Appendix B: Stock Synthesis Evaluation of Kodiak Shelikof

Scallop Plan Team, Mar. 6, 2023

SSC 2022: The SSC recommends that future modeling efforts be focused on an age-structured model (and/or other models for data-limited situations for comparison) for a single district, perhaps Yakutat where the recent fishery has been active.

Response: For now, modelling efforts will continue with the Stock Synthesis framework and be focused on Kodiak Shelikof District. The Shelikof District is an active fishery, with a long history, and has undergone a dynamic trend in harvest and fishery performance. It is currently the second largest contributor to the state-wide GHL behind Yakutat District. Further, it primarily consists of a single bed which has been surveyed five times.

Yakutat District has only been surveyed across all five actively fished beds in 2019 and 2021. Prior to that, only select beds were fished during surveys. In addition, the Yakutat District appears to be a less contiguous population that undergoes somewhat different patterns of recruitment and survival among beds which may complicate model development. Yakutat District will likely be a good subject to further evaluate a population dynamics model developed for Kodiak Shelikof District.

SSC 2022: Models should include discard mortality.

Response: All 23.x models presented include discard mortality.

SSC 2022: If survey dredge efficiency is assumed to be known, include this information as a prior on catchability and force selectivity to be 1.0 for a reasonable range of sizes rather than allowing dredge selectivity to be less than 1.0 across the entire size range.

Response: All models presented in this iteration applied dredge efficiency outside of the model and assumed catchability = 1 for the dredge survey. As we gain additional information on dredge efficiency - particularly the new survey dredge - I will evaluate a model using the approach suggested here. Model 23.3 assumes full selectivity throughout the size range, while other models attempt to estimate selectivity across the full size range.

SSC 2022: Consider dropping the westward region large-mesh trawl survey index as it is highly uncertain. If the trawl index is retained, provide justification for the implausibly small log(SE) = 0.01 for several of the observations.

Response: The Westward Region Trawl Survey data has been dropped from the analysis in all models.

SSC 2022: As recommended by the SPT, further work on standardizing the fishery CPUE index will be needed, including a careful evaluation of its suitability as an index of abundance by region or overall.

Response: Additional work on CPUE standardization is presented in Appendix C.

SSC 2022: Provide an explicit basis for data weighting. Recent groundfish assessments may be helpful to assess the range of approaches commonly employed.

Response: I will address the basis for data weighting in the next iteration of model development.

SSC 2022: Provide a basis for the selection of the variance in recruitment deviations.

Response: I will address the basis for recruitment variation in the next iteration of model development.

SSC 2022: Provide a graphical summary of the fits to size-at-age data.

Response: Fits to size-conditional age data are provided in Appendix B.

Model Structure

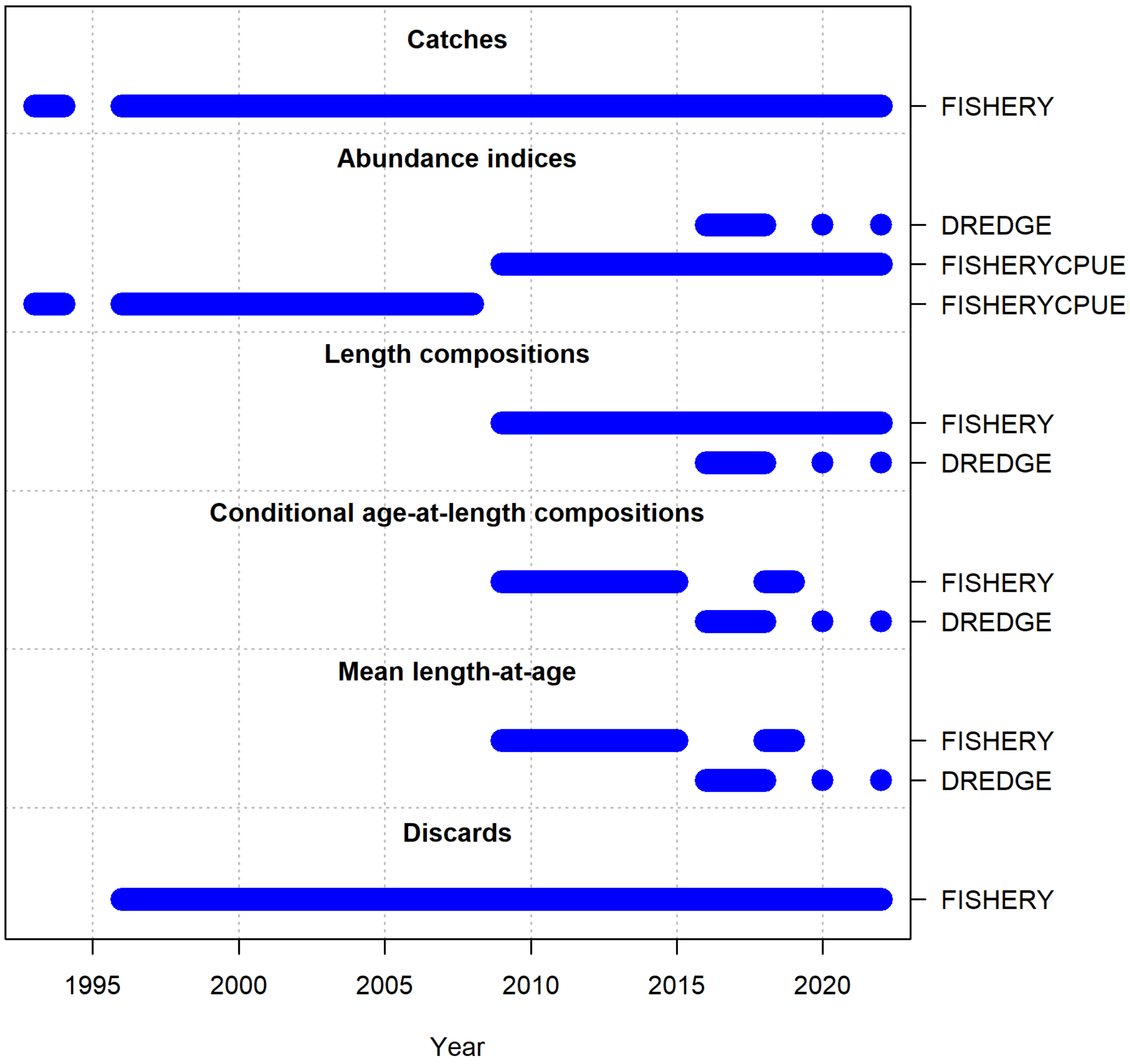
- Size structure consisted of 33 shell height bins ranging from 2.1 cm to 18.1+ cm.
- Age structure consisted of 18 age bins (ages 1 - 18+).
- The modeled timeseries spans from 1992 - 2022.
- Each modeled year includes a single 12 month season (April - March) with model processes occurring at the following time steps:
  - The ADF&G Dredge Survey occurs in May (month 2).
  - Spawning occurs in June (month 3).
  - The month that the fishery occurs in varies from July (month 4) to January (month 10).

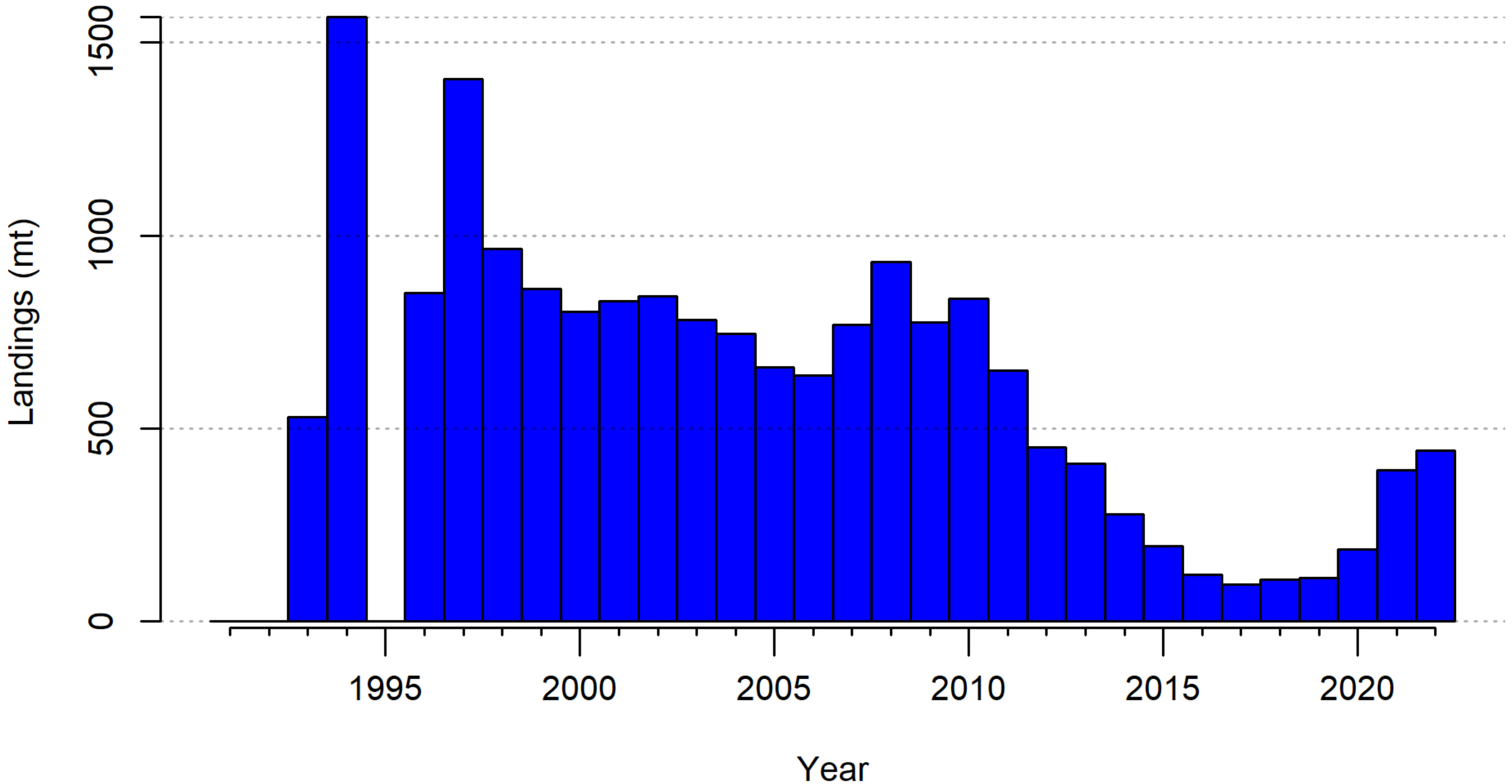
Assumptions

1. Males and females are combined in all model processes, and the sex ratio was assumed to be 50:50.
2. Natural mortality (0.19 yr^{-1}) is kept constant across all sizes and modeled years.
3. Shell height at age is estimated using the Schnute (1981) parametrization of von Bertalanffy growth. The minimum age for von Bertalanffy growth is age-0 and the age at maximum shell height is age-18.
4. Round weight at shell height is allometric and estimated outside of the model
5. Maturity is a logistic function of shell height and estimated outside of the model using survey gonad condition data. Individuals can first become mature at age-3.

Assumptions

6. Egg production (i.e. fecundity) is assumed to be equal to spawning biomass.
7. Annual recruitment is estimated using with unconstrained annual recruitment deviations distributed $\mathcal{N}(0, 2)$
8. Catchability (Q) was estimated as a proportional scalar for both fishery CPUE indices separately, and is constant across years. Dredge survey catchability is assumed full (i.e., $Q = 1$).
9. Fishery and survey selectivities (i.e., size and age) are estimated as a logistic function of shell height and are constant across years. All models assumed selectivity was based on shell height and not age.


