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Stock assessment work for Alaska pollock in the Eastern Bering Sea

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Model tuning: observation versus process-error specifications

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Eastern Bering Sea pollock stock assessment model evaluations

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1 Background

Each year we attempt to show how the Eastern Bering Sea walleye pollock assessment model is affected by data and assumptions. In most recent years, the evaluations have arisen from alternative methods for data processing (e.g., use of the VAST index, including NBS region, etc.). This year we evaluate new treatment of the acoustic data collected from the bottom-trawl survey data (the acoustic vessels of opportunity (AVO) series). In addition, we updated and re-evaluated some of the other input data specifications. This included reconsidering the relative weights among different data sets. We present alternative process-error specifications (e.g., the amount of allowed variability among processes related to time-varying selectivity) and compare that with an alternative where additional observation error variance was estimated. We also began to take the steps needed to be able to compare the current model across different assessment software platforms. Table 1 below shows the model evaluations examined, the naming convention used, relevant comparisons, and notes.

Table 1: Preliminary model configuration comparisons for the EBS pollock stock assessment, September 2023.

Description	Notes
Base	Original from folder 07, now in folder base22 with new code that accommodates arbitrary number of age-error matrices by gear and year, and the generalized Gamma distribution for index data
AVO new series	Newly integrated acoustic backscatter from "Acoustic vessels of opportunity"—namely the bottom-trawl survey vessels. Includes data from 2009 (data from early and in 2011 and 2013 omitted).
AVO full	As in "AVO new" series but with data from 2006-2008, 2011, and 2013 used from previous series (rescaled to have the same mean)
Tuned TV selectivity for ATS	As in "AVO full" but with time-varying (TV) acoustic-trawl survey (ATS) selectivity variability "tuned" to achieve model consistency with input variance terms
Tuned observation errors for indices	As in "AVO full" but with input index variability estimated for consistency with model fit
Ageing error Diagonal	Include age-determination error matrix As in base but uses only the diagonal of the covariance matrix for the bottom-trawl survey (BTS) biomass estimates
Generalized Gamma distribution applied to BTS data	This is based on the MCMC posterior samples generated from the process of accounting for density-dependence within tows; the goal is to evaluate annually varying distribution assumptions compared to the standard lognormal distribution.
Alternative wt-age for SSB	Show how stock changes assuming a constant weight-at-age for SSB calculations Use empirical mean values from A-season fishery as a proxy Use predicted mean values from the year and cohort random-effects model
Base Proposed	Full AVO series and with the smoothed mean-wt-age (random effect model)

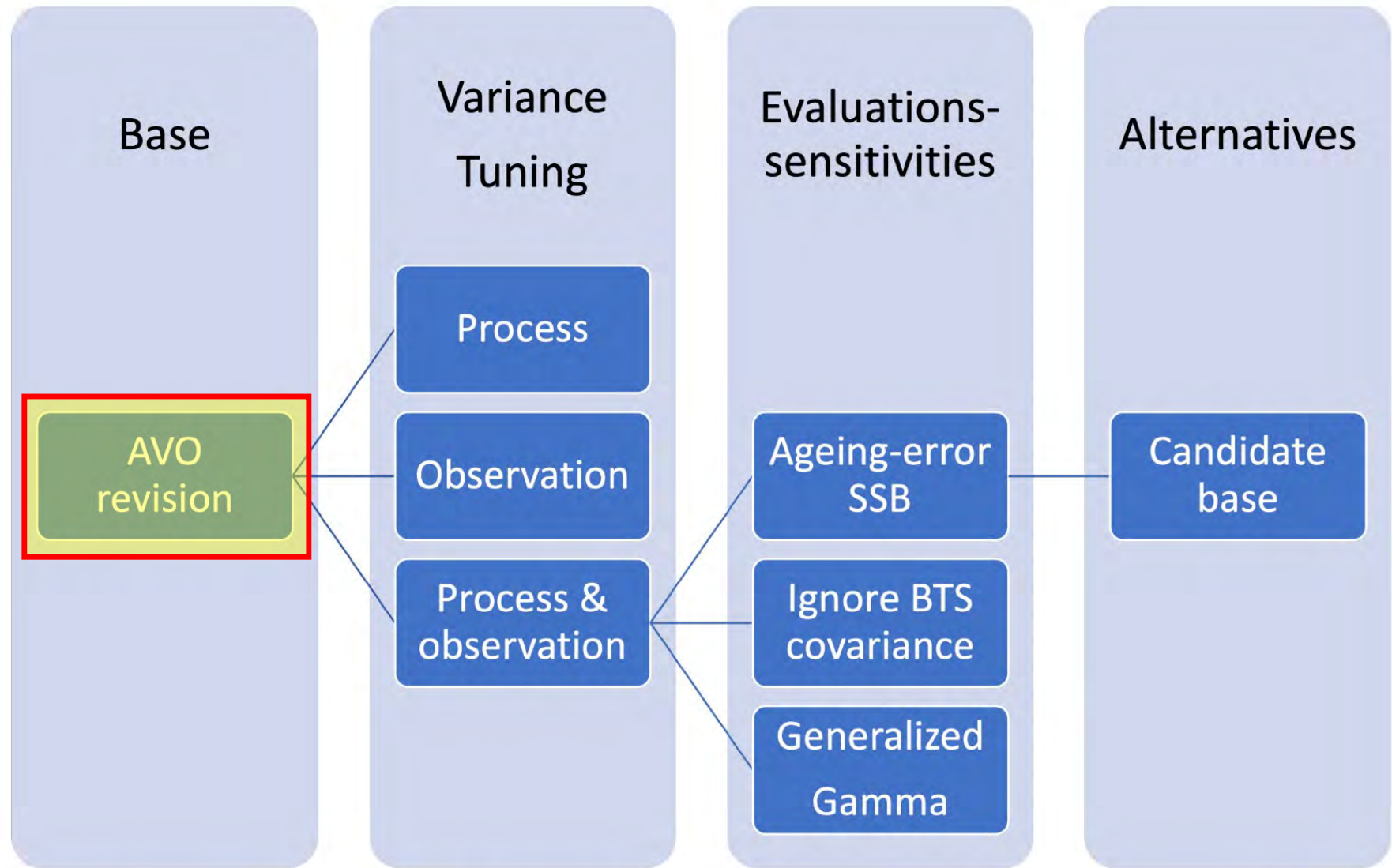


Figure 1: Schematic of approach for evaluating some planned changes in the EBS pollock assessment. See text for details.

