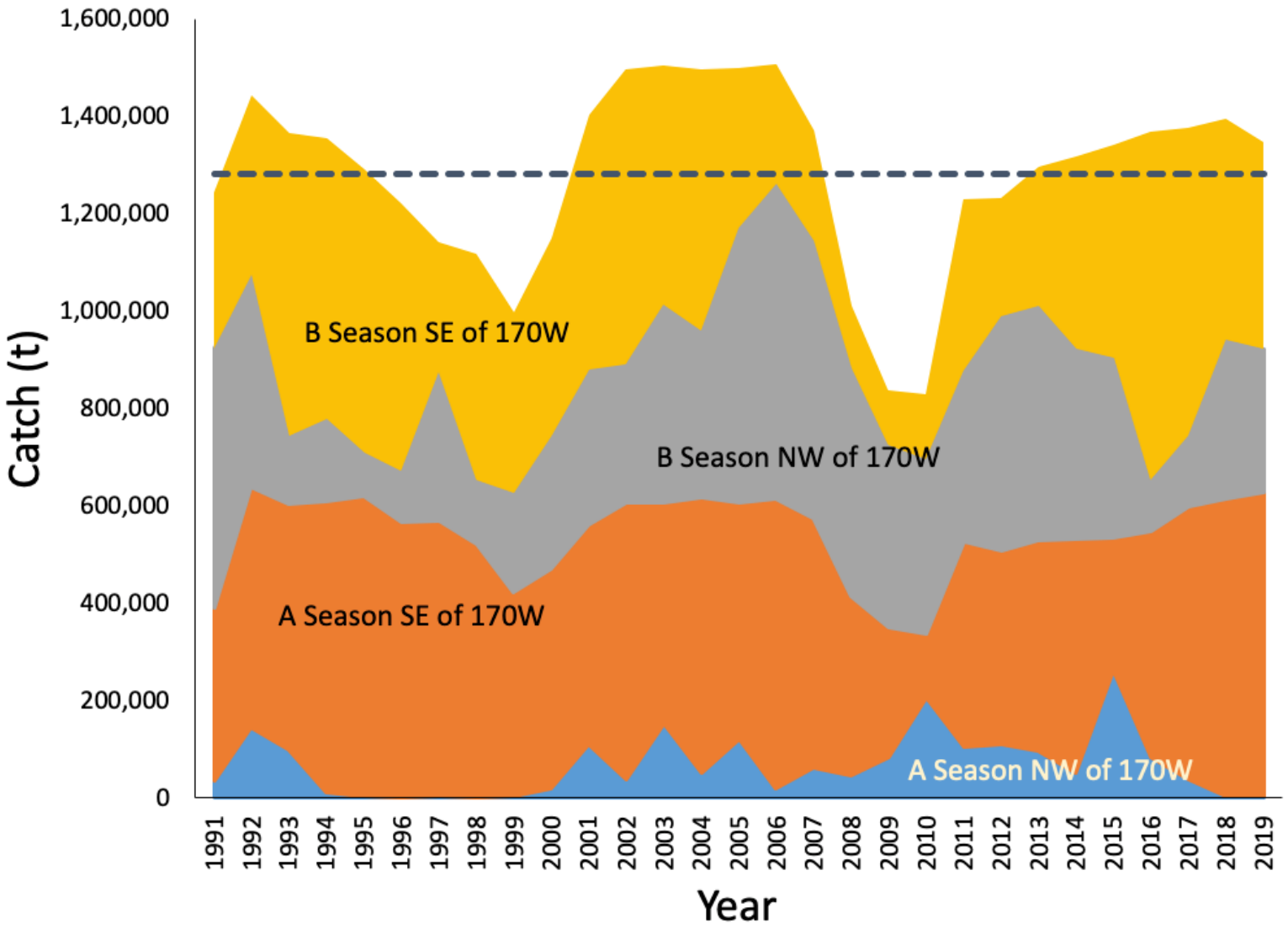
NOAA FISHERIES

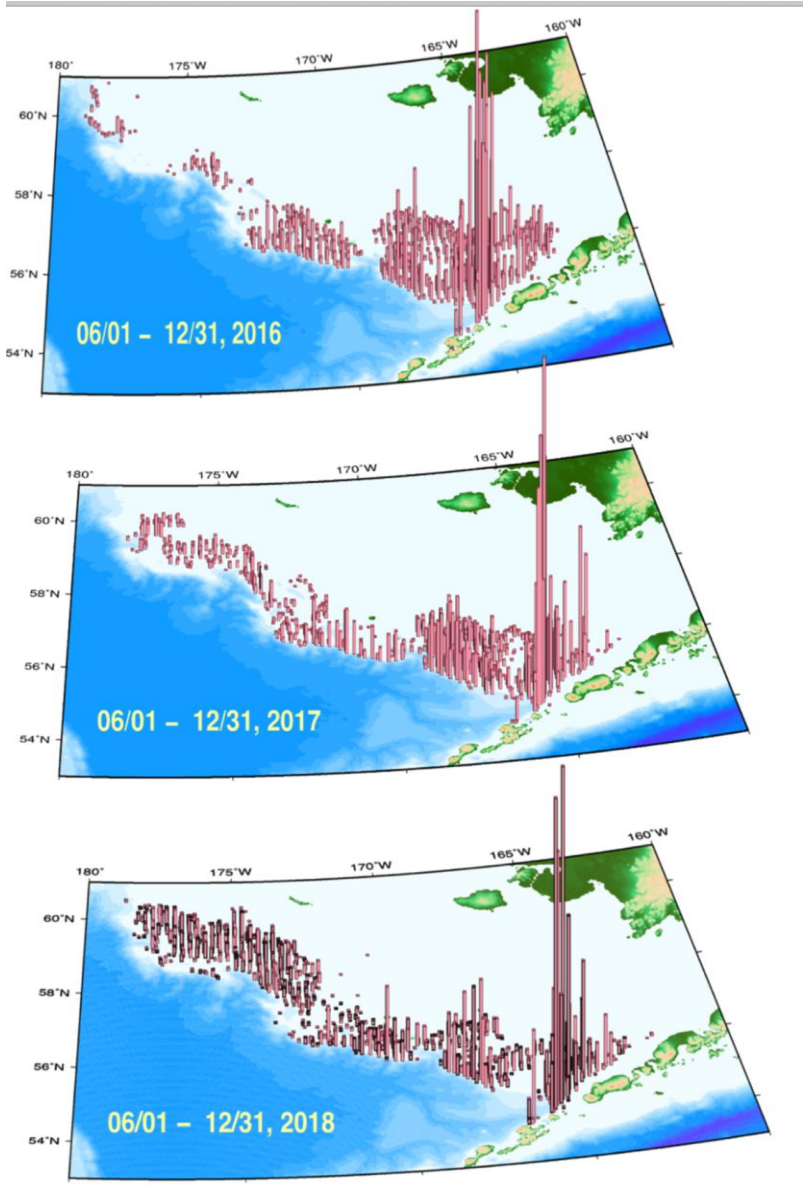
EBS Pollock stock assessment

2019 BSAI Plan Team meeting

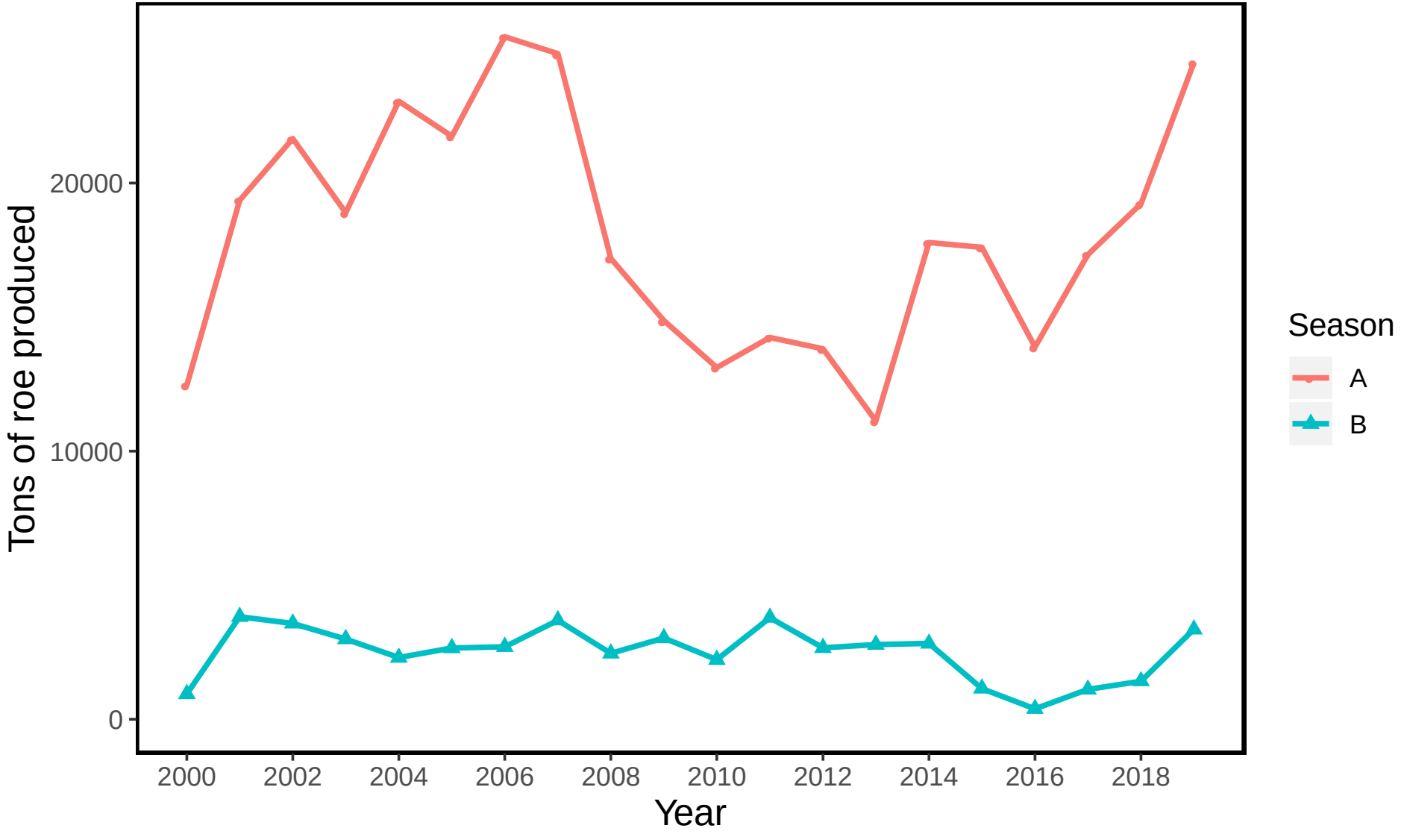
Seasonal and area catch patterns

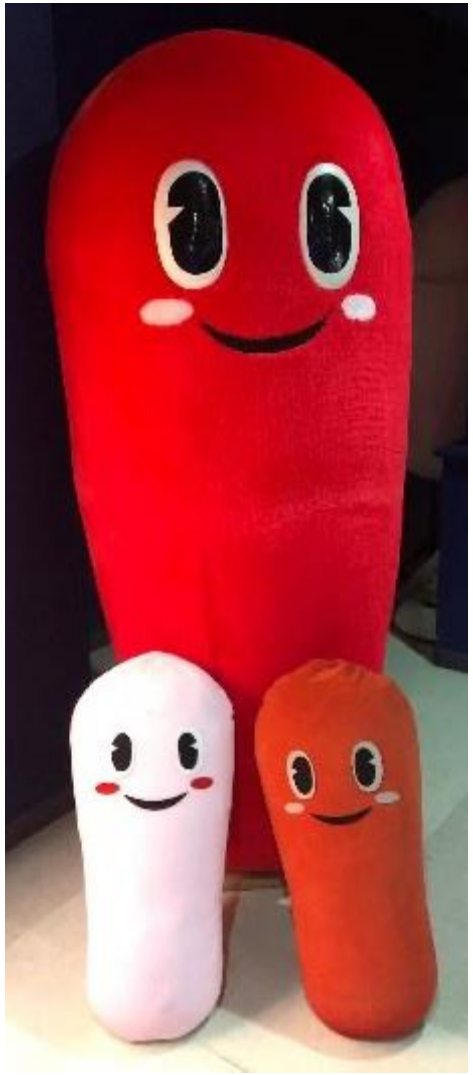
Eastern Bering Sea pollock

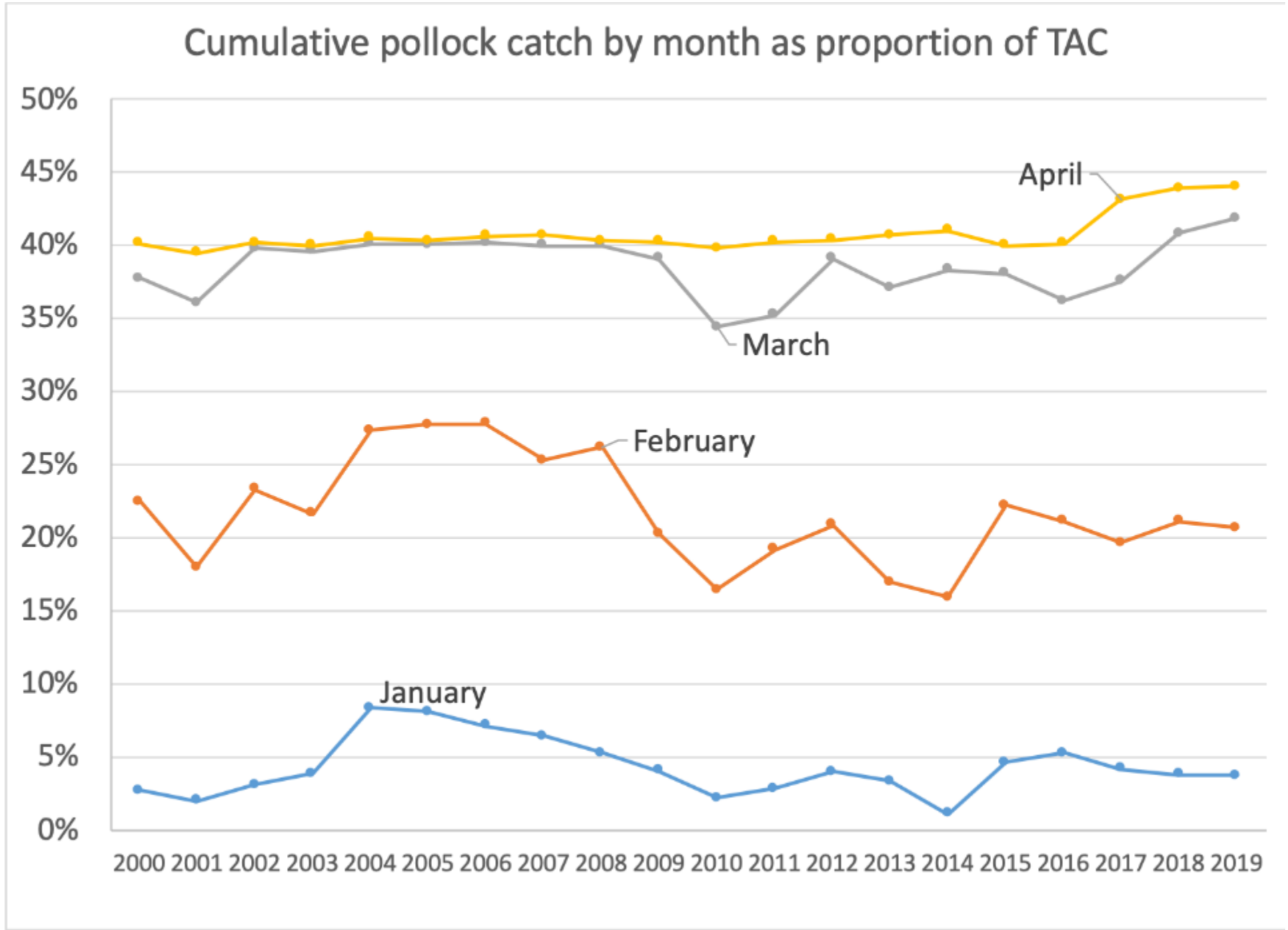


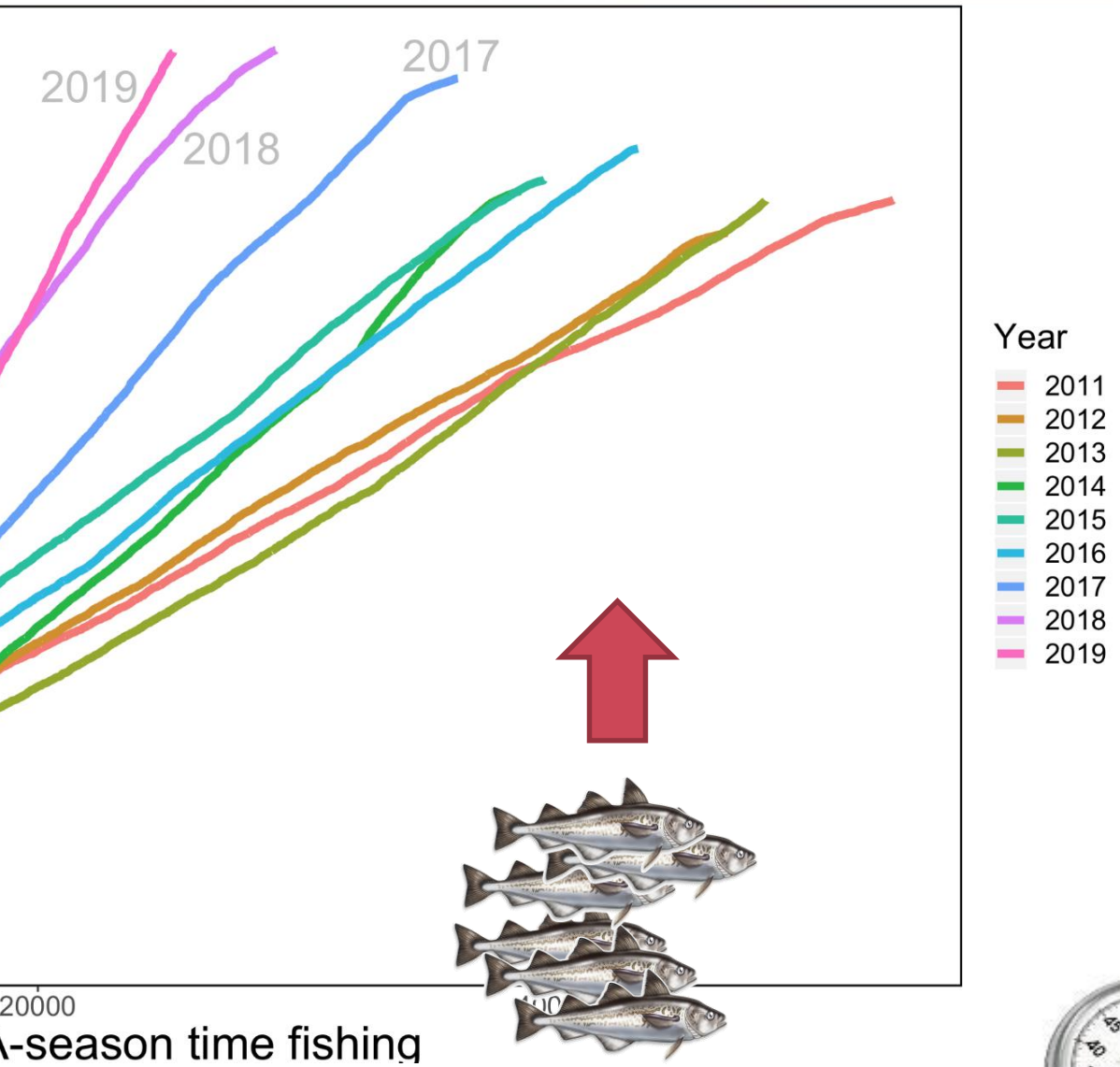


Fishing: Seasonal roe production

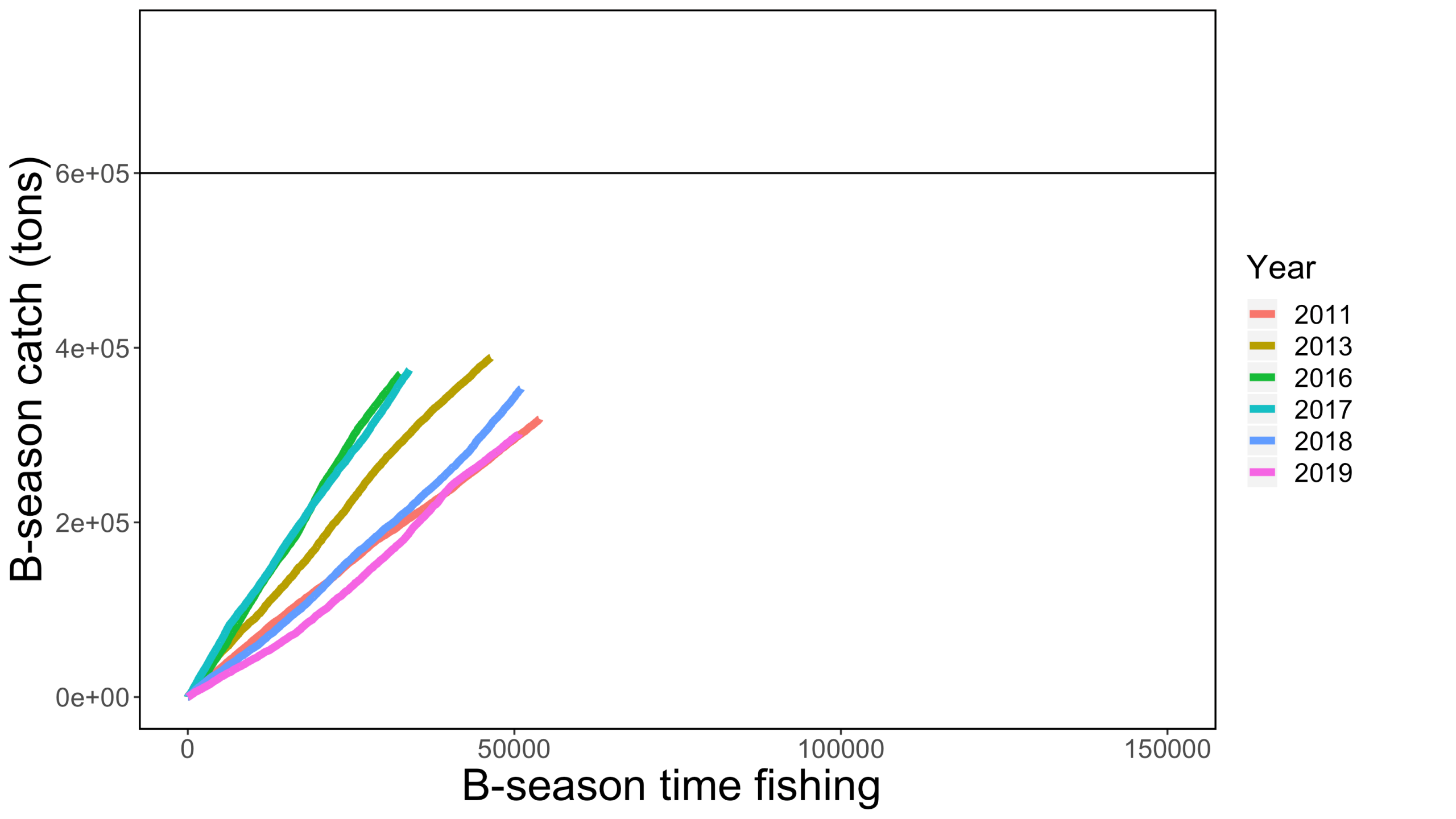


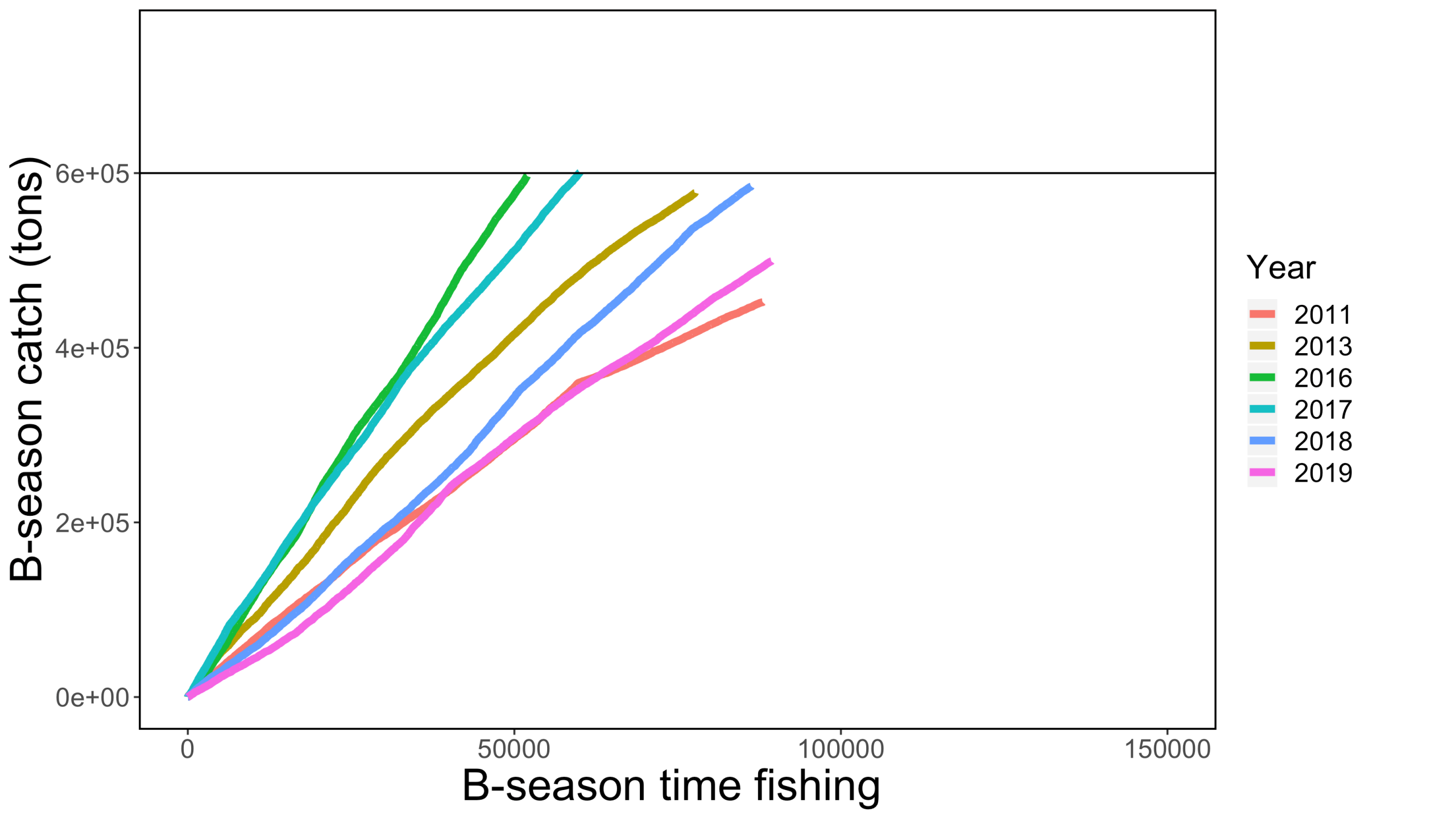


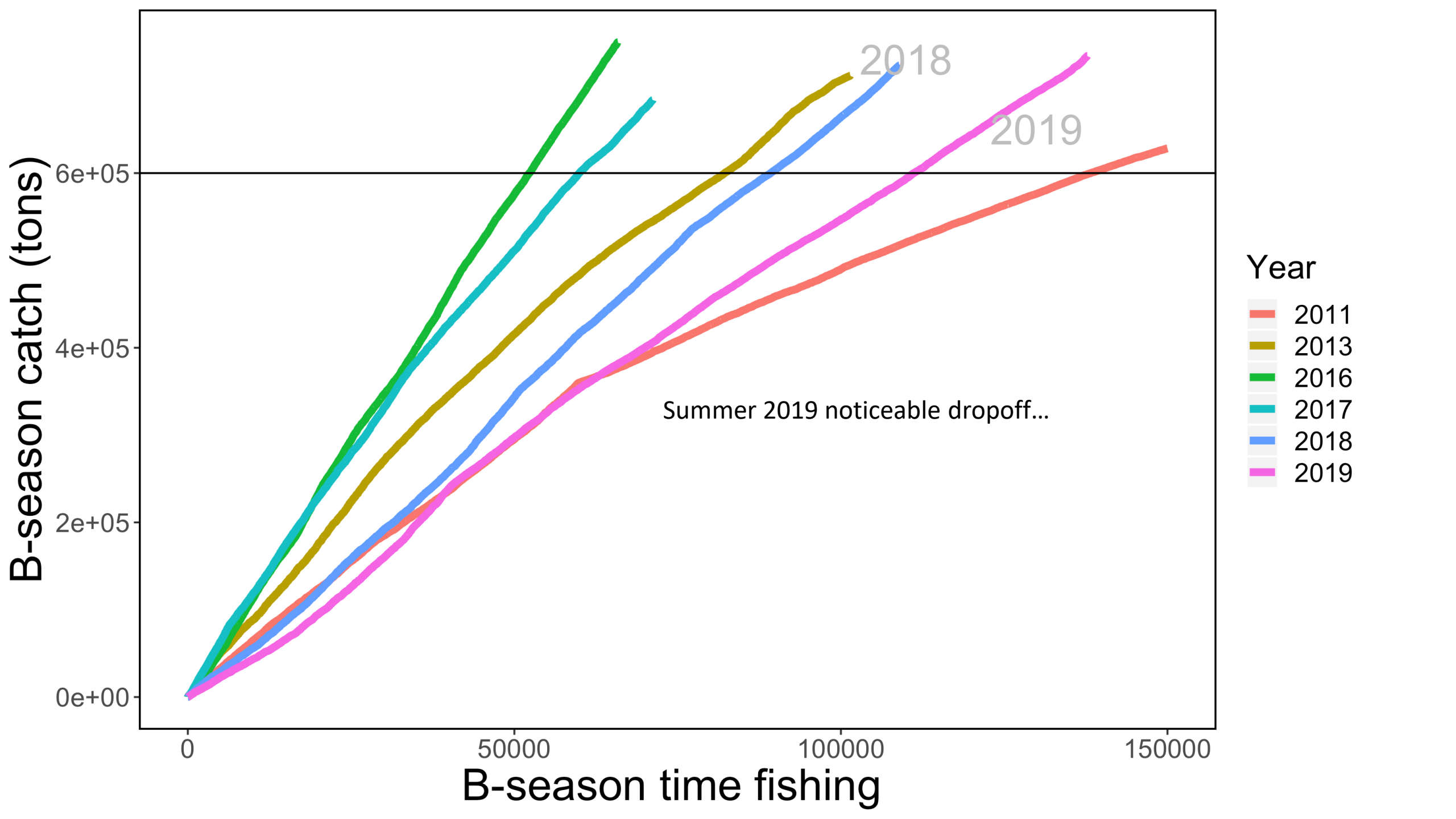

Cumulative pollock catch by month as proportion of TAC
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
April
March
February
January
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

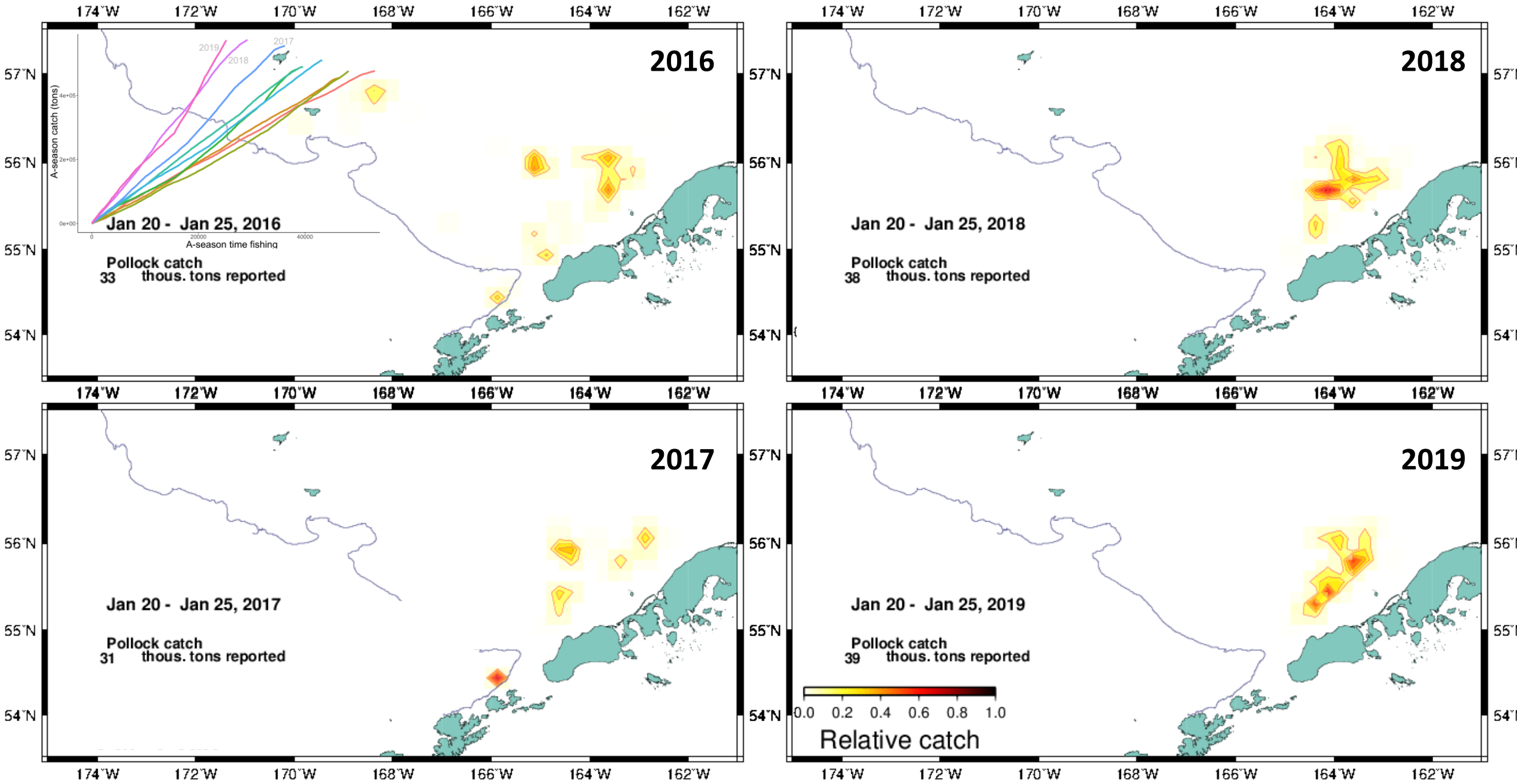

2019
2018
2017
Year
2011
2012
2013
2014
2015
2016
2017
2018
2019
20000
A-season time fishing

Compare to B-season (summer) conditions…

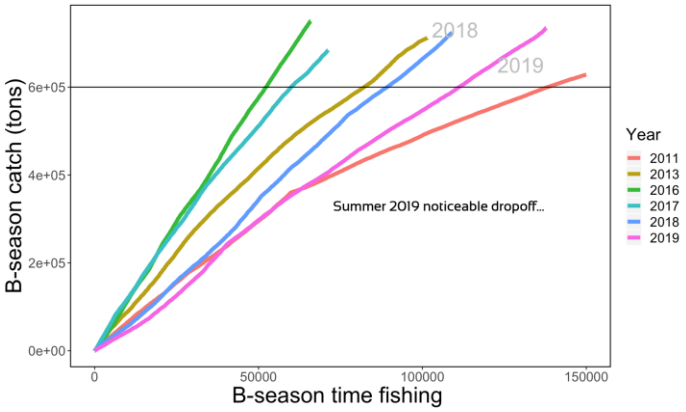

B-season catch (tons)
6e+05
4e+05
2e+05
0e+00
0
50000
100000
150000
B-season time fishing
Year
2011
2013
2016
2017
2018
2019


B-season catch (tons)
6e+05
4e+05
2e+05
0e+00
0
50000
100000
150000
B-season time fishing
Year
2011
2013
2016
2017
2018
2019

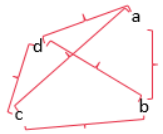

2018
2019
Summer 2019 noticeable dropoff…
B-season catch (tons)
6e+05
4e+05
2e+05
0e+00
0
50000
100000
150000
B-season time fishing
Year
2011
2013
2016
2017
2018
2019

