Eastern Bering Sea walleye pollock stock assessment

September 2024

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Summary

- σ_R can be reasonably well estimated in both traditional stock assessment models, Caution about applying σ_R estimates blindly in management settings
- Incorporating the natural mortality-at-age and year from CEATTLE had a modest impact on the SRR because the recruitment scales were higher.
- The model code was updated to work as an operating model so that a full-feedback simulation loop could be used to test different management procedures.
- Presently the ecosystem factors that affect the pollock TAC are mostly related to the constraint due to the 2-Mt cap.
- Alternative guideline (in the form of “advice”) with historical patterns of catch might be useful for management in future simulation testing

Stock-recruit relationship sensitivities

Selectivity
Time series length
Temperature
Priors (on steepness)
Form (e.g., Ricker versus Beverton-Holt), σ_R

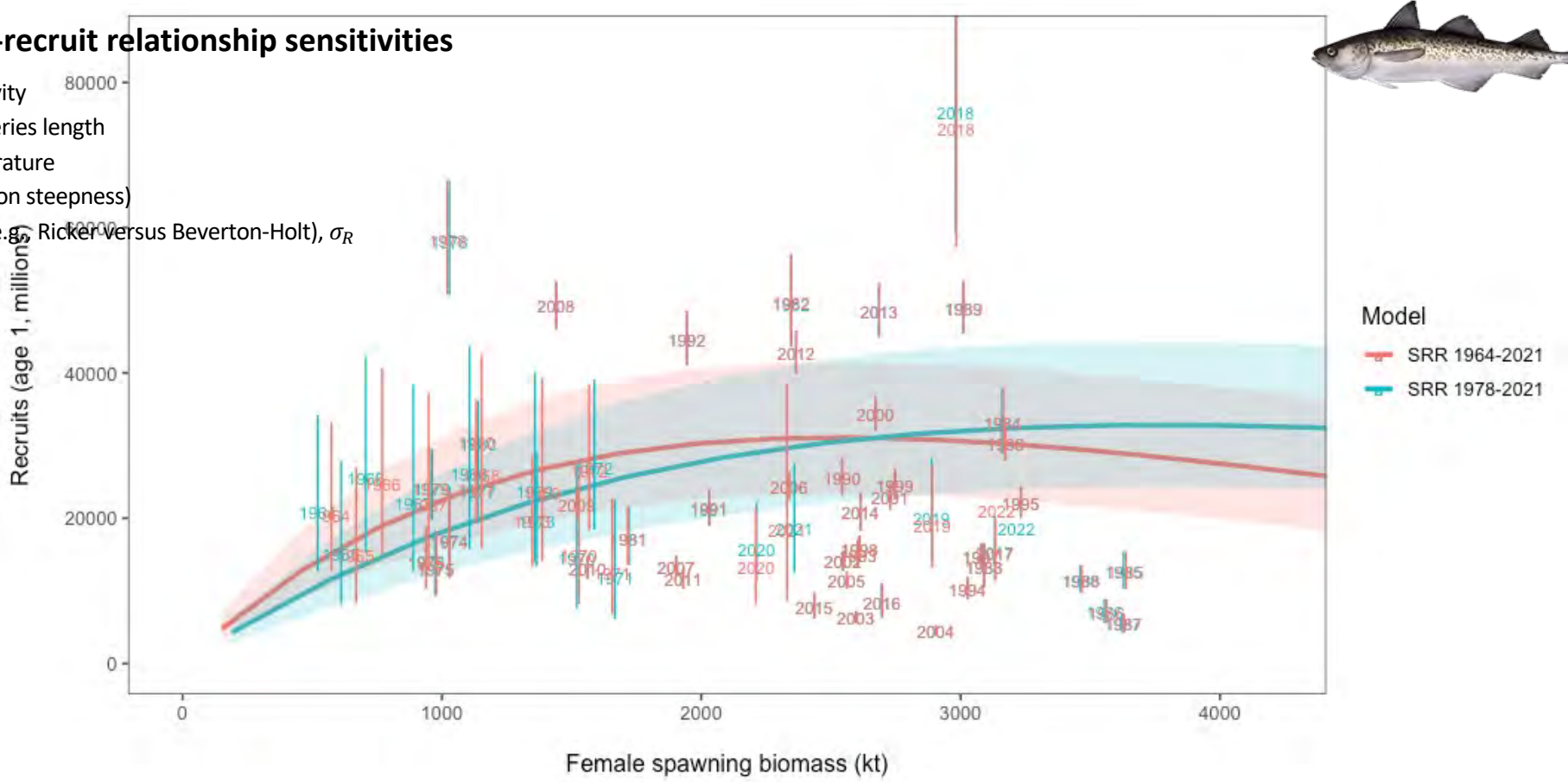


Figure 1: Model results comparing last year's selected model (SRR 1978-2021) with one where the the full time series is used for the stock-recruitment relationship conditioning. The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

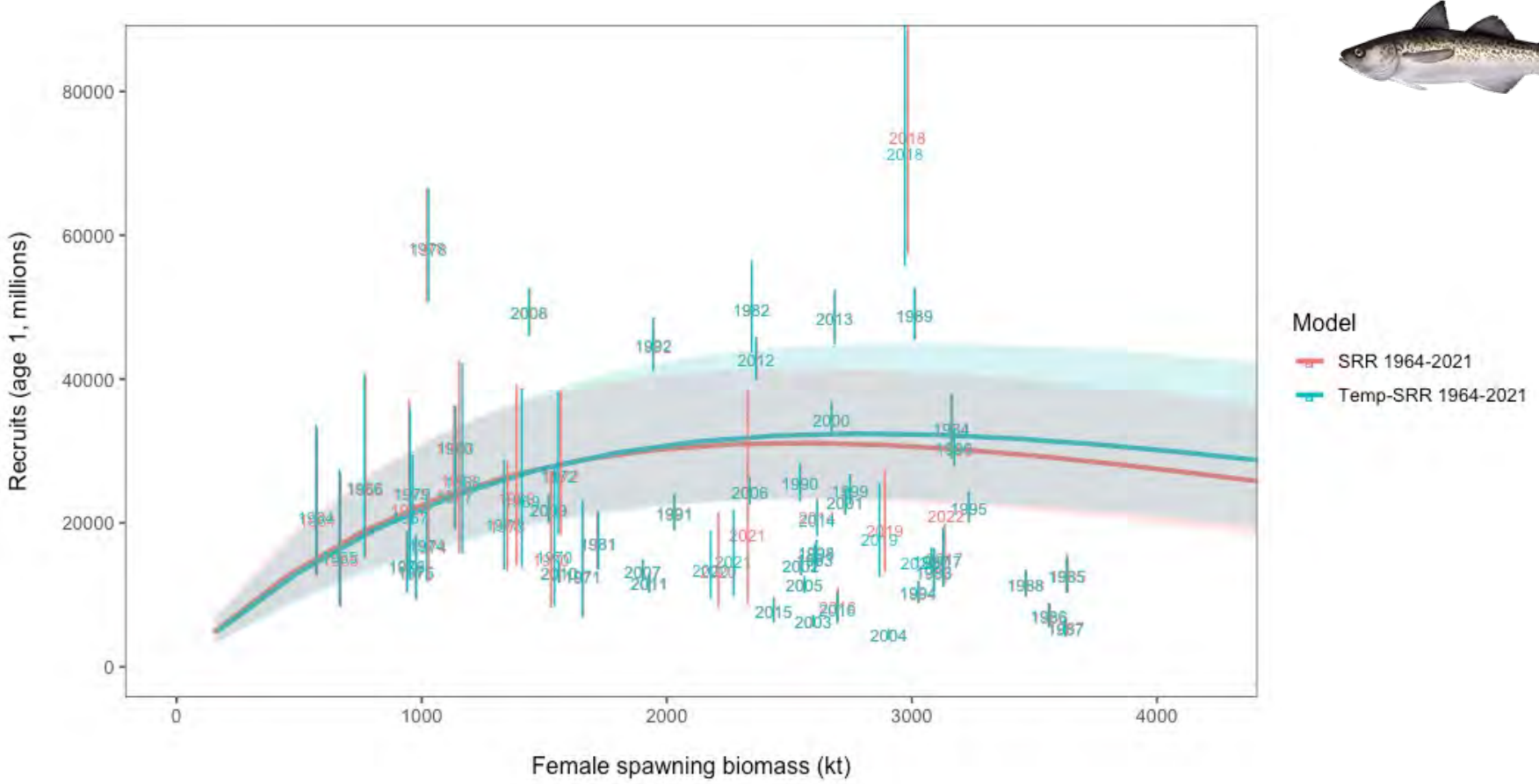


Figure 2: Model results comparing the model (SRR 1964-2021) with one including sea-surface tempurature a covariate. The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

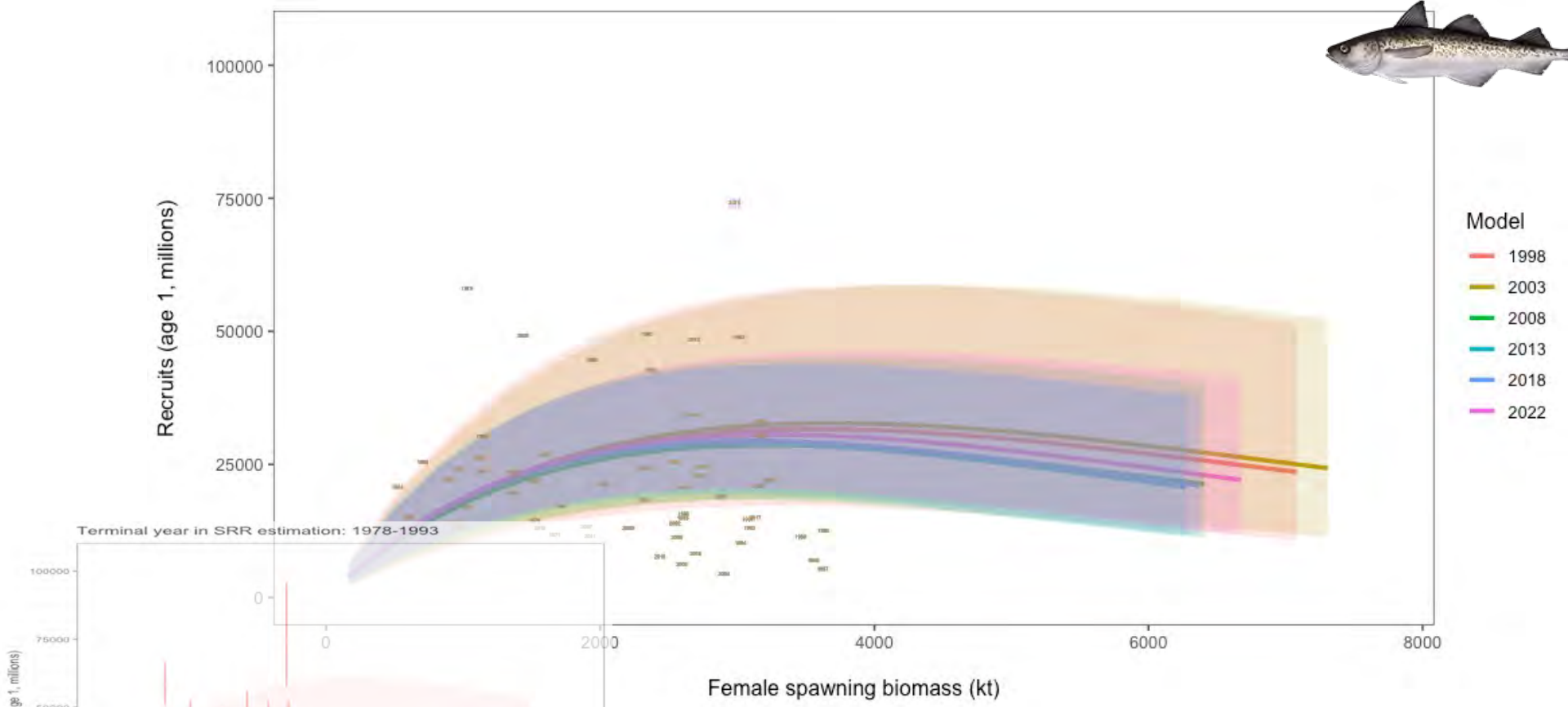


Figure 3: SRR curves as estimated in the 2023 assessment for different terminal years included in the estimation.

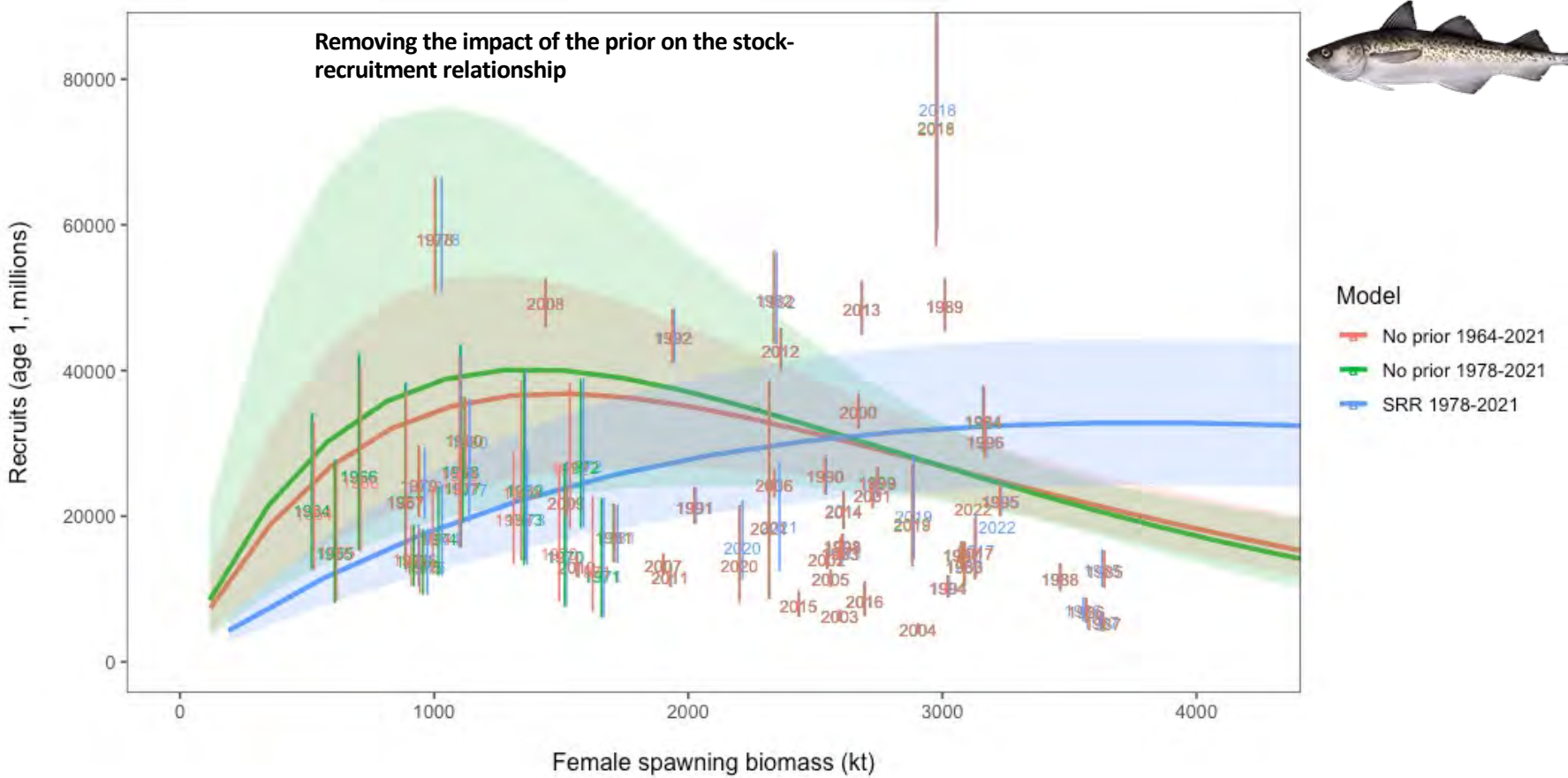
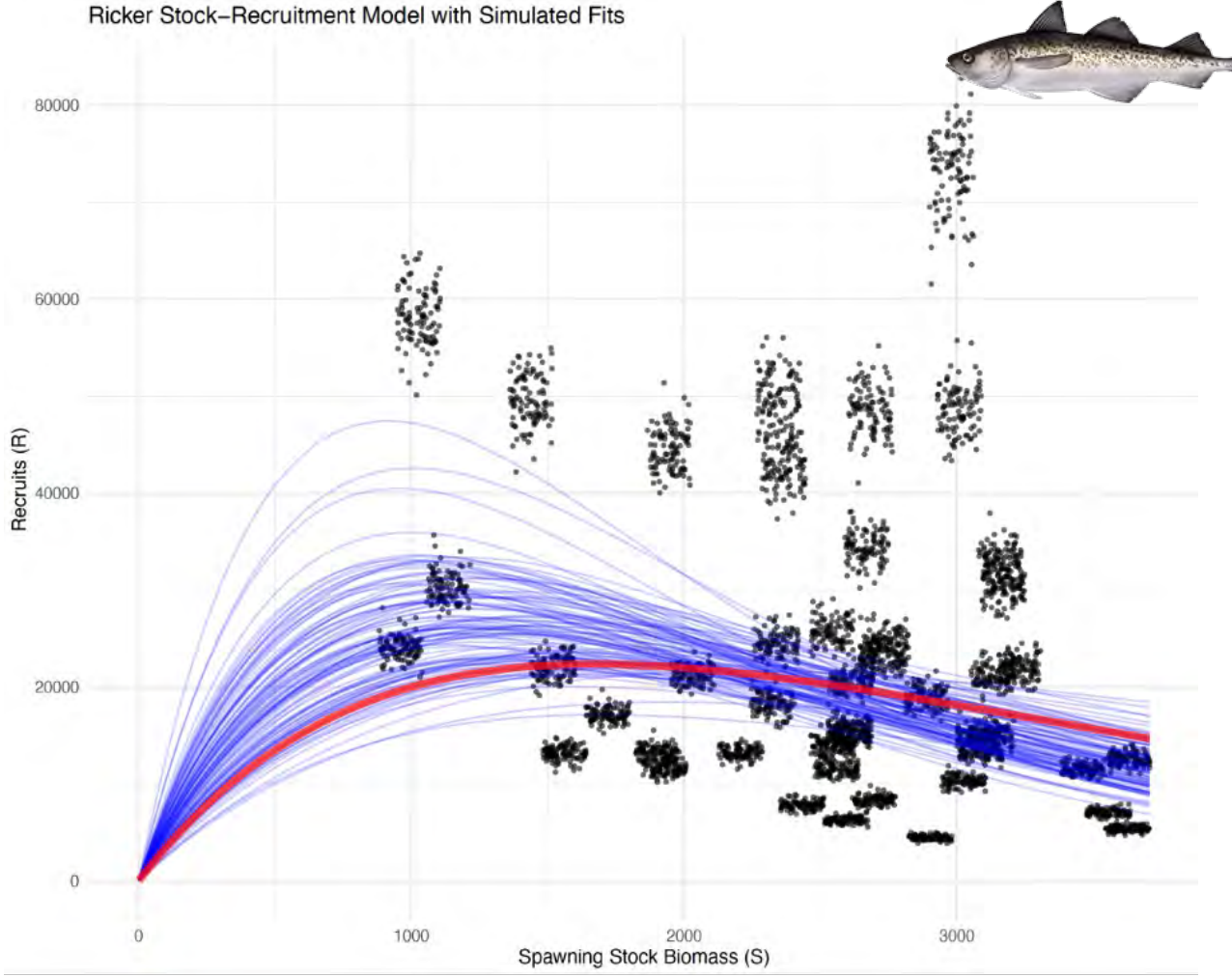


Figure 5: Model results comparing last year's model (SRR 1978-2021) with ones excluding the effect of prior distributions and different period lengths. The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

Figure 6: Results from simulation-estimation scenarios from the type of data available for EBS pollock, 1978-2022. The clusters of black dots show resampled stock-recruit data.



