Stock assessment work for Alaska pollock in the Eastern Bering Sea

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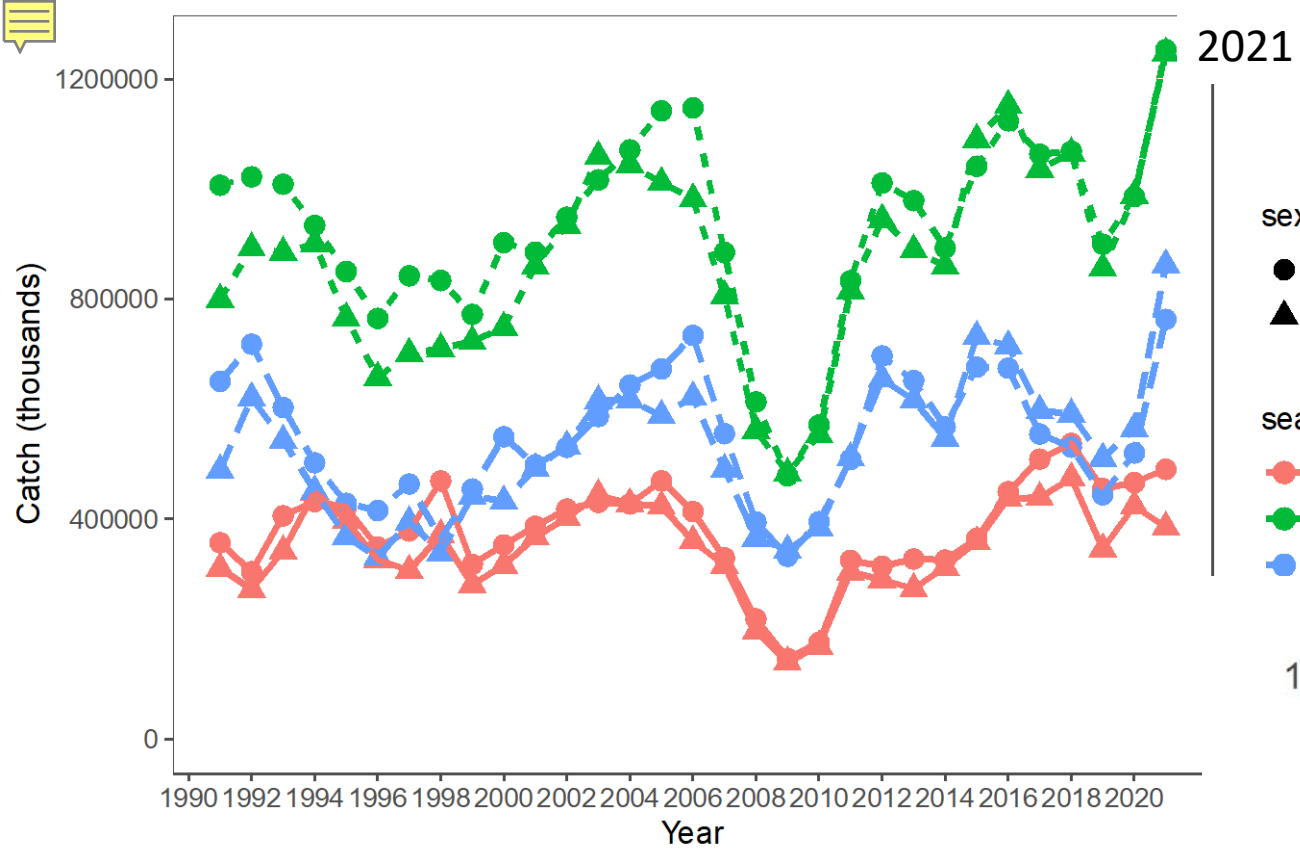
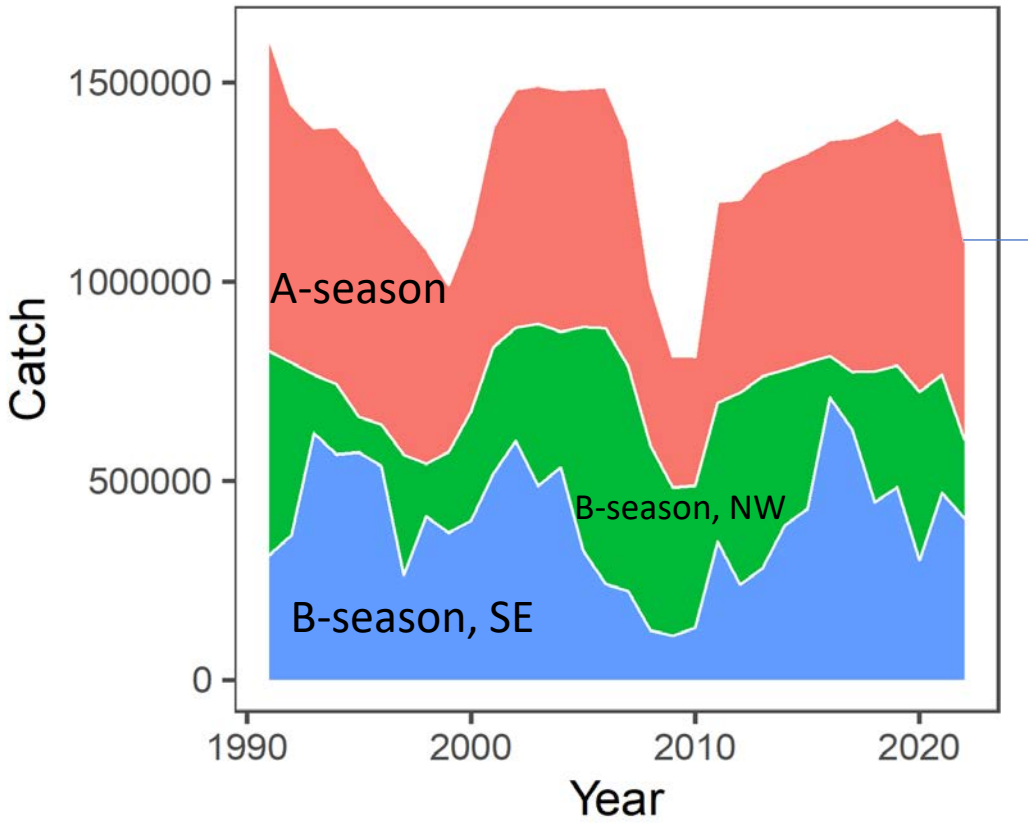
Alaska Fisheries Science Center

Fishery catches

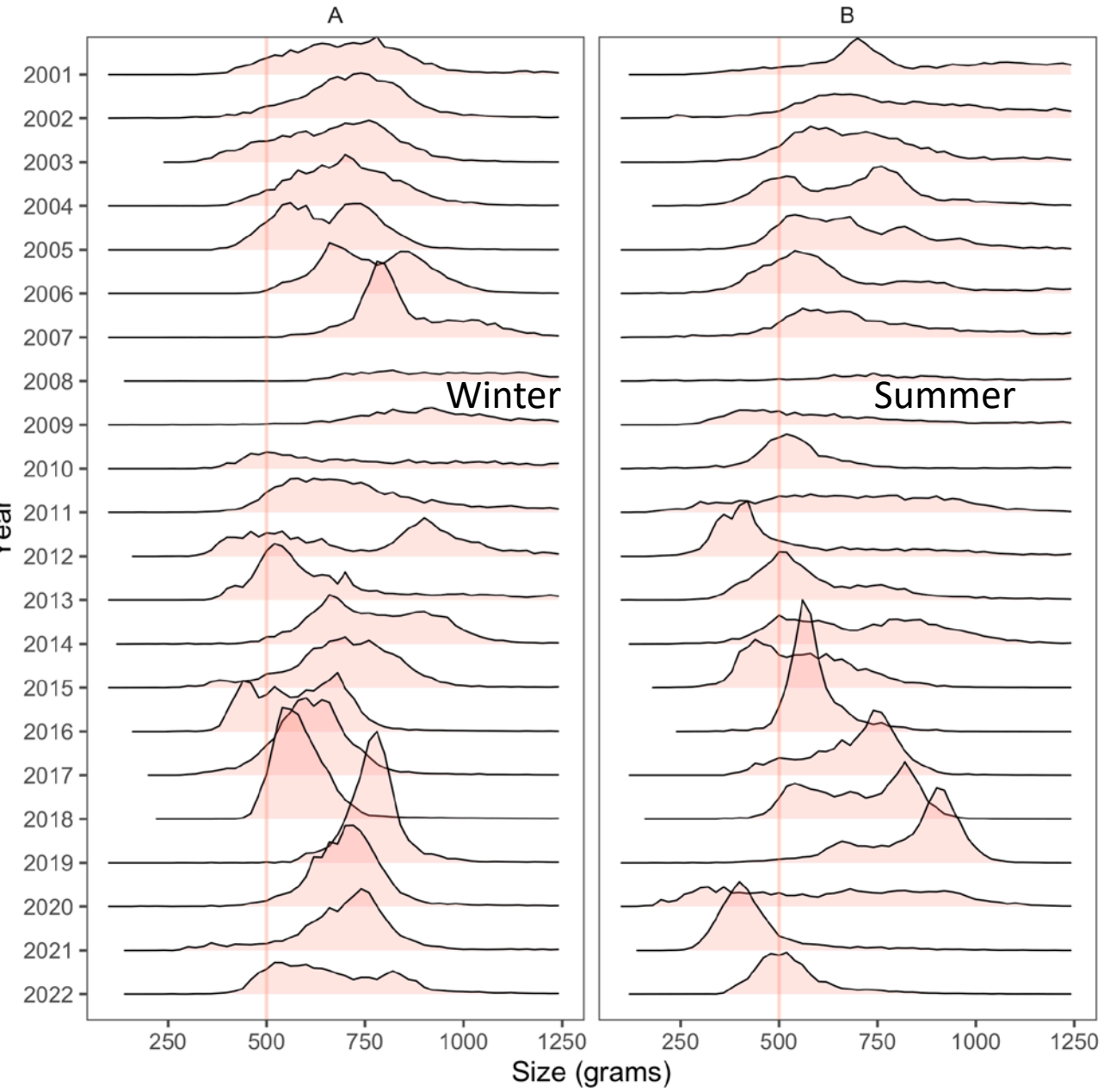




2022
(1.11 million t)

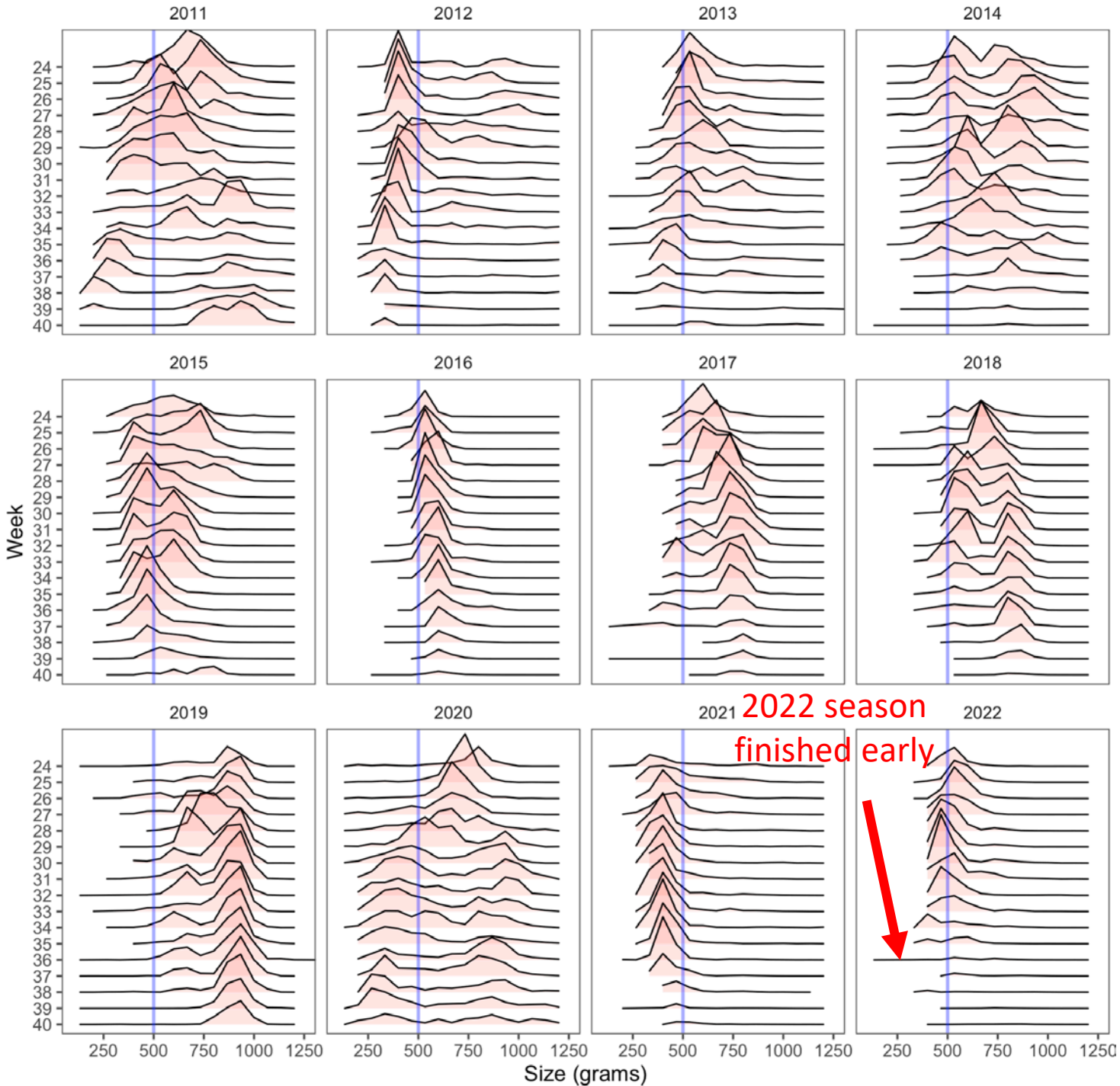
Bering Sea Pollock Fishing conditions

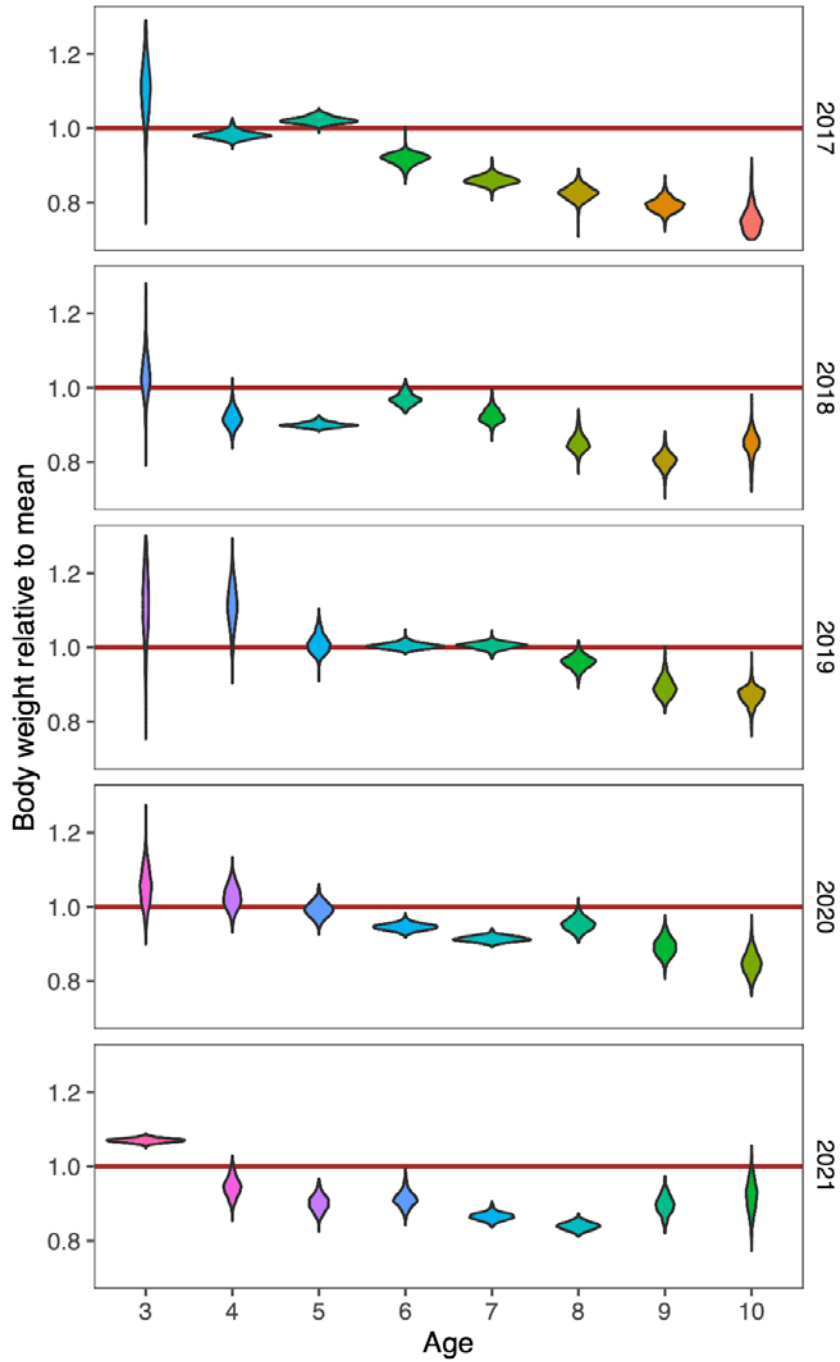
Trends in weight frequency of catch



B-season

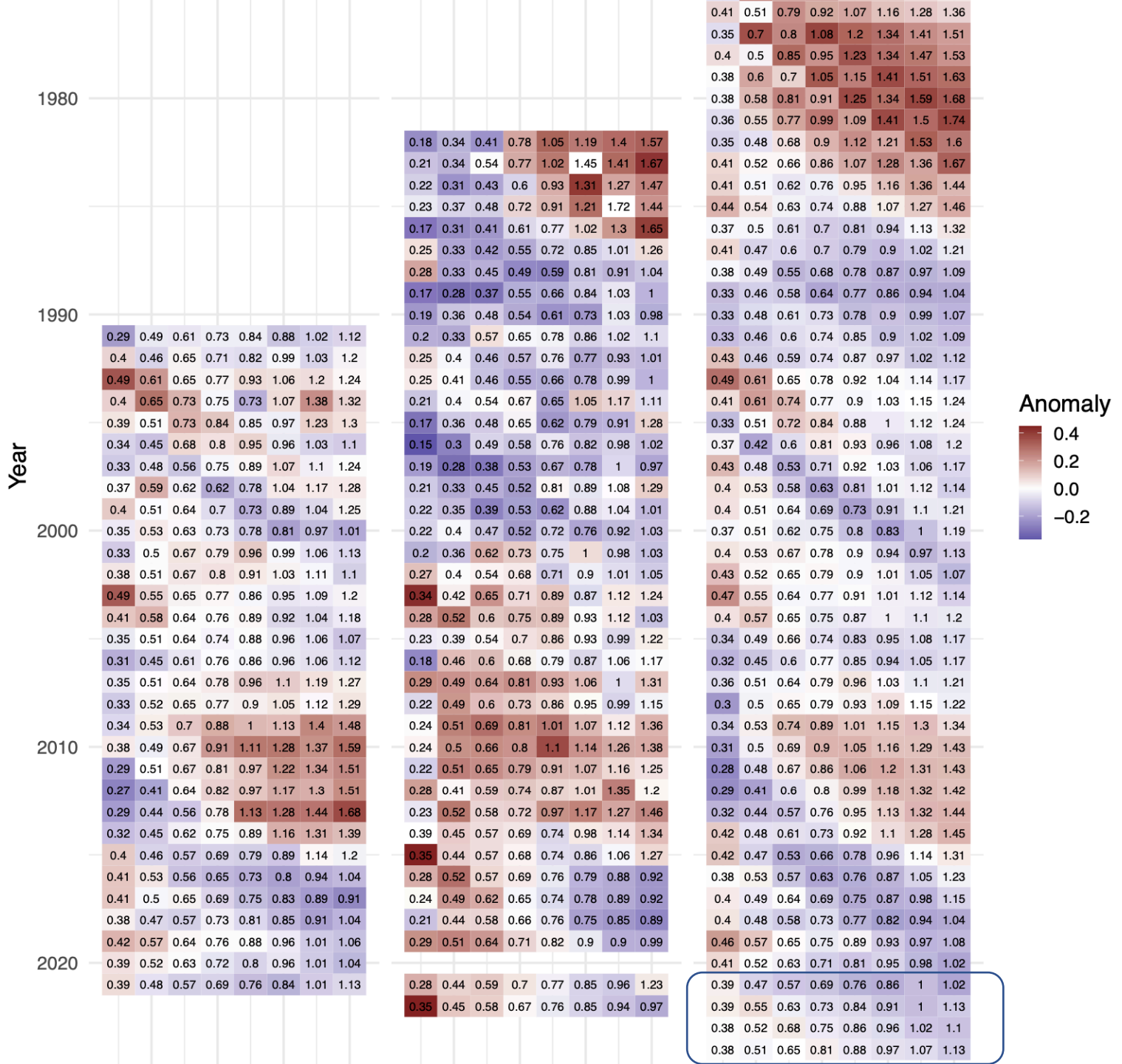
Tow-by-tow mean weight frequency by week



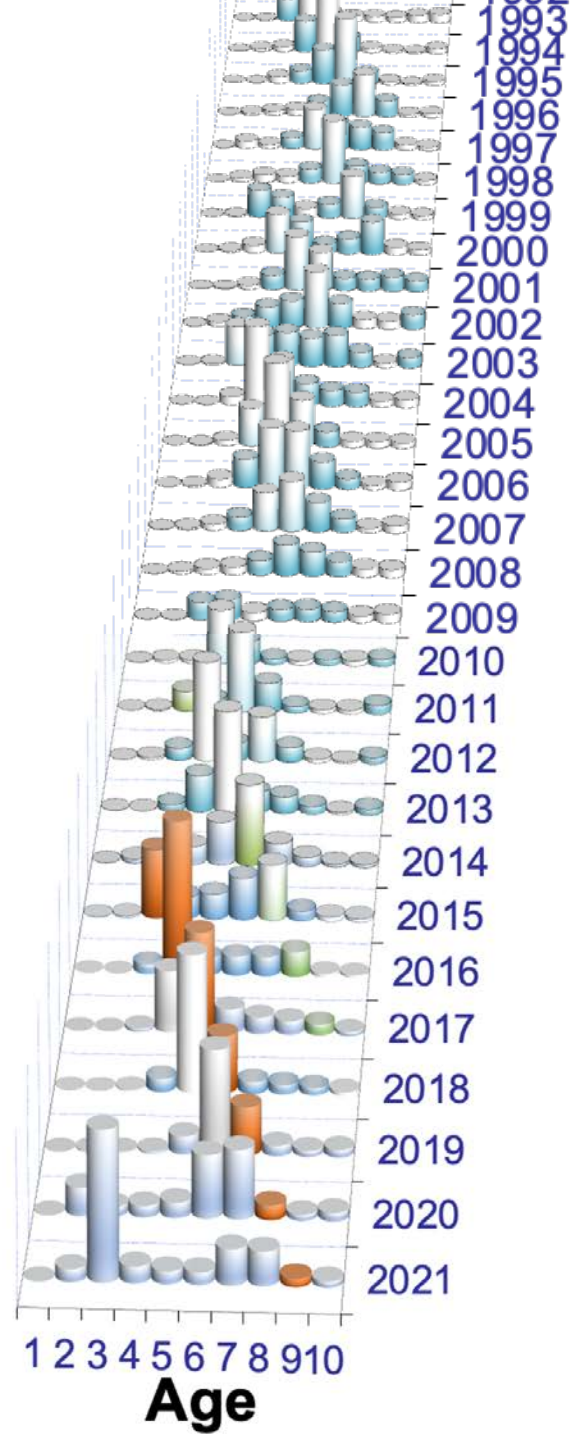

Body weight relative to mean
1.2
1.0
0.8
2017
2018
2019
2020
2021
3
4
5
6
7
8
9
10
Age

