GOA Pollock

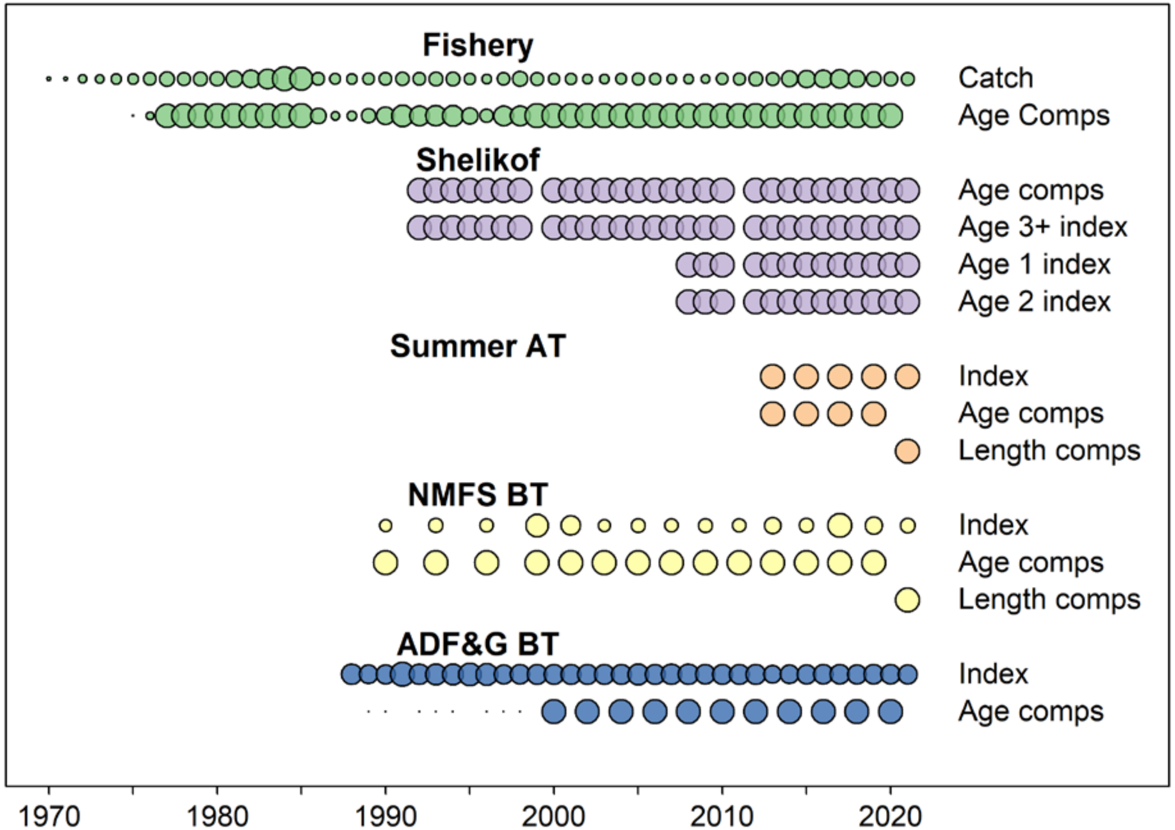
Cole Monnahan, Martin Dorn
September 2022 GOA Plan Team

Outline

- Review data
- Propose 4 alternative models
  - Add sigmaR=1.3 to all deviations
  - Remove prior on NMFS BT catchability
  - Add more flexibility to fishery selectivity
  - New idea for calculating winter apportionment
  - Estimated summer AT survey selectivity
- Update on research for Shelikof catchability
  - Estimate process errors (MCMC and WHAM)
  - Link to survey timing inside the model (WHAM)

New data available this year

2021 model data



2022 new data

- 2021 fishery ages,
- 2021 Summer AT ages
- 2021 NMFS BT ages
- 2022 Shelikof index and ages
- 2022 ADF&G index

Model 19.1a: Adding recruit penalty

In December 2021 the SSC noted "... *that recruitment deviations in the GOA pollock assessment are unconstrained except for the terminal two years, and suggests that exploring a moderate constraint on recruitment deviations in all years, as is commonly applied in other assessments, may be warranted.*"

- Model 19.1 has a penalty of σ_R=1 on the first eight, and last two recruitment deviations.
- All other devs are unpenalized and freely estimated.
- Generally causes no estimation issues
- But some advantages to a consistent one
- **What value to use for σ_R?**

NOAA FISHERIES

Model 19.1a: Adding recruit penalty

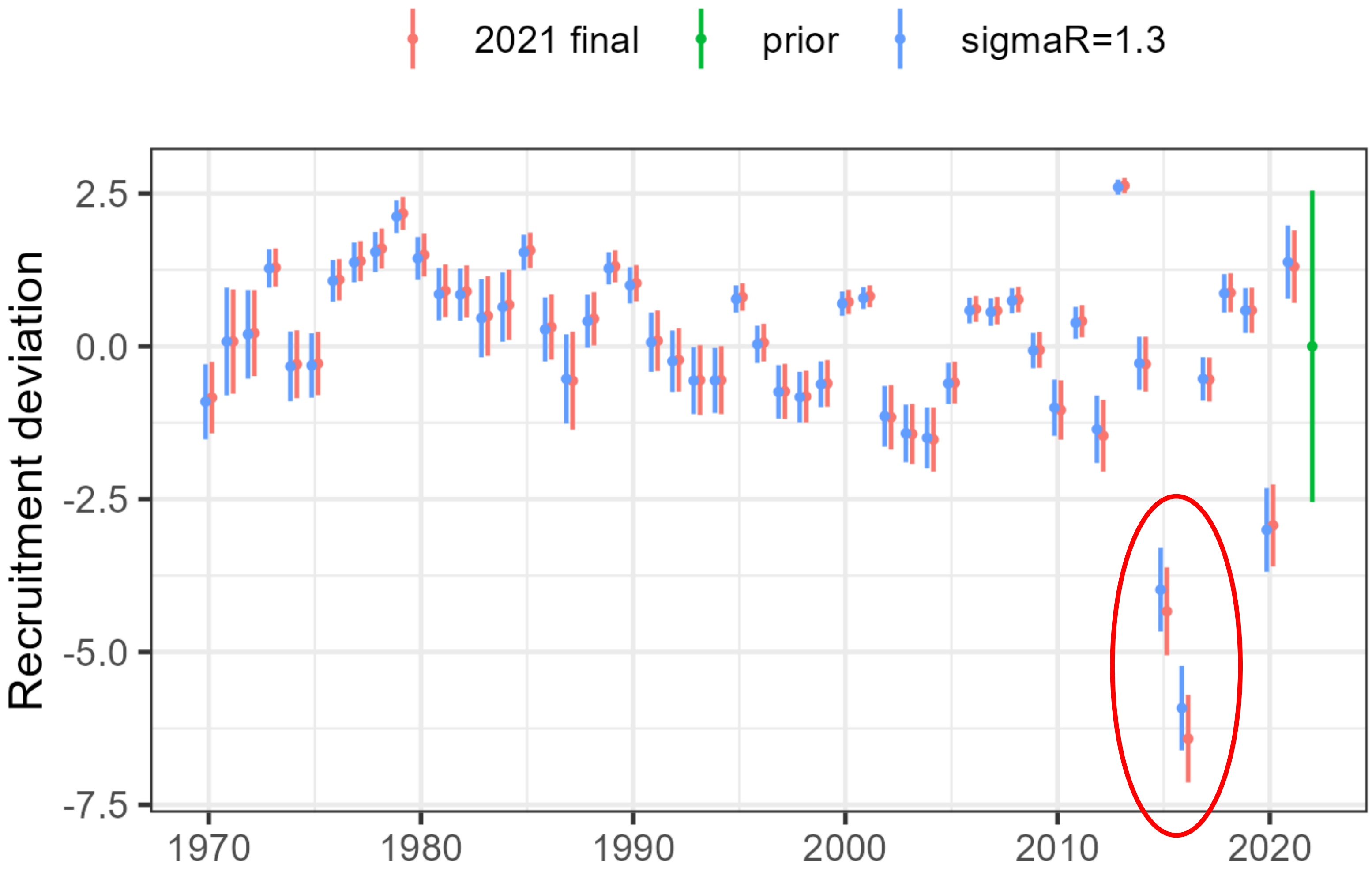
- **What value to use for σ_R?**
- WHAM was used to estimate this with marginal maximum likelihood

$$\sigma_R \sim N(1.34, 0.14)$$

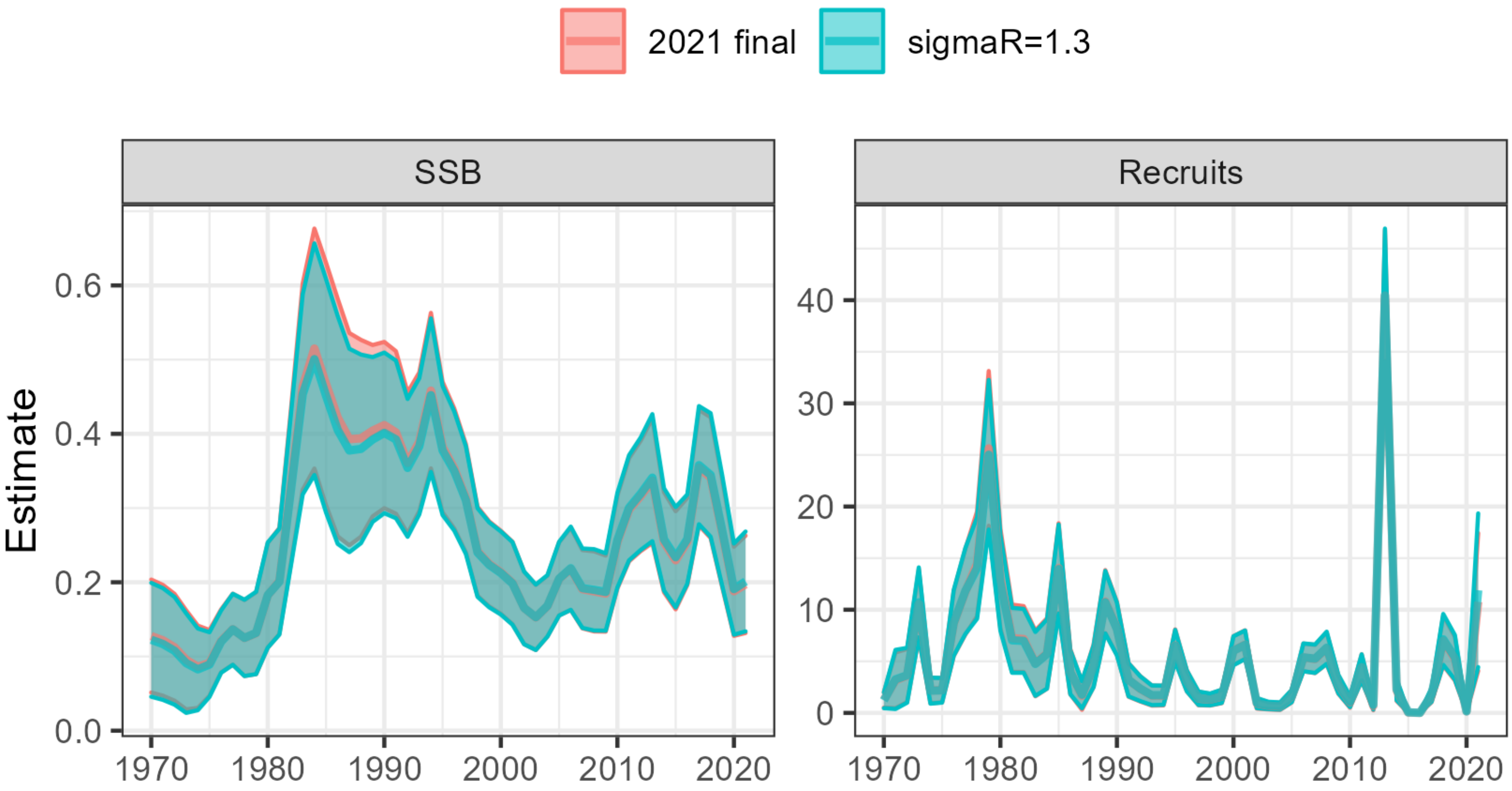
- So a value of 1.3 was used for all deviations.
- This had a minimal impact on the model.

