GOA Pollock

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2023 November Plan Team

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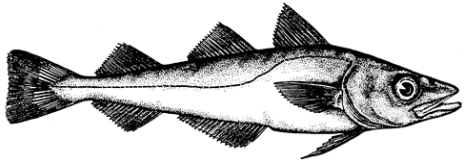
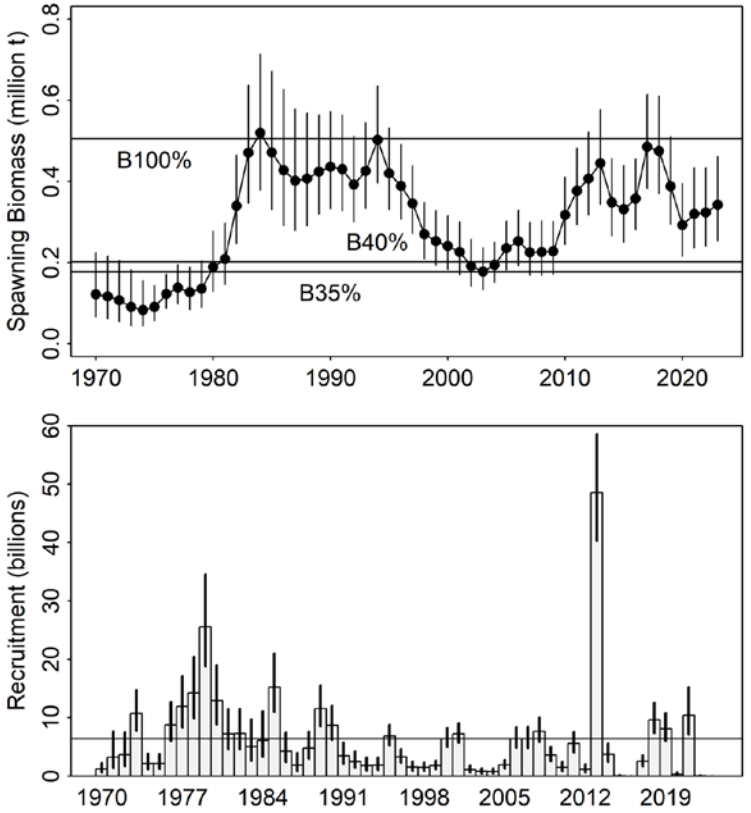
Collaborators: Bridget Ferriss, Kalei Shotwell, Denise McKelvey, David McGowan



Gulf of Alaska pollock
Overview of results



Author's 2023 ABC = 232,543 t

- Increase of 56% from 2023
- 2025 ABC decreases to 157,687 t
- No reduction from max ABC

Changes to model:

- No structural changes
- Converted to TMB (23.0)

Concerns:

- Extremely small recent cohorts
- Poor fit to NMFS bottom trawl index

Positives:

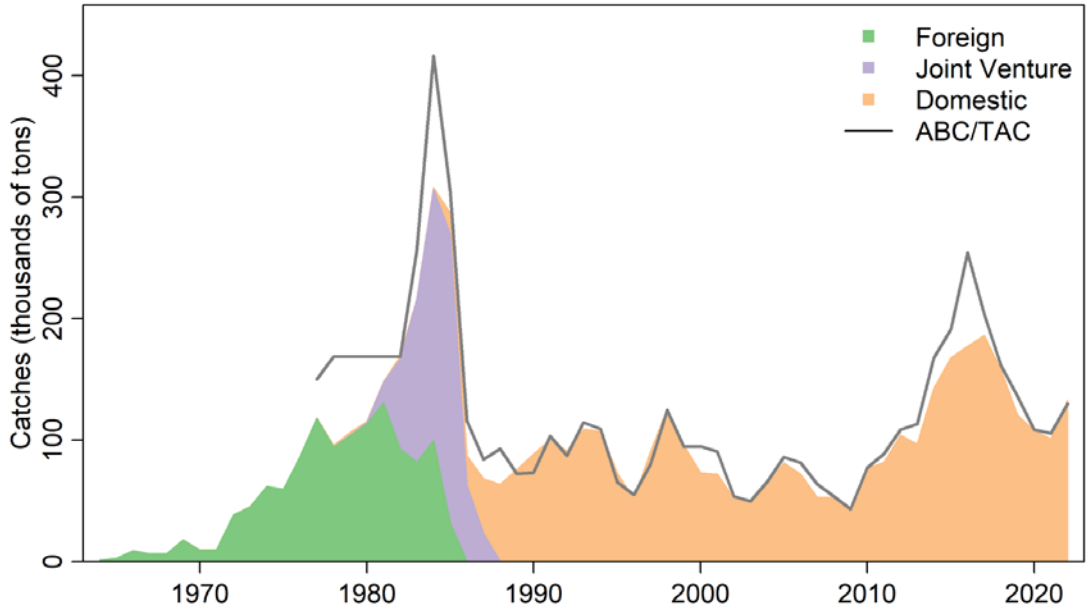
- 2017, 2018, 2020 cohorts above average
- 2012 estimate up to ~50 billion
- Good environmental conditions

Model overview

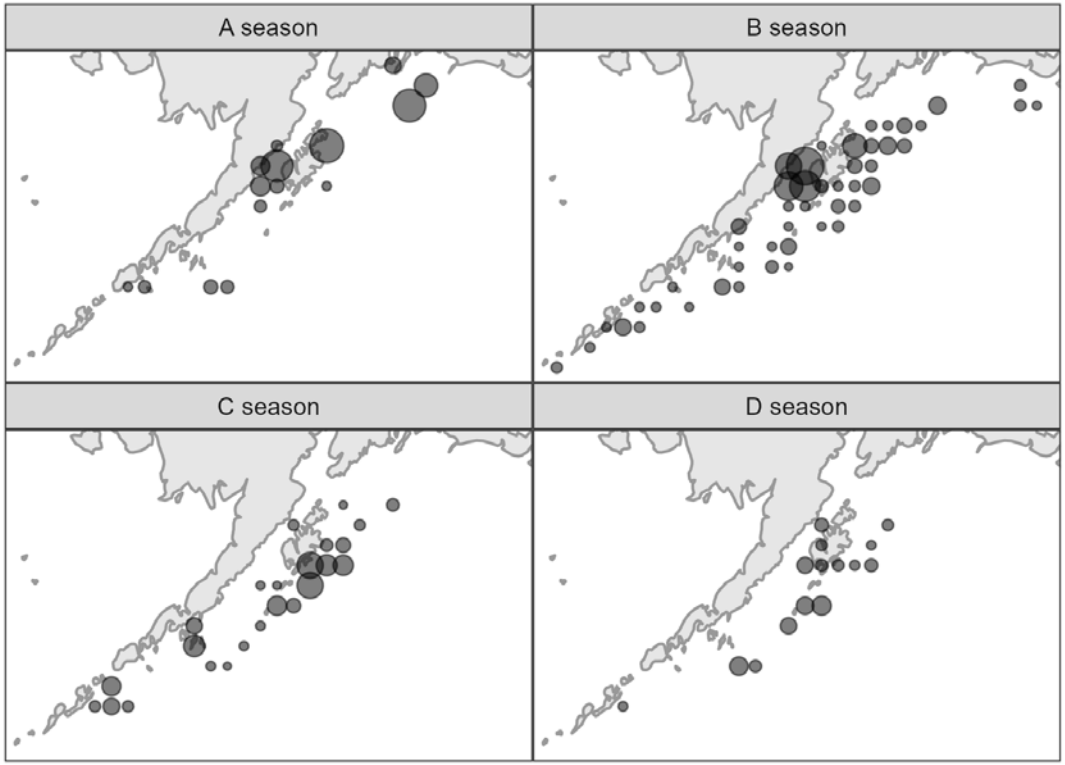
- Single-sex, single single, ages 1-10+
- Empirical weight at age
  - No internal length dynamics, all age-based processes
  - Length comps converted via specified matrices
- Fishery selectivity is time-varying double logistic
- Fitted to 4 surveys
  - NMFS winter (Shelikof) + summer (coast wide) acoustic
  - NMFS and ADF&G summer bottom trawl
- Time-varying catchability for Shelikof and ADF&G
- σ_R=1.3 in 2022 but up to 1.8 this year
- Francis tuning used for compositional data

Catch history

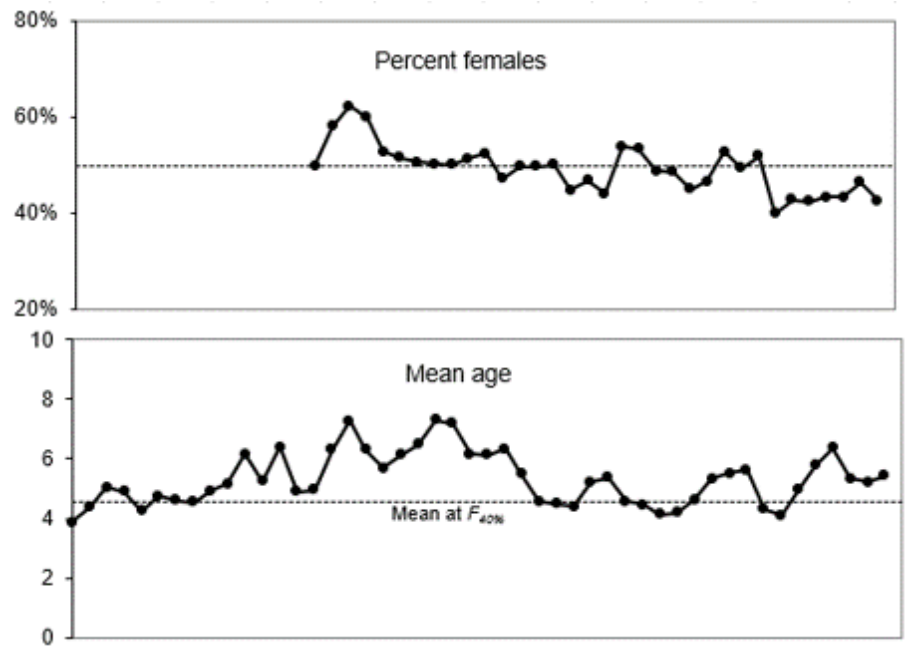
- 2022 projected catch = 129,754 t
- 2022 realized catch = 132,698 t
- 2023 projected catch = 145,215 t