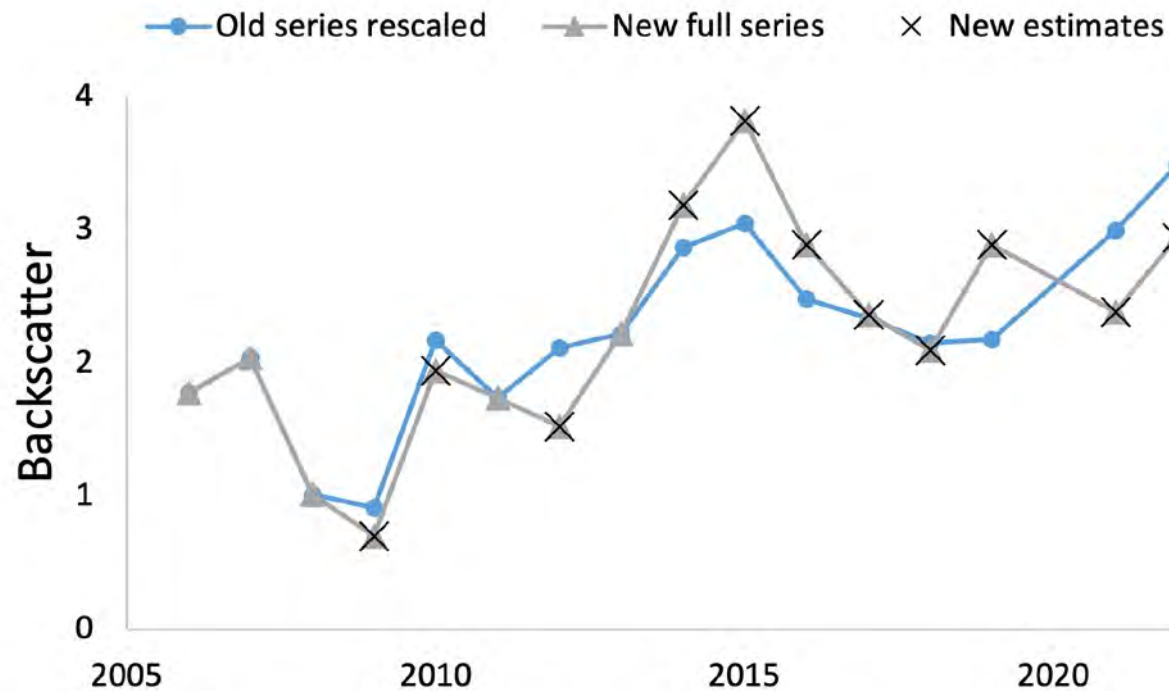
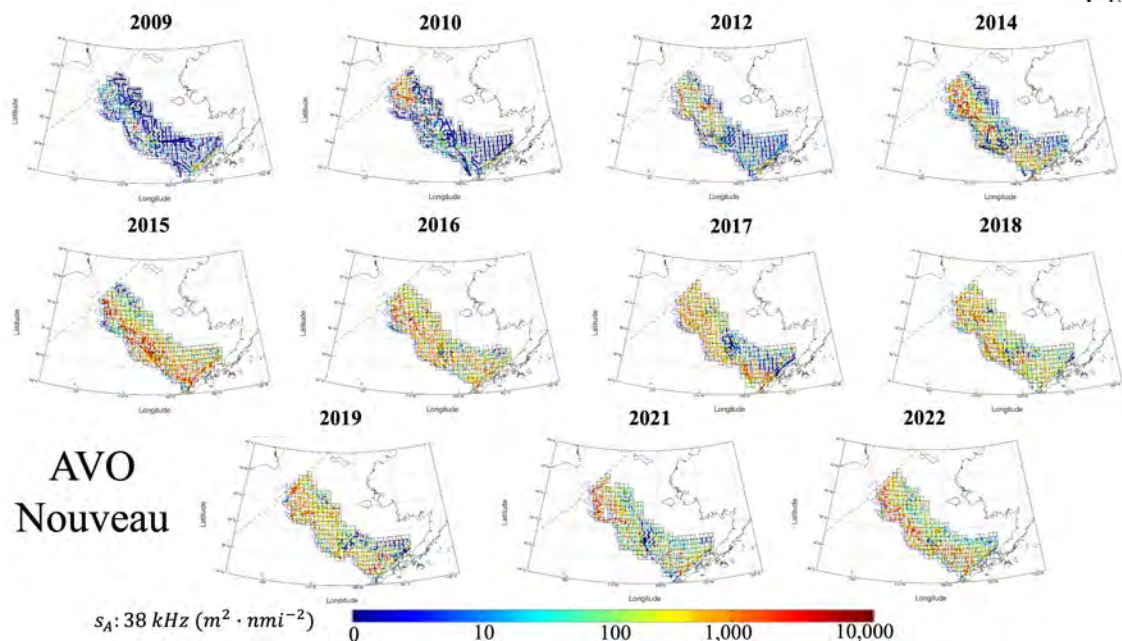


Figure 2: Time series of EBS pollock data from the acoustic vessels of opportunity (AVO) showing the years of new data compared to previous series and the full series.



EBS pollock
 new opportunistic
 acoustics from NMFS
 bottom-trawl survey

EBS pollock
new opportunistic
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Table 2: Goodness-of-fit measures to primary data for different assessment model configurations. RMSE=root-mean square log errors, NLL=negative log-likelihood (may not be comparable across model configurations), SDNR=standard deviation of normalized residuals, Eff. N=effective sample size for composition data)

	Component	Base 22	AVO new	AVO full
Lower better	RMSE BTS	0.166	0.166	0.166
	RMSE ATS	0.233	0.232	0.231
	RMSE AVO	0.221	0.341	0.292
	RMSE CPUE	0.093	0.093	0.093
Consistent ~1.0	SDNR BTS	0.990	0.980	0.980
	SDNR ATS	1.270	1.240	1.240
	SDNR AVO	0.650	1.710	1.460
Higher better	Eff. N Fishery	1,238	1,230	1,233
	Eff. N BTS	224	223	224
	Eff. N ATS	204	202	203
Lower better	Catch NLL	3	3	4
	BTS NLL	32	31	31
	ATS NLL	14	13	13
	AVO NLL	3	16	17
	Fish Age NLL	145	146	145
	BTS Age NLL	159	159	159
	ATS Age NLL	35	36	36
	NLL selectivity	158	158	158
	NLL Priors	20	20	20
	Data NLL	410	424	425
	Total NLL	623	637	638

Table 3: Summary of model results and the stock condition for EBS pollock. Biomass units are thousands of t.

Component	Base 22	AVO new	AVO full
B_{2023}	4,000	3,800	4,000
$CV_{B_{2023}}$	0.13	0.11	0.11
B_{MSY}	2,667	2,653	2,660
$CV_{B_{MSY}}$	0.2	0.2	0.2
B_{2023}/B_{MSY}	150%	144%	149%
B_0	6,640	6,608	6,624
$B_{35\%}$	2,114	2,101	2,111
SPR rate at F_{MSY}	33%	33%	33%
Steepness	0.61	0.61	0.61
Est. $B_{2022}/B_{2022, no fishing}$	0.61	0.6	0.61
B_{2022}/B_{MSY}	143%	137%	141%

