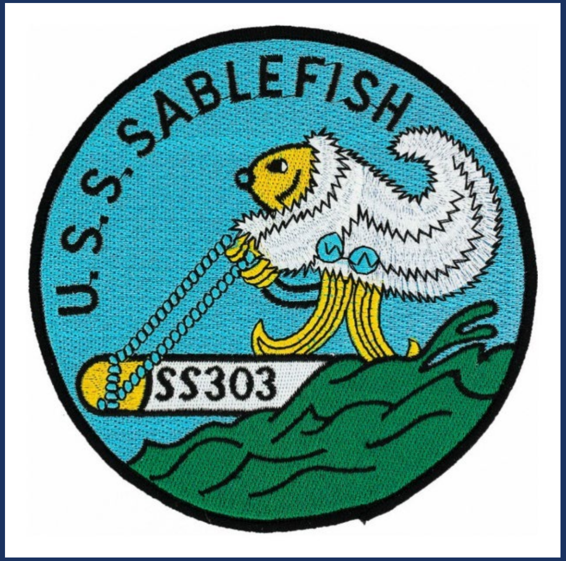
Sablefish Model Changes and CIE Review Summary

2026 September Groundfish Joint Plan Team

Daniel Goethel and Matt Cheng

August 2026

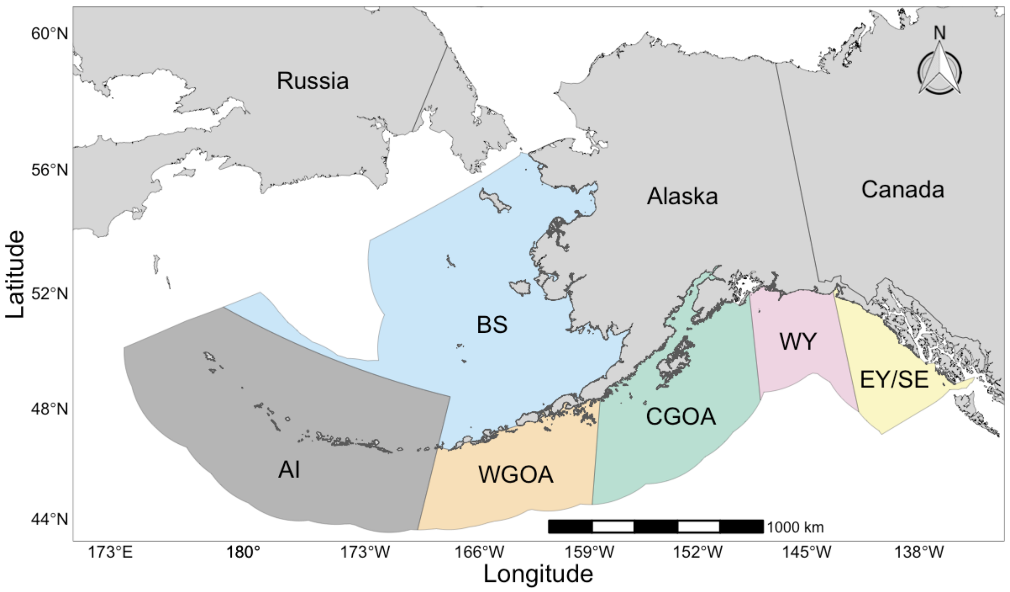


Presentation Outline

- Summary of Model Changes, Data Issues, and Results
- Single Region Model Bridging and Development (Model *26.1_1Reg*)
- Spatially-Implicit Model Development Approach (Model *26.2_FAA*)
- Model Comparison of Model *26.1_1Reg* and Model *26.2_FAA*
- Sensitivity Runs and Spatial Model Outputs
- CIE Review Summary and Model Conclusions
- Apportionment
- *Next Presentation*: Sablefish MSE Results (Josh Zahner)

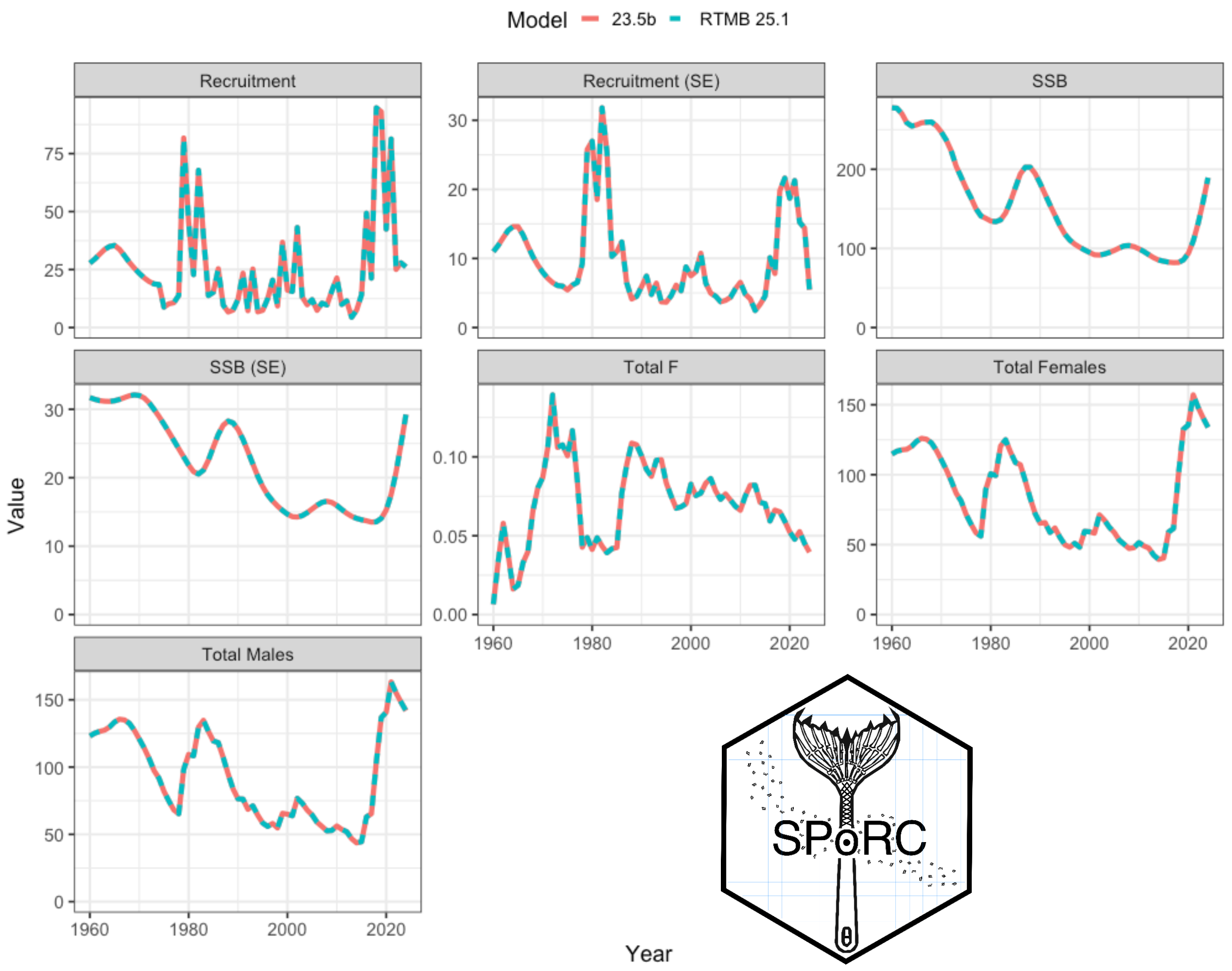
Sablefish Management

- One of the only NPFMC stocks assessed and managed AK-wide
- Spans 3 large marine ecosystems:
  - Bering Sea (BS)
  - Aleutian Islands (AI)
  - Gulf of Alaska (GOA)
- Alaska-wide Acceptable Biological Catch (ABC) is apportioned to the 6 management regions to set the Biologically-informed Regional Distributions (BRDs):
  - BS, AI, WG, CG, EG (WY/SEO)
  - Based on moving 5-year average of LLS biomass proportions across regions
  - Attempts to distribute fishing pressure proportional to biomass
  - AK-wide ABC ~50% utilized in recent years, but BRDs >80% utilized in GOA



Background

- Last operational sablefish assessment used to set catch advice was in 2024 using bespoke ADMB Model *23.5*
- New model reviewed and approved by NPFMC PT and SSC in 2025 using SPoRC platform (Model *25.12*)
  - Provided a 1:1 ADMB to SPoRC bridge
  - Never used for management advice due to US government shutdown

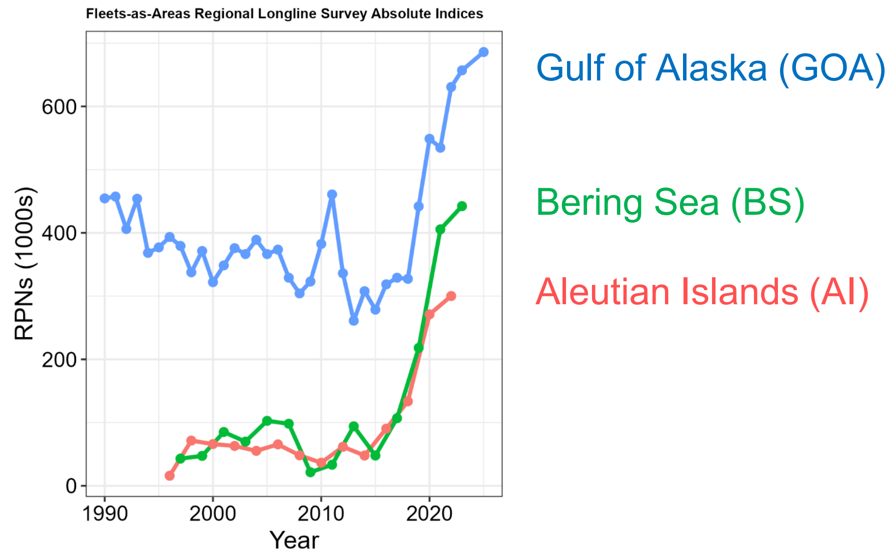


https://chengmatt.github.io/SPoRC/

NOAA Longline Survey Design Changes (2025)

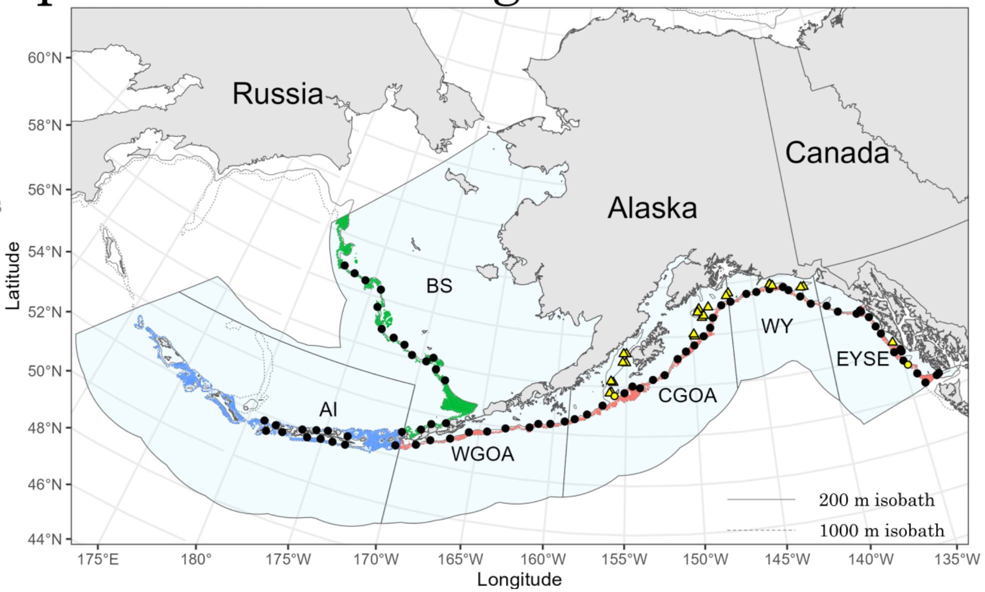
- Change in NOAA longline survey design/footprint starting in 2025
  - Historically sampled GOA annually and BS in odd years and AI in even years (~75+% of stock sampled annually)
  - No survey in 2024 – cost recovery limitations
  - Starting in 2025 sample GOA in odd years and BS+AI in even years (~50% of stock sampled annually)

LLS Relative Population Numbers (RPNs)



Survey footprint recent changes

- Red GOA footprint sampled odd years
- Green (BS) and blue (AI) footprint sampled even years
- Black circles are current stations
- Yellow circles are index stations lost in 2025
- Yellow triangles are non-index gully stations lost in 2025



Primary Sablefish Concerns for CIE Review

- **How best to handle recent changes in NOAA Longline Survey (LLS) design?**
  - Should a **spatially-implicit** model (also known as *'Fleets-As-Areas' or FAA*) be used to avoid fitting imputed LLS indices?
- Are best practices for modeling sex- and fleet-structure being used in the assessment?
- Which data should be included in the assessment (e.g., indices, length compositions)?

CIE 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.

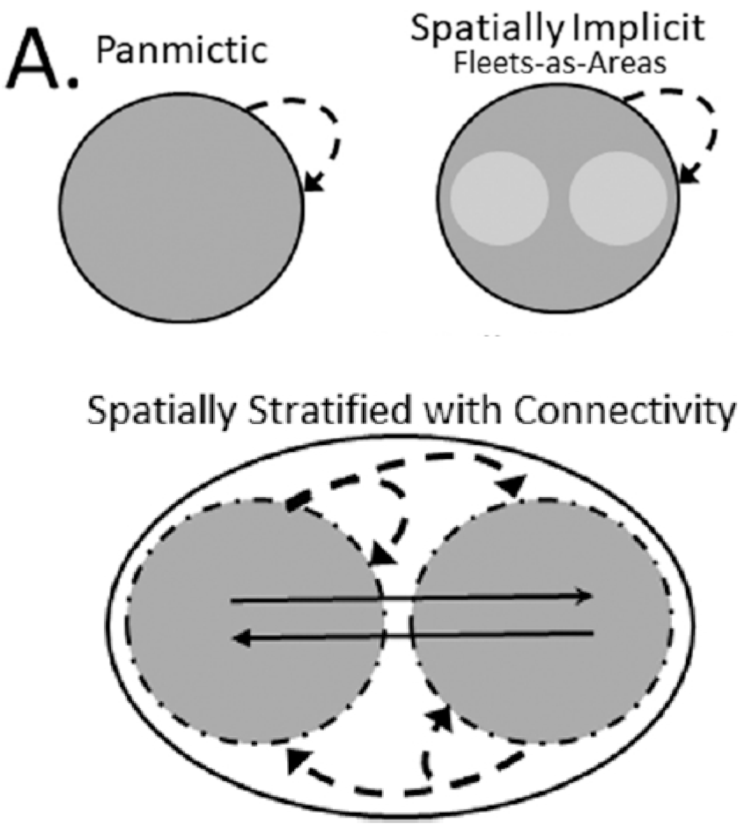
2) Highlight potential strengths and weaknesses of the FAA assessment, including model assumptions, estimates, fits to data (survey indices and age compositions along with fishery catch-at-age data), model diagnostics, and major sources of uncertainty.
   a) Indicate whether the model provides the best 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.

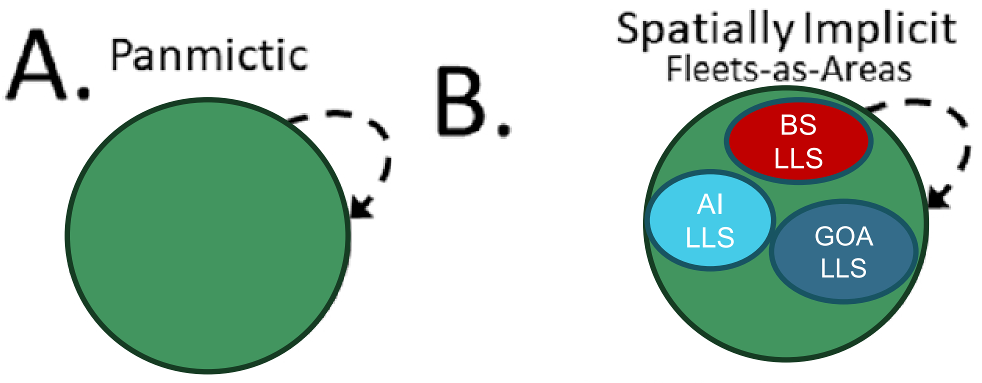
Why Spatially-Implicit?

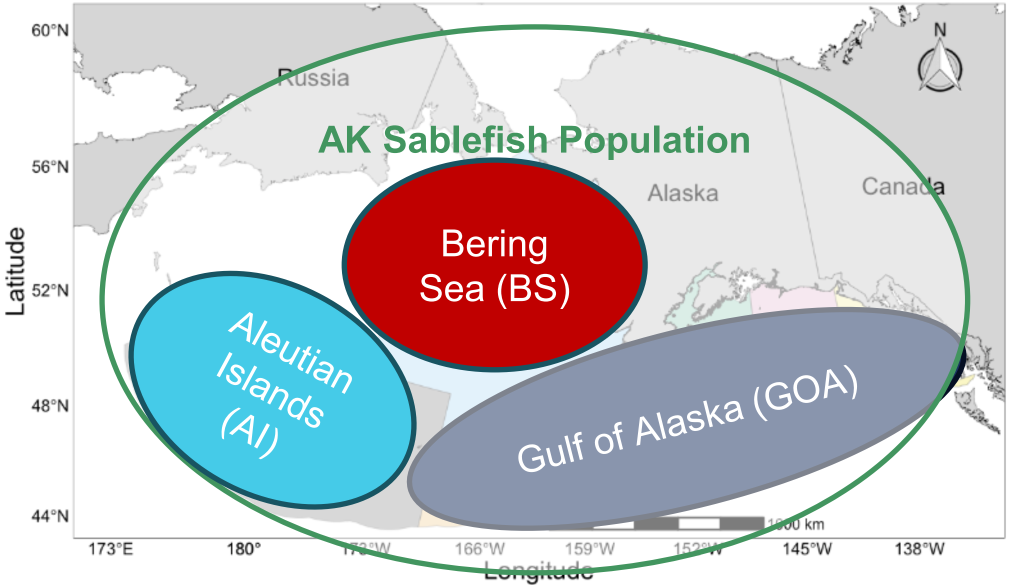
- Single region LLS index requires imputing ~50% of RPNs to maintain consistent scaling across years
- Spatially implicit FAA model allows fitting the indices and compositions at the regional scale
  - Implicitly accounts for regional heterogeneity, availability, and movement through fleet structure
  - Limited complexity (e.g., don't need to estimate movement)
  - More difficult to interpret dynamics (e.g., selectivity)
  - Partitioning data regionally may lead to low sample sizes



Model Options for 2026

- 3 model versions (reviewed by the CIE):
  - *26.1_1Reg:*
    - Updated single region model
    - Refines data inputs, improves parametrization, and better aligns with best practices
    - Uses ‘carryover’ NOAA Longline Survey (LLS) index values.
  - ***26.2_FAA* (Recommended Model)*:***
    - New spatially-implicit model (building from *26.1_1Reg*)
    - Disaggregates the LLS into regional fleets (separate indices, age compositions, catchability, and selectivity)
    - All other data sources aggregated to a single region (same as *26.1_1Reg*; i.e., fishery fleets)
    - Explicitly handles survey design change (no imputed values)
  - *26.3_5Reg:*
    - Updated 5-region, spatially explicit model
    - Not being put forward for management advice currently (stability and parametrization issues)





General Model Structure

- *All data updated through 2025*
- Single region (AK-wide)
- Sex-specific (males and females) dynamics:
  - Growth (size-age transition)
  - Selectivity
  - Natural Mortality (M)
  - 50:50 recruitment sex ratio
- Start year 1960
- Age structured (SCAA), projecting forward from initial ages and recruitment at age-2
- Assume yearly deviations from average recruitment
- Each fleet (fishery and survey) has independent, sex-specific selectivity **(and regional LLS selectivity for the FAA model)**
- Fishing mortality (F) estimated with yearly deviations for each fleet (fixed gear and trawl)
- Catchability (q) parameters freely estimated for each index (NOAA and Japanese LLS) and **regionally for the FAA 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

Documents and Materials

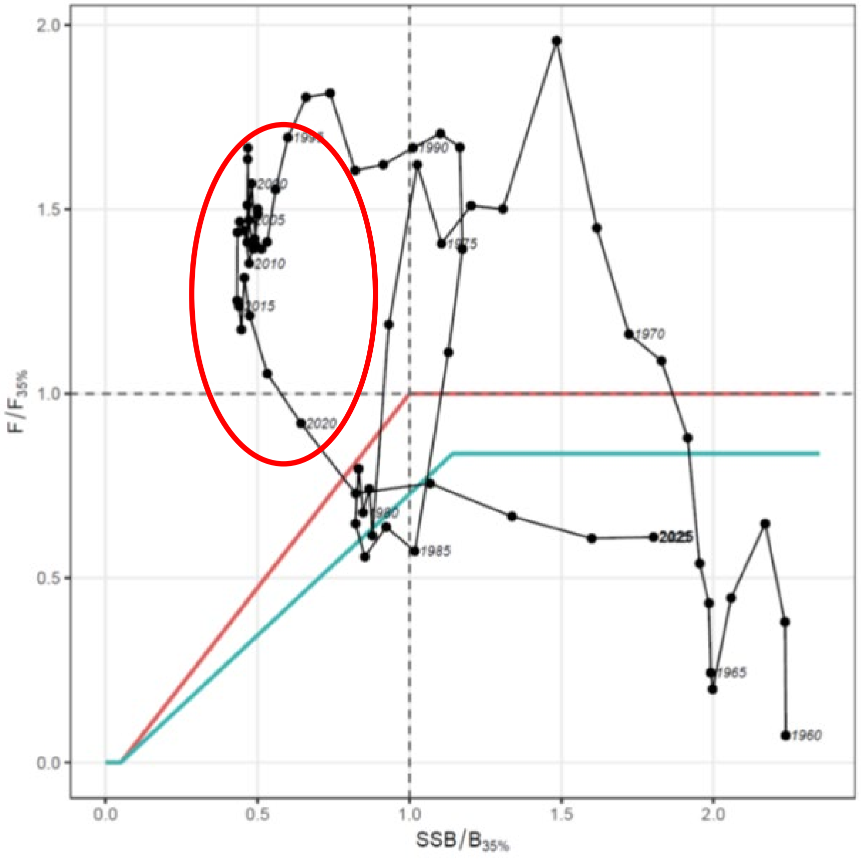
- Documents for CIE review:
  - Off-cycle *draft* SAFE report with data through 2025
  - 5 appendices
- CIE GitHub Repo:
  - https://github.com/dgoethel-noaa/2026_Sablefish_CIE/tree/main
  - Contains model run code (R scripts), model outputs (R data files), presentations, and documents for review
- **September JPT sablefish document summarizes model updates and CIE reports**
  - https://drive.google.com/open?id=1IpzJdXA4IfZIKiEQTC1He13m8XAljHZQ

