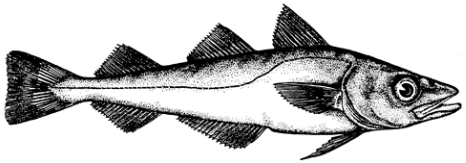
GOA Pollock



Cole Monnahan
2024 November Plan Team
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Collaborators: Bridget E. Ferriss, S. Kalei Shotwell, Zack Oyafuso, Mike Levine, James T. Thorson, Lauren Rogers, Jane Sullivan, and Juliette Champagnat

Author's <u>2025 ABC = 181,022 t</u>

- Increase of 56% from 2023
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Changes (cumulative) to model:

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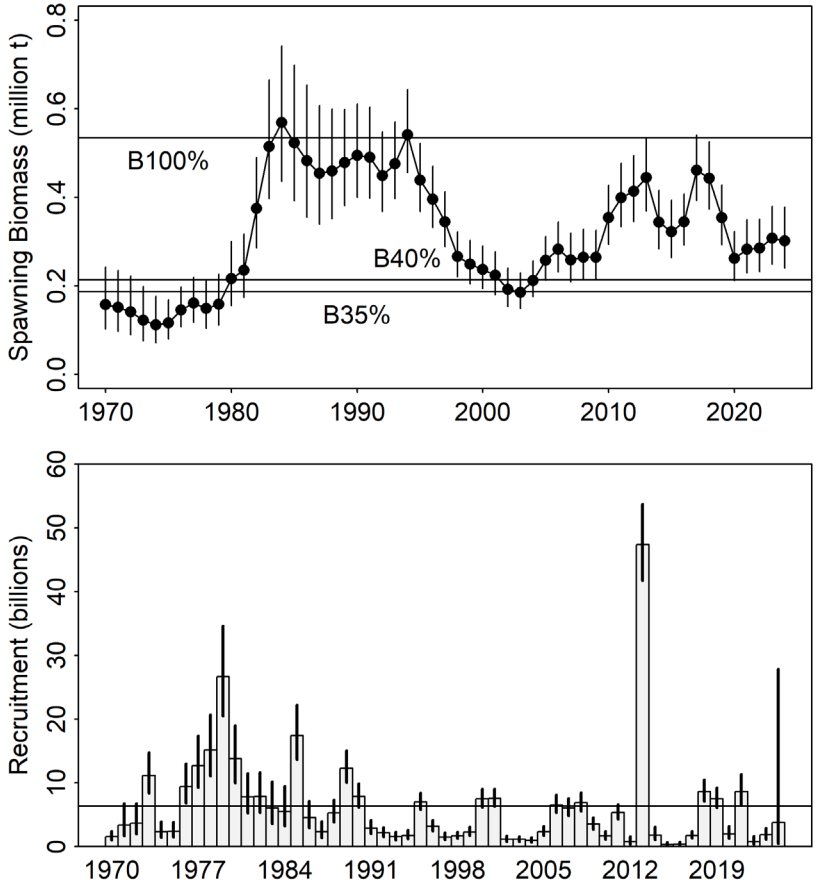
Positives:

- 2017, 2018, 2020 cohorts above average
- Better retrospective pattern

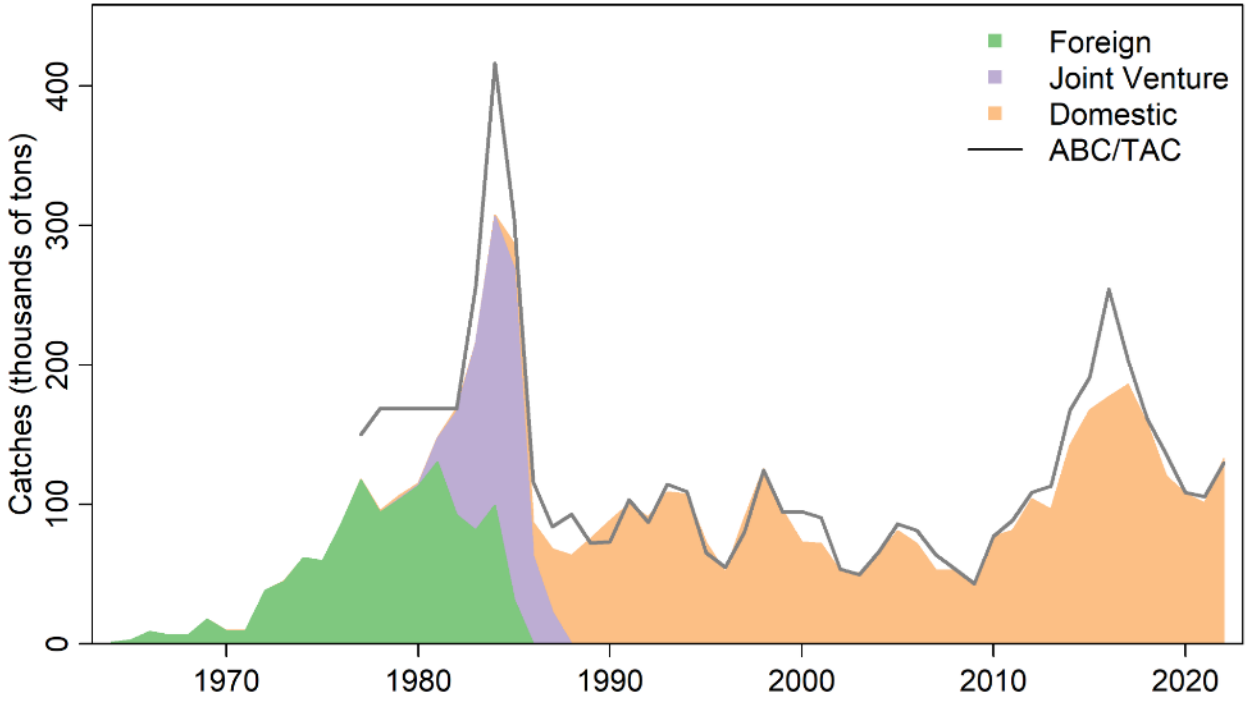


Model overview

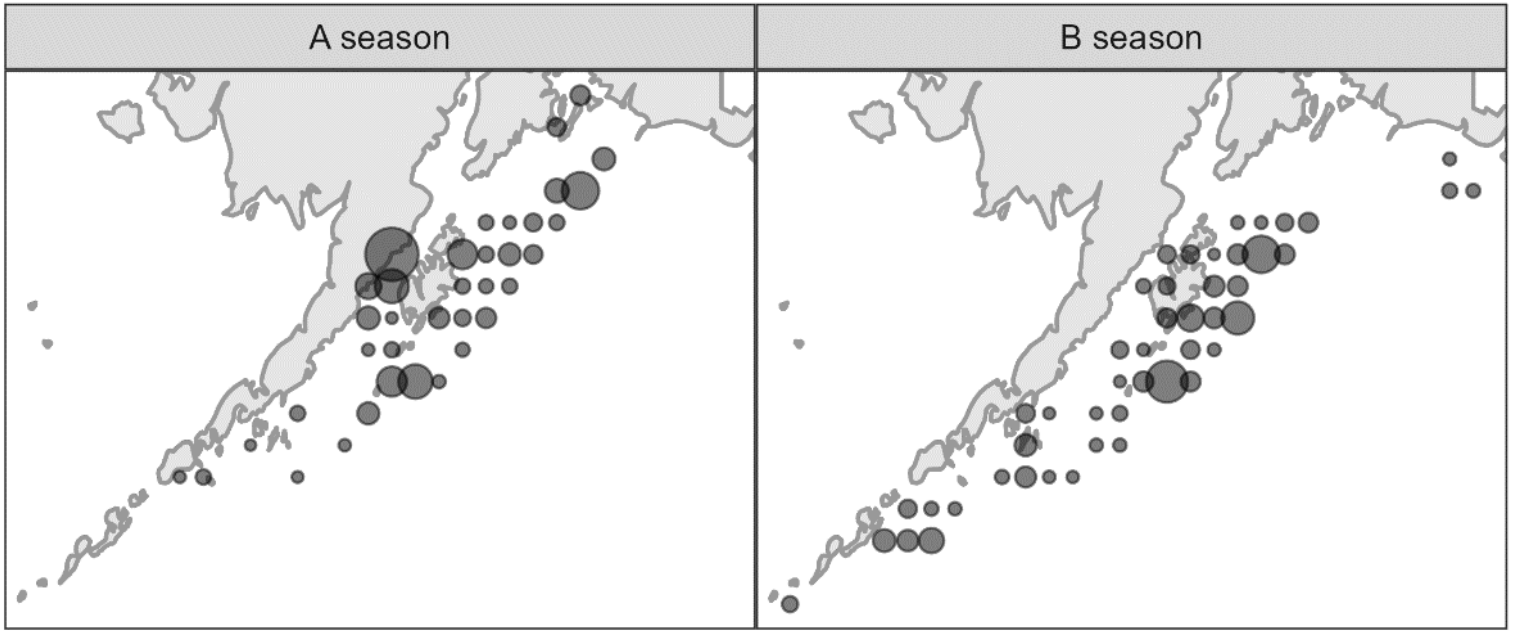
- Single-sex, single fishery, ages 1-10+
- Empirical weight at age
  - No internal length dynamics, all age-based processes
  - Length comps converted via specified matrices
- Fishery selectivity is double logistic
  - Time-varying (RW) initial slope/intercept
- Fitted to 4 surveys
  - NMFS winter (Shelikof) + summer (coast wide) acoustic
  - NMFS and ADF&G summer bottom trawl
- Time-varying catchability for Shelikof and ADF&G
- Prior on NMFS BT catchability sets scale and stabilizes model

Catch history

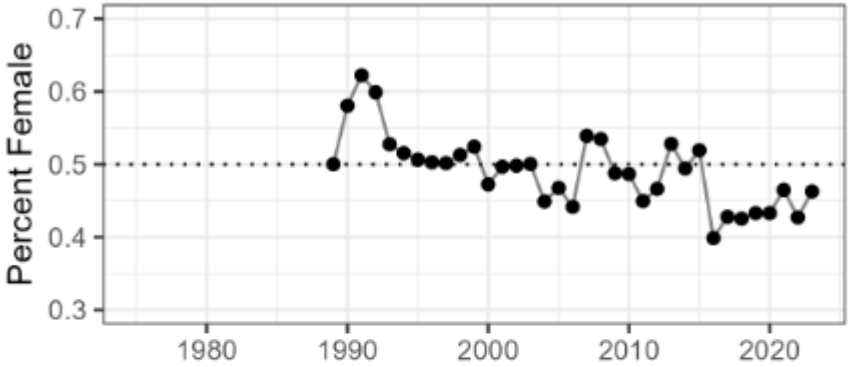
2023 projected catch = 145,215 t
2023 realized catch = 135,103 t
2024 projected catch = 131,000 t (CGOA closure in Sep-2024)