Beverton-Holt stock-recruitment relationship

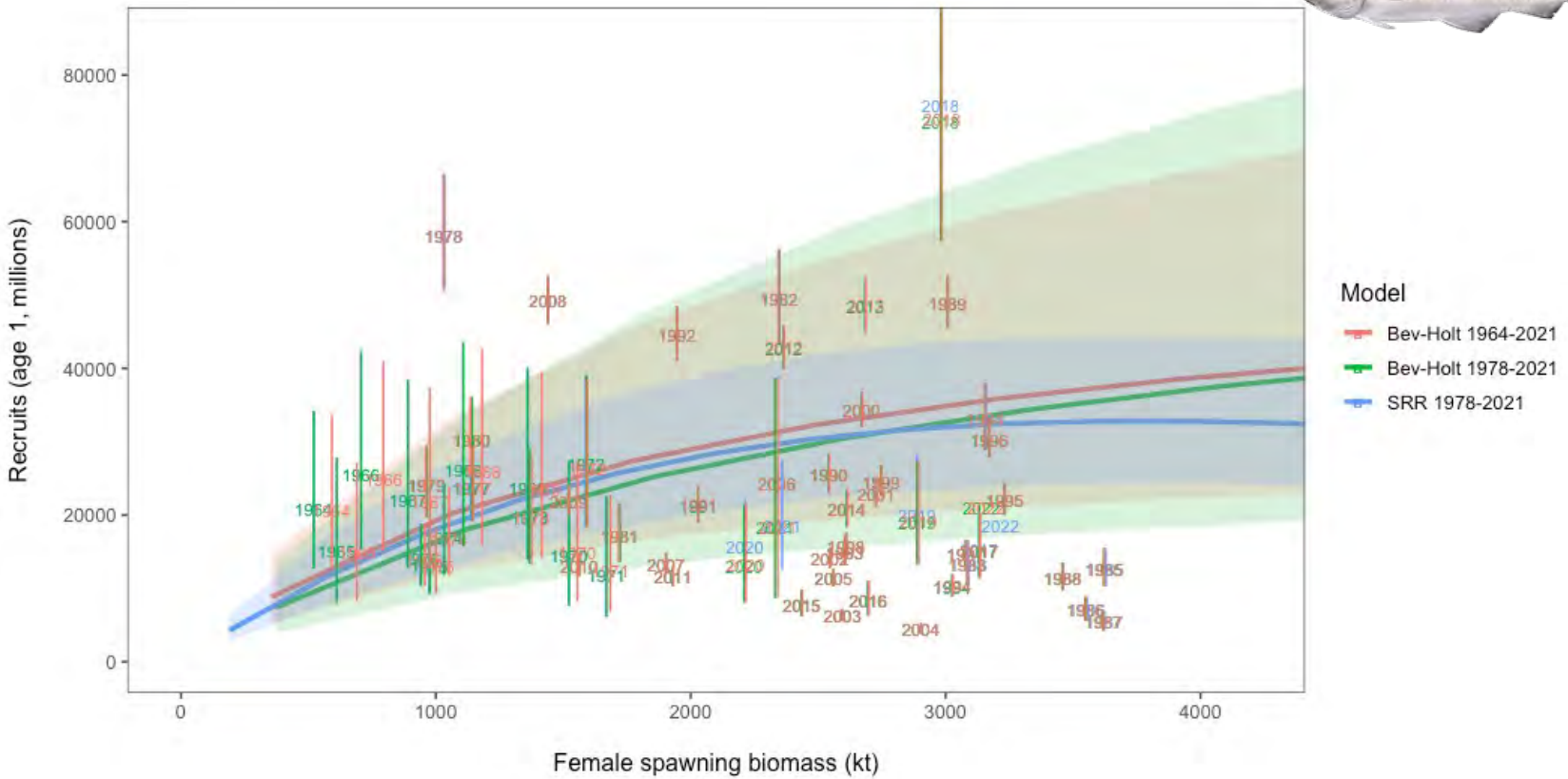


Figure 7: Model results comparing the Ricker model (SRR 1978-2021) with one assuming Beverton-Holt (short and long periods). The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

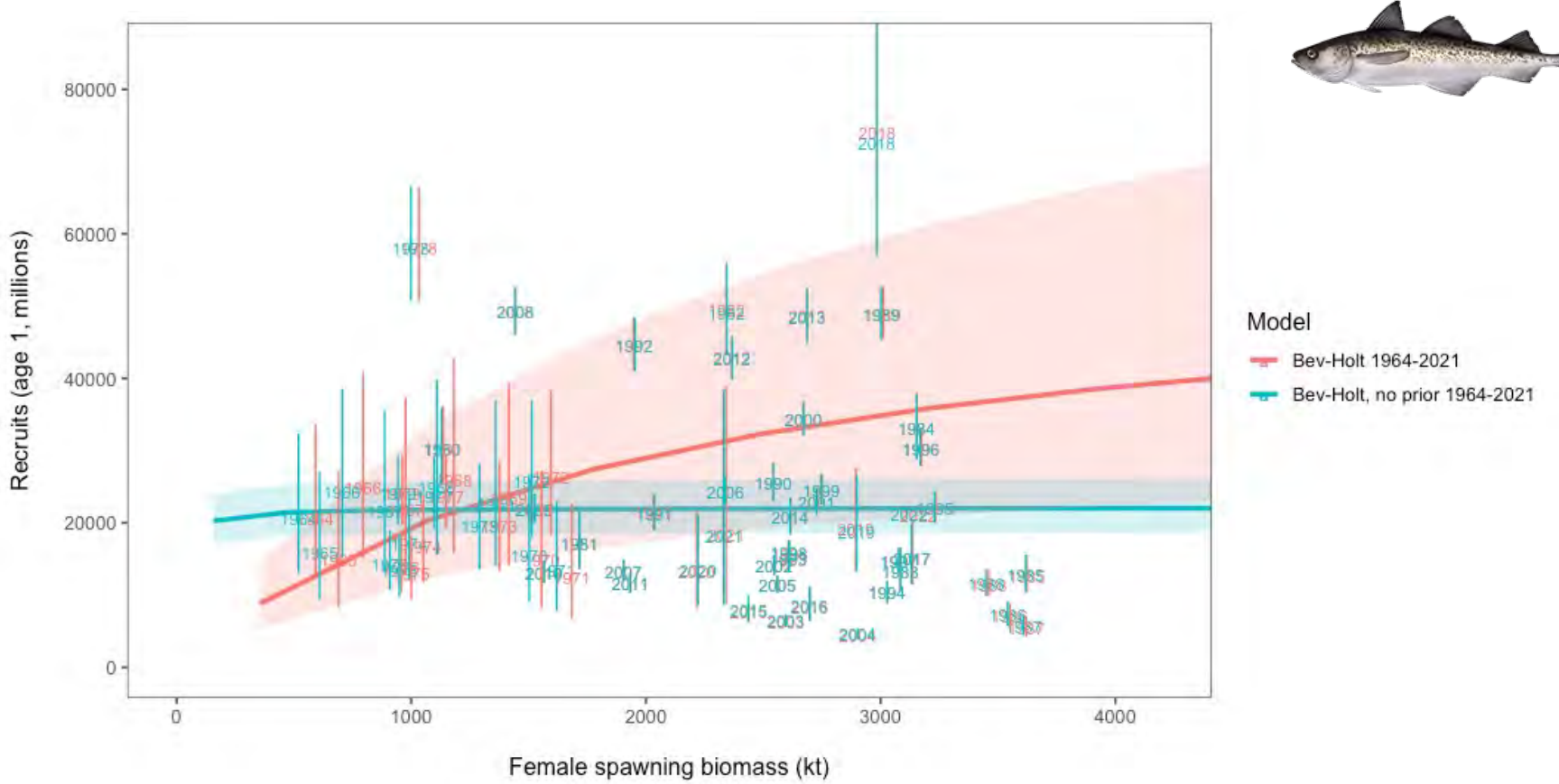


Figure 8: Model results comparing the Beverton-Holt model with and without the prior distribution on steepness. The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

Specified variability about the SRR

The SSC requested that we ensure that the bias correction is applied in the application of fitting the SRR. We confirm specifically,

$$\hat{R}_t = f(B_{t-1})e^{\epsilon_t - 0.5\sigma_R^2}$$

where $\epsilon_t \sim N(0, \sigma_R^2)$. With the recruitment component of the negative log-likelihood as

$$-ln(L_{rec}) = \sum_{t=1}^{T}\left[\frac{\left(\chi_t + \frac{\sigma_R^2}{2}\right)^2}{2\sigma_R^2} + ln(\sigma_R)\right]$$

where $\chi_t = \log(\dot{R}_t) - \log(\hat{R}_t)$.

Note that the bias correction term falls within the likelihood because the bias applies to the SRR model estimates. That is, the bias is applied to the SRR model estimates of age-1 recruitment so that the reference points are consistent with the assessment model scale.

Specified variability about the SRR

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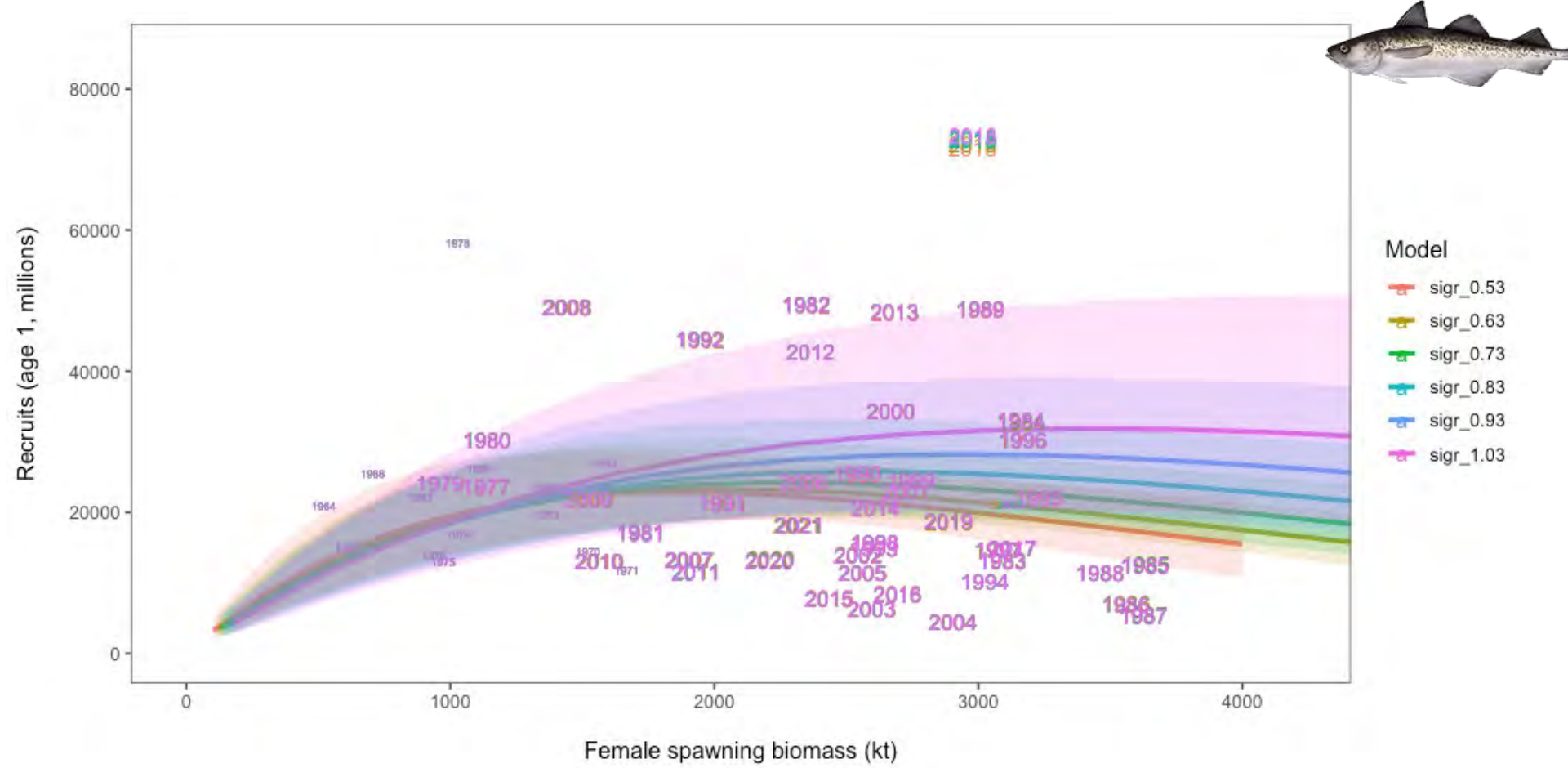
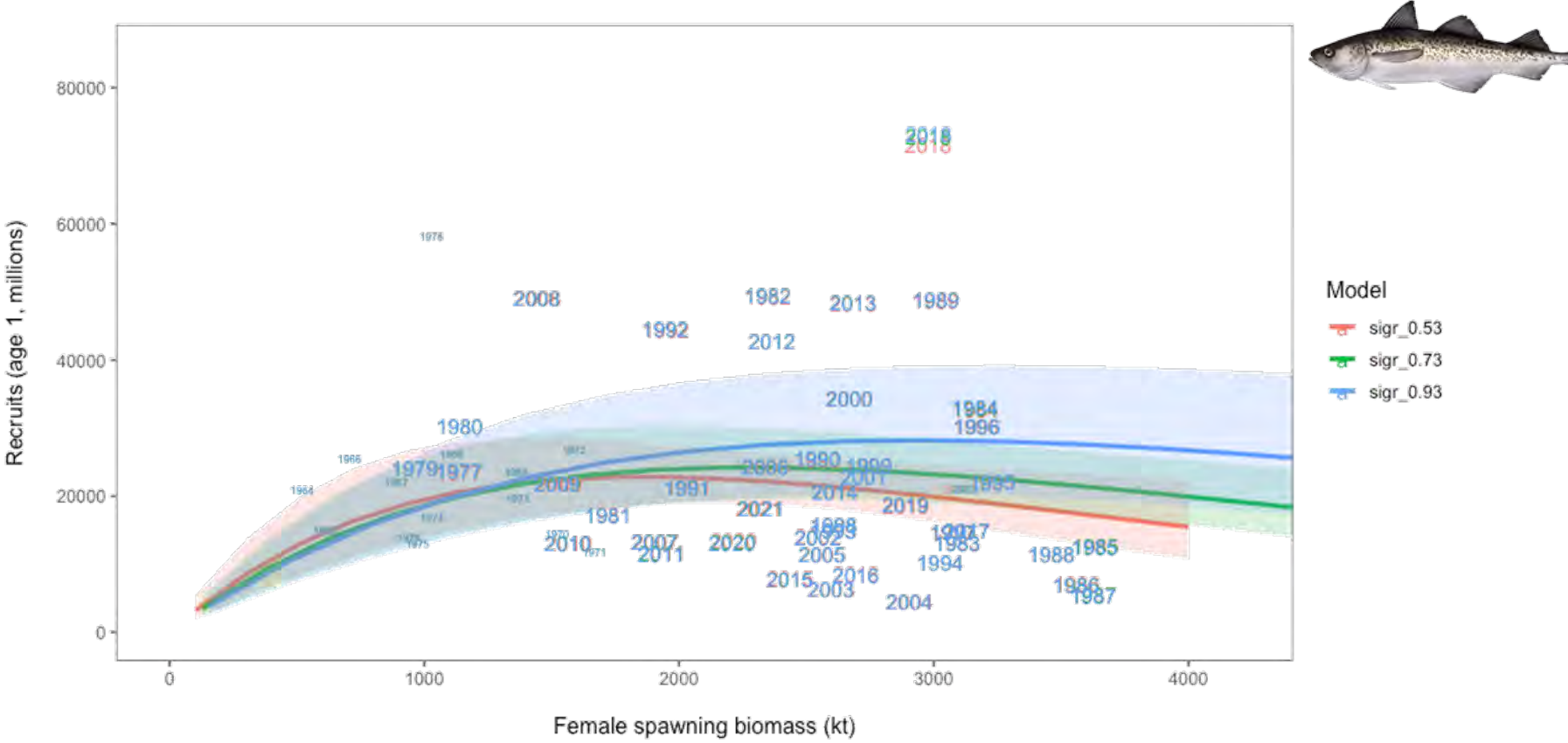
Profile negative log-likelihood of σ_R for the different components used to tune the model.