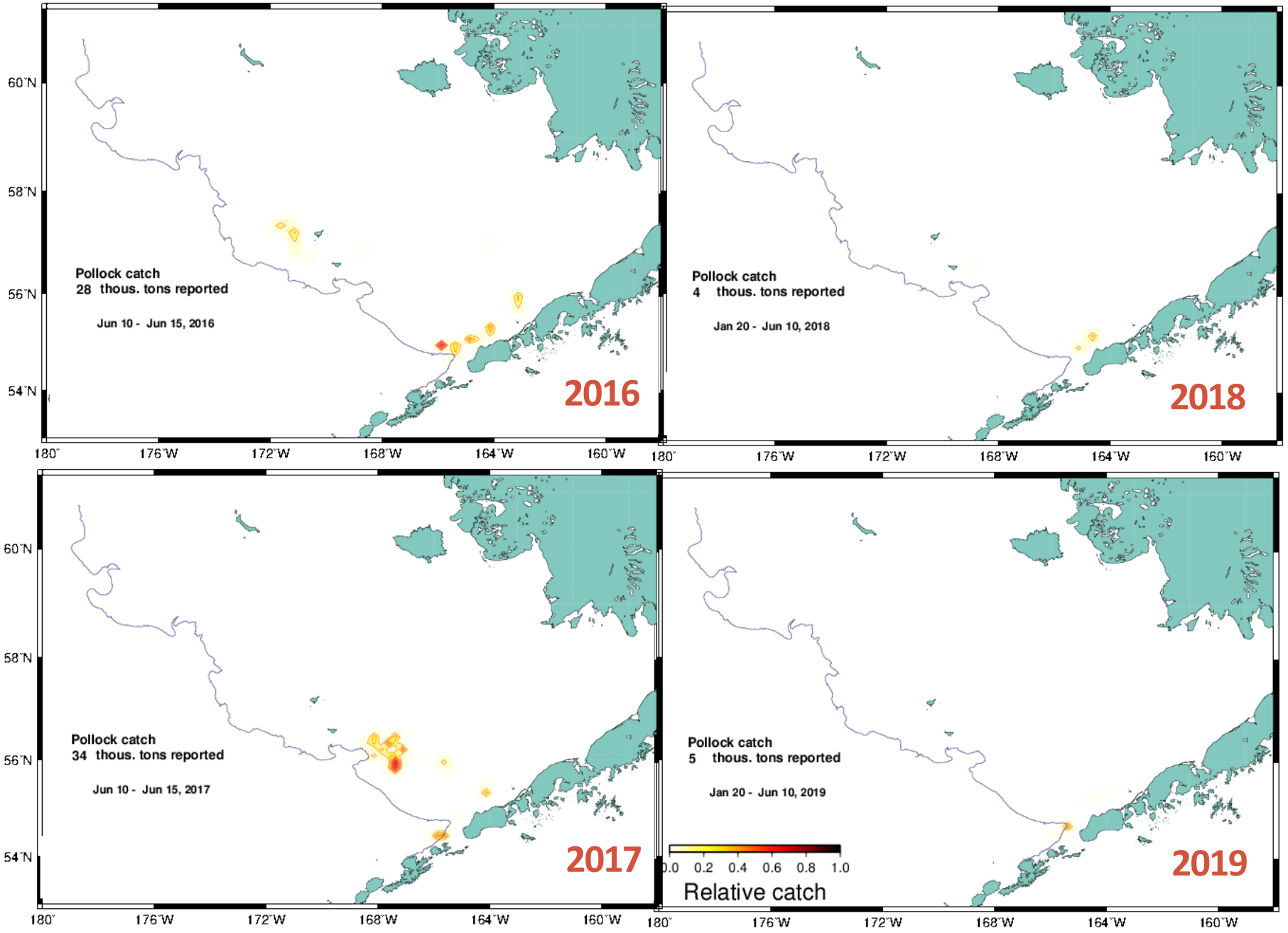


Winter season fishing patterns



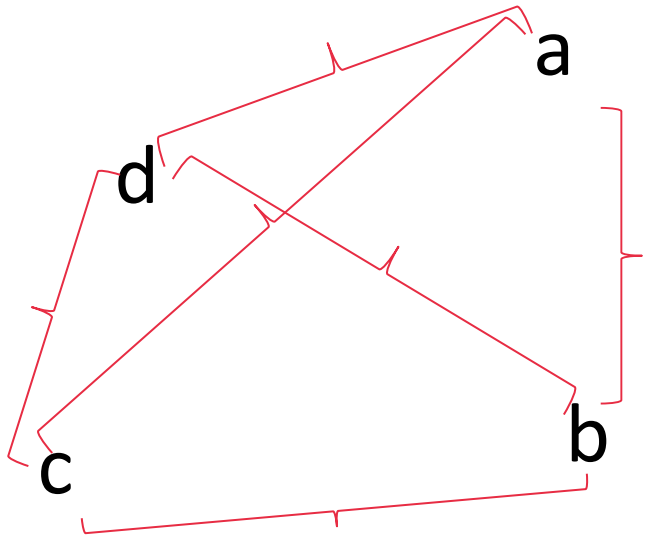
Summarizing spatial fishery patterns



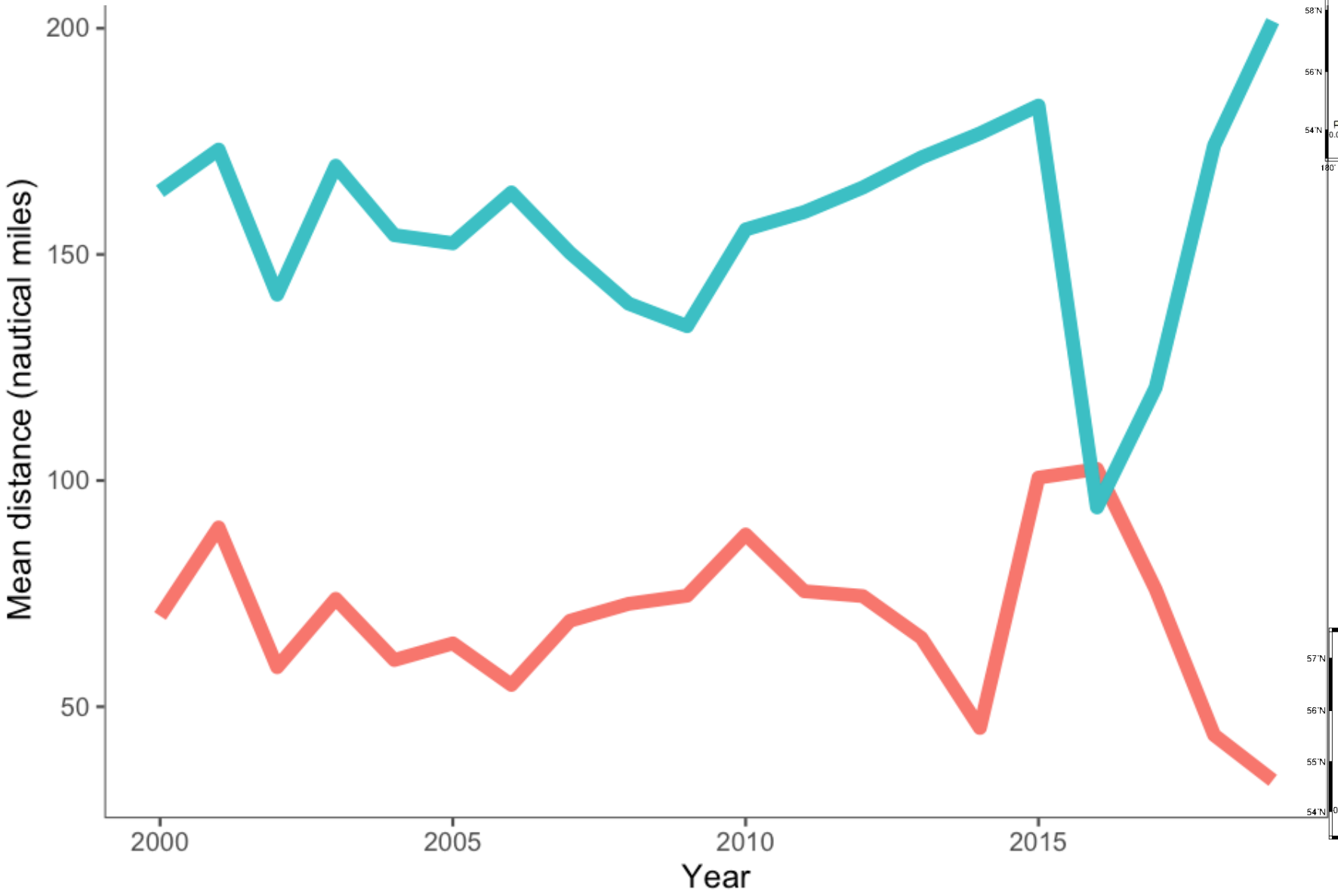


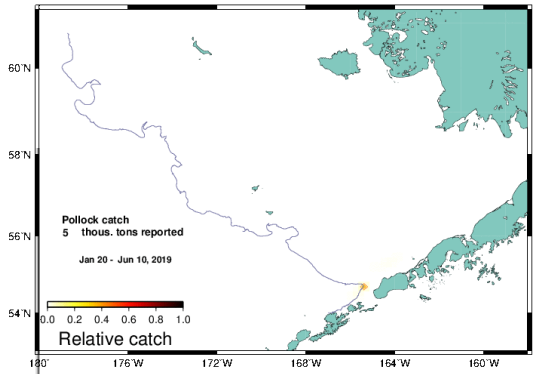
Summer fishing distributions

Summarizing spatial fishery patterns

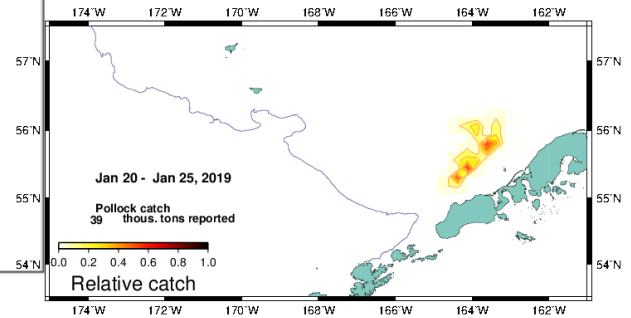


All pollock boats combined…

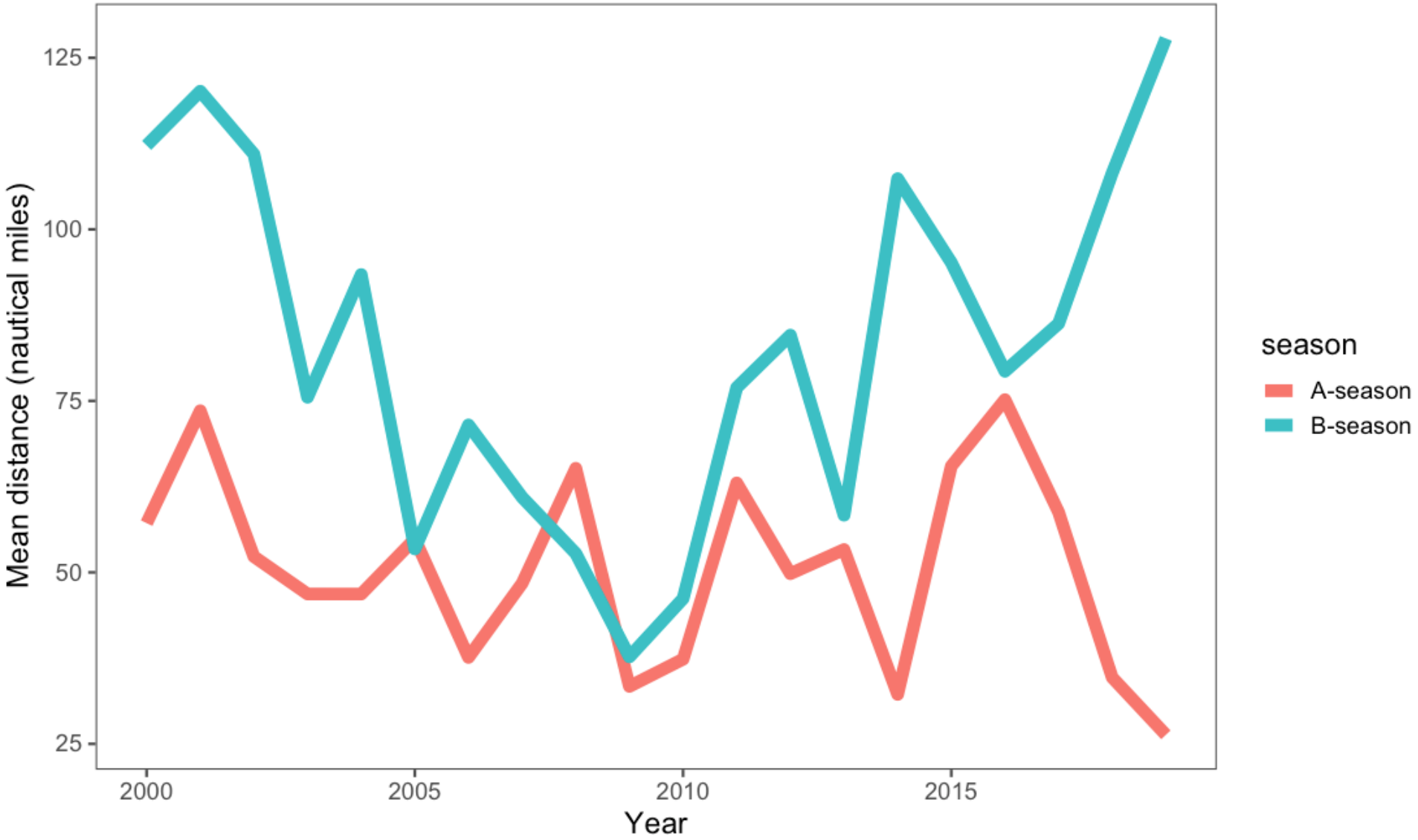




season
A-season
B-season

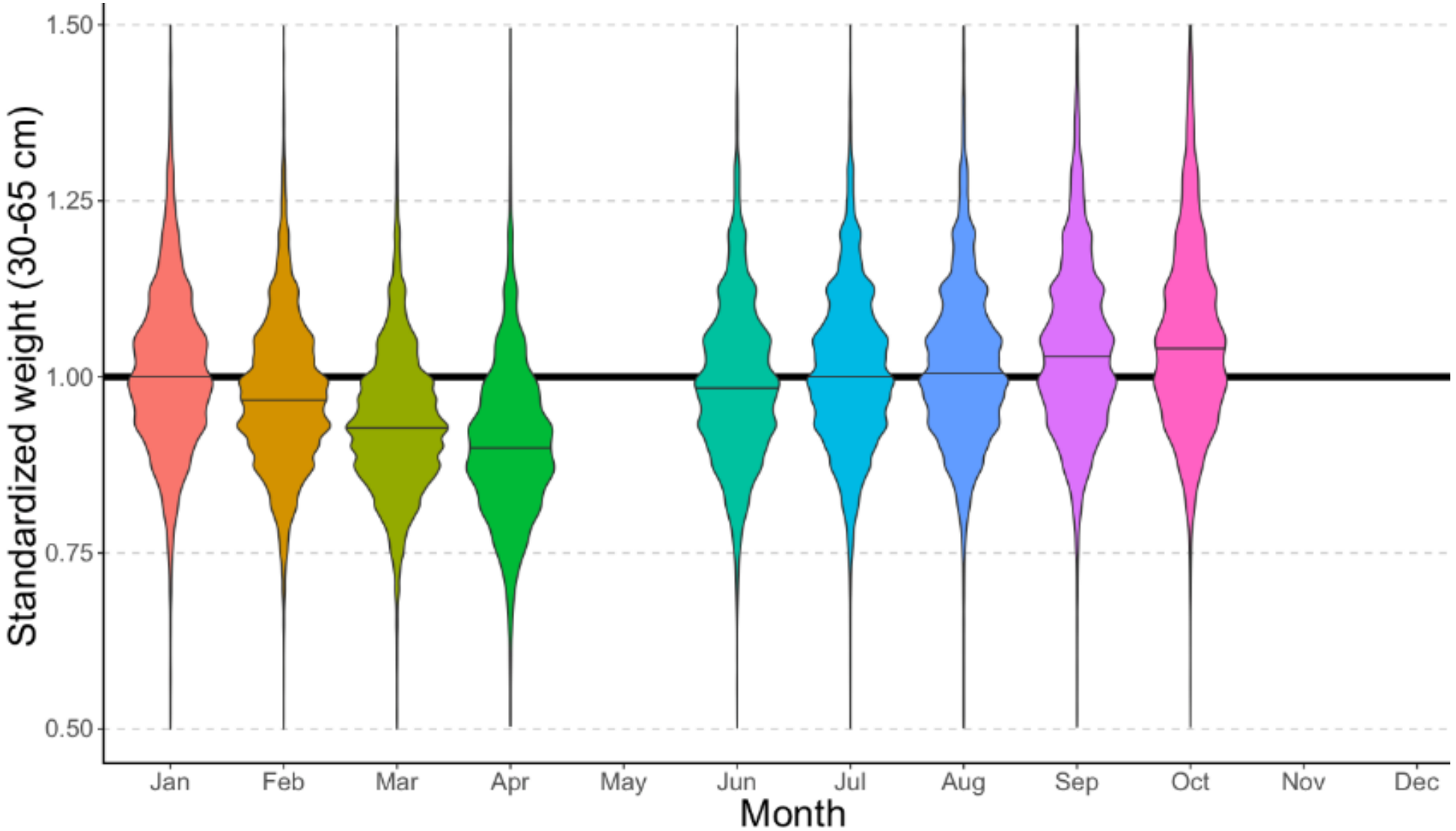


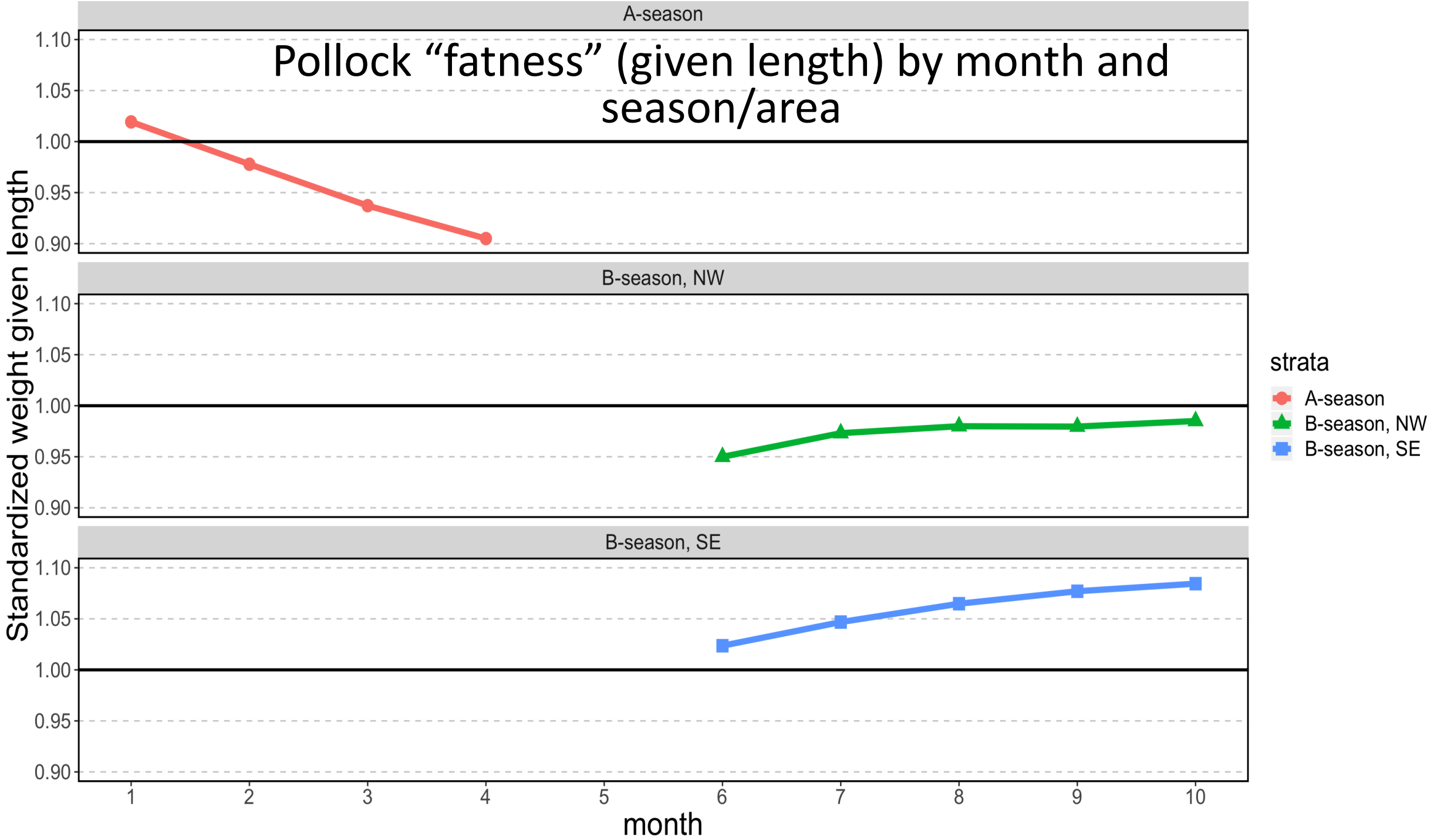
Shore-based catcher boats only…



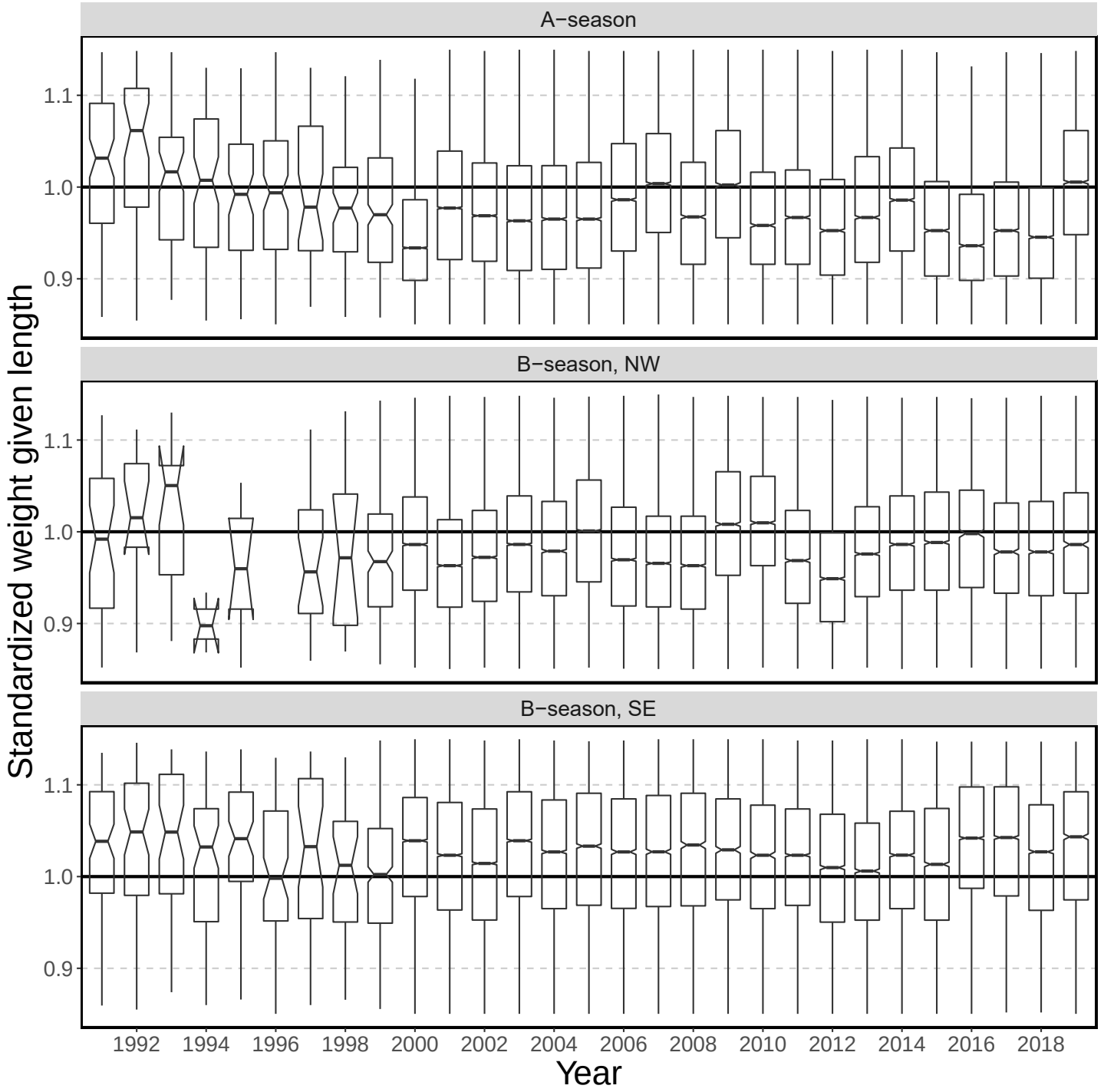
- Fishery observer sampling…
  - Patterns in pollock growth

Pollock “fatness” (given length) by month

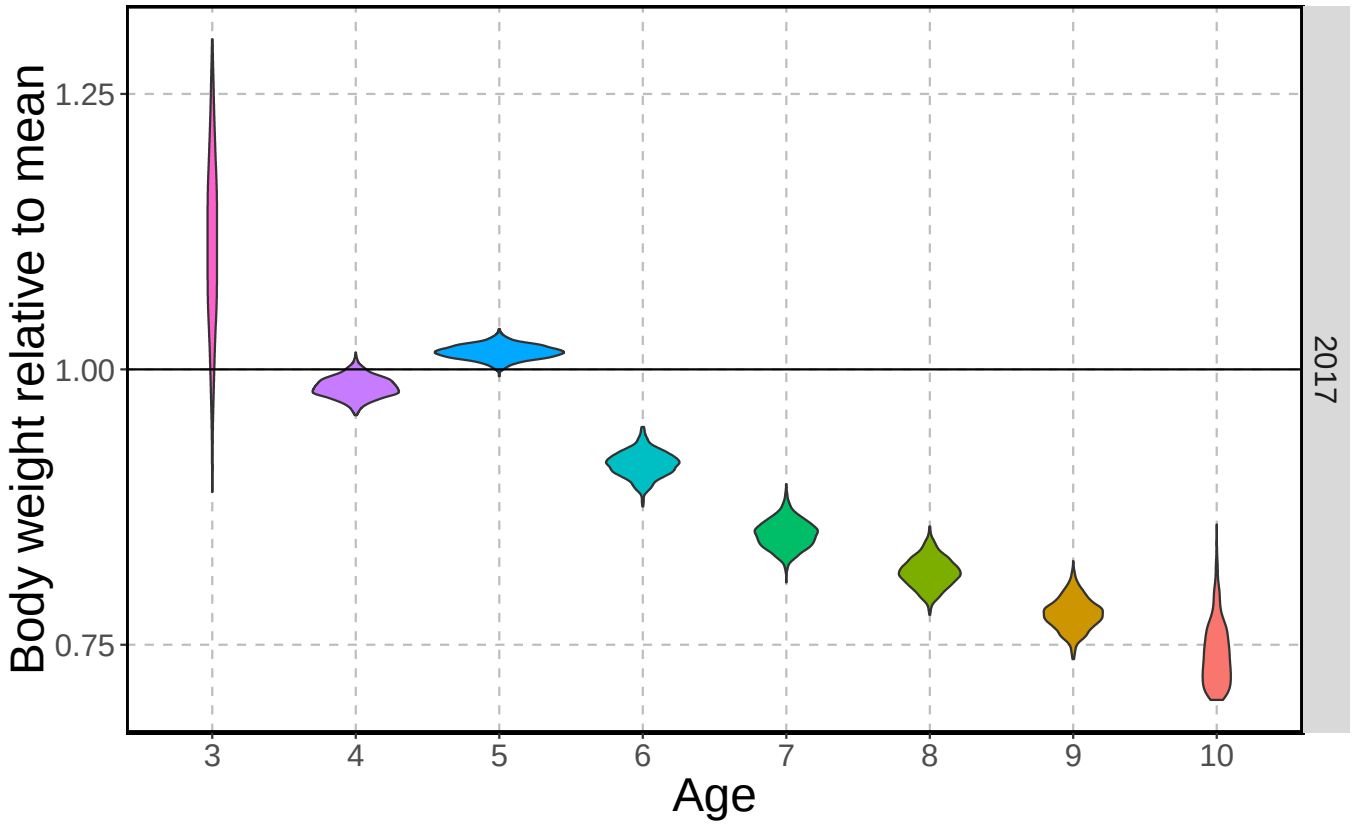



Pollock “fatness” (given length) by month and season/area
A-season
B-season, NW
B-season, SE
Standardized weight given length
1.10
1.05
1.00
0.95
0.90
1
2
3
4
5
6
7
8
9
10
month
strata
A-season
B-season, NW
B-season, SE

Pollock “fatness” (given length) by year and season

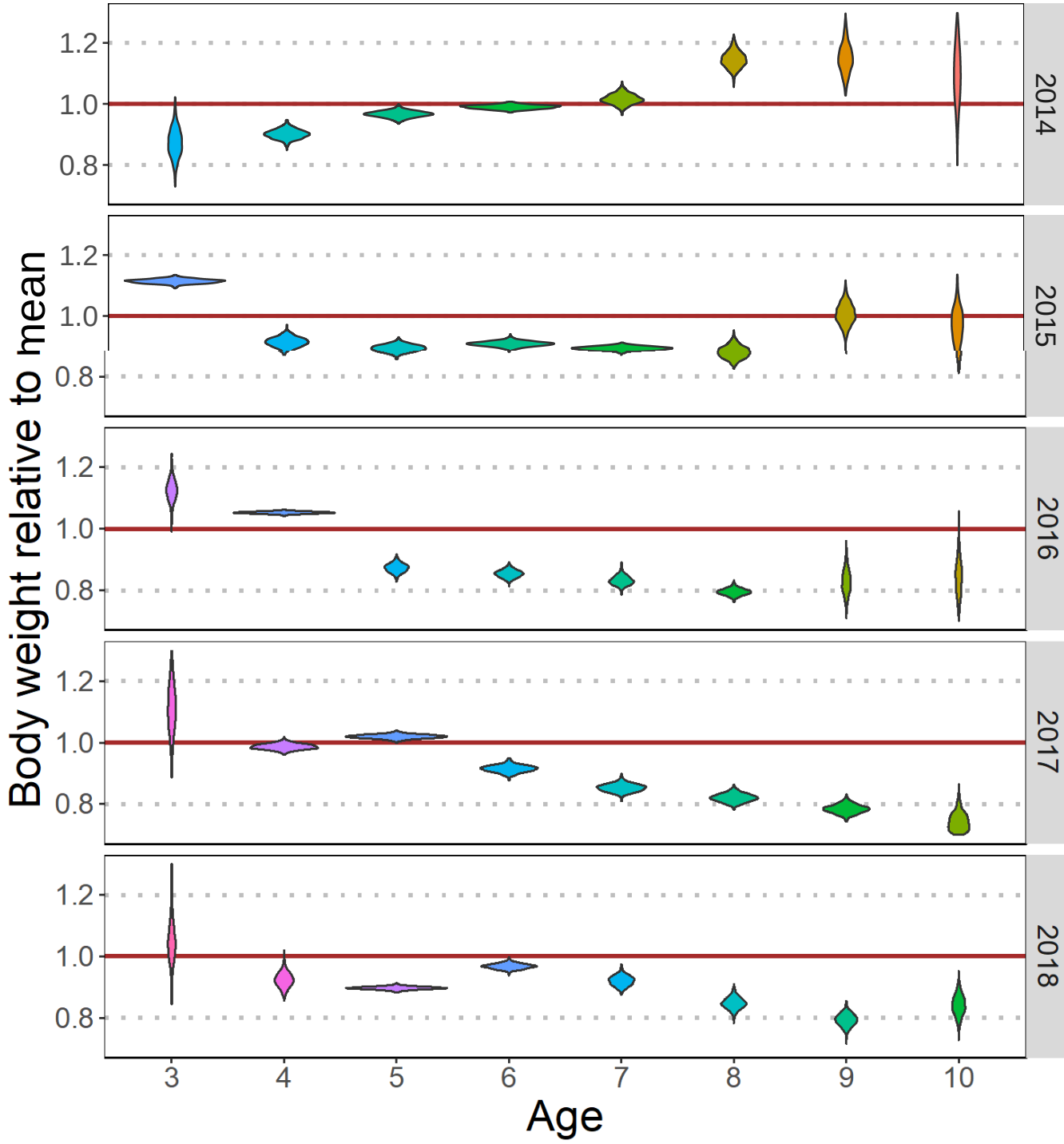


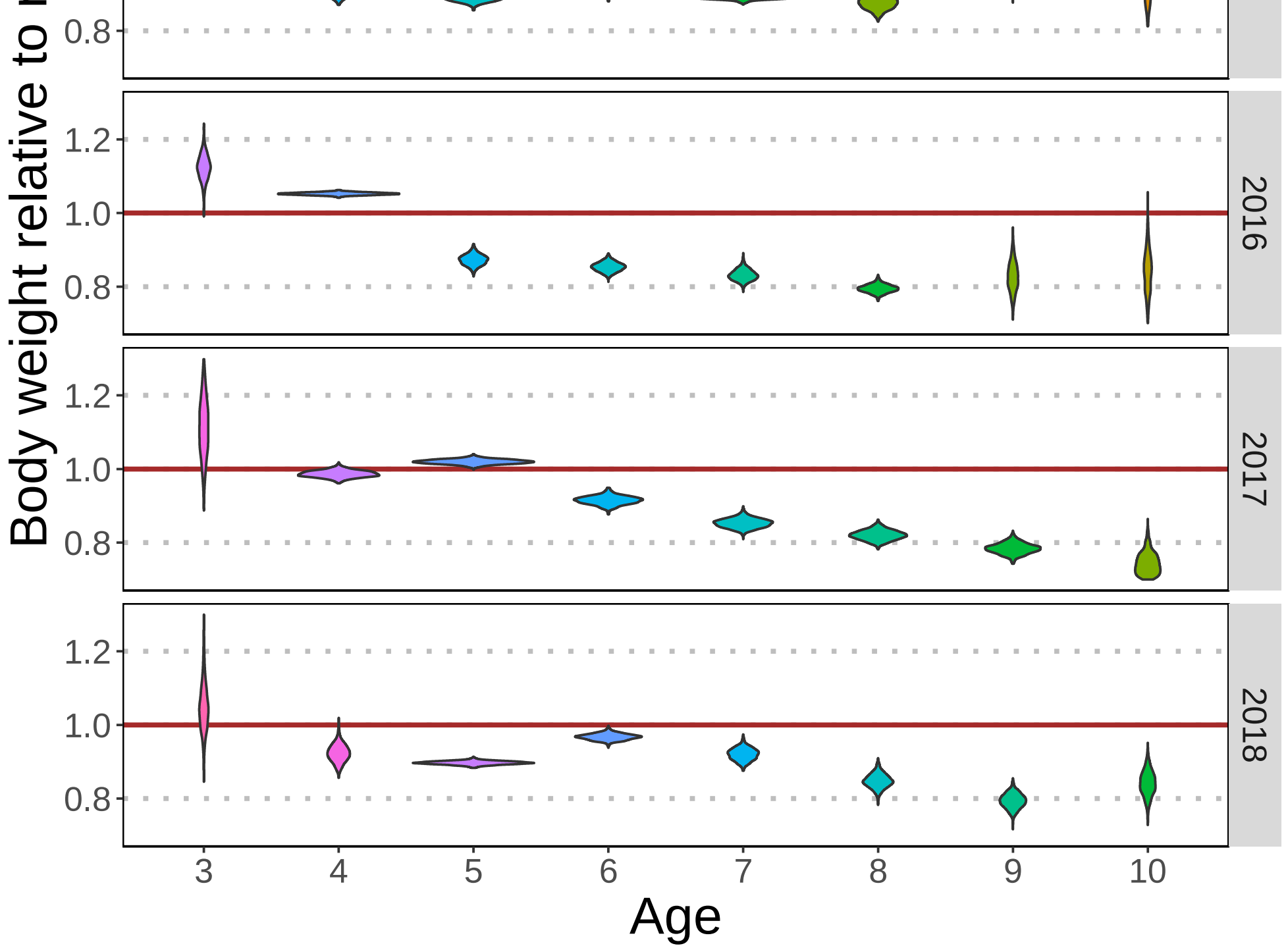
Looking at weight-at-age



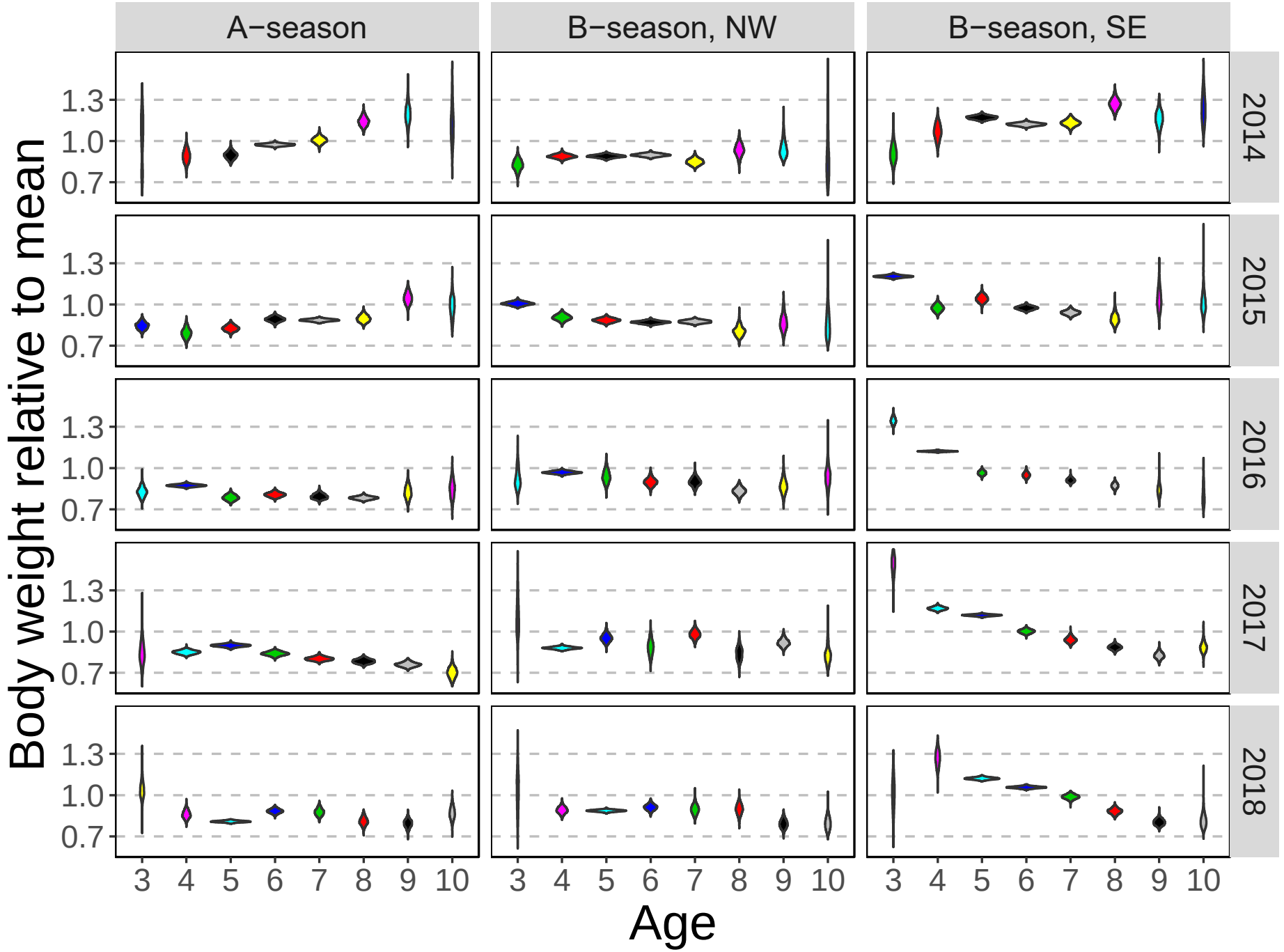
Are pollock smaller at age than normal???

