Assessment of the Pacific Cod Stock in the Eastern Bering Sea

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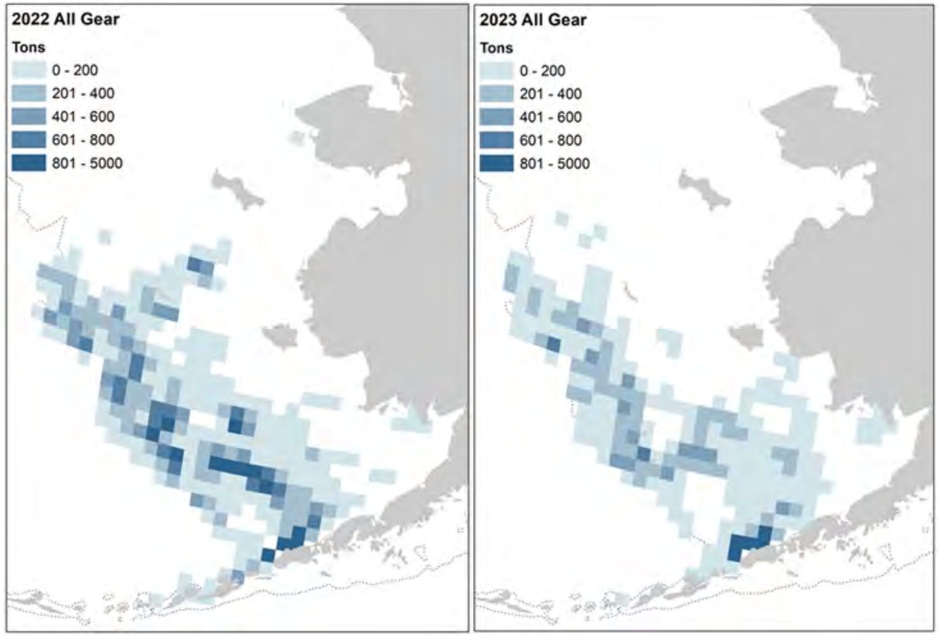
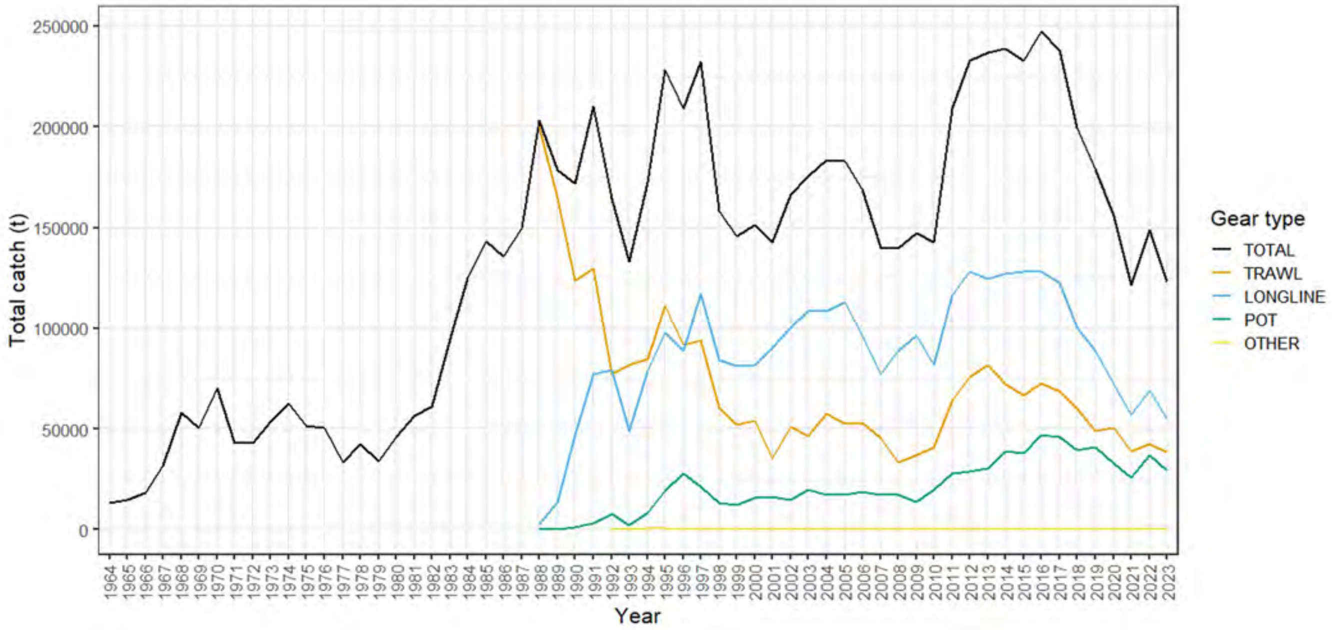
NOAA FISHERIES

https://afsc-assessments.github.io/EBS_PCOD/2023_ASSESSMENT/NOVEMBER_MODELS/

Fishery data

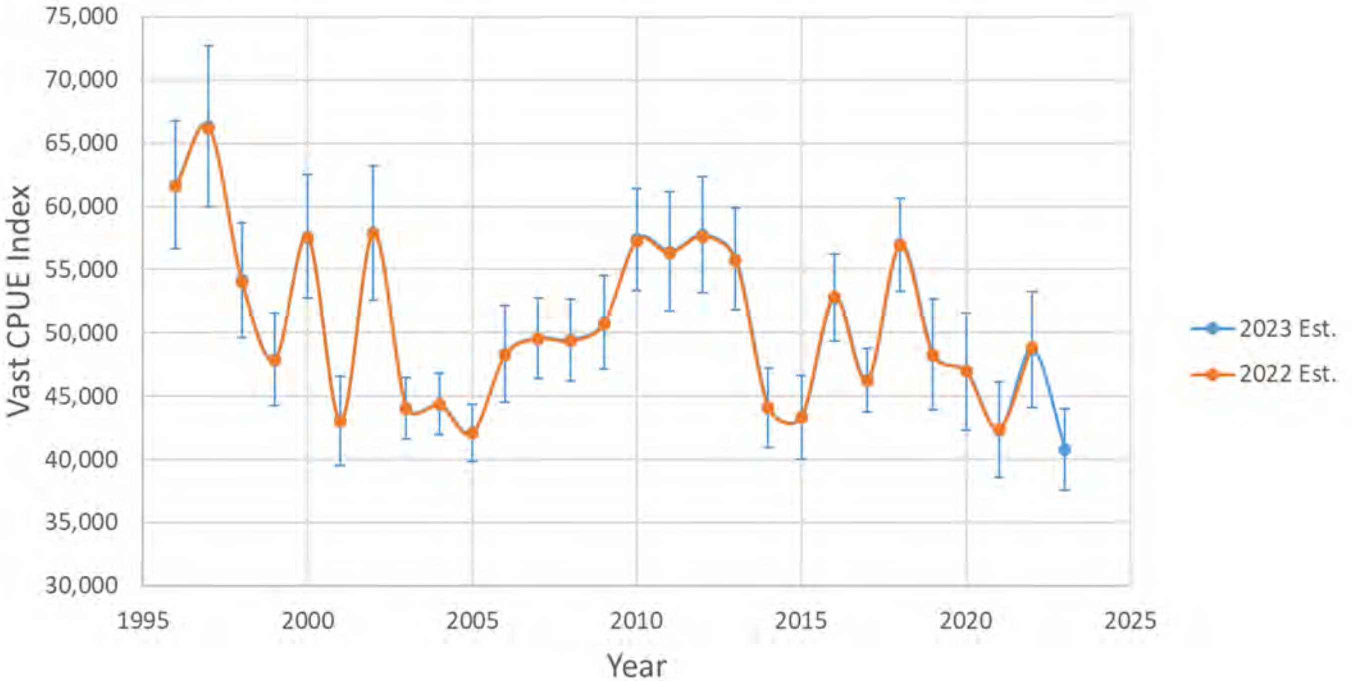
- 2023 ABC is 144,834 t and catch as of Oct. 3 = 123,208 t
    - Longline is the highest proportion
    - Continued southward shift in fishery
    - Little observed fishing north of St. Matthew Island in 2023



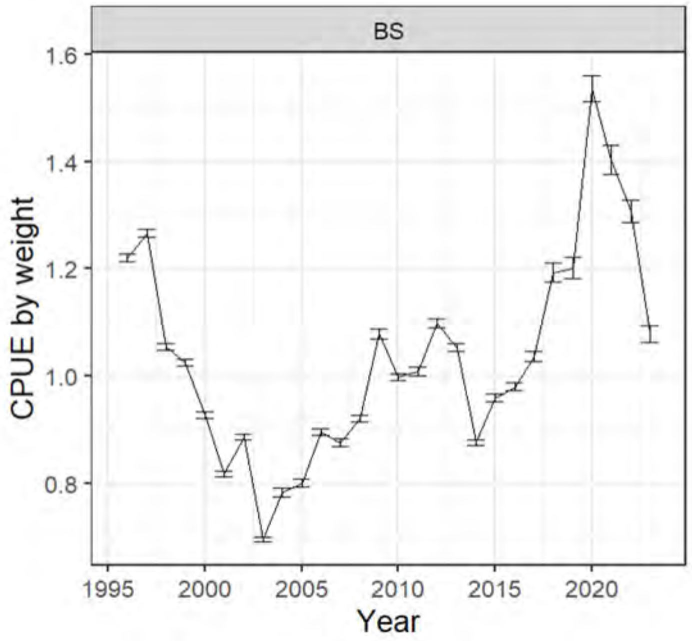


CPUE indices

- VAST longline winter CPUE index
  - Downward trend overall with 16% drop

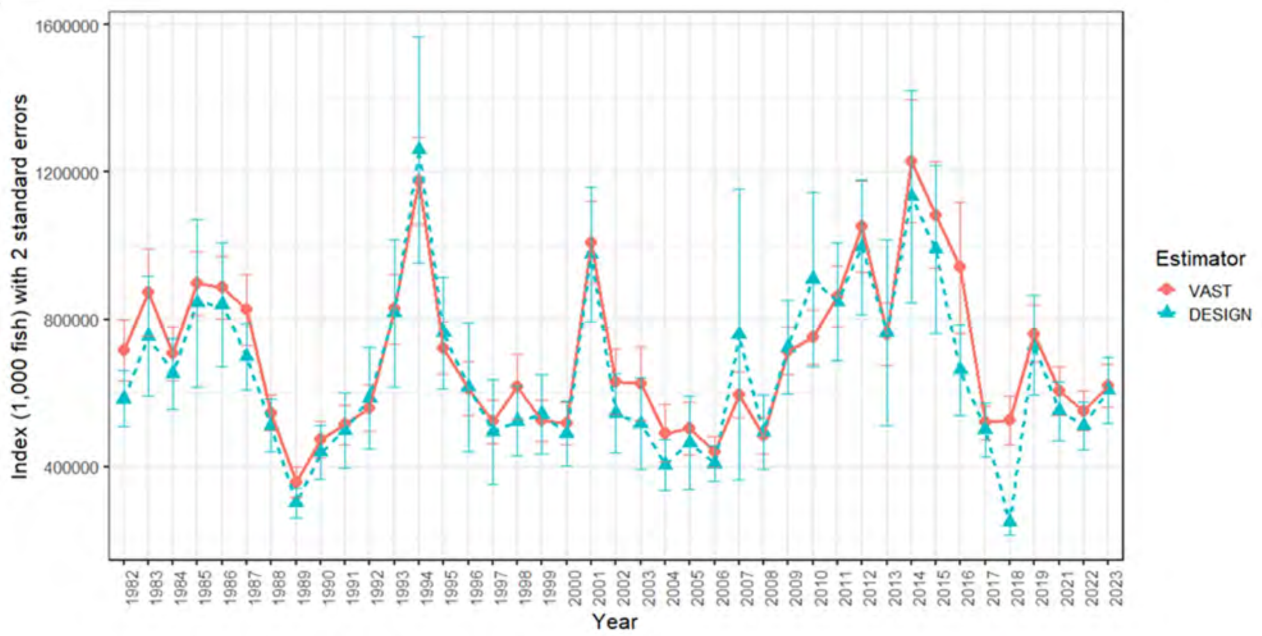


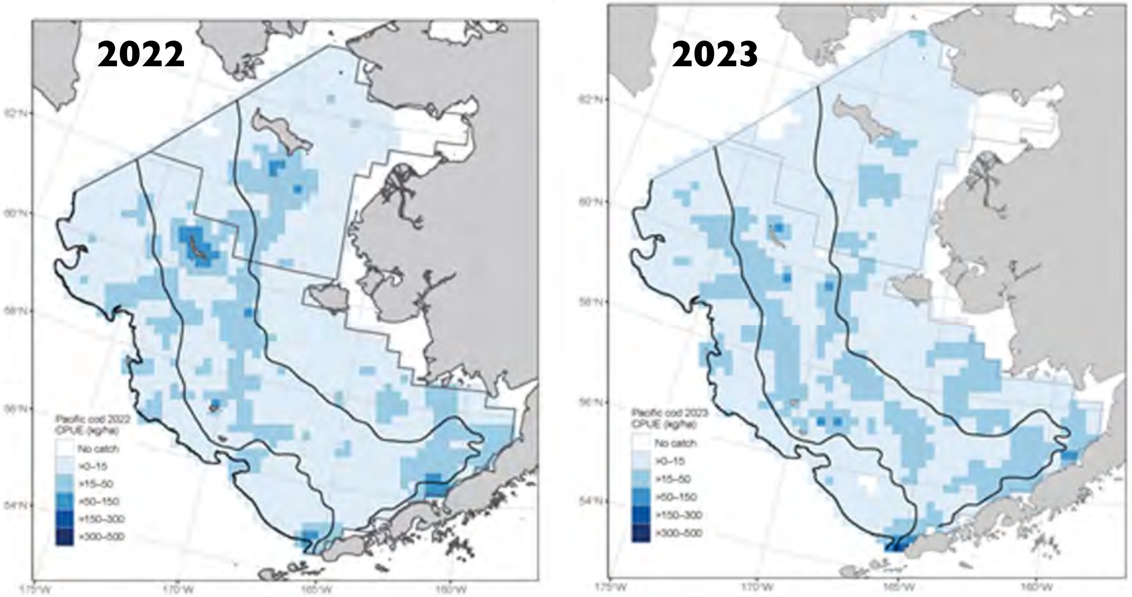
- All gear naïve CPUE index
  - Downward trend to near average since all-time high in 2020

