EBS Pollock stock assessment

James Ianelli, Ben Fissel, Kirstin Holsman, Alex De Robertis, Taina Honkalehto, Stan Kotwicki, Cole Monnahan, Elizabeth Siddon, and James Thorson

Alaska Fisheries Science Center, National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE., Seattle, WA 98115-6349
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The following table applies for Model 16.2, the model used for last year's assessment advice. An alternative table is provided for this same model but ignores the new Saildrone acoustic data collected in 2020. As in past years, the ABC recommendation reflects the Tier 3 estimate.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2020	2021	2021	2022
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)	9,128,000 t	8,494,000 t	8,129,000 t	7,633,000 t
Projected female spawning biomass (t)	2,991,000 t	2,674,000 t	2,592,000 t	2,400,000 t
B_0	5,777,000 t	5,777,000 t	5,799,000 t	5,799,000 t
B_{msy}	2,148,000 t	2,148,000 t	2,259,000 t	2,259,000 t
F_{OFL}	0.449	0.449	0.342	0.342
$maxF_{ABC}$	0.383	0.383	0.304	0.304
F_{ABC}	0.225	0.225	0.215	0.215
OFL	4,085,000 t	3,385,000 t	2,584,000 t	2,364,000 t
$maxABC$	3,485,000 t	2,888,000 t	2,298,000 t	2,102,000 t
ABC	2,043,000 t	1,767,000 t	1,626,000 t	1,484,000 t
Status	2018	2019	2019	2020
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

The following table applies for Model 20.0, the model used for last year's assessment but with data from the uncrewed surface vehicles (USVs) included as an extension of the acoustic trawl survey. An alternative table is provided for this model which excludes the USV data from 2020. As in past years, the ABC recommendation reflects the Tier 3 estimate.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2020	2021	2021	2022
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)	9,128,000 t	8,494,000 t	8,145,000 t	7,641,000 t
Projected female spawning biomass (t)	2,991,000 t	2,674,000 t	2,602,000 t	2,406,000 t
B_0	5,777,000 t	5,777,000 t	5,792,000 t	5,792,000 t
B_{msy}	2,148,000 t	2,148,000 t	2,257,000 t	2,257,000 t
F_{OFL}	0.449	0.449	0.341	0.341
$maxF_{ABC}$	0.383	0.383	0.304	0.304
F_{ABC}	0.225	0.225	0.214	0.214
OFL	4,085,000 t	3,385,000 t	2,594,000 t	2,366,000 t
$maxABC$	3,485,000 t	2,888,000 t	2,307,000 t	2,105,000 t
ABC	2,043,000 t	1,767,000 t	1,626,000 t	1,484,000 t
Status	2018	2019	2019	2020
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Response to SSC and Plan Team comments

General comments

The SSC recommended that a detailed review of the support for retaining the EBS Pollock assessment in Tier 1 versus reclassifying it as Tier 3 be pursued in the 2020 assessment.

- *We evaluated factors affecting the Tier classification.*

The SSC had a number of recommendations for additional research supporting this assessment:

The SSC encourages further investigation of the apparent shift between a clear 2012 year-class to mixed 2012-2013 year classes in the data, suggestive of potentially variable ageing bias.

- *The newly available 2019 fishery age data shows a similar relative proportion of these two year classes; this suggests (based on earlier inquiries with the age-determination experts) that this pattern is reasonable.*

Noting the work in deriving an external estimate of temporal variability in catchability for the bottom trawl survey (relative to the acoustic survey) due to vertical availability, the SSC noted that catchability would logically also vary for the acoustic survey. The SSC encourages further work to develop the simultaneous modelling of these two surveys, accounting for vertical and distributional shifts (including into the northern Bering Sea survey area; NBS). When sufficiently explored, the SSC looks forward to assessment model configurations that explore the use of a time-series from this method.

- *Work on this topic stalled as analysts focused their efforts on methods to incorporate the uncrewed surface vessels (USVs) to collect acoustic data.*

The SSC supports ongoing genetic studies to determine the relationship between pollock in the NBS and EBS, as well as other surrounding regions (AI, GOA).

- *A post doctoral researcher has begun this work but progress has been limited due to lab access and other factors related to the pandemic.*

The SSC supports the continued use of a formal decision table to illustrate risks of alternative harvest strategies.

- *This was included in this year's assessment report.*

SSC / PT requests

The SSC also looks forward to estimates of movement and abundance along the US-Russia EEZ boundary based on echosounders fixed to moorings in this area.

- *The moored sounders have been recovered in September 2020 but the data have yet to be processed.*

From previous requests:

Re-examine the geographic subset of data currently used to develop the AVO index, specifically to see if including Bristol Bay data improves the correlation.

- *Work on this continues but was given lower priority given that the AVO was not part of this year's assessment.*

Explore "A" season trends in mean weight-at-length with a GAM or similar technique, to determine if the trends are either predominantly environmental or predominantly fishery-driven, Regarding σ_R, explore alternative fixed values or estimation methods.

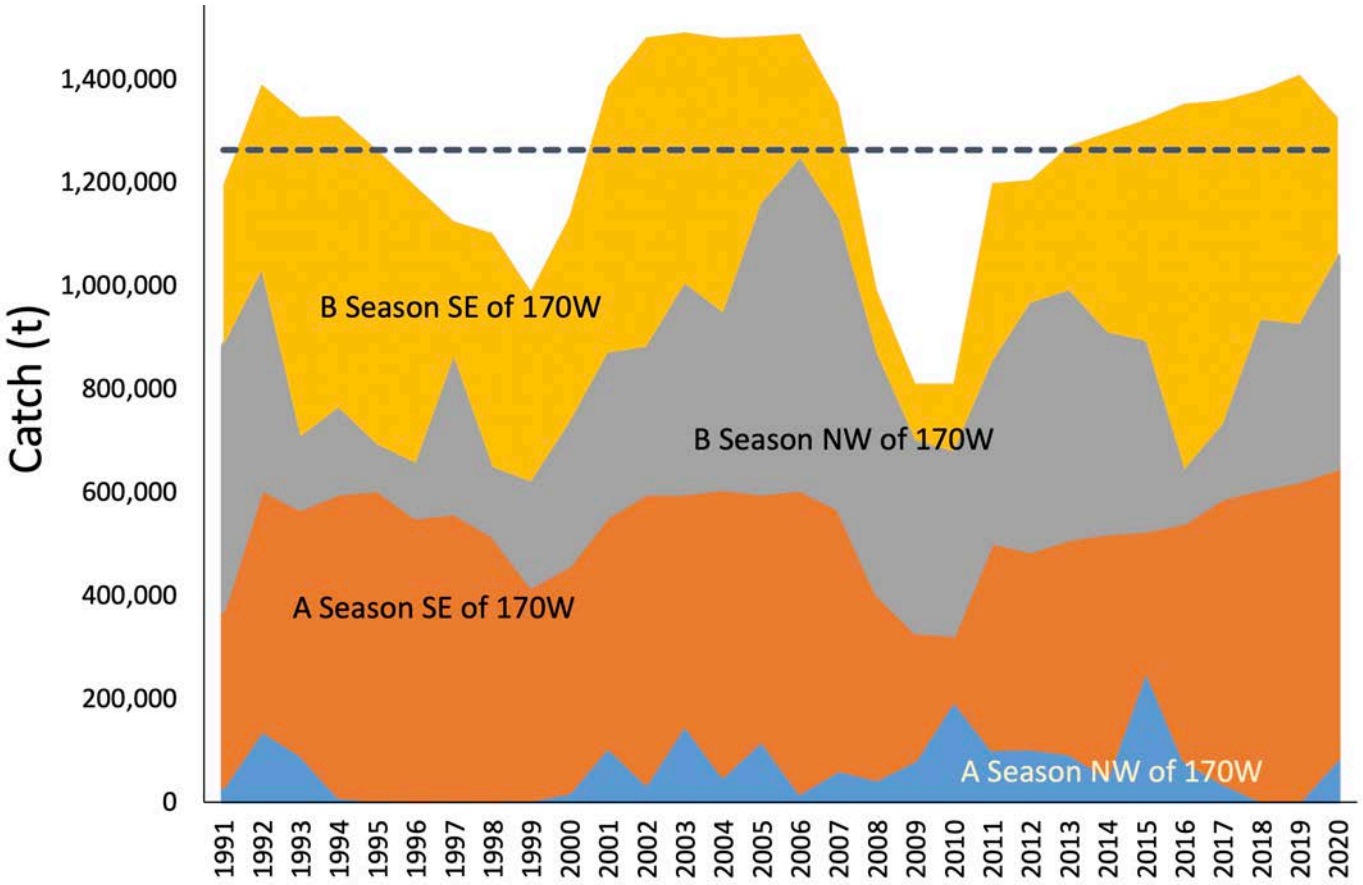
- *Trends in mean weight given length are again presented. The extent that fishery affects this pattern was shown to be related to timing. Further work is needed to establish a mean baseline (in time and space) to try to sort out environmental effects hypotheses. Values of σ_R were explored in previous years, no further work was done on this in 2020.*

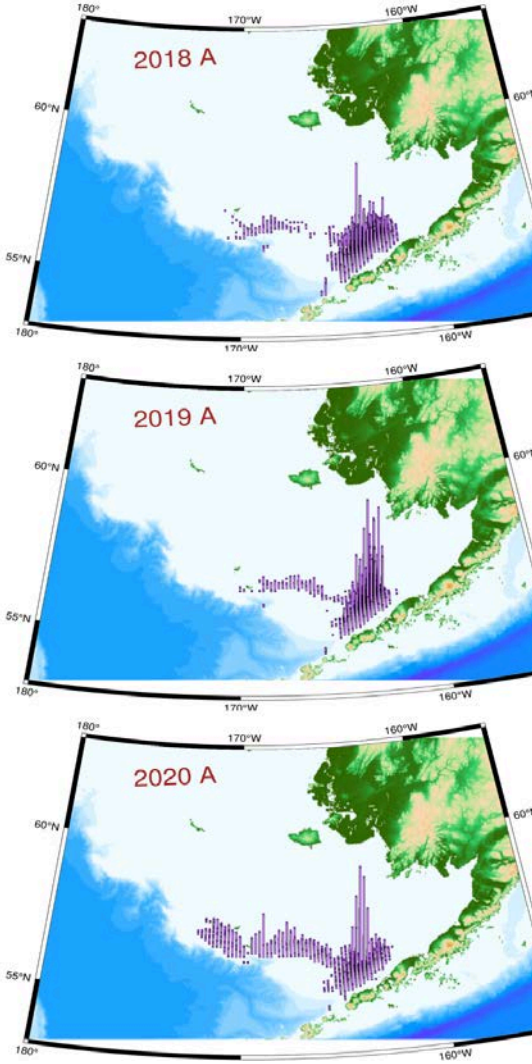
EBS Pollock

Fishery data

Seasonal and area catch patterns

Eastern Bering Sea pollock

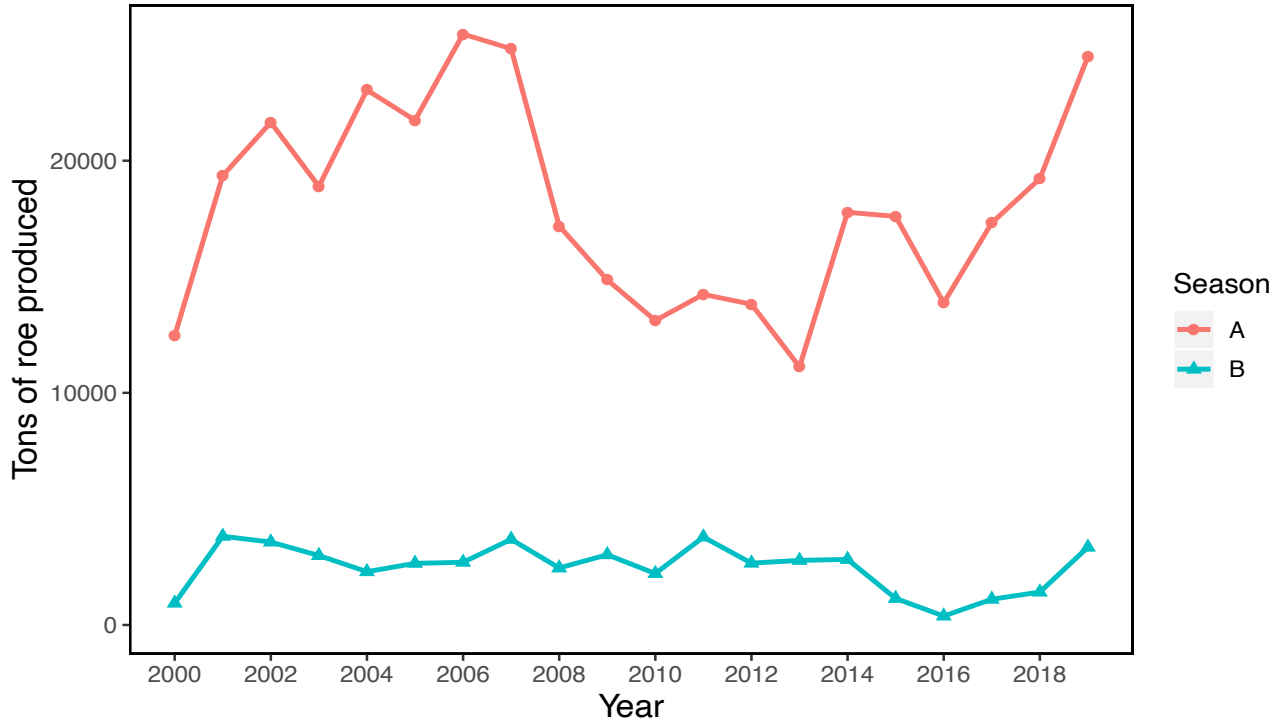




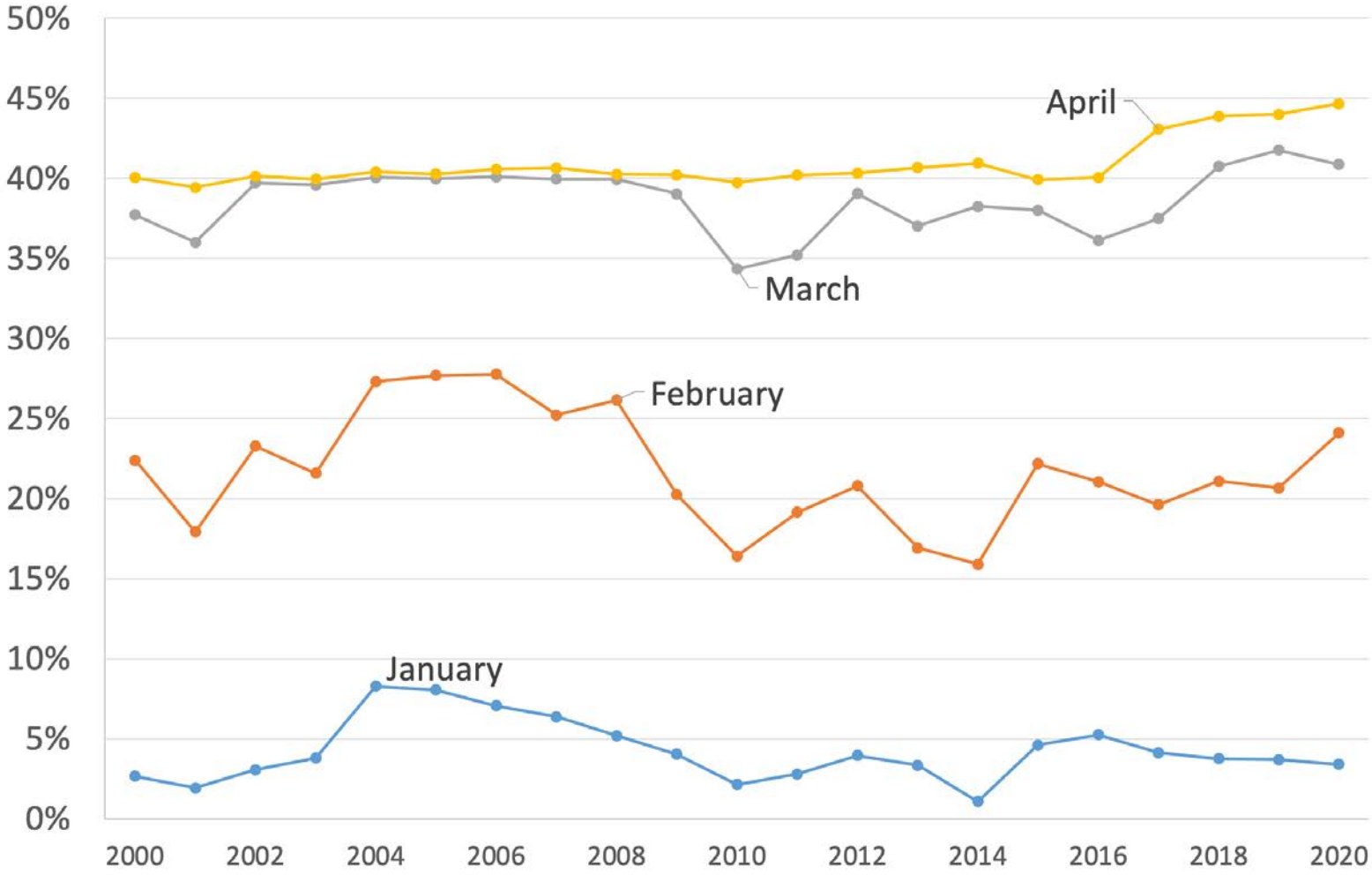
Pollock product forms...

Year	Pollock catch	"Recovery" Products / Catch	t pollock discarded	Proportion discarded	Proportion Fishmeal	Proportion Fillets	Proportion Roe
2000	1,132,739	9%	21,620	1.9%	10%		7%
2001	1,387,455	12%	17,324	1.2%	10%	28%	7%
2002	1,481,818	13%	20,870	1.4%	9%	30%	7%
2003	1,490,804	14%	16,754	1.1%	9%	34%	6%
2004	1,480,548	14%	23,161	1.6%	9%	34%	7%
2005	1,483,002	15%	17,424	1.2%	9%	32%	6%
2006	1,488,030	14%	15,554	1.0%	8%	34%	8%
2007	1,354,502	16%	16,103	1.2%	7%	34%	7%
2008	990,587	16%	7,611	0.8%	8%	34%	7%
2009	810,857	20%	5,951	0.7%	7%	36%	5%
2010	810,362	21%	3,760	0.5%	8%	33%	5%
2011	1,199,213	18%	4,822	0.4%	8%	34%	5%
2012	1,205,293	19%	5,271	0.4%	8%	33%	4%
2013	1,270,827	20%	5,311	0.4%	8%	34%	3%
2014	1,297,849	20%	14,343	1.1%	8%	34%	4%
2015	1,322,317	19%	9,475	0.7%	9%	33%	5%
2016	1,353,686	18%	9,160	0.7%	10%	29%	4%
2017	1,359,367	19%	8,205	0.6%	10%	31%	4%
2018	1,379,301	18%	11,175	0.8%	10%	33%	5%
2019	1,409,235	18%	9,097	0.6%	10%	34%	6%
2020	1,325,792	16%	11,605	0.9%	11%	32%	7%

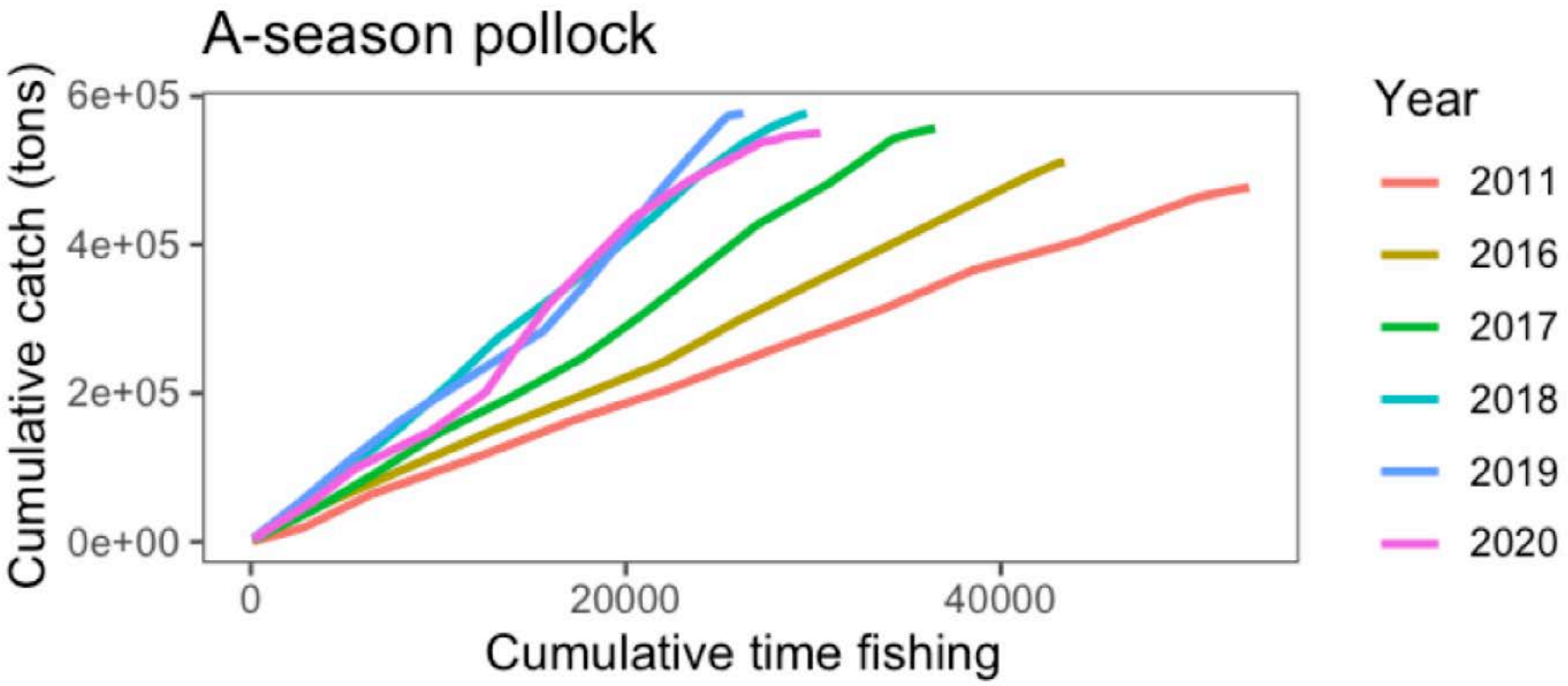
Fishing: Seasonal roe production



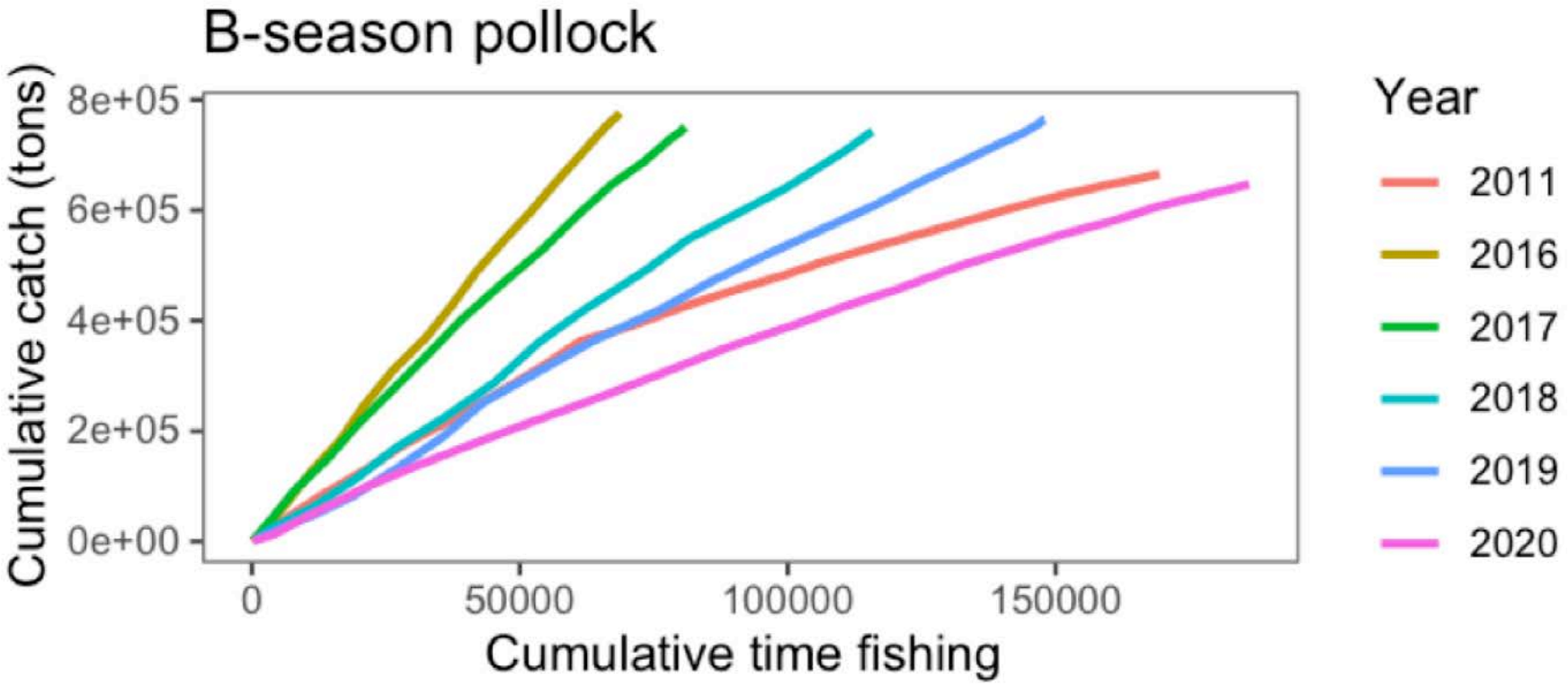
Cumulative pollock catch by month as proportion of TAC