NOAA FISHERIES

Model 19.1a: Adding recruit penalty



Model 19.1a: Adding recruit penalty



Model 19.1a: Adding recruit penalty

Summary and recommendation

- Largest effect was shrinkage on smallest cohorts
- 2.9% increase in 2022 ABC
- More in line w/ other platforms like WHAM, improves Bayesian estimation
- This model is therefore **recommended**

Model 19.1b: No prior on BT q

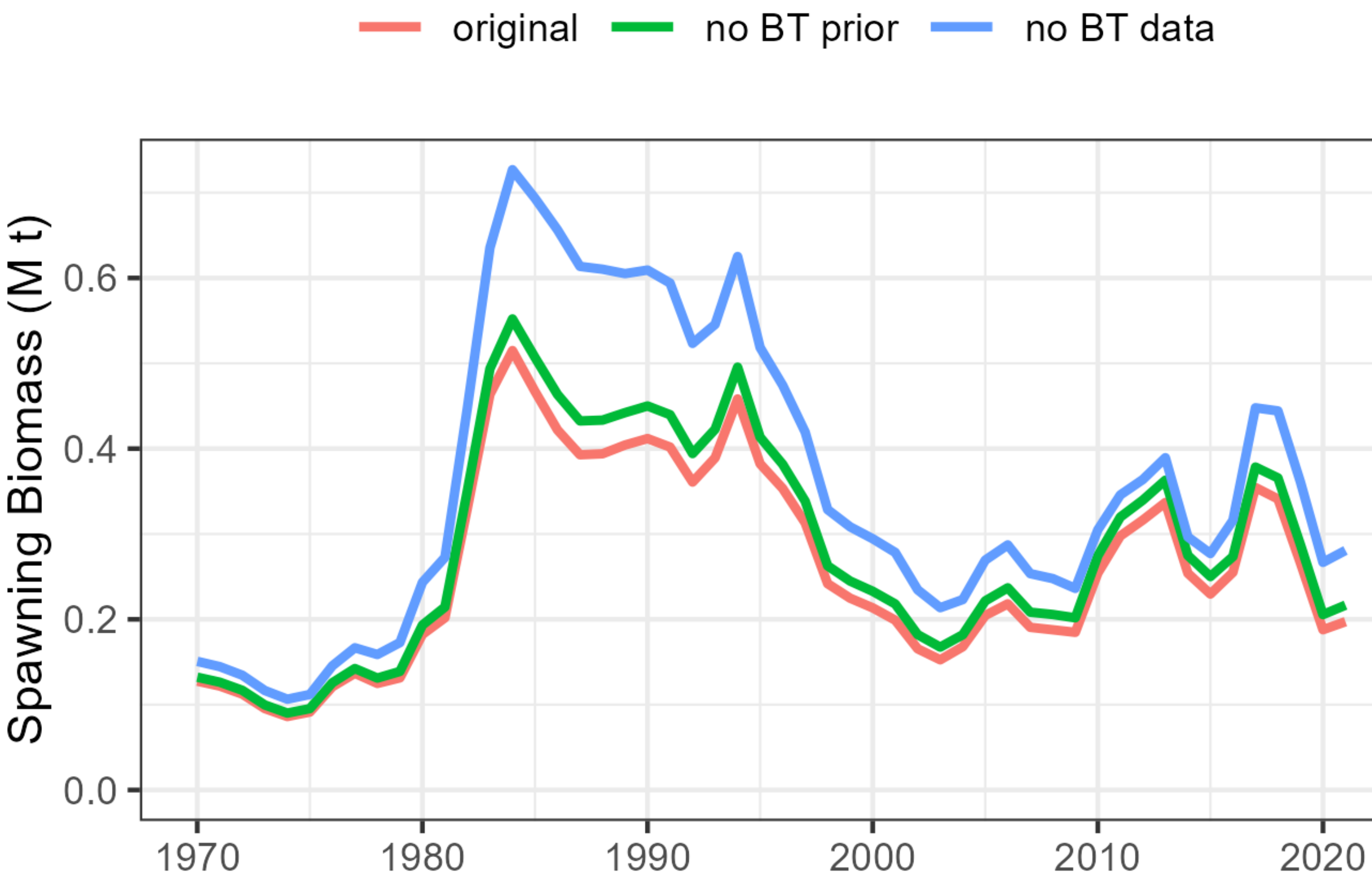
- In 2021 the NMFS bottom trawl (BT) survey was dropped completely to test effect
- PT recommended "*...the author further research [prior on BT q], including conducting a prior sensitivity analysis and potentially looking at applying priors (if available) for other surveys in the assessment.*
- NMFS bottom trawl (BT) prior on catchability:

$$\log q_{BT} \sim N(\log(.85), 0.1)$$

- This prior has large influence on stabilizing stock scale estimates

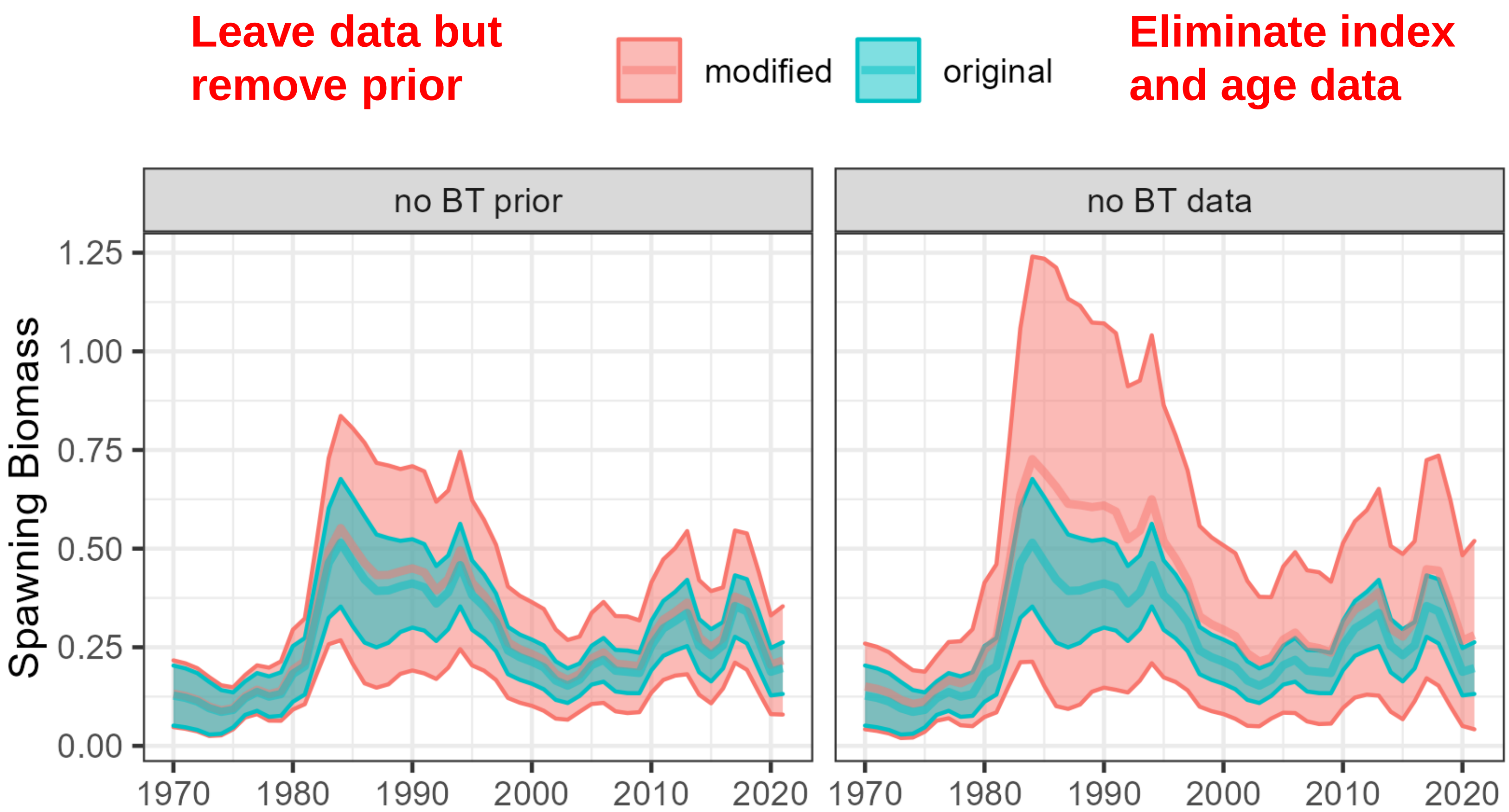
Model 19.1b: No prior on BT q

- What happens w/ no data vs no prior?



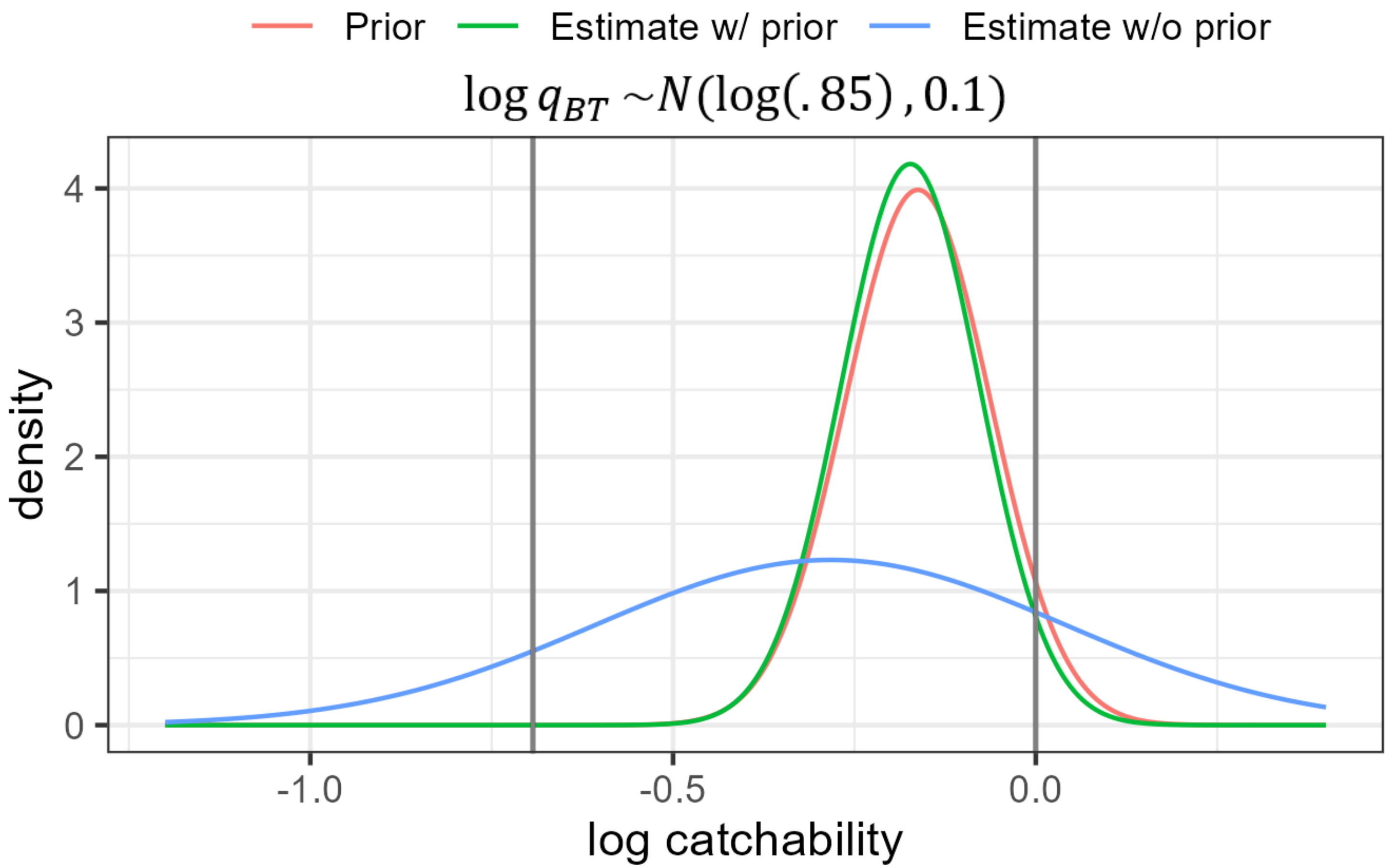
Model 19.1b: No prior on BT q

- What happens w/ no data vs no prior?



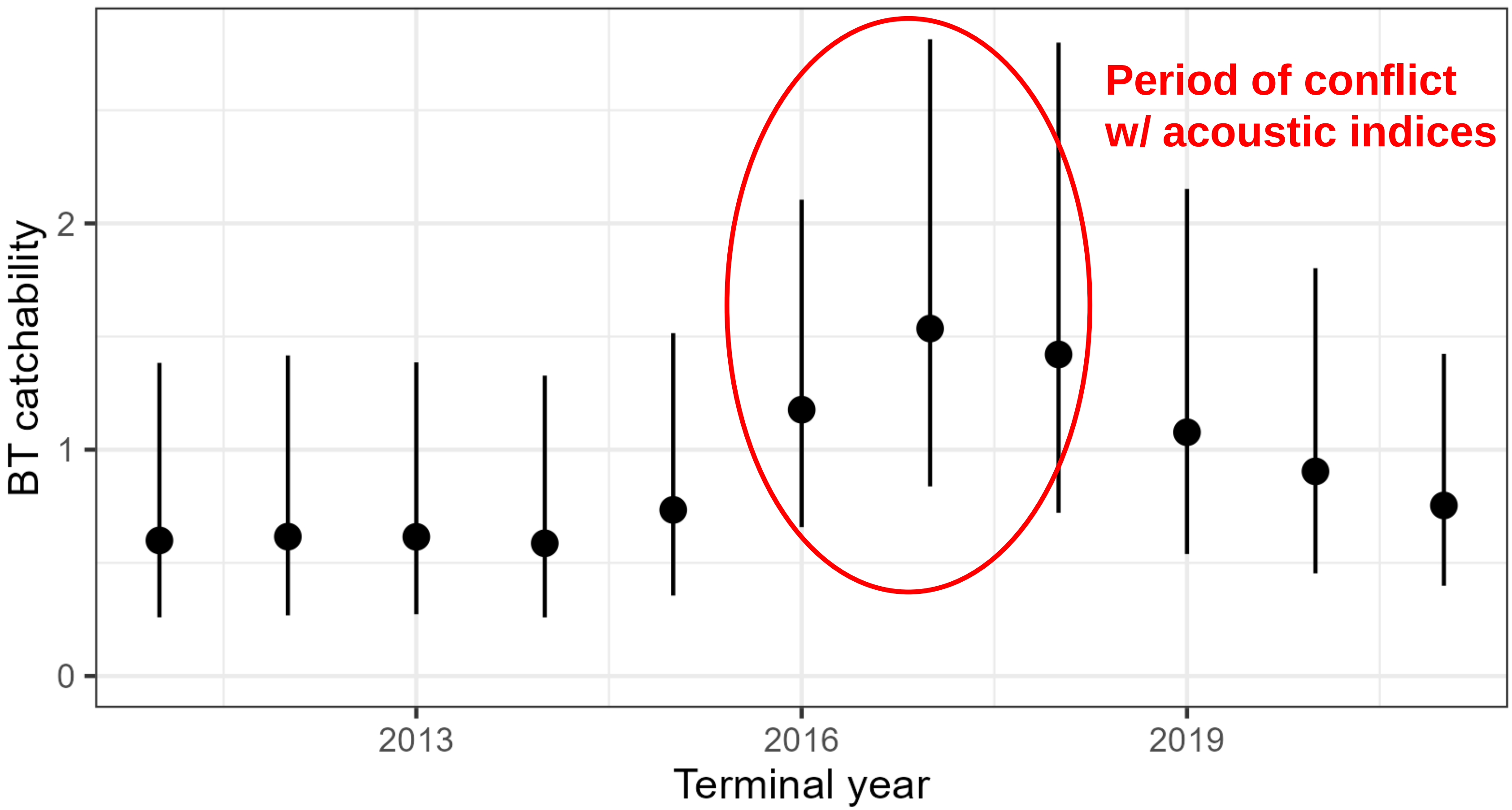
Model 19.1b: No prior on BT q

- What happens w/ no prior?