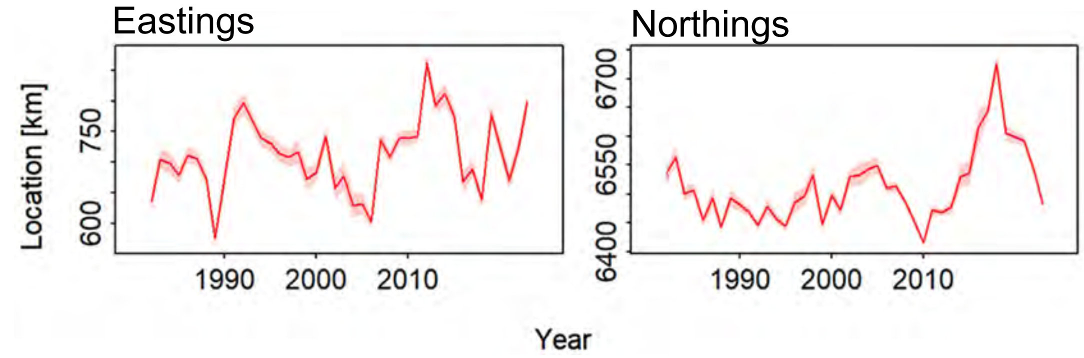


Bottom trawl survey

- Increase in abundance (+12%)
- Small decline in biomass (-4%)
- Southeastern shift in distribution

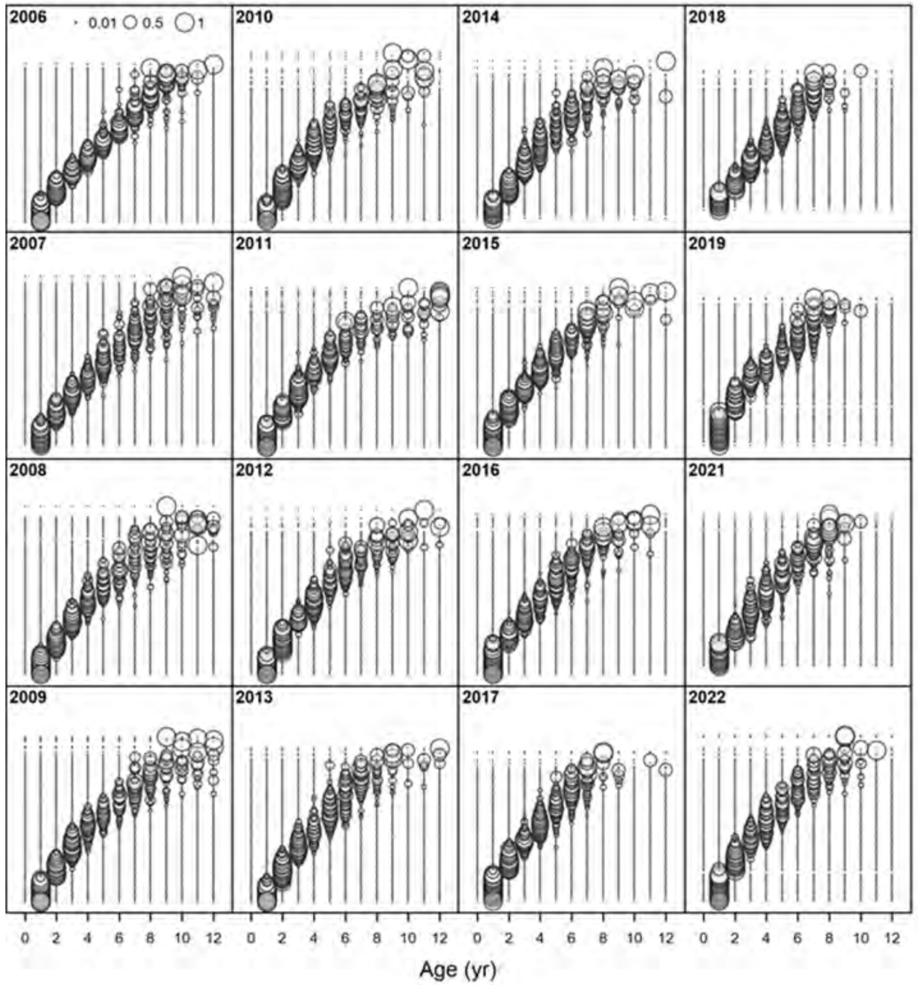


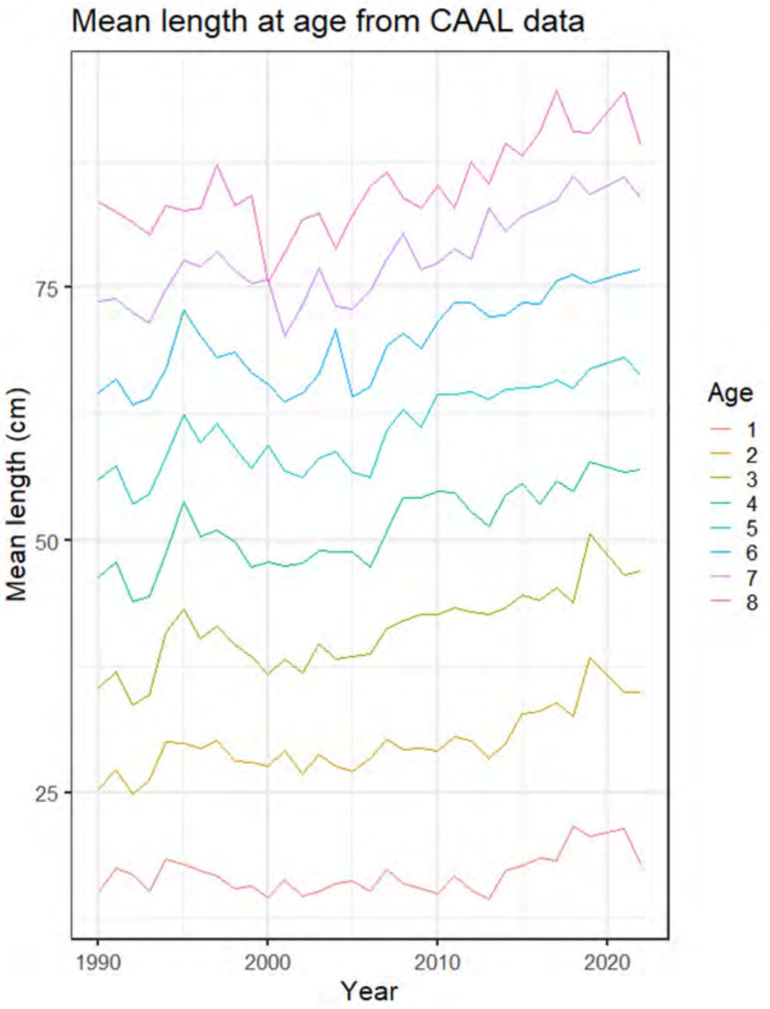




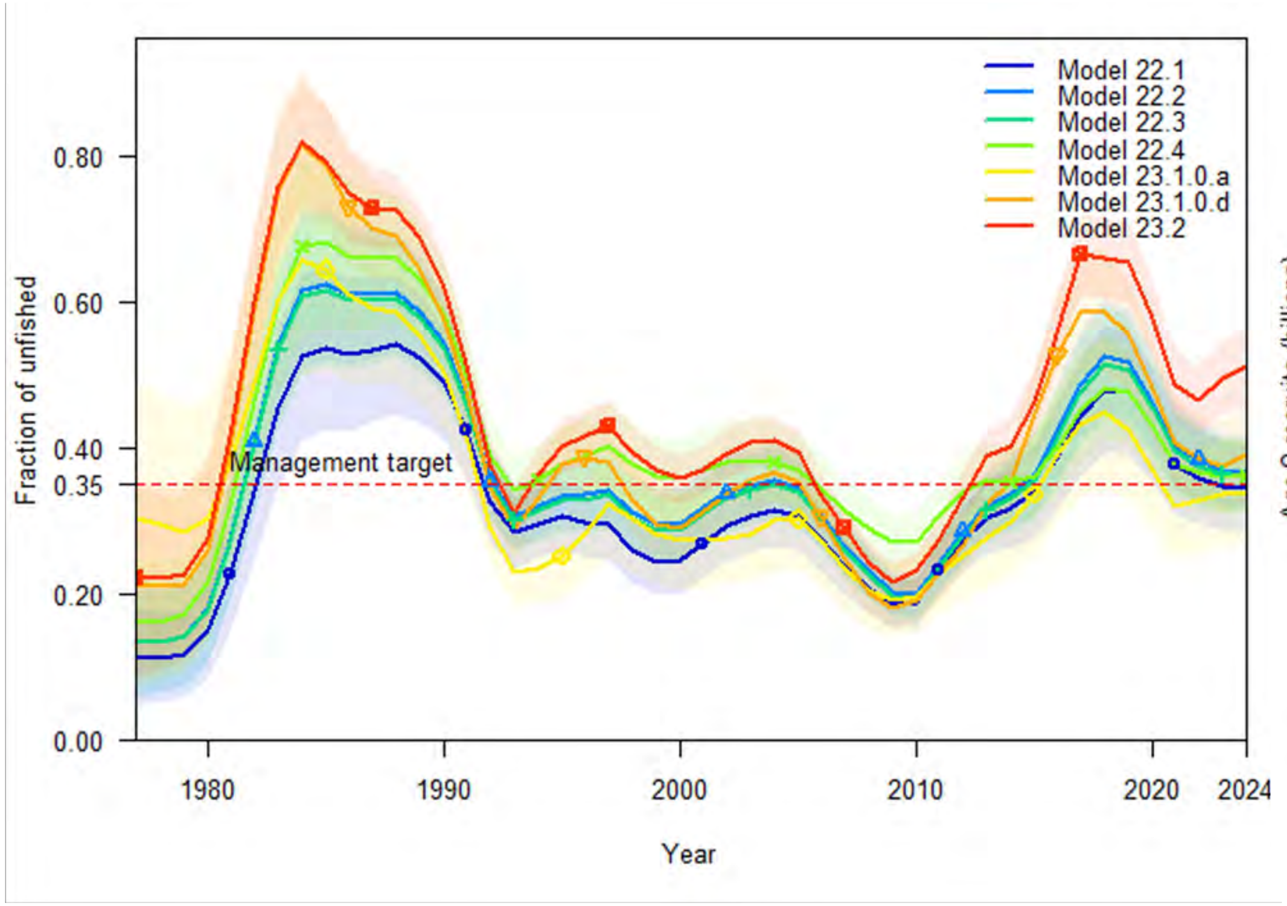
Bottom trawl survey CAAL

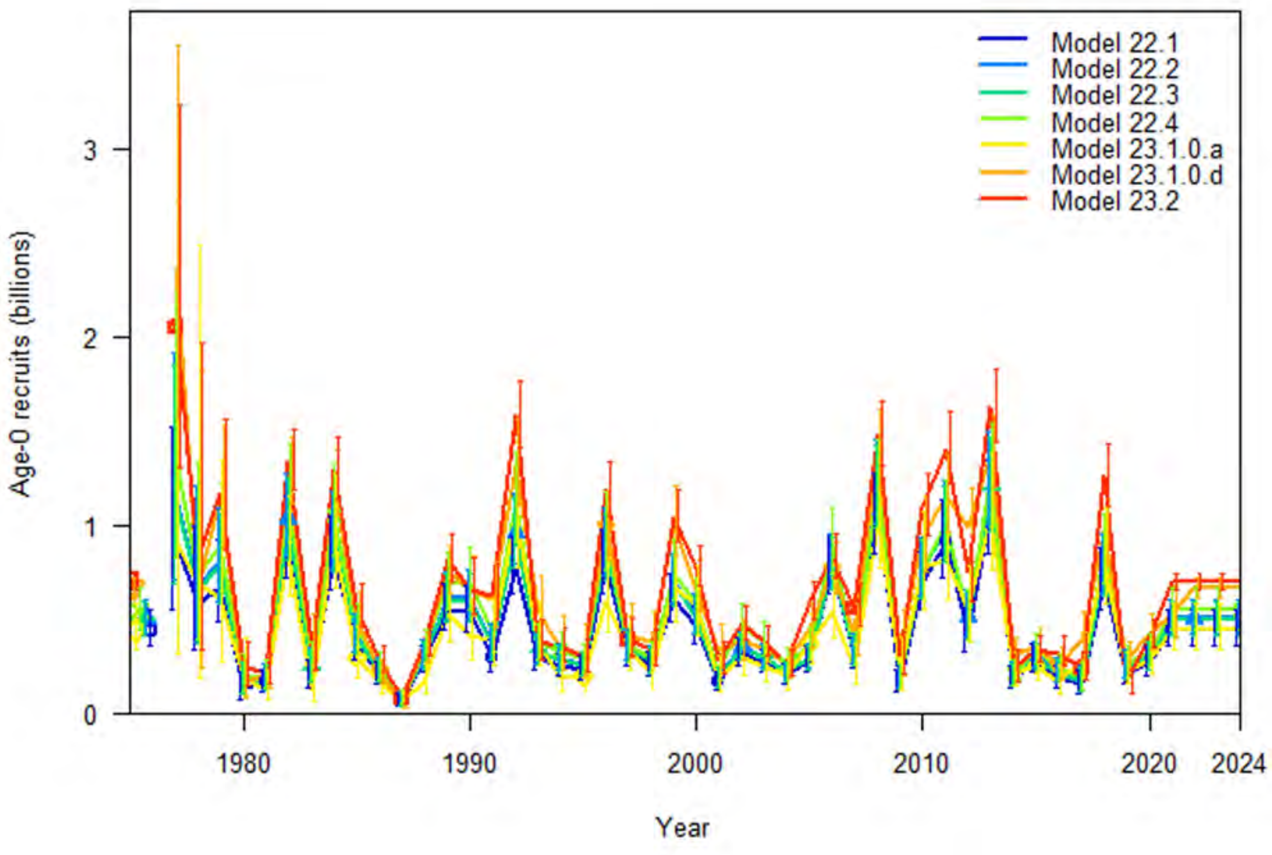
- Demonstrates change in aging post-2007, and
- Increasing growth trend since 2008





