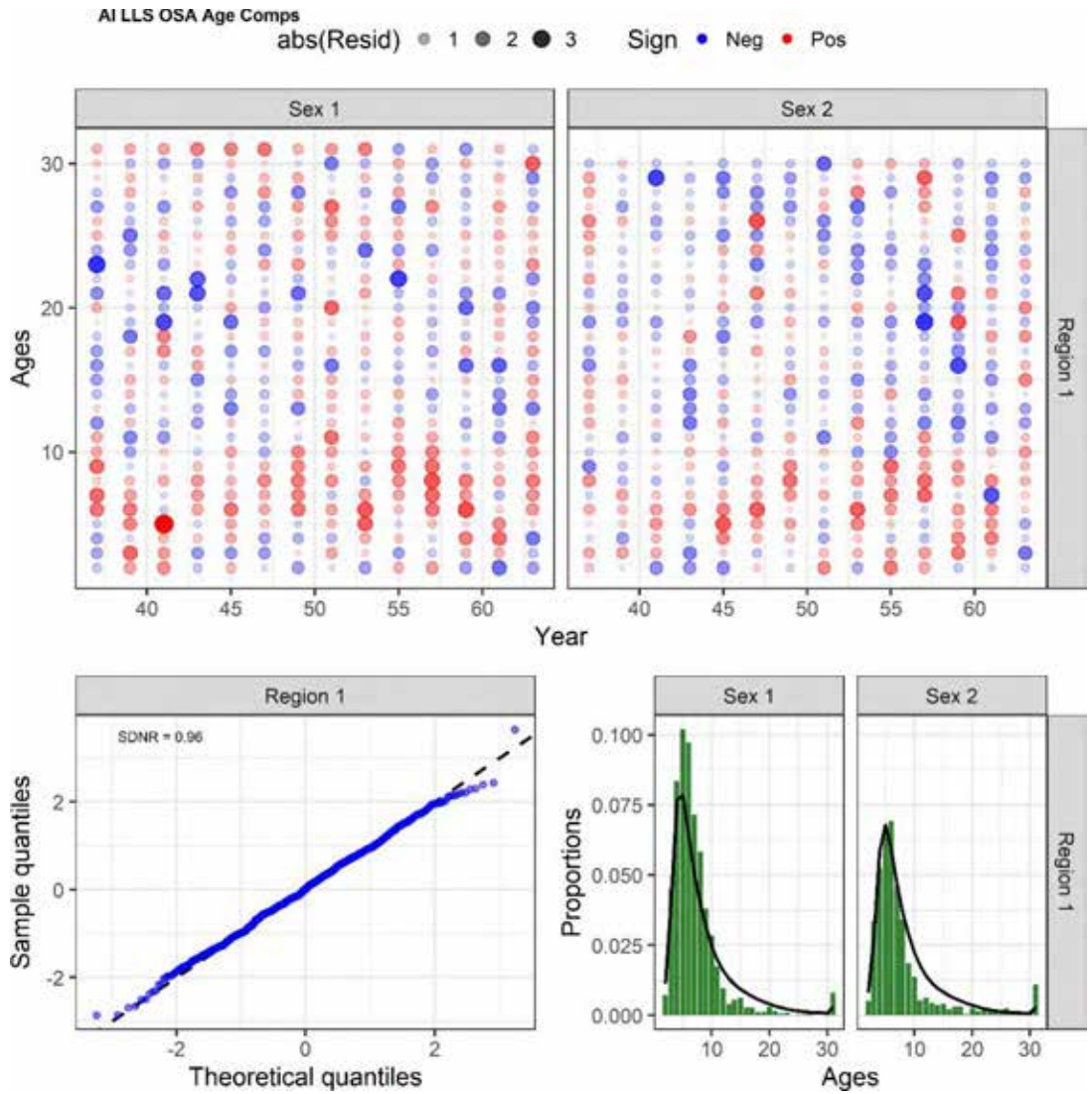

Figure SM3C.27. Fits to AI NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

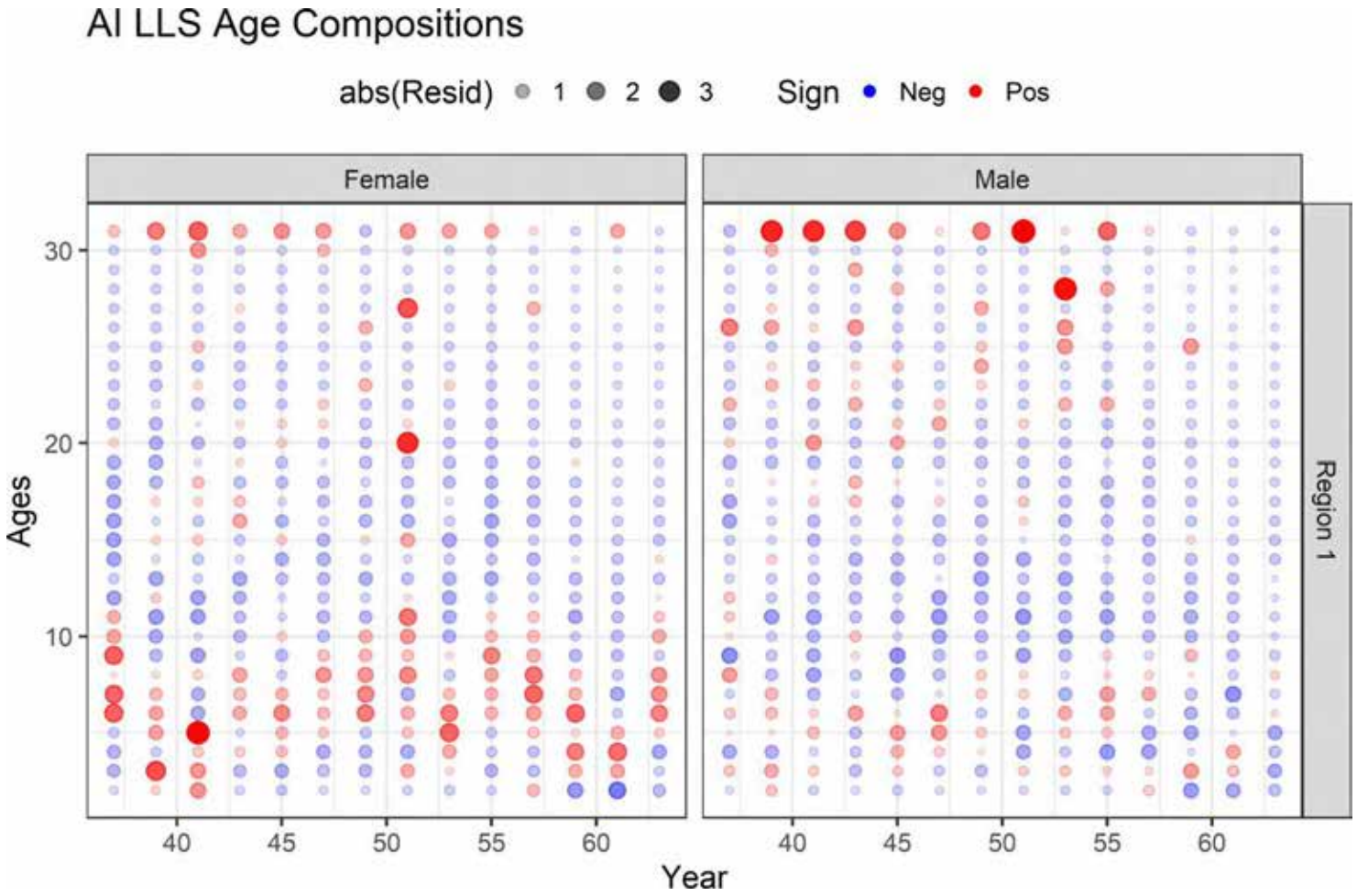

Figure SM3C.28. Fits to AI NOAA longline survey age composition data based on Pearson residuals for model *26.2_FAA*.

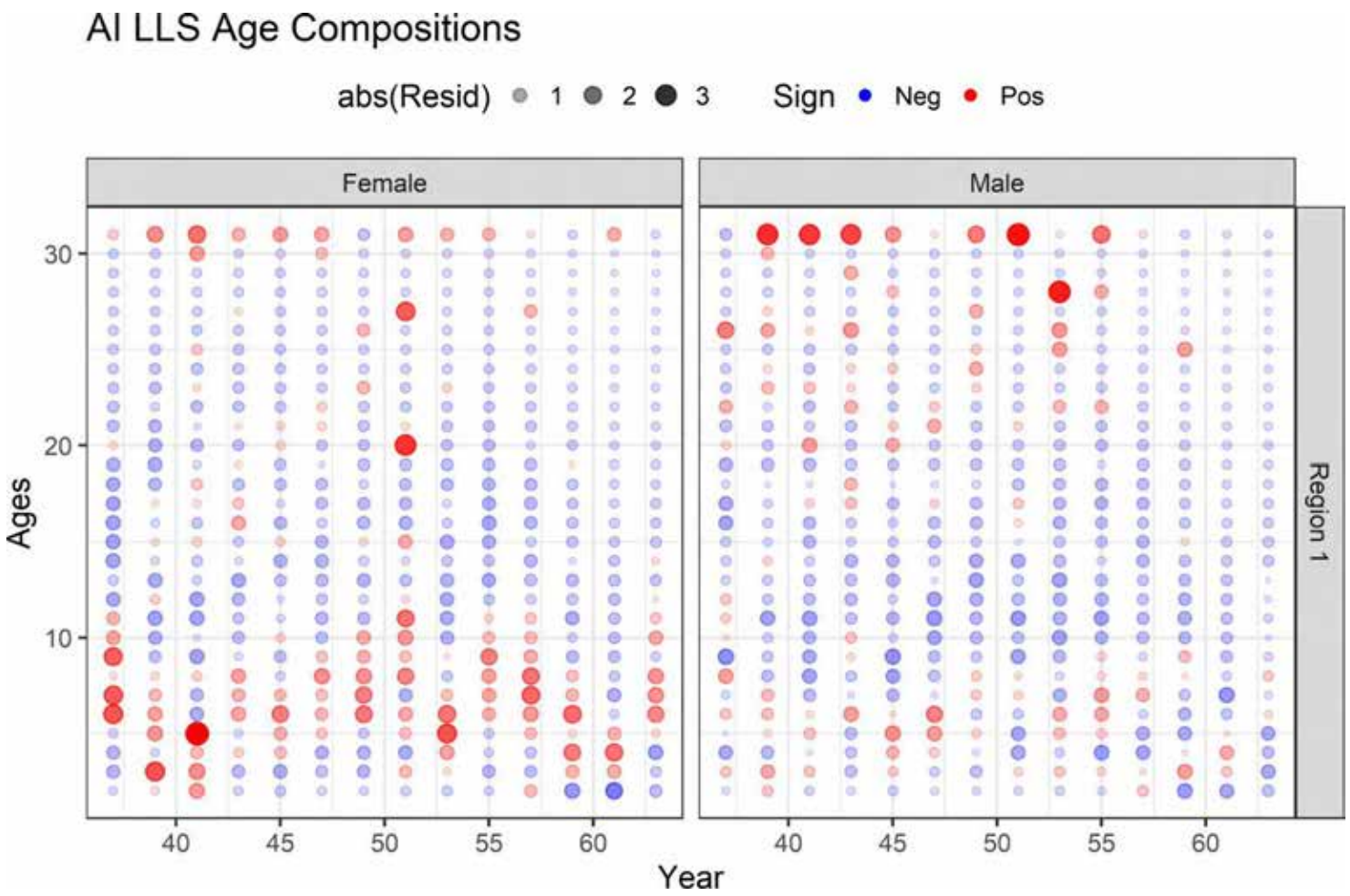

Figure SM3C.29. Fits to AI NOAA longline survey age composition data based on Pearson residuals for model *26.2a_FAA_Fsh+Srvy*.

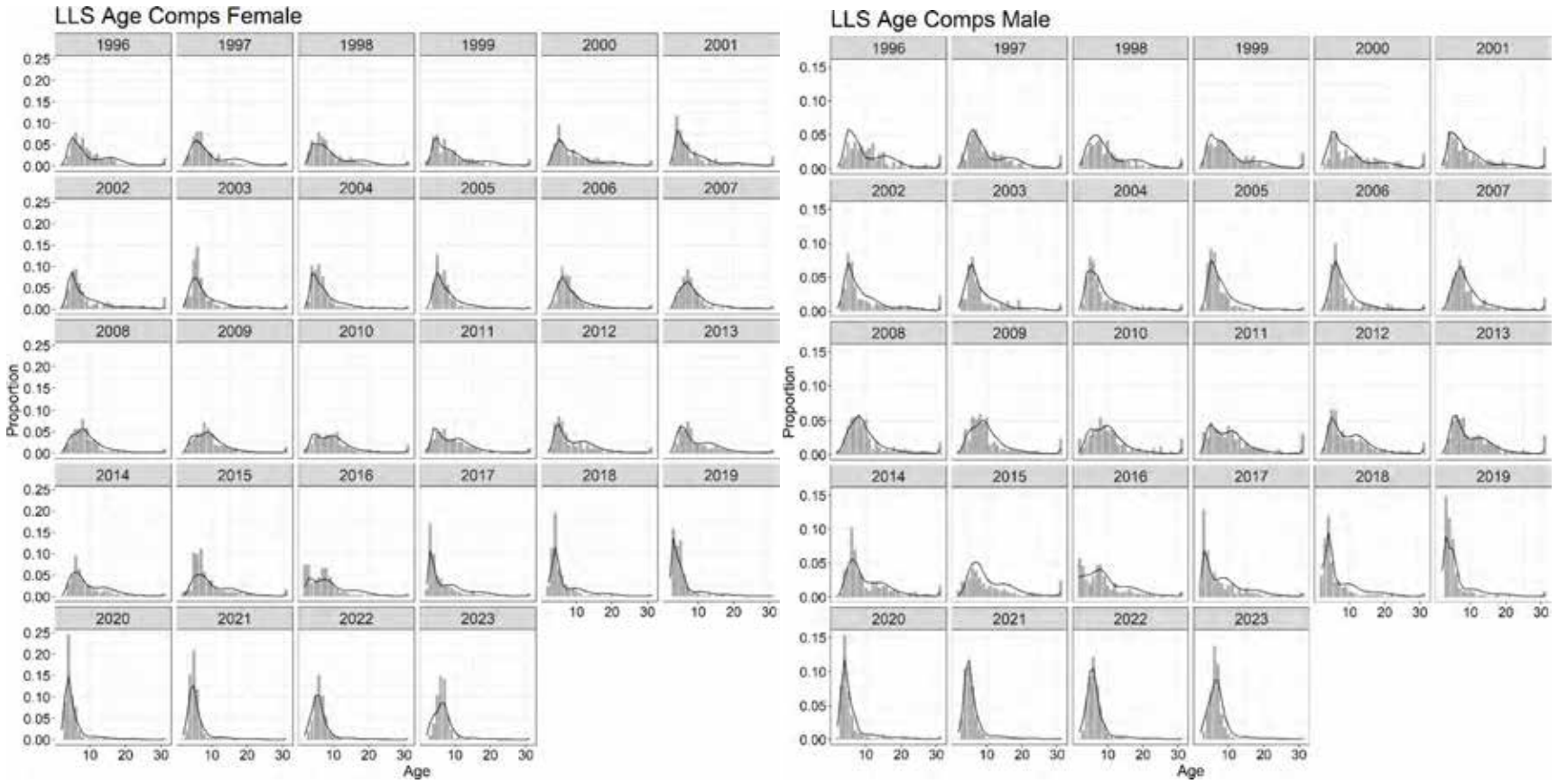

Figure SM3C.30. Fits to NOAA longline survey age composition data by year and sex (females left and males right) for model *26.1 _1Reg*.

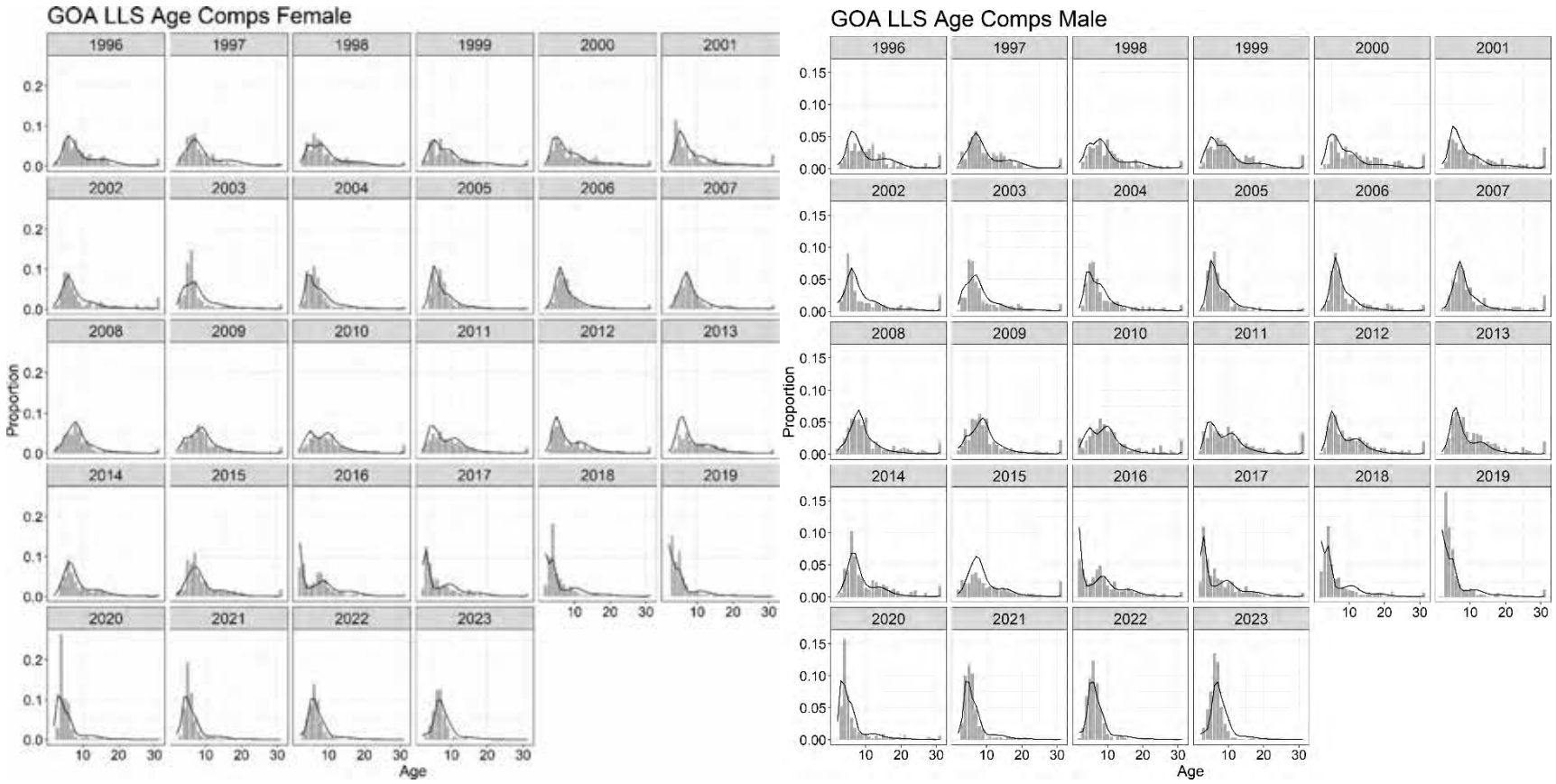

Figure SM3C.31. Fits to GOA NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2 _FAA.*

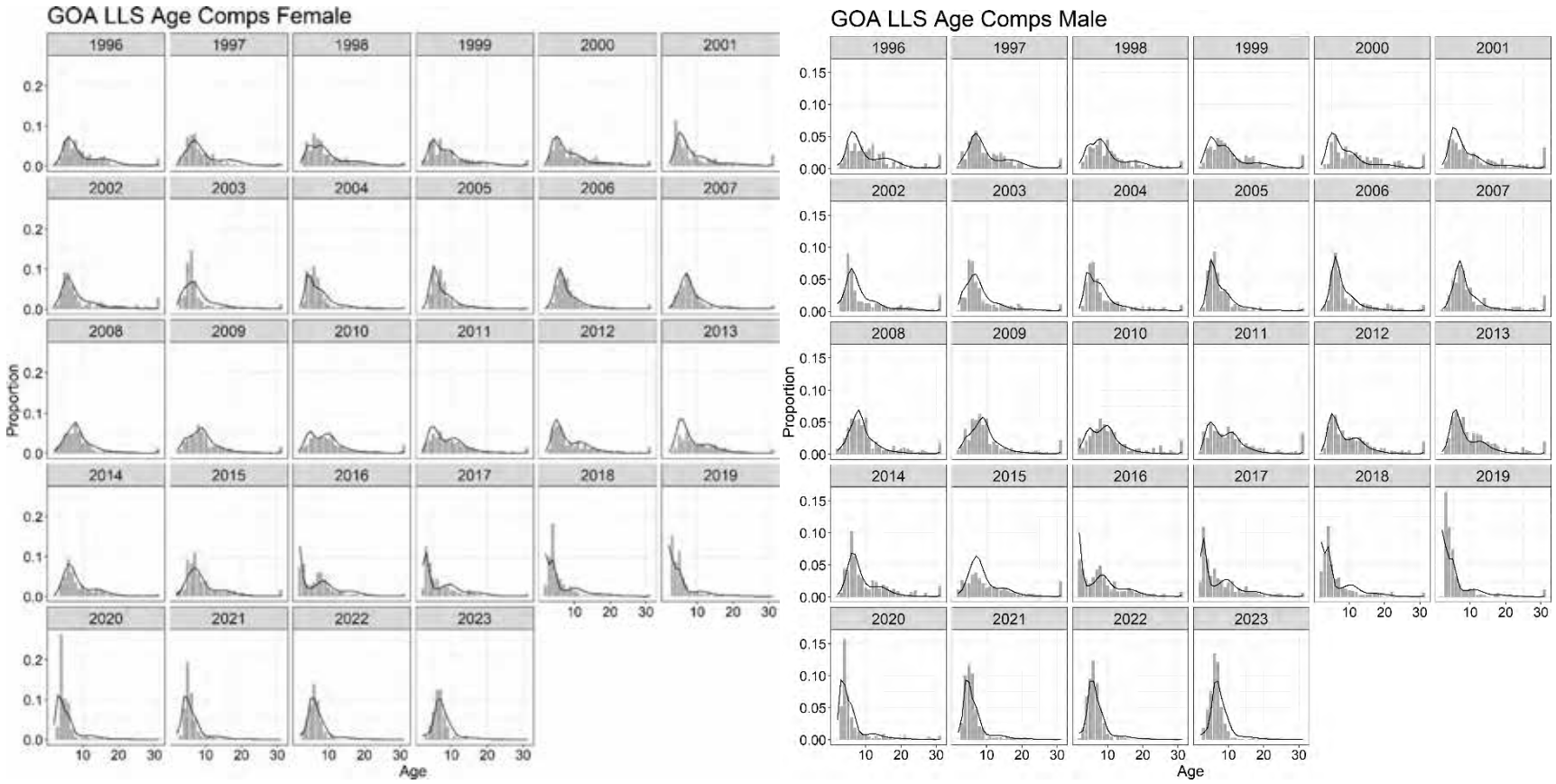

Figure SM3C.32. Fits to GOA NOAA longline survey age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

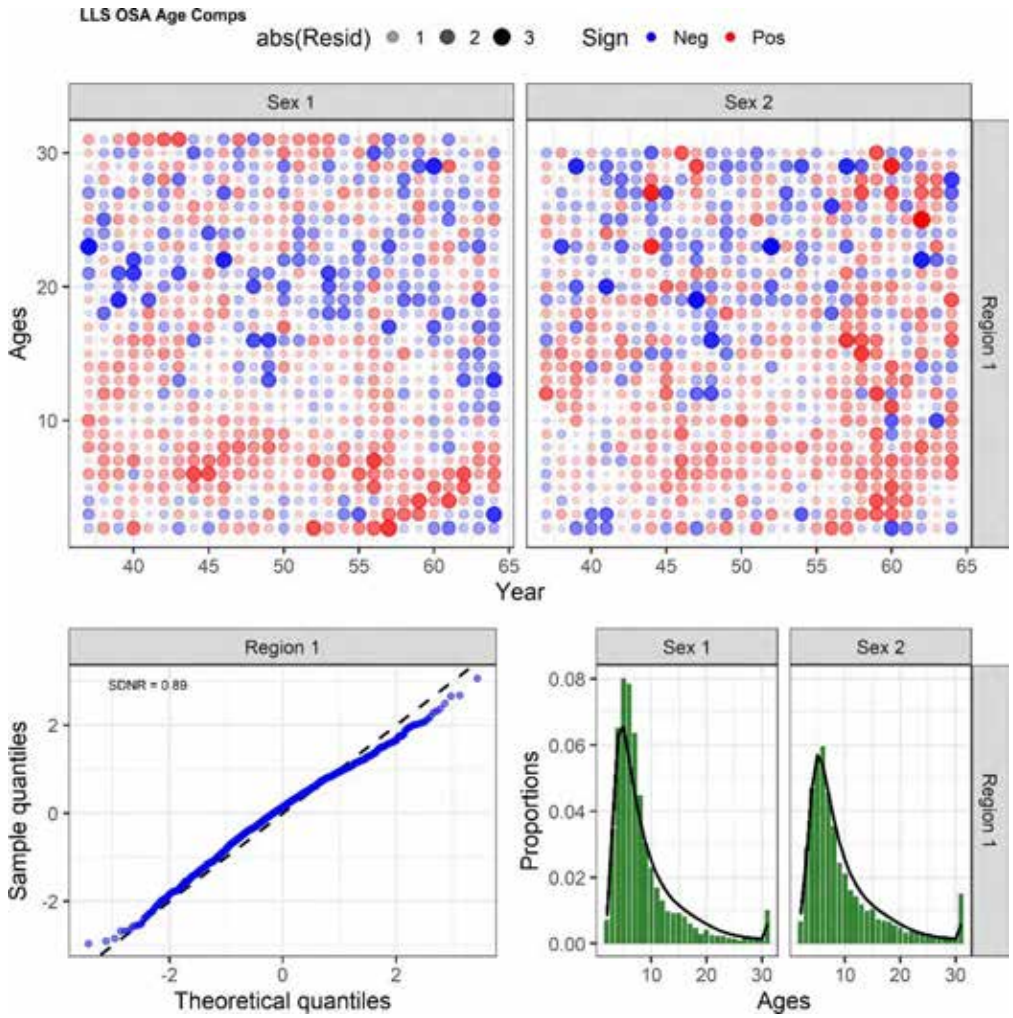

Figure SM3C.33. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg.*

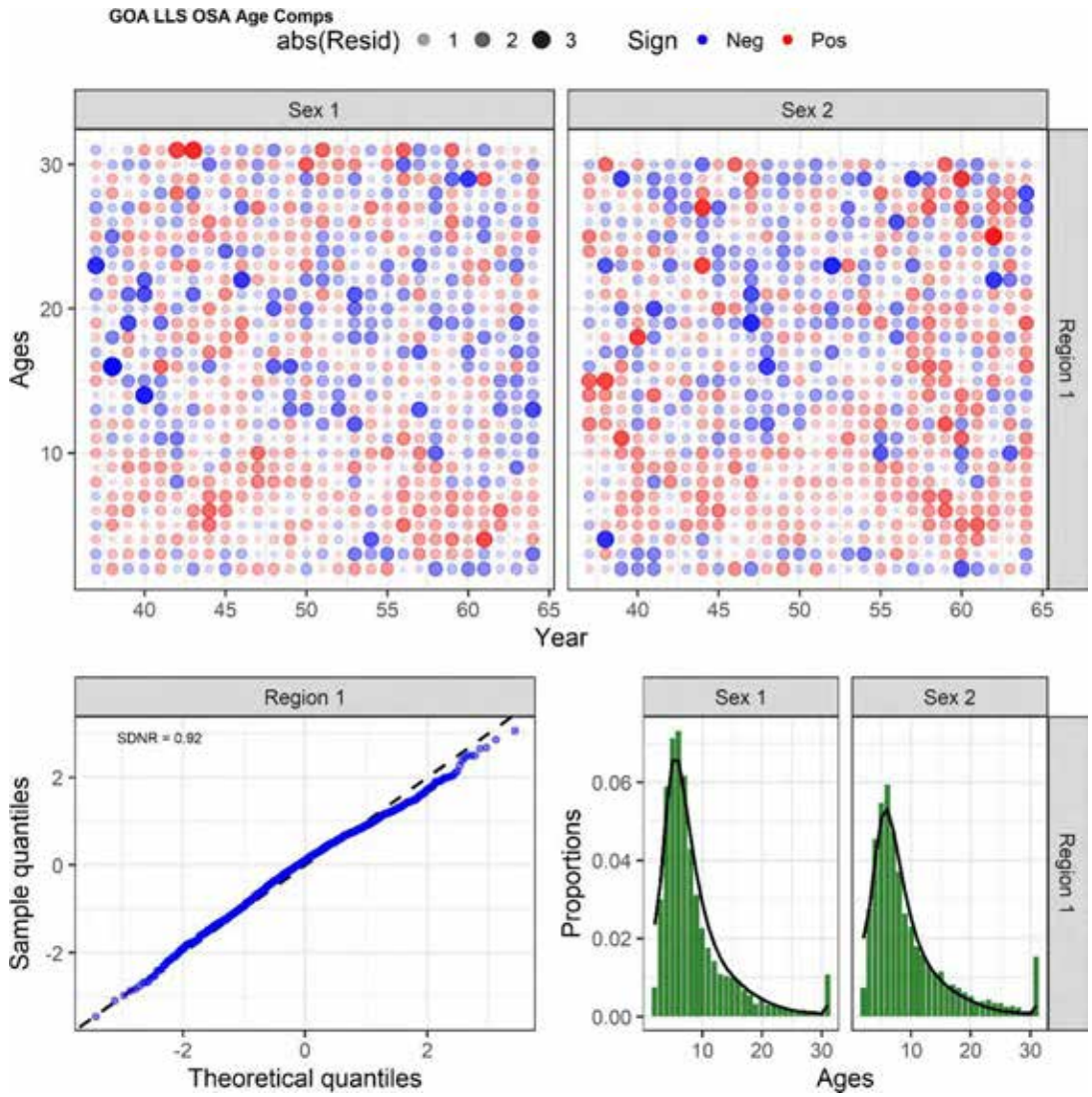

Figure SM3C.34. Fits to GOA NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

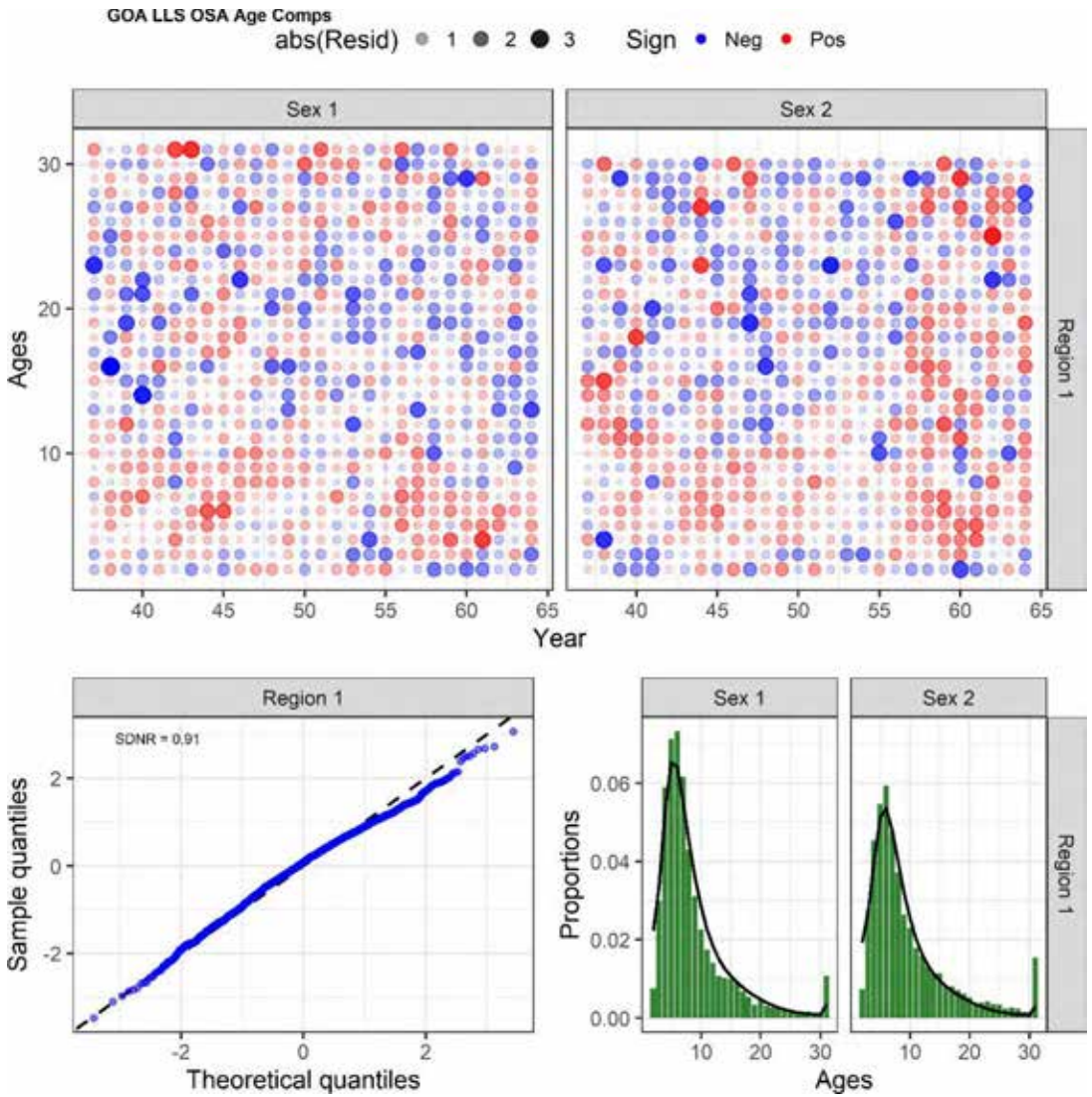

Figure SM3C.35. Fits to GOA NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

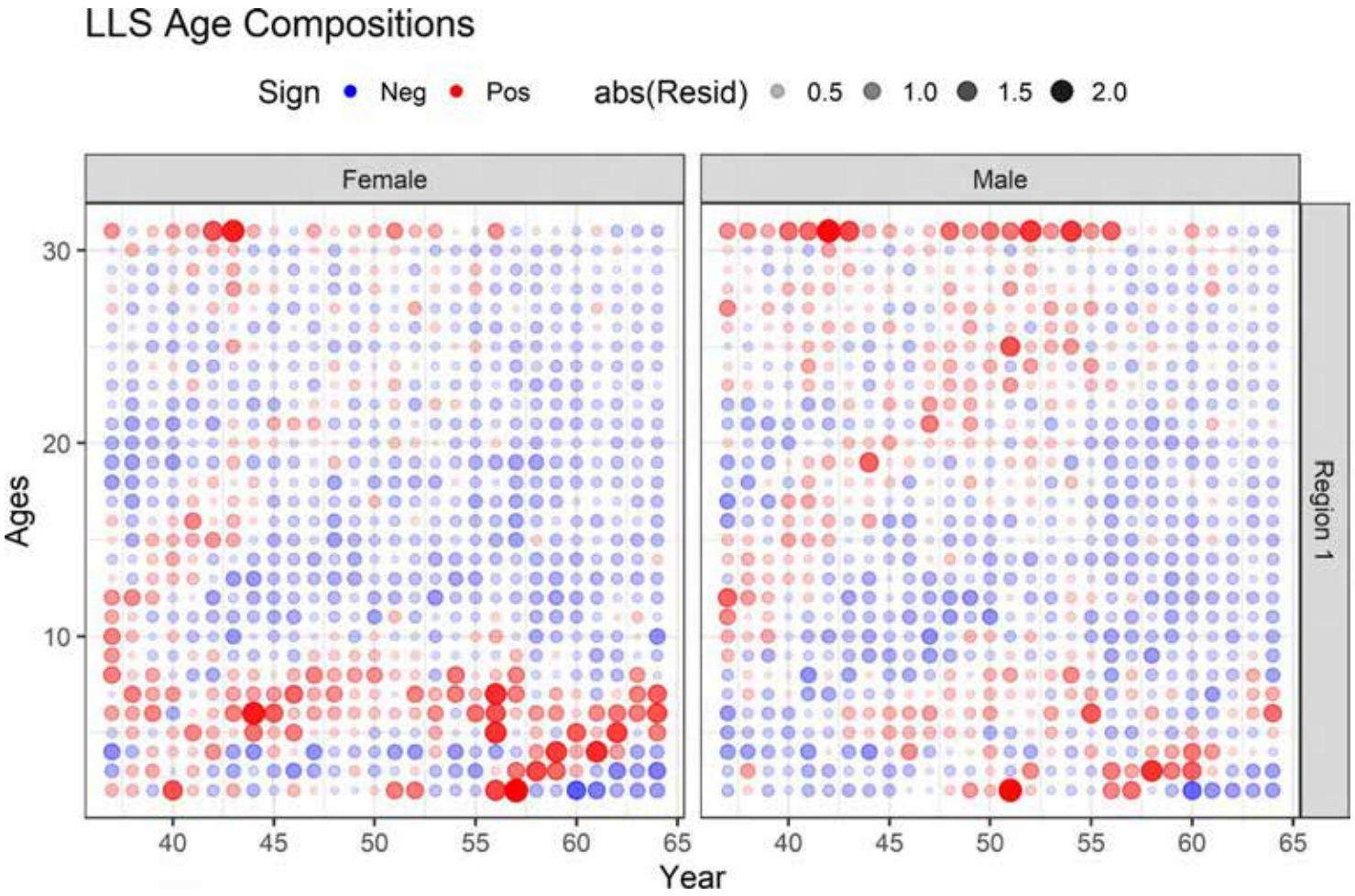

Figure SM3B.36. Fits to NOAA longline survey age composition data based on Pearson residuals for model *26.1_1Reg*.

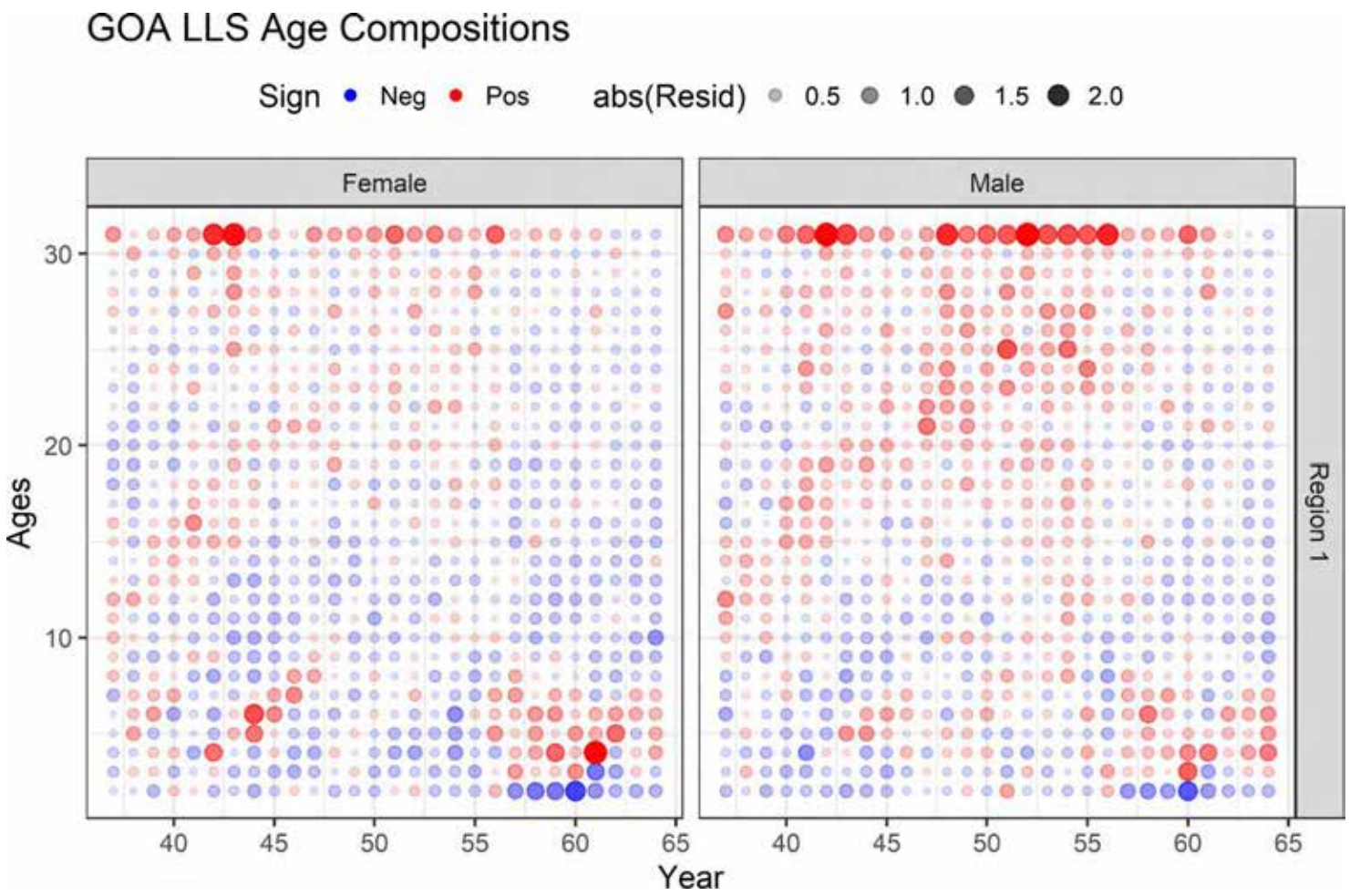

Figure SM3C.37. Fits to GOA NOAA longline survey age composition data based on Pearson residuals for model *26.2_FAA*.

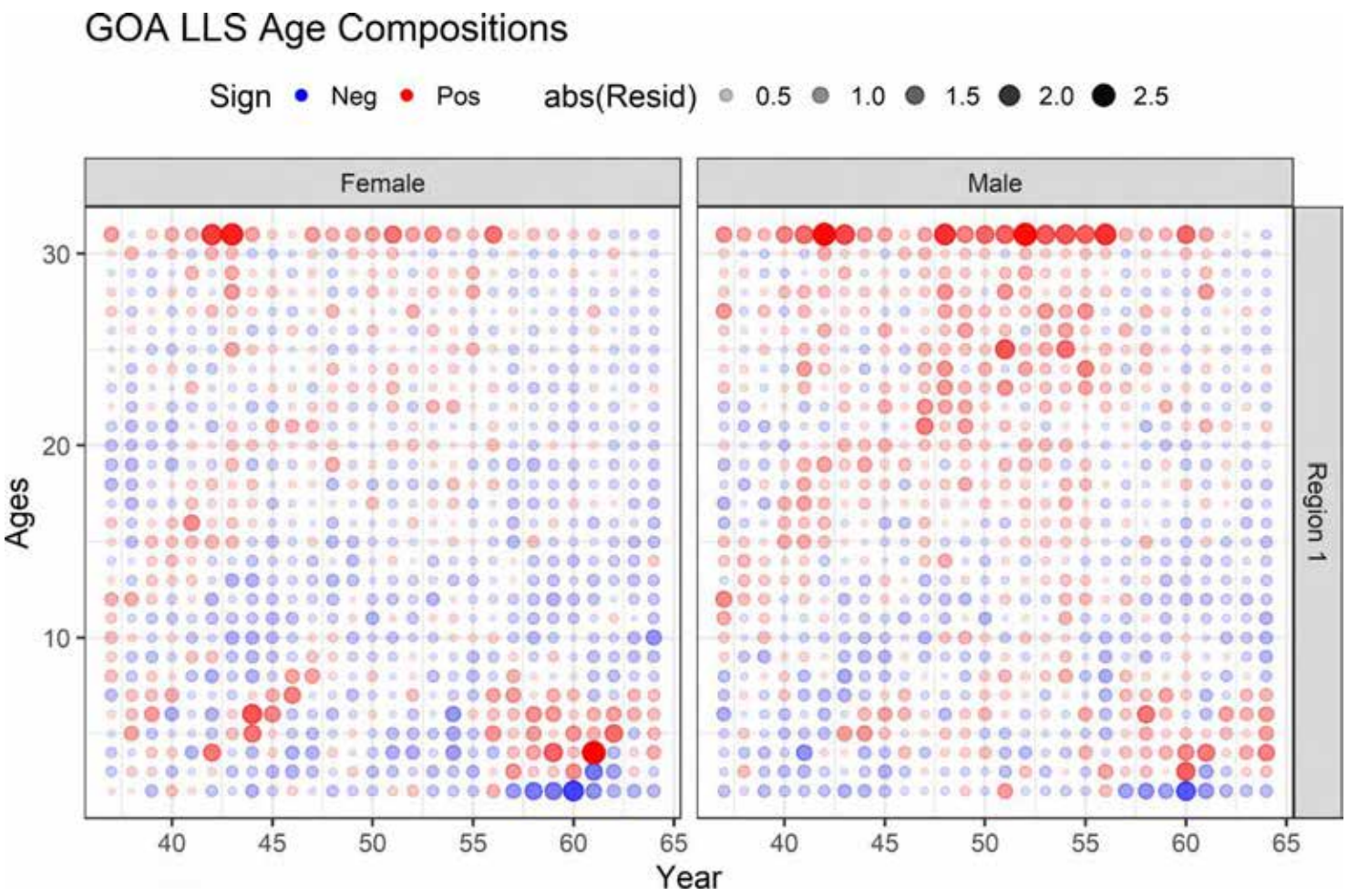

Figure SM3C.38. Fits to GOA NOAA longline survey age composition data based on Pearson residuals for model *26.2a_FAA_Fsh+Srvy*.

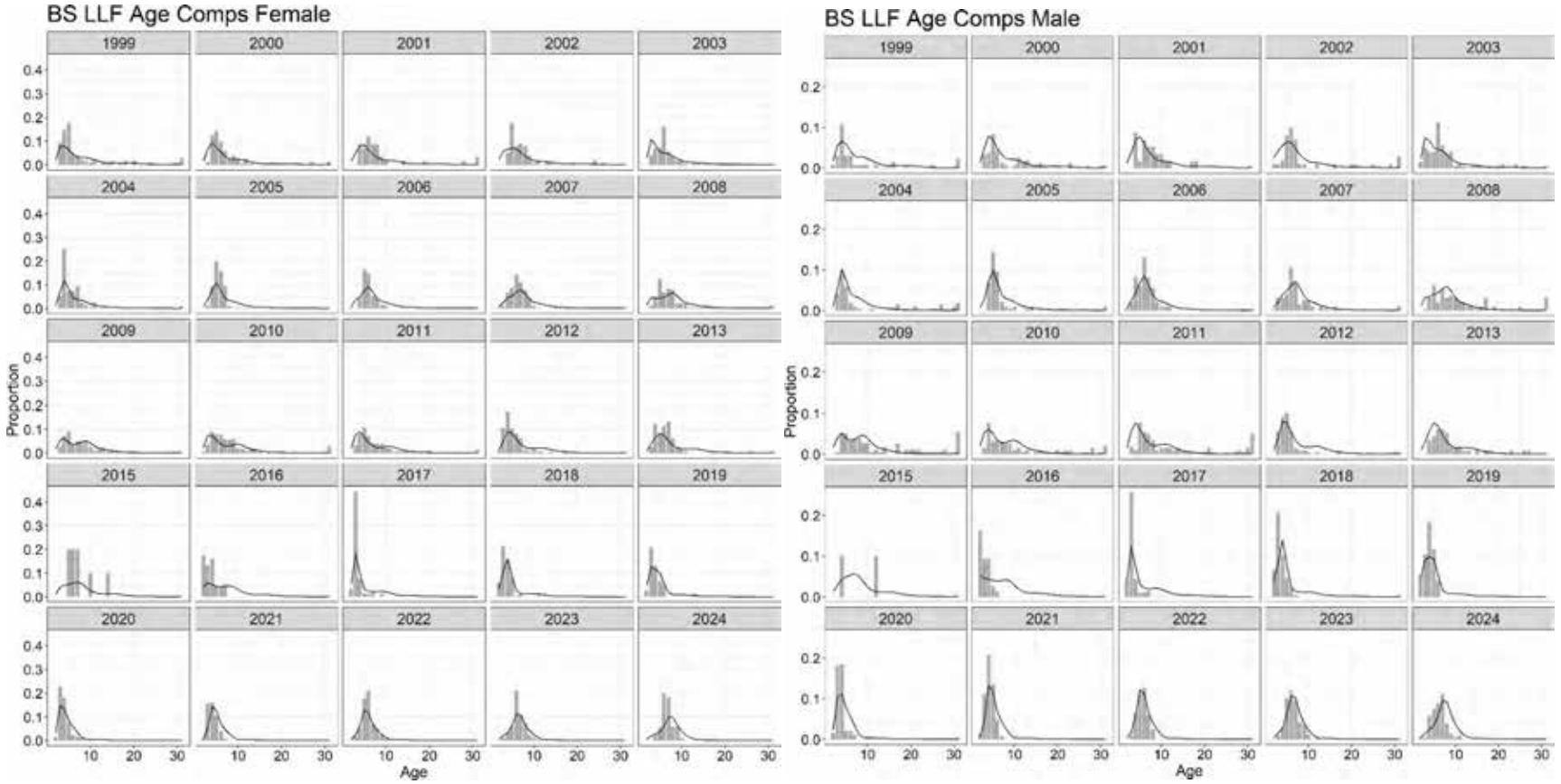

Figure SM3C.39. Fits to BS fixed gear fishery age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

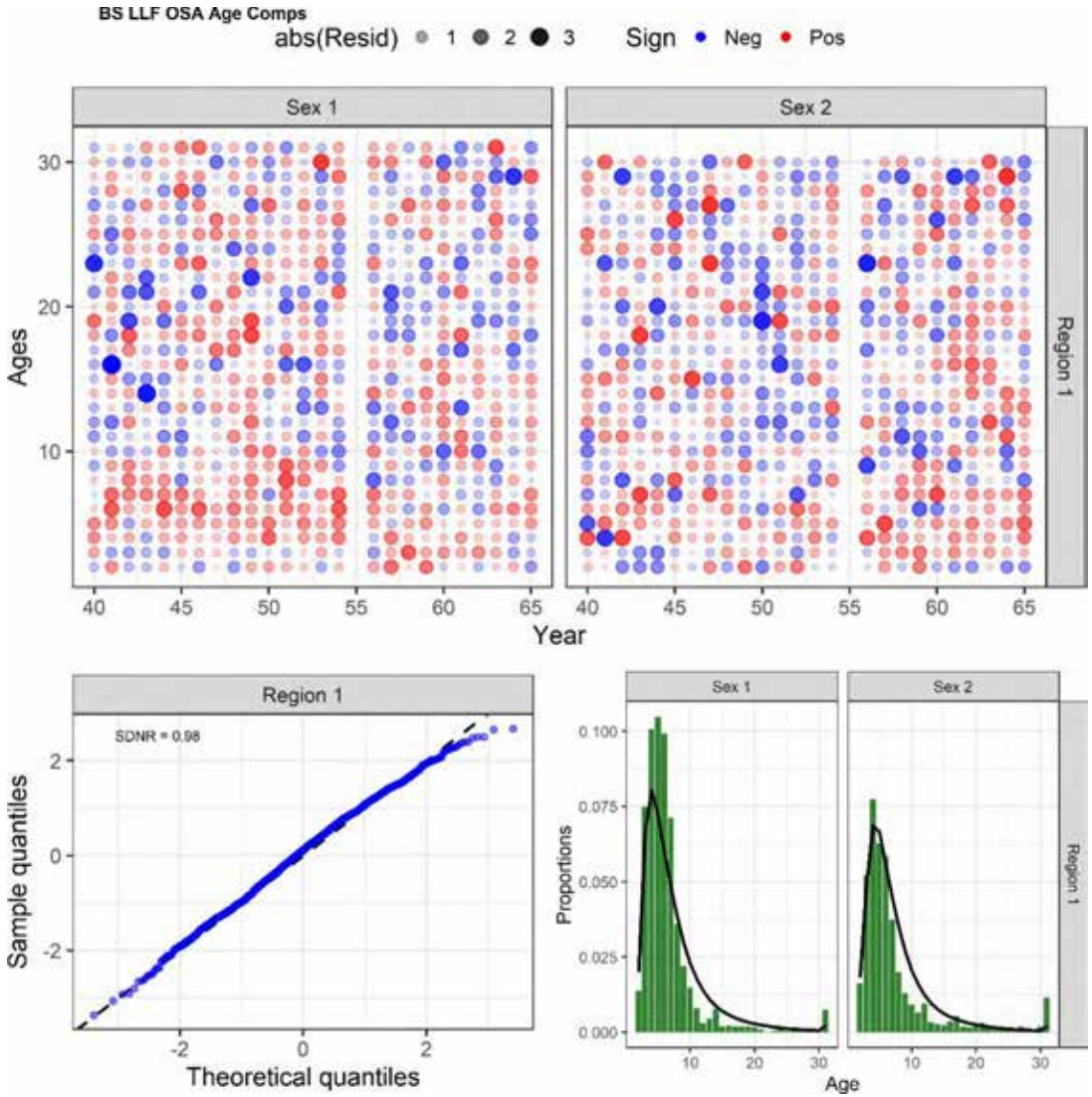

Figure SM3C.40. Fits to BS fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

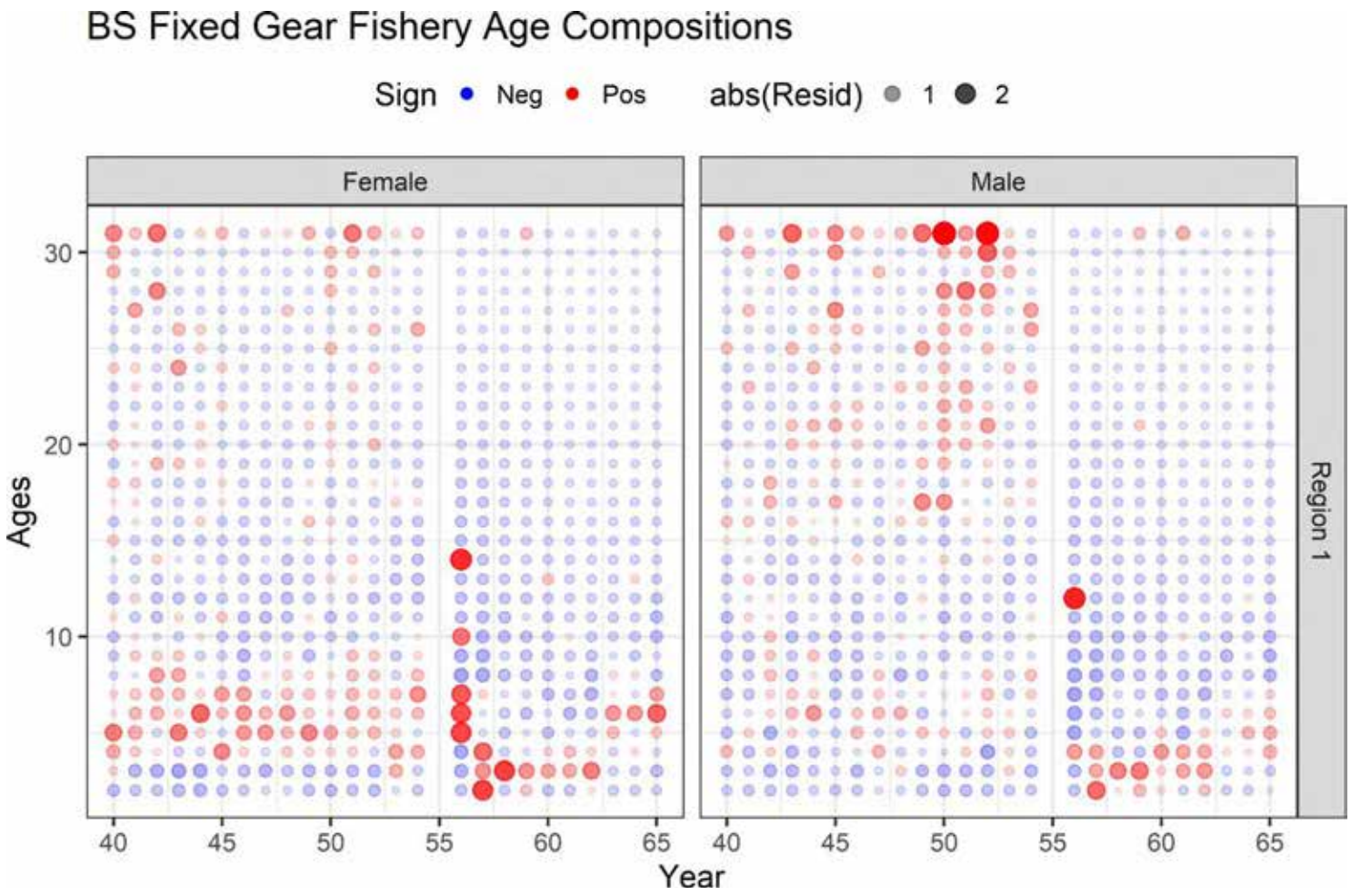

Figure SM3C.41. Fits to the BS fixed gear fishery age composition data based on Pearson residuals for model *25. 2_FAA_Fsh+Srvy*.

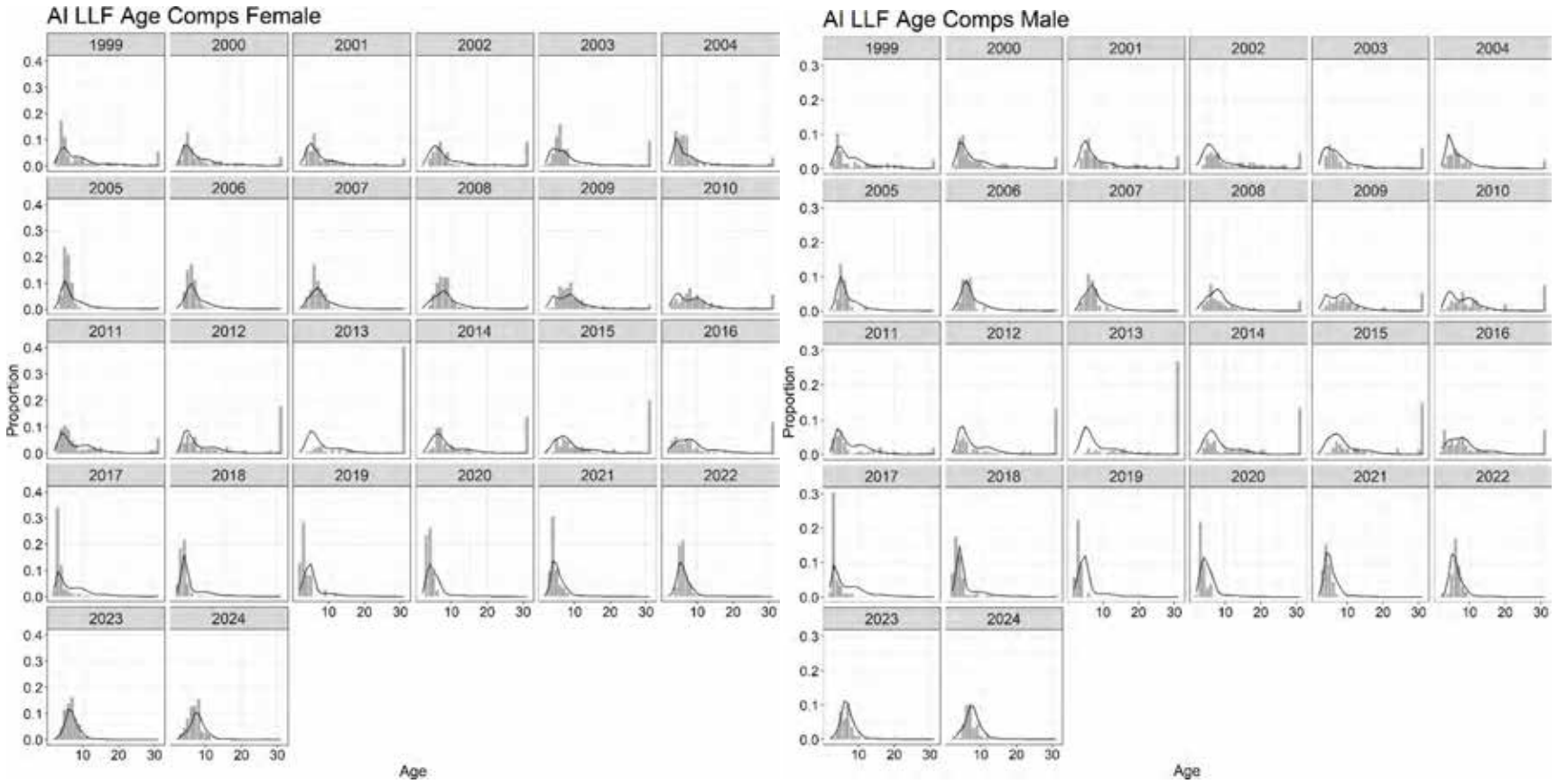

Figure SM3C.42. Fits to AI fixed gear fishery age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

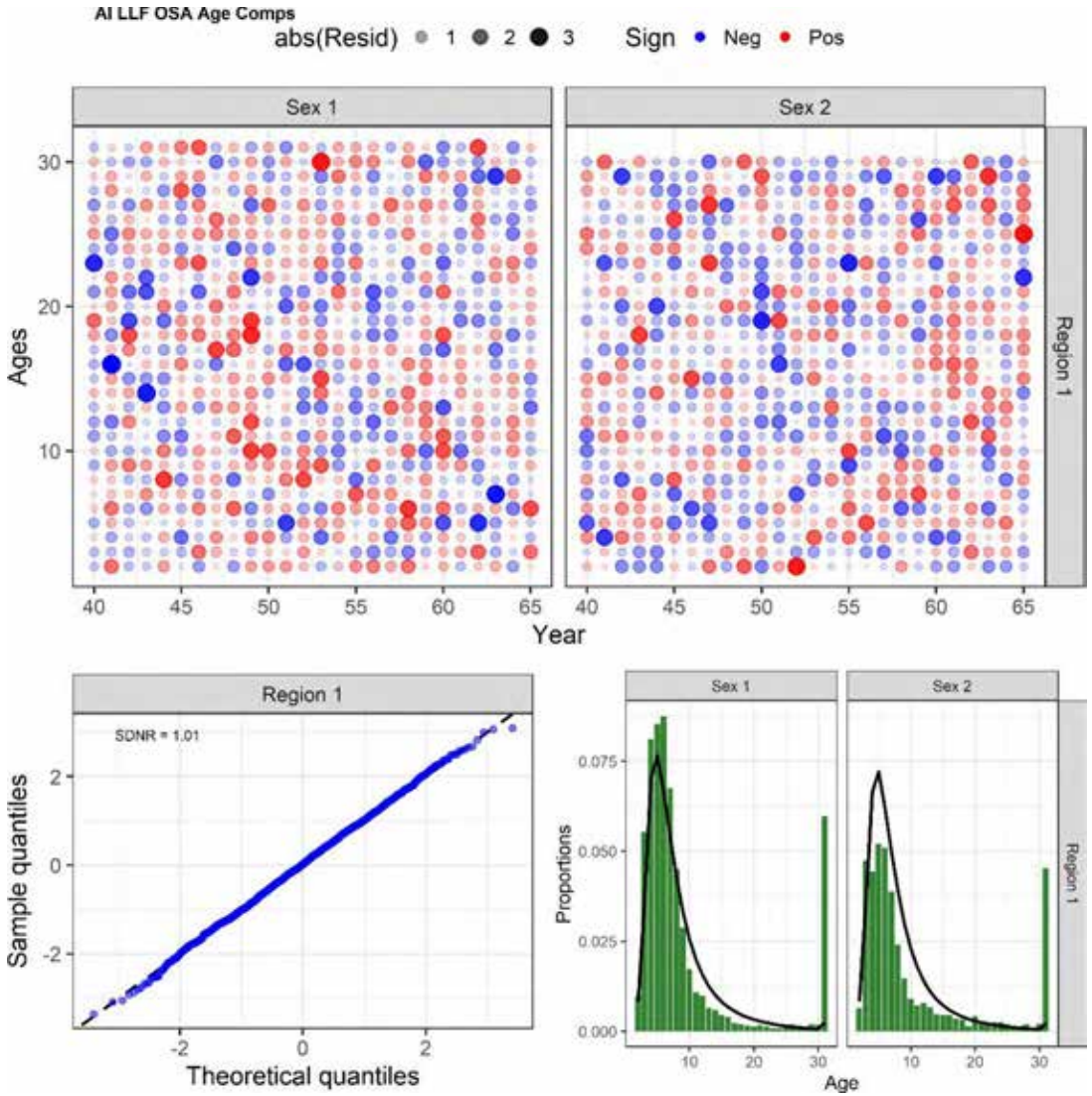

Figure SM3C.43. Fits to AI fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

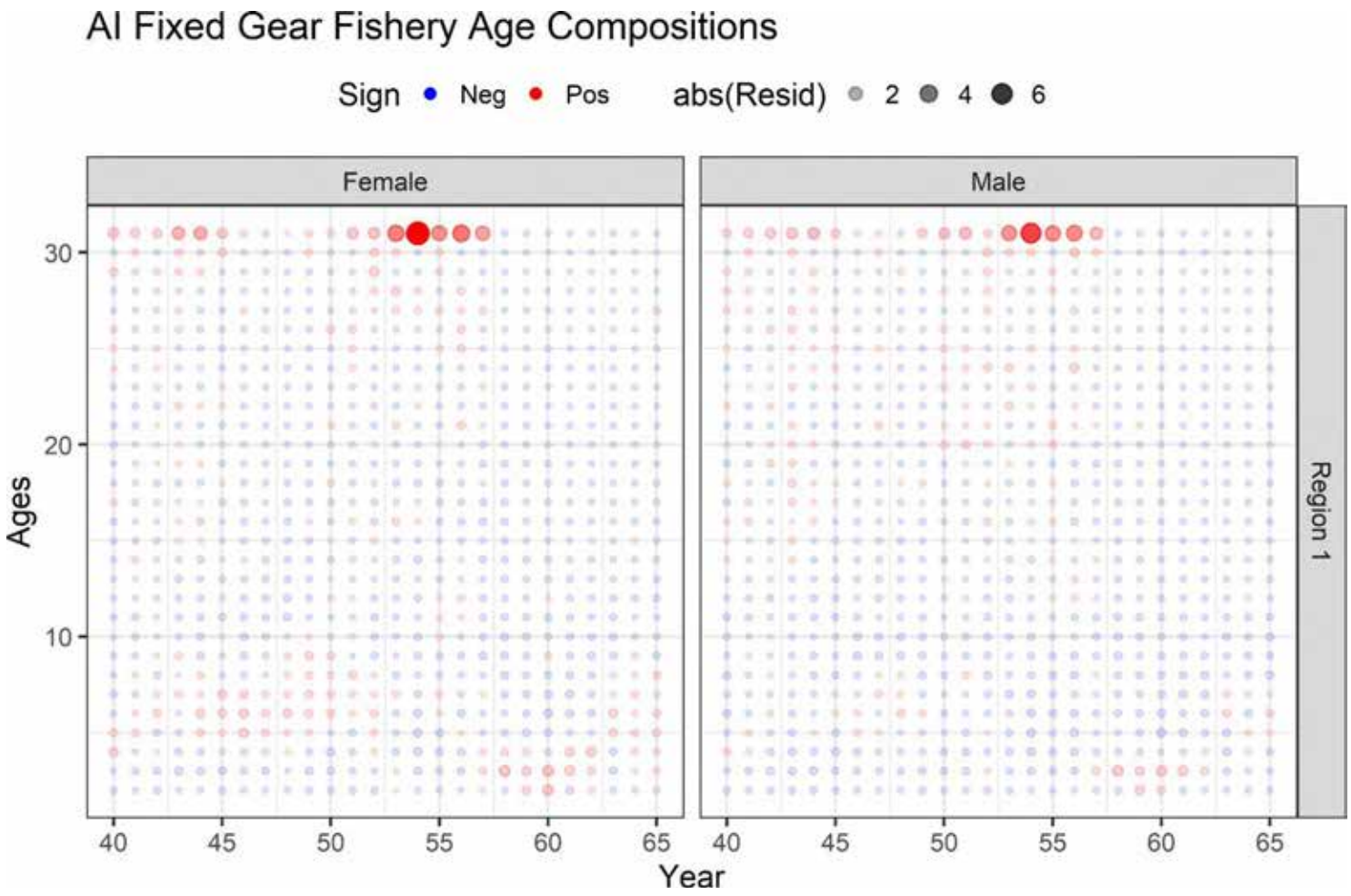

Figure SM3C.44. Fits to the AI fixed gear fishery age composition data based on Pearson residuals for model *25. 2_FAA_Fsh+Srvy*.

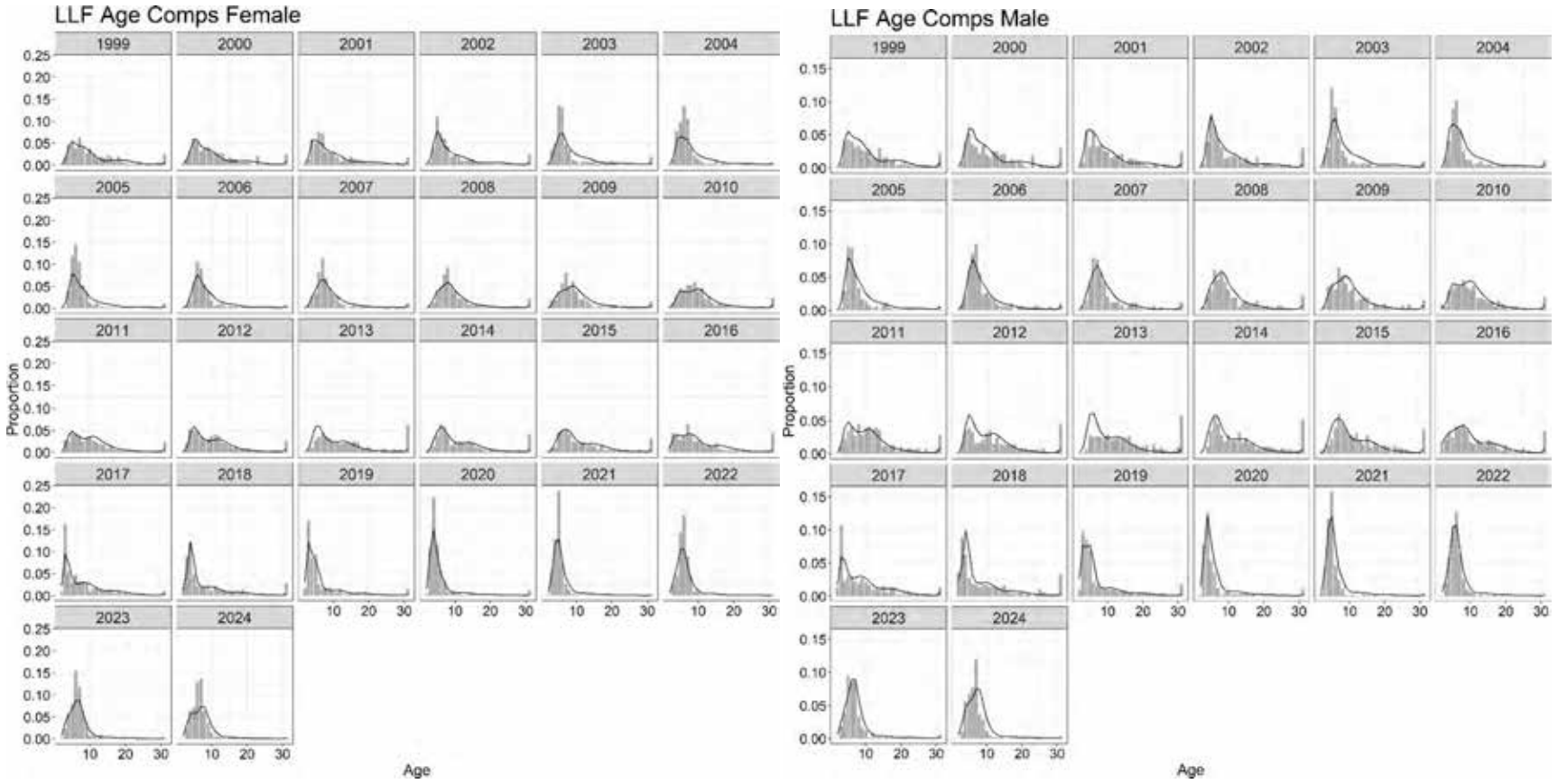

Figure SM3C.45. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

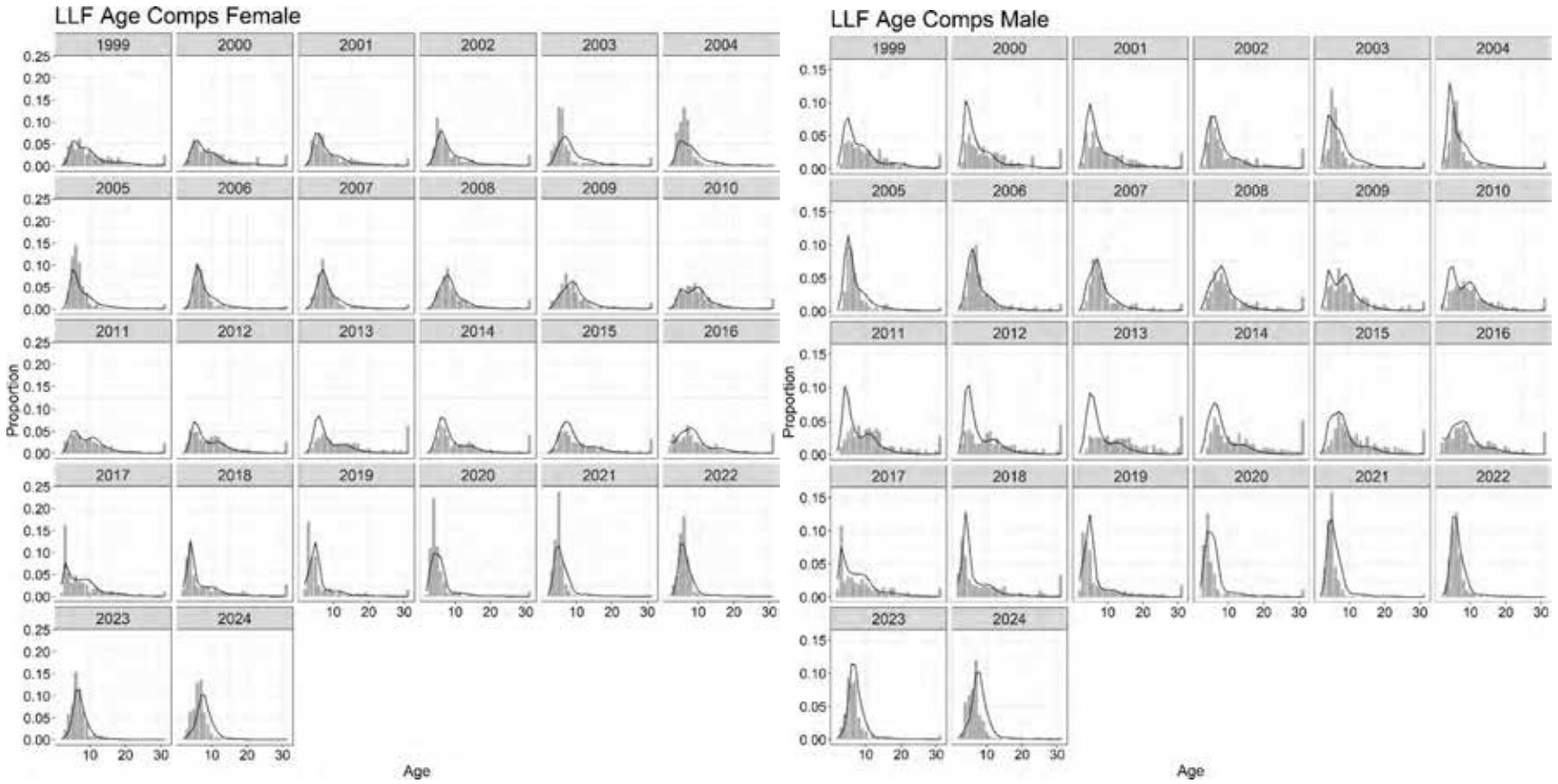

Figure SM3C.46. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for model *26.2_FAA*.

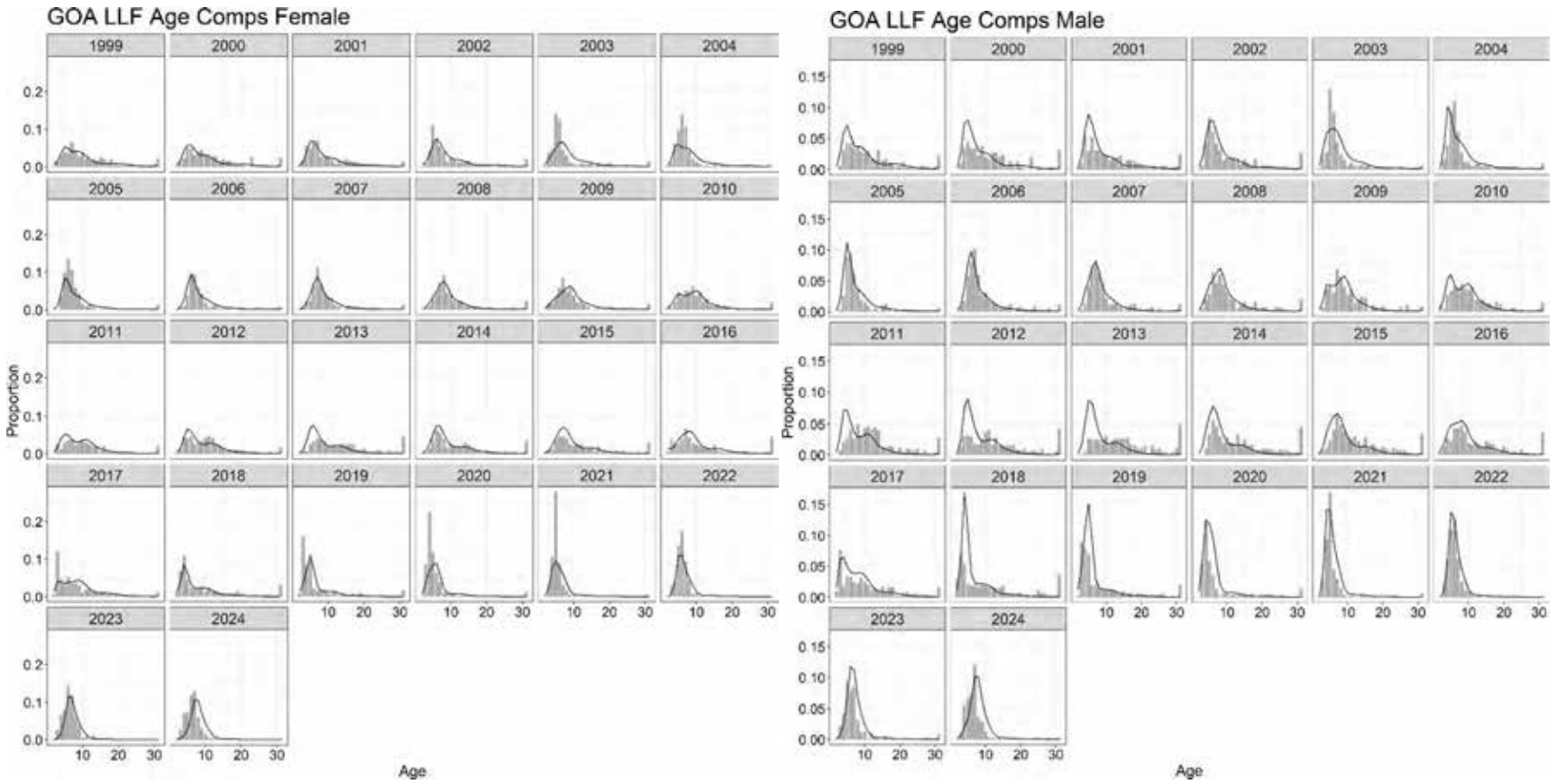

Figure SM3C.47. Fits to GOA fixed gear fishery age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

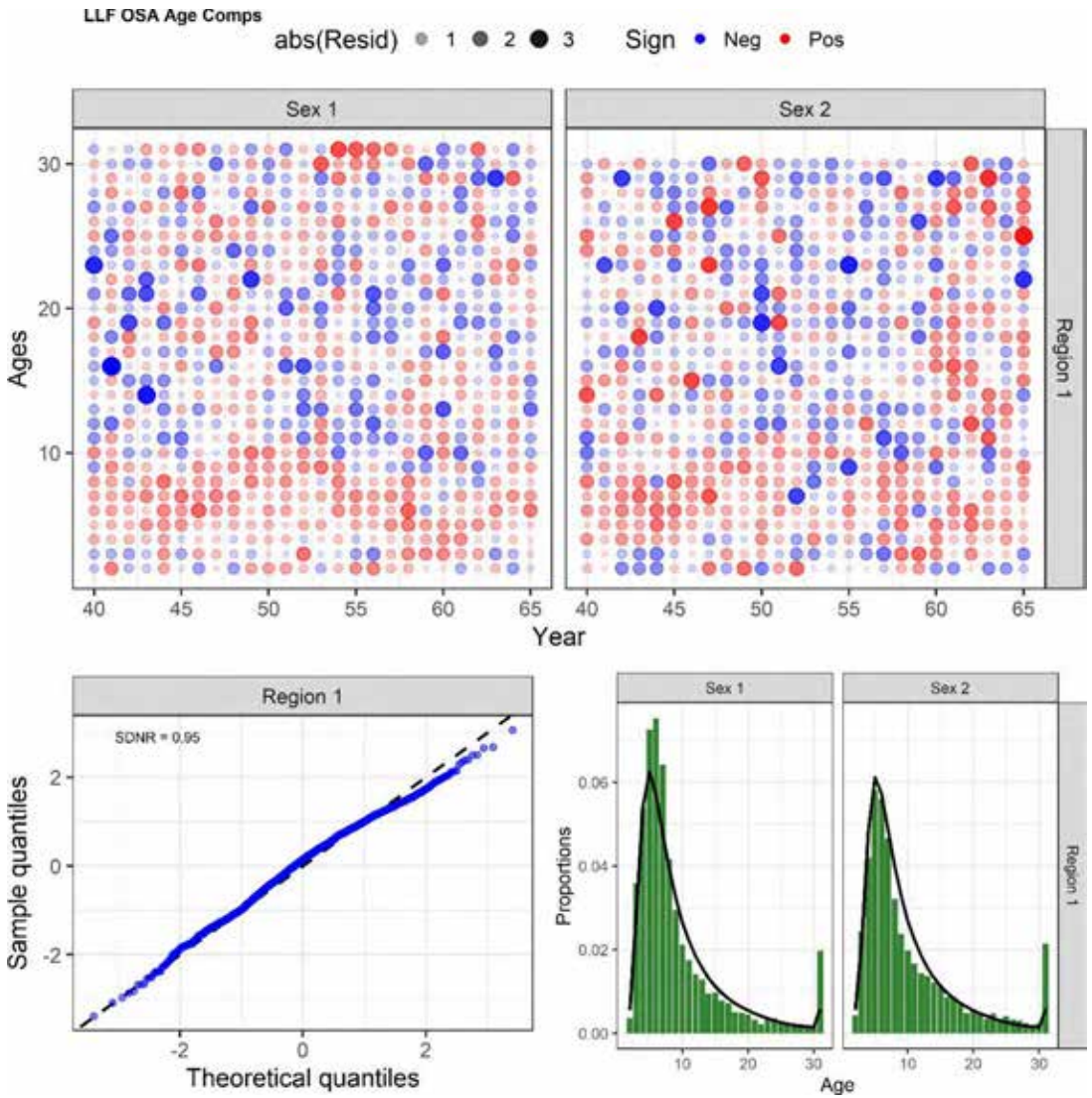

Figure SM3C.48. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

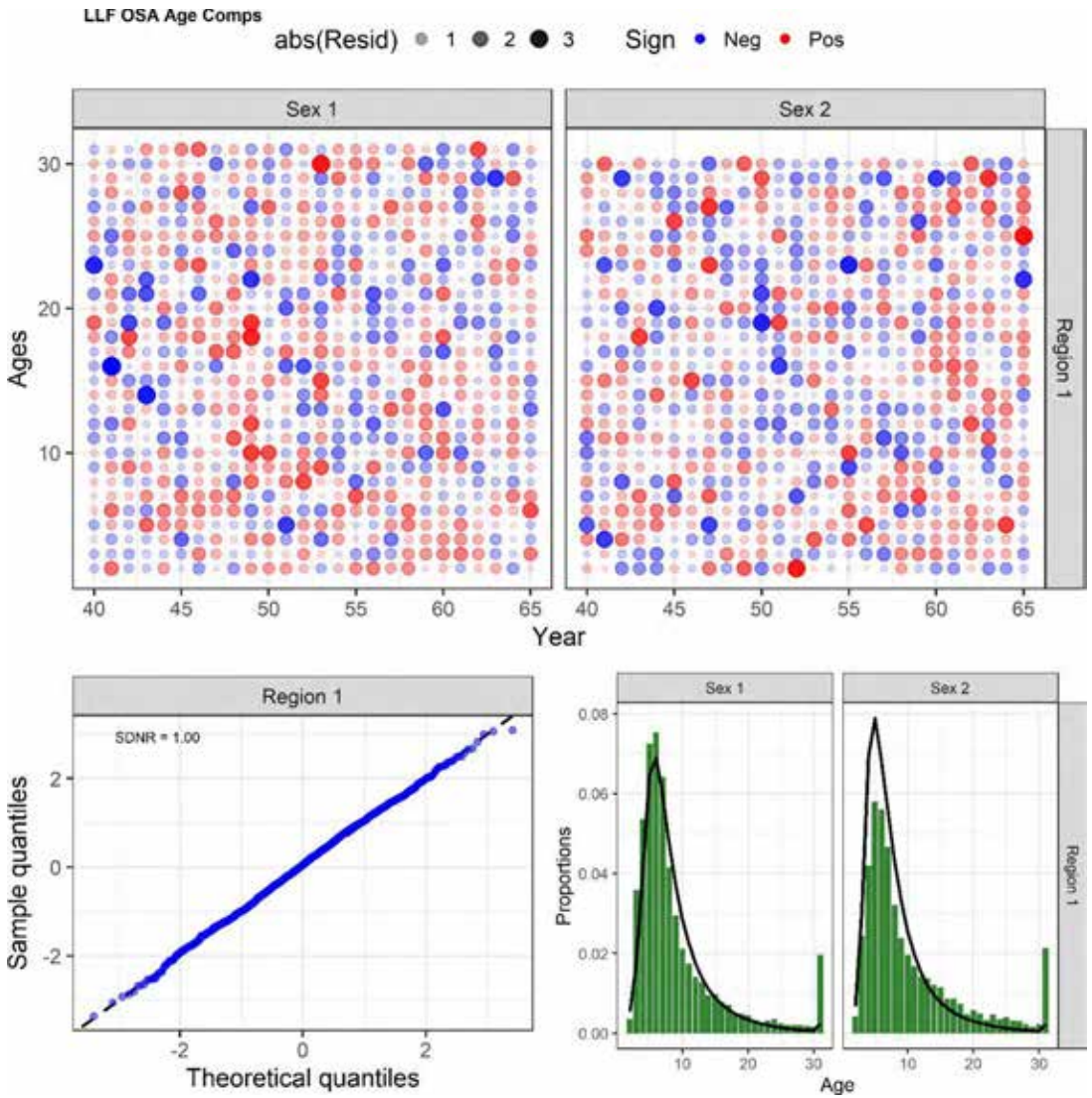

Figure SM3C.49. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

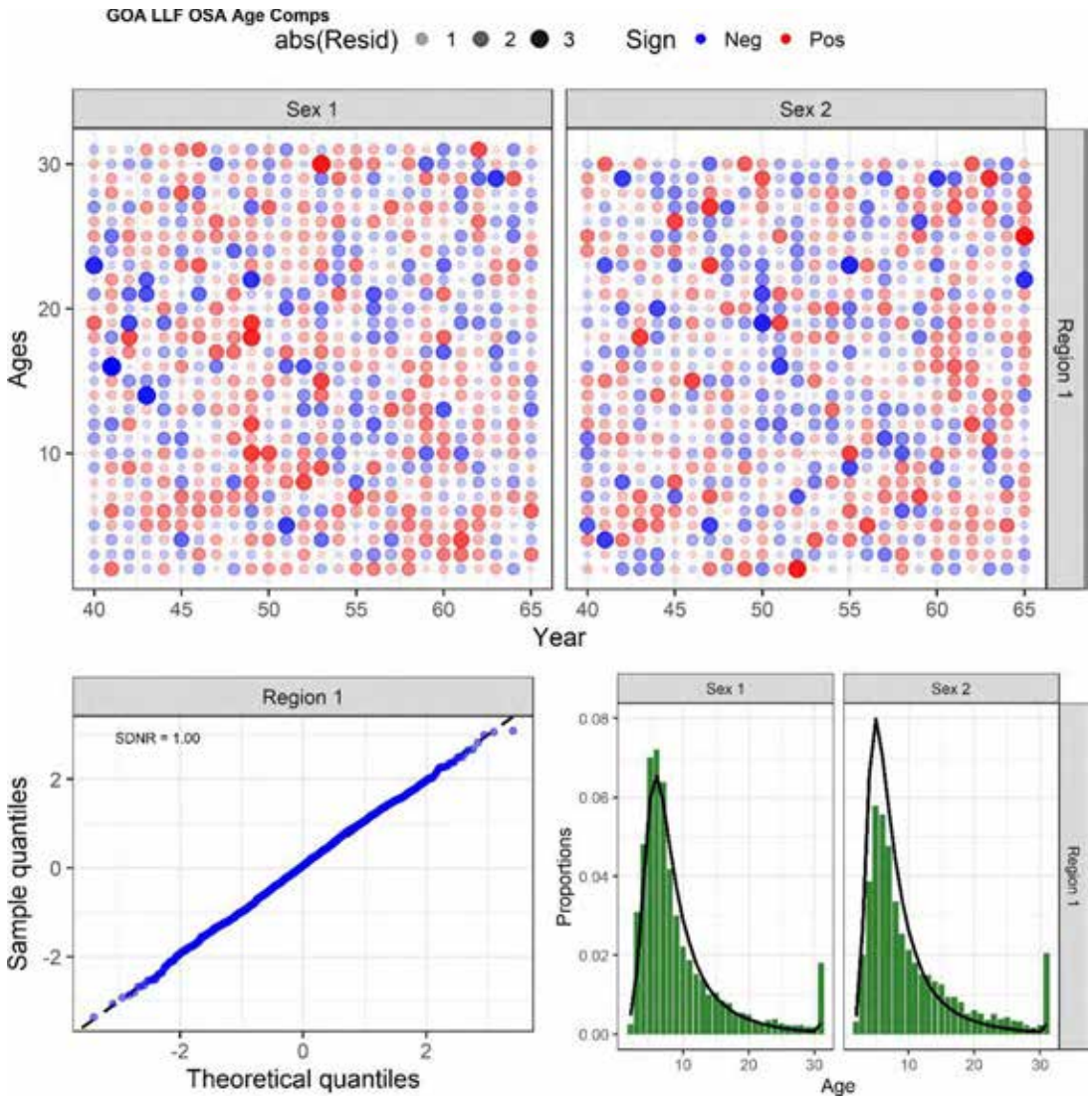

Figure SM3C.50. Fits to GOA fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

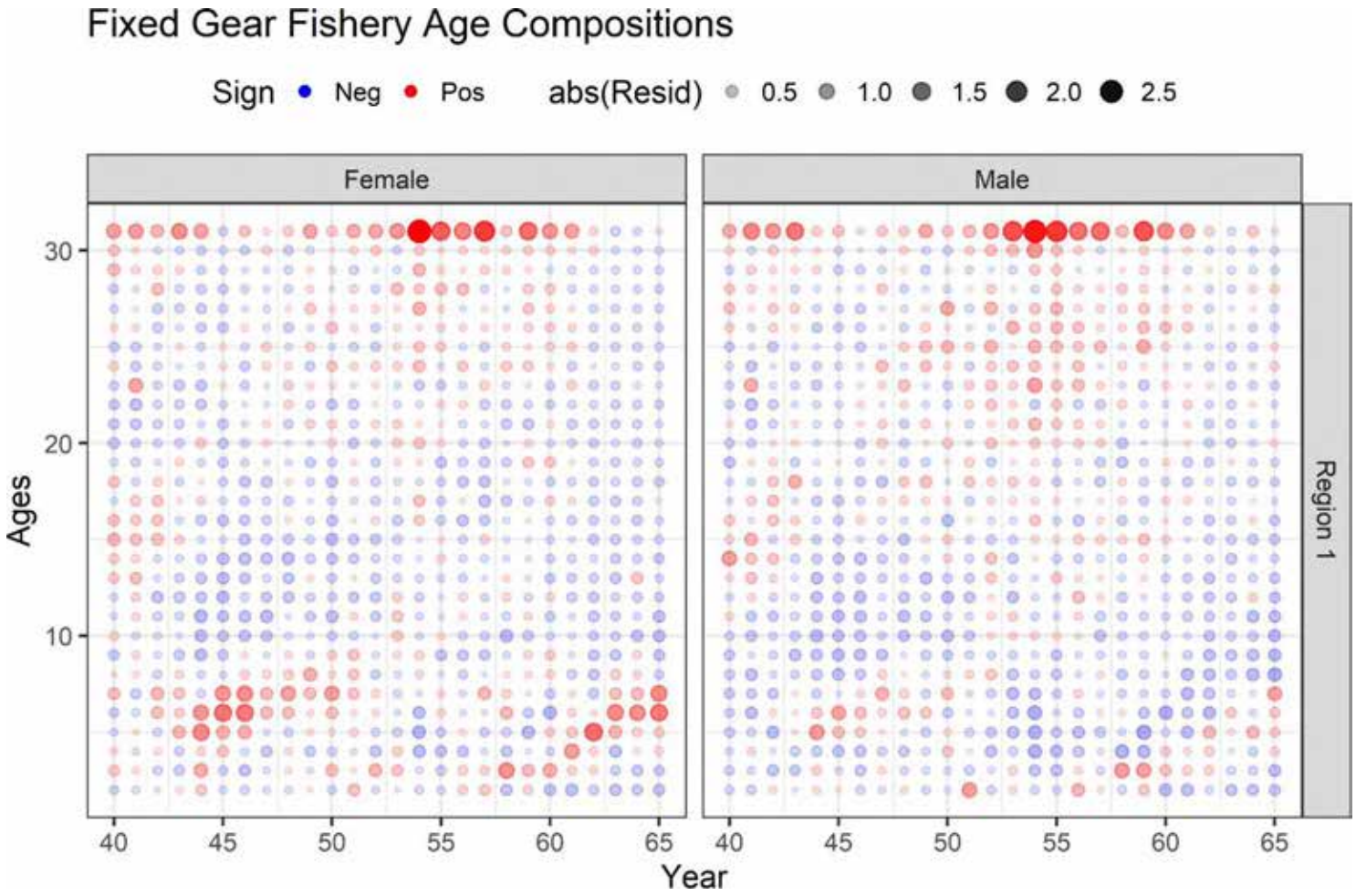

Figure SM3C.51. Fits to the fixed gear fishery age composition data based on Pearson residuals for model *26.1_1Reg*.

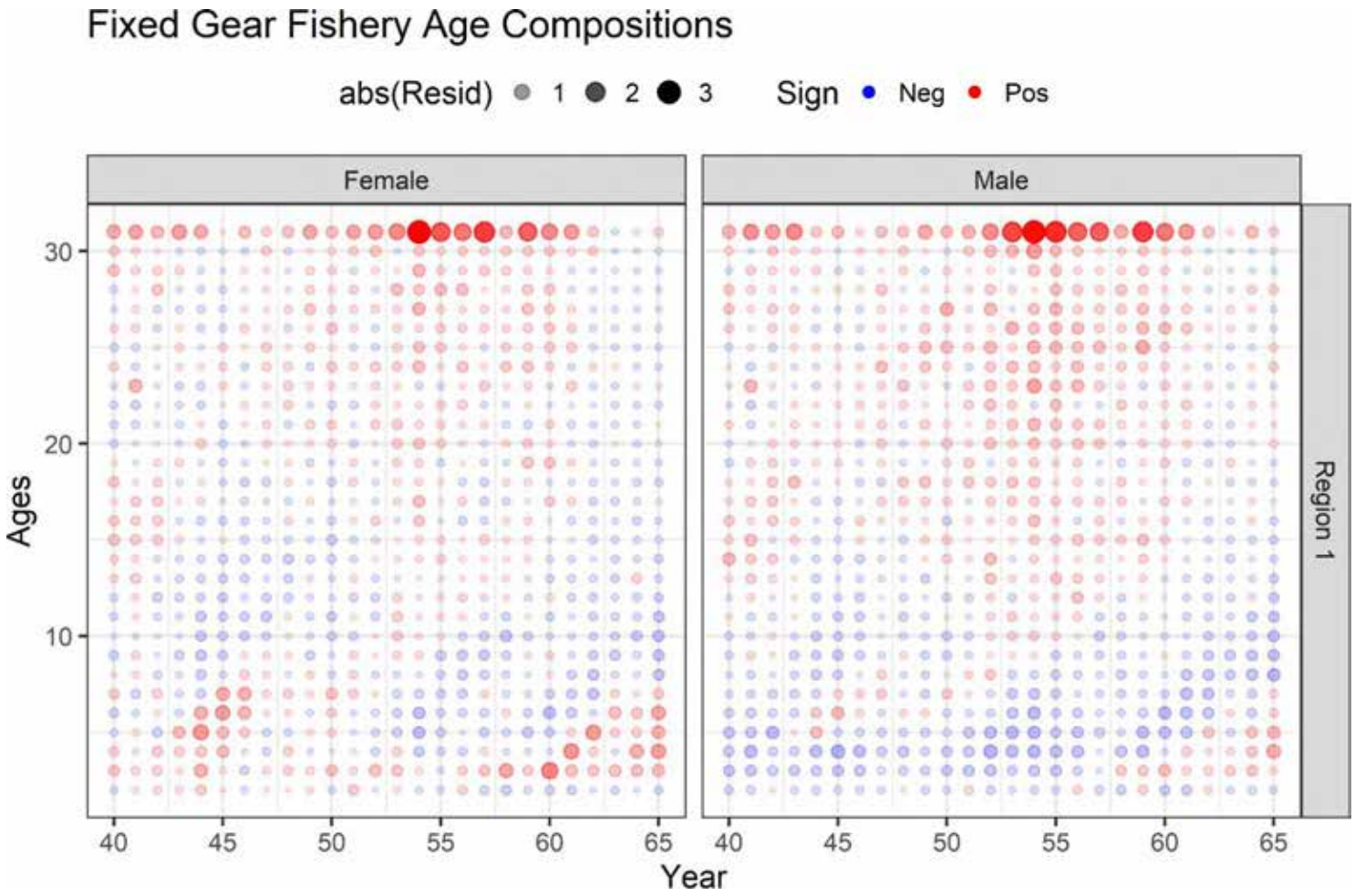

Figure SM3C.52. Fits to the fixed gear fishery age composition data based on Pearson residuals for model *25. 2_FAA*.

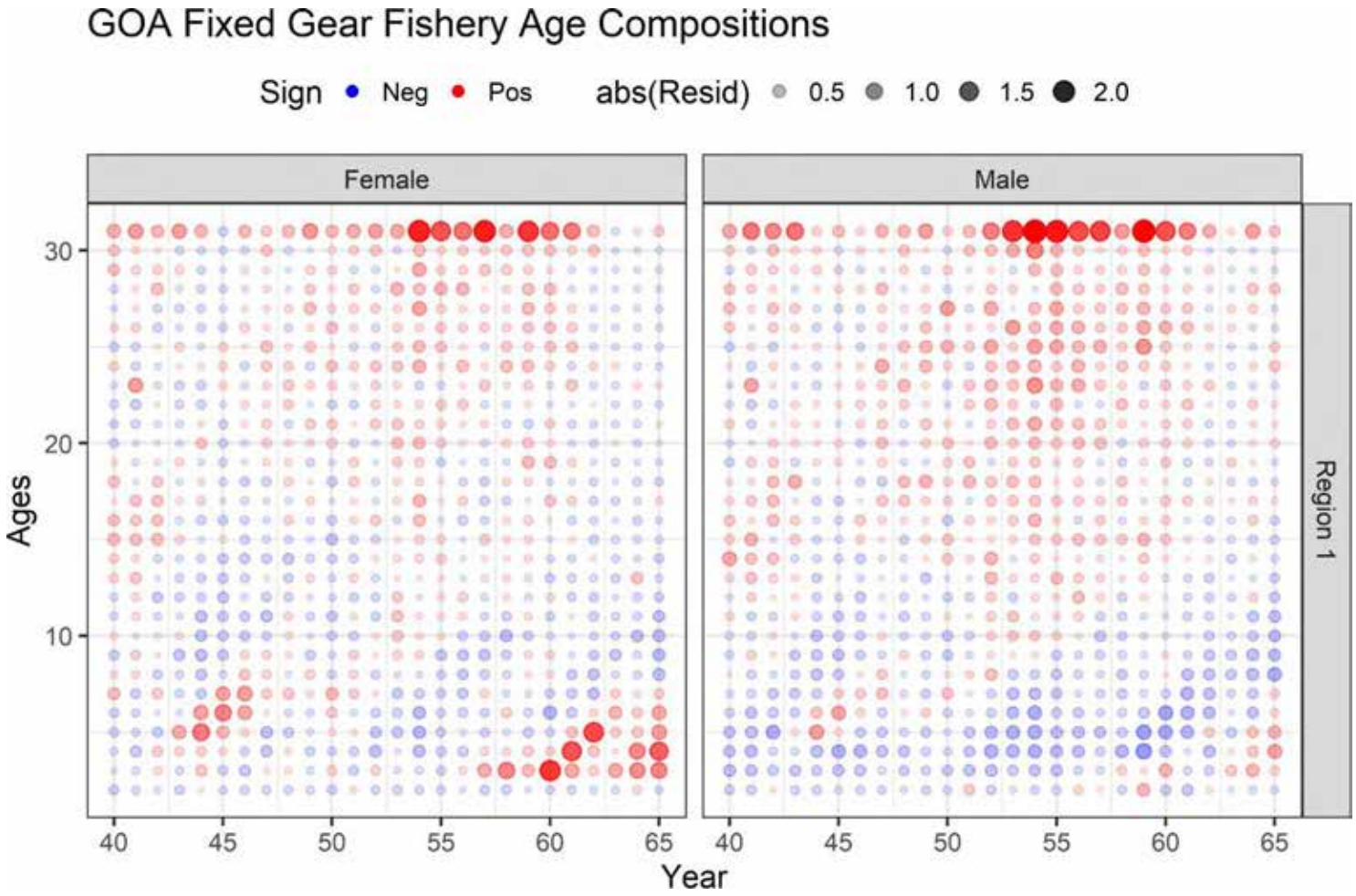

Figure SM3C.53. Fits to the GOA fixed gear fishery age composition data based on Pearson residuals for model *25. 2_FAA_Fsh+Srvy*.

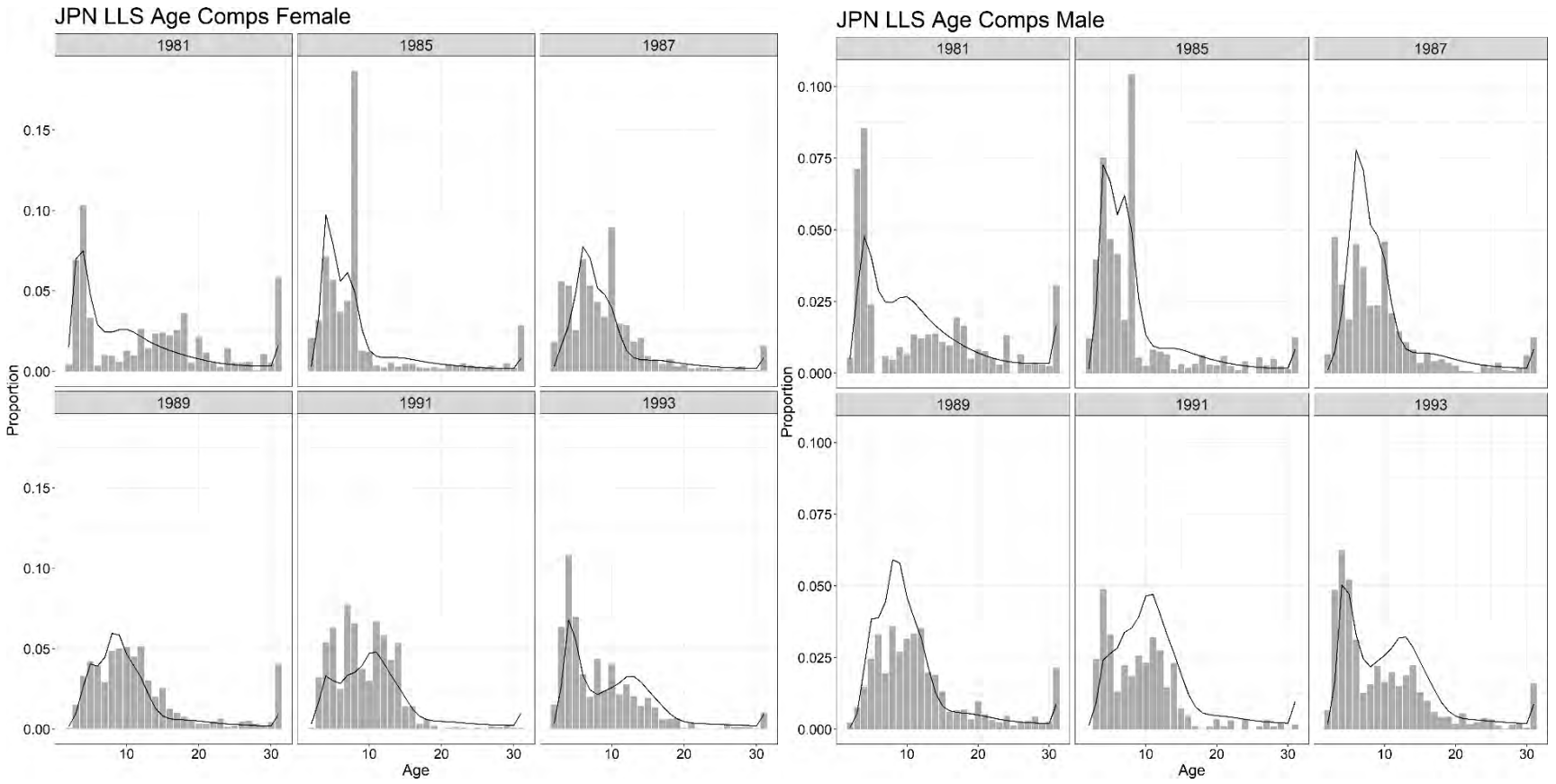

Figure SM3C.54. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *26.1 _1Reg*.

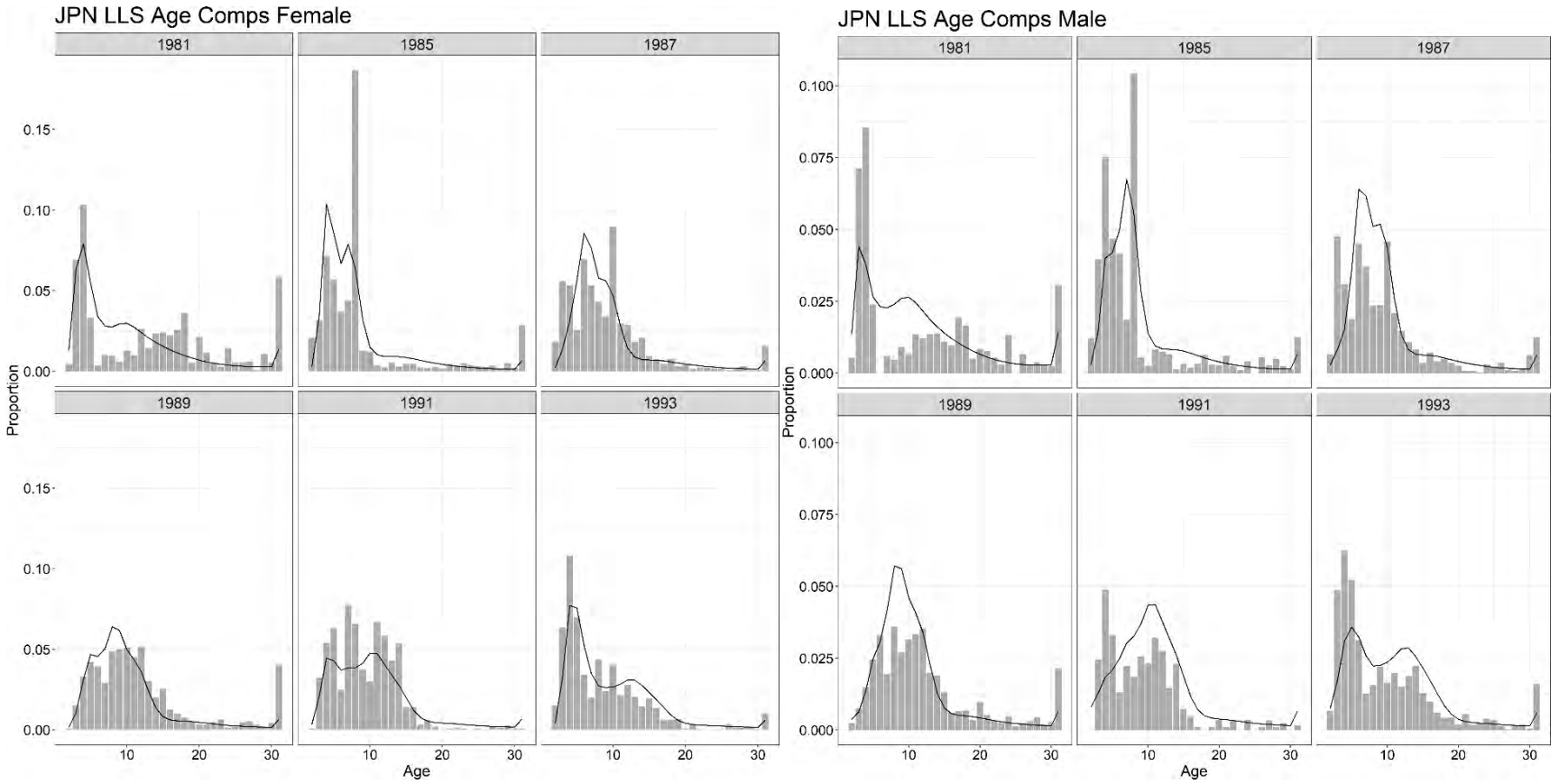

Figure SM3C.55. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *26.2 _FAA.*

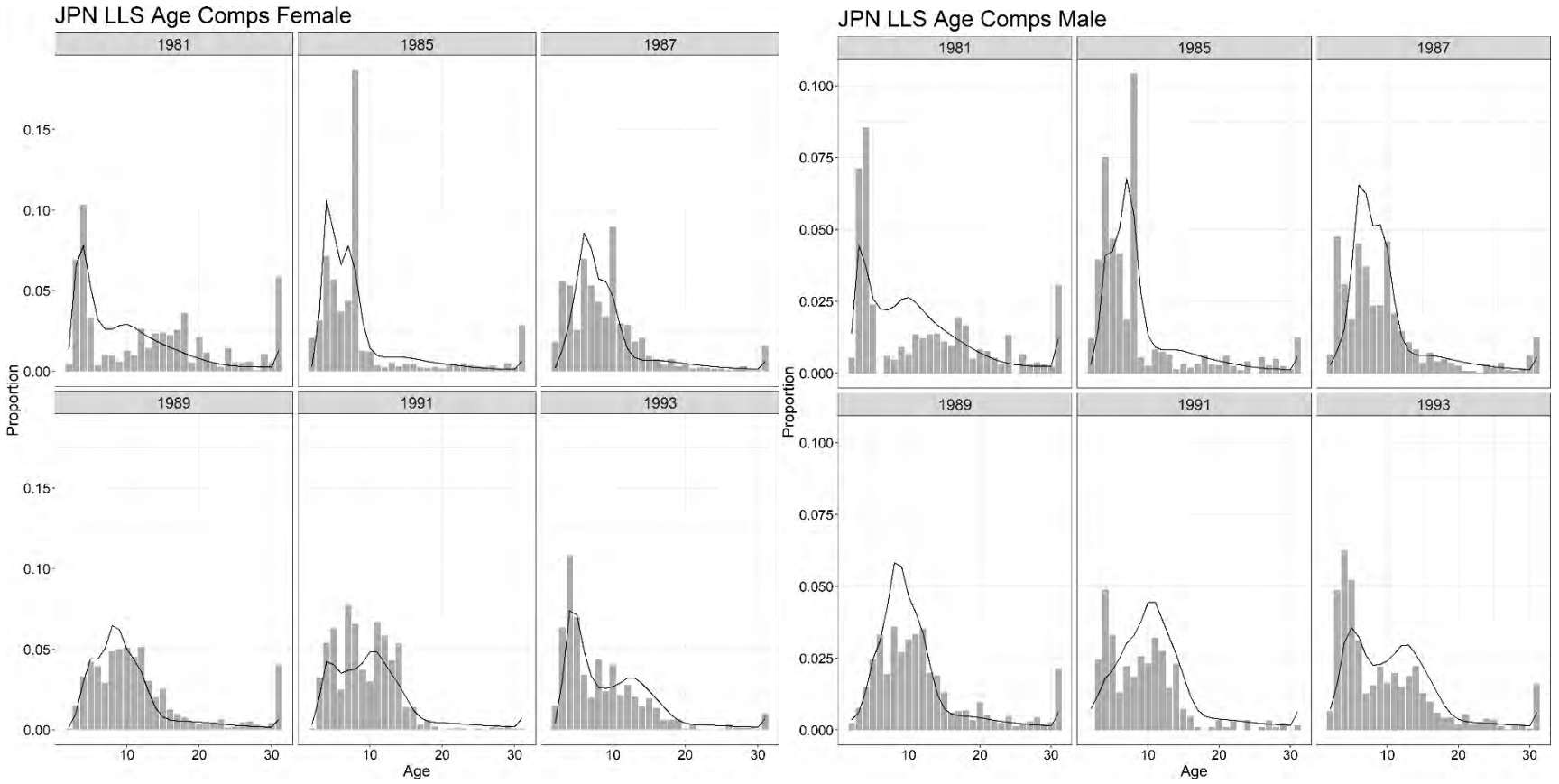

Figure SM3C.56. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *26.2a_FAA_Fsh+Srvy*.

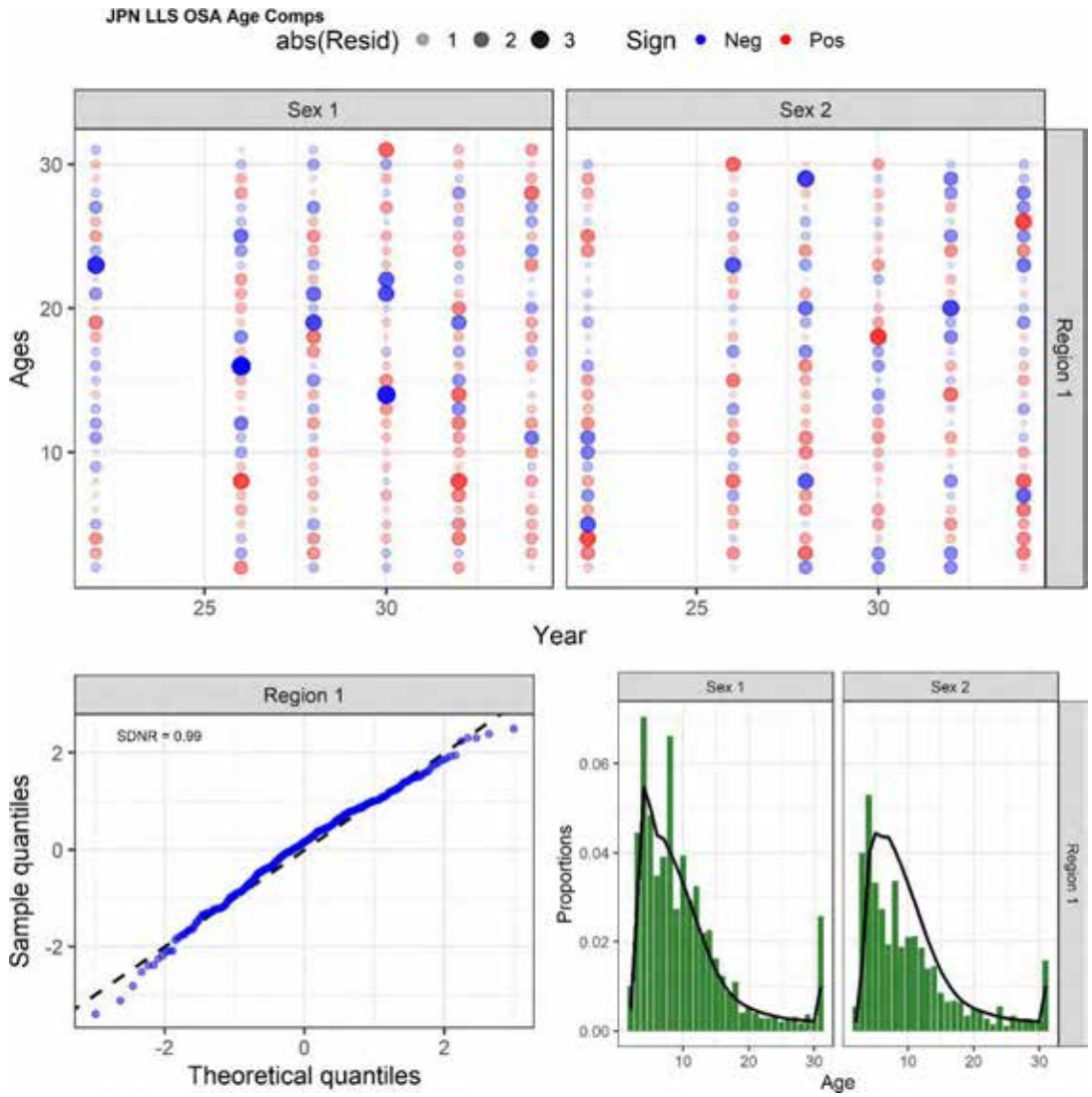

Figure SM3C.57. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

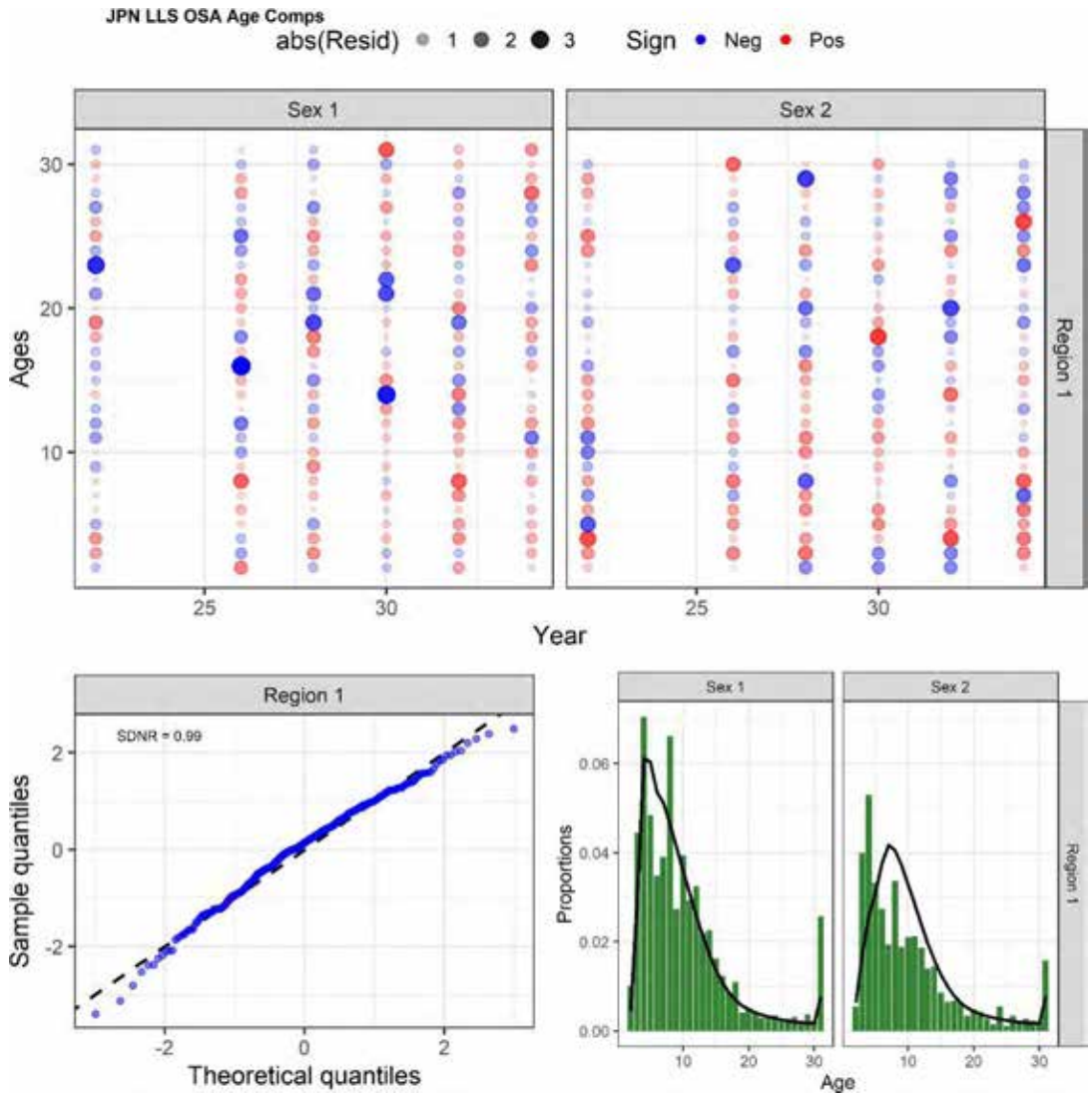

Figure SM3C.58. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

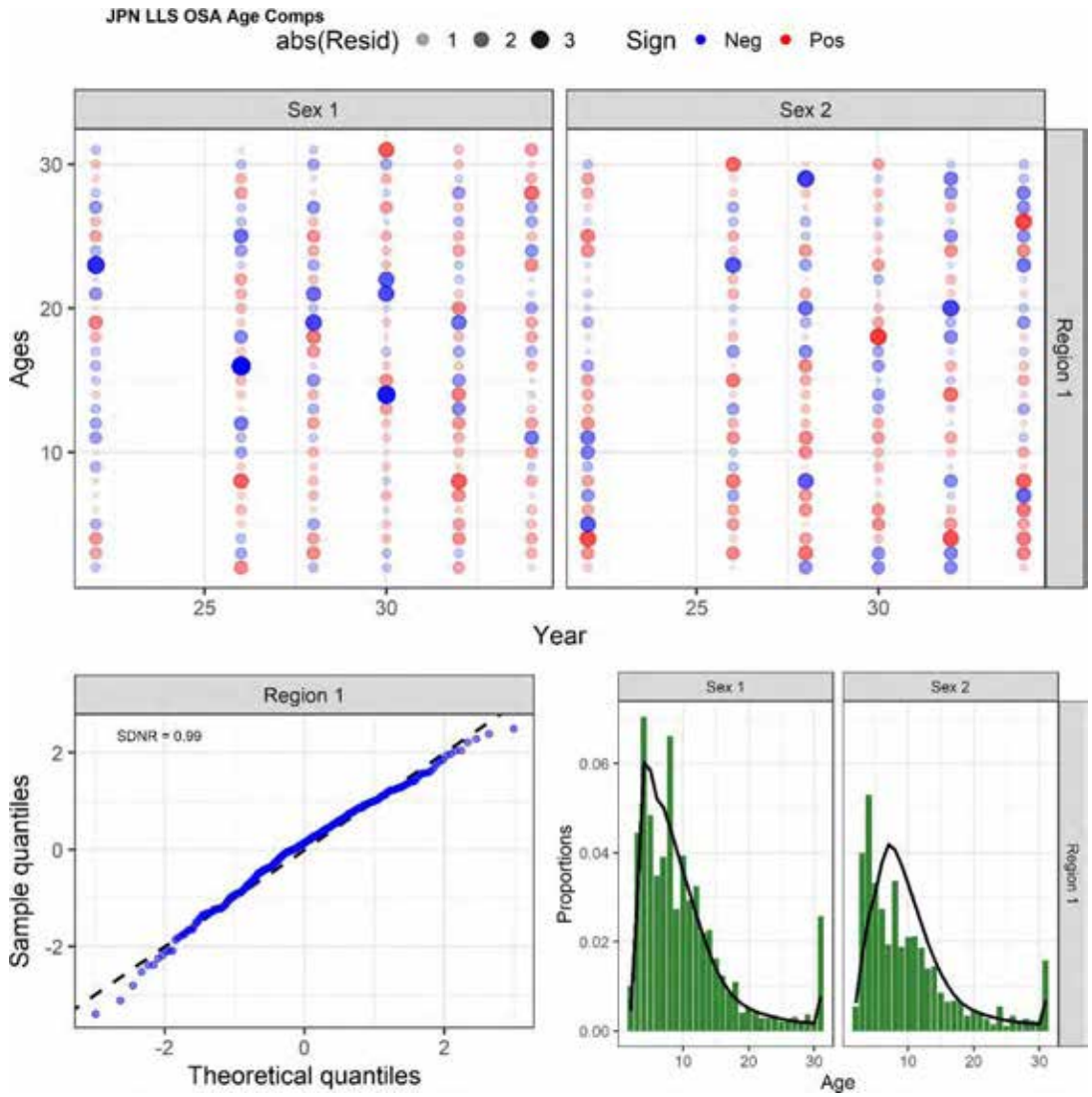

Figure SM3C.59. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

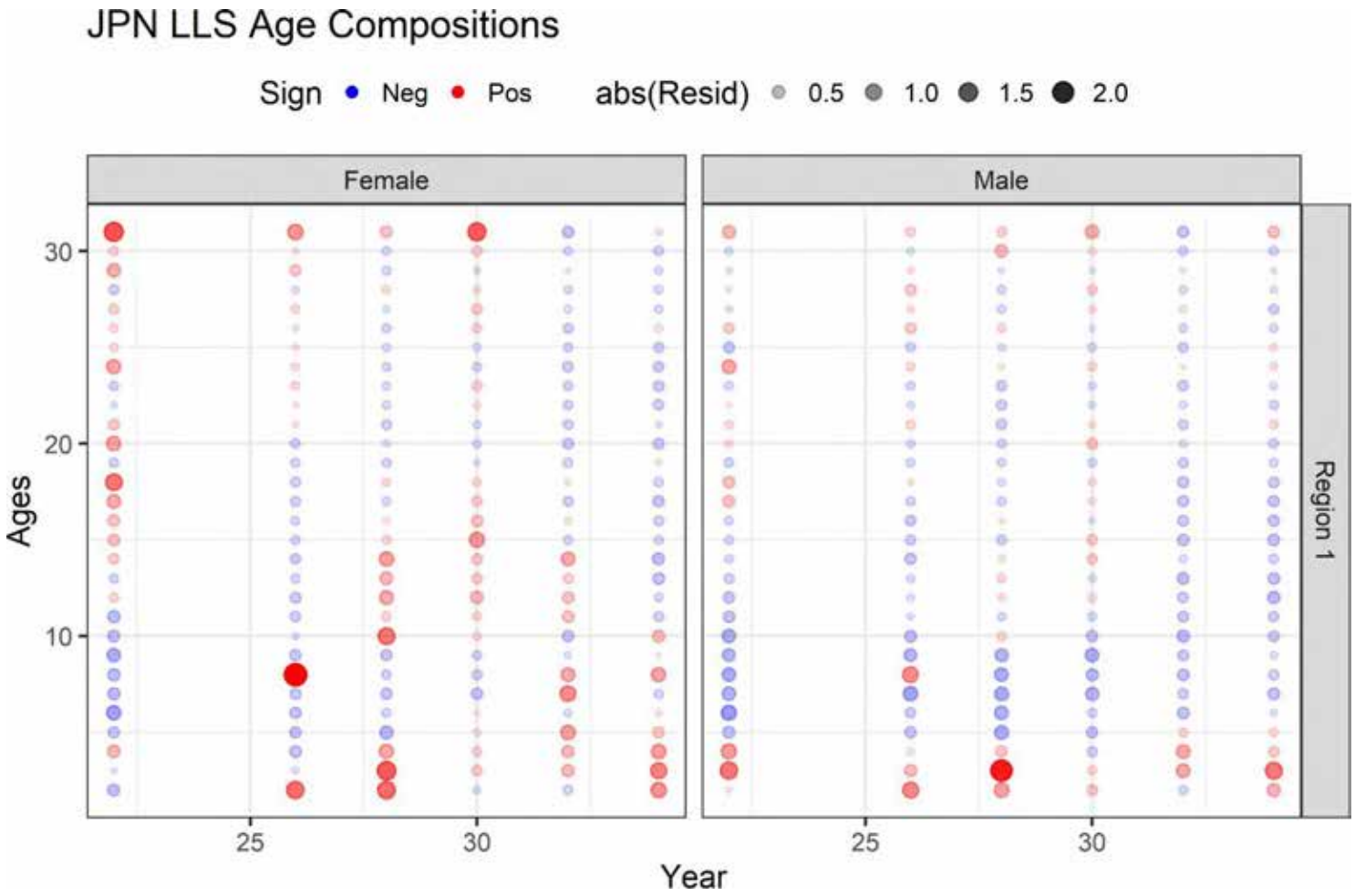

Figure SM3B.60. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for model *26.1_1Reg*.

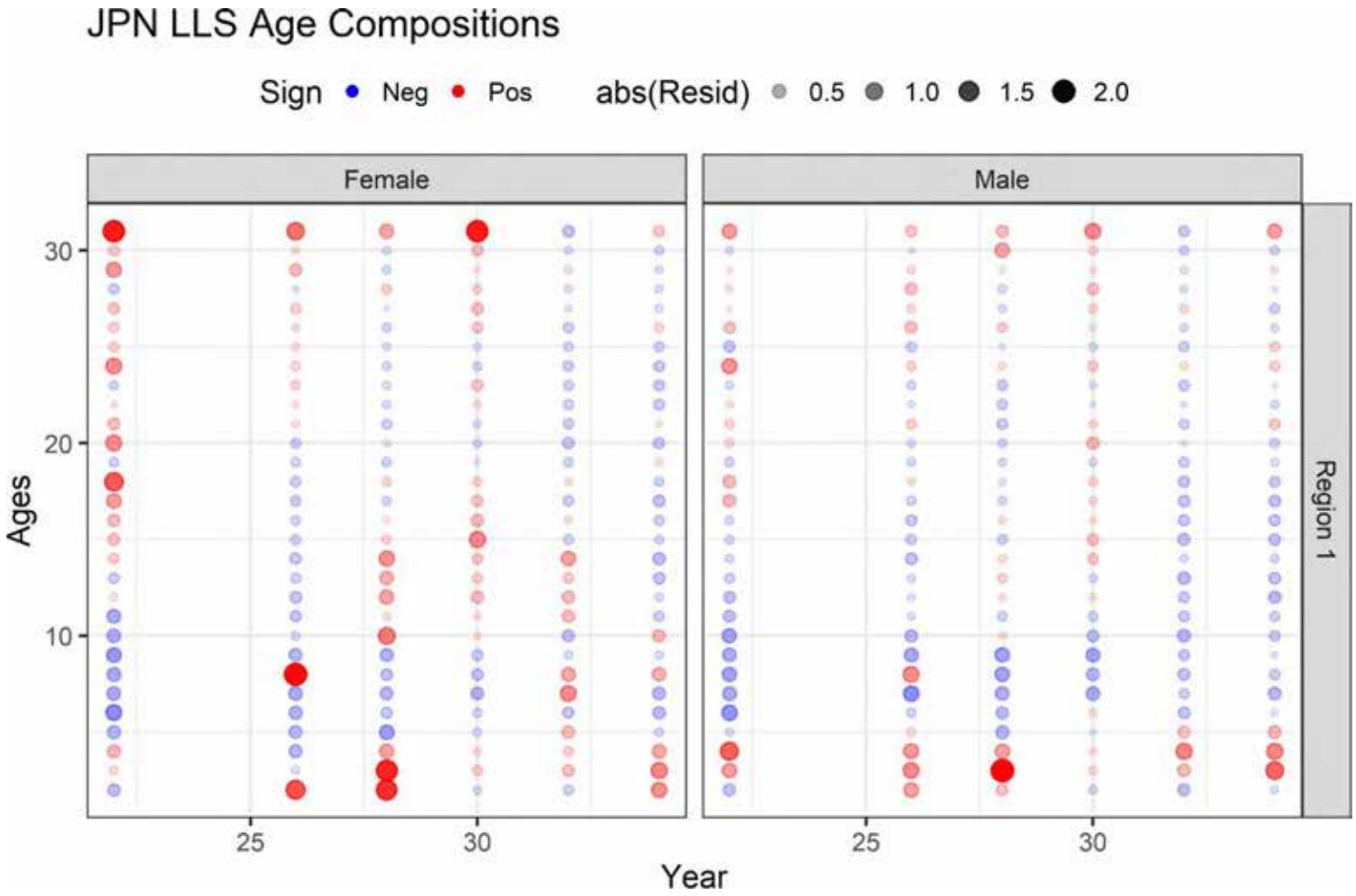

Figure SM3B.61. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for model *26.2_FAA.*

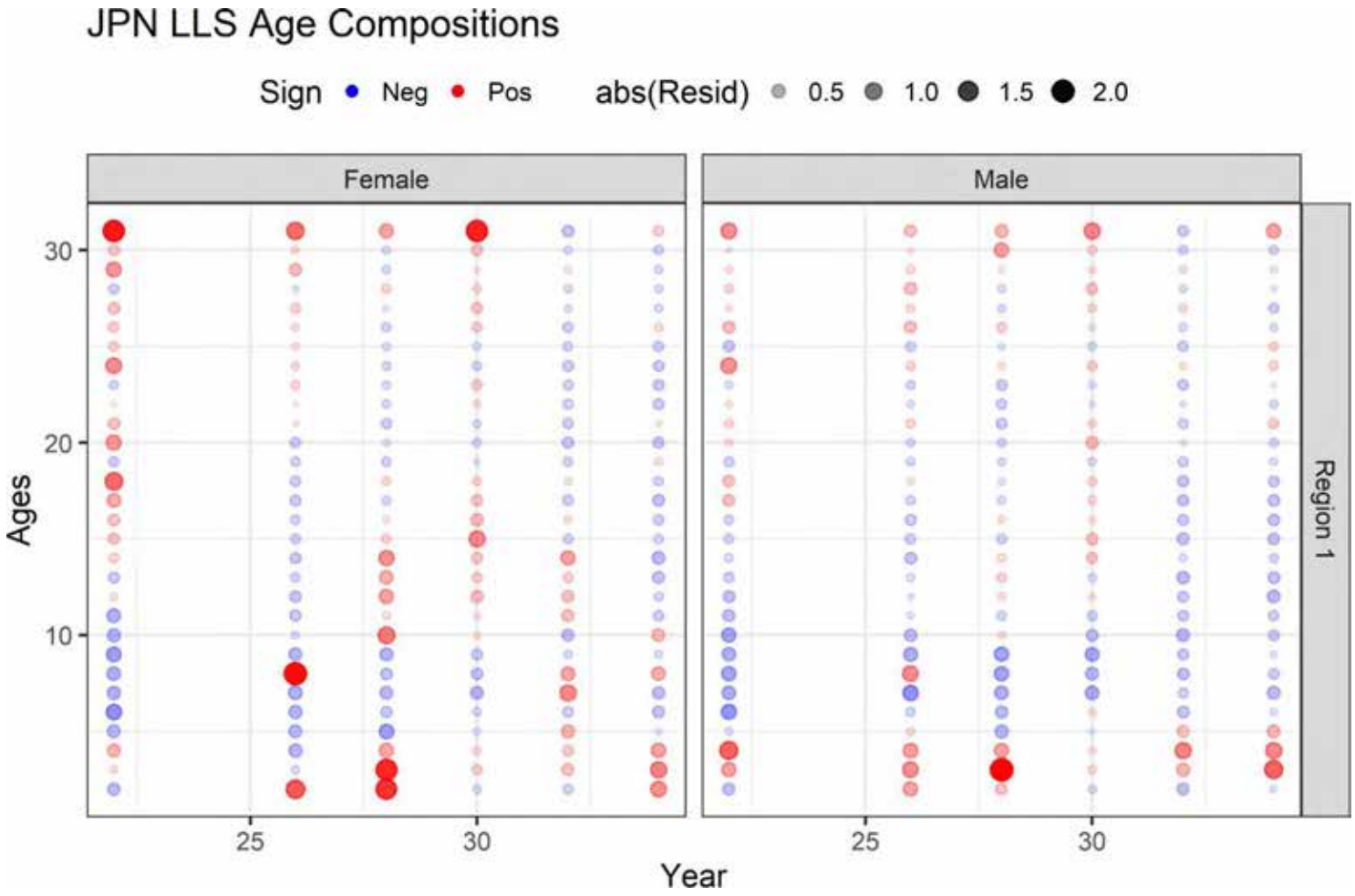

Figure SM3B.62. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for model *26.2a_FAA_Fsh+Srvy*.

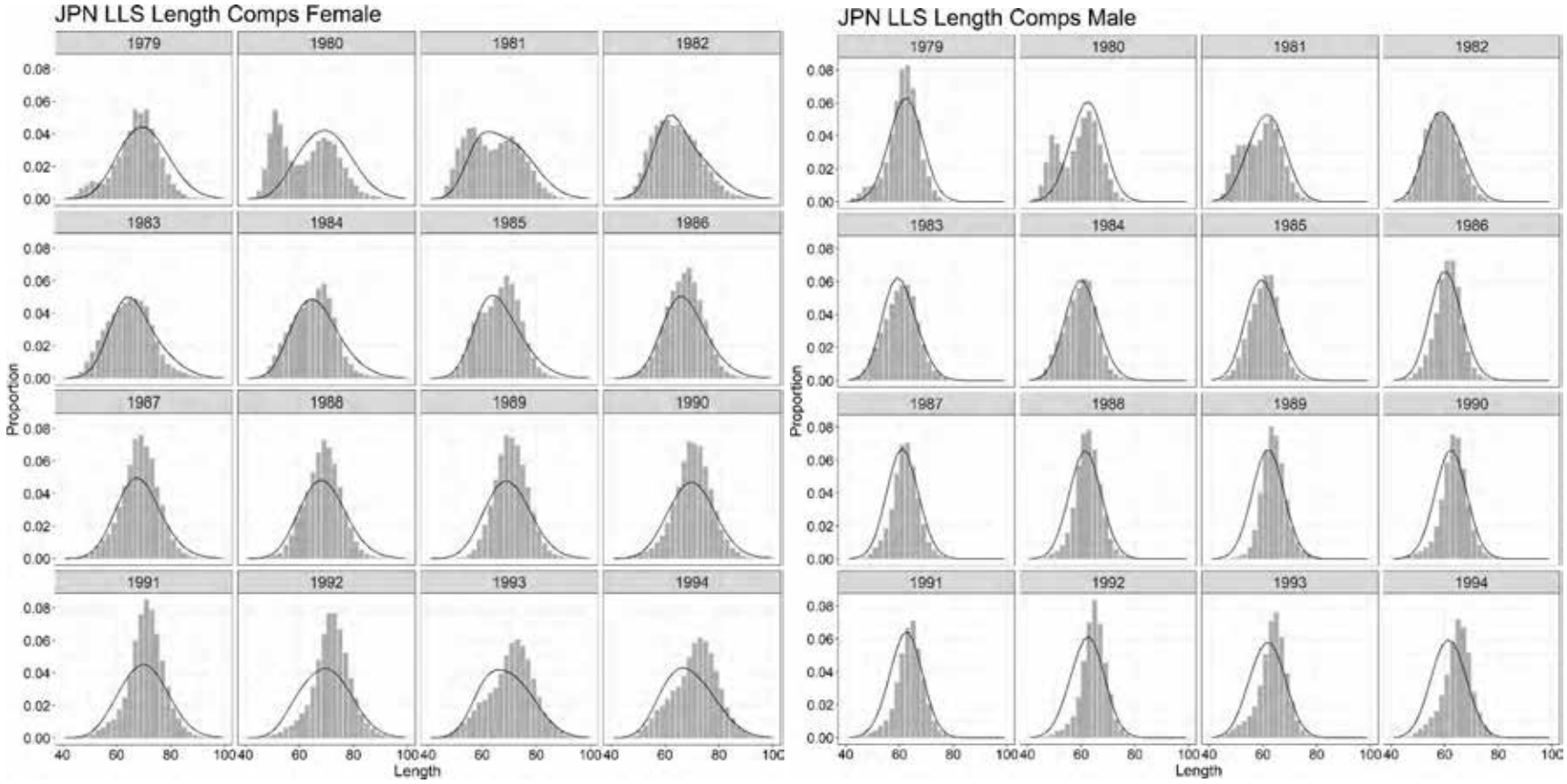

Figure SM3C.63. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.1 _1Reg*.

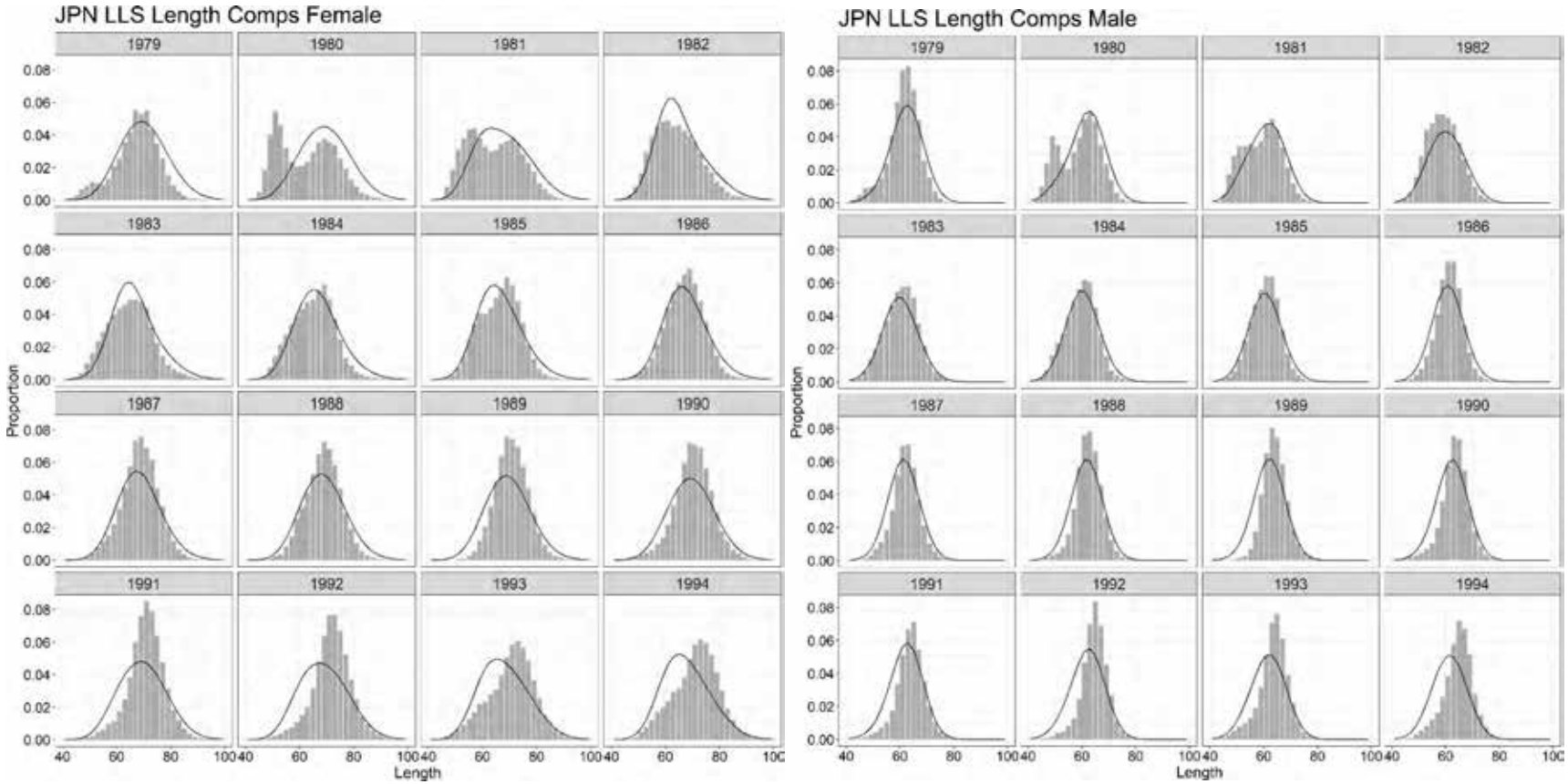

Figure SM3C.64. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.2 _FAA.*

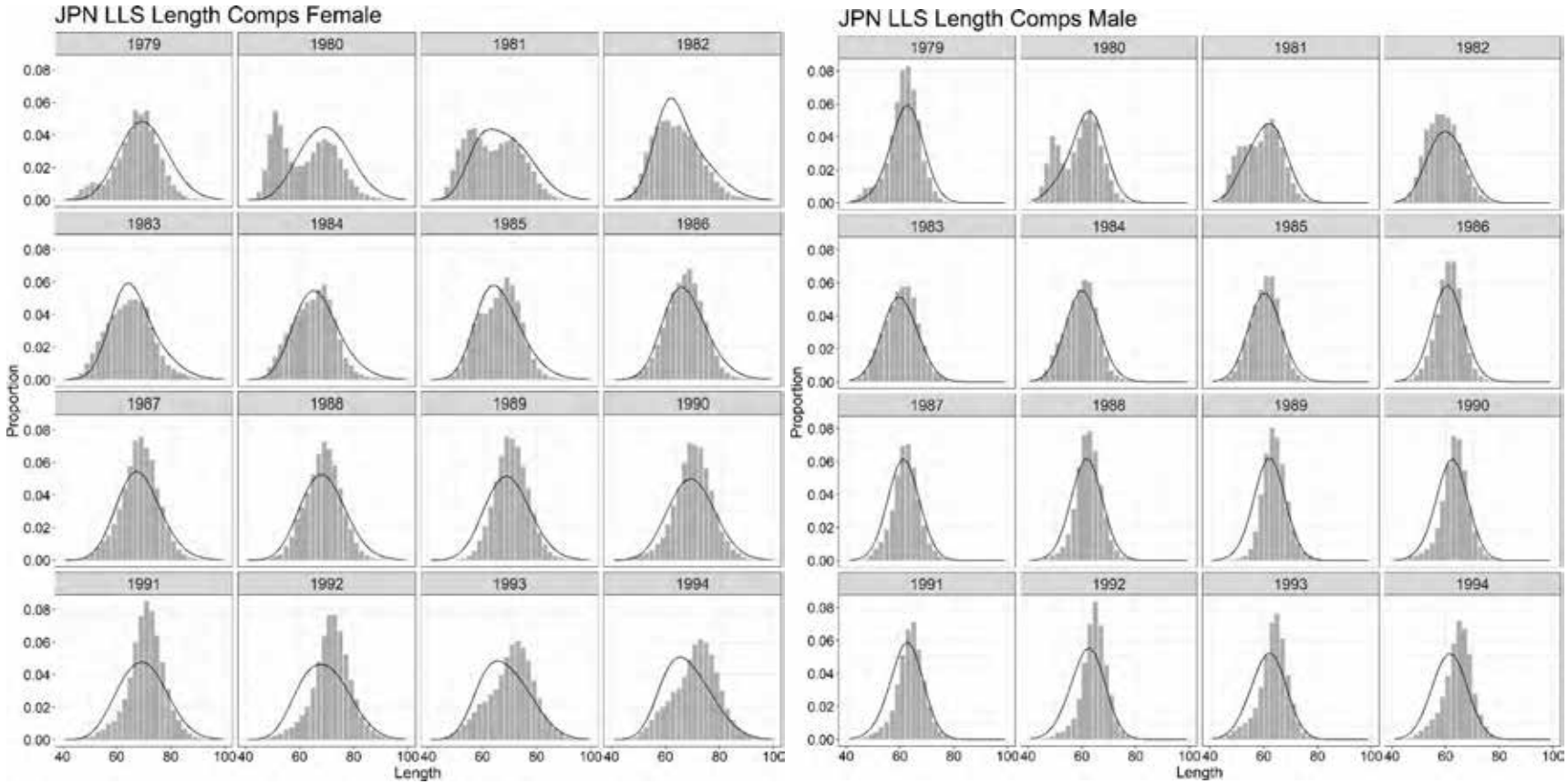

Figure SM3C.65. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.2a_FAA_Fsh+Srvy*.

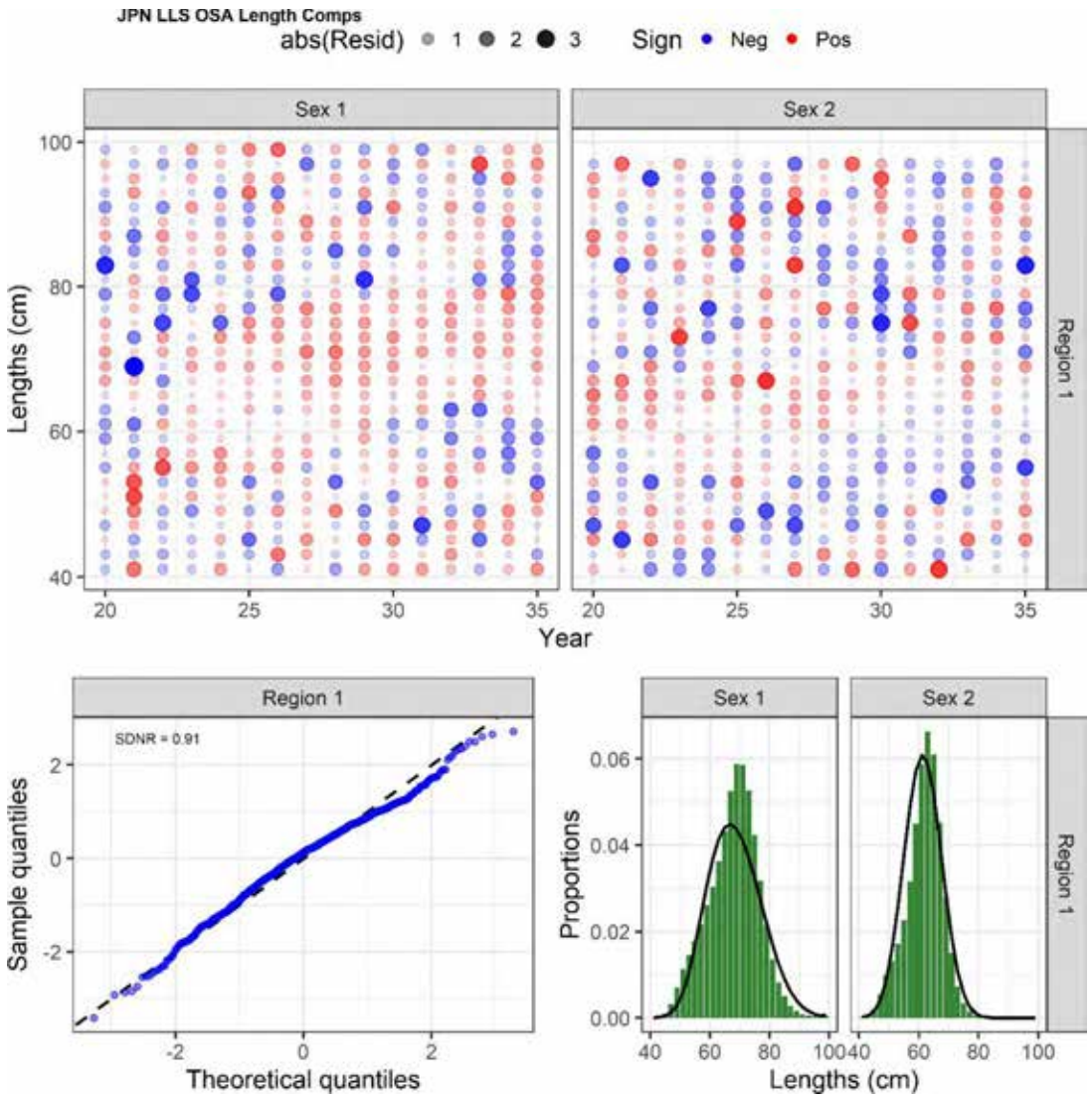

Figure SM3C.66. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

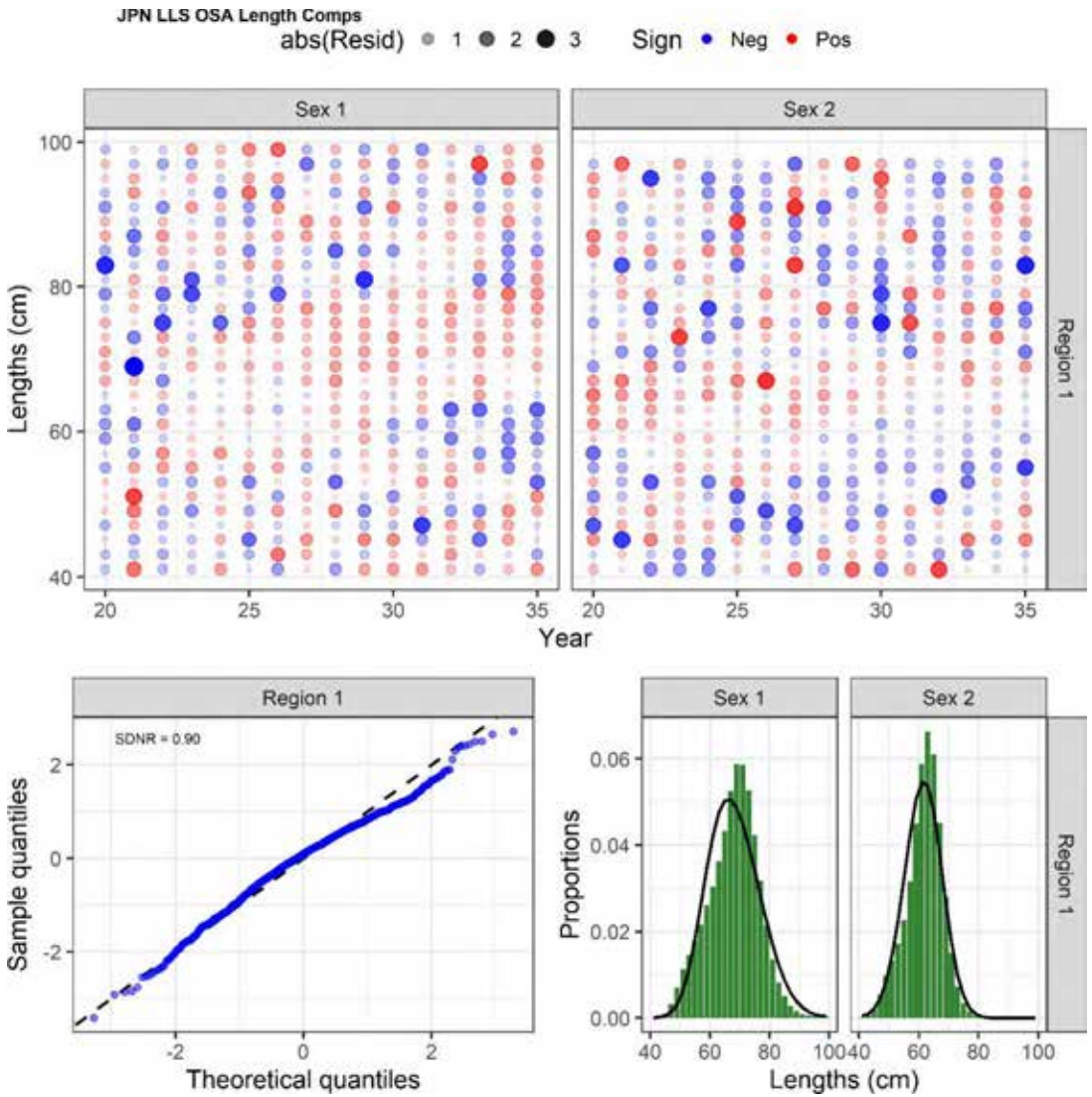

Figure SM3C.67. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

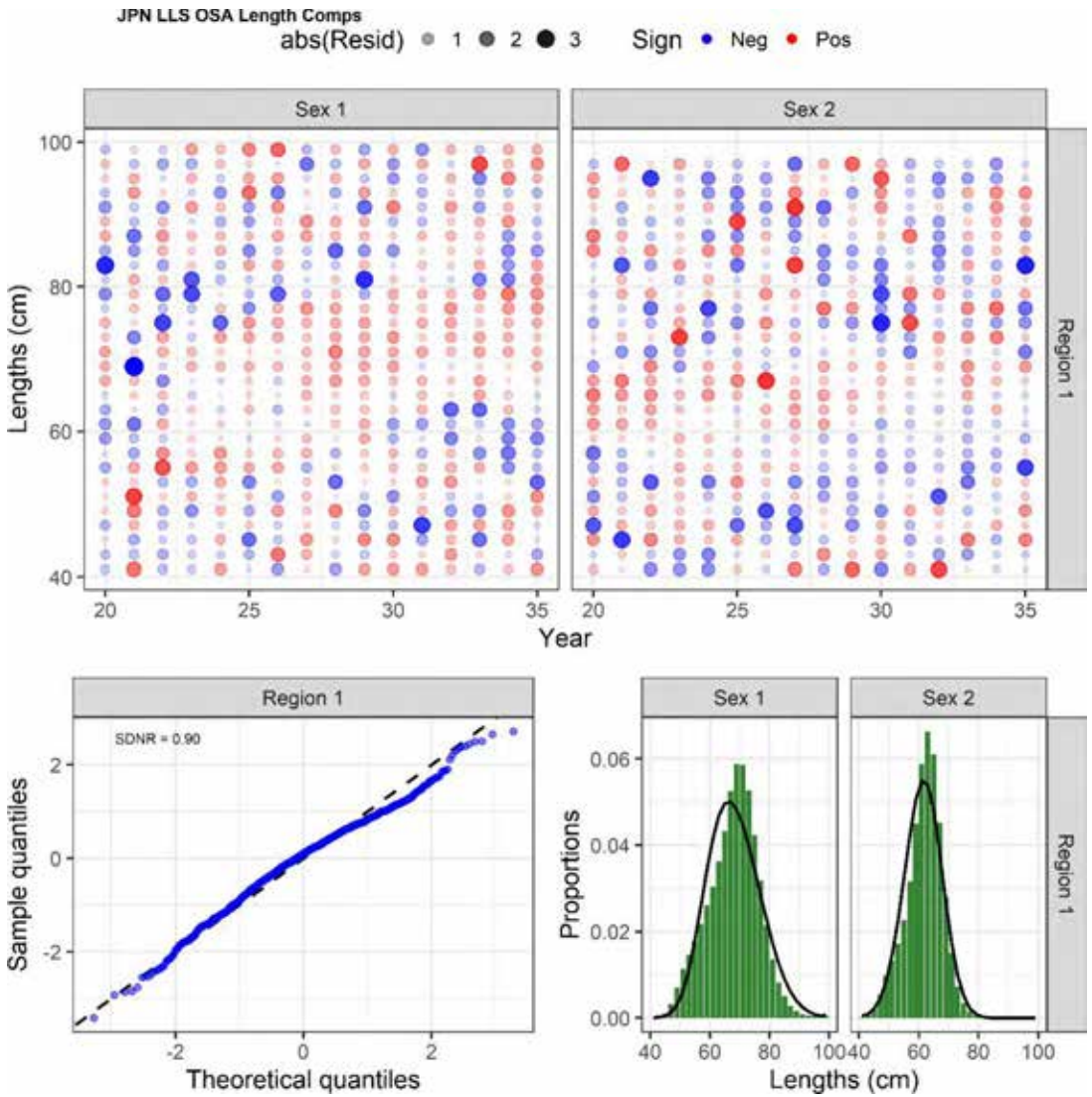

Figure SM3C.68. Fits to Japanese longline survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

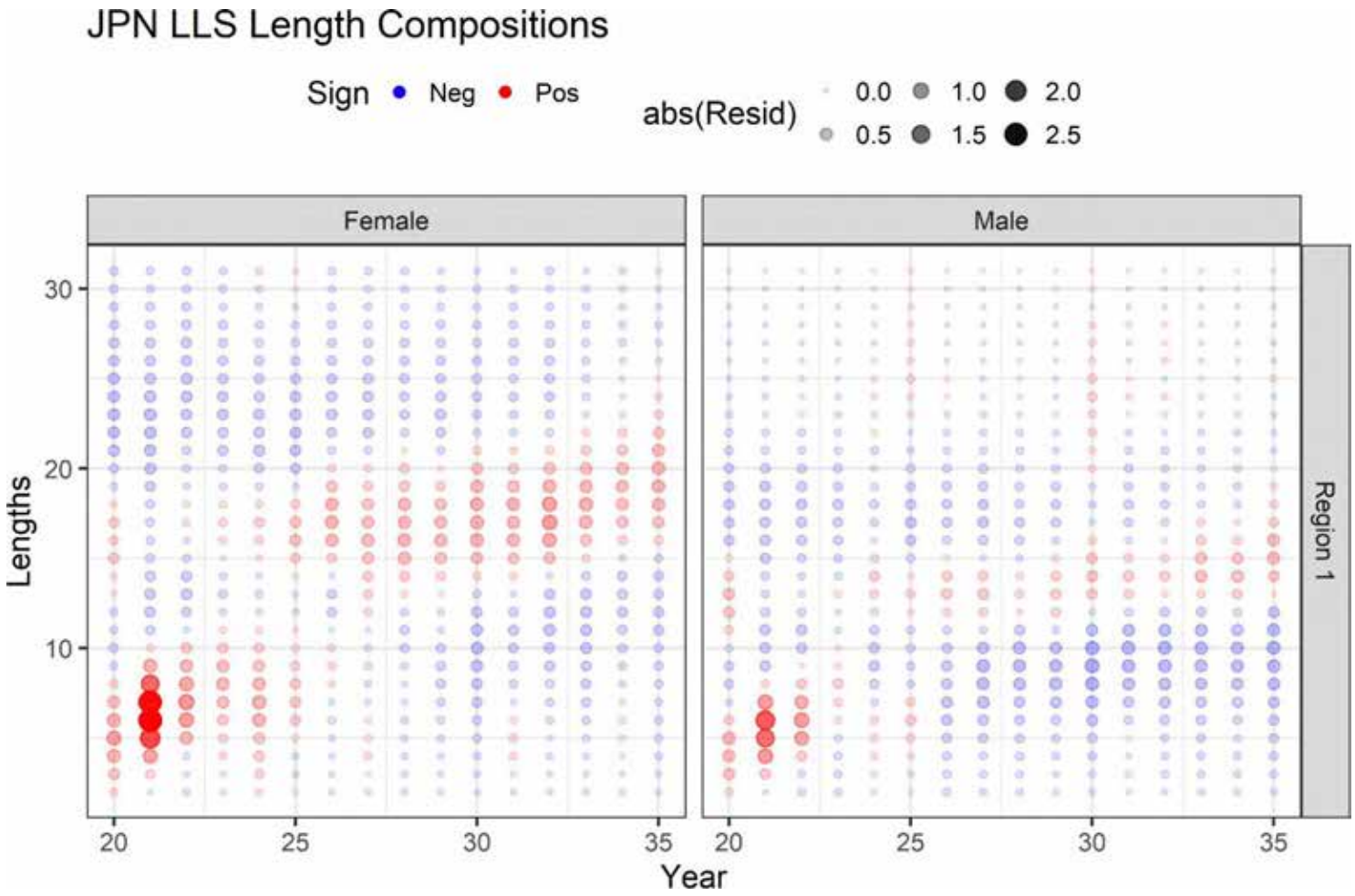

Figure SM3C.69. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.1_1Reg*.

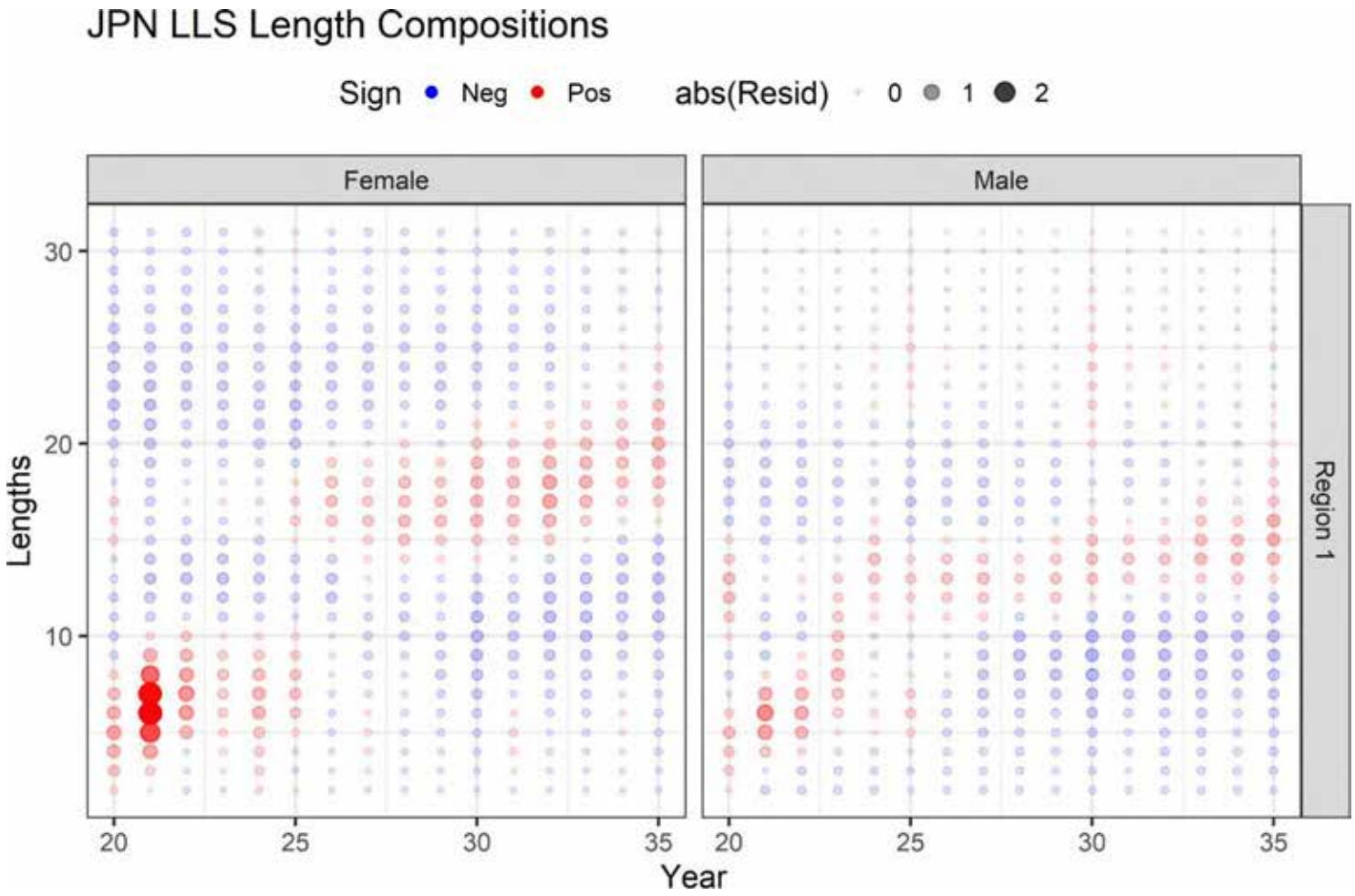

Figure SM3C.70. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.2_FAA*.

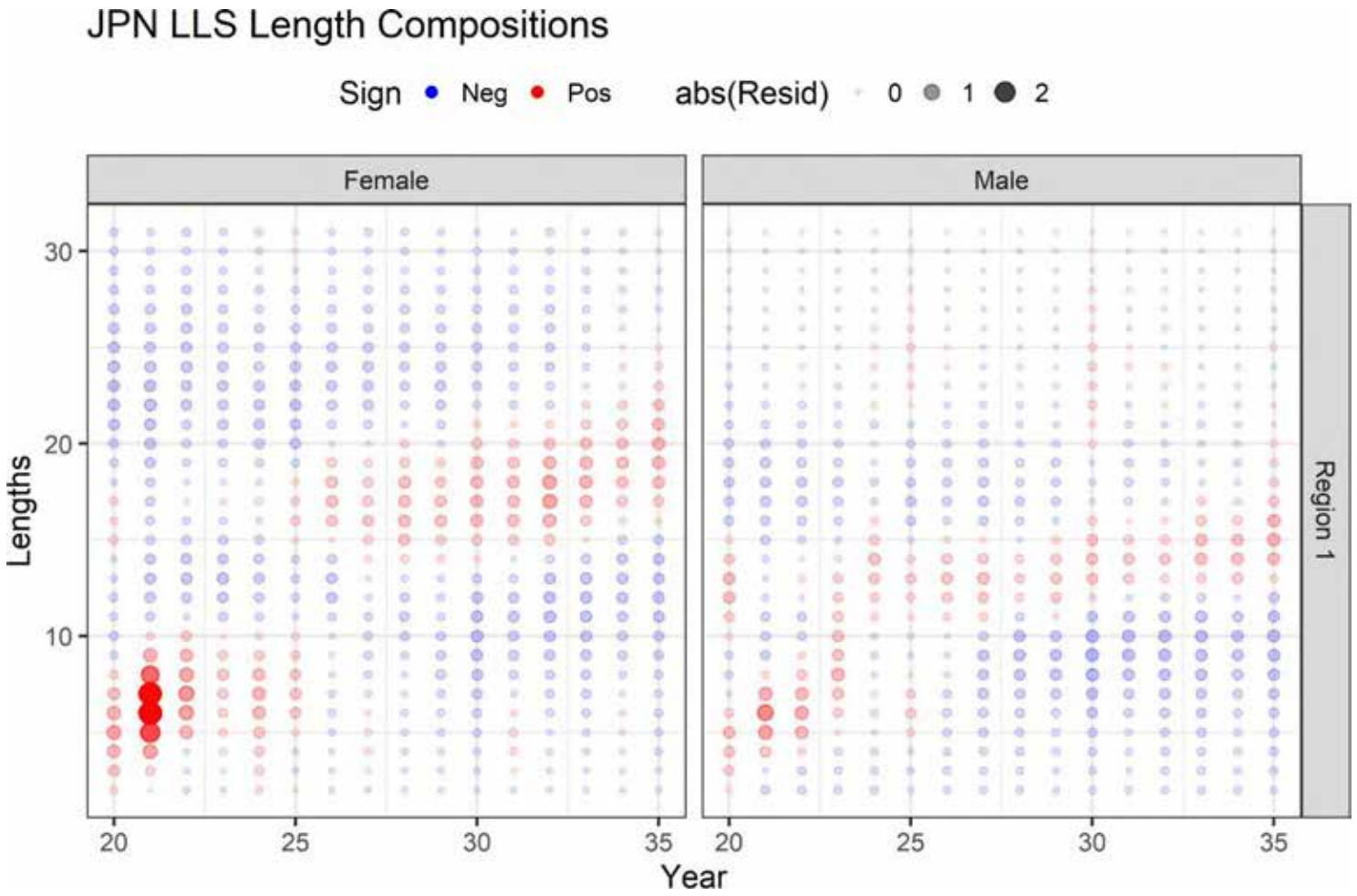

Figure SM3C.71. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.2a_FAA_Fsh+Srvy*.

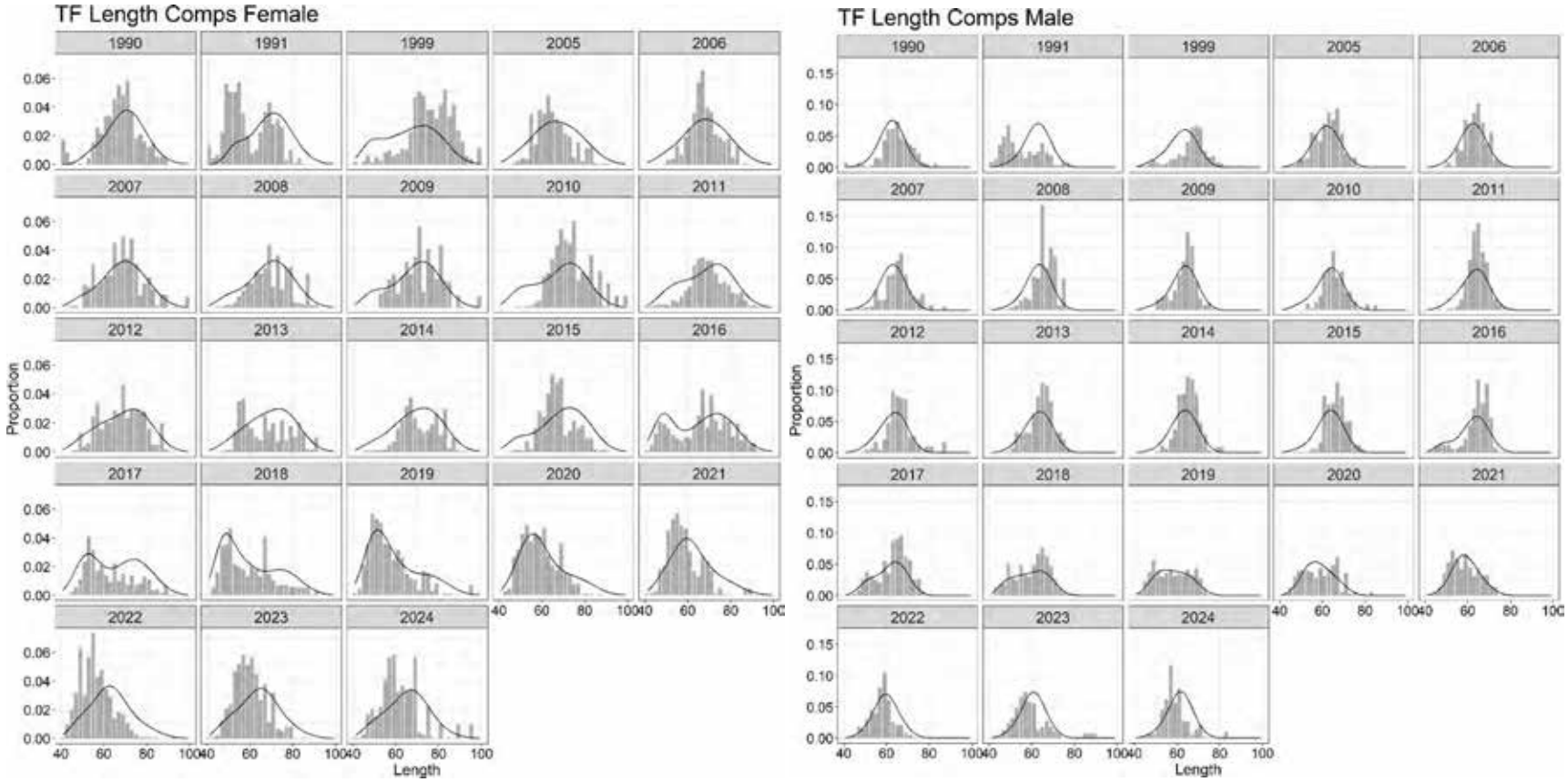

Figure SM3C.72. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

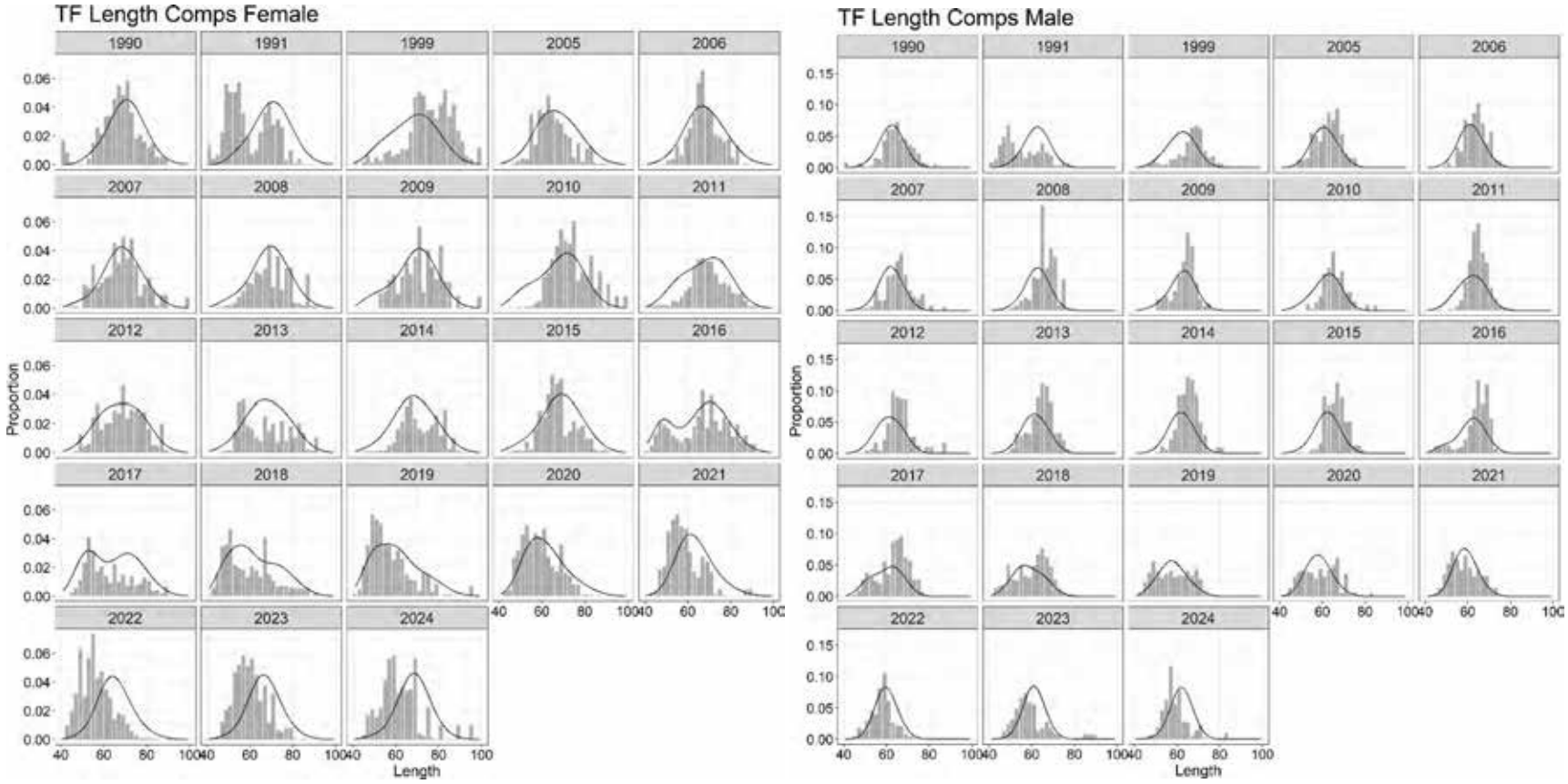

Figure SM3C.73. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.2_FAA*.