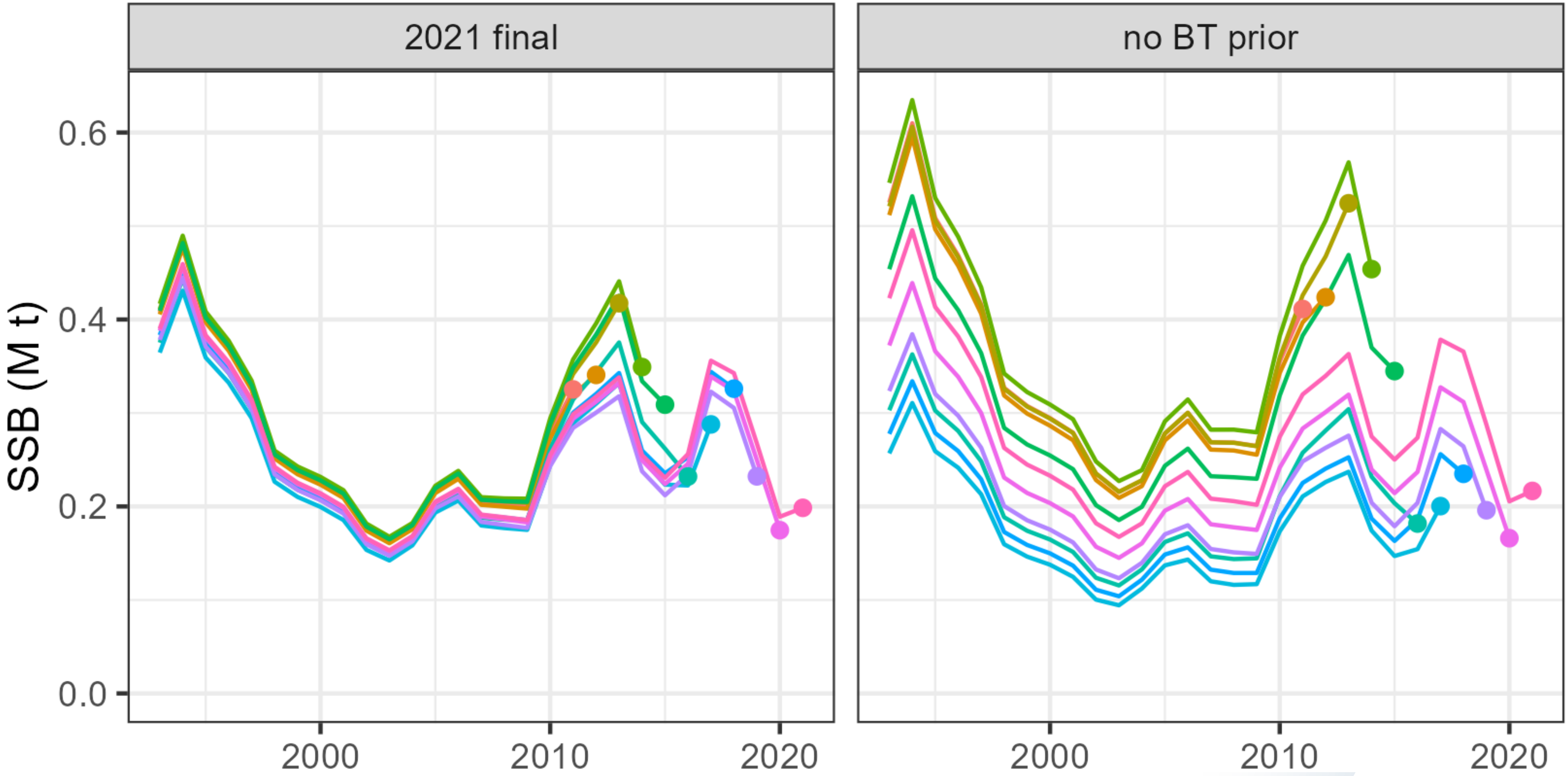
Model 19.1b: No prior on BT q

- Is the model stable w/o the prior?



Model 19.1b: No prior on BT q

- Is the model stable w/o the prior?



Model 19.1b: No prior on BT q

Summary and recommendation

- Uncertainty much higher
  (median CV(SSB) increase from 0.14 to 0.276)
- The model scale will be more unstable, particular with index conflicts
- Expect worse retrospective patterns
- But is this more accurate?
- **We defer to the PT for recommendation**

Model 19.1c: Flexible fishery selex

- 2019 PT *recommended the author examine fishery selectivity, as persistent patterns in the catch-at-age residuals may represent artifacts of the selectivity functional form used.*
- Base form is double-logistic with time-varying:
  - Ascending slope & inflection point
- 2021 found increased process errors did not resolve patterns: **Suggested alternative parametric forms unlikely to help**
- Several alternatives were explored to improve fits to ages 3-4 and 9-10 separately.

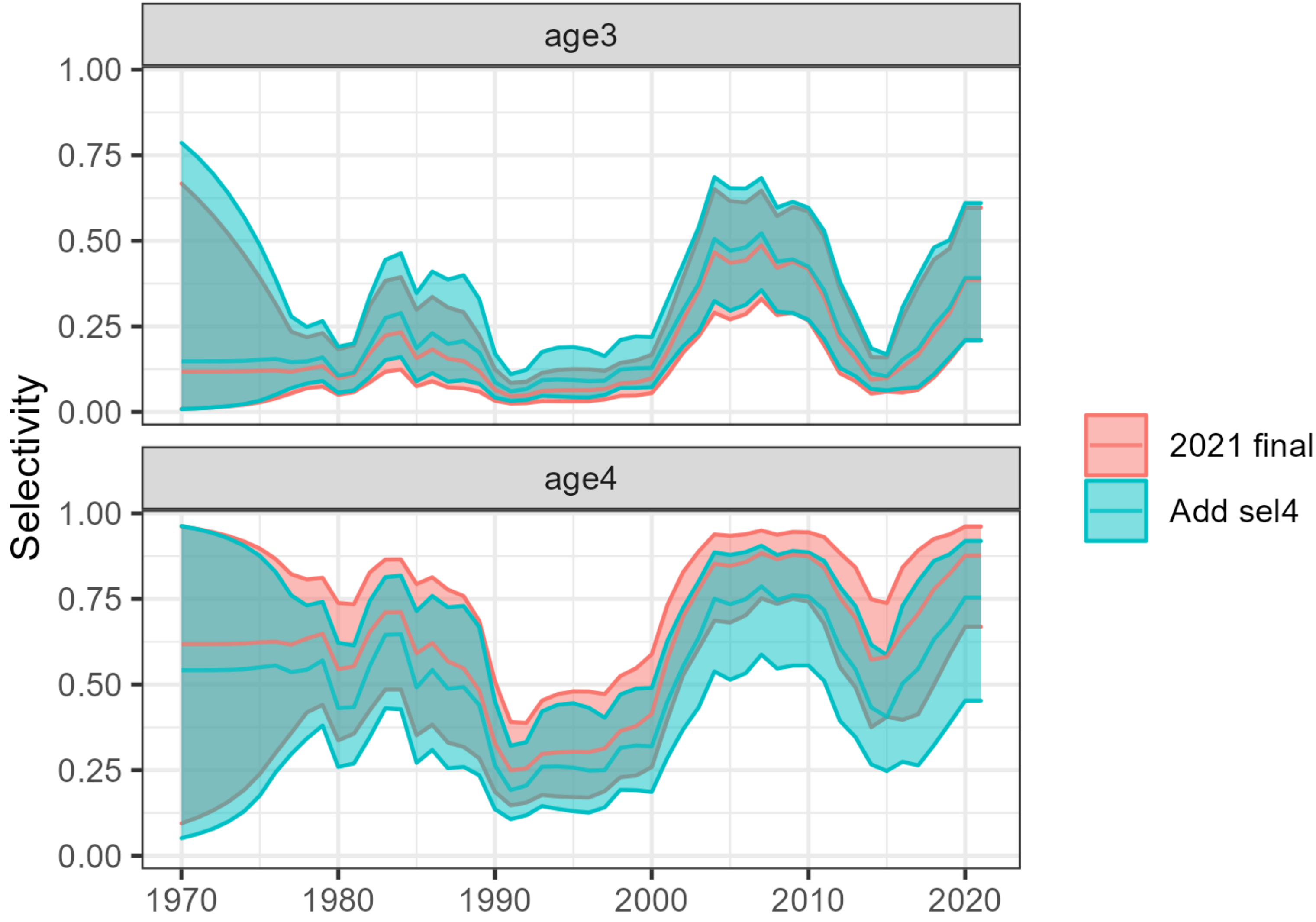
Model 19.1c: Flexible fishery selex

- Implication is that a parametric form cannot deal with large fluctuations in some adjacent ages
- Instead an alternative was tried, estimating an offset for age 4 selex:

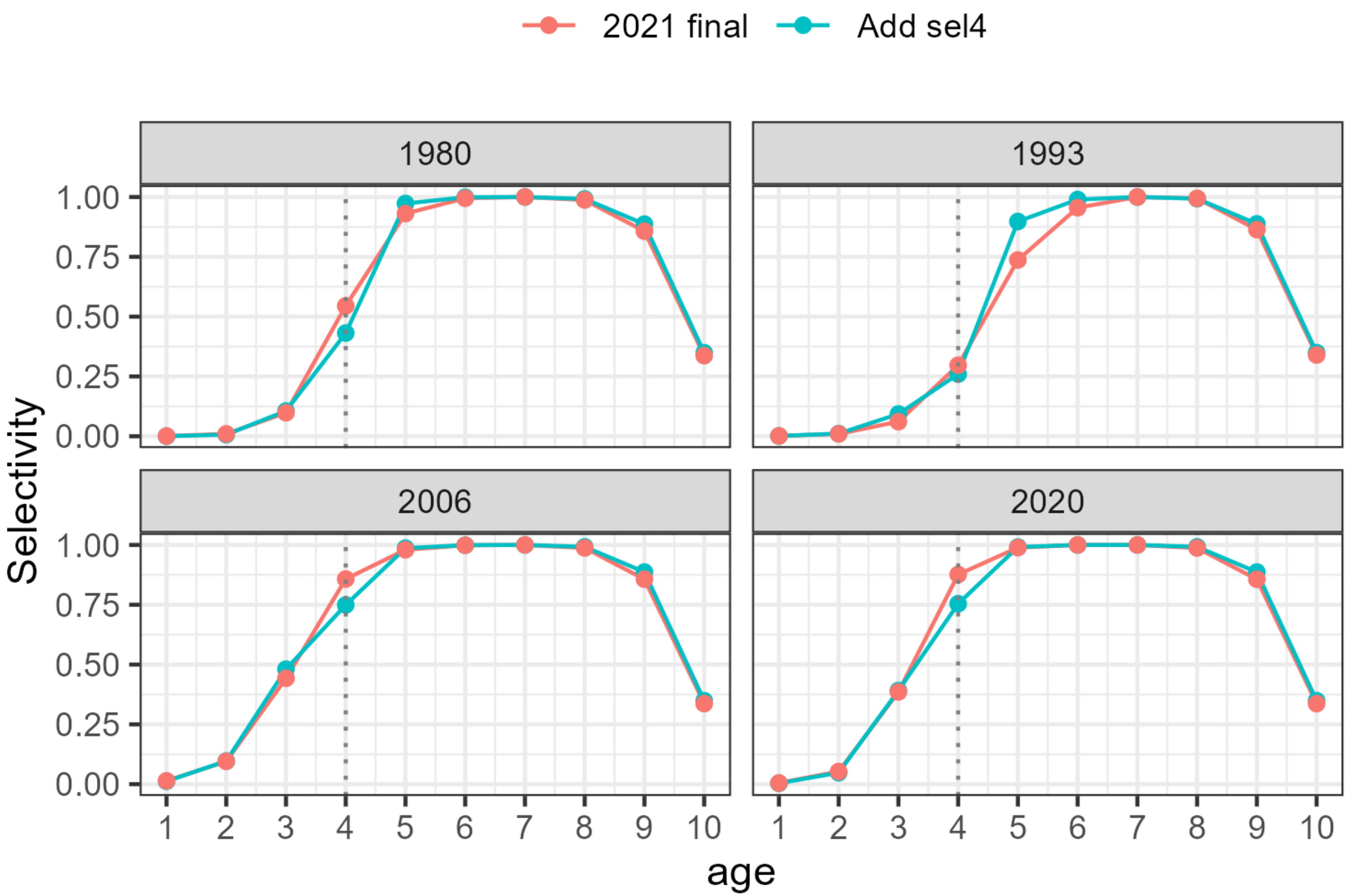
$$\text{sel}(4) = \text{inv.logit}(\text{logit}(\text{sel}(4)) + \theta_4)$$

- Estimated as $\theta_4 = -0.985$ (CI: -1.47– -0.5),
- I.e., a lower value for age 4 selex, and increase for age 3