Assessment models





Assessment Models

https://afsc-assessments.github.io/EBS_PCOD/2023_ASSESSMENT/NOVEMBER_MODELS/

- 2022 Ensemble
  - Same models and weighting as 2022 New Ensemble
    - Updated data

- 2023 new models
  - Model 23.1.0.a
    - Simplification of Model 22.2
  - Model 23.1.0.d
    - Model 23.1.0.a with time varying growth and selectivity
  - Model 23.2
    - Model 23.1.0.d with survey conditional age-at-length data

2023 New Models

- Model 23.1.0.a
  - Simplification of Model 22.2
    - Non-time varying parameters for growth and selectivity
    - Aging bias fixed
    - Generic multinomial instead of Dirichlet multinomial
    - Input sample sizes based on bootstrap
    - Francis TA1.8 iterative weighting

2023 Models	Fixed natural mortality	Annually varying growth	Annually varying survey selectivity	Time block* on fishery selectivity	CAAL
23.1.0.a					
23.1.0.d	X	X	X	X	
23.2	X	X	X	X	X

* Fishery time blocks are 1977-1989 and 1990-2023

Model Evaluation: Ensemble vs. 2023

- For the Ensemble the Dirichlet multinomial log(Θ) continued to tend to the upper bound for length comp data and needed to be fixed there for the models to converge.

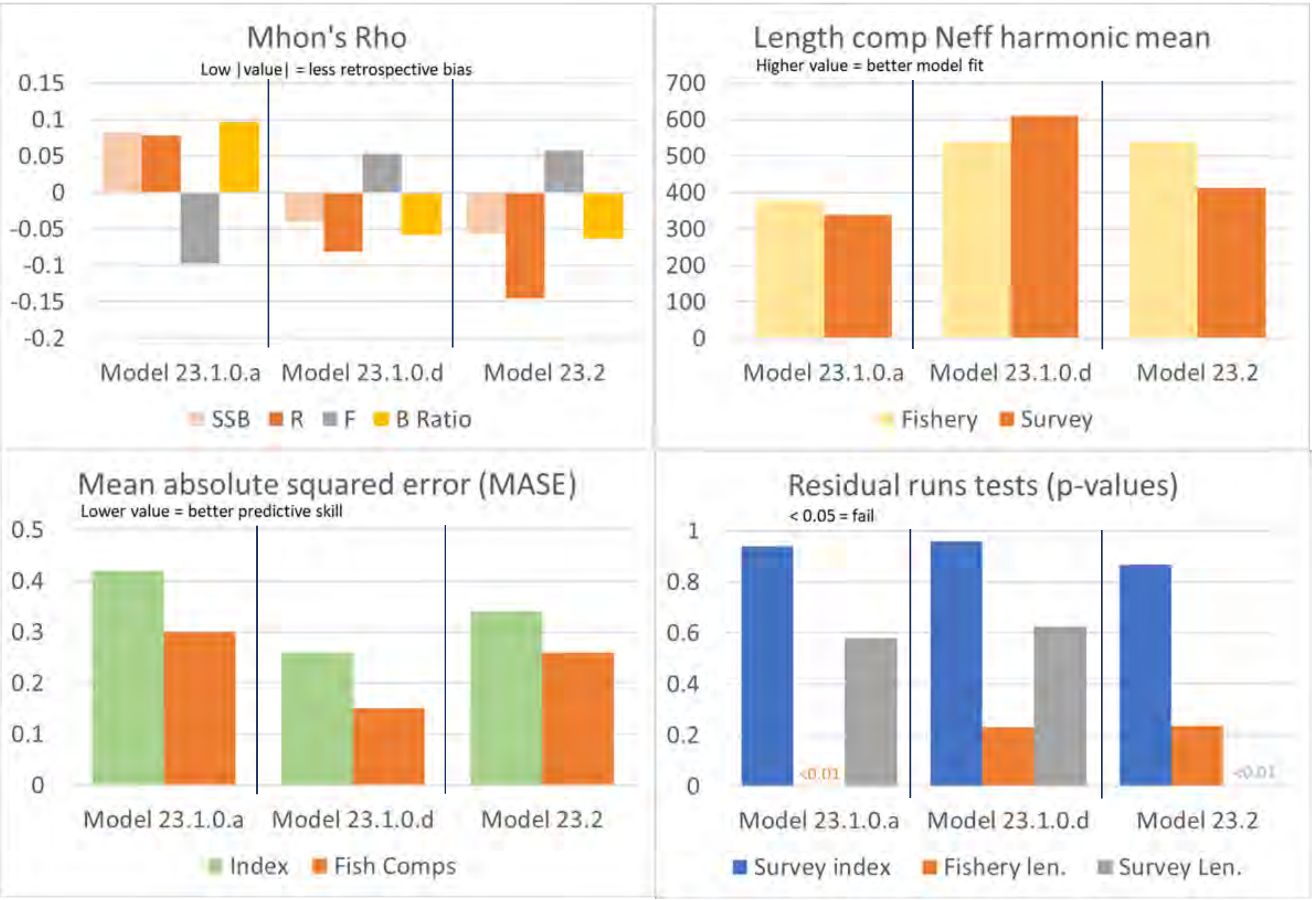
- 2022 Ensemble models consistently failed jitter tests (50 jitters at 0.1)
    - For all Ensemble models <u>**no**</u> jitter run converged to the same MLE or even the same objective function suggesting complex likelihood surface with substantial local minima.
    - For the three 2023 models > 76% of runs converged to MLE

- **In the Authors' opinion the failure of the Ensemble models to consistently converge at the MLE is enough to disqualify them for consideration for use in management**

2023 Model Diagnostic Comparison

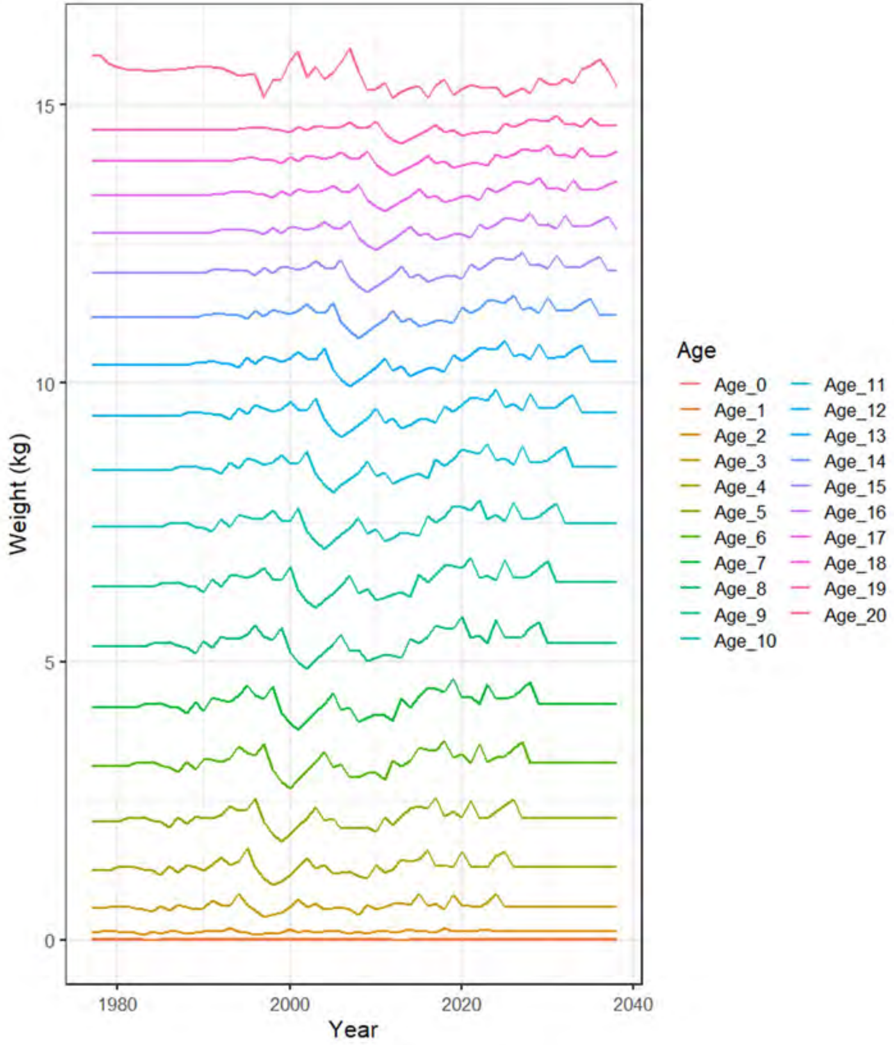
- Model 23.1.0.d best overall performance
  - Least retrospective bias
  - Best overall fit to comp and index data
  - Best MASE predictive skill
  - Passed all residual runs tests
  - Index RMSSR closest to 1.0

- Model 23.1.0.a best jitter performance with 98% convergence at the MLE
  - Model 23.1.0.d at 86%
  - Model 23.2 at 76%.

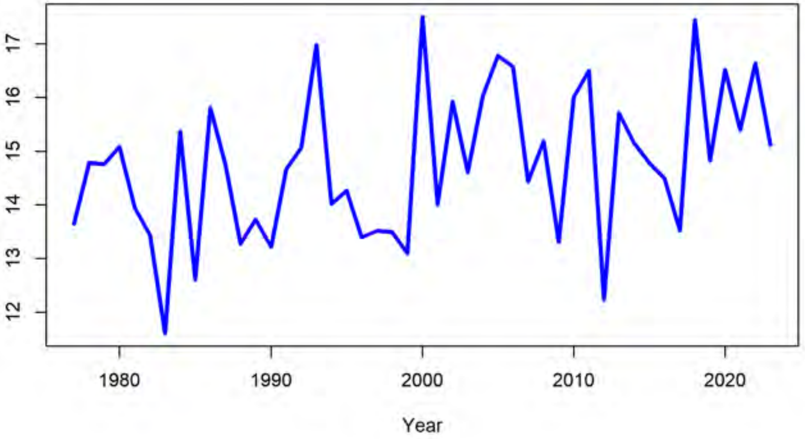


Model 23.1.0.d Results - Growth

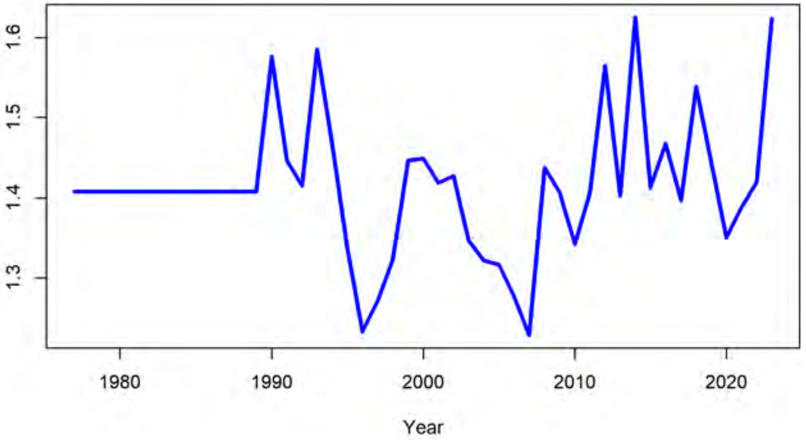
- Richards with time varying parameters
  - $L_{1.5}$ - Models initial size and acts as a cohort effect
    - Variable with an overall increasing trend over time
  - Richard's ρ - Shapes growth curve and acts as annual effect
    - Variable with increasing trend since 2010



