Assessment of the Yellowfin Sole Stock in the Bering Sea and Aleutian Islands

Ingrid Spies, Meaghan Bryan, Lewis Barnett, Emily Markowitz, Zack Oyafuso, Elizabeth Siddon

November 14,2023Presentation to the Bering Sea and Aleutian Islands Plan Team

NOAA FISHERIES

Selected SSC comments (SSC December 2022)

SSC: The SSC recommends that for future Tier 1-3 assessments some consideration be given as to how best to represent biomass estimates in the Executive Summary table for each stock (currently, model total biomass and spawning stock biomass are provided) so that the relationship of the biomass to the OFL and ABC in the stock status table is clear.

Authors' response: Within the document we include biomass estimates that are based on all age classes. However, the estimates involve an application of expected age-specific selectivity which can be variable. Therefore, ABC and OFL are calculated from age 6+ fish because the fishery does not select for ages 5 and under. This should serve as a reasonable proxy for considering ABC and OFLs in the context of exploitation rates.

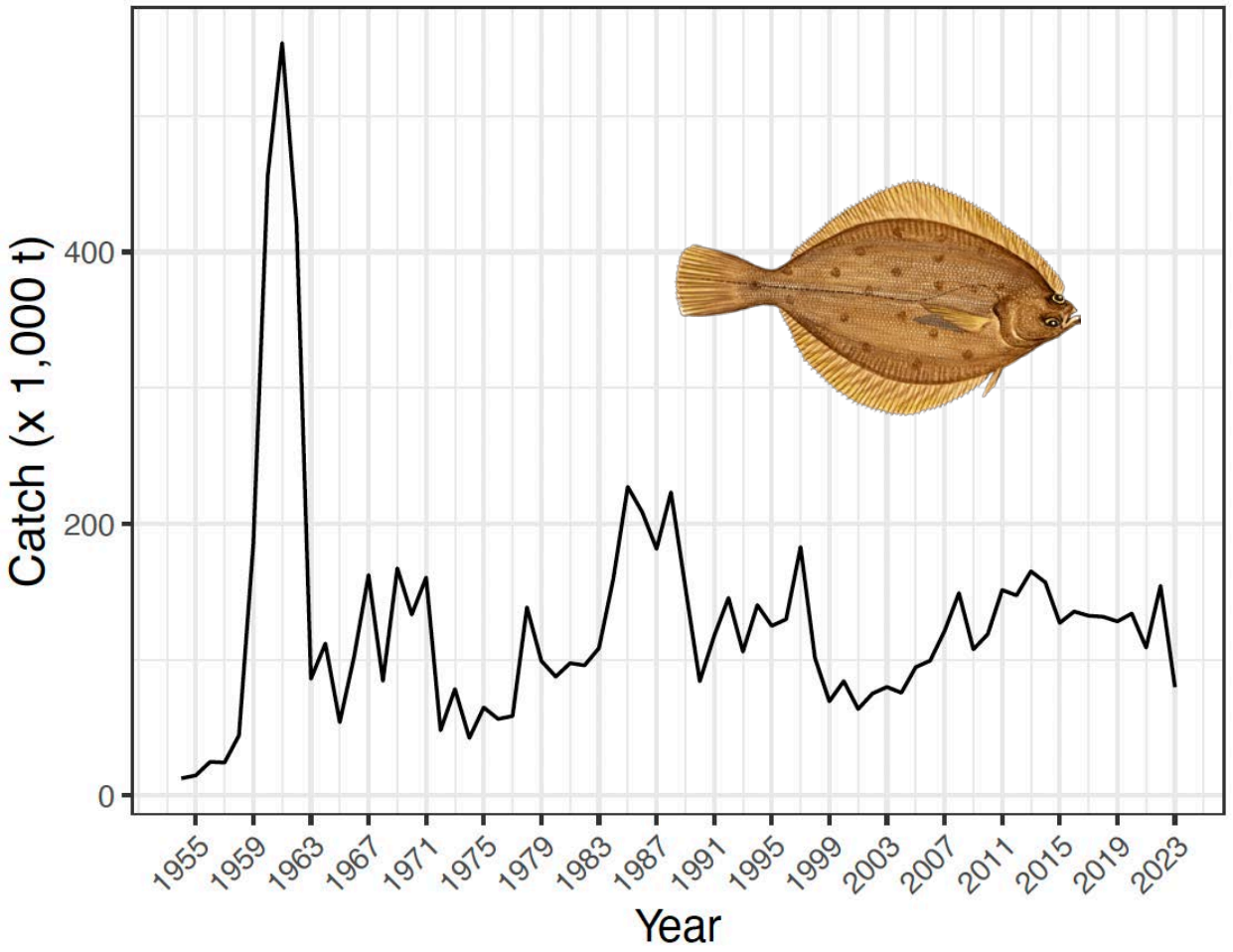
Selected SSC comments (SSC December 2022)

SSC: For all assessments using VAST, the SSC requests a figure comparing the VAST estimate used in the previous assessment to the current assessment (if new data are added), noting that VAST will refit the time series when additional data are added, and the estimated extent and directionality of spatial correlation may change. The SSC anticipates the changes will likely be small; however, given these are new methods for many assessments, this figure would provide information on the stability of estimates.

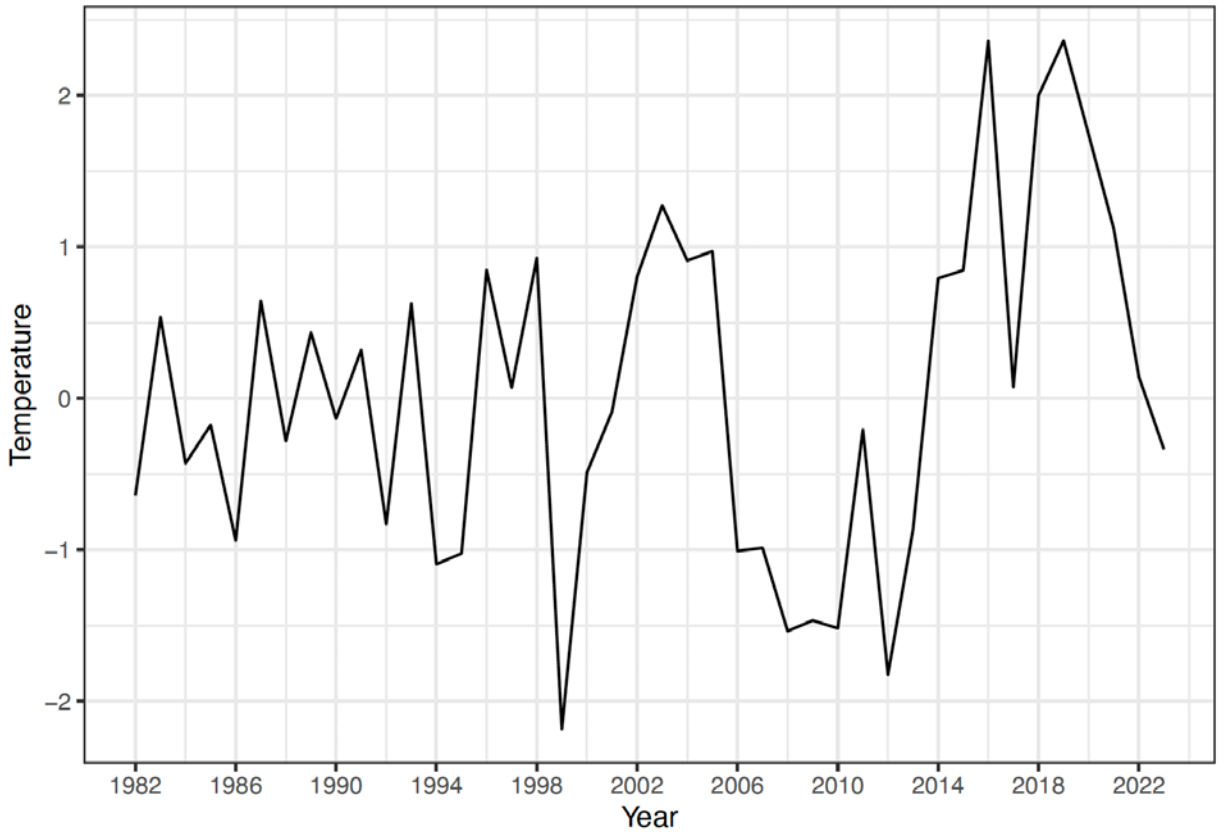
Authors' response:
This figure has been created, see Figure 1.

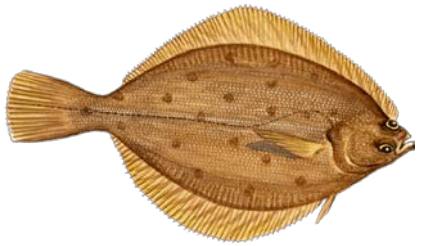
Fishery and catch

Yellowfin sole annual total catch (1,000s t) in the eastern Bering Sea from 2003-2023

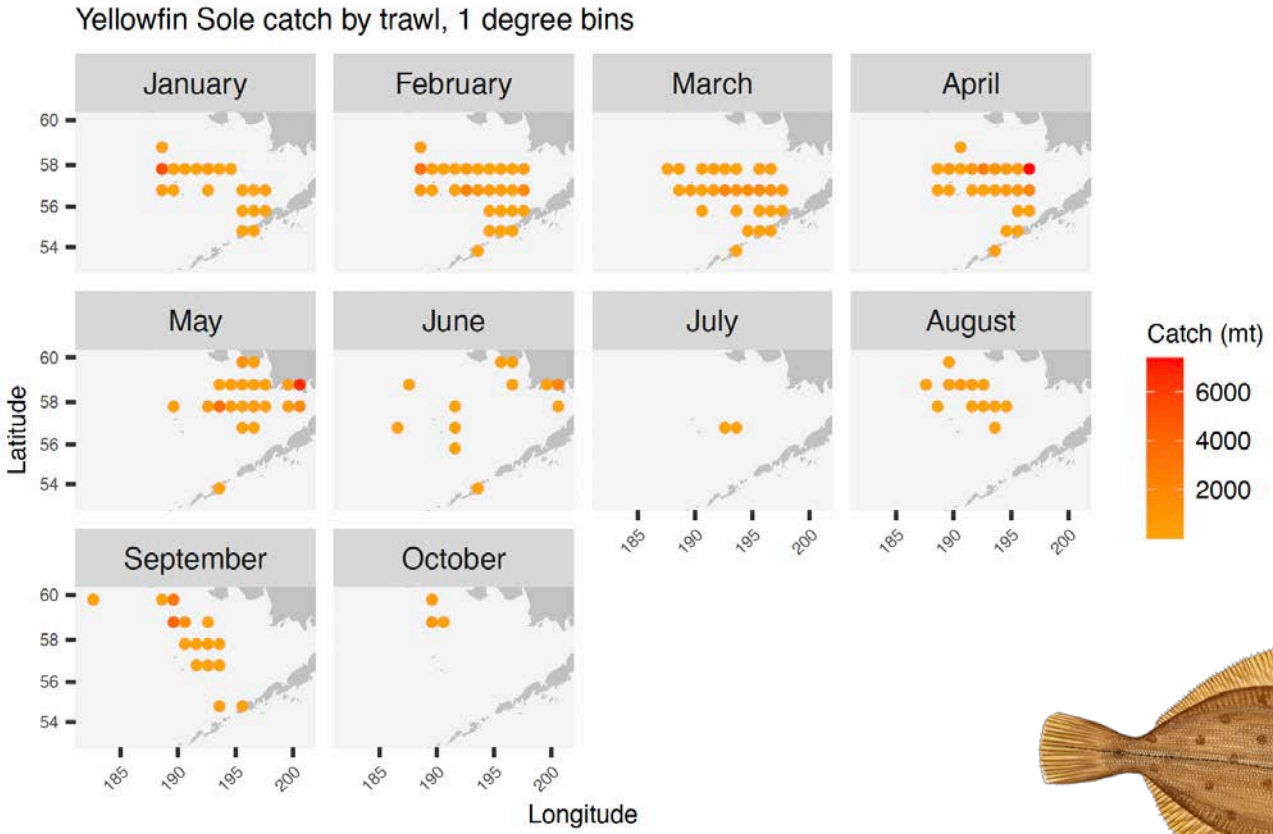


Bottom temperature anomalies from the NMFS survey <100 m, 1982-2023

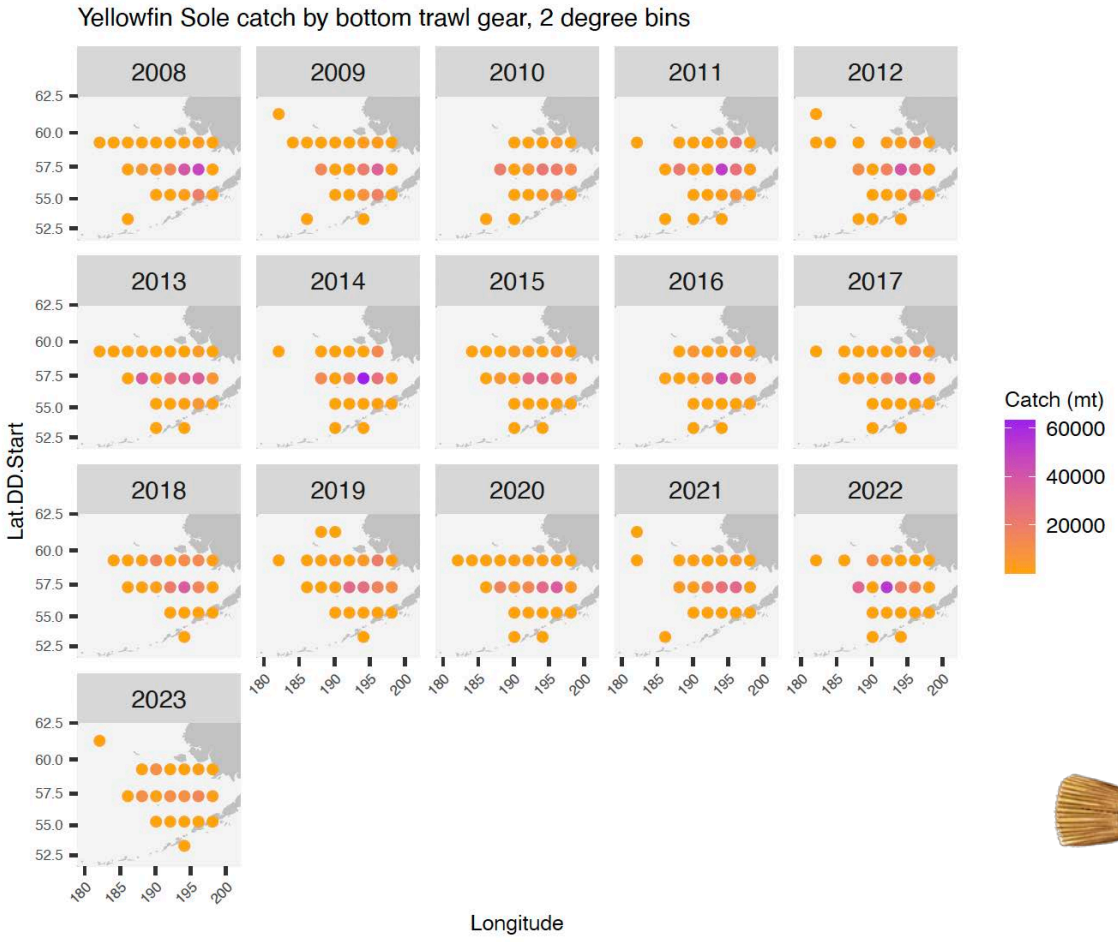


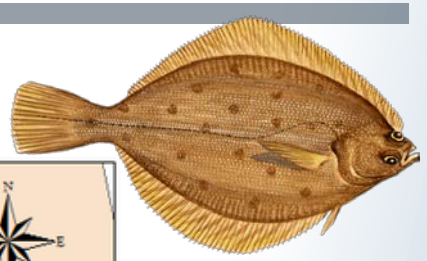


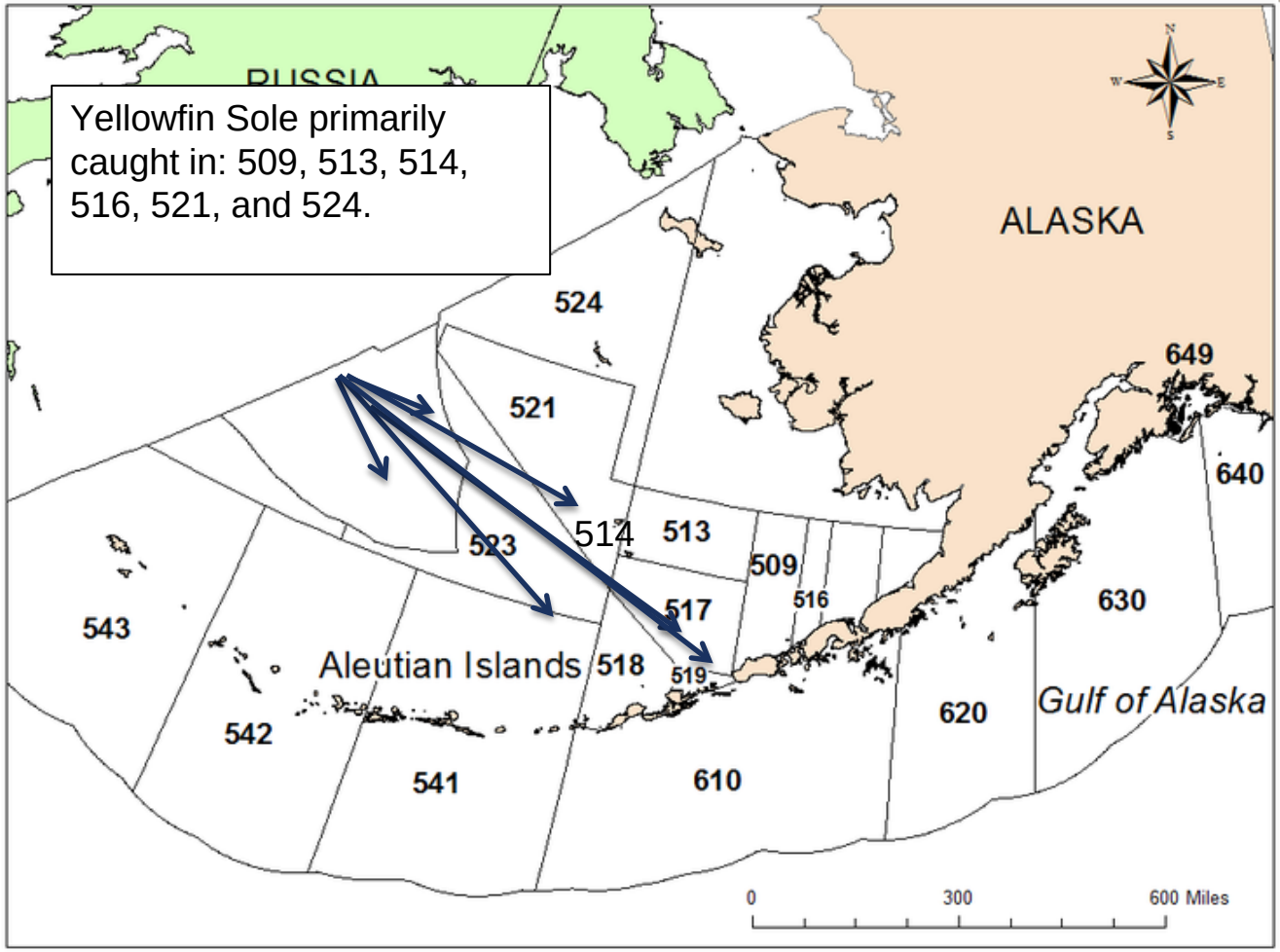
Catch and CPUE in 2023 were strong until June when demand decreased.