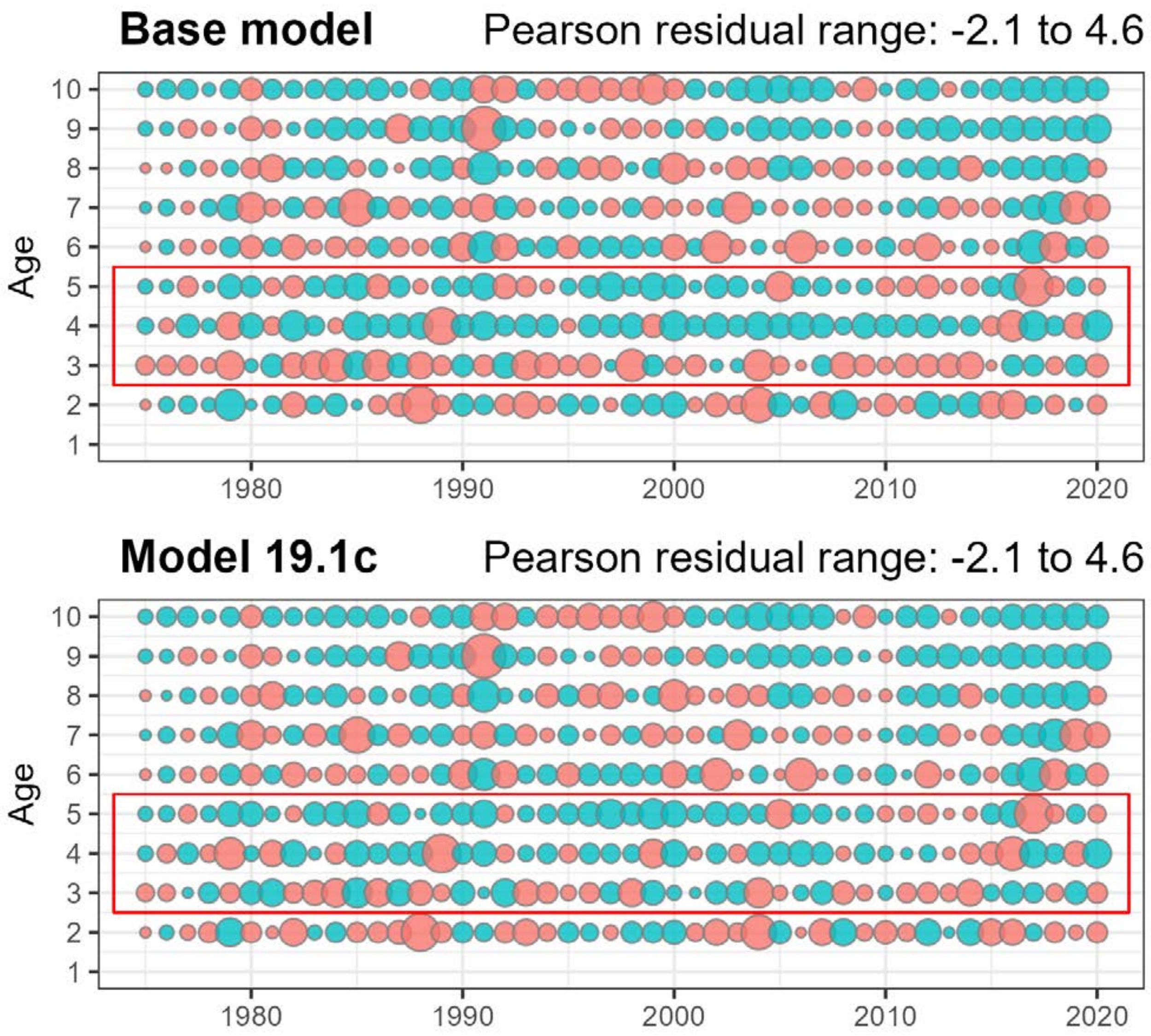
Model 19.1c: Flexible fishery selex



Model 19.1c: Flexible fishery selex

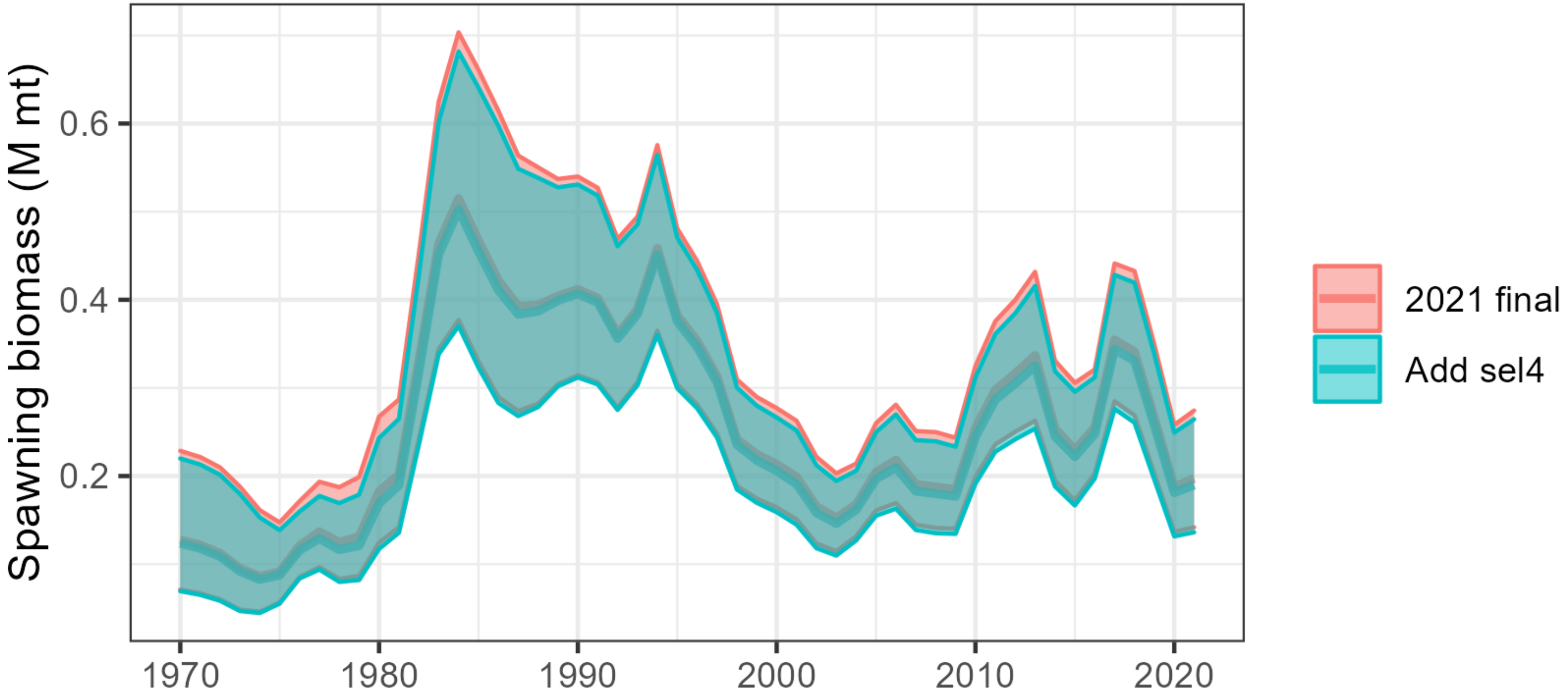


Model 19.1c: Flexible fishery selex



Model 19.1c: Flexible fishery selex

- Improves the age 4 residuals and reduces NLL by 8 units with 1 parameter
- But has minimal impact on model



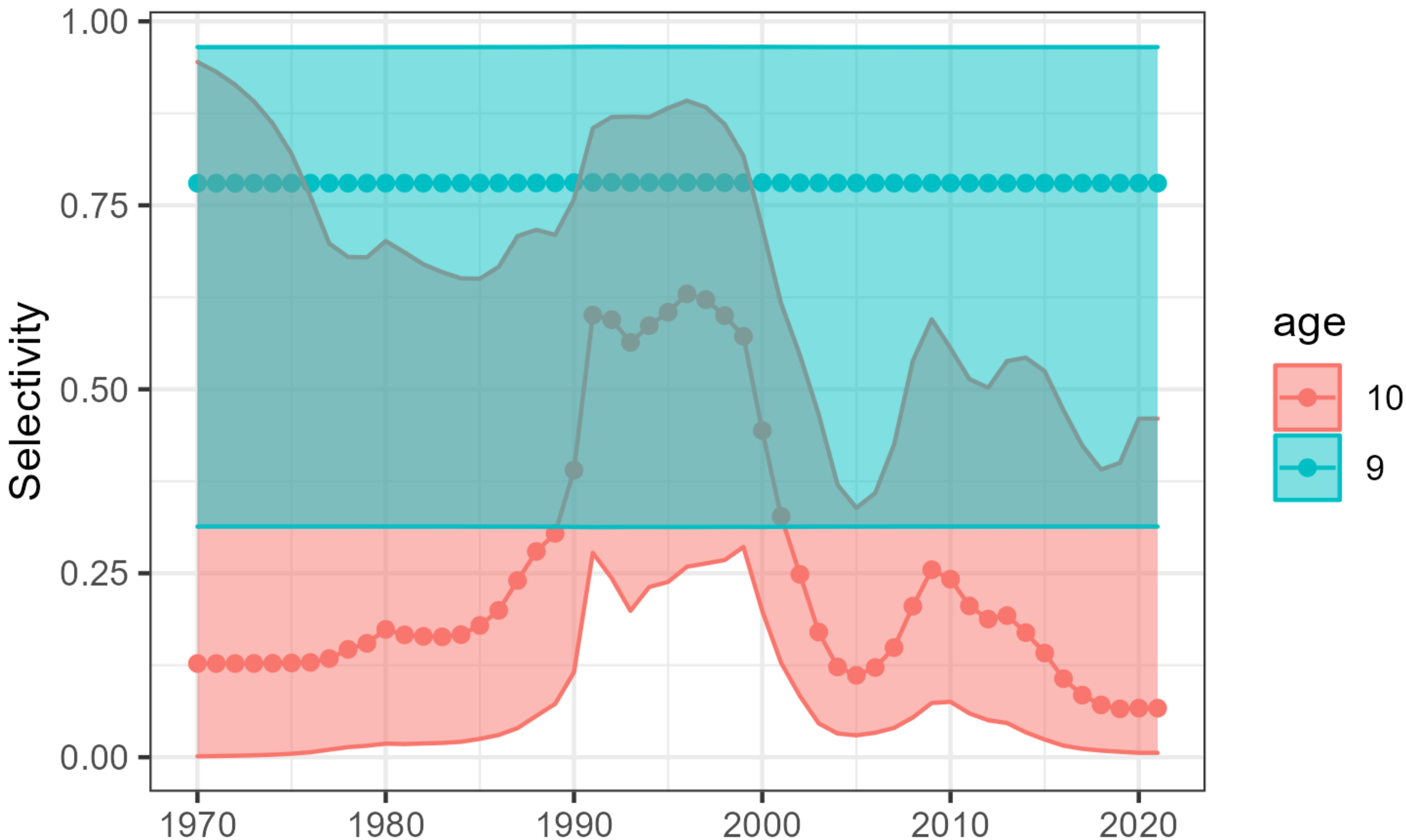
NOAA FISHERIES

Model 19.1c: Flexible fishery selex

- Patterns also occur in ages 9-10.
- A similar “offset” approach did not help, nor did adding time-varying descending parameters
- Experimentation suggested detaching age 10 selectivity from parametric curve
  - Estimate as random walk in logit space
- Improvement to residuals was limited
- And uncertainty in selectivity was very high

Model 19.1c: Flexible fishery selex

- And uncertainty in selectivity was very high



Model 19.1c: Flexible fishery selex

Summary and recommendation

- Age 4“offset” was parsimonious and effective
- Attempts to “fix” age 9-10 resids was unsuccessful. Why?
  - We know Pearson residuals can be unreliable
  - New “one step ahead” approach replaces them[1]
  - (Preliminary) Suggests the pattern is an artefact of the inadequateness of Pearson (there is none!)
- **We recommend the age 4 offset, but no changes to ages 9-10**
  - **Model 19.1c defined as this**

[1]See beta R package https://github.com/fishfollower/compResidual, Trijoulet et al. (2022)

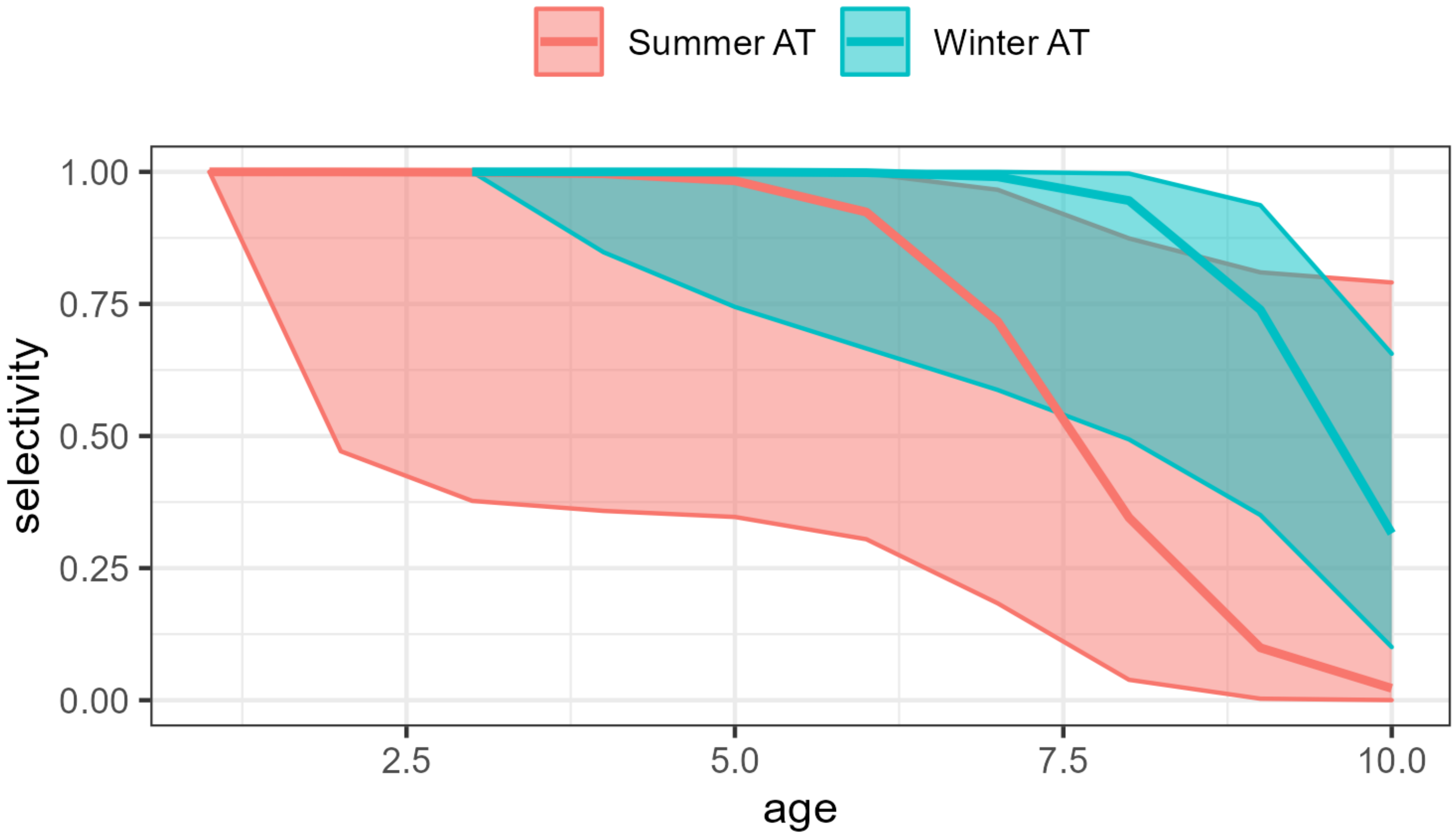
NOAA FISHERIES

Model 19.1d: Summer AT selex

- Summer acoustic survey has only 4 years of age comps. This year will be the 5th.
- Currently the selectivity is fixed at 1 for all ages (due to limited data)
- But there could be enough to estimate it now
- A descending logistic was fitted and compared to the winter acoustic survey