- 2008 year class generally small at age
- 2012 looks better!

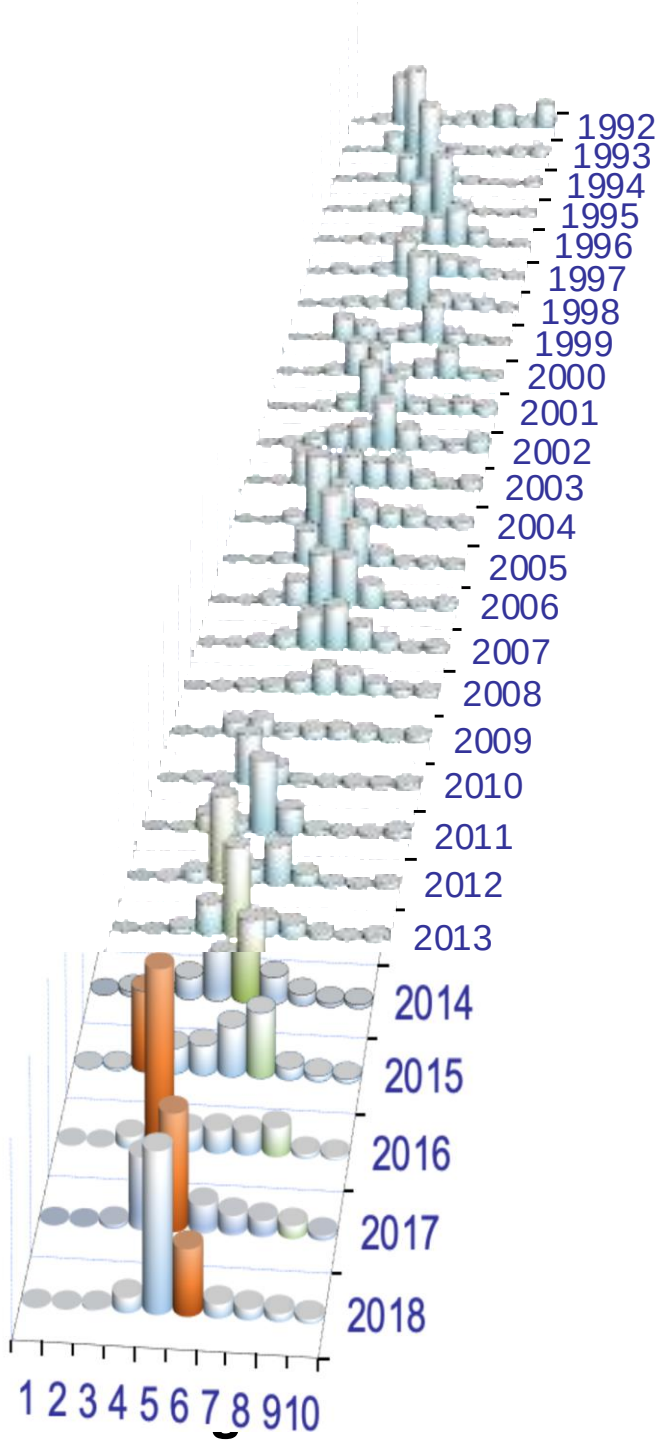


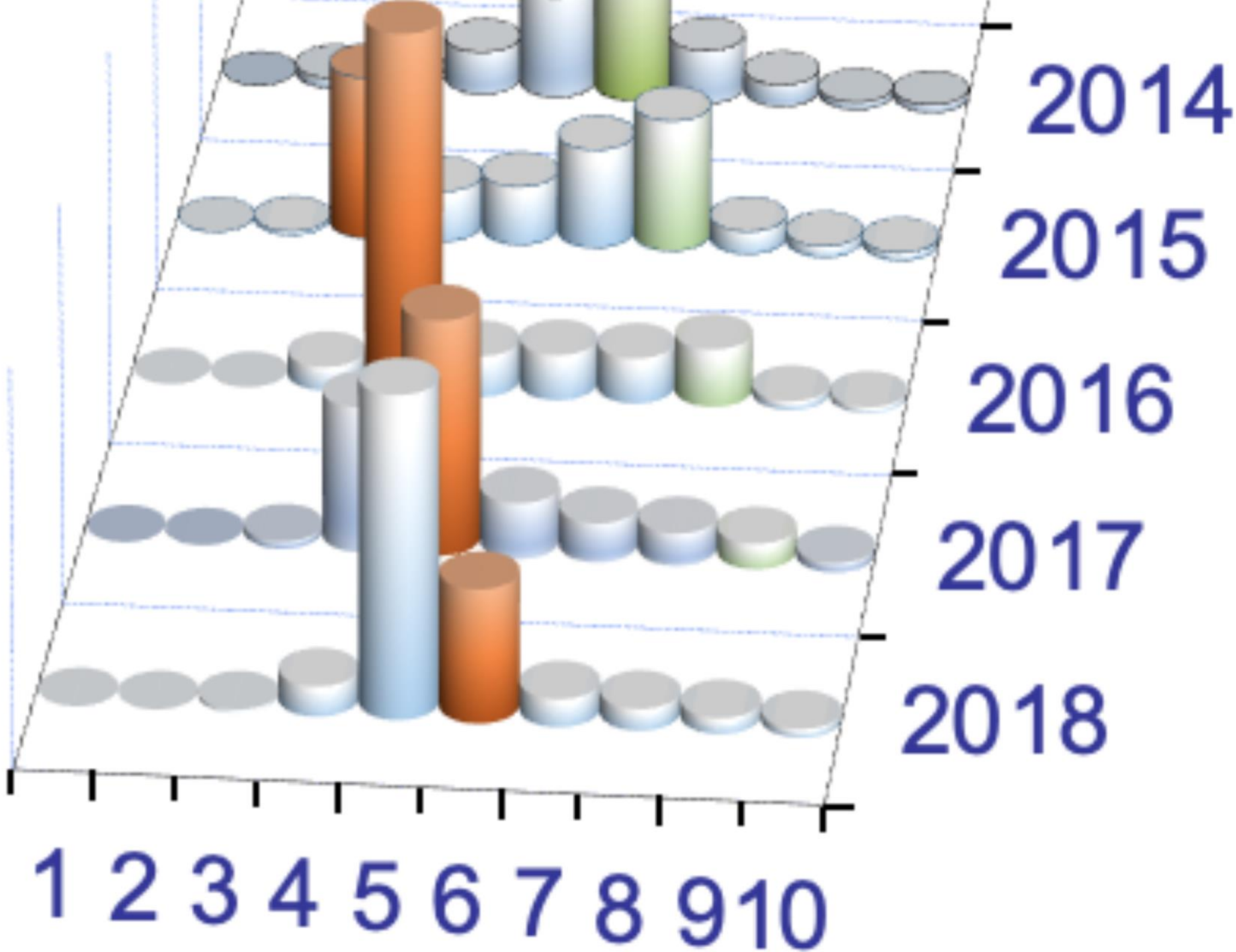

Body weight relative to
0.8
1.2
1.0
0.8
2016
1.2
1.0
0.8
2017
1.2
1.0
0.8
2018
3
4
5
6
7
8
9
10
Age

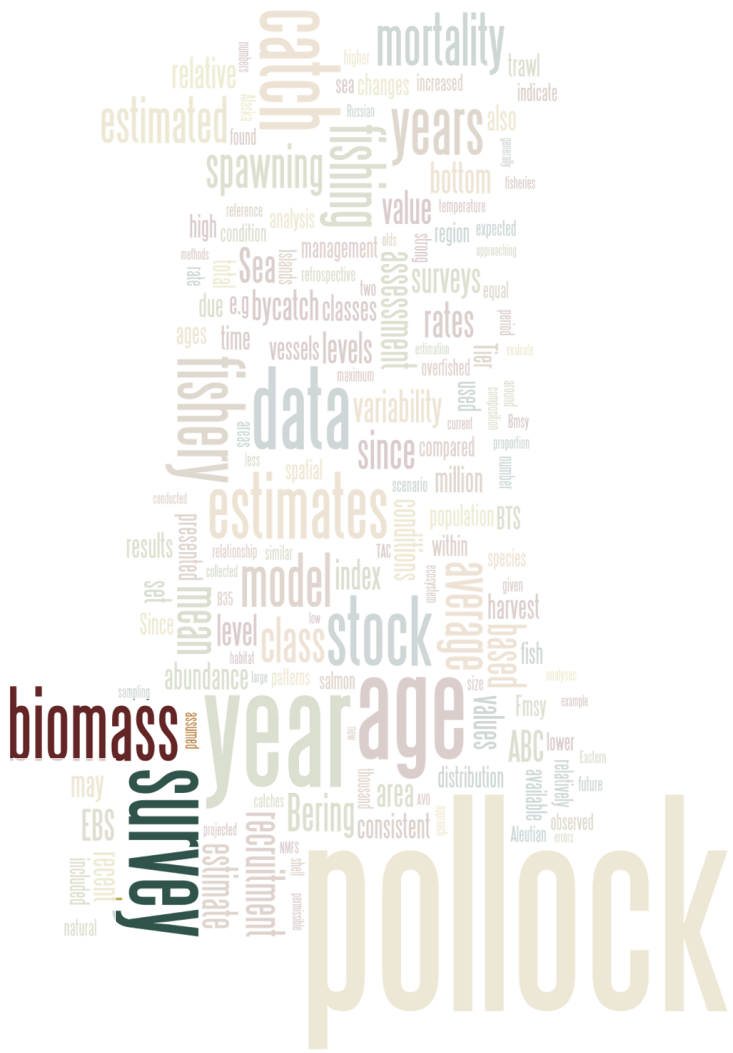
Average fishery weight-at-age by season and year…



Fishery catch-at-age



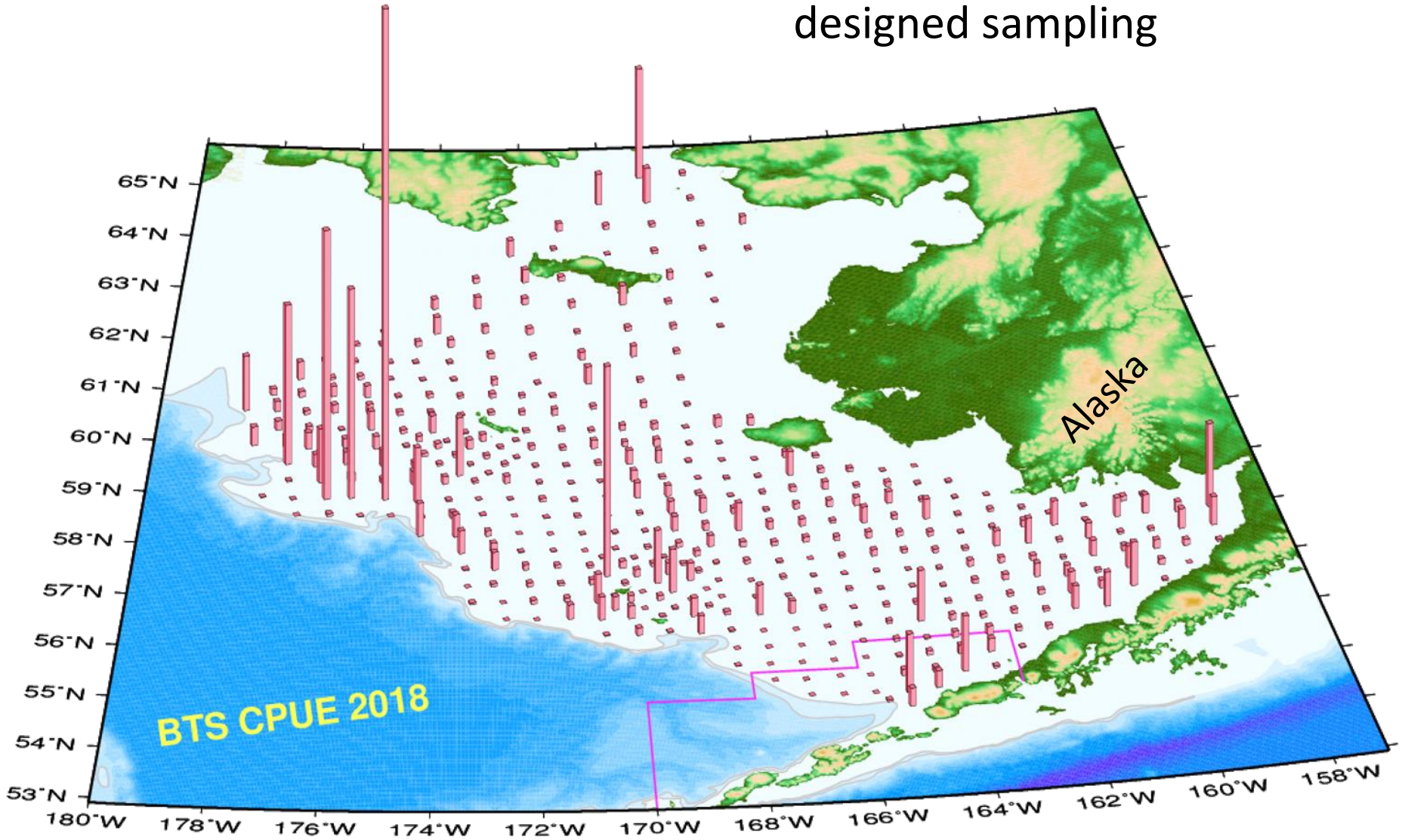

2014
2015
2016
2017
2018
1 2 3 4 5 6 7 8 9 10

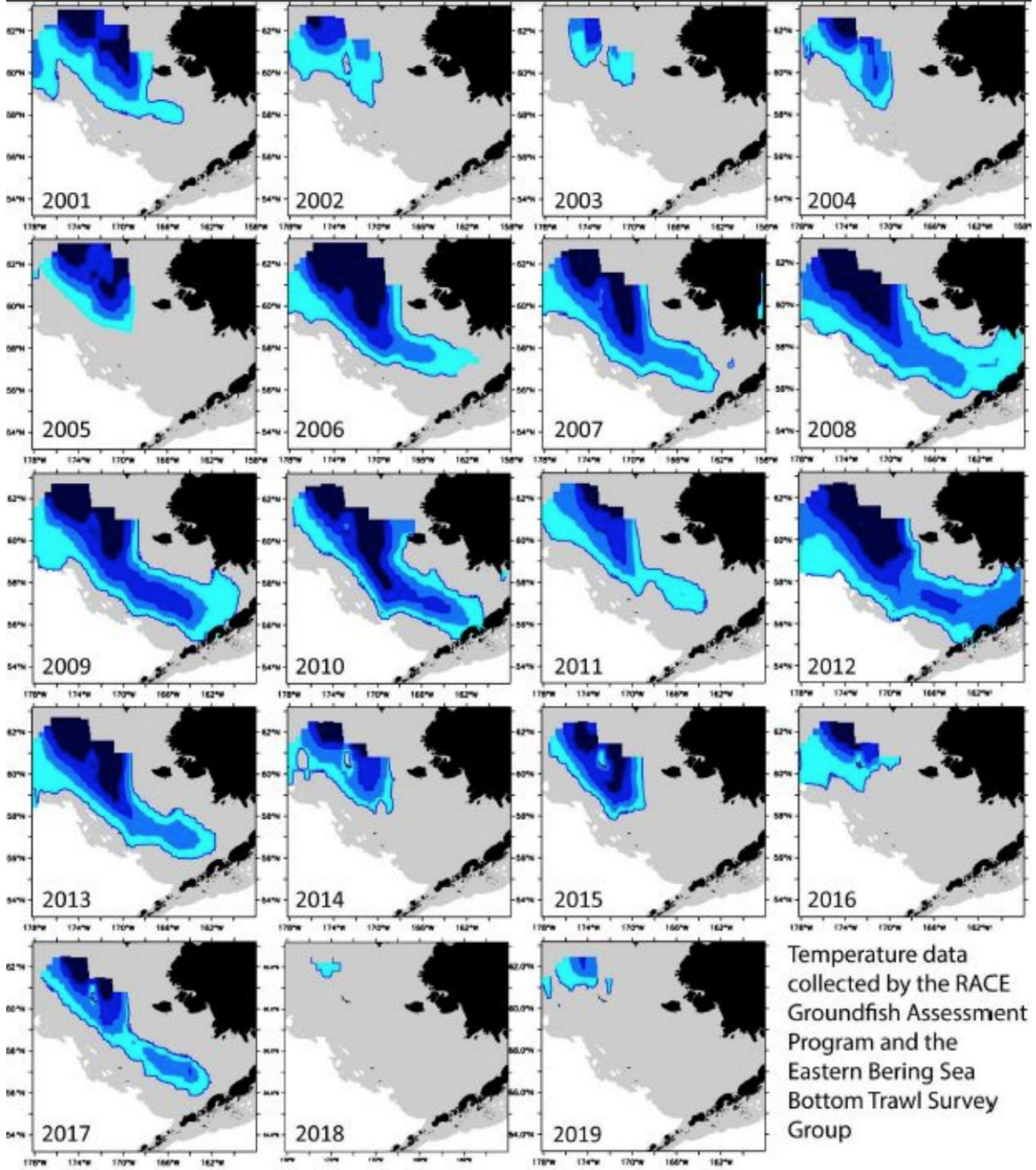


Eastern Bering Sea pollock surveys

Scientific research survey

Independent from fishery data—
designed sampling



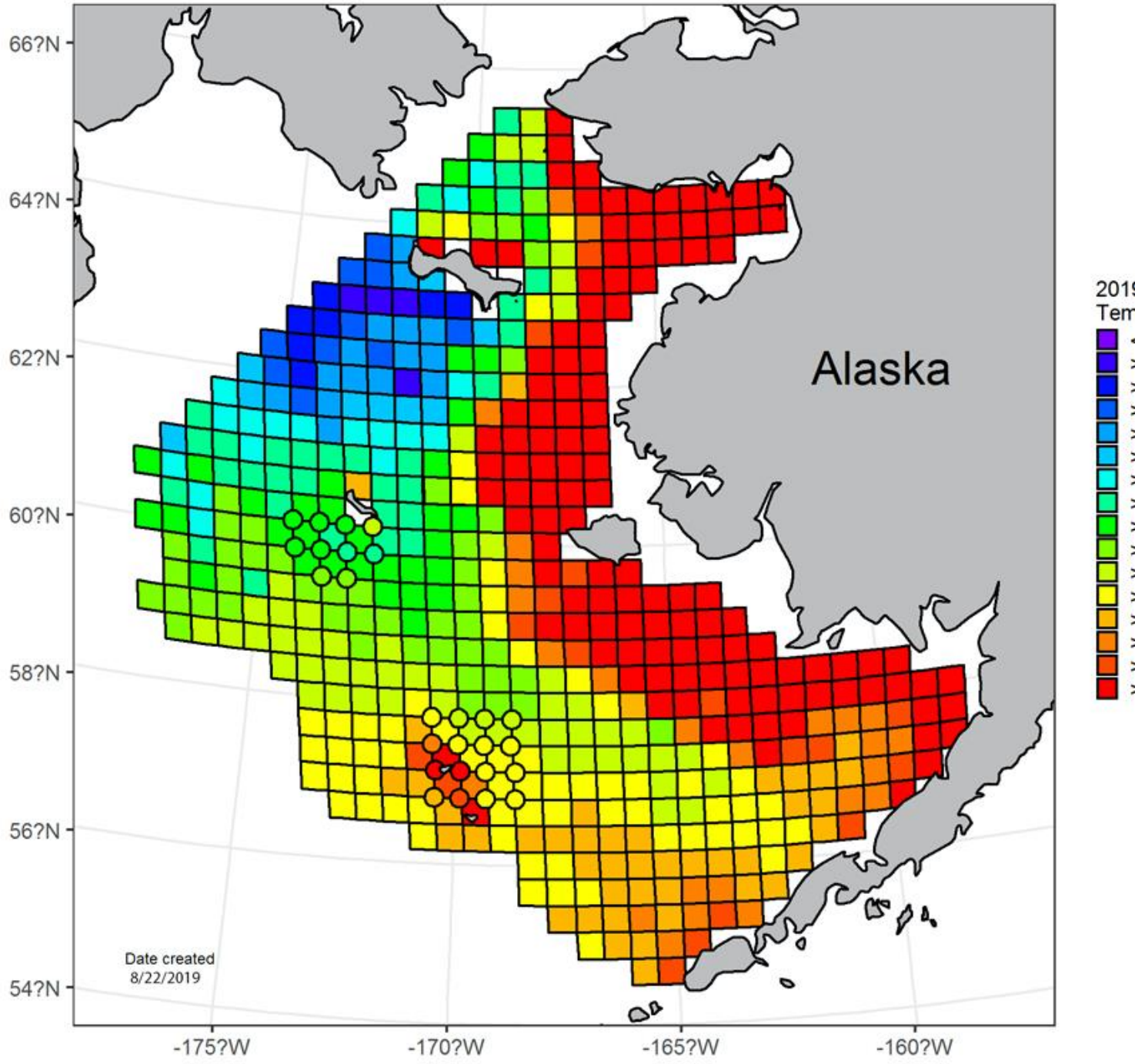


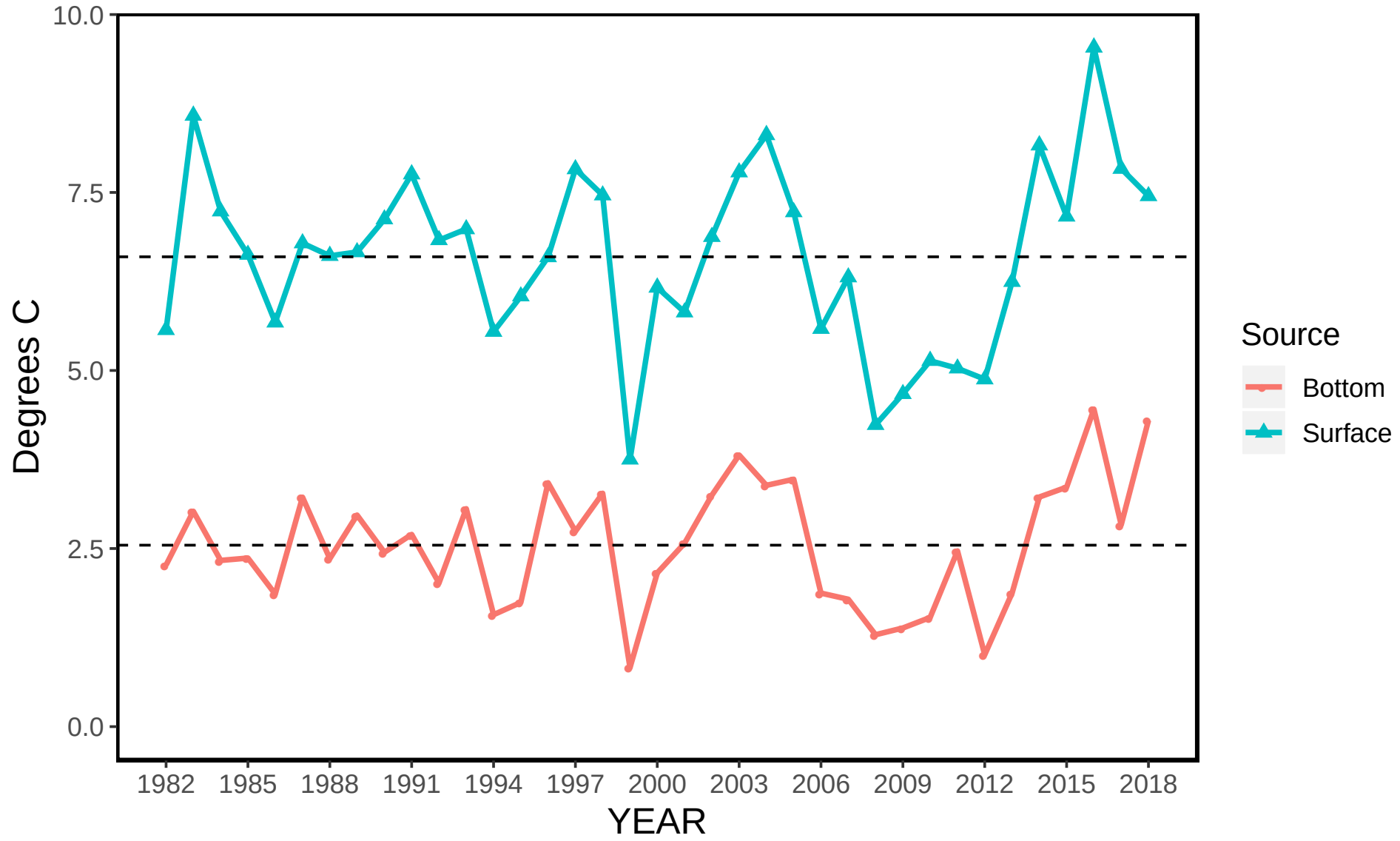
Temperature data collected by the RACE Groundfish Assessment Program and the Eastern Bering Sea Bottom Trawl Survey Group

Cold pool extent…

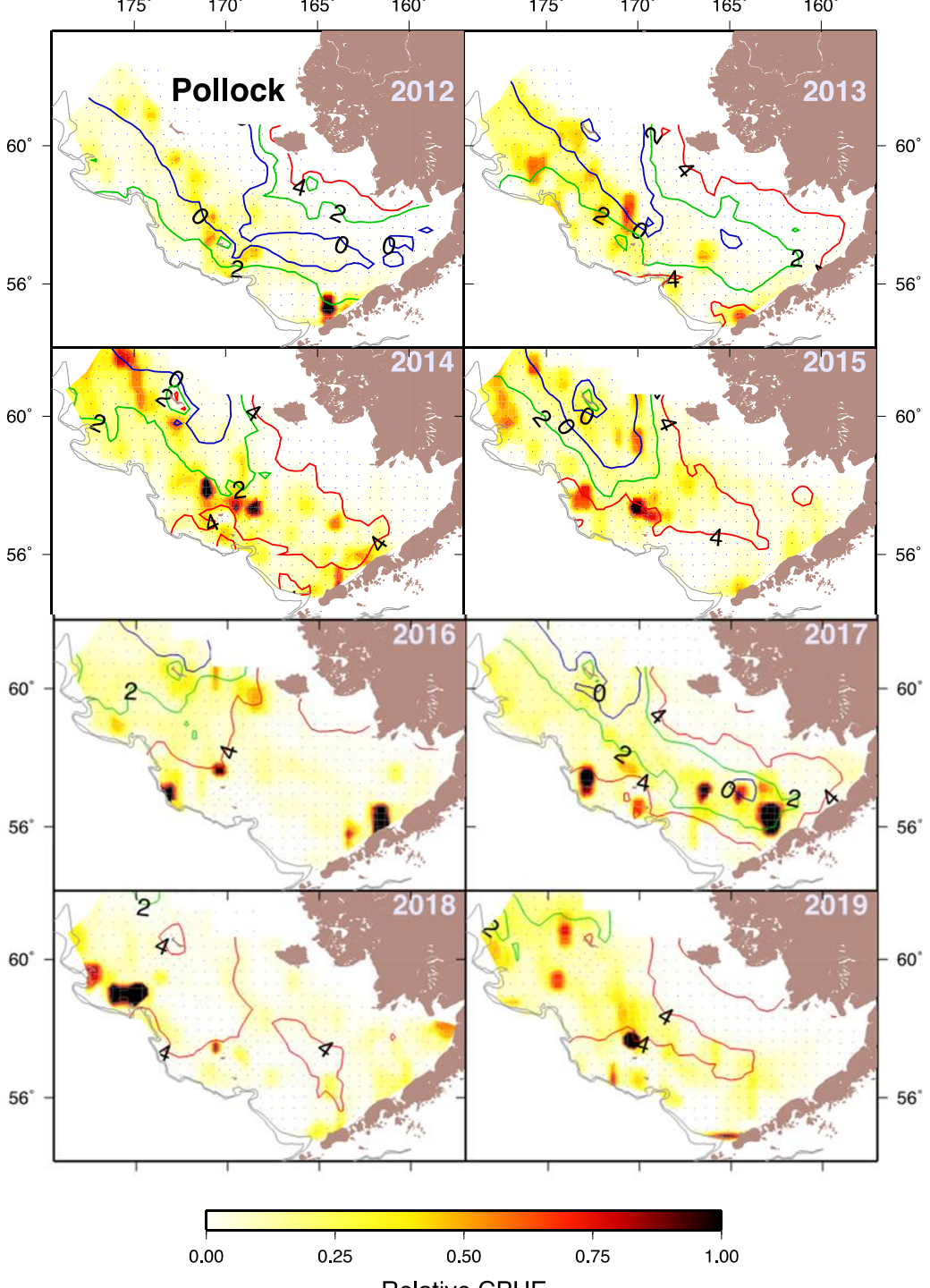
2019 summer bottom temperatures

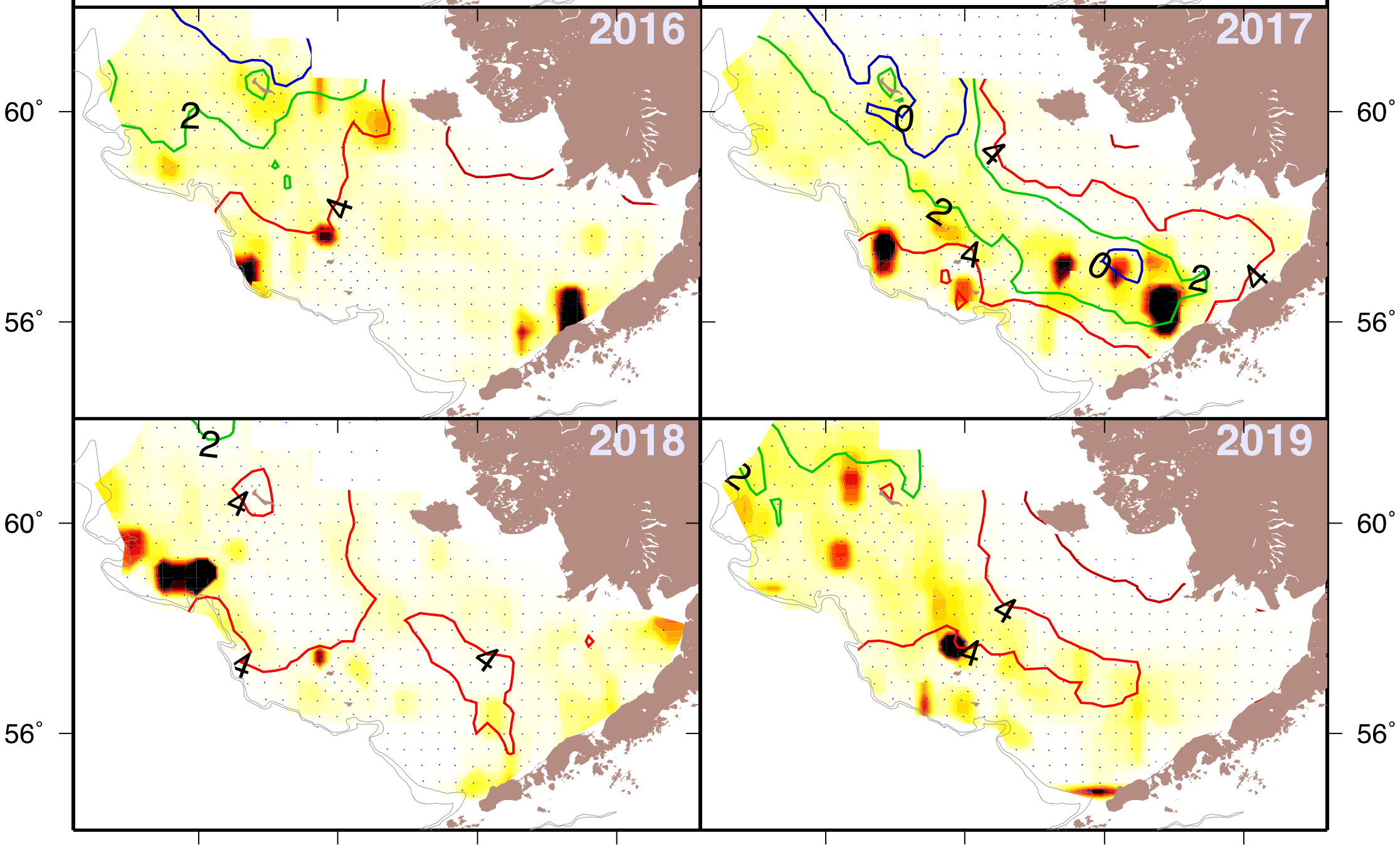
- More cold pool than last year
- VERY warm in inner shelf region…




10.0
7.5
5.0
2.5
0.0
Degrees C
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
YEAR
Source
Bottom
Surface