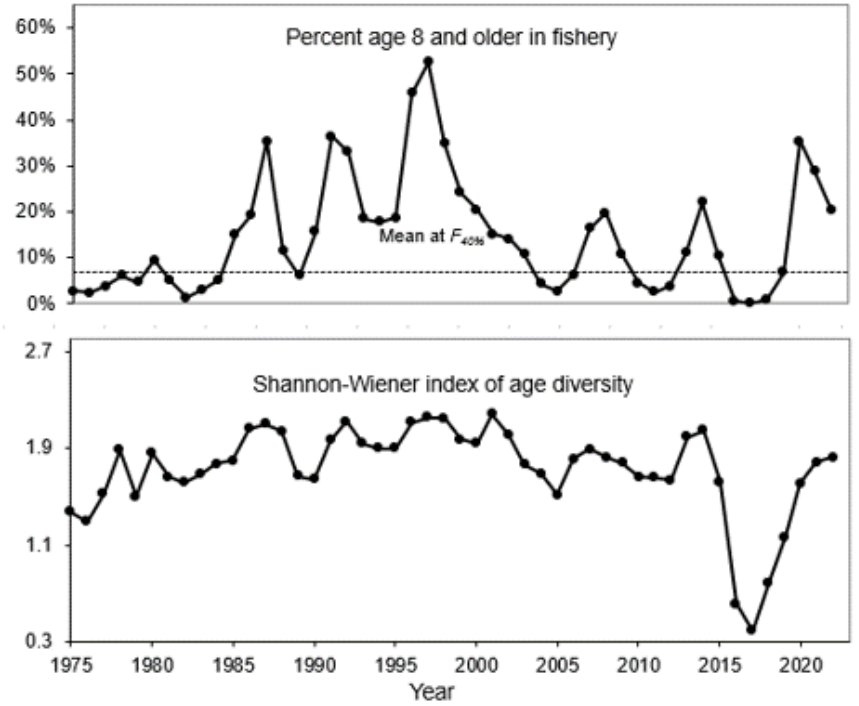


2022 fishery catch distribution



Fishery catch indicators

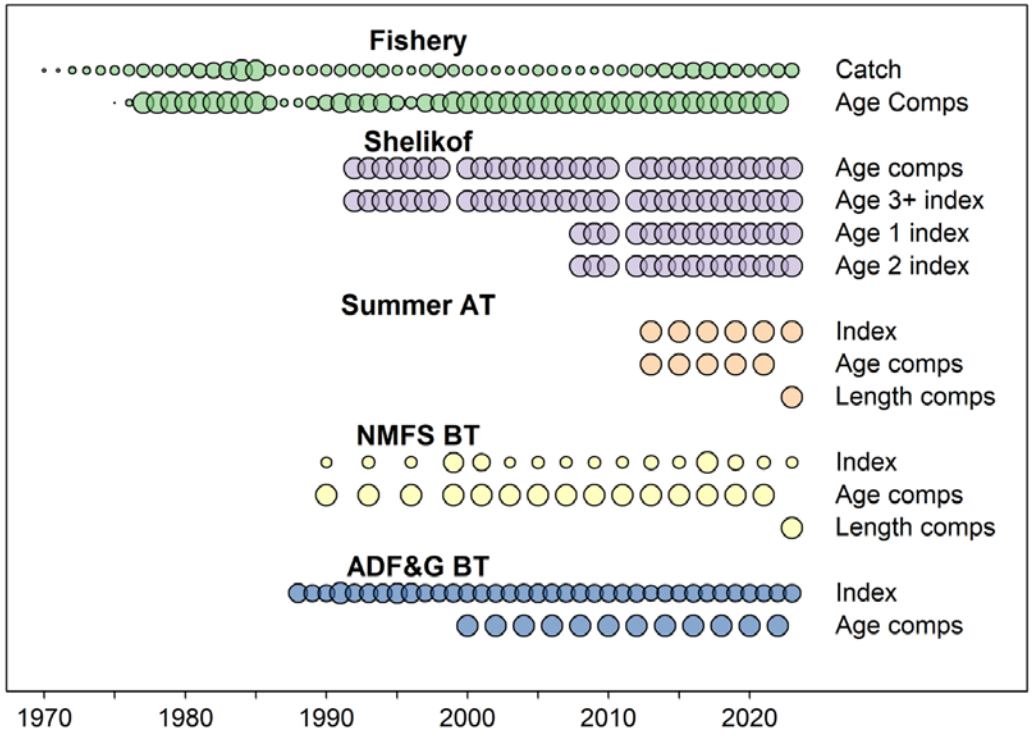




New data available in 2023

2023 was an “on” year in the GOA

- Winter acoustic survey (index and ages)
- Summer acoustic survey (index and lengths)
- NMFS bottom trawl survey (index)
- ADF&G bottom trawl index



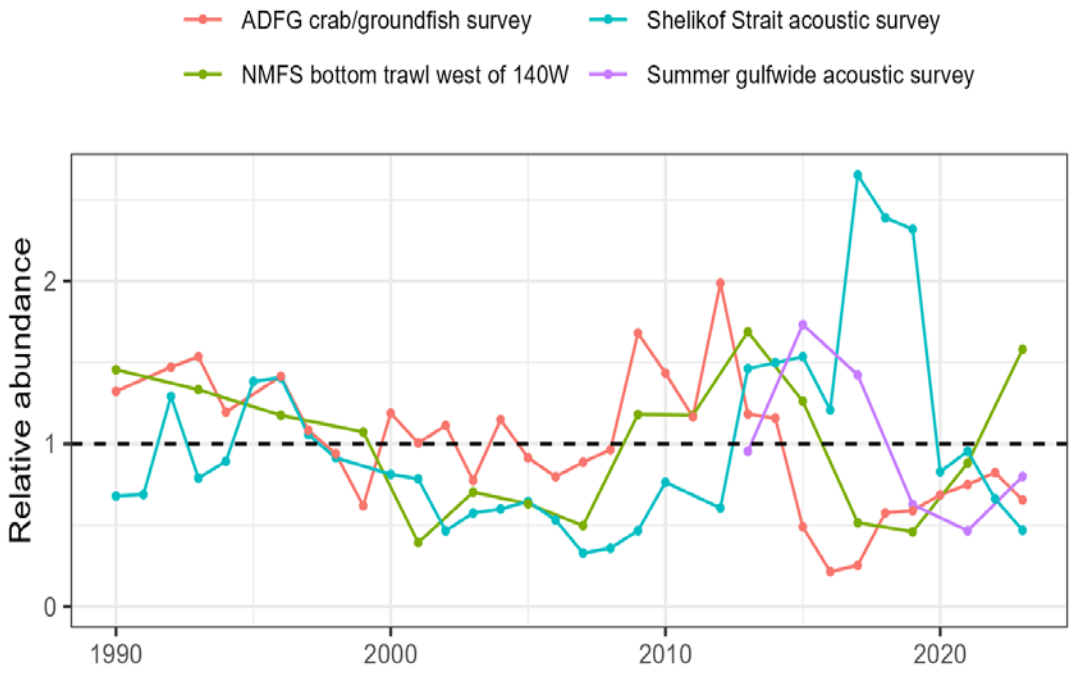
Conflicting signs in the data

Shelikof (3+)
259 kt (27% decrease from 2022)

Summer acoustic
740 kt (72% increase from 2021)

NMFS bottom trawl
888 kt (79% increase from 2021)

ADF&G bottom trawl
102 kt (1% decrease from 2022)



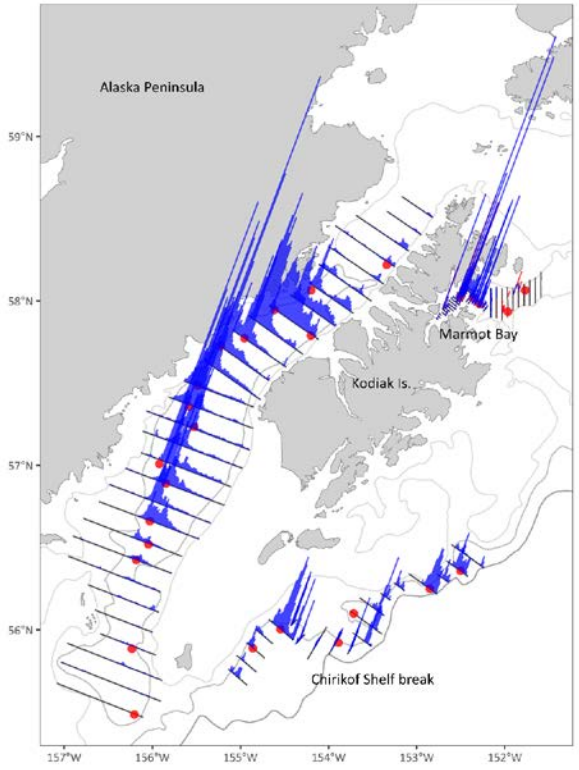
These are the processed values used in the assessment

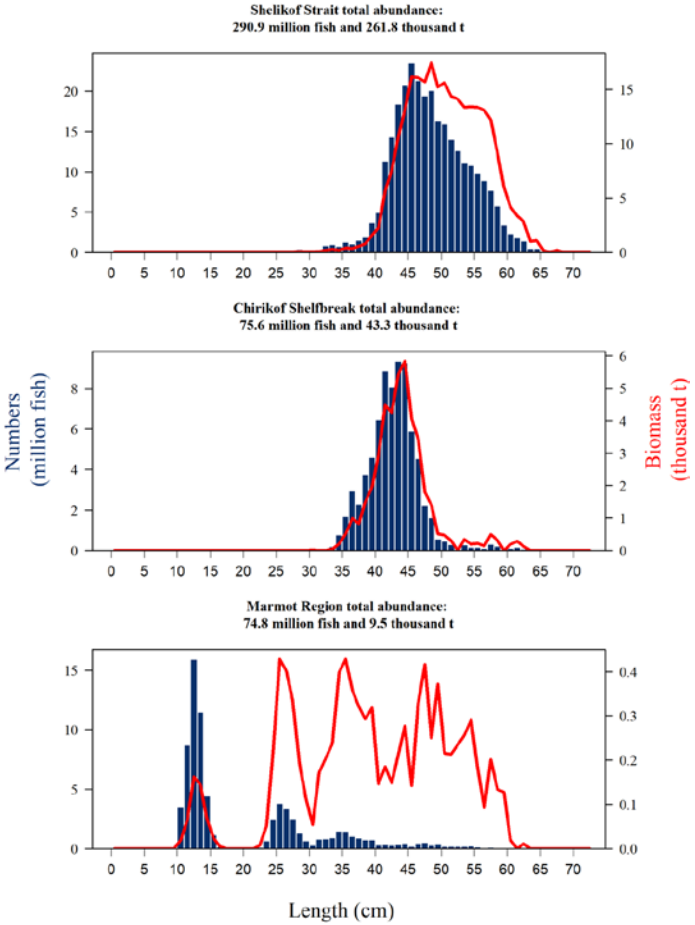
These are the raw survey estimates

Winter acoustic results

Shelikof down and no small fish

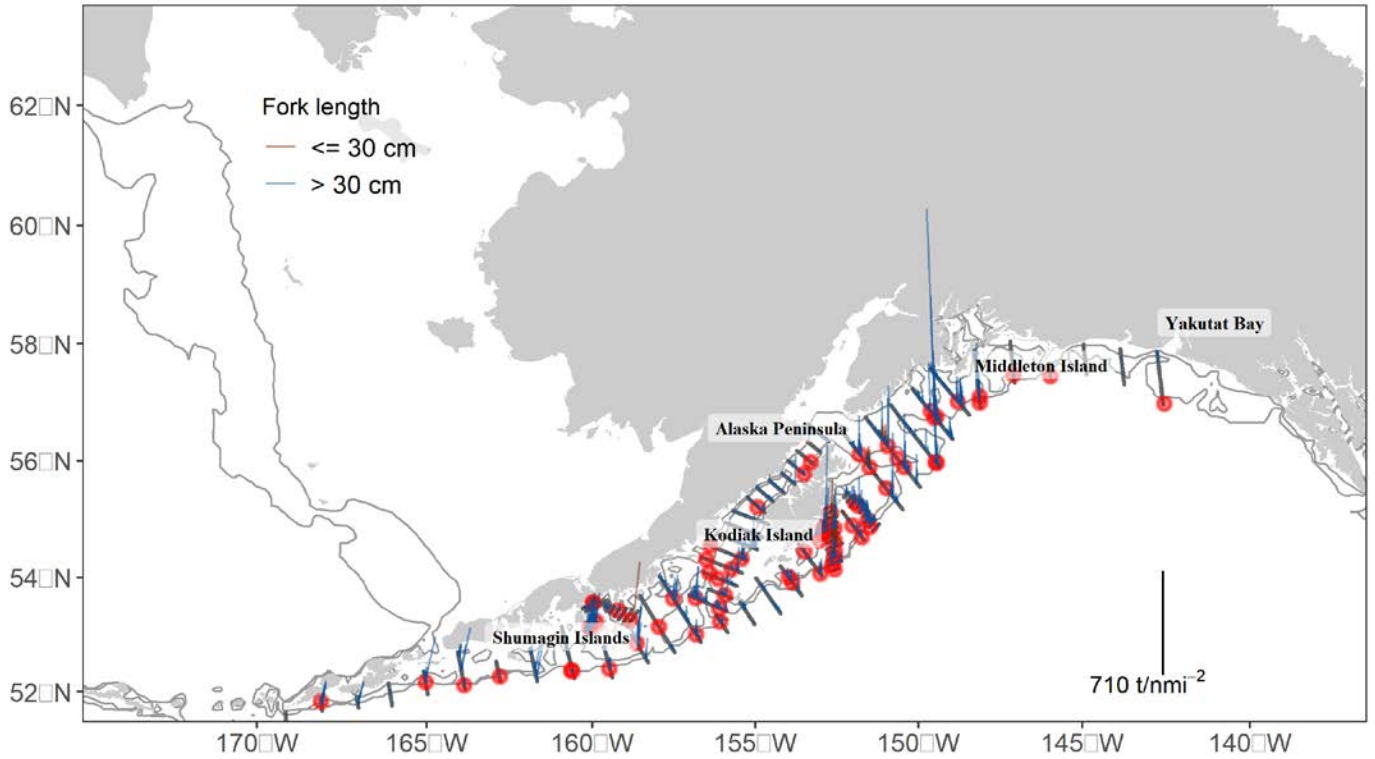
Chirikof and Marmot Bay are both up, but within historical norm





