# Eastern Bering Sea pollock stock assessment

Jim Ianelli, Taina Honkalehto, Sophia Wassermann, Nathan Lauffenburger, Carey McGilliard, Elizabeth Siddon

Alaska Fisheries Science Center

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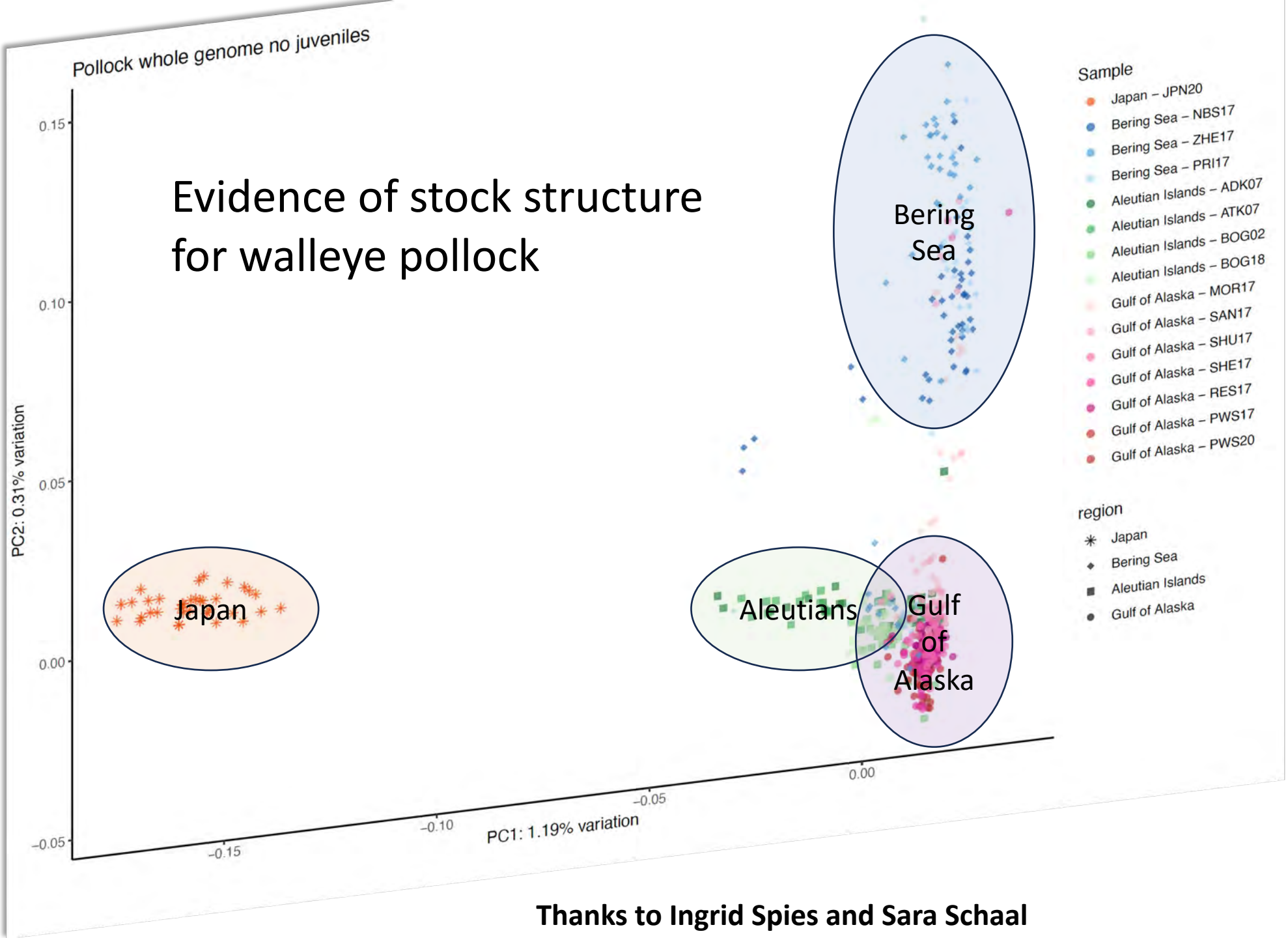
# Pollock genetics

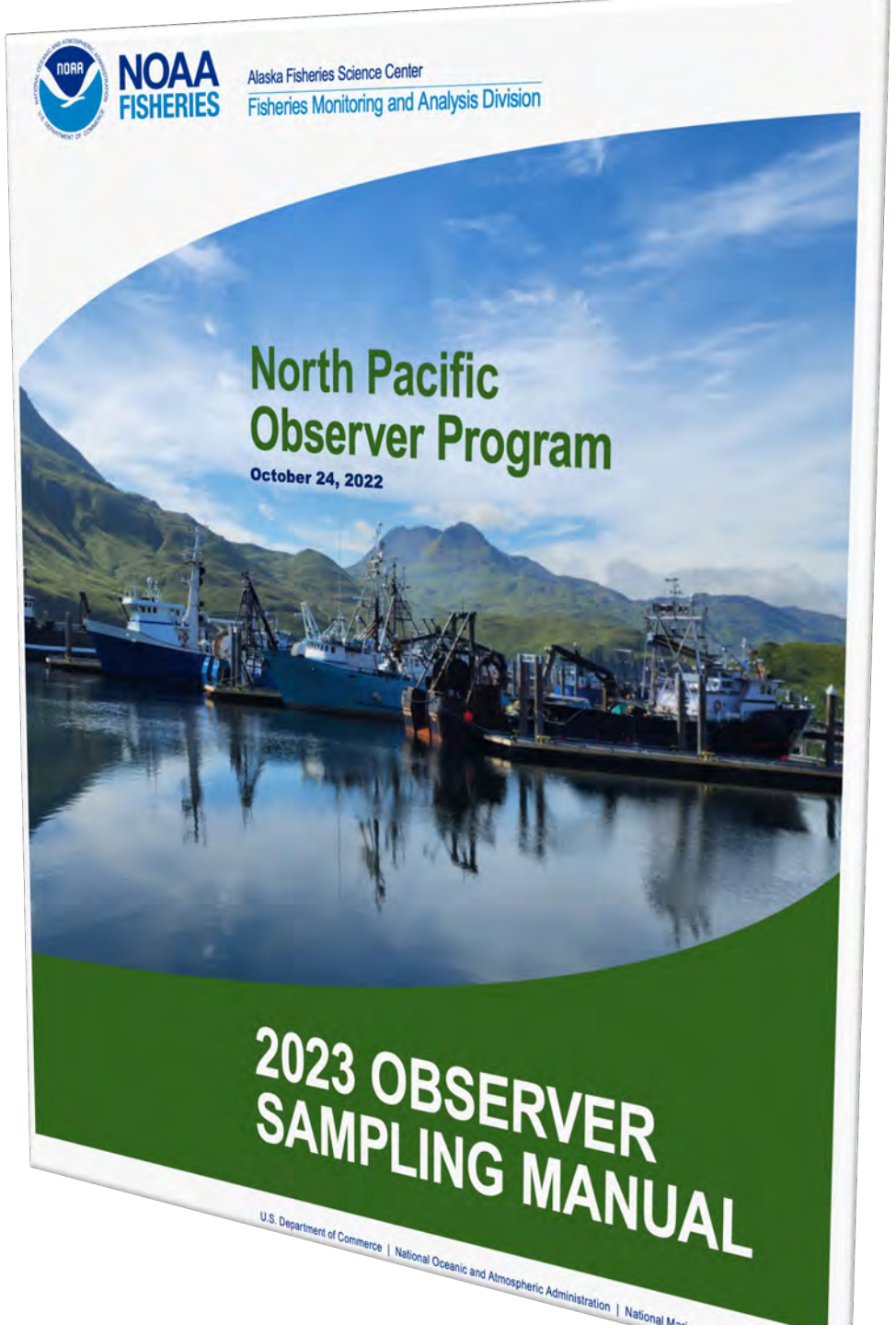
## Evidence of stock structure for walleye pollock



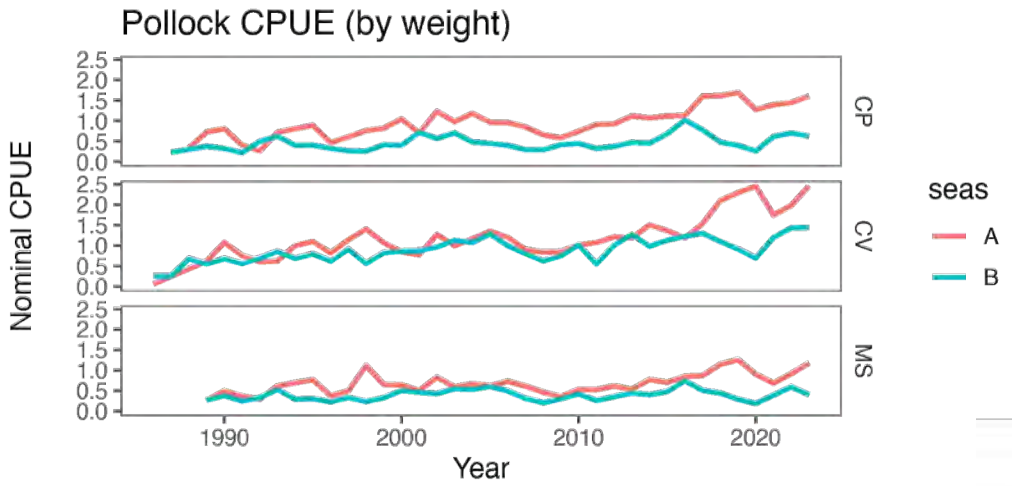

**Thanks to Ingrid Spies and Sara Schaal**

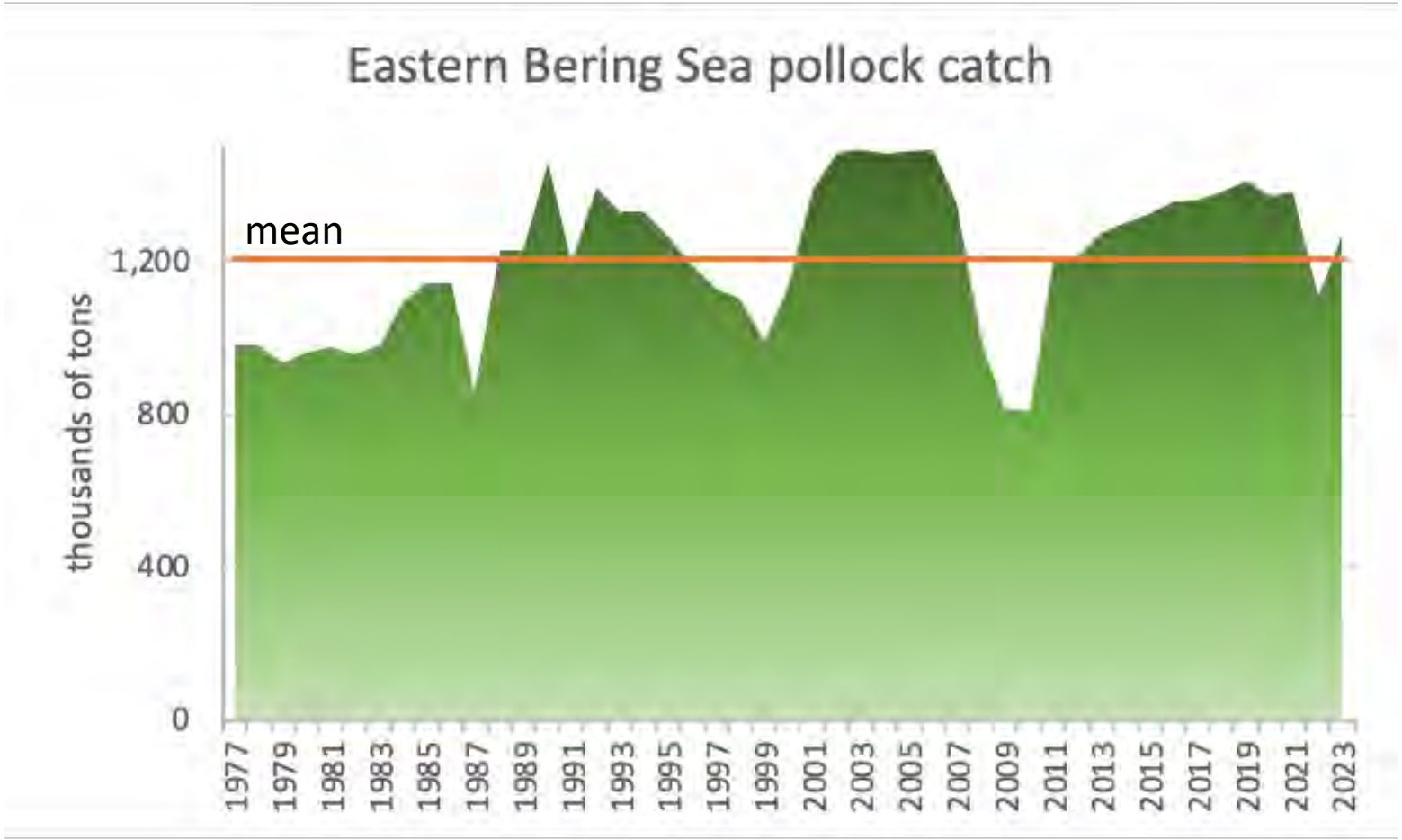
# Observer coverage

Is extensive!



# Fishing conditions



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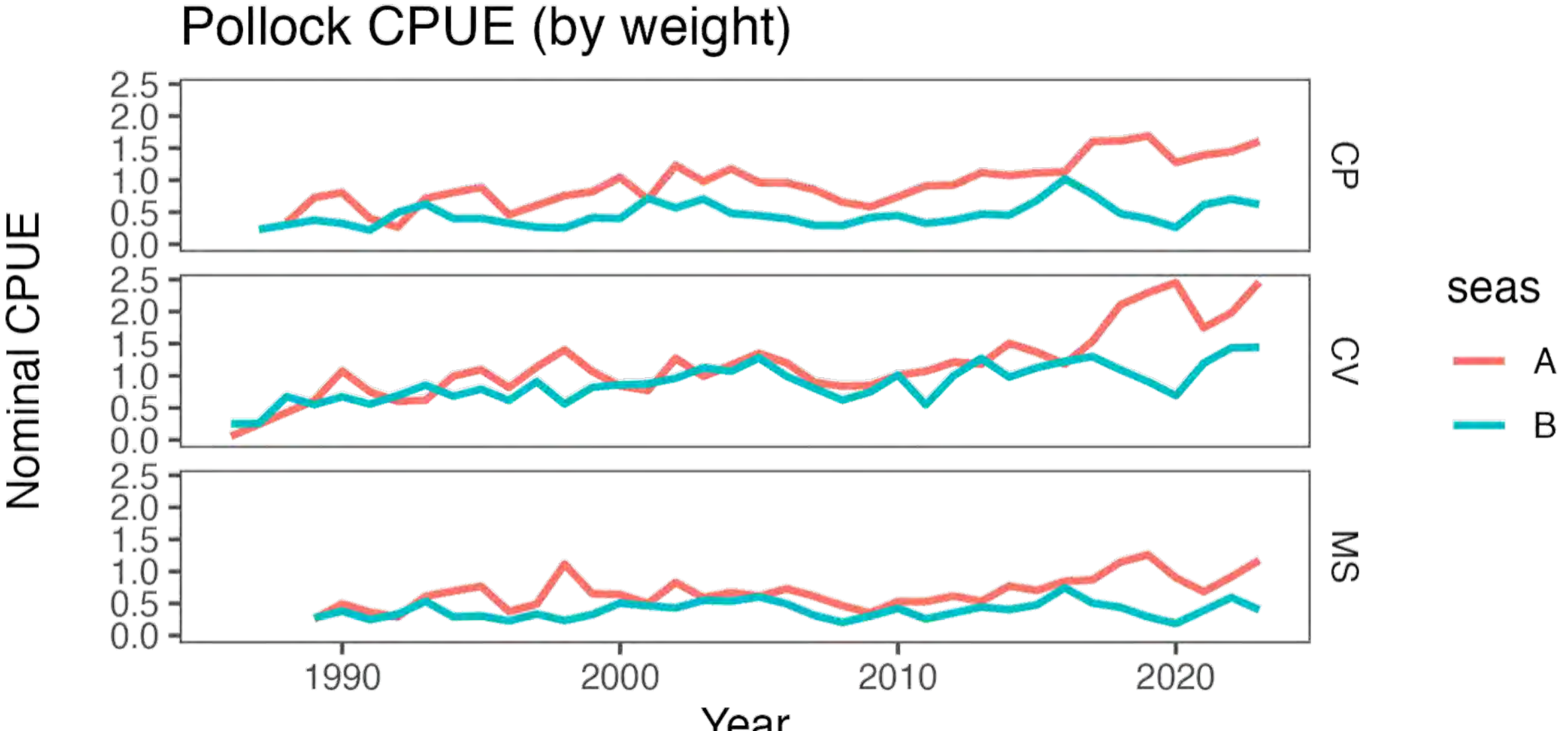
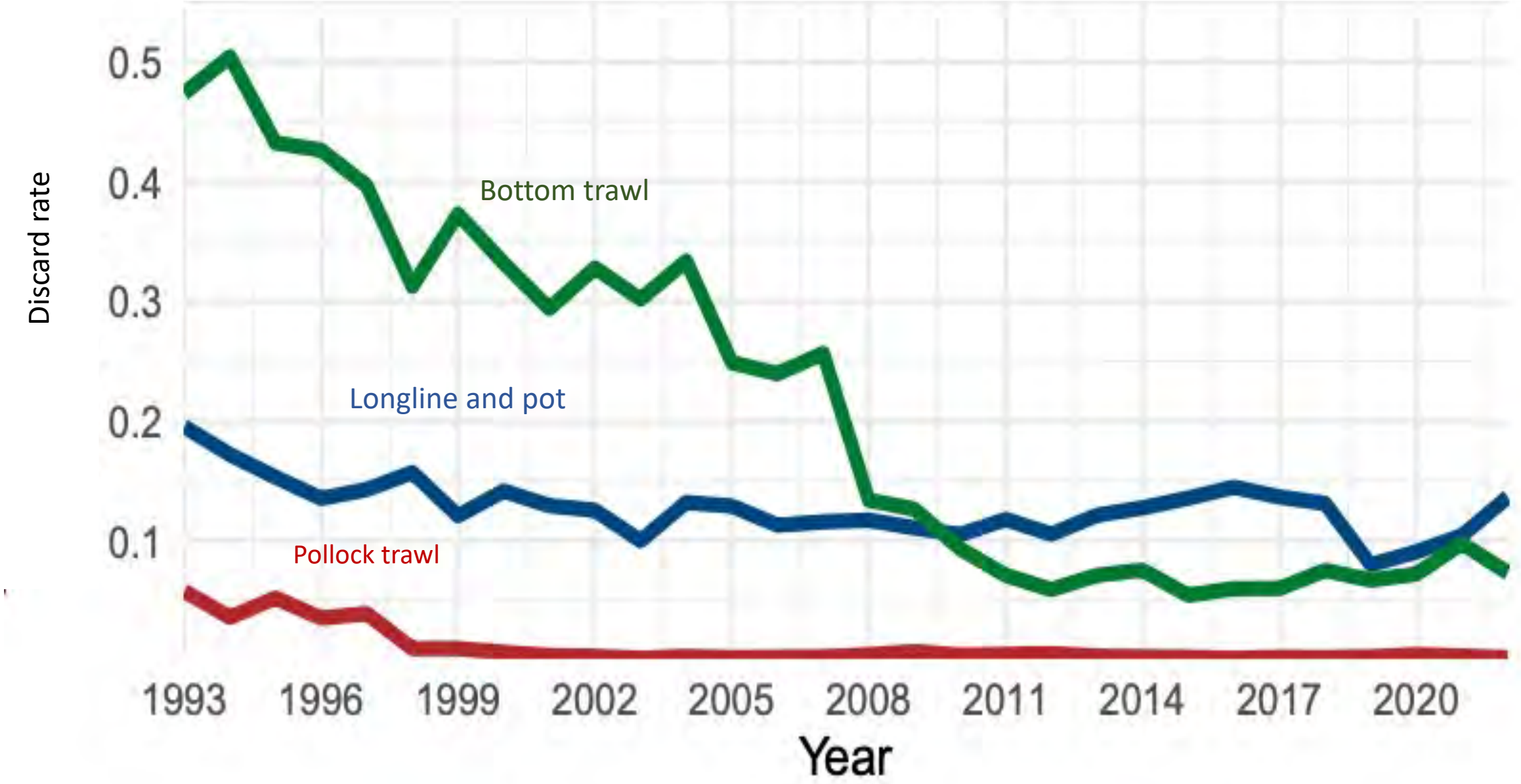


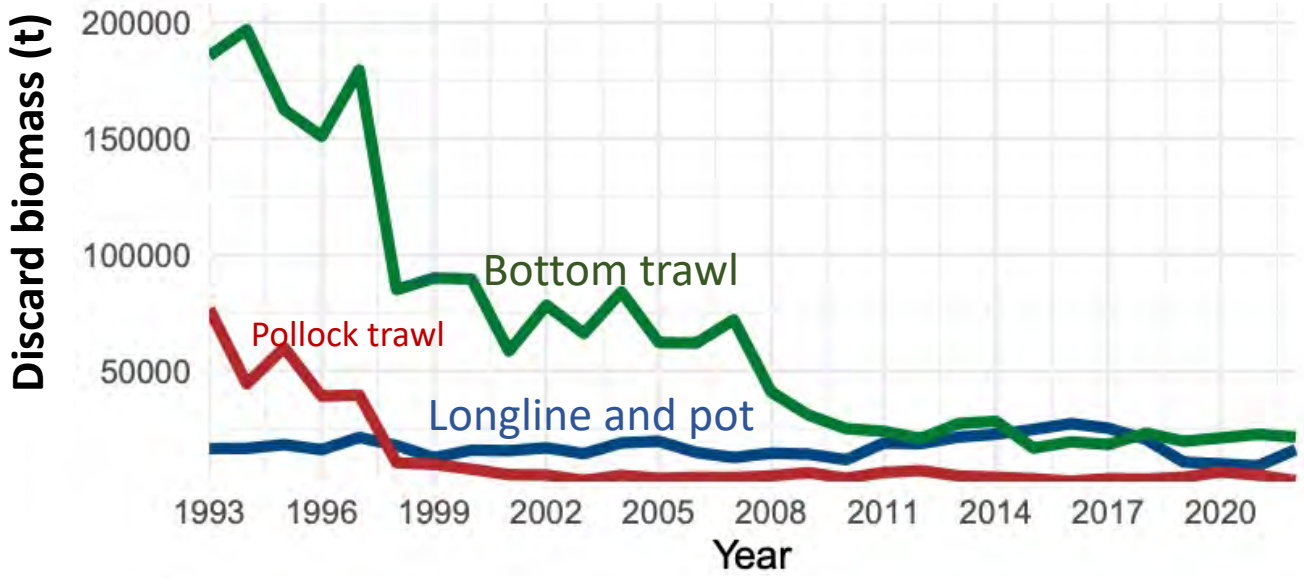
# Fishery discard rates among “sectors” in the EBS

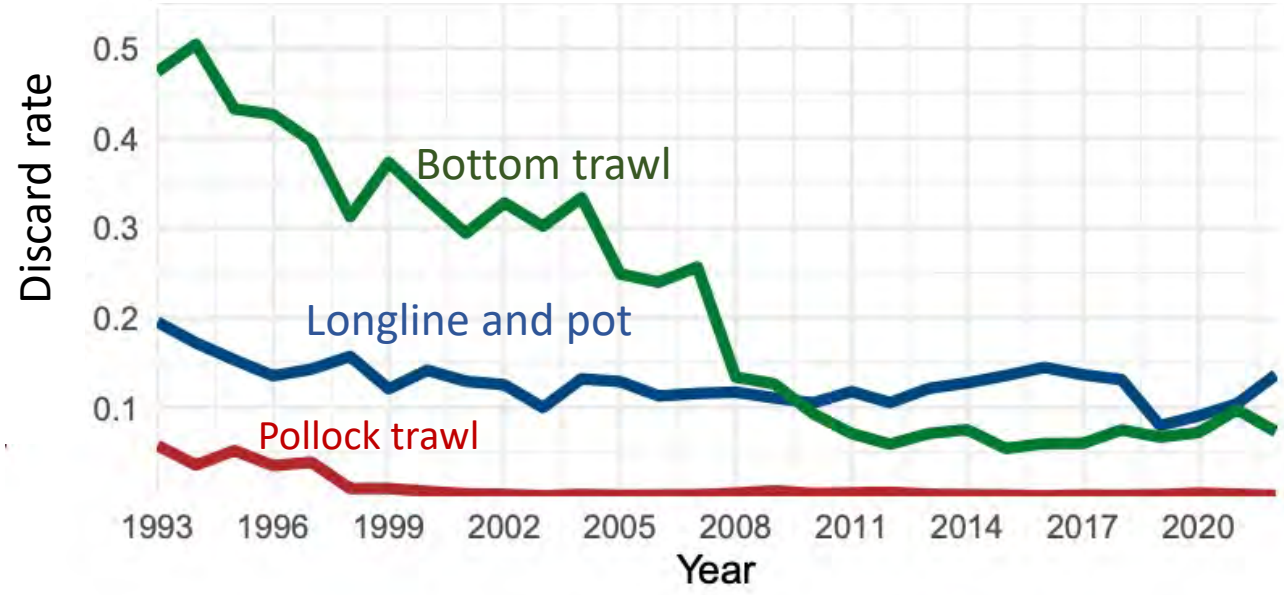


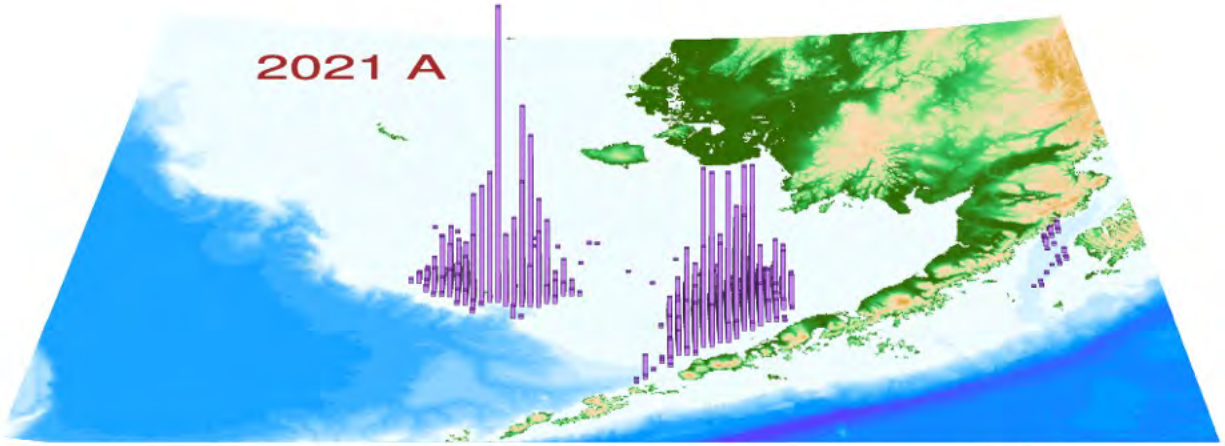
# Tonnage also low in pollock fishery…

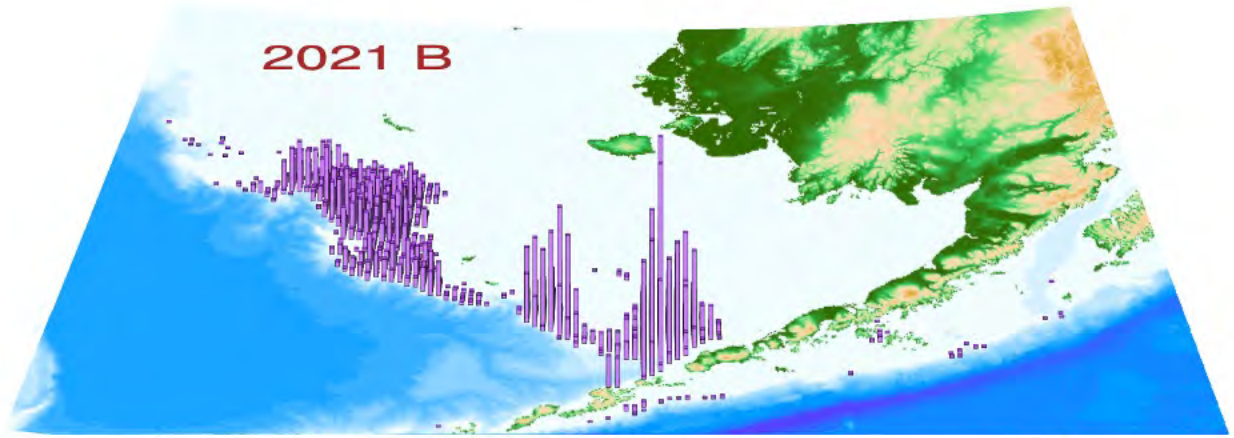
Table 3: Estimates of discarded and retained pollock (t) for the Northwest and Southeastern Bering Sea, 1991–2023. SE represents the EBS east of 170W, NW is the EBS west of 170W, source: NMFS Blend and catch-accounting system database. 2023 data are preliminary.