Catch of yellowfin sole by non-pelagic trawl gear in the eastern Bering Sea, 2008-2023, by year, reported by observers.

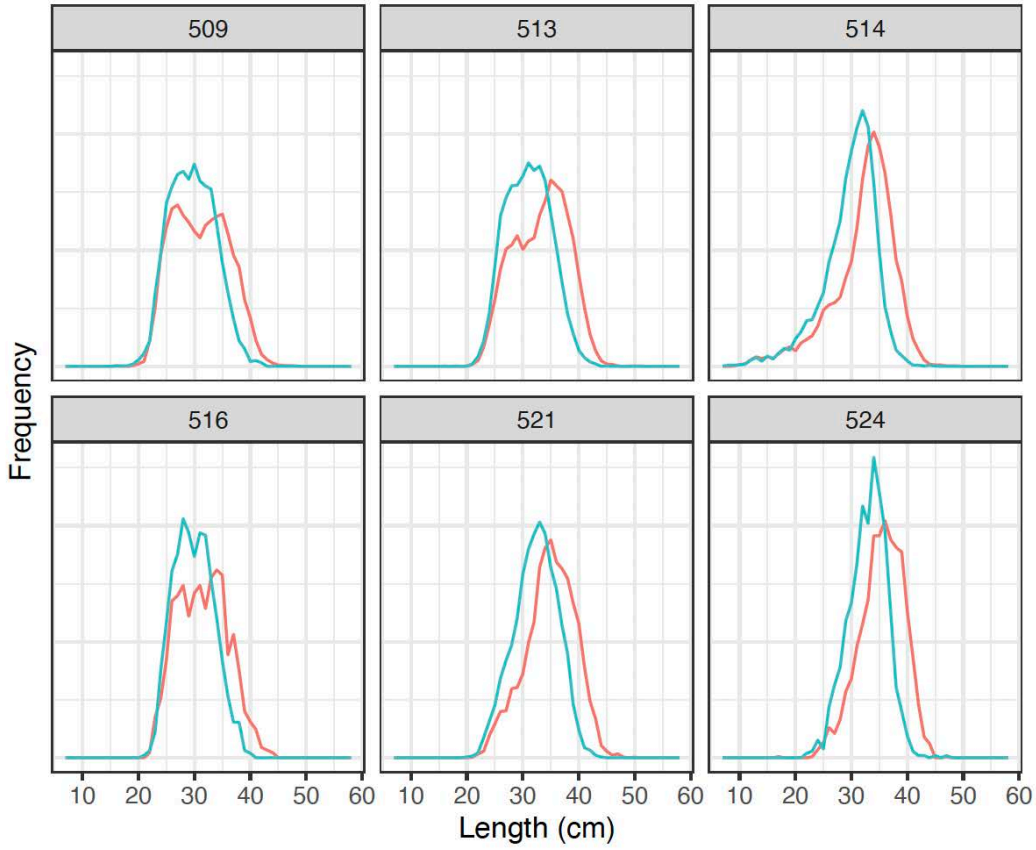


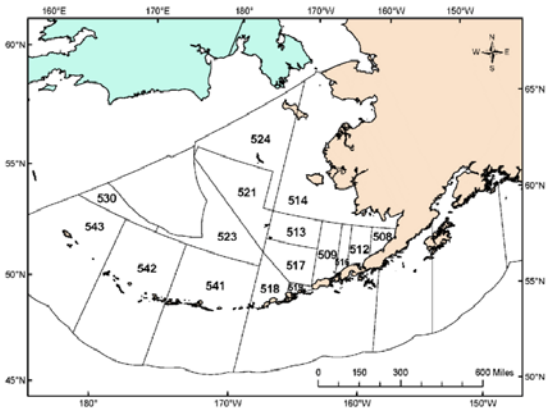




NOAA FISHERIES

Size composition of the yellowfin sole catch in 2023 caught by trawl gear, by subarea





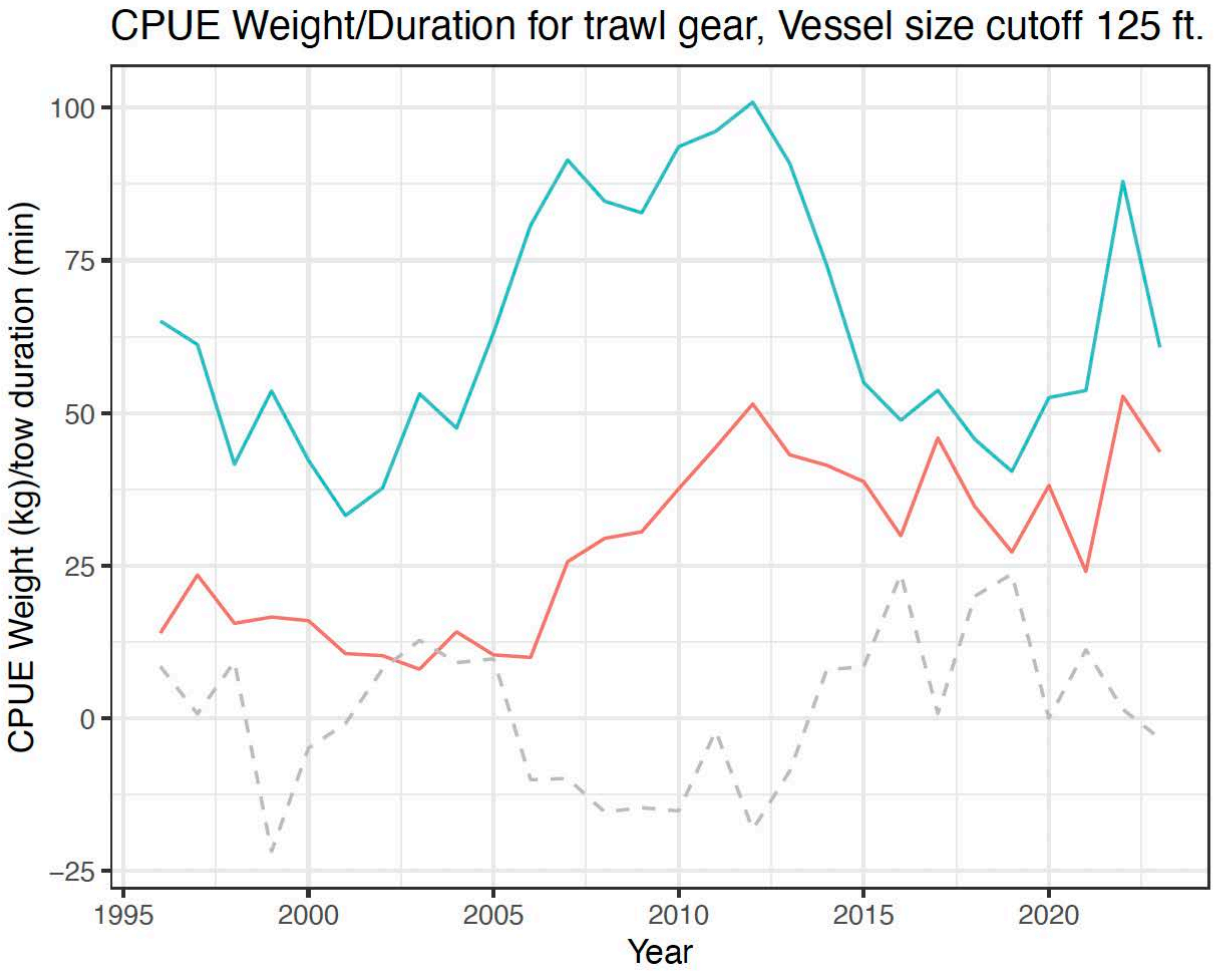
Sex

Females

Males

Primary areas where yellowfin sole are caught: 509, 513, 514, 516, 521, and 524.

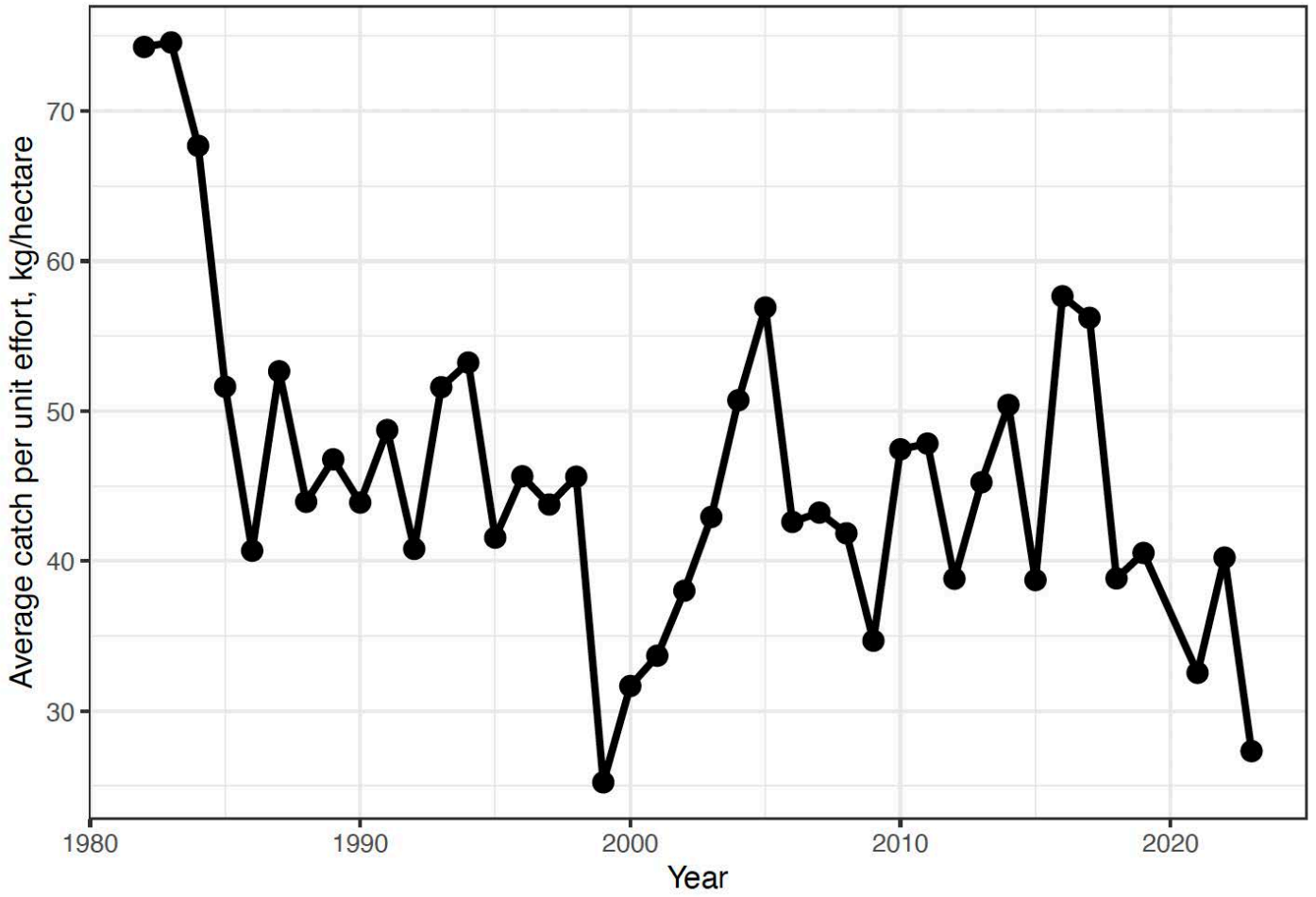
Catch per unit effort based on yellowfin sole fishery data, 1996-2023



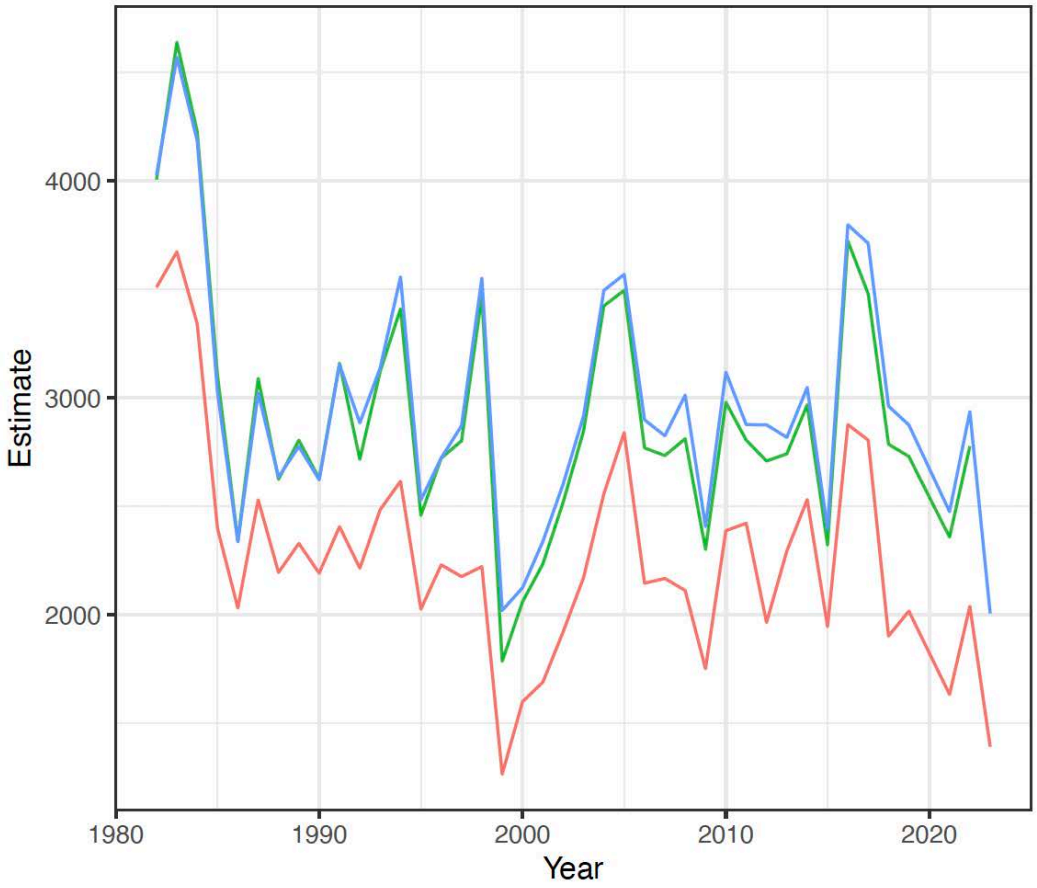
The EBS bottom temperature anomalies from 1996-2023 (x10 for visualization) are shown as a dotted line.