SRR curves as estimated in the 2023 assessment for different fixed values of sigmaR.



SRR curves as estimated in the 2023 assessment for different fixed values of sigmaR.

Specified variability about the SRR

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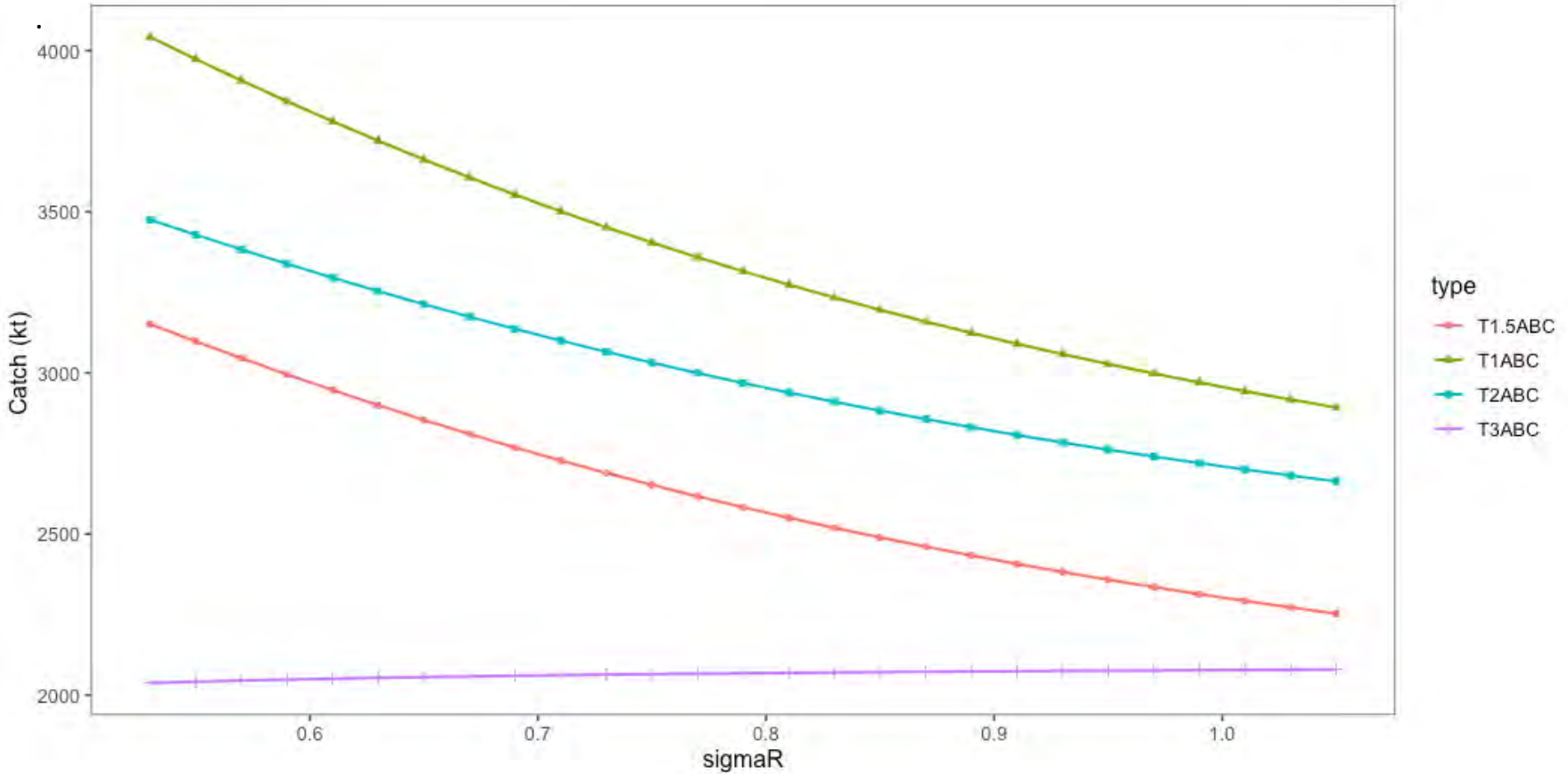
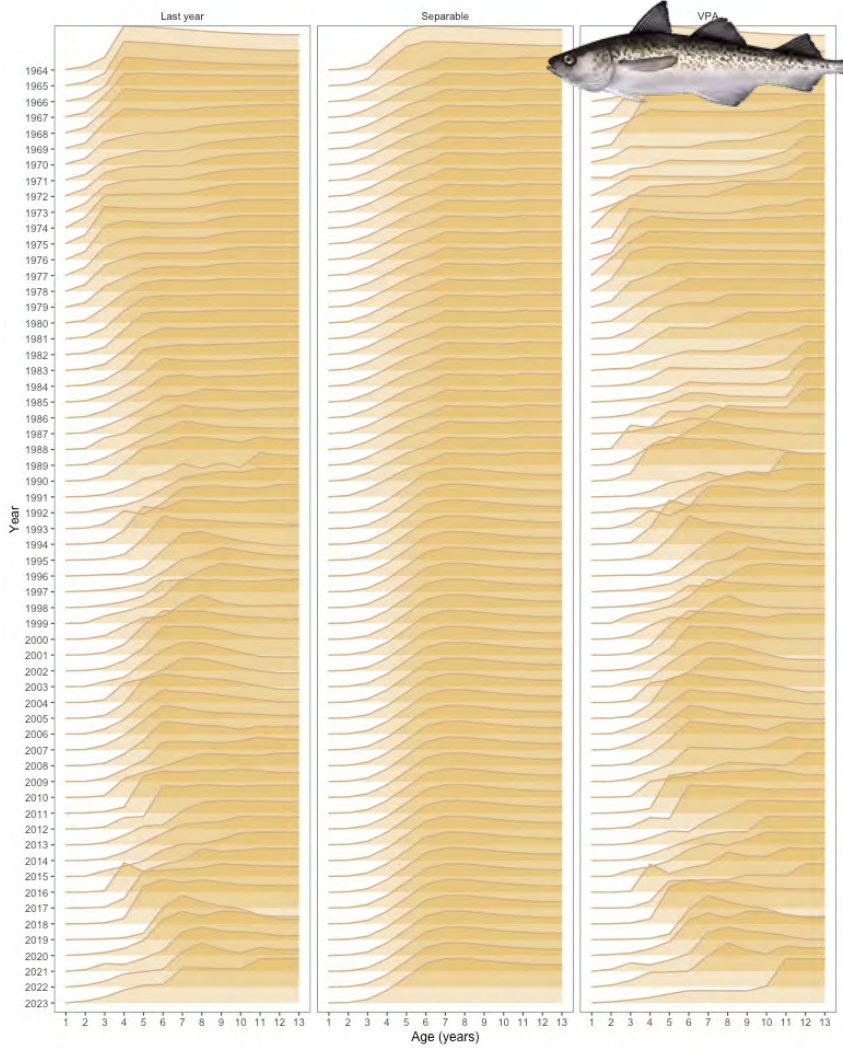


Figure 10: Impact of σ_R on the ABC values from the 2023 assessment.

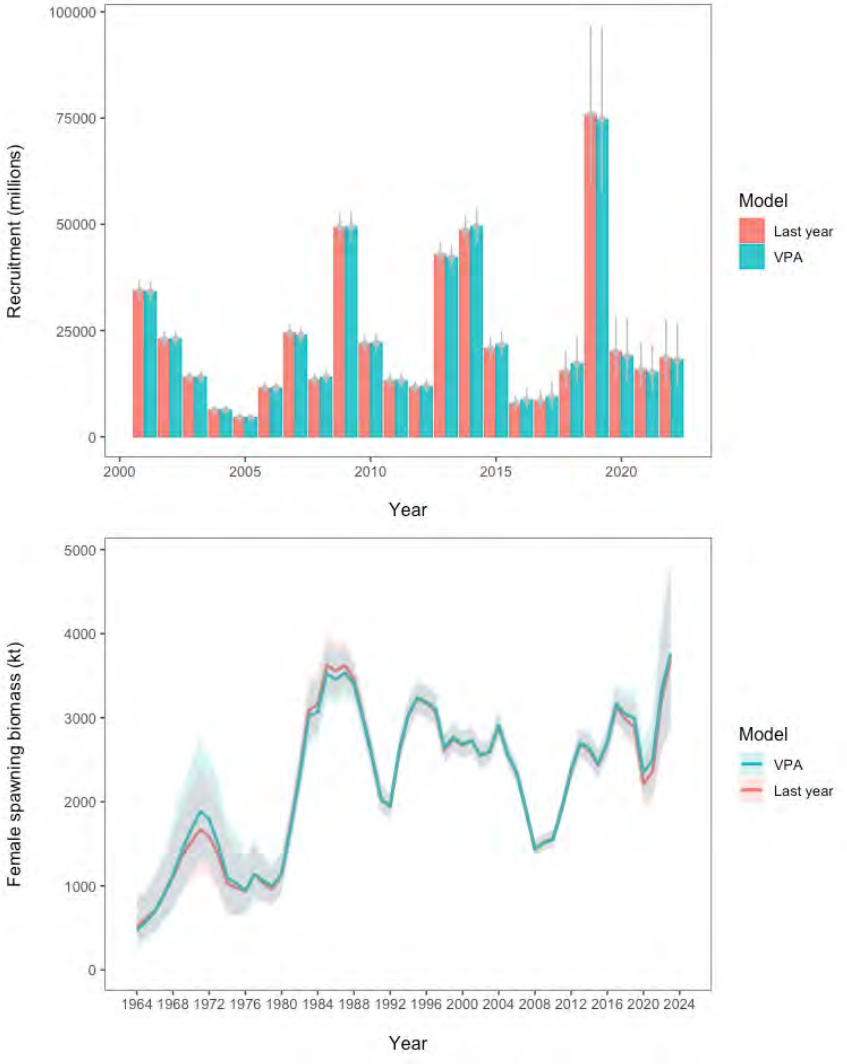
Evaluating the impact of selectivity assumptions on stock recruitment relationships (SRR)



Selectivity-at-age patterns for three models: last-year's, separable, and VPA.

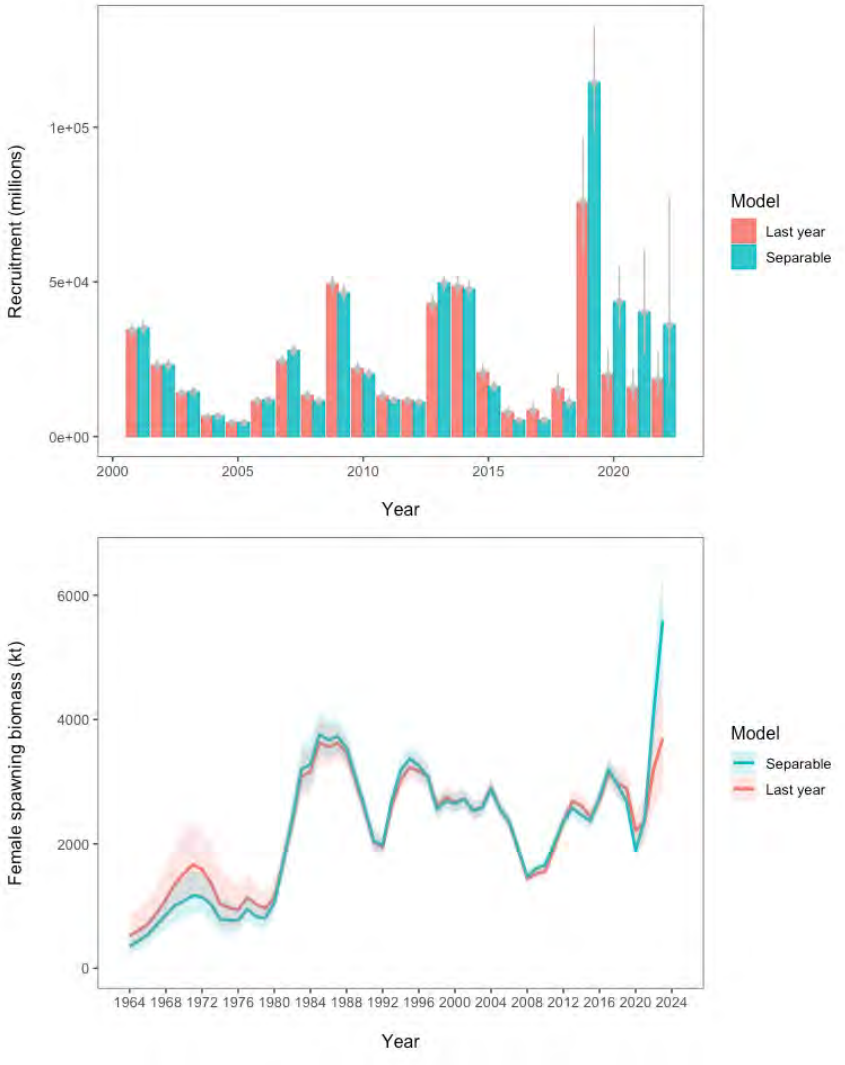
VPA-like versus 2023 model

Figure 14: Model results comparing last year's selected model with one where the selectivity is more highly variable over time (VPA). Recruitment is shown in the top panel and spawning biomass in the lower.



Separable versus 2023 model

Figure 15: Model results comparing last year's selected model with one where the selectivity is constant over time (separable). Recruitment is shown in the top panel and spawning biomass in the lower.



Model results comparing last year's selected model with one where the selectivity is fixed over time (separable) for the estimated stock-recruitment relationship. Note that the vertical bars represent the 95% confidence intervals for the age-1 recruitment.

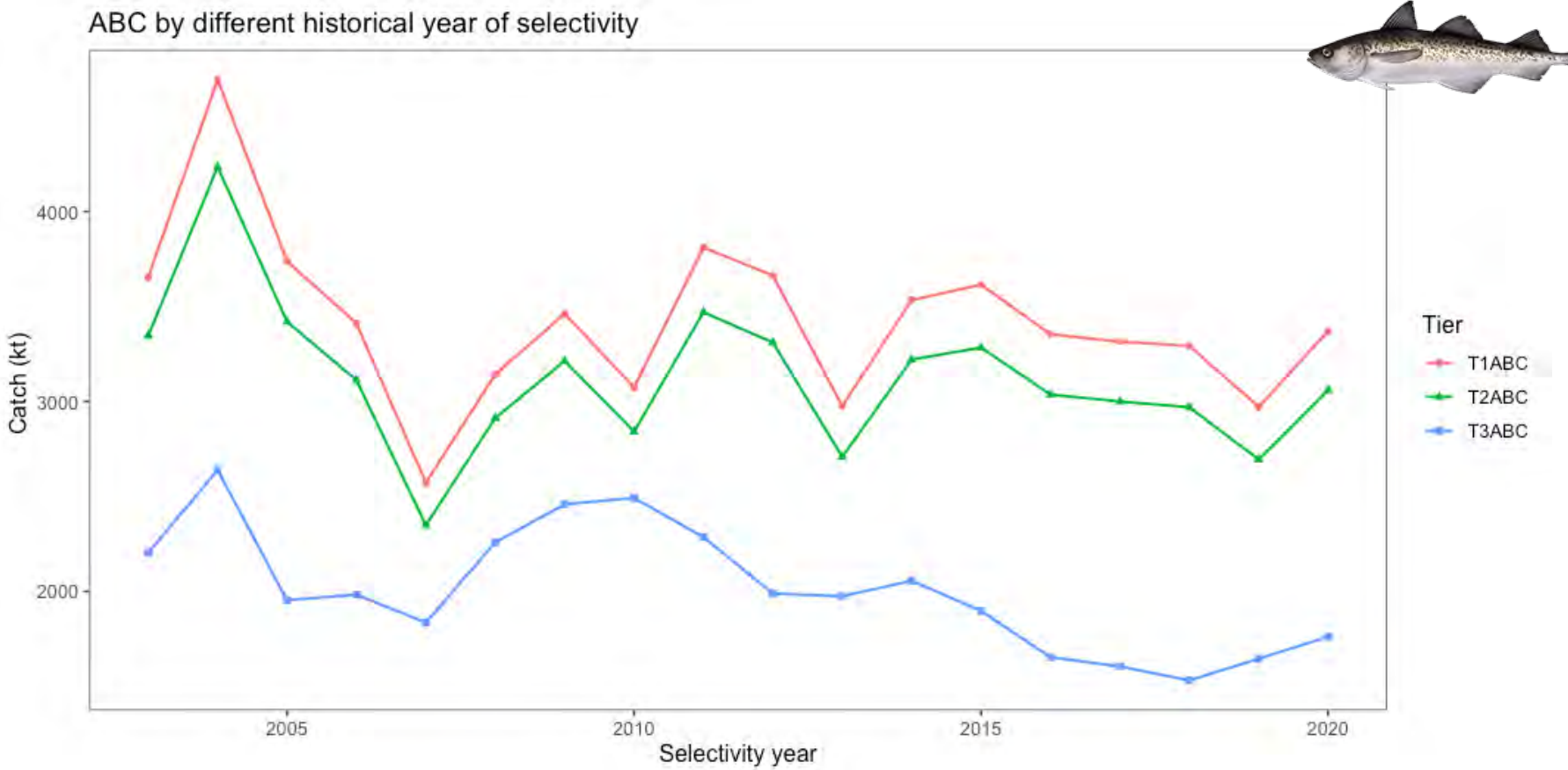


Figure 17: Difference in projected Tiers 1-3 ABC by year of selectivity estimate from the 2023 assessment. The horizontal axis refers to the year from whic the selectivity was used for catch advice.