Thanks to D. McKelvey

Summer acoustic results



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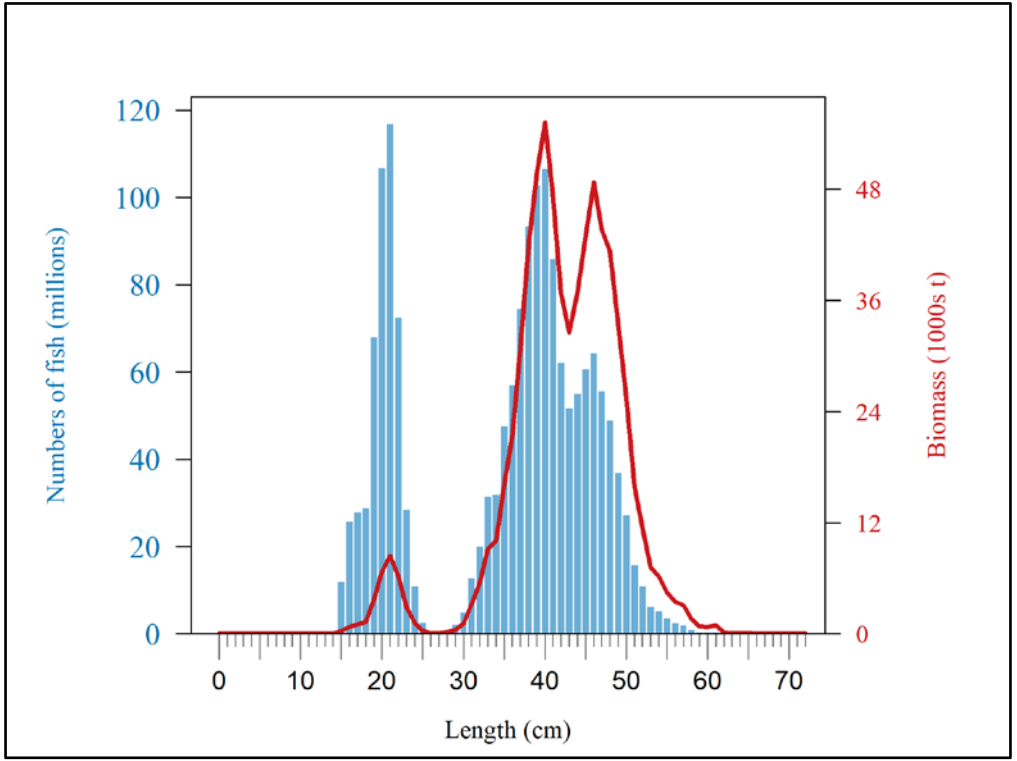

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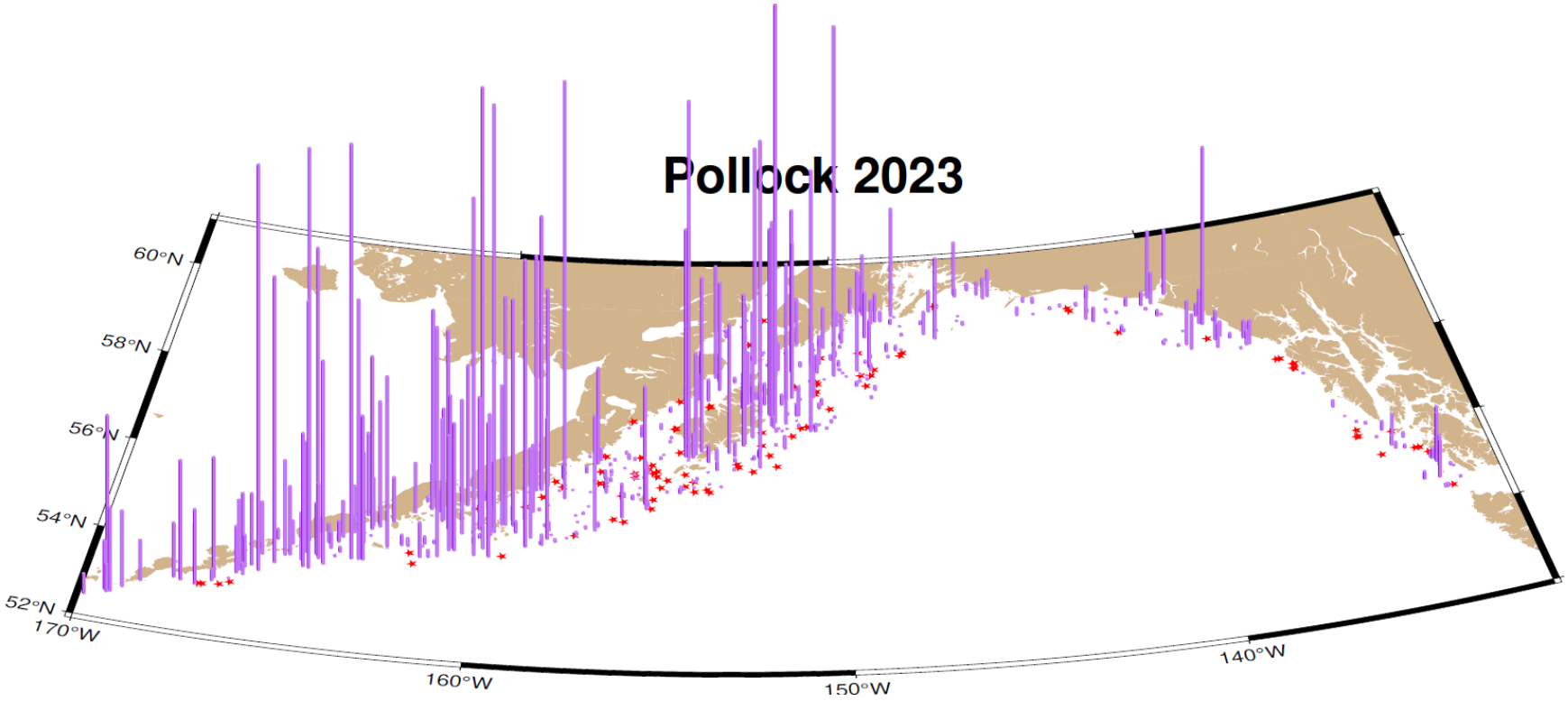
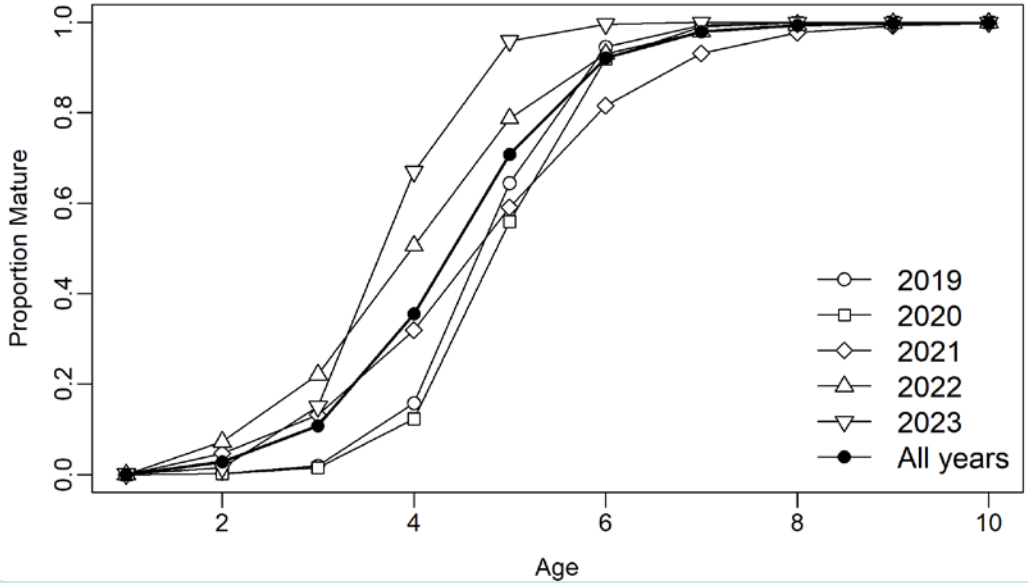
NMFS bottom trawl results

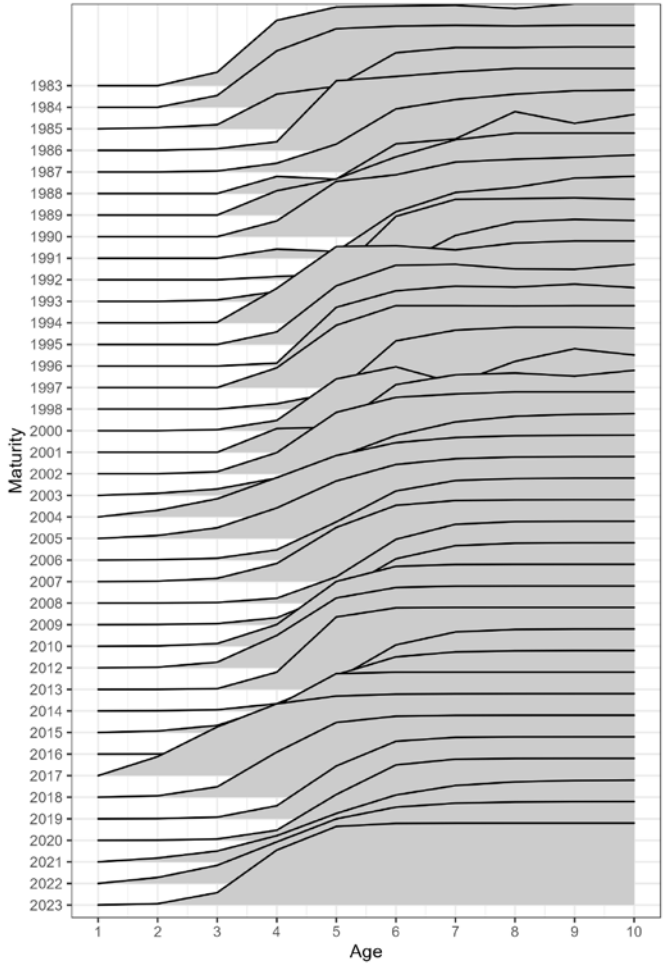


Maturity: recent estimates

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

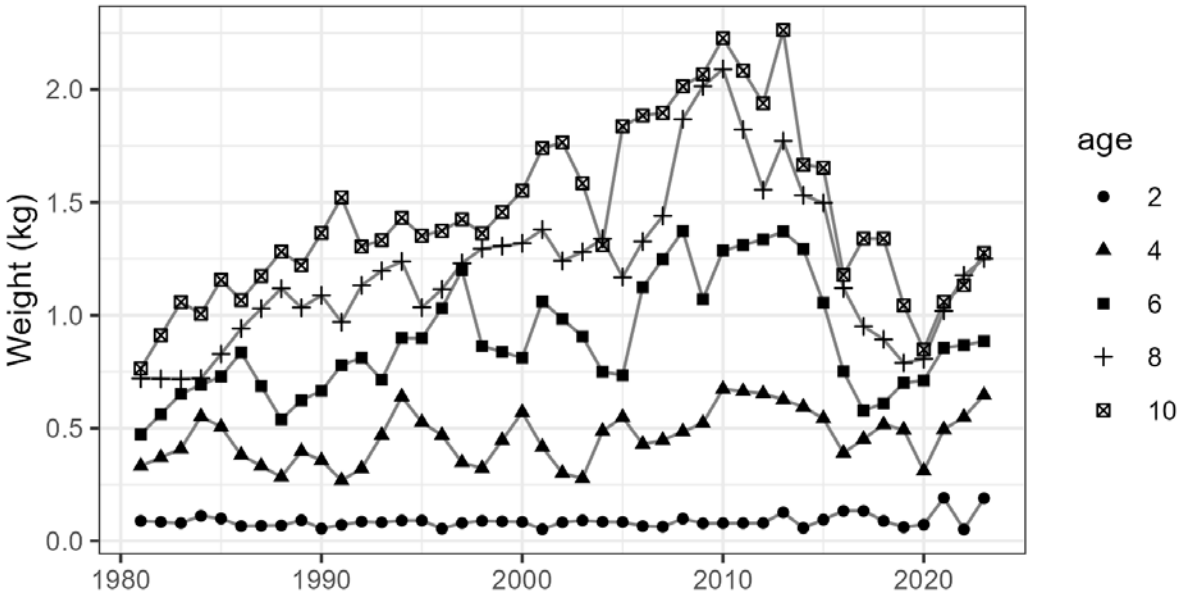
Average of all years used in projections