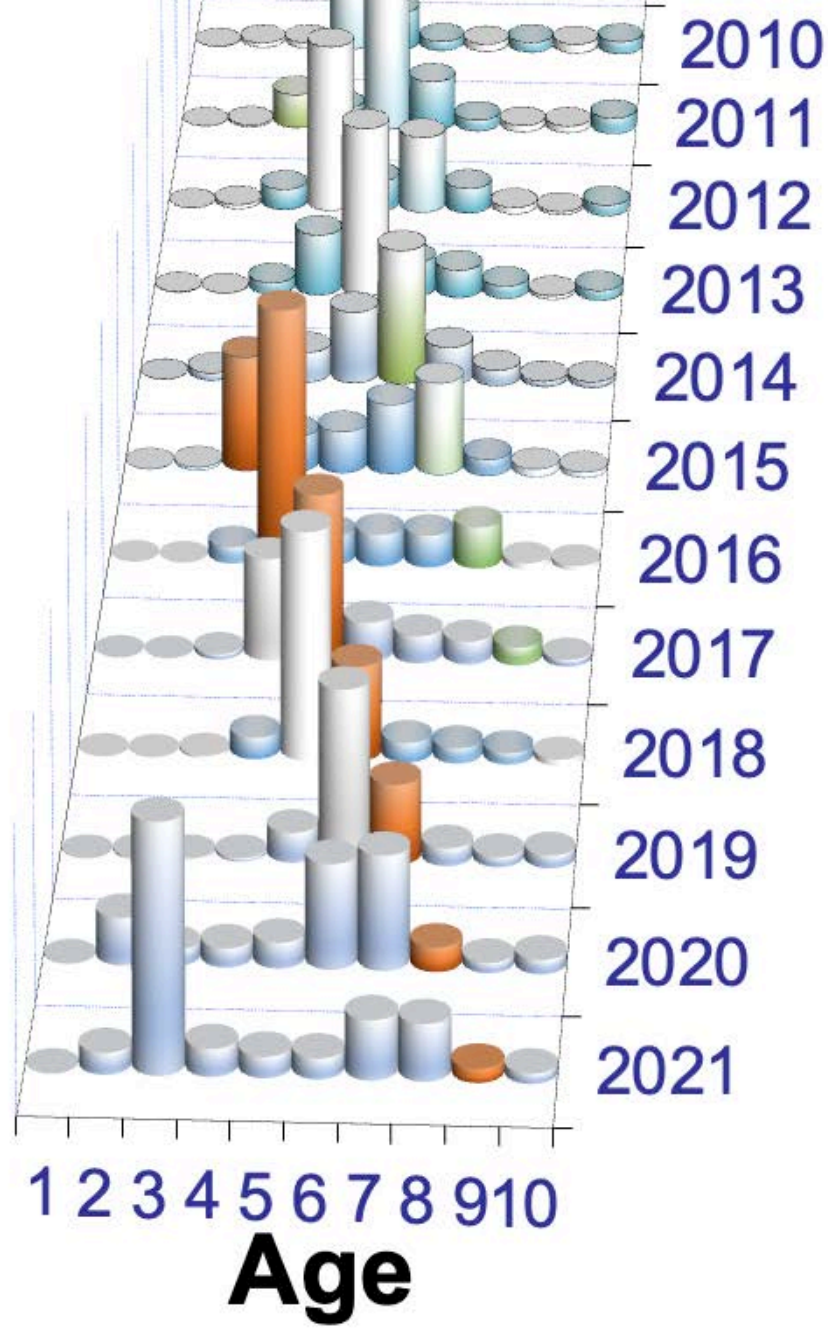
Historical wt-age

- And projected…

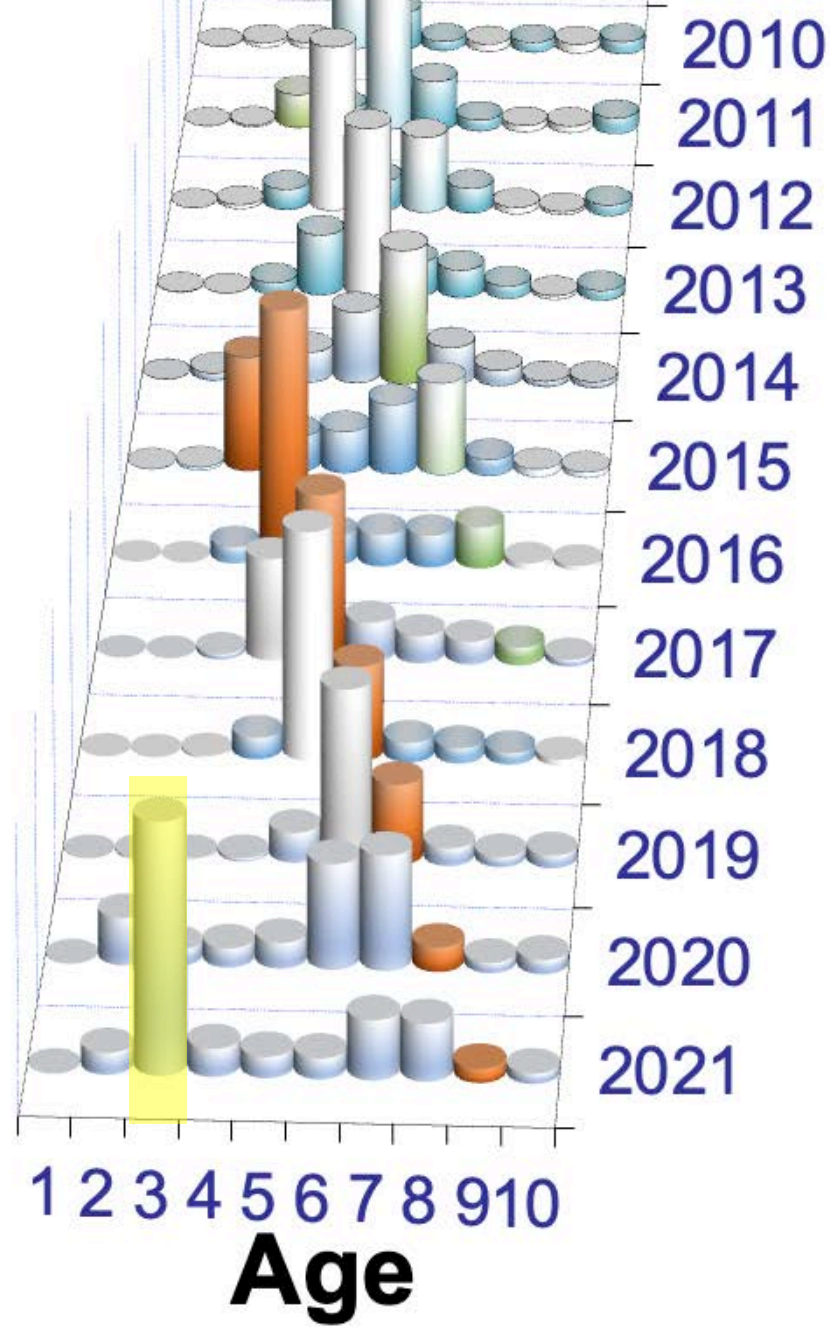


Fishery catch-at-age




2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
1 2 3 4 5 6 7 8 9 10
Age

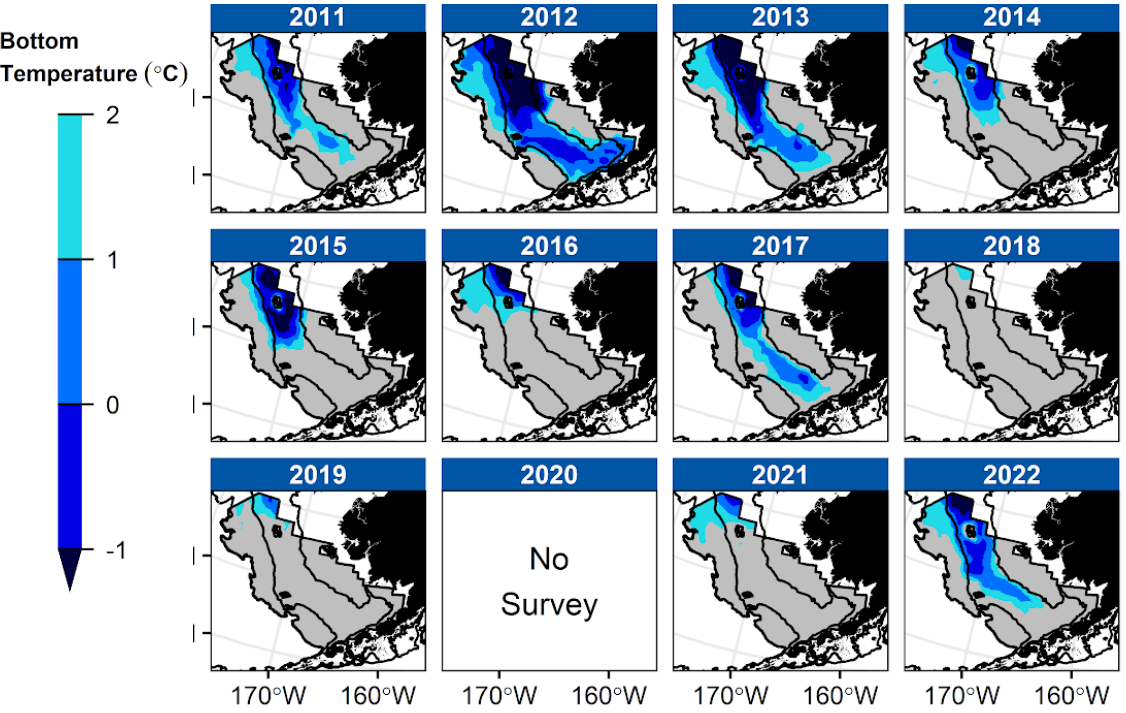
2021 New information



Survey work

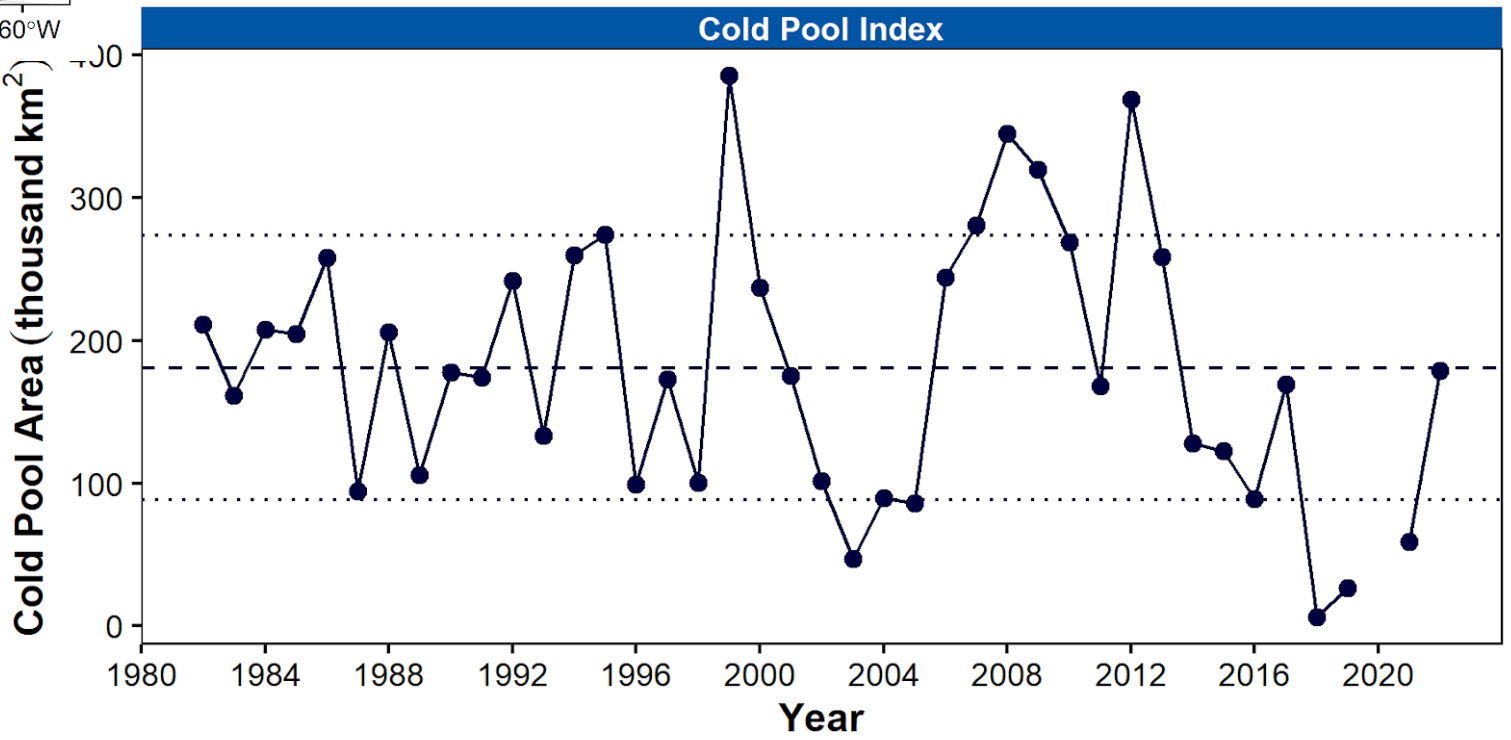
FV *Vesteraalen*
2014-present
8th year

FV *Alaska Knight*
2010-present
11th year



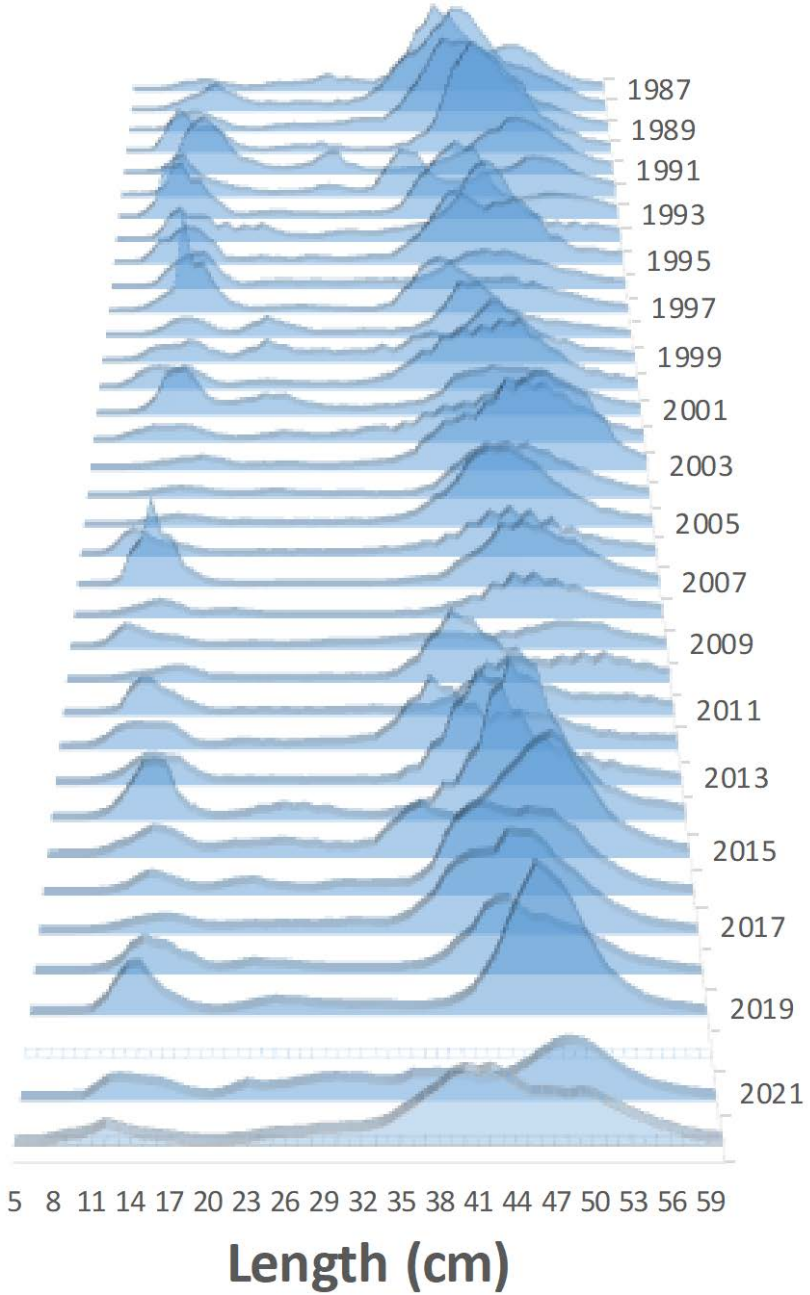
Survey data bottom temperature

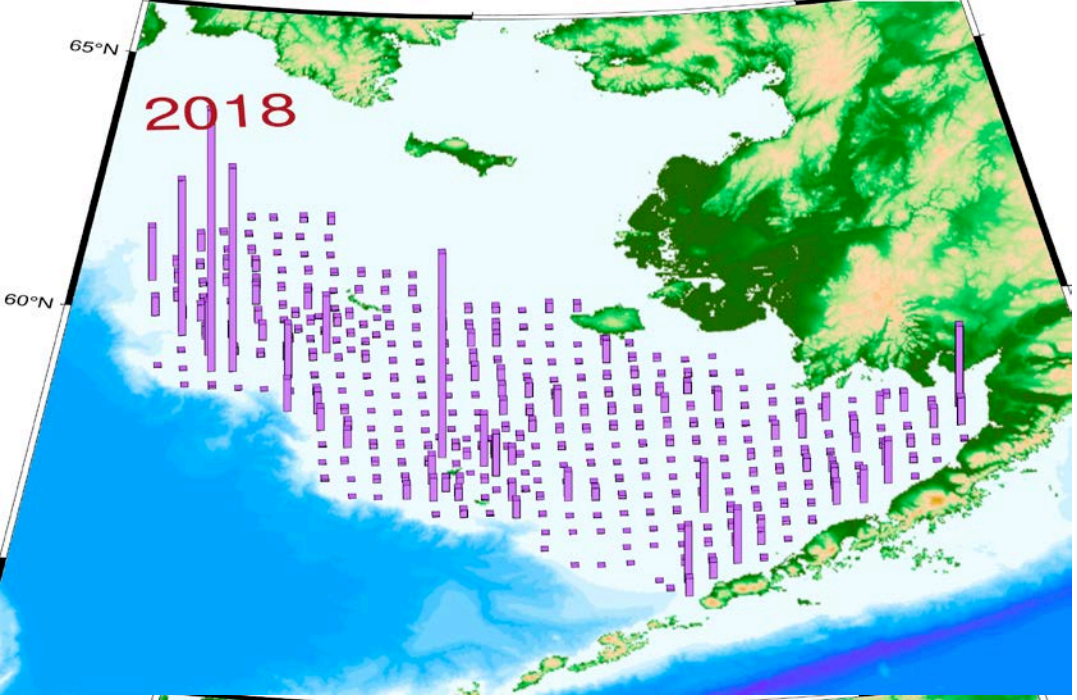
Cold pool extent

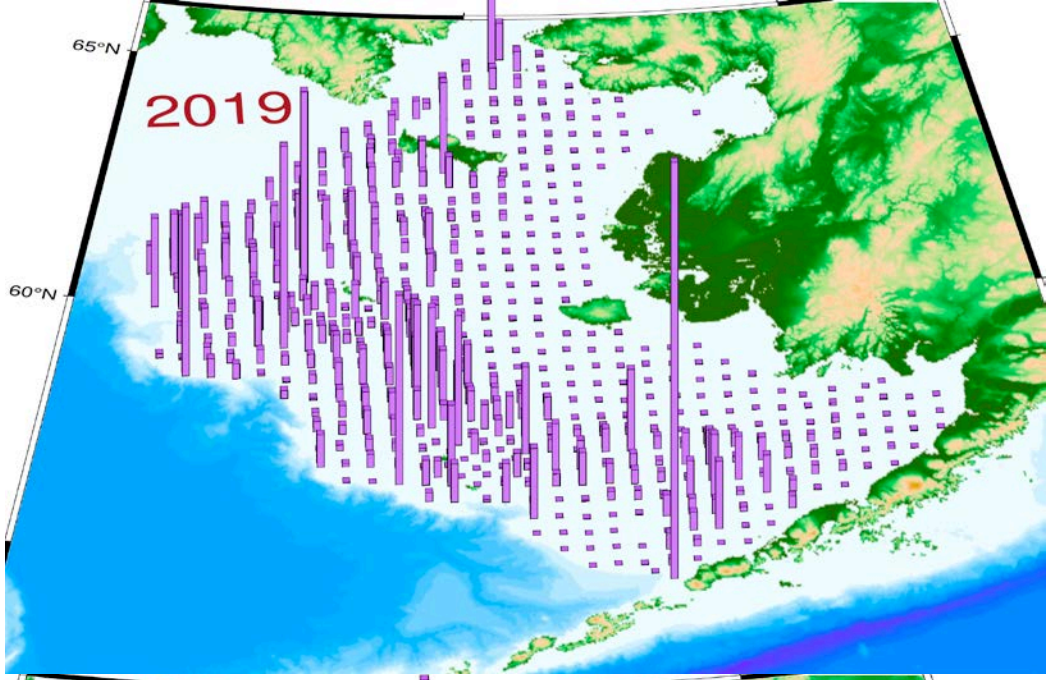


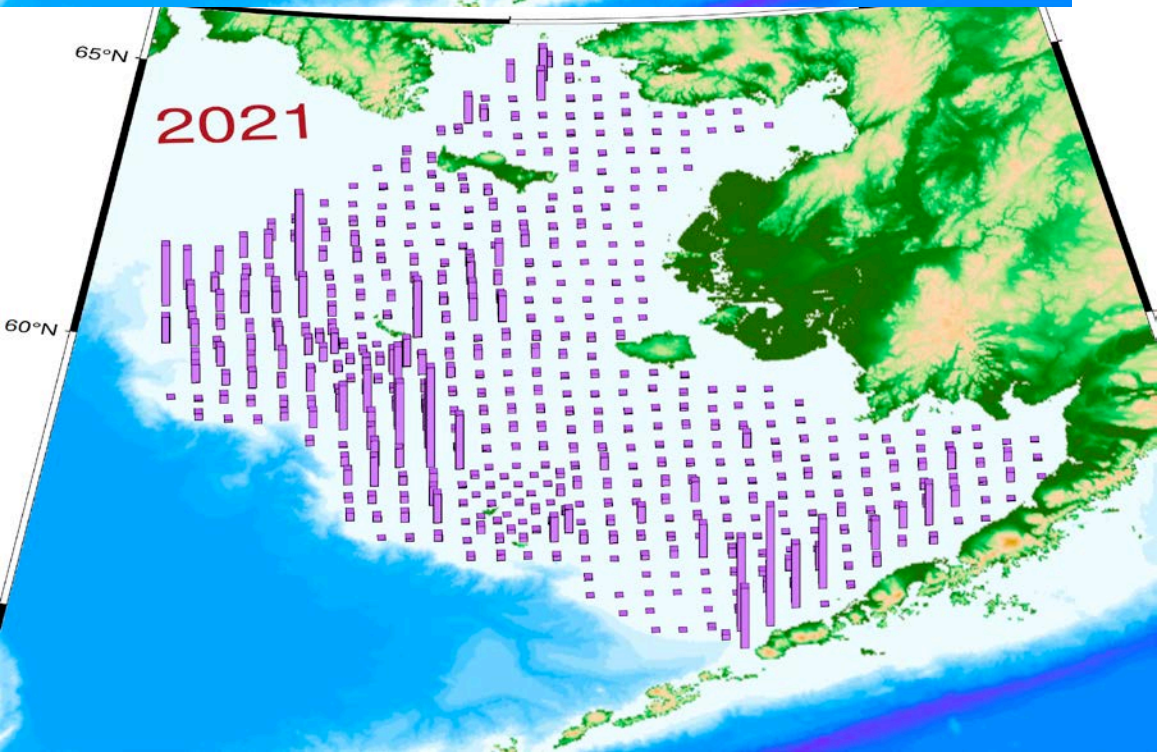
Survey abundance-at-length

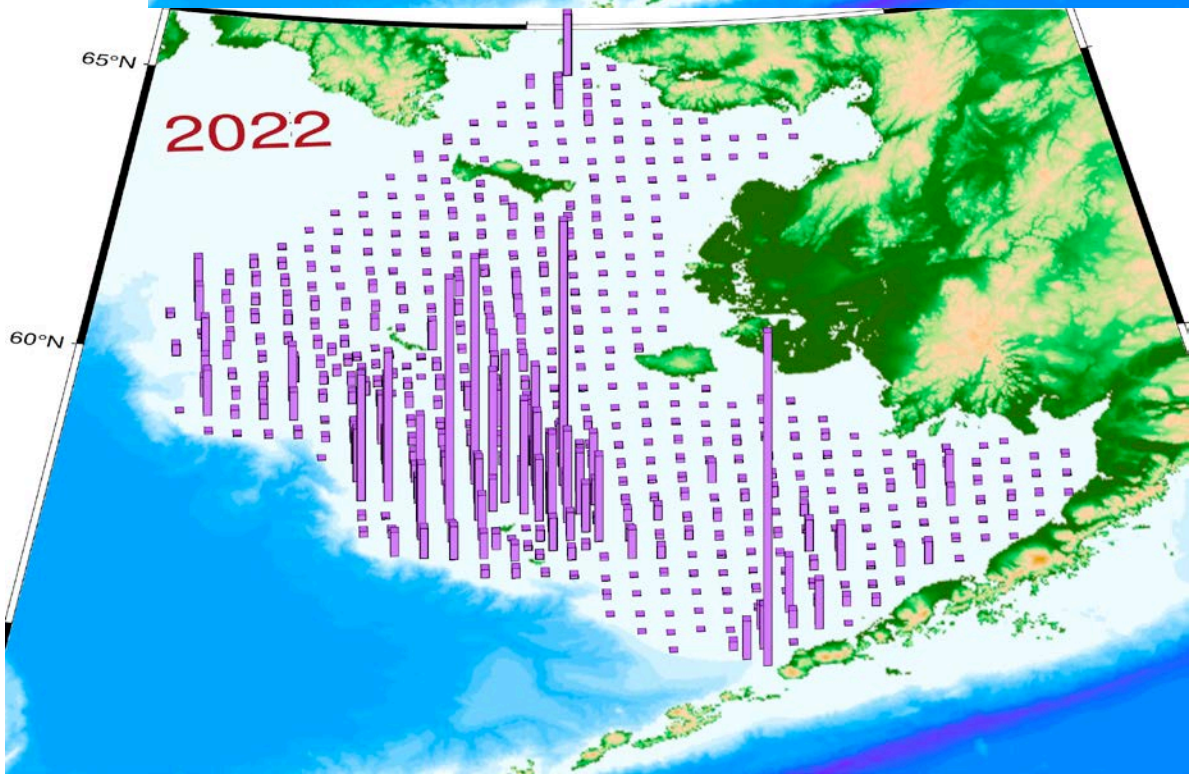
- Eastern Bering Sea pollock



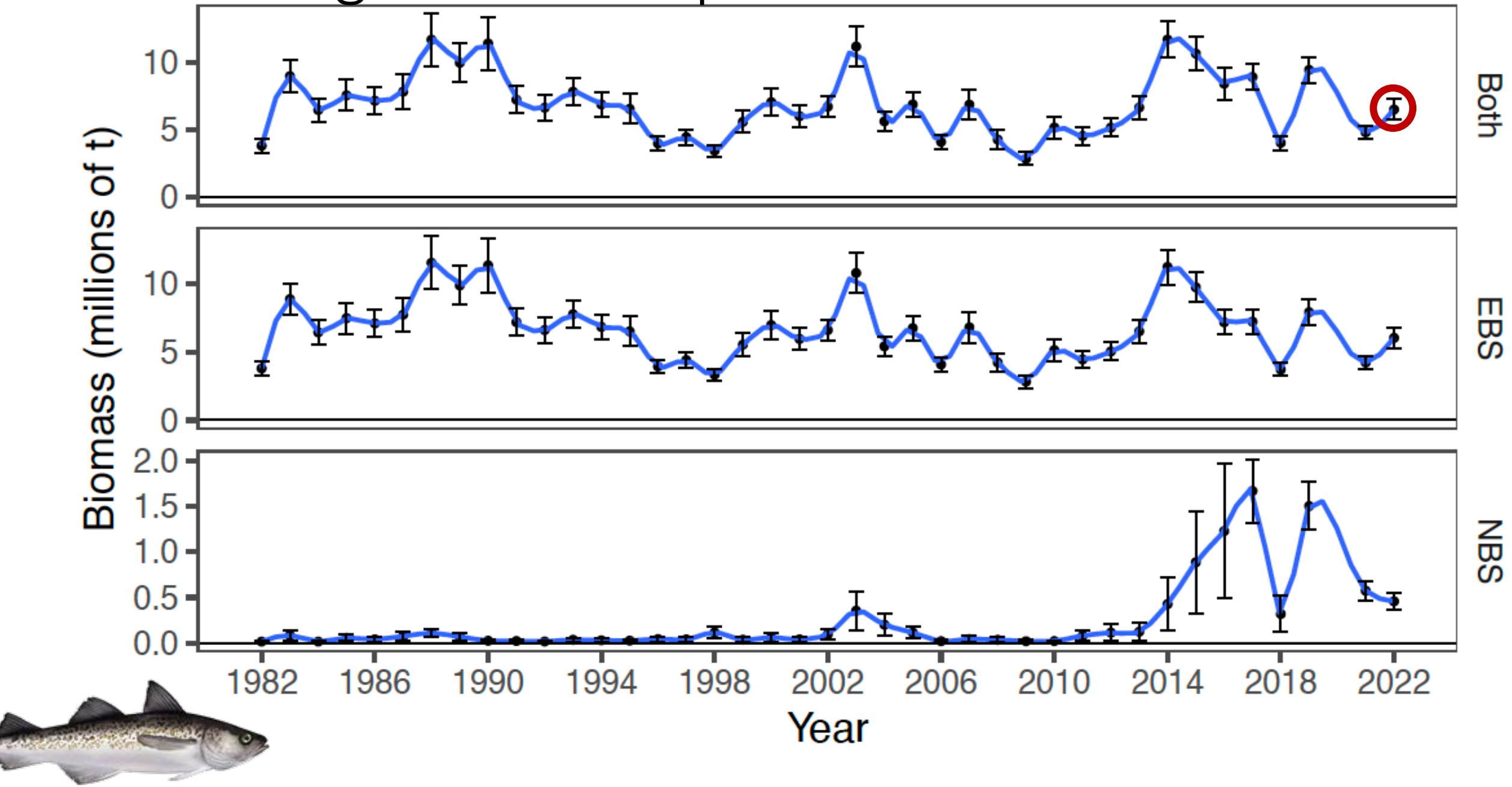

65°N
2018
60°N


65°N
2019
60°N


65°N