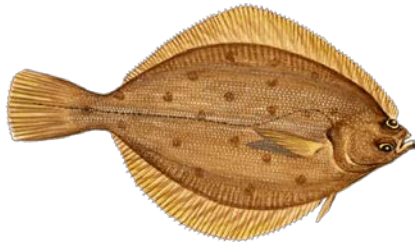
Survey

Average catch per unit effort on NMFS eastern Bering Sea surveys, 1987-2022, in kg/hectare

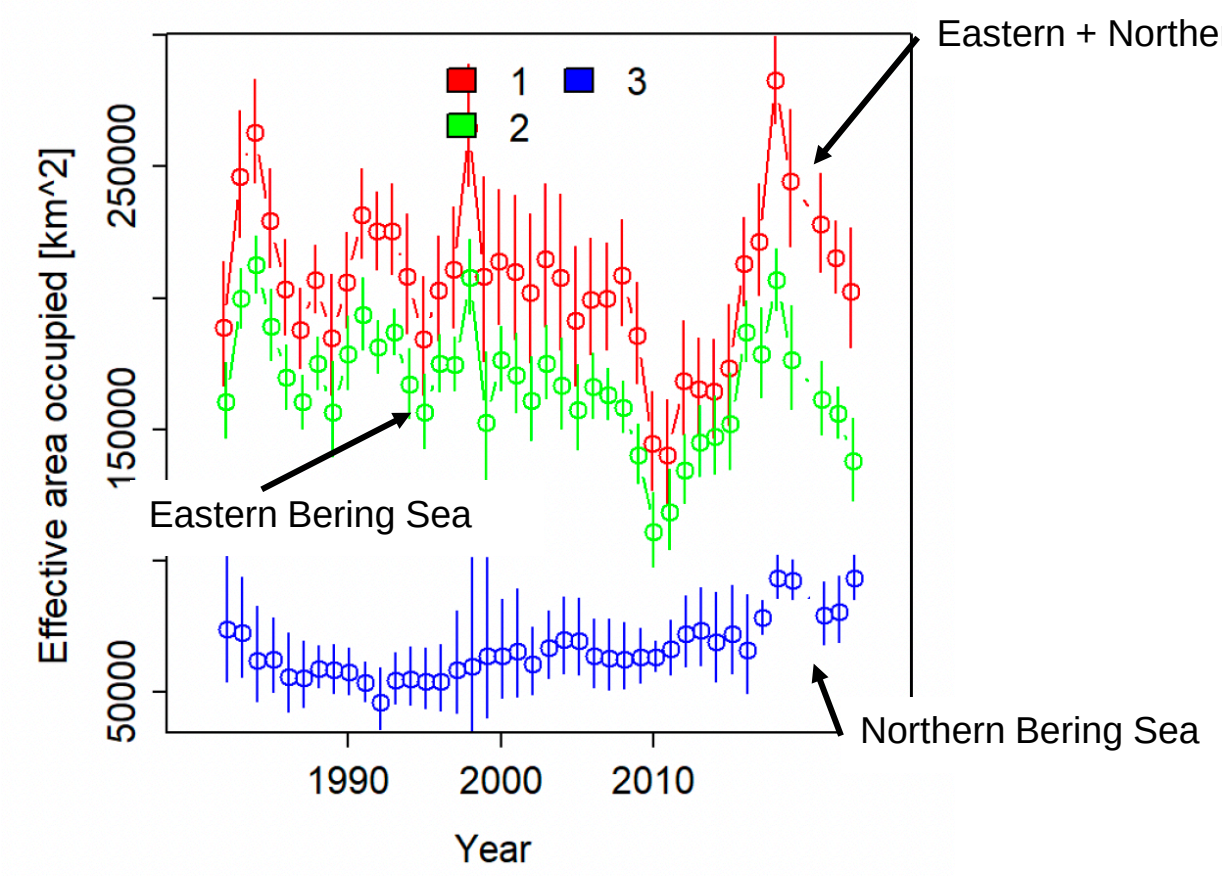


VAST biomass estimates for the EBS+NBS, generated in 2023 (VAST_2023) and 2022 (VAST_2022), and design-based estimate for the eastern Bering Sea only (DB_2023)

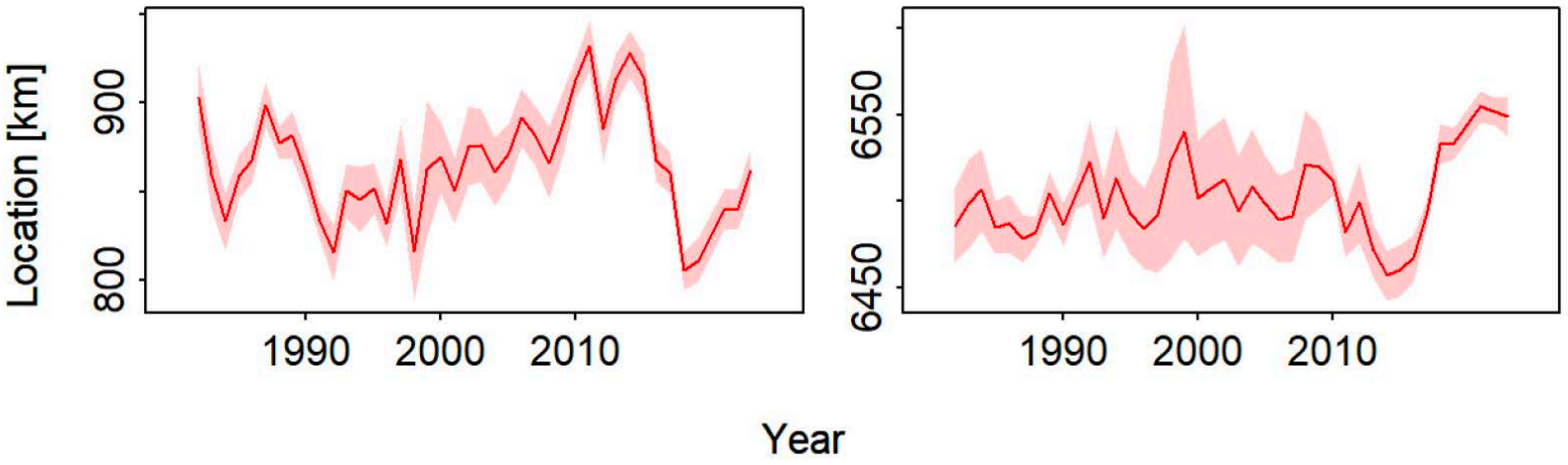




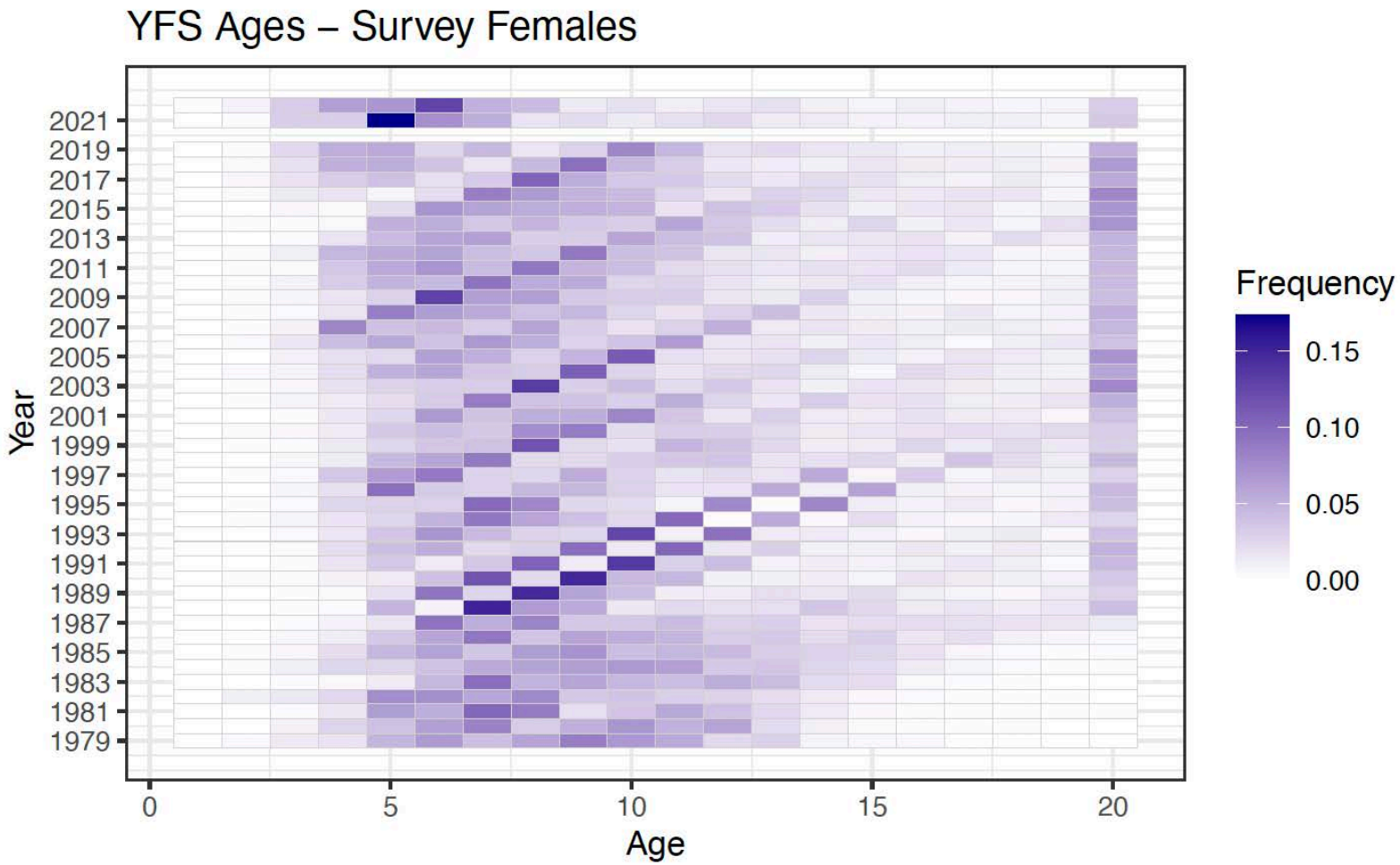
The effective area occupied by yellowfin sole (VAST).



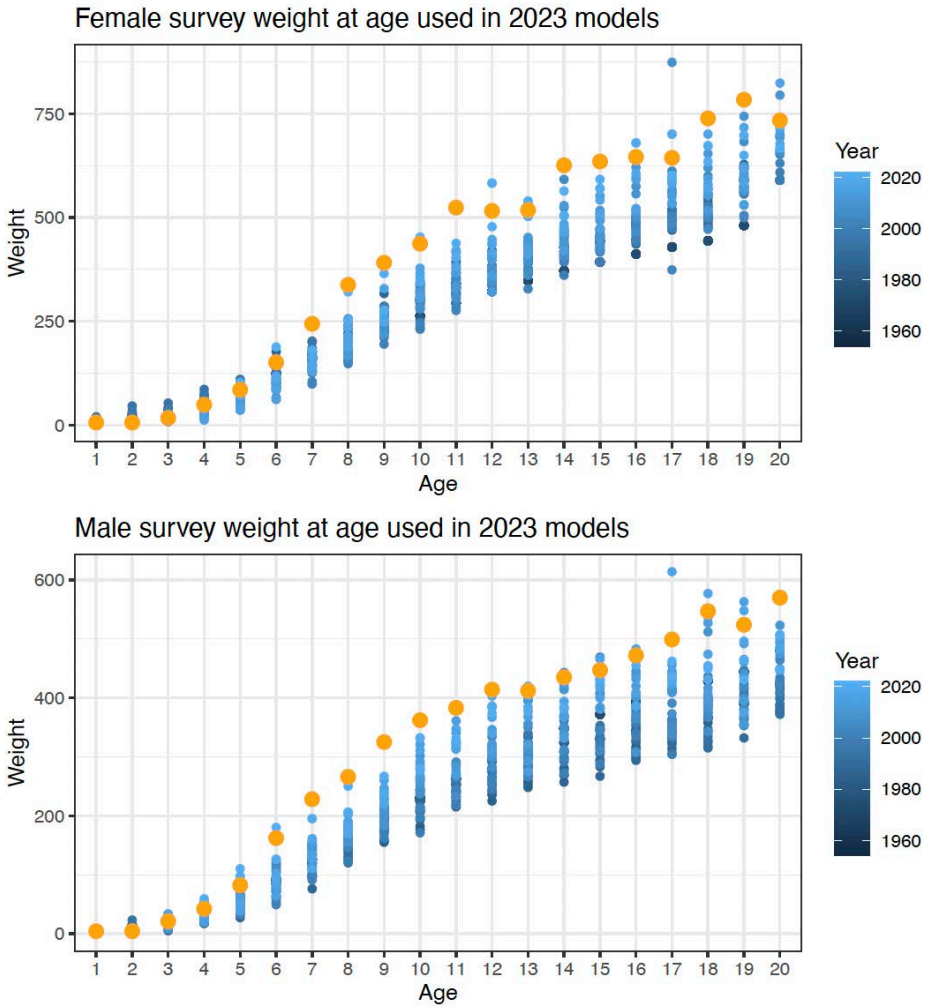
Center of gravity plot with eastings (Longitude) in the left panel and northings (Latitude) in the right panel for VAST index estimate (EBS+NBS)



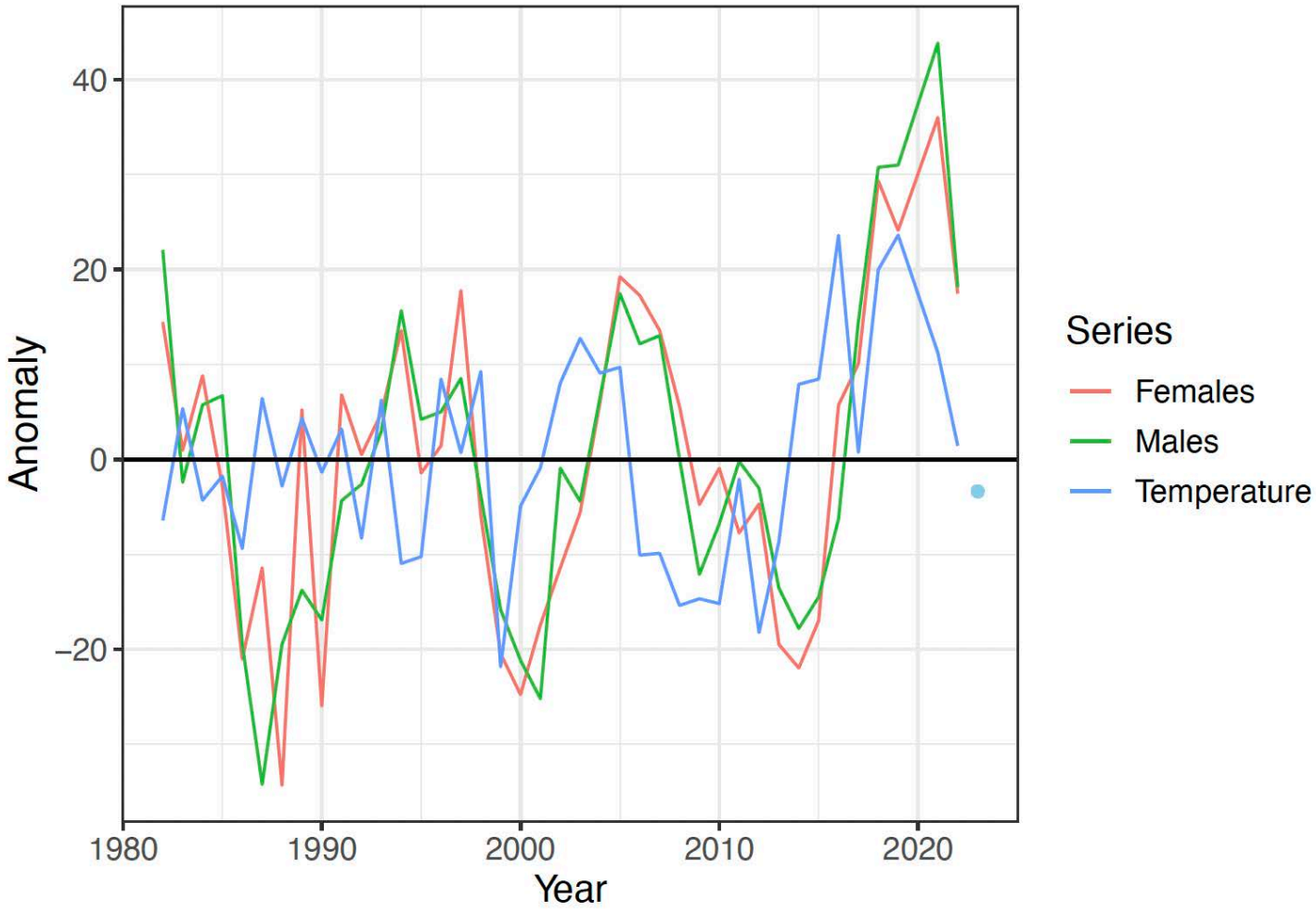
Age frequency of yellowfin sole females and males from the AFSC/NMFS research surveys, 1977-2022



Mean weight at age (g) for yellowfin sole females and males from the EBS survey,1954-2023 used in Model 22.1, 23.0



Yellowfin sole length-at-age anomalies, for 5-year old males and females, and bottom temperature anomalies from the eastern Bering Sea survey area <100 m.



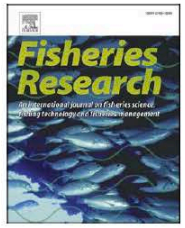
New maturity index for Northern Bering Sea yellowfin sole

Fisheries Research 252 (2022) 106335

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres



Check for updates

Delineating yellowfin sole (*Limanda aspera*) reproduction in the northern Bering Sea provides information across the eastern Bering Sea continental shelf

Todd T. TenBrink

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115, USA

Models

2023 Models – BSAI yellowfin sole

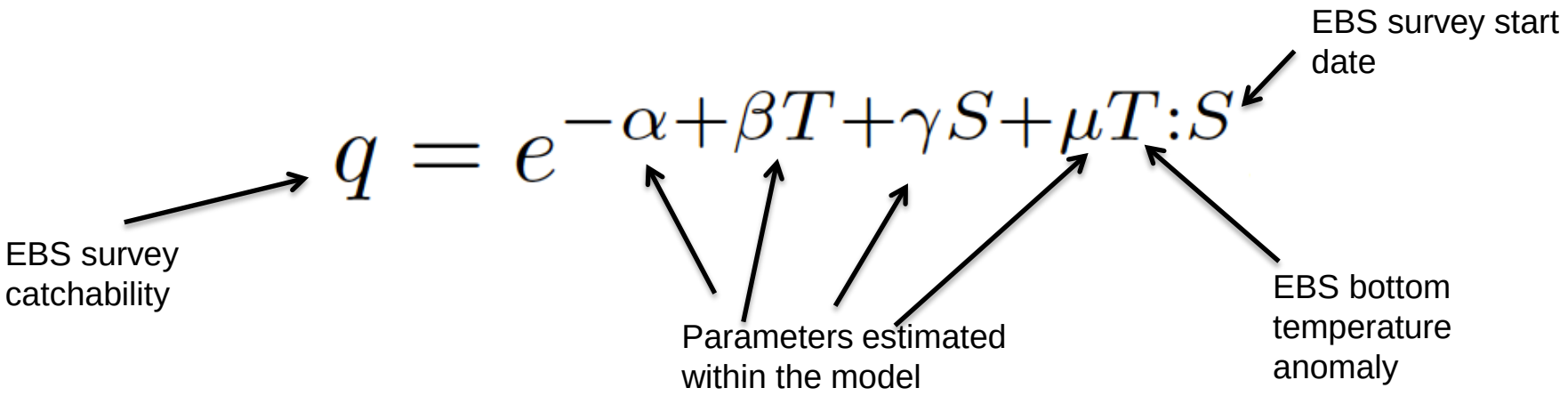
- Model 22.1
  - Accepted by the BSAI Plan Team and the SSC in 2022.
  - Survey biomass index data (1982-2023) and age compositions used VAST estimates for the combined EBS and NBS.
- Model 23.0
  - Same as Model 22.1,
  - EXCEPT a single-sex fishery selectivity rather than a separate fishery selectivity for males and females. Same as Model 22.1,
  - Authors' preferred model.