$L_{1.5}$



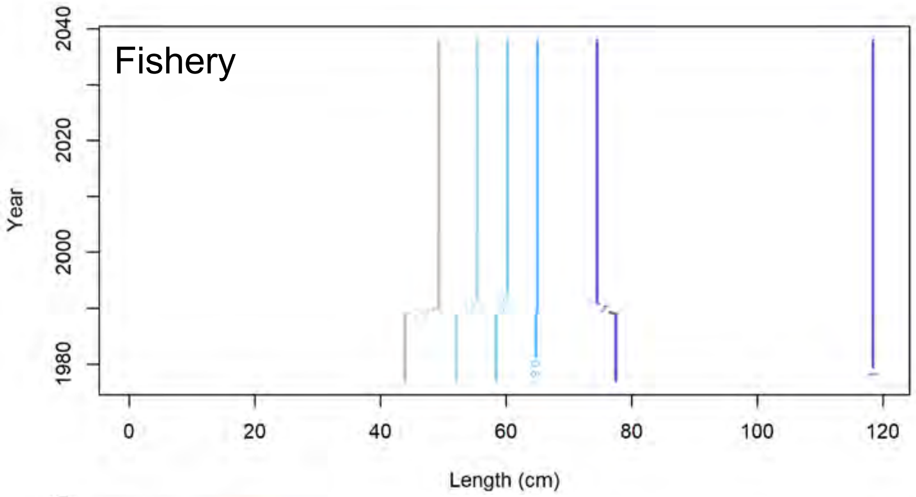
Richard's ρ

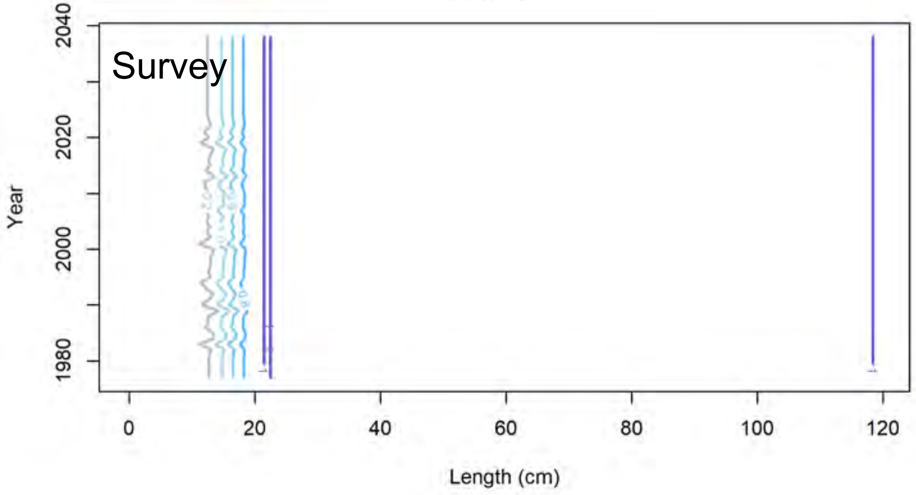


Model 23.1.0.d Results - Selectivity

- Fishery - Time blocks 1977-1989 and 1990-2023
  - Asymptotic double normal with peak and ascending width fit for the two time blocks

- Survey – Time varying 1977-2023
  - Asymptotic double normal with peak and ascending width fit
  - Peak parameter fit with random deviations with σ tuned iteratively to set the variance of the estimates plus the sum of the estimates' variances equal to 1.0.

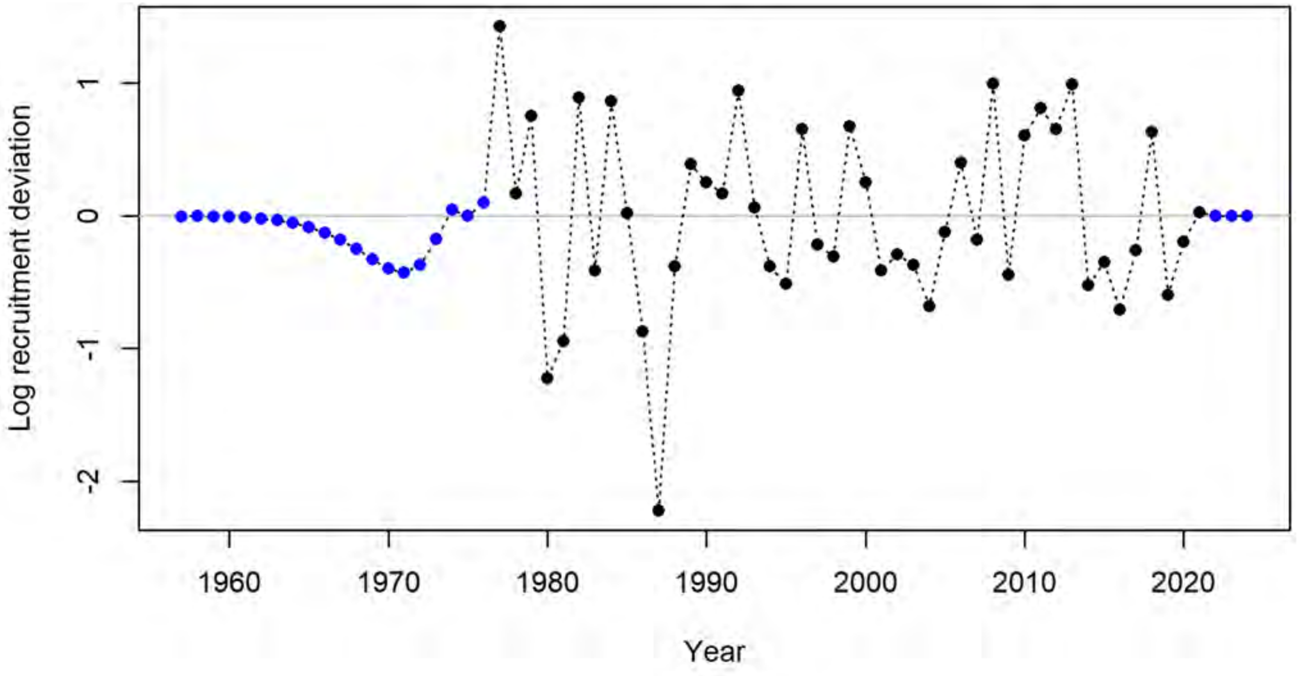




Model 23.1.0.d Results - Recruitment

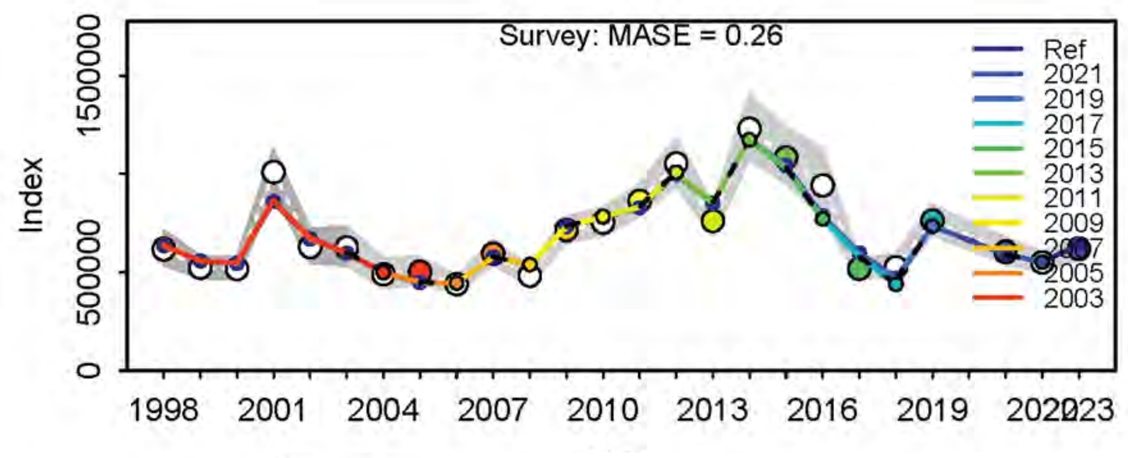
- σ_R = 0.74
  - Iteratively tuned to match the square root of the variance of the estimates plus the sum of the estimates' variances (Methot and Taylor 2011)

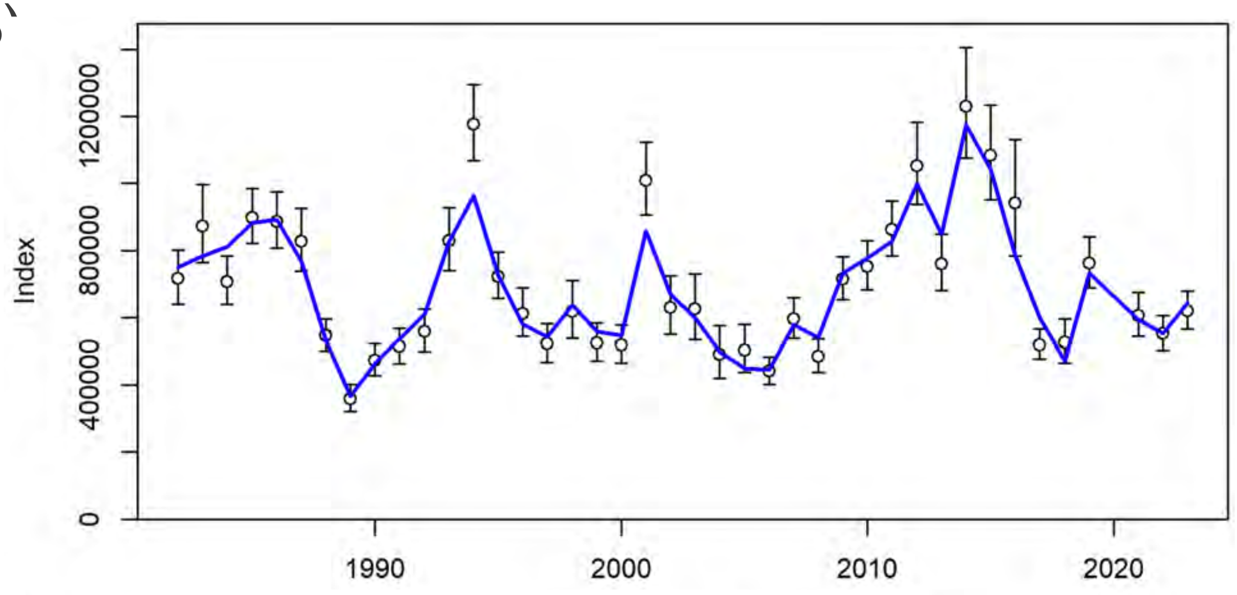
- Highly variable 1977-1989
- Recent recruitment
  - Good 2010-2013
  - Poor 2014-2017 and 2019-2020
  - 2018 above average
  - 2021 near average

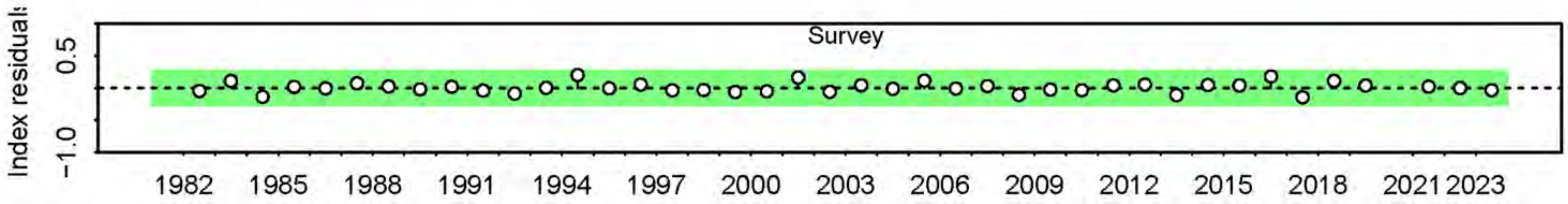


Model 23.1.0.d Results - Index

- Tight fit to the survey index
  - Insignificant autocorrelation in residuals (p-value = 0.959)
  - Good MASE predictive score (0.26`