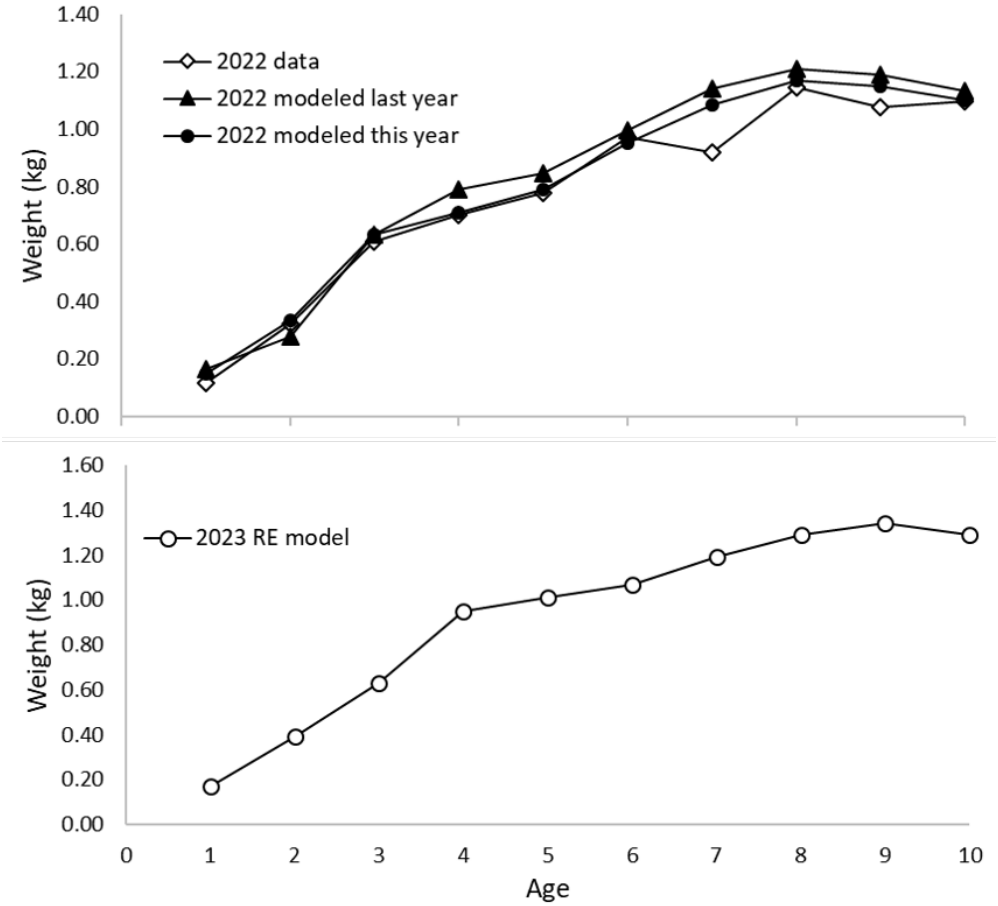
Spawning weight at age (WAA)

- 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 2022 fishery WAA last year?
- OK?



Key parameters estimated externally

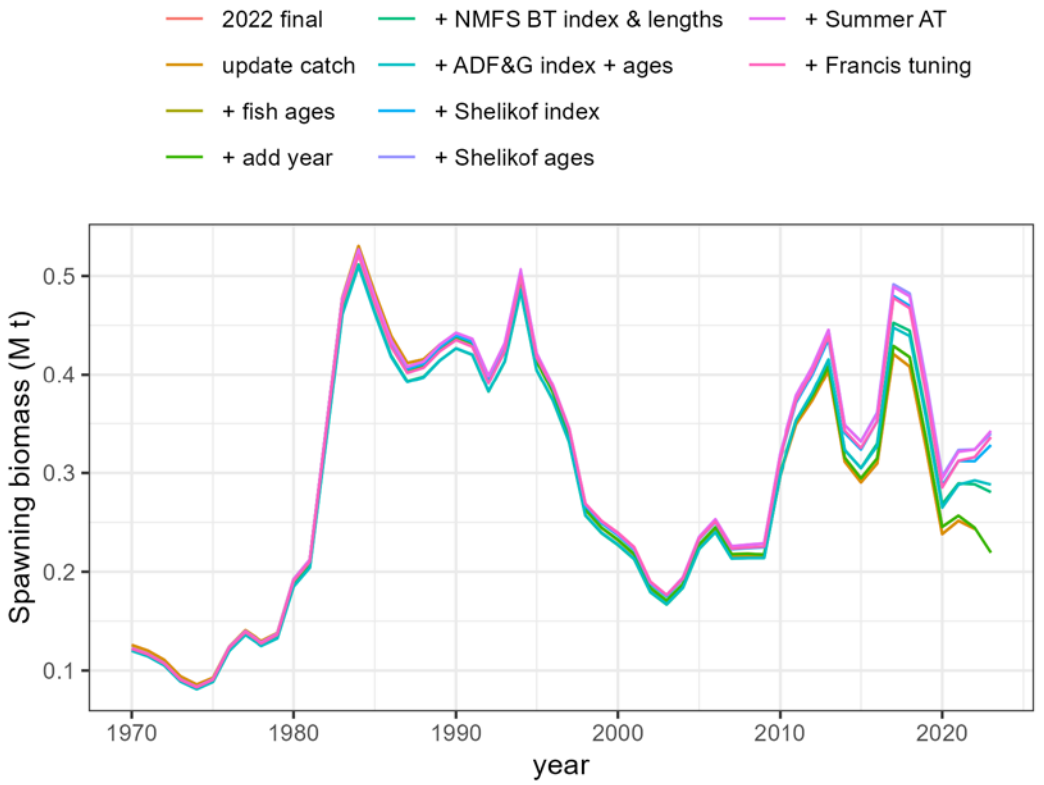
- Natural mortality: age-specific
- Fishery WAA
  - Data used through 2022
  - A RE model used for 2023 and projections
- Spawning WAA
  - Annual data exclusively from Shelikof Strait
  - 5-year average for projections
- Population WAA
  - Projections use average of last 3 NMFS BT surveys
- Proportion 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 1970-2023 = 54	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 1970-2023 = 54	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) = 108	Estimated as deviations from mean selectivity and constrained by random walk process error
Mean survey catchability	No. of surveys = 6	Catchabilities estimated on a log scale. Separate catchabilities were also estimated for age-1 and age-2 winter acoustic indices.
Annual changes in survey catchability	2 * (No. years-1) = 108	Annual catchability for winter acoustic surveys and ADF&G surveys estimated as deviations from mean catchability and constrained by random walk process error
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.
Total	123 estimated parameters + 216 process errors = 339	

Sequential addition of data

- Big increases with addition of NMFS BT and Shelikof data
- Moderate w/ summer AT
- Recent trend but also scale



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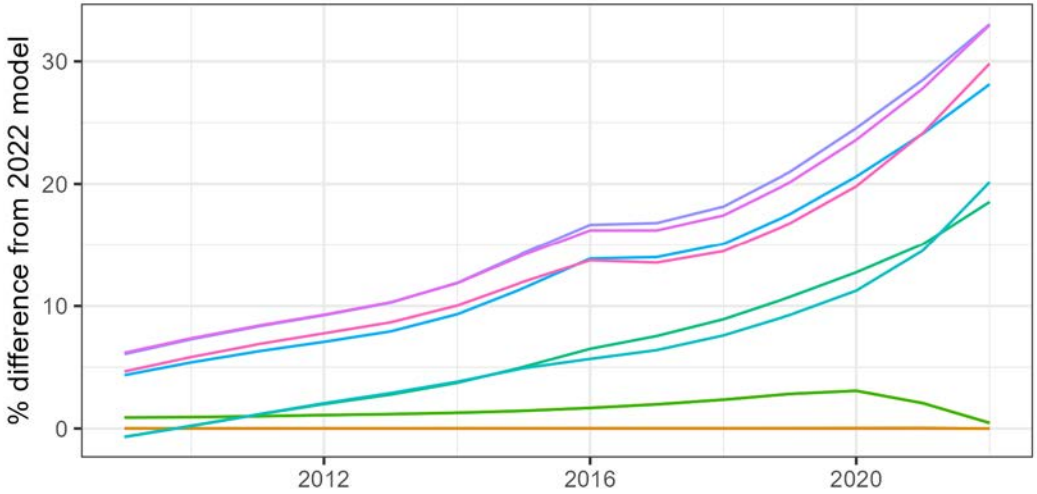
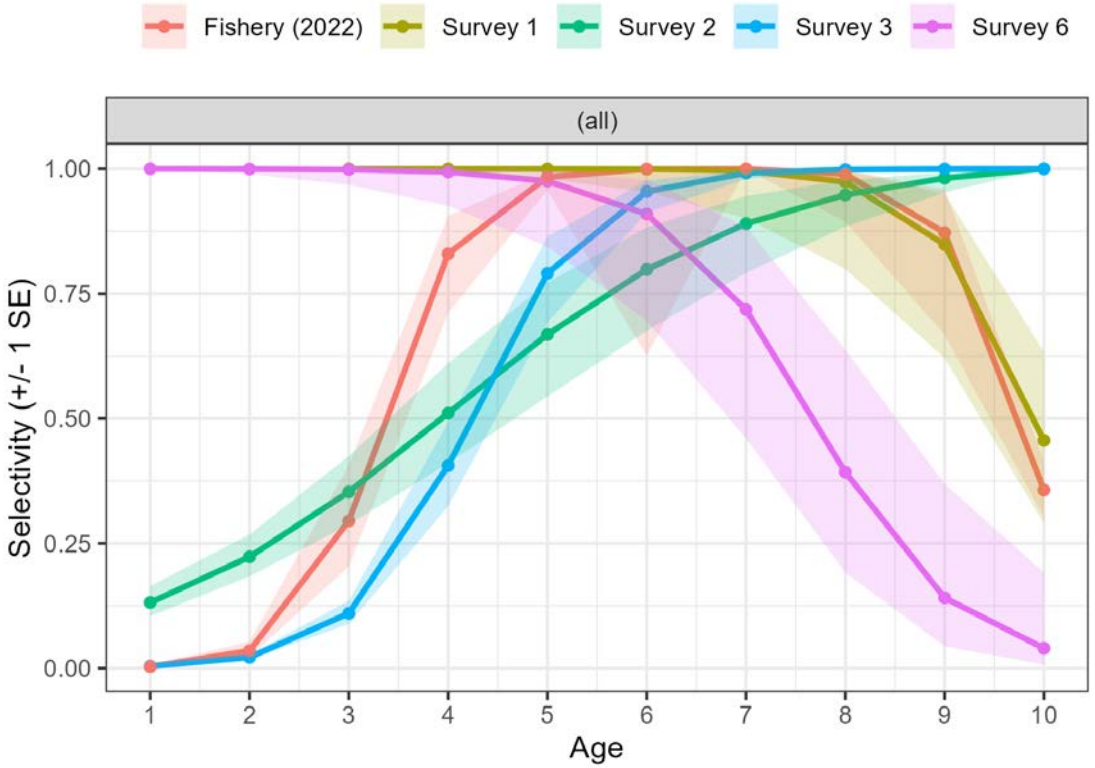
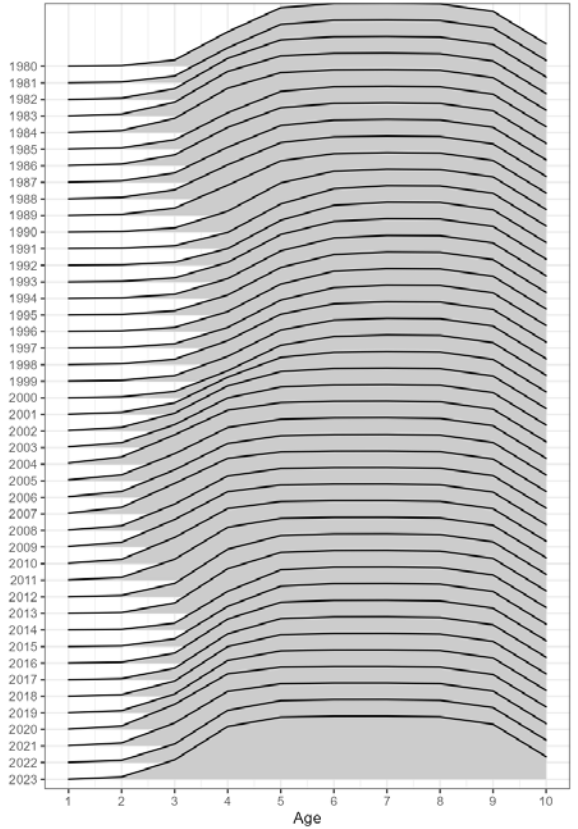