Catches
FISHERY
Abundance indices
DREDGE
FISHERYCPUE
FISHERYCPUE
Length compositions
FISHERY
DREDGE
Conditional age-at-length compositions
FISHERY
DREDGE
Mean length-at-age
FISHERY
DREDGE
Discards
FISHERY
1995
2000
2005
2010
2015
2020
Year



0
500
1000
1500
Landings (mt)
1995
2000
2005
2010
2015
2020
Year

Fixed Population Parameters

- Natural Mortality *M* = 0.19 yr^{-1}

- Round weight at shell height

$$W = 1.21\text{x}10^{-4} \cdot SH^{2.86}$$

- Size at maturity, SM_{50} = 7.3 cm, slope β_1= -1.5

- Dredge efficiency (*Q* = 0.83)

Model Scenarios

22.1a: Model KSH22.1 (Jackson 2022) with updated 2022 ADF&G Dredge Survey biomass and size and age composition data, as well as 2022/23 fishery catch, CPUE (based on retained catch), and size composition data.

23.0: Model 22.1a including fishery discarded catch from 1996/97-2022/23 and size composition from 2009/10-2022/23.

23.0a: Model 23.0 with extra standard error on standardized fishery CPUE from 2009/10-2022/23.

23.0a1: Model 23.0a without dredge survey size and age composition data from 2016 - 2018.

23.0a3: Model 23.0a with down-weighted dredge survey size and age composition data from 2016 - 2018.

23.3: Model 23.0a with full dredge survey selectivity (i.e. selectivity = 1) across all size classes.

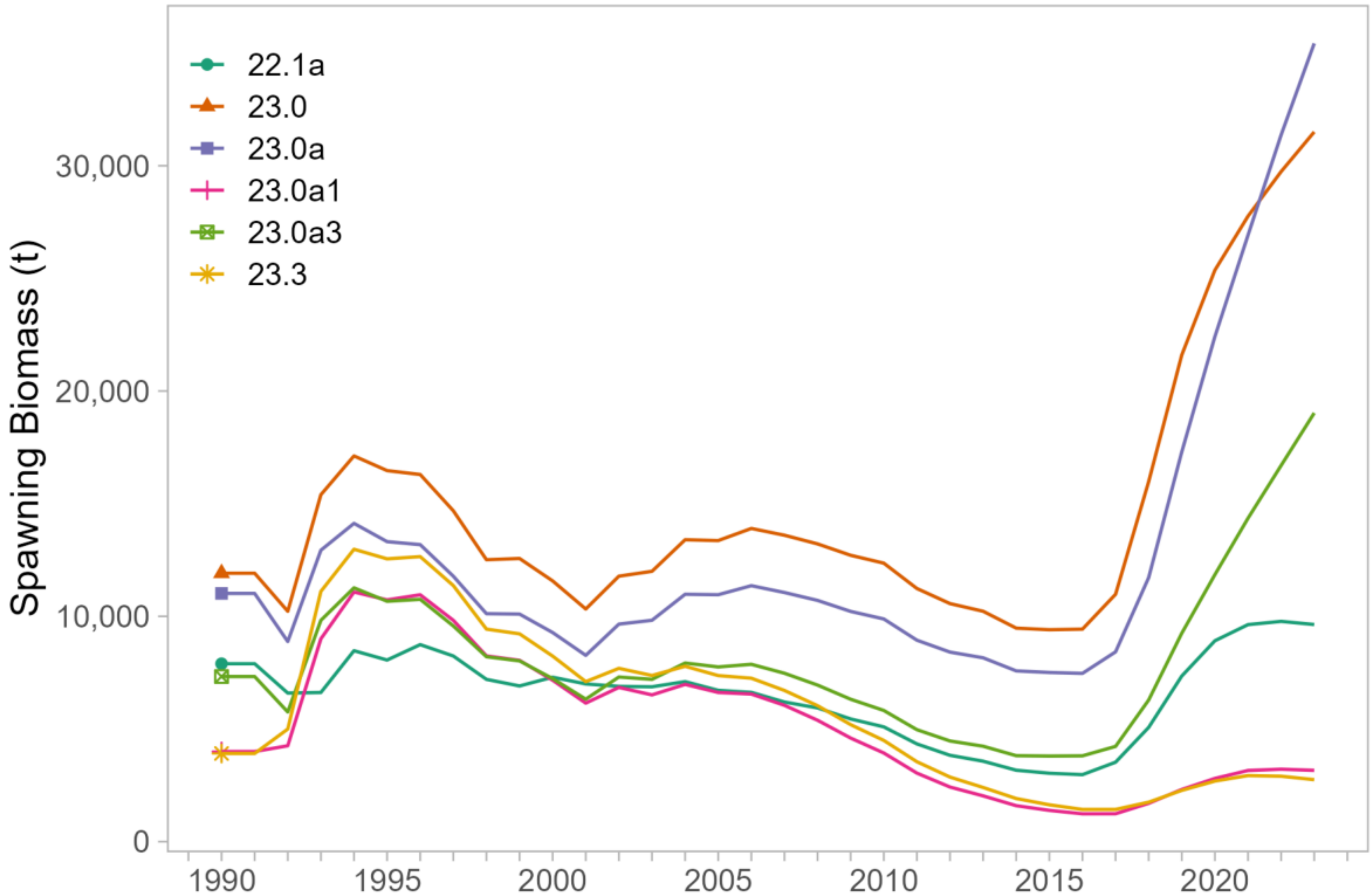


Figure 33: Estimated spawning stock biomass (t) by model scenario, without 95% confidence intervals.

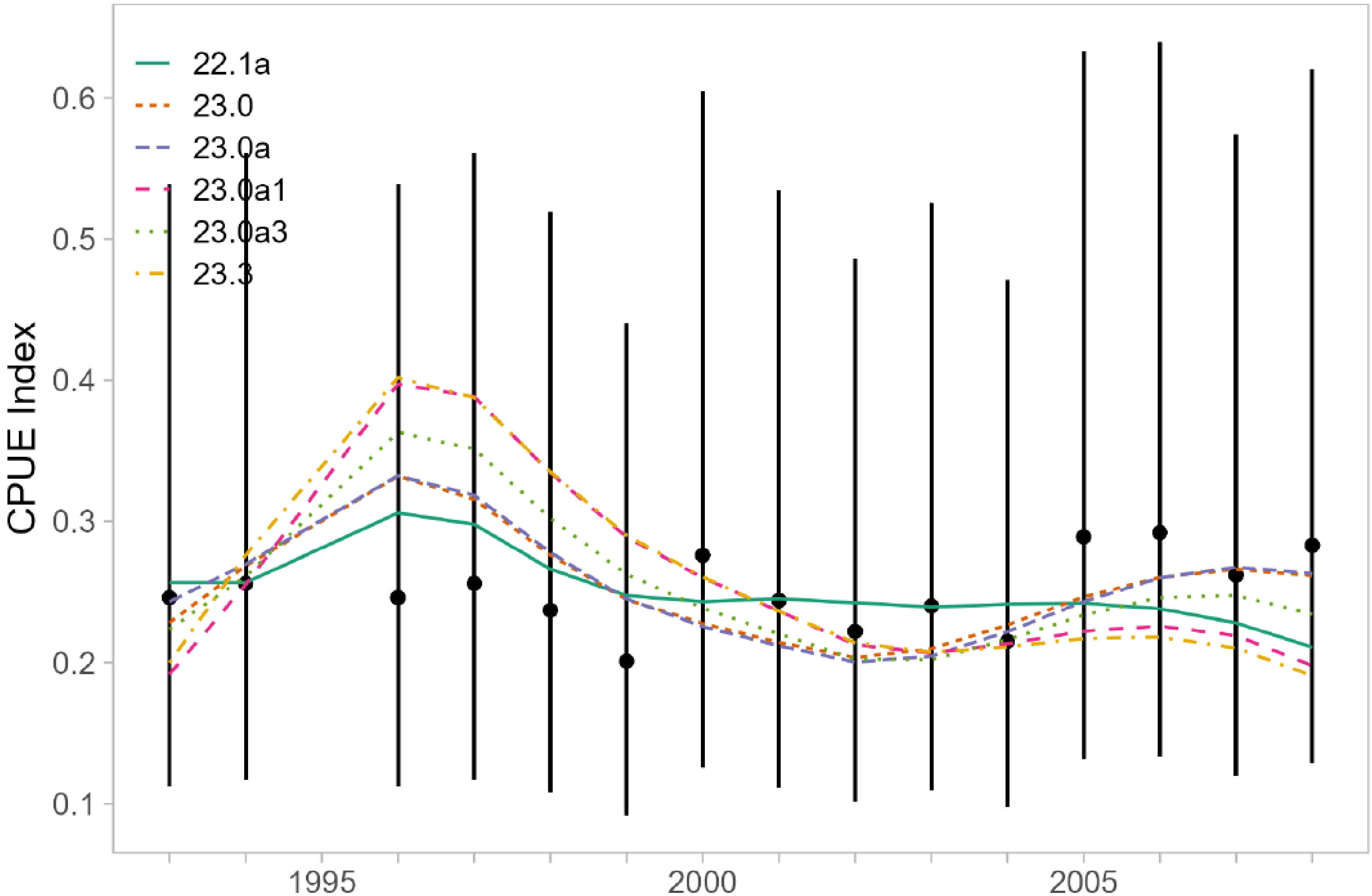


Figure 1: Fit to nominal fishery CPUE index from 1992-2008 by model scenario. Error bars indicate 95% confidence intervals.