Documents For Review (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)

Summary

- Developed a new spatially implicit (fleets-as-areas, FAA) model structure to explicitly handle NOAA longline survey design changes
- Model building involved over 100 model alternatives, 4 different spatial structures, and a spatially explicit closed loop simulation analysis
- **2026 Recommended Model**: Spatially implicit Model *26.2_FAA*
  - Does not rely on imputed survey data, which may artificially inflate SSB scale
  - More robust to known spatial processes based on closed loop simulations
  - CIE approved and recommended
- However, SSB and catch advice decline considerably due to downward scaling of SSB
  - **Change in ABC across model options IS NOT due to a biological change/concern, just an update of the model structures**



Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt
26.1_1Reg	1	216.4521	369.6689	0.04642913	40.85173	139.0172	0.07903
26.2_FAA	1	193.1500	358.1881	0.05874255	31.69570	122.4267	0.08054

SSC and JPT Recommendations

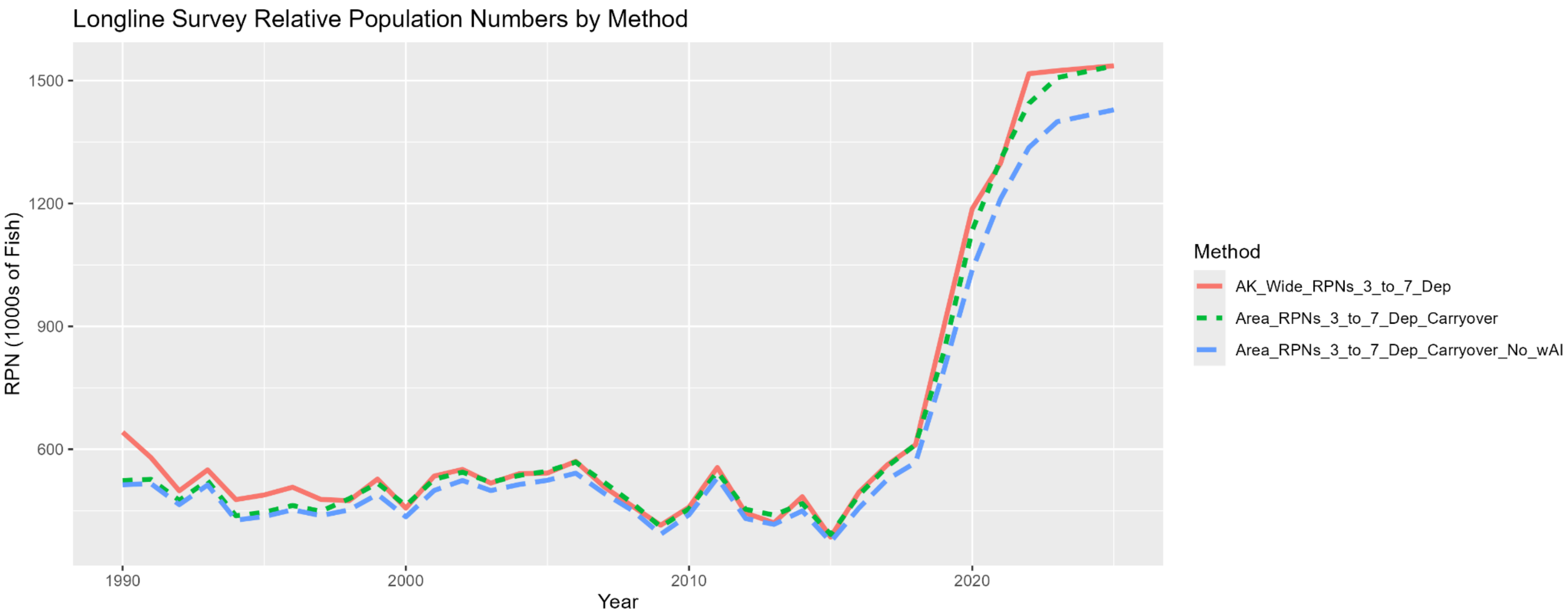
- *Continue development of spatial models*
  - Model *26.3_5Reg* was updated and improved for 2026 but not recommended for operational management
- *Continue exploring sex-specific dynamics*
  - Now estimating sex-specific natural mortality (*M*) in all models
- *Explore time-varying growth*
  - Sensitivity runs presented with time-varying growth/WAA (Cheng et al. 2025)
  - High uncertainty and limited annual sample sizes (weight)
- *Compare empirical length and weight-at-age directly with modeled estimates*
  - Not done explicitly, but have explored time-varying growth/WAA
- *Explore time-varying selectivity*
  - Sensitivity runs presented with TV selex and Dirichlet Multinomial, but lead to degraded fits to survey indices and poor retrospective performance
  - CIE recommends **not** using TV selex or DM at this time
- *Document ISS and ESS*
  - ISS, ESS, and SE are now provided in a table
- *Implement the Hulson and Williams (2024) ISS*
  - Not yet available for LLS or fishery age compositions
- *The Teams recommended testing approaches where fishery composition data inform removals only rather than population structure or recruitment.*
  - ??

Model Updates: Single Region

- **Updates implemented step-wise (in isolation) and sequentially**
- Update selectivity priors
- Assume logistic trawl selectivity
- Scale ISS to account for yearly variation in sampling
- Update growth/WAA
- *Estimate sex-specific M*
- Remove CPUE index
- *Drop early LLS and fixed gear fishery lengths*
- **Use 'carryover' LLS index**
- Remove extrapolated western AI stations from LLS

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.

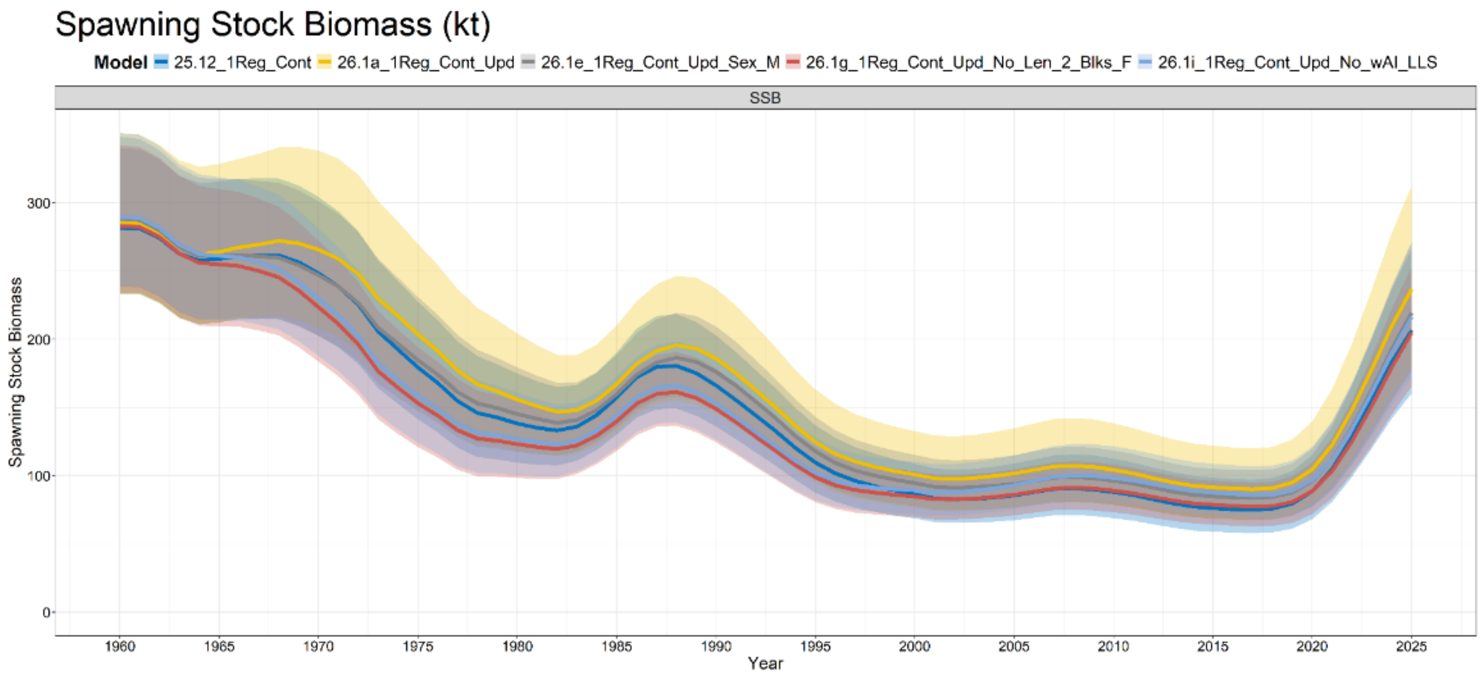
Model Updates: Index Creation

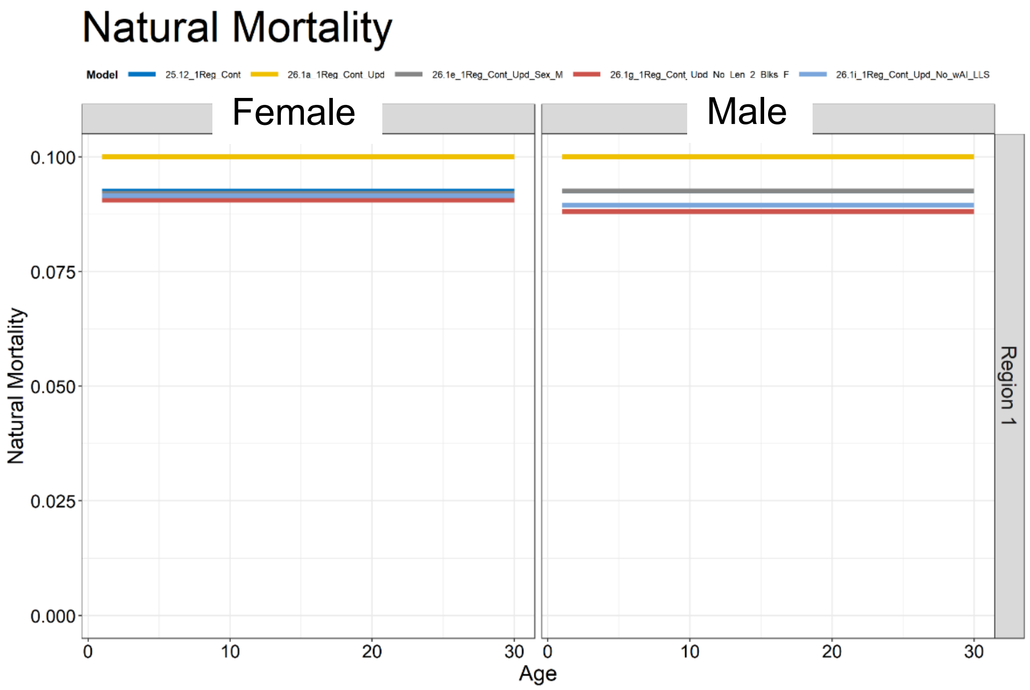


Note that AK-Wide uses an extrapolation for non-surveyed regions (BS/AI) based on change in GOA RPN, whereas the area_RPN methods sum area RPNs with no exptrapolation.
The Carryover approach maintains the previous year's value for a non-surveyed region in the following year. The No_wAI method drops the extrapolated western AI stations from the RPN index.

Summary: Single Region Updates

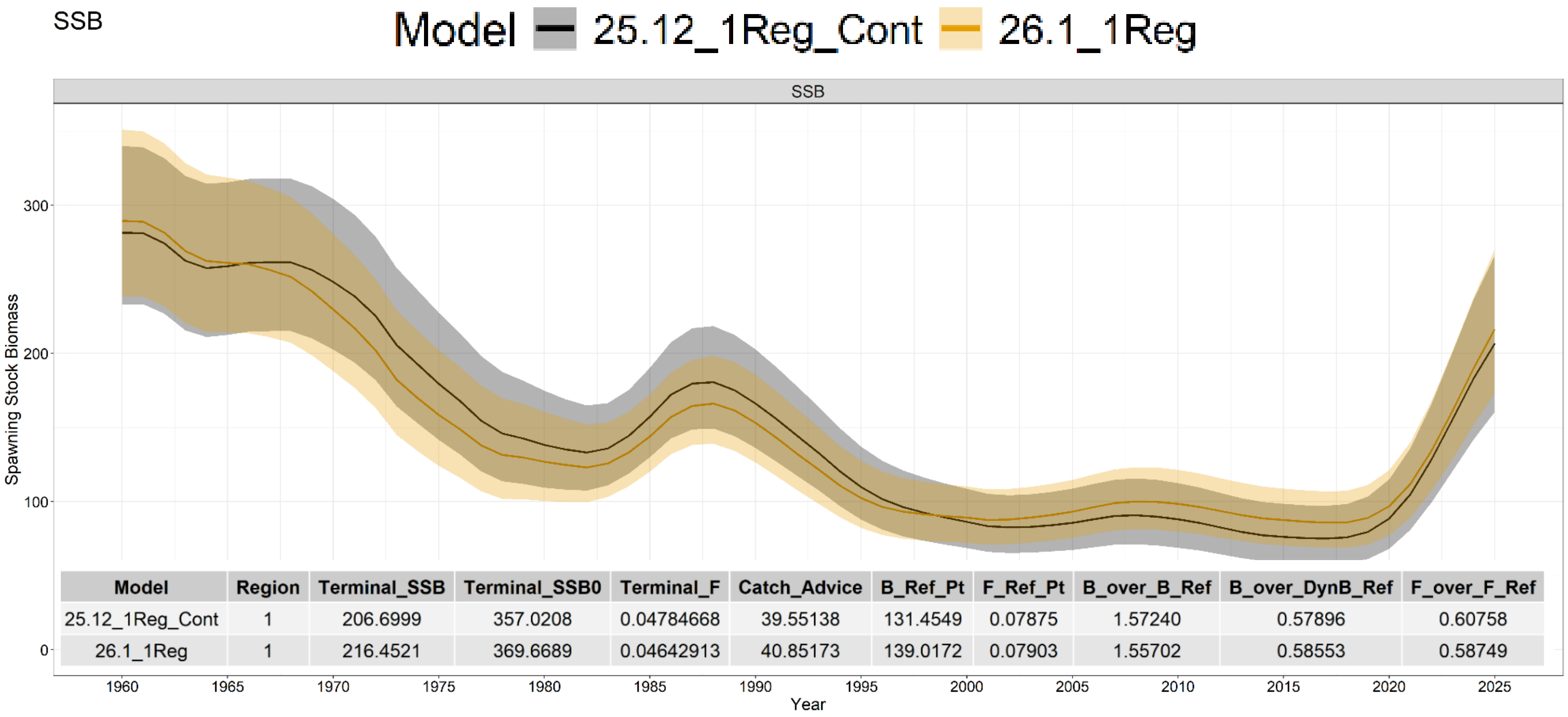
- Moderate rescaling across model updates, often associated with changes in *M* estimates
  - Given long-lived nature of sablefish, small changes in *M* can have strong impact on SSB scaling
  - More realistic (lower) estimates as moved to sex-specific *M* and dropped length data





Comparison to Model *25.12_Cont*

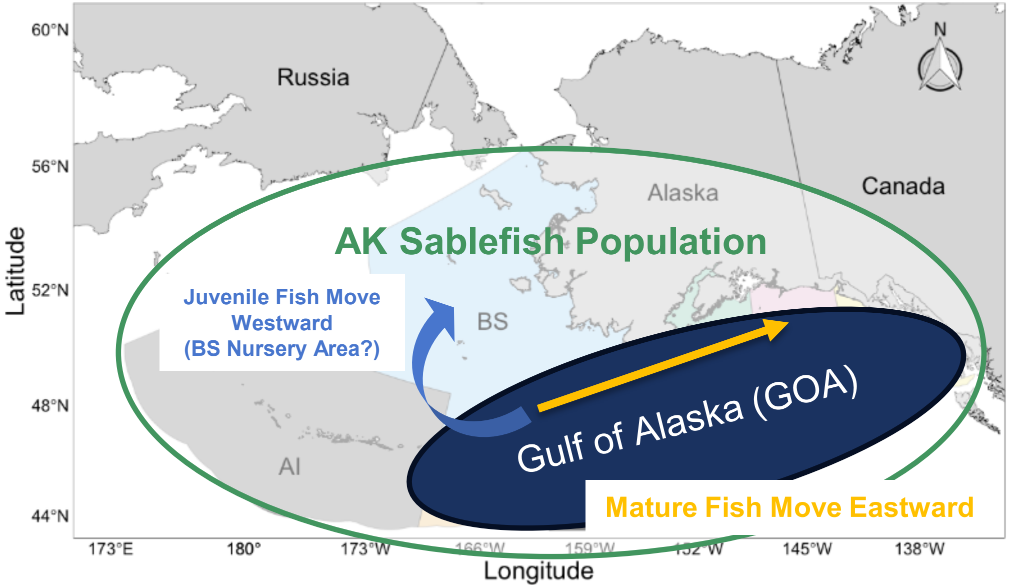
- Model *26.1_1Reg* (final single region model) led to minor improvements in data fits, but underlying issues (fitting index vs. age comps) unresolved
- Little difference in population trend across model updates, but minor changes in scaling



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

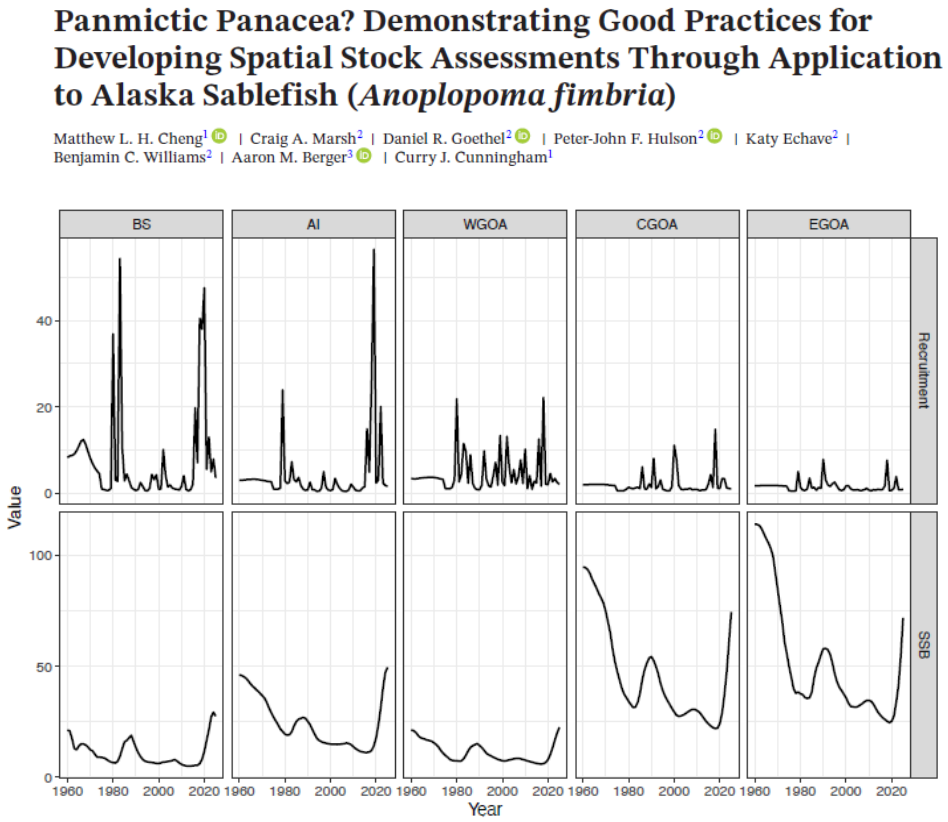
Primary Considerations for Spatially-Implicit Model

- Minimum fleet structure is 3 ‘regions’ (BS, AI, GOA):
  - Allow fitting LLS data at scale that ensures concordant annual survey footprint within each region
    - Constant *q* for a given region
- Parsimony vs. complexity
  - Consider sample size limitations, especially for estimation of time-varying selectivity (time blocks)
- What processes are we trying to address?
  - Fundamentally LLS footprint and availability
  - Ontogenetic movement patterns