Data used in Models 22.1 and 23.0

Data source	Year
Fishery catch	1954 - 2023
Fishery age composition	1964 - 2022
Fishery weight-at-age	Catch-at-age methodology
Survey biomass and standard error	1982 - 2023 (not 2020)
Bottom temperature	1982 - 2023
Survey age composition	1979 - 2022 (not 2020)
Annual length-at-age and weight-at-age from surveys	1979 - 2022 (not 2020)
Age at maturity	Combined 1992 and 2012 sample

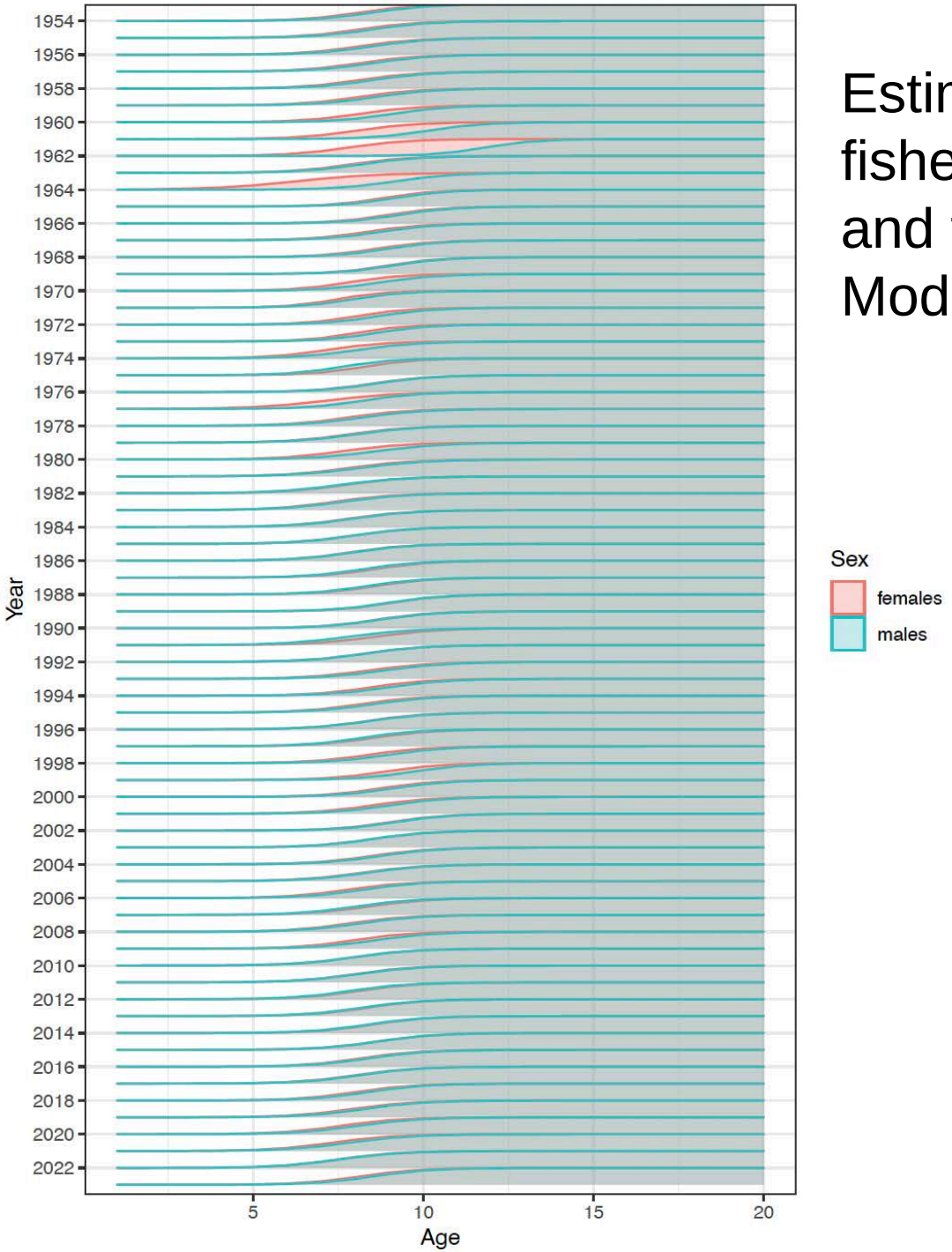
The model incorporates bottom temperature and survey timing into the equation for catchablity

Survey catchability is proportional to temperature through this equation

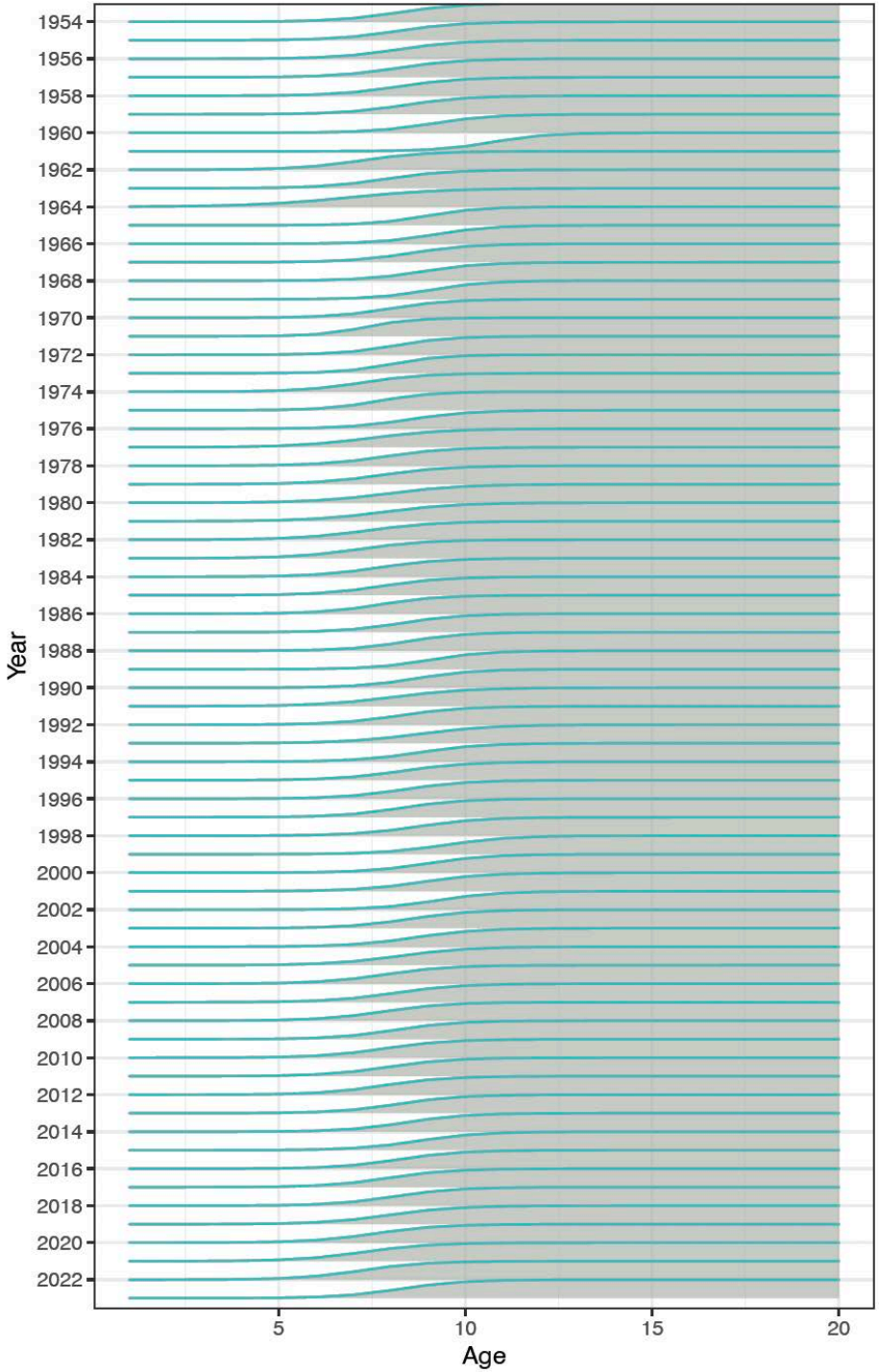


Data weighting, Models 22.1 and 23.0

- Survey age comps was initially weighted based on the number of hauls from which otoliths were collected.
- Model-based and VAST survey age composition data were weighted using Francis (2011).
- The mean survey age composition weights were used to weight fishery age composition data.

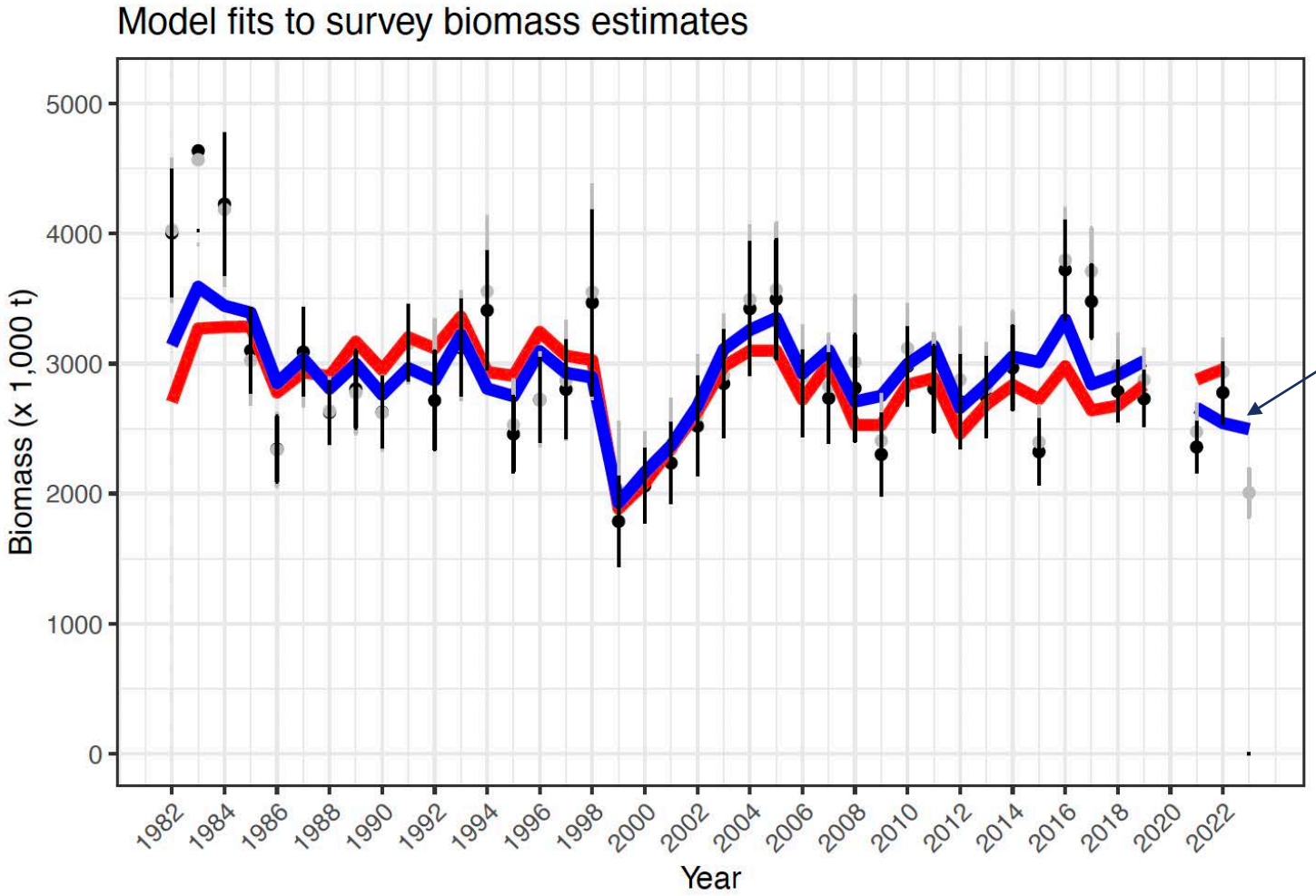


Estimate of yellowfin sole fishery selectivity for males and females, 1954-2023, Model 22.1



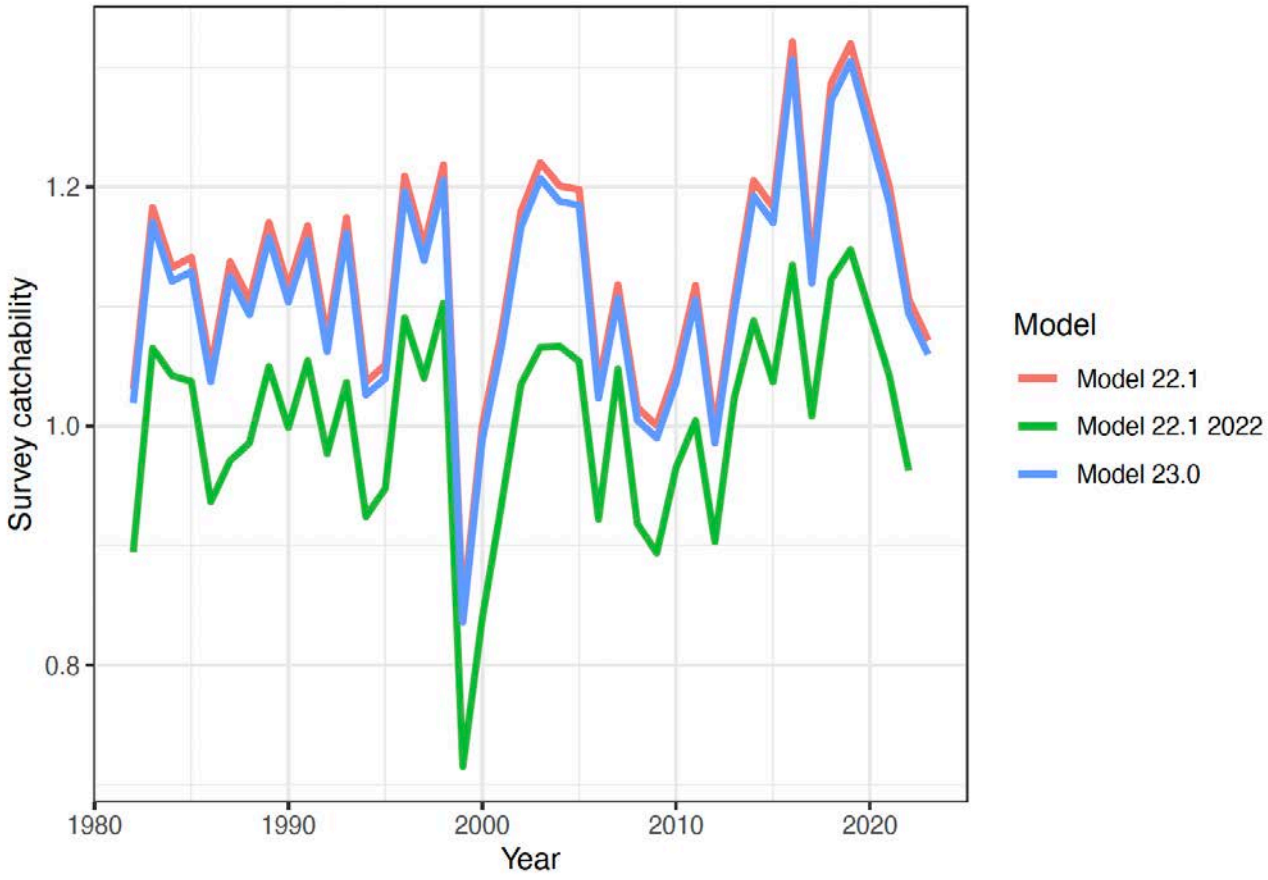
Estimate of yellowfin sole fishery selectivity for males and females, 1954-2023, Model 23.0

Annual EBS bottom trawl survey biomass and 95% CI for yellowfin sole, 1982-2023, with 2022 Model 22.1 (red line), Model 22.1 (orange line), and Model 23.0 (blue line)

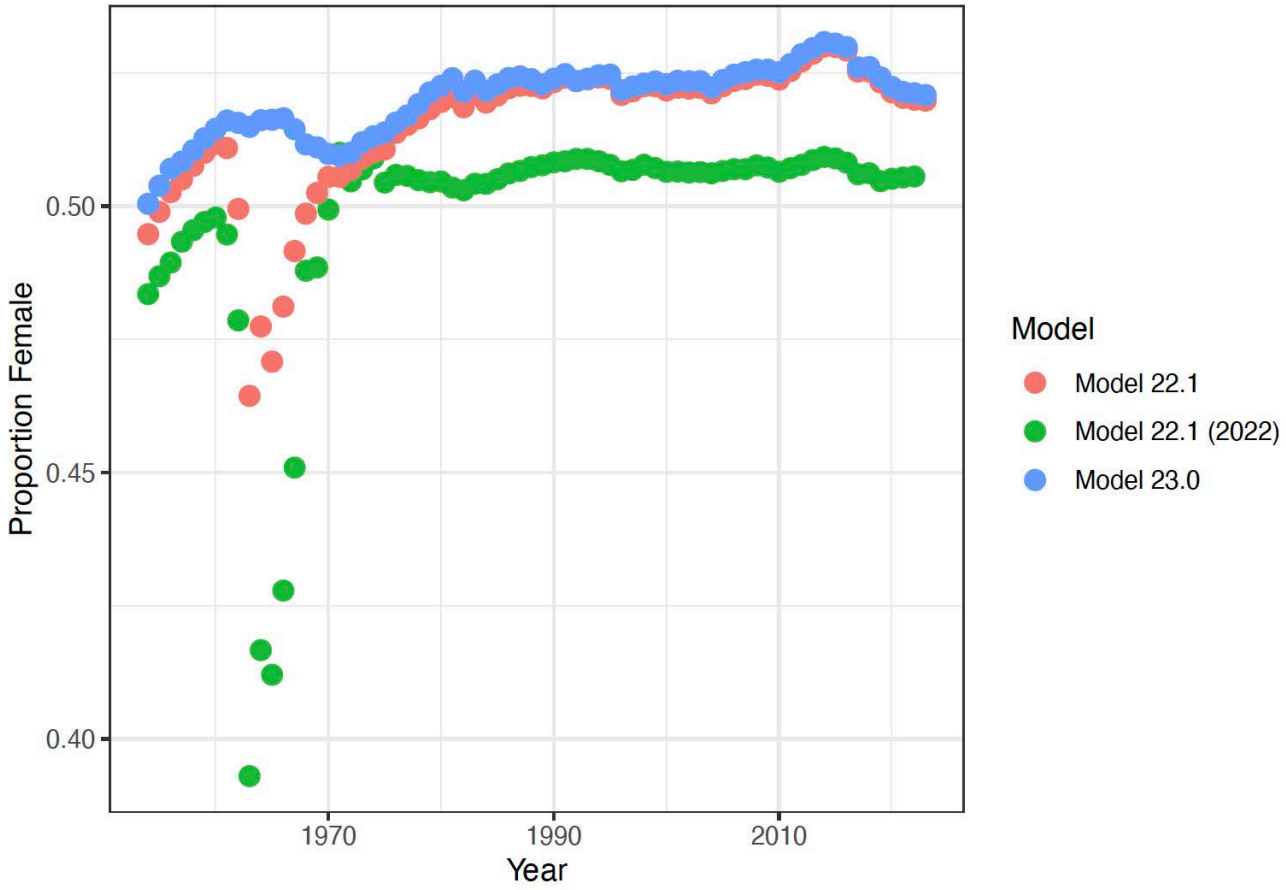


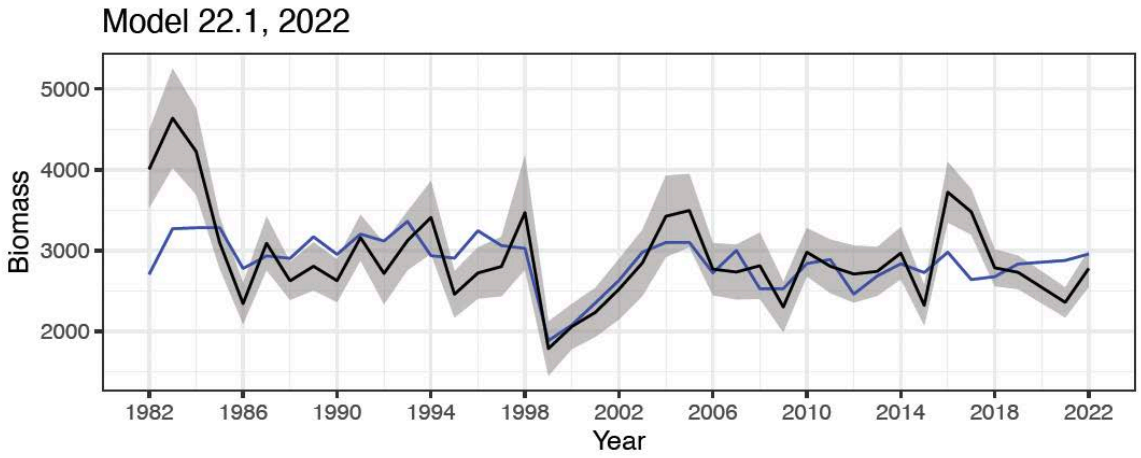
Model 22.1 and 23.0 for 2023 are identical.