2021
60°N


65°N
2022
60°N

E. Bering Sea Alaska pollock



New VAST age-comps

- Bottom trawl survey

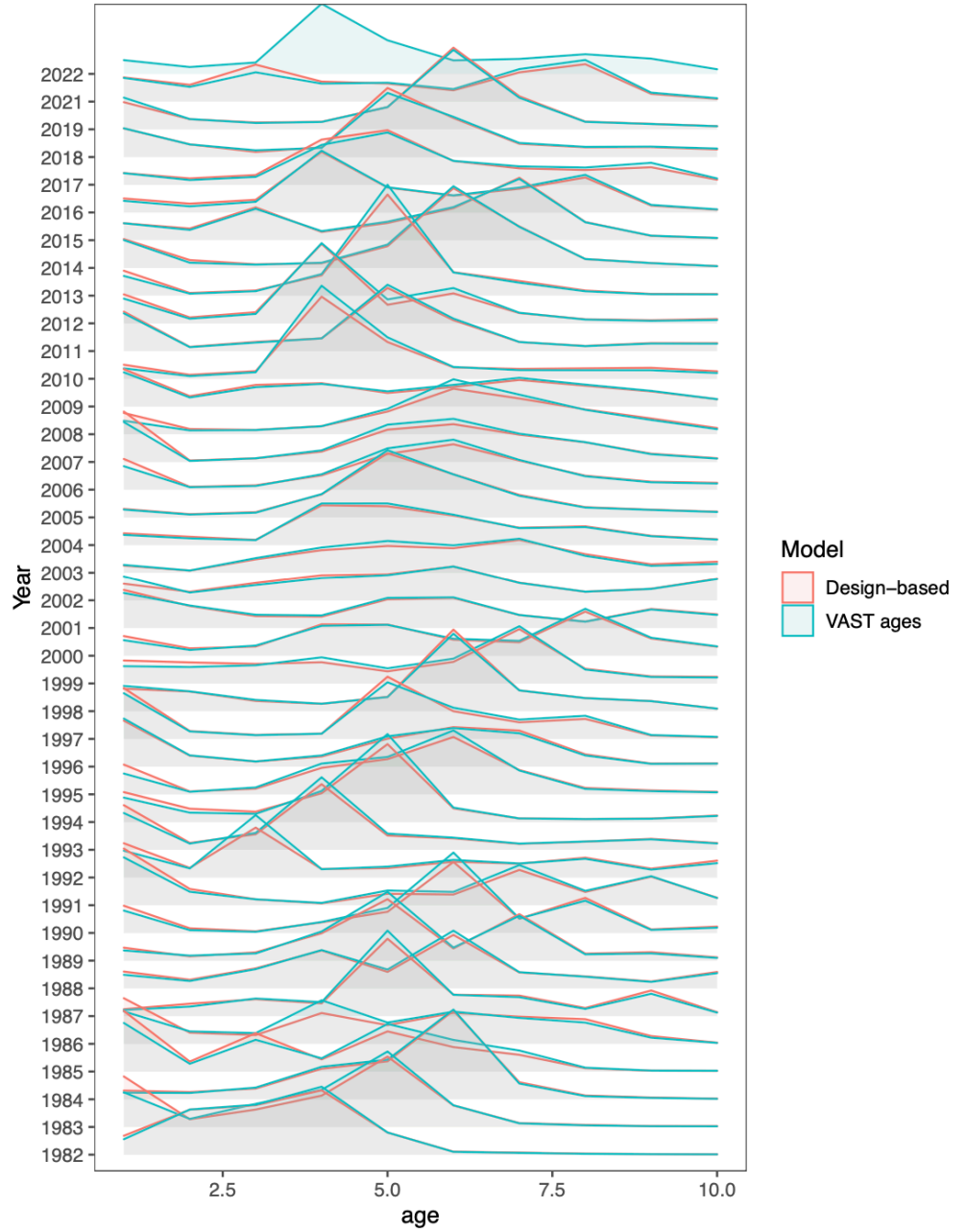
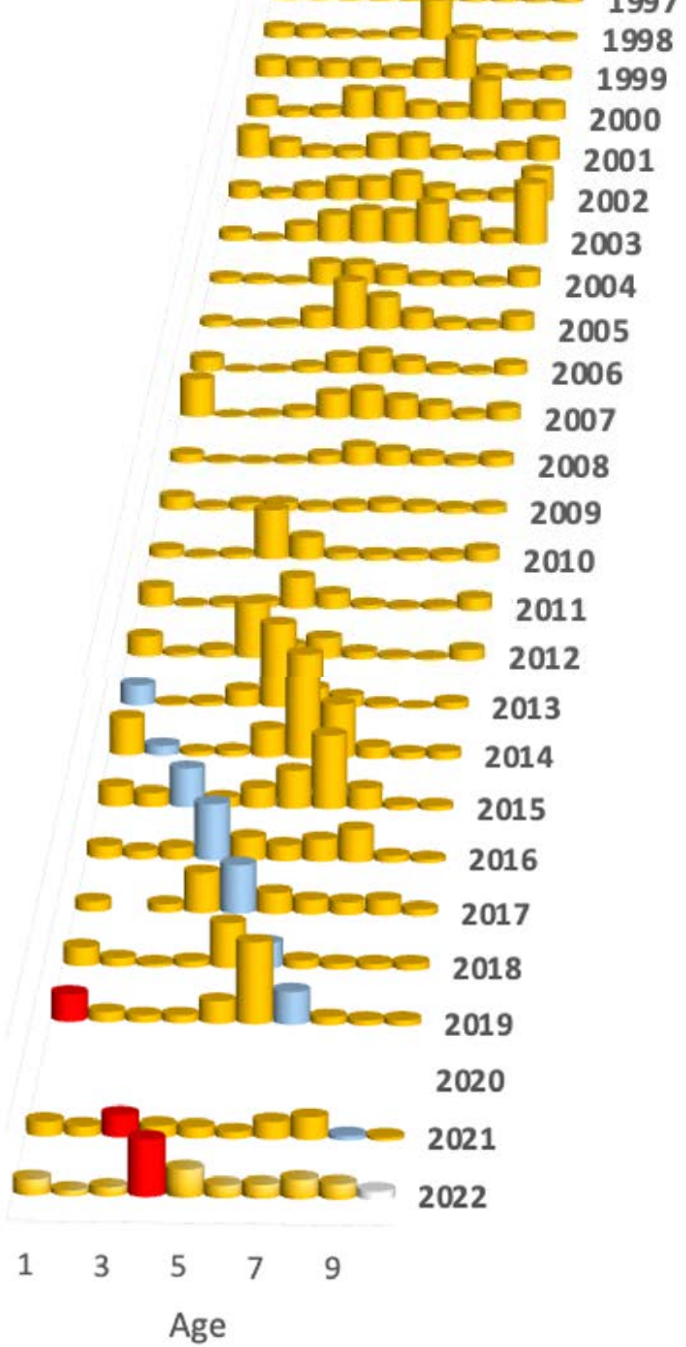
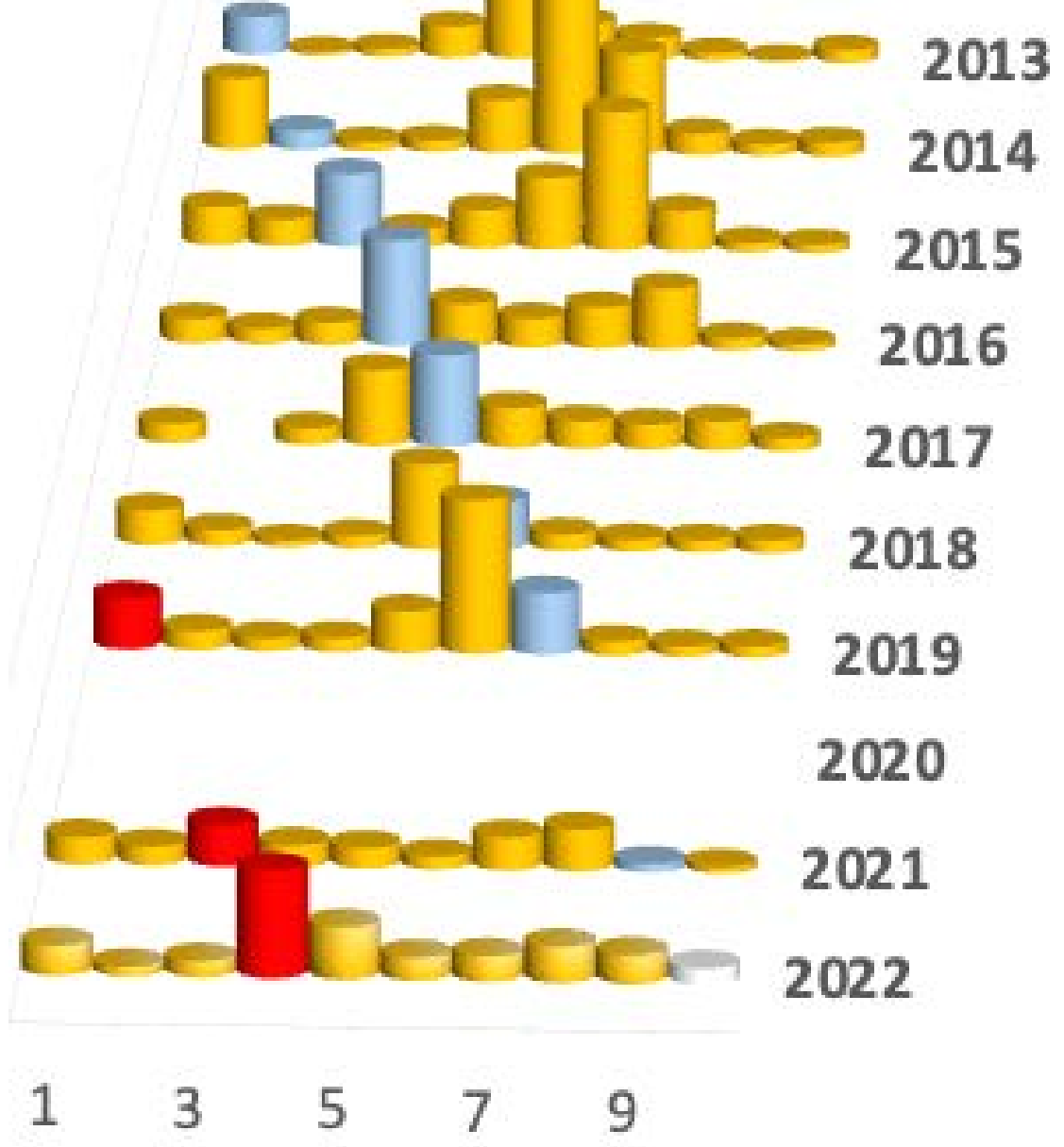


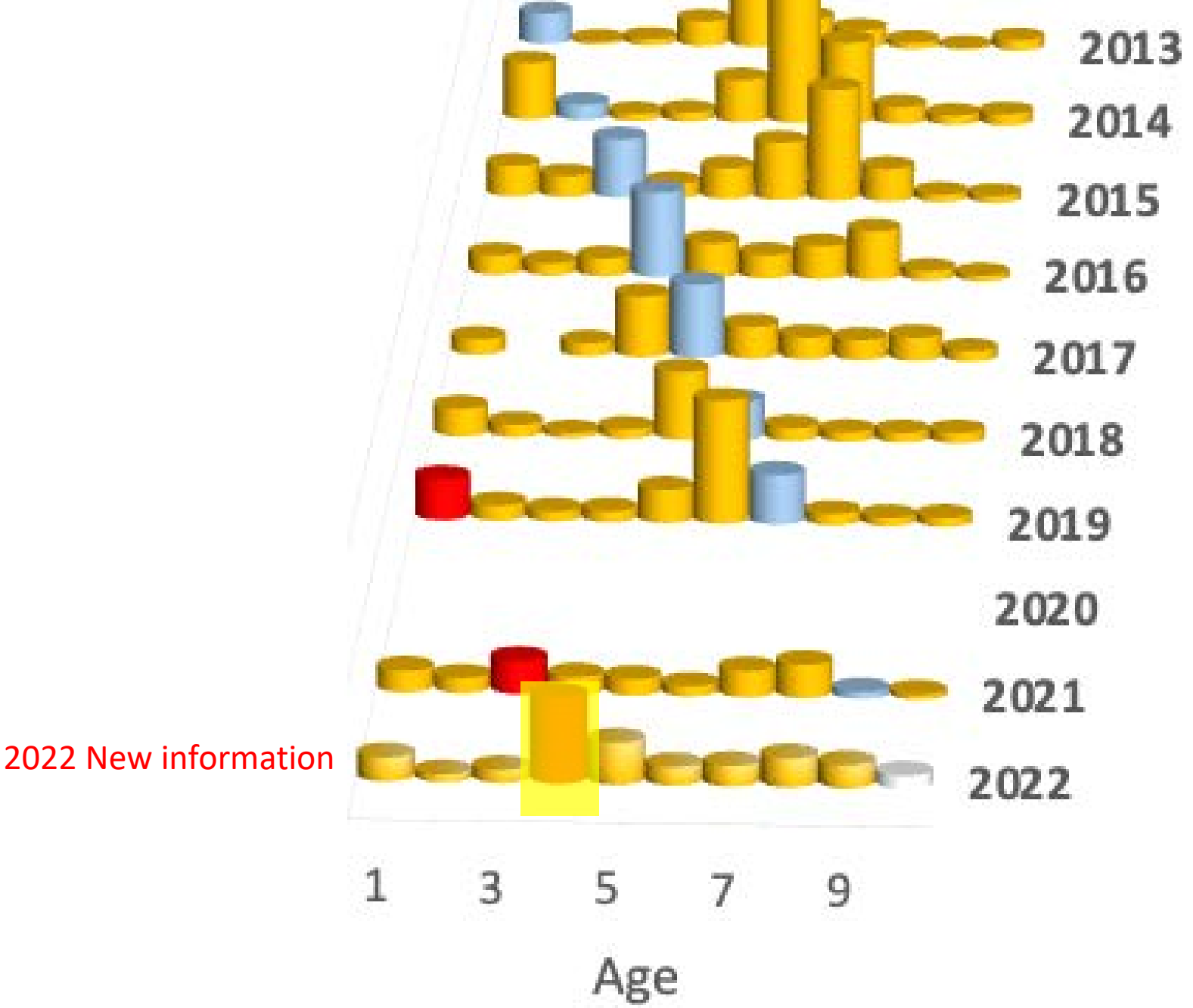
Figure 1-20. Comparison of EBS pollock estimated proportions-at-age from the bottom trawl surveys using the standard design-based estimates and those using the VAST spatio-temporal model, 1982-2022 (no data from 2020).

Survey abundance-at-age

- Eastern Bering Sea pollock




2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
1
3
5
7
9
Age


2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2022 New information
1
3
5
7
9
Age

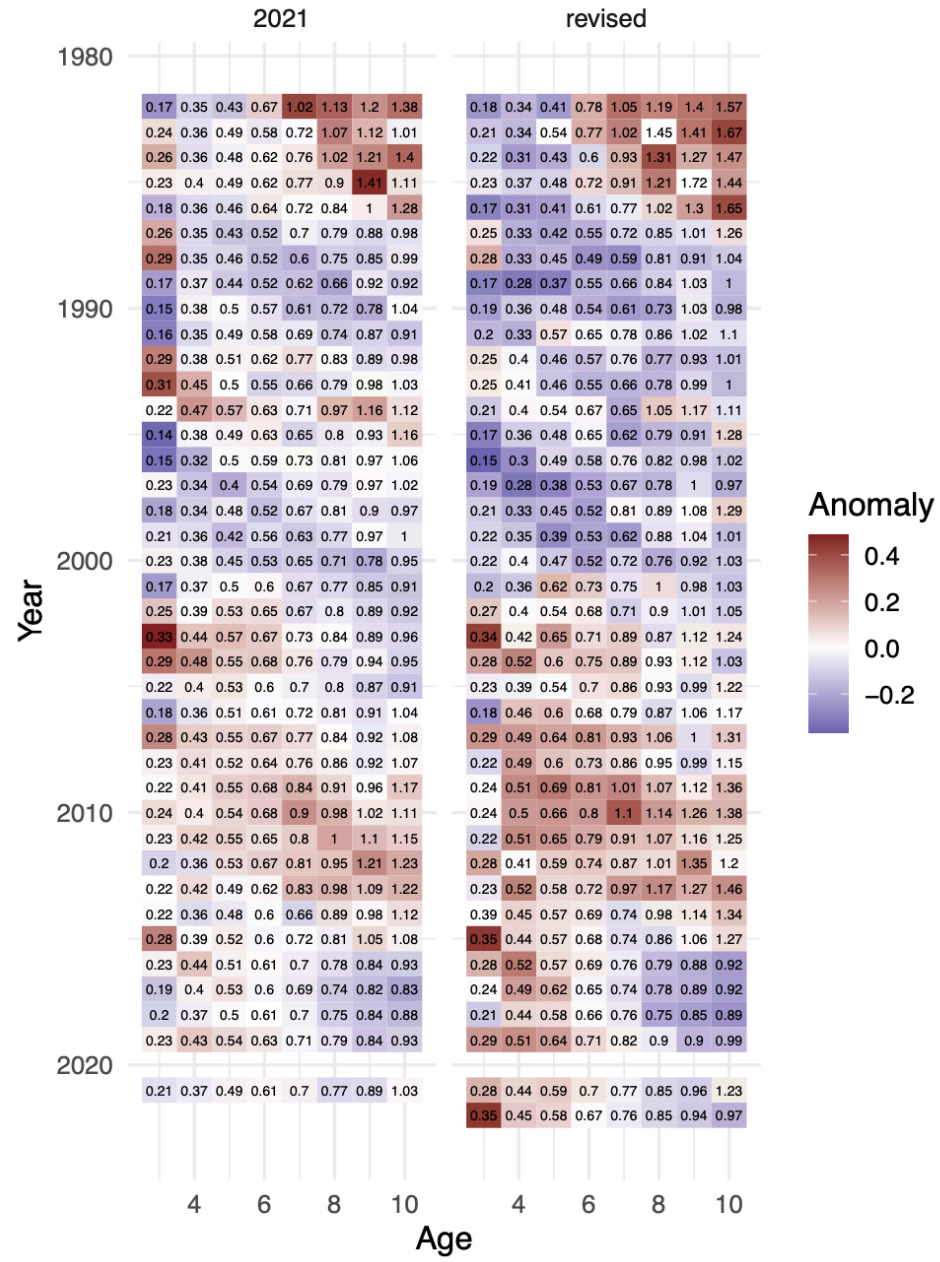
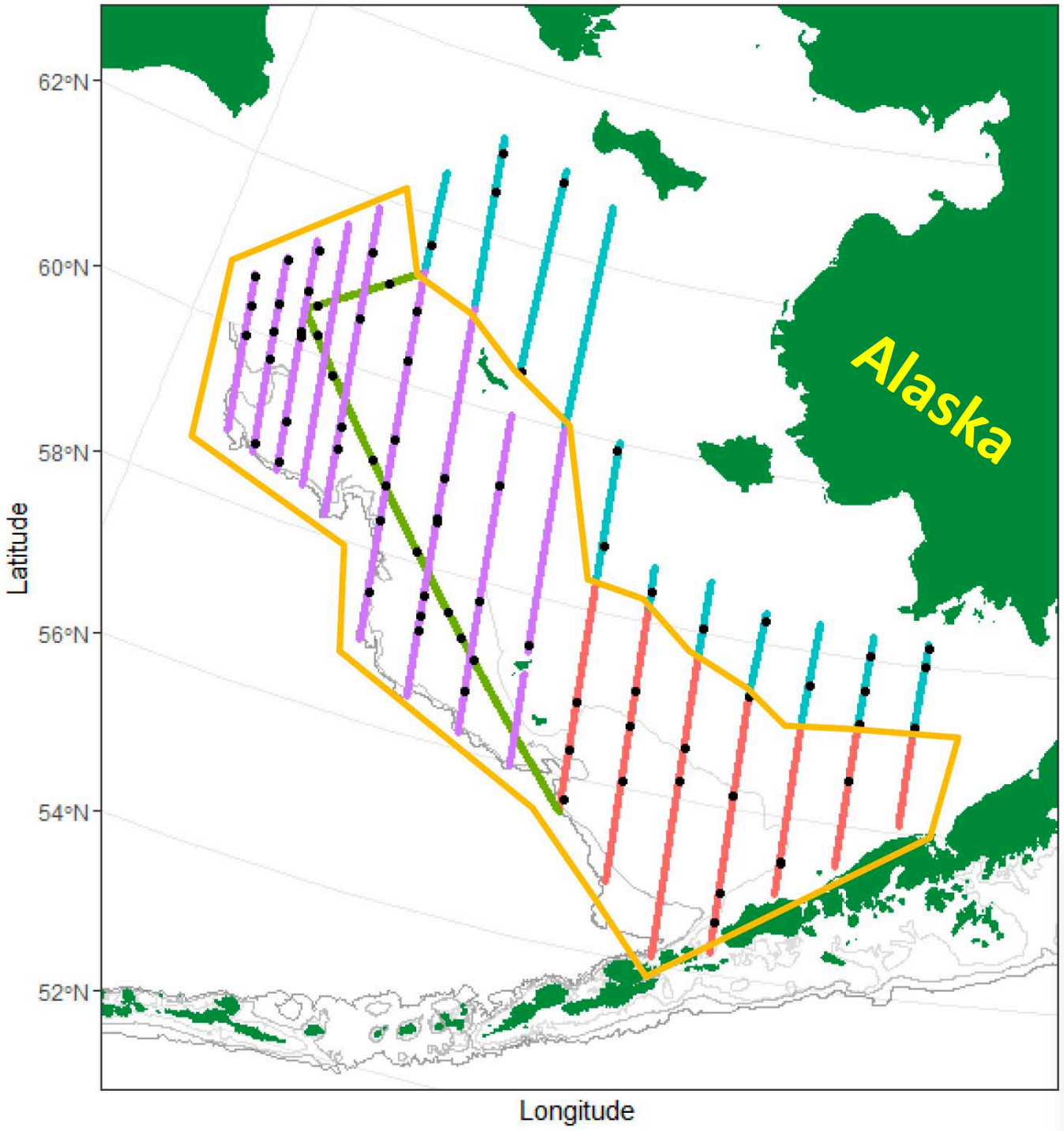
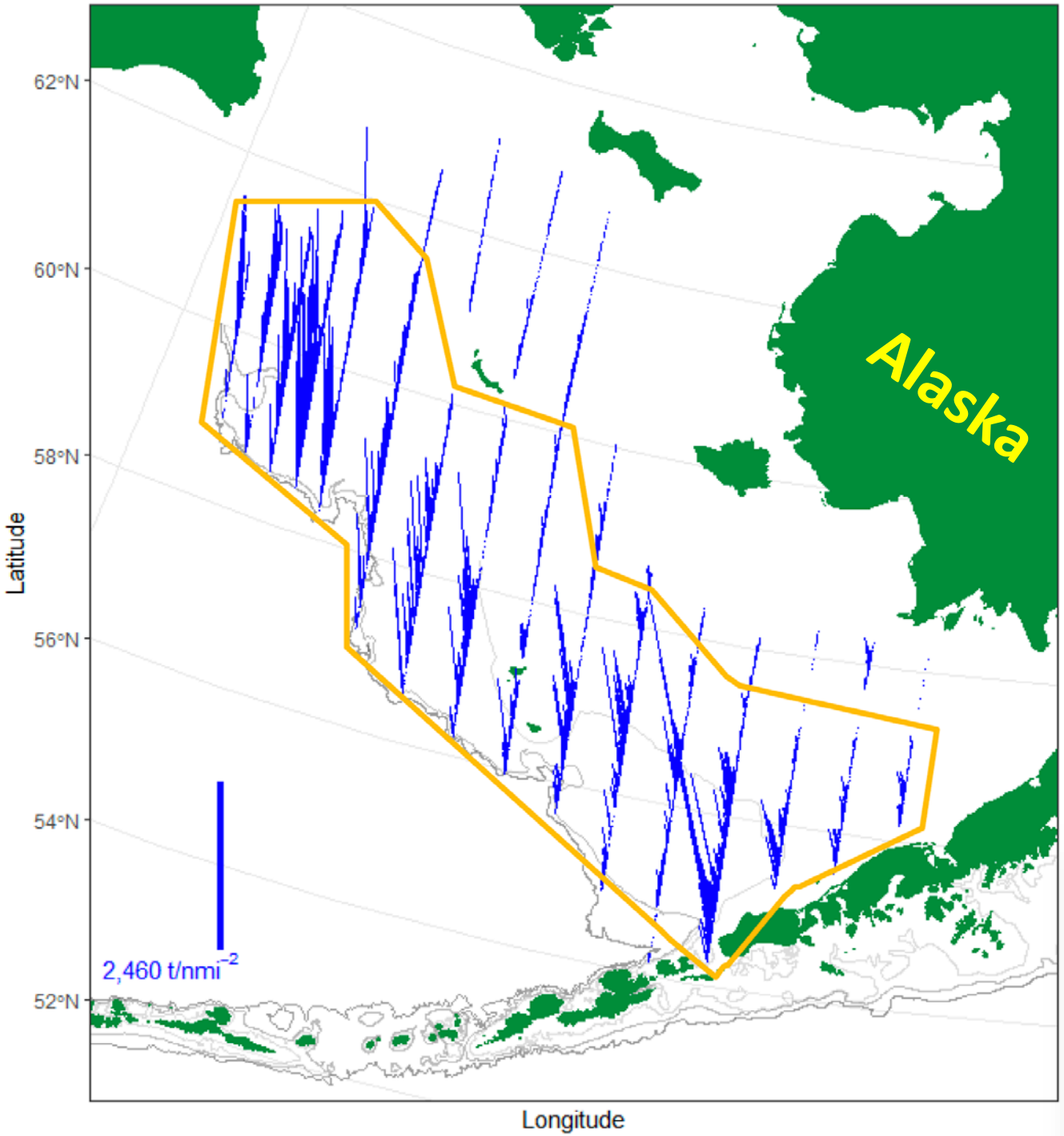