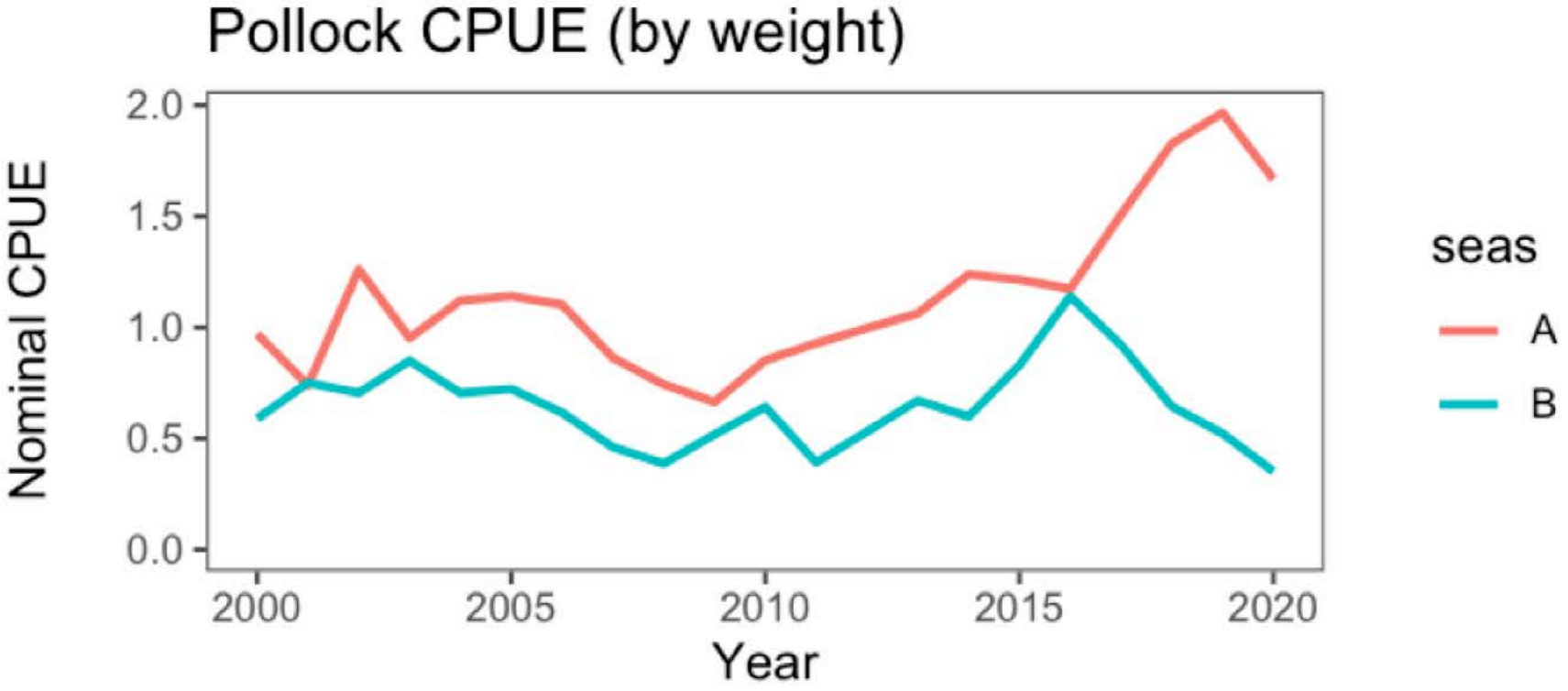


Fishing conditions

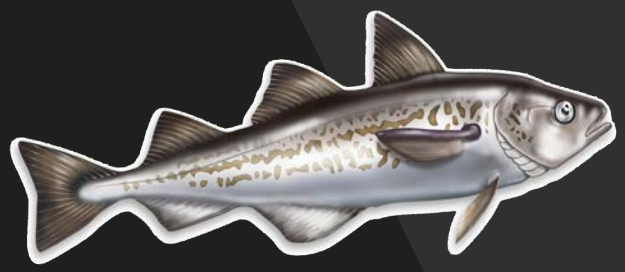


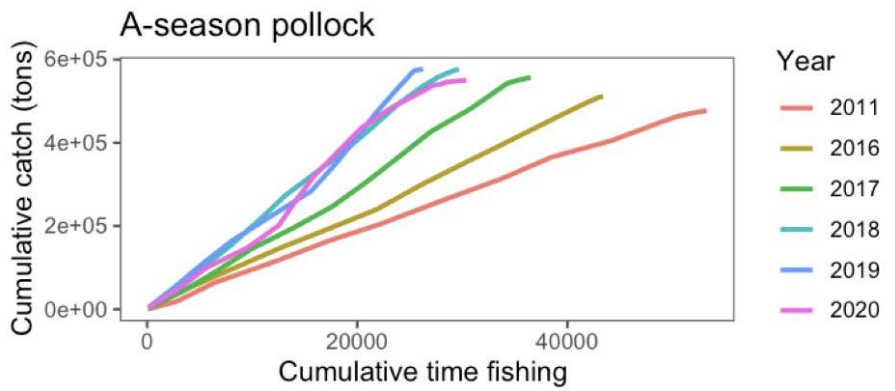
Fishing conditions

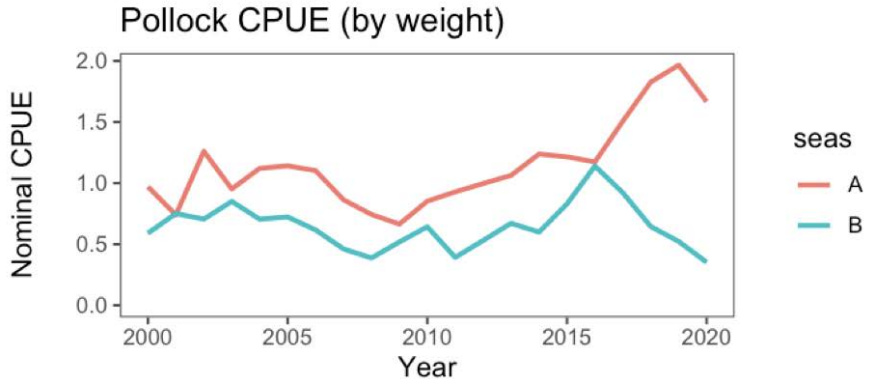


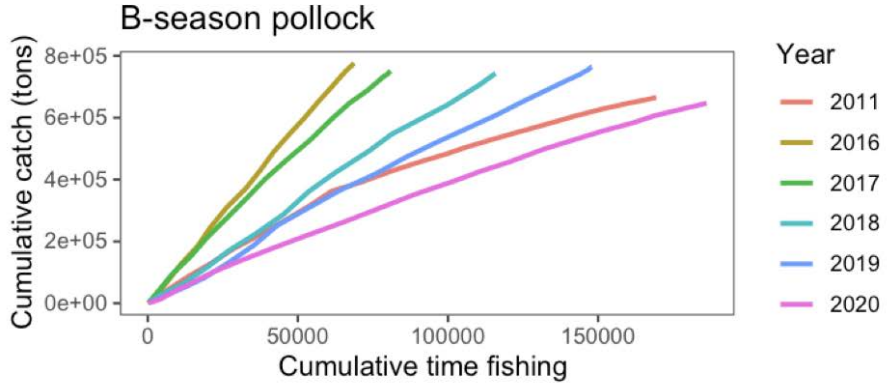

Pollock CPUE (by weight)
Nominal CPUE
2.0
1.5
1.0
0.5
0.0
2000
2005
2010
2015
2020
Year
seas
A
B

Fishing conditions

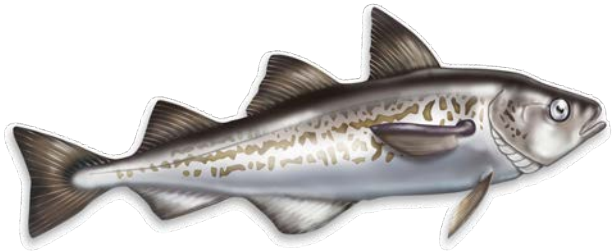


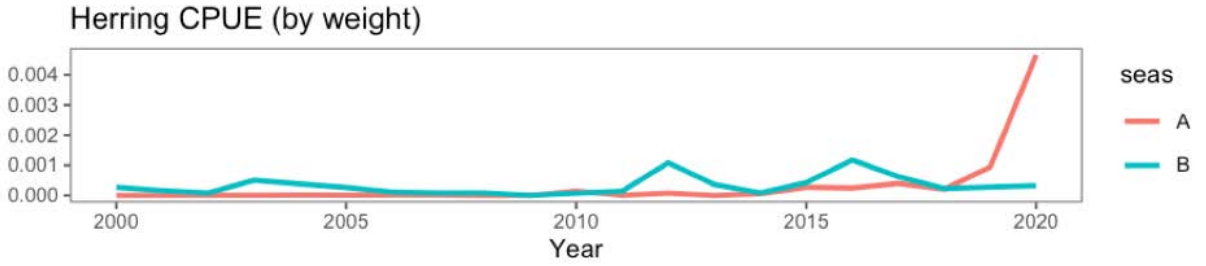


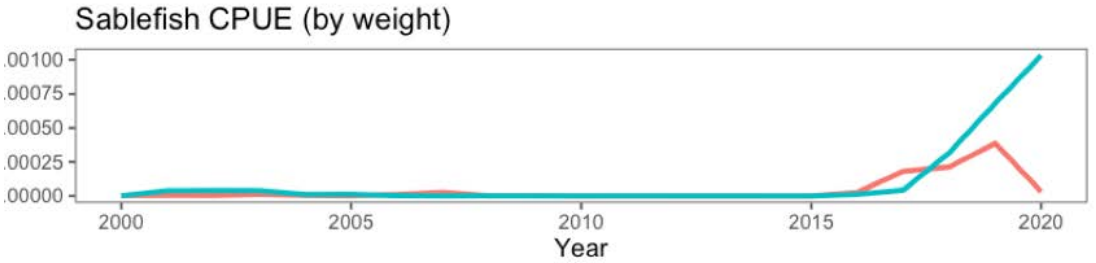


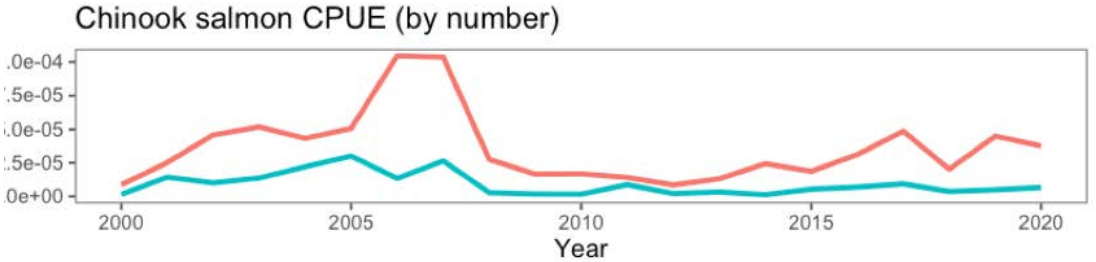


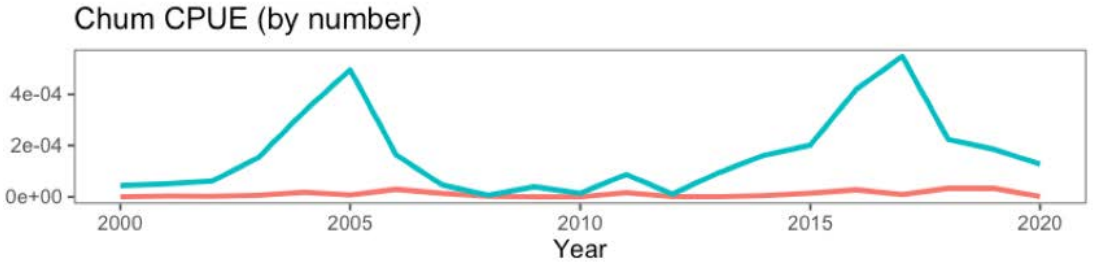
CPUE

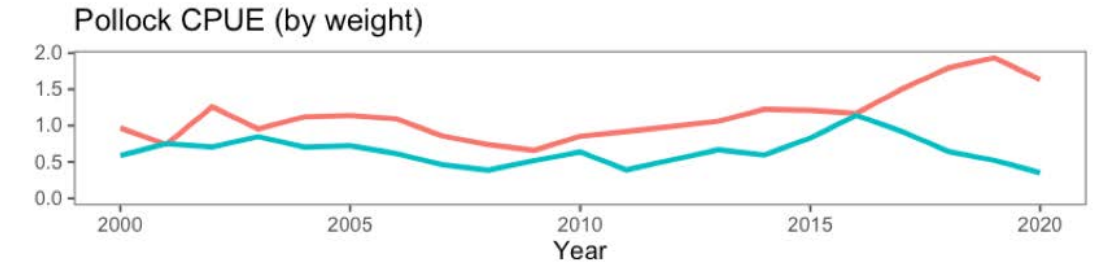



Herring CPUE (by weight)
0.004
0.003
0.002
0.001
0.000
2000
2005
2010
2015
2020
Year
seas
A
B

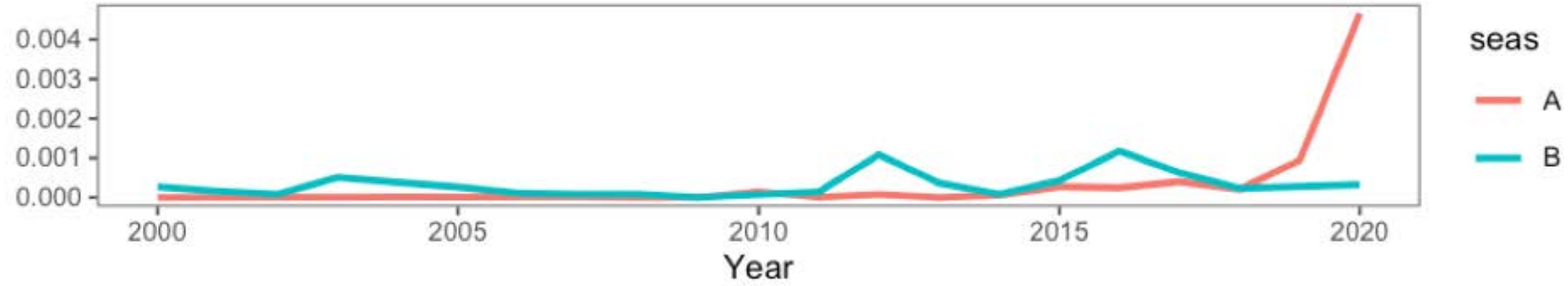

Sablefish CPUE (by weight)
.00100
.00075
.00050
.00025
.00000
2000
2005
2010
2015
2020
Year


Chinook salmon CPUE (by number)
.0e-04
.5e-05
.0e-05
.5e-05
.0e+00
2000
2005
2010
2015
2020
Year

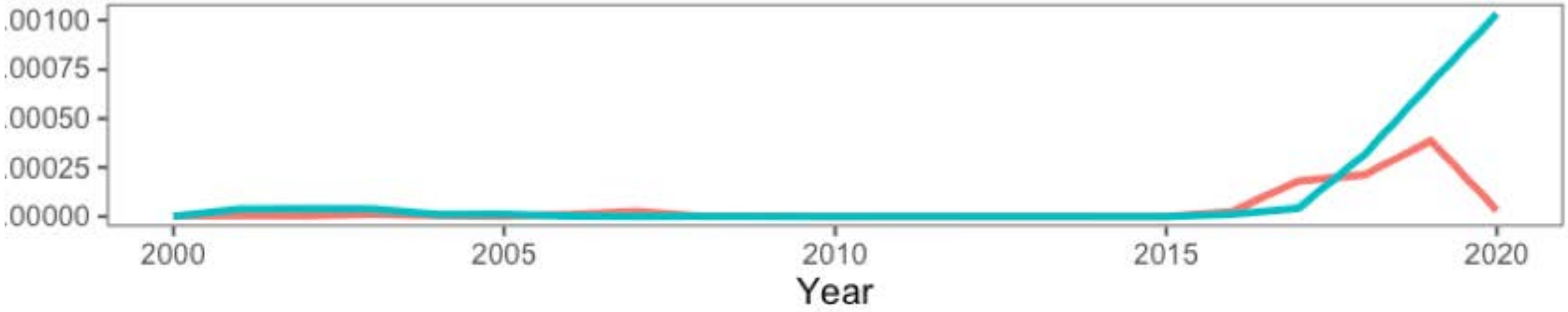

Chum CPUE (by number)
4e-04
2e-04
0e+00
2000
2005
2010
2015
2020
Year


Pollock CPUE (by weight)
2.0
1.5
1.0
0.5
0.0
2000
2005
2010
2015
2020
Year

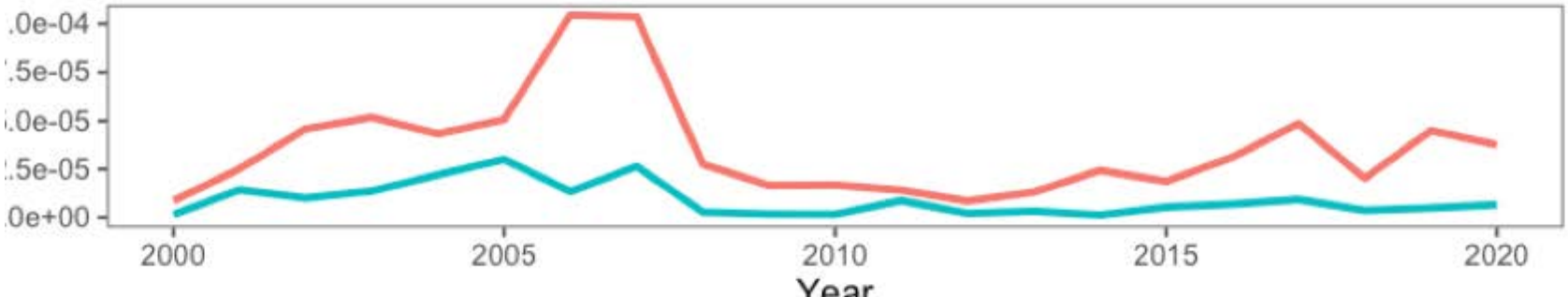
Herring CPUE (by weight)



Sablefish CPUE (by weight)

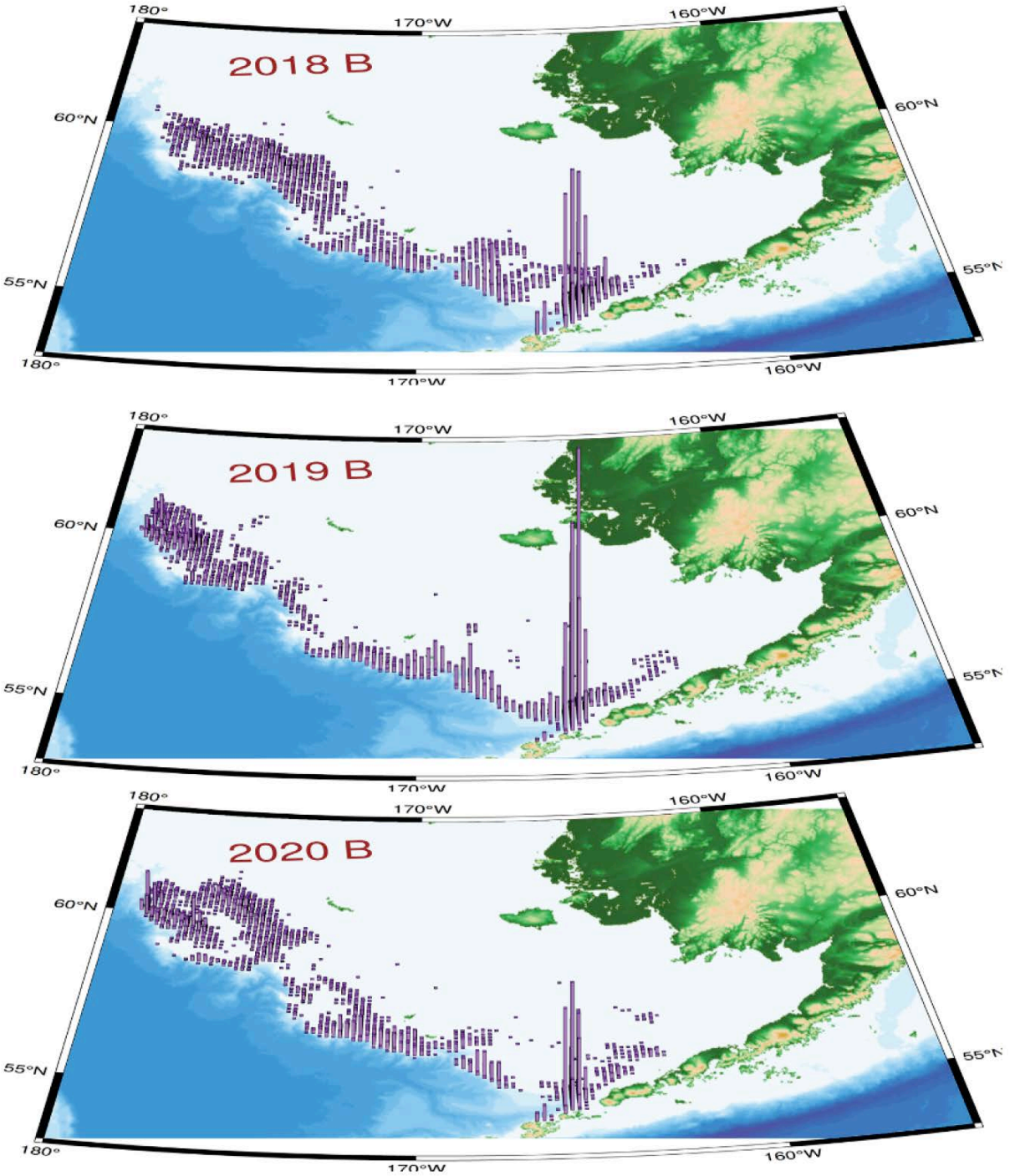


Chinook salmon CPUE (by number)



B-season

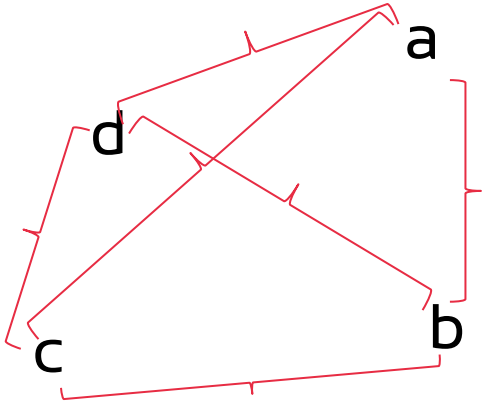
Fishery locals



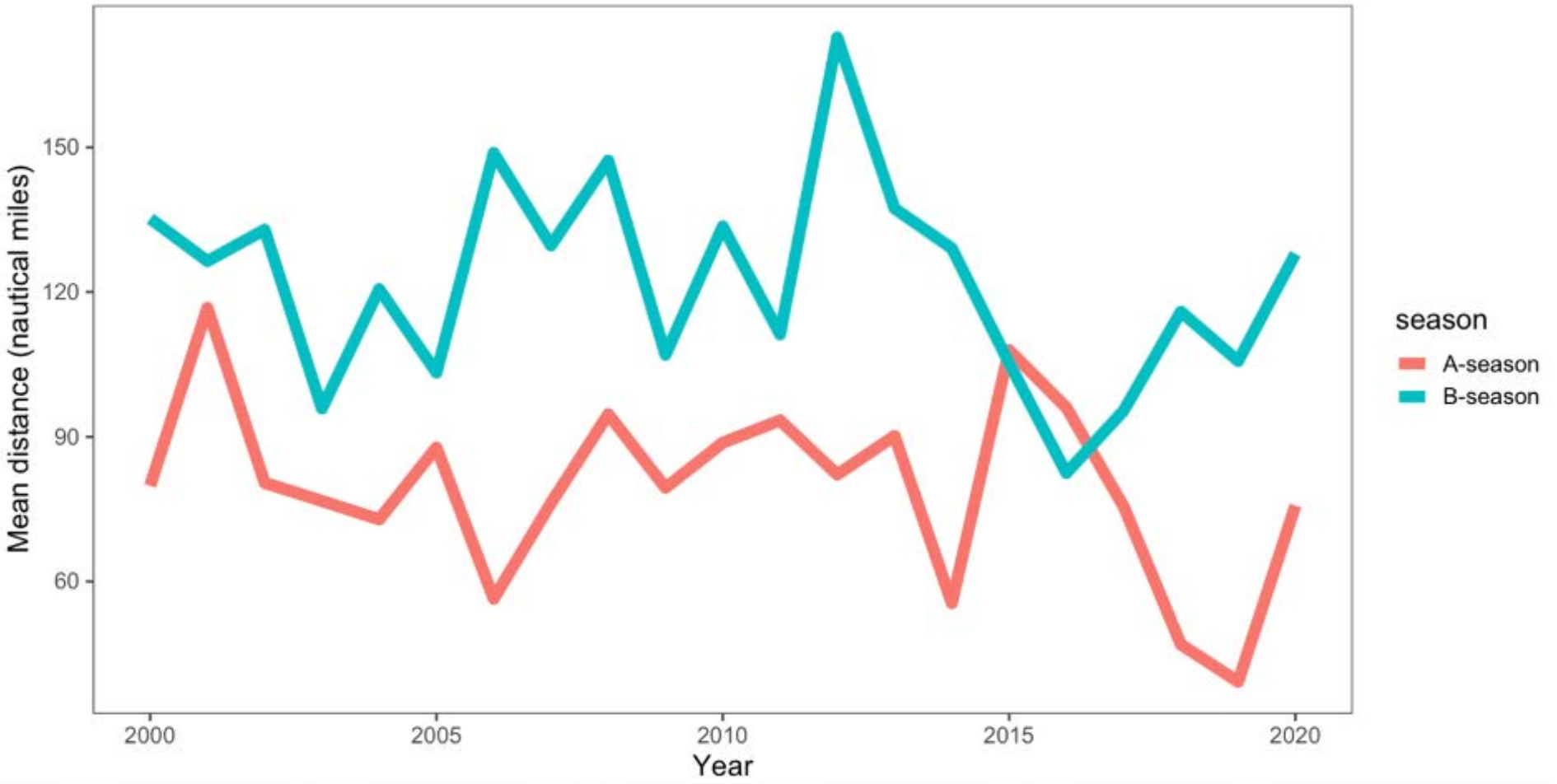
Fishing patterns of fleet

- Fishing harder…and more dispersed?