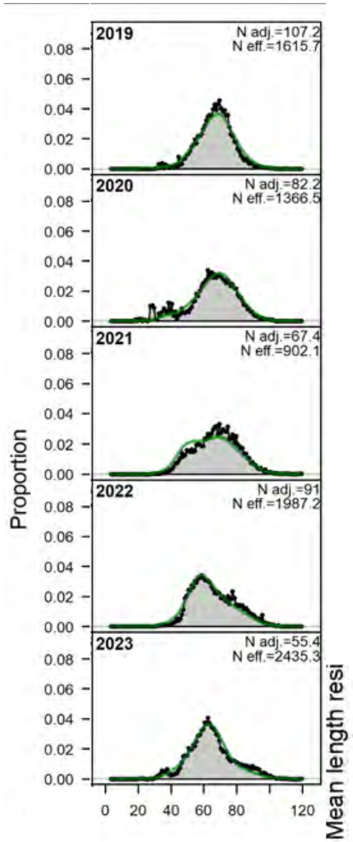


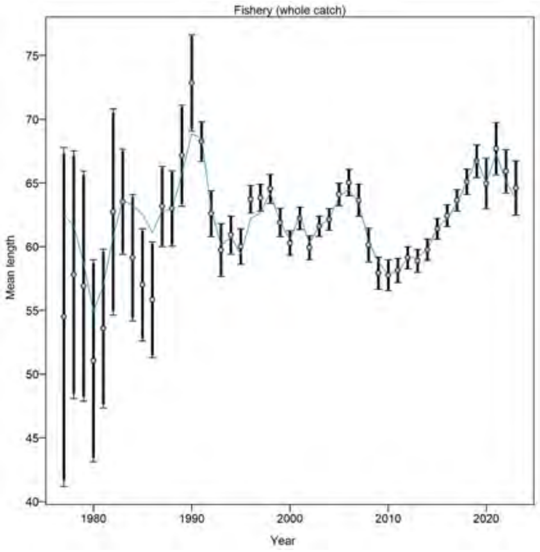


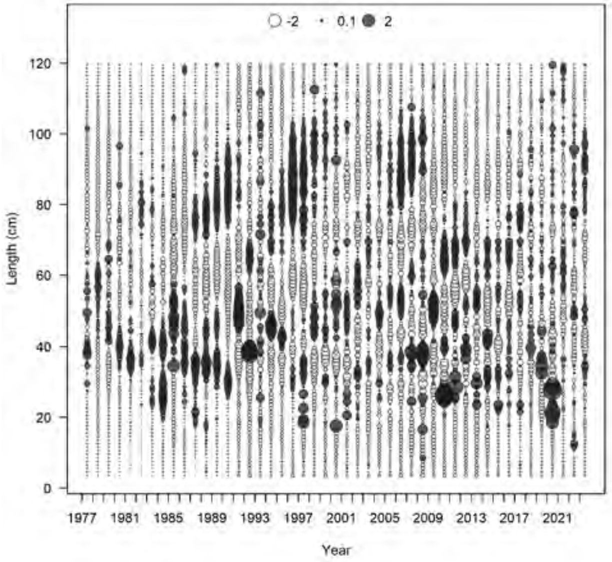


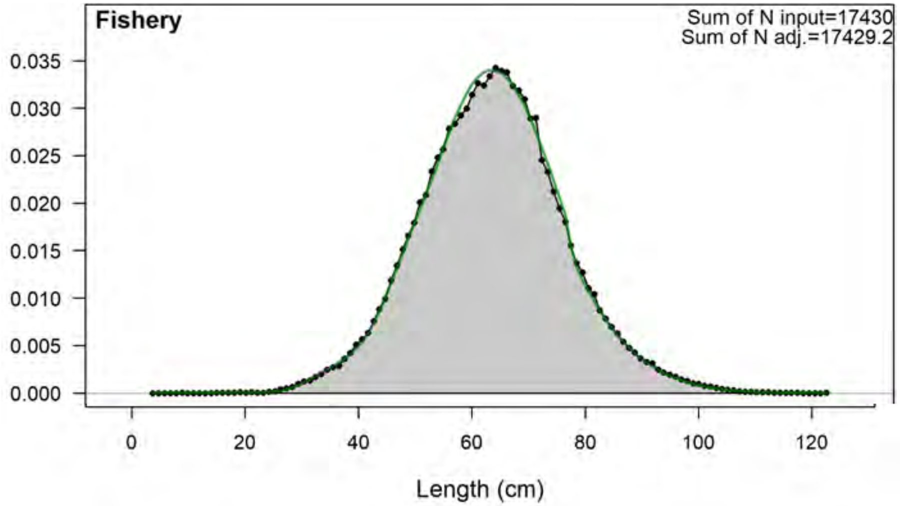
Model 23.1.0.d Results – Fishery lengths

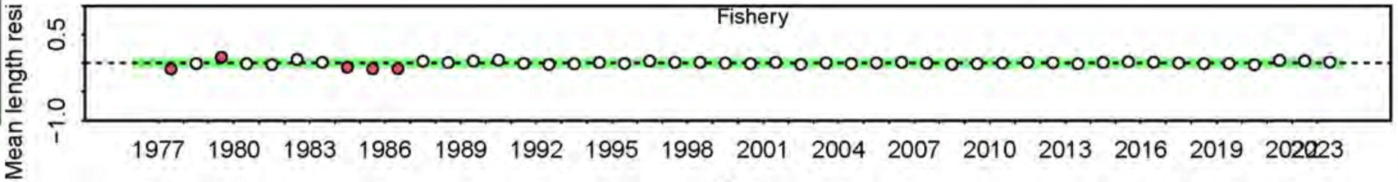
- Good fit to the fishery length composition
    - Insignificant autocorrelation in residuals (p-value = 0.231)
    - Good MASE predictive skill (0.15)

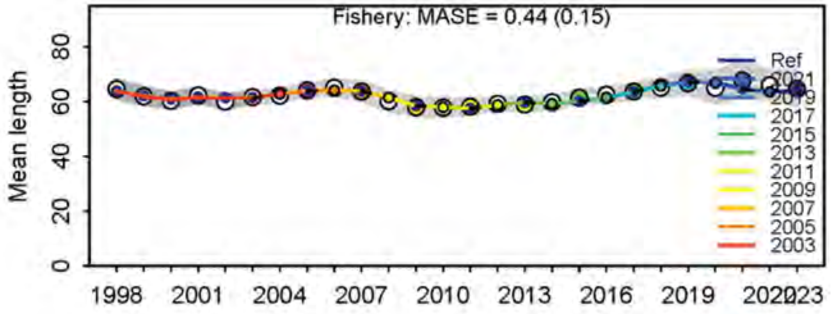






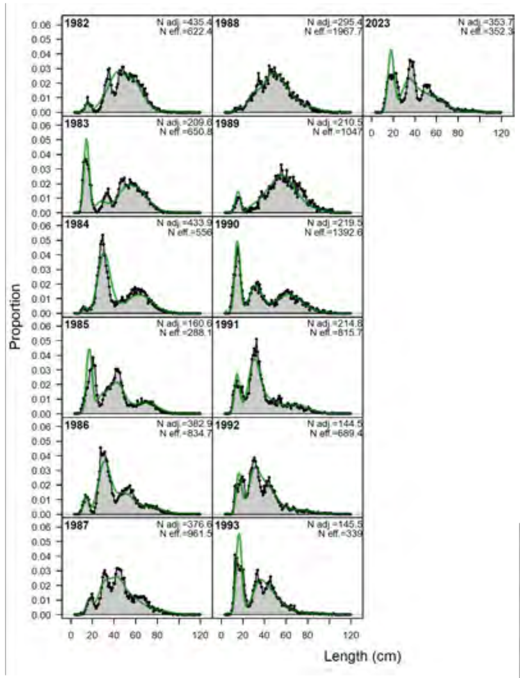


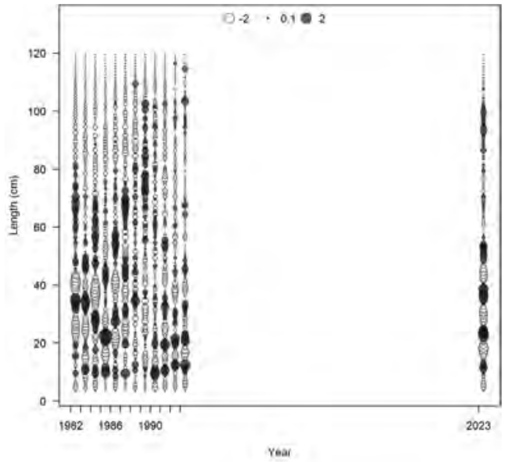


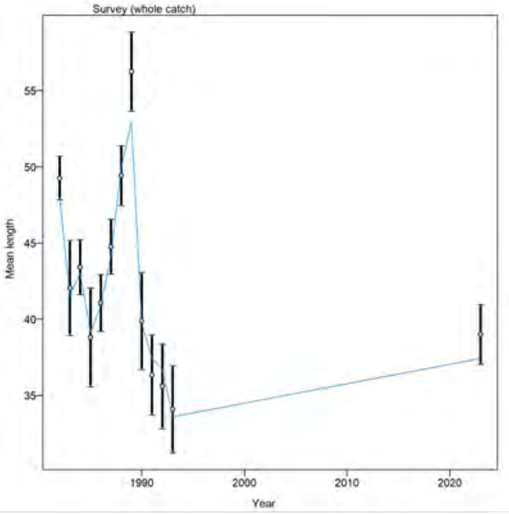


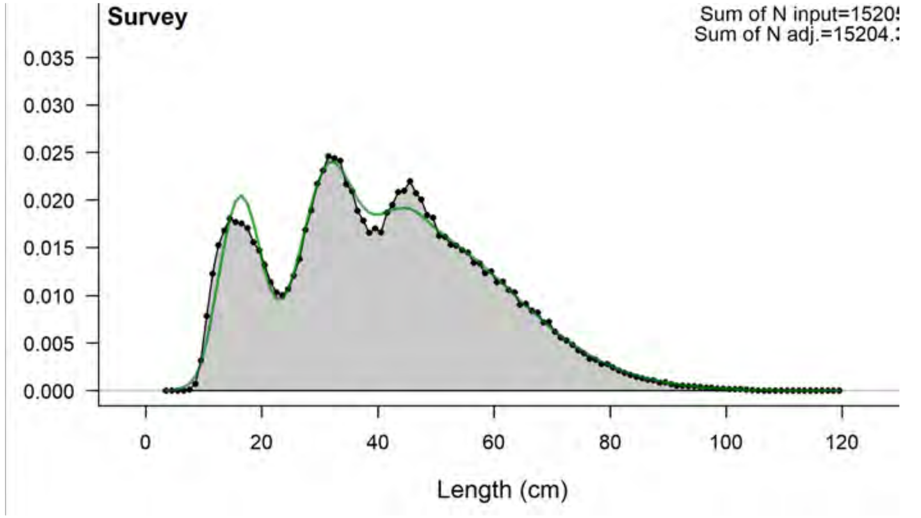
Model 23.1.0.d Results – Survey lengths

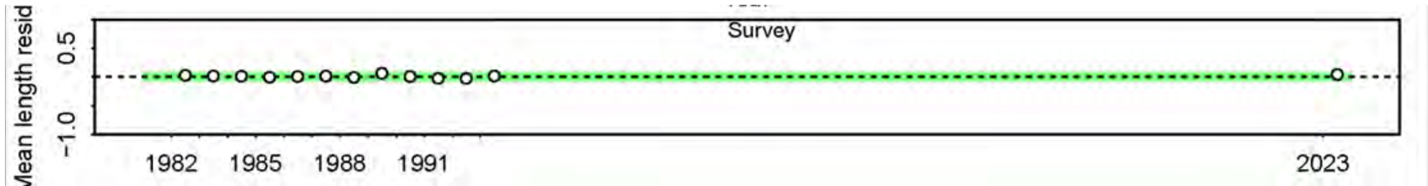
- Good fit to the survey length composition
  - Insignificant autocorrelation in residuals (p-value = 0.625)
  - Tendency to overestimate large modes < 20 cm