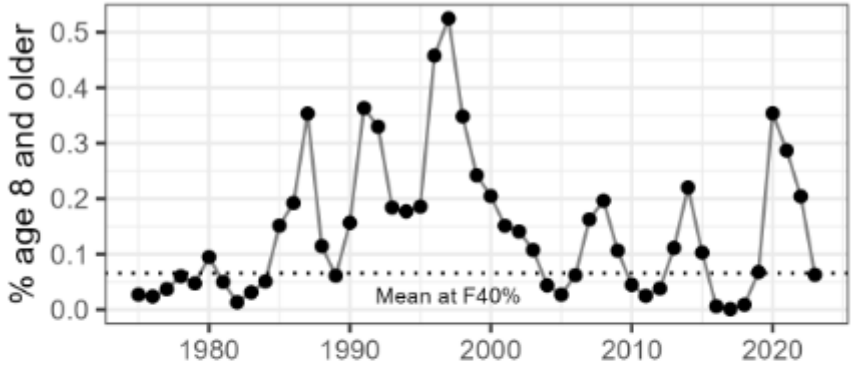


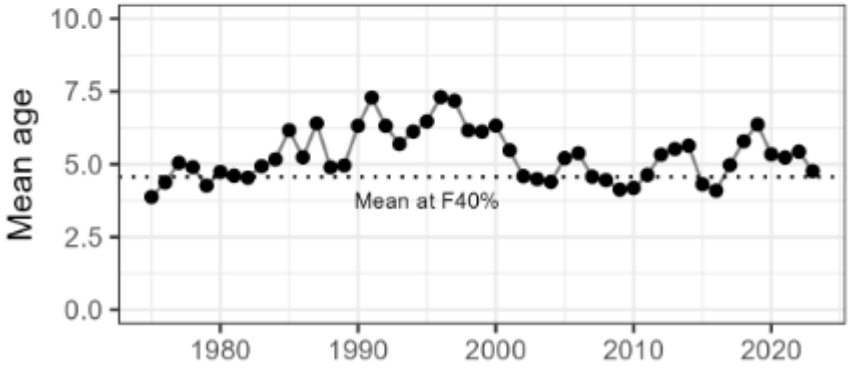
2023 fishery catch distribution



Fishery catch indicators





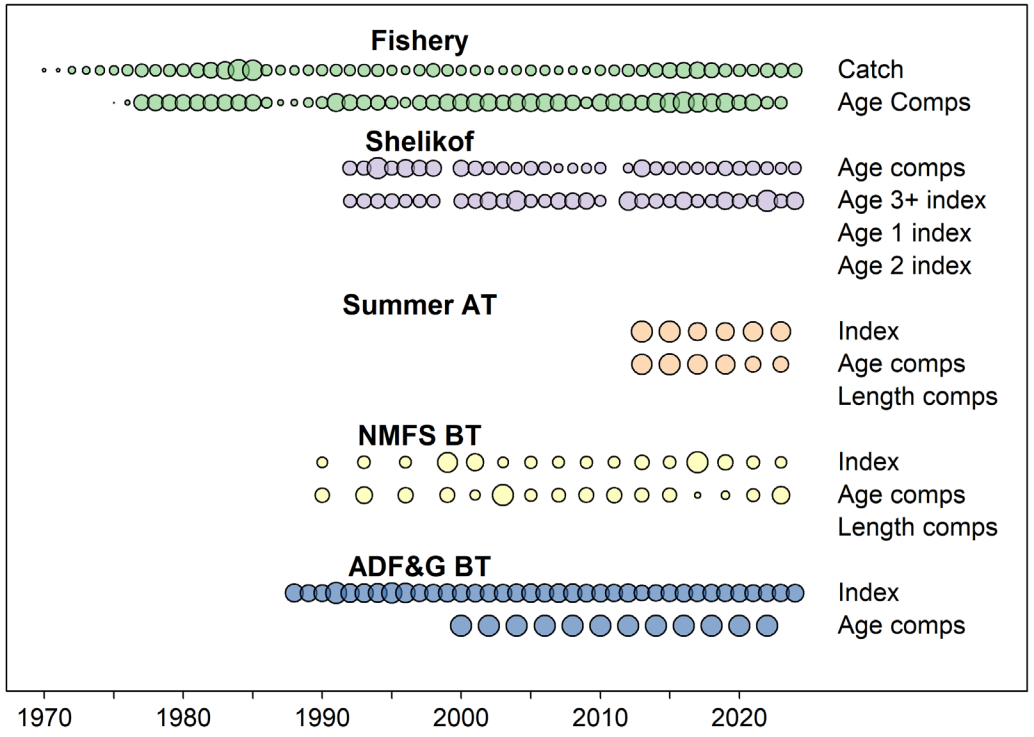


New data available in 2024

2024 was an “off” year in the GOA

- 2024 winter Shelikof acoustic survey (index and ages)
- 2023 Summer acoustic ages
- 2023 NMFS bottom trawl ages
- 2024 ADF&G bottom trawl index

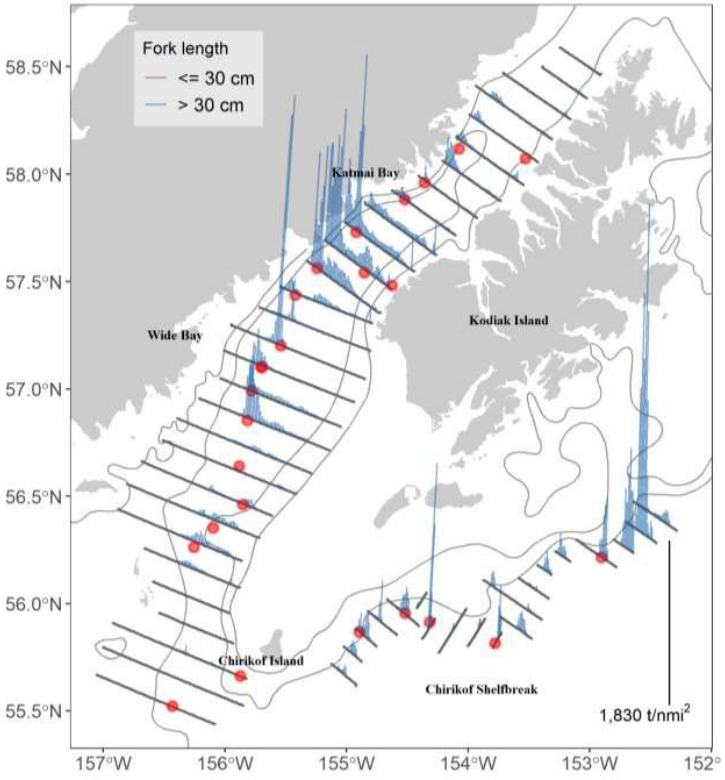
Shelikof up 12%
ADF&G up 17%

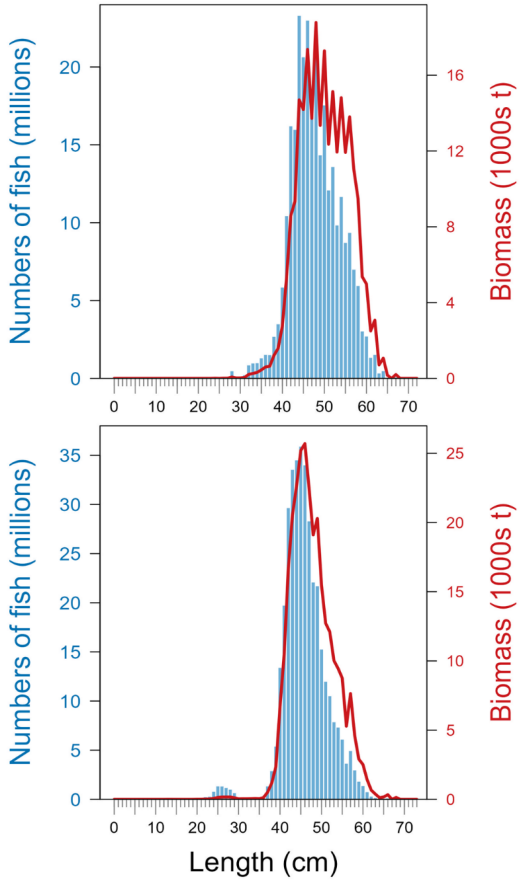


Winter acoustic results

Shelikof up 12%
No small fish (same as 2023)

Chirikof up 189% to 115 kt





Winter acoustic results

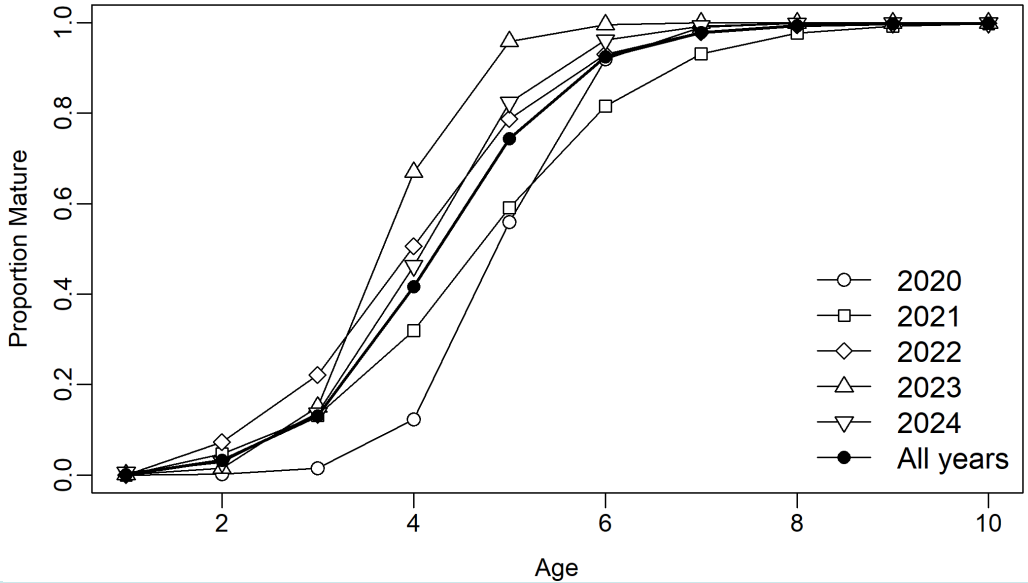
Shelikof up 12%
No small fish (same as 2023)

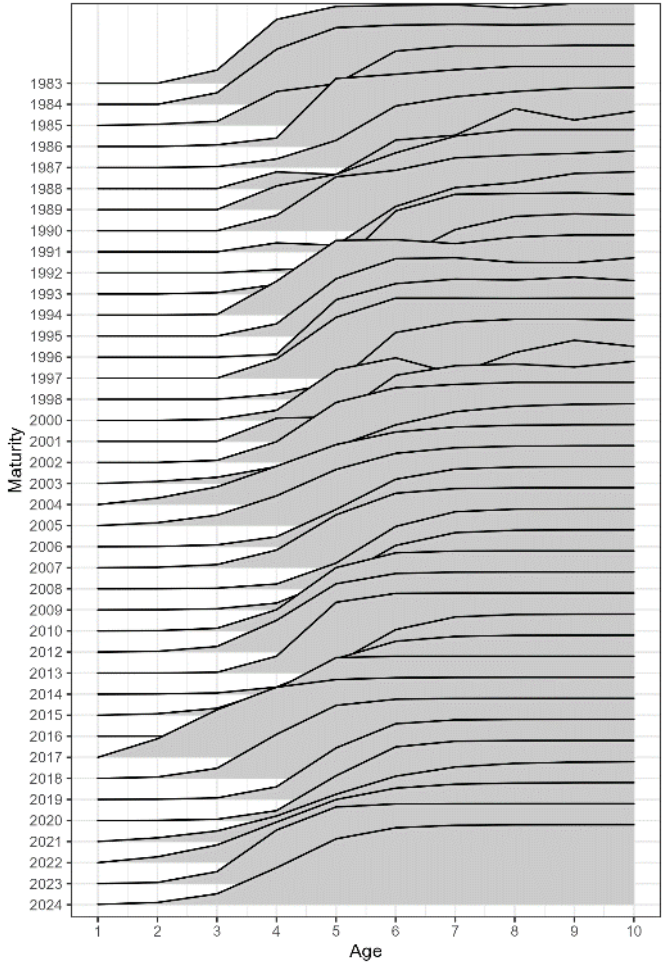
Chirikof up 189% to 115 kt

Maturity: recent estimates

Estimated from Shelikof data. Data after 2003 use local abundance weighting.