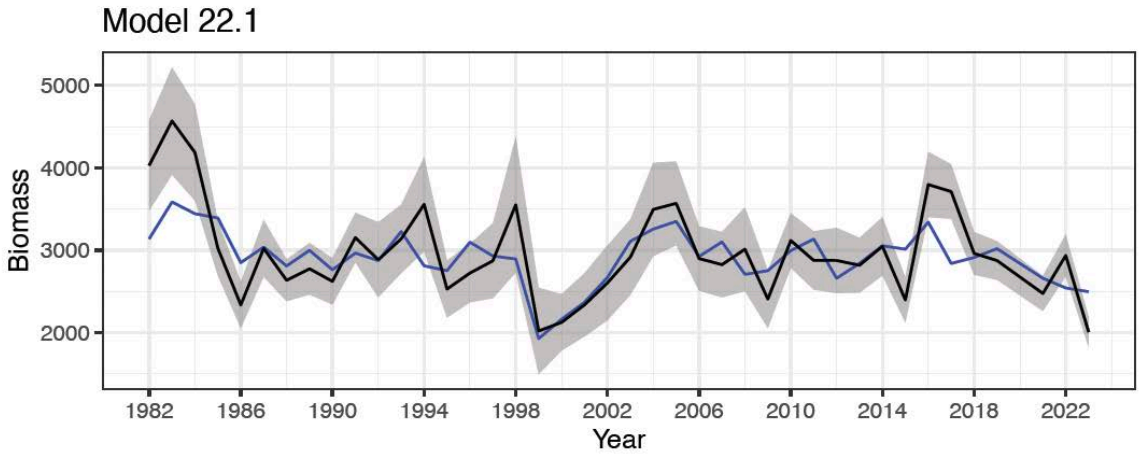
Survey catchability for yellowfin sole Model 22.1 (2022 and 2023 versions) and 23.0, 1982-2023

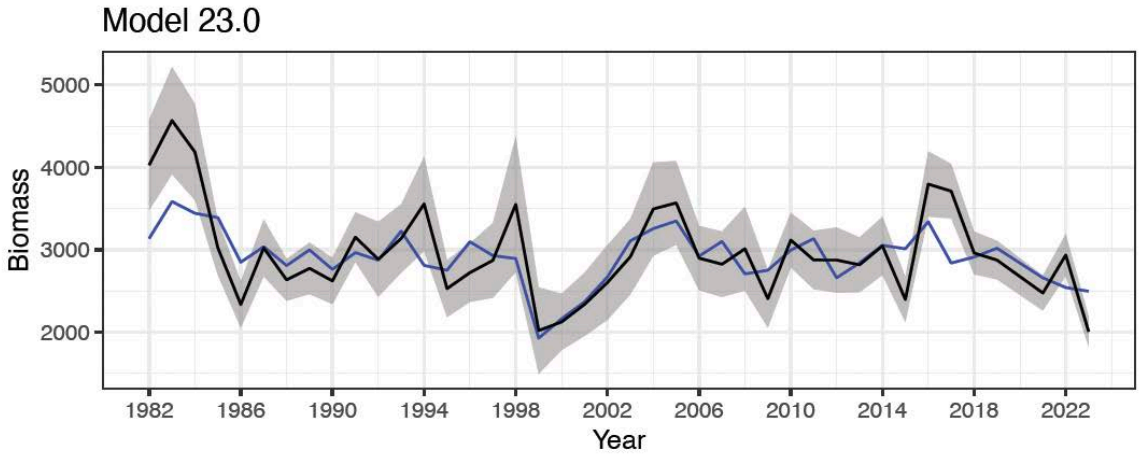


Model estimates of the proportion of female yellowfin sole in the population, 1982-2023 for Models 22.1 (from 2022 and 2023), and Model 23.0





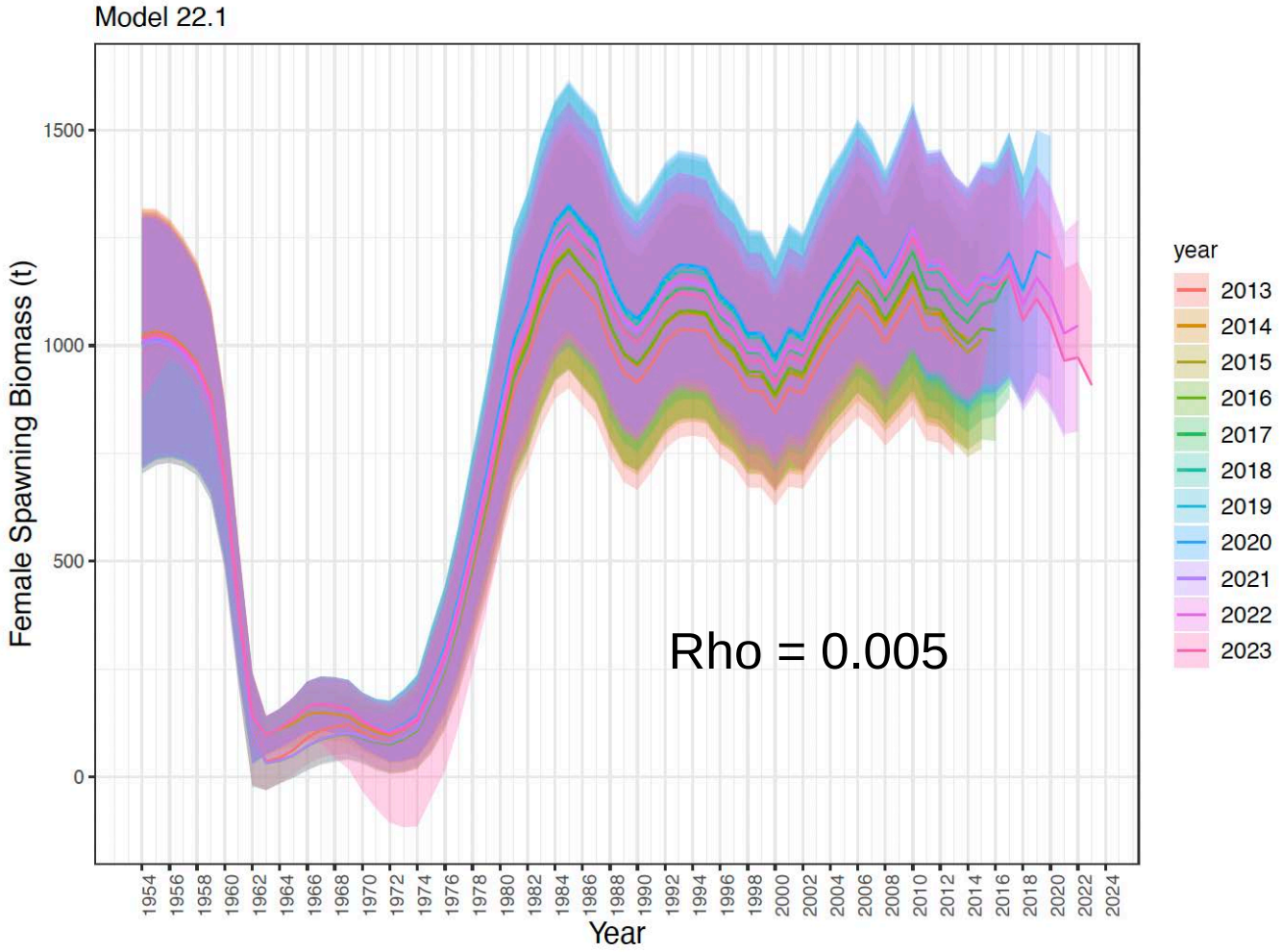




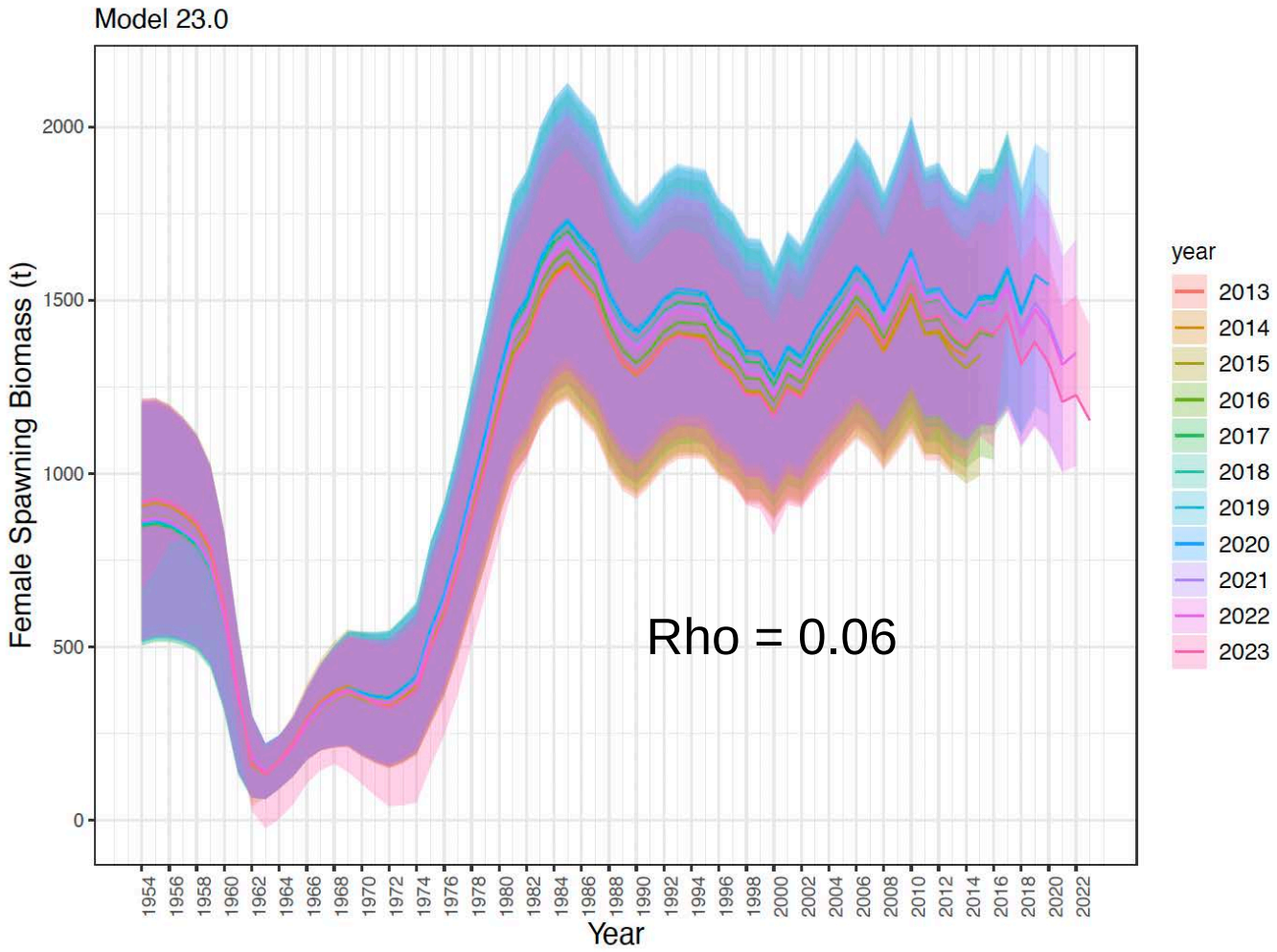
Models fit to NMFS NBS+EBS model-based (VAST) estimates for yellowfin sole, from 1982-2023

- The 2022 VAST index differs from the 2023 index due to the addition of an additional year (which affects the entire time series).
- Blue lines are model estimates, grey represent survey estimates.

Retrospective plot of female spawning biomass for yellowfin sole, Model 22.1



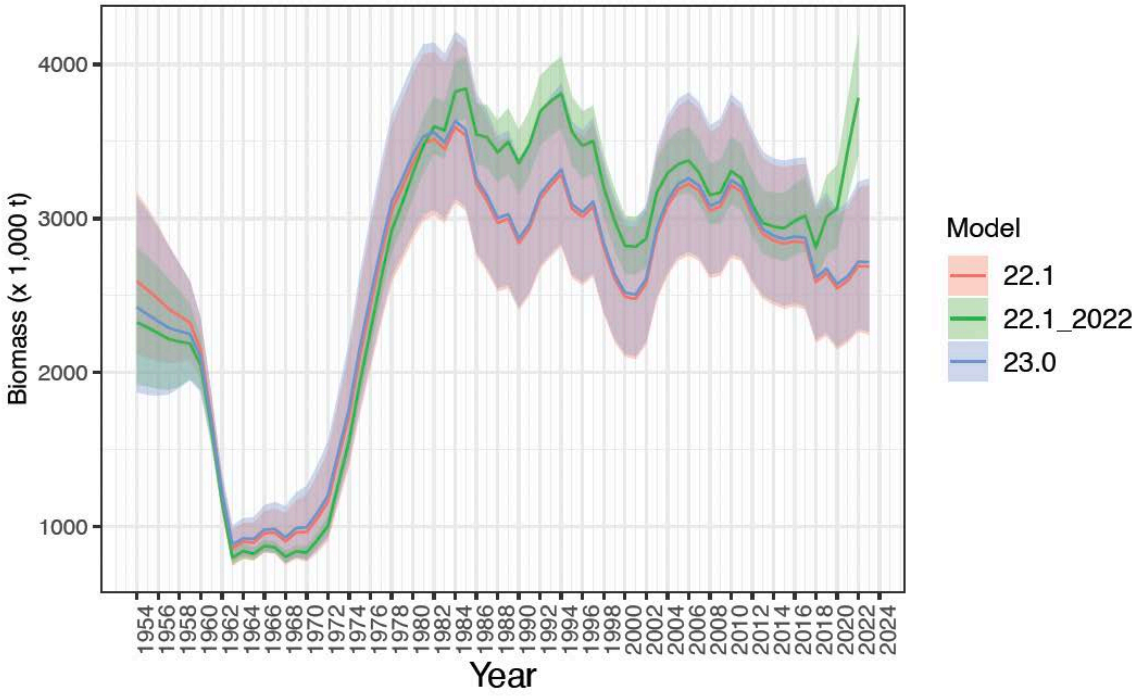
Retrospective plot of female spawning biomass for yellowfin sole, Model 23.0