Pollock density and temperature




2016
2017
2018
2019
60°
56°
0
2
4

What about shifting fish distributions…

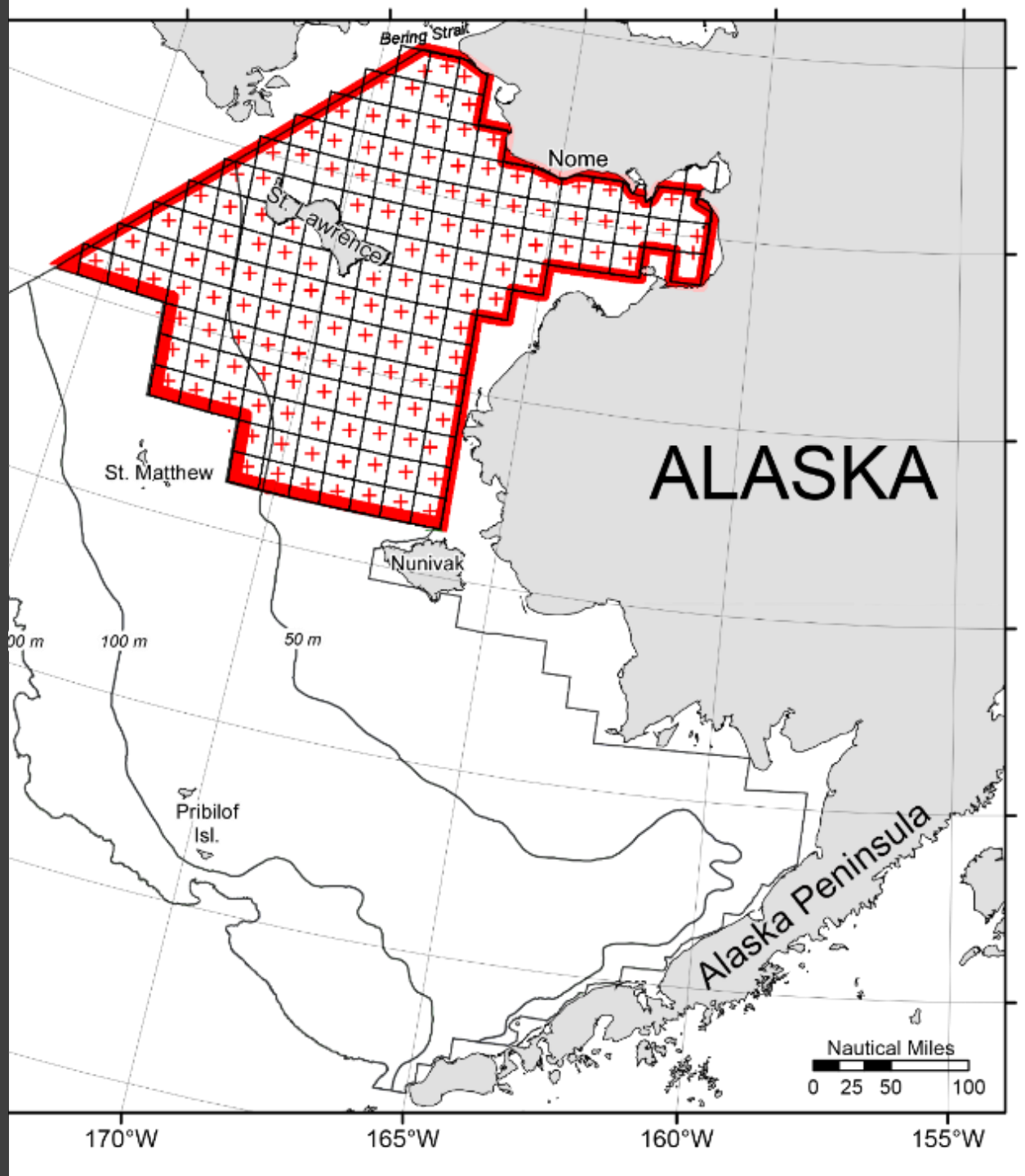
- Requires expanding survey area…
- Affects survey priorities at the AFSC

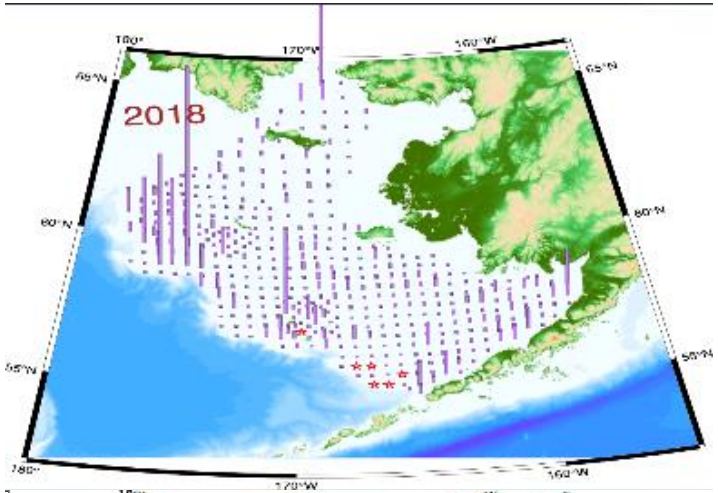
Survey stations in northern area…”NBS”

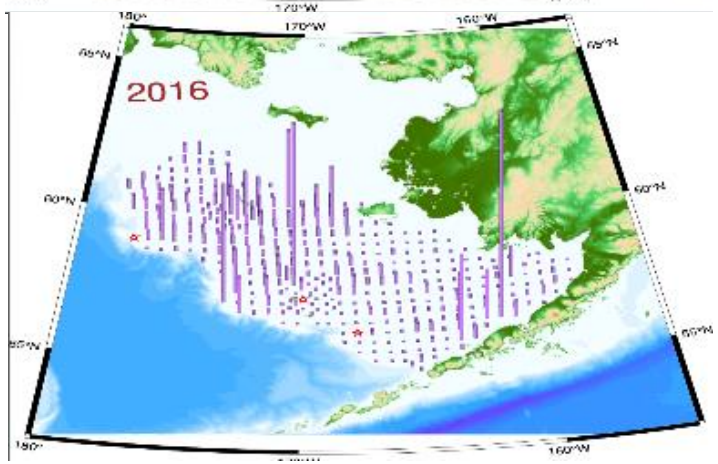
Formally surveyed in 2010 and 2017

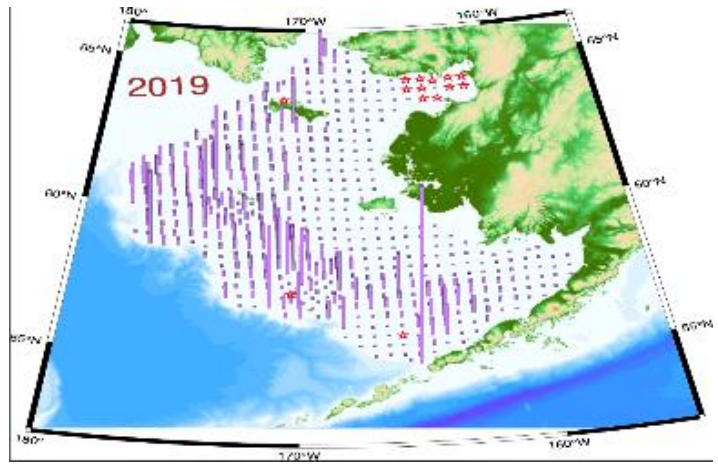
2018 an “emergency”

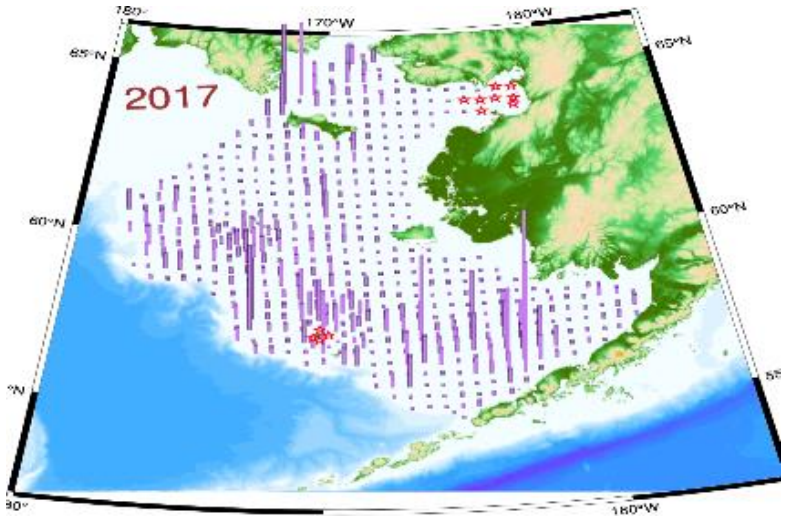
2019 a “full” Nbs

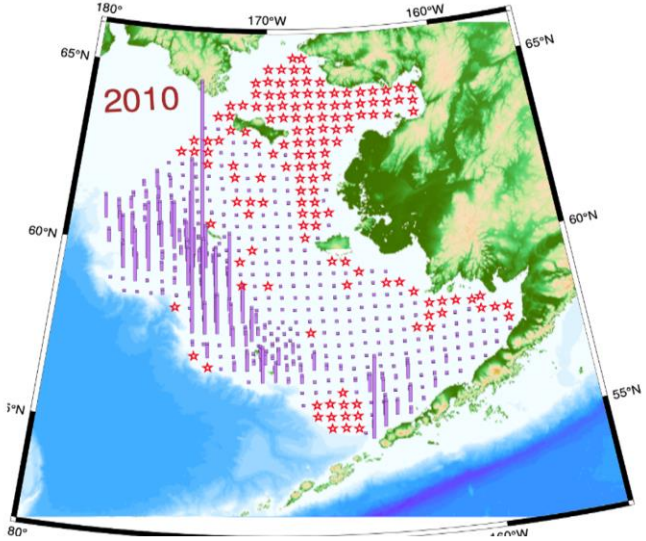








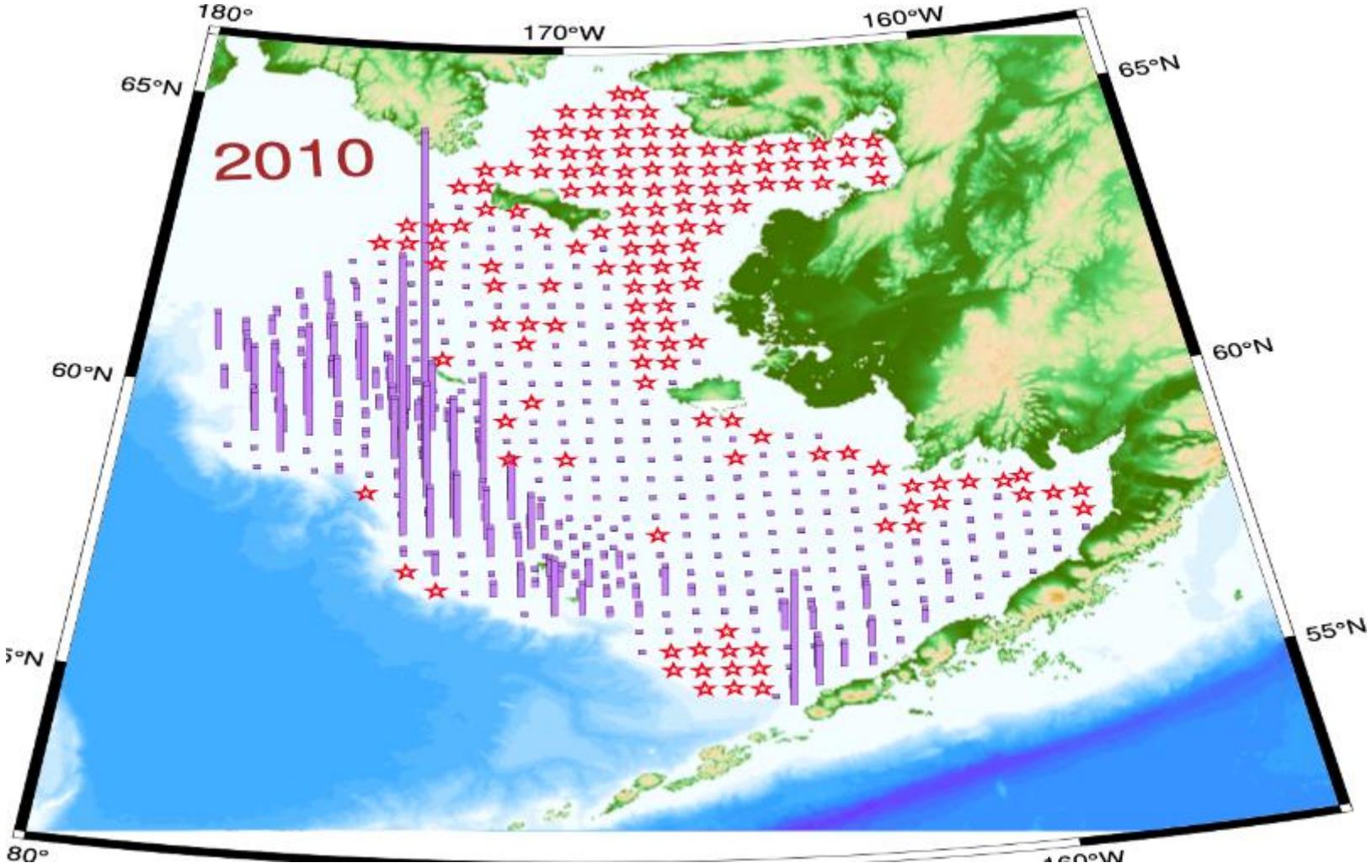




Northern area: trace amounts

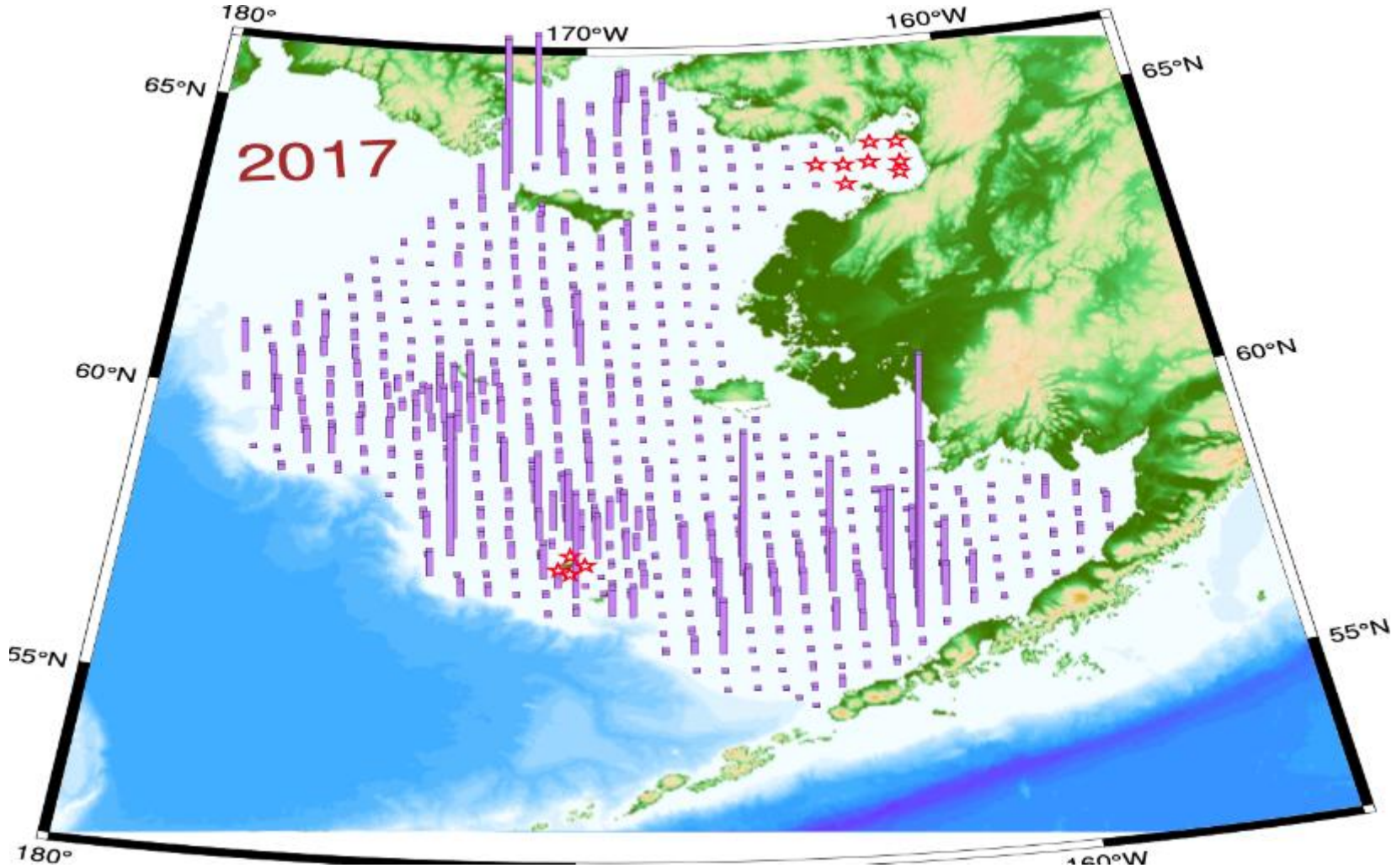
Bottom trawl survey spatial patterns

2010 standard survey
(3.74 million t pollock estimated)



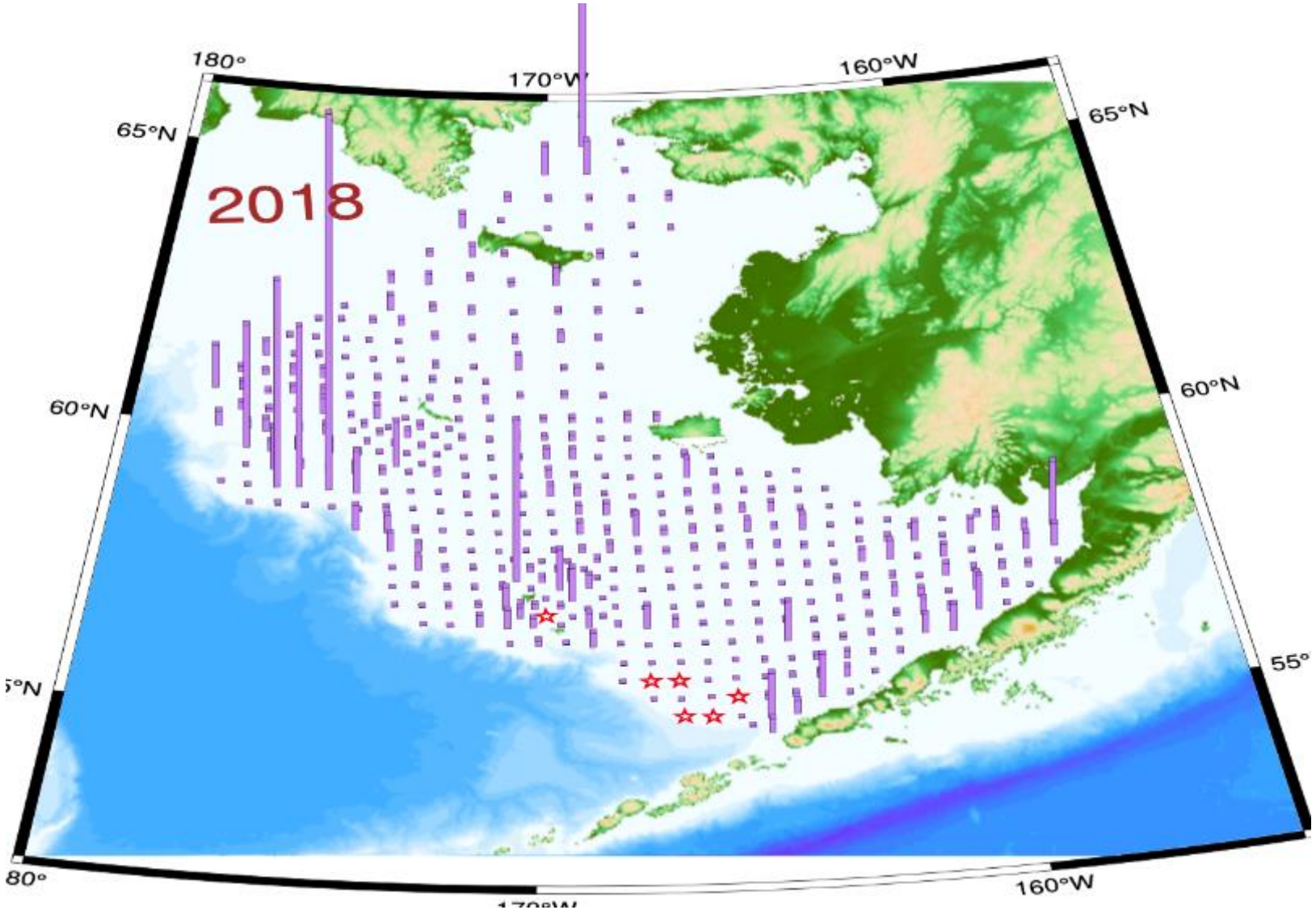
Northern area: trace amounts

2017 standard survey
(4.81 million t pollock estimated)



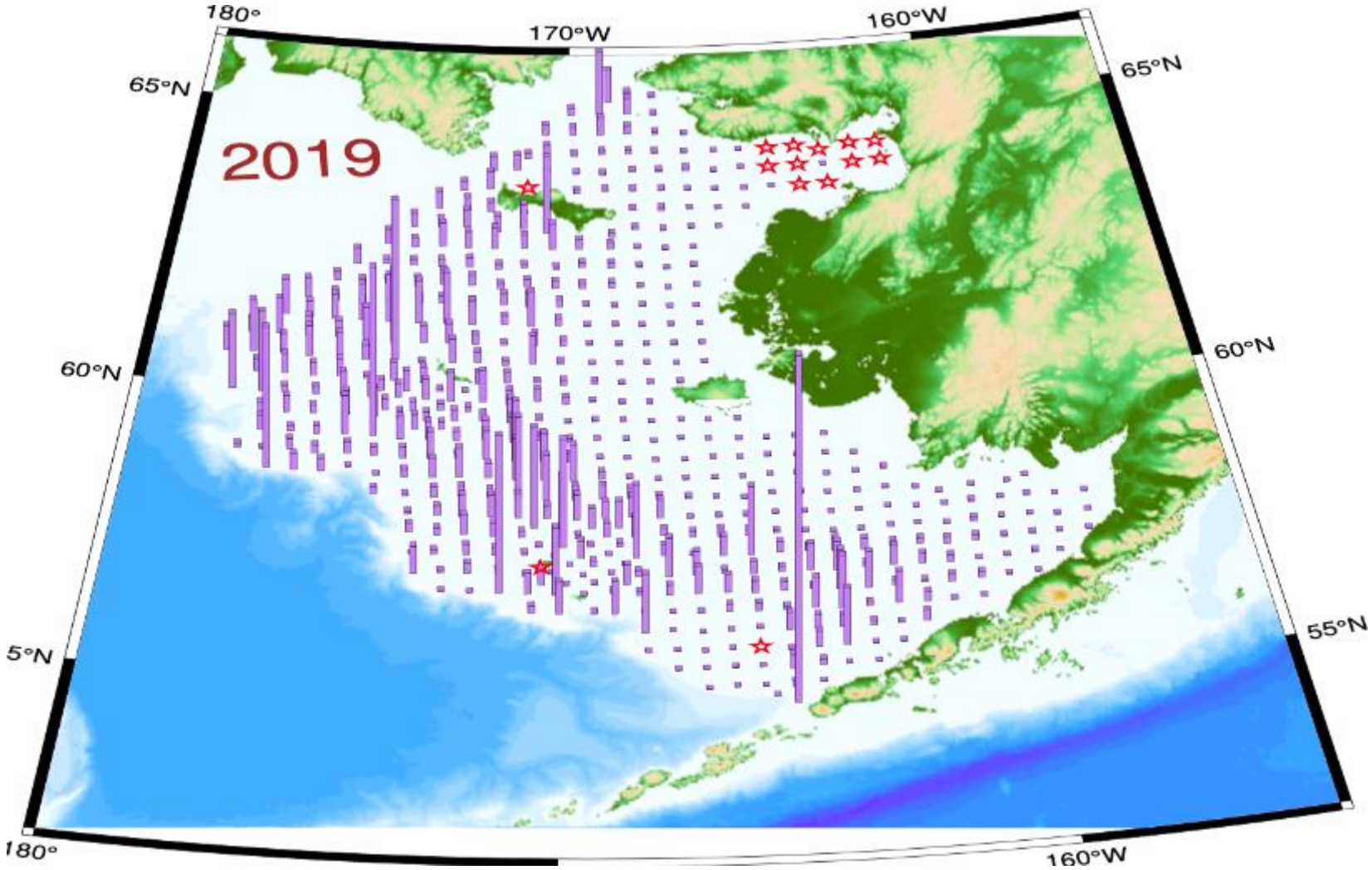
Northern area: 1.34 million t

2018 standard survey
(3.1 million t pollock estimated)



Northern area: 1.15 million t

2019 standard survey
(5.4 million t pollock estimated)



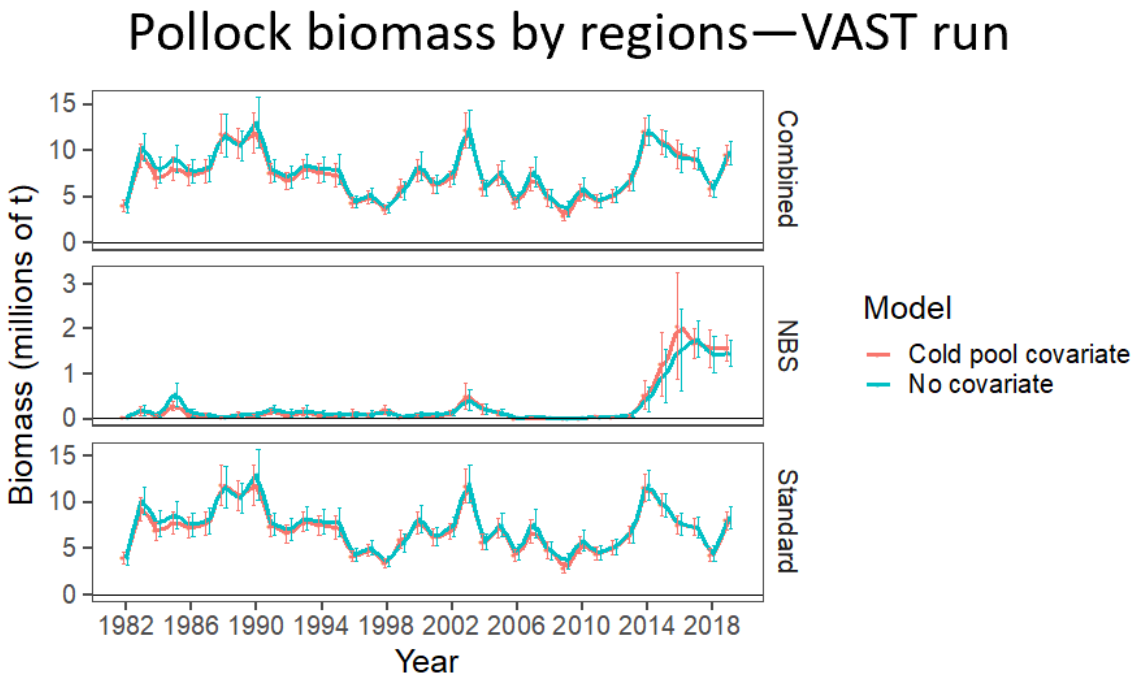
Northern area: 1.2xx million t

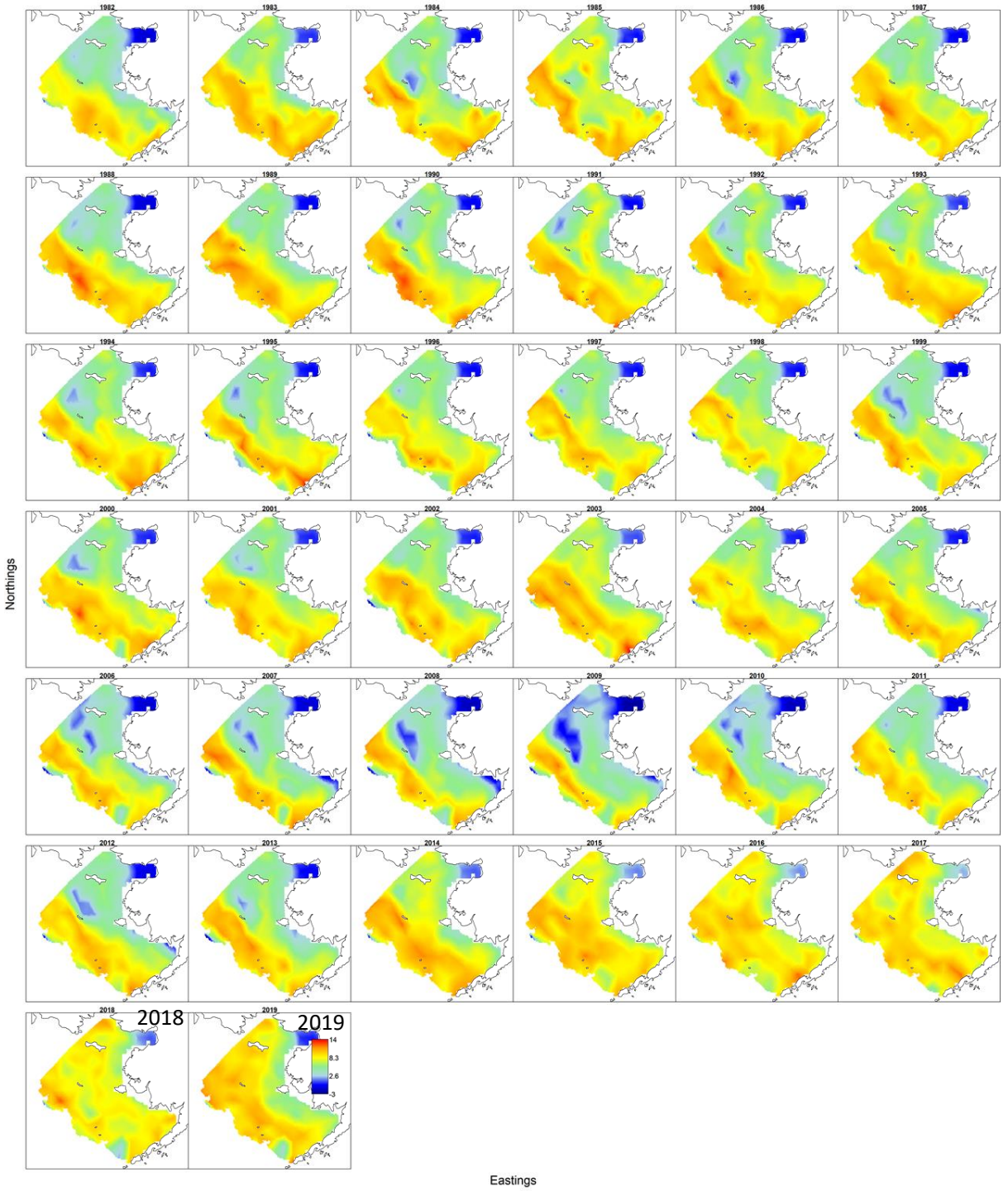
New this year

- Evaluation of the cold-pool impact
- Survey age compositions also done using VAST
- Preliminary Acoustic-trawl index available
  - Included in alternative model runs