Selectivity



Fishery selectivity: double logistic with time-varying ascending limb



Fishery fits

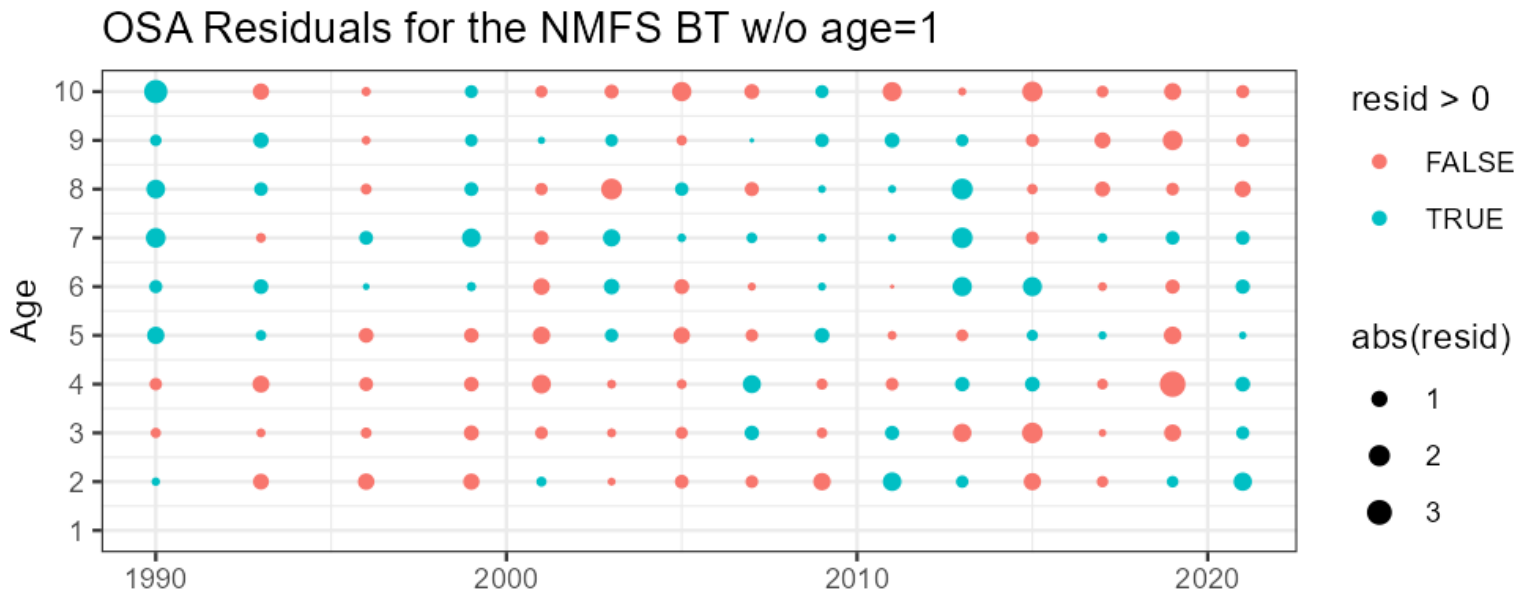
- Switched to OSA residuals for age comps
- Fishery patterns (ages 3 & 4) remain
- Resolved w/ non-parametric models (not put forward this year)