Summarizing spatial fishery patterns



All pollock boats combined…

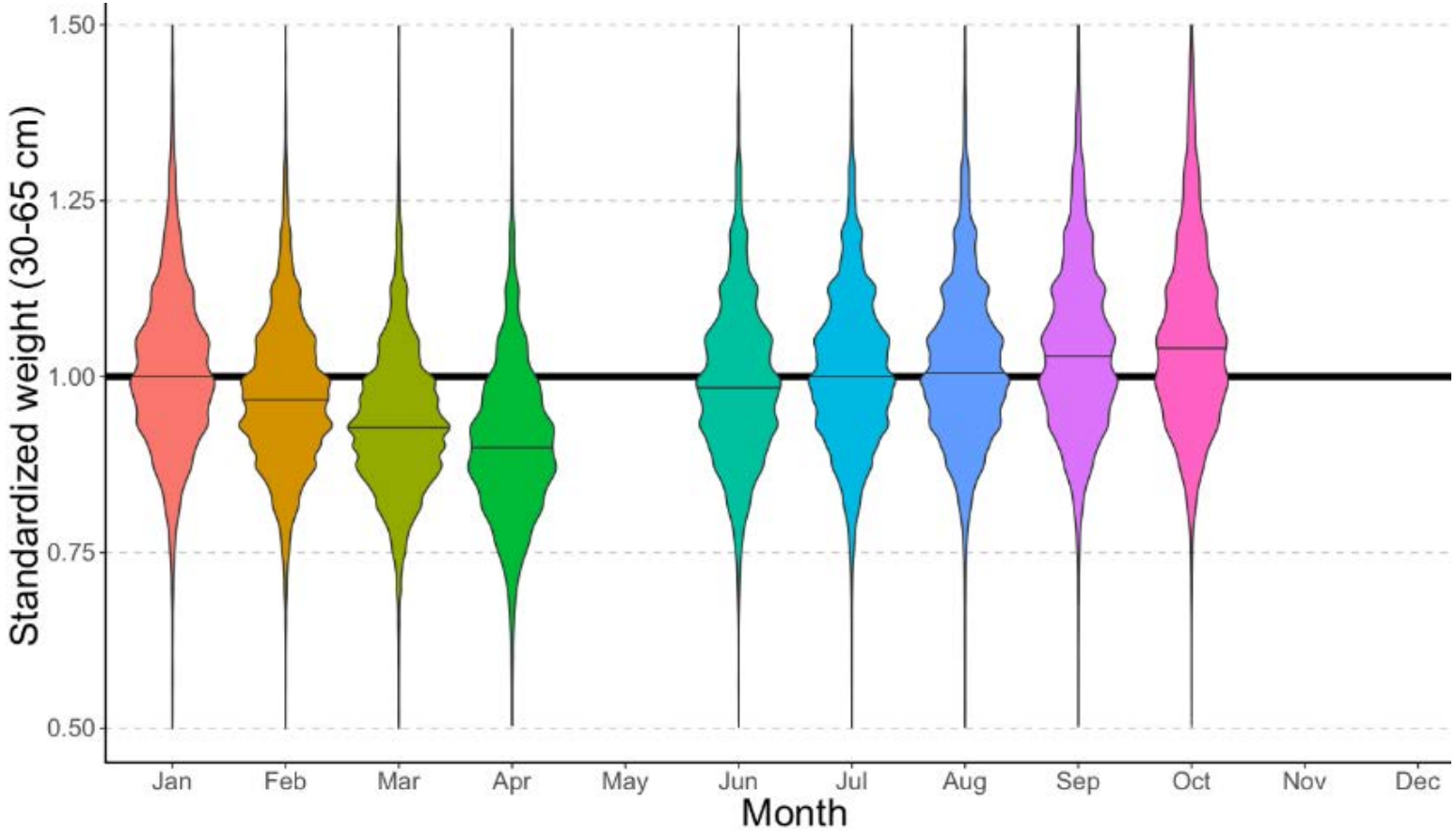


2020 Fish condition

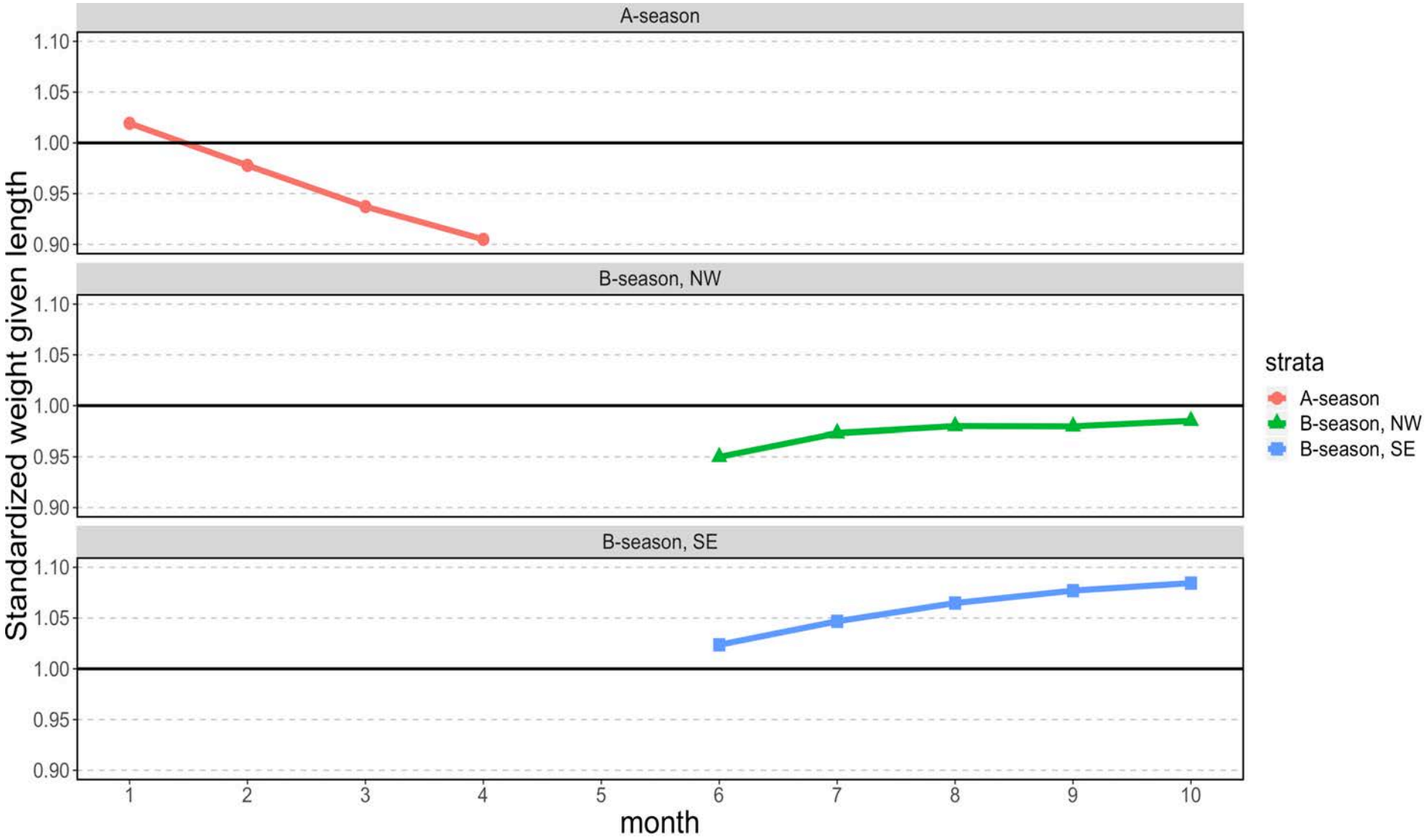
Wild Alaska Pollock...

- Fishery observer sampling...
  - Patterns in pollock growth

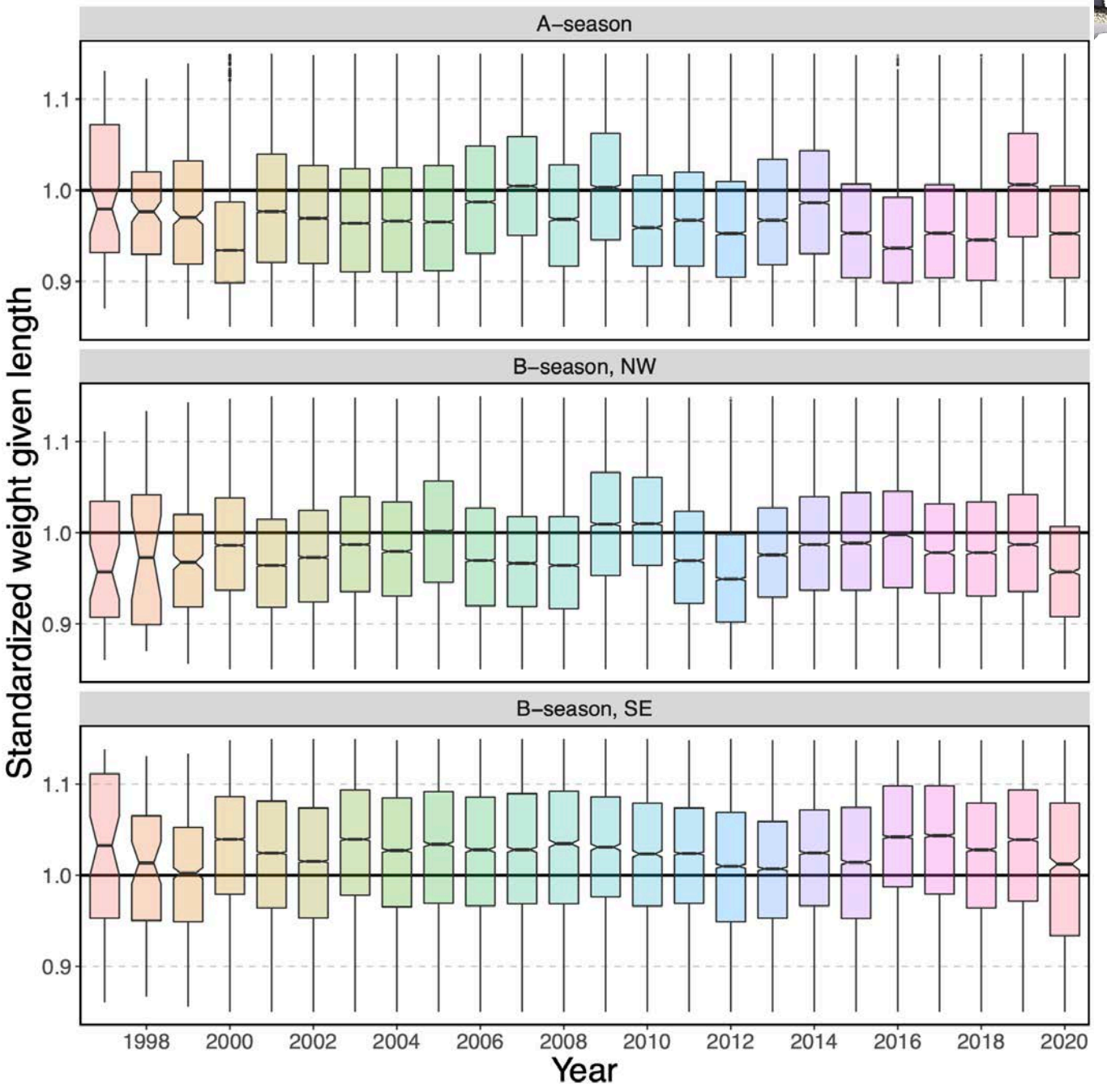
Climatology on pollock “fatness” (given length) by month

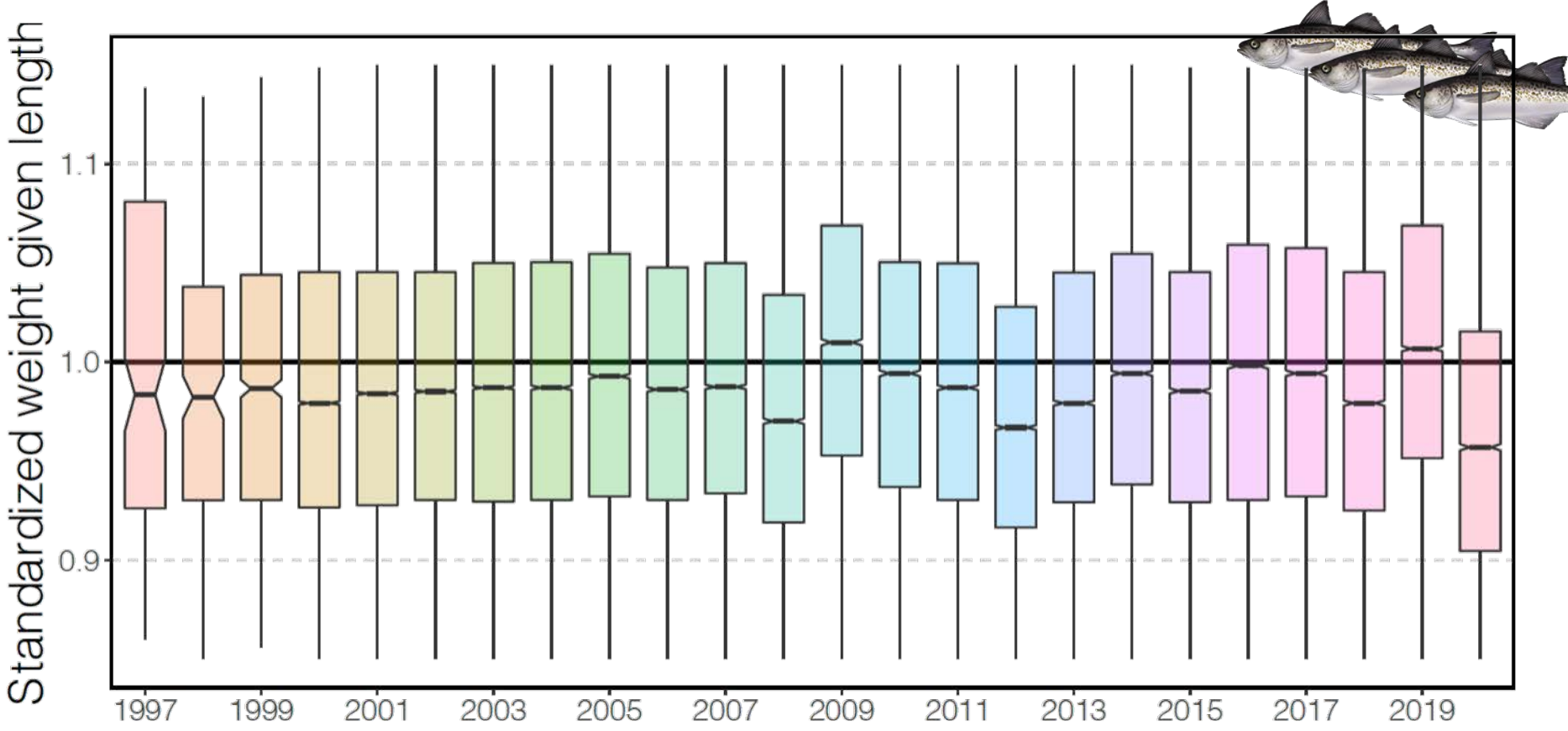


Pollock climatology on "fatness" (given length) by month and season/area



Pollock "fatness" (given length) by year and season



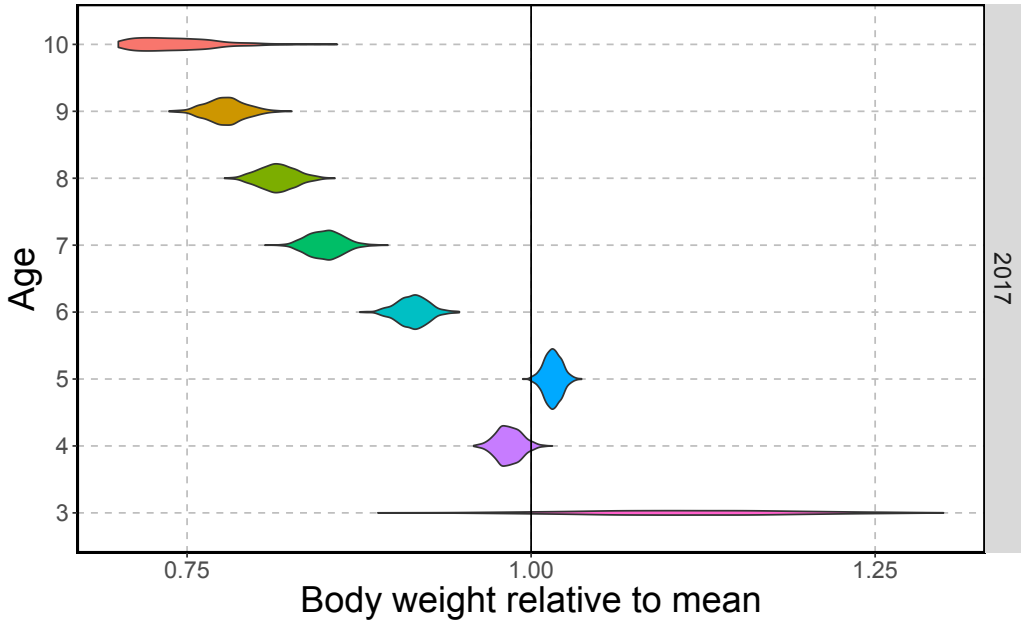


Summary on fish fatness (given length)

2020 generally skinny!

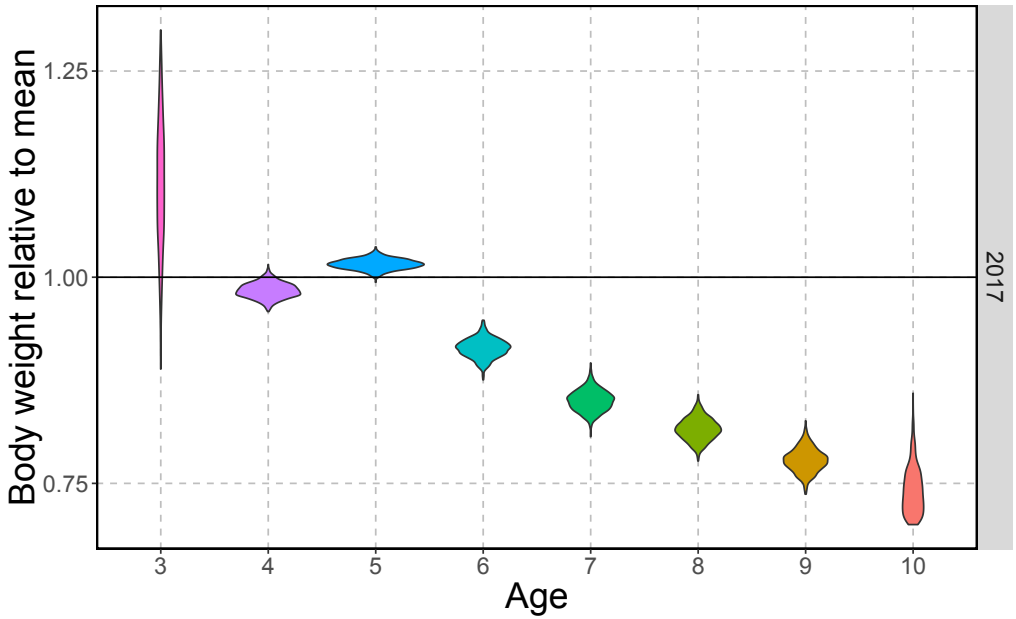
What about size at age?

Looking at weight-at-age



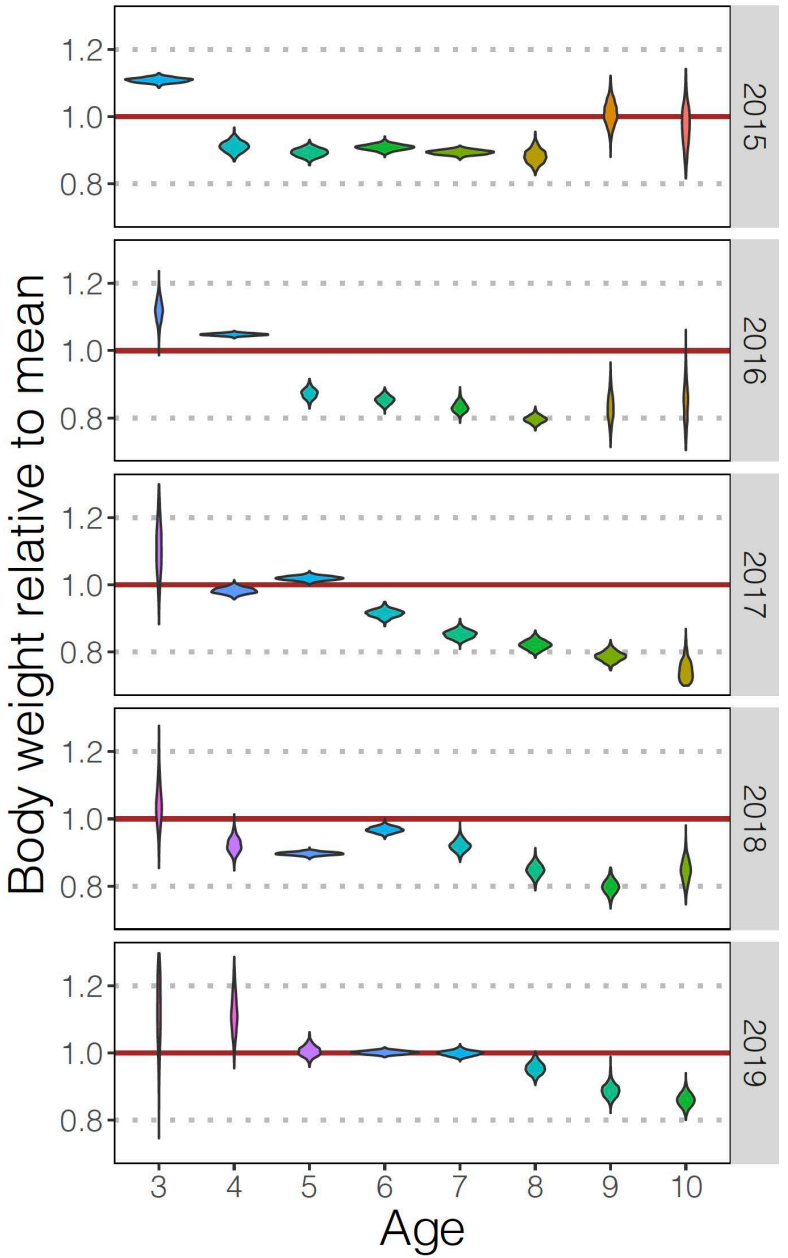
Are pollock smaller at age than normal???

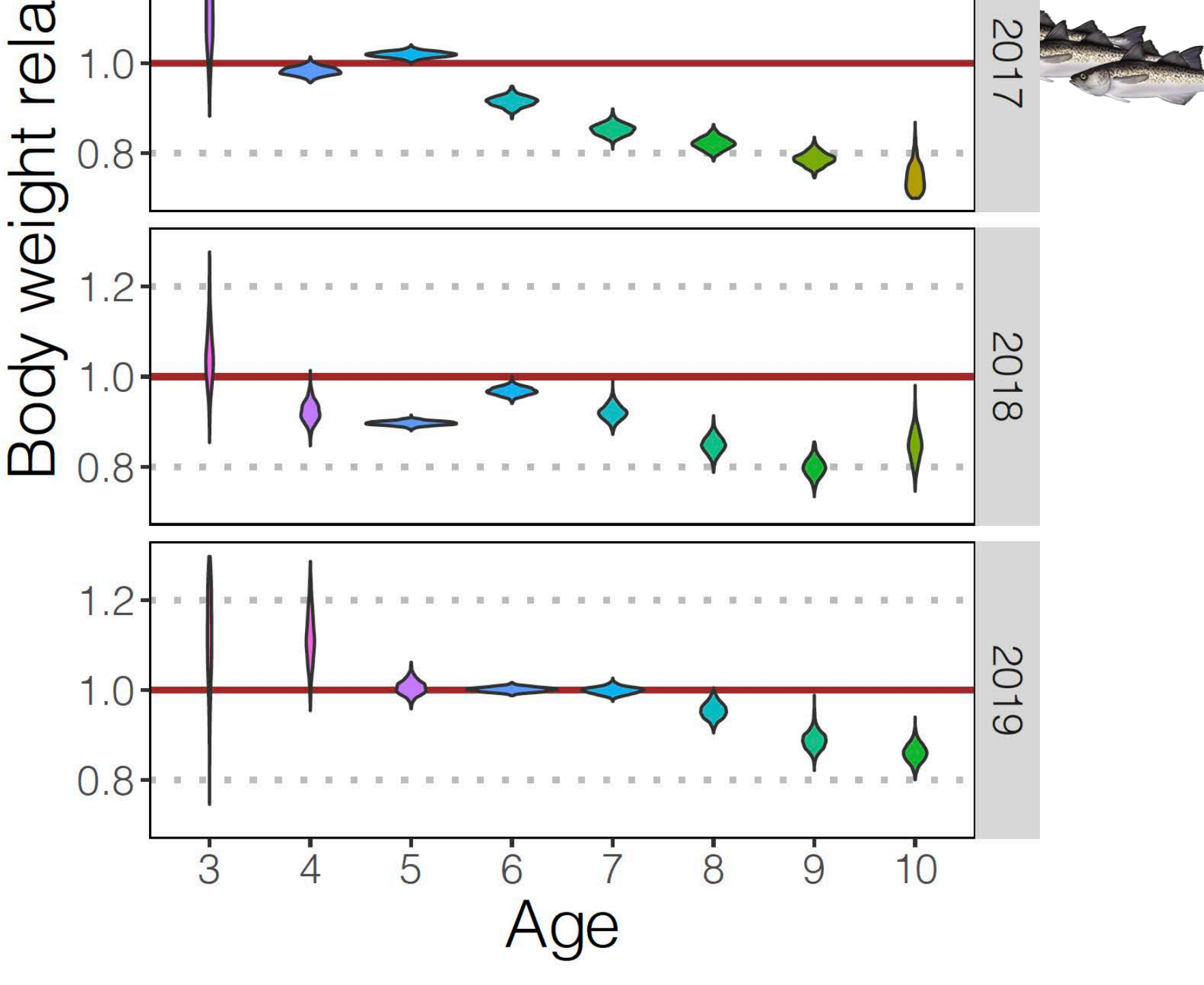
Looking at weight-at-age



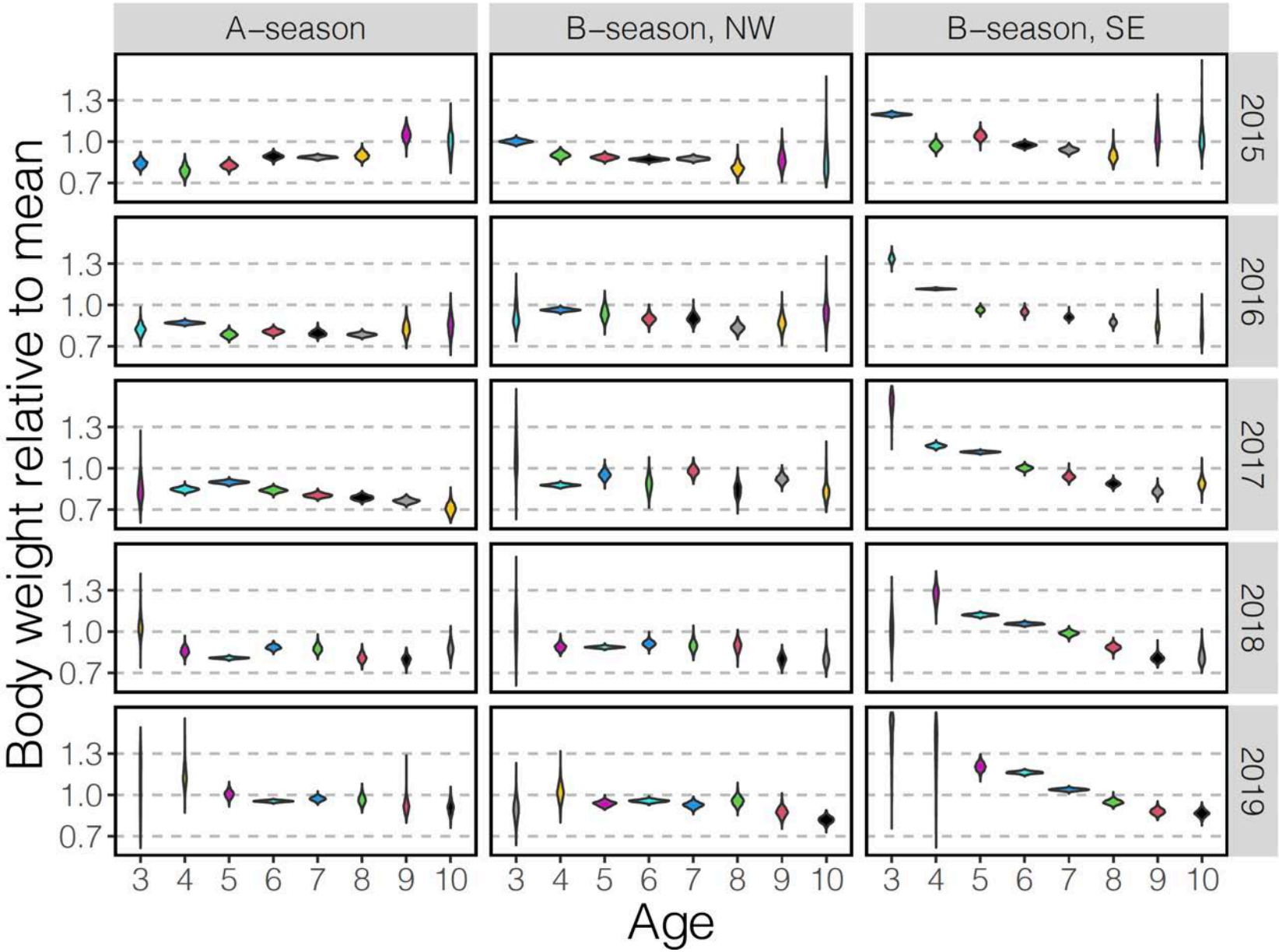
Are pollock smaller at age than normal???