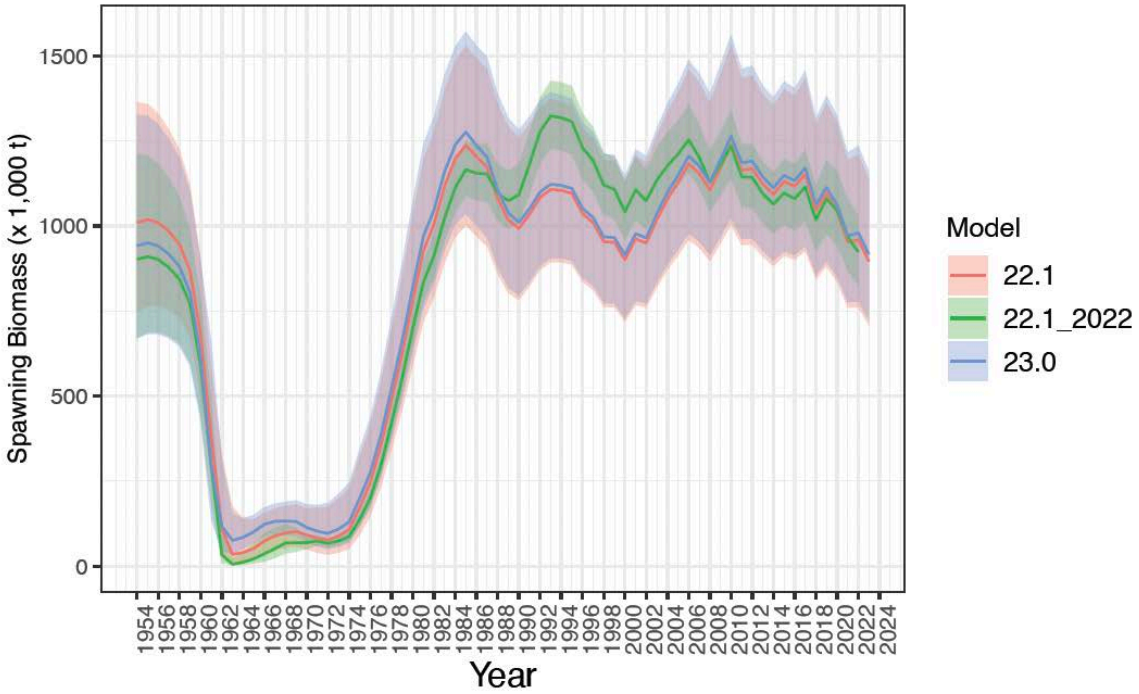


Model evaluation

- AIC for Model 22.1 = 3345.167
- AIC for Model 23.0 = 2670.419

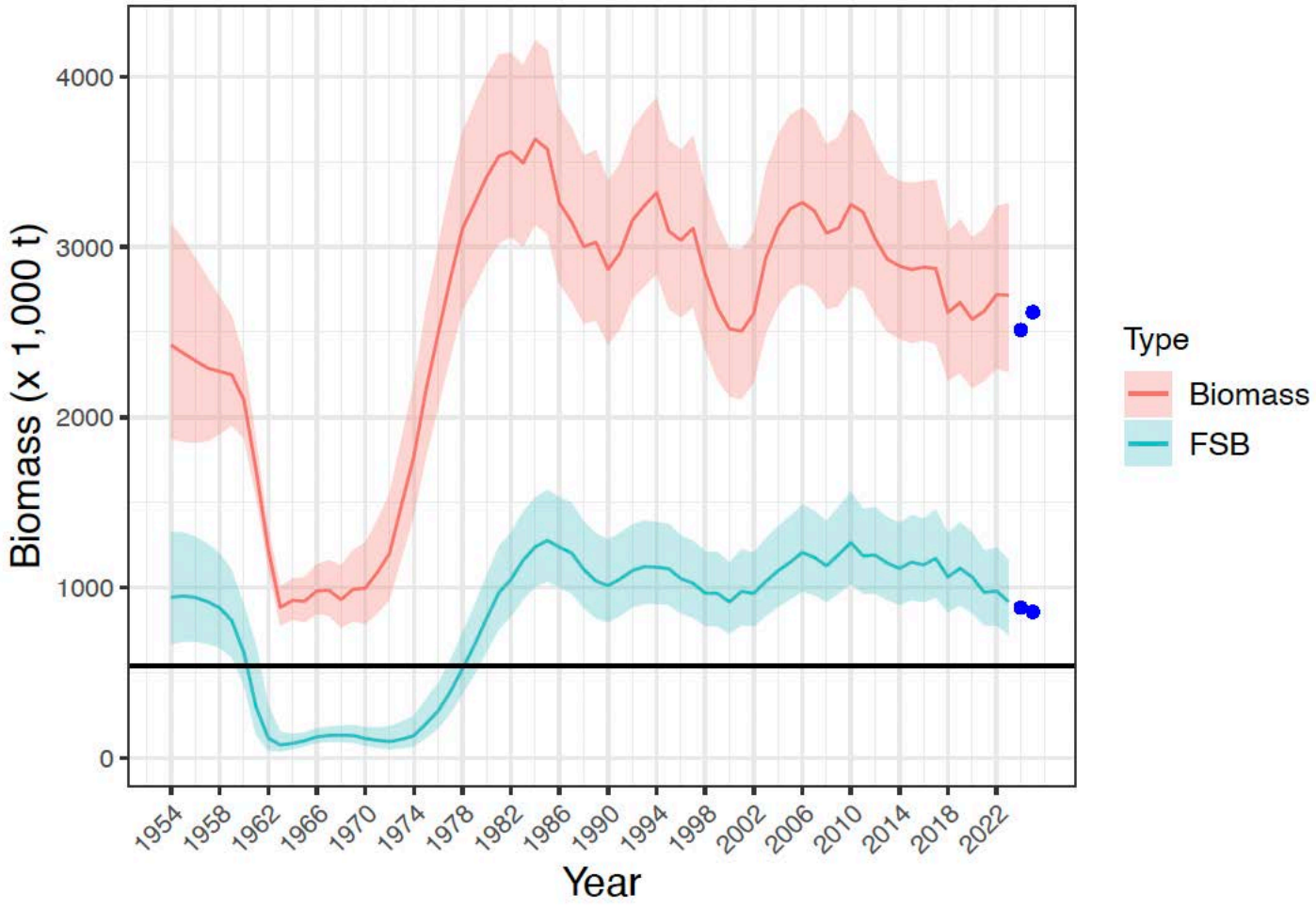
- Model 23.0 provided parsimony and a significant improvement to the model fit to the data.

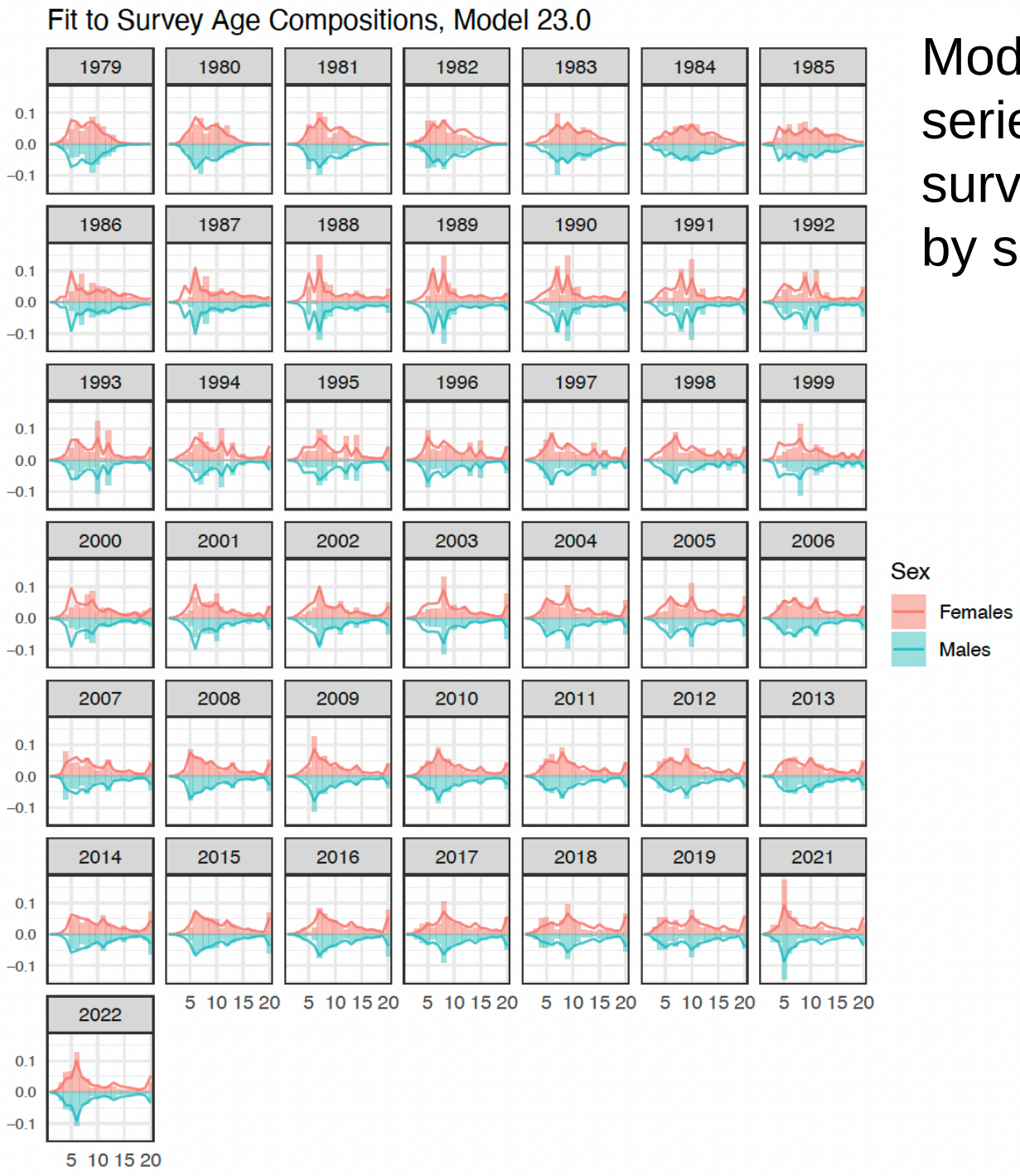




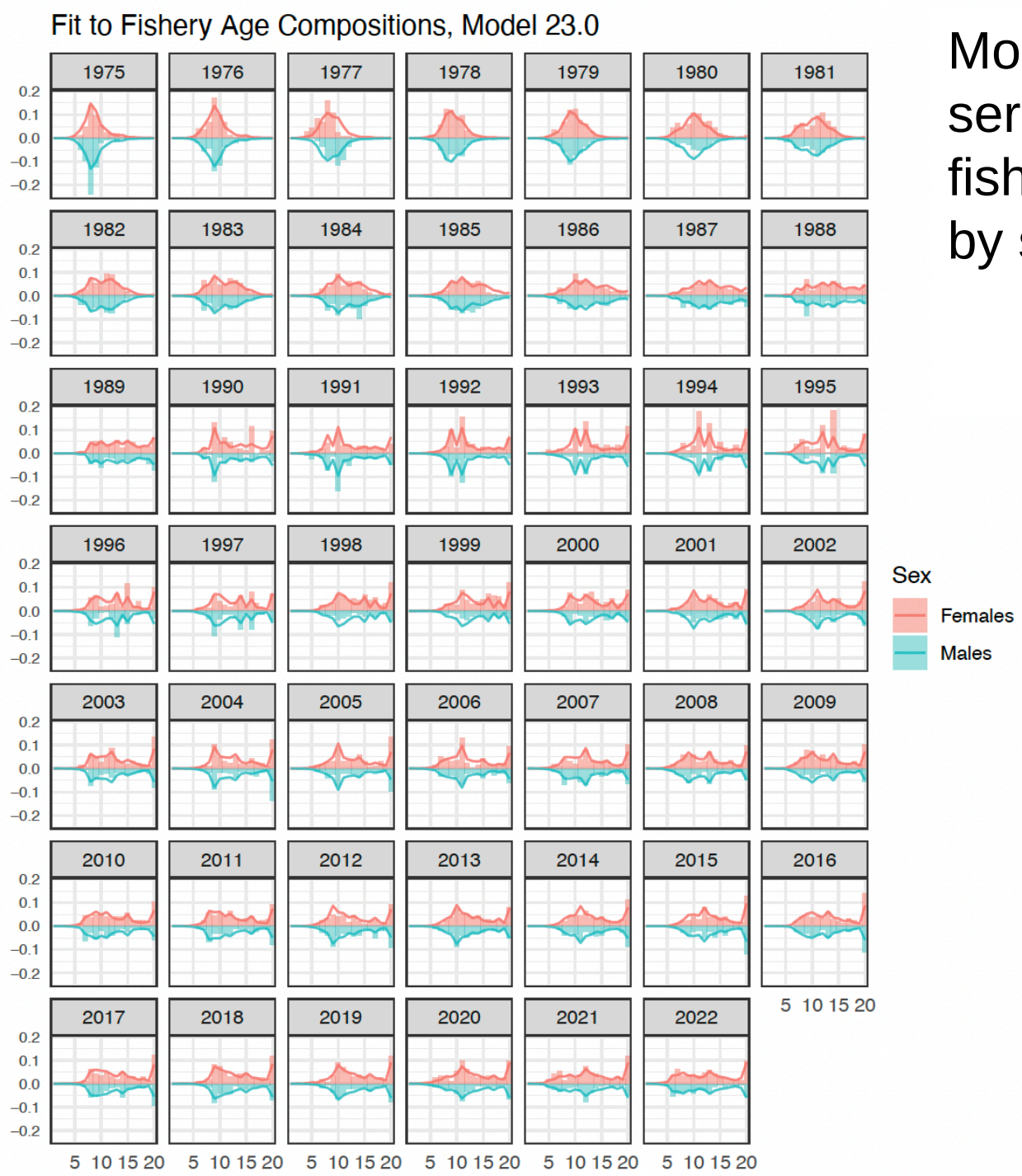
Total (age 2+) and spawning stock biomass for yellowfin sole, and total numbers, for all models, 1954-2023

Model estimates of yellowfin sole total (age 2+) and female spawning biomass with 95% confidence intervals, 1954-2023, Model 23.0. Dots indicate projections for 2024 and 2025.



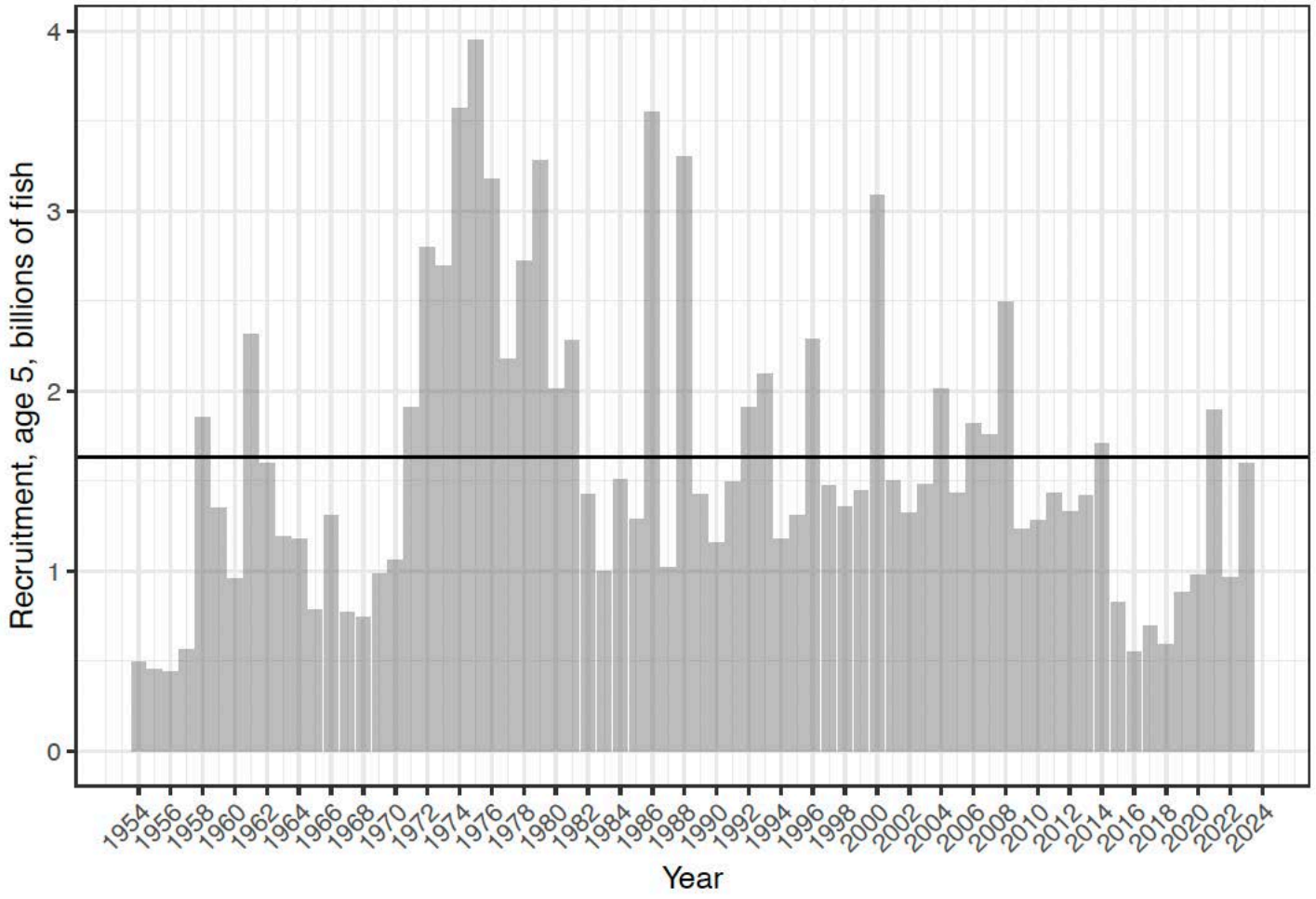


Model 23.0 fit to the time-series of yellowfin sole survey age composition, by sex, 1979-2023

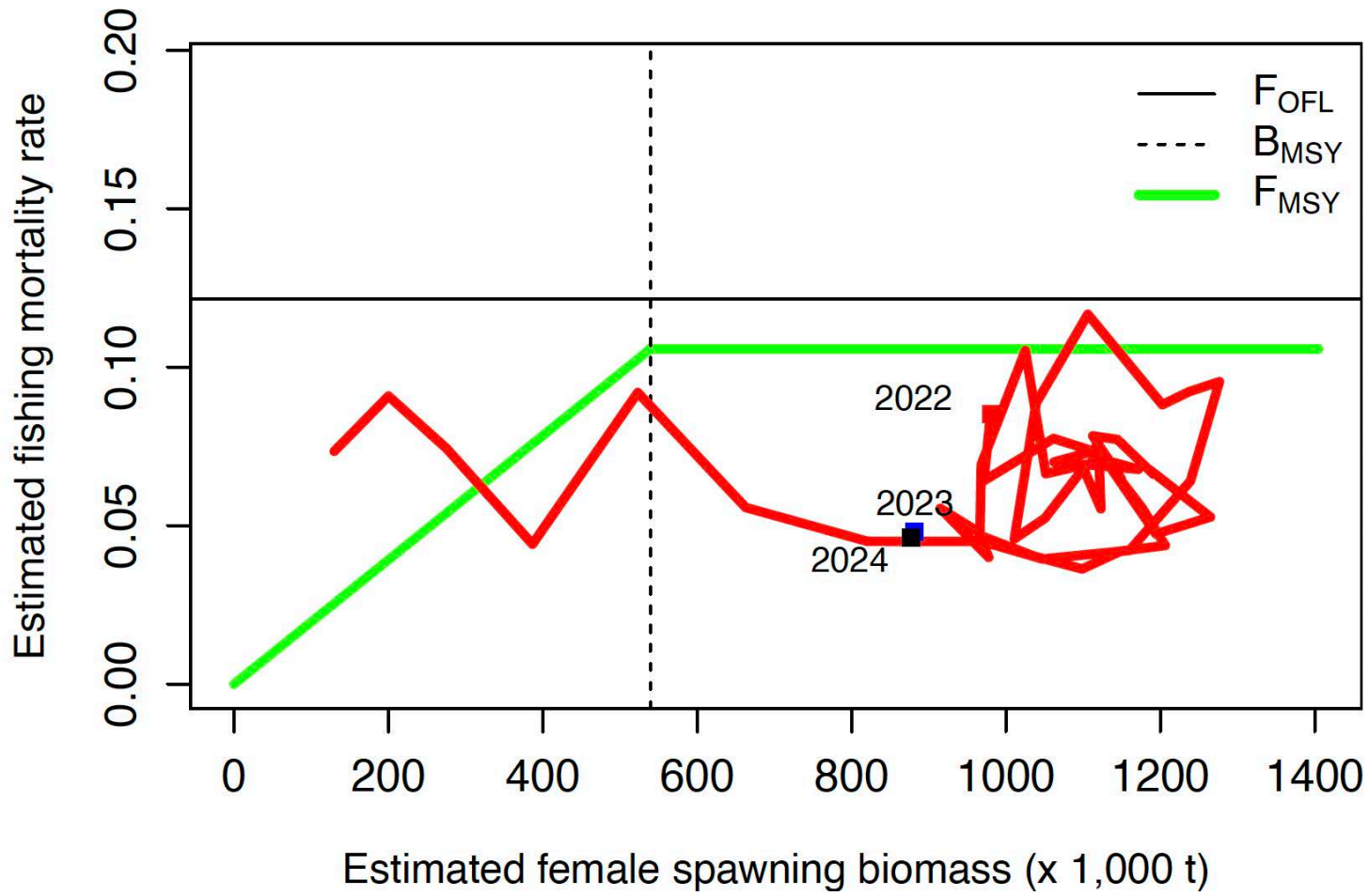


Model 23.0 fit to the time-series of yellowfin sole fishery age composition, by sex, 1975-2023