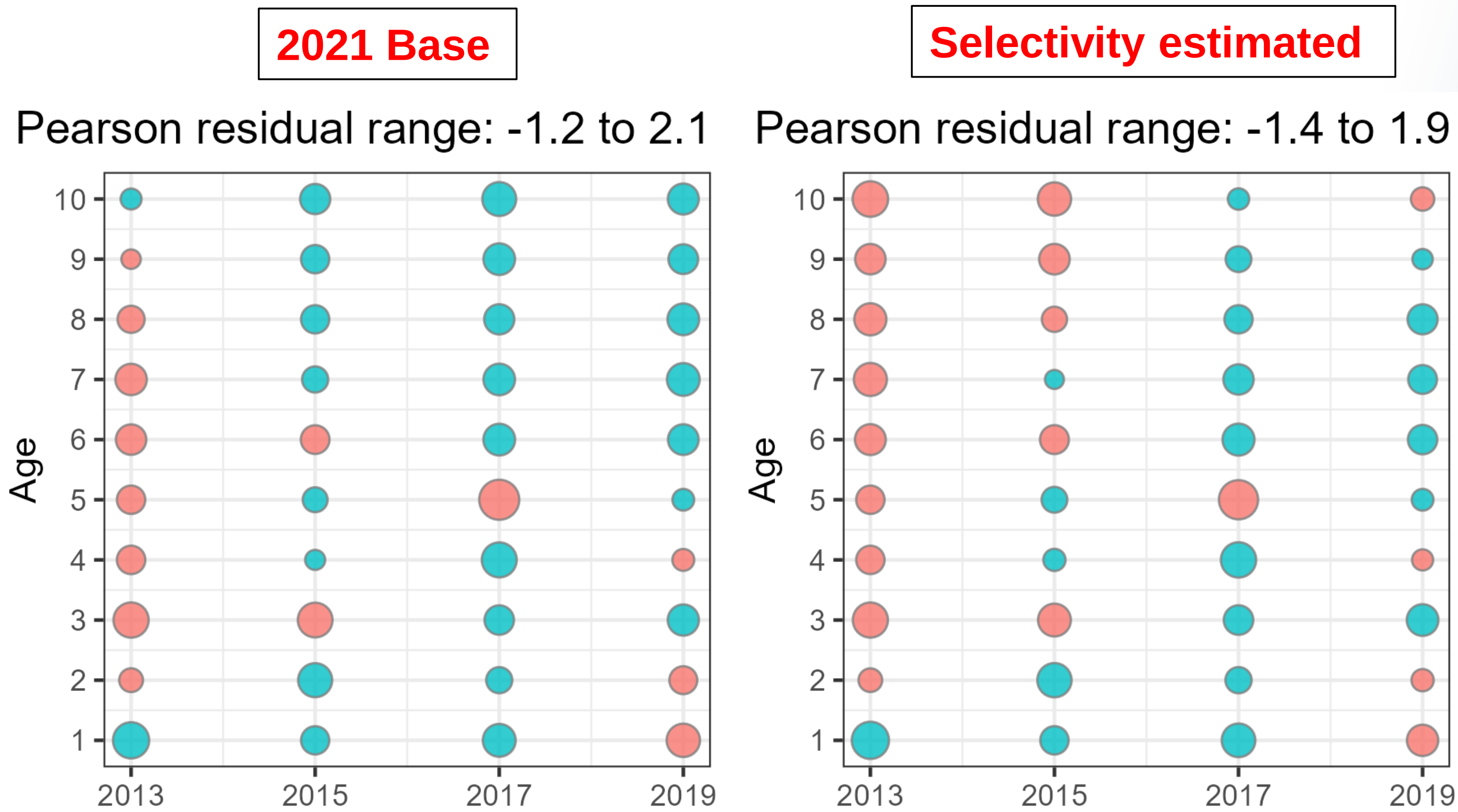
Model 19.1d: Summer AT selex

- Mean and 95% CI calculated in logit space
- Both suggest decreasing selectivity w/ age



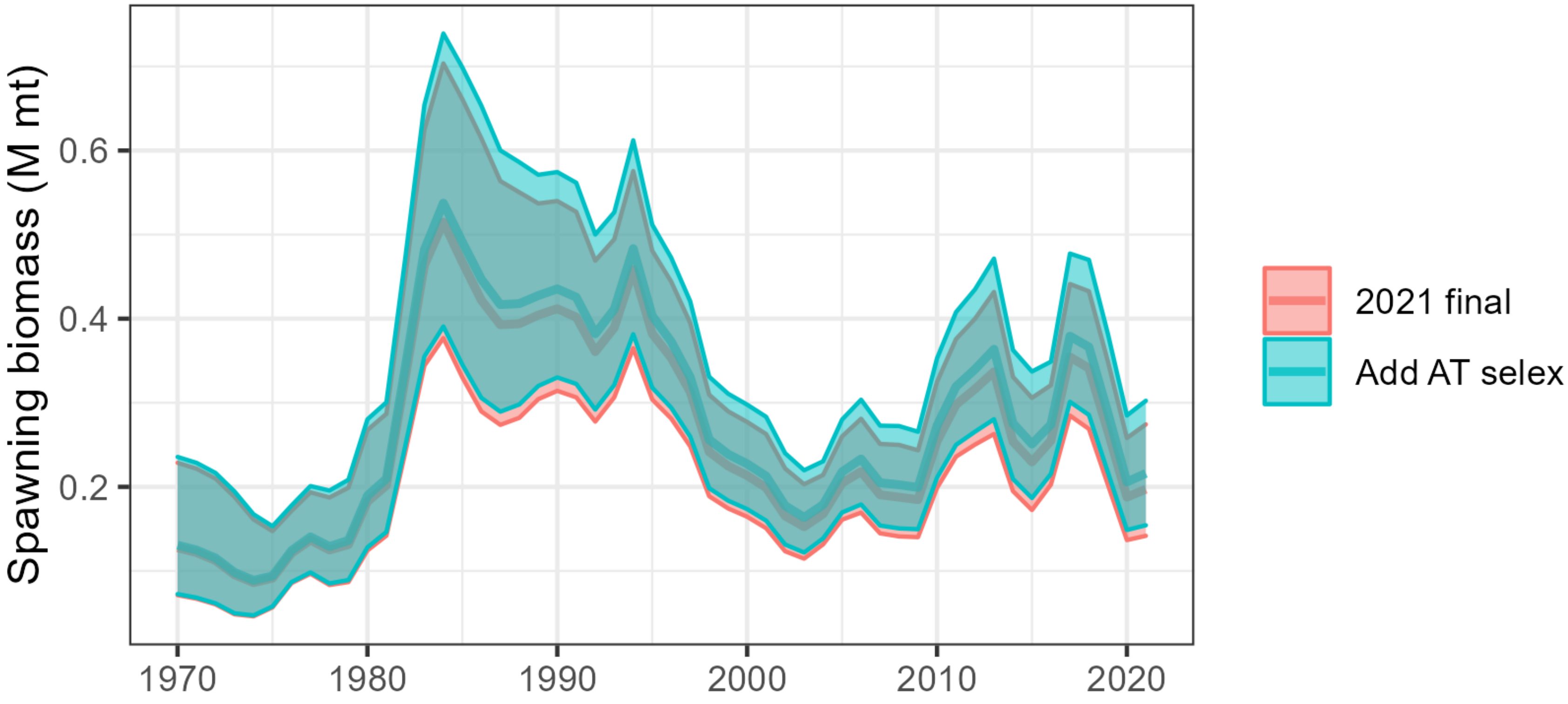
Model 19.1d: Summer AT selex

- Marginal improvement to Pearson residuals



Model 19.1d: Summer AT selex

- There is a small increase in scale
- 4% increase in 2022 ABC
- 3.1 NLL improvement, but two extra parameters



Model 19.1d: Summer AT selex

<u>Summary and recommendation</u>

- The estimates will improve over time and more accurately reflect the selectivity
- With only 4 years of comps, statistically it seems unjustified

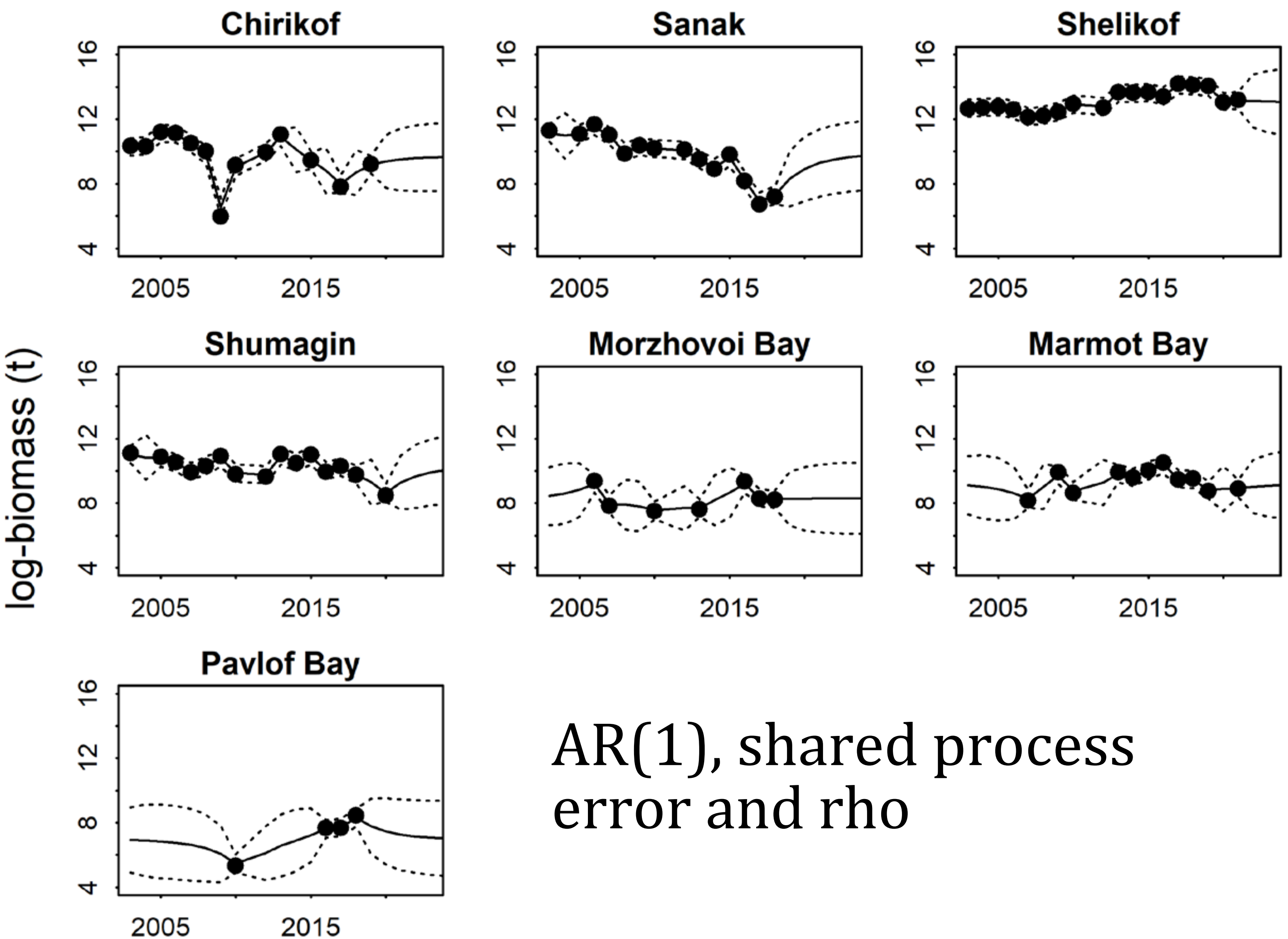
The authors recommend revisiting this when the 2021 age comps are available and if improved performance then adopting it.

Updating winter apportionment

- In 2021 the SSC "*suggested simplifying the computations in the Appendix to reflect the new season structure to the extent possible, without changing the underlying methodology.*"
- This will be done
- Acoustic surveys in subareas (Shumagins, Chirikof, etc.) are used in apportionment.
  - Last 3-4 survey estimates are used
- Raises question of when subareas are infrequently surveyed
- Proposal: use a time-series model estimate in place

NOAA FISHERIES

Updating winter apportionment



AR(1), shared process error and rho

Updating winter apportionment

Advantages:

- Uncertainty in area apportionment can be calculated (via the delta method).
- Reverts to mean when data lacking
  - Better than using old data?
- Could be used to prioritize areas to sample
  - Which would influence apportionment the most?

Disadvantages:

- Assumes stationarity in a changing climate
- Complexity

Does the PT recommend this?

Model configuration recommendations?

Plan team recommendations?

- Which models are recommended for 2022?