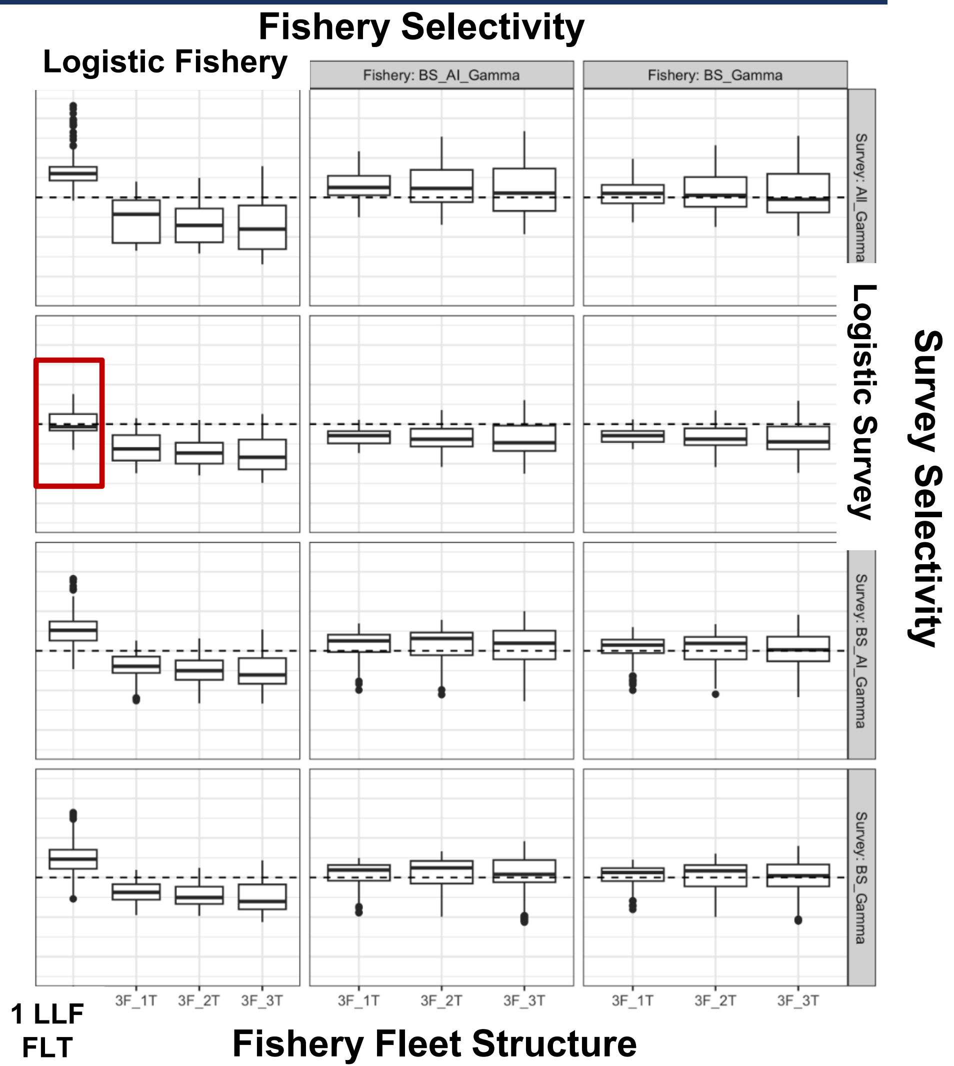
FAA Model Development

- Use spatially explicit simulations to identify robust FAA models
  - Start with minimum necessary complexity (3 LLS fleets)
  - Explore 3 primary axes of complexity:
    - Number of fixed gear fishery fleets (1 vs. 3)
    - Number of time blocks in fishery/survey (1, 2, 3)
    - Shape of fishery/survey selectivity by region (BS/AI dome vs. logistic)
- Implement the most promising structures in SPoRC and fit to real-world data
- Implement spatially-explicit closed loop simulation to identify relative performance
- Assess **stability, parsimony, and performance** to narrow operationally feasible models



FAA Model Development – Simulations

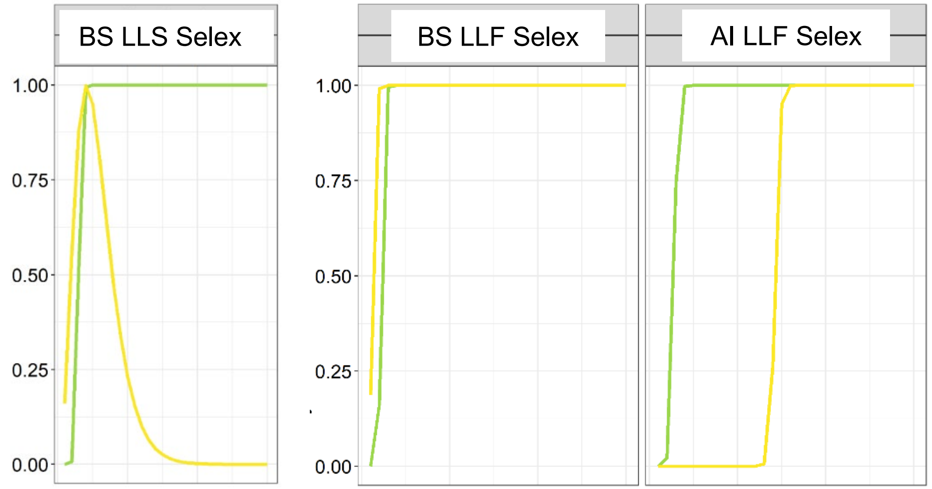
- **Goal:** Use simulation cross-testing to remove poorly performing FAA configurations
- **Methods:** Implemented a spatially explicit 5-region OM and tested 56 FAA model variants with simulated data across 100 iterations
- **Conclusions:** The most parsimonious configuration demonstrated unbiased estimates and robust performance
  - Single longline fishery fleet (LLF), 3 LLS fleets, logistic selectivity for all fleets



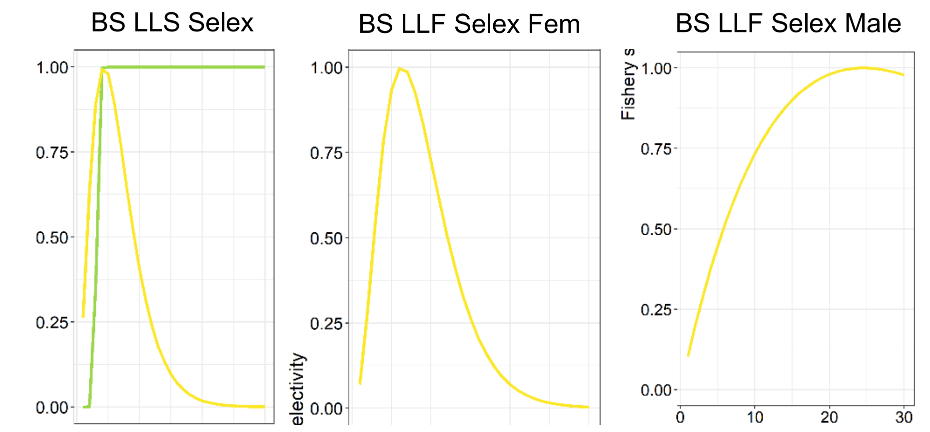
FAA Model Development – Applications with Actual Data

- **Goal:** Assess **stability** of FAA models when confronted with real-world data limitations
- **Methods:** Implemented more than 100 FAA models (guided by simulation results)
- **Conclusions: Parsimony** was the name of the game
  - Adding regional fishery fleets could not be implemented with time blocks
  - Domed selectivity was extremely unstable
  - Data partitioning and sample sizes were a primary limiting factor

Domed LLS Selectivity

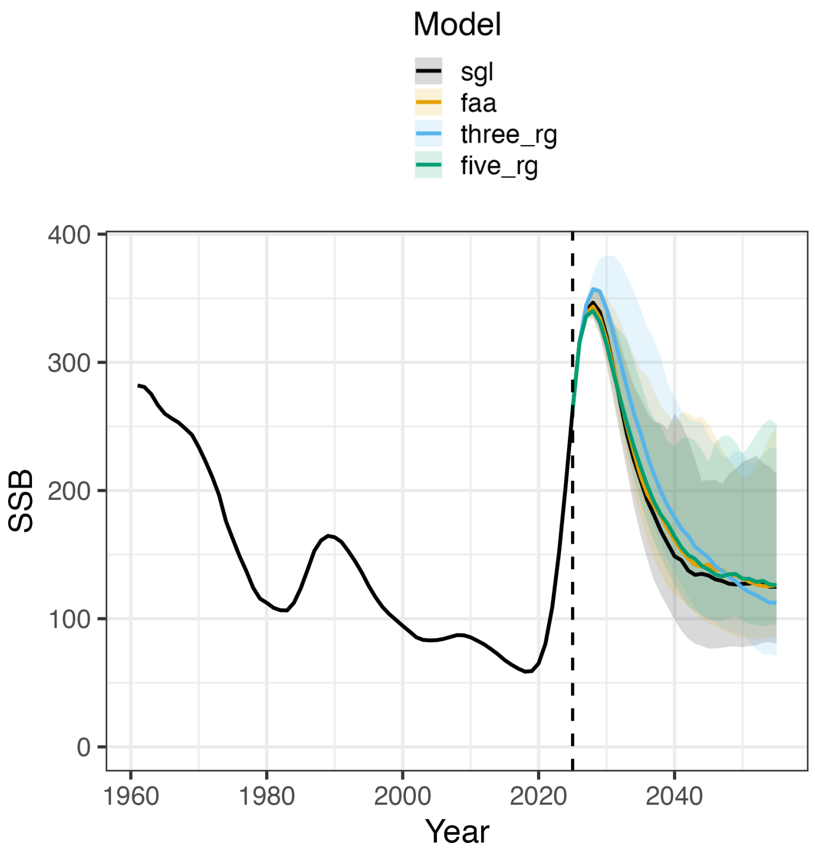


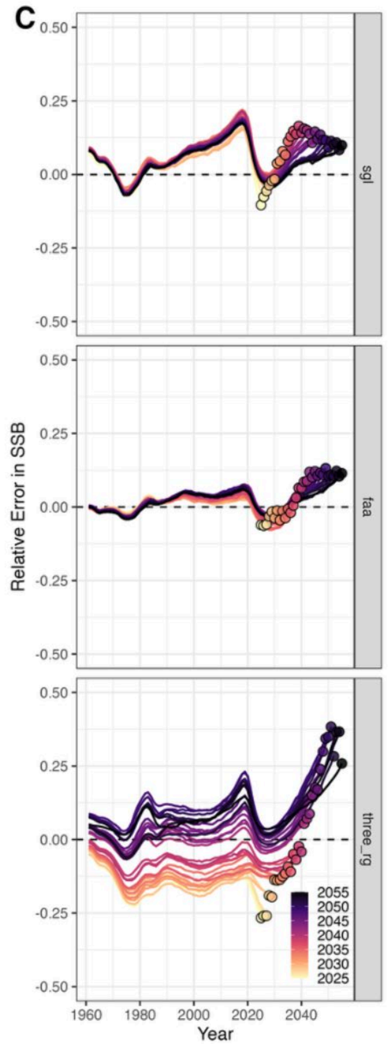
Domed LLS and LLF Selectivity



FAA Model Development – Closed Loop Simulations

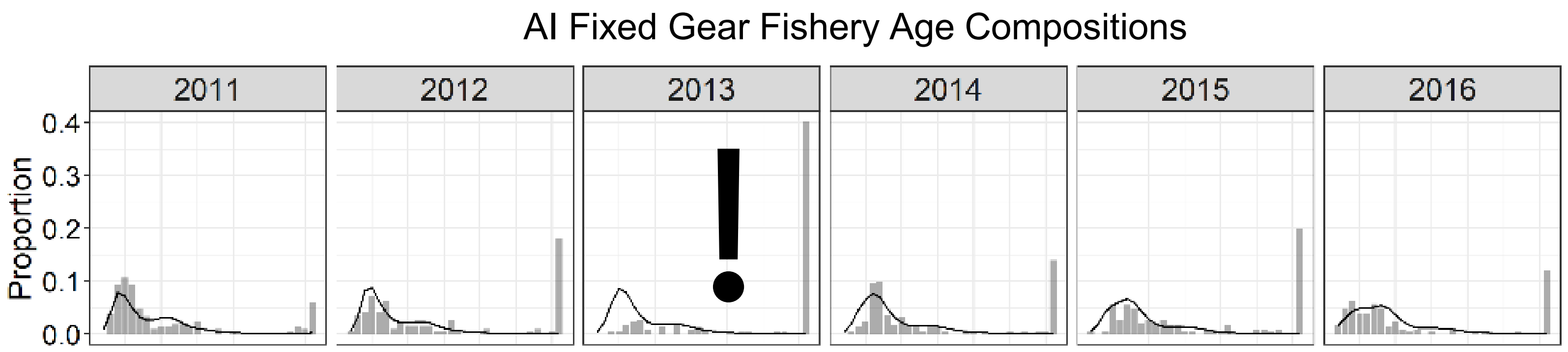
- **Goal:** Evaluate which model structure was most robust to underlying spatial dynamics and NOAA LLS footprint changes
- **Methods**: Spatially explicit closed loop simulation (30 years, 100 iterations) emulating NOAA LLS design changes over time
- **Conclusions**: Spatially implicit (FAA) model performed best (lowest bias, highest stability)
  - All models resulted in similar SSB and catch trajectories
  - Single region model tended to overestimate SSB
  - Spatial model was very unstable





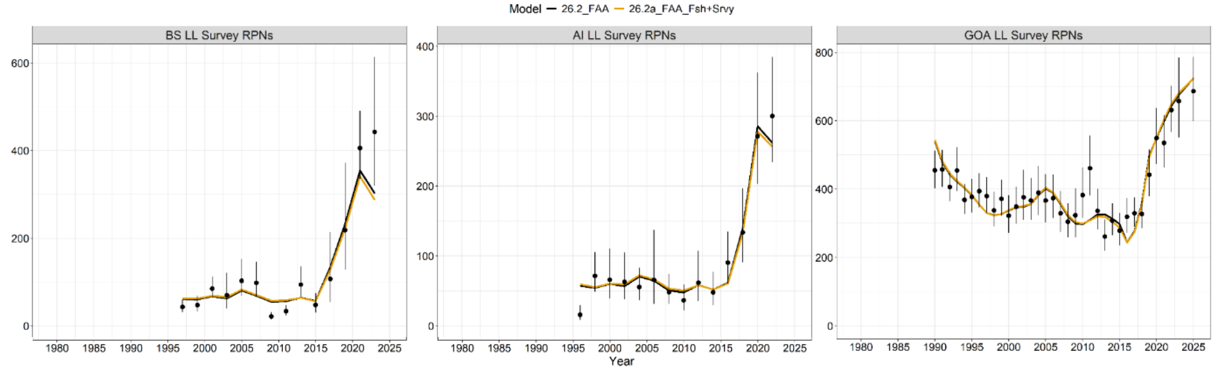
FAA Final Models

- *26.2_FAA*: Add regional fleet structure to only the LLS
- *26.2a_FAA_Fsh+Srvy*: Add regional fleet structure to the LLS and the fixed gear fishery
  - Need to remove fishery selectivity time blocks for stability
  - No domed selectivity
  - Issues with sparsity of fishery data and plus groups

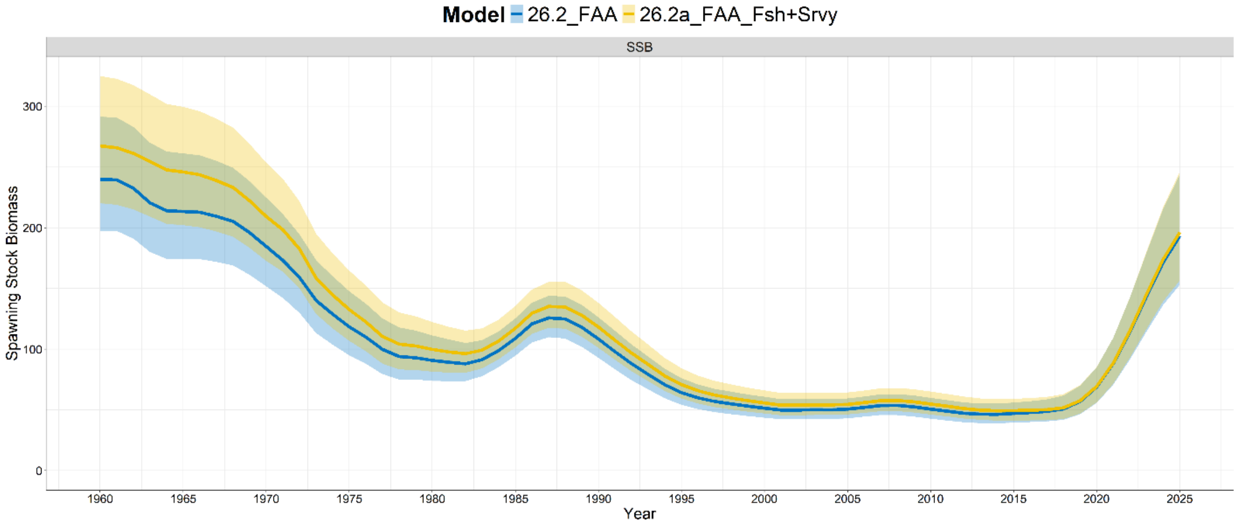


FAA Comparison Summary

- Both models generally demonstrated similar trends and scaling
- Diagnostics were adequate, given difficulty fitting regional trends within a single region assessment
- **Recommendation**: Model ***26.2_FAA*** is the most stable spatially-implicit configuration that addresses LLS data limitations and does not require fitting imputed data



Spawning Stock Biomass (kt)



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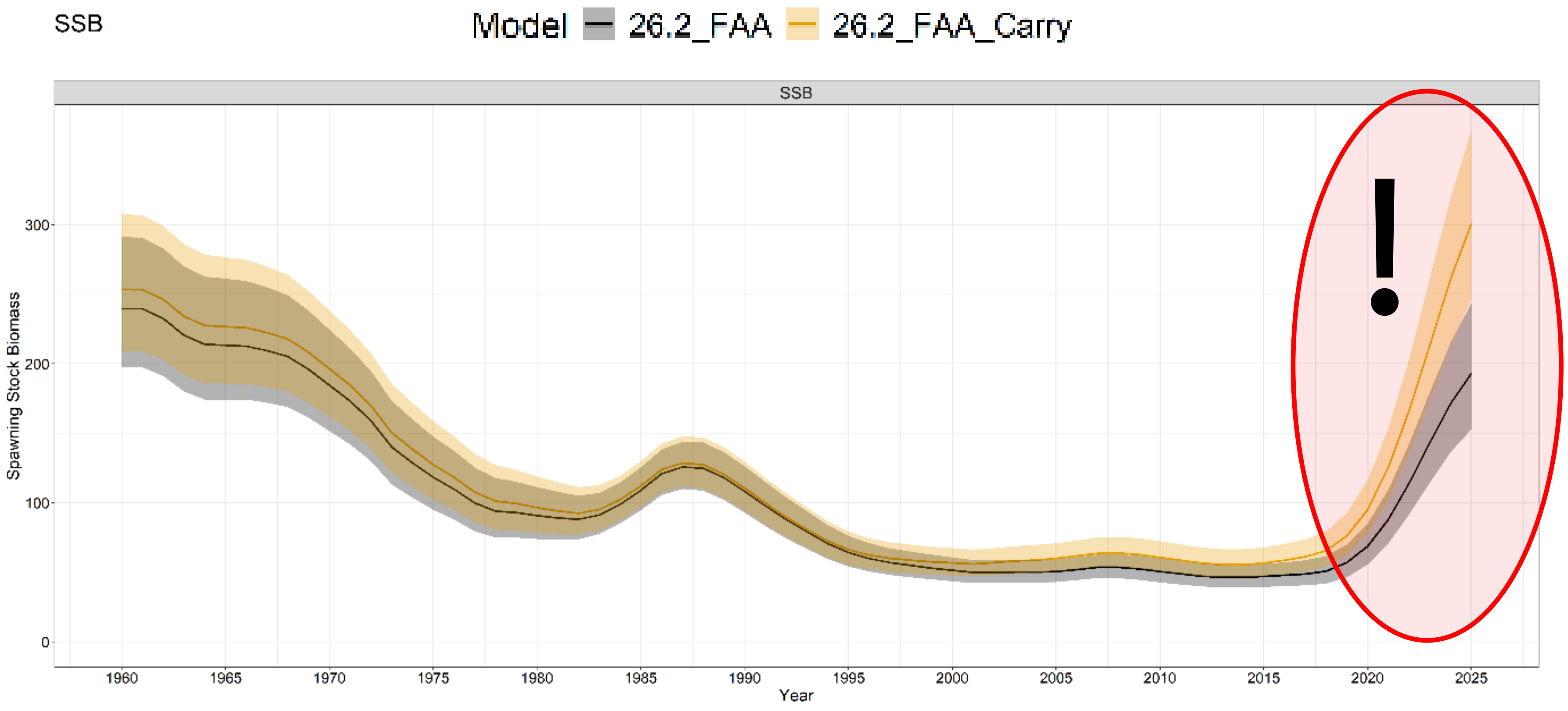
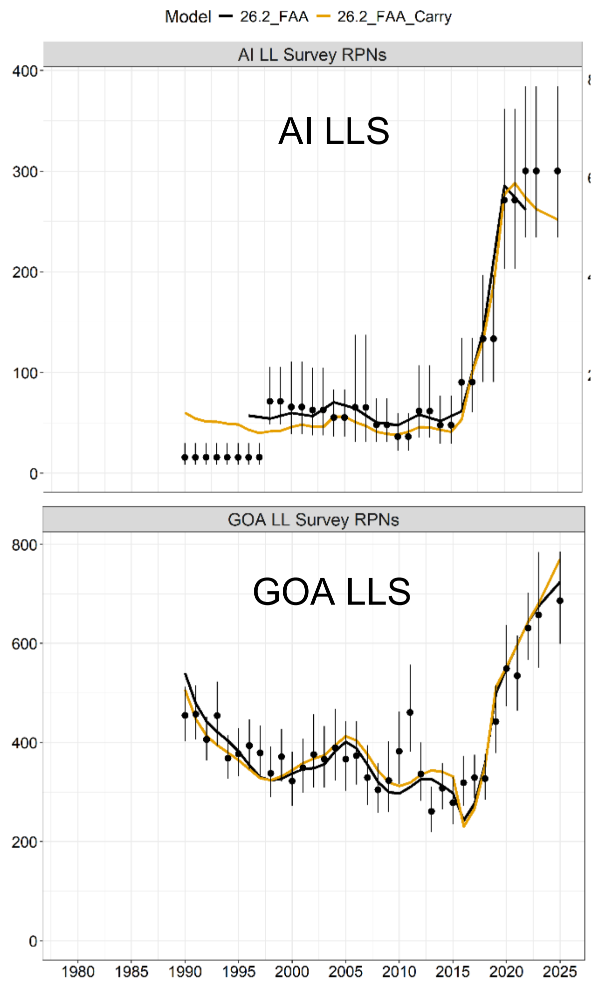
26.2_FAA	1	193.1500	358.1881	0.05874255	31.69570	122.4267	0.08054
26.2a_FAA_Fsh+Srvy	1	196.3059	353.5244	0.05864900	33.14317	120.4123	0.08484

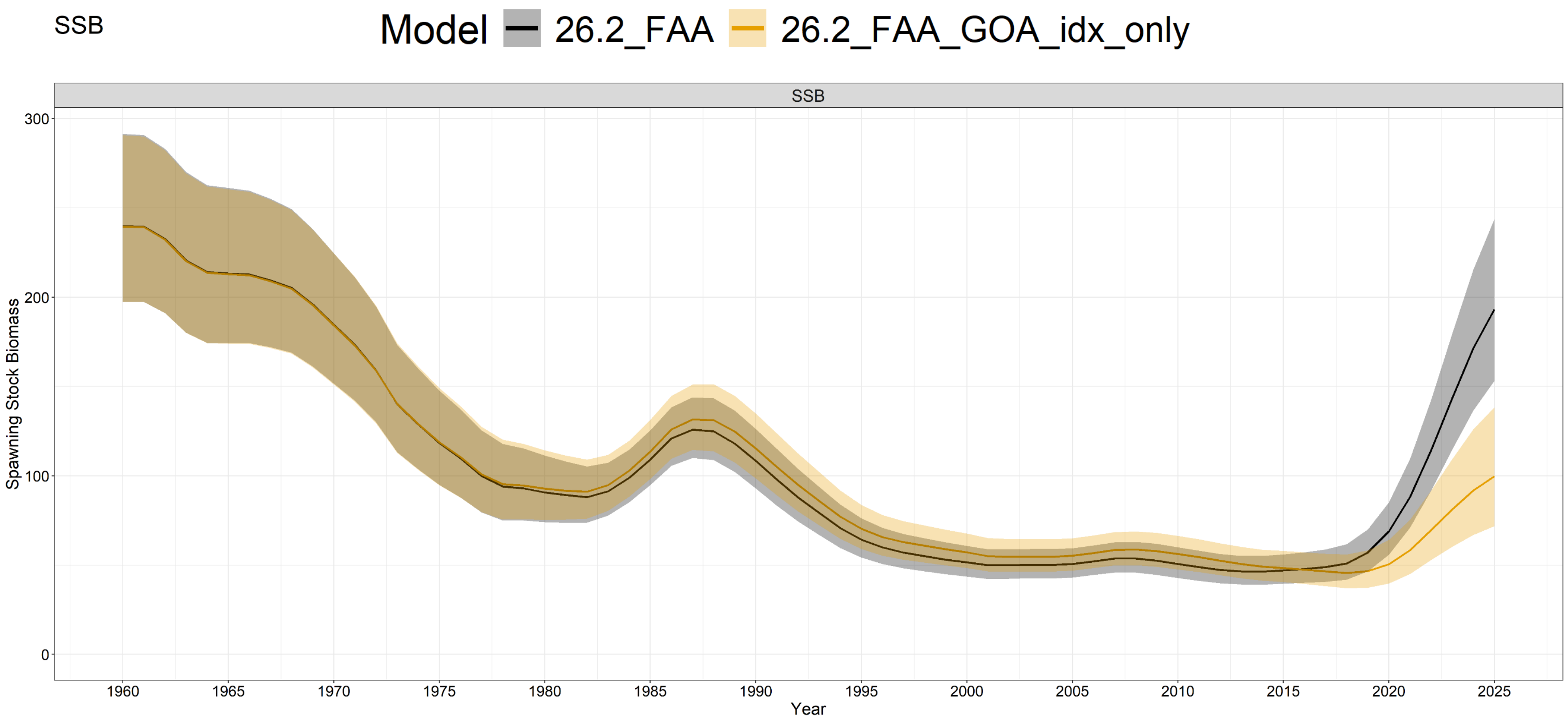
What if: Implemented a FAA Carryover Index?





Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt
26.2_FAA	1	193.1500	358.1881	0.05874255	31.6957	122.4267	0.08054
26.2_FAA_Carry	1	301.1013	462.3924	0.03737749	53.9853	145.3347	0.08519

What if: Only Used GOA Index?

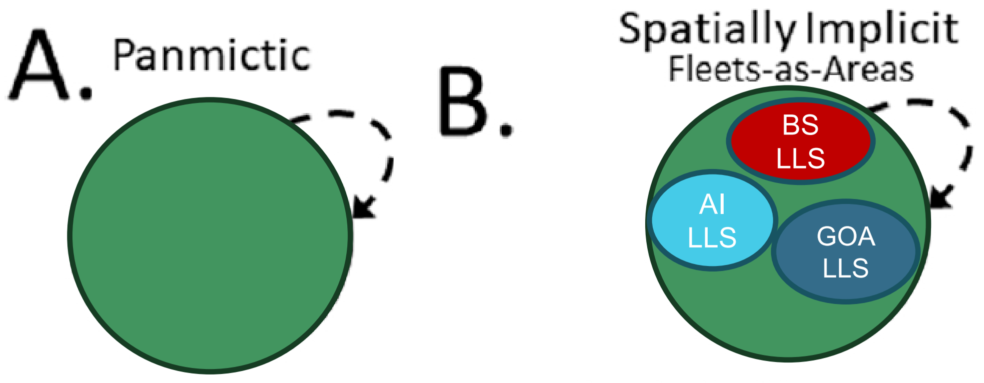


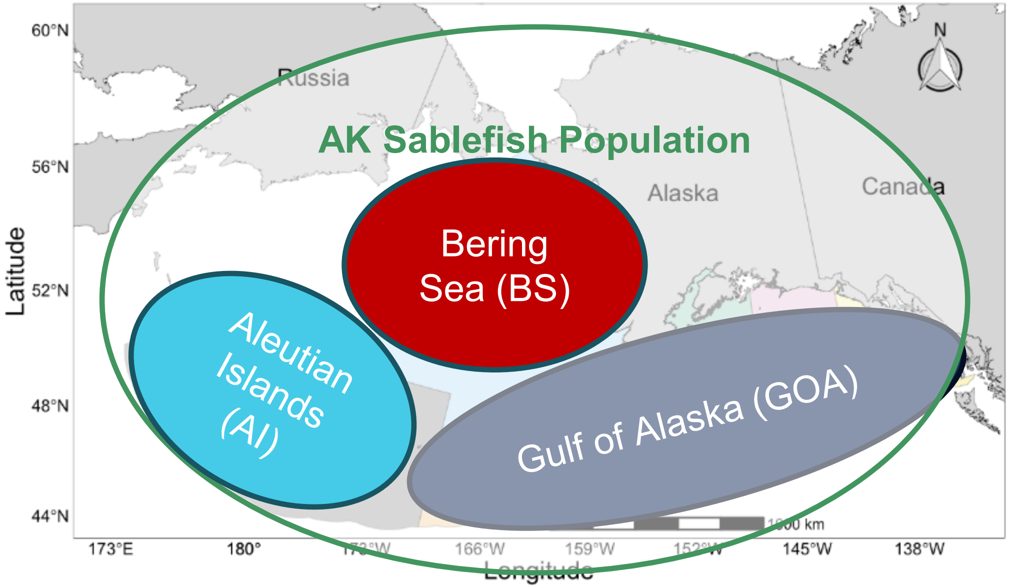
Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt
26.2_FAA	1	193.15003	358.1881	0.05874255	31.6957	122.4267	0.08054
26.2_FAA_GOA_idx_only	1	99.68628	263.9019	0.10053539	$\boxed{17.5747}$	106.6333	0.07584

ABC ≈ GOA BRD

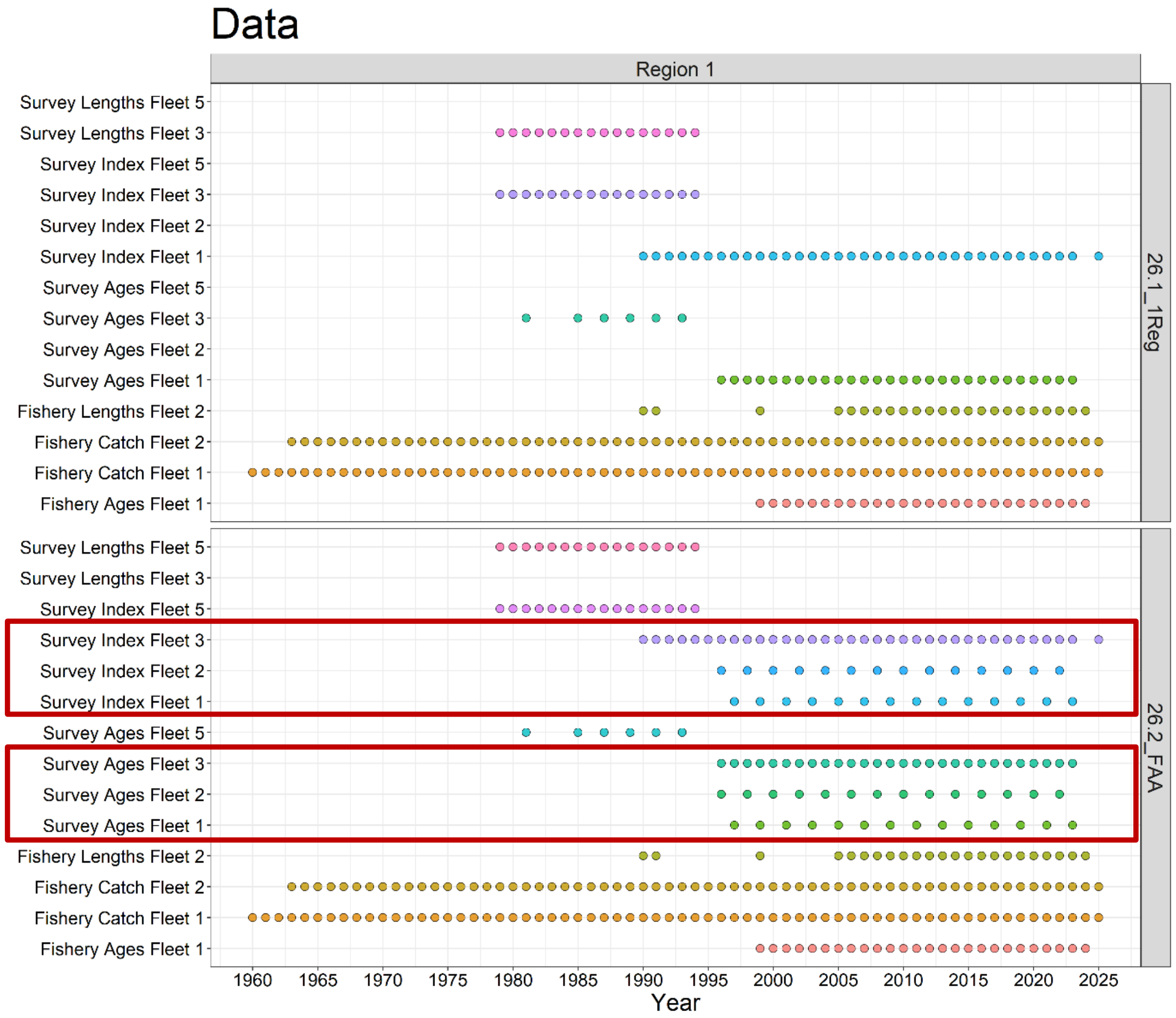
Final Model Comparison

- Two primary models developed that differed only in fleet structure (implicit spatial structure):
  - ***26.1_1Reg*** – Single region panmictic model with no regional fleet structure
    - All data aggregated to a single region
  - ***26.2_FAA*** – Single region, spatially implicit FAA model
    - Implicitly accounts for regional heterogeneity/availability/movement through fleet structure
    - All data aggregated to a single region **except** NOAA Longline Survey indices and age compositions
    - LLS data disaggregated by region – BS, AI, and GOA





Data Summary



- Data updated through 2025 including GOA LLS indices
- Age compositions (LLS, LLF) have 1 year lag (2023 for LLS, 2024 for LLF)

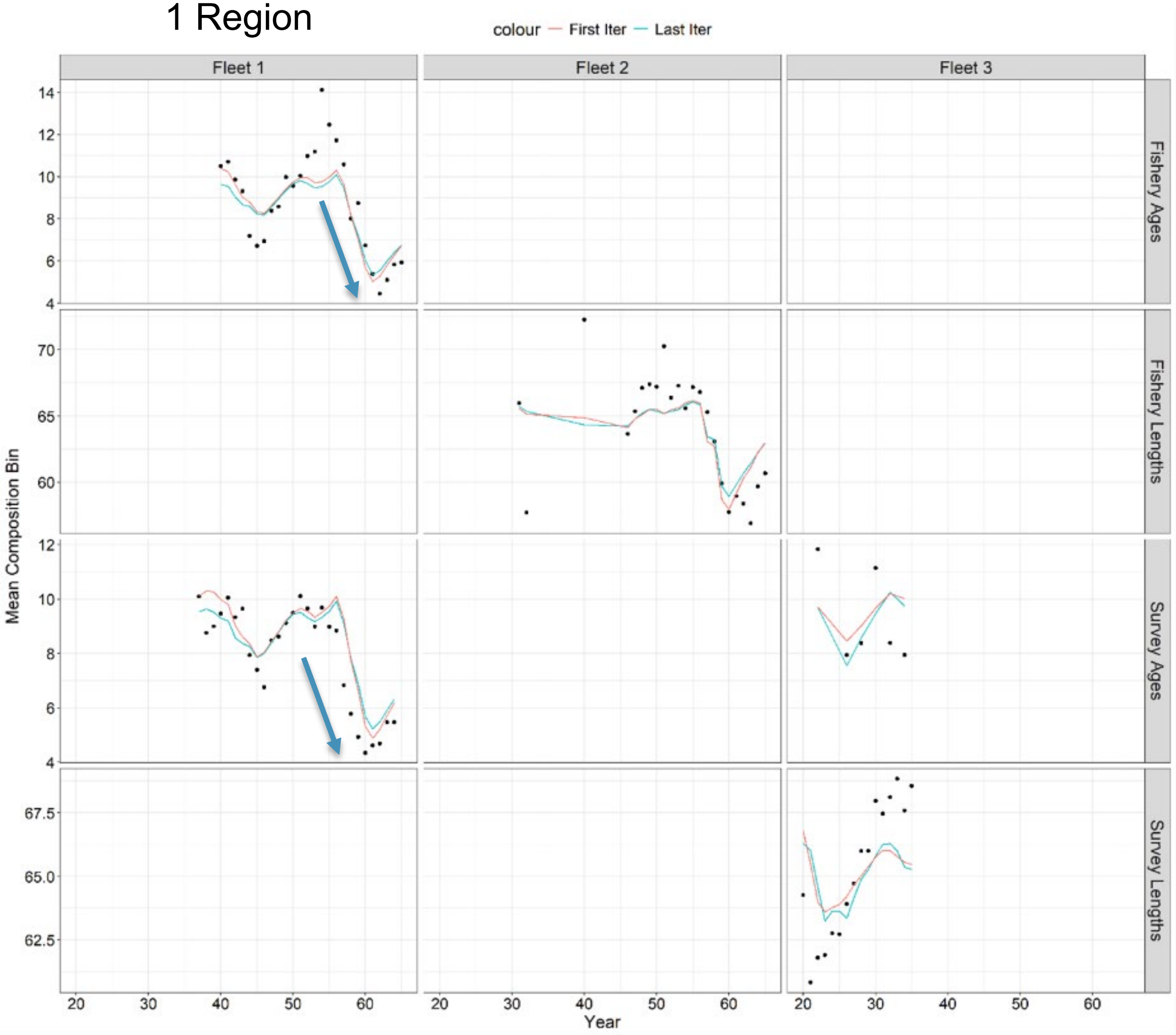
Francis Reweighting and Effective Sample Size

- SE higher for BS and AI surveys
- Composition (age/length) Input Sample Sizes (ISS) scaled within fleets relative to observed yearly samples
  - For FAA model, scaling of NOAA LLS ISS was across regions to maintain information on relative sample sizes across regions
- ESS determined from Francis reweighting
- Strong downweighting of fishery age comps
- For FAA, AI LLS age comps upweighted
  - Better agreement with indices?
  - Intermediary between BS and GOA comps?

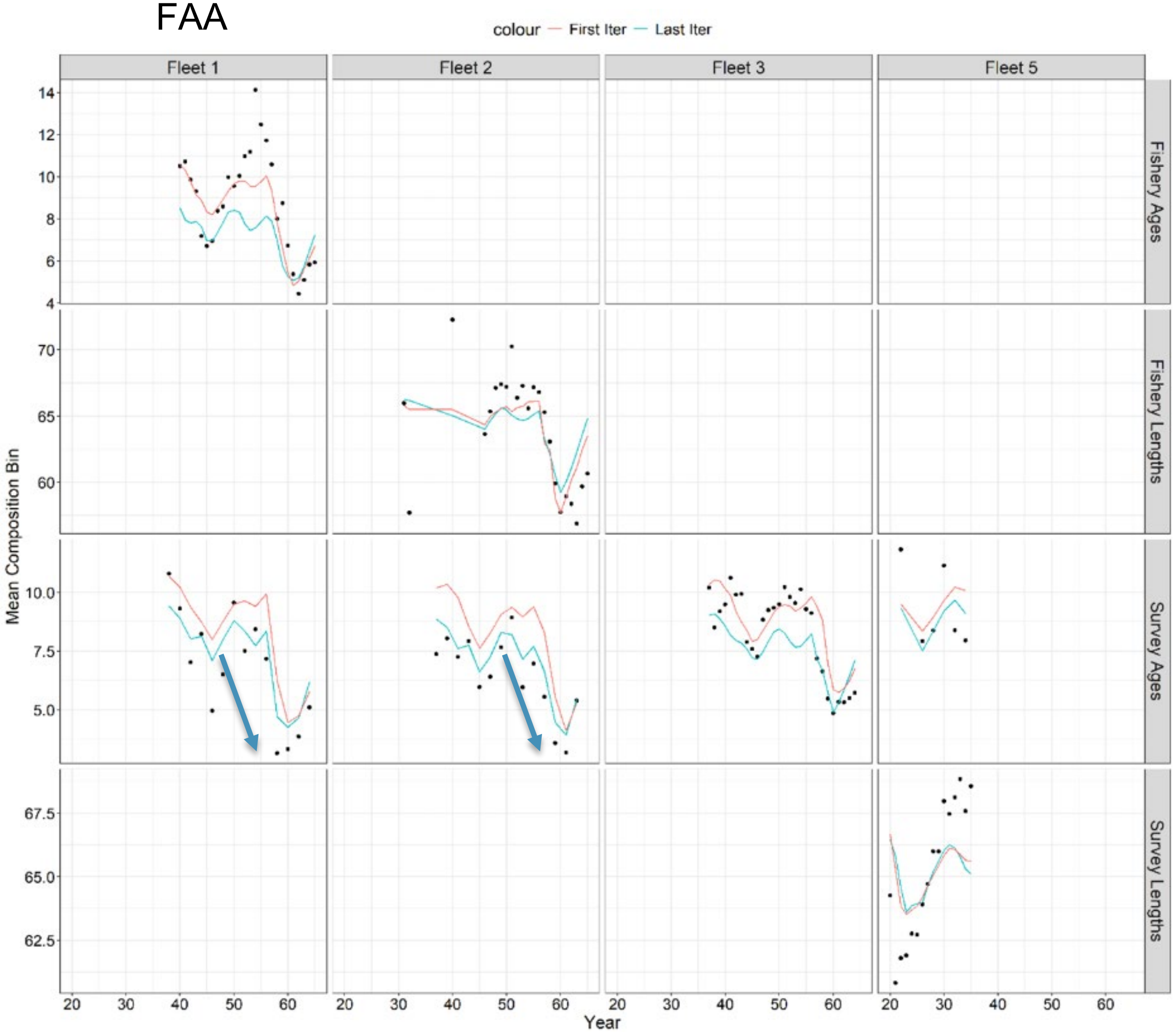
Data Source	*26.1_1Reg*				*26.2_FAA*			
	SE	**ISS**	**Data Wt**	**ESS**	**SE**	**ISS**	**Data Wt**	**ESS**
Fixed Gear Catch	0.05	--	--	--	0.05	--	--	--
Trawl Catch	0.05	--	--	--	0.05	--	--	--
NOAA Longline Survey RPN BS	--	--	--	--	0.20	--	--	--
NOAA Longline Survey RPN AI	--	--	--	--	0.24	--	--	--
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