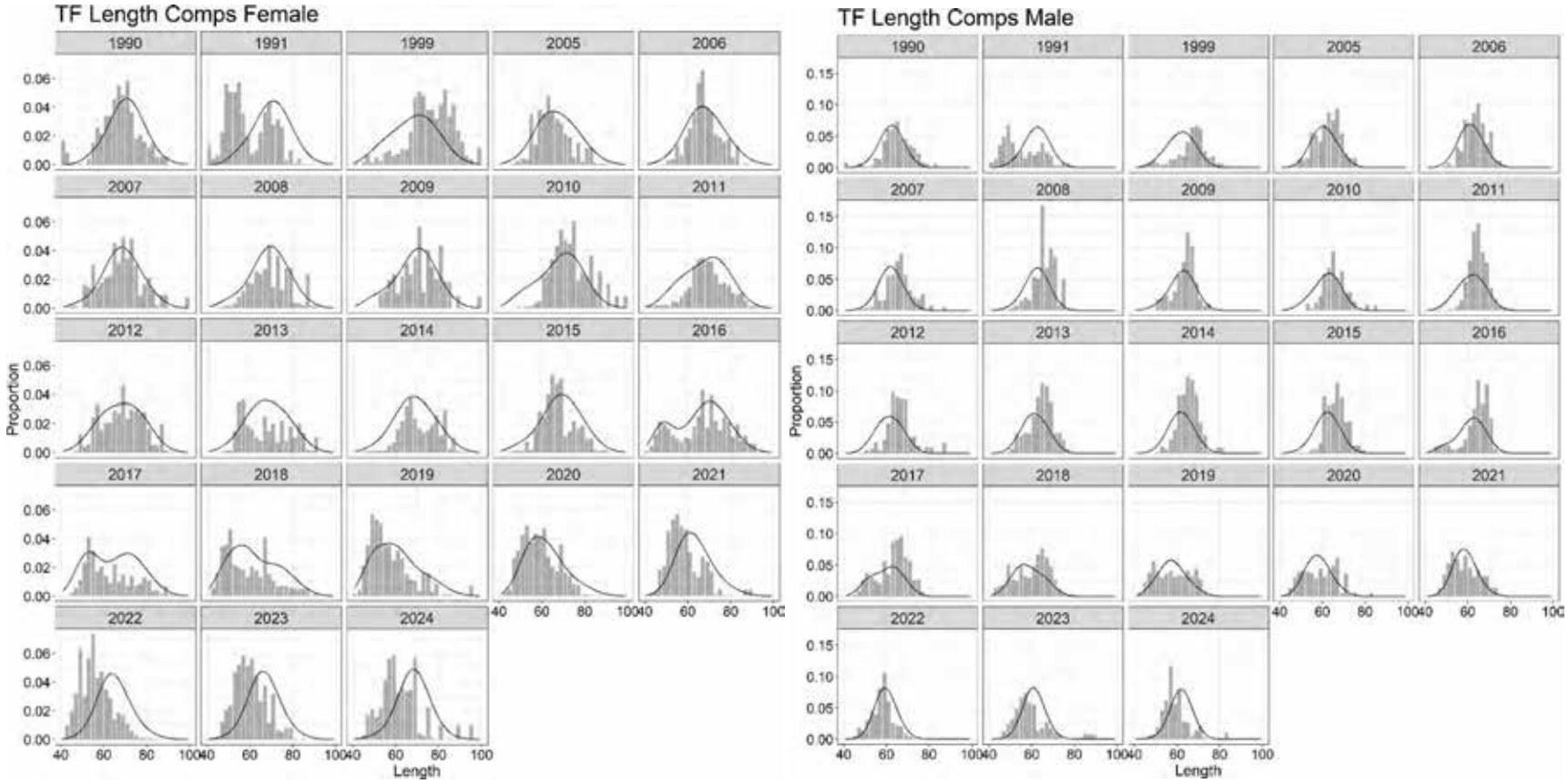

Figure SM3C.74. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.2a_FAA_Fsh+Srvy*.

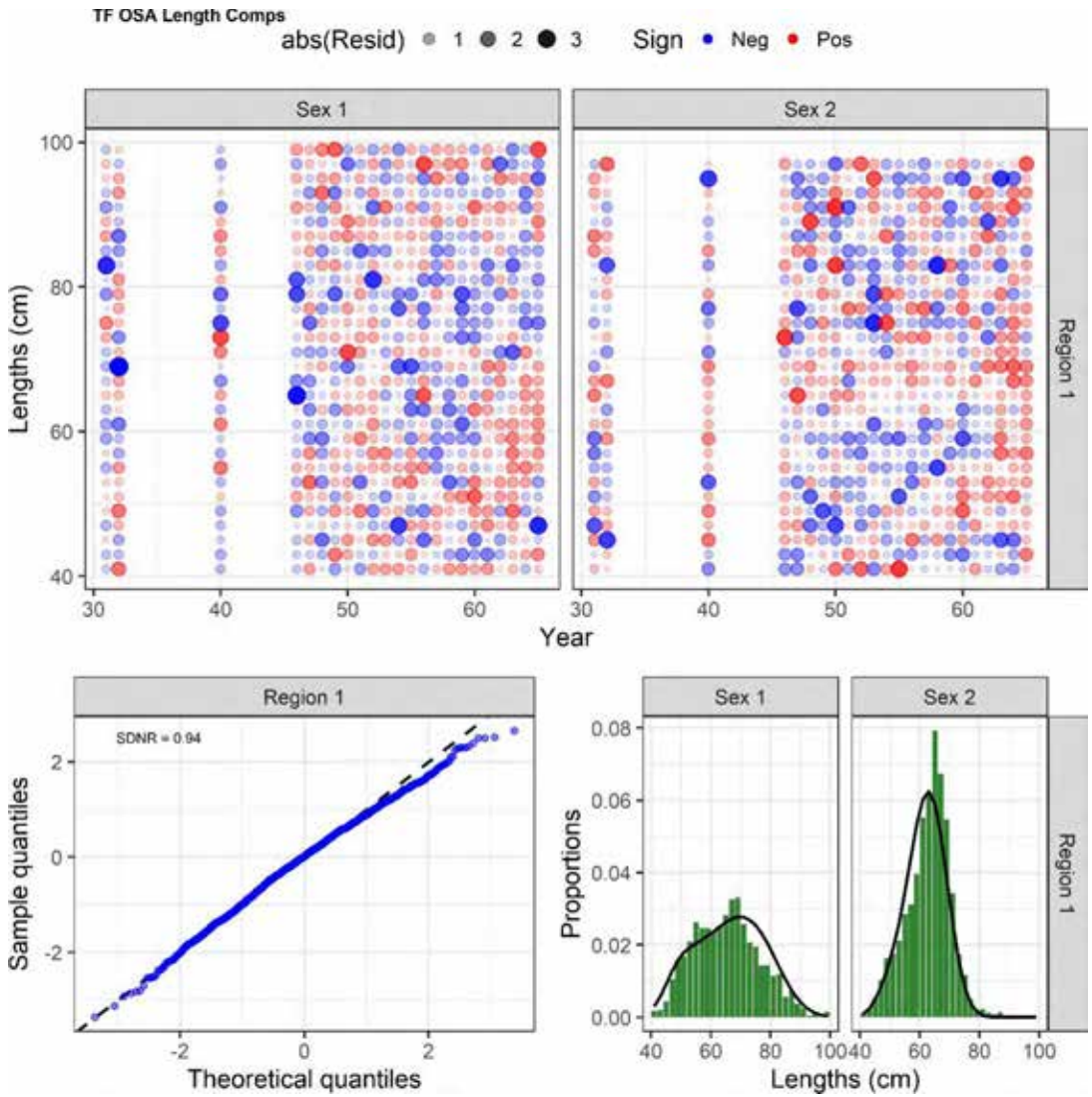

Figure SM3C.75. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

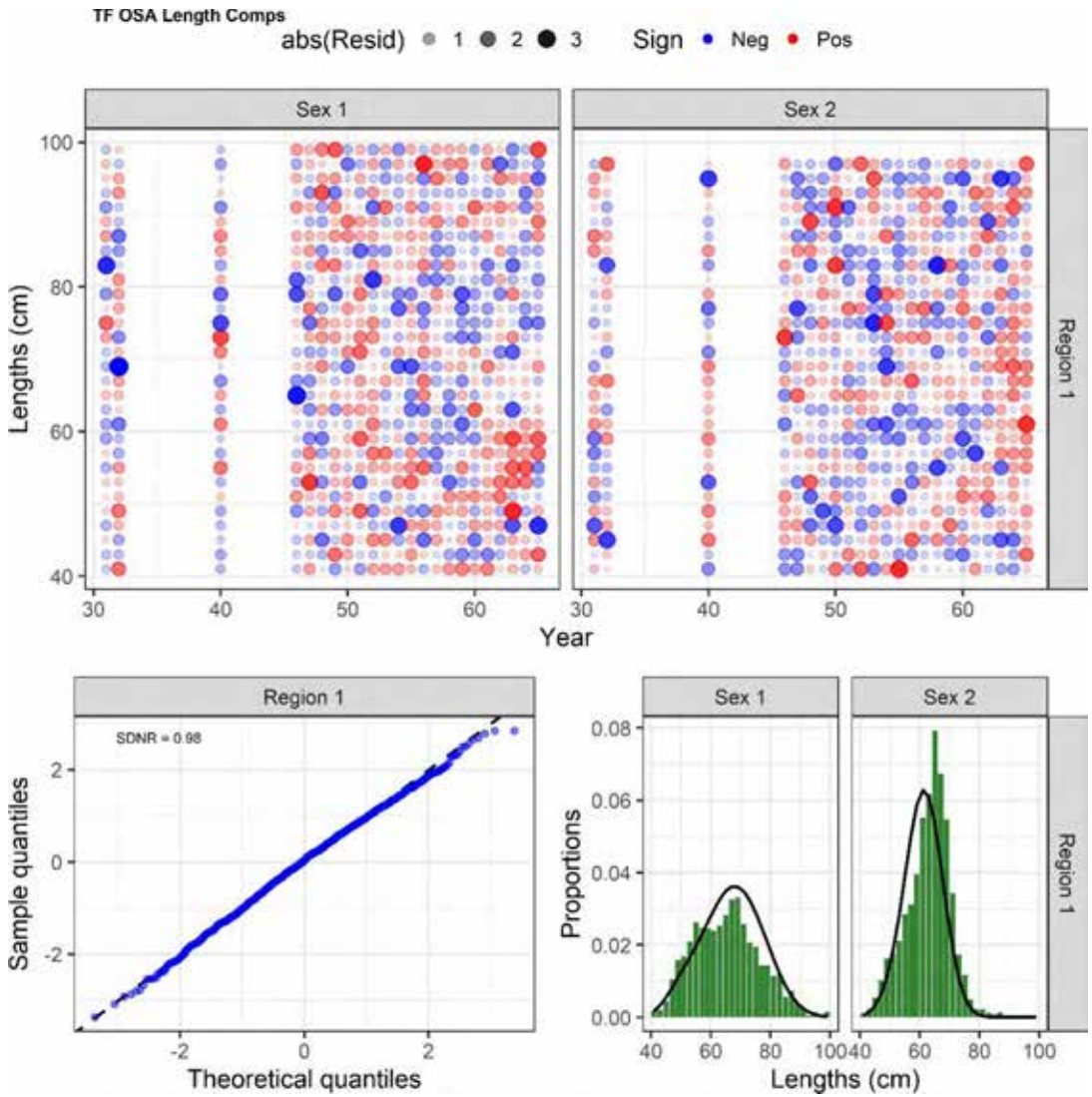

Figure SM3C.76. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

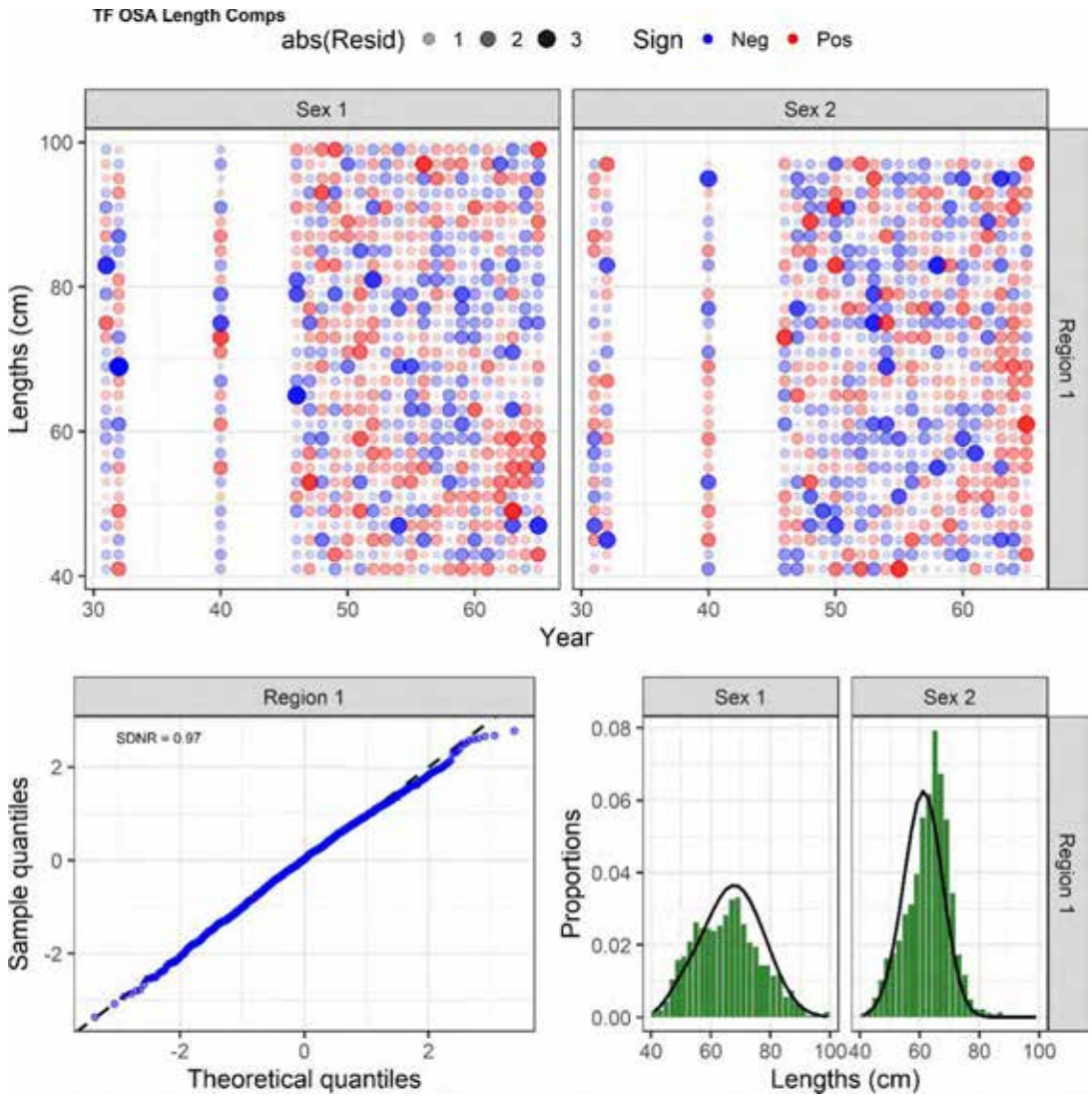

Figure SM3C.77. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2a_FAA_Fsh+Srvy*.

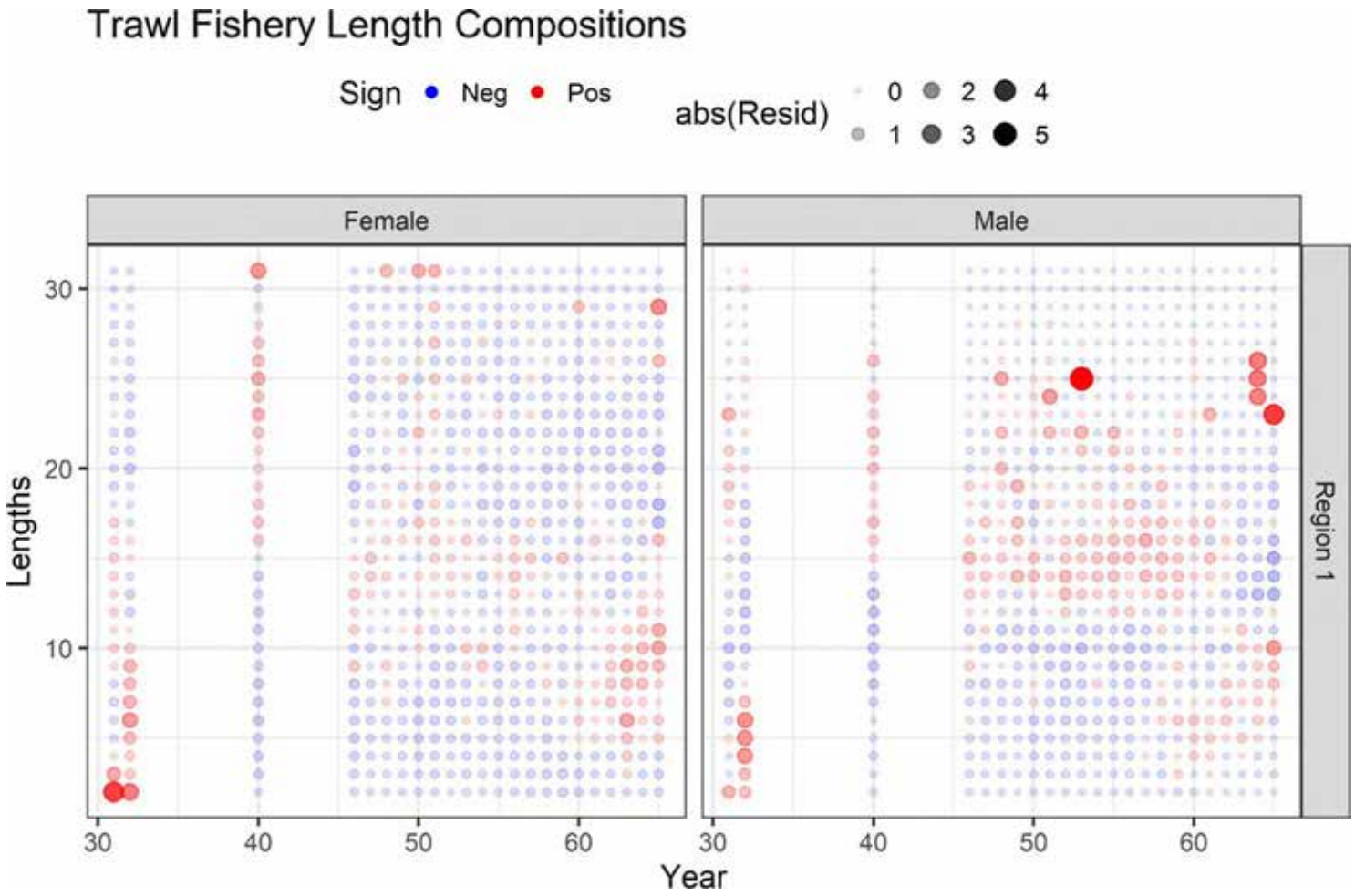

Figure SM3C.78. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.1_1Reg*.

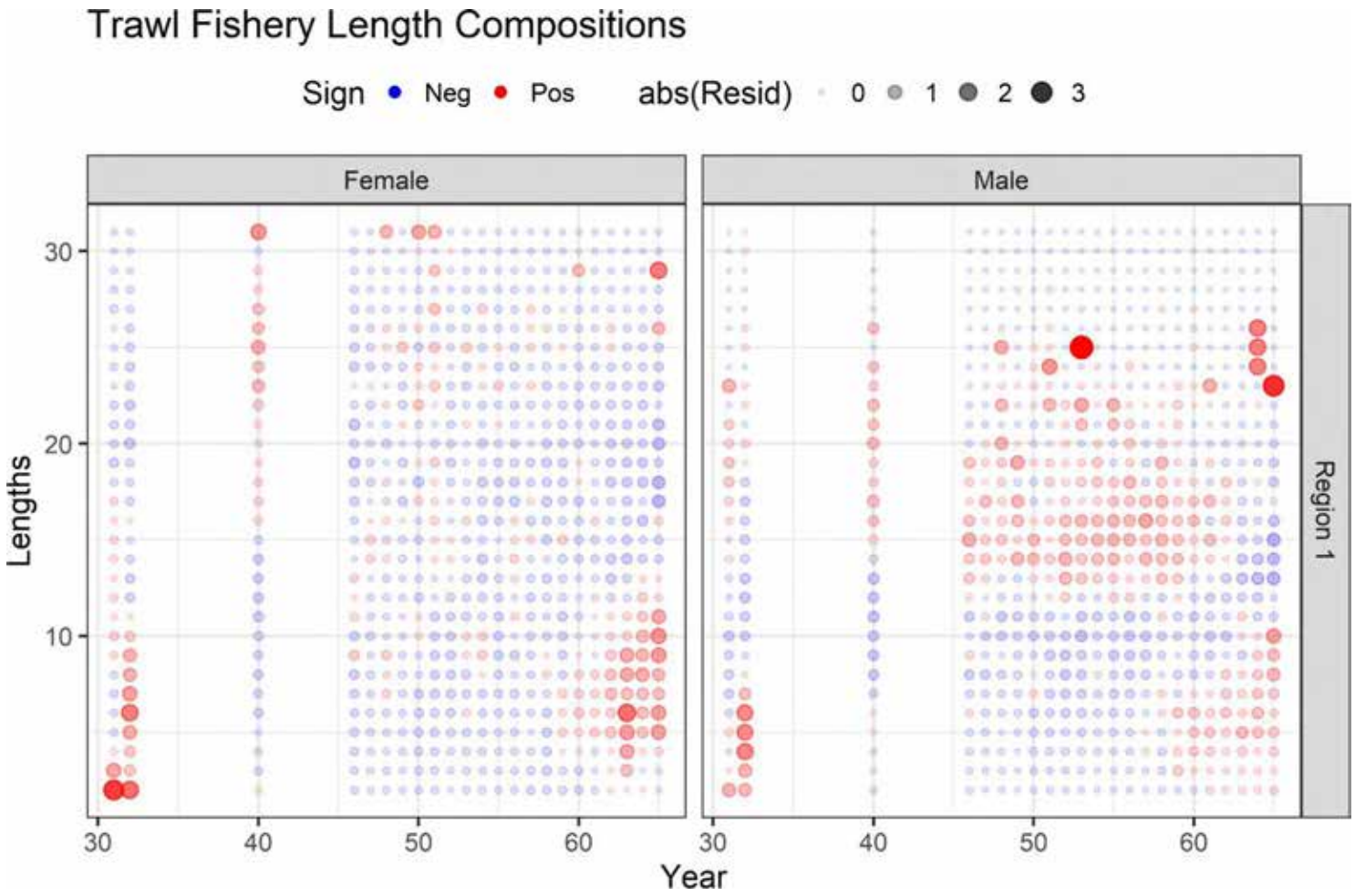

Figure SM3C.79. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.2_FAA*.

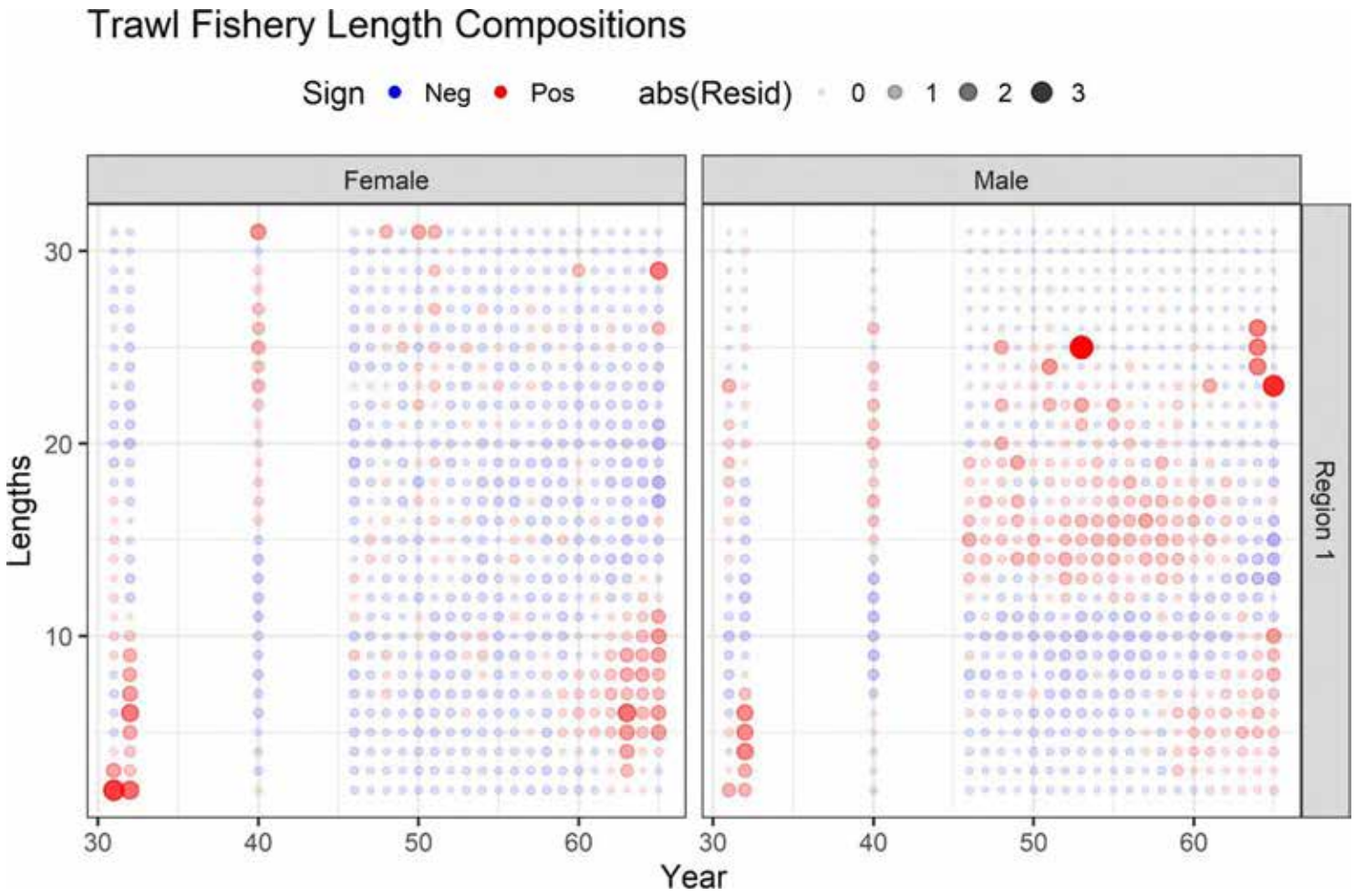

Figure SM3C.80. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.2a_FAA_Fsh+Srvy*.

Figure SM3C.81. Time series estimates of total biomass (kt) for each model.

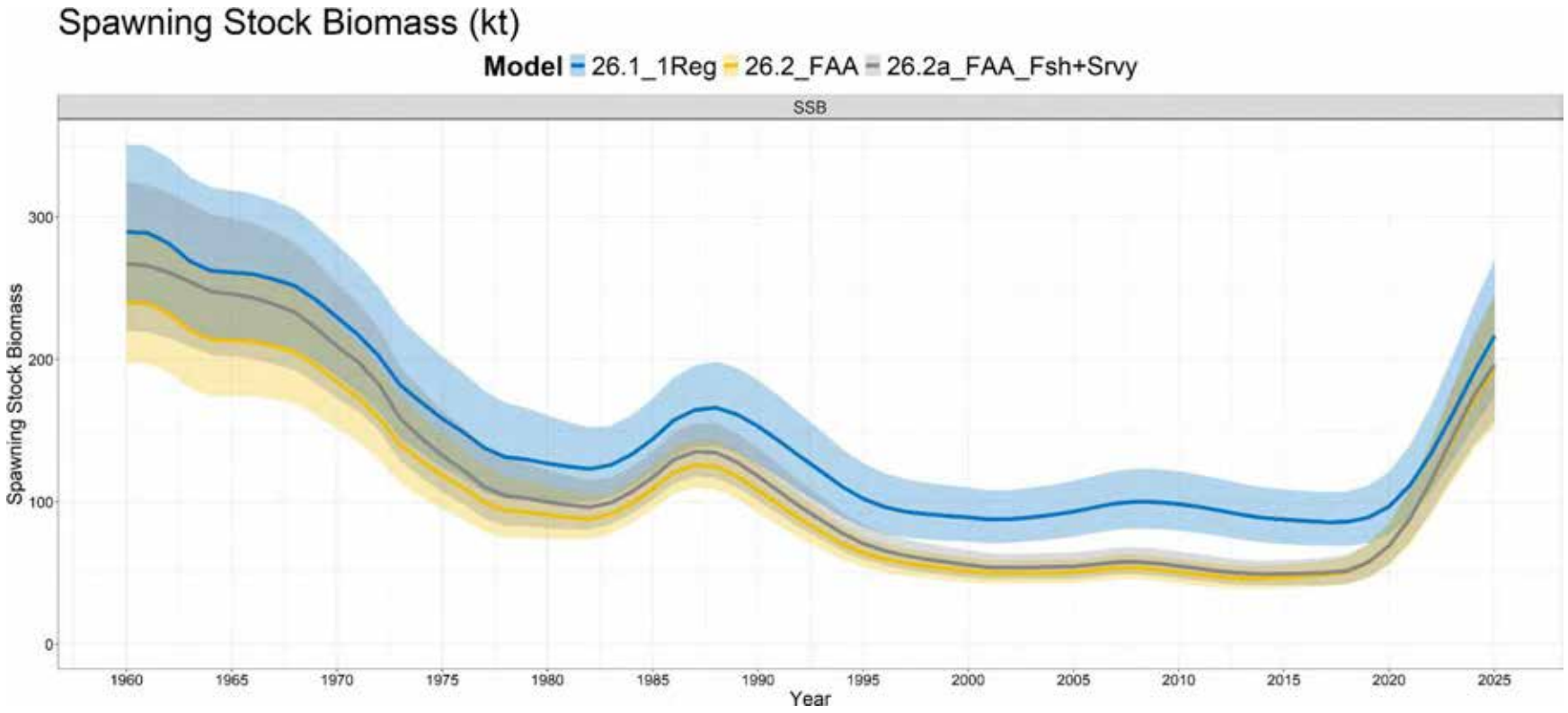

Figure SM3C.82. Time series estimates of spawning stock biomass (kt) for each model.

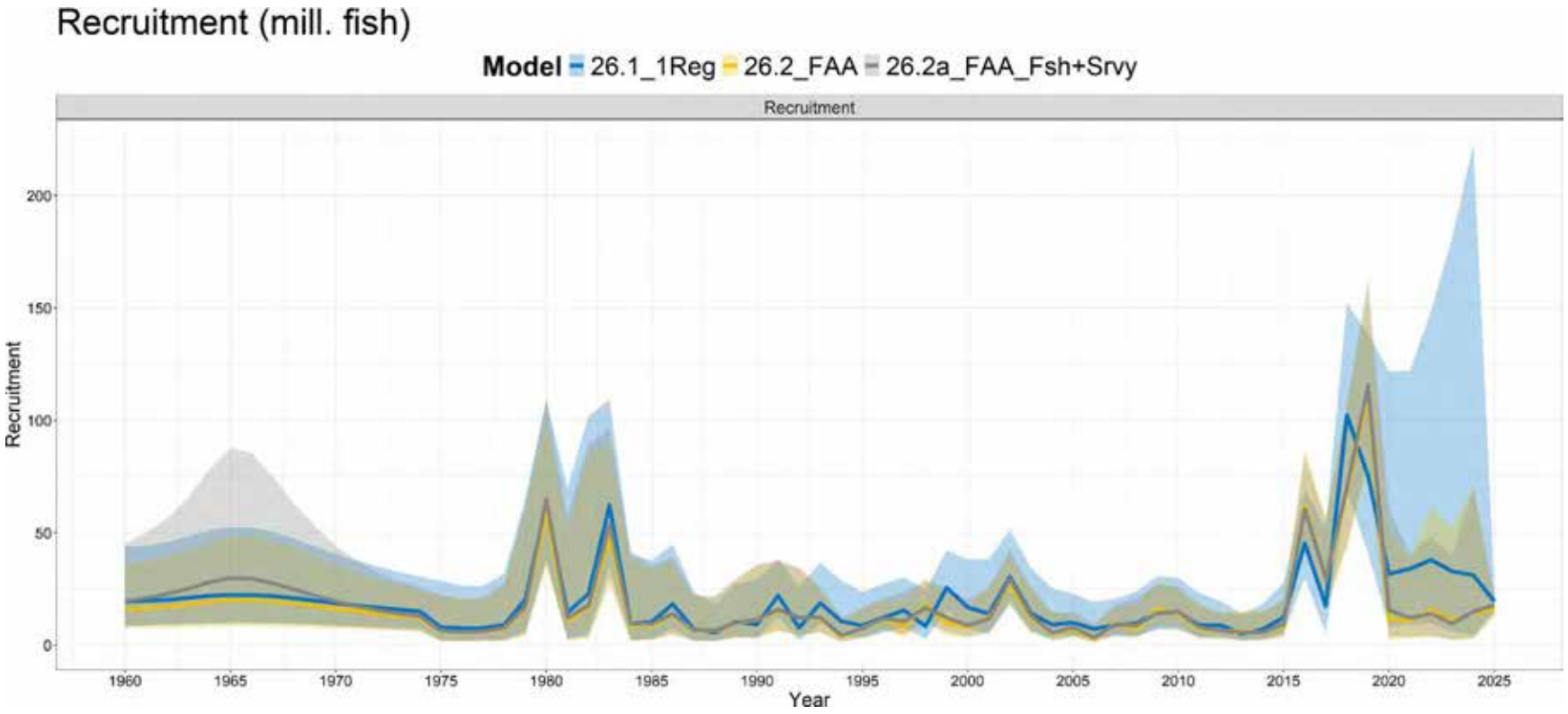

Figure SM3C.83. Time series estimates of recruitment (millions of fish) for each model.

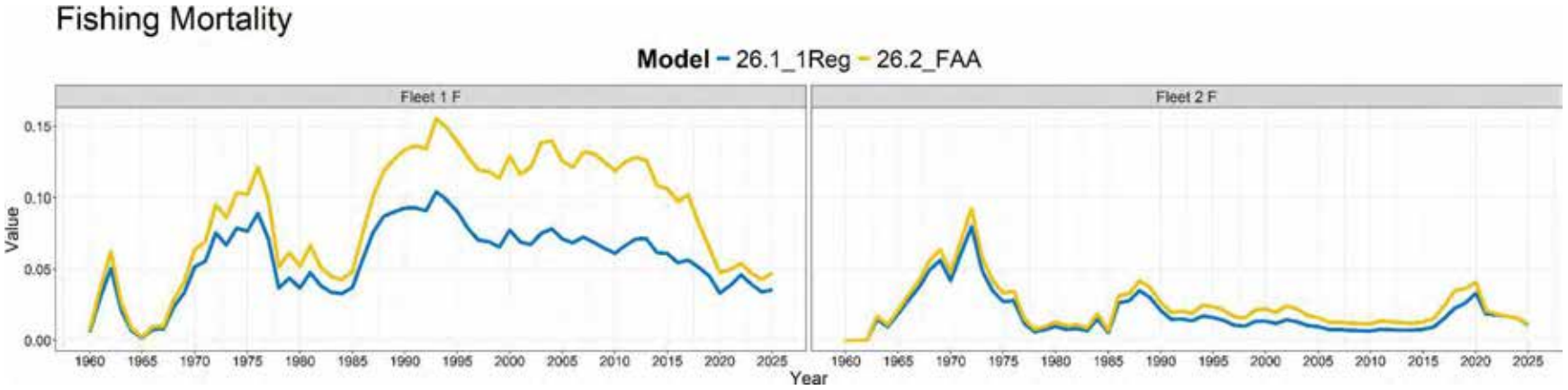

Figure SM3C.84. Time series estimates of fishing mortality (yr^{-1}) for Model *26.1_1Reg* and Model *26.2_FAA*. Fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery.

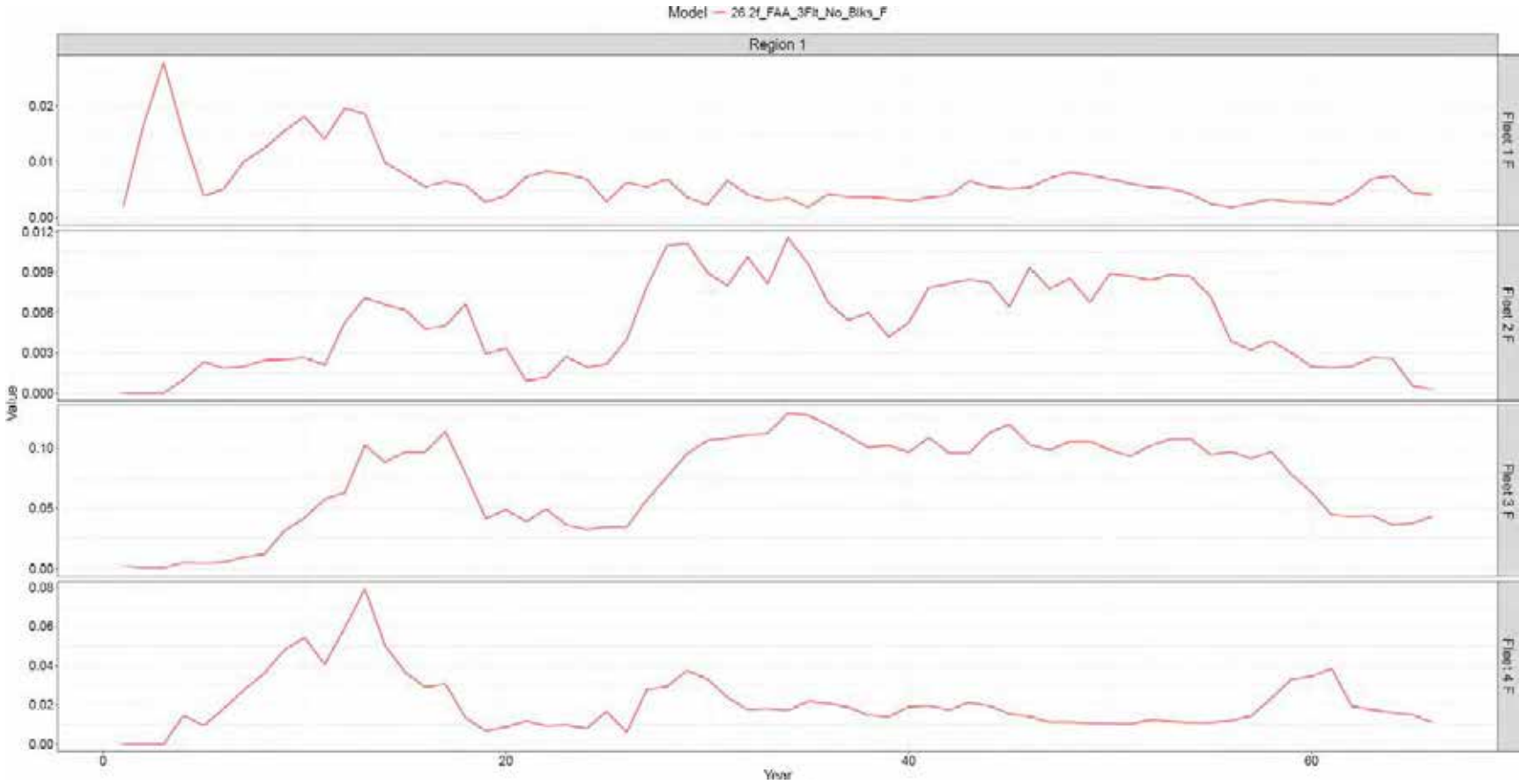

Figure SM3C.85. Time series estimates of fishing mortality (yr^{-1}) for Model *26.2a_FAA_Fsh+Srvy*. Fishery Fleet 1 is the BS fixed gear fleet, Fishery Fleet 2 is the AI fixed gear fleet, Fishery Fleet 3 is the GOA fixed gear fleet, and Fishery Fleet 4 is the trawl fleet. Note the difference in y-axis scales. Year 1 is 1960.

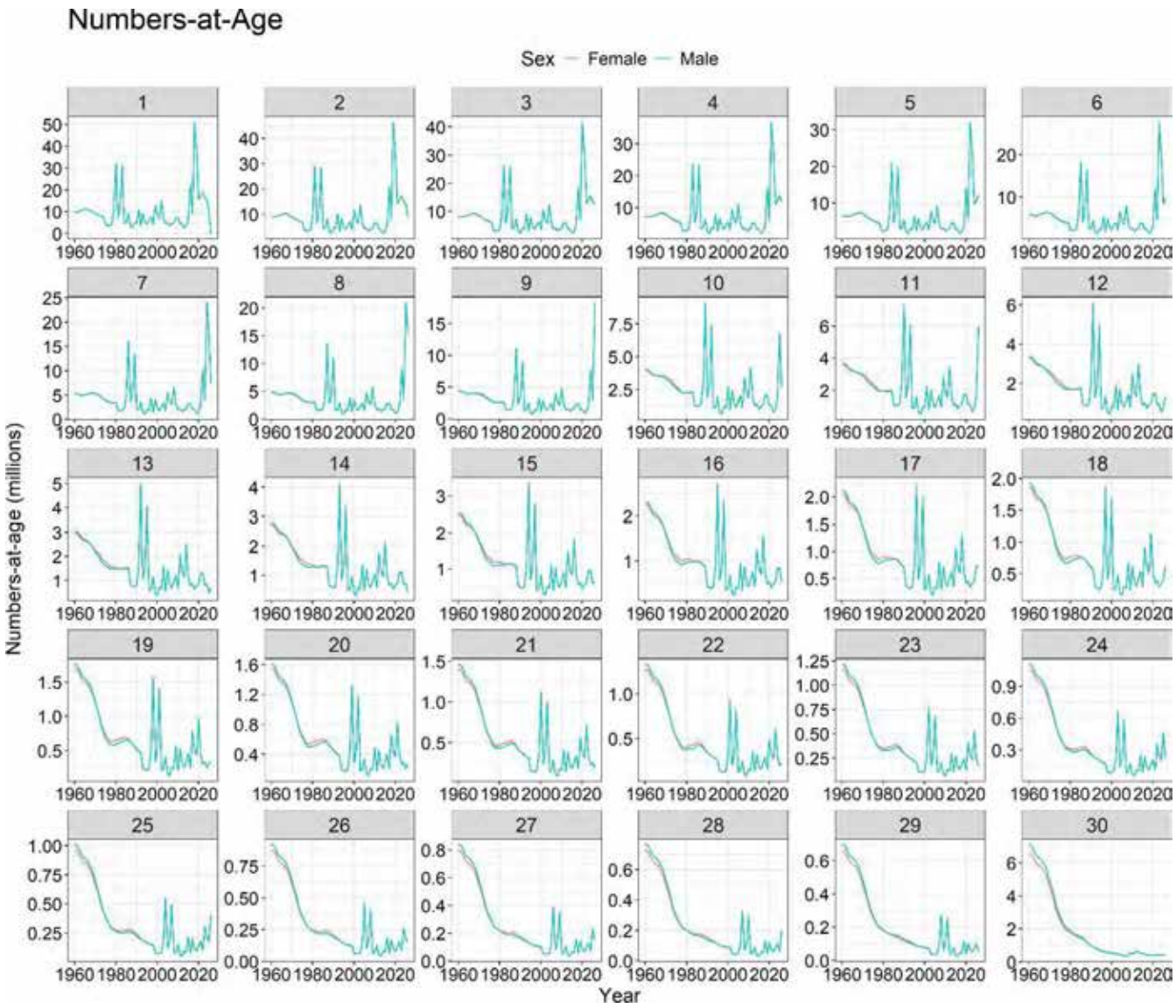

Figure SM3C.86. Time series estimates of numbers-at-age (millions of fish) by sex for model *26.1_1Reg*.

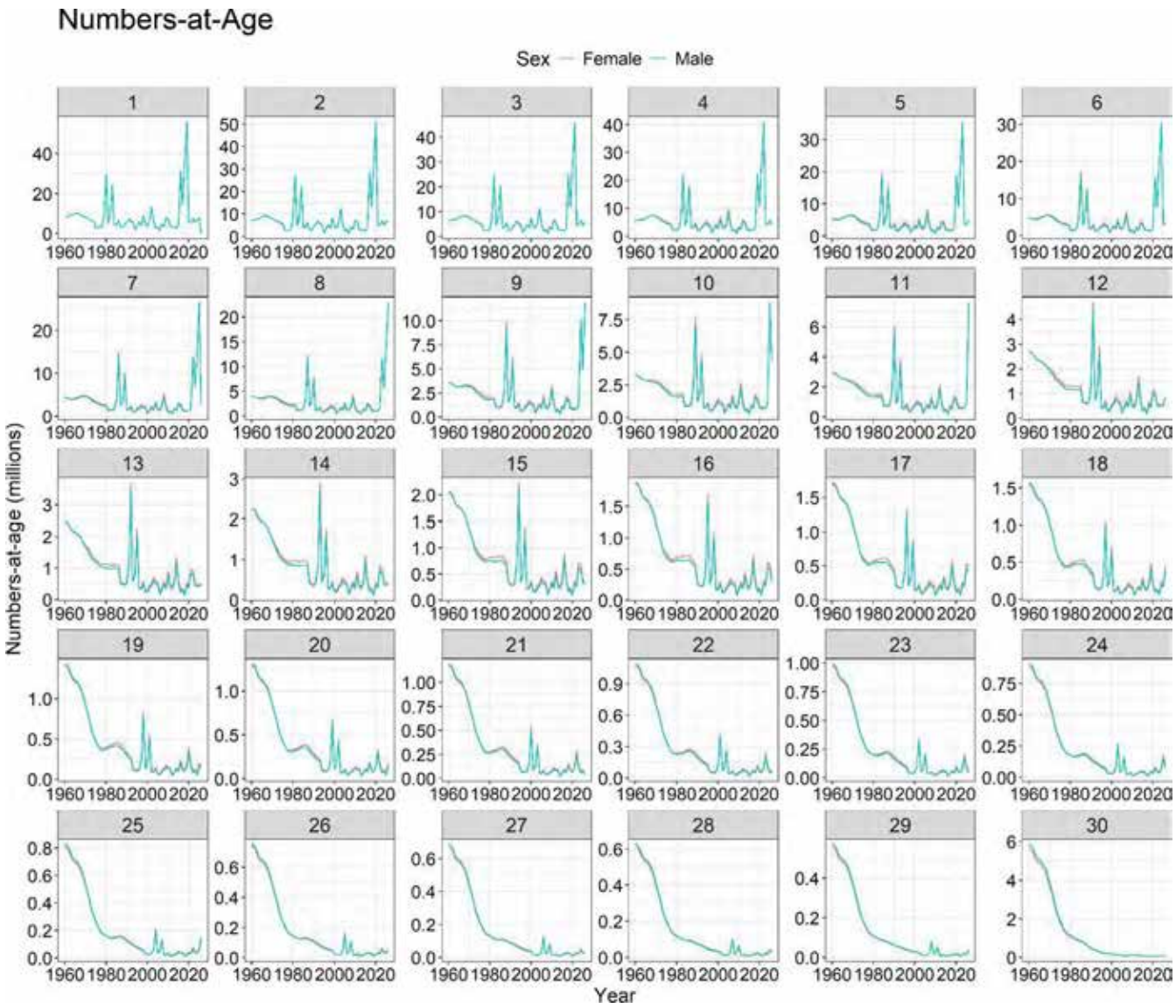

Figure SM3C.87. Time series estimates of numbers-at-age (millions of fish) by sex for model *26.2_FAA*.

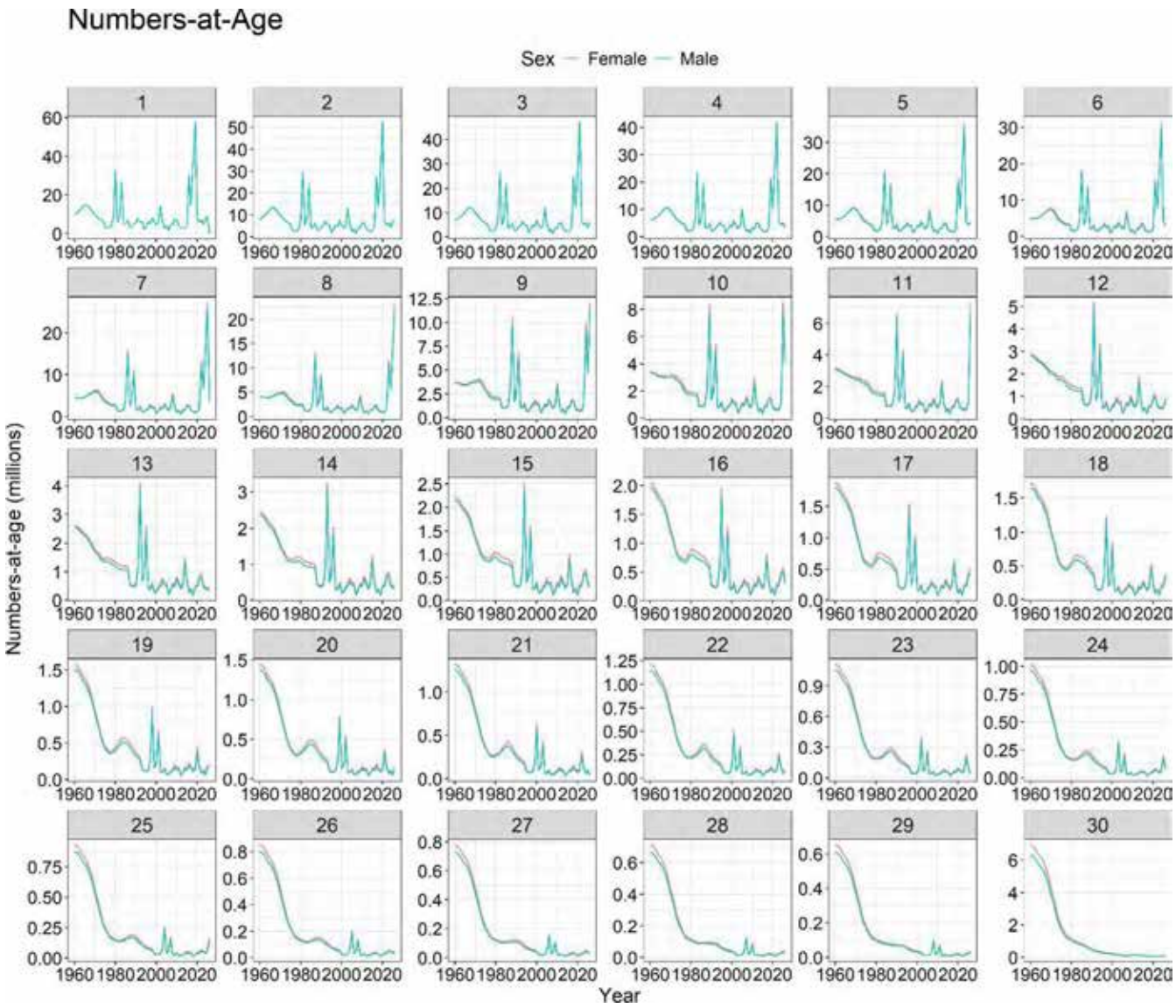

Figure SM3C.88. Time series estimates of numbers-at-age (millions of fish) by sex for model *26.2a_FAA_Fsh+Srvy*.

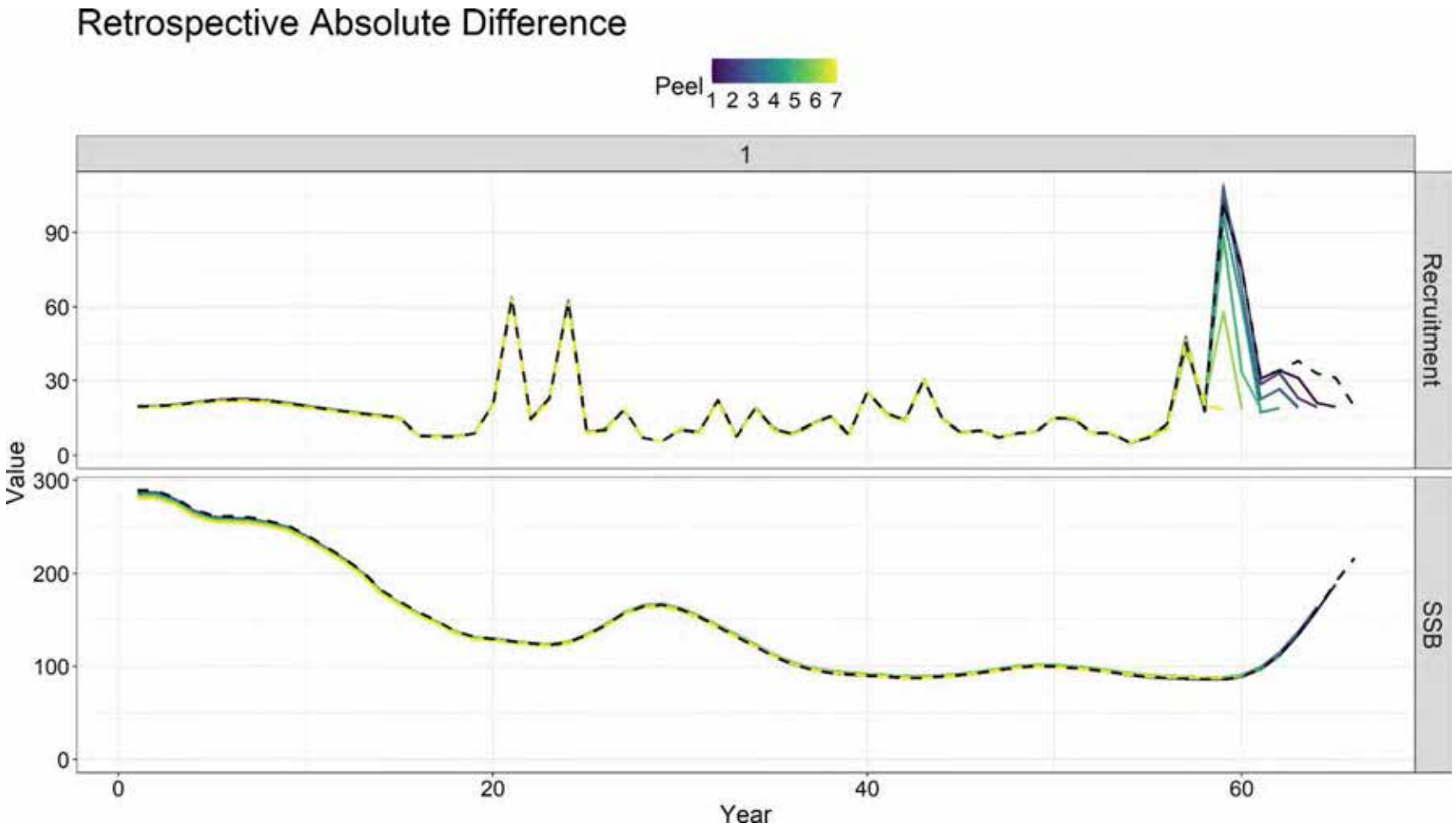

Figure SM3C.89. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.0054.

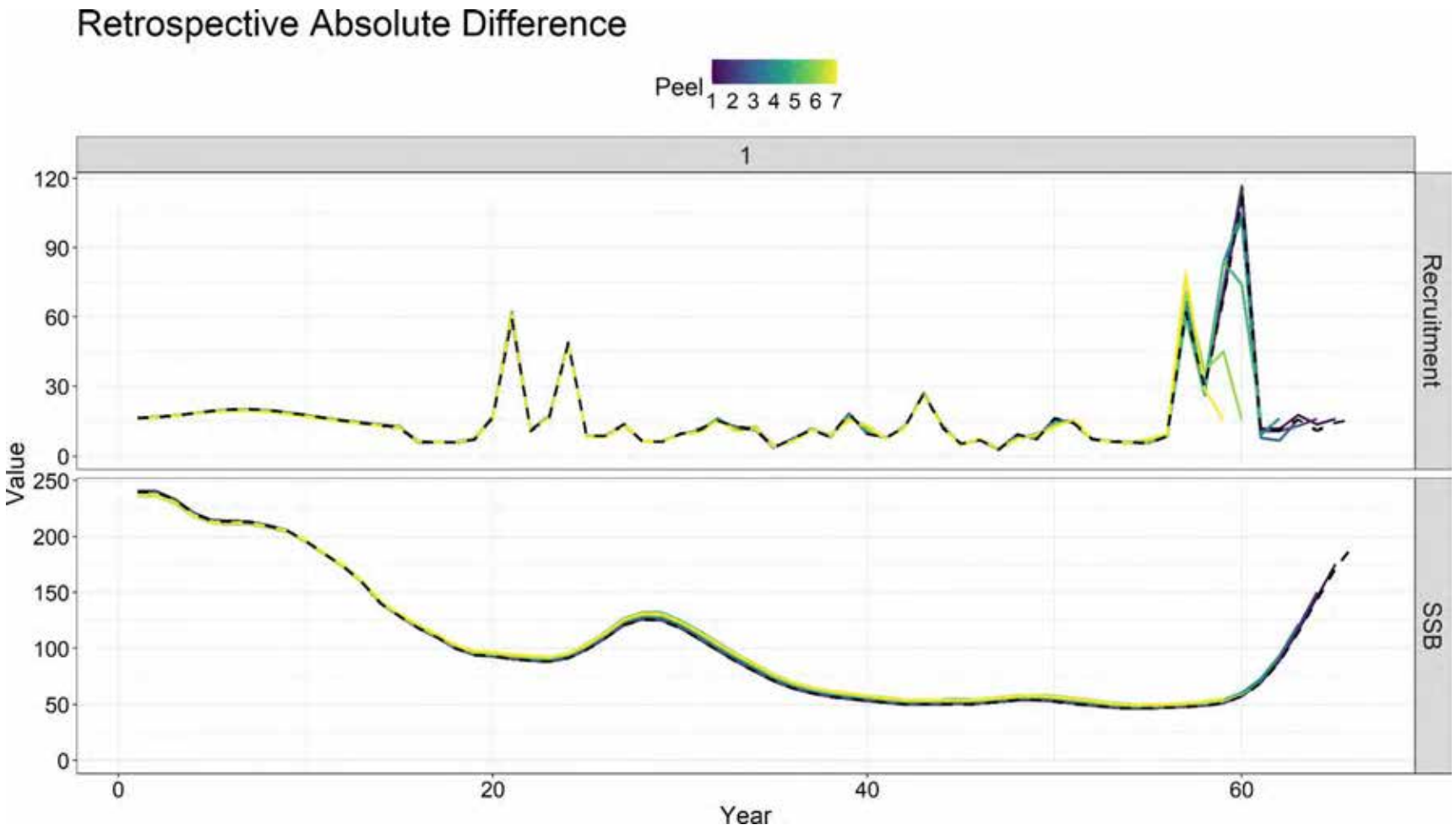

Figure SM3C.90. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.046.

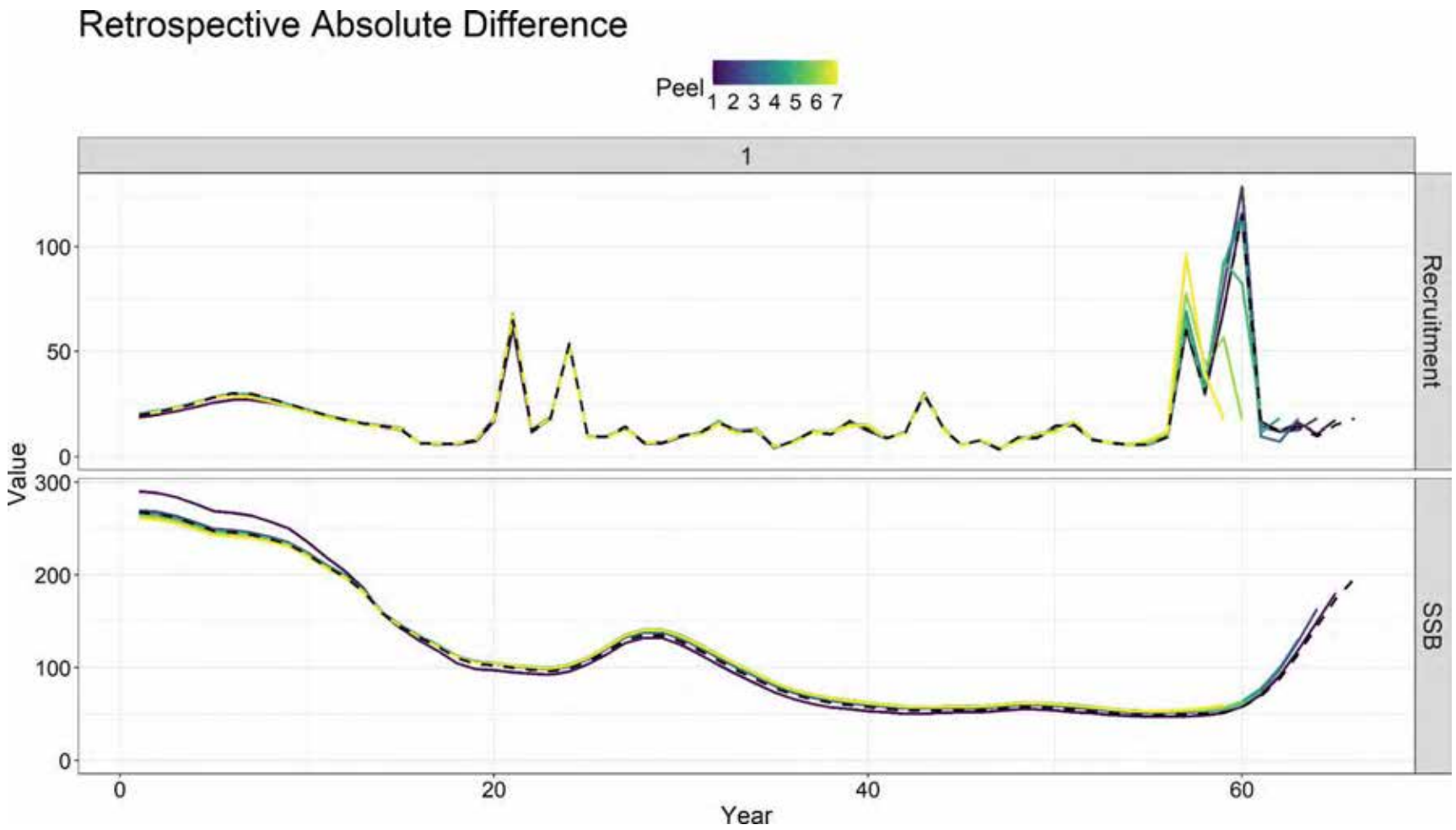

Figure SM3C.91. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2a_FAA_Fsh+Srvy*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.11.

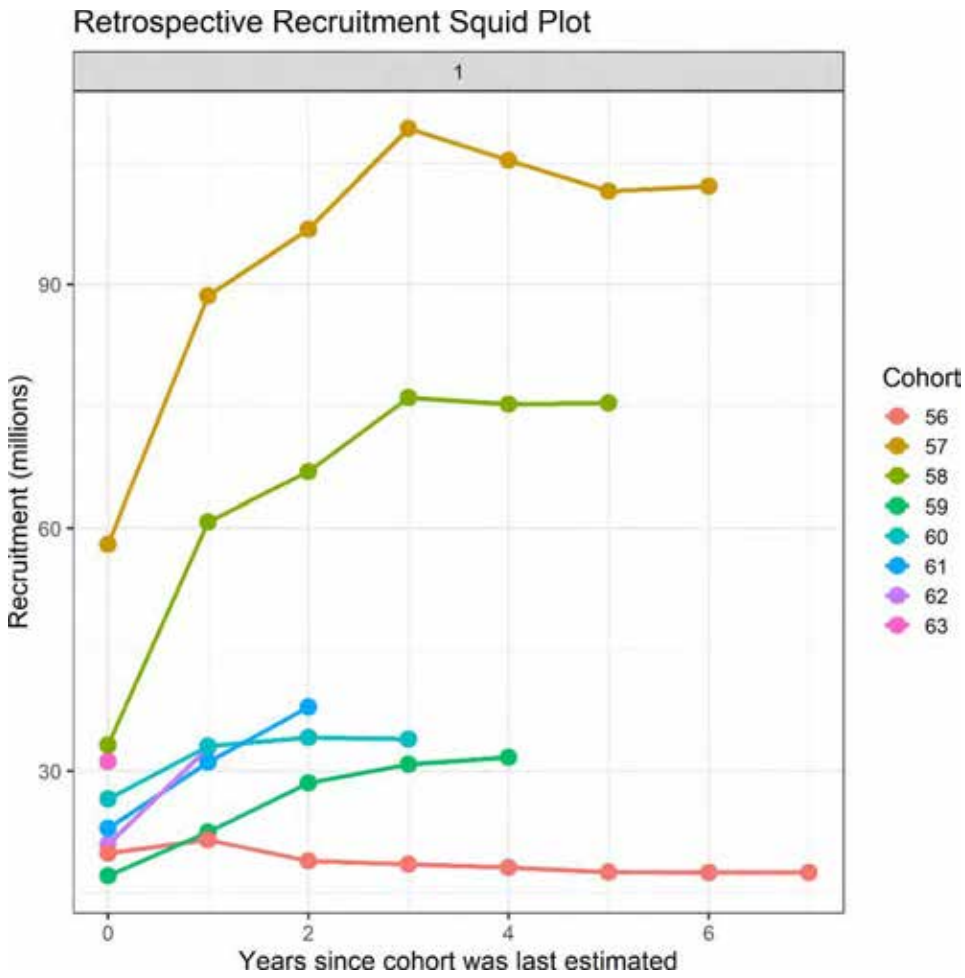

Figure SM3C.92. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis for model *26.1_1Reg*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Cohort 56 represents the 2015 year class (2017 recruitment event).

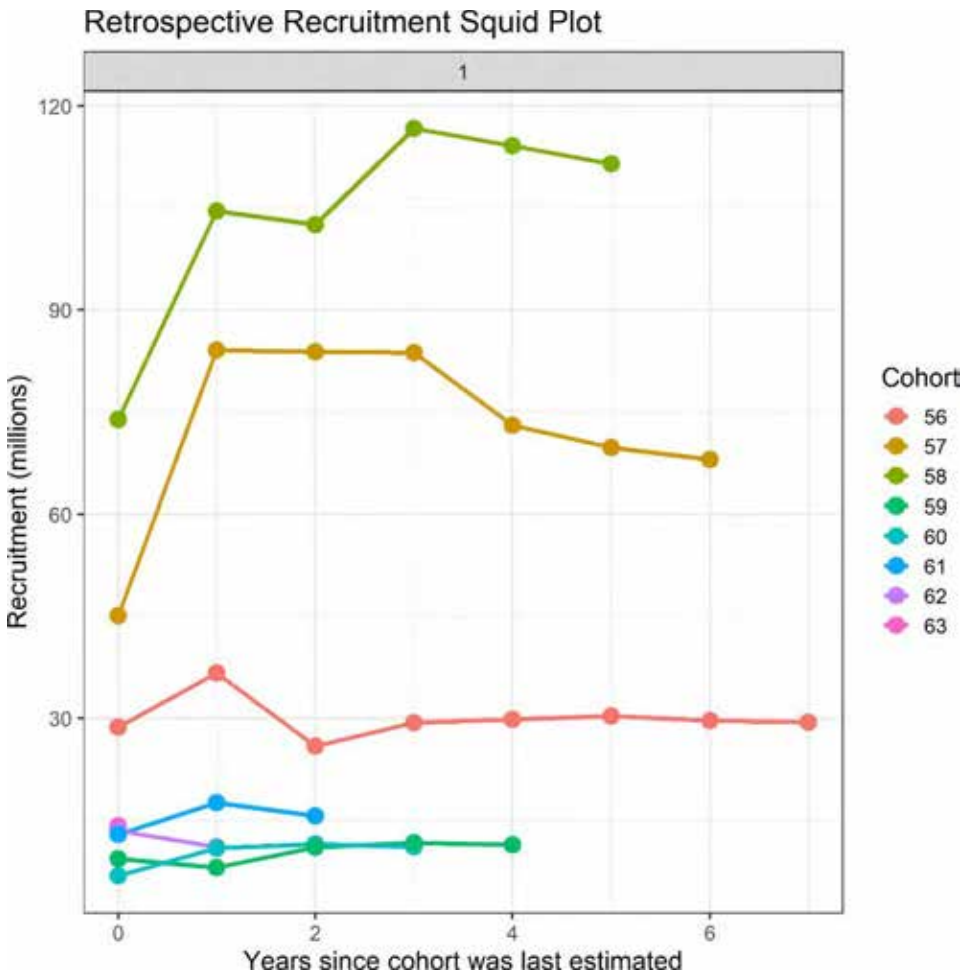

Figure SM3C.93. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis for model *26.2_FAA*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Cohort 56 represents the 2015 year class (2017 recruitment event).

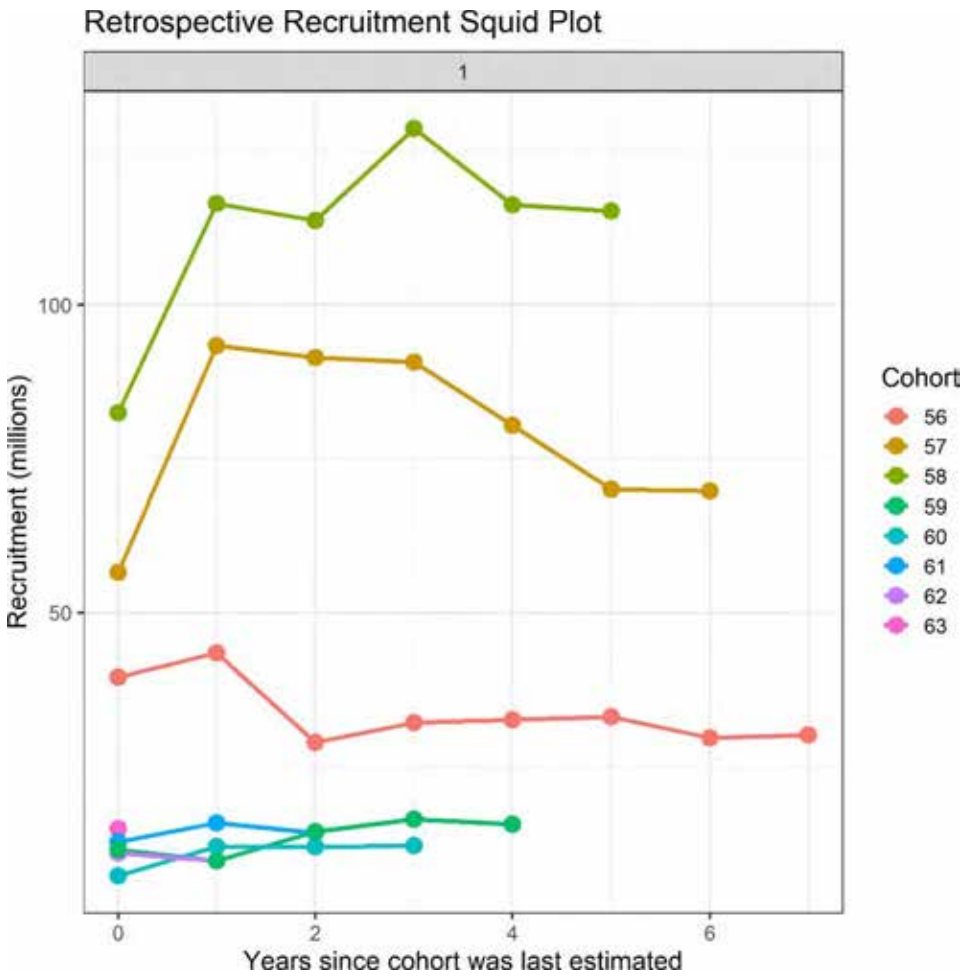

Figure SM3C.94. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis for model *26.2a_FAA_Fsh+Srvy*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Cohort 56 represents the 2015 year class (2017 recruitment event).

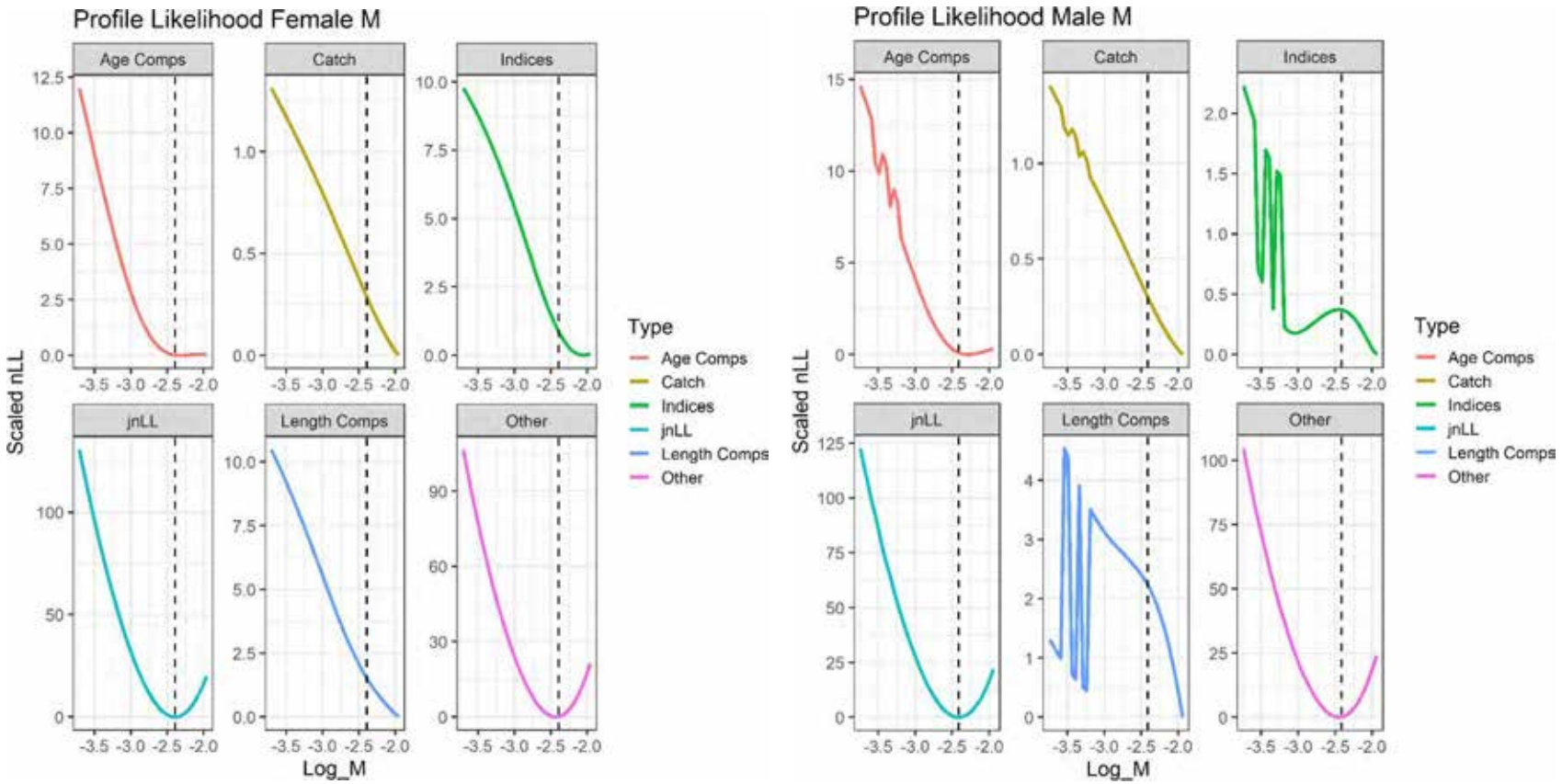

Figure SM3C.95. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for model *26.1_1Reg*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

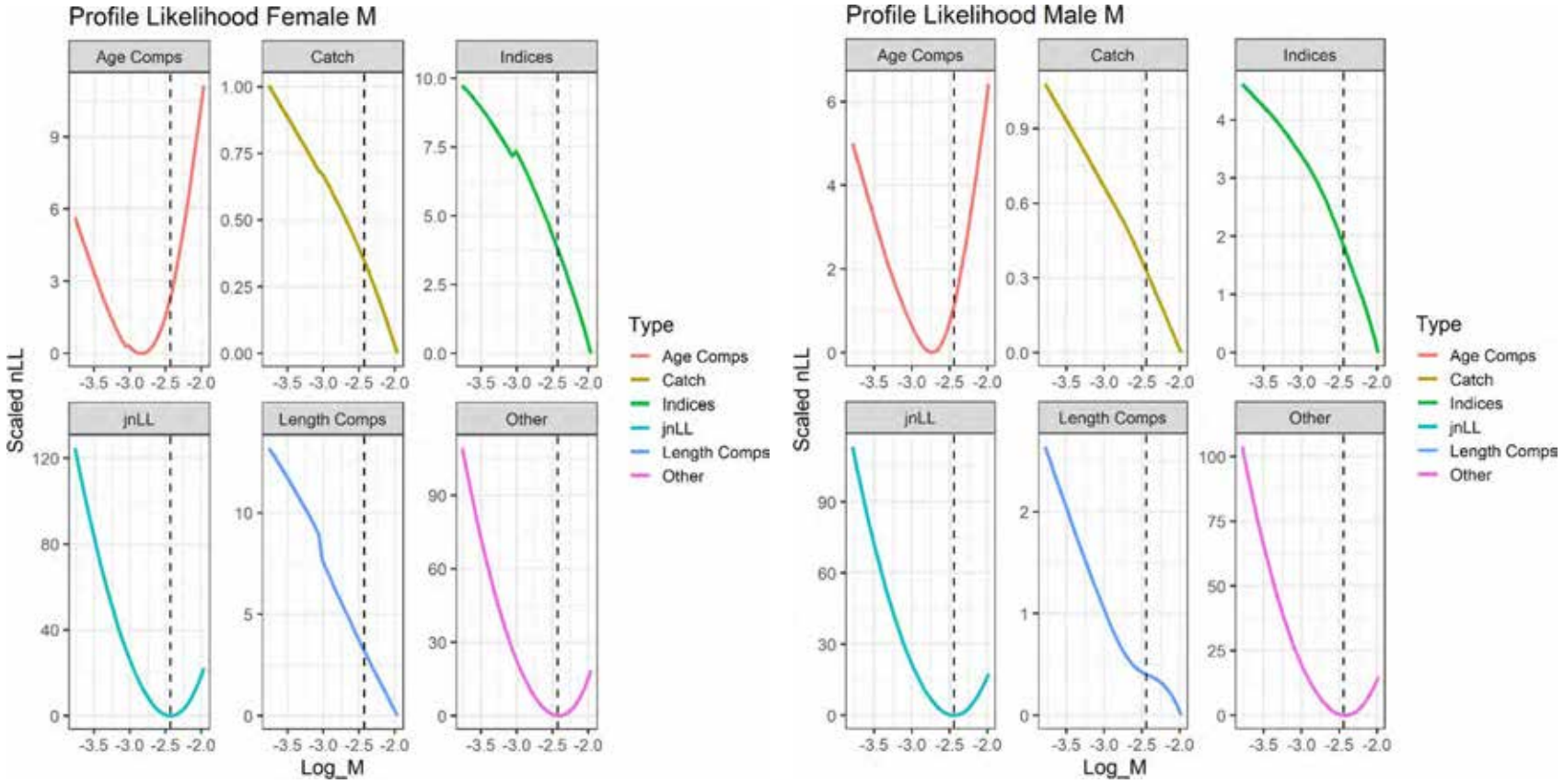

Figure SM3C.96. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for model *26.2_FAA*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

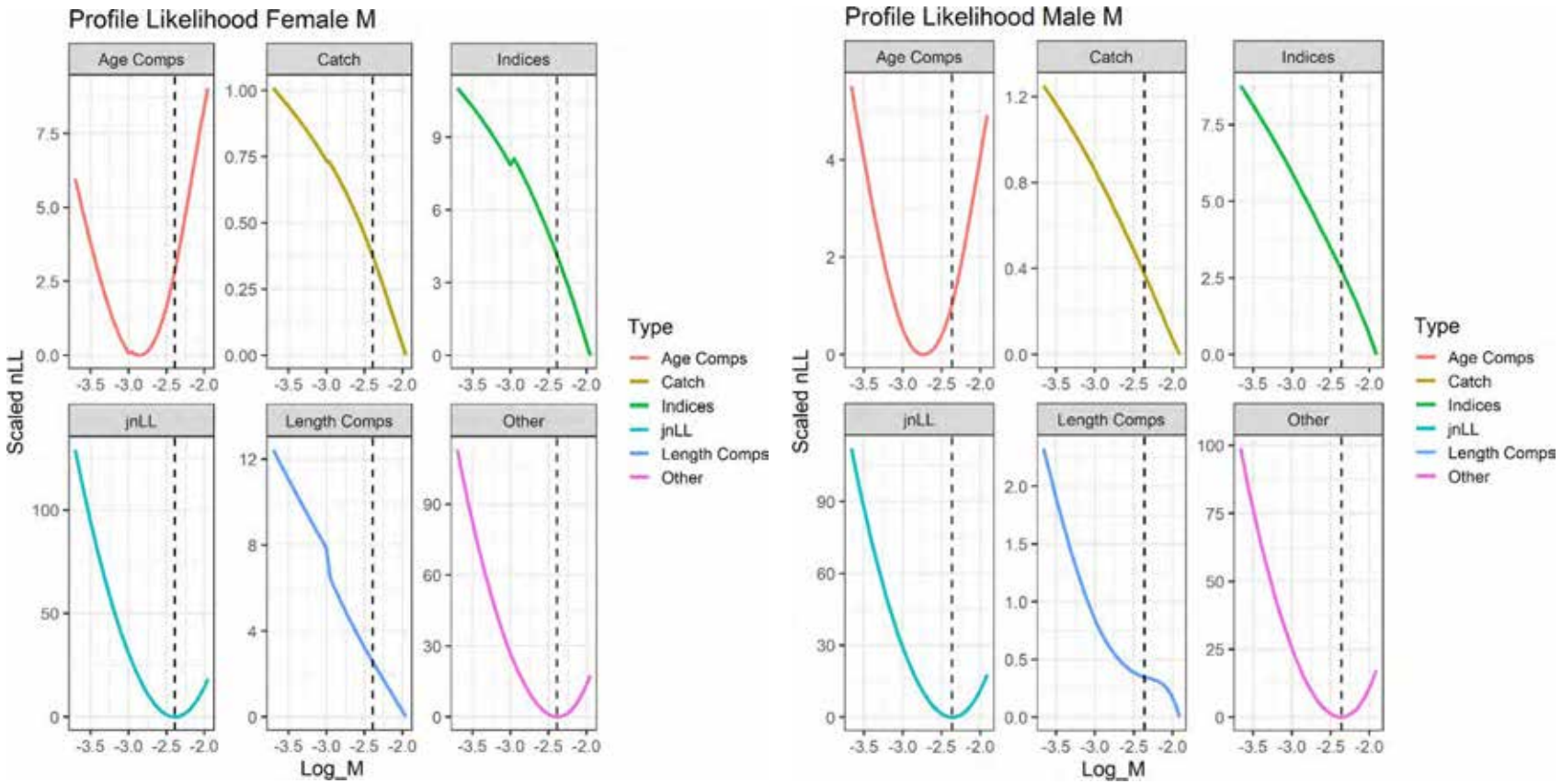

Figure SM3C.97. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for model *26.2a_FAA_Fsh+Srvy*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

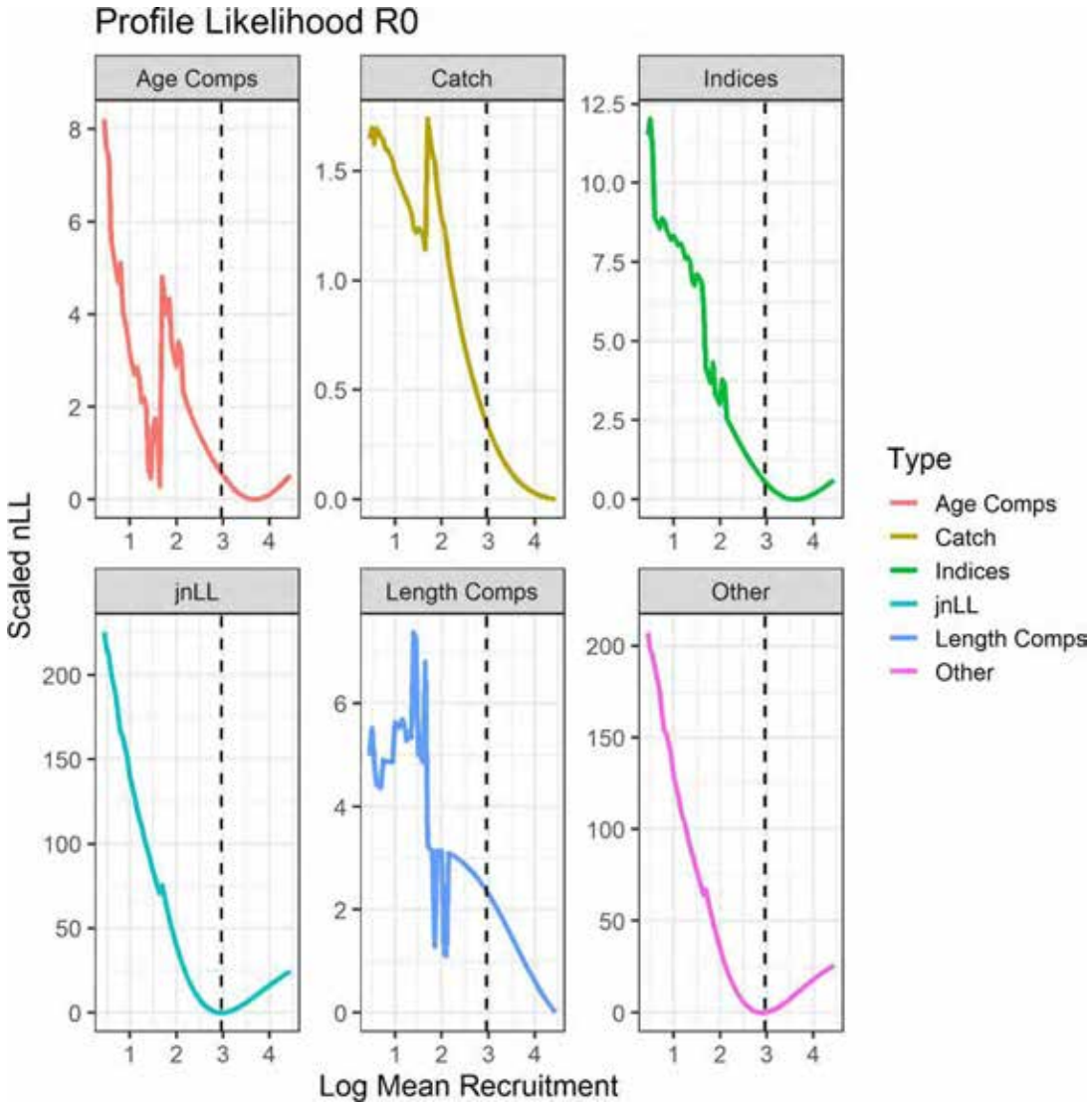

Figure SM3C.98. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for model *26.1_1Reg*.

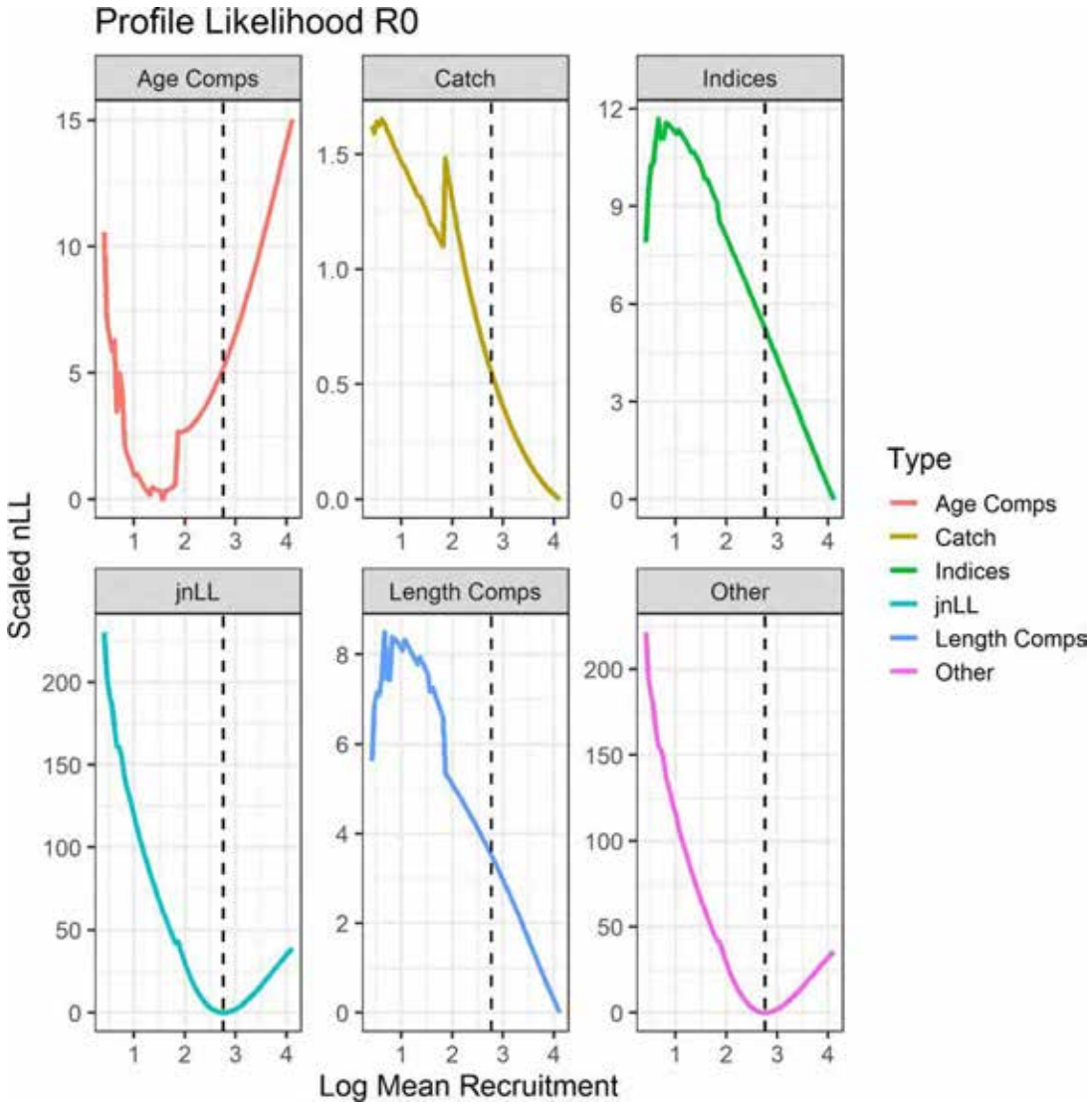

Figure SM3C.98. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for model *26.2_FAA*.

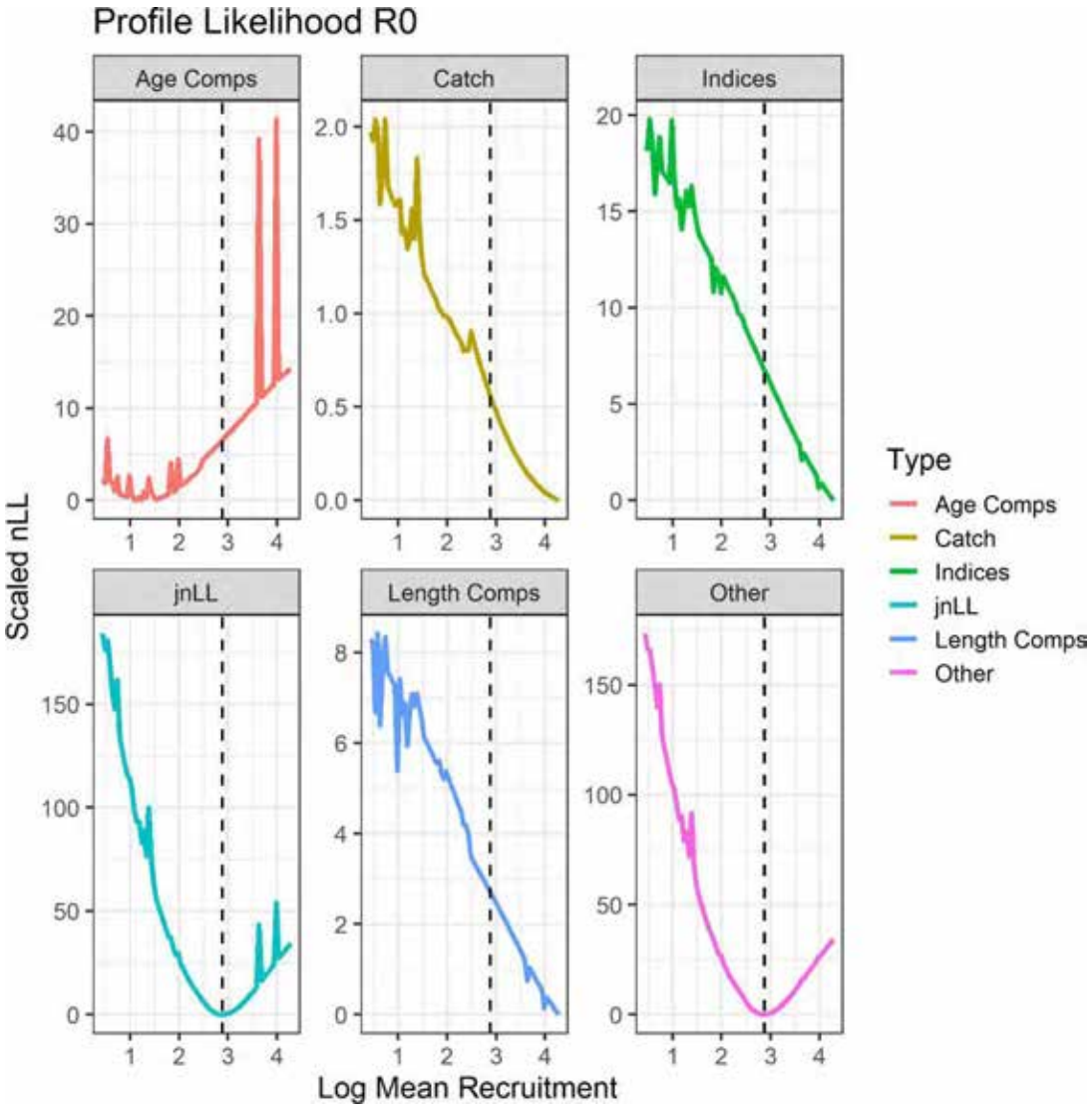

Figure SM3C.99. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for model *26.2a_FAA_Fsh+Srvy*.

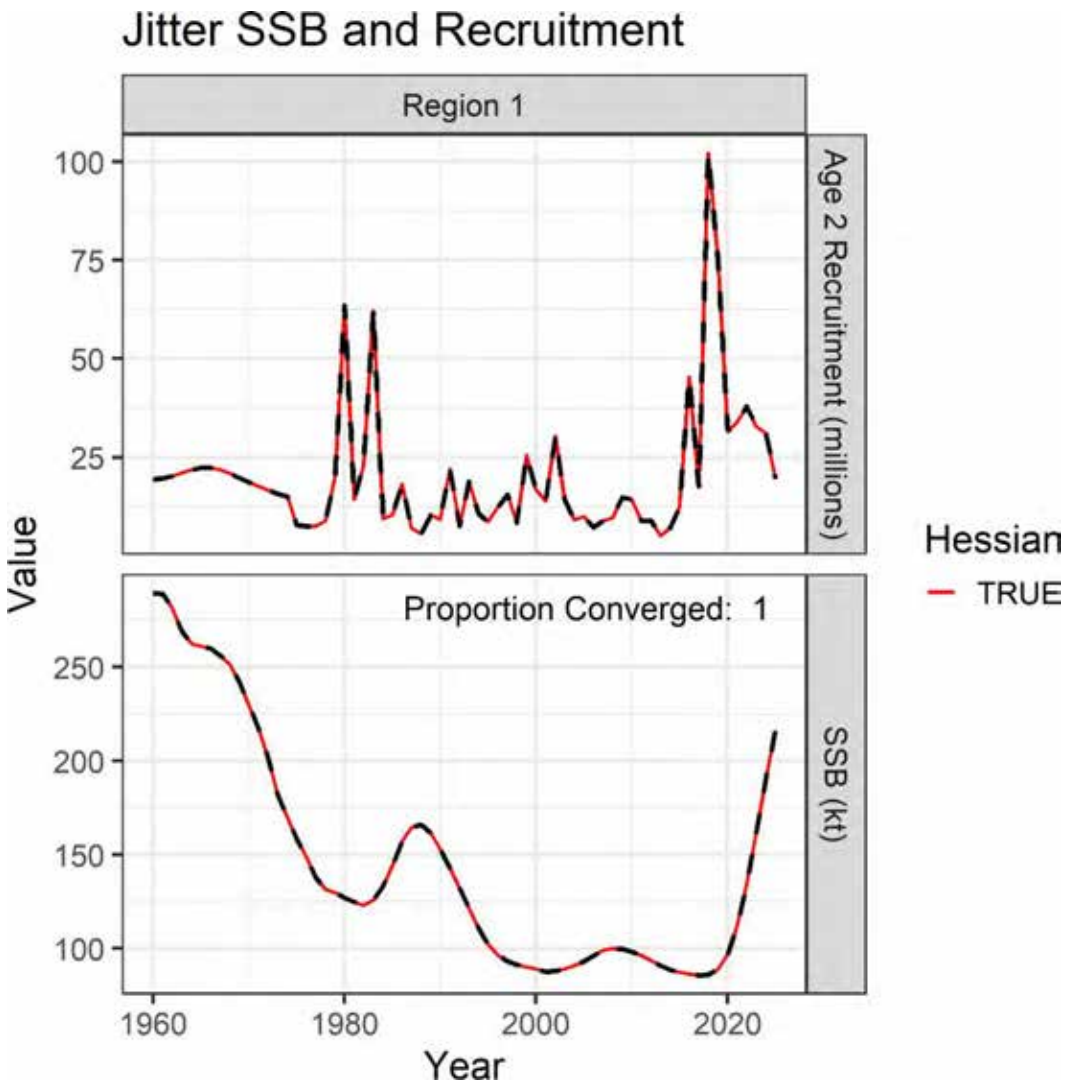

Figure SM3C.100. Results of a jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.1 _1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

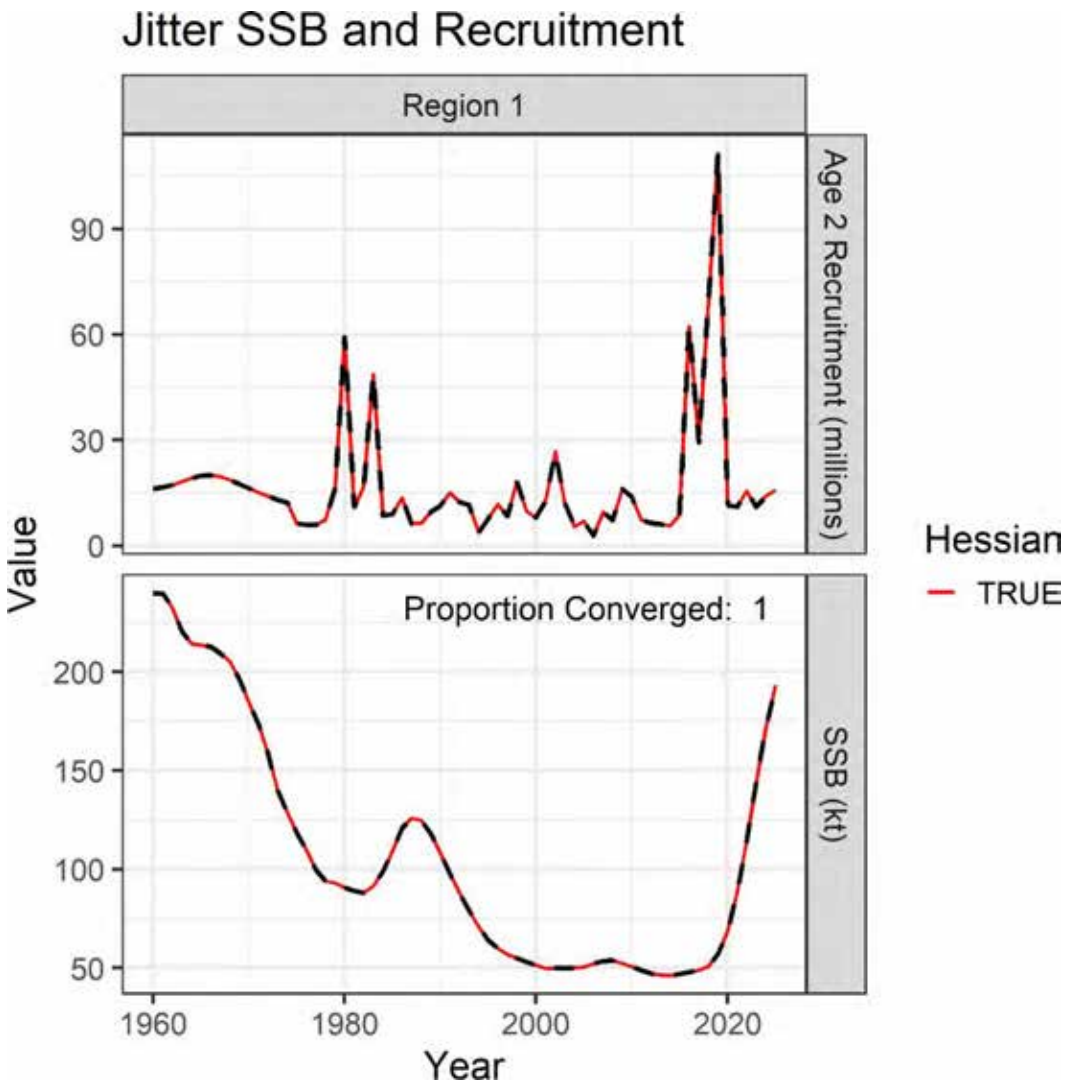

Figure SM3C.101. Results of a jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.2 _FAA*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

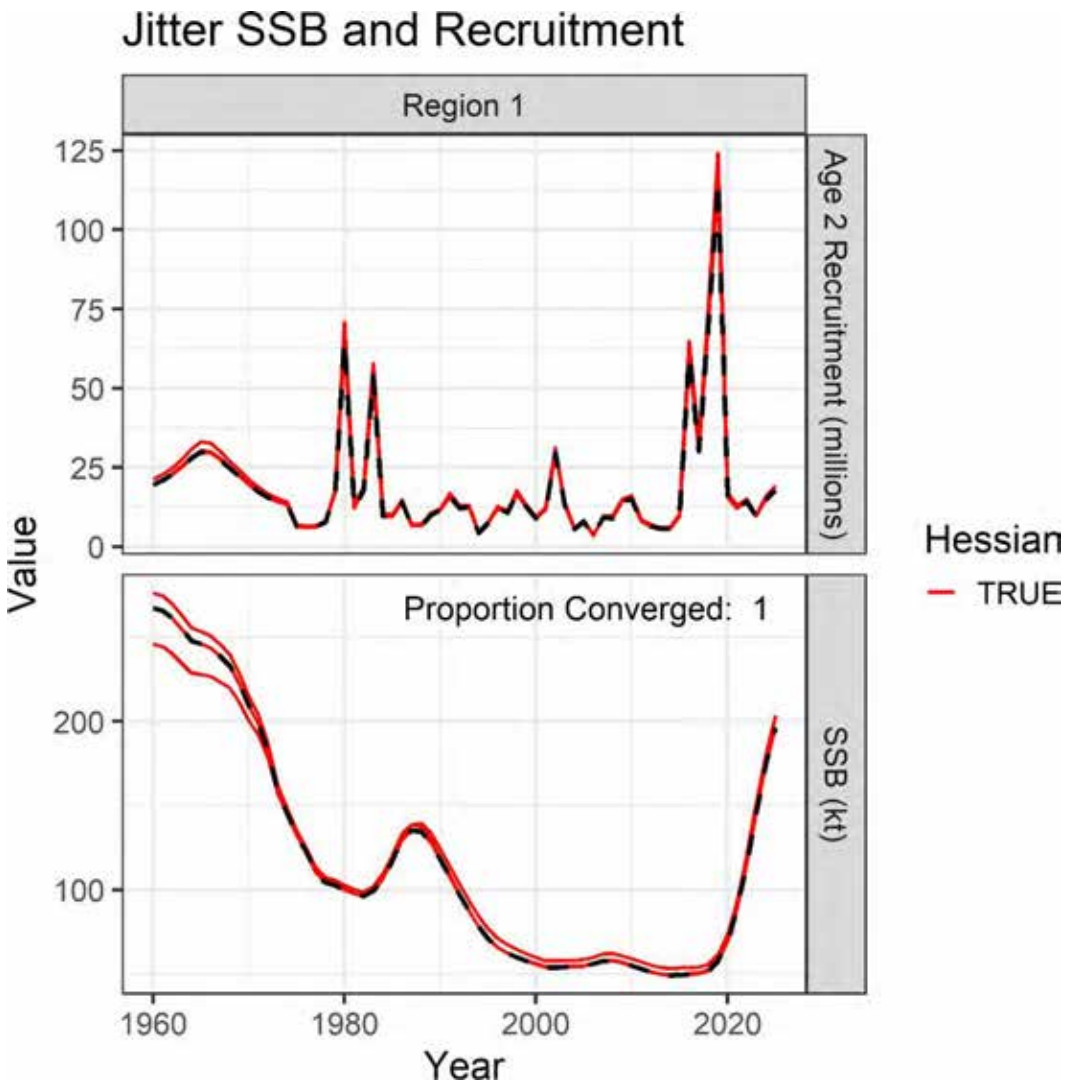

Figure SM3C.102. Results of a jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.2a_FAA_Fsh+Srvy*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

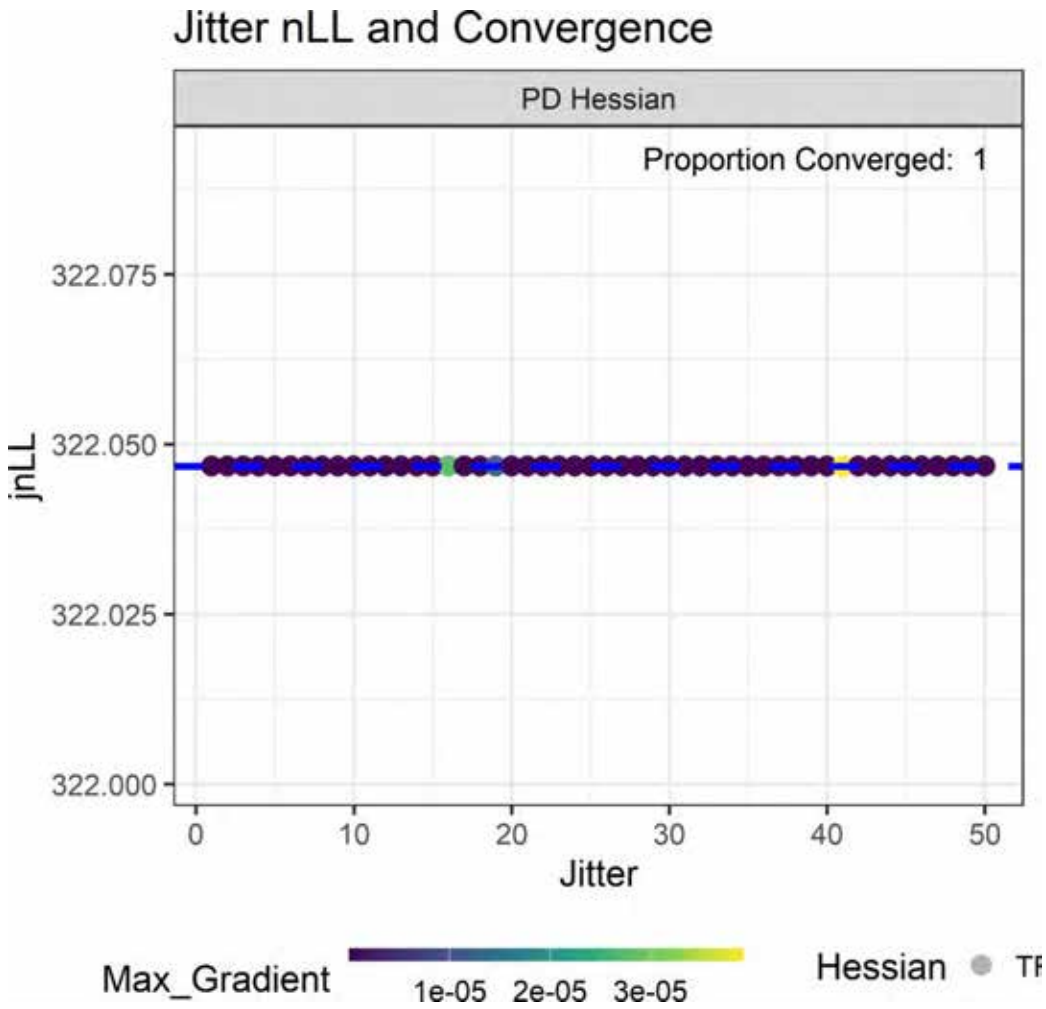

Figure SM3C.103. Results of a jitter analysis showing the joint negative log-likelihood values for converged (Positive Definite, PD, Hessian) and non-converged runs (non-Positive Definite Hessian) for model *26.1_1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

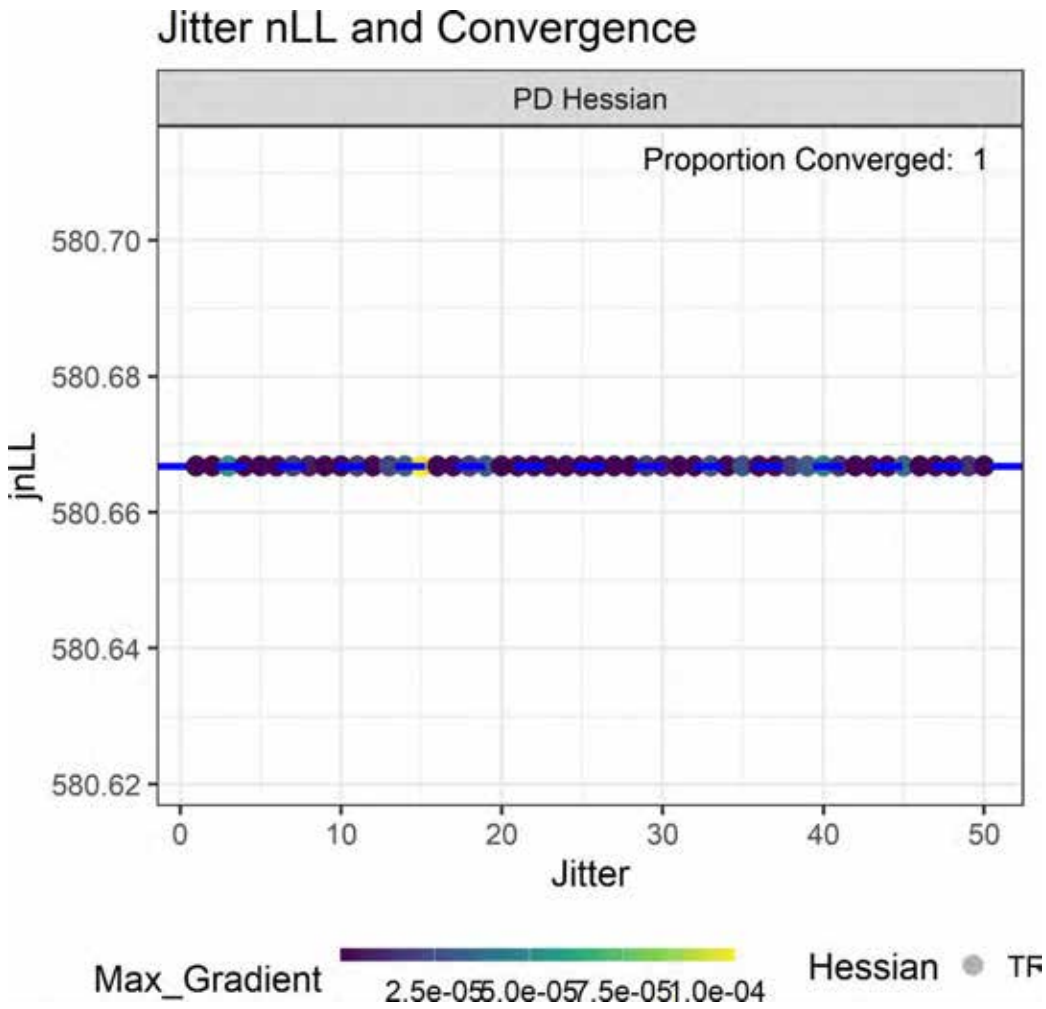

Figure SM3C.104. Results of a jitter analysis showing the joint negative log-likelihood values for converged (Positive Definite, PD, Hessian) and non-converged runs (non-Positive Definite Hessian) for model *26.2_FAA*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

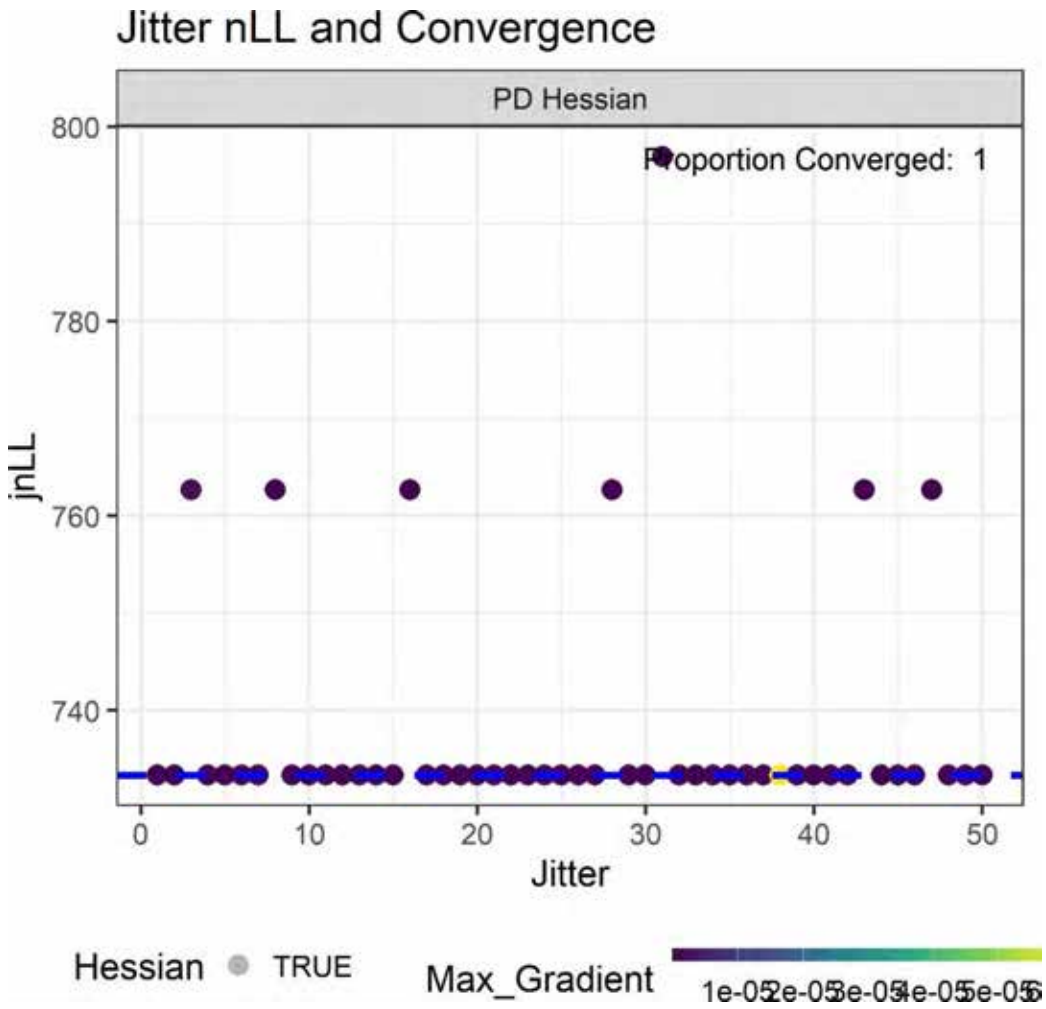

Figure SM3C.105. Results of a jitter analysis showing the joint negative log-likelihood values for converged (Positive Definite, PD, Hessian) and non-converged runs (non-Positive Definite Hessian) for model *26.2a_FAA_Fsh+Srvy*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$.

Appendix 3D: Results of Spatial Stock Assessment Models for Alaska Sablefish

Matthew LH. Cheng, Daniel R. Goethel

Introduction

Alaska sablefish (*Anoplopoma fimbria*) are currently managed as a single panmictic stock across the Gulf of Alaska (GOA), Bering Sea (BS), and Aleutian Islands (AI), informed by an age-and sex-structured statistical catch-at-age model. While the operational assessment assumes that the stock is spatially homogenous, research over the past several decades, along with knowledge of fishery dynamics, suggest that spatial structure likely exists to some degree. For instance, individuals have been shown to demonstrate age-specific (ontogenetic) movement patterns, wherein younger individuals reside in the BS and AI, and move towards the GOA as they mature (Cheng et al., 2025; Heifetz and Fujioka, 1991). In recent years, large recruitment events of age-2 individuals have also generally been found to occur in western regions (BS and AI). Moreover, fishery effort is primarily concentrated in the GOA regions, likely resulting in differential harvest impacts across space. Taken together, these patterns suggest that spatial heterogeneity in recruitment, movement, and harvest dynamics likely plays a role in shaping Alaska sablefish population dynamics.

One approach to improving understanding of spatial population dynamics is the use of spatially-explicit stock assessment models. In general, these models resemble single-region stock assessment models, but data are typically disaggregated across spatial regions, and movement dynamics are often incorporated into population processes. Importantly, spatial models often involve an increase in the number of parameters estimated, coupled with a decrease in the amount of data informing parameter estimates through regional partitioning of data. Thus, spatial stock assessment models are often subject to greater tensions between model complexity and data availability, raising the practical question of whether the gains in structural realism directly translate to improved management performance relative to simpler alternatives (i.e., single-region models).

Despite the potential increase in model complexity and instability relative to single-region alternatives, several motivations exist for developing spatially-explicit stock assessment models in the case of sablefish. First, spatial models can provide a more mechanistic understanding of regional population dynamics and allow monitoring of localized depletion, which are not made explicit from a panmictic stock assessment model. Second, spatial models can serve as conditioning frameworks for operating models used in management strategy evaluations (MSEs). Lastly, spatial models potentially provide a means to address spatial changes in survey design, allowing the accommodation of missing data, and circumventing the need to interpolate missing data, as would be the case in a single-region model. In the following, we present the development of two alternative spatial stock assessment models for Alaska sablefish.

Methods

General Model Structure

Spatial stock assessment models were developed using the SPoRC (Stochastic Population over Regional Components) modelling framework (Cheng et al., 2026). SPoRC is a generalized statistical catch-at-age model written in RTMB (Kristensen et al., 2016) with the ability to

support multi-region, multi-fleet, multi-sex configurations, while also integrating tagging data. Two configurations of spatial models were developed: a three-region model and a five-region model. The three-region model partitions the stock across the BS, AI, and GOA, while the five-region model further disaggregates the GOA into the western GOA (WGOA), the central GOA (CGOA), and the eastern GOA (EGOA). Both configurations share common population dynamics and model specifications, differing primarily in spatial resolution and the number of estimated parameters. The spatial assessment models were based partly on the dynamics of the single region (or fleets as areas) model, the conceptual model shown in Figure 3D.1, and the parameterization of pervious work (Cheng et al., 2025). In particular, spatial models represented 30 ages (2 – 31+), sex-specific dynamics (females and males), 65 years (1960 – 2025), two fishery fleets (longline and trawl), and two survey fleets (domestic and Japanese longline surveys). Within each annual time step, the population was subject to the following processes in sequence: recruitment of age-2 individuals, movement among regions, followed by mortality from fishing and natural mortality. Further details on model dynamics, observation equations, and likelihoods are described in https://chengmatt.github.io/SPoRC/articles/c_model_equations.html.

Recruitment

Recruitment in both spatial models were assumed to follow a mean recruitment relationship, where global mean recruitment is apportioned across spatial regions. Lognormal recruitment deviations are estimated to vary across space and time, with the standard deviation of recruitment deviations fixed at 1.2 across all regions. Recruits were assumed to be unable to move, in order to mitigate potential confounding with movement and recruitment dynamics.

Natural Mortality

Natural mortality is sex-specific and assumed to be constant across sexes and ages, consistent with the single-region and fleets as areas models presented. Both values are fixed according to those estimated in the fleets as areas model (*26.2b_FAA_3Flt_LLS_Only*).

Growth and Maturity

Weight-at-age and maturity-at-age are treated as fixed quantities and are assumed to be constant across space, where values are taken from the operational assessment. Weight-at-age is assumed to be sex-specific and follows a von Bertalanffy growth function (females asymptote at a larger size than males), while maturity-at-age is only modelled for females and is represented as a logistic function.

Movement

Movement among regions was modelled as a discrete time Markovian process, assuming constant rates across time, but age-specific movement. Age-specific movement was represented as three age-blocks represented young individuals (ages 2 – 7), intermediate aged individuals (8 – 15), and old individuals (16 – 31) to approximately capture ontogenetic shifts in spatial distribution (i.e., movement from western to eastern regions as individuals matured).

Selectivity and Catchability

Across all fishery and survey fleets, selectivity was parameterized as sex-specific logistic functions. The longline fleet estimated time-varying selectivity as two time-blocks to capture a

change in fleet structure (i.e., shifting from hook-and-line gear to pot gear), while the trawl fleet estimated time-invariant selectivity. Both survey fleets similarly estimated time-invariant selectivity. Selectivity was assumed to be constant across regions. Catchability for both survey fleets were freely estimated and assumed to remain constant across space and time.

Tag Reporting

Tag reporting rates were to characterize tag recaptures. Tag reporting was assumed to be constant across regions, but was allowed to vary across time as time blocks. In particular, three time-blocks were estimated, coinciding with large changes in fishery dynamics (inception of an individual fishing quota fishery and a change in fleet structure).

Observation Models and Likelihoods

Catch

Region-specific expected removals (weight) by the longline and trawl fishery are predicted using Baranov's catch equation, and are fit to assuming a lognormal likelihood with negligible error (standard deviation of catch is assumed to be fixed at 0.05).

Survey Indices

Region-specific survey indices (numbers) are fit to for both the domestic and Japanese longline survey fleets assuming a lognormal likelihood and design-based estimates of uncertainty. Unlike the single-region models, regional indices are fit directly without the need for interpolation or carryover values, and is able to adequately accommodate missing data.

Compositions

Both age and length-compositions are fit to assuming a Multinomial likelihood, where input sample sizes are generally based on *a priori* knowledge of sampling practices (i.e., regions and fleets with higher sampling coverage have larger sample sizes). Sex-specific compositions are available for all fishery and survey fleets and are fit to jointly (i.e., considering sex-specific compositions as a single vector; Cheng et al., 2025). Unlike the single-region counterparts, no data-weighting is performed to further adjust sample sizes, given complexities with respect to data-weighting in spatial models.

Tagging Data

Since the inception of the longline survey, approximately 400,000 individuals have been tagged, with about 35,000 individuals recaptured. Thus, tagging data are expected to be highly informative of movement dynamics. Expected tag recaptures are predicted using a Brownie tag attrition submodel, and are fit using a multinomial release-conditioned likelihood, where the probability of recapture in each region is derived from the model's predicted movement and survival processes. Moreover, the maximum tag liberty was restricted to 15 years (i.e., tags were not tracked or fit to beyond 15 years at liberty) to reduce computation time. To prevent tagging data from having due influence on overall model estimation, multinomial weights are scaled by a factor of 0.5.

Model Estimation and Diagnostics

All parameters were estimated using penalized maximum likelihood using RTMB, where the objective function was the sum of negative log-likelihoods for catch data, survey indices, compositions, tagging, penalties (i.e., recruitment), and priors placed on parameters. The three-region model estimates a total of 723 parameters, while the five-region model estimates a total of 1208 parameters. For both models, the largest share of parameters primarily results from fishing mortality deviations (~50%), followed by recruitment deviations (~27%), initial age deviations (~12%), and movement parameters (~5%).

Several diagnostic tools were utilized to assess model adequacy, stability, and performance. In particular, all models were inspected to ensure that maximum gradient components for all parameters were < 1e-5, as well as a positive definite Hessian matrix. Model fits to catch data, survey indices, both age- and length-compositions, and tagging data were also evaluated. Lastly, retrospective analyses (7-year peels) were conducted to understand model stability under sequential data removal and to evaluate retrospective consistency in recruitment and spawning stock biomass (*SSB*).

Results

Both spatial models converged with maximum gradient components for all parameters < 1e-5, along with an invertible Hessian matrix. In general, most data sources were adequately fit and did not demonstrate systematic misfits. For instance, both spatial models provided good fits to regional catch data (Fig. 3D.2 and 3D.3). Likewise, abundance indices from both survey fleets were generally fit well, although indices in the most recent years for the GOA regions appeared to be slightly overpredicted (Fig. 3D.4 and 3D.5). With respect to composition data, both models appeared to capture general patterns, wherein western regions often had higher proportions of younger fish, and eastern regions demonstrated higher proportions of older fish (Fig 3D.6 – 3D.43). While fits to composition data were generally adequate, there were some patterns in composition data that neither spatial model was able to reconcile. In particular, exceptionally large plus groups as observed by the longline fishery in the Aleutian Islands were underpredicted in some years (i.e., positive residuals for the plus group; Fig. 3D.7 and 3D.22). Relative to other data sources, tagging data were moderately well fit, although recaptures in recent periods appeared more difficult to reconcile (Fig. 3D.44 and 3D.45).

Retrospective analyses for both three-region and five-region models generally demonstrated similar patterns, where all regions exhibited positive retrospective patterns in *SSB* that often coincided with recruitment estimates from several years prior being overestimated (Fig. 3D.46 and 3D.47). Interestingly, recruitment estimates in the AI from the three-region model demonstrated some instability in certain retrospective peels (i.e., recruits in the Al are estimated at values close to 0), likely reflecting confounding (and revision of estimates) between movement and recruitment as age data were sequentially removed from the analysis (Fig. 3D.46). These results further highlight that spatially-explicit stock assessment models for Alaska sablefish will likely require careful annual tuning and evaluation of model structure, parameterization, and data weighting to ensure stable and biologically realistic dynamics through time.

Model estimates of recruitment and *SSB* were largely concordant between the spatial models (Fig. 3D.48). Both the pattern and scale of both recruitment and *SSB* were similar, with large recruitment events primarily occurring in western regions (BS and AI) and sustained recruitment events in the eastern regions (WGOA, CGOA, and EGOA) (Fig. 3D.48 and 3D.49). Moreover, regions exhibiting high recruitment did not necessarily coincide with regions of high SSB, presumably due to the estimated ontogenetic movement dynamics (i.e., younger individuals primarily residing in western regions and moving eastward as they mature), as well as potential unmodelled larval dispersal processes (Cheng et al., 2025) (Fig. 3D.48 and 3D.49).

Overall, results from the spatial model highlight that spatial heterogeneity in population dynamics likely exists, driven in part by movement dynamics, differential spatial harvest, and underlying oceanographic processes. Despite the presence of such heterogeneity, aggregated time-series estimates from spatial models generally align with simpler alternatives in the case of Alaska sablefish (e.g., the single-region model; Cheng et al., 2025), suggesting that these simpler alternatives provide similar advice management purposes. Importantly, retrospective analyses underscored the potential for instability in spatial models, and the need for further work to fine-tune these models. We propose that the developed spatial model serves as a useful research tool for: 1) understanding spatial population dynamics, and 2) serving as conditioning tools for simulation exercises.

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Figures

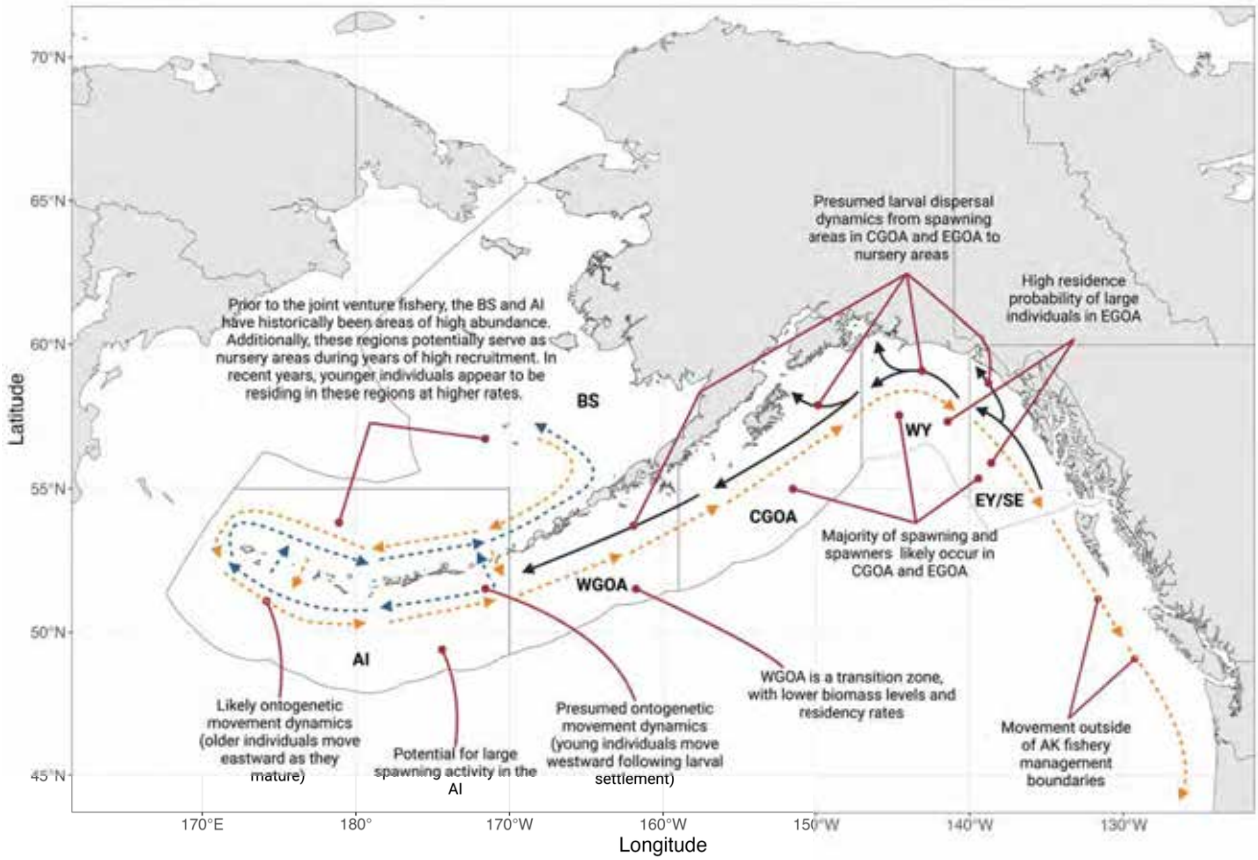

Figure 3D.1. Conceptual model of spatial sablefish dynamics. Black solid arrows represent hypotheses on larval dispersal, blue dashed arrows are hypotheses regarding the movement dynamics of younger individuals, and orange dashed arrows are hypotheses on general movement dynamics of individuals as they mature.

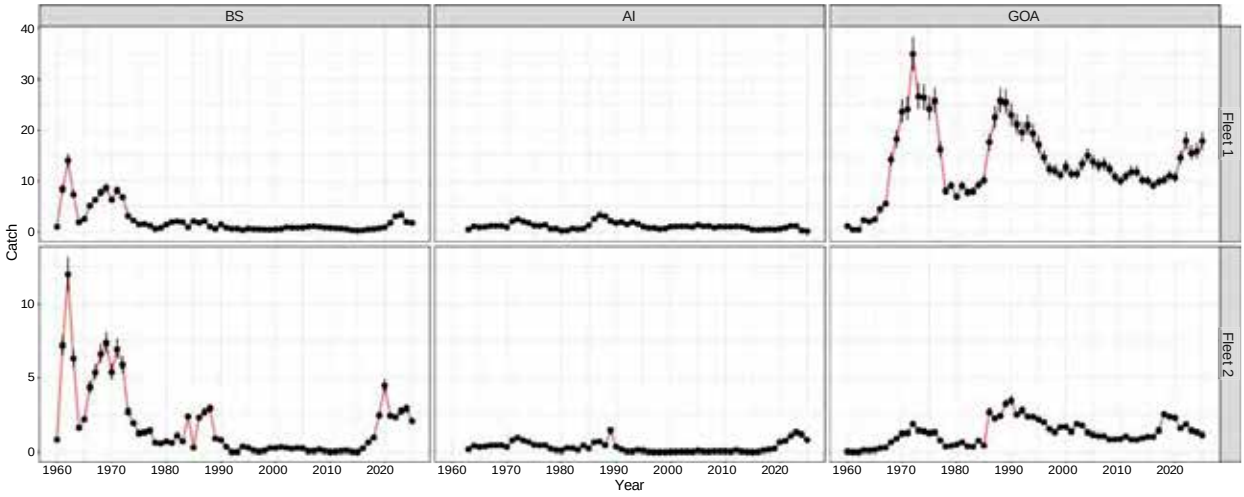

Figure 3D.2. Fits to regional catch data by fishery fleet for the three-region model. Fleet 1 represents the longline fishery while fleet 2 represents the trawl fishery. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

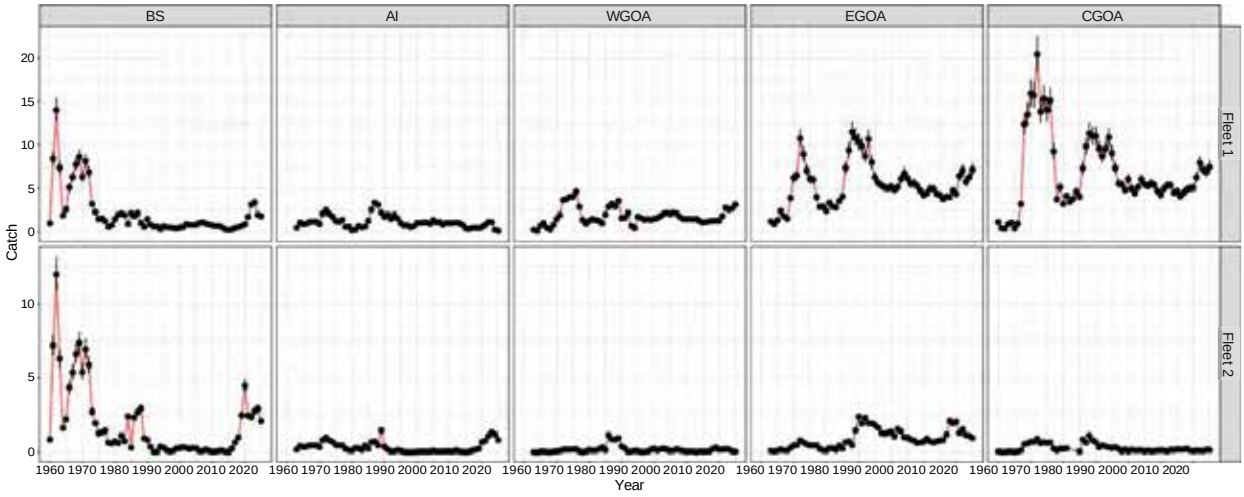

Figure 3D.3. Fits to regional catch data by fishery fleet for the five-region model. Fleet 1 represents the longline fishery while fleet 2 represents the trawl fishery. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

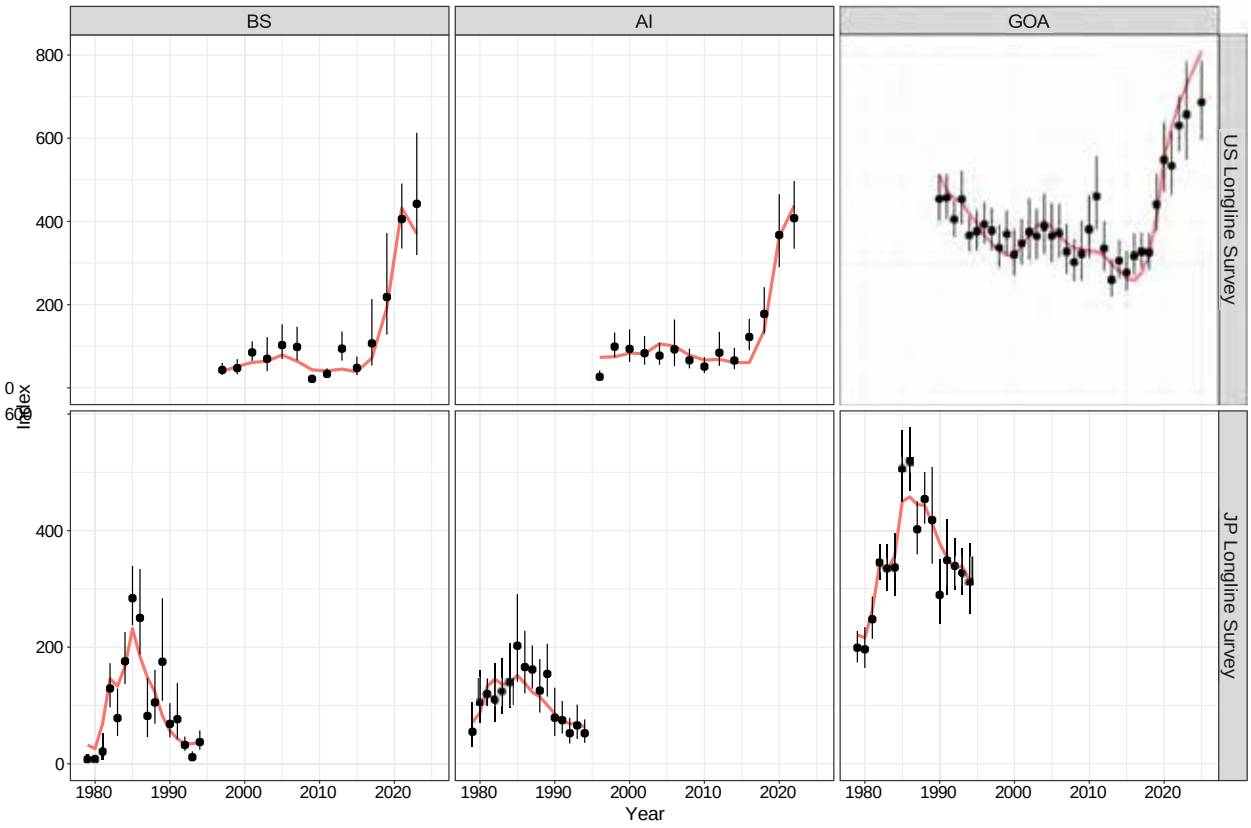

Figure 3D.4. Fits to regional survey indices by survey fleet for the three-region model. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

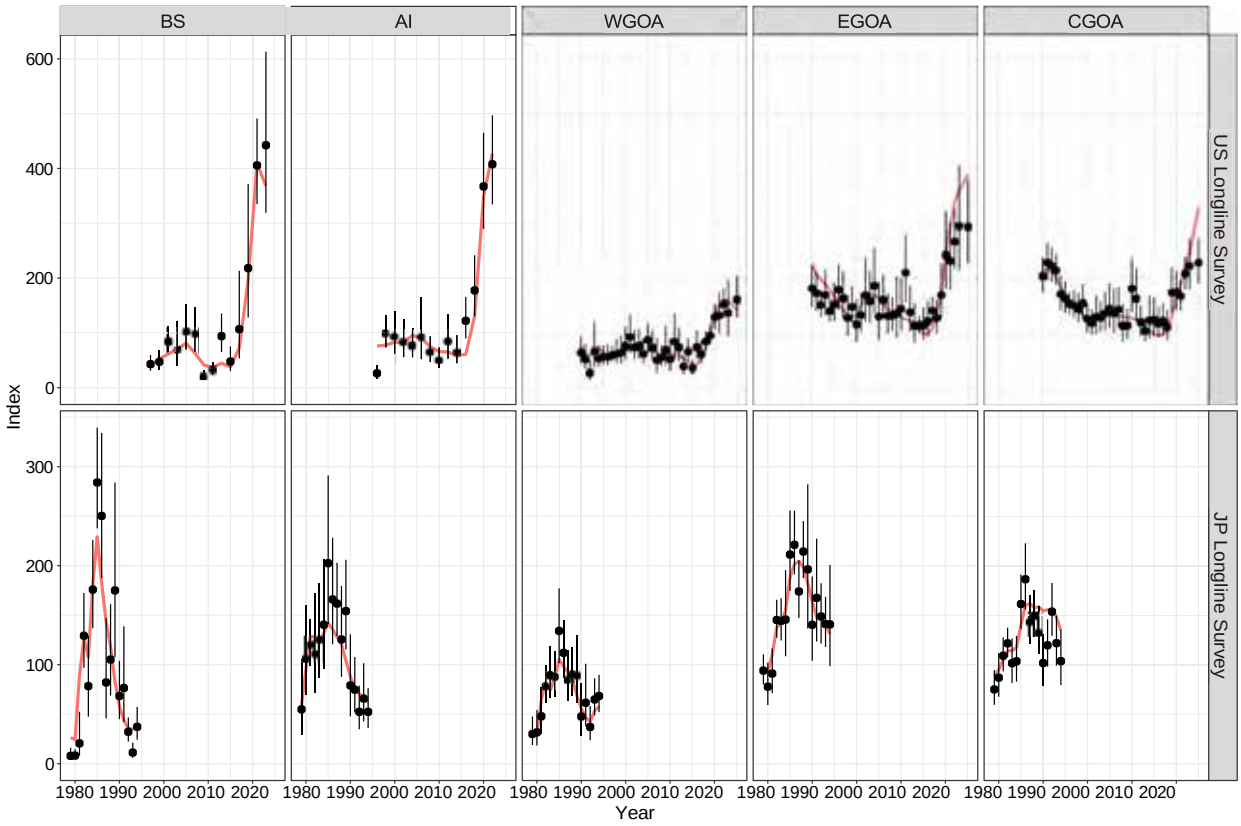

Figure 3D.5. Fits to regional survey indices by survey fleet for the three-region model. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

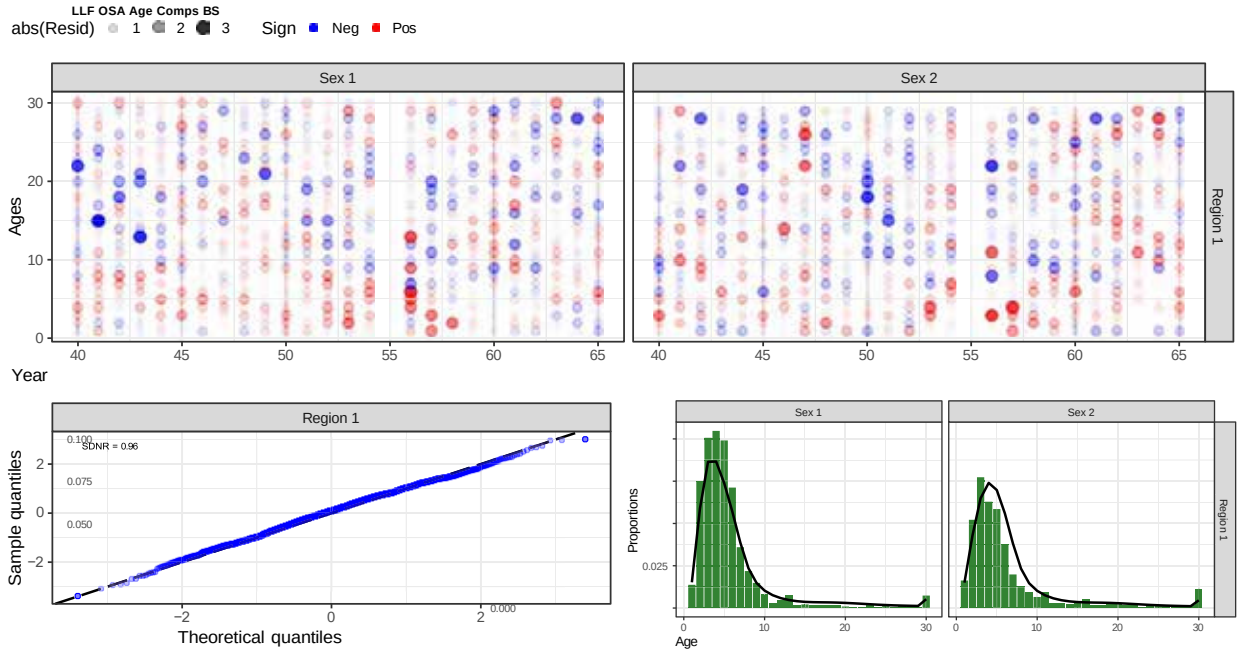

Figure 3D.6. Age composition fits from the three-region model for the longline fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

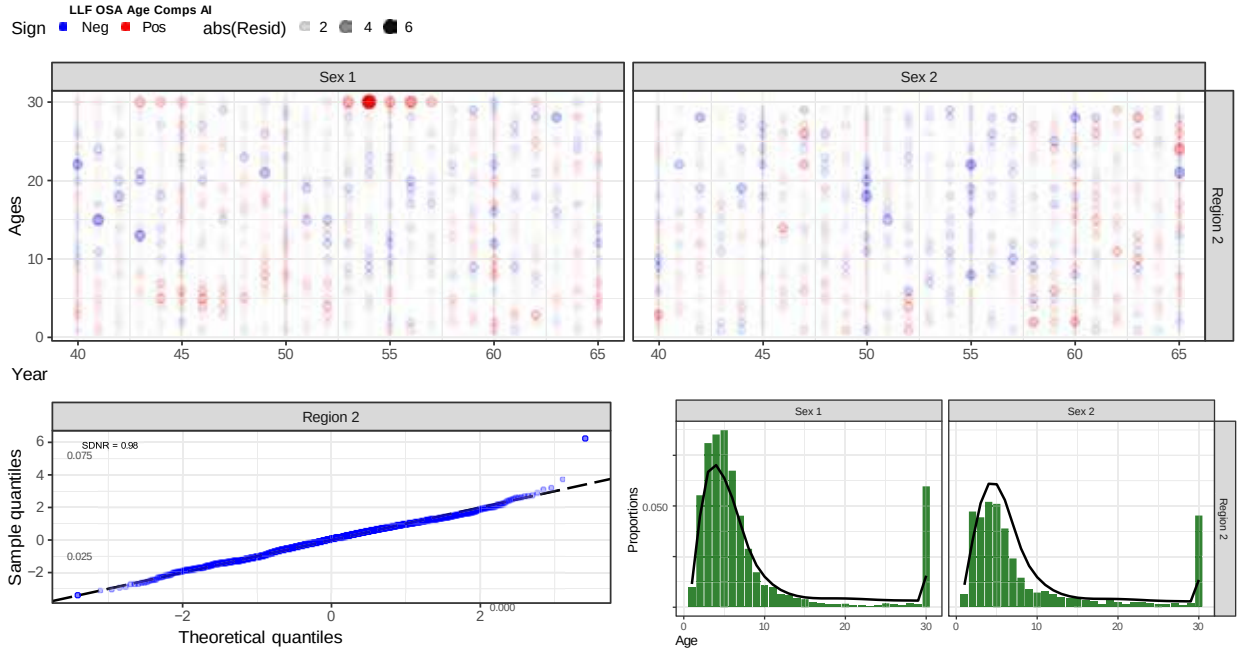

Figure 3D.7. Age composition fits from the three-region model for the longline fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

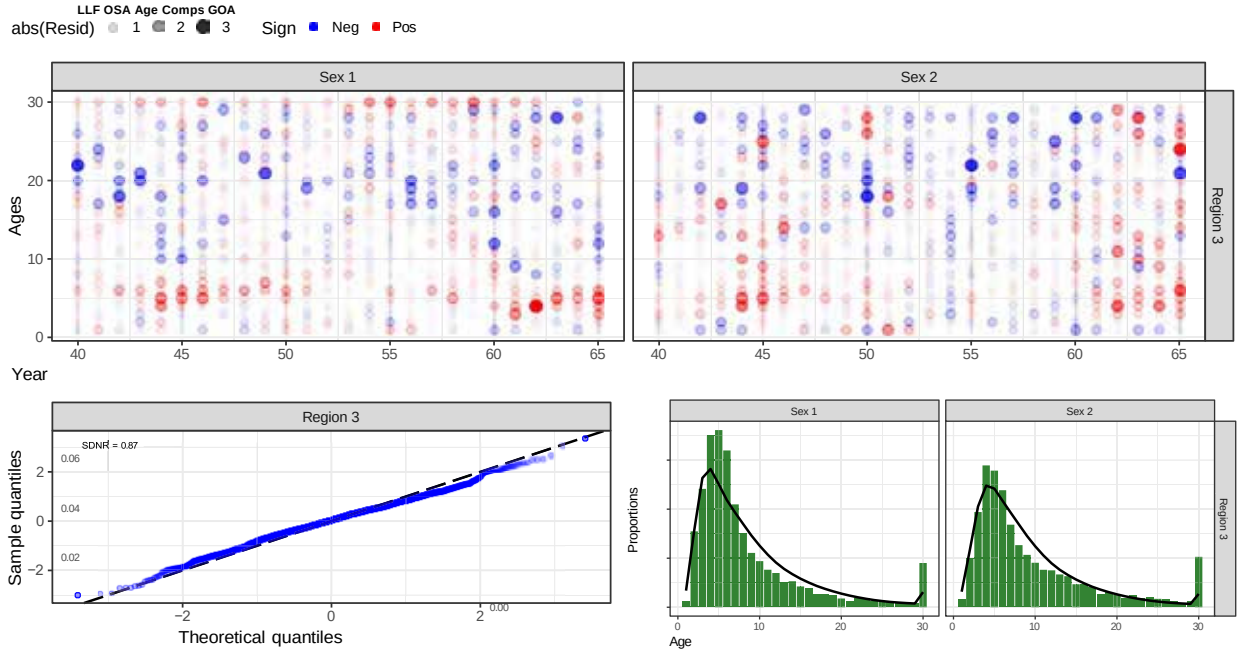

Figure 3D.8 Age composition fits from the three-region model for the longline fishery in the Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

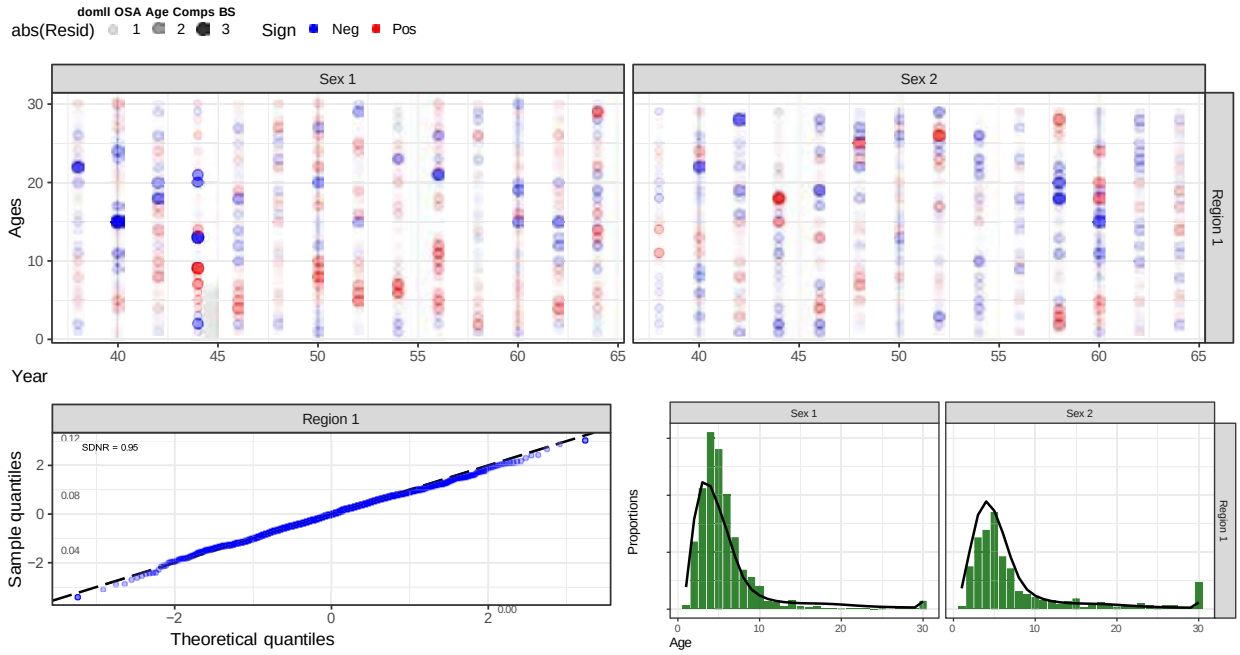

Figure 3D.9 Age composition fits from the three-region model for the domestic longline survey in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

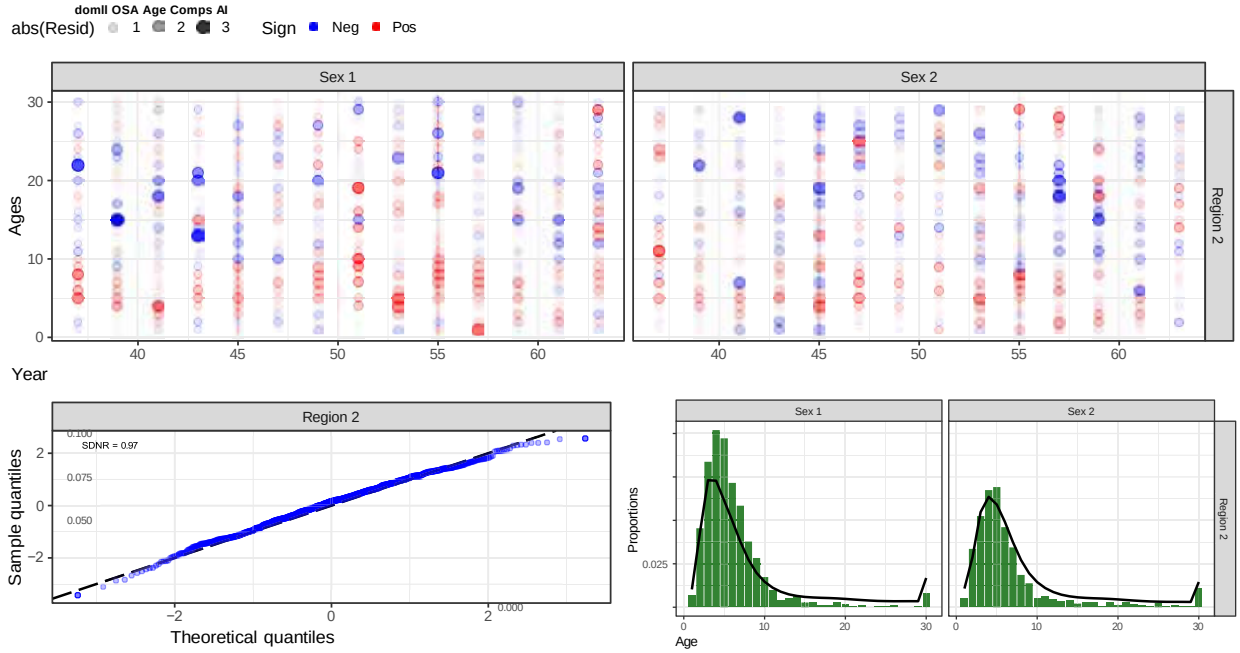

Figure 3D.10 Age composition fits from the three-region model for the domestic longline survey in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

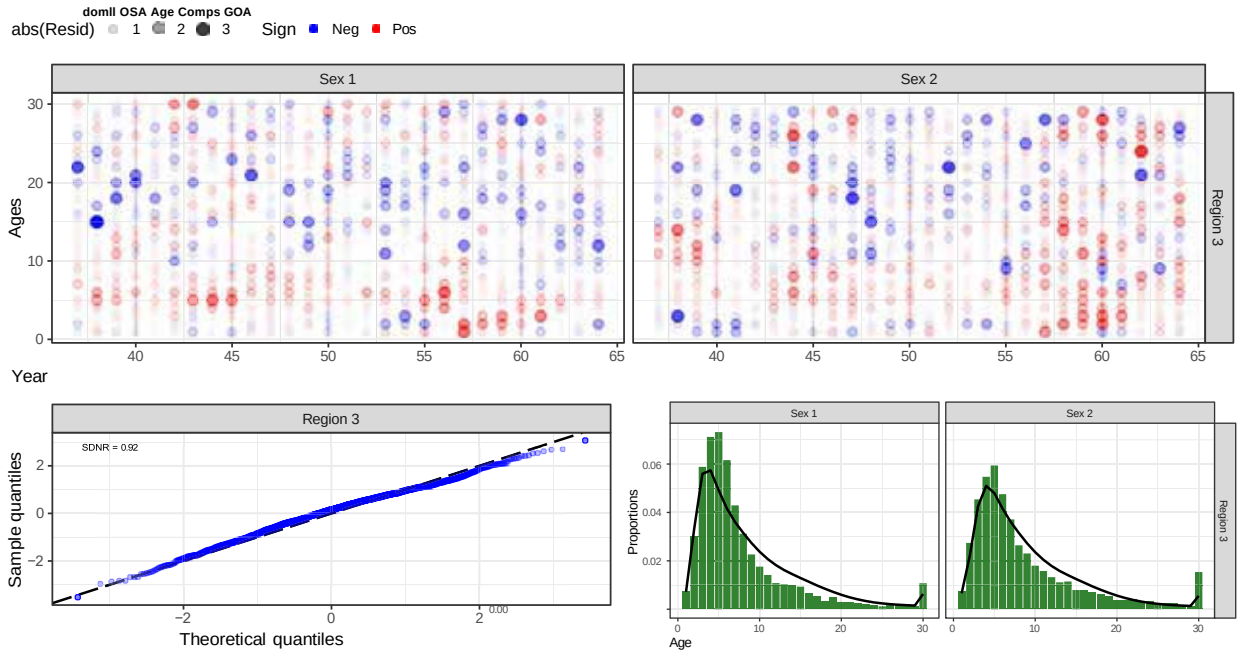

Figure 3D.11. Age composition fits from the three-region model for the domestic longline survey in the Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

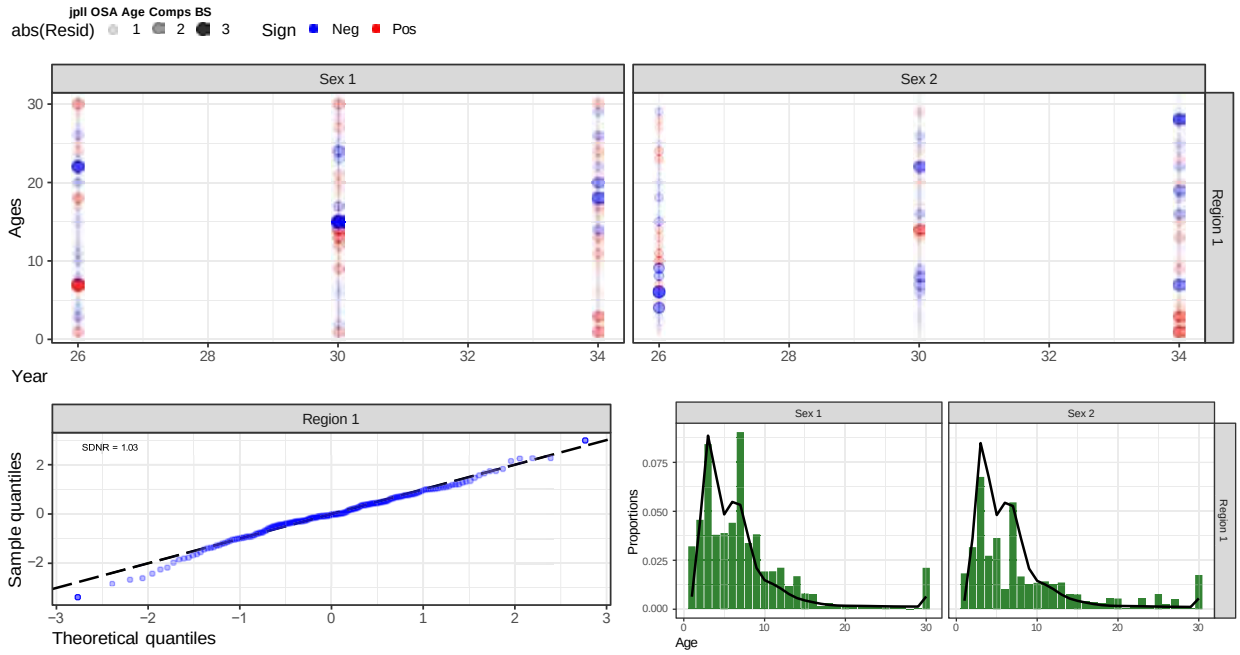

Figure 3D.12. Age composition fits from the three-region model for the Japanese longline survey in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

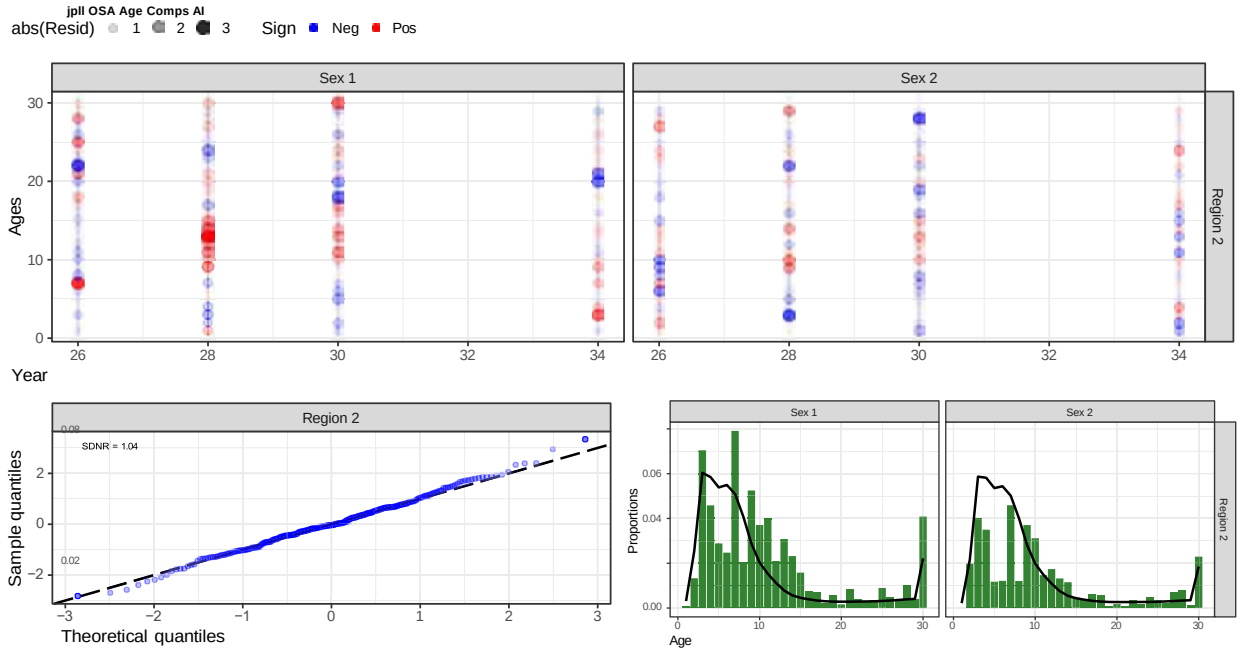

Figure 3D.13. Age composition fits from the three-region model for the Japanese longline survey in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

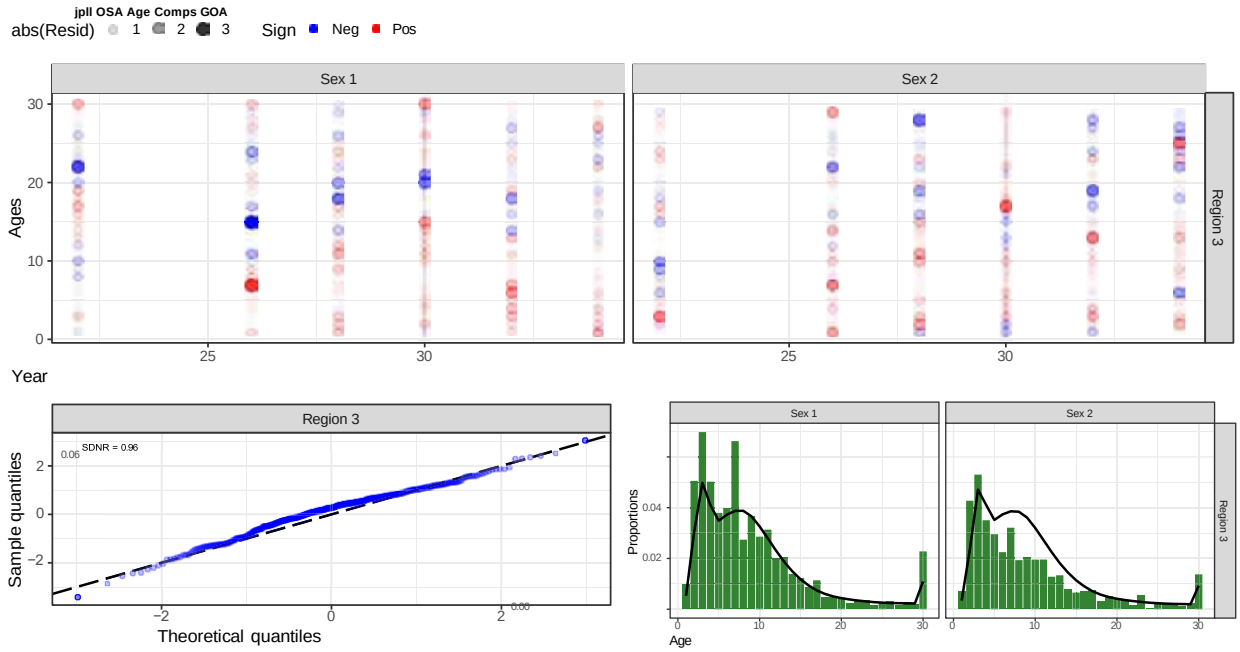

Figure 3D.14. Age composition fits from the three-region model for the Japanese longline survey in the Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

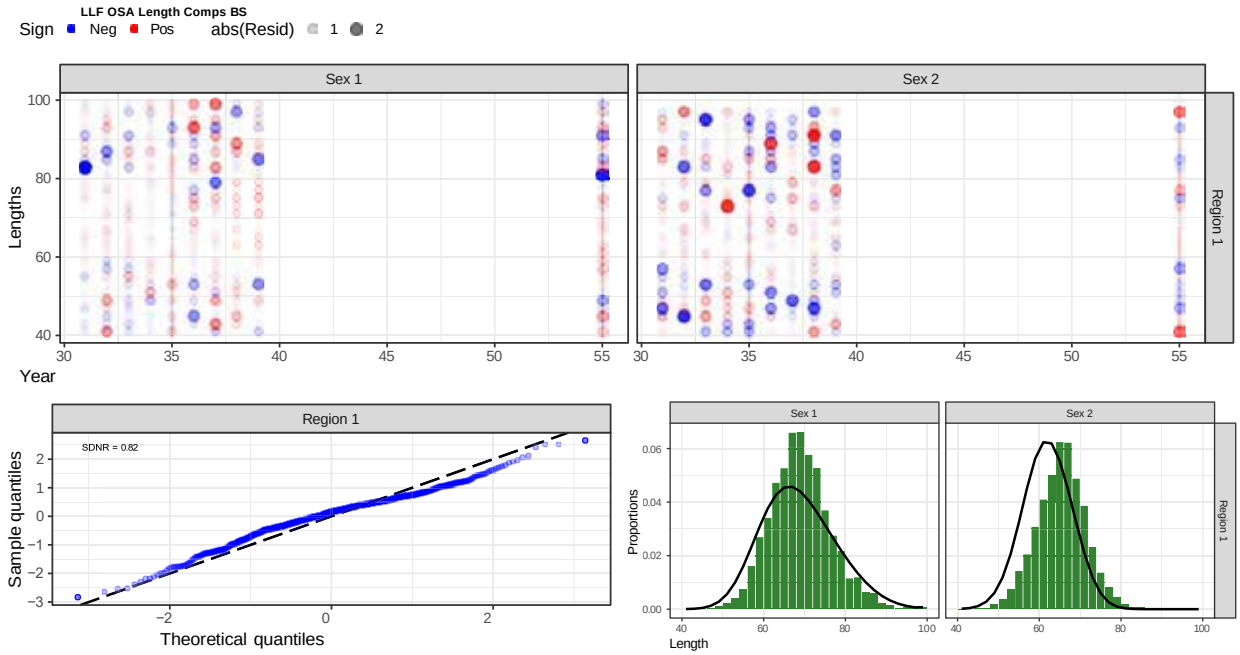

Figure 3D.15. Length composition fits from the three-region model for the longline fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

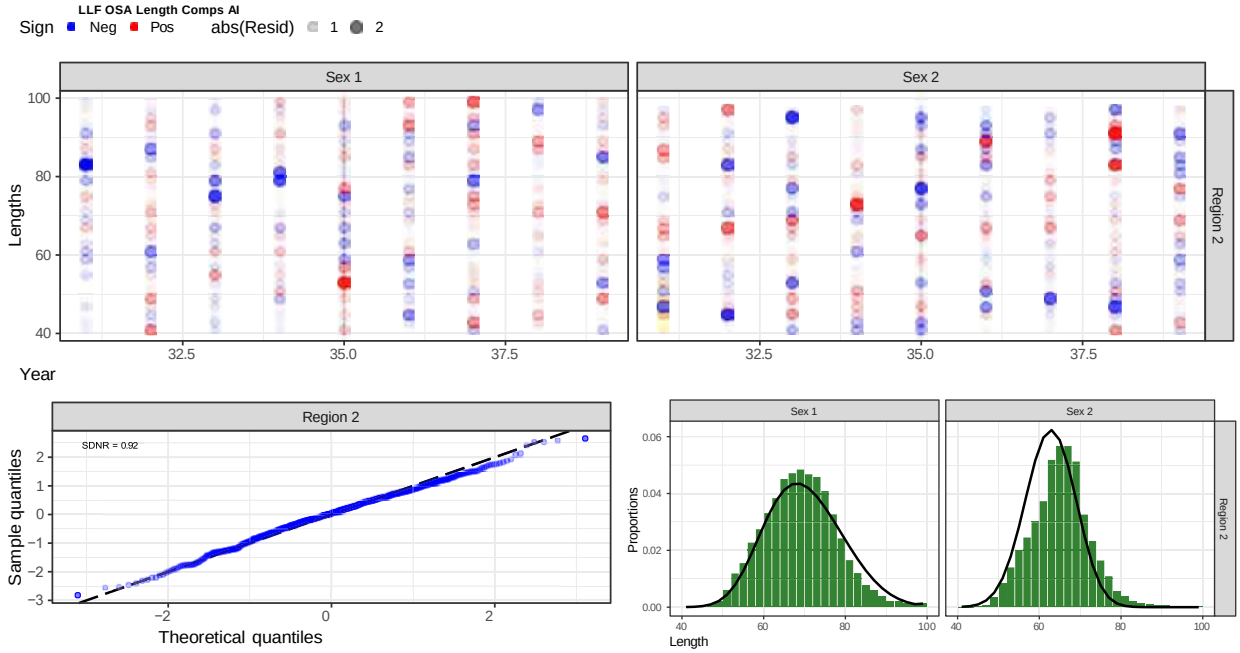

Figure 3D.16. Length composition fits from the three-region model for the longline fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

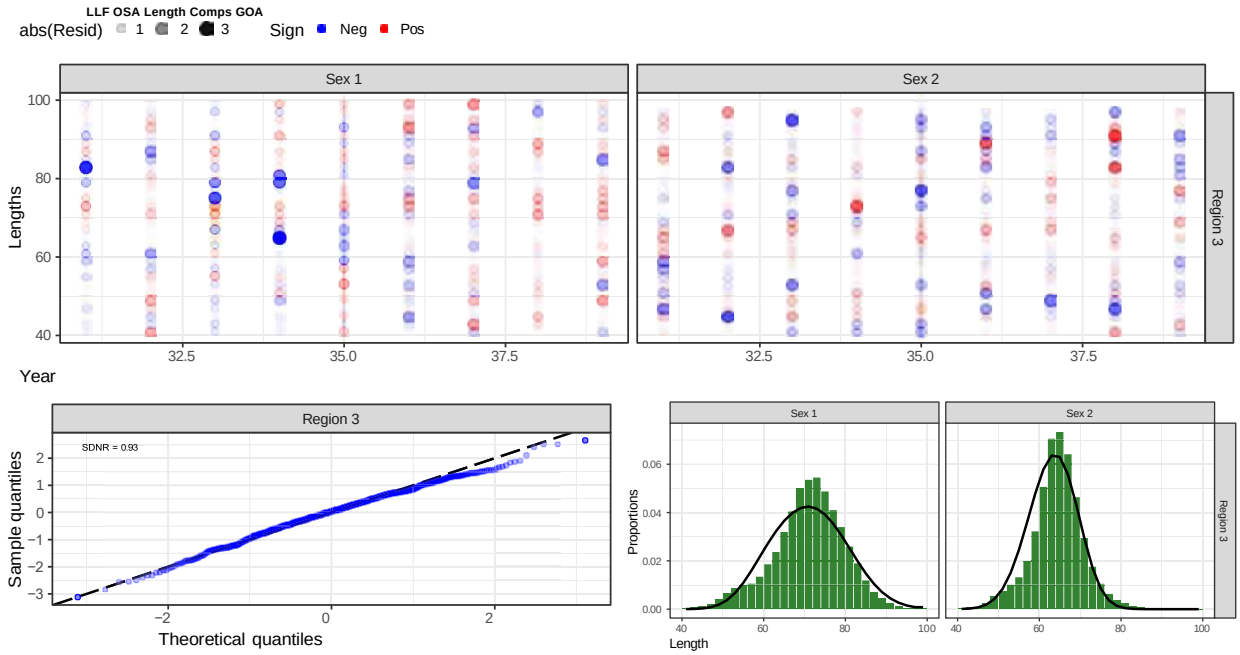

Figure 3D.17. Length composition fits from the three-region model for the longline fishery in the Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

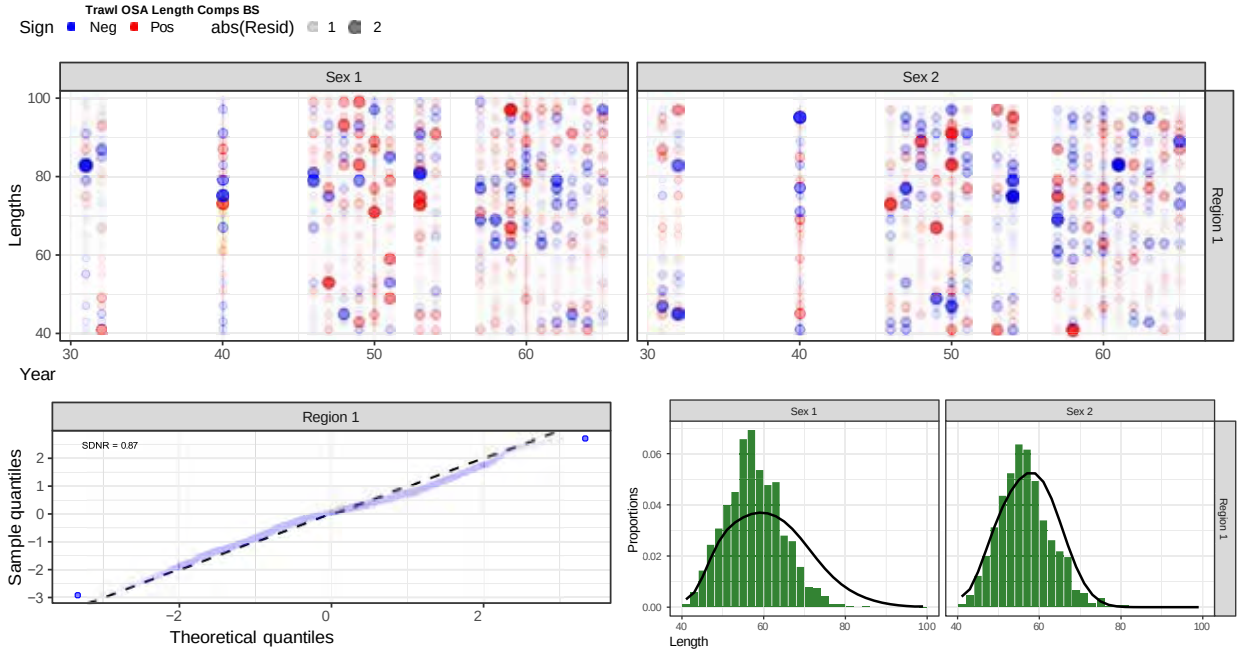

Figure 3D.18 Length composition fits from the three-region model for the trawl fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

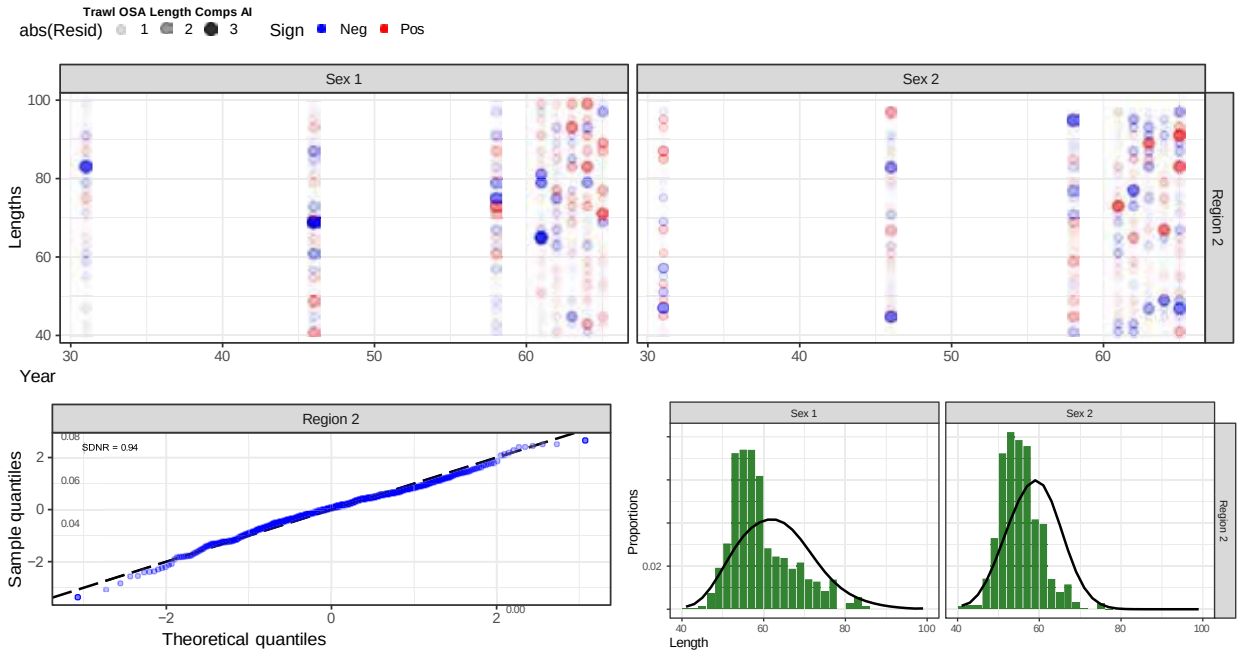

Figure 3D.19 Length composition fits from the three-region model for the trawl fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