	2022 max ABC	2022 OFL	2022 SSB	2021 SSB
Base model 19.1 (2021)	133,081	154,983	186,481	195,758
19.1a	137,004	159,587	190,808	199,588
19.1b	141,230	164,325	204,529	215,550
19.1c	127,870	149,272	179,463	188,040
19.1d	138,399	161,026	202,768	215,137

Change relative to 2021 base

	2022 max ABC	2022 OFL	2022 SSB	2021 SSB
Base model 19.1 (2021)	0.0%	0.0%	0.0%	0.0%
19.1a	2.9%	3.0%	2.3%	2.0%
19.1b	6.1%	6.0%	9.7%	10.1%
19.1c	-3.9%	-3.7%	-3.8%	-3.9%
19.1d	4.0%	3.9%	8.7%	9.9%

GOA Pollock Research updates

Cole Monnahan & Lauren Rogers
September 2022 GOA Plan Team

Shelikof catchability research models

In December 2021 regarding Shelikof acoustic survey catchability, the SSC:

1. Supported "*future research to .. estimate the process error variance internally within the assessment model*."
2. Reiterated "*its recommendation …to explore the use of covariates related to the timing of the survey to inform survey catchability ….*"

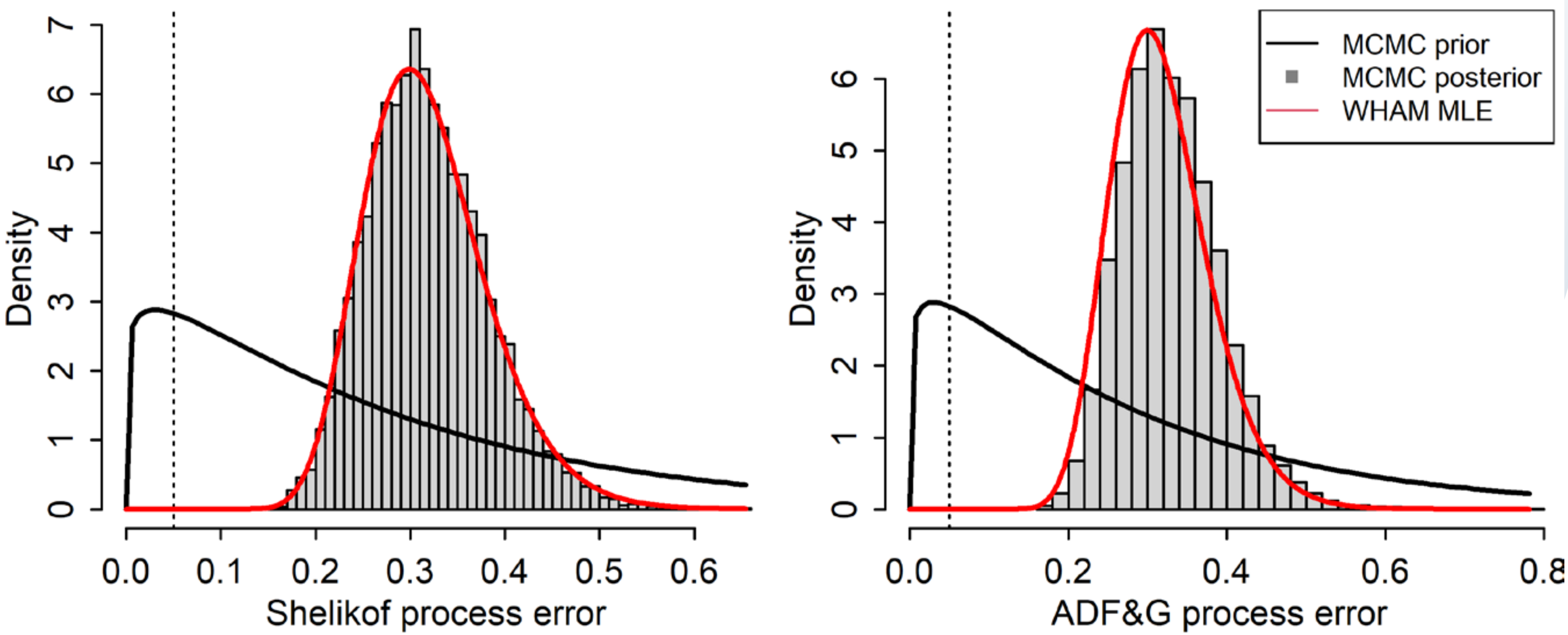
We explored both of these requests

Shelikof catchability: Estimating process errors

- Process error estimation (hierarchical variances) difficult in ADMB
  - Fixed somewhat arbitrarily, including this assessment
- TMB (e.g. WHAM) uses the Laplace approximation
- Long history in Bayesian literature for estimation, particularly for no-U-turn sampler
- NUTS available in ADMB so conceptually straightforward
- Some technical issues (skipped here)
  - Worked well (run time ~15 minutes)
  - q1=Shelikof, q3=ADF&G process errors

Shelikof catchability: Estimating process errors

- Compares extremely well against WHAM
- Much larger than assumed values (dashed vertical lines)
- Proof of concept approach for any ADMB model
- Run MCMC then use median value in assessment?

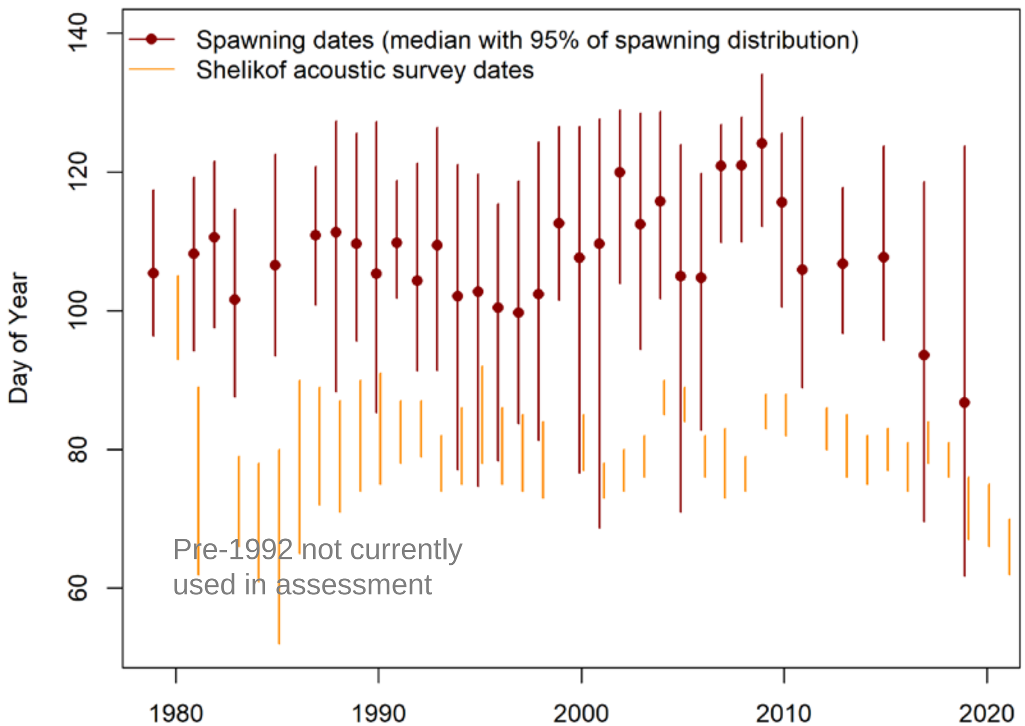


Shelikof catchability: incorporating timing covariates

L. Rogers, C. Monnahan, K. Williams, D. Jones, M. Dorn (in prep)

Background: Analysis of larval pollock showed spawn timing varies year to year by up to ~4 weeks. Spawning occurs earlier when temperatures are warmer and spawning stock is older.

Hypothesis: Changes in spawn timing relative to survey timing affect availability of pollock to the winter Shelikof survey.

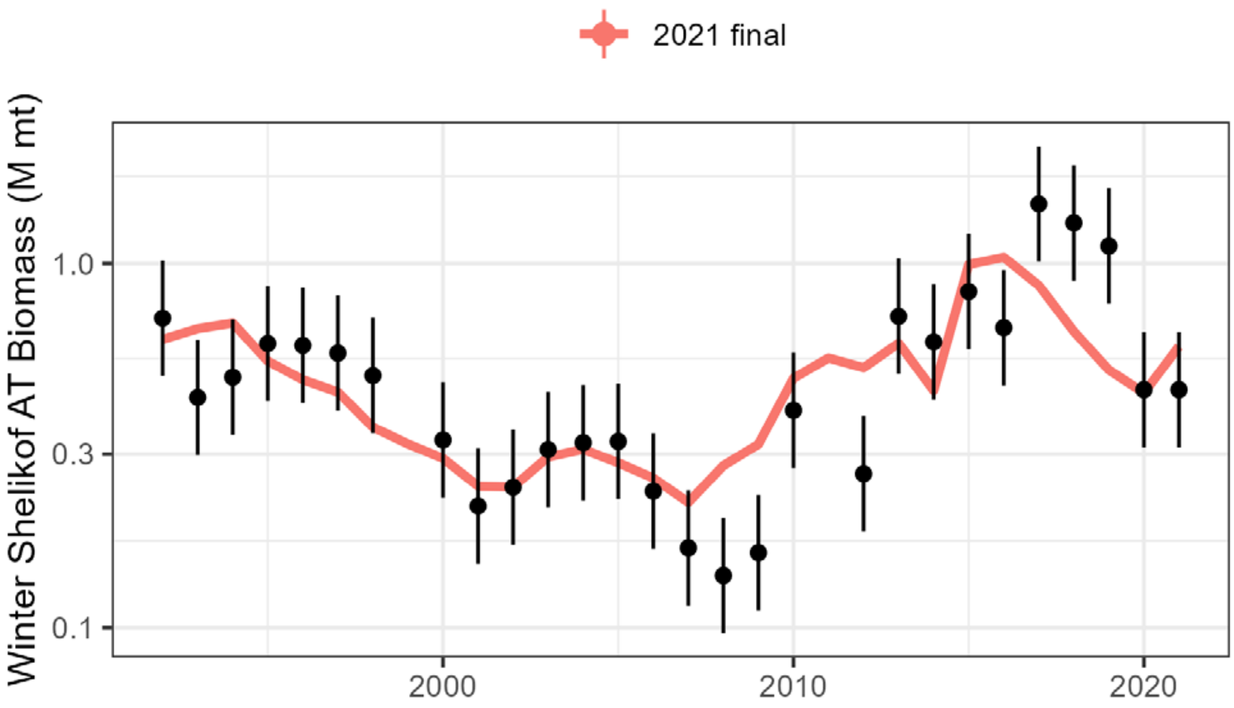


Spawning dates from Rogers and Dougherty 2019 (with 2017 & 2019 added). Reconstructed from EcoFOCI larval surveys.

Survey dates from D. Jones, MACE. Shows only survey passes used for biomass estimates

Caveats: not sampling full temporal spawning distribution (missing early and late spawned individuals). However: confident we are capturing *interannual variability*

Shelikof catchability: incorporating timing covariates



Residuals from model-predicted survey biomass versus actual survey estimates were used as an indicator of potential changes in pollock availability to the Shelikof survey.

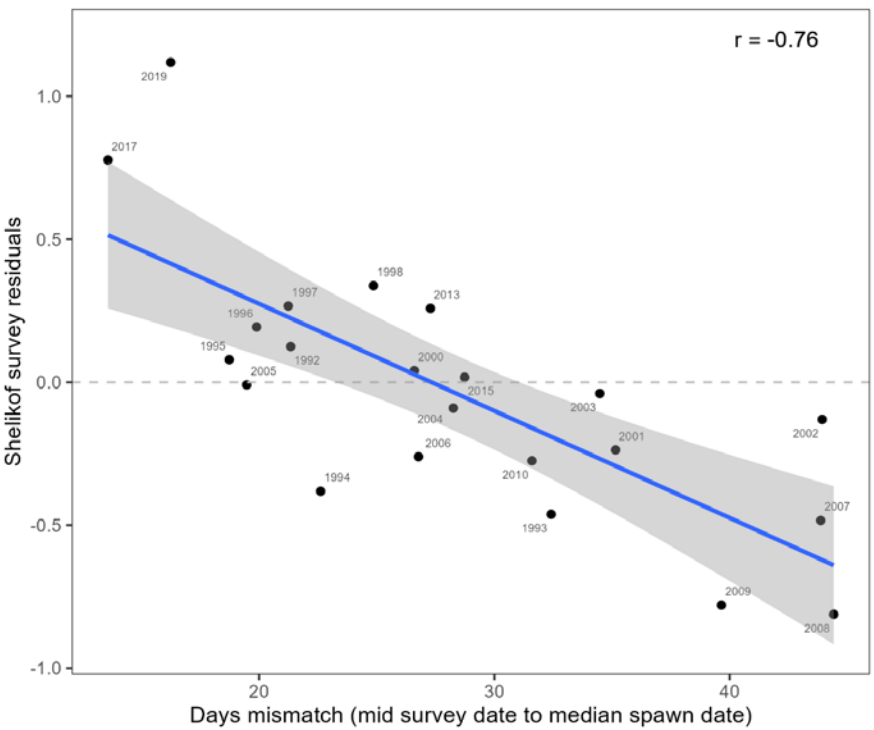
Developed two covariates indicating relative timing:

1) "Mismatch" in timing (days from mid survey date to median spawn date)
2) Proportion females >30cm spawning or spent ("Fem30p")

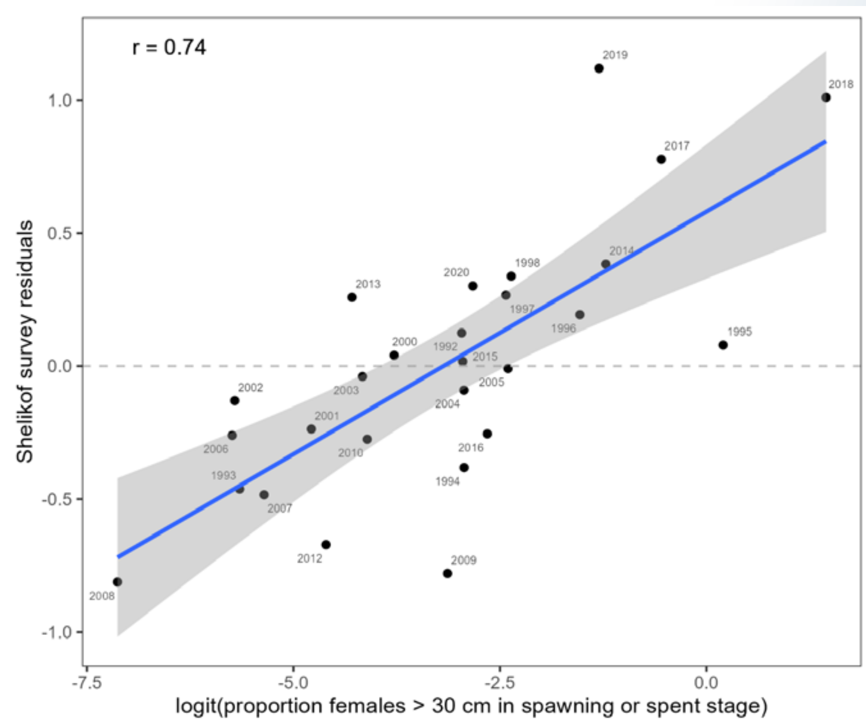
Shelikof catchability: incorporating timing covariates

Survey estimates tend to be high relative to the model (positive residuals) when the survey is closer in timing (i.e. later) relative to peak spawning.