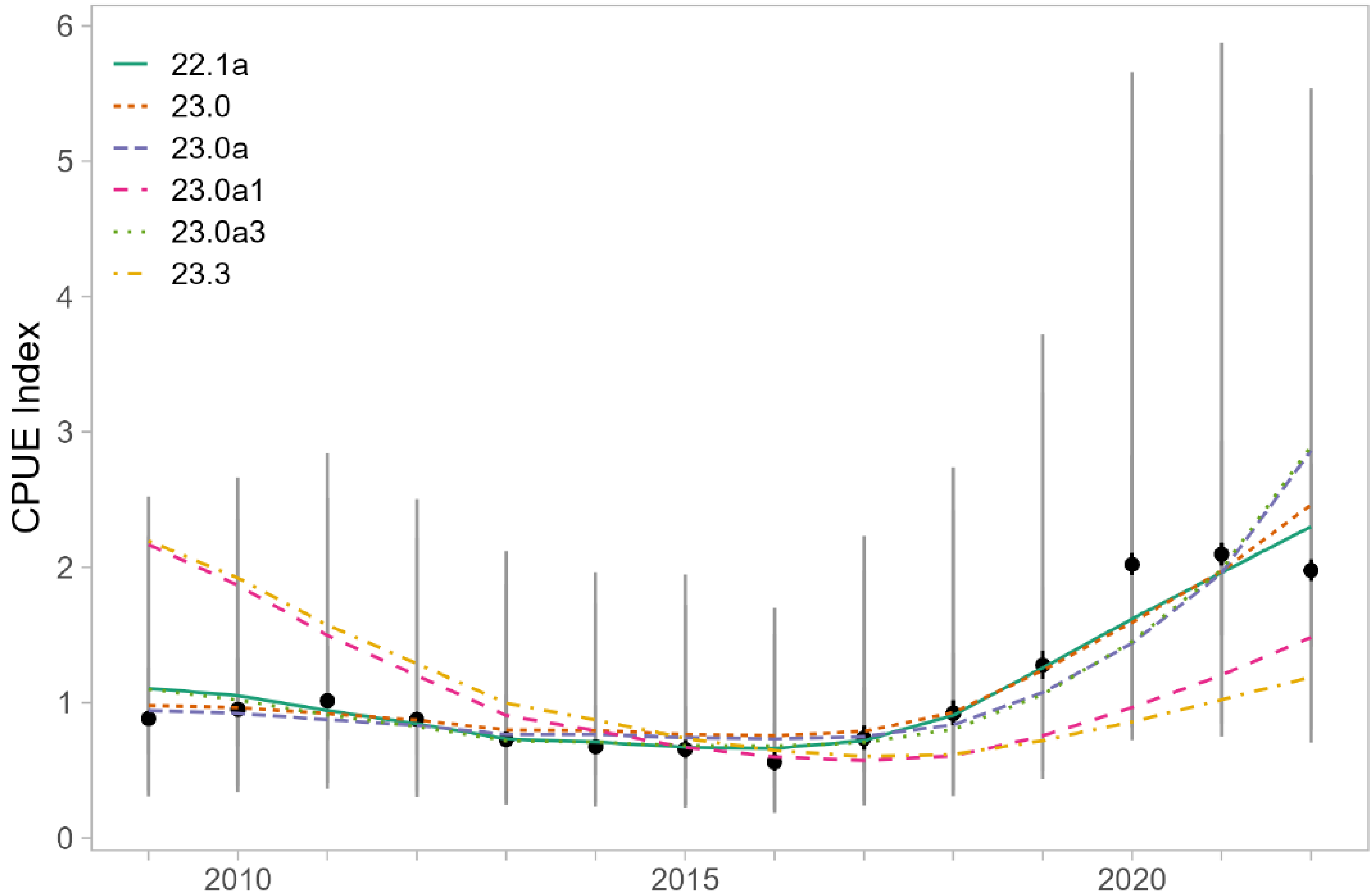


Figure 2: Fit to standardized fishery CPUE index from 2009-2022 by model scenario. Black error bars indicate 95% confidence intervals and grey error bars indicate addition estimated error.

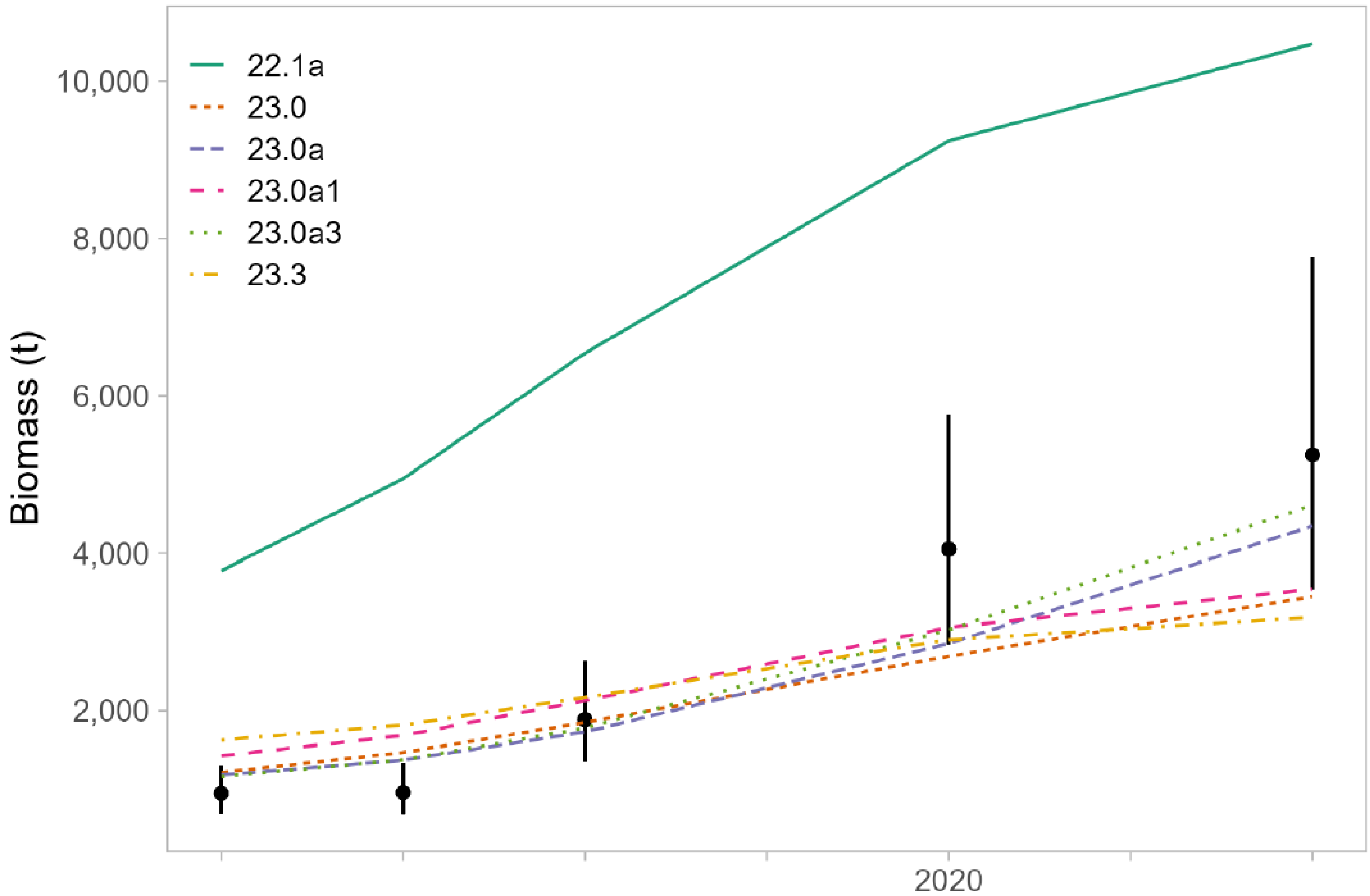


Figure 3: Fit to ADF&G dredge survey biomass by model scenario. Black error bars indicate 95% confidence intervals and grey error bars indicate addition estimated error.

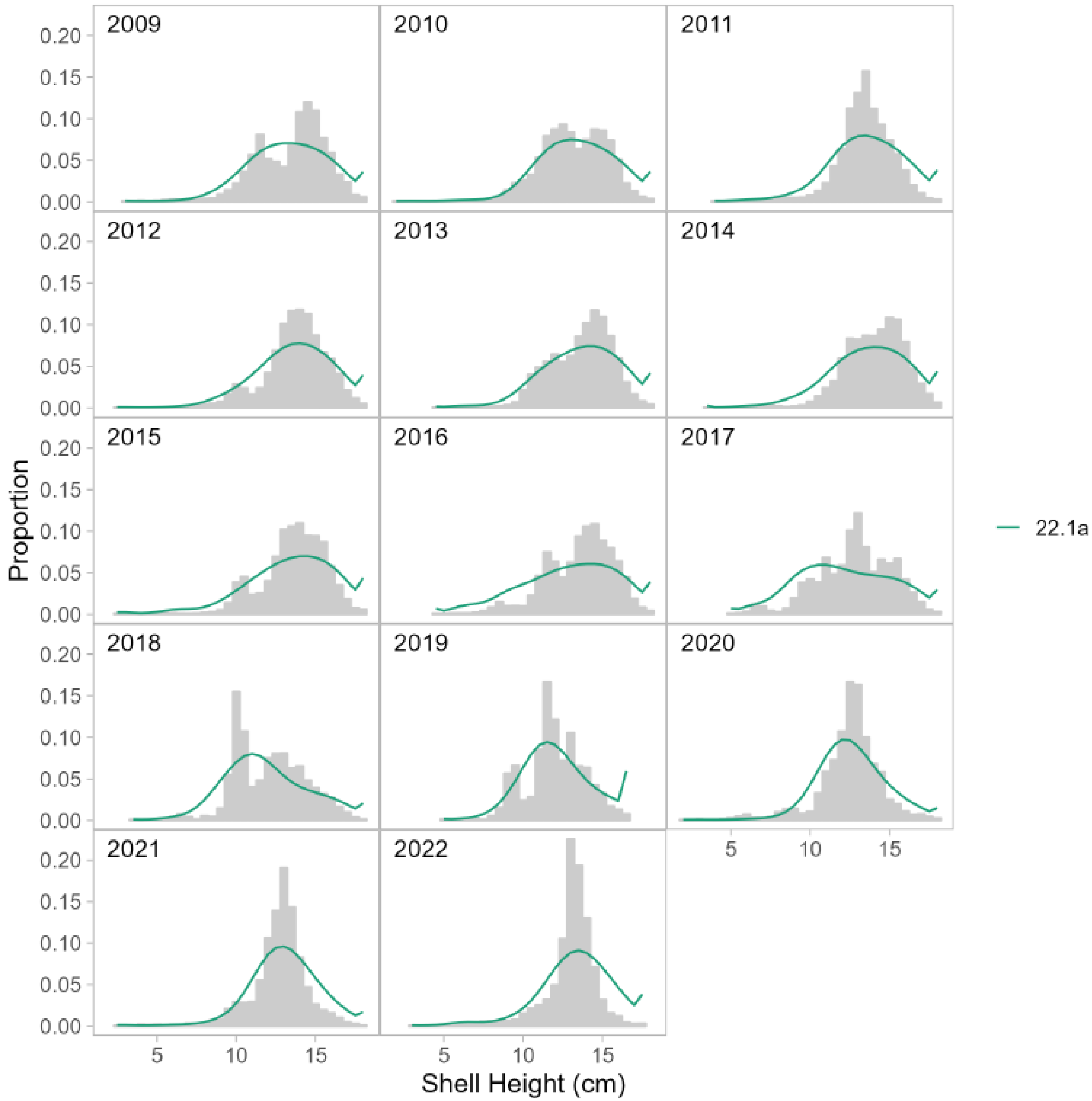


Figure 4: Fit to fishery shell height composition (i.e., retained and discarded scallops) for model 22.1a.