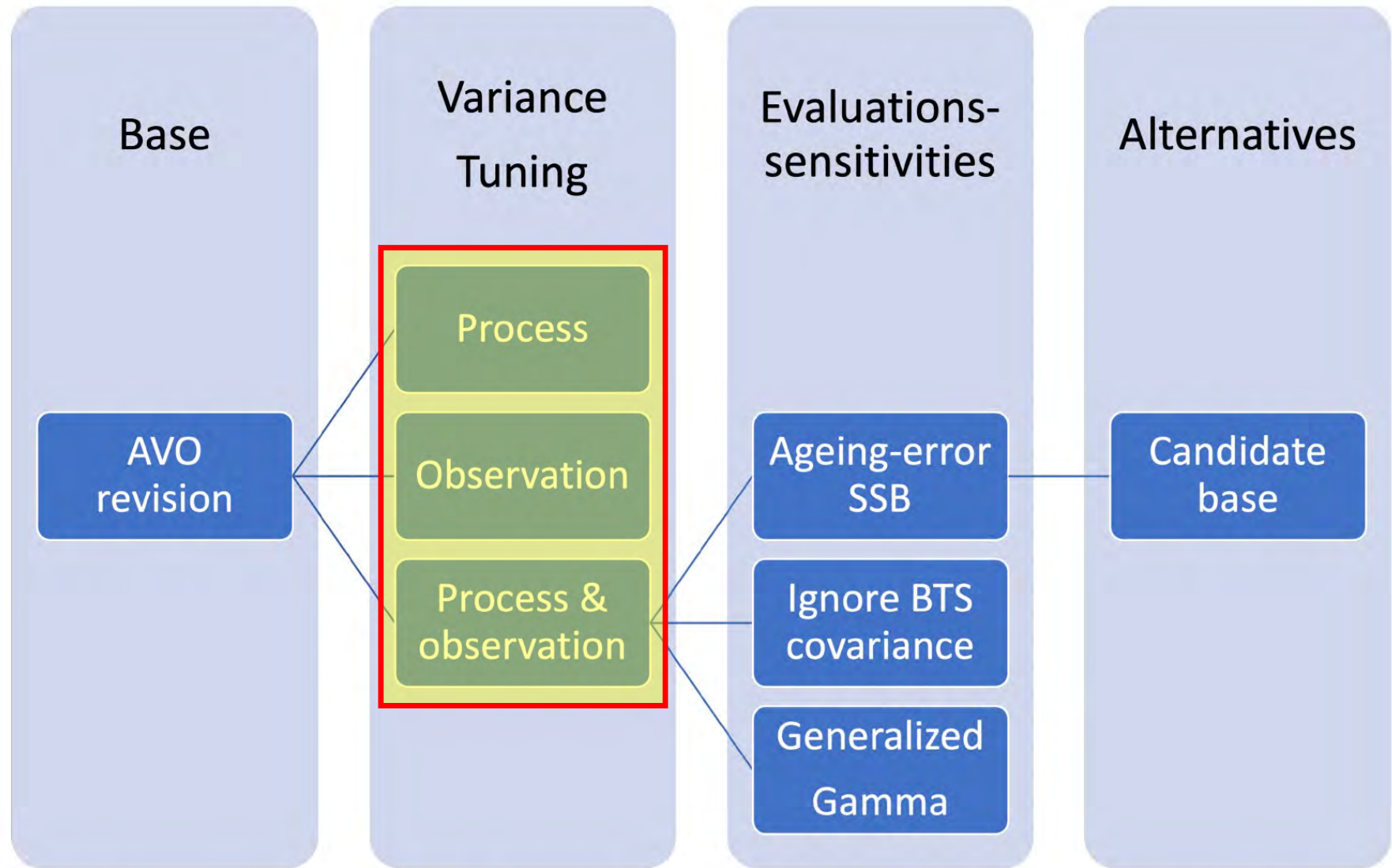


Figure 1: Schematic of approach for evaluating some planned changes in the EBS pollock assessment. See text for details.

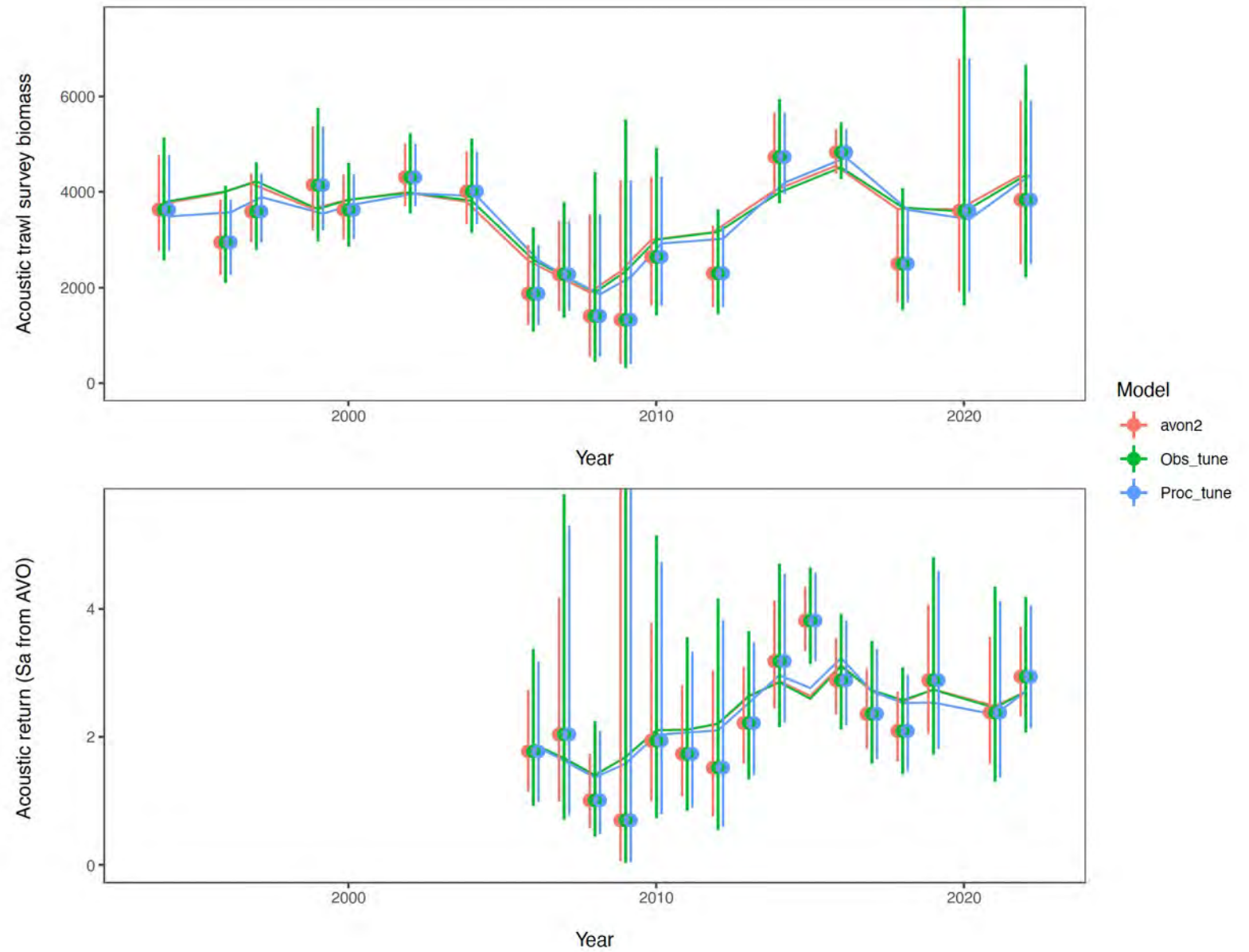


Figure 5: Comparison of the model fit to acoustic trawl survey (top) and acoustic vessels of opportunity (AVO; bottom) for the 2022 assessment and tuning process error terms or observation errors.