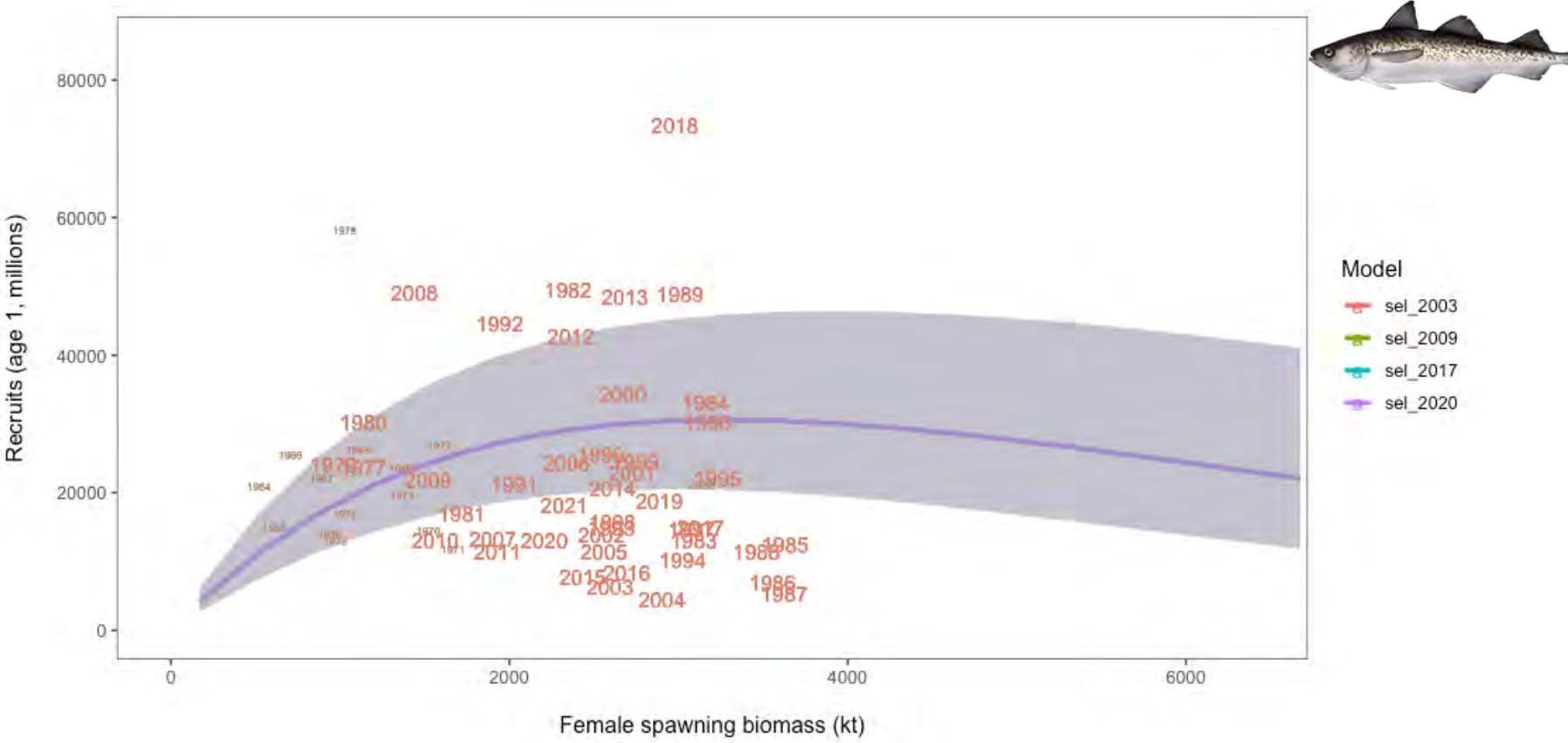


Figure 18: SRR curves as estimated using the historical estimates of annual selectivities.

Conditioning the stock-recruitment relationship to have F_{MSY} equal to $F_{35\%}$

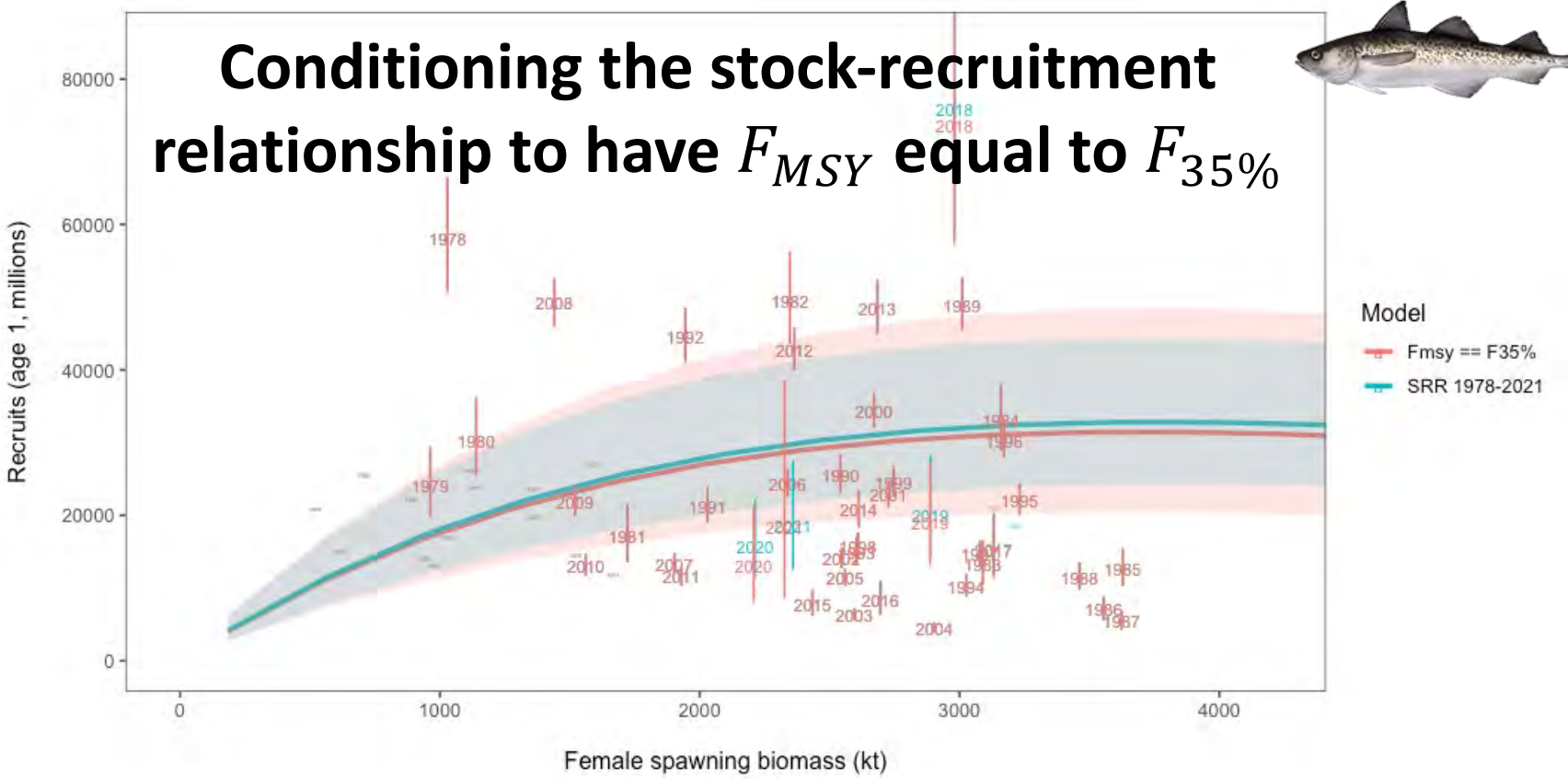


Figure 19: Model results comparing last year's selected model (SRR 1978-2021) with one where the SRR was conditioned such that F_{MSY} was equal to the SPR rate of F_{35}. The vertical bars represent the 95% confidence intervals for the age-1 recruitment.

Incorporating natural mortality-at-age arising from CEATTLE

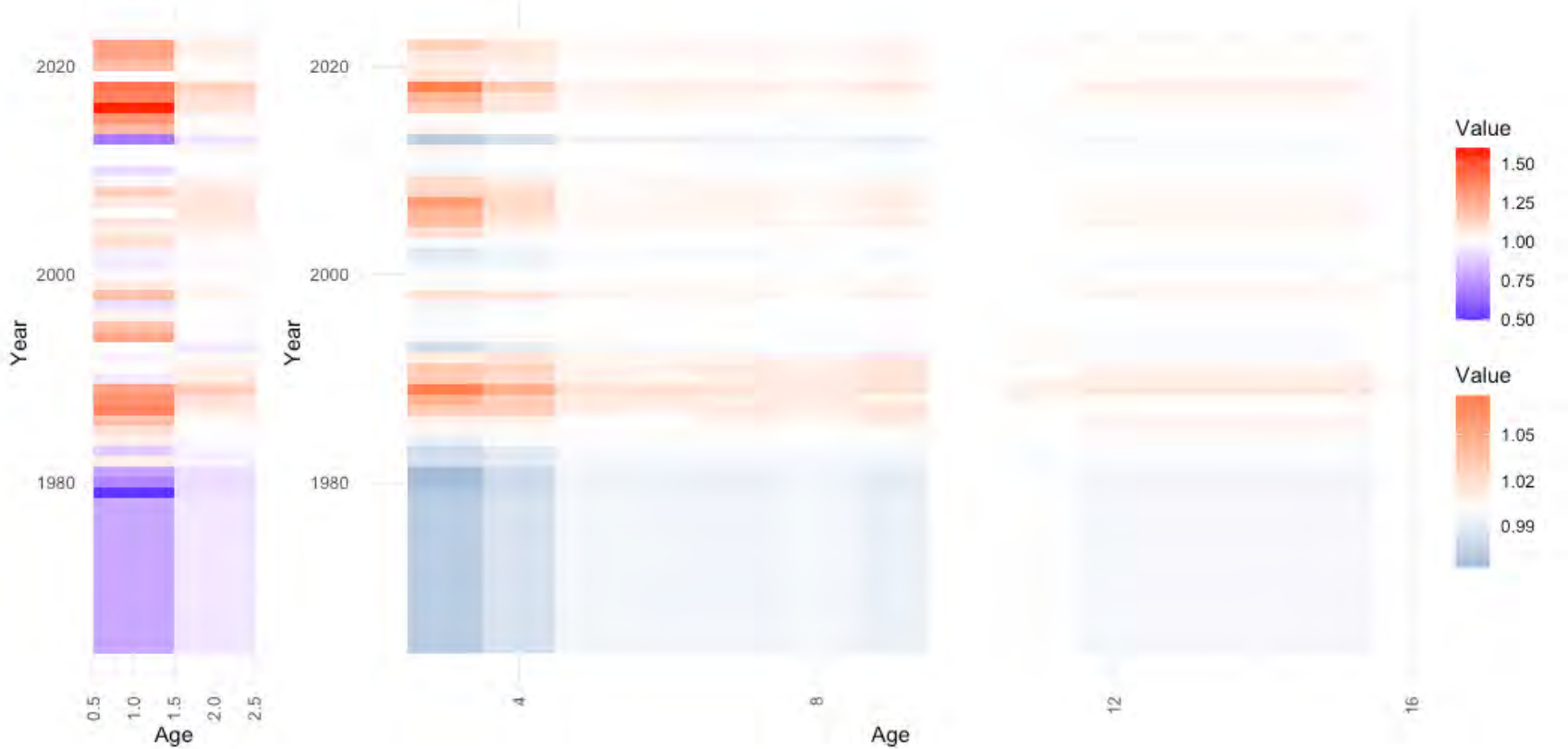
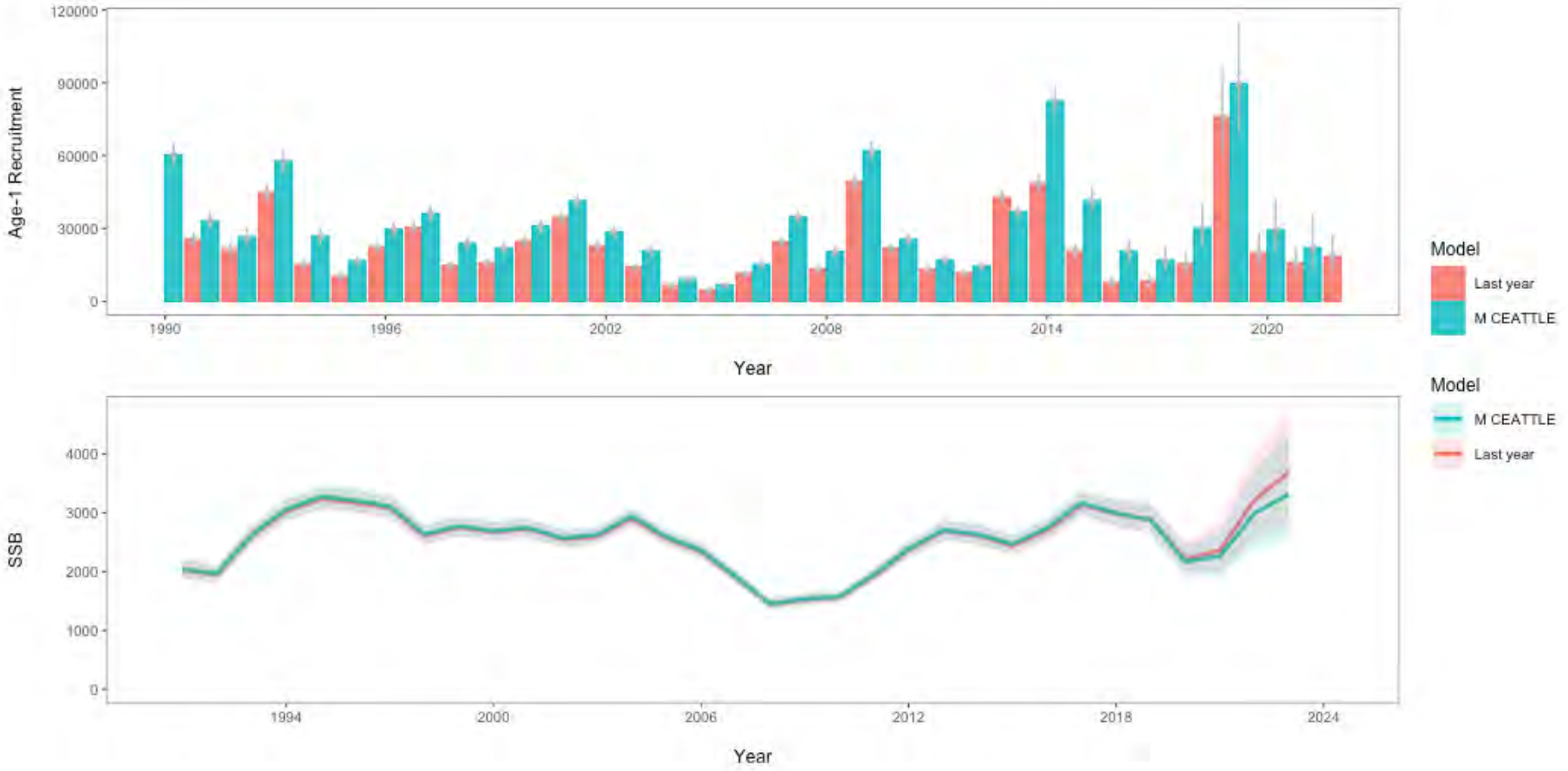


Figure 20: Depiction of the natural mortality (variability from mean value at age) as estimated from CEATTLE.



Model results comparing last year's selected model with one where the natural mortality matrix estimated from CEATTLE is used.