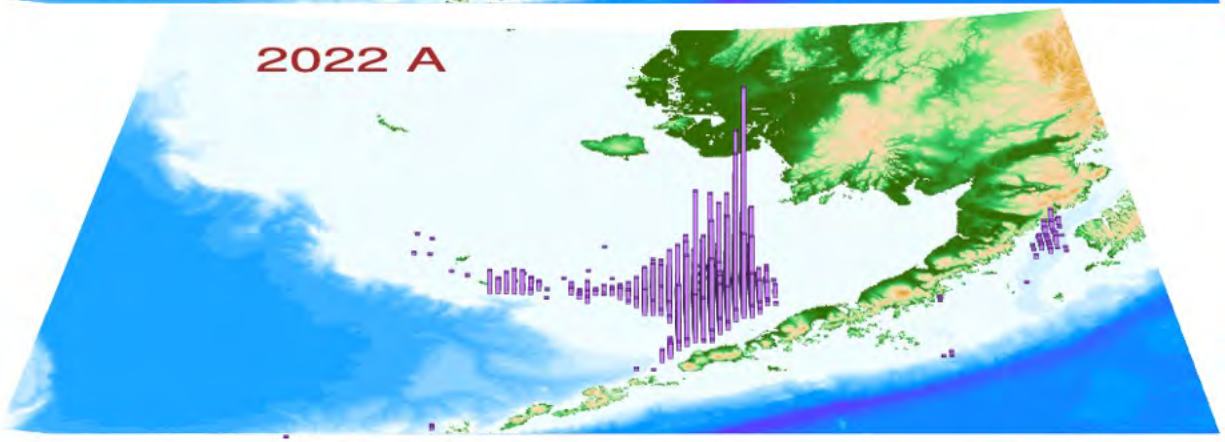
| Year | NW Discarded | SE Discarded | NW Retained | SE Retained | Total | Discarded % |
|---|---|---|---|---|---|---|
| 1991 | 48,257 | 66,792 | 493,852 | 586,763 | 1,195,664 | 9.6% |
| 1992 | 57,578 | 71,194 | 502,163 | 759,365 | 1,390,299 | 9.3% |
| 1993 | 26,100 | 83,986 | 206,073 | 1,010,443 | 1,326,602 | 8.3% |
| 1994 | 16,084 | 88,098 | 160,693 | 1,064,476 | 1,329,352 | 7.8% |
| 1995 | 9,715 | 87,492 | 82,226 | 1,084,814 | 1,264,247 | 7.7% |
| 1996 | 4,838 | 71,368 | 101,100 | 1,015,474 | 1,192,781 | 6.4% |
| 1997 | 22,557 | 71,032 | 281,986 | 748,858 | 1,124,433 | 8.3% |
| 1998 | 1,581 | 14,291 | 130,934 | 957,098 | 1,103,903 | 1.4% |
| 1999 | 1,912 | 26,912 | 204,786 | 756,071 | 989,680 | 2.9% |
| 2000 | 1,942 | 19,678 | 291,591 | 819,499 | 1,132,710 | 1.9% |
| 2001 | 2,450 | 14,874 | 422,770 | 947,103 | 1,387,197 | 1.2% |
| 2002 | 1,441 | 19,430 | 319,002 | 1,140,904 | 1,480,776 | 1.4% |
| 2003 | 2,959 | 13,795 | 554,629 | 919,397 | 1,490,779 | 1.1% |
| 2004 | 2,781 | 20,380 | 387,763 | 1,069,628 | 1,480,552 | 1.6% |
| 2005 | 2,586 | 14,838 | 678,282 | 787,316 | 1,483,022 | 1.2% |
| 2006 | 3,677 | 11,877 | 657,147 | 815,330 | 1,488,031 | 1.0% |
| 2007 | 3,769 | 12,334 | 622,484 | 715,915 | 1,354,502 | 1.2% |
| 2008 | 1,643 | 5,968 | 506,237 | 476,730 | 990,578 | 0.8% |
| 2009 | 1,936 | 4,014 | 450,596 | 354,238 | 810,784 | 0.7% |
| 2010 | 1,270 | 2,490 | 553,802 | 252,623 | 810,186 | 0.5% |
| 2011 | 1,376 | 3,444 | 449,773 | 744,438 | 1,199,031 | 0.4% |
| 2012 | 1,190 | 4,080 | 585,154 | 614,791 | 1,205,214 | 0.4% |
| 2013 | 1,225 | 4,084 | 573,869 | 691,582 | 1,270,760 | 0.4% |
| 2014 | 1,786 | 12,556 | 437,391 | 845,684 | 1,297,417 | 1.1% |
| 2015 | 2,418 | 7,055 | 622,907 | 689,193 | 1,321,574 | 0.7% |
| 2016 | 1,036 | 8,124 | 184,574 | 1,158,948 | 1,352,681 | 0.7% |
| 2017 | 1,356 | 6,848 | 179,803 | 1,171,173 | 1,359,181 | 0.6% |
| 2018 | 2,005 | 9,170 | 328,590 | 1,039,523 | 1,379,288 | 0.8% |
| 2019 | 1,979 | 7,126 | 305,202 | 1,095,040 | 1,409,346 | 0.6% |
| 2020 | 2,450 | 9,364 | 504,370 | 851,053 | 1,367,236 | 0.9% |
| 2021 | 1,534 | 12,379 | 350,715 | 1,011,629 | 1,376,258 | 1.0% |
| 2022 | 3,538 | 9,925 | 203,091 | 889,124 | 1,105,677 | 1.2% |
| 2023 | 3,660 | 8,820 | 405,467 | 841,214 | 1,259,161 | 1.0% |
| Mean | 7,292 | 24,964 | 386,031 | 846,225 | 1,264,512 | 2.1% |

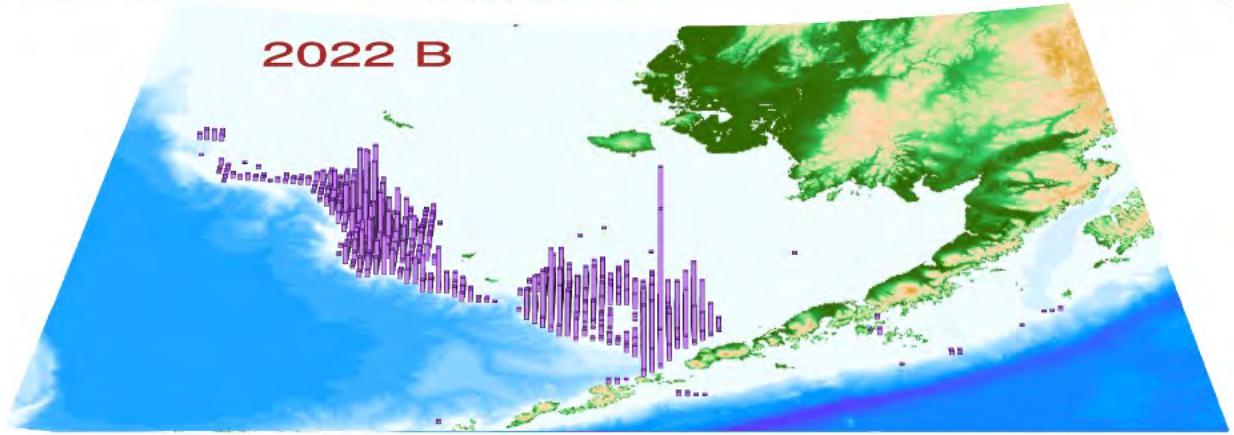


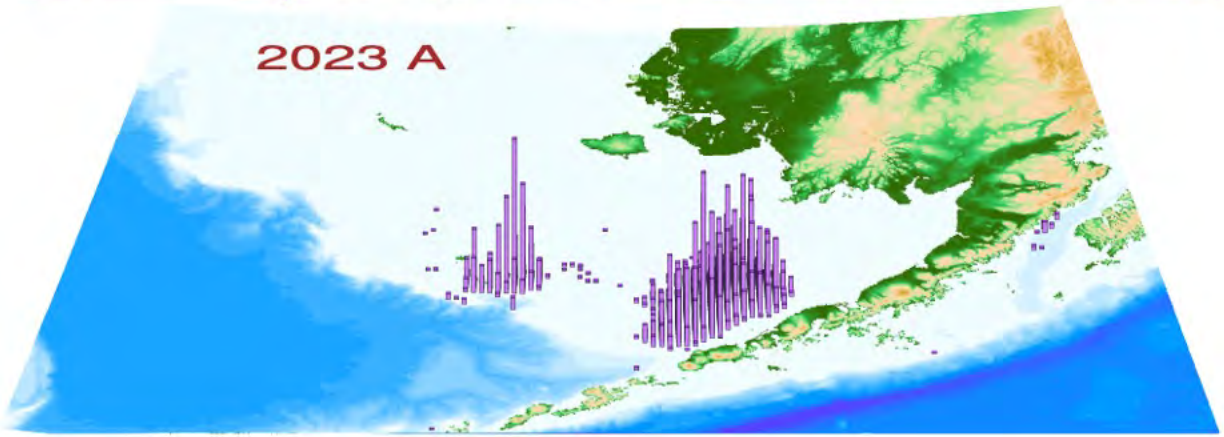



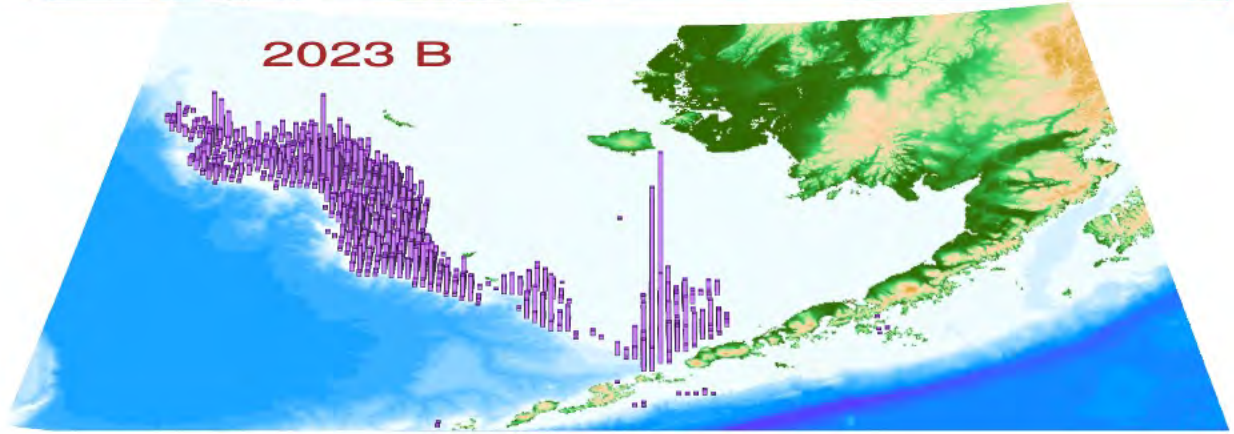

2021 A

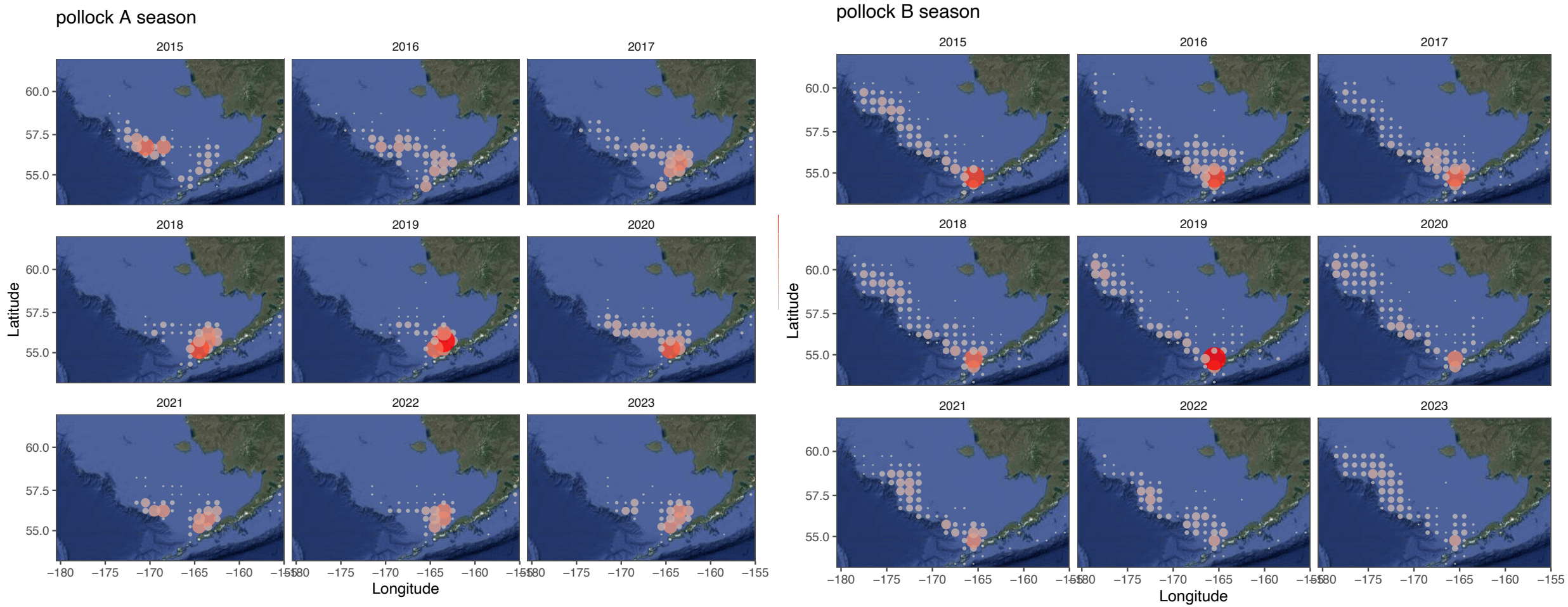

2021 B


2022 A


2022 B

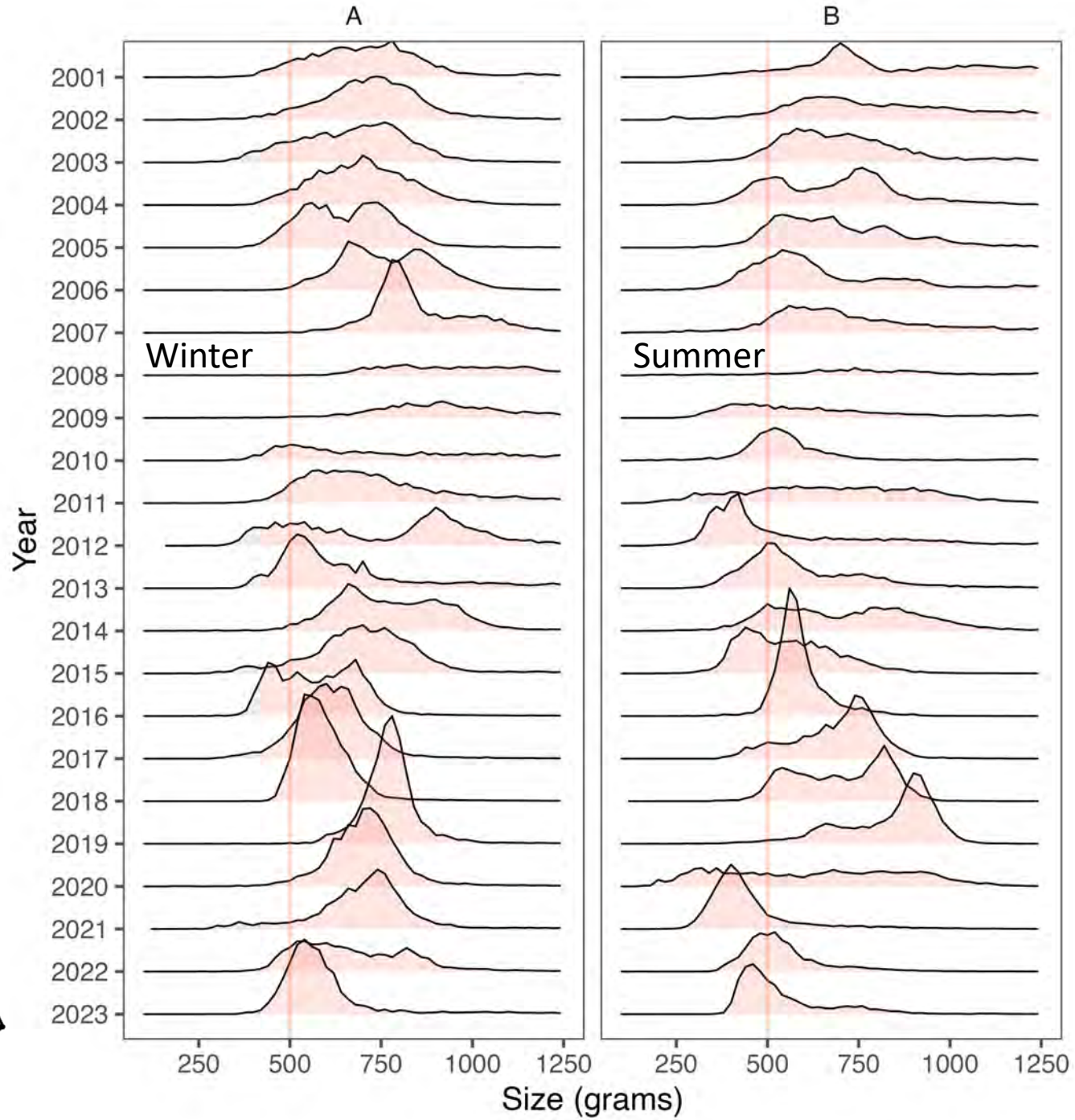

2023 A


2023 B


pollock A season
pollock B season
2015
2016
2017
2018
2019
2020
2021
2022
2023
60.0
57.5
55.0
Latitude
−180
−175
−170
−165
−160
−155
Longitude
pollock

# Bering Sea Pollock Fish conditions

Trends in weight frequency of catch

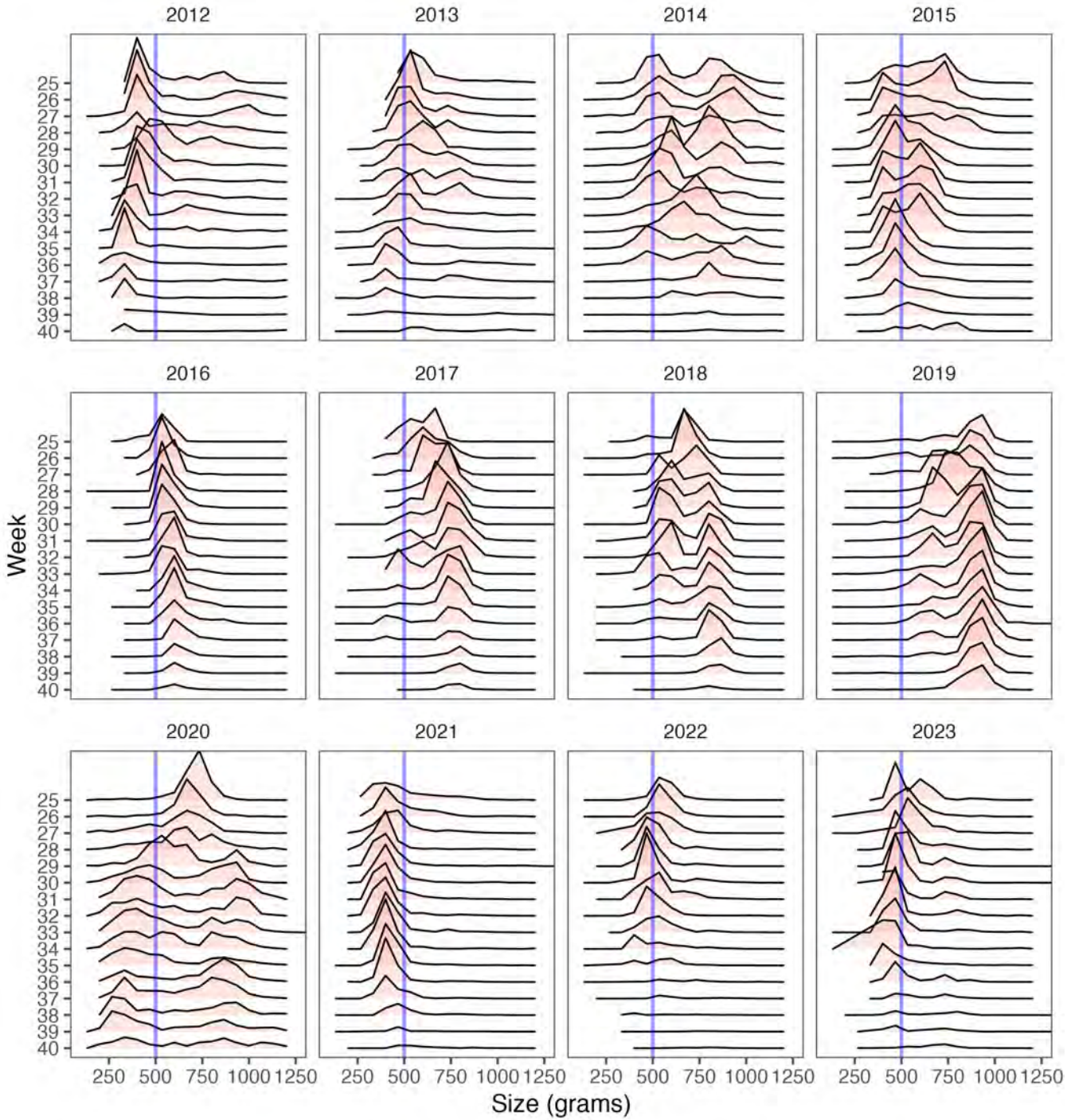


# B-season

Tow-by-tow mean weight frequency

Season progression by week

2023 season
Consistent size
around 500 grams



# Fishery data on pollock “condition”

- Relative

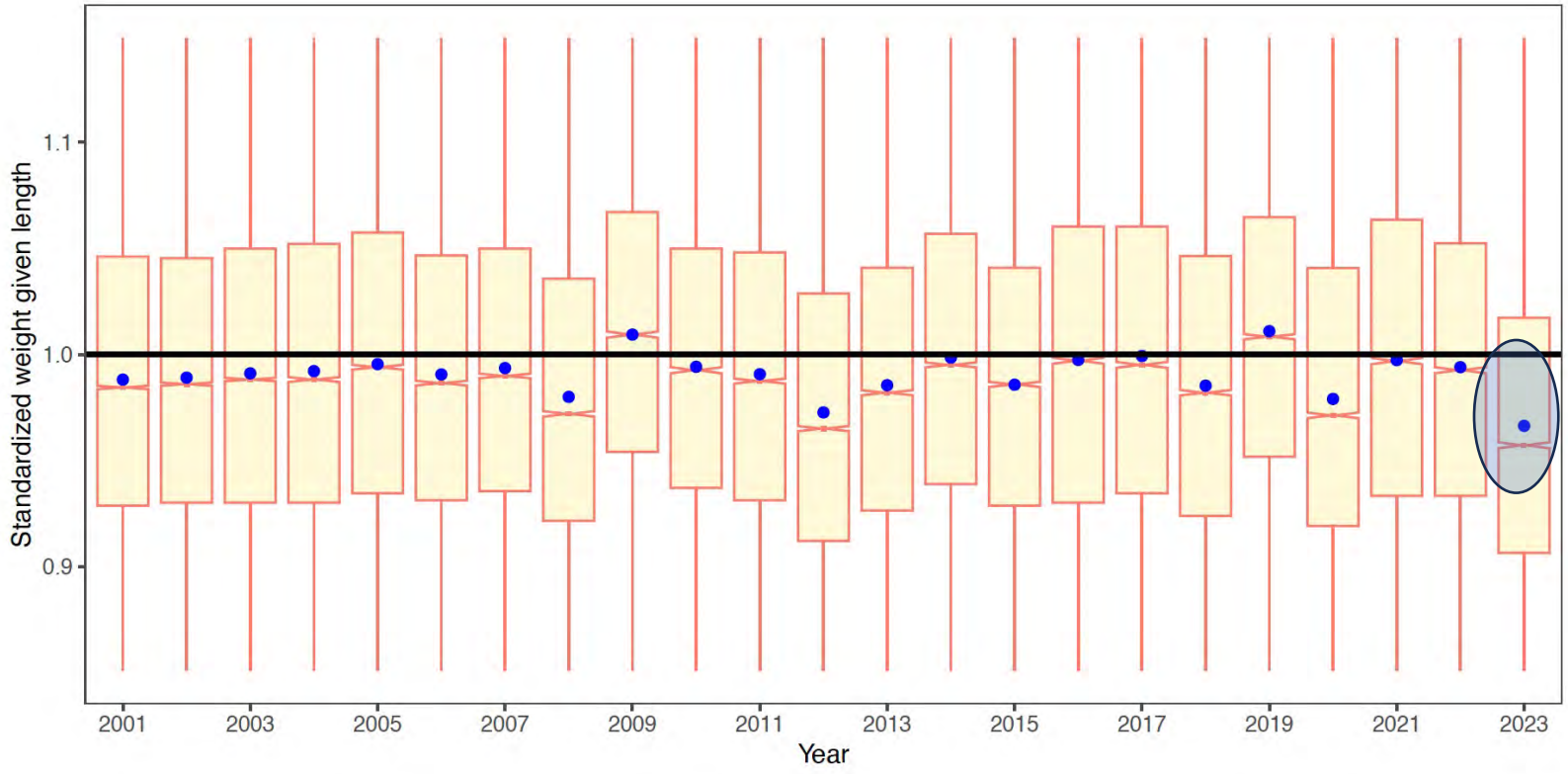
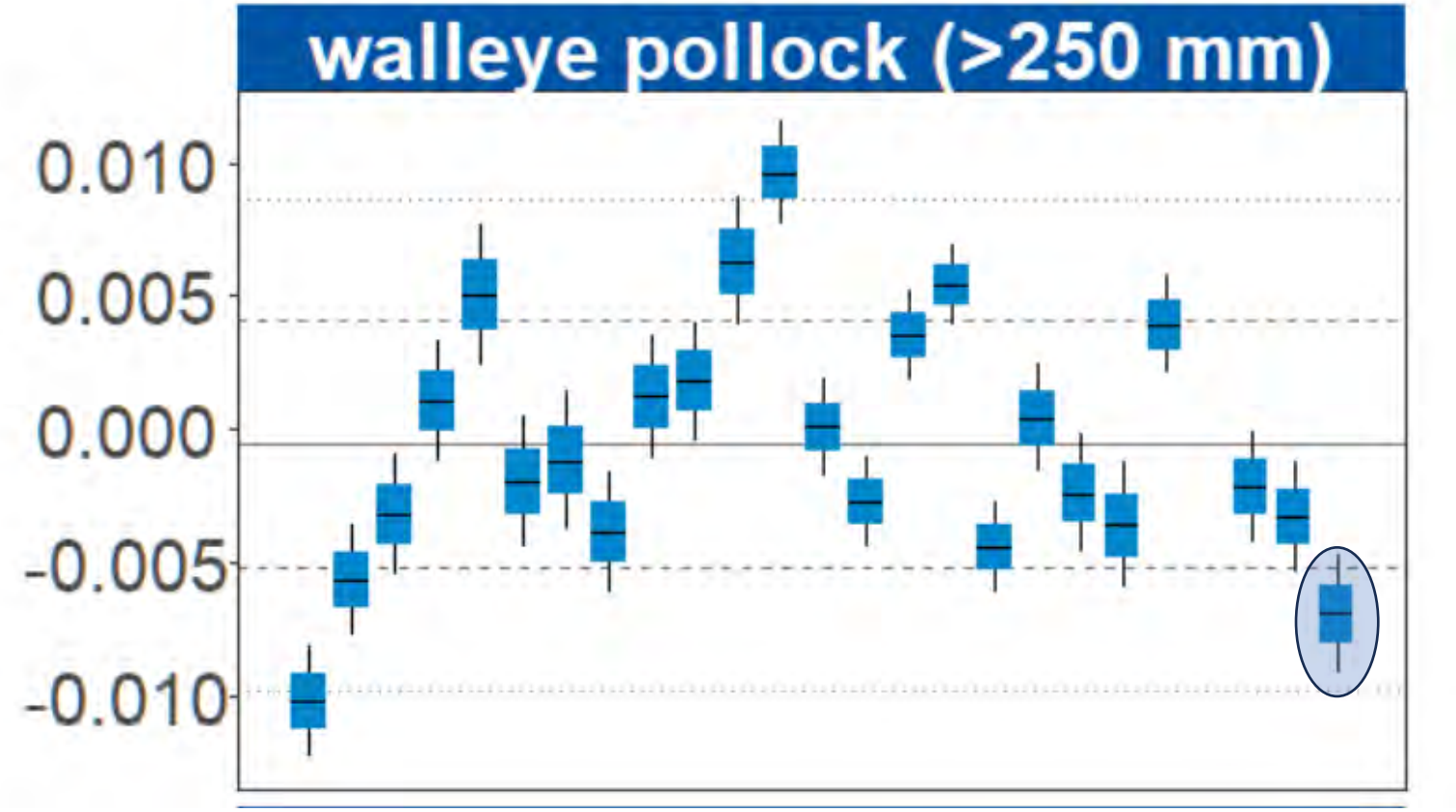


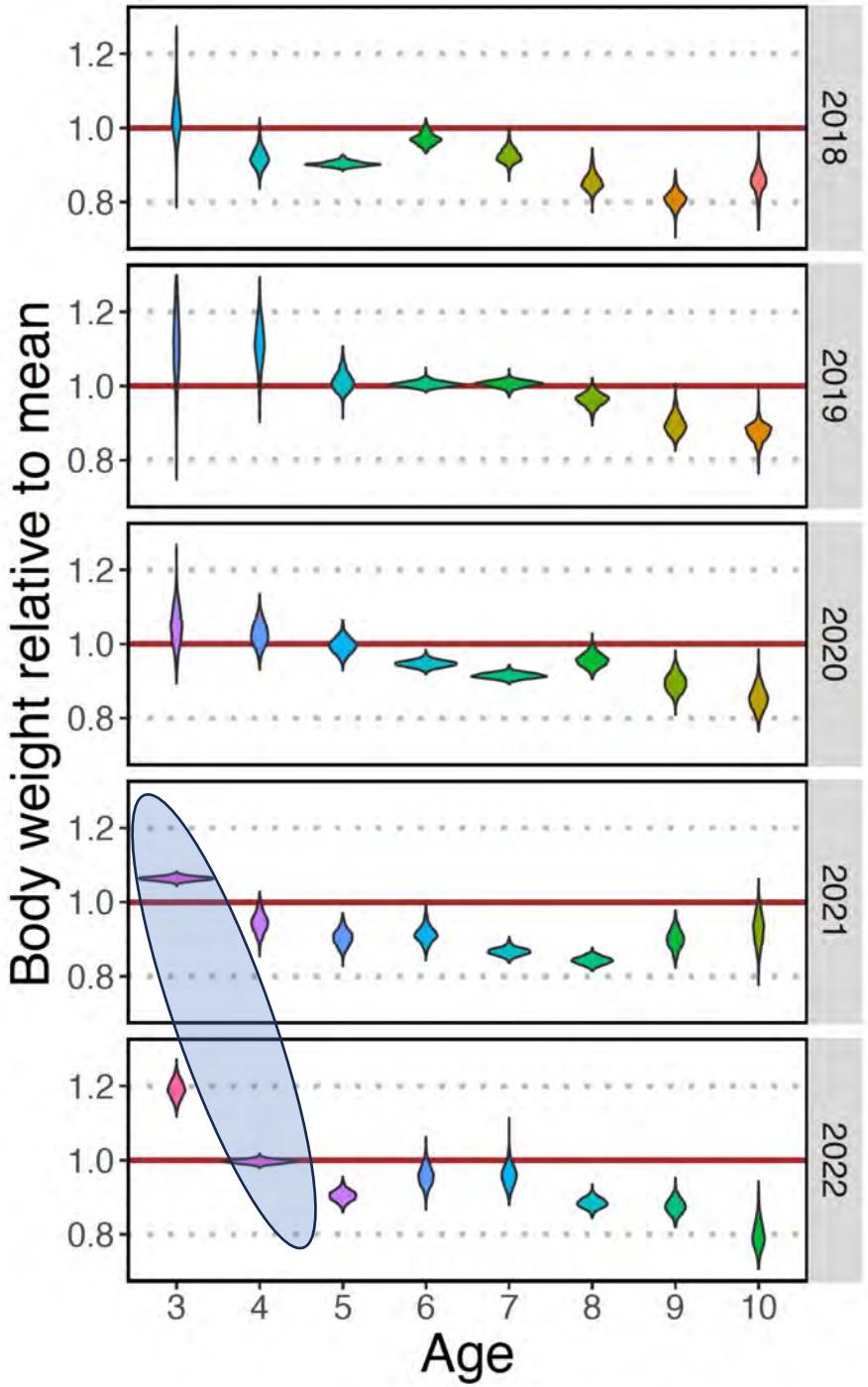

Figure 28: EBS pollock body mass (given length) anomaly (standardized by overall mean body mass at each length) by year, 1991–2023.