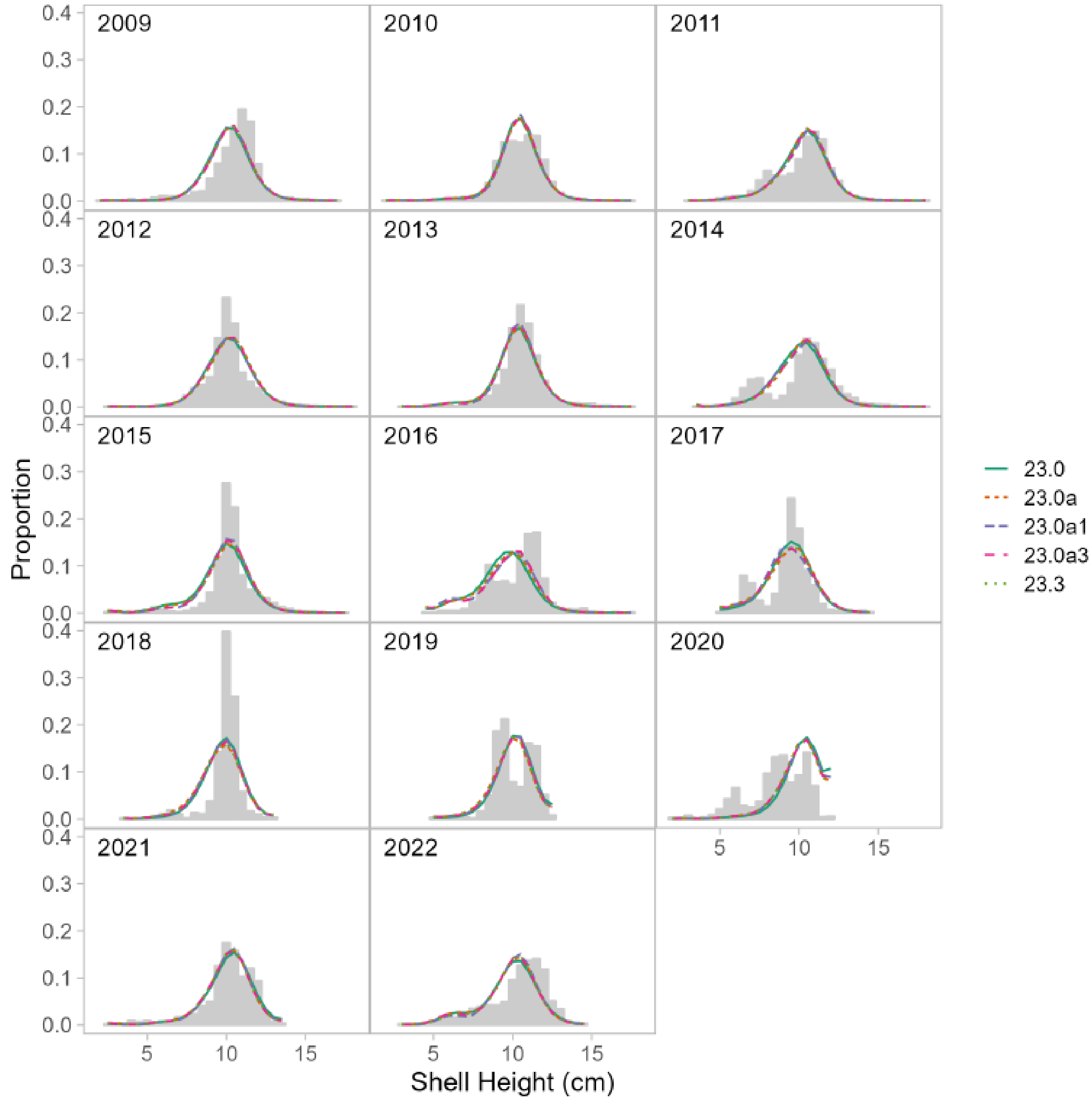


Figure 5: Fit to fishery discarded scallop shell height composition by model scenario.

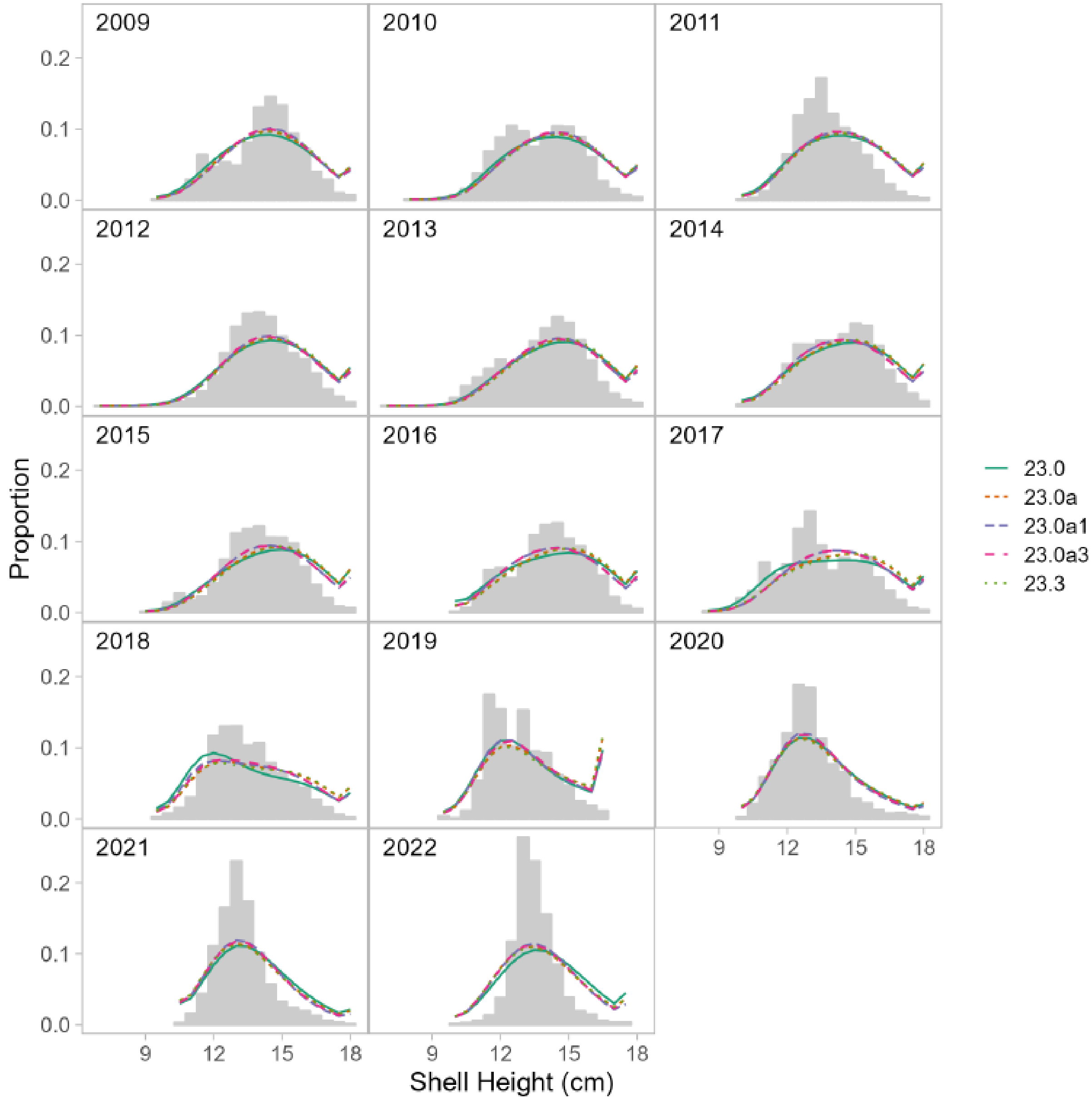


Figure 6: Fit to fishery retained scallop shell height composition by model scenario.

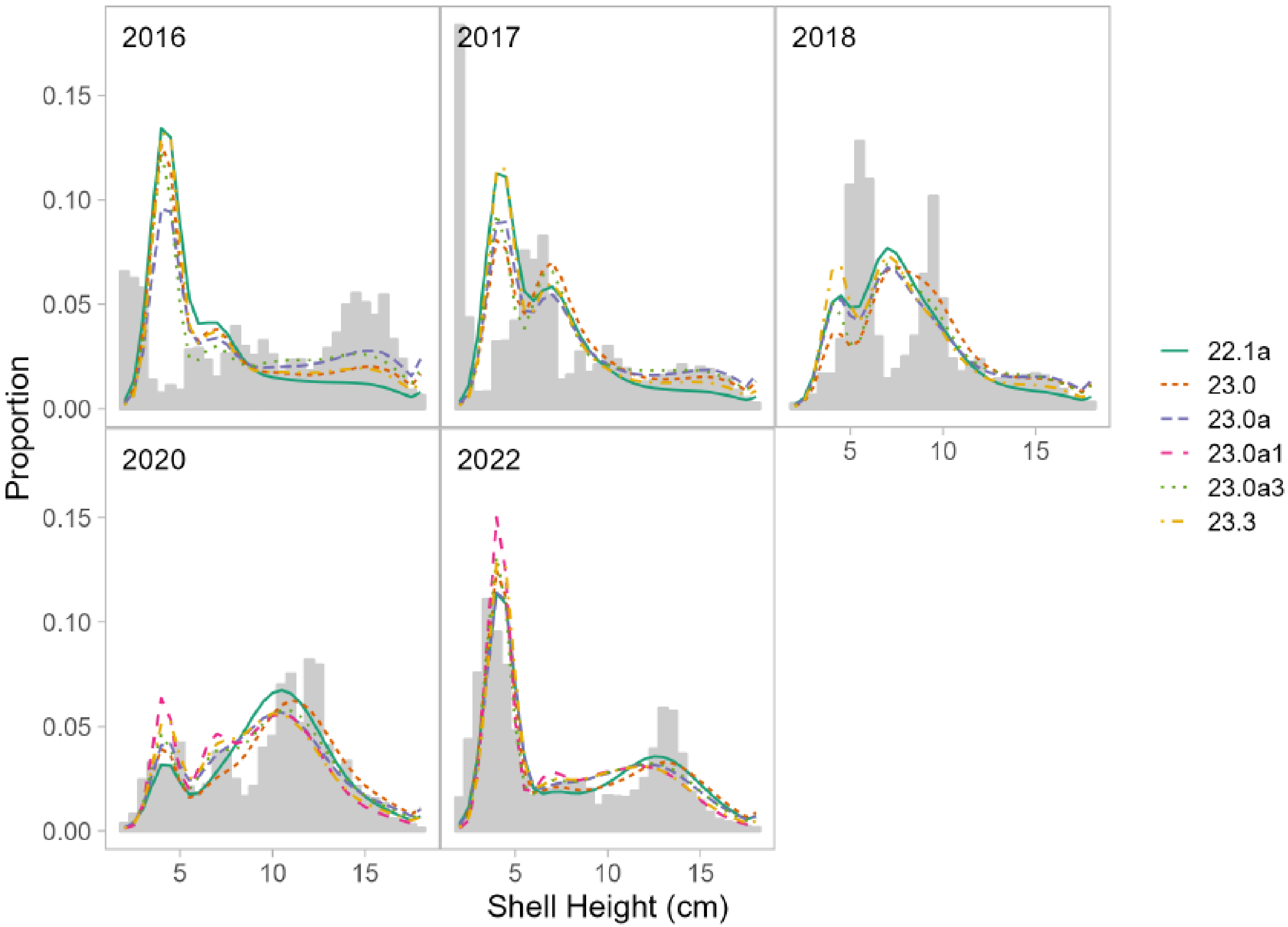


Figure 7: Fit to ADF&G dredge survey shell height composition by model scenario.