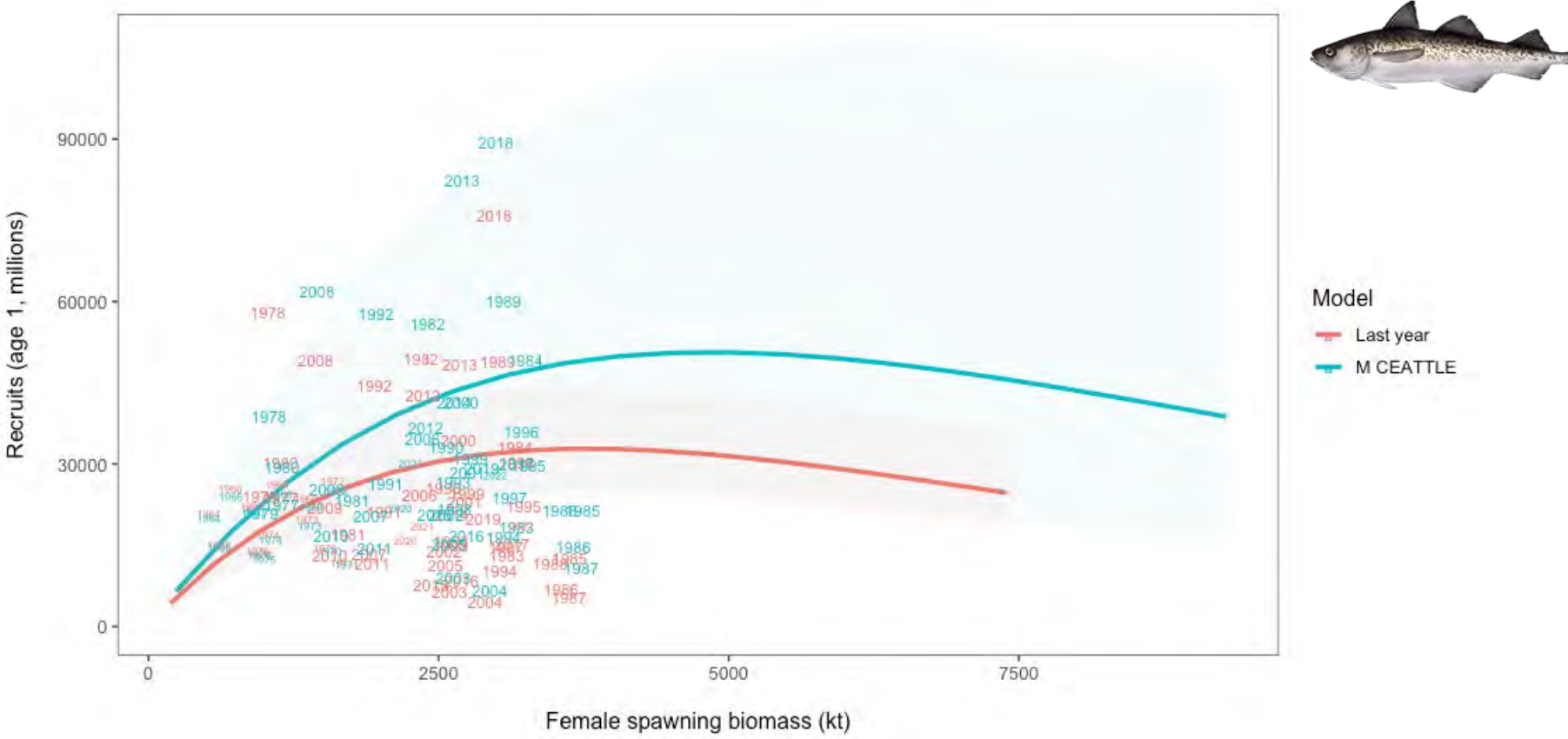


Figure 22: Model results comparing last year's selected model with one where the natural mortality matrix estimated from CEATTLE is used.

Omitting early CPUE data and foreign fishery data

The SSC requested a model run where the early CPUE data were excluded. This was done and showed that the model was insensitive to the early CPUE data (Figure 23).

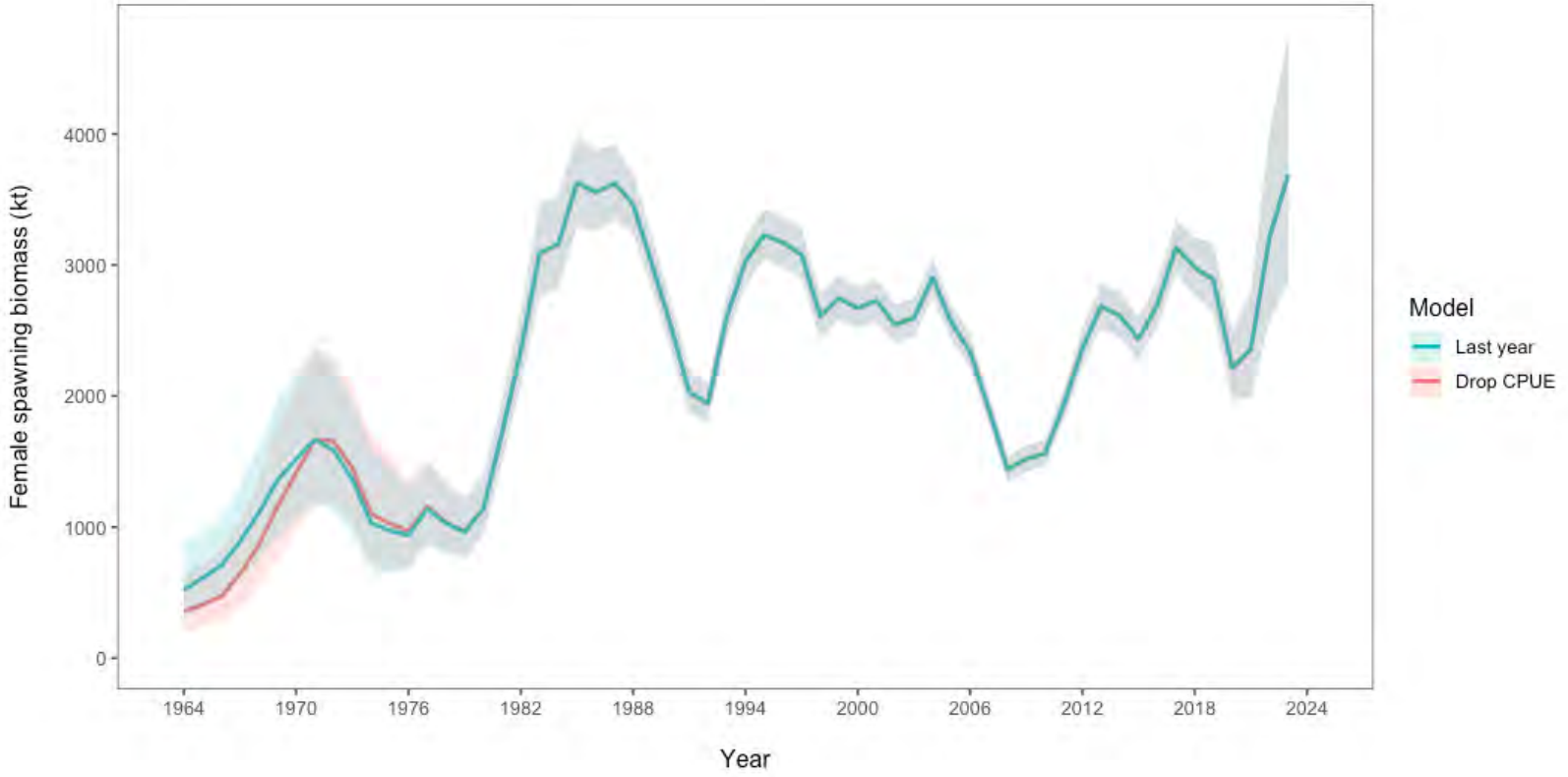


Figure 23: Model results comparing last year's selected model with one where the early CPUE data are excluded.

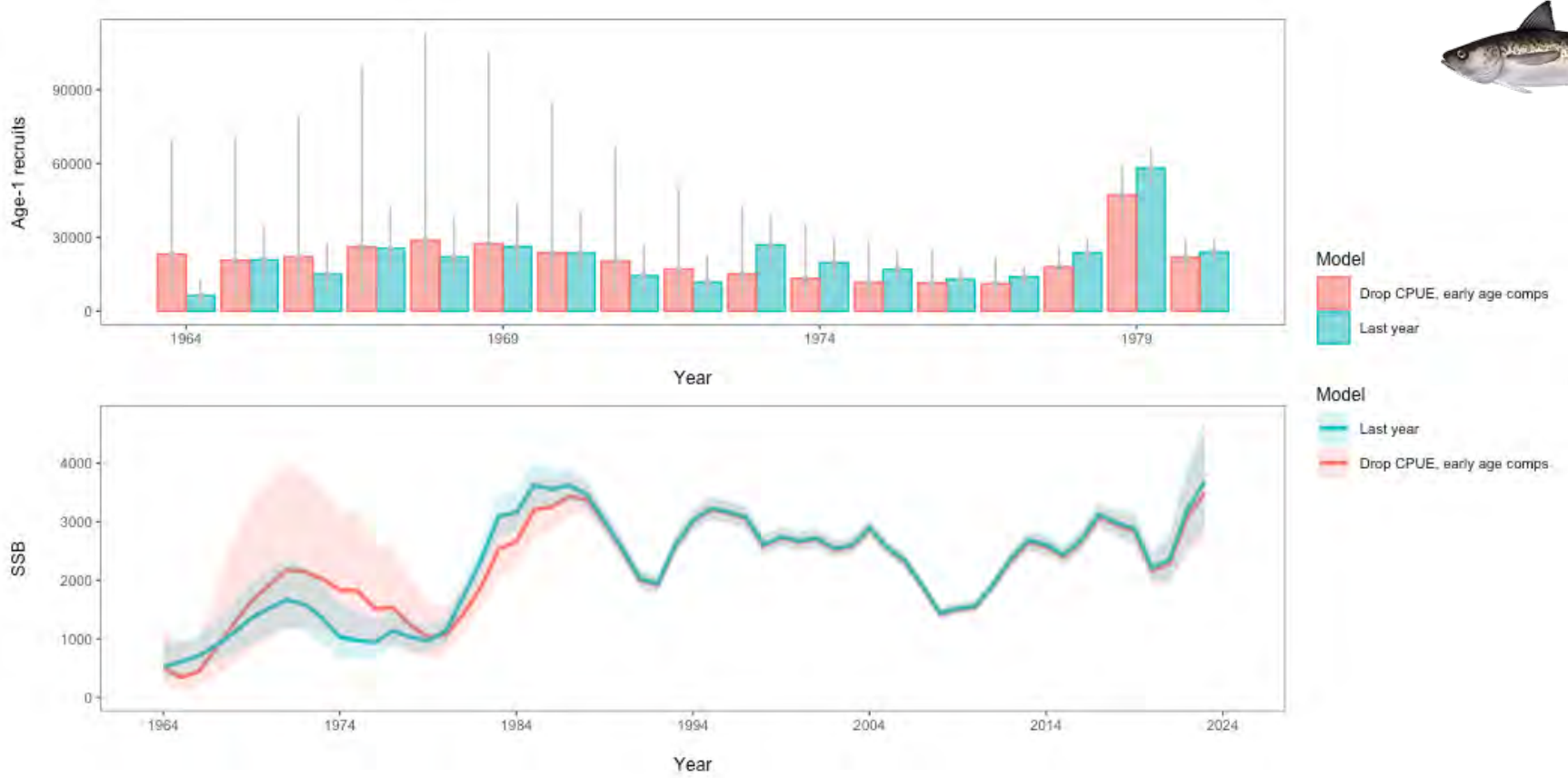


Figure 24: Model results comparing last year's selected model with one where the early CPUE data and the early age compositions are downweighted (effectively removed). Note that for the recruitment plot (top) the year-range is shifted to see the impact of model differences.

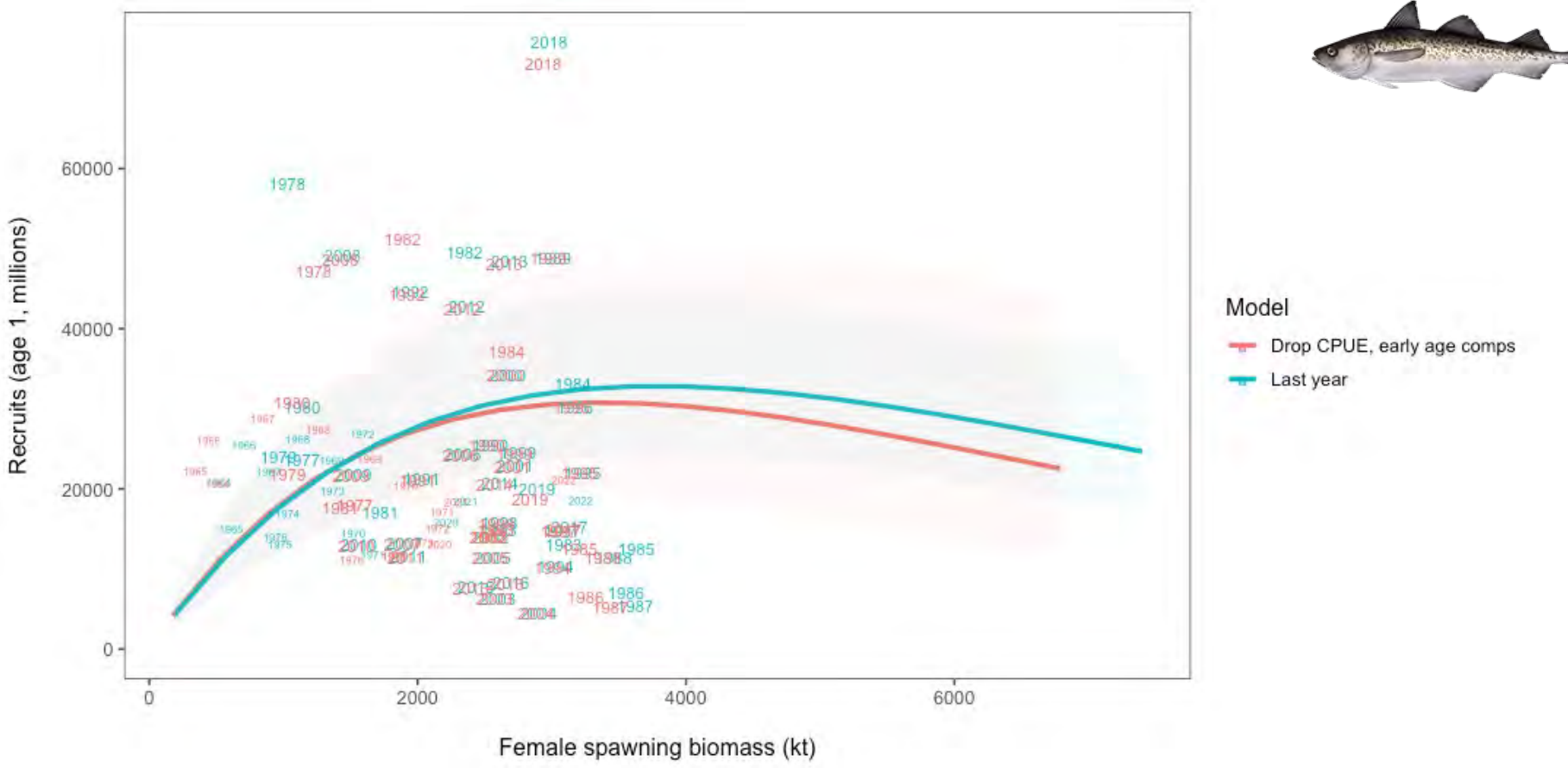


Figure 25: Model results of the stock-recruit relationships comparing last year's selected model with one where the early CPUE data and the early age compositions are downweighted (effectively removed).

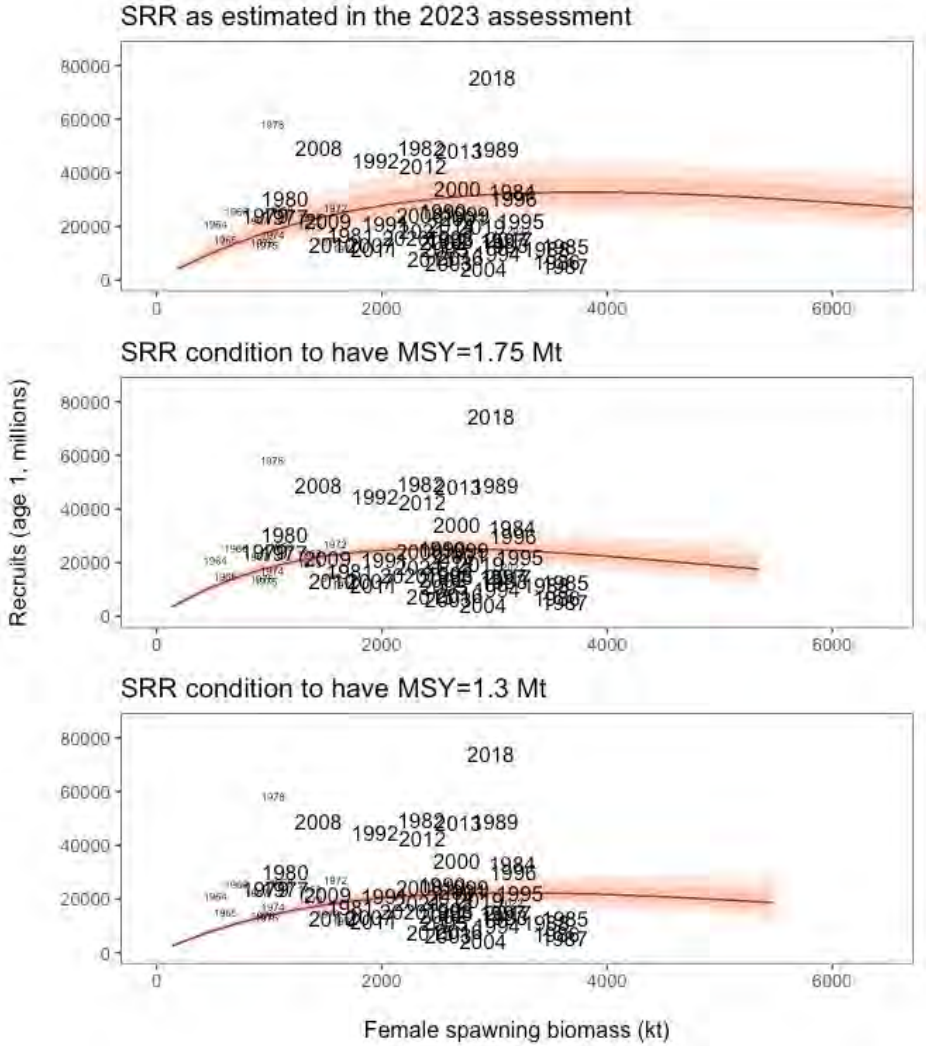
Pollock movement issues

2011 EBS pollock assessment

- Compiled all of the available Russian pollock survey biomass estimates
- Modest positive relationship with bottom temperatures
- Similar to moored sea-floor echo-sounders
- Research model evaluation has begun but more work needed
  - Perhaps apply DSEM results?