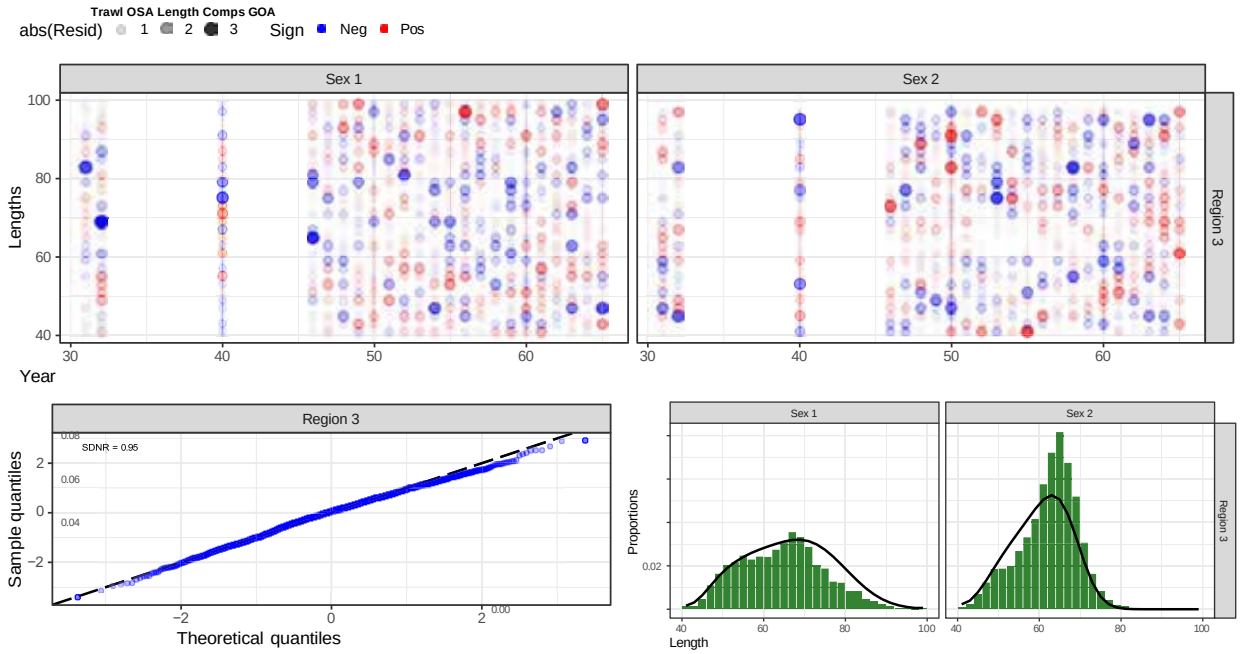

Figure 3D.20 Length composition fits from the three-region model for the trawl fishery in the Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

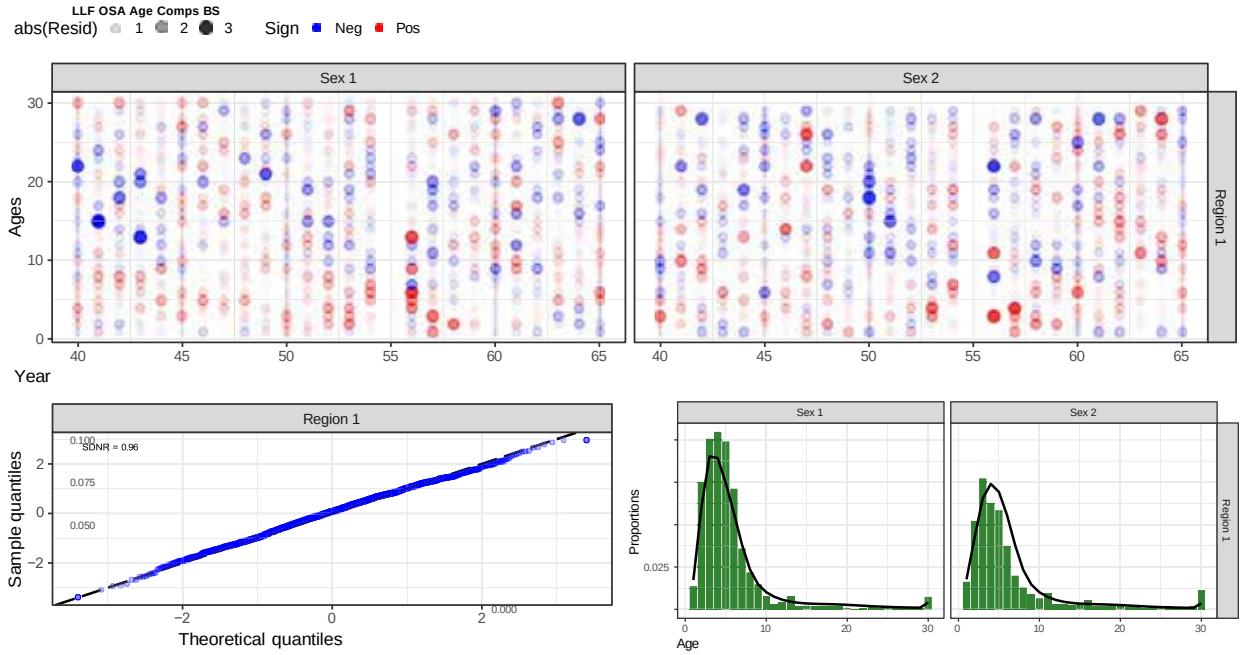

Figure 3D.21. Age composition fits from the five-region model for the longline fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

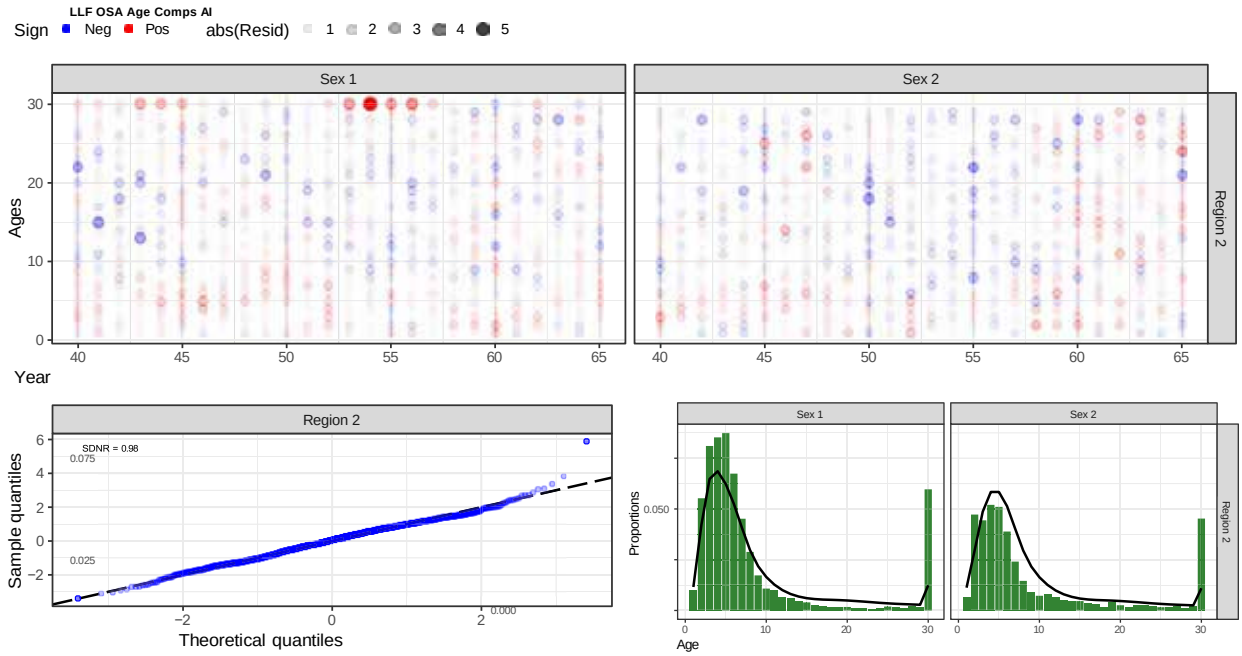

Figure 3D.22. Age composition fits from the five-region model for the longline fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

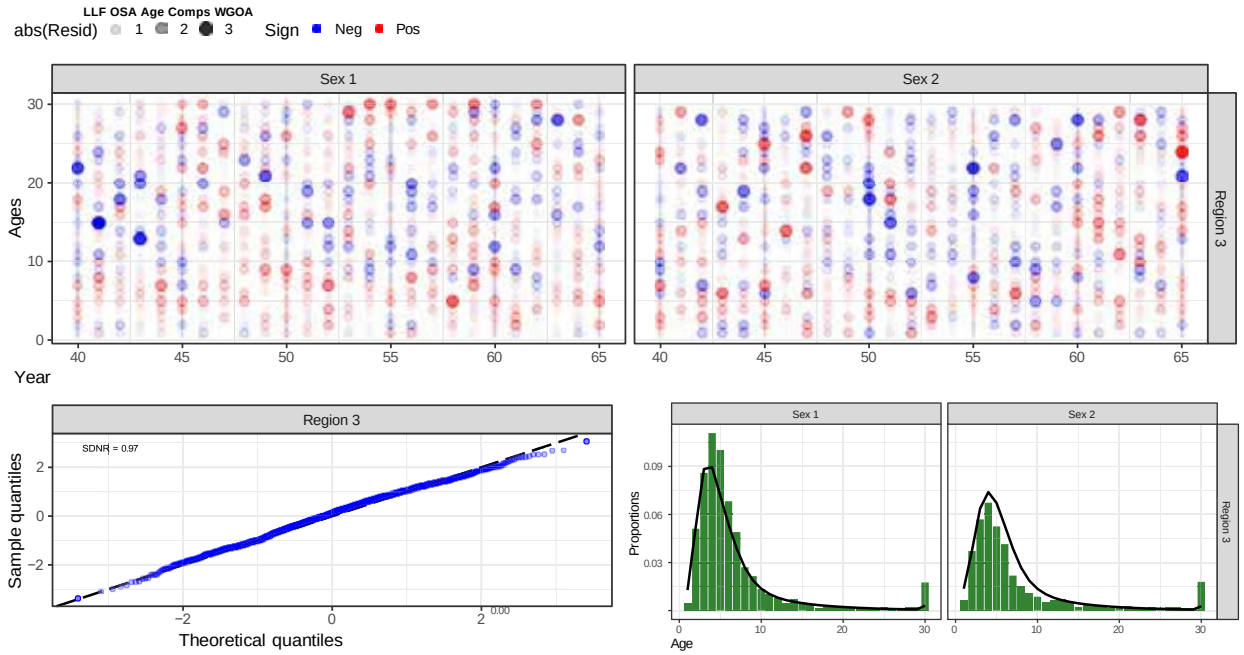

Figure 3D.23. Age composition fits from the five-region model for the longline fishery in the western Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

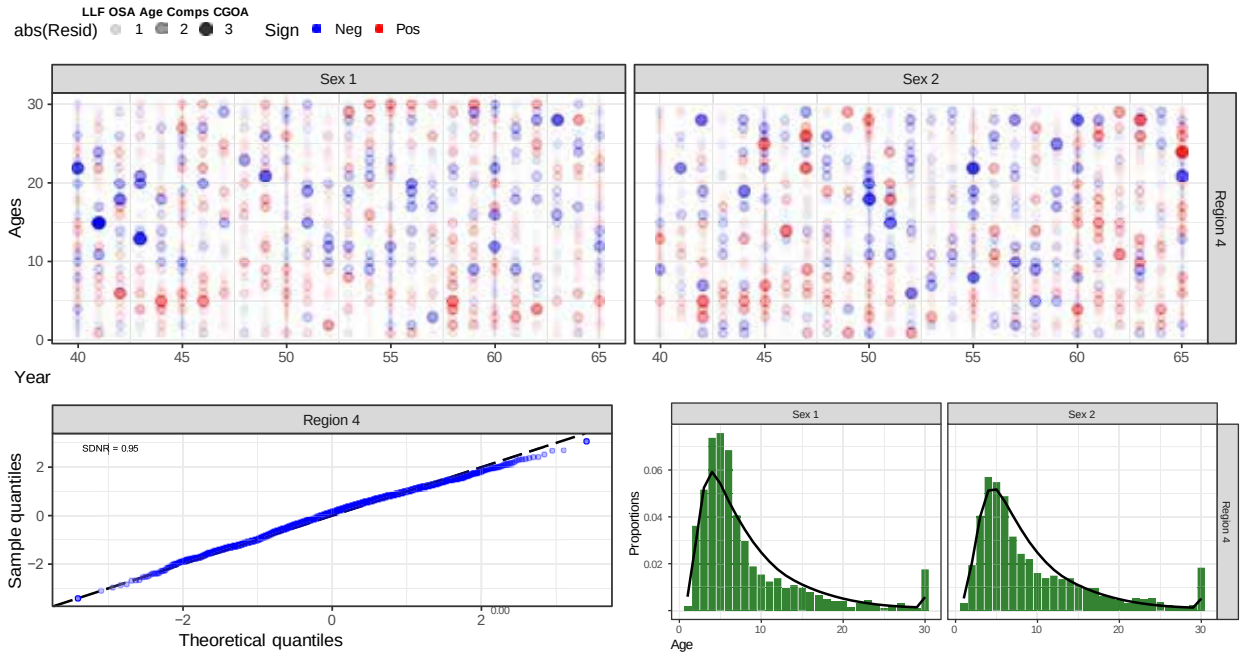

Figure 3D.24. Age composition fits from the five-region model for the longline fishery in the central Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

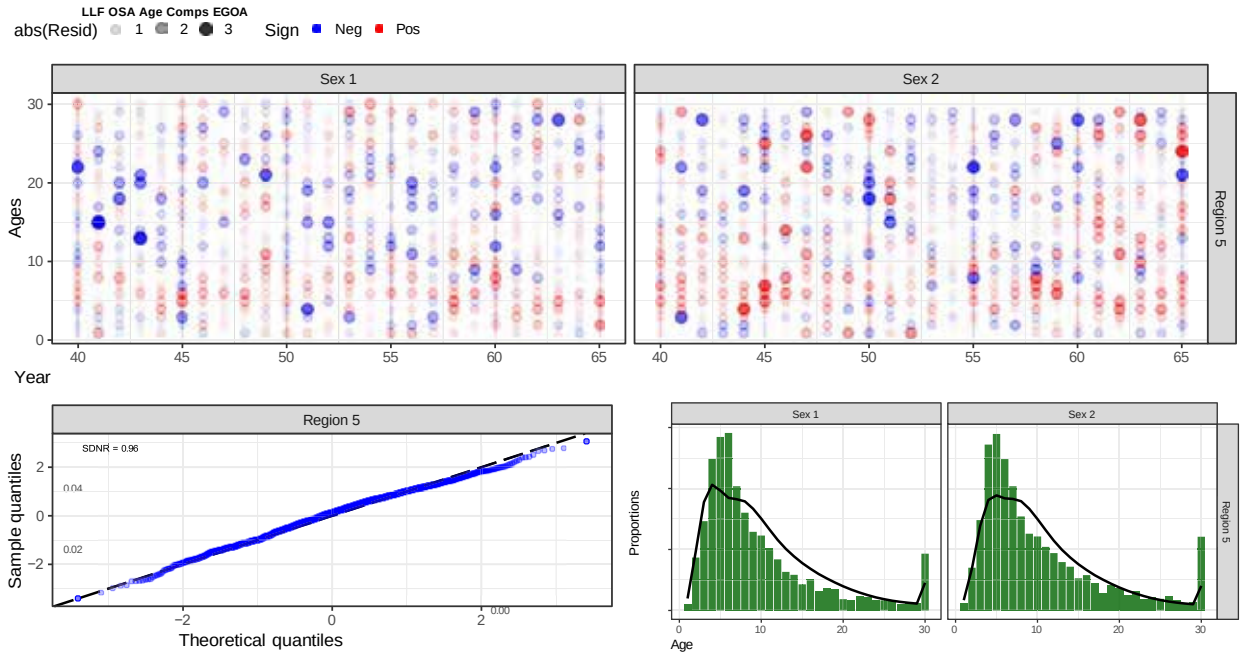

Figure 3D.25. Age composition fits from the five-region model for the longline fishery in the eastern Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

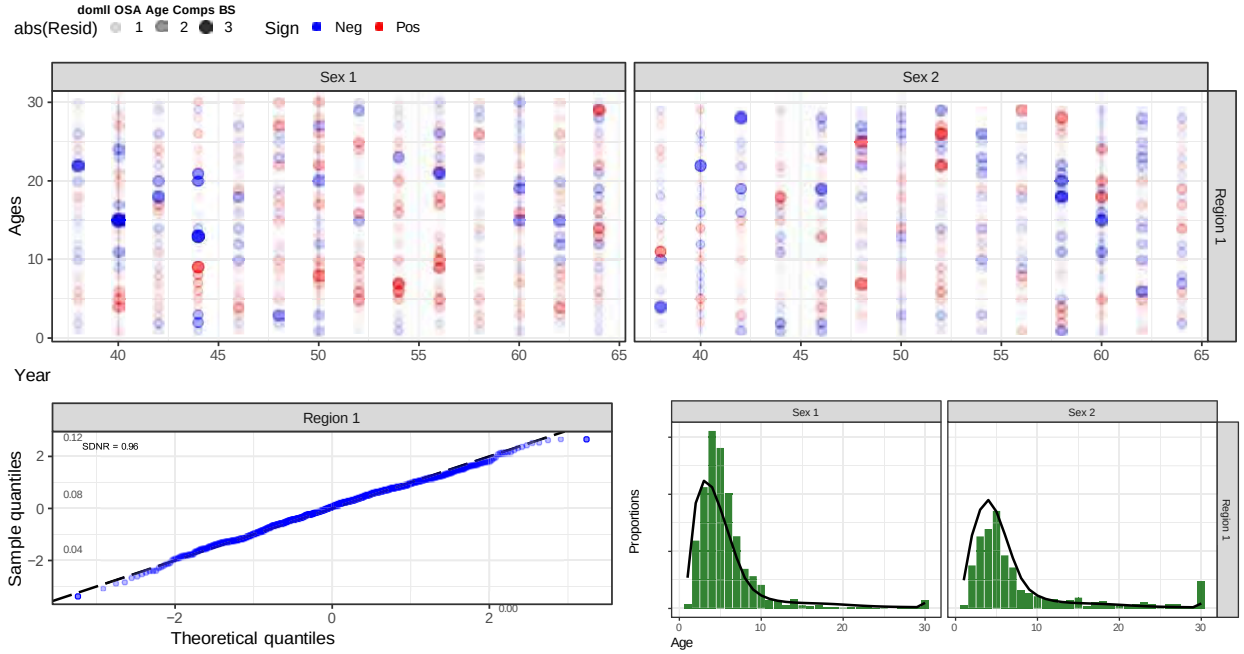

Figure 3D.24. Age composition fits from the five-region model for the domestic longline survey in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

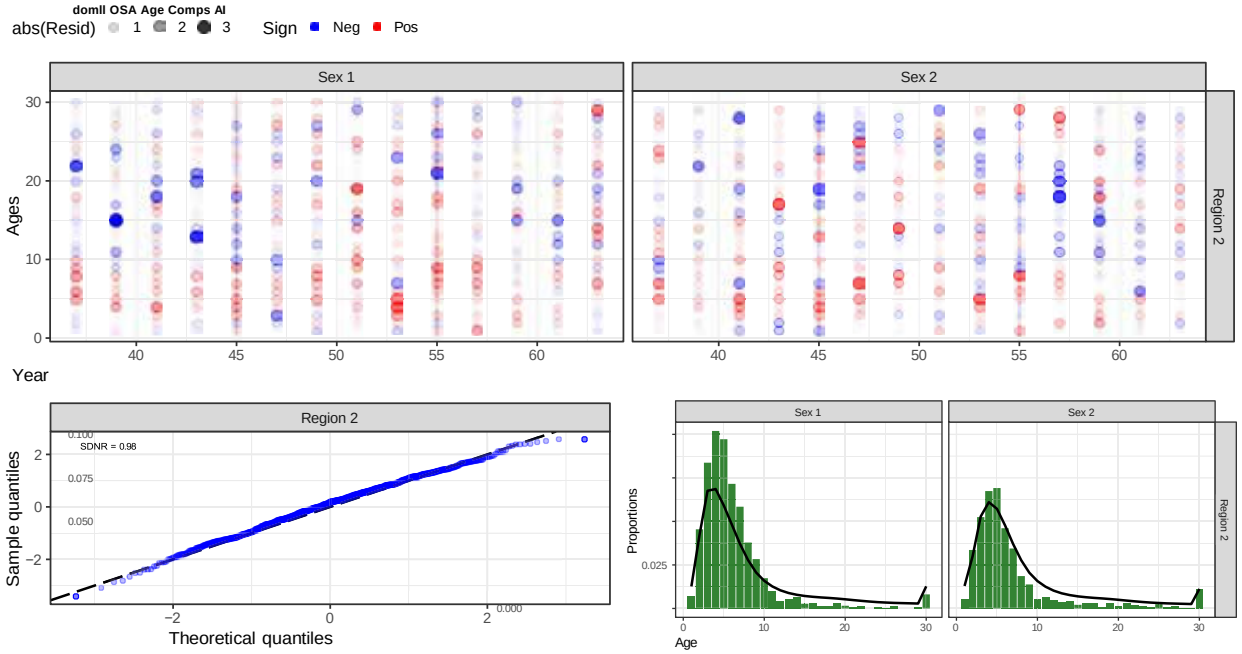

Figure 3D.25. Age composition fits from the five-region model for the domestic longline survey in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

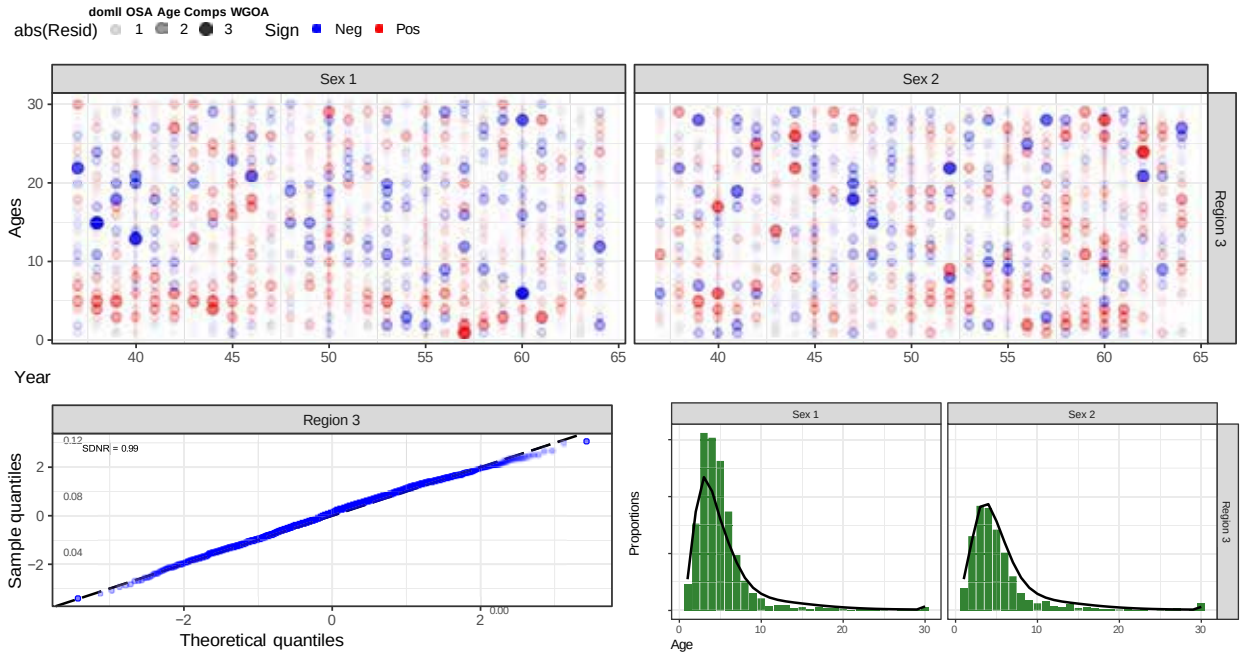

Figure 3D.26. Age composition fits from the five-region model for the domestic longline survey in the western Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

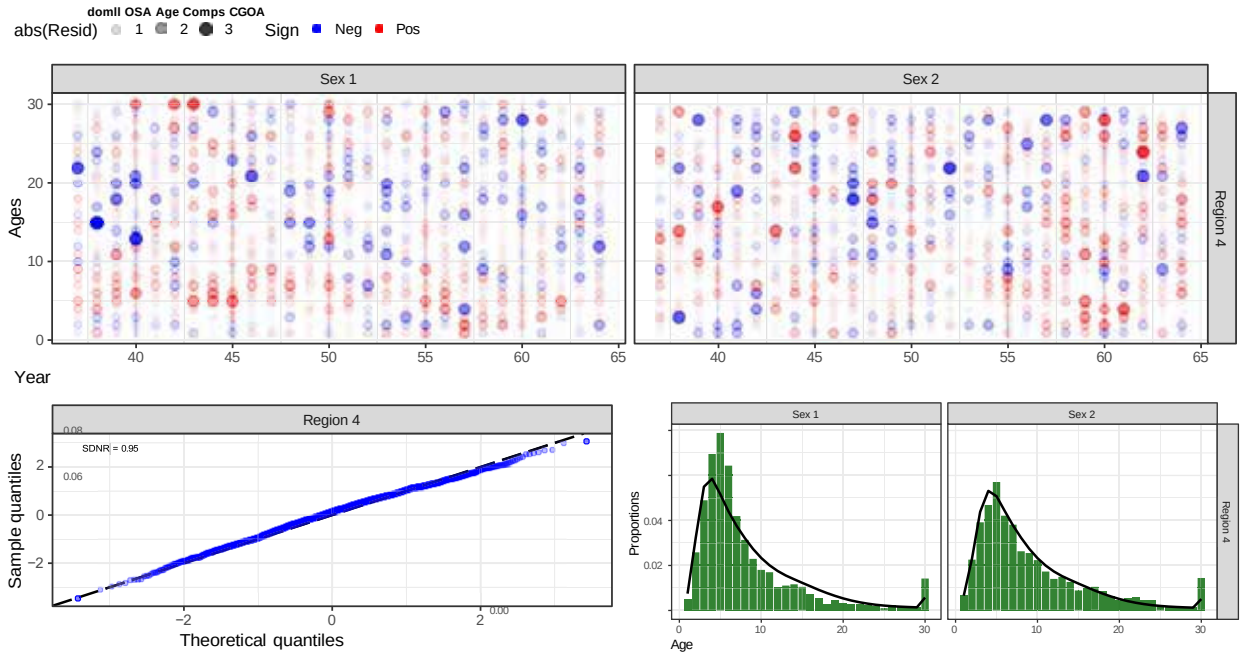

Figure 3D.27. Age composition fits from the five-region model for the domestic longline survey in the central Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

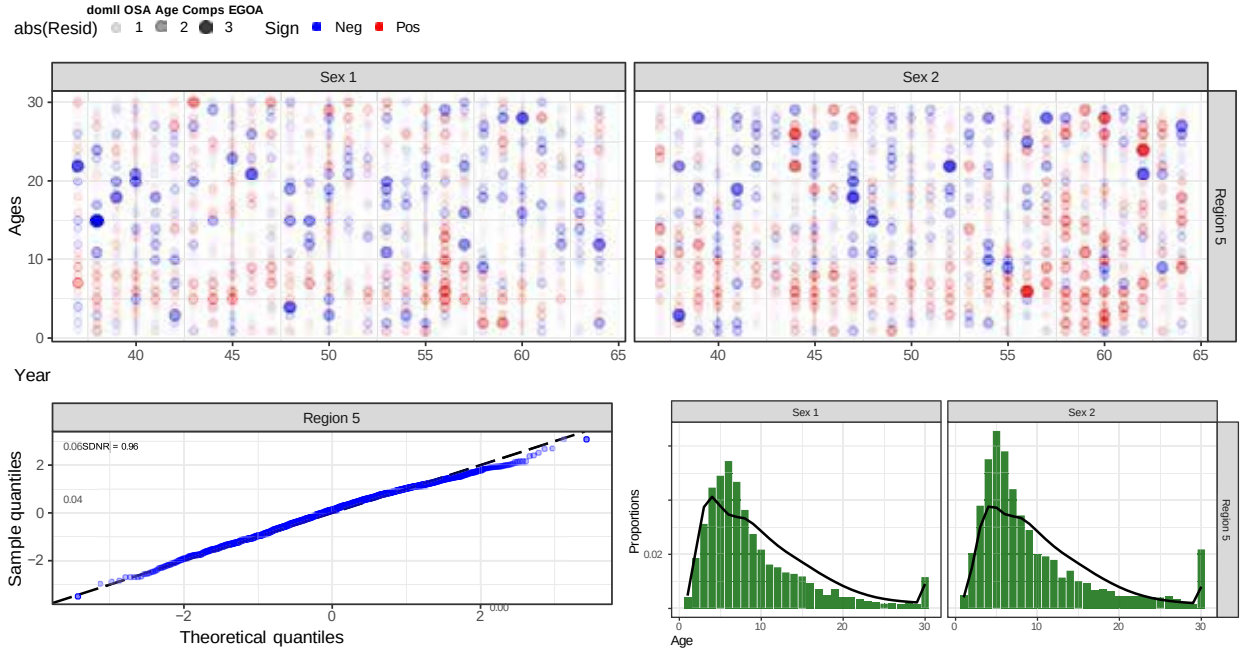

Figure 3D.28 Age composition fits from the five-region model for the domestic longline survey in the eastern Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

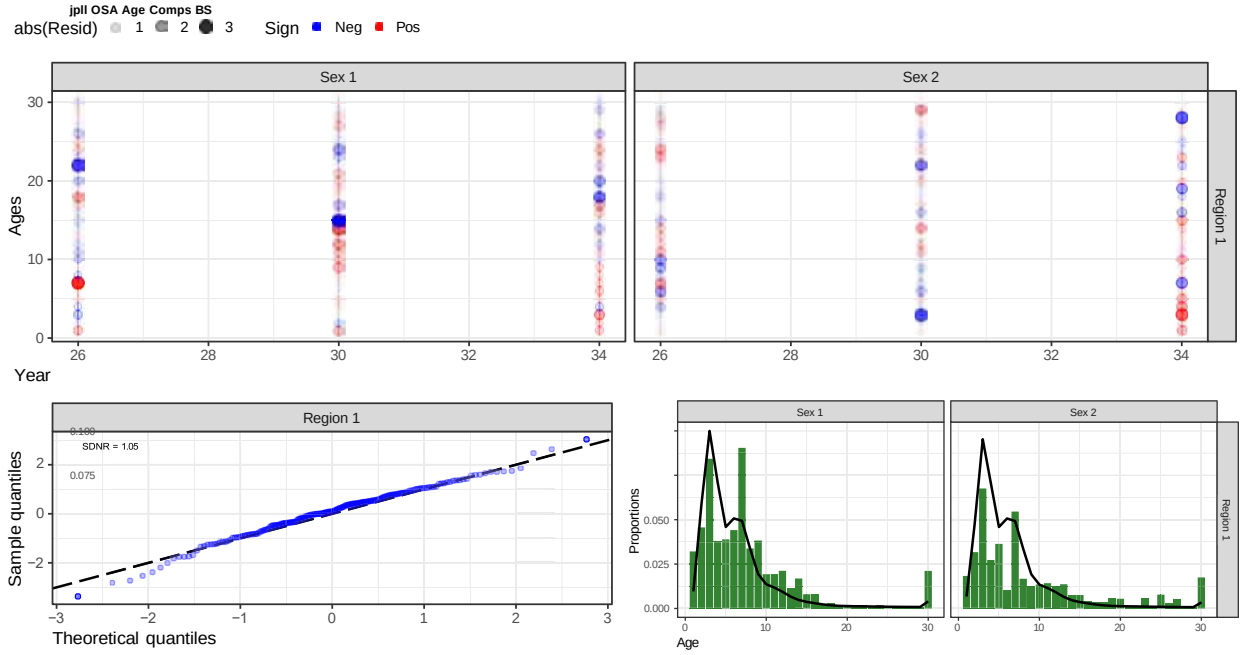

Figure 3D.29 Age composition fits from the five-region model for the Japanese longline survey in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

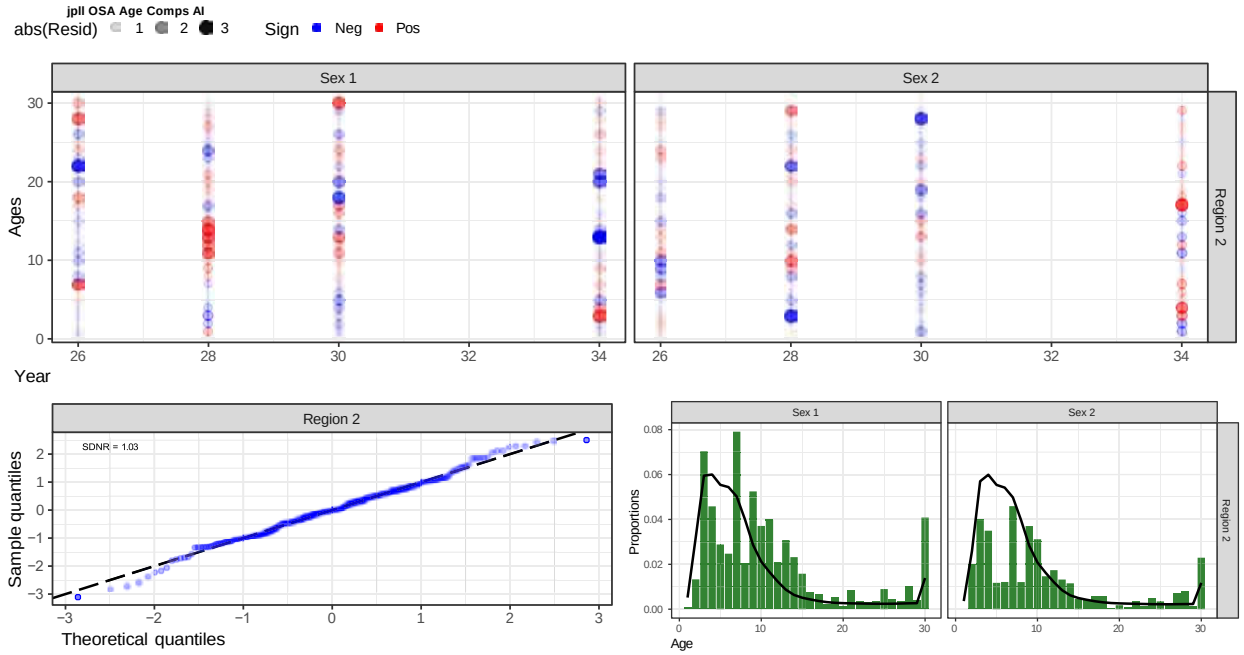

Figure 3D.30 Age composition fits from the five-region model for the Japanese longline survey in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

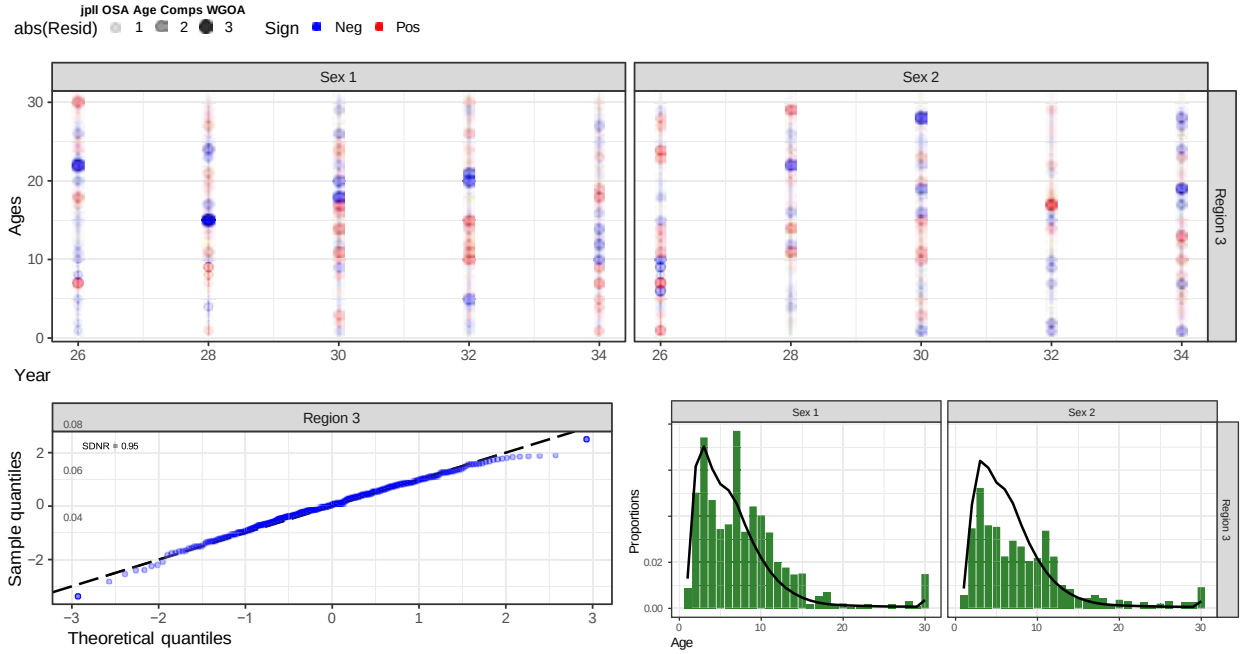

Figure 3D.31. Age composition fits from the five-region model for the Japanese longline survey in the western Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

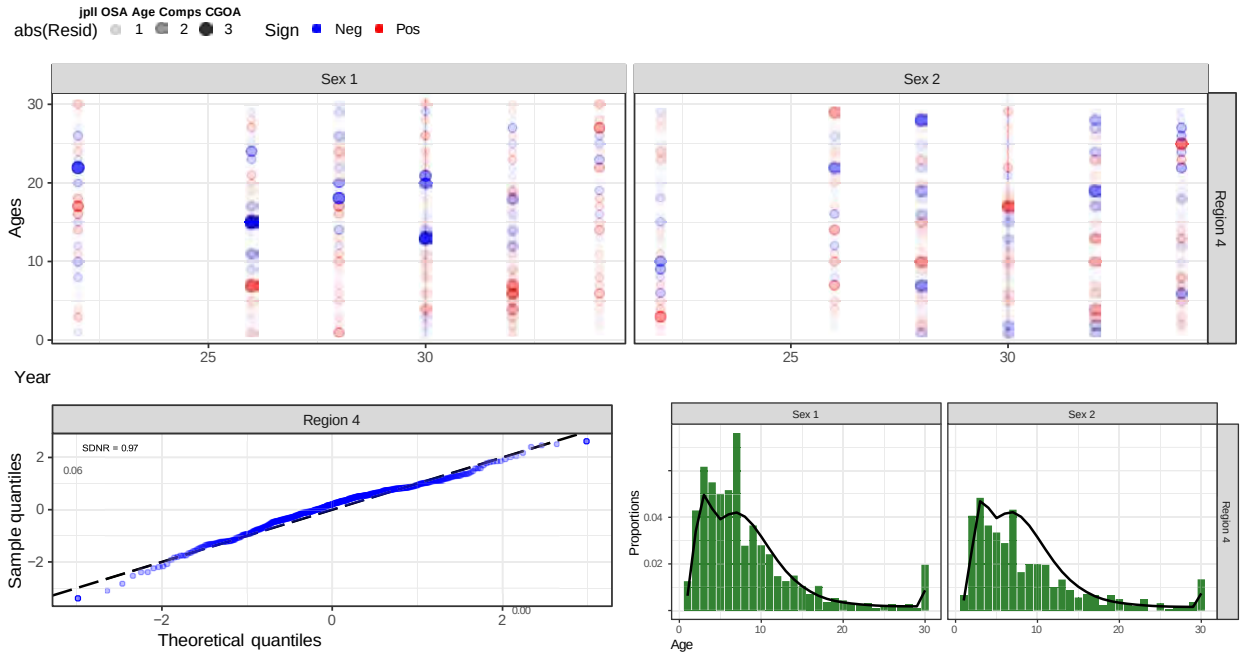

Figure 3D.32. Age composition fits from the five-region model for the Japanese longline survey in the central Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

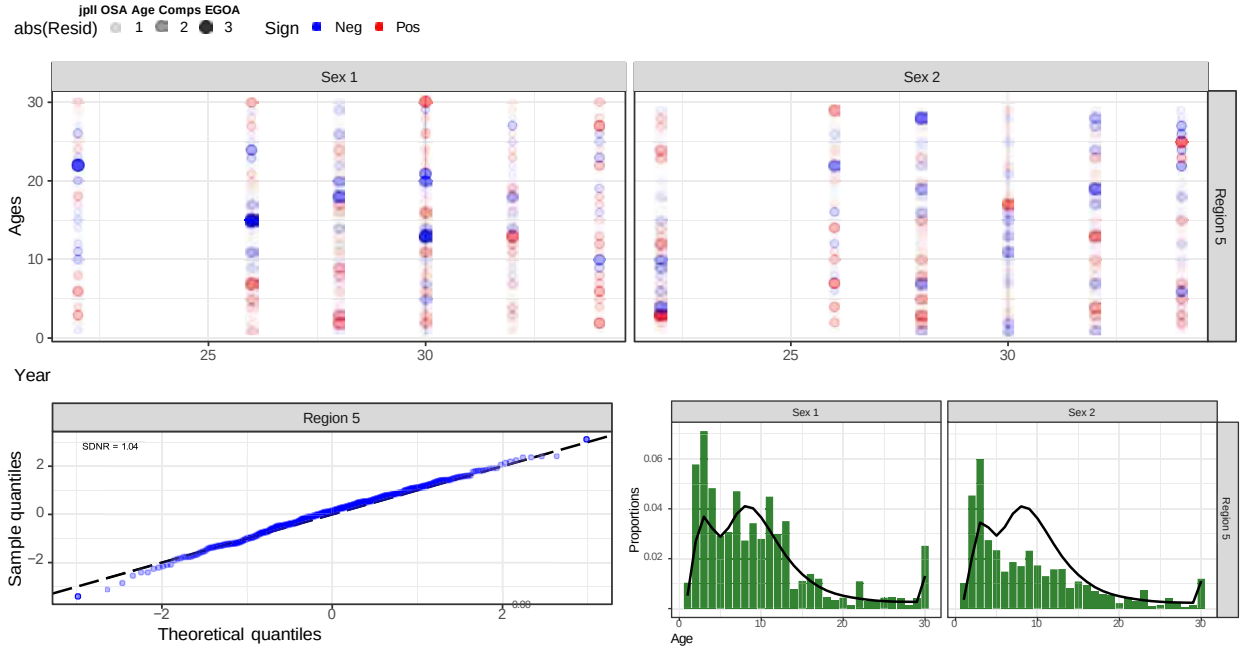

Figure 3D.33. Age composition fits from the five-region model for the Japanese longline survey in the eastern Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

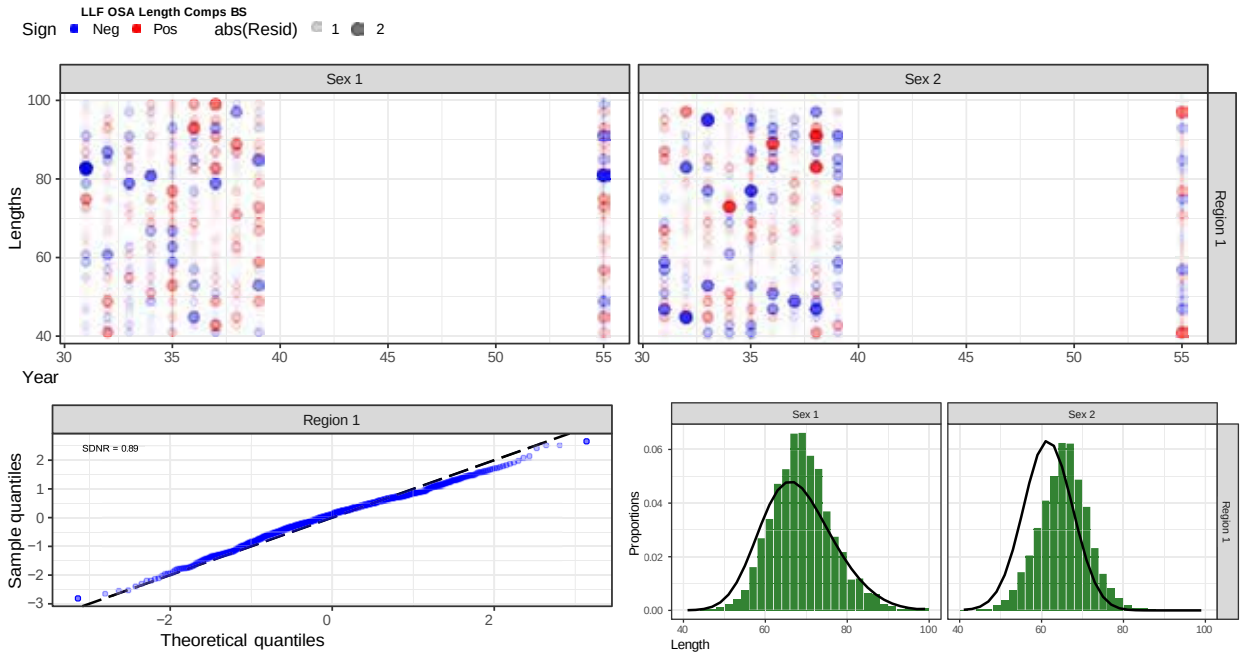

Figure 3D.34. Length composition fits from the five-region model for the longline fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

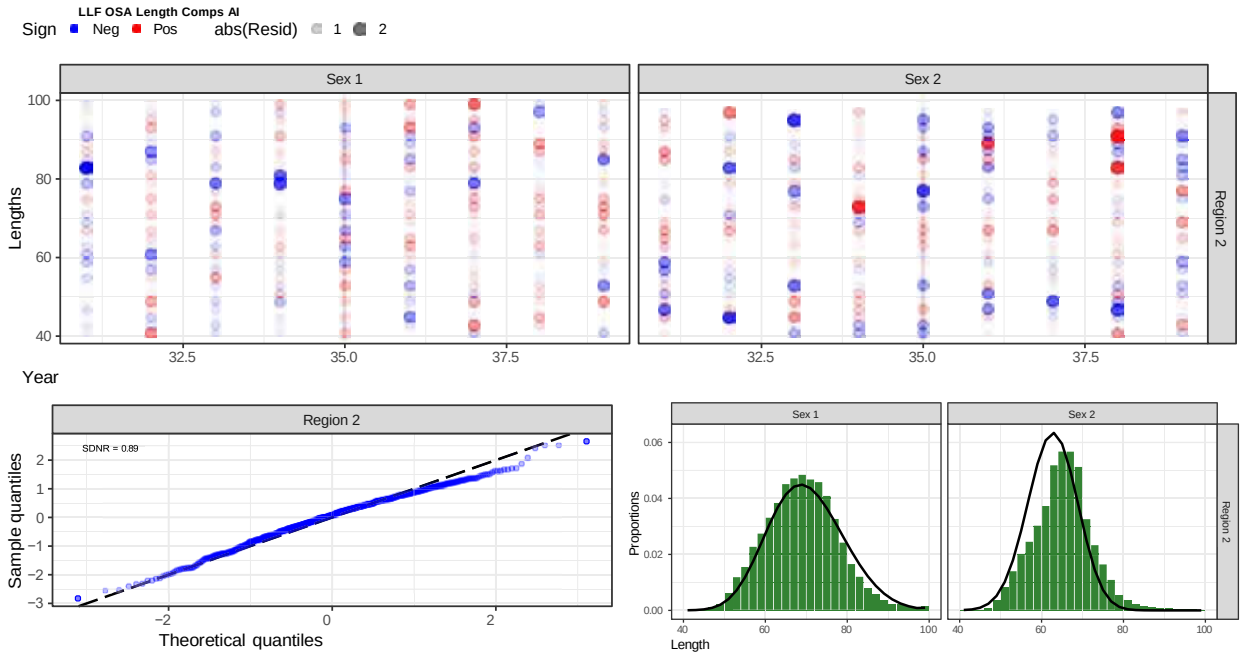

Figure 3D.35. Length composition fits from the five-region model for the longline fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

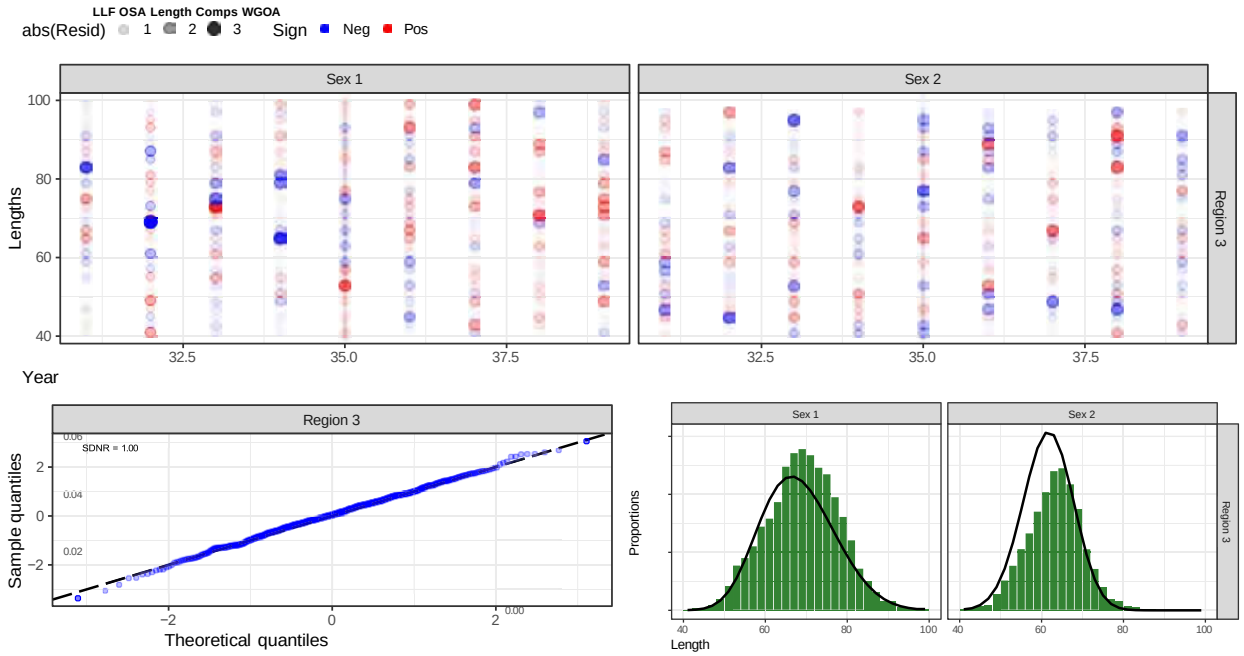

Figure 3D.36. Length composition fits from the five-region model for the longline fishery in the western Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

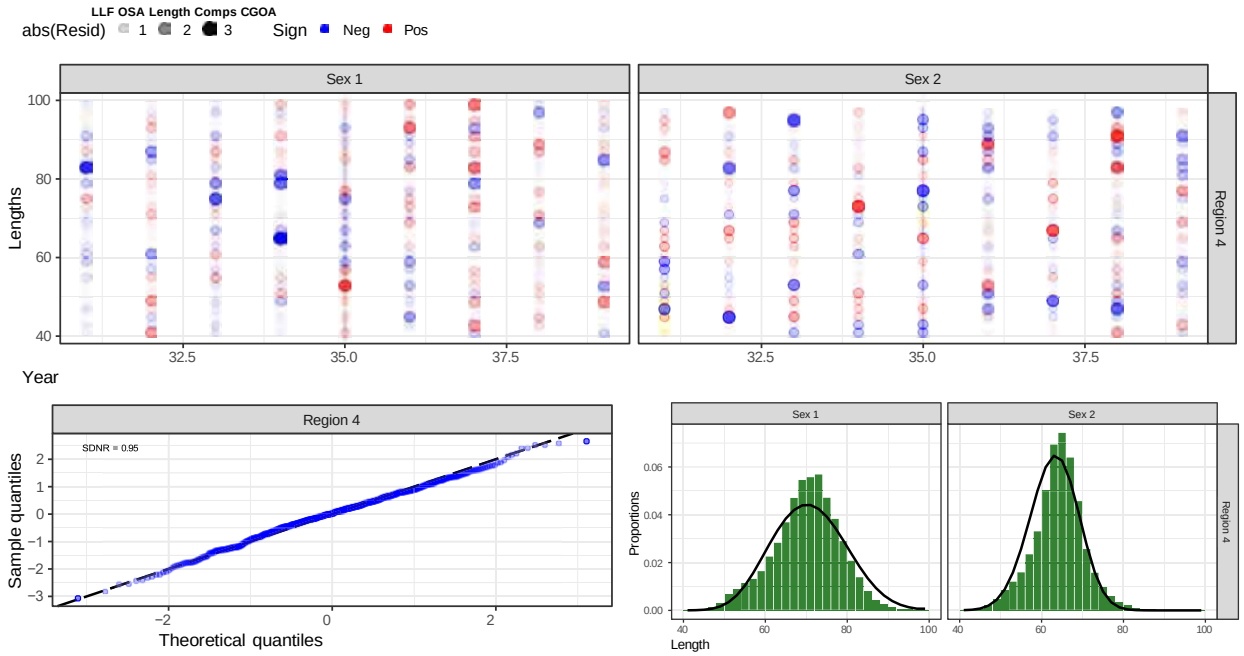

Figure 3D.37. Length composition fits from the five-region model for the longline fishery in the central Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

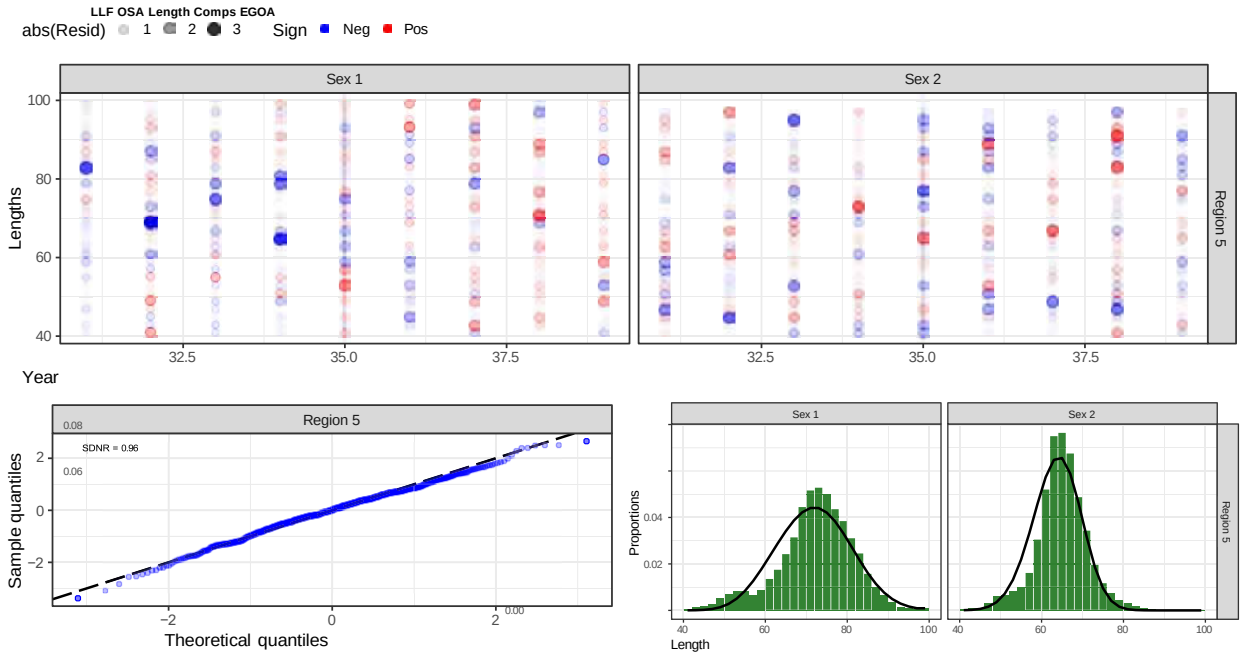

Figure 3D.38 Length composition fits from the five-region model for the longline fishery in the eastern Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

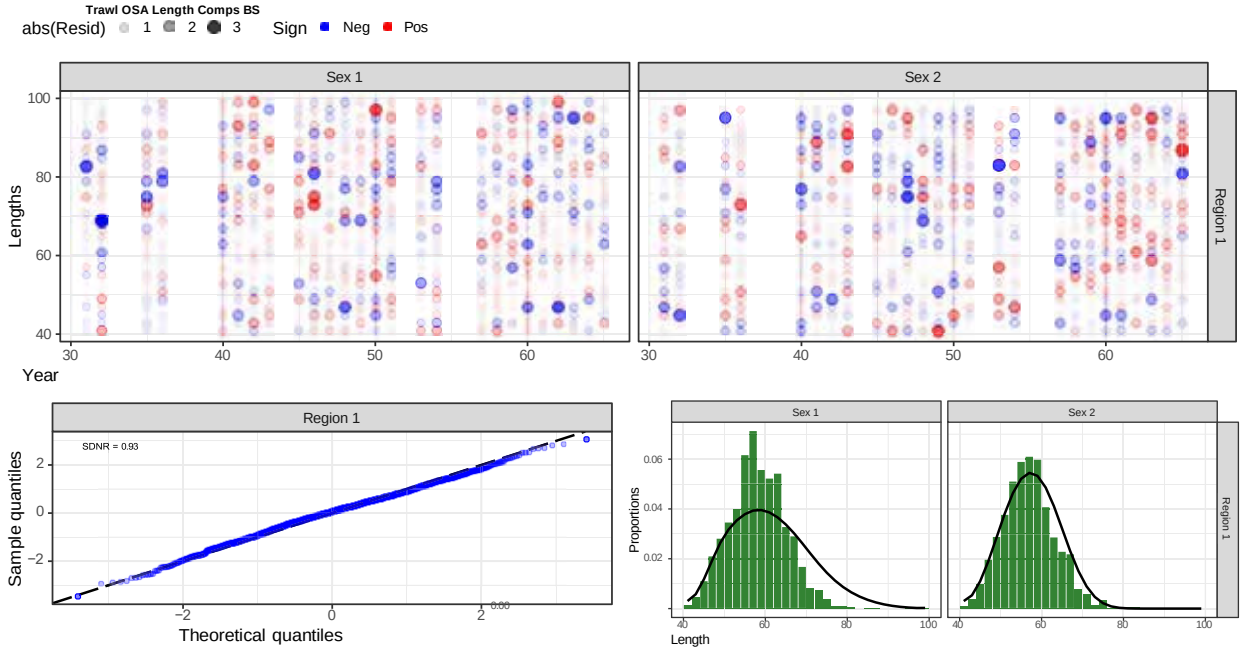

Figure 39 Length composition fits from the five-region model for the trawl fishery in the Bering Sea. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

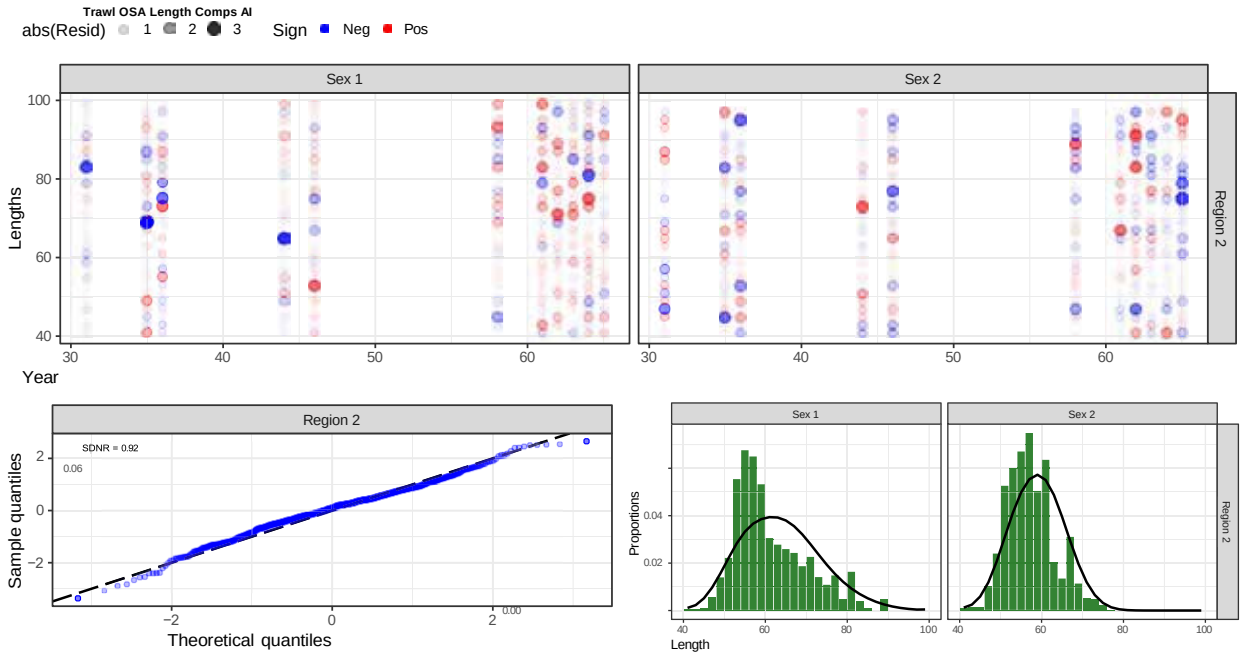

Figure 3D.40 Length composition fits from the five-region model for the trawl fishery in the Aleutian Islands. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

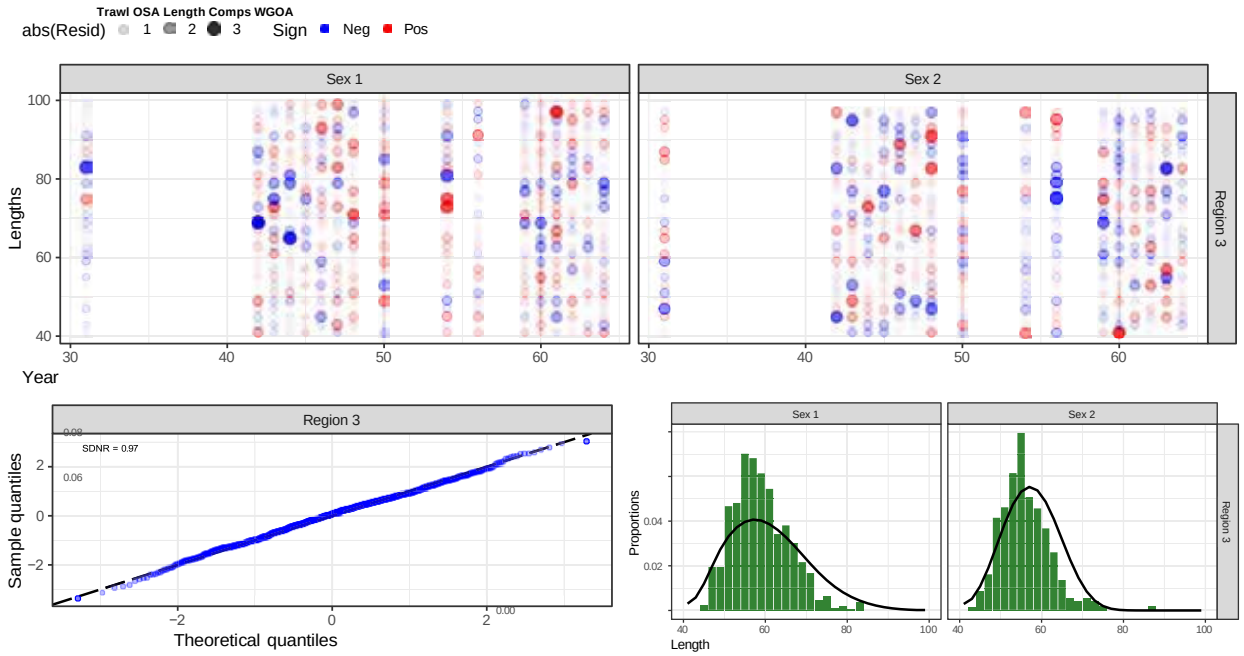

Figure 3D.41. Length composition fits from the five-region model for the trawl fishery in the western Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

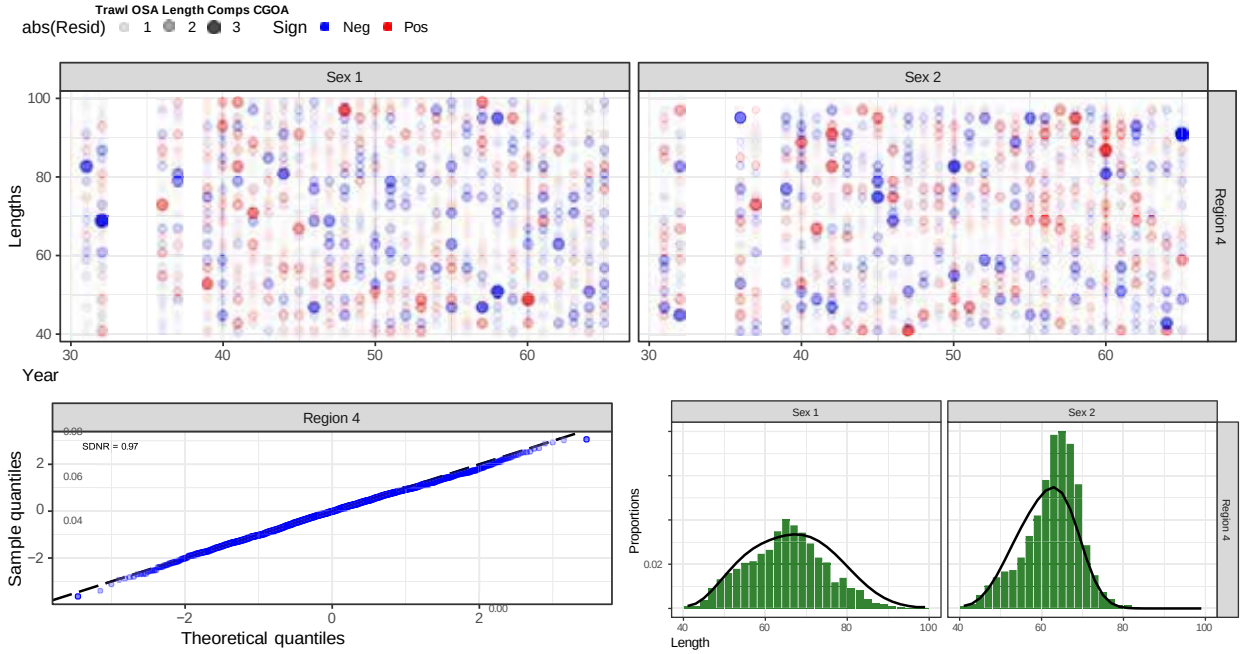

Figure 3D.42. Length composition fits from the five-region model for the trawl fishery in the central Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

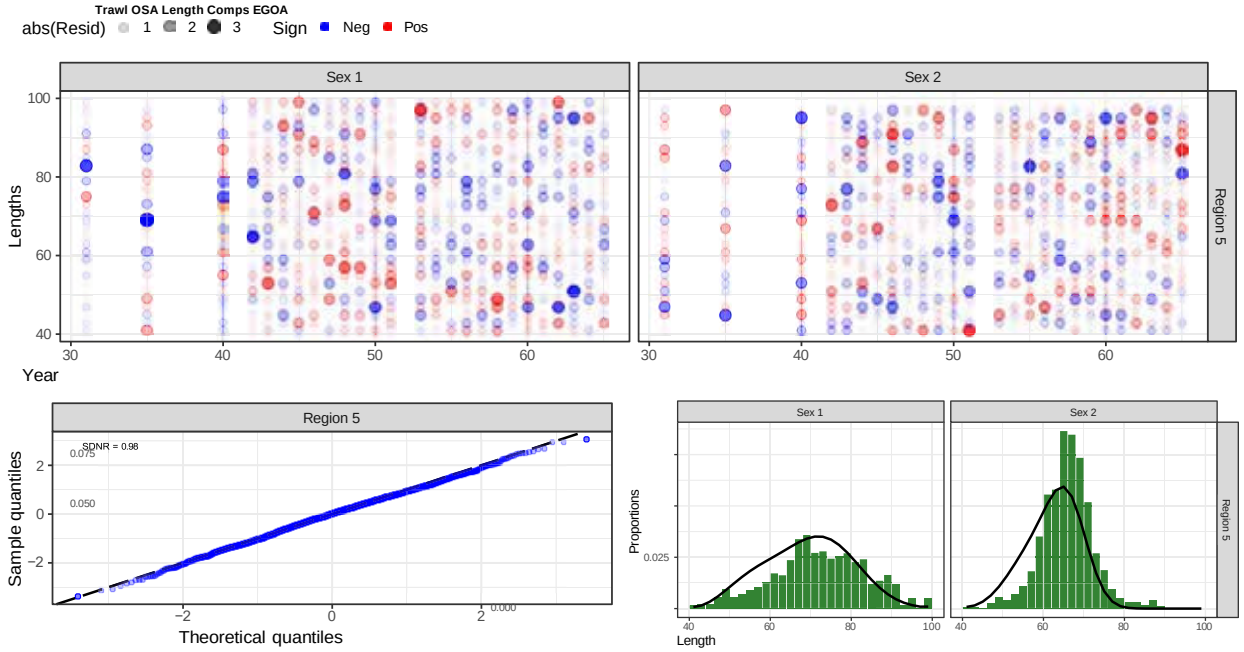

Figure 3D.43. Length composition fits from the five-region model for the trawl fishery in the eastern Gulf of Alaska. The upper panel depicts one-step ahead (OSA) residuals for females (Sex 1) and males (Sex 2). The bottom left panel represents a quantile-quantile plot of OSA residuals, with the standard deviation of the normalized residual displayed on the left corner. The bottom right panel illustrates aggregate fits to the composition data (green denotes observed, black denotes expected).

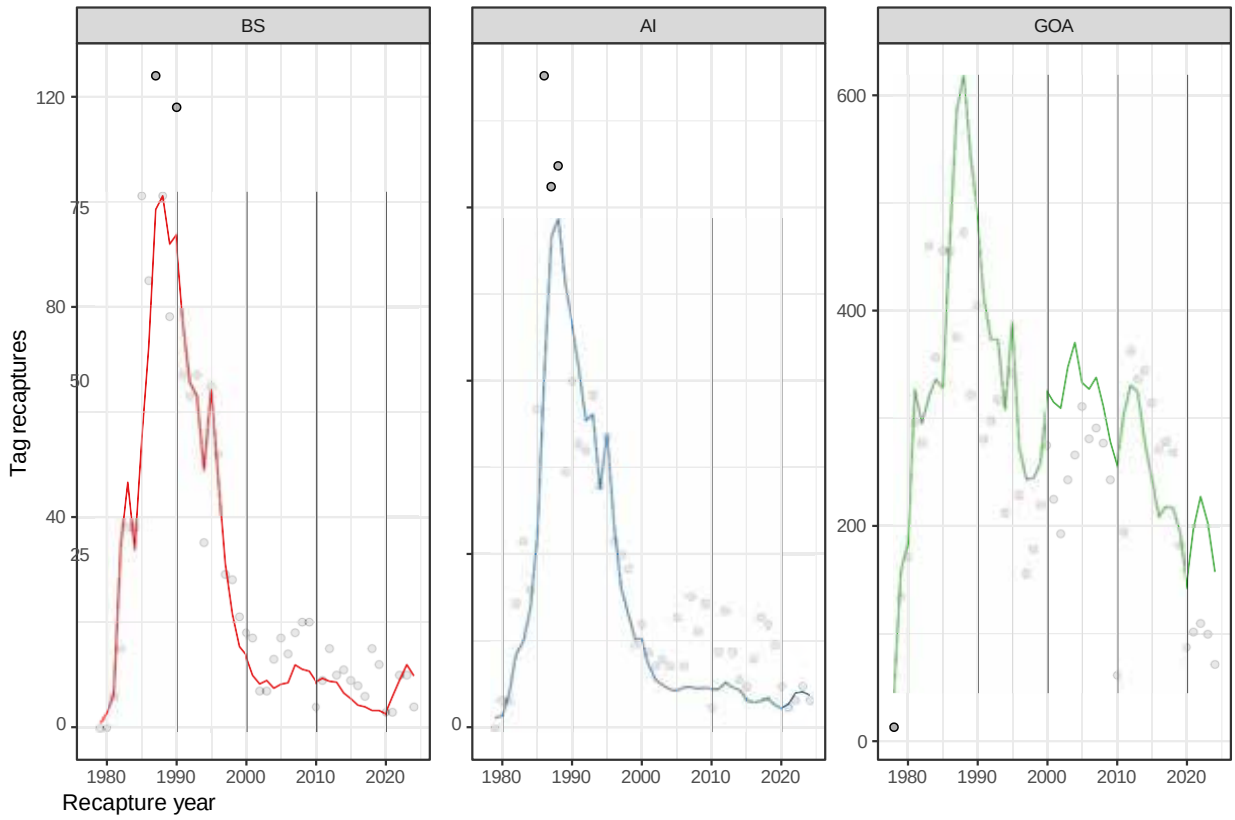

Figure 3D.44. Fits to tag recaptures across regions for the three-region model. Colored lines represent the model expectation while grey points denote observed recaptures.

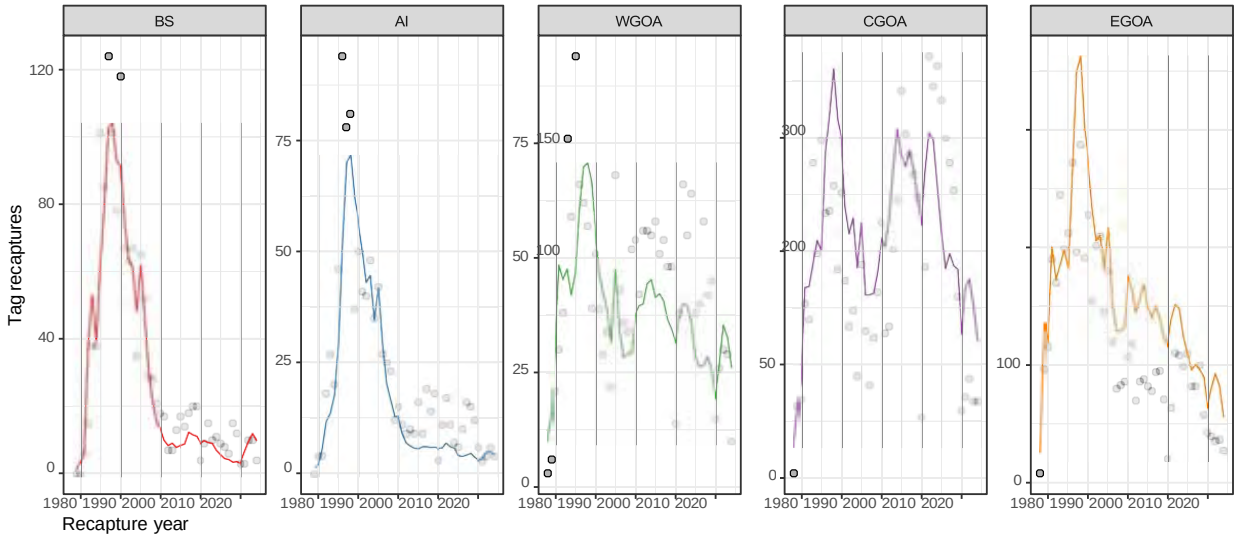

Figure 3D.45. Fits to tag recaptures across regions for the five-region model. Colored lines represent the model expectation while grey points denote observed recaptures.

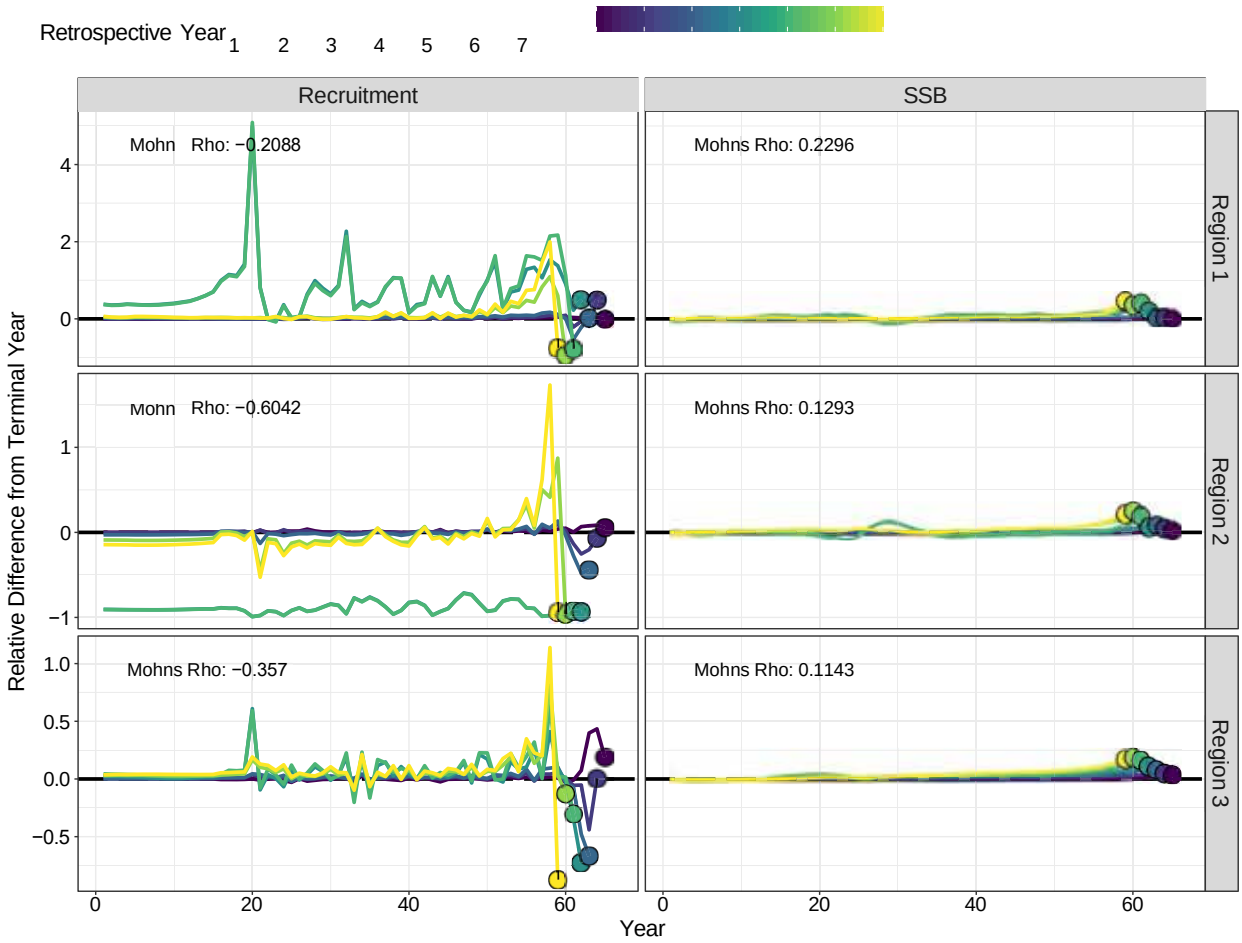

Figure 3D.46. Retrospective analysis from the three-region model. Column panels represent time series of recruitment and spawning stock biomass (*SSB*) as data are sequentially removed. Row panels denote the modeled regions, where region 1 represents the Bering Sea, region 2 represents the Aleutian Islands, and region 3 represents the Gulf of Alaska. Mohn's rho values are shown in the upper left of each panel.

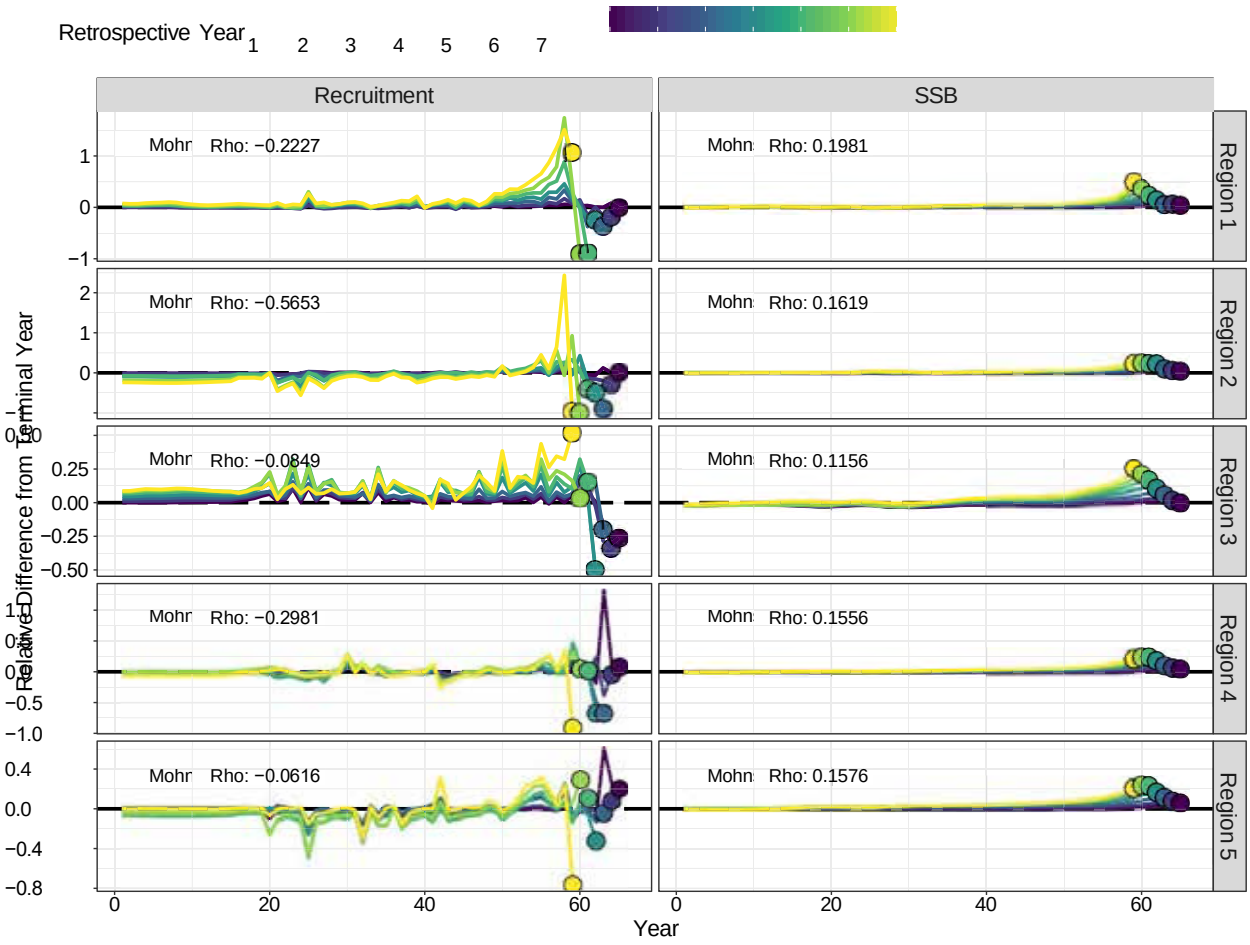

Figure 3D.47. Retrospective analysis from the five-region model. Column panels represent time series of recruitment and spawning stock biomass (*SSB*) as data are sequentially removed. Row panels denote the modeled regions, where region 1 represents the Bering Sea, region 2 represents the Aleutian Islands, region 3 represents the western Gulf of Alaska, region 4 represents the central Gulf of Alaska, and region 5 represents the eastern Gulf of Alaska. Mohn's rho values are shown in the upper left of each panel.

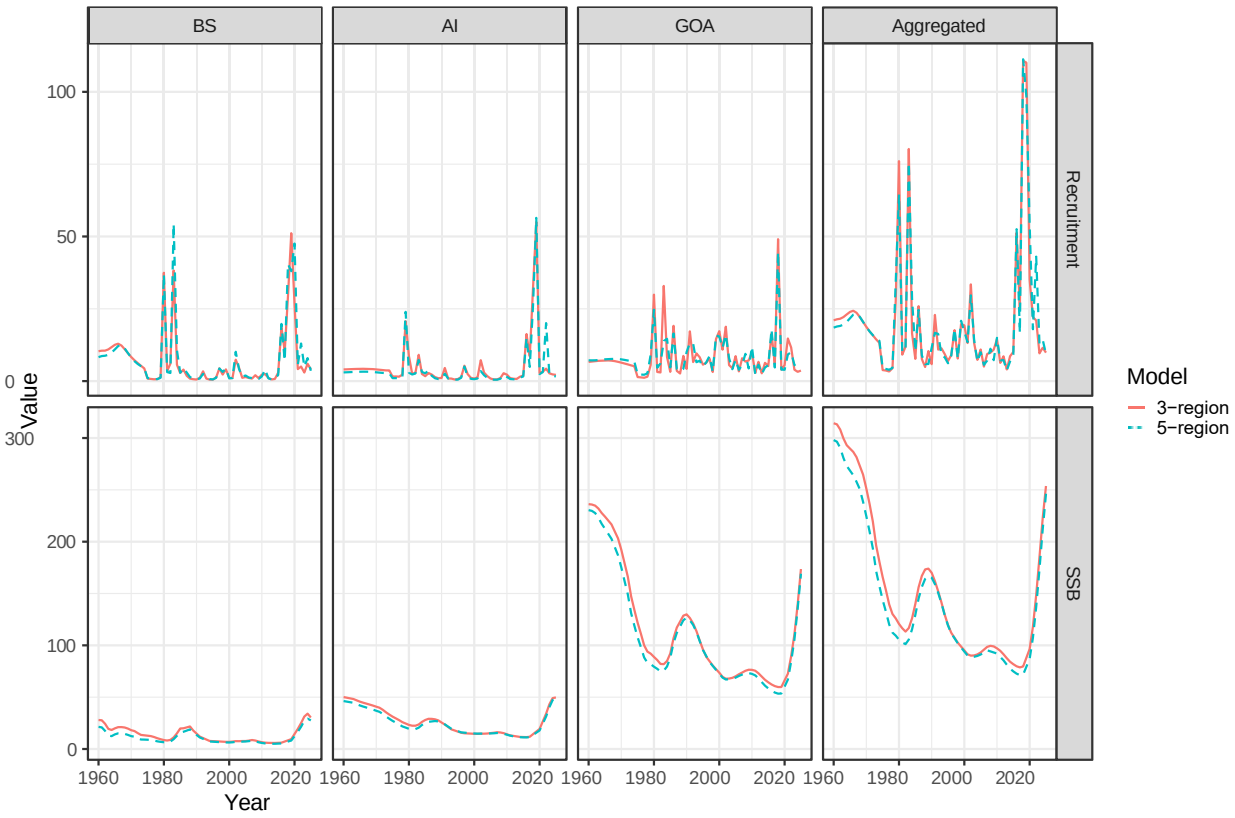

Figure 3D.48 Comparison of time-series of recruitment and spawning stock biomass (*SSB*) between the three-region and five-region spatial models. Time-series estimates for the Gulf of Alaska from the five-region model are summed up across the western, central, and eastern Gulf of Alaska for comparison with the three-region model.

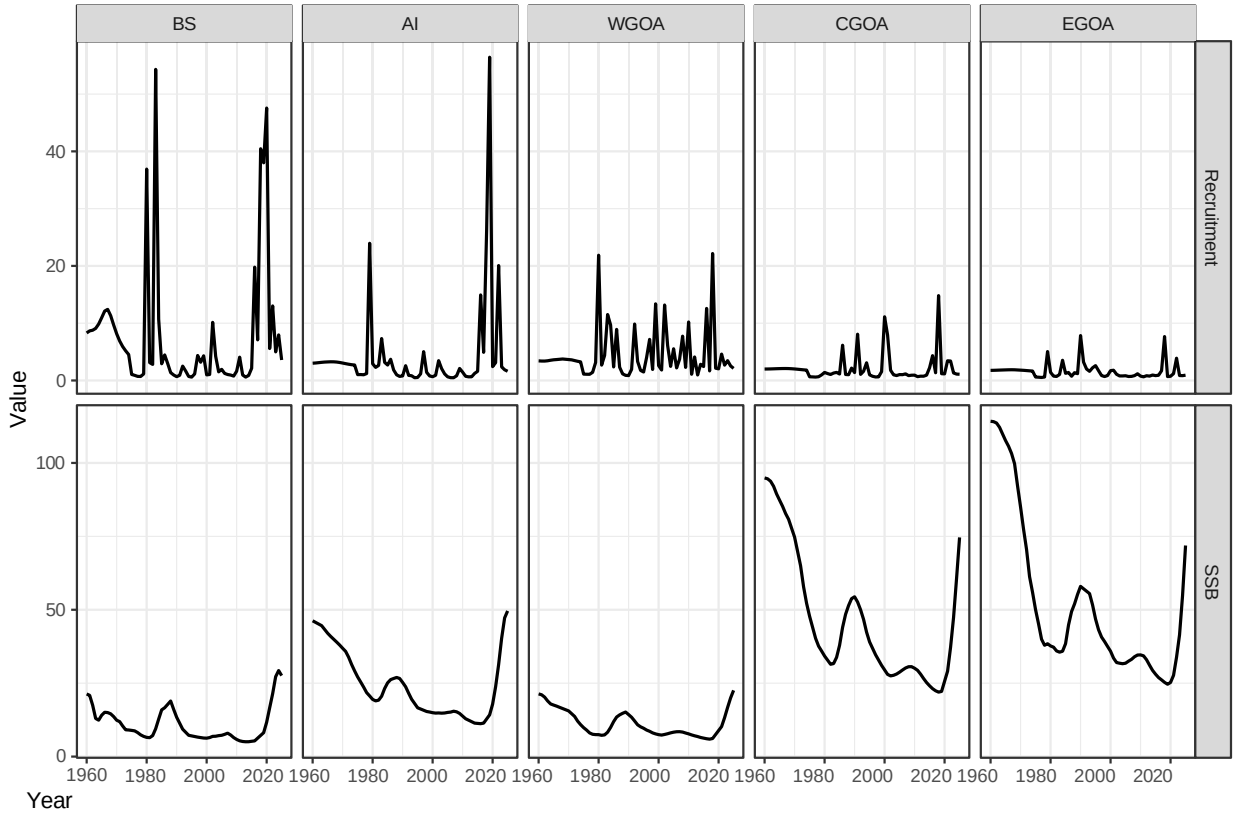

Figure 3D.49 Time-series of recruitment and spawning stock biomass (*SSB*) for the five-region spatial model.

Appendix 3E: Evaluating Alternative Assessment Structures for Alaska Sablefish Under Survey Design Changes via Closed-Loop Simulation

Matthew LH. Cheng, Daniel R. Goethel, Pete J. Hulson, Curry J. Cunningham

Introduction

Alaska sablefish in federal waters are managed across six fishery management areas spanning the Gulf of Alaska (GOA), Aleutian Islands (AI), and Bering Sea (BS), with management advice derived from a panmictic stock assessment model. Consequently, the assessment is both complex and unique among assessed Alaska groundfish species in that it encompasses the full spatial extent of federal management areas. Under this framework, data sources (e.g., abundance indices and age- and length-compositions) are aggregated across spatial regions to represent population-wide sampling processes and dynamics. As a result, assessment of Alaska sablefish depends on synoptic sampling coverage across fishery and survey fleets to ensure that aggregated data streams remain representative of population-wide trends.

A primary data source informing the assessment model is the NOAA domestic longline survey, a sablefish dedicated cost-recovery survey that provides representative abundance indices of sablefish across their Alaskan range (1996–2026), along with composition data to characterize population age structure and recruitment dynamics. Historically, the survey sampled the GOA annually while alternating between the BS and AI in odd and even years, respectively. Abundance indices in unsampled regions were interpolated using the proportional change observed between consecutive years in the GOA, while composition data were aggregated only across sampled regions. Such an approach is likely reasonable when trends in the GOA are representative of other regions or when abundance in unsampled regions is comparatively low (as was the case historically). However, recent changes in the economic conditions of the Alaska sablefish fishery rendered cost recovery infeasible, necessitating modifications to the existing survey design to accommodate potential operating losses. Starting in 2025, the domestic longline survey was modified to sample the GOA during odd years and the BS and AI during even years.

Such a substantial change to one of the most informative data sources for the Alaska sablefish assessment has prompted several lines of inquiry. First, if the survey is no longer synoptic, how can population-wide abundance indices and age compositions be constructed for use within a panmictic assessment framework? This concern is compounded by recent recruitment dynamics, which suggest that large recruitment events originate primarily from the BS and AI, with approximately 50% of the population biomass residing in these regions in any given year. As a result, both conditions under which historical interpolation was considered reasonable have likely degraded: abundance in unsampled regions is no longer comparatively low, and GOA trends are unlikely to be representative of population-wide dynamics. Thus, the extent to which historical interpolation methods used to impute unsampled regions can continue to provide reliable population-wide information remains questionable. Given the aforementioned complications, two questions arise: first, to what extent does fitting spatially incomplete data and historical interpolation within a panmictic framework compromise assessment performance, and second, can alternative model structures that accommodate data at the spatial scale at which they were collected offer improved model performance? In the following sections, we use a complementary

simulation-testing framework (i.e., cross-testing and closed-loop simulations) based on a five-region model of Alaska sablefish (Cheng *et al.* 2025) to directly evaluate these questions by comparing the performance of alternative model structures when confronted with a change in survey design.

Methods

We first describe the three alternative model structures considered, followed by a description of the simulation testing framework used to evaluate their performance.

General Description of Alternative Model Structures Considered

We considered three model structures in our simulation-testing framework: (1) a single-region panmictic model serving as a baseline that closely mimics the existing operational stock assessment, (2) a fleets-as-areas (FAA) model, and (3) a spatial model. The latter two represent alternative structures that accommodate data at the spatial scale at which they are collected, rather than requiring aggregation to a population-wide level. Below, we provide general descriptions of each.

The single-region model closely mimicked the operational stock assessment model (Goethel and Cheng 2024; Appendix 3A and 3B). It was sex- and age-structured, modelled removals from two fishery fleets (longline and trawl), and was further informed by two survey fleets (the contemporary domestic longline survey and a historical Japanese longline survey). The longline fishery was assumed to follow logistic selectivity, whereas the trawl fishery followed dome-shaped gamma selectivity. Both survey fleets were assumed to follow logistic selectivity patterns.

FAA models are widely used to accommodate spatial heterogeneity by allowing fleet-specific dynamics to implicitly capture variation in spatial availability. In such formulations, spatial structure is not explicitly modelled; instead, spatial heterogeneity in population dynamics is represented through fleet-specific catchability and selectivity processes. In the case of Alaska sablefish, an FAA model was further considered given its ability to potentially accommodate spatially incomplete data. Given that an FAA model has not previously been applied to Alaska sablefish, limited guidance was available to inform its specification. We therefore used a cross-testing simulation framework to first identify a robust FAA model structure prior to further evaluation in a closed-loop simulation setting (further described below).

The third model structure explicitly represented spatial population dynamics to directly leverage regionally collected data, as well as the wealth of tagging data to inform movement estimation avaialbe for Alaska sablefish. In general, this spatial model closely followed the parameterization of Cheng *et al.* (2025) and Appendix 3D with the exception that three regions (BS, AI, and GOA) were modeled rather than five. Recruitment was assumed to arise from regional mean recruitment with spatially and temporally varying lognormal deviations. In addition, all demographic rates (e.g., natural mortality, growth, and maturity) were assumed to be constant across both space and time. Movement was modeled as an unstructured Markov process with three age blocks representing young (ages 2–7), intermediate (ages 8–15), and old (ages 16–31) individuals, to approximately capture ontogenetic movement dynamics.

Simulation Testing Framework

The simulation testing framework used here employed a two-stage approach. In the first stage, we conducted simulation cross-testing to identify a robust FAA model structure for Alaska sablefish, given that no prior FAA formulation exists on which to base model specification. In the second stage, we conducted closed-loop simulations using the three model structures described above to evaluate: 1) potential biases resulting from mismatches in spatial structure, 2) the impacts of changes in survey design on assessment performance, and 3) the robustness of management advice produced by each model under spatial and survey design uncertainty. In both stages, the operating model (OM) was conditioned using estimates from a five-region spatial stock assessment model parameterized via Cheng et al. (2025) and Appendix 3D.

Stage 1: Cross Testing Fleets-as-Areas Models

Simulation cross-testing is widely used to evaluate model robustness under varying degrees of model misspecification (Deroba *et al.* 2015). In general, cross-testing involves an OM representing the true system dynamics that is used to generate data to which various estimation models (EMs) are fitted. Outputs from the OM therefore provide the basis for comparison, allowing evaluation of how well different EMs are able to reproduce the underlying system dynamics despite model misspecification, while also highlighting the relative strengths and limitations of alternative model structures.

As previously mentioned, the OM forming the basis of this work was conditioned on estimates from the five-region spatial stock assessment model encompassing the BS, AI, western GOA (WGOA), central GOA (CGOA), and eastern GOA (EGOA) (see Cheng et al. 2025 for further details). The OM was sex-and age-structured and assumed age-varying ontogenetic movement dynamics, with younger individuals residing in western regions, moving eastward as they matured. Additionally, the OM generated region- and fleet-specific data streams, including fishery catch, survey abundance indices, and both fishery and survey age-composition data across each spatial region and fleet considered in the assessment framework. Fishery catches were simulated assuming a lognormal distribution with a standard deviation of 0.05, while composition data were all simulated with a multinomial likelihood, with an input sample size of 20 for each region. Survey abundance indices were also simulated with a lognormal distribution, with a standard deviation of 0.2. Fleets included the longline fishery, trawl fishery, domestic longline survey, and historical Japanese longline survey.

To identify a FAA model structure for use in subsequent simulations that was robust to mis-specified spatial structure, and to inform the specification of a potential operational FAA assessment model, a semi-factorial design was implemented. This design varied across three key dimensions relevant to spatial sablefish dynamics: 1) fishery fleet structure, 2) longline fishery selectivity, and 3) domestic longline survey selectivity. While not exhaustive, these factors captured the primary structural decisions required to accommodate key spatial processes while maintaining a tractable number of model combinations.

A total of four alternative fishery fleet structures were considered, ranging from fully aggregated to fully disaggregated representations of the longline and trawl fisheries. The first configuration

treated both fisheries as single aggregated fleets across all regions. The second configuration disaggregated the longline fishery into BS, AI, and GOA fleets while retaining a single aggregated trawl fleet. The third configuration further disaggregated the trawl fishery into a BS fleet and a combined AI/GOA fleet. The fourth configuration fully disaggregated both fisheries into BS, AI, and GOA fleets, yielding six total fishery fleets.

Fishery selectivity parameterizations were explored through several alternative configurations that varied in the extent to which dome-shaped selectivity was permitted across longline fishery fleets. Specifically, four configurations were considered: 1) all longline fleets parameterized with asymptotic logistic selectivity, 2) all longline fleets parameterized with dome-shaped gamma selectivity, 3) only the BS longline fleet parameterized with dome-shaped gamma selectivity while remaining fleets retained logistic selectivity, and 4) both the BS and AI longline fleets parameterized with dome-shaped gamma selectivity while remaining fleets retained logistic selectivity. The trawl fishery fleet was consistently parameterized using gamma selectivity across all configurations, consistent with the current operational assessment model and its relatively small contribution to total catch, as well as its tendency to harvest smaller individuals.

Survey selectivity parameterizations followed an analogous structure for the domestic longline survey. Four configurations were considered: 1) all domestic survey fleets parameterized with asymptotic logistic selectivity, 2) all domestic survey fleets parameterized with gamma selectivity, 3) only the BS domestic survey fleet parameterized with gamma selectivity while the AI and GOA survey fleets retained logistic selectivity, and 4) both the BS and AI domestic survey fleets parameterized with gamma selectivity while the GOA survey fleet retained logistic selectivity. The historical Japanese longline survey was consistently parameterized with asymptotic logistic selectivity across all configurations, reflecting prior assumptions regarding its selectivity and maintaining consistency with the operational assessment model.

The intention of allowing gamma (dome-shaped) selectivity in select fishery and survey fleets was to reflect expected spatial heterogeneity in population age and size structure arising from ontogenetic movement and spatial asynchrony in recruitment patterns. In particular, BS and AI regions tend to represent a relatively higher proportion of younger individuals (likely to be more domed), whereas GOA regions are more strongly dominated by larger, older fish (i.e., likely to be more logistic).

Note that the survey fleets maintained the same fleet structure across all simulations, reflecting the primary objective of the FAA framework to accommodate the revised survey design and to explicitly handle spatially incomplete observations. The domestic longline survey was therefore represented as three region-specific fleets corresponding to BS, AI, and GOA (with WGOA, CGOA, and EGOA combined), while the Japanese survey was represented as a single aggregated fleet. Taken together, these specifications resulted in 56 estimation models evaluated in the cross-testing experiment (some fleet structures are not compatible with all selectivity options; e.g., 1 longline fishery fleet and 1 trawl fleet).

Model Evaluation

To identify a robust FAA model formulation among the 56 alternatives explored, we compared relative bias in estimates of spawning stock biomass (*SSB*), alongside convergence rates across

models. These results were evaluated alongside *a priori* considerations of model performance, biological realism, with additional attention to implications for model stability (i.e., model convergence). A total of 100 simulations were conducted for this exercise.

Stage 2: Closed-Loop Simulation Framework

Complementing the cross-testing simulation framework used to identify a robust FAA model, closed-loop simulations were conducted to evaluate the effects of data interpolation within a single-region model on management performance, as well as the potential benefits of employing EMs capable of accommodating spatially incomplete data. Briefly, closed-loop simulations are analogous to management strategy evaluations (MSEs), in which an OM is specified to represent the true underlying system dynamics. The OM generates monitoring data that are subsequently used within EMs. The EMs are then fit to the monitoring data and provide estimates of key management quantities (e.g., *SSB*), which are subsequently incorporated within a harvest control rule (HCR) to generate catch advice. The resulting catch advice is then fed back into the OM to simulate removals in subsequent years, thereby completing the feedback loop (Punt *et al.* 2016). This process continues iteratively through time. Such an approach has been widely applied and is particularly useful in this context for evaluating the potential impacts of alternative EMs on management advice.

Similar to the cross-testing simulation framework, the OM was conditioned on estimates from a sex-and age-structured five-region spatial model (Cheng *et al.* 2025), parameterized with age-varying movement dynamics. The OM generated fishery catches, fishery age and length compositions, survey age and length compositions, survey abundance indices, and tagging data for use in a spatial stock assessment model. Fishery catches were simulated assuming a lognormal distribution with a standard deviation of 0.05, while all composition datasets were simulated using a multinomial likelihood with an input sample size of 20 for each region. Similarly, survey abundance indices were simulated assuming a lognormal likelihood with a standard deviation of 0.2. Tagging data were simulated using a multinomial release-conditioned likelihood, assuming 2,000 tags released per tagging cohort, corresponding approximately to the average across all tag release events. Future recruitment dynamics within the OM were simulated by jointly resampling a vector of recruitment values from a given year, thereby preserving potential spatial correlation in recruitment dynamics among regions (Fig. 3E.1 and 3E.2). A total of 30 closed-loop projection years were simulated following the terminal year of the conditioning period.

A total of three EMs and one ‘reference’ model were evaluated within the closed-loop simulation framework. The ‘reference’ model was used as a baseline for comparison, and was based on the true values of the OM. To evaluate the management performance of the existing single-region stock assessment model, as well as the implications of aggregating spatially incomplete data, the first EM was parameterized to mimic the operational single-region stock assessment model. Under this configuration, all data were aggregated into a single-region model. Under the alternating survey design (i.e., data prior to the projection period), unsampled regions in the survey abundance indices were imputed using carryover values from the most recent year in which those regions were sampled. Similarly, age-composition data were aggregated by combining catch-weighted compositions across sampled regions. Following the change in survey design, the same interpolation approach was applied during the closed-loop projection period. However, because

fewer regions were sampled under the revised design, a greater proportion of the survey abundance indices required imputation.

Leveraging insights from the cross-testing simulation framework, the second EM was a FAA parameterized model to evaluate the general performance of models capable of accommodating spatially incomplete data. Within the FAA model, survey fleets were generally treated as spatially disaggregated. Data from the BS and AI regions were fit directly, whereas data from the GOA were aggregated across the WGOA, CGOA, and EGOA regions. Specifically, GOA abundance indices were summed across regions, while GOA age-composition data were combined using catch-weighted aggregation. Missing observations were treated explicitly as missing data, and therefore no interpolation of unsampled regions was required. Aggregation or disaggregation of fishery fleet data follows the most robust structure identified in the cross-testing simulation framework.

The third EM was a three-region spatially-explicit model, with regions analogous to the FAA model (i.e., BS, AI, and GOA regional structure). As in the FAA model, data from the BS and AI regions were fit directly, while those from the GOA were aggregated across the WGOA, CGOA, and EGOA regions. The model followed the general parameterization of the five-region OM (Cheng et al. 2025), with the exception of the reduced regional structure. Age-varying movement dynamics were specified and tagging data were integrated into the model. Missing observations were again treated explicitly as missing data, with no interpolation applied.

A five-region "reference" model was also parameterized and used as a reference case for comparison. Specifically, this model was based directly on the OM and therefore assumed full knowledge of the underlying system dynamics. As such, it represents an upper-bound case in which management is conditioned on perfect information, providing an informative benchmark for evaluating the performance of the alternative EMs. A five-region EM was not further considered as a candidate EM due to the greater parsimony of the three-region formulation, which is expected to yield comparable performance, as well as large computational constraints associated with the closed-loop simulation framework.

As part of the closed-loop simulation framework, each model provides catch advice that is subsequently fed back into the OM to simulate removals. In general, catch advice in Alaska is based on estimates of *SSB* and a threshold harvest control rule *HCR*, in which *B40%* is used as the reference point for adjusting fishing intensity (i.e., if *SSB* > *B40%*, fishing occurs at *F40%*; otherwise, fishing mortality declines linearly with decreasing *SSB*). However, SSB estimates and resulting catch advice are generated on different spatial scales across models and are not directly consistent with the five-region spatial structure of the OM.

In the case of the single-region and FAA models, *SSB* and *B40%* are estimated on an Alaska-wide basis, and a corresponding Alaska-wide fishing mortality rate is derived. This rate is applied in a projection model to generate total Alaska-wide catch. These catches are subsequently apportioned to the management units using a five-year rolling average of survey biomass proportions by region, with missing years and regions imputed using values from previous sampled years. Regionally apportioned catches are then distributed to the longline and trawl fleets using pre-specified gear allocation rates (NPFMC 2024b, 2024a).

By contrast, the three-region and five-region spatially explicit models produce spatially explicit estimates of *SSB*. To maintain consistency in the application of the harvest control rule, regional *SSB* estimates are aggregated to an Alaska-wide total and compared to an Alaska-wide *B40%* reference point, defined using global spawning potential ratio (SPR). The associated *F40%* is then applied uniformly across regions in the projection model, such that attainment of *B40%* is evaluated at the Alaska-wide scale (i.e., comparison of *SSB* to *B40%*) while exploitation is implemented regionally. This yields spatially explicit catch advice, which is then distributed to longline and trawl fleets using pre-specified gear allocation rates (NPFMC 2024b, 2024a). For the three-region model, projected catches from the GOA are subsequently apportioned across the WGOA, CGOA, and EGOA using a five-year rolling average of survey biomass proportions, consistent with the single-region and FAA approaches. Note that projection of regional catch advice can also be derived by comparing regional *SSB* quantities to local reference points to obtain local fishing mortality rates. However, this approach was not undertaken to maintain comparability across all models.

Model Evaluation

The performance of the alternative EMs was evaluated relative to the five-region reference model, which served as the "true" model. Comparisons were made between emergent trajectories of *SSB* and catch from each EM and those from the five-region reference model, at both regional and Alaska-wide scales. For the three simplified EMs (i.e., the single-region, FAA, and three-region models), relative error in SSB was additionally examined across closed-loop years to understand the drivers of observed differences in *SSB* and catch trajectories and to assess potential bias associated with implementing these models in a management context. Simulations were conducted until approximately 100 converged replicates were obtained for each projection year, where a converged replicate was defined as a full 30-year simulation in which all model components successfully converged; non-converged replicates were discarded.

Results

Cross-testing simulations of FAA models revealed several insights regarding robust model configurations. In general, most models demonstrated good convergence rates (~90 – 100%). Consistent with the findings of previous studies, assuming dome-shaped gamma selectivity for all fishery and survey fleets resulted in large positive biases in *SSB* across all fishery fleet structures, likely due to the estimation of substantial cryptic biomass (Fig. 3E.3). Conversely, assuming logistic selectivity for all fishery fleets produced persistent negative biases under configurations with multiple longline and trawl fleets (Fig. 3E.3). Despite these biases, certain configurations were effective in mitigating error. In particular, the combination of three longline fleets (BS, AI, and GOA) and one trawl fleet, coupled with certain fleets assuming dome-shaped selectivity, exhibited relatively small biases (~5%) (Fig. 3E.4). Similarly, the simplest configuration with a single longline and single trawl fishery fleet, combined with logistic selectivity across all survey fleets also performed robustly. Presumably, the lack of a FAA structure in the fishery appears to perform robustly because a large proportion of total catch is derived from the GOA, with relatively minor contributions from other regions. In addition, disaggregation in the survey fleets may be sufficient to capture spatial heterogeneity in population age structure, thereby reducing the need for explicit fishery fleet disaggregation. Nevertheless, the FAA model configuration that exhibited

the least median *SSB* bias across the entirety of the time-series was 3 longline and 1 trawl fishery fleet, coupled with fishery and survey selectivity assumed to be dome-shaped in the BS, and logistic elsewhere. In subsequent closed-loop simulations, this least biased FAA model configuration will be used and notes as the FAA model.

Application of alternative EMs in closed-loop simulations indicated that, regardless of model structure, trajectories of regional and Alaska-wide SSB were broadly similar (Fig. 3E.5 and 3E.6). However, some differences were evident among EMs. In particular, the three-region spatially explicit model produced the highest SSB during the early period of the projection, followed by the lowest SSB toward the end of the simulation period. The single-region model generally yielded the second-lowest SSB across the time series, whereas the FAA and five-region models exhibited similar trends and magnitudes throughout the projection period (Fig. 3E.5 and 3E.6).

Differences in catch levels generally reflected SSB trends, with periods of higher *SSB* generally associated with lower realized catch levels (Fig. 3E.7 and 3E.8). However, in contrast to *SSB* trajectories, regional catch levels were more variable among EMs. In particular, the FAA and single-region models produced higher catch levels in the BS and AI, and lower catch levels in the GOA regions, during the initial portion of the projection period, whereas the spatial model variants exhibited the opposite pattern. During the later portion of the projection period, the three-region model tended to produce the highest catch levels despite exhibiting lower catches initially. In general, all EMs prescribed higher catch levels during the final years of the projection period relative to the five-region reference model. Differences among models in regional catch trajectories likely reflected the distinct apportionment methods used by each EM.

Trends in SSB and catch levels that emerged from these closed-loop simulations can generally be explained by biases inherent to each EM (Fig. 3E.9). All models tended to underestimate SSB during the initial projection period, which translated to lower realized catch and higher SSB levels relative to the five-region baseline comparison. In general, the magnitude of underestimation was greatest for the three-region model, followed by the single-region and FAA model. Toward the end of the time-series, positive biases were evident across all EMs, again with the largest magnitude occurring in the three-region model, followed by the single-region and FAA model. Accordingly, catch levels tended to be overprescribed relative to the five-region reference model (Fig. 3E.9), which subsequently translated into lower SSB levels. Biases in the single-region model were likely attributable to the aggregation of spatially incomplete data, whereas biases in the FAA model were primarily associated with insufficient flexibility in survey selectivity to account for spatial changes in availability arising from ontogenetic movement and recruitment dynamics. Lastly, biases in the three-region model were most likely driven by model instability associated with recruitment, movement, and their related confounding effects. In particular, recruitment estimates occasionally shifted markedly among years, with some regions in certain years estimating unrealistically low recruitment levels approaching zero (not shown), while the same regions in other years estimated substantially higher recruitment levels. These dynamics likely contributed to both positive and negative biases and indicate that the three-region model likely requires careful tuning to achieve stable behavior in an operational context. Thus, simple ‘update’ assessments would likely not be feasible given the potential need to refine the model within each assessment cycle.

Taken together, results from this complementary simulation-testing framework provide important context for considering alternative models for management use. In particular, none of the EMs considered here resulted in detrimental management outcomes (i.e., depletion of *SSB* to exceedingly low levels), despite the various biases that were evident (Fig. 3E.9). Moreover, while spatial models were, in theory, more biologically plausible, they were also generally less stable, subject to greater data demands, and likely required more analyst tuning in an operational context. Important trade-offs associated with model development time, model learning, and implementation under a spatial framework should therefore also be considered when evaluating spatial models for management applications. By contrast, both the single-region and FAA models demonstrated greater model stability. While the FAA model tended to exhibit the least bias of the EMs considered, additional consideration with respect to model stability may still be required (given the addition of new parameters) when applied to real-world data.

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Figures

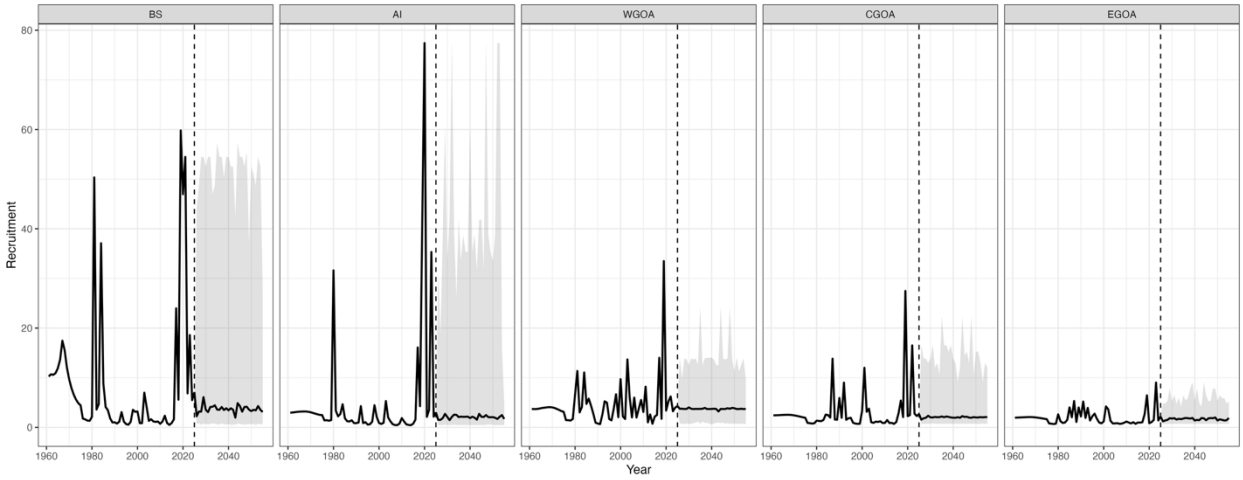

Figure 3E.1. Median trajectories and associated 95% simulation intervals of regional recruitment in the closed-loop simulation framework. Column panels denote regions and the dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period.

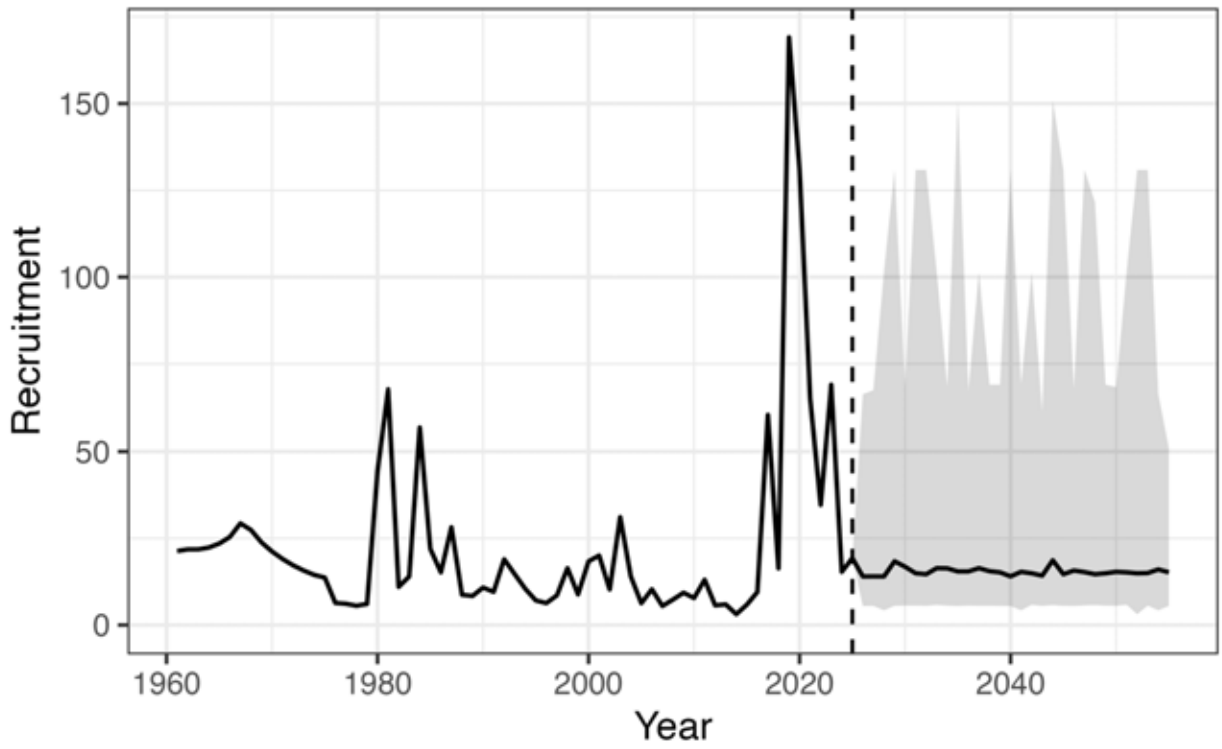

Figure 3E.2. Median trajectories and associated 95% simulation intervals of Alaska-wide recruitment in the closed-loop simulation framework. The dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period.

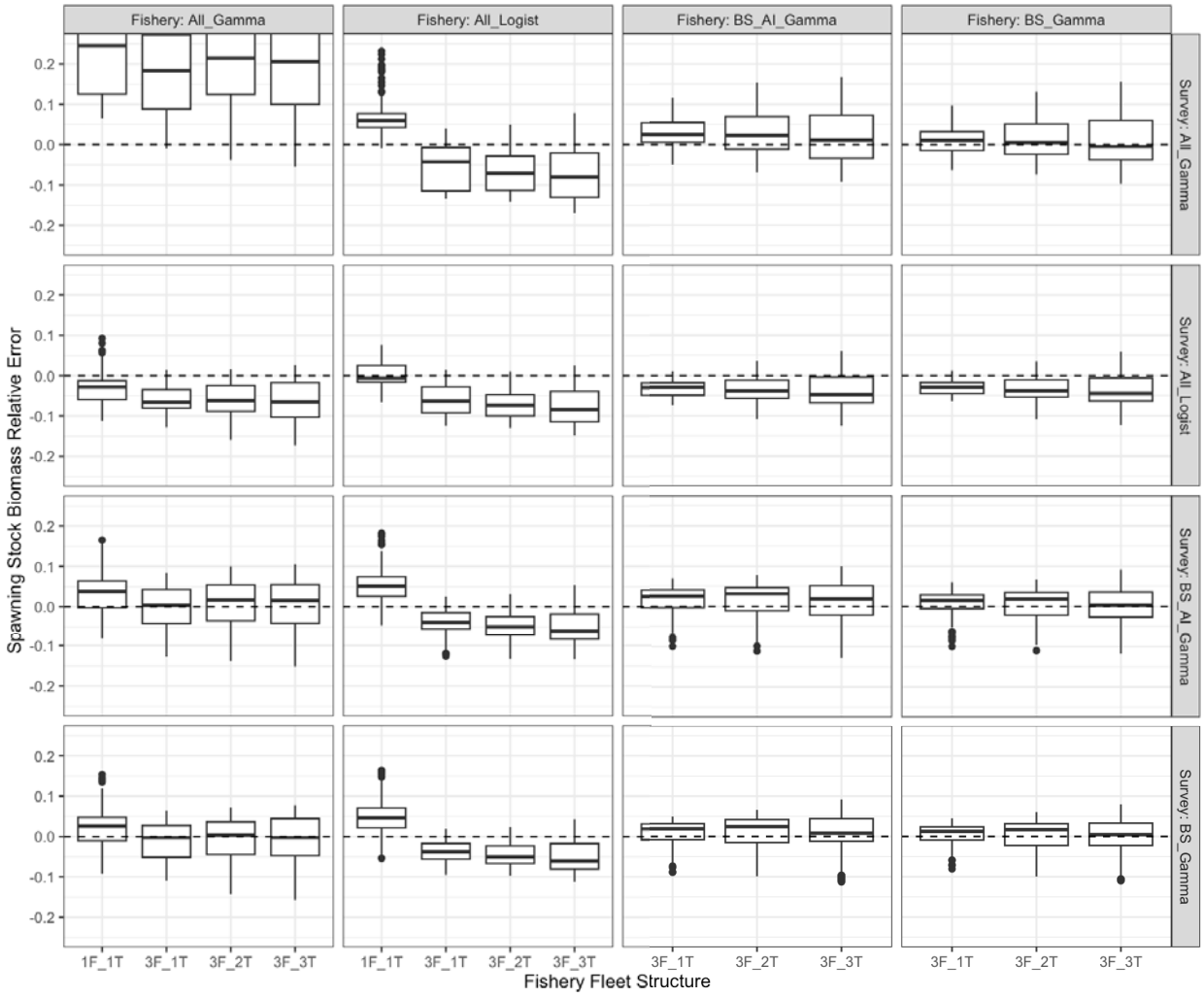

Figure 3E.3. Relative error in spawning stock biomass (*SSB*) across fleets-as-areas (FAA) model configurations evaluated in the cross-testing simulation framework, shown as boxplots. The x-axis denotes fishery fleet structures considered; column panels represent alternative fishery selectivity parameterizations; and row panels represent alternative survey selectivity parameterizations. The dashed horizontal line indicates zero relative bias. Fishery fleet structures are defined as follows: 1F_1T represents a single longline fleet and a single trawl fleet; 3F_1T represents three longline fleets (BS, AI, GOA) and one trawl fleet; 3F_2T represents three longline fleets (BS, AI, GOA) and two trawl fleets (BS+AI, GOA); and 3F_3T represents three longline fleets (BS, AI, GOA) and three trawl fleets (BS, AI, GOA). Longline fishery and domestic longline survey selectivity configurations are defined as follows: All_Gamma denotes gamma selectivity for all fleets; All_Logist denotes logistic selectivity for all fleets; BS_AI_Gamma denotes gamma selectivity for BS and AI fleets with logistic selectivity elsewhere; and BS_Gamma denotes gamma selectivity for BS fleets with logistic selectivity elsewhere.

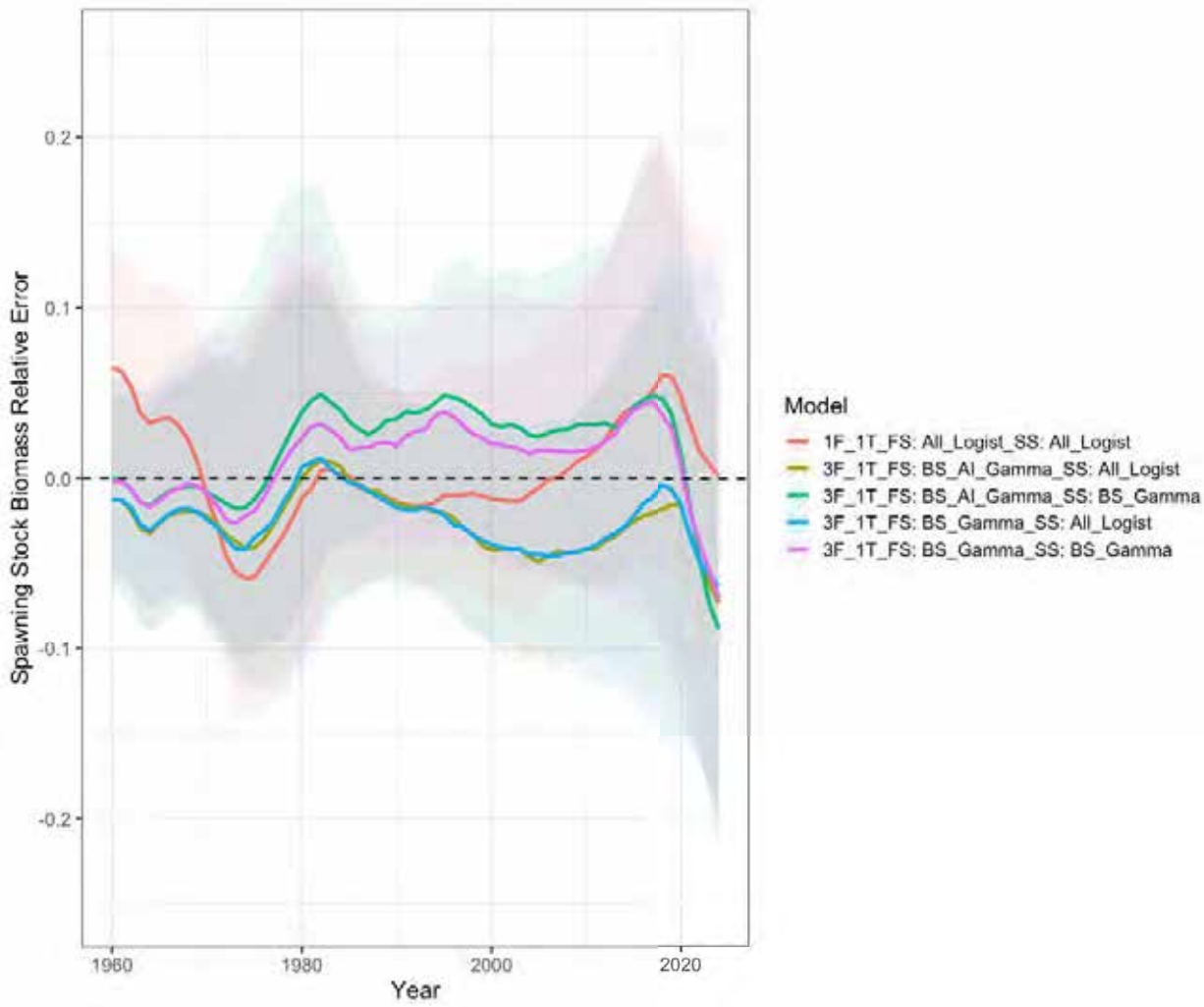

Figure 3E.4. Time-series of relative error in spawning stock biomass (*SSB*) across fleets-as-areas (FAA) model configurations evaluated in the cross-testing simulation framework. Solid lines denote the median, while shaded regions represent 95% simulation intervals. Fishery fleet structures are defined as follows: 1F_1T represents a single longline fleet and a single trawl fleet; 3F_1T represents three longline fleets (BS, AI, GOA) and one trawl fleet. Longline fishery (FS) and domestic longline survey selectivity (SS) configurations are defined as follows: All_Logist denotes logistic selectivity for all fleets; BS_AI_Gamma denotes gamma selectivity for BS and AI fleets with logistic selectivity elsewhere; and BS_Gamma denotes gamma selectivity for BS fleets with logistic selectivity elsewhere. The purple line depicts the model that exhibits the least median *SSB* bias across the entirety of the modelled time-series.

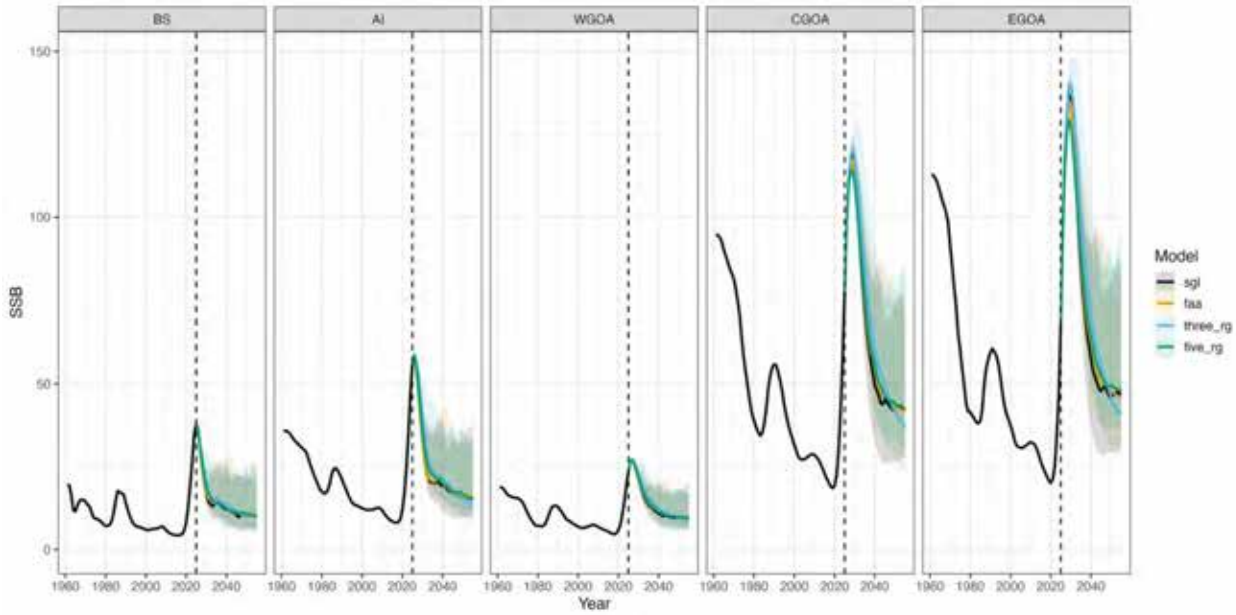

Figure 3E.5. Median trajectories and associated 95% simulation intervals of regional spawning stock biomass (*SSB*) resulting from the application of different estimation models (EMs; colors) in the closed-loop simulation framework. Column panels denote regions, colors represent different EMs applied, and the dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period. Model names are as follows: *sgl* represents a single-region model, *faa* represents the best fleets-as-areas model, *three_rg* represents the three-region spatially explicit model, and *five_rg* denotes the five-region reference model .

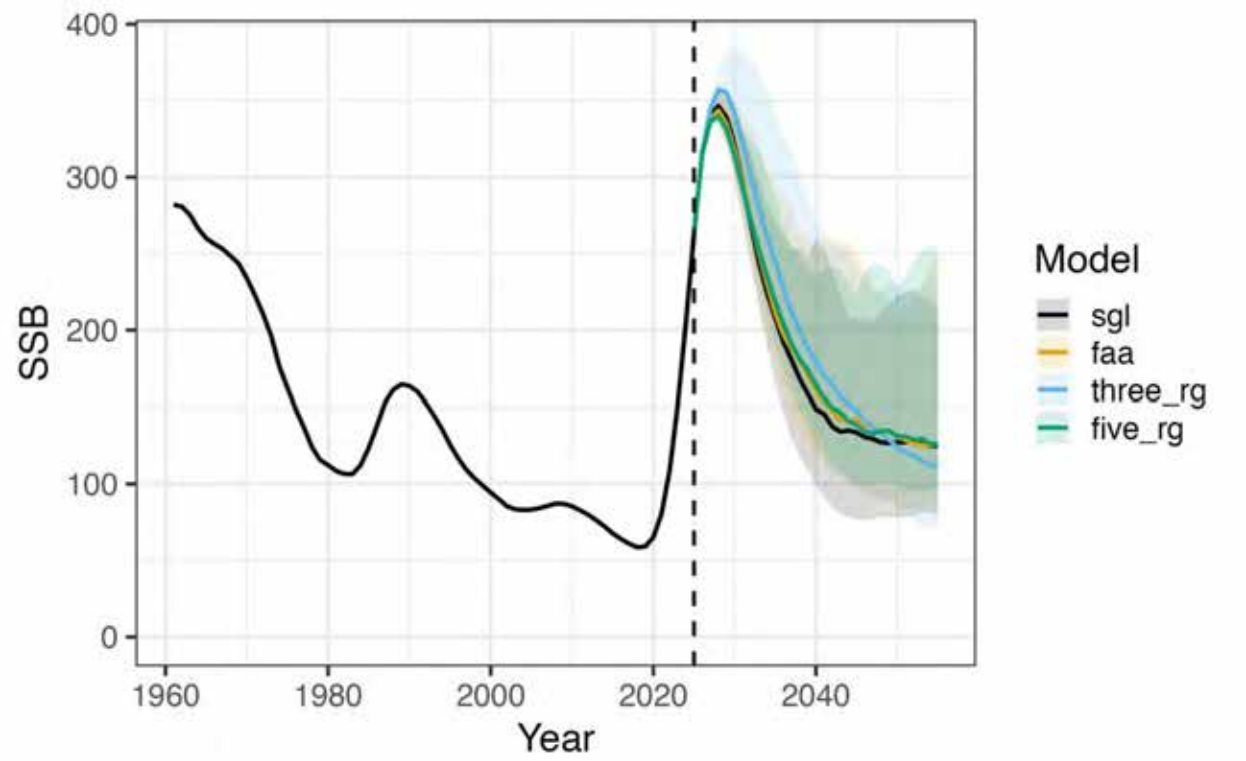

Figure 3E.6. Median trajectories and associated 95% simulation intervals of Alaska-wide spawning stock biomass (*SSB*) (summed across regions) resulting from the application of different estimation models (EMs; colors) in the closed-loop simulation framework. The dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period. Model names are as follows: *sgl* represents a single-region model, *faa* represents a fleets-as-areas model, *three_rg* represents the three-region model, and *five_rg* denotes the five-region reference model .

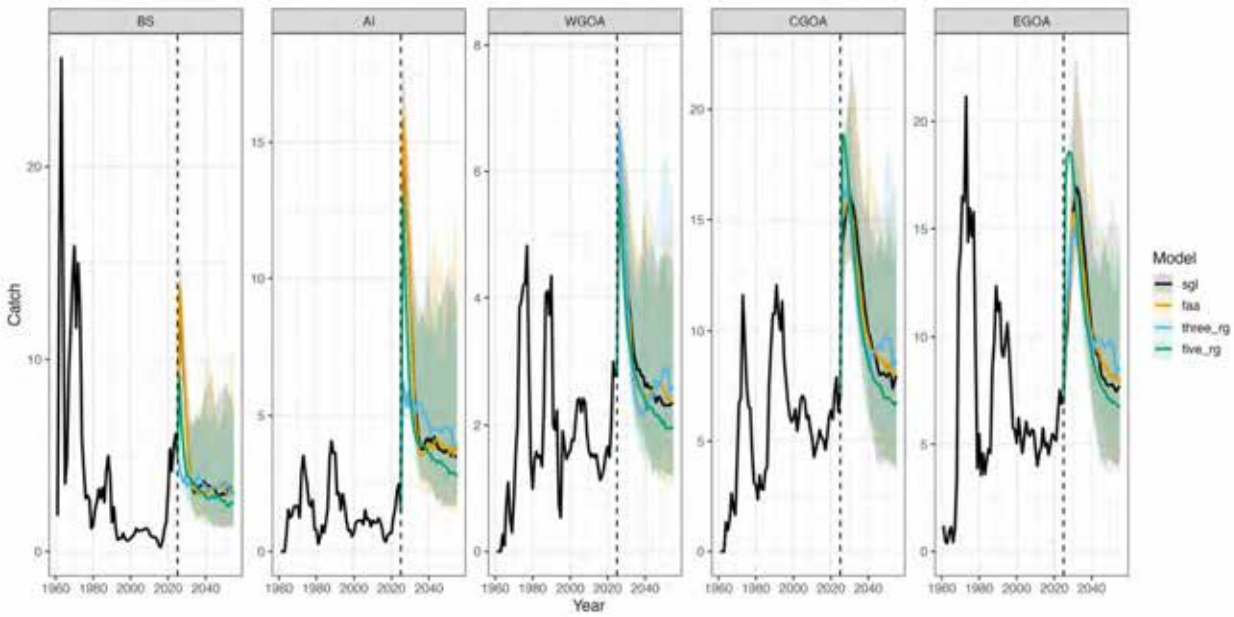

Figure 3E.7. Median trajectories and associated 95% simulation intervals of regional catch (summed across fleets) resulting from the application of different estimation models (EMs; colors) in the closed-loop simulation framework. Column panels denote regions, colors represent different EMs applied, and the dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period. Model names are as follows: *sgl* represents a single-region model, *faa* represents a fleets-as-areas model, *three_rg* represents the three-region model, and *five_rg* denotes the five-region reference model .

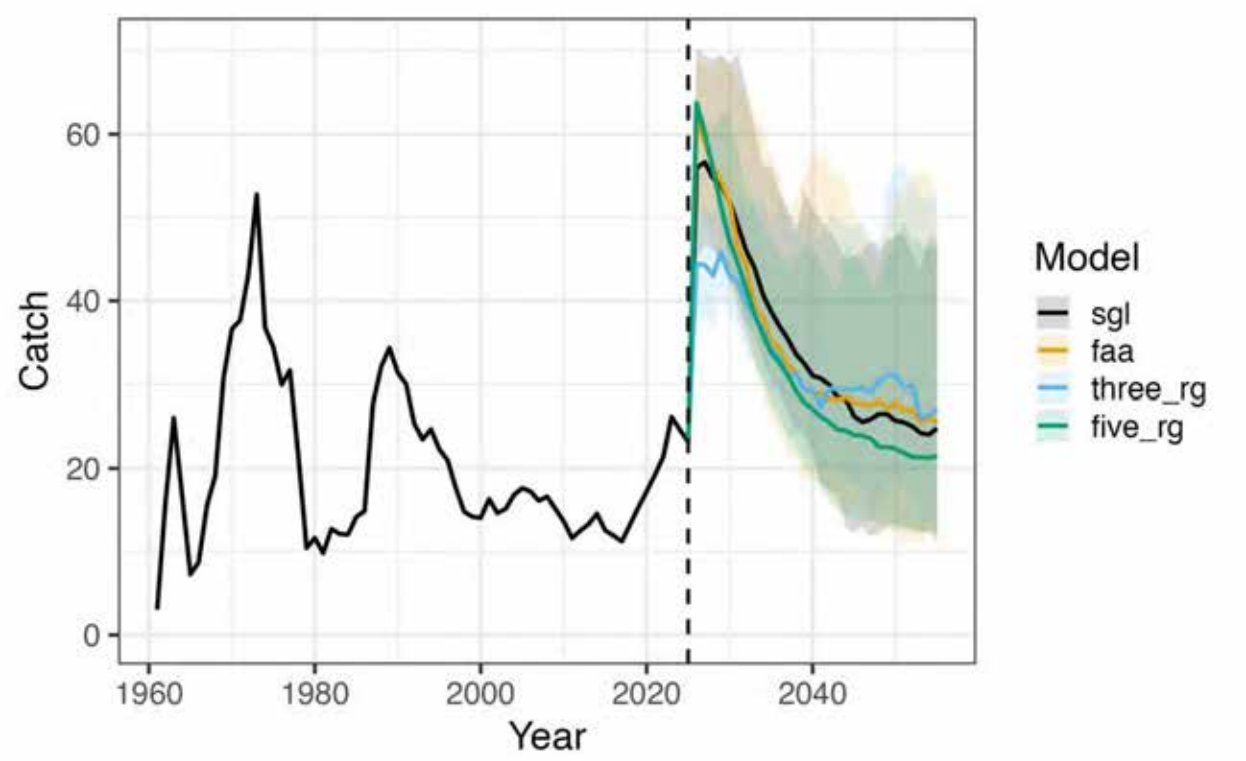

Figure 3E.8. Median trajectories and associated 95% simulation intervals of Alaska-wide catch (summed across regions and fleets) resulting from the application of different estimation models (EMs; colors) in the closed-loop simulation framework. The dashed vertical line depicts the start of the closed-loop projection period. Values to the left of the dashed line represent the historical conditoning period. Model names are as follows: *sgl* represents a single-region model, *faa* represents a fleets-as-areas model, *three_rg* represents the three-region model, and *five_rg* denotes the five-region reference model .

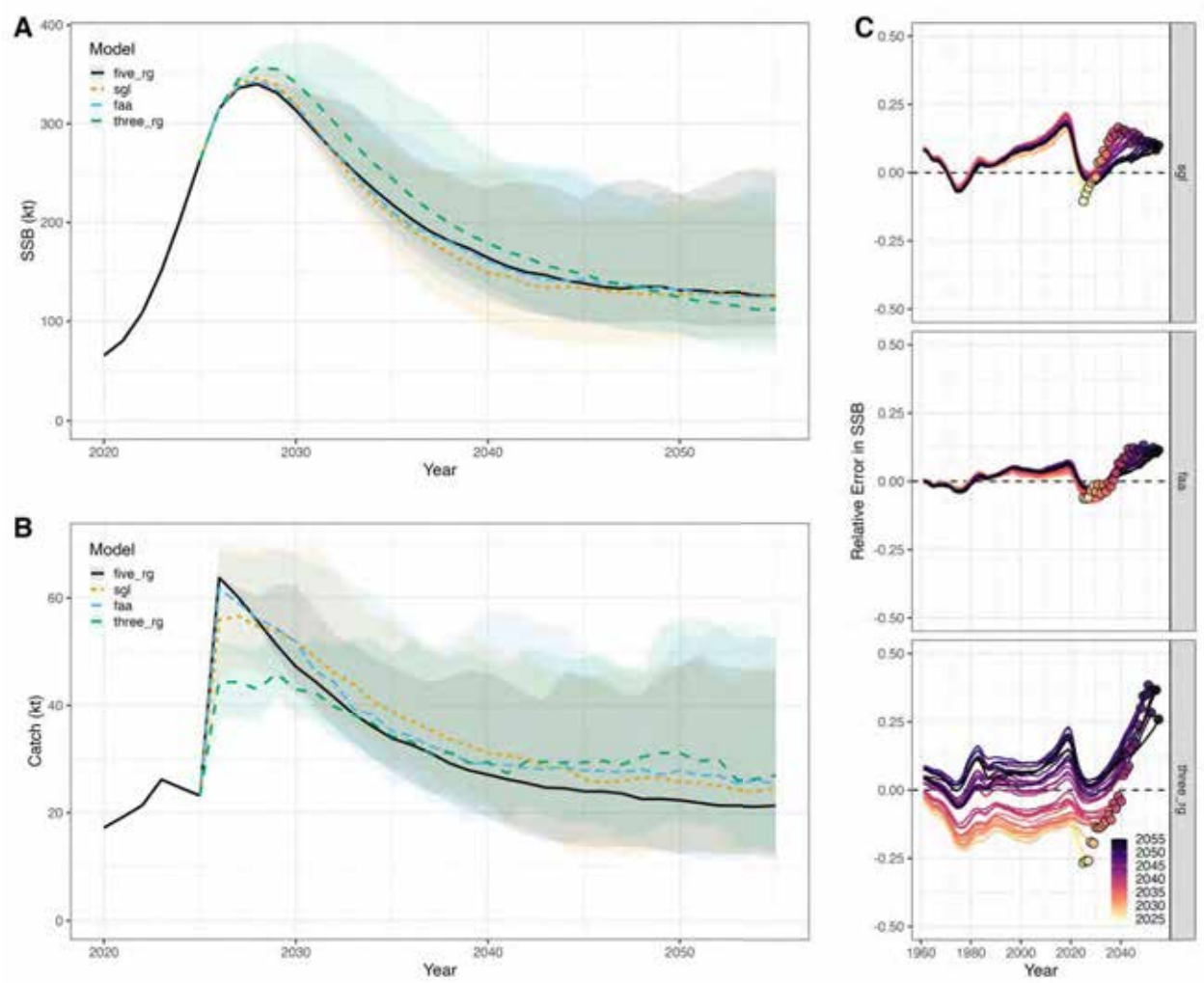

Figure 3E.9. Summary of results from the closed-loop simulation framework employed. Panels A and B depict trajectories and associated 95% simulation intervals of Alaska-wide spawning stock biomass (*SSB*) (summed across regions) and catch (summed across regions and fleets) resulting from the application of different estimation models (EMs; colors) in the closed-loop simulation framework. Panel C shows the median relative error in SSB for each EM (row panels) by closed-loop projection year (colors), where the terminal year of each projection is indicated by a colored point.

Appendix 3F: 2026 Interim Assessment of the Sablefish Stock in Alaska Prepared for the 2026 Center for Independent Experts (CIE) Review

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May 2026

Contributors:
Katy Echave, Kevin Siwicke, Dana Hanselman, and Chris Lunsford

This report may be cited as:

Goethel, D.R. and Cheng, M.L.H. 2026. Assessment of the sablefish stock in Alaska: 2026 Center for Independent Experts (CIE) Review Document. North Pacific Fishery Management Council, Anchorage, AK.

The last operational full assessment for sablefish was in 2021 and a full description of the model can be found in the 2021 SAFE document:
https://www.fisheries.noaa.gov/resource/data/2021-assessment-sablefish-stock-alaska

The last update assessment was performed in 2024:
https://www.npfmc.org/wp-content/PDFdocuments/SAFE/2024/Sablefish.pdf

Changes that were planned (but not used operationally due to the US government shutdown) for the full assessment in 2025 (Model *25.12*) are described in the September NPFMC Plan Team document:
https://meetings.npfmc.org/CommentReview/DownloadFile?p=02344a6f-99f3-4239-990e-e5dd9393e1a7.pdf&fileName=Sablefish%20proposed%20model%20changes.pdf

The following appendices can be found at the CIE GitHub repository:

Appendix 3A. The Spatial Population over Regional Components (SPoRC) Model: Technical Description of the Assessment Model for Sablefish (here)
Appendix 3B. Model Building and Bridging Exercise for the Sablefish Single Region Models (Bridging from Model *25.12* to *26.1_1Reg*) (here)
Appendix 3C. Development of a Fleets-as-Areas (FAA) Stock Assessment Model for Alaska Sablefish (*Model 26.2_FAA*) (here)
Appendix 3D. Results of Spatial Stock Assessment Models for Alaska Sablefish (here)
Appendix 3E. Evaluating Alternative Assessment Structures for Alaska Sablefish Under Survey Design Changes via Closed-Loop Simulation (here)

Executive Summary

Summary of Changes to the Assessment

In 2024, there was an update assessment for sablefish (*Anoplopoma fimbria*) using Model *23.5*. A full assessment was scheduled for 2025 with model changes implemented (Model *25.12*) and reviewed at the North Pacific Fisheries Management Council's (NPFMC) September Groundfish Plan Team meeting. However, an operational assessment was not performed in 2025 due to the US government shutdown. For the 2026 Center for Independent Expert's (CIE) review of the sablefish assessment, two models are being provided as potential candidates for the operational assessment in 2026 and beyond (results from the continuity Model *25.12_1Reg_Cont* are available as part of the model building exercise; Appendix 3B).

Model *26.1_1Reg* builds from Model *25.12*, but implements updates to parametrization (e.g., estimating sex-specific natural mortality, *M*, and switching to a logistic selectivity function for the trawl fishery fleet) and data inputs (e.g., removing catch-per-unit effort, CPUE, data, removing length compositions for fleets with age compositions, updating growth and weight estimates, and updating how the NOAA longline survey index is calculated; Appendix 3B). Additionally, a spatially-implicit fleets-as-areas (FAA) model was developed (Model *26.2_FAA*) to fit the longline survey data at a regional scale, such that extrapolation of the resulting indices would no longer be necessary (Appendix 3C). Because large portions of the sablefish resource (~50%) are not being surveyed in a given year (i.e., the survey now covers the Gulf of Alaska, GOA, in odd years and the Bering Sea, BS, and Aleutian Islands, AI, in even years), the longline survey extrapolation approach is not ideal. Model *26.2_FAA* was built from Model *26.1_1Reg* with incremental complexity in fleet structure of the longline survey, which resulted in three total NOAA longline survey fleets (instead of just one aggregate fleet as in Model *26.1_1Reg*). Each regional fleet (BS, AI, and GOA) was modeled with its own estimated selectivity function and catchability parameter, *q*, by fitting to regionally disaggregated indices and age composition data, thereby, eliminating the need to extrapolate indices or aggregate composition data across regions. Two spatially explicit assessments were also developed that integrated mark-recapture data and estimated movement among either 3 regions (matching the regional structure of the longline survey in the FAA model; Model *26.3a_Spat_3Reg*) or 5 regions (matching the management structure across Alaska; Model *26.3_Spat_5Reg*; Appendix 3D). However, neither spatial model is being put forward for operational management due to model stability concerns and the need for further model refinement.

A closed loop simulation analysis was also undertaken to understand performance of the various model structures being explored (i.e., single region, FAA, and three region spatial models; Appendix 3E). The simulation analysis utilized a spatially explicit simulation operating model conditioned on the five region spatial assessment. The results of the simulation experiment helped guide model building, particularly the structure of the FAA model, and provided insight on expected assessment performance in terms of potential bias and stability. Moreover, it also identified expected management outcomes via the closed loop feedback and implemented $F_{40\%}$ sloped harvest control rule (HCR) currently utilized for sablefish management.

Units

Throughout the document mass (i.e., for spawning stock biomass, SSB, biomass, and catch) is reported in metric tons (abbreviated as either mt or t; equivalent to a tonne) or kilotons (kt; equivalent to 1,000 metric tons). Recruitment (age-2) and abundance are in millions of fish. Fishing and natural mortality are instantaneous rates ($year^{-1}$).

Changes to the Input Data

Newly available data since the 2024 assessment that were used in the assessment models for 2026 (*26.1_1Reg and 26.2_FAA)* included (Table 3.3):

- Length data from the trawl fisheries for 2024.
- Age data from the fixed gear fishery for 2024.
- Finalized catch for 2024 and 2025.
- The NOAA longline survey abundance indices for 2025.
- Updated length- and weight-at-age estimates using survey age-length-weight data through 2023.
- For the single region NOAA longline survey index (used in Model *26.1_1Reg*), the index was constructed using a 'carryover' approach for non-surveyed regions (i.e., for a given region the Relative Population Numbers, RPN – the survey index, from the previous time the region was surveyed was used for off-year survey RPNs) instead of extrapolating off-year survey RPN values for the BS or AI based on RPN change in the GOA (this traditional approach is no longer feasible given the change in survey design in 2025 because the GOA is no longer surveyed every year).
- The input sample size (ISS) for composition data utilized a relative scaling within gears/surveys to maintain information on sampling across years (previously a static ISS was used for each gear).

Data that was removed from the proposed assessment models for 2026, include:

- The fixed gear fishery CPUE index, including the historical Japanese CPUE (1964 – 1981) and the domestic CPUE (1995 – 2022).
- The fixed gear fishery length composition data from 1990 – 1998.
- The NOAA Longline Survey length composition data from 1990 – 1995.
- For the NOAA Longline Survey index, extrapolated relative population numbers (RPNs) from stations in the western AI were removed from the index.

Changes to the Assessment Methodology

For Model *26.1_1Reg*, changes from the previously reviewed Model *25.12*, included:

- Sex-specific *M* was estimated.
- Logistic selectivity was assumed for the trawl fishery (instead of domed).
- The fixed gear fishery early/pre-IFQ (1960 -- 1994) time block was removed.
- All selectivity parameter linkages were removed.
- The selectivity parameter priors were updated.

For Model *26.2_FAA*, changes from Model *26.1_1Reg*, included:

- A spatially-implicit FAA structure was implemented for the NOAA Longline Survey fleets, which disaggregated the longline survey into three separate regional fleets (BS, AI, and GOA), each of which had an independently estimated set of selectivity parameters and *q* values that were estimated by fitting the corresponding disaggregated indices (without any carryover or extrapolation approaches applied) and age compositions.

Summary of Results

In 2025, the NOAA Longline Survey was conducted using the new survey design where only the GOA was sampled. The indices continued to increase, though rates of increase in the GOA RPNs were not as large as in recent years (Figures 3.7 – 3.8). Due to biological and socioeconomic drivers, catch has remains below acceptable biological catch (ABC) with the proportion of the quota utilized less than 50% in 2024 and 2025.

Two models are presented, where an FAA model was identified as a potential suitable structure for sablefish, as it could disaggregate NOAA Longline Survey data by region and avoid the need for 'carryover' extrapolation of the NOAA Longline Survey index as is required in the single region assessment (Model *26.1_1Reg*; see Appendix 3B). Ultimately, the choice of model structure for sablefish is a tradeoff between model stability, assessment complexity, and assumed data representativeness (See Table Below). Although

an FAA model would forego the need for data extrapolation, it may be more unstable and might overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high).

For both models, fit to the available data retain similar issues, where NOAA Longline Survey indices are generally well fit at the expense of composition data, primarily due to the Francis reweighting approach of 'right-weighting' the data to ensure adequate fit to the indices. Although residual patterns in the composition data remain, the aggregated fits continue to appear adequate given associated model tension between fitting the NOAA Longline Survey indices versus age compositions (a long-standing issue with the sablefish assessment; Goethel and Cheng, 2024). Both models have trouble reconciling the larger year classes and population growth suggested by the age composition data in recent years compared with the more tempered, but still extremely rapid, population growth observed in the survey RPNs since ~2018. No major diagnostic issues were identified for either model based on retrospective analysis, profile likelihoods, MCMC, or jitter analysis. Thus, both Model *26.1_1Reg* and Model *26.2_FAA* appear to be robust and stable models and adequate for interpreting sablefish population dynamics.

Population trends align across models with both indicating strong 2014, 2016, and 2017 year classes, and a reduction towards average recruitment since 2020 (Figure 3.20). Recent recruitment trends in Model *26.2_FAA* differ moderately from those in Model *26.1_1Reg*. For instance, the time series average recruitment has declined, while the interpretation of recent dynamics has altered resulting in a larger estimate of the 2014 and 2017 year classes and a smaller 2016 year class (Figure 3.20). Alterations in recruitment estimates are due to differences in recruitment signals across the regional NOAA Longline Survey age compositions, where the AI provides a mixture of recruitment signals (strong 2014, 2016, and 2017 year classes; Figure 3.44) that balances those in the BS (strong 2014 and 2016 and very strong 2017 year classes; Figure 3.41) and GOA (strong 2014 and very strong 2016 year classes; Figure 3.36).

Although Model *26.2_FAA* assumes a moderate downward scaling of SSB and catch advice, general population dynamics and stock status remain consistent with Model *26.1_1Reg* (Figure 3.21). Interestingly, an exploratory run with the FAA model, where extrapolated regional carryover indices were constructed and fit to better emulate the aggregate index used in Model *26.1_1Reg*, led to a strong upward scaling of SSB, particularly since the start of the NOAA Longline Survey in the mid-1990s (Appendix 3C, Figure 3C.12). Thus, there may be inherent risk with using extrapolated survey data in the assessment, which can potentially result in artificially inflating SSB and catch advice. Moreover, the phase-plane for Model *26.2_FAA* suggests that overfishing may have been occurring on the sablefish population for much of the 2000s, until recent recruitment events began entering the population around 2021 (and ABC utilization rates declined; Figure 3.85). Therefore, the FAA model suggests that the single region model may be more risk prone, if population scale is more in line with those estimated in Model *26.2_FAA*.

Overall, the sablefish age structure continues to gradually expand as the recent large year classes (e.g., 2014, 2016, and 2017) begin to enter ages that are nearing full maturity. For instance, the 2014 year class is now 12 years old, while the larger 2016 year class is 10 years of age. It is expected that these cohorts will continue to survive in large numbers and help expand the age structure over the next 5 – 10 years.

Sablefish are managed under Tier 3 of the NPFMC harvest control rule (HCR), which aims to maintain the population at $B_{40\%}$. For both models, female spawning biomass in 2026 is projected to be ~$B_{67\%}$ placing sablefish in NPFMC Tier 3a. Spawning biomass is projected to increase rapidly in the near-term, and the maximum permissible value of F_{ABC} under Tier 3a is 0.08 with an F_{OFL} of 0.09 and 0.10 for the single region and FAA models, respectively. Due to the scaling differences among models, the projected ABC and OFL levels differ by ~10,000 mt. For Model *26.1_1Reg*, 2026 ABC and OFL are 41,000 mt and 48,000 mt, respectively. For Model *26.2_FAA*, 2026 ABC and OFL are 32,000 mt and 38,000 mt, respectively. For both models, projections indicate that the Alaskan sablefish stock is not subject to overfishing, not overfished, and not approaching an overfished condition.

ES1. Summary of tradeoffs between using a single region (1Reg), Fleets-as-Areas (FAA), and muti-region (spatial) models for sablefish.

Model	*Benefits*	*Issues*	*MSE Conclusions*	*Tradeoffs*
Single Region Model (1Reg)	High sample sizes. Low model complexity. Intuitive and transparent results. High inertia towards moving away from status quo assessment methodology.	Requires fitting extrapolated data for the Longline Survey Index. Implicit historical over-weighting of GOA composition data during aggregation or high interannual variability recently (GOA then BS/AI). Little signal from BS/AI compositions, because GOA given higher weight (RPNs or catch) in data aggregation. Ignores spatial structure.	Moderate SSB bias and moderate instability due to the survey extrapolation and aggregated composition data but impacts on resulting management advice may be negligible.	Higher sample sizes and improved stability but requires fitting the extrapolated longline survey index and primarily represents the recruitment signals from the GOA due to data aggregation assumptions.
Fleets-as-Areas (FAA)	Fitting non-extrapolated Longline Survey index. Fitting disaggregated survey compositions. Better accounts for signals from BS/AI compositions on recent year class strength. Implicitly accounts for ontogenetic movement dynamics	Low sample sizes and sparse data for BS/AI compositions. Increased instability from added complexity (estimating extra *q* and selectivity parameters for 'regional' survey fleets and/or extra *F* and selectivity parameters for fishery fleets). Non-intuitive estimates that are difficult to interpret (e.g., due to using multiple fleets that are interacting with a single underlying population – not multiple populations/regions). Selectivity needs to be flexible to address ontogenetic dynamics.	Low SSB bias and instability with improved performance over other structures when survey coverage decreases, but adequate flexibility in selectivity parametrizations is likely needed to ensure good performance.	Able to fit the regional longline survey indices without aggregation and likely provides more robust outputs when survey coverage decreases, but sample size limitations may prevent adequate selectivity flexibility to address ontogenetic availability issues due to model instability.
Spatial (3 or 5 Region)	Fit data at the regional scale it was collected. Better account for signals from each region. More intuitive than FAA. Explicitly account for ontogenetic movement dynamics.	Increased sample size limitations. Increased parametrization decisions related to spatial processes. Lack of best practices for fitting tagging data (e.g., dealing with tag mixing issues and data weighting). Increased parameter correlation, particularly between regional recruitment parameters and movement. Diagnostics can be difficult to interpret. Increased instability.	High instability due to overparameterization and low sample sizes but best represents localized dynamics.	Best represents spatial dynamics but suffers from high model instability due to data sparsity that requires extremely careful parametrization, while appropriate handling of tagging data is difficult and potentially subjective.

Summary Table

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *26.1_1Reg*:		Estimated *this* SAFE for Model *26.2_FAA*:	
	2025	2026*	2026	2027**	2026	2027^
M Female (estimated)[#]	0.11		0.092		0.088	
M Male (estimated)	--		0.090		0.087	
Average Recruitment (millions of fish)	26		21		18	
Tier	3a		3a		3a	
Projected Total Biomass (Age 2+; kt)	705	696	628	611	469	453
Projected Female Spawning Biomass (kt)	220	241	237	253	205	211
$B_{100\%}$ (kt)	303	303	348	348	306	306
$B_{40\%}$ (kt)	121	121	139	139	122	122
$B_{35\%}$ (kt)	106	106	122	122	107	107
F_{OFL}	0.10	0.10	0.09	0.09	0.10	0.10
$maxF_{ABC}$	0.09	0.09	0.08	0.08	0.08	0.08
F_{ABC}	0.09	0.09	0.08	0.08	0.08	0.08
OFL (kt)	59	58	48	46	38	35
max ABC (kt)	50	50	41	40	32	30
ABC (kt)	50	50	41	40	32	30
Status	As determined *last* year for:		As determined *this* year for:		As determined *this* year for:	
	2023	2024	2024	2025	2024	2025
Overfishing	No	n/a	No	n/a	No	n/a
Overfished	n/a	No	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 mt in 2025 (a yield ratio of 0.49 was assumed based on a 2024 extrapolated catch of 23,000 mt and an ABC of 47,000 mt). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.

**The 2026 SAFE Model *26.1_1Reg* projections were based on specified catch of 20,000 mt in 2026 (a yield ratio of 0.49 was assumed based on a 2025 catch of 23,200 mt and an ABC of 47,600 mt).

^The 2026 SAFE Model *26.2_FAA* projections were based on specified catch of 16,000 mt in 2026 (a yield ratio of 0.49 was assumed based on a 2025 catch of 23,200 mt and an ABC of 47,600 mt).

[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.

Spatial Catch Apportionment

A five-year moving average of the NOAA Longline Survey proportions of biomass in each region are used to apportion catch to management area, as a means to ensure regional catch is in relative proportion to regional biomass. The apportionment values are updated yearly as new survey data are collected.

Accounting for Whale Depredation

For the final recommended ABC (ABC_w) or OFL (OFL_w), sperm and killer whale depredation in the fixed gear fishery is accounted for by reducing the maximum ABC by the last estimate of the three-year average of depredation estimates by area. Beginning in 2023, whale depredation estimates have been held constant at the 2022 levels, per SSC recommendations. By accounting for whale depredation in the assessment and associated catch projections, the approach does not create additional regulations or burden for in-season management. The ABC is reduced by ~170 mt and the OFL by ~200 mt annually to account for depredation.

Introduction

For a full description of the sablefish resource and fishery dynamics, see Goethel et al. (2021; available at https://www.fisheries.noaa.gov/resource/data/2021-assessment-sablefish-stock-alaska).

Sablefish are found from northern Mexico to the Gulf of Alaska (GOA), westward to the Aleutian Islands (AI), northward in the Bering Sea (BS), and into the northwestern Pacific Ocean off the Siberian coast of Russia and the Kuril Islands in Japan (Wolotira et al. 1993). Genetic analysis has found no population sub-structure throughout their range along the US West Coast to Alaska and suggested that observed differences in growth and maturation rates may be due to phenotypic plasticity or are environmentally driven (Jasonowicz et al., 2017; Kapur et al., 2020; Timm et al., 2024). Sablefish are assessed as a single, homogeneous population in Federal waters off Alaska, because of their high movement rates and panmictic stock structure. However, management is by discrete regions to distribute exploitation throughout their wide geographical range, including the Bering Sea (BS), Aleutian Islands (AI), Western GOA (WG), Central GOA (CG), and Eastern GOA (EG) (composed of West Yakutat, WY, and Southeast Outside, SEO; Figure 3.1).

Adult sablefish live at depths greater than 200 m and are highly mobile, though, exact movement patterns and drivers are not well understood (Hanselman et al., 2015). Recently, results of a spatially explicit tag-integrated assessment model (Cheng et al., 2025d) demonstrated support for historical hypotheses of a clockwise ontogenetic movement pattern (Heifetz and Fujioka, 1991), wherein immature fish tend to move towards and reside in western region (WG, BS, AI) and then move eastward as they mature with high residency of older fish in the CG and EG. Spawning occurs in winter at depths of 300 - 500 m near the edges of the continental slope (Mason et al. 1983). Juvenile sablefish spend their first two to three years on the continental shelf of the GOA and the southeast BS. After their second summer, they begin moving offshore to deeper water, typically reaching their adult habitat, the upper continental slope, at 4 to 5 years of age. This corresponds to the age range when sablefish start becoming reproductively viable (Mason et al. 1983, Rodgveller et al. 2016).

Drivers of recruitment dynamics for sablefish are not well understood, but, unlike other Alaska groundfish species, they appear to have responded positively to recent large marine heatwaves in the North Pacific potentially due to their rapid growth (Callahan et al., 2021). Although young, immature sablefish are found throughout Alaska federal waters, recent extremely large year classes have been more concentrated in western regions, especially the eastern Bering Sea (EBS) shelf (Cheng et al., 2025d). Thus, the EBS may act as a nursery ground during periods of high recruitment and may represent recolonization of a pre-industrial fishing population center (Sasaki, 1985). For further information on sablefish life history dynamics and ecosystem drivers see the Sablefish Ecosystem and Socioeconomic Profile (ESP; the last full ESP is available here in Appendix 3C and the most recent ESP update is available here in Appendix 3D).

Fishery

Sablefish have been exploited since the end of the 19th century with rapid fishery expansion in the 1960s when Japanese longliners began operations in the EBS (Table 3.1, Figures 3.1 -- 3.4). As the fishing grounds in the EBS were preempted by expanding Japanese trawl fisheries, the Japanese longline fleet expanded to the AI and the GOA in the 1970s (Figure 3.1). Heavy fishing by foreign vessels resulted in a peak in total catch at 53,000 t in 1972, which led to a substantial population decline and implementation of fishery regulations in Alaska. The U.S. longline fishery began expanding in 1982 in the GOA and by 1988 the U.S. harvested all sablefish taken in Alaska, primarily by hook-and-line gear in the eastern and central GOA. Over the last two decades, the EG and CG have constituted the bulk of sablefish landings (~4 – 7kt each), followed by the WG (~1 – 3kt), and BS and AI (0.2 – 2kt each). In the 2010s, the AI experienced slightly higher catch than the BS (Figure SM3C.12), which corresponded with a period of high catch rates of old,

large fish (e.g., from 2010 to 2016 ~20 – 70% of the AI age compositions were composed of fish older than age-30 leading to an unrealistically large plus group in the population level age compositions during that period; Figures 3.48 and SM3C.42). Catch and effort in the AI has decreased drastically since 2023 (likely due to poor sablefish markets and the high cost of fishing given the distance to fishing grounds in the AI). In 2025, there were no observed trips or biological sampling from the AI due to a combination of low fishing effort and the sampling design of observer deployment.

From a year round fishery in 1983, the fishing season shrank to 10 days in 1994, warranting the "derby" fishery label. In 1995, Individual Fishery Quotas (IFQ) were implemented for hook-and-line vessels along with an 8-month season. The IFQ Program is a catch share fishery that issued quota shares to individuals based on sablefish and halibut landings made from 1988 -- 1990. Since the implementation of IFQs, the number of longline vessels with sablefish IFQ experienced a substantial and anticipated decline from 616 in 1995 to 362 in 2011, which was expected as shareholders consolidated their holdings and fished fewer vessels to reduce costs (Fina, 2011). The season dates have varied by several weeks since 1995, but the monthly pattern has been from March to November with the majority of landings occurring in May to June. IFQ management increased fishery catch rates and decreased the harvest of immature fish after implementation (Sigler and Lunsford 2001).

In response to consistent sperm whale depredation on hook and line gear, the NPFMC passed a regulation in 2015 to allow pot fishing in the GOA starting in 2017. In 2017, pot fishing made up a small proportion of the fixed gear catch (~15%). However, since 2021 the majority of removals by the fixed gear fleet was taken by pot gear (Table 3.1, Figure 3.3). The transition to pot gear was extremely rapid and primarily driven by the increasing popularity of collapsible 'slinky' pots that are easier to store on smaller vessels while effectively eliminating whale depredation that has been rampant on hook and line gear (Figure 3.5; Peterson and Carothers, 2013; Peterson and Hanselman, 2017; Cheng et al., 2024a).

Sablefish are also caught during trawl fisheries for other species groups such as rockfish and deep-water flatfish, and more recently walleye pollock. Allocation of the Total Allowable Catch (TAC) by gear group varies by management region and influences the amount of catch in each region. Allocation percentages by area are: 80% to fixed gear and 20% to trawl in the Western and Central GOA; 95% to fixed gear and 5% to trawl in the Eastern GOA (i.e., 5% to trawl in WY, given trawling bans in the SEO management area); 50% to fixed gear and 50% to trawl in the eastern BS; and 75% to fixed gear and 25% to trawl gear in the Aleutian Islands. For much of the last twenty years, trawl gear has constituted around 10% of total sablefish catch, but this proportion increased rapidly starting around 2016 and reaching a peak of 39% in 2020 (Table 3.1; Figure 3.4). Recent increases in trawl fishery sablefish catch are predominantly from the BS due to the increased prevalence of small sablefish from recent strong year classes on the primary fishing grounds in the EBS (Tables 3.1 – 3.2, Figures 3.1 – 3.2). Although most sablefish catch in trawl gears are incidental, haul-specific targeting of sablefish has risen, particularly in the CG and WG, as part of other directed bottom trawl fisheries likely due to the increasing prevalence of sablefish. Over the last two decades, the majority of sablefish catch in trawl gears has occurred in the CG (0.5 – 2kt), but since 2018 catch in the BS has increased rapidly (~1 – 5kt) as has the catch in the AI (~0.5 – 1.25kt). The increase in the BS and AI is attributable to the rapid increase in small sablefish due to strong recruitment since 2016, which have typically been first encountered in the BS and AI (see Appendix 3D), particularly in the pelagic trawl fisheries on the EBS shelf (see Appendix 3E of the 2024 SAFE).

Five State of Alaska fisheries land sablefish outside the IFQ program, including those in Prince William Sound, Chatham Strait, and Clarence Strait with minor fisheries in the northern GOA and AI. The minor state fisheries were established by the State of Alaska in 1995 at the same time that the Federal Government established the IFQ fishery, primarily to provide open-access fisheries to fishermen who could not participate in the IFQ fishery. State catch from the northern GOA and AI minor fisheries are included in the current assessment, because they are reported using the area code of the adjacent Federal waters in the

Alaska Regional Office Catch Accounting System (CAS), the source of the catch data used in the assessment. Major state fisheries in the Northern Southeast Inside (NSEI) or Southern Southeast Inside (SSEI) waters are managed and assessed by the ADFG and catch associated with these fisheries are not included in the model.

Further details on the Alaskan sablefish fisheries can be found in the 2024 SAFE, Appendices 3D – 3F. Appendix 3D contains the sablefish Ecosystem and Socioeconomic Profile (ESP), which includes summaries of various fishery socioeconomic metrics. Appendix 3E describes the catch of small sablefish in the eastern Bering Sea in the various trawl fisheries. Appendix 3F summarizes sampling and observer coverage rates in the sablefish fisheries, including analysis of coverage rates by electronic monitoring (EM).

Management Measures and Bycatch

A summary of historical catch and management measures pertinent to sablefish in Alaska are provided in Table 3.2. As noted, the sablefish fixed gear fishery transitioned to IFQs in 1995 to avoid the growing derby-style fishery dynamics. Recently, the legalization of pot gear in the GOA in 2017 has had a monumental shift on gear usage, leading to a rapid transition from a predominantly hook-and-line fixed gear fishery to one composed primarily of longline pots since 2021 (Cheng et al., 2024a). Under current regulations, release of any sablefish by the sablefish IFQ fishery is prohibited, as long as there is remaining IFQ for persons onboard the fishing vessel. Following recent extreme recruitment of sablefish starting around 2014, markets for sablefish have become flooded causing socioeconomic downturns and resulting in upwards of 50% of the Alaska sablefish quota being left unharvested in recent years (Goethel et al., 2025). The NPFMC is currently exploring options to loosen full retention requirements based on requests from stakeholders to be able to release small, low value fish (NPFMC, 2024; Goethel et al., 2025; https://shinyfin.psmfc.org/small_sablefish/).

Sablefish discards in groundfish target fisheries are dominated by trawl fisheries in recent years, primarily in the BSAI due to an influx of recent large year classes in the BS, but discards have declined substantially starting in 2023 (Table SM3.3). Bycatch of federally managed groundfish species in the sablefish target fishery has primarily been composed of shortspine thornyhead, arrowtooth flounder, halibut, skates, and shortraker and rougheye rockfish, with amounts of incidental catch increasing drastically (by upwards of three-fold) in 2024 for many flounder and rockfish species (Table SM3.4). In terms of non-target bycatch, grenadiers are consistently the primary species encountered in the target sablefish fishery (Table SM3.5). The predominant prohibited species catch (PSC) in both the BSAI and GOA sablefish target fisheries is golden king crab and tanner crab (Table SM3.6).

Data

A variety of data sources are included in the assessment and were updated for 2026 (as available; Table 3.3), including fishery catch (Figure 3.4; Table 3.1), fishery and survey compositional data (Tables 3.4 – 3.5), and various indices of abundance and biomass (Figures 3.6 – 3.11; Table 3.6). The final input data used for the assessment can be found on the sablefish SAFE GitHub site at https://github.com/dgoethel-noaa/2026_Sablefish_CIE/tree/main/Model%20Runs/_Final_Mods). All data is pulled directly from the Alaska Fisheries Information Network (AKFIN) database, which maintains and hosts fishery catch, observer, and survey data for the Alaska region. All data is QA/QC'd by the collection agency prior to uploading to the AKFIN database. For further information on data collection protocols, estimation procedures, and quality assurance measures see the associated documents and webpages (e.g., Alaska Regional Office Catch Accounting System for fishery catch, North Pacific Observer Program for fishery biological samples, the NOAA Longline Survey for fishery independent indices and biological samples, and the AFSC Age and Growth Program for otolith age determination).

Data Used in the Assessment

Fixed Gear and Trawl Fishery Catch and Compositions

For all fishery data, data streams for two fleets are created: fixed gear and trawl gear (Figure 3.4). The fixed gear fleet represents a combination of the historic Japanese fleet and the current U.S. domestic fleet combining both hook-and-line and pot longline gear. Given the lack of reliable historic composition data to estimate selectivity, the Japanese fleet cannot be independently partitioned. Conversely, because the recent transition from hook-and-line to longline pot occurred so rapidly (<5 years) and the apparent similarity in selectivity between these gear types, combining hook and pot gear into a single fixed gear fleet has been deemed adequate (Cheng et al., 2024a,b). Similarly, given the lack of age data and limited length frequency sample sizes, all trawl gears (i.e., bottom and pelagic) are combined into a single trawl fleet.

Length, catch, and effort data were historically collected from the Japanese and U.S. fixed gear and trawl fisheries, and are now collected from U.S. fixed gear and trawl fisheries. The Japanese data were collected by fishermen trained by Japanese scientists. The U.S. fishery length and age data are collected by at-sea and plant observers. No otoliths were collected from the fisheries until 1999, because of the difficulty of obtaining representative samples from the fishery, and otoliths are only routinely collected from the directed fixed gear fishery (not the trawl fishery). Observer coverage, and resulting biological sampling, varies by region due to the level of fishing effort, sampling strata of associated vessels, and the amount of electronic monitoring (EM) in the region and sampling strata (e.g., EM coverage is much higher for fixed gear vessels in the CG and EG; see summary of fishery data collection in Appendix 3F of the 2024 Sablefish SAFE).

The catch used in this assessment (Table 3.1) represents total catch (landings plus bycatch or discards -- which are minimal in the fixed gear IFQ fishery -- assuming 100% mortality), and includes catch from minor state-managed fisheries (i.e., these are reported by federal statistical areas and directly incorporated into the NOAA catch accounting system) in the northern GOA and in the AI region (constituting about 1% of the average total catch). Additionally, all non-commercial sablefish removals (see Table 3.1) are integrated into the fixed gear fishery catch, including research catches and Alaska state sport fishery removals not associated with the NSEI or SSEI waters fisheries, as well as estimates of whale depredation from hook-and-line gear (see next section). Trawl fishery catch is summed across all trawl gear types (e.g., bottom and pelagic) with widely differing distributions and targeting. For instance, pelagic trawls primarily catch smaller sablefish as bycatch in the EBS pollock fishery, whereas bottom trawls catch larger sablefish across the Alaska region occasionally during targeted hauls.

Age compositions from the U.S. fixed gear fishery are available since 1999 with relatively consistent sample sizes (~1,200 otoliths aged yearly; Tables 3.4 and 3.5), and sex and length data recorded for each otolith. Aged sablefish otoliths are available the year following collection (i.e., there is a one year lag for use in the assessment), and the total number of aged otoliths varies slightly due to otolith damage or issues during the age reading process (Table 3.5). To ensure representative composition data for the entire population, a random sampling protocol (e.g., across size, sex, and haul) is first used to identify which fishery otoliths to age in a given year. The goal is to choose ~200 otoliths from each of the six management regions, where regional allocations are adjusted slightly when any given region does not have the requisite number of samples. Next, a weighted mean is used to determine the population aggregate, sex-specific age compositions to ensure a representative estimate of catch-at-age by sex. The regional age proportions are calculated across both sexes and weighted by total catch in numbers by region (to better reflect recruitment as opposed to older fish – as is the case when weighting by catch in biomass). Because the joint approach to fitting compositions is used for all models (Cheng et al., 2025c), a single vector of compositions that sums to one across both sexes and all ages is calculated each year, hence this single vector for each region is weighted by total regional catch and not sex-specific catch. Finally, the weighted average (by catch in numbers) is taken across all regions to provide the final vector of population age compositions across both

sexes. The two-stage protocol ensures adequate samples from across Alaska, such that differences in composition data by region are taken into account, while simultaneously avoiding over-weighting regions with lower catch. For models that disaggregate regions or fleets as regions (e.g., spatially explicit or implicit models, see Appendix 3C and 3D), weighted averages are no longer needed as the raw age compositions from a given region can be used directly (except when modeling the GOA as a single unit, then the same weighted average approach is used but just for regions within the GOA). Length compositions from the fixed gear fishery are collected but not used in the assessment models.

Only length data is available from the trawl fishery and sample sizes are generally much lower than in the directed fisheries, representing a mixture of lower sablefish catch and different observer protocols in non-directed fisheries (Tables 3.4 and 3.5). To obtain representative catch-at-length, the same approach using regional catch (in numbers) weighted averages as the fixed gear fishery age compositions is used to construct a single vector of population level trawl length compositions across sexes. As with fixed gear fishery age compositions, trawl fishery length compositions are available to the assessment on a one year lag from data collection. Only years with at least 300 length samples are used in the assessment.

Whale Depredation

Whale depredation on hook-and-line gear has been pervasive in the fishery, so a general additive modeling (GAM) approach for estimating fixed gear fishery whale depredation was developed (Peterson and Hanselman, 2017) and the model estimates were updated in 2022 (Goethel et al., 2022). The two-step modeling approach estimates total fishery depredation based on observer and high-resolution catch data (i.e., in 1/3° by 1/3° bins). First, the impact on depredated sets (i.e., a CPUE reduction factor) is estimated using a Generalized Additive Mixed Model (GAMM). Next, a Generalized Additive Model (GAM) with a zero-inflated Poisson distribution is used to determine the proportion of sets in an area depredated by whales. The total depredation is then determined based on the number of sets depredated per grid, the reduction in catch per depredated set, and the total catch per grid. Estimated depredation has generally been below 1,000 t per annum, often composing less than 1% of the total catch in recent years. Despite low overall impact relative to total catch, depredation varies by area and species with orca depredation higher in western regions (primarily the WG) and sperm whale depredation more significant in the CG and EG (Figure 3.5). Whale depredation estimates are added to the fixed gear catch and accounted for in associated catch projections (i.e., in the final whale-depredated catch recommendation values). Since 2023, fishery whale depredation values have been held constant at 2022 levels (131 t), per SSC recommendations (i.e., the depredation model is no longer updated annually).