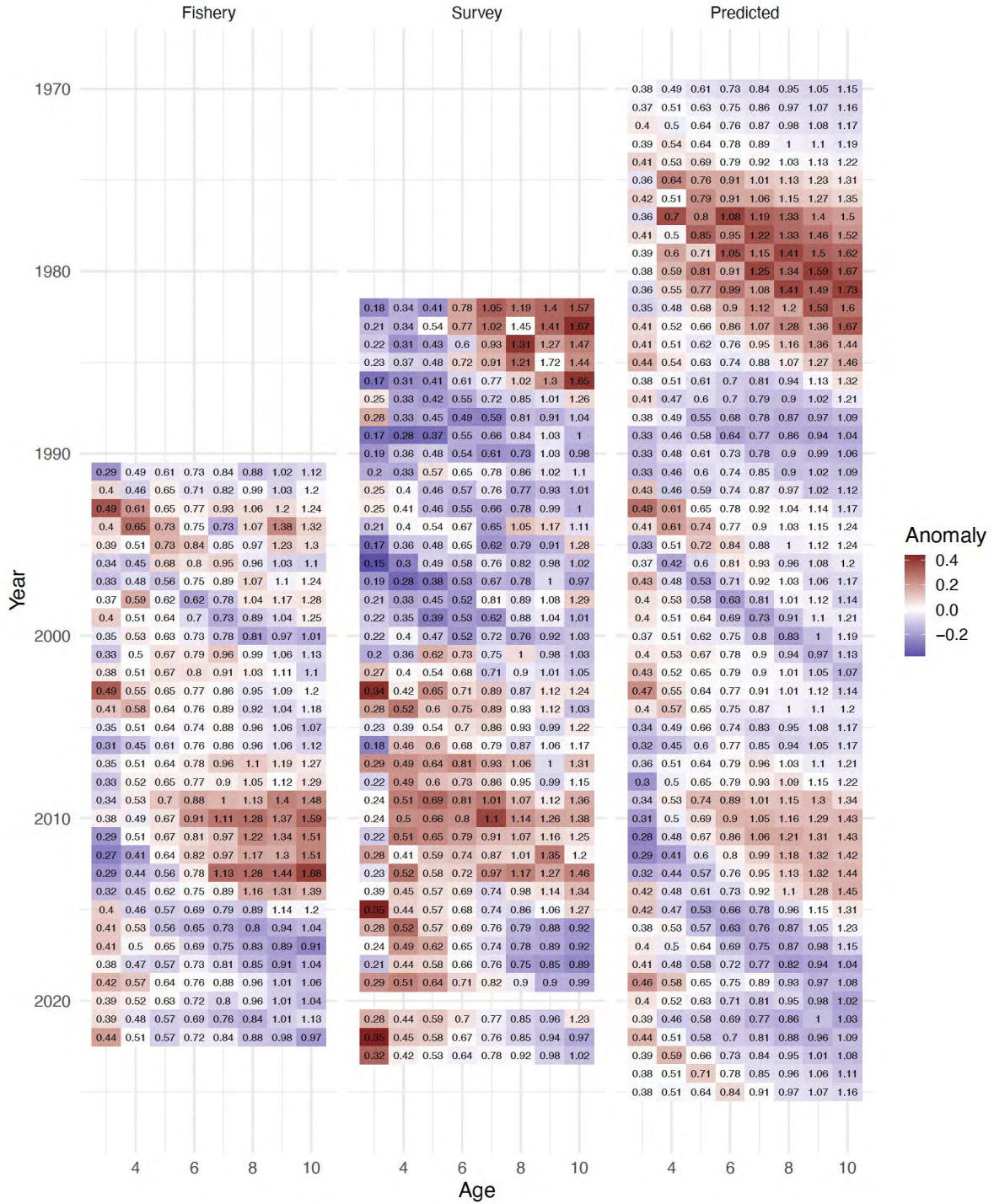
# Survey data on pollock condition…

- Relative

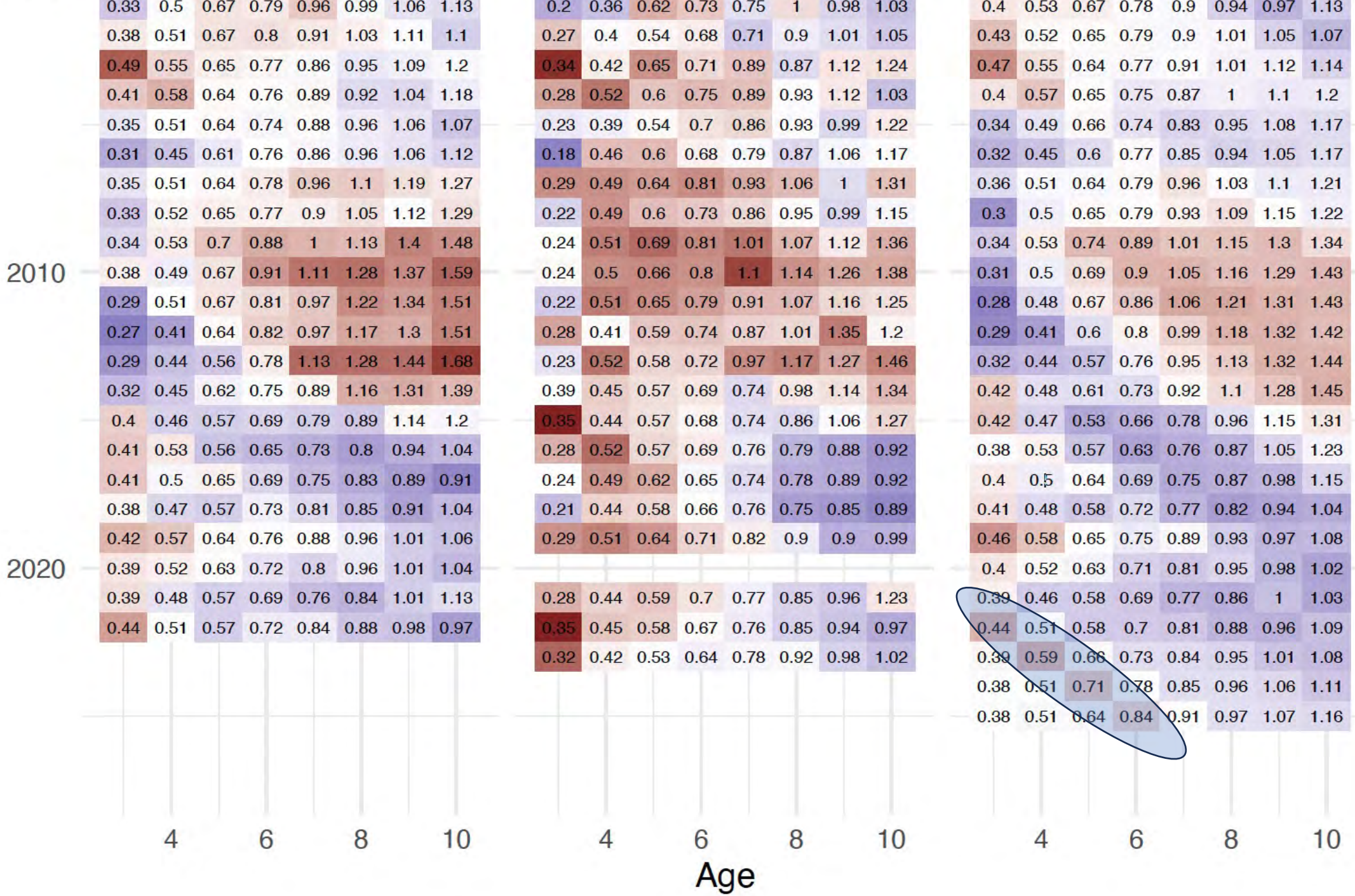


# Fishery weight-at-age

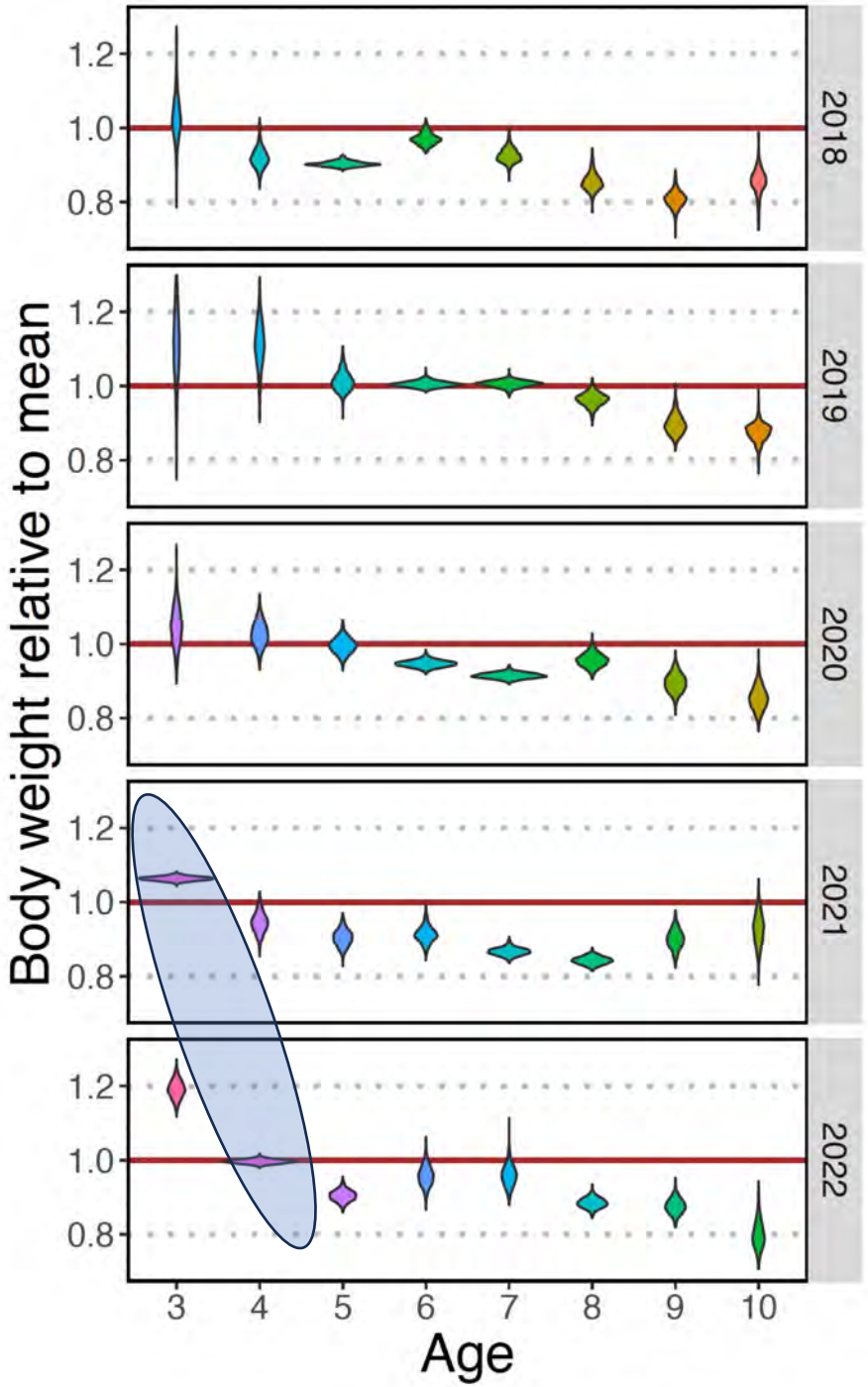


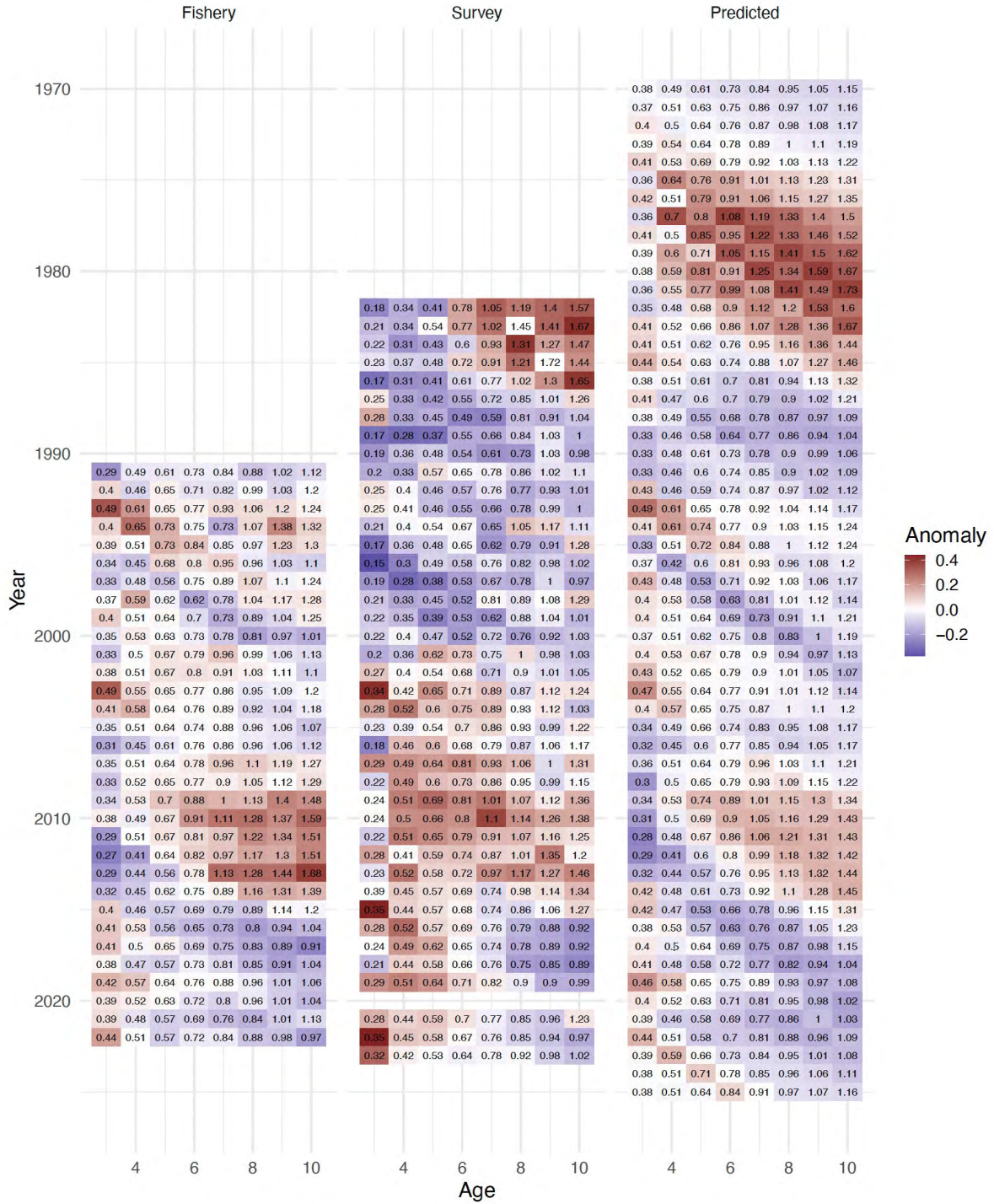



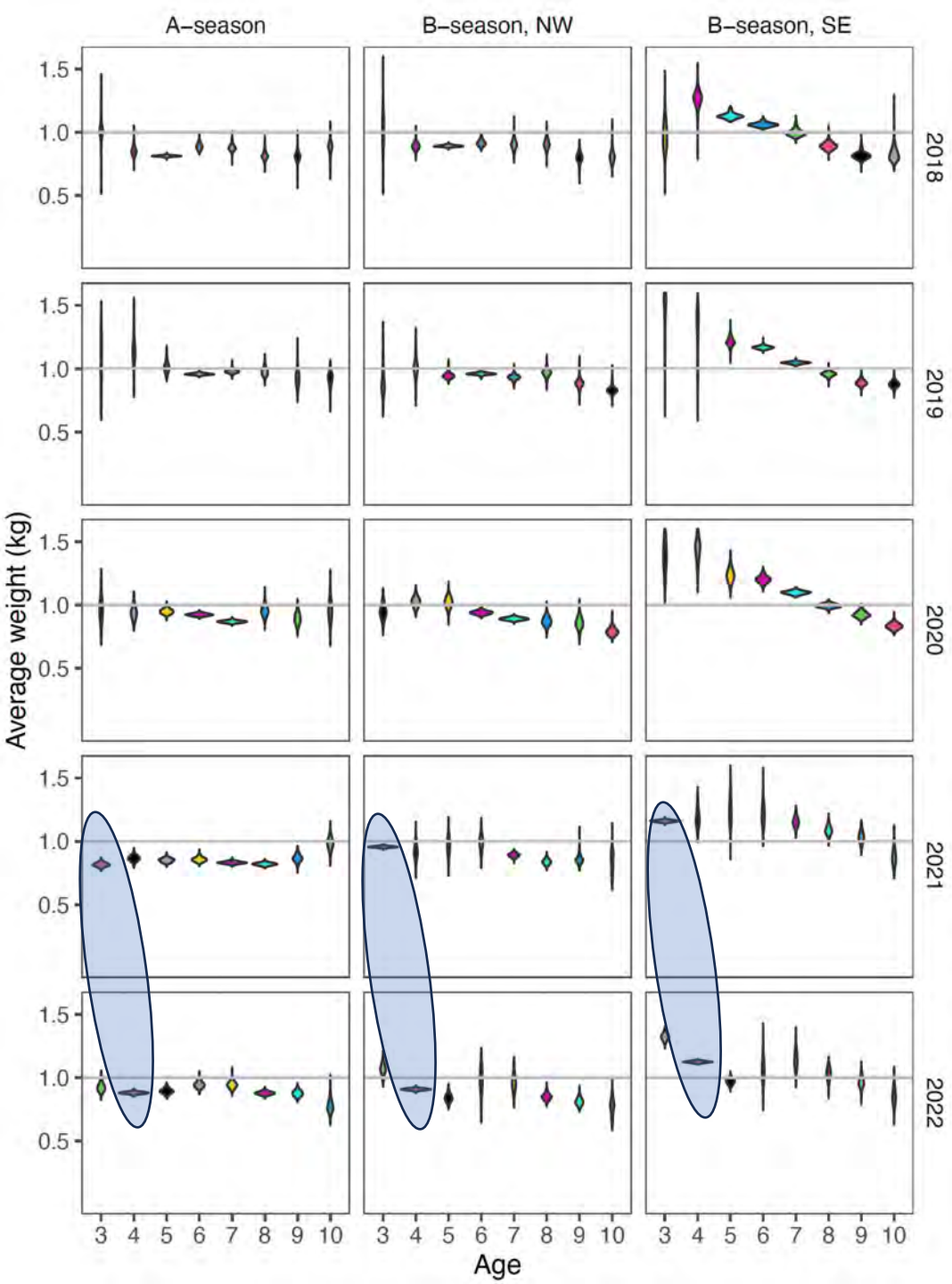
# Fishery weight-at-age



# Fishery weight-at-age

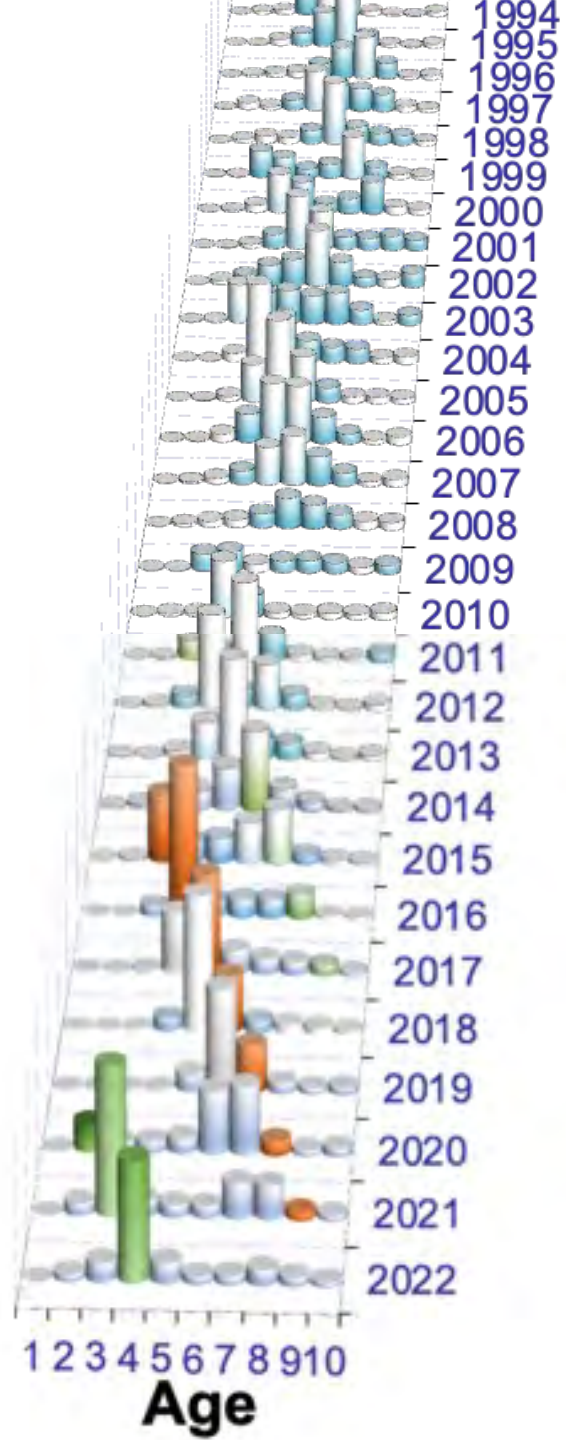


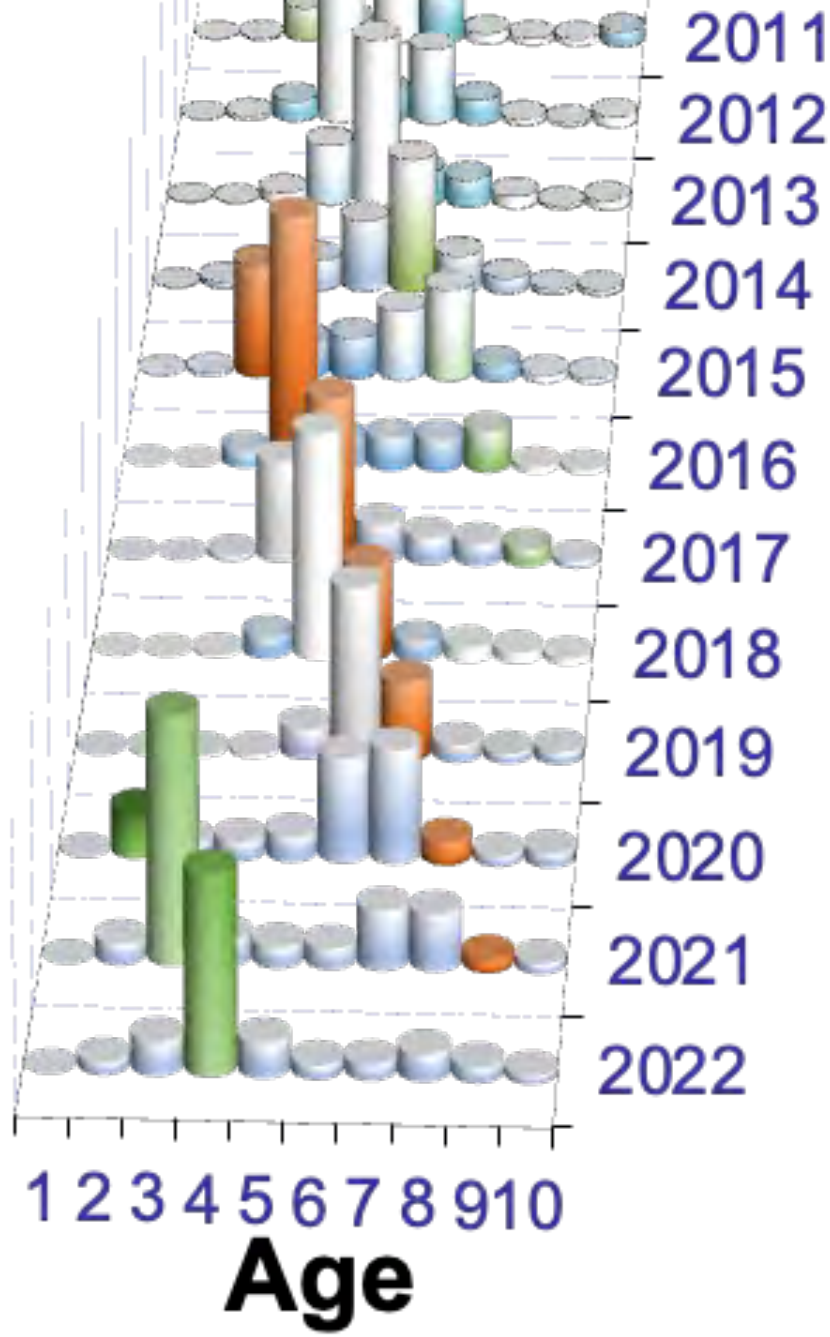






# Fishery weight-at-age by season and area

# Fishery catch-at-age



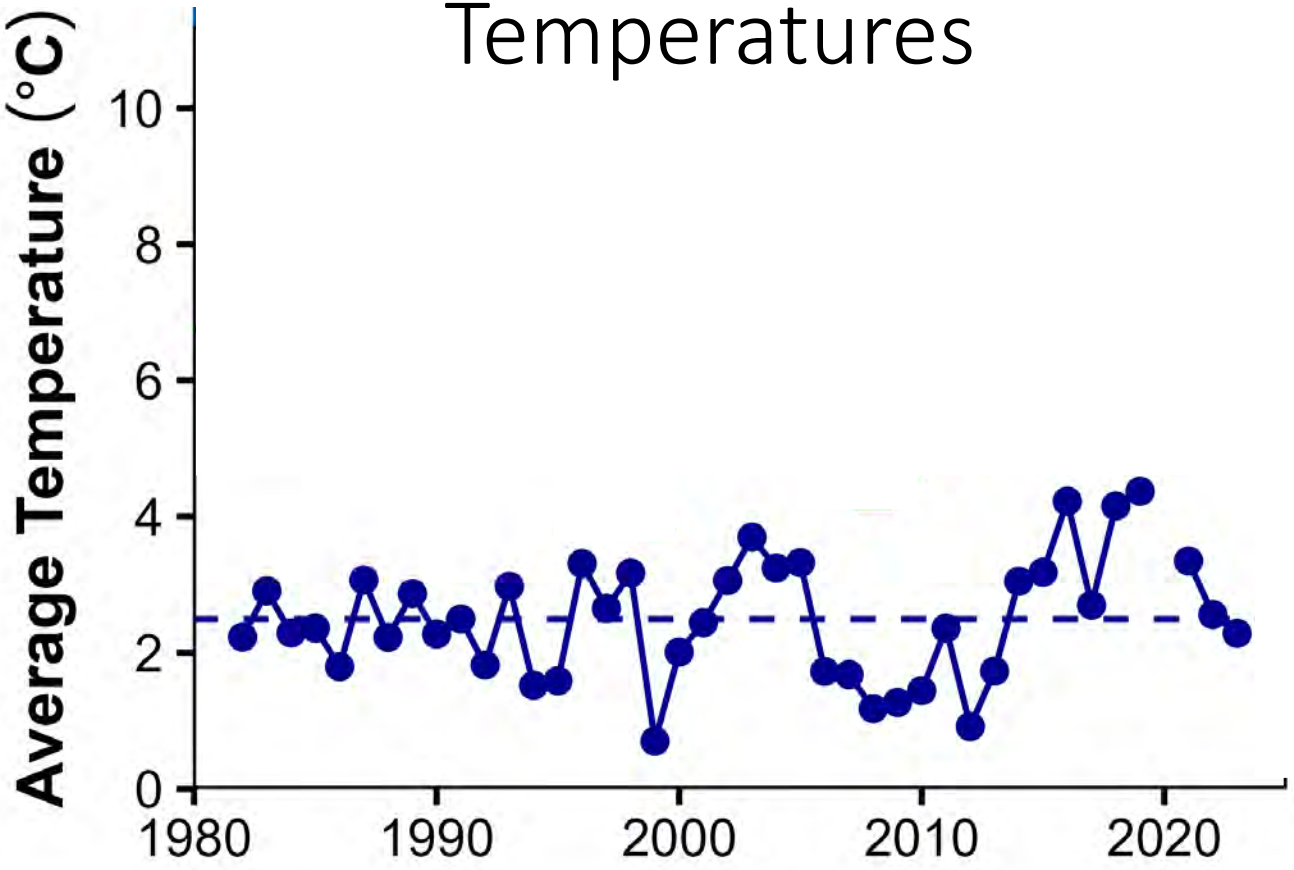

2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
1 2 3 4 5 6 7 8 9 10
Age

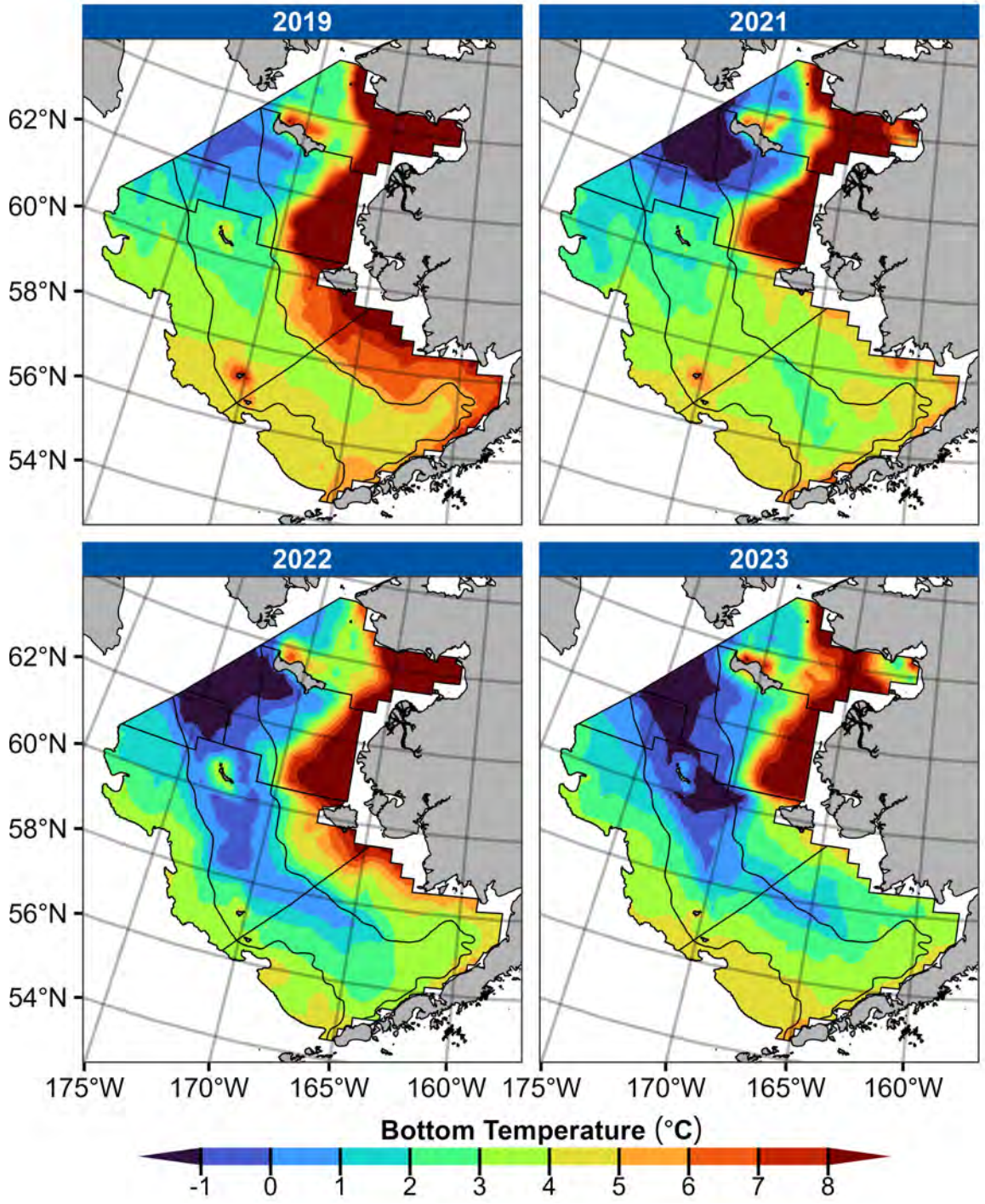
# Survey work

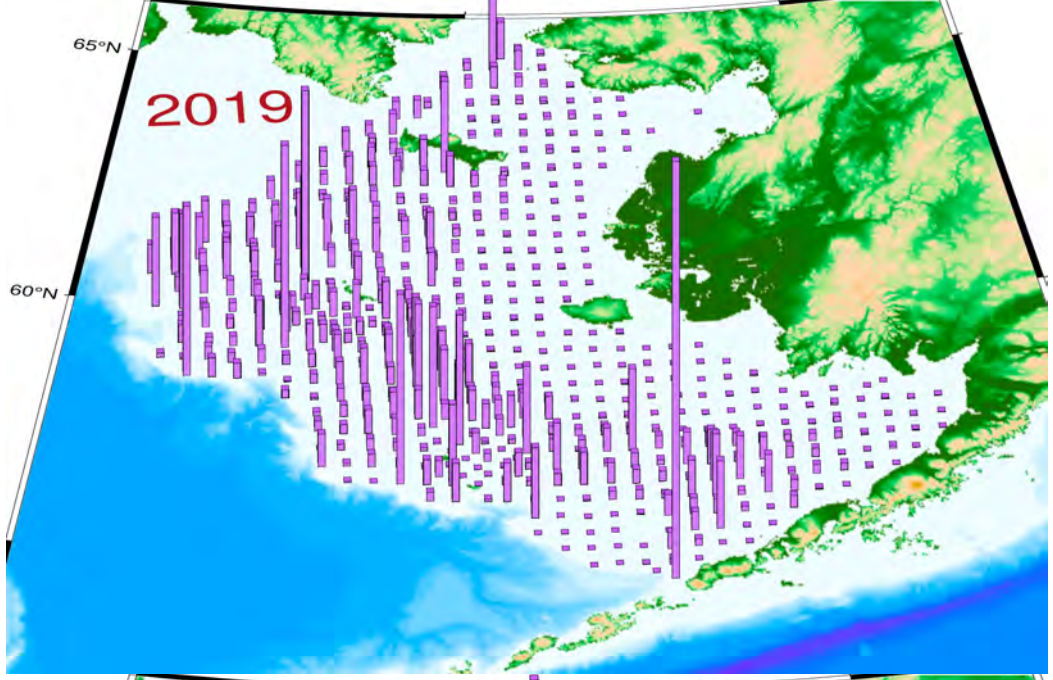
FV *Alaska Knight*
2010-present
12th year