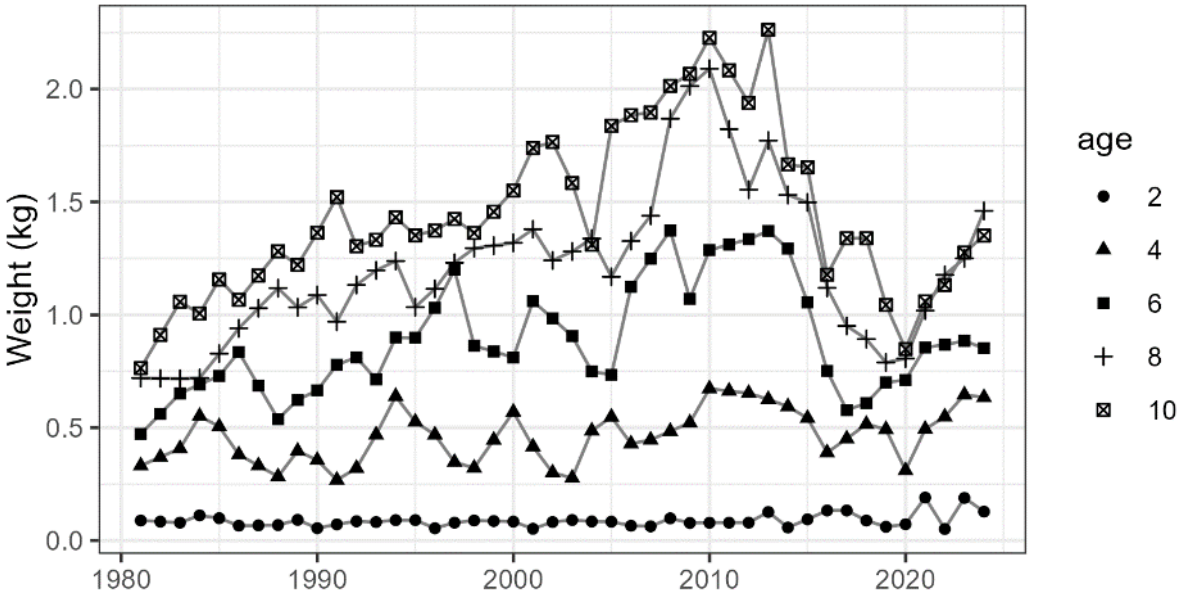
Average of all years used in projections





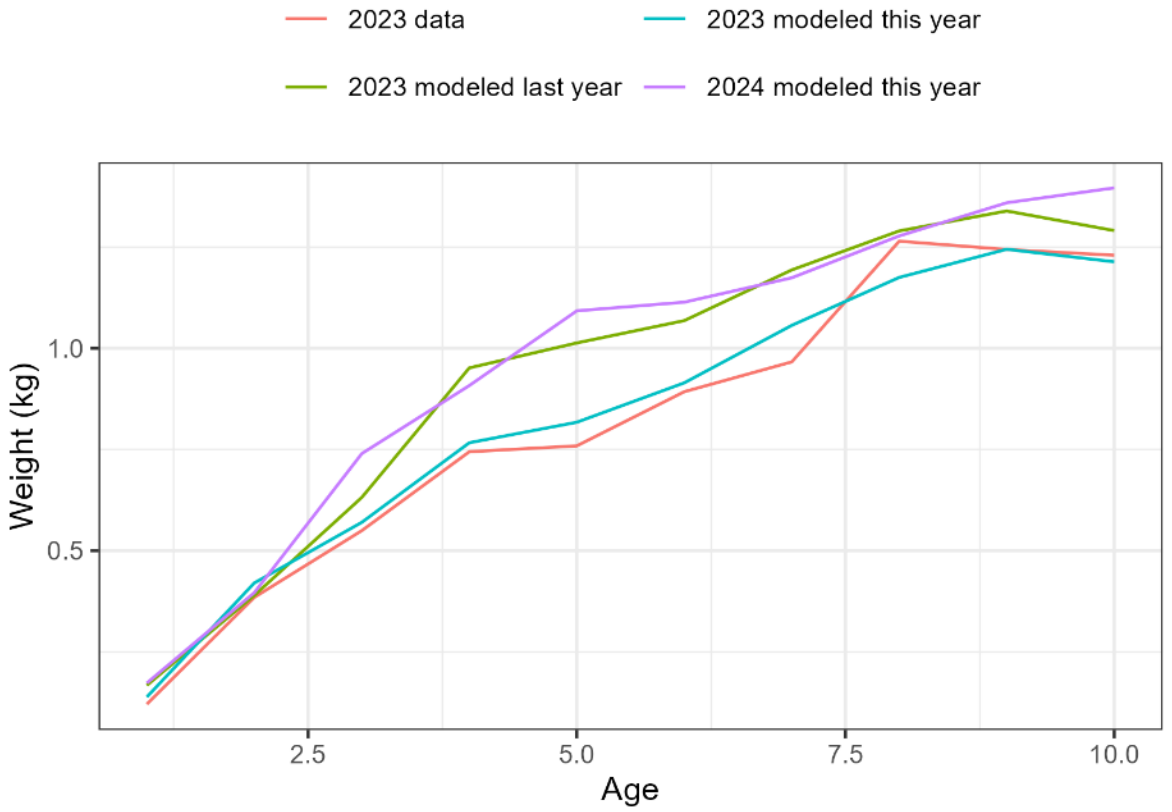
Spawning weight at age (WAA)

- WAA from Shelikof survey
- Declined from 2012 to 2020
- Increasing again
- 5-year average used for projections



Fishery WAA

- Did the RE model accurately predict the 2023 fishery WAA last year?
- Not really



NMFS BT updates

- Stock definition is W of 140W, but survey extends east
- Previously, only the index filtered stations east of 140W
- This year, Z. Oyafuso and I revised historical age compositions and weights-at-age to also filter them
- Had a minimal impact on assessment (shown later)
- But is an improvement to have survey extent consistent across data products

Key parameters estimated externally

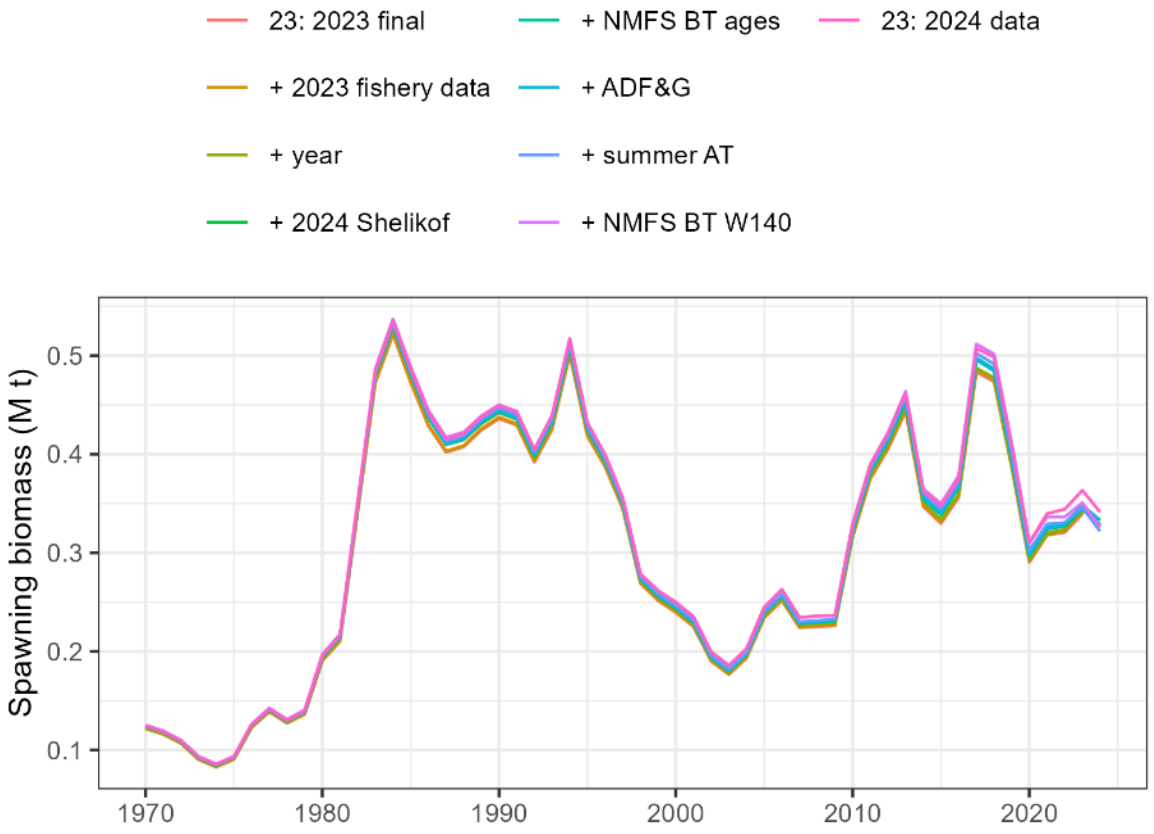
- Natural mortality: age-specific
- Fishery WAA
  - Data used through 2023
  - A RE model used for 2024 and projections
- Spawning WAA
  - Annual data exclusively from Shelikof Strait
  - 5-year average for projections
- Population WAA
  - Projections use average of last 3 NMFS BT surveys
- Proportion mature at age
  - Long-term (1983-present) average used throughout

Parameters estimated internally

Population process modeled	Number of parameters	Estimation details
Mean recruitment	1	Estimated in log space
Recruitment deviations	Years 1970-2024 = 55	Estimated as log deviances from the log mean with all years constrained by random deviation process error of 1.3.
Natural mortality	Age-specific= 10	Not currently estimated in the model
Fishing mortality	Years 1970-2024 = 55	Estimated as log deviances from the log mean
Mean fishery selectivity	4	Slope parameters estimated on a log scale, intercept parameters on an arithmetic scale
Annual changes in fishery selectivity	2 * (No. years-1) = 110	Estimated as deviations from mean selectivity and constrained by random walk process error
Mean survey catchability	No. of surveys = 4	Catchabilities estimated on a log scale.
Annual changes in survey catchability	(No. years-1) = 54	Annual catchability for winter acoustic surveys and ADF&G surveys estimated as deviations from mean catchability and constrained by random walk process error
Covariate smoothing on catchability link for Shelikof survey	AR(1) process error and correlation, and effect size (3), as well as annual random effects (55)	The random effects are integrated out and not included in the total here.
Survey selectivity	8 (2 each for the Shelikof and summer acoustic surveys, and the NMFS and ADF&G BT surveys)	Slope parameters estimated on a log scale.
Overdispersion for Dirichlet-multinomial age composition	Fishery (1) and surveys (4)	Estimated in log space
Total	297 fixed effects (55 random effects)	

Sequential addition of data

- Track 2023 accepted model (23) changes as new data are added
- Relatively stable trend and scale compared to 2023