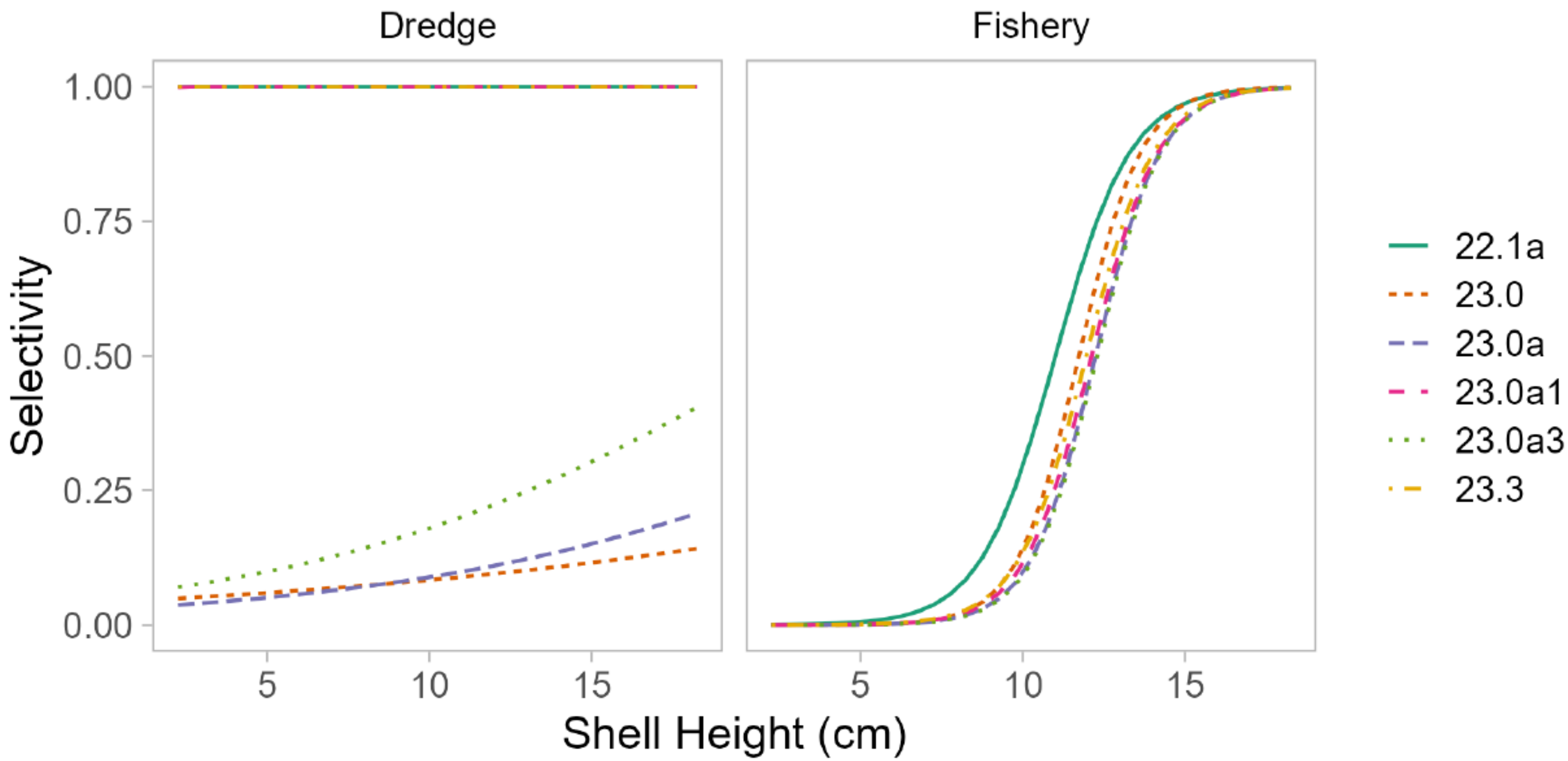


Figure 8: Fishery and ADF&G dredge survey shell height selectivity by model scenario.

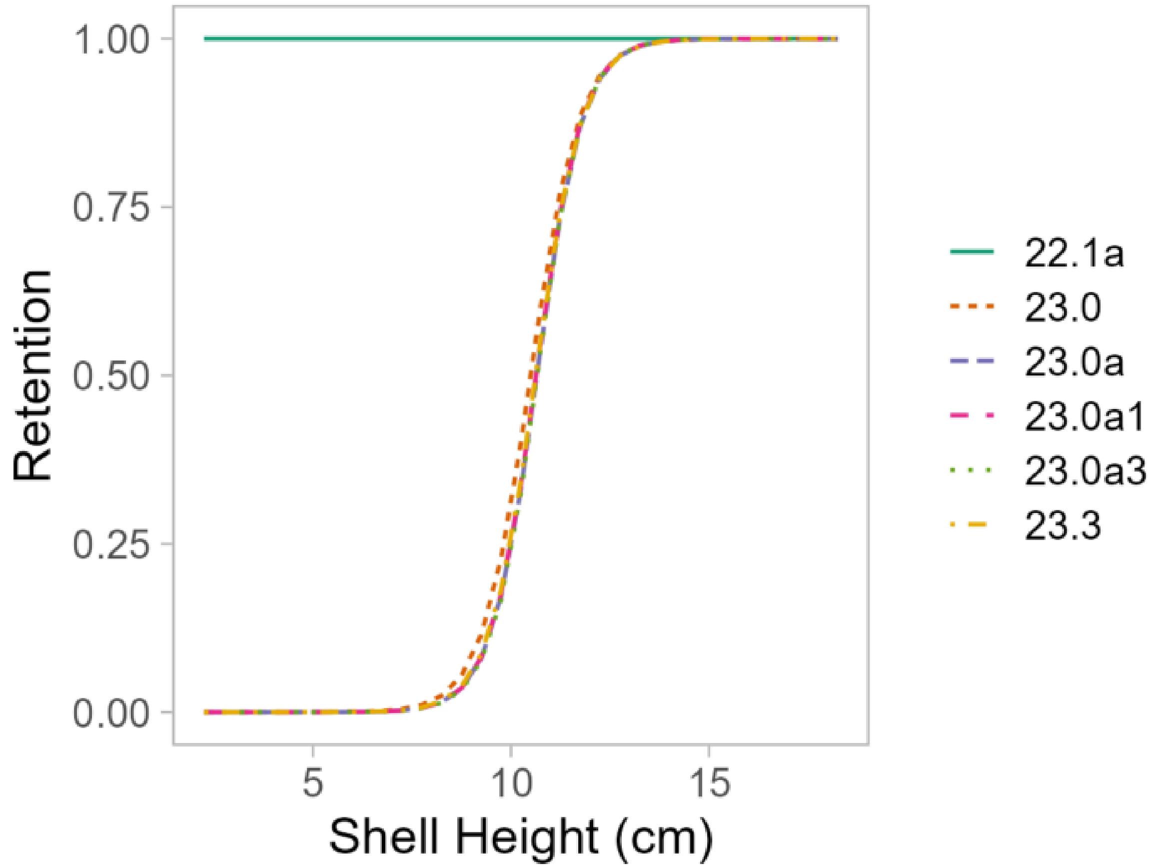


Figure 9: Fishery retention on the basis of shell height by model scenario.

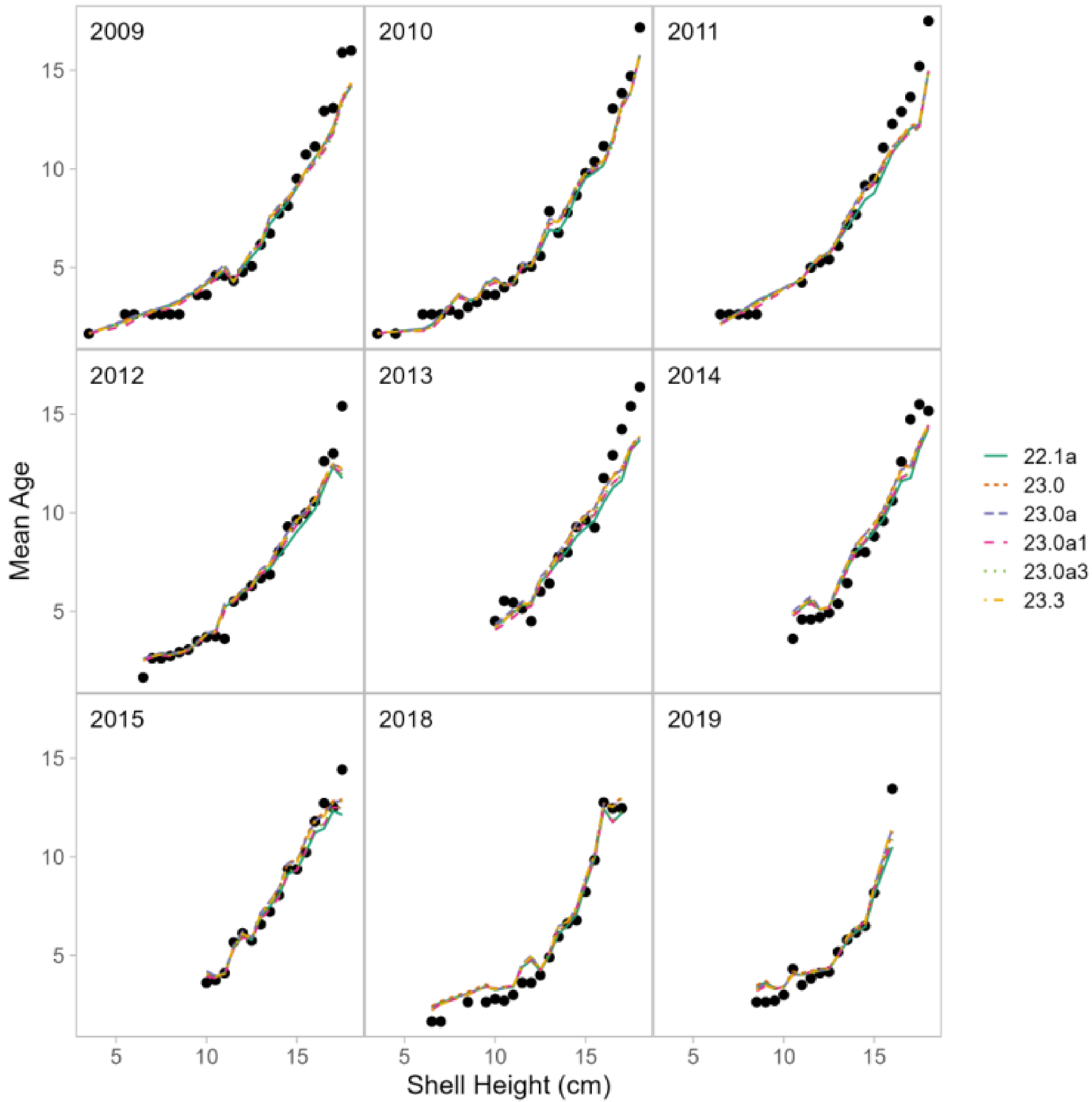


Figure 10: Fit to fishery age composition by model scenario.

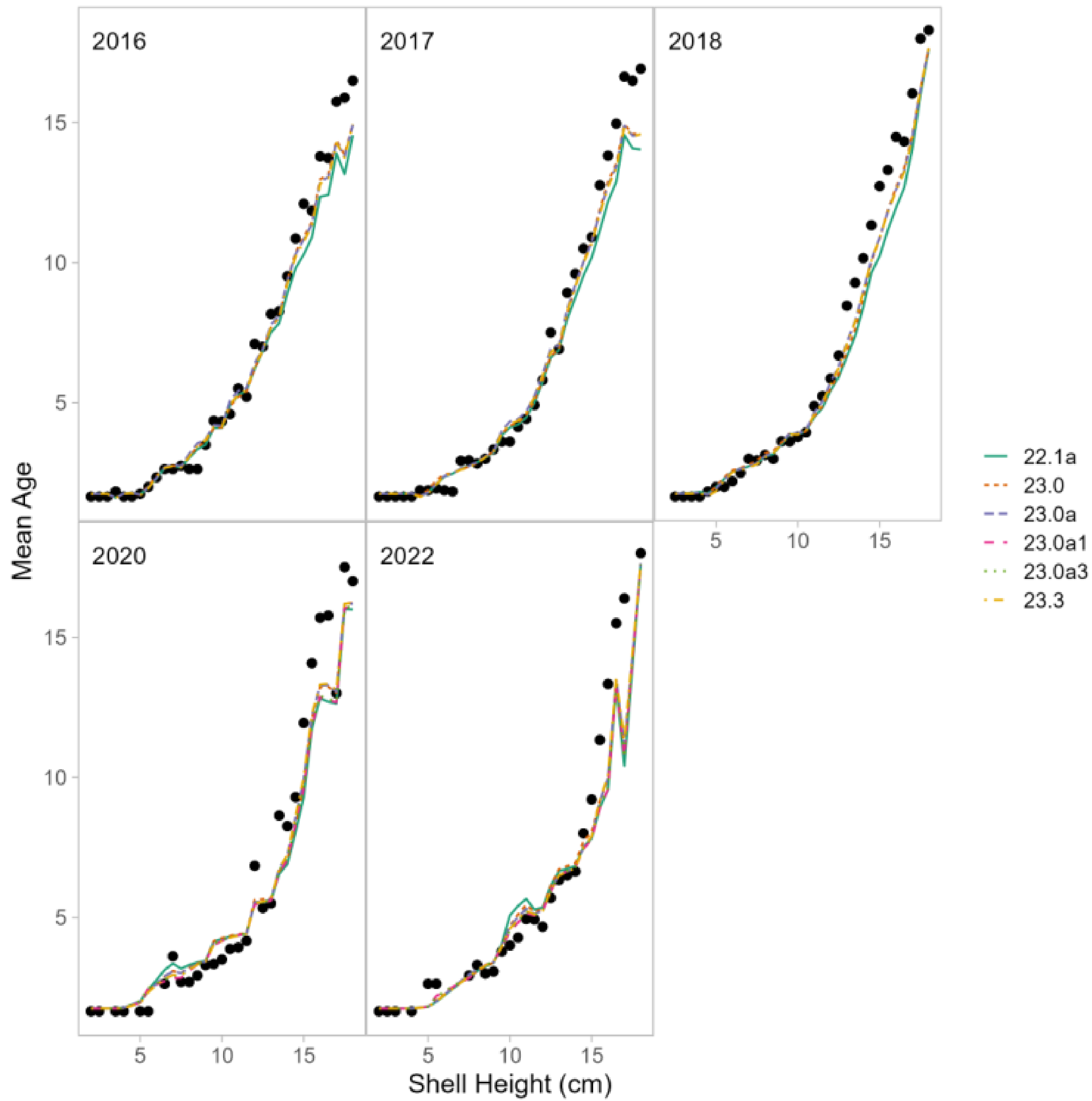


Figure 17: Fit to ADF&G dredge survey age composition by model scenario.