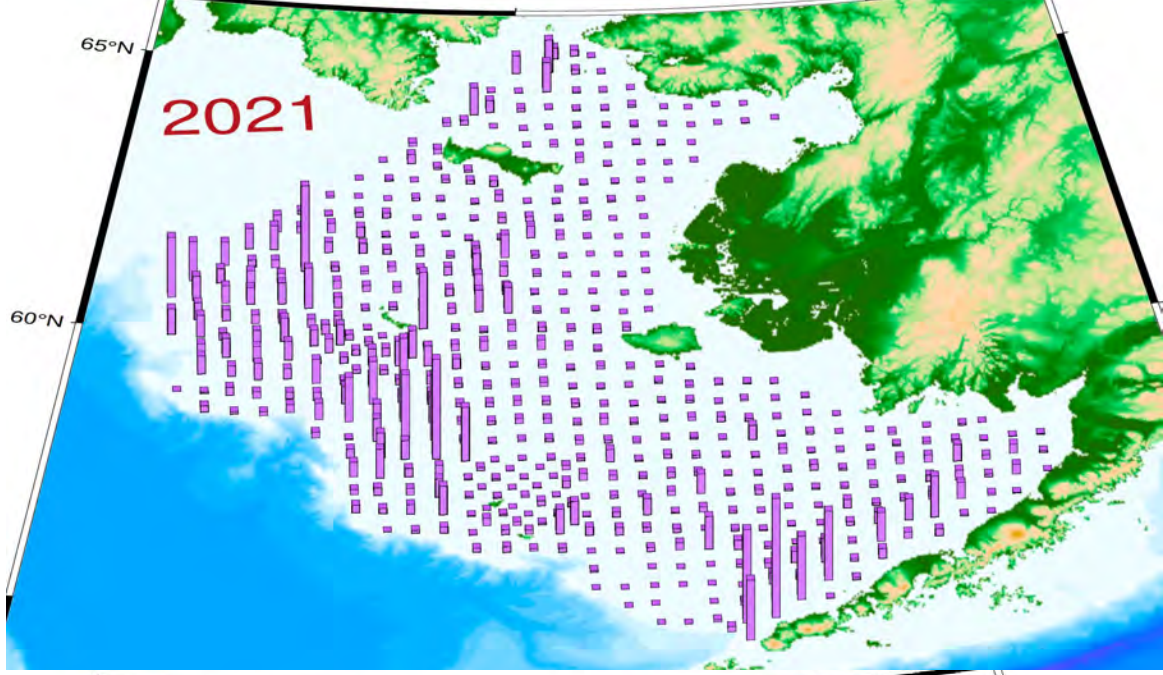
FV *Northwest Explorer*
2023
1st year

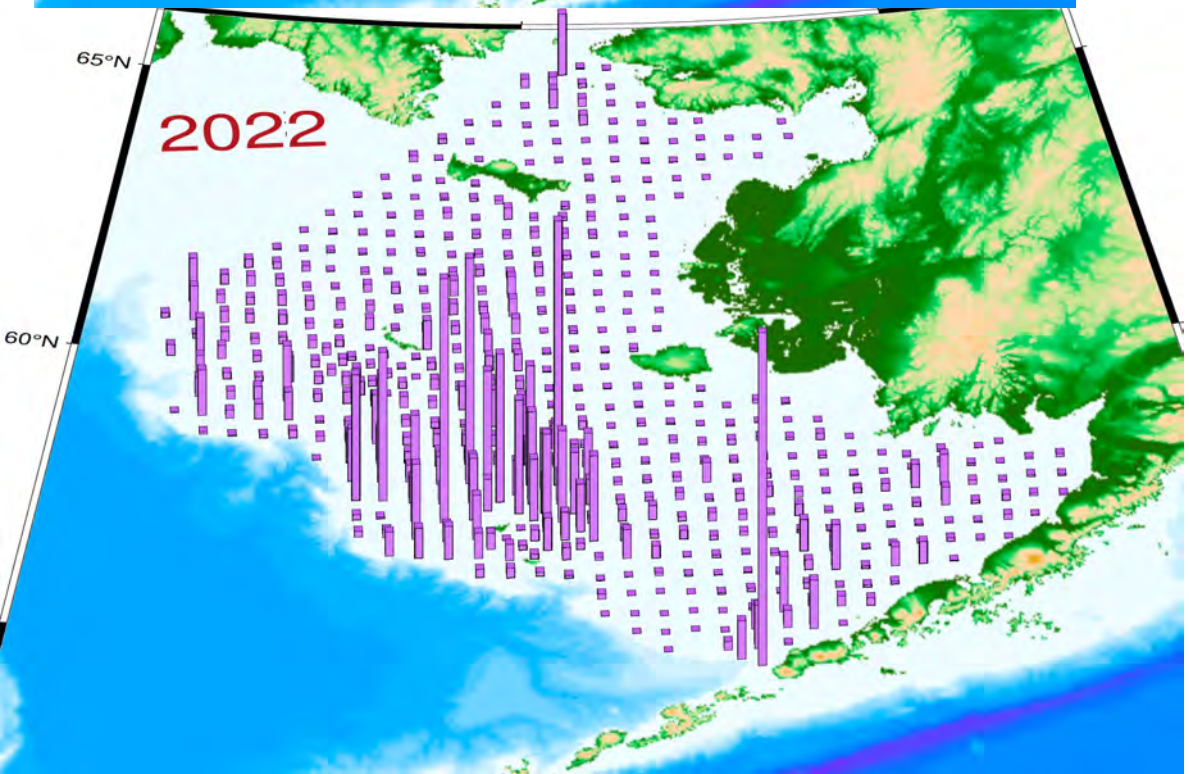
# Survey Bottom Temperatures

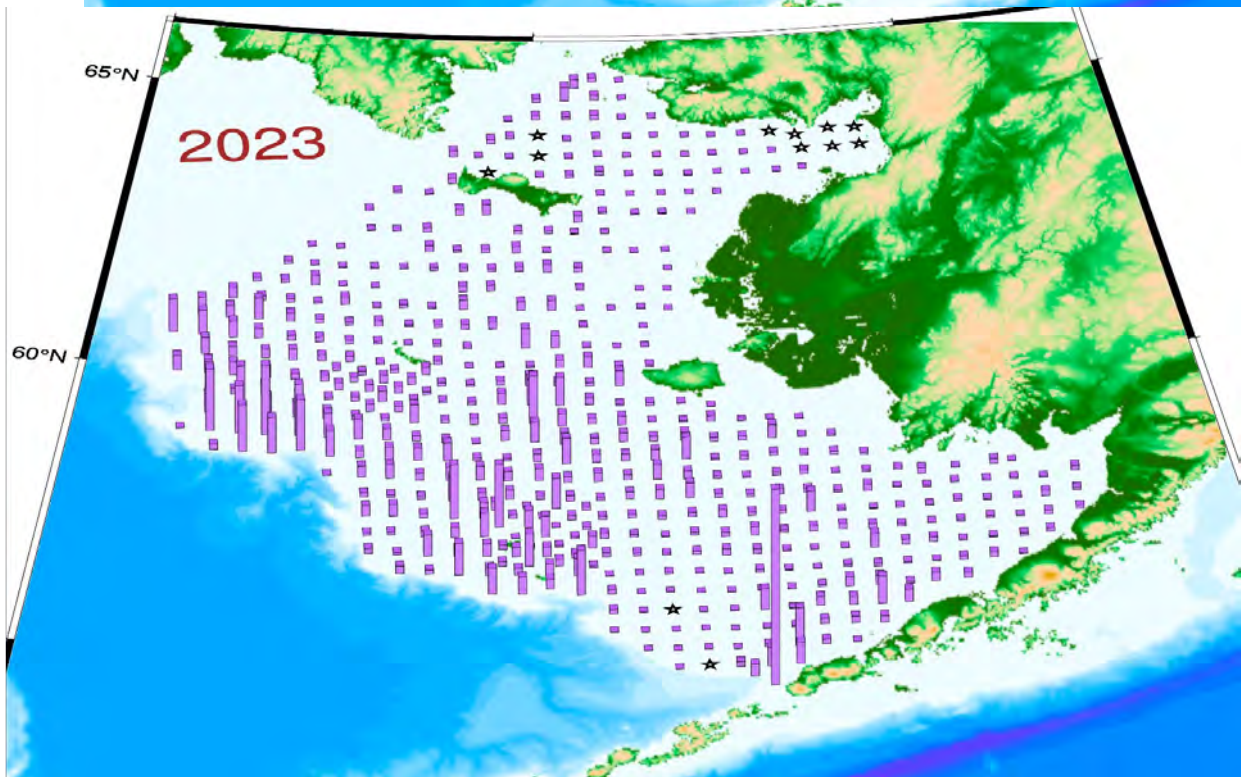



65°N
60°N
2019

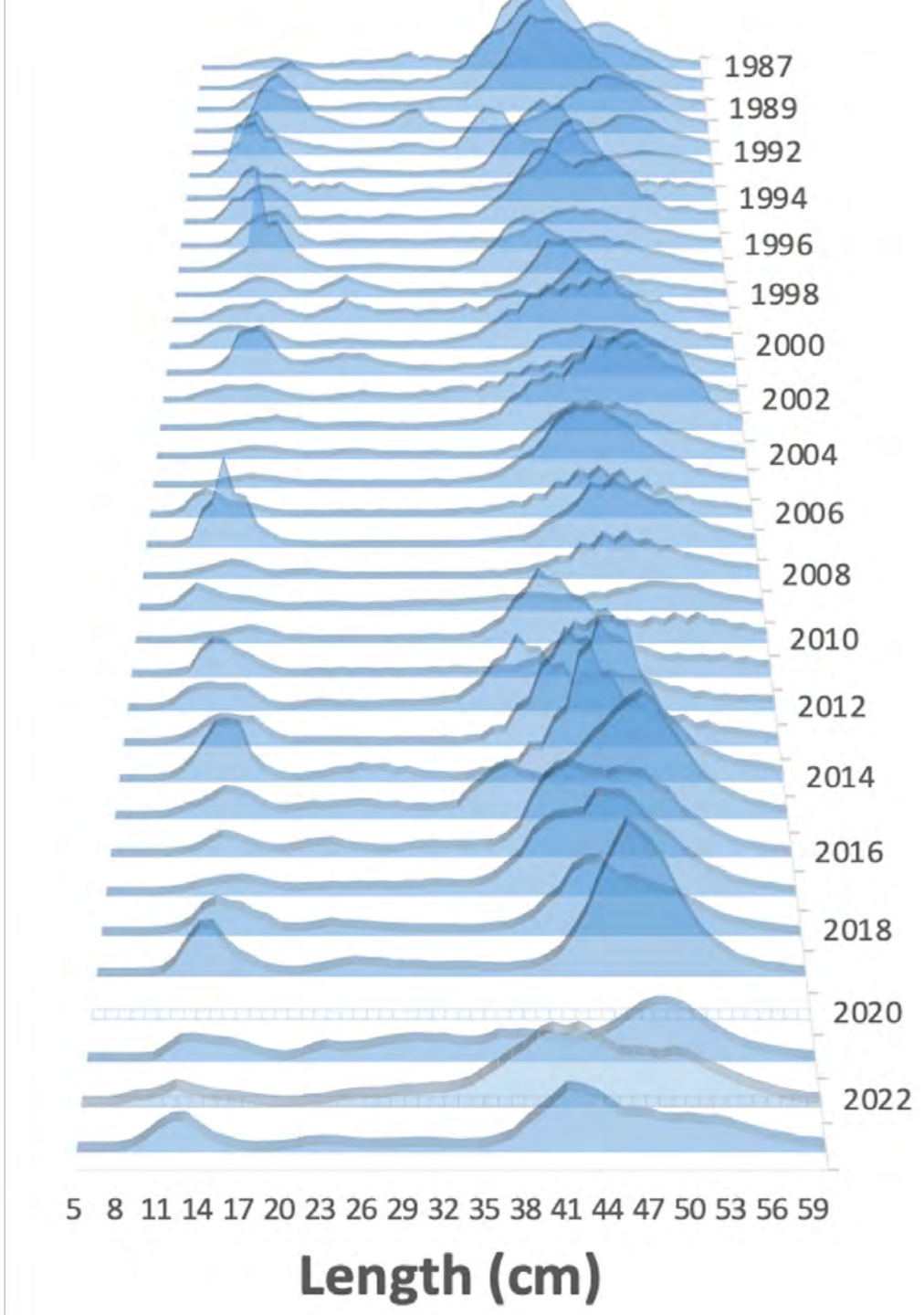

65°N
60°N
2021


65°N
60°N
2022


65°N
60°N
2023

# Bottom-trawl survey

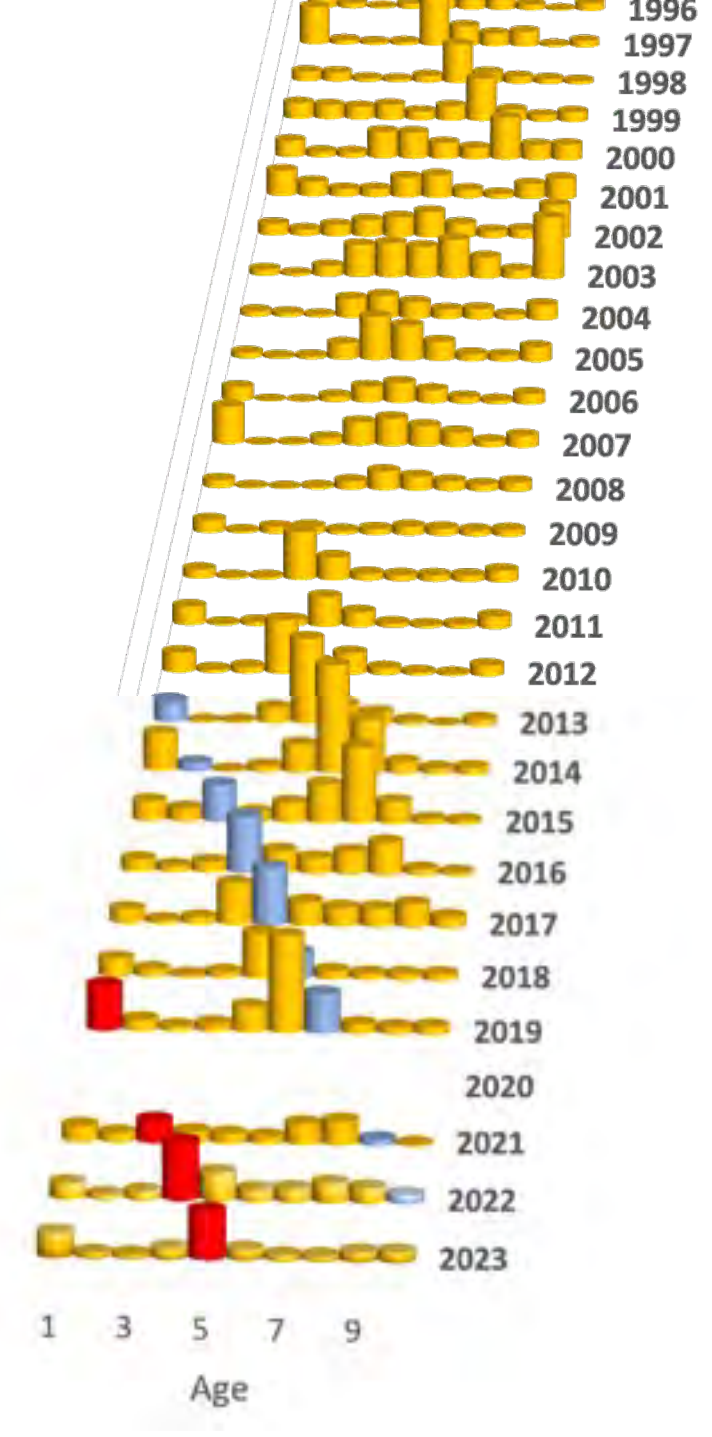
- Abundance at length

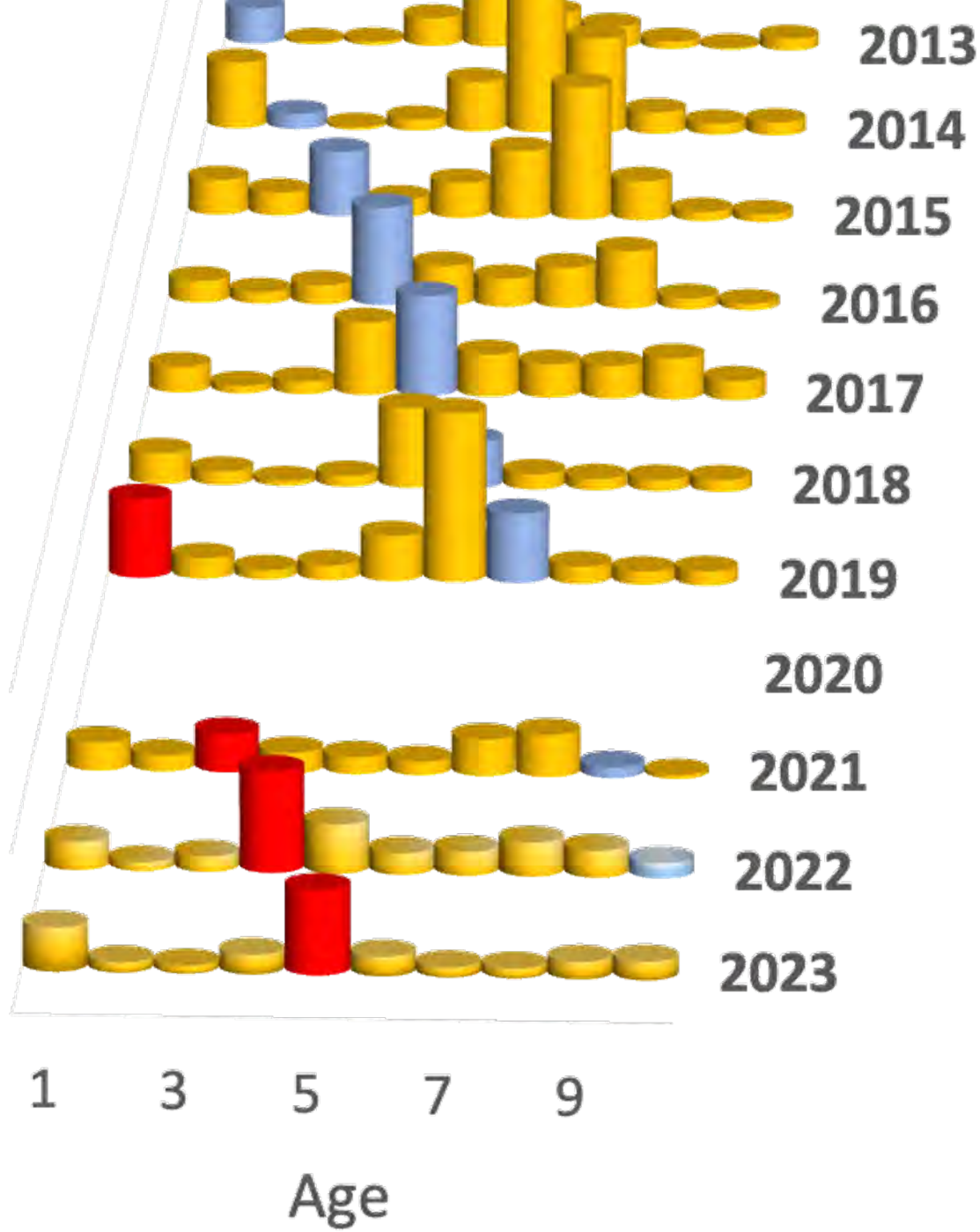


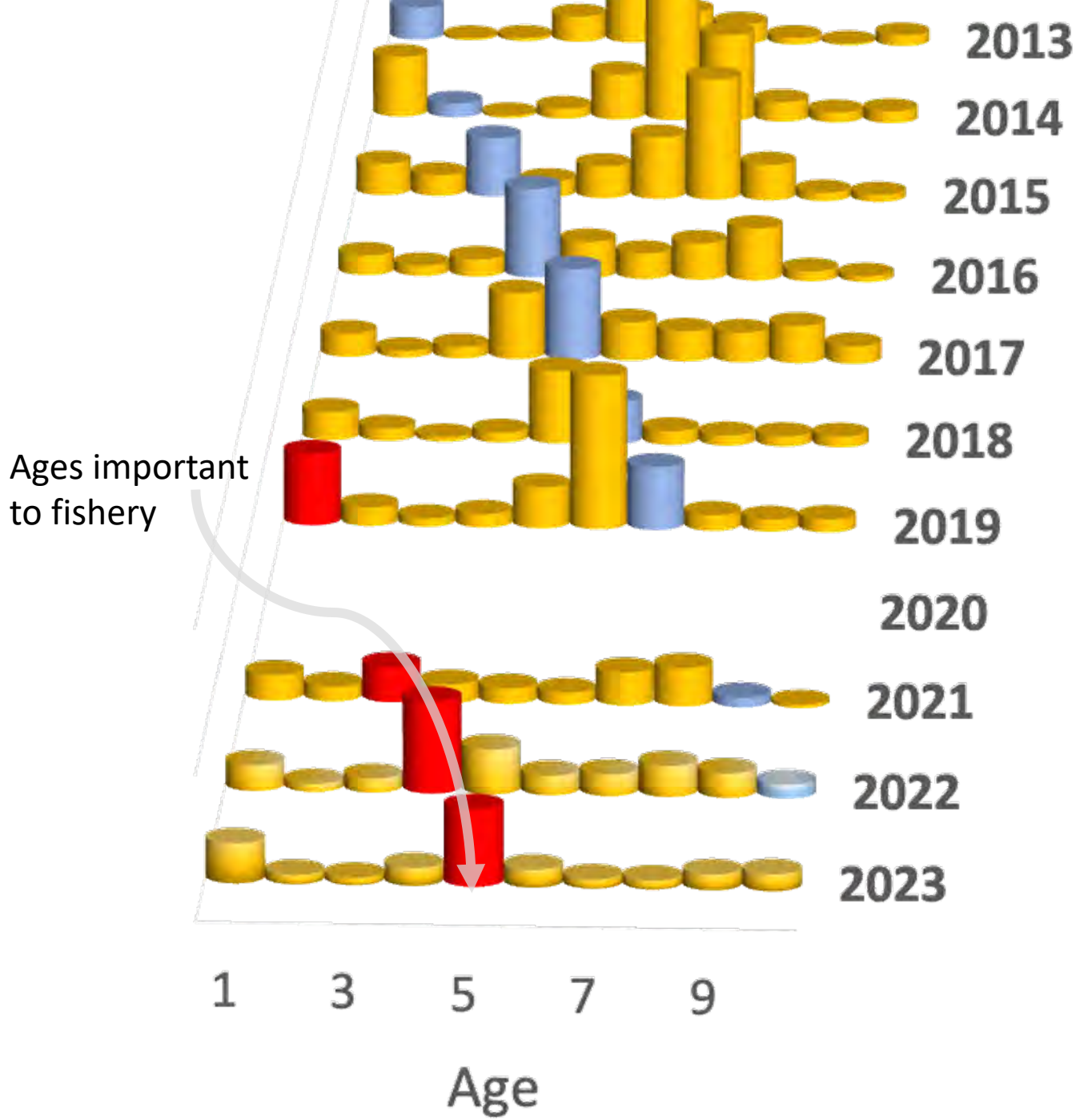
# Survey abundance-at-age

- Eastern Bering Sea pollock

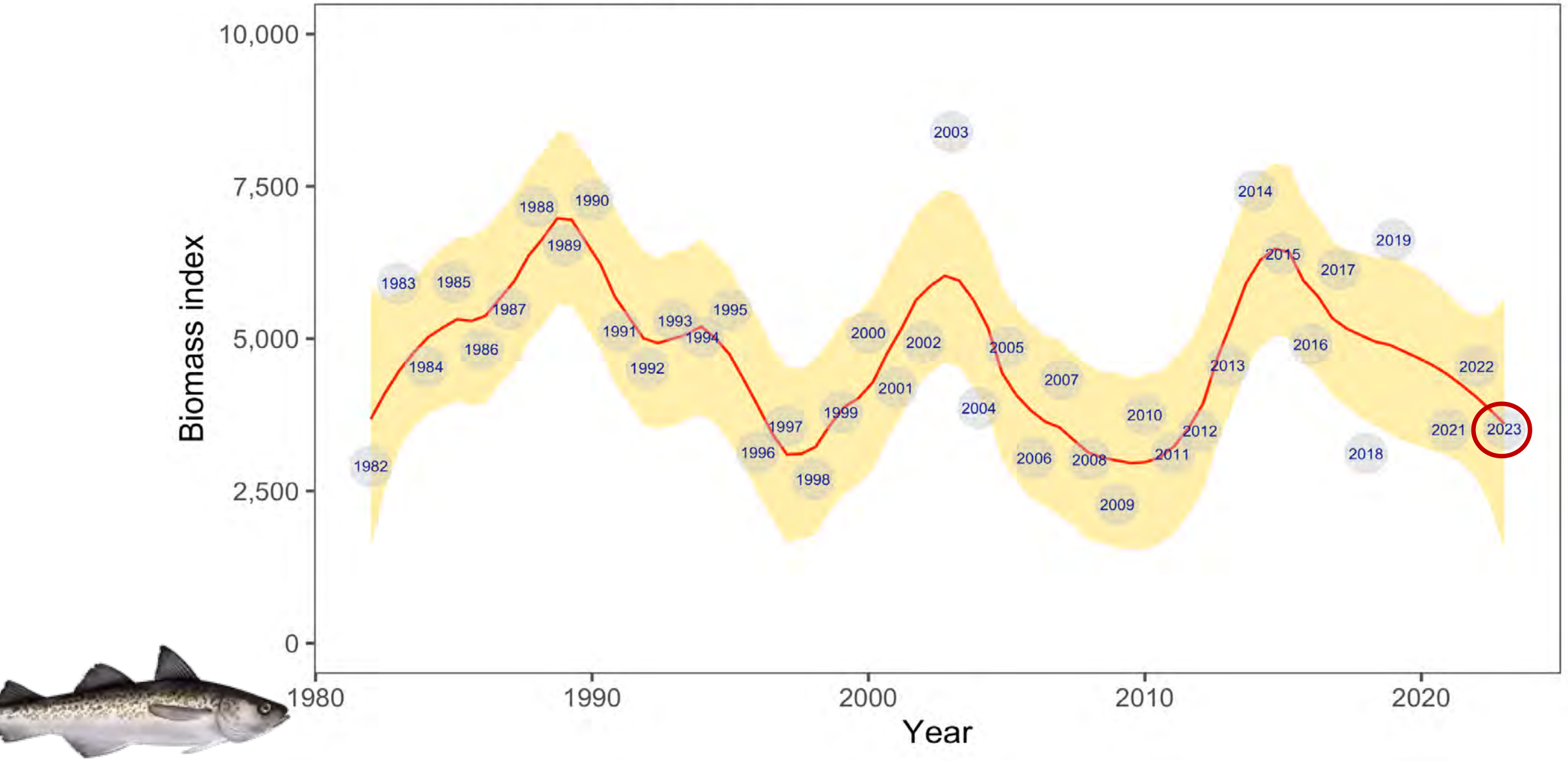
Vertical scale is population numbers at age



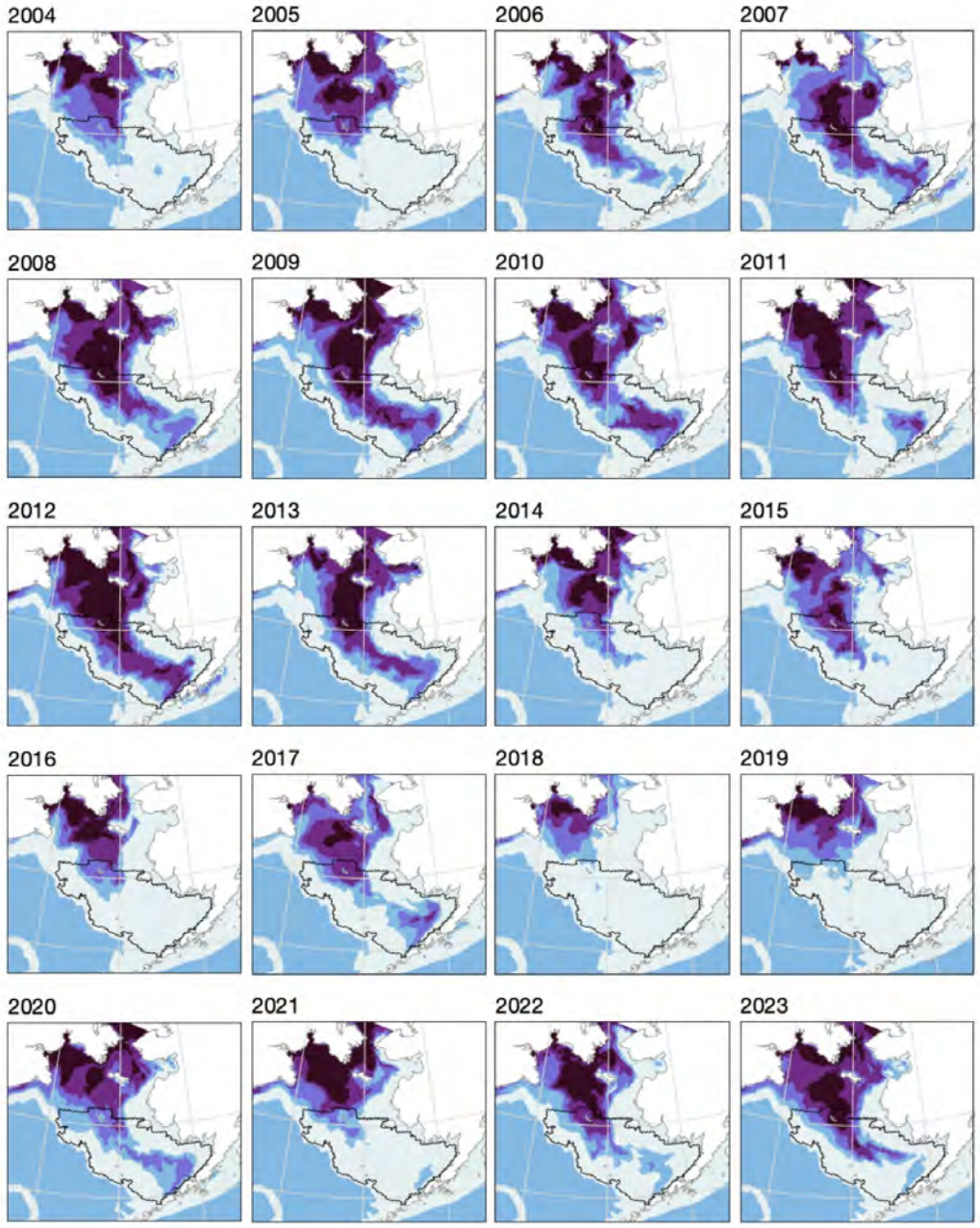

2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
1
3
5
7
9
Age

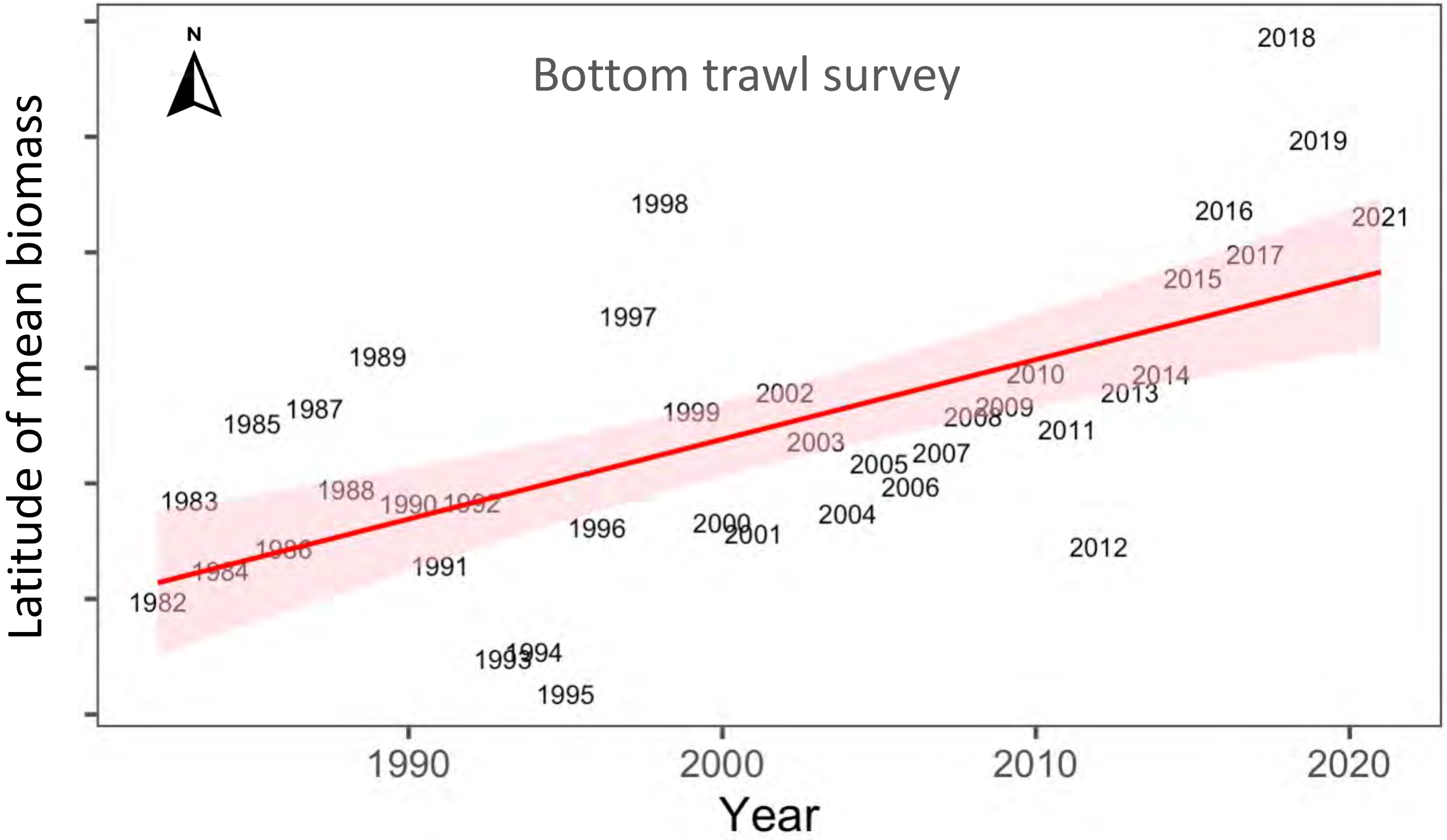

Ages important
to fishery
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
1
3
5
7
9
Age