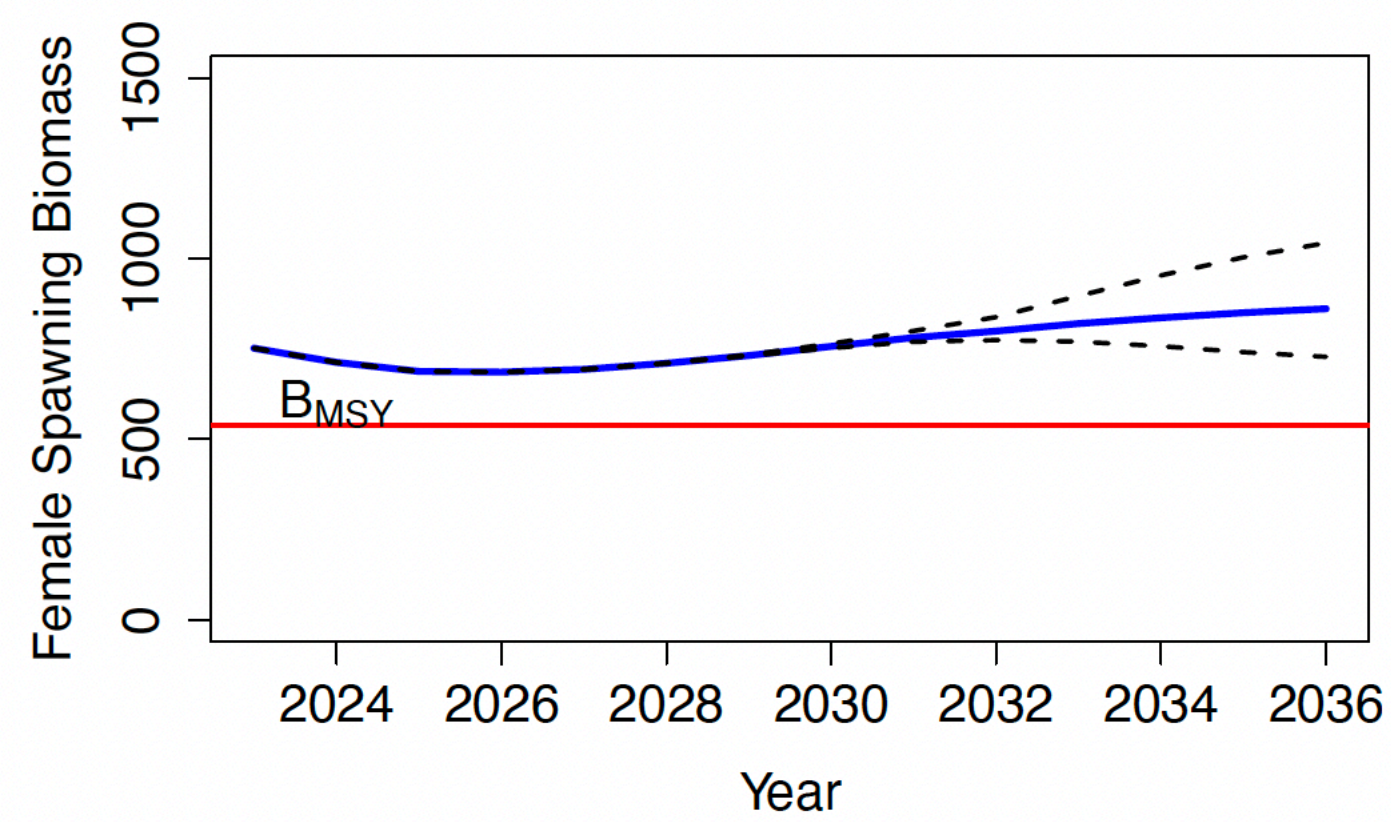
Year-class strength of age 5 yellowfin sole estimated by the stock assessment model. The horizontal line represents the average of the estimates from recruitment, 1954-2019, 1.6 billion, Model 23.0



Yellowfin sole fishing mortality rate and female spawning biomass from 1975 to 2023 compared to the $F_{35\%}$ and $F_{40\%}$ control rules, based on Model 23.0. Vertical line is $B_{35\%}$. Squares indicate estimates for 2023, 2024, and 2025



Projected yellowfin sole female spawning biomass for 2023 to 2036 (blue line), fishing at the 5-year (2018-2022) average fishing mortality eate, F=0.0741, Model 23.0.



Model 23.0 Summary Table

Quantity	As estimated or *specified* *last* year for: 2023	2024	As estimated or *recommended* *this* year for: 2024	2025
M (natural mortality rate)	0.12, 0.125	0.12, 0.125	0.12, 0.137	0.12, 0.137
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	3,321,640 t	4,062,230 t	2,512,810 t	2,616,800 t
Projected female spawning biomass (t)	885,444 t	897,062 t	881,640 t	857,354 t
B_0	1,407,000 t	1,407,000 t	1,516,980 t	1,516,980 t
B_{MSY}	475,199 t	475,199 t	539,657 t	539,657 t
F_{OFL}	0.122	0.122	0.121	0.121
$maxF_{ABC}$	0.114	0.114	0.106	0.106
F_{ABC}	0.114	0.114	0.106	0.106
OFL (t)	404,882 t	495,155 t	305,298 t	317,932 t
$maxABC$	378,499 t	462,890 t	265,913 t	276,917 t
ABC (t)	378,499 t	462,890 t	265,913 t	276,917 t
Status	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 22.1 Summary Table

Quantity	As estimated or *specified* *last* year for: 2023	2024	As estimated or *recommended* *this* year for: 2024	2025
M (natural mortality rate)	0.12, 0.125	0.12, 0.125	0.12, 0.136	0.12, 0.136
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	3,321,640 t	4,062,230 t	2,488,060 t	2,589,290 t
Projected female spawning biomass (t)	885,444 t	897,062 t	862,542 t	857,354 t
B_0	1,407,000 t	1,407,000 t	1,483,320 t	1,483,320 t
B_{MSY}	475,199 t	475,199 t	539,657 t	539,657 t
F_{OFL}	0.122	0.122	0.122	0.122
$maxF_{ABC}$	0.114	0.114	0.108	0.108
F_{ABC}	0.114	0.114	0.106	0.106
OFL (t)	404,882 t	495,155 t	303,291 t	315,630 t
$maxABC$	378,499 t	462,890 t	267,486 t	278,368 t
ABC (t)	378,499 t	462,890 t	267,486 t	278,368 t
Status	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

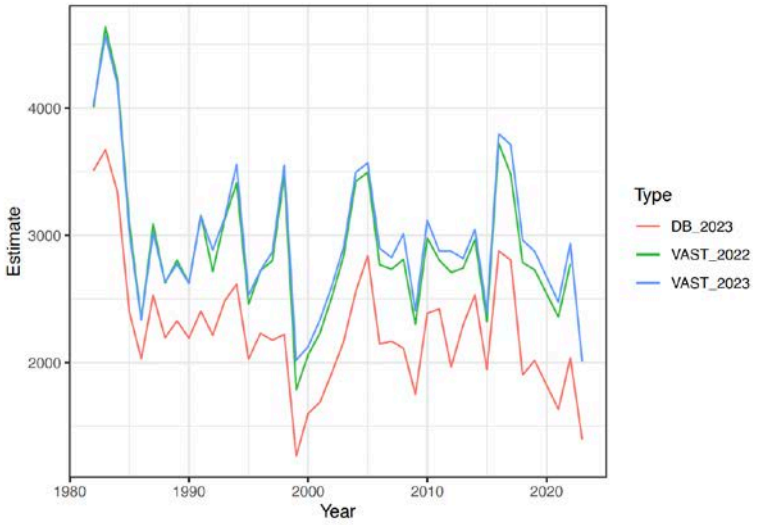
Risk Table

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: No concern	Level 2: Major concern	Level 2: Major concern	Level 1: No concern

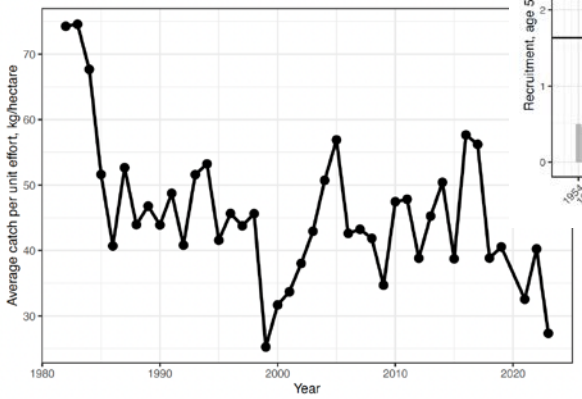
Risk Table

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: No concern	Level 2: Major concern	Level 2: Major concern	Level 1: No concern

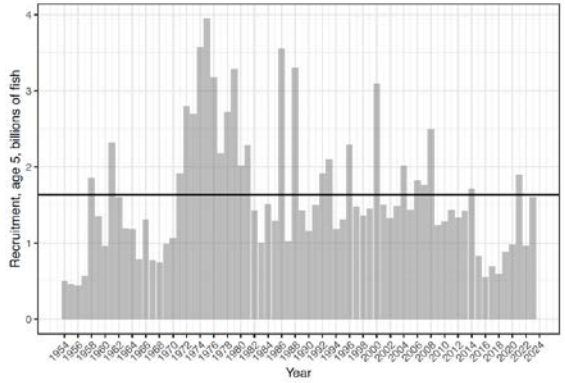
Biomass estimates (2nd lowest since 1982)



CPUE

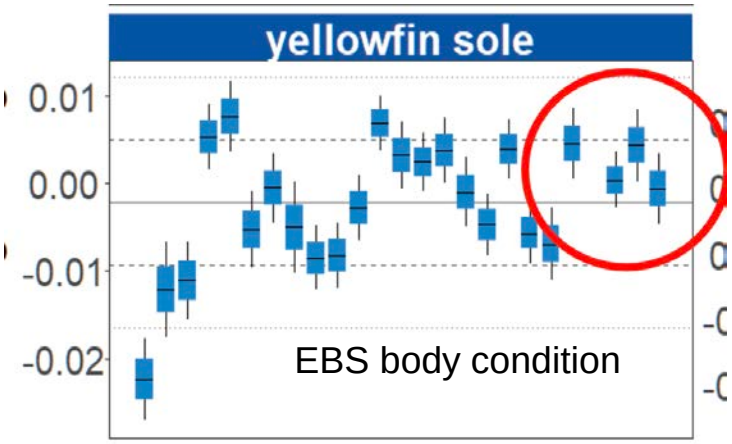


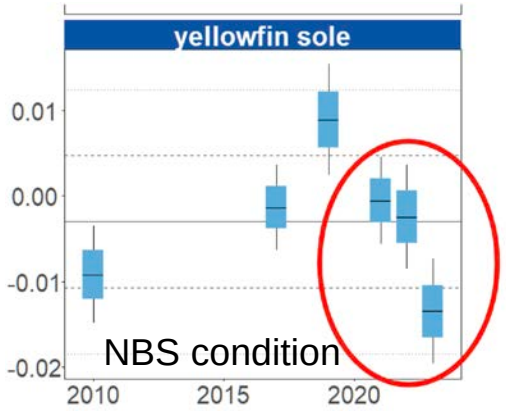
Recruitment

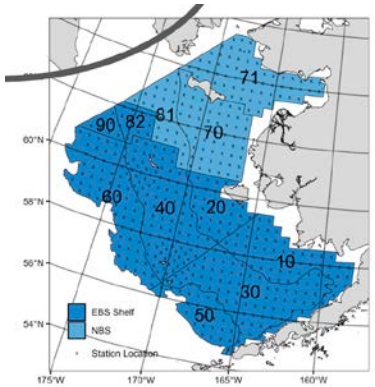


Risk Table

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: No concern	Level 2: Major concern	Level 2: Major concern	Level 1: No concern







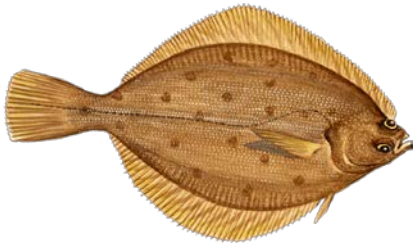
Prey: Declining and negative adult fish condition indicate potential concerns in prey availability over the northern shelf.

Condition Index: Rohan & Prohaska

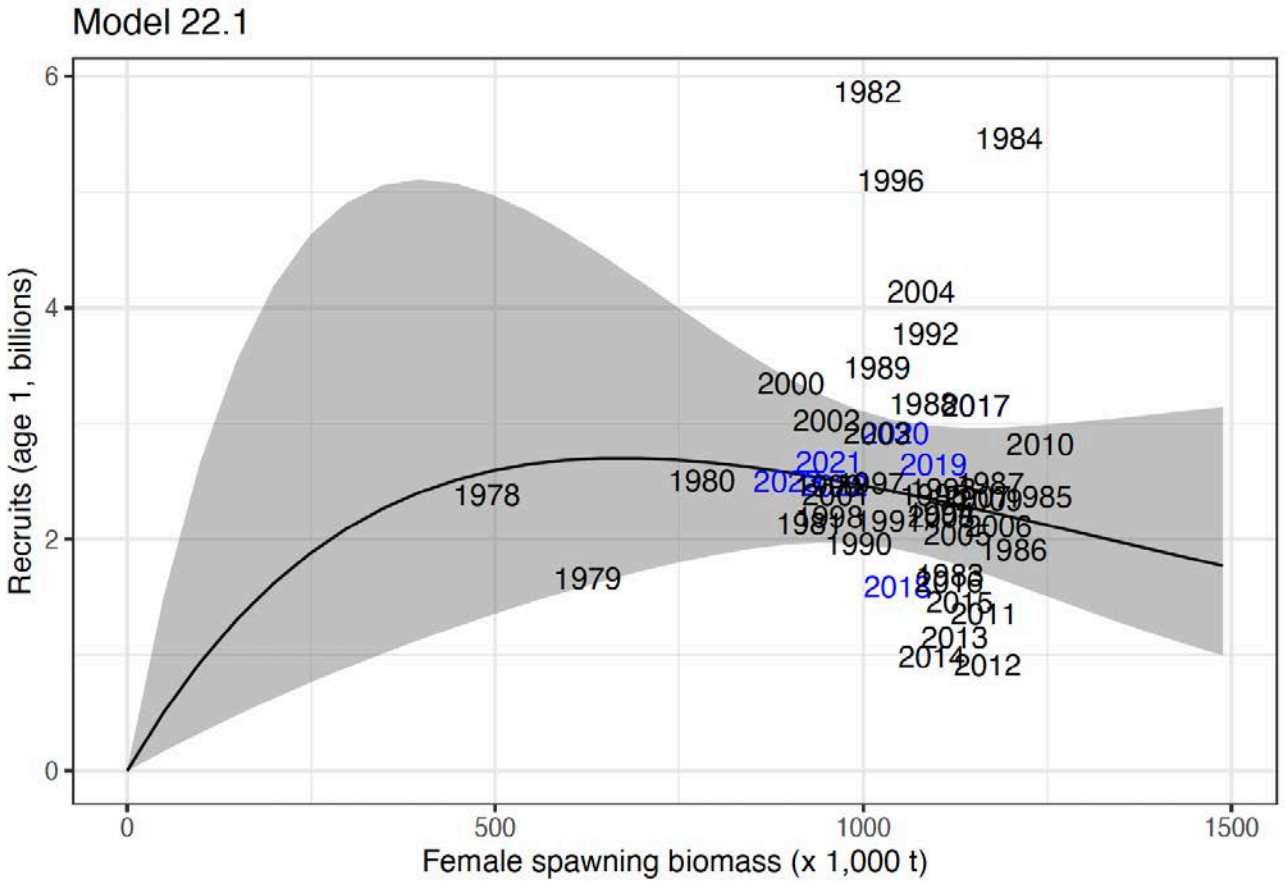
Risk Table

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: No concern	Level 2: Major concern	Level 2: Major concern	Level 1: No concern

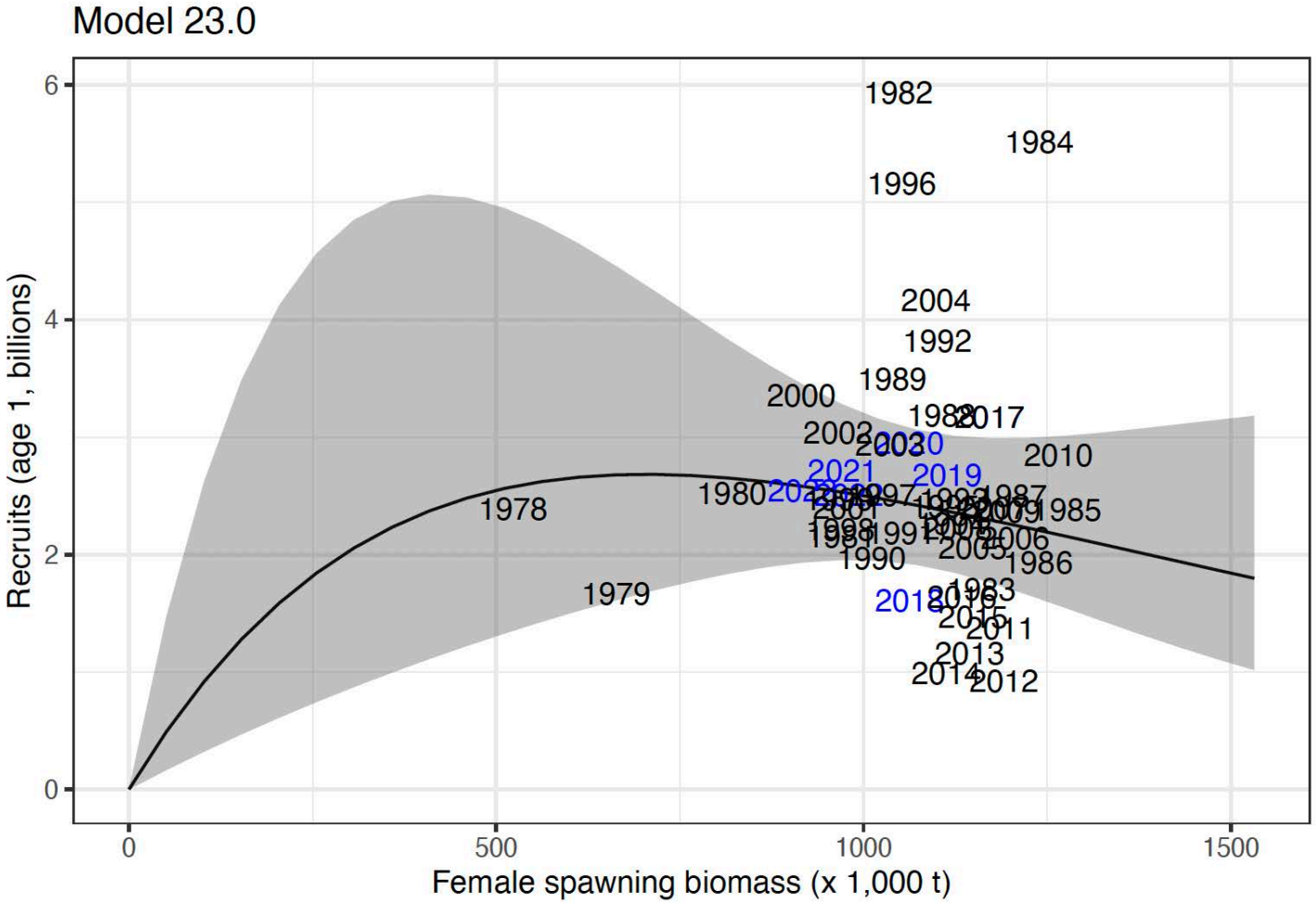
Questions?