Fit to Mean Age/Length

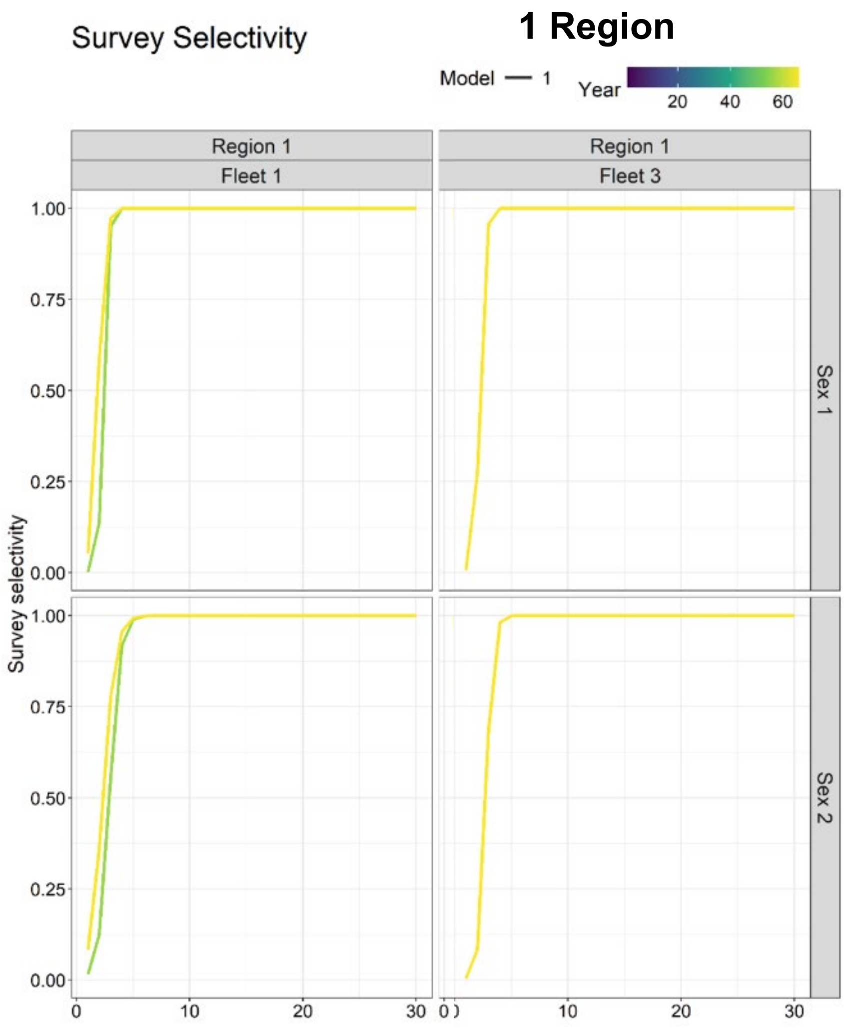
1 Region

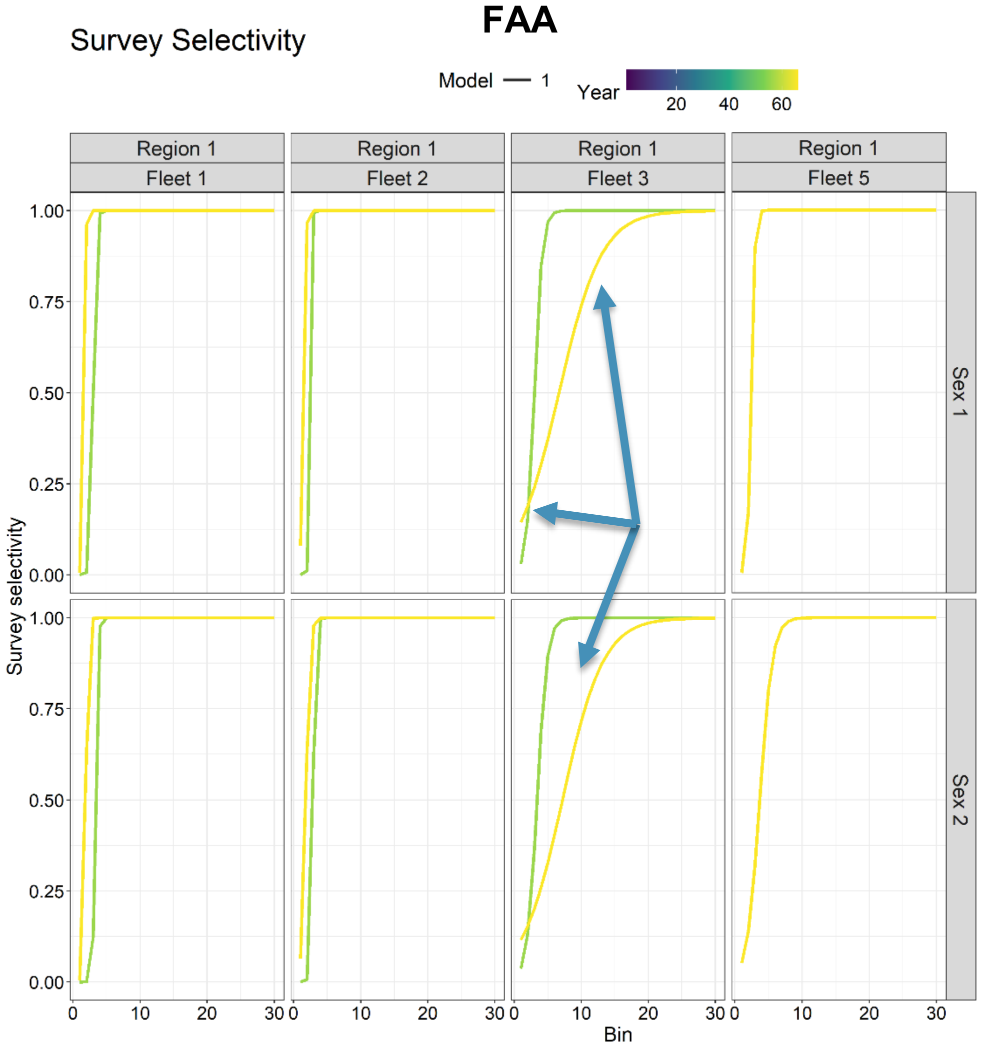


FAA



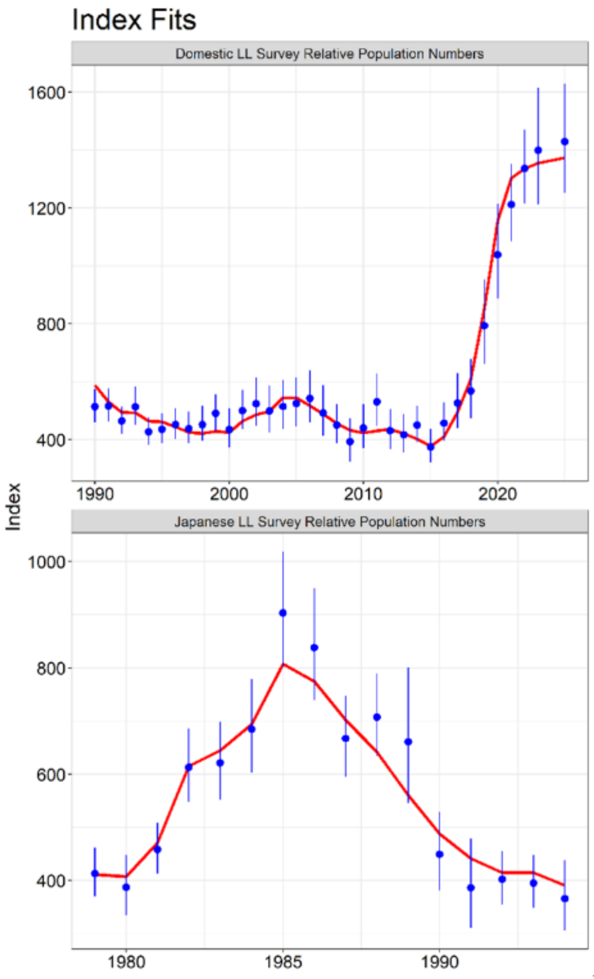
Model Estimates: Survey Selectivity



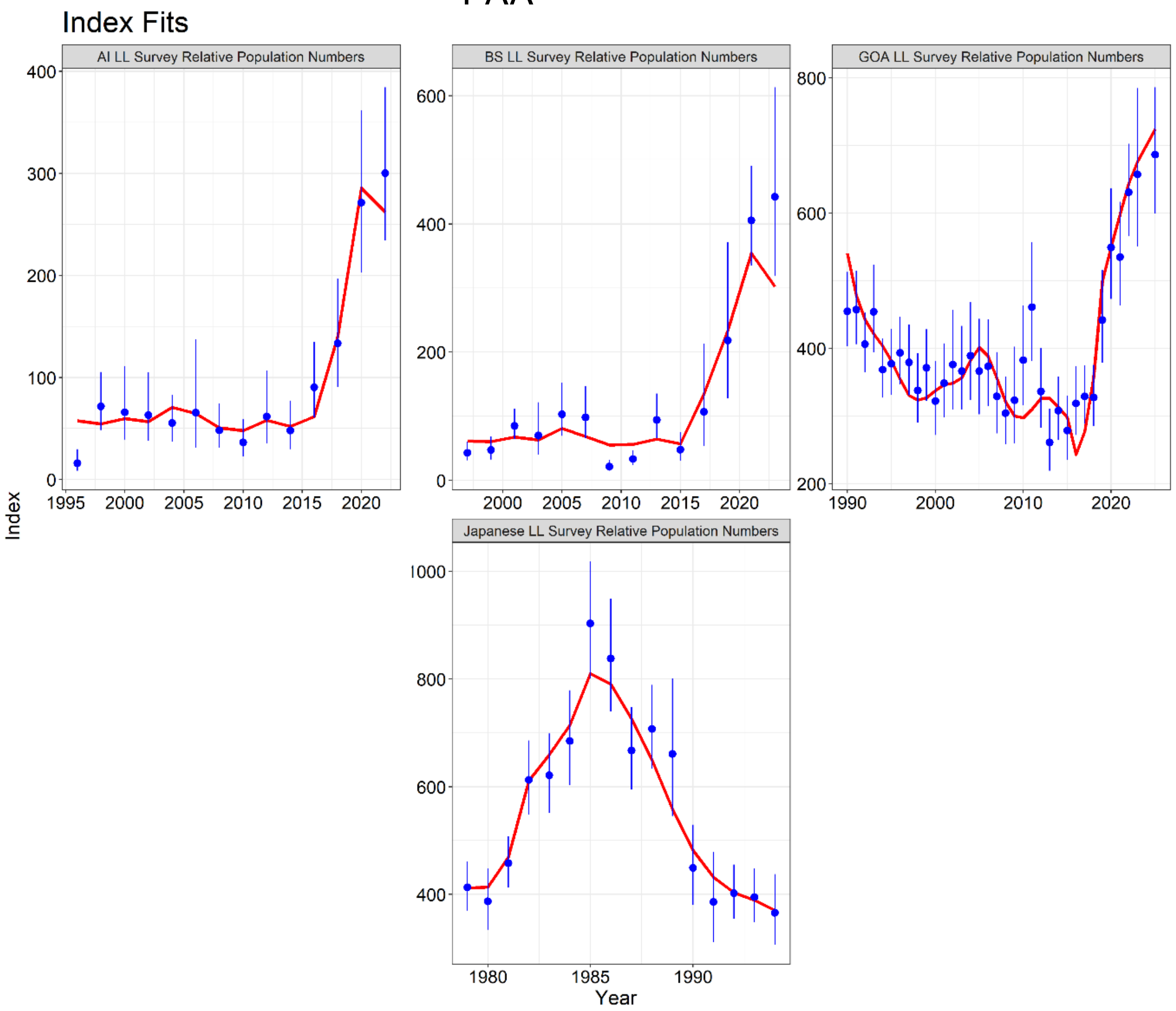


Residual Analysis: Survey Indices

1 Region

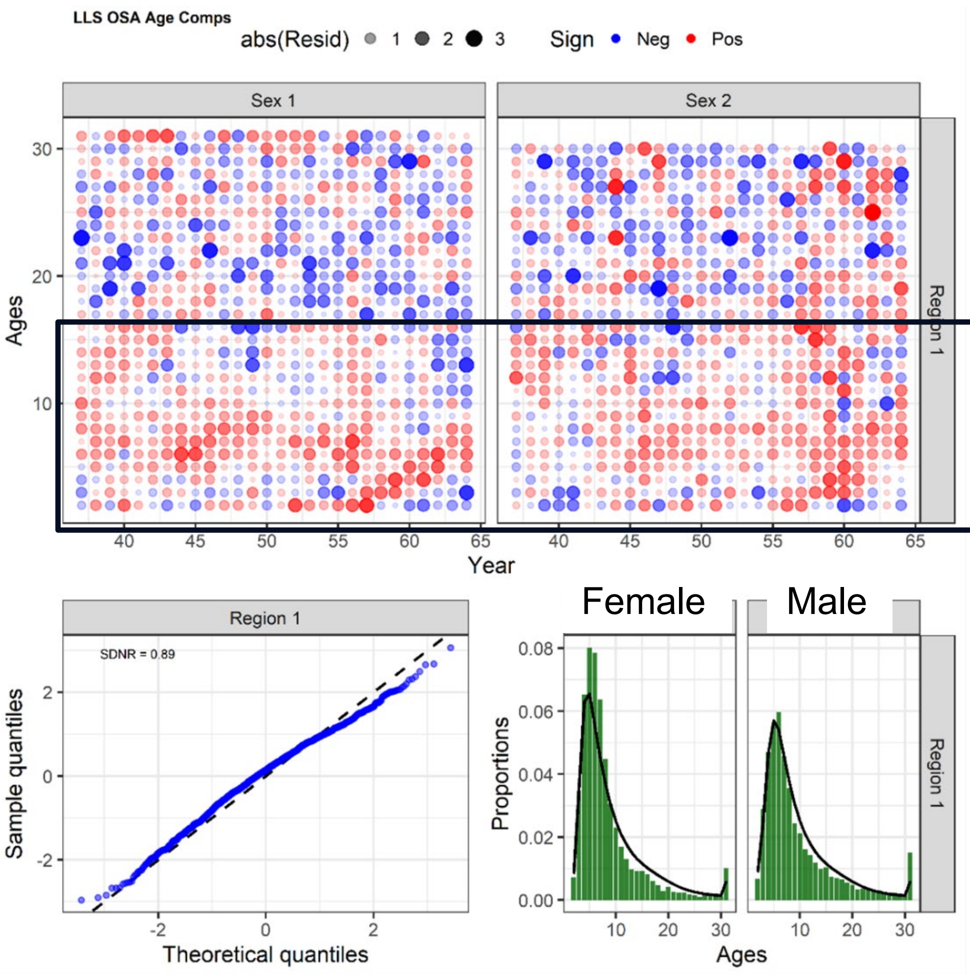


FAA

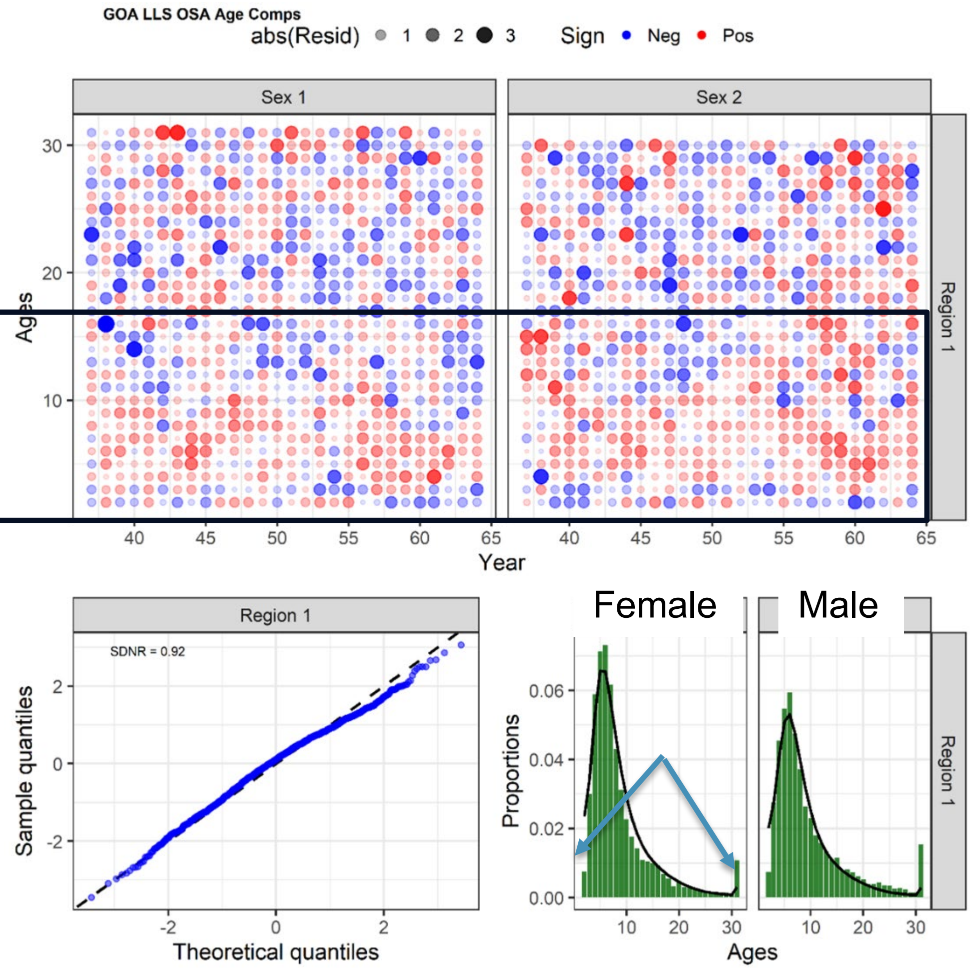


Residual Analysis: Survey Age Compositions OSAs

1 Region

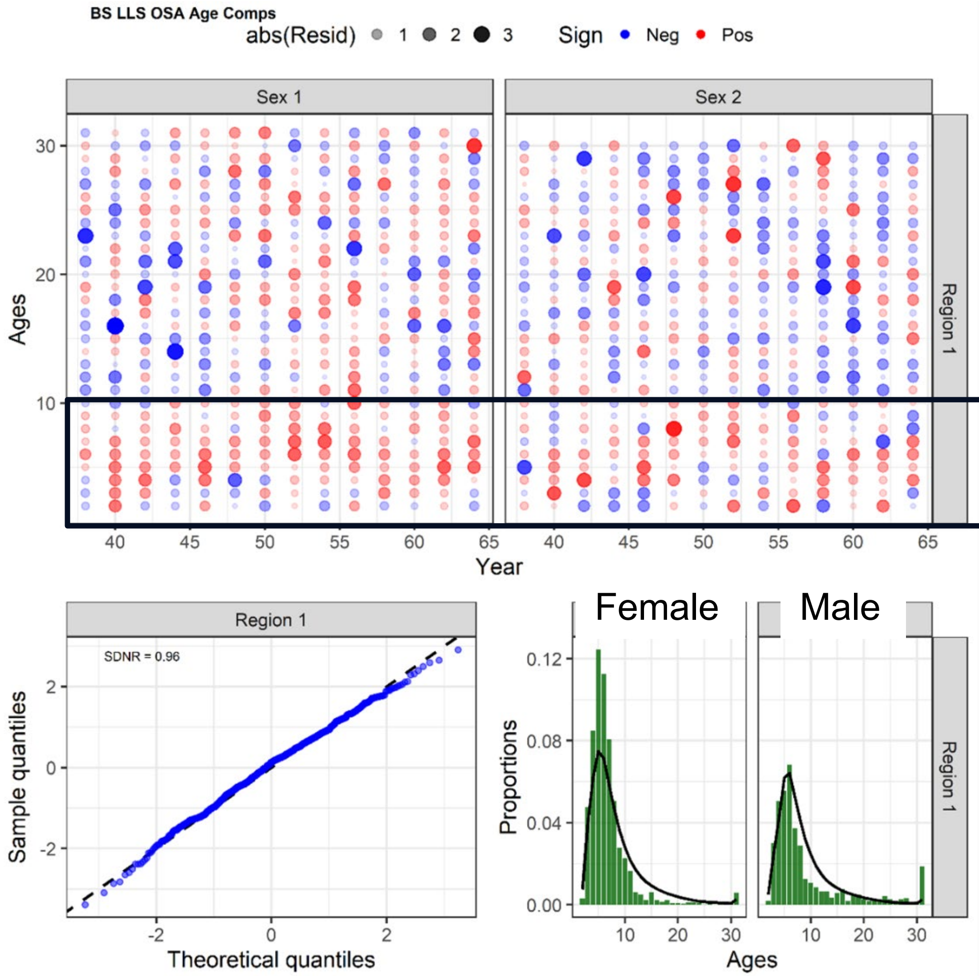


FAA Gulf of Alaska

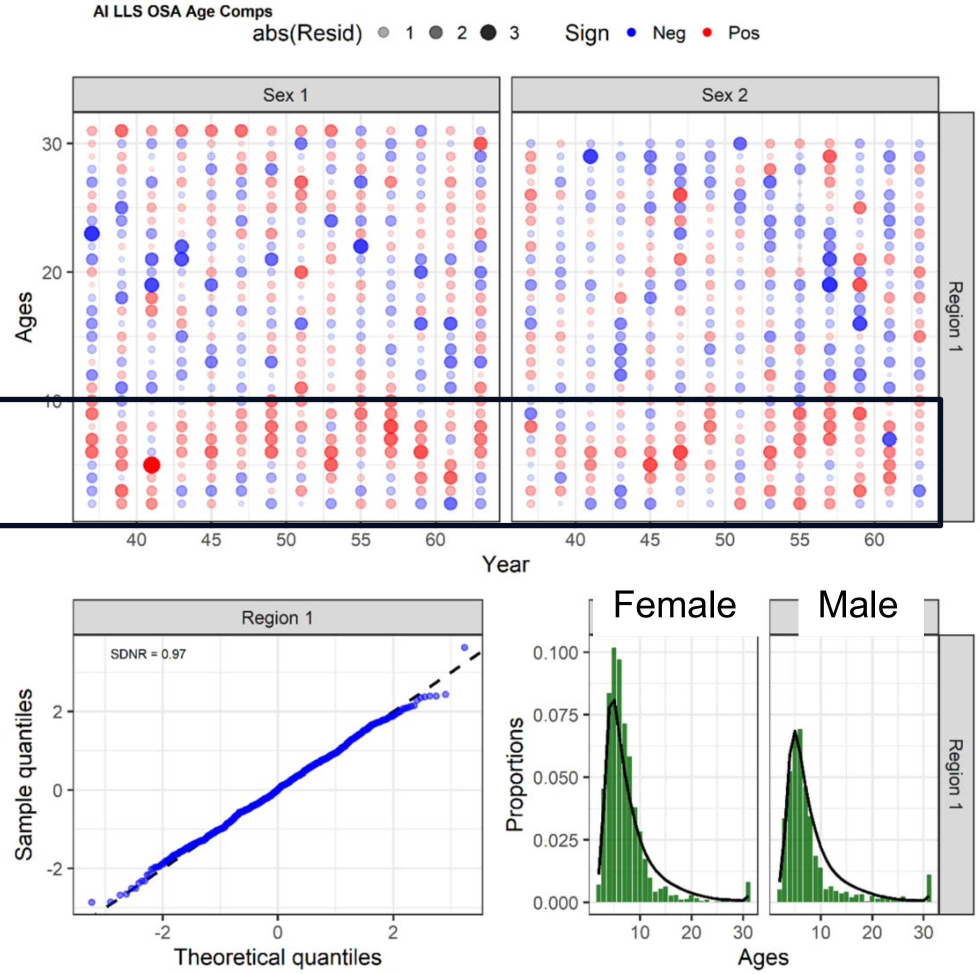


Residual Analysis: FAA Survey Age Compositions OSAs

FAA Bering Sea

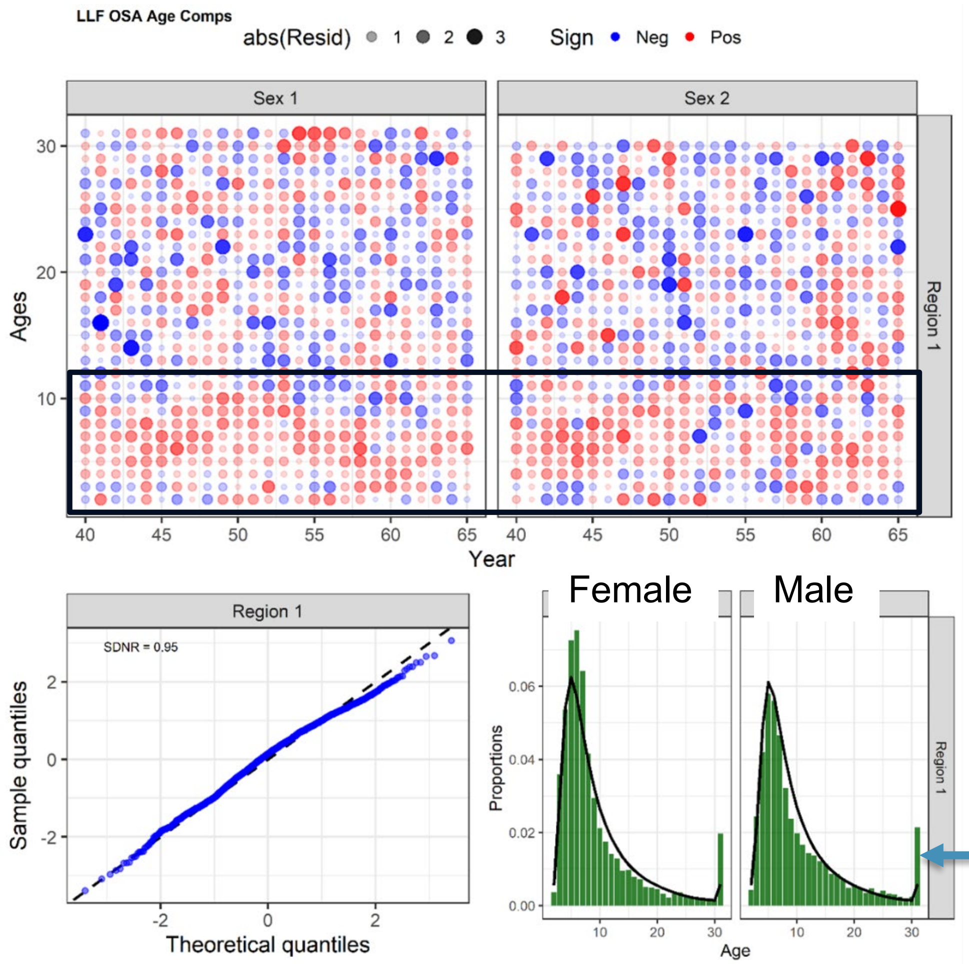


FAA Aleutian Islands

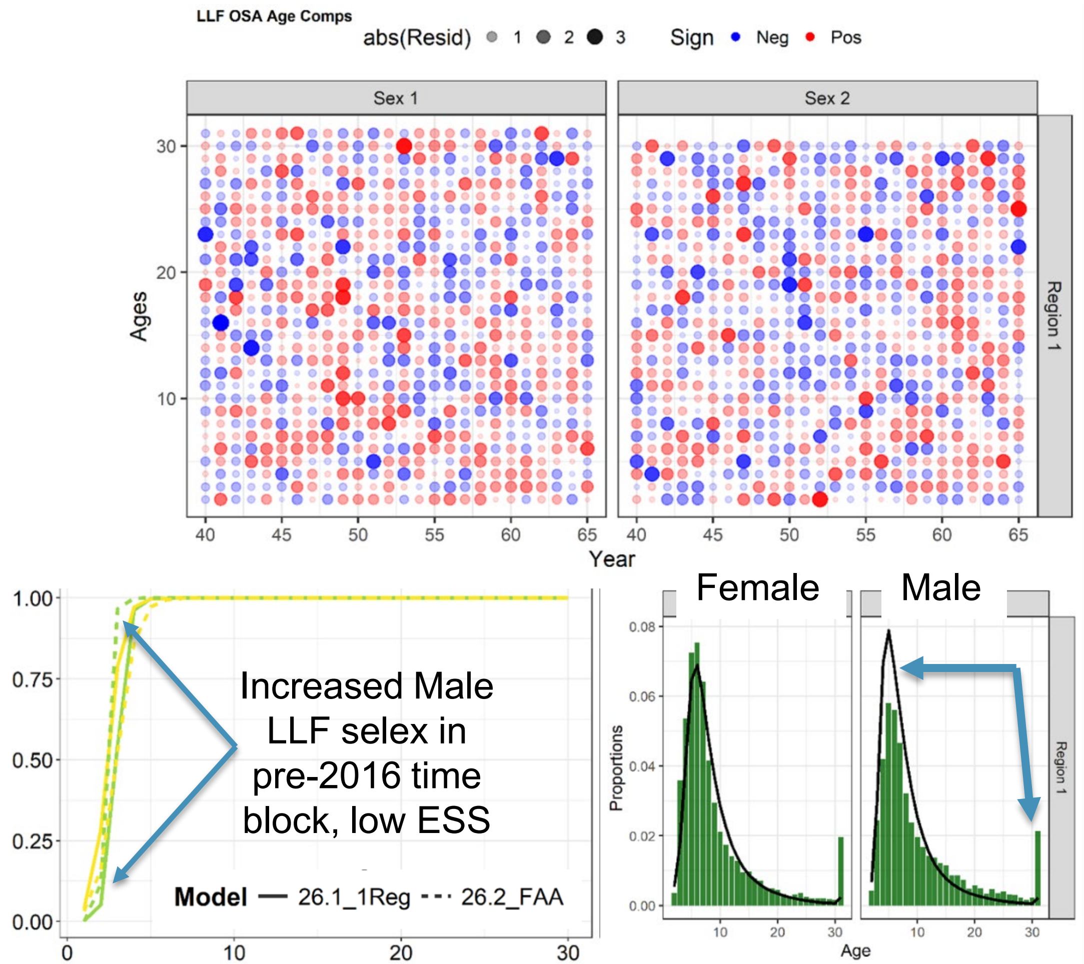


Residual Analysis: Fishery Age Compositions

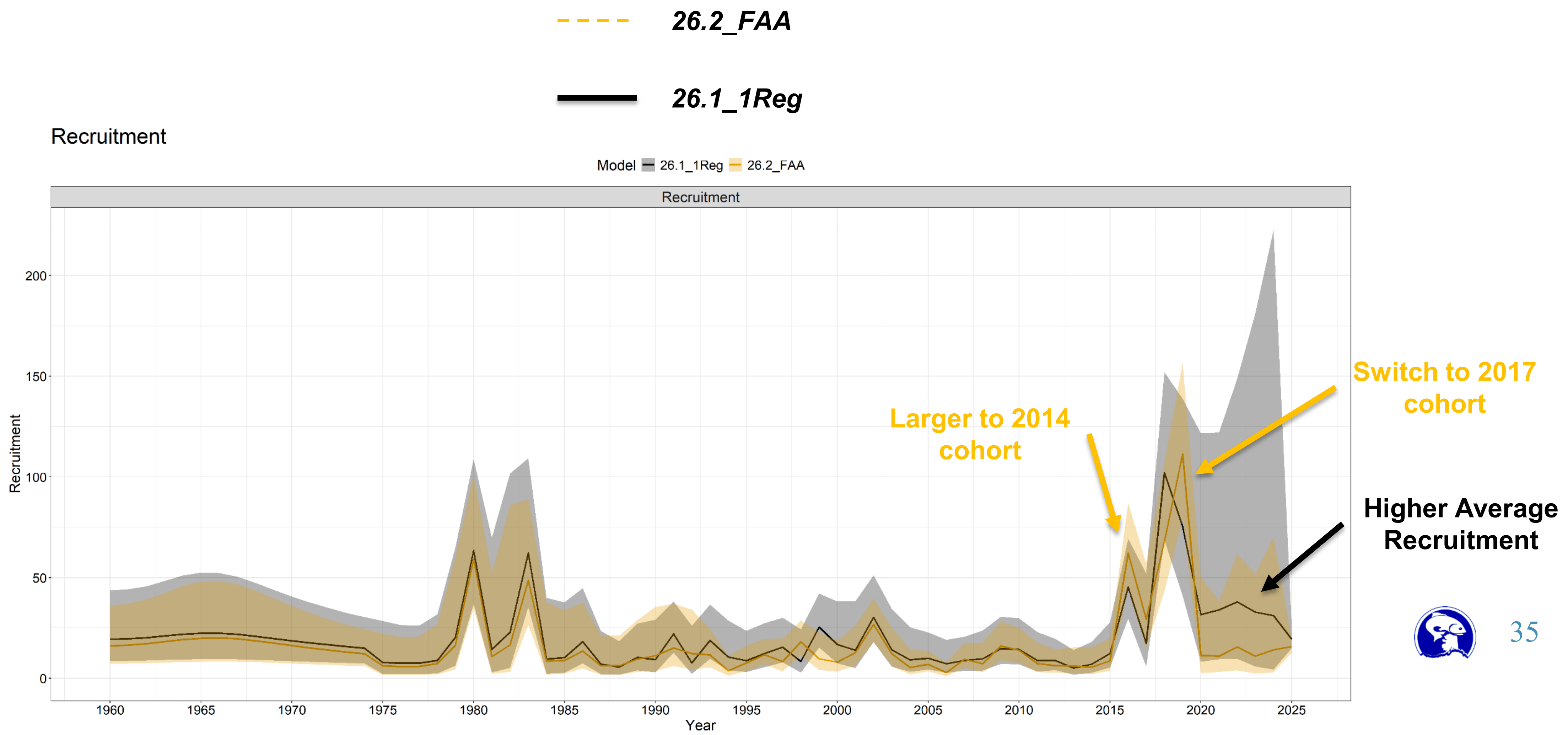
1 Region



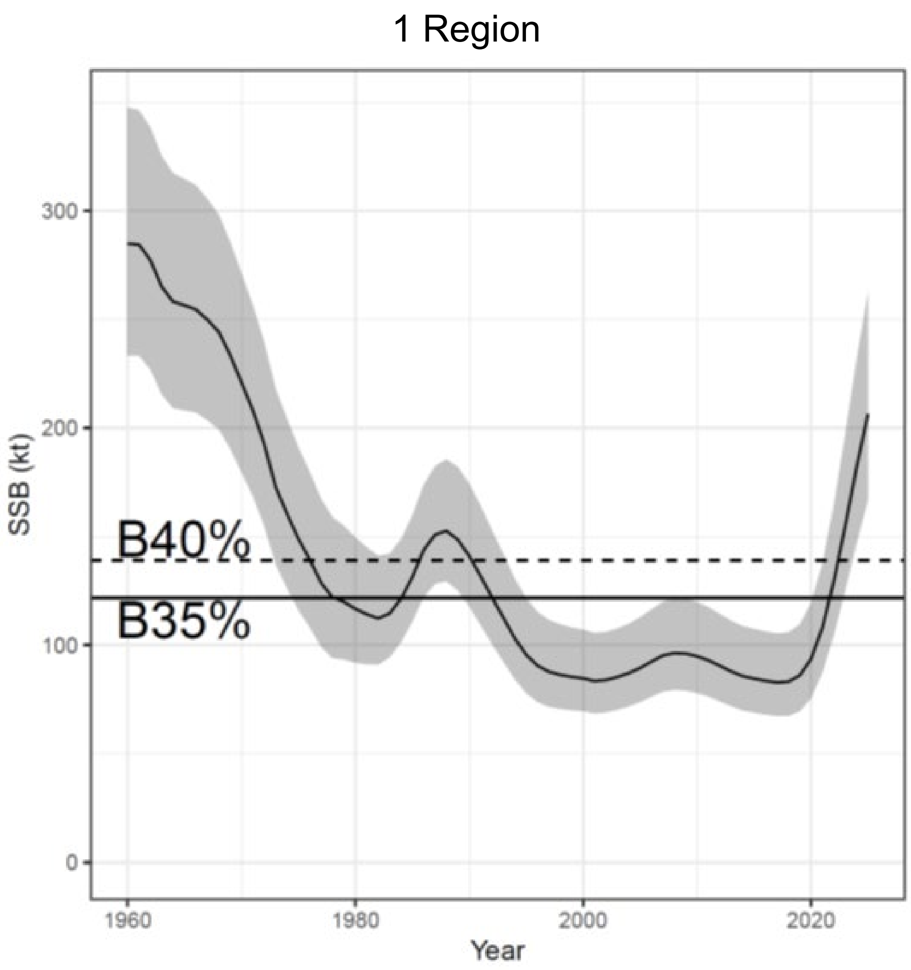
FAA

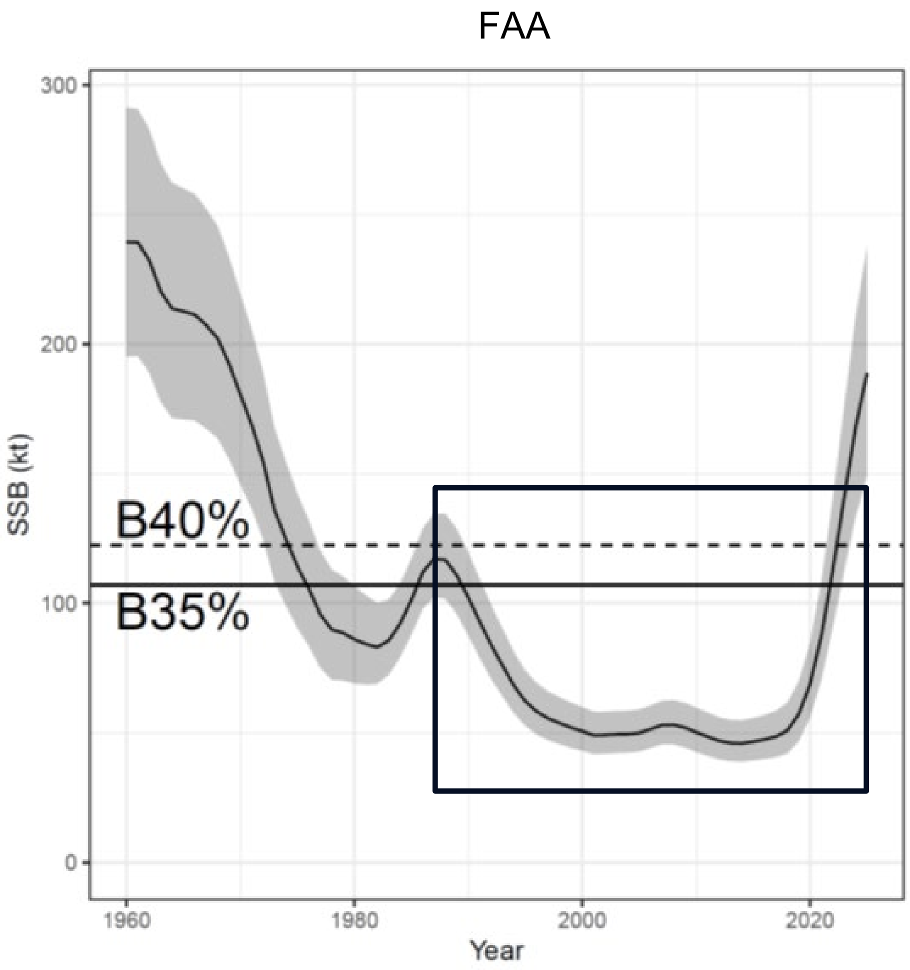


Time Series Trends: Recruitment



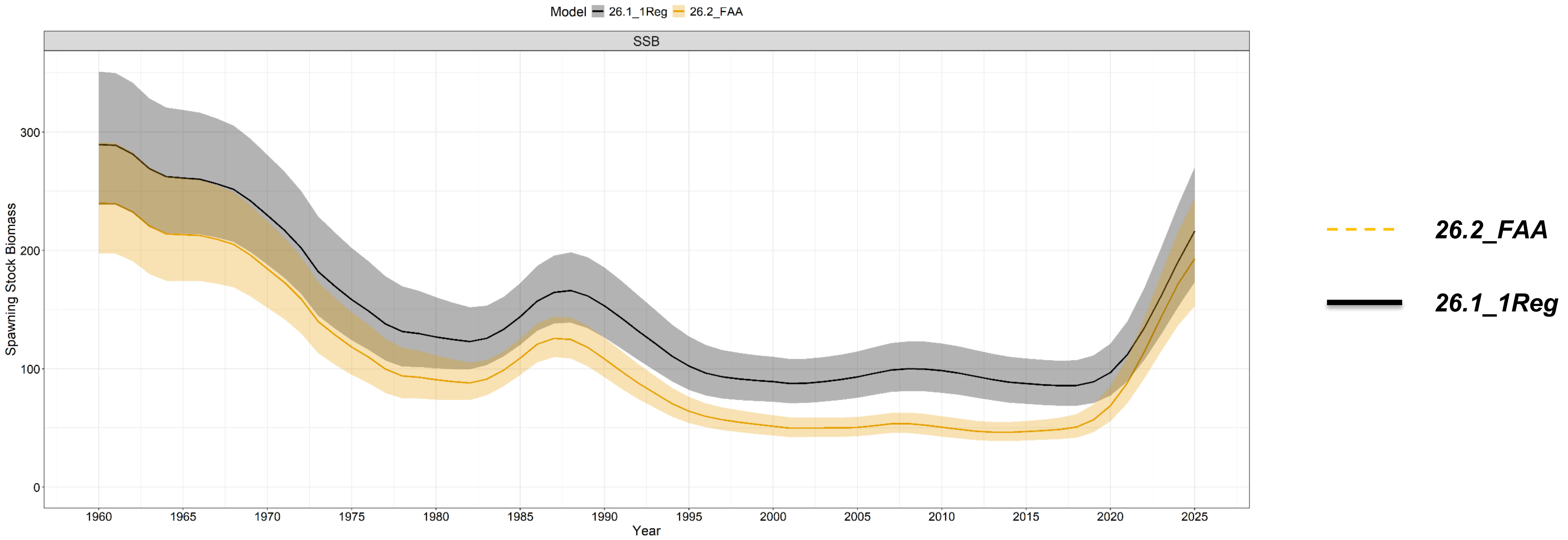
Time Series Trends: SSB





Time Series Trends: SSB

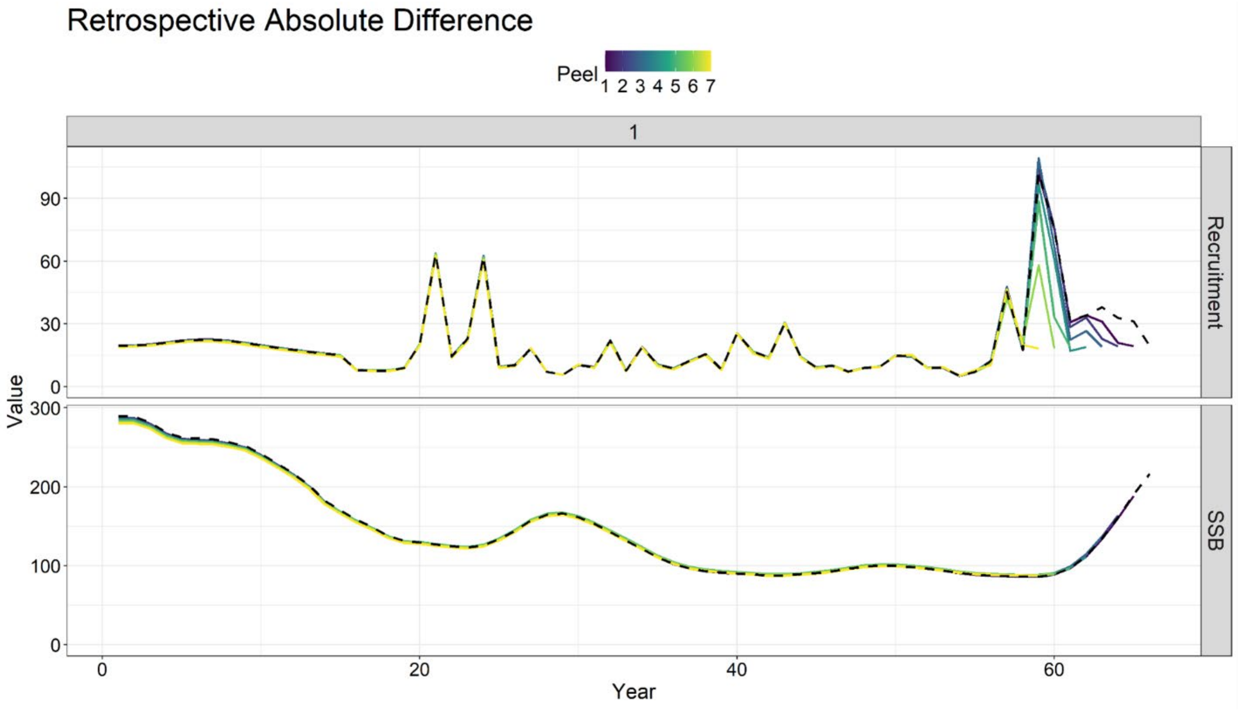
SSB



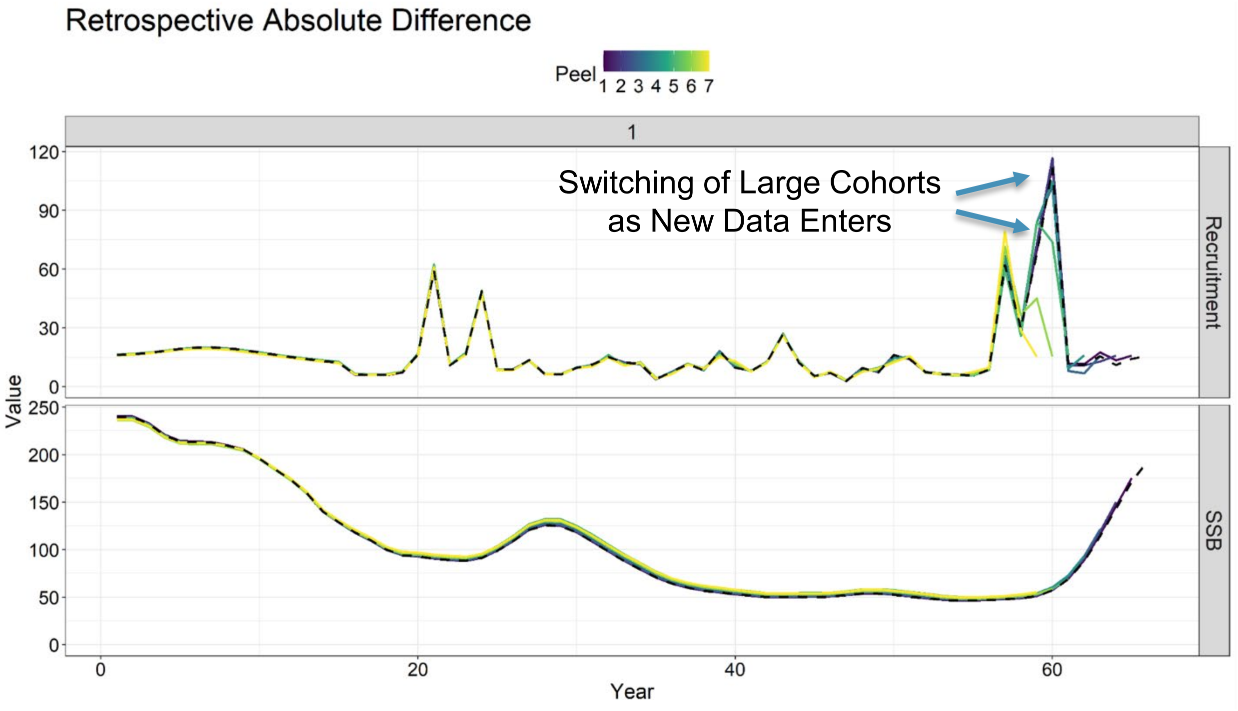