Figure 1-21. Panels showing the values for mean pollock weight-at-age used in the previous assess
ment (left panel) and the values revised for this assessment as based on more data and appropriat
CPUE weighting (right panel). the shadings indicate anomalies over time within ages (columns).

Acoustic survey-NOAA Ship

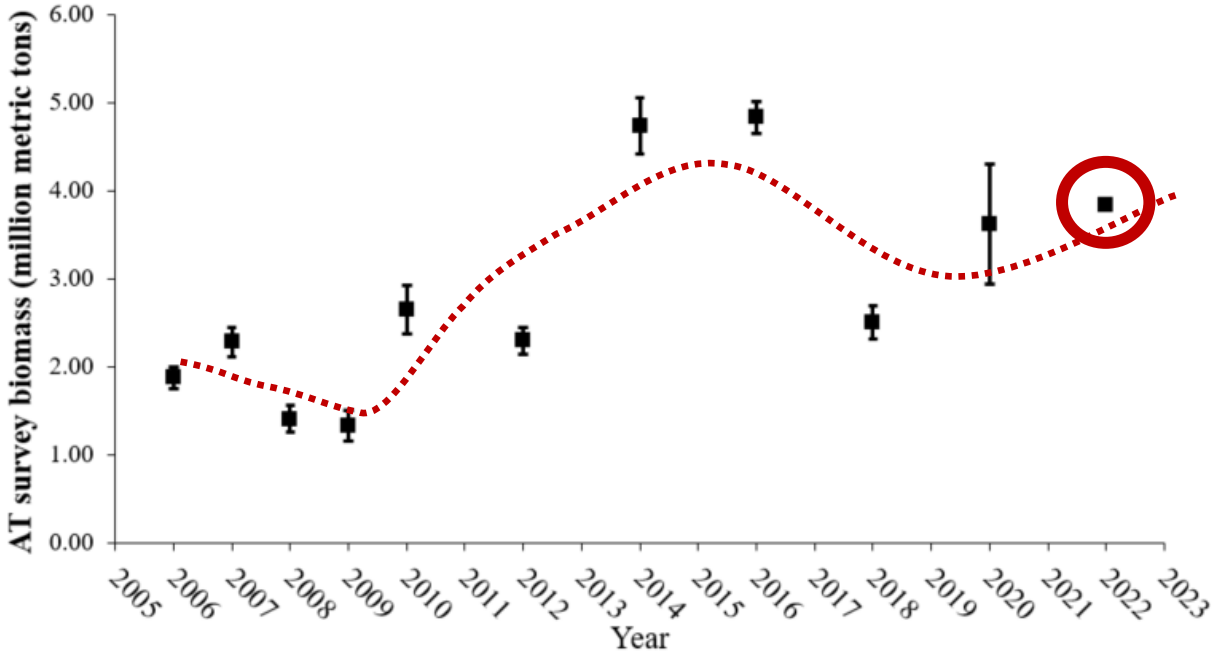


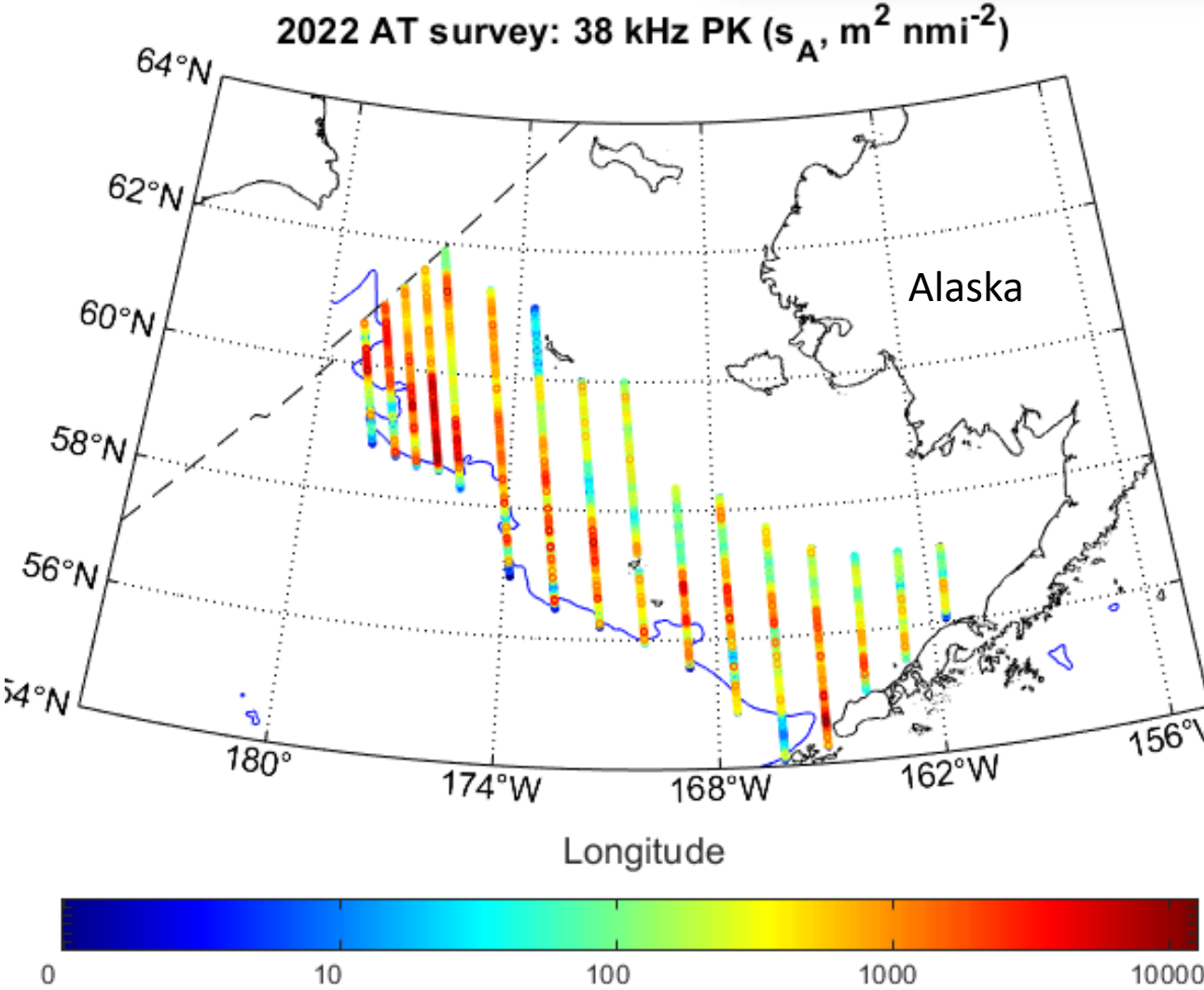
COVID19 protocol issues a challenge

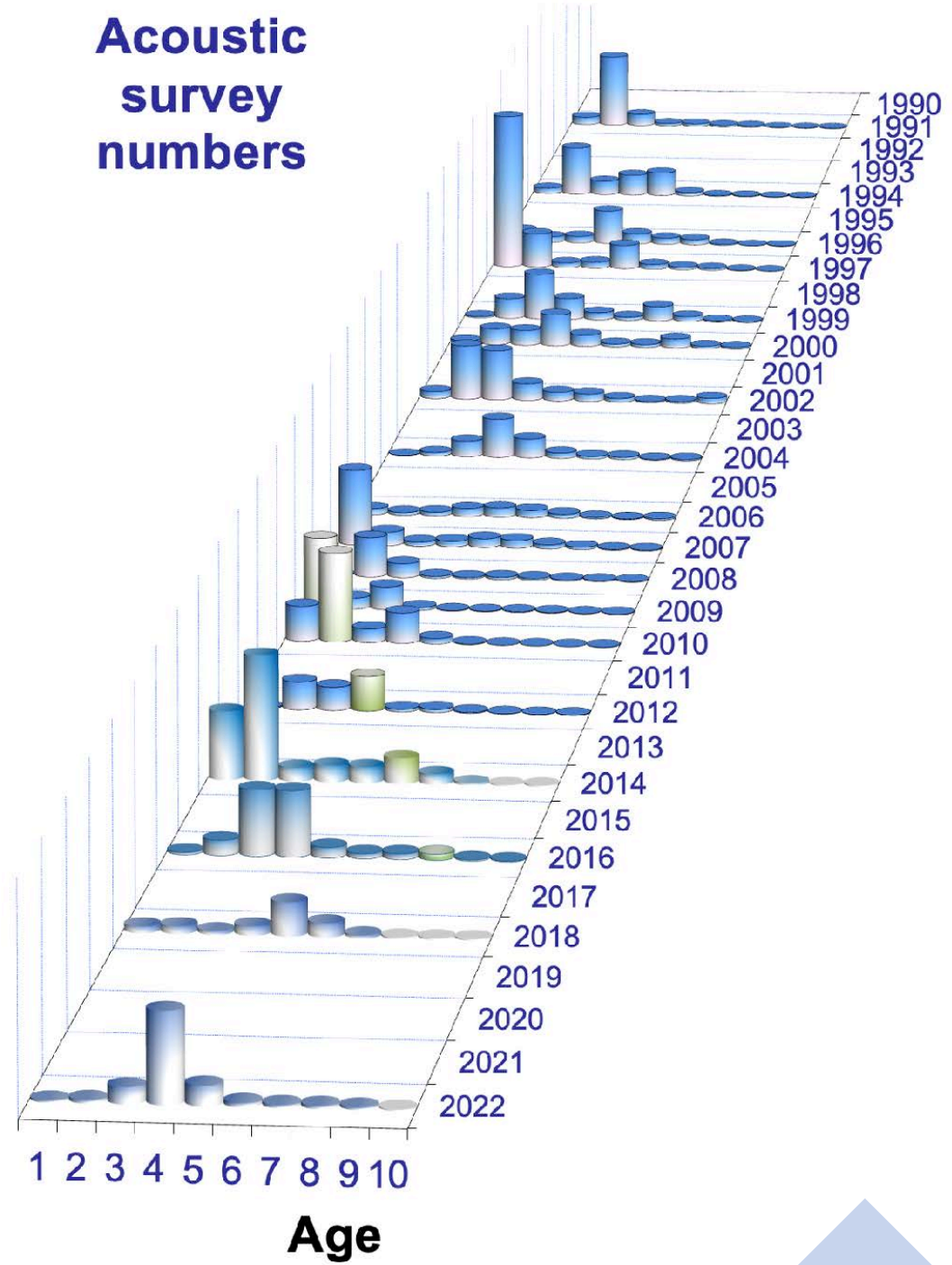

62°N
60°N
58°N
56°N
54°N
52°N
Latitude
Alaska
2,460 t/nmi^{-2}
Longitude


OSCAR DYSON
NOAA

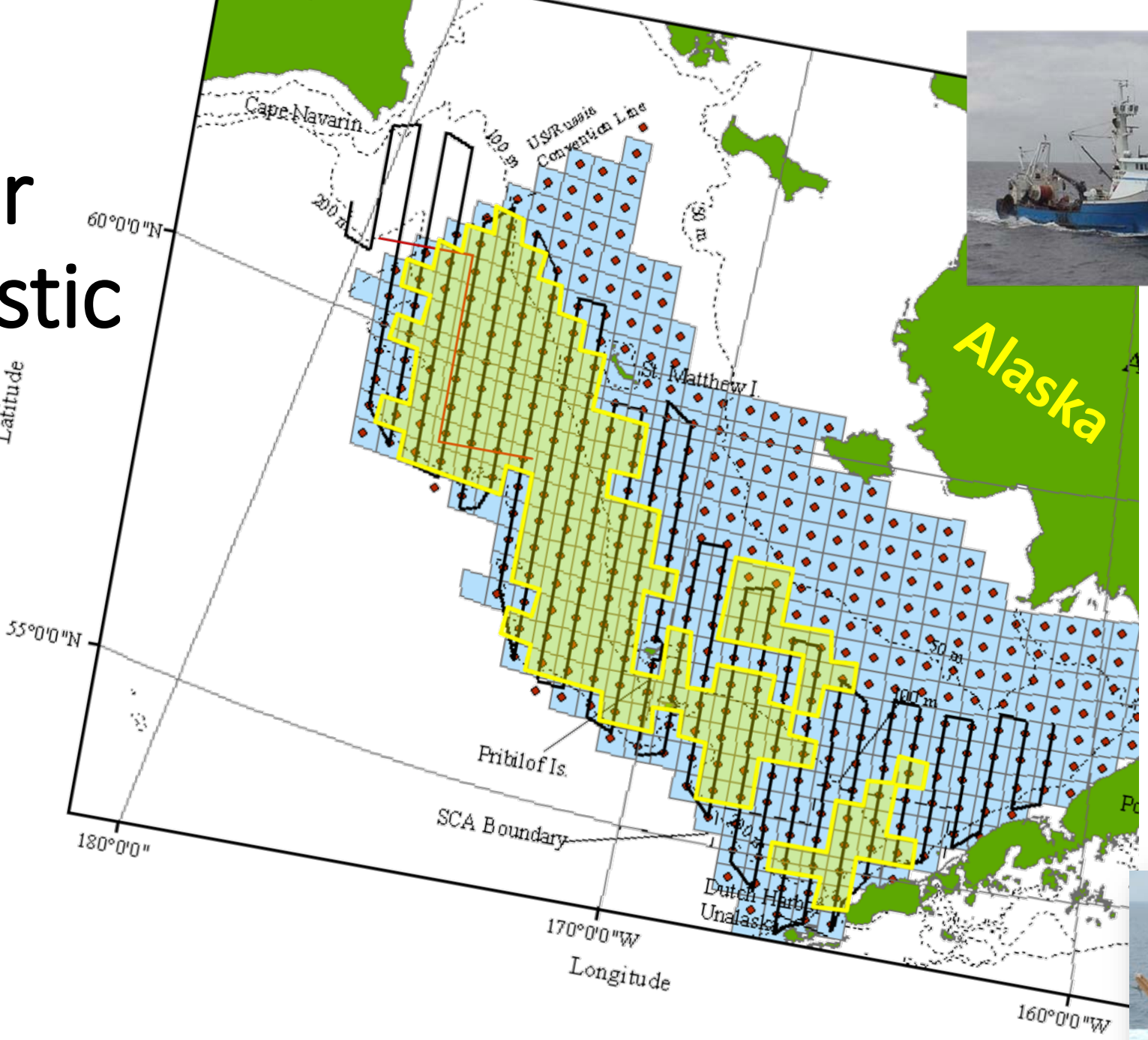
Acoustic survey results



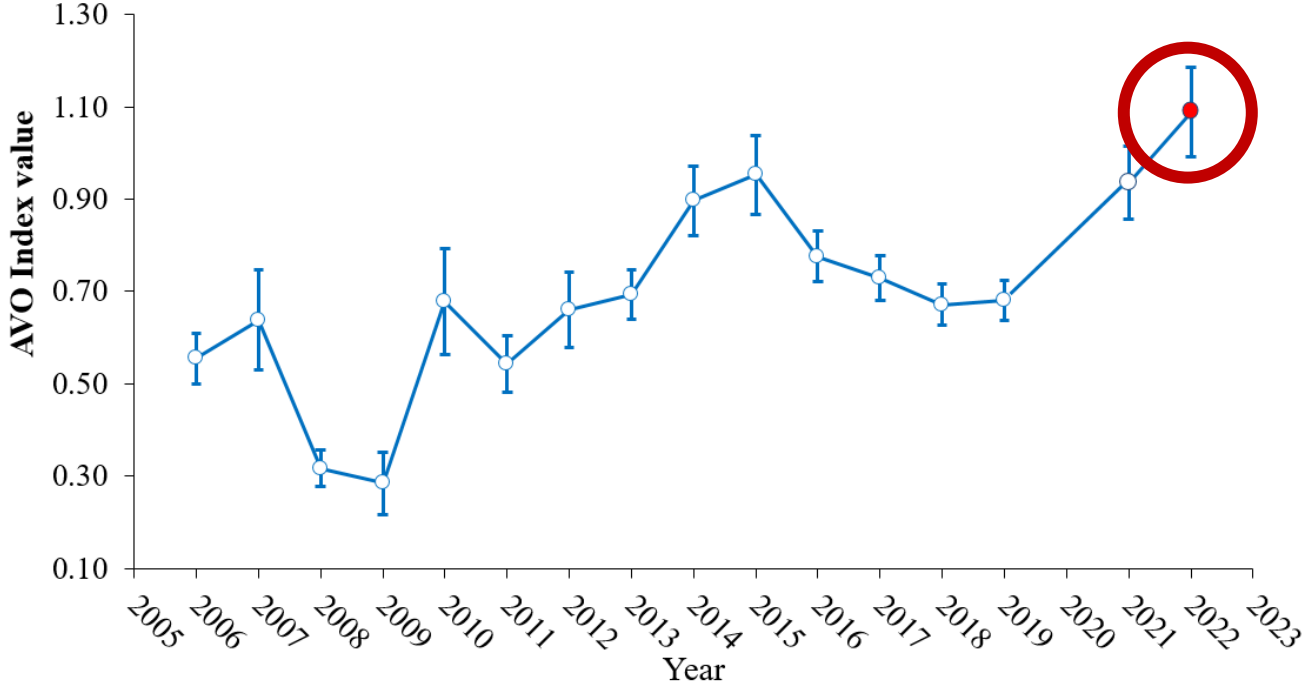


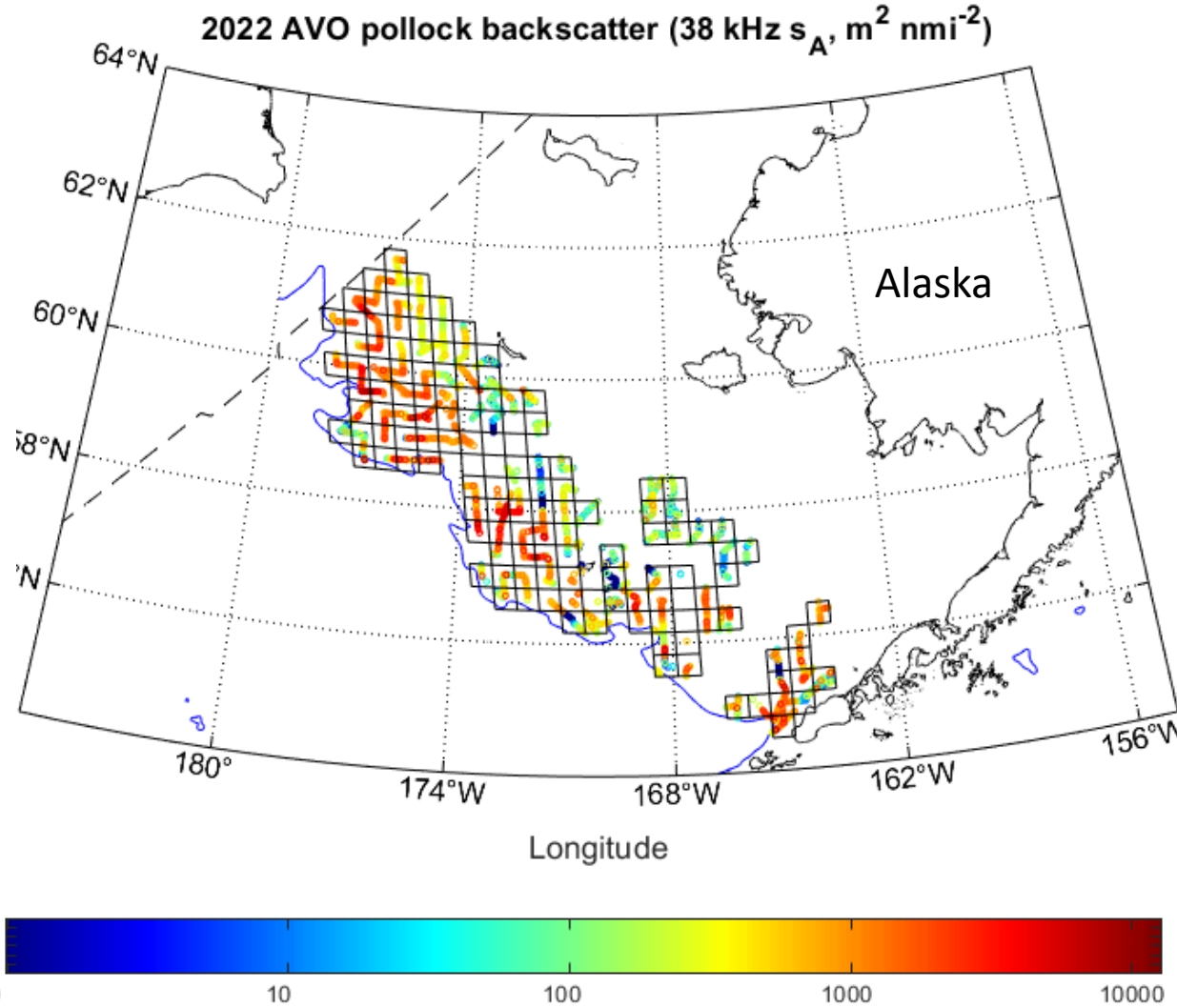

Acoustic survey numbers
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
1 2 3 4 5 6 7 8 9 10
Age