Shelikof fits

- No concerns

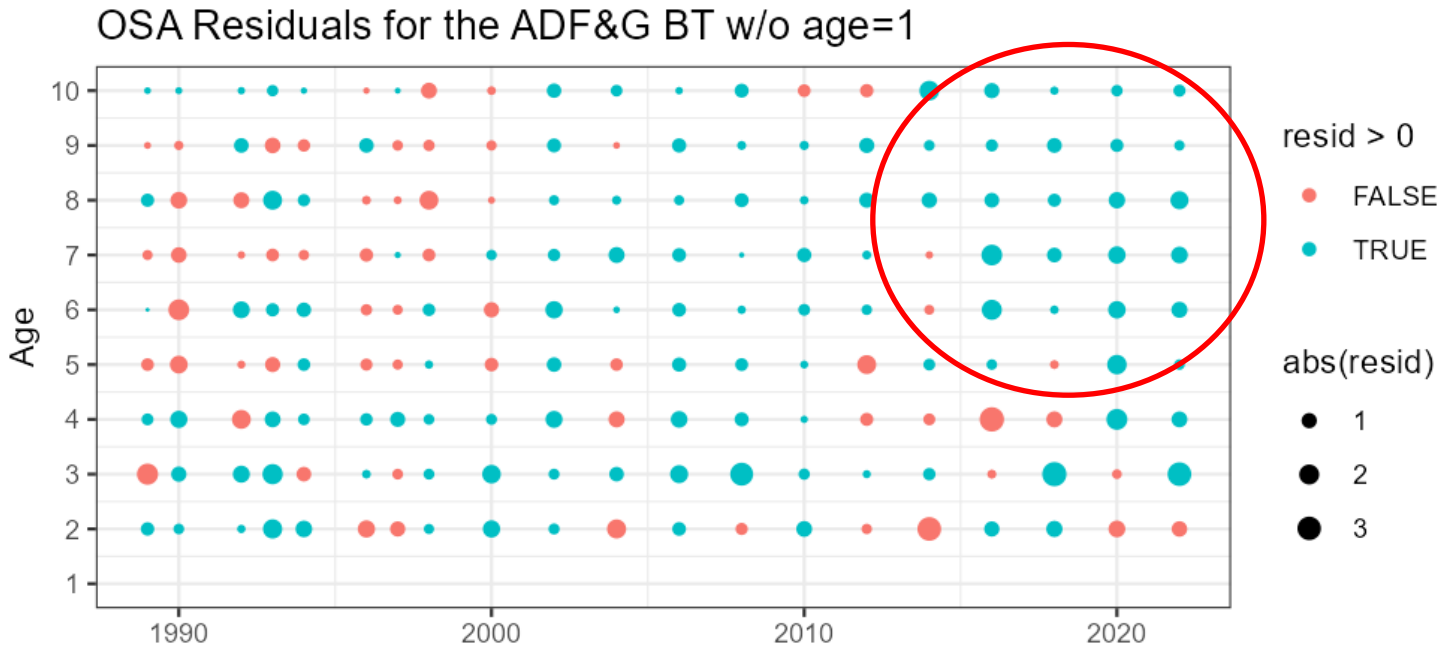
NMFS BT fits

- No concerns



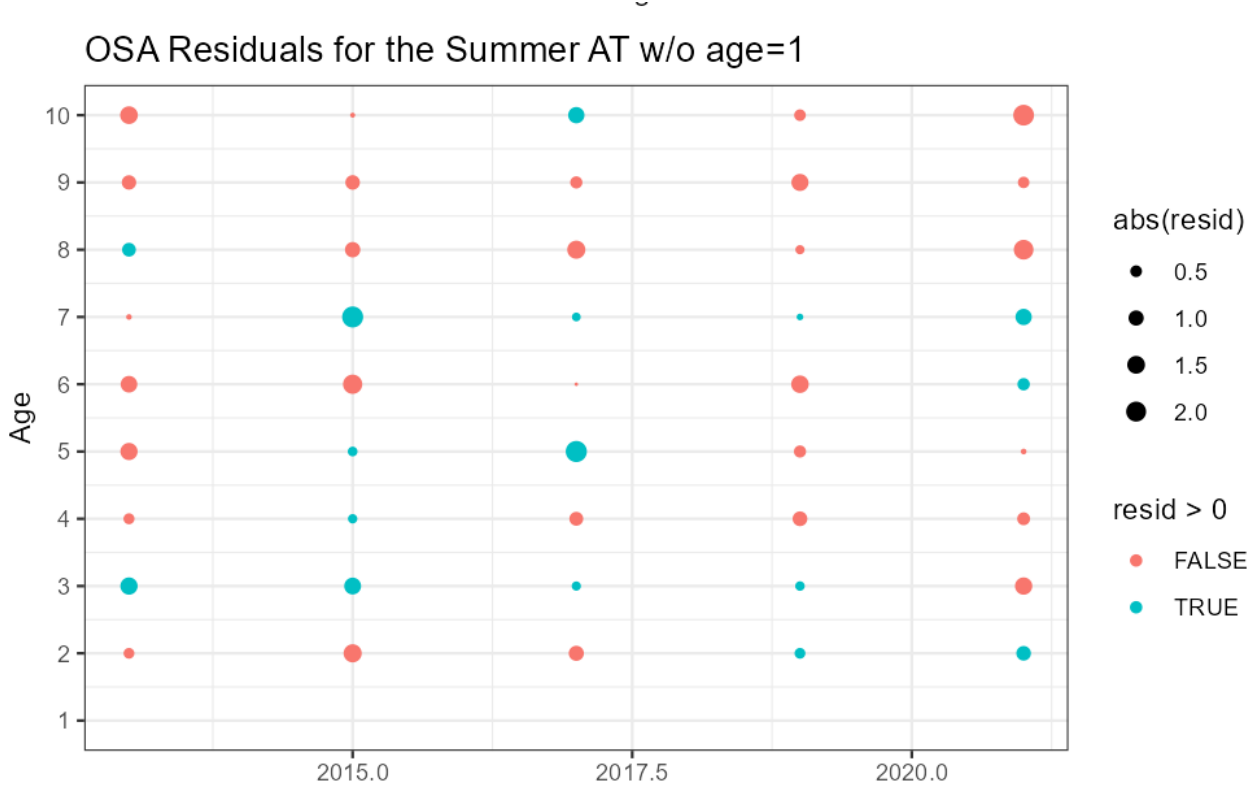
ADF&G bottom trawl fits

- Some large residuals and pattern of positive residuals



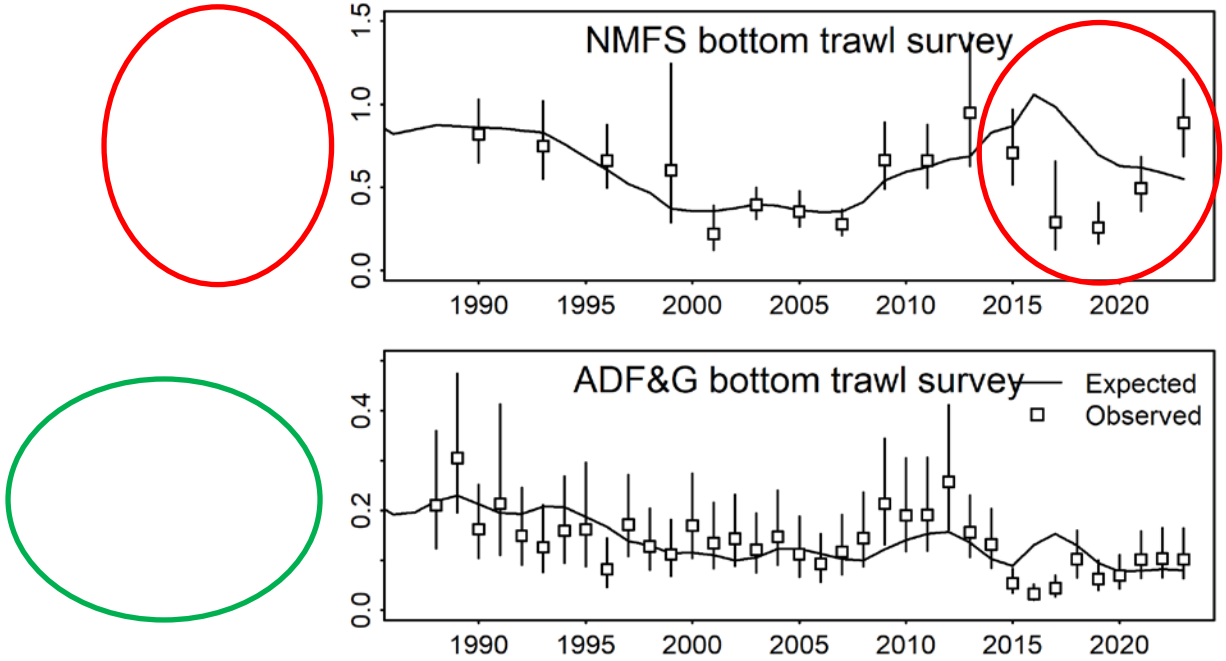
Summer acoustic fits

- No concerns



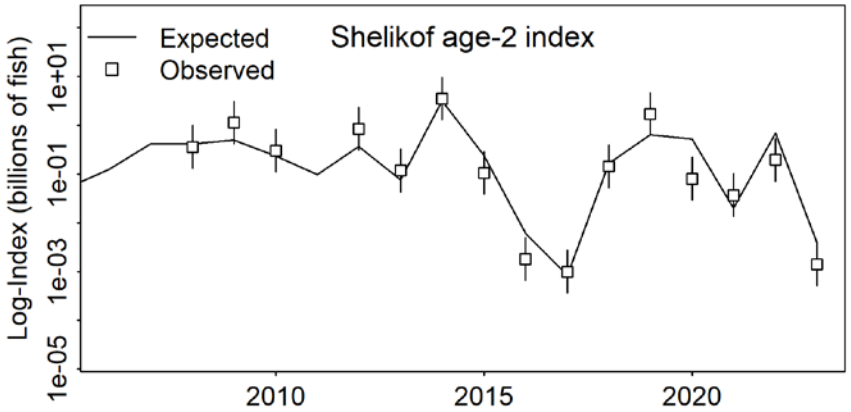
Index fits

- Poor fits, wrong trends for key surveys



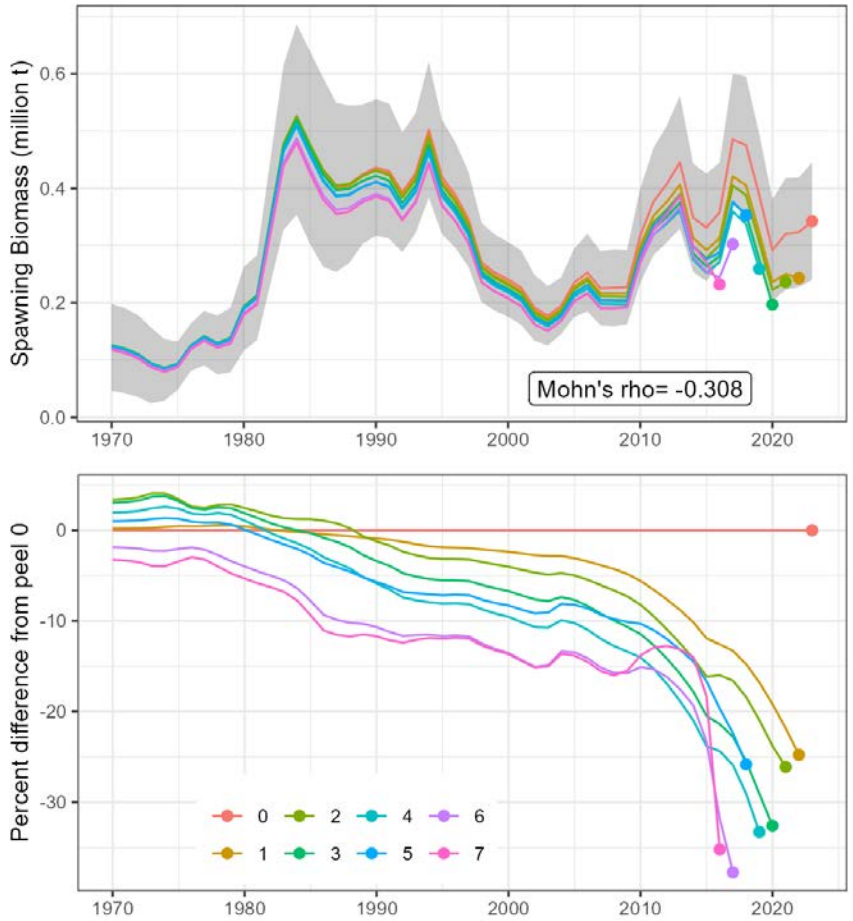
Index fits

- Record low age-1 estimate in 2023 fits poorly
- Will have to wait for corroboration from other data sets next year
- Although length data also imply few age 1s



Retrospective patterns

- Rho is expected to range from -0.2 to 0.3 by chance (based on bootstrapping)
- Thus rho=-0.3 this year is significant
- Uses 7 peels, previously used 10



Projections: an aside

- This year we noticed an issue in the projections
- 2023 SSB was 14% lower in “proj” than the assessment
- Why can’t proj reproduce the assessment?
  - Input spawning WAA is different (2023 data vs 5-year average)
- Does that invalidate proj? No, because the 2024 initial NAA are almost identical in this case
  - Due to similar fishery selectivity and fishery WAA
- How to calculate SPR-based BRP under substantial variation?

Fishery selectivity function

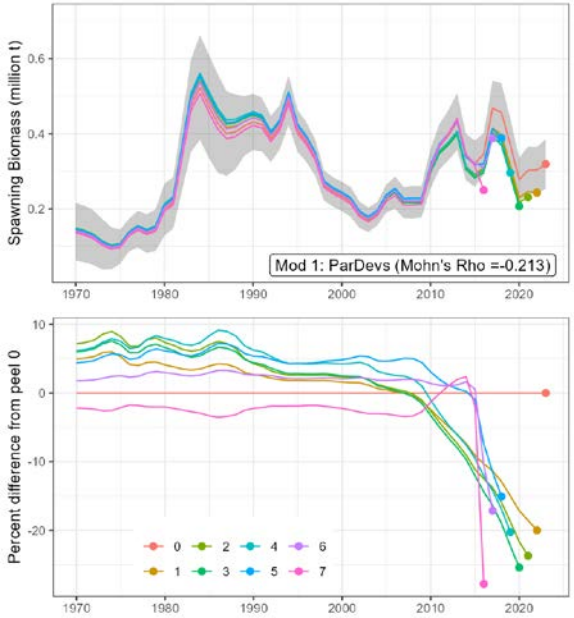
- **Problem:** current selectivity results in persistent residual patterns in age comp data
  - **Current approach:** parametric double logistic w/ random effects
  - **Alternative approach:**
    - Non-parametric 2D AR(1) age, year
    - 3D AR(1) by age, year, cohort using conditional variance

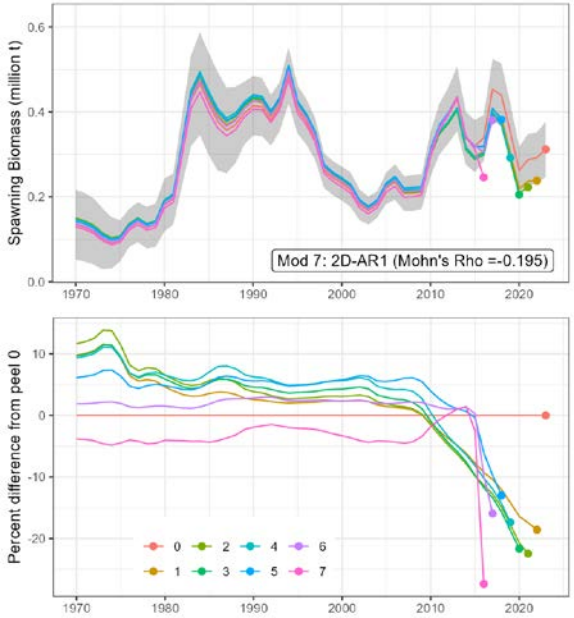
Performance metrics

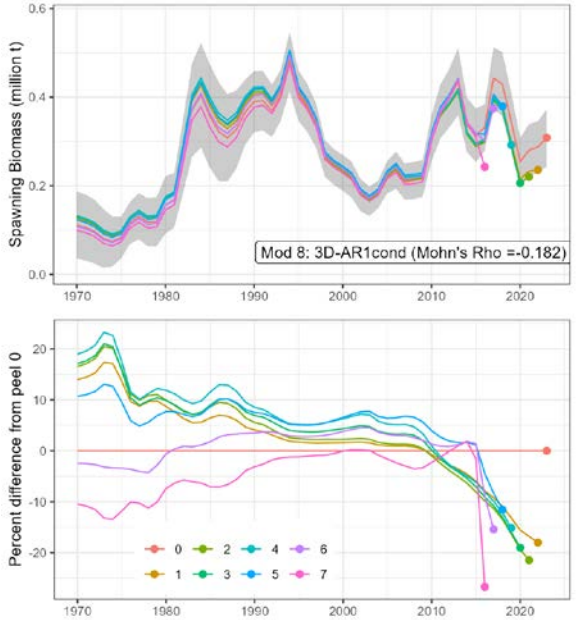
1. One-step-ahead composition residuals
    a. Do the alternatives reduce residual patterns? YES
2. Marginal AIC
    a. Do the alternatives result in better model fits? YES
3. Retrospective analysis (SSB)
    a. Do the alternatives reduce model misspecification?
        i. Maybe?
4. Do projected selex curves outperform simple average?
    a. For the most part…

Retrospective SSB

3D-AR1 has lowest retrospective bias in SSB







Projection performance

- **Problem:** what selectivity to use for projections used to calculate reference points?
  - **Current approach:** 4 year average (e.g. 2019-2022 for 2023 assessment)
  - **Alternative approach:** use model based projections
    - Selectivity is likely more similar between year Y and Y-1 than Y and Y-5
    - Allows correlation structure to inform short-term projections (e.g. cohort, year, and age effects)

Projection performance

- **Approach:** retrospective skill testing of projected vs average age-specific selectivity
  - 7 peels
  - Age-data for terminal year not included (mimics data collection)
  - No adjustments to comp weights

Note: Model is slightly different assessment (estimates variance and doesn't estimate q-devs for years without data)

Retrospective analysis

- Projected selectivity in Y+1 from peeled model compared to estimated selectivity from “full model”
  - Calculate Mohn’s Rho and Mean Squared Error
  - For selex and B0, B40, OFL, and ABC

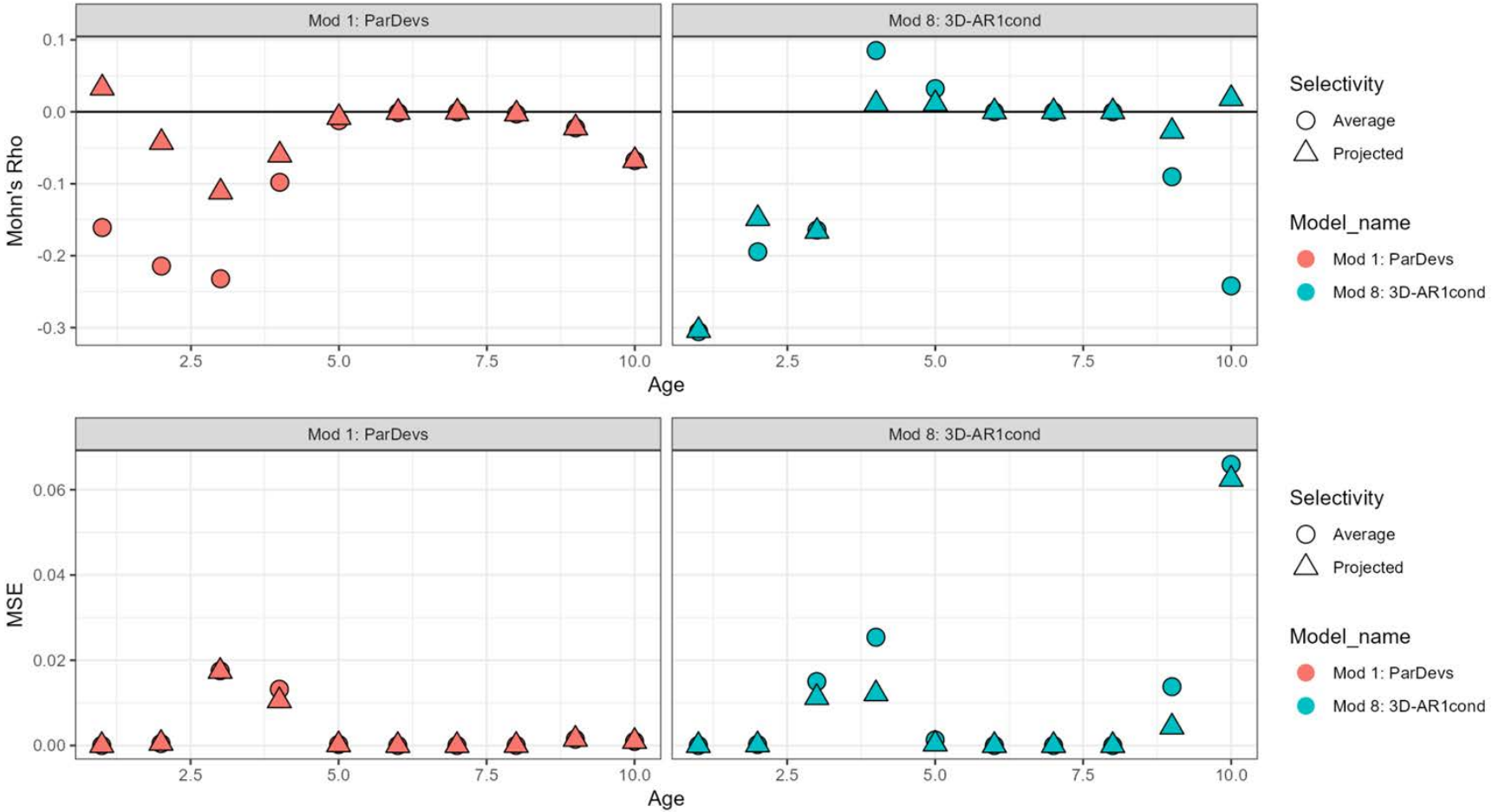
$$RE_{age} = \sum_{p}^{N_p} \left(Sel_{M(y-p),age,y-p+1} - Sel_{M(y),age,y-p+1} \right) / Sel_{M(y),age,y-p+1} / N_p$$

$$MSE_{age} = \sum_{p}^{N_p} \left(Sel_{M(y-p),age,y-p+1} - Sel_{M(y),age,y-p+1} \right)^2 / N_p$$