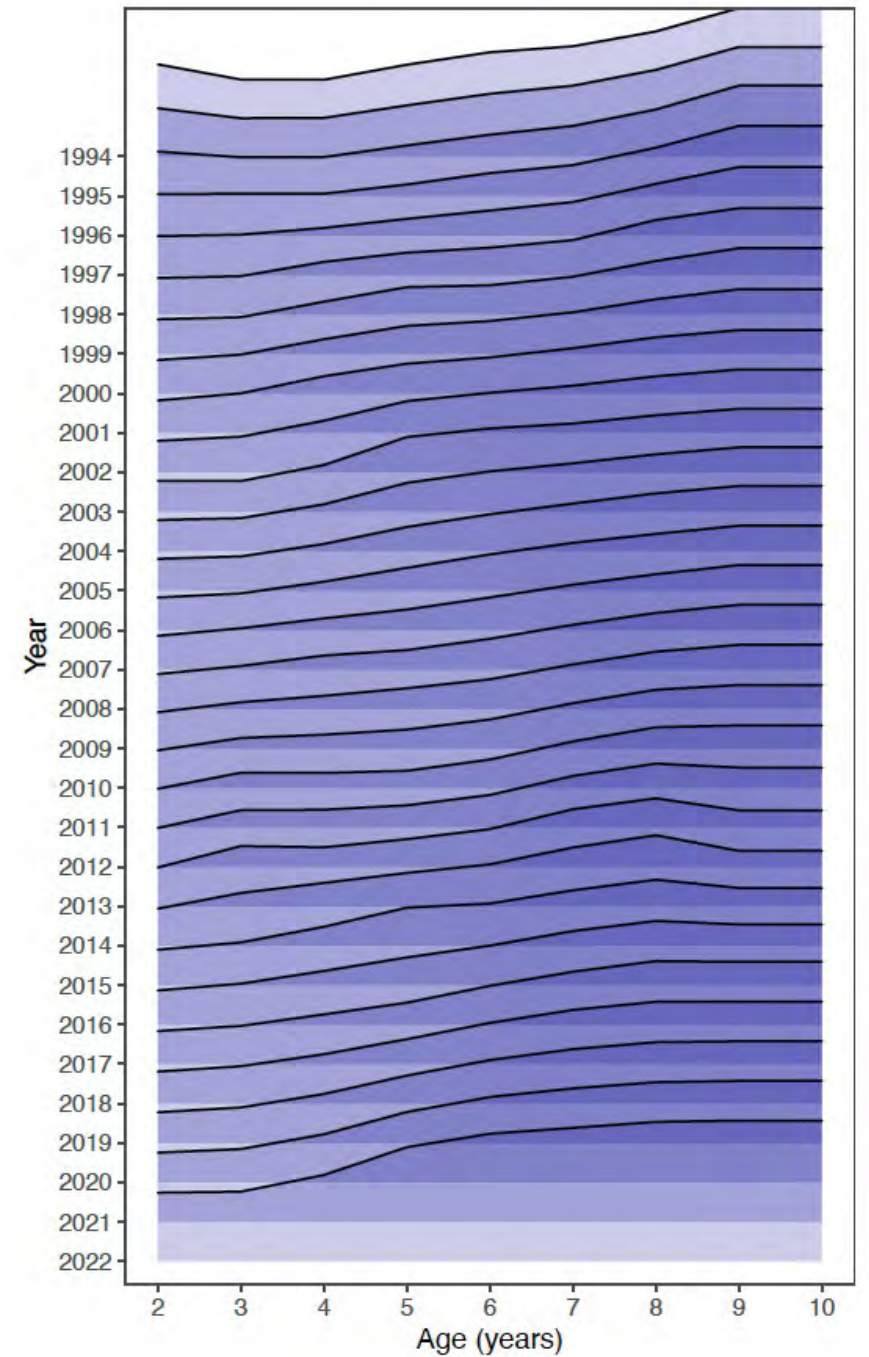
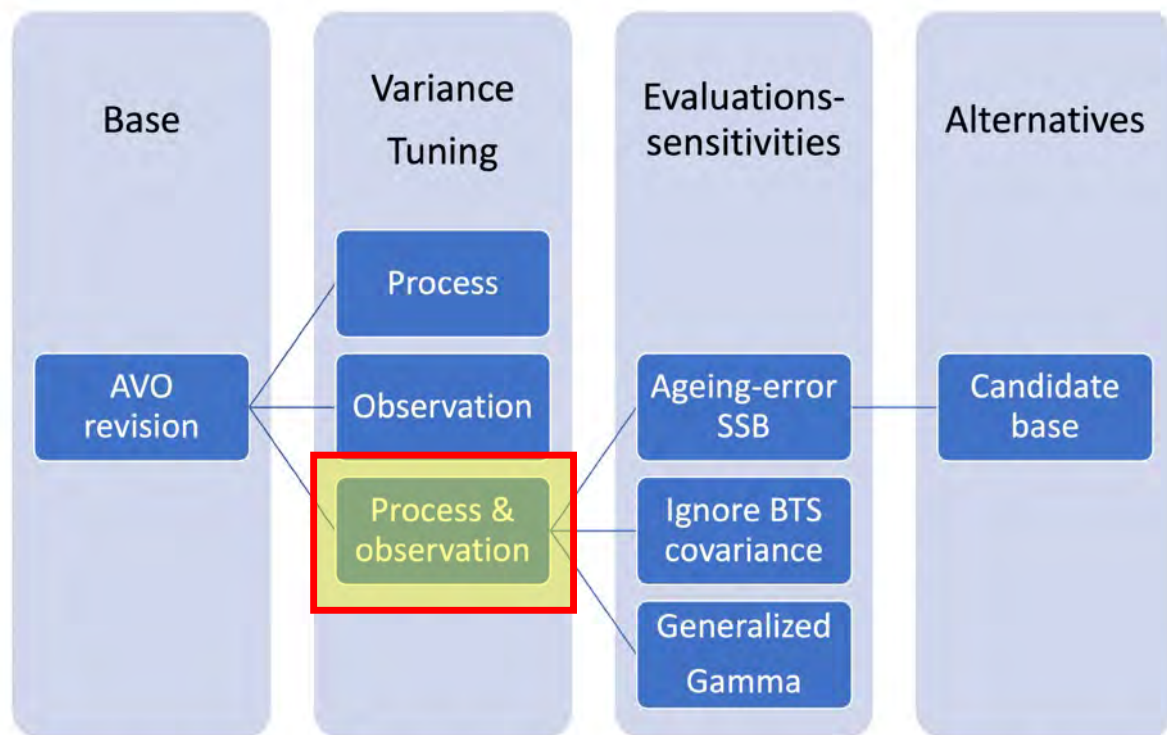
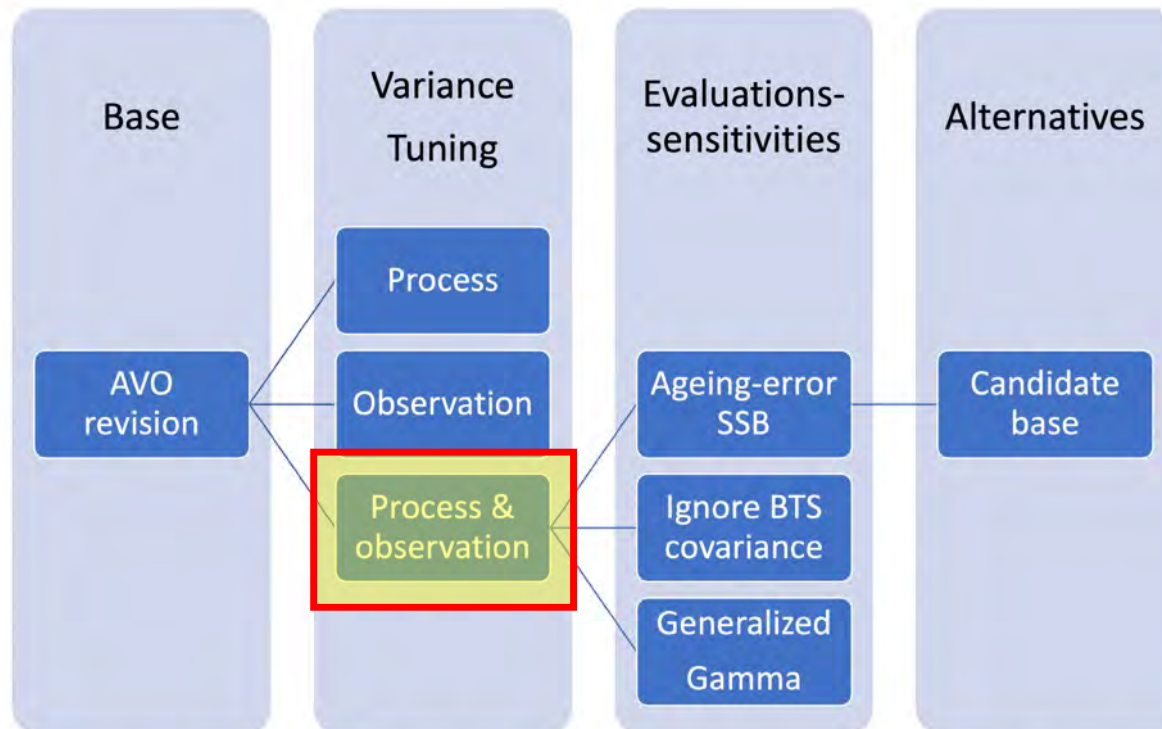


Figure 7: Time varying acoustic trawl selectivity estimates for the process-error tuned model.