- 2012 and 2013 year classes about
  average weight in 2019

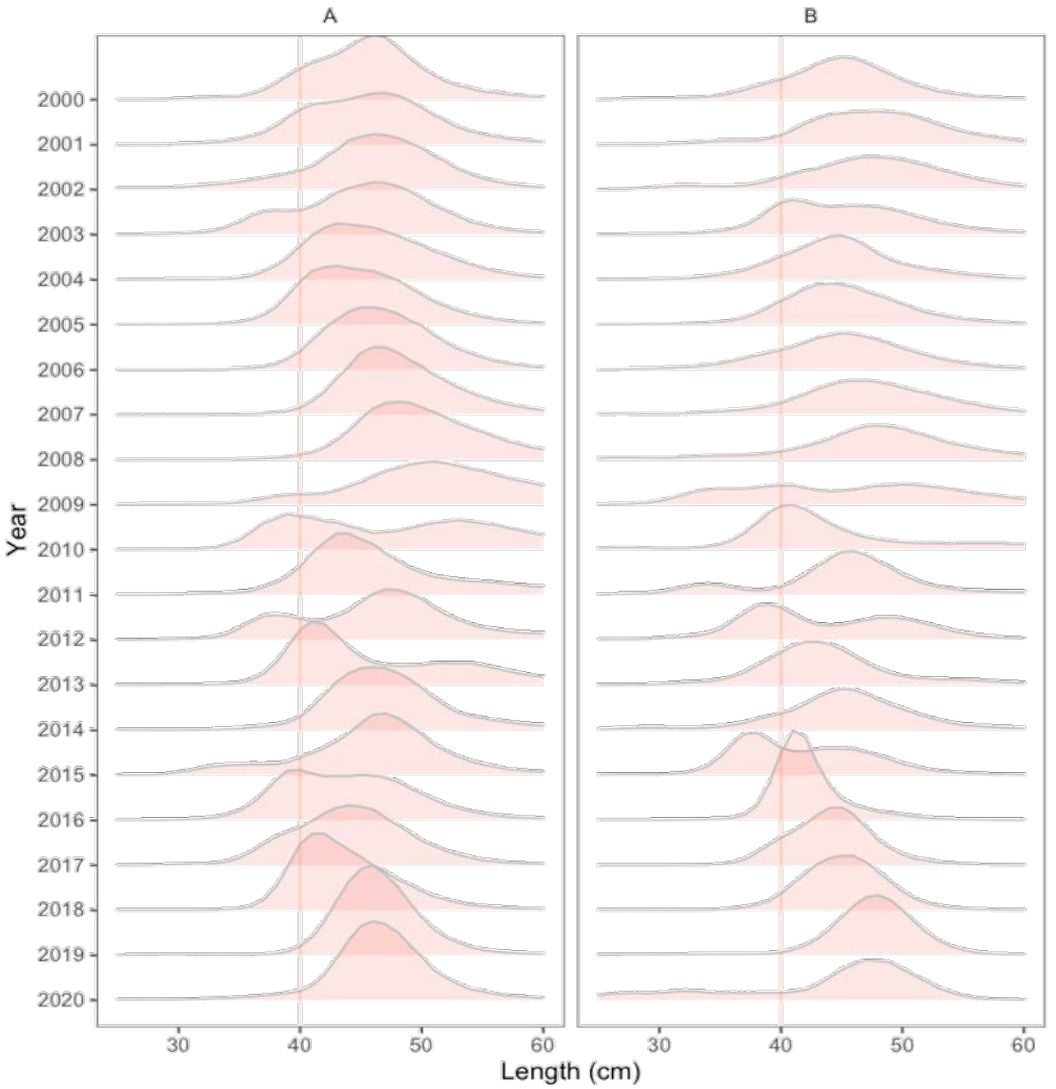


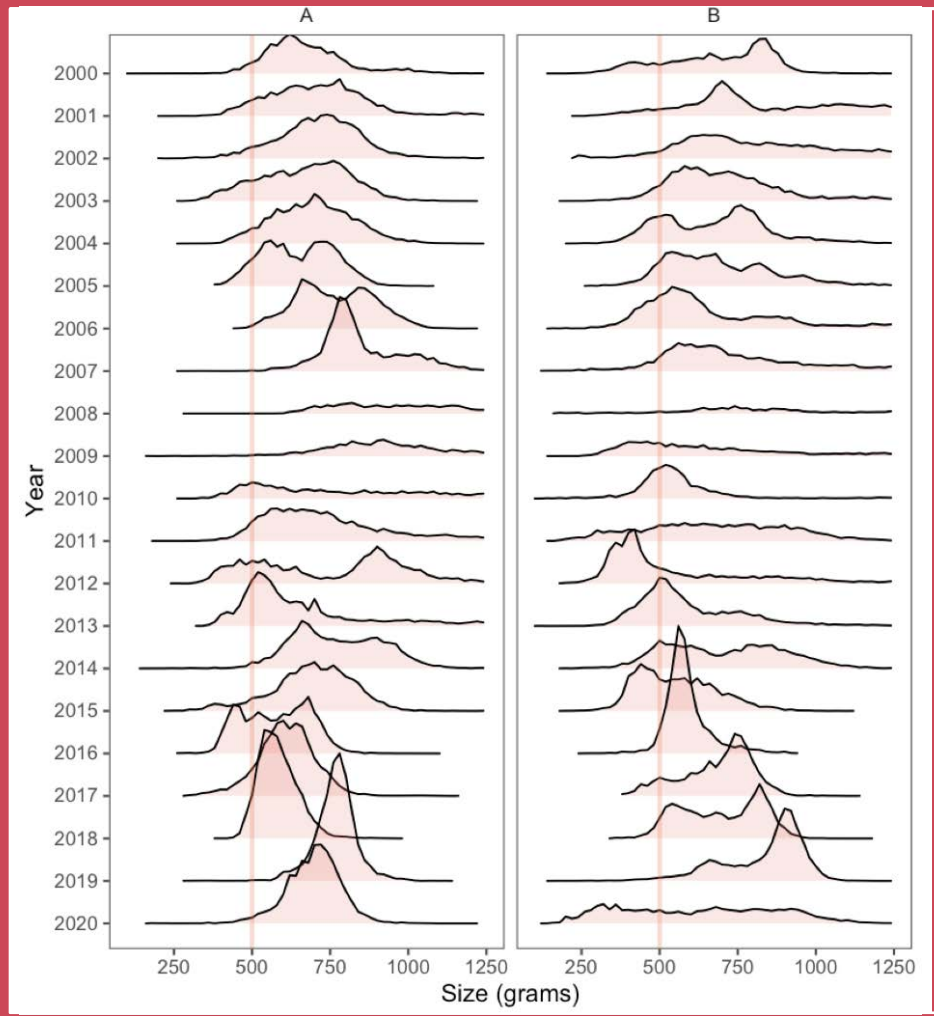

Body weight rela
1.0
0.8
2017
1.2
1.0
0.8
2018
1.2
1.0
0.8
2019
3
4
5
6
7
8
9
10
Age

Average fishery weight-at-age by season, area, and year...



Fishery length frequency from observers





Size distributions by sample mean weight in tows…

Binned weight frequency

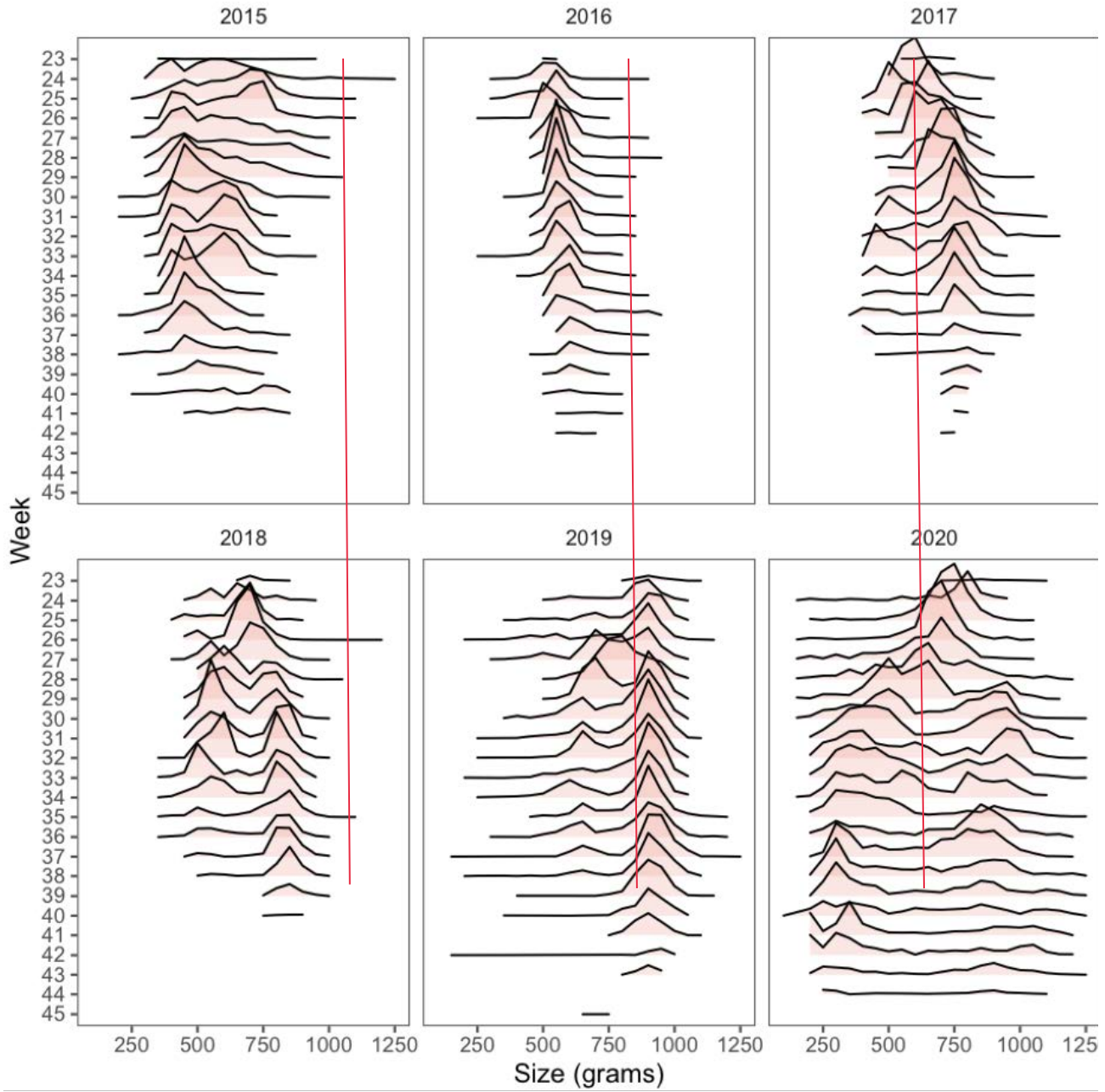
Tow sample mass

divided by

Tow sample N

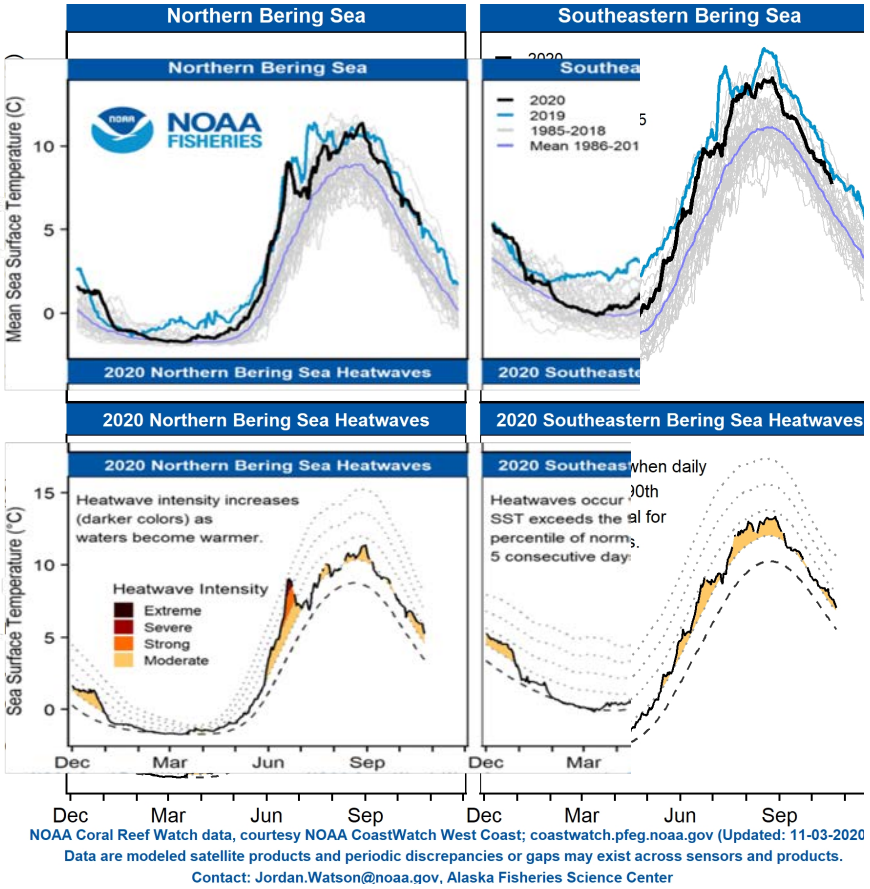
Weekly catch by size bin

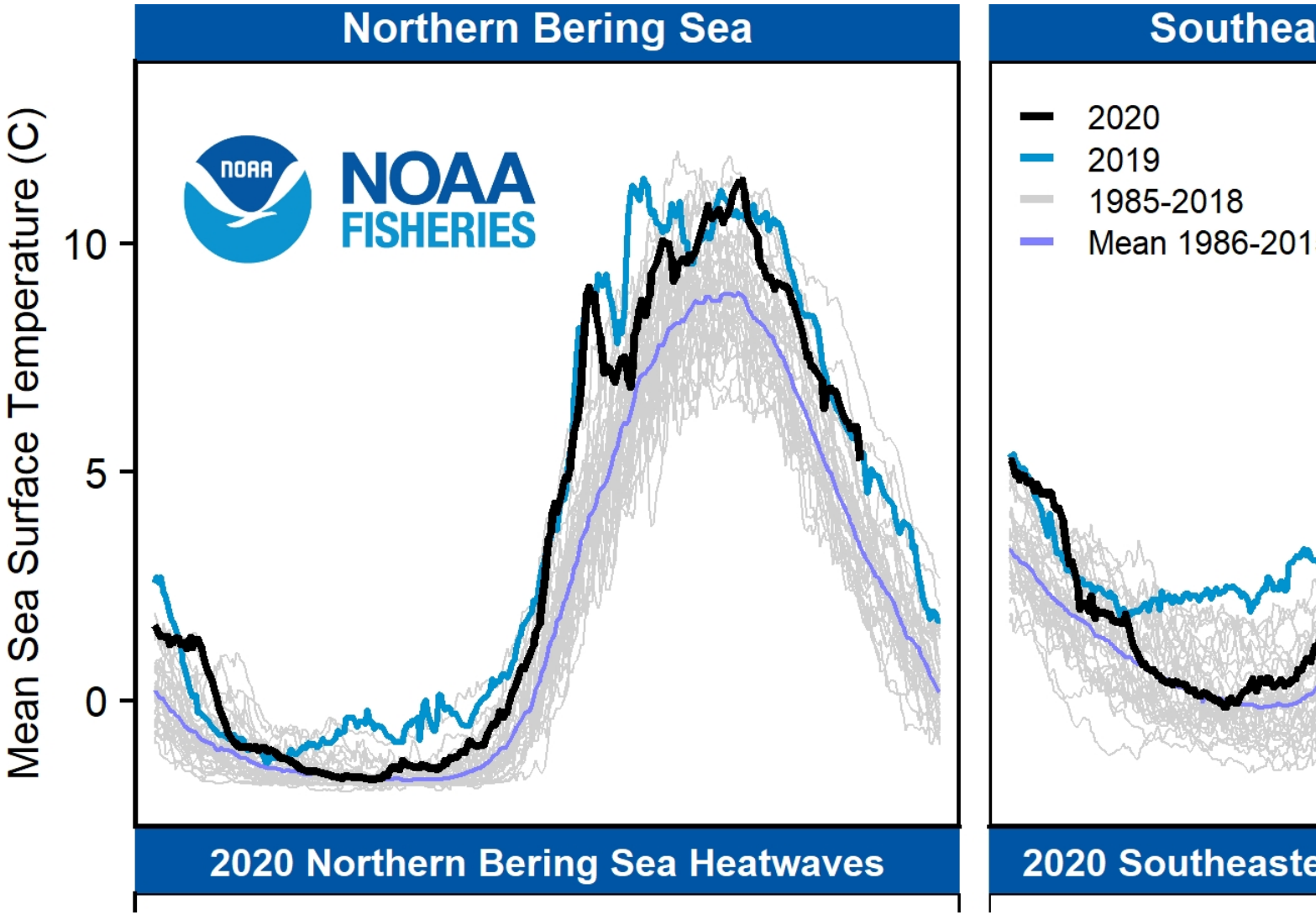
2020 seems pretty unusual!

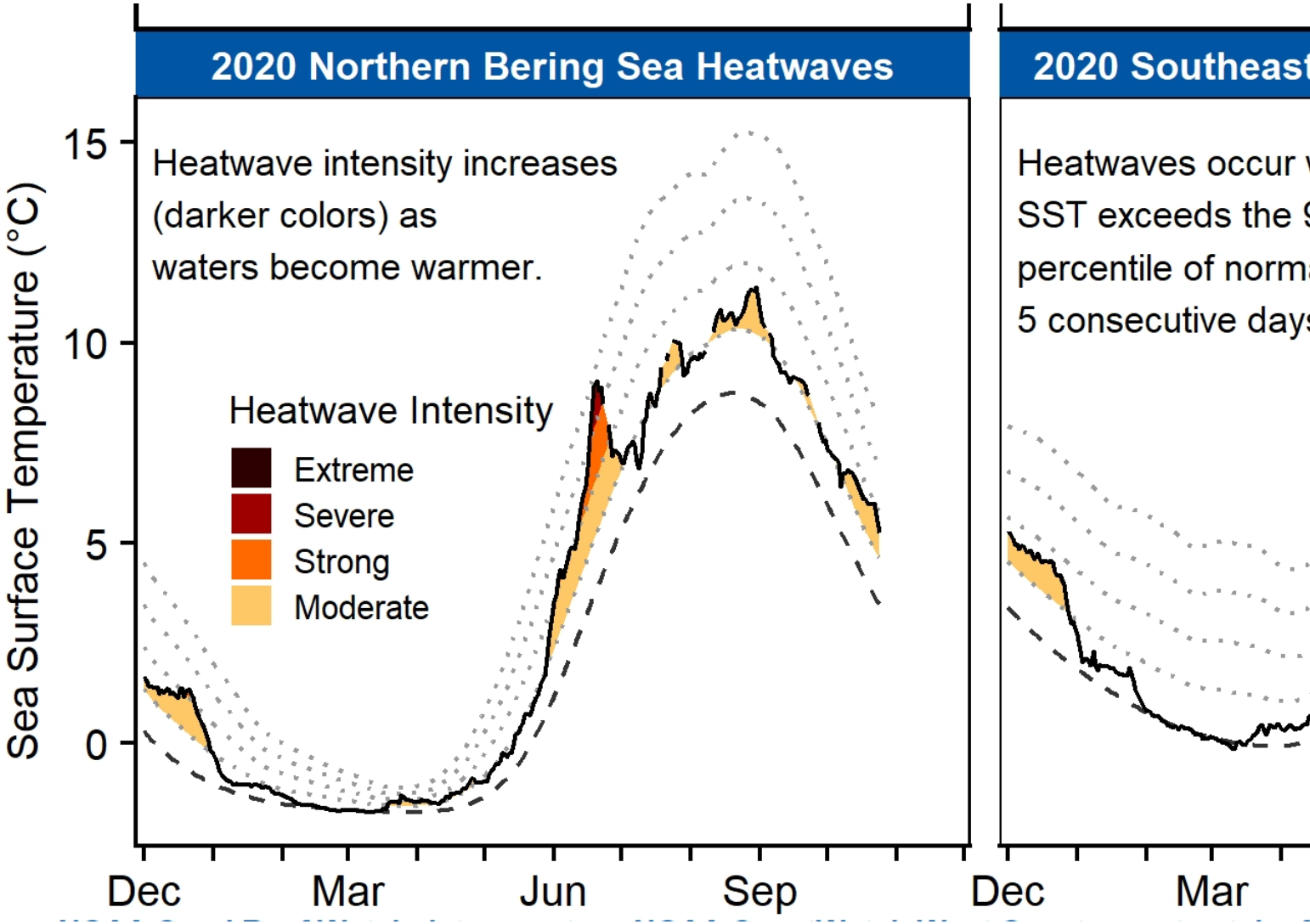


Heatwave?

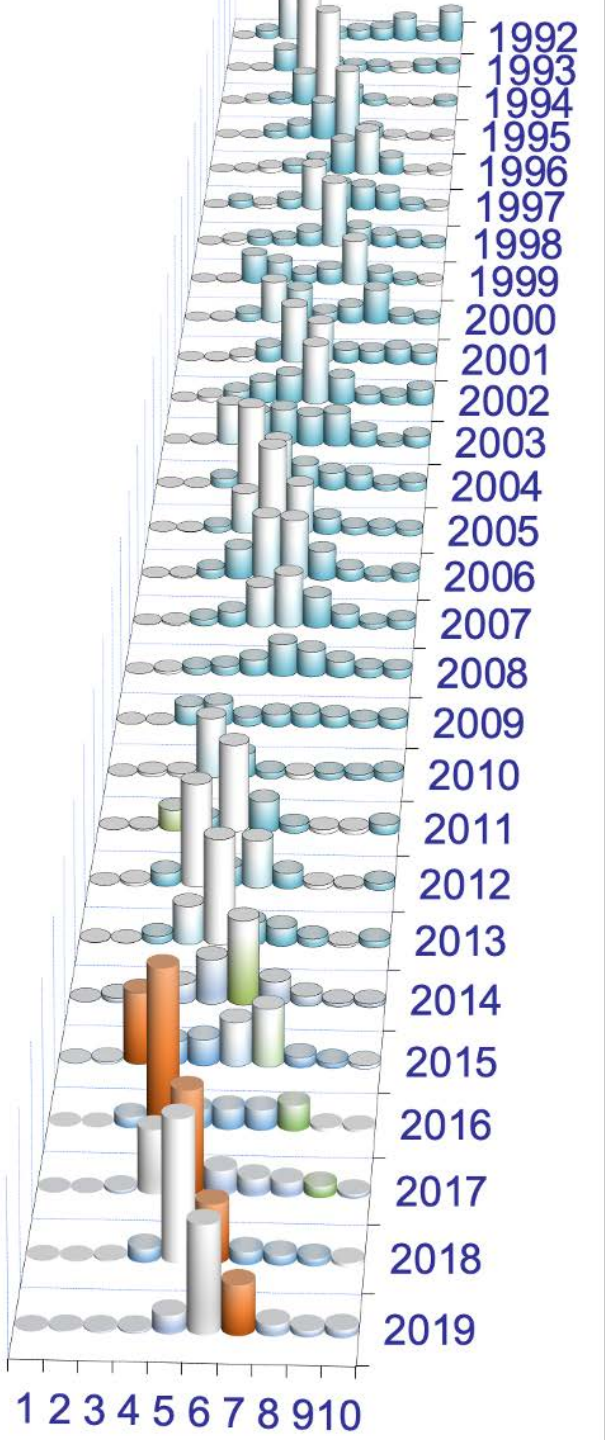
Thanks to Jordan Watson

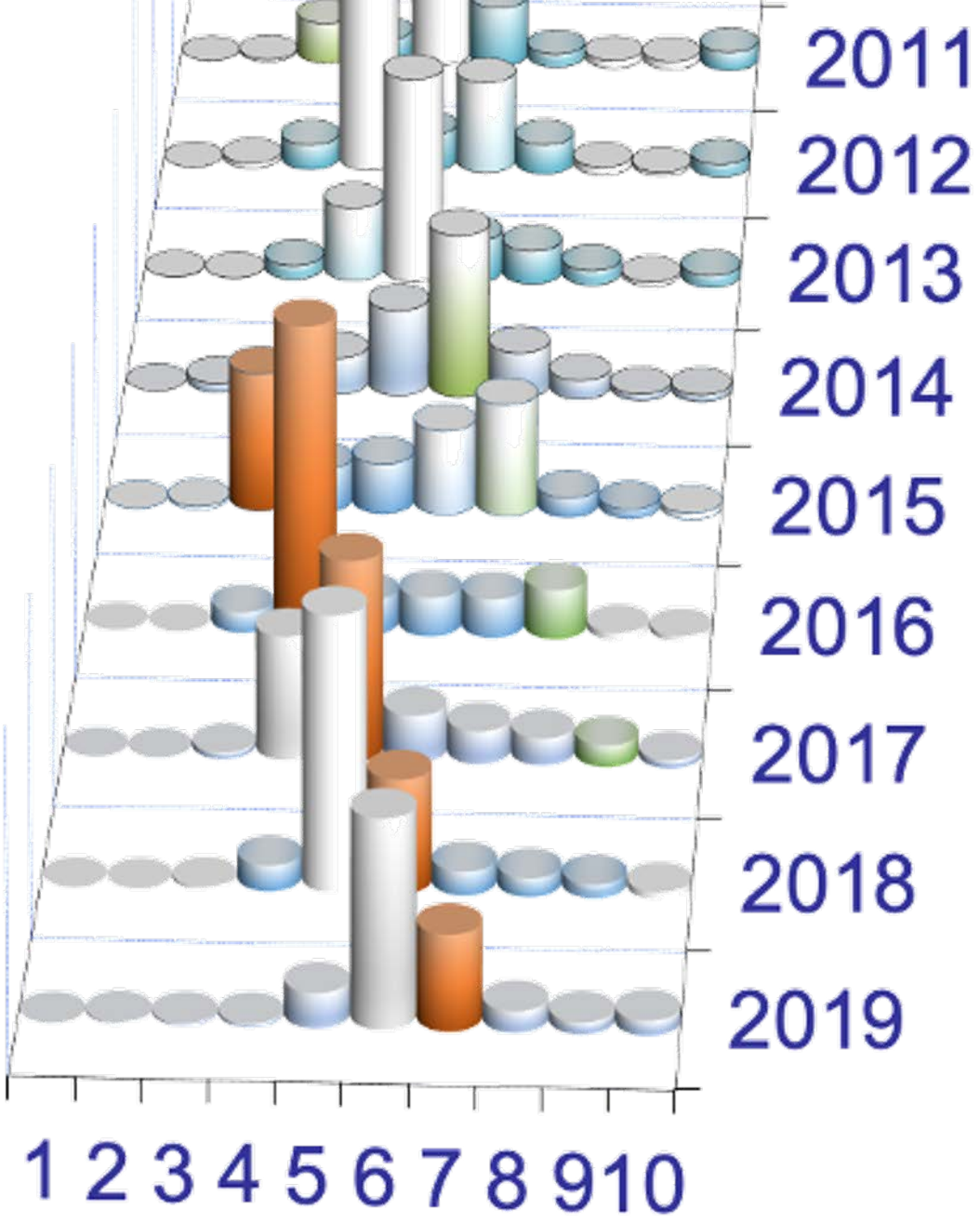



Northern Bering Sea
Southea
NOAA
FISHERIES
2020
2019
1985-2018
Mean 1986-201
Mean Sea Surface Temperature (C)
10
5
0
2020 Northern Bering Sea Heatwaves
2020 Southeaste

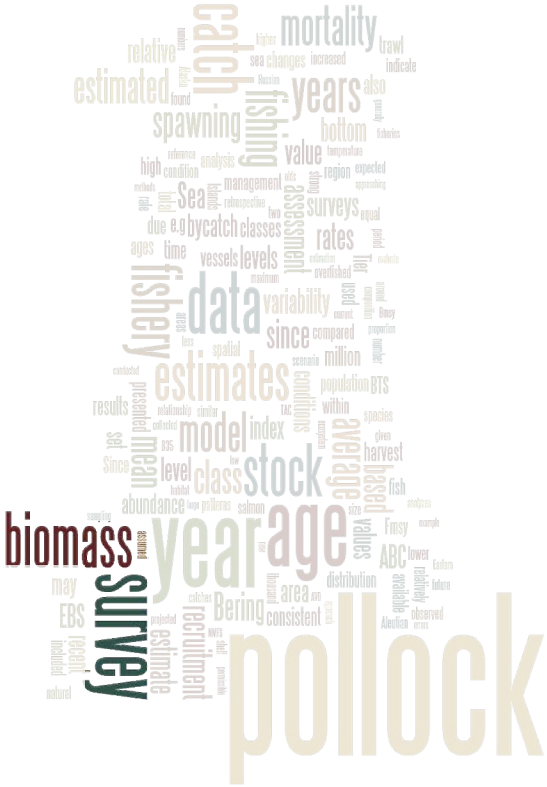

2020 Northern Bering Sea Heatwaves
2020 Southeast
Heatwave intensity increases
(darker colors) as
waters become warmer.
Heatwave Intensity
Extreme
Severe
Strong
Moderate
Sea Surface Temperature (°C)
15
10
5
0
Dec
Mar
Jun
Sep
Dec
Mar
Heatwaves occur
SST exceeds the
percentile of norm
5 consecutive days