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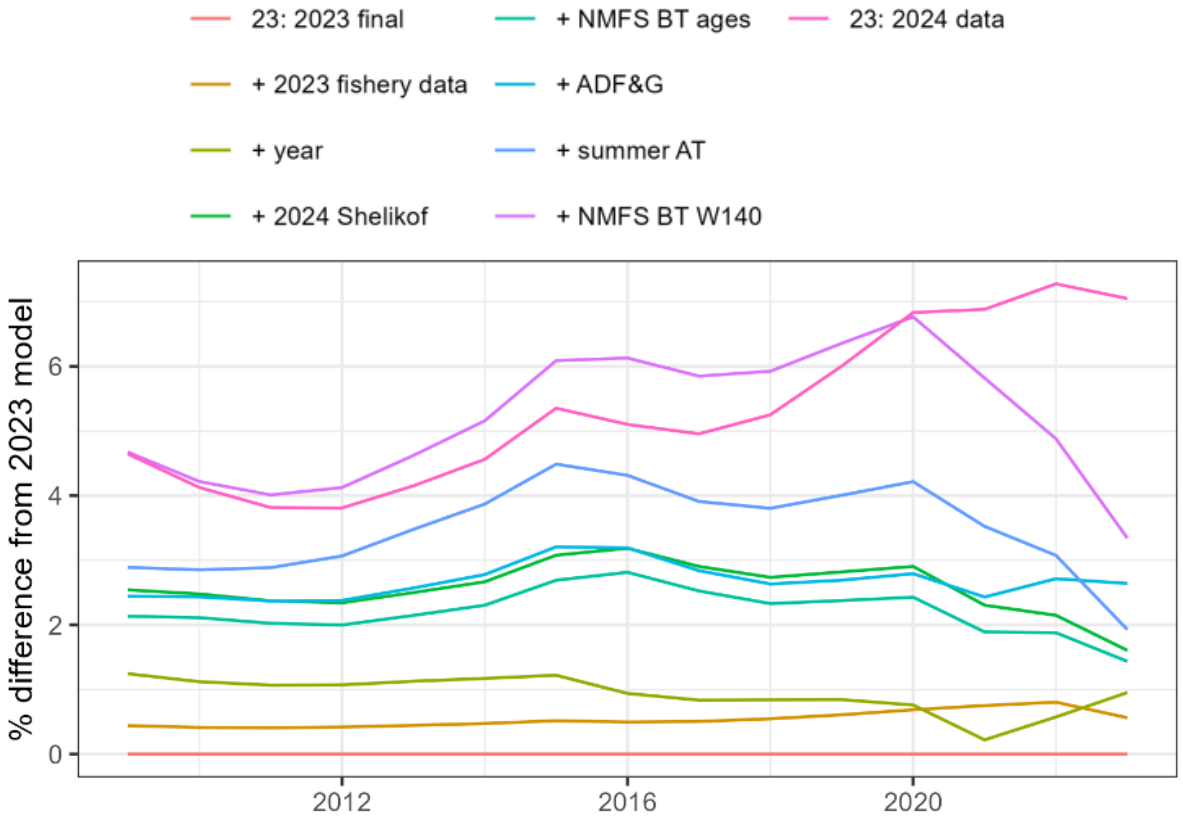
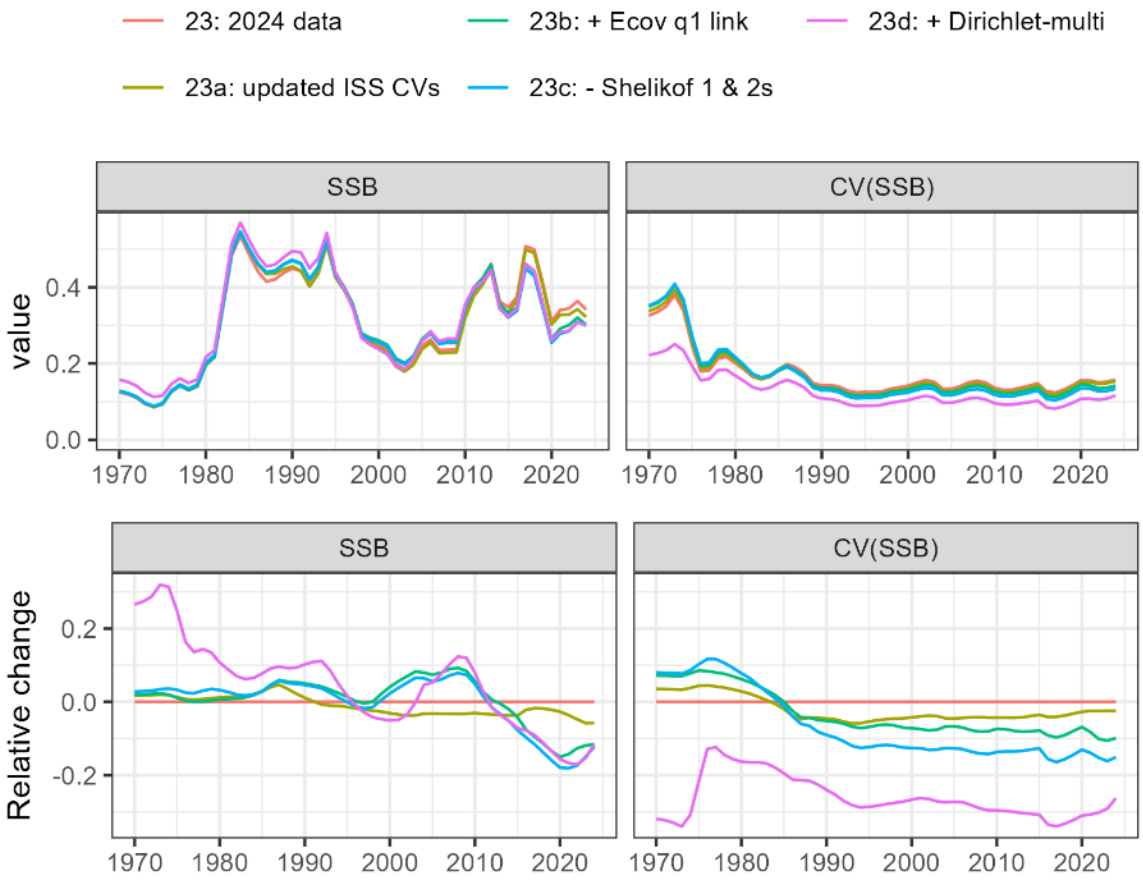
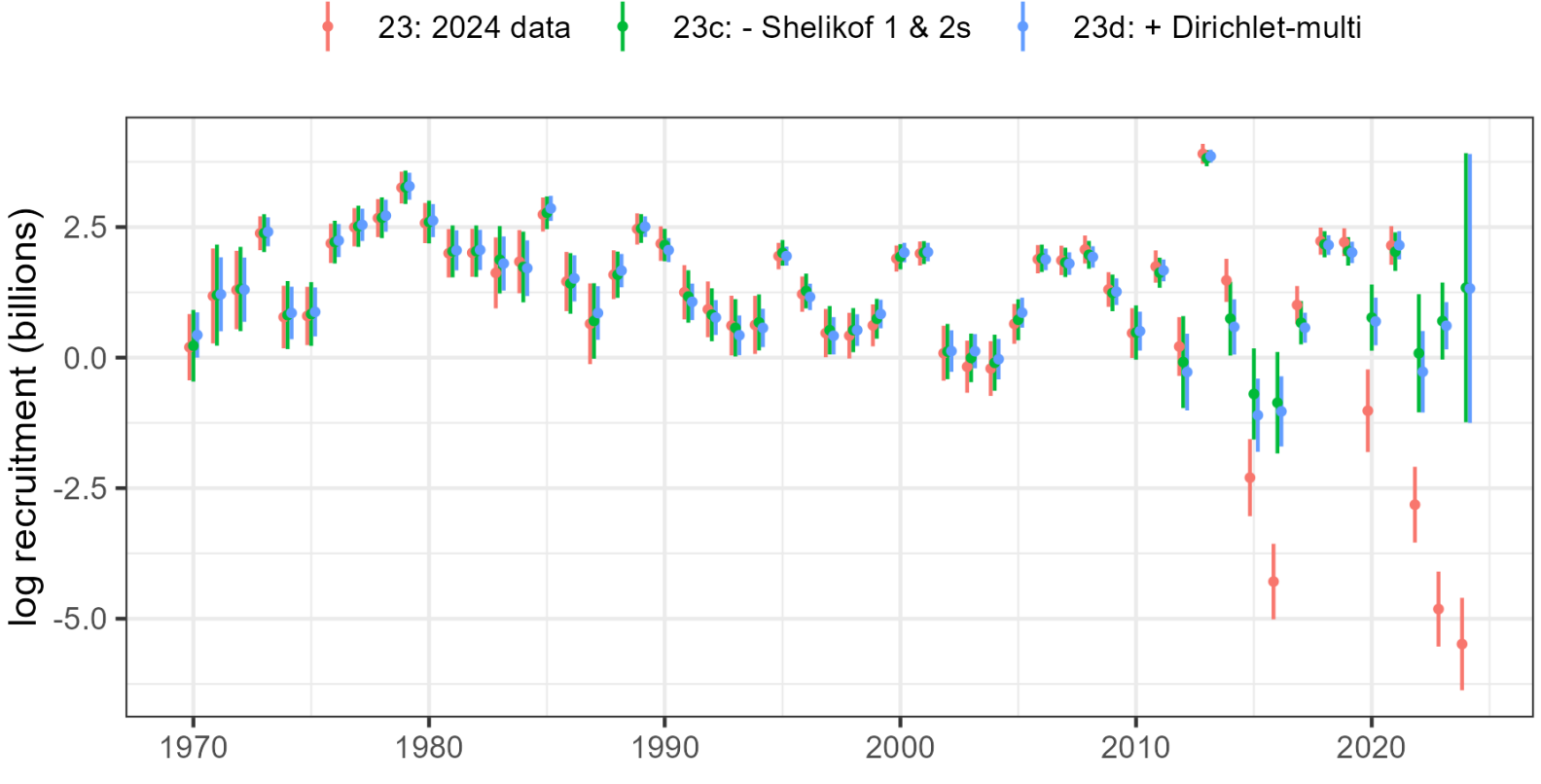


Model alternatives

- Biggest changes were models 23b and 23d
  - Increased early SSB, decreased recent
  - Decreased uncertainty
- Otherwise fairly stable



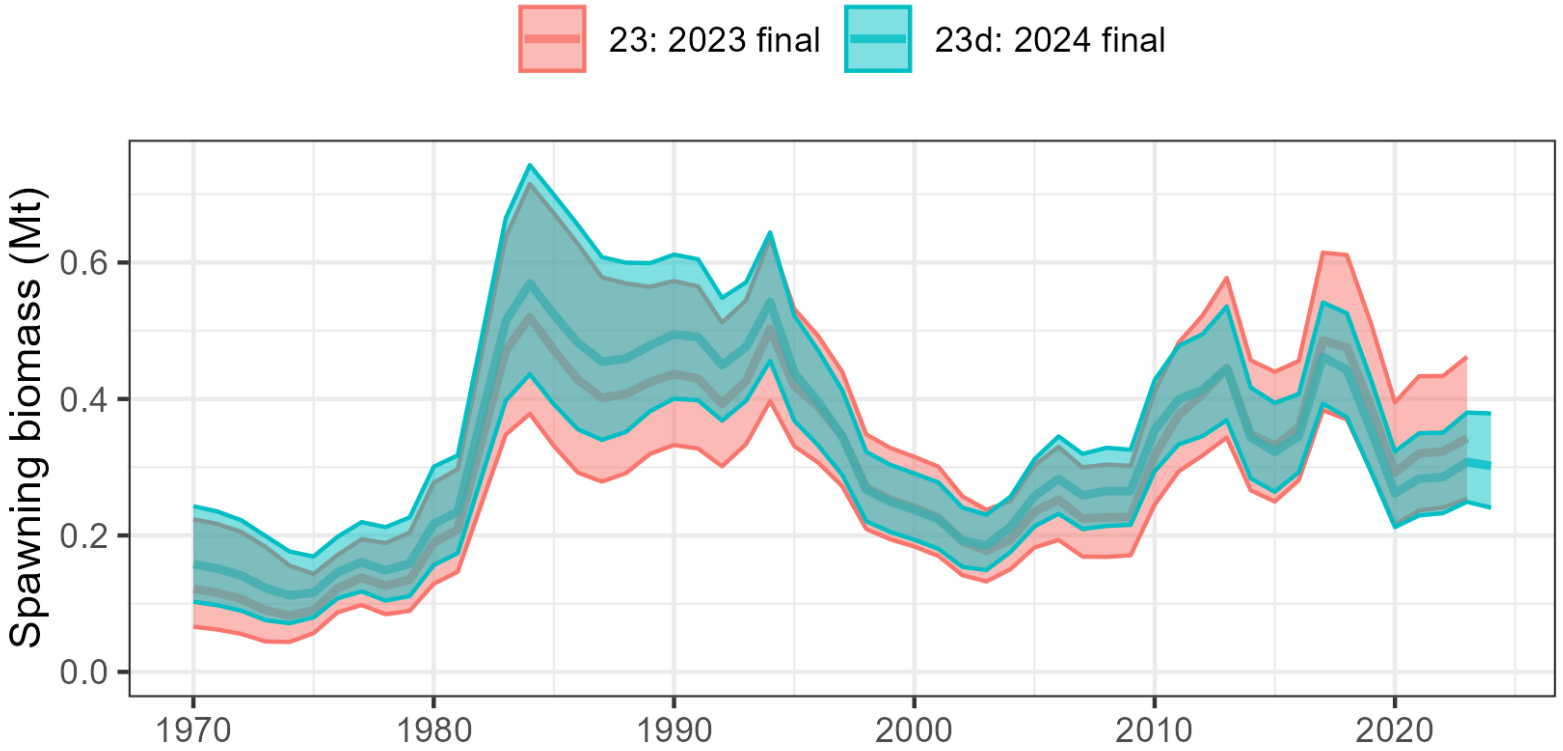
Model alternatives: Recruitment estimates