NOAA and Japanese Longline Survey Indices and Compositions

Japan and the U.S. conducted a cooperative fixed station Alaska-wide longline survey for sablefish annually from 1978 (the fist year was experimental and not included in indices) to 1994 (herein termed the 'Japanese Longline Survey'; Sasaki 1985; Sigler and Fujioka 1988). In 1988, NOAA instigated a domestic longline survey for sablefish (herein termed the 'NOAA Longline Survey') that has been conducted annually in the GOA with the aim of continuing the Japanese Longline Survey methodology, and was expanded to biennial sampling of the AI starting in 1996 and biennial sampling of the eastern BS starting in 1997. Catch, effort, age (since 1996 and sporadically on the Japanese survey), length, and weight (since 1996) have been collected annually. Relative population abundance in numbers (RPNs) are computed using survey catch rates scaled to management area sizes, except for initial survey years (i.e., the RPN time series begins in 1990; Kimura and Zenger, 1997).

The NOAA Longline Survey operates on a cost-recovery basis, where the sale of the catch offsets the cost of the survey. Due to market conditions and vessel availability, the longline survey was cancelled in 2024. Starting in 2025, a new survey contract led to a shortened schedule, resulting in an unforeseen change in

experimental design. The GOA is now sampled in odd-numbered years and the BS and AI are sampled in even-numbered years. Details on the survey operations and recent trends can be found in Siwicke and Malecha (2026).

Longline gear is unable to estimate absolute population numbers or biomass, but it can provide a relative index, in this case a relative population number (RPN). Catch per unit effort (CPUE, $\hat{\theta}_{i,j,k}$) from station (*i*), depth strata (*j*), and geographic area (*k*) is calculated as

$$\hat{\theta}_{i,j,k} = \frac{n_fish_{i,j,k}}{n_skate_{i,j,k}},$$

where $n_fish_{i,j,k}$ is the number of fish caught and $n_skate_{i,j,k}$ is the number of skates of gear at station *i*, depth stratum *j*, and geographic area *k*, after filtering out skates of gear with > 5 ineffective hooks and adjusting the number of fish to a standard 45-hook skate. These are used to get an estimate of the mean CPUE for depth stratum *j* and geographic area *k*

$$\mathrm{E}\left[\bar{\theta}_{j,k}\right] = \frac{\sum_i \hat{\theta}_{i,j,k}}{n_{j,k}},$$

where $n_{j,k}$ is the number of station-level CPUE observations within depth stratum *j* and geographic area *k*. The associated sample variance of CPUE by depth stratum *j* and geographic area *k* is

$$\hat{V}\left[\bar{\theta}_{j,k}\right] = \frac{\sum_i (\hat{\theta}_{i,j,k} - \bar{\theta}_{j,k})^2}{n_{j,k}}.$$

Each depth stratum within a geographic region has an area weight ($w_{j,k}$) which is used to scale the CPUE to an RPN ($\bar{\psi}_{j,k}$) for each depth stratum *j* and area *k*

$$\mathrm{E}\left[\bar{\psi}_{j,k}\right] = \bar{\theta}_{j,k} w_{j,k},$$

These RPNs can then be summed across depth strata and geographic areas to provide regional or management area RPNs for areas sampled. Area sizes were refined in 2014 (Echave et al., 2013). The total RPN variance of an area ($\hat{V}[\hat{\psi}_k]$) combines sample variance of CPUE and area sizes with covariance of CPUE among depth stratum:

$$\hat{V}[\hat{\psi}_k] = \sum_j w_{j,k}^2 \hat{V}\left[\bar{\theta}_{j,k}\right] + 2 \sum_j \sum_{m \neq j} cov\left[\bar{\theta}_{j,k}, \bar{\theta}_{m,k}\right],$$

where *j* and *m* are different depth strata in the same region. These variances can be summed with the associated RPNs to regional or management areas.

To enable development of a consistent abundance index for use in a single region assessment model for sablefish, an extrapolation is necessary for unsurveyed regions in a given year. The extrapolation ensures that the resulting index represents the entire Alaska-wide population in a given year, avoiding annual fluctuations due to differences in survey coverage in even and odd years. By creating a single consistently scaled index, the assessment model can assume a time-invariant catchability (*q*) scalar instead of trying to estimate time-varying catchability and implicitly losing information on population trends and scale. In past assessments, for years when the BS and AI were being biennially sampled, estimates for RPNs in off-years (*y*) for a given region were extrapolated from the previous year RPN in that region based on an assumption of a proportional change as the annually sampled GOA:

$$RPN_{AI,y} = RPN_{AI,y-1}\frac{RPN_{GOA,y}-RPN_{GOA,y-1}}{RPN_{GOA,y-1}},$$
$$RPN_{BS,y} = RPN_{BS,y-1}\frac{RPN_{GOA,y} - RPN_{GOA,y-1}}{RPN_{GOA,y-1}}.$$

Extrapolating the BS or AI based on the GOA trends generally aligns with the assumption of a single population across Alaska, which is supported by the high mobility of sablefish and cross-region movement (see tagging section below). However, it ignores potential depth-based shifts in demographics that may differ among these large regions, as well as recent differences in RPN trends for the AI and BS which have increased more rapidly than the GOA (Figures 3.8 – 3.9).

With the 2025 survey redesign, the GOA extrapolation approach is no longer feasible as the GOA is only surveyed in odd years. Thus, a new approach was implemented termed the 'carryover' method, where holdover RPN values from the last time a given region (*k*) was surveyed (*y-1*) are used for interim years (*y*) between survey sampling events:

$$RPN_{k,y} = RPN_{k,y-1}$$

The carryover approach ensures a consistent scaling similar to the previous GOA extrapolation method, but relies solely on an assumption of steady-state regional dynamics. For use in the assessment model, the approach likely leads to conservative catch recommendations during periods of rapid population growth and moderate overestimation of catch during periods of population decline (Goethel and Cheng, 2025; See Appendix 3E). For 2026, the carryover method was implemented for all survey years for the NOAA Longline Survey RPN index (i.e., for the single region assessment models; Figures 3.6 – 3.7). Ultimately, the population trends between the GOA and carryover extrapolation approaches remain similar, but the GOA extrapolation approach predicts more rapid recent growth with higher interannual variability (Figure 3.7).

Due to concerns with either extrapolation approach, mainly, basing index trends on extrapolated data and potentially inflating RPNs, regional NOAA Longline Survey indices were also constructed for 2026 (i.e., for the fleets-as-areas and research-oriented spatial models) based solely on the observed data in a given year (i.e., without any extrapolation). Regional indices were constructed for the BS, AI, and GOA by summing RPNs from stations within the associated regions. Thus, the regional indices represent only the 'observed' survey data and, when summed across regions, are less than the single region extrapolated indices by the amount of the extrapolation in a given year (Figure 3.7).

Historically, the NOAA Longline Survey indices have also utilized an extrapolation within the AI region to account for a decrease in survey coverage of western AI stations between the Japanese and NOAA Longline Surveys. Mainly, the NOAA Longline survey has not sampled the northwestern or southwestern AI, given logistical constraints and associated costs with sampling remote regions of Alaska. Thus, extrapolations have been used to estimate the unsampled western AI RPNs in even-numbered years based on ratios between the western and eastern AI from the Japanese survey from 1983 to 1994. The northwestern AI is extrapolated from the observed northeastern AI RPNs based on a fixed ratio of 0.1820, while the southwestern AI is extrapolated from the southeastern AI RPNs based on a fixed ratio of 0.6581. The western AI extrapolation implicitly assumes a proportional, time-invariant linkage in regional population trends between the northwest or southwest AI with the northeast or southeast AI, respectively. However, the extrapolation methods do not account for numerous quantitative and experimental design changes that have occurred in the 30+ years since they were calculated (e.g., changes in area sizes). Therefore, given the low reliability of these extrapolation methods, the lack of observed data from the western AI, and the rapid

changes in Alaska-wide sablefish population dynamics, it was deemed appropriate to remove the western AI extrapolated stations from the AI RPNs for 2026.

Finally, whale depredation on the NOAA Longline Survey is accounted for by removing stations or adjusting area-RPNs depending on the form of depredation. Sets impacted by killer whale depredation are removed from calculations, because of the significant and variable impacts killer whales can have on catch rates. For sets impacted by sperm whale depredation, which is more difficult to detect, catch rates are inflated (i.e., an inflation factor of 1.18 or 1/0.85) based on depredation estimates from an area-wide Generalized Linear Mixed Model (GLMM) using year, depth strata, station, management area, and total number of effective hooks as explanatory variables (Hanselman et al., 2018a). The standard error and covariance of this estimate is included in the total variance of the RPNs. Because sperm whale depredation only occurs on a subset of the stations, the overall increase in the RPN index is modest, ranging from 1 - 5 % over time (Figure 3.10). The correction by area is minimal, but generally most impactful in EG stations.

The lowest RPN values in the NOAA Longline Survey time series occurred in 2015, but have increased rapidly with new time series highs continually being reached each year (Figures 3.6 – 3.7). However, population growth appears to be leveling off, at least in the GOA based on the 2025 GOA index (Figure 3.8). On a station by station basis, catch rates were generally higher in both the EG and WG in 2025 compared to 2023 but lower in the CG (Figure 3.11).

Since 1996, a random sample of otoliths has been collected and aged (~1,200 per year; Tables 3.4 – 3.5) from the NOAA Longline Survey, where survey protocols require otoliths be taken if a sablefish is caught on the first hook of a skate (Siwicke and Malecha, 2026). A similar two stage method as is used for the fixed gear fishery age compositions is used for the Japanese and NOAA Longline Survey age compositions, where a random selection of otoliths are aged, then regional compositions are weighted by regional RPNs to determine a weighted average population level survey age compositions. For the random sampling, there is a goal of aging ~900 otoliths from RPN stations (i.e., those that are used in the assessment) and 300 from gully (not included in the RPN index) stations. Of the 900 otoliths from RPN stations, there was an annual target of 600 from the GOA and 300 from either the BS or AI (depending on which region was surveyed). Historically, the number of GOA RPN otoliths that were aged was ~700 due to insufficient otoliths from other strata (Table 3.5). With survey changes in 2025, new targets include ~900 aged otoliths from the GOA and 300 from gully (non-RPN) stations in odd years, then 600 each from the BS and AI in even years. As noted, the regional age compositions are weighted by RPNs in each region to obtain a representative estimate of survey catch-at-age. For models that fit to regional data, the weighted average only needs to be applied within regions with multiple areas (i.e., the GOA). Age compositions are available to the assessment on a one year lag from data collection. Length data are collected from the NOAA Longline Survey, but not used in the assessment model.

From 1979 - 1994 otolith collections from the Japanese Longline Survey were length-stratified and only aged sporadically (approximately biennially; Table 3.4). Length compositions were collected annually and used in the assessment to enable stable estimation of survey selectivity parameters. As with other composition data sources, the regional Japanese Longline Survey age and length compositions were weighted by regional RPNs to achieve a representative population level survey catch-at-age.

Biological Inputs

Because the assessment model is age-structured, but length data from the Japanese Longline Survey and trawl fishery must be fit, a size-age transition matrix must be constructed based on mean length estimates (with uncertainty) from a growth curve. Two time blocks (pre- and post-1996) of growth are assumed in the assessment to account for potential changes in growth between historical and recent periods, and address changes in data collection protocols on the NOAA Longline Survey. For instance, before 1996 otolith

collection was length-stratified and no weights were collected, while random otolith collection and weight sampling began in 1996. Age-length pairs from the Japanese Longline Survey are utilized to estimate pre-1996 growth parameters, based on bias-corrected age-length pairs (Echave, 2021). Thus, these growth parameter estimates remain unchanged from previous assessments (see Goethel et al., 2021). For the post-1996 time block, growth schedules (length-at-age and weight-at-age) were re-estimated using the NOAA Longline Survey age and length data from 1996 through 2023, with estimation assuming a von Bertalanffy growth function. Estimation of growth followed the methods established and approved in previous assessments (Echave, 2021). Sablefish growth exhibits strong sexual dimorphism with males reaching a much smaller maximum size, despite similar growth over the first ~5 years of life (Figure 3.12). In general, updated growth estimates were largely consistent with prior values (Table SM3.7). However, growth rates among younger individuals declined across both sexes, likely attributable to the influence of decreased growth rates of recent cohorts due to density dependence from extreme recruitment events (Cheng et al. 2025a). Size-age transition matrices were constructed using the re-estimated growth curves with normal error fit to the standard deviations of the collected lengths-at-age, which generally aligned across time blocks and with previous estimates (Figure 3.13).

Given the larger maximum sizes achieved by females, the resulting maximum weights achieved are also much higher (Figure 3.14). Not surprisingly, the associated weight-at-age for females is higher, especially as males approach their asymptotic maximum size starting around age-15 (Figure 3.15). Sablefish maturity schedules were developed based on histological data using an age-based logistic regression (Table SM3.7; see Williams and Rodgveller, 2021).

Sablefish are difficult to age, especially those older than eight years (Kimura and Lyons 1991). To compensate, an ageing error matrix based on known-age otoliths collected from tagged young-of-the-year fish is used (Heifetz et al. 1999; Hanselman et al. 2012). The ageing error matrix is directly incorporated into the assessment to account for uncertainty in the ageing process.

Sablefish first appear on the upper continental slope, where the longline survey and longline fishery occur, at age-2, with a fork length of about 45 cm. A higher proportion of young fish are susceptible to trawl gear compared to fixed gear. Trawl fisheries usually occur on the continental shelf and shelf break inhabited by younger fish. The transition towards pot gear in the fixed gear fishery may allow a higher proportion of small fish to be selected, but the location of fixed gear fishing activities (e.g., size-based targeting of more valuable larger fish) and the optional use of escape rings may limit the number of small sablefish retained by pots. Given these considerations, recruitment in the assessment occurs at age-2, which is when fish primarily become susceptible to the various gears. Based on analysis of NOAA Longline Survey sex-specific age data, a 50:50 sex ratio is assumed at the age of recruitment (i.e., age-2).

Sablefish are a relatively long-lived species with a maximum observed age in Alaska of 94 years (Kimura et al., 1998). However, relatively few fish older than age-31 are seen within the age composition data, aside from a few years of high catch rates of particularly old fish in the AI during the 2010s (Figures 3.48 and SM3C.42). Thus, based on the age composition data, a maximum age of 31 (modeled as a plus group) is assumed. Given the complex and sex-specific population dynamics, estimating natural mortality (M) within the assessment is difficult. Thus, a prior for M is required. The M prior was updated in 2025 [$\sim N(\ln(0.085), 0.1^2)$] based on estimates of natural mortality from previous tagging models (0.0852 from Hanselman et al., 2018b), while also considering realistic average longevity values and estimates of sablefish natural mortality from assessments on the US west coast and British Columbia (See Goethel and Cheng, 2025). In terms of longevity, a mean of 0.085 corresponds to a maximum age of ~65 years, which was deemed appropriate, on average, because there are only 6 fish >70 years in the survey age compositions. The US west coast trawl survey observes slightly more older sablefish, and the associated longevity based prior in the west coast sablefish assessment was based on a maximum age of 75 resulting in a prior of $\sim N(0.072, 0.31^2)$. The final estimate of natural mortality from the west coast sablefish assessment was 0.088 (Wetzel

et al., 2025). For British Columbia, sex-specific natural mortality is estimated as part of the management procedure process, where female *M* is ~0.094 and male *M* is ~0.05 (DFO, 2023).

Data Input Changes for 2026

Newly available data since the 2024 assessment that were used in the assessment models for 2026 (*26.1_1Reg and 26.2_FAA)* included (Table 3.3):

- Length data from the trawl fisheries for 2024.
- Age data from the fixed gear fishery for 2024.
- Finalized catch for 2024 and 2025.
- The NOAA longline survey abundance indices for 2025.
- Updated inputs of length- and weight-at-age estimated using all available survey age-length-weight data through 2023.
- For the aggregate NOAA longline survey index (used in Model *26.1_1Reg*), the index was constructed using the 'carryover' approach for non-surveyed regions.

Data that was removed from the assessment models for 2026, include:

- The fixed gear fishery CPUE index, including the historical Japanese CPUE (1964 – 1981) and the domestic CPUE (1995 – 2022).
- The fixed gear fishery length composition data from 1990 – 1998.
- The NOAA longline survey length composition data from 1990 – 1995.
- For the NOAA Longline Survey index, extrapolated relative population numbers (RPNs) from stations in the western AI were removed from the index.

Available Data Not Used in the Assessment

NOAA Gulf of Alaska Trawl Survey

Since 1984, NOAA has conducted triennial or biennial multispecies trawl surveys in the GOA on the upper continental slope to 500 m depth. GOA trawl survey biomass indices were not used in the assessment model prior to 2007, because they were not considered good indicators of the relative biomass of adult sablefish since the full range of sablefish habitat is not sampled and sablefish may also outswim the net. Beginning in 2007, trawl survey indices were integrated into the assessment, primarily as an index of juvenile sablefish biomass. However, recent evidence suggests that the NOAA Longline Survey provides an adequate indicator of incoming recruitment strength, while signals regarding recent cohort strength in the longline survey data have countered those observed in the trawl survey, and the indices themselves strongly diverged in 2023 (Figure 3.6). Thus, the trawl survey index was again removed from the assessment in 2025 (See Goethel and Cheng, 2025). The GOA trawl survey index was at its lowest level of the time series in 2013, more than quadrupled until 2021, then declined precipitously by ~50% in 2023 and remained relatively stable in 2025 (Figure 3.6; Table 3.6). Lengths are sampled during each survey year (Table 3.4). AI and BS trawl survey biomass estimates are also available, but not used in the assessment model given their relatively low sablefish biomass estimates, high sampling error, and relatively short time series, especially in the BS.

Fixed Gear Fishery Catch-per-Unit Effort Index

Based on Japanese longline fishery catch rate data, a nominal index of historical CPUE was previously included in the assessment from 1964 – 1981 (Table 3.5). For the domestic fixed gear fishery, records of catch weight and effort for vessels that target sablefish are collected by observers and also reported by vessel captains in voluntary and required logbooks. A combined gear (i.e., including data from both hook-

and-line and pot gear) standardized fixed gear CPUE index was developed (Cheng et al., 2023) and used in previous assessments (Table 3.5; Goethel and Cheng, 2024). However, the logbook data needed to produce the standardized index is no longer available to NOAA, and the last year of the CPUE index is 2022. Although the CPUE index generally matches trends in the NOAA Longline Survey RPNs, the CPUE index generally lags RPNs by several years (likely due to the fishery targeting larger fish and CPUE better representing mature biomass, whereas the RPNs better reflect total biomass; Figure 3.6). Given that the CPUE index can no longer be updated and the likely issues with standardizing for management and gear changes, the CPUE index was removed from the assessment in 2026 (See Appendix 3B). Likewise, the Japanese CPUE index was removed, since it cannot be standardized and given the lack of information on the provenance of the underlying data.

NOAA Longline Survey and Fixed Gear Fishery Length Compositions

Extensive length data from the NOAA Longline survey and fixed gear fishery are available, where survey length data are available in the year of collection while fishery length data is available on a one year lag. Length data were randomly collected for all years since 1990 for both the survey and fishery. Given the difficulties in adequately addressing assumptions for fitting length data in an age-structured assessment (e.g., accounting for time-varying growth and seasonal growth dynamics), length data has been removed for all data sources that otherwise have age data from which selectivity can be estimated (See Appendix 3B; Goethel and Cheng, 2025).

Tagging Data

The spatial distribution and movement of sablefish have been studied by the Alaska Fisheries Science Center (AFSC) through various forms of tagging data, including traditional anchor tags, electronic archival tags, and pop off satellite tags. Tagging occurs on the NOAA Longline Survey and approximately 5% of the longline survey catch of sablefish are tagged and released each year, which generally equals about 3,000 – 3,500 fish per year. Since 1972, approximately 413,000 sablefish have been tagged in Alaska waters, of which over 38,500 have been recovered. The AFSC sablefish tag program has one of the longest time series of groundfish tag data in the nation. These data have been used to examine movement patterns, evaluate areal apportionment strategies of annual catch quotas, validate ageing methods, examine growth and mortality, and develop spatially explicit tagging and assessment models. Additionally, the AFSC conducts a GOA juvenile tagging program that has released 42,625 juvenile sablefish with conventional tags and 1,082 electronic archival tags have been implanted, with 2,630 conventional tag returns and 41 electronic tag returns. Because of the known-age (age-1) of juvenile sablefish, this tagging program provides valuable information that differs from the tagging of adults on the NOAA Longline Survey. Tagging of known-age juveniles before they leave coastal areas offers an opportunity to document age-specific movement, that is, recoveries of known-age fish provides information on the age at which fish become available to the fisheries (Maloney and Sigler 2008). Recoveries of known-age fish can also provide evaluation of ageing methods, such as otolith reading, enabling the development of ageing error matrices (Heifetz et al. 1999; Hanselman et al. 2012).

Recovered tags from both programs are either physically returned to the Auke Bay Laboratory with a prepaid business reply envelope or are reported with the tag reporting application that can be downloaded for free to a mobile or tablet device. Typical information given by the respondent and collected is: (1) tag number, (2) date of capture, (3) location, (4) size of fish, (5) sex, (6) depth of capture and (7) gear type. In recent years, as many as 500 to 1,000 tag recoveries have been submitted per year. The number of individuals returning tags varies widely. Many fishers and processors associate the tagging programs with the NMFS observer program and utilize observers onboard fishing vessels and in processing plants to collect and return all tags from that particular vessel or plant. The usual number of non-NOAA people participating ranges between 300 and 400 annually.

Existing data sets are used to match recovery and release information for each tag submitted. With each tag recovery, a small reward (hat) is offered along with a brief letter describing the history of the fish in terms of movement and growth. Additionally, an annual tag reward lottery drawing is held in which all tags recovered in the past year are entered into a drawing for a monetary reward. These incentives are to encourage participation and improve tag recovery rates.

Further information on the tagging program and the data can be found in the most recent report to industry on the sablefish tag program (Echave et al., 2013) and at the AFSC groundfish tag website found at https://apps-afsc.fisheries.noaa.gov/maps/tagmap/tagmap-v2/combined.php. The tagging data has been analyzed extensively via tagging studies (e.g., Maloney and Sigler, 2008; Hanselman et al., 2015; Kapur et al., 2025) and is integrated directly into the spatially explicit model recently developed for sablefish (Cheng et al., 2025d; See Appendix 3D).

Population Trends in Nearby Regions Not Incorporated in the Assessment Model

Alaska Northern Southeast and Southern Southeast Inside Waters

Sablefish in the Northern Southeast Inside (NSEI) Subdistrict waters and Southern Southeast Inside (SSEI) Subdistrict waters of Alaska are treated as separate stocks from the federal population, but some migration into and out of Alaska federal and state waters has been confirmed with tagging studies (Hanselman et al. 2015). NSEI sablefish continue to demonstrate similar population trends as the federal stock with strong recent recruitment observed, particularly the 2016-year class, which is now over 50% mature and comprises approximately 32% of the biomass (Figure 3.16). The NSEI longline survey CPUE has remained substantially above the long term mean since 2020 with minimal variation over the last three years. However, estimates from the 2023 stock assessment suggest sablefish spawning stock biomass remains at lower levels than estimated during the 1980s and 1990s. In SSEI waters, the longline survey CPUE showed a 40% increase from 2022 to 2023 (Figure 3.16). The SSEI pot fishery CPUE increased 10% from 2022 to 2023 while the SSEI longline fishery CPUE decreased in recent years, most likely due to a substantial shift from longline gear to pot gear. Alaska state fisheries are seeing a similar rapid transition from hook-and-line gear to pot gear as the federal fishery.

Canada

The estimated biomass trend for the British Columbia (BC) stock of sablefish is similar to that in Alaska federal waters, with strong increases in the mid-2010s due to above average recruitment in 2016 – 2017. Spawning stock biomass has shown consistent increases in recent years (Figure 3.17). The survey index value in 2023 was 10% less than the 2022 value, but still in line with the above-average levels seen since 2018. Total allowable catches (TACs) for the BC Sablefish stock are determined using a surplus production model implemented as part of a management procedure approach chosen through management strategy evaluation (Kendra Holt, pers. comm.).

United States West Coast (Washington, Oregon, and California)

The United States West Coast stock of sablefish was most recently assessed by NOAA's Northwest Fisheries Science Center in 2025. At the beginning of 2025, spawning output (i.e., the biomass of mature females) was estimated at 74,409 metric tons (mt), corresponding to a stock status of 33.9% relative to unfished conditions. The population declined rapidly from the mid-1970s to levels below the minimum stock size threshold (MSST) by the mid-1990s. From 2000 to 2020, spawning output remained relatively stable but below the MSST. Since 2020, however, the population has increased steadily, reaching its highest spawning output since 1989 (Figure 3.18). This recent increase is driven by several above-average recruitment years since 2013, including strong cohorts in 2013, 2016, 2020, 2021, and 2023 (Figure 3.18).

Recruitment estimates for 2024 remain highly uncertain at the time of the assessment. Stock size and status are projected to continue increasing over the next several years, with spawning output expected to surpass the management target ($B_{40\%}$) by 2027, even under projected catches that are considerably higher than the recent average (5,651 mt per year over the last five years).

Pacific Sablefish Transboundary Assessment Team (PSTAT)

Concurrent sablefish trends seen in Alaska, Canada, and the West Coast highlights the need to better understand the contribution to Alaska sablefish productivity from other areas and vice versa. A Pacific Sablefish Transboundary Assessment Team (PSTAT) consisting of scientists from the U.S. (west coast and Alaska regions, including both federal and state scientists) and Canada has been working to better understand the dynamics, population trends, and biology of sablefish across the eastern Pacific Ocean (https://www.pacificsablefishscience.org/). The PSTAT has engaged in a multi-year research endeavor that produced three key products: 1) a tagging model estimating movement across the northeastern Pacific (Kapur et al., 2025); 2) a spatially structured, data-conditioned operating model (OM), and 3) the development of an MSE for the transboundary sablefish stock, with seven management strategies explored (Kapur et al., 2024). No future meetings are scheduled due to lack of future funding for PSTAT work.

Analytic approach

Model Structure

The assessment models are implemented in the generalized R-TMB based Spatial Populations over Regional Components (SPoRC) stock assessment R package (Cheng et al., 2026; https://chengmatt.github.io/SPoRC/index.html), which utilizes the integrated analysis paradigm (Maunder and Punt, 2013). Two assessment model configurations are presented with identical parametrizations and assumptions, aside from the treatment of the NOAA Longline Survey data. Model *26.1_1Reg* utilizes a single aggregate index based on the carryover extrapolation method and aggregates associated age compositions Alaska-wide. Conversely, Model *26.2_FAA* utilizes a spatially implicit fleets-as-areas (FAA) configuration, where the NOAA Longline Survey is disaggregated into BS, AI, and GOA fleets with each fleet having a unique index and set of age compositions. Separate catchability and selectivity parameters are then estimated for each regional survey fleet. The following describes the general assessment structure as it applies to both model configurations and highlights areas of discrepancy in terms of survey dynamics. A complete description of the general SPoRC assessment model structure as it pertains to the sablefish application is available in Appendix 3A. Associated R code for implementing each model as well as data inputs and model outputs and figures are available from the GitHub repo (Model *26.1_1Reg*, Model *26.2_FAA*). Information on model bridging from previous AD Model Builder applications to SPoRC as well as recent assessment model changes and rationale is available in the 2025 model development document (Goethel and Cheng., 2025). Bridging from Model *25.12* to Model *26.1_1Reg* is provided in Appendix 3B, while development of Model *26.2_FAA* is provided in Appendix 3C. A research-oriented spatially explicit model has also been developed and is described in Appendix 3D, but not discussed further here.

Spatial Structure

The assessment models both assume a single Alaska-wide sablefish population. For Model *26.1_1Reg*, a single region panmictic configuration is used where spatial homogeneity is assumed across Alaska, with all data sets fit Alaska-wide. In Model *26.2_FAA*, the FAA configuration uses selectivity and catchability assumptions to implicitly account for spatial heterogeneity. Similar to the single region assessment, the FAA model assumes that the 'regional' survey trends in indices and compositions represent the dynamics from a single underlying population, where survey-specific catchability (q) and selectivity estimates are

used to implicitly account for varying age-specific availability (e.g., due to the survey footprint being smaller than the distribution of the population of inference or caused by ontogenetic or seasonal migration patterns; Berger et al., 2012; Waterhouse et al., 2014). Interpreting the dynamics of FAA models can be less intuitive, because each fleet is still operating on a single, homogeneous population, such that variability in indices and compositions can only be interpreted as changes in availability to a given fleet. Thus, when signals in the data (e.g., survey indices or compositions) differ for fundamental population processes (e.g., recruitment) across space, the model must attempt to rectify these differences primarily through selectivity differences, potentially leading to non-intuitive predictions (e.g., predicted survey abundance trends). The FAA model foregoes the need for using any extrapolated data and can fit regionally disaggregated data, but may overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high). In particular, given the need for a sex-specific model for sablefish, data sparsity is of concern as compositions are partitioned by sex and region.

Age and Recruitment Dynamics

An age structured statistical catch-at-age (SCAA) framework was utilized, which tracks population numbers-at-age by sex. Sex-specific modeling was required to address sexually dimorphic growth and associated selectivity (Cheng et al., 2025b). Equilibrium age structure in 1960 (model start year) was initialized assuming exponential decay from the mean recruitment based on natural mortality and an assumption that fixed gear fishing mortality is at 10% of the mean fishing mortality. Estimated age deviations were then applied to the equilibrium age structure to define the final initial age structure.

Recruitment at age-2 is estimated based on lognormal deviations about a mean recruitment parameter. As described in Methot and Taylor (2011), a bias correction term was implemented in the stock-recruit relationship and recruitment penalty term in the objective function to ensure that recruitment estimates were mean unbiased. The correction term was scaled linearly from 0 in data poor years (when there was little information to inform recruitment) to 0.9 in recent data rich years (when there was extensive information to inform recruitment), but then declined near the terminal year to account for lack of information on the most recent year classes. The values of the bias correction terms were iteratively tuned as described in Methot and Taylor (2011). For sablefish, the break points for the bias correction term included a start year of 1968 (i.e., start of the increasing linear ramp), a max of 0.9 starting in 1984, and a subsequent decline (i.e., start of the declining linear ramp) starting in 2023 to account for limited information in the compositional data for recent recruitment events. To ensure adequate flexibility to estimate extreme, spasmodic recruitment events the recruitment variance term (σ_R) was fixed at 0.9 for the recent period (since 1975), while historical recruitment was constrained with a value of 0.4 to aid model stability in years with no composition data.

The population was then projected forward from the initial age structure and annual age-2 recruitment assuming age-based dynamics that tracked fish from age-2 to age-31+, where the terminal age was a plus group. Exponential cohort decay was modeled via total instantaneous mortality composed of natural and fishing mortality.

Demographic Parameters

Primary demographic parameters were estimated outside the model and treated as fixed inputs, including maturity- (single time block), length- (two time blocks, pre- and post-1996), and weight-at-age (single time block; see Table SM3C.7 for age-based values for all inputs). To allow fitting length data directly (i.e., in the trawl fishery and Japanese Longline Survey), predicted age compositions were converted to length compositions using input size-age transition matrices. Because sablefish can be difficult to age, an ageing error matrix was directly integrated into the assessment based on known-age otoliths (Hanselman et al., 2012). Sex-specific natural mortality is estimated with a prior [~$N($ln(0.085), 0.1^2)].

Fishery Dynamics

The model assumes two primary fishing fleets (i.e., the directed fixed gear fishery, including both pot and hook-and-line gear, and the combined trawl gear fishery) each with independent dynamics, including unique fishing mortality and fishery selectivity parameters. Each fleet had an estimated mean fishing mortality parameter and annual lognormal deviations. Selectivity was estimated by sex and fishery using a two-parameter (i.e., age at 50% selectivity, $a_{50\%}$, and the slope of the curve, k) logistic selectivity function estimated with priors [$\sim N(\ln(4),1.5^2)$, estimated in log-space]. Two selectivity time blocks were assumed for the fixed-gear fishery (1960 – 2015 and 2016 – present), roughly corresponding to the transition point between gear types from a primarily hook-and-line fishery to a primarily pot fishery (Cheng et al., 2024a,b). The trawl fishery had a single time block.

Survey Structure

Two fishery-independent survey fleets were modeled, including the NOAA Longline Survey and the Japanese Longline Survey. Each survey fleet was modeled by estimating a single catchability parameter and sex-specific logistic survey parameters (parametrized in the same way as the fishery selectivity functions), where selectivity parameters were estimated with priors [$\sim N(\ln(3),1.5^2)$, estimated in log-space]. A single selectivity and catchability time block was assumed for the Japanese Longline Survey, while the NOAA Longline Survey was modeled with two selectivity time blocks (1990 – 2015 and 2016 -- present), to address apparent changes in age-specific availability by depth and region in recent years and a single catchability time block. For Model *26.2_FAA*, the NOAA Longline Survey indices were disaggregated as regional (BS, AI, and GOA) fleets. Each regional NOAA Longline Survey fleet was modeled with unique, estimated catchability and sex-specific logistic selectivity parameters (with two selectivity time blocks).

Observation Models and Estimated Parameters

Each of the data sources (i.e., fishery catch by fleet, fixed gear fishery age compositions, trawl fishery length compositions, NOAA and Japanese Longline Survey indices, NOAA Longline Survey age compositions, and Japanese Longline Survey age and length compositions; Figure 3.19; Table 3.3) are fit directly in the model. Indices and catch utilized a lognormal error structure with yearly standard errors (SEs; See Table 3.6 for the yearly SE values). For the compositional data, a multinomial error distribution was assumed. To account for interannual variability in composition data, a scaled input sample size (ISS) was utilized that proportionately scaled the ISS within a fleet based on the actual number of samples collected. Relative ISS values were assigned using a linear scaling based on the minimum and maximum samples taken across all years and the fleet-specific maximum ISS (see the maximum ISS values for each in Table 3.5) and a minimum ISS of 20. Generally, to better represent expected information content and representativeness of the data sources, age data was given a relatively higher maximum ISS than length data, survey data was given a higher value than fishery data, and the NOAA Longline Survey a higher value than the Japanese Longline Survey data.

A statistical maximum likelihood estimation (MLE) framework enabled estimation of key parameters, using a penalized likelihood approach that included normal penalty functions [i.e., recruitment deviations from mean recruitment, $\sim N(0, \sigma_R^2)$, and fishing mortality deviations from mean fishing mortality, $\sim N(0, 0.75^2)$] and lognormal priors (i.e., natural mortality and selectivity parameters). In total, 253 parameters were estimated for Model *26.1_1Reg* and 271 parameters for Model *26.2_FAA*, which represented the addition of 2 catchability parameters and 16 survey selectivity parameters to enable fitting the regional NOAA Longline Survey data in the FAA model (Table 3.7).

To ensure appropriate data weighting and avoid overfitting compositional data, the two-stage Francis iterative reweighting method was applied to 'right-weight' the compositional data and account for correlation among composition bins (Francis, 2011, 2017). In Stage 1, the model was run with equal input compositional data weights (i.e., all sources of age and length composition data fit in the model were given a weight, λ, of 1.0; exploratory runs demonstrated that final weights were insensitive to initial weights). Then, the compositional data weights were adjusted following Method TA1.8 and weighting assumption T3.4 of Francis (2011, Appendix Table A1, therein; i.e., using the assumption of a multinomial distribution and accounting for correlations among ages or length bins). In Stage 2, the model was then rerun with the new weights. The weights were iteratively adjusted until the difference between the current weights and the revised weights were minimal (i.e., the weights converged; for sablefish this usually took less than 10 iterations). The final 'effective' sample sizes after Francis reweighting were determined by multiplying the ISS by the data weights (See Table 3.8 for mean SE, ISS, and ESS for each data source fit in the model). It is worth noting that self-weighting Dirichlet multinomial likelihoods for the composition data were explored (See 'Sensitivity Runs' in Appendices 3B and 3C) to circumvent the need for data reweighting procedures, but fits to indices were greatly degraded and the approach was not pursued further.

Definitions

Recruitment was the estimated number of age-2 sablefish (in millions of fish). Total biomass (in kilotons) was the abundance of all sablefish age-2 and older multiplied by sex-specific input weight-at-age. Spawning stock biomass (SSB) was the mass of mature (based on input age-based maturity) females (in kilotons). Summary fishing mortality was fully selected *F*, which is the instantaneous mortality at the age of maximum fishery selectivity, summed across fleets.

Model Alternatives and Justification

As noted, two models were developed, which differed in their treatment of the NOAA Longline Survey data. Model *26.2_FAA* disaggregated survey data by region and avoided the need for index 'carryover' extrapolations as in Model *26.1_1Reg*. Ultimately, the choice of model structure for sablefish is a tradeoff between model stability, assessment complexity, and assumed data representativeness (See Appendix 3C, Table 3C.1). Although the FAA model would forego the need for data extrapolation, it may be more unstable and might overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high).

For Model *26.2_FAA*, changes from Model *26.1_1Reg*, included:

- A spatially-implicit FAA structure was implemented for the NOAA Longline Survey fleets, which disaggregated the longline survey into three regional fleets (BS, AI, and GOA), each of which had an independently estimated set of selectivity parameters and *q* values that were estimated by fitting the corresponding disaggregated indices (without any carryover or extrapolation approaches applied) and age compositions.

Model Bridging and Final Model Development

An extensive model bridging and development exercise was undertaken in 2026, which involved first implementing Model *25.12_1Reg_Cont* with updated data through 2025 and implementing Francis reweighting. Next, a single region model bridging exercise was implemented using incremental stepwise progression from Model *25.12_1Reg* to Model *26.1_1Reg* (the final single region model; See Appendix 3B). For Model *26.1_1Reg*, changes from the previously reviewed Model *25.12*, included:

- Sex-specific *M* was estimated.
- Logistic selectivity was assumed for the trawl fishery (instead of domed).
- The fixed gear fishery early/pre-IFQ (1960 -- 1994) time block was removed.

- All selectivity parameter linkages were removed.
- The selectivity parameter priors were updated.

Next, a FAA model development exercise was undertaken to develop a suitable model of intermediate complexity that did not rely on any extrapolated survey data, which was informed by an extensive, spatially explicit closed loop simulation analysis (Appendix 3E). Model building started with Model *26.1_1Reg* and added incremental complexity in fleet structure until adequate data fits and diagnostics were achieved (See Appendix 3C), which resulted in *Model 26.2_FAA*.

Model Evaluation

Model convergence was identified through successful inversion of the Hessian matrix, a maximum gradient component of less than 1e-4, reasonable estimates of uncertainty (SE), and limited parameter correlation. A jitter analysis was implemented to identify if altering the starting parameters led to an improved fit to the observed data, which would indicate that the model did not find a global minimum and suggest model instability. For the jitter analysis, the model was rerun 50 times with new starting parameter values. These new parameter values were determined by altering the starting values specified for the original model using an additive random deviation selected from a normal distribution ~$N(0, 0.1)$.

Model performance and goodness of fit were determined by examining joint negative log-likelihood components, visual fits to the data (including indices of abundance and age and length composition data), runs tests for index data, and residual analysis of both Pearson and one step ahead (OSA) residuals (to identify potential age or time trends in residuals; for OSA residuals the first age or length bin was dropped). Evaluating compositional model fits using Pearson residuals has the potential to result in spurious conclusions regarding lack of fit and/or independence, because correlated observations are retained. OSA residuals, which decorrelate observations arising from multinomial distributions, are increasingly being recommended as best practice for interpreting stock assessment model fits (Trijoulet et al., 2023). The overall interpretation of OSA and Pearson residuals is similar: large magnitude (e.g., greater than three) or systematic trends in residuals could indicate model misspecification. Finally, time series estimates of population trends were explored to ensure these were consistent with observations from the resource and general expert judgement regarding temporal dynamics.

Uncertainty

Two forms of uncertainty were evaluated, including the Hessian approximations from the MLEs and the posterior distributions from Markov Chain Monte Carlo (MCMC) simulations. For MCMCs, the recruitment bias adjustment was turned off and priors were implemented on most parameters. The SparseNUTS package was utilized for MCMC with 20,000 iterations, 150 warmups (based on defaults of SparseNUTS), and 4 chains. Key diagnostics were reported including maximum Rhat and the minimum effective sample size.

Model Diagnostic Analyses

Retrospective Analysis

Retrospective analysis is the examination of the consistency among successive estimates of the same parameters obtained as new data are sequentially removed from a model. A seven-year retrospective analysis (i.e., terminal years 2018 through 2025) was undertaken to examine whether any significant time trends in estimates of spawning biomass or recruitment were present. Because the recent fishery and survey selectivity time blocks begin in 2016, peels before 2017 preclude informative retrospective analysis due to model instability when attempting to estimate selectivity parameters with only one year of data. ‘Mohn’s

rho' (ρ), a measure of overall retrospective bias, was calculated as the mean of the relative 'bias' across all retrospective peels.

Historical Assessment Retrospective Analysis

An historical assessment retrospective analysis addresses consistency across successive stock assessment applications with the actual data available in the terminal model year. An 'all model' historical retrospective was undertaken, which compared the actual assessment outputs from the model used as the basis of management advice for a given SAFE year (i.e., going back to the 2018 SAFE; this included successive applications of models *16.5*, *21.12*, *23.5,* and *25.12*).

Profile Likelihoods

Likelihood profiles allow exploration of how the likelihood response surface varies for different values of a given parameter and highlights potential tension between data sources for estimation of key parameters. A likelihood profile was developed for the primary scaling parameters, mean recruitment and natural mortality.

Model Sensitivity Runs

Extensive model sensitivity runs were performed for both Model *26.1_1Reg* (Appendix 3B) and Model *26.2_FAA* (Appendix 3C) as part of the model bridging and model development process. See the associated appendices for results of the sensitivity model runs. No further model runs are presented here.

Results

Model Bridging and Final Model

Each model building step for the single region model helped improve model stability as diagnosed via various convergence diagnostics (e.g., maximum gradient values, number and degree of parameter correlations, jitter analysis, and profile likelihoods; see Appendix 3B). Model *26.1_1Reg* demonstrates more stable selectivity estimation, which has been an ongoing concern for the sablefish assessment, often requiring linking parameters across sexes. Moreover, improving biological realism by estimating sex-specific *M* helped stabilize estimates and move them towards more realistic, lower values. Similarly, removal of length compositions (for fleets where age compositions exist) further reduced model tension, providing better alignment in scaling parameters among the age composition data and the indices. By improving model parametrization, reducing model tension from uncertain data sources, and improving biological realism, the resulting Model *26.1_1Reg* appears to provide a more robust assessment of the sablefish population compared to Model *25.12_1Reg_Cont*. Results from the updated continuity model (Model *25.12_1Reg_Cont*) with data through 2025, suggest that Model *26.1_1Reg*, and Model *26.2_FAA* provided similar interpretations of the population trends and recruitment dynamics (Figures 3.20 – 3.21). In particular, the continuity and final single region models did not demonstrate any major differences, aside from Model *26.1_1Reg* demonstrating slightly more rapid declines in SSB historically and moderately increased rebuilding recently (Figure 3.21). Model *26.2_FAA* demonstrated moderate differences in interpretation of recent recruitment, while providing a strong downward scaling in SSB (See Model Evaluation and Appendix 3C).

Data Reweighting

As expected, Francis reweighting significantly downweighted the composition data to ensure adequate fit to the indices (Table 3.8). Not surprisingly, the NOAA Longline Survey age compositions retained the

highest final ESS, likely because these data most closely reflect the trends in the indices. However, the significant downweighting of the compositions further exemplifies the internal model tension between fitting the trends represented in the NOAA Longline Survey index compared to age compositions. Despite similar signals of rapid population growth since 2015, the model wants to interpret the magnitude of the recent year classes as much larger when closely fitting the compositions compared to the index. The fit to the mean age or length clearly demonstrates the difficulty fitting the rapid transition to a smaller, younger population since 2015. The mean age in the fishery has dropped from nearly 15 to less than 5 in ~7 years with a similar drop in the NOAA Longline Survey from a mean age of 10 to 5 in ~5 years (Figure 3.22). Moreover, reduction in mean age in the NOAA Longline Survey appears strongly driven by the BS and AI, as seen in the fit to mean age from the regional age compositions in Model *26.2_FAA* (Figure 3.23). Given that the AI age compositions receive moderate upweighting relative to other age composition data in the FAA model (Table 3.3), it is likely that the AI compositions better align with the trends in the indices, such that the Francis reweighting upweights the AI because it allows simultaneously good fit to the indices. The resulting fit to the mean composition bins after reweighting do not drastically change in the FAA compared to the single region model (Figures 3.22 – 3.23). However, disaggregation of the NOAA Longline Survey age compositions better elucidates the rapid reduction in mean age in recent years, particularly in the BS and AI, as well as the comparatively higher variation in mean age in these regions compared to the GOA.

Jitter Analysis

Jitter analyses for Models *26.1_1Reg* and *26.2_FAA* both indicated robust solutions (Figures 3.24 – 3.27), with negligible variation in objective function values across runs. Moreover, all jitter runs demonstrated small parameter gradients and positive definite Hessian matrices. Because no jitter run improved upon the original solution, both models were retained for all subsequent analyses. In the future, jitter analyses will apply larger parameter perturbations to better confirm solution robustness.

Model Evaluation

Both models had a positive-definite Hessian, small maximum gradient component (2.91 e -10 for Model *26.1_1Reg* and 7.64 e -10 for Model *26.2_FAA*), and no major parameter correlation, indicating (when also accounting for the jitter analysis results) that both models converged to a robust solution. However, a number of parameters demonstrate high uncertainty, including historical recruitment deviations defining the initial age structure (given lack of compositional data at the start of the model), recent recruitment deviations (due to elevated uncertainty associated with limited data on incoming year classes), and a handful of selectivity parameters (likely caused by the number of model partitions resulting from sex-specific dynamics; Tables SM3.8 – SM3.9). The objective function values by data source indicated that the compositional data, particularly the NOAA longline survey ages, and catch data had the largest absolute contributions (Figures 3.28 – 3.29).

Relative performance of each model are provided in Appendix 3C (Table 3C.2), and can be summarized as:

26.1_1Reg (full results here):

- Requires extrapolating (using the carryover method) ~50% of the NOAA Longline Survey index RPNs in a given year (to maintain a consistent scale for the single region assessment) for non-surveyed regions.
- Results in a stable model that provides good fits to the NOAA Longline Survey ‘carryover’ index.
- Demonstrates mediocre fits to age compositions.

- GOA composition data are implicitly upweighted during data aggregation due to higher sampling and catch, which likely under-represents recruitment signals from the BS and AI, resulting in an extremely large 2016 year class.

26.2_FAA (full results here):

- Model remains relatively stable and demonstrates adequate fits to the regionally disaggregated NOAA Longline Survey indices.
- Shows similar tension as the single region model when simultaneously trying to fit indices and age compositions, and demonstrates poor fit to the fixed gear fishery male age compositions.
- GOA NOAA Longline Survey selectivity becomes less steep, reflecting the need for the model to alias regional availability through selectivity estimation.
- Recruitment trends better reflect signals from the BS and AI as evident by increasing estimates of 2014 and 2017 year classes and decreases in the 2016 year class.
- Moderate downward scaling of SSB is due to decreasing estimates of M and R_0, likely reflecting the removal of extrapolated index data.

For both models, fit to the available data retain similar issues, where survey indices are generally well fit at the expense of composition data, primarily due to the Francis reweighting. Residual patterns in the composition data remain, but the aggregated fits appear adequate. Fundamentally, both models have trouble reconciling the much larger year classes and population growth suggested by the age composition data compared with the rapid, but more tempered, population growth observed in the survey RPNs. Both Model *26.1_1Reg* and Model *26.2_FAA* appear to provide robust and stable models for interpreting sablefish population dynamics. Although Model *26.2_FAA* assumes a moderate downward scaling of SSB and catch advice, general population dynamics and stock status remain consistent with Model *26.1_1Reg*. Interestingly, an exploratory run with the FAA model, where extrapolated regional carryover indices were fit to emulate the aggregate carryover index used in Model *26.1_1Reg*, led to a strong upward scaling of SSB, particularly since the start of the NOAA Longline Survey in the mid-1990s (Appendix 3C, Figure 3C.12). Thus, there may be inherent risk with using extrapolated survey data in the assessment, which might potentially result in artificially inflating SSB and catch advice.

Goodness of Fit

Fit to the catch data was good for both models, given the high assumed standard error (Figure 3.30). For *Model 26.1_1Reg*, the fit to both survey indices was also extremely good and the associated runs test did not indicate any significant non-randomness (Figures 3.31 and 3.33). The regionally disaggregated NOAA Longline Survey indices demonstrate general agreement on long-term population trends across regions, with all indicating rapid population growth since 2015 (Figure 3.32). Model *26.2_FAA* provided adequate fit to each index, given the slight discrepancies in signals. However, differences in the shape of the survey selectivity curves across regional fleets (i.e., much steeper in BS and AI compared to GOA; Figure 3.82) leads to a divergent trend in the last few years in the predicted indices. The BS and AI predicted indices begin to decline despite observed RPNs continuing to increase, while the GOA continues to increase and better fits the increasing observed GOA index (Figure 3.32). The reason for the divergence across regions is due to the tradeoff between survey selectivity, cohort mortality, and reductions in estimated year class sizes since the 2017 year class. Mainly, for the BS and AI survey indices, maximum selectivity occurs around age-4, so a cohort's maximum contribution to RPNs will decline after this age due to ongoing mortality (i.e., the size of the cohort can only decline). Conversely, in the GOA, survey selectivity is maximum around age-20, so there is a tradeoff between slowly increasing selectivity and increasing cohort mortality across the lifespan, such that maximum contributions to RPNs likely occur at intermediate ages (but much later than in the BS and AI). Because the 2017 year class has reached full selection in the BS and AI surveys, it is the largest cohort in the time series, and subsequent cohorts have been much smaller,

the model predicts a decline in BS and AI RPNs starting around 2022 (i.e., when the cohort reaches age-5). For the GOA, the predicted survey index continues to increase because the tipping point between mortality and selectivity has not yet been reached. To verify that this is true, a sensitivity run was undertaken with a steeper GOA survey selectivity, which resulted in the predicted GOA index increasing much more rapidly, leading to overestimation of the recent observed index and a decline in the predicted index after 2023 (Appendix 3C, Figure 3C.10). The index runs test indicated moderate non-randomness in the fit to the GOA NOAA Longline Survey index, particularly associated with the early data (prior to 2000), then underestimation from 2015 – 2020 and overestimation since 2020 (Figure 3.34).

For Model *26.1_1Reg*, fits to the composition data remain mediocre due to tension between fitting the index and age composition data. The poorer fits to the composition data can partially be attributed to the Francis reweighting approach (Francis, 2011), which prioritizes fit to the abundance indices. Fits to the NOAA Longline Survey age compositions were adequate, with a tendency to overestimate at age-2 and underestimate the peak of cohort abundance around ages 5-7, then slightly overestimate again between ages 10 through 20 (Figure 3.35). Fit to the mean proportions across the time series were generally good (Figure 3.37). Many of the same patterns observed from visual analysis of compositional data fits were observed in analysis of residuals (both Pearson and OSA residuals are provided for each compositional data source; Figures 3.37 and 3.39). Residual patterns indicate underestimation of recent large cohorts as they enter the population (e.g., since 2016; Figure 3.37), but the model has trouble fitting the massive recent cohorts (e.g., 2014, 2016, and 2017) when they begin to appear in the composition data at age-3 (Figure 3.35). The same patterns are observed in the fixed gear fishery age compositions (Figures 3.47), though recent recruitment events tend to be first observed at a slightly later age (e.g., age-4 or age-5), but fit to mean proportions is generally good. Moderate residual patterning exists, but the magnitude of residuals is relatively low (Figures 3.49 and 3.51). However, the predicted size of the plus group is greatly underestimated compared to the observed proportions (Figure 3.47), which has been an ongoing concern for the assessment (Goethel and Cheng, 2024). The large plus group is due an inordinate catch of large, old fish in the AI during the early 2010s (20 – 70% of catch from the AI was older than age-30 during these years; Appendix 3C, Figure SM3C.42), and fitting these data is not possible with realistic population dynamics (and application of a spatial model does not resolve the issue either, See Appendix 3D). Japanese Longline Survey age compositions are noisy but adequately fit (Figures 3.53, 3.55, and 3.57), while fit to the associated length compositions also appear adequate (Figures 3.59, 3.60, and 3.63). Trawl fishery length compositions are also relatively noisy and, at times, bimodal (representing the aggregation across diverse trawl fleets; Figure 3.66). However, fit to the mean proportions is reasonable and balances fitting the catch of small fish from the pelagic trawls with catch of larger females in bottom trawls (Figures 3.67 and 3.69).

Given the disaggregation by region of the NOAA Longline Survey age compositions in Model *26.2_FAA*, it is not possible to make a direct comparison to Model *26.1_1Reg* survey composition fits. However, because the GOA compositions are more highly sampled and receive higher relative weight in the aggregation method for the single region model, the GOA compositions in the FAA model are quite similar (Figures 3.35 – 3.36). Generally, the observed and predicted survey compositions from Model *26.1_1Reg* are similar to the fit to the GOA age composition fits in Model *26.2_FAA*, with generally similar residual patterns (Figures 3.37 – 3.40). A noticeable difference is that Model *26.2_FAA* strongly overestimates age-2 compositions across sexes but has slightly improved estimates for intermediate ages (e.g., ages 10 to 20; Figure 3.38). Fits to the BS and AI NOAA Longline Survey age compositions tend to be adequate for Model *26.2_FAA*, especially considering the relatively lower sample sizes and increased sparsity across ages (Figures 3.41 and 3.44). The AI age data tends to be fit slightly better, given the relatively higher data weight (ESS). Residual patterns for all NOAA Longline Survey regional fleets tend to reflect the pervasive trend seen in Model *26.1_1Reg* of generally underestimating peak abundance at ages 4 – 6 and overestimating intermediate ages 10 – 20 (Figures 3.42 – 3.43 and 3.45 – 3.46).

Compared to Model *26.1_1Reg*, the fit to the fixed gear fishery male age compositions for Model *26.2_FAA* is noticeably worse, where expected values are much higher than observed for ages 4 – 6 (Figure 3.48). The pattern was present in Model *26.1_1Reg* for certain years (e.g., 2012 -- 2013) but has become much more exacerbated in Model *26.2_FAA*. Fixed gear fishery male selectivity in the first time block is estimated to be much steeper in Model *26.2_FAA* (Figure 3.80), which is likely driving the overestimation of young male fish. The relative downweighting of the fishery age compositions relative to the multiple NOAA Longline Survey age composition data sets is probably also a primary factor in the poorer fit to the fishery age compositions in Model *26.2_FAA*. Residual patterns remain similar to Model *26.1_1Reg* with generally low magnitude of residuals (Figures 3.49 – 3.52). No major changes in the fits to the Japanese Longline Survey (Figures 3.53 – 3.64) or trawl fishery compositions (Figures 3.65 – 3.70) were detected for Model *26.2_FAA* compared to Model *26.1_1Reg*.

Time Series Results

For both models, sablefish abundance and biomass dropped throughout much of the 1960s and 1970s (Table 3.9, Figures 3.71 – 3.72), as the population began to be heavily exploited, with catches peaking at 53,000 mt in 1972 (Table 3.1, Figure 3.1). The population recovered in the mid-1980s due to a series of strong year classes in the late 1970s and early 1980s (Figures 3.73 – 3.78). The population subsequently declined as these strong year classes were removed, with a slight rebound in the early 2000s due to a handful of above average year classes in the late 1990s, then declined to a time series low in 2015 (Figures 3.71 – 3.72). Associated with a series of extremely large recruitment events since 2014, age-2+ biomass has approximately tripled since 2015, which represents sablefish population levels on par with those at the time the fishery expanded in the 1960s. The population age structure is slowly expanding as recent year classes begin to enter more fully mature age classes, but the number of fish greater than age-10 still remains low compared to historical levels (Figures 3.73 – 3.74; see Tables SM3.10 – SM3.11 for numbers-at-age by sex). However, over the course of the next decade, it is expected that the large 2014, 2016, and 2017 year classes will continue to help expand the age structure. SSB typically lags behind biomass with less pronounced extremes and, aside from a ten-year upswing in the 1980s, had been on a general downward trajectory for the entire time series (Table 3.9; Figures 3.71 – 3.72). However, SSB has more than doubled from the time series low in 2017, but remains well below time series high levels observed in the 1960s.

Sablefish are characterized by highly spasmodic recruitment events with periodic year classes that are well above average, then prolonged periods of depressed recruitment (Figures 3.75 – 3.76). Moreover, no apparent relationship between SSB and subsequent recruitment exists, with many of the larger cohorts being spawned from relatively low SSB (Figures 3.77 – 3.78). However, the large recruitment events in the late 1970s and early 1980s were associated with a more balanced age structure, which may indicate a potential age diversity and spawning portfolio effect on recruitment success (e.g., Griffiths et al., 2023). The largest historical recruitment event was the 1978 year class followed by the 1981 year class, but below average recruitment events then occurred throughout much of the 1980s and early 1990s (Table 3.9, Figures 3.77 – 3.78). Since 2014, recruitment has been at or above the time series mean (Figures 3.75 – 3.76). The 2014, 2016, and 2017 year classes are the three of the largest cohorts in the time series. However, recruitment events since 2020 appear to have declined back towards the time series mean level (Figures 3.75 – 3.76). However, the size of recent strong recruitment events is uncertain, given that they are informed by limited age and length composition data. Recruitment trends in Model *26.2_FAA* do differ moderately from those in Model *26.1_1Reg*. For instance, the time series average recruitment has declined, while the interpretation of recent dynamics has altered slightly resulting in a larger estimate of the size of the 2014 and 2017 year classes and a smaller 2016 year class (Figure 3.20). Alterations in recruitment estimates are attributable to subtle differences in recruitment signals across the regional NOAA Longline Survey age compositions, where the AI appears to provide a mixture of recruitment signals (strong 2014, 2016, and 2017 year classes; Figure 3.44) that balances those in the BS (strong 2014 and 2016 and very strong 2017 year classes; Figure 3.41) and GOA (strong 2014 and very strong 2016 year classes; Figure 3.36). However, there may also be

a data-year interaction related to the timing of the AI survey in even years (potentially matching years when some of the large recent recruitment events have occurred; e.g., 2014 and 2016).

Estimates of natural mortality are generally lower for males than females and lower for Model *26.2_FAA* (i.e., 0.088 for females and 0.087 for males) than Model *26.1_1Reg* (i.e., 0.092 for females and 0.090 for males; Figure 3.79) The downward shift in *M* likely indicates improved model parametrization, given that previous assessment models tended to estimate unrealistically high *M* values (Goethel and Cheng, 2025). Generally, selectivity has shifted towards younger fish for the longline survey and fixed gear fishery over time (Figures 3.80 – 3.82). Males tend to be selected at an older age than females in all fleets, likely because they are smaller at a given age. Compared to the fixed gear, younger fish are more vulnerable and older fish are less vulnerable to trawl gear, reflecting the preponderance of pelagic trawl gear data (that primarily interacts with small sablefish on the EBS shelf) in the aggregate trawl fishery length compositions. For Model *26.2_FAA*, survey selectivity for the GOA becomes much less steep (Figure 3.82) in the recent time block. The GOA selectivity shape reflects the model assuming that the younger age classes (< age-20 and aside from age-2) were less available to the GOA survey, and is required by the model to avoid overestimating the GOA survey index (See Appendix 3C).

Fishing mortality was estimated to be high in the 1970s, relatively low in the early 1980s, then increased in the 1990s before undergoing a gradual decline throughout the 2000s (Figure 3.83). Over the last five years, fishing mortality has steadily declined and is on par with the low levels of the early 1980s. Fishing mortality from the trawl fleet is generally less than half that of the fishing mortality in the fixed gear fleet. The estimates of fixed gear fishing mortality have increased slightly in Model *26.2_FAA* compared to Model *26.1_1Reg*, associated with the relative increase in *M* (Figure 3.79) and downward scaling of overall population biomass (Figure 3.21). Recent management has generally constrained fishing mortality to below limit reference point values, while biomass is above limit reference point values (Figures 3.84 – 3.85). However, recent low fishing mortality is primarily associated with poor sablefish market conditions leading to low ABC utilization in recent years (~50% in 2024 and 2025). Interestingly, the phase-plane for Model *26.2_FAA* suggests that overfishing may have been occurring on the sablefish population for much of the 2000s, until recent recruitment events began entering the population around 2021 and ABC utilization rates declined (Figure 3.85). Therefore, the FAA model suggests that the single region model may be more risk prone, if population scale is more in line with those estimated in Model *26.2_FAA*.

Overall, disaggregating the NOAA Longline Survey indices and age compositions and using an FAA structure (Model *26.2_FAA*), led to moderate downward rescaling in SSB and average recruitment, primarily due to a decline in *M* estimates as well as other scaling parameters (Table 3.10). The result is a strong decline in $B_{40\%}$ and catch advice (i.e., Acceptable Biological Catch, ABC; See Summary Table). Generally, the SSB trends remain consistent, though stock rebuilding increases more rapidly since 2018 in Model *26.2_FAA* compared to Model *26.1_1Reg*. The primary difference between models is the interpretation of recent recruitment events, where Model *26.2_FAA* now predicts that the 2017 year class is much larger than the 2016 year class, and all subsequent recruitment has been considerably lower than in Model *26.1_1Reg* (Figures 3.75 – 3.76).

Uncertainty

For both Model *26.1_1Reg* and *26.2_FAA*, MCMC diagnostics indicated adequate performance (maximum Rhat of 1.008 and minimum effective sample size of 401 for each) to allow for model inference. The MLE and MCMC estimates of parameters were generally similar, with some minor discrepancies among mean estimates for recent recruitment (Table 3.10). For primary scaling parameters (mean recruitment and catchability), the marginal posterior histograms from MCMC and asymptotic normal distributions generally align for both models (Figures 3.86 – 3.87), and no major pairwise correlations were noted aside from expected moderate correlation among primary scaling parameters (Figures 3.88 -- 3.89).

Comparison to Last Assessment Model

Generally, the population trends from the 2024 SAFE (Model *23.5*) are similar to those in both Model *26.1_1Reg* and Model *26.2_FAA*, though population scale and average recruitment have declined, particularly in Model *26.2_FAA* (Table 3.11; Figure 3.94). More importantly, model results for Model *26.1_1Reg* closely align with Model *25.12_1Reg_Cont* (the continuity model from 2025; Figures 3.20 – 3.21), despite the 2025 model not being used for provision of final management advice (due to the US government shutdown in 2025).

Model Diagnostic Analyses

Retrospective Analysis

The retrospective analysis indicated that the models are quite consistent, demonstrating a slight tendency to underestimate population scale and terminal SSB (Mohn's ρ = 0.0054 for Model *26.1_1Reg* and ρ = 0.046 for Model *26.2_FAA*; Figures 3.90 – 3.91). Variability exists in the estimates of recent year class strength, and Model *26.1_1Reg* tends to underestimate large year classes until about four years after it is first estimated (Figure 3.92). Similarly, for Model *26.2_FAA*, large recruitment year classes are often initially underestimated, but estimates tend to stabilize more quickly (Figure 3.93). However, the internal tension and differences in recruitment signals across age composition data sources (e.g., the different NOAA Longline Survey regional compositions) for Model *26.2_FAA* is apparent, given the switch between 2016 and 2017 being the dominant year class as more data is integrated over time (Figure 3.91). As noted, the GOA compositions tend to favor the 2016 year class, whereas the BS favors the 2017 year class and the AI demonstrates strong signals for both. Aside from conflicting signals within the age compositions themselves, there is likely also a year-data interaction, given the historical odd-even year survey design for the BS and AI regions, respectively. Therefore, the retrospective pattern partially reflects a data availability issue, where initial recruitment signals are probably dominated by patterns in the GOA, then shift slightly towards the BS and AI signals as those data become available. However, uncertainty in recruitment estimates and associated recruitment retrospective patterns for both models do not lead to retrospective patterns in SSB, because by the time a year class begins to significantly contribute to the SSB (e.g., by around age-5) the estimate of year class strength has already stabilized.

Historical Assessment Retrospective Analysis

Aside from Model *16.5* (i.e., used as the basis of management advice prior to 2021), which tended to severely overestimate recruitment and SSB growth, recent models have been highly consistent from one year to the next (i.e., based on the 'all model' historical retrospective; Figure 3.94). Model *26.2_FAA* demonstrates a significant downward scaling of population biomass, but trends remain similar to previous models, albeit with a moderately higher rate of population growth since 2018.

Profile Likelihoods

Likelihood profiles on key scaling parameters show similar trends across models, although those from Model *26.2_FAA* tend to be more stable and demonstrate a stronger minima for the age composition data (i.e., the primary source of information on recruitment and *M*; Figures 3.95 – 3.98). Not surprisingly, given the final estimates (Table 3.10), the age composition data indicate lower values for M and R_0 in Model *26.2_FAA*.

Harvest Recommendations

Population Projections

A standard set of seven projections is required for each stock managed under Tiers 1, 2, or 3 by the NPFMC. Five of the seven standard scenarios support the alternative harvest strategies analyzed in the Alaska Groundfish Harvest Specifications Final Environmental Impact Statement. For all projections, yearly recruitment is simulated as an inverse Gaussian distribution parameterized using historical recruitment estimates (1979 – 2023; average recruitment was 21 million for Model *26.1_1Reg* and 18 million for Model *26.2_FAA*). A common random number seed is used across projection scenarios to ensure a common time series of recruitment across all 1,000 simulations. Projections start from the terminal year numbers-at-age and all projection parameters (e.g., selectivity, natural mortality, and biological inputs) are taken from the estimated or assumed values from the terminal year of the assessment. The relative fishing mortality among fishing fleets in the terminal year is used to assign future fleet-specific fishing mortality (associated with projection specific catch). The same assumptions are used to define biological reference points using spawning biomass per-recruit calculations. For NPFMC Tier 3 stocks, F_{ABC} is defined as $F_{40\%}$ and F_{OFL} is defined as $F_{35\%}$, except when reduced by the NPFMC threshold/sloped HCR due to SSB falling below SSB_{OFL} ($B_{35\%}$). For scenarios 1, 2, 6, and 7, the NPFMC threshold HCR is used to reduce specified fishing mortality when the biomass drops below the specified limit reference point ($B_{35\%}$; See Figure 3.84).

The seven projection scenarios are ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC}):

- *Scenario 1*: In all future years, F is set equal to *max* F_{ABC}.
- *Scenario 2*: In 2026 and 2027, F is set equal to the F associated with the specified catch, which is the whale corrected ABC multiplied by the fraction of the 2025 ABC that was harvested (i.e., a harvest ratio of 49% was calculated in 2025). For the remainder of the future years, maximum permissible ABC is used.
- *Scenario 3*: In all future years, F is set equal to 50% of max F_{ABC}.
- *Scenario 4*: In all future years, F is set equal to the 2020 – 2024 average F.
- *Scenario 5*: In all future years, F is set equal to zero.
- *Scenario 6*: In all future years, F is set equal to F_{OFL}. This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its B_{MSY} level in 2025, or 2) above ½ of its B_{MSY} level in 2025 and above its B_{MSY} level in 2034 under this scenario, then the stock is not overfished.
- *Scenario 7*: In 2026 and 2027, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its B_{MSY} level in 2027, or 2) above 1/2 of its B_{MSY} level in 2027 and expected to be above its B_{MSY} level in 2037 under this scenario, then the stock is not approaching an overfished condition.

Spawning biomass, fishing mortality, and yield are tabulated for the seven standard projection scenarios (Tables 3.12 – 3.13). In Scenario 2 (Specified Catch), the specified catches are used to increase the accuracy of the short-term projections. For catch projections in the two years following the assessment terminal year, the ratio of the terminal year catch to terminal year ABC is used to determine the fraction of the ABC to be removed in each projection year. This method results in slightly higher future ABCs due to the lower initial removals in the initial projection years.

Status Determination

For the purpose of ABC and OFL reporting, the specified catch projections (Scenario 2) are used and reported in the executive summary. Under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition?

The official catch estimate for the most recent complete year (2025) is 23,200 mt, which is less than the 2025 OFL of 58,500 mt. Therefore, the stock is not being subjected to overfishing. For Model *26.1_1Reg*, because 2025 SSB is at $B_{62\%}$ (i.e., above $B_{35\%}$), sablefish are not overfished. Similarly, given that the 2027 SSB is projected to be at $B_{73\%}$ (i.e., above $B_{35\%}$), sablefish are not approaching an overfished condition (Table 3.12). For Model *26.2_FAA*, because 2025 SSB is at $B_{63\%}$ (i.e., above $B_{35\%}$), sablefish are not overfished. Similarly, given that the 2027 SSB is projected to be at $B_{69\%}$ (i.e., above $B_{35\%}$), sablefish are not approaching an overfished condition (Table 3.12).

Thus, **overfishing is not occurring** on Alaskan sablefish and the stock **is not overfished nor is it approaching an overfished condition.**

Acceptable Biological Catches (ABCs) and Overfishing Limits (OFLs)

Sablefish are managed under Tier 3 of the NPFMC harvest control rule, which aims to maintain the population at $B_{40\%}$.

For Model *26.1_1Reg*, the updated point estimate of $B_{40\%}$ is 139,000 t. Since projected female spawning biomass (combined areas) for 2026 is 237,000 mt (equivalent to $B_{68\%}$), sablefish is in sub-tier "a" of Tier 3. The updated point estimates of $F_{40\%}$, and $F_{35\%}$ from this assessment are 0.08 and 0.09, respectively. Thus, the maximum permissible value of F_{ABC} under Tier 3a is 0.08, which translates into a 2026 ABC (combined areas, before whale adjustments) of 41,000 mt. The OFL fishing mortality rate is 0.09, which translates into a 2026 OFL (combined areas) of 48,000 mt.

For Model *26.2_FAA*, the updated point estimate of $B_{40\%}$ is 122,000 mt. Since projected female spawning biomass (combined areas) for 2026 is 205,000 mt (equivalent to $B_{67\%}$), sablefish is in sub-tier "a" of Tier 3. The updated point estimates of $F_{40\%}$, and $F_{35\%}$ from this assessment are 0.08 and 0.10, respectively. Thus, the maximum permissible value of F_{ABC} under Tier 3a is 0.08, which translates into a 2026 ABC (combined areas, before whale adjustments) of 32,000 mt. The OFL fishing mortality rate is 0.10, which translates into a 2026 OFL (combined areas) of 38,000 mt.

Area Apportionment of Harvests

An apportionment method that tracks regional biomass, or a proxy thereof, is likely the best defense against localized depletion or other conservation concerns (e.g., disproportionately targeting spawners in only a handful of regions or population strongholds). Based on a biological perspective, the five-year average survey apportionment method was recommended by the SSC in 2020, because it tracks biomass across management regions to the best of our current ability (i.e., by using estimates of regional biomass from the yearly longline survey that targets sablefish in primary adult habitat). Because a moving five-year average is used, the apportionment values change each year as new survey data is added into the calculation. Given that sablefish are assumed to be a single population across the GOA and BSAI, area-specific OFLs are not implemented. Explorations with the spatial model (Appendices 3D and 3E) concluded that the area apportionment based on survey biomass generally matched recommended regional harvest levels from the spatial assessment (Cheng et al., 2025d).

Data Gaps and Research Priorities

In terms of the assessment model and general knowledge of sablefish dynamics, the following research is being considered:

- Allow for time-varying growth (estimated internally or externally) to address the potential for

declines in growth due to recent extreme year classes, and explore the incorporation of tagging data to inform growth processes.
- Continue to explore the use of self-weighting likelihoods in combination with time-varying selectivity formulations.
- Update the aging error matrix.
- Expand the survey age-structure (i.e., set the plus group to age-41+ or age-51+) to reduce the size of the plus group and better represent the age-structured dynamics.
- Explore use of bootstrapping methods to determine appropriate input sample sizes for compositional data using the methods of Hulson and Williams (2024).
- Pending NPFMC action on small sablefish release motions, explore methods for handling discards in the assessment model.
- Develop quantitative methods to inform recent recruitment based on analysis of environmental data and alternate data sets available in the ESP.
- Expand the spatial model to get a better understanding of juvenile distribution, spawning locations, and habitat utilization (e.g., using electronic and satellite tagging) through integration of a high-resolution tagging and movement model.
- Explore the use of data-weighting methods for tagging and composition data in the spatial model.
- Expand the spatial model into a full life cycle model that incorporates larval individual-based modeling outputs to inform connectivity during early life history stages and ecosystem drivers of settlement success.
- Continue work on the sablefish MSE tool to identify robust harvest control rules that account for age structure and fishery performance metrics.

Acknowledgments

The authors wish to acknowledge the many additional contributors that help make this sablefish assessment possible each year. The feedback we receive from industry participants is vital in aiding our understanding of patterns in the fishery and the stock. The careful data collection by fishery observers and survey biologists is greatly appreciated and form the backbone of all of our assessments. Finally, we thank our excellent AFSC Age and Growth program.

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Tables

Table 3.1. Alaska sablefish total catch (mt). Eastern GOA includes West Yakutat (WY) and Southeast Outside (SEO). Catch is as of May 1, 2026 (from www.akfin.org). The values in this table are not adjusted for whale depredation. Abbreviations are: Bering Sea (BS), Aleutian Islands (AI), Western Gulf of Alaska (WGOA), Central Gulf of Alaska (CGOA), Eastern Gulf of Alaska (EGOA), West Yakutat (WY), Southeast Outside (SEO), non-commercial (Non-Comm.), Hook and Line (HAL).

		By Area							By Gear			
Year	Total	AI	BS	WGOA	CGOA	EGOA	WY	SEO	Non-Comm.	HAL	Trawl	Pot	% Trawl
1960	3,100	-	1,861	-	-	1,193	-	-	-	3,100	-	-	-
1961	16,100	-	15,627	-	-	451	-	-	-	16,100	-	-	-
1962	26,400	-	25,989	-	-	390	-	-	-	26,400	-	-	-
1963	16,900	664	13,706	266	1,324	941	-	-	-	10,600	6,300	-	37
1964	7,300	1,541	3,545	92	955	1,140	-	-	-	3,300	4,000	-	55
1965	8,700	1,249	4,838	764	1,449	433	-	-	-	900	7,800	-	90
1966	15,600	1,341	9,505	1,093	2,632	1,012	-	-	-	3,800	11,800	-	76
1967	19,200	1,652	11,698	523	1,955	3,368	-	-	-	3,900	15,300	-	80
1968	31,000	1,673	14,374	297	1,658	12,938	-	-	-	11,200	19,800	-	64
1969	36,800	1,673	16,009	836	4,214	14,099	-	-	-	15,400	21,400	-	58
1970	37,800	1,248	11,737	1,566	6,703	16,604	-	-	-	22,700	15,100	-	40
1971	43,500	2,936	15,106	2,047	6,996	16,382	-	-	-	22,900	20,600	-	47
1972	53,000	3,531	12,758	3,857	11,599	21,320	-	-	-	28,500	24,500	-	46
1973	36,900	2,902	5,957	3,962	9,629	14,439	-	-	-	23,200	13,700	-	37
1974	34,600	2,477	4,258	4,207	7,590	16,006	-	-	-	25,500	9,100	-	26
1975	29,900	1,747	2,766	4,240	6,566	14,659	-	-	-	23,300	6,600	-	22
1976	31,700	1,659	2,923	4,837	6,479	15,782	-	-	-	25,400	6,300	-	20
1977	21,403	1,897	2,718	2,968	4,270	9,543	-	-	3	18,900	2,500	-	12
1978	10,414	821	1,193	1,419	3,090	3,870	-	-	14	9,200	1,200	-	12
1979	12,031	782	1,376	999	3,189	5,391	-	-	131	10,400	1,500	-	12
1980	10,584	275	2,205	1,450	3,027	3,461	-	-	184	8,400	2,000	-	19
1981	12,838	533	2,605	1,595	3,425	4,425	-	-	238	11,000	1,600	-	12
1982	12,348	964	3,238	1,489	2,885	3,457	-	-	348	10,200	1,800	-	15
1983	12,082	684	2,712	1,496	2,970	3,818	-	-	282	10,200	1,600	-	13
1984	14,511	1,061	3,336	1,326	3,463	4,618	-	-	411	10,300	3,800	-	26
1985	15,076	1,551	2,454	2,152	4,209	4,098	-	-	576	13,000	1,500	-	10
1986	29,419	3,285	4,184	4,067	9,105	8,175	-	-	519	21,600	7,300	-	25
1987	35,666	4,112	4,904	4,141	11,505	10,500	-	-	466	27,600	7,600	-	21
1988	39,107	3,616	4,006	3,789	14,505	12,473	-	-	707	29,300	9,100	-	23
1989	35,564	3,704	1,516	4,533	13,224	11,852	-	-	764	27,500	7,300	-	21
1990	30,880	2,120	2,330	1,993	12,066	11,707	-	-	664	25,532	4,684	-	15
1991	27,092	2,190	1,209	1,931	11,178	9,938	4,069	5,869	645	23,349	3,097	-	11
1992	24,574	1,553	613	2,221	10,355	9,158	4,408	4,750	674	20,977	2,910	13	12
1993	26,099	2,078	669	740	11,955	9,976	4,620	5,356	682	22,912	2,506	-	10
1994	24,174	1,727	694	539	9,377	11,243	4,493	6,750	594	20,614	2,938	29	12
1995	21,080	1,119	930	1,747	7,673	9,223	3,872	5,352	388	18,062	2,613	18	12
1996	17,834	764	648	1,649	6,773	7,558	2,899	4,659	441	15,147	2,187	59	12
1997	14,951	781	552	1,374	6,234	5,666	1,930	3,735	344	12,975	1,632	1	11
1998	14,242	535	563	1,432	5,922	5,422	1,956	3,467	368	12,386	1,487	1	10
1999	13,977	683	675	1,488	5,874	4,867	1,709	3,159	390	11,566	1,985	37	14
2000	15,894	1,049	742	1,587	6,173	6,020	2,066	3,953	324	13,402	2,019	149	13
2001	14,435	1,074	864	1,588	5,518	5,021	1,737	3,284	370	12,057	1,783	225	12
2002	15,205	1,118	1,144	1,865	6,180	4,441	1,550	2,891	457	11,993	2,243	512	15
2003	16,797	1,118	1,012	2,118	6,994	5,170	1,822	3,347	386	13,671	2,060	680	12
2004	17,896	955	1,041	2,173	7,310	6,041	2,241	3,801	376	15,042	1,656	822	9
2005	16,951	1,481	1,070	1,930	6,706	5,399	1,824	3,575	366	13,741	1,556	1,288	9
2006	15,904	1,151	1,078	2,151	5,921	5,251	1,889	3,362	353	13,218	1,246	1,087	8
2007	16,284	1,169	1,182	2,101	6,004	5,502	2,074	3,429	326	13,087	1,235	1,636	8
2008	14,857	899	1,141	1,679	5,495	5,337	2,016	3,321	305	12,490	1,122	940	8
2009	13,364	1,100	916	1,423	4,967	4,656	1,831	2,825	302	11,370	1,057	635	8
2010	12,275	1,048	752	1,354	4,512	4,270	1,579	2,692	339	10,422	1,005	510	8
2011	13,328	1,027	707	1,395	4,922	4,936	1,902	3,034	341	11,251	1,180	556	9
2012	14,144	1,205	744	1,352	5,328	5,243	2,033	3,210	272	12,259	1,102	511	8
2013	13,851	1,082	635	1,358	5,187	5,349	2,102	3,246	240	12,134	1,037	439	7
2014	11,806	813	314	1,194	4,736	4,489	1,671	2,817	259	10,195	1,025	326	9
2015	11,179	422	210	998	4,626	4,677	1,866	2,811	246	9,721	1,090	122	10
2016	10,472	340	531	1,052	4,195	4,106	1,651	2,455	248	8,701	1,336	187	13
2017	12,552	588	1,150	1,181	4,838	4,510	1,694	2,816	285	8,464	2,272	1,531	18
2018	14,494	664	1,536	1,389	5,778	4,881	1,861	3,019	246	8,690	3,780	1,778	26
2019	16,912	663	3,162	1,533	6,280	4,915	1,802	3,113	360	8,268	5,154	3,130	30
2020	19,416	1,232	5,329	1,462	6,041	4,971	1,835	3,137	381	5,813	7,493	5,730	39
2021	21,748	1,578	4,169	1,994	7,325	6,201	2,329	3,872	481	4,644	4,853	11,771	22
2022	27,420	2,230	5,514	3,028	8,165	7,971	2,750	5,221	512	4,056	5,366	17,485	20
2023	25,493	2,488	6,132	2,789	6,457	7,151	2,453	4,698	498	3,310	5,602	16,103	22
2024	23,515	1,430	4,904	2,783	7,317	6,976	2,390	4,586	105	3,406	5,506	14,497	24
2025	23,641	948	3,909	3,136	7,708	7,546	2,293	5,247	394	2,814	4,105	16,321	18

Table 3.2. Summary of management measures with time series of catch, ABC, OFL, and TAC. All values are in metric tons (mt). Catch is as of May 1, 2026 (from www.akfin.org). Catch does not include non-commercial catch (i.e., as opposed to Table 3.1).

Year	Catch	OFL	ABC	TAC	Management measure
1980	10,400			18,000	Amendment 8 to the Gulf of Alaska Fishery Management Plan established the West and East Yakutat (now SEO) management areas for sablefish.
1981	12,600			19,300	
1982	12,000			17,300	
1983	11,800			14,500	
1984	14,100			14,800	
1985	14,500			13,500	Amendment 14 of the GOA FMP allocated sablefish quota by gear type: 80% to fixed gear and 20% to trawl gear in WGOA and CGOA and 95% fixed to 5% trawl in the EGOA.
1986	28,900			21,400	Pot fishing banned in Eastern GOA.
1987	35,200			27,700	Pot fishing banned in Central GOA.
1988	38,400		44,200	36,400	
1989	34,800		37,100	32,200	Pot fishing banned in Western GOA.
1990	30,200		33,400	33,200	Amendment 15 of the BSAI FMP allocated sablefish quota by gear type: 50% to fixed gear in and 50% to trawl in the EBS, and 75% fixed to 25% trawl in the Aleutian Islands.
1991	26,400		28,800	28,800	
1992	23,900	34,100	25,200	25,200	Pot fishing banned in Bering Sea (57 FR 37906).
1993	25,400	33,200	25,000	25,000	
1994	23,600	35,900	28,800	28,800	
1995	20,700	25,700	25,300	25,300	Amendment 20 to the Gulf of Alaska Fishery Management Plan and 15 to the Bering Sea/Aleutian Islands Fishery Management Plan established IFQ management for sablefish beginning in 1995. These amendments also allocated 20% of the fixed gear allocation of sablefish to a CDQ reserve for the Bering Sea and Aleutian Islands.
1996	17,400	22,800	19,600	19,400	Pot fishing ban repealed in Bering Sea except from June 1-30.
1997	14,600	45,600	17,200	16,800	Maximum retainable allowances for sablefish were revised in the Gulf of Alaska. The percentage depends on the basis species.
1998	13,900	27,800	16,800	16,800	
1999	13,600	24,700	15,900	15,400	
2000	15,600	21,500	17,200	17,200	
2001	14,100	20,700	16,900	16,900	
2002	14,700	26,100	17,300	17,300	
2003	16,400	28,900	20,900	20,900	
2004	17,500	30,800	23,000	22,600	
2005	16,600	25,400	21,000	21,000	
2006	15,600	25,300	21,000	20,700	
2007	16,000	23,700	20,100	20,100	
2008	14,600	21,300	18,000	18,000	Pot fishing ban repealed in Bering Sea for June 1-30 (74 FR 28733).
2009	13,100	19,000	16,100	16,100	
2010	11,900	18,000	15,200	15,200	
2011	13,000	19,000	16,000	16,000	
2012	13,900	20,400	17,200	17,200	
2013	13,600	19,200	16,200	16,200	
2014	11,500	16,200	13,700	13,700	
2015	10,900	16,100	13,700	13,700	NPFMC passes Amendment 101 to allow pot fishing in the GOA.
2016	10,200	13,400	11,800	11,800	Whale depredation accounted for in survey and fishery.
2017	12,300	15,400	13,100	13,100	Pot fishing begins in the GOA.
2018	14,200	29,500	15,000	15,000	
2019	16,600	32,800	15,100	15,100	
2020	19,000	50,500	22,000	18,300	OFL changed to Alaska-wide. TAC set below ABC based on AP recommendation.
2021	21,300	60,400	29,600	26,100	
2022	26,900	40,400	34,500	34,500	
2023	25,000	47,400	40,500	39,600	
2024	23,400	55,100	47,100	39,000	
2025	23,200	58,500	47,600	39,300	

Table 3.3. Data used in the 2026 assessment models. Years in **bold** are data new to this assessment.

Source	Data	Years
Fixed Gear Fisheries	Catch	1960 – **2025**
Trawl Fisheries	Catch	1960 – **2025**
Non-Commercial Catch	Catch	1977 – **2025**
U.S. Fixed Gear Fisheries	Age	1999 – **2024**
U.S. Trawl Fisheries	Length	1990,1991,1999, 2005 – **2024**
Japan-U.S. Cooperative Longline Survey	RPNs, Length	1979 - 1994
	Age	1981, 1985, 1987, 1989, 1991, 1993
NOAA Domestic Longline Survey	RPNs	1990 – 2023, **2025**
	Age	1996 – 2023

Table 3.4. Sample sizes for age and length data for all available data (not all data is used in the assessment). Japanese fishery data are from Sasaki (1985), U.S. fishery data are from the observer databases, and NOAA survey data are from AFSC databases.

	Age Samples			Length Samples				
Year	Japanese LL Survey	NOAA LL Survey	Fixed Gear Fishery	Japanese LL Survey	NOAA LL Survey	NOAA Trawl Survey	Fixed Gear Fishery	Trawl Gear Fishery
1979				18,673				
1980				26,568				
1981	490			32,789				
1982				62,241				
1983				65,579				
1984				98,077				
1985	1,294			120,453				
1986				121,834				
1987	1,211			98,246				
1988				108,695				
1989	2,069			105,575				
1990				71,858	86,960	4,954	32,936	1,204
1991	797			64,052	81,747		28,182	655
1992				73,075	90,725		20,929	
1993	1,718			74,402	82,033	7,015	21,943	
1994				69,020	62,714		11,914	
1995					80,652		17,735	
1996		957			72,720	4,299	14,416	
1997		1,126			73,694		20,330	
1998		912			48,094		8,932	
1999		791	1,141		62,812	3,968	28,070	447
2000		911	1,148		52,556		32,208	471
2001		889	1,003		64,448	3,501	30,315	422
2002		901	1,059		60,004		33,719	527
2003		872	1,185		62,972	4,839	36,077	463
2004		949	1,145		69,977		31,199	717
2005		976	1,114		62,514	4,643	36,213	2,541
2006		949	1,154		66,060		32,497	898
2007		905	1,115		59,425	3,690	29,854	2,142
2008		947	1,164		56,830		23,414	2,268
2009		963	1,126		55,637	3,455	24,674	1,897
2010		940	1,159		62,820		24,530	1,634
2011		954	1,190		73,063	2,064	22,659	1,877
2012		947	1,165		53,514		22,203	2,533
2013		957	1,157		43,230	1,206	16,093	2,674
2014		1,010	1,126		46,885		19,524	2,210
2015		1,098	1,176		44,150	2,023	20,056	2,320
2016		990	1,169		60,353		12,857	1,630
2017		975	1,190		61,616	2,860	12,345	2,625
2018		976	1,174		63,287		13,269	3,306
2019		946	1,140		84,705	7,555	13,537	2,620
2020		972	1,188		91,432		9,122	9,421
2021		963	1,183		76,162	8,208	15,762	7,681
2022		972	1,174		66,850		16,152	6,485
2023		916	991		61,037	2,795	17,993	6,732
2024			1,181				12,178	6,383
2025					93,164	2,249		

Table 3.5. The actual number of samples and associated Input Sample Size (ISS) by year for age and length composition data used in the assessment model. ISS is calculated using a relative linear scaling within each gear based on the maximum and minimum number of samples (see text). The single region model uses the values from the 'AK' row, while the fleets-as-areas (FAA) model uses the 'AK' row for all data sources except the NOAA Longline Survey (i.e., regional ISS are used for each regional fleet).

		Age Samples						Length Samples			
		Japanese LL Survey		NOAA LL Survey		Fixed Gear Fishery		Japanese LL Survey		Trawl Fishery	
Year	Reg	#	ISS	#	ISS	#	ISS	#	ISS	#	ISS
1979	AK							18,673	29		
1980	AK							26,568	32		
1981	AK	490	43					32,789	35		
1982	AK							62,241	49		
1983	AK							65,579	50		
1984	AK							98,077	65		
1985	AK	1,294	85					120,453	75		
1986	AK							121,834	75		
1987	AK	1,211	81					98,246	65		
1988	AK							108,695	70		
1989	AK	2,069	125					105,575	68		
1990	AK							71,858	53	1,204	28
1991	AK	797	59					64,052	49	655	24
1992	AK							73,075	53		
1993	AK	1,718	107					74,402	54		
1994	AK							69,020	52		
	AI			204	34						
1996	GOA			753	82						
	AK			957	172						
	BS			223	36						
1997	GOA			903	95						
	AK			1,126	200						
	AI			323	44						
1998	GOA			589	68						
	AK			912	165						
	BS			193	33						
1999	GOA			599	68						
	AK			791	144	1,141	145			447	22
	AI			281	41						
2000	GOA			630	71						
	AK			911	165	1,148	146			471	22
	BS			315	44						
2001	GOA			574	66						
	AK			889	161	1,003	129			422	22
	AI			248	38						
2002	GOA			653	73						
	AK			901	163	1,059	136			527	22
	BS			166	31						
2003	GOA			706	78						
	AK			872	158	1,185	150			463	22
	AI			282	41						
2004	GOA			667	74						
	AK			949	171	1,145	145			717	24
	BS			301	42						
2005	GOA			675	75						
	AK			905	164	1,114	142			2,541	40
	AI			295	42						
2006	GOA			654	73						
	AK			949	171	1,154	146			898	26
2007	BS			286	41						
	GOA			619	70						

	AK	905	164	1,115	142		2,142	37
	AI	265	39					
2008	GOA	682	76					
	AK	947	171	1,164	148		2,268	38
	BS	189	33					
2009	GOA	774	84					
	AK	963	173	1,126	143		1,897	35
	AI	156	30					
2010	GOA	784	85					
	AK	940	169	1,159	147		1,634	32
	BS	171	31					
2011	GOA	**783**	**85**					
	AK	954	172	1,190	150		1,877	34
	AI	242	37					
2012	GOA	705	78					
	AK	947	171	1,165	148		2,533	40
	BS	237	37					
2013	GOA	720	79					
	AK	957	172	1,157	147		2,674	41
	AI	198	33					
2014	GOA	812	87					
	AK	1,010	181	1,126	143		2,210	37
	BS	132	28					
2015	GOA	966	100					
	AK	1,098	196	1,176	149		2,320	38
	AI	304	43					
2016	GOA	686	76					
	AK	990	178	1,169	148		1,630	32
	BS	300	42					
2017	GOA	675	75					
	AK	975	175	1,190	150		2,625	41
	AI	297	42					
2018	GOA	679	75					
	AK	976	175	1,174	149		3,306	47
	BS	299	42					
2019	GOA	647	73					
	AK	946	170	1,140	145		2,620	41
	AI	296	42					
2020	GOA	676	75					
	AK	972	175	1,188	150		9,421	100
	BS	300	42					
2021	GOA	663	74					
	AK	963	173	1,183	150		7,681	85
	AI	298	42					
2022	GOA	674	75					
	AK	972	175	1,174	149		6,485	75
	BS	300	42					
2023	GOA	616	70					
	AK	916	165	991	128		6,732	77
2024	AK			1,181	149		6,383	74

Table 3.6. Sablefish abundance or biomass index values (only the NOAA Longline Survey and Japanese Longline Survey RPNs are used in the assessment model) along with associated standard errors (SEs). Relative population number (RPN; in 1000s of fish) equals CPUE in numbers weighted by respective strata areas. Relative population weight (RPW; in kilotons) equals CPUE in weight multiplied by strata areas. NMFS trawl survey biomass estimates (kilotons) are from the Gulf of Alaska only at depths < 500 m. The single region model uses the values from the 'AK' row, while the fleets-as-areas (FAA) model uses the 'AK' row for all data sources except the NOAA Longline Survey (i.e., regional RPNs are used for each regional fleet).

		Relative Population Numbers (RPNS)				Relative Population Weights (RPWs) or Biomass									
Year		NOAA LL Survey*		Japanese LL Survey		NOAA LL Survey*		Japanese LL Survey		NOAA Trawl Survey		Japanese Fishery CPUE		Fixed Gear Fishery CPUE	
	Reg	RPN	SE	RPN	SE	RPW	SE	RPW	SE	RPW	SE	RPW	SE	RPW	SE
1964	AK											1,452	0.1		
1965	AK											1,806	0.1		
1966	AK											2,462	0.1		
1967	AK											2,855	0.1		
1968	AK											2,336	0.1		
1969	AK											2,443	0.1		
1970	AK											2,912	0.1		
1971	AK											2,401	0.1		
1972	AK											2,247	0.1		
1973	AK											2,318	0.1		
1974	AK											2,295	0.1		
1975	AK											1,953	0.1		
1976	AK											1,780	0.1		
1977	AK											1,511	0.1		
1978	AK											942	0.1		
1979	AK			413	0.06			1,075	0.05			809	0.1		
1980	AK			387	0.07			968	0.05			1,040	0.1		
1981	AK			458	0.05			1,146	0.03			1,343	0.1		
1982	AK			613	0.06			1,572	0.03						
1983	AK			621	0.06			1,632	0.03						
1984	AK			685	0.07			1,804	0.04						
1985	AK			903	0.06			2,569	0.04						
1986	AK			838	0.06			2,456	0.04						
1987	AK			667	0.06			2,068	0.04						
1988	AK			707	0.06			2,088	0.03						
1989	AK			661	0.10			2,177	0.07						
1990	GOA	455	0.06			1,553	0.04								
	AK	513	0.06	449	0.08	1,710	0.04	1,454	0.06	214	0.17				
1991	GOA	457	0.06			1,625	0.04								
	AK	516	0.06	386	0.11	1,782	0.04	1,321	0.07						
1992	GOA	406	0.06			1,416	0.04								
	AK	465	0.05	402	0.06	1,573	0.03	1,390	0.04						
1993	GOA	454	0.07			1,573	0.05								
	AK	513	0.07	395	0.06	1,730	0.04	1,318	0.04	248	0.16				
1994	GOA	368	0.06			1,455	0.04								
	AK	427	0.06	366	0.09	1,612	0.04	1,288	0.06						
1995	GOA	377	0.07			1,384	0.04								
	AK	436	0.06			1,541	0.04							0.35	0.03
1996	AI	16	0.32			50	0.21								
	GOA	394	0.06			1,583	0.04								
	AK	452	0.06			1,739	0.04			144	0.17			0.34	0.03
1997	BS	42	0.17			157	0.11								
	GOA	379	0.07			1,396	0.05								

	AK	438	0.06	1,553	0.04			0.37	0.04
	AI	71	0.20	217	0.13				
1998	GOA	338	0.08	1,238	0.05				
	AK	452	0.07	1,612	0.05			0.33	0.03
	BS	47	0.19	125	0.13				
1999	GOA	371	0.07	1,338	0.05				
	AK	490	0.06	1,680	0.04	103	0.10	0.33	0.03
	AI	66	0.27	188	0.18				
2000	GOA	322	0.09	1,202	0.06				
	AK	435	0.08	1,514	0.05			0.33	0.03
	BS	85	0.14	255	0.09				
2001	GOA	349	0.08	1,252	0.05				
	AK	499	0.07	1,695	0.05			0.31	0.03
	AI	63	0.26	209	0.17				
2002	GOA	376	0.10	1,344	0.07				
	AK	524	0.08	1,807	0.05			0.32	0.03
	BS	70	0.28	219	0.18				
2003	GOA	367	0.09	1,236	0.06				
	AK	499	0.08	1,663	0.05	187	0.14	0.35	0.03
	AI	55	0.21	142	0.14				
2004	GOA	389	0.10	1,243	0.06				
	AK	514	0.08	1,605	0.06			0.33	0.03
	BS	103	0.20	260	0.13				
2005	GOA	366	0.10	1,202	0.07				
	AK	524	0.08	1,604	0.05	178	0.13	0.36	0.04
	AI	65	0.38	181	0.25				
2006	GOA	374	0.09	1,304	0.06				
	AK	542	0.08	1,744	0.06			0.30	0.03
	BS	98	0.20	286	0.13				
2007	GOA	329	0.09	1,120	0.06				
	AK	493	0.09	1,586	0.06	110	0.12	0.31	0.03
	AI	48	0.22	148	0.15				
2008	GOA	304	0.08	1,052	0.06				
	AK	451	0.08	1,487	0.05			0.32	0.03
	BS	21	0.20	71	0.13				
2009	GOA	323	0.11	1,108	0.07				
	AK	393	0.10	1,328	0.06	105	0.12	0.28	0.03
	AI	36	0.25	119	0.17				
2010	GOA	383	0.10	1,279	0.06				
	AK	440	0.09	1,470	0.06			0.26	0.03
	BS	33	0.17	91	0.12				
2011	GOA	461	0.10	1,406	0.06				
	AK	531	0.09	1,616	0.06	84	0.19	0.25	0.03
	AI	62	0.28	145	0.19				
2012	GOA	336	0.09	1,029	0.06				
	AK	431	0.08	1,266	0.05			0.27	0.03
	BS	94	0.19	254	0.12				
2013	GOA	261	0.09	870	0.06				
	AK	417	0.08	1,270	0.05	59	0.17	0.22	0.02
	AI	48	0.24	136	0.16				
2014	GOA	308	0.08	988	0.06				
	AK	450	0.07	1,379	0.05			0.21	0.02
	BS	48	0.23	135	0.15				
2015	GOA	279	0.09	894	0.06				
	AK	374	0.08	1,166	0.05	65	0.10	0.19	0.02

2016	AI	90	0.20	217	0.13				
	GOA	319	0.08	933	0.05				
	AK	457	0.07	1,286	0.05			0.17	0.02
2017	BS	107	0.35	181	0.22				
	GOA	329	0.07	923	0.05				
	AK	526	0.09	1,321	0.05	118	0.18	0.19	0.02
2018	AI	134	0.20	252	0.13				
	GOA	327	0.07	770	0.05				
	AK	568	0.09	1,204	0.05			0.17	0.02
2019	BS	218	0.27	426	0.17				
	GOA	442	0.08	952	0.05				
	AK	794	0.09	1,631	0.06	210	0.09	0.19	0.02
2020	AI	271	0.15	496	0.10				
	GOA	549	0.08	1,339	0.05				
	AK	1,038	0.08	2,262	0.05			0.20	0.02
2021	BS	406	0.10	916	0.06				
	GOA	535	0.07	1,311	0.05				
	AK	1,211	0.06	2,723	0.04	290	0.11	0.27	0.03
2022	AI	300	0.13	632	0.08				
	GOA	631	0.06	1,600	0.04				
	AK	1,337	0.05	3,147	0.03			0.37	0.04
2023	BS	442	0.17	962	0.11				
	GOA	657	0.09	1,548	0.06				
	AK	1,400	0.07	3,142	0.05	140	0.12		
2025	GOA	686	0.07	1750	0.05				
	AK	1,429	0.07	3,344	0.04	153	0.14		

*NOAA Longline Survey RPNs assume ‘carryover’ values for survey areas not sampled every year, including Aleutian Islands (1990 -- 1995 and subsequent odd numbered years), Bering Sea (1990 -- 1996 and subsequent even numbered years), and BS+AI (2025). There was no longline survey in 2024.

Table 3.7. Summary of the parameters estimated within the assessment model.

Parameter Name	***25.12_1Reg_Cont***	***26.1_1Reg***	***26.2_FAA***
Catchability	5	2	4
Mean recruitment	1	1	1
Natural Mortality	1	2	2
Initial Deviations	28	28	28
Recruitment Deviations	65	65	65
Mean Fishing Mortality	2	2	2
Fishing Mortality Deviations	129	129	129
Fishery Selectivity	14	12	12
Survey Selectivity	11	12	28
Total	256	253	271

Table 3.8. The assumed error terms for each data source used in the final assessment models. Fit to catch and survey data assumed lognormal error with an associated assumed standard error (SE). Fit to composition data (ages and lengths) assumed a multinomial distribution with associated sample sizes (input sample size, ISS, and final 'effective' sample size, ESS). Each model used Francis data reweighting to 'right-weight' the composition data relative to the indices (Francis, 2011), which resulted in a weighting factor (λ , Data Wt) used to scale the ISS to achieve the final ESS. Values represent the mean across all years of associated data, where the yearly SE can be found in Table 3.6 and the yearly ISS can be found in Table 3.5 (associated yearly ESS can be calculated by multiplying the ISS by the respective Data_Wt for the given data source).

Data Source	*26.1_1Reg*				*26.2_FAA*			
	SE	**ISS**	**Data Wt**	**ESS**	**SE**	**ISS**	**Data Wt**	**ESS**
Fixed Gear Catch	0.05	--	--	--	0.05	--	--	--
Trawl Catch	0.05	--	--	--	0.05	--	--	--
NOAA Longline Survey RPN BS	--	--	--	--	0.20	--	--	--
NOAA Longline Survey RPN AI	--	--	--	--	0.24	--	--	--
NOAA Longline Survey RPN GOA	--	--	--	--	0.08	--	--	--
NOAA Longline Survey RPN AK	0.07	--	--	--	--	--	--	--
Coop Survey RPN	0.07	--	--	--	0.07	--	--	--
Fixed Gear Age Composition	--	145	0.12	18	--	145	0.04	6
NOAA Longline Survey Age Composition BS	--	--	--	--	--	37	0.51	19
NOAA Longline Survey Age Composition AI	--	--	--	--	--	39	1.91	75
NOAA Longline Survey Age Composition GOA	--	--	--	--	--	77	0.29	23
NOAA Longline Survey Age Composition AK	--	171	0.28	47	--	--	--	--
Japanese Longline Survey Age Composition	--	83	0.17	14	--	83	0.18	15
Japanese Longline Survey Size Composition	--	55	0.34	19	--	55	0.33	18
Trawl Fishery Size Composition	--	45	0.25	12	--	45	0.14	7

Table 3.9. Estimates (MLE mean) of recruitment (millions of age-2 fish) and spawning biomass (kt) with lower and upper lower 95% MCMC credible intervals for Model *26.1_1Reg* and Model *26.2_FAA*.

	26.1_1Reg						*26.2_FAA*					
Year	**Recruits**	**2.5% CI**	**97.5% CI**	**SSB**	**2.5% CI**	**97.5% CI**	**Recruits**	**2.5% CI**	**97.5% CI**	**SSB**	**2.5% CI**	**97.5% CI**
1960	19	7	37	304	233	348	16	6	30	252	195	291
1961	19	7	37	304	233	346	16	6	31	252	195	291
1962	20	7	38	296	227	339	17	6	33	245	189	283
1963	20	8	41	284	215	325	18	7	35	232	178	270
1964	21	8	43	276	209	317	19	7	38	225	172	262
1965	22	8	45	275	208	315	19	7	40	224	171	260
1966	22	8	44	272	207	312	19	7	41	223	171	258
1967	21	8	43	267	204	306	19	7	40	218	167	252
1968	21	8	40	261	199	298	18	7	37	213	164	246
1969	20	7	38	250	191	286	17	7	34	203	156	234
1970	19	7	35	237	180	271	16	6	31	190	146	219
1971	18	7	32	223	169	257	15	6	28	177	136	205
1972	17	7	30	207	155	240	14	6	25	162	124	189
1973	16	7	28	186	137	218	13	5	23	142	108	168
1974	15	6	26	173	126	204	12	5	21	131	99	155
1975	7	1	17	161	116	191	6	1	13	120	90	142
1976	7	1	16	151	108	180	6	1	13	111	84	132
1977	7	1	16	140	99	167	6	1	13	101	75	120
1978	9	2	20	134	94	159	7	1	17	95	70	113
1979	20	3	45	132	93	155	16	3	48	94	70	110
1980	64	21	91	129	92	150	60	9	76	91	69	107
1981	14	2	47	126	91	145	11	2	42	90	69	103
1982	23	3	67	124	91	141	16	3	62	88	69	100
1983	63	9	86	127	94	142	49	4	67	92	72	101
1984	10	2	35	134	101	149	9	2	30	99	79	107
1985	10	2	28	145	111	160	9	2	26	109	88	117
1986	18	3	30	158	122	174	14	2	25	121	98	129
1987	7	2	18	165	128	183	6	1	15	126	102	135
1988	6	1	14	167	129	186	6	1	15	125	102	134
1989	10	2	20	162	125	182	10	2	19	118	96	128
1990	9	2	22	154	118	174	11	2	22	108	88	120
1991	22	8	32	144	109	164	15	4	26	98	79	109
1992	8	2	20	133	101	153	12	2	24	88	71	99
1993	19	6	30	122	92	142	12	4	20	79	64	90
1994	11	3	22	111	84	131	4	1	9	71	58	81
1995	9	2	18	103	78	122	8	2	13	64	53	74
1996	12	4	22	97	74	115	12	6	17	60	49	69
1997	16	5	25	94	72	112	8	2	15	57	47	66
1998	8	2	19	92	71	110	18	9	25	55	46	64
1999	26	12	37	91	70	108	10	3	18	53	44	62
2000	17	5	30	90	70	107	8	2	15	52	43	60
2001	14	3	29	88	69	106	13	4	20	50	42	58
2002	30	14	45	88	69	106	27	17	37	50	42	58
2003	14	4	27	90	70	108	12	4	20	50	42	58
2004	9	2	19	91	72	110	5	1	11	50	42	58
2005	10	3	18	94	74	113	7	2	11	51	43	59
2006	7	2	14	97	76	117	3	1	7	52	44	61
2007	9	3	16	100	79	120	10	3	14	54	46	62
2008	10	3	18	101	79	121	7	2	15	54	46	63

2009	15	5	25	100	79	121	16	6	24	53	44	62
2010	14	5	24	99	78	120	14	6	22	51	43	60
2011	9	2	17	97	76	117	7	2	14	49	41	58
2012	9	3	15	94	74	114	6	2	11	47	40	56
2013	5	1	11	92	72	111	6	2	11	47	39	55
2014	7	2	14	89	70	109	6	1	12	46	39	55
2015	12	4	23	88	69	107	9	3	18	47	39	56
2016	46	25	63	87	68	106	62	41	83	48	40	57
2017	18	4	39	86	67	105	29	11	51	49	41	58
2018	103	61	141	87	67	106	68	37	99	51	42	62
2019	76	30	119	90	70	110	112	72	148	57	47	70
2020	32	4	72	98	76	119	11	2	33	69	56	85
2021	33	5	73	113	87	138	11	2	26	88	71	108
2022	42	4	79	136	105	165	16	2	38	115	91	141
2023	33	3	64	163	125	197	10	1	29	144	113	176
2024	21	3	71	192	147	232	11	2	33	172	133	211
2025	21	14	23	219	167	263	17	12	18	194	149	238

Table 3.10. Key scaling parameter estimates along with their uncertainty, including 95% credible intervals from MCMC analysis for each model. Recruitment is in millions of fish. All parameter estimates are in ln-space.

Model	Parameter	Mean (MCMC)	Median (MCMC)	SD (MCMC)	97.5% CI	2.5% CI	Mean (MLE)	SD (MLE)
	ln_Mean_Recruit	2.87	2.86	0.13	2.66	3.09	3.03	0.13
	ln_M_Female	-2.41	-2.41	0.07	-2.52	-2.29	-2.39	0.07
	ln_M_Male	-2.43	-2.43	0.07	-2.55	-2.31	-2.41	0.07
26.1_1Reg	ln_q NOAA Longline Survey	1.90	1.91	0.10	1.73	2.06	1.90	0.10
	ln_q Japanese Longline Survey	1.73	1.73	0.10	1.56	1.89	1.71	0.09
	ln_Mean_Recruit	2.67	2.67	0.11	2.49	2.86	2.82	0.11
	ln_M_Female	-2.44	-2.44	0.07	-2.57	-2.32	-2.43	0.07
	ln_M_Male	-2.46	-2.46	0.08	-2.59	-2.32	-2.44	0.08
	ln_q NOAA Longline Survey BS	0.53	0.53	0.10	0.36	0.68	0.55	0.10
26.2_FAA	ln_q NOAA Longline Survey AI	0.31	0.32	0.10	0.15	0.47	0.33	0.10
	ln_q NOAA Longline Survey GOA	2.17	2.18	0.08	2.04	2.31	2.20	0.08
	ln_q Japanese Longline Survey	2.07	2.06	0.09	1.92	2.21	2.08	0.08

Table 3.11. Comparison of the 2024 SAFE model (*23.5*; last published sablefish assessment) estimates and the 2026 assessment outputs for recruitment and spawning stock biomass (SSB) including the % change from the 2024 SAFE estimates (Diff %).

	Recruits (millions)					SSB (kt)				
Year	2024 SAFE	2026 *26.1_1Reg*	Diff (%)	2026 *26.2_FAA*	Diff (%)	2024 SAFE	2026 *26.1_1Reg*	Diff (%)	2026 *26.2_FAA*	Diff (%)
1960	28.4	19	-33%	16	-44%	283.0	304	7%	252	-11%
1961	30.2	19	-37%	16	-47%	282.0	304	8%	252	-11%
1962	32.3	20	-38%	17	-47%	275.0	296	8%	245	-11%
1963	34.3	20	-42%	18	-48%	264.0	284	8%	232	-12%
1964	35.5	21	-41%	19	-46%	259.0	276	7%	225	-13%
1965	36.0	22	-39%	19	-47%	261.0	275	5%	224	-14%
1966	34.3	22	-36%	19	-45%	263.0	272	3%	223	-15%
1967	31.5	21	-33%	19	-40%	264.0	267	1%	218	-17%
1968	28.6	21	-27%	18	-37%	264.0	261	-1%	213	-19%
1969	26.0	20	-23%	17	-35%	259.0	250	-3%	203	-22%
1970	23.8	19	-20%	16	-33%	251.0	237	-6%	190	-24%
1971	21.8	18	-17%	15	-31%	241.0	223	-7%	177	-27%
1972	20.2	17	-16%	14	-31%	227.0	207	-9%	162	-29%
1973	19.1	16	-16%	13	-32%	207.0	186	-10%	142	-31%
1974	18.9	15	-21%	12	-37%	194.0	173	-11%	131	-32%
1975	8.8	7	-20%	6	-32%	180.0	161	-11%	120	-33%
1976	10.2	7	-31%	6	-41%	167.0	151	-10%	111	-34%
1977	10.8	7	-35%	6	-44%	153.0	140	-8%	101	-34%
1978	13.9	9	-35%	7	-50%	144.0	134	-7%	95	-34%
1979	83.0	20	-76%	16	-81%	141.0	132	-6%	94	-33%
1980	46.0	64	39%	60	30%	137.0	129	-6%	91	-34%
1981	23.0	14	-39%	11	-52%	136.0	126	-7%	90	-34%
1982	69.3	23	-67%	16	-77%	138.0	124	-10%	88	-36%
1983	39.7	63	59%	49	23%	147.0	127	-14%	92	-37%
1984	14.1	10	-29%	9	-36%	161.0	134	-17%	99	-39%
1985	15.5	10	-35%	9	-42%	179.0	145	-19%	109	-39%
1986	25.5	18	-29%	14	-45%	196.0	158	-19%	121	-38%
1987	9.8	7	-29%	6	-39%	205.0	165	-20%	126	-39%
1988	6.8	6	-12%	6	-12%	205.0	167	-19%	125	-39%
1989	7.7	10	30%	10	30%	197.0	162	-18%	118	-40%
1990	12.3	9	-27%	11	-11%	184.0	154	-16%	108	-41%
1991	23.7	22	-7%	15	-37%	170.0	144	-15%	98	-42%
1992	7.5	8	7%	12	60%	157.0	133	-15%	88	-44%
1993	25.5	19	-25%	12	-53%	144.0	122	-15%	79	-45%
1994	6.9	11	59%	4	-42%	130.0	111	-15%	71	-45%
1995	7.5	9	20%	8	7%	119.0	103	-13%	64	-46%
1996	12.6	12	-5%	12	-5%	112.0	97	-13%	60	-46%
1997	20.7	16	-23%	8	-61%	107.0	94	-12%	57	-47%
1998	9.5	8	-16%	18	89%	103.0	92	-11%	55	-47%
1999	37.2	26	-30%	10	-73%	99.0	91	-8%	53	-46%
2000	16.3	17	4%	8	-51%	96.0	90	-6%	52	-46%
2001	15.8	14	-11%	13	-18%	93.0	88	-5%	50	-46%
2002	43.7	30	-31%	27	-38%	93.0	88	-5%	50	-46%
2003	13.3	14	5%	12	-10%	94.0	90	-4%	50	-47%
2004	10.0	9	-10%	5	-50%	96.0	91	-5%	50	-48%
2005	12.1	10	-17%	7	-42%	98.0	94	-4%	51	-48%
2006	7.6	7	-8%	3	-61%	102.0	97	-5%	52	-49%
2007	10.6	9	-15%	10	-6%	104.0	100	-4%	54	-48%
2008	9.9	10	1%	7	-29%	105.0	101	-4%	54	-49%
2009	16.0	15	-6%	16	0%	103.0	100	-3%	53	-49%
2010	21.6	14	-35%	14	-35%	101.0	99	-2%	51	-50%
2011	10.2	9	-12%	7	-31%	97.0	97	0%	49	-49%
2012	11.6	9	-22%	6	-48%	93.0	94	1%	47	-49%
2013	4.5	5	11%	6	33%	89.0	92	3%	47	-47%

2014	7.6	7	-8%	6	-21%	86.0	89	3%	46	-47%
2015	14.3	12	-16%	9	-37%	85.0	88	4%	47	-45%
2016	49.9	46	-8%	62	24%	84.0	87	4%	48	-43%
2017	21.5	18	-16%	29	35%	83.0	86	4%	49	-41%
2018	95.9	103	7%	68	-29%	83.0	87	5%	51	-39%
2019	94.3	76	-19%	112	19%	86.0	90	5%	57	-34%
2020	42.7	32	-25%	11	-74%	95.0	98	3%	69	-27%
2021	82.4	33	-60%	11	-87%	110.0	113	3%	88	-20%
2022	25.1	42	67%	16	-36%	133.0	136	2%	115	-14%
2023	27.9	33	18%	10	-64%	161.0	163	1%	144	-11%
2024	--	21	--	11	--	191.0	192	1%	172	-10%
2025	--	--	--	--	--	--	219	--	194	--

Table 3.12. Sablefish spawning biomass (kilotons), fishing mortality, and yield (kilotons) for the seven projection harvest scenarios (columns) outlined in the 'Population Projections' section for Model *26.1_1Reg*. The 'Specified Catch' scenario uses the proportion of the ABC utilized in 2024 (~49%) to set the realized yield for 2026 and 2027. SSB and yield are in kilotons.

Year	Maximum Permissible F	Author's F (Specified Catches)	Half maximum F	5-year Average F	No Fishing	Overfished	Approaching Overfished
Spawning biomass (kt)							
2025	216	216	216	216	216	216	216
2026	237	237	237	237	237	237	237
2027	244	253	244	248	262	241	244
2028	245	264	246	254	283	239	245
2029	242	260	243	256	300	233	239
2030	236	253	237	254	313	224	230
2031	228	243	229	249	323	213	219
2032	219	232	219	242	330	202	207
2033	209	221	210	235	336	192	196
2034	201	210	201	228	339	182	185
2035	192	201	193	221	342	173	176
2036	185	192	186	215	344	166	168
2037	178	184	179	209	346	159	162
2038	173	178	175	205	347	154	156
Fishing mortality							
2025	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2026	0.08	0.04	0.08	0.06	0.00	0.09	0.08
2027	0.08	0.04	0.08	0.06	0.00	0.09	0.08
2028	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2029	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2030	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2031	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2032	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2033	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2034	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2035	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2036	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2037	0.08	0.08	0.08	0.06	0.00	0.09	0.09
2038	0.08	0.08	0.08	0.06	0.00	0.09	0.09
Yield (kt)							
2025	24	24	24	24	24	24	24
2026	41	20	40	31	0	48	41
2027	40	21	39	30	0	46	40
2028	38	41	38	30	0	44	45
2029	37	39	36	29	0	42	43
2030	36	38	35	28	0	40	41
2031	34	36	34	28	0	38	39
2032	33	34	32	27	0	36	37
2033	32	33	31	26	0	35	35
2034	31	32	30	25	0	33	34
2035	30	31	29	25	0	32	33
2036	29	30	28	24	0	31	32
2037	28	29	28	24	0	30	31
2038	27	28	27	24	0	30	30

Table 3.13. Sablefish spawning biomass (kilotons), fishing mortality, and yield (kilotons) for the seven projection harvest scenarios (columns) outlined in the 'Population Projections' section for Model *26.2_FAA*. The 'Specified Catch' scenario uses the proportion of the ABC utilized in 2024 (~49%) to set the realized yield for 2026 and 2027. SSB and yield are in kilotons.

Year	Maximum Permissible F	Author's F (Specified Catches)	Half maximum F	5-year Average F	No Fishing	Overfished	Approaching Overfished
Spawning biomass (kt)							
2025	193	193	193	193	193	193	193
2026	205	205	205	205	205	205	205
2027	203	211	200	205	219	200	203
2028	196	212	191	200	229	191	196
2029	188	202	180	193	236	179	185
2030	179	192	170	185	241	169	173
2031	171	182	160	178	246	159	163
2032	164	174	152	172	251	151	155
2033	158	166	145	166	256	144	147
2034	153	160	139	162	261	139	141
2035	149	154	134	158	265	134	136
2036	145	149	130	154	269	130	132
2037	141	145	127	151	272	126	128
2038	138	142	125	150	274	124	124
Fishing mortality							
2025	0.06	0.06	0.06	0.06	0.06	0.06	0.06
2026	0.08	0.04	0.09	0.07	0.00	0.10	0.08
2027	0.08	0.04	0.09	0.07	0.00	0.10	0.08
2028	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2029	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2030	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2031	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2032	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2033	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2034	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2035	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2036	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2037	0.08	0.08	0.09	0.07	0.00	0.10	0.10
2038	0.08	0.08	0.09	0.07	0.00	0.10	0.10
Yield (kt)							
2025	24	24	24	24	24	24	24
2026	32	16	37	28	0	38	32
2027	30	16	35	27	0	35	30
2028	29	31	33	26	0	33	34
2029	28	30	31	25	0	32	33
2030	27	28	30	24	0	30	31
2031	26	27	28	24	0	29	30
2032	25	26	27	23	0	28	28
2033	25	25	26	23	0	27	27
2034	24	25	26	22	0	26	27
2035	23	24	25	22	0	26	26
2036	23	23	25	21	0	25	25
2037	22	23	24	21	0	24	25
2038	22	22	24	21	0	24	24

Figures

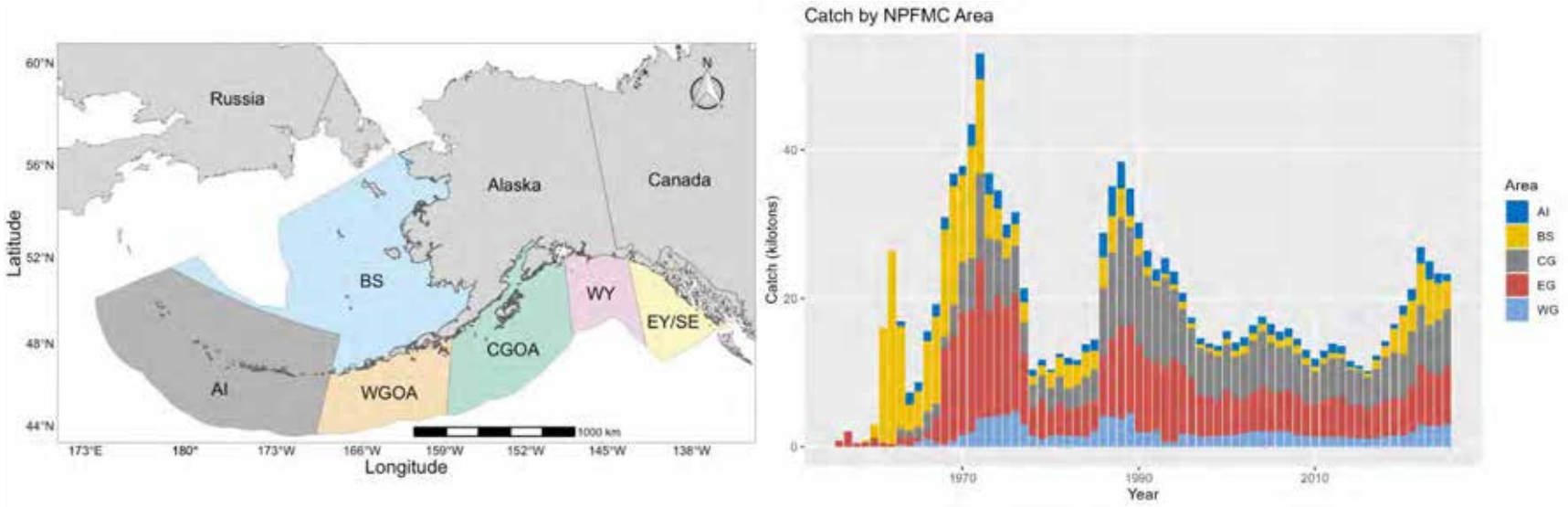

Figure 3.1. Sablefish North Pacific Fishery Management Council management areas and total catch (kt) summed across all fleets by management area.

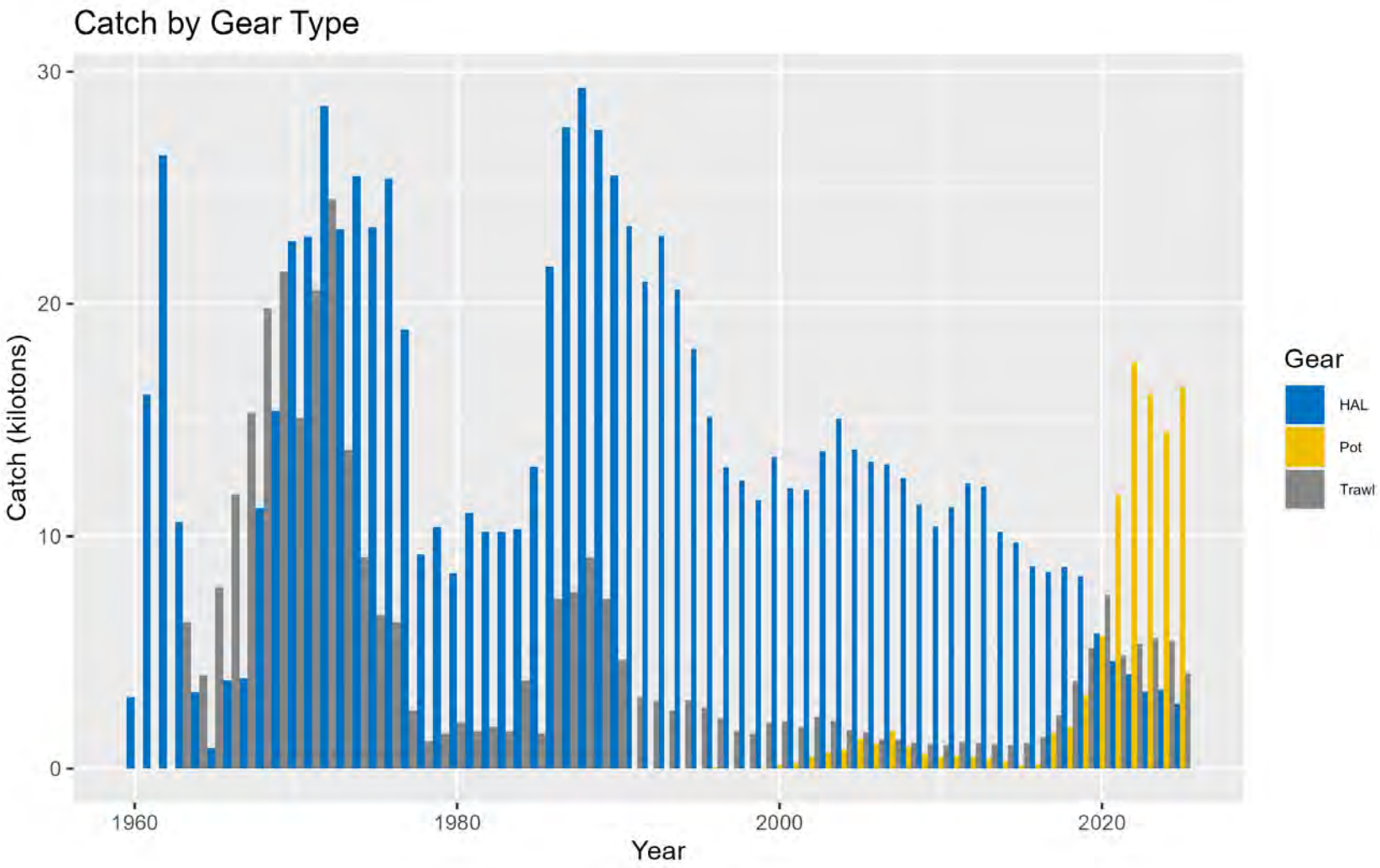

Figure 3.2. Sablefish catch (kt) by gear type. Note that hook and line (HAL) and pot gear catch are combined into a single 'fixed gear' fleet in the model.

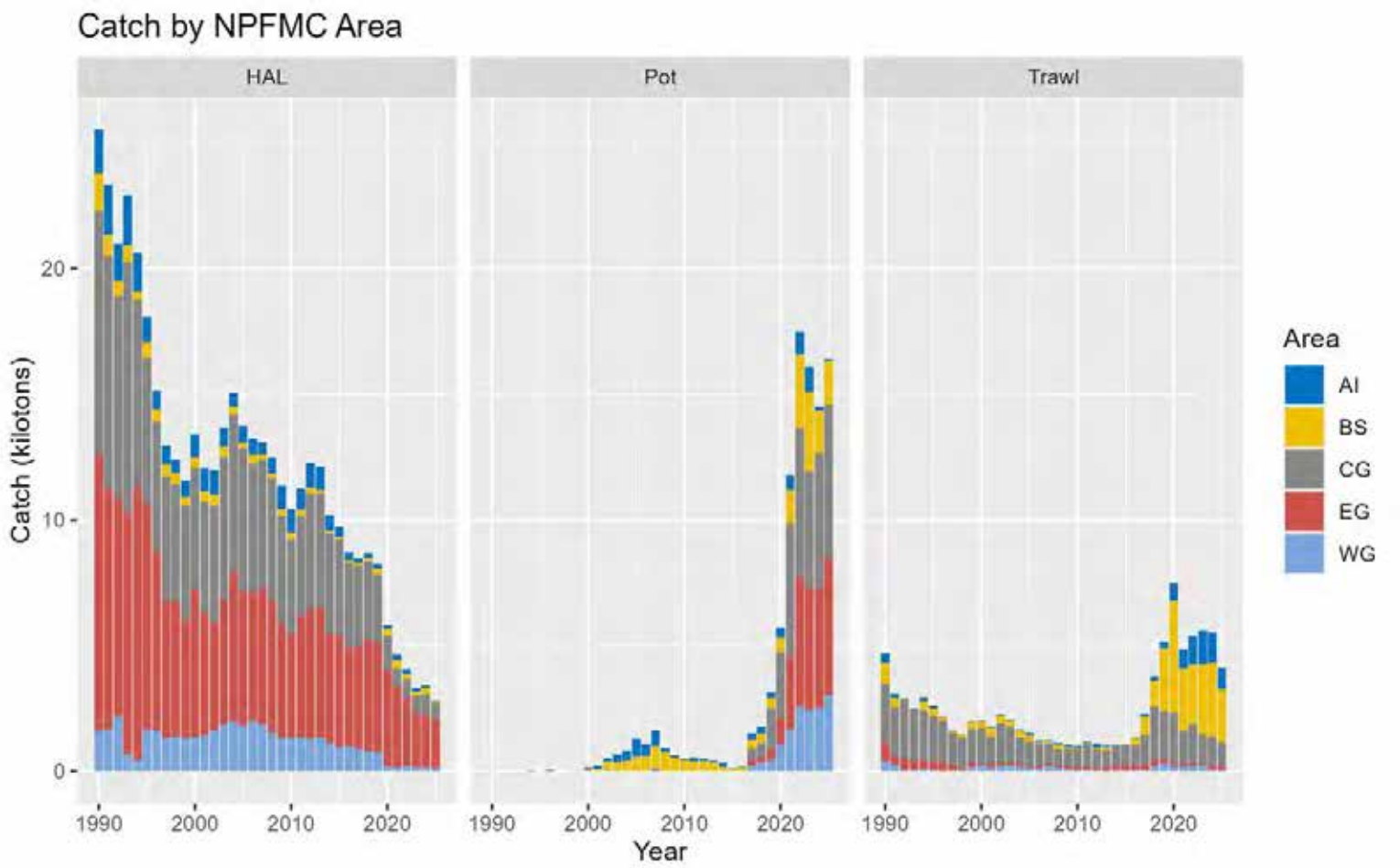

Figure 3.3. Sablefish catch (kt) by fleet (facet) and North Pacific Fishery Management Council area (colored bars).

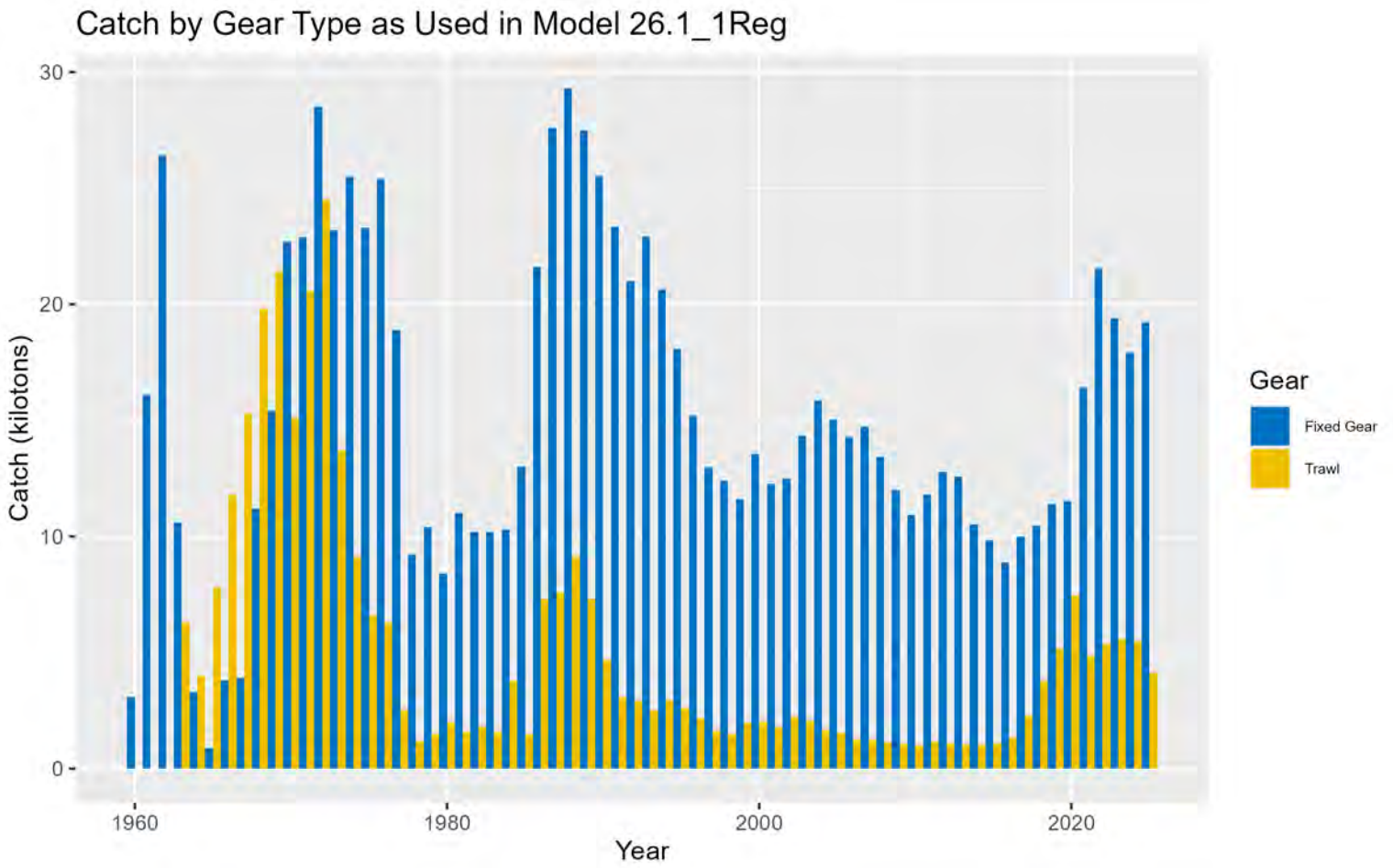

Figure 3.4. Sablefish total catch (kt) by fleet as used in the assessment models. Note the fixed gear fleet includes hook-and-line and pot gear.

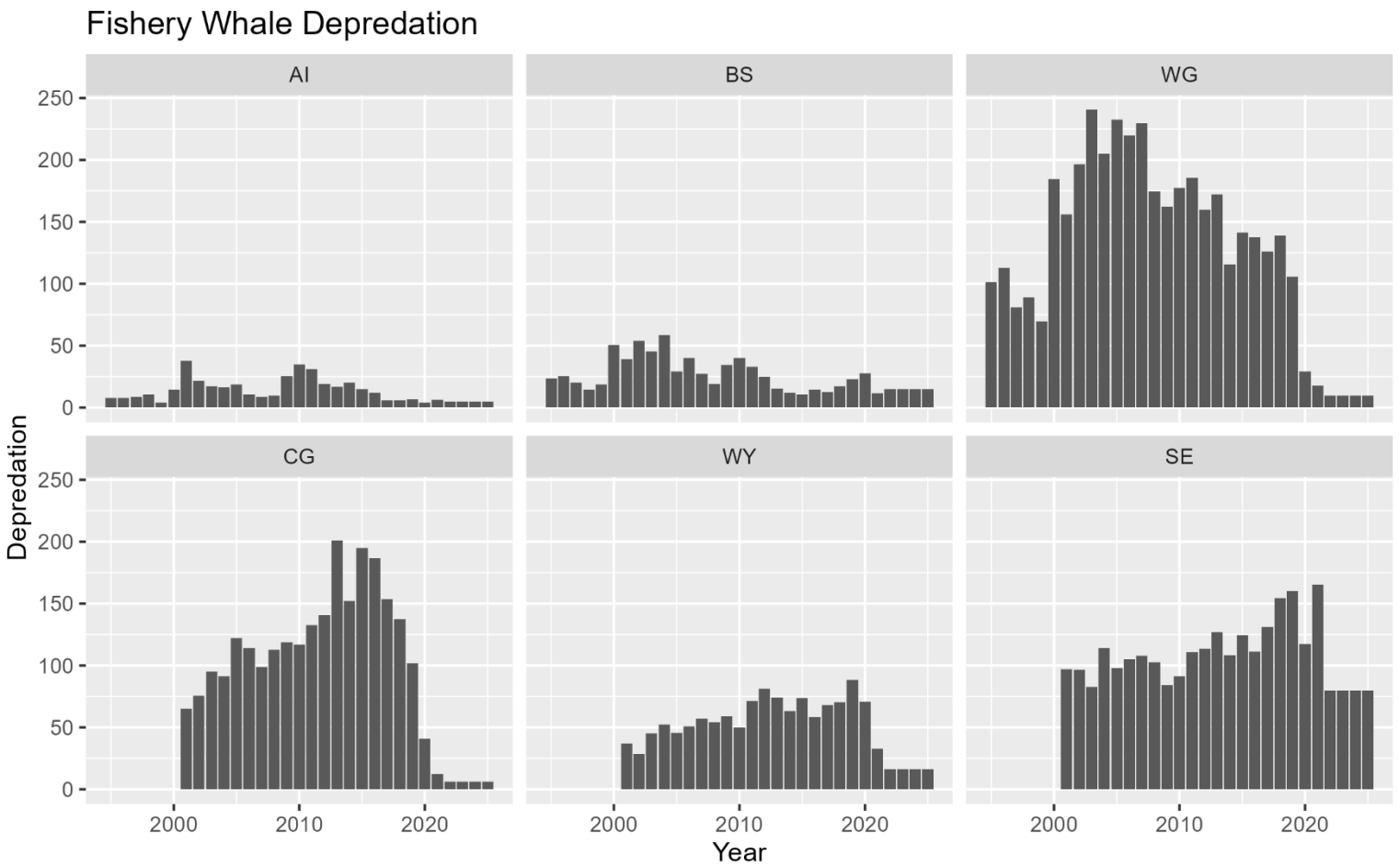

Figure 3.5. Estimated whale depredation in the sablefish fixed gear fishery. Depredation estimates reflect catch removals (metric tons, mt) by region (panel) due to orcas (top row) and sperm whales (bottom row). Starting in 2023 estimates were held constant at 2022 values, given the strong reduction in depredation due to the largescale switch to pot gear.

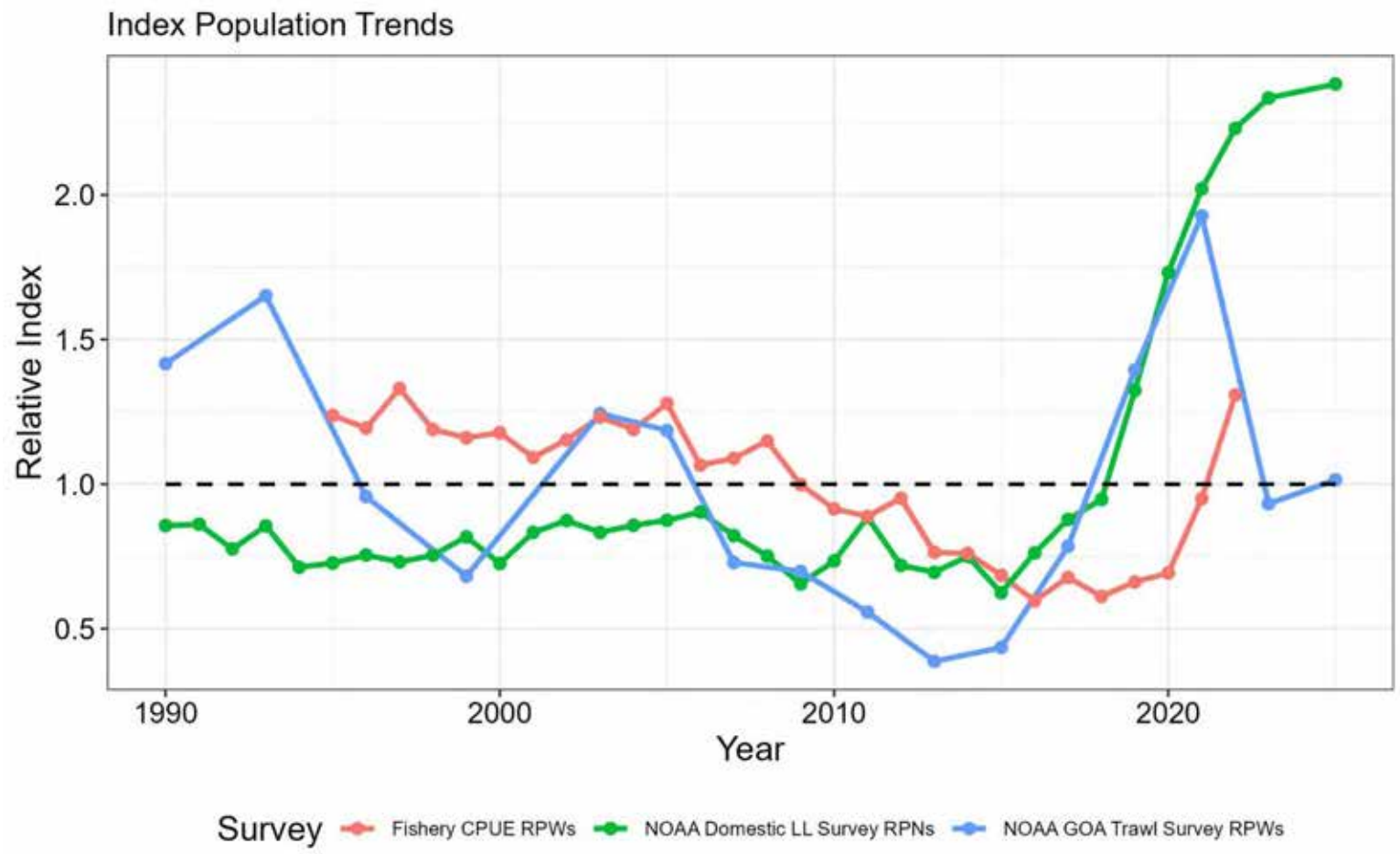

Figure 3.6. Comparison of the three abundance and biomass indices for sablefish, including the NOAA Longline Survey relative population numbers (RPNs), the fixed gear fishery standardized CPUE (in weight), and the NOAA Gulf of Alaska (stations < 500m depth) Trawl Survey relative population weights (RPWs). Each index is relativized to the associated mean value for the time series. Note that only the NOAA Longline Survey index is currently used in the assessment and represents the single region 'carryover' index. There was no NOAA Longline Survey in 2024.

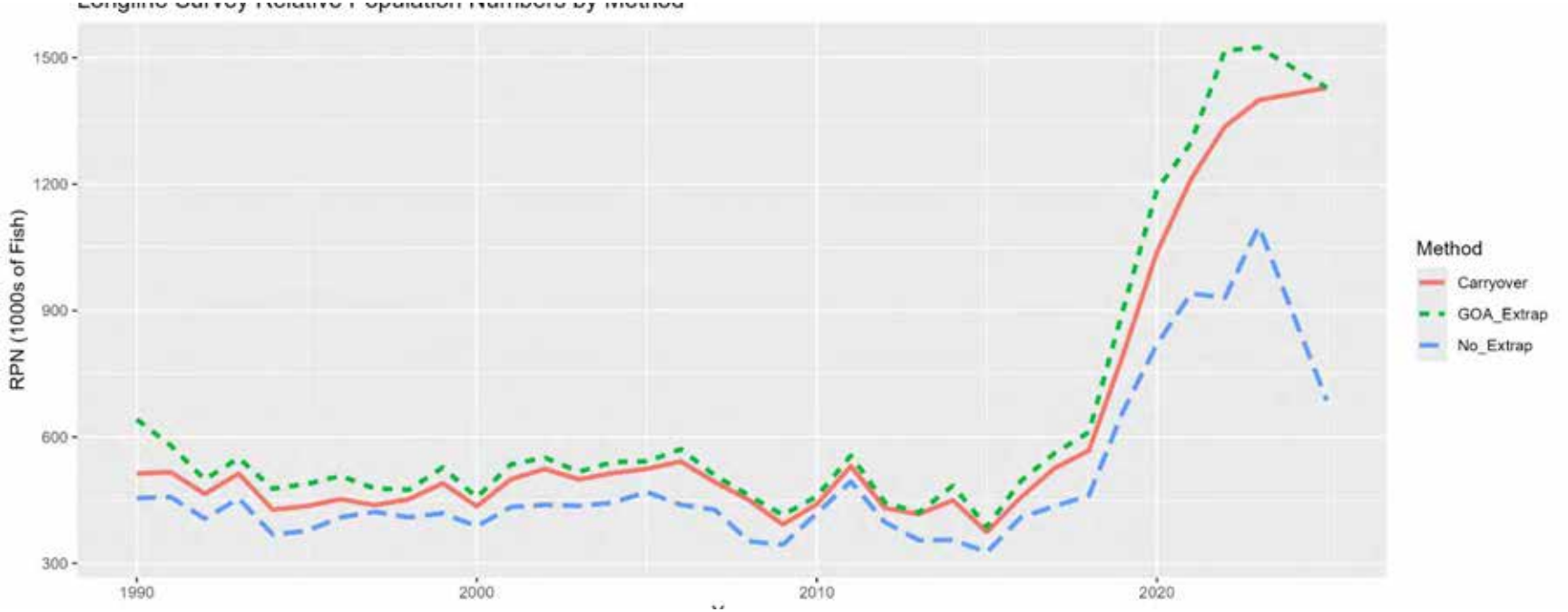

Figure 3.7. Comparison of the three versions of the NOAA Longline Survey abundance index for sablefish (relative population numbers, RPNs) demonstrating different extrapolation methods and station inclusion. The GOA_Extrap index (used in Model *25.12_1Reg_Cont*) represents the traditional approach of extrapolating the BS/AI in unsurveyed years based on the year-over-year change in the GOA, then switching to the 'carryover' approach in 2025, and including the extrapolated western Aleutian Island (AI) stations in the index. The Carryover index (used in Model *26.1_1Reg*) represents the new method for all years, where holdover RPNs for unsurveyed regions are used based on the RPN from that region the last time it was surveyed, and excluding western AI extrapolated stations. The No_Extrap index represents the sum of the area-specific RPNs without any extrapolation (i.e., including only RPNs from stations actually surveyed in a given year) and excluding western AI extrapolated stations – this index represents the sum of the regional indices as used in Model *26.2_FAA*.

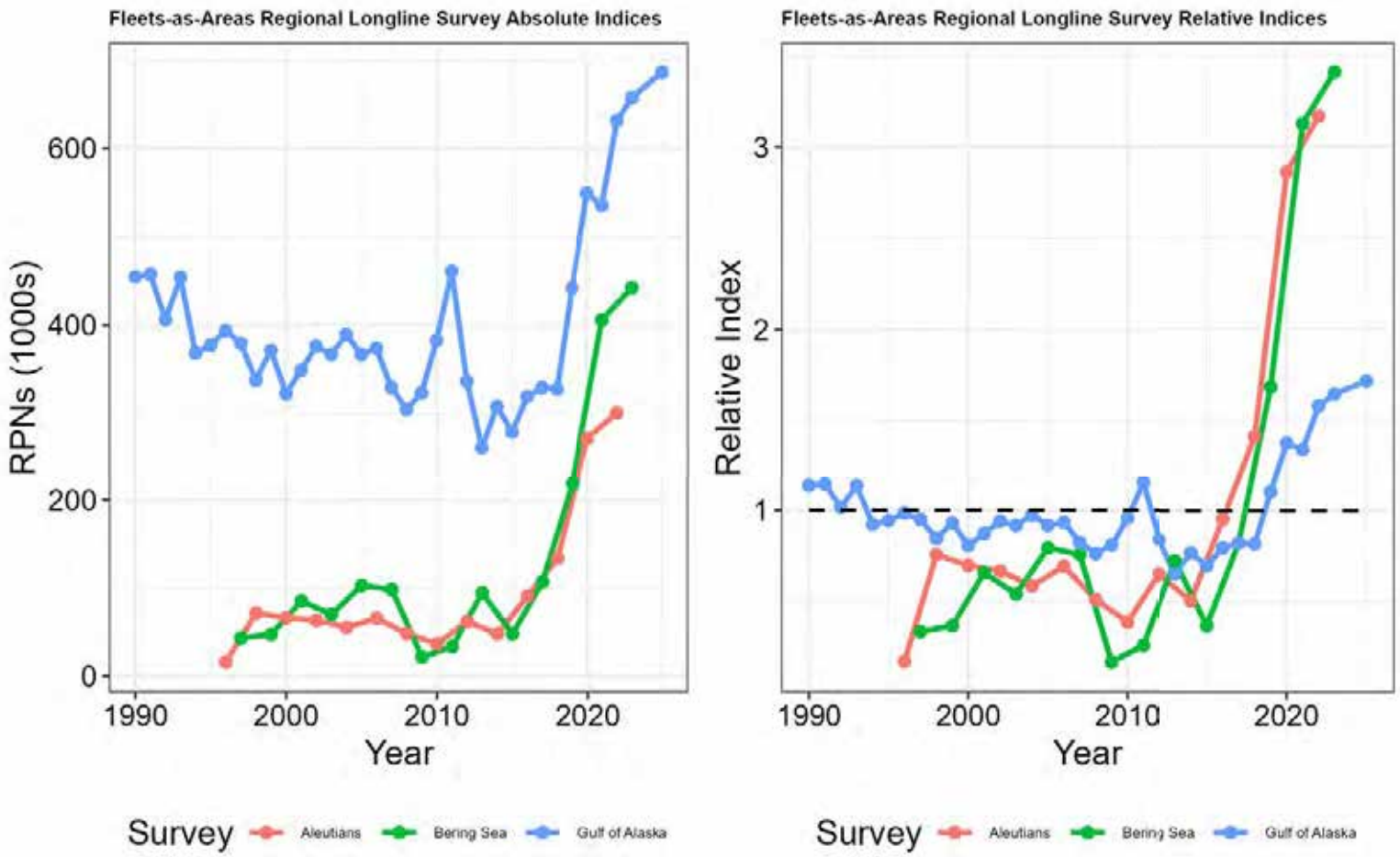

Figure 3.8. The regional NOAA Longline Survey indices as used in Model *26.2_FAA*, which do not include any extrapolation or western AI extrapolated stations. The left hand panel shows the absolute relative population numbers (RPNs, 1000s) for each region, whereas the right panel shows each index relativized to the associated mean value for the time series. Note that the Bering Sea was historically surveyed in odd years and the Aleutian Islands are surveyed in even years (i.e., sampling occurs every other year in these regions), there was no survey in 2024, and only the GOA was surveyed in 2025.

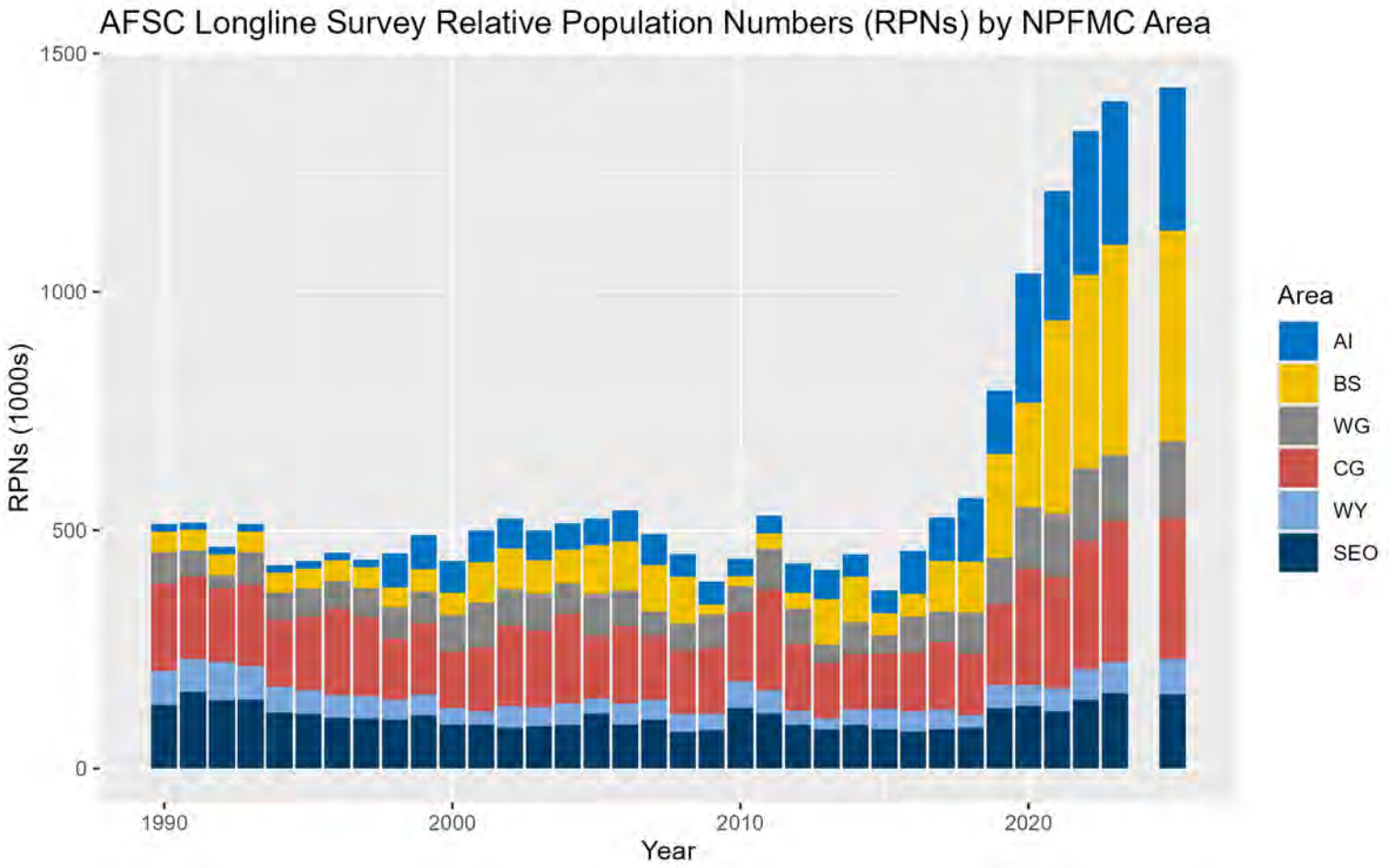

Figure 3.9. Relative abundance (relative population numbers, RPNs, in thousands) by region from the NOAA domestic longline survey utilizing the carryover method for non-surveyed regions (i.e., matching the combined index used in Model *26.1_1Reg*). Note that the Bering Sea is surveyed in odd years and the Aleutian Islands are surveyed in even years (i.e., sampling occurs every other year in these regions), there was no survey in 2024, and only the GOA was surveyed in 2025. The regional trends for non-surveyed regions are extrapolated by using holdover values from the last time the given region was surveyed.

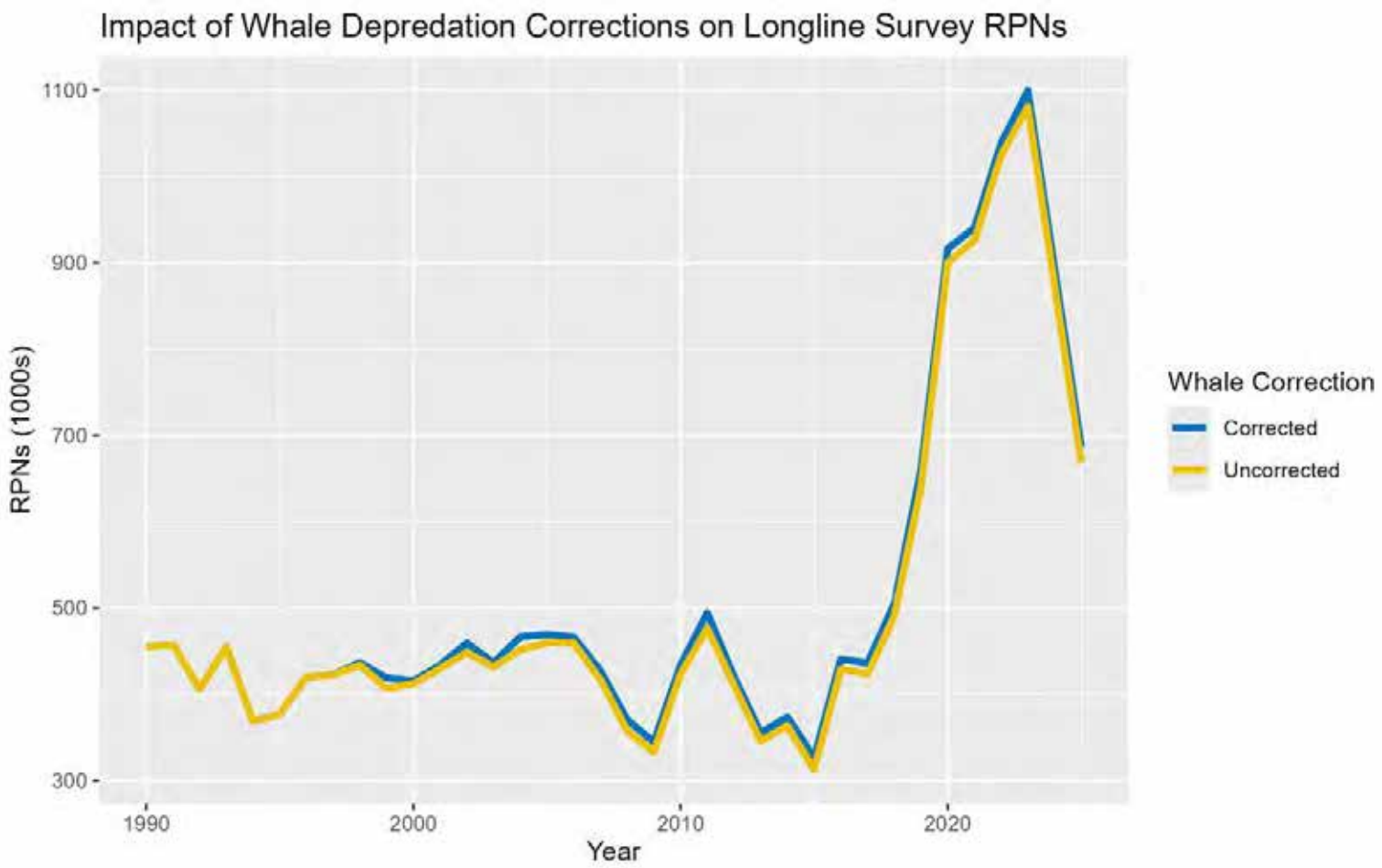

Figure 3.10. NOAA Longline Survey relative population numbers (RPNs, 1000s of fish) with (blue line) and without (yellow line) corrections for sperm whale depredation. Note that these are the summed regional RPN values that do not include extrapolations for areas not surveyed in the given year, thus, they are less than the final index by the 'carryover' RPN values.

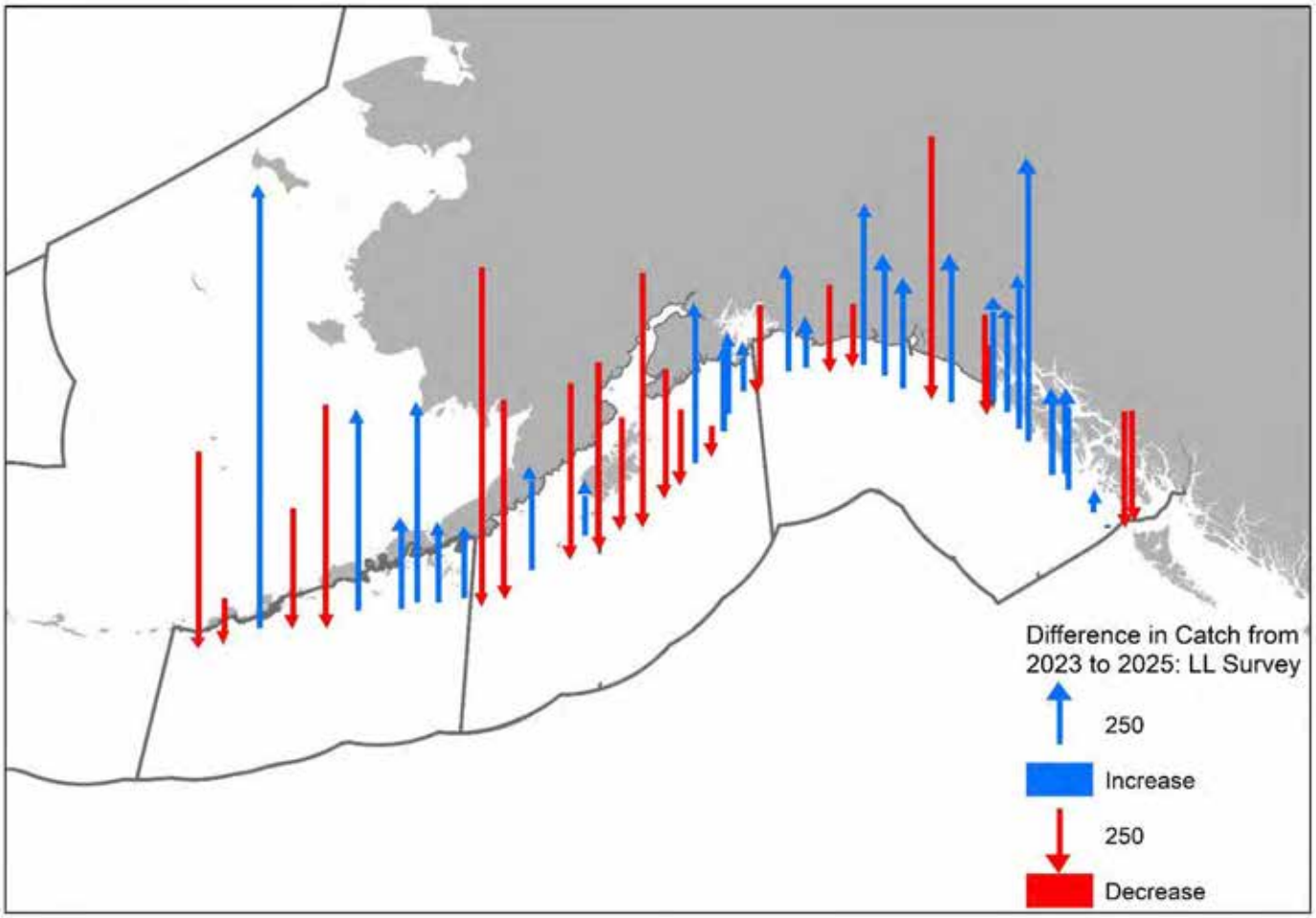

Figure 3.11. Comparison of the 2023 and 2025 NOAA Longline Survey catches in the Gulf of Alaska in terms of the difference in numbers of fish caught per station from 2023 to 2025. Numbers are not corrected for sperm whale depredation.

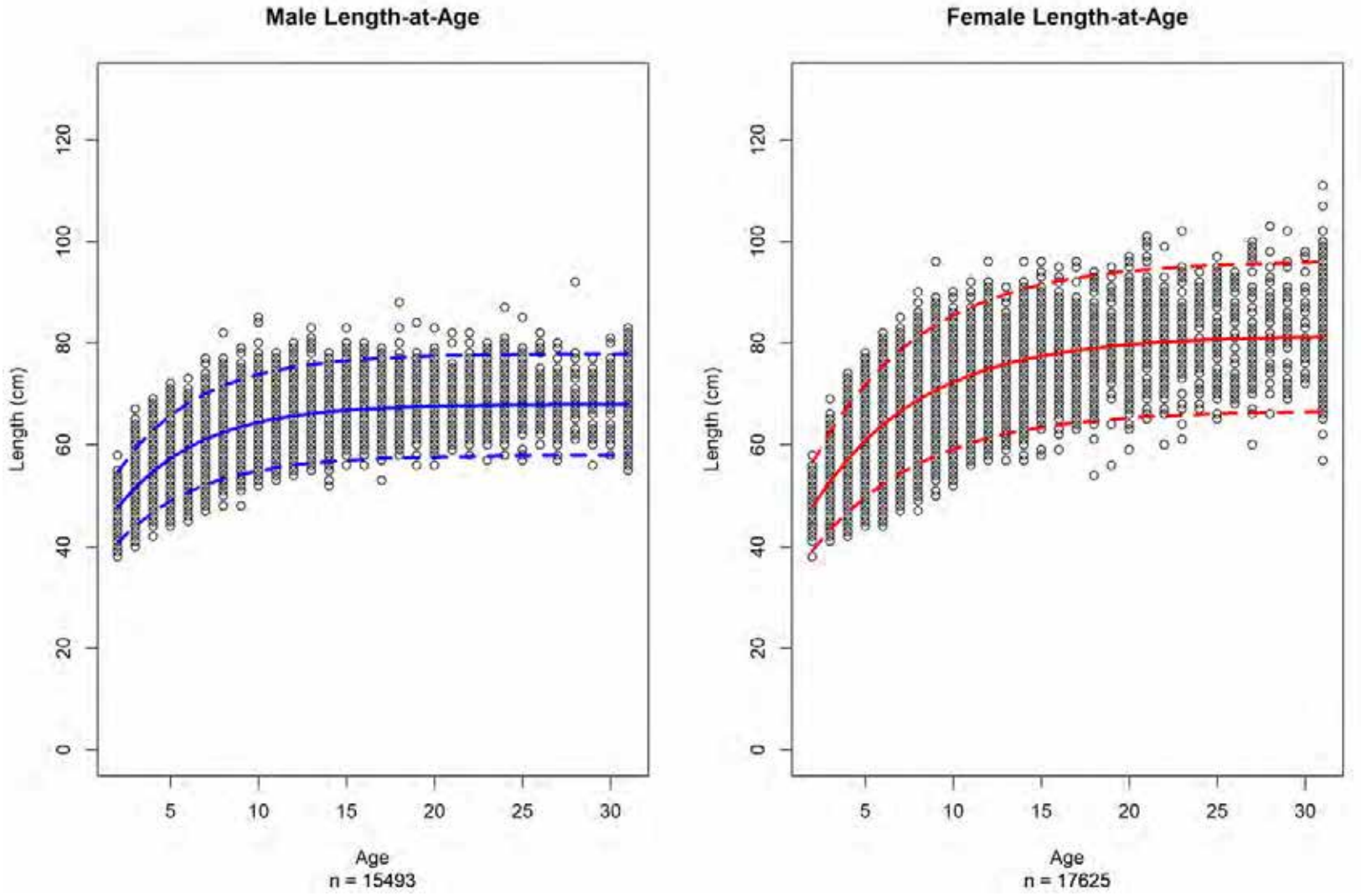

Figure 3.12. Observed (open circles) age-length pairs from the NOAA Longline Survey from 1996 – 2023 and predicted (colored lines) von Bertalanffy growth curves with associated 95% confidence intervals (dashed lines) for males (left panel) and females (right panel). Sex-specific sample sizes (*n*) are listed under each plot.

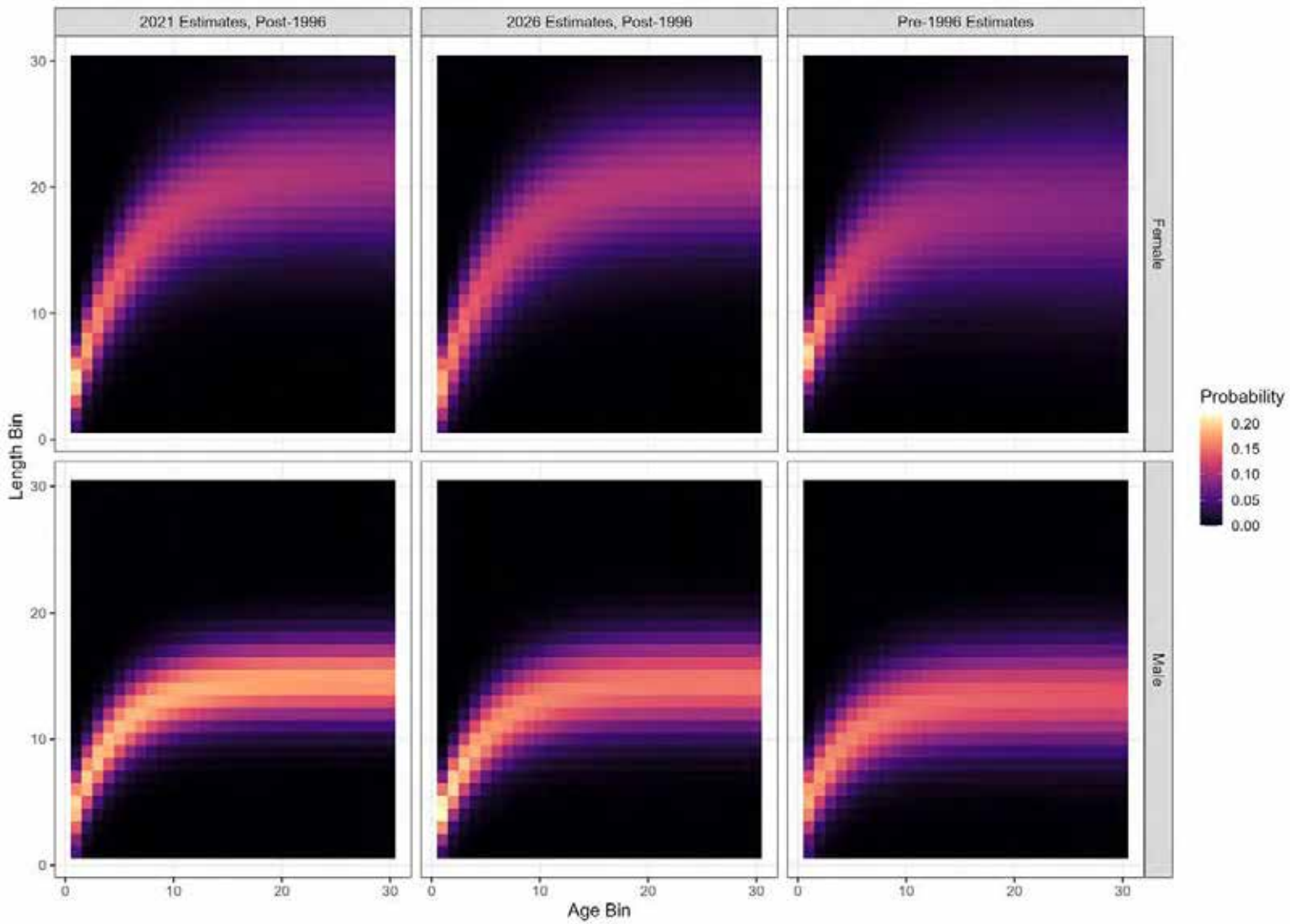

Figure 3.13. Comparison of size-age transition matrices from the previous SAFE (as estimated in 2021, 2021 Estimates) and as estimated in 2026 (2026 Estimates) with all NOAA Longline Survey data from 1996 – 2023, as well as the pre-1996 size-ag transitions estimated previously using the bias-corrected NOAA Longline Survey data prior to 1996 (and used in all models; see Echave, 2021).

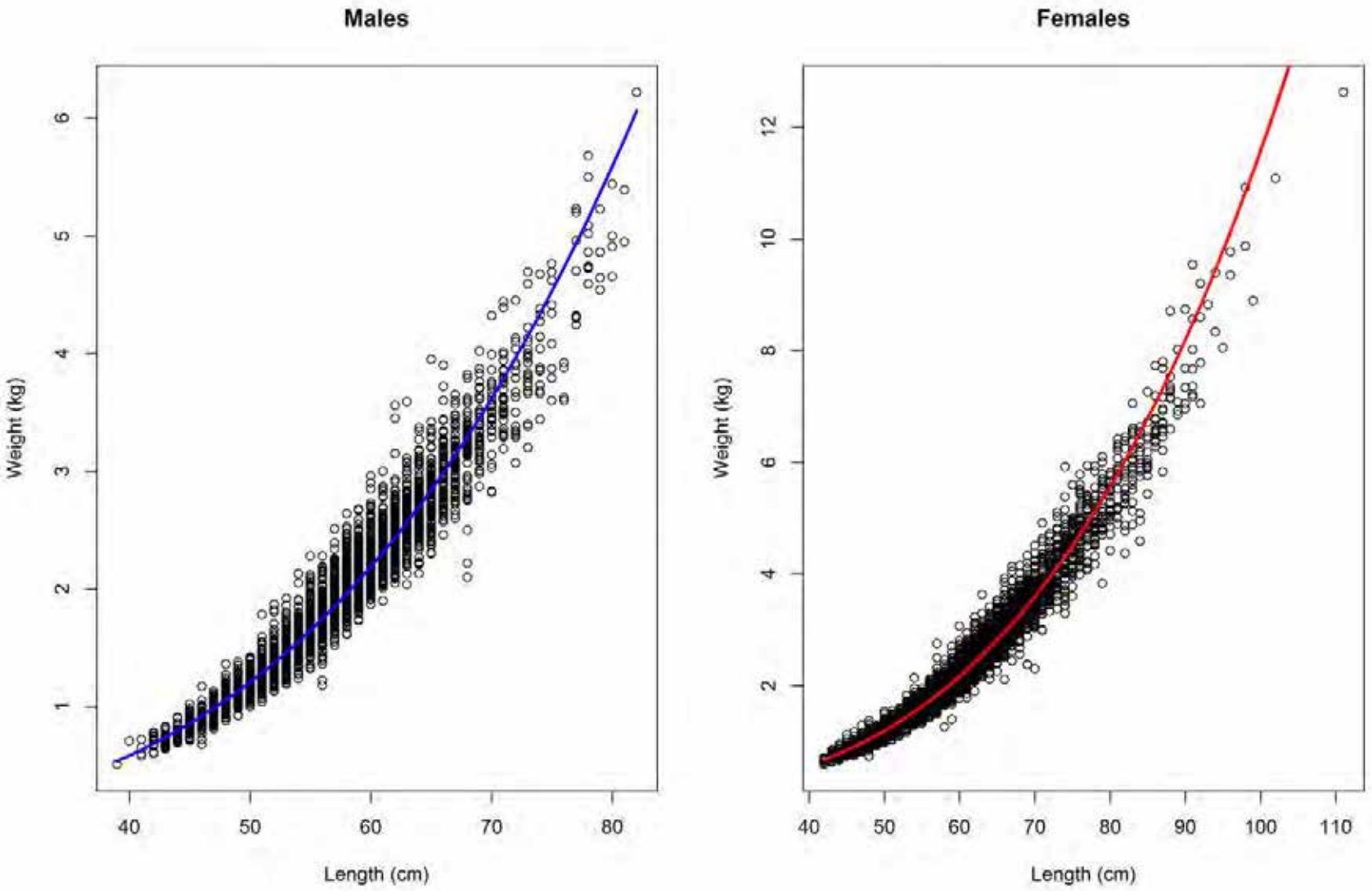

Figure 3.14. Observed (open circles) weight-length pairs from the NOAA Longline Survey from 1996 – 2023 and predicted (colored lines) weight-length curves for males (left panel) and females (right panel).

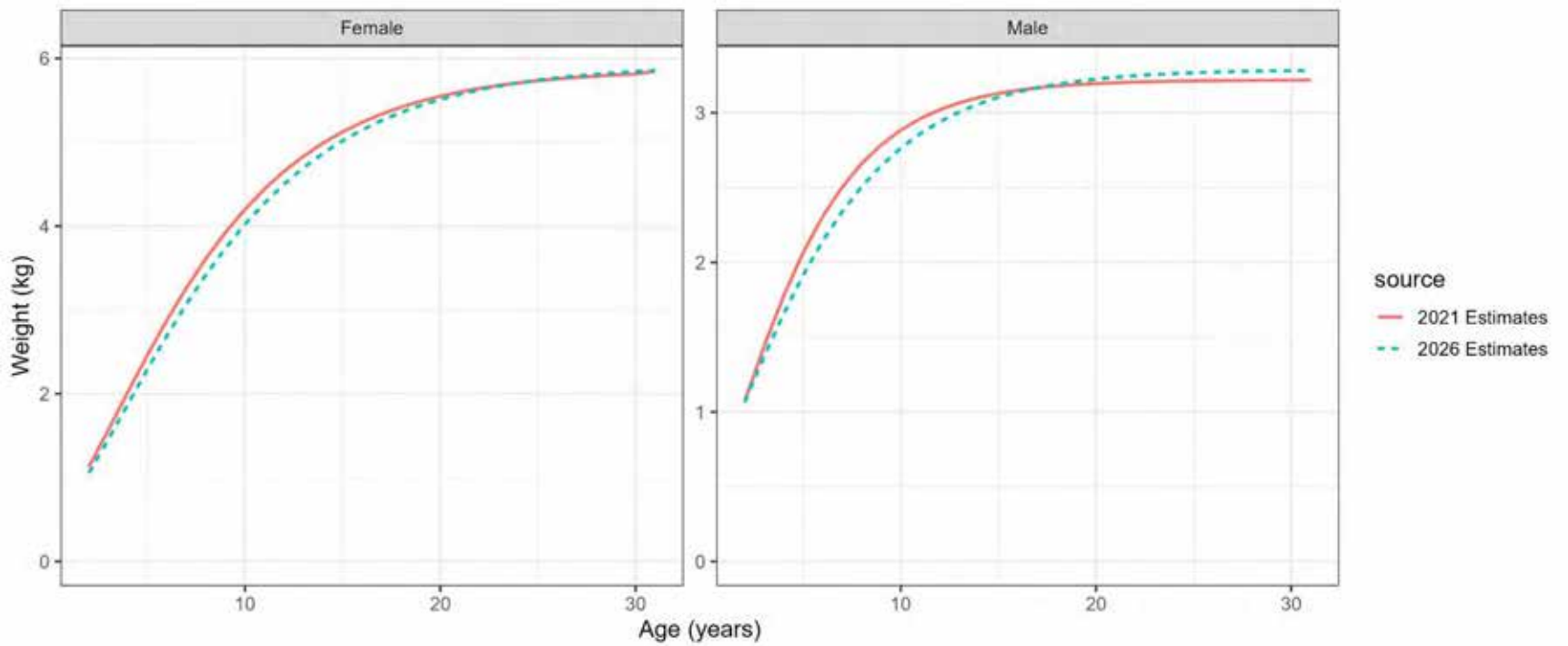

Figure 3.15. Comparison of weight-at-age estimates from the previous SAFE (as estimated in 2021, 2021 Estimates) and as estimated in 2026 (2026 Estimates) with all NOAA Longline Survey data from 1996 – 2023. The estimated weight-at-age is based on the estimate length-weight parameters and mean length from the von Bertalanffy growth curve estimates.

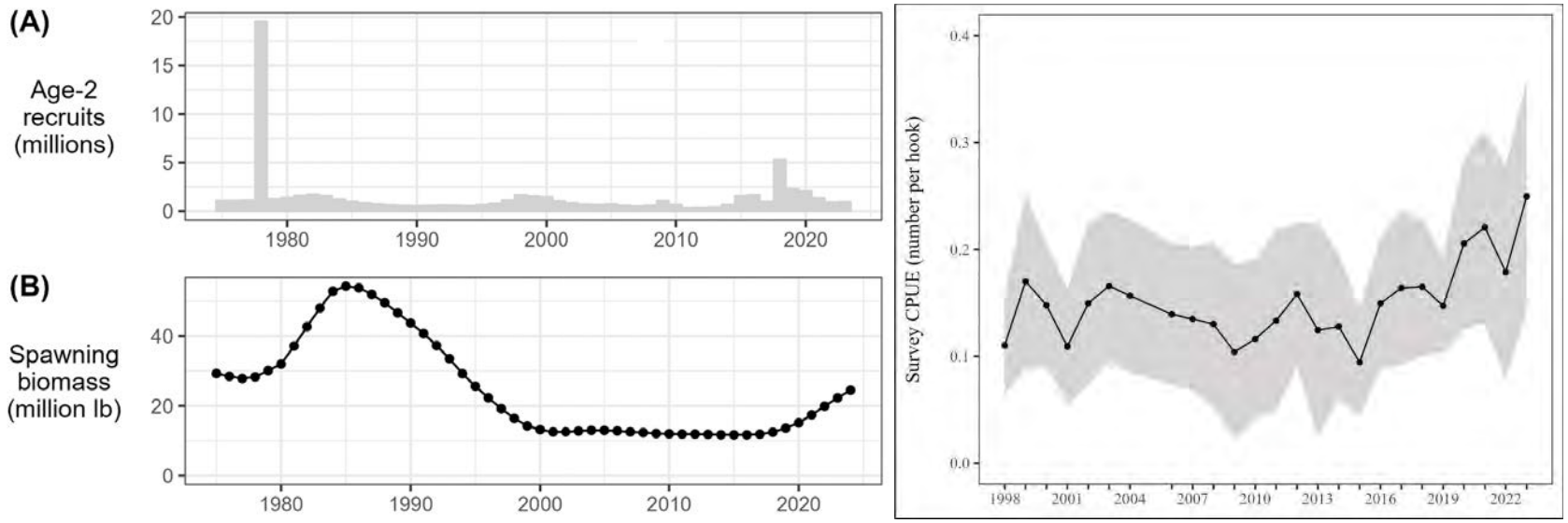

Figure 3.16. Model predictions for the ADFG Northern Southeast Inside (NSEI) sablefish stock assessment (left panels; reproduced here with permission from Rhea Ehresmann, pers. comm., https://github.com/commfish/seak_sablefish) of age-2 recruitment (millions; top) and female spawning stock biomass (million pounds; bottom). Southern Southeast Inside (SSEI) sablefish longline survey catch-per-unit-effort (CPUE) in individuals per hook (right panel) from 1998 to 2023 (except 2005; reproduced here with permission from Rhea Ehresmann, pers. Comm.).