Survey estimates tend to be high relative to the model (positive residuals) when more females are spawning or spent during survey.



Survey timing “mismatch”



Proportion females spawning or spent (“Fem30p”)

NOAA FISHERIES

Shelikof catchability: incorporating timing covariates

- Goal: link timing covariates to catchability **internal to the model**
- Random-walk q controls for <u>spatial availability</u>
- These covariates control for <u>timing availability</u>
- WHAM presents a convenient framework to do this (impossible in ADMB?)
    1. Cov. smoothed w/ AR(1) <u>inside assessment</u>
    2. Estimated cov. linked to q in the assessment

$$log(q_y) = \mu + \tau_y + \beta_1 E_y + \ldots + \beta_n E^n{}_y$$

Mean offset

Annual random effect (e.g., RW, AR(1))

Covariate effects

Estimated covariate

NOAA FISHERIES

Shelikof catchability: incorporating timing covariates

- For each of the two covariates:
  - Fem30p: (logit(proportion females >30cm spent or spawning)
  - mismatch: mid survey date to median spawn date
- Estimate three model versions:
  1. RW: Random walk (RW) only. No covariate effect.
  2. Cov: linear covariate term only.
  3. RW + Cov: combination of 1 and 2
- AIC used to compare (covariate fit for #1 also)
- Caveat: This WHAM model does not match the 2021 base model

Shelikof catchability: incorporating timing covariates

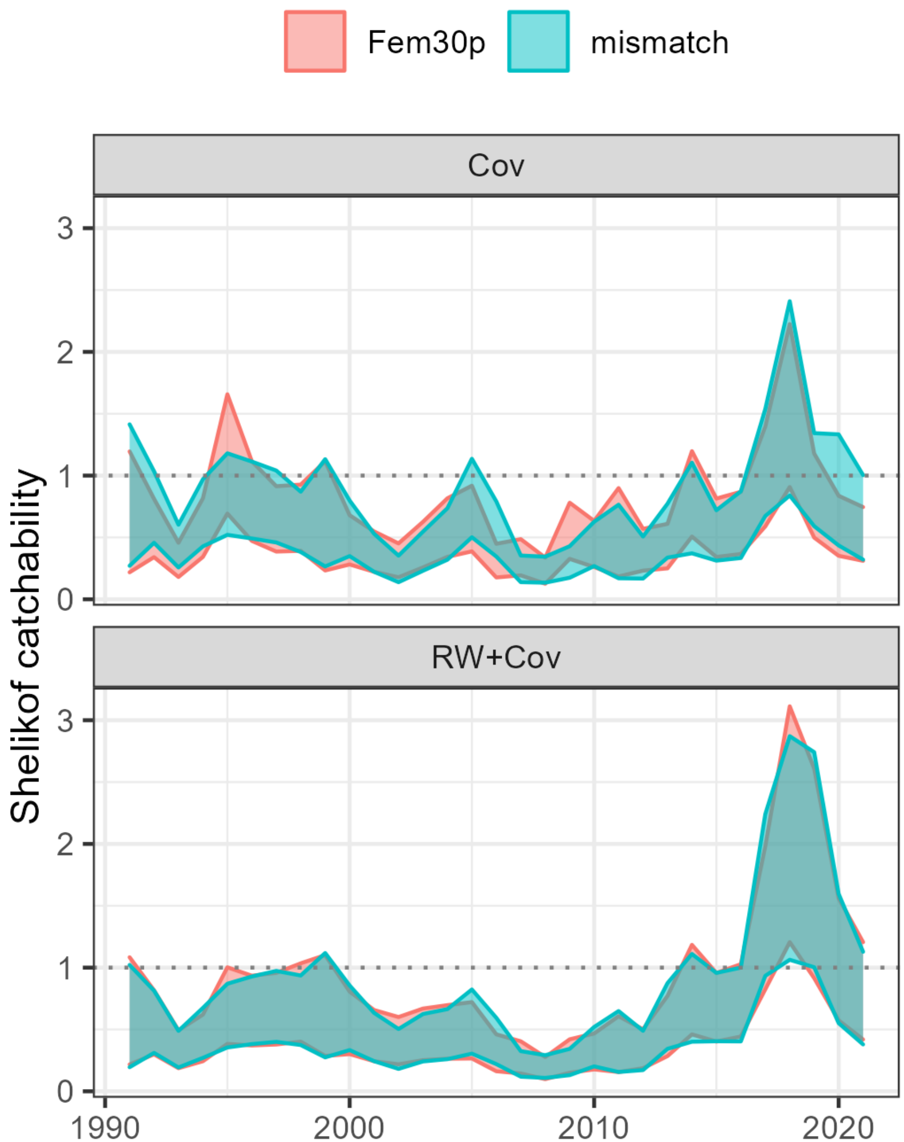
	ΔAIC Fem30p	ΔAIC mismatch	RW sd Fem30p	RW sd mismatch
RW	8.6	12.7	0.34	0.34
Cov	13.8	7.1	--	--
RW + Cov	0.0	0.0	0.22	0.17
	% variance reduction		58.1%	75.0%

Statistical support for both covariates

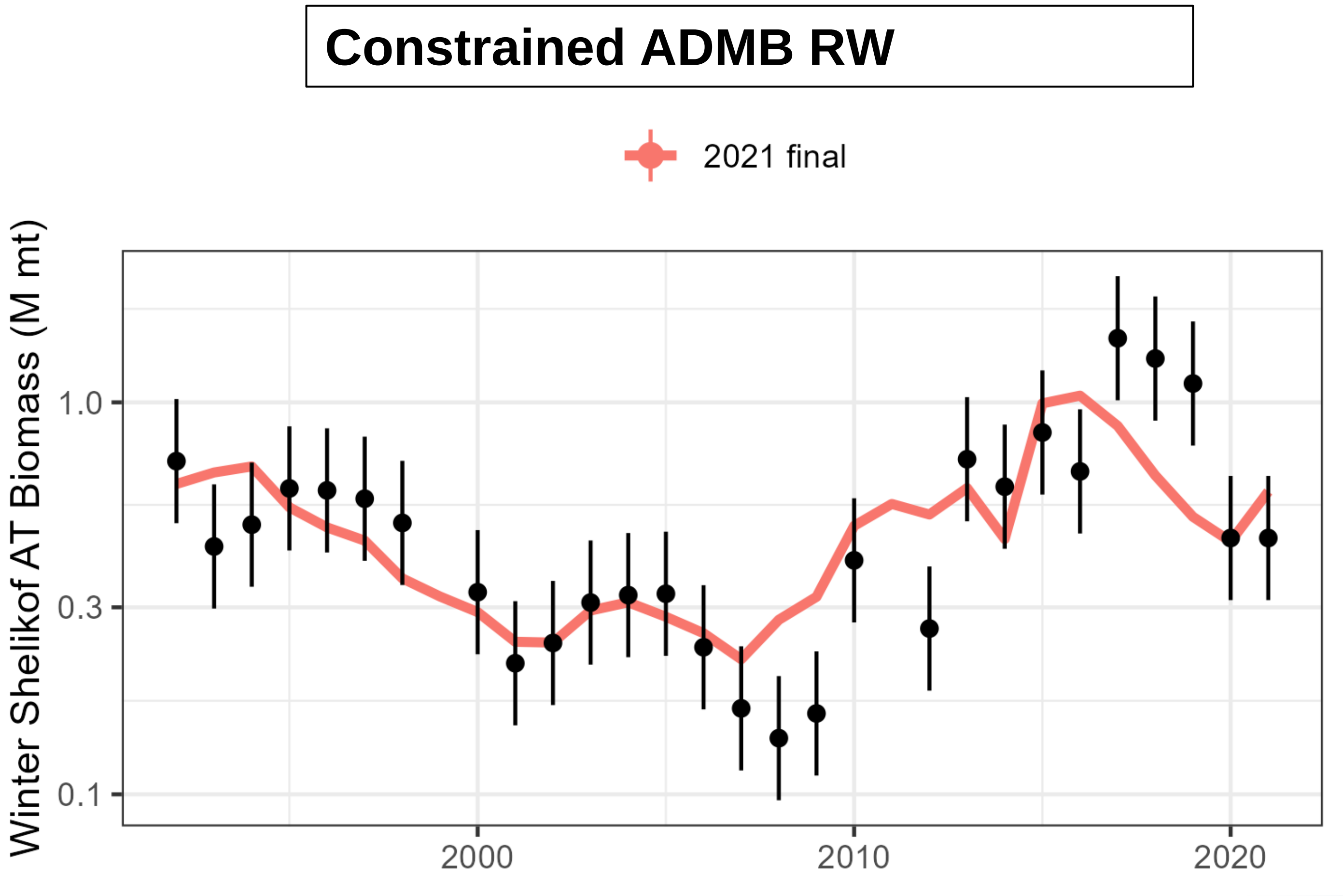
58.1% and 75.0% reduction in RW variance w/ added covariate

But predicts catchability (>1)

Caveat: WHAM does not match ADMB model perfectly!