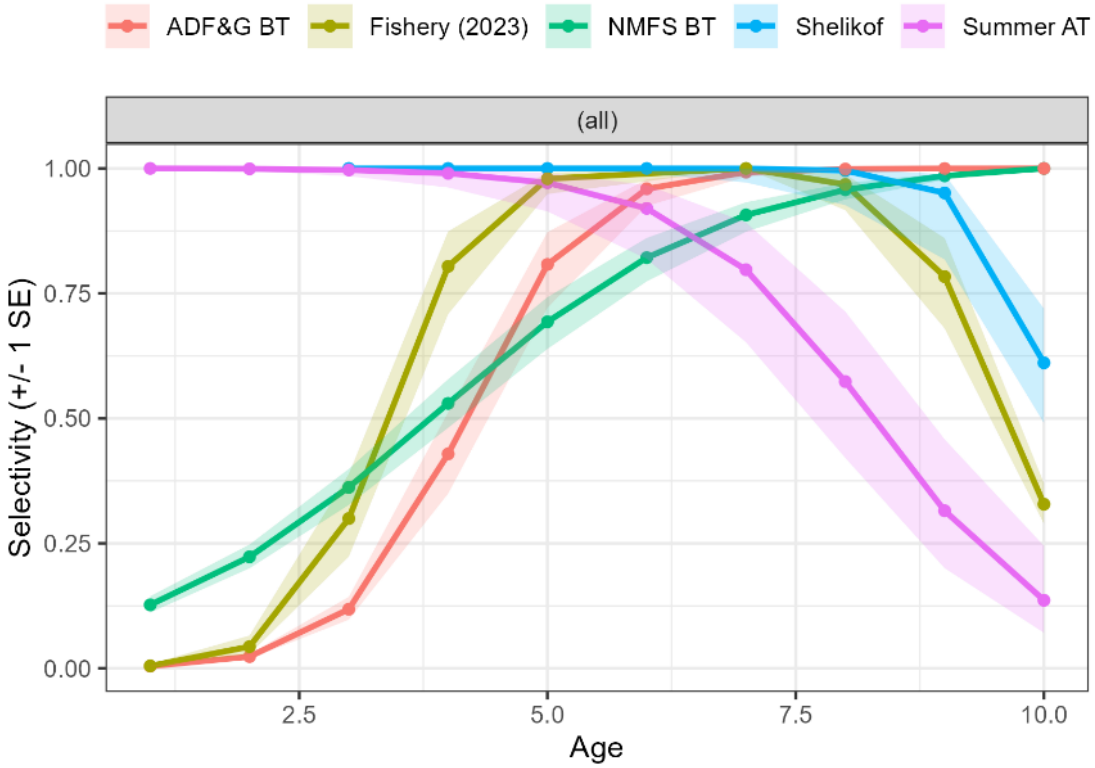
Model alternatives: management advice

Model Version	2025 SSB (t)	B100	FOFL	FABC	OFL	ABC
23: 2024 data	259,437	534,000	0.308	0.261	186,778	161,183
23a: updated ISS CVs	245,952	529,000	0.309	0.262	180,218	155,540
23b: + Ecov q1 link	231,139	528,000	0.314	0.266	174,504	150,545
23c: - Shelikof 1 & 2s	238,824	529,000	0.316	0.267	205,536	177,035
23d: 2024 final	243,078	535,000	0.321	0.271	210,111	181,022

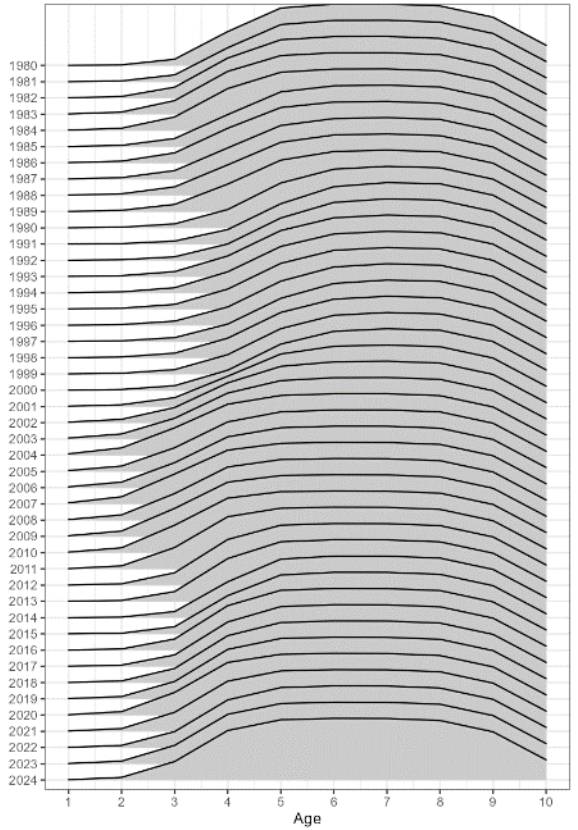
Final model compared to last year



Selectivity

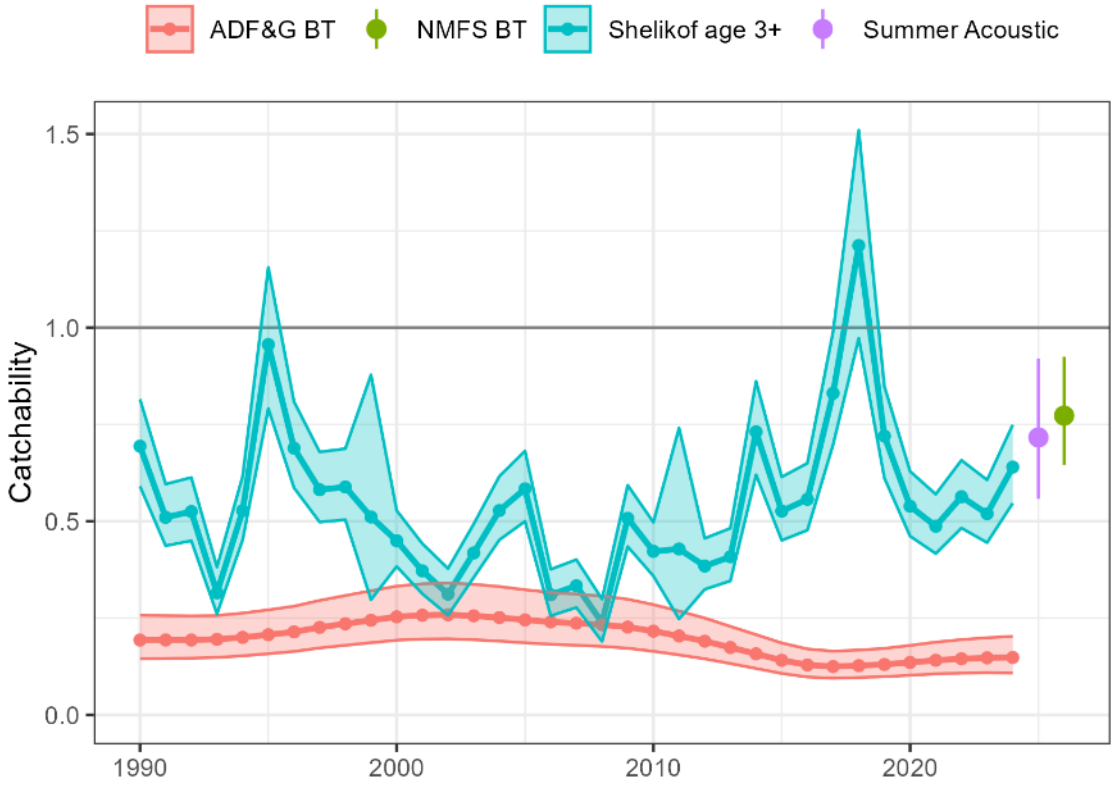


Fishery selectivity: double logistic with time-varying ascending limb



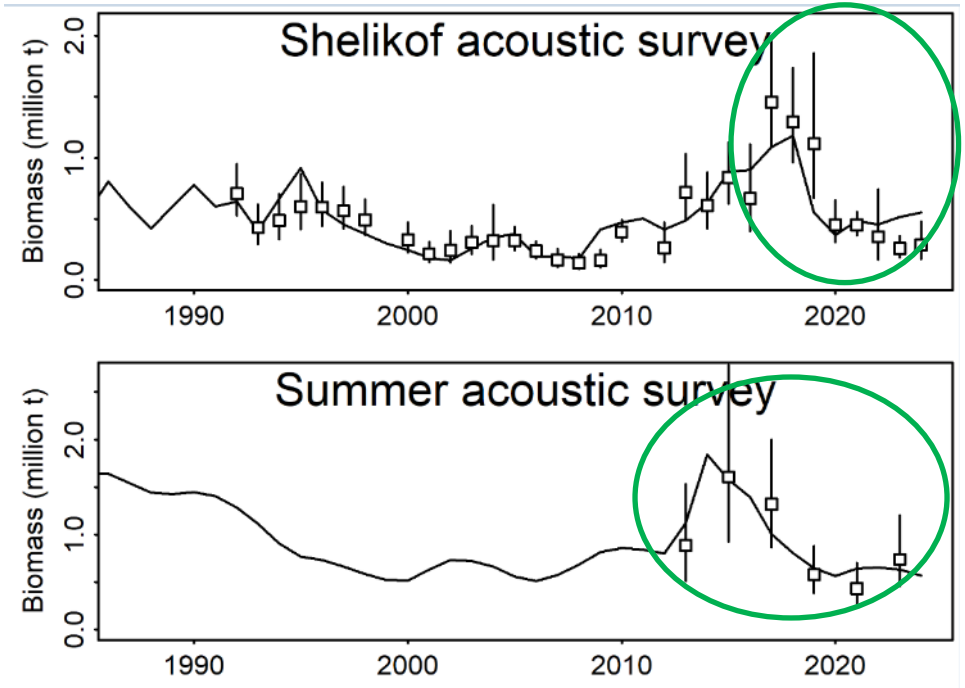
Estimates of catchability

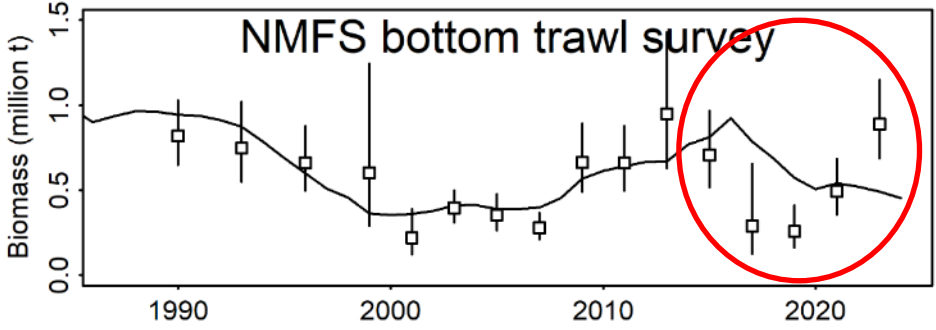
- Shelikof driven by timing covariate (Rogers et al. 2024)
- Smoothed w/ AR(1) internally