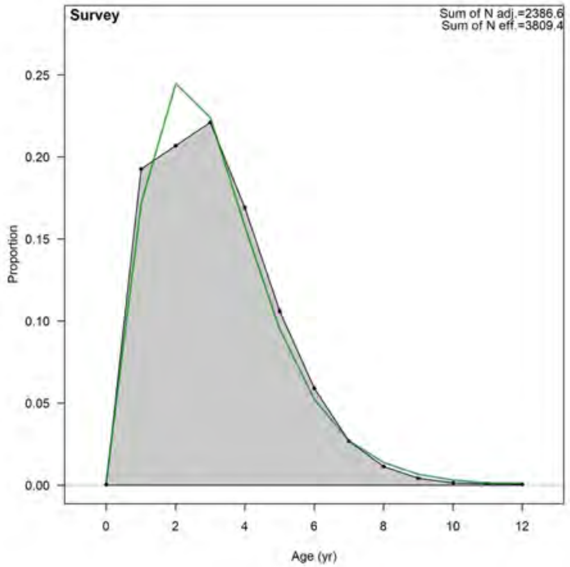


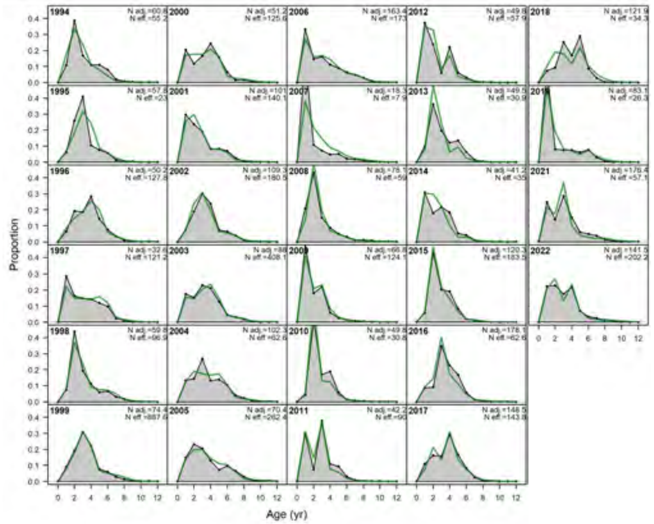


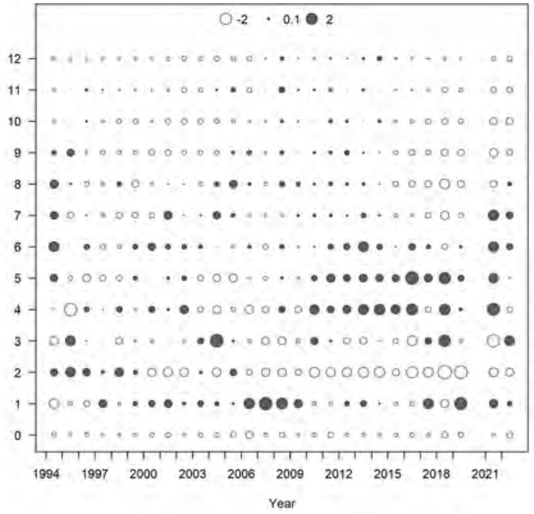


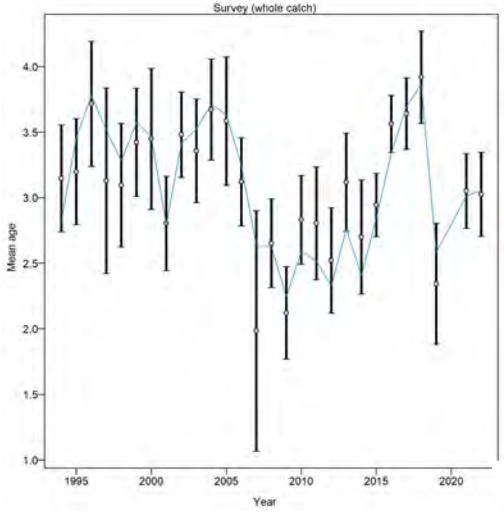
Model 23.1.0.d Results – Survey Ages

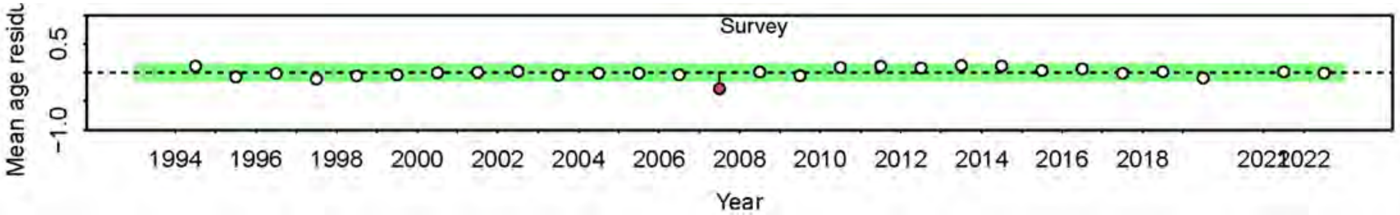
- Good fit to the survey age composition
  - Insignificant autocorrelation in residuals (p-value = 0.128)
  - Good MASE predictive skill (0.23)

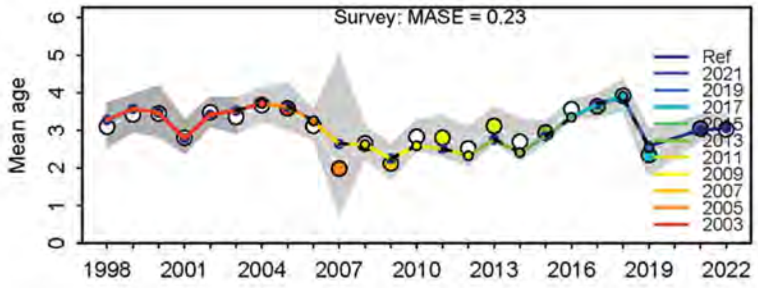






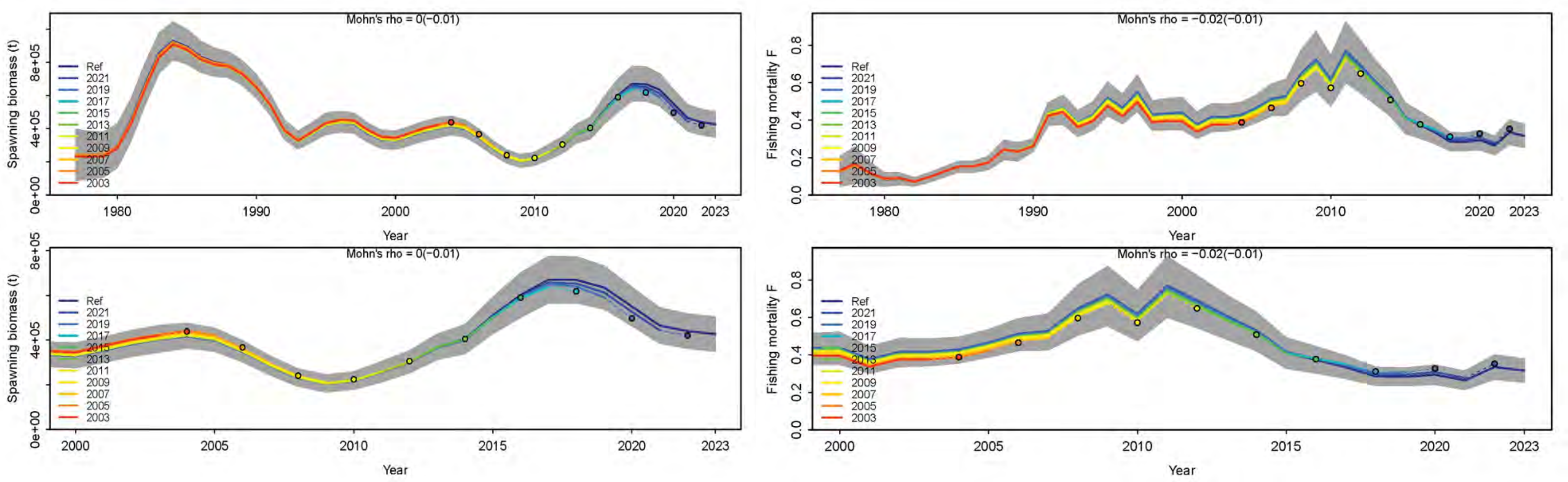






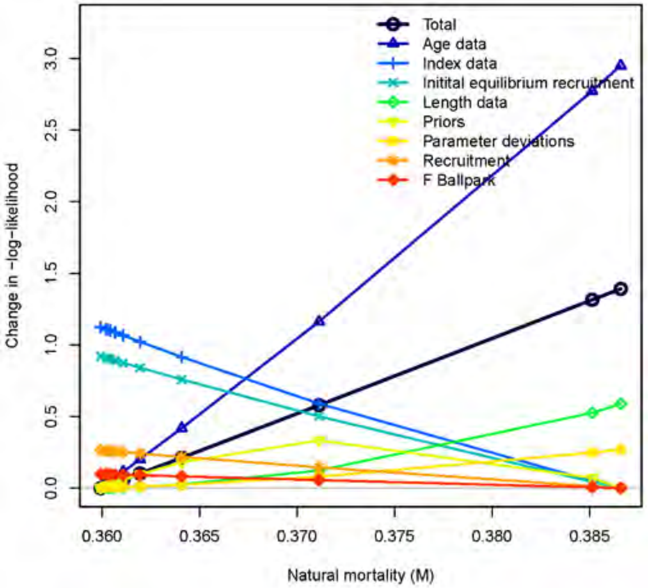
Model 23.1.0.d Results – Retrospective

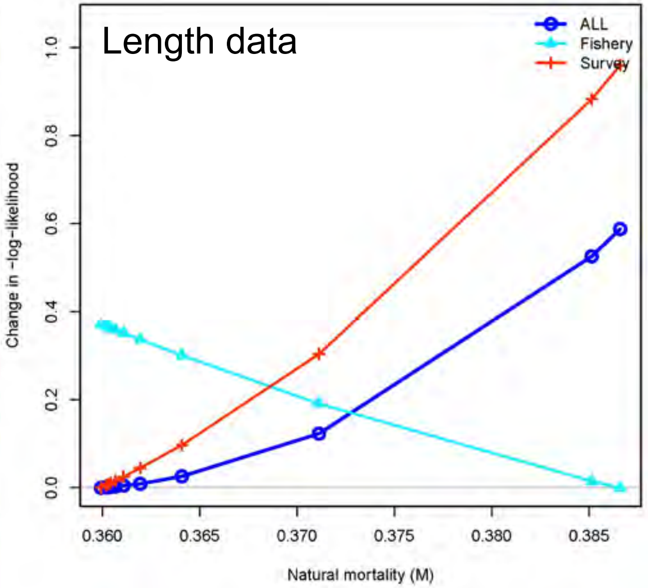
- Good retrospective behavior with low negative retrospective bias for SSB
    - SSB Mohn's ρ = -0.041

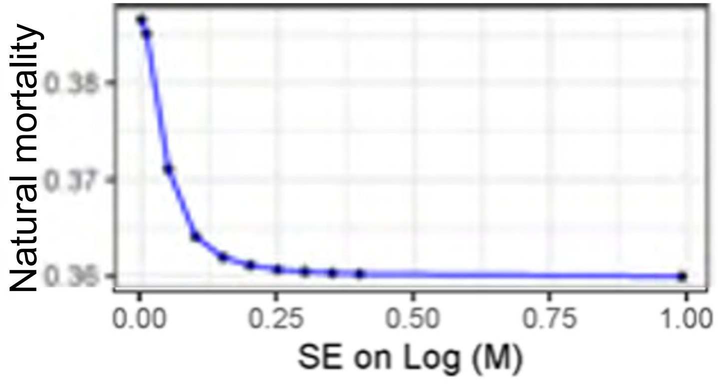


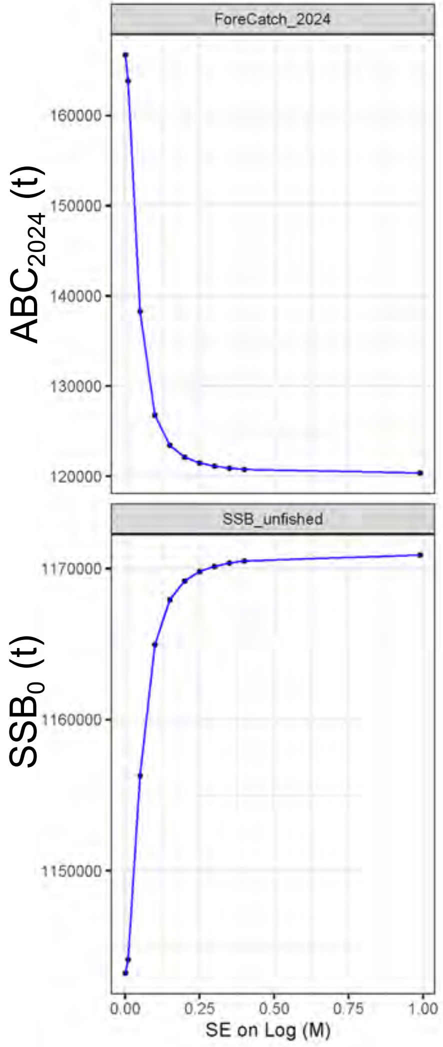
Model 23.1.0.d Results – SE of M Profile

- Profile over SE of the M prior shows model sensitive to assumptions on natural mortality
  - Data conflicts
    - Index and fishery length composition indicate higher M
    - Survey length and age composition indicate lower M