# E. Bering Sea bottom trawl survey

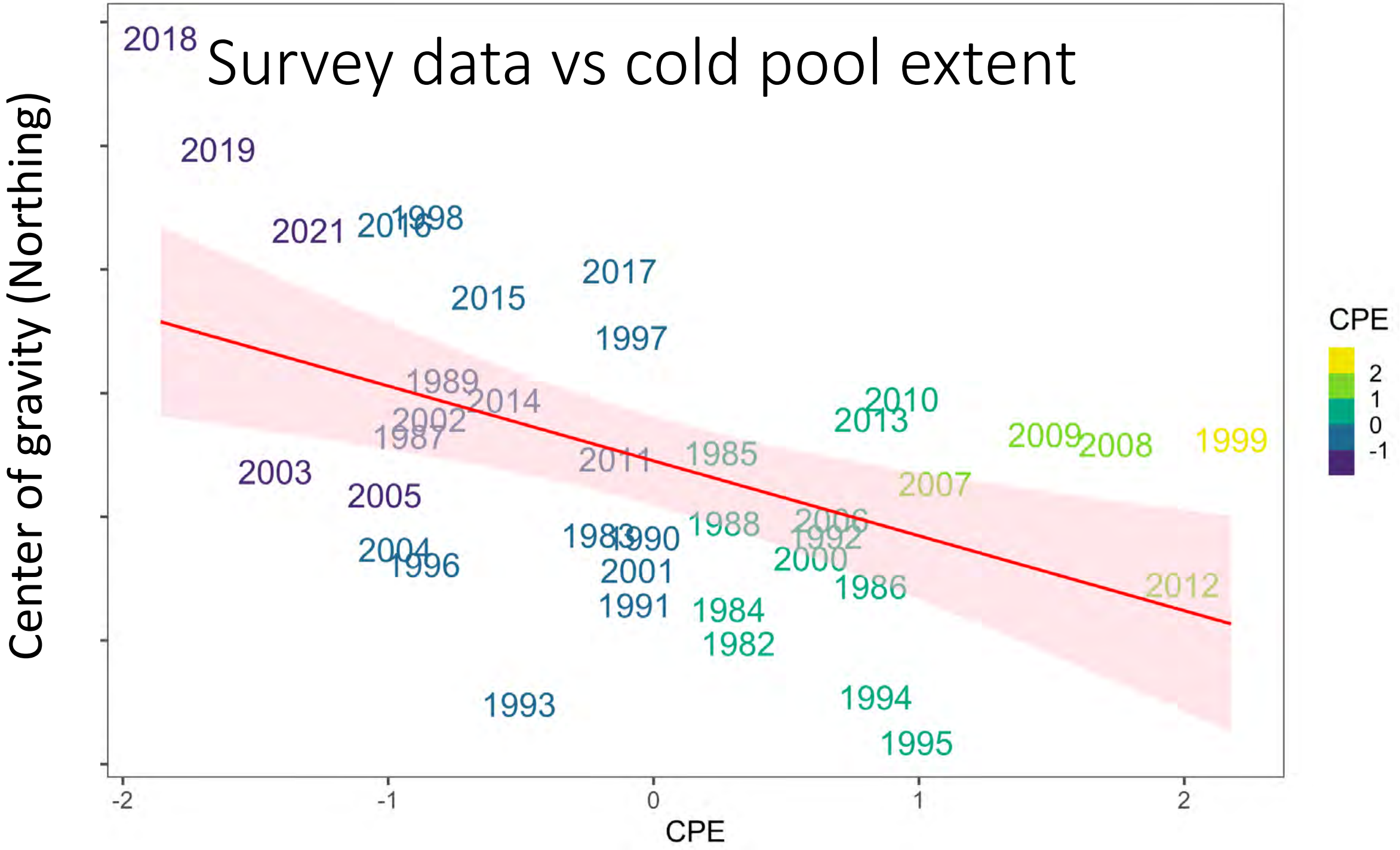


# Cold pool extent



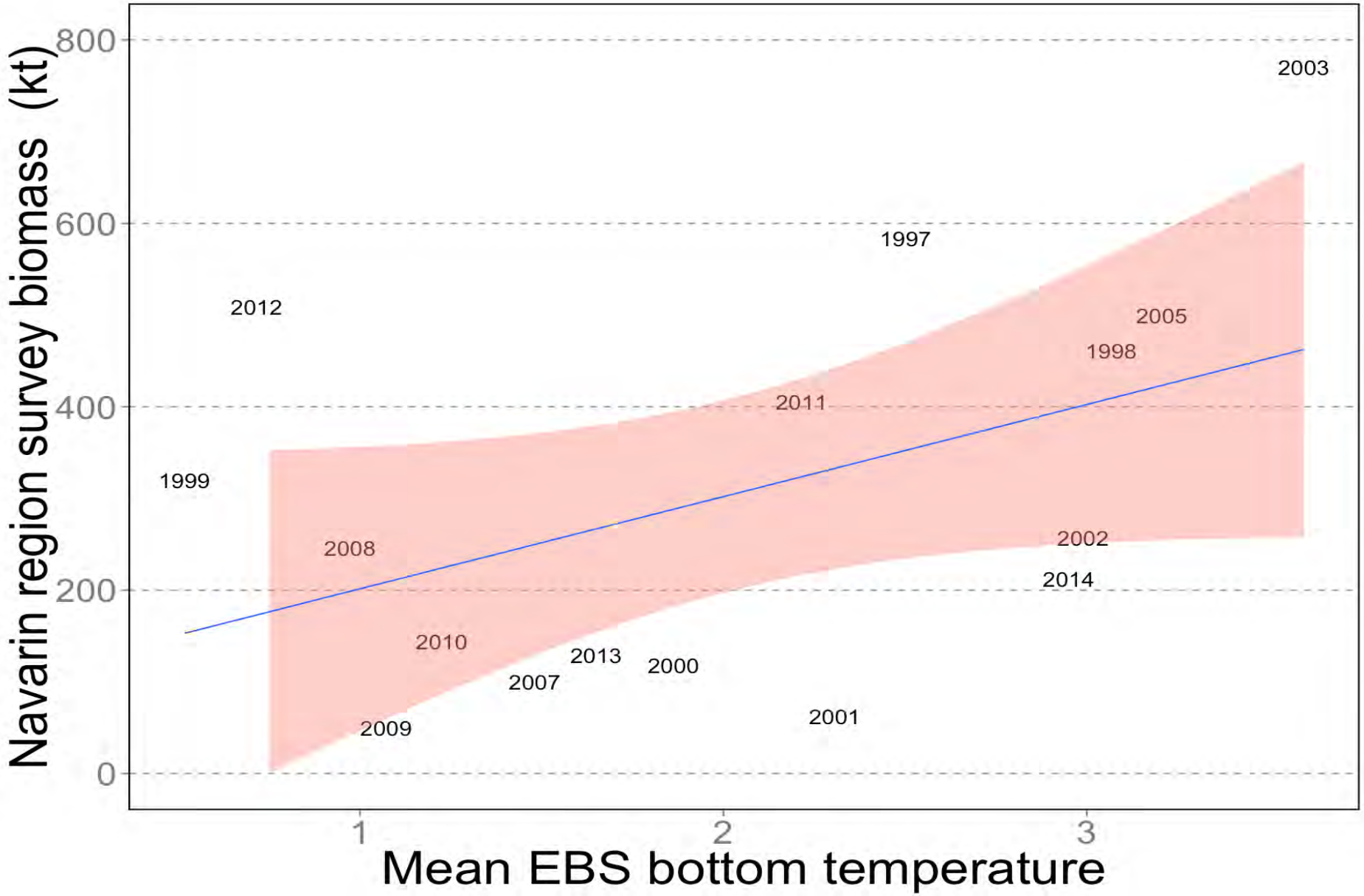

Bottom trawl survey
N
Latitude of mean biomass
Year
1990
2000
2010
2020
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2021

# Survey data vs cold pool extent



# Temperature and Overlap into Russian Zone?

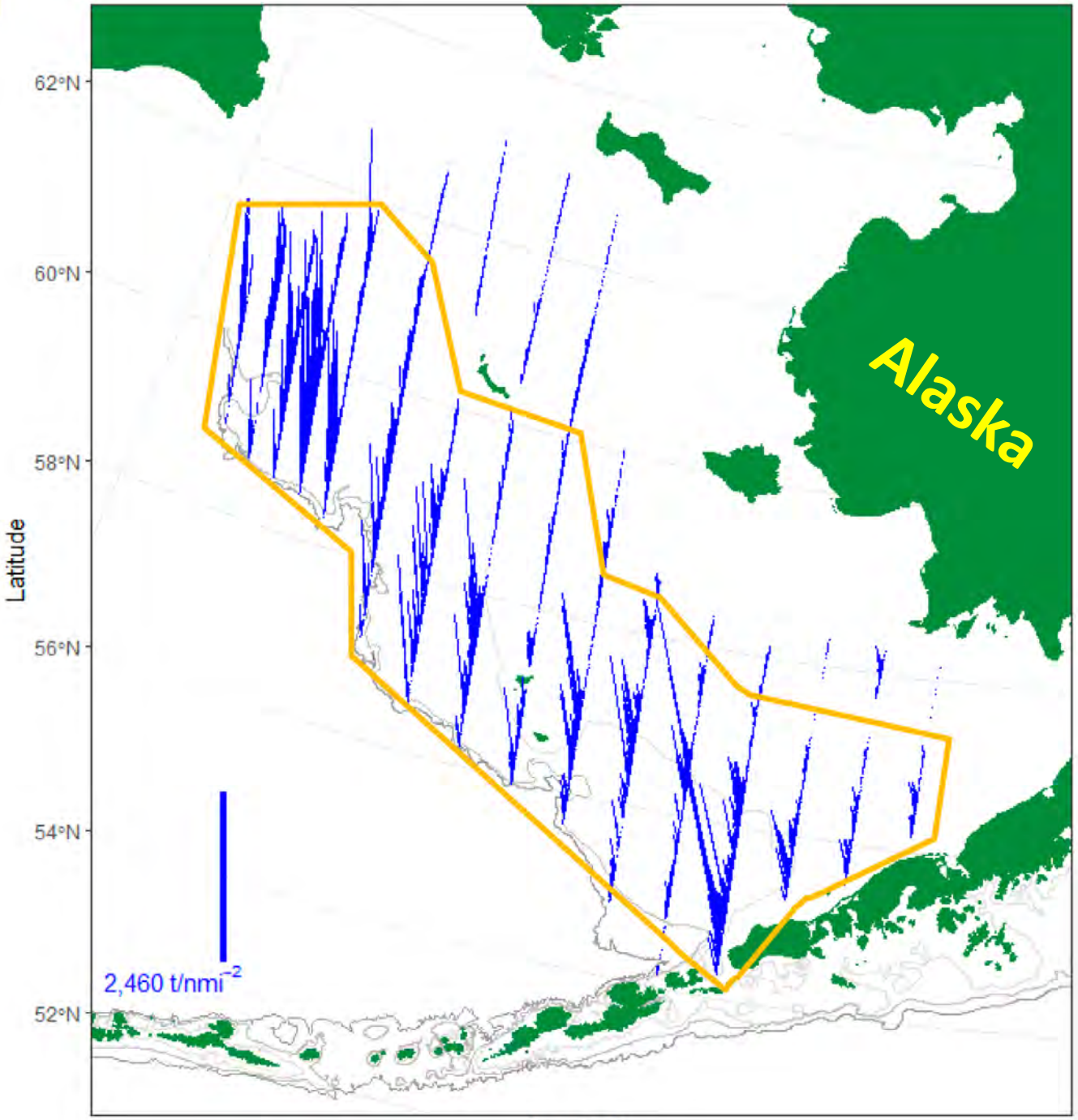
**From 2015 Assessment**



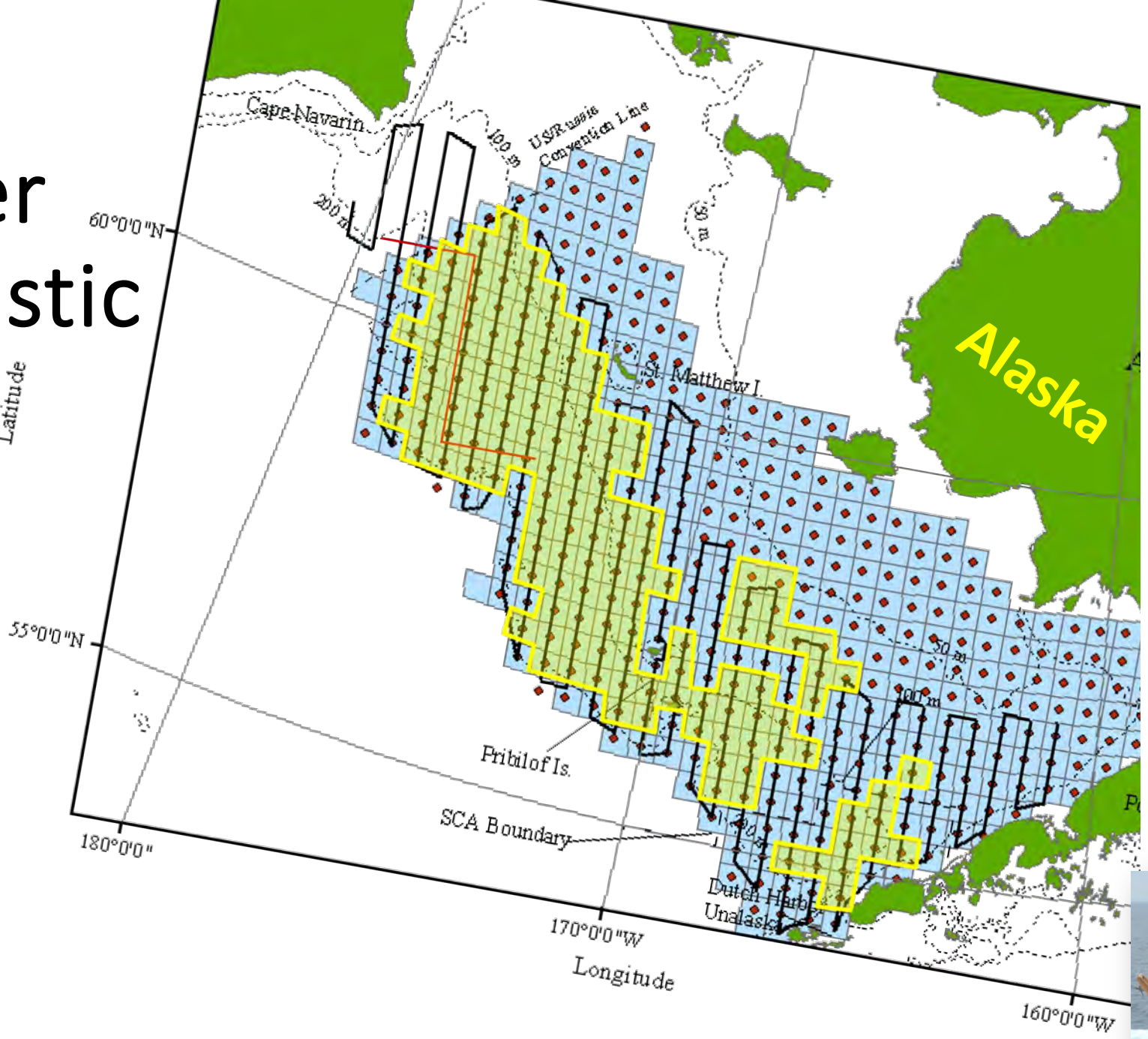
# Acoustic survey-NOAA Ship

# Most recent in 2022

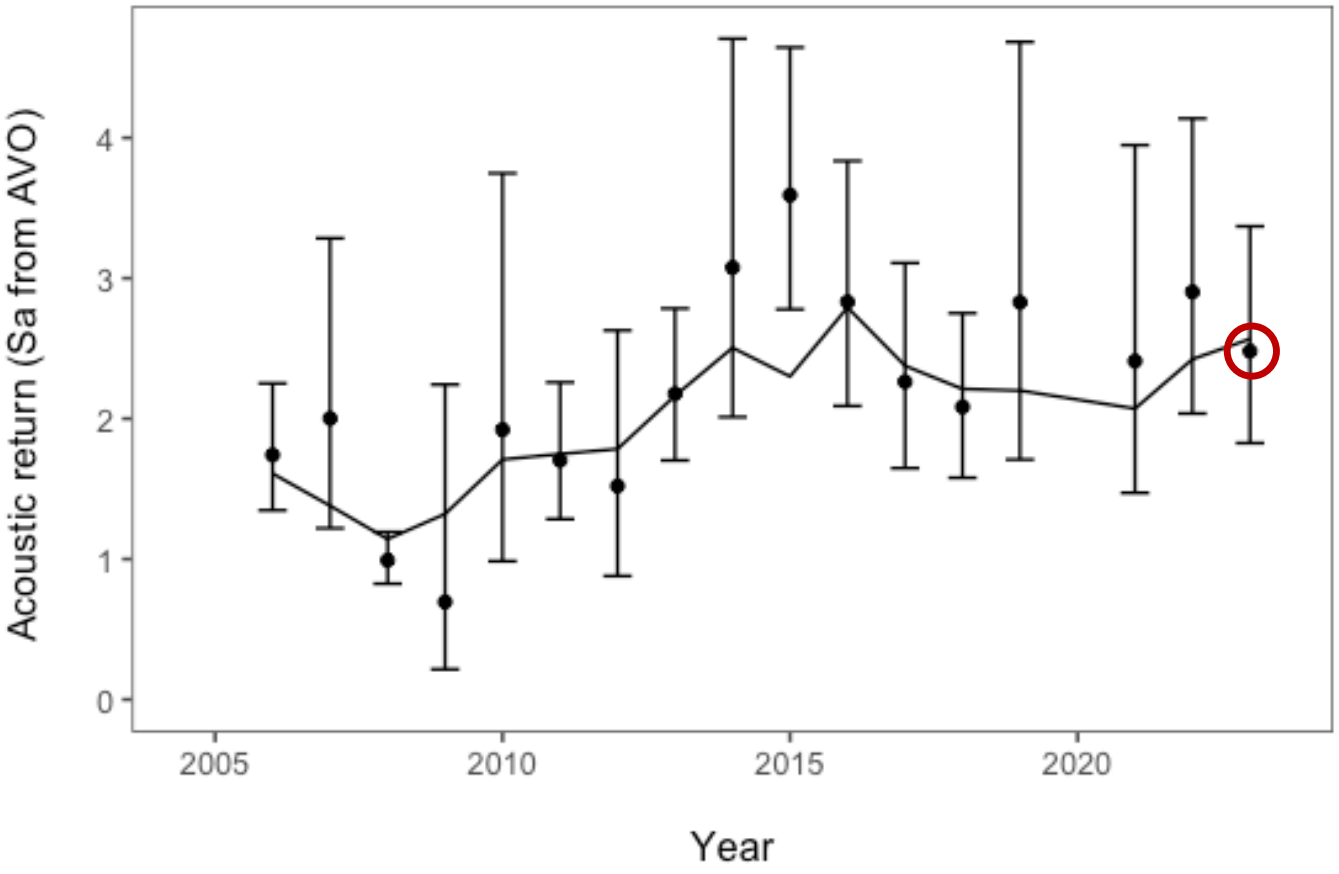
Last year's

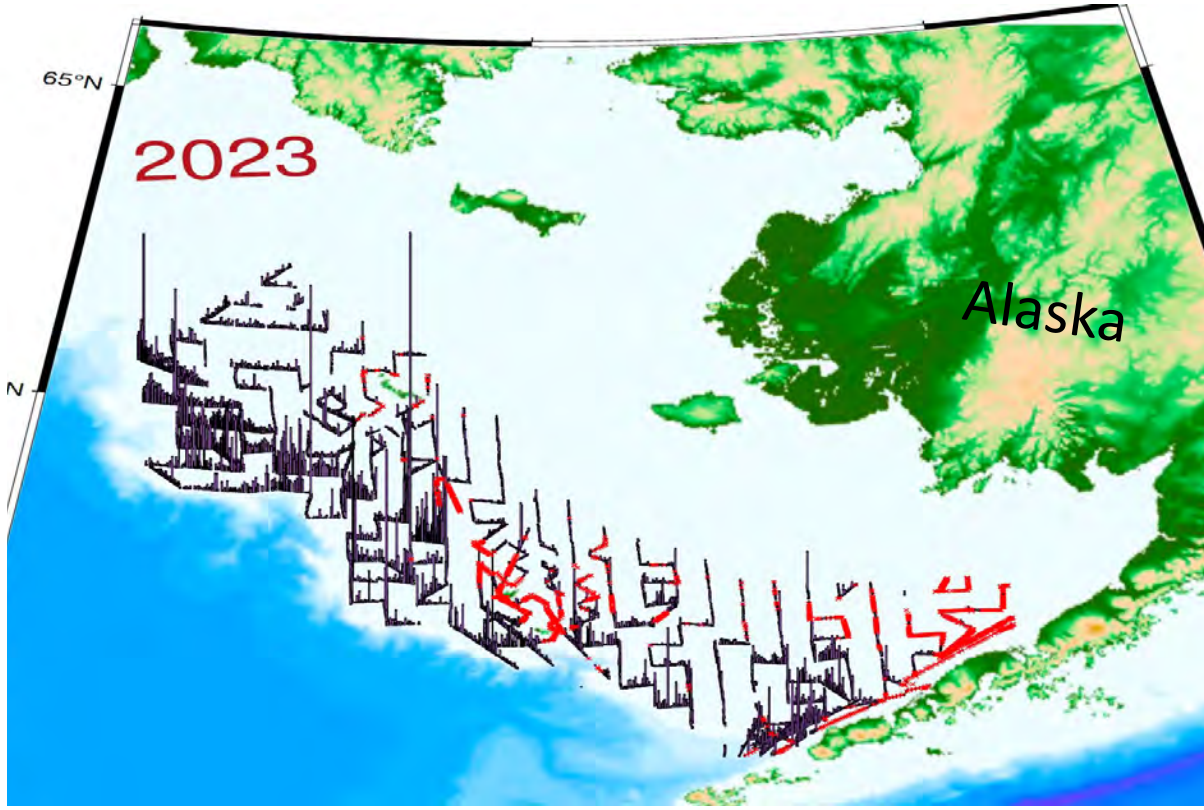


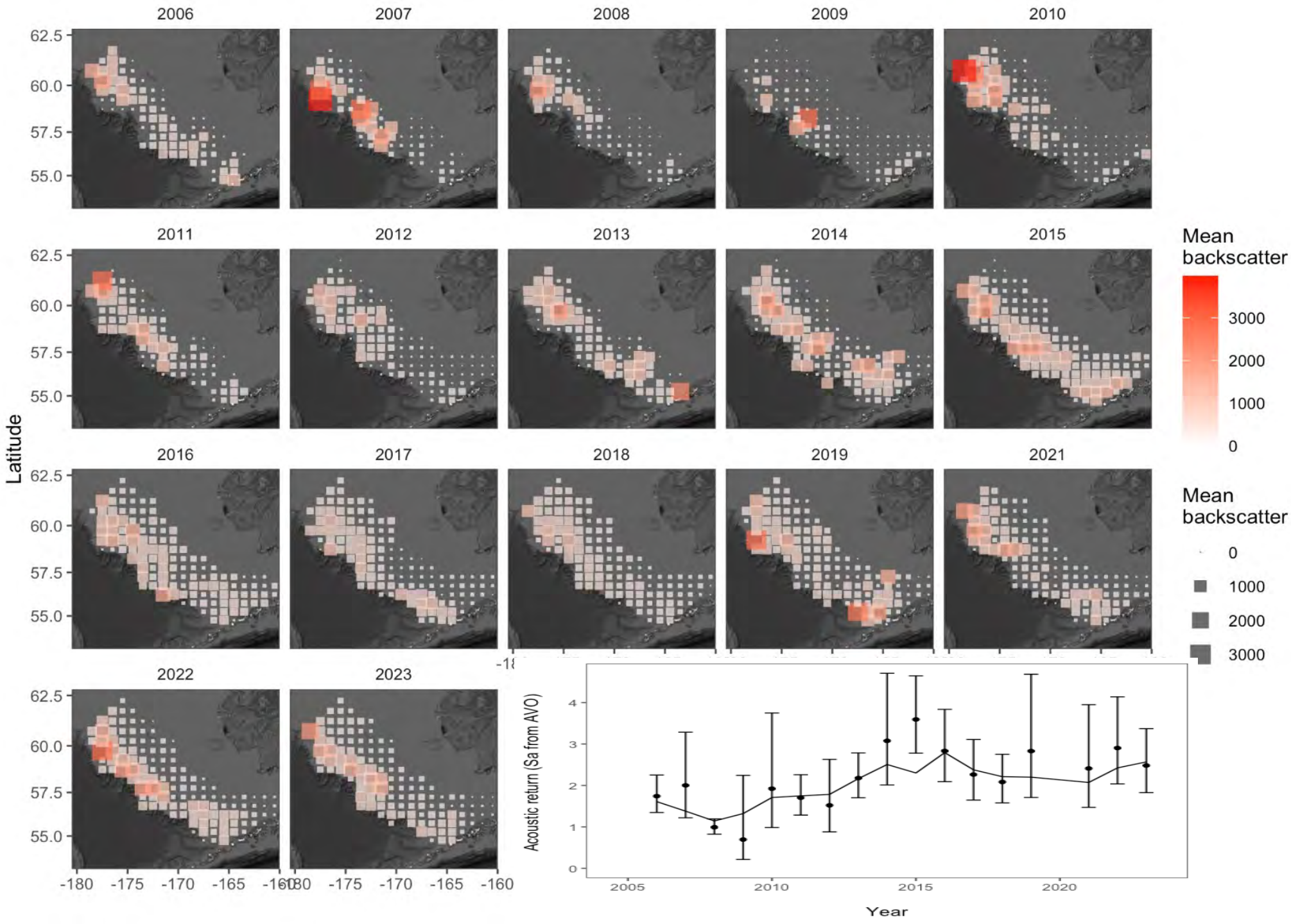
# Other acoustic data



# Opportunistic acoustic survey results



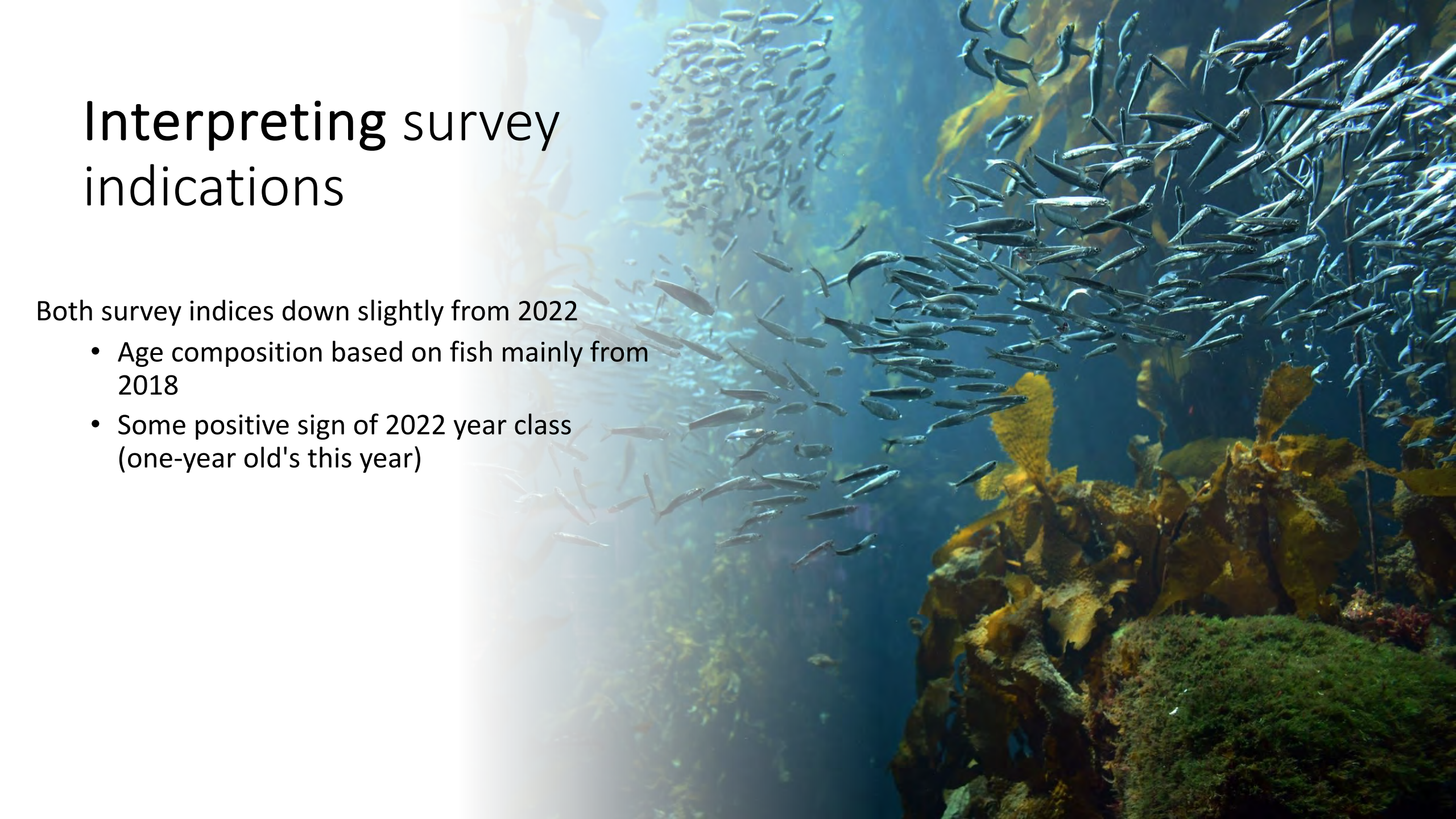




2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2021
2022
2023
Latitude
62.5
60.0
57.5
55.0
-180
-175
-170
-165
-160
Mean backscatter
3000
2000
1000
0
Mean backscatter
0
1000
2000
3000
Acoustic return (Sa from AVO)
0
1
2
3
4
2005
2010
2015
2020
Year

# **Interpreting** survey indications

Both survey indices down slightly from 2022

- Age composition based on fish mainly from 2018
- Some positive sign of 2022 year class (one-year old's this year)



# **Interpreting** survey indications

Both survey indices down slightly from 2022

- Age composition based on fish mainly from 2018
- Some positive sign of 2022 year class (one-year old's this year)

- Spawning biomass projection down
  - Above where catch rate advice would drop
  - *Concern for recruitment, as always..*

# Modeling…

# Analyses presented at October Council meeting

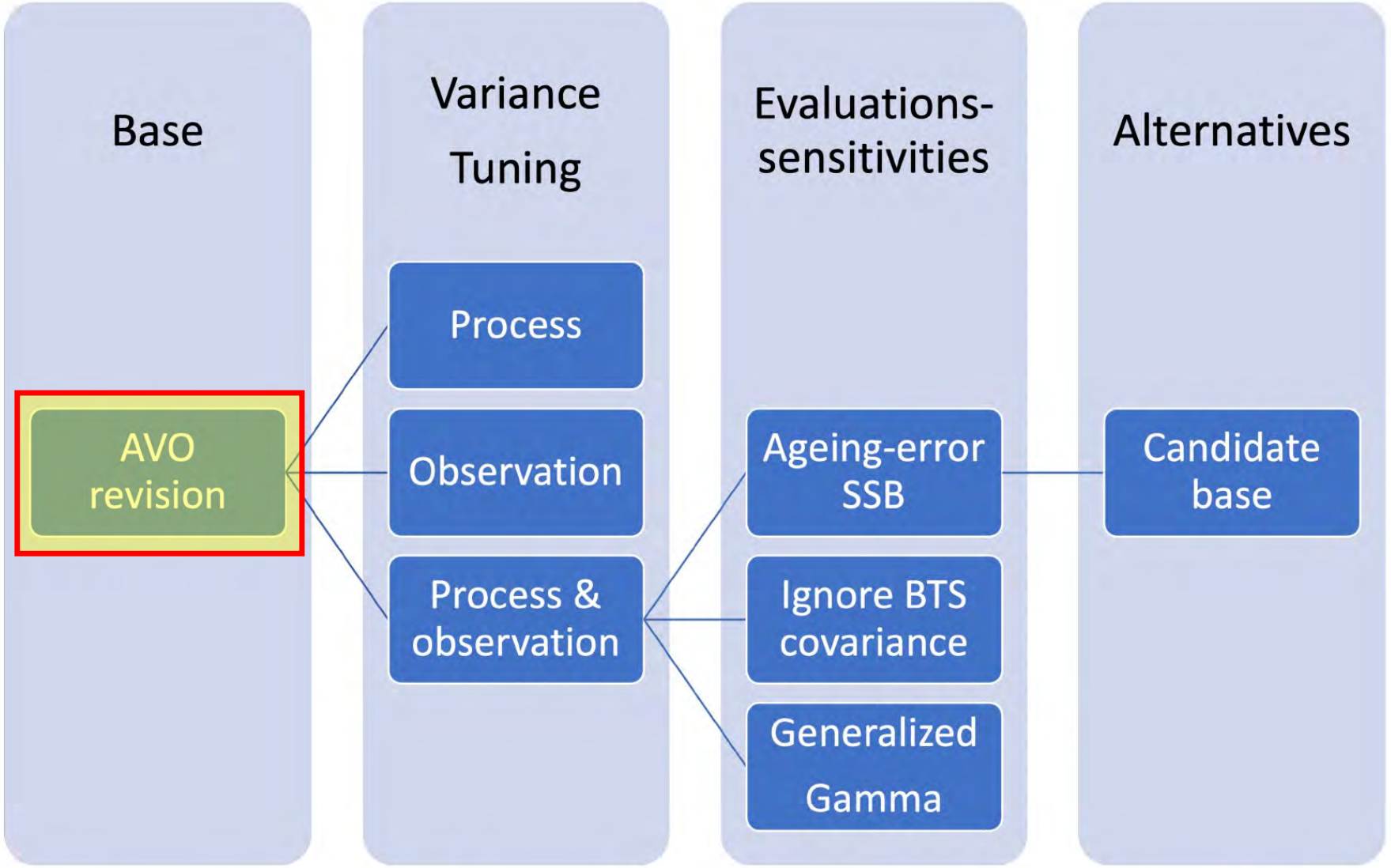



Figure 1: Schematic of approach for evaluating some planned changes in the EBS pollock assessment. See text for details.