Other acoustic data

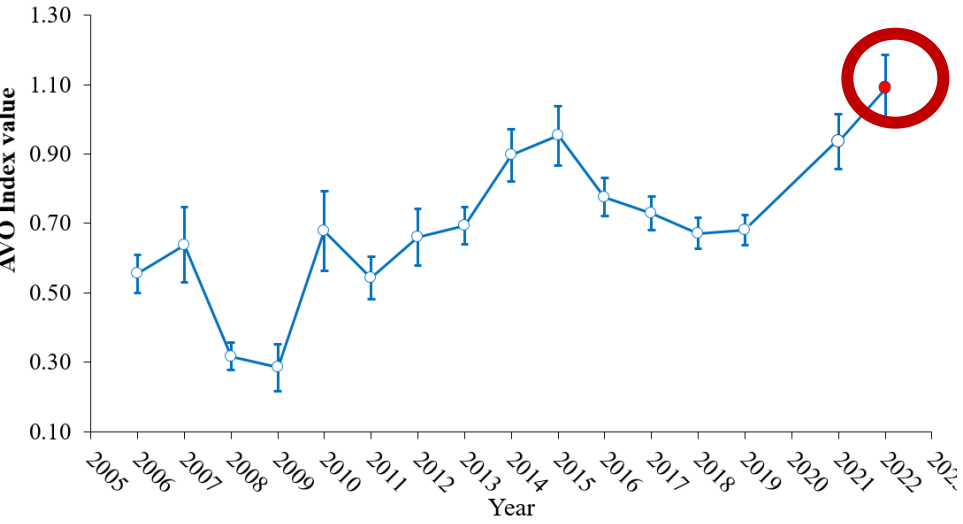


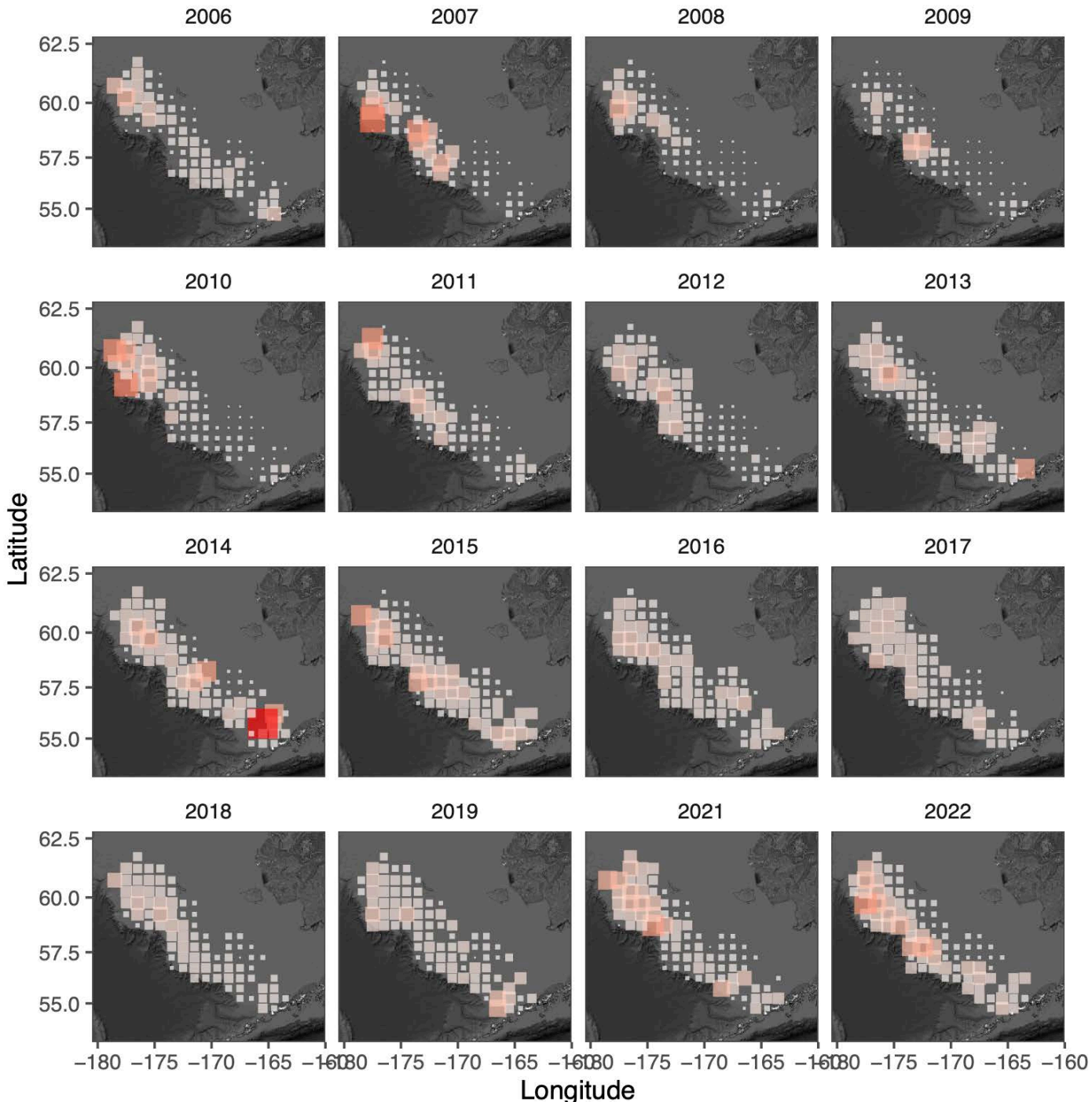
Opportunistic acoustic survey results





AVO time series





Interpreting survey indications

Up from previous years

- Three indices up from 2021 estimates
- Age composition (in 2 indices) consistent
- Fishery age composition also shows abundant 2018 year class

Model fits

NMFS Bottom trawl survey…

Bottom trawl survey biomass

15000
10000
5000
0

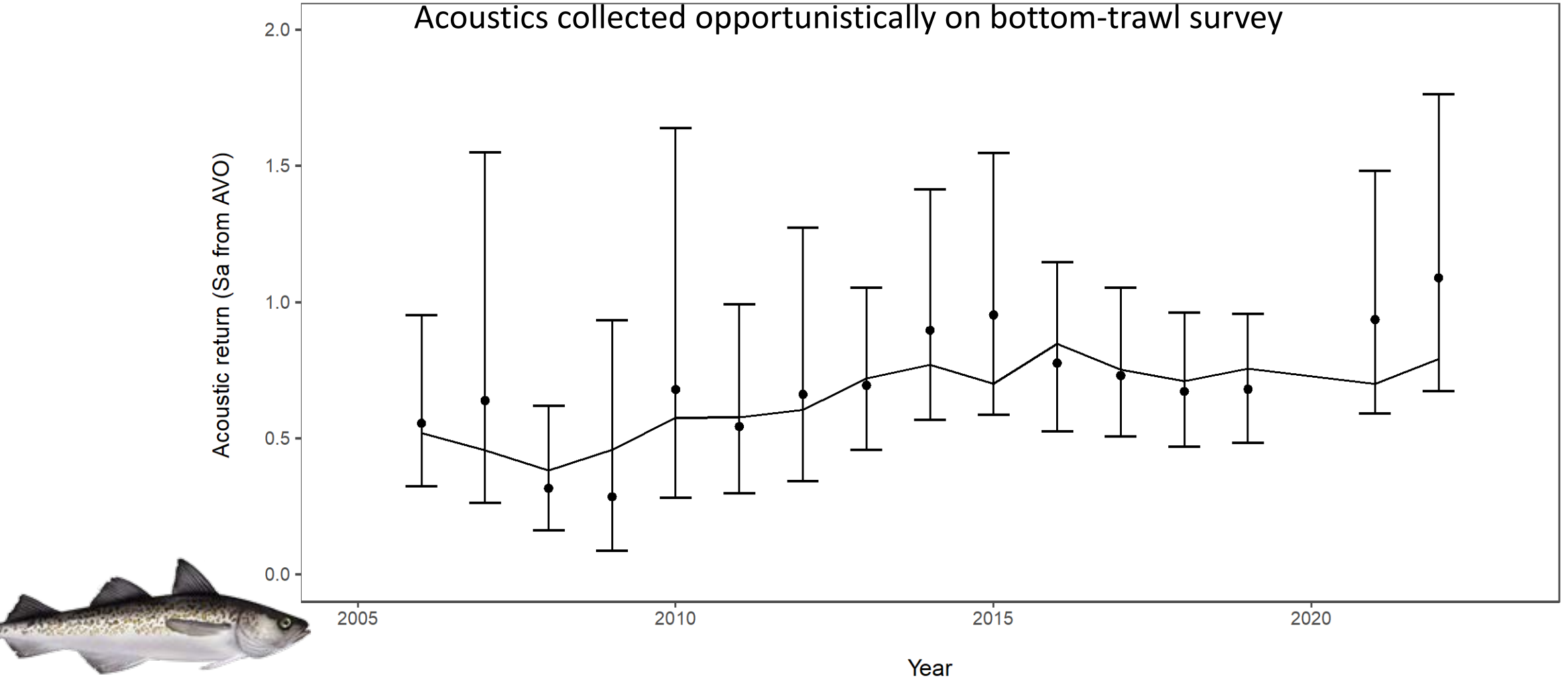
1980
1990
2000
2010
2020

Year

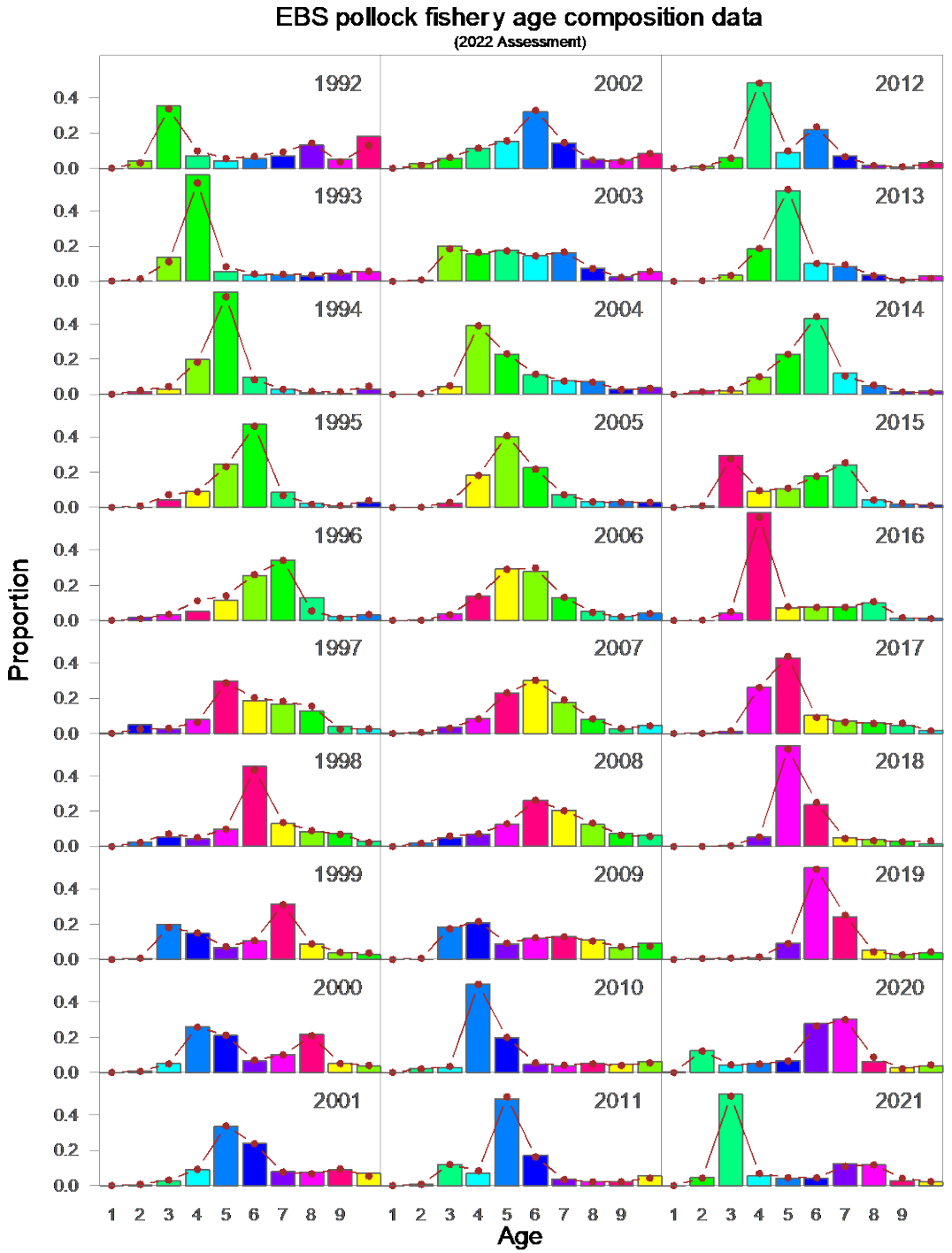
NMFS Bottom trawl survey…

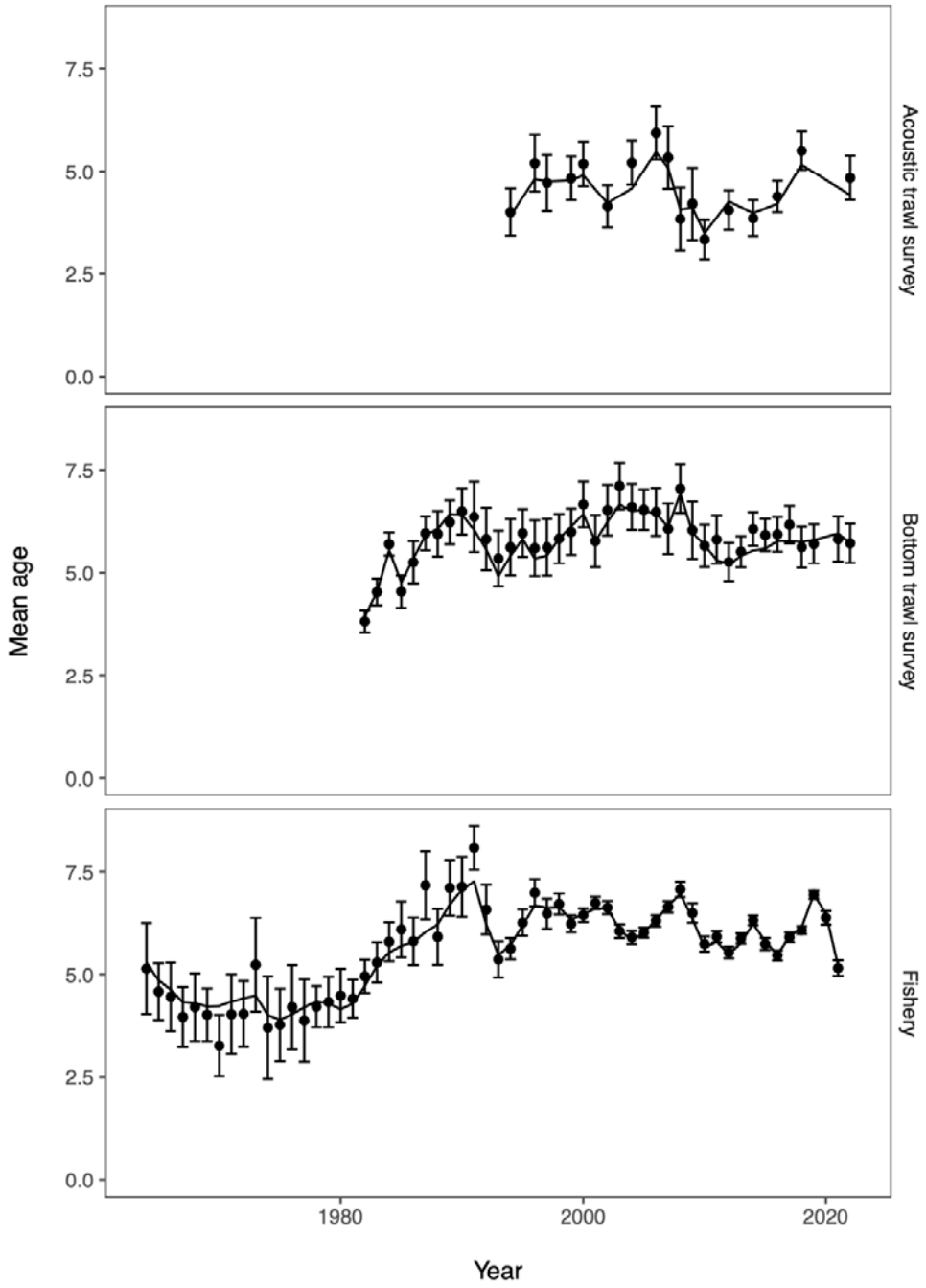
Fit to acoustic-trawl index

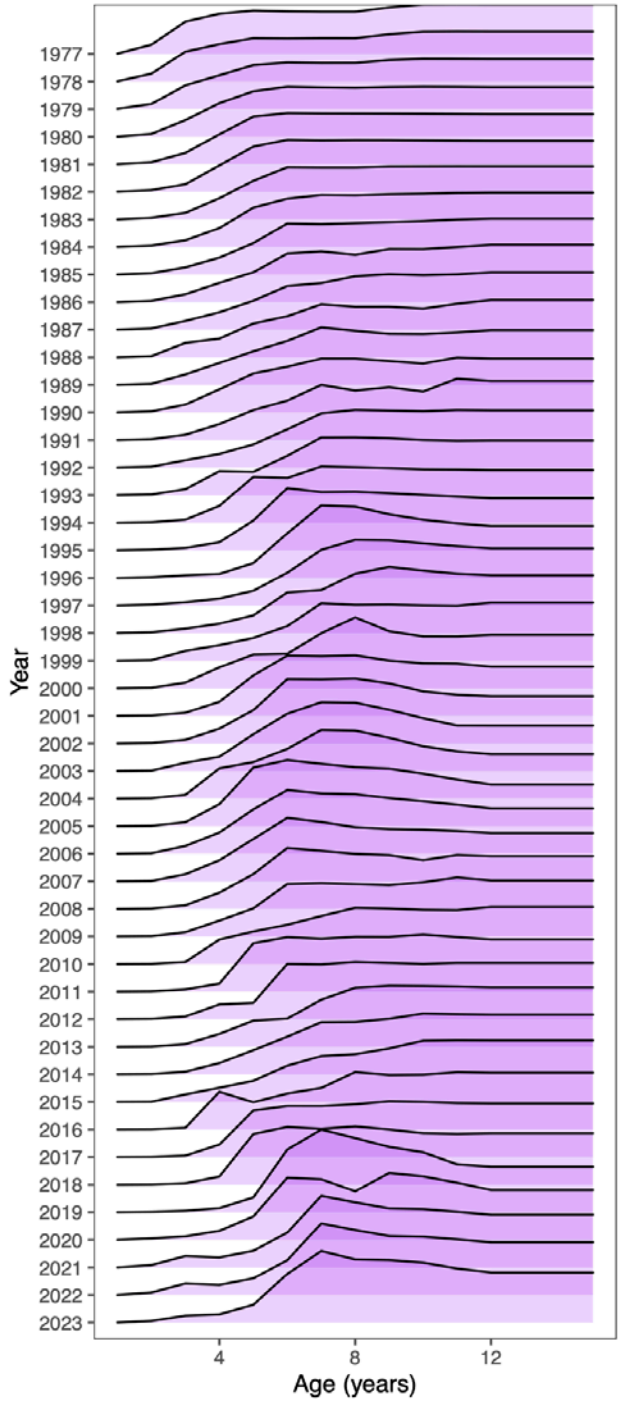
AVO Index


Acoustics collected opportunistically on bottom-trawl survey
Acoustic return (Sa from AVO)
2.0
1.5
1.0
0.5
0.0
2005
2010
2015
2020
Year

Fishery age composition fits







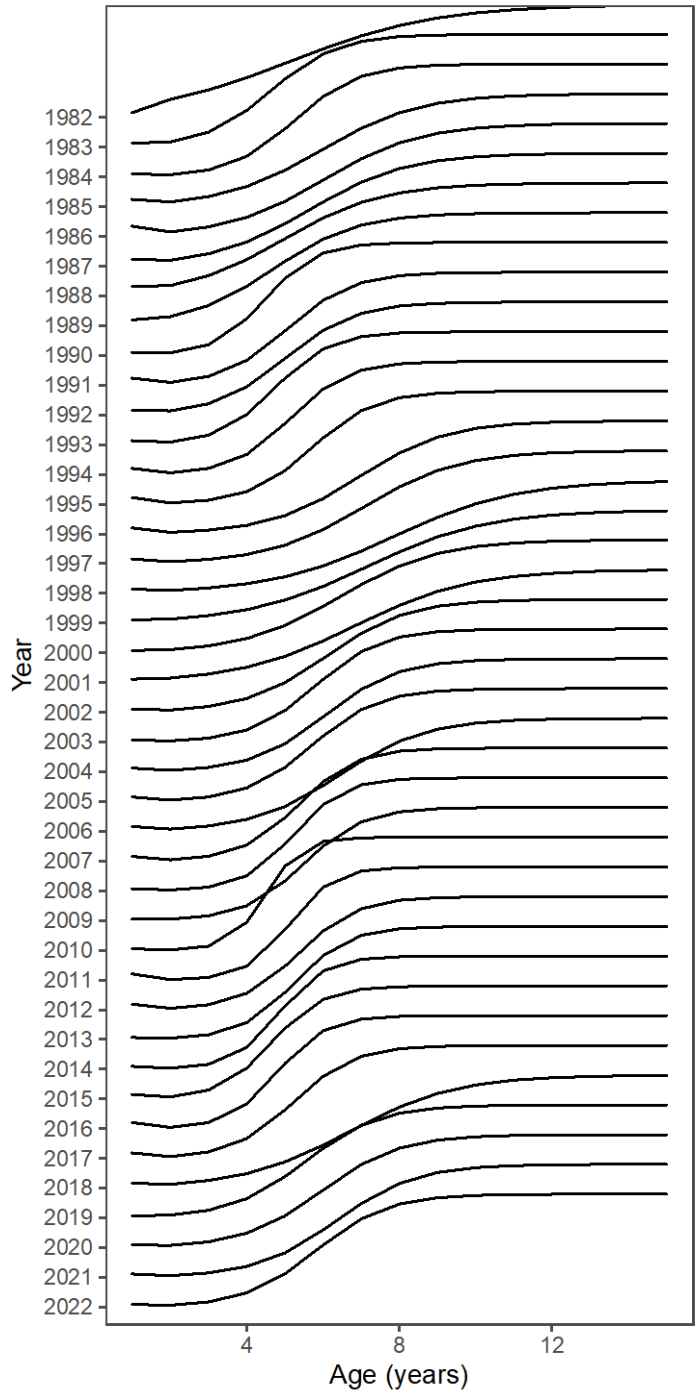
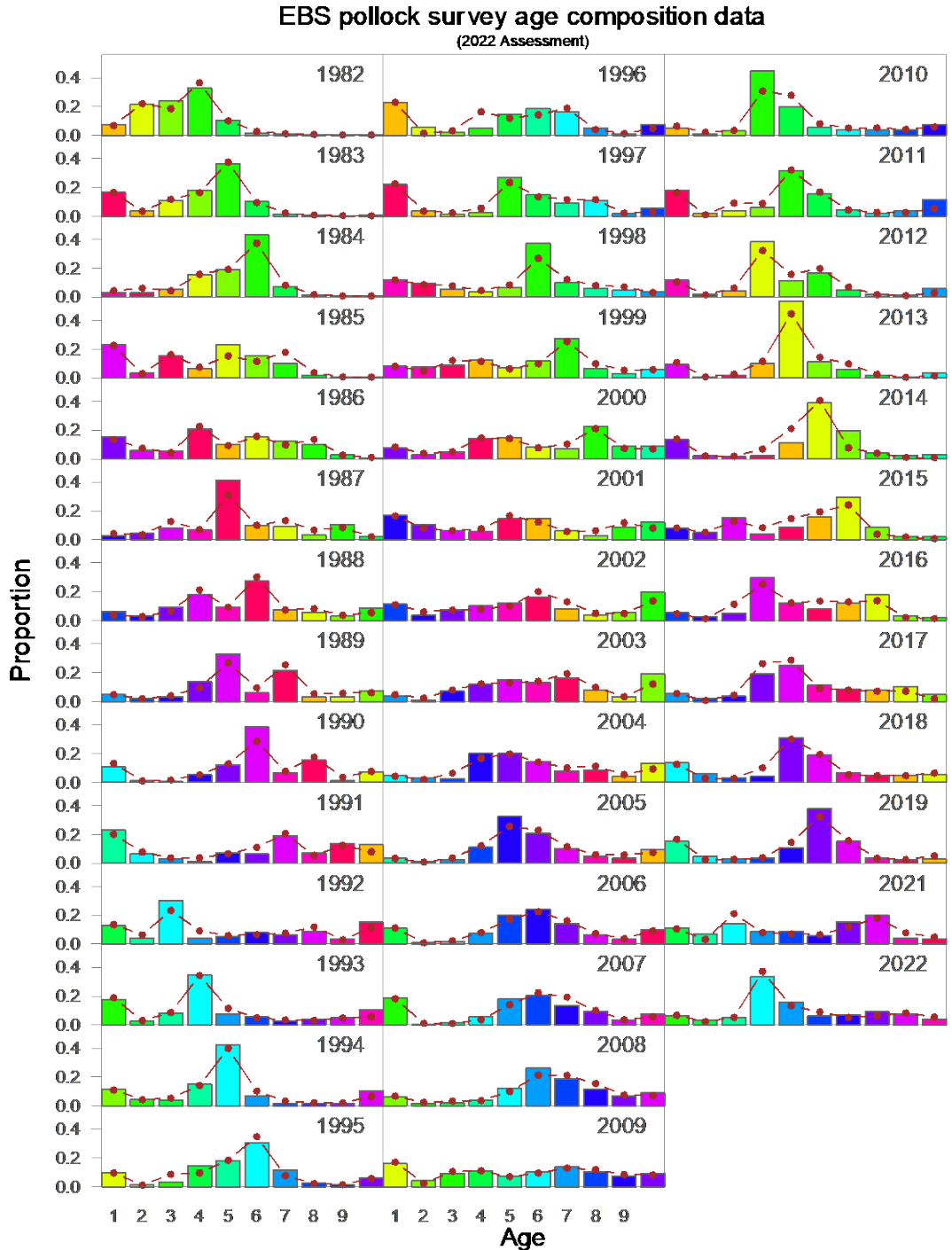