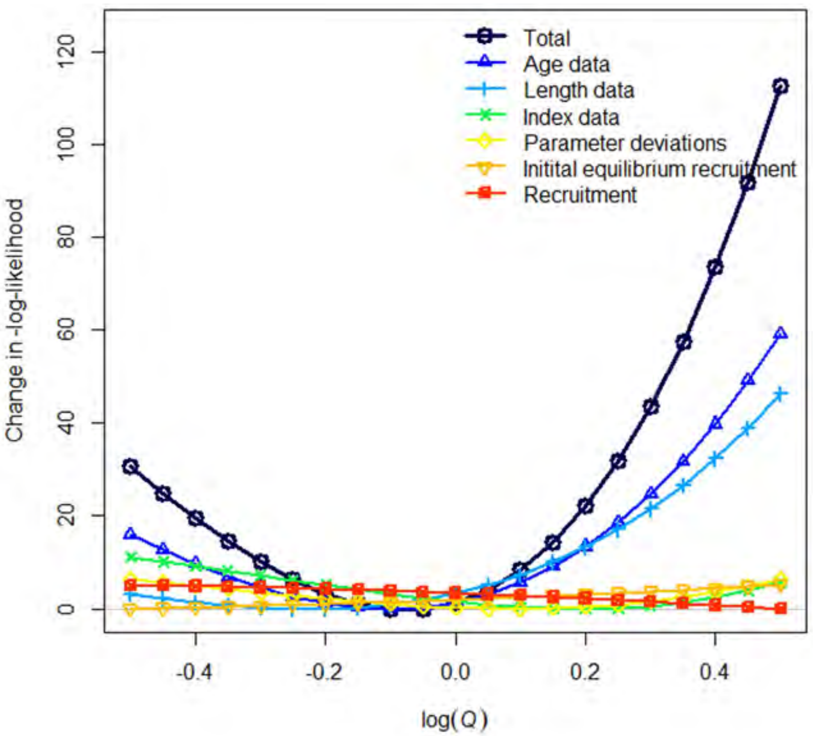


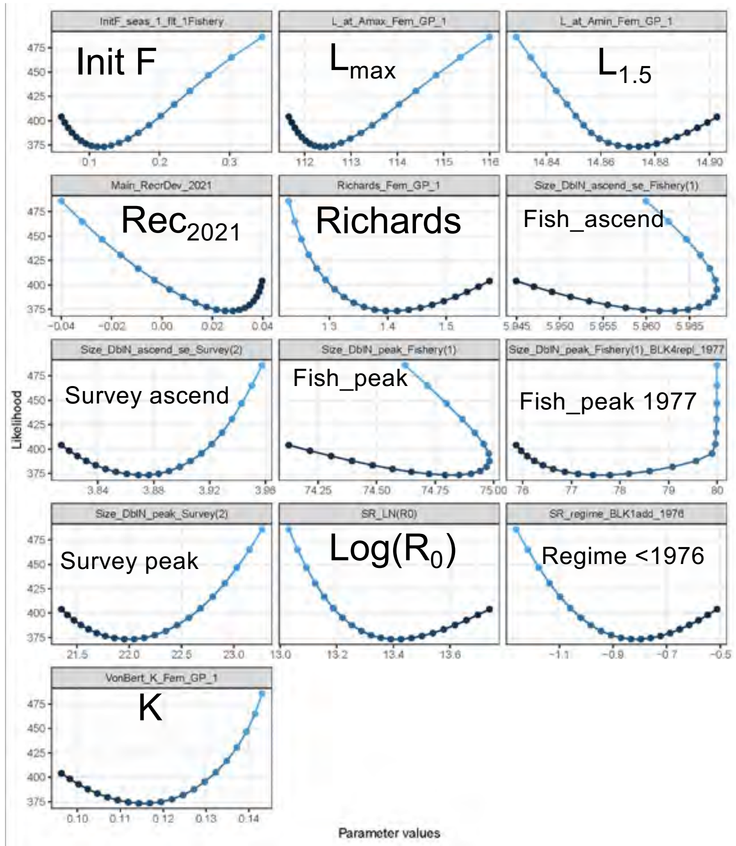


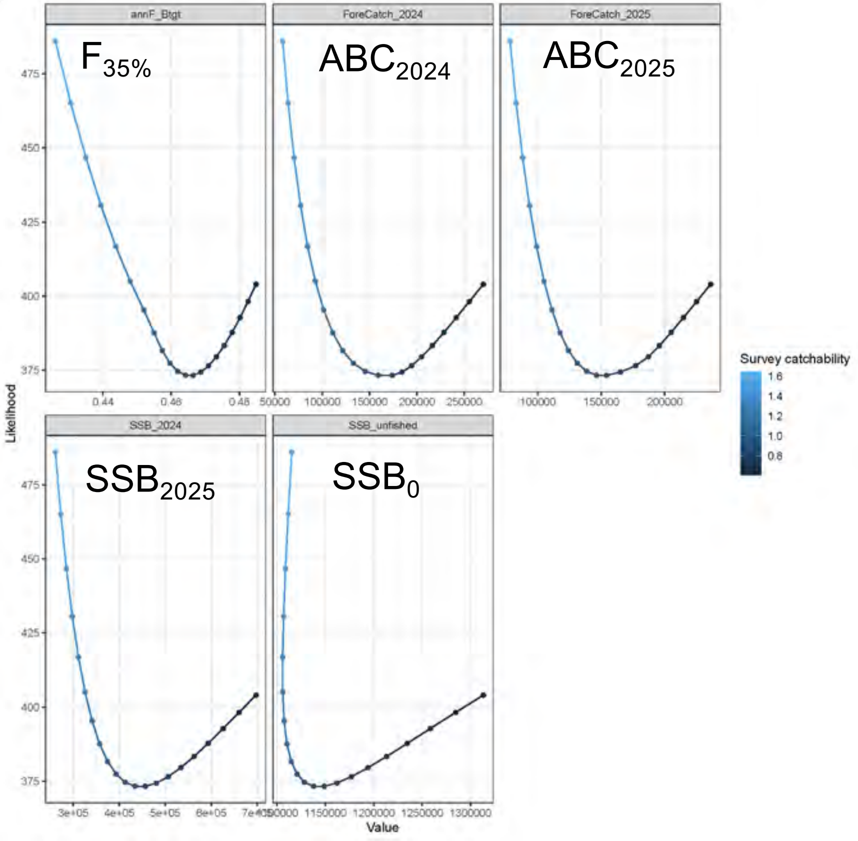


Model 23.1.0.d Results – Q Profile

- Profile over survey catchability shows model with fixed natural mortality less sensitive

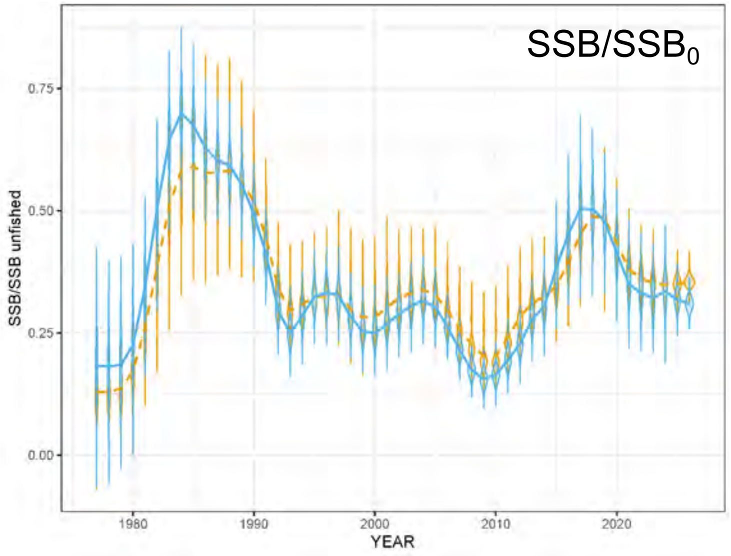


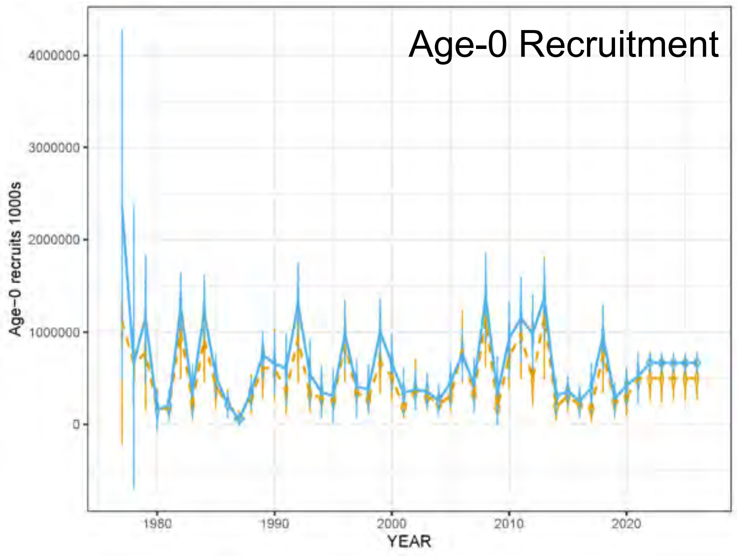


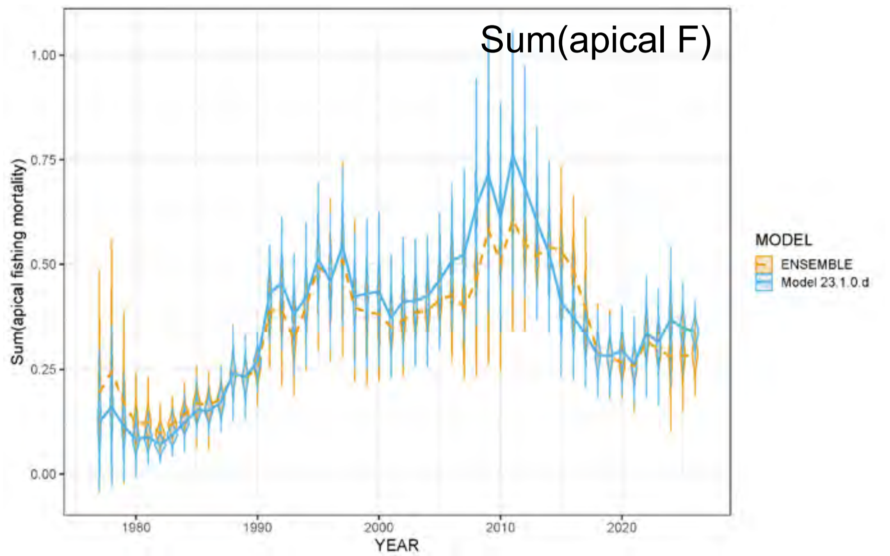


Model 23.1.0.d Timeseries

- SSB - Similar trends to 2022 ensemble
  - Higher peaks and lower troughs
- R - Same peaks and valleys to 2022 ensemble
  - Strong 2018 year class w/ low surrounding year classes
- F - Similar to 2022 ensemble but some key differences
  - Higher F 1991-2015
  - Lower F 2016-2021