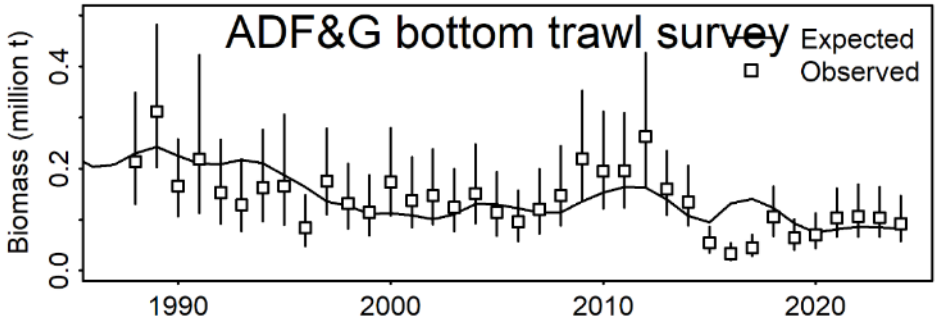


Index fits

- Improved Shelikof fits (q-link); poor NMFS BT

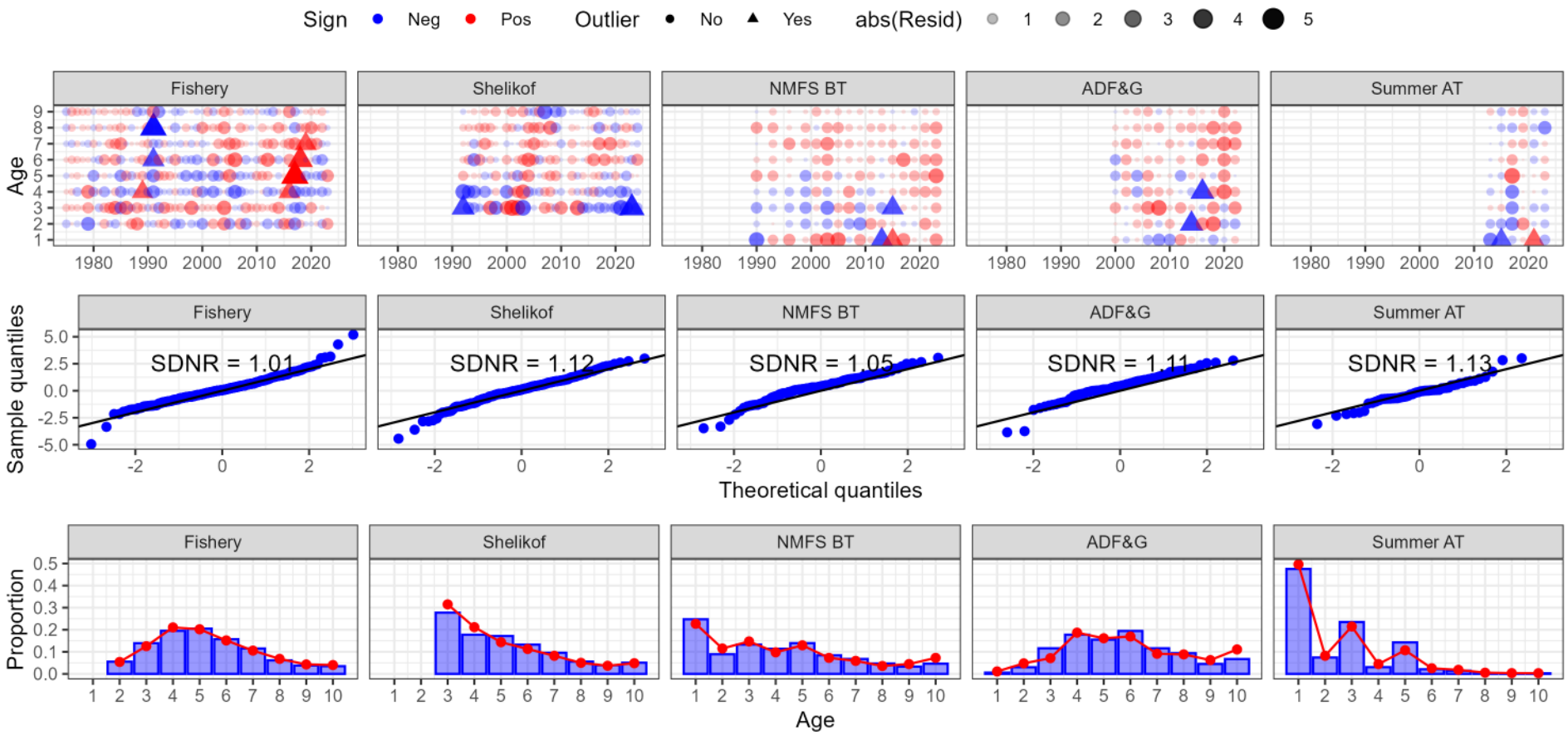






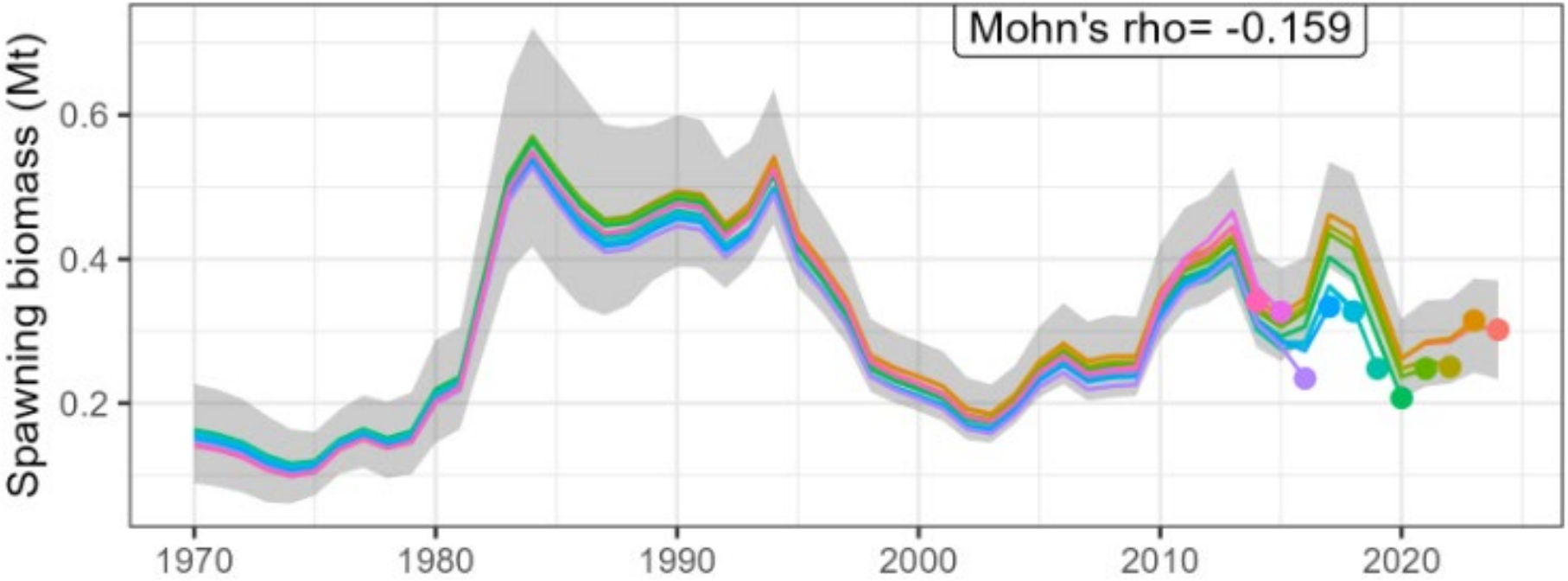
Index fits

- Age 1 and 2 indices from Shelikof are no longer fit (model 23c)

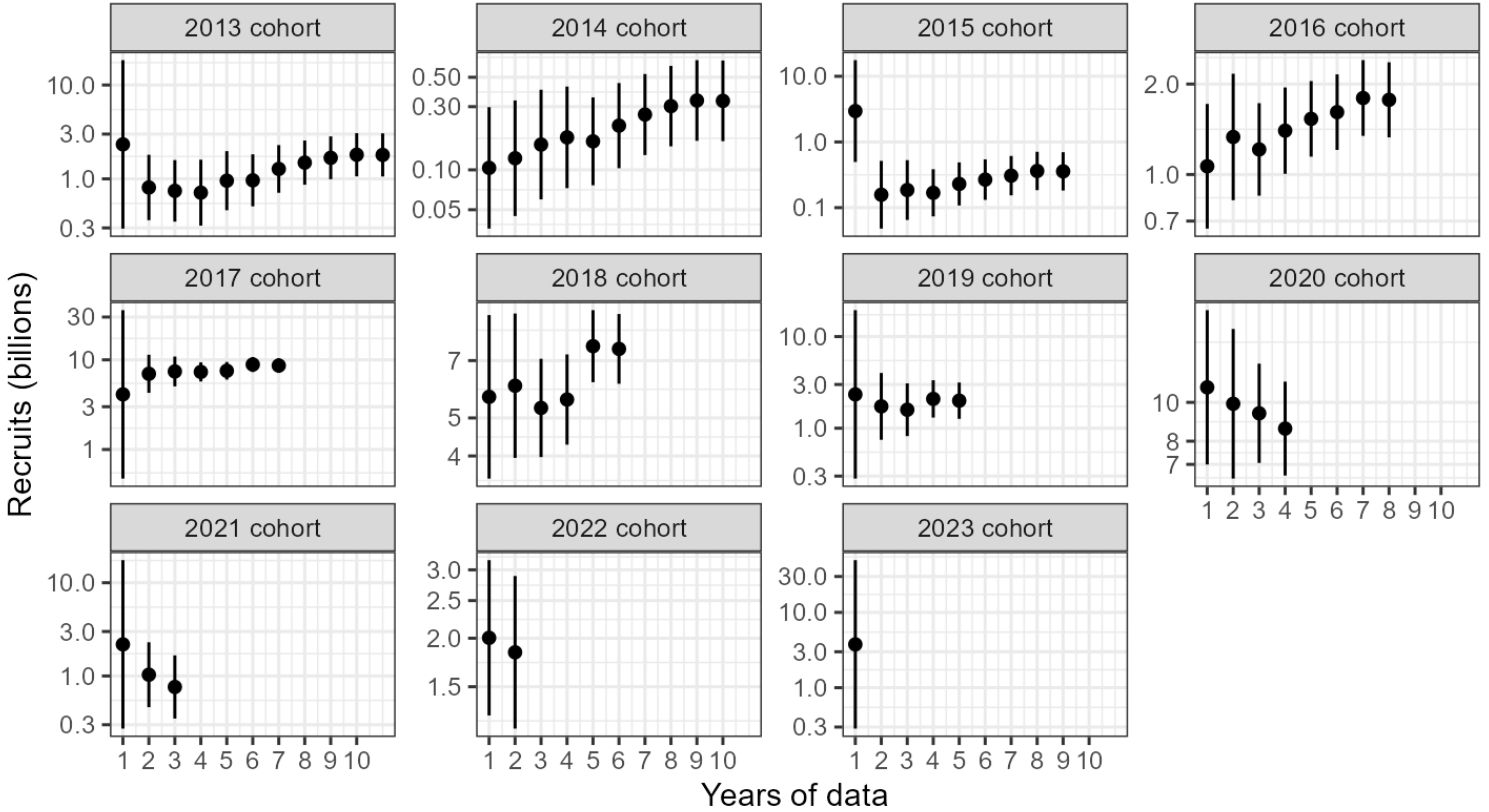

Sign
Neg
Pos
Outlier
No
Yes
abs(Resid)
1
2
3
4
5
Fishery
Shelikof
NMFS BT
ADF&G
Summer AT
Age
1980
1990
2000
2010
2020
Sample quantiles
SDNR = 1.01
SDNR = 1.12
SDNR = 1.05
SDNR = 1.11
SDNR = 1.13
Theoretical quantiles
Proportion
Age

Retrospective patterns

- Rho not significant (null range -0.2 to 0.3)