Model	Region	Terminal_SSB	Terminal_SSB0	Terminal_F	Catch_Advice	B_Ref_Pt	F_Ref_Pt
26.1_1Reg	1	216.4521	369.6689	0.04642913	40.85173	139.0172	0.07903
26.2_FAA	1	193.1500	358.1881	0.05874255	31.69570	122.4267	0.08054

Retrospective Analysis

1 Region



FAA



Sensitivity Runs

- Developed same set of sensitivity runs for single region and spatially-implicit models
- Two purposes:
  - Identify impacts of potential time-varying growth and weight-at-age (TVWAA) using methods of Cheng et al. (2025)
  - Explore methods to better fit composition data (DM and ContTVSel)
- Represent a subset of the exploratory model runs implemented throughout the model development process

Model Group	*Model Name*	*Major Changes*
Sensitivity Runs	*26.2_FAA_TVWAA*	(*26.2_FAA+*) Incorporate time-varying empirical weight-at-age.
	26.2_FAA_ContTVSel	(*26.2_FAA* +) Specify continuous semi-parametric time-varying survey selectivity for the domestic NOAA longline survey.
	26.2_FAA_DM	(*26.2_FAA* +) Specify Dirichlet-multinomial likelihoods for composition data.
	26.2_FAA_ContTVSel_DM	(*26.2_FAA* +) Combines *26.2_FAA_ContTVSel* and *26.2_FAA_DM*.