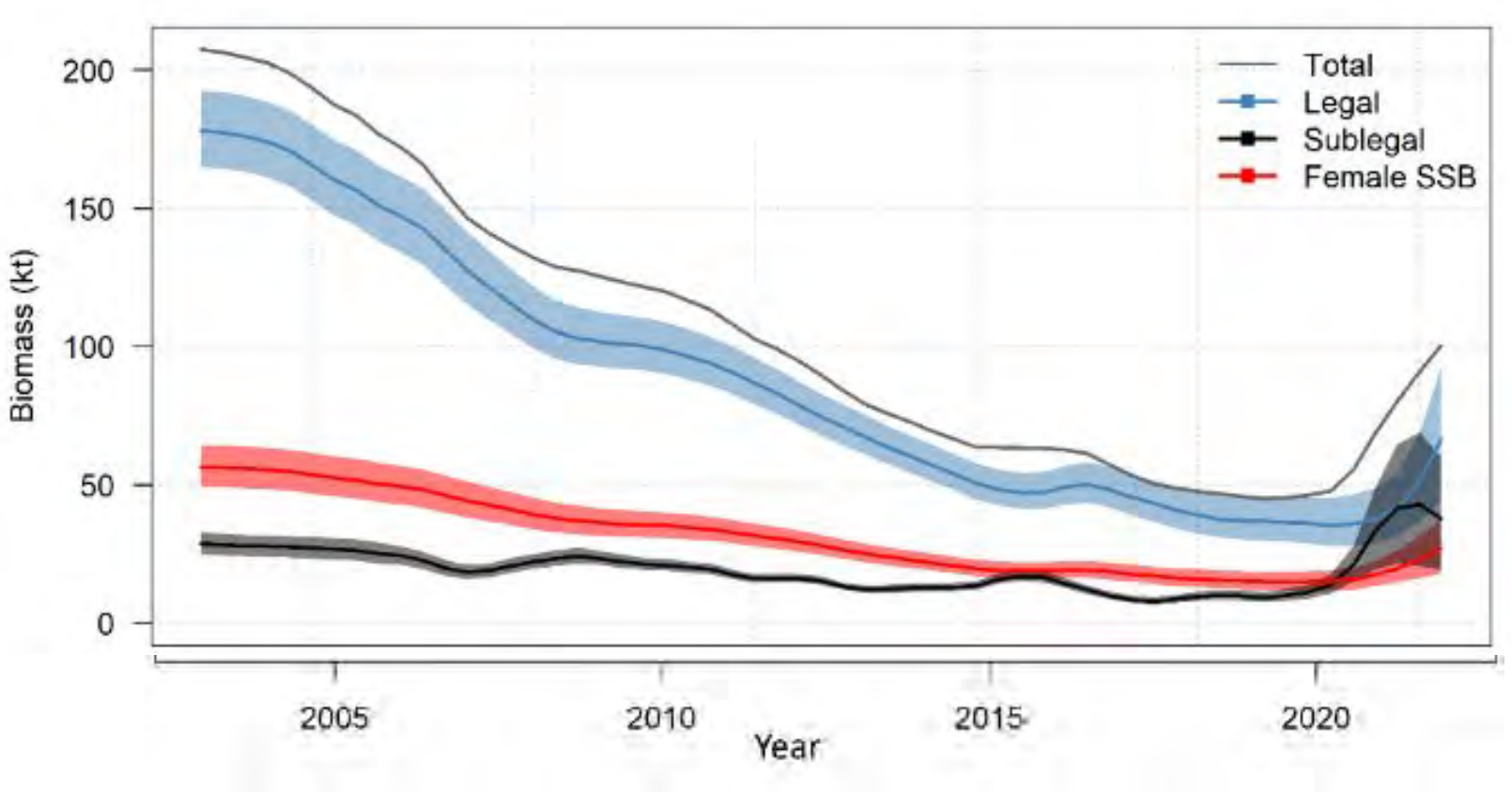

Figure 3.17. Time series of total biomass, legal-sized biomass, sub-legal-sized biomass, and female spawning biomass (SSB) estimates for the British Columbia stock of sablefish based on weighted averages over the five OM scenarios used in 2022. Note that total, legal, and sub-legal biomass estimates include both female and male fish, while SSB is shown for only female Sablefish (reproduced here with permission from Kendra Holt, DFO Canada, pers. comm.).

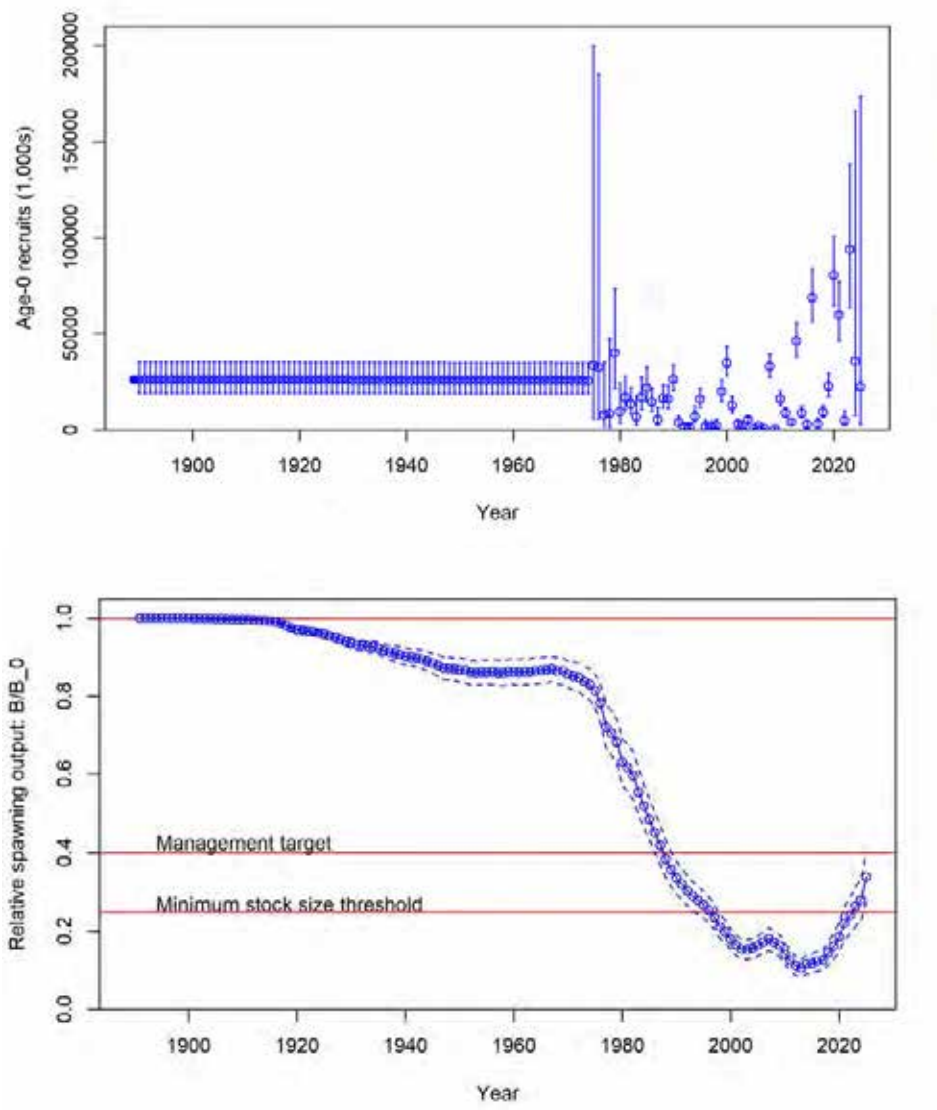

Figure 3.18. Time series (dots) of recruitment (1000s of age-0 fish, top panel) and relative spawning output (bottom panel) with associated 95% confidence intervals (bars or dashed lines) for west coast USA sablefish (reproduced here with permission from Wetzel et al. 2025).

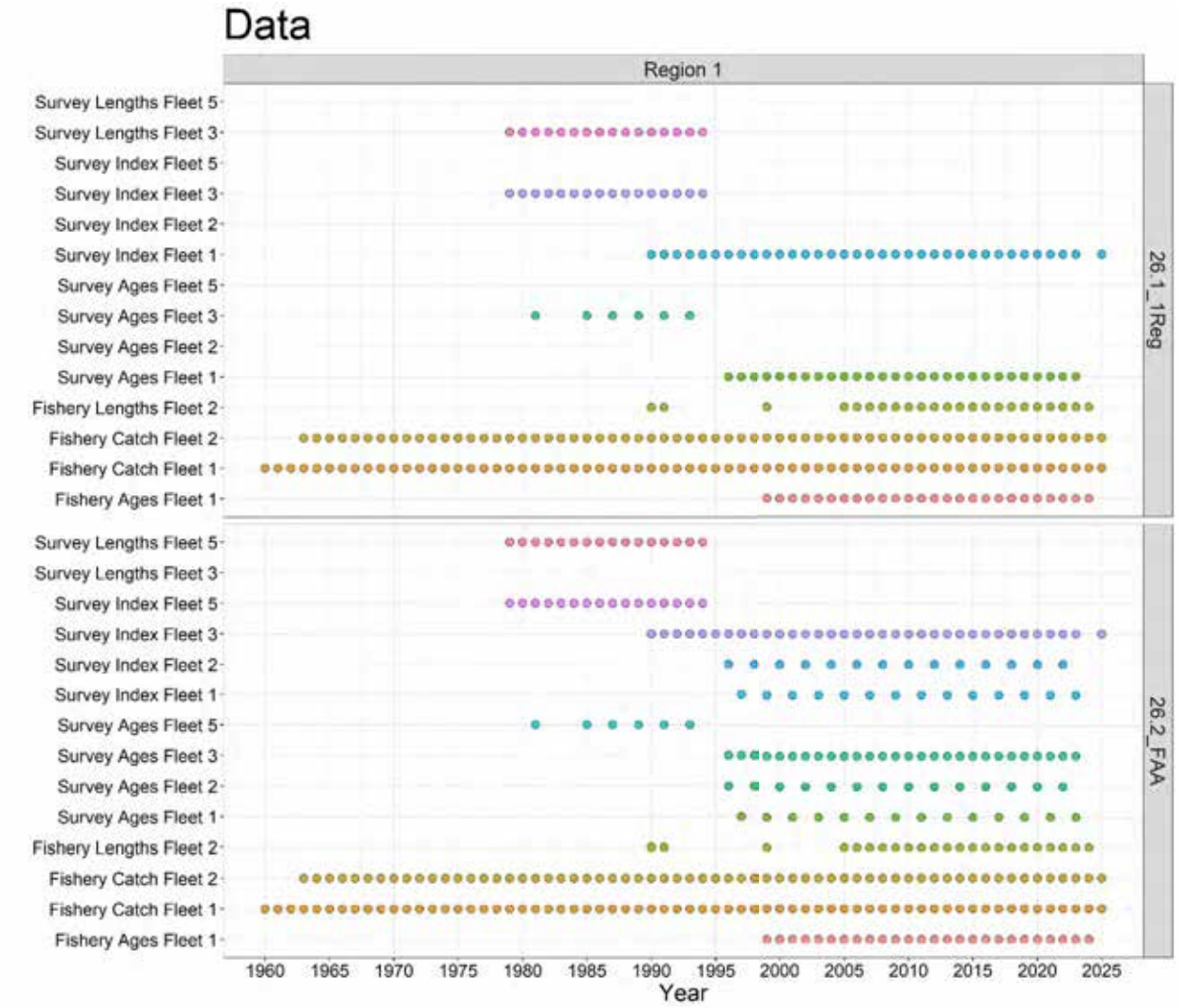

Figure 3.19. Data inputs used by each model. Fishery Fleet 1 is the fixed gear fleet and Fishery Fleet 2 is the trawl fleet. Note that survey fleet numbers vary across models. For Model *26.1_1Reg* Survey Fleet 1 is the NOAA Longline Survey and survey Fleet 3 is the Japanese Longline Survey. For Model *26.2_FAA* Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey.

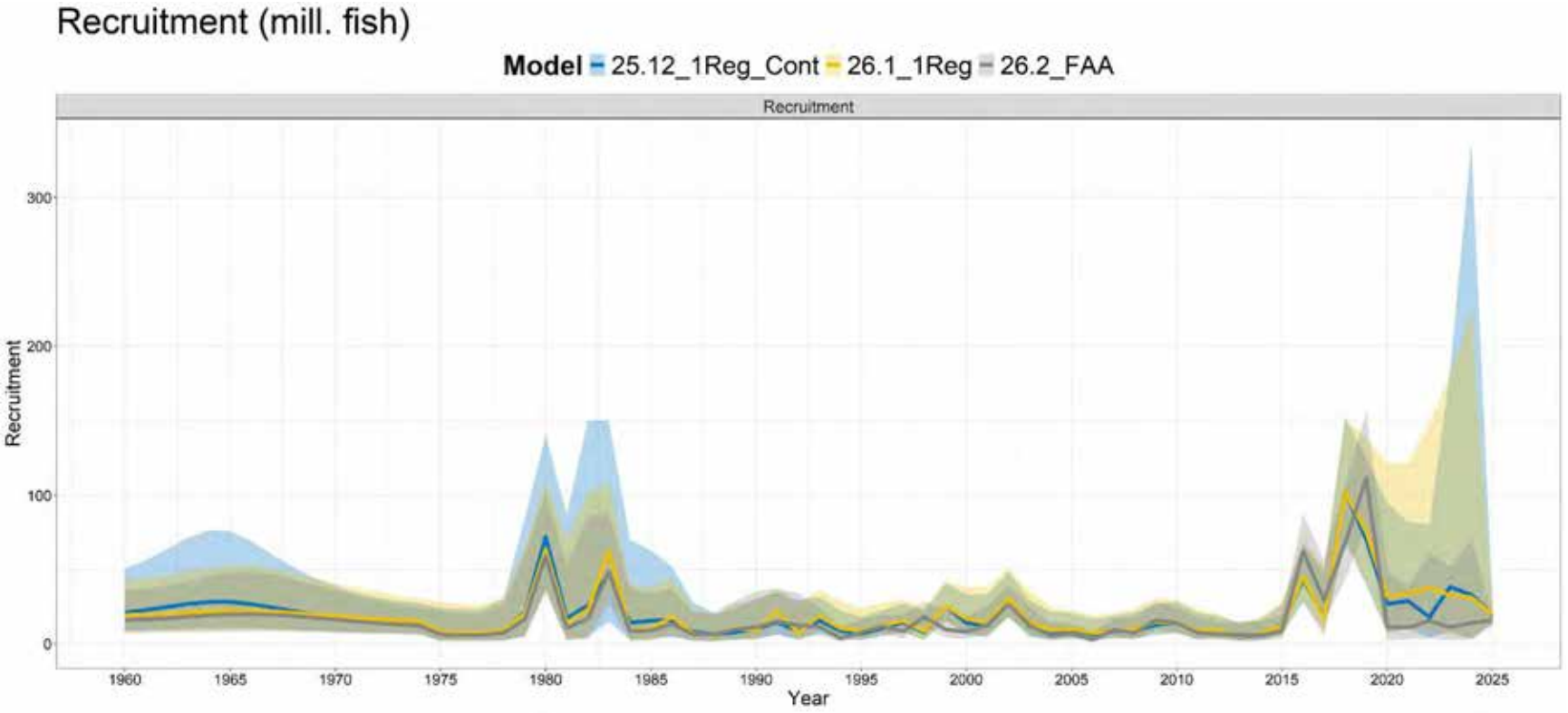

Figure 3.20. Results of the model bridging exercise in terms of recruitment (millions of age-2 fish, lines) with 95% confidence intervals (associated shaded regions). Model *25.12_1Reg_Cont* (blue line) is the continuity model updated with data through 2025. Model *26.1_1Reg* (yellow line) is the final single region model. Model *26.2_FAA* (grey line) is the final fleets-as-areas model. For a description of stepwise model building from Model *25.12_1Reg_Cont* to Model *26.1_1Reg* see Appendix 3B. For a description of the development of Model *26.2_FAA* (adding incremental complexity from Model *26.1_1Reg*) see Appendix 3C.

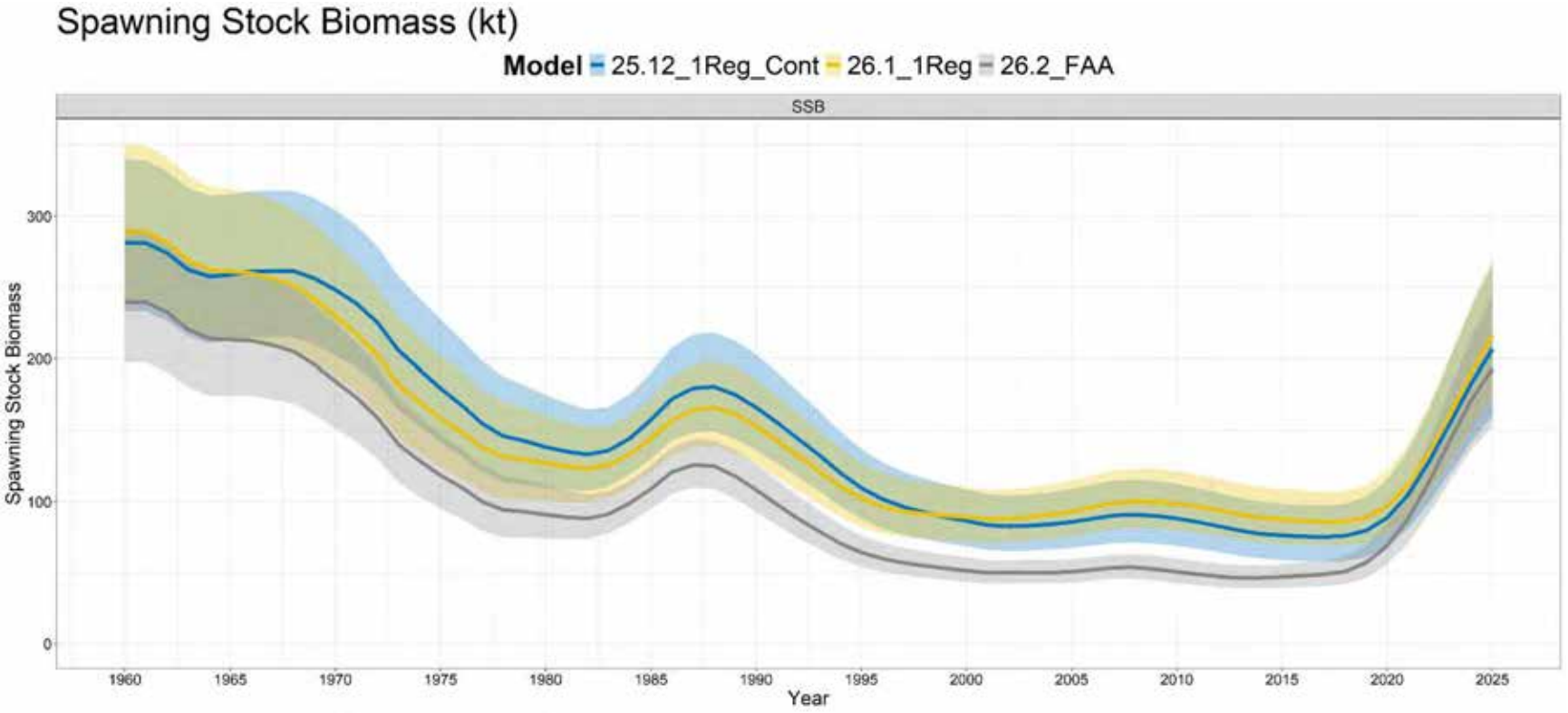

Figure 3.21. Results of the model bridging exercise in terms of spawning stock biomass (kt, lines) with 95% confidence intervals (associated shaded regions). Model *25.12_1Reg_Cont* (blue line) is the continuity model updated with data through 2025. Model *26.1_1Reg* (yellow line) is the final single region model. Model *26.2_FAA* (grey line) is the final fleets-as-areas model. For a description of stepwise model building from Model *25.12_1Reg_Cont* to Model *26.1_1Reg* see Appendix 3B. For a description of the development of Model *26.2_FAA* (adding incremental complexity from Model *26.1_1Reg*) see Appendix 3C.

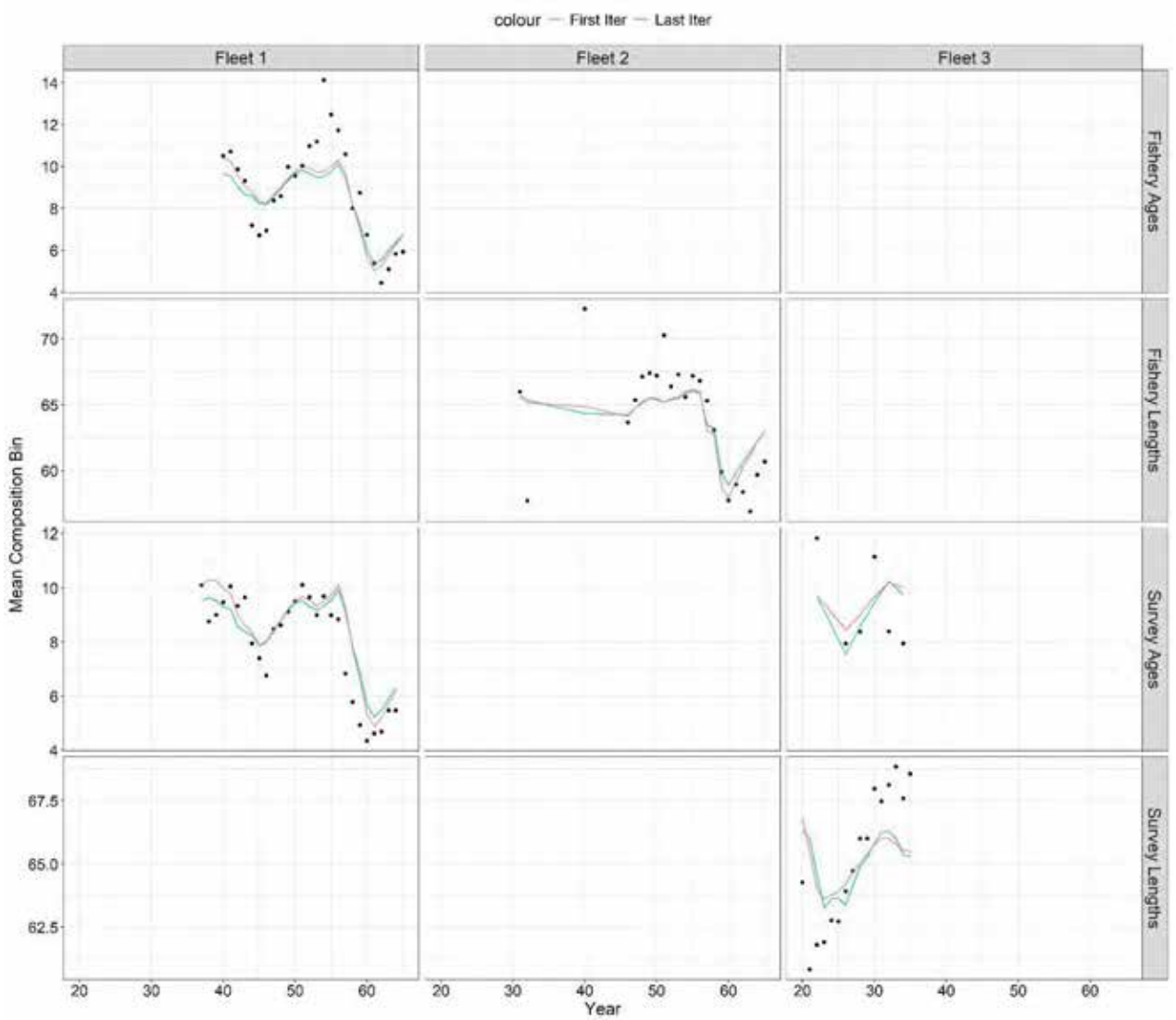

Figure 3.22. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.1_1Reg*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey fleet 1 is the NOAA Longline Survey and fleet 3 is the Japanese Longline Survey. Year 1 is 1960.

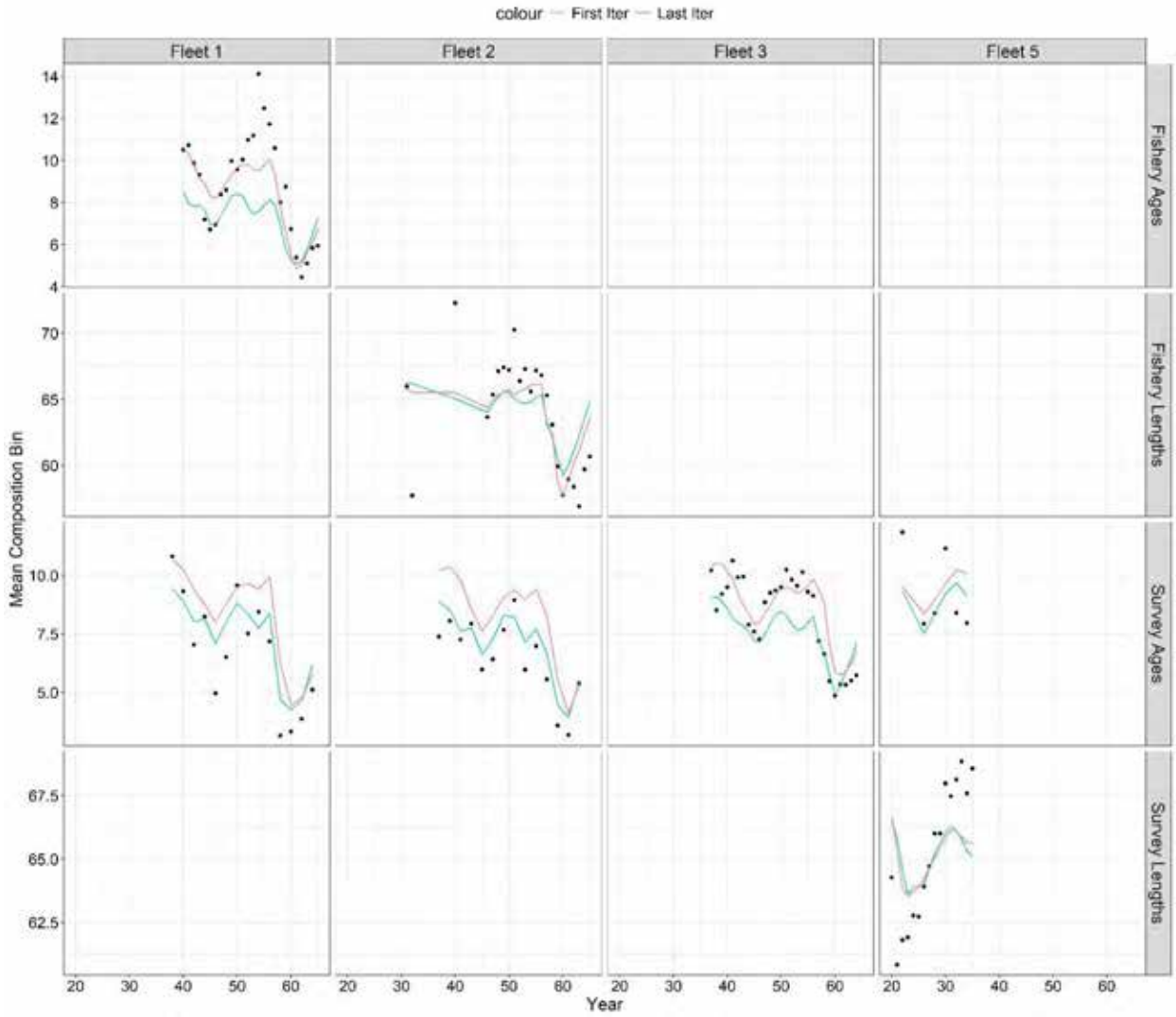

Figure 3.23. Fits to the mean age or mean length by year for each compositional data source at the start (using equal data weights, red line) and end (using final data weights, blue lines) of the Francis reweighting method (Francis, 2011) for Model *26.2_FAA*. Fishery fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery. Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey, and Survey Fleet 5 is the Japanese Longline Survey. Year 1 is 1960.

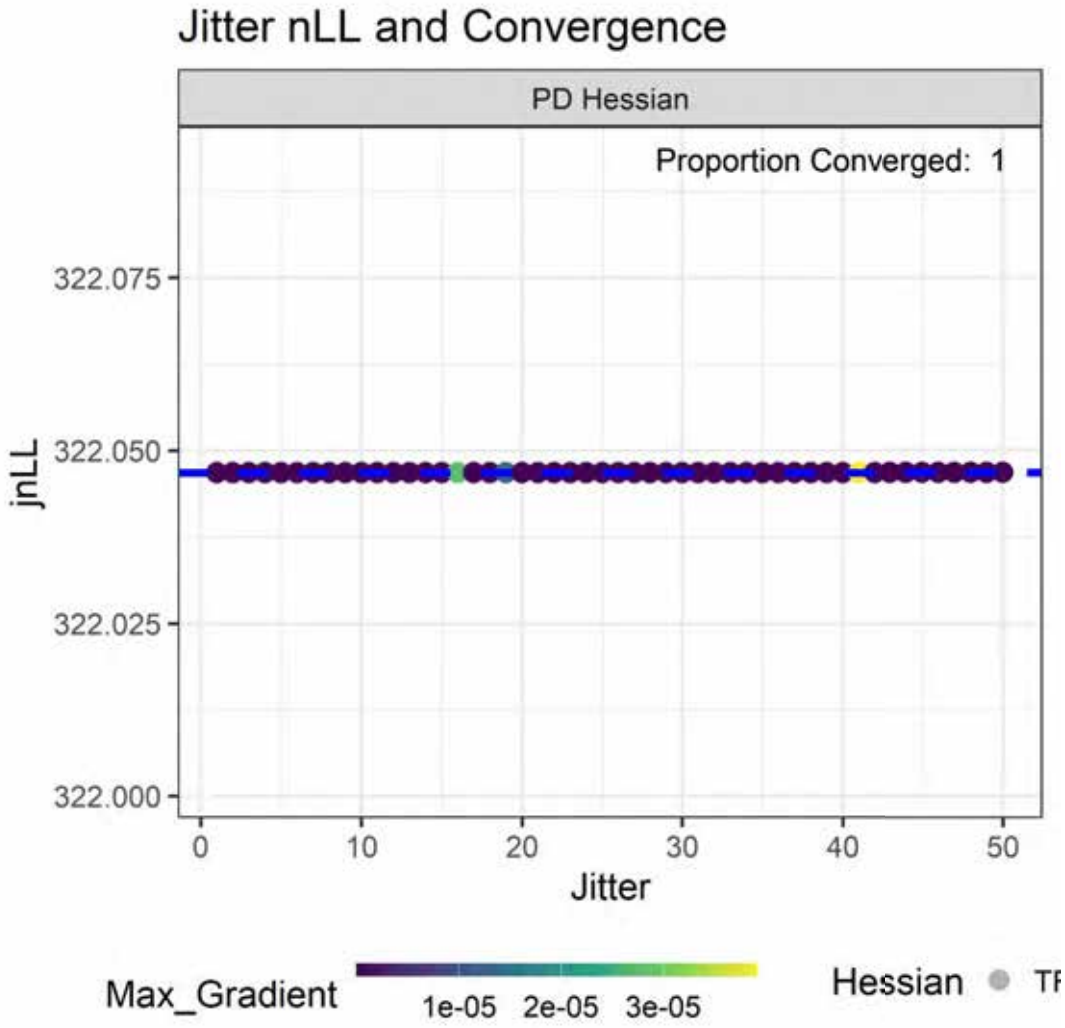

Figure 3.24. Results of the jitter analysis in terms of total joint negative log-likelihood (jnLL) values for Model *26.1_1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$. All 50 jitter runs are shown and the model with the smallest jnLL was used as the base model.

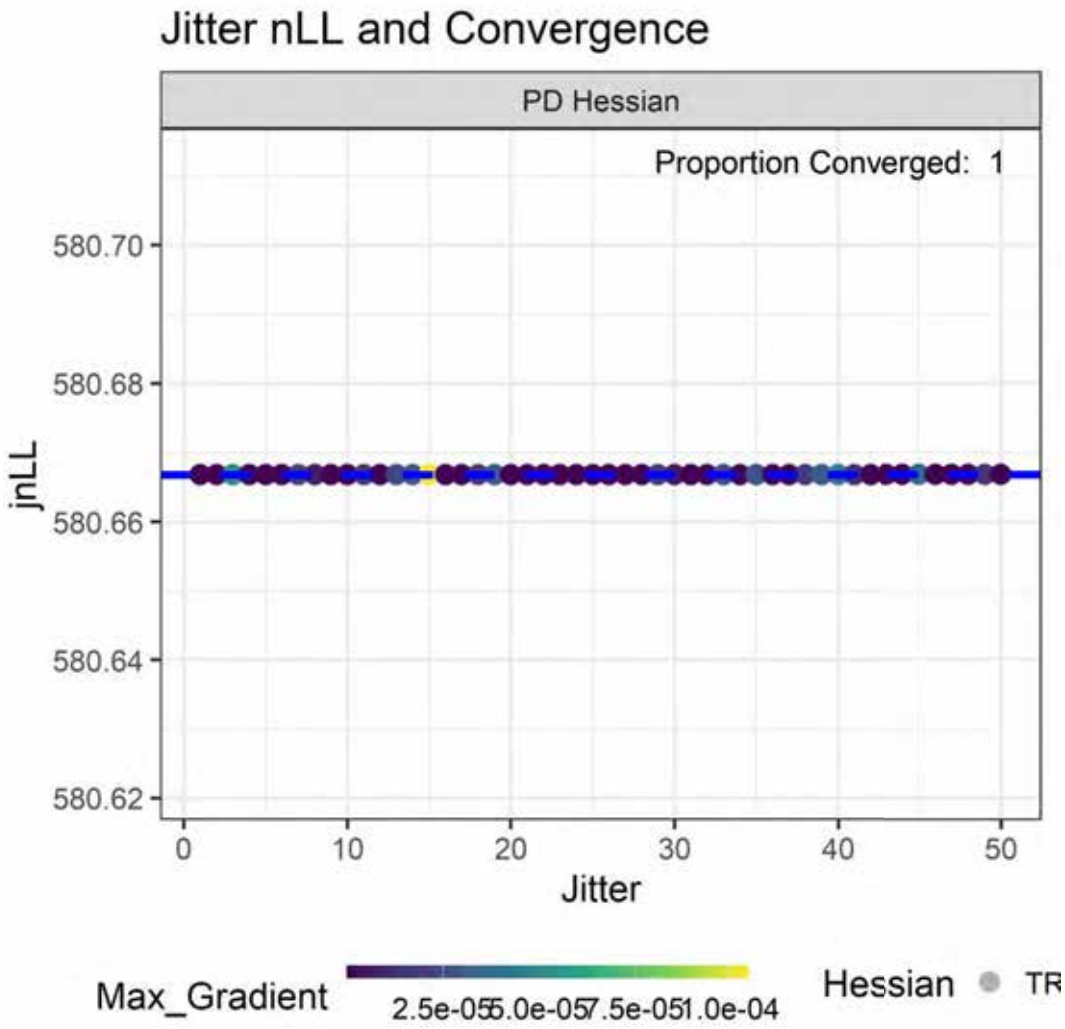

Figure 3.25. Results of the jitter analysis in terms of total joint negative log-likelihood (jnLL) values Model *26.2_FAA*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$. All 50 jitter runs are shown and the model with the smallest jnLL was used as the base model.

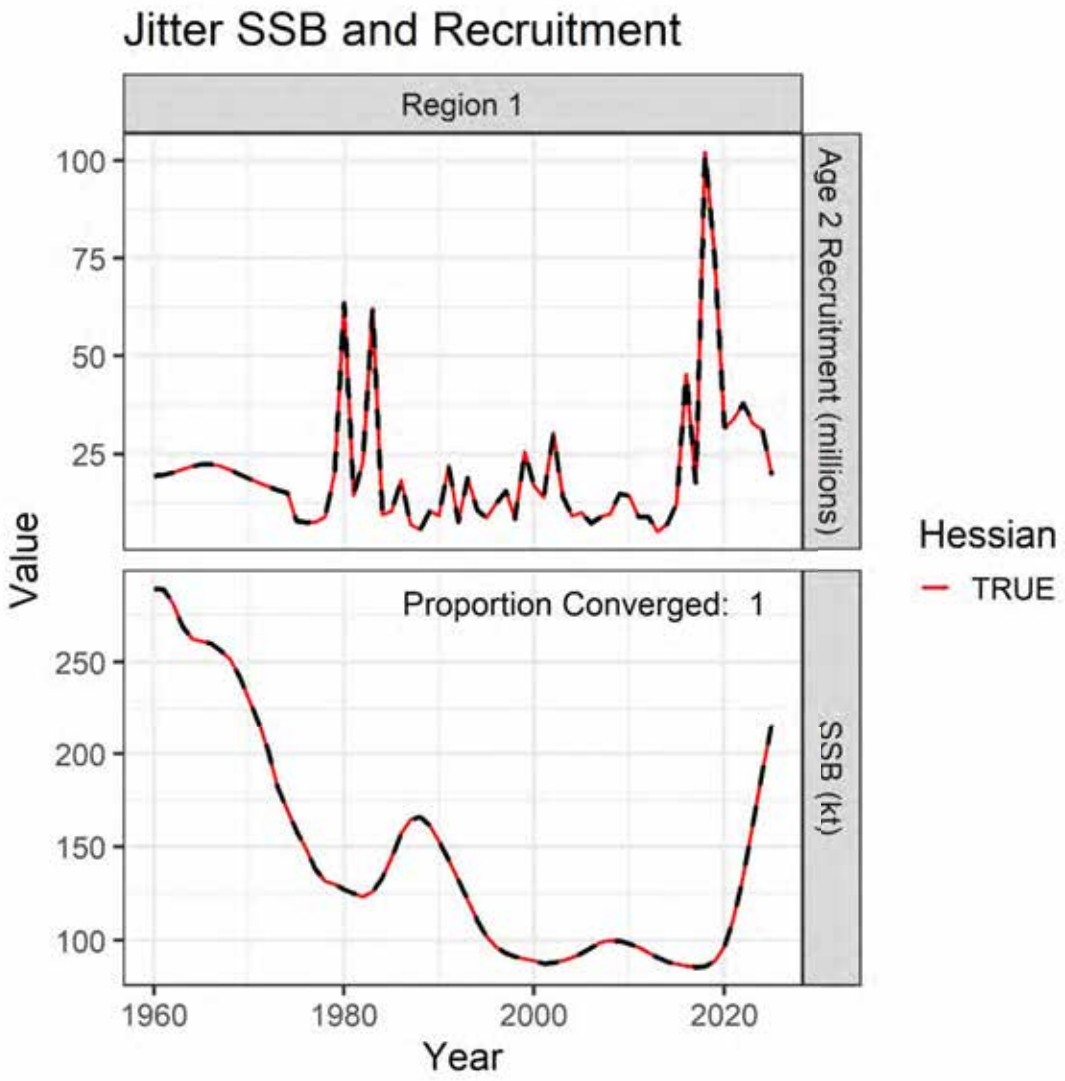

Figure 3.26. Results of the jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.1_1Reg*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$ and all 50 jitter runs are shown.

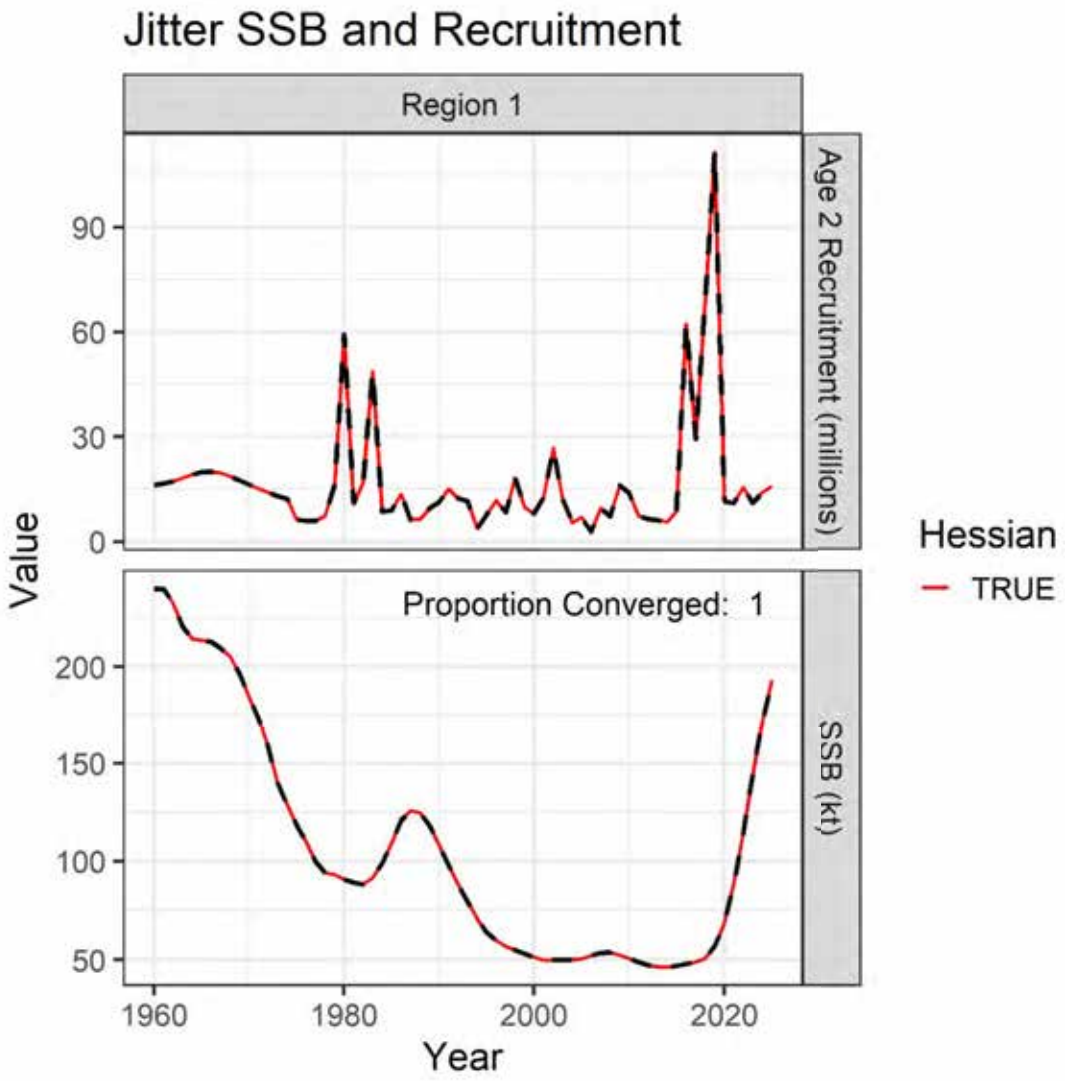

Figure 3.27. Results of the jitter analysis showing recruitment (top panel) and SSB (bottom panel) for each jitter iteration for Model *26.2_FAA*. The starting parameter values were randomly jittered assuming ~$N(0,0.1^2)$ and all 50 jitter runs are shown.

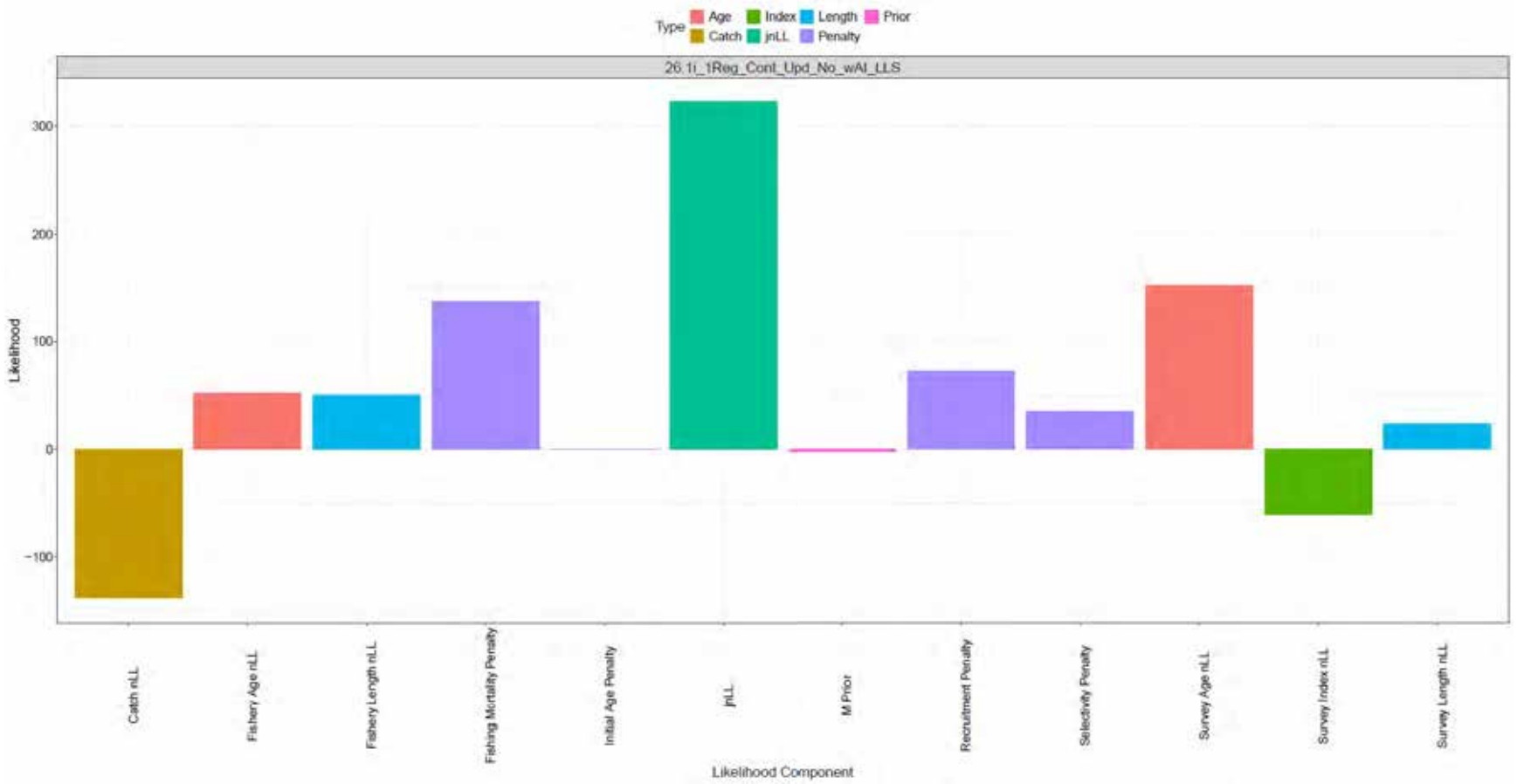

Figure 3.28. Joint negative log-likelihood (jnLL) components from Model *26.1_1Reg* where different colors represent the various data sets and priors or penalty terms. Note that due to differences in likelihood structures and data inputs (regional disaggregation of fleets) used in Model *26.1_1Reg* compared to Model *26.2_FAA*, Figures 3.25 and 3.26 are not directly comparable.

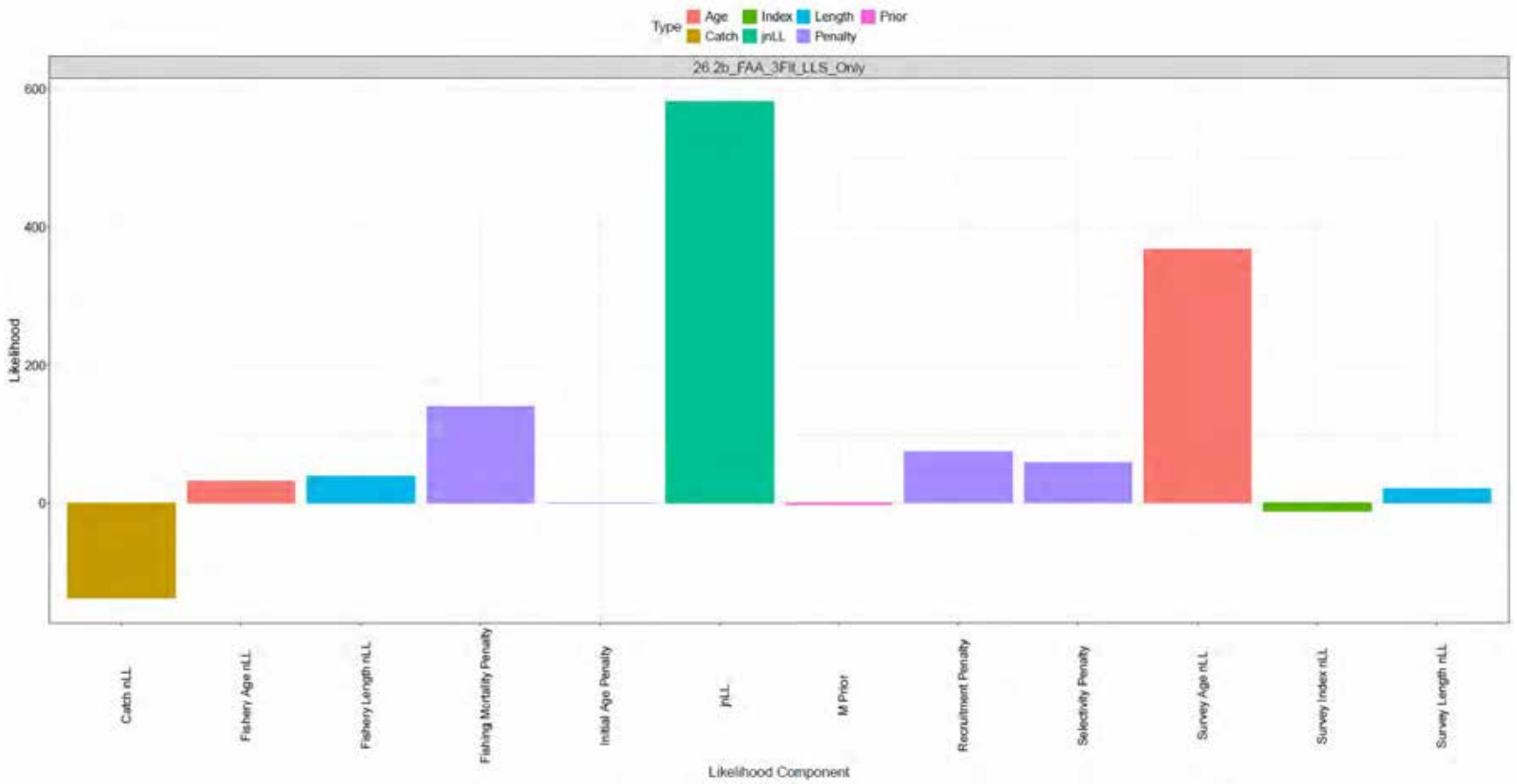

Figure 3.29. Joint negative log-likelihood (jnLL) components from Model *26.2_FAA* where different colors represent the various data sets and priors or penalty terms. Note that due to differences in likelihood structures and data inputs (regional disaggregation of fleets) used in Model *26.1_1Reg* compared to Model *26.2_FAA*, Figures 3.28 and 3.29 are not directly comparable.

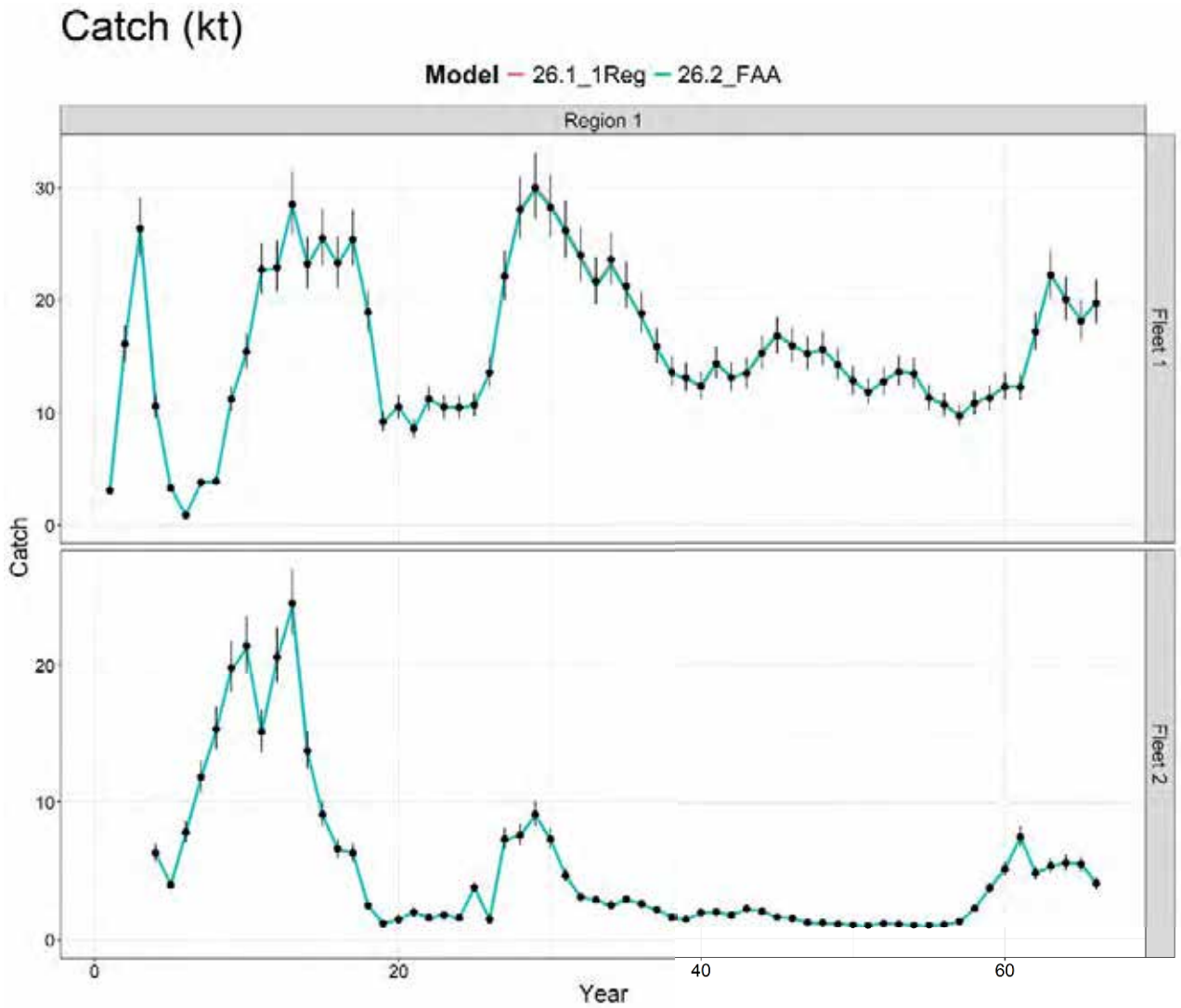

Figure 3.30. Fit to the catch data (black dots with 95% confidence intervals) by fleet (fleet 1 is the fixed gear fishery and fleet 2 is the trawl fleet) for Model *26.1_1Reg* (red line) and Model *26.2_FAA* (blue line). Note the varying y-axis scales.

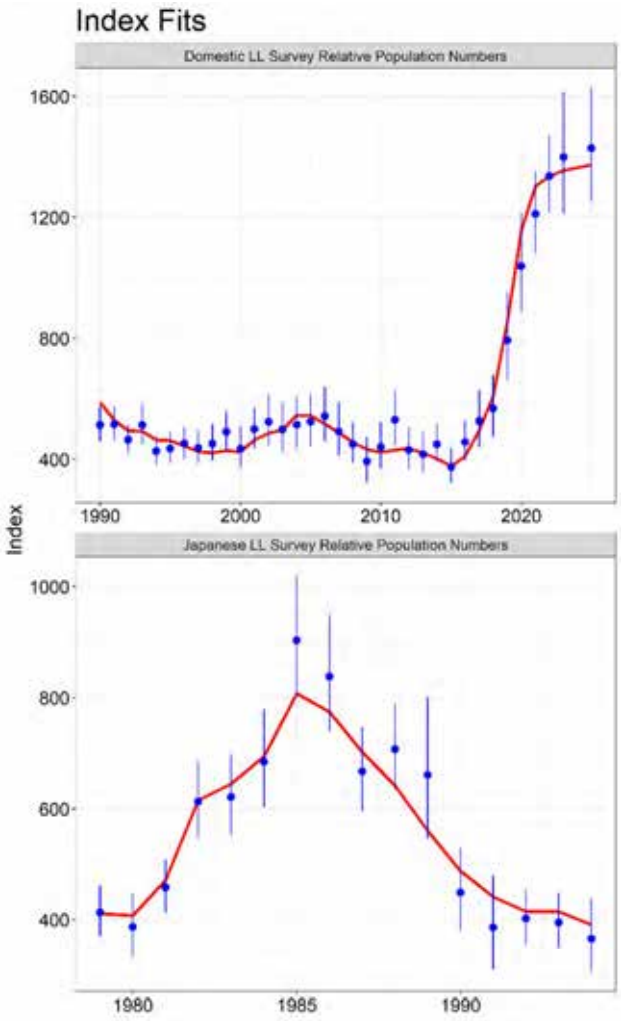

Figure 3.31. Model *26.1_1Reg* fit to indices, including the NOAA Longline Survey RPNs (top, 1000s of fish) and Japanese Longline Survey RPNs (bottom, 1000s of fish). Red lines are model predicted values, and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

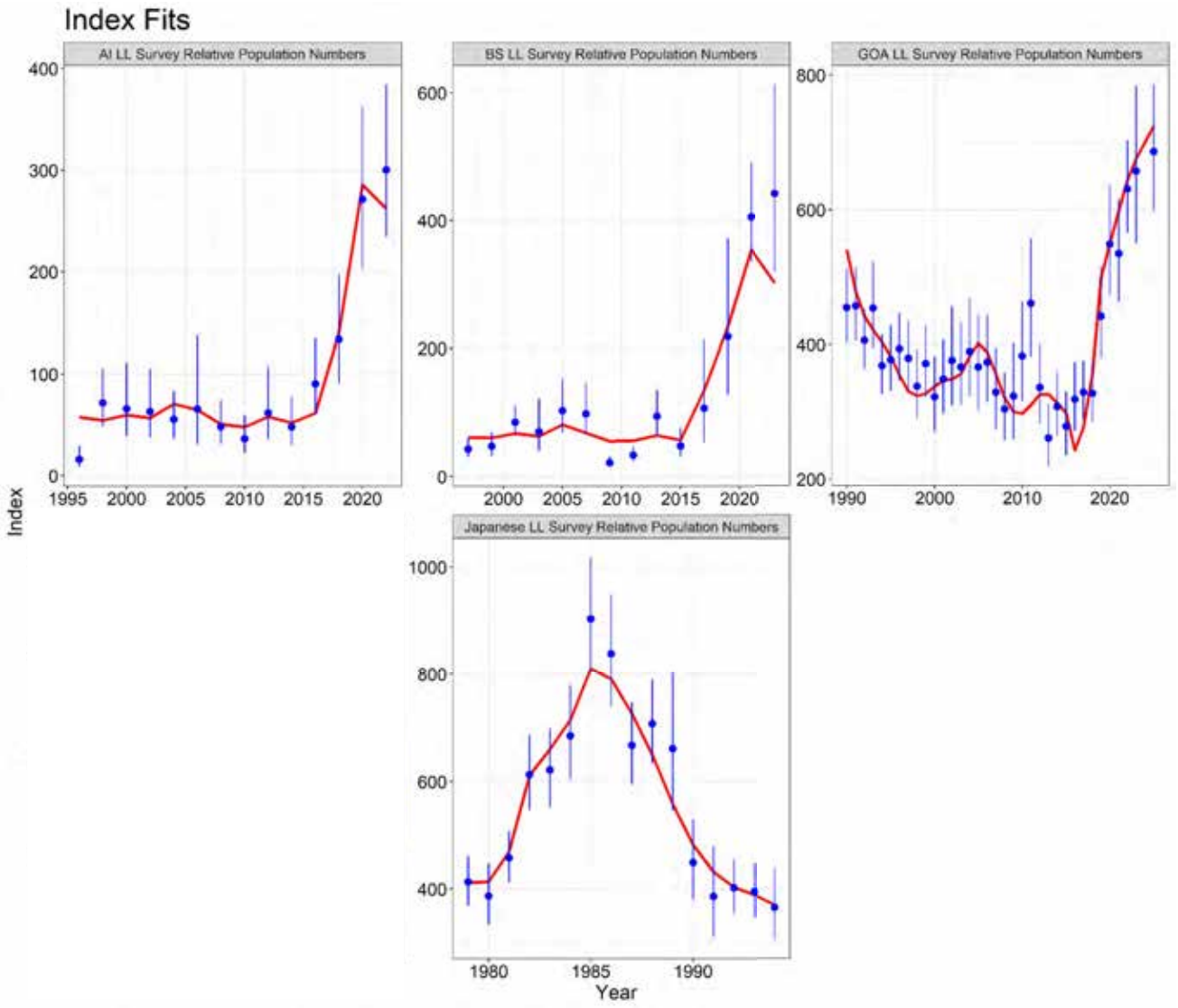

Figure 3.32. Model *26.2_FAA* fit to indices, including the NOAA Longline Survey RPNs (top, 1000s of fish) by region (columns) and Japanese Longline Survey RPNs (bottom, 1000s of fish). Red lines are model predicted values, and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

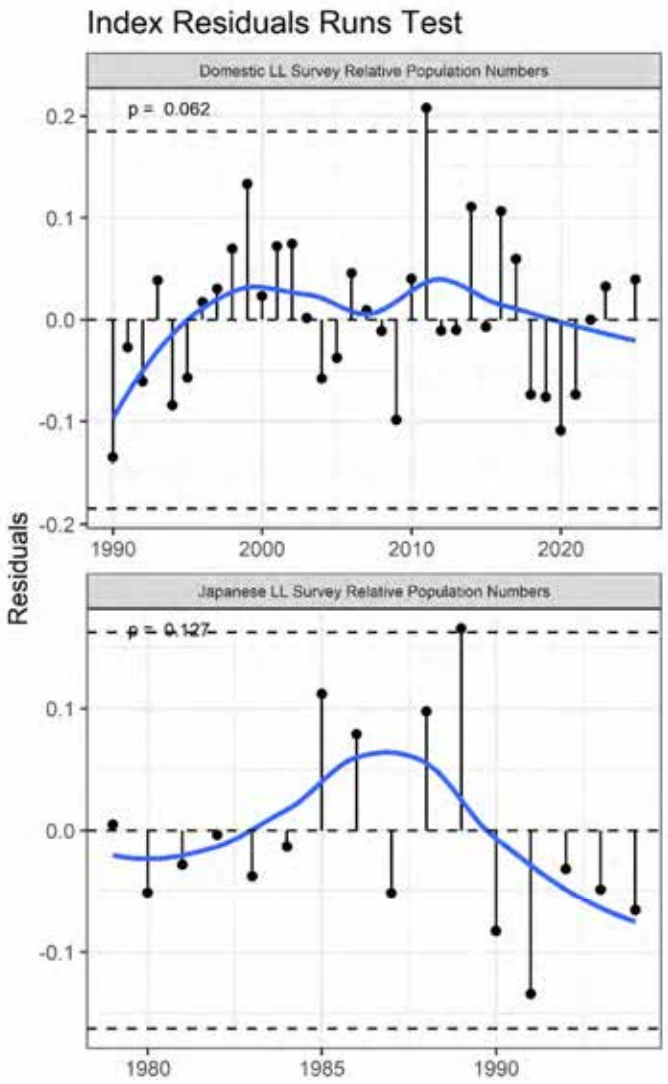

Figure 3.33. Results of an index residuals runs test for Model *26.1_1Reg* , where the black dots are the residual values, the blue lines represent a loess smoother across years, and the dashed lines represent the 95% confidence intervals.

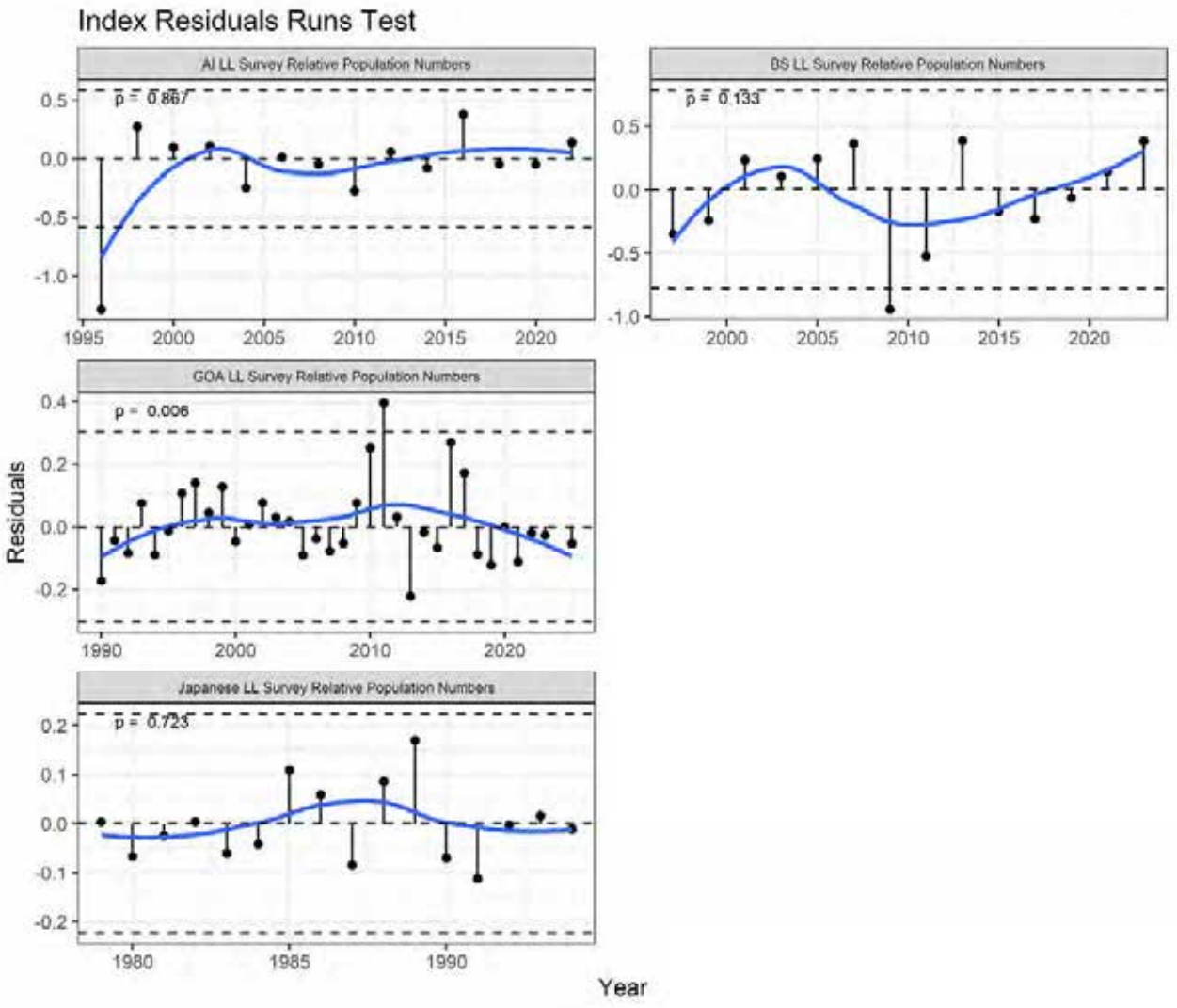

Figure 3.34. Results of an index residuals runs test for Model *26.2_FAA* , where the black dots are the residual values, the blue lines represent a loess smoother across years, and the dashed lines represent the 95% confidence intervals.

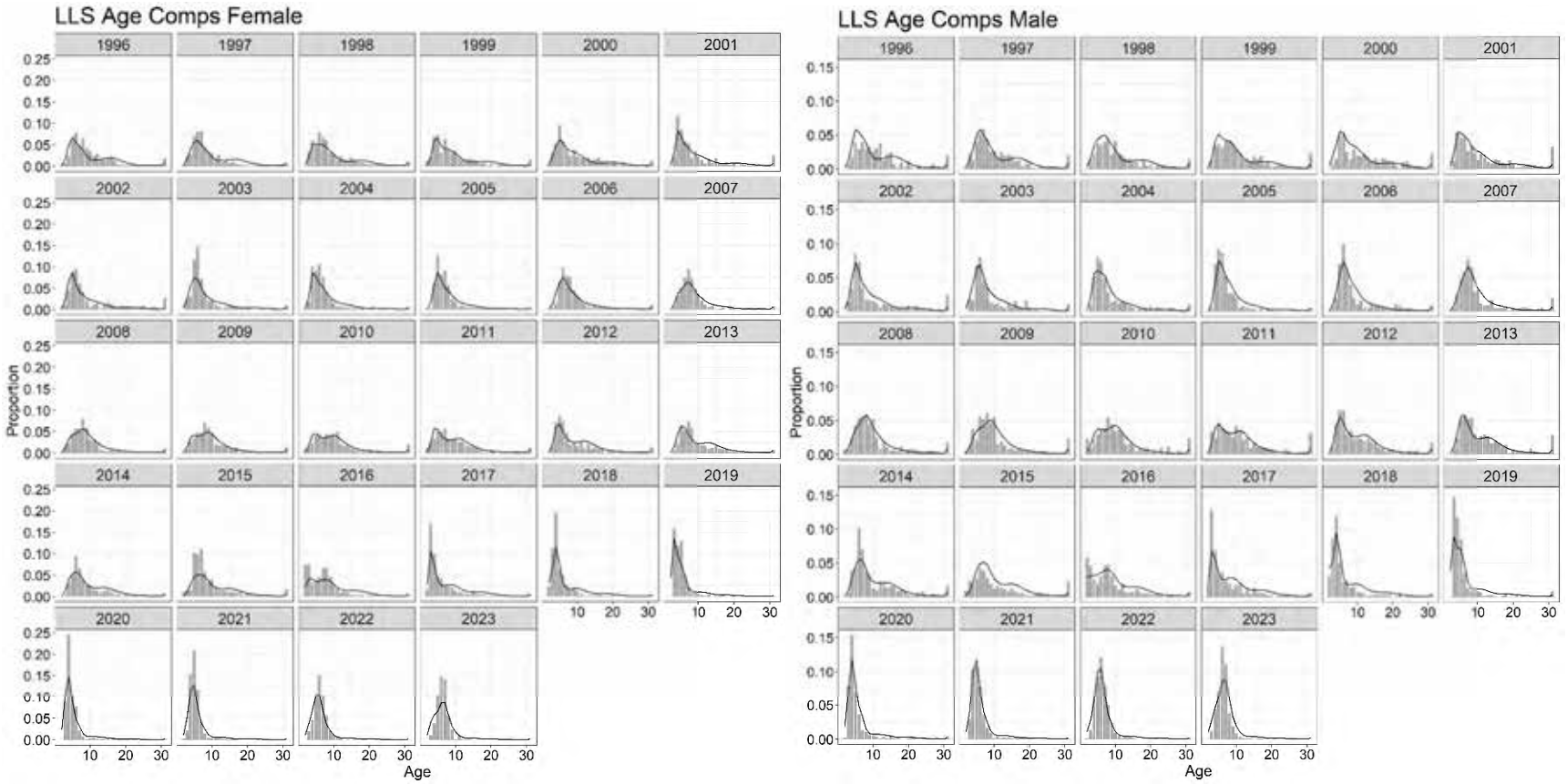

Figure 3.35. Fits to NOAA longline survey age composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

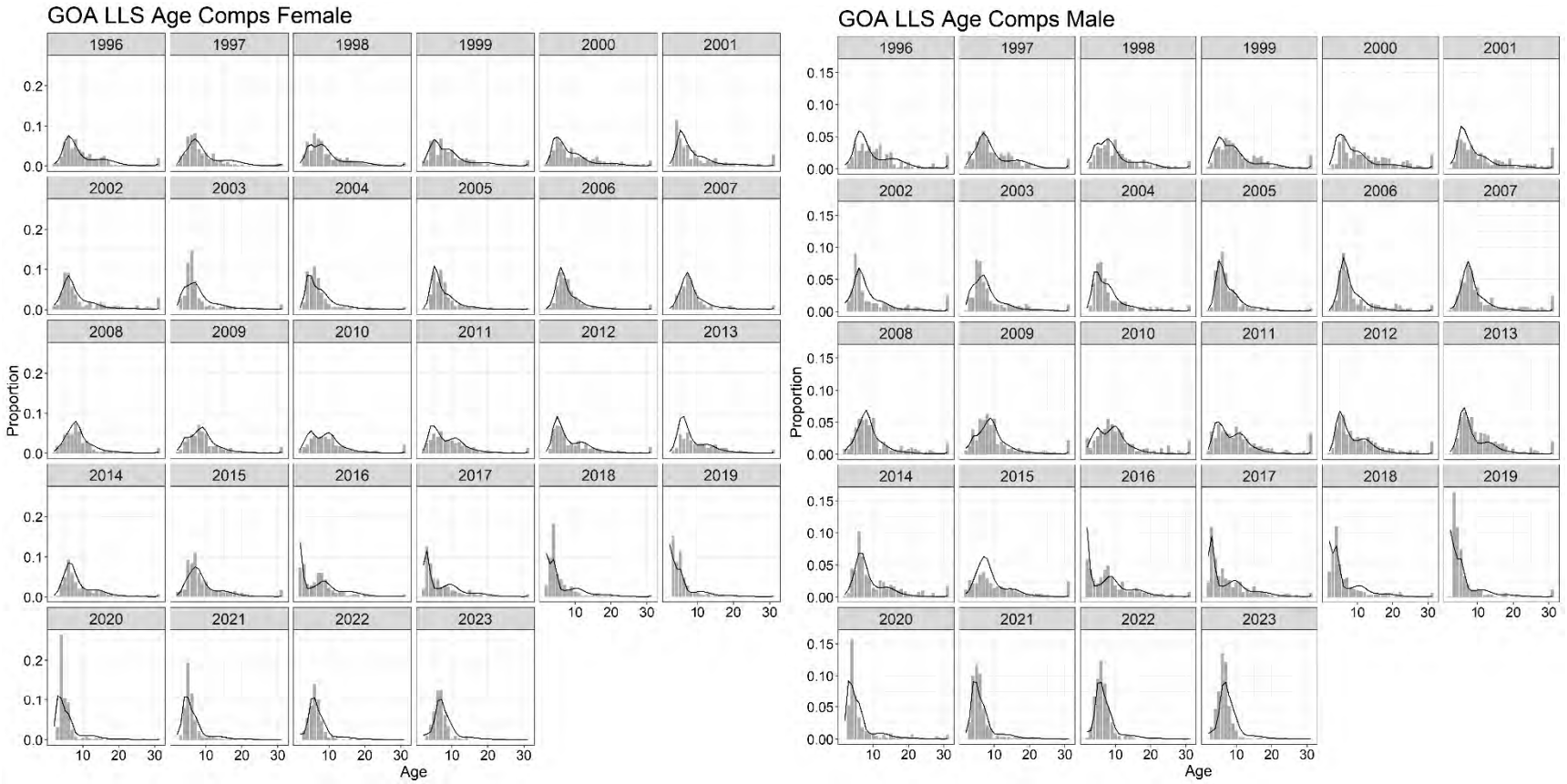

Figure 3.36. Fits to GOA NOAA Longline Survey age composition data by year and sex (females left and males right) for Model *26.2_FAA*.

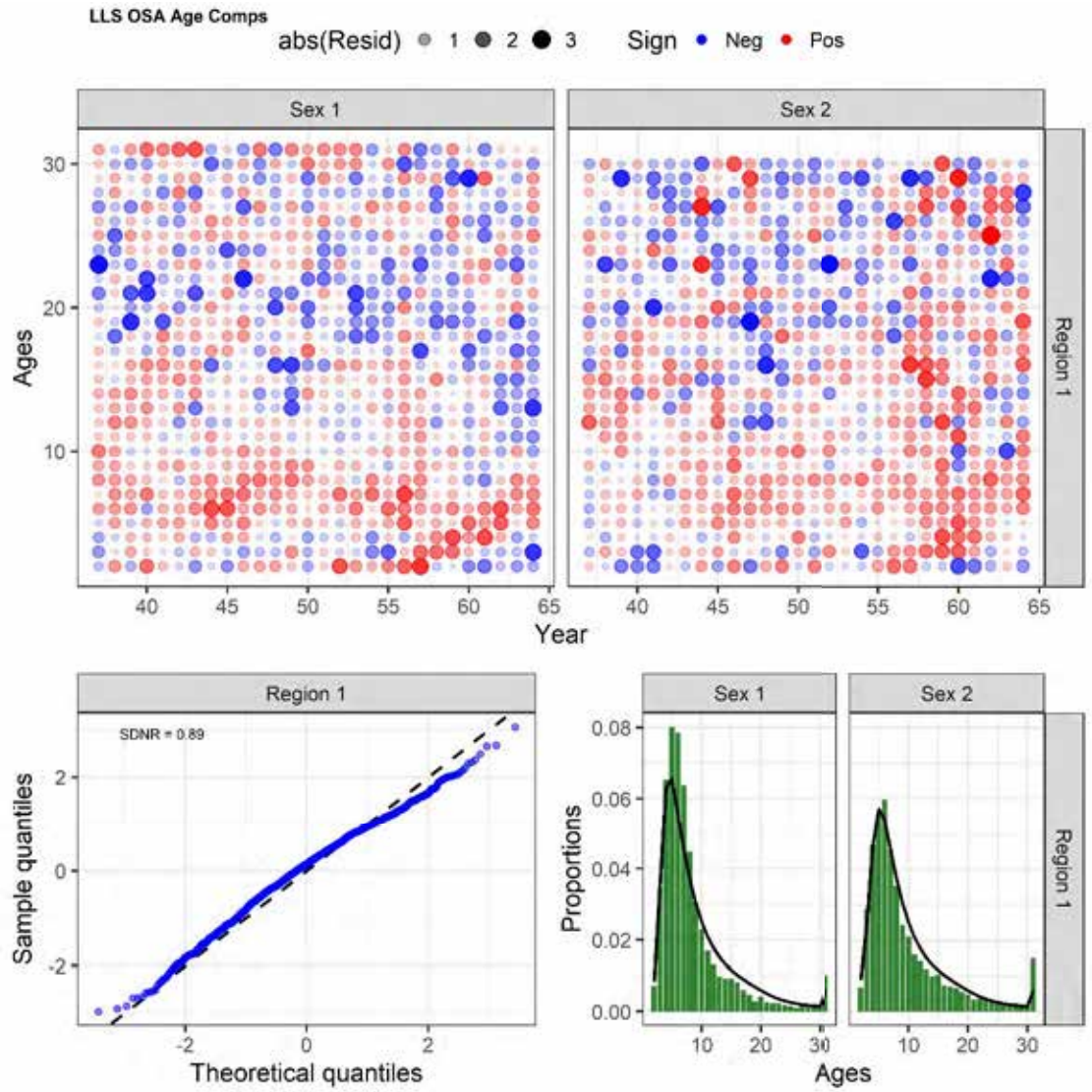

Figure 3.37. Fits to NOAA longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

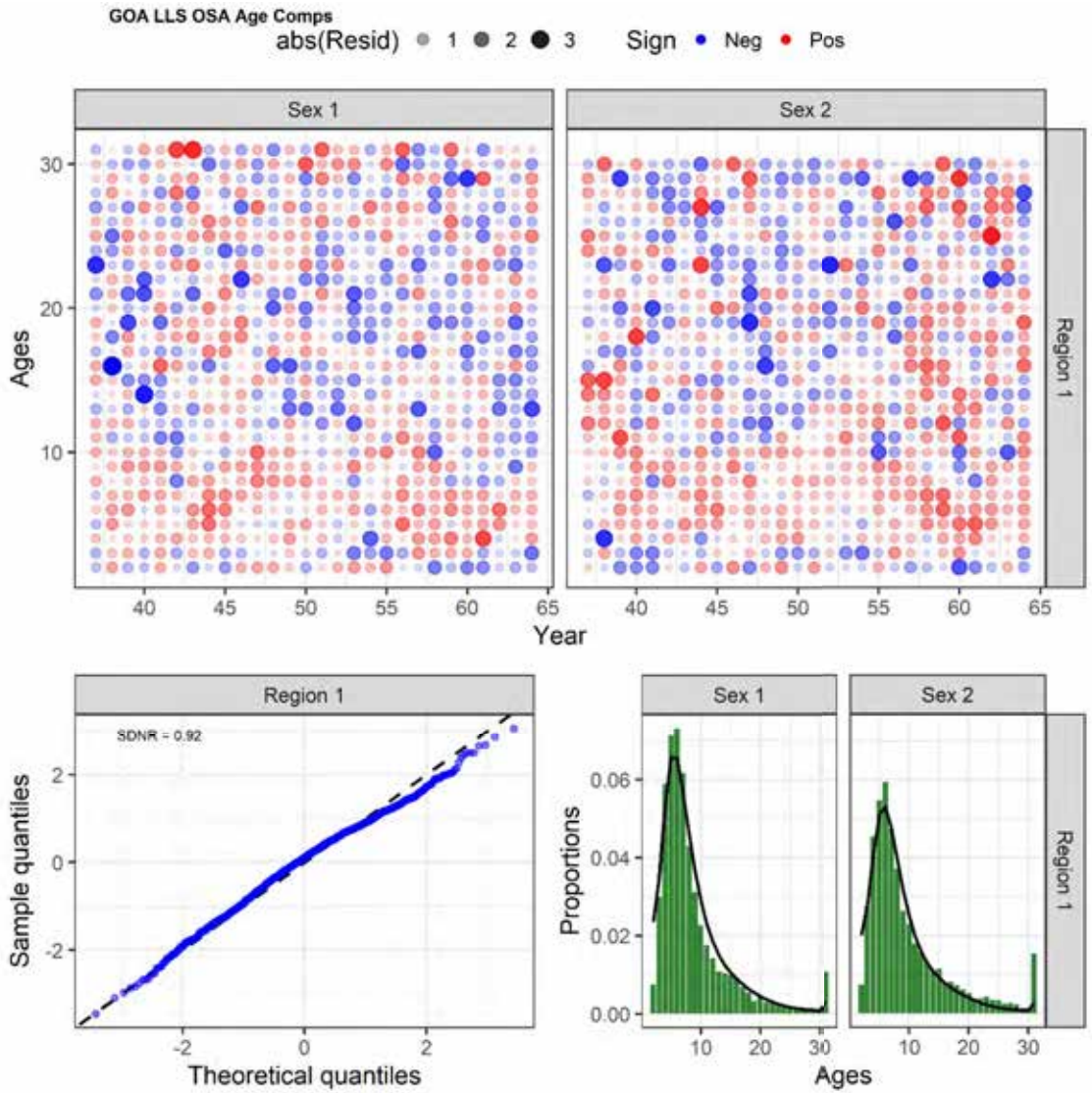

Figure 3.38. Fits to GOA NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

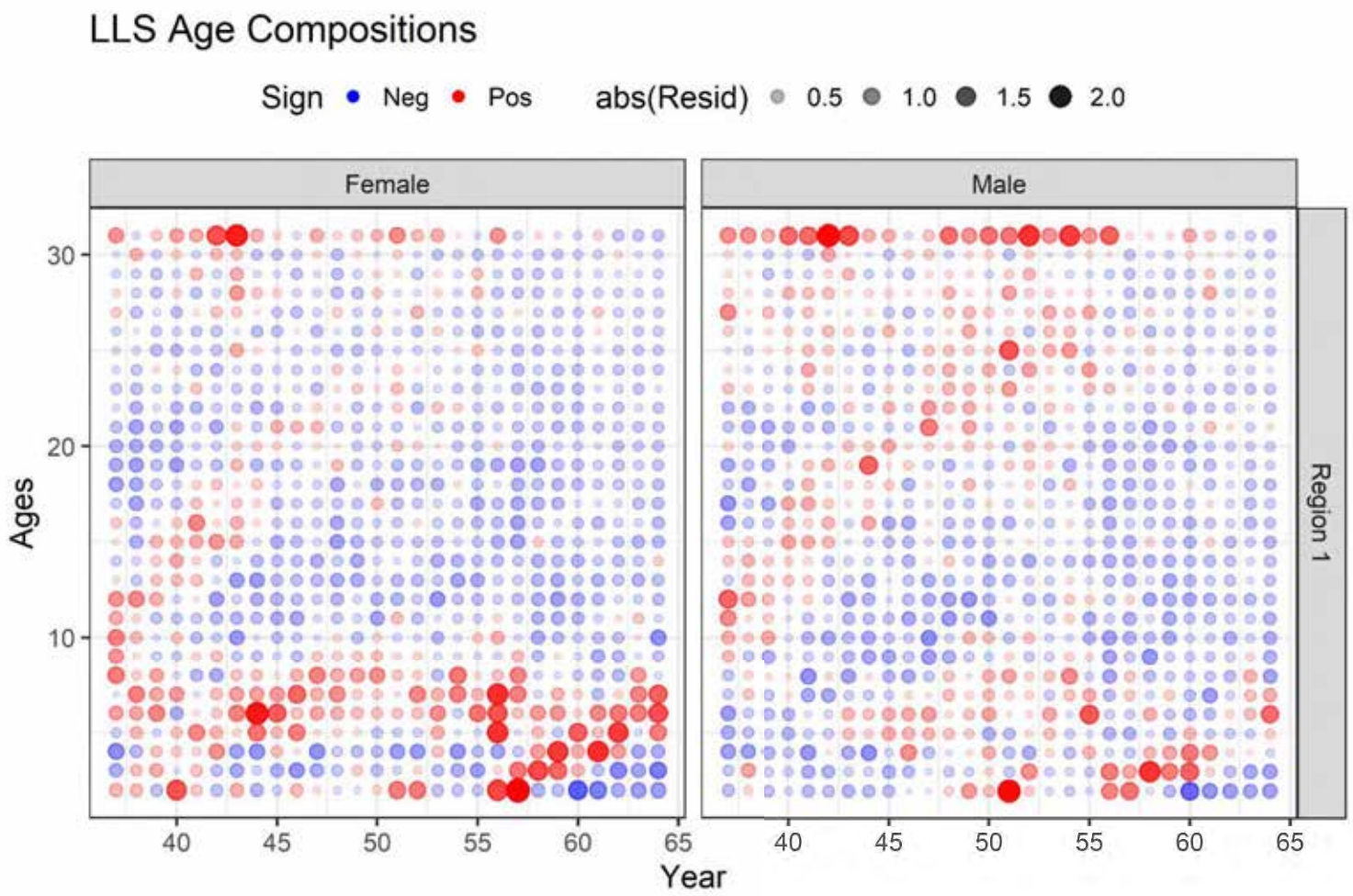

Figure 3.39. Fits to NOAA longline survey age composition data based on Pearson residuals for Model *26.1_1Reg*.

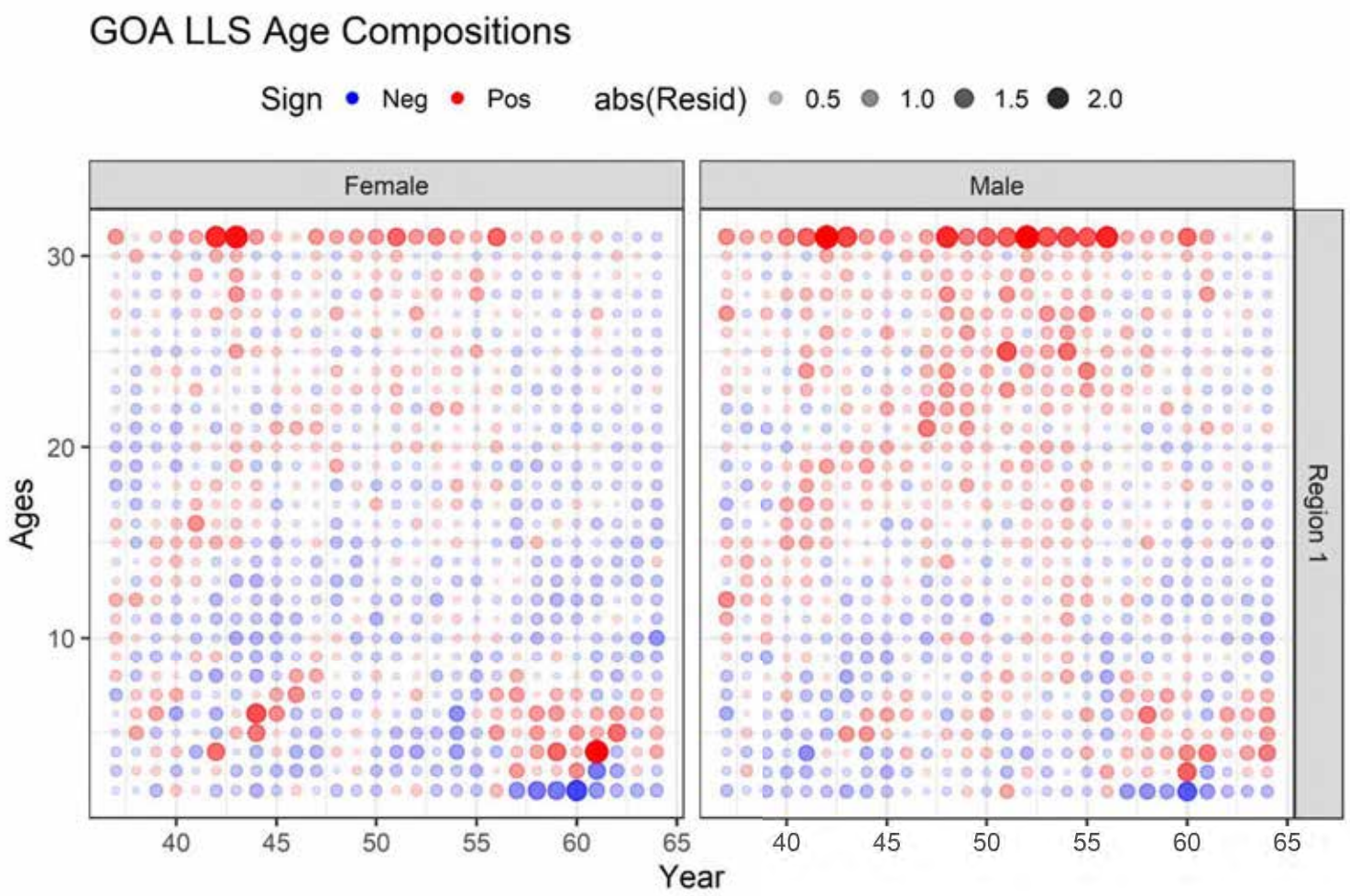

Figure 3.40. Fits to GOA NOAA Longline Survey age composition data based on Pearson residuals for Model *26.2_FAA*.

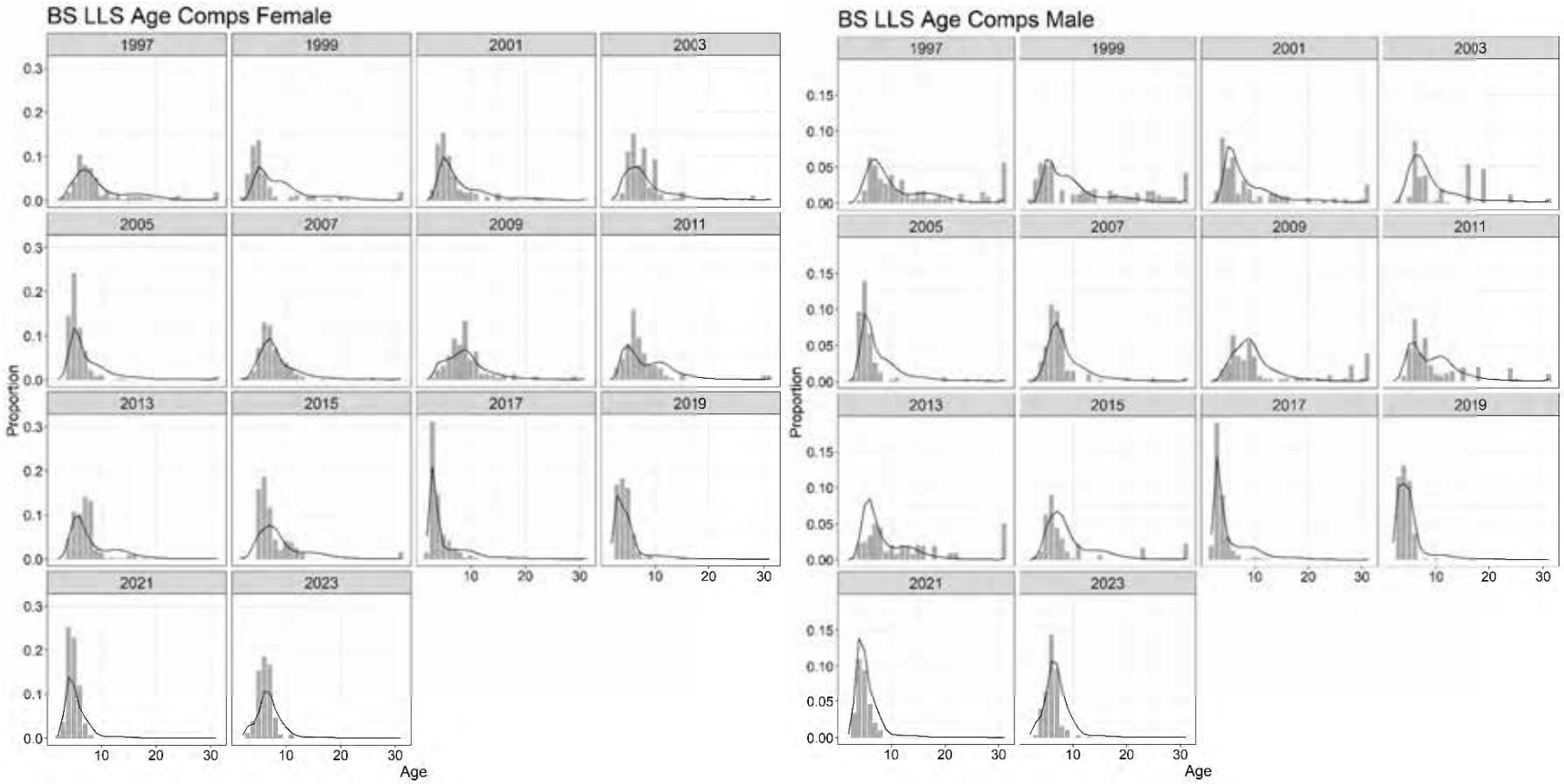

Figure 3.41. Fits to BS NOAA Longline Survey age composition data by year and sex (females left and males right) for Model *26.2_FAA*.

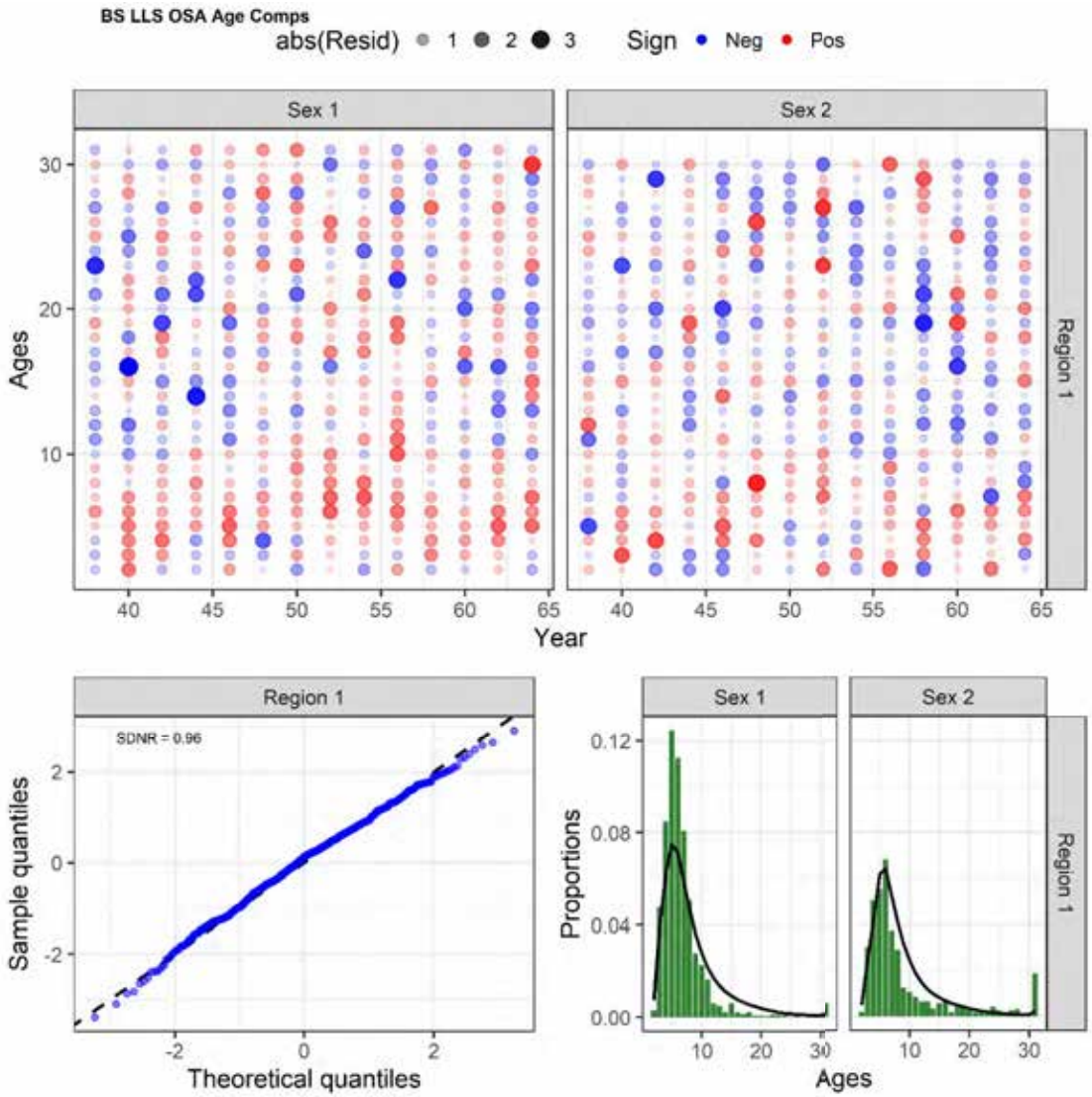

Figure 3.42. Fits to BS NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

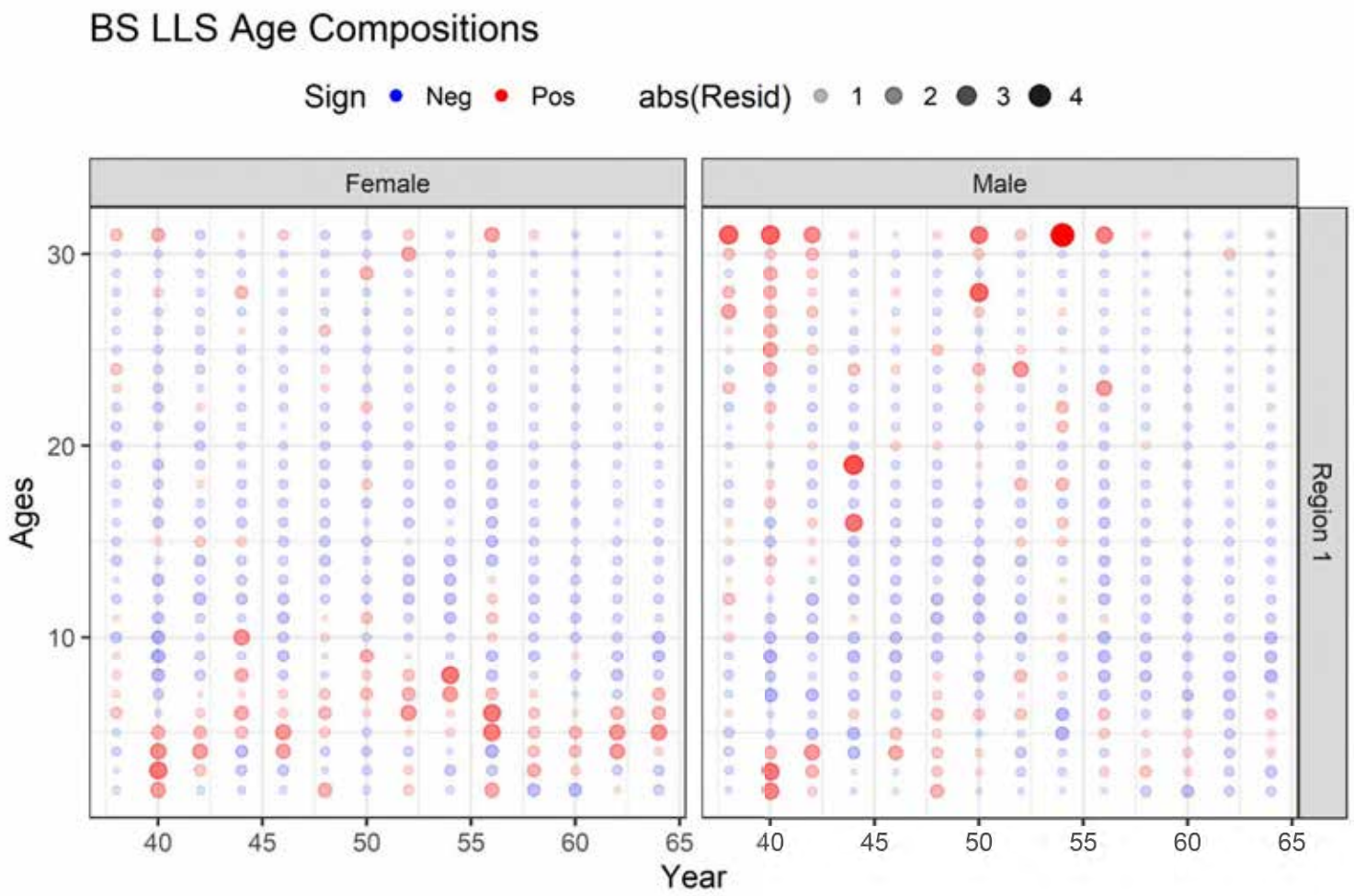

Figure 3.43. Fits to BS NOAA Longline Survey age composition data based on Pearson residuals for Model *26.2_FAA.*

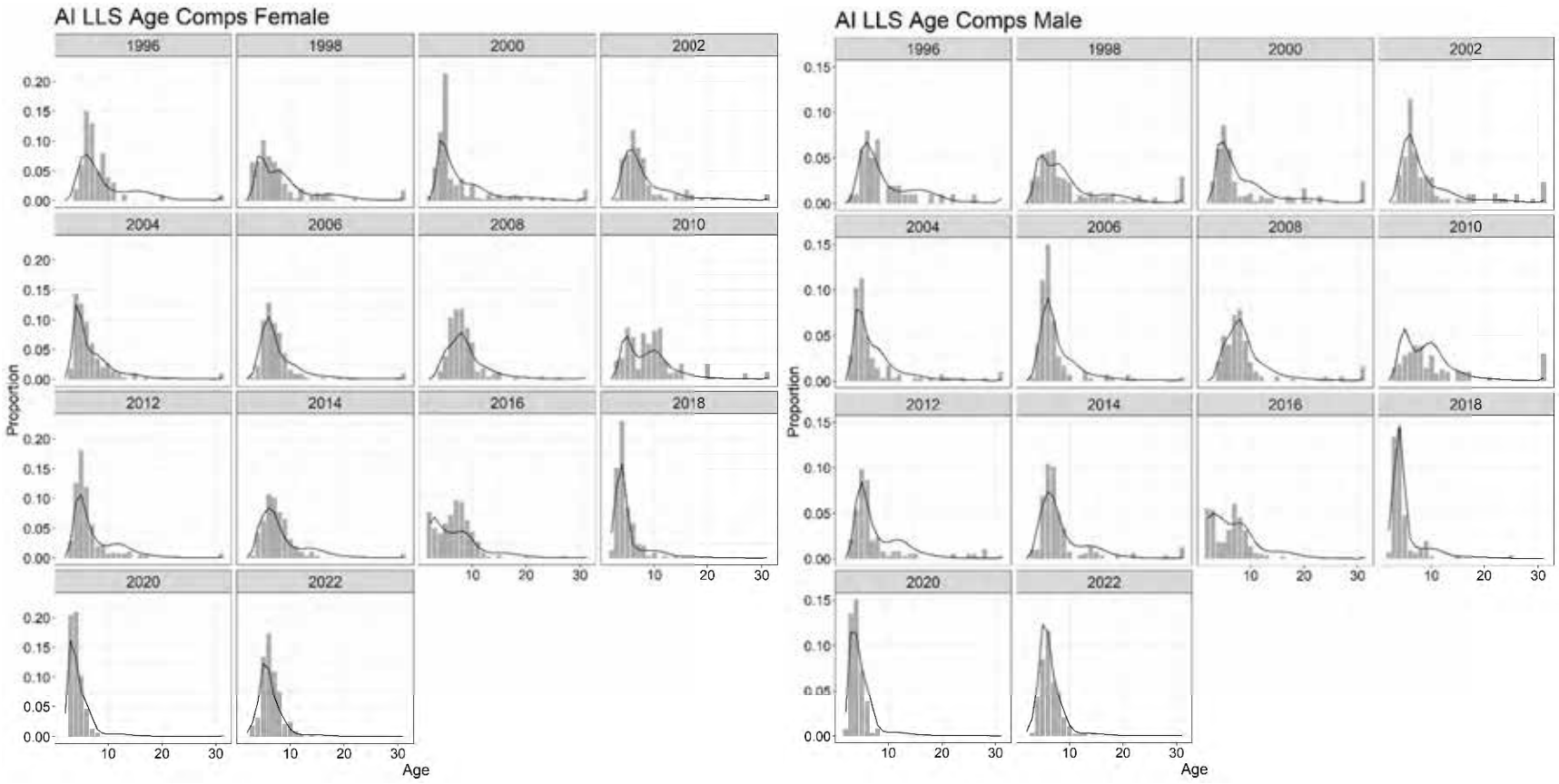

Figure 3.44. Fits to AI NOAA Longline Survey age composition data by year and sex (females left and males right) for Model *26.2_FAA*.

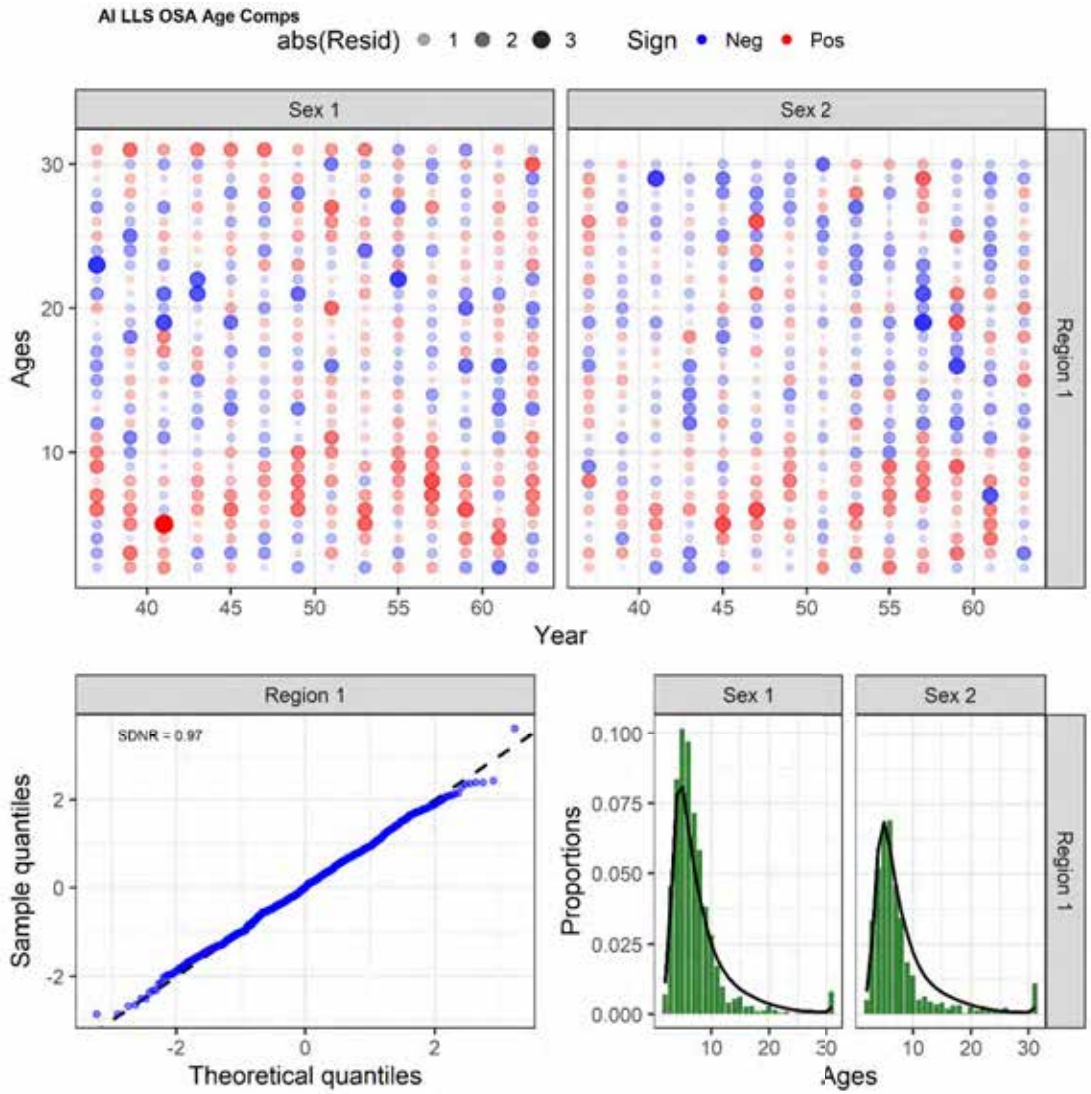

Figure 3.45. Fits to AI NOAA Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

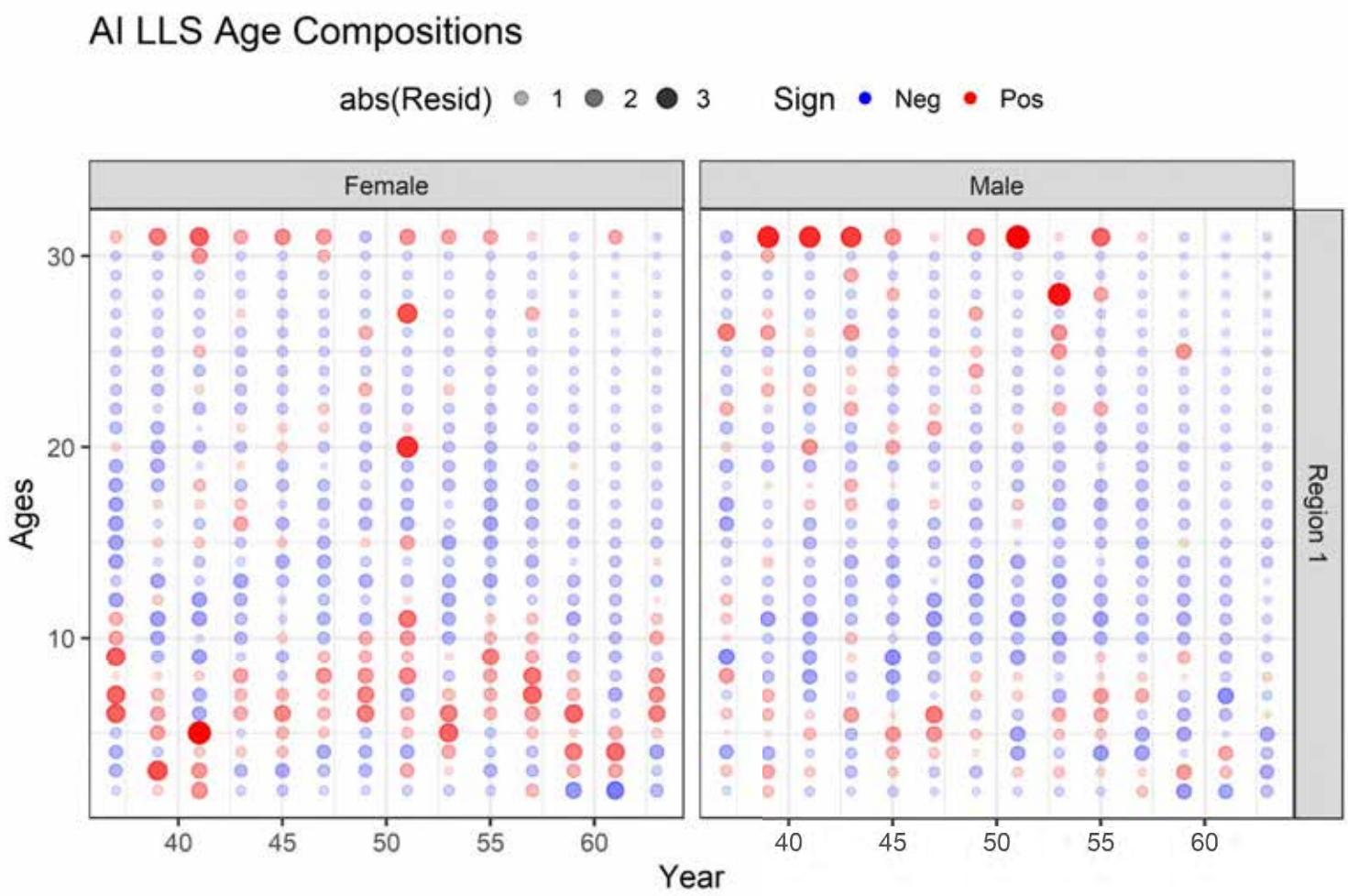

Figure 3.46. Fits to AI NOAA longline survey age composition data based on Pearson residuals for Model *26.2_FAA*.

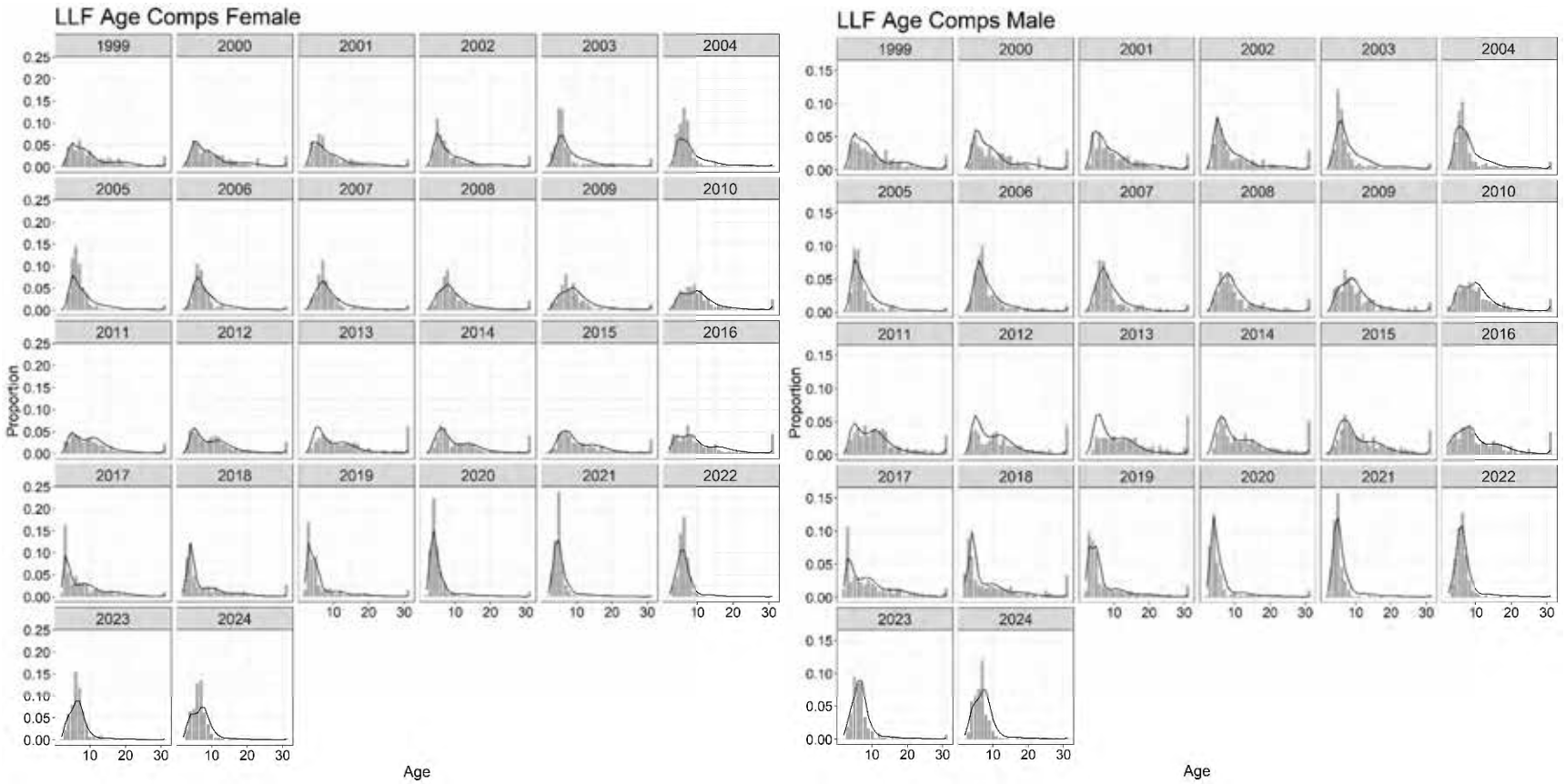

Figure 3.47. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

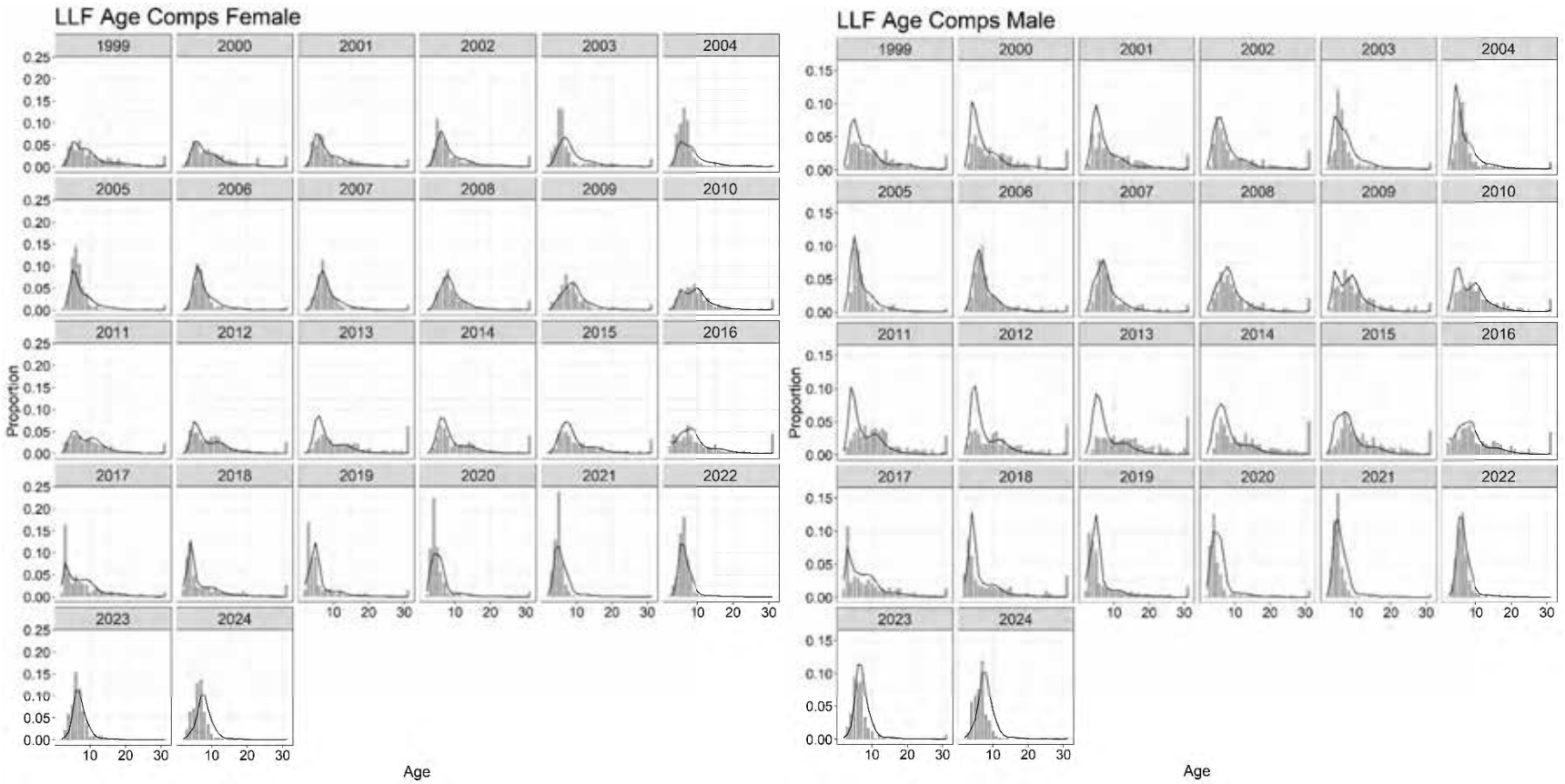

Figure 3.48. Fits to fixed gear fishery age composition data by year and sex (females left and males right) for Model *26.2_FAA.*

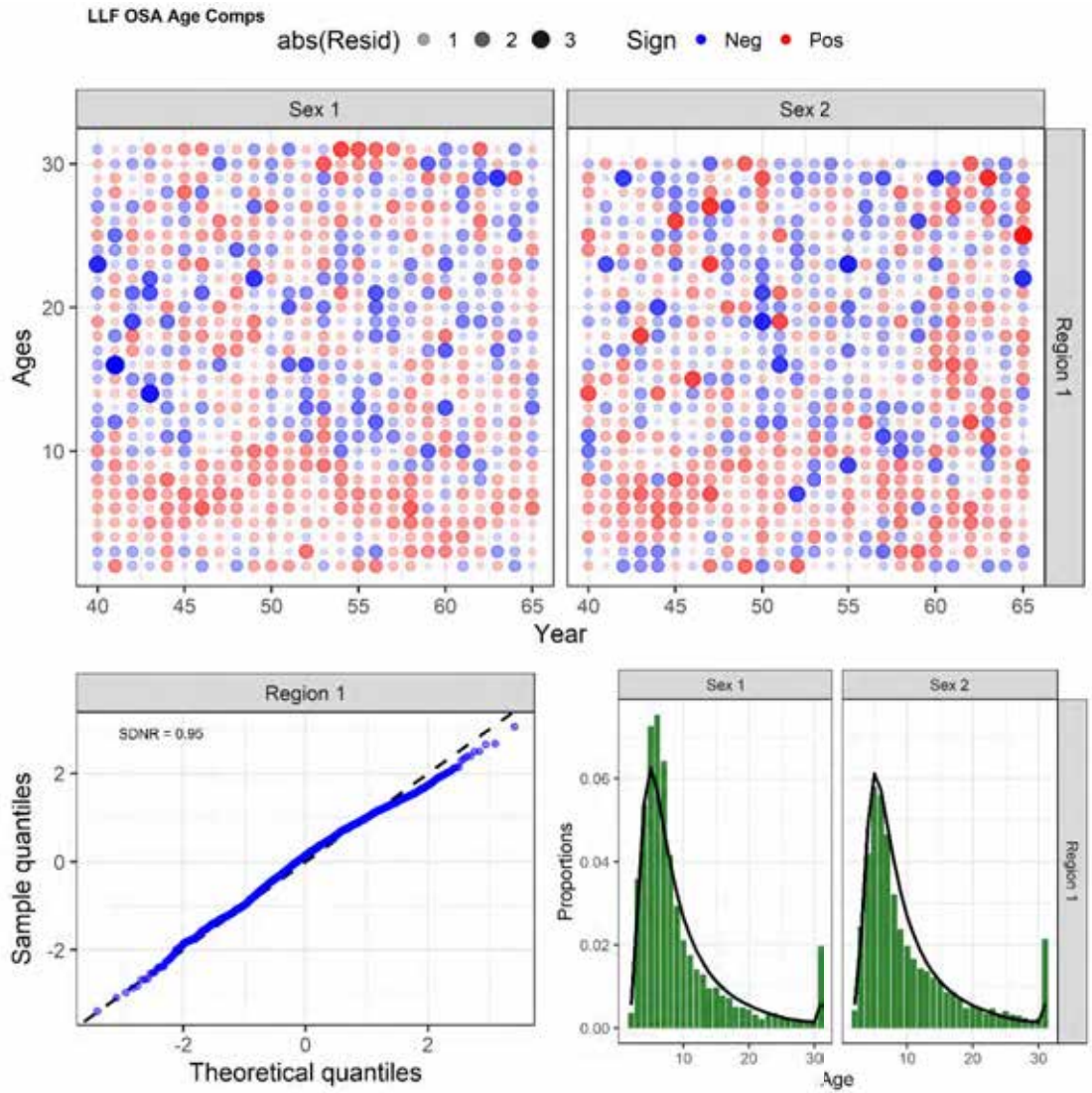

Figure 3.49. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

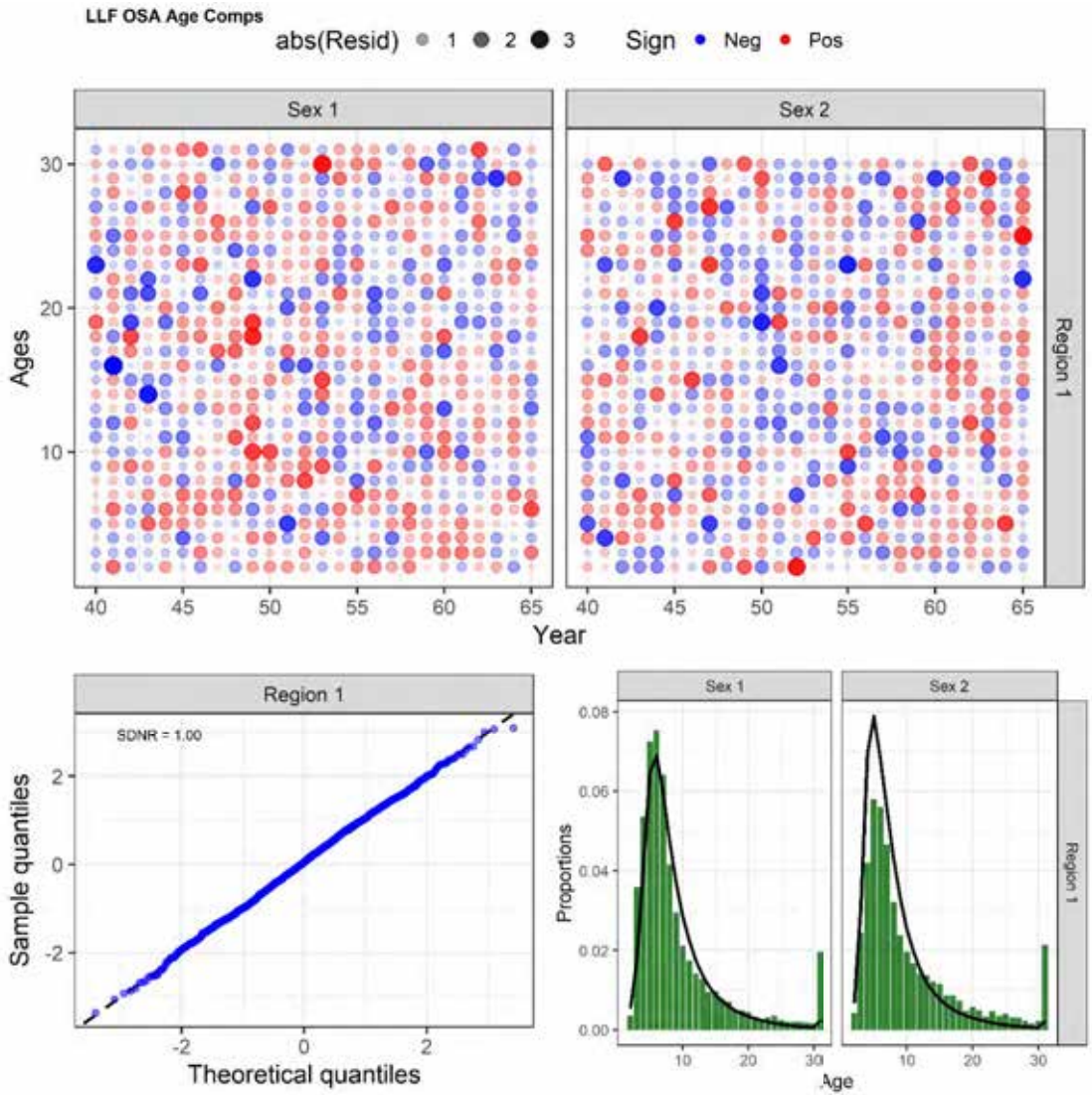

Figure 3.50. Fits to fixed gear fishery age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

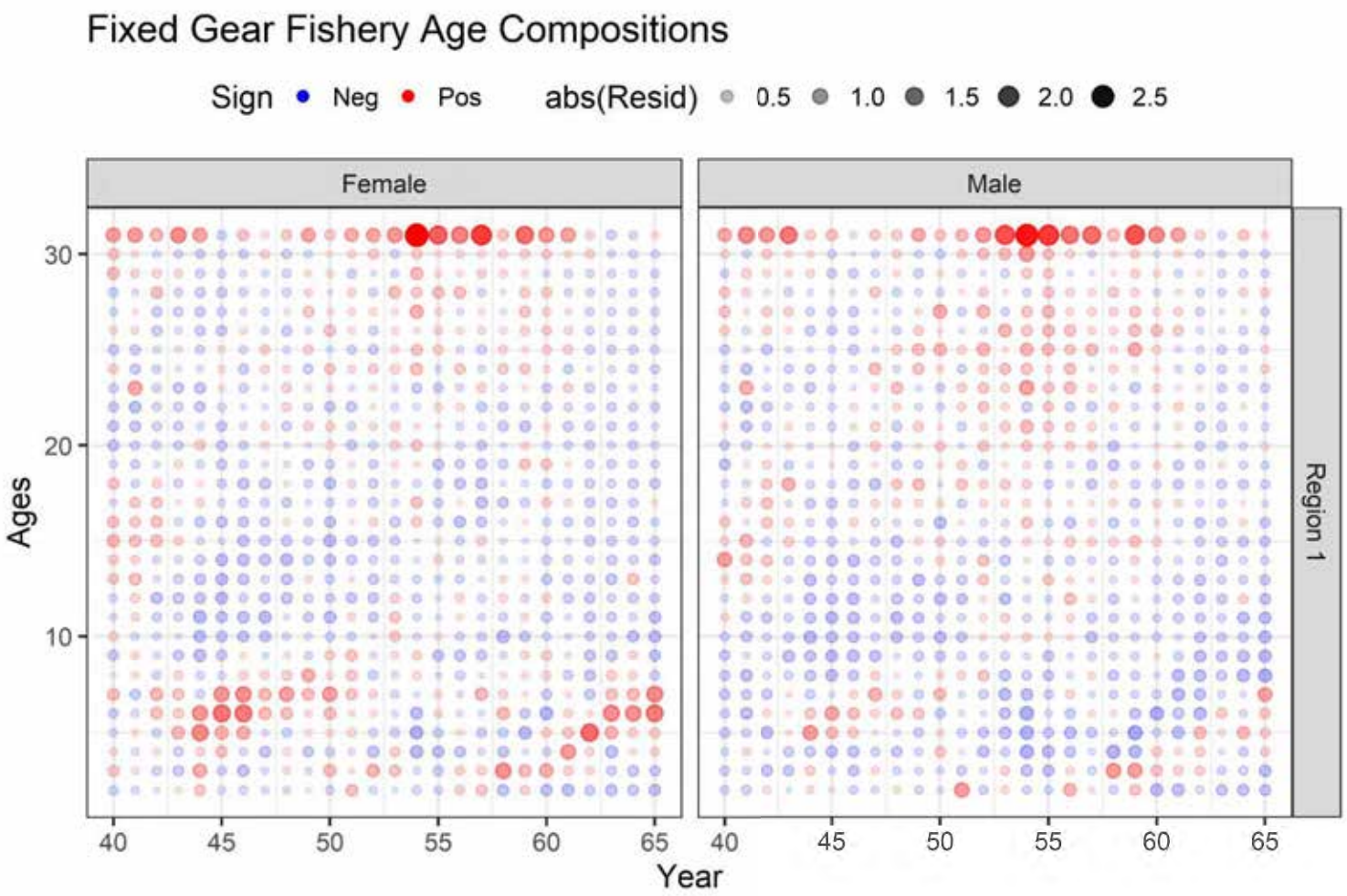

Figure 3.51. Fits to the fixed gear fishery age composition data based on Pearson residuals for Model *26.1_1Reg*.

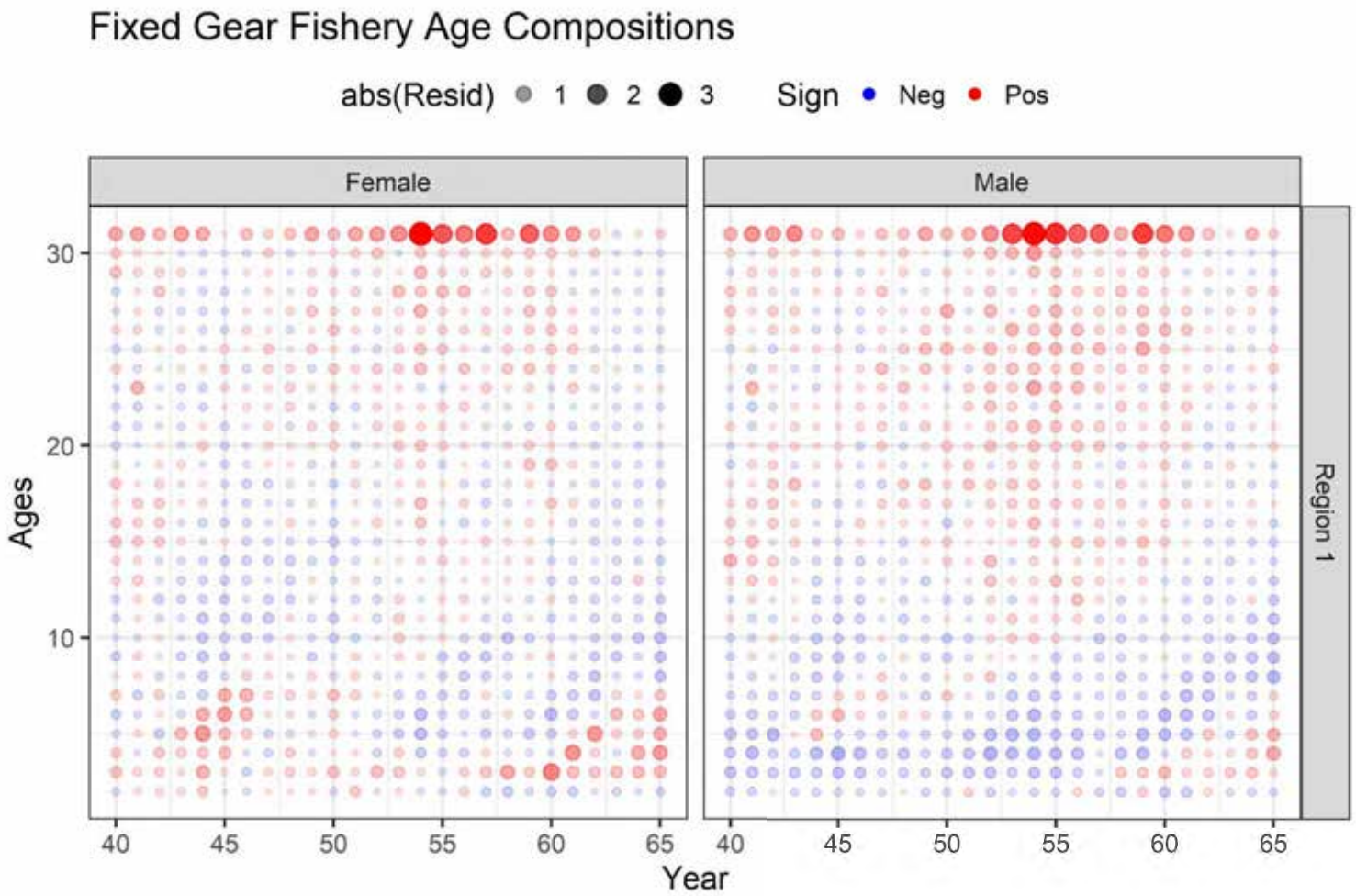

Figure 3.52. Fits to the fixed gear fishery age composition data based on Pearson residuals for Model *26. 2_FAA*.

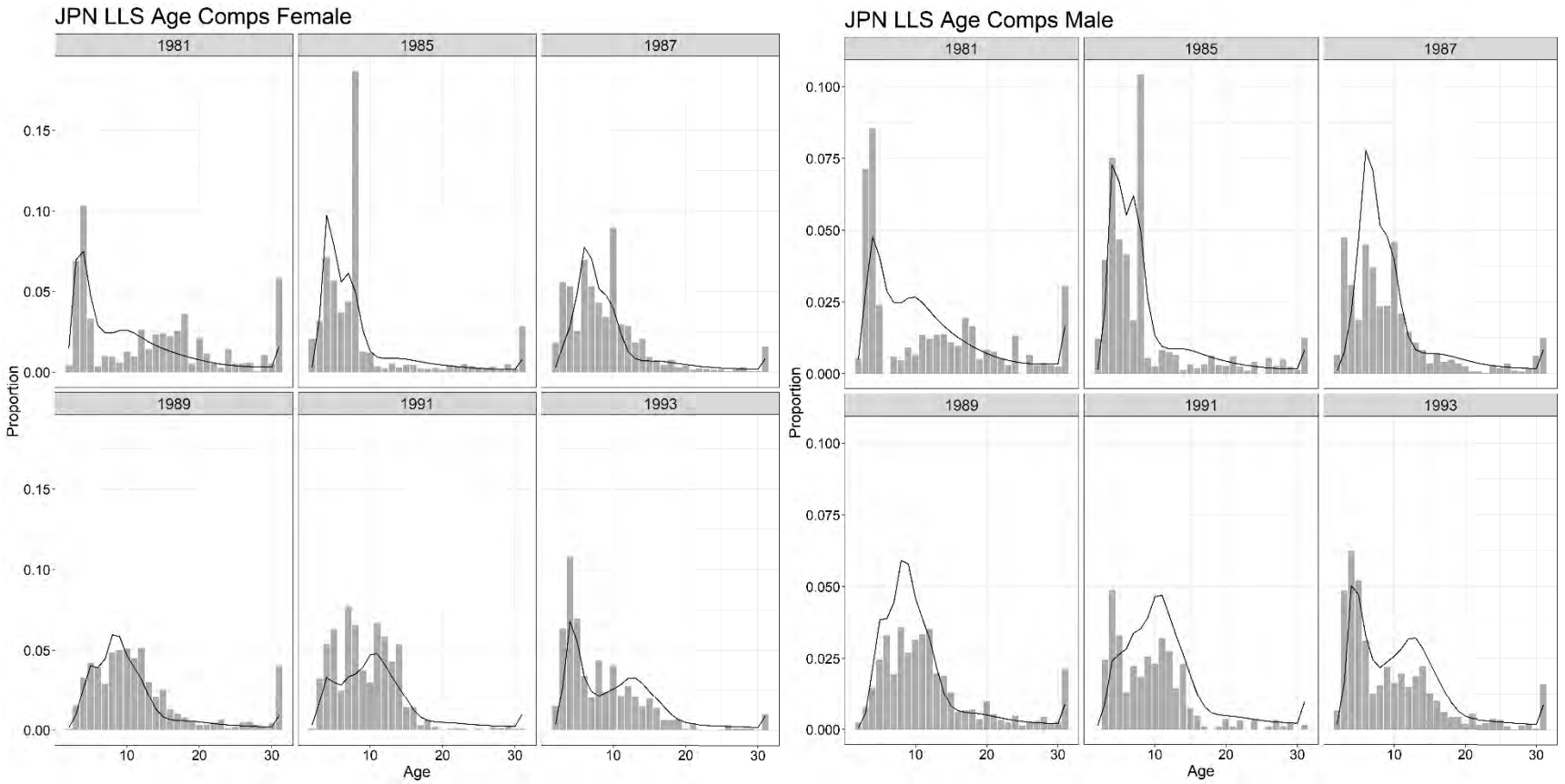

Figure 3.53. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for model *26.1_1Reg*.

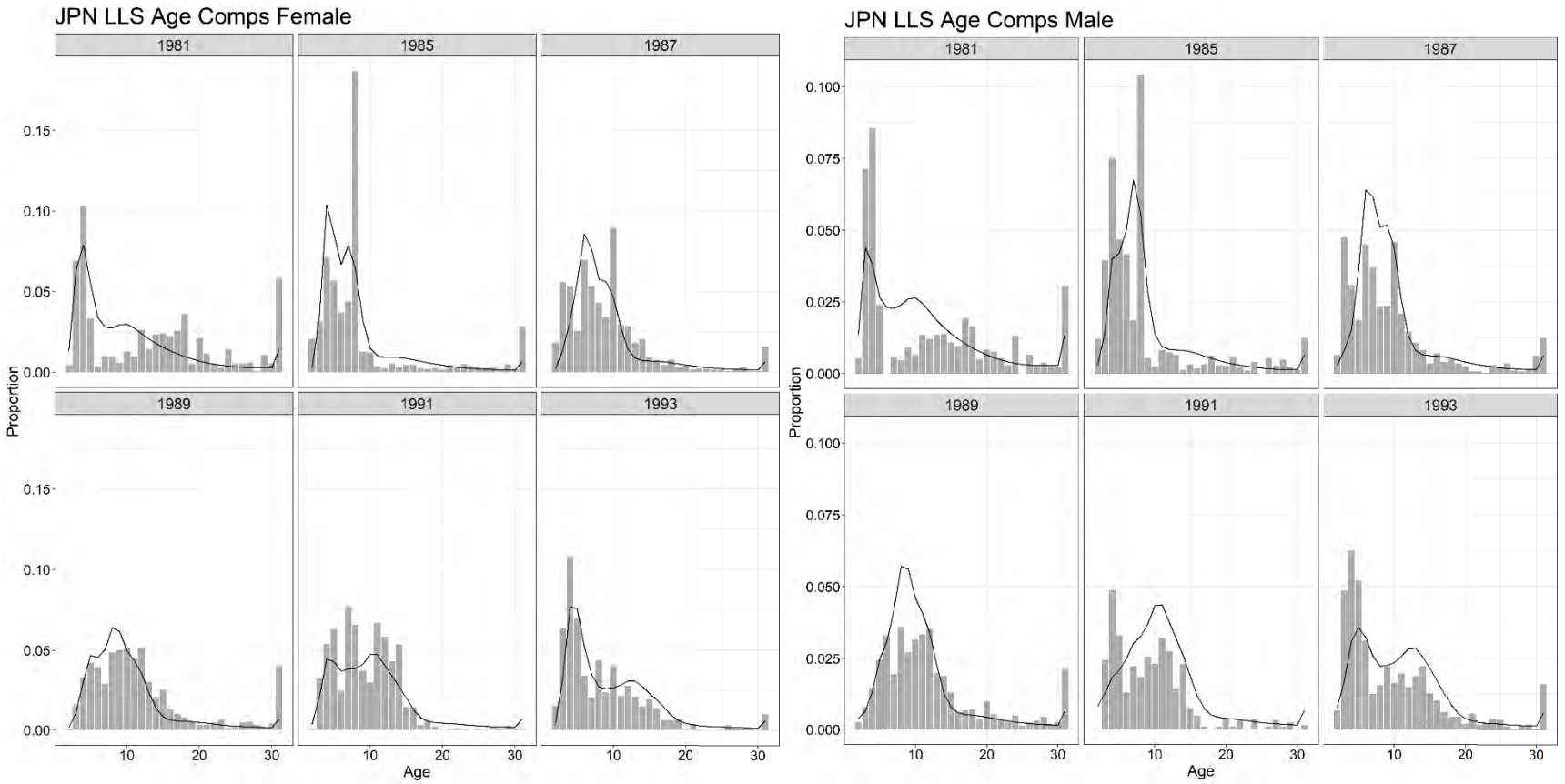

Figure 3.54. Fits to Japanese Longline Survey age composition data by year and sex (females left and males right) for Model *26.2_FAA*.

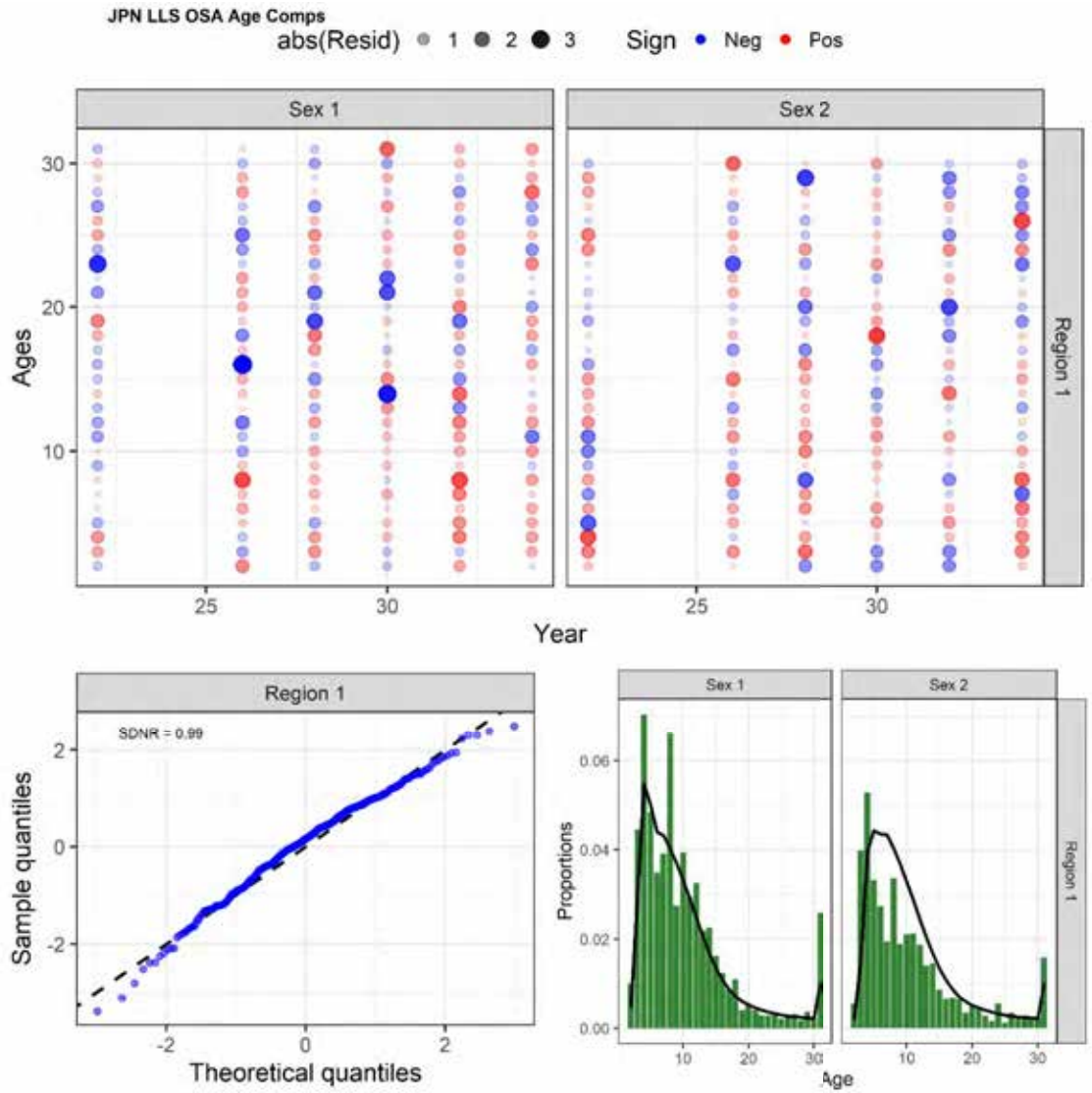

Figure 3.55. Fits to Japanese Longline Survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

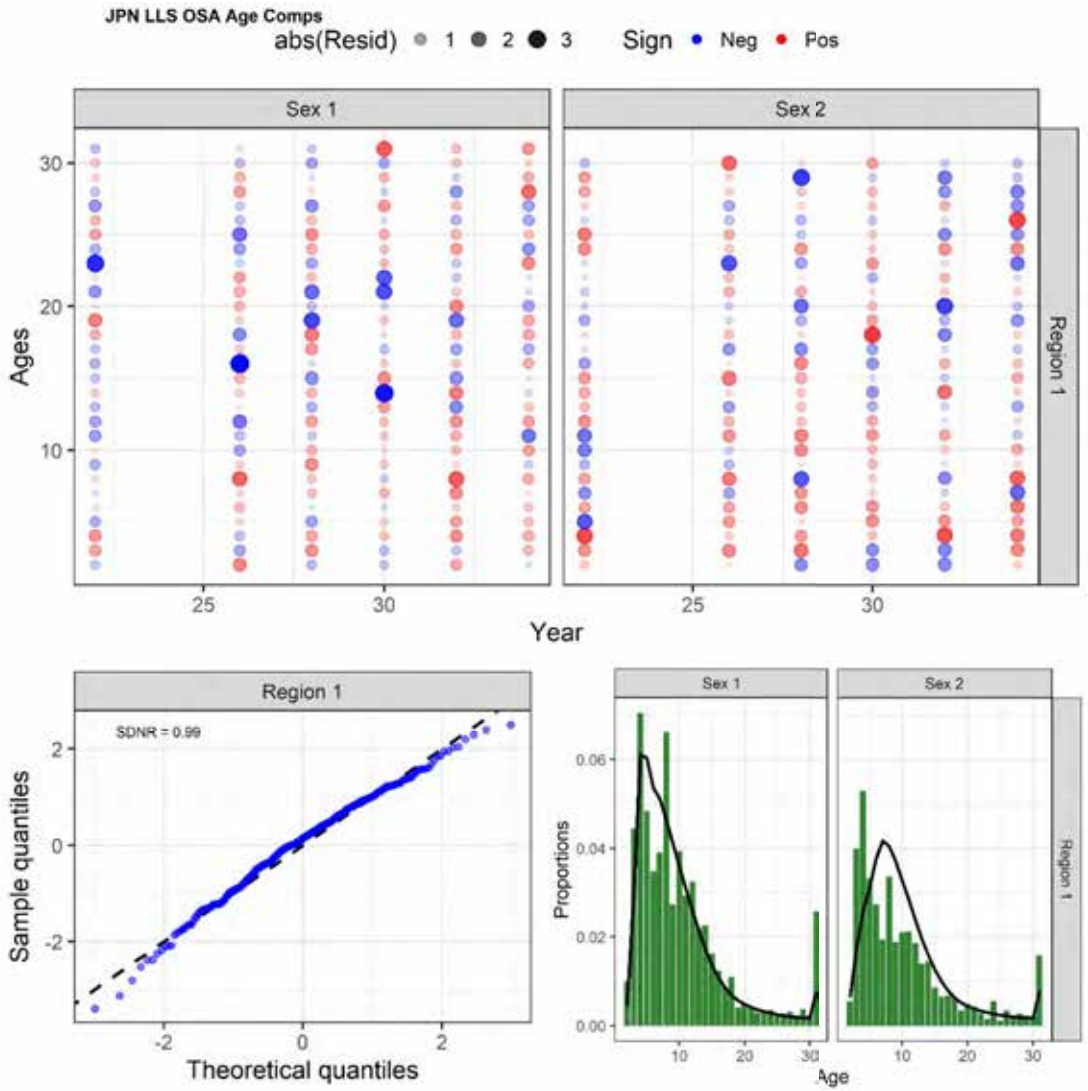

Figure 3.56. Fits to Japanese longline survey age composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

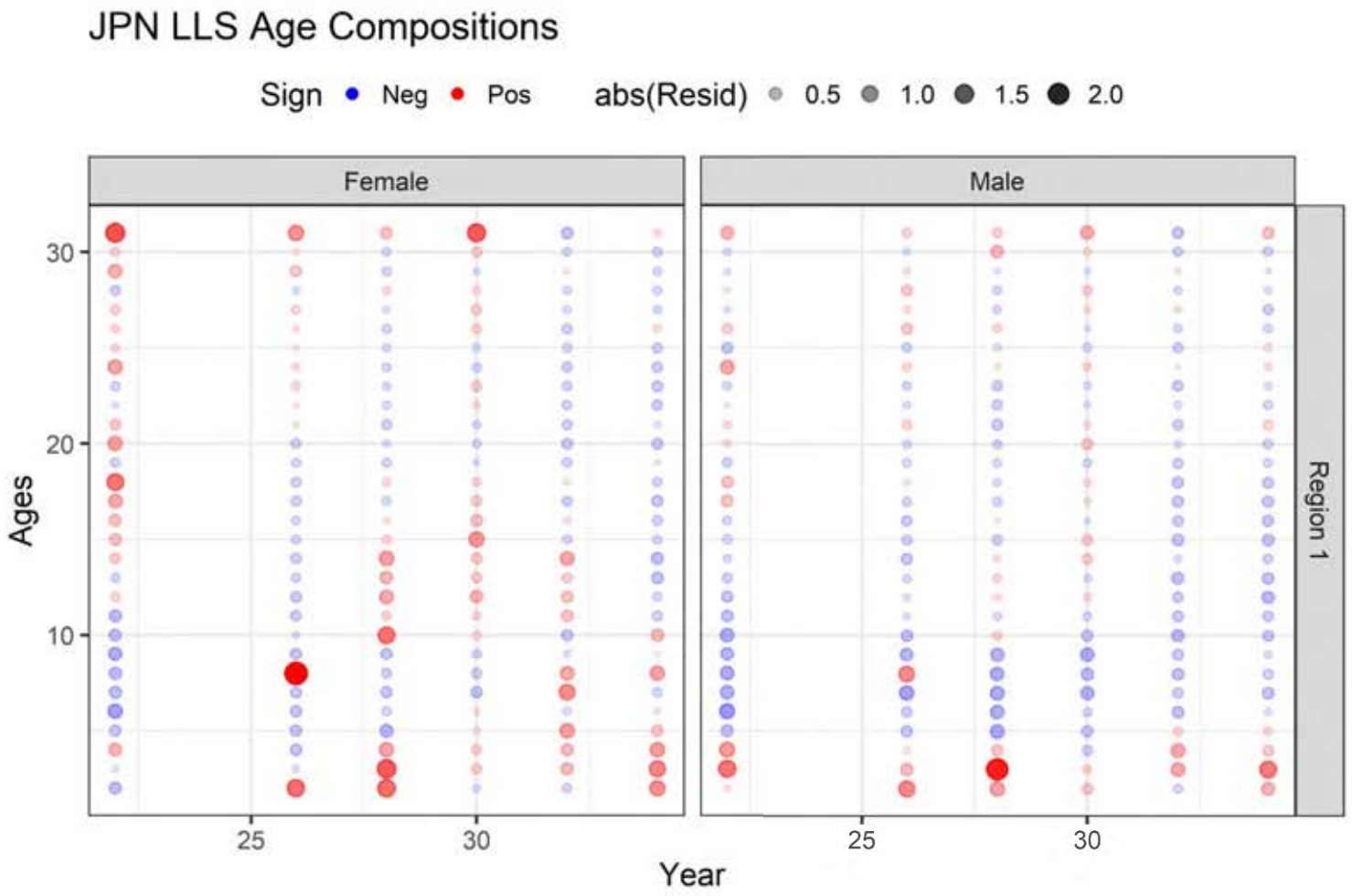

Figure 3.57. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for Model *26.1_1Reg*.

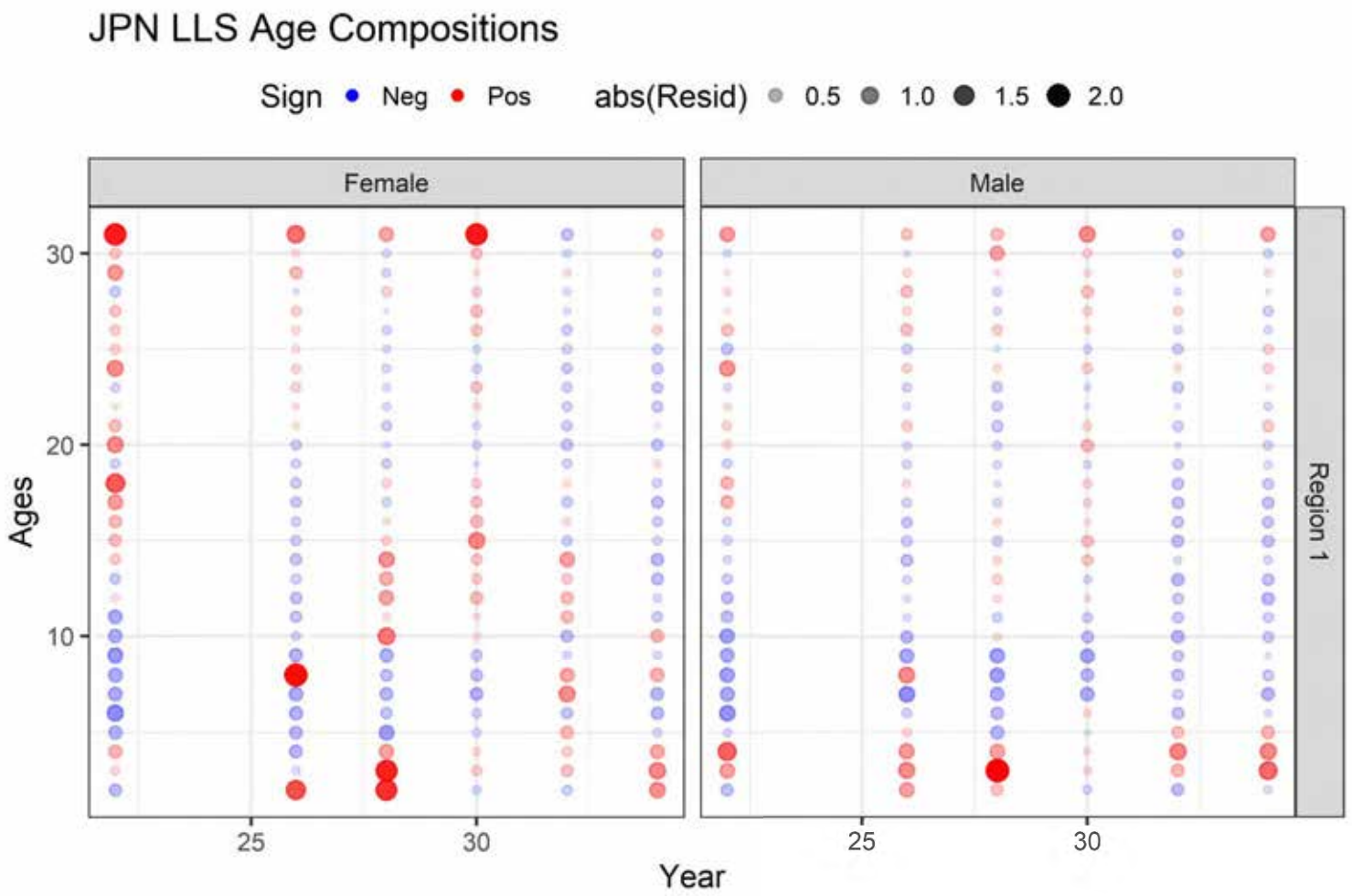

Figure 3.58. Fits to the Japanese Longline Survey age composition data based on Pearson residuals for Model *26.2_FAA*.

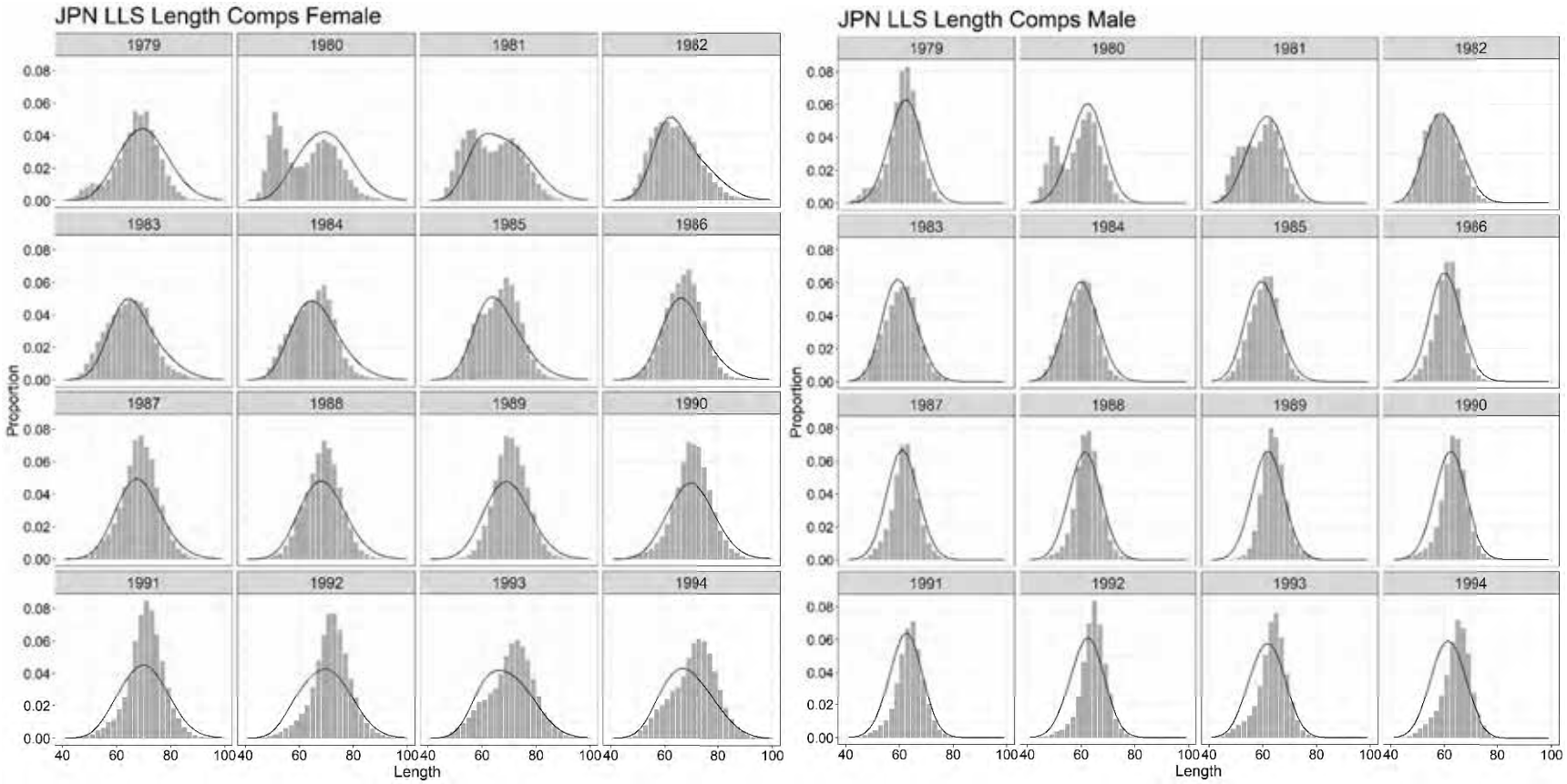

Figure 3.59. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

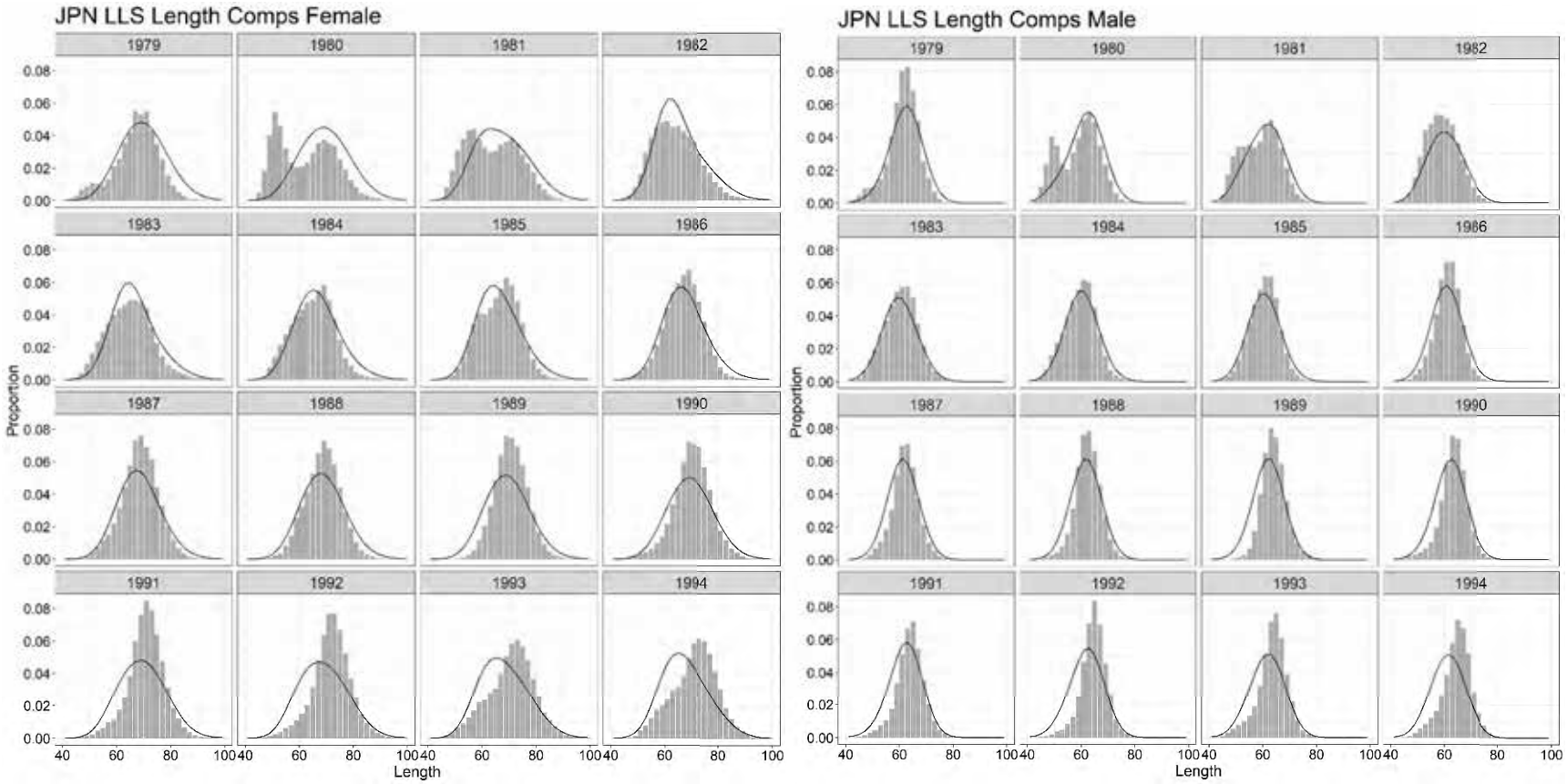

Figure 3.60. Fits to Japanese Longline Survey length composition data by year and sex (females left and males right) for Model *26.2_FAA*.

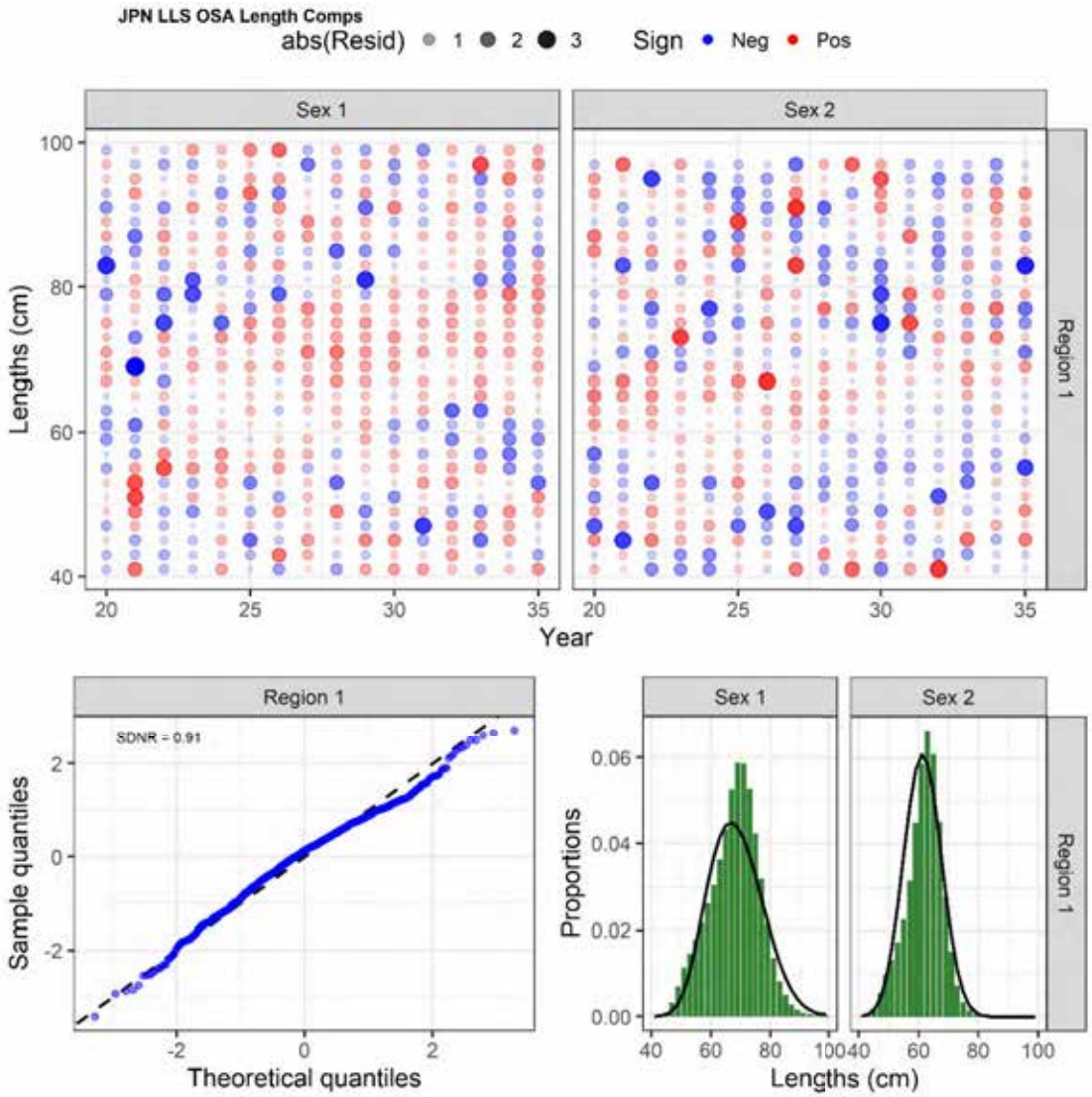

Figure 3.61. Fits to Japanese Longline Survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

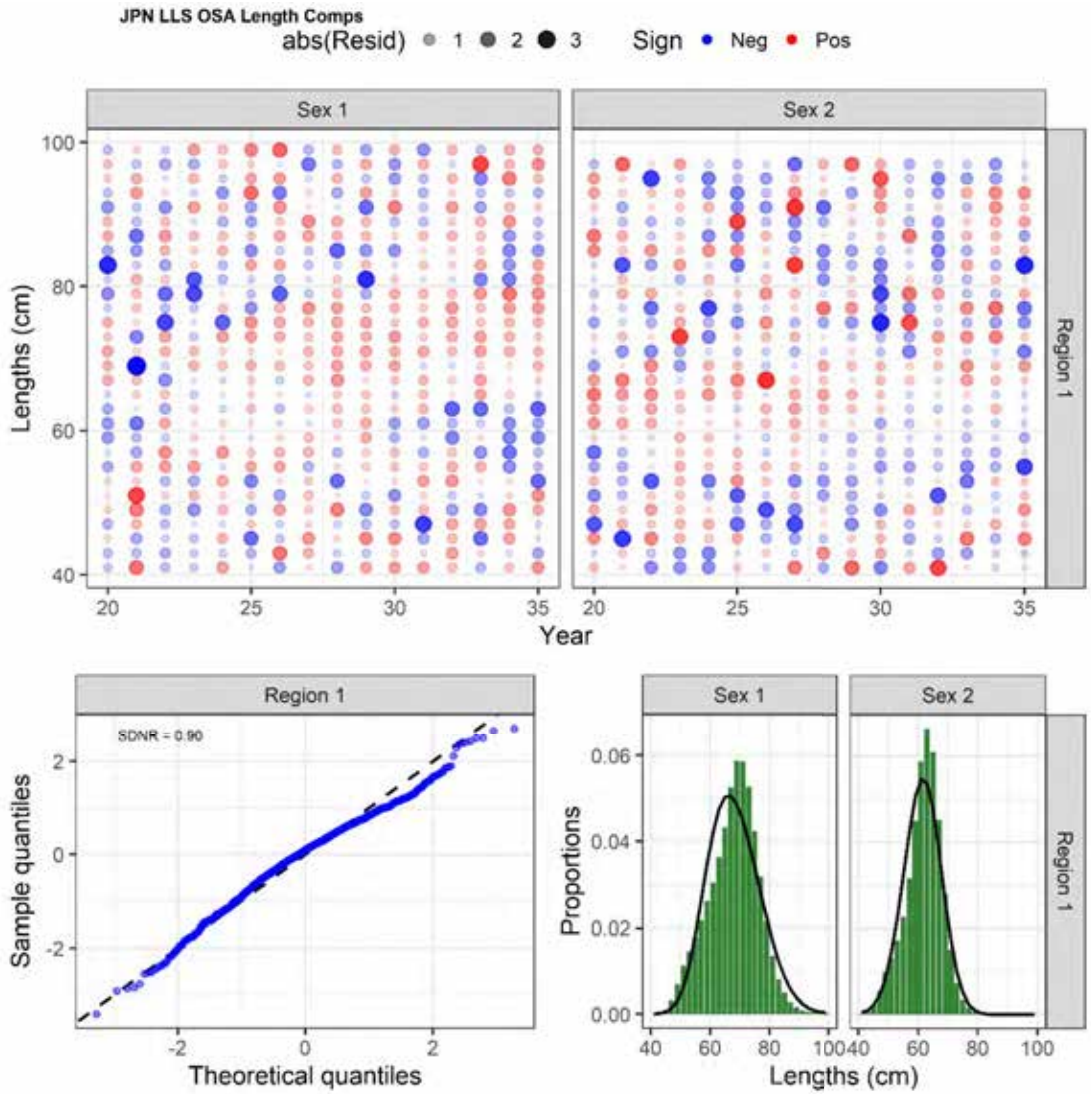

Figure 3.62. Fits to Japanese Longline Survey length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

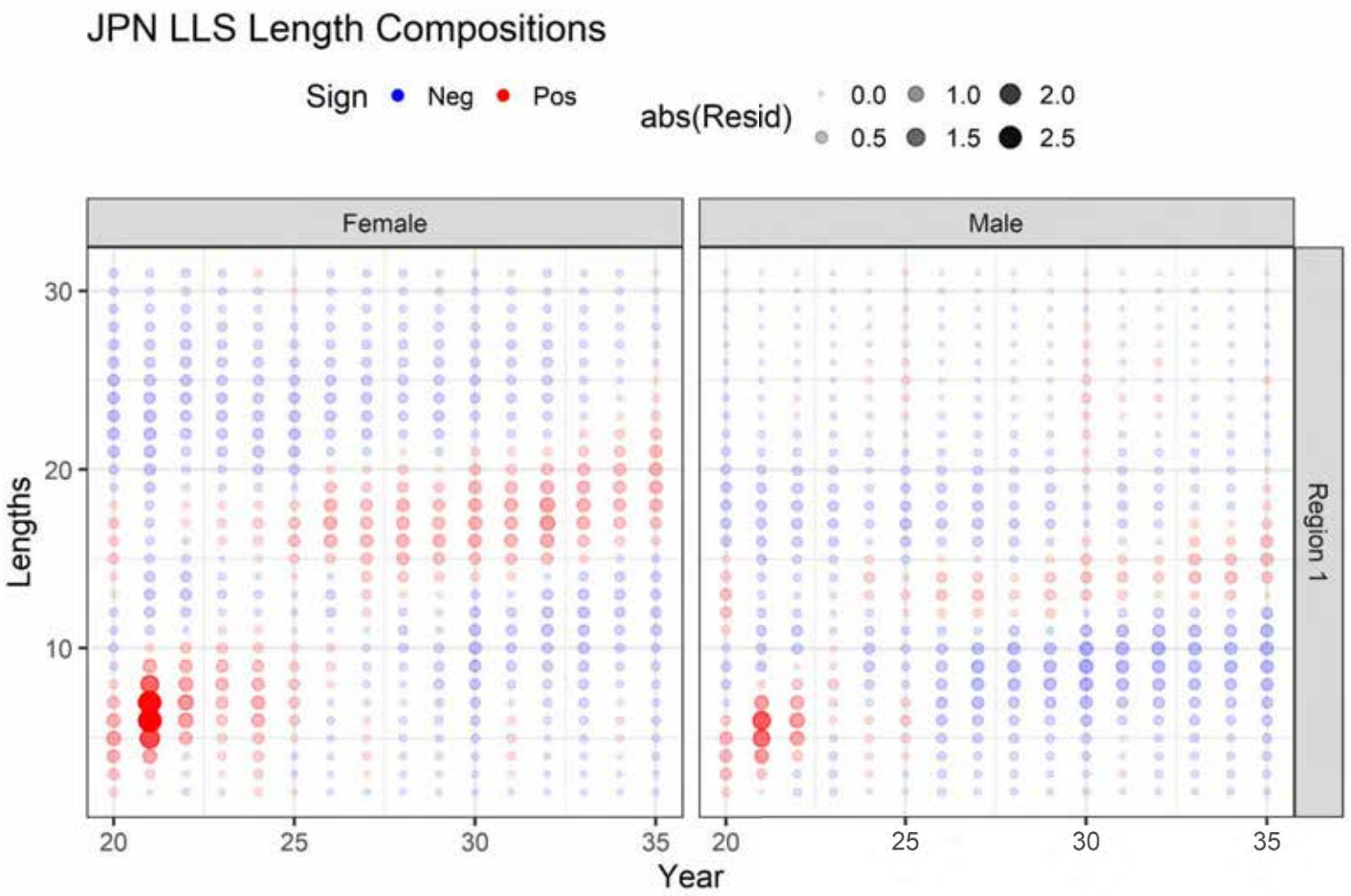

Figure 3.63. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.1_1Reg*.