# Analyses presented at October Council meeting

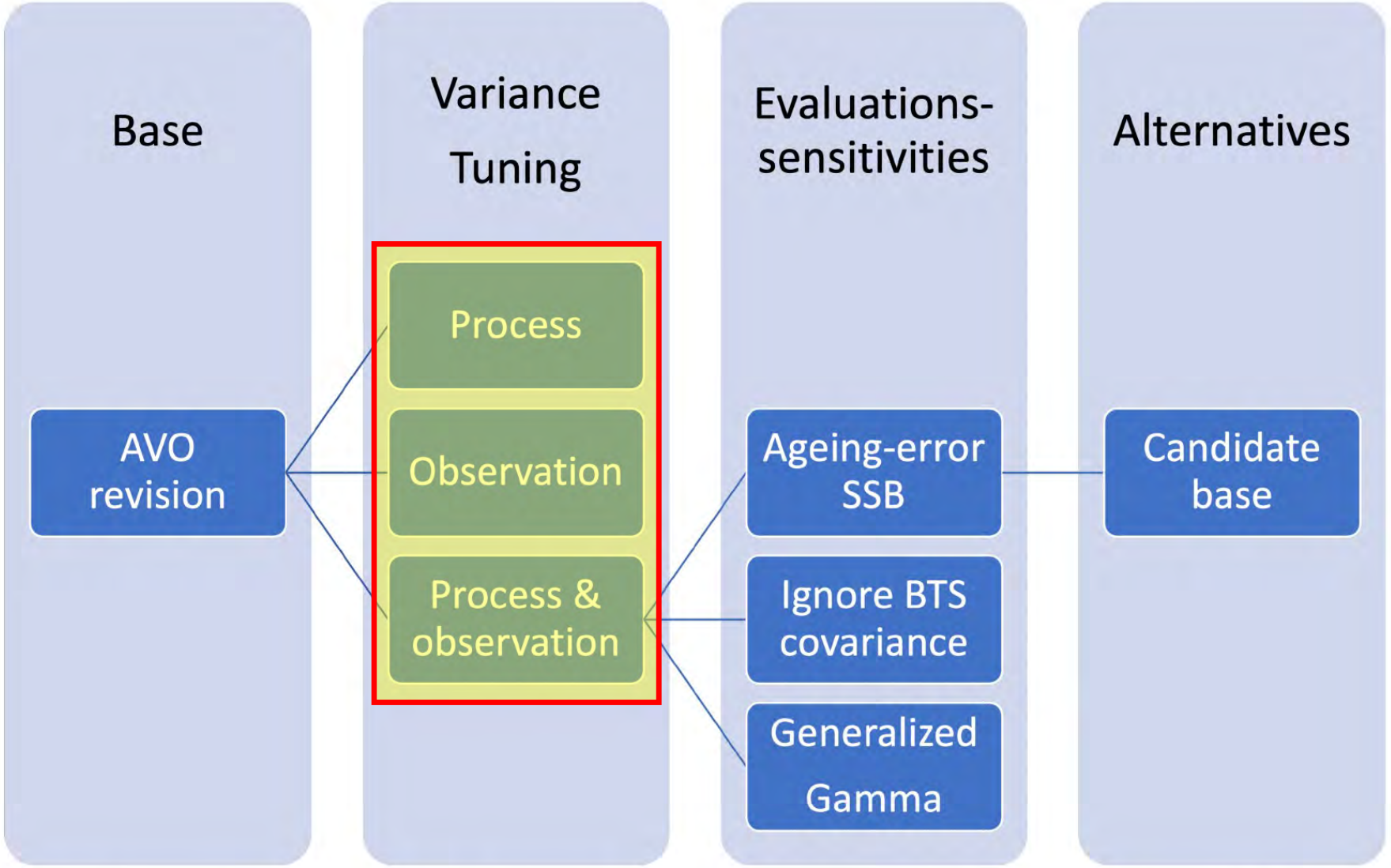
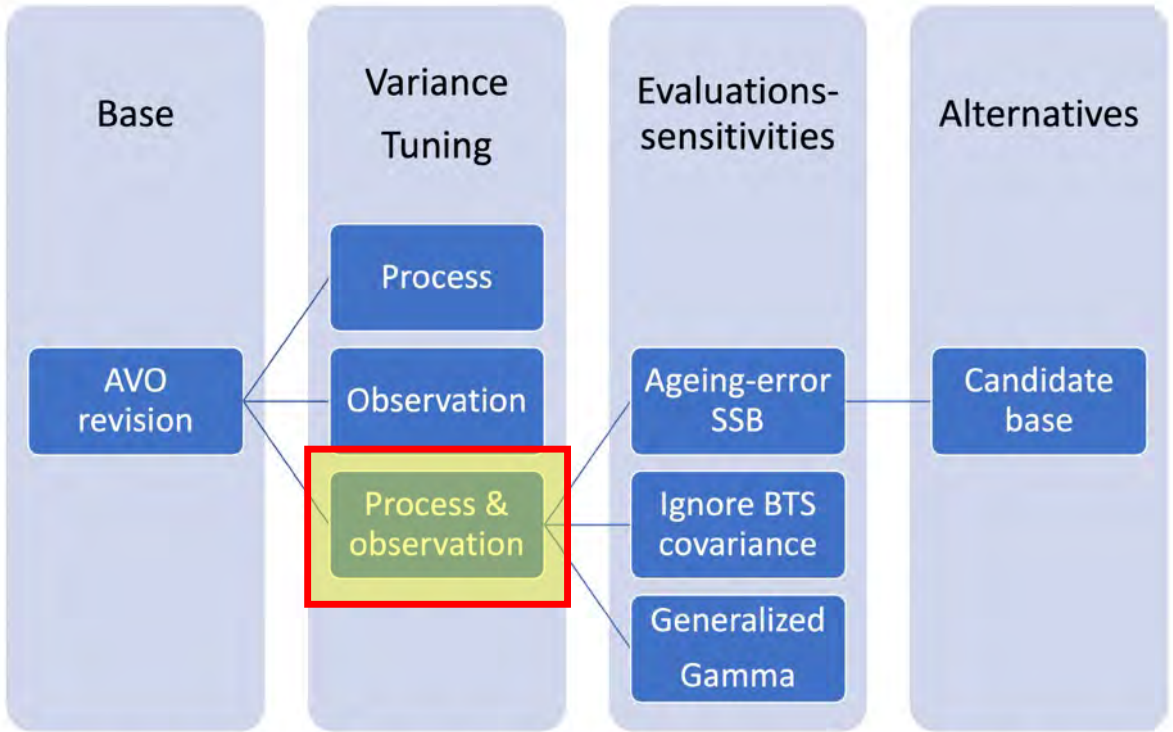



Figure 1: Schematic of approach for evaluating some planned changes in the EBS pollock assessment. See text for details.

# Analyses presented at October Council meeting



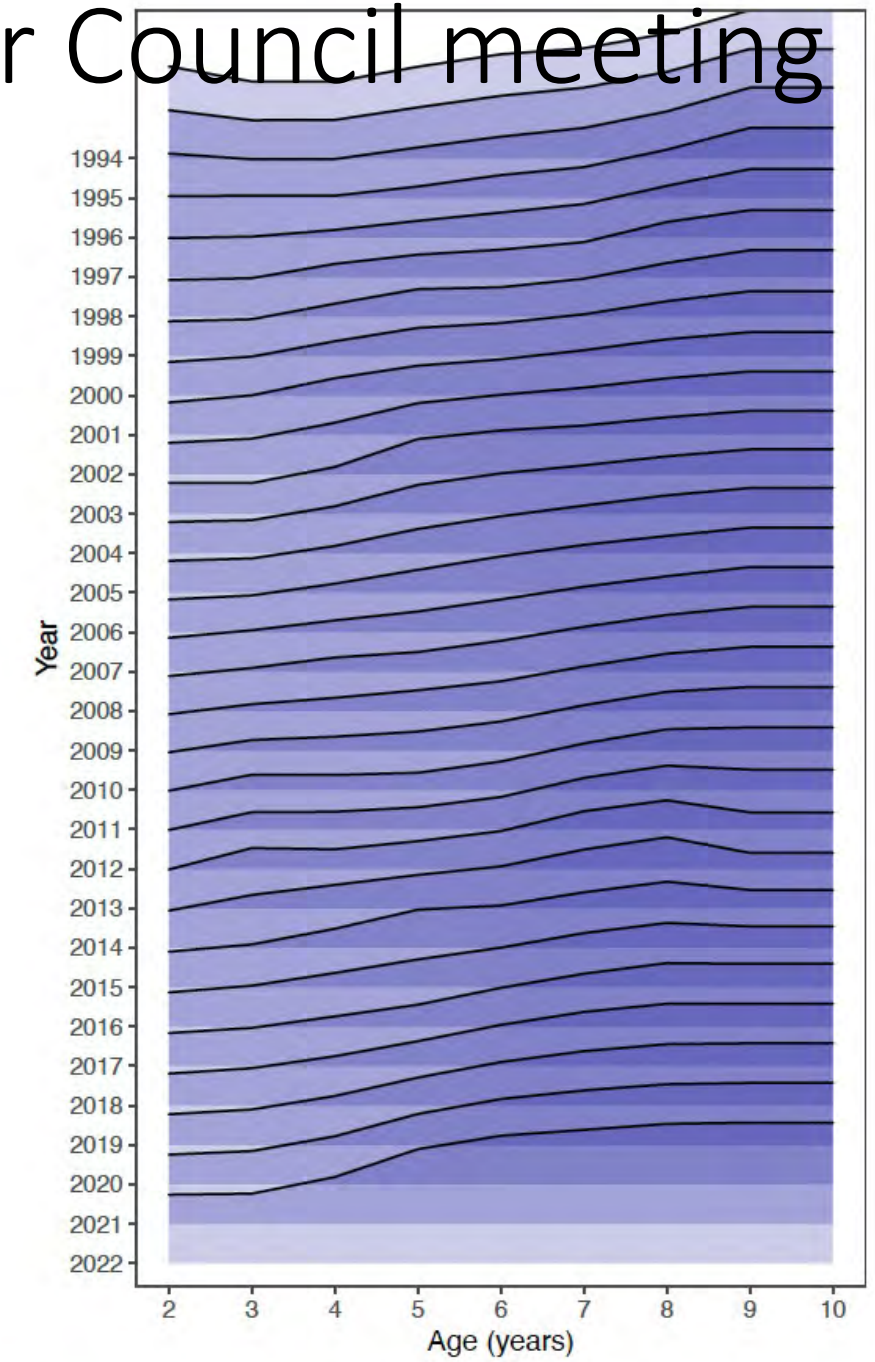
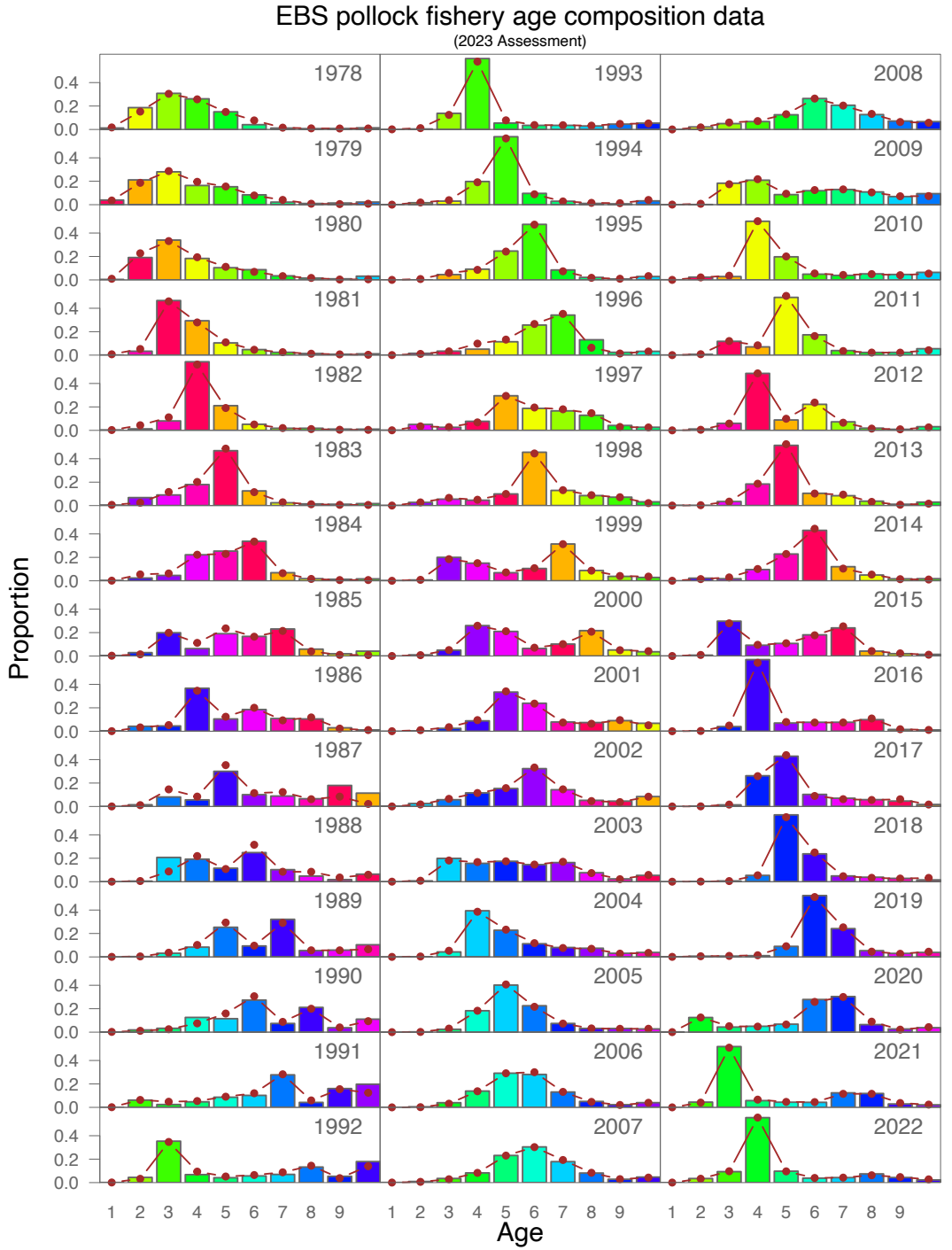



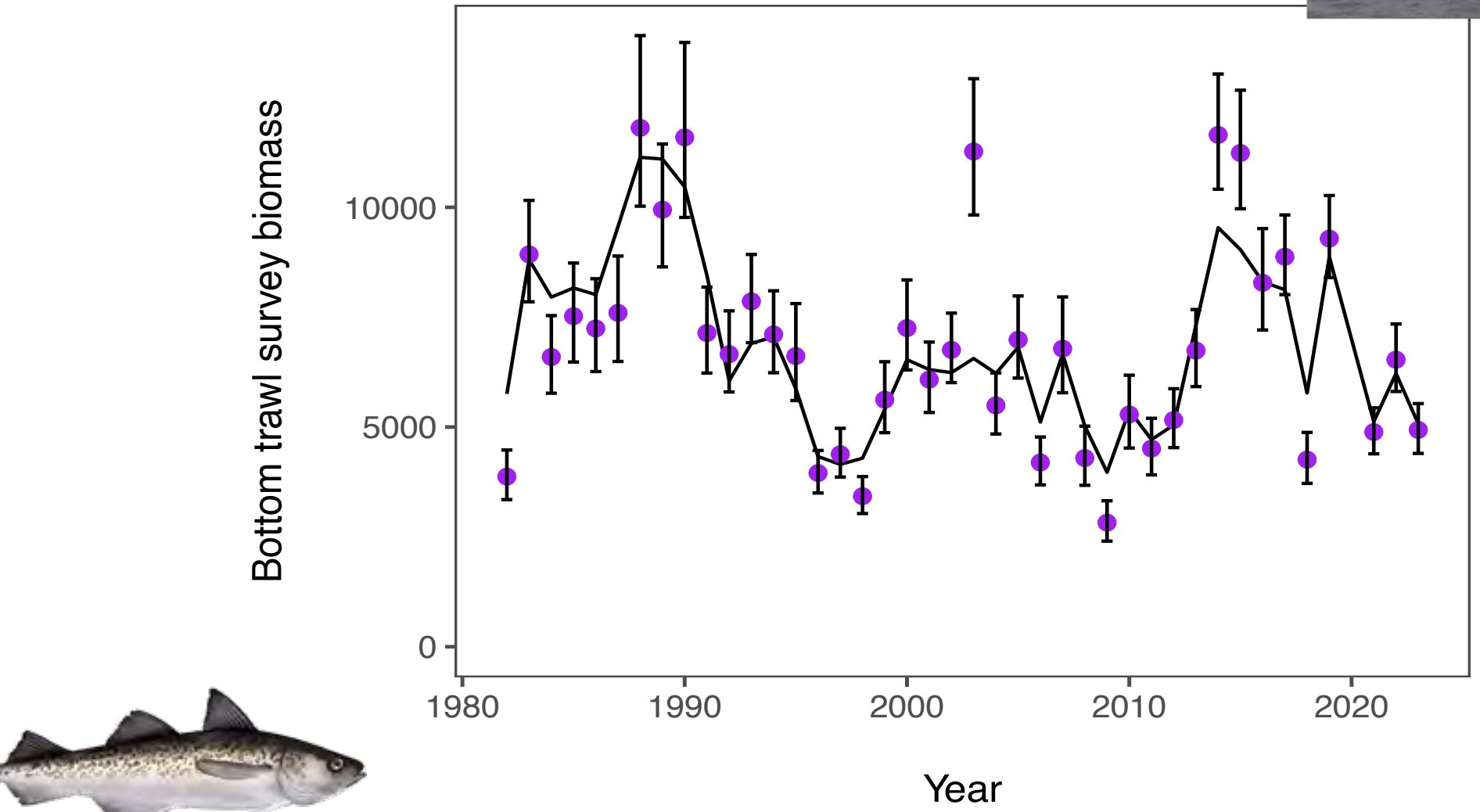

Figure 7: Time varying acoustic trawl selectivity estimates for the process-error tuned model.

# Model fits

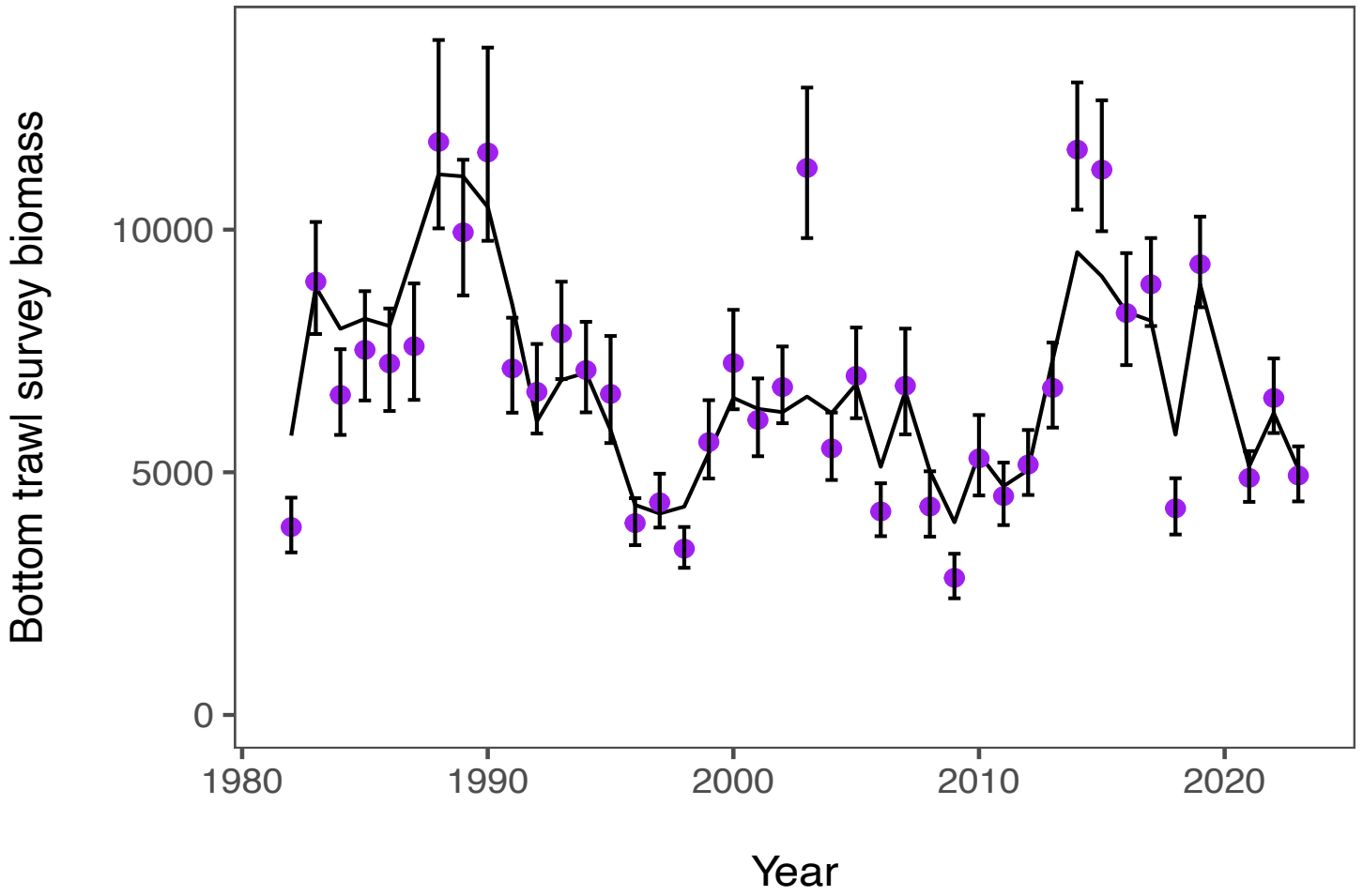
# Fishery age composition fits

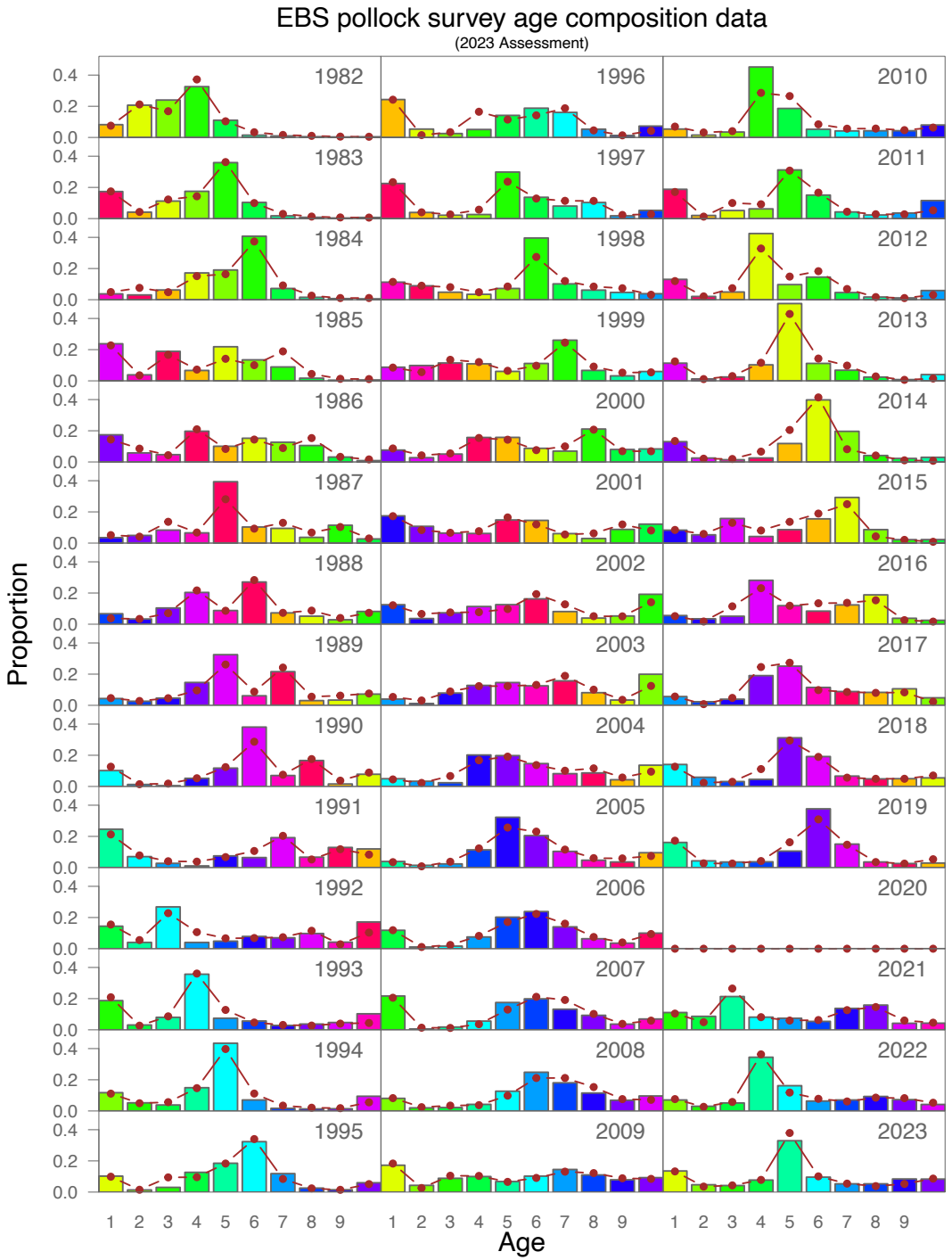


# NMFS Bottom trawl survey…

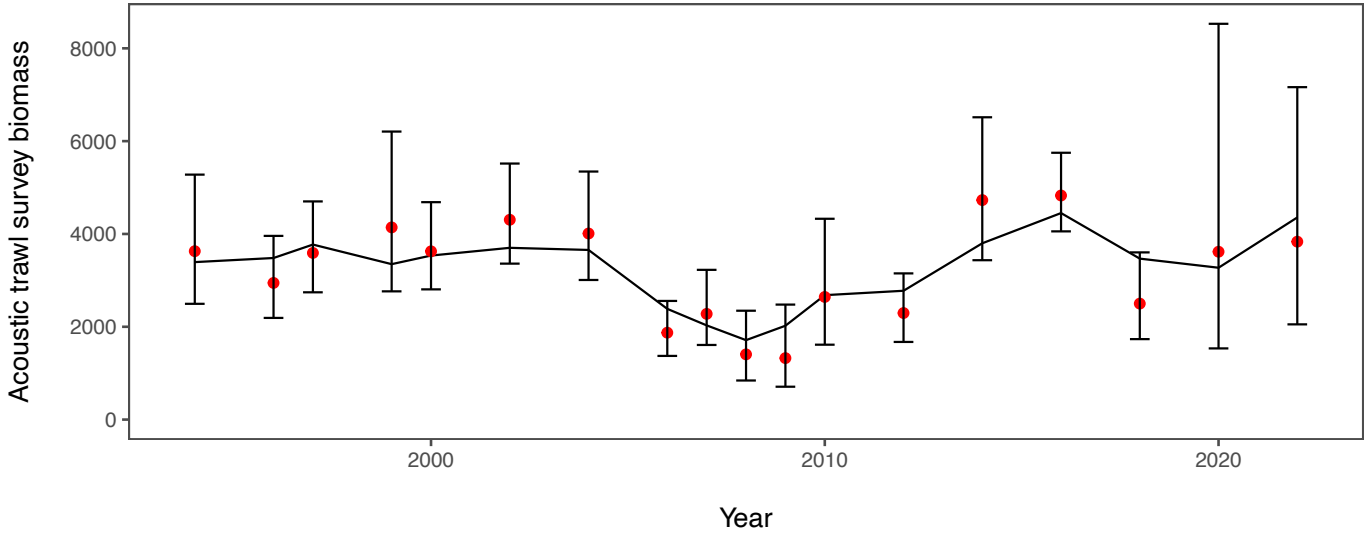


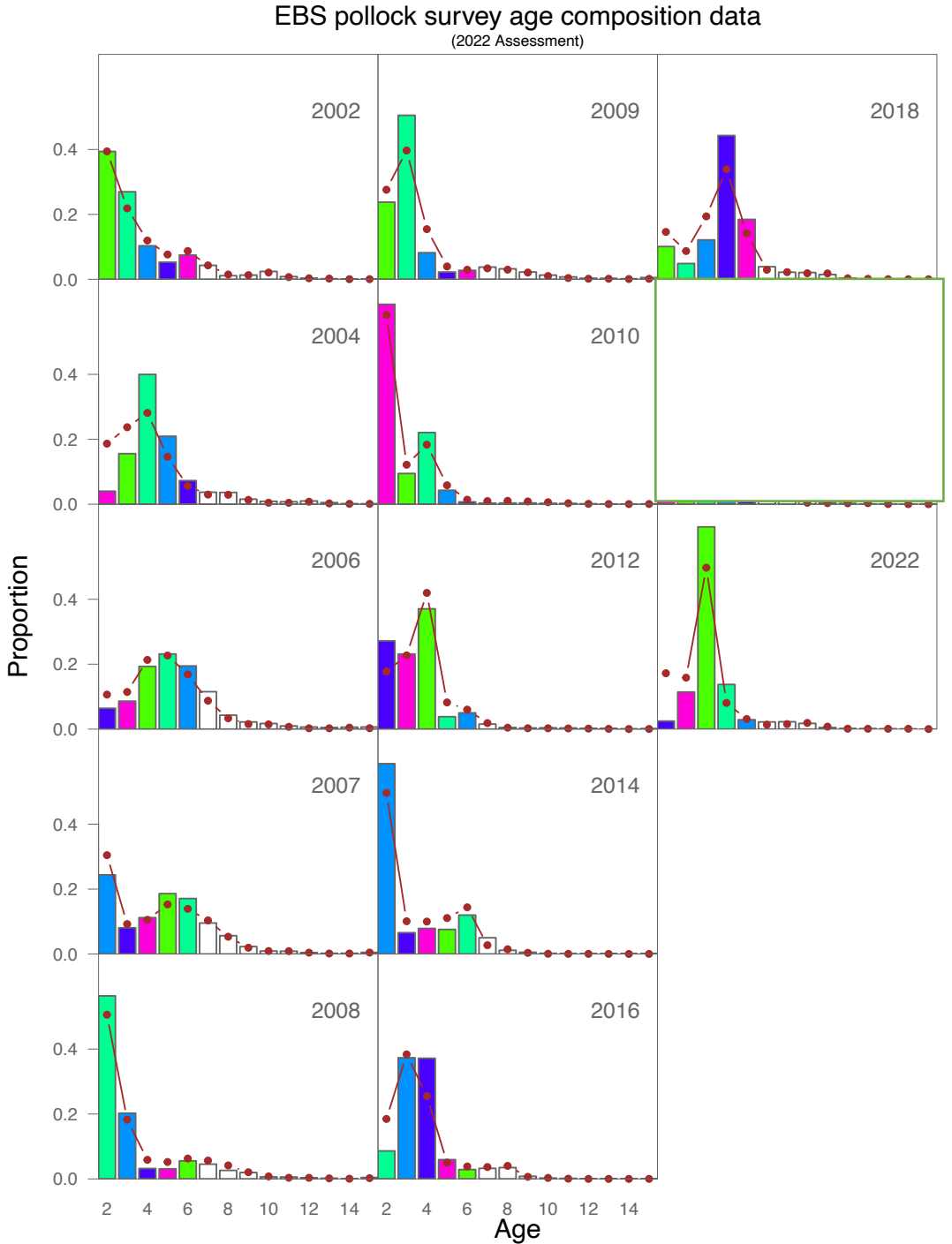
# Bottom-trawl survey fits

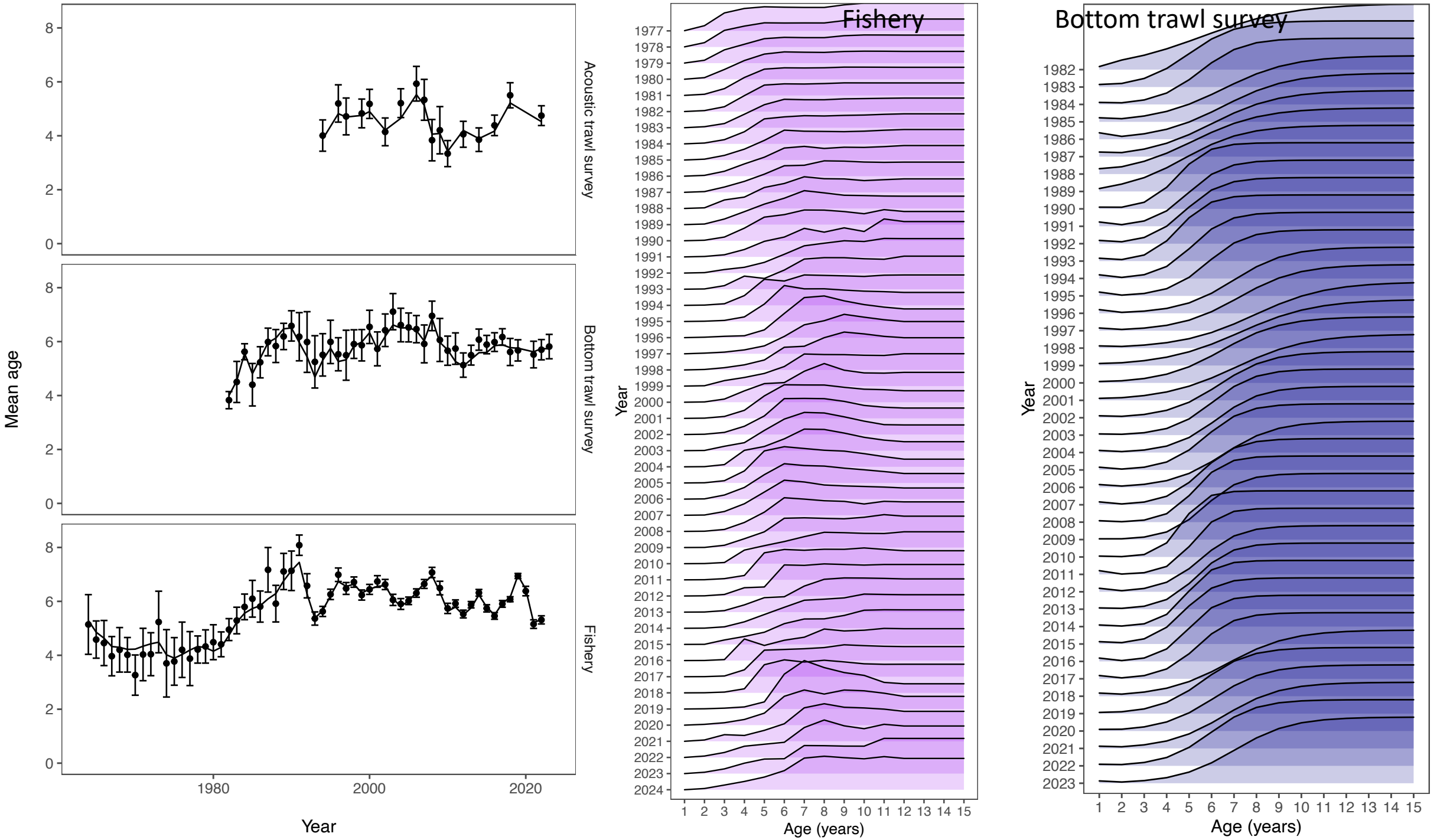




# Acoustic-trawl survey fits

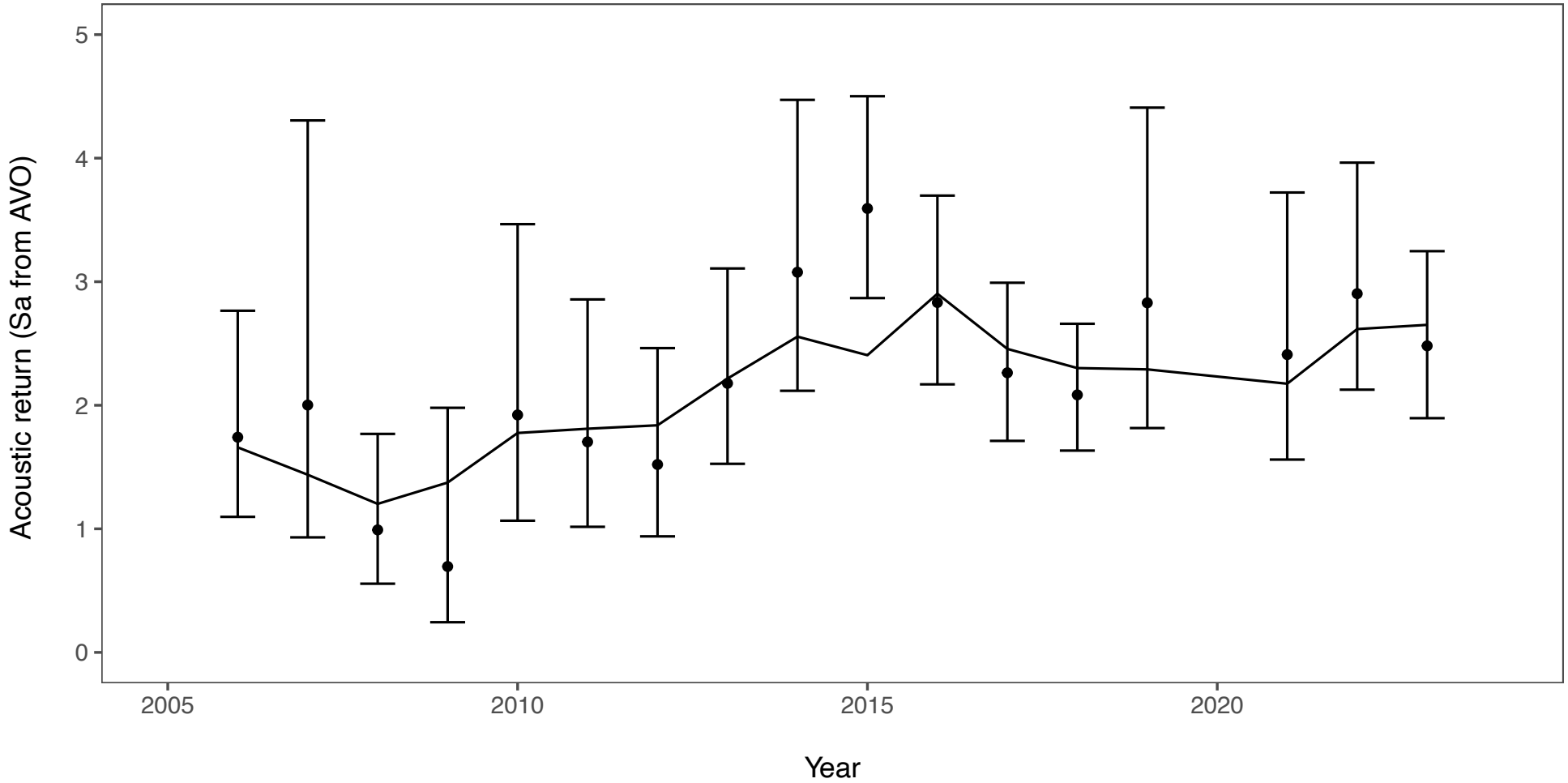





Mean age
Acoustic trawl survey
Bottom trawl survey
Fishery
Year
Fishery
Bottom trawl survey
Year
Age (years)
Year
Age (years)