Fishery catch-at-age



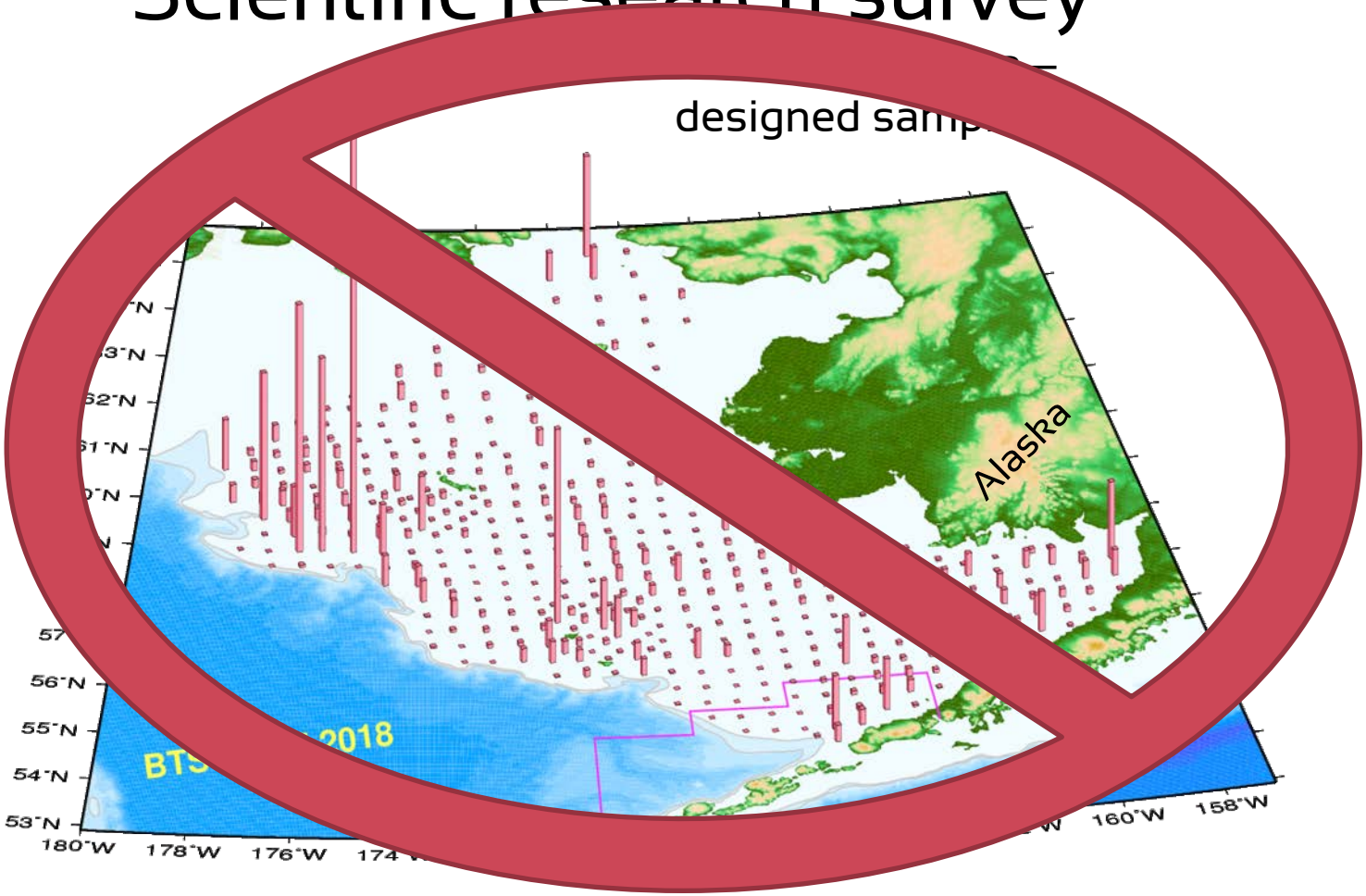

2011
2012
2013
2014
2015
2016
2017
2018
2019
1 2 3 4 5 6 7 8 9 10

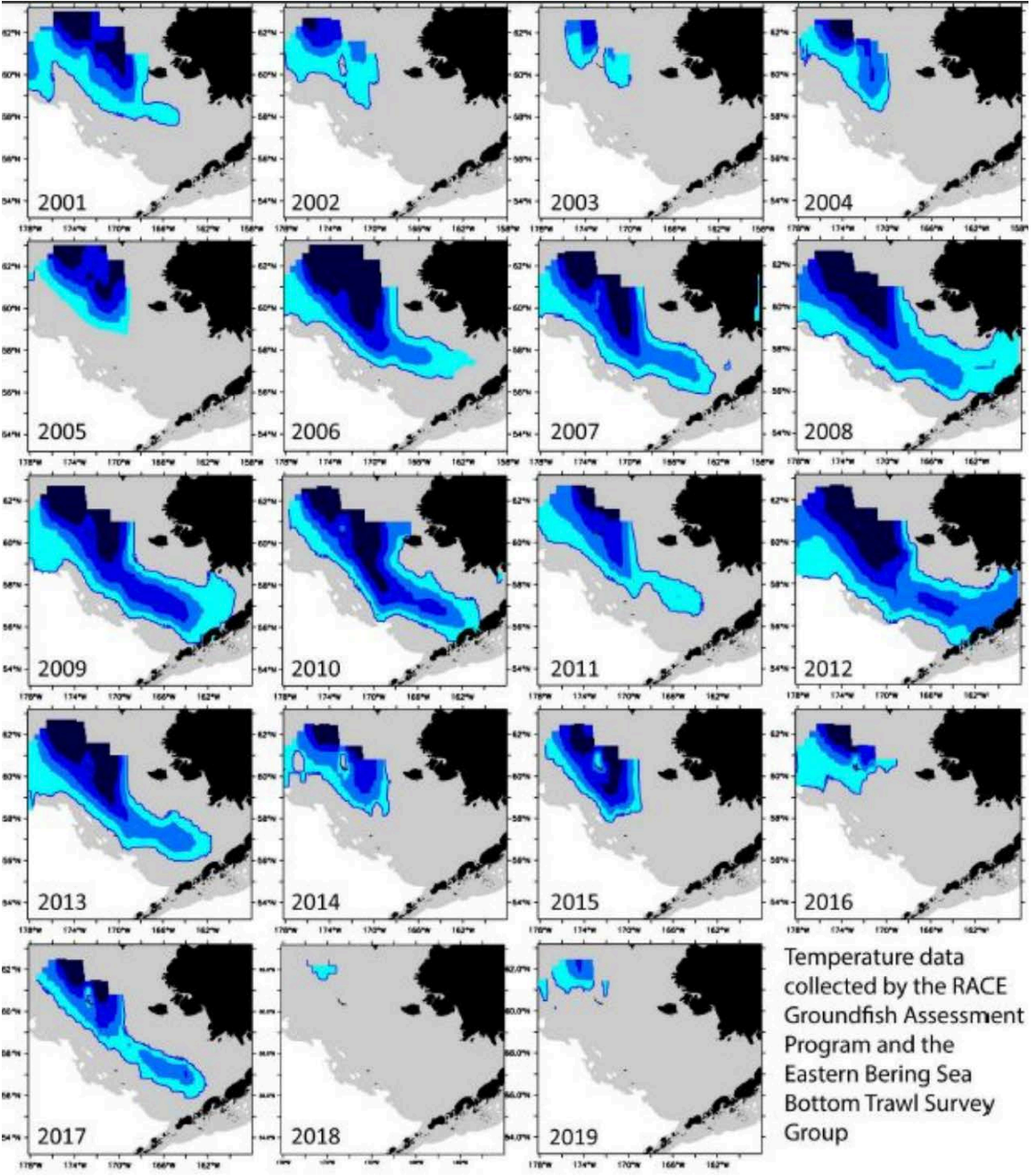
Eastern Bering Sea pollock surveys



Scientific research survey

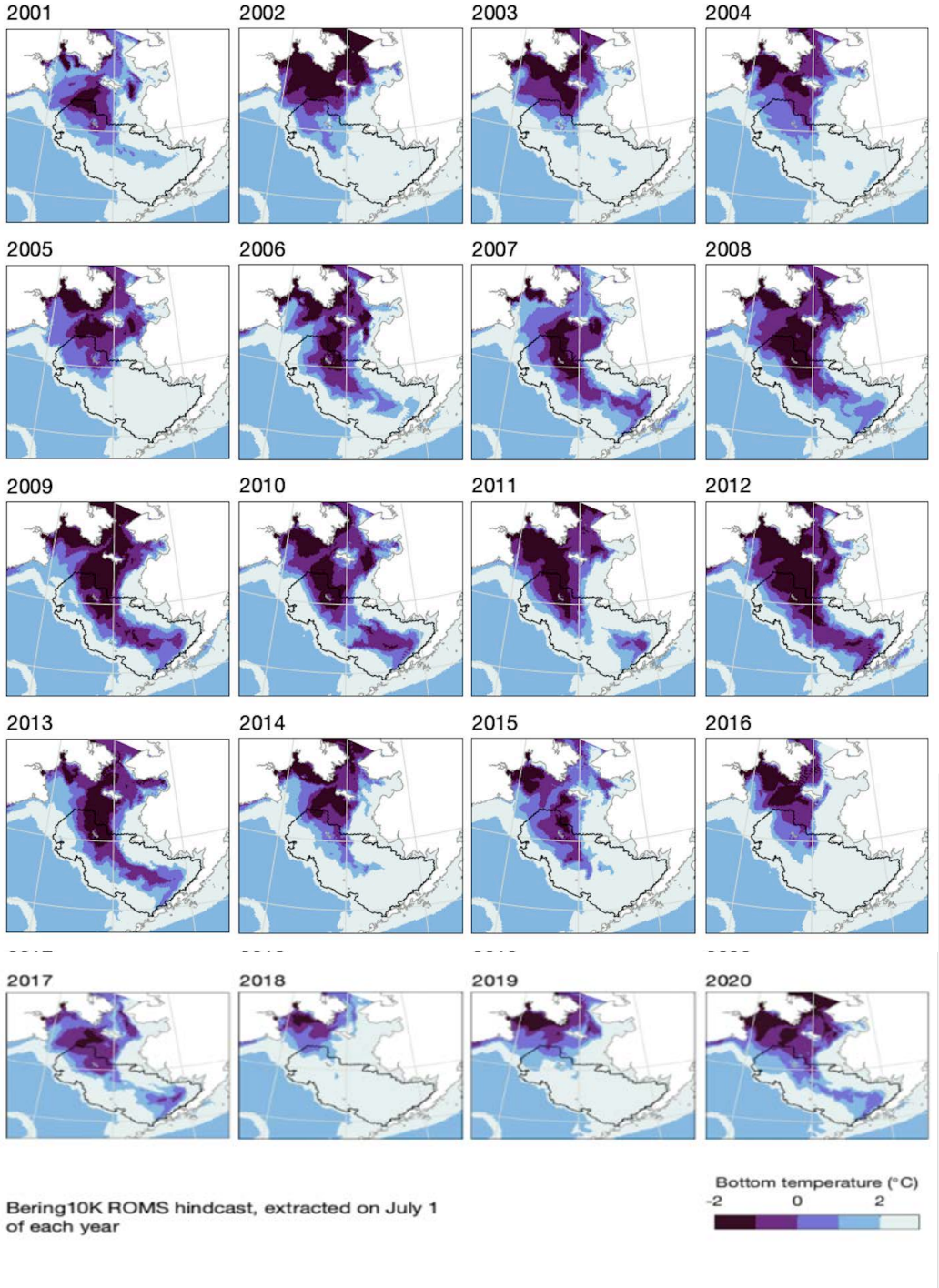
designed samp



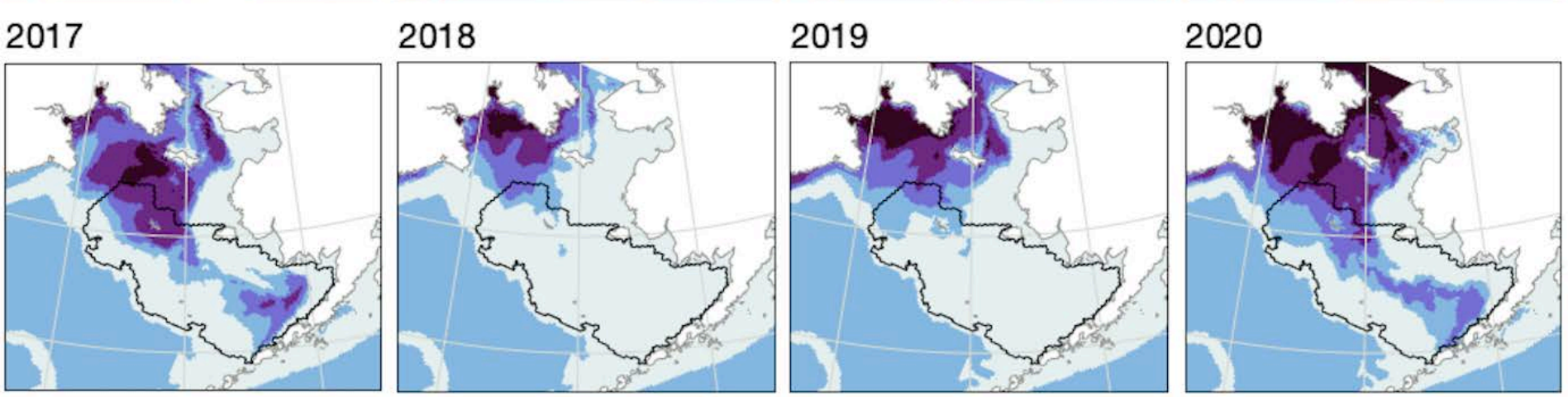


Temperature data collected by the RACE Groundfish Assessment Program and the Eastern Bering Sea Bottom Trawl Survey Group

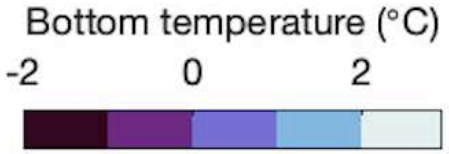
Cold pool extent...based on data...



Cold pool extent…based on physical models (ROMs)

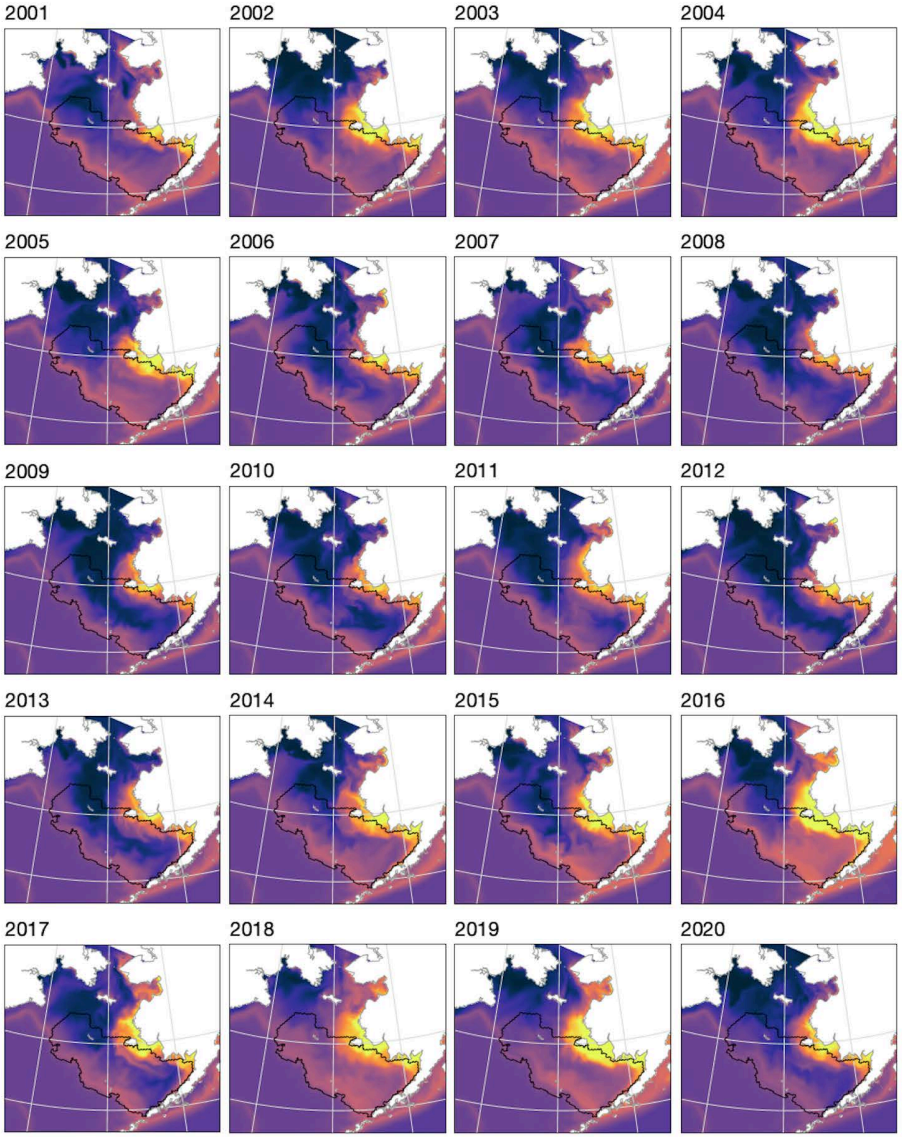


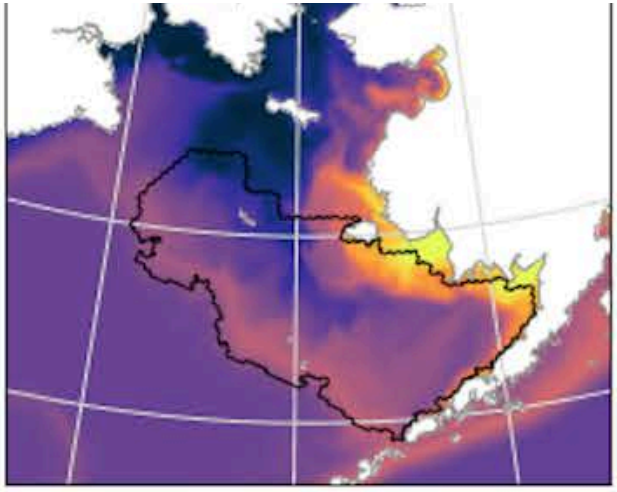
Bering10K ROMS hindcast, extracted on July 1 of each year

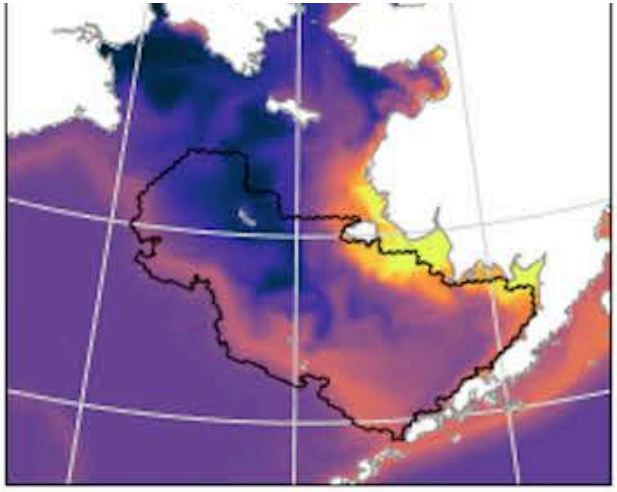


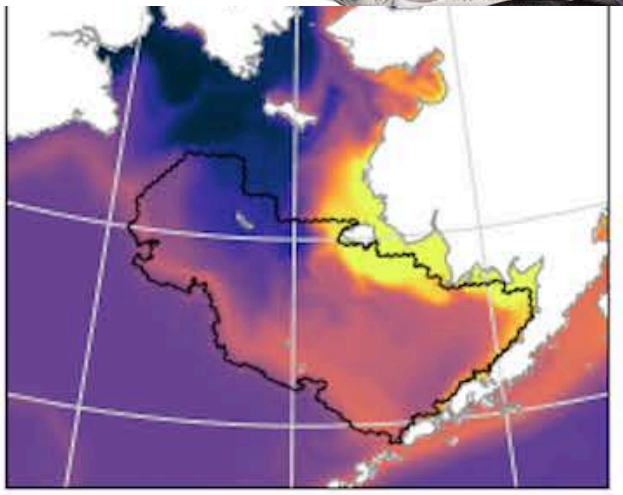
Summer bottom temperatures

- Hindcasts from ROMs
  - Courtesy Dr. Kelly Kearney, AFSC
- More like average!

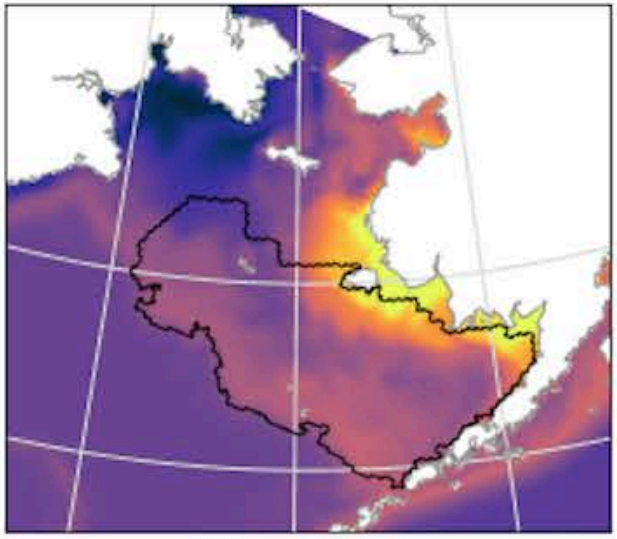




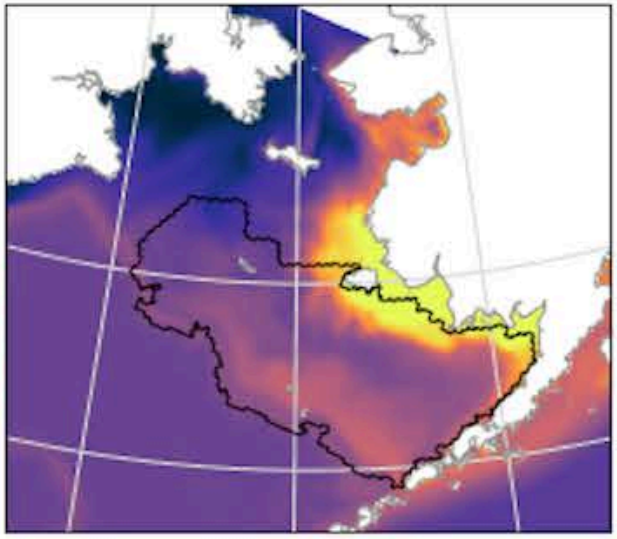




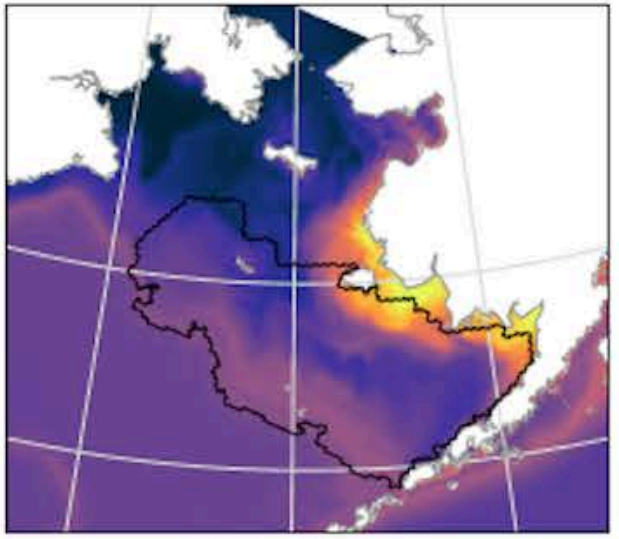
2018



2019

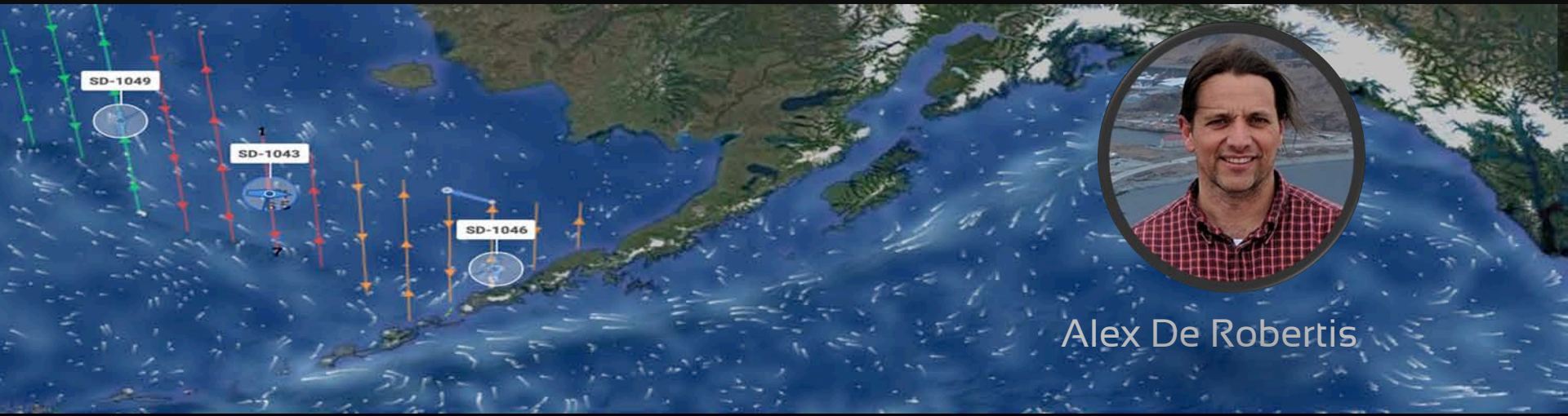


2020



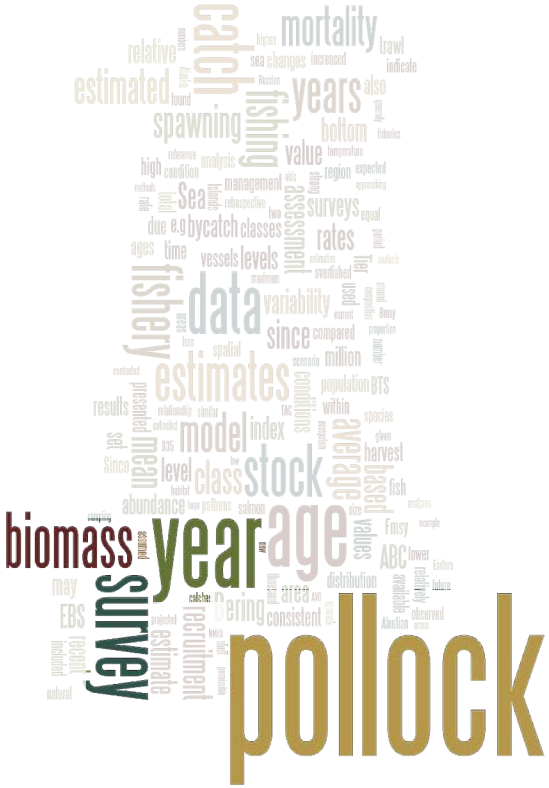
Alex De Robertis, Mike Levine, Nathan Lauffenburger, Jim Ianelli, Cole Monnahan,
Rick Towler, Taina Honkalehto, Darin Jones, Sarah Stienessen, Denise McKelvey,
Saildrone, Inc.