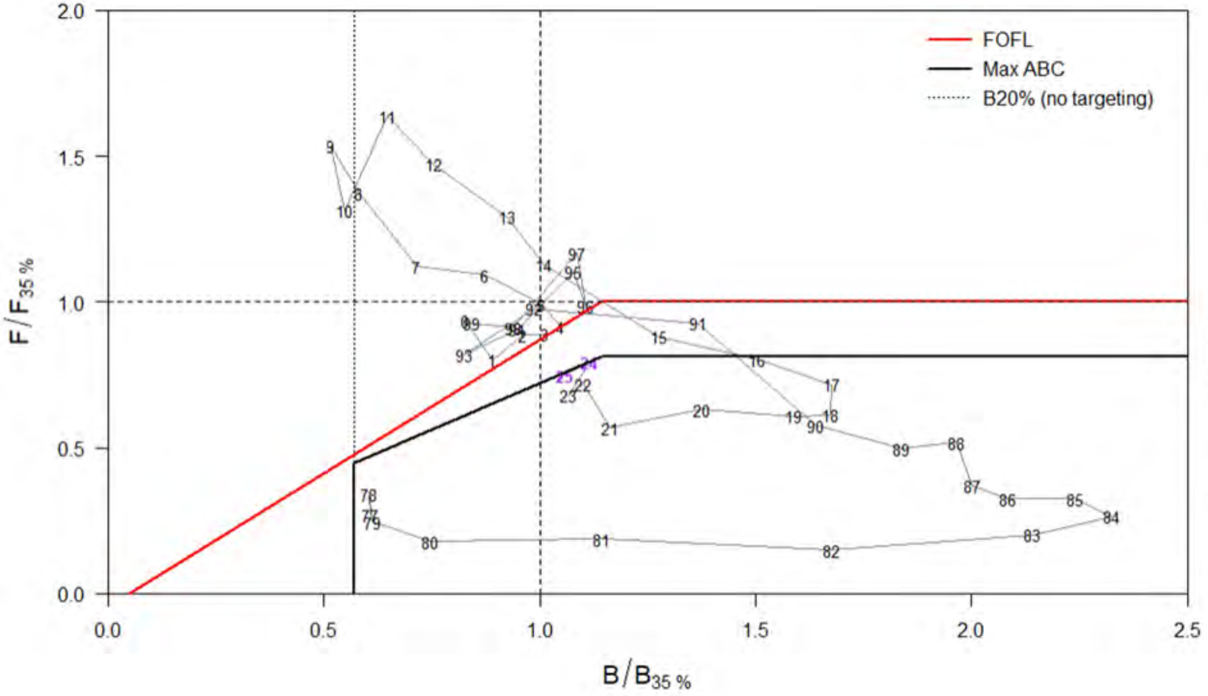


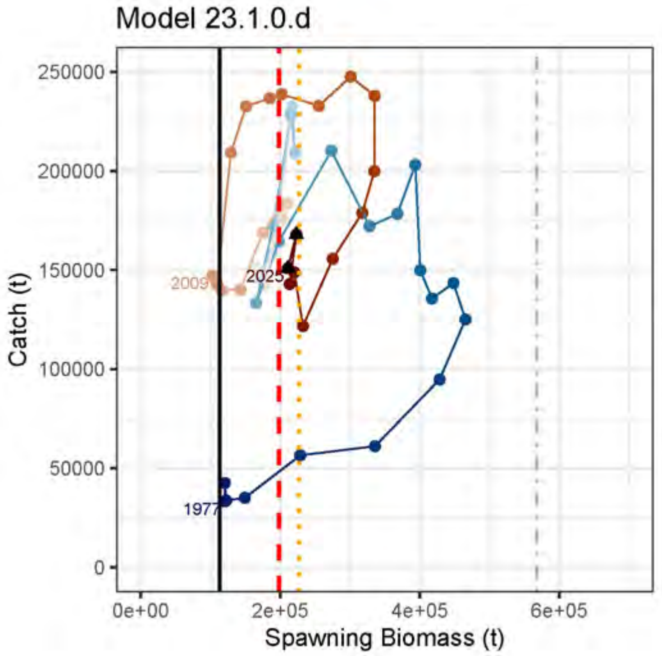


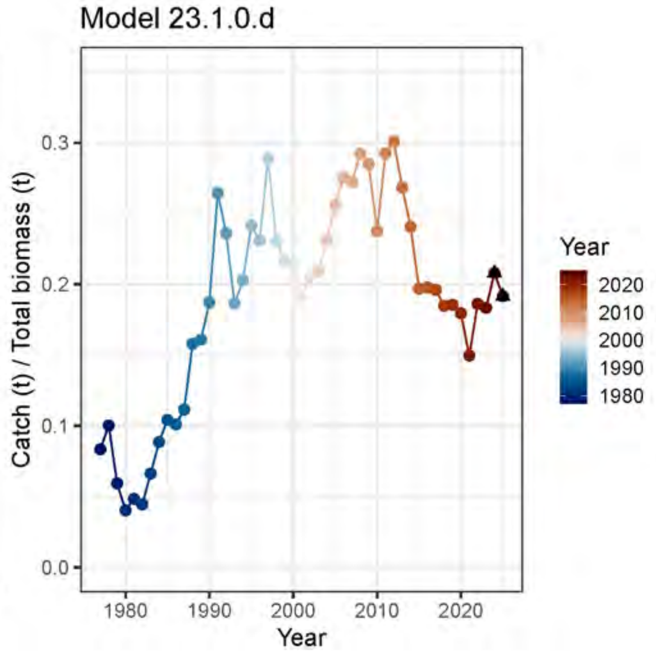


Model 23.1.0.d Timeseries – Phase plane

- Recent lower fishing pressure 2015-2023
- High fishing pressure 2006-2014

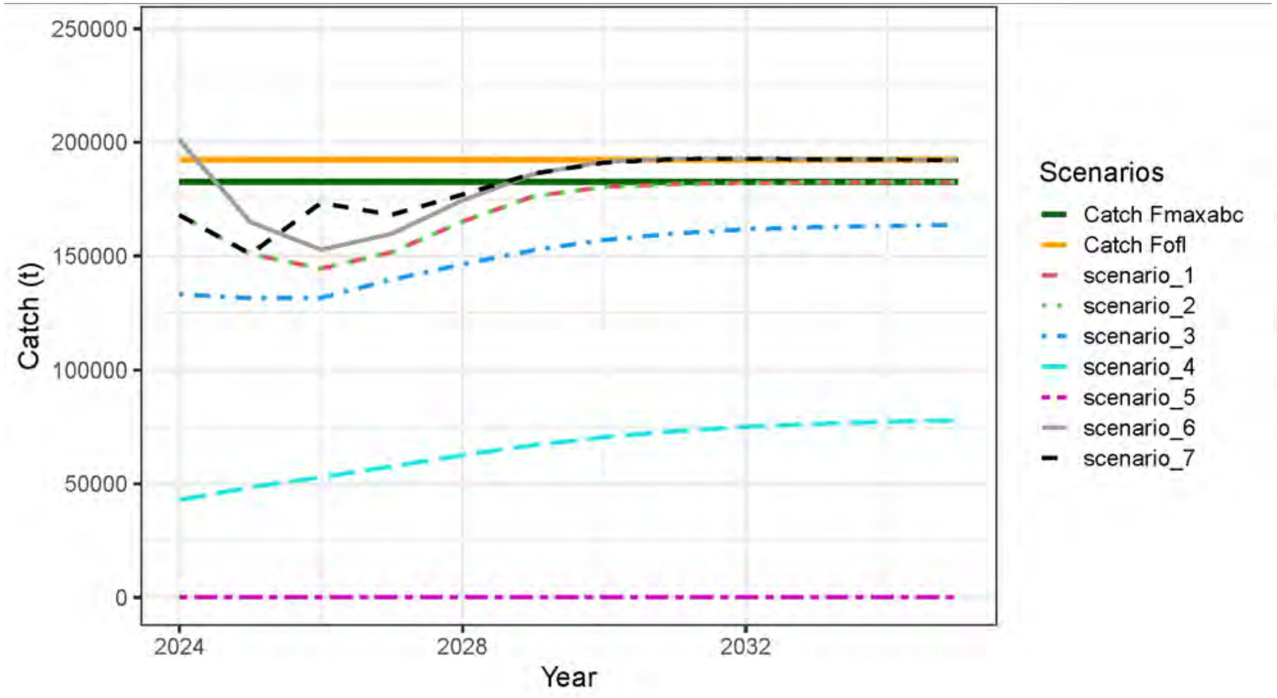


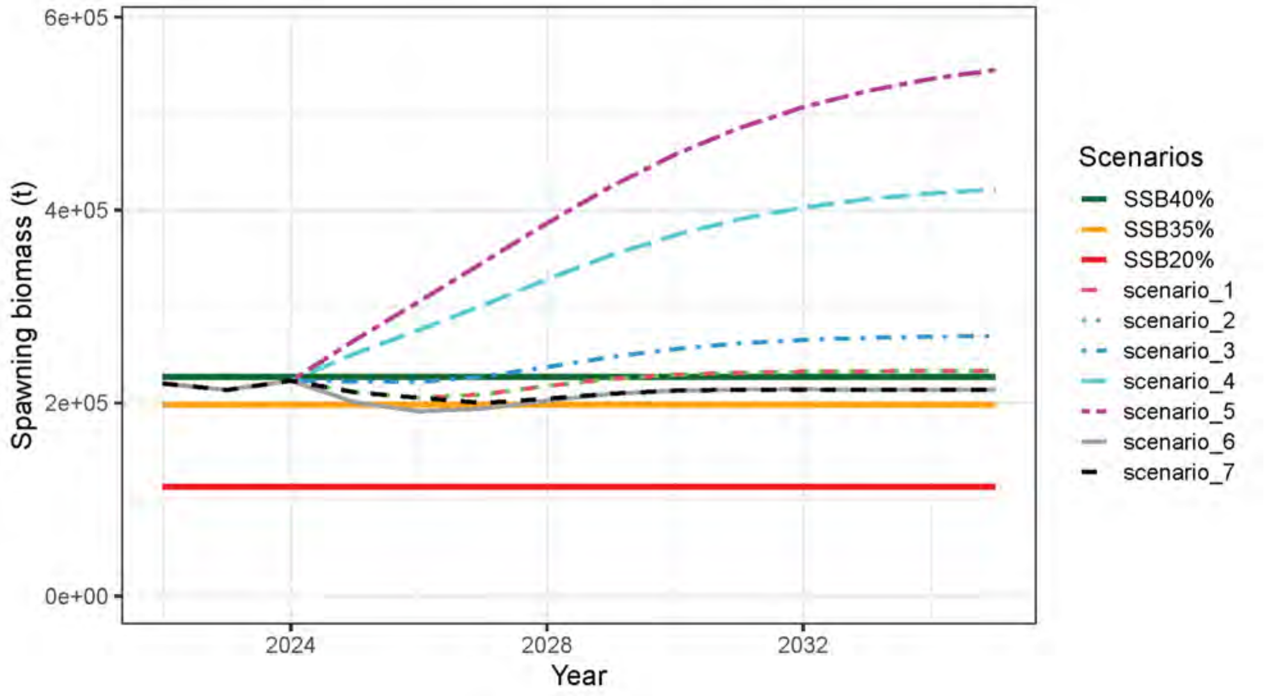




Model 23.1.0.d Projections

- Not overfished or overfishing
- $B_{38\%}$ in 2023 with the expectation of decline through 2026 to a low of $B_{36\%}$
- Under all scenarios above $B_{35\%}$ by 2035

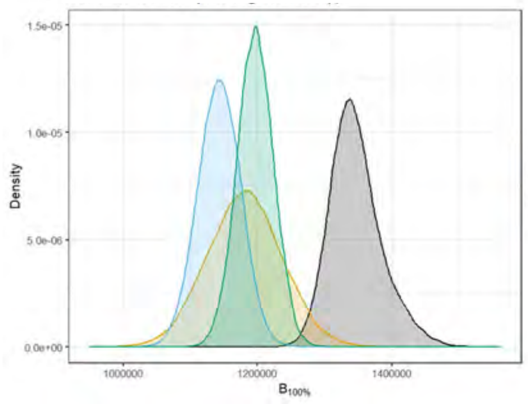




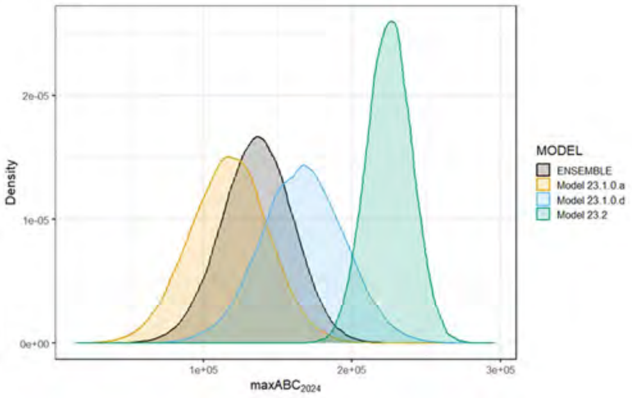
Model 23.1.0.d Projections

- Higher M and lower $B_{100\%}$ results in higher F and higher ABC/OFL
- No risk table concerns
- Not overfished or overfishing

$B_{100\%}$



$maxABC_{2024}$

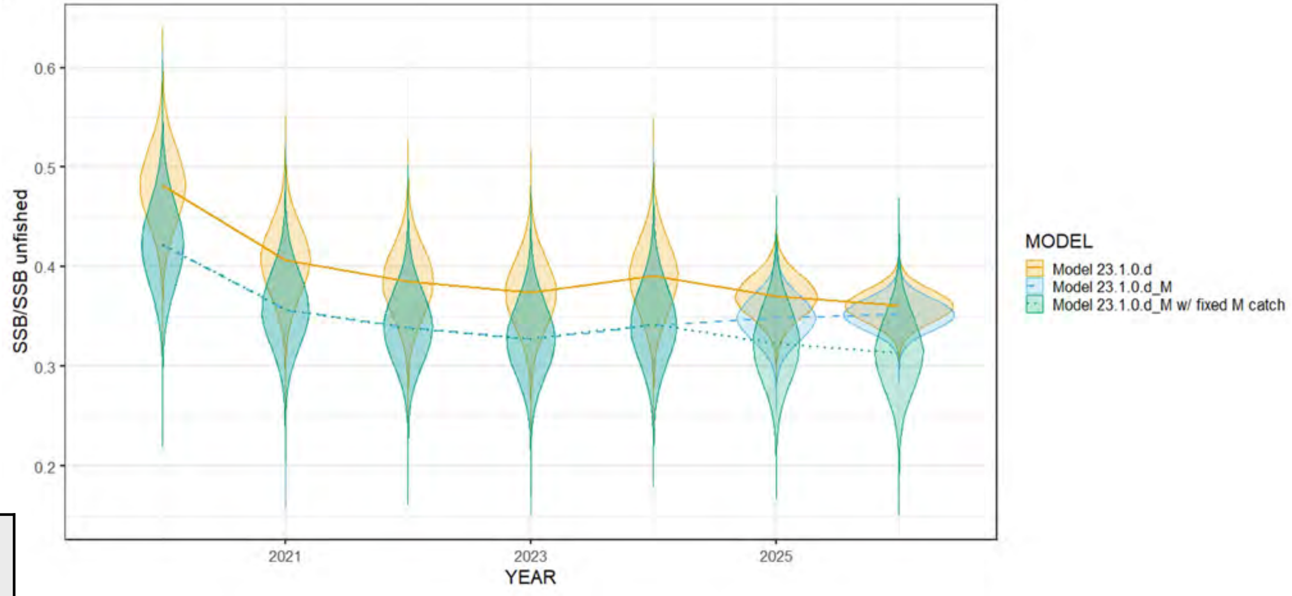


Assessment-related	Population dynamics	Environmental/ ecosystem	Fishery Performance
Level 1: No Concern	Level 1: No Concern	Level 1: No Concern	Level 1: No Concern

Quantity	As estimated or *specified last* year for: 2023	2024	As estimated or *recommended this* year for: 2024*	2025*
M (natural mortality rate)	0.34	0.34	0.386	0.386
Tier	3b	3b	3b	3b
Projected total (age 0+) biomass (t)	844,578	831,566	808,203	787,837
Projected female spawning biomass (t)	245,594	242,911	223,107	211,131
$B_{100\%}$	668,477		567,465	
$B_{40\%}$	267,391		226,986	
$B_{35\%}$	233,467		198,612	
F_{OFL}	0.36	0.35	0.46	0.43
$maxF_{ABC}$	0.29	0.29	0.37	0.35
F_{ABC}	0.29	0.29	0.37	0.35
OFL (t)	172,495	166,814	200,995	180,798
maxABC (t)	144,834	140,159	167,952	150,876
ABC (t)	144,834	140,159	167,952	150,876
Status	As determined *this* year for: 2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 23.1.0.d Assumptions on M

- What if our assumptions on M are wrong?
  - Projection of SSB with catch set at ABC from Model 23.1.0.d but with lower M shows increase in uncertainty and lower status in projections to 2026



	Model 23.1.0.d fixed natural mortality w/ catch at fixed maxABC	Model 23.1.0.d Fit natural mortality w/ catch at fit maxABC	Model 23.1.0.d Fit natural mortality w/ catch at fixed maxABC
$B_{2025}/B_{100\%}$	0.370	0.348	0.322
$B_{2026}/B_{100\%}$	0.360	0.352	0.313
$Pr(B_{2025} > B_{35\%})$	82.45%	46.86%	22.96%
$Pr(B_{2026} > B_{35\%})$	74.34%	55.21%	15.60%
$Pr(B_{2025} < B_{20\%})$	<0.001%	<0.001%	0.055%
$Pr(B_{2026} < B_{20\%})$	<0.001%	<0.001%	0.111%

Thank You!

Questions?

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