Figure 1-36. EBS pollock model fits to observed mean age for the Acoustic trawl survey (top), the bottom trawl survey (middle) and fishery (bottom)

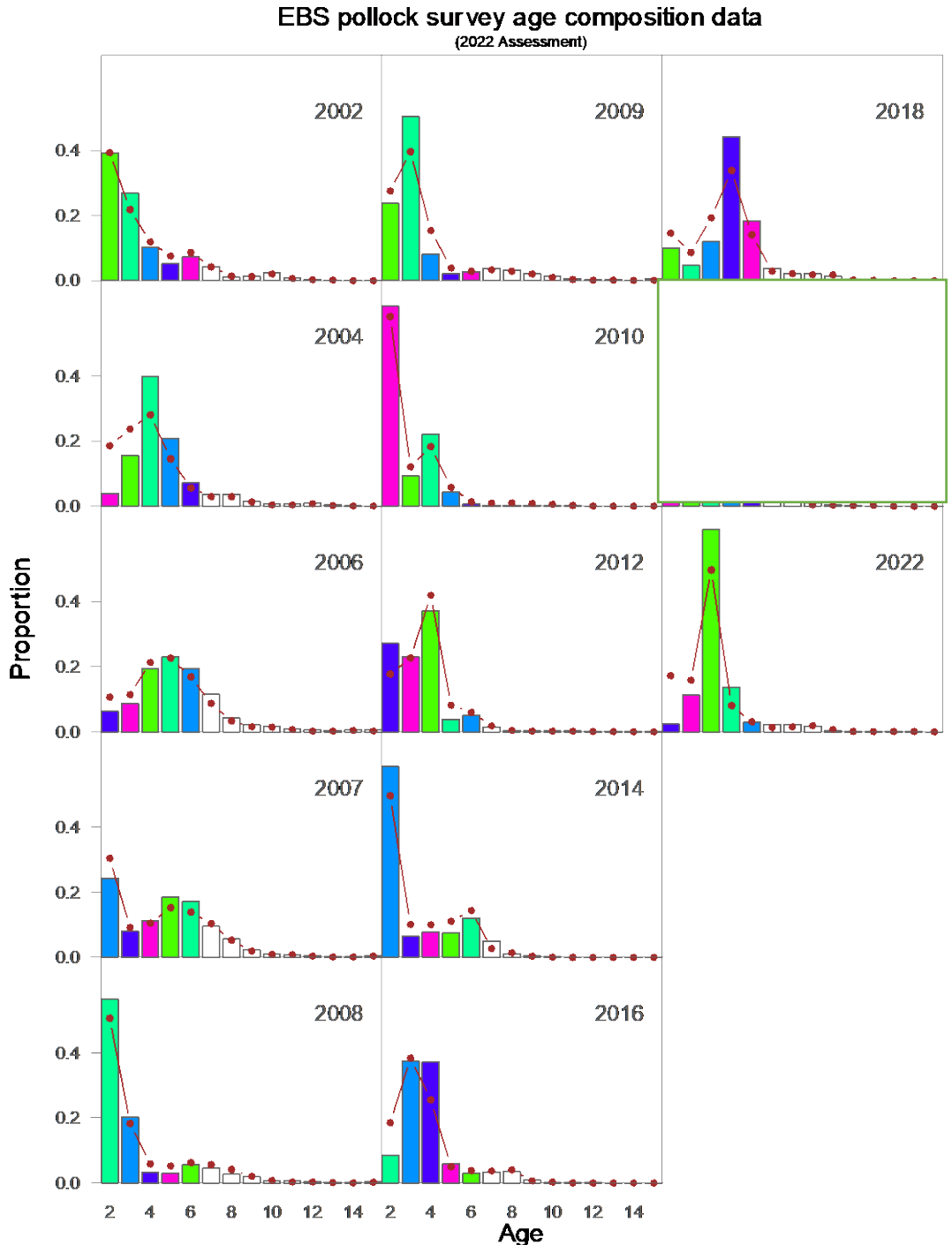
Bottom-trawl survey age composition fits



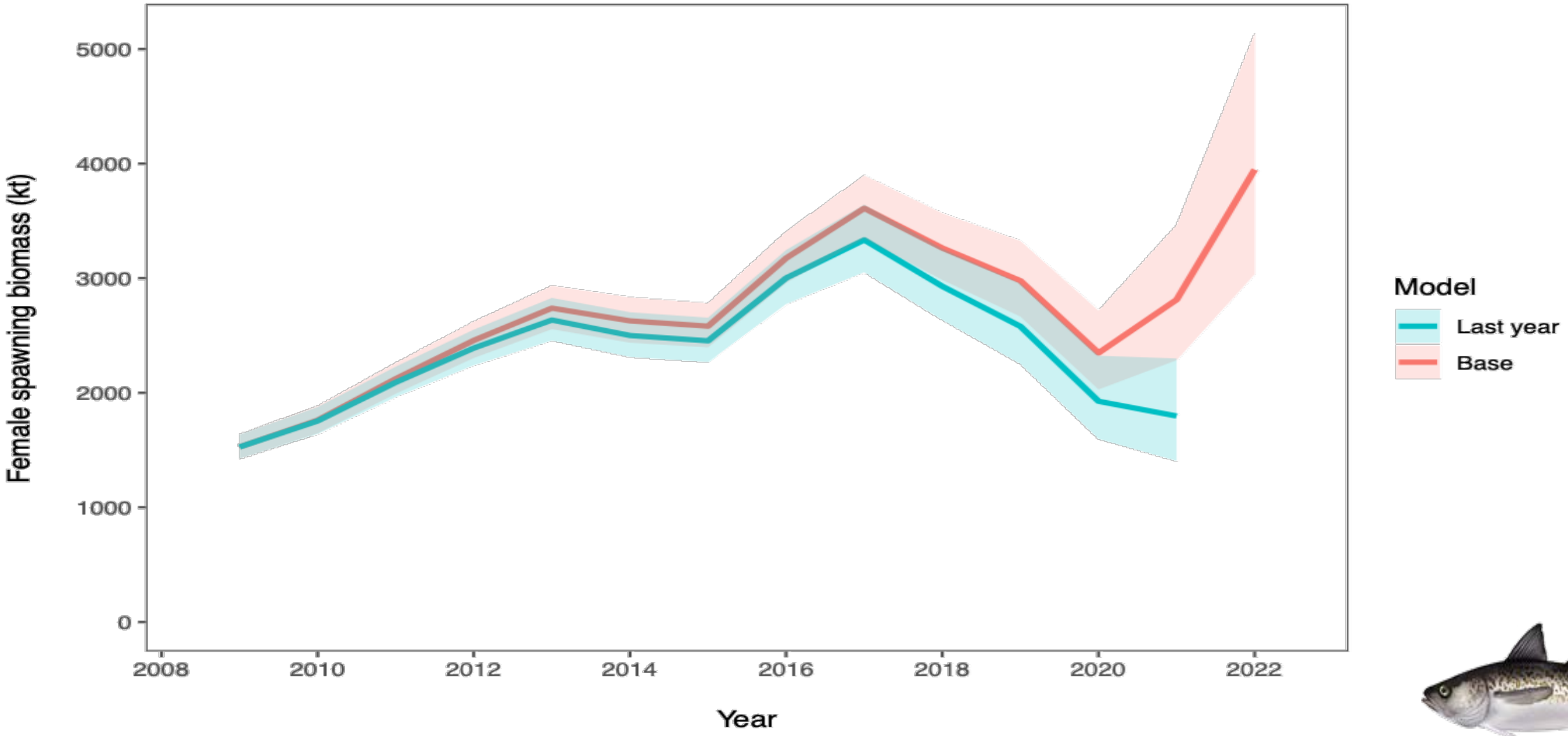
Acoustic-trawl survey age composition fits

NOTE: No age data in 2020

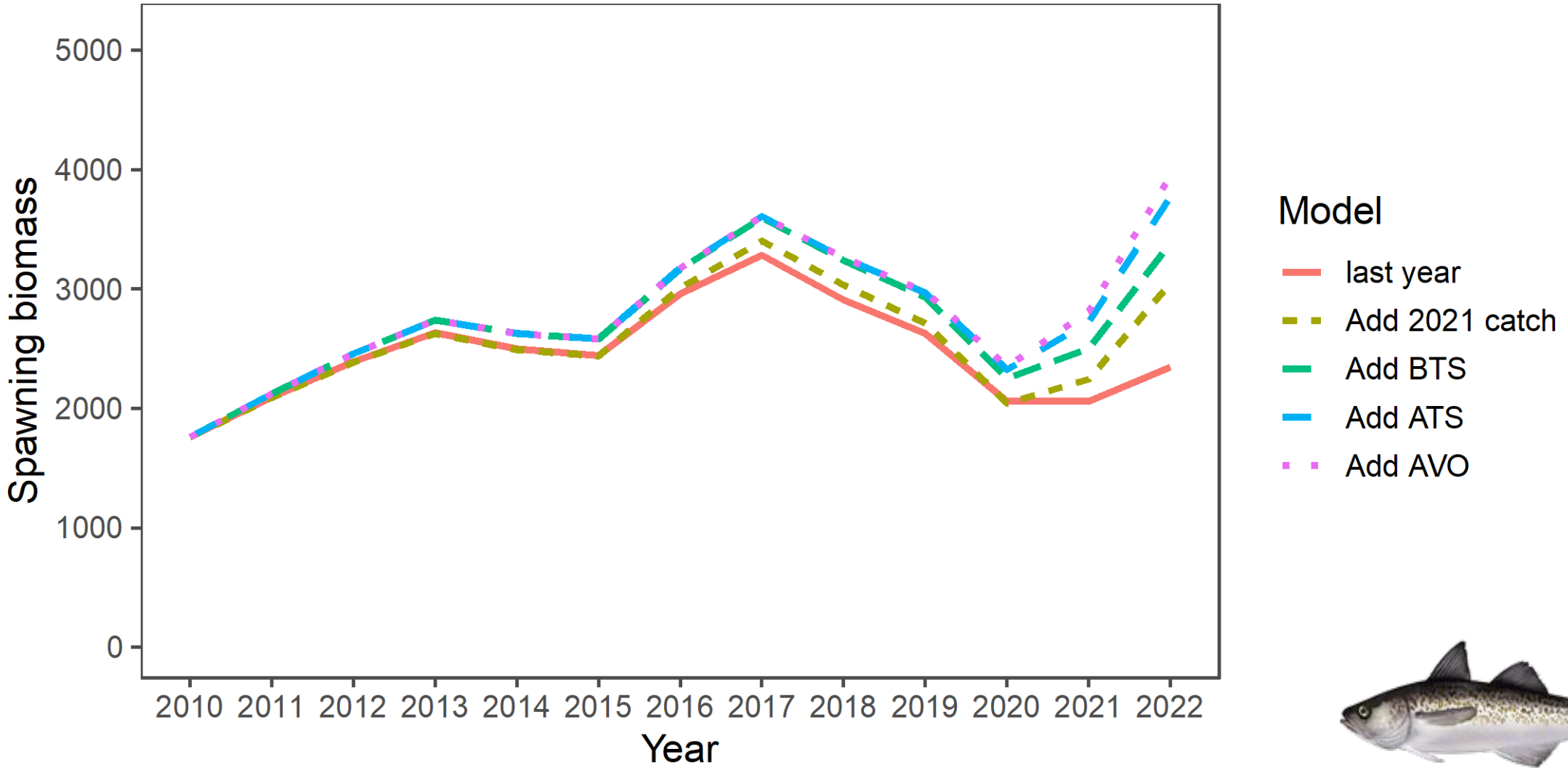
Figure panel gets no weight



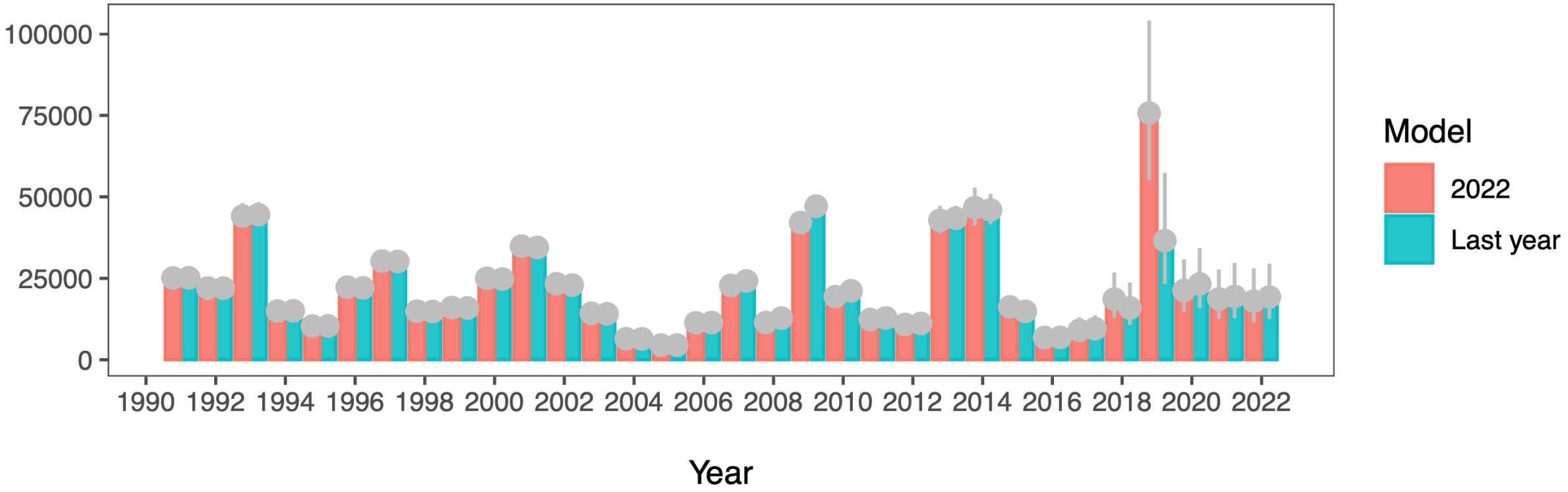
Putting new data in: Spawning biomass change



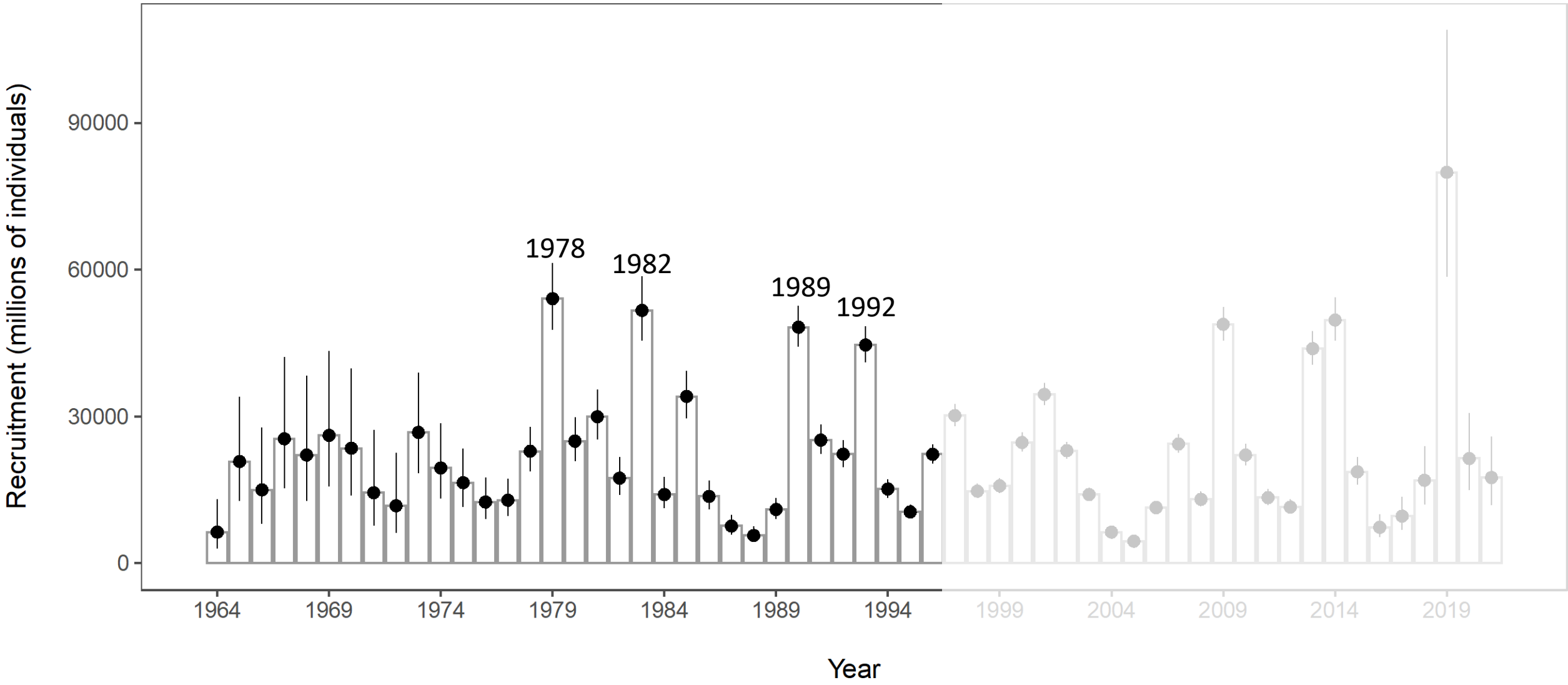
Incremental effect of new data

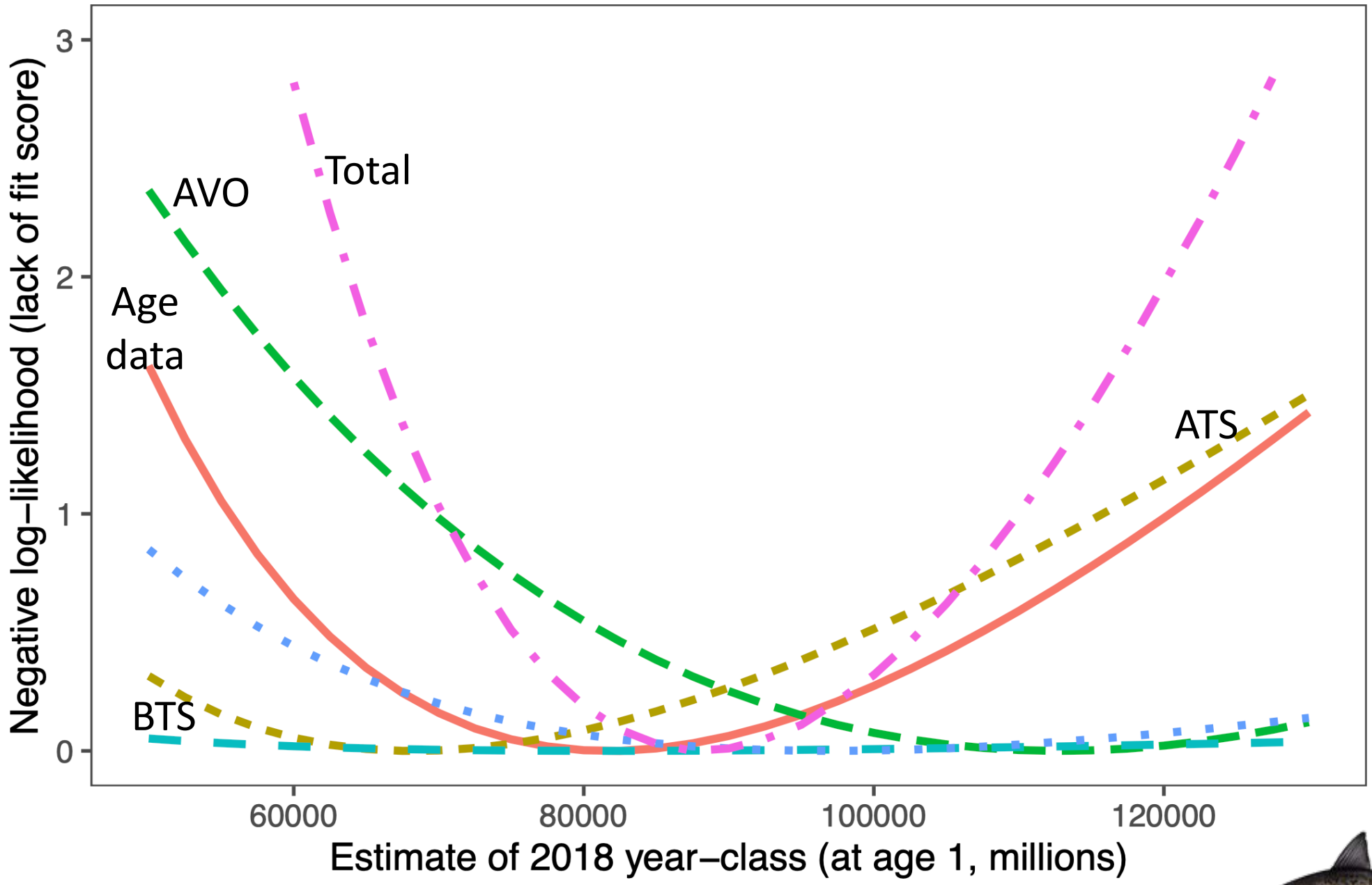


Recruitment estimates revised from last year



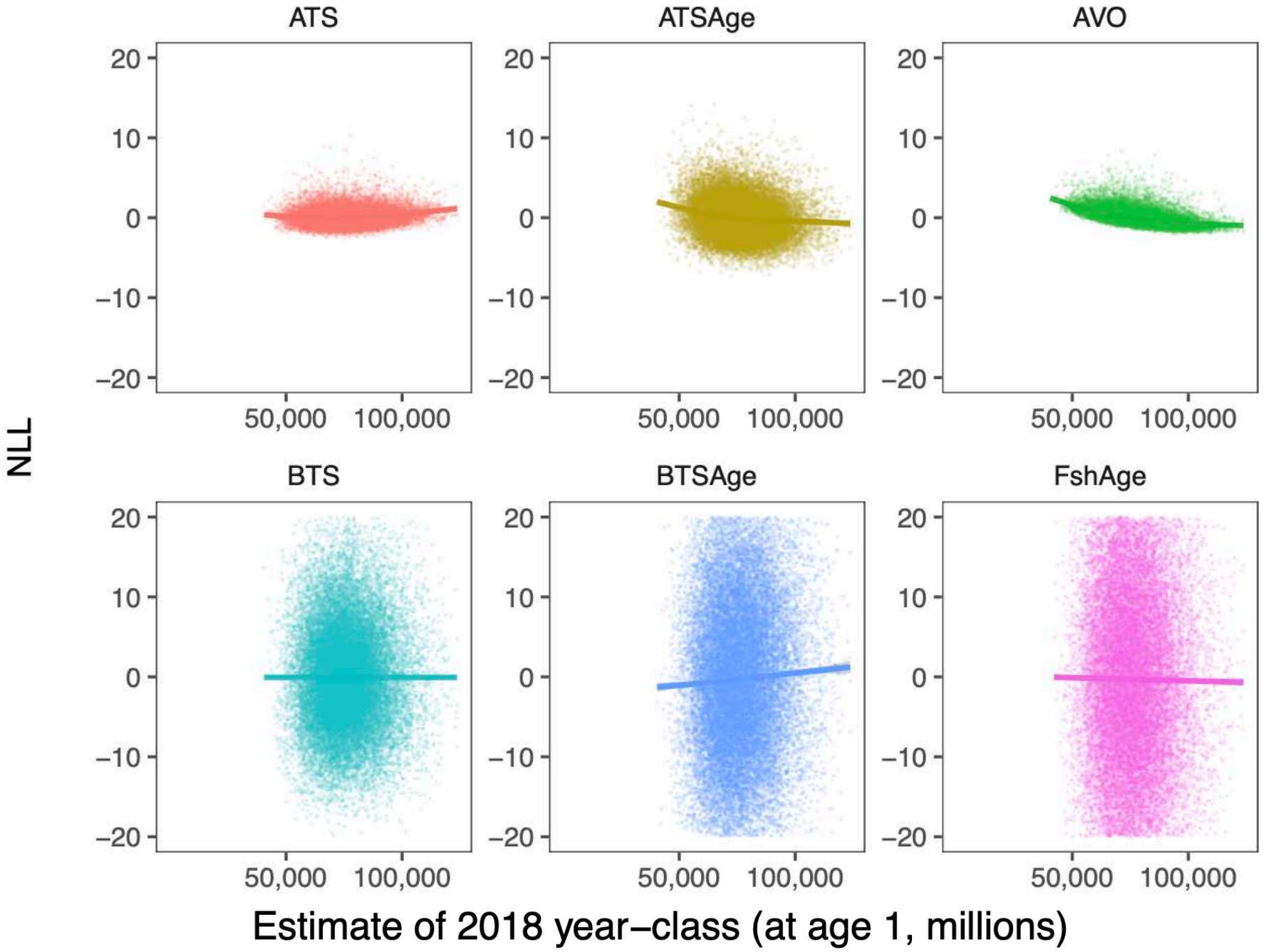
Recruitment time series




Negative log−likelihood (lack of fit score)
3
2
1
0
AVO
Total
Age
data
ATS
BTS
60000
80000
100000
120000
Estimate of 2018 year−class (at age 1, millions)

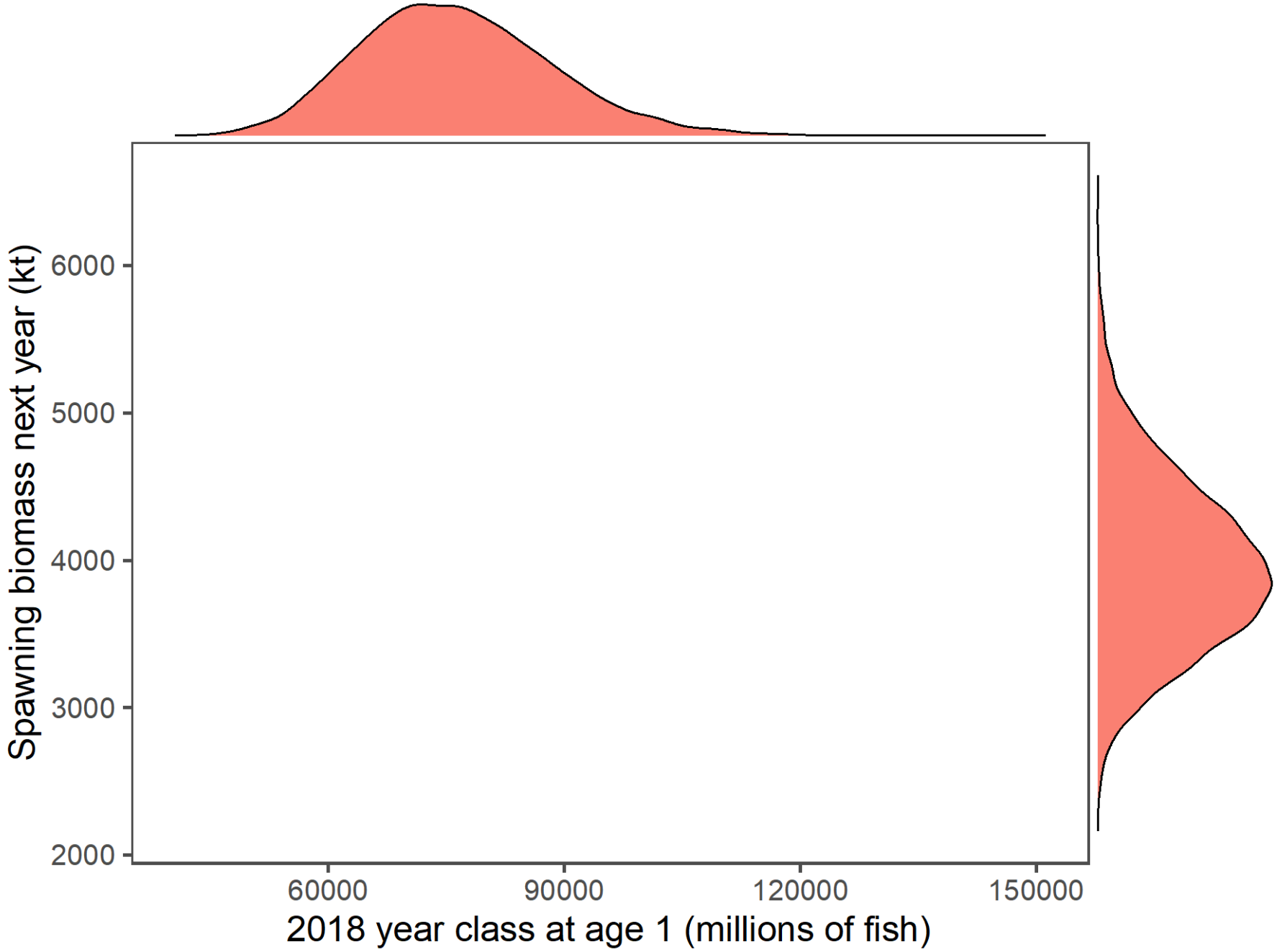
“profiles”

- From posterior components



How much does the 2018 year class estimate affect spawning biomass?