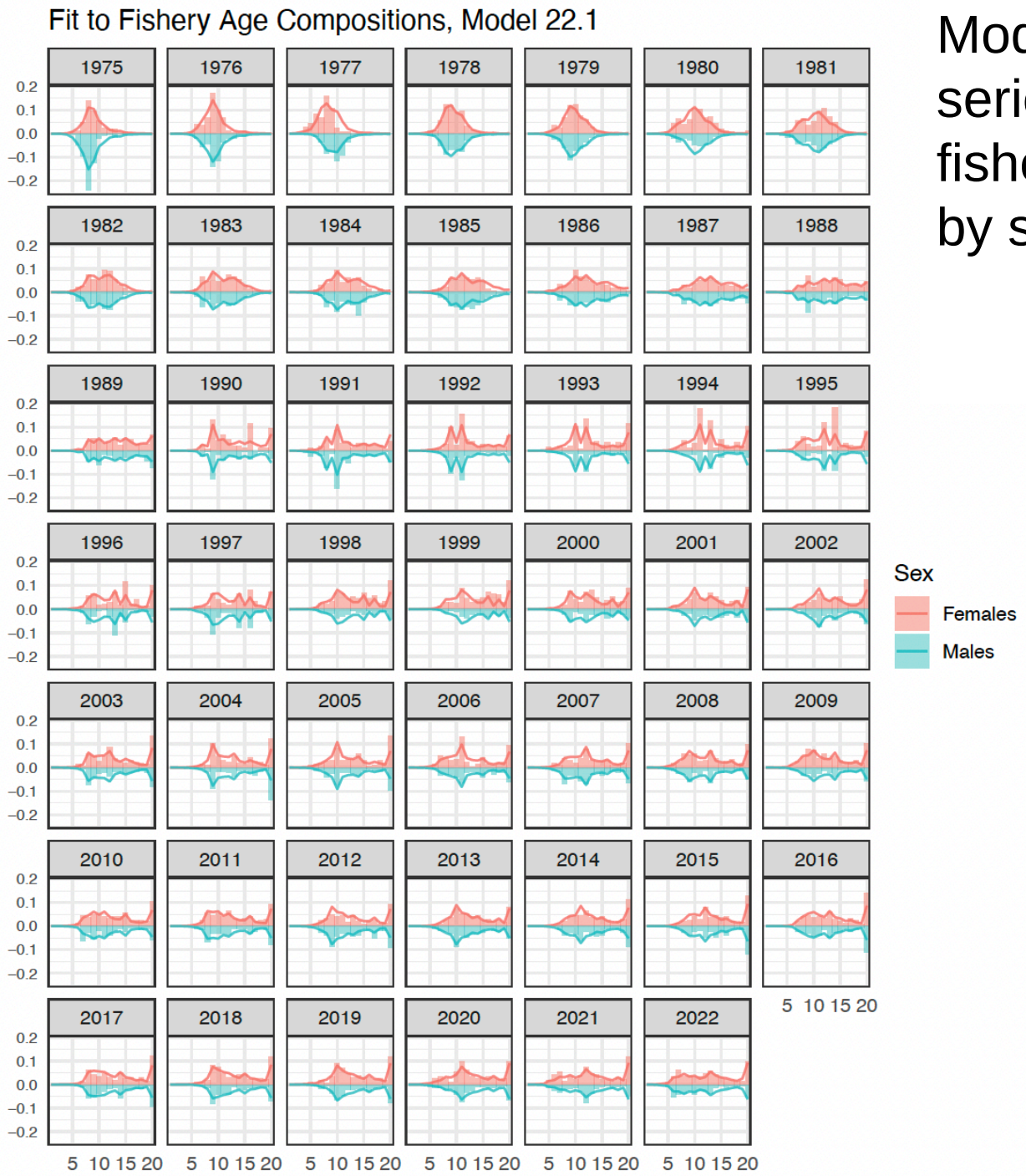


Ricker stock recruitment curve for yellowfin sole Model 22.1 with 95% confidence intervals (shaded region) fit to female spawning biomass and recruitment data from 1978-2017

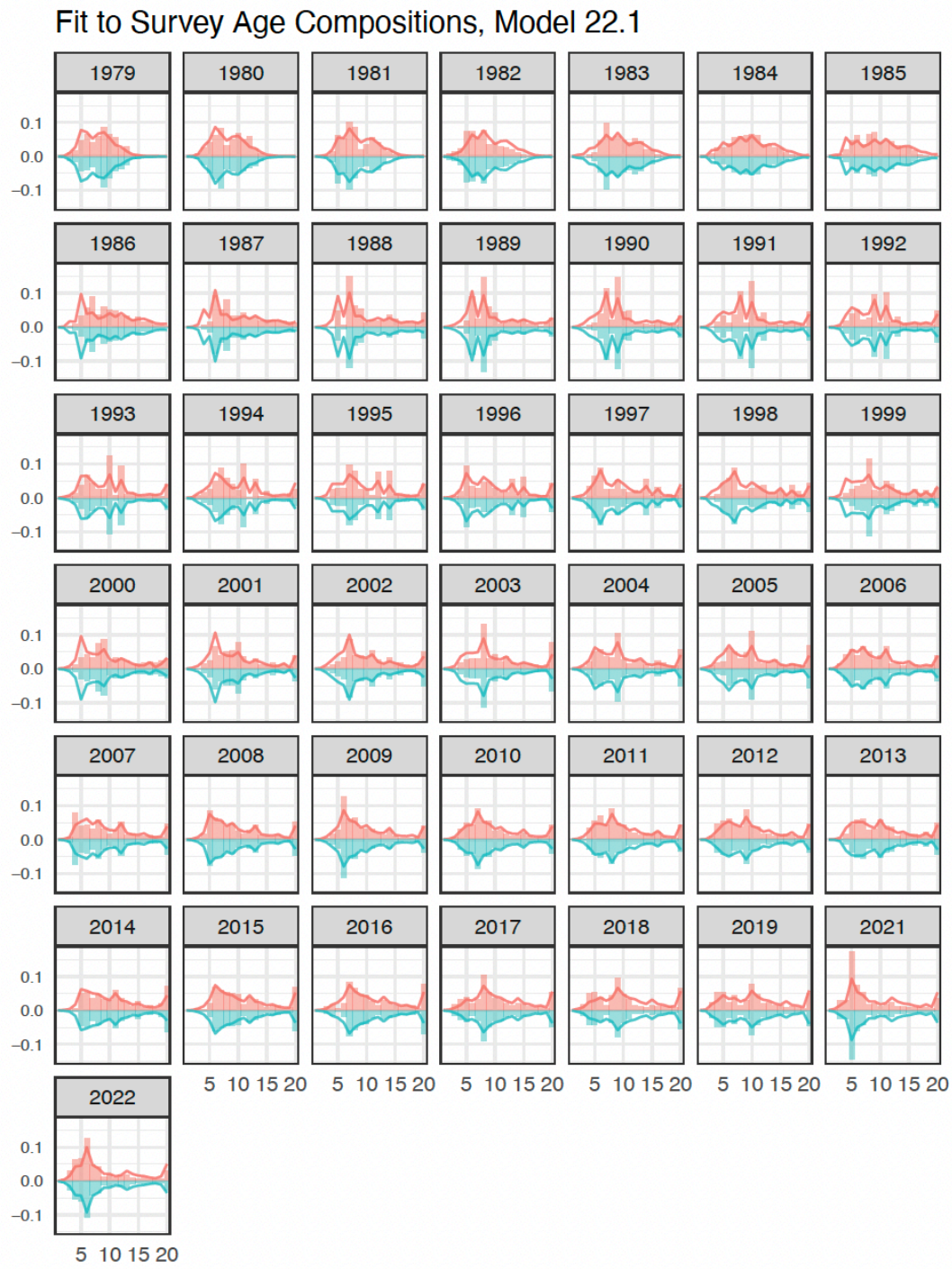


Ricker stock recruitment curve for yellowfin sole Model 23.0 with 95% confidence intervals (shaded region) fit to female spawning biomass and recruitment data from 1978-2017



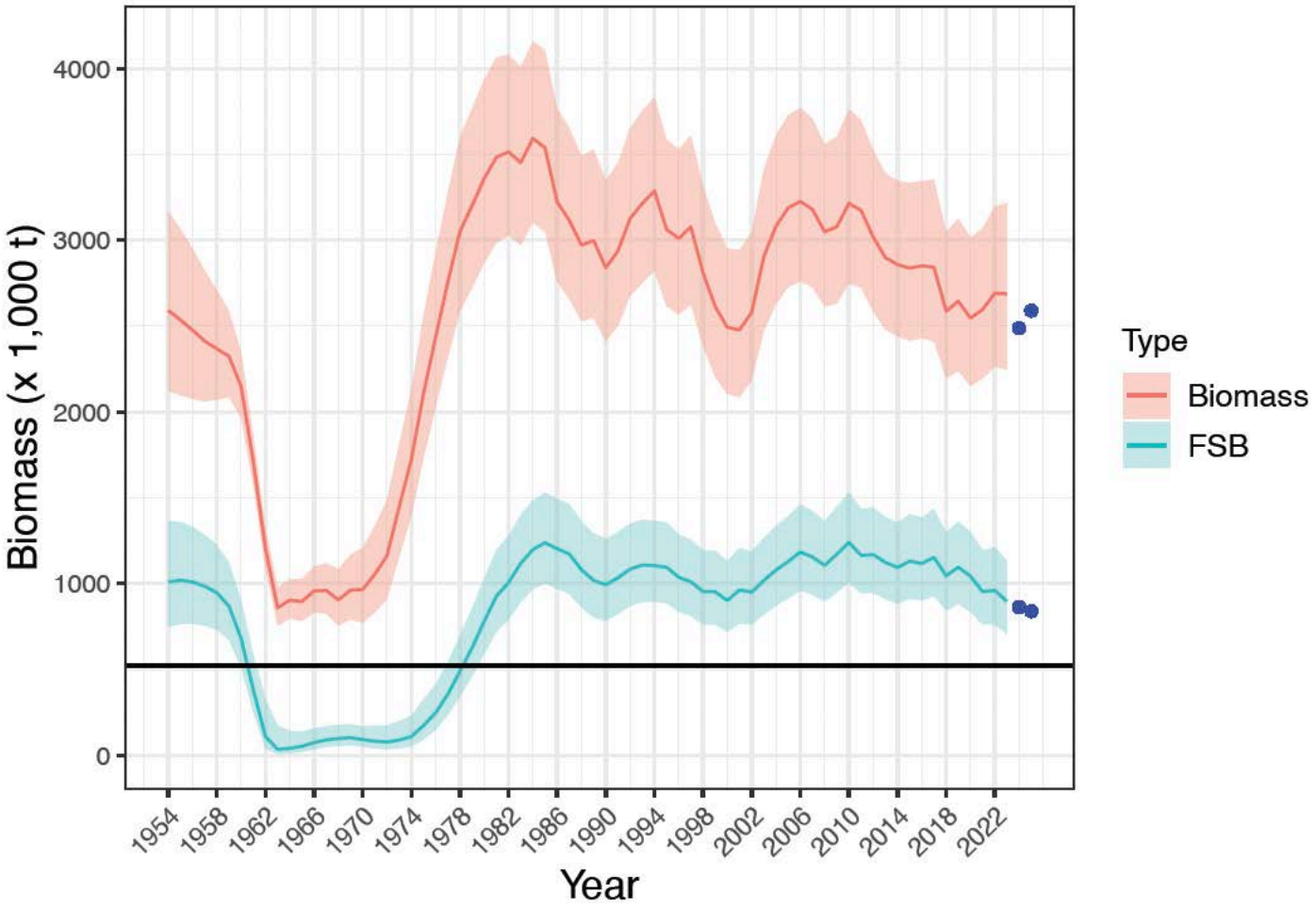


Model 22.1 fit to the time-series of yellowfin sole fishery age composition, by sex, 1975-2023

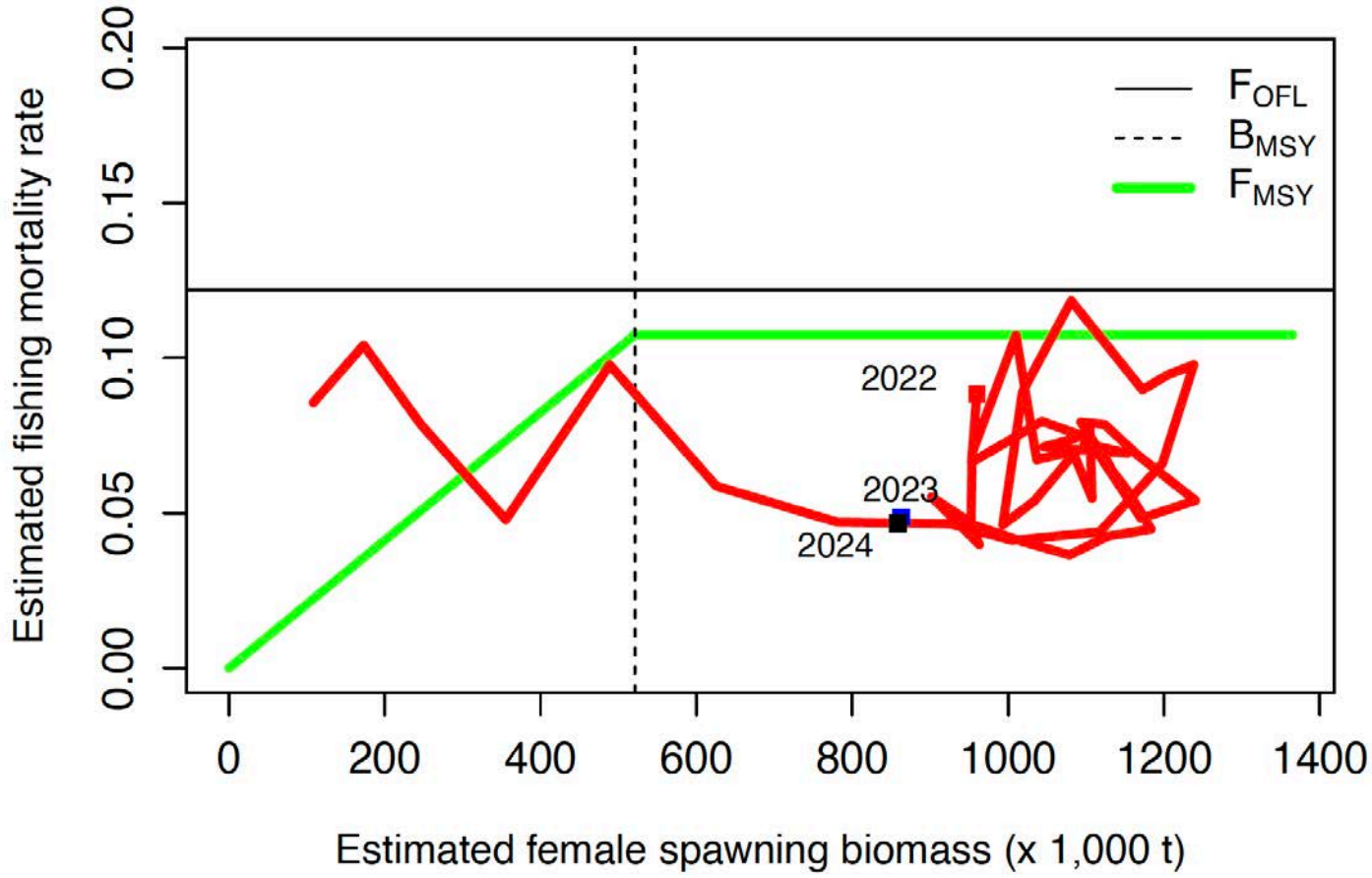


Model 22.1 fit to the time-series of yellowfin sole survey age composition, by sex, 1979-2023

Model estimates of yellowfin sole total (age 2+) and female spawning biomass with 95% confidence intervals, 1954-2023, Model 22.1. Dots indicate projections for 2024 and 2025.



Yellowfin sole fishing mortality rate and female spawning biomass from 1975 to 2023 compared to the $F_{35\%}$ and $F_{40\%}$ control rules, based on Model 22.1. Vertical line is $B_{35\%}$. Squares indicate estimates for 2023, 2024, and 2025



Distributional Assumptions

The suite of parameters estimated by the model are classified by three likelihood components:

Data component	Distributional assumption
Trawl fishery catch-at-age	Multinomial
Trawl survey population age composition	Multinomial
Trawl survey biomass estimates and S.E.	Log-normal