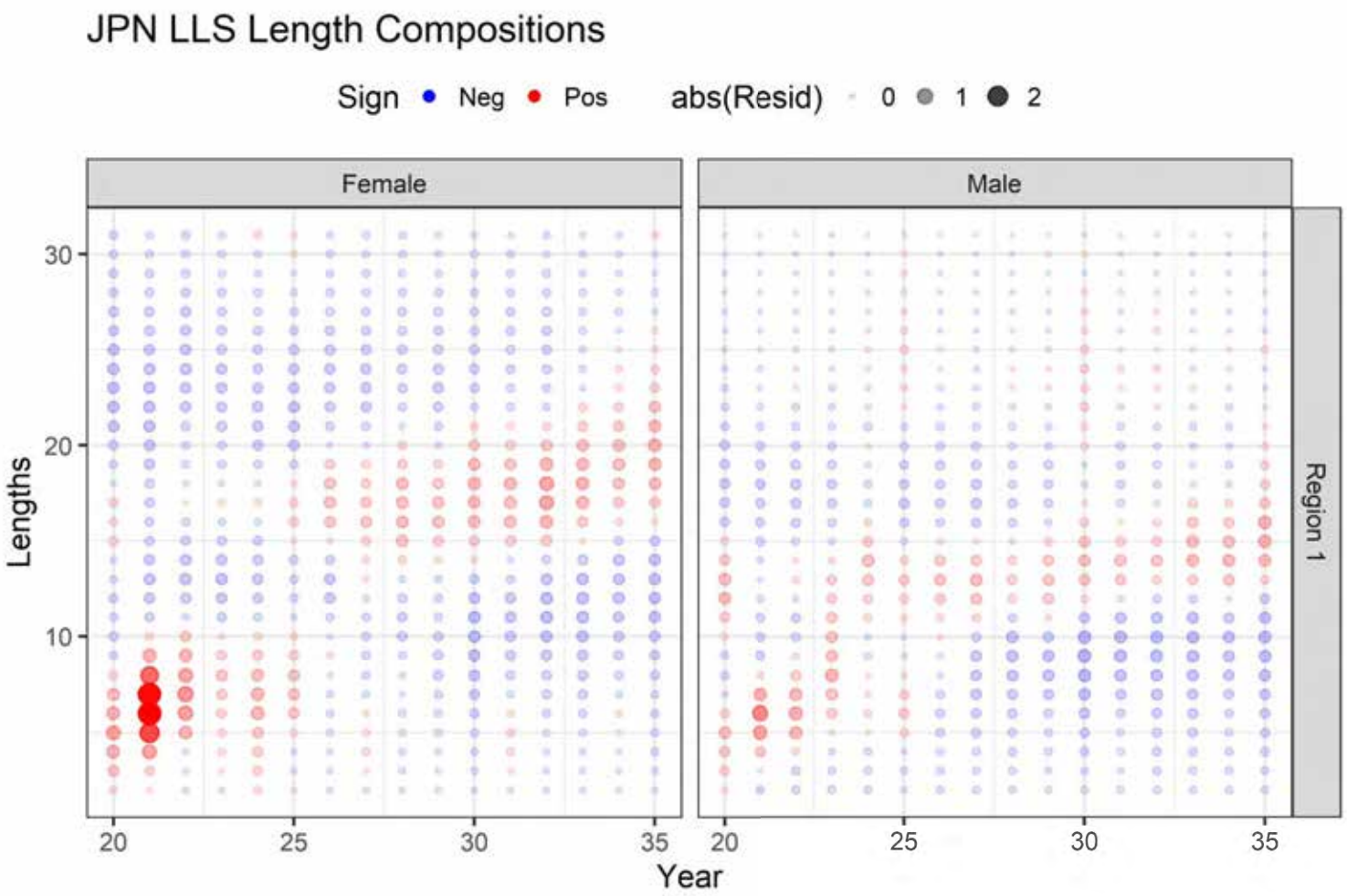

Figure 3.64. Fits to the Japanese Longline Survey length composition data based on Pearson residuals for Model *26.2_FAA*.

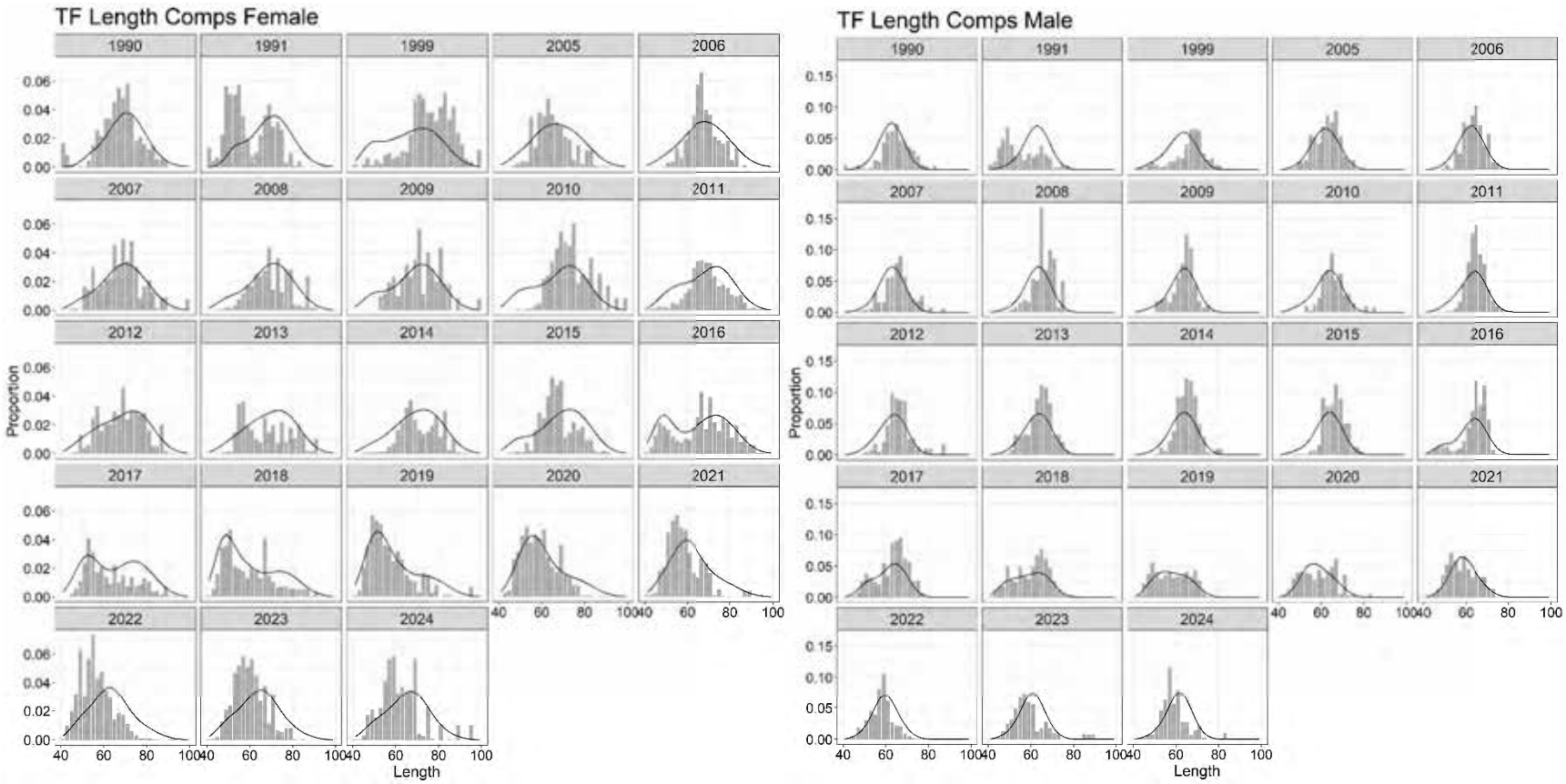

Figure 3.65. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.1_1Reg*.

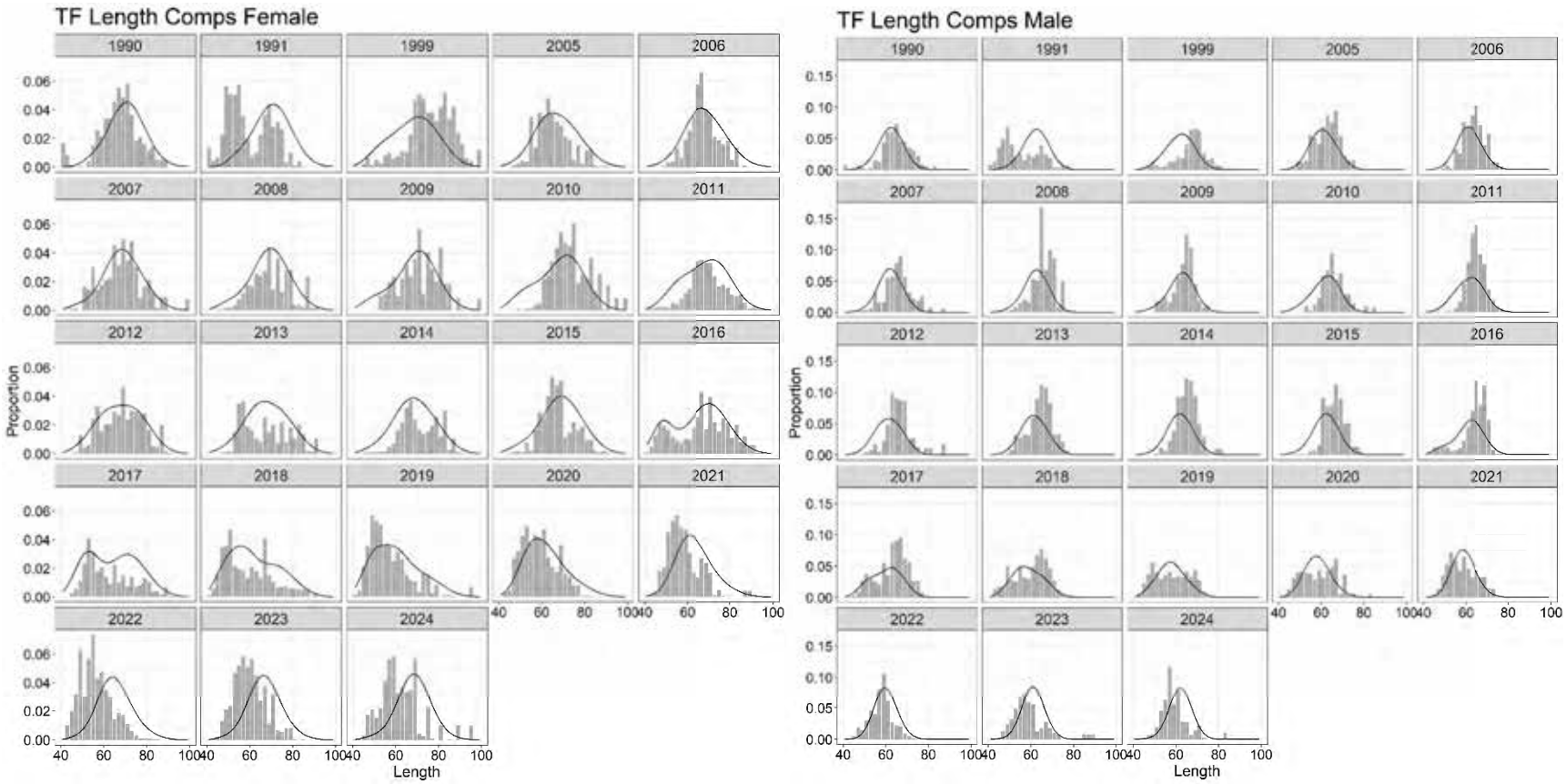

Figure 3.66. Fits to the trawl fishery length composition data by year and sex (females left and males right) for Model *26.2_FAA*.

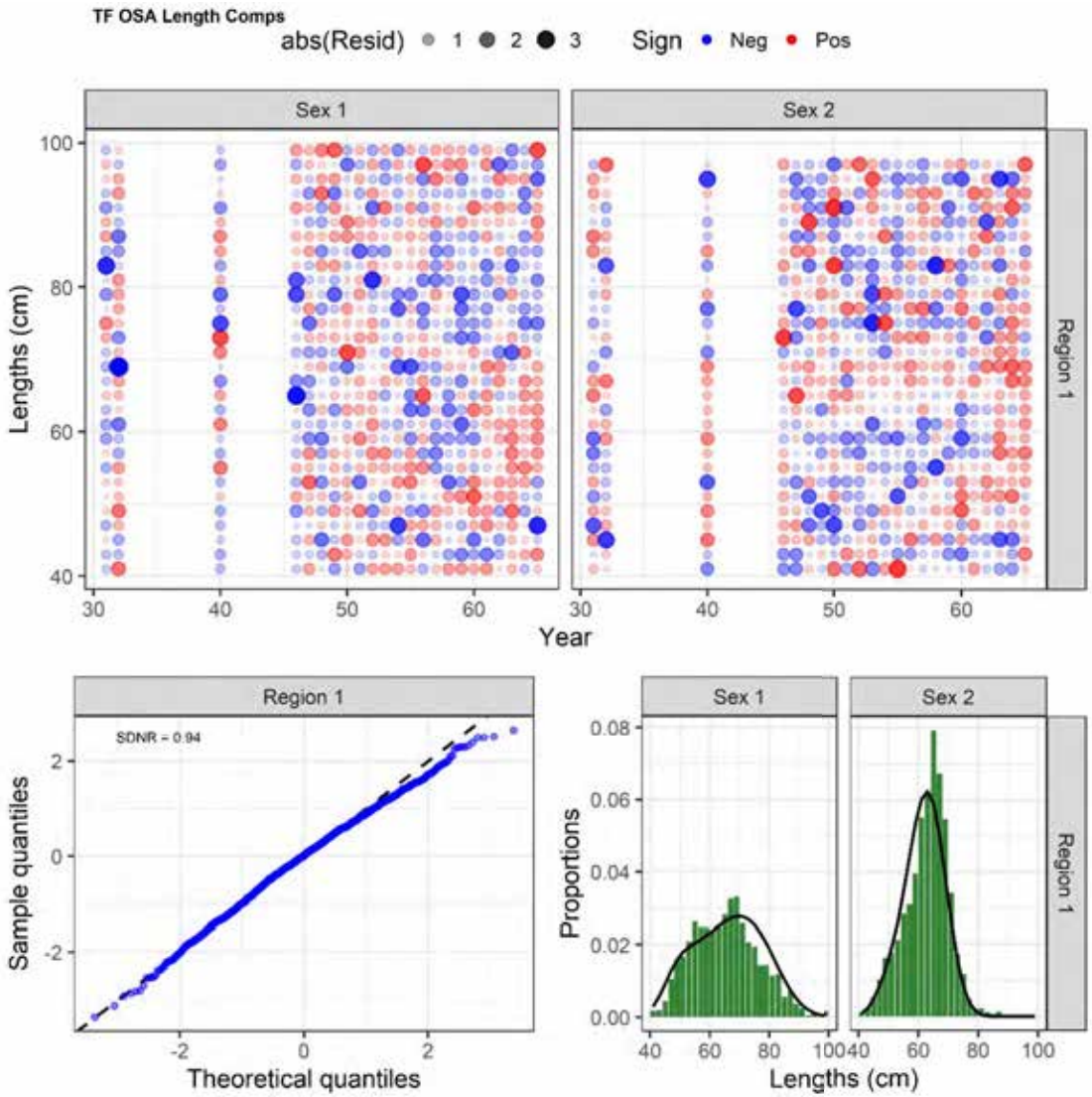

Figure 3.67. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.1_1Reg*.

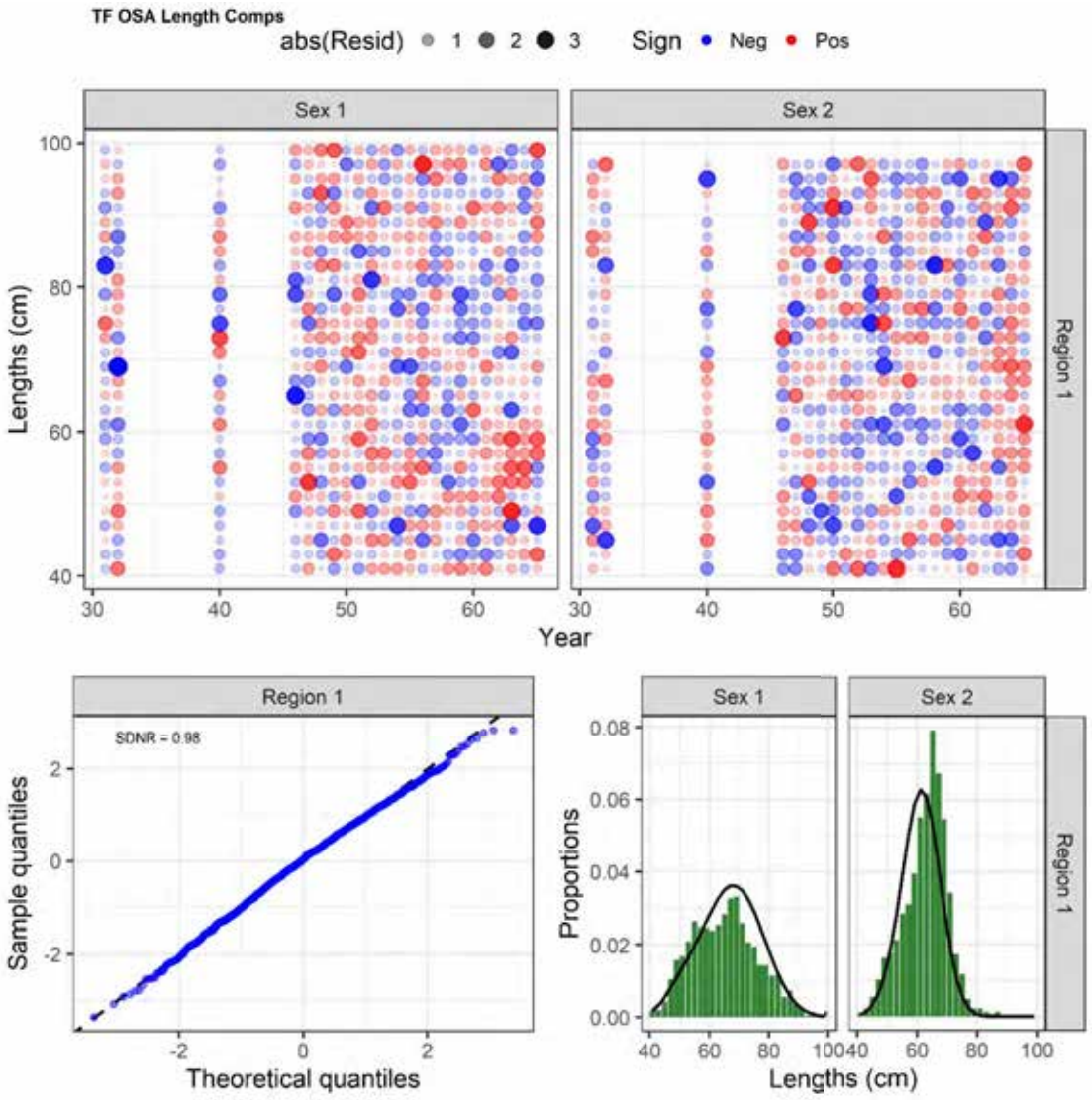

Figure 3.68. Fits to trawl fishery length composition data, including one step ahead (OSA) residuals (top panel), quantile residuals (bottom left panel), and aggregate (mean across all years) fit to the age compositions (bottom right panel; green bars are observed proportions and black lines are expected model estimated proportions), for Model *26.2_FAA*.

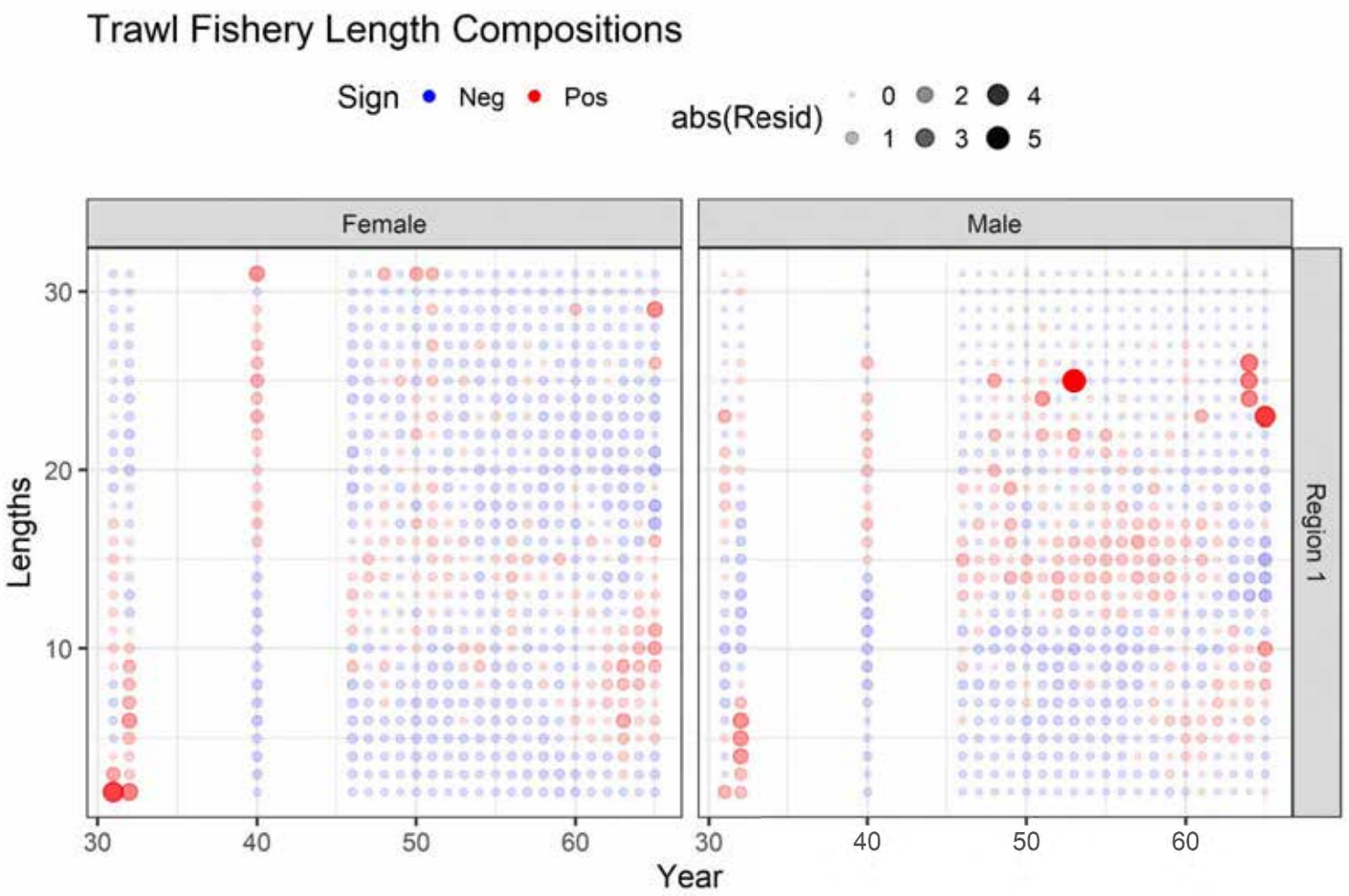

Figure 3.69. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.1_1Reg*.

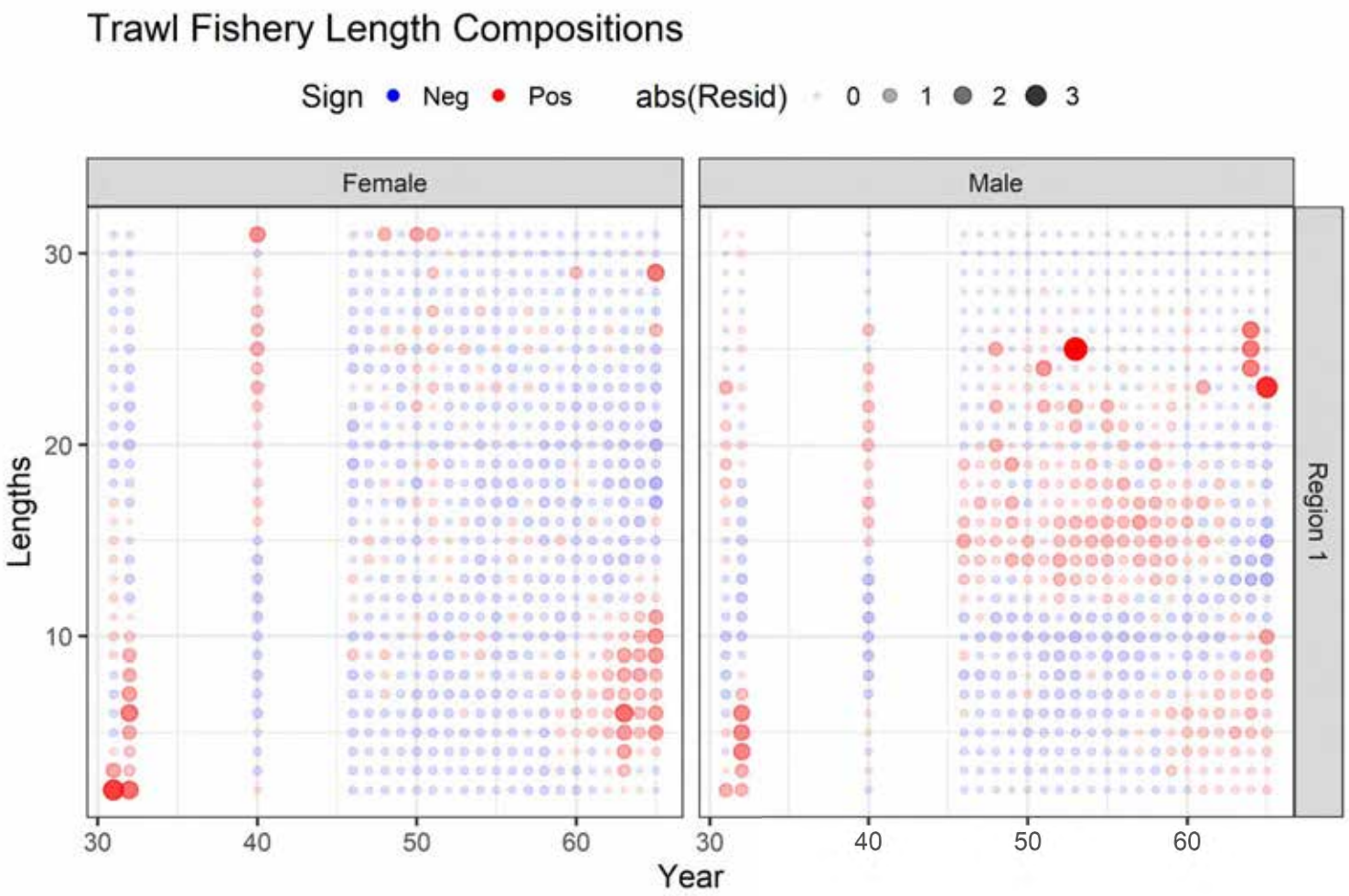

Figure 3.70. Fits to the trawl fishery length composition data based on Pearson residuals for Model *26.2_FAA*.

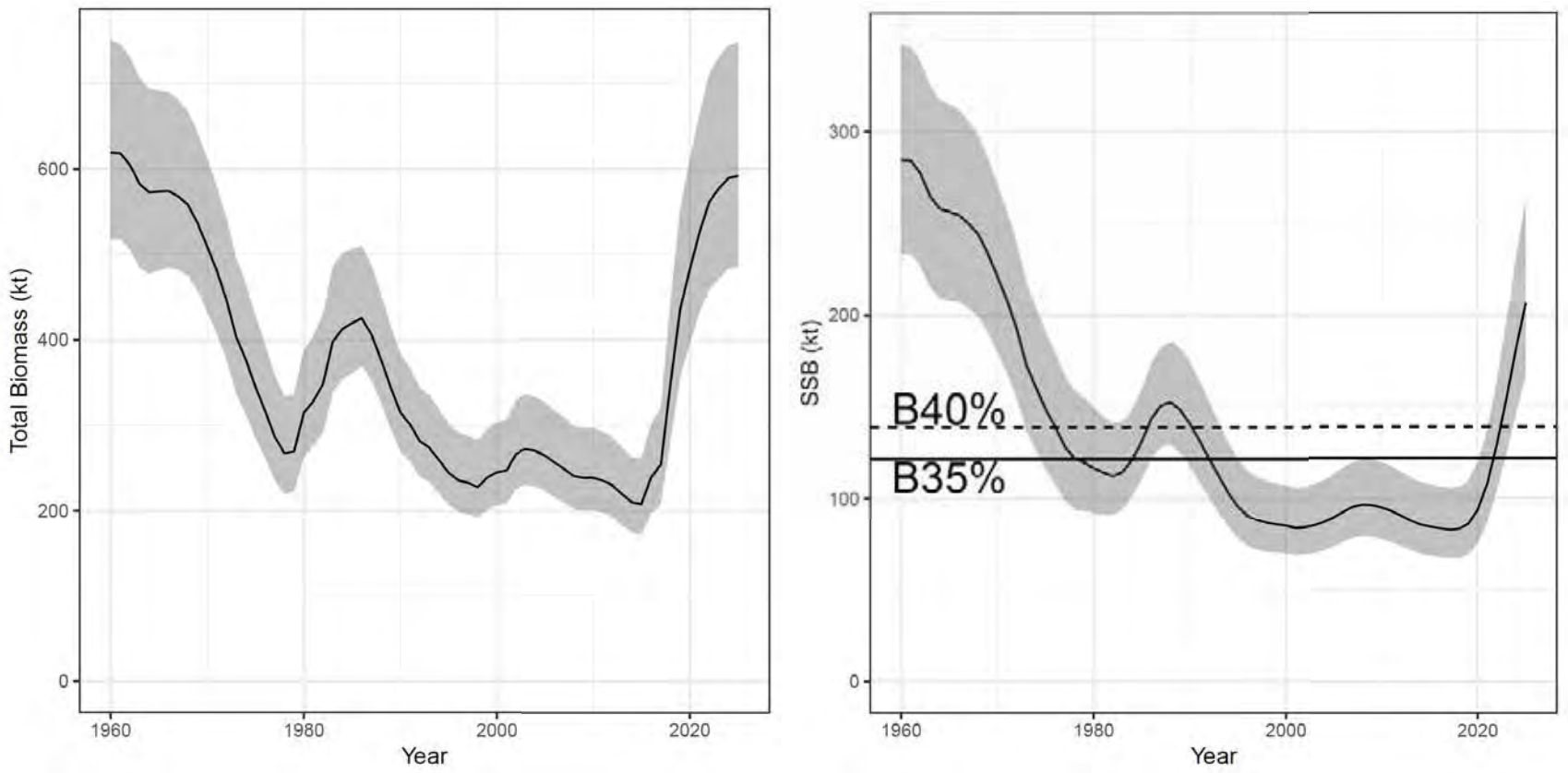

Figure 3.71. Estimated sablefish MCMC median (black line) total biomass (left panel) and spawning biomass (right panel) with 95% MCMC credible intervals (grey fill) for Model *26.1_1Reg*. Values are in kilotons. The $B_{35\%}$ (black solid line) and $B_{40\%}$ (black dashed line) reference points are shown on the SSB panel.

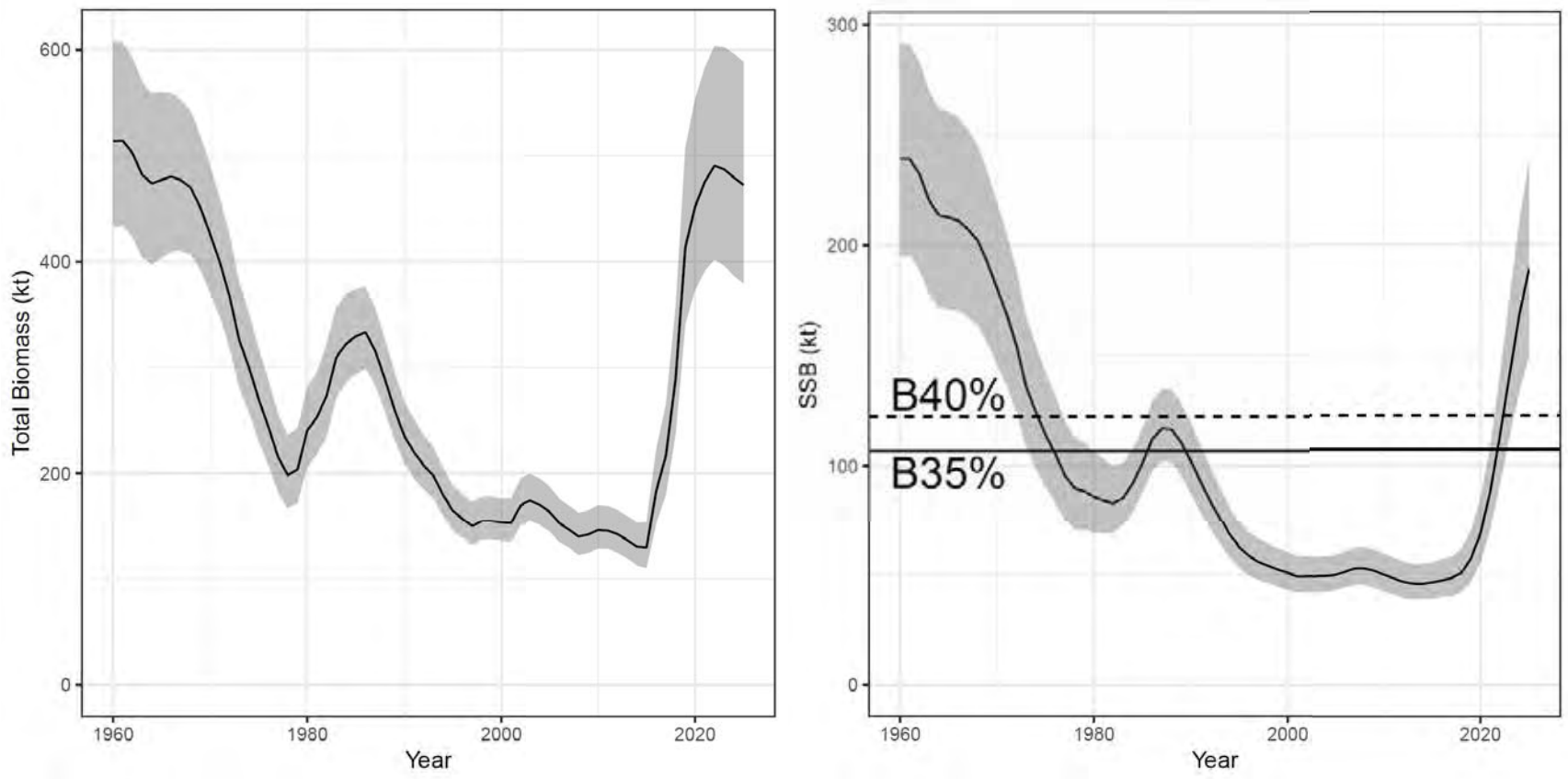

Figure 3.72. Estimated sablefish MCMC median (black line) total biomass (left panel) and spawning biomass (right panel) with 95% MCMC credible intervals (grey fill) for Model *26.2_FAA*. Values are in kilotons. The $B_{35\%}$ (black solid line) and $B_{40\%}$ (black dashed line) reference points are shown on the SSB panel.

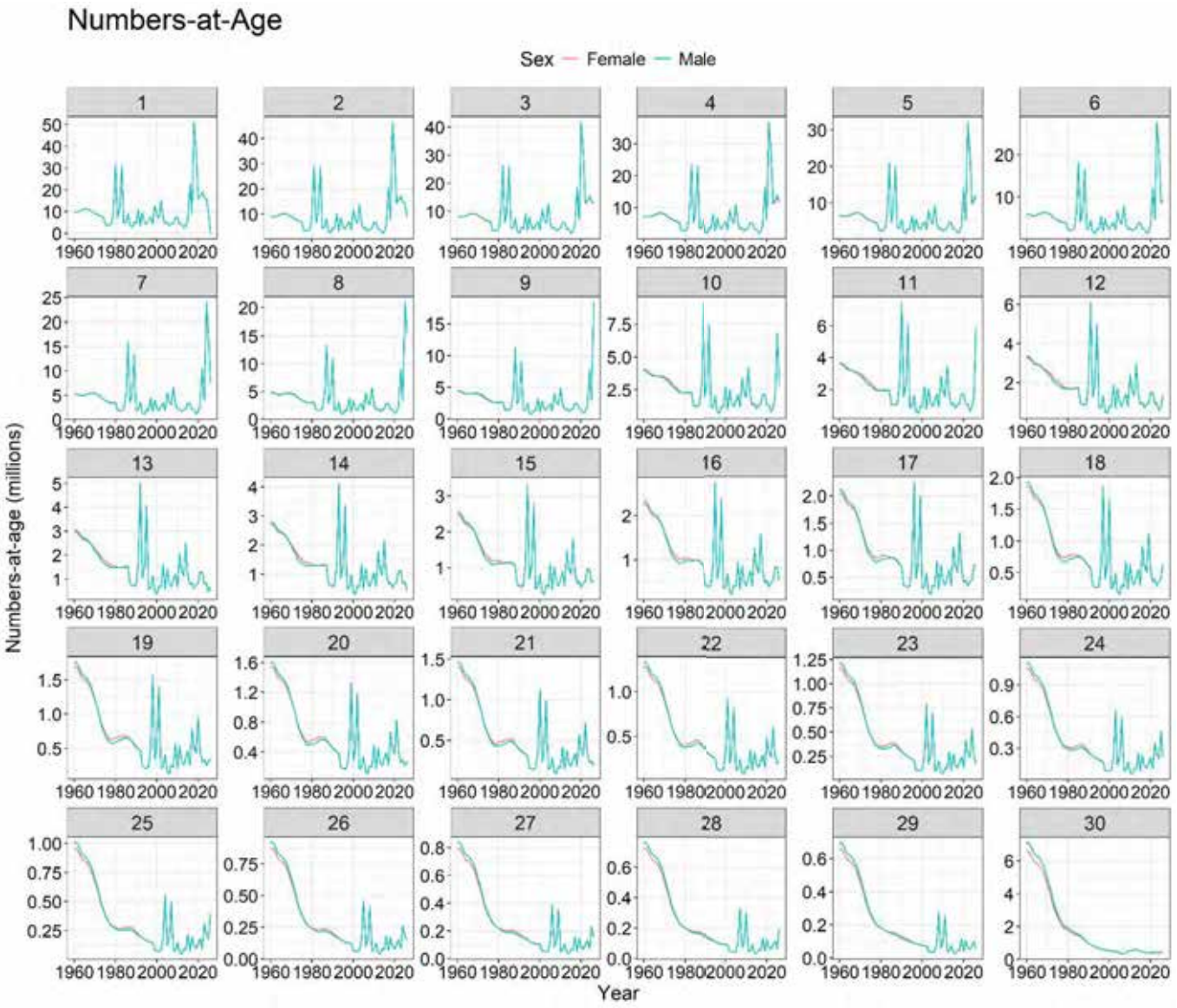

Figure 3.73. Model *26.1_1Reg* estimated population numbers (millions of fish) by sex (line color), age (facet), and year (x-axis).

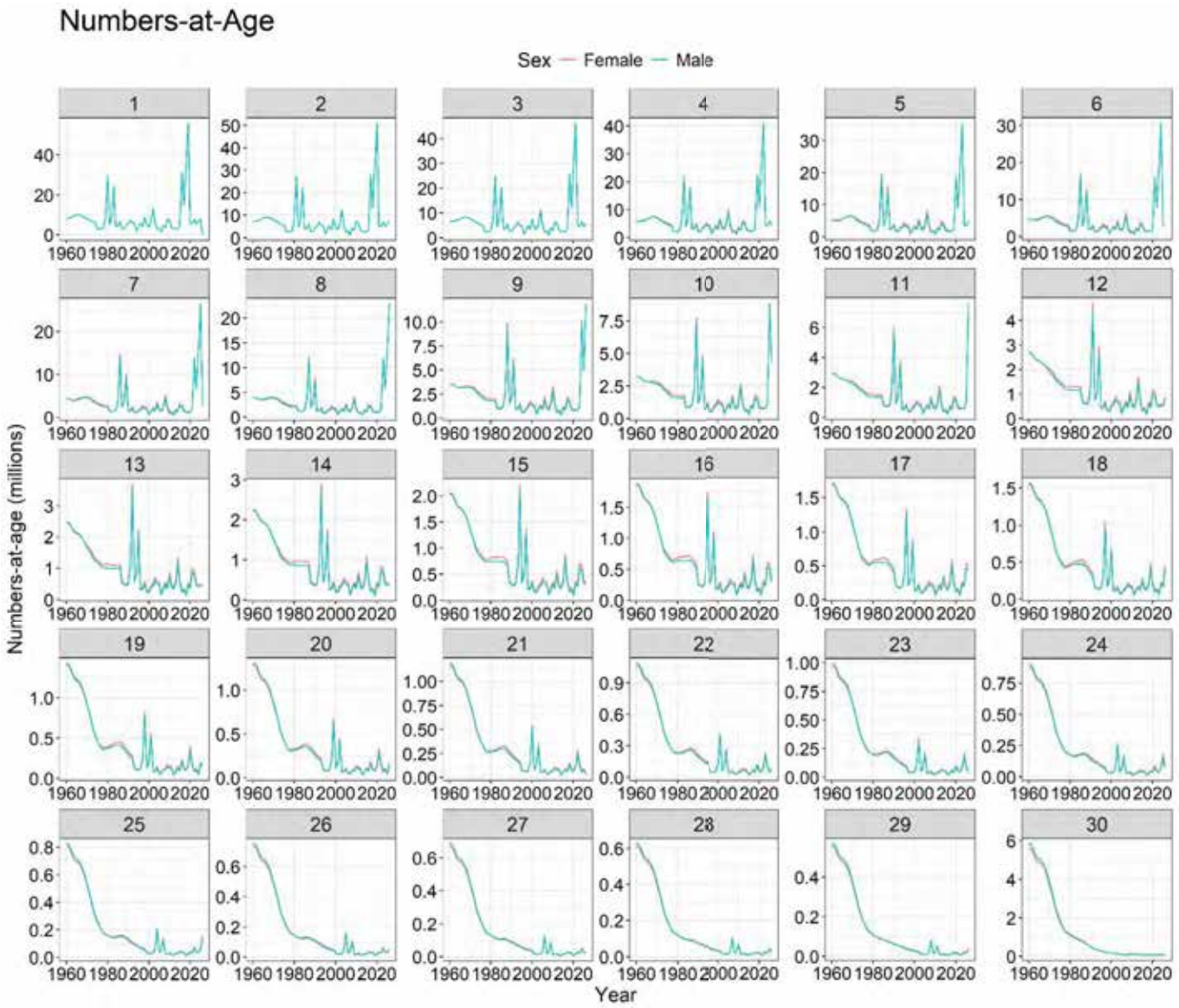

Figure 3.74. Model *26.2_FAA* estimated population numbers (millions of fish) by sex (line color), age (facet), and year (x-axis).

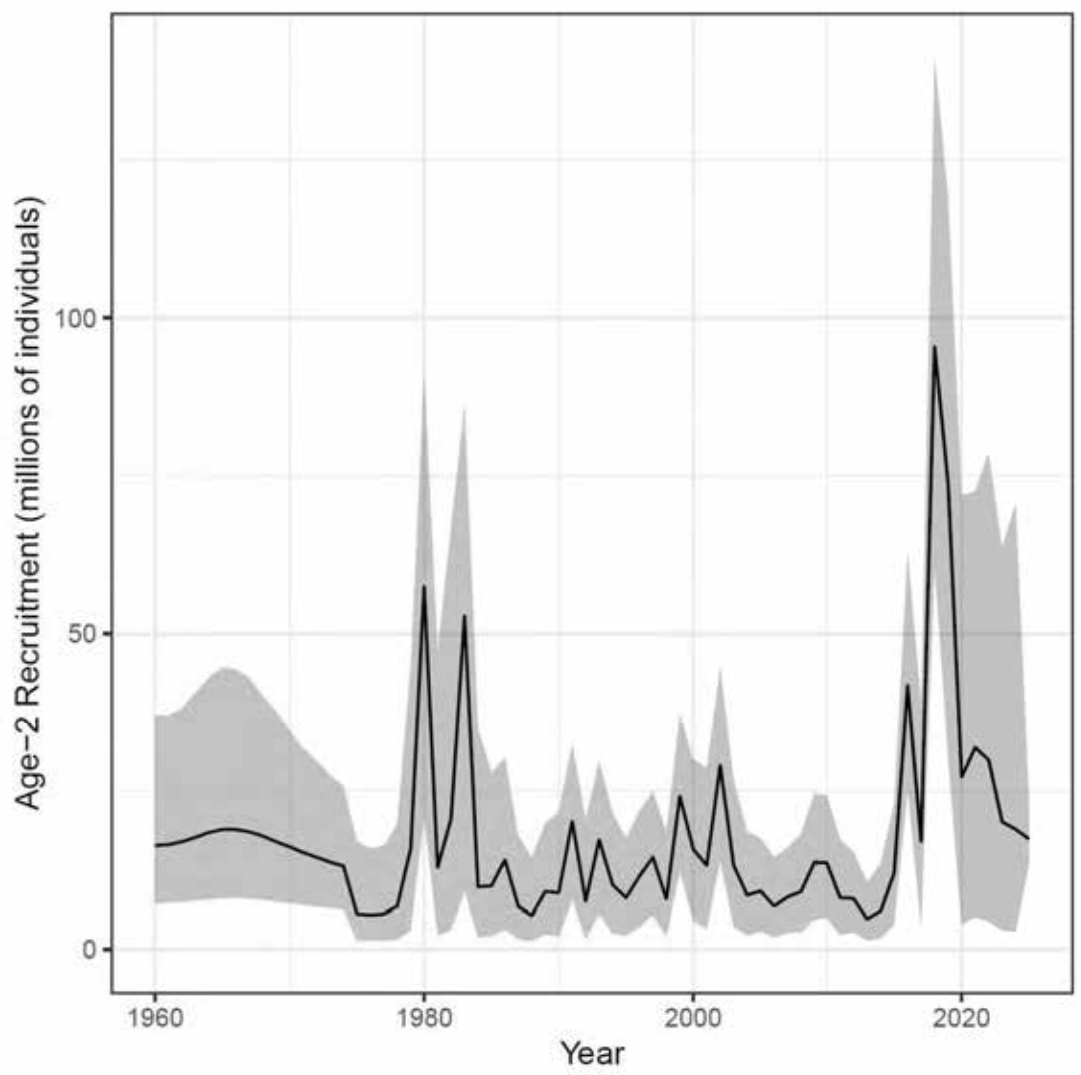

Figure 3.75. Estimated MCMC median (black line) recruitment of age-2 sablefish (millions of fish) with MCMC 95% credible intervals (grey fill) by recruitment year for Model *26.1_1Reg*. The estimate for the 2025 recruitment is fixed at the mean recruitment with no deviation parameter estimated.

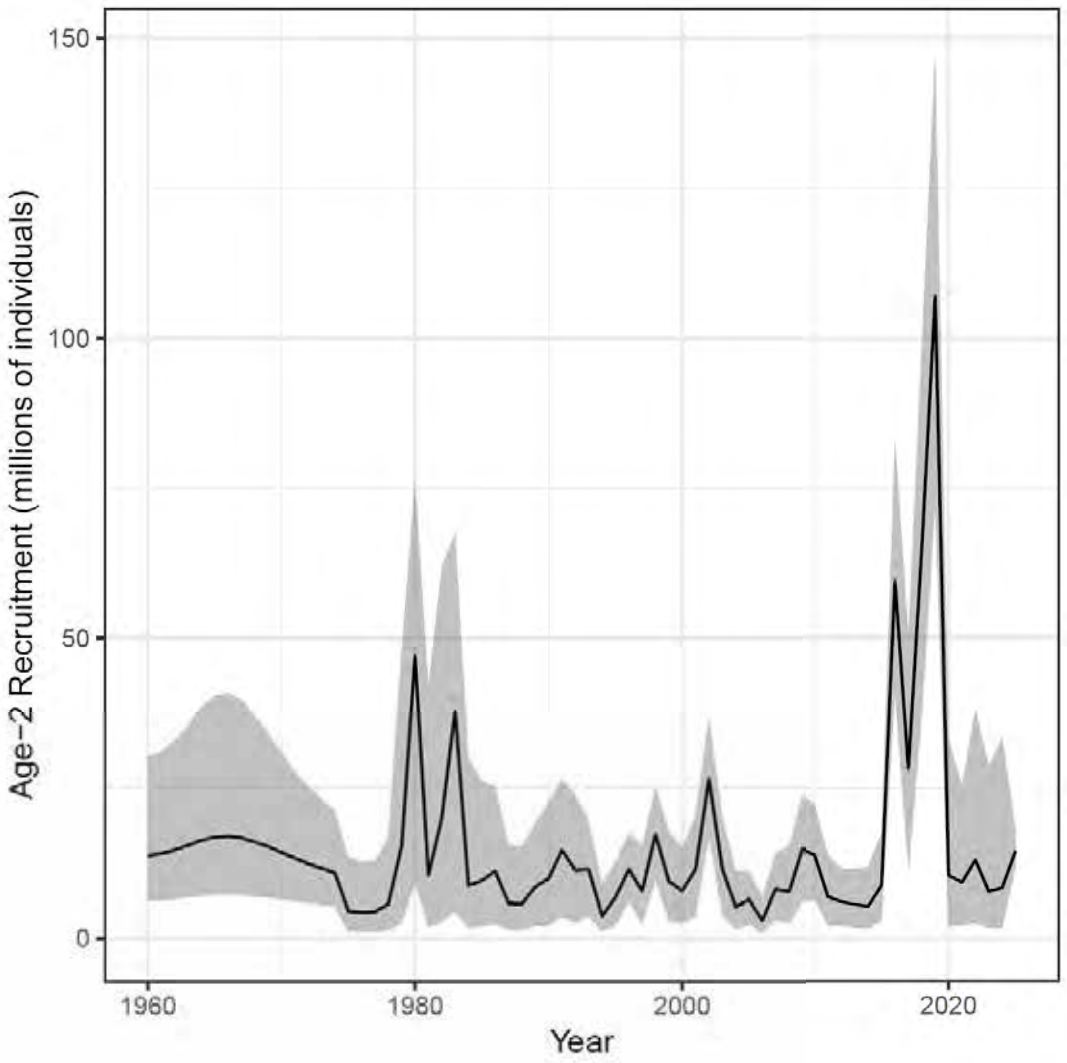

Figure 3.76. Estimated MCMC median (black line) recruitment of age-2 sablefish (millions of fish) with MCMC 95% credible intervals (grey fill) by recruitment year for Model *26.2_FAA*. The estimate for the 2025 recruitment is fixed at the mean recruitment with no deviation parameter estimated.

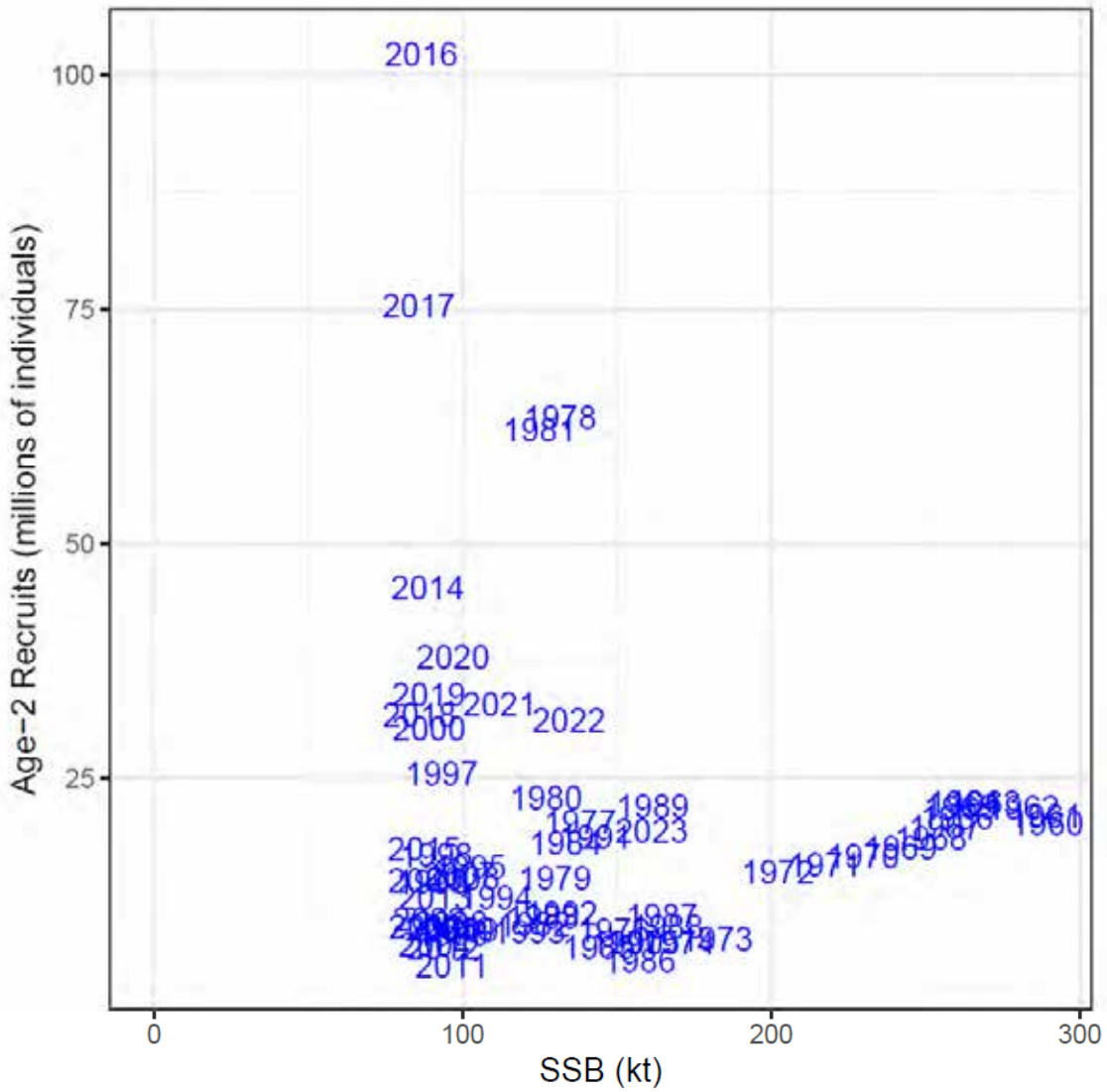

Figure 3.77. Age-2 recruits (millions of fish) and corresponding spawning stock biomass (kilotons) for each year class (identified by plotted year text) for Model *26.1_1Reg*.

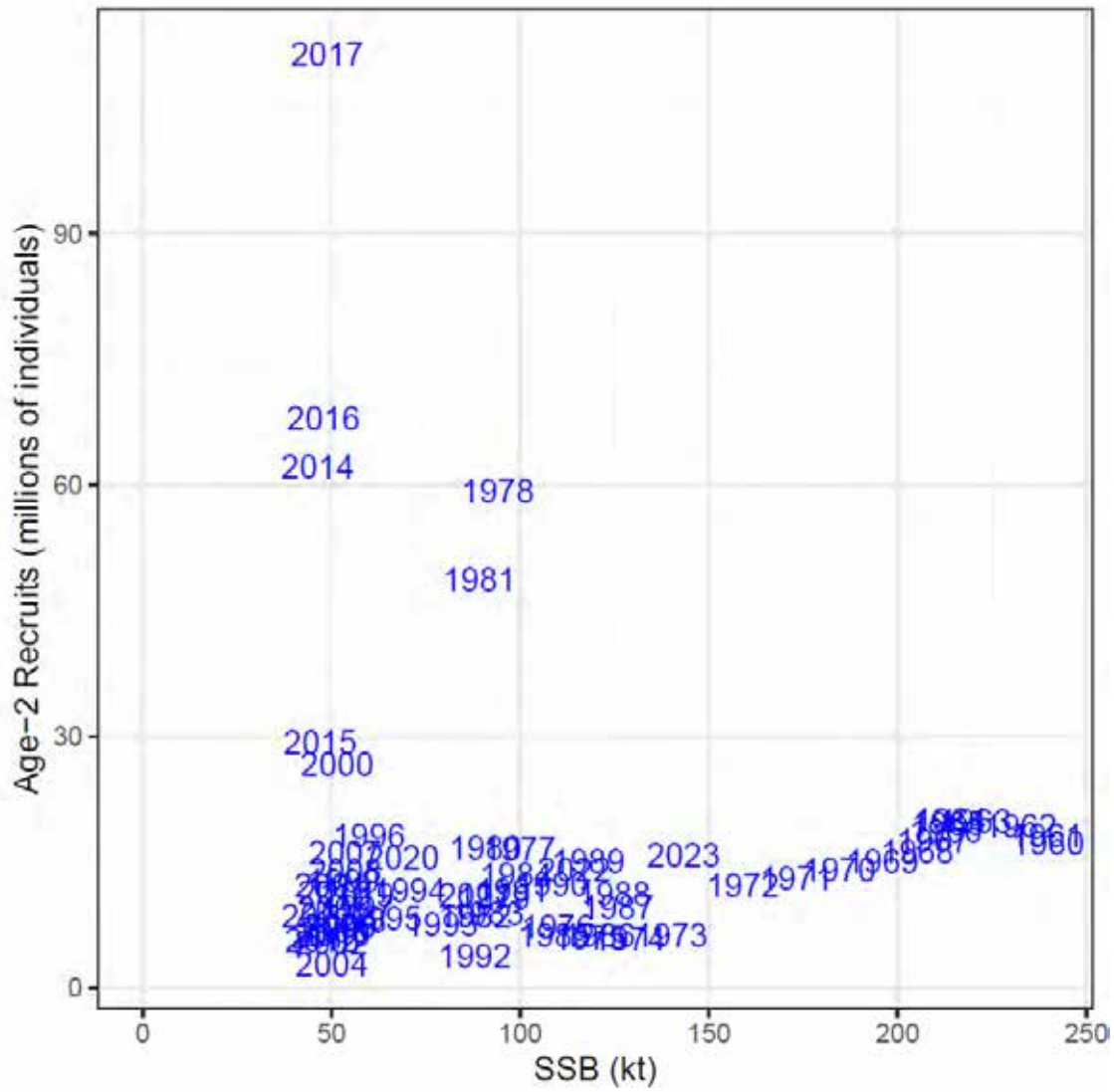

Figure 3.78. Age-2 recruits (millions of fish) and corresponding spawning stock biomass (kilotons) for each year class (identified by plotted year text) for Model *26.2_FAA*.

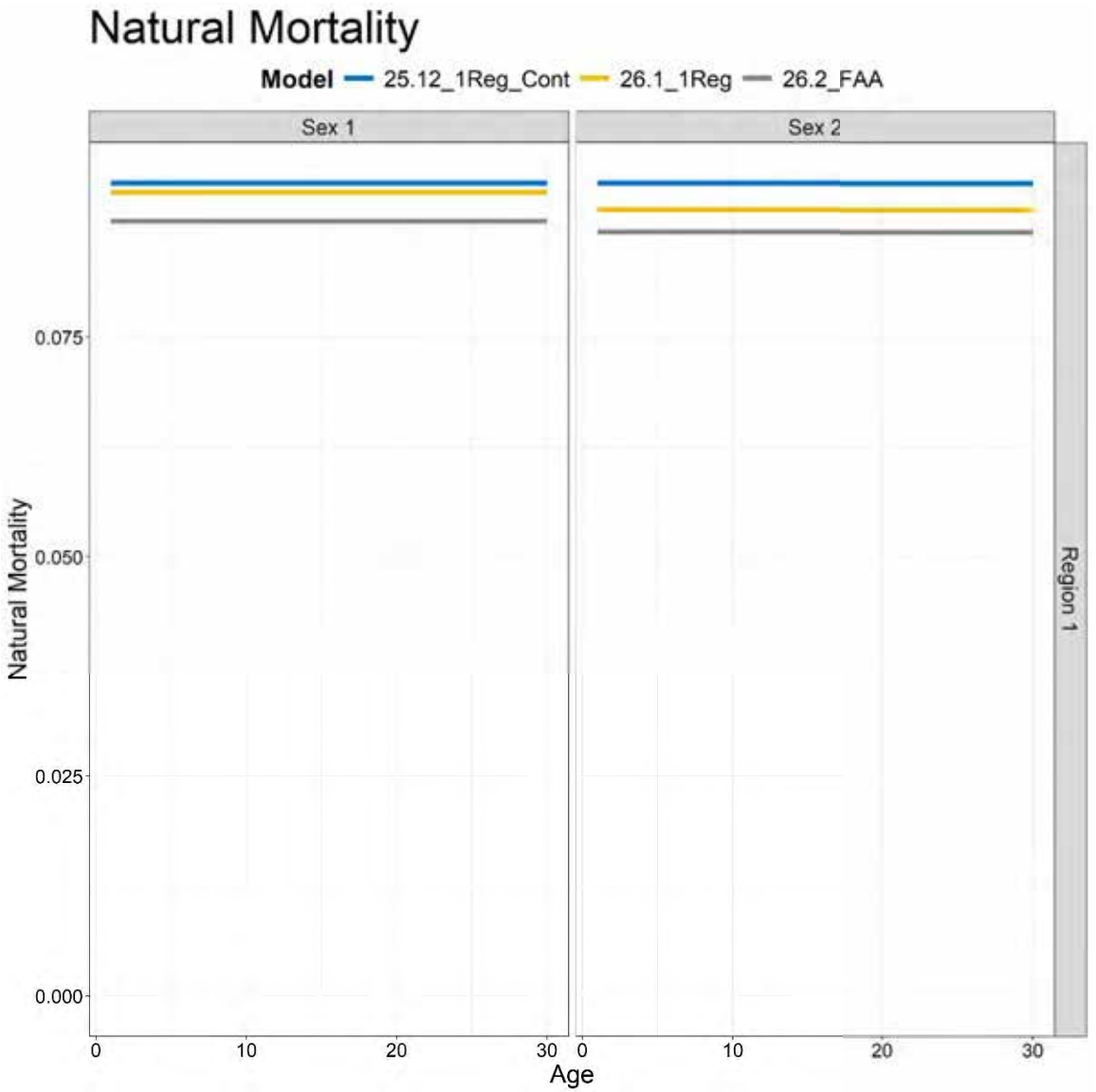

Figure 3.79. Natural mortality estimates from Model *25.12_1Reg_Cont* (blue line), Model *26.1_1Reg* (yellow line), and Model *26.2_FAA* (grey line). Sex 1 is females and sex 2 is males.

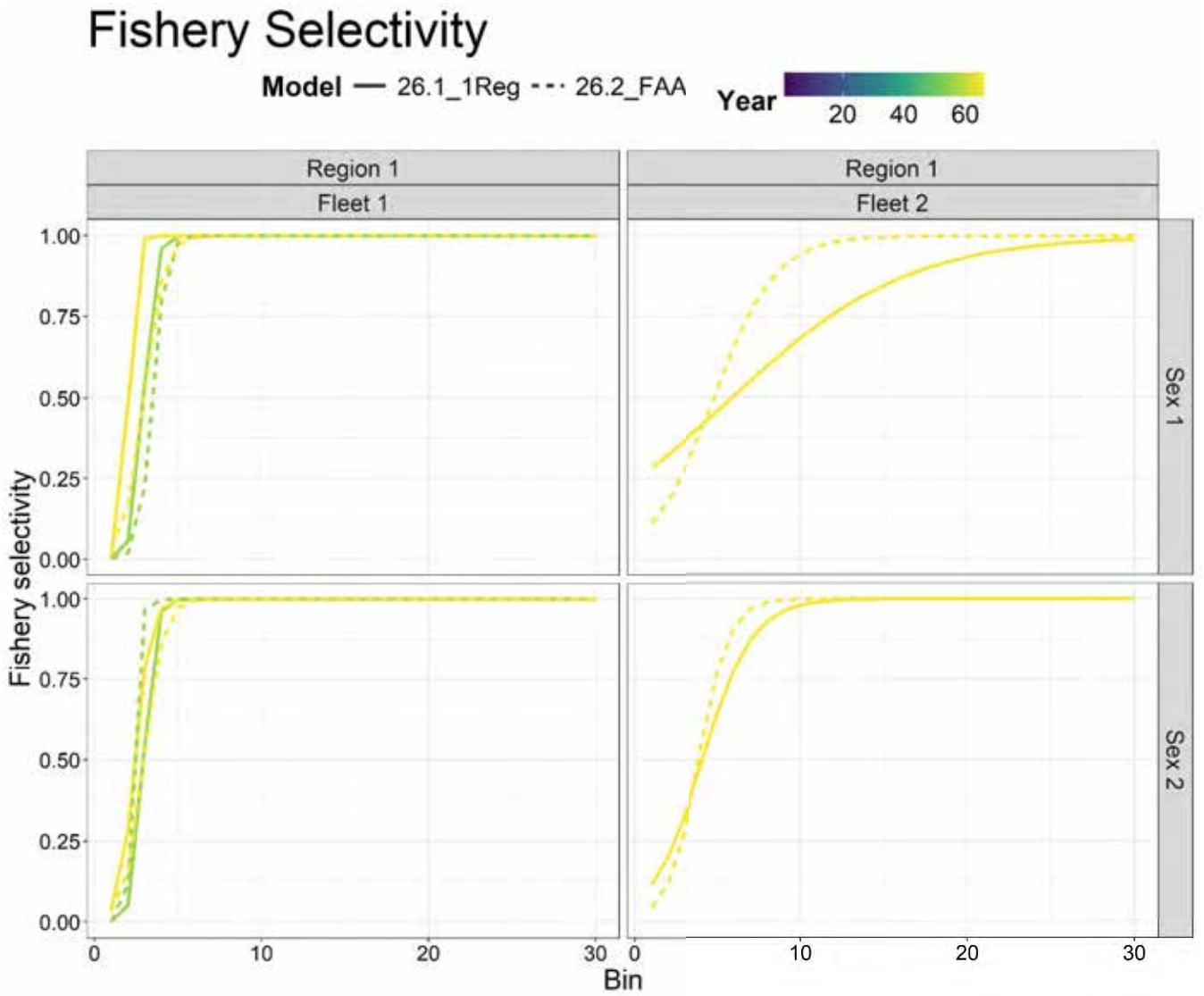

Figure 3.80. Fishery selectivity estimates from Model *26.1_1Reg* (solid line) and Model *26.2_FAA* (dashed line) where different colors represent the different time blocks. Fleet 1 is the fixed gear fleet (green is pre-2016 time block and yellow is post-2016 time block) and fleet 2 is the trawl fleet (single time block, yellow line). Sex 1 is females and sex 2 is males.

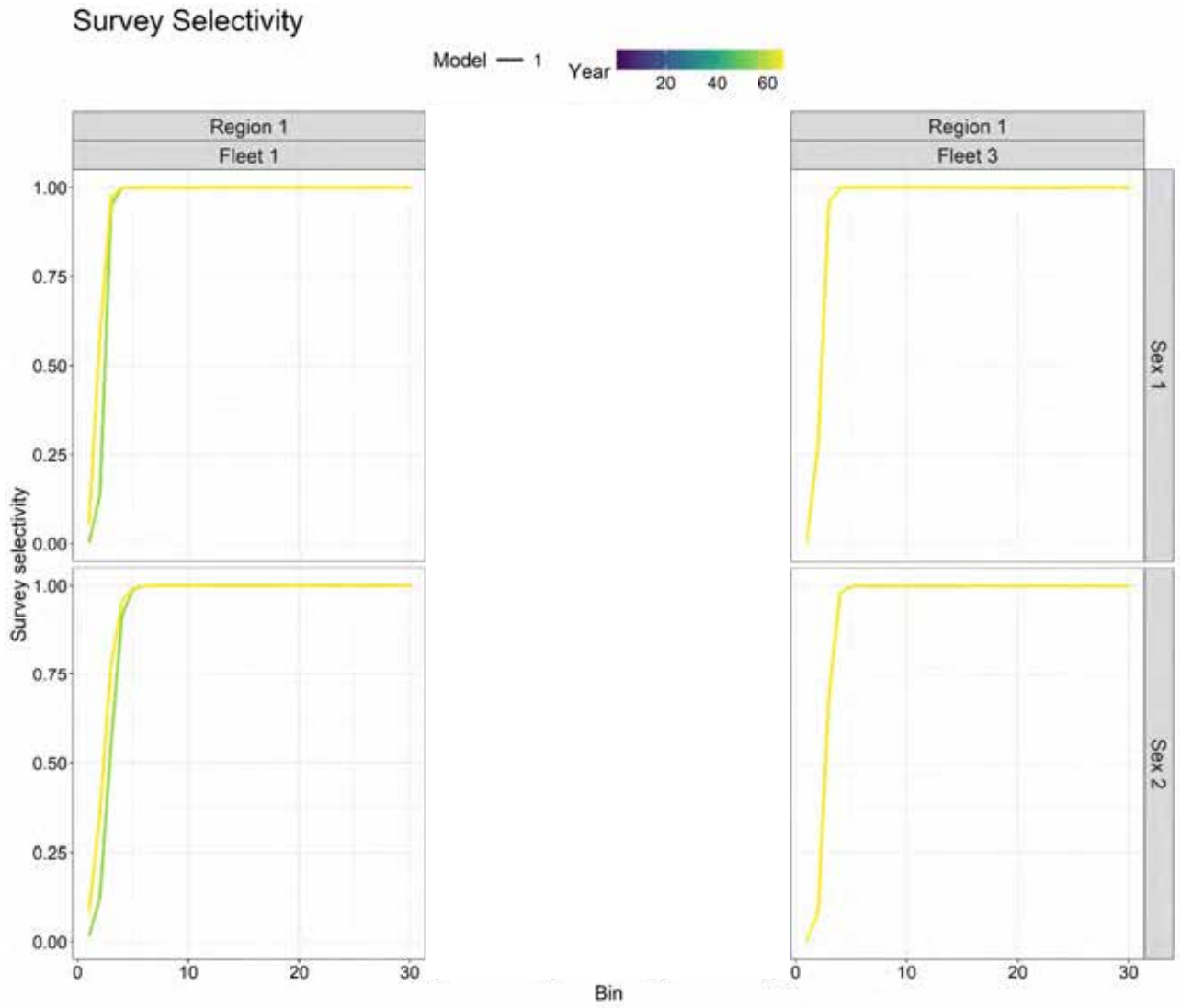

Figure 3.81. Survey selectivity estimates from Model *26.1_1Reg* where different colors represent the different time blocks. Fleet 1 is the NOAA Longline Survey (green is pre-2016 time block and yellow is post-2016 time block) and fleet 3 is the Japanese Longline Survey (single time block, yellow line). Sex 1 is females and sex 2 is males.

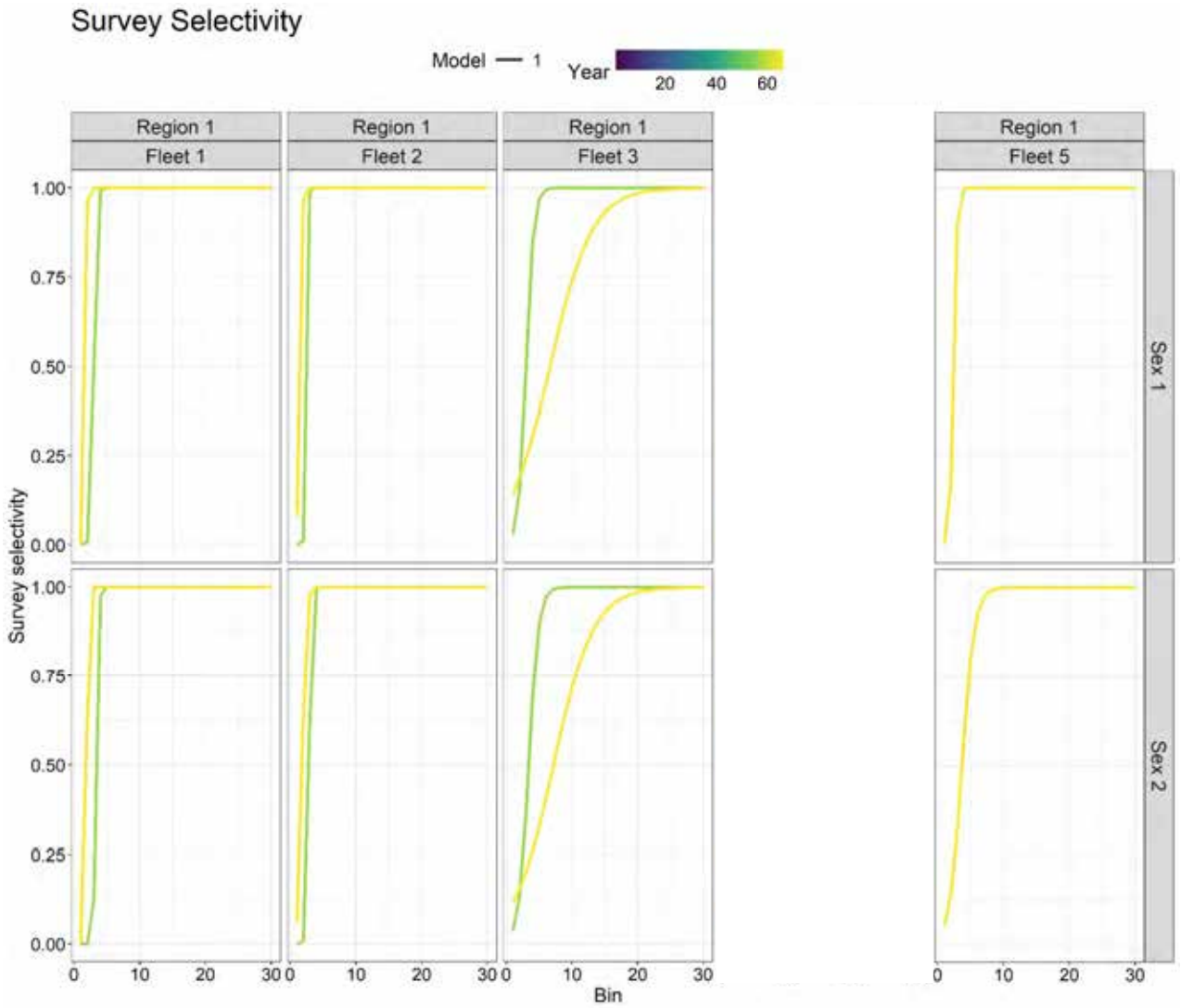

Figure 3.82. Survey selectivity estimates from Model *26.2_FAA* (solid lines) and Model *26.2a_FAA_Fsh+Srvy* (dashed lines) where different colors represent the different time blocks. Survey Fleet 1 is the BS NOAA Longline Survey, Survey Fleet 2 is the AI NOAA Longline Survey, Survey Fleet 3 is the GOA NOAA Longline Survey (green is pre-2016 time block and yellow is post-2016 time block). Survey Fleet 5 is the Japanese Longline Survey (single time block, yellow line). Sex 1 is females and sex 2 is males.

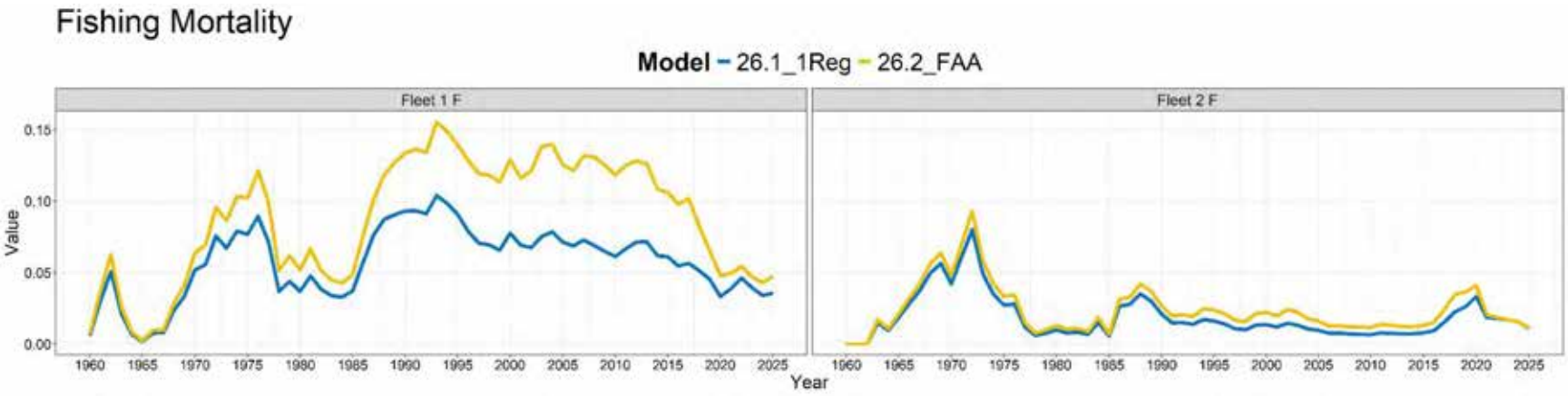

Figure 3.83. Time series estimates of fishing mortality (yr^{-1}) for Model *26.1_1Reg* and Model *26.2_FAA*. Fleet 1 is the fixed gear fishery and fleet 2 is the trawl fishery.

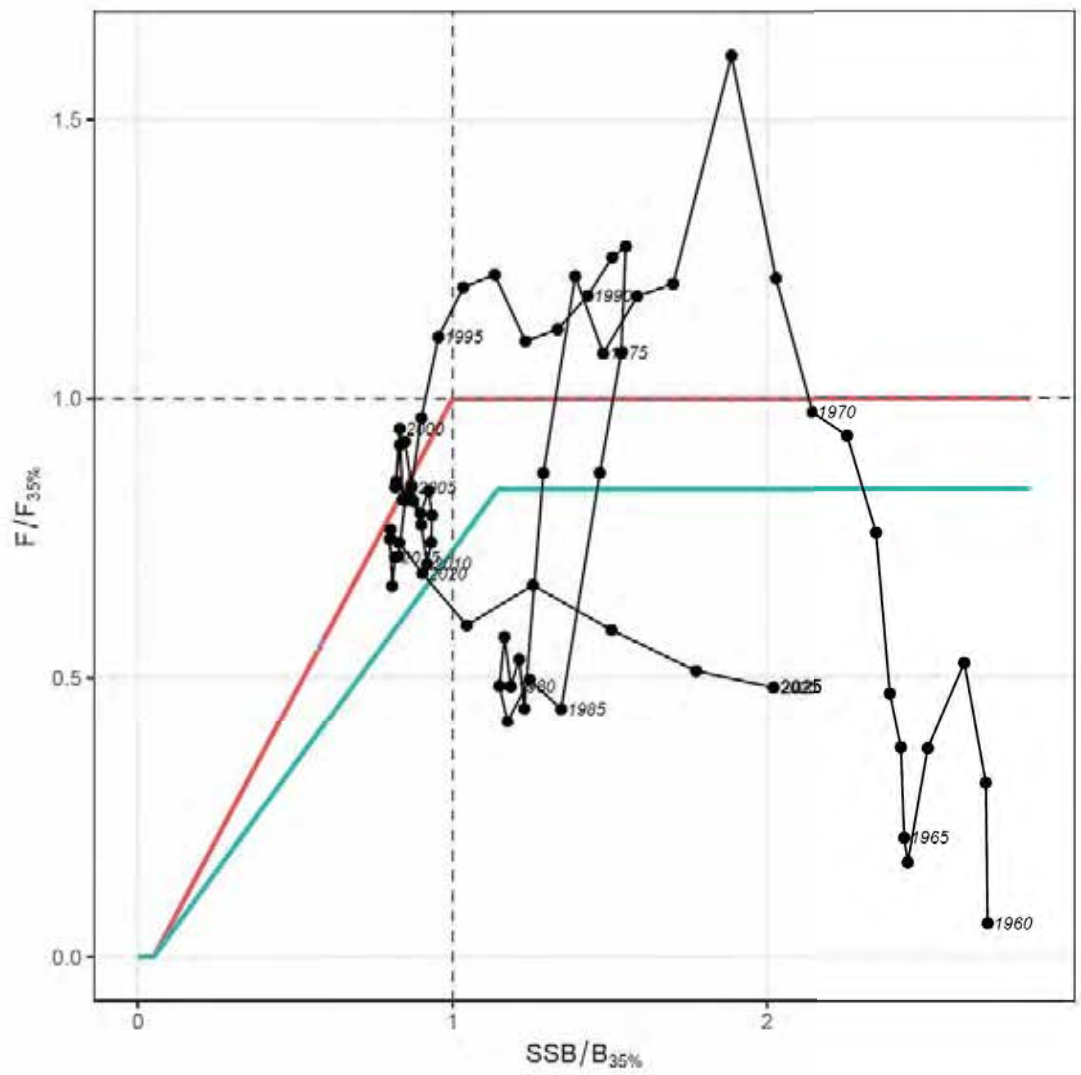

Figure 3.84. Phase-plane diagram illustrating the time series of sablefish estimated spawning biomass relative to the level at $B_{35\%}$ and fishing mortality relative to $F_{35\%}$ (equal to F_{OFL}) for Model *26.1_1Reg*. F_{ABC} for the max ABC is equivalent to $F_{40\%}$ and the associated threshold HCR is demonstrated by the blue line. The red line represents a threshold HCR associated with fishing at F_{OFL}.

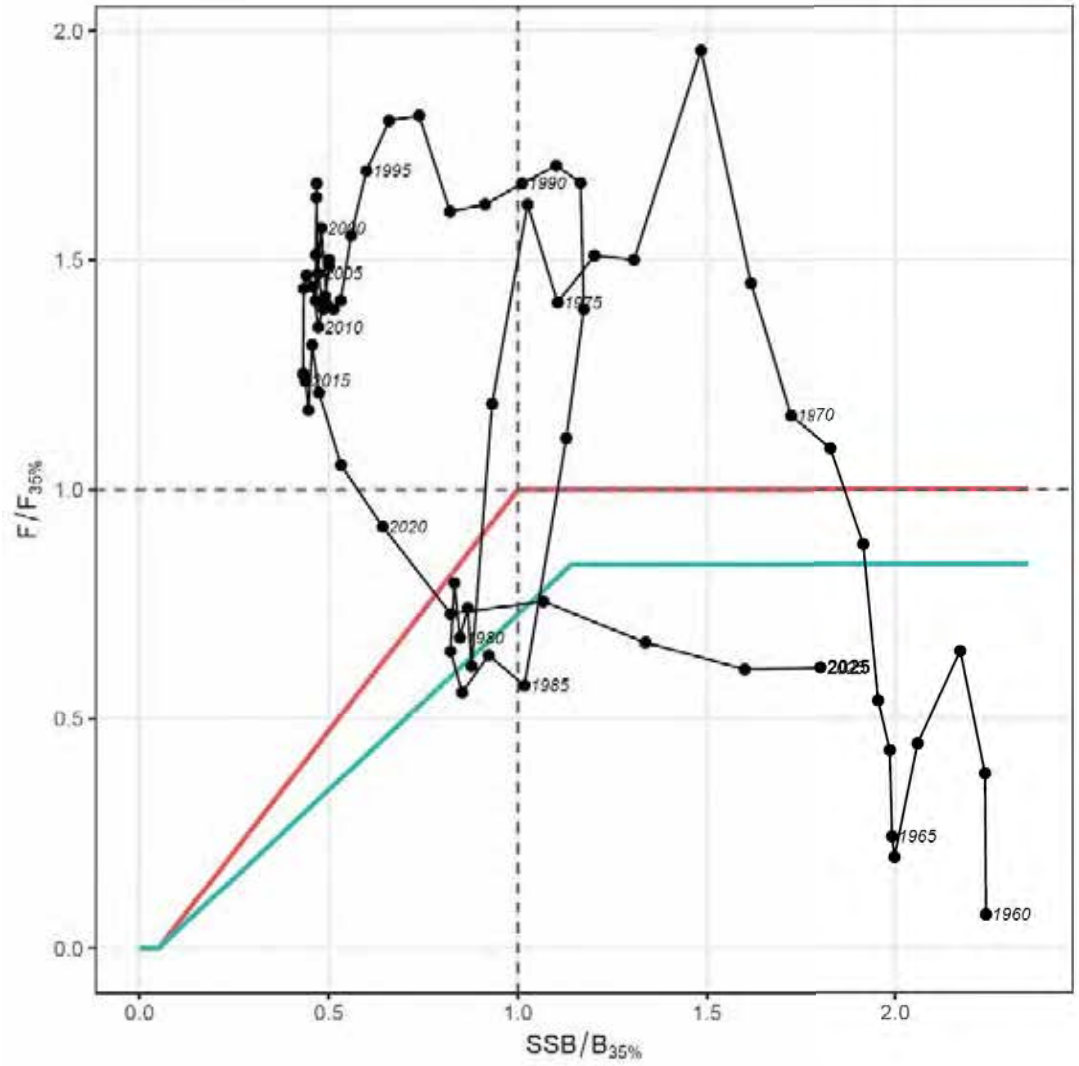

Figure 3.85. Phase-plane diagram illustrating the time series of sablefish estimated spawning biomass relative to the level at $B_{35\%}$ and fishing mortality relative to $F_{35\%}$ (equal to F_{OFL}) for Model *26.2_FAA*. F_{ABC} for the max ABC is equivalent to $F_{40\%}$ and the associated threshold HCR is demonstrated by the blue line. The red line represents a threshold HCR associated with fishing at F_{OFL}.

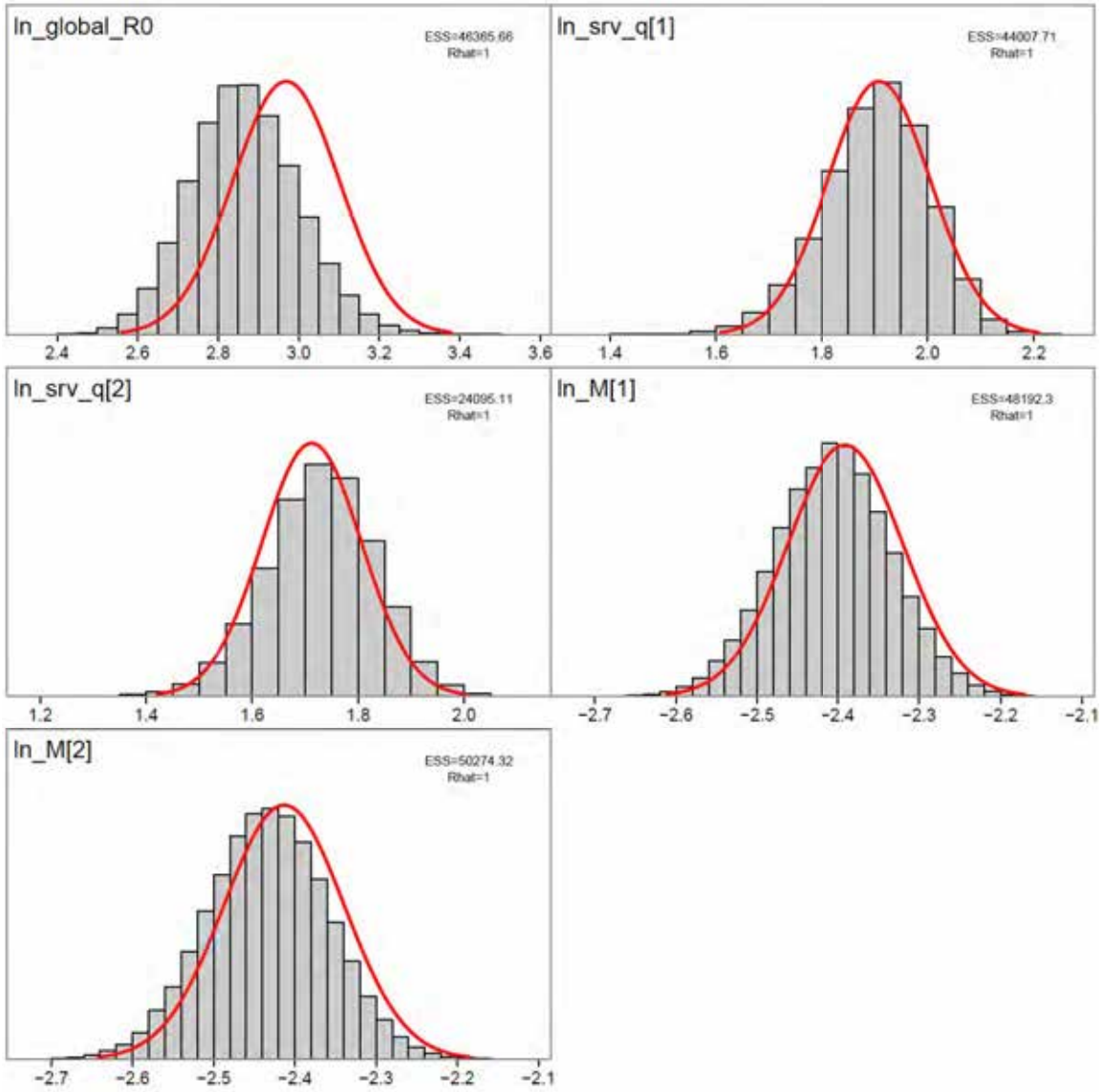

Figure 3.86. Key parameter marginal posterior histograms from MCMC and asymptotic normal distributions (red line) from the inverse Hessian (MLE) for Model *26.1_1Reg*. MCMC effective sample size (ESS) and R-hat estimates are printed in the top right corner.

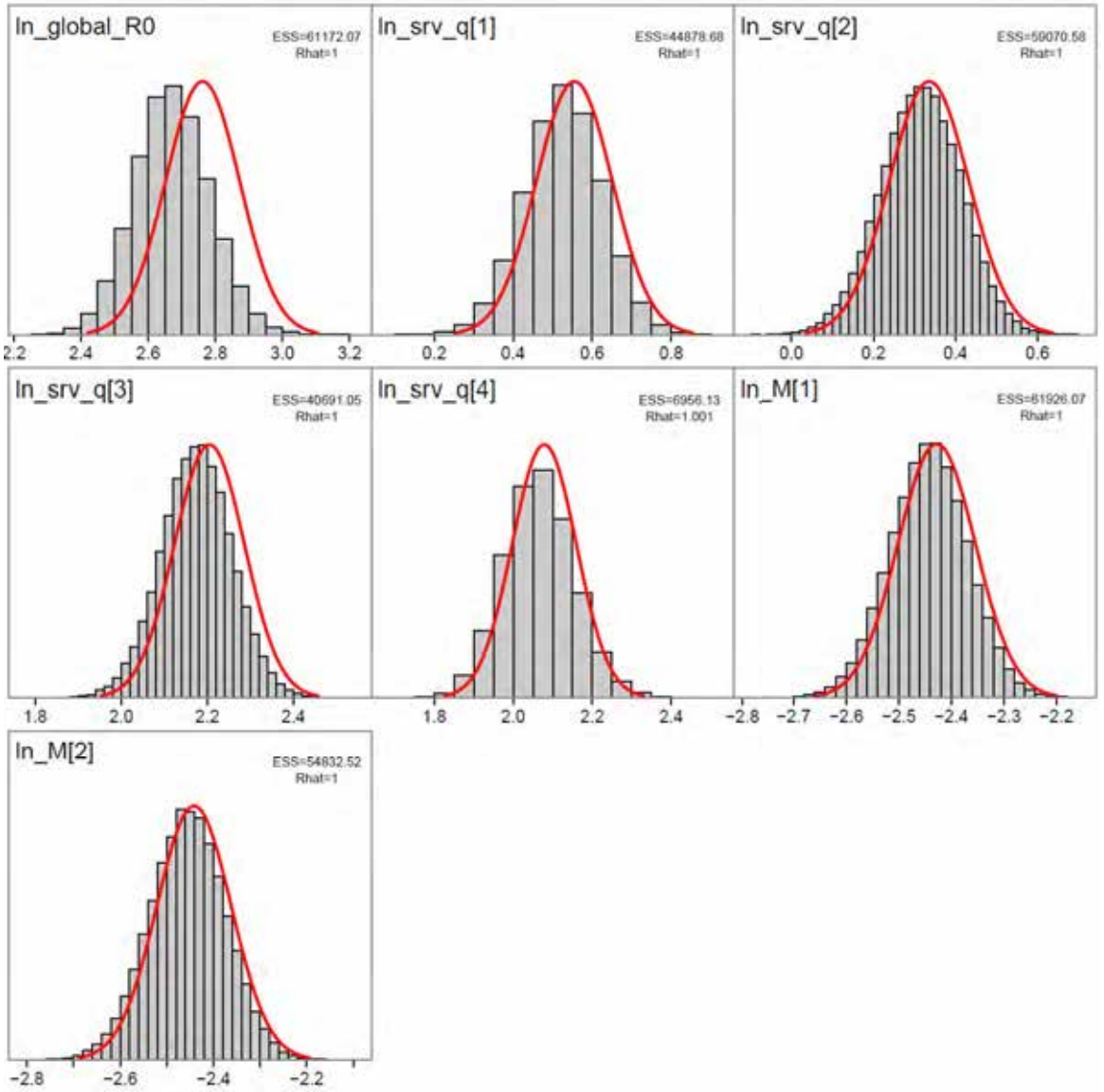

Figure 3.87. Key parameter marginal posterior histograms from MCMC and asymptotic normal distributions (red line) from the inverse Hessian (MLE) for Model *26.2_FAA*. MCMC effective sample size (ESS) and R-hat estimates are printed in the top right corner.

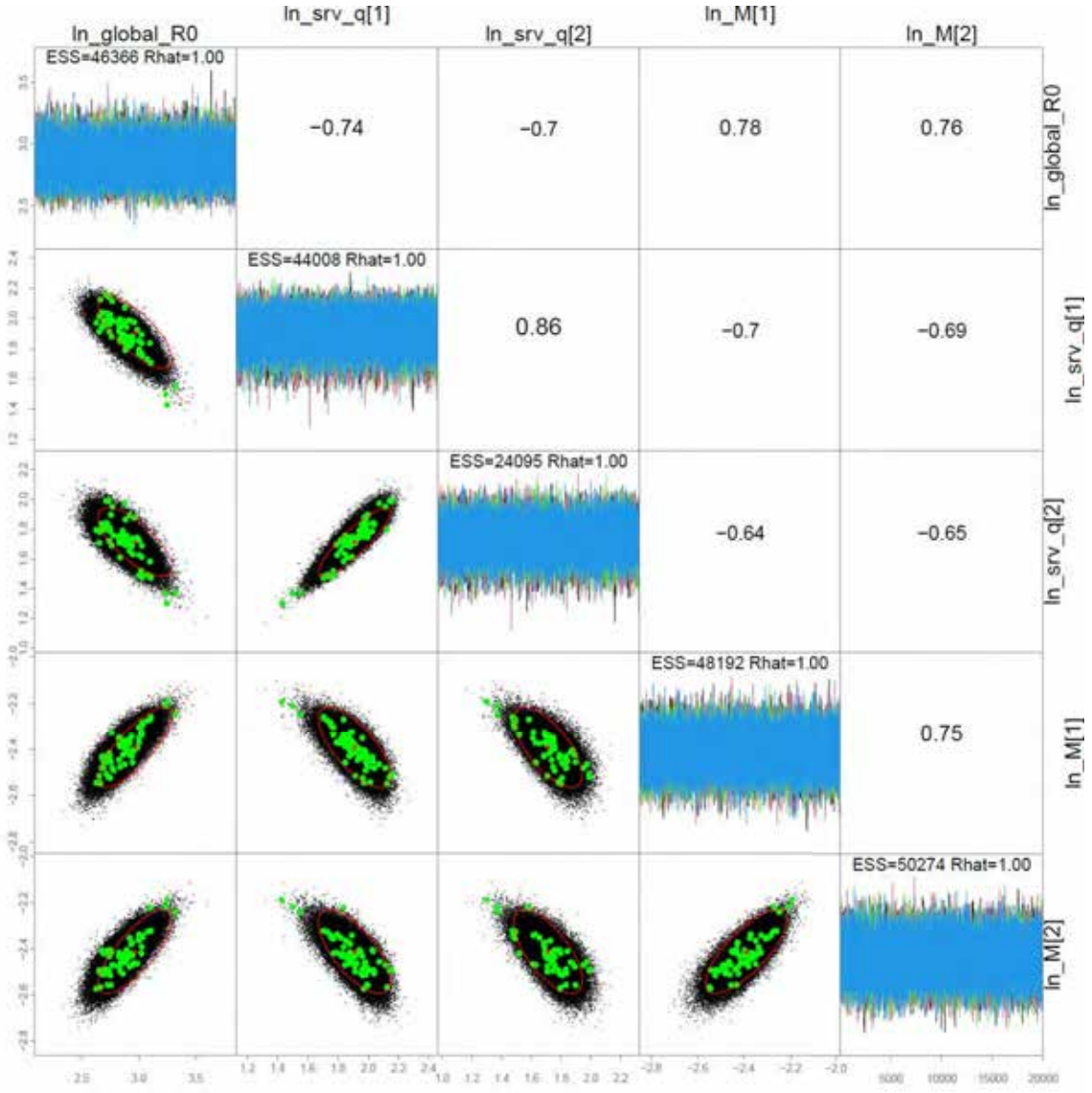

Figure 3.88. MCMC pairwise correlation plots among key model parameters for Model *26.1_1Reg*, where diagnostics are shown along the diagonal and parameter correlations are shown in the upper right quadrant.

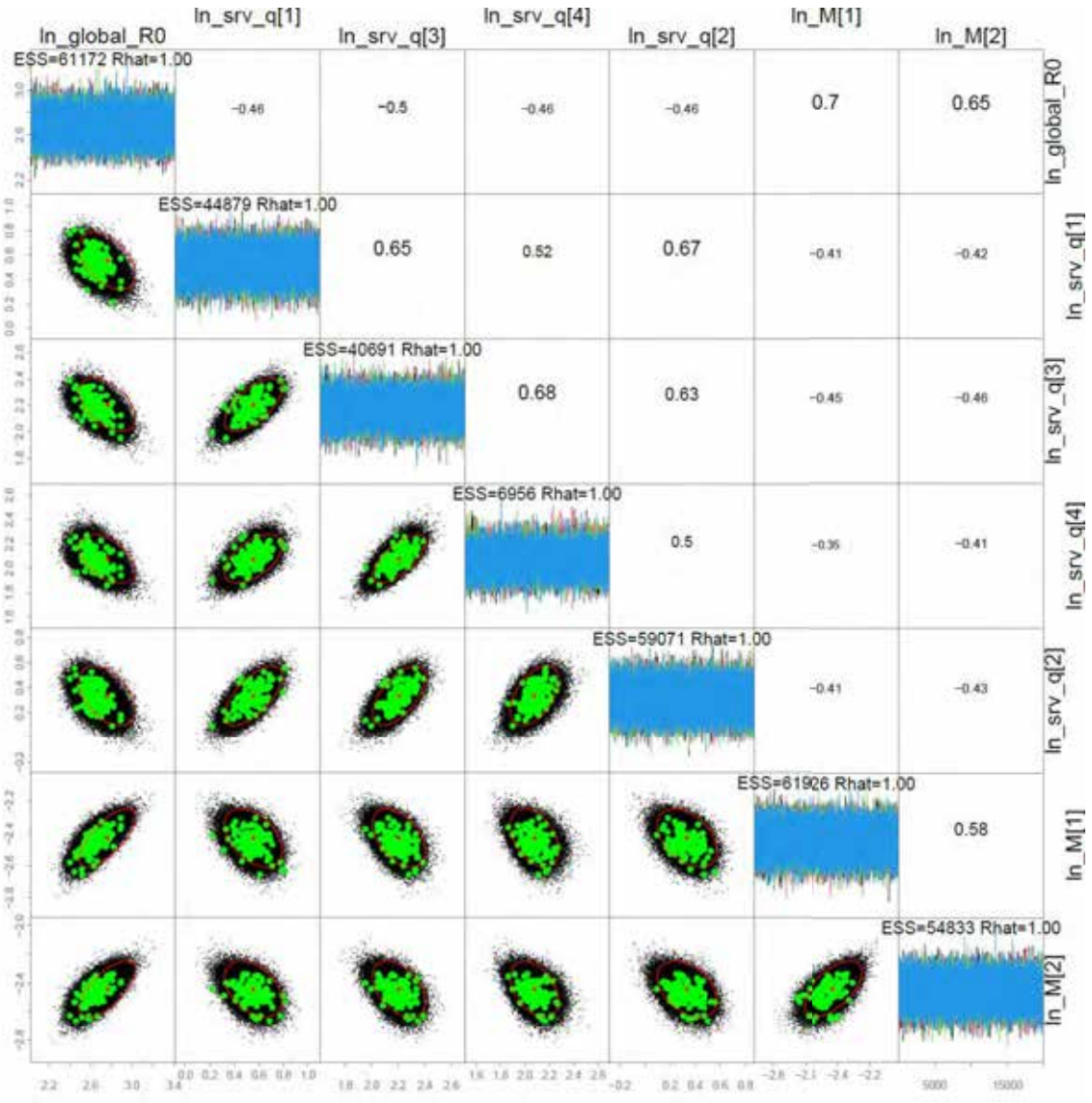

Figure 3.89. MCMC pairwise correlation plots among key model parameters for Model *26.2_FAA*, where diagnostics are shown along the diagonal and parameter correlations are shown in the upper right quadrant.

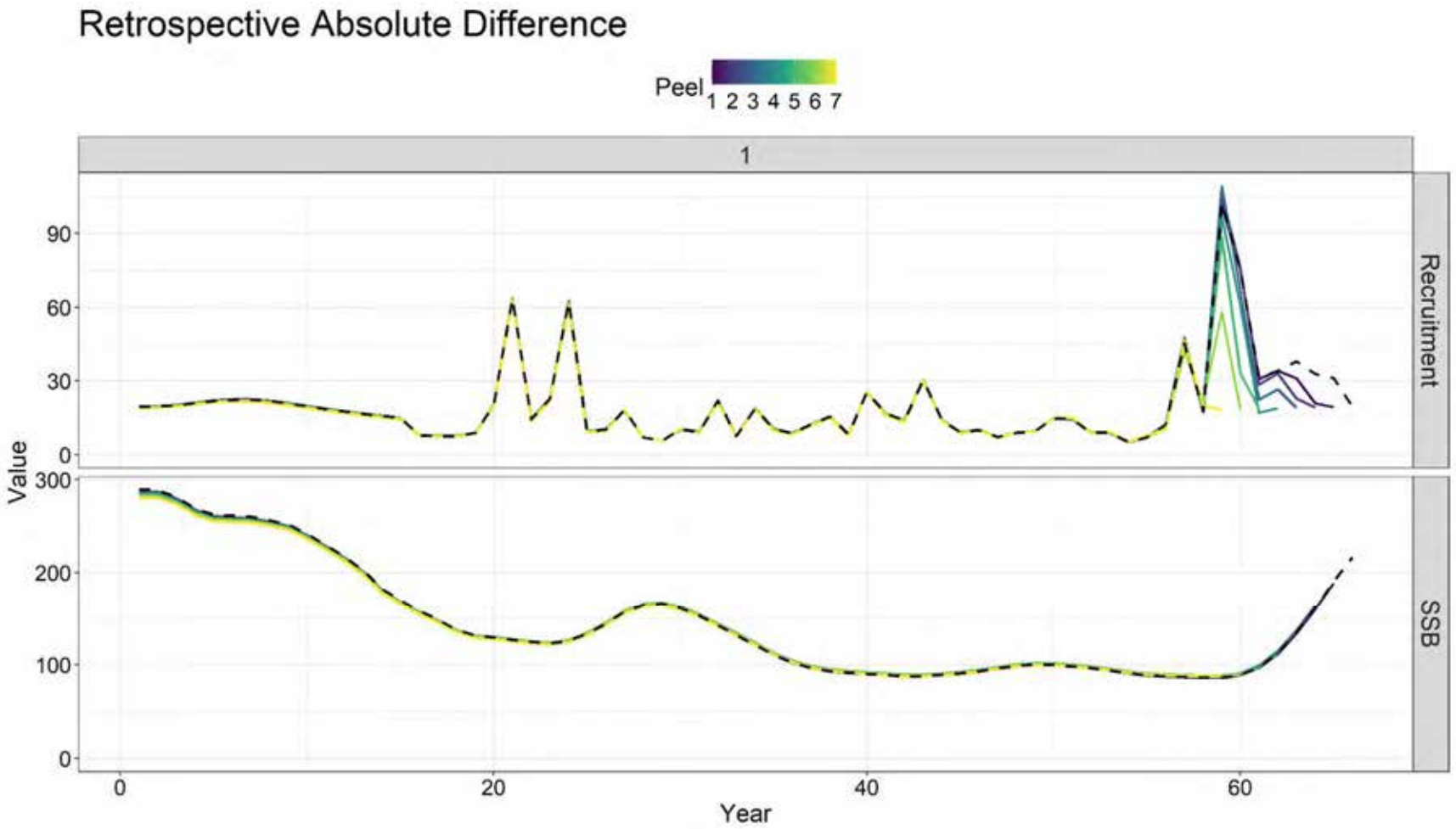

Figure 3.90. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.0054.

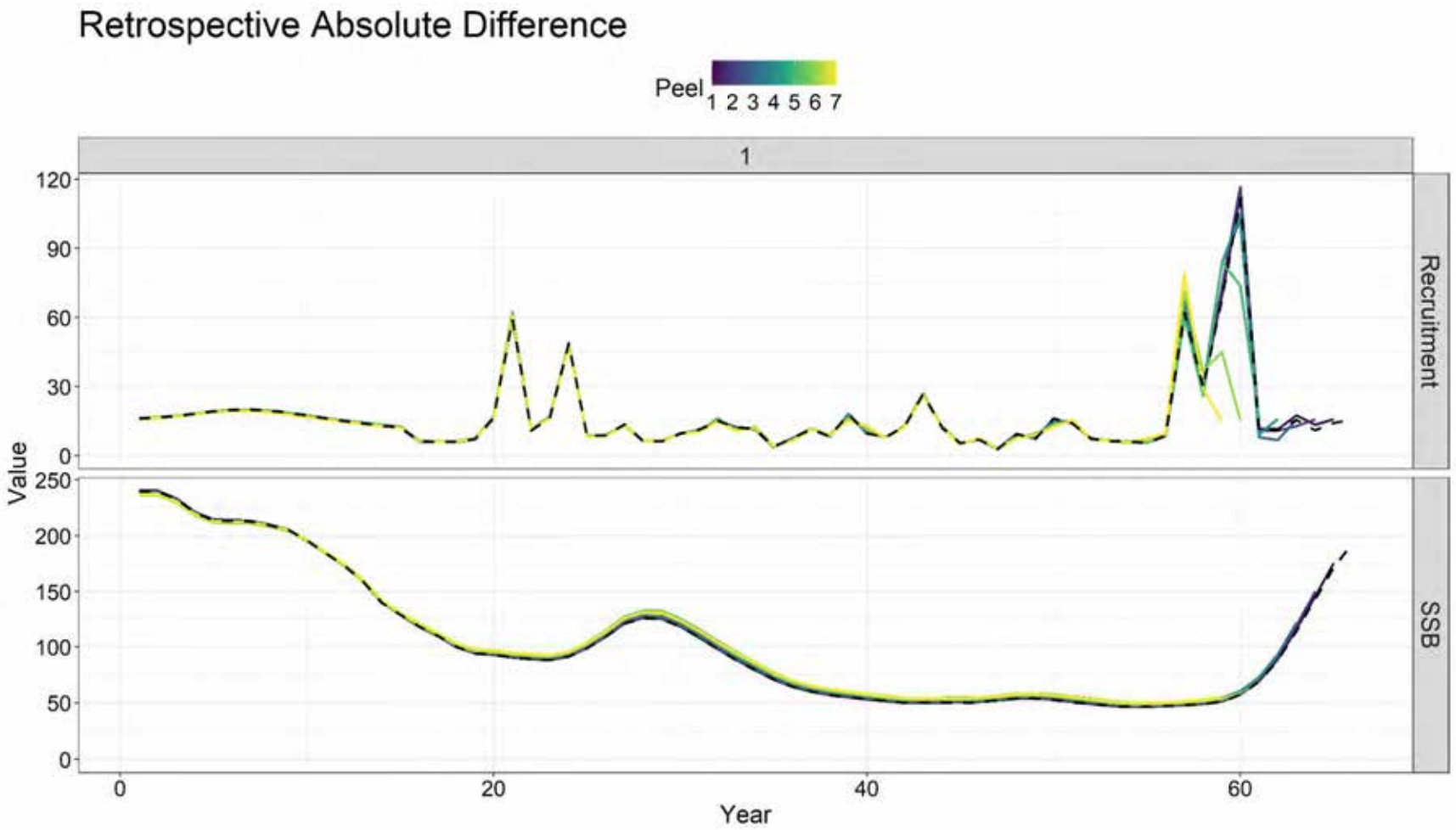

Figure 3.91. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.046.

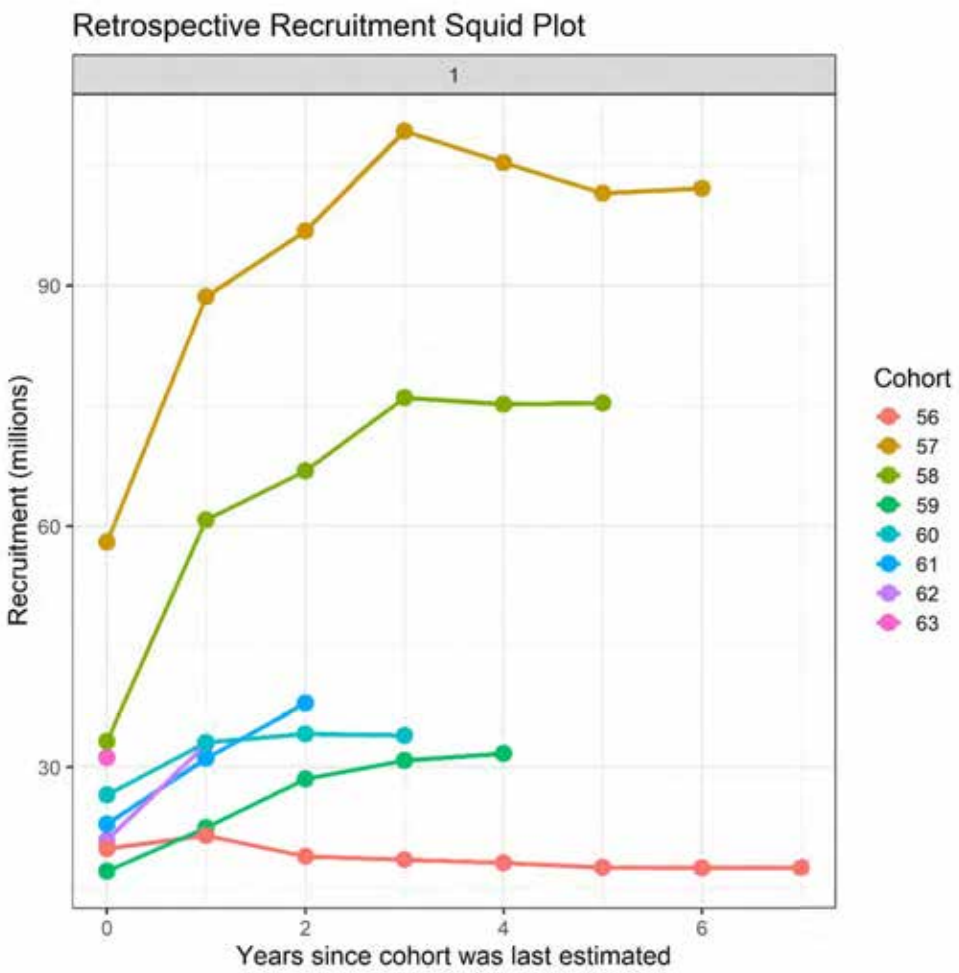

Figure 3.92. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis for model *26.1_1Reg*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Cohort 56 represents the 2015 year class (2017 recruitment event).

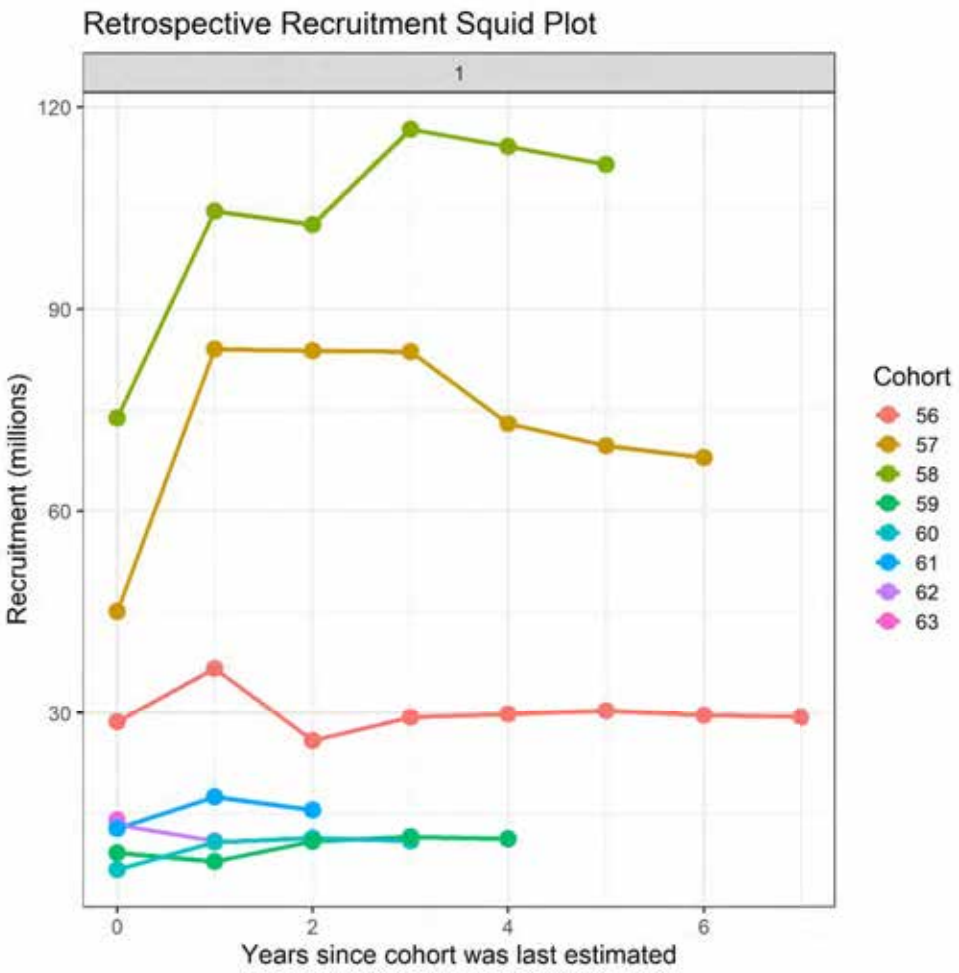

Figure 3.93. Comparison of a recruitment retrospective 'squid' plot representing how estimates of a given year class change as data are added in a seven-year retrospective analysis for model *26.2_FAA*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Cohort 56 represents the 2015 year class (2017 recruitment event).

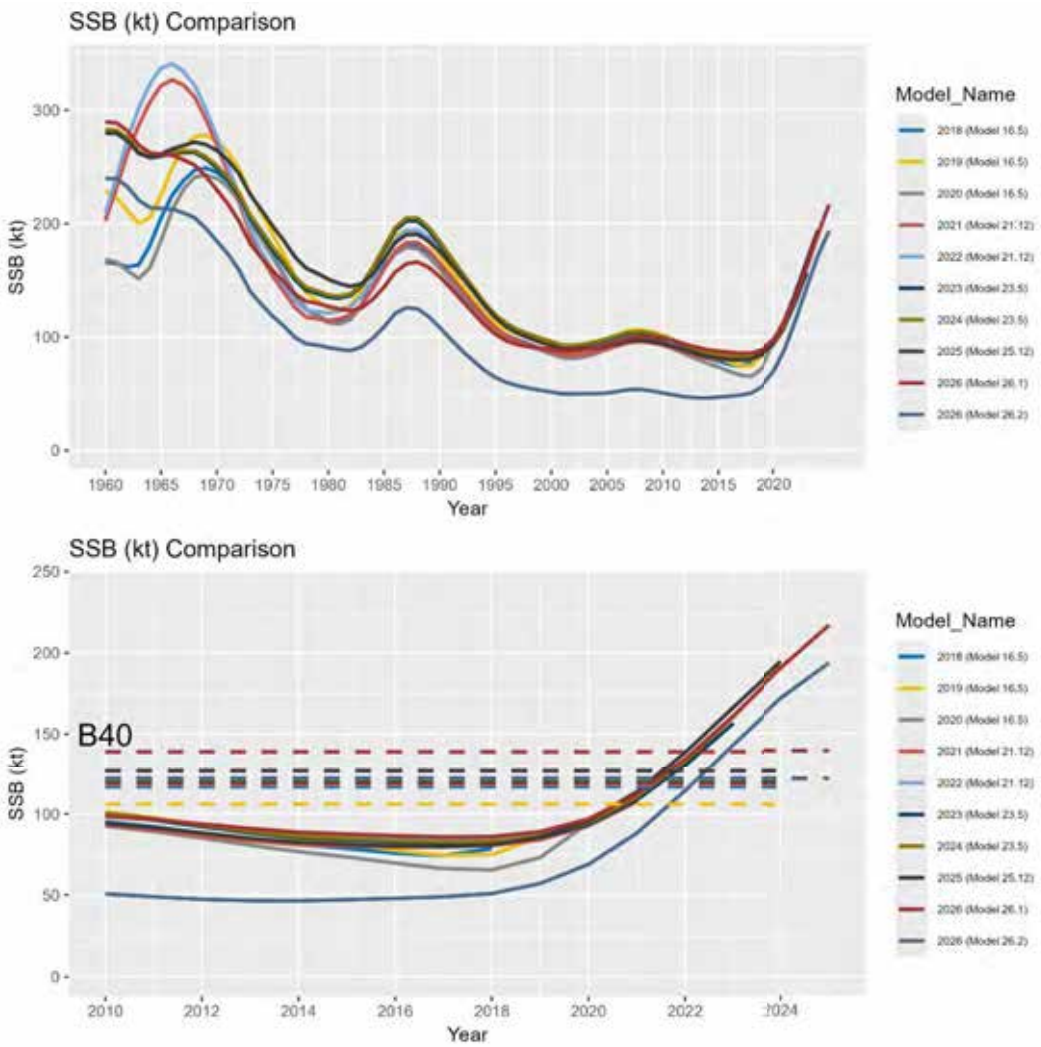

Figure 3.94. Results of the 'all model' historical retrospective illustrating estimated spawning stock biomass (in kilotons). Results are based on the accepted model in each terminal model year, including application of Model *25.12* for 2025 (although there was no SAFE), Model *23.5* for 2023 and 2024, Model *21.12* for 2021 and 2022, and Model *16.5* model for earlier model years. Models *26.1_1Reg* and Model *26.2_FAA* are shown for 2026. The top panel shows the entire time series of SSB from each assessment model, while the bottom panel shows the same results since 2010 overlaid with corresponding estimates of $B_{40\%}$.

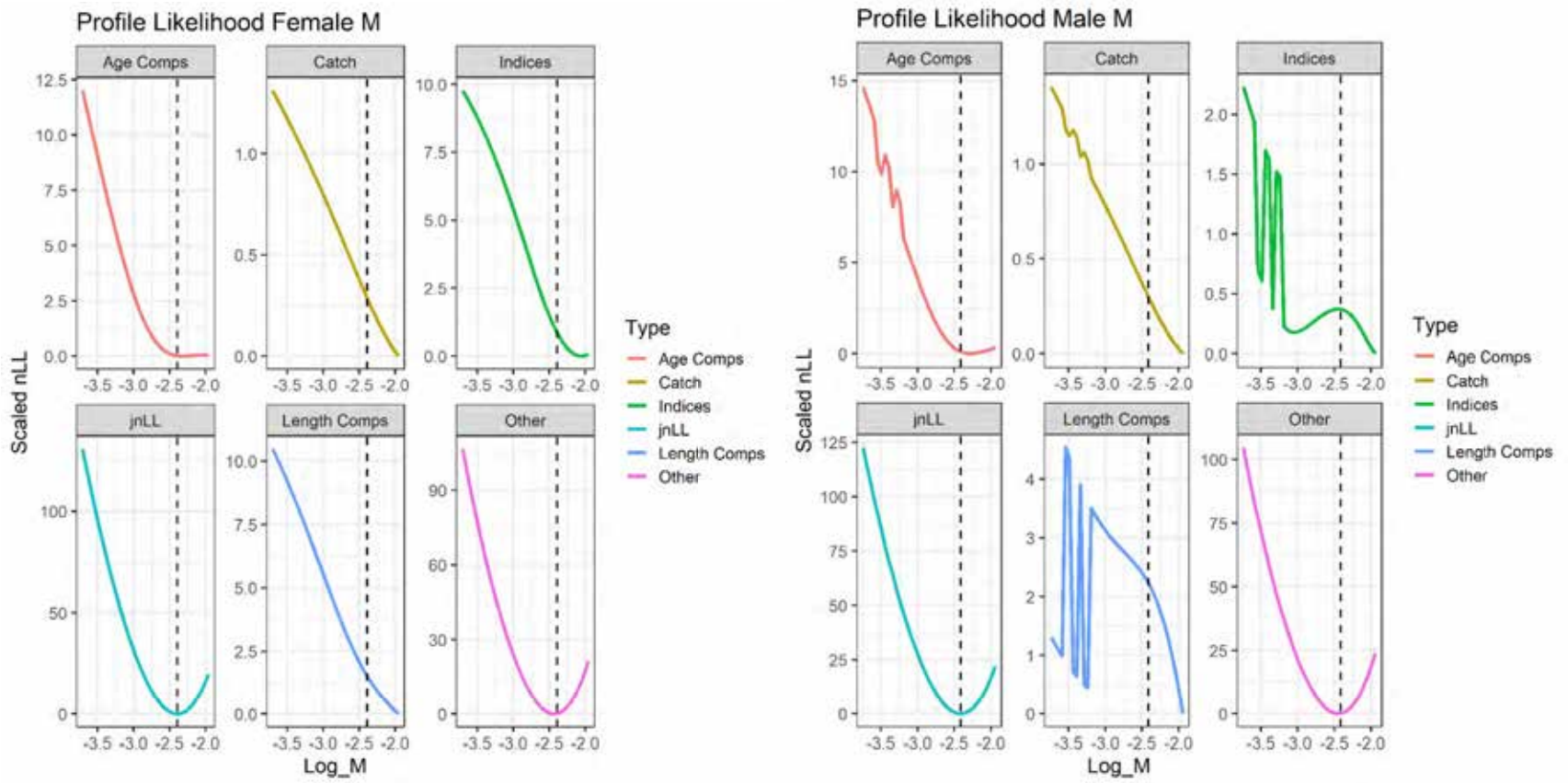

Figure 3.95. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for Model *26.1_1Reg*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

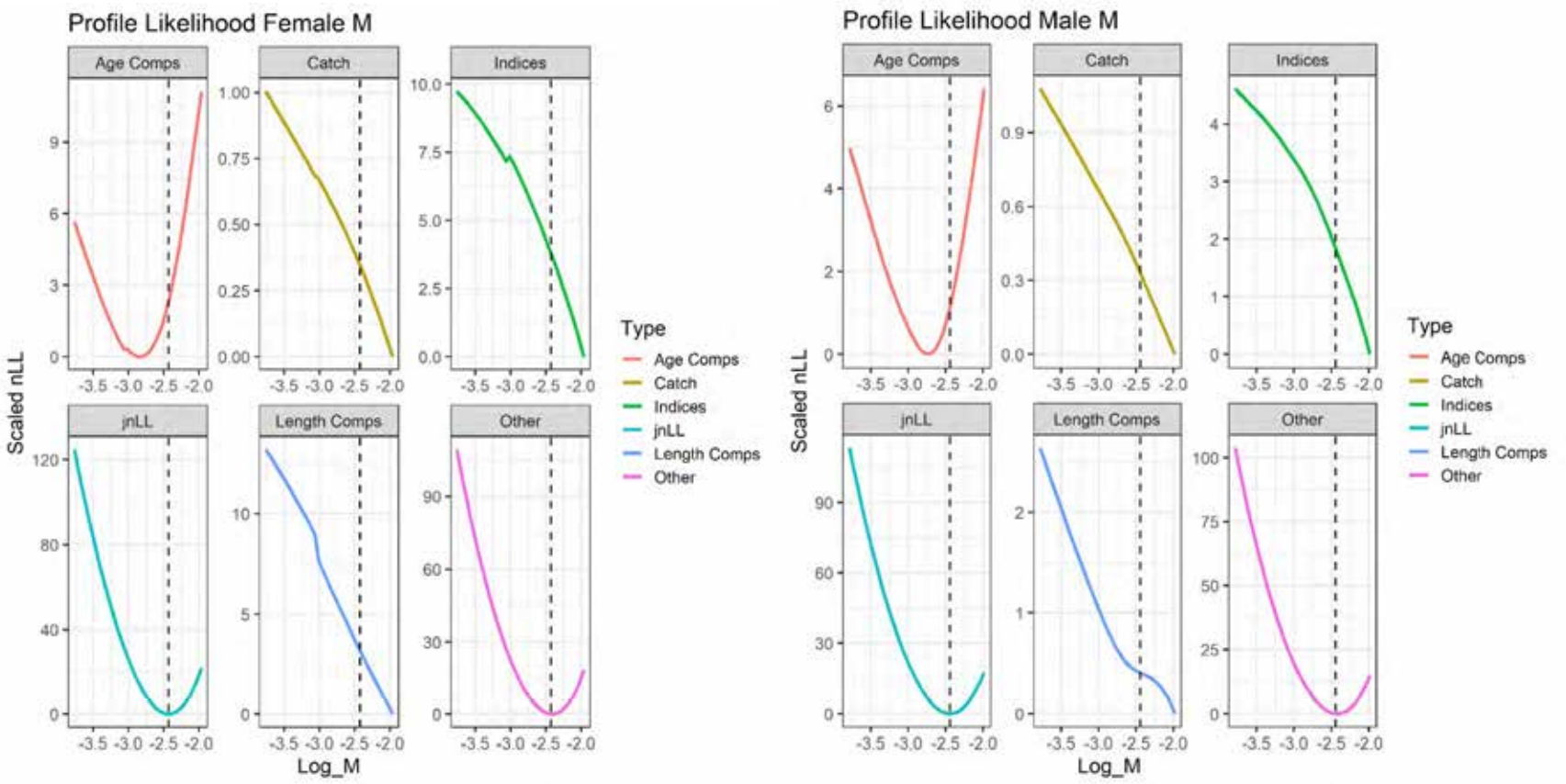

Figure 3.96. Likelihood profile for the natural mortality parameter (*M*) for females (left) and males (right), where panels represent the profile for each data type used in the model, for Model *26.2_FAA*. The 'other' category represents the priors and penalties, which is particularly dominated by the *M* prior.

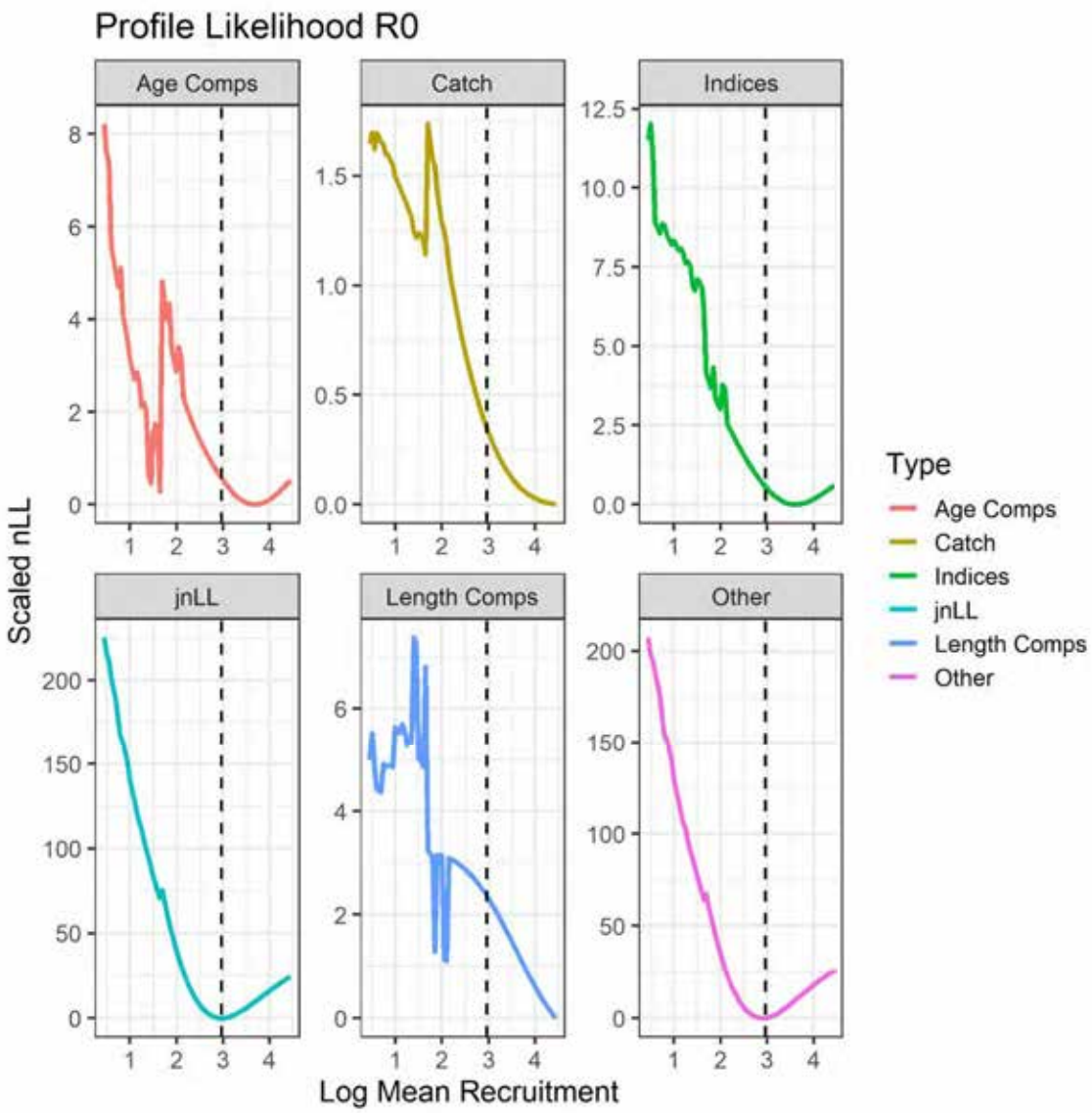

Figure 3.97. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for Model *26.1_1Reg*.

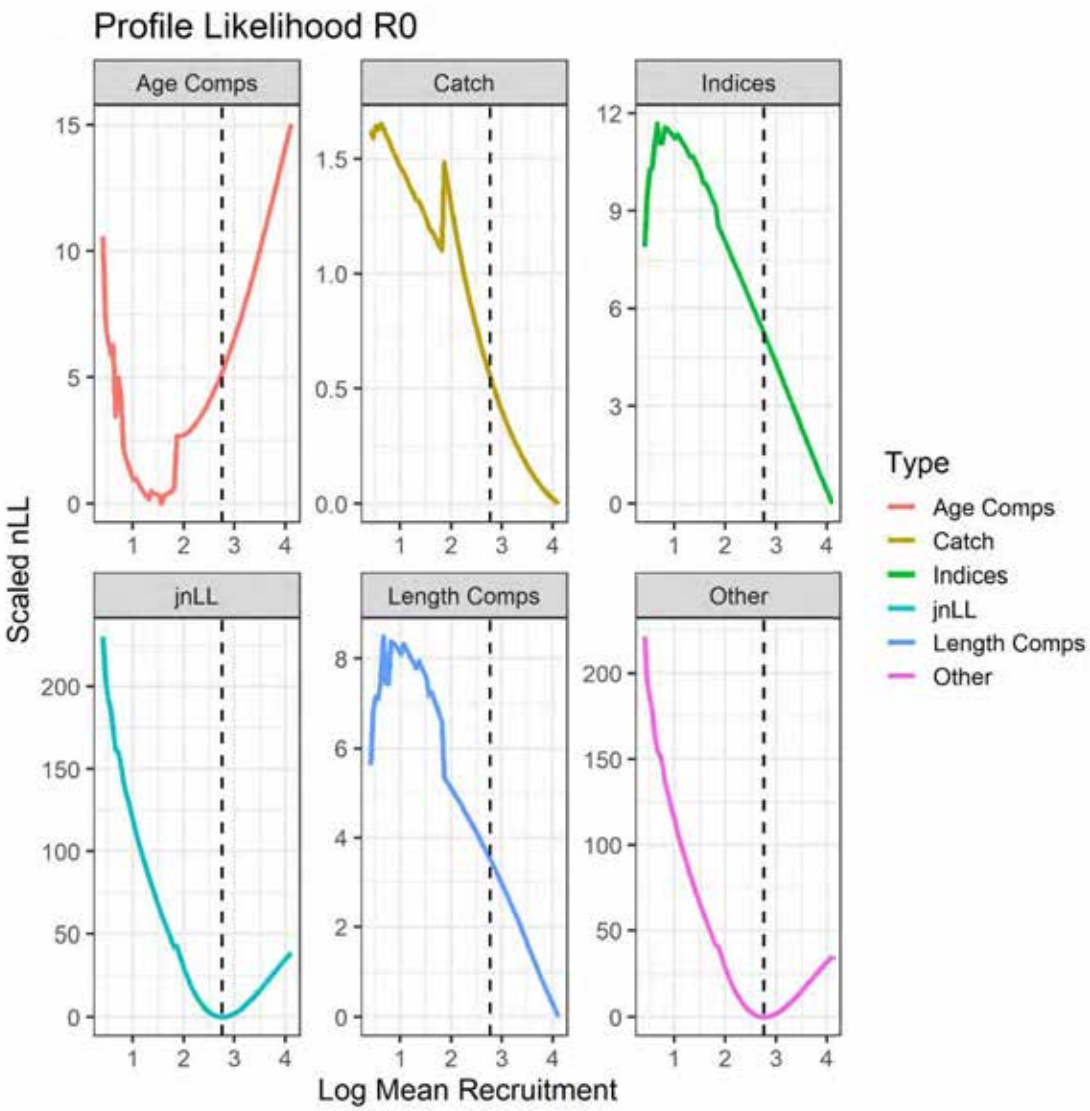

Figure 3.98. Likelihood profile for the mean recruitment (R_0), where panels represent the profile for each data type used in the model, for Model *26.2_FAA*.

Supplemental Material

Sablefish Longline Survey Fishery and Whale Interactions

NMFS has requested the assistance of the fishing fleet to avoid the annual longline survey stations since the inception of sablefish IFQ management in 1995. We request that fishermen stay at least five nm away from each survey station for 7 days before and 3 days after the planned sampling date (3 days allows for survey delays). Since 2021, survey calendars have been made available online (https://www.fisheries.noaa.gov/resource/document/alaska-sablefish-longline-survey-station-schedule). While the survey is being conducted, the skipper of the vessel makes announcements on the radio detailing the planned set locations for the upcoming days. Vessels encountered near survey stations are contacted by the survey vessel captain and interviewed to determine potential effects on survey catches. Typically, vessels have been aware of the survey and have not been fishing close to survey locations. Even with communication, there are some instances where survey gear was fished nearby commercial fishing gear or where commercial fishing had recently occurred. There are generally few interactions during the 90-day survey (Table SM3.1). In 2023 there were eight instances of vessel interactions that may have impacted survey catch or required the survey vessel to move the day's sets from their originally intended locations. In the GOA, there were 5 interactions with pot boats (3 in Southeast Outside, 1 in West Yakutat, and 1 in the Central GOA) and 3 interactions with longline vessels (1 in the western GOA and 2 in the central GOA). There were no vessel interactions in the Bering Sea. The number of sets impacted by whales is also tallied (Table SM3.2) and those sets are dropped (for orca interaction; 16 stations, mostly in the BS) or catch rates inflated using the survey whale inflation factor (for sperm whales; 12 stations, mostly in the eastern GOA; see 'Whale Depredation Estimation' section). No longline survey was conducted in 2024.

Table SM3.1. Count of longline survey and fishery vessel interactions by area, fishery gear type, and year.

	Longline		Trawl		Pot		Total	
Year	Stations	Vessels	Stations	Vessels	Stations	Vessels	Stations	Vessels
1995	8	7	9	15	0	0	17	22
1996	11	18	15	17	0	0	26	35
1997	8	8	8	7	0	0	16	15
1998	10	9	0	0	0	0	10	9
1999	4	4	2	6	0	0	6	10
2000	10	10	0	0	0	0	10	10
2001	1	1	1	1	0	0	2	2
2002	3	3	0	0	0	0	3	3
2003	4	4	2	2	0	0	6	6
2004	5	5	0	0	1	1	6	6
2005	1	1	1	1	0	0	2	2
2006	6	6	1	2	0	0	7	8
2007	8	6	2	2	0	0	10	8
2008	2	2	2	2	0	0	4	4
2009	3	3	0	0	0	0	3	3
2010	2	2	1	1	0	0	3	3
2011	3	3	0	0	0	0	3	3
2012	5	5	0	0	0	0	5	5
2013	5	5	0	0	0	0	5	5
2014	2	2	0	0	0	0	2	2
2015	3	3	1	1	0	0	6	6
2016	5	5	1	1	0	0	6	6
2017	8	10	3	3	3	3	13	16
2018	9	9	3	3	0	0	12	12
2019	4	4	1	1	4	4	9	9
2020	1	1	1	1	3	3	5	5
2021	0	0	0	0	4	4	4	4
2022	1	1	0	0	7	7	8	8
2023	2	3	0	0	4	5	6	8

Table SM3.2. Count of stations where sperm (S) or killer whale (K) depredation occurred and the number of stations sampled (in parentheses) by management area. Only stations used for RPN calculations are included. Areas not surveyed in a given year are left blank. If there were no whale depredation data taken, it is denoted with an "n/a". Killer whale depredation did not always occur on all skates of gear, and only those skates with depredation were removed from calculations of RPNs and RPWs.

	BS (16)		**AI (14)**		**WG (10)**		**CG (16)**		**WY (8)**		**SEO (17)**	
Year	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**	**S**	**K**
1996			n/a	1	n/a	0	n/a	0	n/a	0	n/a	0
1997	n/a	2			n/a	0	n/a	0	n/a	0	n/a	0
1998			0	1	0	0	0	0	4	0	0	0
1999	0	7			0	0	3	0	6	0	4	0
2000			0	1	0	1	0	0	4	0	2	0
2001	0	5			0	0	3	0	0	0	2	0
2002			0	1	0	4	3	0	4	0	2	0
2003	0	7			0	3	2	0	1	0	2	0
2004			0	0	0	4	3	0	4	0	6	0
2005	0	2			0	4	0	0	2	0	8	0
2006			0	1	0	3	2	1	4	0	2	0
2007	0	7			0	5	1	1	5	0	6	0
2008			0	3	0	2	2	0	8	0	9	0
2009	0	10			0	2	5	1	3	0	2	0
2010			0	3	0	1	2	1	2	0	6	0
2011	0	7			0	5	1	1	4	0	9	0
2012			1	5	1	5	2	0	4	0	3	0
2013	0	11			0	2	2	2	3	0	7	0
2014			1	3	0	4	4	0	6	0	4	0
2015	0	9			0	5	4	0	6	0	7	0
2016			1	0	0	3	3	2	5	0	6	0
2017	0	11			1	2	4	0	3	0	9	0
2018			0	2	0	3	3	0	7	0	9	0
2019	0	10			1	4	6	3	6	0	4	0
2020			0	7	1	5	3	1	4	0	6	0
2021	0	10			0	1	5	0	1	0	2	0
2022			0	1	0	4	2	0	1	0	5	0
2023	0	12			0	3	2	1	2	0	8	0

Supplemental Catch Data

In order to address NS1 total accounting requirements, discards (Table SM3.3), FMP bycatch (Table SM3.4), nontarget bycatch (Table SM3.5), and prohibited species catch (PSC; Table SM3.6) are reported in this appendix. Note that all non-commercial catch is now accounted for in the assessment model catch, so no additional table is provided for these sources of removal.

Table SM3.3. Retained and discarded catch of sablefish (t) by year, fleet, and management (FMP) region. Abbreviations are: HAL = hook-and-line; POT = pot; TRW = trawl; and JIG = jig fishery. Source: NMFS Alaskan Regional Office Catch Accounting System via AKFIN (www.akfin.org), accessed on October 10, 2024. Discards are included in the assessment model catch assuming 100% mortality.

		Gulf of Alaska		Bering Sea/Aleutian Islands	
Year	**Gear Type**	**Retained**	**Discarded**	**Retained**	**Discarded**
2020	HAL	4,954	440	188	231
	POT	4,614	136	948	32
	TRW	1,088	1,243	2,239	2,924
2021	HAL	3,723	354	252	315
	POT	9,647	193	1,881	50
	TRW	1,142	460	1,374	1,875
2022	HAL	3,234	401	200	222
	POT	13,493	156	3,781	56
	TRW	1,354	527	2,209	1,276
2023	HAL	2,655	335	188	135
	POT	11,850	94	4,155	9
	TRW	1,173	291	3,648	485
2024	HAL	1,916	162	85	161
	JIG	0.01	NA	NA	NA
	POT	10,052	55	1,043	5
	TRW	993	229	3,864	48

Table SM3.4. Bycatch (t) of FMP groundfish species by year in the targeted sablefish fishery. Source: NMFS Alaskan Regional Office Catch Accounting System via AKFIN (www.akfin.org), accessed on October 10, 2024.

	2020		2021		2022		2023		2024	
Species	**R**	**D**	**R**	**D**	**R**	**D**	**R**	**D**	**R**	**D**
Arrowtooth Flounder	24.1	410.6	34.4	504.1	38.5	435.0	170.5	237.8	456.5	80.0
BSAI Kamchatka Flounder	9.0	7.4	9.7	3.9	60.3	18.9	235.6	26.6	497.3	12.9
BSAI Other Flatfish	0.7	0.2	5.0	0.7	22.4	14.6	133.8	6.3	374.8	19.9
BSAI Shortraker Rockfish	1.1	0.3	1.6	0.1	6.4	2.3	16.9	2.3	14.0	2.6
BSAI and GOA Skate	0.5	174.3	3.9	68.3	0.6	71.9	4.4	214.2	21.3	98.8
Flathead Sole	6.5	5.3	3.0	1.4	31.4	5.3	79.8	3.1	269.2	7.6
GOA Deep Water Flatfish	0.2	14.3	0.6	13.6	2.0	19.9	0.1	14.3	0.2	14.0
GOA Demersal Shelf Rockfish	9.8	1.0	17.5	2.1	20.7	2.2	17.9	0.5	20.9	0.3
GOA Rex Sole	1.5	6.8	0.3	2.2	0.7	3.3	2.1	0.9	3.8	1.4
GOA Skate, Big	0.7	28.0	2.4	31.0	1.5	27.7	1.6	22.2	0.4	2.4
GOA Skate, Longnose	7.9	54.1	4.8	122.3	4.7	212.8	4.6	91.7	3.4	29.6
GOA Thornyhead Rockfish	227.1	18.6	108.9	12.2	76.3	11.5	60.3	6.4	51.8	4.6
Greenland Turbot	10.4	1.0	1.9	1.7	91.3	7.2	117.9	23.3	237.7	5.3
Halibut	589.1	217.1	604.3	222.7	663.5	299.0	548.9	284.3	424.9	94.0
Octopus	0.0	2.6	0.0	1.3	0.2	2.1	0.2	25.3	0.0	3.1
Other Rockfish	17.6	12.8	22.6	27.8	119.6	26.1	106.6	52.9	395.5	82.8
Pacific Cod	39.7	19.9	64.6	16.4	23.6	13.2	44.3	4.4	135.7	11.2
Pacific Ocean Perch	58.5	1.7	23.7	0.4	40.7	12.4	104.7	18.0	124.2	8.3
Pollock	6.7	13.8	5.2	55.8	26.3	13.0	139.0	15.4	322.0	10.7
Rougheye Rockfish	125.2	49.2	96.6	62.5	98.7	35.2	105.2	19.0	66.4	12.0
Shortraker Rockfish	100.4	135.6	71.1	116.4	56.9	35.6	58.6	18.9	37.1	18.8

Table SM3.5. Bycatch of nontarget species and HAPC biota in the targeted sablefish fishery. Source: NMFS AKRO Blend/Catch Accounting System via AKFIN, October 10, 2024.

Species Group	2020	2021	2022	2023	2024
Benthic urochordata	0.01	0.07	0.04	0.18	0.11
Brittle star	0.29	0.33	2.56	0.60	1.93
Corals Bryozoans	1.08	1.48	2.91	0.43	0.27
Eelpouts	0.14	0.55	9.52	19.75	92.54
Giant Grenadier	1,408.95	795.91	589.45	955.23	700.49
Grenadier	482.61	167.89	143.37	148.39	15.12
Hermit crab	0.01	0.01	0.07	0.07	0.36
Invertebrate	0.06	0.13	0.24	0.04	0.12
Misc crabs	4.25	3.86	5.35	8.71	8.38
Misc fish	39.16	29.05	71.71	38.42	10.69
Pandalid shrimp	0.04	--	0.04	0.29	0.43
Sculpin	--	4.26	6.91	171.66	11.78
Scypho jellies	0.34	0.26	0.58	1.06	0.76
Sea anemone	1.01	2.58	3.90	8.57	14.17
Sea pens whips	0.54	0.22	0.04	0.27	0.65
Sea star	7.47	3.83	16.68	32.64	49.15
Snails	2.91	3.71	7.08	20.07	2.16
Sponge	0.33	0.30	0.68	1.31	1.47
Squid	0.73	0.47	10.26	24.08	55.49
Urchins, dollars, cucumbers	0.54	0.34	1.39	5.55	29.73

Table SM3.6. Prohibited Species Catch (PSC) estimates (in metric tons for halibut and numbers of animals for crab and salmon) by year and management (FMP) region for the sablefish target fishery. HAL is hook and line gear; POT is pot gear; and TRW is trawl gear. Source: NMFS Alaska Regional Office Catch Accounting System PSCNQ via AKFIN (www.akfin.org), accessed on October 10, 2024.

Gulf of Alaska

Species	Gear Type	2020	2021	2022	2023	2024
Bairdi Tanner Crab	HAL	-	10	16	29	16
	POT	96	359	481	71	25
	TRW	1,668	1,535	1,554	250	-
Blue King Crab	HAL	-	-	-	-	-
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Chinook Salmon	HAL	-	-	-	-	-
	POT	-	-	-	-	-
	TRW	-	711	-	-	-
Golden (Brown) King Crab	HAL	47	17	30	5	0
	POT	39	64	187	1,470	1,432
	TRW	-	-	-	16	-
Halibut	HAL	147	117	116	33	33
	POT	37	73	78	37	15
	TRW	21	35	18	3	2
Herring	HAL	-	-	-	-	-
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Non-Chinook Salmon	HAL	114	149	11	-	0
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Opilio Tanner (Snow) Crab	HAL	-	-	-	-	-
	POT	2	-	-	-	-
	TRW	-	-	-	-	-
Red King Crab	HAL	-	0	-	-	-
	POT	-	-	-	-	-
	TRW	-	-	-	-	-

Bering Sea/Aleutian Islands

Species	Gear Type	2020	2021	2022	2023	2024
Bairdi Tanner Crab	HAL	2	4	14	49	1
	POT	167	685	1,288	133	123
	TRW	-	-	69	1,223	1,469
Blue King Crab	HAL	1	0	9	6	0
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Chinook Salmon	HAL	0	0	0	0	0
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Golden (Brown) King Crab	HAL	0	42	2	1	46
	POT	5,789	28,750	10,340	22,792	6,992
	TRW	-	135	618	2,510	1,193
Halibut	HAL	4	11	0	0	-
	POT	7	10	13	8	8
	TRW	1	3	7	29	46
Herring	HAL	-	-	-	-	-
	POT	-	-	-	-	-
	TRW	-	0	-	0	1
Non-Chinook Salmon	HAL	0	0	0	0	0
	POT	-	-	-	-	-
	TRW	-	-	-	-	-
Opilio Tanner (Snow) Crab	HAL	14	29	44	204	8
	POT	374	846	1,675	1,274	65
	TRW	-	-	171	212	59
Red King Crab	HAL	0	0	2	3	0
	POT	18	-	-	25	-
	TRW	-	-	-	-	76

Additional Assessment Inputs and Outputs

Table SM3.7. Estimates of von Bertalanffy growth parameters and length-weight parameters for sablefish (top panel) and associated fork length (cm), weight (kg), and proportion mature by age and sex (bottom panel). The 2021 values represent estimates used in previous assessments as estimated in Echave (2021). The 2026 estimates represent the updated growth and weight estimates using all NOAA Longline Survey data from 1996 through 2023.

Parameter	Type	Sex	2021 Estimates	2026 Estimates
L_∞	Length-at-age	Female	81.2	81.5
L_∞	Length-at-age	Male	67.9	67.9
k	Length-at-age	Female	0.17	0.16
k	Length-at-age	Male	0.23	0.22
t_0	Length-at-age	Female	3.28	3.45
t_0	Length-at-age	Male	3.30	3.62
W_∞	Weight-at-age / Length-weight	Female	5.87	5.92
W_∞	Weight-at-age / Length-weight	Male	3.22	3.29
β	Weight-at-age / Length-weight	Female	3.02	3.23
β	Weight-at-age / Length-weight	Male	3.02	3.19

	Fork Length (cm)				Round Weight (kg)				Maturity
Age	2021 Male	2026 Male	2021 Female	2026 Female	2021 Male	2026 Male	2021 Female	2026 Female	Female
2	47.9	47.8	48.0	47.9	1.1	1.1	1.1	1.1	0.02
3	52.0	51.7	53.2	52.9	1.4	1.4	1.6	1.5	0.05
4	55.3	54.9	57.6	57.2	1.8	1.7	2.0	1.9	0.09
5	57.9	57.4	61.3	60.8	2.1	1.9	2.5	2.3	0.18
6	60.0	59.5	64.4	63.9	2.3	2.1	2.9	2.7	0.31
7	61.6	61.1	67.0	66.6	2.5	2.3	3.3	3.1	0.49
8	62.9	62.4	69.2	68.8	2.7	2.5	3.6	3.4	0.67
9	64.0	63.5	71.1	70.7	2.8	2.6	3.9	3.7	0.81
10	64.8	64.4	72.7	72.3	2.9	2.8	4.2	4.0	0.90
11	65.4	65.1	74.0	73.7	3.0	2.9	4.4	4.3	0.95
12	66.0	65.7	75.1	74.9	3.0	2.9	4.7	4.5	0.98
13	66.4	66.1	76.1	75.9	3.1	3.0	4.8	4.7	0.99
14	66.7	66.5	76.9	76.7	3.1	3.1	5.0	4.9	0.99
15	66.9	66.8	77.6	77.5	3.1	3.1	5.1	5.0	1.00
16	67.1	67.0	78.1	78.1	3.2	3.1	5.2	5.1	1.00
17	67.3	67.2	78.6	78.6	3.2	3.2	5.3	5.3	1.00
18	67.4	67.4	79.0	79.0	3.2	3.2	5.4	5.4	1.00
19	67.5	67.5	79.4	79.4	3.2	3.2	5.5	5.4	1.00
20	67.6	67.6	79.7	79.7	3.2	3.2	5.5	5.5	1.00
21	67.7	67.7	79.9	80.0	3.2	3.2	5.6	5.6	1.00
22	67.7	67.7	80.1	80.2	3.2	3.2	5.6	5.6	1.00
23	67.8	67.8	80.3	80.4	3.2	3.3	5.7	5.7	1.00
24	67.8	67.8	80.4	80.6	3.2	3.3	5.7	5.7	1.00
25	67.8	67.9	80.6	80.7	3.2	3.3	5.7	5.7	1.00
26	67.9	67.9	80.7	80.8	3.2	3.3	5.8	5.8	1.00
27	67.9	67.9	80.8	81.0	3.2	3.3	5.8	5.8	1.00
28	67.9	67.9	80.8	81.0	3.2	3.3	5.8	5.8	1.00
29	67.9	67.9	80.9	81.1	3.2	3.3	5.8	5.8	1.00
30	67.9	67.9	80.9	81.2	3.2	3.3	5.8	5.8	1.00
31+	67.9	68.0	81.0	81.2	3.2	3.3	5.8	5.9	1.00

Table SM3.8. Maximum likelihood estimation parameter values and standard errors from the inverse of the Hessian for all estimated parameters for Model *26.1_1Reg*.

Parameter	Estimate	Std. Error
ln_global_R0	2.97	0.13
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.01	0.40
ln_RecDevs	0.00	0.40
ln_RecDevs	0.01	0.40
ln_RecDevs	0.04	0.40
ln_RecDevs	0.08	0.41
ln_RecDevs	0.12	0.42
ln_RecDevs	0.14	0.42
ln_RecDevs	0.14	0.42
ln_RecDevs	0.12	0.42
ln_RecDevs	0.08	0.41
ln_RecDevs	0.03	0.40
ln_RecDevs	-0.03	0.39

ln_RecDevs	-0.08	0.38
ln_RecDevs	-0.13	0.37
ln_RecDevs	-0.18	0.36
ln_RecDevs	-0.23	0.35
ln_RecDevs	-0.72	0.66
ln_RecDevs	-0.74	0.64
ln_RecDevs	-0.72	0.64
ln_RecDevs	-0.53	0.65
ln_RecDevs	0.32	0.59
ln_RecDevs	1.48	0.27
ln_RecDevs	0.02	0.80
ln_RecDevs	0.50	0.75
ln_RecDevs	1.53	0.28
ln_RecDevs	-0.35	0.72
ln_RecDevs	-0.27	0.66
ln_RecDevs	0.30	0.46
ln_RecDevs	-0.65	0.61
ln_RecDevs	-0.88	0.60
ln_RecDevs	-0.27	0.49
ln_RecDevs	-0.38	0.58
ln_RecDevs	0.49	0.28
ln_RecDevs	-0.58	0.62
ln_RecDevs	0.33	0.34
ln_RecDevs	-0.24	0.50
ln_RecDevs	-0.44	0.50
ln_RecDevs	-0.09	0.40
ln_RecDevs	0.14	0.33
ln_RecDevs	-0.48	0.54
ln_RecDevs	0.63	0.25
ln_RecDevs	0.22	0.41
ln_RecDevs	0.03	0.51
ln_RecDevs	0.81	0.26
ln_RecDevs	0.05	0.45
ln_RecDevs	-0.39	0.51
ln_RecDevs	-0.30	0.42
ln_RecDevs	-0.62	0.49
ln_RecDevs	-0.42	0.42
ln_RecDevs	-0.34	0.45
ln_RecDevs	0.09	0.37
ln_RecDevs	0.06	0.37
ln_RecDevs	-0.42	0.48
ln_RecDevs	-0.42	0.40
ln_RecDevs	-0.97	0.51
ln_RecDevs	-0.65	0.48

ln_RecDevs	-0.09	0.41
ln_RecDevs	1.21	0.21
ln_RecDevs	0.26	0.55
ln_RecDevs	2.02	0.19
ln_RecDevs	1.72	0.30
ln_RecDevs	0.85	0.68
ln_RecDevs	0.92	0.65
ln_RecDevs	1.03	0.69
ln_RecDevs	0.71	0.87
ln_RecDevs	0.47	1.00
ln_M	-2.39	0.07
ln_M	-2.41	0.07
ln_F_mean	-3.03	0.13
ln_F_mean	-4.18	0.22
ln_F_devs	-2.13	0.13
ln_F_devs	-0.47	0.13
ln_F_devs	0.05	0.13
ln_F_devs	-0.83	0.13
ln_F_devs	-0.03	0.14
ln_F_devs	-1.98	0.13
ln_F_devs	-0.47	0.14
ln_F_devs	-3.27	0.13
ln_F_devs	0.20	0.14
ln_F_devs	-1.83	0.13
ln_F_devs	0.62	0.14
ln_F_devs	-1.80	0.13
ln_F_devs	0.89	0.13
ln_F_devs	-0.72	0.13
ln_F_devs	1.18	0.13
ln_F_devs	-0.36	0.12
ln_F_devs	1.31	0.13
ln_F_devs	0.07	0.12
ln_F_devs	1.02	0.13
ln_F_devs	0.14	0.12
ln_F_devs	1.39	0.13
ln_F_devs	0.45	0.12
ln_F_devs	1.65	0.12
ln_F_devs	0.33	0.12
ln_F_devs	1.16	0.12
ln_F_devs	0.49	0.12
ln_F_devs	0.83	0.12
ln_F_devs	0.47	0.12
ln_F_devs	0.58	0.12
ln_F_devs	0.62	0.12

ln_F_devs	0.60	0.12
ln_F_devs	0.40	0.12
ln_F_devs	-0.25	0.12
ln_F_devs	-0.27	0.12
ln_F_devs	-0.94	0.12
ln_F_devs	-0.10	0.12
ln_F_devs	-0.70	0.12
ln_F_devs	-0.27	0.11
ln_F_devs	-0.45	0.12
ln_F_devs	-0.01	0.12
ln_F_devs	-0.69	0.11
ln_F_devs	-0.22	0.12
ln_F_devs	-0.61	0.11
ln_F_devs	-0.35	0.11
ln_F_devs	-0.81	0.11
ln_F_devs	-0.38	0.11
ln_F_devs	-0.02	0.11
ln_F_devs	-0.26	0.11
ln_F_devs	-1.00	0.11
ln_F_devs	0.17	0.11
ln_F_devs	0.55	0.11
ln_F_devs	0.46	0.11
ln_F_devs	0.60	0.11
ln_F_devs	0.60	0.11
ln_F_devs	0.83	0.11
ln_F_devs	0.63	0.11
ln_F_devs	0.68	0.11
ln_F_devs	0.66	0.11
ln_F_devs	0.32	0.11
ln_F_devs	0.66	0.11
ln_F_devs	-0.03	0.11
ln_F_devs	0.64	0.11
ln_F_devs	-0.02	0.11
ln_F_devs	0.77	0.11
ln_F_devs	-0.11	0.11
ln_F_devs	0.71	0.11
ln_F_devs	0.11	0.11
ln_F_devs	0.63	0.11
ln_F_devs	0.05	0.11
ln_F_devs	0.49	0.11
ln_F_devs	-0.08	0.11
ln_F_devs	0.38	0.11
ln_F_devs	-0.35	0.11
ln_F_devs	0.37	0.11

ln_F_devs	-0.42	0.11
ln_F_devs	0.31	0.11
ln_F_devs	-0.14	0.11
ln_F_devs	0.48	0.11
ln_F_devs	-0.12	0.11
ln_F_devs	0.36	0.11
ln_F_devs	-0.25	0.11
ln_F_devs	0.34	0.11
ln_F_devs	-0.05	0.11
ln_F_devs	0.45	0.11
ln_F_devs	-0.16	0.11
ln_F_devs	0.49	0.11
ln_F_devs	-0.39	0.11
ln_F_devs	0.39	0.11
ln_F_devs	-0.46	0.11
ln_F_devs	0.36	0.11
ln_F_devs	-0.69	0.11
ln_F_devs	0.41	0.11
ln_F_devs	-0.69	0.11
ln_F_devs	0.36	0.11
ln_F_devs	-0.77	0.11
ln_F_devs	0.30	0.11
ln_F_devs	-0.81	0.11
ln_F_devs	0.24	0.11
ln_F_devs	-0.85	0.11
ln_F_devs	0.33	0.11
ln_F_devs	-0.68	0.11
ln_F_devs	0.39	0.11
ln_F_devs	-0.73	0.11
ln_F_devs	0.40	0.11
ln_F_devs	-0.76	0.11
ln_F_devs	0.25	0.11
ln_F_devs	-0.74	0.11
ln_F_devs	0.24	0.11
ln_F_devs	-0.66	0.11
ln_F_devs	0.13	0.11
ln_F_devs	-0.49	0.11
ln_F_devs	0.16	0.12
ln_F_devs	0.02	0.12
ln_F_devs	0.06	0.12
ln_F_devs	0.39	0.12
ln_F_devs	-0.06	0.13
ln_F_devs	0.54	0.13
ln_F_devs	-0.37	0.13

ln_F_devs	0.77	0.13
ln_F_devs	-0.22	0.12
ln_F_devs	0.19	0.13
ln_F_devs	-0.04	0.12
ln_F_devs	0.16	0.13
ln_F_devs	-0.20	0.12
ln_F_devs	0.11	0.13
ln_F_devs	-0.35	0.12
ln_F_devs	0.01	0.13
ln_F_devs	-0.30	0.12
ln_F_devs	-0.34	0.12
ln_fish_fixed_sel_pars	1.08	0.08
ln_fish_fixed_sel_pars	1.10	0.51
ln_fish_fixed_sel_pars	0.70	0.09
ln_fish_fixed_sel_pars	1.54	0.79
ln_fish_fixed_sel_pars	1.08	0.09
ln_fish_fixed_sel_pars	1.12	0.62
ln_fish_fixed_sel_pars	0.88	0.16
ln_fish_fixed_sel_pars	0.81	0.51
ln_fish_fixed_sel_pars	1.78	0.58
ln_fish_fixed_sel_pars	-1.67	0.69
ln_fish_fixed_sel_pars	1.41	0.29
ln_fish_fixed_sel_pars	-0.42	0.43
ln_srv_fixed_sel_pars	0.87	0.09
ln_srv_fixed_sel_pars	1.56	0.70
ln_srv_fixed_sel_pars	0.64	0.07
ln_srv_fixed_sel_pars	1.17	0.30
ln_srv_fixed_sel_pars	1.06	0.06
ln_srv_fixed_sel_pars	0.78	0.27
ln_srv_fixed_sel_pars	0.84	0.11
ln_srv_fixed_sel_pars	0.60	0.34
ln_srv_fixed_sel_pars	0.81	0.09
ln_srv_fixed_sel_pars	1.41	1.18
ln_srv_fixed_sel_pars	1.01	0.12
ln_srv_fixed_sel_pars	1.16	0.87
ln_srv_q	1.91	0.10
ln_srv_q	1.71	0.09

Table SM3.9. Maximum likelihood estimation parameter values and standard errors from the inverse of the Hessian for all estimated parameters for Model *26.2_FAA*.

Parameter	Estimate	Std. Error
ln_global_R0	2.76	0.11
ln_InitDevs	0.00	0.40
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.06	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.05	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.04	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.03	0.39
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.02	0.40
ln_InitDevs	-0.01	0.40
ln_InitDevs	-0.01	0.40
ln_RecDevs	0.02	0.40
ln_RecDevs	0.04	0.41
ln_RecDevs	0.08	0.41
ln_RecDevs	0.14	0.43
ln_RecDevs	0.20	0.44
ln_RecDevs	0.23	0.45
ln_RecDevs	0.24	0.45
ln_RecDevs	0.21	0.44
ln_RecDevs	0.17	0.43
ln_RecDevs	0.11	0.42
ln_RecDevs	0.04	0.40

ln_RecDevs	-0.03	0.39
ln_RecDevs	-0.10	0.37
ln_RecDevs	-0.17	0.36
ln_RecDevs	-0.23	0.35
ln_RecDevs	-0.75	0.65
ln_RecDevs	-0.79	0.64
ln_RecDevs	-0.75	0.64
ln_RecDevs	-0.52	0.66
ln_RecDevs	0.32	0.66
ln_RecDevs	1.61	0.28
ln_RecDevs	-0.06	0.80
ln_RecDevs	0.39	0.83
ln_RecDevs	1.49	0.31
ln_RecDevs	-0.25	0.75
ln_RecDevs	-0.21	0.68
ln_RecDevs	0.21	0.52
ln_RecDevs	-0.56	0.63
ln_RecDevs	-0.56	0.62
ln_RecDevs	-0.13	0.56
ln_RecDevs	0.02	0.59
ln_RecDevs	0.31	0.46
ln_RecDevs	0.11	0.52
ln_RecDevs	0.05	0.39
ln_RecDevs	-1.06	0.54
ln_RecDevs	-0.37	0.39
ln_RecDevs	0.06	0.27
ln_RecDevs	-0.28	0.44
ln_RecDevs	0.50	0.24
ln_RecDevs	-0.13	0.44
ln_RecDevs	-0.31	0.43
ln_RecDevs	0.15	0.37
ln_RecDevs	0.89	0.20
ln_RecDevs	0.10	0.37
ln_RecDevs	-0.72	0.50
ln_RecDevs	-0.47	0.35
ln_RecDevs	-1.35	0.52
ln_RecDevs	-0.14	0.32
ln_RecDevs	-0.42	0.45
ln_RecDevs	0.38	0.29
ln_RecDevs	0.24	0.30
ln_RecDevs	-0.40	0.45
ln_RecDevs	-0.55	0.42
ln_RecDevs	-0.58	0.47
ln_RecDevs	-0.67	0.51

ln_RecDevs	-0.24	0.42
ln_RecDevs	1.73	0.17
ln_RecDevs	0.98	0.34
ln_RecDevs	1.82	0.23
ln_RecDevs	2.32	0.17
ln_RecDevs	0.03	0.75
ln_RecDevs	0.00	0.64
ln_RecDevs	0.35	0.70
ln_RecDevs	-0.18	0.78
ln_RecDevs	-0.12	0.81
ln_M	-2.43	0.07
ln_M	-2.44	0.08
ln_F_mean	-2.65	0.11
ln_F_mean	-3.88	0.15
ln_F_devs	-2.31	0.13
ln_F_devs	-0.66	0.13
ln_F_devs	-0.13	0.13
ln_F_devs	-1.00	0.13
ln_F_devs	-0.21	0.15
ln_F_devs	-2.15	0.13
ln_F_devs	-0.64	0.14
ln_F_devs	-3.45	0.13
ln_F_devs	0.02	0.14
ln_F_devs	-2.01	0.13
ln_F_devs	0.44	0.14
ln_F_devs	-1.98	0.13
ln_F_devs	0.71	0.14
ln_F_devs	-0.91	0.13
ln_F_devs	1.00	0.13
ln_F_devs	-0.54	0.13
ln_F_devs	1.12	0.13
ln_F_devs	-0.10	0.12
ln_F_devs	0.84	0.13
ln_F_devs	-0.02	0.12
ln_F_devs	1.22	0.13
ln_F_devs	0.30	0.12
ln_F_devs	1.50	0.13
ln_F_devs	0.20	0.12
ln_F_devs	1.03	0.13
ln_F_devs	0.38	0.12
ln_F_devs	0.71	0.13
ln_F_devs	0.37	0.12
ln_F_devs	0.47	0.13
ln_F_devs	0.54	0.12

ln_F_devs	0.51	0.13
ln_F_devs	0.34	0.12
ln_F_devs	-0.32	0.13
ln_F_devs	-0.31	0.12
ln_F_devs	-1.01	0.13
ln_F_devs	-0.14	0.12
ln_F_devs	-0.76	0.12
ln_F_devs	-0.30	0.12
ln_F_devs	-0.47	0.12
ln_F_devs	-0.06	0.13
ln_F_devs	-0.70	0.12
ln_F_devs	-0.32	0.12
ln_F_devs	-0.64	0.12
ln_F_devs	-0.45	0.12
ln_F_devs	-0.86	0.12
ln_F_devs	-0.50	0.12
ln_F_devs	-0.10	0.12
ln_F_devs	-0.38	0.12
ln_F_devs	-1.11	0.12
ln_F_devs	0.07	0.12
ln_F_devs	0.41	0.12
ln_F_devs	0.36	0.11
ln_F_devs	0.46	0.12
ln_F_devs	0.52	0.11
ln_F_devs	0.70	0.11
ln_F_devs	0.59	0.11
ln_F_devs	0.58	0.12
ln_F_devs	0.64	0.11
ln_F_devs	0.25	0.12
ln_F_devs	0.66	0.11
ln_F_devs	-0.05	0.12
ln_F_devs	0.64	0.11
ln_F_devs	-0.02	0.12
ln_F_devs	0.79	0.11
ln_F_devs	-0.07	0.12
ln_F_devs	0.74	0.11
ln_F_devs	0.17	0.11
ln_F_devs	0.68	0.11
ln_F_devs	0.13	0.11
ln_F_devs	0.60	0.11
ln_F_devs	0.02	0.11
ln_F_devs	0.52	0.11
ln_F_devs	-0.22	0.11
ln_F_devs	0.52	0.11

ln_F_devs	-0.28	0.11
ln_F_devs	0.47	0.11
ln_F_devs	0.03	0.11
ln_F_devs	0.60	0.11
ln_F_devs	0.06	0.11
ln_F_devs	0.50	0.11
ln_F_devs	-0.06	0.11
ln_F_devs	0.54	0.11
ln_F_devs	0.15	0.11
ln_F_devs	0.67	0.12
ln_F_devs	0.06	0.11
ln_F_devs	0.68	0.12
ln_F_devs	-0.17	0.12
ln_F_devs	0.57	0.12
ln_F_devs	-0.26	0.12
ln_F_devs	0.54	0.11
ln_F_devs	-0.50	0.12
ln_F_devs	0.62	0.11
ln_F_devs	-0.49	0.12
ln_F_devs	0.62	0.11
ln_F_devs	-0.54	0.11
ln_F_devs	0.57	0.11
ln_F_devs	-0.56	0.11
ln_F_devs	0.52	0.12
ln_F_devs	-0.58	0.11
ln_F_devs	0.57	0.12
ln_F_devs	-0.41	0.11
ln_F_devs	0.60	0.12
ln_F_devs	-0.47	0.11
ln_F_devs	0.58	0.12
ln_F_devs	-0.53	0.12
ln_F_devs	0.43	0.12
ln_F_devs	-0.54	0.12
ln_F_devs	0.41	0.12
ln_F_devs	-0.47	0.12
ln_F_devs	0.32	0.12
ln_F_devs	-0.30	0.12
ln_F_devs	0.37	0.15
ln_F_devs	0.17	0.12
ln_F_devs	0.15	0.24
ln_F_devs	0.52	0.14
ln_F_devs	-0.08	0.22
ln_F_devs	0.56	0.15
ln_F_devs	-0.39	0.23

ln_F_devs	0.68	0.16
ln_F_devs	-0.35	0.24
ln_F_devs	-0.01	0.16
ln_F_devs	-0.27	0.17
ln_F_devs	-0.11	0.16
ln_F_devs	-0.41	0.14
ln_F_devs	-0.20	0.15
ln_F_devs	-0.50	0.13
ln_F_devs	-0.28	0.14
ln_F_devs	-0.40	0.14
ln_F_devs	-0.60	0.14
ln_fish_fixed_sel_pars	1.25	0.10
ln_fish_fixed_sel_pars	0.97	0.61
ln_fish_fixed_sel_pars	1.08	0.27
ln_fish_fixed_sel_pars	0.54	0.70
ln_fish_fixed_sel_pars	0.86	0.18
ln_fish_fixed_sel_pars	1.68	1.00
ln_fish_fixed_sel_pars	1.08	0.29
ln_fish_fixed_sel_pars	0.56	0.75
ln_fish_fixed_sel_pars	1.57	0.25
ln_fish_fixed_sel_pars	-0.61	0.43
ln_fish_fixed_sel_pars	1.35	0.20
ln_fish_fixed_sel_pars	0.07	0.43
ln_srv_fixed_sel_pars	1.10	0.07
ln_srv_fixed_sel_pars	1.60	0.79
ln_srv_fixed_sel_pars	0.48	0.21
ln_srv_fixed_sel_pars	2.14	0.70
ln_srv_fixed_sel_pars	1.21	0.09
ln_srv_fixed_sel_pars	1.74	0.86
ln_srv_fixed_sel_pars	0.64	0.10
ln_srv_fixed_sel_pars	1.77	0.76
ln_srv_fixed_sel_pars	0.90	0.12
ln_srv_fixed_sel_pars	2.26	0.61
ln_srv_fixed_sel_pars	0.35	0.18
ln_srv_fixed_sel_pars	1.76	0.62
ln_srv_fixed_sel_pars	1.07	0.04
ln_srv_fixed_sel_pars	1.69	0.72
ln_srv_fixed_sel_pars	0.60	0.11
ln_srv_fixed_sel_pars	1.18	0.36
ln_srv_fixed_sel_pars	1.10	0.09
ln_srv_fixed_sel_pars	0.55	0.30
ln_srv_fixed_sel_pars	1.90	0.16
ln_srv_fixed_sel_pars	-1.16	0.26
ln_srv_fixed_sel_pars	1.23	0.10

ln_srv_fixed_sel_pars	0.30	0.28
ln_srv_fixed_sel_pars	1.97	0.15
ln_srv_fixed_sel_pars	-1.11	0.24
ln_srv_fixed_sel_pars	0.89	0.11
ln_srv_fixed_sel_pars	1.32	0.76
ln_srv_fixed_sel_pars	1.31	0.16
ln_srv_fixed_sel_pars	0.07	0.36
ln_srv_q	0.55	0.10
ln_srv_q	0.34	0.10
ln_srv_q	2.20	0.08
ln_srv_q	2.08	0.08

Table SM3.10. Number (in millions of fish) of sablefish estimated by Model *26.1_1Reg* by age and year. Columns are age with age-31+ being the plus group. The terminal year plus one (2026) numbers are incremented based on the terminal year (2025) mortality and recruitment is set at 0.