Retrospective bias
Selex

- Projected selectivity reduces MSE and Mohn's Rho compared to using average selectivity
- 3D-AR1 has worse Mohn's Rho and MSE for selex than current approach

Model	Metric	Selex	Age-average	% Difference
1 (ParDev)	MSE	Avg	0.0022	
1	MSE	Proj	0.0021	95.45%
1	Rho	Avg	-0.0415	
1	Rho	Proj	-0.0165	39.76%
7 (2D-AR)	MSE	Avg	0.0033	
7	MSE	Proj	0.0028	84.85%
7	Rho	Avg	-0.0617	
7	Rho	Proj	-0.0513	83.14%
8 (3D-AR)	MSE	Avg	0.0099	
8	MSE	Proj	0.0068	68.69%
8	Rho	Avg	-0.0673	
8	Rho	Proj	-0.0494	73.40%


Mod 1: ParDevs
Mod 8: 3D-AR1cond
Mohn's Rho
0.1
0.0
-0.1
-0.2
-0.3
2.5
5.0
7.5
10.0
Age
Selectivity
Average
Projected
Model_name
Mod 1: ParDevs
Mod 8: 3D-AR1cond
MSE
0.06
0.04
0.02
0.00

Retrospective bias BRPs

- For AR models projected selectivity reduces MSE and Mohn's Rho compared to using average selectivity
- 3D-AR1 has worse Mohn's Rho and MSE for OFL and ABC than current approach, but better for B0

Model	Metric	Selex	ABC	% Diff
1 (ParDev)	MSE	Avg	0.0064	
1	MSE	Proj	0.0066	102.83%
1	Rho	Avg	0.2507	
1	Rho	Proj	0.2490	99.33%
7 (2D-AR)	MSE	Avg	0.0062	
7	MSE	Proj	0.0062	98.56%
7	Rho	Avg	0.2534	
7	Rho	Proj	0.2492	98.35%
8 (3D-AR)	MSE	Avg	0.0077	
8	MSE	Proj	0.0070	91.91%
8	Rho	Avg	0.2866	
8	Rho	Proj	0.2678	93.45%

Overview

3D-AR1 may outperform current selectivity

- Reduces retrospective bias in SSB, B0, & B40 at cost of increased retrospective bias in selex, ABC, & OFL

Projected selectivity outperforms average selectivity

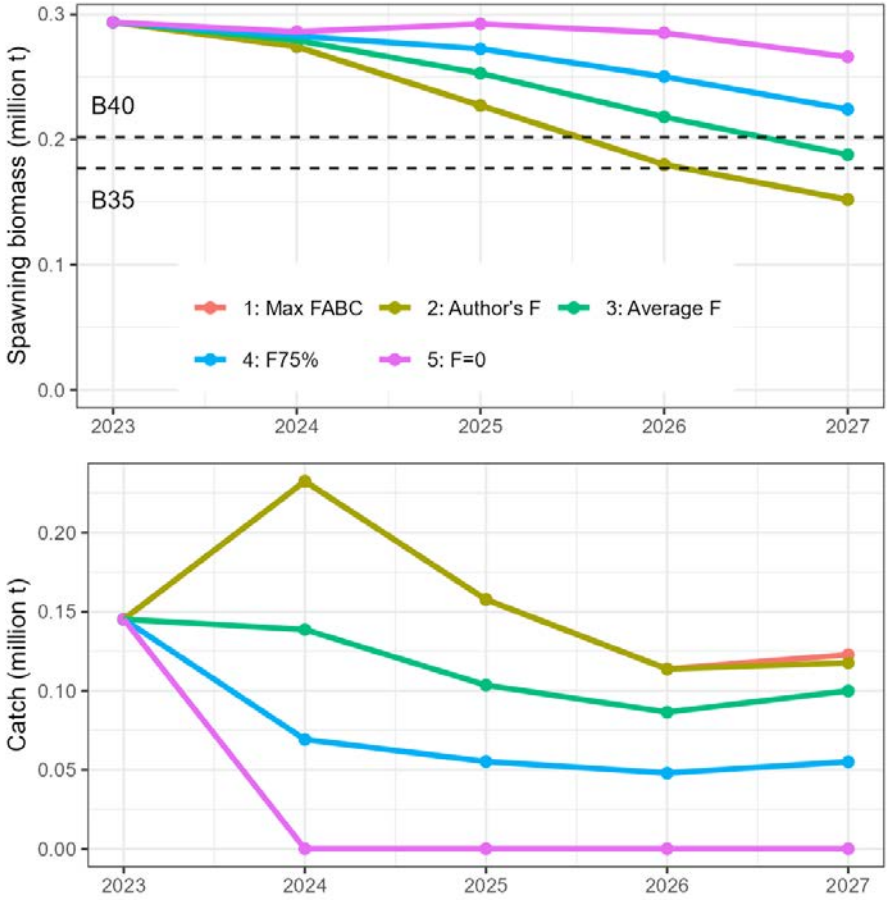
- Projected selectivity decreases Mohn's Rho in selex, ABC, & OFL for all models
    - However increases MSE for double logistic

Next steps

- Rerun with different terminal years of the assessment
- Account for reweighting in retrospective peels
- Evaluate average vs projected weight-at-age
- Incorporate projected selex into assessment in 2024
- Any advice on how to structure these experiments?

Projections in 2023

- GOA pollock has substantial time-varying quantities (WAA, maturity)
- What to use for SPR?
- Can projections recreate 2023 assessment?
  - SSB, no 2024 NAA, yes



Projections in 2023

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- What to use for SPR?
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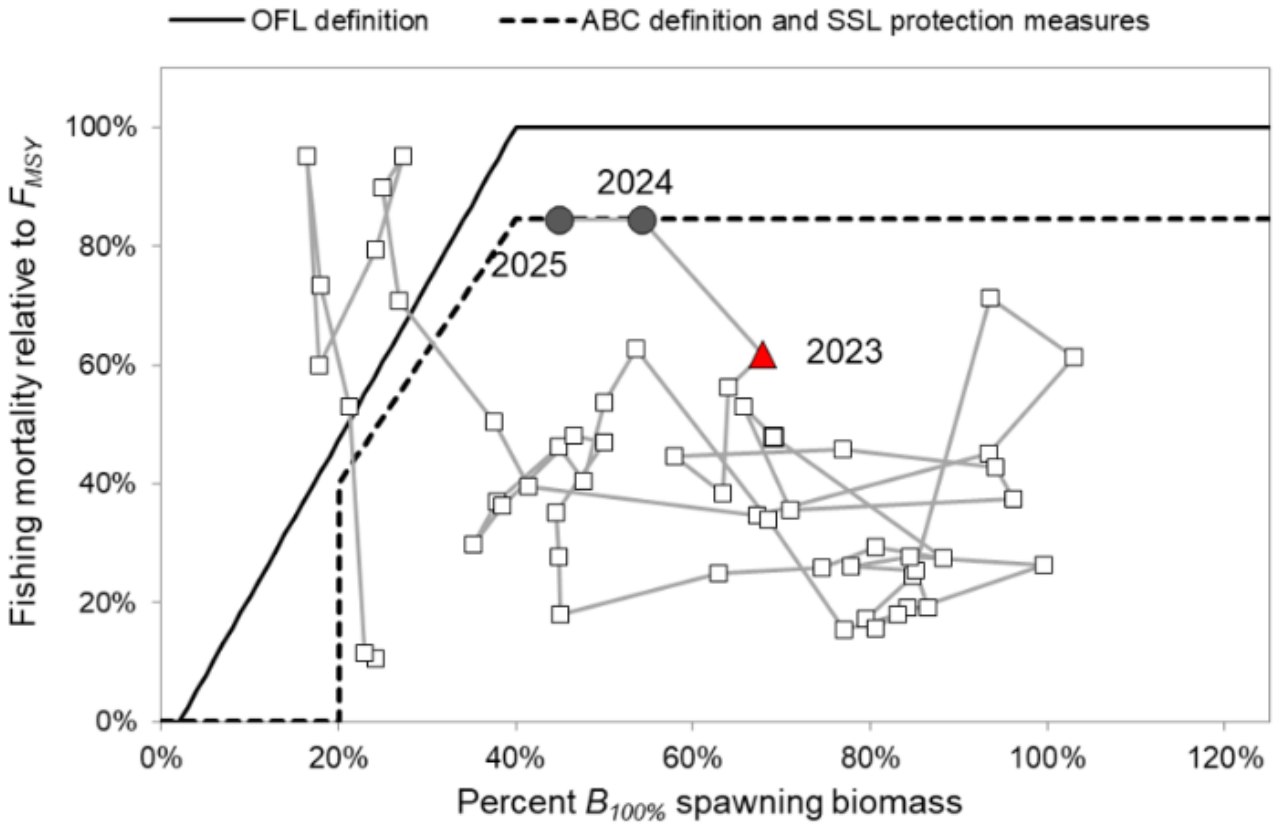
	2020	2021	2022	2023
SPR (F=0)	0.076	0.076	0.076	0.080
Mean Recruits (billions)	5.858	5.656	6.139	6.295
B100	443,000	430,000	469,000	505,000
B40	177,000	172,000	188,000	202,000
Terminal SSB	184,000	197,000	243,000	342,000
Depletion	0.415	0.458	0.518	0.677
Projected maxABC for next year	105,722	133,081	148,937	232,543
Recruits in 2013 (billion)	39.4887	40.4539	44.193	49

Status trends



Risk table: overview

Summary and ABC recommendation

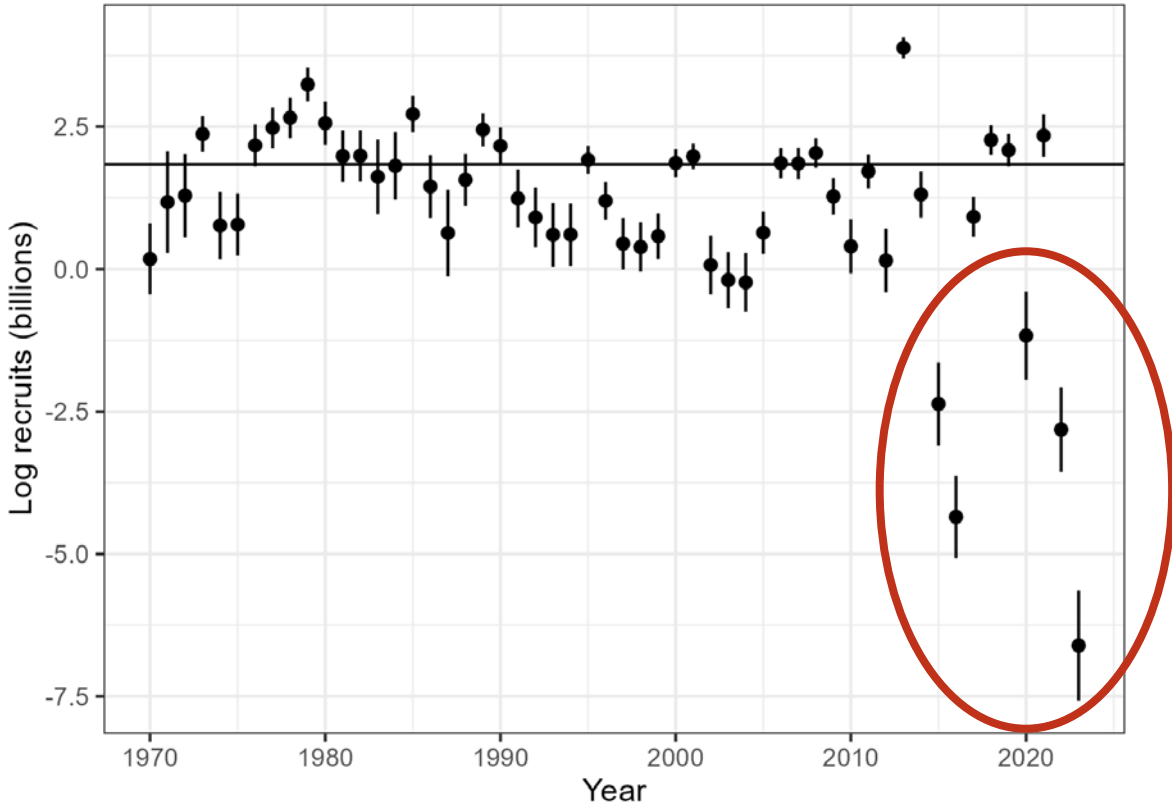
Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 2: Major concern	Level 1: No concern	Level 1: No concern	Level 1: No concern

- Assessment concerns: poor fit to NMFS BT index, retrospective
- Population concerns: extreme low cohorts

Risk table: population dynamics concerns

A few vanishingly small recruits in recent years

- Are they real?
- Is that a regime shift?
- What does that mean for recruitment variability?