Confronting transitions in fishery fleet structure and selectivity: practical recommendations for integrated age-structured stock assessments based on simulation analysis

Matthew LH. Cheng[a], Daniel R. Goethel[b], Peter-John F. Hulson[b], and Curry J. Cunningham[a]

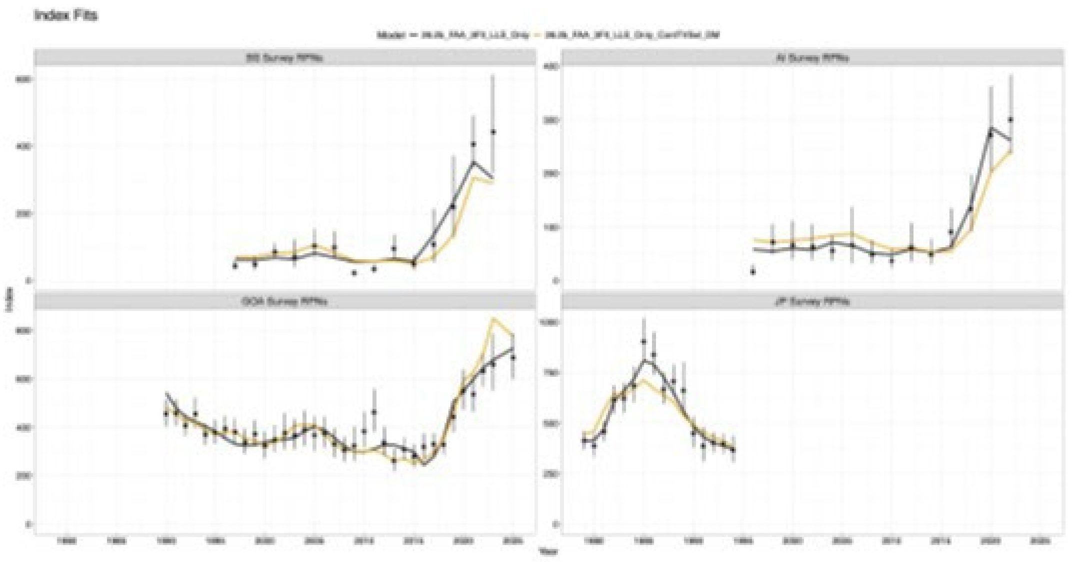
Canadian Journal of Fisheries and Aquatic Sciences

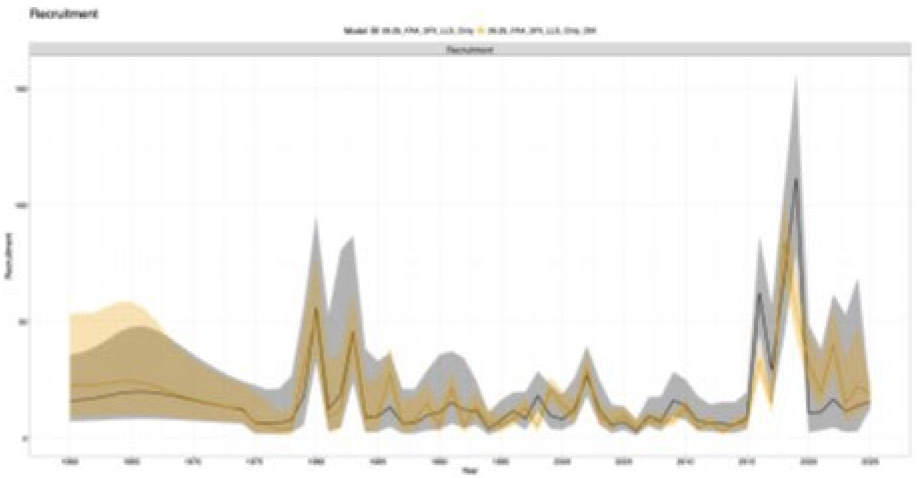
"Slim pickings?": Extreme large recruitment events may induce density-dependent reductions in growth for Alaska sablefish (*Anoplopoma fimbria*) with implications for stock assessment

Matthew LH. Cheng[a], Daniel R. Goethel[b], Peter-John F. Hulson[b], Katy B. Echave[b], and Curry J. Cunningham[a]

Sensitivity Runs: FAA

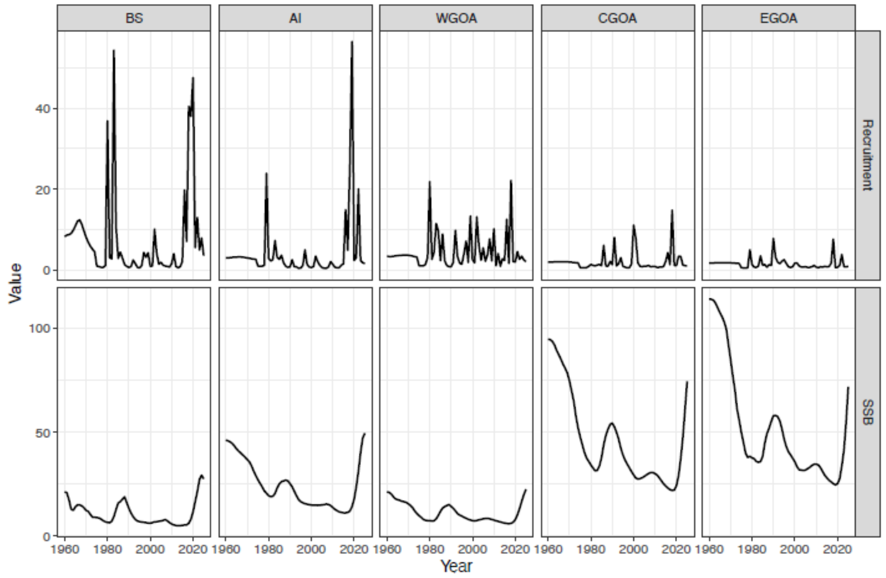
- *26.2_FAA_ContTVSel_DM :*
  - Semi-parametric time-varying survey selectivity
  - Dirichlet-Multinomial likelihood for composition data
- Fits to indices degraded, with some improvements in composition fits
- Retrospective performance is much worse
- Increased variability in recruitment and higher population scale

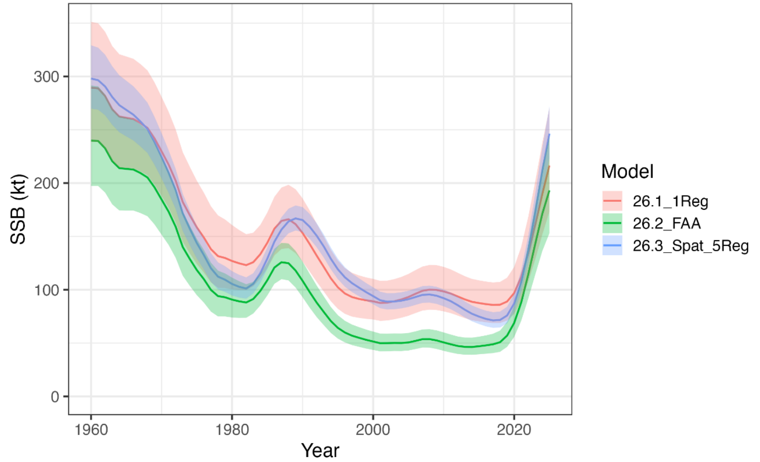




Spatial Model Results

- *26.3_5Reg:*
  - 5 region spatial model
  - Estimates age-varying, time-invariant movement across regions
  - Fits conventional mark-recapture data
- Provides adequate fits to all regional data sources, including tagging data
- Demonstrates similar scaling as the single region models
- Still need to refine parametrization of movement (time-varying) and selectivity (spatially-varying) and how best to handle data weighting (tagging data)





CIE Review

- Reviewers:
  - **Klaas Hartman:** University of Tasmania
  - **Peter Stephenson (Retired):** Department of Fisheries in Western Australia
  - **Sam Subbey:** Institute of Marine Research (IMR)
- ***Aaron Berger (Chair):*** NWFSC
- **NOTE:** going into the CIE review there was no strong model preference, but discussions and feedback emphasized that Model *26.2_FAA* was likely the better approach

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.

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 Review: Feedback

- **“The review concludes that the FAA assessment provides an appropriate and scientifically defensible basis for operational management…and represents the Best Scientific Information Available (BSIA).”**
- *“A brief review of the [SPoRC] codebase indicated that good software engineering practices have been adopted.”*
- “I was highly impressed by the organization, transparency, and professionalism of the review process.”
- “The openness and willingness of the assessment team to engage in scientific discussion represent a model for future assessment reviews.”

CIE Review: Feedback

- *"The data available for the assessment model is likely to be the limiting factor for the assessment, rather than the model structure and approach."*
- **"More otoliths need to read to improve the information on age structure."**
- "The scientific survey is well designed but limited in spatial extent…an expansion back to the previous level would improve model robustness."

Table 6. -- Average, minimum, and maximum numbers of production-species otoliths aged per year by the Alaska Fisheries Science Center Age and Growth Program from 2005-2024.

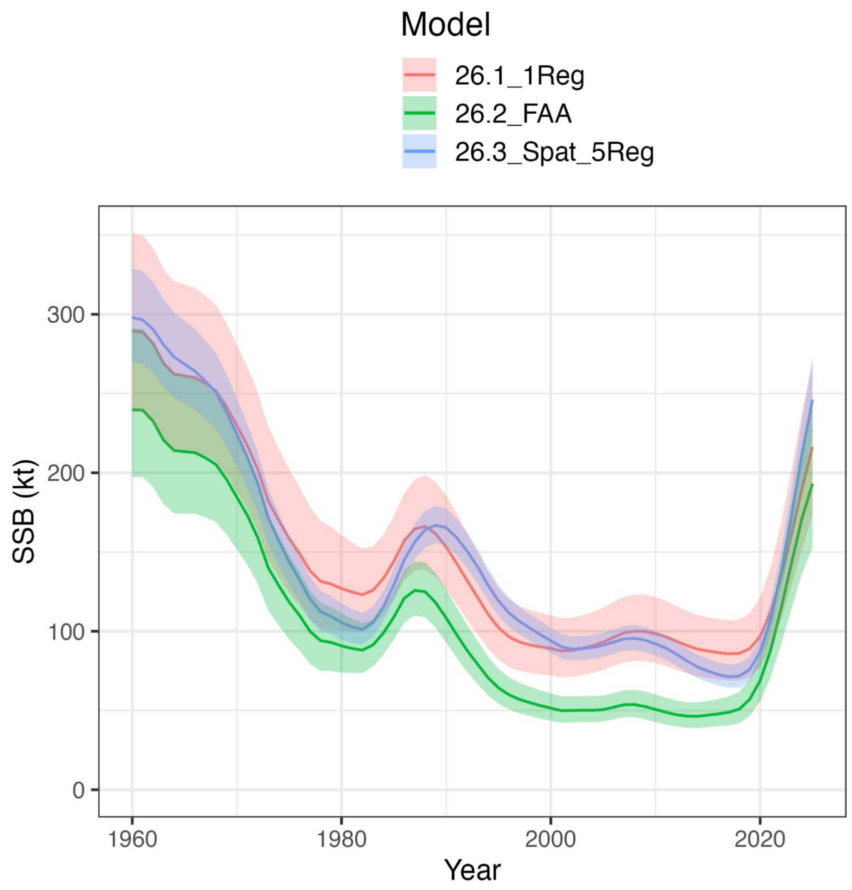
Species	Average	Minimum	Maximum
ALASKA PLAICE	482	258	885
ARROWTOOTH FLOUNDER	1,318	173	2,526
ATKA MACKEREL	1,936	988	4,423
DOVER SOLE	430	161	839
DUSKY ROCKFISH	660	47	1,306
FLATHEAD SOLE	1,828	250	4,128
GREENLAND TURBOT	688	92	2,048
KAMCHATKA FLOUNDER	879	24	2,121
NORTHERN ROCKFISH	1,117	535	1,755
PACIFIC COD	4,036	868	10,146
PACIFIC OCEAN PERCH	2,248	880	3,204
REX SOLE	1,024	119	2,219
ROCK SOLES	1,698	526	6,224
ROUGHEYE/BLACKSPOTTED ROCKFISH	1,287	300	4,738
SABLEFISH (BLACK COD)	2,434	2,177	2,993
WALLEYE POLLOCK	11,141	8,408	14,441
YELLOWFIN SOLE	1,376	490	2,029

CIE Review: Issues to Continue Exploring

- Use more extreme jitter perturbations
- Perform sensitivity analysis to *M* and explore alternate priors (Jeffrey's)
- Continue exploring alternate selectivity functional forms (dome, semi-parametric) and time blocking (TV selex) as more age compositions become available
  - BUT, *do not* use time-varying selectivity or DM at this time, given instability
- Perform simulations to identify optimal age composition sample sizes
- Explore spatial patterns in CPUE, observer sampling, and fishery behavior
- Do AK-wide larval dispersal modeling to better understand recruitment
- Deploy more satellite and archival tags and develop protocols for analyzing tag tracks (HMMs with geomagnetic data)
- Make the spatial model operational! (and address spatial reference point/HCRs)

Conclusions: Model Performance

- Neither model resolves issues with fitting composition data
  - The tension between fitting LLS age compositions and indices remains regardless of structure
  - Moderate age composition residual trends, but aggregate fits are adequate
  - Plus group is being strongly underestimated
- Other diagnostics do not show any major issues with either model
- Population trends generally align, but scaling has decreased moderately in *26.2_FAA*
  - Impact of imputed data in single region LLS index?
  - SSB and catch advice decline considerably
- Moderate differences interpreting recent recruitment dynamics
  - *26.2_FAA* better reflects recruitment signals from BS and AI (stronger 2014 + 2017 cohorts)
- Sensitivity runs fail to improve model performance



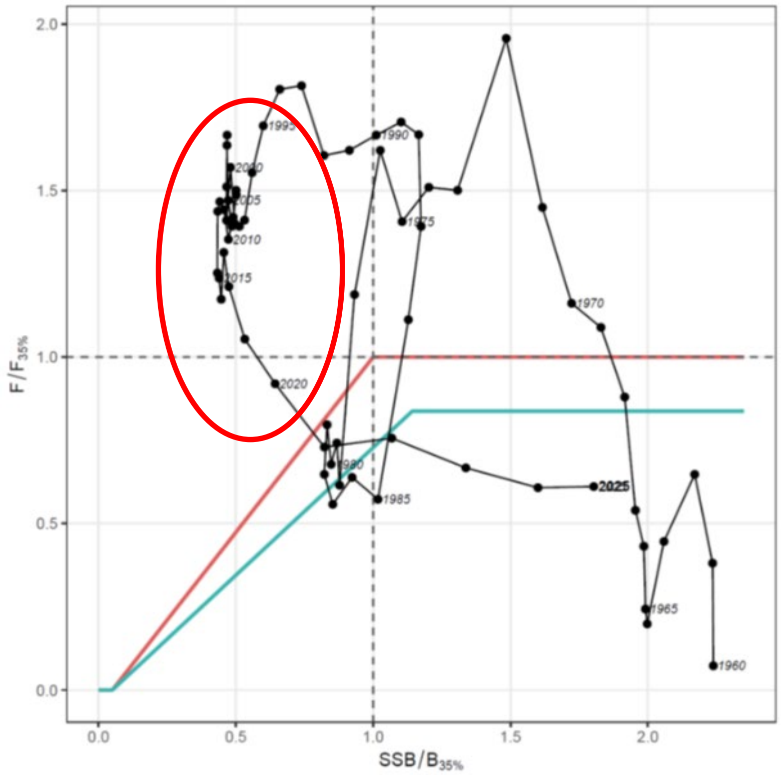
Conclusions: Model Tradeoffs

- Choice of model structure for sablefish is a tradeoff between:
  - Model stability
  - Assessment complexity
  - Assumed data representativeness
- Single region model is stable and provides good diagnostics, but…
  - Requires fitting imputed index data
  - Likely overrepresents GOA data in the compositions
- FAA model foregoes the need for using imputed data, but…
  - May be more unstable
  - Might overinterpret signals from sparse composition data (e.g., if the noise to signal ratio is high)

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.	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	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.

Conclusions: Model Choice

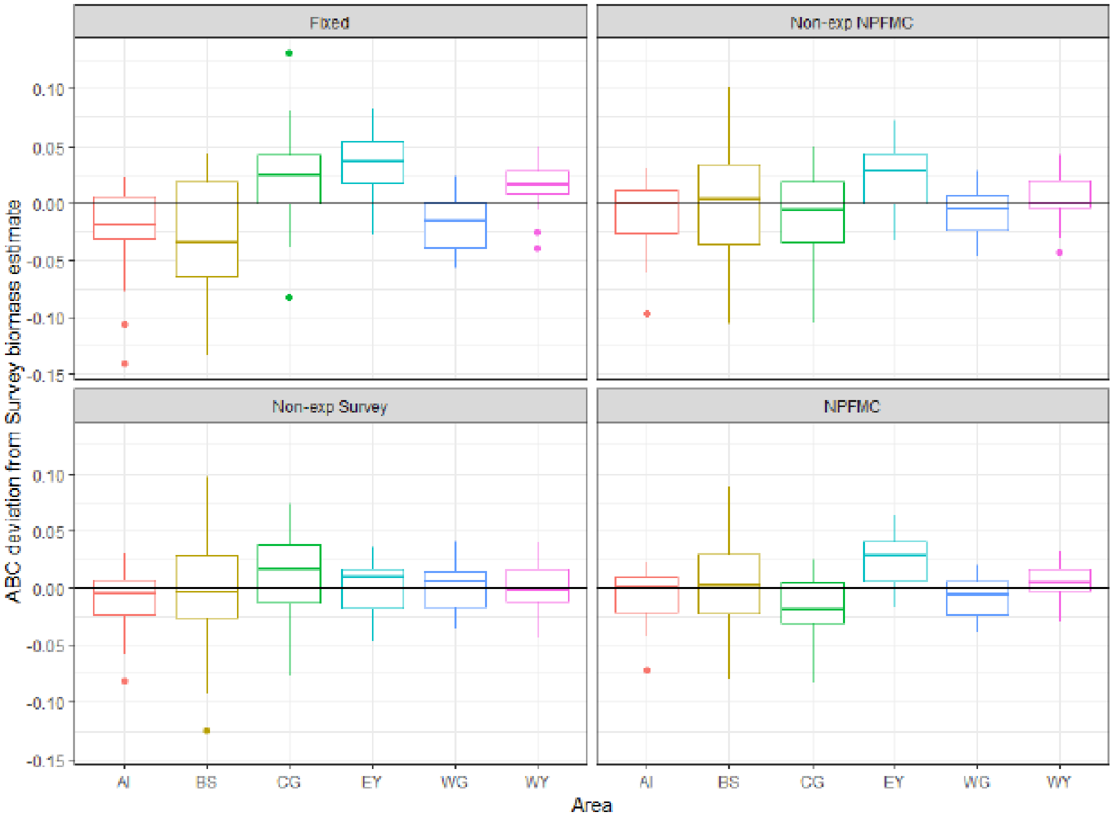
- **Model *26.2_FAA* is the recommended model for 2026**
  - Provides best balance of parsimony, complexity, stability, and performance
  - The CIE endorsed Model *26.2_FAA* as providing the Best Scientific Information Available
  - Will also present results from *26.1_1Reg* in November (but no plans to update Model *25.12_Cont*)
  - *'The sablefish assessment is currently **limited by data** (age compositions) and **more complex modeling or statistical assumptions are unlikely to provide further improvements** in model performance' – CIE Reviewers*
- Concern that using 'carryover' (or imputed) values for single region index may inflate population scale in Model *26.1_1Reg*
- *26.2_FAA* demonstrates a more pessimistic management history
  - Well above fishing mortality targets for much of the 2010s
  - **But the change in ABC across model options IS NOT due to a biological change/concern, simply due to an update of the model structures**
  - May warrant consideration of how to handle short-term quota changes…