Year	Sex	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31+
1960	Female	9.7	8.8	7.9	7.0	6.4	5.8	5.3	4.8	4.3	4.0	3.6	3.3	3.0	2.7	2.5	2.3	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	6.6
1961	Female	9.8	8.9	8.0	7.2	6.4	5.8	5.2	4.8	4.3	3.9	3.6	3.3	3.0	2.7	2.5	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	6.5
1962	Female	10.1	9.0	8.1	7.2	6.3	5.7	5.1	4.6	4.2	3.8	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	6.4
1963	Female	10.5	9.2	8.2	7.2	6.3	5.5	4.9	4.4	4.0	3.7	3.3	3.0	2.8	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	6.1
1964	Female	11.0	9.6	8.3	7.3	6.4	5.6	4.9	4.4	3.9	3.6	3.2	2.9	2.7	2.4	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	5.9
1965	Female	11.2	10.0	8.7	7.6	6.6	5.8	5.0	4.4	3.9	3.5	3.2	2.9	2.7	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	5.8
1966	Female	11.2	10.2	9.0	7.9	6.8	6.0	5.2	4.5	4.0	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	5.7
1967	Female	10.9	10.1	9.2	8.1	7.0	6.1	5.3	4.6	4.0	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.5
1968	Female	10.5	9.9	9.1	8.2	7.3	6.3	5.4	4.7	4.1	3.6	3.1	2.8	2.5	2.3	2.0	1.8	1.7	1.5	1.4	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	5.3
1969	Female	9.9	9.4	8.9	8.1	7.2	6.3	5.5	4.7	4.1	3.5	3.1	2.7	2.4	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	5.0
1970	Female	9.3	8.9	8.4	7.8	7.0	6.2	5.4	4.7	4.0	3.5	3.0	2.6	2.3	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	4.6
1971	Female	8.8	8.4	8.0	7.3	6.6	5.9	5.2	4.6	3.9	3.4	2.9	2.5	2.2	1.9	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	4.2
1972	Female	8.3	7.9	7.5	6.9	6.2	5.6	5.0	4.4	3.8	3.3	2.8	2.4	2.1	1.8	1.6	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	3.7
1973	Female	7.9	7.4	7.0	6.4	5.7	5.1	4.5	4.0	3.5	3.1	2.6	2.2	1.9	1.7	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	3.2
1974	Female	7.5	7.1	6.7	6.0	5.4	4.7	4.2	3.8	3.3	2.9	2.5	2.2	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	2.9
1975	Female	3.9	6.8	6.4	5.7	5.0	4.4	3.9	3.5	3.1	2.7	2.4	2.1	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	2.6
1976	Female	3.8	3.6	6.1	5.5	4.8	4.2	3.7	3.3	2.9	2.6	2.3	2.0	1.7	1.5	1.2	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	2.3
1977	Female	3.8	3.4	3.2	5.3	4.6	4.0	3.5	3.0	2.7	2.4	2.1	1.9	1.6	1.4	1.2	1.0	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	2.1
1978	Female	4.4	3.4	3.1	2.8	4.5	3.9	3.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	1.9
1979	Female	10.2	4.0	3.1	2.8	2.5	3.9	3.4	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	1.9
1980	Female	31.7	9.3	3.7	2.8	2.4	2.2	3.4	2.9	2.6	2.2	2.0	1.7	1.5	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.8
1981	Female	7.2	28.9	8.4	3.3	2.4	2.1	1.9	3.0	2.6	2.2	1.9	1.7	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.7
1982	Female	11.5	6.6	26.2	7.4	2.8	2.1	1.8	1.6	2.6	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.6
1983	Female	31.1	10.4	5.9	23.4	6.5	2.5	1.8	1.6	1.4	2.3	1.9	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.6
1984	Female	4.8	28.3	9.5	5.3	20.6	5.7	2.2	1.6	1.4	1.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.5
1985	Female	5.1	4.3	25.7	8.4	4.7	18.0	5.0	1.9	1.4	1.2	1.1	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.4
1986	Female	9.1	4.7	3.9	22.9	7.4	4.1	15.8	4.4	1.7	1.2	1.1	1.0	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	1.4
1987	Female	3.5	8.2	4.2	3.4	19.6	6.3	3.5	13.4	3.7	1.4	1.0	0.9	0.8	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	1.3
1988	Female	2.8	3.2	7.4	3.7	2.9	16.4	5.3	2.9	11.2	3.1	1.2	0.9	0.8	0.7	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	1.2
1989	Female	5.2	2.5	2.9	6.4	3.0	2.4	13.4	4.3	2.4	9.1	2.5	1.0	0.7	0.6	0.5	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	1.1
1990	Female	4.6	4.7	2.3	2.5	5.3	2.5	2.0	11.0	3.5	1.9	7.5	2.1	0.8	0.6	0.5	0.4	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	1.0
1991	Female	11.0	4.2	4.2	2.0	2.0	4.3	2.0	1.6	9.0	2.9	1.6	6.1	1.7	0.6	0.5	0.4	0.4	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.9
1992	Female	3.8	10.0	3.8	3.6	1.6	1.7	3.6	1.7	1.3	7.4	2.4	1.3	5.0	1.4	0.5	0.4	0.3	0.3	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.8
1993	Female	9.4	3.5	9.0	3.3	3.0	1.4	1.4	3.0	1.4	1.1	6.1	2.0	1.1	4.1	1.1	0.4	0.3	0.3	0.2	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.8
1994	Female	5.3	8.5	3.1	7.8	2.7	2.5	1.1	1.1	2.4	1.1	0.9	5.0	1.6	0.9	3.4	0.9	0.4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.7
1995	Female	4.4	4.8	7.7	2.7	6.4	2.2	2.0	0.9	0.9	2.0	0.9	0.7	4.1	1.3	0.7	2.7	0.8	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1996	Female	6.2	4.0	4.4	6.7	2.2	5.3	1.8	1.7	0.7	0.8	1.6	0.8	0.6	3.4	1.1	0.6	2.3	0.6	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.6
1997	Female	7.8	5.6	3.6	3.8	5.6	1.9	4.4	1.5	1.4	0.6	0.6	1.4	0.6	0.5	2.8	0.9	0.5	1.9	0.5	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1998	Female	4.2	7.1	5.1	3.1	3.2	4.7	1.6	3.8	1.3	1.2	0.5	0.5	1.1	0.5	0.4	2.4	0.8	0.4	1.6	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
1999	Female	12.7	3.8	6.4	4.4	2.7	2.7	4.0	1.3	3.2	1.1	1.0	0.4	0.5	1.0	0.5	0.4	2.0	0.6	0.3	1.3	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
2000	Female	8.4	11.6	3.5	5.6	3.8	2.3	2.3	3.4	1.1	2.7	0.9	0.8	0.4	0.4	0.8	0.4	0.3	1.7	0.5	0.3	1.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5
2001	Female	7.0	7.6	10.5	3.0	4.7	3.2	1.9	1.9	2.9	0.9	2.3	0.8	0.7	0.3	0.3	0.7	0.3	0.3	1.4	0.4	0.2	0.9	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.5
2002	Female	15.2	6.4	6.9	9.2	2.6	4.0	2.7	1.6	1.6	2.4	0.8	1.9	0.7	0.6	0.3	0.3	0.6	0.3	0.2	1.2	0.4	0.2	0.8	0.2	0.1	0.1	0.1	0.0	0.1	0.5
2003	Female	7.1	13.8	5.7	6.1	7.8	2.2	3.4	2.3	1.4	1.4	2.0	0.7	1.6	0.5	0.5	0.2	0.2	0.5	0.2	0.2	1.0	0.3	0.2	0.7	0.2	0.1	0.1	0.0	0.0	0.5
2004	Female	4.6	6.4	12.5	5.0	5.1	6.6	1.8	2.8	1.9	1.1	1.2	1.7	0.6	1.3	0.5	0.4	0.2	0.2	0.4	0.2	0.1	0.8	0.3	0.1	0.6	0.2	0.1	0.0	0.0	0.4
2005	Female	5.0	4.2	5.8	10.9	4.2	4.3	5.5	1.5	2.4	1.6	1.0	1.0	1.4	0.5	1.1	0.4	0.4	0.2	0.2	0.3	0.2	0.1	0.7	0.2	0.1	0.5	0.1	0.0	0.0	0.4
2006	Female	3.6	4.5	3.8	5.1	9.2	3.6	3.6	4.7	1.3	2.0	1.4	0.8	0.8	1.2	0.4	0.9	0.3	0.3	0.1	0.1	0.3	0.1	0.1	0.6	0.2	0.1	0.4	0.1	0.0	0.4
2007	Female	4.5	3.3	4.1	3.3	4.3	7.8	3.0	3.1	3.9	1.1	1.7	1.1	0.7	0.7	1.0	0.3	0.8	0.3	0.3	0.1	0.1	0.2	0.1	0.1	0.5	0.2	0.1	0.3	0.1	0.3
2008	Female	4.8	4.1	3.0	3.6	2.8	3.7	6.6	2.6	2.6	3.3	0.9	1.4	1.0	0.6	0.6	0.9	0.3	0.7	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.4
2009	Female	7.4	4.4	3.7	2.6	3.1	2.4	3.1	5.6	2.2	2.2	2.8	0.8	1.2	0.8	0.5	0.5	0.7	0.2	0.6	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.5
2010	Female	7.2	6.7	4.0	3.2	2.3	2.6	2.0	2.7	4.8	1.9	1.9	2.4	0.7	1.0	0.7	0.4	0.4	0.6	0.2	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.5
2011	Female	4.4	6.5	6.1	3.5	2.8	1.9	2.2	1.7	2.3	4.1	1.6	1.6	2.1	0.6	0.9	0.6	0.4	0.4	0.5	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3	0.5
2012	Female	4.5	4.0	5.9	5.4	3.0	2.4	1.6	1.9	1.5	1.9	3.5	1.3	1.4	1.7	0.5	0.8	0.5	0.3	0.3	0.4	0.1	0.4	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.7
2013	Female	2.6	4.1	3.7	5.2	4.6	2.5	2.0	1.4	1.6	1.3	1.6	2.9	1.1	1.2	1.5	0.4	0.6	0.4	0.3	0.3	0.4	0.1	0.3	0.1	0.1	0.0	0.0	0.1	0.0	0.6
2014	Female	3.5	2.3	3.7	3.2	4.4	3.9	2.1	1.7	1.2	1.4	1.1	1.4	2.5	1.0	1.0	1.2	0.3	0.5	0.4	0.2	0.2	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.1	0.5
2015	Female	6.2	3.2	2.1	3.2	2.8	3.8	3.3	1.8	1.4	1.0	1.2	0.9	1.2	2.1	0.8	0.8	1.1	0.3	0.5	0.3	0.2	0.2	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.5
2016	Female	22.7	5.6	2.9	1.9	2.8	2.4	3.2	2.8	1.6	1.2	0.9	1.0	0.8	1.0	1.8	0.7	0.7	0.9	0.3	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.0	0.5
2017	Female	8.7	20.6	5.0	2.5	1.6	2.4	2.0	2.8	2.4	1.3	1.1	0.7	0.9	0.7	0.9	1.5	0.6	0.6	0.8	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.0	0.4
2018	Female	51.1	7.9	18.2	4.3	2.1	1.4	2.0	1.7	2.4	2.1	1.1	0.9	0.6	0.7	0.6	0.7	1.3	0.5	0.5	0.7	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.0	0.4
2019	Female	37.7	46.3	7.0	15.7	3.7	1.8	1.2	1.8	1.5	2.0	1.8	1.0	0.8	0.5	0.6	0.5	0.6	1.1	0.4	0.4	0.6	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.4

2020	Female	15.8	34.1	41.0	6.1	13.5	3.2	1.6	1.0	1.5	1.3	1.7	1.5	0.8	0.7	0.5	0.5	0.4	0.5	1.0	0.4	0.4	0.5	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.4
2021	Female	17.0	14.3	30.3	35.8	5.3	11.8	2.7	1.4	0.9	1.3	1.1	1.5	1.3	0.7	0.6	0.4	0.5	0.3	0.5	0.8	0.3	0.3	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.4
2022	Female	19.0	15.4	12.8	26.4	31.2	4.6	10.2	2.4	1.2	0.8	1.1	0.9	1.3	1.1	0.6	0.5	0.3	0.4	0.3	0.4	0.7	0.3	0.3	0.4	0.1	0.2	0.1	0.1	0.1	0.4
2023	Female	16.4	17.2	13.7	11.0	22.9	26.9	4.0	8.8	2.1	1.0	0.7	1.0	0.8	1.1	1.0	0.5	0.4	0.3	0.3	0.3	0.3	0.6	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.4
2024	Female	15.6	14.9	15.3	11.9	9.6	19.9	23.4	3.4	7.7	1.8	0.9	0.6	0.8	0.7	1.0	0.8	0.5	0.4	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.3	0.1	0.1	0.1	0.4
2025	Female	9.7	14.2	13.3	13.5	10.5	8.4	17.4	20.5	3.0	6.7	1.6	0.8	0.5	0.7	0.6	0.8	0.7	0.4	0.3	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.2	0.1	0.1	0.4
2026	Female	0.0	8.9	12.7	11.7	11.8	9.2	7.4	15.3	17.9	2.6	5.8	1.4	0.7	0.4	0.6	0.5	0.7	0.6	0.4	0.3	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.1	0.4
1960	Male	9.7	8.8	7.9	7.1	6.4	5.8	5.3	4.8	4.4	4.0	3.7	3.4	3.1	2.8	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	7.1
1961	Male	9.8	8.9	8.1	7.2	6.4	5.8	5.3	4.8	4.4	4.0	3.7	3.3	3.0	2.8	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	7.1
1962	Male	10.1	9.0	8.1	7.2	6.4	5.7	5.2	4.7	4.3	3.9	3.6	3.3	3.0	2.7	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	6.9
1963	Male	10.5	9.2	8.2	7.2	6.3	5.6	5.0	4.5	4.1	3.7	3.4	3.1	2.8	2.6	2.4	2.1	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	6.6
1964	Male	11.0	9.6	8.4	7.4	6.4	5.6	4.9	4.4	4.0	3.6	3.3	3.0	2.7	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	6.4
1965	Male	11.2	10.0	8.8	7.6	6.7	5.8	5.0	4.4	4.0	3.6	3.3	3.0	2.7	2.5	2.2	2.0	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	6.3
1966	Male	11.2	10.2	9.1	8.0	6.9	6.0	5.2	4.5	4.0	3.5	3.2	2.9	2.7	2.4	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	6.2
1967	Male	10.9	10.2	9.3	8.2	7.1	6.1	5.3	4.6	4.0	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	6.0
1968	Male	10.5	10.0	9.3	8.3	7.3	6.3	5.4	4.7	4.0	3.5	3.1	2.7	2.5	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.8
1969	Male	9.9	9.5	9.0	8.2	7.3	6.3	5.4	4.6	4.0	3.4	3.0	2.6	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	5.4
1970	Male	9.3	9.0	8.6	7.9	7.1	6.2	5.4	4.6	3.9	3.4	2.9	2.5	2.2	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	4.9
1971	Male	8.8	8.5	8.1	7.5	6.8	6.0	5.2	4.5	3.8	3.2	2.8	2.4	2.1	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	4.5
1972	Male	8.3	8.0	7.6	7.1	6.3	5.6	4.9	4.3	3.7	3.1	2.6	2.3	2.0	1.7	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	4.0
1973	Male	7.9	7.6	7.2	6.5	5.8	5.1	4.5	3.9	3.4	2.9	2.4	2.1	1.8	1.5	1.3	1.2	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	3.5
1974	Male	7.5	7.2	6.8	6.2	5.5	4.8	4.2	3.7	3.2	2.7	2.3	2.0	1.7	1.4	1.2	1.1	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	3.1
1975	Male	3.9	6.8	6.5	5.9	5.2	4.5	3.9	3.4	3.0	2.6	2.2	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	2.8
1976	Male	3.8	3.6	6.2	5.6	4.9	4.3	3.7	3.3	2.8	2.5	2.1	1.9	1.6	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	2.5
1977	Male	3.8	3.4	3.3	5.3	4.7	4.1	3.5	3.1	2.7	2.3	2.0	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	2.2
1978	Male	4.4	3.4	3.1	2.9	4.5	3.9	3.4	3.0	2.6	2.2	1.9	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	2.1
1979	Male	10.2	4.1	3.1	2.8	2.5	4.0	3.5	3.0	2.6	2.3	2.0	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	2.0
1980	Male	31.7	9.3	3.7	2.8	2.4	2.2	3.5	3.0	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.9
1981	Male	7.2	29.0	8.5	3.3	2.4	2.1	1.9	3.0	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.8
1982	Male	11.5	6.6	26.4	7.5	2.9	2.1	1.9	1.7	2.6	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	1.7
1983	Male	31.1	10.5	6.0	23.6	6.6	2.5	1.9	1.6	1.4	2.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	1.6
1984	Male	4.8	28.4	9.5	5.4	20.8	5.8	2.2	1.6	1.4	1.3	2.0	1.7	1.5	1.3	1.1	1.0	0.9	0.7	0.6	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.6
1985	Male	5.1	4.4	25.9	8.5	4.7	18.2	5.1	1.9	1.4	1.2	1.1	1.8	1.5	1.3	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	1.5
1986	Male	9.1	4.7	4.0	23.1	7.5	4.1	16.0	4.5	1.7	1.2	1.1	1.0	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	1.5
1987	Male	3.5	8.3	4.3	3.5	19.8	6.4	3.5	13.5	3.8	1.4	1.1	0.9	0.8	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	1.3
1988	Male	2.8	3.2	7.5	3.7	2.9	16.5	5.3	2.9	11.1	3.1	1.2	0.9	0.8	0.7	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	1.2
1989	Male	5.2	2.6	2.9	6.5	3.1	2.4	13.4	4.3	2.4	9.0	2.5	1.0	0.7	0.6	0.5	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	1.1
1990	Male	4.6	4.7	2.3	2.5	5.3	2.5	2.0	10.9	3.5	1.9	7.3	2.0	0.8	0.6	0.5	0.4	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	1.0
1991	Male	11.0	4.2	4.3	2.0	2.1	4.4	2.1	1.6	8.9	2.8	1.6	6.0	1.7	0.6	0.5	0.4	0.4	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.9
1992	Male	3.8	10.1	3.8	3.7	1.7	1.7	3.6	1.7	1.3	7.3	2.3	1.3	4.9	1.4	0.5	0.4	0.3	0.3	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.8
1993	Male	9.4	3.5	9.1	3.3	3.1	1.4	1.4	3.0	1.4	1.1	6.0	1.9	1.1	4.0	1.1	0.4	0.3	0.3	0.2	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.8
1994	Male	5.3	8.6	3.1	7.9	2.7	2.5	1.1	1.1	2.4	1.1	0.9	4.9	1.6	0.9	3.3	0.9	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.7
1995	Male	4.4	4.9	7.8	2.7	6.5	2.2	2.1	0.9	0.9	2.0	0.9	0.7	4.0	1.3	0.7	2.7	0.7	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1996	Male	6.2	4.0	4.4	6.7	2.3	5.4	1.8	1.7	0.8	0.8	1.6	0.8	0.6	3.3	1.0	0.6	2.2	0.6	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.6
1997	Male	7.8	5.6	3.6	3.8	5.7	1.9	4.5	1.5	1.4	0.6	0.6	1.4	0.6	0.5	2.7	0.9	0.5	1.8	0.5	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.6
1998	Male	4.2	7.1	5.1	3.2	3.3	4.8	1.6	3.8	1.3	1.2	0.5	0.5	1.1	0.5	0.4	2.3	0.7	0.4	1.5	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
1999	Male	12.7	3.8	6.4	4.5	2.7	2.8	4.1	1.3	3.2	1.1	1.0	0.4	0.5	1.0	0.4	0.3	1.9	0.6	0.3	1.3	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
2000	Male	8.4	11.6	3.5	5.7	3.8	2.3	2.3	3.4	1.1	2.7	0.9	0.9	0.4	0.4	0.8	0.4	0.3	1.6	0.5	0.3	1.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5
2001	Male	7.0	7.7	10.6	3.0	4.8	3.2	1.9	2.0	2.9	1.0	2.3	0.8	0.7	0.3	0.3	0.7	0.3	0.2	1.4	0.4	0.2	0.9	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.5
2002	Male	15.2	6.4	7.0	9.3	2.6	4.0	2.7	1.6	1.7	2.4	0.8	1.9	0.7	0.6	0.3	0.3	0.6	0.3	0.2	1.2	0.4	0.2	0.8	0.2	0.1	0.1	0.1	0.0	0.1	0.5
2003	Male	7.1	13.8	5.8	6.1	7.9	2.2	3.4	2.3	1.4	1.4	2.0	0.7	1.6	0.5	0.5	0.2	0.2	0.5	0.2	0.2	1.0	0.3	0.2	0.7	0.2	0.1	0.1	0.0	0.0	0.5
2004	Male	4.6	6.5	12.6	5.1	5.2	6.6	1.8	2.9	1.9	1.1	1.2	1.7	0.6	1.3	0.5	0.4	0.2	0.2	0.4	0.2	0.1	0.8	0.3	0.1	0.5	0.2	0.1	0.0	0.0	0.4
2005	Male	5.0	4.2	5.9	11.0	4.3	4.3	5.6	1.5	2.4	1.6	1.0	1.0	1.4	0.5	1.1	0.4	0.4	0.2	0.2	0.3	0.2	0.1	0.7	0.2	0.1	0.5	0.1	0.0	0.0	0.4
2006	Male	3.6	4.6	3.8	5.2	9.3	3.6	3.7	4.7	1.3	2.0	1.4	0.8	0.8	1.2	0.4	0.9	0.3	0.3	0.1	0.1	0.3	0.1	0.1	0.6	0.2	0.1	0.4	0.1	0.0	0.4
2007	Male	4.5	3.3	4.1	3.3	4.4	7.9	3.1	3.1	4.0	1.1	1.7	1.1	0.7	0.7	1.0	0.3	0.8	0.3	0.3	0.1	0.1	0.2	0.1	0.1	0.5	0.2	0.1	0.3	0.1	0.3
2008	Male	4.8	4.1	3.0	3.6	2.8	3.7	6.7	2.6	2.6	3.4	0.9	1.4	1.0	0.6	0.6	0.9	0.3	0.7	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.4
2009	Male	7.4	4.4	3.7	2.7	3.1	2.4	3.2	5.7	2.2	2.2	2.8	0.8	1.2	0.8	0.5	0.5	0.7	0.2	0.6	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.1	0.1	0.5
2010	Male	7.2	6.8	4.0	3.3	2.3	2.6	2.1	2.7	4.8	1.9	1.9	2.4	0.7	1.0	0.7	0.4	0.4	0.6	0.2	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.5
2011	Male	4.4	6.6	6.1	3.5	2.8	1.9	2.3	1.8	2.3	4.1	1.6	1.6	2.1	0.6	0.9	0.6	0.4	0.4	0.5	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3	0.5
2012	Male	4.5	4.1	6.0	5.4	3.0	2.4	1.7	1.9	1.5	2.0	3.5	1.4	1.4	1.8	0.5	0.8	0.5	0.3	0.3	0.5	0.1	0.4	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.7
2013	Male	2.6	4.1	3.7	5.2	4.6	2.6	2.0	1.4	1.6	1.3	1.7	3.0	1.1	1.2	1.5	0.4	0.6	0.4	0.3	0.3	0.4	0.1	0.3	0.1	0.1	0.0	0.0	0.1	0.0	0.6
2014	Male	3.5	2.3	3.7	3.2	4.5	3.9	2.2	1.7	1.2	1.4	1.1	1.4	2.5	1.0	1.0	1.3	0.3	0.5	0.4	0.2	0.2	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.1	0.5
2015	Male	6.2	3.2	2.1	3.3	2.8	3.8	3.3	1.9	1.5	1.0	1.2	0.9	1.2	2.1	0.8	0.8	1.1	0.3	0.5	0.3	0.2	0.2	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.5
2016	Male	22.7	5.6	2.9	1.9	2.8	2.4	3.3	2.8	1.6	1.2	0.9	1.0	0.8	1.0	1.8	0.7	0.7	0.9	0.3	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.0	0.5
2017	Male	8.7	20.6	5.1	2.6	1.6	2.4	2.0	2.8	2.4	1.4	1.1	0.7	0.9	0.7	0.9	1.6	0.6	0.6	0.8	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.0	0.4
2018	Male	51.1	7.9	18.5	4.4	2.2	1.4	2.1	1.7	2.4	2.1	1.2	0.9	0.6	0.7	0.6	0.7	1.3	0.5	0.5	0.7	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.0	0.4
2019	Male	37.7	46.5	7.1	16.1	3.8	1.9	1.2	1.8	1.5	2.0	1.8	1.0	0.8	0.5	0.6	0.5	0.6	1.1	0.4	0.4	0.6	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.4

2020	Male	15.8	34.3	41.7	6.2	13.9	3.3	1.6	1.0	1.5	1.3	1.7	1.5	0.8	0.7	0.5	0.5	0.4	0.5	1.0	0.4	0.4	0.5	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.4
2021	Male	17.0	14.4	30.9	36.8	5.4	12.1	2.8	1.4	0.9	1.3	1.1	1.5	1.3	0.7	0.6	0.4	0.5	0.4	0.5	0.8	0.3	0.3	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.4
2022	Male	19.0	15.5	13.0	27.2	32.1	4.7	10.5	2.4	1.2	0.8	1.1	0.9	1.3	1.1	0.6	0.5	0.3	0.4	0.3	0.4	0.7	0.3	0.3	0.4	0.1	0.2	0.1	0.1	0.1	0.4
2023	Male	16.4	17.3	13.9	11.4	23.6	27.7	4.1	9.0	2.1	1.0	0.6	1.0	0.8	1.1	1.0	0.5	0.4	0.3	0.3	0.3	0.3	0.6	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.4
2024	Male	15.6	15.0	15.6	12.3	9.9	20.5	24.0	3.5	7.8	1.8	0.9	0.6	0.8	0.7	0.9	0.8	0.5	0.4	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.3	0.1	0.1	0.1	0.4
2025	Male	9.7	14.2	13.5	13.8	10.8	8.7	17.9	21.0	3.1	6.8	1.6	0.8	0.5	0.7	0.6	0.8	0.7	0.4	0.3	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.2	0.1	0.1	0.4
2026	Male	0.0	8.9	12.8	12.0	12.1	9.4	7.6	15.7	18.3	2.7	5.9	1.4	0.7	0.4	0.6	0.5	0.7	0.6	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.1	0.5

Table SM3.11. Number (in millions of fish) of sablefish estimated by Model *26.2_FAA* by age and year. Columns are age with age-31+ being the plus group. The terminal year plus one (2026) numbers are incremented based on the terminal year (2025) mortality and recruitment is set at 0.

Year	Sex	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31+
1960	Female	8.1	7.2	6.4	5.8	5.2	4.7	4.3	3.9	3.6	3.2	2.9	2.7	2.4	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.6
1961	Female	8.3	7.4	6.6	5.9	5.2	4.7	4.3	3.9	3.5	3.2	2.9	2.7	2.4	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.6
1962	Female	8.6	7.6	6.7	6.0	5.2	4.6	4.2	3.8	3.4	3.1	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	5.4
1963	Female	9.1	7.9	6.9	6.1	5.2	4.5	4.0	3.6	3.3	3.0	2.7	2.5	2.2	2.0	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	5.1
1964	Female	9.6	8.3	7.2	6.3	5.4	4.6	4.0	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	5.0
1965	Female	9.9	8.8	7.6	6.6	5.7	4.9	4.2	3.6	3.2	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	4.9
1966	Female	10.0	9.1	8.0	6.9	5.9	5.1	4.4	3.7	3.2	2.8	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	4.8
1967	Female	9.8	9.1	8.3	7.3	6.2	5.3	4.6	3.9	3.3	2.8	2.5	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	4.6
1968	Female	9.3	8.9	8.3	7.5	6.5	5.5	4.7	4.0	3.4	2.9	2.5	2.2	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	4.4
1969	Female	8.8	8.5	8.1	7.4	6.5	5.6	4.7	4.0	3.4	2.9	2.4	2.1	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	4.1
1970	Female	8.1	8.0	7.7	7.2	6.4	5.6	4.7	3.9	3.3	2.8	2.4	2.0	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	3.7
1971	Female	7.6	7.4	7.2	6.8	6.2	5.4	4.6	3.9	3.3	2.7	2.3	2.0	1.7	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	3.3
1972	Female	7.0	6.9	6.7	6.4	5.8	5.1	4.4	3.7	3.2	2.6	2.2	1.8	1.6	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	2.9
1973	Female	6.5	6.4	6.2	5.8	5.2	4.6	4.0	3.4	2.9	2.4	2.0	1.7	1.4	1.2	1.0	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	2.4
1974	Female	6.1	5.9	5.7	5.5	4.9	4.3	3.7	3.2	2.7	2.3	1.9	1.6	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	2.1
1975	Female	3.1	5.6	5.4	5.1	4.5	4.0	3.4	3.0	2.5	2.2	1.8	1.5	1.3	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.8
1976	Female	2.9	2.8	5.0	4.8	4.2	3.7	3.2	2.8	2.4	2.0	1.7	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	1.6
1977	Female	3.0	2.7	2.6	4.5	3.9	3.4	2.9	2.5	2.2	1.9	1.6	1.4	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	1.4
1978	Female	3.7	2.7	2.4	2.3	3.7	3.2	2.8	2.4	2.1	1.8	1.5	1.3	1.1	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2
1979	Female	8.3	3.3	2.5	2.2	2.0	3.2	2.8	2.4	2.1	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2
1980	Female	29.6	7.6	3.1	2.2	1.9	1.7	2.8	2.4	2.0	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1981	Female	5.4	27.1	6.9	2.8	1.9	1.6	1.5	2.4	2.0	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0
1982	Female	8.3	4.9	24.7	6.2	2.4	1.7	1.4	1.3	2.0	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.0
1983	Female	24.3	7.6	4.5	22.3	5.4	2.1	1.4	1.2	1.1	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.9
1984	Female	4.3	22.2	7.0	4.1	19.6	4.7	1.8	1.2	1.1	0.9	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.9
1985	Female	4.4	3.9	20.3	6.3	3.6	17.1	4.1	1.5	1.1	0.9	0.8	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.8
1986	Female	6.8	4.1	3.6	18.3	5.5	3.1	14.8	3.6	1.3	0.9	0.8	0.7	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.8
1987	Female	3.1	6.2	3.7	3.2	15.6	4.6	2.6	12.3	2.9	1.1	0.8	0.6	0.6	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1988	Female	3.1	2.9	5.6	3.3	2.7	12.7	3.7	2.1	9.9	2.4	0.9	0.6	0.5	0.5	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.6
1989	Female	4.8	2.9	2.6	4.9	2.7	2.1	10.1	2.9	1.6	7.7	1.8	0.7	0.5	0.4	0.4	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1990	Female	5.6	4.4	2.6	2.3	4.0	2.1	1.7	7.9	2.3	1.3	6.0	1.4	0.5	0.4	0.3	0.3	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.5
1991	Female	7.5	5.1	4.0	2.3	1.9	3.2	1.7	1.3	6.2	1.8	1.0	4.7	1.1	0.4	0.3	0.2	0.2	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1992	Female	6.2	6.9	4.7	3.5	1.9	1.5	2.5	1.3	1.0	4.9	1.4	0.8	3.7	0.9	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1993	Female	5.8	5.6	6.3	4.1	2.9	1.5	1.2	2.0	1.0	0.8	3.8	1.1	0.6	2.9	0.7	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
1994	Female	1.9	5.3	5.1	5.5	3.3	2.2	1.1	0.9	1.5	0.8	0.6	2.9	0.9	0.5	2.2	0.5	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1995	Female	3.8	1.7	4.8	4.5	4.4	2.6	1.7	0.9	0.7	1.2	0.6	0.5	2.3	0.7	0.4	1.7	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1996	Female	5.8	3.5	1.6	4.2	3.6	3.5	2.0	1.4	0.7	0.5	0.9	0.5	0.4	1.8	0.5	0.3	1.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2
1997	Female	4.2	5.3	3.2	1.4	3.5	2.9	2.8	1.6	1.1	0.5	0.4	0.7	0.4	0.3	1.4	0.4	0.2	1.1	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.2
1998	Female	9.1	3.8	4.9	2.8	1.2	2.8	2.3	2.2	1.3	0.9	0.4	0.3	0.6	0.3	0.2	1.1	0.3	0.2	0.8	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2
1999	Female	4.8	8.3	3.5	4.3	2.3	0.9	2.3	1.9	1.8	1.0	0.7	0.4	0.3	0.5	0.2	0.2	0.9	0.3	0.1	0.7	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
2000	Female	4.0	4.4	7.5	3.1	3.6	1.9	0.8	1.8	1.5	1.4	0.8	0.6	0.3	0.2	0.4	0.2	0.2	0.7	0.2	0.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2001	Female	6.4	3.7	4.0	6.7	2.5	2.8	1.5	0.6	1.4	1.2	1.1	0.7	0.4	0.2	0.2	0.3	0.2	0.1	0.6	0.2	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2002	Female	13.4	5.8	3.3	3.6	5.5	2.0	2.3	1.2	0.5	1.1	1.0	0.9	0.5	0.3	0.2	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2
2003	Female	6.1	12.2	5.3	3.0	2.9	4.4	1.6	1.8	1.0	0.4	0.9	0.8	0.7	0.4	0.3	0.1	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1
2004	Female	2.7	5.6	11.1	4.7	2.4	2.3	3.5	1.3	1.4	0.7	0.3	0.7	0.6	0.6	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1
2005	Female	3.4	2.5	5.1	9.8	3.8	1.9	1.8	2.7	1.0	1.1	0.6	0.2	0.6	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.1
2006	Female	1.4	3.1	2.2	4.5	8.1	3.0	1.5	1.5	2.2	0.8	0.9	0.5	0.2	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.1
2007	Female	4.8	1.3	2.9	2.0	3.7	6.5	2.4	1.2	1.2	1.7	0.6	0.7	0.4	0.1	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
2008	Female	3.6	4.4	1.2	2.5	1.6	3.0	5.2	1.9	1.0	0.9	1.4	0.5	0.6	0.3	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1
2009	Female	8.0	3.3	4.0	1.1	2.1	1.3	2.4	4.1	1.5	0.8	0.7	1.1	0.4	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
2010	Female	7.0	7.3	3.0	3.5	0.9	1.7	1.0	1.9	3.3	1.2	0.6	0.6	0.9	0.3	0.4	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
2011	Female	3.7	6.4	6.7	2.7	2.9	0.7	1.4	0.8	1.5	2.7	1.0	0.5	0.5	0.7	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
2012	Female	3.2	3.4	5.8	5.9	2.2	2.3	0.6	1.1	0.7	1.2	2.1	0.8	0.4	0.4	0.6	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2013	Female	3.1	2.9	3.1	5.2	4.9	1.8	1.9	0.4	0.9	0.5	1.0	1.7	0.6	0.3	0.3	0.4	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	Female	2.8	2.8	2.7	2.7	4.2	3.9	1.4	1.5	0.4	0.7	0.4	0.8	1.3	0.5	0.3	0.2	0.4	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2015	Female	4.3	2.6	2.6	2.4	2.3	3.5	3.2	1.2	1.2	0.3	0.6	0.3	0.6	1.1	0.4	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2016	Female	31.1	4.0	2.4	2.3	2.0	1.9	2.8	2.6	0.9	1.0	0.2	0.5	0.3	0.5	0.9	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2017	Female	14.7	28.3	3.6	2.0	1.9	1.6	1.5	2.3	2.1	0.8	0.8	0.2	0.4	0.2	0.4	0.7	0.3	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2018	Female	34.0	13.4	25.4	3.1	1.7	1.6	1.3	1.2	1.9	1.7	0.6	0.7	0.2	0.3	0.2	0.3	0.6	0.2	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2019	Female	55.7	30.9	12.0	22.1	2.6	1.4	1.3	1.1	1.0	1.5	1.4	0.5	0.5	0.1	0.2	0.2	0.3	0.5	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1

2020	Female	5.7	50.7	27.8	10.5	18.8	2.2	1.2	1.1	0.9	0.8	1.3	1.2	0.4	0.4	0.1	0.2	0.1	0.2	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2021	Female	5.5	5.2	45.7	24.5	9.1	16.1	1.8	1.0	0.9	0.8	0.7	1.1	1.0	0.4	0.4	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2022	Female	7.8	5.0	4.7	40.5	21.4	7.8	13.9	1.6	0.9	0.8	0.7	0.6	0.9	0.8	0.3	0.3	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
2023	Female	5.5	7.1	4.6	4.1	35.2	18.4	6.7	11.8	1.4	0.7	0.7	0.6	0.5	0.8	0.7	0.3	0.3	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
2024	Female	7.1	5.0	6.4	4.1	3.6	30.5	15.9	5.8	10.2	1.2	0.6	0.6	0.5	0.4	0.7	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.1
2025	Female	7.9	6.4	4.6	5.7	3.6	3.2	26.5	13.8	5.0	8.8	1.0	0.5	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1
2026	Female	0.0	7.2	5.8	4.1	5.0	3.1	2.7	22.9	11.9	4.3	7.6	0.9	0.5	0.4	0.4	0.3	0.5	0.5	0.2	0.2	0.0	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.1
1960	Male	8.1	7.2	6.4	5.8	5.2	4.7	4.3	3.9	3.6	3.2	3.0	2.7	2.5	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	5.8
1961	Male	8.3	7.4	6.6	5.9	5.2	4.7	4.3	3.9	3.6	3.2	3.0	2.7	2.5	2.2	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.8
1962	Male	8.6	7.6	6.7	5.9	5.2	4.6	4.2	3.8	3.4	3.1	2.9	2.6	2.4	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	5.7
1963	Male	9.1	7.9	6.9	5.8	5.0	4.5	4.0	3.6	3.3	3.0	2.7	2.5	2.2	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	5.3
1964	Male	9.6	8.3	7.2	6.1	5.2	4.4	3.9	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.3	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	5.2
1965	Male	9.9	8.8	7.6	6.5	5.5	4.6	4.0	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.5	5.1
1966	Male	10.0	9.1	8.1	6.9	5.9	5.0	4.2	3.6	3.2	2.8	2.5	2.3	2.1	1.9	1.7	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	5.0
1967	Male	9.8	9.2	8.3	7.3	6.2	5.2	4.4	3.7	3.2	2.8	2.5	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	4.8
1968	Male	9.3	9.0	8.4	7.5	6.4	5.4	4.6	3.8	3.2	2.7	2.4	2.2	1.9	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	4.6
1969	Male	8.8	8.5	8.1	7.3	6.4	5.5	4.6	3.9	3.2	2.7	2.3	2.0	1.8	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	4.2
1970	Male	8.1	8.0	7.7	7.0	6.2	5.4	4.6	3.8	3.2	2.7	2.2	1.9	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	3.8
1971	Male	7.6	7.4	7.2	6.6	5.9	5.2	4.4	3.7	3.1	2.6	2.2	1.8	1.6	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	3.5
1972	Male	7.0	6.9	6.7	6.1	5.4	4.8	4.1	3.6	3.0	2.5	2.1	1.7	1.5	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	3.0
1973	Male	6.5	6.4	6.2	5.5	4.8	4.2	3.7	3.2	2.7	2.3	1.9	1.6	1.3	1.1	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	2.5
1974	Male	6.1	6.0	5.8	5.1	4.5	3.9	3.3	2.9	2.5	2.1	1.8	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	2.2
1975	Male	3.1	5.6	5.4	4.7	4.2	3.6	3.1	2.7	2.3	2.0	1.7	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	1.9
1976	Male	2.9	2.8	5.0	4.4	3.8	3.4	2.9	2.5	2.1	1.9	1.6	1.4	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	1.7
1977	Male	3.0	2.7	2.6	4.1	3.5	3.0	2.6	2.2	1.9	1.7	1.5	1.2	1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	1.4
1978	Male	3.7	2.7	2.4	2.1	3.3	2.9	2.5	2.2	1.8	1.6	1.4	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.3
1979	Male	8.3	3.3	2.5	2.1	1.8	2.9	2.5	2.2	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2
1980	Male	29.6	7.6	3.0	2.1	1.8	1.6	2.5	2.1	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1981	Male	5.4	27.1	6.9	2.6	1.8	1.6	1.4	2.1	1.8	1.6	1.4	1.2	1.0	0.9	0.8	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1
1982	Male	8.3	5.0	24.6	5.9	2.3	1.6	1.3	1.2	1.8	1.6	1.3	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.0
1983	Male	24.3	7.6	4.5	21.4	5.1	1.9	1.4	1.1	1.0	1.6	1.3	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.9
1984	Male	4.3	22.3	6.9	3.9	18.7	4.5	1.7	1.2	1.0	0.9	1.3	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.9
1985	Male	4.4	3.9	20.3	6.1	3.4	16.2	3.8	1.5	1.0	0.9	0.7	1.2	1.0	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.9
1986	Male	6.8	4.1	3.6	17.7	5.3	3.0	14.0	3.3	1.3	0.9	0.7	0.6	1.0	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.8
1987	Male	3.1	6.2	3.7	3.0	14.8	4.4	2.5	11.6	2.7	1.0	0.7	0.6	0.5	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.7
1988	Male	3.1	2.9	5.6	3.0	2.5	12.0	3.5	2.0	9.3	2.2	0.8	0.6	0.5	0.4	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.7
1989	Male	4.8	2.9	2.6	4.5	2.4	1.9	9.4	2.8	1.5	7.3	1.7	0.7	0.5	0.4	0.3	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.6
1990	Male	5.6	4.4	2.6	2.1	3.6	1.9	1.5	7.3	2.1	1.2	5.6	1.3	0.5	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.5
1991	Male	7.5	5.1	4.0	2.1	1.6	2.8	1.5	1.2	5.7	1.7	0.9	4.4	1.0	0.4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1992	Male	6.2	6.9	4.6	3.2	1.6	1.3	2.2	1.2	0.9	4.5	1.3	0.7	3.5	0.8	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
1993	Male	5.8	5.6	6.2	3.7	2.5	1.3	1.0	1.7	0.9	0.7	3.5	1.0	0.6	2.7	0.6	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
1994	Male	1.9	5.3	5.1	4.9	2.9	1.9	1.0	0.8	1.3	0.7	0.6	2.7	0.8	0.4	2.1	0.5	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.3
1995	Male	3.8	1.7	4.8	4.0	3.8	2.2	1.5	0.8	0.6	1.0	0.5	0.4	2.1	0.6	0.3	1.6	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.3
1996	Male	5.8	3.5	1.6	3.8	3.1	3.0	1.7	1.2	0.6	0.5	0.8	0.4	0.3	1.6	0.5	0.3	1.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2
1997	Male	4.2	5.3	3.1	1.3	3.0	2.5	2.4	1.4	0.9	0.5	0.4	0.6	0.3	0.3	1.3	0.4	0.2	1.0	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.2
1998	Male	9.1	3.8	4.8	2.6	1.0	2.4	2.0	1.9	1.1	0.7	0.4	0.3	0.5	0.3	0.2	1.0	0.3	0.2	0.8	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
1999	Male	4.8	8.3	3.4	3.9	2.1	0.8	1.9	1.6	1.5	0.9	0.6	0.3	0.2	0.4	0.2	0.2	0.8	0.2	0.1	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2000	Male	4.0	4.4	7.5	2.8	3.2	1.7	0.7	1.6	1.3	1.2	0.7	0.5	0.2	0.2	0.3	0.2	0.1	0.7	0.2	0.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2001	Male	6.4	3.7	4.0	6.0	2.2	2.5	1.3	0.5	1.2	1.0	1.0	0.6	0.4	0.2	0.1	0.3	0.1	0.1	0.5	0.2	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2002	Male	13.4	5.8	3.3	3.2	4.9	1.8	2.0	1.1	0.4	1.0	0.8	0.8	0.4	0.3	0.2	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2003	Male	6.1	12.2	5.2	2.7	2.6	3.9	1.4	1.6	0.8	0.3	0.8	0.6	0.6	0.4	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1
2004	Male	2.7	5.6	11.0	4.2	2.1	2.0	3.0	1.1	1.2	0.7	0.3	0.6	0.5	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1
2005	Male	3.4	2.5	5.0	8.8	3.3	1.7	1.6	2.4	0.9	1.0	0.5	0.2	0.5	0.4	0.4	0.2	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1
2006	Male	1.4	3.2	2.2	4.1	7.0	2.6	1.3	1.3	1.9	0.7	0.8	0.4	0.2	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.1
2007	Male	4.8	1.3	2.8	1.8	3.3	5.7	2.1	1.1	1.0	1.5	0.6	0.6	0.3	0.1	0.3	0.3	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
2008	Male	3.6	4.4	1.2	2.3	1.4	2.6	4.5	1.7	0.8	0.8	1.2	0.4	0.5	0.3	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1
2009	Male	8.0	3.3	3.9	0.9	1.8	1.1	2.1	3.6	1.3	0.7	0.6	1.0	0.4	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
2010	Male	7.0	7.4	3.0	3.2	0.8	1.5	0.9	1.7	2.9	1.1	0.5	0.5	0.8	0.3	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
2011	Male	3.7	6.4	6.6	2.4	2.6	0.6	1.2	0.7	1.3	2.3	0.9	0.4	0.4	0.6	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
2012	Male	3.2	3.4	5.8	5.4	2.0	2.1	0.5	0.9	0.6	1.1	1.8	0.7	0.3	0.3	0.5	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2013	Male	3.1	2.9	3.0	4.7	4.3	1.6	1.6	0.4	0.8	0.5	0.8	1.5	0.5	0.3	0.3	0.4	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2014	Male	2.8	2.8	2.6	2.5	3.7	3.4	1.3	1.3	0.3	0.6	0.4	0.7	1.2	0.4	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2015	Male	4.3	2.6	2.6	2.2	2.0	3.0	2.8	1.0	1.1	0.3	0.5	0.3	0.6	0.9	0.4	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2016	Male	31.1	4.0	2.3	2.1	1.8	1.6	2.5	2.3	0.8	0.9	0.2	0.4	0.2	0.4	0.8	0.3	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2017	Male	14.7	28.4	3.6	2.0	1.8	1.5	1.3	2.0	1.9	0.7	0.7	0.2	0.3	0.2	0.4	0.6	0.2	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2018	Male	34.0	13.4	25.5	3.1	1.7	1.4	1.2	1.1	1.6	1.5	0.5	0.6	0.1	0.3	0.2	0.3	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2019	Male	55.7	31.0	12.1	22.2	2.6	1.4	1.2	1.0	0.9	1.3	1.2	0.4	0.5	0.1	0.2	0.1	0.2	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

2020	Male	5.7	50.9	28.0	10.6	18.9	2.2	1.2	1.0	0.8	0.7	1.1	1.0	0.4	0.4	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2021	Male	5.5	5.2	46.1	24.7	9.1	16.0	1.8	1.0	0.8	0.7	0.6	0.9	0.9	0.3	0.3	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2022	Male	7.8	5.1	4.7	40.9	21.5	7.8	13.7	1.6	0.8	0.7	0.6	0.5	0.8	0.7	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
2023	Male	5.5	7.1	4.6	4.2	35.4	18.4	6.7	11.7	1.3	0.7	0.6	0.5	0.5	0.7	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1
2024	Male	7.1	5.0	6.5	4.1	3.6	30.6	15.9	5.8	10.1	1.1	0.6	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1
2025	Male	7.9	6.5	4.6	5.8	3.6	3.2	26.5	13.7	5.0	8.7	1.0	0.5	0.4	0.4	0.3	0.5	0.5	0.2	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1
2026	Male	0.0	7.2	5.9	4.1	5.0	3.1	2.7	22.9	11.9	4.3	7.5	0.9	0.5	0.4	0.3	0.3	0.4	0.4	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1

Appendix 3G: Changes to the Alaska-wide Sablefish Stock Assessment for 2026 and Summary of the Center for Independent Experts (CIE) Review of the Assessment

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and
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Executive Summary

An independent, external review of the Alaska-wide sablefish stock assessment was conducted by the Center for Independent Experts (CIE) in Juneau, AK from June 16 – 18, 2026. The purpose of the peer review was to determine whether the best scientific information available (BSIA) was being used to assess the Alaska sablefish population and develop robust management advice. The primary consideration for the review was how the stock assessment should be structured to handle recent NOAA Longline Survey (LLS) design changes, where the annual survey footprint was truncated beginning in 2025 (i.e., with only the Gulf of Alaska, GOA, being surveyed in odd years and the Bering Sea, BS, and Aleutian Islands, AI, being surveyed in even years). For the CIE review, a series of model building and bridging exercises were undertaken, which started with the single region continuity model (Model *25.12_1Reg_Cont*), then bridged to a new single region model (Model *26.1_1Reg*) that incorporated updates to input data and model parametrization (see Table 1 and Appendix 3B). Next, a new spatially implicit model (termed a 'fleets-as-areas', FAA, model; also referred to as an areas-as-fleets model) was developed (Model *26.2_FAA*). The parametrization of Model *26.2_FAA* matched that of the updated single region model (Model *26.1_1Reg*) but disaggregated the LLS into three regional fleets (GOA, BS, and AI) and fit regional indices and age composition data explicitly without requiring imputation for missing data (i.e., non-surveyed regions). This document briefly summarizes the six documents produced for and reviewed by the CIE panel as well as the three CIE reviewer reports (all available from the September groundfish Joint Plan Team e-Agenda).

As noted, the model development process started with the 2025 single-region continuity model (Model *25.12_1Reg_Cont*) and built towards Model *26.1_1Reg* through refined data inputs (i.e., removal of CPUE data and length compositions for data sources with age compositions as well as updated growth and weight estimates), updated model parametrizations (i.e., estimating sex-specific natural mortality and assuming logistic selectivity for the trawl fleet), and improved single region survey index creation methodology (i.e., use of the 'carryover' approach and removal of extrapolated western AI stations; see Table 1 and Appendix 3B). To address incomplete annual survey spatial coverage, various parametrizations of a spatially implicit FAA model were then explored, which built upon Model *26.1_1Reg* and added regionally disaggregated fleet structure then explored alternative selectivity options, resulting in Model *26.2_FAA* (see Appendix 3C). Although three-region and five-region spatially explicit models were also developed that estimated movement and integrated mark-recapture data, these were deemed too unstable for operational management (see Appendix 3D). To help identify robust model structures given uncertainty from the new LLS design, a spatially explicit closed-loop simulation analysis conditioned on the five-region spatial assessment was implemented to evaluate assessment performance when confronted with realistic spatial dynamics and data availability scenarios (Appendix 3E).

Both models (Model *26.1_1Reg* and Model *26.2_FAA*) displayed limited diagnostic issues, but a persistent tension remained across modeling approaches when attempting to balance rapid population growth and extreme recruitment signals from age compositions against more moderate growth observed in the LLS indices (a longstanding issue for the sablefish assessment). Similar population trends were estimated across models, with strong 2014-, 2016-, and 2017-year classes. However, Model *26.2_FAA* led to a moderate downward scaling of spawning stock biomass and a ~25% reduction in Acceptable Biological Catch (ABC)

compared to Model *26.1_1Reg*. The difference in scaling highlights the potential risk of using extrapolated survey indices in a single-region model and assuming composition data in surveyed regions are representative of the entire population, both of which may act to artificially inflate biomass and catch advice. Closed-loop simulations indicated that the spatially implicit FAA model was likely more robust and stable compared to either the single-region or fully spatial models, despite potential data limitations from sparse regional age composition data (see Appendix 3E).

The CIE reviewers endorsed the spatially implicit FAA model (Model *26.2_FAA*) as providing the BSIA for operational sablefish assessment and management advice. Moreover, the CIE reviewers noted that current assessment limitations stem from fundamental data issues, where further model complexity or alternative statistical assumptions were unlikely to lead to any meaningful improvement in model performance. The CIE panel concluded that investment in data collection, particularly increased otolith age reading and broader spatial coverage of the LLS, would provide the best avenue for improving management advice for sablefish.

Given the endorsement of the CIE reviewers and the conclusions of the assessment authors (as detailed in the SAFE document produced for the CIE review), Model *26.2_FAA* is being proposed for the basis of Alaska sablefish assessment and management advice in 2026. **For the final 2026 sablefish SAFE, results and writeups will be based on Model *26.2_FAA*, but comparisons of population trajectories (SSB, recruitment) and catch advice (7 projection scenarios) will be provided for both Model *26.2_FAA* and Model *26.1_1Reg* (Model *25.12_1Reg_Cont* will no longer be updated).**

Finally, because sablefish are assessed Alaska-wide, the resultant Alaska-wide ABC must be apportioned to management region and changes in the LLS design require updating the apportionment approach. Sablefish apportionment is based on the five-year moving average of regional biomass proportions from the LLS. Starting in 2026, the sablefish apportionment approach will use the same index carryover values as used to develop the revised single region LLS index (as in Model *26.1_1Reg*). Mainly, for non-surveyed regions in a given year, the index values are fixed (carried over) at the value from the last survey year for that region. Based on comparison of 2023 apportionment values across the old and revised method, the update in methodology has small impacts on regional apportionment (Table 8). The removal of the extrapolated western AI stations reduces the relative apportionment to the AI region, which proportionally increases apportionment to other regions. Overall, the updated apportionment approach ensures consistency with how LLS indices are constructed in the new single region model, while maintaining the long-term apportionment goals of 1) distributing catch proportional to biomass to avoid deleterious localized population impacts; and 2) avoiding large interannual fluctuations in the distribution of the ABC across management regions.

2026 Sablefish Model Development and Evaluation

A new spatially implicit fleets-as-areas (FAA) model (Model *26.2_FAA*) was introduced for the Center for Independent Experts (CIE) review in Juneau, AK from June 16 – 18, 2026 as an alternative to the updated single-region assessment framework (Model *26.1_1Reg*). Unlike the single-region approach, Model *26.2_FAA* disaggregates the NOAA longline survey (LLS) into three regional fleets—the Gulf of Alaska, Bering Sea, and Aleutian Islands—to fit regional abundance indices and age composition data explicitly. Both models were presented and reviewed by the CIE panel. The primary benefit of the spatially implicit FAA model is the ability to treat non-surveyed regions in a given year as missing data rather than relying on imputed data to generate a single aggregated index. In general, a spatially implicit FAA model can accurately represent fish populations that are reproductively well-mixed (i.e., panmictic) but that demonstrate complex movement resulting in spatially-varying availability. However, applying FAA models to populations with limited movement or complex population structure may lead to increased model bias, which must be weighed against the data demands and complexity of implementing a fully spatial assessment. Nonetheless, sablefish are likely a good candidate for a spatially implicit FAA model given their panmictic stock structure and high movement potential, despite underlying ontogenetic connectivity patterns.

The model development process involved a stepwise transition from the 2025 continuity model (Model *25.12_1Reg_Cont*) to Model *26.1_1Reg* by refining data inputs and model parametrization, including estimation of sex-specific natural mortality and improved methods for deriving the single region LLS index among other updates (see Table 1 and Appendix 3B). To address incomplete annual survey spatial coverage, various parametrizations of a spatially implicit FAA model were explored that built upon Model *26.1_1Reg,* but disaggregated fleet structure then explored alternative selectivity options, which resulted in Model *26.2_FAA* (see Appendix 3C). Although three-region and five-region spatially explicit models were also developed that estimated movement and integrated mark-recapture data, these were deemed too unstable for operational management (see Appendix 3D). To help identify robust model structures given uncertainty from the new LLS design, a spatially explicit closed-loop simulation analysis conditioned on the five-region spatial assessment was implemented to evaluate assessment performance when confronted with realistic spatial dynamics and data availability scenarios (Appendix 3E).

Evaluating the single-region model (Model *26.1_1Reg*) against the spatially implicit model (Model *26.2_FAA*) highlighted key considerations for model selection in terms of model stability, data treatment, and sample sizes. While Model *26.2_FAA* eliminates the need to impute LLS index data across non-surveyed regions, it introduces the potential for overinterpreting sparse regional composition data (see Table 2). However, the closed loop simulation indicated that the spatially implicit FAA model was likely more robust and more stable than either the single region or spatial assessment models under data conditions emulating the current survey design (Appendix 3E). When fitting the real-world data, both models exhibited a persistent tension between fitting survey indices compared to age compositions, where the former are given more emphasis via Francis reweighting and generally better fit (Table 3 describes the estimated parameters for each model and associated maximum gradient, while Table 4 shows input and effective sample sizes after Francis reweighting). Although residual patterns in the composition data remain for either model, the aggregated fits were adequate (see 2026 CIE SAFE) as were the fits to the LLS indices (Figures 1 – 3). Generally, both models have trouble reconciling the larger year classes and population growth suggested by the age composition data in recent years compared with the more tempered, but still extremely rapid, population growth observed in the LLS indices since ~2018.

Parameter estimates and population trends generally aligned across models (Table 5; Figures 4 -- 6) with both indicating strong 2014-, 2016-, and 2017-year classes, and a reduction towards average recruitment since 2020. However, Model *26.2_FAA* estimated larger 2014- and 2017-year classes and a smaller 2016-

year class (Figure 5). Alterations in recruitment estimates are due to differences in recruitment signals across the regional LLS age compositions, where the AI provides a mixture of recruitment signals (strong 2014-, 2016-, and 2017-year classes) that balances those in the BS (strong 2014 and 2016 and very strong 2017-year classes) and GOA (strong 2014 and very strong 2016-year classes). Model *26.2_FAA* results in a moderate downward scaling of spawning stock biomass (SSB) compared to Model *26.1_1Reg* (Figure 6). Ultimately, catch advice (Acceptable Biological Catch, ABC) from model *26.2_FAA* is ~25% lower than that from Model *26.1_1Reg* (Table 6). Aside from model tension resulting from trying to fit age-compositions and abundance indices simultaneously, no major diagnostic issues existed with either model (e.g., no strong retrospective patterns were observed; Figures 6 – 8).

Interestingly, an exploratory run with Model *26.2_FAA* using imputed regional 'carryover' indices (i.e., where the regional indices now summed to the aggregate index used in Model *26.1_1Reg*) led to a strong upward scaling of SSB, particularly since the start of the LLS in the mid-1990s (Appendix 3C). Thus, there may be inherent risk with using an extrapolated survey index in the assessment, which can potentially result in artificially inflating SSB and catch advice. Moreover, the phase-plane for Model *26.2_FAA* suggests that overfishing may have been occurring on the sablefish population for much of the 2000s. Therefore, the single region model may be more risk prone, if population scale is more in line with that estimated in Model *26.2_FAA*.

Extensive sensitivity runs were undertaken for both the single region (Appendix 3B) and spatially-implicit assessments (Appendix 3C), including exploration of time-varying growth and weight-at-age, continuous time-varying survey selectivity, the use of the Dirichlet-multinomial (DM) distribution for composition data, and the combination of continuous time-varying selectivity with the DM distribution. None of the alternative approaches greatly improved model performance (e.g., fits to data) and often led to model instability and degraded diagnostics (e.g., increased retrospective patterns). Thus, none were put forth for consideration as the operational assessment. Moreover, three- and five-region spatial assessments were developed and updated (Appendix 3D), illustrating interesting regional patterns in recruitment, SSB, and ontogenetic movement. However, the spatial models were not deemed insufficiently stable for operational management advice and require further exploration and testing, specifically to enable estimation of time-varying movement, regionally-varying selectivity, and how best to handle data weighting of mark-recapture data relative to the other data sources.

2026 CIE Review of the Alaska-wide Sablefish Assessment

An independent, external review of the Alaska-wide sablefish stock assessment was conducted by the Center for Independent Experts (CIE) in Juneau, AK from June 16 – 18, 2026. The purpose of the peer review was to determine whether the best scientific information available (BSIA) was being used to assess the Alaska sablefish population and develop robust management advice.

Review Purpose and Goals

The reviewers were tasked with understanding sablefish biological and fishery dynamics, appraising the assessment data inputs and limitations, and, ultimately, reviewing the stock assessment framework being utilized. The overarching goals of this review process were to:

1. Ensure the FAA stock assessment (Model *26.2_FAA*) supports the development of robust advice for use by the North Pacific Fishery Management Council based on the BSIA;
2. Provide an independent external review of this stock assessment to confirm that it meets the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3. Understand and identify appropriate FAA model structure and fits to key data sources (indices, landings, and age compositions);

4. Identify research needed to improve the assessment and advice for fishery managers.

Terms of Reference (ToRs) for the Peer Review

CIE reviewers are contracted to complete their independent peer review based on the ToRs. Therefore, the CIE-NOAA Fisheries review and approval process is based on whether the CIE independent reports addressed each of the ToRs.

1) Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.
   a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

2) Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.
   a) Indicate whether the model provides the best scientific information available for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

3) Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

CIE Documentation

The documents associated with the CIE review are available for download from the CIE GitHub Repo and the associated NPFMC groundfish joint plan team (JPT) e-Agenda. A new *draft* Stock Assessment and Fishery Evaluation (SAFE) report was created for the CIE review, which served as the primary document for review. The SAFE summarizes input data, model structure, and outputs for two sablefish assessment models: Model *26.1_1Reg* and Model *26.2_FAA*. The main goal of the review was to provide recommendations on which model structure provided the best scientific basis for developing operational management advice for sablefish in 2026 and beyond. The CIE review meeting was structured around comparing and contrasting performance of these two model structures.

Five appendices were developed that summarized different aspects of model building, which provided additional context for understanding the two models presented in the main SAFE document. These include a summary of the Stochastic Population Over Regional Components (SPoRC) stock assessment platform (a generalized RTMB-based R package) and model structure (Appendix 3A), single region model changes since 2025 (Appendix 3B), fleets-as-areas (FAA) model development (Appendix 3C), summary of spatial models (3D), and a summary of a spatially explicit closed loop simulation that was used to inform model structure decisions (Appendix 3E). All of the appendices were meant as sources of additional information for understanding the decisions regarding model structure in the main SAFE document.

The final documents for review by the CIE included (available here):

- 2026 Assessment of the Sablefish Stock in Alaska: 2026 Center for Independent Experts (CIE) Review Document (here)
- Appendix 3A. The Spatial Population over Regional Components (SPoRC) Model: Technical Description of the Assessment Model for Sablefish (here)

- Appendix 3B. Model Building and Bridging Exercise for the Sablefish Single Region Models (Bridging from Model *25.12* to *26.1_1Reg*) (here)
- Appendix 3C. Development of a Fleets-as-Areas (FAA) Stock Assessment Model for Alaska Sablefish (*Model 26.2_FAA*) (here)
- Appendix 3D. Results of Spatial Stock Assessment Models for Alaska Sablefish (here)
- Appendix 3E. Evaluating Alternative Assessment Structures for Alaska Sablefish Under Survey Design Changes via Closed-Loop Simulation (here)

Additionally, the presentations given during the CIE review are uploaded and available at the GitHub repository (here).

Additional sablefish background documents, which were not part of the review requirements, were also provided to reviewers and uploaded (available here). Within the background documents, the assessment documents folder was of particular value for understanding previous modeling decisions (in particular Goethel and Cheng, 2025, describing changes to the model implemented in 2025).

The data and model files (R files) used to run the assessment in SPoRC as well as model outputs are available on the GitHub repo (here). If there are any questions about models, files, or repo organization, please contact the assessment authors.

The final CIE review reports, which were developed independently by each of the three reviewers, are also available on the GitHub repo (here) and the JPT e-Agenda.

CIE Panel Main Conclusions

The CIE review of the Alaska-wide sablefish stock assessment evaluated the transition from the historical single-region panmictic model to the spatially implicit fleets-as-areas (FAA) model (specifically Model *26.2_FAA*). The reviewers were highly complimentary of the organization, transparency, and thorough preparation of the assessment team, noting that the comprehensive background documentation, well-structured presentations, and accessible GitHub repository made it easy to run and explore models independently. Moreover, the CIE Review Report submitted by Dr. Sam Subbey noted that:

> "The openness and willingness of the assessment team to engage in scientific discussion represents a model for future assessment reviews…Presentations were well prepared, discussions were constructive, and the assessment authors demonstrated a commendable willingness to critically evaluate the strengths and weaknesses of their own work…A particularly positive aspect of the review was the breadth of analyses available for evaluation."

The reviewers supported the transition from ADMB to the modernized RTMB-based SPoRC platform and agreed that the three-fleet spatially implicit fleets-as-areas (Model *26.2_FAA*) assessment represented the BSIA. Specifically, the reviewers noted that the FAA framework resulted in a pragmatic balance between parsimony and complexity. Moreover, Model *26.2_FAA* provided a robust scientific basis for operational management advice by successfully overcoming the challenges of missing regional data from the recent LLS redesign without needing to impute survey indices. Furthermore, while the spatially explicit (three- and five-region) models were recognized as promising long-term research tools with strong conceptual advantages, reviewers agreed they are currently too unstable for operational use due to data and parametrization limitations. Overall, the documentation and supporting analyses were commended for their rigor, depth, and clarity in exploring sensitivity runs and structural choices to support assessment parametrization decisions. Moreover, reviewers appreciated that many of the model uncertainties had been explored with simulation analysis (including the new spatially explicit closed loop simulation developed for the CIE review) and published in the peer-review literature. The full review reports are summarized below with specific recommendations provided in Table 7, including assessment author responses and an

outline of future plans to address each comment.

- **Operational Assessment Model (Model *26.2_FAA*):** The reviewers concluded that the spatially implicit fleets-as-areas (FAA) Model *26.2_FAA* provides the most scientifically defensible basis for operational management advice compared to the single-region Model *26.1_1Reg*. It represents the BSIA for estimating stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).
- **Handling Survey Redesign:** The primary advantage of the FAA approach is its ability to more appropriately handle the revised NOAA Longline Survey (LLS) sampling design (Gulf of Alaska in odd years, Bering Sea and Aleutian Islands in even years). Specifically, the FAA model treats missing (non-surveyed) region data for the LLS directly as missing values rather than relying on imputation or carryover values.
- **Model Structure and Fleet Parameterization:** The chosen 3-fleet configuration—splitting the LLS into Bering Sea (BS), Aleutian Islands (AI), and Gulf of Alaska (GOA) regional fleets—captures essential biological and spatial dynamics (such as ontogenetic availability) without overparameterization. Adding further fleet subdivisions or complex time-varying selectivity causes estimation instability, likely due to limited age data (see Appendix 3C, particularly Model *26.2a_FAA_Fsh+Srvy* and Model *26.2_FAA_ContTVSel_DM*).
- **Data Limitations and Structural Conflicts:** The reviewers agreed that the persistent structural conflict/tension between survey indices and age composition data was best handled through Francis reweighting, and that more complex parametrizations (full time-varying selectivity) or alternate statistical assumptions (Dirichlet multinomial) would not resolve the conflict. Ultimately, the assessment is currently limited by data quality and coverage (e.g., age sample sizes and reduced survey footprint) and not by model structure – more complexity is not the solution to data deficiencies.
- **Spatially Explicit Models:** Spatially explicit (three- and five-region) models are conceptually superior for dealing with complex sablefish ontogenetic movement patterns and spatial processes. Although the spatial models represent a promising research platform, they are currently too unstable for operational management due to overparameterization, sparse spatial age composition data, and poorly constrained movement dynamics. However, as the spatial models are further refined, they should be considered for the basis of operational management advice.

Comprehensive Summary of Recommendations

1. Assessment Model Parameterization and Diagnostics

- **Adopt Model *26.2_FAA*:** Transition to Model *26.2_FAA* for operational management advice using the current parametrization and fleet configurations, including three longline survey fleets (BS, AI, GOA) and logistic selectivity for all fleets.
- **Data Reweighting and Likelihoods:** Continue using Francis reweighting for composition data. Do not use Dirichlet-multinomial likelihoods or continuous time-varying selectivity at this time due to potential for overweighting compositional data and increased model instability.
- **Natural Mortality (*M*):** Perform sensitivity analyses on *M* to quantify the impact of its tightly constrained prior on OFL and ABC estimates. Evaluate use of alternative prior formulations (e.g., Jeffrey's non-informative priors or tagging-derived priors) via simulation.
- **Jitter Analyses:** Re-run jitter convergence tests with larger perturbations of starting values to further confirm global convergence.
- **Model Communication:** Carefully frame and explain FAA results to managers and stakeholders, focusing on fleet/availability characteristics rather than complex mathematical spatial proxies.

2. Data Streams and Survey Design

- **Survey Footprint Protection:** Maintain or expand the NOAA Longline Survey footprint. Resist further survey reductions, as diminished survey coverage will increase assessment uncertainty. Expanding coverage back to full annual surveys (and including the western Aleutian Islands) would significantly improve model robustness.
- **Discontinue Integration of Conflicting Data Streams:** Remove the trawl survey indices (due to high sampling variability and inconsistent trends) and CPUE indices (due to gear changes and lack of updated logbook data since 2022).
- **Fishery Logbooks:** Continue to analyze CPUE data when/if logbook data become available to the AFSC in the future, especially to better understand spatial catch and effort patterns. Continued development of CPUE indices provides an additional abundance index that can be used as an external (to the assessment) check on population trends and can help track spatial fleet shifts within management areas.
- **Depredation Protocols:** Formally document and standardize protocols for removing survey skates compromised by killer whale or sperm whale depredation.

3. Otolith Collection and Aging

- **Increase/Maintain Aging Capacity:** Maintain otolith collection at or above current levels (~1,200 survey and fishery otoliths aged annually, though fishery ages have recently decreased to 600) to reduce spatial and age sparseness (given that the model includes 30 ages and disaggregates the survey age compositions by region). Increase the number of otoliths aged annually (and evaluate reading archived historic otoliths). Increased otolith reading would reduce age sparseness, better inform recruitment and selectivity estimation (including the potential to implement more complex time-varying selectivity options), reduce uncertainty, and potentially enable operationalizing the spatial assessment model.
- **Staffing and Training:** Hire and train an additional otolith reader or reallocate readers from easier to age species.
- **Evaluate Sample Size Impacts:** Conduct simulation sensitivity tests with the FAA model to determine optimal regional sample sizes and evaluate how reduced age sample sizes impact model stability.
- **Aging Error Research:** Further investigate sources of uncertainty in otolith aging. Evaluate whether reducing assumed aging error improves model stability.

4. Research on Spatially Explicit Models and Biology

- **Observer Data Analysis:** Examine observer age compositions spatially to determine if spatial shifts in fishing effort caused historical "plus group" (age 31+) anomalies.
- **Tagging Programs & Otolith Recovery:** Expand mark-recapture programs (including pop-up satellite tags and juvenile tagging) to better estimate age-specific movement rates and regional connectivity. Increase incentives for fishers/processors (e.g., higher lottery payouts or more tickets) to return tagged fish with otoliths.
- **Calcein Injection:** Consider injecting tagged survey fish with calcein to assist in verifying annual growth annuli.
- **Environmental and Dispersal Modeling:** Expand hydrodynamic/larval dispersal models (e.g., MOM-6) to include the Bering Sea and Aleutian Islands to better understand spatial recruitment connectivity.
- **Spatial Reference Points:** Investigate and resolve the mismatch between spatial model outputs and management requirements, including how to define Tier 3 reference points across multiple spatial areas.

5. Software Engineering (SPoRC Package)

- **Technical Documentation:** Develop and maintain a comprehensive technical design document for the SPoRC package to assist future developers, succession planning, and collaboration.
- **Unit Testing:** Expand automated formal unit tests within the SPoRC codebase and run them routinely (e.g., automated weekly builds).

Plans for the 2026 Alaska-wide Sablefish Stock Assessment

Given the endorsement of the CIE reviewers and the conclusions of the assessment authors (as detailed in the SAFE document produced for the CIE review), Model *26.2_FAA* is being proposed for the basis of Alaska sablefish assessment and management advice in 2026. Based on closed loop simulations and model performance when fit to the real-world data, Model *26.2_FAA* is deemed to provide a more robust model that better handles extant data limitations associated with the LLS redesign. Although model scale of SSB and resultant catch advice have declined moderately compared to the single region Model *26.1_1Reg*, the change in scale is not surprising given that Model *26.2_FAA* no longer includes extrapolated indices which appear to artificially inflate model scale. **For the final 2026 sablefish SAFE, results and writeups will be based on Model *26.2_FAA*, but comparisons of population trajectories (SSB, recruitment) and catch advice (7 projection scenarios) will be provided for both Model *26.2_FAA* and Model *26.1_1Reg* (Model *25.12_1Reg_Cont* will no longer be updated).**

Response to SSC and JPT Comments

The following summarizes feedback and planned analyses to address recommendations from the groundfish Joint Plant Team (JPT) and the Science and Statistical Committee (SSC) since the last operational stock assessment was reviewed (2024). Review body comments are in italics with author responses provided directly after each comment.

NPFMC SSC Comments (December 2024)

The SSC agrees with the author and JGPT that exploring additional sex-specific dynamics, in particular disaggregating age data by sex, should be a priority. This may help address troublesome patterns in (sex-aggregated) age composition residuals and (sex-disaggregated) length composition residuals, which may reflect some combination of time-varying (e.g. density-dependent) growth, time-varying selectivity, differences in M between sexes, deviations from a 50:50 sex ratio, and aging errors.

The 2025 model updates as integrated into Model *25.12_1Reg_Cont* aimed to better model sex-specific dynamics, primarily through fitting sex-disaggregated composition data. Moreover, all models presented in 2026 fit sex-disaggregated compositions and estimate sex-specific natural mortality.

The SSC further suggests explorations of models that allow for variations in growth over time, given the results from Cheng et al. (2024) that provide strong evidence of density-dependent growth. Variability in growth could result in the residual patterns noted above.

Sensitivity models were presented in both 2025 and 2026 that explore time-varying growth and weight-at-age as estimated in Cheng et al. (2024). Although these models provide interesting insight and have important impacts on SSB, they do not improve model performance or reduce residual patterns. Moreover, there is considerable uncertainty in the time-varying growth estimates, given sample size limitations. Thus, these models are not put forward as the basis of management advice.

The SSC supports the plan team recommendation to explore the use of time-varying selectivity in the model to address the poor fit to the fishery CPUE index and fishery catch-at-age data.

Multiple approaches to time-varying selectivity were presented as sensitivity runs in 2025 and 2026. Although representing a promising avenue of research, continuous time-varying selectivity formulations do not greatly improve fits to the age compositions and often reduce fits to the longline survey indices. Moreover, they tend to cause model instability, given the number of model partitions included for sablefish (i.e., sex, age/length, fleet, year). The CIE reviewers recommended maintaining the status quo for selectivity parametrization, which includes two time blocks for the fishery and survey. Moreover, the CIE reviewers explicitly stated that continuous time-varying selectivity should not be utilized at this time. Thus, the time blocked selectivity approach has been maintained for all 2026 models.

The SSC re-iterates a recommendation from last year to explore the Hulson and Williams (2024) bootstrapping approach for determining appropriate input sample sizes for compositional data.

The Hulson and Williams (2024) ISS approach has not been fully developed for longline survey data nor has it been developed for fishery compositions. Until these methods are resolved for all data sources, it was not deemed appropriate to implement as it may introduce model issues (i.e., when only one type of composition data uses a bootstrapped ISS but others do not). To address these concerns, a new time-varying ISS approach was introduced that scaled ISS relative to the number of samples in a given year and fleet (see Appendix 3B). However, regardless of approach for setting ISS, the ISS likely has limited impact on model outputs or performance given the degree of rescaling from ISS to ESS that occurs with the Francis reweighting.

The SSC appreciates the clarification of how the recruitment bias correction is currently handled in the model but encourages further explorations regarding the treatment of recruitment variances. As noted last year: "The SSC encourages the use of an appropriate sigma constraining recruitment but notes that the maximum likelihood estimate of a random effects variance is negatively biased. This can be avoided by iteratively tuning in a maximum likelihood framework (per the approach of Methot and Taylor) or by using a full Bayesian analysis such that the recruitment deviations are integrated out."

The iterative tuning method of Methot and Taylor was integrated and used to determine the recruitment bias correction parameters, but had little impact on values. Work is ongoing to move towards treatment of recruitment as random effects, given that the RTMB SPoRC model is capable of handling REs. However, initial explorations indicate that integration of REs greatly increases model run time. This work will continue to determine if recruitment REs are a feasible alternative in the future.

The SSC shares PT concerns over the loss of logbook data and supports the PT recommendation to consider developing a standardized fishery CPUE index using observer data only, especially if the longline survey cannot be conducted each year.

Investigations of the observer data suggest that the sample sizes are likely not sufficient to develop a robust CPUE index and are often extremely limited in certain regions (e.g., the AI in 2025 had no observed sablefish targeting trips).

The SSC encourages further work on skip spawning to assess its potential impact on reproductive potential, perhaps through the development of an index for the ESP.

Until resources are available to collect sablefish maturity estimates during spawning periods (winter), assessment of skipped spawning is not feasible.

The SSC encourages assessment authors to seek out local knowledge regarding fishery CPUE, in particular regarding any issues with the performance of slinky pots that may affect CPUE.

The assessment authors hold annual meetings with three industry groups and use these opportunities to discuss changes in the fishery and on the water observations. We are not currently aware of any issues with slinky pots that may affect CPUE, but will continue to discuss fishing practices with stakeholders.

Joint Groundfish Plan Team Comments (November 2024)

The Teams recommended the author explore the potential impact of time-varying selectivity, either by directly modeling it as a time-varying process or by mitigating its impact on other parameters, such as by exploring changes in the set of ages over which the age-length comps are fitted. The Teams recommended exploration of data-weighting methods that can be estimated jointly with changes in the variance of the time-varying selectivity parameters.

See response to SSC comment above regarding time-varying selectivity. For 2026, continuous selectivity parametrizations were also combined with the self-weighting Dirichlet-Multinomial likelihood for composition data. The resulting model tended to overfit the composition data at the expense of the LLS index data, resulting in extremely volatile recruitment estimates. The CIE reviewers noted explicitly that time-varying selectivity and the DM likelihood should not be utilized for sablefish at this time. As such, the models put forward for 2026 do not utilize either methodology.

The Teams recommended that the author perform a runs test of randomness to test autocorrelation in the fits to the indices.

We now output and report an index runs test as a residual diagnostic for all model runs.

If there are sufficient data, the Teams recommended exploring ways to update the standardized fishery CPUE index using only observer data.

See response to similar SSC comment above. Observer data is insufficient to produce a reliable CPUE index that adequately represents trends across all management regions.

NPFMC SSC Comments (October 2025)

The SSC also recommends including biennial survey impacts on extrapolation in the 2026 CIE review.

The LLS design changes were a primary focus of the CIE review and impetus for moving to the new FAA model.

Document Francis reweighting and effective sample sizes across datasets.

A table is now included for all model runs that provides the SE for indices and the mean ISS and ESS (after Francis reweighting) for compositional data sets.

Compare empirical length and weight-at-age directly with model estimates.

Comparison of the external estimates of growth and WAA with empirical values has not been undertaken, but is a topic that will be explored in the future. However, empirical WAA values are likely to be noisy given the relatively low level of weight samples (compared to length samples) taken on the LLS. Model sensitivity runs with time-varying growth and weight-at-age using the methods of Cheng et al. (2025) are presented in Appendices 3B and 3C.

Continue evaluation of flexible fishery selectivity and alternative composition likelihoods.

See responses to similar comments above.

Continue development of spatial models and sex-specific mortality.

The spatial models were updated for 2026 and sex-specific natural mortality is estimated in all new models put forward in 2026.

Continue exploring approaches for using fishery composition data to inform removals only rather than population structure or recruitment.

It is unclear how this would be accomplished as composition data inherently reflects the age structure of the population along with recruitment, as modified through availability and gear selectivity. Further guidance is requested on how this might be achieved.

Explore inclusion of environmental covariates in R-TMB/SPoRC.

Although environmental covariates are possible to include in SPoRC, there are no reliable covariates that have been identified for sablefish.

Model proportions of age-groups by area using spatial approaches.

The spatial assessment explicitly models compositions by region.

Clarifying the likelihood for the prior on M on the scale of M, not logM, and the other likelihood component.

It is unclear exactly what is being requested with this comment.

Avoid using an ad hoc approach to down weighting anomalous size comp data points.

The only downweighting used is Francis reweighting, which is a relatively objective and well-established method for data weighting. It is unclear what this recommendation is suggesting.

Consider the reduced survey frequency in the risk tables

For 2026, survey frequency and footprint will be specifically addressed in the risk table.

Joint Plan Team Comments (September 2025)

The Teams recommended clarifying and documenting the results of Francis reweighting and include tables of input sample sizes and final effective sample sizes. This also extends to the indices since multipliers appear to remain in use (i.e., "lambdas"; it is better to report the variance or CVs implied).

As noted in the SSC comments above, these tables are now provided for all model runs.

The Teams recommended comparing empirical length and weight-at-age directly with modeled estimates.

As noted in SSC comments above, this is a research priority but has not yet been addressed.

The Teams recommended testing approaches where fishery composition data inform removals only rather than population structure or recruitment.

As noted in the SSC comments above, it is unclear exactly how this would be undertaken and further guidance is requested.

Apportionment

Because sablefish are assessed Alaska-wide but managed across 6 management units spanning three fishery management plans (FMPs; GOA, BS, and AI), the resultant Alaska-wide ABC must be apportioned to management region. Currently, sablefish apportionment is based on the five-year moving average of regional biomass proportions from the LLS. Because the LLS is not synoptic, imputation is required to fill in index values for non-surveyed regions in a given year to enable calculation of annual regional apportionment. Although apportionment does not require developing a single region-wide 'index', it does require index values for each region. Survey index imputation is necessary for apportionment even though the recommended spatially-implicit assessment (Model *26.2_FAA*) was specifically designed to avoid the need to use imputed survey index values.

Previously, the survey apportionment method utilized the same assumptions as were used to construct the single region LLS index (as used in Model *25.12_1Reg_Cont*). Mainly, for regions that were not surveyed in a given year (i.e., BS or AI), associated index values in off years were constructed by extrapolating from the previous value in that region based on the year over year growth in the GOA. However, with the new LLS design starting in 2025, this approach is no longer feasible because the GOA is no longer surveyed annually.

Thus, starting in 2026, the sablefish apportionment approach will use the same index carryover values as used to develop the revised single region LLS index (as in Model *26.1_1Reg*). As documented in Appendix 3A, the new index construction maintains a carryover value for non-surveyed regions (i.e., if a region is not surveyed, the index value for that region is held constant at the value from that region the last time it was surveyed). Moreover, for the construction of the AI index, previously extrapolated western AI stations -- which have not been surveyed since the early 1990s -- will be removed. Thus, the regional survey biomass (i.e., relative population weight, RPW) values used in the five-year average to determine apportionment are produced using the same methods as the associated regional survey numbers (i.e., relative population numbers, RPN) that are summed to construct the single region index used in Model *26.1_1Reg*. Thus, the apportionment relies on carryover values, as this is the most reliable way to develop a synoptic evaluation of regional biomass proportions from a spatially incomplete annual survey.

To provide a comparison of how the new survey index construction impacts apportionment across regions, we calculated apportionment using the previous approach (using GOA growth to extrapolate and including western AI extrapolated stations) and the new carryover approach (using carryover regional values and dropping the western AI extrapolated stations) since 2016, with emphasis on 2023 as the most recent year that a full comparison was possible. Because there was no survey in 2024 and 2025 was the first year of the new survey design, using 2023 as an exemplar year provided the most direct comparison of how the two methods might differ. For both apportionment calculations, the five-year average apportionment included a moving average of the five previous years (e.g., for 2023 apportionment, the 2019—2023 LLS index value were used in the calculation).

Results demonstrate that the change in index construction method has small impacts on regional apportionment (Figure 1; Table 8). The removal of the extrapolated western AI stations reduces the relative contribution of the AI, which proportionally increases apportionment to all other regions for the new proposed method. Of note, the BS proportions are scaled upwards due to the change in the AI but scaled downwards by a similar amount due to the switch to the carryover values. Because the carryover approach leads to a more moderate recent rate of increase in the BS (compared to extrapolating based on GOA year

over year change), the BS index is generally lower. Ultimately, the two influences on the BS proportion act to essentially cancel one another out leading to little change in the BS apportionment, while the apportionment values in the GOA increase moderately across methods. Overall, the updated apportionment approach ensures consistency with how LLS indices are constructed in the new single region model, while maintaining the long-term apportionment goals of 1) distributing catch proportional to biomass to avoid deleterious localized population impacts; and 2) avoiding large interannual fluctuations in the distribution of the ABC across management regions. Values for 2025 apportionment under the proposed approach are similar to the 2023 values with minor changes due to updated GOA survey data for 2025 (Table 8), while similar moderate changes are expected for 2026 with the addition of BS and AI survey data.

Tables

Table 1. Summary of the single region model bridging and model changes from Model *25.12_1Reg_Cont* to Model *26.1_1Reg*.

Model Group	*Model Name*	*Major Changes*	*Conclusions*
Continuity Model	*25.12_1Reg_Cont*	(*25.12*) None.	The continuity model retains minor instability due to selectivity parametrizations and conflicting signals among age and length data as well as the various indices; further model updates are warranted to improve performance and increase stability.
Model Parametrization (Section 1)	*26.1a_1Reg_Cont_Upd*	(*25.12+*) Remove selectivity links, update selectivity priors, and reduce survey CV.	Improved selectivity parametrization greatly improved model stability, while decreased survey CV led to minor improvements in fit to LLS index; moderate rescaling resulted from an increase in the *M* estimate that led to increases in SSB and catch advice.
	26.1b_1Reg _ISS	(*26.1a+*) Implement relative scaled input sample size (ISS) across years.	The scaled ISS had minimal impact on estimates (e.g., selectivity) but led to minor improvements in fits to composition data and mean age.
	26.1c_1Reg_TF_log	(*26.1b+*) Implement logistic selectivity for the trawl fishery.	Implementing the logistic function for trawl fishery selectivity improved model stability and led to minimal improvements to trawl fishery length composition fits, particularly larger females.
Biology (Section 2)	*26.1d_1Reg_Upd_Bio*	(*26.1c+*) Utilize updated length and weight parameters.	Led to minor scaling changes in biomass due to slight decrease in mean weight of fish under 15 years of age.
	26.1e_1Reg_Upd_Sex_M	(*26.1d+*) Estimate sex-specific natural mortality (*M*).	Caused moderate reduction in *M* estimates across ages, which led to increases in *F* along with reductions in SSB and catch advice.
Data Usage (Section 3)	*26.1f_1Reg_No_CPUE*	(*26.1e+*) Remove the fishery CPUE index.	Resulted in minor improvements in fit to the LLS index and changes to estimates of fishery selectivity (particularly in the pre-1995 block).
	26.1g_1Reg_No_Len_2_Blks_F	(*26.1f+*) Drop fixed gear fishery and NOAA LLS lengths along with associated early fishery time block.	Improved model stability considerably and led to minor changes to fishery selectivity and male *M*, leading to increases in *F* and downward scaling of SSB and catch advice; fits to early age compositions improved slightly.
	26.1h_1Reg_LLS_Carry	(*26.1g+*) Implement 'carryover' approach for NOAA LLS calculation in all years.	The 'carryover' LLS index construction approach leads to a slightly different index trajectory that is more steadily increasing in recent years, while the model is better able to fit this trend; the lower initial index values and steady recent increases lead to an upward scaling of SSB and catch advice.
	26.1i_1Reg_No_wAI_LLS	(*26.1h+*) Drop extrapolated western AI stations from the NOAA LLS index.	Removal of the extrapolated western AI stations causes the LLS index to be scaled downwards and tampers the rate of increase in recent years (given that the increasing catch rates in the AI cause the extrapolation to have a stronger impact), which results in a minor reduction in recent SSB and catch advice.
Final 1 Region Model	***26.1_1Reg***	(*26.1i*) None.	Improved parametrization and removal of uncertain and potentially contradictory data sets greatly improved model stability; updates to the LLS index construction improve consistency and better reflect observed dynamics; and improved biological inputs and parametrization likely help to better reflect sex-specific sablefish dynamics.

Table 2. Summary of tradeoffs between using a single region (1Reg), spatially implicit (Fleets-as-Areas, FAA), and muti-region (spatial) models for sablefish.

Model	*Benefits*	*Issues*	*MSE Conclusions*	*Tradeoffs*
Single Region Model (1Reg)	Higher sample sizes. Low model complexity. Intuitive and transparent results. Limited change from status quo assessment methodology.	Requires fitting extrapolated data for the Longline Survey Index. Implicit over-weighting of GOA composition data during aggregation or high interannual variability due to reduced survey footprint. Little signal from BS/AI compositions, because GOA given higher weight (RPNs or catch) in data aggregation. Ignores spatial structure.	Moderate SSB bias and moderate instability due to the survey extrapolation and aggregated composition data but impacts on resulting management advice may be negligible.	Higher sample sizes but requires fitting the extrapolated longline survey index and age compositions primarily represent the recruitment signals from the GOA due to data aggregation assumptions.
Spatially Implicit Model (Fleets-as-Areas, FAA)	Fitting non-extrapolated Longline Survey index. Fitting disaggregated survey compositions. Better accounting for signals from BS/AI compositions on recent year class strength. Implicitly accounting for ontogenetic movement dynamics	Low sample sizes and sparse data are likely for BS/AI age compositions. Increased instability may exist due to added complexity (estimating extra q and selectivity parameters for 'regional' survey fleets). Non-intuitive estimates may result that are difficult to interpret (e.g., due to using multiple fleets that are interacting with a single underlying population – not multiple populations/regions). Selectivity may need to be more flexible to address ontogenetic dynamics and changes in availability across age classes.	Low SSB bias and high model stability with improved performance over other structures when survey spatial coverage decreases, but adequate flexibility in selectivity parametrizations is likely needed to ensure good performance.	Able to fit the regional longline survey indices without aggregation and likely provide more robust outputs when survey coverage decreases, but sample size limitations may prevent adequate selectivity flexibility to address ontogenetic availability issues due to model instability.
Spatial Model (3 or 5 Region)	Fit data at the regional scale it was collected. Better account for signals from each region. More intuitive than FAA. Explicitly account for ontogenetic movement dynamics.	Increased sample size limitations. Increased parametrization decisions related to spatial processes. Lack of best practices for fitting tagging data (e.g., dealing with tag mixing issues and data weighting). Increased parameter correlation, particularly between regional recruitment parameters and movement. Diagnostics can be difficult to interpret.	High instability due to overparameterization and low sample sizes but best represents localized dynamics.	Best represents spatial dynamics but suffers from high model instability due to data sparsity that requires extremely careful parametrization, while appropriate handling of tagging data is difficult and potentially subjective.

		Increased instability.		

Table 3. Summary of the parameters estimated within each assessment model and the associated maximum gradient component.

Parameter Name	***25.12_1Reg_Cont***	***26.1_1Reg***	***26.2_FAA***
Catchability	5	2	4
Mean recruitment	1	1	1
Natural Mortality	1	2	2
Initial Deviations	28	28	28
Recruitment Deviations	65	65	65
Mean Fishing Mortality	2	2	2
Fishing Mortality Deviations	129	129	129
Fishery Selectivity	14	12	12
Survey Selectivity	11	12	28
Total	256	253	271
Maximum Gradient	2.64 e -05	2.91 e -10	7.64 e -10

Table 4. The assumed error terms for each data source used in the assessment models. Fit to catch and survey data assumed lognormal error with an associated assumed standard error (SE). Fit to composition data (ages and lengths) assumed a multinomial distribution with associated sample sizes (input sample size, ISS, and final 'effective' sample size, ESS). Each model used Francis data reweighting to 'right-weight' the composition data relative to the indices (Francis, 2011), which resulted in a weighting factor (λ , Data Wt) used to scale the ISS to achieve the final ESS. Values represent the mean across all years of associated data, where the yearly SE can be found in Table 3.6 of the CIE SAFE document and the yearly ISS can be found in Table 3.5 (associated yearly ESS can be calculated by multiplying the ISS by the respective Data_Wt for the given data source).

Data Source	*25.12_1Reg_Cont*				*26.1_1Reg*				*26.2_FAA*			
	SE	**ISS**	**Data Wt**	**ESS**	**SE**	**ISS**	**Data Wt**	**ESS**	**SE**	**ISS**	**Data Wt**	**ESS**
Fixed Gear Catch	0.05	--	--	--	0.05	--	--	--	0.05	--	--	--
Trawl Catch	0.05	--	--	--	0.05	--	--	--	0.05	--	--	--
Fixed Gear Fishery CPUE	0.20	--	--	--	--	--	--	--	--	--	--	--
NOAA Longline Survey RPN BS	--	--	--	--	--	--	--	--	0.20	--	--	--
NOAA Longline Survey RPN AI	--	--	--	--	--	--	--	--	0.24	--	--	--
NOAA Longline Survey RPN GOA	--	--	--	--	--	--	--	--	0.08	--	--	--
NOAA Longline Survey RPN AK	0.09	--	--	--	0.07	--	--	--	--	--	--	--
Coop Survey RPN	0.09	--	--	--	0.07	--	--	--	0.07	--	--	--
Fixed Gear Age Composition	--	20	0.80	16	--	145	0.12	18	--	145	0.04	6
Fixed Gear Size Composition	--	20	3.48	70								
NOAA Longline Survey Age Composition BS	--	--	--	--	--	--	--	--	--	37	0.51	19
NOAA Longline Survey Age Composition AI	--	--	--	--	--	--	--	--	--	39	1.91	75
NOAA Longline Survey Age Composition GOA	--	--	--	--	--	--	--	--	--	77	0.29	23
NOAA Longline Survey Age Composition AK	--	20	3.54	71	--	171	0.28	47	--	--	--	--
NOAA Longline Survey Size Composition AK	--	20	2.29	46	--	--	--	--	--	--	--	--
Japanese Longline Survey Age Composition	--	20	0.64	13	--	83	0.17	14	--	83	0.18	15
Japanese Longline Survey Size Composition	--	20	1.03	21	--	55	0.34	19	--	55	0.33	18
Trawl Fishery Size Composition	--	20	0.35	7	--	45	0.25	12	--	45	0.14	7

Table 5. Key scaling parameter estimates along with their uncertainty, including 95% credible intervals from MCMC analysis for each model. Recruitment is in millions of fish. All parameter estimates are in ln-space. For Model 25.12_1Reg, only a single natural mortality (*M*) is estimated and shared across sexes.

	25.12_1Reg_Cont		***26.1_1Reg***		***26.2_FAA***	
Parameter	**Mean (MLE)**	**SD (MLE)**	**Mean (MLE)**	**SD (MLE)**	**Mean (MLE)**	**SD (MLE)**
ln_Mean_Recruit	2.95	0.17	3.03	0.13	2.82	0.11
ln_M_Female	-2.38	0.09	-2.39	0.07	-2.43	0.07
ln_M_Male	--	--	-2.41	0.07	-2.44	0.08
ln_q NOAA Longline Survey	2.06	0.12	1.90	0.10	--	--
ln_q NOAA Longline Survey BS	--	--	--	--	0.55	0.10
ln_q NOAA Longline Survey AI	--	--	--	--	0.33	0.10
ln_q NOAA Longline Survey GOA	--	--	--	--	2.20	0.08
ln_q Japanese Longline Survey	1.68	0.11	1.71	0.09	2.08	0.08

Table 6. Summary of ABC and OFL for each assessment model compared to those output during the last operational assessment (2024). The values were provided as part of the *draft* 2026 CIE SAFE report and are not meant for use as management advice.

Quantity/Status	Specified *last* SAFE for Model *23.5*:		Estimated *this* SAFE for Model *26.1_1Reg*:		Estimated *this* SAFE for Model *26.2_FAA*:	
	2025	2026*	2026	2027**	2026	2027^
M Female (estimated)[#]	0.11		0.092		0.088	
M Male (estimated)	--		0.090		0.087	
Average Recruitment (millions of fish)	26		21		18	
Tier	3a		3a		3a	
Projected Total Biomass (Age 2+; kt)	705	696	628	611	469	453
Projected Female Spawning Biomass (kt)	220	241	237	253	205	211
$B_{100\%}$ (kt)	303	303	348	348	306	306
$B_{40\%}$ (kt)	121	121	139	139	122	122
$B_{35\%}$ (kt)	106	106	122	122	107	107
F_{OFL}	0.10	0.10	0.09	0.09	0.10	0.10
$maxF_{ABC}$	0.09	0.09	0.08	0.08	0.08	0.08
F_{ABC}	0.09	0.09	0.08	0.08	0.08	0.08
OFL (kt)	59	58	48	46	38	35
max ABC (kt)	50	50	41	40	32	30
ABC (kt)	50	50	41	40	32	30
Status	As determined *last* year for:		As determined *this* year for:		As determined *this* year for:	
	2023	2024	2024	2025	2024	2025
Overfishing	No	n/a	No	n/a	No	n/a
Overfished	n/a	No	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No	n/a	No

*The 2024 SAFE projections of future SSB and biomass were based on specified catch of 25,000 mt in 2025 (a yield ratio of 0.49 was assumed based on a 2024 extrapolated catch of 23,000 mt and an ABC of 47,000 mt). Specified catch projections are utilized in response to management requests for a more accurate two-year projection. SSB and biomass are less than presented when the maximum ABC is removed in 2025.

**The 2026 CIE SAFE Model *26.1_1Reg* projections were based on specified catch of 20,000 mt in 2026 (a yield ratio of 0.49 was assumed based on a 2025 catch of 23,200 mt and an ABC of 47,600 mt).

^The 2026 CIE SAFE Model *26.2_FAA* projections were based on specified catch of 16,000 mt in 2026 (a yield ratio of 0.49 was assumed based on a 2025 catch of 23,200 mt and an ABC of 47,600 mt).

[#]A single female natural mortality parameter is estimated in Model *23.5* and is used for both sexes.

Table 7. Summary of CIE reviewer recommendations for improving the Alaksa sablefish stock assessment model.

Category	Primary Target / Issue	Specific Recommendation	Objective / Expected Benefit	Author Response	Planned Action
Model Structure	Operational Model Choice	Adopt Model *26.2_FAA* with 3 survey fleets (BS, AI, GOA) and logistic selectivity.	Provides BSIA; handles alternating biennial survey coverage without data extrapolation.	The authors agree and plan to put forth the new Model *26.2_FAA* for sablefish.	The authors are proposing Model *26.2_FAA* for 2026 advice.
	Natural Mortality (*M*)	Conduct sensitivity analyses on *M* values and evaluate alternative prior formulations (e.g., Jeffrey's priors, this should be done via simulation analysis before testing operationally).	Quantifies impact of *M* prior on OFL/ABC and provides better understanding of weak parameter identifiability.	An *M* sensitivity analysis was performed as part of the 2025 updates and demonstrated the expected result – *M* is a critical model scalar that directly scales SSB and ABC. The work in 2025 extensively explored appropriate *M* priors and we believe the current parametrization is adequate, given the extensive uncertainty and associated model instability in estimating *M*.	Integrating alternative prior formulations into SPoRC will be explored over the next year. When available, the authors will explore *M* sensitivity again and identify whether new prior formulations are warranted (using simulation analysis).
	Selectivity in the FAA Model	Use of dome shaped selectivity should continue to be investigated as more age composition data for the BS and AI become available in the coming years. Similarly, there should be further investigation into different time blocks for the FAA assessment. The use of sex-specific spline selectivity could be investigated.	Selectivity curves were limited to logistic. This is an appropriate restriction, however it does limit the capacity of the FAA model to capture spatial aspects (such as the heightened presence of juveniles and the old plus class fish in the Aleutians). Various forms of domed selectivity would allow the model to have further flexibility to fit the age compositions but also add instability. Alternate time blocks would help to demonstrate if there are other formulations that result in stable parameter estimation.	A number of domed selectivity FAA model sensitivity runs were presented at the CIE, including gamma and semi-parametric continuous time selectivity. Although these models helped better account for availability in the BS and AI, the models were increasingly unstable (i.e., demonstrated degraded retrospective performance) and did not significantly improve fits to the age composition data. Similarly, various time blocks were explored for the survey and fishery as well as continuous selectivity options. None of these model alternatives showed significantly improved diagnostics and were often more unstable.	The authors will continue to explore models with domed selectivity and alternate time blocks, including continuous time and semi-parametric variants. However, many of these models add instability and undue complexity and will not be put forth for management advice unless model performance improves significantly.
	Recruitment	Explore episodic recruitment in the model structure.	The interannual changes in survey age composition data (GOA odd years,	The authors have discussed integration of recruitment stanzas	Sensitivity runs with recruitment stanzas will be explored in the

	Parametrization		BS/AI even years) likely causes underestimation of recruitment in high recruitment years and overestimation in low recruitment years (shrinkage towards mean recruitment in recent years). Including recruitment stanzas (time-varying R_0) might alleviate the over/under-estimation issue to some degree, but the information to parameterize this could be limited.	to reflect high or low recruitment periods. However, identification of the associated temporal break points may be subjective, and, as noted, adding additional recruitment parameters is likely to add model instability. Moreover, the introduction of recruitment stanzas has important implications for management biomass reference points, which are based on an assumed time period of average recruitment. Adding stanzas would require a decision as to which stanza to use for calculation of reference points.	coming year but are unlikely to be stable enough for use in management. Moreover, the recruitment variance term (σ_R = 0.9) was chosen to allow extreme fluctuations in recruitment deviations and should be flexible enough to allow recruitment to vary widely and implicitly account for the cyclical changes in sablefish recruitment.
Diagnostics	Jitter Analyses	Re-run jitter convergence tests with larger perturbations of starting values.	Larger perturbations will help further confirm global convergence.	Initial jitter runs were set up following general AFSC guidelines but can easily be altered to better test convergence.	Future jitter diagnostics will utilize larger perturbations, as recommended.
Data Inputs	LLS RPNs vs. RPWs	Further explorations of whether it is best to fit the LLS index in numbers or weight would be useful.	The LLS is currently fit as a numbers-based index (RPNs). In years of strong recruitment, the RPN can be dominated by small fish. It might be preferable to fit the index in weight (RPW) to better reflect population biomass.	The 2016 CIE review recommended fitting the index as RPNs to better reflect recruitment signals (at a time when recruitment had been low for over a decade). At the time, the assessment team evaluated fitting RPNs vs. RPWs and concluded that converting numbers to weight would add uncertainty to the assessment outputs (given the low number of fish weight samples). Moreover, the age composition data already provides information on the proportions of younger and older fish.	The authors do not currently plan to reevaluate this model assumption, given that a thorough analysis was undertaken during the last CIE review. As noted, RPWs are much more uncertain due to weight sampling protocols and there is no reason to believe that fitting RPWs would provide a significantly different interpretation of population trajectory or alter model performance.
	Fishery CPUE & Trawl Survey	Discontinue use of trawl survey indices and commercial CPUE data.	Improves retrospective pattern diagnostics and parsimony by removing conflicting/unreliable data.	The authors agree with this approach and neither index has been included in either of the proposed models.	Moving forward both indices will be monitored in the SAFE, but neither will be included in the assessment.

Survey Design	Depredation Protocols	Formally document and standardize protocols for removing survey skates affected by whale depredation.	Ensures consistency, transparency, and reproducibility in survey index calculations.	The LLS team is currently working on more objective ways to account for whale depredation and agree that more formal documentation will be critical once methods are finalized.	Important changes to the LLS index construction and protocols are being explored and once finalized, will be documented in a NOAA Technical Memorandum.
	Longline Survey Footprint	Maintain survey footprint and prevent further spatial/station reductions; evaluate expanding back to annual surveys or including WAI.	Reduces biomass trend lag, stabilizes recruitment estimates, and lowers assessment uncertainty.	The authors and LLS team fully agree with this recommendation, and no plans are currently under consideration to change the survey footprint from the 2025 and 2026 levels. Further expansion would likely necessitate further dedicated funding from NOAA and is not under consideration at this time.	Expansion of the LLS would be considered in the future pending long-term funding acquisition.
Data Collection	Otolith Aging Capacity	Increase the number of otoliths aged annually (utilizing archived otoliths) and hire/train an additional reader.	Improves age composition sample sizes across all regions and sexes, aiding model fit.	Although the authors support this recommendation, the AFSC Age and Growth Program (AGP) is currently working at full capacity and is unlikely to be able to read more sablefish otoliths.	If AGP capacity increases in the future, the authors will work with age readers to identify appropriate increases in target sablefish otoliths to read.
	Tagging & Otolith Recovery	Enhance tag return incentives (e.g., larger lottery prizes) for returning tagged fish with otoliths.	Increases known-age tag recoveries to refine aging error matrices and movement estimates.	Unfortunately, funding to increase tag return incentives is not currently available. Given the pace of work on commercial vessels and processing plants, the likelihood of attaining otoliths along with tags is likely low, though this would be a valuable source of information. We do currently attain approximately 12% of tag returns from the LLS, where we collect the otoliths for future ageing. However, as noted above, the capacity to age more otoliths by the AGP does not currently exist.	Options will be explored for obtaining otoliths from recaptured fish, pending improved capacity to age otoliths by the AGP.
	Age Validation	Inject a subset of tagged survey fish with calcein and explore trends in ageing error with region/depth.	Assists in verifying annual growth annuli and reduces otolith aging error.	This would require extensive collaboration with the LLS and AGP teams to develop a special project that may not be feasible	The survey team and AGP will discuss the potential cost/benefits of this recommendation to determine if it would provide

				given the current LLS vessel limitations.	significant improvement to current ageing protocols and/or would be feasible on the LLS. The toxicity of calcein would need to be considered for sablefish being sent to market.
	Age Sample Size Impacts	Perform simulation sensitivity analysis to identify cost/benefit of increased age reading on assessment performance.	Will determine the expected benefit from increasing aging capacity and where otolith collection might have biggest impact spatially.	In order to fully test the value of aging data, a high spatial resolution operating model (OM) is necessary to account for the spatiotemporal nature (sparsity and correlation) of age samples, especially given the spatial domain of the assessment and low level of sampling in certain regions (e.g., the AI had no otoliths taken by observers in 2025). A simple simulation based on effective sample size (ESS) by region (i.e., increasing or decreasing multinomial ESS for simulating age compositions as is typically done) does not provide a robust conclusion as to the value of additional aging data. Indeed, the results are more or less pre-determined where higher ESS (more samples) will inherently reduce assessment uncertainty and bias (as has been demonstrated in many simulations). Accounting for realistic data sparsity and likely spatial correlation requires new simulation frameworks that are not currently available for sablefish.	Development of a high-resolution OM for sablefish is a long-term research goal for the assessment team, but likely will require additional funding to complete. In the interim (coming year), the authors will explore further OM scenarios with the spatially explicit closed loop simulation model to identify potential benefits of increased aging across regions.
	Spatial Catch & Effort	Collect spatially explicit catch and effort data from logbooks for fixed gear fleet.	Would provide a spatially explicit fishery-dependent CPUE index and tracks spatial shifts in fishing grounds.	The logbook data is no longer being processed and would require additional resources to do so.	If logbook data becomes available, this recommendation will be revisited.
Spatial Research	Observer Data Analysis	Examine observer age compositions spatially.	Analysis of aging data collection locations will help determine if spatial shifts in fishing effort caused	Extensive analysis of otolith collection sites across years as well as vessels was undertaken prior to	Unfortunately, much of the analysis of AI observer data is confidential due to the limited

			historical "plus group" (age 31+) anomalies.	the CIE review in 2025. Interesting patterning was discovered, especially from the AI where periodic pulses of extremely large and old fish have been caught by the fishery. Based on observer data, it does appear that fishing effort shifts into the western AI drove the emergence of the large plus groups. However, it is unclear if subsequent decline in effort in that region was due to declining CPUE, declining value (gas prices and/or sablefish prices), or other socioeconomic factors.	number of active/observed vessels and the spatial nature of the data. Aggregated summaries of the data analysis will be developed and shared with review bodies in the near future. The authors plan to update the analysis annually as a way to track shifts in fishing effort distribution, locations of otolith collection spatially, and especially changes in dynamics in the AI.
	Stock Structure & Dispersal	Conduct larval dispersal modeling (MOM-6) across BS/AI and expand tagging (electronic/satellite).	Refines spatial movement parameters and connectivity assumptions for future spatial models.	Both of these recommendations are long-term research priorities for the assessment team but require additional funding to obtain the expertise to develop larval dispersal models and/or Hidden Markov Models (HMM) to analyze satellite tag tracks from geomagnetic fields.	The assessment team will continue to lead efforts and write grants to obtain funding for these recommendations.
	Added Operating Model Complexity	Include an additional population/region in the AI (i.e., a western AI region) within the spatially explicit operating model (OM), which only interacts with the fishing fleet in certain years.	Adding a region to the AI in the spatial simulation framework would help determine what influence a de facto spawning refugia (i.e., a western AI region composed of large, older fish that is only lightly fished in certain years) might have on assessment performance, especially in relation to the appearance of sporadic large plus groups in the fishery. It is noted that this would be a significant piece of work.	The authors have been in discussions on how to formulate such an OM for over a year but are primarily limited by issues with model conditioning for the new region given limited observed data. Primarily, initializing the population in this region as well as the level of movement out of this region are critical assumptions.	The authors are planning multiple research products based on the spatial closed loop simulations, one of which will include an additional western AI region. The results of the work will be presented when completed (~1-2 years).
	Make Spatial Model Operational	The Alaska-wide assessment should move towards a spatial model when it is sufficiently stable to provide reliable projections for calculating the reference points.	Given the extensive spatial complexity in sablefish biological and fishery dynamics, the spatial model is conceptually more appropriate to explicitly handle these spatial processes. Moreover, the considerable variation in catch across east, middle and west GOA (highest in the east),	The assessment team agrees that the spatial model has many appealing aspects and can better represent sablefish spatial dynamics. Extensive effort has been put into this model and continues, mainly to address issues related to spatially varying	The assessment team plans to provide annual updates to the five-region assessment model and will continue to explore the potential for its use as the basis of operational management advice, if and when it is deemed stable and robust (and when issues related to spatial

			would best be represented by a 5-area model rather than a 3-area model.	selectivity, time-varying movement, integration of electronic tagging data, and data weighting (tag data vs. other data inputs).	reference points and HCRs have been resolved).
	Spatial Reference Points	Develop methods to define and implement Tier 3 spatial management reference points and harvest control rules (HCRs).	Resolves uncertainty in how spatial reference points should be calculated and the scale at which they should be implemented (e.g., regionally vs. globally).	The assessment team is currently undergoing work to better define and understand the implications of different definitions of reference points in a spatial context. Because fish can now move among regions in a spatial model, defining equilibrium reference points becomes more complex. Additionally, many of the underlying issues must be determined by managers (e.g., should the HCR be applied globally or regionally) to guide how the authors should implement management catch projections.	The authors will continue simulation work exploring spatial reference points and HCRs and will update the review bodies (PT, SSC) on this work, as requested.
Software	Package Documentation	Write a formal technical design and architecture document for SPoRC.	Facilitates open collaboration, long-term maintainability, and developer succession.	This is an excellent recommendation to accompany the extensive documentation and vignettes currently available for SPoRC.	The lead developer will work on developing a formal design document for SPoRC in the coming year.
	Quality Assurance	Expand unit testing suite and automate routine (e.g., weekly) execution.	Prevents bug introduction and ensures long-term software stability as features are added.	Although already utilized for many code aspects, expansion of unit tests is a good suggestion.	The lead developer has already implemented this recommendation.

Table 8. Comparison of regional apportionment for 2023 based on the previous approach (i.e., extrapolating based on GOA for non-surveyed regions and including western AI extrapolated stations) and the updated approach that is consistent with the revised single region index construction (i.e., using carryover values for non-surveyed regions and removing the extrapolated western AI stations) used for Model *26.1_1Reg*. 2023 is used as a basis of comparison to ensure full consistency in approaches (given survey footprint change in 2025 and given that there was no survey in 2024) and are based on a five-year average including years 2019—2023. Note that apportionment values are rounded to the nearest hundredth in the table, but percent change is calculated on the raw values. Values for 2025 apportionment under the revised approach are also provided demonstrating minor changes due to updated survey data for 2025. Note that the WY and SEO apportionments do not include the 5% trawl allocation to SEO reallocated to WY (as is done in the final harvest specifications).

Region	2023 Apportionment Previous Approach (GOA Extrapolation)	2023 Apportionment Revised Approach (Carryover Values)	Percent Change from Old to New Apportionment for 2023	2025 Apportionment Revised Approach (Carryover Values)
BS	0.28	0.28	-1%	0.28
AI	0.24	0.19	-21%	0.20
WGOA	0.10	0.11	10%	0.11
CGOA	0.20	0.23	15%	0.23
WY	0.06	0.06	10%	0.06
SEO	0.12	0.13	11%	0.12

Figures

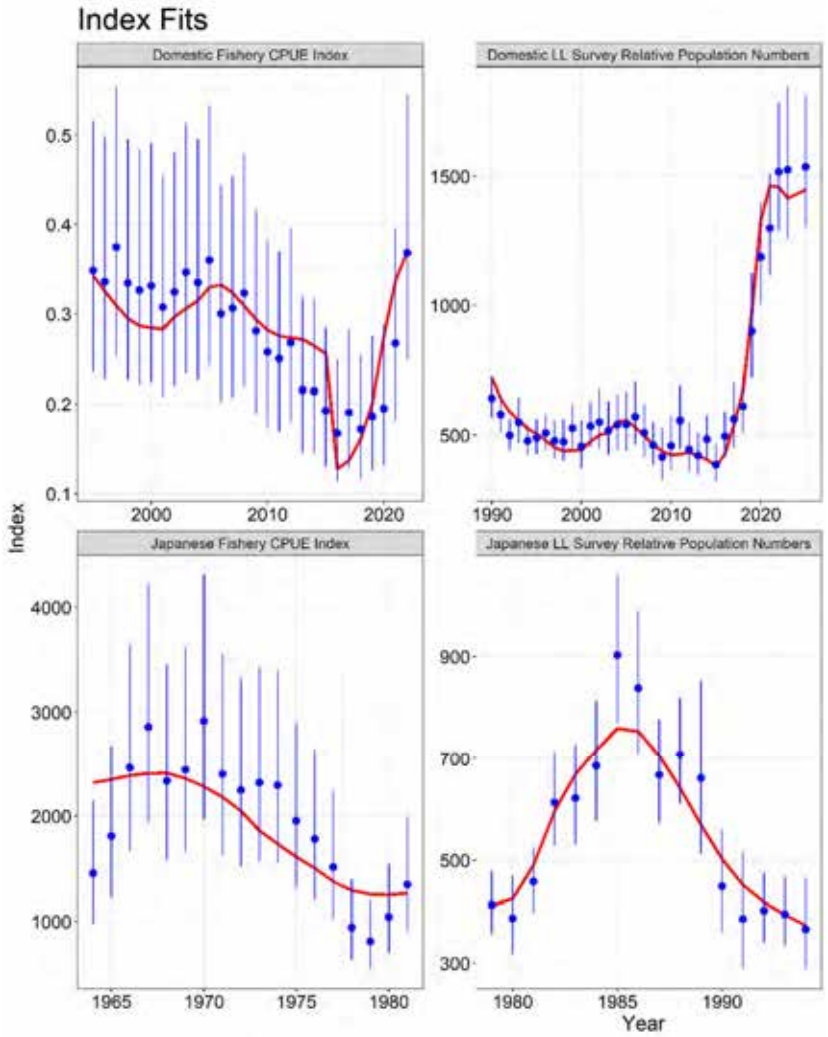

Figure 1. Model *25.12_1Reg_Cont* fit to indices, including the domestic fishery CPUE (top left), Japanese fishery CPUE (bottom left), NOAA Longline Survey RPNs (top right), and Japanese Longline Survey RPNs (bottom right). Red lines are model predicted values and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

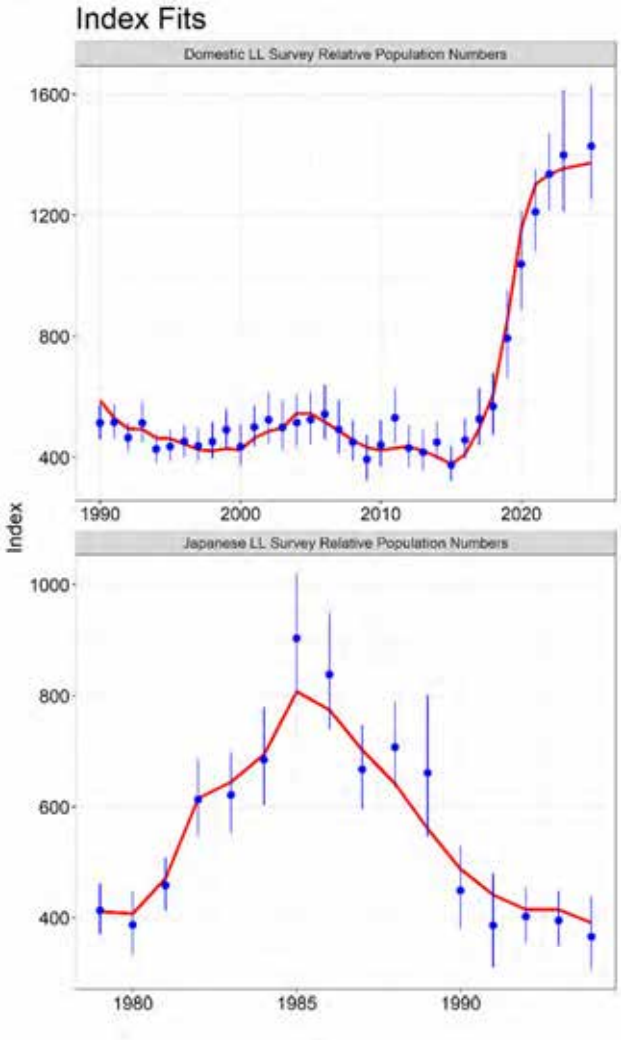

Figure 2. Model *26.1_1Reg* fit to indices, including the NOAA Longline Survey RPNs (top, 1000s of fish) and Japanese Longline Survey RPNs (bottom, 1000s of fish). Red lines are model predicted values, and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

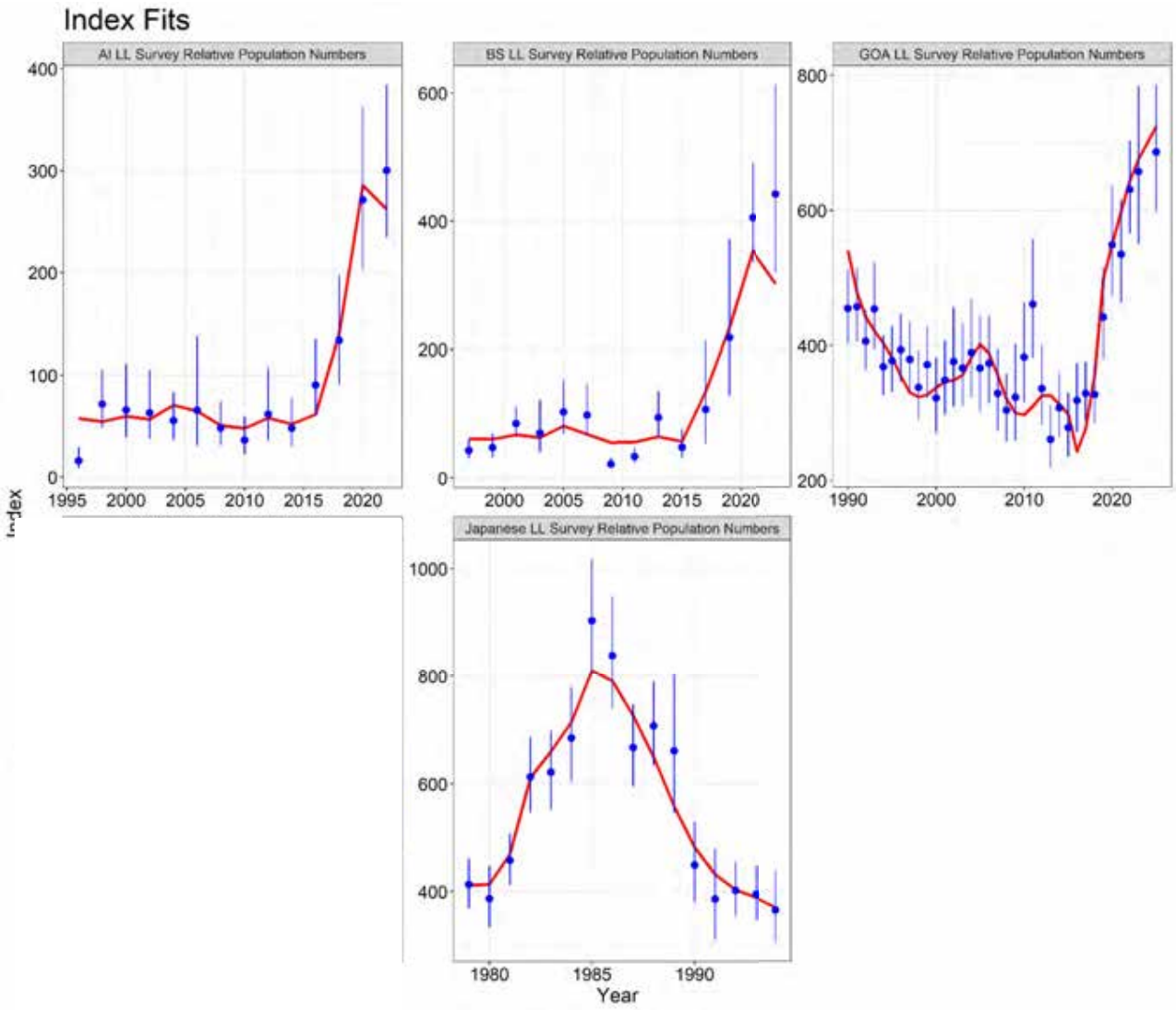

Figure 3. Model *26.2_FAA* fit to indices, including the NOAA Longline Survey RPNs (top, 1000s of fish) by region (columns) and Japanese Longline Survey RPNs (bottom, 1000s of fish). Red lines are model predicted values, and blue dots are observed values (with 95% confidence intervals based on the assumed standard errors).

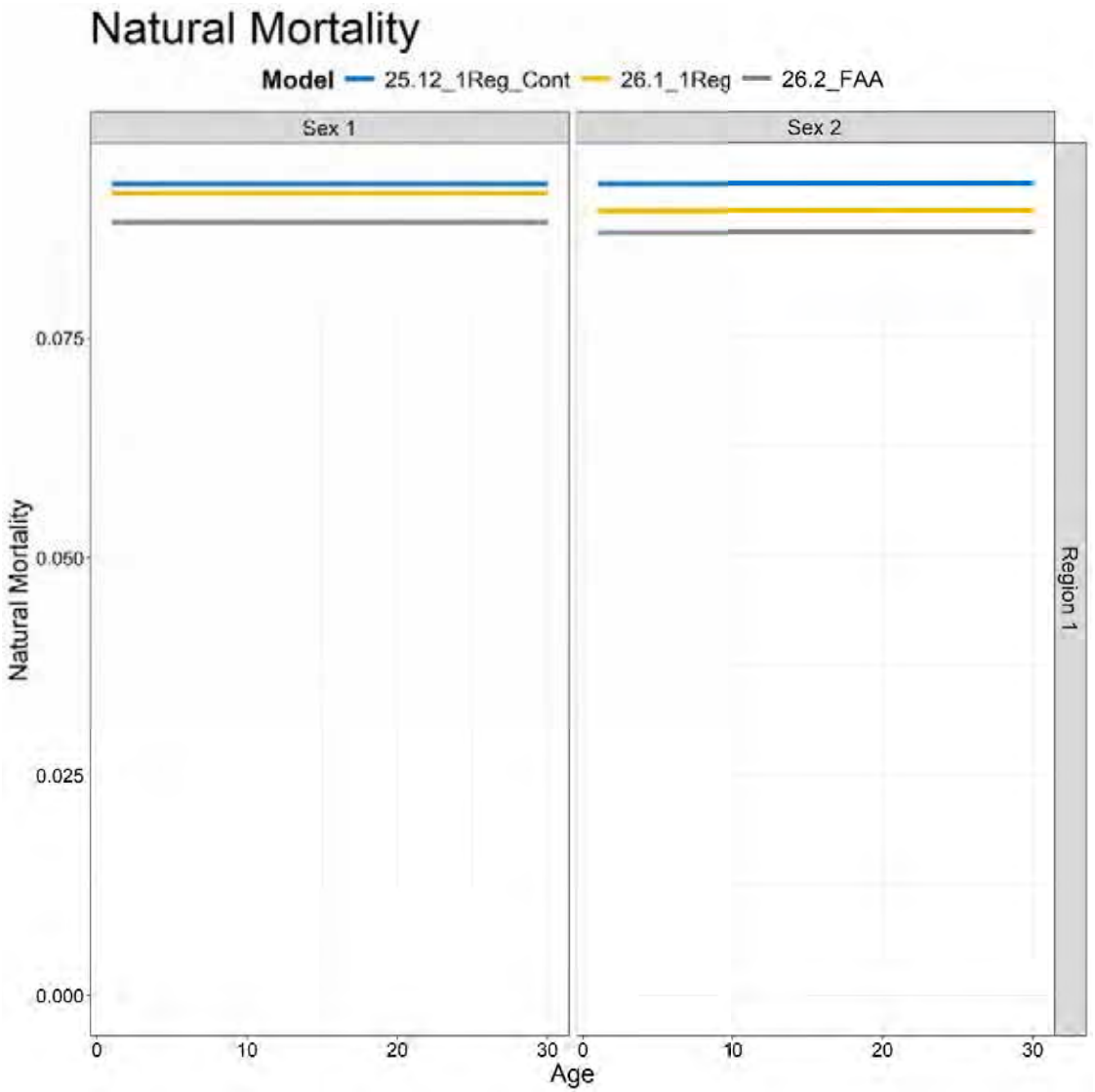

Figure 4. Natural mortality estimates from Model *25.12_1Reg_Cont* (blue line), Model *26.1_1Reg* (yellow line), and Model *26.2_FAA* (grey line). Sex 1 is females and sex 2 is males.

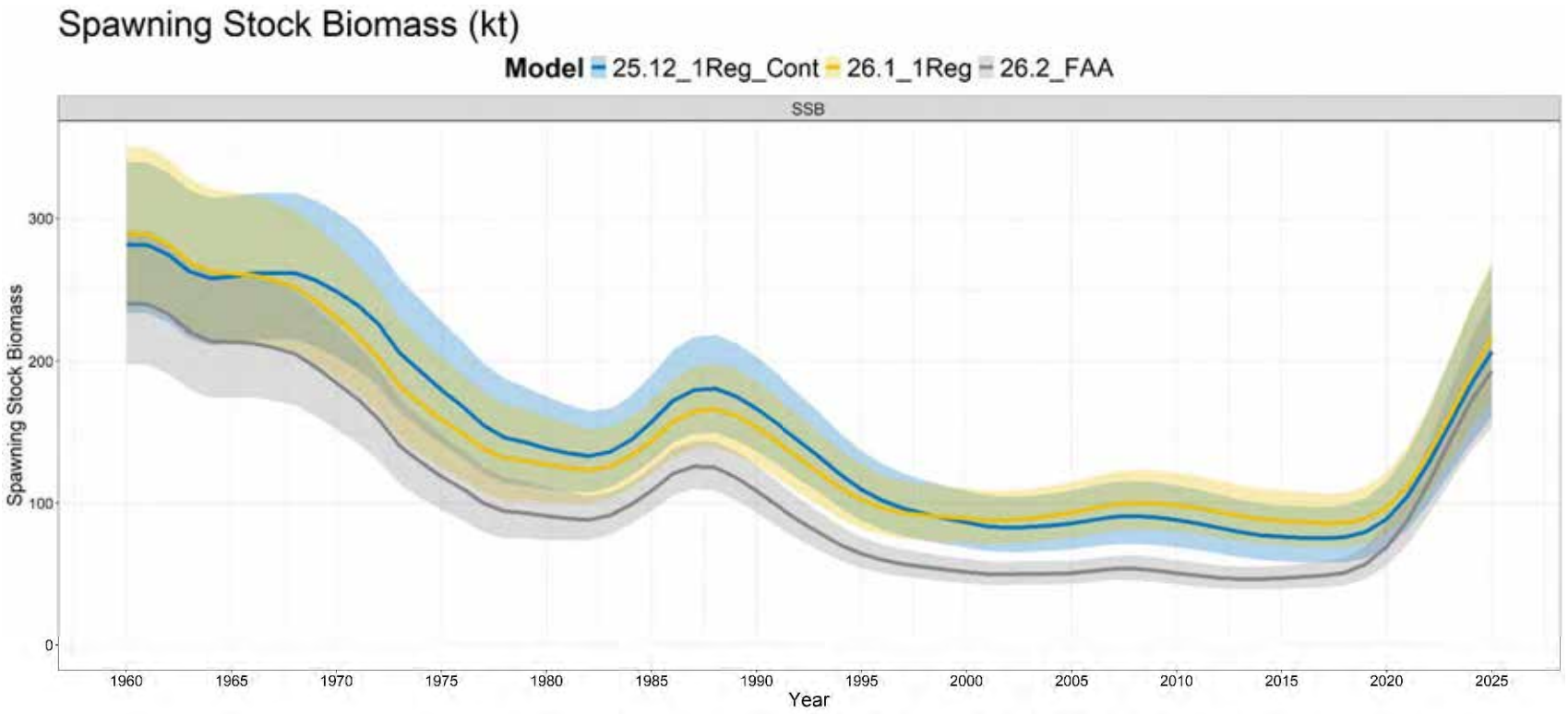

Figure 5. Comparison of spawning stock biomass (SSB, in kilotons) from Model *25.12_1Reg_Cont* (blue line), Model *26.1_1Reg* (yellow line), and Model *26.2_FAA* (grey line), where shaded regions represent the 95% confidence intervals.

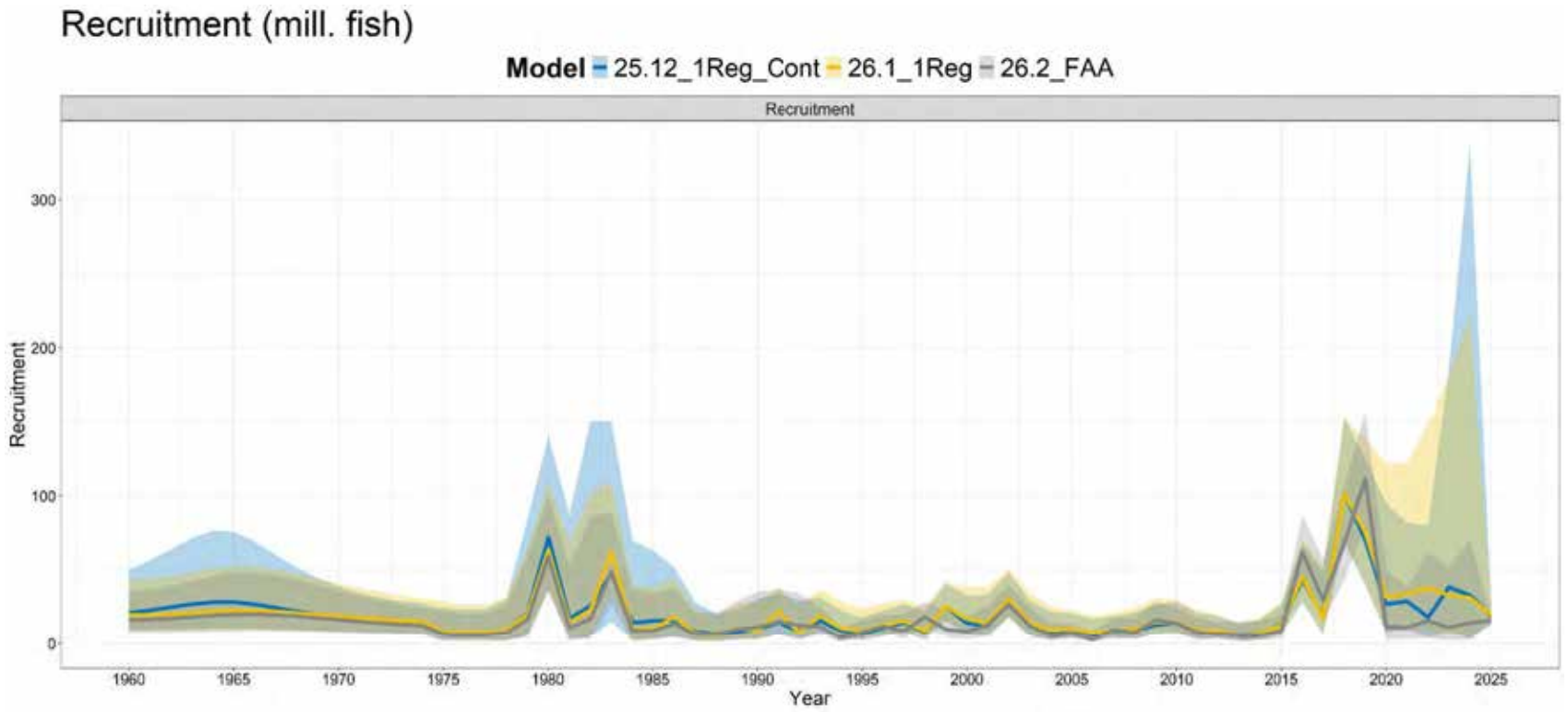

Figure 6. Comparison of recruitment (in millions of fish) from Model *25.12_1Reg_Cont* (blue line), Model *26.1_1Reg* (yellow line), and Model *26.2_FAA* (grey line), where shaded regions represent the 95% confidence intervals.

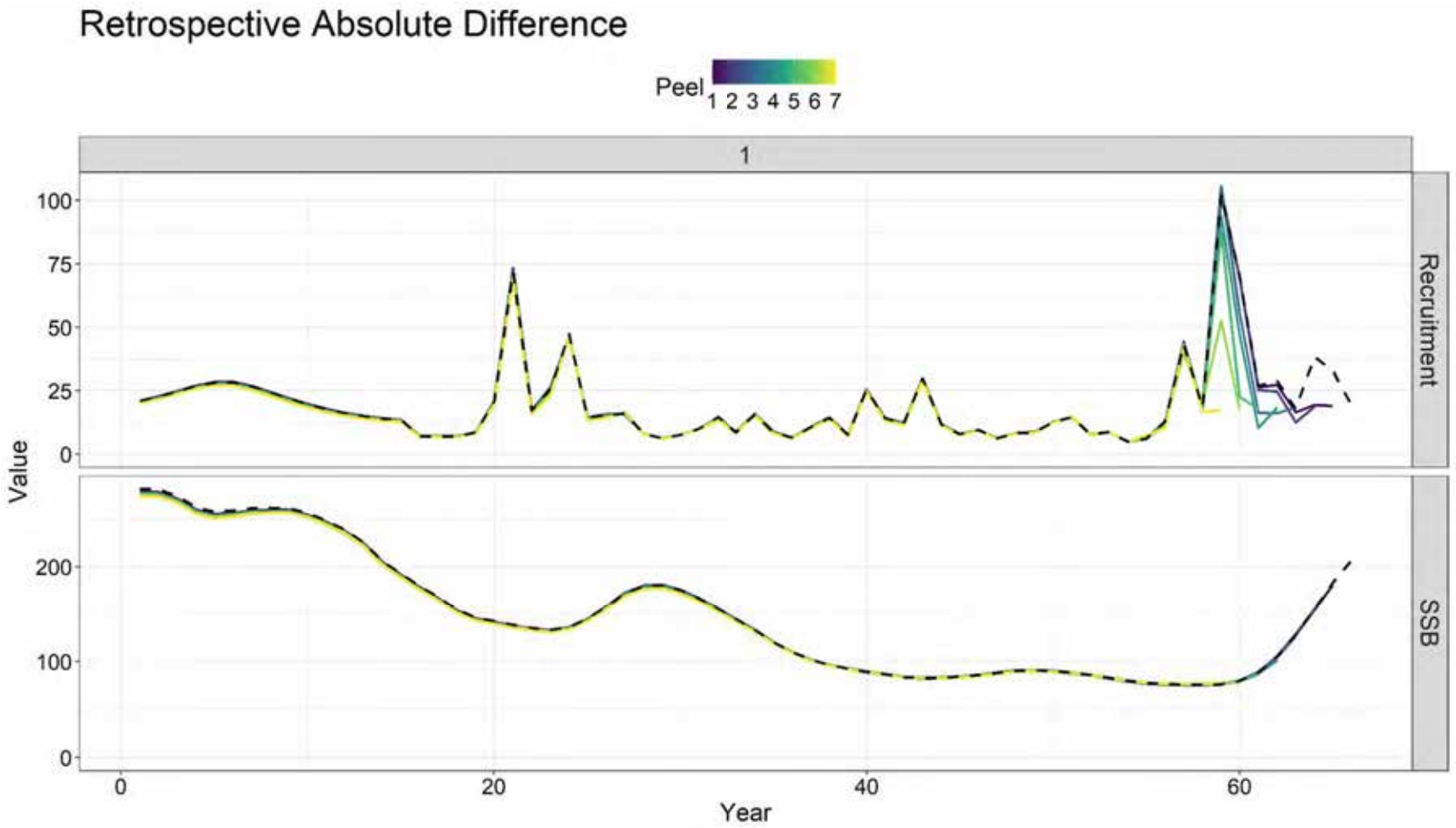

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Figure 7. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *25.12_1Reg_Cont*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was -0.014.

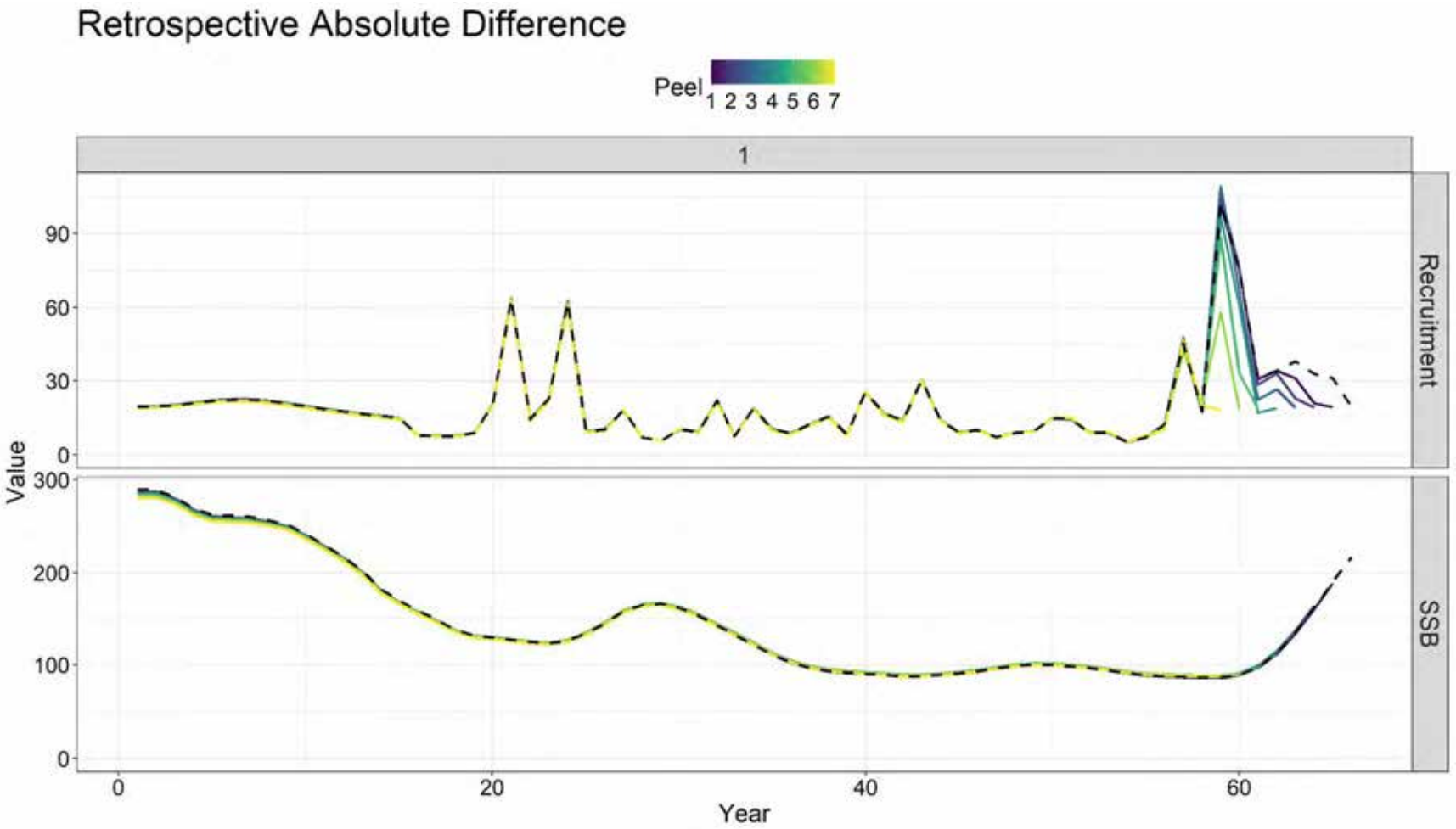

Figure 8. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven year retrospective analysis for Model *26.1_1Reg*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.0054.

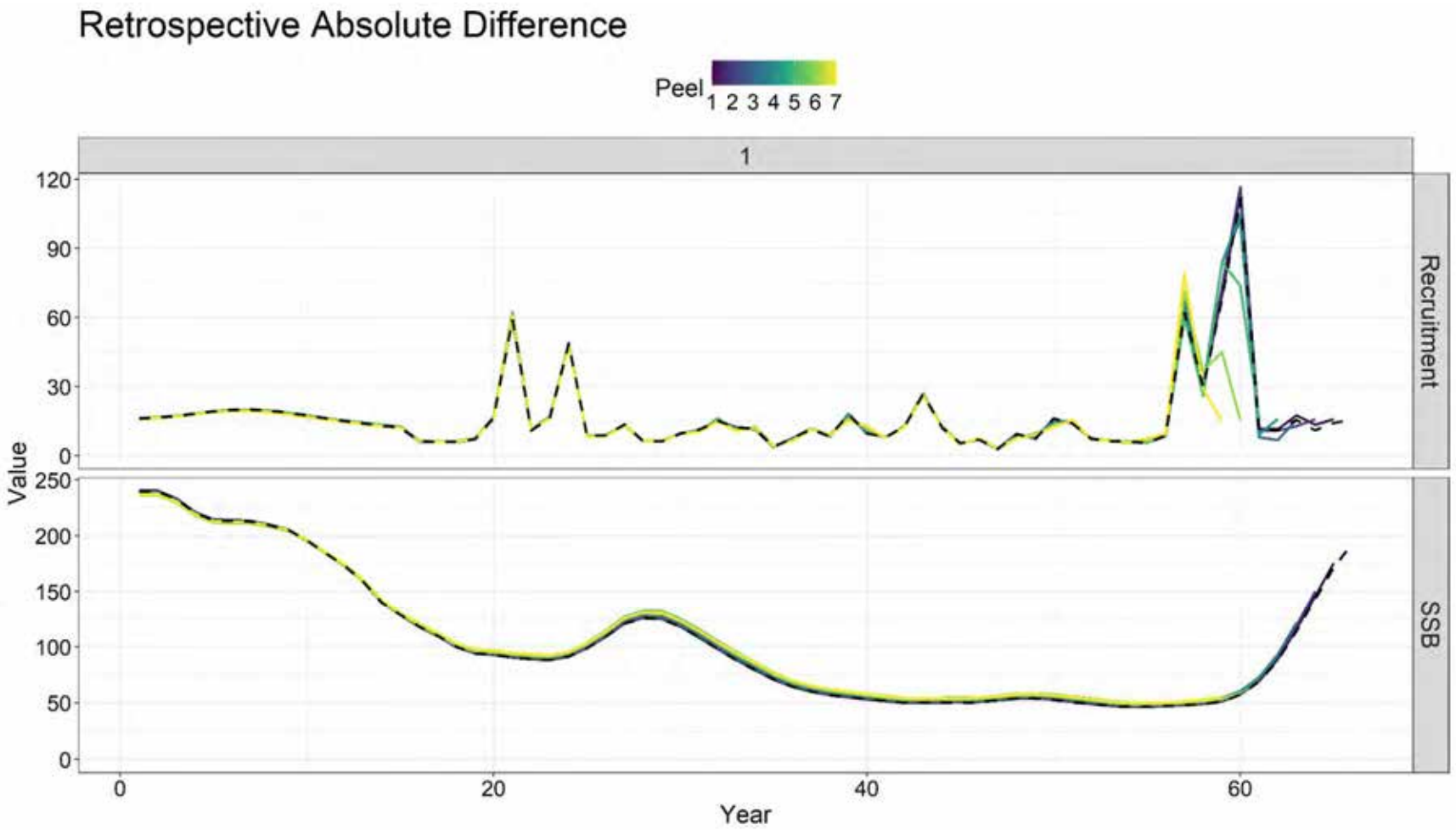

Figure 9. Comparison of recruitment (millions of fish; top panel) and spawning stock biomass (SSB; bottom panel) time series estimates from a seven-year retrospective analysis for Model *26.2_FAA*. Francis reweighting was undertaken for each peel to ensure consistency and to match how an assessment would be performed in a real-world situation. Mohn's rho for SSB was 0.046.

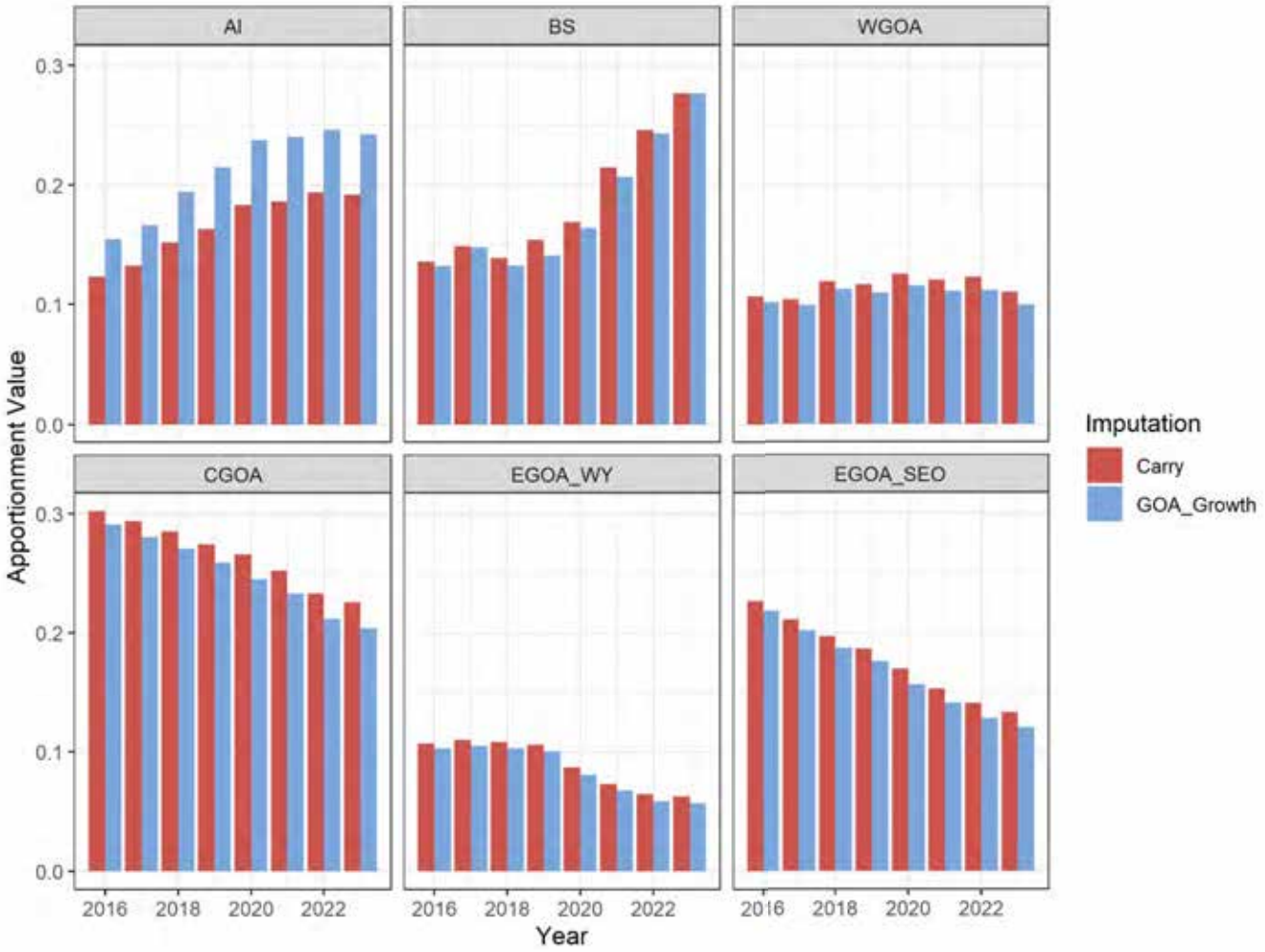

Figure 10. Comparison of regional apportionment from 2016 to 2023 for the previous approach (i.e., extrapolating based on the GOA year over year growth for non-surveyed regions and including western AI extrapolated stations; *GOA_Growth*) and the updated approach (i.e., using carryover values for non-surveyed regions and removing the extrapolated western AI stations; *Carry*). Note that the WY and SEO apportionments do not include the 5% trawl allocation to SEO reallocated to WY (as is done in the final harvest specifications).

Appendix 3H: CIE Reviewer Report: Klaas Hartmann

Dr. Klaas Hartmann

Executive Summary

Excellent background information was provided for the review and comprehensive presentations and discussion were held. I was impressed by the quality of work that has been conducted, including the quality of the codebase and the extent to which the work has been published in peer reviewed journals.

Changes to fishing and the scientific survey have introduced new challenges for the existing single region panmictic assessment. The presented fleets as areas (FAA) model addresses these issues whilst avoiding the complexity of a full spatial assessment model. A full spatial assessment model was also presented but uncertainty in stock structure and input data limit its additional utility.

The scientific survey is well structured and implemented. However, the assessment is limited by the scale of the survey, the extent of observer coverage, the lack of catch and effort logbooks and the number of fish that are aged. Within these constraints, the FAA model, 26.2_FAA, provided a good fit to the data and provides the best balance between the model complexity and capturing sufficient biological detail.

From the presented diagnostics and discussions 26.2_FAA is appropriate for assessing stock status and supporting management decisions. The resulting OFL and ABC are lower than for the single region panmictic assessment, however the difference is not of unexpected magnitude for a significant model change. Overall, use of this model is consistent with using the best scientific information available (BSIA).

A spatial assessment model was also presented. The data and understanding of population structure needed to support this model was limited; this is akin to the limitations observed with more complex FAA models. A key finding consistent across the presented models is that uncertainty in stock structure and data limitations are restricting the application of more complex models.

The results and discussions revealed a number of potential research directions that would support the future development of a spatial model (or improved FAA model). Prioritization of this work would have to consider the relative costs and benefits (out of scope of this review).

1. Background

Sablefish (*Anoplopoma fimbria*) are a long-lived (90+ years), highly mobile, sexually dimorphic demersal species that live at depths greater than 200m (as adults). In Alaska Federal waters, sablefish are assessed and managed as a single population with the total quota apportioned across 6 management regions (Aleutian Islands, Bering Sea, Western Gulf of Alaska, Central Gulf of Alaska, Western Yakutat, and Southeast Outside) and among two fishing sectors (i.e., fixed gear and trawl gear). Since rationalization (i.e., implementation of individual fishing quotas, IFQs) occurred in the 1990s, sablefish have been one of the most valuable finfish resources in Alaska ($124 million in ex-vessel value in 2022). Catch advice for sablefish is based on a statistical catch-at-age integrated stock assessment model fit to fishery-independent survey data and fishery-dependent catch-age data. The sablefish assessment is reviewed annually by the North Pacific Fishery Management Council's (NPFMC) Science and Statistical Committee (SSC) as part of the quota specification process, and last underwent a CIE review in 2016.

2. Review Process and Role of Reviewer

The CIE review for the Sablefish Stock in Alaska took place over three days in Juneau from 16-18 June 2026. The meeting was chaired by Aaron Berger, with CIE reviewers Peter Stephenson, Sam Subbey and Klaas Hartmann (myself).

Comprehensive documentation was provided in advance, this included:

- A review document written specifically for the CIE review with comprehensive details (178pp., (Goethel and Cheng 2026))
- Five appendices that focus on specific issues to investigate during the review (392pp.)
- A github repository with code and model runs for most of the results provided in the main report and appendices
- Presentations for most of the sessions covered in the three days of the review
- Previous (2024 and 2021) assessment reports
- Extensive supporting documents categorized by topic (131 documents, mostly journal publications)

The quality and breadth of the background documents enabled the team to be well prepared prior to the site visit. The CIE review document (and appendices) was excellent and was key to enabling me to efficiently familiarize myself with the fishery and be able to concentrate on key topics and the terms of reference. I was also impressed with the amount of work on this assessment that has been published in the peer reviewed literature.

The extensive code repository on github was well organized with good documentation and relatively straightforward to install. The assessments were easy to modify and re-run. The stock assessment team were able to efficiently conduct analyses requested by the CIE reviewers. Consequently, limited analyses were conducted by the CIE reviewers themselves; I ran only a small number of analyses to confirm my understanding of the model and conduct some basic exploration.

The site visit was highly organized with a clear agenda. The agenda was well structured with an appropriate mix of presentations and opportunity for discussion. The required experts on key topics were present during appropriate topics and available as further questions arose. Several additional analyses were requested by the CIE team, including myself, and these were readily conducted with sufficient time for discussing the results throughout the meeting.

3. Terms of Reference 1

Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.

a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

The assessment has previously been conducted using a single area stock assessment model that was developed specifically for this fishery (e.g., (Goethel and Cheng 2024)). Genetic studies indicate a genetic panmixia across the broader region (Jasonowicz et al. 2017; Timm et al. 2024). However, Sablefish are long lived and it is understood that mixing rates within Alaska are low with periodic migrations occurring. Factors influencing migration are poorly understood, however evidence indicates movement is age specific with a general pattern of juvenile fish moving from the Gulf of Alaska (GoA) to the Bering Sea (BS) and Aleutian Islands (AI) whilst mature fish move Eastwards to the GoA.

Typical movement between the management areas is variable with estimated annual movement rates out of any given area ranging between 10% and 88% (Hanselman et al. 2015). A broader spatial study found that annual retention rates within the Alaskan stock were 92% (Kapur et al. 2025). However, this considered only movement down the North American coast, not movement across the Western boundary to Kamchatka.

Given the biological spatial structure, use of a single region model can be inappropriate, particularly if the spatial distribution of catches and/or the spatial coverage of scientific

data is not comprehensive or changes through time. Both of these changes have occurred in recent years:

Spatial catch distribution

The proportional TAC distribution has historically ensured a consistent proportion of catches across the regions, however recent undercatch of TAC has enabled the proportions to change. Since 2019 the proportion of catch from the Bering Sea has almost doubled while proportions in the Central and Eastern GOA have decreased by 25%.

Changes in age frequency data are apparent that are too rapid to be explained by demographic processes in a well-mixed population (e.g., rapid emergence and disappearance of a plus group cohort). These were most apparent in observer data and may have been due to spatial shifts in the fishing locations. However, some of these trends were also present in the scientific survey.

Catch and effort logbooks are unavailable, consequently spatial shifts in catch within each of the five management areas are not recorded or understood. Although additional analysis of observer data may be possible.

Scientific data changes

The fishery independent survey does not cover all regions in each year. Previously the GoA has been sampled every year with BS and AI sampled in alternating years. Changing economic conditions and vessel availability have altered the sampling regime such that GoA is sampled every second year and the BS/AI sampled together in every second year.

Relative Population Numbers (RPN)

For the single region model a single abundance index, referred to as the relative population numbers (RPN) is required. This needs to be derived from the scientific index which has varying spatial coverage.

Previously, in each year either AI or BS was not sampled. The missing RPN for this region was extrapolated by assuming the RPN had the same relative change as GOA. The regional RPNs were then combined to provide the single RPN for the model.

Juveniles are proportionally more abundant in the AI/BS than in the GOA. Consequently, with this method, following a recruitment pulse, the GOA RPN will potentially lag behind AI/BS and the reverse in a period of pronounced recruitment reduction. The extrapolation therefore incorporates this lag in the index. This was evident in the RPN summaries presented.

Due to the survey changes, the GOA RPN is no longer available each year, making the previous extrapolation process impossible. The new approach is to carry forward RPN

values in missing regions until the region is surveyed. By definition this creates a lag during periods of increase and decline. For example, the last BS and AI RPNs are the highest on record and will be carried forward.

Due to these issues, using extrapolation methods to fill in missing values (which are then input as data to the assessment model) raises concerns. This has become a more significant issue with the new survey sampling scheme and potential for further changes in future. For these reasons it would be more consistent to use a modelling approach that enables missing values to be formally incorporated.

Fleets as areas (FAA) approach

An FAA model approximates a fishery with spatial structure using several fleets with selectivity curves that combine true gear selectivity and size/age specific spatial availability. It provides an accurate description of a system with complete population mixing at each time step, followed by varied spatial availability of age/size classes. The less movement there is in a given fishery, the higher the potential for biases arising from this approach. This concern needs to be balanced with the potential added complexity and information requirements of a fully spatially structured stock assessment.

Using an FAA approach, the regional RPNs can be incorporated with the missing data represented as such. This is a significant improvement over the extrapolation and carry forward approaches discussed above, however this will still create an under-estimate of the extent of an extended period of high or low recruitment (discussed further in ToR 2).

Using an FAA approach enables the spatial variations in age composition data to be represented through regional selectivity. This reduces the alternating bias that will be present in future years where age structure data will alternate between BS/AI (with higher proportional juvenile abundance) and the GoA.

The FAA approach will also enable appropriately aged animals to be removed by the fishery in each region. The TACs have historically ensured a consistent proportion of catches across the regions (making this issue less important), however recent undercatch of TAC has enabled the proportions to change (as described above).

FAA Structure

A range of FAA models and approaches were presented. The NOAA longline survey index and age composition were divided into three fleets (BS, AI and GoA) – this was included in all FAA model variants as this was one of the key drivers for using FAA. Other options examined included:

- Regional fixed gear fleets
- Different selectivity curves
- Time varying selectivity

Models were evaluated on the basis of key criteria:

- Model stability
- Data fit
- Convergence criteria
- Diagnostics including retrospective fits.

This was assessed using a five area spatial operating model to conduct both cross-testing and closed-loop simulation.

The model 26.2_FAA includes the three separate NOAA longline survey fleets with fleet specific logistic selectivity and catchability. This is the minimal complexity required to address the key elements motivating the use of a FAA model. This model provided a good fit, with good convergence and model stability. Inclusion of further complexity resulted in minimal improvement in model fit and a range of issues regarding model stability, convergence and retrospective fits.

These results indicated that 26.2_FAA incorporates the best structure for informing management decisions out of those examined. The spatial structure of 26.2_FAA and its outputs are appropriate and directly applicable to management requirements.

However, this choice limits the flexibility of the model to represent spatial complexity. For instance, the use of logistic selectivity prevents modelling a scenario where abundance of juvenile and old fish in one area are disproportionately high (e.g., AI in some years). Permitting this flexibility in the model did not notably improve fits and resulted in model stability concerns. As discussed in ToR 2, this could be indicative of issues in the data and understanding of population structure that cannot be resolved through alternative model structures.

ToR 1 Recommendations/Findings:

1. Mark-recapture analyses and spatial variations in age composition data indicate that the current single region panmictic assessment may be inappropriate.
2. Recent (and possible future) changes in the survey index make continued use of the current assessment model increasingly challenging.
3. Methods for filling missing RPN values can lead to biases, with those biased values presented to the assessment model as data. Instead, missing values should be considered as such by the assessment model, this is made possible by the FAA approach.
4. The presented FAA models provide a good balance between model complexity and realism, with clear advantages over both the single region and spatially explicit models.
5. Based on the presented results, the model 26.2_FAA provides the best trade-off between model complexity and inclusion of key underlying fishery/population

dynamics. It provides a suitable basis for operational management advice and produces the required outputs.

4. Terms of Reference 2

Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.

a) Indicate whether the model provides the best scientific information available for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

Operating Model

The operating model used to test assessment models was a five-area spatial assessment model. This was parameterized based on the best available data. A key constraint here is that this model does not generate some of the characteristics of the age-frequency data that are observed and which create model fit issues.

Variants of the operating model could be used to test model robustness to alternative hypotheses. For example, inclusion of an additional population in AI that only interacts with the fishing fleet in some years. It is noted that this would be a significant piece of work and efforts may be better directed at exploring these hypotheses directly with other approaches (see ToR 3).

Survey Index Fits

The GOA Selectivity is shifted towards older animals, whilst AI and BS selectivity reaches one for all but the youngest age classes. The generalized understanding is that juveniles move to AI and BS, whilst mature fish move to the GoA. The selectivity is consistent with the first part of this generalization whilst the limitation on the selectivity curve shape prevents representing the latter.

I found that the fitted selectivity curves result in a high correlation between AI and BS RPN index fitted values. Due to the broad selectivity and long lived nature of the species, the capacity for inter-annual variability is limited. In contrast, the GOA index corresponds to a smaller number of age classes and can have greater inter-annual variability.

As GOA does not select for young age classes the AI and BS RPNs (and age structure) are the primary drivers for recent recruitment estimates. Consequently, I expected the reduction in AI and BS data to result in recent recruitment deviation estimates being closer to zero – which I confirmed. In periods of sustained high recruitment (as in recent years) this will result in an under-estimate of recent recruitment and stock status (and

vice-versa in periods of below average recruitment). Incorporating episodic recruitment in the model structure could be considered, however the information to parameterize this could be limited.

Age composition residuals

There was substantial discussion of the age composition fits and a comparison of fits across a range of model parametrizations. A key issue is the periodic presence of a plus group in the observer age composition data, appearing in 1999-2004 and 2008-2018. This plus group does not appear to the same extent in the survey age composition data. There are too few fish in intermediate age classes for the fluctuations in the plus group to have occurred through normal demographic processes.

Discussions indicated that it is likely to have arisen due to specific fishing locations visited by the observer vessel during this time. If this is the true origin, it indicates a key limitation of the assessment. One hypothesis is that there appears to be a population in which at least the old fish remain largely resident and which is only fished from time to time. Consequently, data from this population is occasionally present in observer age composition data, it is generally not sampled by the survey and an unknown amount of catch comes from this region.

Additional analysis of the observer data could be undertaken to investigate the hypothesis that spatial changes in coverage resulted in the emergence and disappearance of the plus group. If it does relate to fishing in a specific spatial area, one approach would be to remove this data from the assessment, however this would also necessitate estimating and removing the corresponding catch. Additional simulations were run at the review which removed the plus group and found that the assessment results were robust – this is reassuring for the model's suitability for support management.

Data limitations

A significant amount of effort has been applied to modelling this population. This has produced a comprehensive assessment model. This has reached the point at which the data rather than the model structure is likely the limiting factor.

Age composition data – A small proportion of the collected otoliths are aged. Others are archived. Age compositions are limited by the small sample size and much smoother distributions could be provided to the assessment model by increasing the sample size (in future and/or historic). The impacts of sample size could be guided by assessment analyses using the operating model.

Age estimates are highly uncertain, likely as fish experience limited seasonal temperature changes at their resident deep depths. As such, it is also possible that age

uncertainty is correlated with aspects such as the location and age of the fish, investigating this further could be warranted.

Survey – The scientific survey has an excellent structure that was thoroughly probed in the review. The limitation is the spatial coverage. As described here and in ToR 1, the limited coverage will result in recruitment and biomass trends lagging behind in periods of sustained high or low recruitment. This is through both the RPN and age composition data. An additional hole is that the West Aleutian Islands have not been sampled for an extended period and this is an area that is poorly understood.

Logbook catch/effort data – Historically it was possible to generate a CPUE index, however this has been discontinued due to a lack of data. I was surprised that key catch and effort logbook data is not collected. This would provide a highly valuable additional fishery abundance index, as well as allowing changes in the fishery to be examined. For example, the impact of changing gear types and changing fishing grounds within a management area. The latter may be of particular relevance in recent years as there have been large economic changes within the fishery.

Natural mortality – Natural mortality is highly constrained by the prior. Relaxing the prior resulted in model stability issues. More comprehensive sensitivity analyses (with natural mortality constrained to other values) should be conducted to quantify the impact of the prior on the OFL and ABC.

Suitability for estimating current stock status, projecting future abundance, and determining OFLs and ABCs

As described, the model has limitations, however these are largely attributable to limitations of the datasets and the required information to transition to a full spatial model is incomplete. Consequently, the FAA model provides a pragmatic balance between model complexity and realism given information limitations.

The FAA model is harder to interpret and explain, particularly as selectivity now incorporates both spatial and fleet processes. Careful consideration needs to be given on communicating this effectively. Discussion of the characteristics of different fleets may be more effective than a full explanation of the FAA analogy.

The 2027 OFL and ABCs recommended by 26.2_FAA (the preferred FAA model) are approximately 25% lower than obtained by 26.1_1Reg (the single region panmictic model). Whilst this is a notable difference it is not of an unexpected magnitude given the transition to a new assessment approach and the improvements this has entailed (see ToR 1). The information presented indicates that the 26.2_FAA provides the current best scientific information available for assessing the stock and supporting management decisions.

ToR 2 Recommendations/Findings:

1. From the presented models, 26.2_FAA provided the best compromise between parsimony and model complexity. There are some aspects of the data that it does not reproduce; however, overall, no significant issues or concerns were identified and it is appropriate for assessing the stock and supporting management decisions.
2. Results from the FAA model are harder to communicate and careful stakeholder communication will be important.
3. Natural mortality was highly constrained by the prior. Sensitivity analyses should be conducted to examine the effect on the OFL and ABC.
4. Selectivity curves were limited to logistic. This is an appropriate restriction on the basis discussed above, however it does limit the capacity of the FAA model to capture spatial aspects (such as the heightened presence of juveniles and the old plus class fish in the Aleutians). If consistent datasets for this are developed (see ToR 3) use of dome shaped selectivity should be reinvestigated.
5. The observer data should be examined spatially to determine whether spatial shifts in fishing caused the appearance of the plus group.
6. The operating model could be expanded to incorporate alternative hypotheses that reproduce observed anomalies in the age composition data.
7. The data available for the assessment model is likely to be the limiting factor for the assessment, rather than the model structure and approach. Improvements in available data would address the current weaknesses of the model.
8. Consider increasing the number of otoliths that are aged - both as a routine process in future years and potentially increasing historic sample sizes from the otolith archive. In both cases, the assessment model could be used to advise the most effective sampling regime.
9. The scientific survey is well designed but limited in spatial extent. The current spatial sampling scheme is suitable given the extremely limited resources; however, an expansion back to the previous level, or above (e.g., including WAI) would significantly improve model robustness and provide earlier indication of below/above average recruitment periods. This is a key limitation for the assessment.
10. Development of a fishery logbook including spatial data would provide an additional abundance index and enable closer consideration of changes in fishing characteristics (such as locations fished within each management area).

5. Terms of Reference 3

Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

Spatial models require improved understanding of i) sufficient knowledge of stock structure to formulate an appropriate model and ii) appropriate ongoing data collection to enable the model to be fitted. Without these, it is not expected that a spatial model would provide a substantial improvement beyond the FAA model. Indeed, this has been the finding of the presented spatial model results.

Understanding stock structure

Some anomalies in the age composition data (see ToR 1 and 2) were hypothesized to be due to additional population structure not represented in the spatial structure of the data or the model structure. In the first instance, further analysis of existing datasets could provide additional guidance (e.g., examining observer data spatially as discussed in ToR 2).

Other projects / analyses that would support understanding of stock structure were discussed during the review and have the potential to inform the robust development of the spatial model. These include:

- Larval dispersal modelling to inform connectivity and explore connections to recruitment strength,
- Expanded mark-recapture tagging programs across a range of age classes and locations,
- Pop-up satellite tagging to inform movement,
- Review uncertainty in otolith ages, in particular in relation to the origin, size and age of the fish.

Ongoing Data Collection

Some potential improvements to ongoing data collection have been discussed in ToR 2. Ultimately the best spatial model structure may not neatly align with the management areas that are currently used for spatial characterization of the models. As such for both FAA and spatial models, datasets may have to be spatially restructured to alternative areas. This would apply both to future data collection as well as a need to restructure historic datasets.

Regardless of the appropriate spatial structure, the current data streams are limiting. The limitations discussed in ToR 2 are holding back the potential for further development of the FAA model and the meaningful application of a spatial model.

Expanding these programs is a key requirement for the development of a more robust assessment model.

Software engineering aspects

Bespoke stock assessment models (such as SPoRC; (Cheng et al. 2026)) enable assessment models to be highly customized to suit the fishery under assessment. However, such modelling frameworks are typically developed and maintained by a relatively small development team. This introduces a heightened risk of significant errors from the outset, or introduced as features are added. A brief review of the codebase indicated that good software engineering practices have been adopted, which will mitigate this risk, these include:

- Use of a version control system (github)
- Well organised code with good function documentation and comments
- Five complex unit tests.

I was particularly impressed with the presence of formalised unit tests – in my view these are underutilized in fisheries science. I strongly recommend that these continue to be updated to test new features and are run routinely to provide early detection of new bugs.

Individual functions are well documented, there is a good user guide and the assessment model has been published (Cheng et al. 2026). However, the assessment model would benefit from a clear design document aimed at current and future developers; in particular to ensure the codebase remains manageable as the package grows. This would be especially useful for succession planning and collaboration. This will be increasingly important as model complexity increases; as expected if spatial model development is further pursued.

ToR 3 Recommendations/Findings:

Existing data analysis

1. Investigate methods for splitting out the West Aleutian region (into separate fleets / areas).
2. Investigate temporal changes in Aleutian observer coverage and the link to changes in age composition data.
3. Examine factors that may contribute to uncertainty in otolith aging data.

Annual data collection

4. Investigate the feasibility of obtaining spatial catch and effort logbook data.
5. Ensure that age composition and survey data do not diminish below current levels (see also ToR 2) and expand these programs to support the development of a more robust assessment model.

Specific research projects

6. Support research regarding spatial stock structure including approaches such as larval dispersal modelling, pop up satellite tags and expanded mark recapture programs.

Software engineering

7. Develop and maintain a clear technical design document for SPoRC.
8. Continue to expand the SPoRC unit tests and ensure tests are conducted as a matter of routine (e.g., automated weekly).

6. Appendix 1: Bibliography

Note: A full bibliography of provided materials is not included as it is too extensive. These are available at https://github.com/dgoethel-noaa/2026_Sablefish_CIE

Cheng, M.Lh., Goethel, D.R., Cunningham, C.J., Hulson, P.F., Ianelli, J.N., and Omori, K.L. 2026. The SPoRC Stock Assessment Package: A Generalized Next-Generation Platform to Assess Spatial, Age and Sex-Structured Populations. Fish and Fisheries **27**(3): 754–770. doi:10.1111/faf.70082.

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Kapur, M., Rogers, L., Goethel, D.R., Cheng, M.Lh., Hanselman, D., Echave, K., Haltuch, M.A., Holt, K.R., English, P., Berger, A.M., and Connors, B. 2025. Hidden markov mark-recapture modeling highlights transboundary exchange for northeast pacific sablefish. Fisheries Research **289**: 107498. doi:10.1016/j.fishres.2025.107498.

Timm, L.E., Larson, W.A., Jasonowicz, A.J., and Nichols, K.M. 2024. Whole genome resequencing of sablefish at the northern end of their range reveals genetic panmixia and large putative inversions. ICES Journal of Marine Science **81**(6): 1096–1110. doi:10.1093/icesjms/fsae070.

7. Appendix 2: Performance work statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Fisheries
Center for Independent Experts (CIE) Program
External Independent Peer Review

Alaska-wide Sablefish Stock Assessment
June 16 - 18, 2026

Background

NOAA Fisheries is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA Fisheries science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Sablefish (*Anoplopoma fimbria*) are a long-lived (90+ years), highly mobile, sexually dimorphic demersal species that live at depths greater than 200m (as adults). In Alaska Federal waters, sablefish are assessed and managed as a single population with the total quota apportioned across 6 management regions (Aleutian Islands, Bering Sea, Western Gulf of Alaska, Central Gulf of Alaska, Western Yakutat, and Southeast Outside) and among two fishing sectors (i.e., fixed gear and trawl gear). Since rationalization (i.e., implementation of individual fishing quotas, IFQs) occurred in the 1990s, sablefish have been one of the most valuable finfish resources in Alaska ($124 million in ex-vessel value in 2022). Catch advice for sablefish is based on a statistical catch-at-age integrated stock assessment model fit to fishery-independent survey data and fishery-dependent catch-age data. The sablefish assessment is reviewed annually by the North Pacific Fishery Management Council's (NPFMC) Science and Statistical Committee (SSC) as part of the quota specification process, and last underwent a CIE review in 2016.

Scope

Since the last CIE review (i.e., in 2016), major changes have occurred in the sablefish resource, fishery, longline survey, and assessment model. Specifically, a series of extreme, above average recruitment events

[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

has led to rapid rebuilding of the resource and increasing quotas. Resultant landings of predominantly small, lower value fish have led to market saturation, strong reductions in landed value, and exploration of management options that loosen full retention requirements. Concomitantly, the primary directed fixed gear fleet has undergone rapid gear changes, where a predominantly hook-and-line fishery has transitioned to a longline pot fishery since 2017 (i.e., >85% of sablefish catch in the fixed gear fishery is now taken by pot gear), which has helped to reduce whale depredation.

Additionally, the fishery-independent, cooperative research-based NOAA longline survey, which targets sablefish and serves as the primary index of abundance for the assessment, underwent major survey design changes starting in 2025. Because the survey has traditionally used a cost-recovery approach, whereby survey catch is sold by the fishing company that owns the vessel performing the survey, the decline in sablefish markets prevented the survey from being undertaken in 2024 for the first time in its 30+ year history. Historically, the fixed station survey has sampled the entire Gulf of Alaska (GOA) annually, as well as either the Bering Sea (BS, odd years) or Aleutian Islands (AI, even years). Starting in 2025 a new survey design was enacted to reduce overhead and ensure a fishing company would accept the survey contract, wherein the Gulf of Alaska is now surveyed in odd years (starting in 2025), and the BS and AI are surveyed in even years (starting in 2026). Although the new survey design ensures the ability to continue the longline survey, it results in only ~50% of total stock abundance being surveyed in a given year. Moreover, it raises important challenges for the panmictic assessment in terms of how to integrate survey data that only partially samples the population being assessed.

There have also been major changes to the assessment model since the last CIE review. Most importantly, a new R-TMB based package, the SPoRC (Stochastic Population Over Regional Components) assessment model, has been adopted, which replaces the previous Automatic Differentiation Model Builder (ADMB) based assessment model. Additionally, a number of research-oriented assessment models have been developed exploring alternative spatial structures (e.g., spatially-explicit 3 and 5 region models that estimate movement among regions, as well as a spatially-implicit single region fleets-as-areas, FAA, model), all of which demonstrate promise for dealing with spatial complexities and data gaps that are not well resolved in the single region panmictic assessment. In 2026, the assessment team transitioned from the single region panmictic assessment to the FAA model, because the FAA model could better handle the new longline survey design (i.e., fit the data by region as separate fleets) and implicitly account for ontogenetic movement dynamics (i.e., through selectivity and availability assumptions). Thus, for the purpose of the CIE review, feedback on the FAA model is being requested, particularly with regard to appropriate model structure and parametrization. To help make determinations on the BSIA to assess the Alaska sablefish population, reviewers will be provided the results of closed loop simulation analyses and assessment model runs applied to the sablefish data (including model outputs and diagnostics).

The overarching goals of this review process are to:

1. Ensure the FAA stock assessment supports the development of robust advice for use by the North Pacific Fishery Management Council based on the BSIA;
2. Provide an independent external review of this stock assessment to confirm that it meets the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3. Understand and identify appropriate FAA model structure and fits to key data sources (indices, landings, and age compositions);
4. Identify research needed to improve the assessment and advice for fishery managers.

The specified format and contents of the individual peer review report are found in **Annex 1**. The Terms of Reference (ToRs) of the peer review are included in **Annex 2**. The tentative agenda of this in-person panel review meeting is included in **Annex 3**.

Requirements

NOAA Fisheries requires **3 reviewers** to conduct an impartial and independent peer review in accordance with this Performance Work Statement (PWS), OMB Guidelines, and the ToRs below. Modifications to this Performance Work Statement (PWS) and ToRs cannot be made during the peer review, and the Contracting Officer's Representative (COR) and the CIE contractor shall approve any modifications prior to the peer review. All ToRs must be addressed in each reviewer's report.

The CIE reviewers should have expertise in statistical sex- and age-structured integrated stock assessment models. In particular, experience developing spatially explicit and spatially implicit (i.e., fleets-as-areas) assessment models is imperative. Moreover, understanding of stock assessment good practices are required. Working knowledge of the RTMB programming language, a basic understanding of closed loop simulation, and a background in survey design and/or the use of fishery-independent survey data in stock assessments would all be beneficial.

The chair for this meeting, who is in addition to the CIE reviewer, will not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract.

Tasks for Reviewers

The CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

Pre-review Background Documents: A minimum of two weeks before the peer review, the NOAA Fisheries Project Contact will send (by electronic mail or make available at an FTP site/GitHub Repository) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NOAA Fisheries Project Contact will consult with the CIE on where to send documents. The CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance with the PWS scheduled deadlines specified herein.

The document list is separated into 'summary/background' and 'for review' documents. The CIE reviewers are *encouraged to peruse* the 'summary/background' documents for information on data inputs, previous assessment structures and associated reviews, and ongoing research. However, the CIE reviewers *must review* all of the 'for review' documents in preparation for the peer review, as these contain the results of the primary analyses and model runs that will be discussed during the review panel.

Available documents (available from the public sablefish CIE GitHub repository, as they become available) include:

For Review (available here)

1. A summary document describing the fleets-as-areas assessment model, including the full model description and results, with comparison to outputs from the single region panmictic assessment as well as summary results for all sensitivity model runs;
2. A document summarizing the results of the spatially explicit closed loop simulation analysis;
3. The 2025 Alaskan sablefish stock assessment proposed model changes report (Goethel and Cheng, 2025) produced for the September 2025 Joint Plan Team meeting, presentation, and GitHub repository, which describes recent changes to the current single region panmictic assessment including transition to RTMB and the SPoRC assessment package;
4. The spatial sablefish model publication and model updates report (Cheng et al., 2025a) for the September 2025 Joint Plan Team meeting;
5. Additional supporting documents and presentations as they become available.

Summary/Background (Available here)

1. The 2024 Alaskan sablefish Stock Assessment and Fishery Evaluation (SAFE) report (Goethel and Cheng, 2024) and presentation;
2. The 2024 December SSC (p. 14-16) and November Joint Plan Team (p. 2-3) reports;
3. The 2025 AFSC Longline Survey Cruise Report (Siwicke et al., 2026) and presentation;
4. The 2025 October SSC (pp. 21-23) and September Joint Plan Team (p. 5-6) reports;
5. The SPoRC assessment platform publication (Cheng et al., 2026) and GitHub documentation;
6. Research papers on integrating density-dependent growth (Cheng et al., 2025b) and a pot gear fleet (Cheng et al., 2024a) into the sablefish assessment, simulation studies on selectivity (Cheng et al., 2024b) and sex-specific parametrization (Cheng et al., 2025c) for the sablefish assessment, and considerations for fitting sex-specific composition data (Cheng et al., 2025d) in stock assessments;
7. CIE reviewer reports from the 2016 Alaskan sablefish CIE review.

Please note that outputs of all analyses used as part of the CIE review, including input data, simulation outputs, final proposed assessment models, and all sensitivity assessment models, will be made available on the sablefish CIE GitHub repository

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the PWS and ToRs and shall not serve in any other role unless specified herein. The CIE reviewers shall actively participate in a professional and respectful manner as members of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NOAA Fisheries Project Contact is responsible for any meeting arrangements (e.g., conference room reservations, video conferencing logistics, etc.).

Contract Deliverables - Independent CIE Peer Review Report: Each CIE reviewer shall complete an independent peer review report in accordance with this PWS. Reviewers are not required to reach a consensus, and a summary report *will not* be produced. Each CIE reviewer shall complete their independent peer review according to the required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**. The tentative agenda of the panel review meeting is in **Annex 3**. Each CIE reviewer will deliver their reports according to the specified milestone dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NOAA Fisheries Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the Project Contact for the purpose of their security clearance, and this information shall be submitted at least two weeks in advance. For additional information, please see the following link: https://www.commerce.gov/osy/programs/foreign-access-management. All CIE reviewers must have a REAL ID-compliant form of identification to access Federally owned or leased facilities. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be Juneau, AK.

Period of Performance

The CIE reviewers' duties shall not exceed **14** days to complete all required tasks.

Schedule of Milestones and Deliverables

The contractor shall complete the tasks and deliverables in accordance with the following schedule:

Schedule	Milestones and Deliverables
Within two weeks of award	Contractor secures participation of the CIE reviewers.
At least two weeks prior to the panel review meeting	Pre-review documents are provided to the reviewers.
June 16 - 18, 2026	The reviewers participate and conduct an independent peer review during the panel review meeting.
Approximately 2 weeks later	Contractor receives draft reports.
Within 3 weeks of receiving draft reports	Contractor submits final reports to the US Government.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content in **Annex 1**; (2) The reports shall address each ToR as specified **Annex 2**; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (Travel resources | GSA), and all contractor travel must be approved by the COR prior to the actual travel. Any travel conducted prior to the receipt of proper written authorization from the COR will be done at the Contractor's own risk and expense. International travel is authorized for this contract. Travel is not to exceed $13,000.00.

Confidentiality and Data Privacy

This contract may require that services contractors have access to Privacy Information. Services contractors are responsible for maintaining the confidentiality of all subjects and materials and may be required to sign and adhere to a Non-disclosure Agreement (NDA).

NOAA Fisheries Project Contact:

Chris Lunsford
MESA Program Manager
NOAA Fisheries, Alaska Fisheries Science Center
17109 Pt. Lena Loop Road
Juneau, AK 99801
Chris.Lunsford@noaa.gov

Annex 1: Peer Review Report Requirements

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations as specified in the ToR and provide advice on whether the science reviewed is consistent with and represents the best scientific information available (BSIA).

2. The main body of the reviewer report shall consist of the following sections: Background; Description of the Individual Reviewer's Role in the Review Activities; Summary of Findings for each ToR in which the weaknesses and strengths are described; and Conclusions and Recommendations in accordance with the ToRs.

    a. Each reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings as well as the science, conclusions, and recommendations.

    b. Each reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

    c. Each reviewer should elaborate on any points that they feel might require further clarification.

    d. Each independent CIE report shall be a stand-alone document through which others can understand the weaknesses and strengths of the science reviewed and shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

    Appendix 1: Bibliography of materials provided for review.
    Appendix 2: A copy of the CIE Performance Work Statement.
    Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference (ToRs) for the Peer Review

Review of the Alaska-wide Sablefish Assessment

CIE reviewers are contracted to complete their independent peer review based on the ToRs. Therefore, the CIE-NOAA Fisheries review and approval process is based on whether the CIE independent reports addressed each of the ToRs.

1) Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.
   a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

2) Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.
   a) Advise as to whether the model is consistent with and represents the best scientific information available (BSIA) for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

3) Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

Reviewers must provide details for the basis of their responses to the review ToRs.

Annex 3: *Tentative* Agenda for the CIE Review of the Alaska-wide Sablefish Assessment

North Pacific Fishery Management Council
NOAA Alaska Fisheries Science Center, Auke Bay Laboratories
17109 Pt. Lena Loop Road
Juneau, AK 99801

June 16-18, 2026

Contact: Chris Lunsford (Chris.Lunsford@noaa.gov)

Schedule
(this agenda is *DRAFT* and subject to change)

All times below are Alaska Daylight Time
Daily breaks at ~10:30 and ~15:30, Lunch 12:30-14:00
Tuesday-Thursday, 09:00 – 17:00 AKDT

Tuesday, June 16, 2026

A. Welcome and Introductions

09:00 — 09:15: Welcoming Remarks, Introductions, Logistics	Chris Lunsford
09:15 — 09:30: Announcements, Agenda/ToRs	Chair

B. Sablefish Management, Biology, Fishery, and Data Inputs (ToR 1)

09:30 — 09:50: Biology, Spatial Dynamics	Daniel Goethel
09:50 — 10:10: Sablefish Management/NPFMC FMP Requirements	Sara Cleaver
10:10 — 10:30: Fishery-Dependent Data	Matt Cheng
10:30 — 10:50: *BREAK*	
10:50 — 11:15: Longline Survey Data and Recent Design Changes	Kevin Siwicke
11:30 — 12:00: Assessment History, Inputs, and Other Available Data	Daniel Goethel
12:00 — 12:30: Discussion	
12:30 — 14:00: *LUNCH BREAK*	

C. Assessment Model Configuration (ToR 1)

14:00 — 14:30: Current Model Development Pathway	Daniel Goethel
14:30 — 15:30: General Sablefish Assessment Parametrization	Daniel Goethel
15:30 — 15:50: *BREAK*	
15:50 — 17:00: Discussion	

Wednesday, June 17, 2026

A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs — Chair
09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

B. Spatially Implicit (Fleets-as-Areas) Model Configuration (ToRs 1)

10:50 — 12:00: Results of Spatial Simulations to Optimize FAA Structure — Matt Cheng
12:00 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Comparing Assessment Performance and Diagnostics (ToR 1/2)

14:00 — 14:20: Final Fleets-as-Areas Assessment Configuration — Daniel Goethel
14:20 — 15:30: Outputs/Diagnostics for FAA and Panmictic Models — Daniel Goethel

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion

Thursday, June 18, 2026

A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs — Chair

B. Comparing Assessment Performance and Diagnostics (ToR 1/2)

09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

10:50 — 11:30: Results of a Spatial Closed Loop Simulation Analysis — Matt Cheng
11:30 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Spatial Models (ToR 3)

14:00 — 15:00: 3 and 5 Region Spatial Model Configuration/Outputs — Matt Cheng

15:00 — 15:30: Discussion

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion and Report Writing

ADJOURN

8. Appendix 3: Panel attendance

CIE Reviewers:

Klaas Hartmann- Australia

Peter Stephenson- Australia

Sam Subbey- Norway

NOAA Attendees:

Aaron Berger (NOAA/NMFS NWFSC)

Daniel Goethel (NOAA/NMFS AFSC)

Matt Cheng (NOAA/NMFS AFSC; University of Alaska)

Chris Lunsford (NOAA/NMFS AFSC)

Kristen Omori (NOAA/NMFS AFSC)

Pete Hulson (NOAA/NMFS AFSC)

Kevin Siwicke (NOAA/NMFS AFSC)

Sara Cleaver (NPFMC)

Pat Malecha (NOAA/NMFS AFSC)

Melissa Haltuch (NOAA/NMFS AFSC)

Grant Adams (NOAA/NMFS AFSC)

Jim Ianelli (NOAA/NMFS AFSC)

Cindy Tribuzio (NOAA/NMFS AFSC)

Samara Nehemiah (ASMFC)

Beth Matta (NOAA/NMFS AFSC)

John Brogan (NOAA/NMFS AFSC)

Appendix 3I: CIE Reviewer Report: Peter Stephenson

Dr. Peter Stephenson

Executive Summary

The Assessment Review for Alaska-wide sablefish was conducted on June 16-18 June 2026 in Juneau, Alaska. Present at the review meeting were the review panel of five, including three CIE reviewers, two presenters, and 3-4 other NOAA participants. Another group of NOAA employees viewed the meeting online.