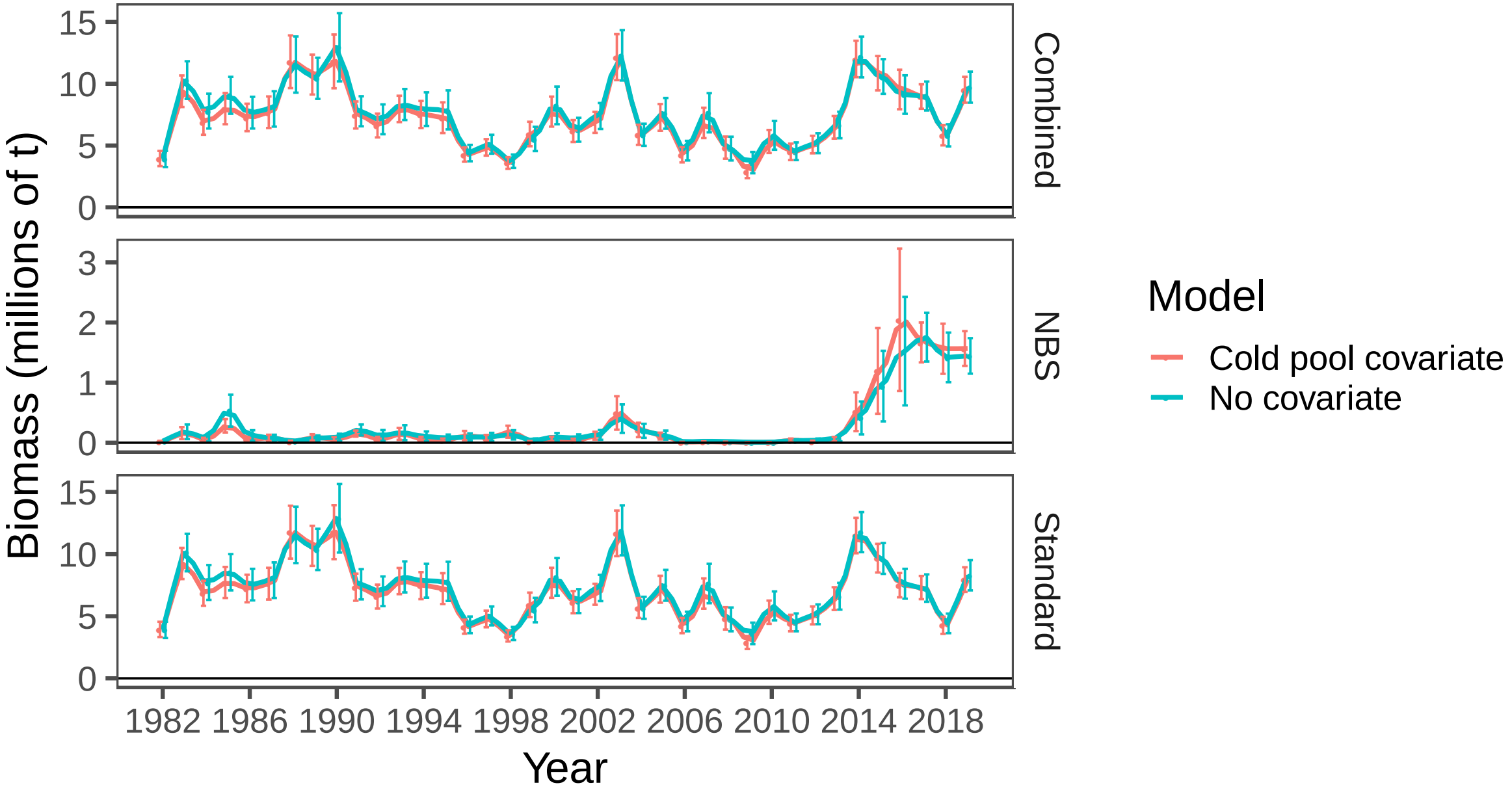
Modeling surveys

- To account for missed areas/years…
- VAST model of Thorson

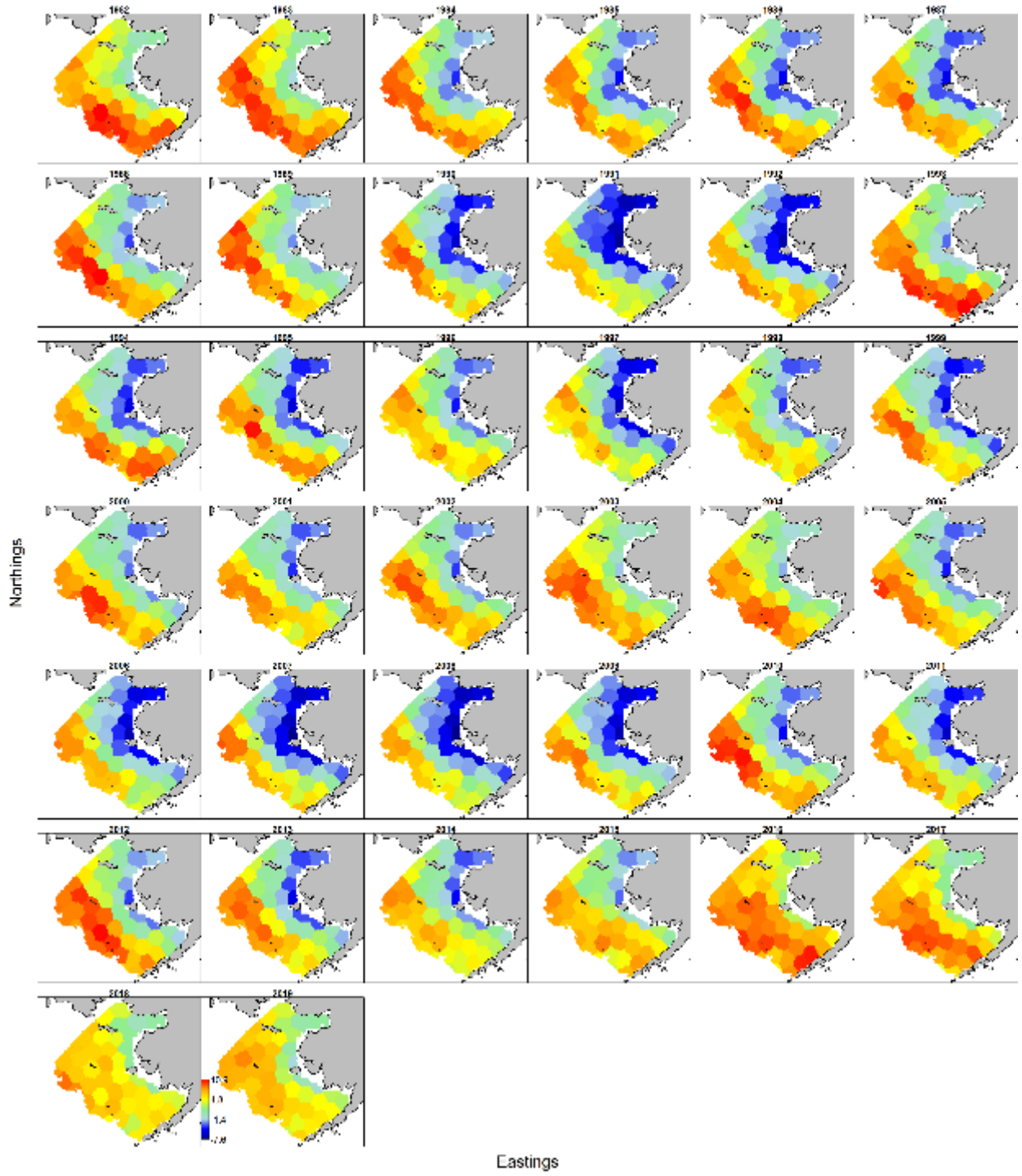




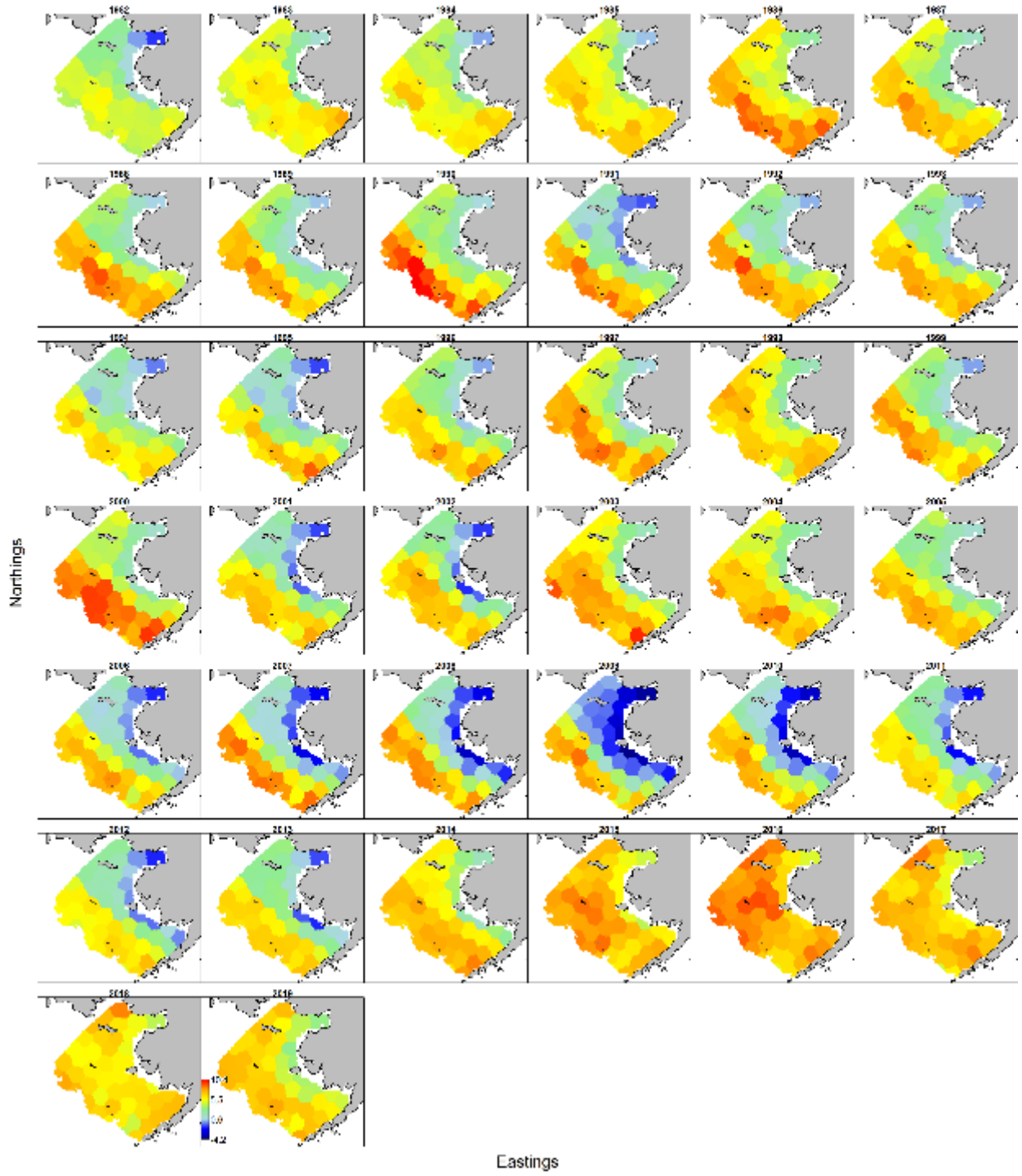
Pollock biomass by regions—VAST run

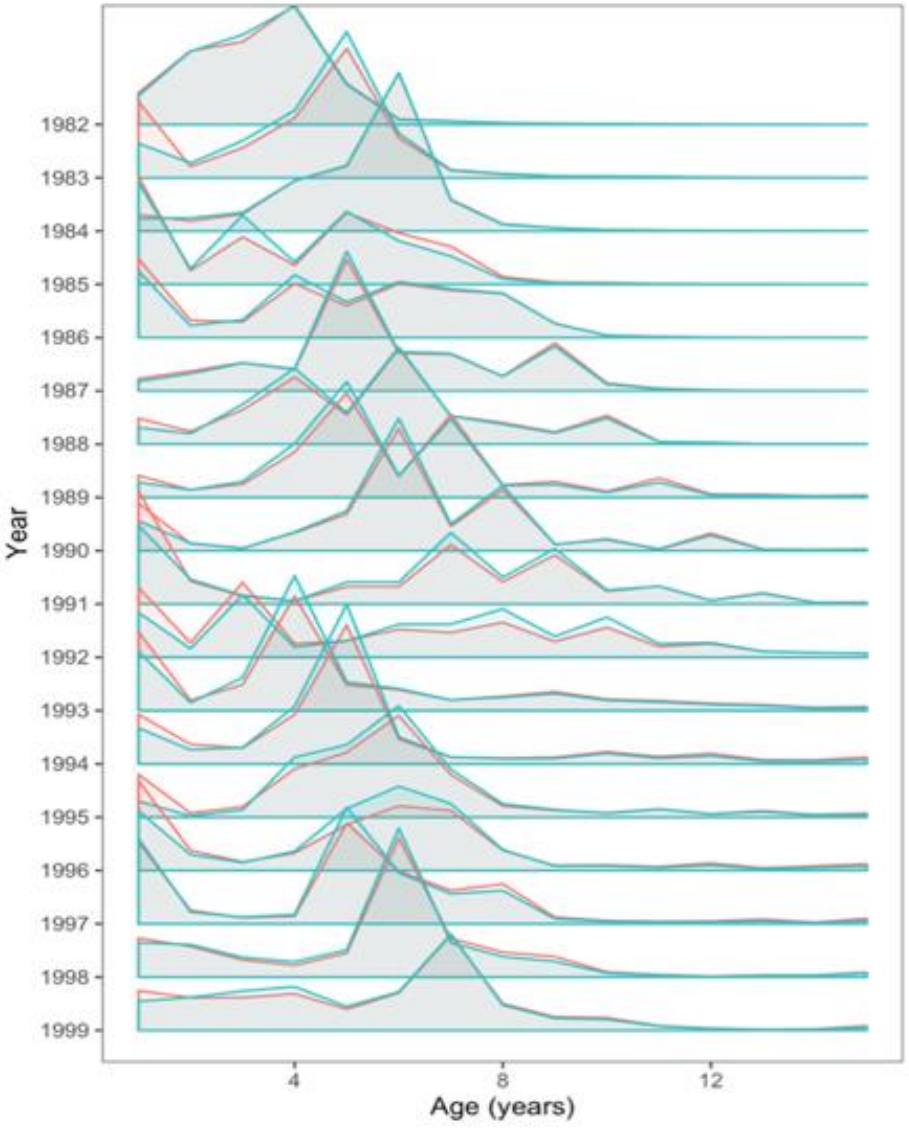


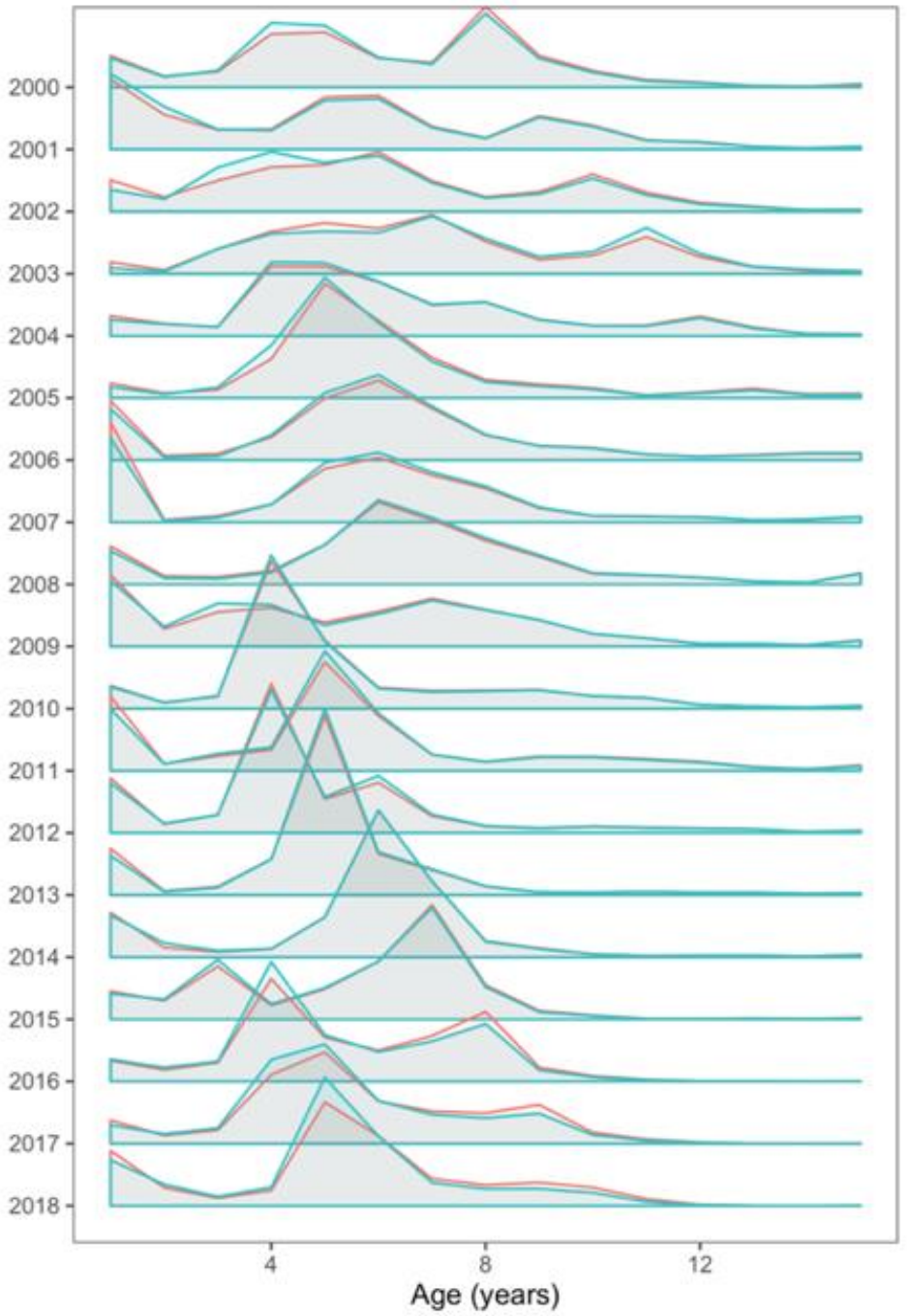
4 Year olds

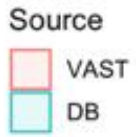


8 Year olds









VAST Age compositions

compared to design-based

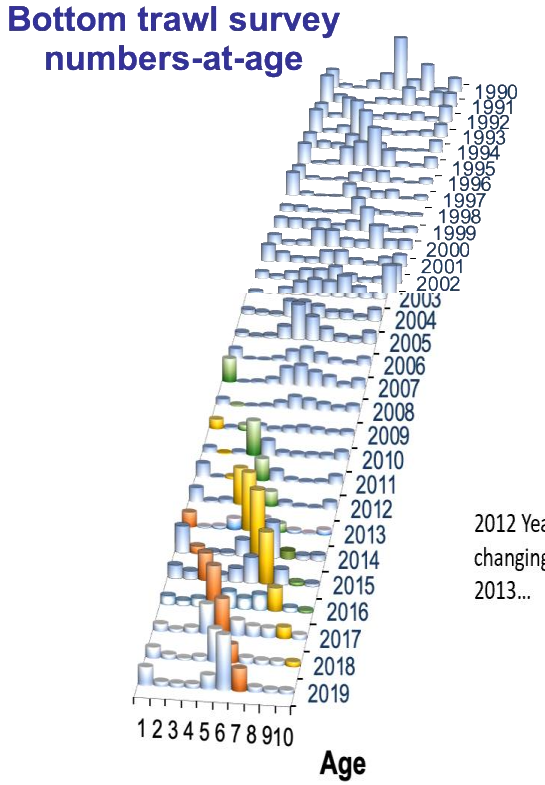
Model configurations

- Base (as in 2018)
- VAST indices—account for Northern Bering Sea biomass
- New work on space-time modeling of survey data
  - Layers of water column
  - Led to an evaluation of effective “catchability”

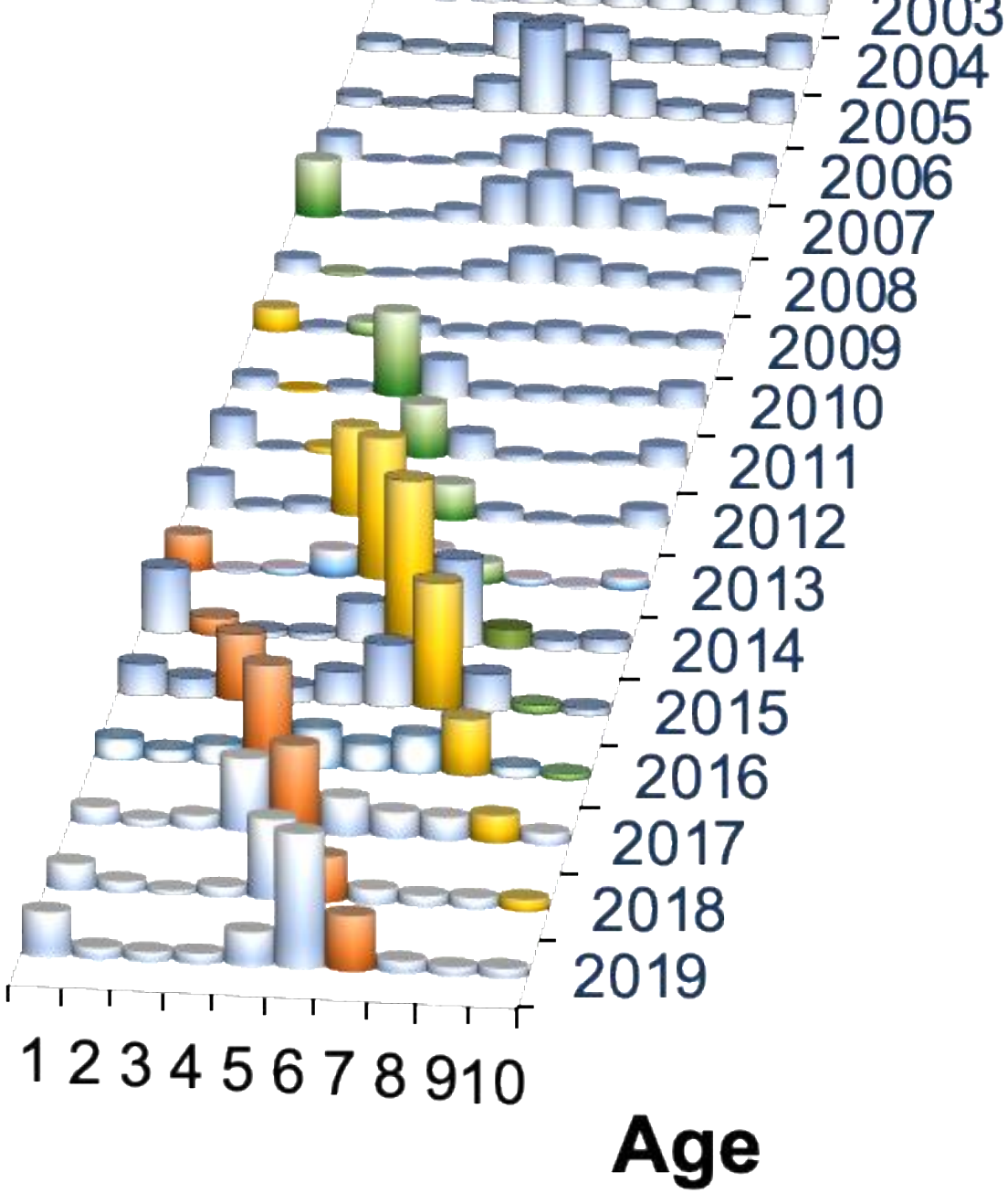
Population numbers of fish

Scientific Research Survey

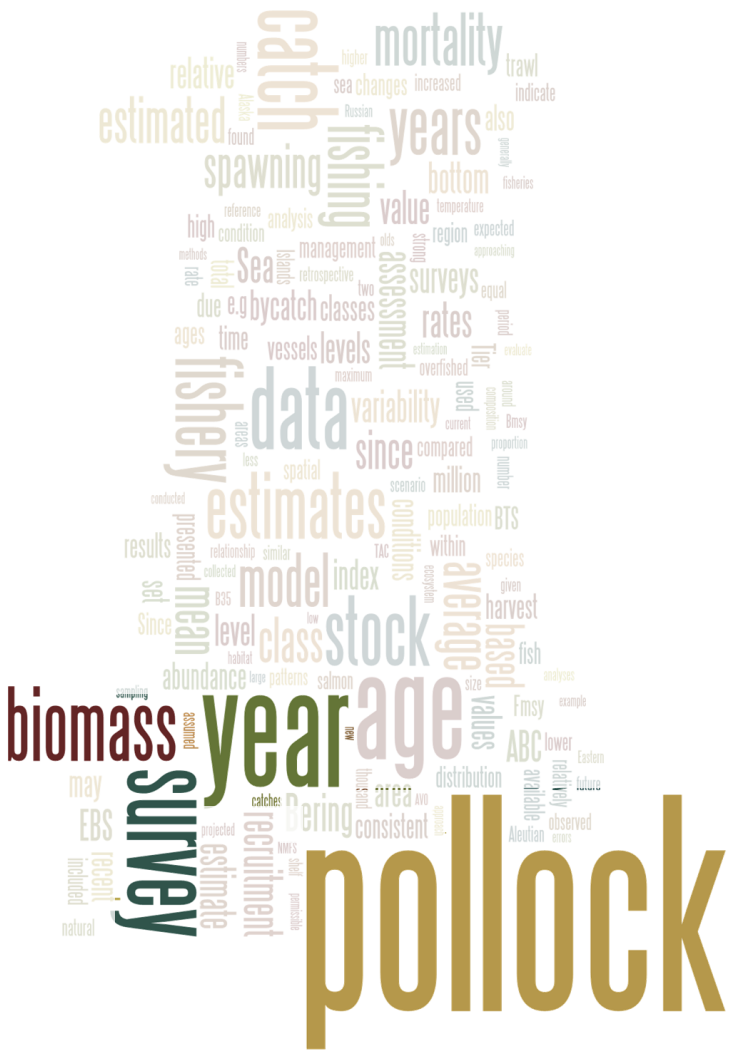
Results



2012 Year class changing to the 2013…



2012 Year class changing to the 2013…



EBS pollock

Assessment

Results

EBS pollock
Assessment
Results

Model details (1 of 2)

- Tuning indices
  - Acoustic Trawl survey
    - Available biennially (usually)
  - Annual fixed-station bottom trawl survey
    - Tested including northern Bering Sea from VAST
  - Acoustic vessel of opportunity (AVO index)
    - 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)

EBS pollock
Assessment
Results

- 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

Data

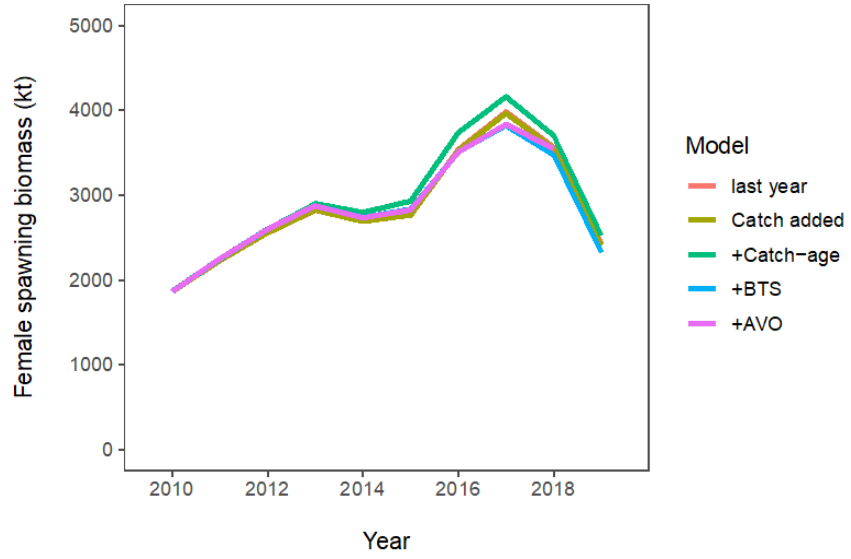
Impact on

Model

New data impact on model…

Data considerations				
Name	**Updated catch to 2019**	**2018 fishery age data**	**2019 Bottom trawl survey data**	**AVO 2019**
Catch	X			
+Age Fishery	X	X		
+BTS	X	X	X	
+AVO	X	X	X	X