Process error fit

Table 4: Goodness-of-fit measures to primary data for different assessment model configurations. RMSE=root-mean square log errors, NLL=negative log-likelihood (may not be comparable across model configurations), SDNR=standard deviation of normalized residuals, Eff. N=effective sample size for composition data)

Component	AVON Full	Proc_tune
RMSE BTS	0.166	0.165
RMSE ATS	0.231	0.208
RMSE AVO	0.292	0.271
RMSE CPUE	0.093	0.093
SDNR BTS	0.980	0.980
SDNR ATS	1.240	1.030
SDNR AVO	1.460	0.990
Eff. N Fishery	1,233	1,236
Eff. N BTS	224	225
Eff. N ATS	203	249
Catch NLL	4	3
BTS NLL	31	31
ATS NLL	13	9
AVO NLL	17	8
Fish Age NLL	145	145
BTS Age NLL	159	159
ATS Age NLL	36	28
NLL selectivity	158	164
NLL Priors	20	20
Data NLL	425	402
Total NLL	638	622



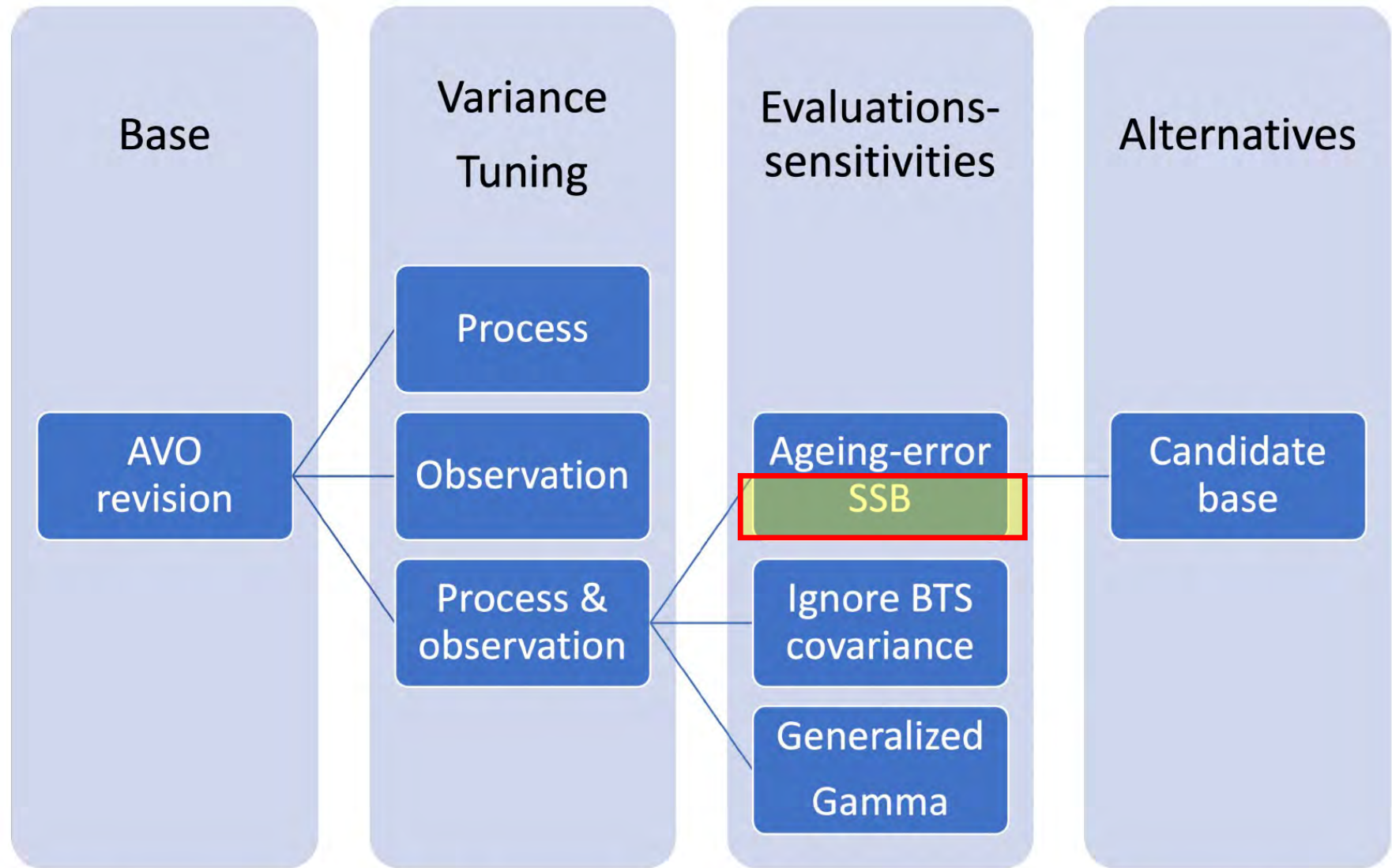


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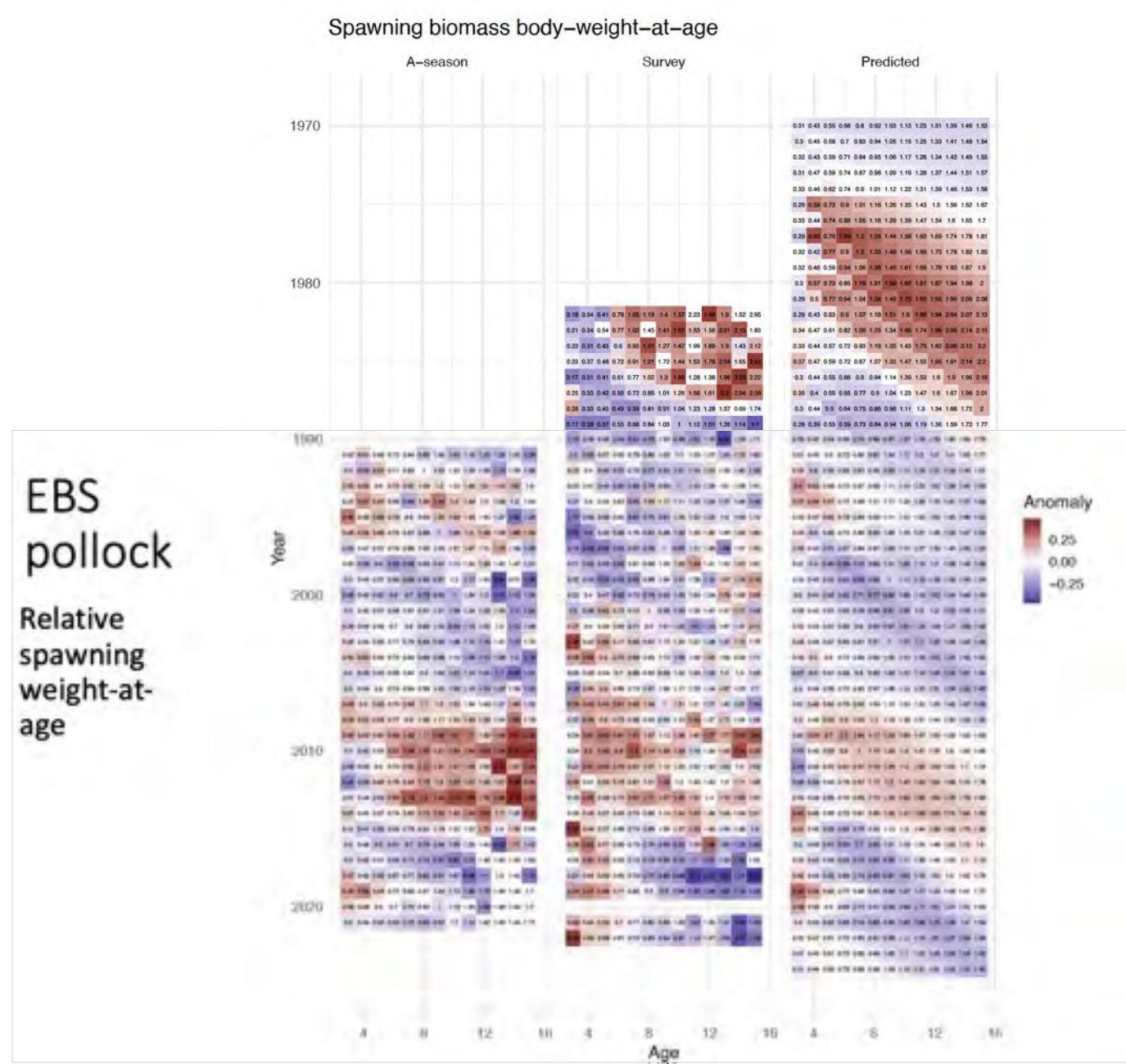
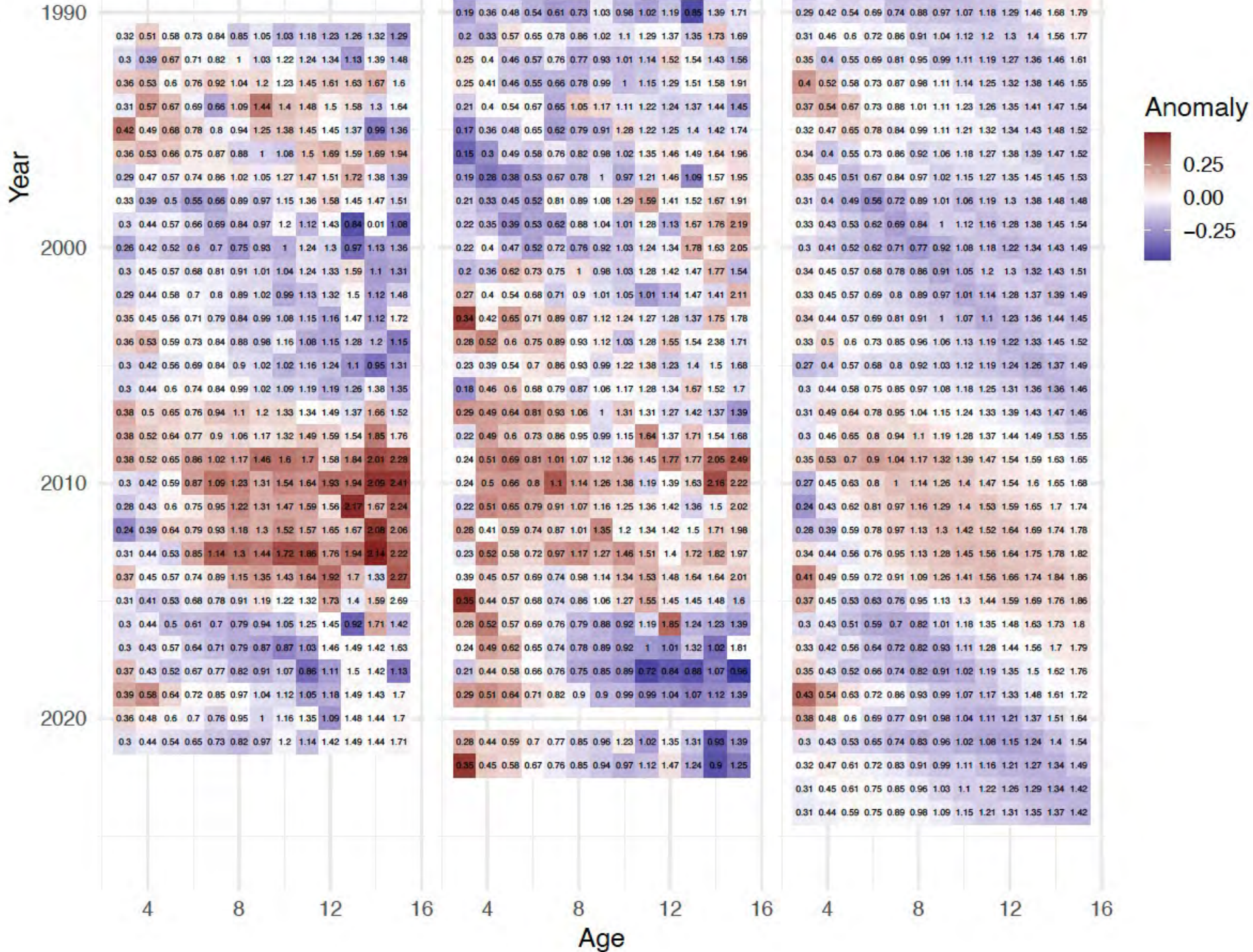


Figure 3: Weight-at-age data (left and middle panel) and predictions (right-most panel) for EBS pollock as an alternative series for spawning biomass weight-at-age. Note that the color shadings indicate the anomaly within age (columns).

EBS pollock

Relative spawning weight-at- age



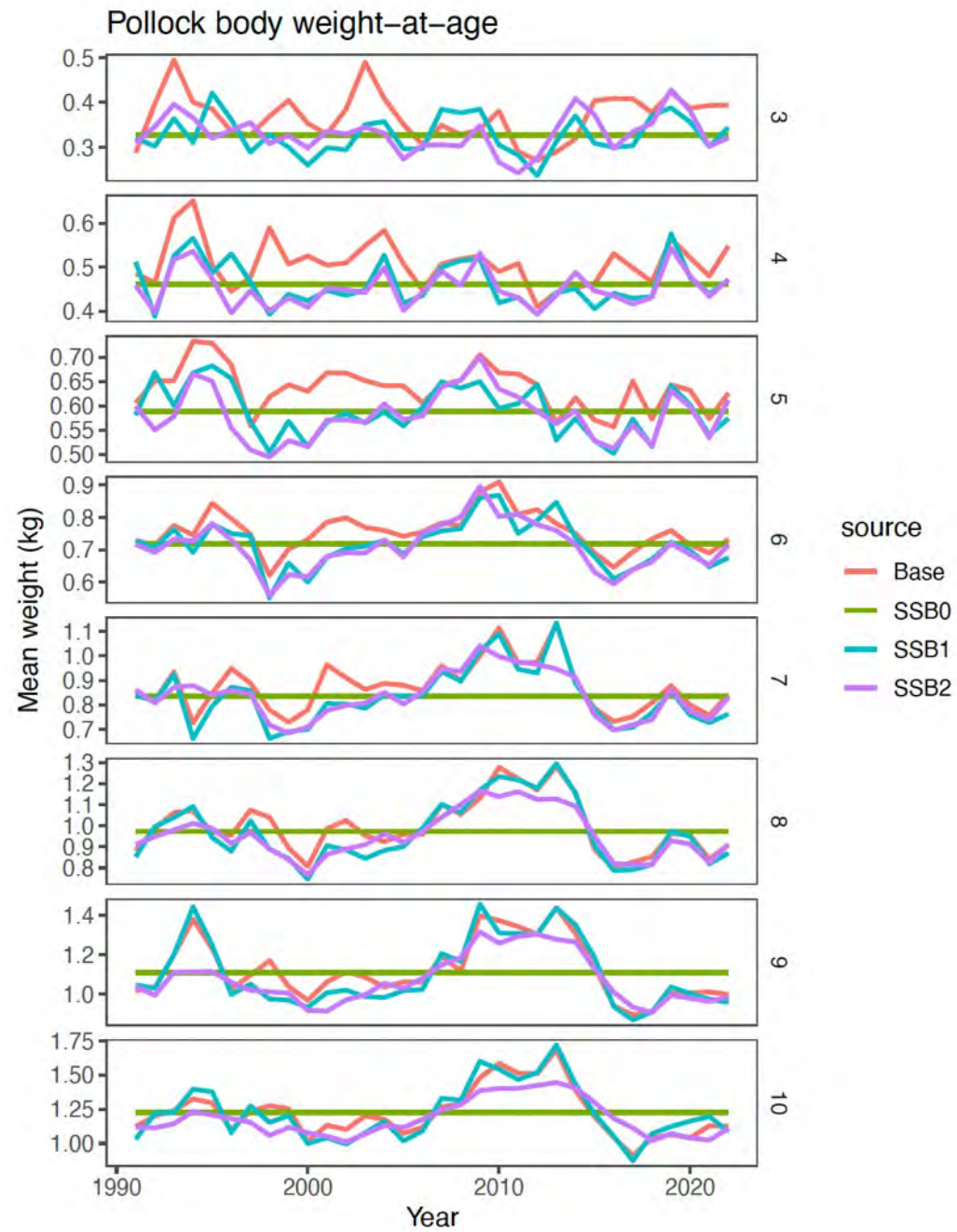


Figure 4: Alternative scenarios for body weight-at-age used for computing spawning biomass for EBS pollock biomass weight-at-age.