Joint posterior distribution



Uncertainty evaluation treatments

Improvements in posterior integration thanks to Monnahan's 2019 work on ADMB no-U-turn sampler

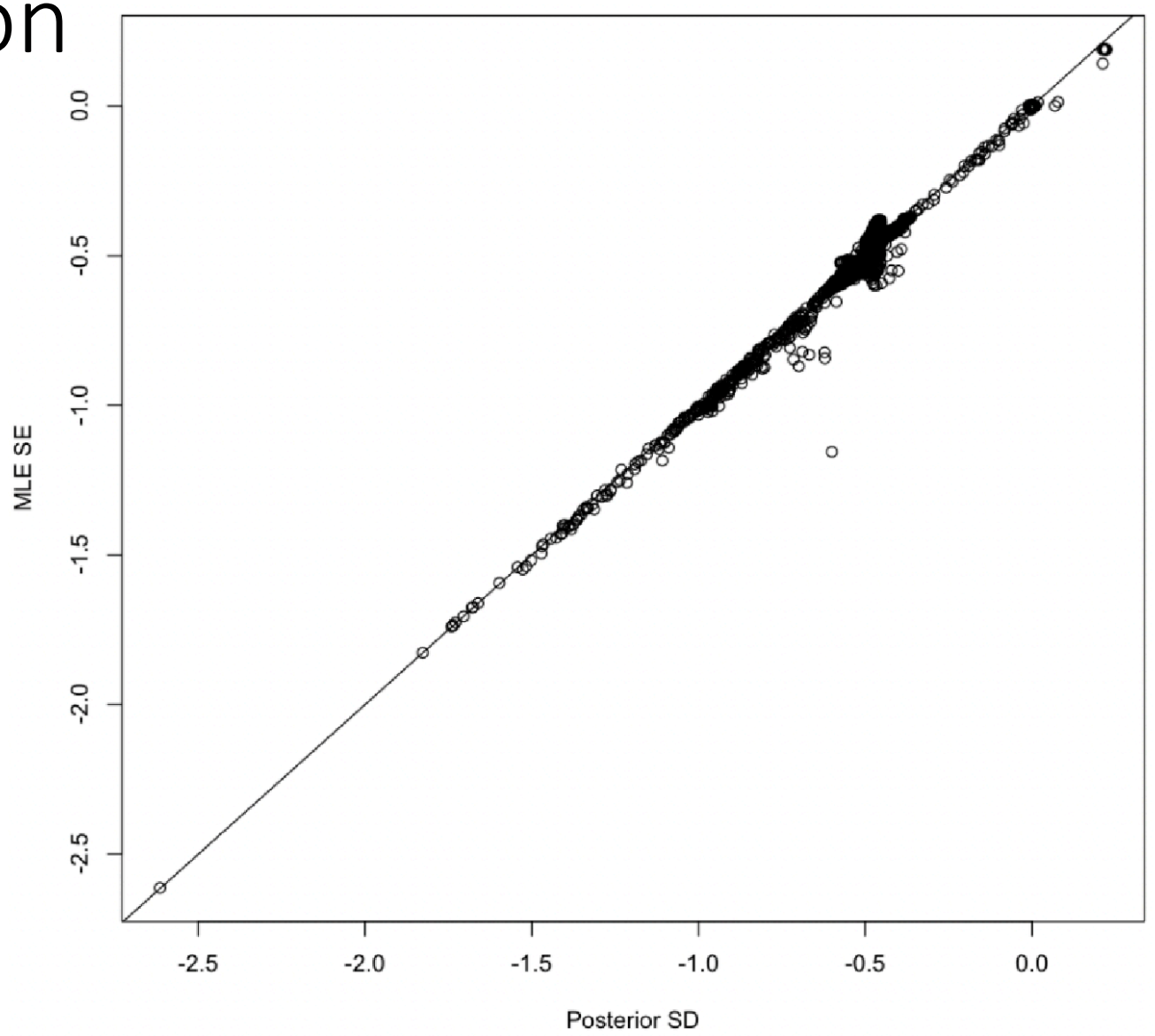


Figure 1-42. Comparison of the asymptotic parameter standard errors (from inverting the Hessian; vertical axis) with the marginals from the MCMC draws (horizontal axis).

Uncertainty evaluation treatments

Improvements in posterior integration thanks to Monnahan's 2019 work on ADMB no-U-turn sampler

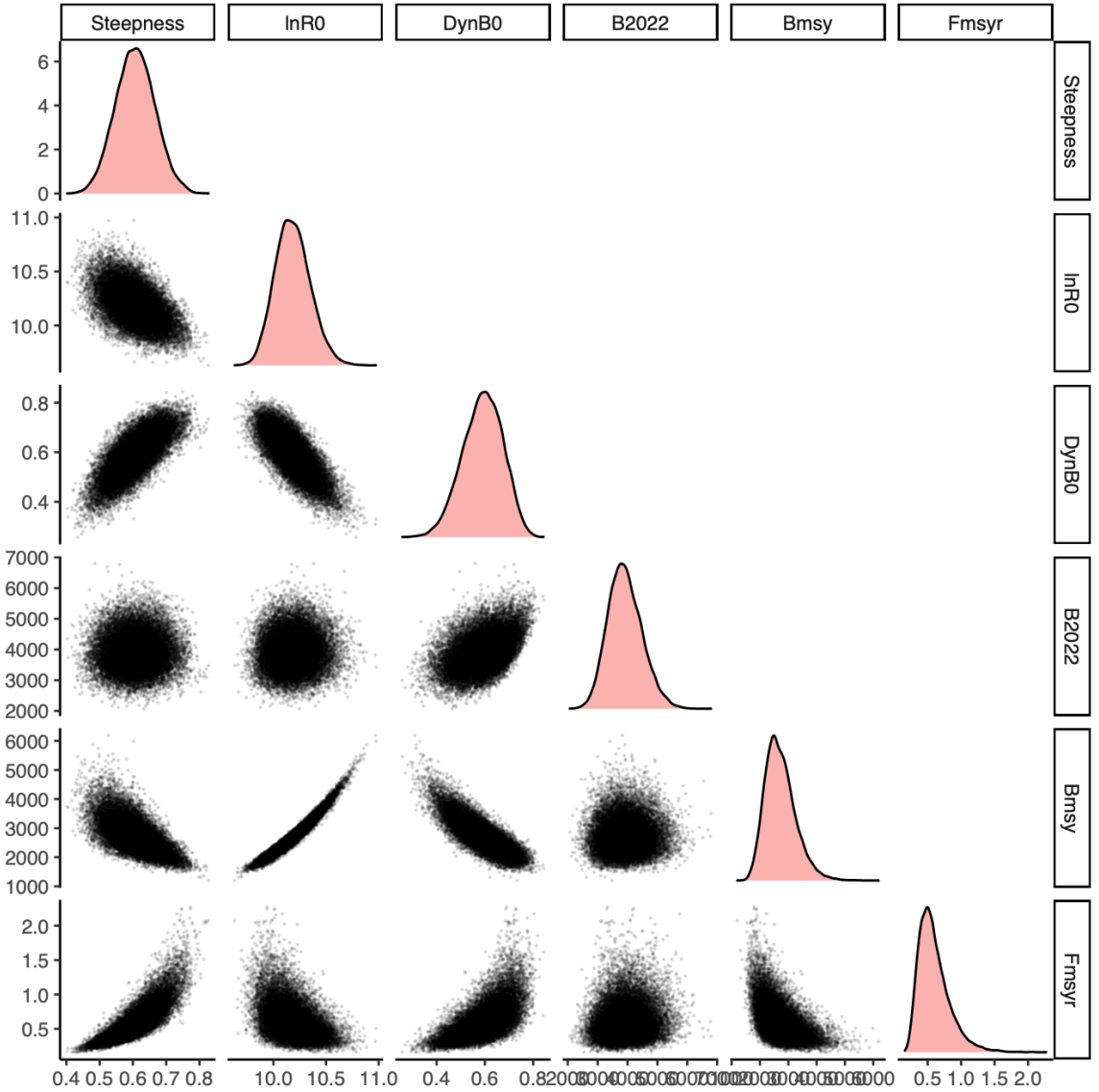
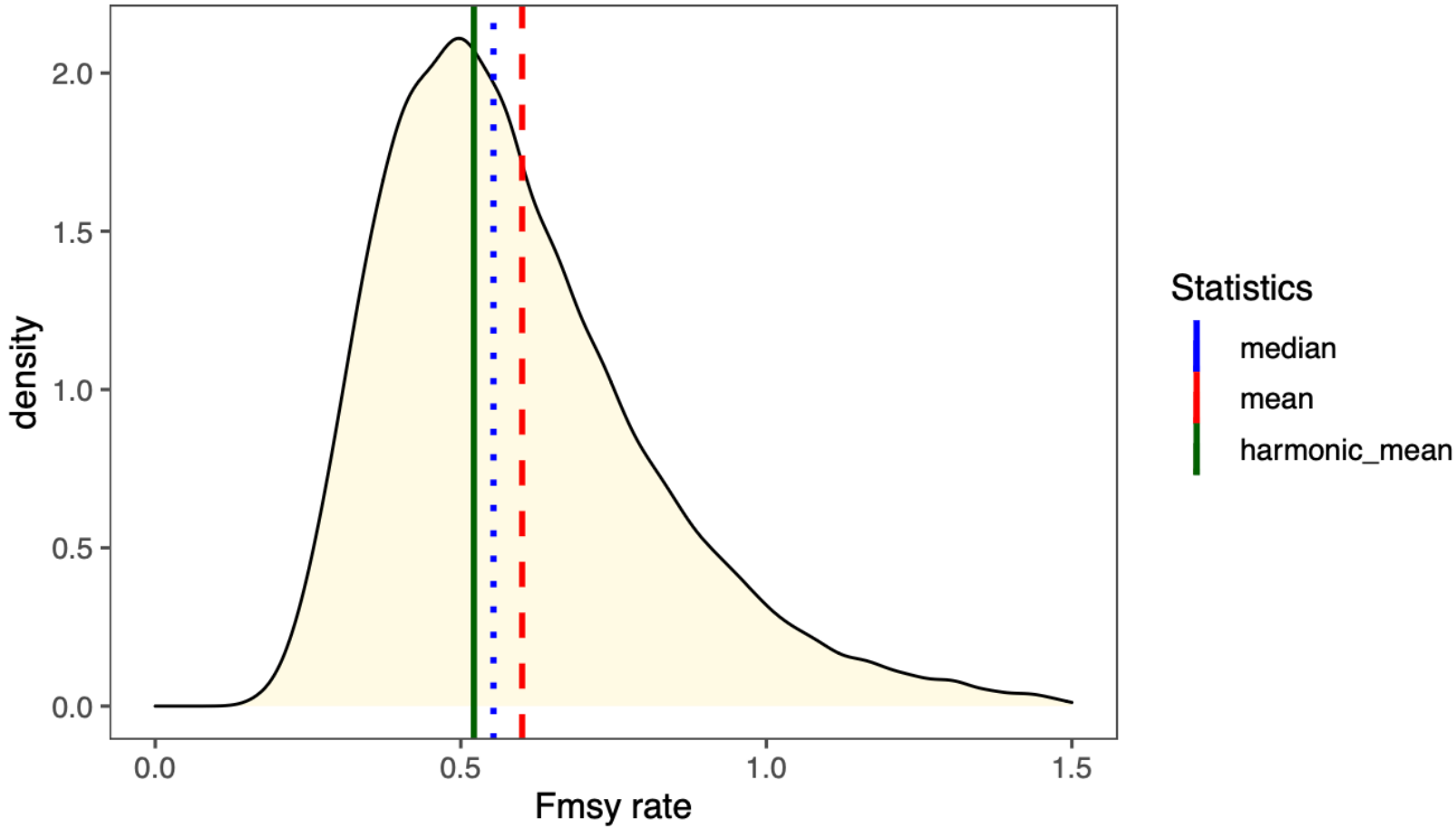


Figure 1-43. Pairwise plot of selected EBS pollock parameters and output from 3 million MCMC iterations thinned such that 5 thousand draws were saved as an approximation to the multivariate posterior distribution. Note that the figures on the diagonal represent the marginal posterior distributions. Key: lnR0 is the parameter that scales the stock-recruit relationship, B_Bmsy is estimated B_{2021}/B_{MSY}, DynB0 is the ratio of spawning biomass estimated for in 2022 over the value estimated that would occur if there had been no fishing, B2022 is the spawning biomass in 2022, and B_Bmean is $B_{2022}/\bar{B}$.

Uncertainty evaluation treatments

Improvements in posterior integration thanks to Monnahan's 2019 work on ADMB no-U-turn sampler



Uncertainty evaluation treatments

Improvements in posterior integration thanks to Monnahan's 2019 work on ADMB no-U-turn sampler

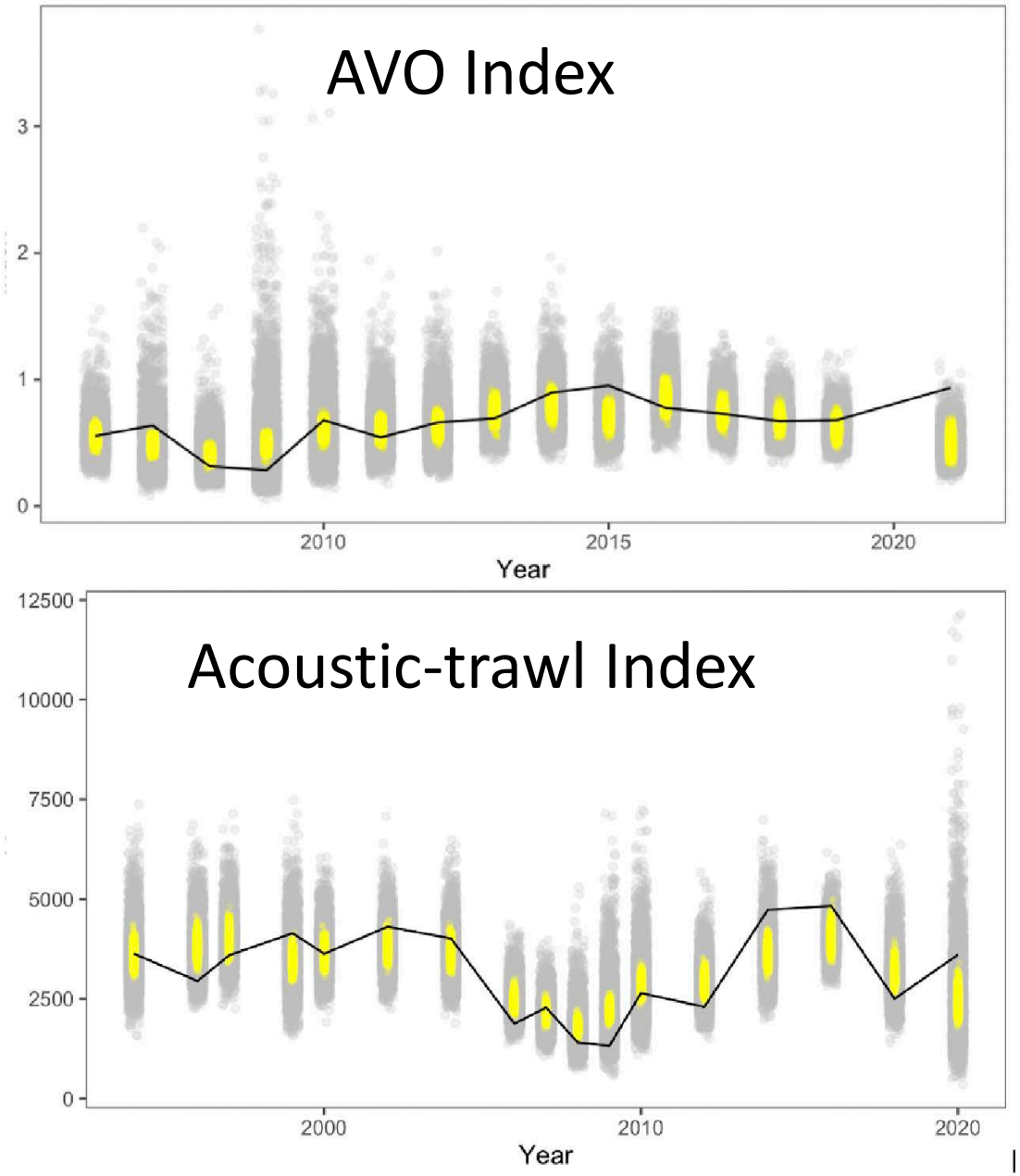
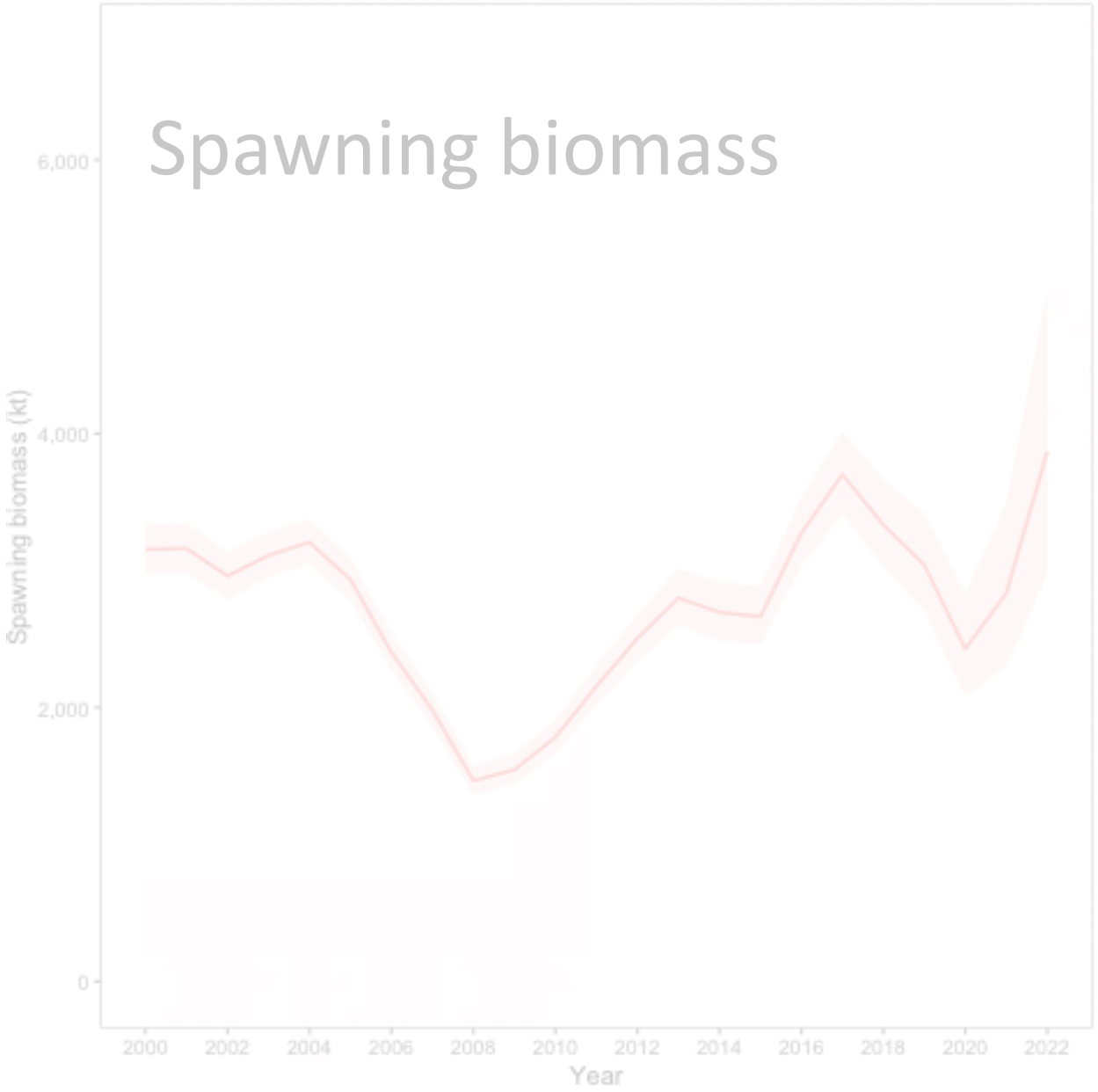


Figure 1-46. Plot of the model prediction (solid line), the distribution of the expected value (yellow dots) and the posterior predictive distribution (grey points).