Data
Impact on
Model

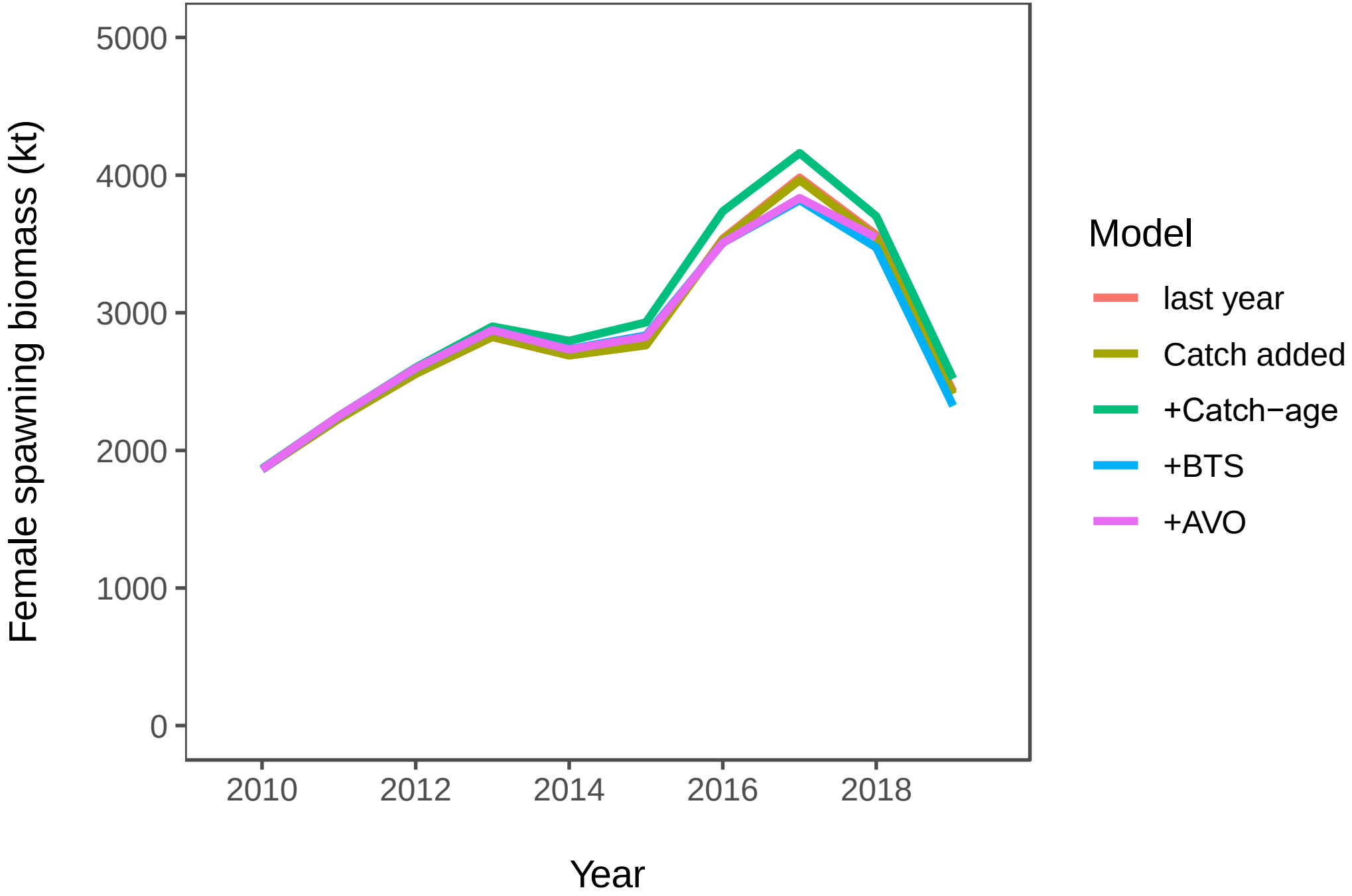


Data
Impact on
Model

Data

Impact on

Model

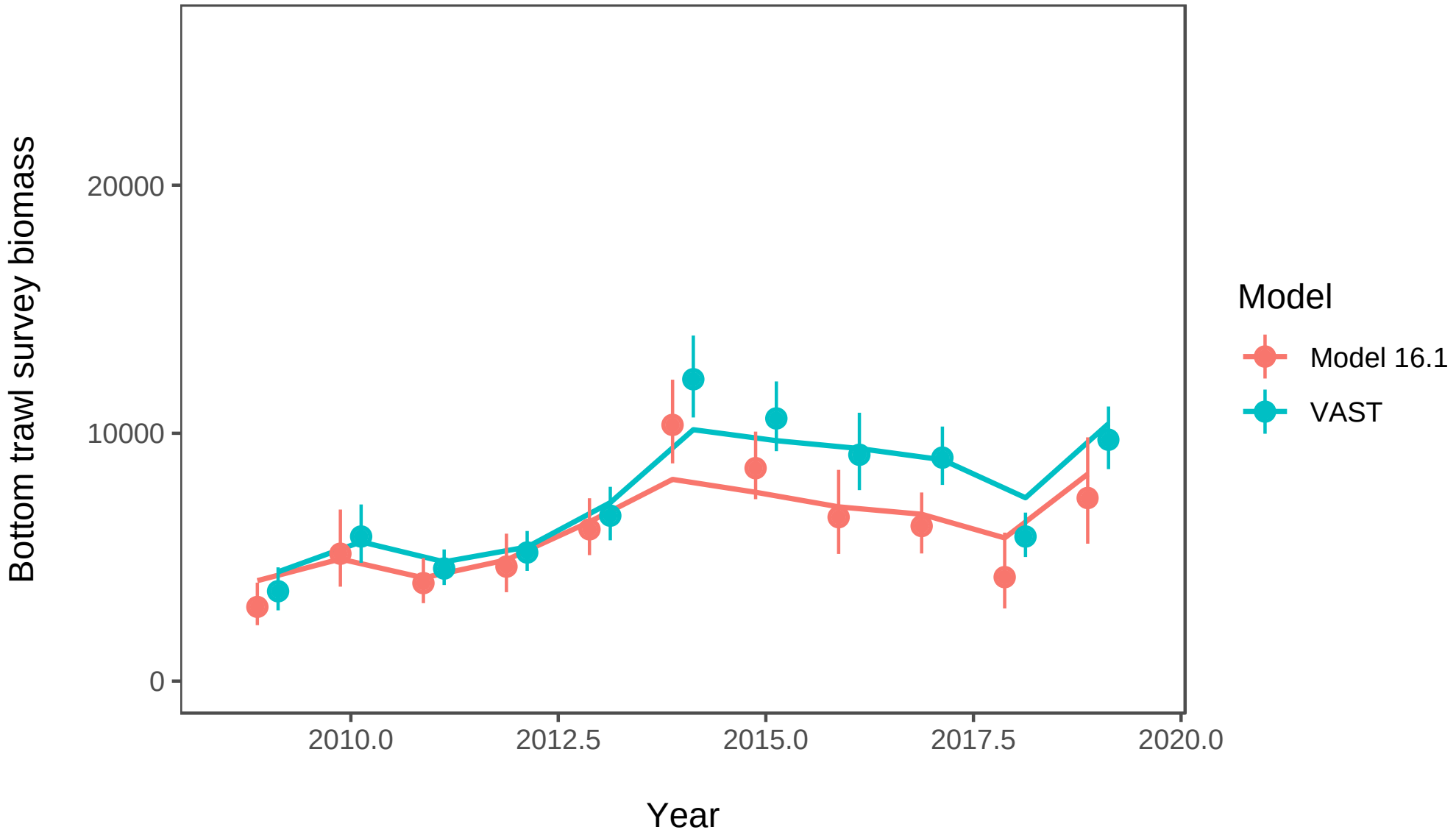


EBS pollock
Assessment
Results

Alternative models for bottom-trawl survey

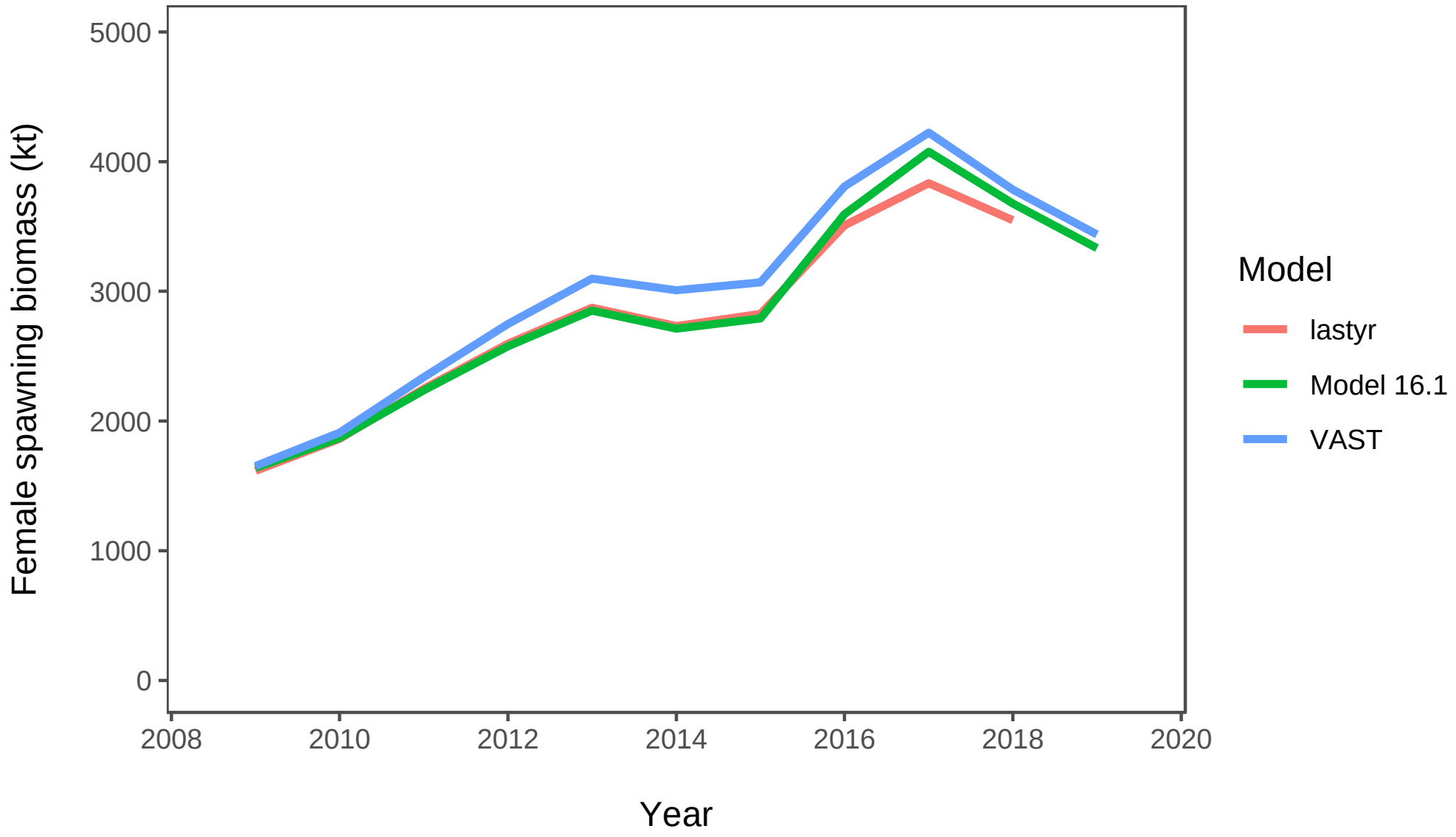
EBS pollock
Assessment
Results

Alternative models for bottom-trawl survey



EBS pollock
Assessment
Results

Alternative models for bottom-trawl survey



New stuff

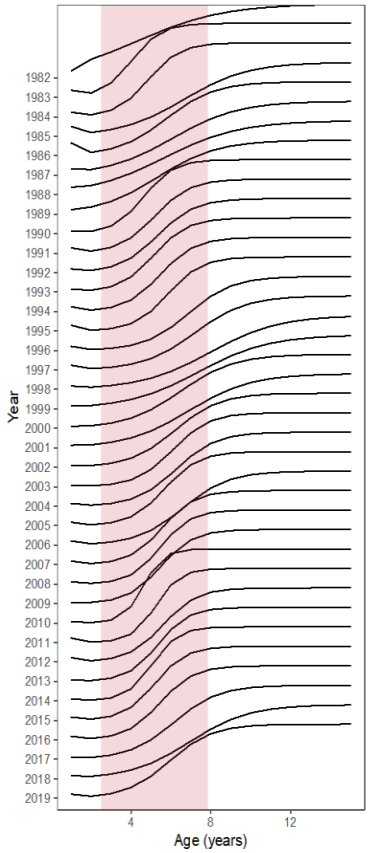
- Layers

- Spatial-temporal survey age compositions

EBS pollock

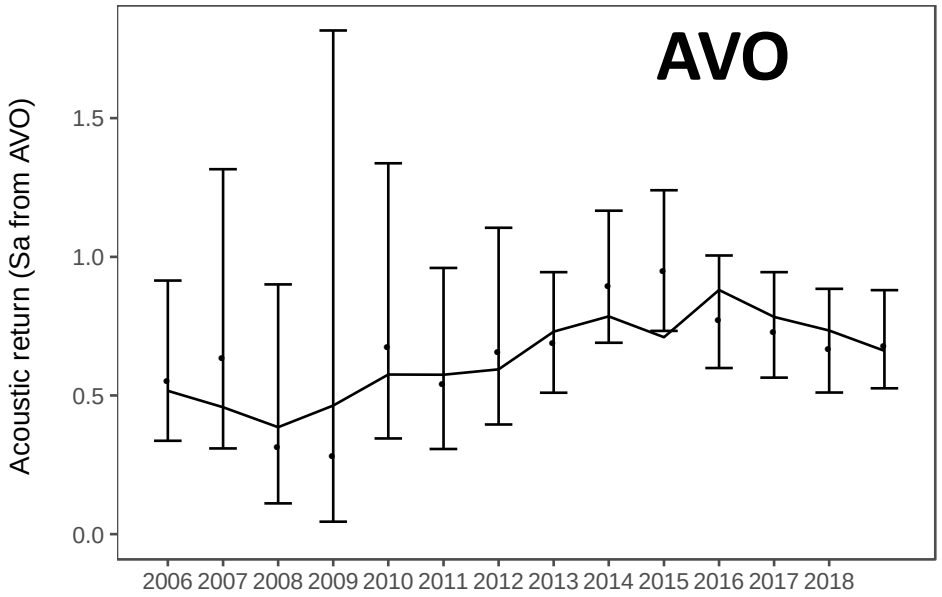
Assessment

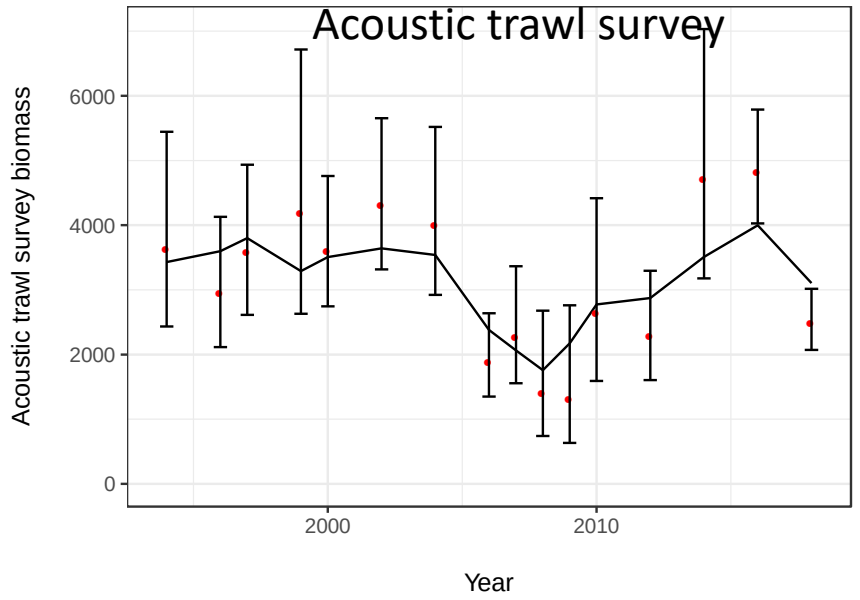
Results

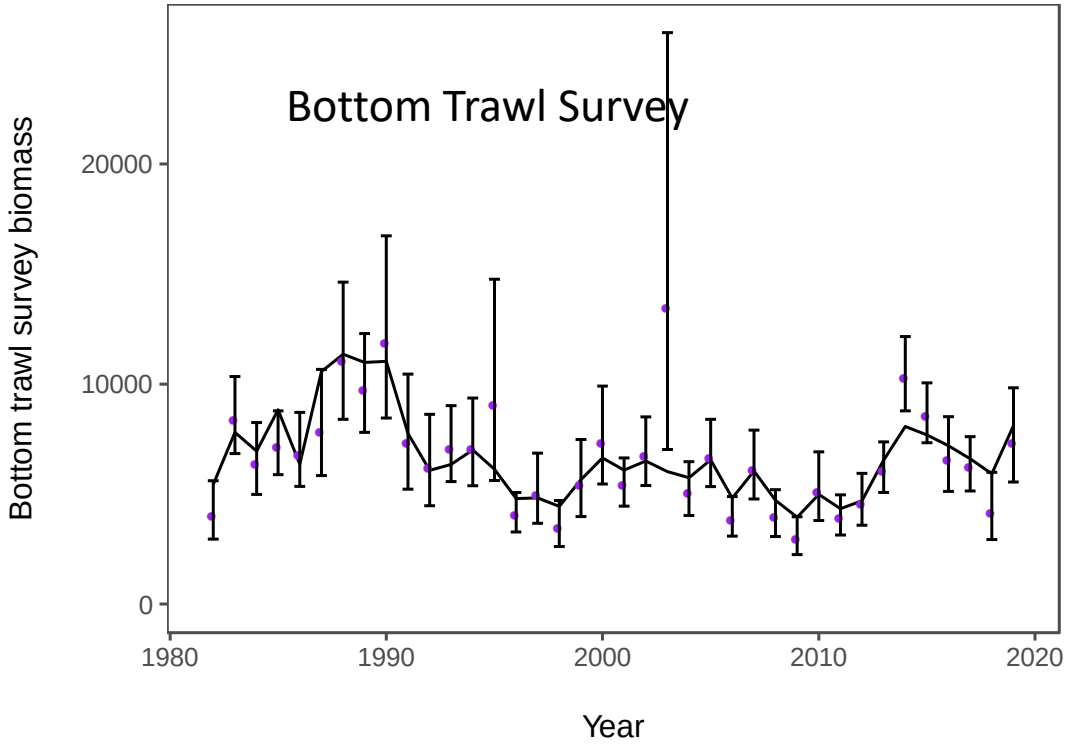


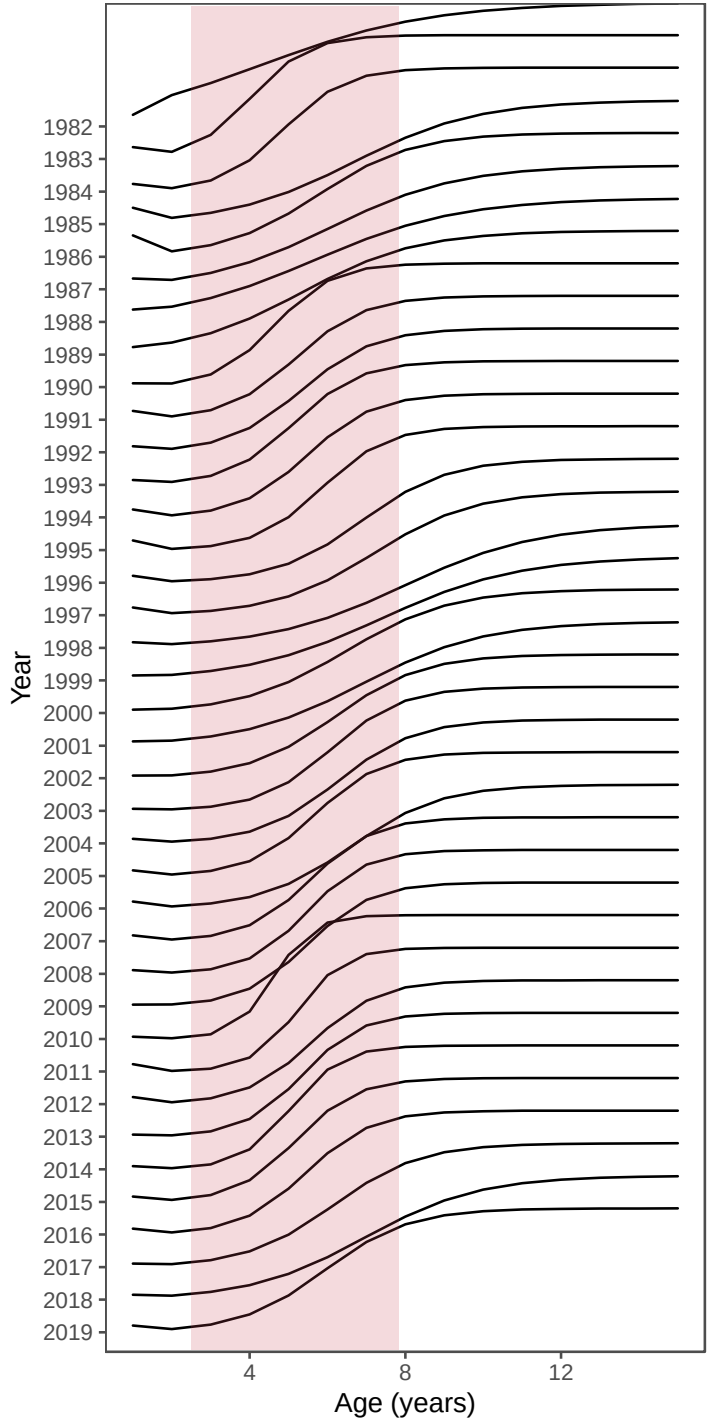
Bottom trawl survey Selectivity …

Model fits to indices









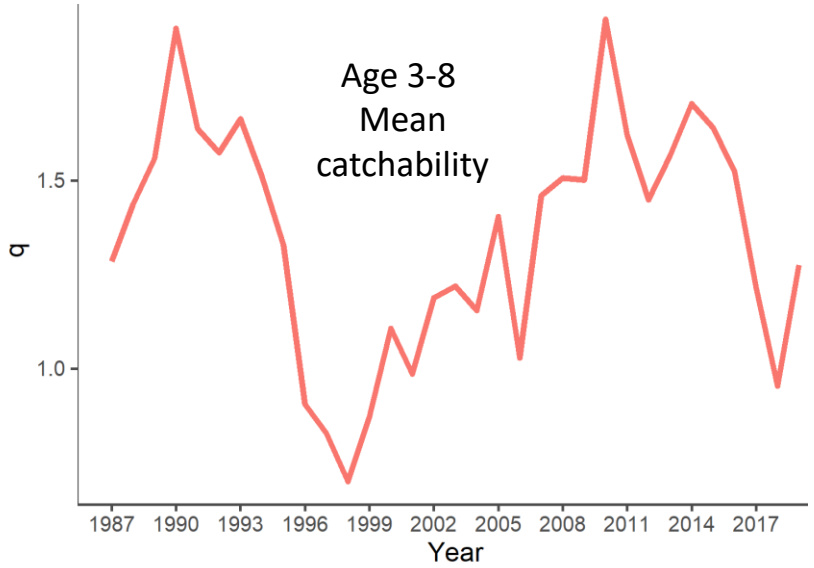
Bottom trawl survey Selectivity

…

Is it just**if**ried?

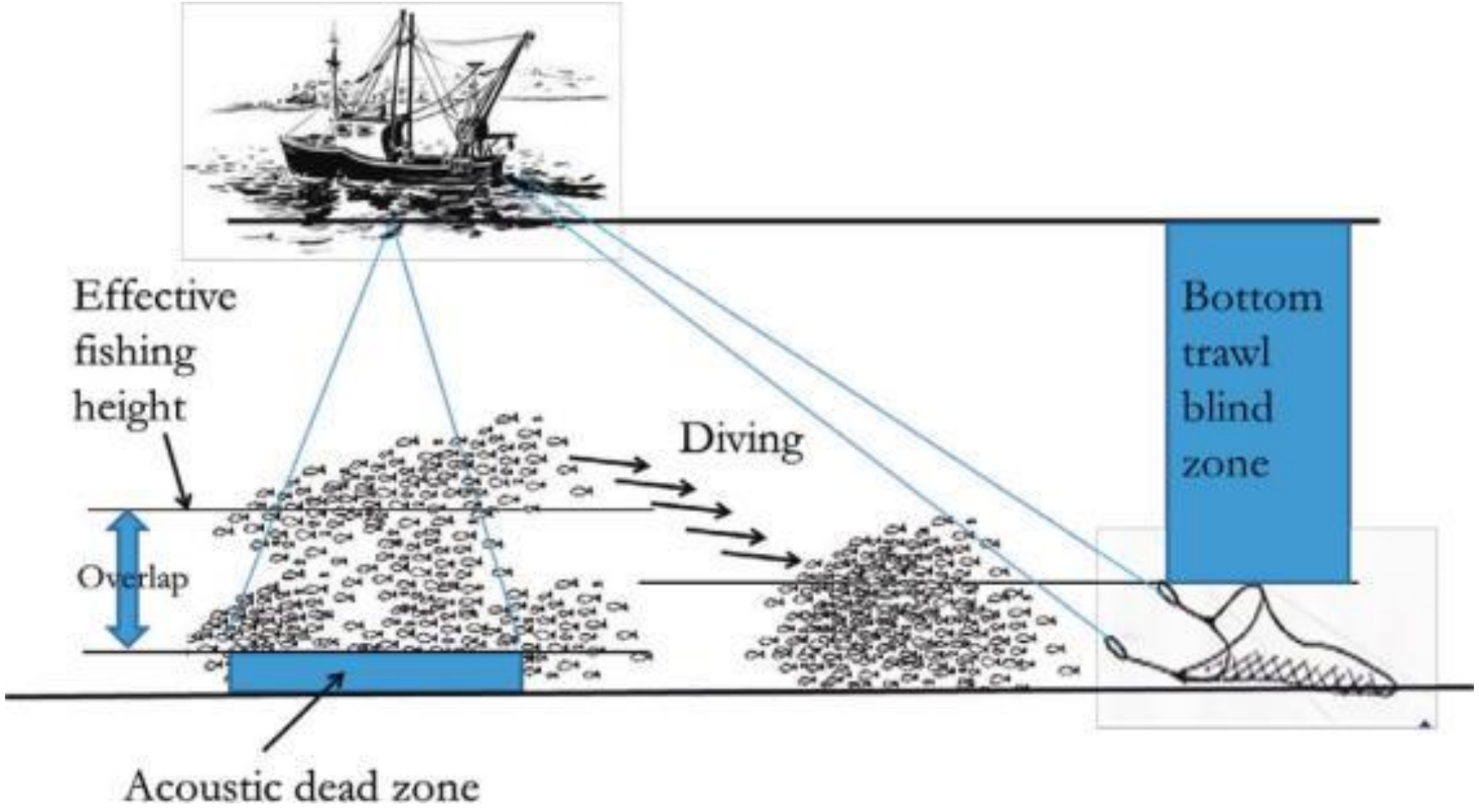
…time varying "catchability" for rigorously conducted scientific fishery-independent survey…

- Incorrect assumption if:
  - Fish don't move
  - They stay in the same place in the water column
- Problem: **how to estimate?**
- Solution
  - "Layers" project combining information

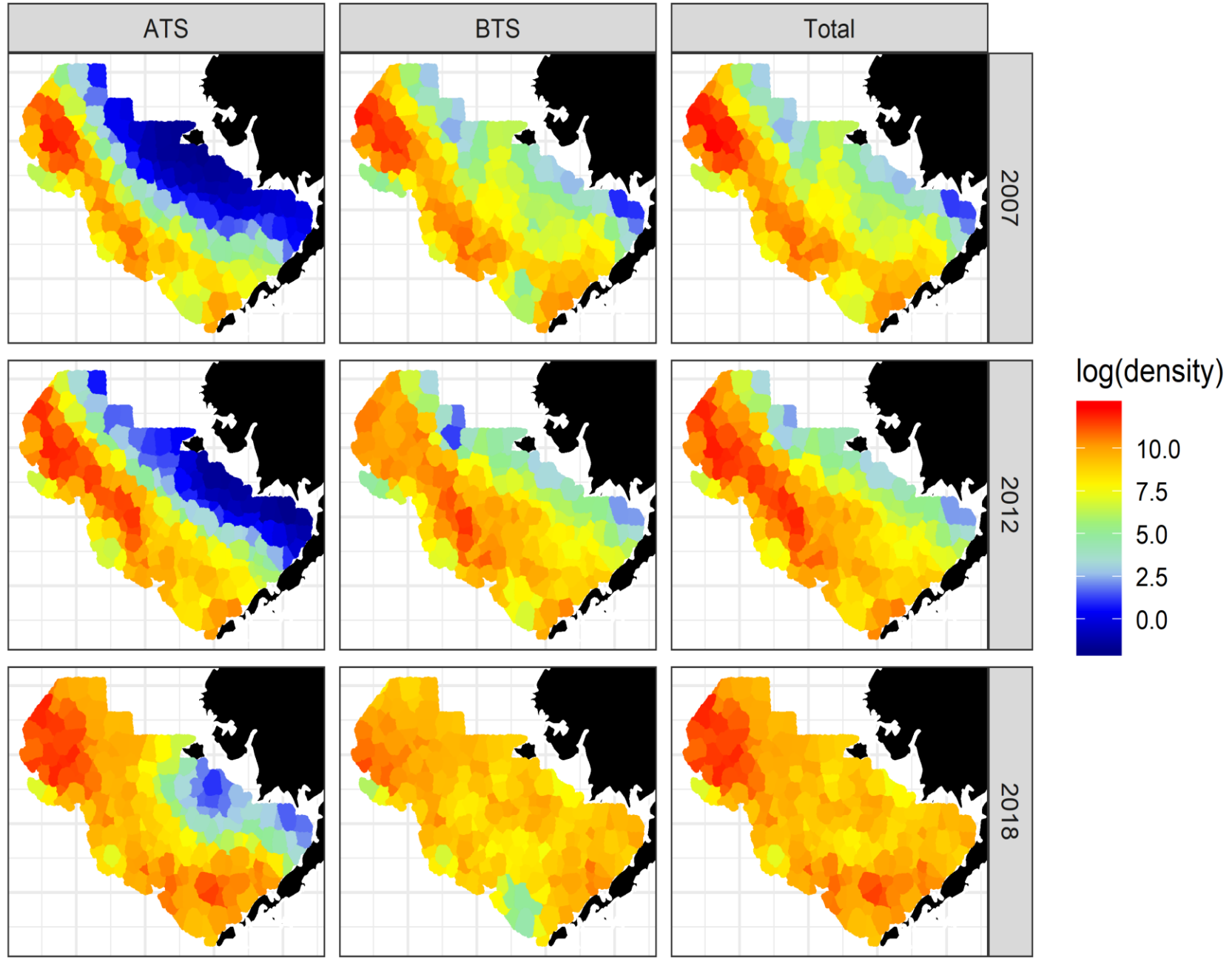


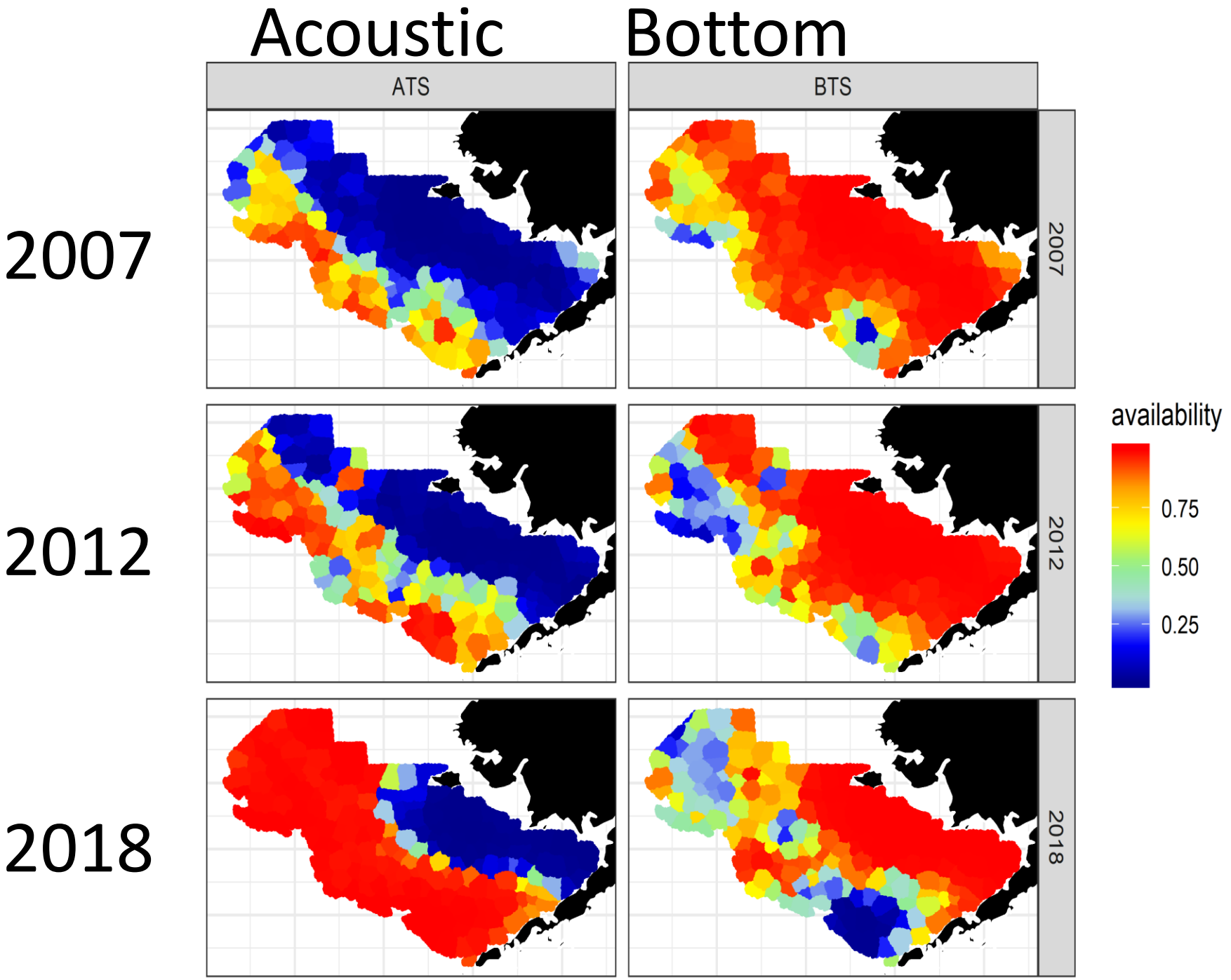
Acoustic and bottom trawl survey spatio-temporal modeling—Incorporating vertical distribution in index standardization

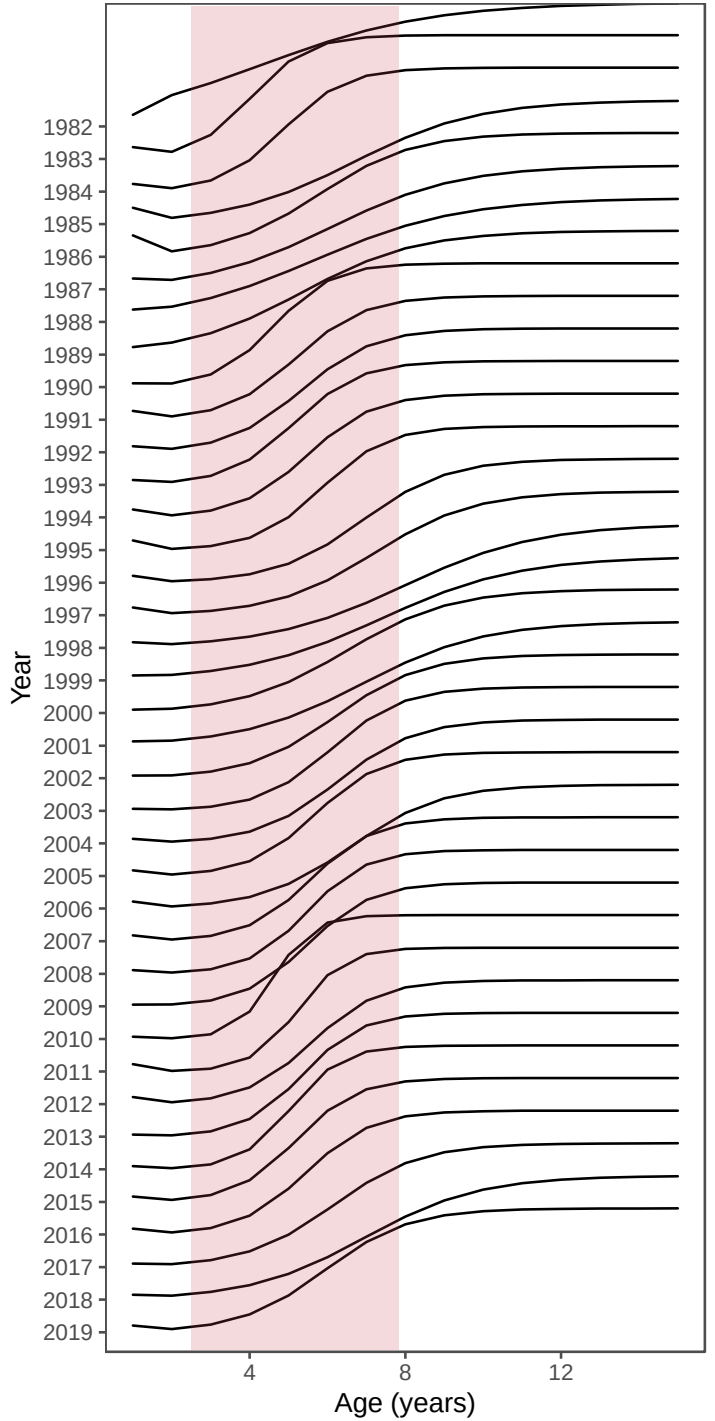
Cole Monnahan



Acoustic Bottom ***Combined***




Acoustic
Bottom
ATS
BTS
2007
2012
2018
availability
0.75
0.50
0.25



Bottom trawl survey Selectivity

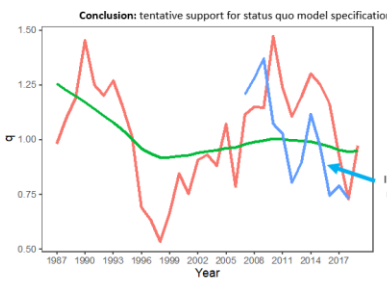
…

Table 27: Goodness of fit to primary data used for assessment model parameter estimation profiling over different constraints on the extent bottom-trawl survey selectivity/availability is allowed to change; EBS pollock.

Less flexibility in survey "catchability"

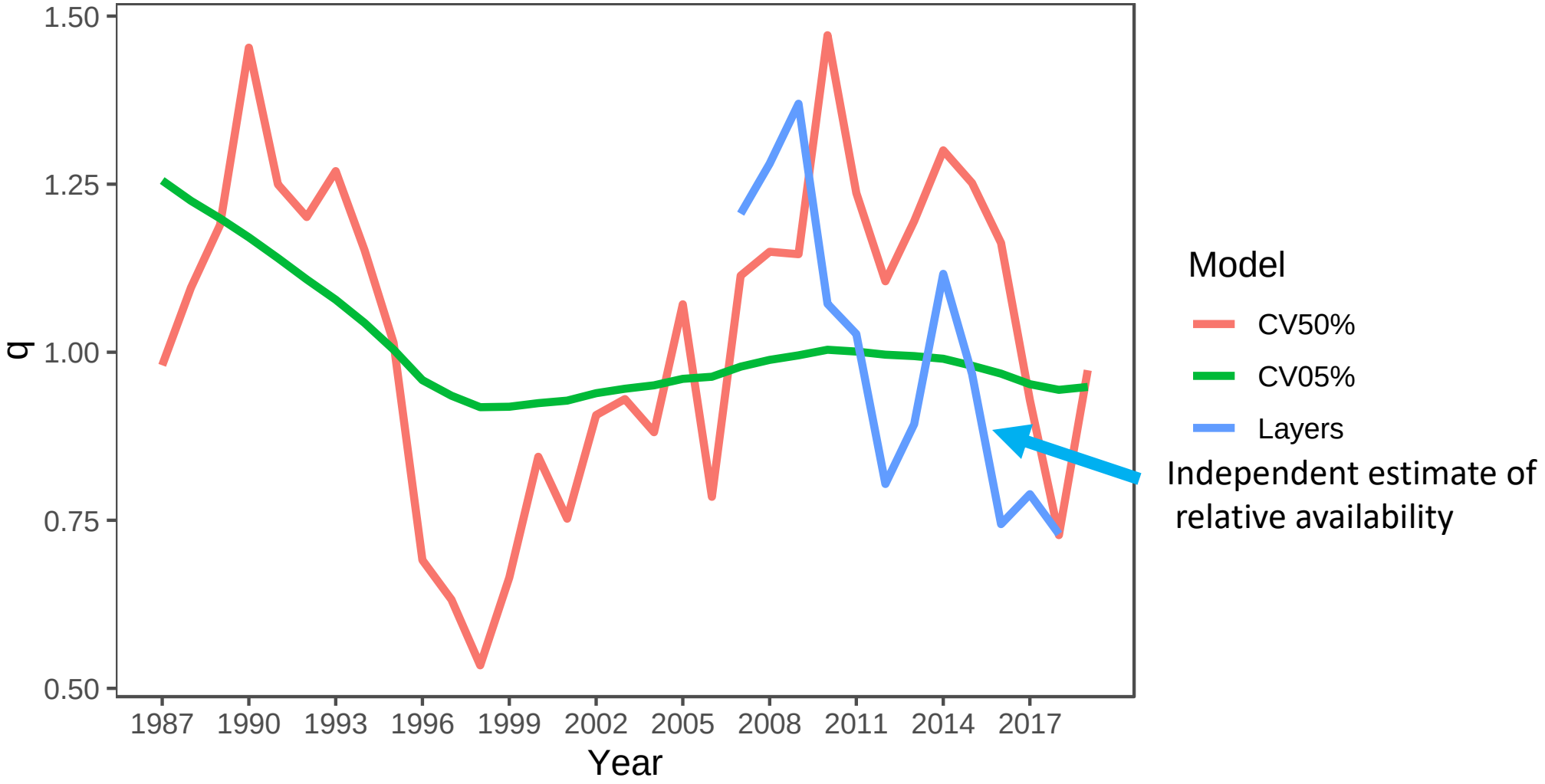
Component	CV70%	CV50%	CV20%	CV10%	CV05%
RMSE BTS	0.19	0.20	0.25	0.29	0.31
RMSE ATS	0.22	0.22	0.22	0.23	0.25
RMSE AVO	0.20	0.20	0.20	0.20	0.20
RMSE CPUE	0.09	0.09	0.09	0.09	0.09
SDNR BTS	1.02	1.19	1.79	2.23	2.47
SDNR ATS	1.10	1.10	1.11	1.14	1.22
SDNR AVO	0.76	0.75	0.74	0.72	0.71
Eff. N Fishery	1365.51	1372.40	1392.26	1372.23	1278.89
Eff. N BTS	208.52	203.80	178.75	159.65	141.48
Eff. N ATS	215.18	215.53	214.51	209.21	200.07
BTS NLL	20.81	28.35	64.62	99.66	122.72
ATS NLL	8.84	8.85	8.97	9.33	10.33
AVO NLL	9.55	9.54	9.53	9.60	9.71
Fish Age NLL	137.34	138.83	143.86	149.91	159.59
BTS Age NLL	146.41	149.94	168.84	190.99	239.72
ATS Age NLL	26.81	26.89	27.61	28.90	30.68

Age 3-8 relative "availability" to bottom tra

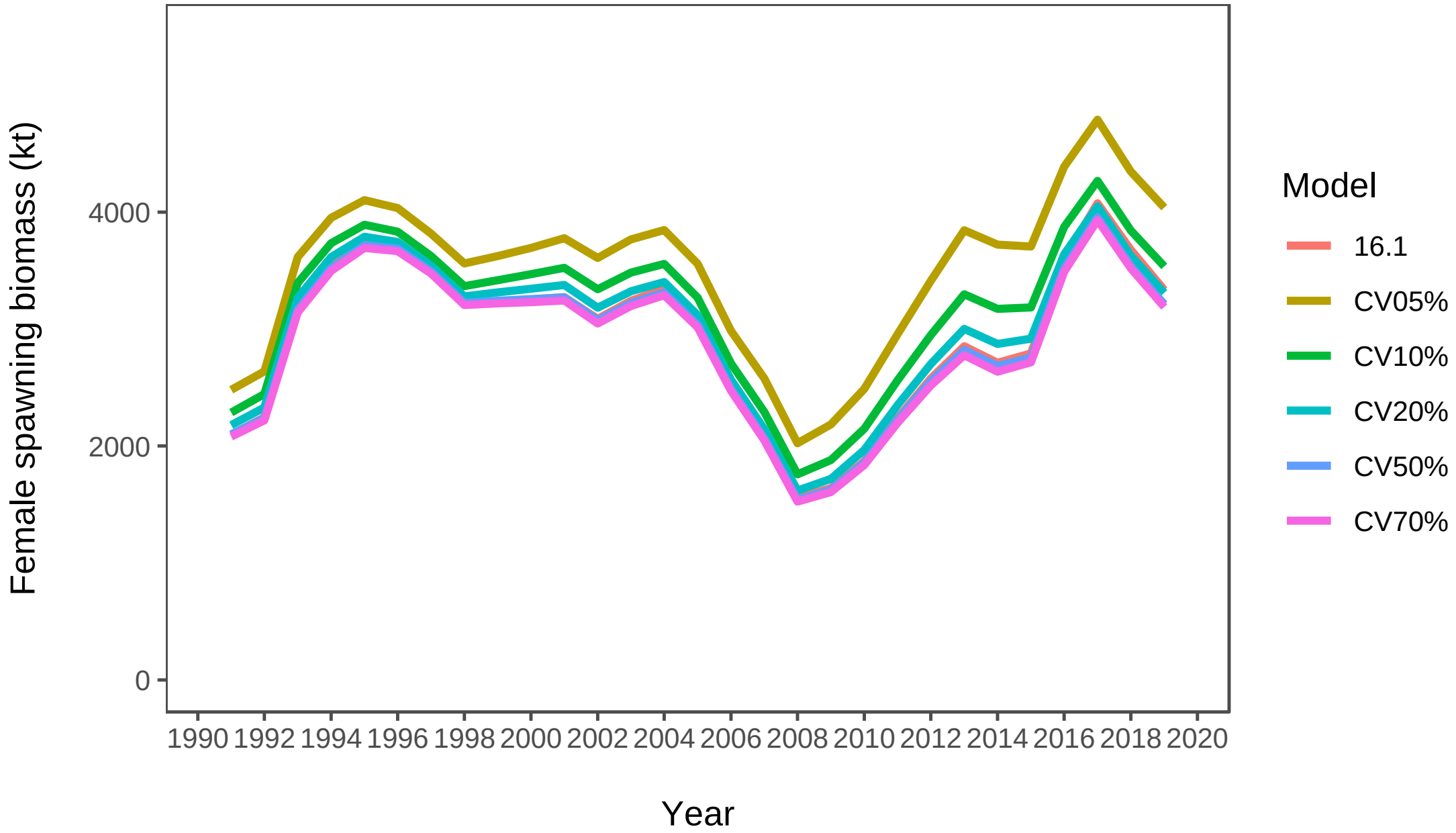


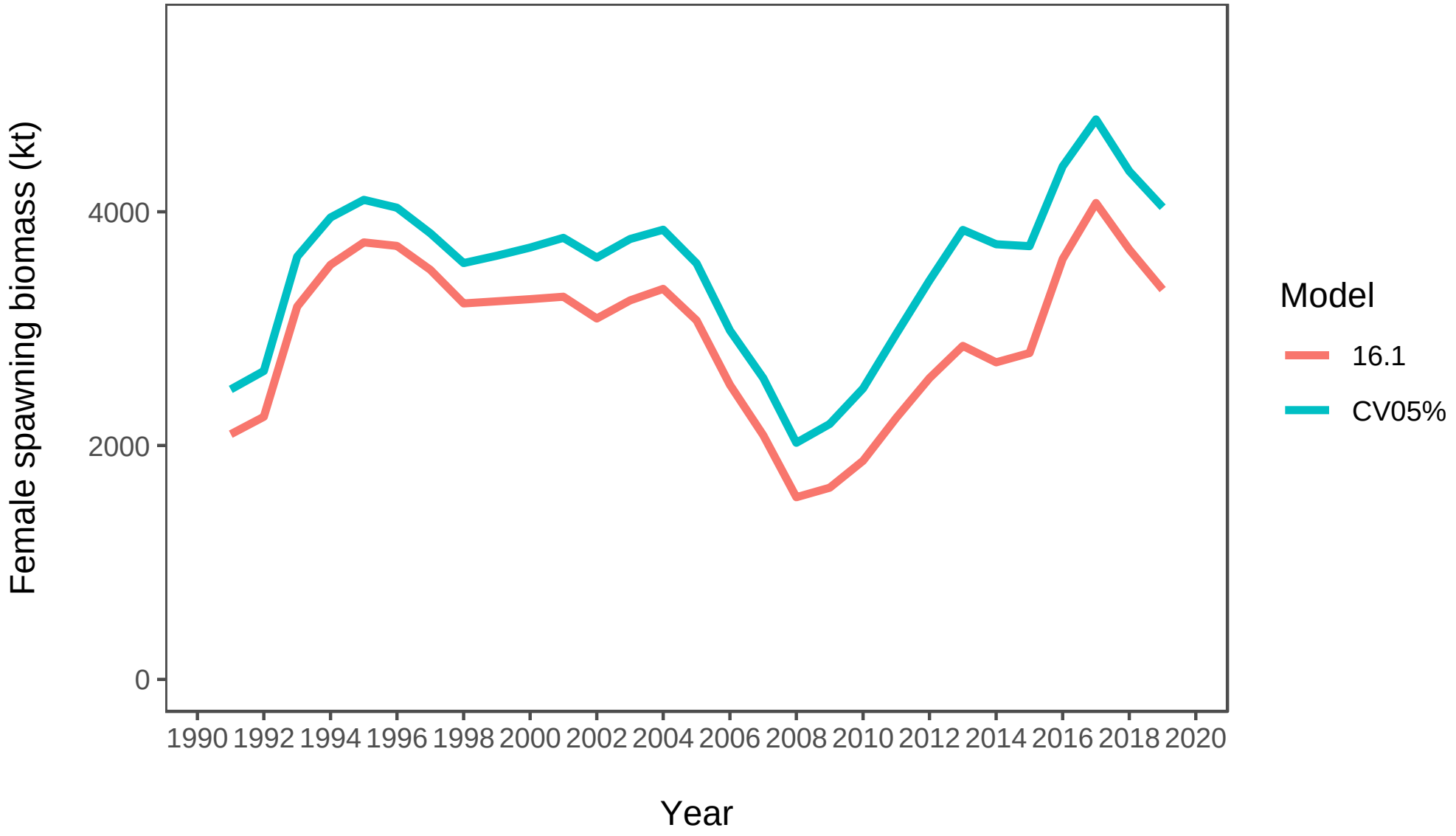
Age 3-8 relative “availability” to bottom trawl survey

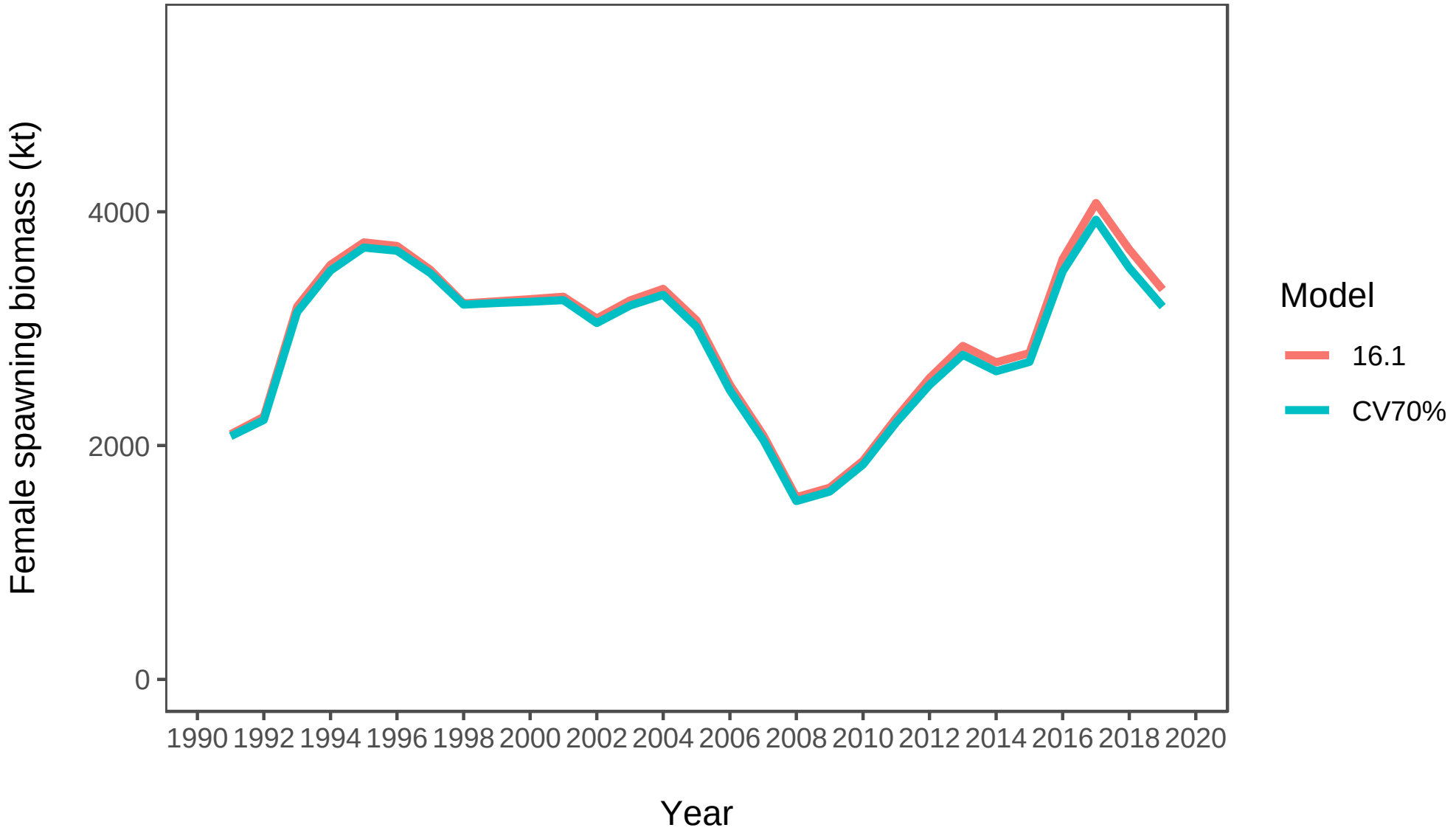
Conclusion: tentative support for status quo model specification…



Impact of constraining availability assumption..