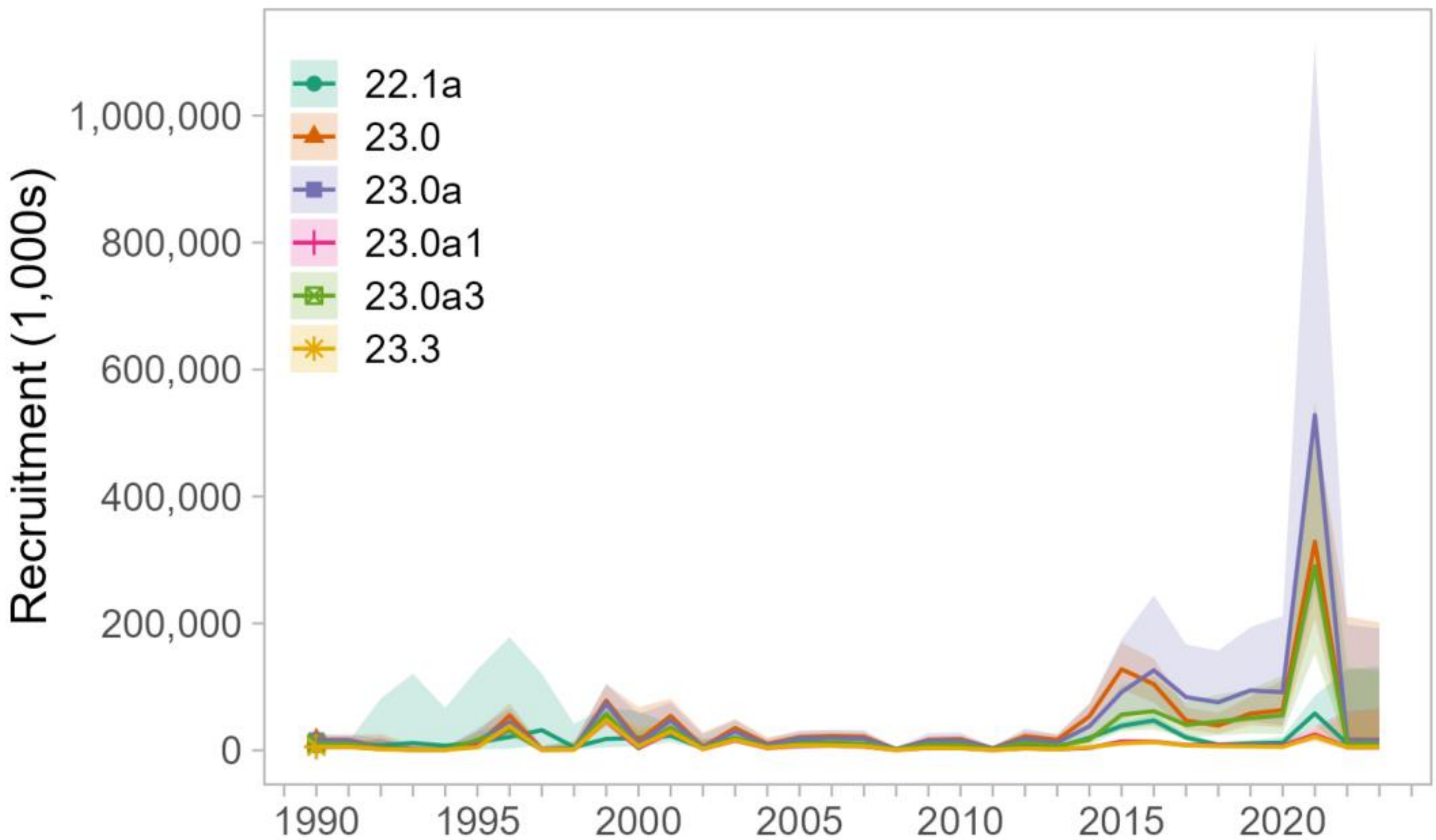


Figure 24: Predicted annual recruitment (millions) by model scenario.

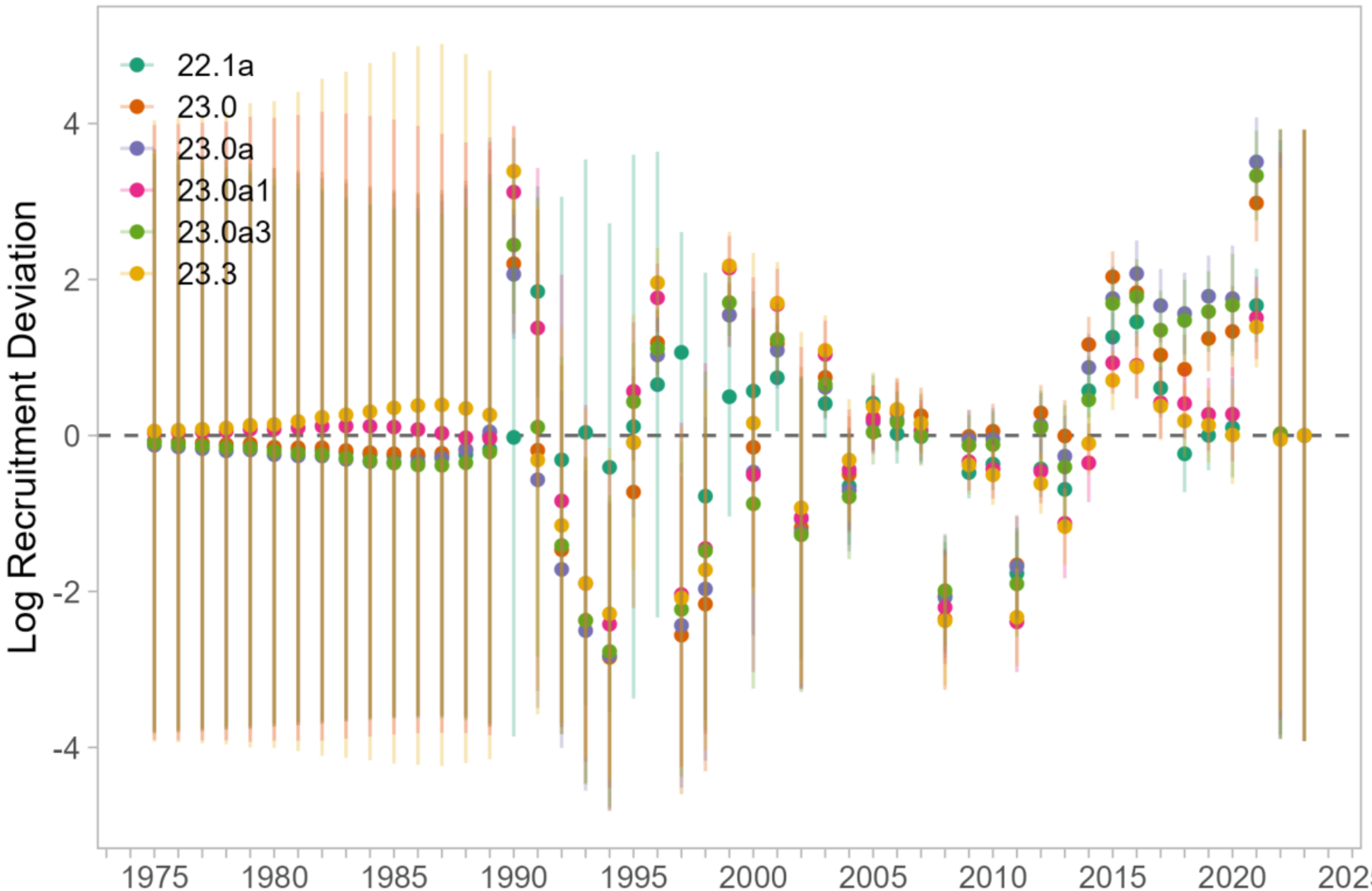


Figure 25: Recruitment deviations and associated 95% confidence intervals.