Apportionment

- Goal:
  - **Distribute catch regionally** in proportion to our best estimates of regional biomass (Longline Survey Biomass)
  - Avoid localized depletion and/or disproportionate harvest of only large, mature fish OR only small, new recruits – **balance harvest across age structure**
- 2020 SAFE rationale:
  - Simulation work indicates that apportionment can be conducted in numerous ways with *little variability in the average implications for the population*.
    - Due to high sablefish movement and the robustness of the existing harvest control rule and management framework.
  - **Our best scientific advice is that catch distribution should not deviate *too far* from survey-estimated biomass proportions across management areas.**

2020 SAFE



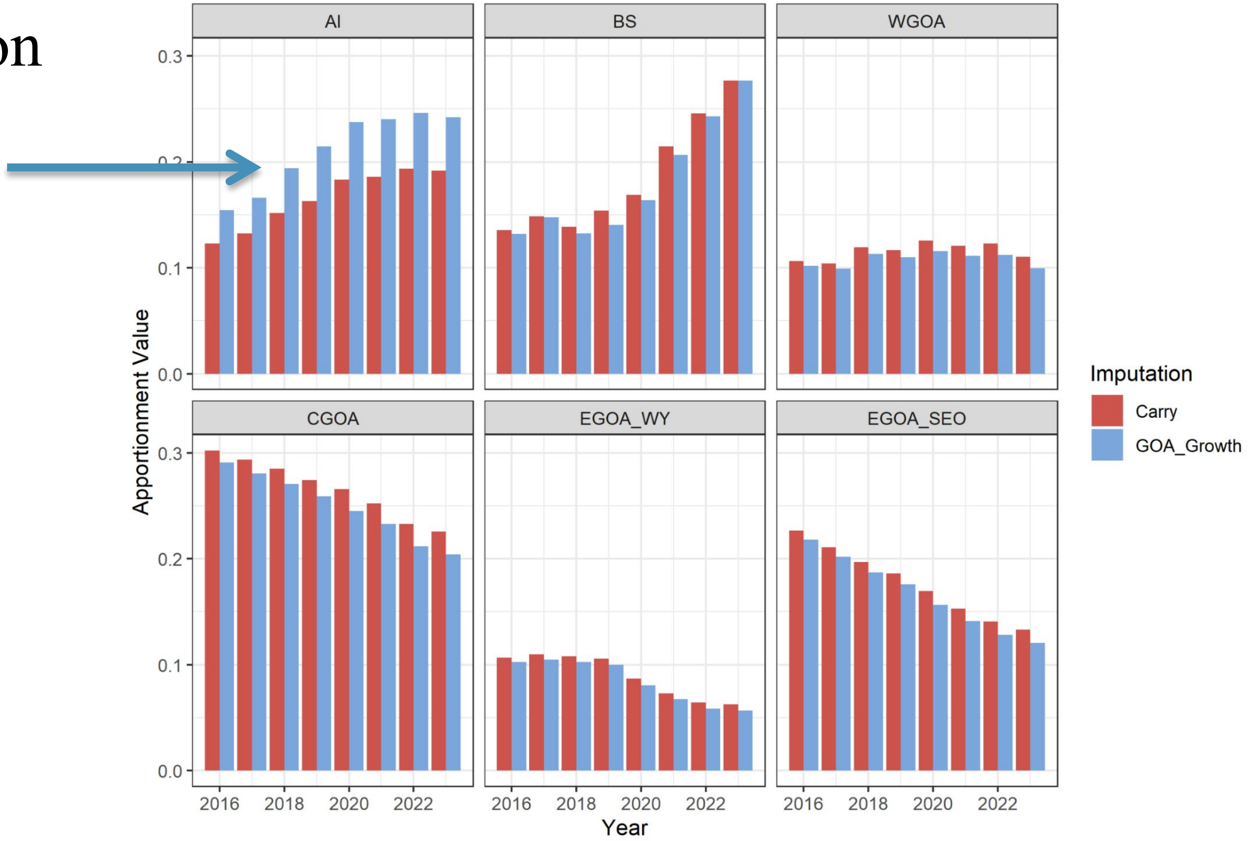
Apportionment

- Apportionment of AK-wide ABC (to determine Biologically-informed Regional Distributions, BRDs) requires synoptic regional survey values in a given year
  - **Not feasible given survey design (not synoptic in any year!)**
- Historically utilized GOA year-over-year change to impute values for BS/AI in survey off-years
  - Same as single region index construction for models *25.12* and earlier
- *Propose switching to using carryover values (fixed at last regional RPN)*
  - Same as single region index construction for Model *26.1_1Reg*
  - Removes western AI extrapolated stations (largest impact on apportionment)

Apportionment

- Impacts of updated apportionment are moderate in terms of proportions by region
  - Largest change is reduction in AI apportionment
  - All regions of GOA undergo slightly increased apportionment
  - BS apportionment is net neutral (for 2023)

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

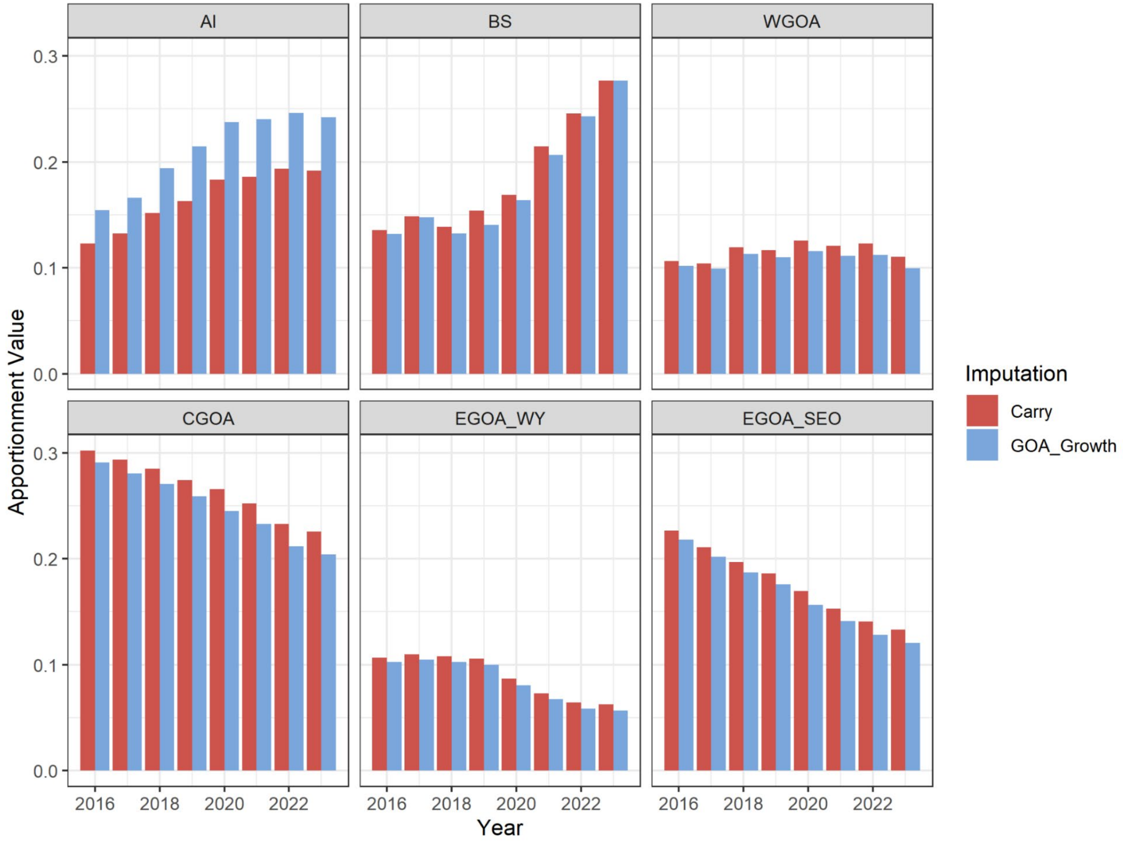


Apportionment

- BUT – combined impact of new model (and associated ABC) and new apportionment leads to important declines in BRDs
  - 32% decline in AK-wide ABC from 2026 harvest specs
  - Only partially offset by new apportionment for GOA

2026 BRDs

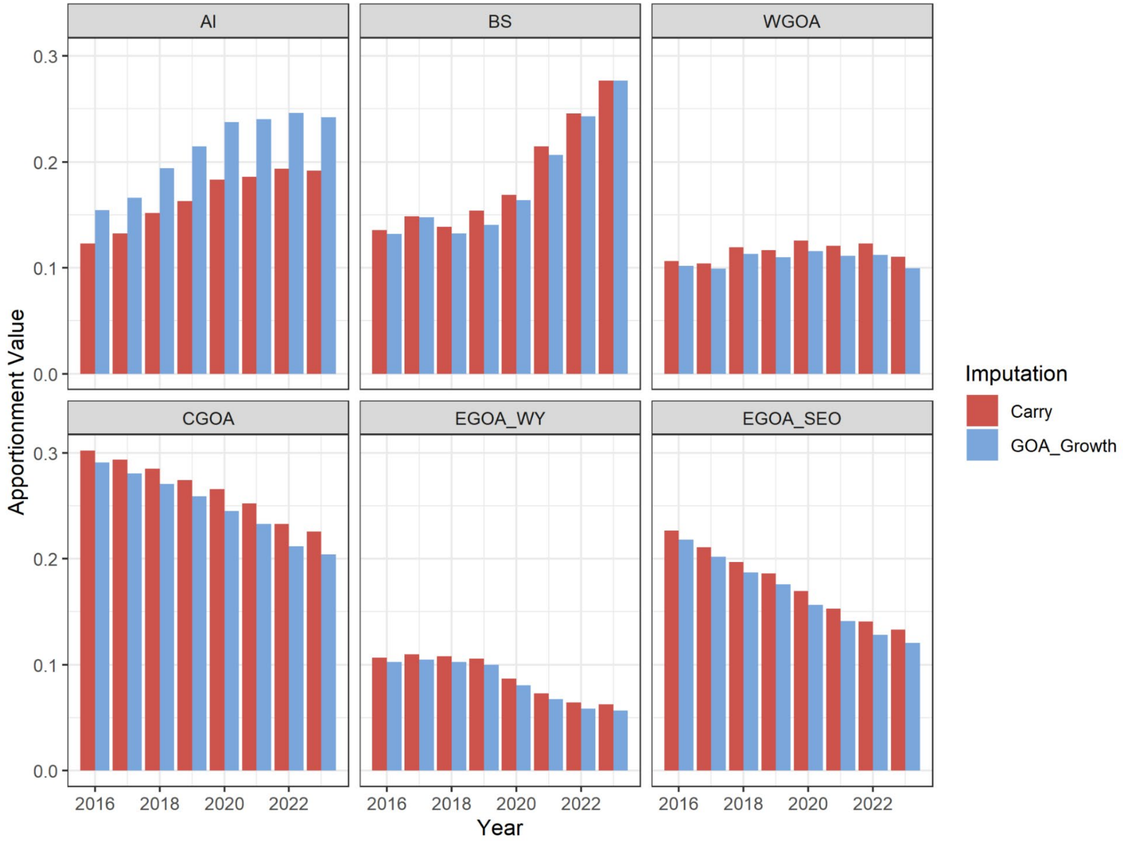
Region	Harvest Specs (GOA Extrap)	Model *26.1_1Reg* (GOA Extrap)	Model *26.2_FAA* (Carryover)	% Change in 2026 BRDs (Harvest Specs to FAA Carryover)
BS	13.0	11.5	8.9	-32%
AI	11.4	9.8	6.1	-47%
BSAI	24.4	21.3	14.9	-39%
WGOA	4.7	4.1	3.5	-25%
CGOA	9.6	8.2	7.4	-23%
WY	2.7	2.3	2.0	-26%
SEO	5.6	4.9	4.3	-24%
GOA	22.6	19.6	17.1	-24%
ABC (AK-Wide)	47	41	32	-32%



Apportionment

- Keeping in mind that ABC is currently ~50% utilized
  - But higher utilization in GOA (>80%)

Region	2025 Catch	2025 BRD*	2025 BRD Utilization	2026 Catch#
BS	3.9	13.2	30%	2.9
AI	1.0	11.6	8%	0.6
BSAI	4.9	24.8	20%	3.5
WGOA	3.1	4.7	66%	2.7
CGOA	7.7	9.7	79%	6.0
WY	2.3	2.7	85%	2.0
SEO	5.2	5.7	91%	3.8
GOA	18.3	22.8	80%	14.5
ABC (AK-Wide)	23	48	49%	18



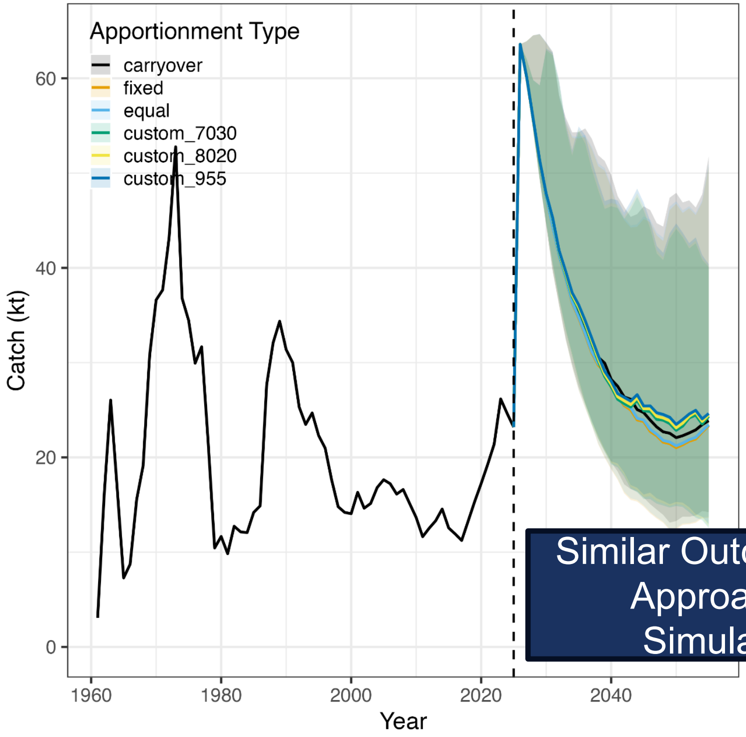
Apportionment

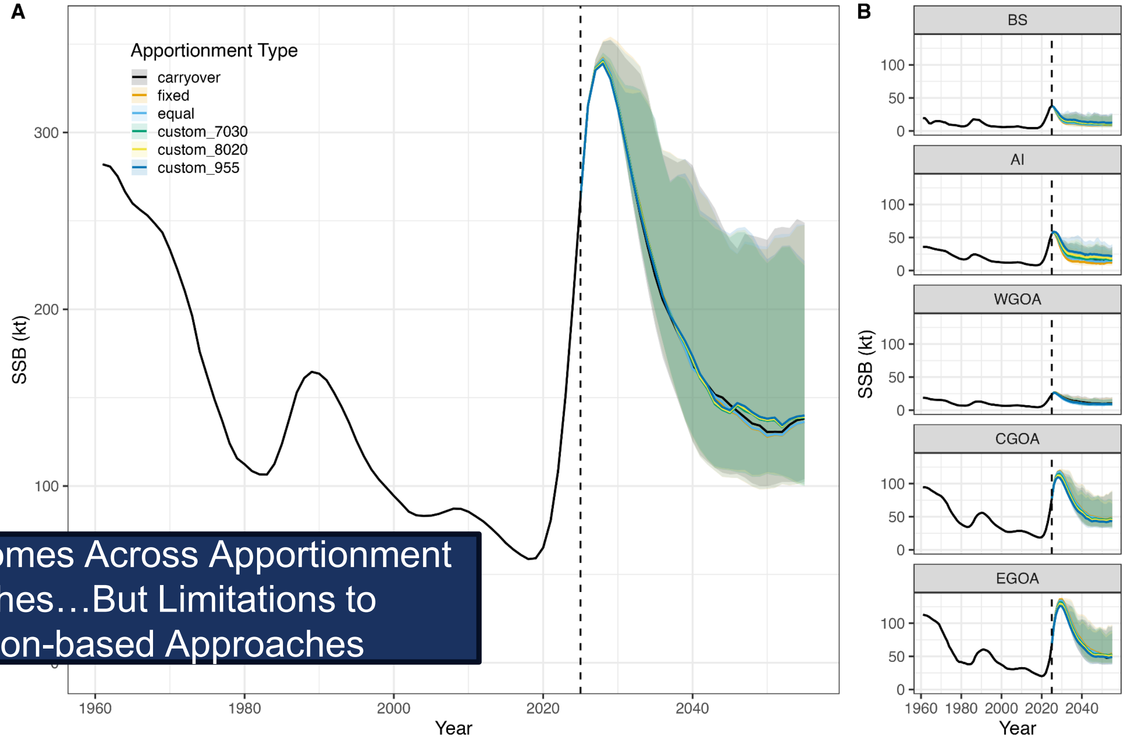
- IF SSC/NPFMC wanted to pursue *short-term* alternative apportionment methods to alleviate sudden reductions in ABC/BRDs…
- *Should use the recommended ABC (e.g., from Model 26.2_FAA)*
- But, BRDs could be altered to offset GOA declines (if desired; noting that BS/AI rarely harvest full BRD):
  - Maintain the 2026 BRDs in the GOA
  - Utilize the GOA BRDs from Model *26.1_1Reg*
- Either alternative would **require commensurate reductions in the BS/AI BRDs** to ensure the recommended Model *26.2_FAA* ABC is not exceeded

	2026 BRDs			2026 Alternative BRDs	
Region	Harvest Specs (GOA Extrap)	Model *26.1_1Reg* (GOA Extrap)	Model *26.2_FAA* (Carryover)	2026 Maintain GOA Harvest Specs	2026 Maintain GOA *26.1_1Reg*
BS	13.0	11.5	8.9	6.6	7.9
AI	11.4	9.8	6.1	2.8	4.6
BSAI	24.4	21.3	14.9	9.5	12.5
WGOA	4.7	4.1	3.5	4.7	4.1
CGOA	9.6	8.2	7.4	9.6	8.2
WY	2.7	2.3	2.0	2.7	2.3
SEO	5.6	4.9	4.3	5.6	4.9
GOA	22.6	19.6	17.1	22.6	19.6
ABC (AK-Wide)	47	41	32	32	32

Apportionment

- Updated analysis (with 5 region OM) supports findings of Fenske et al. (2022)
- Caveats: No EM (use true regional biomass in HCR), no stock recruit relationship (no density-dependence), and does not account for connectivity between GOA SSB and BS age-2 recruitment (larval dispersal and movement of age-1 fish)





Similar Outcomes Across Apportionment Approaches…But Limitations to Simulation-based Approaches

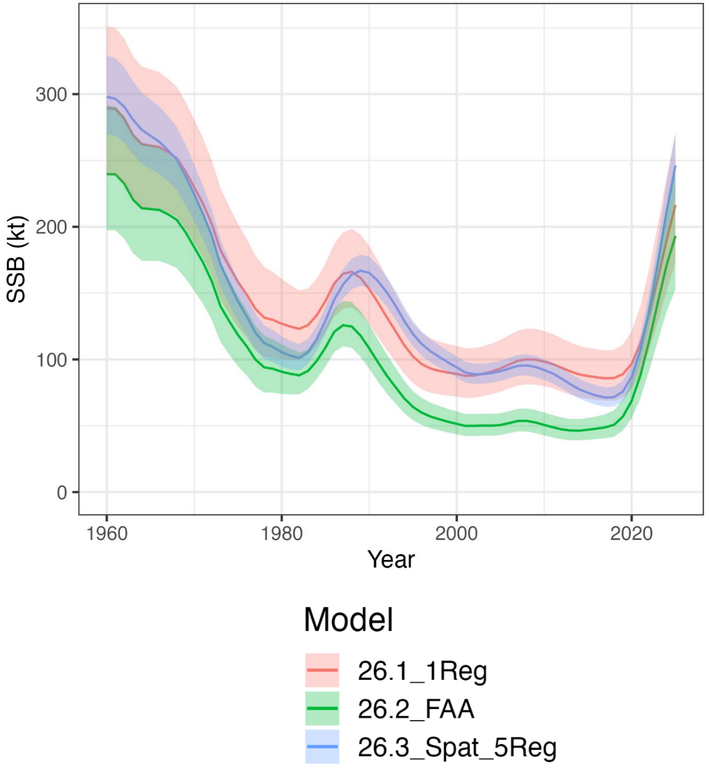
Carryover Represents Proposed Method

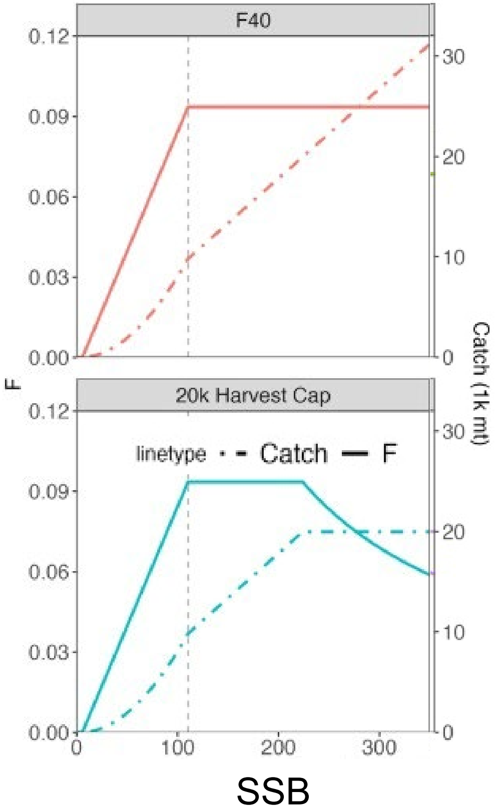
Equal Assumes 20% of ABC Harvested from Each Region

70/30 and 80/20 Apportionment Allows 70% or 80% of ABC to be Harvested from GOA (Akin to 'Alternative' Approaches and Spatial Model)

Final Thoughts

- **Change in ABC across model options IS NOT due to a biological change/concern**
- Moderate deviations from survey-based apportionment are unlikely to cause major biological concerns
- Model *26.2_FAA* provides the BSIA, but it is still implicitly accounting for complex spatial dynamics…
  - What hurdles need to be overcome to **use a spatial model operationally** (spatial BRPs, HCRs)?
- Is there capacity to increase sablefish age reading?
- Should alternative HCRs and/or harvest caps be explored for sablefish (Zahner et al., 2025, 2026)?





QUESTIONS?