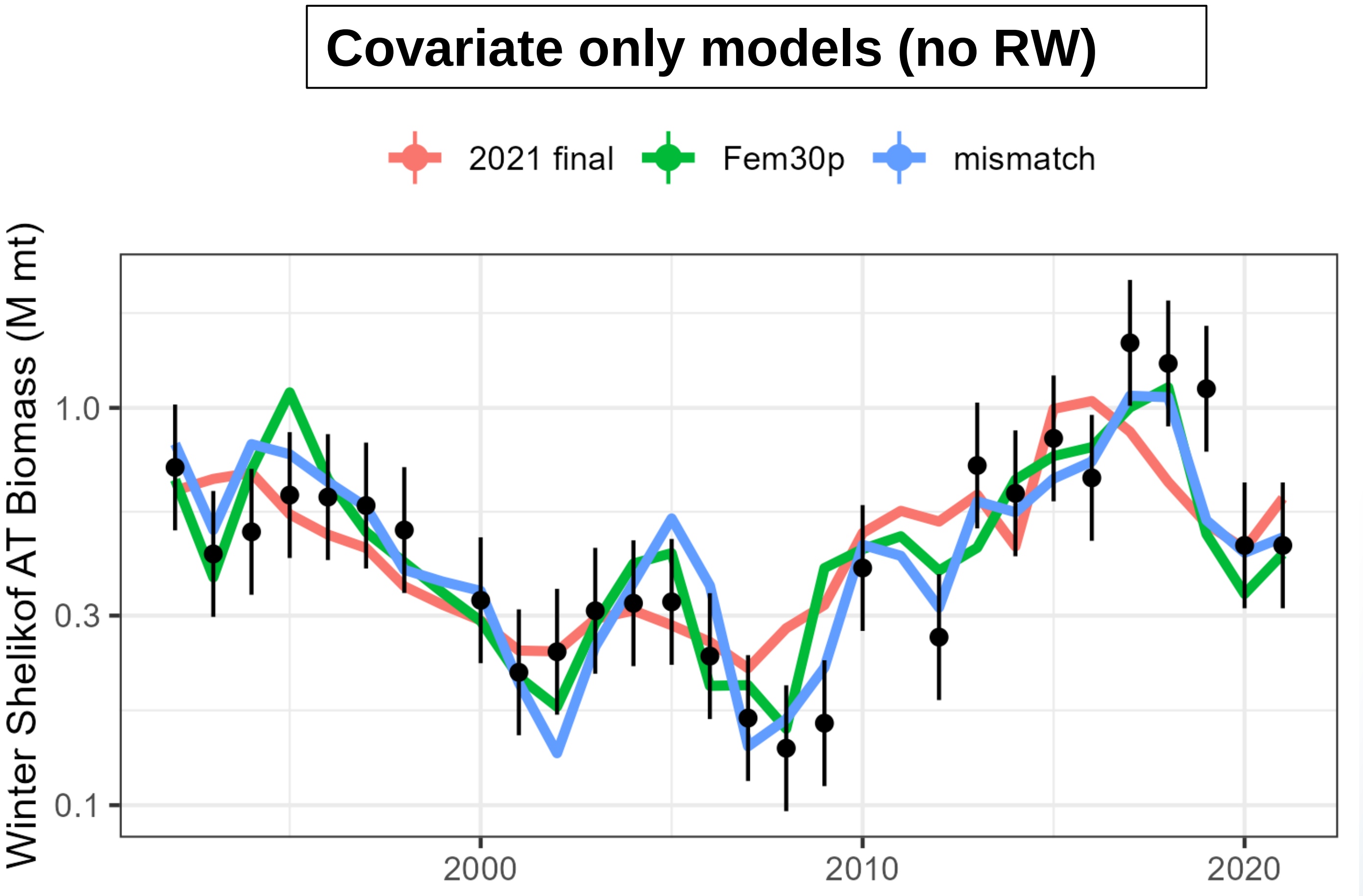


Shelikof catchability: incorporating timing covariates



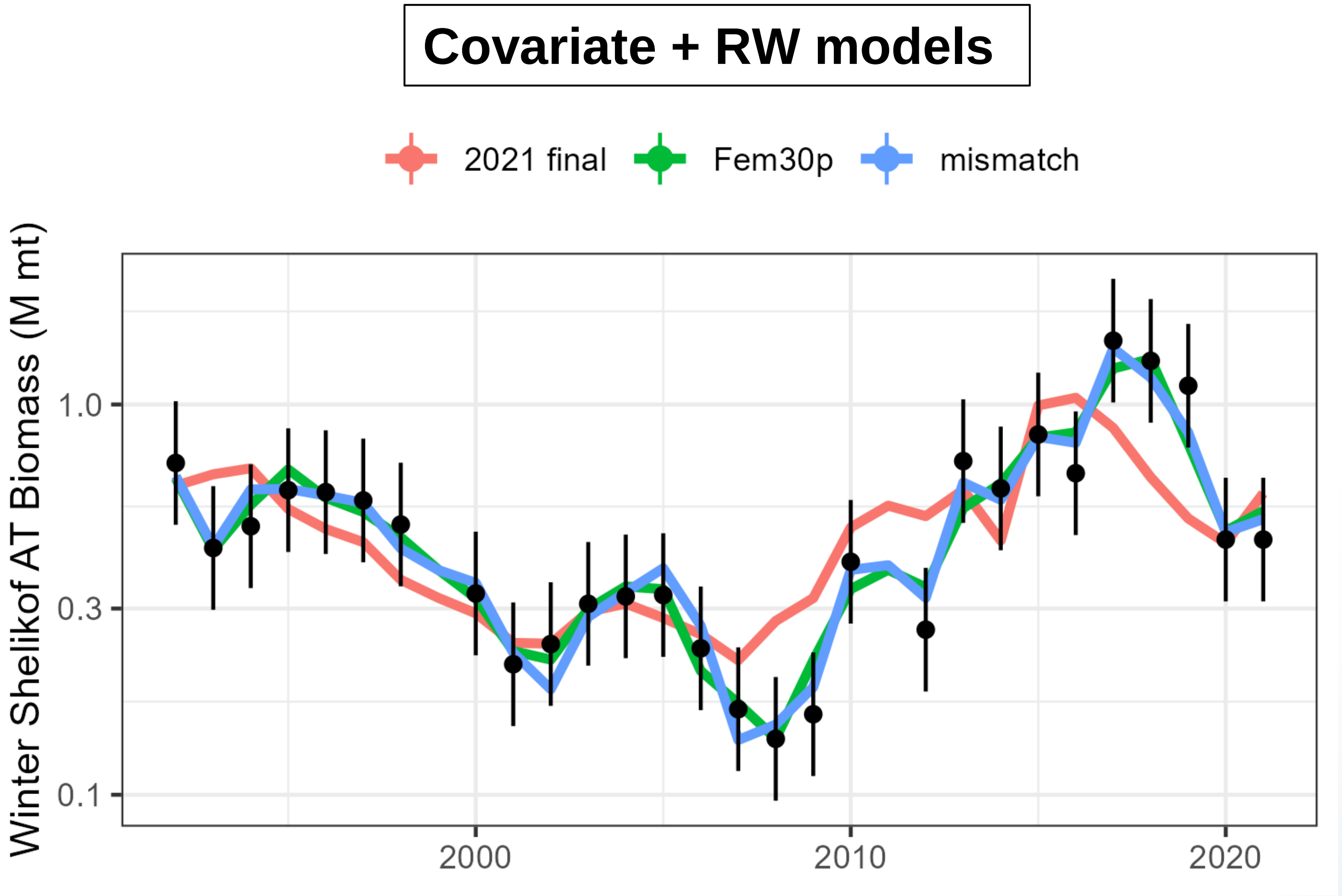
Caveat: WHAM does not match ADMB model perfectly!

Shelikof catchability: incorporating timing covariates



Caveat: WHAM does not match ADMB model perfectly!

Shelikof catchability: incorporating timing covariates



Caveat: WHAM does not match ADMB model perfectly!

Shelikof catchability: incorporating timing covariates

- Both timing metrics are statistically significant and clearly improve the fits to the data
  - But very high estimates of q (>1)
- Covariate + RW was selected, suggesting timing + other effects (spatial?) on availability
- White noise covariates did not do this (not shown).
- A RW can achieve the same fit, but uses more DF (higher sigma) and lacks a mechanism
- This could be coded in the ADMB model, but would be awkward and not fully incorporate uncertainty
- Continued research, see Rogers et al. (in prep)

PT advice on interpretation/future research?

Shelikof catchability: updates on research models

1. Supported "*future research to .. estimate the process error variance internally within the assessment model.*"
   Should higher variances be used? Median from MCMC? Is q=1.5 reasonable?
2. Reiterated "*its recommendation …to explore the use of covariates related to the timing of the survey to inform survey catchability ….*"
   Advice on interpretation/future research?

Questions/Comments/Suggestions?

Acknowledgements

- Martin Dorn for training and transition
- Tim Miller and Brian Stock for WHAM help/advice
- Survey and A&G personnel for collecting and providing data

Extra slides

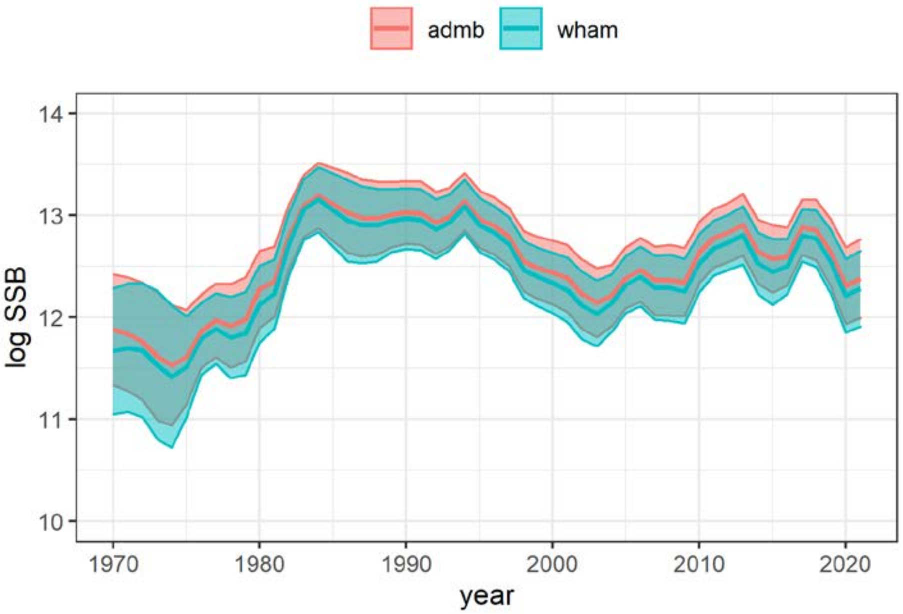
State space with WHAM

RE estimation of IID NAA

- Process error of age 2+ goes to zero, so no effect

	Estimate	SE
log Sigma Recruits	0.29	0.1
log Sigma Age 2+	-4.73	2.57

par	length	purpose
F_devs	51	effort deviations
log_F1	1	initial effort
log_N1_pars	1	initial age structure
log_NAA_sigma	2	sigmaR
logit_q	6	catchabilities
logit_selpars	16	selectivity fixed effects
mean_rec_pars	1	mean recruitment
q_re	104	catchability process errors
selpars_re	104	selectivity deviations
total	286	



DRAFT RESULTS: DO NOT use or distribute without direct permission from the contributor.

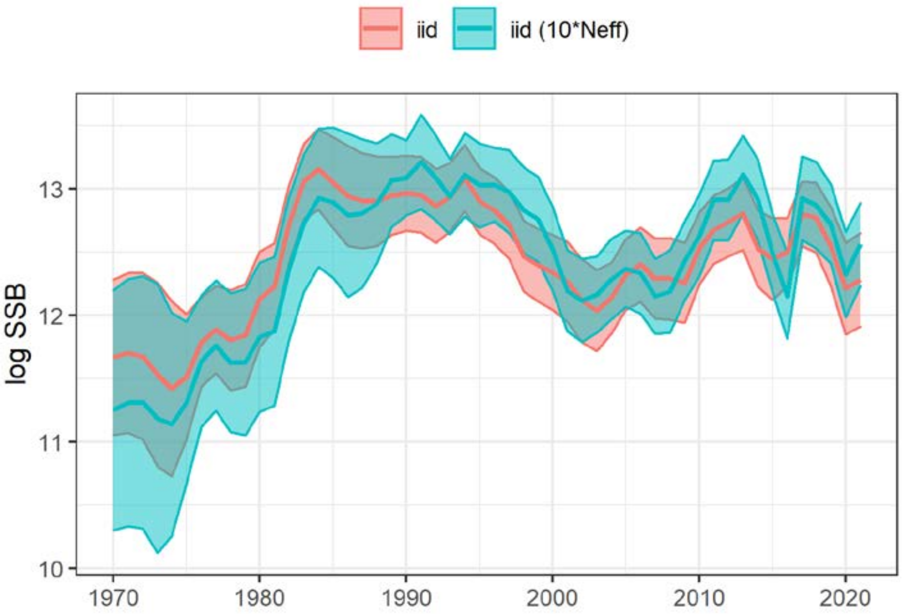
State space with WHAM

RE estimation of IID NAA, inflated Neff=10*Neff

- Now there is a meaningful process error

	Estimate	SE
log Sigma Recruits	0.26	0.11
log Sigma Age 2+	-0.94	0.06

par	length	purpose
F_devs	51	effort deviations
log_F1	1	initial effort
log_N1_pars	1	initial age structure
log_NAA_sigma	2	sigmaR
logit_q	6	catchabilities
logit_selpars	16	selectivity fixed effects
mean_rec_pars	1	mean recruitment
q_re	104	catchability process errors
selpars_re	104	selectivity deviations
total	286	



DRAFT RESULTS: DO NOT use or distribute without direct permission from the contributor.

IID vs AR1 for NAA, inflated Neff

iid

Quantity	Estimate	SE
log_NAA_sigma	0.26	0.11
log_NAA_sigma.1	-0.94	0.06
NAA_rho_a	NA	NA
NAA_rho_y	NA	NA

ar_y

Quantity	Estimate	SE
log_NAA_sigma	0.22	0.11
log_NAA_sigma.1	-1.06	0.08
NAA_rho_a	NA	NA
NAA_rho_y	0.36	0.08

ar1_a

Quantity	Estimate	SE
log_NAA_sigma	0.06	0.11
log_NAA_sigma.1	-1.00	0.07
NAA_rho_a	0.48	0.07
NAA_rho_y	NA	NA

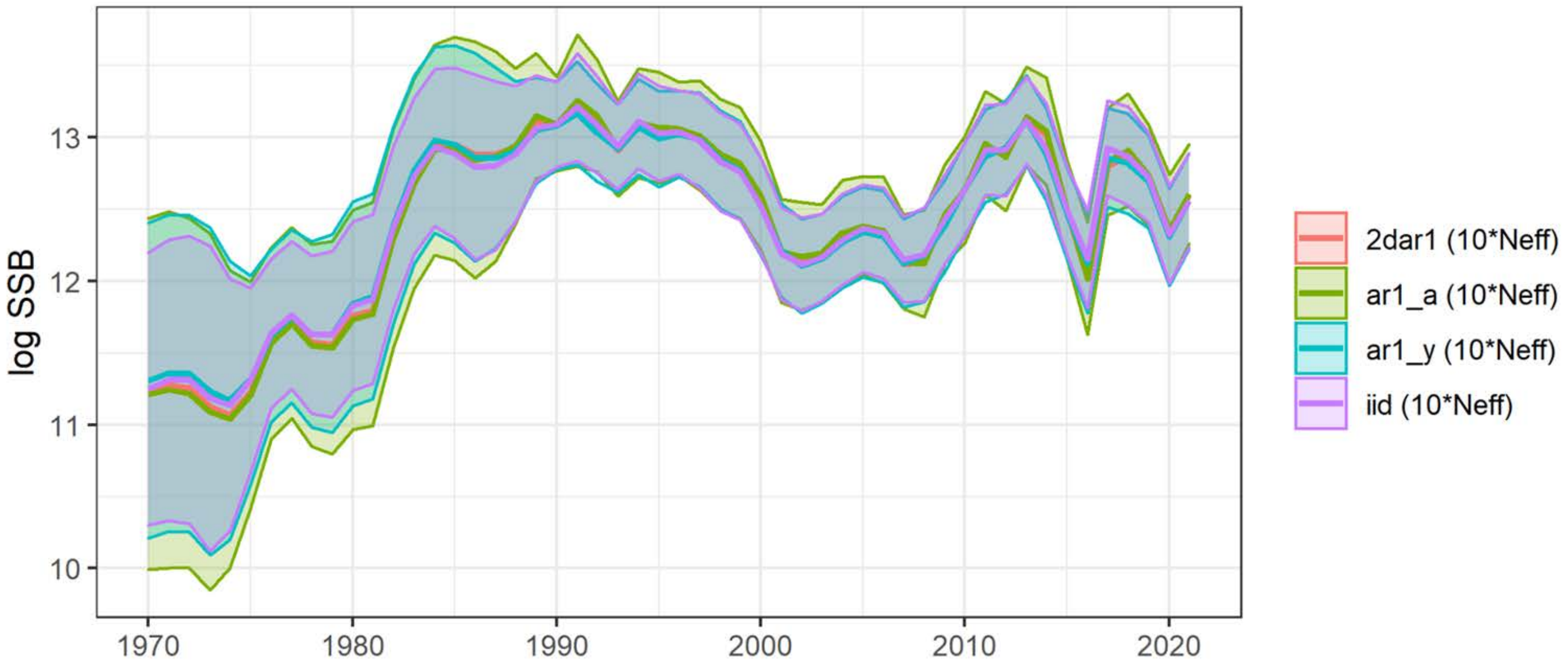
2dar1

Quantity	Estimate	SE
log_NAA_sigma	0.07	NaN
log_NAA_sigma.1	-1.05	NaN
NAA_rho_a	0.41	NaN
NAA_rho_y	0.19	NaN

DRAFT RESULTS: DO NOT use or distribute without direct permission from the contributor.

State space with WHAM

IID vs AR1 for NAA, inflated Neff



DRAFT RESULTS: DO NOT use or distribute without direct permission from the contributor.