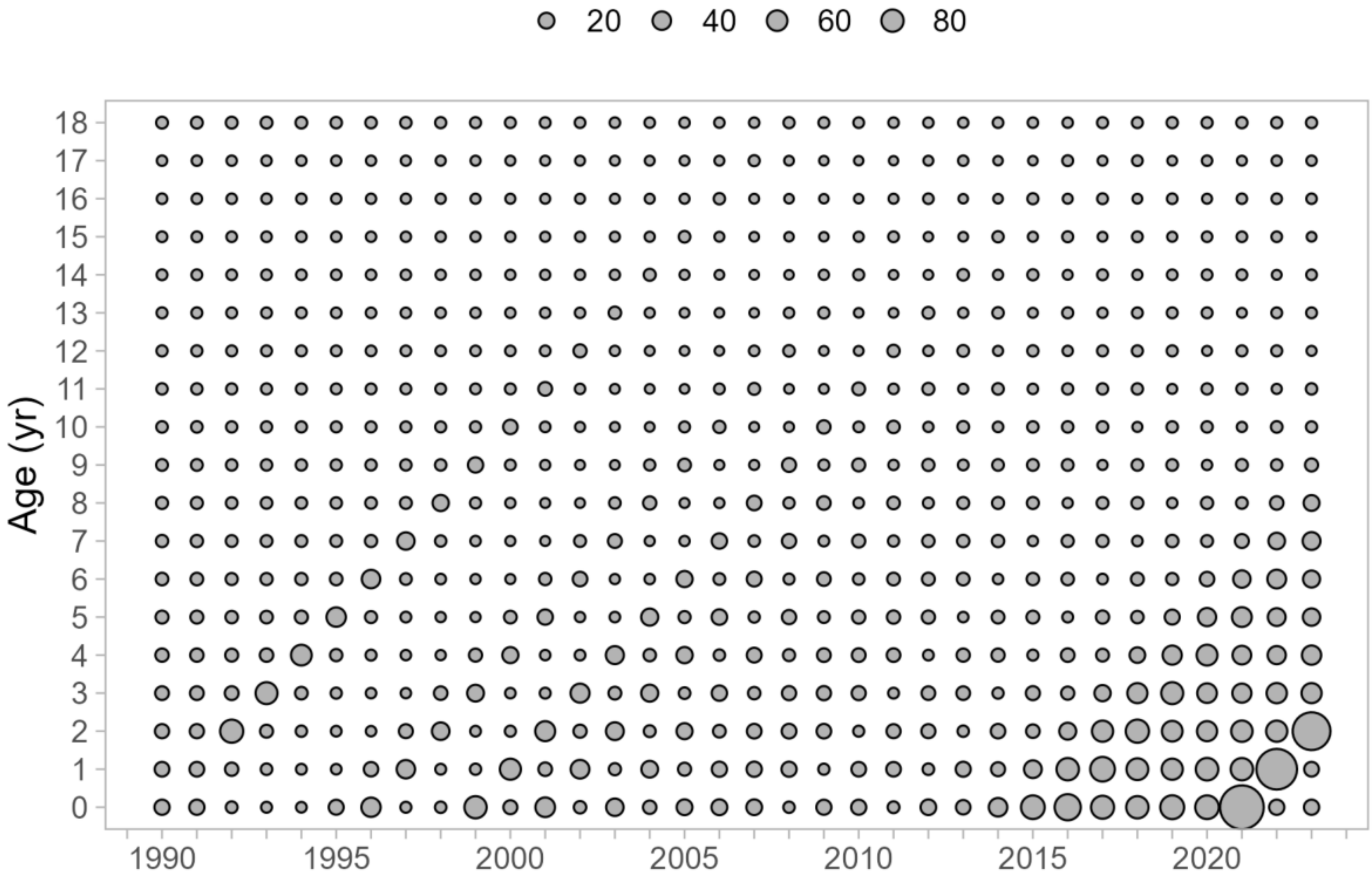


Figure 28: Beginning of year numbers at age matrix (millions) for model 23.0a.

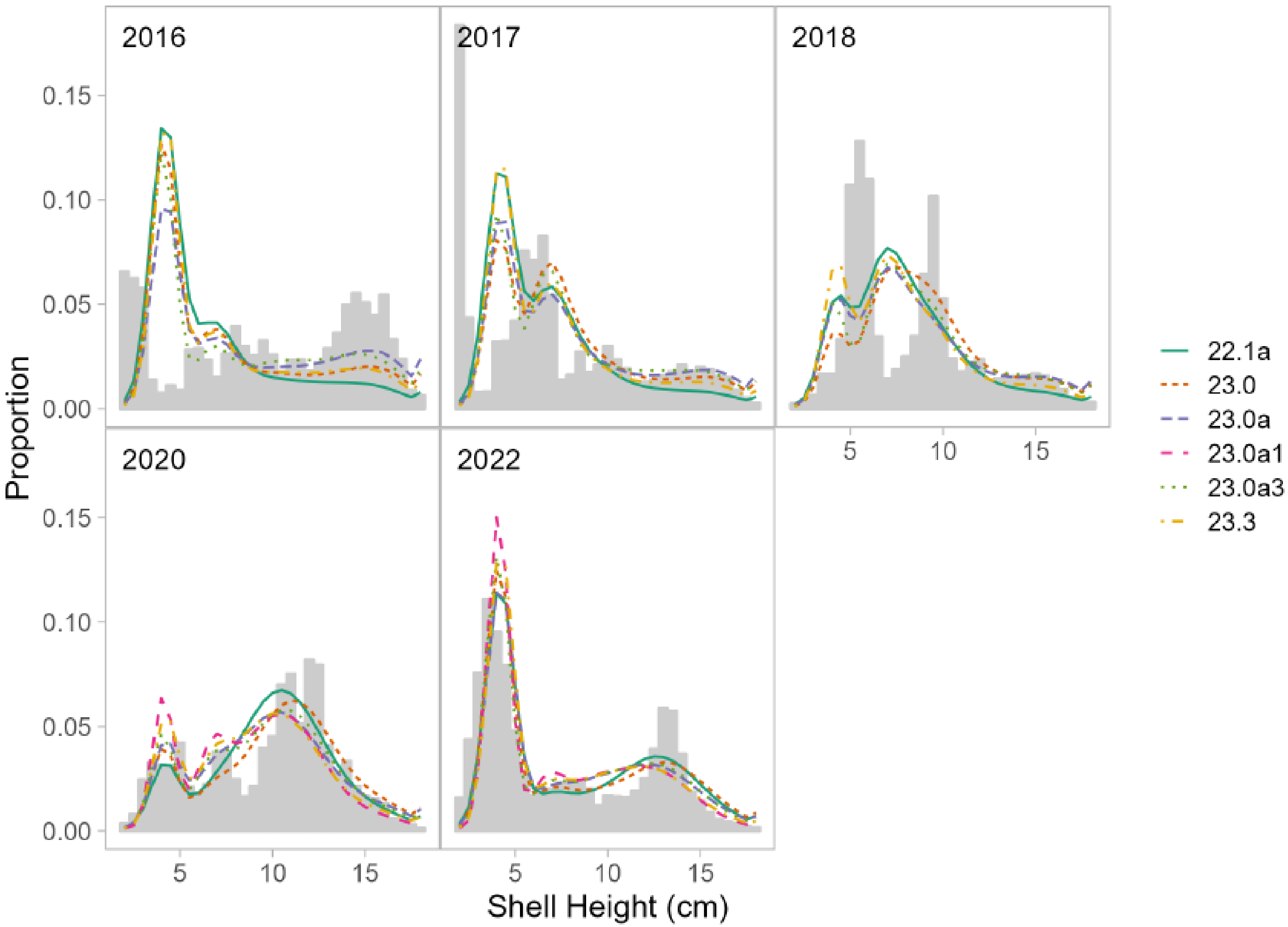


Figure 7: Fit to ADF&G dredge survey shell height composition by model scenario.

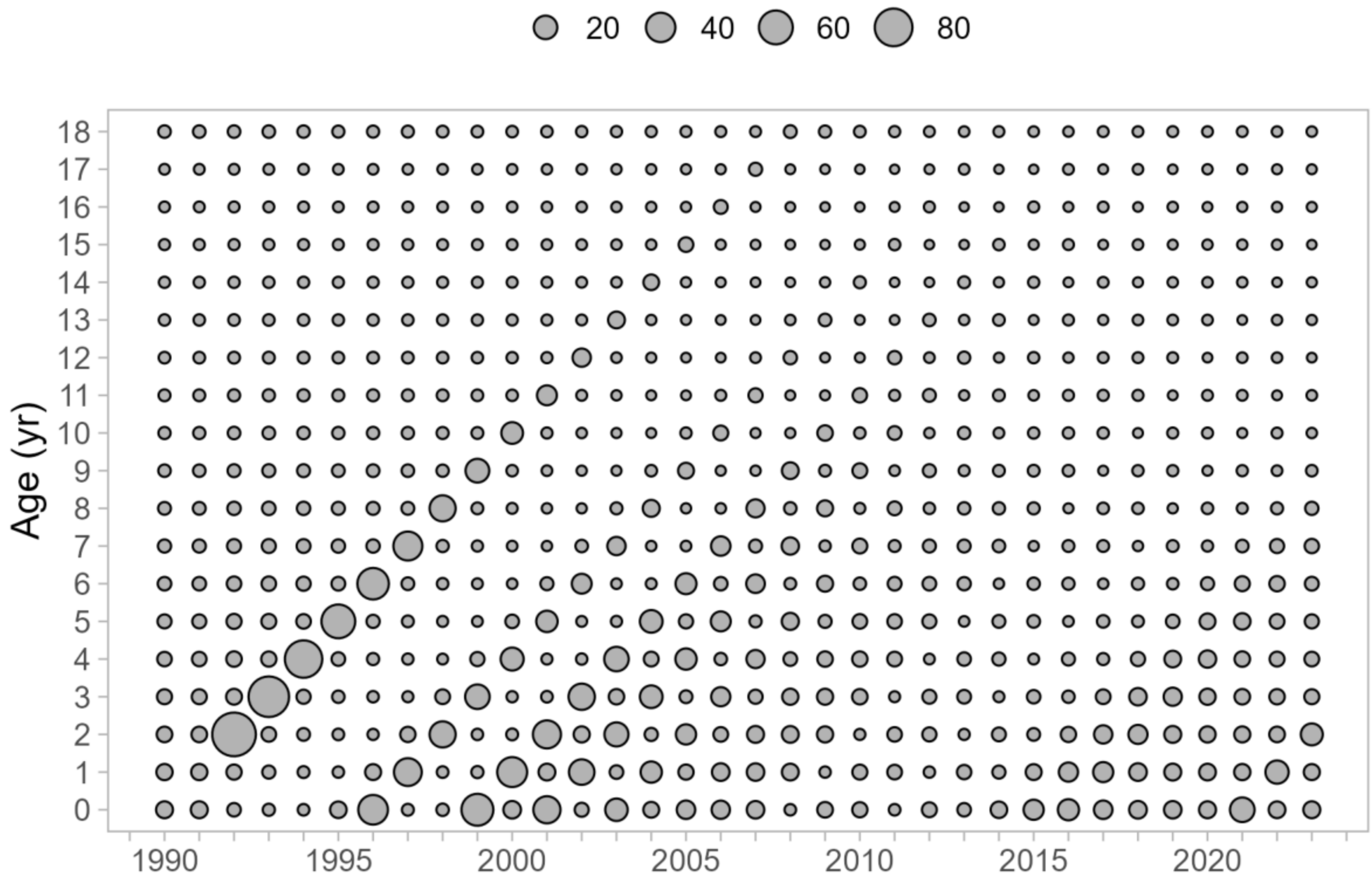


Figure 31: Beginning of year numbers at age matrix (millions) for model 23.3.