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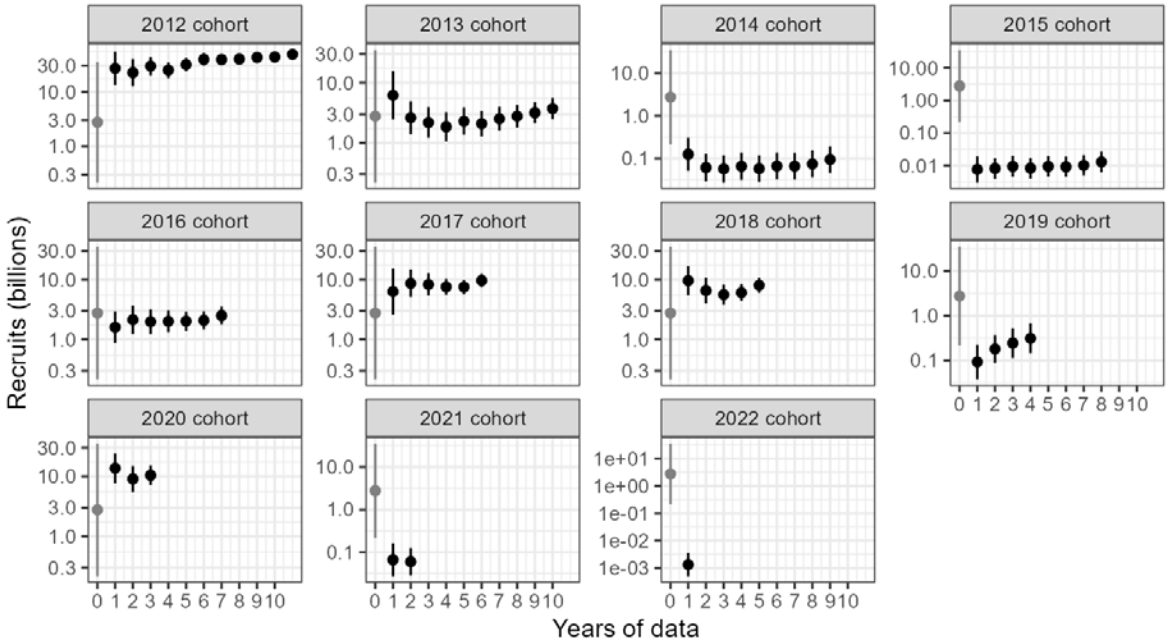

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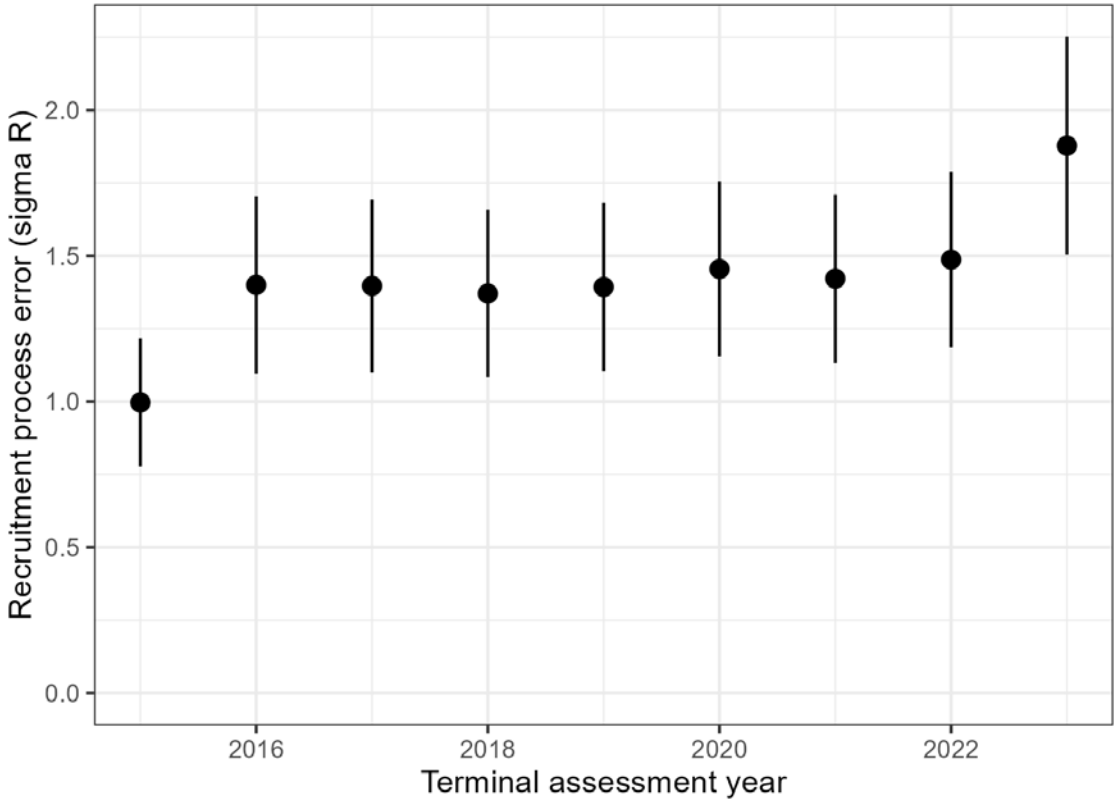
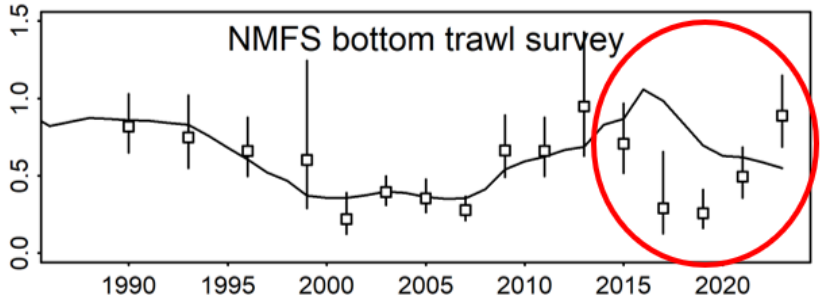
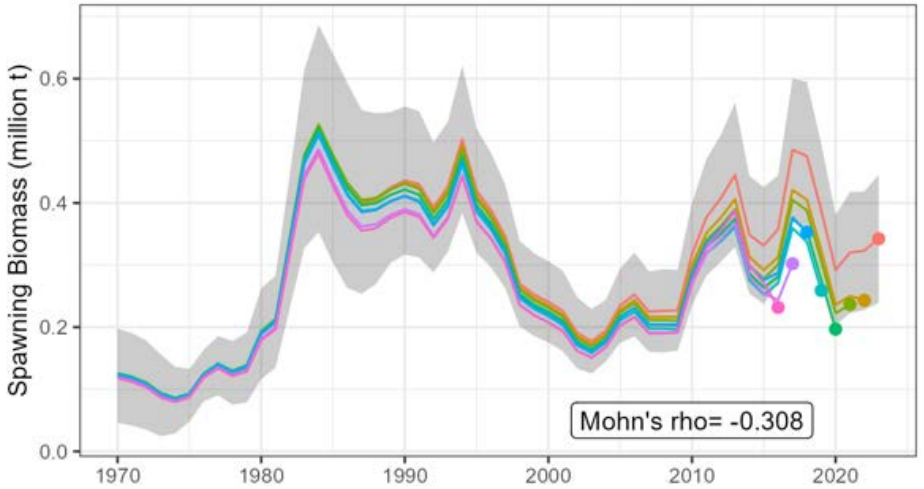
- Is that a regime shift?
- What does that mean for recruitment variability?



Risk table: assessment concerns

- The prior on NMFS BT catchability highly influences scale of stock
- But fits poorly in last 5 surveys
- Bad retrospective, but in the right direction



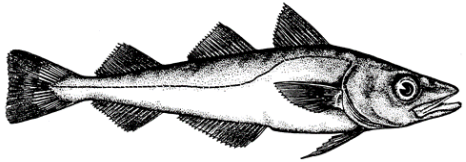


Results for GOA pollock in SE (Tier 5)

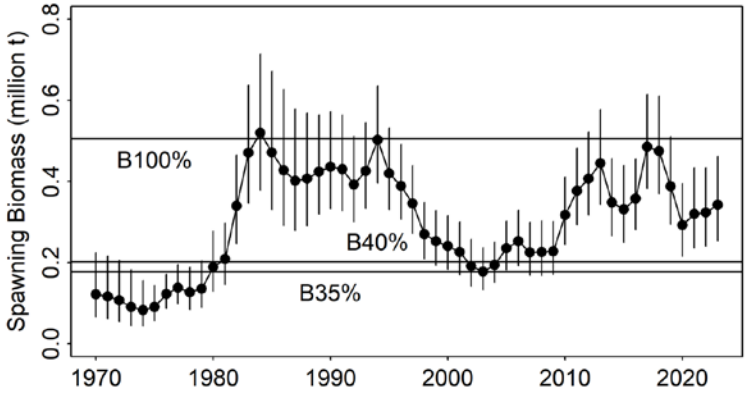
	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity/Status	2023	2024	2024	2025
Biomass (t)	50,505	50,505	43,328	43,328
F_{OFL}	0.30	0.30	0.30	0.30
$maxF_{ABC}$	0.23	0.23	0.23	0.23
F_{ABC}	0.23	0.23	0.23	0.23
OFL (t)	15,150	15,150	12,998	12,998
*max*ABC (t)	11,363	11,363	9,749	9,749
ABC (t)	11,363	11,363	9,749	9,749
	As determined *last* year for:		As determined *this* year for:	
Status	2022	2023	2023	2024
Overfishing	No	n/a	No	n/a

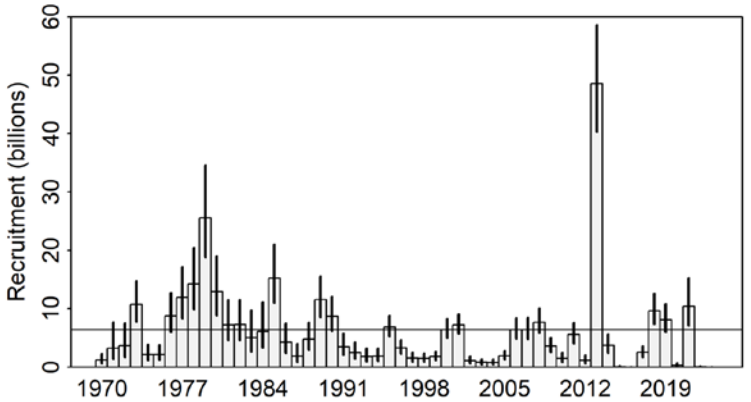
Questions?

- Thanks!



Gulf of Alaska pollock
Overview of results





Author's <u>2023 ABC = 232,543 t</u>

- Increase of 56% from 2023
- 2025 ABC decreases to 157,687 t
- No reduction from max ABC

Changes to model:

- No structural changes
- Converted to TMB (23.0)

Concerns:

- Extremely small recent cohorts
- Poor fit to NMFS bottom trawl index

Positives:

- 2017, 2018, 2020 cohorts above average
- 2012 estimate up to ~50 billion
- Good environmental conditions

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