Retrospective patterns

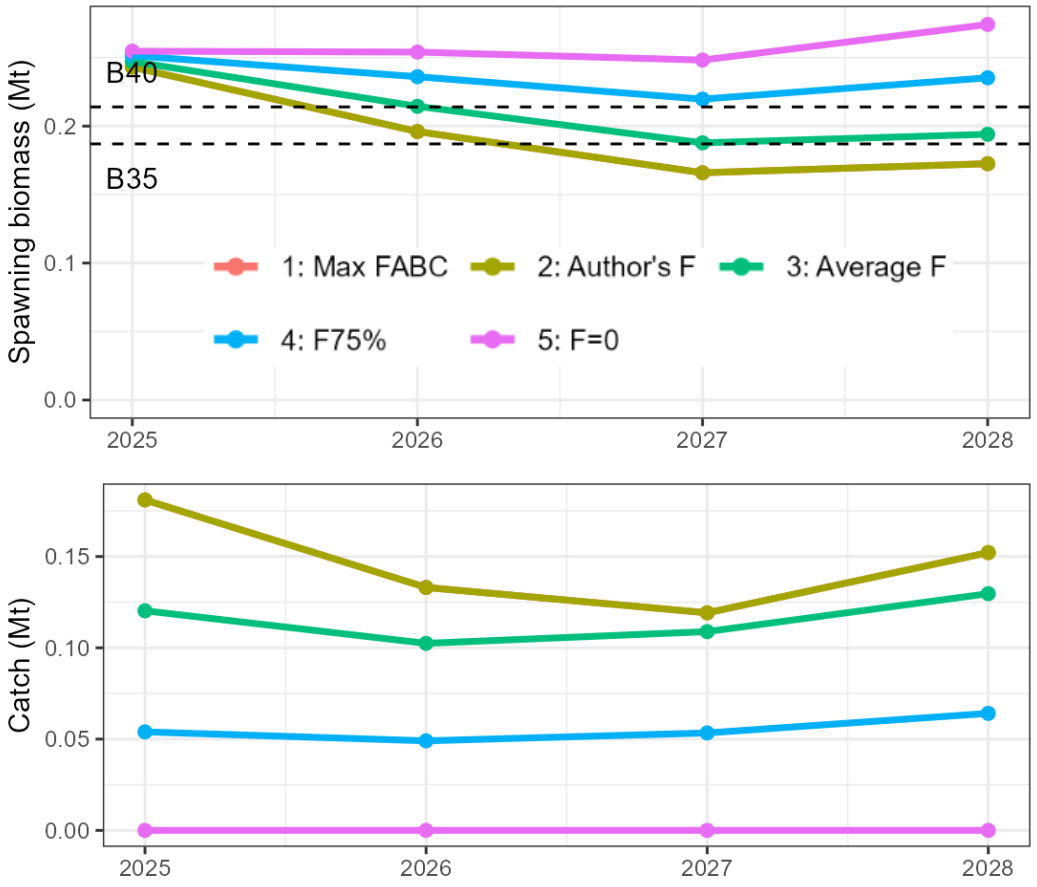


Projections: an aside

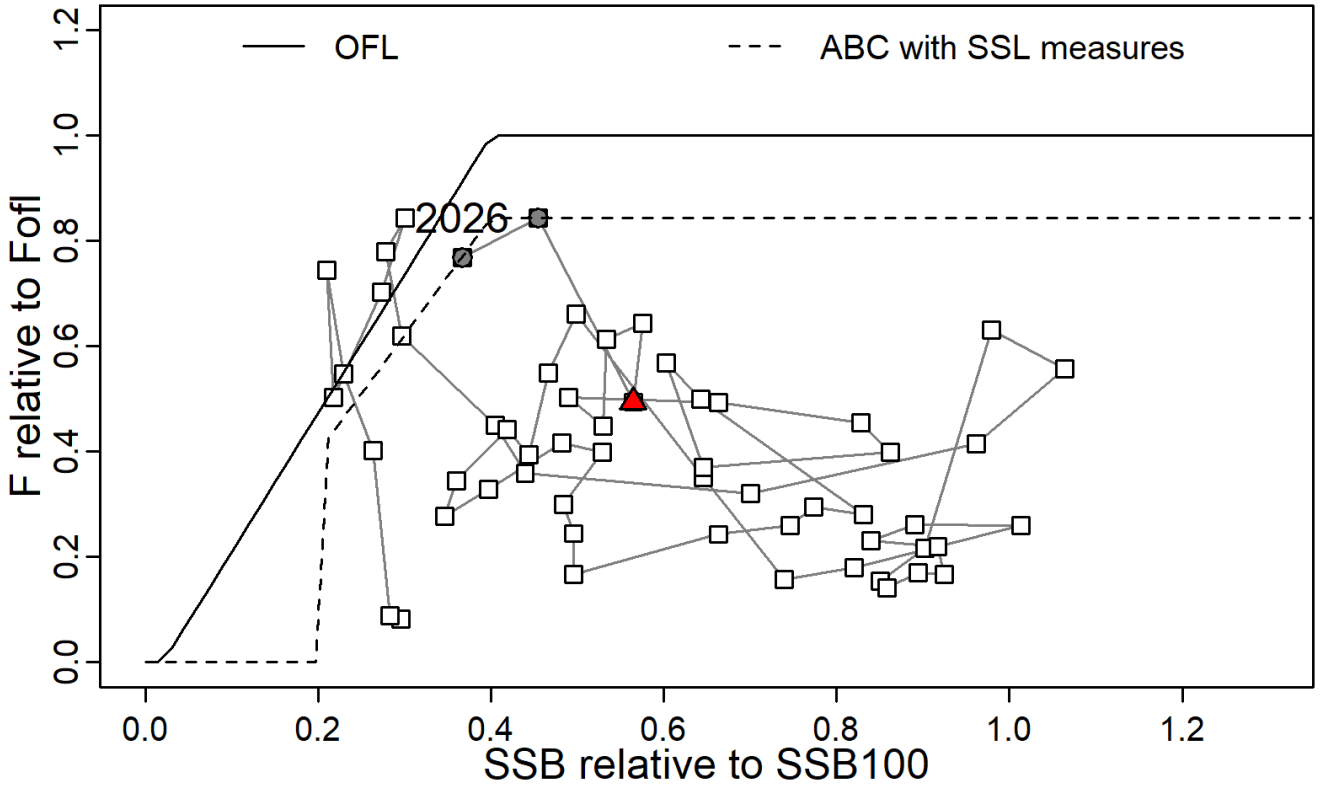
- In 2023 there was an issue in the projections
- 2023 SSB was 14% lower in “proj” than the assessment due to differences in spawning WAA (annual vs 5-year average)
- Starting in 2024 “proj” was configured to start in 2025, bypassing this issue (Thanks to J. Ianelli)

Projections in 2024

- GOA pollock has substantial time-varying quantities (WAA, maturity)
- What to use for SPR?... Ongoing challenge



Status trends



Risk table: overview

Summary and ABC recommendation

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

- Assessment concerns: poor fit to NMFS BT index
- No reduction from maxABC is recommended

Status Summary for Gulf of Alaska Pollock in W/C/WYK Areas

Quantity/Status	As estimated or *specified last* year for: 2024	2025	As estimated or *recommended this* year for: 2025*	2026*
M (natural mortality)	0.300	0.300	0.300	0.300
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass (t)	1,154,403	1,430,029	1,269,931	1,005,310
Projected female spawning biomass (t)	274,141	227,091	243,078	196,028
$B_{100\%}$	505,000	505,000	535,000	535,000
$B_{40\%}$	202,000	202,000	214,000	214,000
$B_{35\%}$	177,000	177,000	187,000	187,000
F_{OFL}	0.307	0.307	0.321	0.321
maxF_{ABC}	0.260	0.260	0.271	0.271
F_{ABC}	0.260	0.260	0.271	0.271
OFL (t)	269,916	182,891	**210,111**	153,971
*max*ABC (t)	232,543	157,687	181,022	133,075
ABC (t)	232,543	157,687	**181,022**	133,075
Status	As determined *last* year for: 2023	2024	As determined *this* year for: 2024	2025
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*[illegible]

W/C/WYK area apportionment

Year	Area	Season A ABC (t)	Season B ABC (t)
2025	610	5,589	31,755
	620	63,267	18,998
	630	16,751	34,854
	640	5,282	
2026	610	4,109	23,344
	620	46,510	13,967
	630	12,314	25,622
	640	3,883	

Changes from 2024 apportionment

	ABC (t)		Percent	
Area	Season A	Season B	Season A	Season B
610	-1,022	-9,038	0.00	0.00
620	-23,194	-5,407	-0.02	0.00
630	-150	-9,920	0.02	0.00
640	-1,503		0.00	

Results for GOA pollock in SE (Tier 5)

Status Summary for Gulf of Alaska Pollock in the Southeast Outside Area

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity/Status	2024	2025	2025	2026
M (natural mortality)	0.30	0.30	0.30	0.30
Tier	5	5	5	5
Biomass (t)	43,328	43,328	43,328	43,328
F_{OFL}	0.30	0.30	0.30	0.30
maxF_{ABC}	0.23	0.23	0.23	0.23
F_{ABC}	0.23	0.23	0.23	0.23
OFL (t)	12,998	12,998	12,998	12,998
*max*ABC (t)	9,749	9,749	9,749	9,749
ABC (t)	9,749	9,749	9,749	9,749
	As determined *last* year for:		As determined *this* year for:	
Status	2023	2024	2024	2025
Overfishing	No	n/a	No	n/a

Questions?

- Thanks!

Collaborators:

- Bridget E. Ferriss, S. Kalei Shotwell, Zack Oyafuso, Mike Levine, James T. Thorson, Lauren Rogers, Jane Sullivan, and Juliette Champagnat

Author's <u>2025 ABC = 181,022 t</u>

- Increase of 56% from 2023
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- 23a: Revamped ISS & CVs
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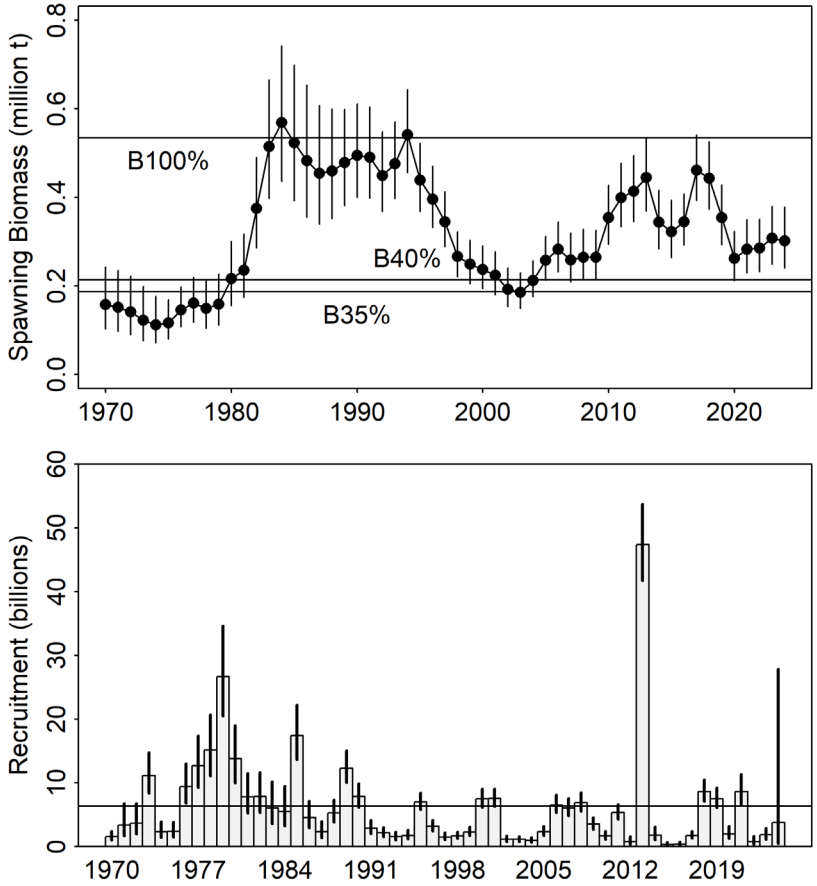
Concerns:

- Poor fit to NMFS bottom trawl index

Positives:

- 2017, 2018, 2020 cohorts above average
- Better retrospective pattern



Extra slides

Appendix 1E: Using causal relationships among ESP indicators to explain variation in recruitment

Coauthors: Juliette Champagnat, James T. Thorson,
Jane Sullivan, Lauren Rogers, S. Kalei Shotwell