2020 Pollock saildrone survey



Alex De Robertis

EBS pollock Assessment Results



Data

The following lists the data used in this assessment:

Source	Type	Years
Fishery	Catch biomass	1964–2020
Fishery	Catch age composition	1964–2019
Fishery	Japanese trawl CPUE	1965–1976
EBS bottom trawl	Area-swept biomass and age-specific proportions	1982–2019
Acoustic trawl survey	Biomass index and age-specific proportions	1994, 1996, 1997, 1999, 2000, 2002, 2004, 2006–2010, 2012, 2014, 2016, 2018, 2020
Acoustic vessels of opportunity (AVO)	Biomass index	2006–2019

Note the 2020 acoustic survey data based on unmanned surface vessel (USV) transects

Model details (1 of 2)

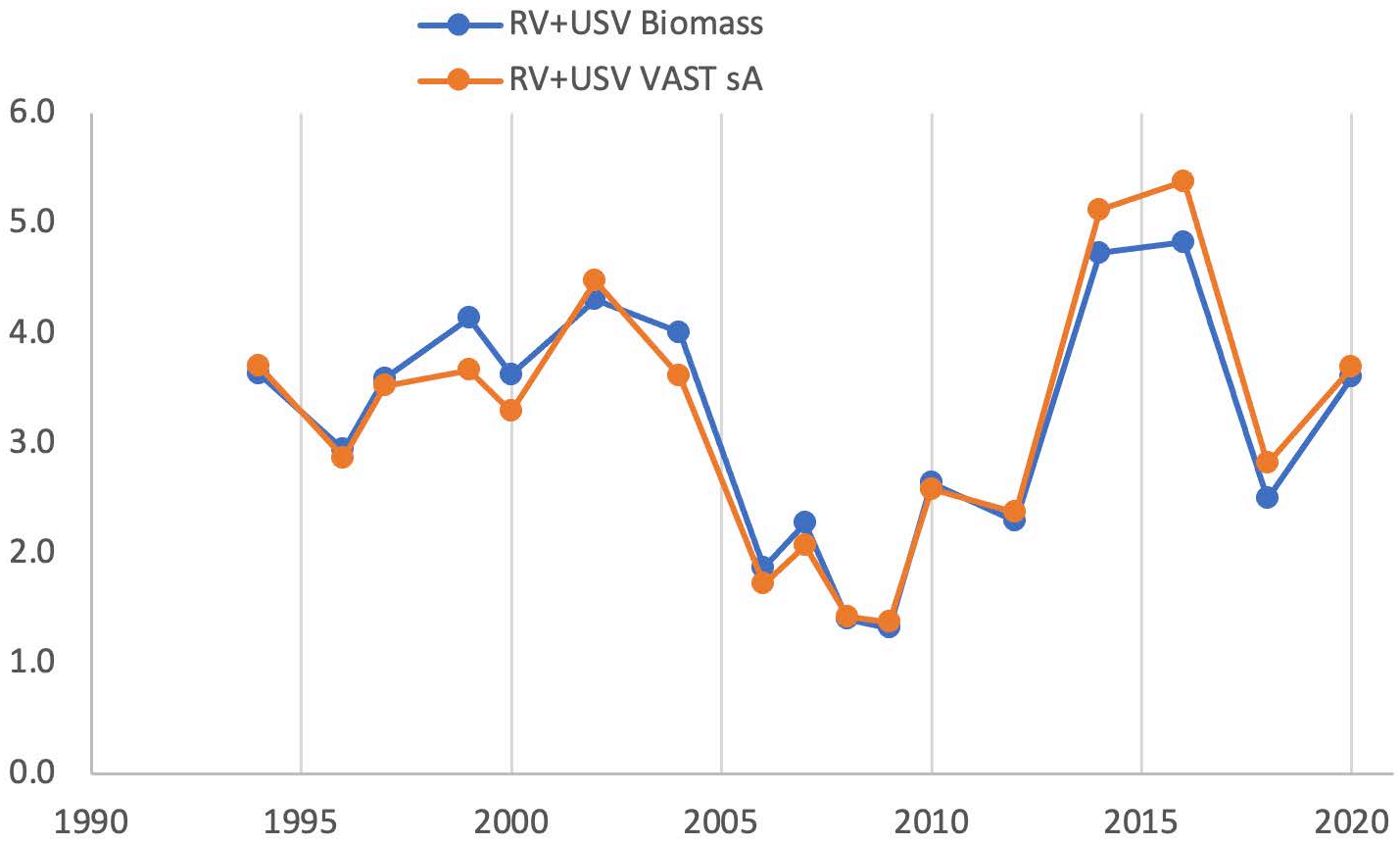
- Tuning indices
  - Acoustic Trawl survey
    - Available biennially (usually!!)
  - Annual fixed-station bottom trawl survey (normally)
  - Acoustic vessel of opportunity (AVO index)
    - Normally Two new years of data every other year
  - Old foreign trawler CPUE (in 1970s)

- Fishery data
  - Total catch
  - Catch-at-age
  - Mean fishery weights-at-age

Model details (2 of 2)

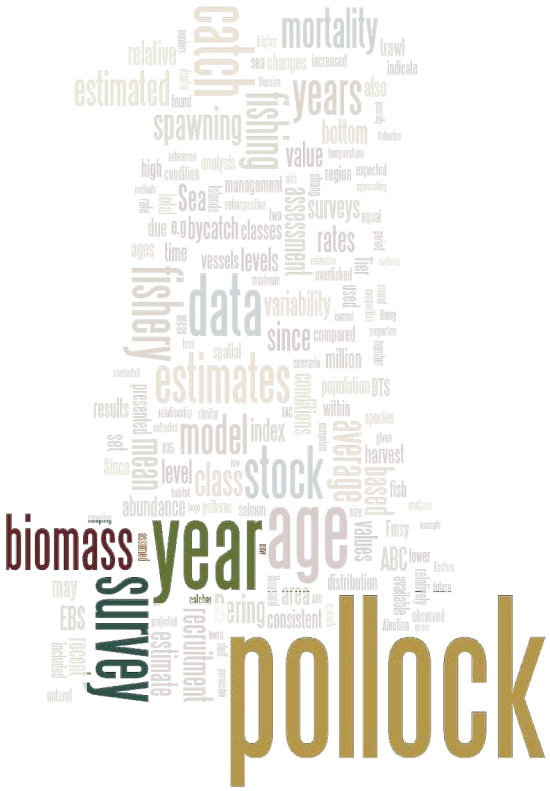
- Age specific schedules
  - Natural mortality
    - Ages 1 and 2 higher, other ages fixed at 0.3
  - Maturity
    - Estimated externally…50% at ~ age 3.5 years
- Other
  - Conditioned on catch biomass (F's estimated)
  - Selectivity varies in fishery
    - Slightly in surveys
  - Stock recruitment model Ricker,
    - Affects ABC values, minimal impact on historical trends
  - Projection options built in to evaluate policy trade offs

Applying survey data in assessment model



Model configurations

- Base (as in 2019)
  - Model 16.2
- Extend acoustic time series with drone data
  - As biomass converted from 2020 back-scatter
  - (Model 20.0)
- Analyze all historical data from research vessels combined with the 2020 drone data
  - All data treated as acoustic back-scatter
  - Uses VAST model for modeling unbalanced data (spatio-temporal aspects)
  - (Model 20.1)



Data

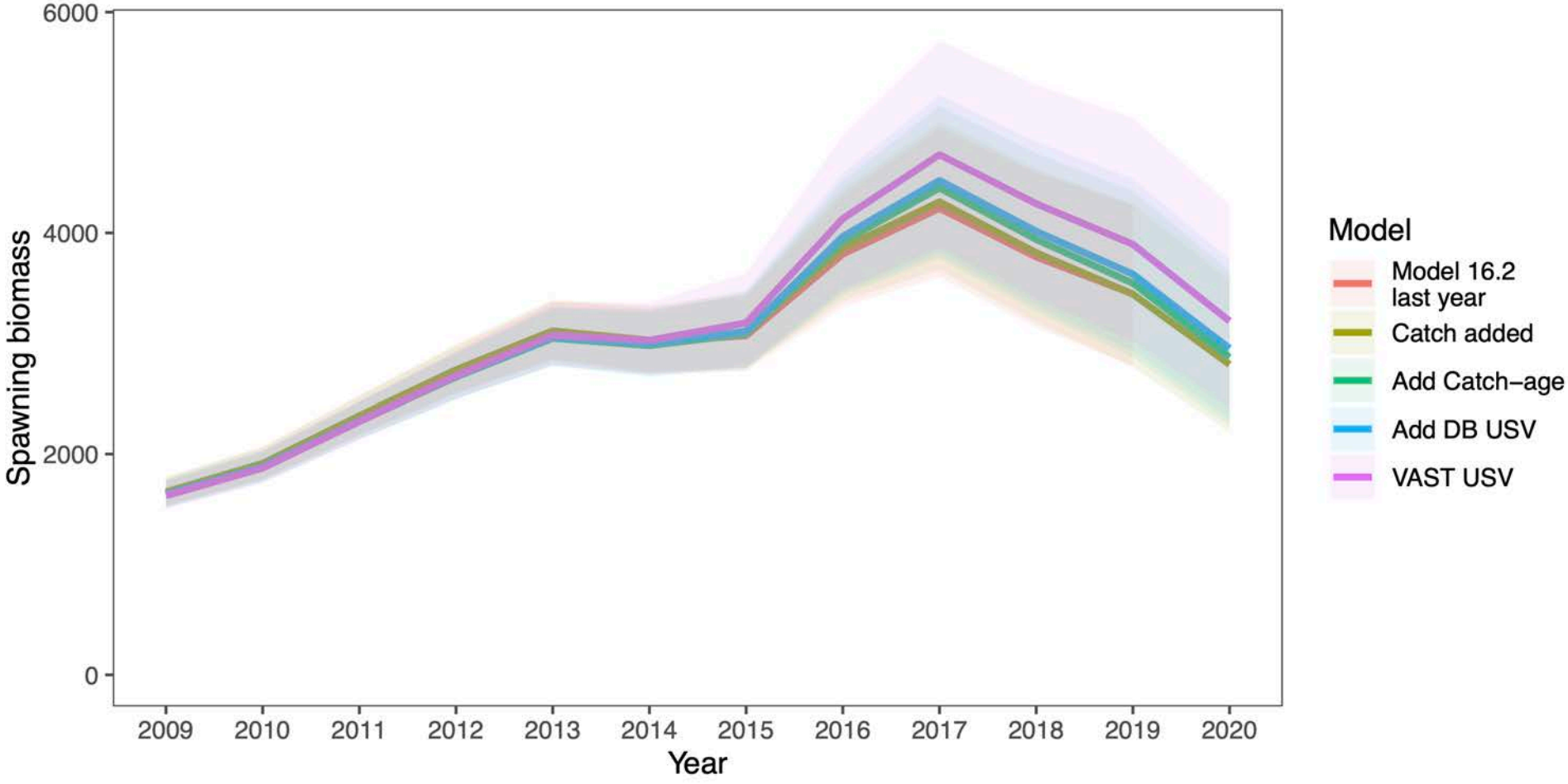
Impact on

Model

New data impact on model…

Data considerations				
Name	Updated catch to 2020	2019 fishery age data	2020 Drone biomass (design based)	2020 Drone backscatter (VAST)
Catch	X			
+ Age Fishery	X	X		
+ Drone (DB)	X	X	X	
+ Drone (VAST)	X	X		X

Data Impact on Model


6000
4000
2000
0
Spawning biomass
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Model
Model 16.2 last year
Catch added
Add Catch−age
Add DB USV
VAST USV

Selected model with USV for management advice

- Converted to biomass (in 2020)
- Similar to results from VAST
  - Was only backscatter

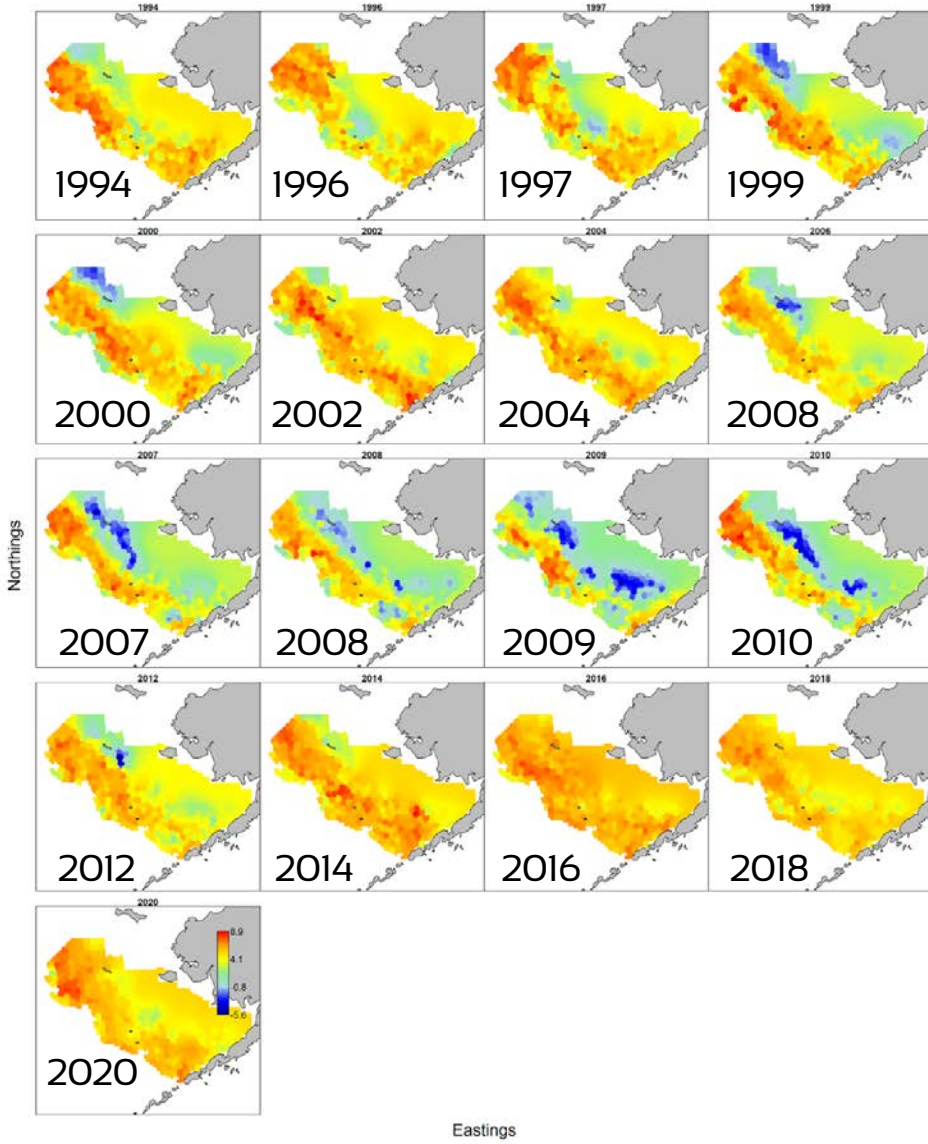
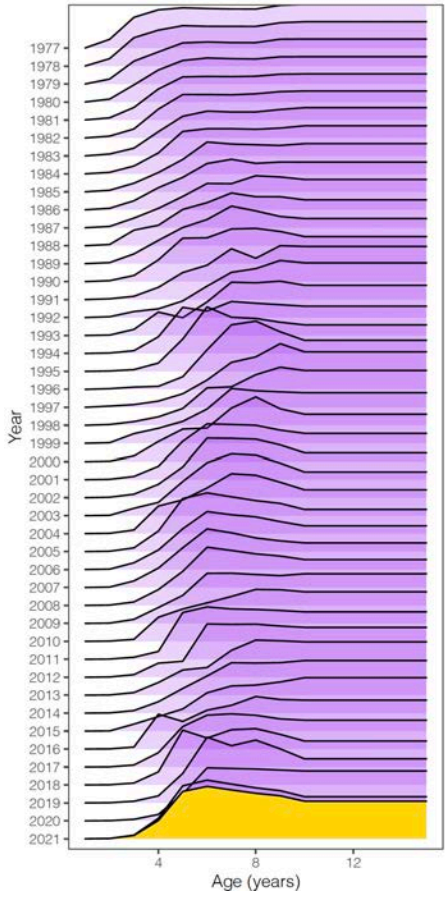
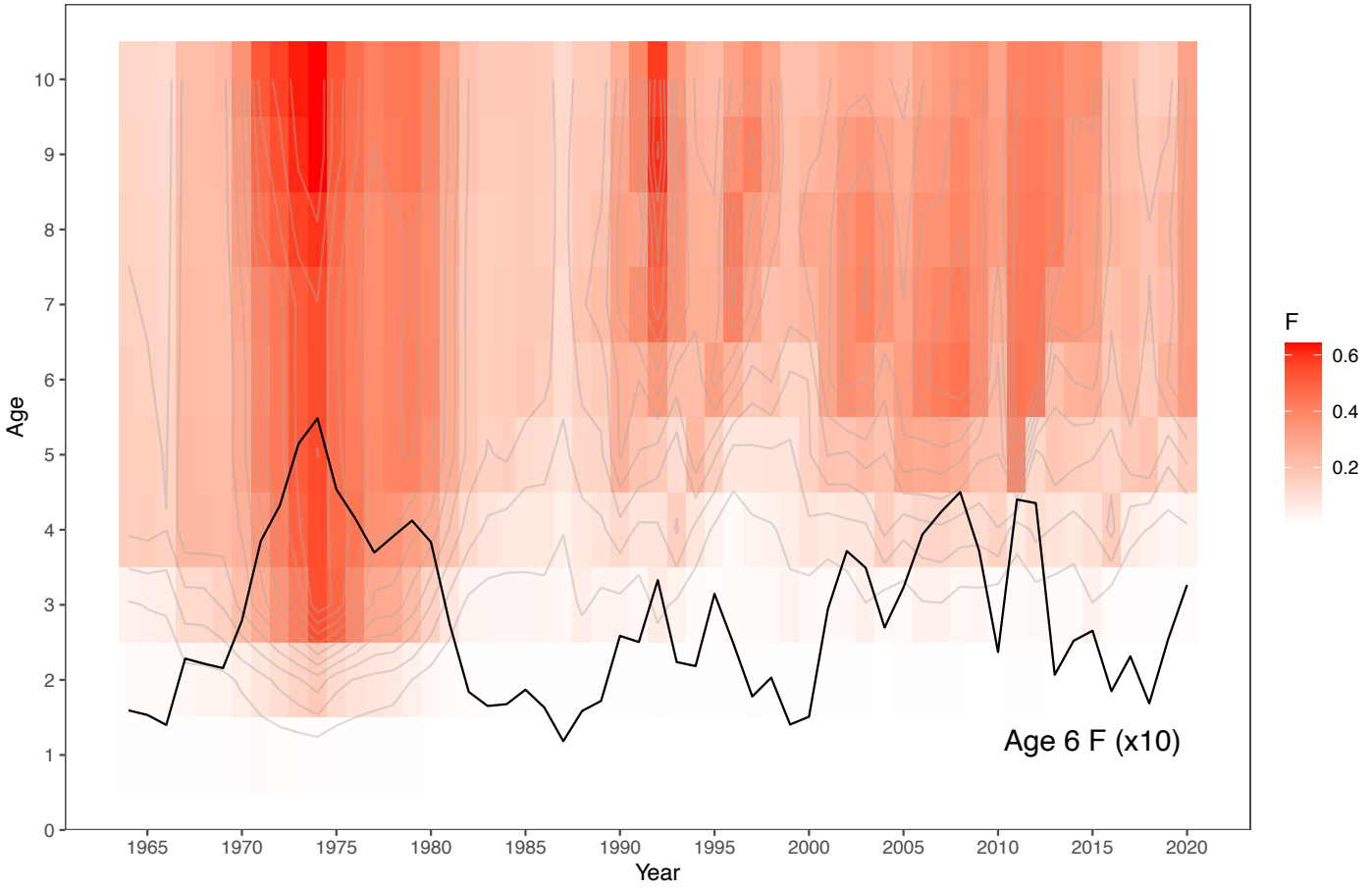


Figure 19: VAST model predicted log-density of pollock abundance based on acoustic backscatter from NMFS acoustic-trawl surveys (1994–2018) and from the 2020 USV transects.

EBS pollock
Assessment
Results

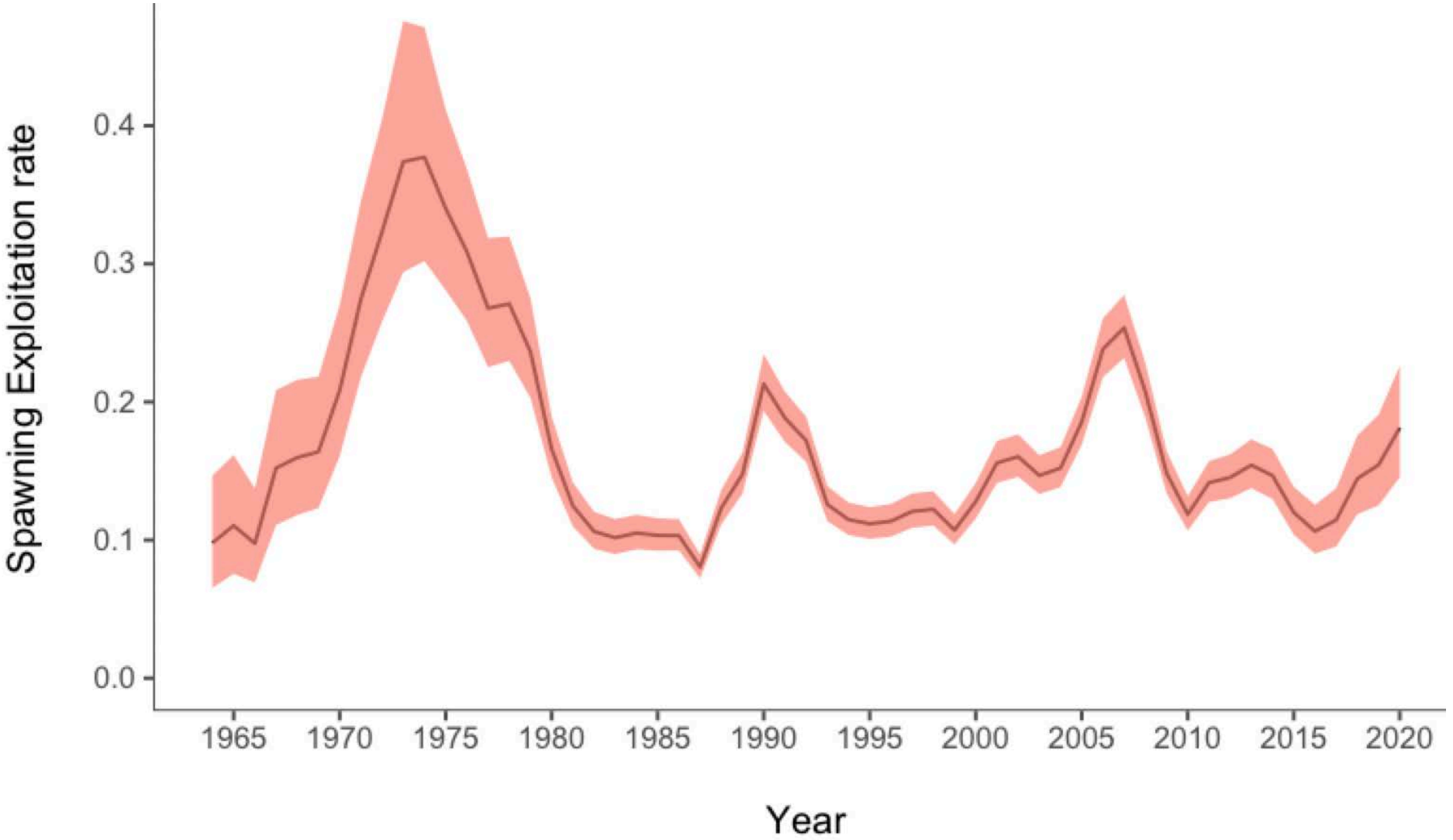
Fishing mortality rates





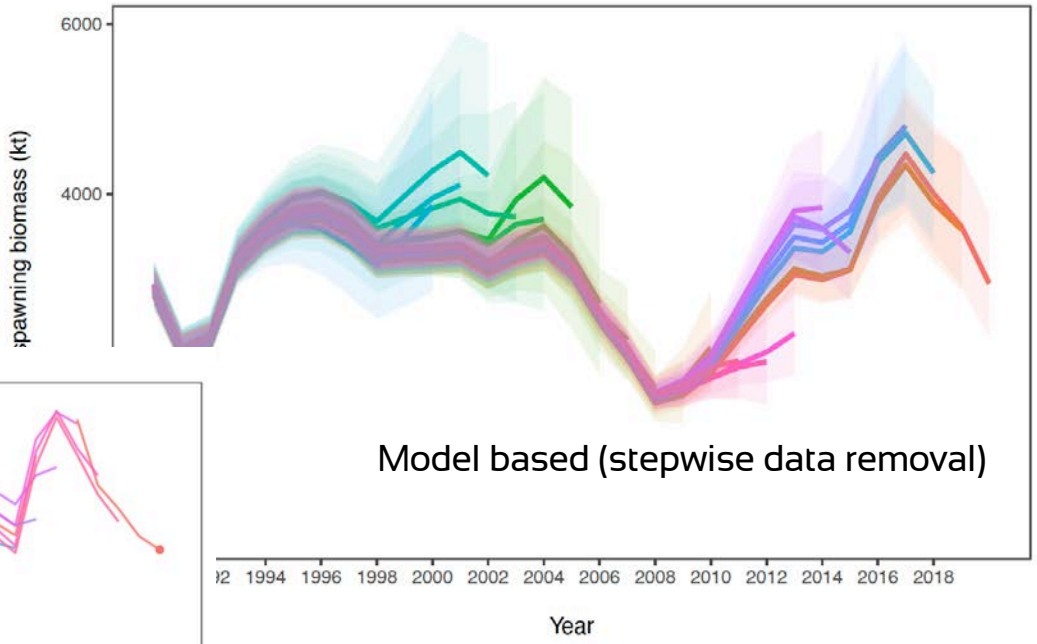
In a given year, what fraction of the estimated spawning stock was removed?