Female spawning biomass (kt)
4000
2000
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Model
16.1
CV05%


Female spawning biomass (kt)
4000
2000
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Model
16.1
CV70%

Layer approach?

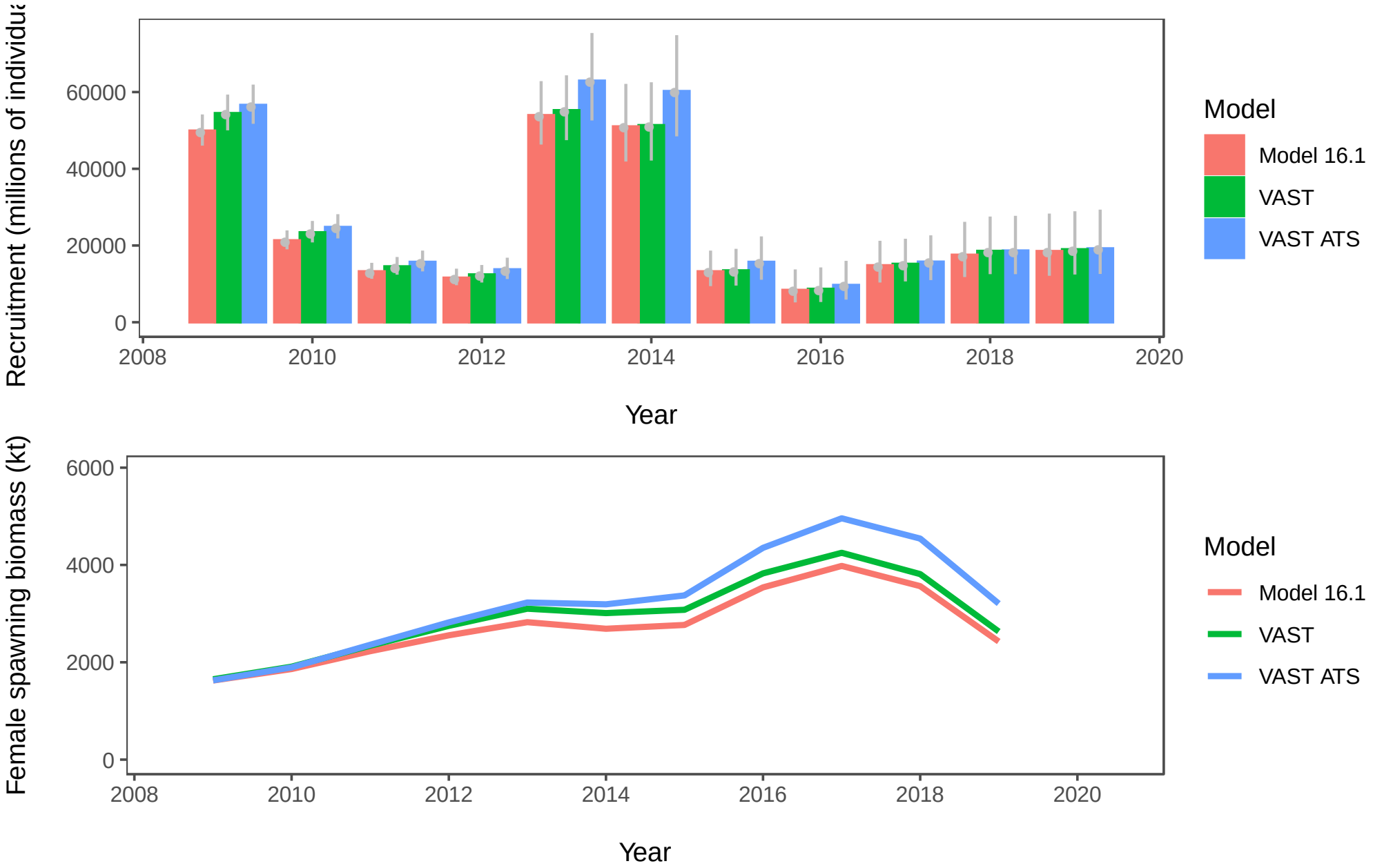
- **C**ombining **O**verlapping **L**ayered **D**ata (COLD?)

Combining Overlapping Layers of Echosign (COLE?)

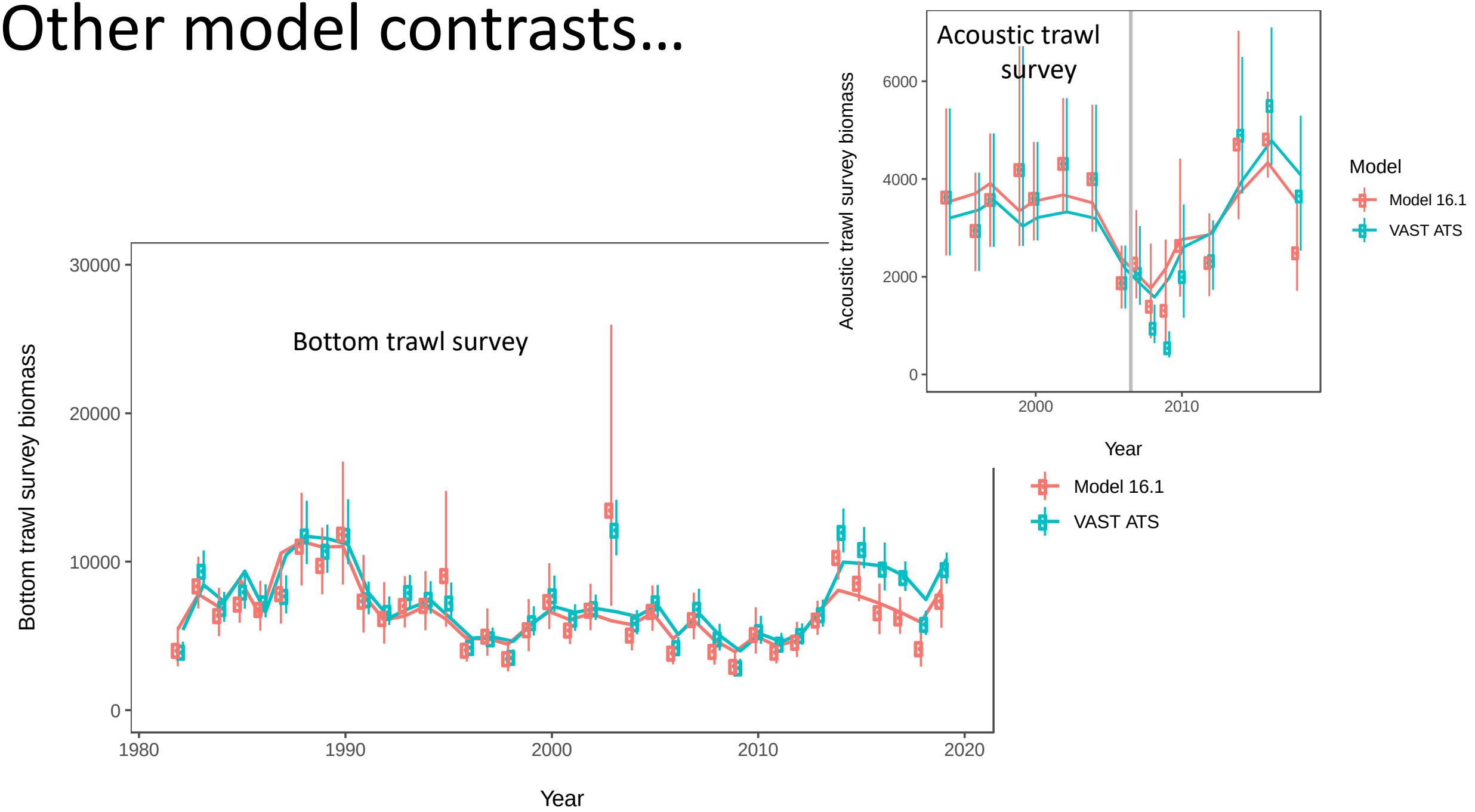
Table 27: Goodness of fit to primary data used for assessment model parameter estimation for different model configurations, EBS pollock.

Component	lastyr	Model 16.1	VAST	VAST+cold-pool	VAST ATS
RMSE BTS	0.240	0.200	0.160	0.170	0.170
RMSE ATS	0.220	0.220	0.220	0.220	0.380
RMSE AVO	0.210	0.200	0.200	0.200	0.220
RMSE CPUE	0.090	0.090	0.090	0.090	0.090
SDNR BTS	1.230	1.190	1.870	2.130	2.120
SDNR ATS	1.110	1.100	1.130	1.140	2.940
SDNR AVO	0.580	0.750	0.730	0.730	0.850
Eff. N Fishery	1438.800	1372.250	1381.800	1376.960	1373.430
Eff. N BTS	168.540	203.810	202.180	203.170	204.190
Eff. N ATS	213.530	215.490	212.720	212.560	220.060
BTS NLL	29.110	28.350	25.440	26.180	25.600
ATS NLL	8.940	8.850	9.000	9.140	26.960
AVO NLL	9.880	9.540	9.620	9.620	9.590
Fish Age NLL	115.290	138.830	139.130	139.550	139.040
BTS Age NLL	165.380	149.950	144.450	145.530	146.120
ATS Age NLL	28.220	26.890	27.030	27.110	25.970

Other model contrasts…



Other model contrasts…



Model results…fit to data

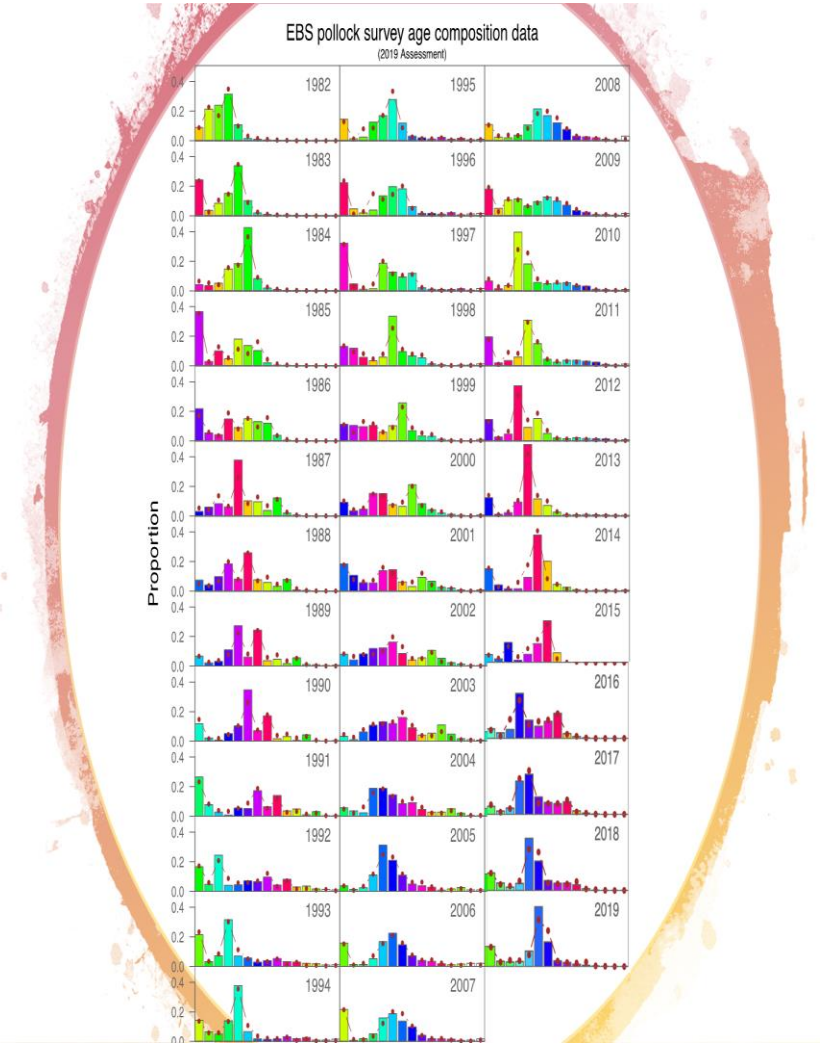
Bering Sea

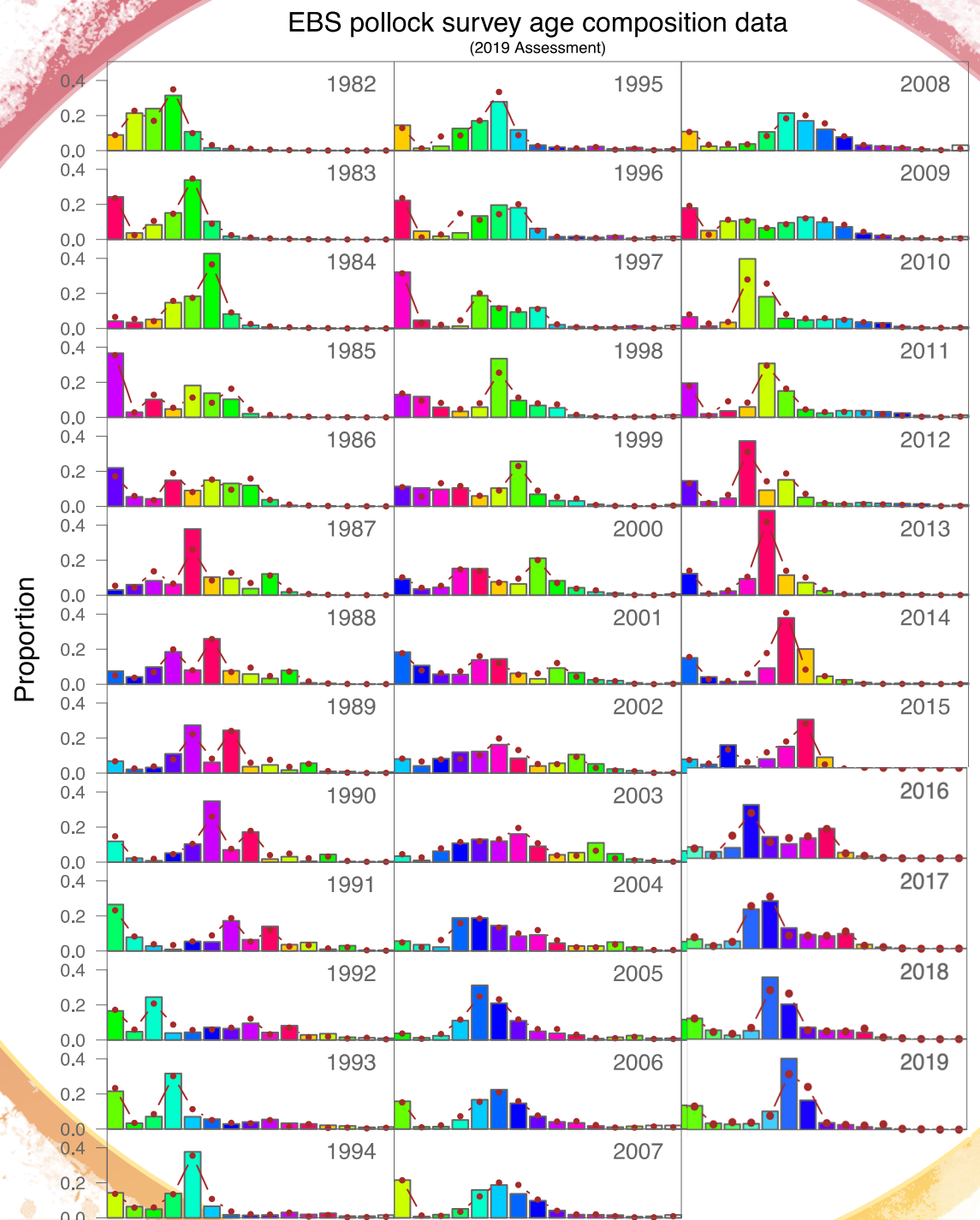
pollock

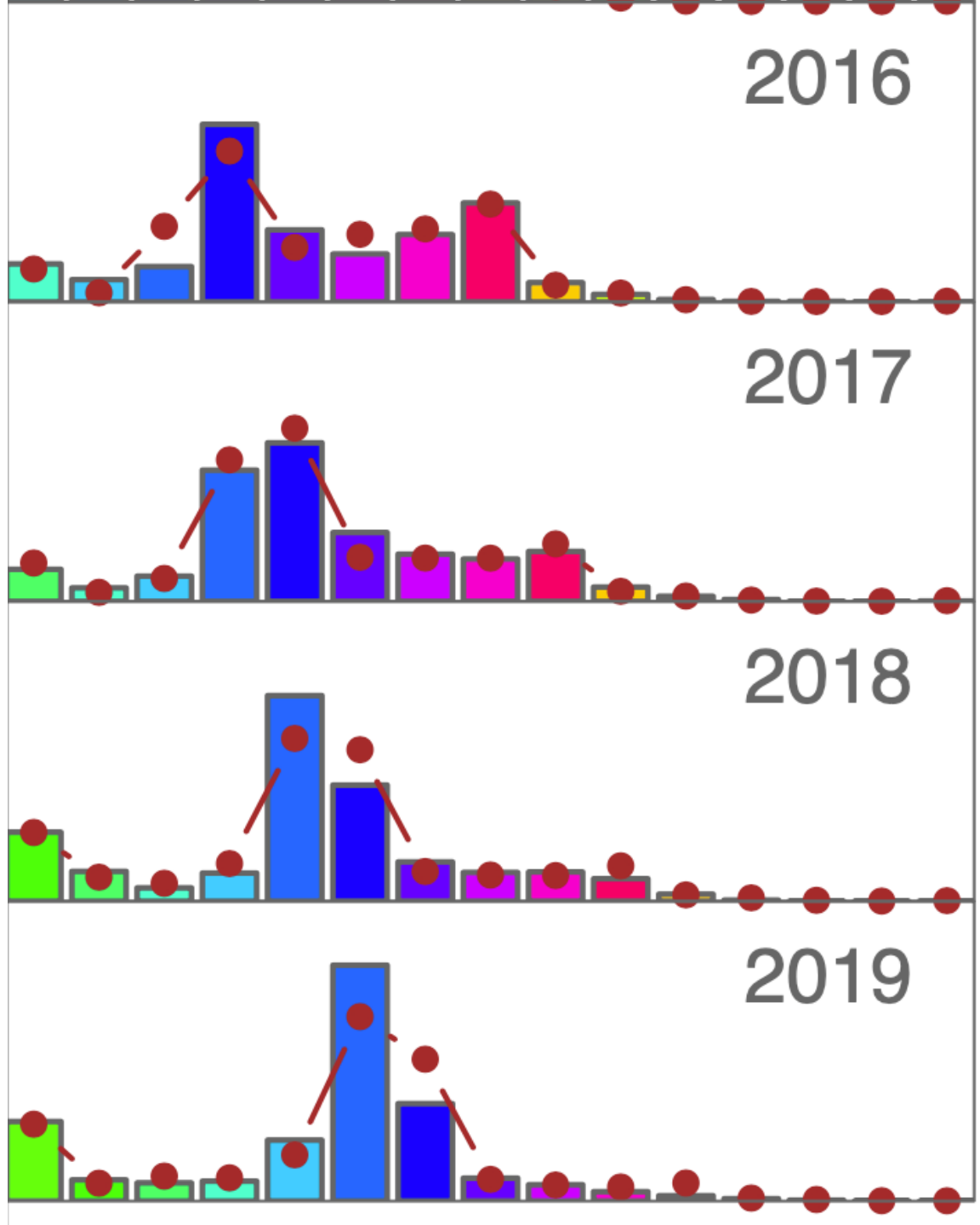
Bottom trawl survey

age data and

fits




EBS pollock survey age composition data
(2019 Assessment)
Proportion
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
0.0
0.2
0.4