- No change in model fit (Table 6)

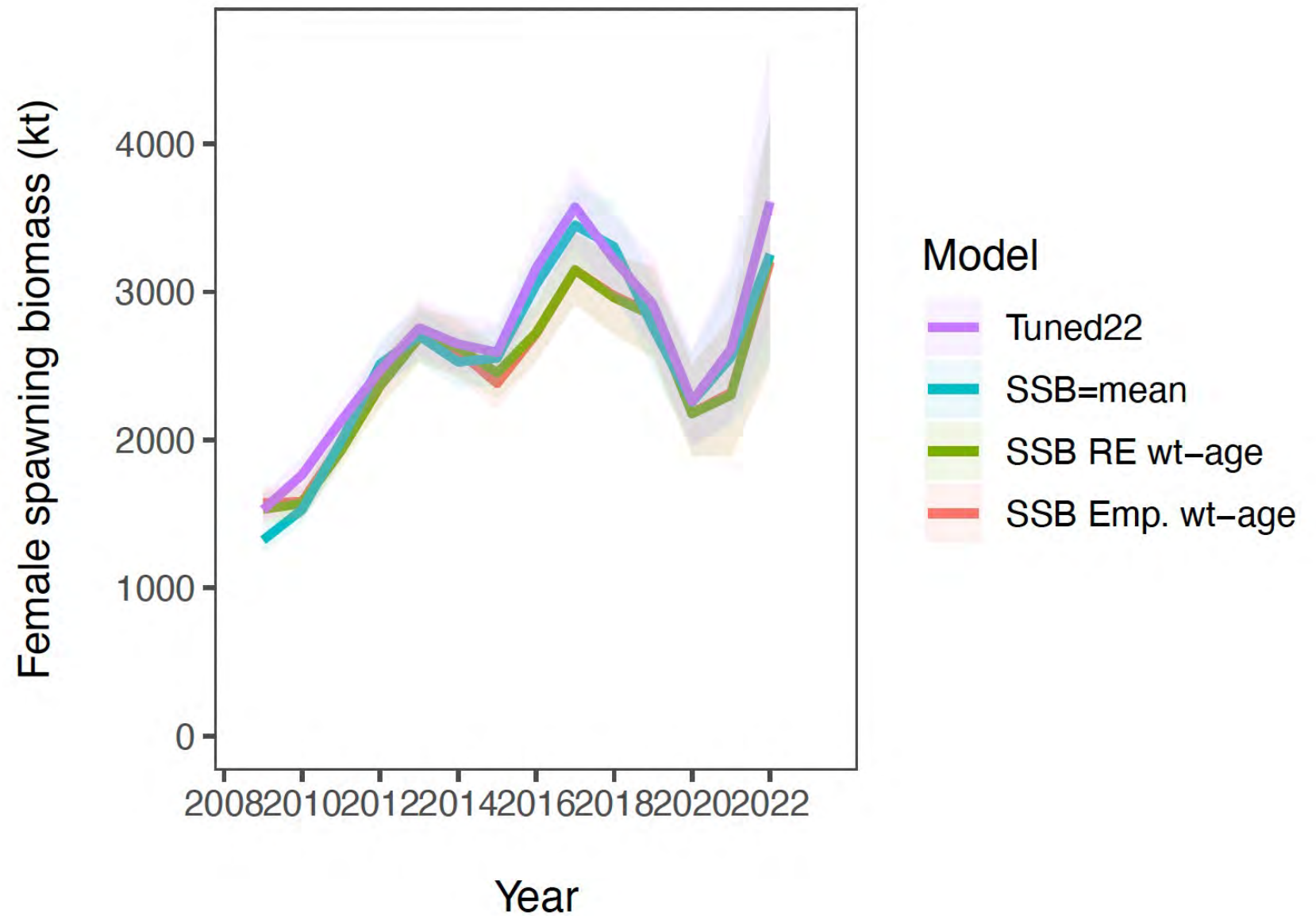


Figure 8: Results of the EBS pollock model for recent spawning biomass estimates comparing the base model under different assumptions about mean body weight-at-age during spawning.

- No change in model fit (Table 6)

Table 7: Summary of model results and the stock condition for EBS pollock. Biomass units are thousands of t.

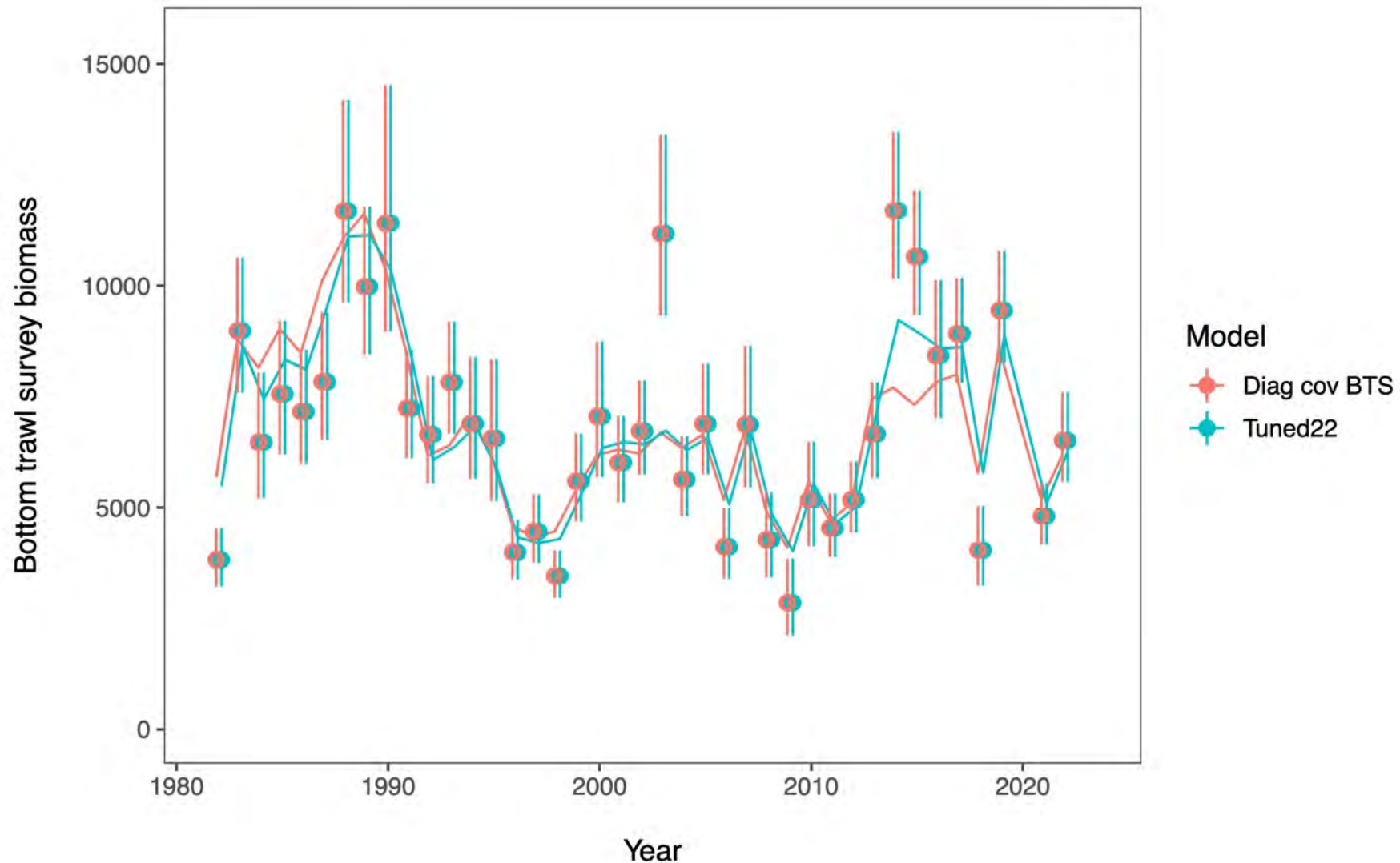
Component	Tuned22	SSB=mean	SSB Emp. wt-age	SSB RE wt-age
B_{2023}	3,800	3,600	3,500	3,600
$CV_{B_{2023}}$	0.14	0.14	0.14	0.14
B_{MSY}	2,659	2,677	2,530	2,634
$CV_{B_{MSY}}$	0.2	0.2	0.19	0.2
B_{2023}/B_{MSY}	143%	133%	137%	137%
B_0	6,618	6,848	6,385	6,577
$B_{35\%}$	2,097	2,127	1,986	2,028
SPR rate at F_{MSY}	33%	33%	34%	34%
Steepness	0.61	0.61	0.6	0.6
Est. $B_{2022}/B_{2022, \text{nofishing}}$	0.59	0.54	0.55	0.55
B_{2022}/B_{MSY}	136%	122%	127%	123%