# AVO Index

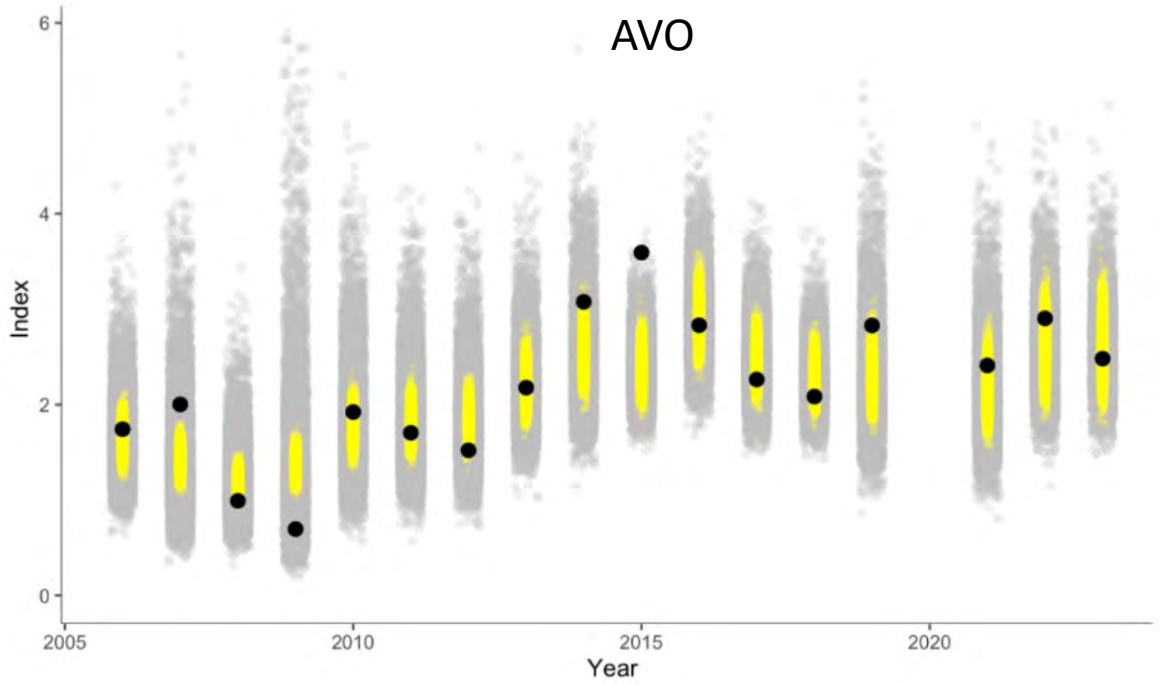
Acoustics collected opportunistically on bottom-trawl survey

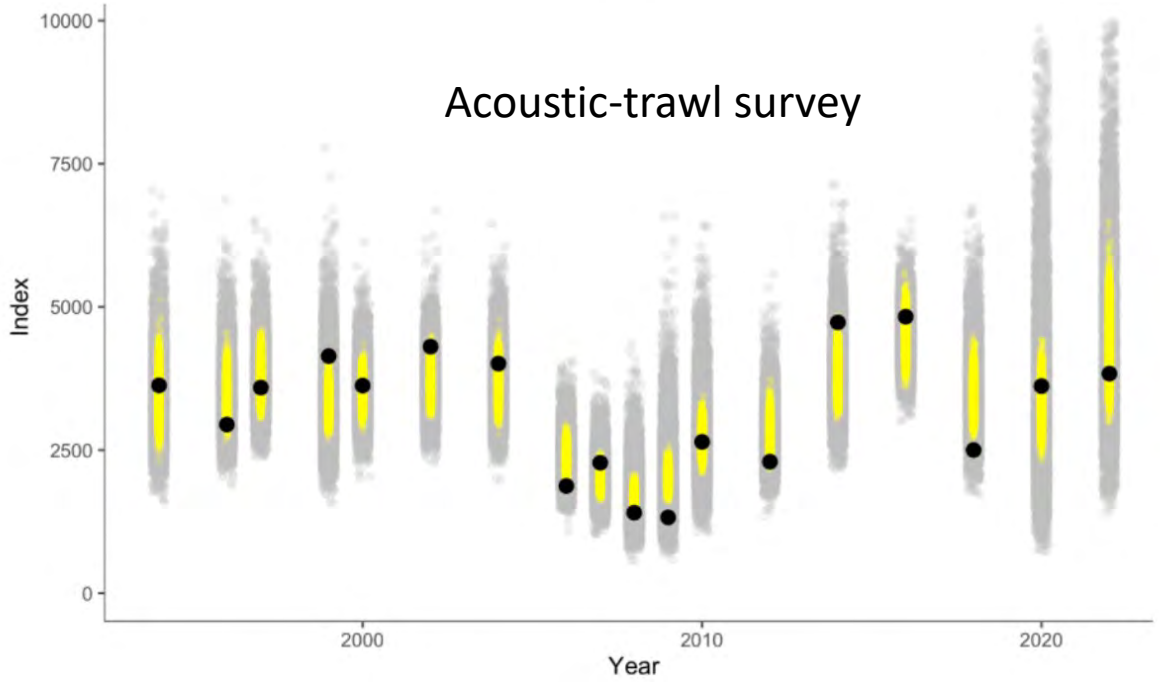


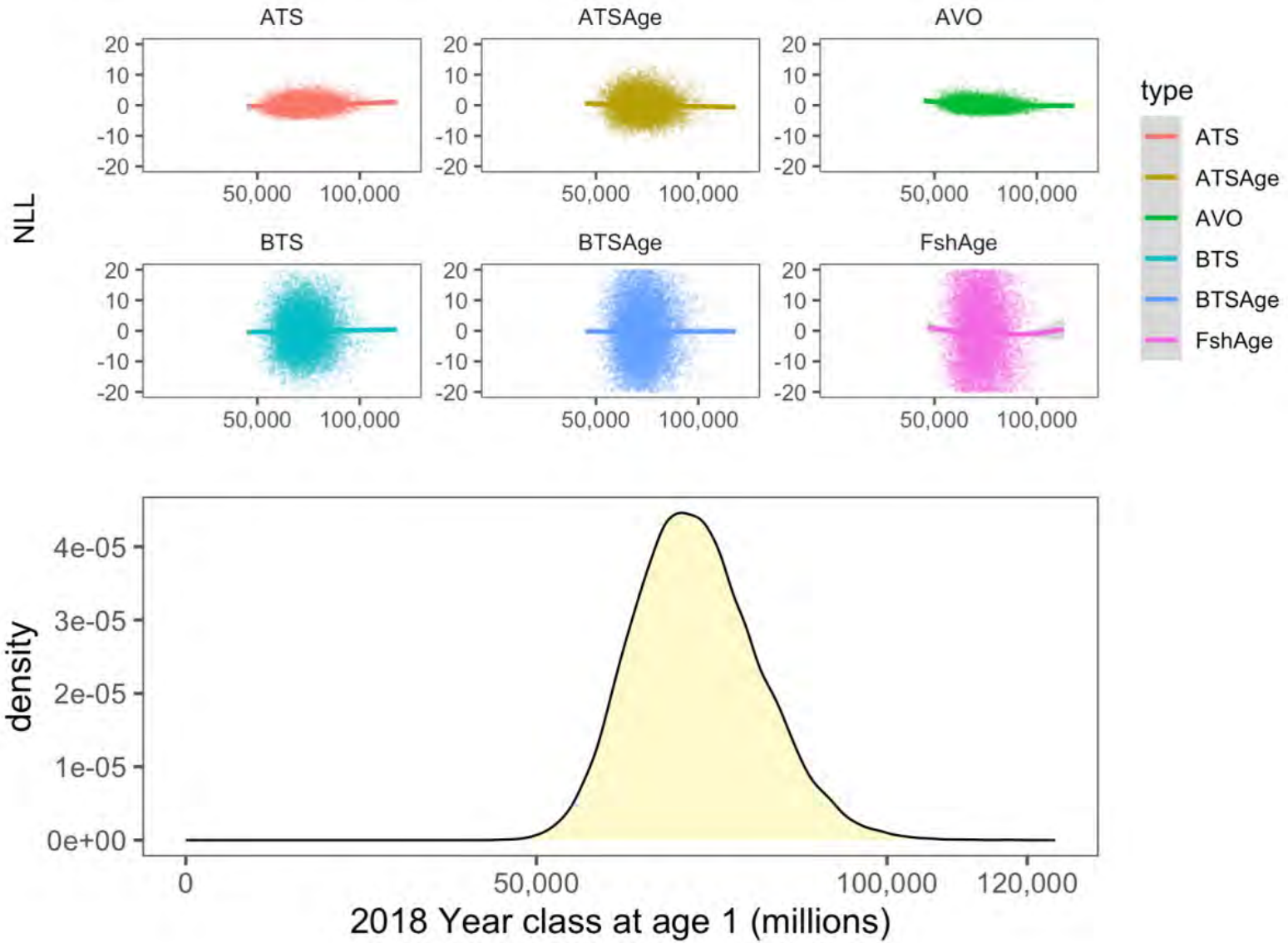
# Diagnostics?

# Posterior predictive distributions

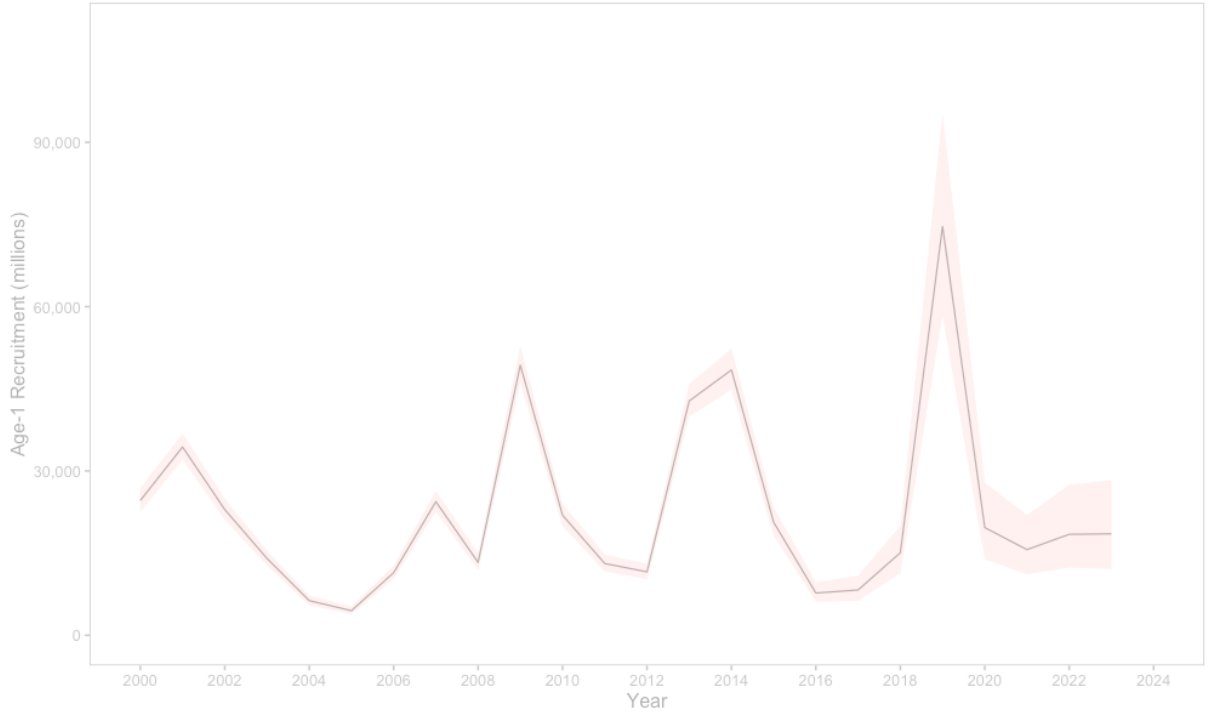
- Model check…



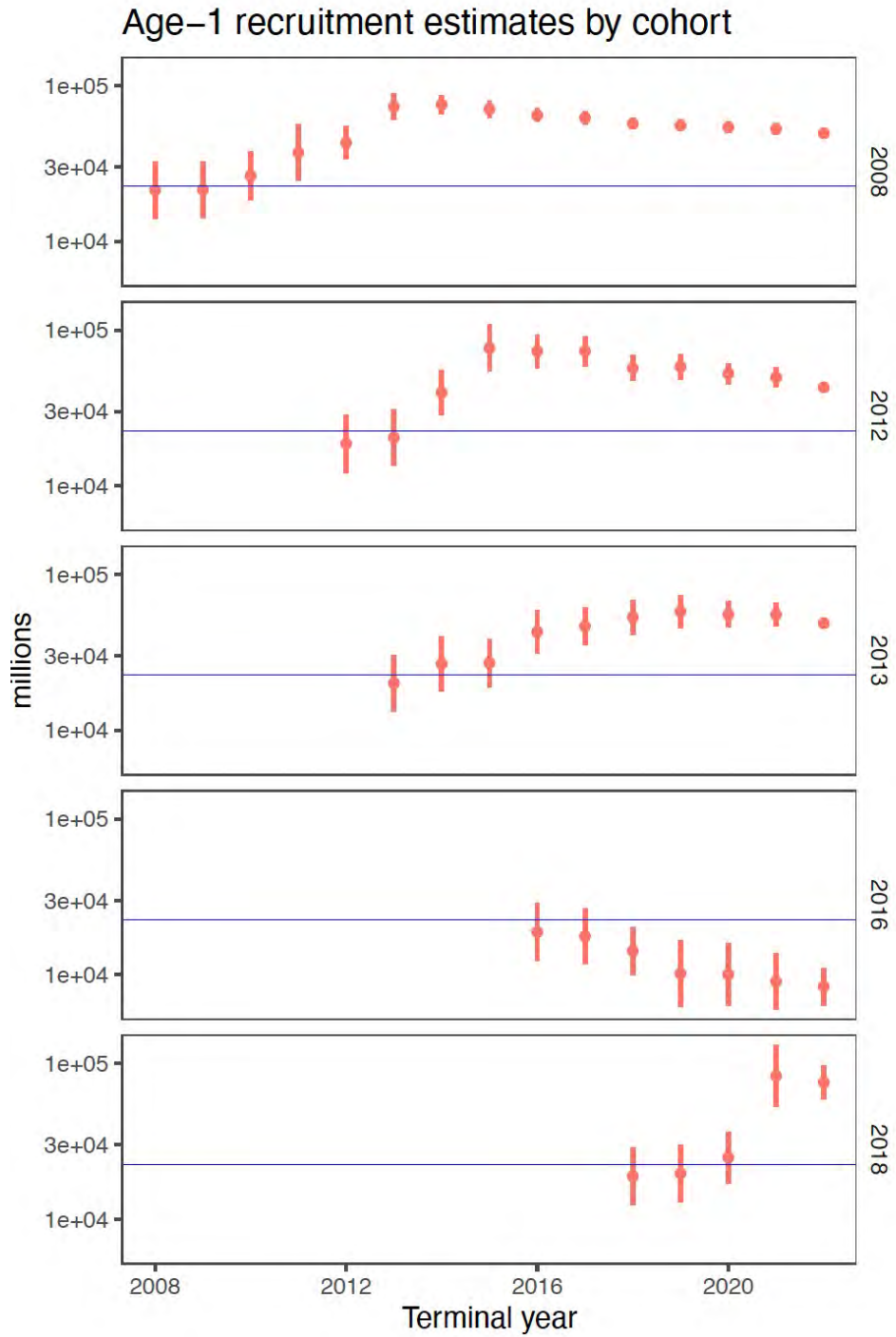




ATS
ATSAge
AVO
BTS
BTSAge
FshAge
NLL
20
10
0
-10
-20
50,000
100,000
type
ATS
ATSAge
AVO
BTS
BTSAge
FshAge
density
4e-05
3e-05
2e-05
1e-05
0e+00
0
50,000
100,000
120,000
2018 Year class at age 1 (millions)

# Retrospective patterns



# Retrospective patterns by cohort



# Retrospective selectivities

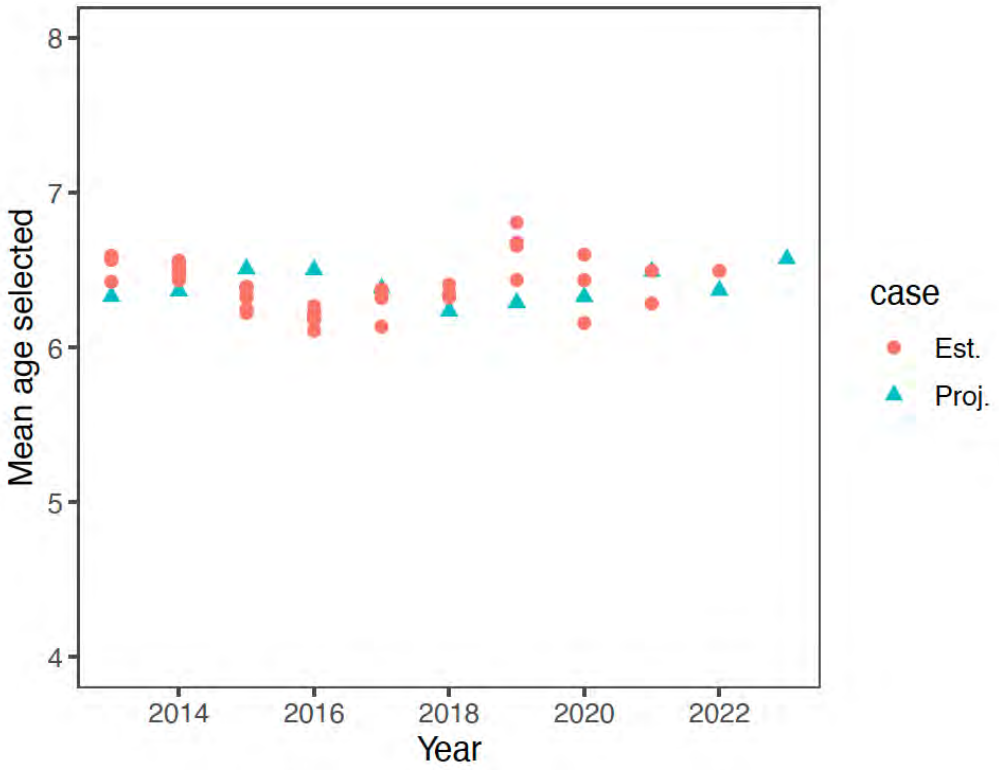



Figure 57: Retrospective pattern for the mean selected age (ages 1-8) based on estimated EBS pollock fishery selectivity compared to the projected selectivity from the year prior.

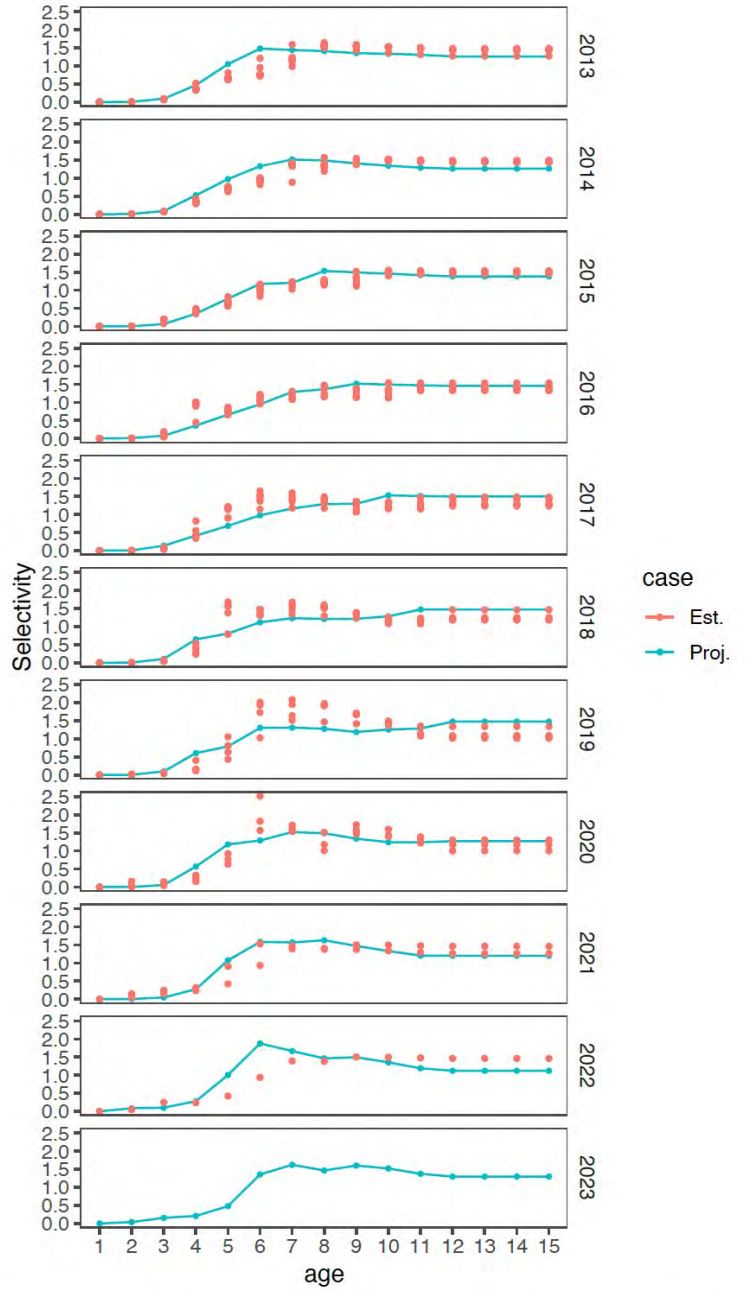
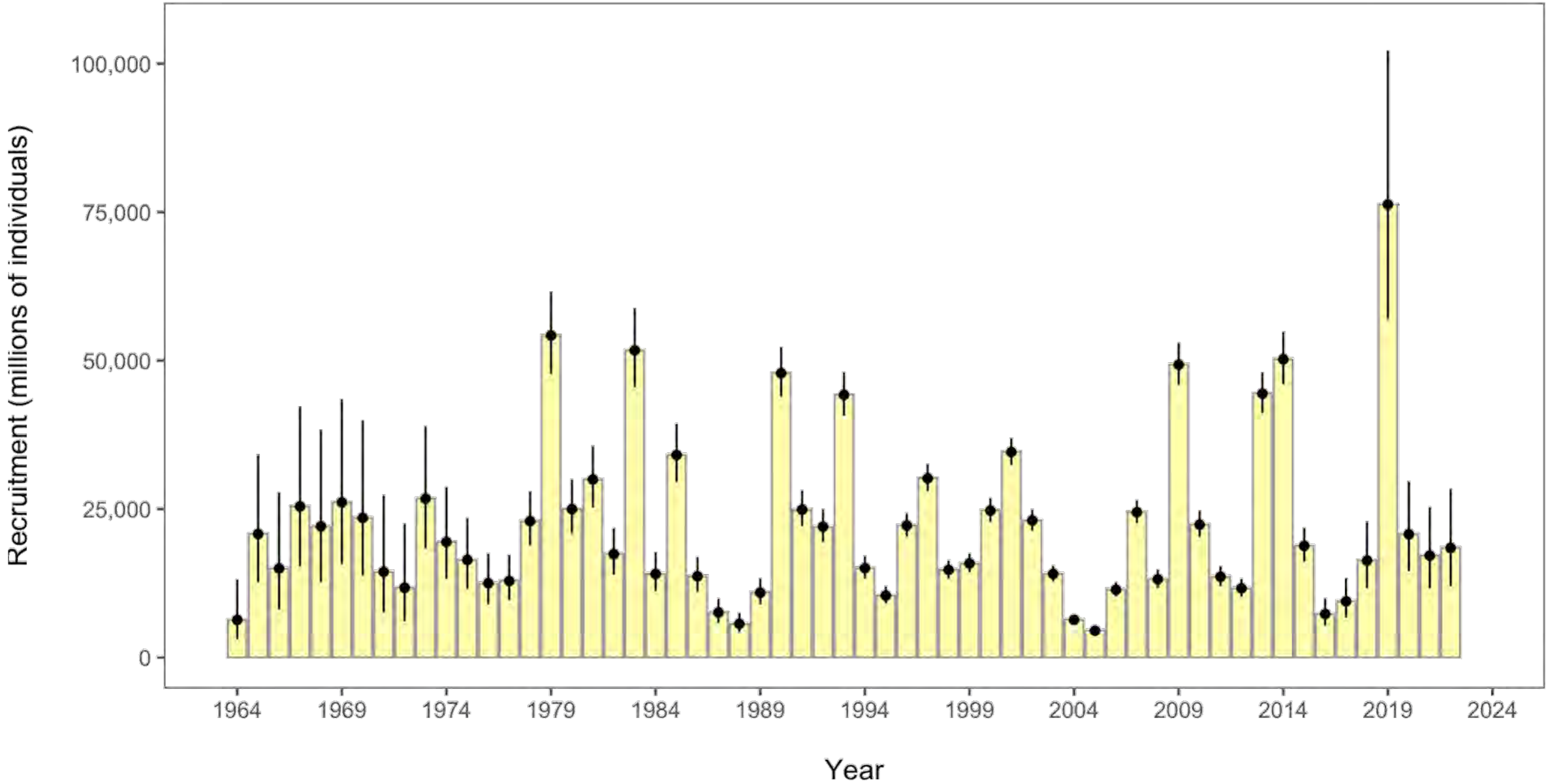


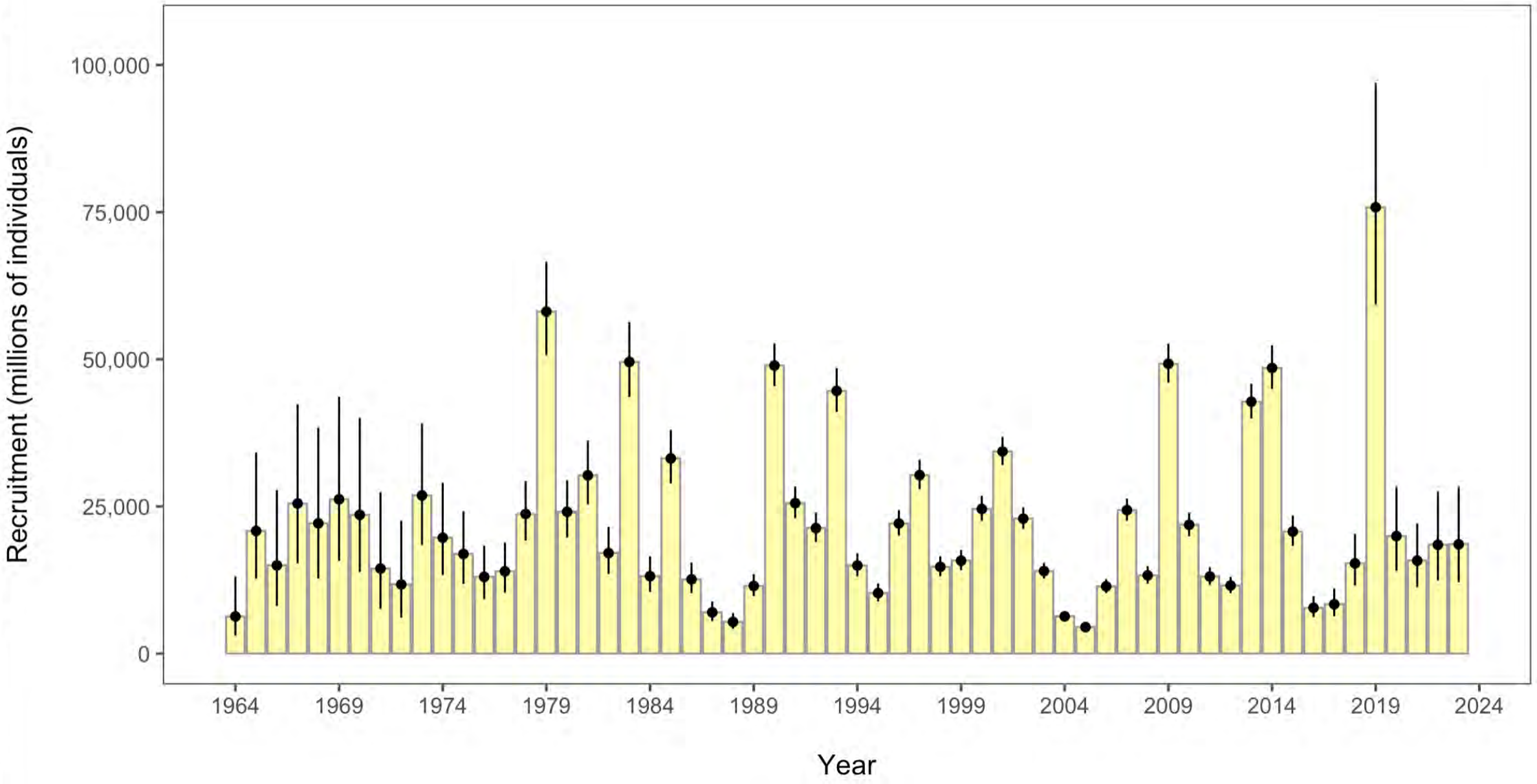

Figure 56: Retrospective pattern for estimated EBS pollock fishery selectivity (dots) compared to the projected selectivity from the year prior (solid line).