Considerations of pollock and ecosystem role

Figure 26: SRR curves as estimated in the 2023 assessment (top) and conditioned on alternative Fmsy assumptions (middle and bottom).



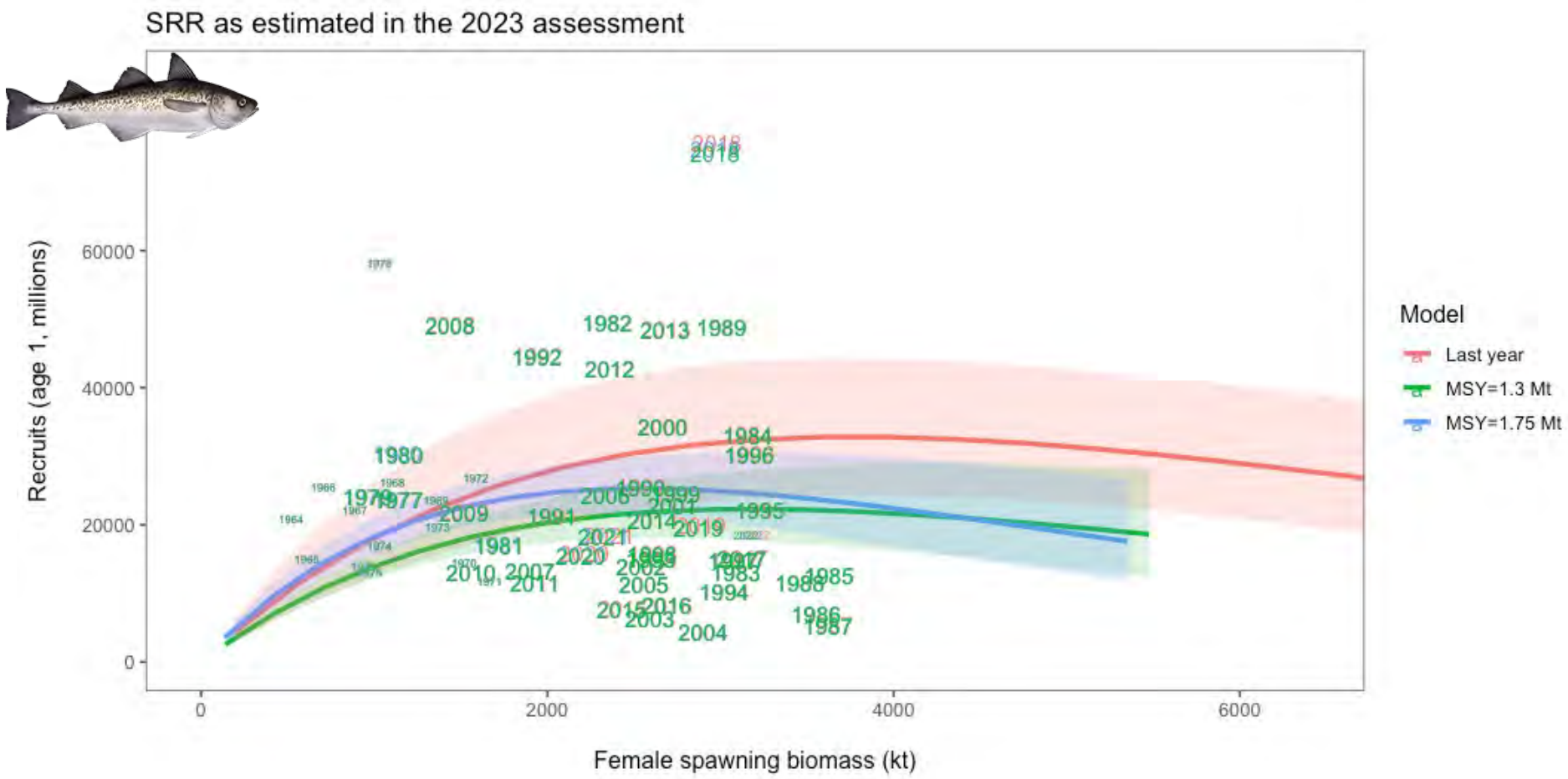


Figure 27: SRR curves as estimated in the 2023 assessment overlaid with those conditioned on alternative Fmsy assumptions.

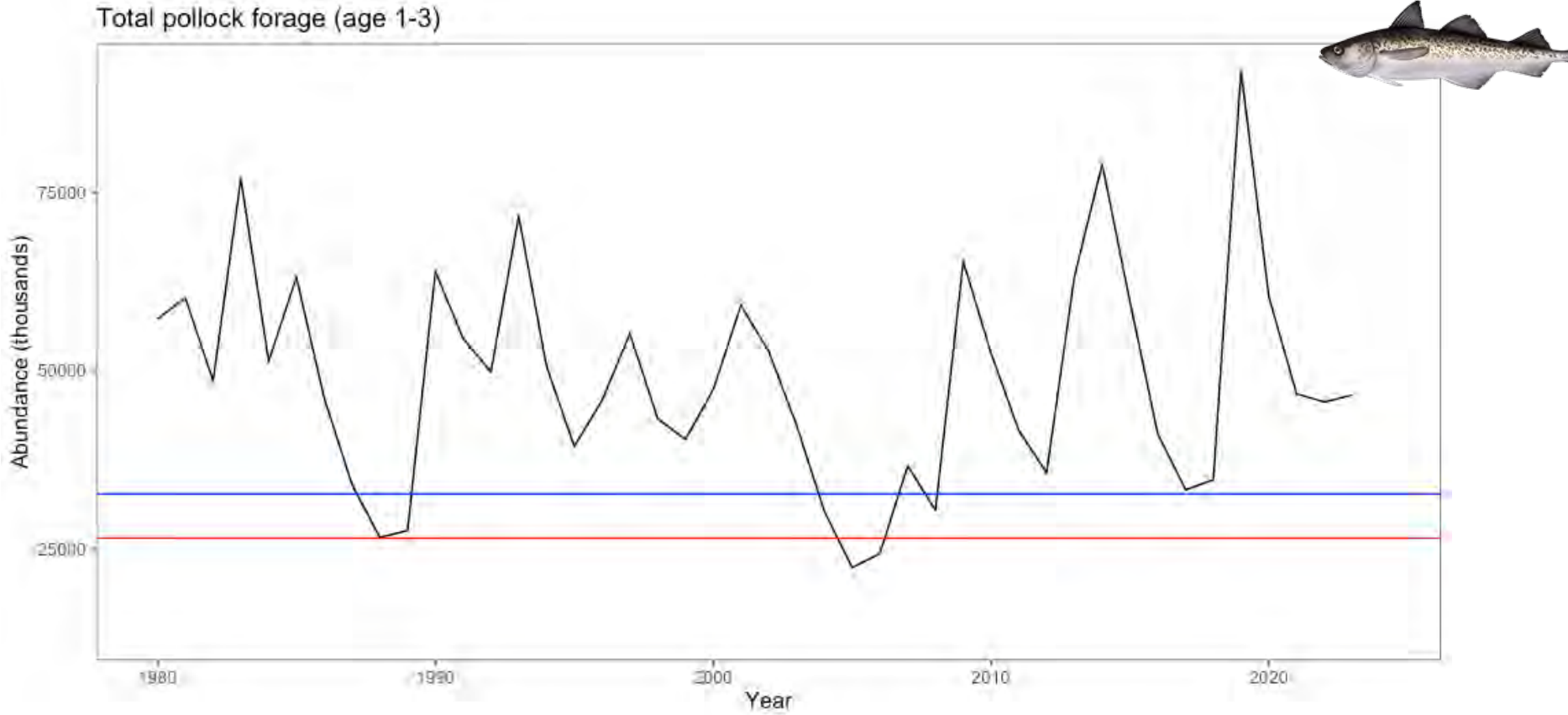


Figure 28: Historical age-1 to age-3 pollock abundance as estimated from the assessment model.

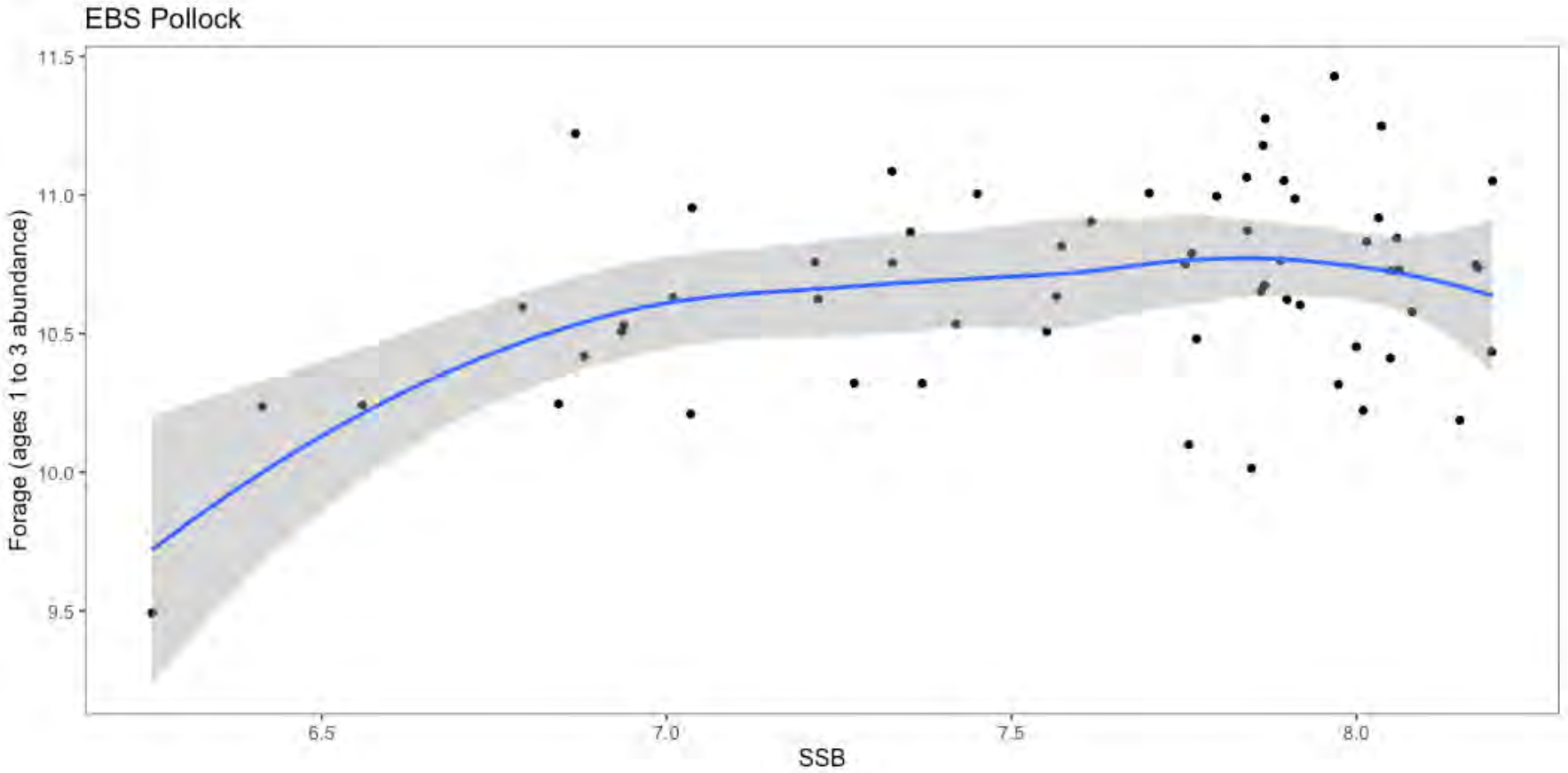


Figure 29: Historical spawning biomass and ‘prey’ abundance for pollock as estimated from the assessment model.

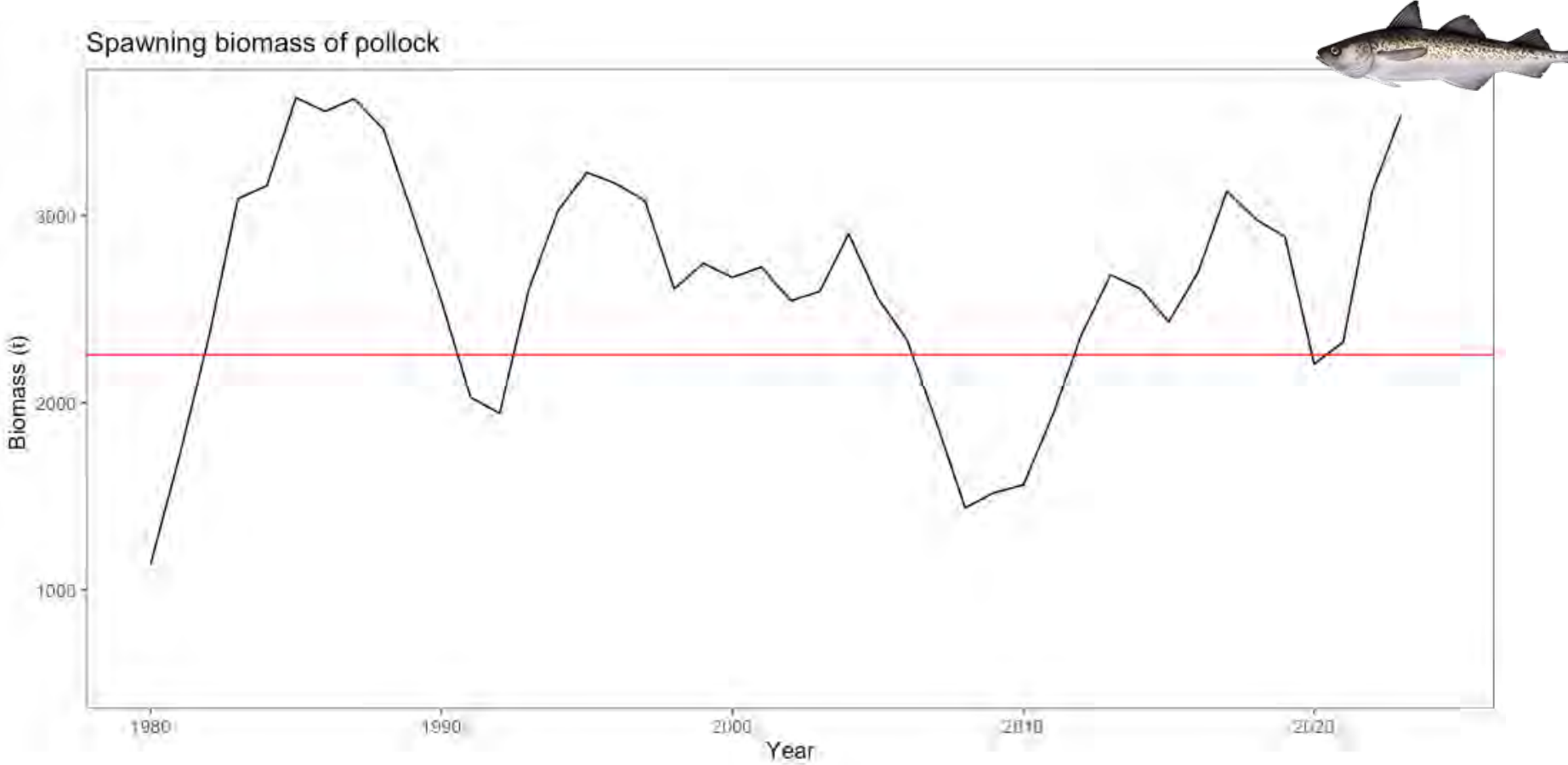


Figure 30: Historical spawning biomass relative to the mean for pollock as estimated from the assessment model. Red horizontal line is the mean value.