The background materials were concise, well structured, and readily available before the meeting. The presentations by the Assessment Team were informative and well organized. During the meetings, the Review Panel made suggestions on what could be investigated, and on most occasions, these had already been considered, and the queries were answered immediately.

The assessment models are implemented in the generalized R-TMB based Spatial Populations over Regional Components (SPoRC) stock assessment package. The data for the model runs was readily available enabling the reviewers to run the model before the meeting. The software is appropriate for the assessment. The justification for the preferred assessment model, FAA, is appropriate, and the conclusions drawn are reliable.

Considering the reports supplied and the presentations at the Review Meeting, I conclude:

> The Fleets As Areas (FAA) assessment provided by the Assessment Group is a superior assessment to the single area model, primarily because of its ability to cope with the missing biannual longline survey data in Gulf of Alaska.
>
> Although the FAA assessment had more sparce data inputs and was unstable for some parameter formulations, it is scientifically sound and provided reliable projection outputs for calculation of Tier 3 reference points.
>
> The FAA assessment provided good evidence that the Alaska-wide sablefish stock is not overfished and is not undergoing overfishing.

The Spatial Model, considered as an alternative assessment tool, will be valuable in the future, but is currently unstable due to paucity of age composition and movement information, difficulties in determining suitable selectivity formulations, and confounding of movement with recruitment. The spatial model should be further investigated as it provides a model structure and outputs that are conceptually more understandable than the FAA model. With further investigation and more comprehensive input data, the 5-area spatial model may be a better choice in the future.

1. Background

1.1 Overview

A Review Panel meeting for North Pacific Fishery Management Council on the Alaska-wide sablefish fishery assessment was held at the NOAA Alaska Fisheries Science Center, Auke Bay Laboratories, on June 16 to 19, 2026.

The Review Panel comprised chairperson, Dr Aaron Berger, appointees of the Centre for Independent Experts, Dr Sam Subbey (CIE), Klaas Hartmann (CIE), Mr Peter Stephenson (CIE), and Dr Chris Lumsford. The other attendees of the meeting and their affiliated organizations are shown in Appendix 3.

1.2 Performance Work Statement, Review Report Requirements and Agenda

The Performance Work Statement is shown in Appendix 2. Imbedded in this document were the links to all the documents required for the review. The participants at the meeting are shown in Appendix 3.

The Peer Review Report Requirements provided by the CIE are presented in Annex 1. This required the Review Panel members to participate in an independent peer review of the stock assessment and prepare an independent CIE report of the assessment and the review process. The meeting agenda is shown in Annex 3.

1.3 Acknowledgements

I gratefully acknowledge the contributions of all participants in the review meeting who helped make it both informative and productive. I particularly commend the presenters, Dr Daniel Goethel and Dr Matt Cheng, for the substantial effort invested in the stock assessment and for preparing high-quality supporting documentation. I also thank the Chair, Dr Aaron Berger, for leading a well-organised and efficient meeting, and Dr Chris Lunsford for his assistance with logistics and for helping to make our stay in Juneau enjoyable. It was a pleasure to work with the other CIE reviewers, whose contributions added valuable perspectives to the meeting discussions.

2. Review of Activities

Prior to the meeting, I read the six core documents that were supplied on a GitHub repository (Appendix 1). These were the primary documents essential to understanding the stock assessment, and consisted of a summary document, and five appendices. These documents were well written and concise and enabled me come to the meeting with a good understanding of the sablefish assessment. In addition, there were several supporting documents (Appendix 1), which I perused.

In prepared reports for a review, it is important that units of measurement like “tons” and “metric tonnes” are avoided as this can lead to confusion.

The files used for the assessment model (Appendix 1) were also available prior to the meeting, enabling the CIE reviewers to run the model prior to the meeting.

During the review meeting, the CIE reviewers asked many questions about different model formulations, and in most cases, to their credit, the assessment scientists had already considered them and were able to answer without having to do additional model runs.

Although preparation of a summary report was not required for this review, the meeting Chair determined that such a report would be useful in providing the assessment team with timely feedback and recommendations for future work. A summary report was prepared and is provided in Appendix 4.

3. Findings Related to the Terms of Reference

The terms of reference for the Alaska wide sablefish stock assessment review are shown in Annex 2. This report contains my evaluation of the assessments in terms of the Terms of Reference supplied to the reviewers.

3.1 Terms of Reference 1

Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.

a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

The Fleets-As-Areas (FAA) assessment has many more parameters to be estimated than the single area assessment and the assessment team spent considerable time explaining the choice of the current FAA model structure and looking carefully at the model inputs to determine the contributions they made to the model stability and model outputs.

Trawl-based indices. The trawl survey provides a long time series from 1984 to 2025, covering the upper continental shelf to a depth of 500 m. Prior to 2007, it was not used in the assessment because it was considered a poor indicator of adult sablefish abundance. Adult sablefish generally occur farther down the slope and may also be able to outswim the trawl gear.

From 2007 to 2024, the trawl index was included in the assessment because it was considered to provide useful information on recruitment. However, over the past decade in the Gulf of Alaska (GOA), the index has shown substantial fluctuations. It was very low in 2013, very high in 2021, and then declined sharply in 2023. These changes, particularly the

2023 decline, were not consistent with trends in the Longline Survey indices, making the trawl index an uncertain source of information on sablefish abundance.

The assessment team also noted that, in recent years, younger sablefish, aged 2–4 years may have moved and resided farther down the slope to depths greater than 500 m, reducing their availability to the trawl survey. In addition, the Aleutian Islands (AI) and Bering Sea (BS) trawl indices have high sampling error.

The model runs with and without the trawl indices produced similar model outputs, for example, spawning biomass. Across AI, BS, and GOA, the trawl indices appeared to add data volume but did not provide additional information beyond that already contained in the Longline Survey indices. Consequently, the trawl survey data were excluded from the assessment.

Overall, the model results indicate that removing the trawl survey data produces a more parsimonious assessment without materially changing key outputs.

Recommendation 4.1.1. I concur with the decision to discontinue use of the trawl survey data in the 2026 assessment.

NOAA Longline Survey. This survey provides a continuous 35-year time series sampling from habitat occupied by sablefish. It tracks both adult and juvenile abundance and shows broadly consistent signals across the Aleutian Islands (AI), Bering Sea (BS), and Gulf of Alaska (GOA).

From 1979 to 1994, the survey was conducted as a Japanese–United States cooperative programme that provided information on relative population numbers, lengths, and ages. From 1990 to 2025, NOAA conducted its own survey, with the overlapping years providing an important calibration period between the two data sources.

The Longline Survey is a fixed-station survey in which, as far as possible, the same sites are fished each year. The number of sites varies by region. Each site typically includes eight skates in the GOA, with fewer skates sometimes in the BS and AI because of habitat and logistical constraints. Each skate has 45 hooks and samples depths of 200, 400, 600, 800, and 1,000 m. In general, otoliths are collected from one fish per skate.

The purpose of the survey is to track changes in population numbers across the fishery, not to determine spatial estimates of biomass. In my view, the survey achieves this objective successfully, as shown by the consistency of Relative Population Number (RPN) values among regions and their agreement with the age composition data.

Adjustments to the Longline Survey data. Adjustments were made in three circumstances:

- Damaged hooks. If more than five hooks on a skate were damaged and therefore not fishable, catch numbers were adjusted on a pro rata basis.

- Sperm whale interactions. If a sperm whale was observed near the vessel and appeared to be interacting with the gear, the skipper and observer determined whether the skate had been affected. Where an effect was identified, a correction factor of 1.18 was applied to the catch for that skate. This adjustment is more commonly applied in the Gulf of Alaska (GOA) than in other regions, but its overall effect is small, typically around 1–5%.
- Killer whale interactions: Killer whale interactions can cause unpredictable and sometimes substantial fish loss from individual skates. If one or more killer whales were observed near the vessel, the skipper and scientist jointly assessed whether the skate had been compromised. If so, the skate was removed from the dataset.

Recommendation 4.1.2. There are guidelines, for the skipper and observer to follow on whether a skate is removed from the dataset. It would be valuable to develop a more formal and agreed protocol to decide if a skate was removed or retained after a killer whale interaction. Given that the adjustment is only 1-5%, this is not a great concern.

From the start of the NOAA survey until 2023, the AI and BS were surveyed biennially, while the GOA was surveyed annually. During this period, the GOA index was used to extrapolate the AI and BS indices in years when those regions were not surveyed. The Relative Population Number (RPN) for each region, AI, BS, and GOA, is calculated as the summed number of sablefish observed in that region during the survey.

In 2024, obtaining a suitable vessel for the Longline Survey became difficult. One vessel was available to conduct the GOA survey for 50 days every second year. This led to a revised design in which the BS and AI are surveyed in even years, and the GOA is surveyed in odd years, with three GOA survey sites being removed. As a result, the GOA survey index for the missing year was filled using the value from the previous year, and the AI and BS survey indices continued to be extrapolated as before. This was an undesirable but necessary interim approach under the revised survey constraints.

Implications of biennial GOA survey coverage. A major concern is the loss of GOA survey coverage in every second year. Replacing the missing GOA index with the previous year's value is problematic and needs to be addressed. In the single-area assessment model, there is no satisfactory solution. By contrast, the Fleets-As-Areas (FAA) assessment allows the even-year data for AI and BS, and the odd-year data for GOA, to be treated as missing observations.

Recommendation 4.1.3. Moving from the single area model to a FAA assessment is highly recommended as it provides a defensible way to accommodate the revised survey design in GOA.

Longline Survey as a numbers-based index. The LLS index for each region AI, BS, and GOA is expressed as Relative Population Numbers (RPN), a numbers-based index. In years of strong recruitment, the RPN can be dominated by small fish. This seems peculiar, making me

wonder whether it might be preferable to convert fish numbers to biomass using a weight-at-age relationship. The assessment team had already evaluated this option and concluded that converting numbers to weight would just add uncertainty to the assessment outputs.

Recommendation 4.1.4. This may be worth further consideration, but as a low priority, because the age composition data already provide information on the proportions of younger and older fish and the conversion of lengths to numbers just increases uncertainty.

CPUE indices. These indices from logbook data were not available to NOAA after 2022. In any case, these data have become increasingly unsuitable for assessment purposes because the stock has changed rapidly since 2015 following several strong recruitment events. The fishery has also undergone major gear changes in recent years, shifting from hook-and-line gear towards pot fishing, particularly through the use of collapsible "slinky" pots that can be carried on smaller vessels.

The CPUE index does not match the Longline Survey index because the fishery tends to target larger fish. This effect has been particularly evident in recent years, following several strong recruitment events.

The Japanese CPUE data from the early period of the fishery were also removed because they could not be standardised and because the provenance of the data was uncertain.

Recommendation 4.1.5. Discontinuing the use of both sources of CPUE data is recommended as it improves model stability and produced better fits in the retrospective analyses.

Age composition data. These data provide important information on recruitment patterns and the age structure of the stock. In the Gulf of Alaska (GOA), otoliths have been collected annually since 1990. Across the Western, Central, and Eastern Gulf areas, the annual age composition sample generally comprises approximately 600–1,200 fish. In the Aleutian Islands (AI) and Bering Sea (BS), age samples are collected every second year. Sampling began in the AI in 1996, with variable annual sample sizes of approximately 140–300 fish, and in the BS in 1997, where sample sizes are smaller and more variable, typically around 50–100 fish.

These data are particularly valuable for identifying strong recruitment events. They indicate strong recruitment in the AI in 2014, 2016, and 2017; in the BS in 2017; and in the GOA in 2014 and 2016.

The assessment model showed considerable tension between the NOAA Longline Survey (LLS) data and the age composition data. When the age composition data were fitted with a multinomial likelihood, the fit to the LLS data deteriorated. This required an adjustment to the effective sample size for the age composition data.

The assessment team used Francis TA1.8 iterative reweighting, which generally reduces the sample size, giving more weight to the LLS index which generally has lower variance, and less

weight to the age composition in the likelihood. This adjustment improved the fit to the survey indices while retaining satisfactory fits to the age composition data. The Francis reweighting is a common and accepted approach, and I agree with its continued use in the sablefish assessment.

The assessment team also explored a Dirichlet–multinomial likelihood to determine whether Francis reweighting could be avoided and whether the tension between the two datasets could be reduced. The resulting fits were unsatisfactory, and this approach was not pursued.

The plus-group. The model fits to the age composition data are generally acceptable, particularly given the longevity of sablefish and the relatively sparse observations in individual age classes. The most conspicuous issue is the large plus group (ages 31 and older). This is especially noticeable in the AI from 2010 to 2016, when large aggregations of older fish were observed. The model estimates for the plus group are substantially below the observed values, and this component of the data cannot be fitted well.

There was discussion at the Review Meeting to remove the plus group entirely. The Assessment Team had already tested this, and key model outputs, including spawning biomass, changed little.

Recommendation 4.1.6. The plus-group should remain in the age composition model input. Although it is visually undesirable, this is not a reason to delete it.

In the FAA model, the issues of tension between the age composition and LLS data, reliance on Francis's reweighting, and poor fit to the plus group, are more serious than in the single-area model because the data are distributed across three regions. Despite these difficulties, the overriding consideration is how best to accommodate the missing years of LLS data. In this respect, the FAA model has a clear advantage over the single-area model because it can treat the missing regional observations as missing data and adjust the model fitting accordingly.

Selectivity. Logistic selectivity is used in all cases for AI, BS, and GOA. Looking at the data, common sense would indicate that a dome shaped selectivity could be more appropriate in some cases. The dome-shaped selectivity was investigated in detail, and it was found that the parameters were difficult to estimate, and the model was unstable compared to the logistic selectivity. The added complexity did not give greatly different estimates of the model outputs, and a simple, more parsimonious model structed was selected.

The assessment team investigated changes to selectivity time blocks. More or different time blocks resulted in model instability and these formulations were rejected.

Recommendation 4.1.7. In the short term, logistic selectivity in the current time blocks is recommended for the assessment, as it is the most parsimonious parameter configuration and has more stable estimation and similar model outputs.

Recommendation 4.1.8. There should be further investigation into different time blocks for the FAA assessment, to see if there are other formulations that result in stable parameter estimation. The use of sex-specific spline selectivity could be investigated. Possibly 4 nodes and the same time blocks as the current logistic selectivity. The extra number of parameters may well be manageable in the FAA model.

Recommendation 4.1.9. The change in the survey design makes the use of the single area model untenable and I recommendation that the FAA model be used for the current sablefish assessment.

3.2 Terms of Reference 2

Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.

Advise as to whether the model is consistent with and represents the best scientific information available (BSIA) for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

Conceptualization of the FAA model. The major drawback of the FAA model is the interpretation of the assessment process. In this assessment, it is assumed there is a single homogeneous population and the differences in the Longline Survey indices and age composition data across AI, BS, and GOA are interpreted as due to changes in the availability of sablefish to the fleet rather than biological differences across the fishery, for example recruitment. The model fitting to the signals coming from the indices and age composition come through estimates of *q* and selectivity.

Recommendation 4.2.1. When reporting the outputs of the assessment to Managers and Stakeholders care needs to be taken to keep it simple and not allude to the conceptual difficulties of the FAA assessment model.

Parameter Estimation. The single area model (26.1_1Reg) has 253 estimated parameters, and the fleets-as-areas model (26.2_FAA) has 271 estimated parameters. The extra parameters in the FAA model are 2 catchability parameters and 16 selectivity parameters.

Jitter Analysis. The Jitter analysis showed, to my great surprise, that the FAA model converged 100% of the time.

Recommendation 4.2.2. The Jitter analysis should be revisited with larger perturbation of the starting values.

Natural Mortality. The model input value of natural mortality (*M*) is highly influential in the model outputs, like spawning biomass. The value of *M*=0.085 was selected based on tagging models. The SAFE report mentions this is associated with maximum age of about 65 years, considered appropriate because few aged fish were greater than 70 years.

In the FAA assessment model, natural mortality is estimated with a prior of *M*=0.085 for males and females, with a small cv. This allows for the error in *M* to be incorporated in the assessment, while constraining it to be close to the best available estimate.

The higher value of natural mortality used in previous assessments, will result in the assessment model determining there are fewer older fish, resulting in lower spawning biomass, lower B/B_{40}, lower B/MSY, and ABC and OFL will decrease.

Recommendation 4.2.3. The choice of 0.085 as the prior for *M* with a small cv is appropriate. In this assessment, *M* is age invariant. I believe that varying *M* with age is unnecessary and unlikely to influence the model outputs. The comment in the SAFE report on the how 0.085 relates to maximum age of 65 was confusing. A brief note on how 65 was derived would be useful.

Fits to the NOAA Longline Survey data. The FAA model has serious tension between the fitting of the NOAA Longline Survey data and the age composition data. This is common and not unexpected. After the Francis iterative re-weighting, the fit to the survey indices improved. The survey data does not provide coverage of the whole sablefish population especially in AI. This inadequacy is common to the single area, FAA, and spatial modelling approaches and will not change.

Age composition The aim is to age approximately 1200 otoliths per year with 300 from AI and BS in alternate years and in GOA 300 from each of East, Central and West. This sample size is possibly large enough to get acceptable age compositions for the single area model.

In the FAA assessment, the sample size of 300, spread over two sexes and ages classes 2 to 70 is barely adequate. There is potential for improving the age composition data without greatly increasing the management cost of the fishery.

The “AFSC Aging Methods Database” lists the number of sablefish otoliths collected and the number aged. An extract from the table is shown below.

	AI		BS		GOA	
Year	Aged	Collected	Aged	Collected	Aged	Collectec
2025	0	0	0	0	0	3051
2023	0	0	300	562	886	3643
2022	298	397	0	0	895	3378
2021	0	0	300	715	889	3951
2020	296	524	0	0	890	2223
2019	0	0	299	954	894	4300
2018	297	441	0	4	891	1778
2017	0	0	300	411	890	2930
2016	303	406	0	455	892	1832

This data indicates that there are many otoliths collected and not aged in all regions of the fishery. The collection of the otoliths is, I expect, a much higher cost than the aging.
Sablefish are extremely difficult to age because of the small differences in seasonal growth due to low temperature variation where the sablefish live. Thus, deciding which annuli are annual growth rings is difficult. It is not a simple matter to find a new person to age sablefish as considerable training and evaluation is necessary.

Recommendation 4.2.4. An investigation should be conducted with the FAA model, of the effect on model stability and model outputs with changes in sample size (like a random sample of half the ages).

Recommendation 4.2.5. The GOA survey changing to every second year may allow more resources for otolith reading. I recommend another otolith reader be employed and trained. Finance might come from the reduced NOAA Longline Survey coverage in GOA. Industry could be approached and asked if they would like to contribute to reading more sablefish otoliths.

Recommendation 4.2.6. As the sablefish otoliths are extremely difficult to age, a new reader could be allocated to reading some of the easily read species, freeing up an experienced sablefish reader to take on more sablefish otolith reading.

Closed loop simulation. The single area model must extrapolate the RPN when the GOA index it not available, resulting in a systemic bias in biomass and recruitment. The closed loop simulation indicated that with the 16 extra parameters, the FAA model was able to better account for the signals in the data, had lower spawning biomass bias, and had greater model stability.

Projections and Management advice. At the present time, the FAA model provides the best information on the state of the Alaska-wide sablefish stock. The FAA model generates reliable projections which are used for estimating the required Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

Recommendation 4.2.7. The FAA model has a huge advantage over the one area model as it can reliably accommodate the problems with the alternate year missing Longline Survey index data in GOA. The FAA model should be adopted for the current assessment.

3.3 Terms of Reference 3

Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

Conceptual Understanding. The spatial assessment model has clear conceptual advantages over the FAA model. The Longline Survey data, age composition, and tagging data is collected on a spatial scale across AI, BS, and GOA and the regional recruitment and movement can be modelled on a spatial scale. This avoids the use of fleet catchability and selectivity to fit the data, which is difficult to conceptualize.

The Longline Survey indices have recently been generally higher in GOA, especially centre and east, indicating that GOA is likely to be the dominant area of the fishery. The larger number of age composition samples in GOA will bias the model fitting to favour GOA data in the FAA model. These problems can be avoided in a 3-area, or better still a 5-area spatial model.

The high recruitment years in AI, BS, and GOA do not occur in the same years. This cannot be modelled in the FAA model with the assumption of a single sablefish population across the whole area of the fishery. With the spatial model, the recruitment can be estimated in each area. This is a far more common-sense approach, allowing for different recruitment in each area.

The current 5-area model structure is a sex-specific, age-structured model with

recruitment estimated in each area with
movement across areas estimated in 3 age blocks over 3 spatially invariant time blocks (pre-1990, 1990-2015, and 2016 to present),
sex-specific but time-invariant logistic selectivity
catchability common over areas
recruitment estimates in each area.

The model has 1208 parameters and takes 25 minutes to run.

In the 5-area model, the fit to the indices is generally good. The age composition is acceptable but not as good in AI and BS as GOA, especially the plus group. The smaller number of aged fish in these two areas has exacerbated this. The fits to the tagging data in each of the 5 areas is good, especially in the early years. Changes in the fishing gear to pots could be contributing to poorer fit in the recent years.

It is clear, especially recently, that the timing of the high recruitment events is different across the fishery, in AI, BS, and GOA. The FAA model unrealistically treats the fishery as one population with a fishery wide recruitment.

For the 5-area model, the retrospective analysis showed positive retrospective patterns indicating model instability. In many cases Mohn's Rho was close to 0.2 and in BS Mohn's Rho >0.2.

Tagging data and movement. The critical additional data required for the 5-area spatial model is the tagging data. This gives us information on the age-specific movement of juveniles, sub-adults and adults, across the regions. The model configuration was to calculate the movement between adjacent regions in 3 age blocks.

Selectivity. Logistic selectivity was used throughout for the 5-area spatial model. All the problems with selectivity in the FAA model exist, but on top of that we have the problem of more selectivity parameters causing instability in the parameter estimation. Loosening up the priors or constraining them tightly were not solutions. Alternative selectivity formulations are required before the spatial model becomes a viable alternative to the FAA model.

Recommendation 4.3.1. Alternative selectivity formulations (like a 4-node spline) need to be explored in the hope of moving to a spatial model in the future.

Data sparsity. The NOAA Longline Survey has reduced coverage in GOA through a reduced number of stations after 2024 and the change to a biennial Longline Survey in GOA. This has increased uncertainty in the model outputs.

Under the current regime, during the NOAA Longline Survey, otoliths will be collected in GOA every second year. It should be clarified if the plan to collect about 3000 otoliths every second year or to maintain 3000 per year.

Recommendation 4.3.2. The NOAA Longline Survey is the only available measure of population trends. Further reductions in the survey coverage would seriously impact the model outputs and must be resisted.

Recommendation 4.3.3. The otolith collection across the fishery should be at least that before the changes to the survey regime GOA.

Recommendation 4.3.4. With a 5-area spatial model, the age composition data will be more sparse in GOA and I recommend that more otoliths need to read to improve the information on age structure and especially recruitment, to inform the assessment model.

Recommendation 4.3.5. The 5-area model makes sense conceptually as it captures the movement and age composition information in the fishery more sensibly. Development of this spatial model should continue.

The 3-area model. This model configuration with areas AI, BS, and GOA had a similar structure to the 5-area model with 723 parameters to be estimated. In general, the fits to the age composition data and the survey indices were like the 5-area model. The retrospective analysis showed concerning retrospective patterns like the 5-area model.

Understanding the model structure. An important positive for the 5-area assessment is that stakeholders, Managers, and Scientists can more easily understand the concepts of biomass in each region, movement, different regional recruitment, and regional increases or decreases in biomass. The allocation of quota, based on the Longline Survey indices in each region is easier to understand in a spatial model because it can be understood that is based on the biomass in each area.

The 5-area model has advantages over the 3-area model as it can potentially pick up regional depletion, matched more clearly with the apportioning of quotas in AI, BS, EG, CG, and WG.

Reporting of projections. The 5-area, and 3-area model show high instability in estimation of the recruitment, movement, and selectivity parameters due to overparameterization and low sample sizes. Although the model configuration needs more flexible selectivity to fit the age composition data, this is not possible due to the limited data. The projections are unreliable as are the estimates of the reference values required to determine the status of the fishery.

Movement Simplification. A possible way to reduce the number of estimated parameters in the 3-area or 5-area area assessment model is to determine the movement across the areas outside the model and bring them in as fixed parameters. This was tried by the assessment team, but the problem is that movement needs to be age specific making this an untenable solution.

Longline Survey Tagged fish. About 5% of the Longline Survey sablefish are tagged and released, about 3000-3500 per year. This amounts to 413,000 sablefish tagged and 38,000 tags recovered. In general, there are no otoliths associated with these tag recoveries as the tags are recovered by fishers and commercial landings. This data is valuable for movement patterns and is vital information for a 5-area or 3-area assessment model

Juvenile tagging. AFSC conducts a tagging program in GOA where 42,625 juvenile sablefish were tagged, with conventional tags, and the number of returns with tags and otoliths is 2630. The otolith recoveries generally come from

- an observer at a plant
- an observer on a vessel,
- a tagged fish being caught during a survey.

The number of tag returns from this program without otoliths is not clear.

This program supplies otoliths of known age, enabling the development of an aging error matrix which is directly incorporated in the assessment model to account for aging error in the model outputs. In addition, this data contributes information on age specific movement.

Recommendation 4.3.6. It is interesting to have a large quantity of information on reader error due to having so many fish of known age. I would like to see if a reduced aging error would improve model stability and how model outputs change.

Longline Survey tag returns. About 500 to 1000 tags are recovered each year from fishers and processors. A recovered tag entitles the individual to a beanie and an entry in the lottery to win $1000. I believe there is potential to gain more aging information from both tagging programs at little extra cost.

Recommendation 4.3.7. The number of otoliths recovered from tagged fish should be encouraged. Tag return incentives could be changed to give the fisher or the processor greater incentive to return the tag with otoliths. Increase the number of shares in the lottery to 5 or 10 shares for a tag with fish frame or otoliths. The prize money could also be increased from $1000 to $2000.

Otolith Staining. Injecting calcein into tagged fish is not a health concern (unlike oxytetracycline) and would greatly contribute to the fish aging process, possibly reducing aging error.

Recommendation 4.3.8. A sample of fish tagged on the Longline Survey be injected with calcein to assist in identification of annual annuli.

Reporting of Reference Points. The Alaska-wide sablefish requires Tier3 reference points. The projections are used to report F_{ABC} defined as $F_{40\%}$ and F_{OFL} defined as $F_{35\%}$. For a 5-area spatial model, where biomass and spawning biomass is estimated in each of the 5 areas, it would make sense to report the reference points in each area. Currently, there are no guidelines on reporting of area specific reference points. With a spatial assessment, it is not clear how F_{ABC} and F_{OFL} would be determined.

Recommendation 4.3.9. The mismatch between the Management requirements and the area specific reference points should be investigated and resolved.

3-area spatial assessment. This assessment model has 723 estimated parameters, compared with 1208 for the 5-area model. In the 3-area spatial model the fit to the survey indices was good and there was an adequate fit to the age composition, except in the middle years. There are moderate retrospective patterns in both the 3-area and the 5-area models. It is slightly worse in BS for the 3-area model and slightly worse in GOA in the 5-area model. The problems involved in determining suitable selectivity formulations, parameter estimation, and model stability, are similar for the 3-area and 5-area assessment.

Recommendation 4.3.10. The Alaska-wide assessment should move towards a spatial model when it is sufficiently stable to provide reliable projections for calculating the reference points. Given the considerable variation in catch across east, middle and west GOA (highest in the east), I recommend that future work on the spatial model should be with a 5-area model, rather than a 3-area model.

Appendix 1 Documents provided for the review.

Core documents

1. Appendix 3A_SPoRC_AssessmetDescription.pdf
2. Appendix 3B_1_Reg_Model_Build_Final.pdf
3. Appendix 3C_FAA_Model_DevelopmentModel_Build_Final.pdf
4. Appendix 3D_Spatial Model _Final.pdf
5. Appendix 3E_Closed_Loop_Sim_Final.pdf
6. Sablefish_SAFE_CIE_2026_Final.pdf

Additional materials supplied for the meeting

1. The 2024 Alaskan sablefish Stock Assessment and Fishery Evaluation (SAFE) report (Goethel and Cheng, 2024) and presentation;
2. The 2024 December SSC (p. 14-16) and November Joint Plan Team (p. 2-3) reports;
3. The 2025 AFSC Longline Survey Cruise Report (Siwicke et al., 2026) and presentation;
4. The 2025 October SSC (pp. 21-23) and September Joint Plan Team (p. 5-6) reports;
5. The SPoRC assessment platform publication (Cheng et al., 2026) and GitHub documentation;
6. Research papers on integrating density-dependent growth (Cheng et al., 2025b) and a pot gear fleet (Cheng et al., 2024a) into the sablefish assessment, simulation studies on selectivity (Cheng et al., 2024b) and sex-specific parametrization (Cheng et al., 2025c) for the sablefish assessment, and considerations for fitting sex-specific composition data (Cheng et al., 2025d) in stock assessments;
7. CIE reviewer reports from the 2016 Alaskan sablefish CIE review.

Model inputs

1. https://github.com/dgoethel-noaa/2026_Sablefish_CIE/tree/main/Model Runs/1Reg_Mods
2. https://github.com/dgoethel-noaa/2026_Sablefish_CIE/tree/main/Model Runs/FAA_Mods

Appendix 2: Performance Work Statement (PWS)

National Oceanic and Atmospheric Administration (NOAA)
NOAA Fisheries
Center for Independent Experts (CIE) Program
External Independent Peer Review

Alaska-wide Sablefish Stock Assessment
June 16 - 18, 2026

Background

NOAA Fisheries is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA Fisheries science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Sablefish (*Anoplopoma fimbria*) are a long-lived (90+ years), highly mobile, sexually dimorphic demersal species that live at depths greater than 200m (as adults). In Alaska Federal waters, sablefish are assessed and managed as a single population with the total quota apportioned across 6 management regions (Aleutian Islands, Bering Sea, Western Gulf of Alaska, Central

[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

Gulf of Alaska, Western Yakutat, and Southeast Outside) and among two fishing sectors (i.e., fixed gear and trawl gear). Since rationalization (i.e., implementation of individual fishing quotas, IFQs) occurred in the 1990s, sablefish have been one of the most valuable finfish resources in Alaska ($124 million in ex-vessel value in 2022). Catch advice for sablefish is based on a statistical catch-at-age integrated stock assessment model fit to fishery-independent survey data and fishery-dependent catch-age data. The sablefish assessment is reviewed annually by the North Pacific Fishery Management Council's (NPFMC) Science and Statistical Committee (SSC) as part of the quota specification process and last underwent a CIE review in 2016.

Scope

Since the last CIE review (i.e., in 2016), major changes have occurred in the sablefish resource, fishery, longline survey, and assessment model. Specifically, a series of extreme, above average recruitment events has led to rapid rebuilding of the resource and increasing quotas. Resultant landings of predominantly small, lower value fish have led to market saturation, strong reductions in landed value, and exploration of management options that loosen full retention requirements. Concomitantly, the primary directed fixed gear fleet has undergone rapid gear changes, where a predominantly hook-and-line fishery has transitioned to a longline pot fishery since 2017 (i.e., >85% of sablefish catch in the fixed gear fishery is now taken by pot gear), which has helped to reduce whale depredation.

Additionally, the fishery-independent, cooperative research-based NOAA longline survey, which targets sablefish and serves as the primary index of abundance for the assessment, underwent major survey design changes starting in 2025. Because the survey has traditionally used a cost-recovery approach, whereby survey catch is sold by the fishing company that owns the vessel performing the survey, the decline in sablefish markets prevented the survey from being undertaken in 2024 for the first time in its 30+ year history. Historically, the fixed station survey has sampled the entire Gulf of Alaska (GOA) annually, as well as either the Bering Sea (BS, odd years) or Aleutian Islands (AI, even years). Starting in 2025 a new survey design was enacted to reduce overhead and ensure a fishing company would accept the survey contract, wherein the Gulf of Alaska is now surveyed in odd years (starting in 2025), and the BS and AI are surveyed in even years (starting in 2026). Although the new survey design ensures the ability to continue the longline survey, it results in only ~50% of total stock abundance being surveyed in a given year. Moreover, it raises important challenges for the panmictic assessment in terms of how to integrate survey data that only partially samples the population being assessed.

There have also been major changes to the assessment model since the last CIE review. Most importantly, a new R-TMB based package, the SPoRC (Stochastic Population Over Regional Components) assessment model, has been adopted, which replaces the previous Automatic Differentiation Model Builder (ADMB) based assessment model. Additionally, a number of

research-oriented assessment models have been developed exploring alternative spatial structures (e.g., spatially-explicit 3 and 5 region models that estimate movement among regions, as well as a spatially-implicit single region Fleets-As-Areas (FAA), all of which demonstrate promise for dealing with spatial complexities and data gaps that are not well resolved in the single region panmictic assessment. In 2026, the assessment team transitioned from the single region panmictic assessment to the FAA model, because the FAA model could better handle the new longline survey design (i.e., fit the data by region as separate fleets) and implicitly account for ontogenetic movement dynamics (i.e., through selectivity and availability assumptions). Thus, for the purpose of the CIE review, feedback on the FAA model is being requested, particularly with regard to appropriate model structure and parametrization. To help make determinations on the BSIA to assess the Alaska sablefish population, reviewers will be provided the results of closed loop simulation analyses and assessment model runs applied to the sablefish data (including model outputs and diagnostics).

The overarching goals of this review process are to:

1. Ensure the FAA stock assessment supports the development of robust advice for use by the North Pacific Fishery Management Council based on the BSIA;
2. Provide an independent external review of this stock assessment to confirm that it meets the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3. Understand and identify appropriate FAA model structure and fits to key data sources (indices, landings, and age compositions);
4. Identify research needed to improve the assessment and advice for fishery managers.

The specified format and contents of the individual peer review report are found in **Annex 1**. The Terms of Reference (ToRs) of the peer review are included in **Annex 2**. The tentative agenda of this in-person panel review meeting is included in **Annex 3**.

Requirements

NOAA Fisheries requires **3 reviewers** to conduct an impartial and independent peer review in accordance with this Performance Work Statement (PWS), OMB Guidelines, and the ToRs below. Modifications to this Performance Work Statement (PWS) and ToRs cannot be made during the peer review, and the Contracting Officer's Representative (COR) and the CIE contractor shall approve any modifications prior to the peer review. All ToRs must be addressed in each reviewer's report.

The CIE reviewers should have expertise in statistical sex- and age-structured integrated stock assessment models. In particular, experience developing spatially-explicit and spatially-

implicit (i.e., fleets-as-areas) assessment models is imperative. Moreover, understanding of stock assessment good practices are required. Working knowledge of the RTMB programming language, a basic understanding of closed loop simulation, and a background in survey design and/or the use of fishery-independent survey data in stock assessments would all be beneficial.

The chair for this meeting, who is in addition to the CIE reviewer, will not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract.

Tasks for Reviewers

The CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

Pre-review Background Documents: A minimum of two weeks before the peer review, the NOAA Fisheries Project Contact will send (by electronic mail or make available at an FTP site/GitHub Repository) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NOAA Fisheries Project Contact will consult with the CIE on where to send documents. The CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance with the PWS scheduled deadlines specified herein.

The document list is separated into 'summary/background' and 'for review' documents. The CIE reviewers are *encouraged to peruse* the 'summary/background' documents for information on data inputs, previous assessment structures and associated reviews, and ongoing research. However, the CIE reviewers *must review* all of the 'for review' documents in preparation for the peer review, as these contain the results of the primary analyses and model runs that will be discussed during the review panel.

Available documents (available from the public sablefish CIE GitHub repository, as they become available) include:

For Review (available here)

1. A summary document describing the fleets-as-areas assessment model, including the full model description and results, with comparison to outputs from the single region panmictic assessment as well as summary results for all sensitivity model runs;
2. A document summarizing the results of the spatially-explicit closed loop simulation analysis;
3. The 2025 Alaskan sablefish stock assessment proposed model changes report (Goethel and Cheng, 2025) produced for the September 2025 Joint Plan Team meeting, presentation, and GitHub repository, which describes recent changes to the current single region panmictic assessment including transition to RTMB and the SPoRC assessment package;
4. The spatial sablefish model publication and model updates report (Cheng et al., 2025a) for the September 2025 Joint Plan Team meeting;

5. Additional supporting documents and presentations as they become available.

Summary/Background (Available here)

1. The 2024 Alaskan sablefish Stock Assessment and Fishery Evaluation (SAFE) report (Goethel and Cheng, 2024) and presentation;
2. The 2024 December SSC (p. 14-16) and November Joint Plan Team (p. 2-3) reports;
3. The 2025 AFSC Longline Survey Cruise Report (Siwicke et al., 2026) and presentation;
4. The 2025 October SSC (pp. 21-23) and September Joint Plan Team (p. 5-6) reports;
5. The SPoRC assessment platform publication (Cheng et al., 2026) and GitHub documentation;
6. Research papers on integrating density-dependent growth (Cheng et al., 2025b) and a pot gear fleet (Cheng et al., 2024a) into the sablefish assessment, simulation studies on selectivity (Cheng et al., 2024b) and sex-specific parametrization (Cheng et al., 2025c) for the sablefish assessment, and considerations for fitting sex-specific composition data (Cheng et al., 2025d) in stock assessments;
7. CIE reviewer reports from the 2016 Alaskan sablefish CIE review.

Please note that outputs of all analyses used as part of the CIE review, including input data, simulation outputs, final proposed assessment models, and all sensitivity assessment models, will be made available on the sablefish CIE GitHub repository

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the PWS and ToRs and shall not serve in any other role unless specified herein. The CIE reviewers shall actively participate in a professional and respectful manner as members of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NOAA Fisheries Project Contact is responsible for any meeting arrangements (e.g., conference room reservations, video conferencing logistics, etc.).

Contract Deliverables - Independent CIE Peer Review Report: Each CIE reviewer shall complete an independent peer review report in accordance with this PWS. Reviewers are not required to reach a consensus, and a summary report *will not* be produced. Each CIE reviewer shall complete their independent peer review according to the required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**. The tentative agenda of the panel review meeting is in **Annex 3**. Each CIE reviewer will deliver their reports according to the specified milestone dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NOAA Fisheries Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship,

country of current residence, and home country) to the Project Contact for the purpose of their security clearance, and this information shall be submitted at least two weeks in advance.
For additional information, please see the following link: https://www.commerce.gov/osy/programs/foreign-access-management. All CIE reviewers must have a REAL ID-compliant form of identification to access Federally owned or leased facilities. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be Juneau, AK.

Period of Performance
The CIE reviewers' duties shall not exceed **14** days to complete all required tasks.

Schedule of Milestones and Deliverables
The contractor shall complete the tasks and deliverables in accordance with the following schedule:

Schedule	**Milestones and Deliverables**
Within two weeks of award	Contractor secures participation of the CIE reviewers.
At least two weeks prior to the panel review meeting	Pre-review documents are provided to the reviewers.
June 16 - 18, 2026	The reviewers participate and conduct an independent peer review during the panel review meeting.
Approximately 2 weeks later	Contractor receives draft reports.
Within 3 weeks of receiving draft reports	Contractor submits final reports to the US Government.

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content in **Annex 1**; (2) The reports shall address each ToR as specified **Annex 2**; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.
Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (Travel resources | GSA), and all contractor travel must be approved by the COR prior to the actual travel. Any travel conducted prior to the receipt of proper written authorization from the COR will be done at the Contractor's own risk and expense. International travel is authorized for this contract. Travel is not to exceed $13,000.00.

Confidentiality and Data Privacy

This contract may require that services contractors have access to Privacy Information. Services contractors are responsible for maintaining the confidentiality of all subjects and materials and may be required to sign and adhere to a Non-disclosure Agreement (NDA).

NOAA Fisheries Project Contact:

Chris Lunsford
MESA Program Manager
NOAA Fisheries, Alaska Fisheries Science Center
17109 Pt. Lena Loop Road
Juneau, AK 99801
Chris.Lunsford@noaa.gov

Annex 1. Peer Review Report Requirements

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations as specified in the ToR and provide advice on whether the science reviewed is consistent with and represents the best scientific information available (BSIA).
2. The main body of the reviewer report shall consist of the following sections: Background; Description of the Individual Reviewer's Role in the Review Activities; Summary of Findings for each ToR in which the weaknesses and strengths are described; and Conclusions and Recommendations in accordance with the ToRs.
    a. Each reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings as well as the science, conclusions, and recommendations.
    b. Each reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
    c. Each reviewer should elaborate on any points that they feel might require further clarification.
    d. Each independent CIE report shall be a stand-alone document through which others can understand the weaknesses and strengths of the science reviewed and shall be an independent peer review of each ToRs.
3. The reviewer report shall include the following appendices:

    Appendix 1: Bibliography of materials provided for review.
    Appendix 2: A copy of the CIE Performance Work Statement.
    Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2. Terms of Reference (ToRs) for the Peer Review

Review of the Alaska-wide Sablefish Assessment

CIE reviewers are contracted to complete their independent peer review based on the ToRs. Therefore, the CIE-NOAA Fisheries review and approval process is based on whether the CIE independent reports addressed each of the ToRs.

1) Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.
   a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

2) Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.
   a) Advise as to whether the model is consistent with and represents the best scientific information available (BSIA) for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

3) Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

Reviewers must provide details for the basis of their responses to the review ToRs.

Annex 3. Agenda for the CIE Review of the Alaska-wide Sablefish Assessment

North Pacific Fishery Management Council

NOAA Alaska Fisheries Science Center, Auke Bay Laboratories

17109 Pt. Lena Loop Road, Juneau, AK 99801

June 16-18, 2026

Contact: Chris Lunsford (Chris.Lunsford@noaa.gov)

Tuesday, June 16, 2026

A. Welcome and Introductions

09:00 — 09:15: Welcoming Remarks, Introductions, Logistics Chris Lunsford

09:15 — 09:30: Announcements, Agenda/ToRs Chair

B. Sablefish Management, Biology, Fishery, and Data Inputs (ToR 1)

09:30 — 09:50: Biology, Spatial Dynamics Daniel Goethel

09:50 — 10:10: Sablefish Management/NPFMC FMP Requirements Sara Cleaver

10:10 — 10:30: Fishery-Dependent Data Matt Cheng

10:30 — 10:50: *BREAK*

10:50 — 11:15: Longline Survey Data and Recent Design Changes Kevin Siwicke

11:30 — 12:00: Assessment History, Inputs, and Other Available Data Daniel Goethel

12:00 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Assessment Model Configuration (ToR 1)

14:00 — 14:30: Current Model Development Pathway Daniel Goethel

14:30 — 15:30: General Sablefish Assessment Parametrization Daniel Goethel

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion

Wednesday, June 17, 2026

A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs Chair

09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

B. Spatially Implicit (Fleets-as-Areas) Model Configuration (ToRs 1)

10:50 — 12:00: Results of Spatial Simulations to Optimize FAA Structure Matt Cheng

12:00 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Comparing Assessment Performance and Diagnostics (ToR 1/2)

14:00 — 14:20: Final Fleets-as-Areas Assessment Configuration Daniel Goethel

14:20 — 15:30: Outputs/Diagnostics for FAA and Panmictic Models Daniel Goethel

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion

Thursday, June 18, 2026

A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs Chair

B. Comparing Assessment Performance and Diagnostics (ToR 1/2)

09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

10:50 — 11:30: Results of a Spatial Closed Loop Simulation Analysis. Matt Cheng

11:30 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Spatial Models (ToR 3)

14:00 — 15:00: 3 and 5 Region Spatial Model Configuration/Outputs Matt Cheng

15:00 — 15:30: Discussion

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion and Report Writing

ADJOURN

Appendix 3 List of Participants

CIE - Center of Independent Experts

NOAA - National Oceanic and Atmospheric Administration

NMFC – National Marine Fisheries Service

AFSC - Alaska Fisheries Science Center

NPFMC - North Pacific Fishery Management Council

ASMFC - Atlantic States Marine Fisheries Commission

UA – University of Alaska

Klass Hartmann	CIE Reviewer Australia	
Peter Stephenson	CIE Reviewer Australia	
Sam Subbey	CIE Reviewer Norway	
Aaron Berger	Meeting Chair	(NOAA/NMFS NWFSC)
Daniel Goethel	Assessment Presenter	(NOAA/NMFS AFSC)
Matt Cheng	Assessment Presenter	(NOAA/NMFS AFSC; UA)
Chris Lunsford	Meeting Organizer	(NOAA/NMFS AFSC)
Kristen Omori	NOAA/NMFS AFSC	
Pete Hulson	NOAA/NMFS AFSC	
Kevin Siwicke	NOAA/NMFS AFSC	
Sara Cleaver	NPFMC	
Pat Malecha	NOAA/NMFS AFSC	
Melissa Haltuch	NOAA/NMFS AFSC	
Grant Adams	NOAA/NMFS AFSC	
Jim Ianelli	NOAA/NMFS AFSC	
Cindy Tribuzio	NOAA/NMFS AFSC	
Samara Nehemiah	ASMFC	
Beth Matta	NOAA/NMFS AFSC	
John Brogan	NOAA/NMFS AFSC	

Appendix 4. Review Panel Summary Report.

TOR 1. Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.

a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

- Trade-offs of adding flexibility using FAA, but then restricting selectivity to only logistic brings you back some. Keep an open mind on some of the alternative selectivity-by-region scenarios that also performed relatively well. Including some alternative selectivity forms beyond gamma.
- Look at some intermediate complex selectivity parameterizations for the time-varying options (or time/age interaction).
- The FAA approach overcomes the difficulties with spatial/temporal survey design, which additionally addresses the most recent design changes.
- FAA adheres to the management structure and retains applicability to the current management framework/advice.
- FAA is a good compromise between capturing sufficient biological complexity and overparameterization (parsimonious model structure)
- Future improvements are unlikely to arise from additional to the presented time-varying selectivity complexity, alternative composition likelihood formulations, or further fleet partitioning. Extensive sensitivity analyses indicate that these approaches do not resolve the fundamental model tensions.
- The current data do not appear sufficient to support a fully spatial process-based assessment model. Additional spatial complexity would likely exacerbate existing identifiability and stability issues unless accompanied by substantial improvements in data quantity, spatial coverage, and understanding of ecological processes.
- Tagging information represents an underutilized source of information and offers opportunities to improve understanding of movement, survival, and stock connectivity. However, methods for integrating tagging information into assessment models requires further development and validation.

TOR 2. Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.

a) Indicate whether the model provides the best scientific information available for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

- FAA is more difficult to interpret (especially selectivity and catchability relative to a one-area interpretation) than a single area model.
- FAA will likely be difficult to communicate to stakeholders.

- The additional parameters required for the FAA model were validated as appropriate given the presented closed loop simulation analyses. It would be beneficial to examine if the results are robust to alternative operating models (states of nature).
- Natural mortality remains difficult to estimate (regardless of single-area or FAA approach). Currently, the estimate of natural mortality is driven by prior, which directly influences population scale and can be confounded with catchability and R0.
- Weakness is that the FAA relies on the survey data for regional dynamics, but the survey does not fully cover the stock footprint, particularly in the AI region. [this weakness remains for other approaches too].

TOR 3. Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

- Investigate Jeffreys priors (i.e., non-informative priors) for natural mortality, which can be helpful when there is a lack of information on what to specify as the prior.
- Investigate the tagging data for estimating M (outside the assessment model), in particular towards achieving an improved prior distribution for use in assessment models.
- Understand the impact of age data quantity on age compositions and, through the application of data weighting, how it influences fits to composition and relative index fits. Will more age data help with age composition fits?
- To make the 3 and/or 5 region spatially-explicit models operational, methods need to be developed to be able to specify spatial reference points. Currently, there is no clear advice on best practices.
- There is a management integration conundrum with the spatial models because the 5-region has a management mismatch and the 3-area has a biological mismatch that would have to be dealt with.
- The fits to the composition data remain an area for model improvement. Investigate whether new information on aging error, the assumed additional survey index CV, selectivity, and other approaches lead to improved fits.

Additional Notes:

- The continued collection of otoliths and aging should at least stay at the current level.
- The survey data and footprint have already been diminished to a level that is significantly impacting model uncertainty, and further reductions would seriously compromise the assessment.
- Extending the current hydrodynamic/environment models (MOM-6 now available) to additionally include the BS and AI area (not just the GOA) would be beneficial to understand dispersal dynamics in these areas.
- While the removal of data (skates) on the survey due to whale depredation is generally formalized on the water, though remains subjective, a formal

description of these protocols should be completed.

3J: CIE Reviewer Report: Samuel Subbey

Sam (Samuel) Subbey

Executive Summary

This review evaluates the 2026 Alaska sablefish stock assessment in response to the Center for Independent Experts (CIE) Terms of Reference, with particular emphasis on the implications of recent NOAA Longline Survey (LLS) redesign, alternative assessment model structures, data limitations, and future research priorities.

A central challenge facing the assessment is the loss of complete annual survey coverage across the stock distribution. Under the current survey design, only a subset of regions is sampled in a given year, requiring reconstruction of approximately half of the Alaska-wide survey index. Historically, this was accomplished through extrapolation procedures that assumed strong spatial relationships among regions. These assumptions are no longer defensible, leading to the development of alternative approaches including the use of carryover indices and the Fleets-As-Areas (FAA) framework.

Overall, the review concludes that the FAA assessment provides an appropriate and scientifically defensible basis for operational management advice under the revised NOAA Longline Survey design and represents the Best Scientific Information Available (BSIA) for current assessment needs.

Two primary assessment models were evaluated:

- **Model 26.1 1Reg**: A traditional Alaska-wide single-region assessment that aggregates all datasets and relies on reconstructed survey indices.
- **Model 26.2 FAA**: A single-population FAA model that disaggregates NOAA Longline Survey data into Bering Sea (BS), Aleutian Islands (AI), and Gulf of Alaska (GOA) fleets while retaining a common underlying population.

The review concludes that both models are scientifically credible and provide generally similar population trends. However, the FAA model offers several important conceptual advantages. Most notably, it avoids reliance on extrapolated survey indices, preserves regional survey information, and better captures recruitment signals originating in the BS and AI. The FAA model therefore appears more consistent with the current survey design and makes more direct use of the spatial structure present in the available data.

At the same time, the FAA model introduces additional complexity and exposes important limitations in the available data. Regional partitioning reduces sample sizes, increases parameter uncertainty, and amplifies identifiability problems associated with selectivity, catchability, and natural mortality. Extensive model-development efforts demonstrated that more complex fleet structures rapidly became unstable, indicating that the final FAA configuration represents the most complex configuration that remained operationally stable and estimable with the available data.

A consistent finding throughout the review is the existence of a persistent conflict between survey indices and composition data. Age compositions indicate strong recent recruitment events, whereas survey indices imply more moderate population growth. Francis reweighting is required in both assessment frameworks to reconcile these conflicting signals. Importantly, multiple sensitivity analyses (e.g., time-varying selectivity, time-varying weight-at-age, Dirichlet-multinomial likelihoods, and combined approaches) failed to resolve this tension. Collectively, these results suggest that the conflict is primarily structural, and reflects

limitations in ecological representation rather than deficiencies in statistical estimation procedures.

The assessment appears to be constrained less by the quantity of observations than by the limited amount of independent information available to identify key processes. The NOAA Longline Survey remains the dominant source of abundance information, yet its effectiveness has been reduced by the revised survey design. Composition datasets are extensive, but frequently conflict with survey indices and require substantial down-weighting. Additional data sources, including CPUE indices, trawl survey information, tagging data, and length compositions, are largely excluded or only partially utilized. Consequently, assessment outputs depend increasingly on model assumptions, data weighting, and informative priors. Natural mortality (M) represents a particularly clear example of this dependence. The FAA model becomes unstable when the prior on natural mortality is relaxed, indicating that mortality is weakly identified by the available data and highly confounded with recruitment, selectivity, and survey catchability. This finding, together with the need for Francis reweighting, highlights broader limitations in parameter identifiability within the current assessment framework.

The review also identifies several ecological processes that are not explicitly represented in the assessment but are likely influencing model behavior. These include:

- Ontogenetic movement and regional connectivity,
- Spatially variable recruitment,
- Availability processes,
- Habitat shifts throughout the life cycle,
- Environmental drivers of recruitment variability.

Collectively, these processes represent plausible sources of structural uncertainty that are only indirectly represented in the current assessment models.

Many assessment challenges currently absorbed by selectivity functions appear more naturally explained by these ecological processes. In particular, FAA selectivity estimates strongly suggest that availability and movement dynamics are being aliased through regional selectivity parameters.

Based on the available evidence, the following conclusions are offered:

1. The FAA framework provides the most scientifically defensible basis for operational management under the current NOAA Longline Survey design. By fitting regional survey observations directly, it eliminates reliance on increasingly difficult-to-defend survey extrapolation procedures while producing stock status estimates broadly consistent with the historical assessment.

2. The current three-fleet FAA configuration (BS, AI, GOA) represents the most appropriate fleet structure supported by the available data. Model development demonstrated that additional fleet partitioning substantially increased parameter uncertainty and reduced model stability.

3. Neither the FAA model nor the historical single-region model fully resolves the persistent conflict between survey indices and composition data. The continued need for Francis reweighting, together with the results of multiple sensitivity analyses, suggests that this conflict is primarily structural rather than statistical.

4. Natural mortality, selectivity, recruitment, and related observation processes remain only weakly identifiable from the available data and continue to depend substantially on informative priors, data weighting, and model assumptions.

5. Future improvements in assessment performance are likely to arise from improved representation of ecological processes (including movement, regional connectivity, availability, and spatial recruitment) rather than from further increases in statistical complexity alone.

Overall, the assessment remains scientifically sound and suitable for management use. However, recent survey changes have fundamentally increased structural uncertainty. The FAA framework represents an important step toward addressing these challenges and provides an appropriate foundation for continued development, while future research should focus on movement, availability, tagging integration, spatial recruitment processes, and other ecological mechanisms that are currently unmodeled.

Background

Sablefish (*Anoplopoma fimbria*) is a long-lived, commercially important groundfish distributed throughout the North Pacific. The Alaska stock is managed as a single population under the North Pacific Fishery Management Council Groundfish Fishery Management Plan and has historically been assessed using an integrated age-structured model that combines fishery catches, fishery-independent survey indices, and age-composition data.

Recent changes to the NOAA Longline Survey (LLS) have created significant challenges for the assessment. Historically, annual survey coverage allowed construction of a consistent Alaska-wide abundance index. However, modifications to survey design resulting from budgetary and logistical constraints now require alternating regional sampling, such that only a subset of the stock distribution is surveyed in any given year. Consequently, approximately half of the survey information required to construct an Alaska-wide index must now be inferred rather than directly observed.

These changes have raised important questions regarding the interpretation and use of survey data within the assessment. In particular, the historical approach of extrapolating abundance indices across regions has become increasingly difficult to justify, motivating the development of alternative assessment approaches that better reflect the spatial structure of the survey data.

To accommodate the revised survey design while preserving a single-stock assessment framework, an alternative observation model (the Fleets-As-Areas (FAA)) approach was developed. The 2026 review therefore, compared two operational assessment frameworks:

1. **Model 26.1 1Reg:** A traditional single-region age-structured assessment in which all survey, catch, and composition data are aggregated to the Alaska-wide scale.

2. **Model 26.2 FAA:** A Fleets-as-Areas (FAA) model that retains a single biological population but disaggregates NOAA Longline Survey indices and age compositions into

three regional fleets: the Bering Sea (BS), Aleutian Islands (AI), and Gulf of Alaska (GOA). This approach was developed to avoid the need for large-scale index extrapolation while retaining a relatively simple assessment structure.

Importantly, the FAA model does not represent a spatial population model. Rather, it retains the assumption of a single Alaska-wide population while representing regional differences through the observation model. This distinction is central to the evaluation presented in this review.

A central theme throughout development of both assessment frameworks has been the persistent difficulty of simultaneously fitting survey indices and composition data. Survey indices, fishery age compositions, and survey age compositions often provide conflicting signals regarding recent recruitment strength and population dynamics. These conflicts have required extensive use of Francis reweighting, sensitivity analyses, and alternative model formulations. Despite considerable model development effort, including evaluation of more than one hundred alternative FAA configurations, none of the candidate models completely resolved these inconsistencies

The review therefore considers not only the relative performance of the competing assessment frameworks, but also the consequences of reduced survey coverage, data representativeness, parameter identifiability, and model complexity.

Particular attention is given to the construction and interpretation of Relative Population Number (RPN) indices, the treatment of conflicting data sources, and the extent to which the current assessment framework adequately represents the underlying ecology of Alaska sablefish.

The objectives of this review are defined by the Center for Independent Experts (CIE) Terms of Reference and focus on three primary areas:

1. Evaluation of the appropriateness of the FAA model for management advice and recommendations regarding fleet structure parametrization.

2. Evaluation of data sources, diagnostics, model performance, and the use of the best scientific information available;

3. Identification of research priorities and opportunities for future assessment development.

Throughout this review, particular emphasis is placed on distinguishing uncertainty arising from observation error, model structure, and ecological processes.

A recurring theme throughout this review is the distinction between statistical uncertainty and structural uncertainty. While observation error and parameter uncertainty remain important, many of the principal challenges encountered in the current assessment arise from limitations in representing spatial dynamics, movement, availability, and other ecological processes within an Alaska-wide assessment framework.

Role in the Review and Pre-Meeting Framing

Engagement with Review Materials

Prior to the CIE review meeting held in Juneau, Alaska (June 16–18, 2026), I conducted a comprehensive review of the materials provided via the Alaska sablefish CIE GitHub repository, including all documents identified as "For Review" in the Performance Work Statement (PWS).

Key documents reviewed included:

- Fleets-as-Areas (FAA) assessment summary document;
- Spatial closed-loop simulation report;
- 2025 sablefish model changes report;
- Spatial sablefish model development and update reports;
- Supporting technical presentations and appendices.

These were supplemented with background materials including previous assessment reports, survey documentation, SPoRC model documentation, relevant methodological publications, and prior CIE review reports.

Purpose of the Review

The Terms of Reference require evaluation of whether the FAA assessment framework constitutes the Best Scientific Information Available (BSIA) for operational management of Alaska sablefish.

Accordingly, the review is not primarily a model selection or goodness-of-fit exercise. Instead, it focuses on whether the FAA framework provides the most scientifically defensible basis for management advice given the available data, revised survey design, biological and spatial uncertainties, and operational management requirements.

The assessment therefore considers (i) data quality and explanatory power; (ii) biological plausibility of model structure; (iii) statistical robustness and identifiability; management utility and performance; and (iv) implications for future assessment development.

Review Framing and Key Considerations

The review is structured around the recognition that FAA represents an intermediate framework between the historical single-region (1Reg) assessment, and fully spatial population dynamic models (3- and 5-region structures with movement).

The central question is therefore whether FAA provides an appropriate balance between:

Data quality, biological plausibility, statistical robustness, and management utility.

Hierarchy of Assessment Models

The assessment framework can be viewed as a progression of increasing spatial and biological complexity:

Model	Population Structure	Observation Structure
1Reg	Single stock	Aggregated observations
FAA	Single stock	Regional observations
3-Region	Spatial structure	Regional observations
5-Region	Spatial structure + movement	Regional observations + movement

A key distinction is that FAA is not a spatial population model; it is a spatially structured observation model applied to a single-stock population. The key evaluative question is therefore:

> Does FAA capture the management-relevant consequences of spatial heterogeneity without introducing unnecessary structural complexity?

Management Context and Motivation for Model Change

A central driver of the FAA framework is the change in NOAA Longline Survey design.

Historically, the survey provided near-complete spatial coverage of the stock range. Under the revised design, coverage is reduced and alternates between regions (GOA and BS/AI), resulting in increased reliance on model-based extrapolation under the 1Reg framework. This creates the core management question:

> Which limitations of the historical assessment are amplified under reduced survey coverage, and does the FAA framework provide a more robust solution?

BSIA Evaluation Framework

The BSIA assessment is structured around four criteria. Specifically, the review considers: 1.

Data Quality: Does the model adequately represent available data?

2. **Biological Plausibility:** Are biological assumptions consistent with current understanding?
3. **Statistical Robustness:** Is the model robust to uncertainty and structural variation?
4. **Management Utility:** Does the model improve management performance relative to alternatives?

A model need not represent the most biologically detailed system to qualify as BSIA; rather, it must be the most scientifically defensible option for management given current information and uncertainty.

Uncertainty Framing

A key premise of the review is that uncertainty must be decomposed into (i) observation, (ii) process, (iii) spatial, (iv) movement, (v)recruitment, and (vi) structural uncertainties.

In this context, structural uncertainty (arising from model formulation and ecological representation) is often more consequential than statistical uncertainty from parameter estimation.

This implies that:

model comparison, sensitivity analysis, and simulation testing may be more informative than uncertainty intervals from any single model.

Evaluation Approach

The review therefore prioritizes robustness across alternative model structures, sensitivity to key assumptions (selectivity, catchability, movement), identifiability of key parameters, and performance under simulated future conditions.

Simulation-based evaluation is treated as particularly important, as it directly addresses management performance rather than retrospective fit alone.

Key Diagnostic Questions for the Review

The following guiding questions frame the evaluation:

1. Does FAA improve management performance relative to the historical assessment?
2. Which parameters and processes are weakly identified?
3. Which assumptions contribute most to uncertainty?
4. How sensitive are results to fleet structure and spatial aggregation?
5. Which spatial processes are captured implicitly versus explicitly?
6. Does simulation evidence support operational adoption?
7. What evidence would be required for fully spatial models to be operationally viable?

The Physical Review Meeting

Throughout the review meeting, I actively participated in all scientific discussions related to the Terms of Reference (ToRs), including presentations on survey design changes, assessment model development, simulation testing, assessment diagnostics, alternative fleet structures, and spatial modeling approaches. Particular attention was devoted to evaluating the suitability of the fleets-as-areas (FAA) model for management use, the consequences of the revised NOAA Longline Survey design, the treatment of age-composition and survey index data, parameter identifiability, and the implications of alternative spatial model configurations. Detailed notes were taken throughout the meeting and form the basis of the findings, conclusions, and recommendations presented in this report. This document represents my independent scientific review of the materials presented and addresses each of the ToRs specified in the PWS.

Overall Conclusions and Suggestions for Improvement

Conduct of the Review

I was highly impressed by the organization, transparency, and professionalism of the review process. The assessment team provided an exceptionally well-structured set of review materials, including detailed assessment reports, supporting technical documents, simulation analyses, model-development reports, presentations, GitHub repositories, and

software documentation. The availability of model code, analytical outputs, sensitivity runs, and supporting materials greatly facilitated independent review and reproducibility. Equally important, the assessment team was extremely responsive both before and during the review. Assistance with installation of the SPoRC assessment framework, access to code and model outputs, clarification of modeling assumptions, and responses to technical questions were provided promptly and professionally. The openness and willingness of the assessment team to engage in scientific discussion represent a model for future assessment reviews.

The review itself was conducted in a highly professional and collegial atmosphere. Presentations were well prepared, discussions were constructive, and the assessment authors demonstrated a commendable willingness to critically evaluate the strengths and weaknesses of their own work. In particular, the extensive model-development process and the willingness to present unsuccessful modeling approaches, stability issues, and alternative hypotheses greatly strengthened the scientific credibility of the review. The meeting provided a thorough examination of both the operational assessment and future spatial modeling approaches, ensuring that the review was not limited solely to the current assessment configuration.

A particularly positive aspect of the review was the breadth of analyses available for evaluation. In addition to the operational assessment models, reviewers were provided with closed-loop simulation studies, alternative FAA configurations, sensitivity analyses, and exploratory spatial models. The assessment team explored more than one hundred alternative FAA model configurations and systematically evaluated issues related to fleet structure, selectivity, stability, survey design, and spatial configuration. This extensive development effort provided a strong scientific basis for evaluating the final assessment recommendations and directly supported the Terms of Reference.

Overall Assessment

From a scientific perspective, I find the transition from the historical single-region assessment toward the fleets-as-areas (FAA) framework to be justified and necessary. The redesign of the NOAA Longline Survey fundamentally changes the information available to the assessment. Under the current survey design, only a portion of the stock distribution is sampled in a given year, requiring reconstruction of a substantial fraction of the Alaska-wide survey index. Consequently, continued reliance on a fully aggregated single-region model requires increasingly strong assumptions regarding spatial extrapolation and data aggregation. The FAA framework represents an important step toward addressing these challenges by fitting survey information at the regional scale and reducing dependence on potentially biased extrapolation procedures.

Principal Findings

The review also highlighted several important strengths of the FAA framework. These include the ability to fit non-extrapolated survey indices, preserve regional recruitment signals, reduce Gulf of Alaska dominance within aggregated composition data, and provide a more coherent treatment of the revised survey design. The FAA model additionally offers a mechanism for partially accommodating ontogenetic movement and regional differences in availability through fleet-specific selectivity and catchability structures.

At the same time, the review identified several important limitations. The most significant unresolved issue remains the persistent conflict between survey indices and composition

data. Despite the application of Francis reweighting, extensive sensitivity analyses, alternative selectivity formulations, and alternative likelihood structures, no modeling approach successfully resolved the tension between these major data sources. This issue appears structural rather than statistical and likely reflects a combination of survey-design changes, regional heterogeneity, availability processes, movement dynamics, and other ecological factors that are not explicitly represented in the assessment model.

A second concern is the degree to which selectivity parameters are required to absorb ecological processes that are not explicitly modeled. Results from the FAA model strongly suggest that selectivity is being used to account for regional availability, ontogenetic movement, and spatial differences in population structure. While this approach is operationally practical, it complicates interpretation of model parameters and contributes to parameter confounding. Similarly, natural mortality remains weakly identifiable and depends substantially on prior assumptions, as evidenced by instability when mortality priors are relaxed.

The review also demonstrates that increased model complexity does not necessarily lead to improved performance. More complex fleet structures, additional regional partitions, and greater selectivity flexibility frequently resulted in instability or poor estimability. This finding reinforces the importance of parsimony and suggests that the current three-region survey-fleet structure (BS, AI, GOA) represents the most appropriate balance between biological realism and statistical stability given the available data.

In my view, the greatest opportunities for future assessment improvement lie not in increasingly complex statistical formulations, but rather in the incorporation of ecological processes that are currently represented only implicitly. These include movement and spatial connectivity, ontogenetic habitat shifts, spatially variable recruitment, availability processes, and the integration of existing tagging data. Explicit representation of these processes may ultimately provide greater gains in model performance and interpretability than further refinements to selectivity structures, composition likelihoods, or weighting approaches.

Despite the concerns described above, I am generally satisfied that the assessment team has applied the best scientific information currently available and has undertaken an exceptionally rigorous and transparent model-development process. The assessment is scientifically credible, the diagnostics are generally acceptable, and the analysis provides a sound basis for management advice. While important structural uncertainties remain, particularly concerning survey design, data conflicts, and ecological representation, these uncertainties are well recognized by the assessment team and have been investigated extensively through simulation testing and sensitivity analyses.

Recommendations for Future Development

Future improvements are unlikely to arise from increasingly complex statistical formulations alone. Greater gains are likely to come from improved representation of ecological processes, including movement and spatial connectivity, ontogenetic habitat shifts, spatially variable recruitment, and availability. Existing tagging and otolith data provide important opportunities to better inform movement, age structure, and regional connectivity and should be more fully incorporated into future model development. Continued collection of otoliths should be maintained at least at current levels, and survey coverage should not be reduced further, as additional reductions would substantially increase assessment uncertainty. Continued development of regional oceanographic models (e.g., extension of MOM-6 to the BS and AI) may also improve understanding of dispersal and recruitment

dynamics.

Final Conclusion

Overall, I conclude that the FAA assessment framework represents the best scientific information currently available for operational management of Alaska sablefish under the present survey design. While the FAA model does not resolve all structural uncertainties and should not be viewed as a fully spatial population model, it provides a scientifically defensible and operationally robust framework that better reflects the spatial structure of the available survey data than the historical single-region assessment. Continued development should focus primarily on improving ecological realism through explicit representation of movement, availability, and regional recruitment processes rather than through further increases in statistical complexity. Subject to the recommendations outlined in this report, I therefore support adoption of the FAA framework for management advice while encouraging continued research to address the remaining structural uncertainties.

ToR 1: Evaluation of the Fleets-as-Areas (FAA) Assessment Framework

ToR 1: Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison with the current single-region (1Reg) assessment. (a) Provide recommendations on the most appropriate parameterization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

Overall Assessment

The review concludes that the Fleets-as-Areas (FAA) framework provides a suitable basis for operational management advice under the current NOAA Longline Survey design. The FAA framework should be viewed as an evolution of the operational assessment rather than a replacement for a fundamentally flawed historical assessment.

Both the historical single-region (1Reg) assessment and the FAA framework assume a single Alaska-wide sablefish population. The principal difference lies in the observation model rather than the biological population model. Whereas the 1Reg assessment aggregates regional observations into a single survey index with common selectivity and catchability, the FAA framework retains regional survey observations throughout estimation by fitting separate regional fleets with region-specific selectivity and catchability parameters.

The principal advantage of the FAA framework is therefore conceptual rather than statistical. It directly utilizes observed regional survey information, avoids reliance on extrapolated survey indices under reduced survey coverage, and preserves regional recruitment signals while maintaining broadly consistent estimates of stock status.

Evidence Supporting the Assessment

The assessment development process provides strong support for the operational FAA model. More than 100 alternative model configurations were explored, including:

- alternative fleet structures;
- time-varying weight-at-age;

- continuous time-varying selectivity;
- Dirichlet-multinomial composition likelihoods; and
- combinations of these approaches.

This extensive model exploration is a major strength of the assessment and demonstrates that the preferred operational model was selected through systematic evaluation of competing hypotheses.

The analyses consistently showed that increasing statistical complexity did not improve overall assessment performance. Time-varying selectivity, although biologically plausible, generally degraded retrospective performance and produced little improvement in model fit. Similarly, Dirichlet-multinomial likelihoods resulted in poorer survey-index fits, increased recruitment variability, inflated biomass estimates, and weaker retrospective behaviour.

These results support continued use of Francis reweighting within the operational assessment.

Remaining Structural Uncertainty

One of the clearest findings is the persistent conflict between NOAA Longline Survey abundance indices and age-composition data.

Although both data sources indicate strong recent recruitment, fitting composition data causes predicted survey indices to exceed observations substantially. Francis reweighting partially reconciles this conflict by reducing the influence of composition data, while alternative statistical formulations failed to resolve the underlying mismatch.

Collectively, the sensitivity analyses indicate that the remaining disagreement among data sources is primarily structural rather than statistical. Increasing model complexity does not resolve these conflicts, suggesting that they reflect limitations in ecological representation rather than deficiencies in the likelihood formulation.

The FAA model should therefore not be interpreted as eliminating all sources of uncertainty. Selectivity, natural mortality and data conflicts remain only weakly identifiable, and continued development of ecological process models, particularly movement and availability, is likely to provide greater benefit than further increases in statistical complexity.

Assessment of Fleet Structure (ToR 1a)

The assessment provides direct empirical evidence regarding the appropriate parameterization of fleet structure.

The principal findings are:

- the historical single-region model remains stable but relies on extrapolated survey information;
- the FAA model using three NOAA Longline Survey fleets (Bering Sea, Aleutian Islands and Gulf of Alaska) remains operationally stable;
- additional regional fishery fleets substantially increase parameter-identifiability problems and model instability.

Accordingly, the review concludes that the current three-region survey-fleet configuration

represents the most appropriate operational parameterization supported by the available data. Additional fleet subdivision is not presently justified and should only be considered if supported by substantially richer regional data.

Interpretation of Regional Selectivity

The FAA model remains a single-stock assessment without explicit movement dynamics. Consequently, regional selectivity and catchability parameters should be interpreted as proxies for regional differences in availability, ontogenetic movement and spatial population structure rather than true gear selectivity alone.

Observed regional differences in apparent selectivity are consistent with ontogenetic movement and changing availability across the stock's range. Explicit representation of movement and availability therefore represents an important opportunity for future model development.

Conclusions and Recommendations

The review supports adoption of the FAA framework as the operational assessment model under the current survey design because it:

- removes dependence on extrapolated survey indices;
- directly fits observed regional survey information;
- retains regional recruitment signals;
- accommodates changing survey coverage while maintaining assessment stability.

The review further recommends that:

1. the FAA framework be adopted as the operational assessment model;
2. the current three-region survey-fleet structure (BS, AI and GOA) be retained;
3. Francis reweighting continue to be used for age-composition data;
4. time-varying selectivity and Dirichlet-multinomial likelihoods not be adopted operationally at present;
5. future research focus on explicit modelling of movement and availability processes and on evaluating alternative fleet structures through simulation testing and Management Strategy Evaluation.

ToR 2: Evaluation of the FAA Model as the Best Scientific Information Available (BSIA)

ToR 2: Highlight the strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to survey indices, age compositions and fishery catch-at-age data, model diagnostics, and major sources of uncertainty. (a) Indicate whether the model provides the Best Scientific Information Available (BSIA) for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

Overall Assessment

The review concludes that the FAA assessment currently represents the Best Scientific Information Available (BSIA) for operational assessment of Alaska sablefish under the revised survey design. Although important structural uncertainties remain, the FAA framework provides a more appropriate representation of the available survey information than the historical single-region assessment and therefore provides an appropriate basis for estimating stock status, projecting future abundance, and determining OFLs and ABCs.

The principal advantages of the FAA framework arise from its direct use of regional survey observations and elimination of survey-index extrapolation, rather than from substantially improved statistical fit.

Strengths

The FAA assessment possesses several important strengths.

- It directly incorporates regional survey information and avoids extrapolated survey indices.
- It retains regional recruitment signals that are partially obscured in the aggregated assessment.
- Both the historical and FAA assessments achieve satisfactory convergence and diagnostic performance, including Hessian and jitter analyses.
- The integrated statistical framework provides flexibility for evaluating alternative biological and statistical hypotheses.
- Extensive model development and closed-loop simulation testing provide confidence that the selected operational model represents the most robust configuration currently supported by the available data.

Collectively, these strengths support the FAA framework as an operational assessment while maintaining continuity with the historical stock assessment.

Weaknesses and Sources of Uncertainty

Despite these strengths, several important sources of uncertainty remain.

The most significant is the persistent conflict between NOAA Longline Survey abundance indices and age-composition data. Although both indicate strong recent recruitment,

simultaneous fitting of both data sources remains difficult, and Francis reweighting continues to be required to balance their influence.

Additional sources of uncertainty include:

- sparse age-composition data in some regions;
- weak identifiability of selectivity and natural mortality;
- sensitivity of biomass scaling to survey design and data weighting;
- the absence of explicit movement dynamics within a single-stock framework.

Sensitivity analyses demonstrated that increasing statistical complexity, including time-varying selectivity and Dirichlet-multinomial likelihoods, did not resolve these issues and generally resulted in poorer retrospective behavior or degraded fits to survey indices. The remaining uncertainty therefore appears to be primarily structural rather than statistical.

Model Assumptions

The FAA assessment retains the principal assumptions of the historical assessment:

- a single Alaska-wide sablefish stock;
- recruitment at age 2 with lognormal variability;
- logistic selectivity functions;
- integrated fitting of survey, fishery and composition data.

Within the FAA framework, regional selectivity and catchability parameters implicitly represent differences in availability, spatial structure and ontogenetic movement. These assumptions provide a practical operational solution but should not be interpreted as explicit ecological process models.

Model Diagnostics

Overall model diagnostics indicate that the operational FAA assessment performs satisfactorily.

The assessment demonstrates:

- satisfactory convergence;
- acceptable retrospective behavior for the preferred model;
- stable parameter estimation under the selected configuration;
- robustness relative to many more complex alternatives that proved operationally unstable.

The development process also showed that greater biological or statistical complexity did not improve overall assessment performance, reinforcing confidence in the selected operational formulation.

Assessment of BSIA (ToR 2a)

The available evidence supports the conclusion that the FAA assessment represents the Best Scientific Information Available for operational management under the current survey design.

Specifically, the FAA framework provides the most appropriate basis for:

- estimating current stock status;
- projecting future stock abundance;
- calculating OFLs and ABCs;
- supporting annual management advice.

This conclusion is based on the framework's improved treatment of regional survey observations, reduced dependence on extrapolated survey indices, extensive model evaluation, and satisfactory diagnostic performance.

However, this recommendation should not be interpreted as indicating that all important uncertainties have been resolved. Remaining structural conflicts among data sources, uncertainty in selectivity and natural mortality, and the absence of explicit movement processes continue to represent important priorities for future assessment development.

Recommendations

The review recommends that:

1. the FAA framework be adopted as the Best Scientific Information Available for operational stock assessment and management advice;
2. Francis reweighting continues to be used until structural conflicts among data sources can be better resolved;
3. future research prioritizes ecological process representation, particularly movement and availability, rather than further increases in statistical complexity;
4. model uncertainty continues to be evaluated through simulation testing and Management Strategy Evaluation.

ToR 3: Recommendations for Improving Spatial Assessment Models

ToR 3: Provide research recommendations for improving the existing research-oriented sablefish spatial (3- and 5-region) assessment models, particularly with respect to their potential future application in operational management.

Overall Assessment

The existing 3- and 5-region spatial assessment models represent valuable research platforms for investigating sablefish spatial dynamics but are not yet sufficiently robust for

routine operational management. The model development presented during this review indicates that current limitations arise primarily from ecological representation and data availability rather than from deficiencies in statistical estimation.

Future research should therefore focus on improving biological realism and reducing structural uncertainty rather than increasing statistical complexity.

Research Priorities

The assessment results suggest that additional flexibility in selectivity functions, alternative composition likelihoods, or increasingly complex weighting schemes are unlikely to resolve the principal sources of model uncertainty. These approaches generally produced only modest improvements in data fit while degrading retrospective performance or increasing parameter uncertainty.

Greater improvements are likely to arise from better representation of the biological processes that generate the observed spatial patterns.

Priority research areas include:

- explicit modelling of ontogenetic movement among regions;
- incorporation of fish availability processes into observation models;
- spatially varying recruitment and recruitment connectivity;
- integration of tagging data to estimate movement rates;
- improved representation of regional population structure.

Improving the Spatial Models

Future development of the 3- and 5-region assessment models should emphasize:

- improving parameter identifiability through parsimonious model structures;
- evaluating alternative movement formulations supported by tagging and survey data;
- strengthening regional age-composition sampling, particularly in the Bering Sea and Aleutian Islands;
- reducing uncertainty associated with changing survey coverage;
- evaluating alternative spatial configurations through simulation testing and Management Strategy Evaluation (MSE).

Particular attention should be given to distinguishing true gear selectivity from regional availability and movement processes, as the present review suggests that selectivity parameters are currently acting as proxies for multiple ecological processes.

Methodological Development

The review suggests that future improvements to the spatial assessment models are more likely to arise from better representation of ecological processes and more parsimonious parameterizations than from increasing statistical complexity alone.

In particular, the FAA model indicates that selectivity parameters are currently absorbing multiple processes, including regional availability, ontogenetic movement and spatial population structure. This parameter confounding contributes to weak identifiability and limits biological interpretability.

Future research should therefore explore parsimonious representations of selectivity, such as penalized spline functions, that reduce the effective number of free parameters while retaining sufficient flexibility to represent regional differences. Such approaches may improve parameter identifiability, reduce overfitting, and facilitate future incorporation of explicit movement and availability processes.

Future work should also investigate alternative prior formulations for natural mortality, including objective Bayesian approaches such as Jeffreys priors. Jeffreys priors are attractive because they are invariant under reparameterization and are often regarded as *objective* priors. However, whether they improve inference when natural mortality is only weakly identified remains an open question.

When the likelihood contains limited information about a parameter, Jeffreys priors may produce diffuse posterior distributions, heavy tails, numerical instability, or unintuitive behavior near parameter boundaries. Consequently, fisheries stock assessments have generally favored informative biological priors derived from life-history relationships rather than purely objective priors.

Accordingly, the review recommends that alternative prior formulations, including Jeffreys priors, be evaluated through simulation studies and Management Strategy Evaluation before consideration for operational implementation. Such studies should compare estimation performance, parameter identifiability, uncertainty quantification, and management performance under alternative prior specifications.

Data Priorities and Process Understanding

A key conclusion from the review is that further improvements to spatial assessment performance are more likely to arise from improved data quality and process understanding than from increased model complexity.

Otolith collection and ageing: The continued collection and ageing of otoliths should be maintained at no less than the current level. Otolith-based data provide essential information for age structure estimation and represent a critical long-term archive for evaluating spatial structure, growth variation, and potential movement processes. Any reduction in otolith sampling effort would further increase uncertainty in already weakly identified parameters and reduce the ability to evaluate spatial hypotheses.

Survey design and footprint stability: The review notes that the effective survey footprint and associated data richness have already been reduced to a level that is materially affecting model uncertainty. Further reductions in spatial or temporal coverage would significantly compromise the ability of both FAA and spatial assessment models to resolve key population dynamics, particularly recruitment variability and regional differences in abundance.

Hydrodynamic and environmental modeling: Extension of existing hydrodynamic and ecosystem models (e.g., MOM-6) to include the Bering Sea and Aleutian Islands, in addition to the Gulf of Alaska, is strongly encouraged. Such developments would provide an important complementary line of evidence for understanding larval dispersal, connectivity, and spatial

population structure, and could help resolve uncertainty currently absorbed by regional selectivity parameters in the assessment models.

Survey data exclusion protocols: The review also notes that exclusion of survey data affected by whale depredation (e.g., skates removal) is currently implemented through operational judgement at-sea. While this practice is generally well understood, it remains partially subjective. The development of a formal, documented protocol for handling depredation-related data exclusions is recommended to ensure transparency, consistency, and reproducibility in survey data processing.

Pathway Toward Operational Use

Before the research-oriented spatial models can be considered for operational management, they should demonstrate:

- stable estimation under routine assessment conditions;
- satisfactory retrospective performance;
- acceptable parameter identifiability;
- improved predictive performance relative to the FAA framework;
- robustness across plausible survey designs and recruitment scenarios.

These attributes should be evaluated through simulation testing and Management Strategy Evaluation before operational implementation.

Recommendations

The review recommends that future research:

1. prioritize explicit modelling of movement and availability rather than further increases in statistical complexity;
2. integrate tagging information into spatial assessment models;
3. improve regional biological sampling, particularly age-composition data;
4. continue development of the 3- and 5-region models as research platforms;
5. evaluate candidate spatial models through Management Strategy Evaluation before considering operational adoption.

Final Synthesis

Together, these recommendations emphasize that future improvements in sablefish spatial assessment are most likely to arise from improved observational data and representation of ecological processes, rather than from increased statistical complexity within the stock assessment models themselves.

Appendices

Appendix 1 – Reports and Presentations

1. Presentations – see list in the agenda (Appendix 3)

Appendix 2 – Documents provided by the CIE

1. Performance Work Statement

Appendix 3 – Information from the panel review meeting

1. Panel membership

Appendix 1

2026 Center for Independent Experts (CIE) Review Document

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May 2026

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This report may be cited as:

Goethel, D.R. and Cheng, M.L.H. 2026. Assessment of the sablefish stock in Alaska: 2026 Center for Independent Experts (CIE) Review Document. North Pacific Fishery Management Council, Anchorage, AK.

The last operational full assessment for sablefish was in 2021 and a full description of the model can be found in the 2021 SAFE document: https://www.fisheries.noaa.gov/resource/data/2021-assessment-sablefish-stock-alaska

The last update assessment was performed in 2024: https://www.npfmc.org/wp-content/PDFdocuments/SAFE/2024/Sablefish.pdf

Changes that were planned (but not used operationally due to the US government shutdown) for the full assessment in 2025 (Model *25.12*) are described in the September NPFMC Plan Team document: https://meetings.npfmc.org/CommentReview/DownloadFile?p=02344a6f-99f3-4239-990ee5dd9393e1a7.pdf&fileName=Sablefish%20proposed%20model%20changes.pdf

The following appendices can be found at the CIE GitHub repository:

Appendix 3A. The Spatial Population over Regional Components (SPoRC) Model: Technical Description of the Assessment Model for Sablefish (here)
Appendix 3B. Model Building and Bridging Exercise for the Sablefish Single Region Models (Bridging from Model *25.12* to *26.1_1Reg*) (here)
Appendix 3C. Development of a Fleets-as-Areas (FAA) Stock Assessment Model for Alaska Sablefish (*Model 26.2_FAA*) (here)
Appendix 3D. Results of Spatial Stock Assessment Models for Alaska Sablefish (here)
Appendix 3E. Evaluating Alternative Assessment Structures for Alaska Sablefish Under Survey Design Changes via Closed-Loop Simulation (here)

Appendix 2

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Fisheries
Center for Independent Experts (CIE) Program External Independent Peer Review

June 16 - 18, 2026

Background

NOAA Fisheries is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA Fisheries science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Sablefish (*Anoplopoma fimbria*) are a long-lived (90+ years), highly mobile, sexually dimorphic demersal species that live at depths greater than 200m (as adults). In Alaska Federal waters, sablefish are assessed and managed as a single population with the total quota apportioned across 6 management regions (Aleutian Islands, Bering Sea, Western Gulf of Alaska, Central Gulf of Alaska, Western Yakutat, and Southeast Outside) and among two fishing sectors (i.e., fixed gear and trawl gear). Since rationalization (i.e., implementation of individual fishing quotas, IFQs) occurred in the 1990s, sablefish have been one of the most valuable finfish resources in Alaska ($124 million in ex-vessel value in 2022). Catch advice for sablefish is based on a statistical catch-at-age integrated stock assessment model fit to fishery-independent survey data and fishery dependent catch-age data. The sablefish assessment is reviewed annually by the North Pacific Fishery Management Council's (NPFMC) Science and Statistical Committee (SSC) as part of the quota specification process, and last underwent a CIE review in 2016.

1 https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

Scope

Since the last CIE review (i.e., in 2016), major changes have occurred in the sablefish resource, fishery, longline survey, and assessment model. Specifically, a series of extreme, above average recruitment events has led to rapid rebuilding of the resource and increasing quotas. Resultant landings of predominantly small, lower value fish have led to market saturation, strong reductions in landed value, and exploration of management options that loosen full retention requirements. Concomitantly, the primary directed fixed gear fleet has undergone rapid gear changes, where a predominantly hook-and-line fishery has transitioned to a longline pot fishery since 2017 (i.e., >85% of sablefish catch in the fixed gear fishery is now taken by pot gear), which has helped to reduce whale depredation.

Additionally, the fishery-independent, cooperative research-based NOAA longline survey, which targets sablefish and serves as the primary index of abundance for the assessment, underwent major survey design changes starting in 2025. Because the survey has traditionally used a cost recovery approach, whereby survey catch is sold by the fishing company that owns the vessel performing the survey, the decline in sablefish markets prevented the survey from being undertaken in 2024 for the first time in its 30+ year history. Historically, the fixed station survey has sampled the entire Gulf of Alaska (GOA) annually, as well as either the Bering Sea (BS, odd years) or Aleutian Islands (AI, even years). Starting in 2025 a new survey design was enacted to reduce overhead and ensure a fishing company would accept the survey contract, wherein the Gulf of Alaska is now surveyed in odd years (starting in 2025), and the BS and AI are surveyed in even years (starting in 2026). Although the new survey design ensures the ability to continue the longline survey, it results in only ~50% of total stock abundance being surveyed in a given year. Moreover, it raises important challenges for the panmictic assessment in terms of how to integrate survey data that only partially samples the population being assessed.

There have also been major changes to the assessment model since the last CIE review. Most importantly, a new R-TMB based package, the SPoRC (Stochastic Population Over Regional Components) assessment model, has been adopted, which replaces the previous Automatic Differentiation Model Builder (ADMB) based assessment model. Additionally, a number of research-oriented assessment models have been developed exploring alternative spatial structures (e.g., spatially-explicit 3 and 5 region models that estimate movement among regions, as well as a spatially-implicit single region fleets-as-areas, FAA, model), all of which demonstrate promise for dealing with spatial complexities and data gaps that are not well resolved in the single region panmictic assessment. In 2026, the assessment team transitioned from the single region panmictic assessment to the FAA model, because the FAA model could better handle the new longline survey design (i.e., fit the data by region as separate fleets) and implicitly account for ontogenetic movement dynamics (i.e., through selectivity and availability assumptions). Thus, for the purpose of the CIE review, feedback on the FAA model is being requested, particularly with regard to appropriate model structure and parametrization. To help make determinations on the BSIA to assess the Alaska sablefish population, reviewers will be provided the results of closed loop simulation analyses and assessment model runs applied to the sablefish data (including 30 model outputs and diagnostics).

The overarching goals of this review process are to:

1. Ensure the FAA stock assessment supports the development of robust advice for use by the North Pacific Fishery Management Council based on the BSIA;
2. Provide an independent external review of this stock assessment to confirm that it meets the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements;
3. Understand and identify appropriate FAA model structure and fits to key data sources (indices, landings, and age compositions);
4. Identify research needed to improve the assessment and advice for fishery managers.

The specified format and contents of the individual peer review report are found in **Annex 1**. The Terms of Reference (ToRs) of the peer review are included in **Annex 2**. The tentative agenda of this in-person panel review meeting is included in **Annex 3**.

Requirements

NOAA Fisheries requires 3 reviewers to conduct an impartial and independent peer review in accordance with this Performance Work Statement (PWS), OMB Guidelines, and the ToRs below. Modifications to this Performance Work Statement (PWS) and ToRs cannot be made during the peer review, and the Contracting Officer's Representative (COR) and the CIE contractor shall approve any modifications prior to the peer review. All ToRs must be addressed in each reviewer's report.

The CIE reviewers should have expertise in statistical sex- and age-structured integrated stock assessment models. In particular, experience developing spatially explicit and spatially implicit (i.e., fleets-as-areas) assessment models is imperative. Moreover, understanding of stock assessment good practices are required. Working knowledge of the RTMB programming language, a basic understanding of closed loop simulation, and a background in survey design and/or the use of fishery-independent survey data in stock assessments would all be beneficial.

The chair for this meeting, who is in addition to the CIE reviewer, will not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract.

Tasks for Reviewers

The CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

Pre-review Background Documents: A minimum of two weeks before the peer review, the NOAA Fisheries Project Contact will send (by electronic mail or make available at an FTP site/GitHub Repository) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NOAA Fisheries Project Contact will consult with the CIE on where to send documents. The CIE reviewers are responsible only for

31 the pre-review documents that are delivered to the reviewer in accordance with the PWS scheduled deadlines specified herein.

The document list is separated into 'summary/background' and 'for review' documents. The CIE reviewers are *encouraged to peruse* the 'summary/background' documents for information on data inputs, previous assessment structures and associated reviews, and ongoing research. However, the CIE reviewers *must review* all of the 'for review' documents in preparation for the peer review, as these contain the results of the primary analyses and model runs that will be discussed during the review panel.

Available documents (available from the public sablefish CIE GitHub repository, as they become available) include:

For Review (available here)

1. A summary document describing the fleets-as-areas assessment model, including the full model description and results, with comparison to outputs from the single region panmictic assessment as well as summary results for all sensitivity model runs;
2. A document summarizing the results of the spatially explicit closed loop simulation analysis;
3. The 2025 Alaskan sablefish stock assessment proposed model changes report (Goethel and Cheng, 2025) produced for the September 2025 Joint Plan Team meeting, presentation, and GitHub repository, which describes recent changes to the current single region panmictic assessment including transition to RTMB and the SPoRC assessment package;
4. The spatial sablefish model publication and model updates report (Cheng et al., 2025a) for the September 2025 Joint Plan Team meeting;
5. Additional supporting documents and presentations as they become available.

Summary/Background (Available here)

1. The 2024 Alaskan sablefish Stock Assessment and Fishery Evaluation (SAFE) report (Goethel and Cheng, 2024) and presentation;
2. The 2024 December SSC (p. 14-16) and November Joint Plan Team (p. 2-3) reports;
3. The 2025 AFSC Longline Survey Cruise Report (Siwicke et al., 2026) and presentation;
4. The 2025 October SSC (pp. 21-23) and September Joint Plan Team (p. 5-6) reports;
5. The SPoRC assessment platform publication (Cheng et al., 2026) and GitHub documentation;
6. Research papers on integrating density-dependent growth (Cheng et al., 2025b) and a pot gear fleet (Cheng et al., 2024a) into the sablefish assessment, simulation studies on selectivity (Cheng et al., 2024b) and sex-specific parametrization (Cheng et al., 2025c) for the sablefish assessment, and considerations for fitting sex-specific composition data (Cheng et al., 2025d) in stock assessments; 32 7. CIE reviewer reports from the 2016 Alaskan sablefish CIE review.

Please note that outputs of all analyses used as part of the CIE review, including input data, simulation outputs, final proposed assessment models, and all sensitivity assessment models, will be made available on the sablefish CIE GitHub repository

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the PWS and ToRs and shall not serve in any other role unless specified herein. The CIE reviewers shall actively participate in a professional and respectful manner as members of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NOAA Fisheries Project Contact is responsible for any meeting arrangements (e.g., conference room reservations, video conferencing logistics, etc.).

Contract Deliverables - Independent CIE Peer Review Report: Each CIE reviewer shall complete an independent peer review report in accordance with this PWS. Reviewers are not required to reach a consensus, and a summary report *will not* be produced. Each CIE reviewer shall complete their independent peer review according to the required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**. The tentative agenda of the panel review meeting is in **Annex 3**. Each CIE reviewer will deliver their reports according to the specified milestone dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NOAA Fisheries Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the Project Contact for the purpose of their security clearance, and this information shall be submitted at least two weeks in advance. For additional information, please see the following link: https://www.commerce.gov/osy/programs/foreign-access-management. All CIE reviewers must have a REAL ID-compliant form of identification to access Federally owned or leased facilities. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be Juneau, AK.

Period of Performance

The period of performance shall be from the time of award through July 2026. The CIE reviewers' duties shall not exceed **14** days to complete all required tasks.

Schedule of Milestones and Deliverables

The contractor shall complete the tasks and deliverables in accordance with the following schedule:

Schedule	Milestones and Deliverables
Within two weeks of award	Contractor secures participation of the CIE reviewers.

At least two weeks prior to the panel review meeting	Pre-review documents are provided to the reviewers.
June 16 - 18, 2026	The reviewers participate and conduct an independent peer review during the panel review meeting.
Approximately 2 weeks later	Contractor receives draft reports.
Within 3 weeks of receiving draft reports	Contractor submits final reports to the US Government.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content in **Annex 1**; (2) The reports shall address each ToR as specified **Annex 2**; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (Travel resources | GSA), and all contractor travel must be approved by the COR prior to the actual travel. Any travel conducted prior to the receipt of proper written authorization from the COR will be done at the Contractor's own risk and expense. International travel is authorized for this contract. Travel is not to exceed $13,000.00.

Confidentiality and Data Privacy

This contract may require that services contractors have access to Privacy Information. Services contractors are responsible for maintaining the confidentiality of all subjects and materials and may be required to sign and adhere to a Non-disclosure Agreement (NDA).

NOAA Fisheries Project Contact:

Chris Lunsford
MESA Program Manager
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AK 99801
Chris.Lunsford@noaa.gov

Annex 1: Peer Review Report Requirements

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations as specified in the ToR and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of the following sections: Background; Description of the Individual Reviewer's Role in the Review Activities; Summary of Findings for each ToR in which the weaknesses and strengths are described; and Conclusions and Recommendations in accordance with the ToRs.

    a. Each reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings as well as the science, conclusions, and recommendations.

    b. Each reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

    c. Each reviewer should elaborate on any points that they feel might require further clarification.

    d. Each independent CIE report shall be a stand-alone document through which others can understand the weaknesses and strengths of the science reviewed and shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

    Appendix 1: Bibliography of materials provided for review.
    Appendix 2: A copy of the CIE Performance Work Statement.
    Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference (ToRs) for the Peer Review

Review of the Alaska-wide Sablefish Assessment

CIE reviewers are contracted to complete their independent peer review based on the ToRs. Therefore, the CIE-NOAA Fisheries review and approval process is based on whether the CIE independent reports addressed each of the ToRs.

1) Review the disseminated documents and analyses, then provide feedback on whether the fleets-as-areas (FAA) assessment provides a suitable basis for operational management advice, particularly in comparison to the current single region panmictic assessment.
   a) Provide recommendations on the most appropriate parametrization of fleet structure (number of fleets per fishery/survey, as a proxy for regions) in the FAA model.

2) Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.
   a) Indicate whether the model provides the best scientific information available for estimating current stock status, projecting future abundance, and determining Overfishing Levels (OFLs) and Acceptable Biological Catches (ABCs).

3) Provide research recommendations for improving the existing research-oriented sablefish spatial (i.e., 3 and 5 region) assessment models, especially in the context of potential future usage in a management context.

Reviewers must provide details for the basis of their responses to the review ToRs.

Annex 3: *Tentative* Agenda for the CIE Review of the Alaska-wide Sablefish Assessment

North Pacific Fishery Management Council
NOAA Alaska Fisheries Science Center, Auke Bay Laboratories
17109 Pt. Lena Loop Road Juneau,
AK 99801
June 16-18, 2026

Contact: Chris Lunsford (Chris.Lunsford@noaa.gov)

Schedule

(this agenda is *DRAFT* and subject to change)

All times below are Alaska Daylight Time
Daily breaks at ~10:30 and ~15:30, Lunch 12:30-14:00
Tuesday-Thursday, 09:00 – 17:00 AKDT

Tuesday, June 16, 2026 A. Welcome and Introductions

09:00 — 09:15: Welcoming Remarks, Introductions, Logistics — Chris Lunsford
09:15 — 09:30: Announcements, Agenda/ToRs — Chair

B. Sablefish Management, Biology, Fishery, and Data Inputs (ToR 1)

09:30 — 09:50: Biology, Spatial Dynamics — Daniel Goethel
09:50 — 10:10: Sablefish Management/NPFMC FMP Requirements — Sara Cleaver
10:10 — 10:30: Fishery-Dependent Data — Matt Cheng

10:30 — 10:50: *BREAK*

10:50 — 11:15: Longline Survey Data and Recent Design Changes — Kevin Siwicke
11:30 — 12:00: Assessment History, Inputs, and Other Available Data — Daniel Goethel
12:00 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Assessment Model Configuration (ToR 1)

14:00 — 14:30: Current Model Development Pathway — Daniel Goethel

14:30 — 15:30: General Sablefish Assessment Parametrization Daniel Goethel

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion

Wednesday, June 17, 2026 A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs Chair
09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

B. Spatially Implicit (Fleets-as-Areas) Model Configuration (ToRs 1)

10:50 — 12:00: Results of Spatial Simulations to Optimize FAA Structure Matt Cheng
12:00 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Comparing Assessment Performance and Diagnostics (ToR 1/2)

14:00 — 14:20: Final Fleets-as-Areas Assessment Configuration Daniel Goethel
14:20 — 15:30: Outputs/Diagnostics for FAA and Panmictic Models Daniel Goethel

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion

Thursday, June 18, 2026 A. Reconvene

09:00 — 09:15: Announcements, Agenda/ToRs Chair

B. Comparing Assessment Performance and Diagnostics (ToR 1/2)

09:15 — 10:30: Discussion

10:30 — 10:50: *BREAK*

10:50 — 11:30: Results of a Spatial Closed Loop Simulation Analysis Matt Cheng
11:30 — 12:30: Discussion

12:30 — 14:00: *LUNCH BREAK*

C. Spatial Models (ToR 3)

14:00 — 15:00: 3 and 5 Region Spatial Model Configuration/Outputs Matt Cheng

15:00 — 15:30: Discussion

15:30 — 15:50: *BREAK*

15:50 — 17:00: Discussion and Report Writing

ADJOURN

Appendix 3

Review Panel

The review panel consisted of the following 4 members:

Dr. Aaron Berger (NOAA/NMFS NWFSC)(Chair)
Dr. Sam (Samuel) Subbey (NORWAY: independent CIE contractor)
Dr. Klass Hartmann (AUSTRALIA: independent CIE contractor)
Dr. Peter Stephenson (AUSTRALIA: independent CIE contractor)

Other Participants

Chris Lunsford (NOAA/NMFS AFSC) – Stock Assessment Program Manager, Juneau
Daniel Goethel (NOAA/NMFS AFSC) – Sablefish author
Matt Cheng (NOAA/NMFS AFSC; University of Alaska) – Sablefish Author
Kristen Omori (NOAA/NMFS AFSC)
Pete Hulson (NOAA/NMFS AFSC)
Kevin Siwicke (NOAA/NMFS AFSC)
Sara Cleaver (NPFMC)
Pat Malecha (NOAA/NMFS AFSC)
Melissa Haltuch (NOAA/NMFS AFSC) Grant Adams (NOAA/NMFS AFSC)
Jim Ianelli (NOAA/NMFS AFSC)
Cindy Tribuzio (NOAA/NMFS AFSC)
Samara Nehemiah (ASMFC)
Beth Matta (NOAA/NMFS AFSC)
John Brogan (NOAA/NMFS AFSC)

Presentation List

- Introduction and Logistics – Aaron/Chris
- Background, Biology (including movement), Key Uncertainties – Dan
- Fishing History and Data Collection – Chris
- Sablefish Management Considerations – Sara
- Longline Survey Data Collection and RPN Construction – Pat
- Data Available for the Assessment (including TS and CPUE) – Dan
- General Assessment Structure (including SPoRC background) – Dan/Matt
- Results of the Closed Loop Simulation Analysis – Matt
- Final Model Parametrizations and Results (Bulk of ToR 1/2) – Dan
- Spatial Model Parametrization and Results (ToR 3) – Matt

Appendix 3K: Results of the Spatially Explicit Stock Assessment Models for Alaska Sablefish with Data Through 2026

Matthew LH. Cheng, Daniel R. Goethel

Introduction

Alaska sablefish (*Anoplopoma fimbria*) are currently managed as a single panmictic stock across the Gulf of Alaska (GOA), Bering Sea (BS), and Aleutian Islands (AI), informed by an age-and sex-structured statistical catch-at-age model. While the operational assessment assumes that the stock is spatially homogenous, research over the past several decades suggest that spatial structure likely exists to some degree. For instance, individuals have been shown to demonstrate age-specific (ontogenetic) movement patterns, wherein younger individuals reside in the BS and AI, and move towards the GOA as they mature (Cheng et al., 2025; Heifetz and Fujioka, 1991). In recent years, large recruitment events of age-2 individuals have also generally occurred in western regions (BS and AI). In general, these events reflect greater overall recruitment to the population, rather than a redistribution of recruits among regions, especially considering the BS historically serving as a stronghold for recruits. Moreover, fishery effort is primarily concentrated in the GOA regions, likely resulting in differential harvest impacts across space. Taken together, these patterns suggest that spatial heterogeneity in recruitment, movement, and harvest dynamics likely play a role in shaping Alaska sablefish population dynamics.

In the following, we present a spatially-explicit stock assessment model for Alaska sablefish, which attempts to explicitly model spatial heterogeneity in population dynamics. Spatially-explicit stock assessment models generally resemble single-region stock assessment models, but data are typically disaggregated across spatial regions, and movement dynamics are often incorporated into population processes. However, it is important to note that spatial models often involve an increase in the number of parameters estimated, coupled with a decrease in the amount of data informing parameter estimates through regional partitioning of data. Thus, spatial stock assessment models are often subject to greater tensions between model complexity and data availability, raising the practical question of whether the gains in structural realism directly translate to improved management performance relative to simpler non-spatial models. Nonetheless, several benefits can be envisioned from the implementation of a spatial model. Firstly, spatial models can provide a more mechanistic understanding of regional population dynamics and allow monitoring of localized depletion, which is not feasible under a non-spatial stock assessment model. Second, spatial models can serve as conditioning frameworks for operating models used in management strategy evaluations (MSEs). Lastly, spatial models potentially provide a means to address spatial changes in survey design, allowing the accommodation of missing data, and circumventing the need to interpolate missing data, as would be the case in a single-region model.

All model files for running the spatial assessment as well as model outputs and diagnostics can be found on the 2026 sablefish SAFE GitHub repo (here).

- Model *26.3_Spat_5Reg*: here
- Model *26.4_Spat_3Reg*: here

Methods

General Model Structure

Spatial stock assessment models were developed using the SPoRC (Stochastic Population over Regional Components) modelling framework (Cheng et al., 2026). SPoRC is a generalized statistical catch-at-age model written in RTMB (Kristensen et al., 2016) with the ability to support multi-region, multi-fleet, multi-sex configurations, while also integrating tagging data. Two configurations of spatial models were developed: a three-region model and a five-region model. The three-region model partitions the population across the BS, AI, and GOA, while the five-region model further disaggregates the GOA into the western GOA (WGOA), the central GOA (CGOA), and the eastern GOA (EGOA). Both configurations share the same population dynamics and model specifications, differing only in their spatial resolution and the number of estimated parameters. The spatial assessment models were generally based on the dynamics of the non-spatial models, the conceptual model shown in Figure 3D.1, and the parameterization of pervious work (Cheng et al., 2025). Specifically, spatial models represented 30 ages (2 – 31+), sex-specific dynamics (females and males), 67 years (1960 – 2026), two fishery fleets (longline and trawl), and two survey fleets (domestic and Japanese longline surveys). Within each annual time step, the population was subject to the following processes in sequence: recruitment of age-2 individuals, movement among regions, followed by mortality from fishing and natural mortality. Further details on model dynamics, observation equations, and likelihoods are described in https://chengmatt.github.io/SPoRC/articles/c_model_equations.html.

Recruitment

Recruitment of age-2 individuals in both spatial models were assumed to follow a mean recruitment relationship, where global mean recruitment is apportioned across spatial regions. Lognormal recruitment deviations were specified to vary across space and time, with the standard deviation of recruitment deviations fixed at 1.2 across all regions, following the convention of the non-spatial models. Similar to many spatial models, we assume that recruits are unable to move, in order to mitigate potential confounding with movement and recruitment dynamics.

Natural Mortality

Natural mortality is sex-specific and assumed to be constant across sexes and ages, consistent with the non-spatial models presented. Both values are fixed according to those estimated in the fleets as areas model (*26.2b_FAA_3Flt_LLS_Only*).

Growth and Maturity

Weight-at-age and maturity-at-age are treated as fixed quantities and are assumed to be constant across space, where values are taken from the non-spatial models. Weight-at-age is assumed to be sex-specific and follows a von Bertalanffy growth function (females asymptote at a larger size than males), while maturity-at-age is only modelled for females and is represented as a logistic function.

Movement

Movement among regions was modelled as a discrete time Markovian process, assuming constant rates across time, but age-specific movement. Age-specific movement was represented as three age-blocks representing young individuals (ages 2 – 7), intermediate aged individuals (8 – 15),

and old individuals (16 – 31) to capture ontogenetic shifts in spatial distribution (i.e., movement from western to eastern regions as individuals matured).

Selectivity and Catchability

Across all fishery and survey fleets, selectivity was parameterized as sex-specific logistic functions. The longline fishery fleet estimated time-varying selectivity as two time-blocks to capture a change in fleet structure (i.e., shifting from hook-and-line gear to pot gear), while the trawl fishery fleet estimated time-invariant selectivity. Both survey fleets similarly estimated time-invariant selectivity. Selectivity was assumed to be constant across regions. Catchability for both survey fleets were freely estimated and assumed to remain constant across space and time.

Tag Reporting

Tag reporting rates were also estimated to characterize tag recapture rates. Tag reporting was assumed to be constant across regions, but was allowed to vary across time as time blocks. In particular, three time-blocks were estimated, coinciding with large changes in fishery dynamics (inception of an individual fishing quota fishery and a change in fixed-gear fleet structure).

Observation Models and Likelihoods

Catch

Region-specific expected removals (weight) by the longline and trawl fishery are predicted using Baranov's catch equation, and are fit to assuming a lognormal likelihood with negligible error (standard deviation of catch is assumed to be fixed at 0.05).

Survey Indices

Region-specific survey indices (numbers) are fit to for both the domestic and Japanese longline survey fleets assuming a lognormal likelihood and design-based estimates of uncertainty. Unlike the single-region models, regional indices are fit directly without the need for interpolation or carryover values, and is able to adequately accommodate missing data.

Compositions

Both age and length-compositions are fit to assuming a Multinomial likelihood, where input sample sizes are generally based on *a priori* knowledge of sampling practices (i.e., regions and fleets with higher sampling coverage have larger sample sizes). Sex-specific compositions are available for all fishery and survey fleets and are fit to jointly (i.e., considering sex-specific compositions as a single vector; Cheng et al., 2025). Unlike the single-region counterparts, no data-weighting is performed to further adjust sample sizes, given complexities with respect to data-weighting in spatial models. Data-weighting assumptions for composition data will be explored in further iterations of the model.

Tagging Data

Since the inception of the longline survey, approximately 400,000 individuals have been tagged, with about 35,000 individuals recaptured. Thus, tagging data are expected to be highly informative of movement dynamics. Expected tag recaptures are predicted using a Brownie tag attrition submodel, and are fit using a multinomial release-conditioned likelihood, where the probability of recapture in each region is derived from the model's predicted movement and survival processes.

Moreover, the maximum tag liberty was restricted to 15 years (i.e., tags were not tracked or fit to beyond 15 years at liberty) to reduce computation time. To prevent tagging data from having due influence on overall model estimation, multinomial weights are scaled by a factor of 0.25. Similar to composition data, data-weighting assumptions for tagging data will continue to be explored in the future.

Model Estimation and Diagnostics

All parameters were estimated using penalized maximum likelihood using RTMB, where the objective function was the sum of negative log-likelihoods for catch data, survey indices, compositions, tagging, penalties (i.e., recruitment), and priors placed on parameters. The three-region model estimates a total of 732 parameters, while the five-region model estimates a total of 1223 parameters. For both models, the largest share of parameters primarily results from fishing mortality deviations (~50%), followed by recruitment deviations (~27%), initial age deviations (~12%), and movement parameters (~5%).

Several diagnostic tools were used to assess model adequacy, stability, and performance. In particular, all models were inspected to ensure that maximum gradient components for all parameters were < 1e-4, as well as a positive definite Hessian matrix. Model fits to catch data, survey indices, both age- and length-compositions, and tagging data were also evaluated (full diagnostics can be found on the GitHub repo). Lastly, retrospective analyses (7-year peels) were conducted to understand model stability under sequential data removal and to evaluate retrospective consistency in recruitment and spawning stock biomass (*SSB*).

Results

Both spatial models converged with maximum gradient components for all parameters < 1e-4, along with an invertible Hessian matrix. In general, most data sources were adequately fit and did not demonstrate systematic misfits. For instance, both spatial models provided good fits to regional catch data (Fig. 3D.2 and 3D.3). Likewise, abundance indices from both survey fleets were generally fit well, although indices in the most recent years for the GOA regions appeared to be overpredicted (Fig. 3D.4 and 3D.5), potentially reflecting the need to model time-varying movement dynamics. With respect to composition data, both models appeared to capture general patterns, wherein western regions often had higher proportions of younger fish, and eastern regions demonstrated higher proportions of older fish. While fits to composition data were generally adequate, there were some complex patterns that neither spatial model was able to reconcile. In particular, exceptionally large plus groups as observed by the longline fishery in the AI region were underpredicted in some years (see the GitHub repo for composition data fits). Relative to other data sources, tagging data were moderately well fit, although recaptures in recent periods appeared more difficult to reconcile (Fig. 3D.6 and 3D.7). Similar to the fits described for survey abundance indices, this may either reflect the need to explicitly represent time-varying movement dynamics, and/or changes in tag reporting dynamics.

Retrospective analyses for both three-region and five-region models generally demonstrated similar patterns, where all regions exhibited positive retrospective patterns in *SSB* that coincided with overestimated recruitment values (relative to the terminal year) from several years prior (Fig. 3D.8 and 3D.9). Interestingly, recruitment estimates in the AI from the three-region model

demonstrated some instability in certain retrospective peels (i.e., recruits in the Al are estimated at values close to 0), likely reflecting confounding (and revision of estimates) between movement and recruitment as age data were sequentially removed from the analysis (Fig. 3D.8). Thus, results from retrospective analyses highlight that spatially-explicit stock assessment models for Alaska sablefish will likely require careful annual tuning and evaluation of model structure, parameterization, and data weighting to ensure stable and biologically realistic dynamics through time.

Model estimates of recruitment and *SSB* were largely concordant between spatial models (Fig. 3D.10). Both the pattern and scale of both recruitment and *SSB* were similar, with large recruitment events primarily occurring in western regions (BS and AI) and sustained recruitment events in the eastern regions (WGOA, CGOA, and EGOA) (Fig. 3D.10 and 3D.11). Moreover, regions exhibiting high recruitment did not necessarily coincide with regions of high SSB, presumably due to the estimated ontogenetic movement dynamics (i.e., younger individuals primarily residing in western regions and moving eastward as they mature), as well as potential unmodelled larval dispersal processes (Cheng et al., 2025) (Fig. 3D.10 and 3D.11).

Overall, results from the spatial model highlight that spatial heterogeneity in population dynamics likely exists, driven in part by movement dynamics, differential spatial harvest, and underlying oceanographic processes. Despite the presence of such heterogeneity, aggregated time-series estimates from spatial models generally align with simpler alternatives in the case of Alaska sablefish (e.g., the single-region model; Cheng et al., 2025), suggesting that non-spatial models can provide similar advice for management purposes in the interim.

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Kristensen, K., Nielsen, A., Berg, C.W., Skaug, H., Bell, B., 2016. TMB: Automatic Differentiation and Laplace Approximation. J. Stat. Soft. 70. https://doi.org/10.18637/jss.v070.i05

Figures

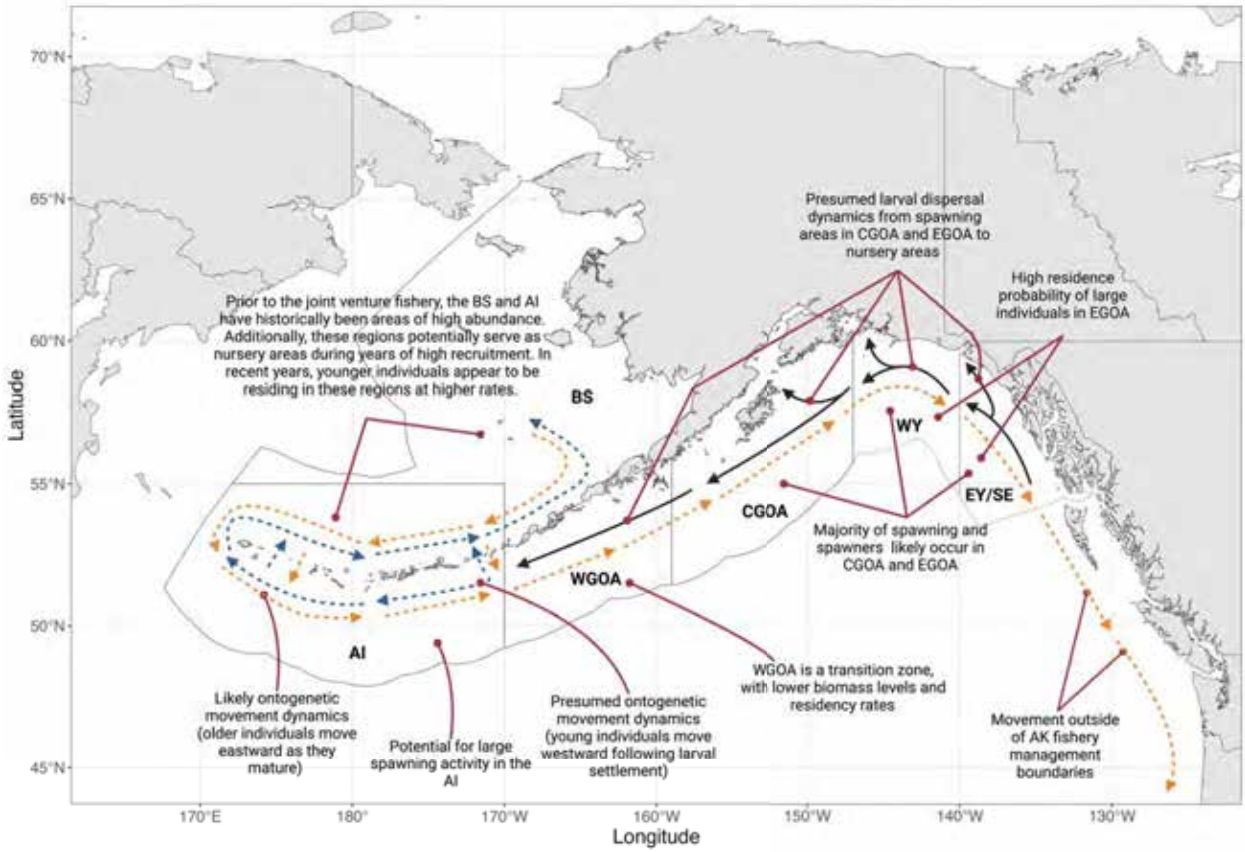

Figure 3D.1. Conceptual model of spatial sablefish dynamics. Black solid arrows represent hypotheses on larval dispersal, blue dashed arrows are hypotheses regarding the movement dynamics of younger individuals, and orange dashed arrows are hypotheses on general movement dynamics of individuals as they mature.

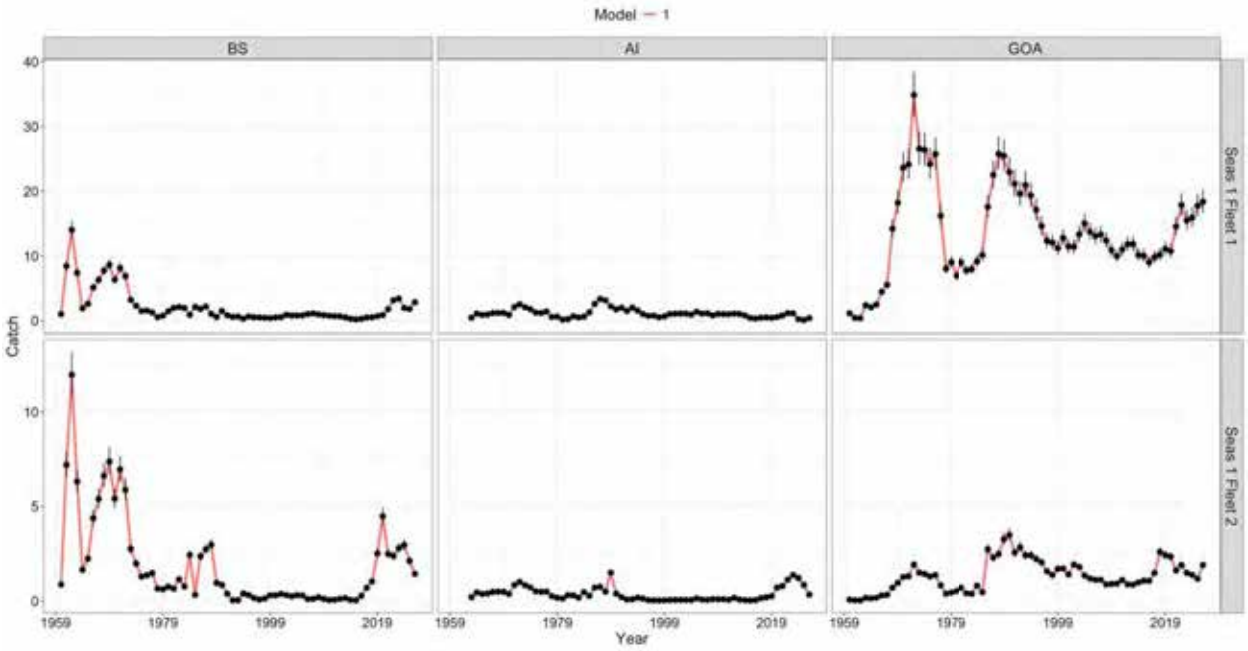

Figure 3D.2. Fits to regional catch data (kt) by fishery fleet for the three-region model. Fleet 1 represents the longline fishery while fleet 2 represents the trawl fishery. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

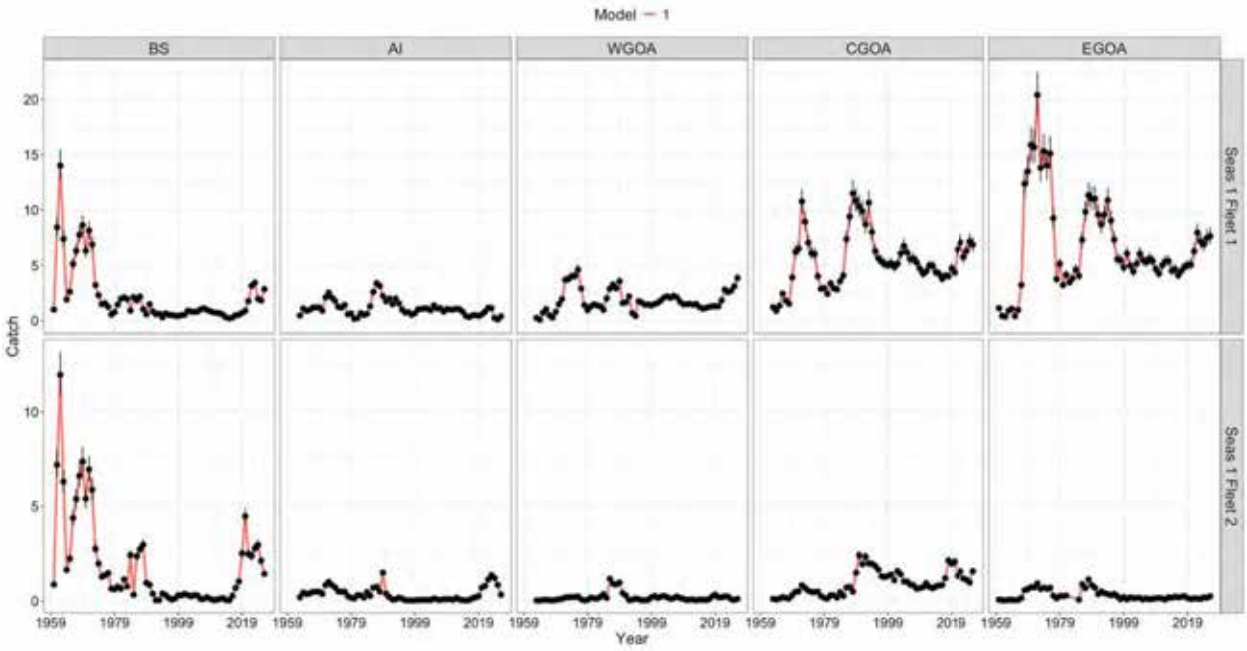

Figure 3D.3. Fits to regional catch data (kt) by fishery fleet for the five-region model. Fleet 1 represents the longline fishery while fleet 2 represents the trawl fishery. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

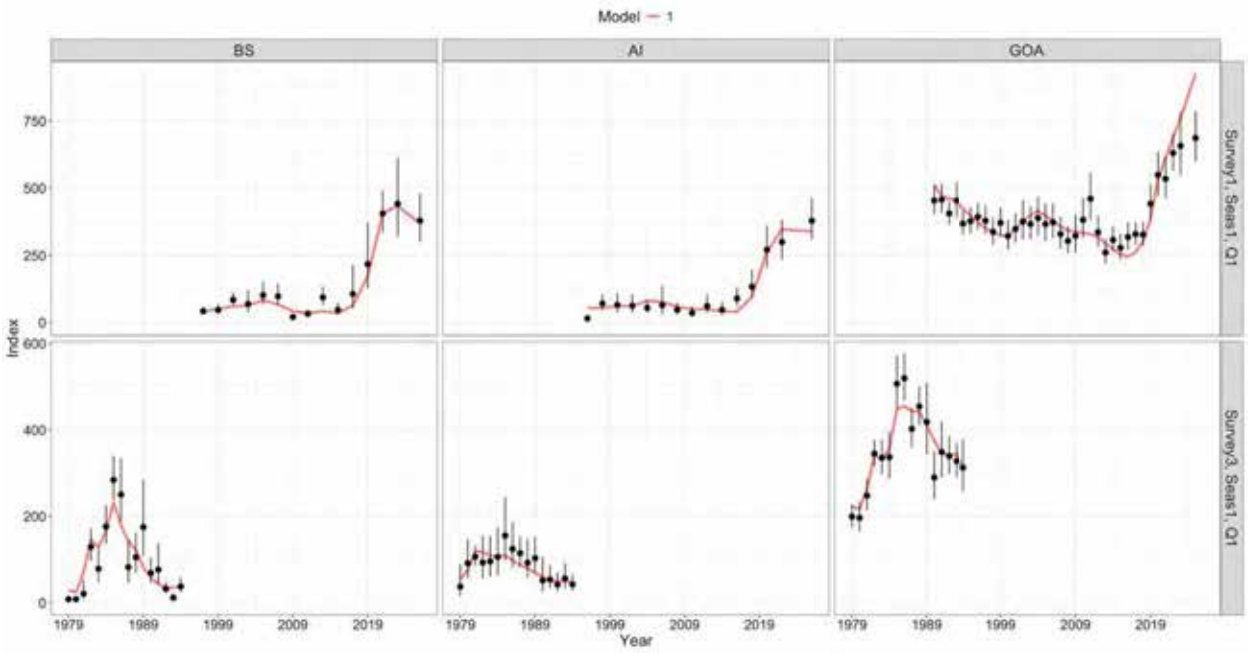

Figure 3D.4. Fits to regional survey indices (numbers) by survey fleet for the three-region model. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

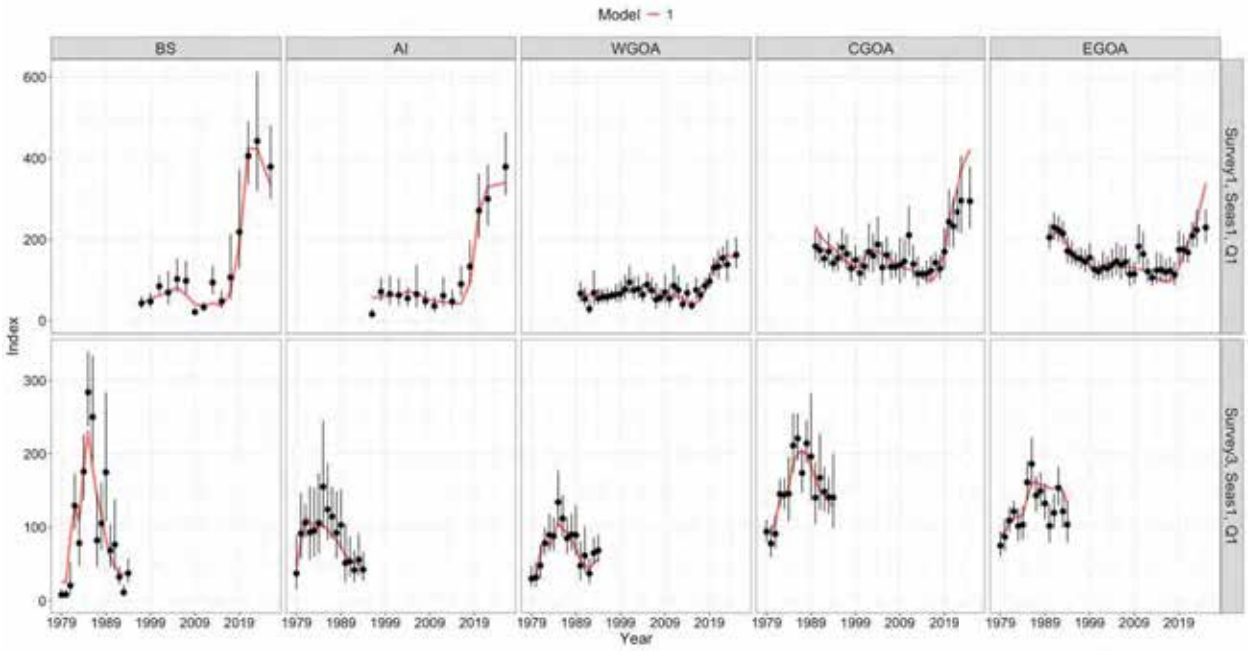

Figure 3D.5. Fits to regional survey indices (numbers) by survey fleet for the three-region model. The redline denotes the model expectation and point ranges represents observed data and their associated 95% confidence intervals.

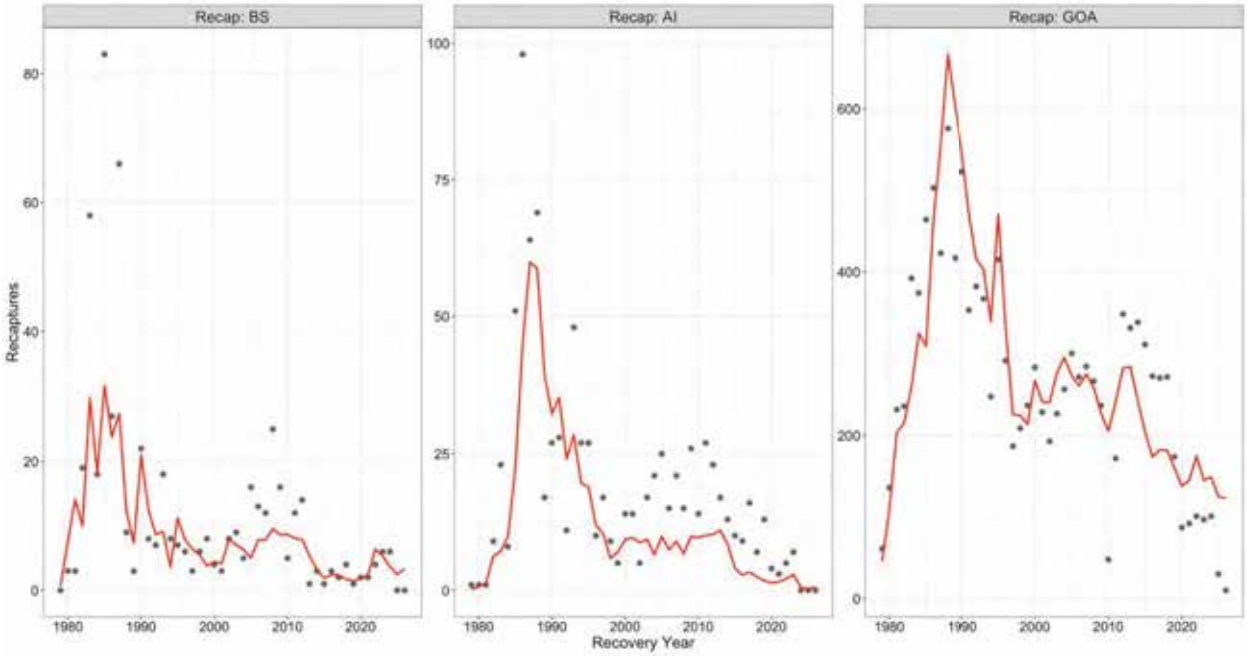

Figure 3D.6. Fits to tag recaptures across regions for the three-region model. Colored lines represent the model expectation while grey points denote observed recaptures.

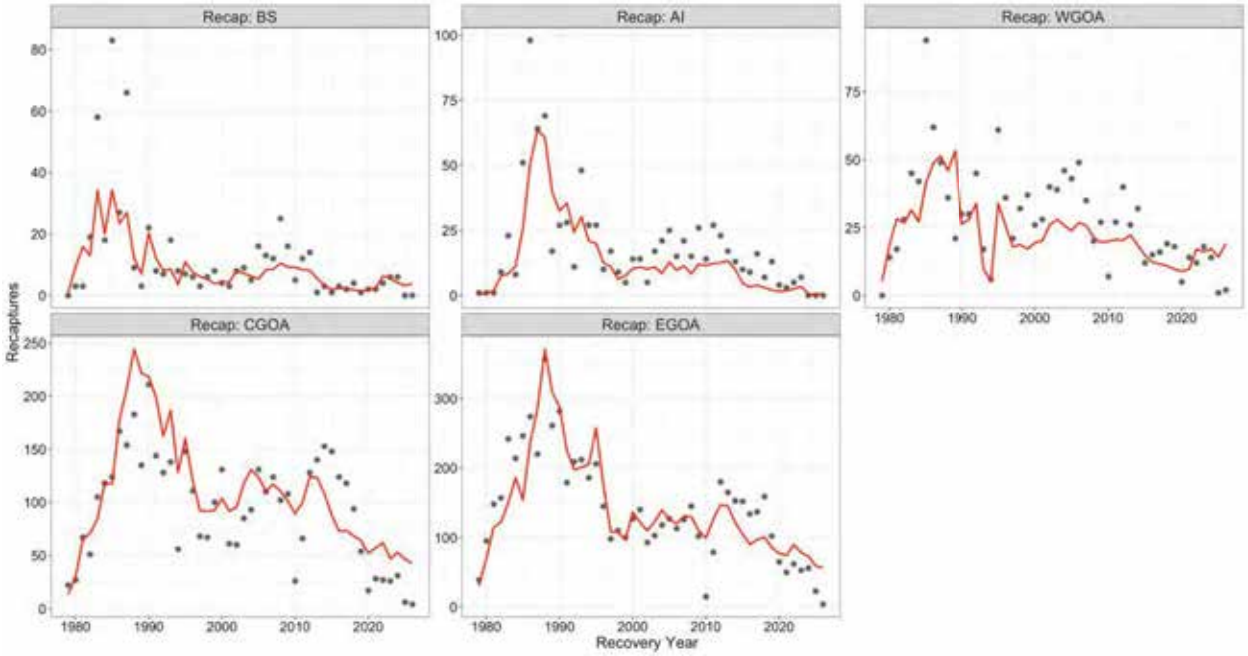

Figure 3D.7. Fits to tag recaptures across regions for the five-region model. Colored lines represent the model expectation while grey points denote observed recaptures.

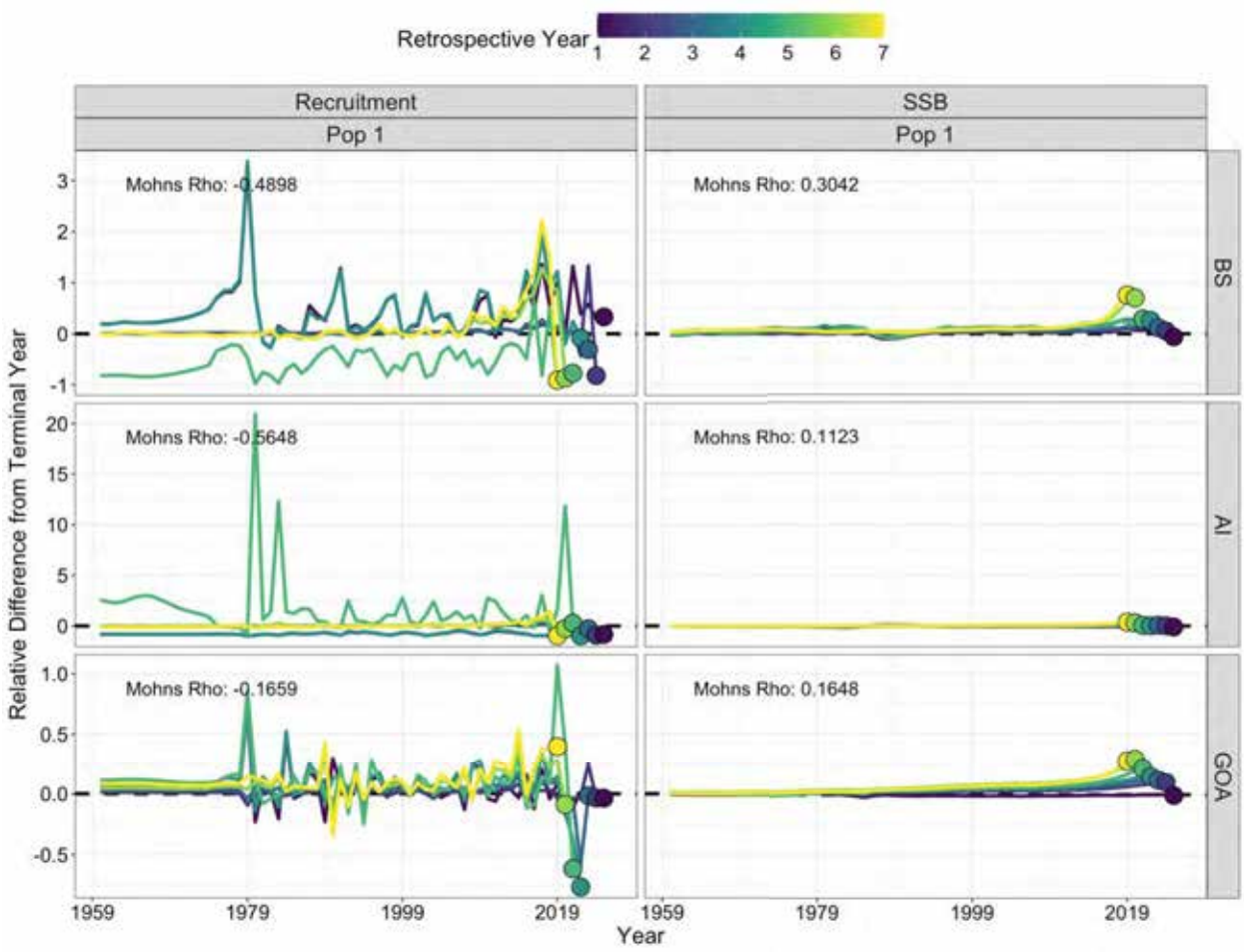

Figure 3D.8. Retrospective analysis from the three-region model. Column panels represent time series of recruitment and spawning stock biomass (*SSB*) as data are sequentially removed. Row panels denote the modeled regions. Mohn's rho values are shown in the upper left of each panel.

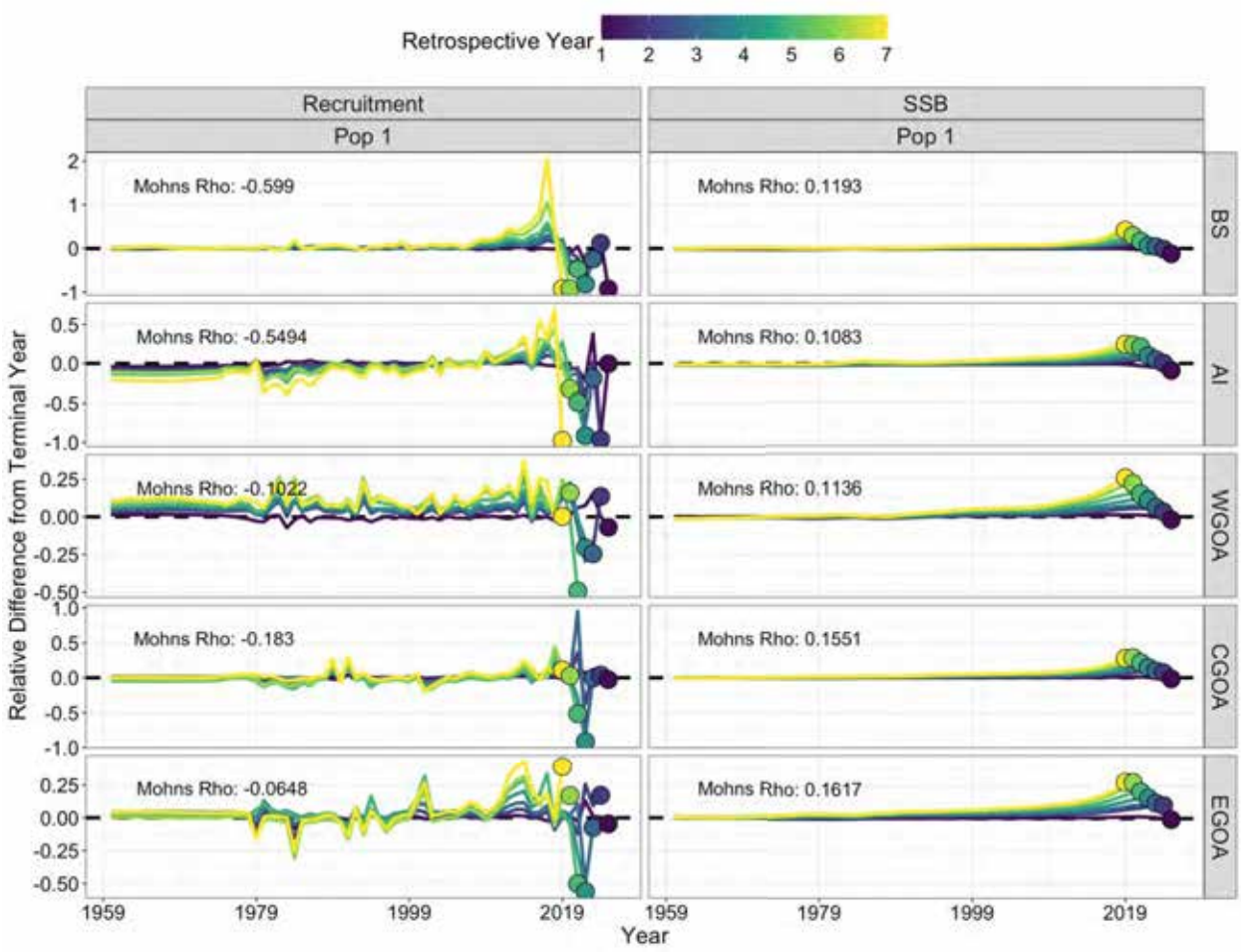

Figure 3D.9. Retrospective analysis from the five-region model. Column panels represent time series of recruitment and spawning stock biomass (*SSB*) as data are sequentially removed. Row panels denote the modeled regions. Mohn's rho values are shown in the upper left of each panel.

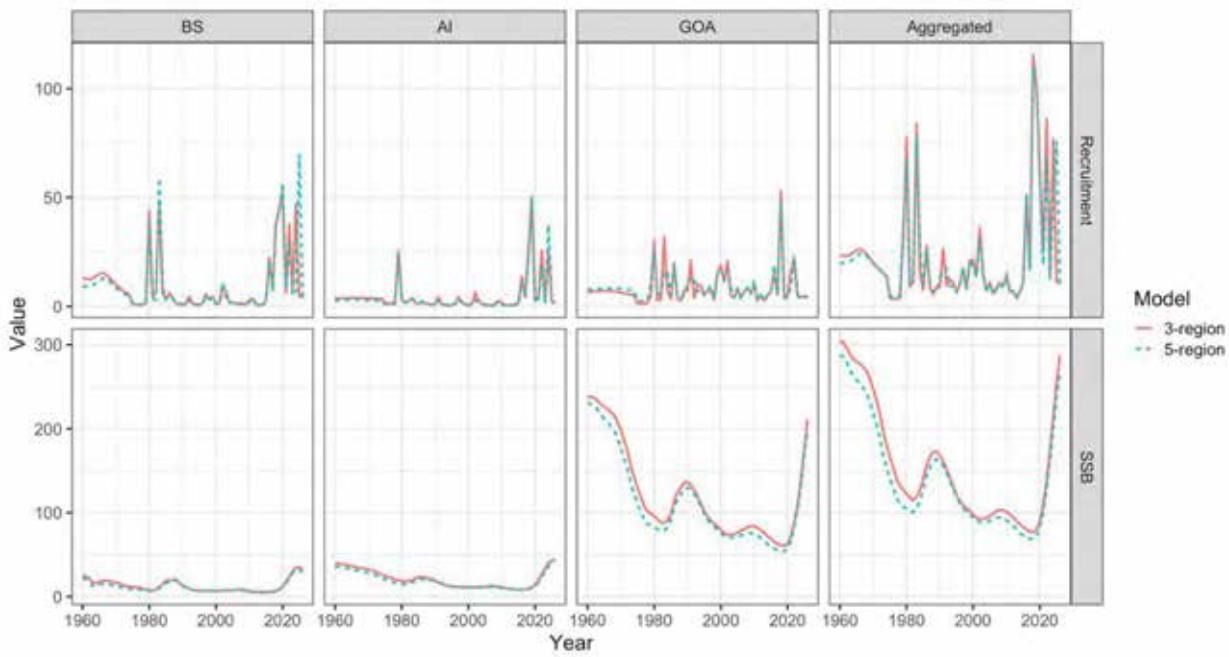

Figure 3D.10. Comparison of time-series of recruitment (age-2; millions of individuals) and spawning stock biomass (*SSB*; kt) between the three-region and five-region spatial models. Time-series estimates for the Gulf of Alaska from the five-region model are summed up across the western, central, and eastern Gulf of Alaska for comparison with the three-region model.

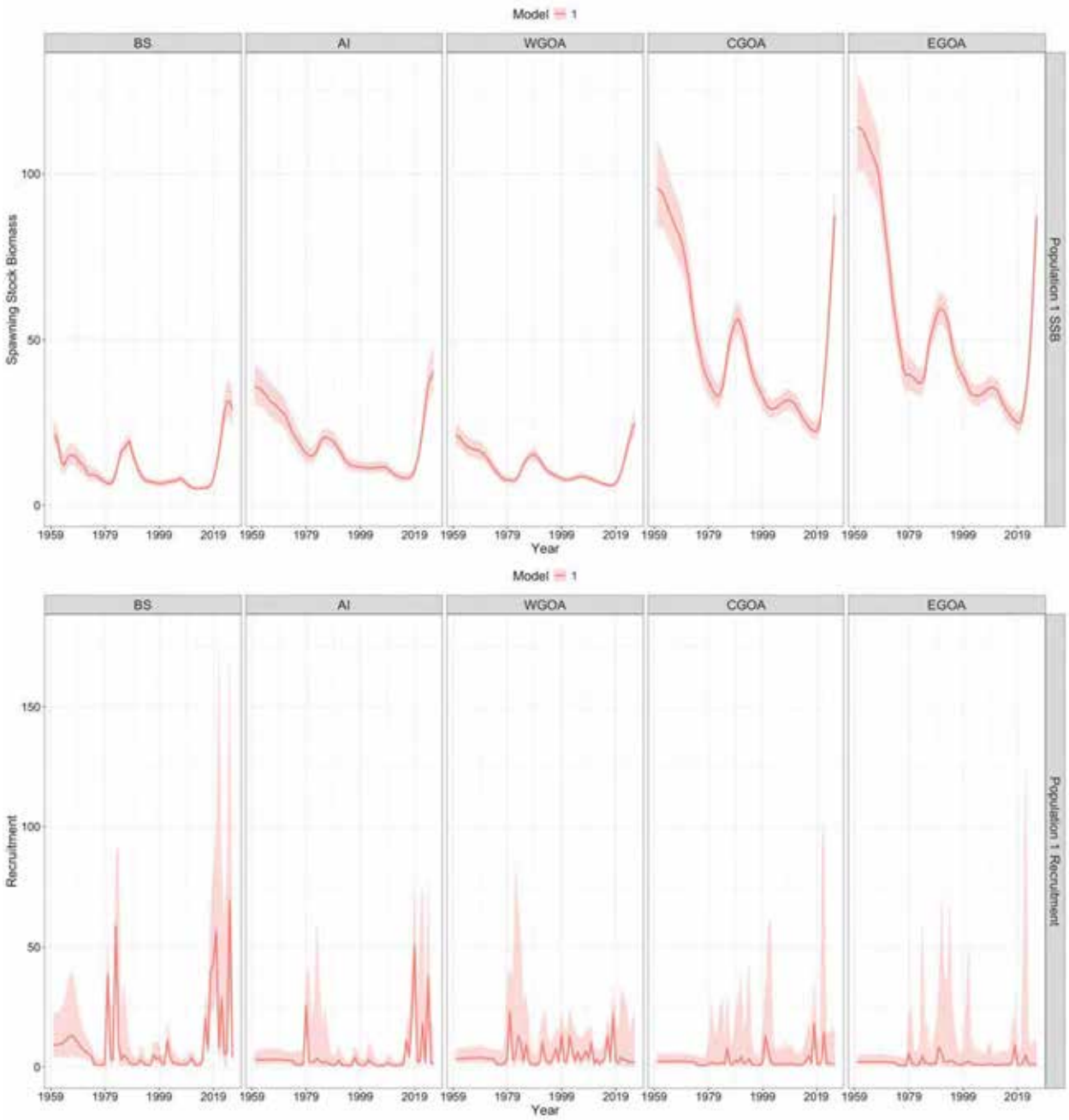

Figure 3D.11. Time-series of recruitment (age-2; millions of individuals) and spawning stock biomass (*SSB*; kt) for the five-region spatial model.

Appendix 3L. Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska - Update

S. Kalei Shotwell and Russel Dame (Editors)

November 2026

With Contributions from:

ESP Team: Katy Echave, Bridget Ferriss, Dan Goethel, Dana Hanselman, Chris Lunsford, Krista Oke, Elizabeth Siddon, Kevin Siwicke, Jane Sullivan

ESP Data: Anna Ableman, Mayumi Arimitsu, Matt Callahan, Wei Cheng, Russel Dame, Dana Hanselman, Jean Lee, Clare Ostle, Kalei Shotwell, Kevin Siwicke, Kally Spalinger

This report may be cited as: Shotwell, S.K., and Dame, R. 2026. Appendix 3L. Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska - Update. *In*: Goethel, D.R., and Cheng, M.L.H. 2026. Assessment of the Sablefish stock in Alaska. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safe-reports/.

This appendix is reviewed separately from the main operational assessment document. Please refer to the 2026 assessments available from https://www.npfmc.org/library/safe-reports/ to access the full ecosystem and socioeconomic profile (ESP) document.

Appendix 3M: Sablefish in Eastern Bering Sea Trawl Fisheries

Kevin A. Siwicke and Katy B. Echave

November 2026

Sablefish catch began increasing in the Eastern Bering Sea (EBS) trawl fisheries starting in 2016. We began evaluating the characteristics of these patterns annually in 2020 using fisheries observer data (Goethel and Cheng 2024, Appendix 3E). Here we present updated information through 2025 and available data from 2026. Sablefish catch in pelagic gear was highest in 2020, whereas sablefish catch reached a recent maximum in the non-pelagic EBS trawl fisheries in 2023 and remained high through 2025 (Table 1). Length data are historically sparser than weight data but provide valuable information about the presence of smaller sablefish entering the population. Historically, age-1 sablefish rarely appear in the length data from the non-pelagic trawl fishery, and the 2024- or 2025-year classes are not apparent in any of the length data through 2026 (Figures 1 and 2). There is a lack of small sablefish (< 0.5 kg mean weight) in 2024 and 2025 catch data (Table 2). The above average age-1 signal, when present, was most obvious in catch data from the 0 to 100 m depth range where it historically appeared during the first 120 days of the year (Figures 3 and 4). The spatial extent of trawl caught sablefish in the EBS is along the entire shelf break, with the highest north of Unimak Pass and some catch on the southeastern EBS shelf (Figure 5). When small sablefish were present, they were commonly found north and east of Unimak Island (Figure 6). This year an age-1 sablefish index is being calculated as the annual number of trawl hauls (combined pelagic and non-pelagic) with a mean sablefish weight < 0.5 kg limited to 0 to 100 m depth range and the first 120 days of the year, divided by the total number of hauls (multiplied by 1000). This differs from previous years that only reported the raw number of hauls with small sablefish, so that it accounts for the varying amounts of observations or effort over the season and location that we expect to see this signal. The year classes with the highest index values in the time-series are 2014, 2016, 2019, and 2022 (Figure 7), with no evidence of strong year classes since. The current stock assessment model includes age data through 2025, and there is evidence that these year classes are recruiting into the fishery.

Literature Cited

Goethel, D.R. and Cheng, M.L.H. 2024. Assessment of the sablefish stock in Alaska. North Pacific Fishery Management Council, Anchorage, AK. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council.

Tables

Table 1. Sablefish catch (t) in the non-pelagic and pelagic trawl fisheries occurring in the Eastern Bering Sea. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

Year	Non-pelagic	Pelagic	Total
2010	29	< 1	30
2011	44	< 1	45
2012	92	< 1	92
2013	133	< 1	133
2014	34	0	34
2015	17	< 1	17
2016	238	20	258
2017	587	107	694
2018	624	424	1,047
2019	1,270	1,260	2,530
2020	1,062	2,570	3,632
2021	1,383	788	2,171
2022	2,089	157	2,246
2023	2,303	281	2,584
2024	2,261	14	2,275
2025	2,053	12	2,065
2026*	354	<1	354

*Catch data is not complete for 2026 and will be updated in 2027.

Table 2. Number of observed hauls for the Eastern Bering Sea pelagic and non-pelagic trawl fisheries that included sablefish, and the number of hauls with mean sablefish weight < 0.5 kg, which are assumed to be predominantly age-1 fish, by year. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

	Non-pelagic		Pelagic	
Year	Total hauls	Hauls < 0.5	Total hauls	Hauls < 0.5
2015	216	147	16	10
2016	455	4	337	3
2017	682	23	831	366
2018	574	1	900	11
2019	1,076	12	1,693	34
2020	920	50	2,037	208
2021	1,158	2	858	20
2022	1,319	0	282	1
2023	1,224	15	559	184
2024	813	0	224	0
2025	871	0	374	3
2026*	231	0	12	1

*Catch data is not complete for 2026 and will be updated in 2027.

Figures

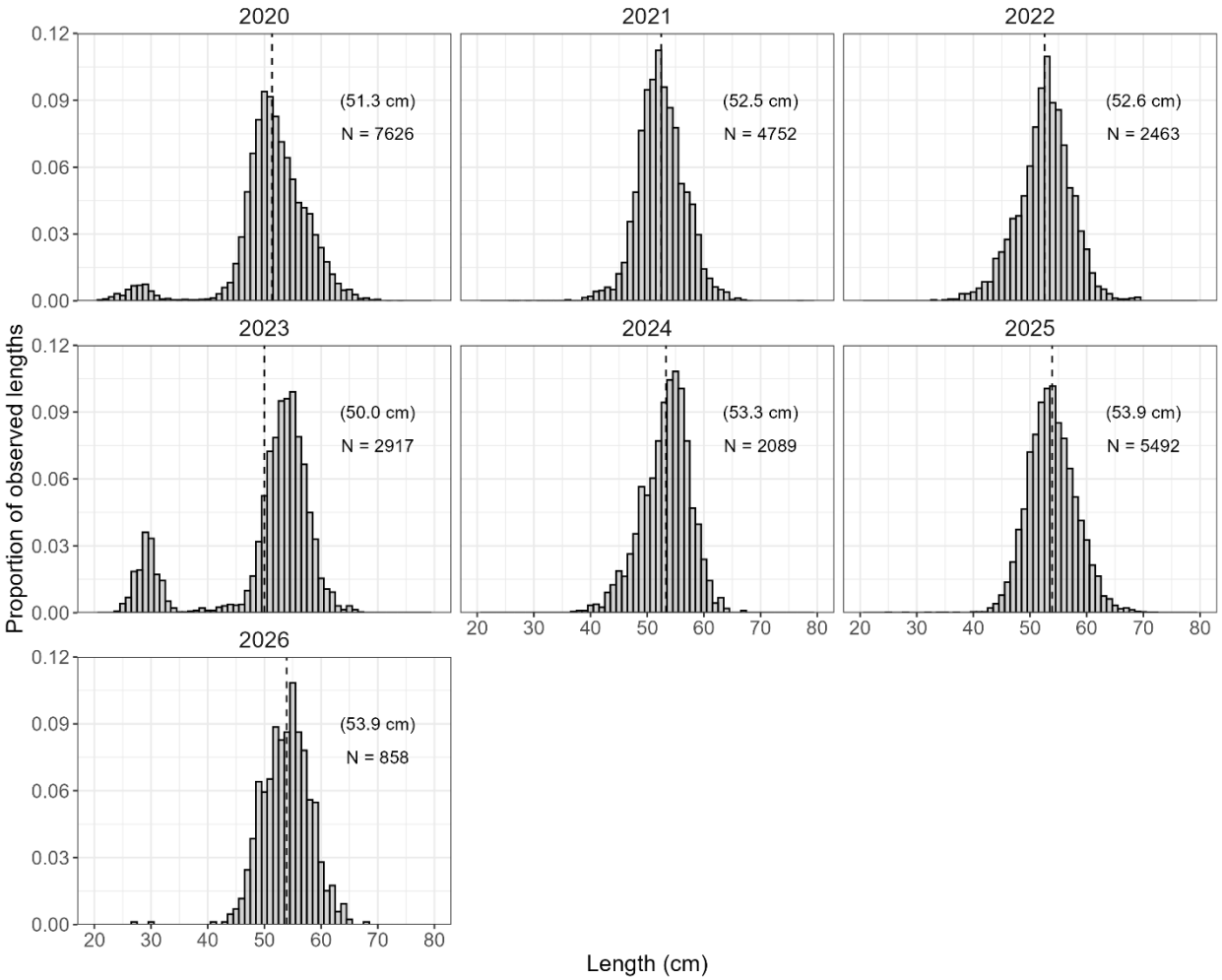

Figure 1. Proportions of sablefish lengths measured by observers in Eastern Bering Sea pelagic trawl fisheries. The vertical dashed line indicates the mean length each year (value shown in parentheses, with sample size, N, below). Note that complete length data taken in 2026 will not be available until next year. Data provided by the NORPAC length database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

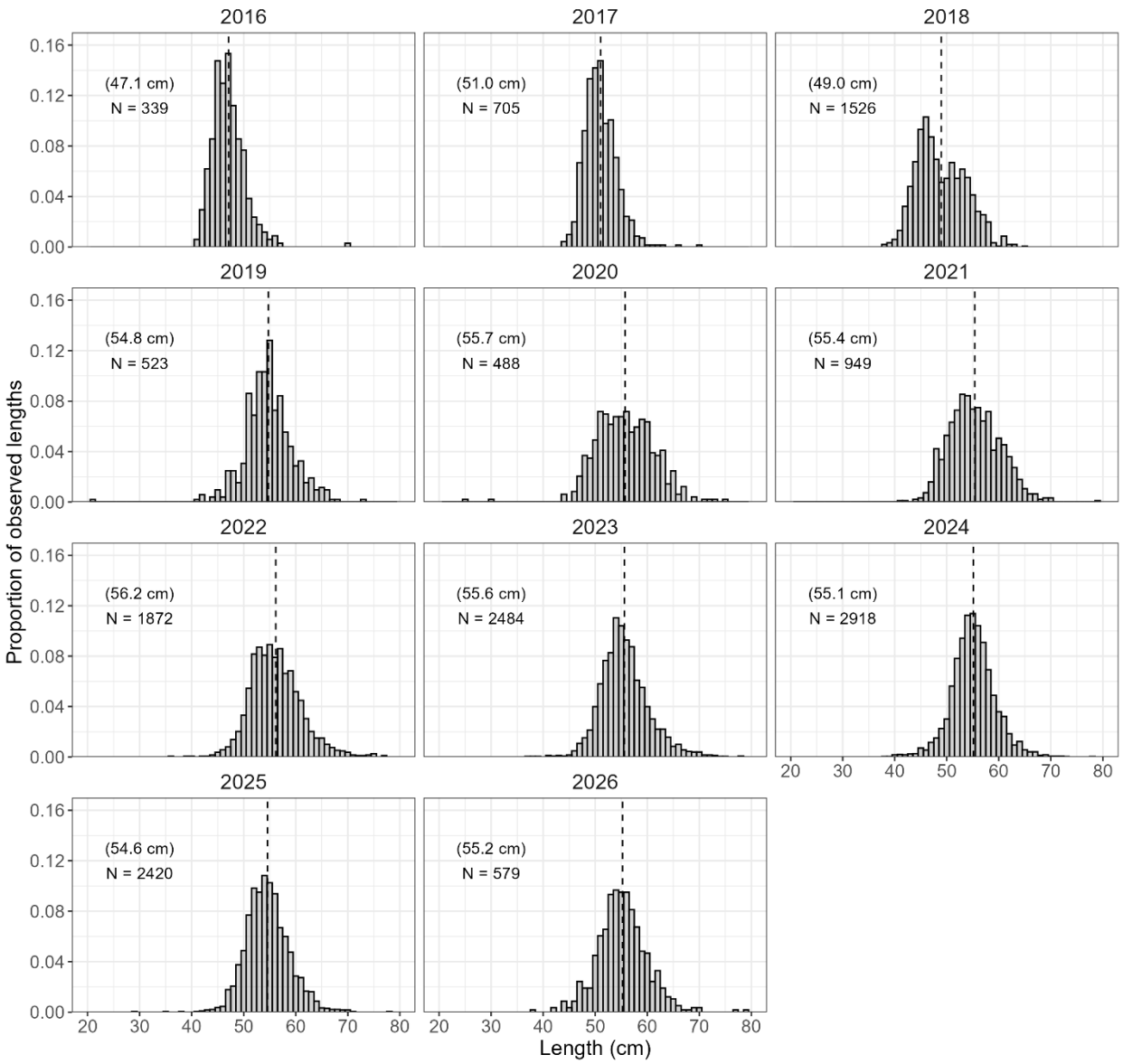

Figure 2. Proportions of sablefish lengths measured by observers in Eastern Bering Sea non-pelagic trawl fisheries. The vertical dashed line indicates the mean length each year (value shown in parentheses, with sample size, N, below). Note that complete length data taken in 2026 will not be available until next year Data provided by the NORPAC length database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

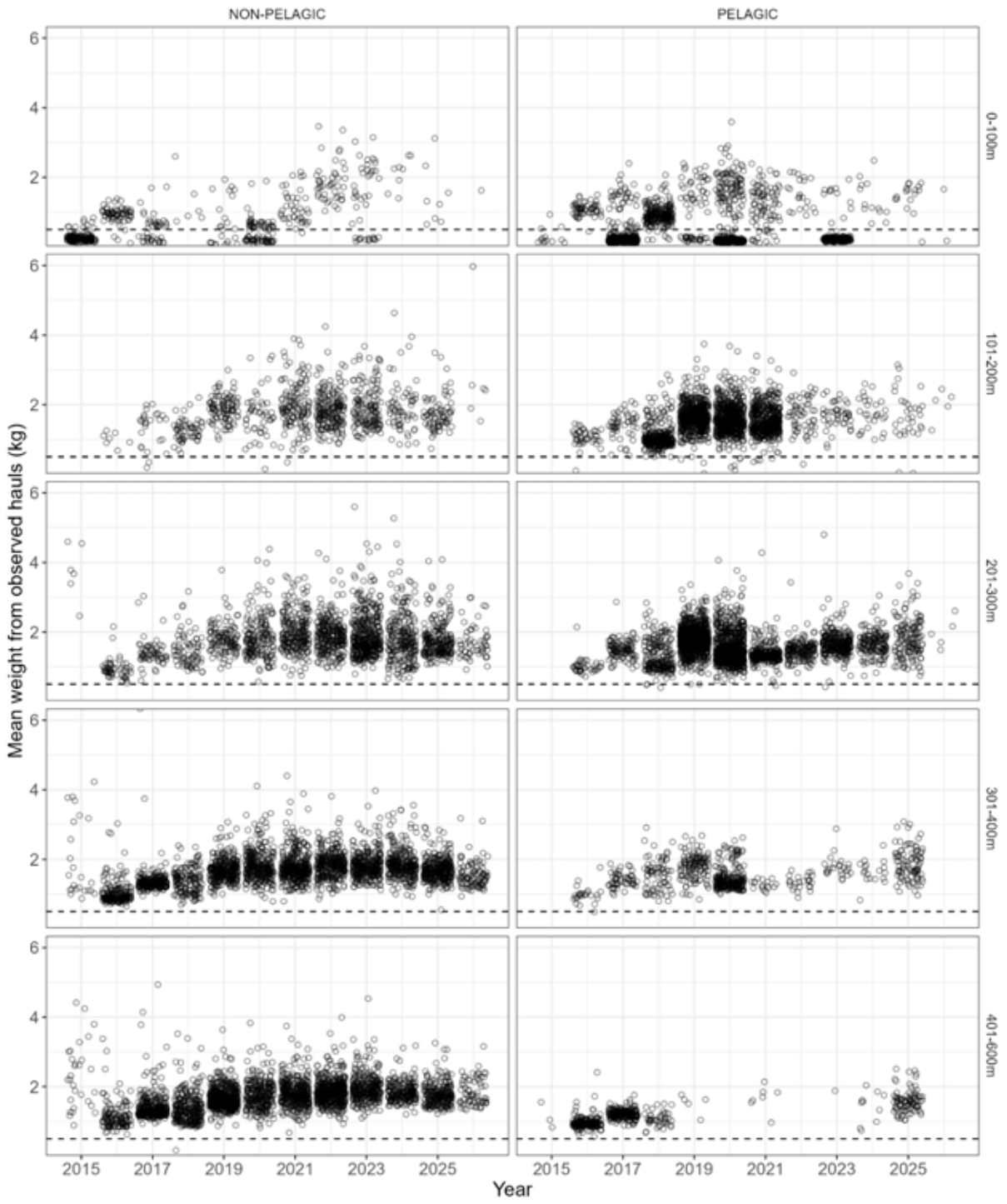

Figure 3. Distributions of the mean weight of sablefish from observed hauls in the Eastern Bering Sea non-pelagic (left) and pelagic (right) trawl fisheries. Catches are binned by 100- or 200-m depth bins (increasing in depth from top to bottom panels). The horizontal dashed lines at 0.5 kg delineate likely age-1 sablefish dominating the catch when more of the distribution is below the line. Catch data from 2026 is incomplete. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

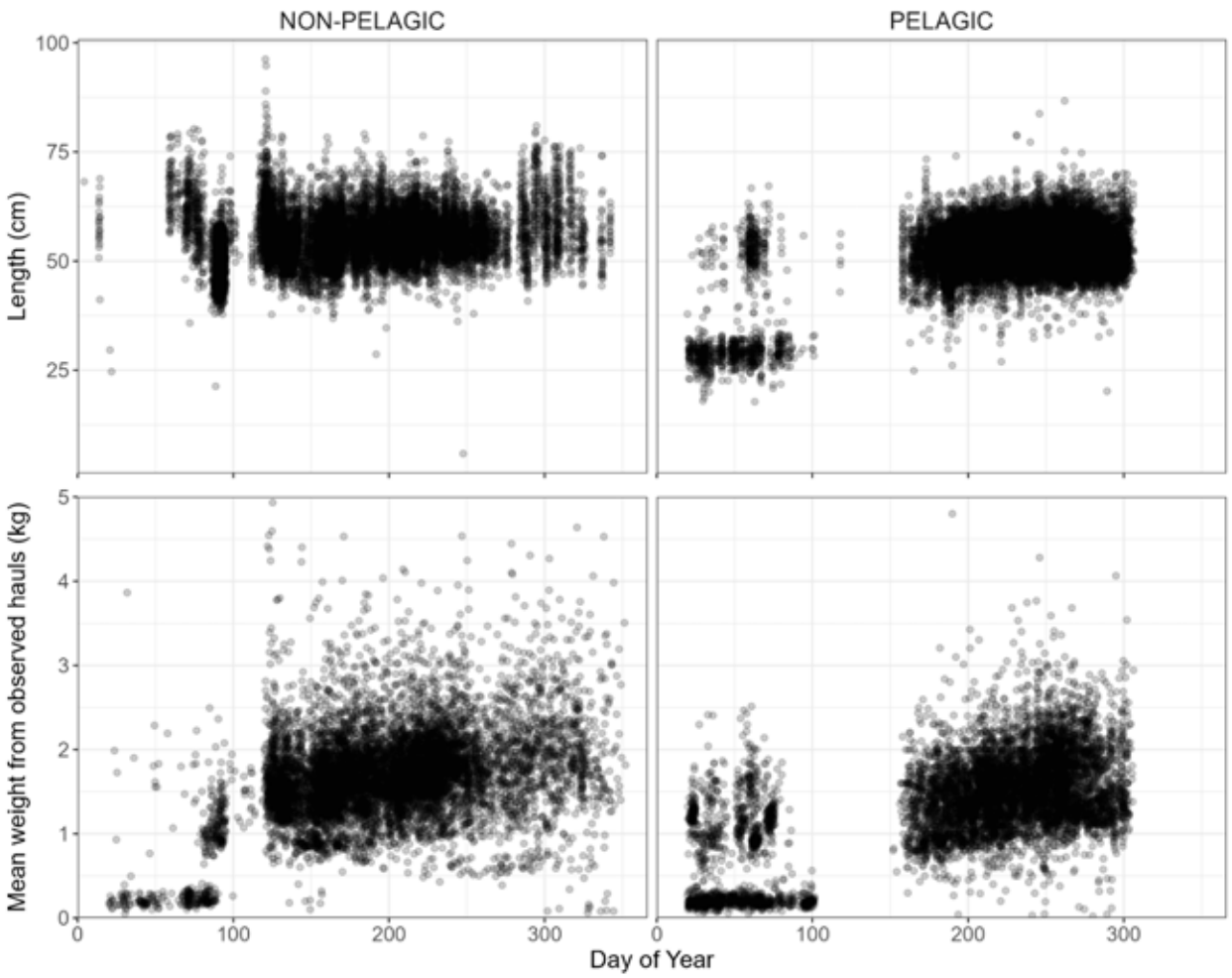

Figure 4. Sablefish catch by lengths (top) and mean weight (bottom) throughout the year from all available observer data in the Eastern Bering Sea between 2010 and 2026 for non-pelagic (left) and pelagic (right) trawl fisheries. Length and catch data provided by the NORPAC length and catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.

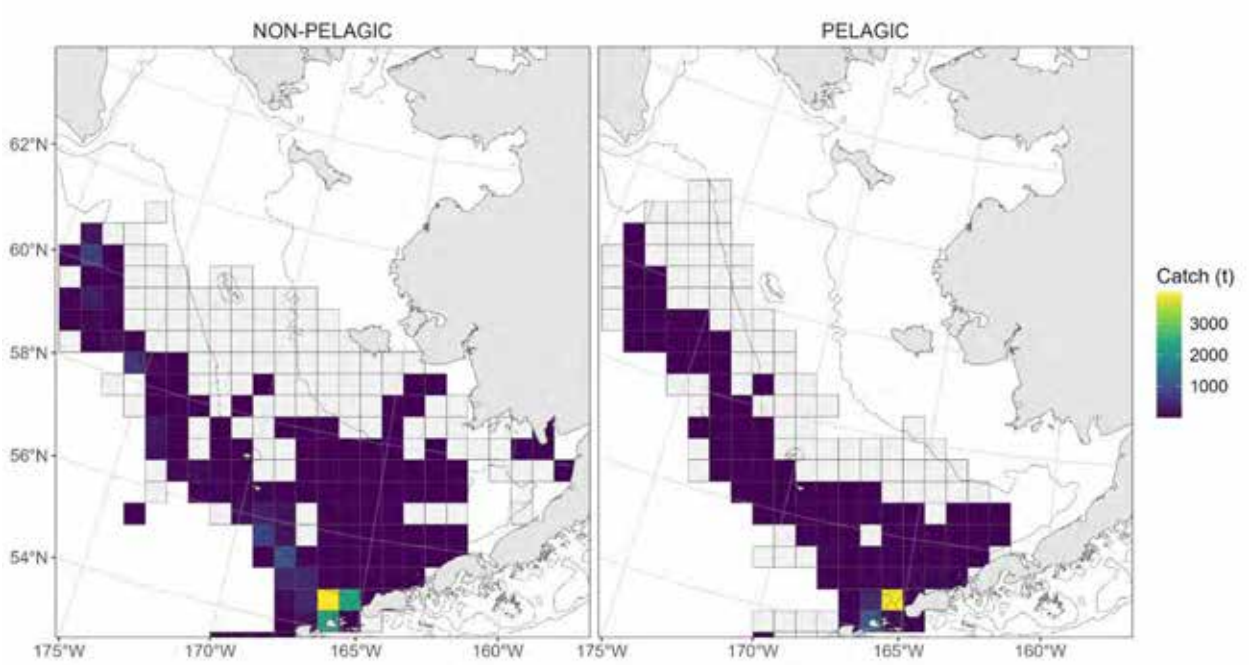

Figure 5. Spatial distribution of observed sablefish catch (t) occurring in non-pelagic and pelagic trawl gear in the eastern Bering Sea since 1991 with light grey cells indicating no sablefish catch. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026. Locations shown have been generalized to generic center locations of a 50 x 50 sq. km grid if there were 3 or more unique vessels, as per NOAA/NMFS regulations.

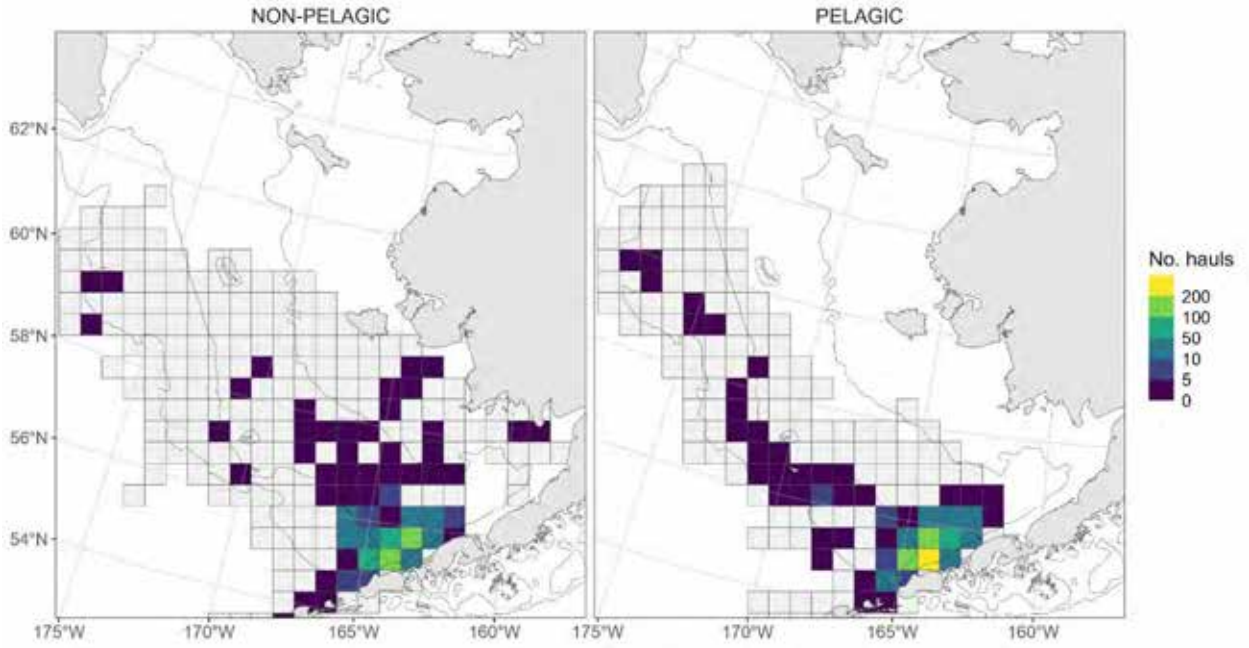

Figure 6. The cumulative number of non-pelagic (left) and pelagic (right) trawl hauls with a mean sablefish weight < 0.5 kg since 1991 with light grey cells indicating no hauls contained small sablefish. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026. Locations shown have been generalized to generic center locations of a 50 x 50 sq. km grid if there were 3 or more unique vessels, as per NOAA/NMFS regulations.

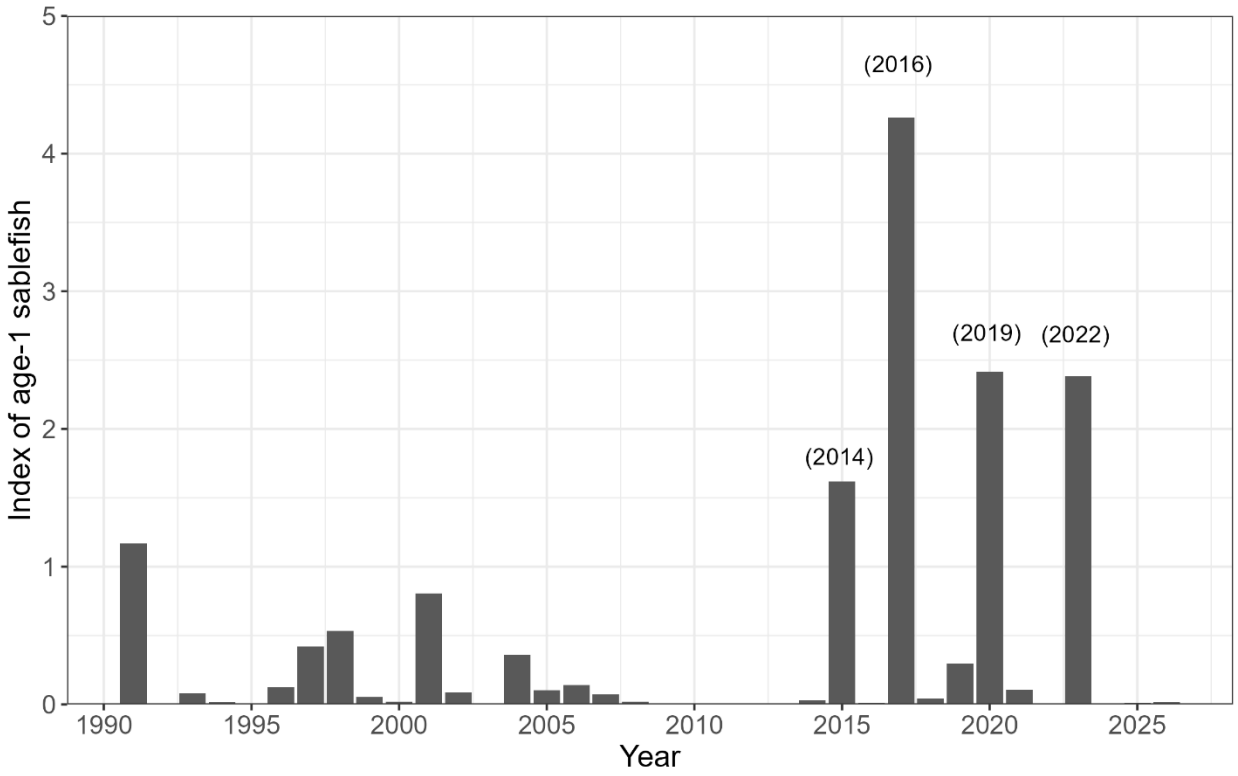

Figure 7. Annual index of age-1 sablefish with year class in parentheses above bars for the greatest four index values. Data provided by the NORPAC catch database accessed via the Alaska Fishery Information Network (AKFIN) on November 2, 2026.