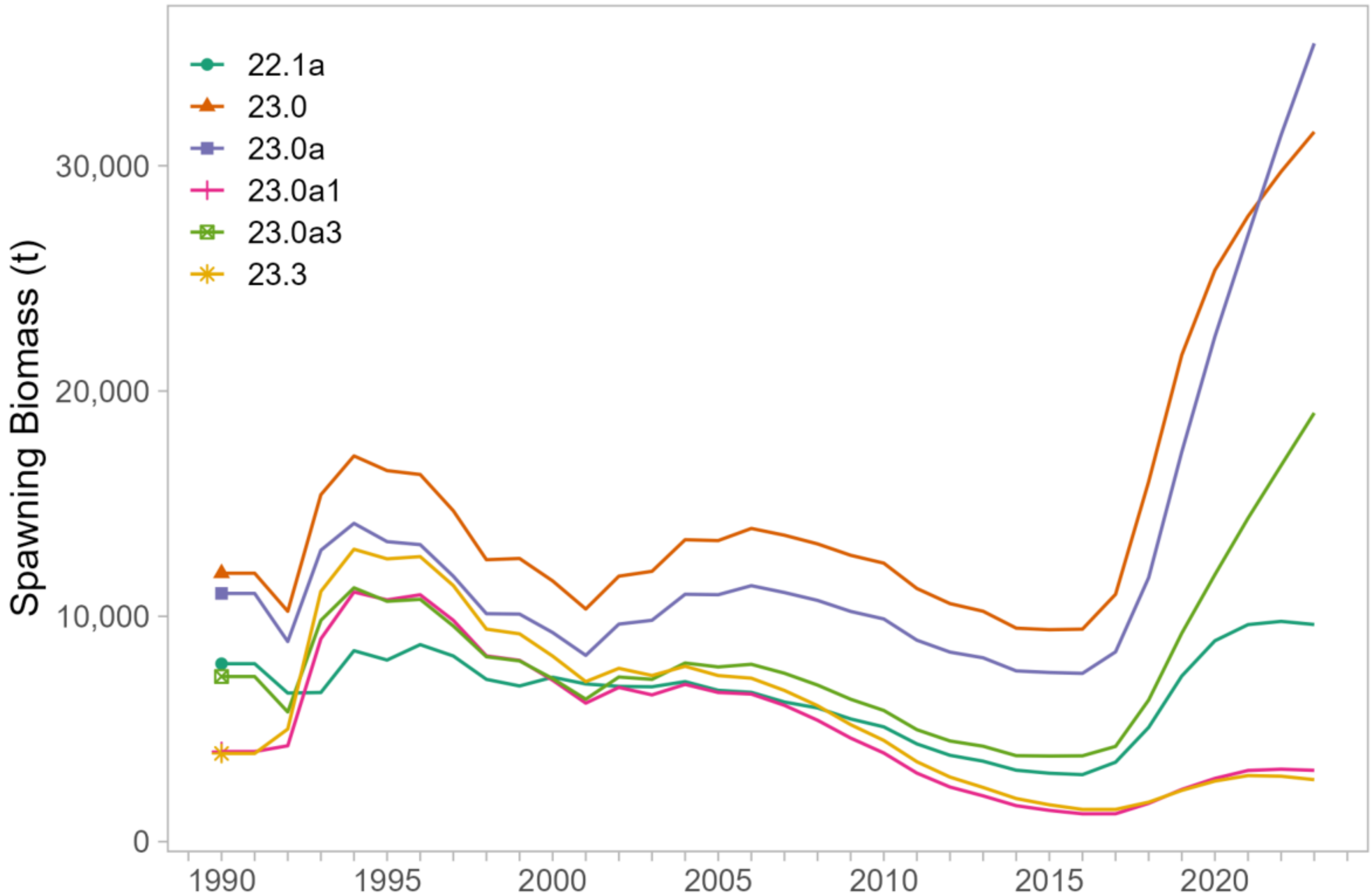


Figure 33: Estimated spawning stock biomass (t) by model scenario, without 95% confidence intervals.

Table 4: Likelihood components by model scenario.

Process	22.1a	23.0	23.0a	23.0a1	23.0a3	23.3
Total	1,850.670	2,283.240	2,064.390	1,643.200	1,713.760	2,023.270
Catch	1.140e-10	2.389e-11	4.182e-11	5.916e-10	1.159e-10	4.599e-10
Discards		290.677	303.024	277.889	289.804	289.401
Recruitment Deviations	3.143	8.971	9.872	7.340	9.153	7.563
CPUE 1992-2008	-12.666	-12.709	-12.641	-10.495	-11.946	-10.255
CPUE 2009-2022	101.576	135.019	-16.877	-3.445	-16.843	-1.714
Survey Biomass	118.316	0.403	-3.089	3.423	-4.083	9.228
Fishery Length Comp.	194.700	435.175	417.418	384.878	386.402	427.855
Survey Length Comp.	207.743	198.960	185.012	29.950	110.848	126.899
Fishery Age Comp.	560.563	555.656	548.610	529.043	543.914	531.135
Survey Age Comp.	452.618	399.826	371.312	134.687	134.854	372.953
Fishery Size at Age	104.093	146.245	130.950	149.250	137.658	137.340
Survey Size at Age	118.869	123.195	129.693	139.441	132.763	131.810
Parameter Priors	1.704	1.821	1.108	1.232	1.239	1.049

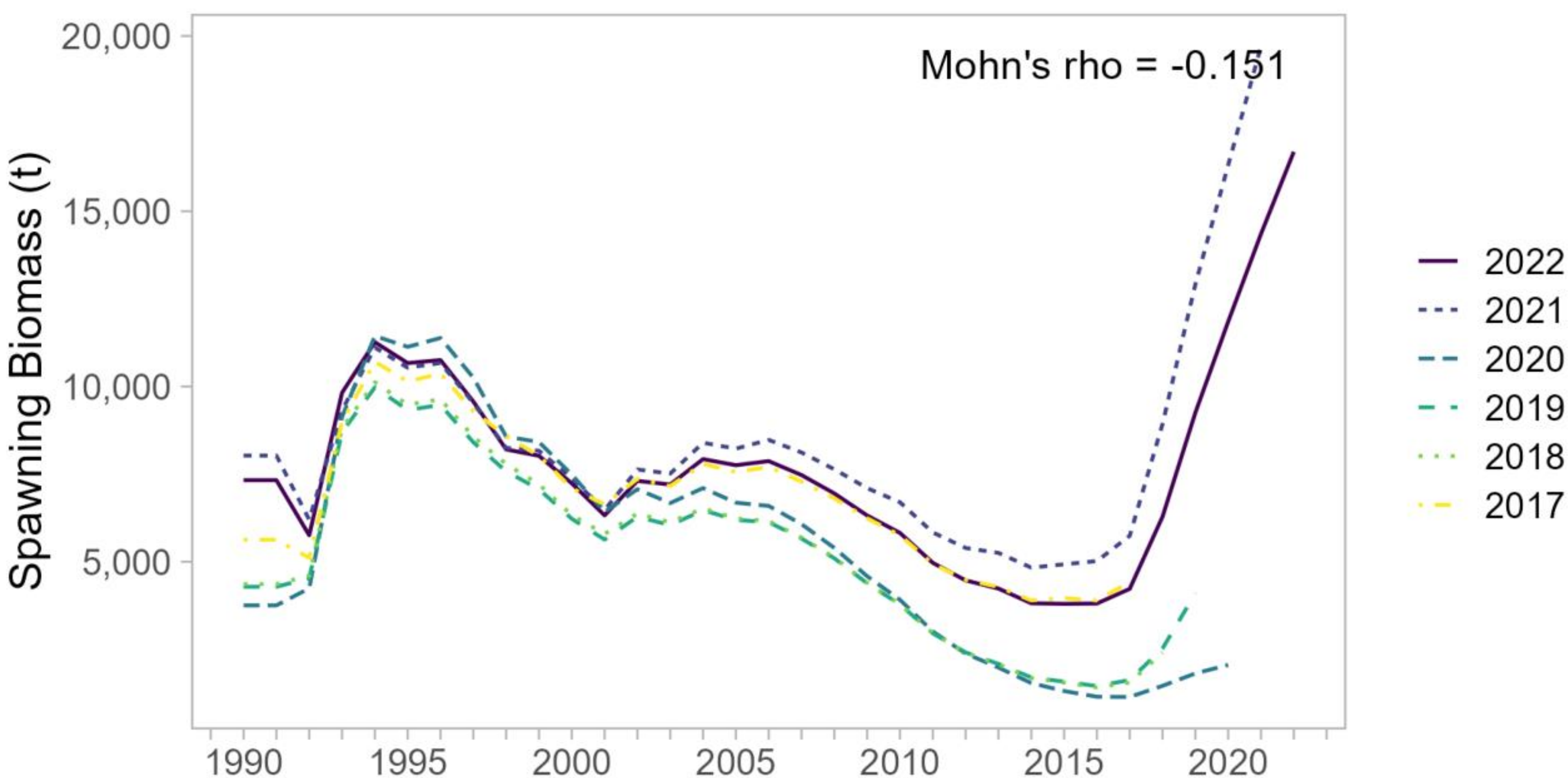


Figure 38: Spawning stock biomass from retrospective analysis of model 23.0a3 going back to 2017.

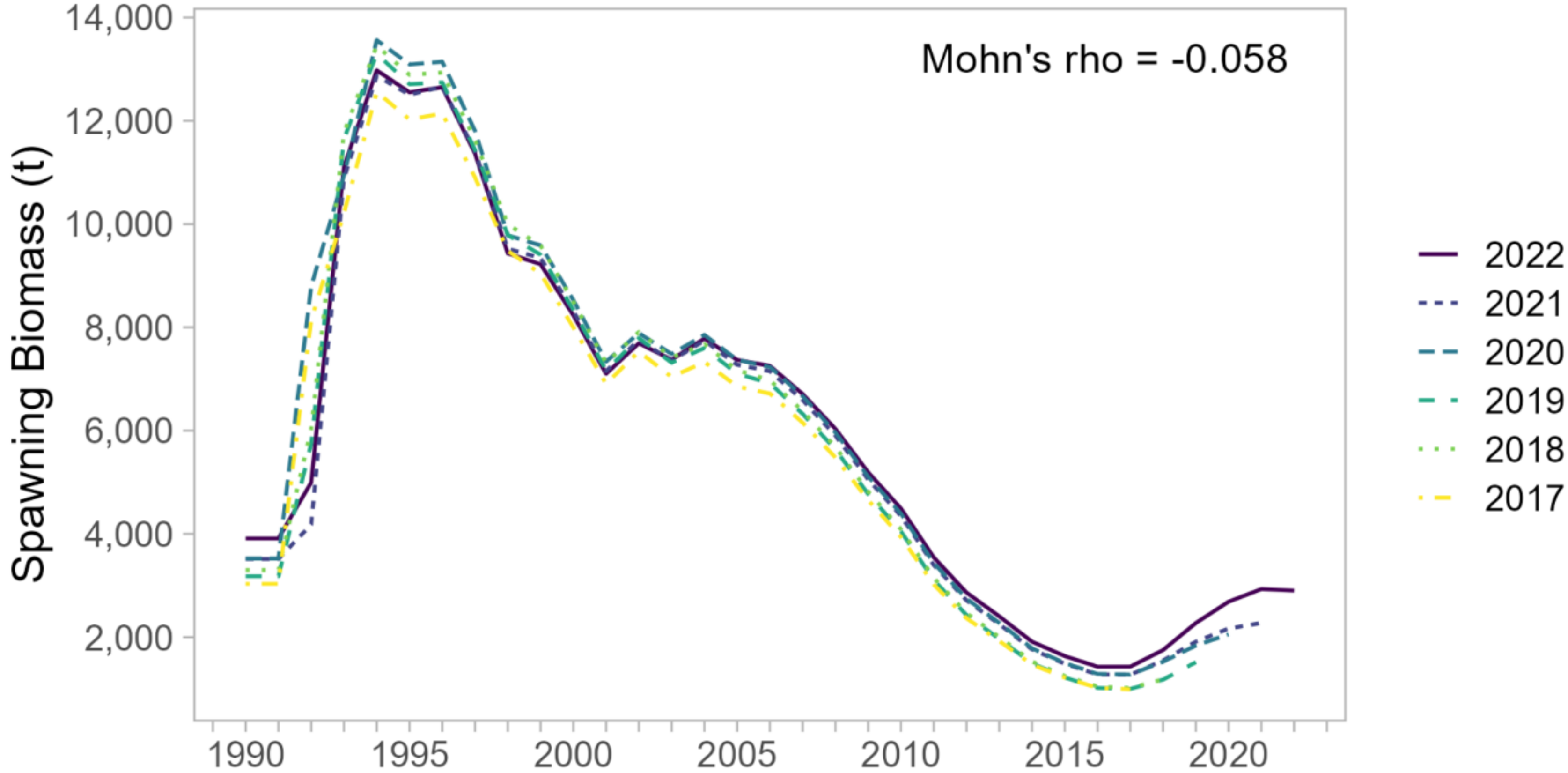


Figure 39: Spawning stock biomass from retrospective analysis of model 23.3 going back to 2017.

Author Recommendation

- Continue with models 23.0a3 and 23.3
- Recover 1992-2008 fishery catch by haul and size composition
- Add recent fishery age composition 2020 - present
- Improve fits to abundance in 23.3
- Estimate dredge survey catchability using q = 0.83 as prior
  - Explore time varying catchability (2016 – 2018, 2020, 2023 – present)
- Troubleshoot dredge selectivity
  - Estimate selectivity for lower third of size range