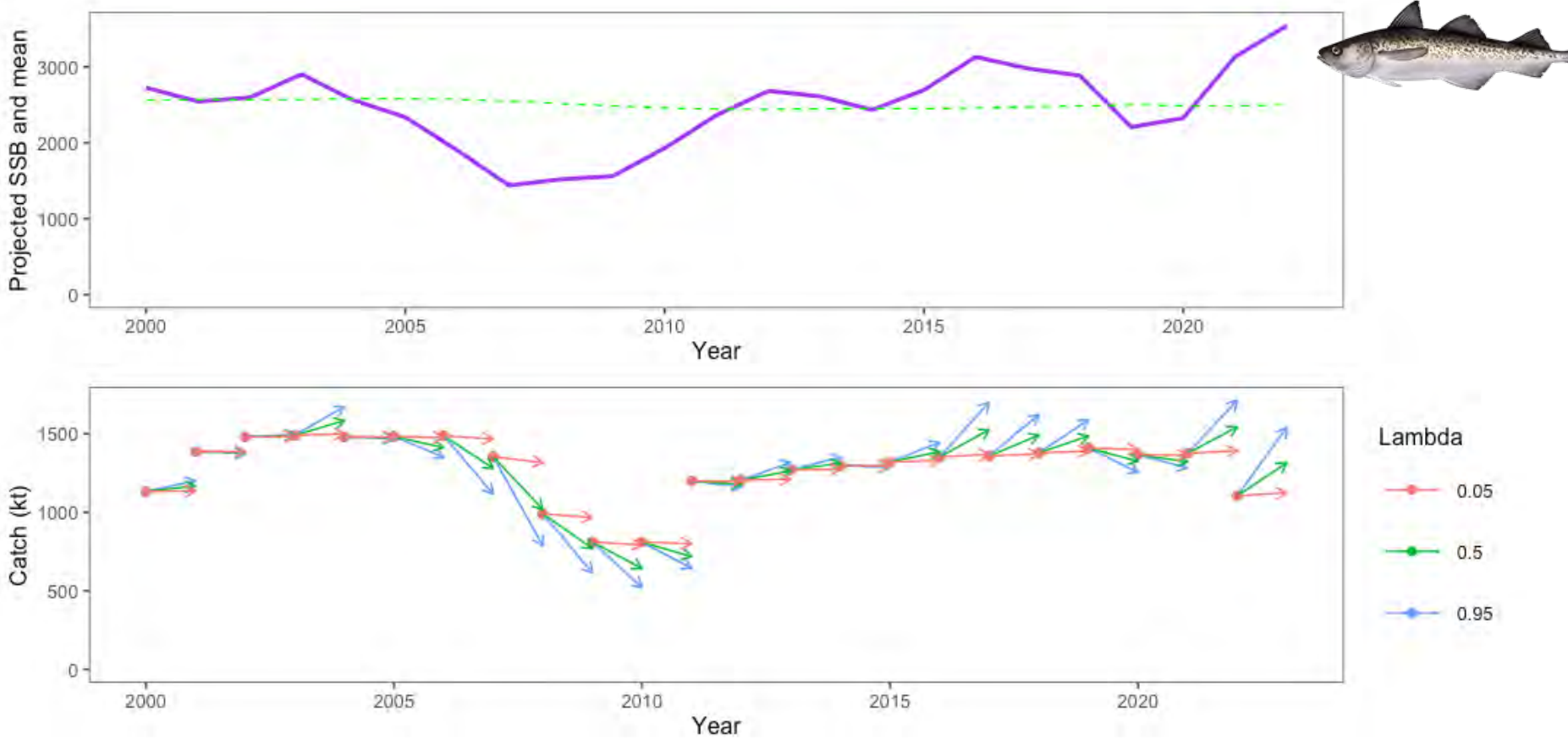


Figure 31: Results from applying a simple catch-advice rule given historical actual catches (points, bottom panel) based on spawning biomass projections and mean SSB (top panel, blue and dashed line, respectively). Arrows represent the catch advice given historical catches and different values of lambda.

Bayesian diagnostics

Figure 32: Diagnostic output for ADNUTS sampling for the 2023 EBS pollock model. For interpretation and guidance on these panels please see Carpenter (2017).

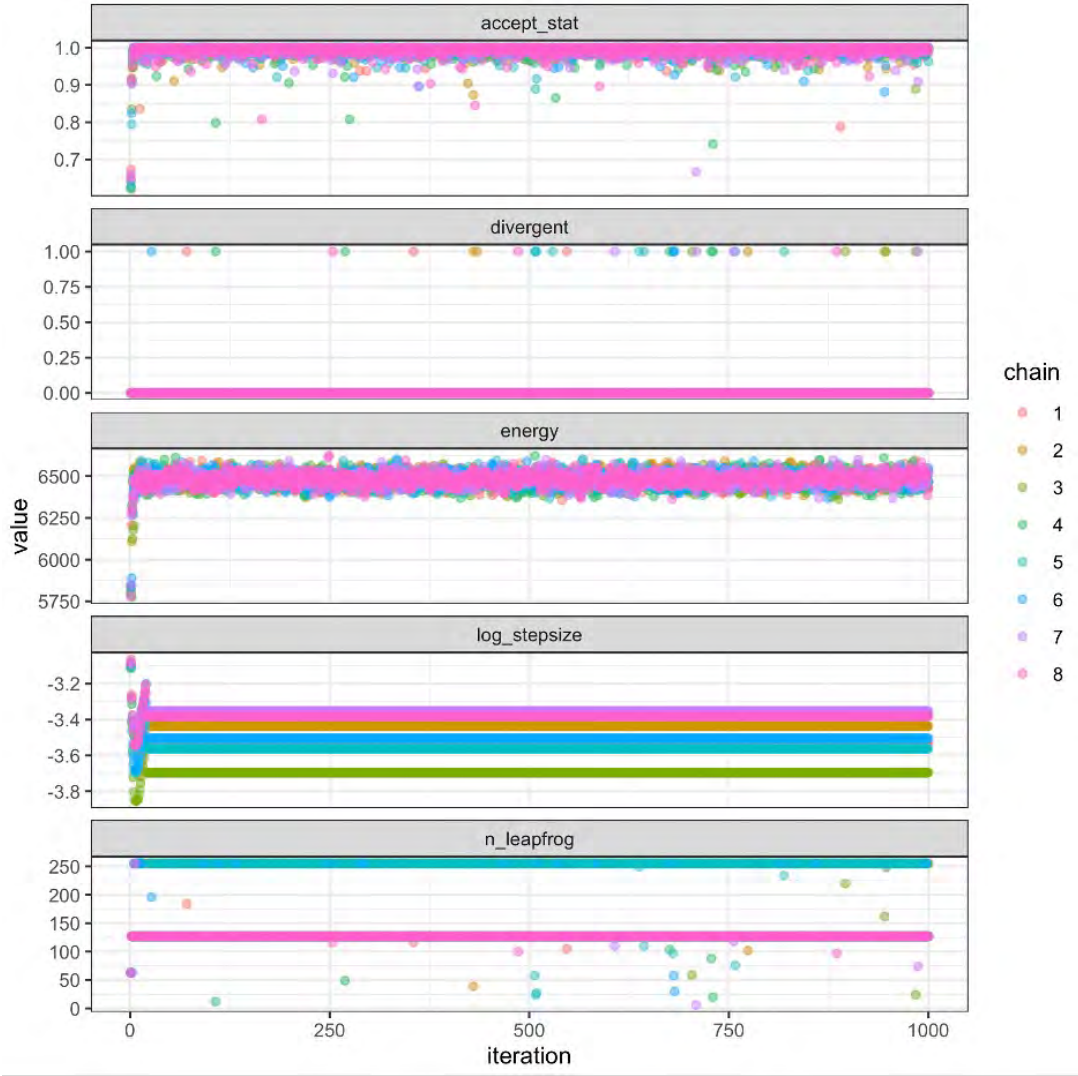
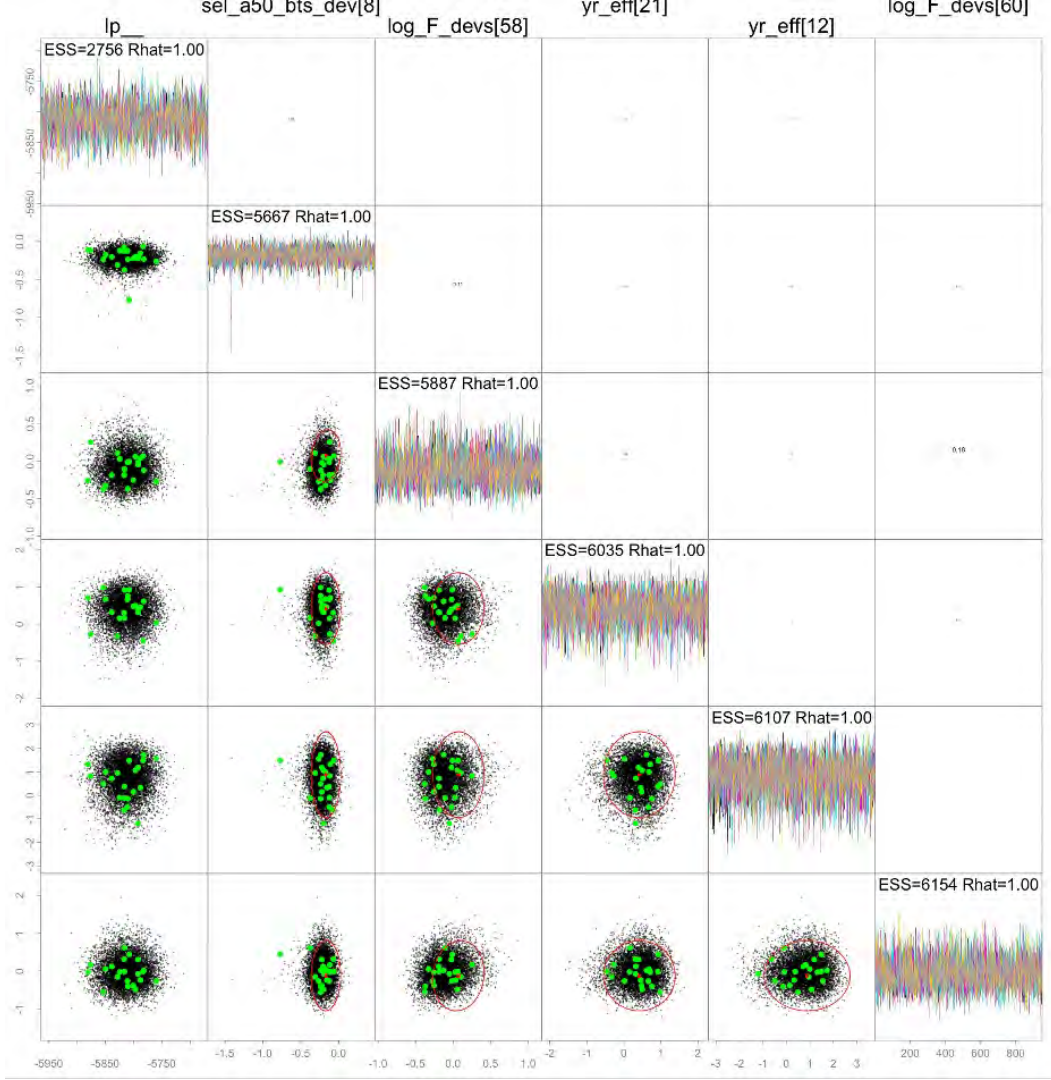


Figure 33: Joint posterior plots for the slowest mixing parameters: The red dots and elipses indicate point estimate and covariance of the MLE results. Trace plots are shown on the diagonals. Upper off-diagonals show correlation coefficients between parameters.



Feedback?

Evaluations pursued

- SRR evaluation of Tier 1—alternatives?
- Eliminate early data?
- CEATTLE –M matrix?
- Catch advice MSE?
- Table of Bayesian diagnostics needed (n chains, length etc)
- Alternatives platform mini-non-bridging exercise
  - (next slides…)

Alternative software platforms

There is continued interest in using alternative software platforms for this assessment. A repository was developed for these alternatives here.

Stock Synthesis 3: A very popular software platform

GOA pollock model: A customized program convertible between ADMB and TMB

SAM: A state-space model for age-structured assessments

AMAK: A general model assessment model developed to have flexible number of fisheries, indices etc.

WHAM: The Woods Hole Assessment Model (written in TMB…withdrawn from this presentation due to limits on time)

Very little effort was made to do fine-scale bridging

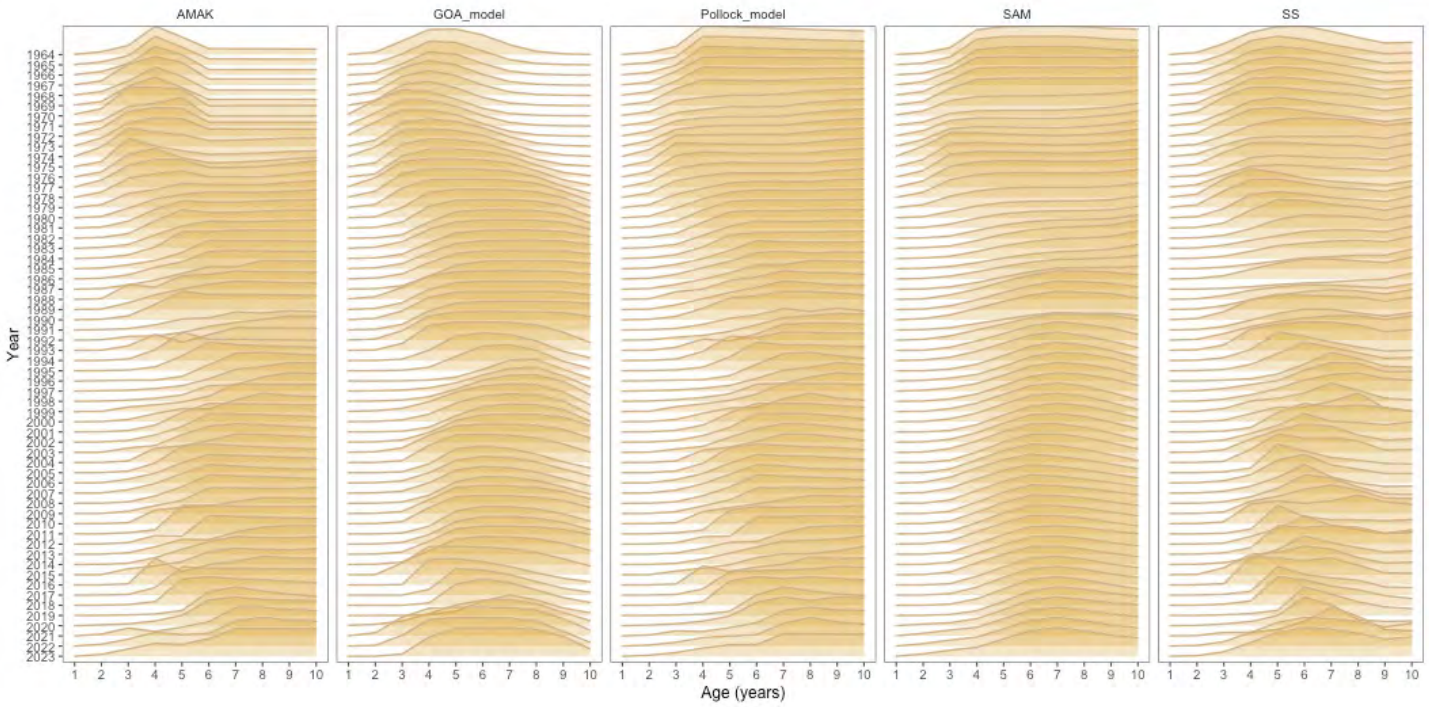


Figure 1: Comparison of the time series of selectivity estimates over different modeling platforms.

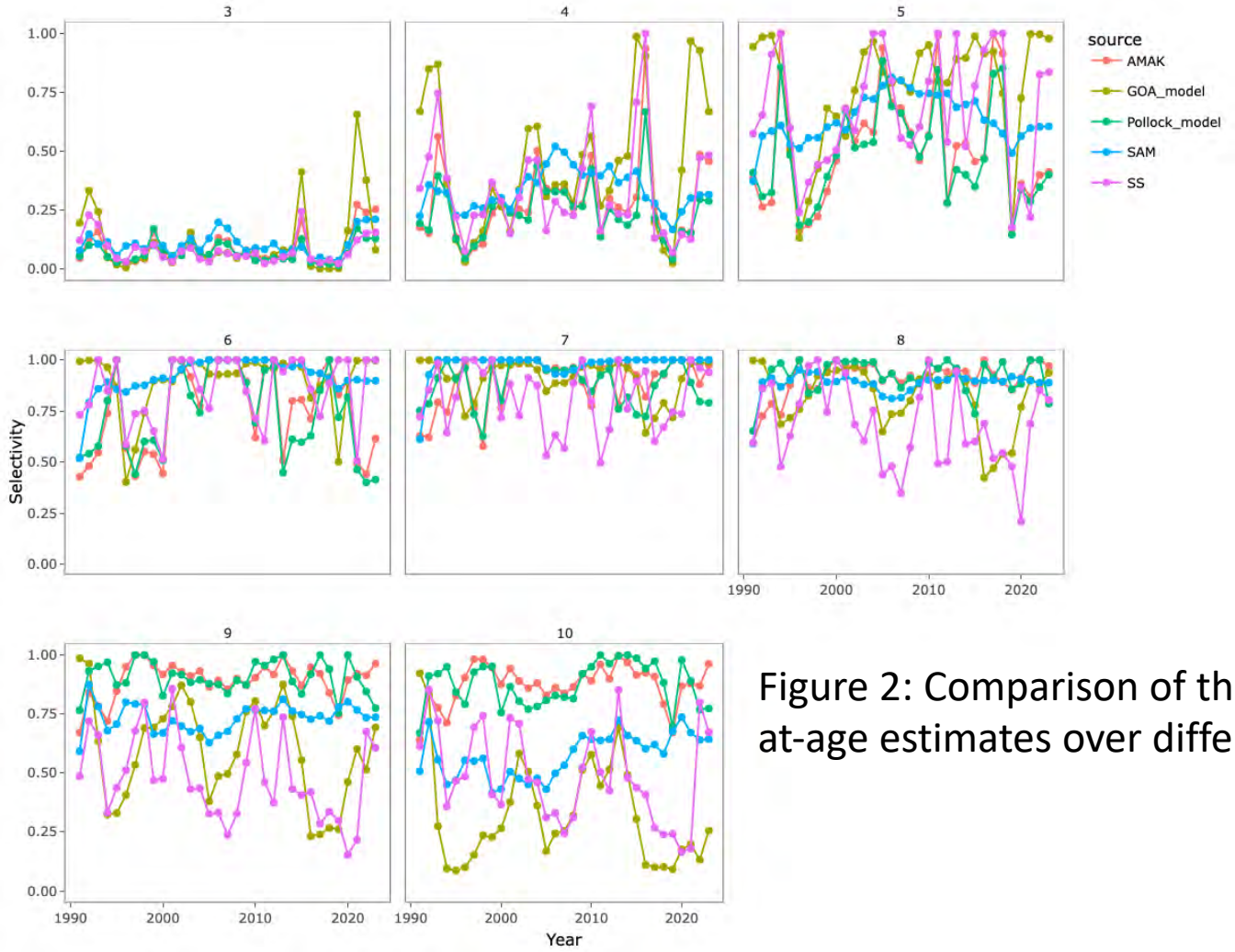


Figure 2: Comparison of the time series of selectivity-at-age estimates over different modeling platforms.