Table 8: Goodness-of-fit measures to primary data for different assessment model configurations. RMSE=root-mean square log errors, NLL=negative log-likelihood (may not be comparable across model configurations), SDNR=standard deviation of normalized residuals, Eff. N=effective sample size for composition data)

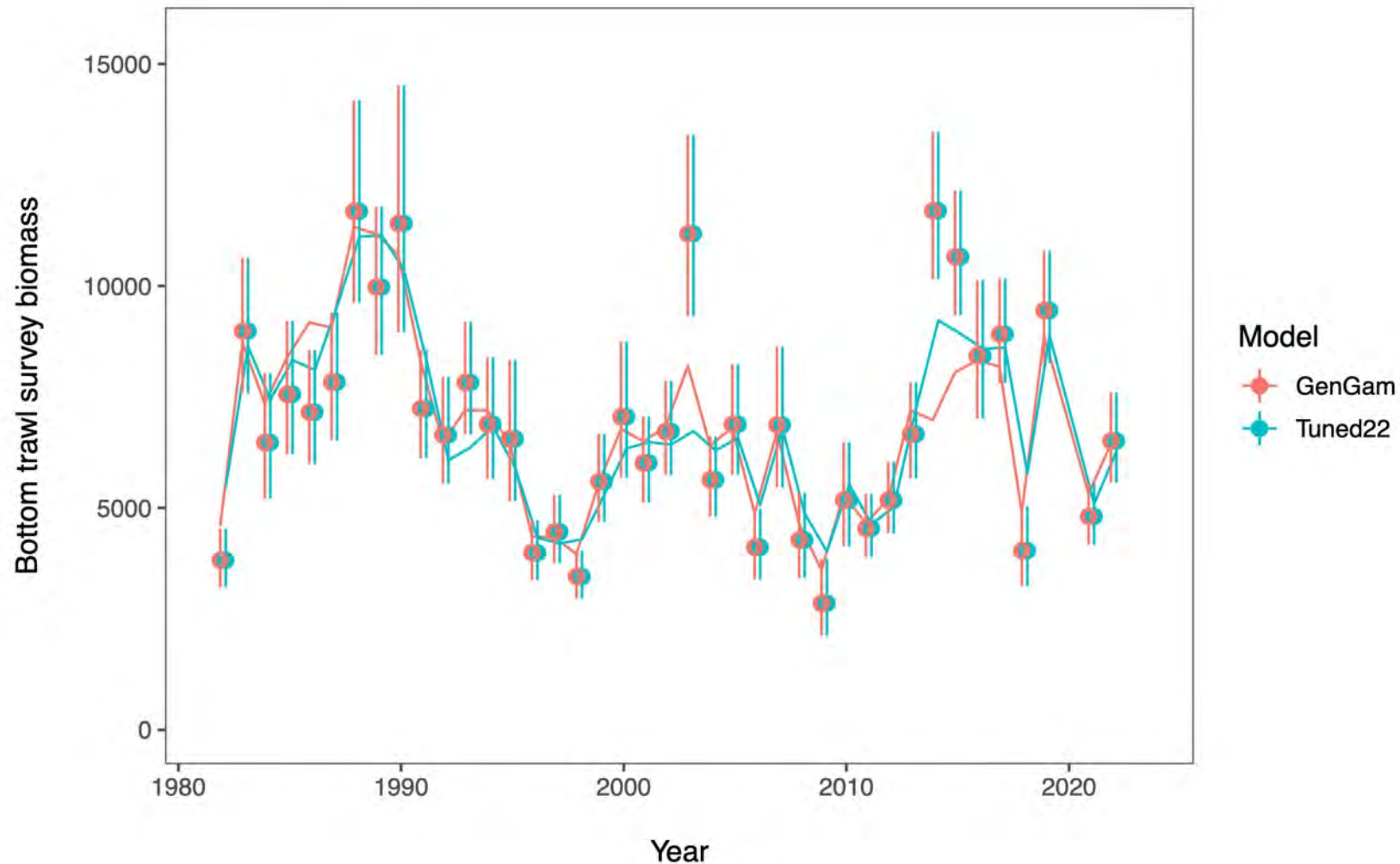
EBS pollock
model fits to
with alternative
error
specifications

Component	Tuned22	Ageing Error	Diag cov BTS	GenGam	
RMSE BTS	0.165	0.161	0.196	0.145	Lower better
RMSE ATS	0.208	0.201	0.210	0.204	
RMSE AVO	0.271	0.261	0.272	0.268	
RMSE CPUE	0.093	0.095	0.093	0.093	
SDNR BTS	0.980	0.950	1.280	1.010	Consistent ~1.0
SDNR ATS	1.030	0.990	1.030	1.020	
SDNR AVO	0.990	0.970	1.000	1.000	
Eff. N Fishery	1,236	998	1,283	1,265	Higher better
Eff. N BTS	225	218	232	219	
Eff. N ATS	249	277	253	249	
Catch NLL	3	3	2	2	Lower better
BTS NLL	31	29	34	308	
ATS NLL	9	8	9	9	
AVO NLL	8	8	8	8	
Fish Age NLL	145	167	140	143	
BTS Age NLL	159	164	149	155	
ATS Age NLL	28	26	28	28	
NLL selectivity	164	156	158	180	
NLL Priors	20	20	20	20	
Data NLL	402	421	391	673	
Total NLL	622	646	604	909	

EBS pollock model fits to bottom-trawl survey data with simplified variance form



EBS pollock model fits to bottom-trawl survey data with generalized Gamma distribution



Thanks to
Cole M.

4 Summary

For the models we explored there was generally improvements to the model specifications that could be made. These were relatively minor impacts on the stock status and trends. For discussions, we therefore recommend:

- Adopting the use of the full revised AVO time series. *The data have been re-calibrated to the acoustic trawl survey and cover a larger area than previous AVO series. This may improve the ability to track expansion and contraction of the pollock stock in mid-water.*
- Allowing modest process error terms consistent with the observation-error specifications. *We prefer to follow allow slight deviations in process errors (here selectivity/availability in the ATS) to achieve consistency with specified survey-based observation-errors*
- Adopting the use of the RE model for A-season fishery mean body weight-at-age. *These smoothed values are based on uncertainty-weighted observations and reflect the pattern most available to the spawning season of pollock.*
- Pursuing model configurations that can best be used to bridge between other software platforms (e.g., WHAM, stock synthesis, and AMAK2). *This practice should help confirm that the model used for this assessment concurs with other software (e.g., as found in Li et al. (2021)) and also provide flexibility and transparency in transferring this assessment to future analysts.*

For future work we plan to adopt a new method for estimating cohort and year random effects for processes such as selectivity (e.g. Cheng et al. (2023)).

EBS pollock
model
configuration
summary

Other aspects

Acknowledgements

Carey McGilliard, Melissa Haltuch

[Package and development](#)

[One-step ahead residual presentation](#)