Beyond regressions: causal modeling

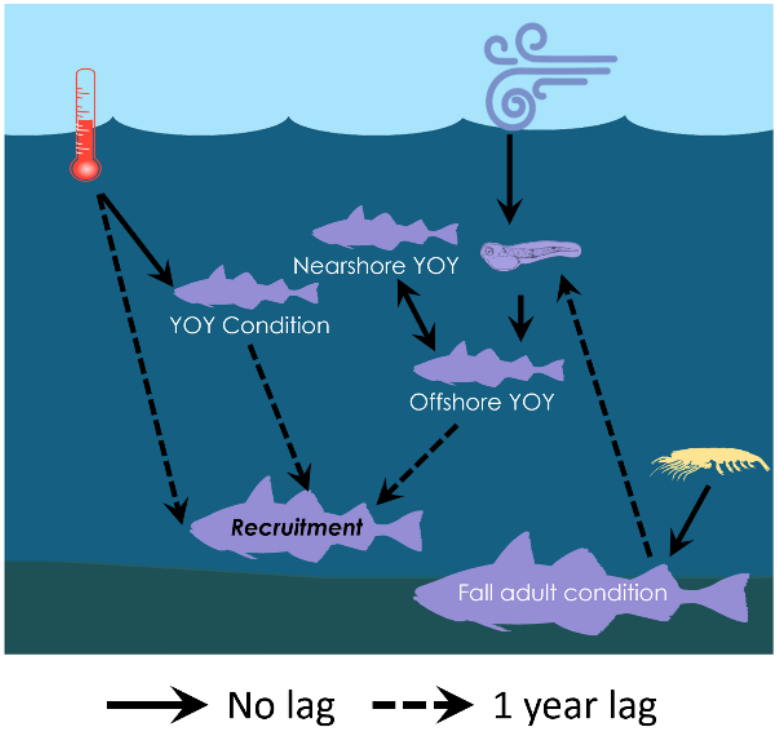
- Stock assessments have a “regression paradigm” to incorporate climate/environmental linkages
- Limitations: collinearity among variables => must pick one and regress
- Causal models try to extend the regression paradigm (Pearl 2009)
  - “a conceptual model that describes the causal mechanisms of a system”
  - Written A -> B (A causes B)
  - An association (correlation) between A and B can be b/c A -> B or B -> A, or some third variable causes them both B <- C -> A
- E.g., Rainfall & umbrella usage are correlated, which causes which?

Beyond regressions: causal modeling

- McElreath (2018) popularized it: “Science before statistics”
- Causal relationships are not informed by the data, they are assumed on expert knowledge and tested with interventions
- **Hypothesis: A causal framework would allow us to better utilize ecosystem/environmental data and expert knowledge, to build next-generation climate-linked AFSC assessments**
- We tested this hypothesis on recruitment for GOA pollock

Science before statistics: causal modeling

Input: Hypothesis of causal map



The science

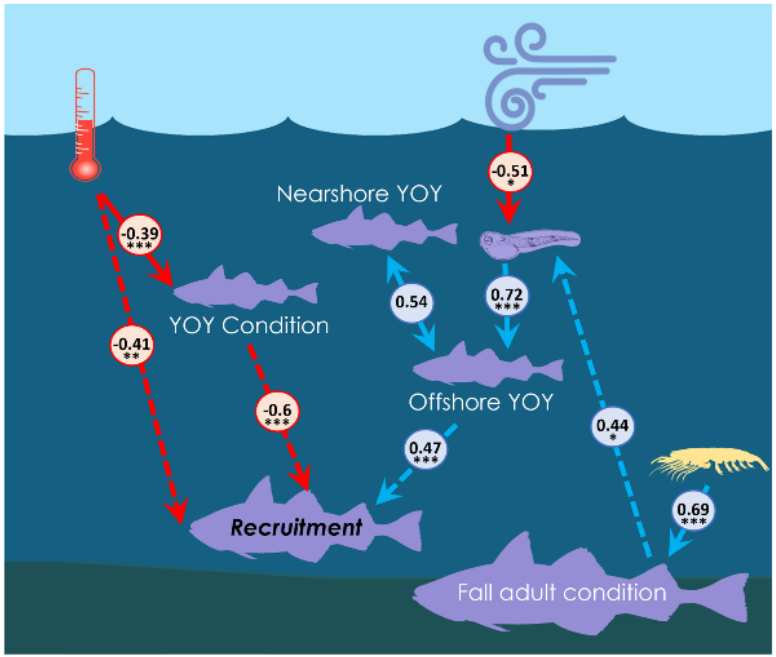
- Worked with experts to develop hypotheses about causal relationships ("maps")
- Expert knowledge, process research
- This map is an assumption
- But we can try to test and validate it

Science before statistics: causal modeling

The statistics

- Use dynamic structural equation models (DSEM; Thorson et al. 2024)
- Assume linear relationships among (transformed) variables
- Smooth variables w/ AR(1) time-series to deal with missing data & do projections
- Embed into stock assessment (TMB required)
- Estimate effect sizes for each link (betas)
- **This is not a regression**

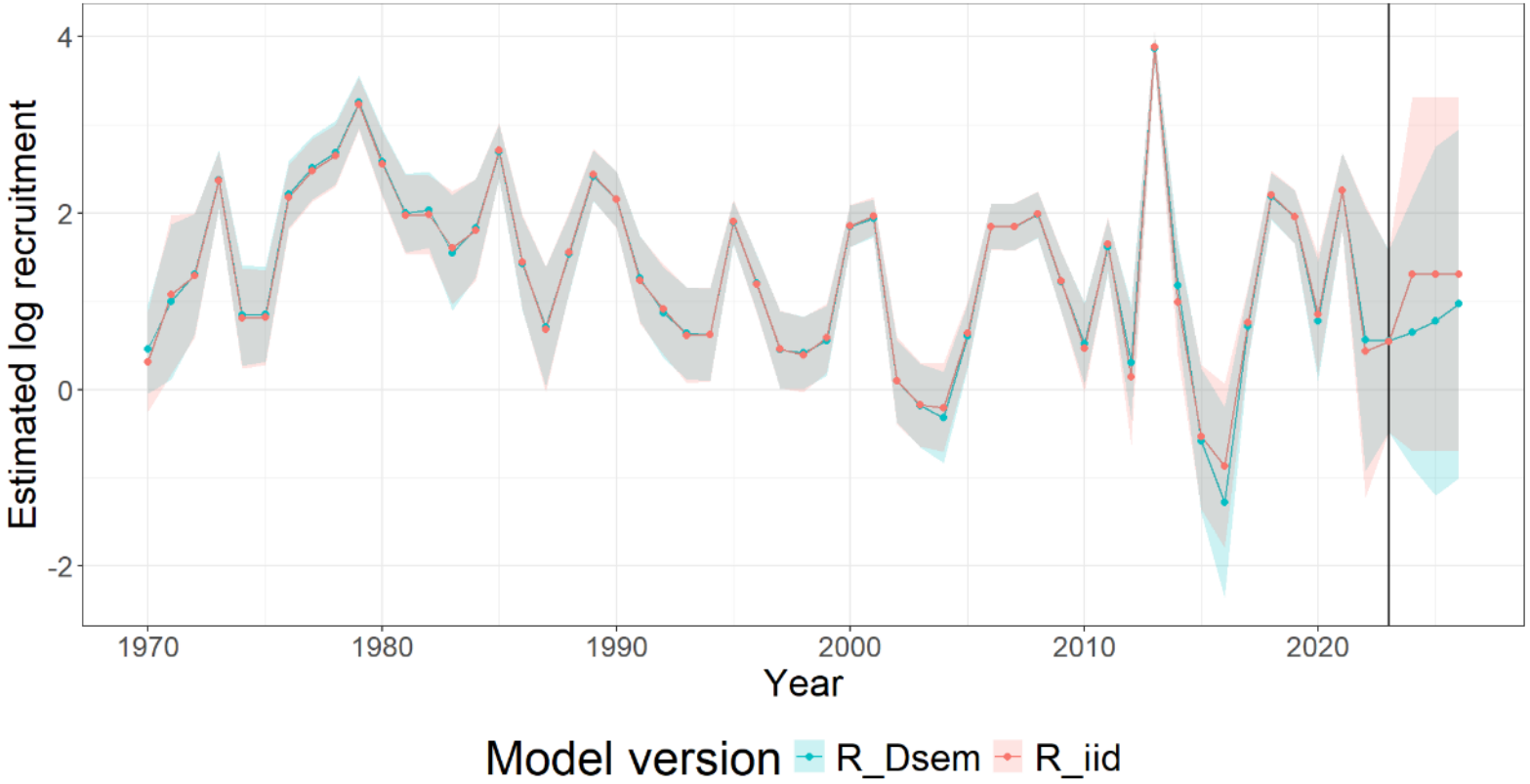
Output: Value of the link



Significance of the link

* (pvalue <0.05),** (pvalue <0.03),*** (pvalue <0.01)

Results for GOA pollock recruitment

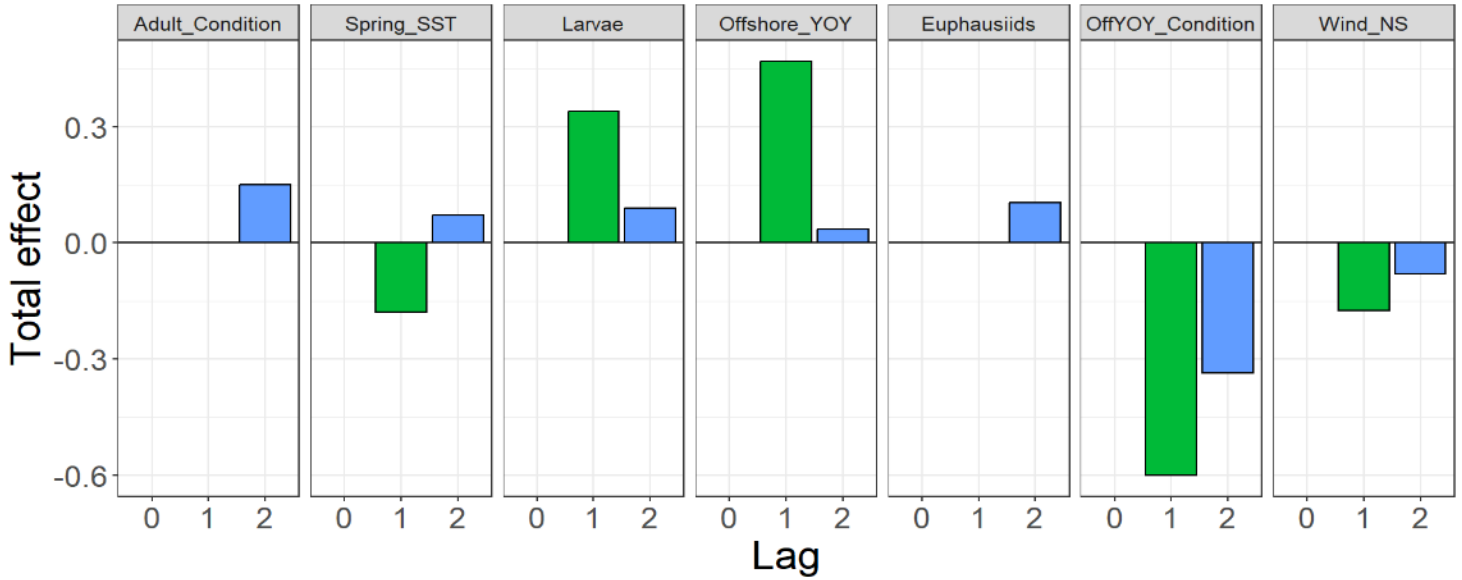


Results: clear statistical support for DSEM model

- Fast and stable optimization (~ 2 mins)
  - Adds 29 fixed effects (10 variances, 10 correlations, 9 betas)
  - 627 random effects (latent variable states)
- 71% reduction in unexplained recruitment variance (σ_R reduced from 1.0 to 0.54)
- 18 AIC units lower (better)
- Improved short-term recruitment predictions (skill testing)

What did we learn about GOA pollock?

- Relative weights of “total effects” on recruitment depends on lag
- Short-term projections of recruitment are improved



Where do we go from here?

- DSEM presents a flexible statistical framework for next-generatio,n climate-linked assessments
- Could be applied to other population processes (growth, mortality, etc.)
- We already have extensive system knowledge and curated data sets ready to go (ESP, ESR)
- Build DSEM into CEATTLE and explore more case studies?
- Champagnat et al. (in prep) explores alternative causal maps, statistical behavior (self-testing etc.), and more model validation

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