Figure 3: Comparison of the time series of age-1 recruitment (top) and spawning biomass (bottom) estimates over different modeling platforms.

Added AMAK runs

base: selectivity at age allowed to vary (sigma penalty=0.7)

cpue: As base but with the early CPUE data included

dbl_logistic: selectivity at age with TV selectivity parameters (3-parameter logistic)

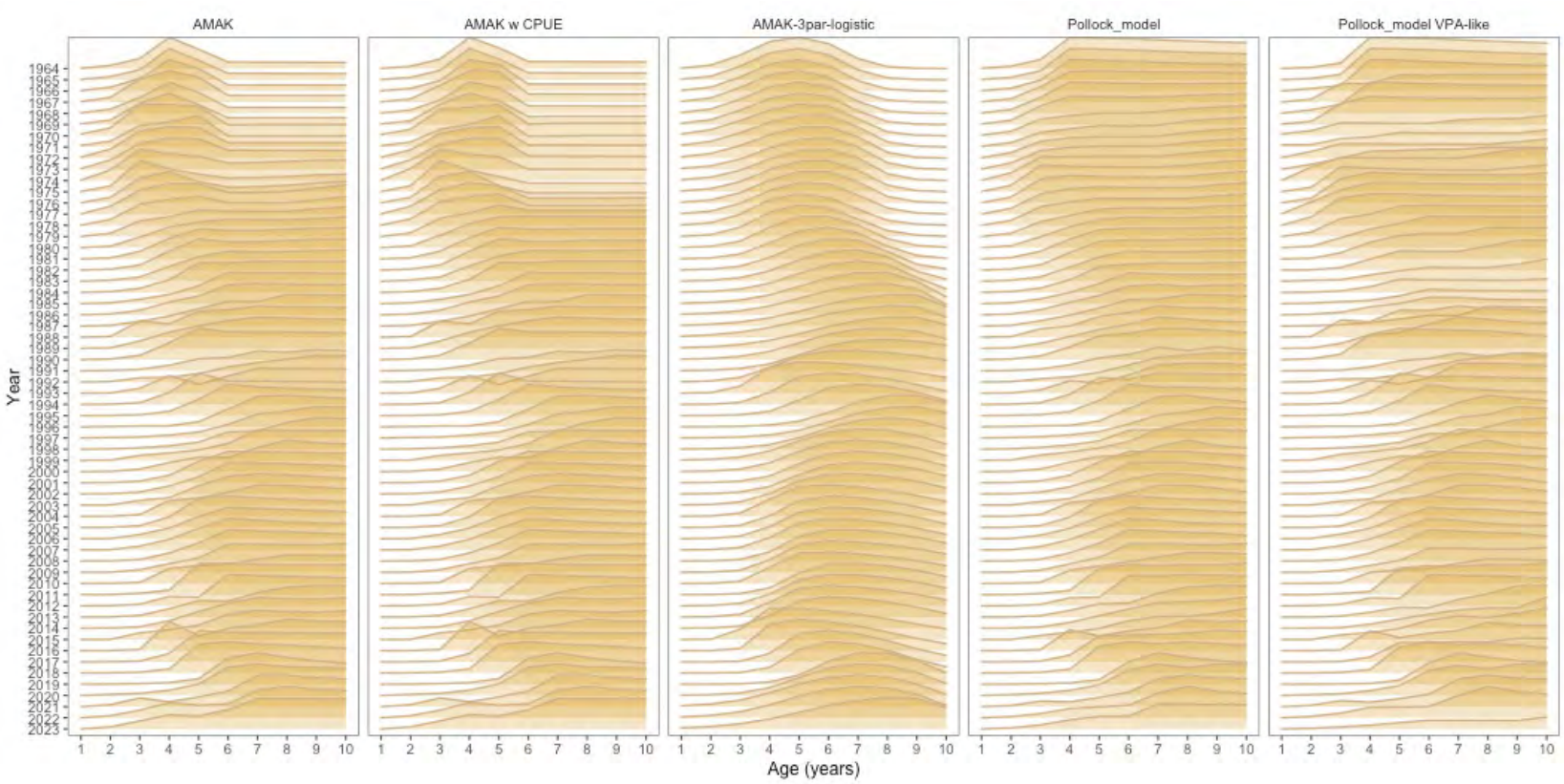


Figure 5: Comparison of the selectivity estimates between different modeling specifications in AMAK

Figure 6: Comparison of the selectivity-at-age estimates between different modeling specifications in AMAK

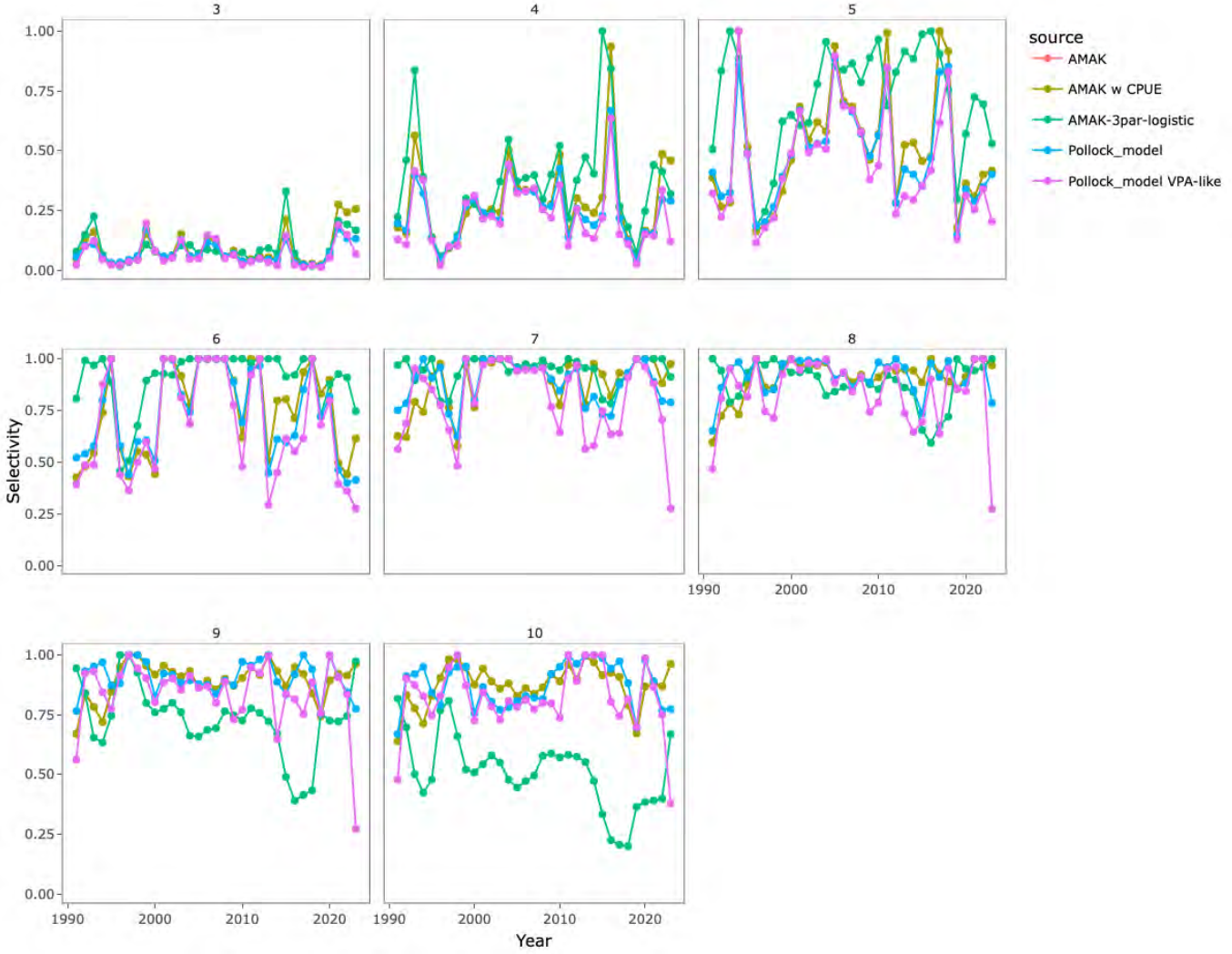


Figure 7: Comparison of the selectivity-at-age estimates between different modeling specifications in AMAK

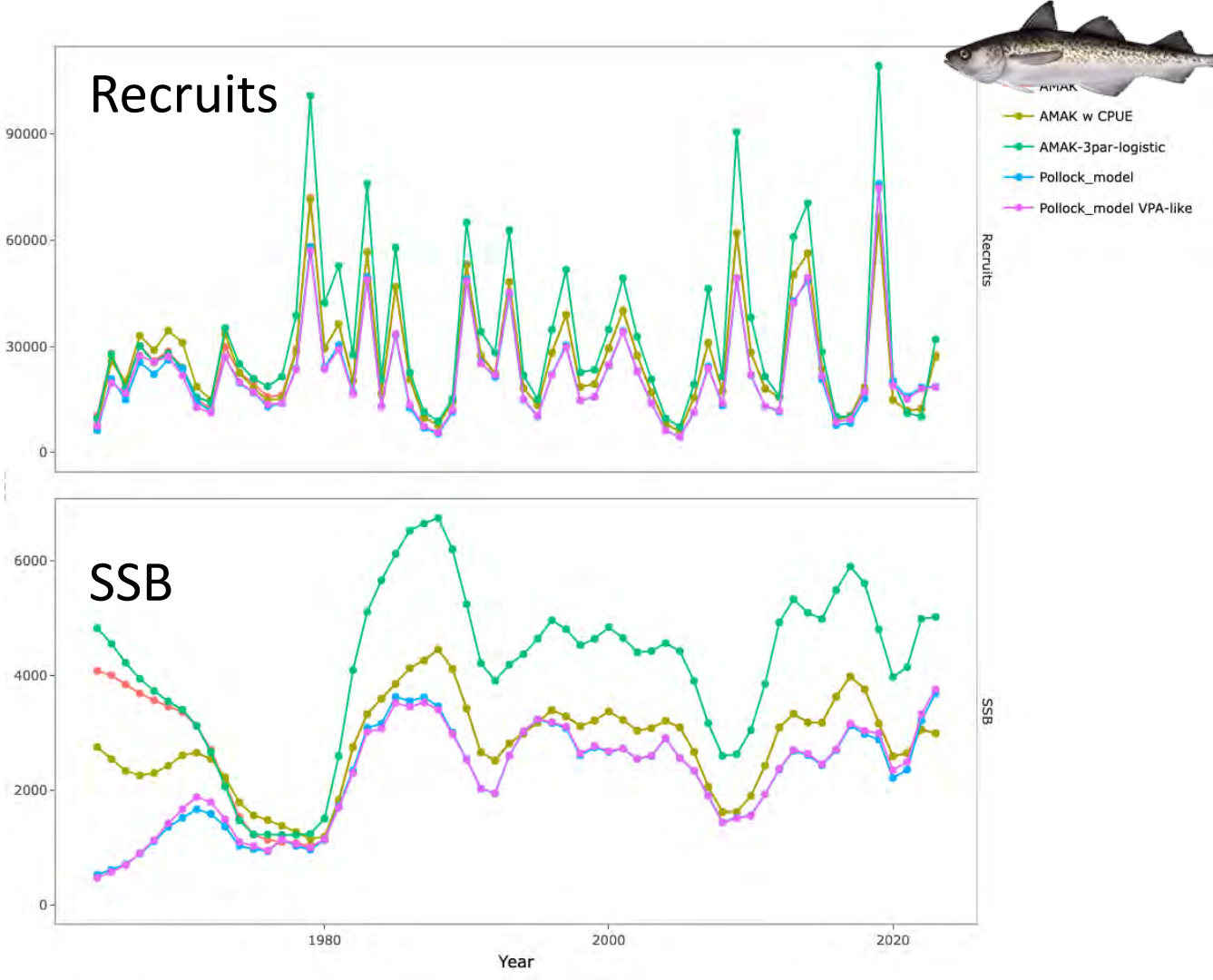
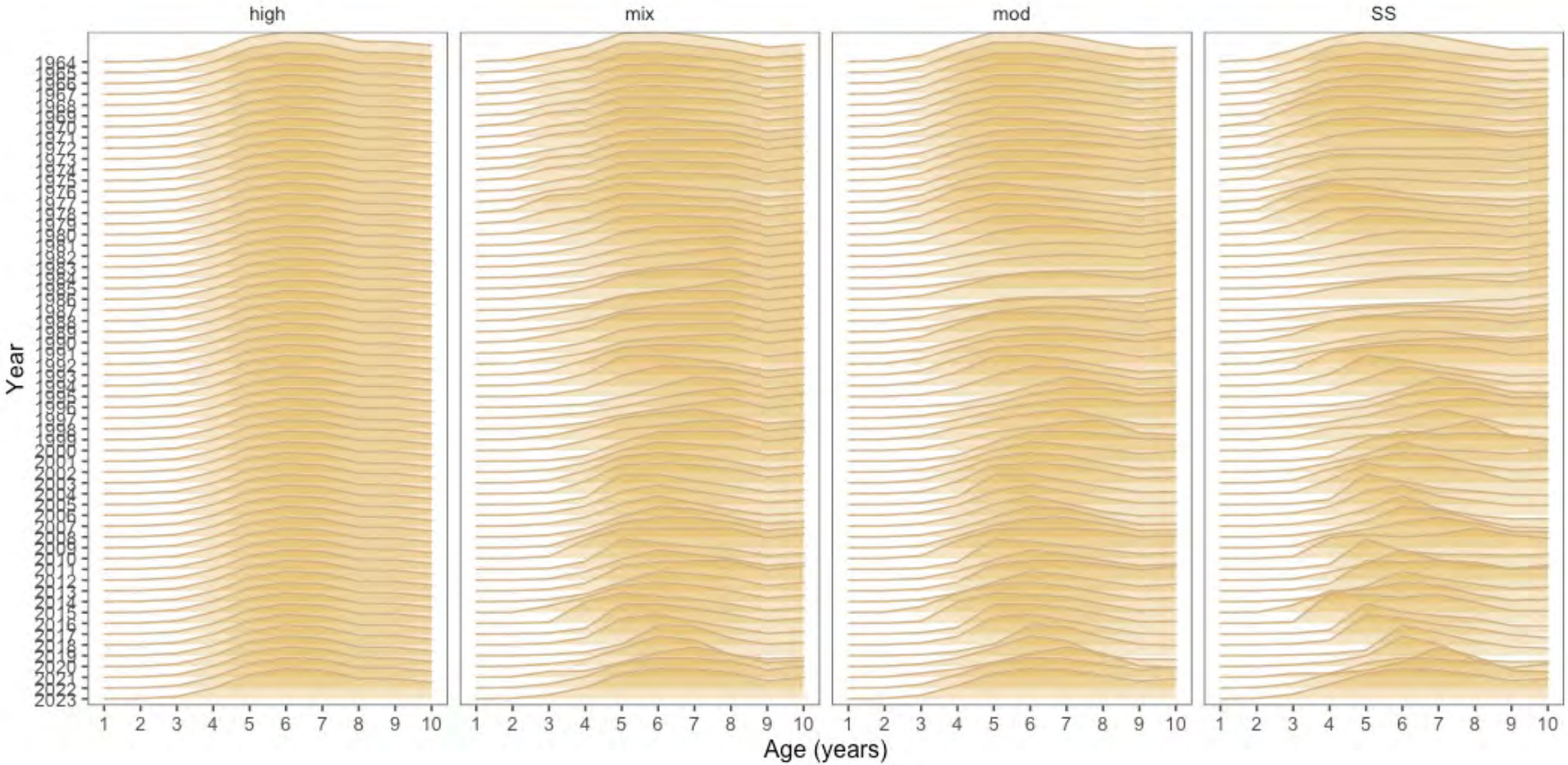


Figure 8: Comparison of the fit to indices between different modeling specifications using the AMAK software platform.

Additional SS3 runs with different selectivity assumptions where:

- **base**: selectivity at age allowed to vary (sigma penalty=0.7)
- **high**: selectivity at age constrained (sigma penalty=0.05)
- **mod**: selectivity at age moderately constrained (sigma penalty=0.4)
- **mix**: selectivity at age moderately constrained for middle ages, high for older ages, loose for younger ages



Selectivity at age

SSB and recruitment