# Historical retrospectives
## (from past assessments)

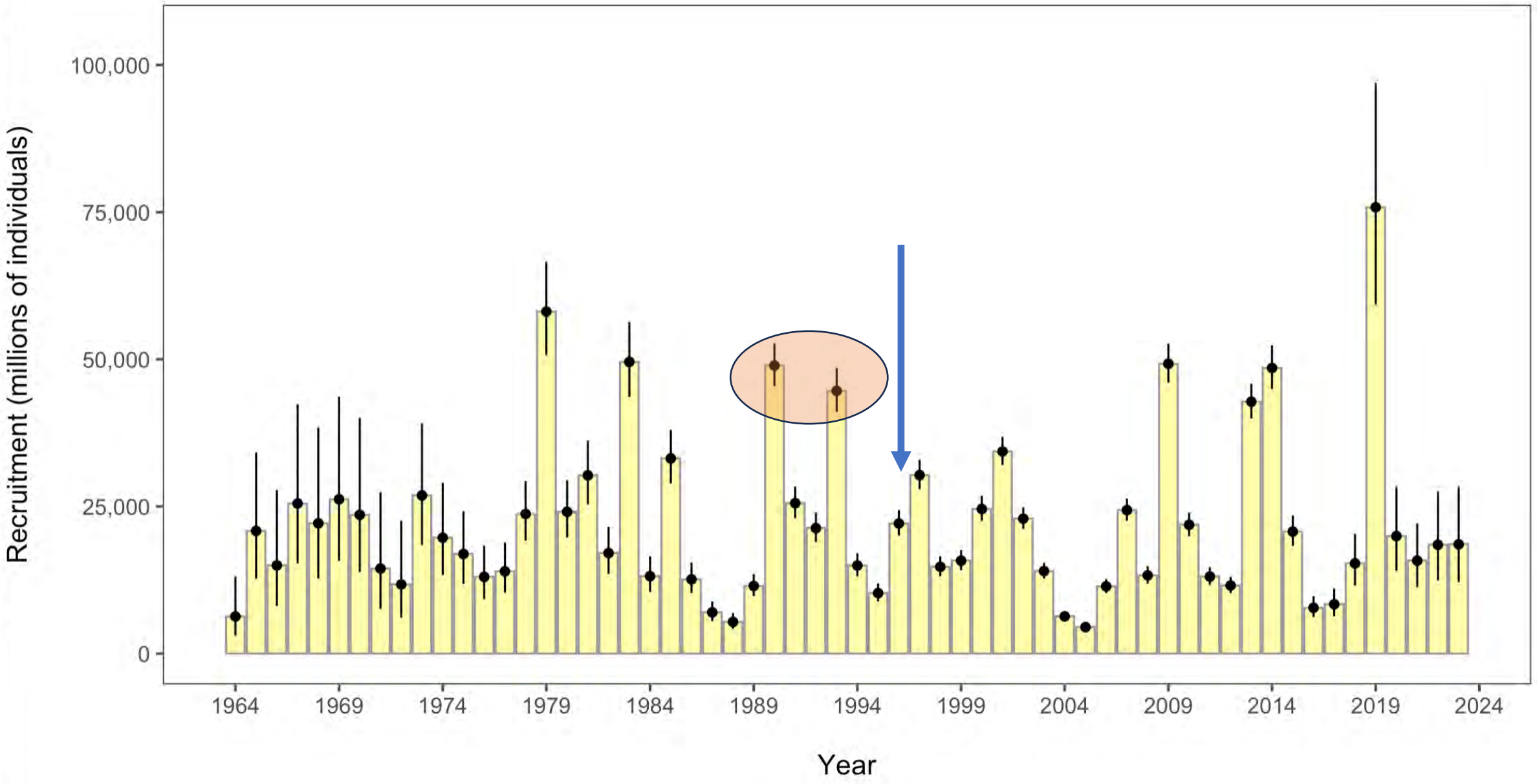
# Last year’s estimated recruitment

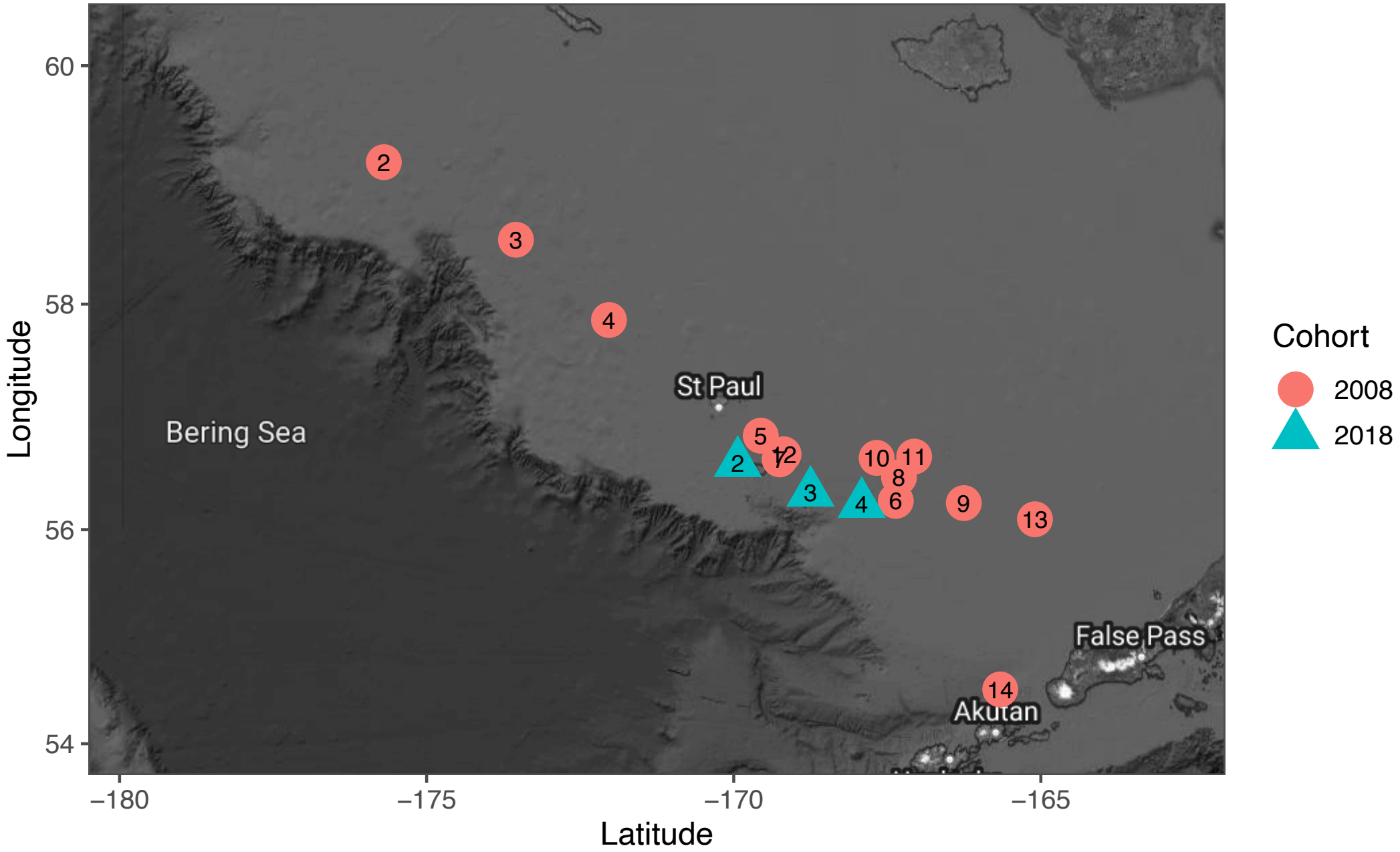


# This year's


Recruitment (millions of individuals)
100,000
75,000
50,000
25,000
0
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
2019
2024
Year

# This year's


Recruitment (millions of individuals)
100,000
75,000
50,000
25,000
0
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
2019
2024
Year


Longitude
60
58
56
54
Bering Sea
St Paul
False Pass
Akutan
2
3
4
5
12
10
11
8
6
9
13
14
2
3
4
−180
−175
−170
−165
Latitude
Cohort
2008
2018

# Outlook for recruitment?

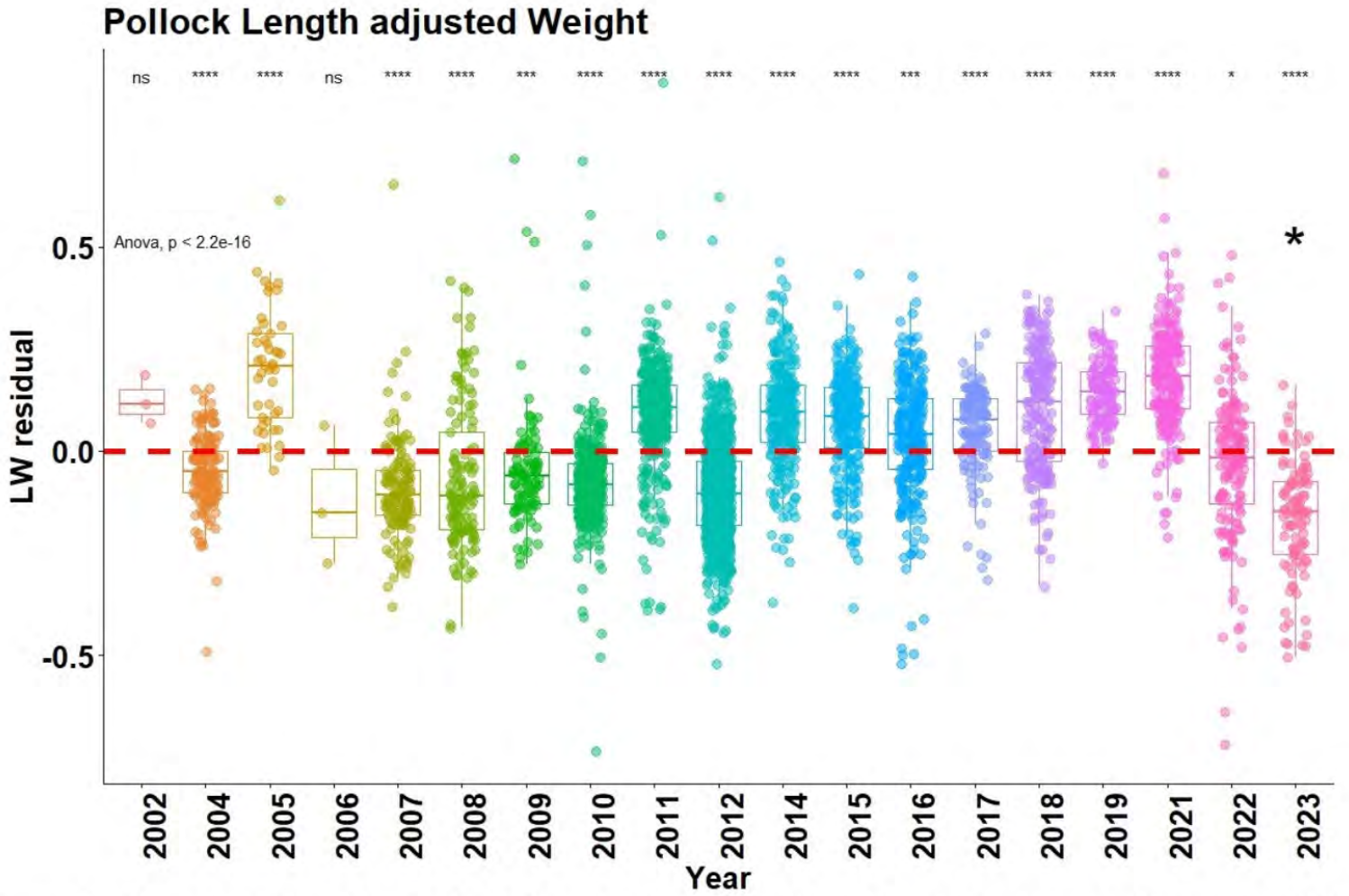



Figure 62: Annual length-weight residuals from log-transformed length-weight regressions for young-of-the-year walleye pollock. The horizontal line indicates the mean of all residuals, the significance of deviations from the mean are denoted by stars above the given year, and "ns" indicates not significant. Length is total length (mm) and mass is total body wet mass (grams). The asterisk above 2023 data indicates that these are preliminary results.

https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/EBSecosys.pdf

# Spawning biomass outlook

- Diversity of ages

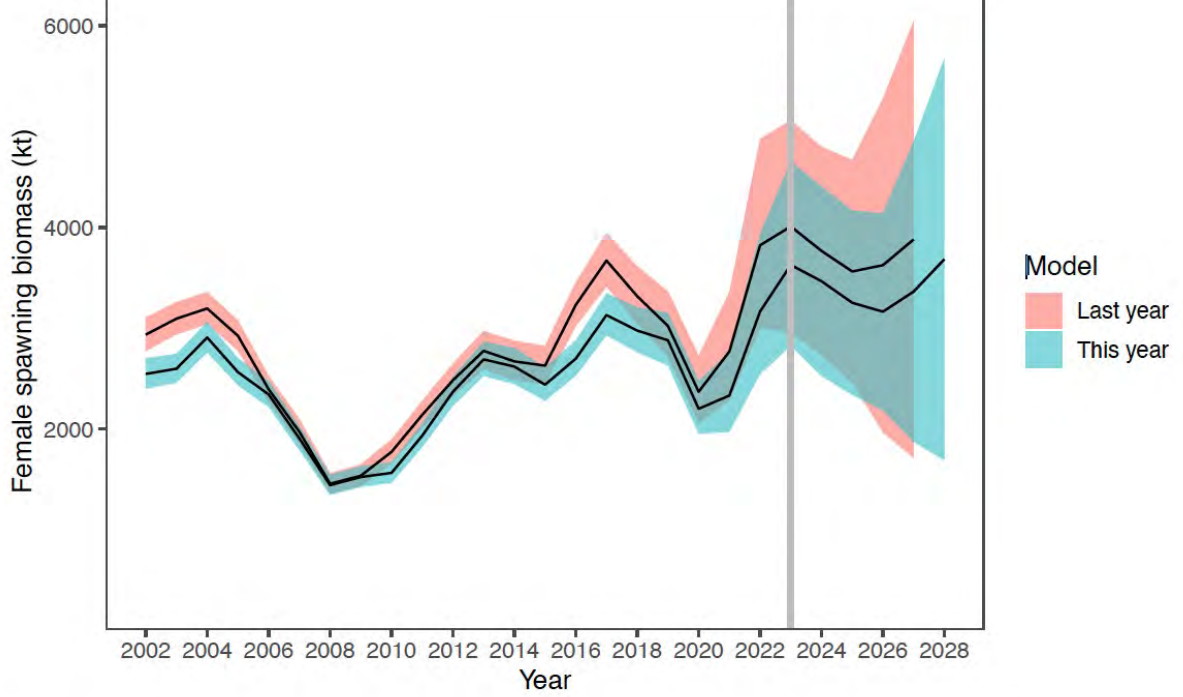



Figure 63: The estimated EBS pollock spawning stock biomass for model 20 last year and this with projections equal to the estimated fishing mortality from 2023.

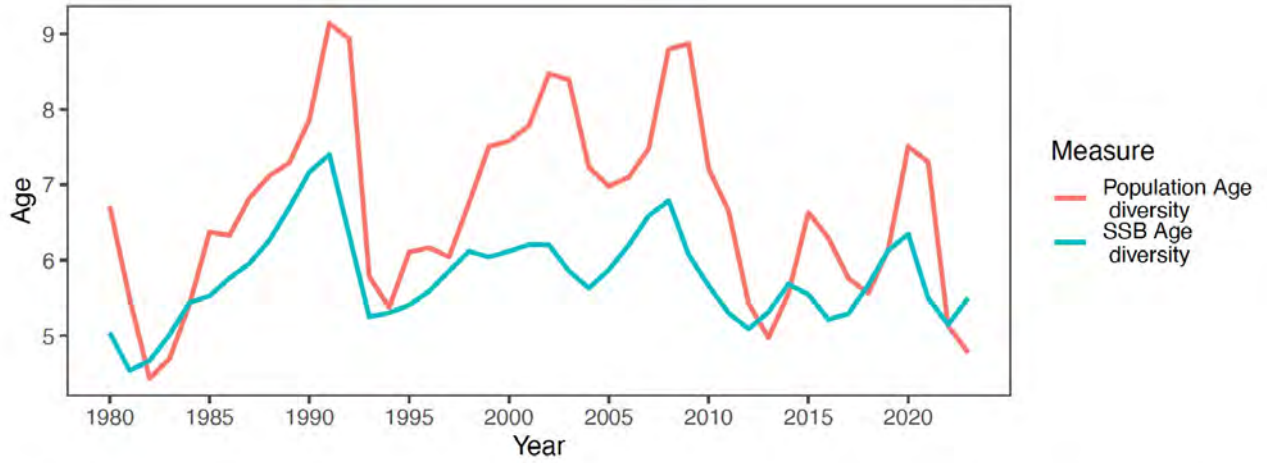



Figure 70: For the mature component of the EBS pollock stock, time series of estimated average age and diversity of ages (using the Shannon-Wiener H statistic), 1980–2023.

# Risk table

Page 40

These results are summarized as:

| Assessment-related | Considerations | | |
|---|---|---|---|
| | Population dynamics | Environmental ecosystem | Fisheries |
| Level 1: No concern | Level 1: No concern | Level 2: Major concern | Level 1: No concern |

Having a score at level 2 suggests that adjustments to the ABC may be prudent. In the past, the SSC has considered factors similar to those presented above and selected an ABC based on Tier 3 estimates. Last year the SSC requested examining Tier 2 values as an alternative. Unlike Tier 3, using Tier 2 would have a constant buffer relative to the Tier 1 value (at about 11%). Setting the ABC to Tier 3 levels provides a very large buffer but one that could be warranted given that the impact on subsequent spawning biomass levels will be much more variable and have a high probability of dropping below the target stock size and result in much reduced future ABCs under the current FMP. It is worth noting that fishing at the full Tier 1 ABC would imply a more than doubling of effort and well exceed the 2 million t groundfish catch limit. Even fishing at a full Tier 3 ABC shows there is a relatively high probability of falling below $B_{MSY}$ values or proxies thereof. Under our standard scenarios, Alternative 3 shows trajectories if fishing effort is held equal to the recent 5-year average. It is noteworthy

# Decision table description

Table 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 |
|---|---|---|
| $P[F_{2024} > F_{MSY}]$ | Probability that the fishing mortality in 2024 exceeds $F_{MSY}$ | OFL definition is based on $F_{MSY}$ |
| $P[B_{2025} < B_{MSY}]$ | Probability that the spawning biomass in 2025 is less than $B_{MSY}$ | $B_{MSY}$ is a reference point target and biomass in 2021 provides an indication of the impact of 2024 fishing |
| $P[B_{2026} < B_{MSY}]$ | Probability that the spawning biomass in 2026 is less than $B_{MSY}$ | $B_{MSY}$ is a reference point target and biomass in 2024 provides an indication of the impact of fishing in 2024 and 2025 |
| $P[B_{2026} < \bar{B}]$ | Probability that the spawning biomass in 2025 is less than the 1978–2023 mean | To provide some perspective of what the stock condition might be relative to historical estimates after fishing in 2024. |
| $P[B_{2028} < \bar{B}]$ | Probability that the spawning biomass in 2028 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 2024. |
| $P[B_{2028} < B_{2024}]$ | Probability that the spawning biomass in 2028 is less than that estimated for 2024 | To provide a medium term expectation of stock status relative to 2024 levels |
| $P[B_{2026} < B_{20\%}]$ | Probability that the spawning biomass in 2026 is less than $B_{20\%}$ | $B_{20\%}$ had been selected as a Steller Sea Lion lower limit for allowing directed fishing |
| $P[p_{a_5,2026} > \bar{p}_{a_5}]$ | Probability that in 2026 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. |
| $P[D_{2025} < D_{1994}]$ | Probability that the diversity of ages represented in the spawning biomass (by weight) in 2025 is less than the value estimated for 1994 | To provide a relative index on the abundance of different age classes in the 2025 population relative to 1994 (a year identified as having low age composition diversity) |
| $P[D_{2028} < D_{1994}]$ | Probability that the diversity of ages represented in the spawning biomass (by weight) in 2028 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) |
| $P[E_{2024} > E_{2023}]$ | Probability that the theoretical fishing effort in 2024 will be greater than that estimated in 2023. | To provide the relative effort that is expected (and hence some idea of costs). |

# Decision table estimates

Table 34: Outcomes of decision (expressed as chances out of 100) given different 2024 catches (first row, in kt). Note that for the 2021 and later year-classes average values were assumed. Constant Fs based on the 2024 catches were used for subsequent years.

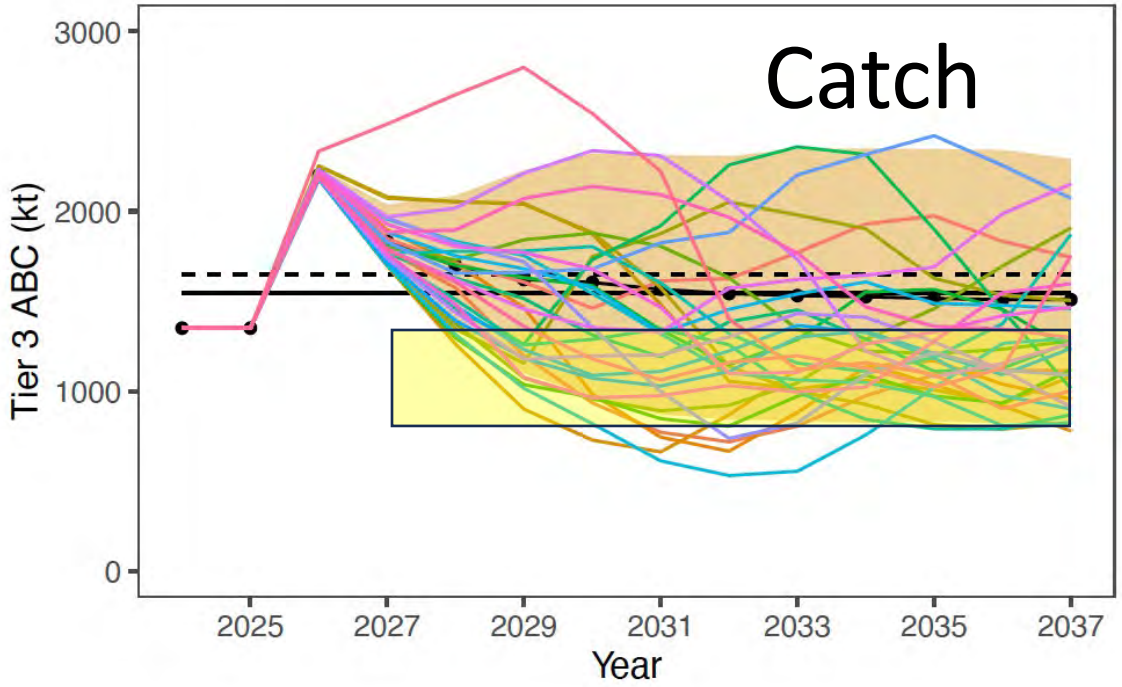
| | 10 | 850 | 1000 | 1260 | 1150 | 1300 | 1450 | 1600 |
|---|---|---|---|---|---|---|---|---|
| $P\left[F_{2024} > F_{MSY}\right]$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $P\left[B_{2024} < B_{MSY}\right]$ | 9 | 17 | 20 | 24 | 22 | 25 | 28 | 31 |
| $P\left[B_{2025} < B_{MSY}\right]$ | 5 | 17 | 21 | 28 | 25 | 30 | 35 | 40 |
| $P\left[B_{2024} < \bar{B}\right]$ | 0 | 2 | 3 | 5 | 4 | 6 | 8 | 11 |
| $P\left[B_{2027} < \bar{B}\right]$ | 0 | 6 | 9 | 14 | 12 | 15 | 18 | 22 |
| $P\left[B_{2027} < B_{2023}\right]$ | 6 | 30 | 36 | 46 | 42 | 48 | 53 | 58 |
| $P\left[B_{2025} < B_{20\%}\right]$ | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| $P\left[p_{a_5,2024} > \bar{p}_{a_5}\right]$ | 7 | 42 | 48 | 58 | 54 | 60 | 64 | 68 |
| $P\left[D_{2024} < D_{1994}\right]$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| $P\left[D_{2027} < D_{1994}\right]$ | 0 | 1 | 2 | 4 | 3 | 4 | 6 | 8 |
| $P\left[E_{2024} > E_{2023}\right]$ | 0 | 4 | 15 | 43 | 31 | 47 | 61 | 71 |

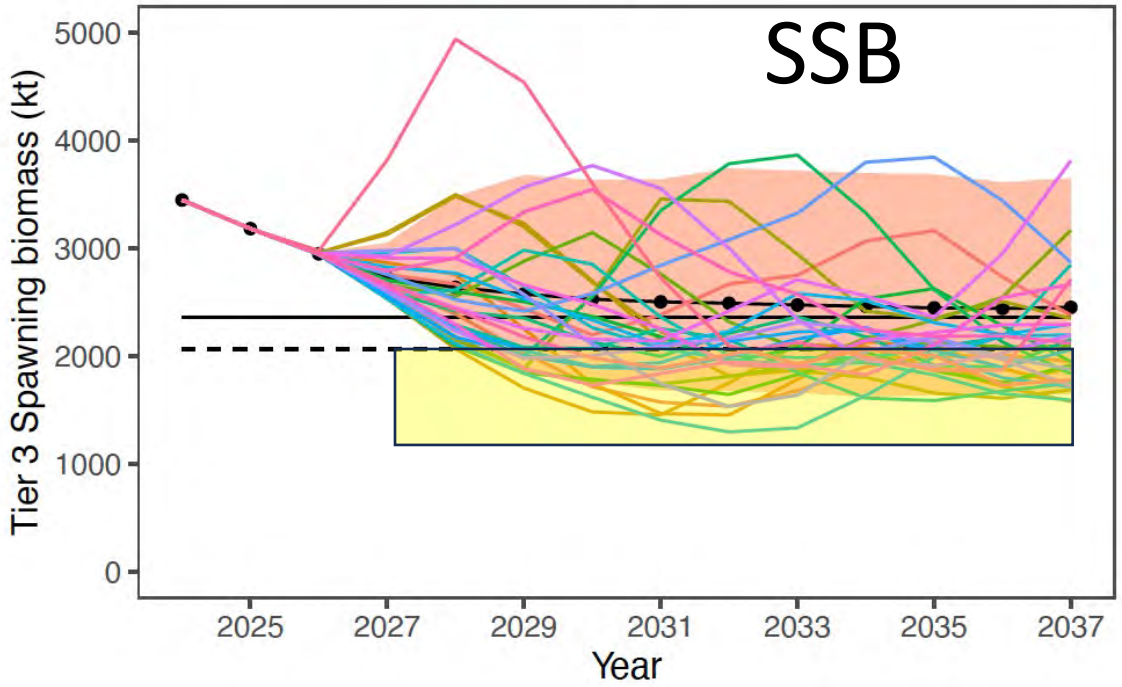
**Catch in kt for 2024**

# Some simple projections

# Tier 3-max permissible ABC

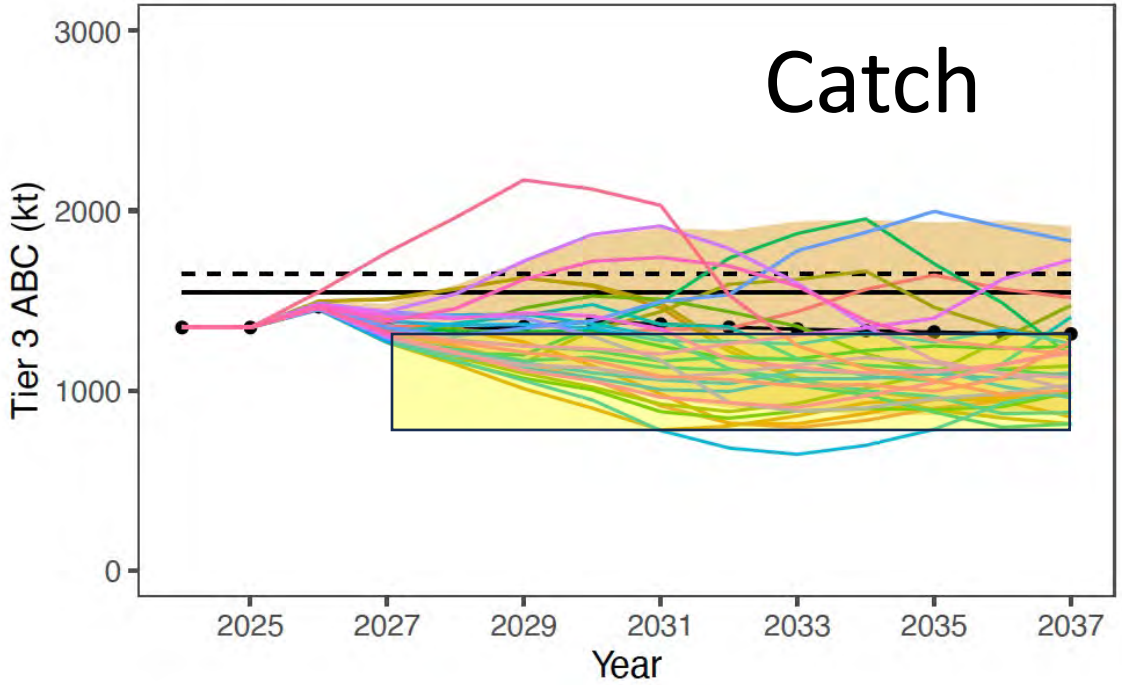
- Projections

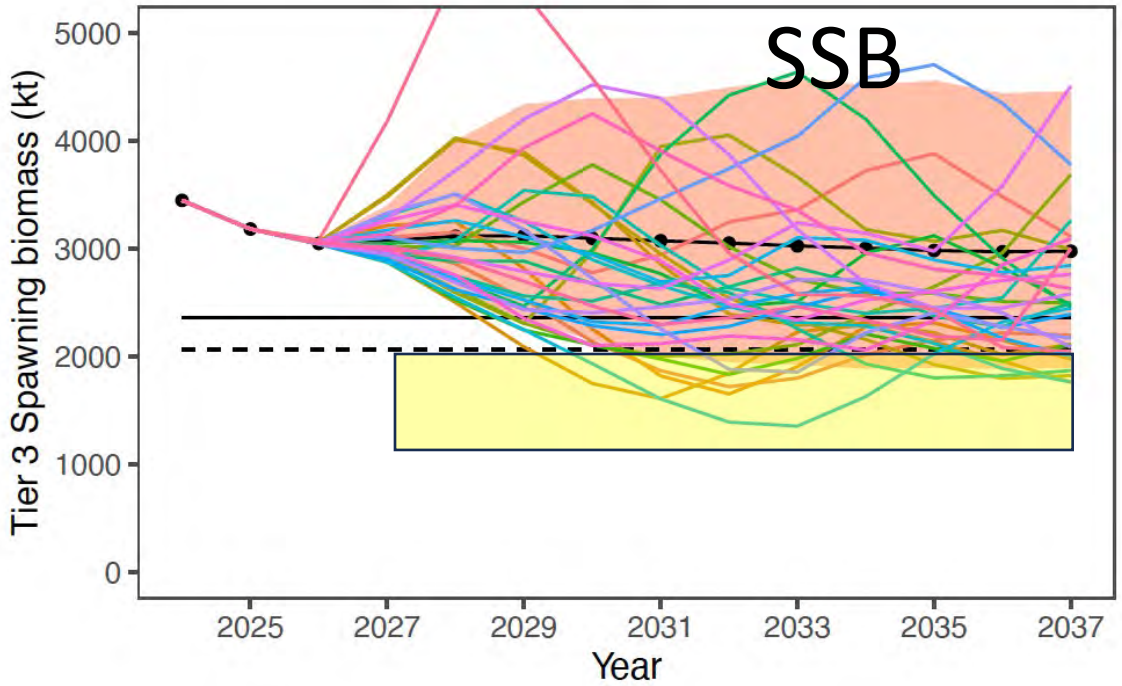


# Fishing at recent average *F*

- Projections



# EBS pollock summary

| Quantity | As estimated or *specified* *last* year for: 2023 | 2024 | As estimated or *recommended* *this* year for: 2024 | 2025 |
|---|---|---|---|---|
| M (natural mortality rate, ages 3+) | 0.3 | 0.3 | 0.3 | 0.3 |
| Tier | 1a | 1a | 1a | 1a |
| Projected total (age 3+) biomass (t) | 12,389,000 t | 11,445,000 t | 10,184,000 t | 9,437,000 t |
| Projected female spawning biomass (t) | 4,171,000 t | 3,944,000 t | 3,518,000 t | 3,255,000 t |
| $B_0$ | 6,653,000 t | 6,653,000 t | 6,728,000 t | 6,728,000 t |
| $B_{msy}$ | 2,674,000 t | 2,674,000 t | 2,689,000 t | 2,689,000 t |
| $F_{OFL}$ | 0.491 | 0.491 | 0.422 | 0.422 |
| $maxF_{ABC}$ | 0.434 | 0.434 | 0.379 | 0.379 |
| $F_{ABC}$ | 0.365 | 0.365 | 0.33 | 0.33 |
| $OFL$ | 3,381,000 t | 4,639,000 t | 3,162,000 t | 3,449,000 t |
| $maxABC$ | 2,987,000 t | 4,099,000 t | 2,837,000 t | 3,095,000 t |
| $ABC$ | 1,910,000 t | 2,275,000 t | 2,313,000 t | 2,401,000 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 |