Spawning exploitation rate

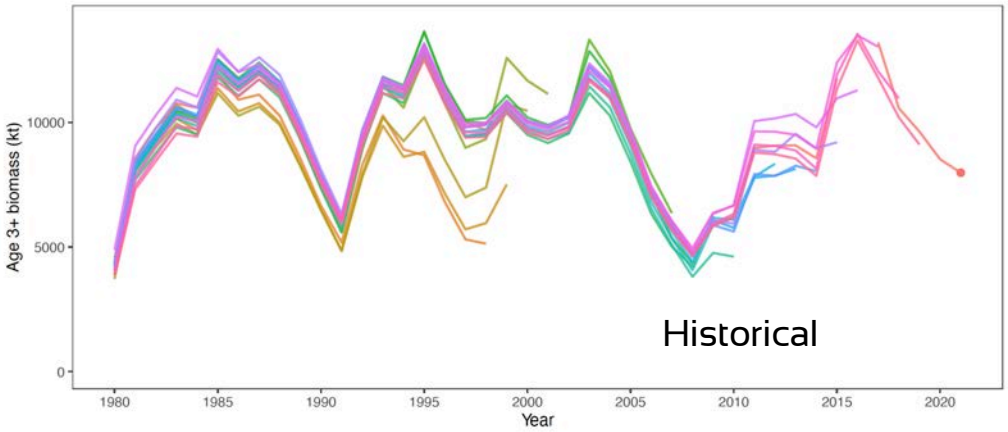


EBS pollock
Assessment
Results

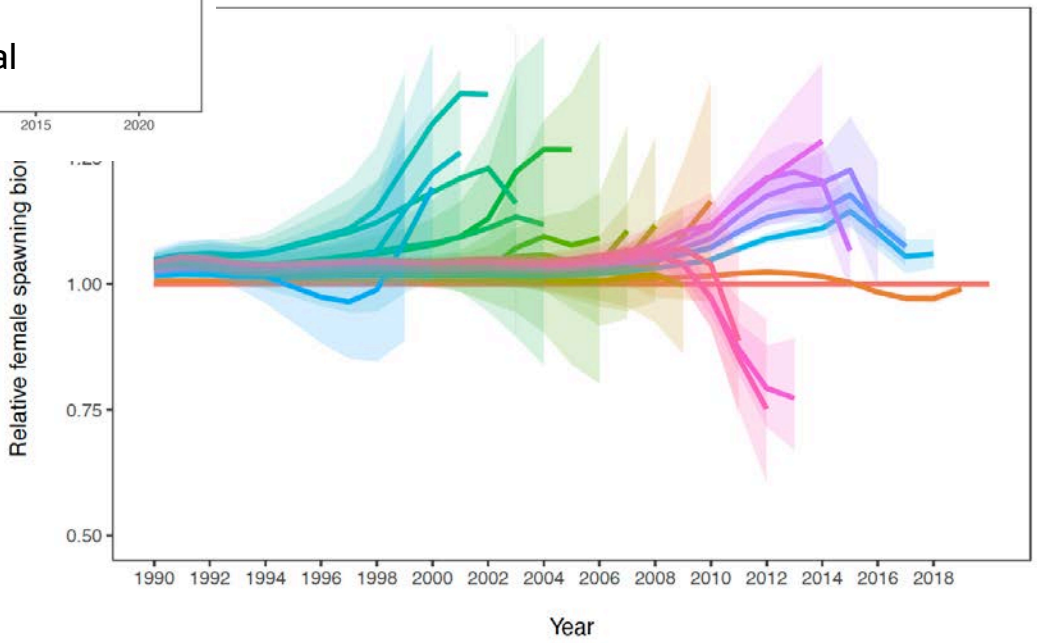
Retrospectives



Model based (stepwise data removal)

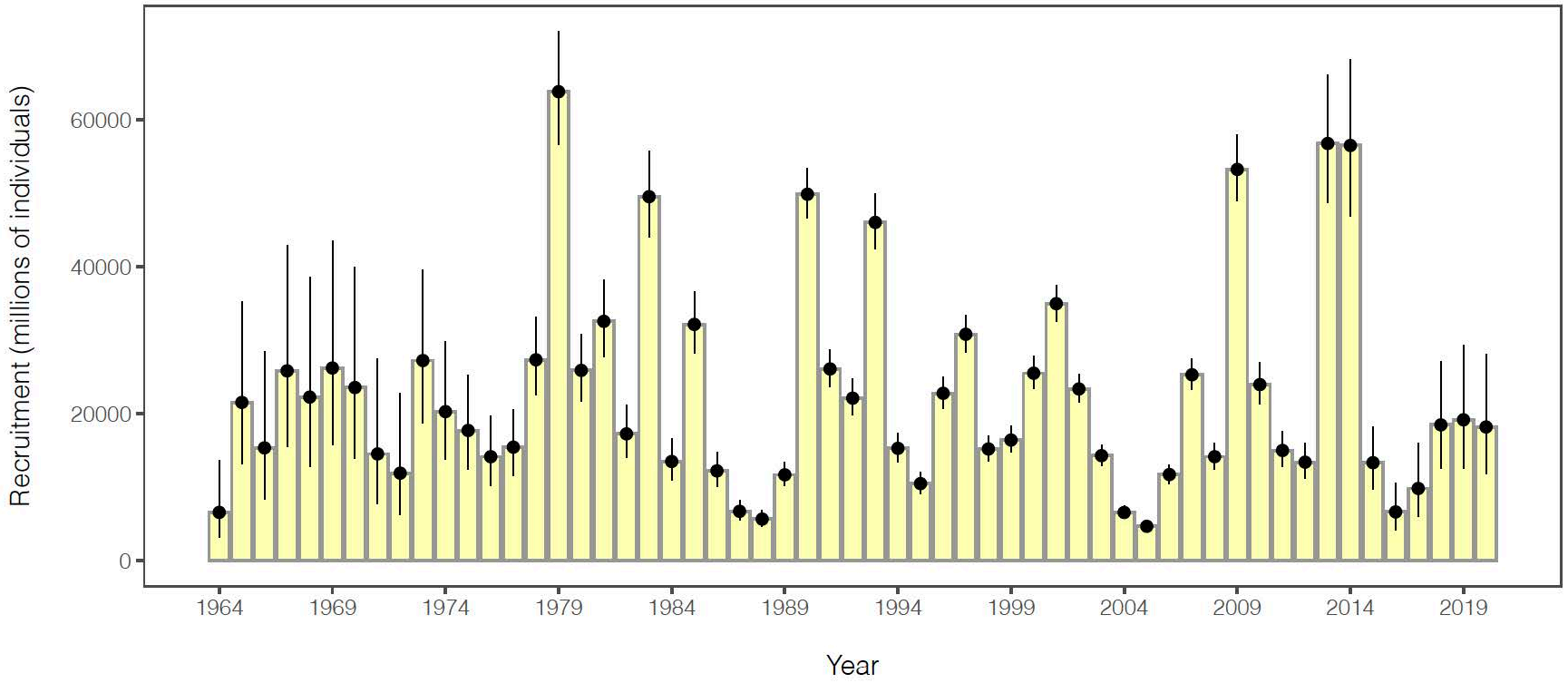


Historical



EBS pollock
Assessment
Results

Estimated recruitment



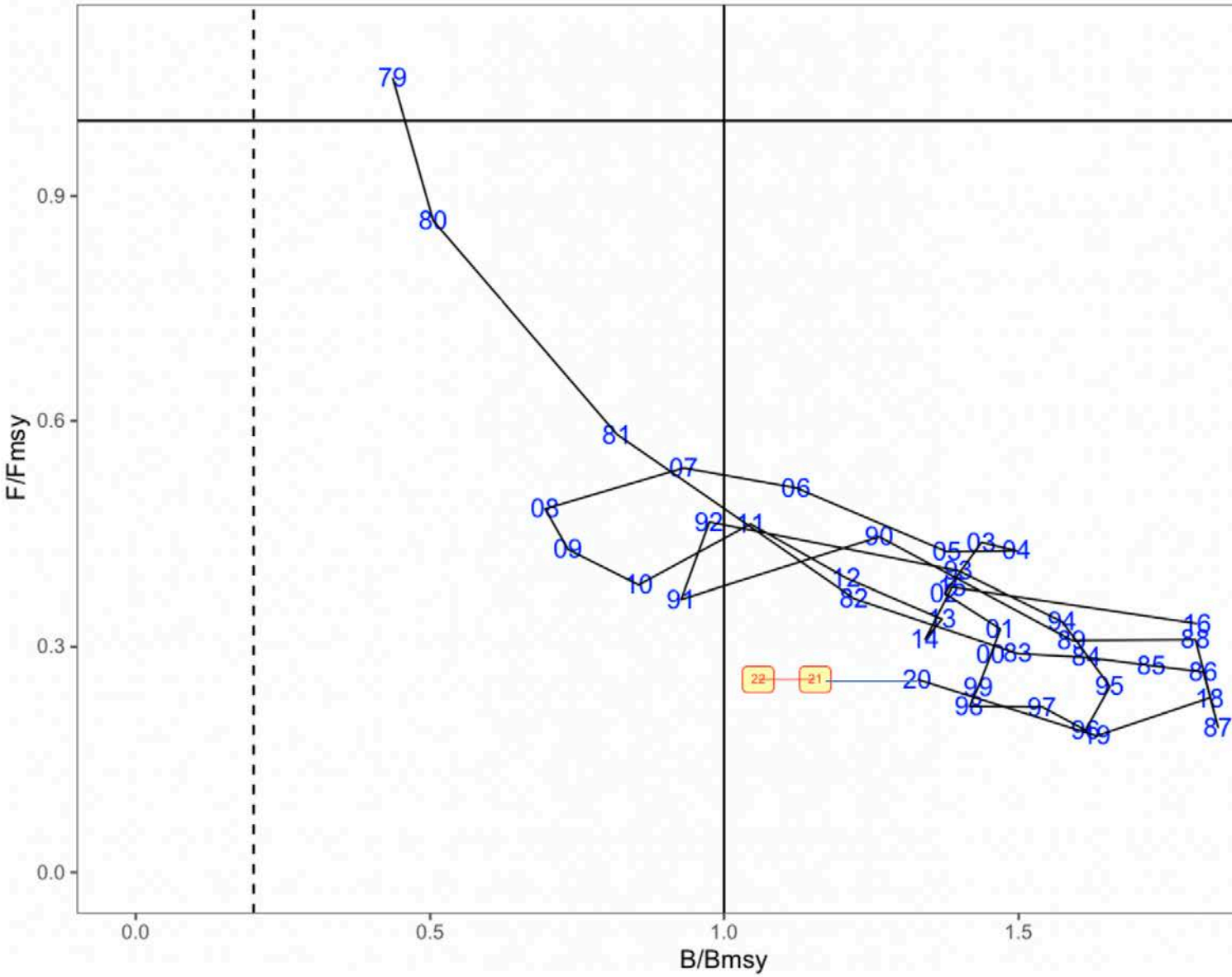


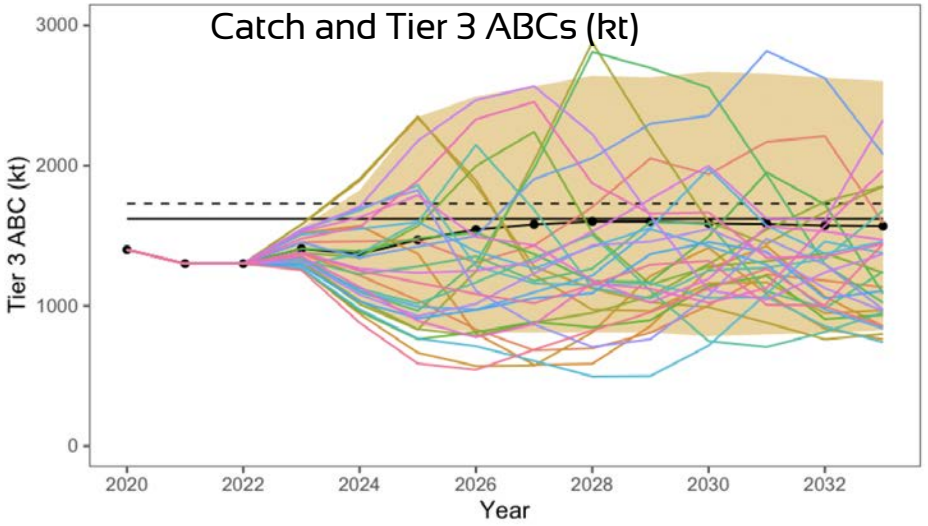
Figure 55: Estimated spawning biomass relative to annually estimated F_{MSY} values mortality rates for EBS pollock. Most recent two years are shaded in yellow

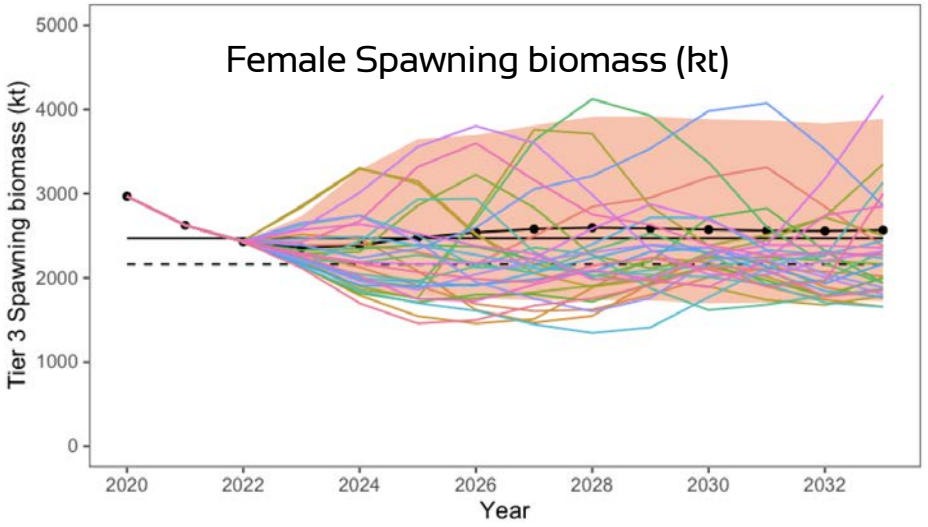
EBS pollock
Assessment
Results

Projections

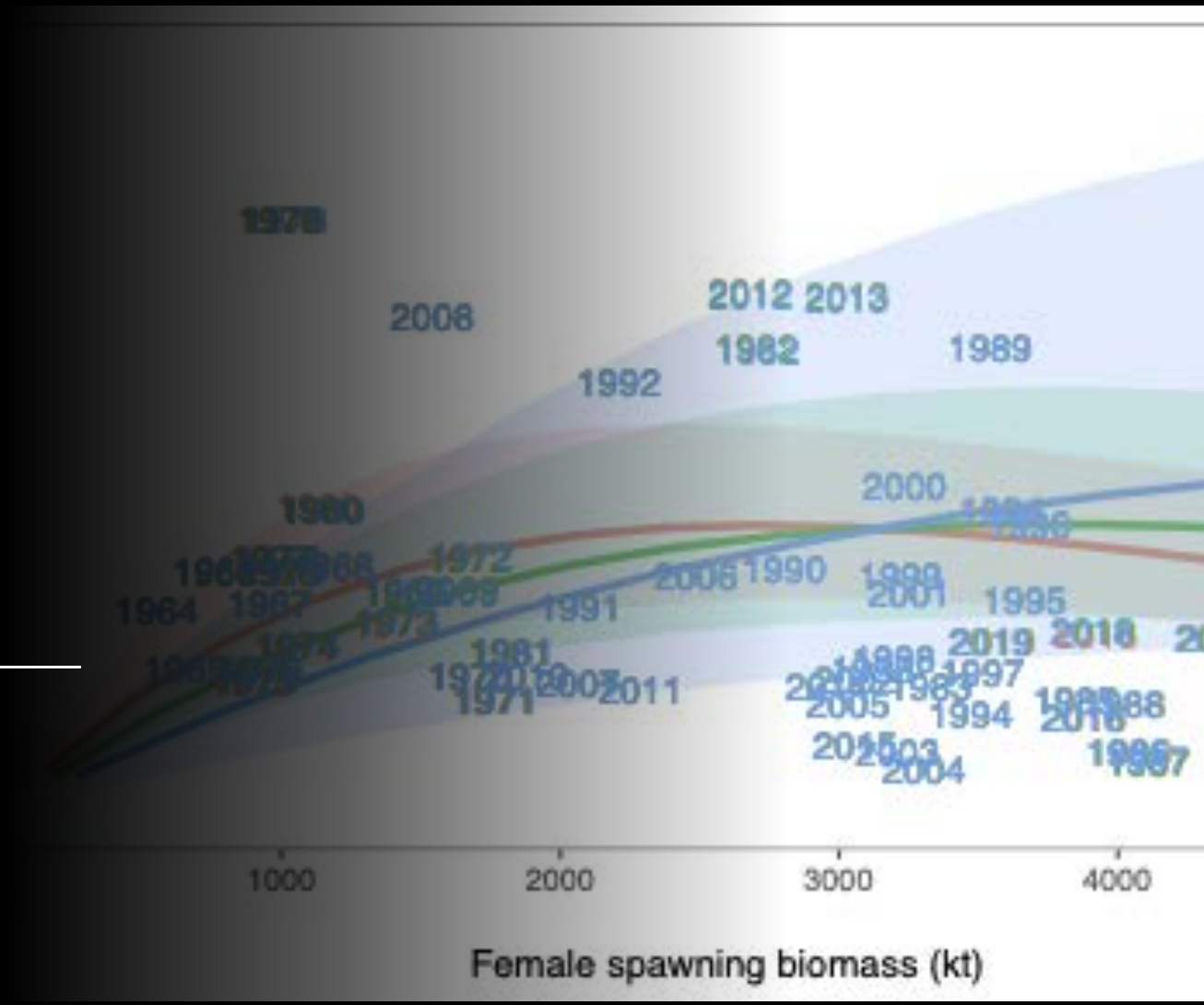
Cautions:

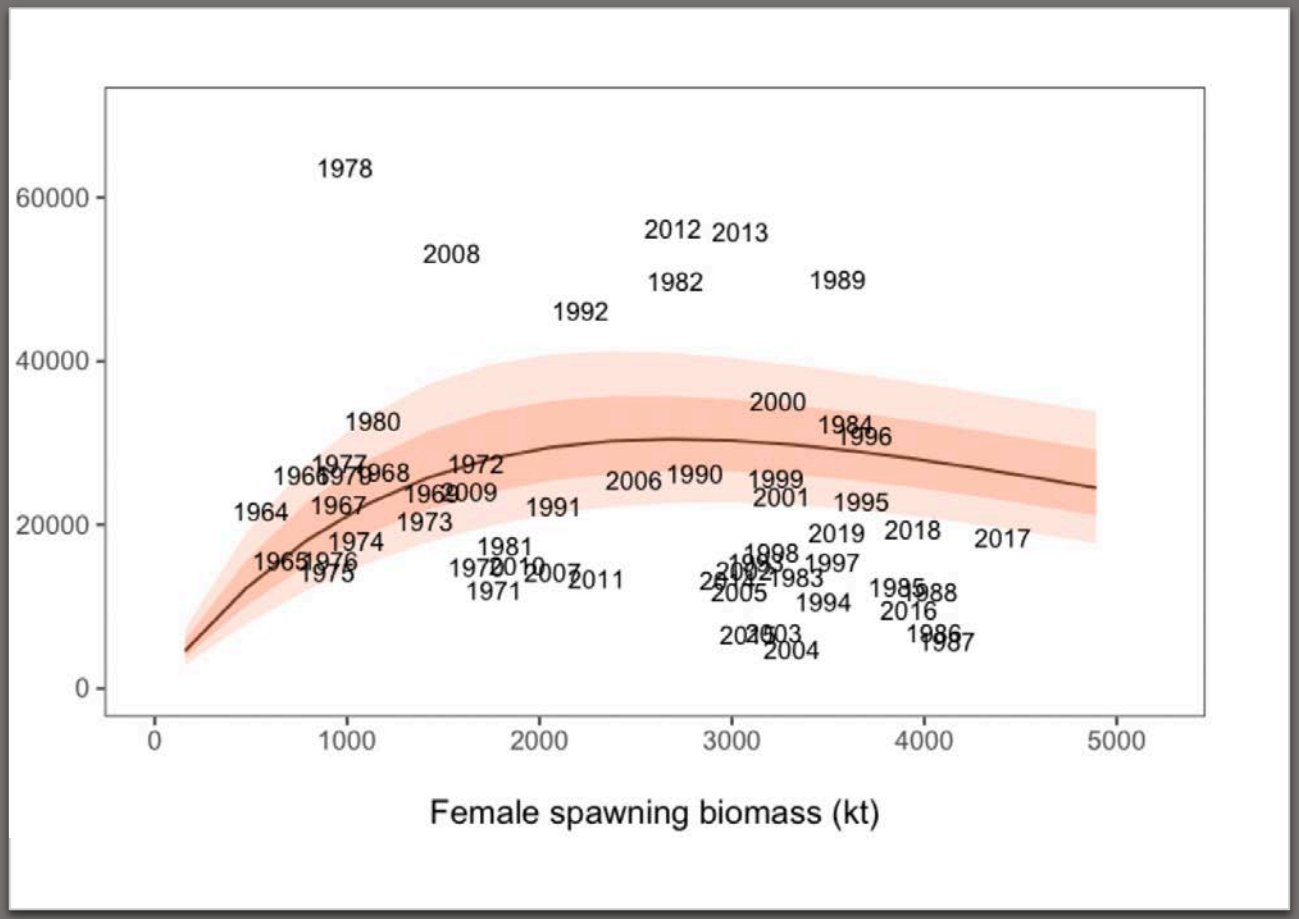
- Current absolute biomass uncertain
- Future weight-at-age may add uncertainty
- Actual year-year fluctuations in catch unrealistic

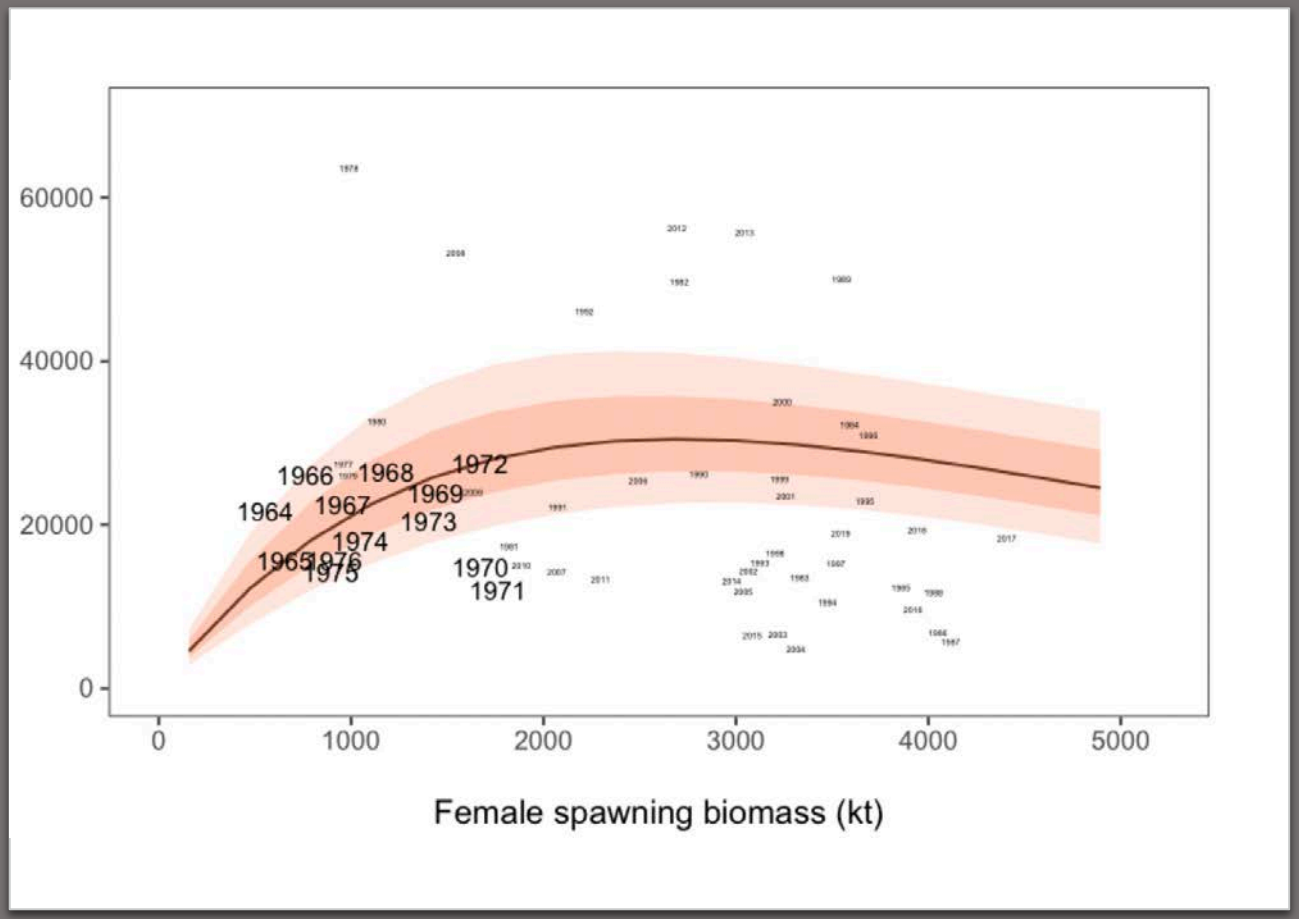


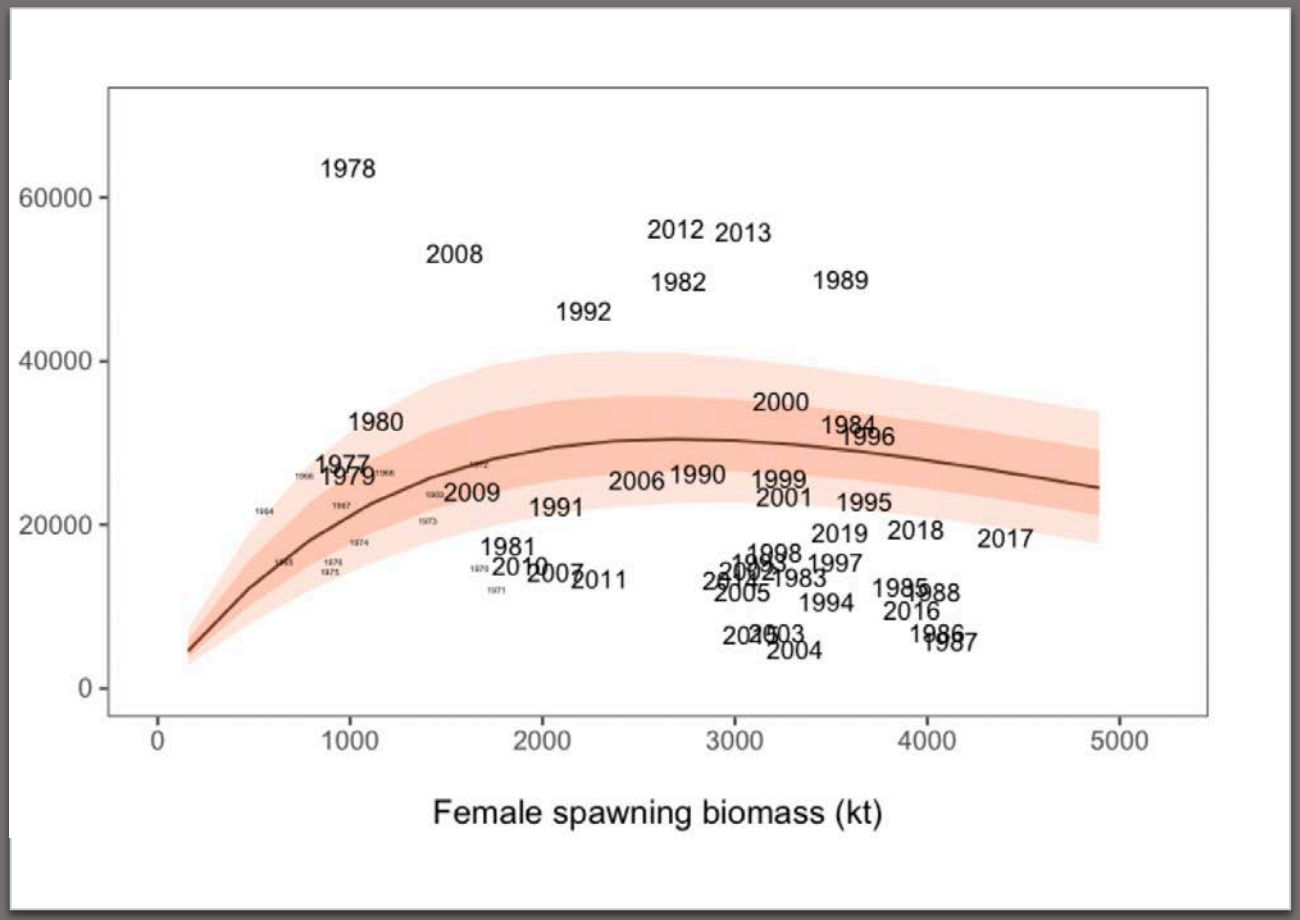


BSAI FMP Tiers…




60000
40000
20000
0
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)
1978
2012
2013
2008
1982
1989
1992
2000
1980
1984
1996
1977
1972
1968
2006
1990
1999
1964
1967
1962
2009
1991
2001
1995
1973
2019
2018
2017
1974
1981
1998
1997
1976
1975
1971
2011
2005
1983
1994
1985
1988
2016
1986
2004
1987