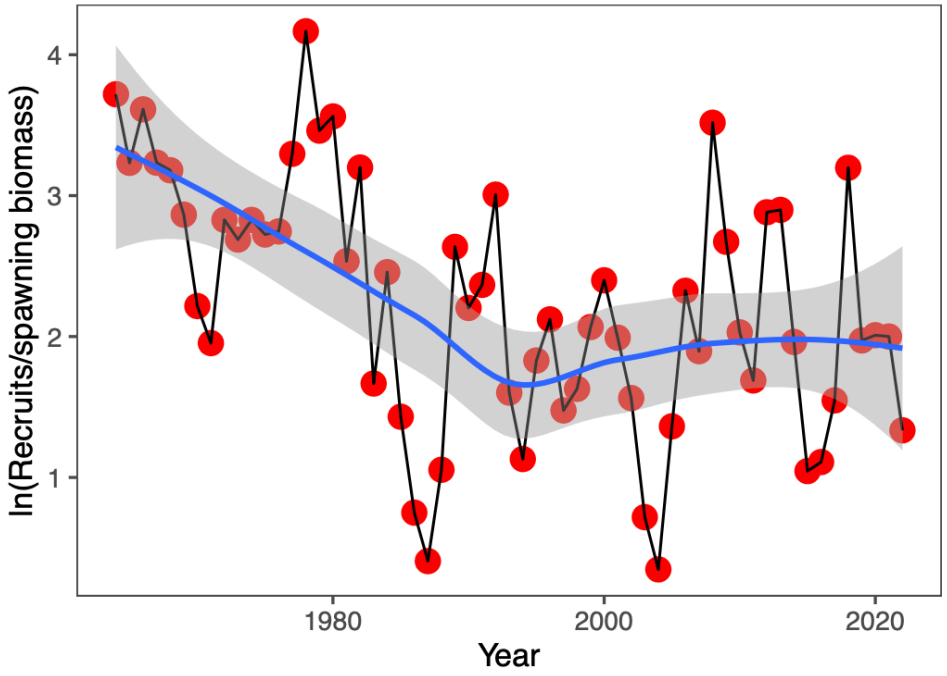
Retrospectives

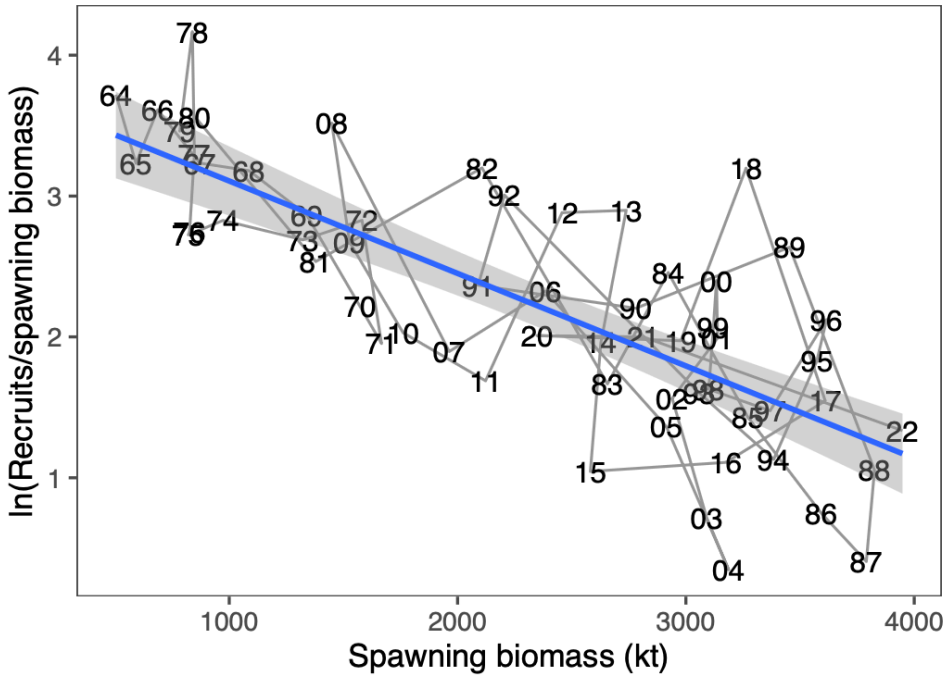
Spawning biomass



Recruitment

Stock-recruit relationship





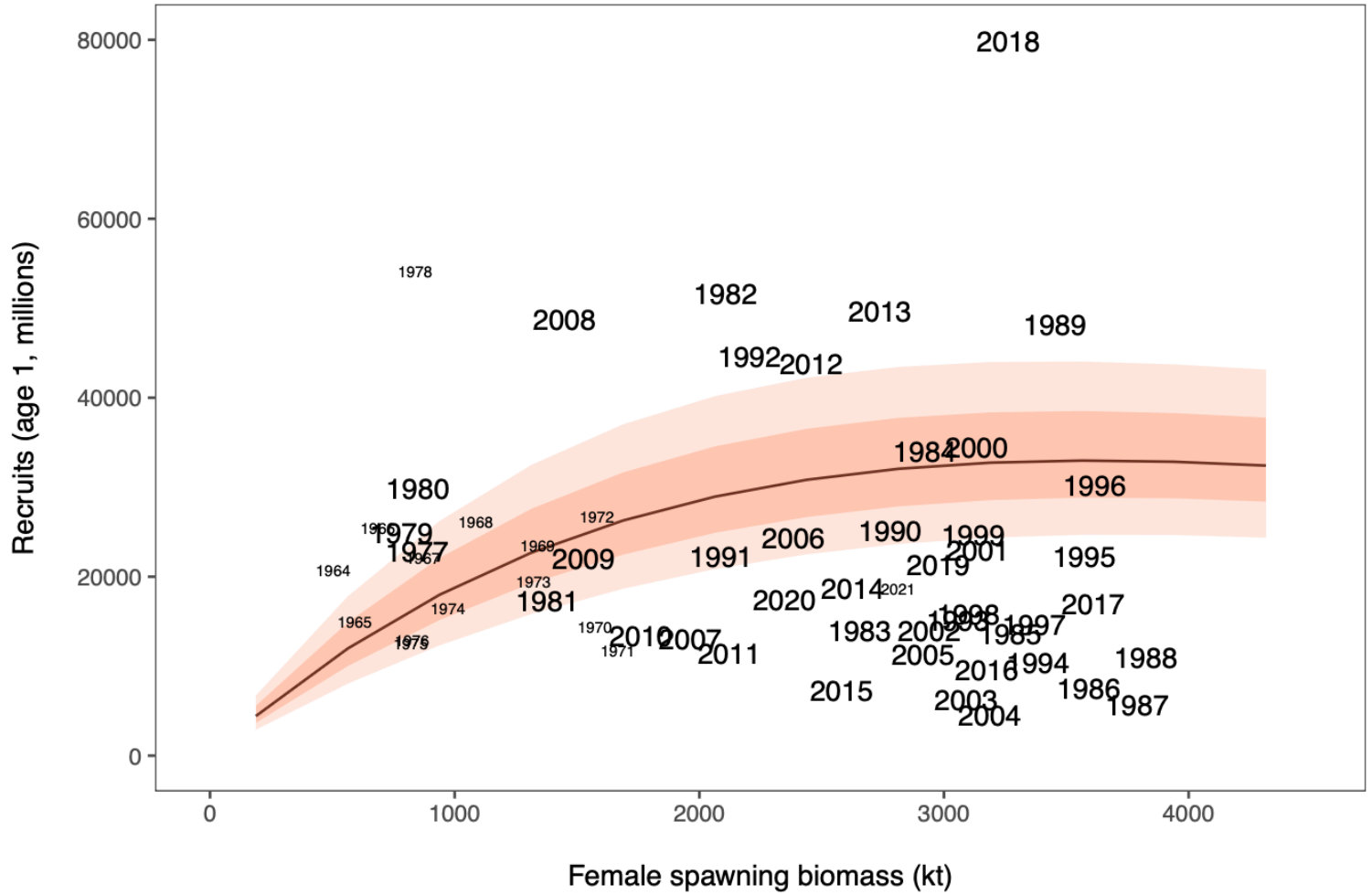
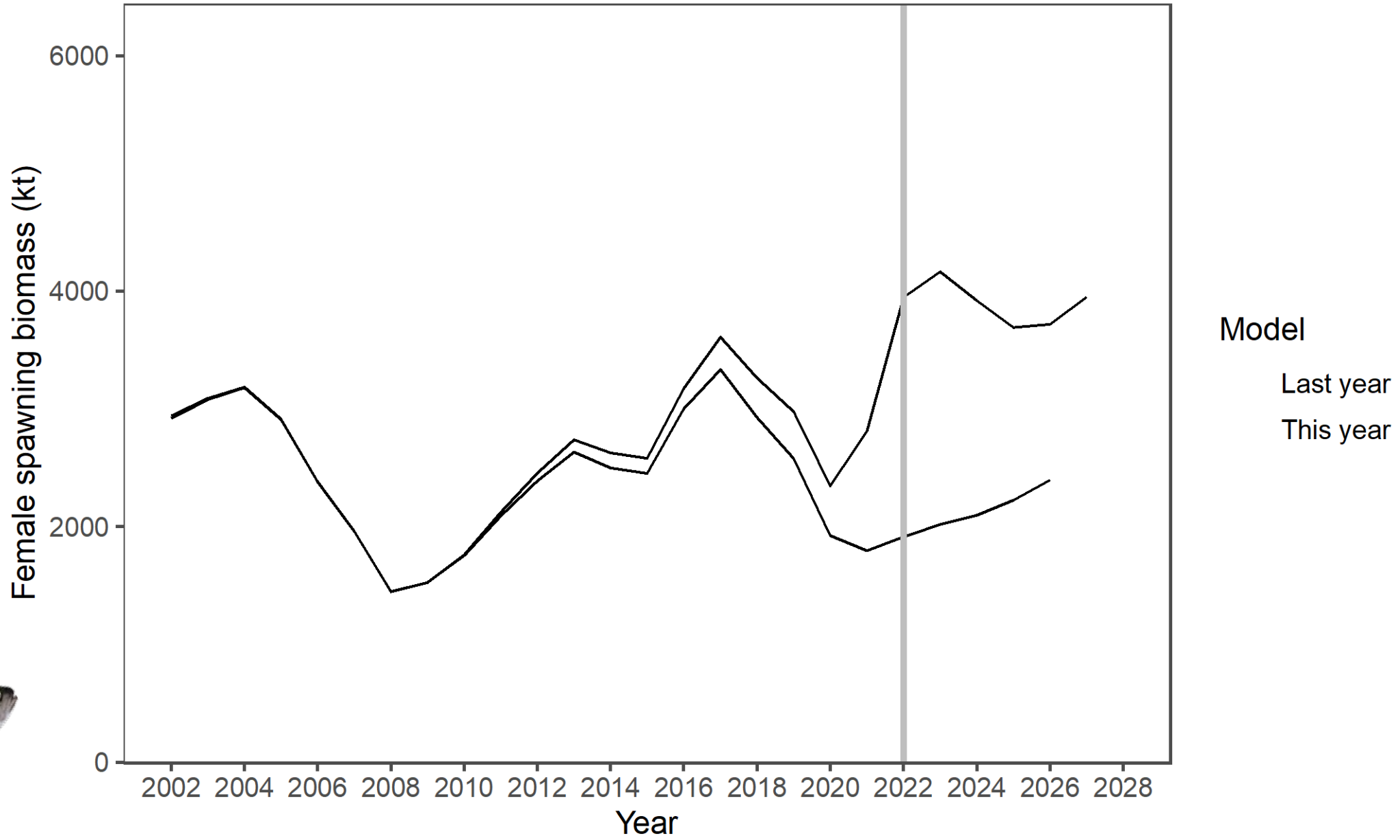


Figure 1-60. Stock-recruitment estimates (shaded represents structural uncertainty) and age-1 EBS pollock estimates labeled by year-classes

Result, new data and update on spawning biomass



Risk tables

Population dynamics considerations

The age structure of EBS pollock has exhibited some peculiarities over time. On the positive side, some strong year-classes appear to have increased in abundance based on the bottom-trawl survey data (e.g., the 1992, 2012, 2013 and 2018 year classes). Conversely, the period from 2000–2007 had relatively poor year-class strengths which resulted in declines in stock below B_{msy} and reduced TACs due to lower ABC values. Given the strong year-class strength from 2018, it appears that the mean recruitment since 2000 has been nearly average but with greater variability than earlier years (Fig. 62). There also are clear density-dependent effects on growth, in particular, the 2012 year class. The stock is estimated to be below B_{msy} at present, and projections indicate a reasonable chance that the stock will decline further given recent catch levels. The extent that the the lack of a cold pool and will impact pollock survival at egg, larval, and juvenile stages is uncertain. Recruitment in the near term is well above average but are hightly uncertain. Additional age-specific aspects of the spawning population indicate that the stock has increased from a low diversity of ages (for both the population and the mean age of the spawning stock weighted by spawning output Fig. 65). **We therefore rated the population-dynamics concern as level 2, substantially increased concern.**

Risk tables

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Risk tables

Assessment considerations

The EBS pollock assessment model has appeared to track the stock from year-to-year based on retrospective analysis in previous assessments. This year however, there was a substantial increase relative to the lower than expected survey observation from 2021; this affected the retrospective analyses which last year indicated a tendency to over estimate the stock trend. The model tracks the available data reasonably well except for the strong increase in the AVO index relative to the last two years. We also recognize that the stock-recruitment relationship selected for this cannibalistic species requires a relatively informative prior distribution in order to have the residuals of the estimates relative to the curve to be less biased nearer the slope of the origin. This could be interpreted as being undesirable and having undue influence on the underlying stock productivity (noting that it has been demonstrated that the prior leads to increased conservativism). **We therefore rated the assessment-related concern as level 2, substantially increased concern.**

These results are summarized as:

Considerations			
Assessment-related	Population dynamics	Environmental or ecosystem	Fisheries
Level 2: Substantially increased concerns	Level 1: Normal	Level 1: Normal	Level 1: Normal

Having a score at level 2 suggests that adjustments to the ABC may be prudent. In the past, the

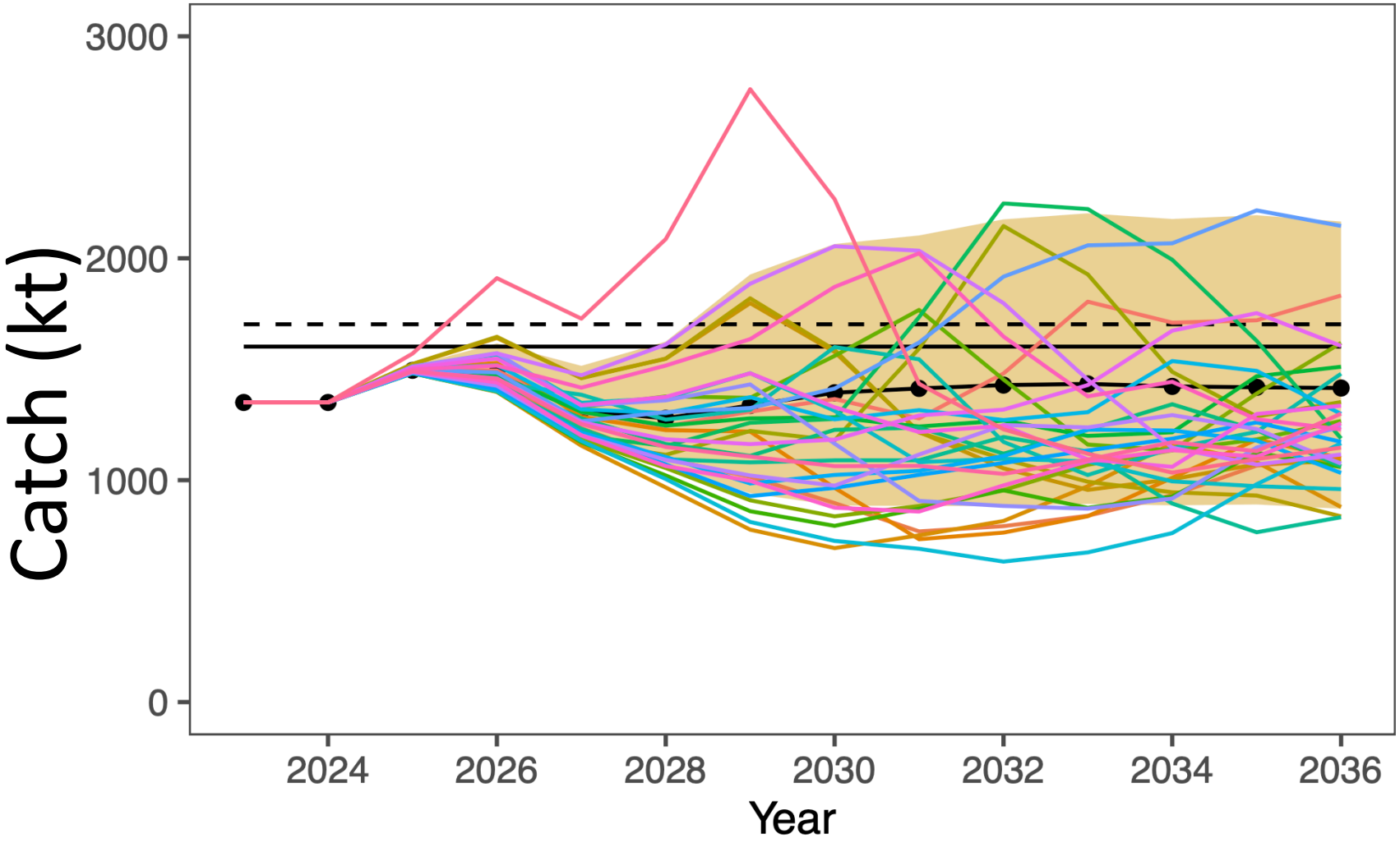
Quantity	As estimated or *specified* *last* year for: 2022	2023	As estimated or *recommended* *this* year for: 2023	2024
M (natural mortality rate, ages 3+)	0.3	0.3	0.3	0.3
Tier	1b	1b	1a	1a
Projected total (age 3+) biomass (t)	6,839,000 t	6,969,000 t	12,389,000 t	11,445,000 t
Projected female spawning biomass (t)	1,881,000 t	1,905,000 t	4,171,000 t	3,944,000 t
B_0	5,575,000 t	5,575,000 t	6,653,000 t	6,653,000 t
B_{msy}	2,220,000 t	2,220,000 t	2,674,000 t	2,674,000 t
F_{OFL}	0.392	0.415	0.491	0.491
$maxF_{ABC}$	0.334	0.353	0.434	0.434
F_{ABC}	0.296	0.314	0.365	0.365
OFL	1,469,000 t	1,704,000 t	3,381,000 t	4,639,000 t
$maxABC$	1,251,000 t	1,451,000 t	2,987,000 t	4,099,000 t
ABC	1,111,000 t	1,289,000 t	1,688,000 t	1,815,000 t
Status	2020	2021	2021	2022
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Status considerations

In summary, the criterion for Tier 1 depends on a reliable estimate of F_{MSY} and the uncertainty (the PDF). Tier 2 also requires a reliable estimate of F_{MSY} (without the PDF requirement). Given the seemingly reasonable posterior marginal density for F_{MSY}, it seems if Tier 1 criterion is unmet, then so would the requirement for Tier 2. Adopting Tier 3, while in principle may result in more conservative catch advice, uses less information available about the stock productivity and requires adopting more assumptions (i.e., that $F_{35\%}$ is a reasonable proxy for F_{MSY}). As noted below in the section on risk evaluations, there are reasons for increased concerns. However, these seem to be unrelated to overall stock productivity as relates to the SRR and estimates of F_{MSY}. Consequently, our overall analysis continues to support the SSC's classification of this stock to be within Tier 1.

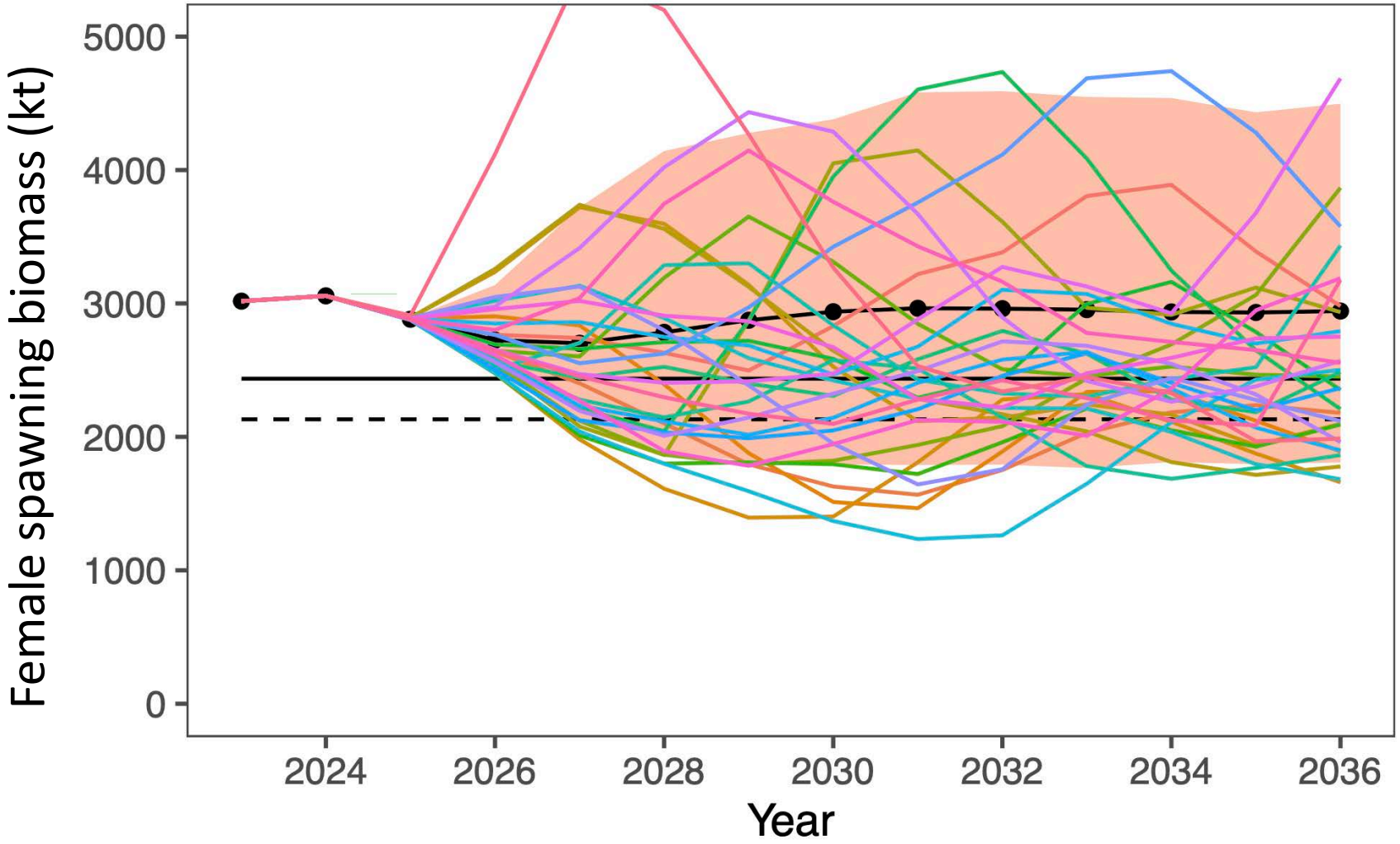
Projections

Effort equal to recent 5-years



Projections

Effort equal to recent 5-years



Decision variables (?)

Table 1-34. Outcomes of decision (expressed as chances out of 100) given different 2023 catches (first row, in kt). Note that for the 2020 and later year-classes average values were assumed. Constant Fs based on the 2023 catches were used for subsequent years.

	10	850	1000	1110	1150	1300	1450	1600
$P[F_{2023} > F_{MSY}]$	0	0	0	0	0	0	0	0
$P[B_{2024} < B_{MSY}]$	4	7	8	9	9	10	12	14
$P[B_{2025} < B_{MSY}]$	2	8	10	12	12	15	19	23
$P\left[B_{2024} < \bar{B}\right]$	0	1	1	1	1	2	3	4
$P\left[B_{2027} < \bar{B}\right]$	0	7	9	12	12	15	19	22
$P[B_{2027} < B_{2023}]$	9	45	52	56	58	63	68	72
$P[B_{2025} < B_{20\%}]$	0	0	0	0	0	0	0	0
$P\left[p_{a_5,2024} > \bar{p}_{a_5}\right]$	1	36	44	50	52	58	64	69
$P[D_{2024} < D_{1994}]$	53	71	74	76	77	80	83	85
$P[D_{2027} < D_{1994}]$	0	2	3	5	5	8	11	15
$P[E_{2023} > E_{2022}]$	0	0	3	18	27	62	85	95

Table 1-33. Details and explanation of the decision table factors selected in response to the Plan Team requests (as originally proposed in the 2012 assessment).

Term	Description	Rationale
$P[F_{2023} > F_{MSY}]$	Probability that the fishing mortality in 2023 exceeds F_{MSY}	OFL definition is based on F_{MSY}
$P[B_{2024} < B_{MSY}]$	Probability that the spawning biomass in 2024 is less than B_{MSY}	B_{MSY} is a reference point target and biomass in 2021 provides an indication of the impact of 2023 fishing
$P[B_{2025} < B_{MSY}]$	Probability that the spawning biomass in 2025 is less than B_{MSY}	B_{MSY} is a reference point target and biomass in 2023 provides an indication of the impact of fishing in 2023 and 2024
$P\left[B_{2025} < \bar{B}\right]$	Probability that the spawning biomass in 2024 is less than the 1978–2022 mean	To provide some perspective of what the stock condition might be relative to historical estimates after fishing in 2023.
$P\left[B_{2027} < \bar{B}\right]$	Probability that the spawning biomass in 2027 is less than the long term mean	To provide some perspective of what the stock condition might be relative to historical estimates after fishing in 2023.
$P[B_{2027} < B_{2023}]$	Probability that the spawning biomass in 2027 is less than that estimated for 2023	To provide a medium term expectation of stock status relative to 2023 levels
$P[B_{2025} < B_{20\%}]$	Probability that the spawning biomass in 2025 is less than $B_{20\%}$	$B_{20\%}$ had been selected as a Steller Sea Lion lower limit for allowing directed fishing
$P\left[p_{a_5,2025} > \bar{p}_{a_5}\right]$	Probability that in 2025 the proportion of age 1–5 pollock in the population exceeds the long-term mean	To provide some relative indication of the age composition of the population relative to the long term mean.
$P[D_{2024} < D_{1994}]$	Probability that the diversity of ages represented in the spawning biomass (by weight) in 2024 is less than the value estimated for 1994	To provide a relative index on the abundance of different age classes in the 2024 population relative to 1994 (a year identified as having low age composition diversity)
$P[D_{2027} < D_{1994}]$	Probability that the diversity of ages represented in the spawning biomass (by weight) in 2027 is less than the value estimated for 1994	To provide a medium-term relative index on the abundance of different age classes in the population relative to 1994 (a year identified as having low age composition diversity)
$P[E_{2023} > E_{2022}]$	Probability that the theoretical fishing effort in 2023 will be greater than that estimated in 2022.	To provide the relative effort that is expected (and hence some idea of costs).