60000
40000
20000
0
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976


60000
40000
20000
0
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)
1978
2012
2013
2008
1982
1989
1992
2000
1980
1984
1996
1977
1979
2009
2006
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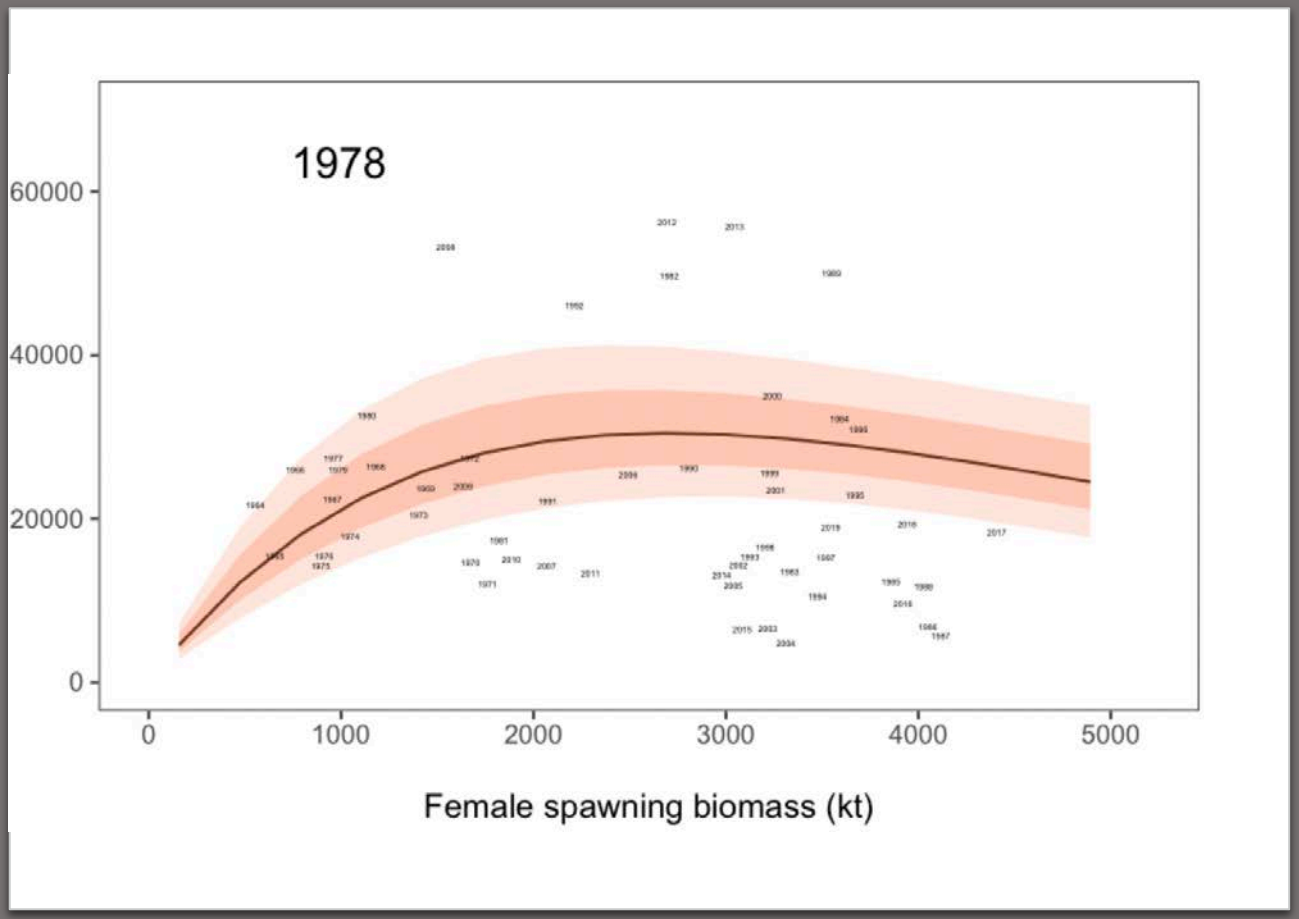
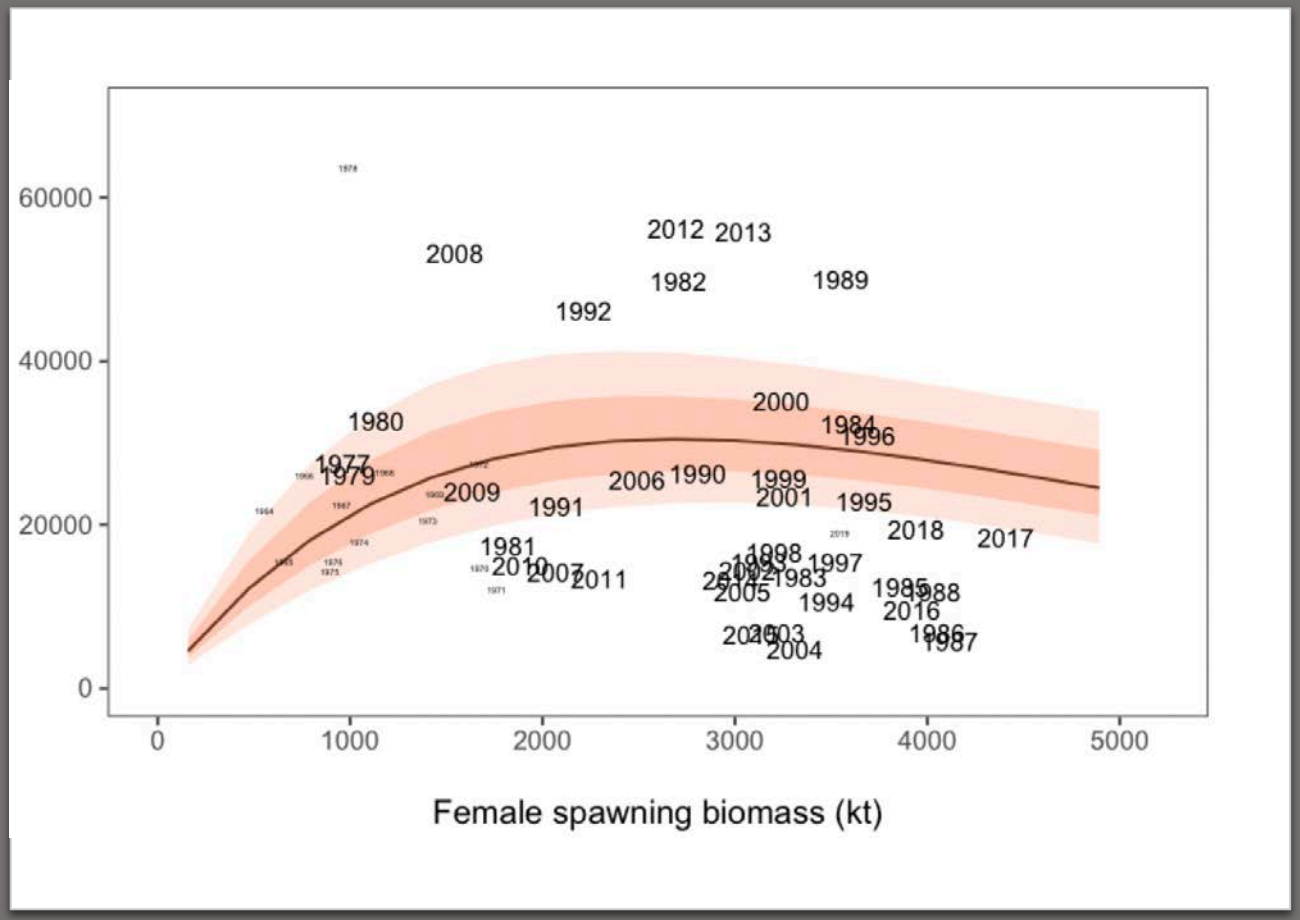

1978
60000
40000
20000
0
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)


60000
40000
20000
0
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)
2012
2013
2008
1982
1989
1992
2000
1980
1984
1996
1977
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2009
2006
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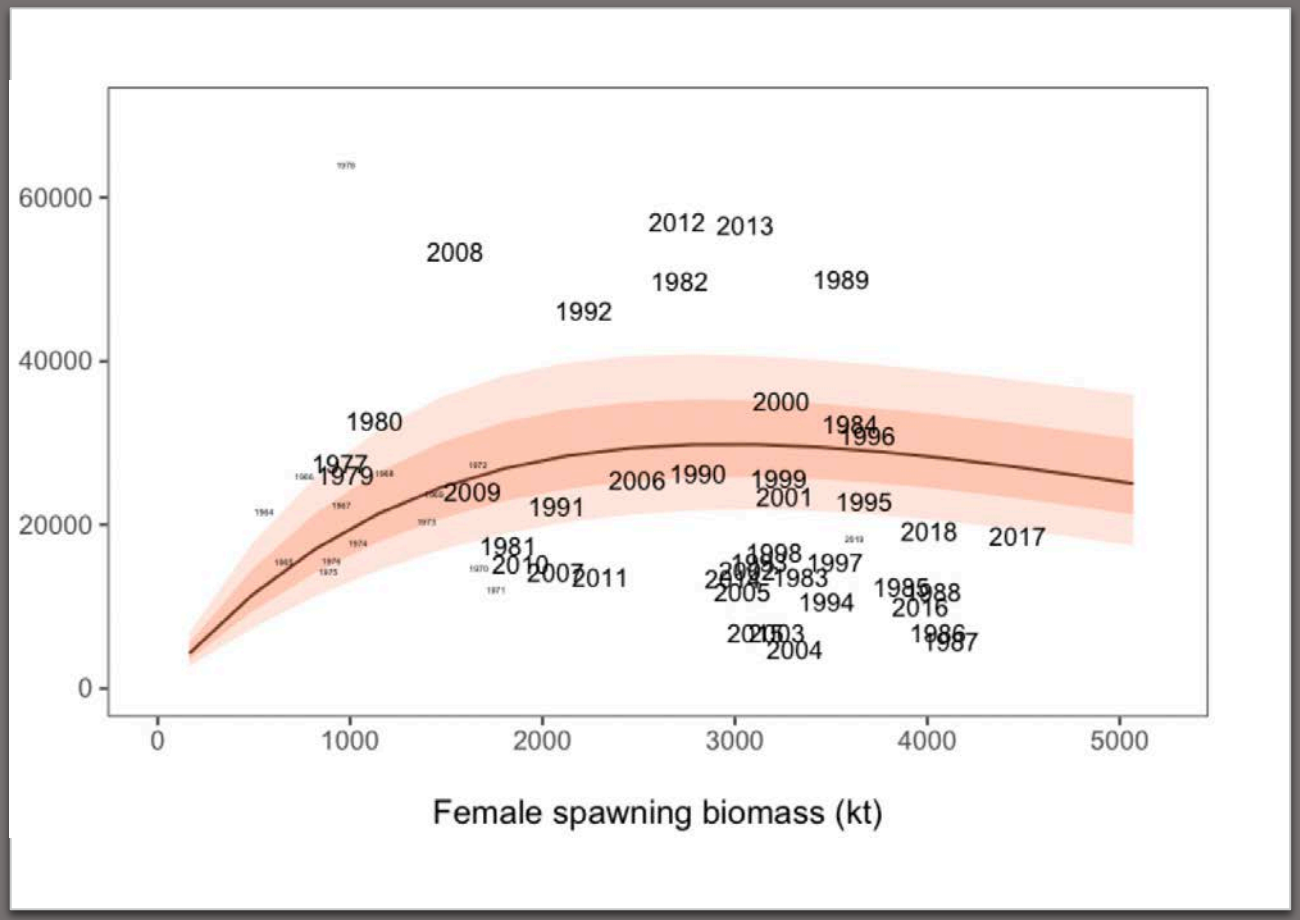
60000
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4000
5000
Female spawning biomass (kt)
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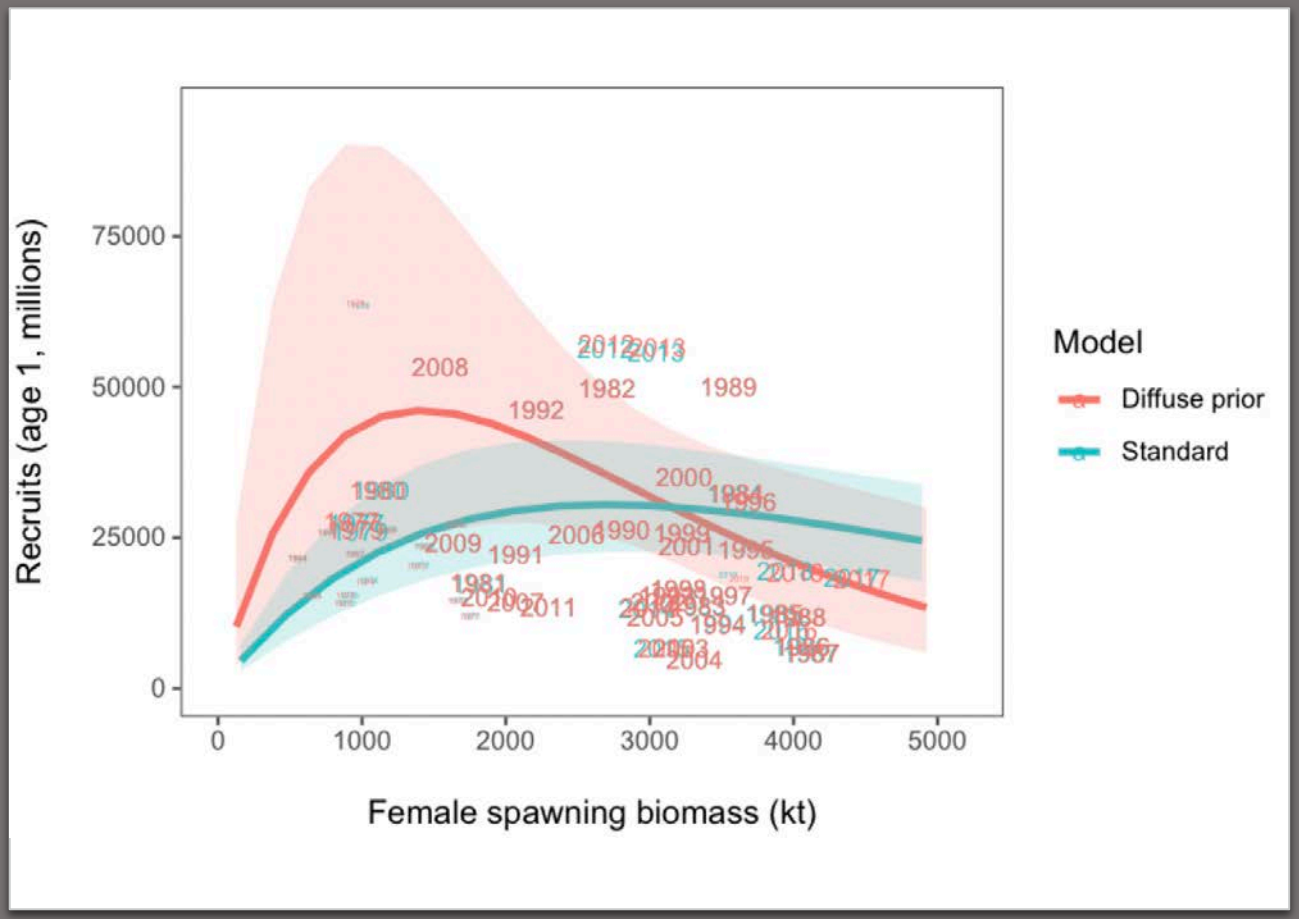
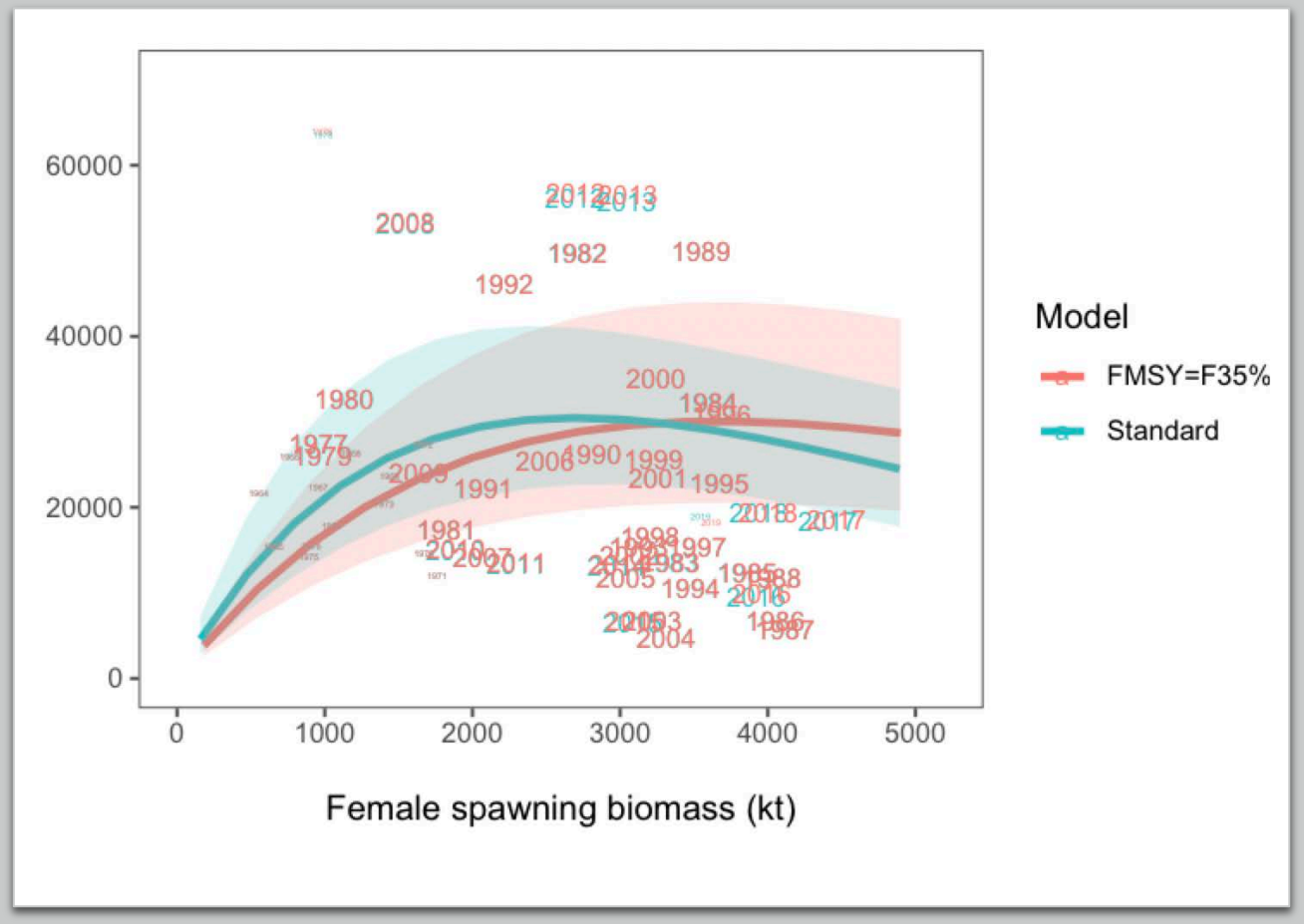


Relaxing assumptions

...

"Tier 3" Stock-recruit relationship



Factors for reducing ABC

	Considerations			
	Assessment-related	**Population dynamics**	**Environmental & ecosystem**	Fishery performance
Level 1 Normal	Typical to moderately increased uncertainty & minor unresolved issues in assessment	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental & ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2 Substantially increased concerns	Substantially increased assessment uncertainty unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals but the pattern is inconsistent across all indicators.	Some indicators showing adverse signals but the pattern is inconsistent across all indicators.
Level 3 Major Concern	Major problems with the stock assessment, very poor fits to data, high level of uncertainty, strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 4 Extreme concern	Severe problems with the stock assessment, severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented. More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock. Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly like to impact the stock.

Summary for Environmental/Ecosystem considerations

- The eastern Bering Sea returned to near-normal climatic conditions in 2020;
- Sea ice extent exceeded the historical median in parts of February and March 2020;
- Ice thickness was low and retreated quickly in spring 2020;
- The spatial extent of the cold pool was average;
- The eastern Bering Sea is experiencing a persistent warm stanza, greater in both magnitude and duration than that of the early 2000s;
- The 2019 year class experienced unfavorable temperature conditions from age-0 to age-1 and is predicted to have below-average recruitment to age-4 in 2023.
- Winter 2019/2020 had an average wind speed direction (north/south) near the long-term average;
- The 2020 springtime drift pattern was mixed indicating larvae may have been retained over the southern middle shelf;
- The spring bloom over the southern shelf occurred about a week earlier than the long-term mean;
- Chlorophyll concentrations over the southern shelf have been below the long-term mean since 2016;
- Low abundance of large copepods during late-summer in 2017-2019 indicate poor overwinter survival and recruitment to age-3 in 2020-2022;
- Condition (weighted length-weight residuals) of juvenile pollock (100-250 mm TL) in 2019 was at the long-term mean indicating moderate foraging conditions;
- Condition of adult pollock (>250 mm TL) in 2019 was above-average indicating good foraging conditions (including cannibalism of juvenile pollock);
- Predation pressure from cannibalism may have been mitigated by the average spatial extent of the cold pool (i.e., thermal barrier);
- The decoupling of abundance timeseries for Pacific cod and walleye pollock suggests a shift in drivers of survival in these two populations and may indicate broad-scale transitions in the ecosystem (e.g., from pelagic- to benthic-dominated production);
- The widespread die-off event of short-tailed shearwaters slowed in 2020 and may reflect better feeding conditions (i.e., euphausiids) over the shelf in 2019.

Risk table

- Ecosystem and fishery performance score of 2

Considerations			
Assessment-related	Population dynamics	Environmental or ecosystem	Fisheries
Level 1: No concern	Level 1: No concern	Level 2: Substantially increased concerns	Level 2: Substantially increased concerns

Table 47: 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
$P\left[F_{2021} > F_{MSY}\right]$	Probability that the fishing mortality in 2021 exceeds F_{MSY}	OFL definition is based on F_{MSY}
$P\left[B_{2022} < B_{MSY}\right]$	Probability that the spawning biomass in 2022 is less than B_{MSY}	B_{MSY} is a reference point target and biomass in 2021 provides an indication of the impact of 2021 fishing
$P\left[B_{2023} < B_{MSY}\right]$	Probability that the spawning biomass in 2023 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 2021 and 2022
$P\left[B_{2023} < \bar{B}\right]$	Probability that the spawning biomass in 2022 is less than the 1978–2020 mean	To provide some perspective of what the stock condition might be relative to historical estimates after fishing in 2021.
$P\left[B_{2025} < \bar{B}\right]$	Probability that the spawning biomass in 2025 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 2021.
$P\left[B_{2025} < B_{2021}\right]$	Probability that the spawning biomass in 2025 is less than that estimated for 2021	To provide a medium term expectation of stock status relative to 2021 levels
$P\left[B_{2023} < B_{20\%}\right]$	Probability that the spawning biomass in 2023 is less than $B_{20\%}$	$B_{20\%}$ had been selected as a Steller Sea Lion lower limit for allowing directed fishing
$P\left[p_{a_5,2023} > \bar{p}_{a_5}\right]$	Probability that in 2023 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.
$P\left[D_{2022} < D_{1994}\right]$	Probability that the diversity of ages represented in the spawning biomass (by weight) in 2022 is less than the value estimated for 1994	To provide a relative index on the abundance of different age classes in the 2022 population relative to 1994 (a year identified as having low age composition diversity)
$P\left[D_{2025} < D_{1994}\right]$	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 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)
$P\left[E_{2021} > E_{2020}\right]$	Probability that the theoretical fishing effort in 2021 will be greater than that estimated in 2020.	To provide the relative effort that is expected (and hence some idea of costs).

- Decision table explanation

(Table 47)

Decision table diagnostics included

Table 48: Outcomes of decision (expressed as chances out of 100) given different 2021 catches (first row, in kt). Note that for the 2018 and later year-classes average values were assumed. Constant Fs based on the 2021 catches were used for subsequent years.

	10	850	1000	1150	1350	1300	1450	1600
$P\left[F_{2021} > F_{MSY}\right]$		1	5	13	29	25	36	47
$P\left[B_{2022} < B_{MSY}\right]$		28	32	35	41	39	44	48
$P\left[B_{2023} < B_{MSY}\right]$		23	27	32	39	37	43	49
$P\left[B_{2022} < \bar{B}\right]$		84	89	93	96	96	97	98
$P\left[B_{2025} < \bar{B}\right]$		28	35	41	50	48	54	60
$P\left[B_{2025} < B_{2021}\right]$		19	23	28	34	33	38	42
$P\left[B_{2023} < B_{20\%}\right]$		1	1	1	2	2	2	3
$P\left[p_{a_5,2023} > \bar{p}_{a_5}\right]$		66	72	76	81	80	83	85
$P\left[D_{2022} < D_{1994}\right]$		0	0	0	0	0	0	0
$P\left[D_{2025} < D_{1994}\right]$		4	5	8	12	11	14	19
$P\left[E_{2021} > E_{2020}\right]$		4	22	47	74	69	82	90

EBS pollock
Assessment
Results

EBS pollock summary

- Outlook
  - Spawning biomass declining
    - From high levels
    - Fishing challenges ~~likely to~~ have increased
  - Recommend stabilization of effort
    - ***ABC ~ 1.34 million t (max permissible under FMP higher)***
  - Stock could drop below B_{msy} by 2021
    - could affect 2021 ABC (and TAC)

The following table applies for Model 20.0, the model used for last year's assessment but with data from the uncrewed surface vehicles (USVs) included as an extension of the acoustic trawl survey. An alternative table is provided for this model which excludes the USV data from 2020. As in past years, the ABC recommendation reflects the Tier 3 estimate.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2020	2021	2021	2022
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)	9,128,000 t	8,494,000 t	8,145,000 t	7,641,000 t
Projected female spawning biomass (t)	2,991,000 t	2,674,000 t	2,602,000 t	2,406,000 t
B_0	5,777,000 t	5,777,000 t	5,792,000 t	5,792,000 t
B_{msy}	2,148,000 t	2,148,000 t	2,257,000 t	2,257,000 t
F_{OFL}	0.449	0.449	0.341	0.341
$maxF_{ABC}$	0.383	0.383	0.304	0.304
F_{ABC}	0.225	0.225	0.214	0.214
OFL	4,085,000 t	3,385,000 t	2,594,000 t	2,366,000 t
$maxABC$	3,485,000 t	2,888,000 t	2,307,000 t	2,105,000 t
ABC	2,043,000 t	1,767,000 t	1,626,000 t	1,484,000 t
Status	2018	2019	2019	2020
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

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Adapting to climate-driven distribution shifts using model-based indices and age composition from multiple surveys in the walleye pollock (*Gadus chalcogrammus*) stock assessment

Cecilia A. O'Leary[1,2] | James T. Thorson[3] | James N. Ianelli[4] | Stan Kotwicki[1]

[1]Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA, Seattle, WA, USA

[2]School of Aquatic and Fishery Science, University of Washington, Seattle, WA, USA

[3]Habitat and Ecological Processes Research Program, Alaska Fisheries Science Center, NOAA, Seattle, WA, USA

[4]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA, Seattle, WA, USA

Correspondence
Cecilia A. O'Leary, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA, Seattle, WA 98115, USA.
Email: cecilia.oleary@noaa.gov

Abstract

The northern Bering Sea is transitioning from an Arctic to subarctic fish community as climate warms. Scientists and managers aim to understand how these changing conditions are influencing fish biomass and spatial distribution in this region, as both are used to inform stock assessments and fisheries management advice. Here, we use a spatio-temporal model for walleye pollock (*Gadus chalcogrammus*) to provide two inputs to its stock assessment model: (a) an alternative model-based biomass index and (b) alternative model-based age compositions. Both inputs were derived from multiple fishery-independent data that span different regions of space and time. We developed an assessment model that utilizes both the standard and model-based inputs from multiple surveys despite inconsistencies in spatial and temporal coverage, and we found that using these data provide an improved spatial and temporal scope of total pollock biomass. Age composition information indicated that pollock density