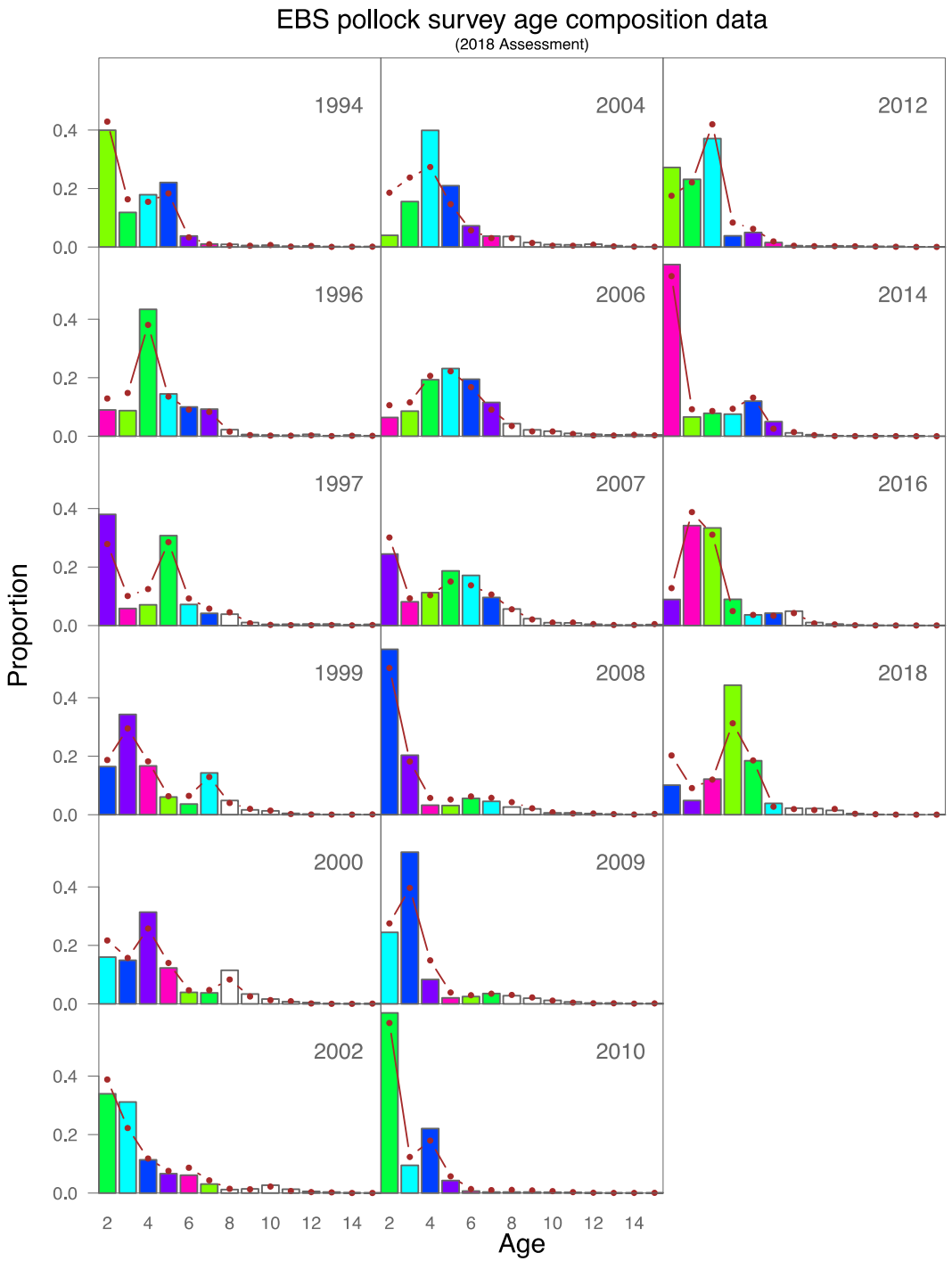

2016
2017
2018
2019

EBS pollock
Assessment
Results

Bering Sea pollock

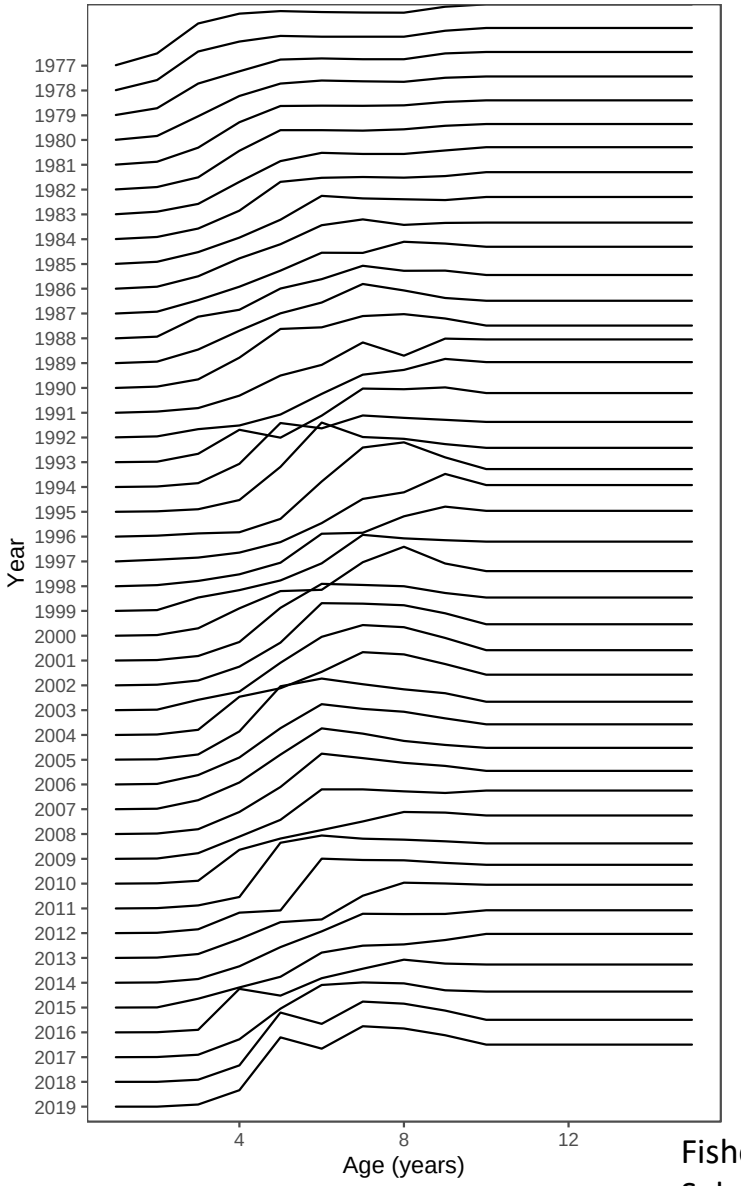
Acoustic survey

age data and fits

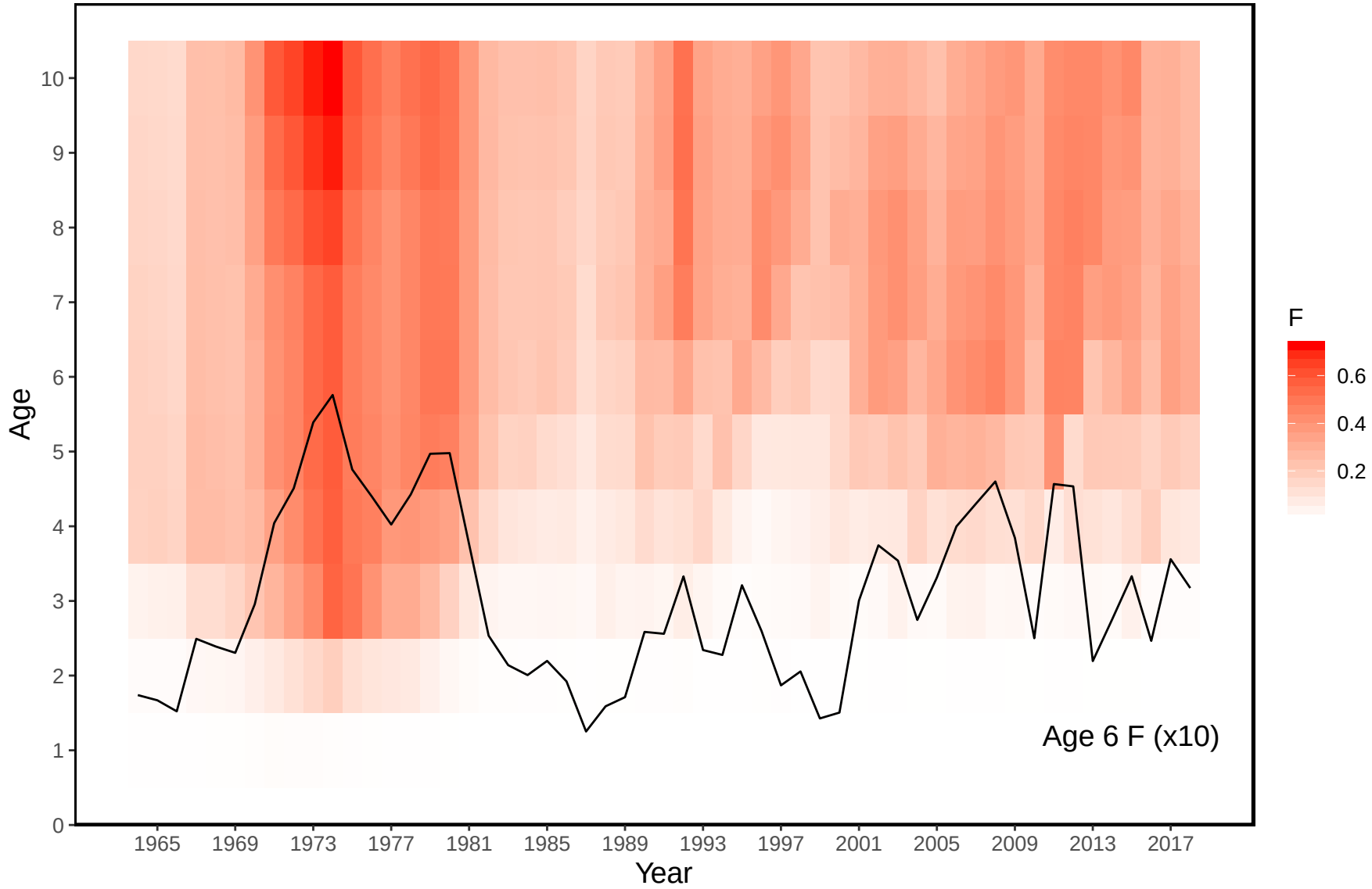


EBS pollock
Assessment
Results

Fishing mortality rates

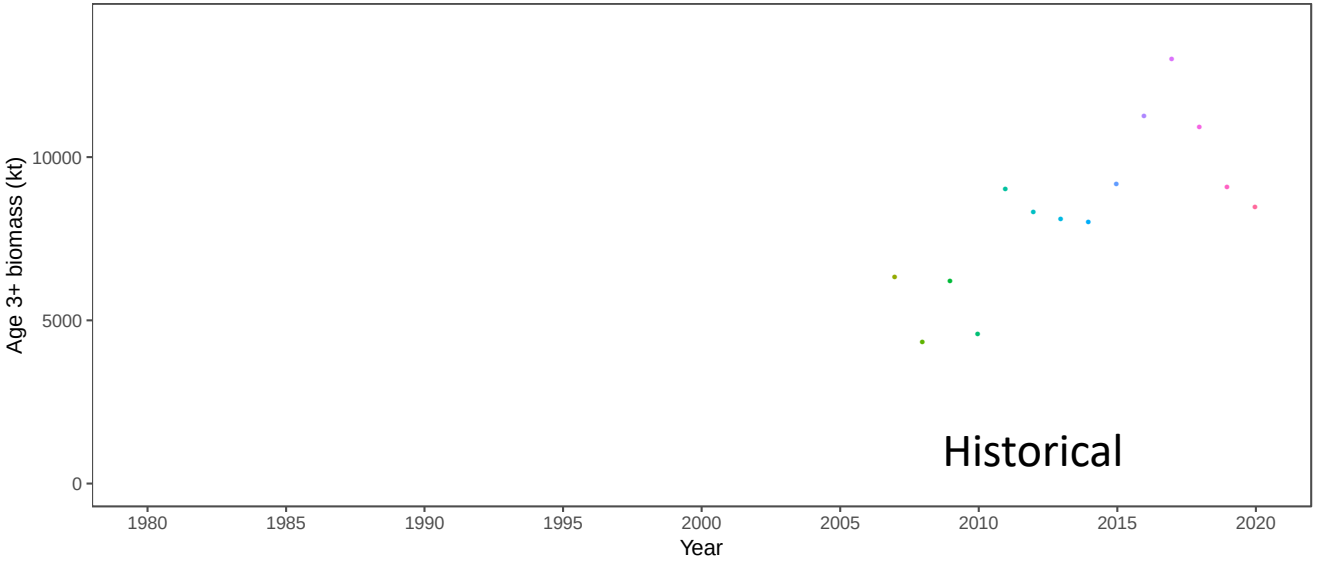


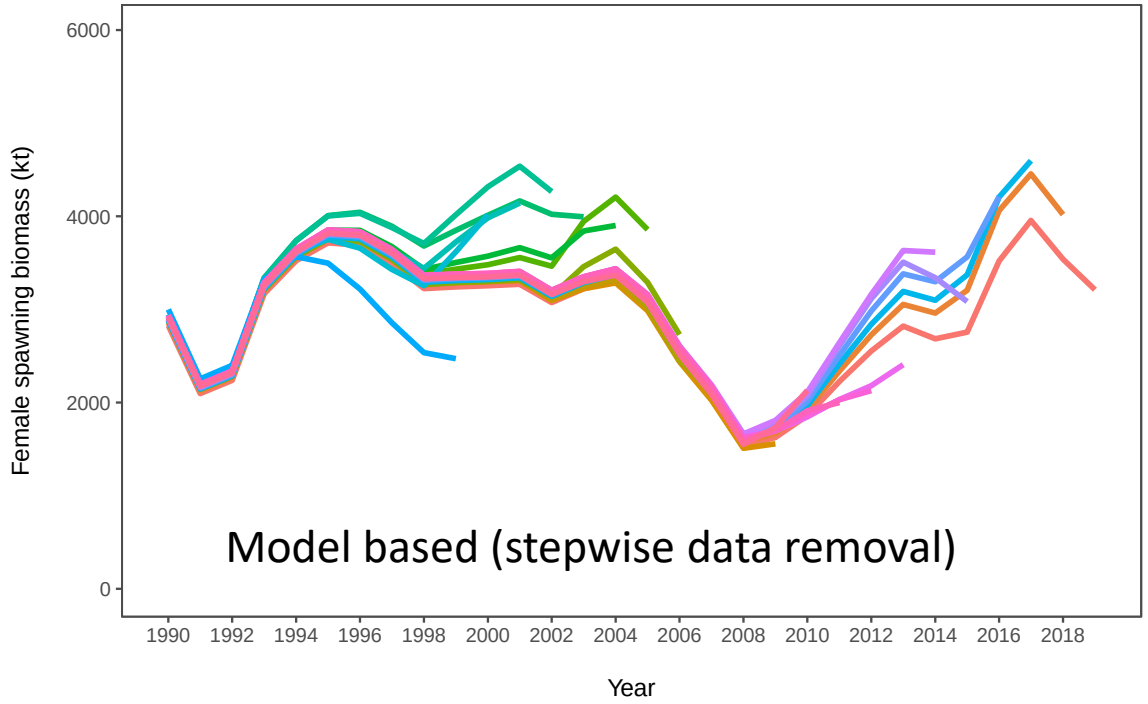
Fishery Selectivity…

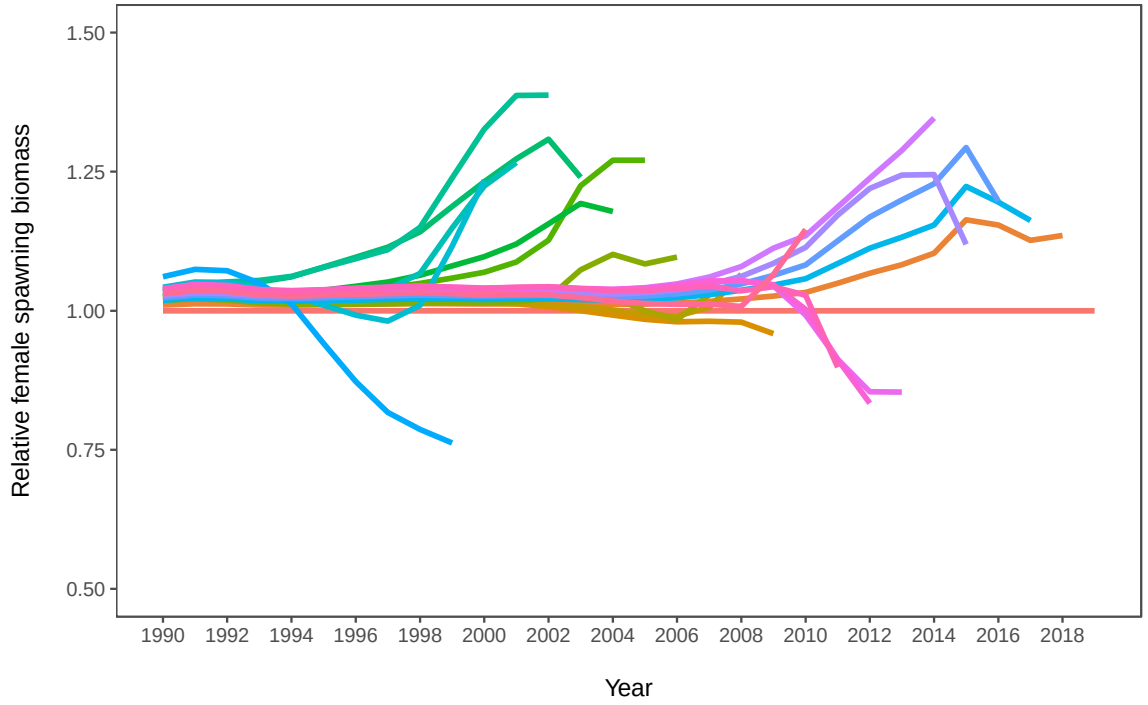


EBS pollock
Assessment
Results

Retrospectives







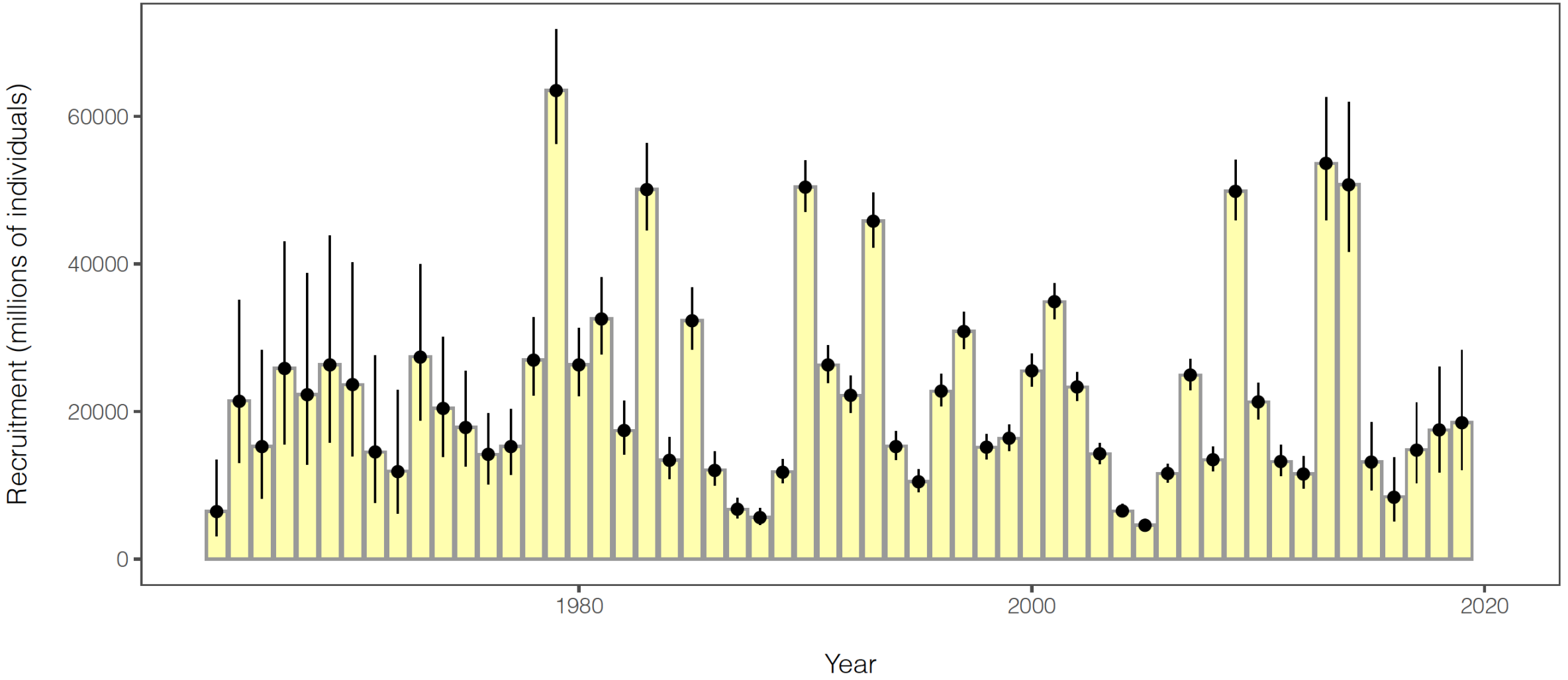
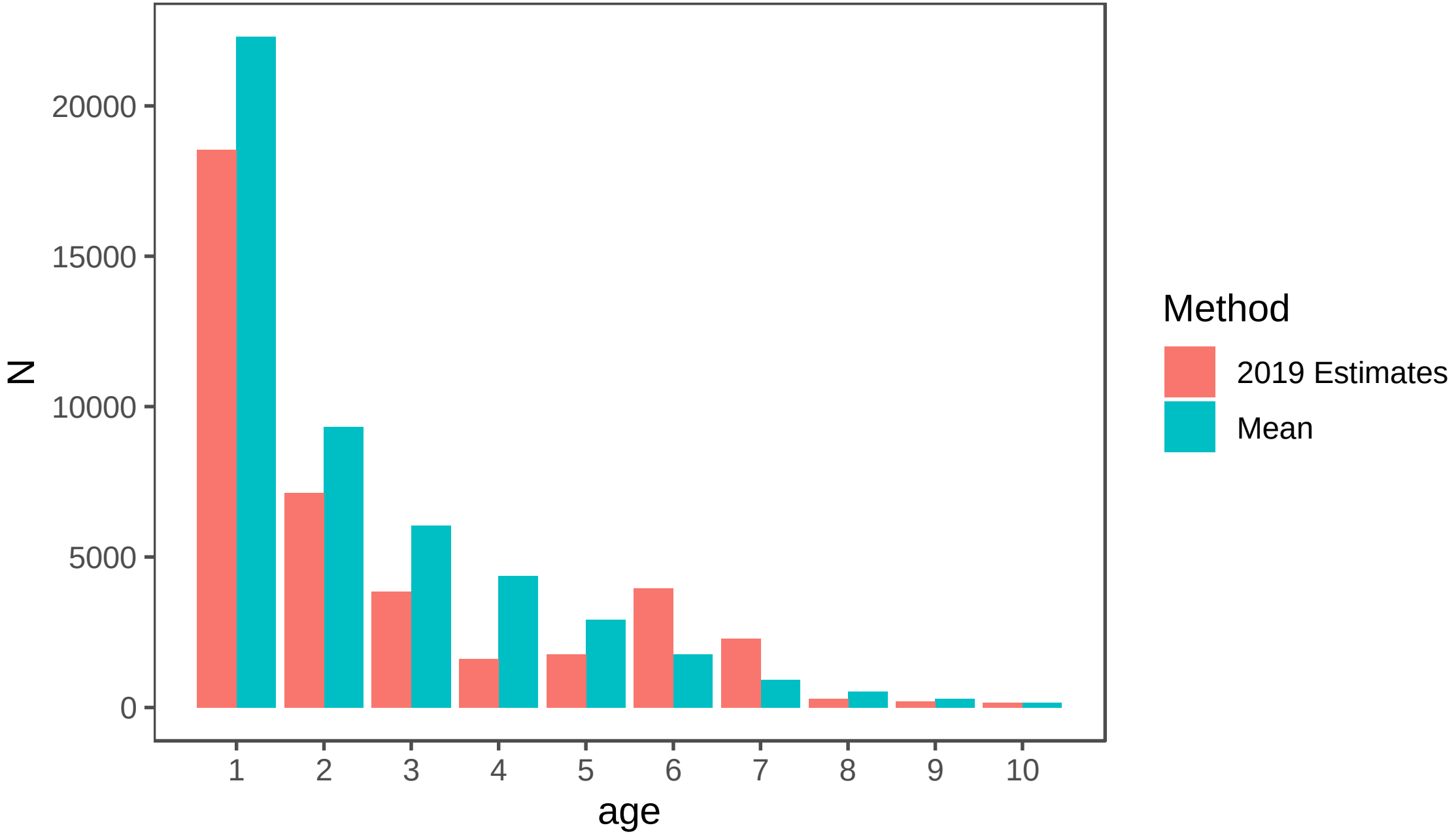
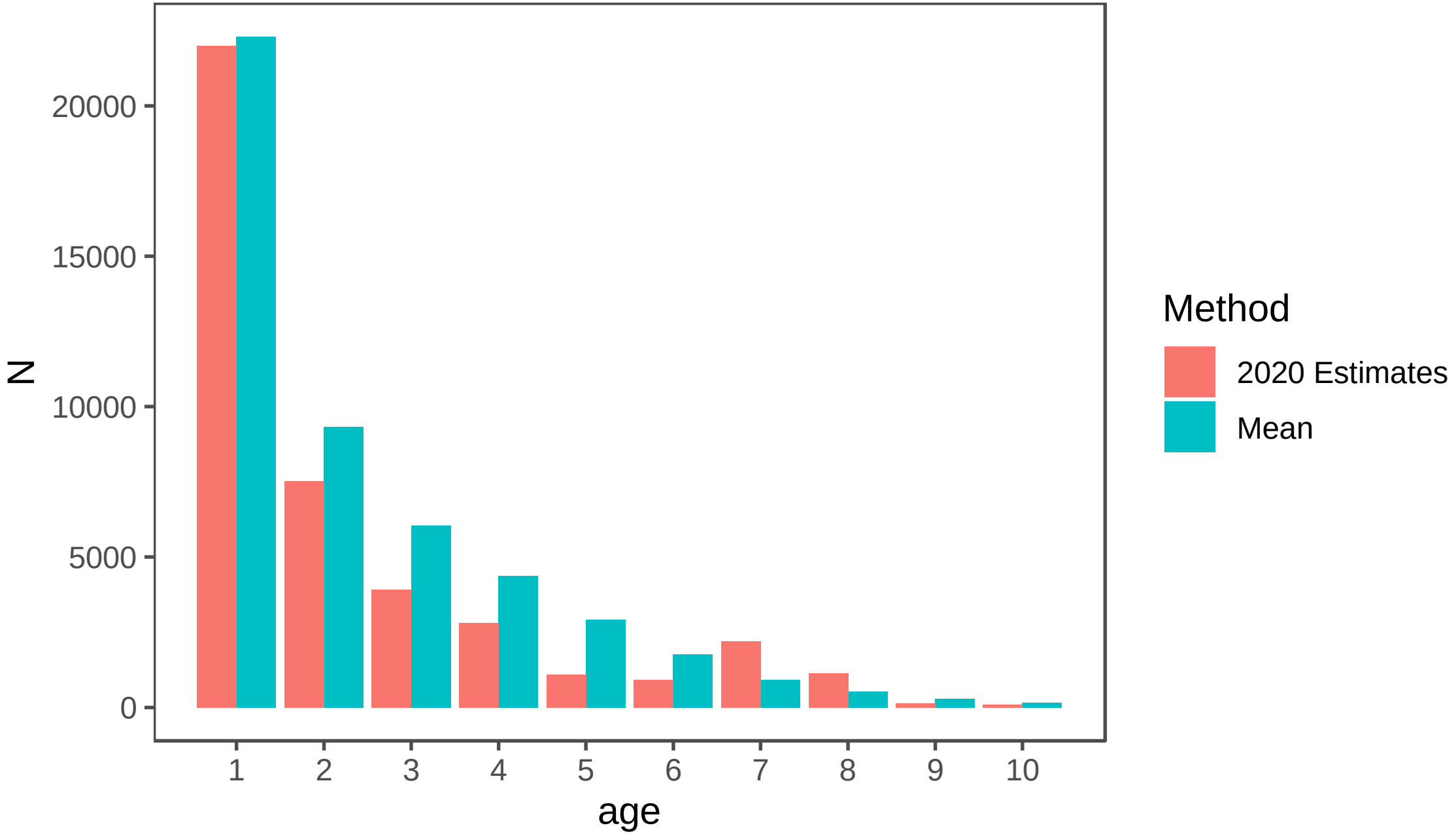
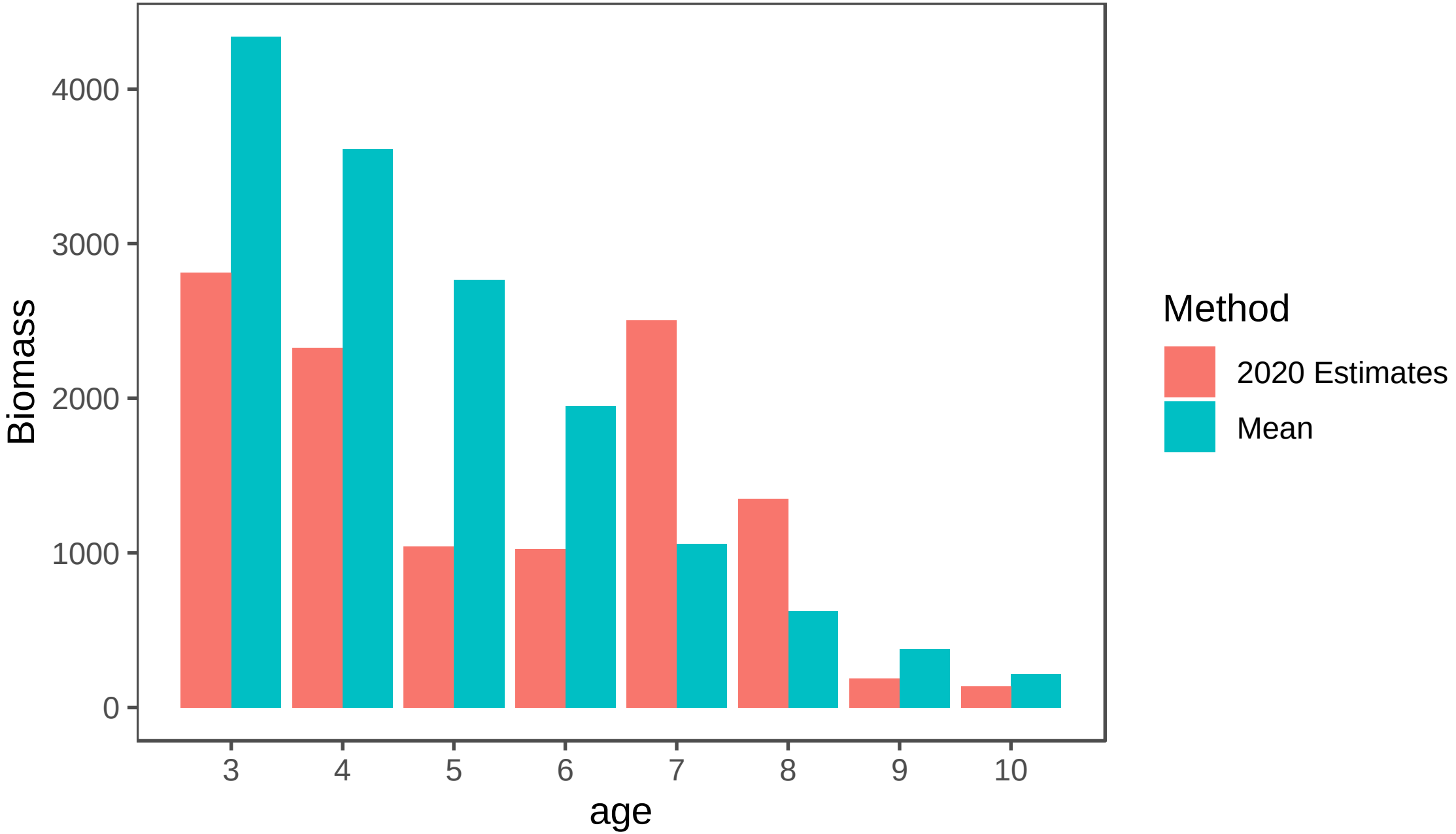
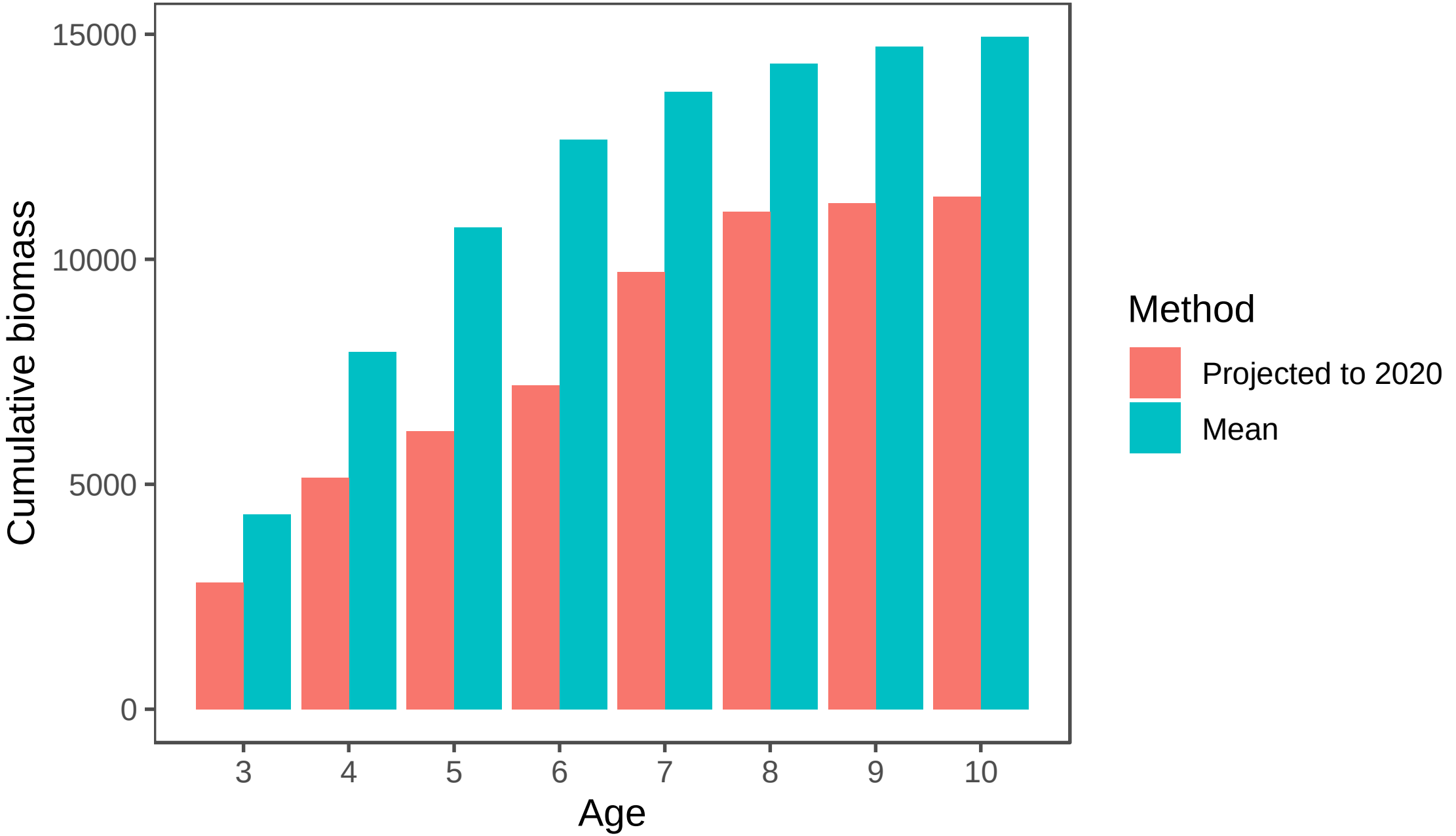


Figure 51: Recruitment estimates (age-1 recruits) for EBS pollock for all years since 1964 (1963–2017 year classes) for Model 16.1. Error bars reflect 90% credible intervals based on model estimates of uncertainty.


20000
15000
10000
5000
0
N
1
2
3
4
5
6
7
8
9
10
age
Method
2019 Estimates
Mean

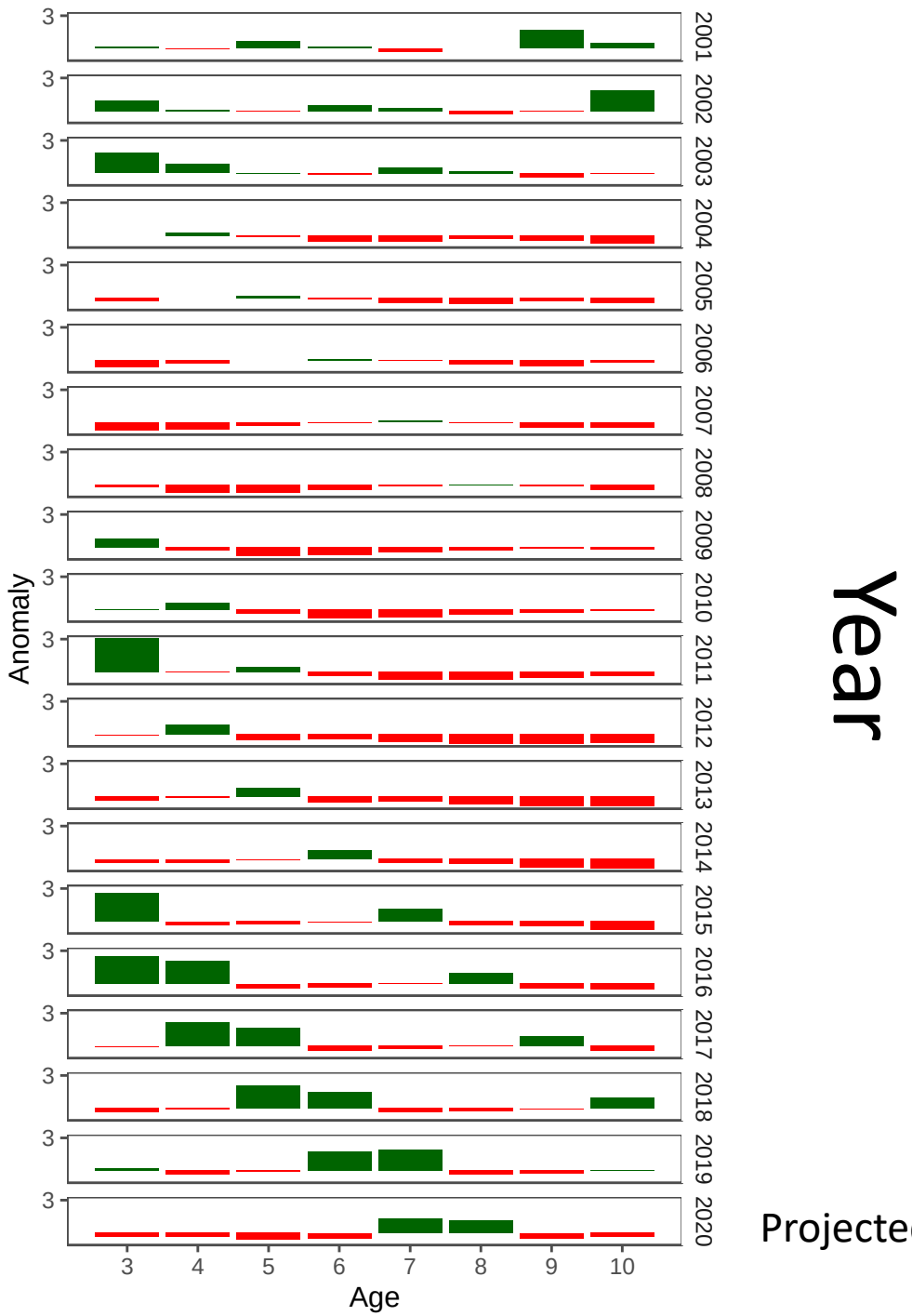

20000
15000
10000
5000
0
N
1
2
3
4
5
6
7
8
9
10
age
Method
2020 Estimates
Mean


Biomass
4000
3000
2000
1000
0
3
4
5
6
7
8
9
10
age
Method
2020 Estimates
Mean

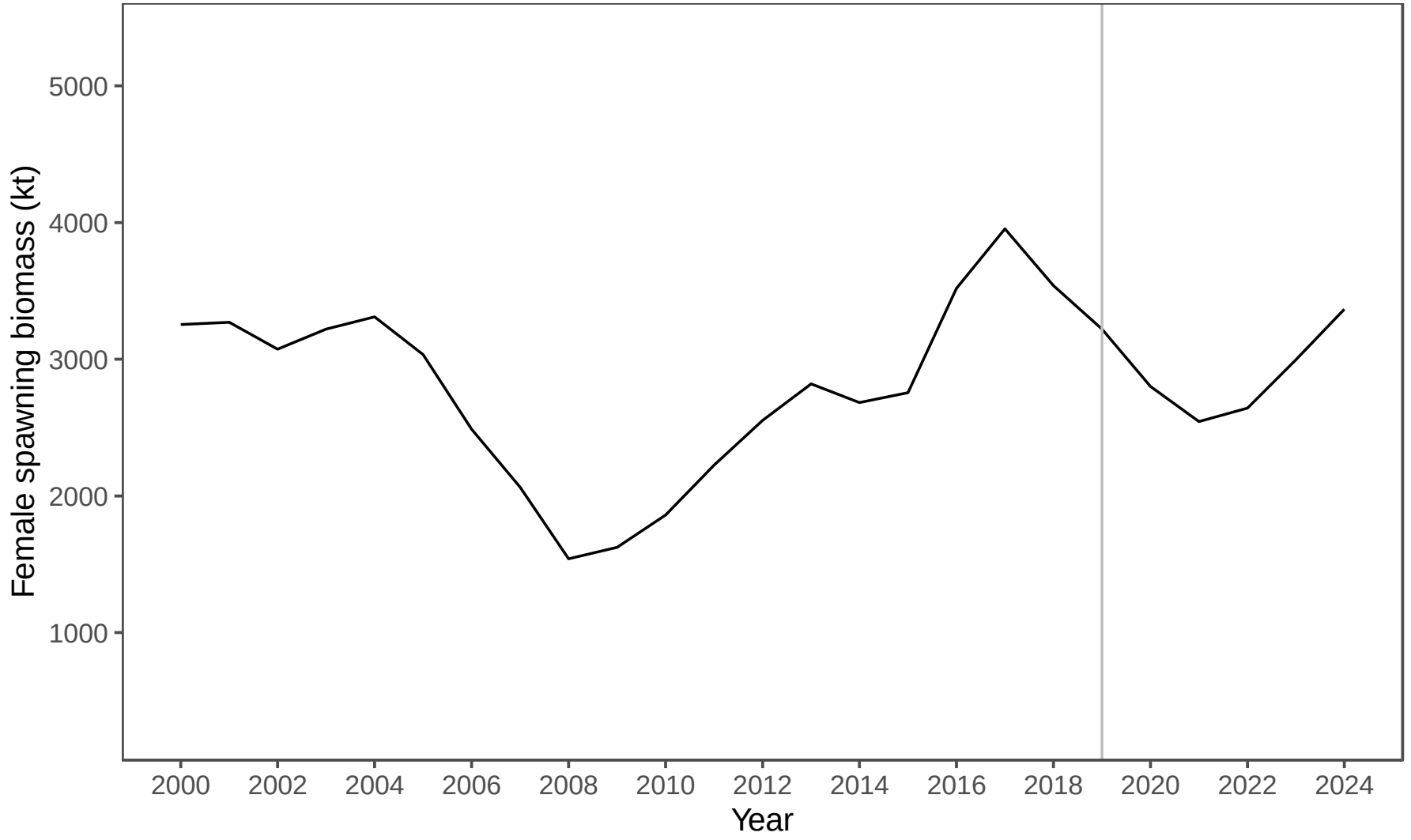

15000
10000
5000
0
Cumulative biomass
3
4
5
6
7
8
9
10
Age
Method
Projected to 2020
Mean

Age structured anomalies

- Biomass at age relative to mean



Spawning biomass projection



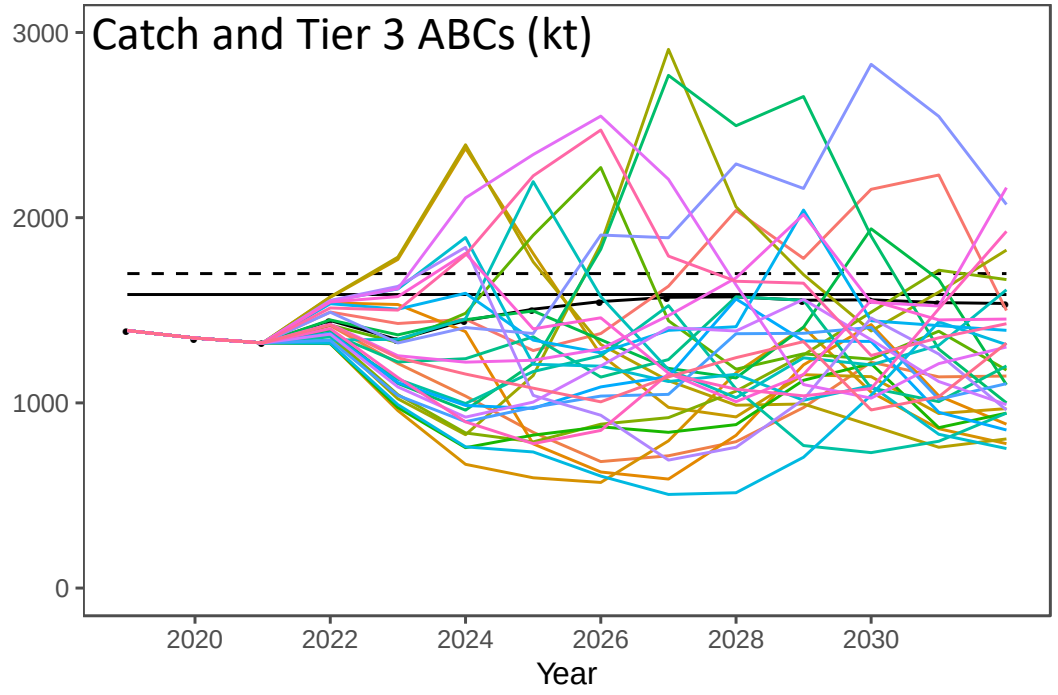
EBS pollock
Assessment
Results

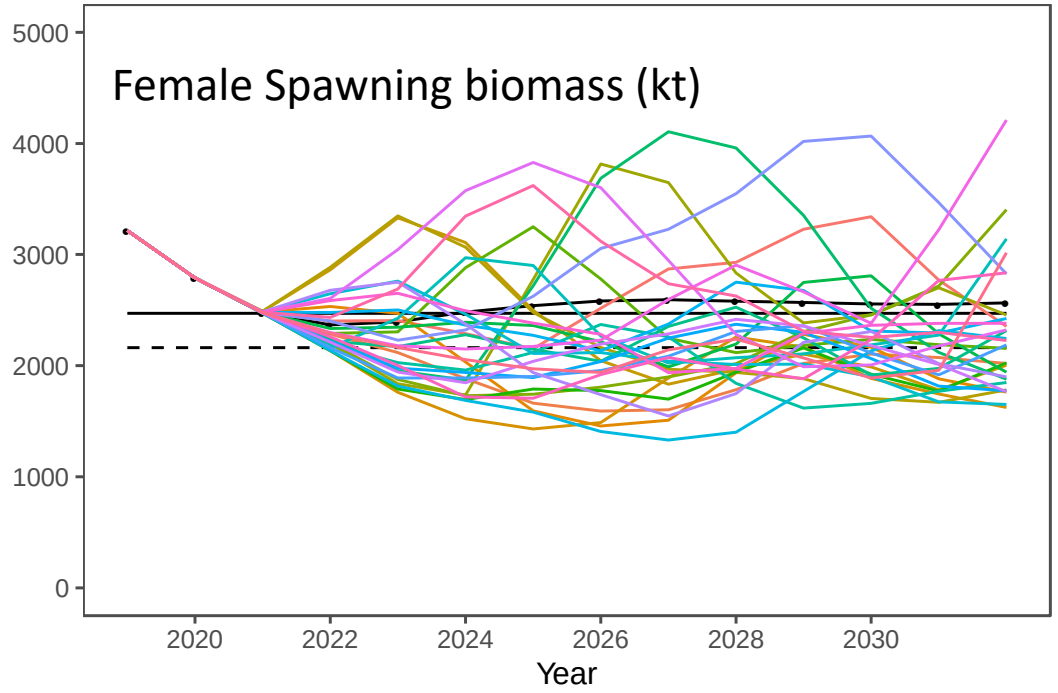
Projections

Cautions:

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

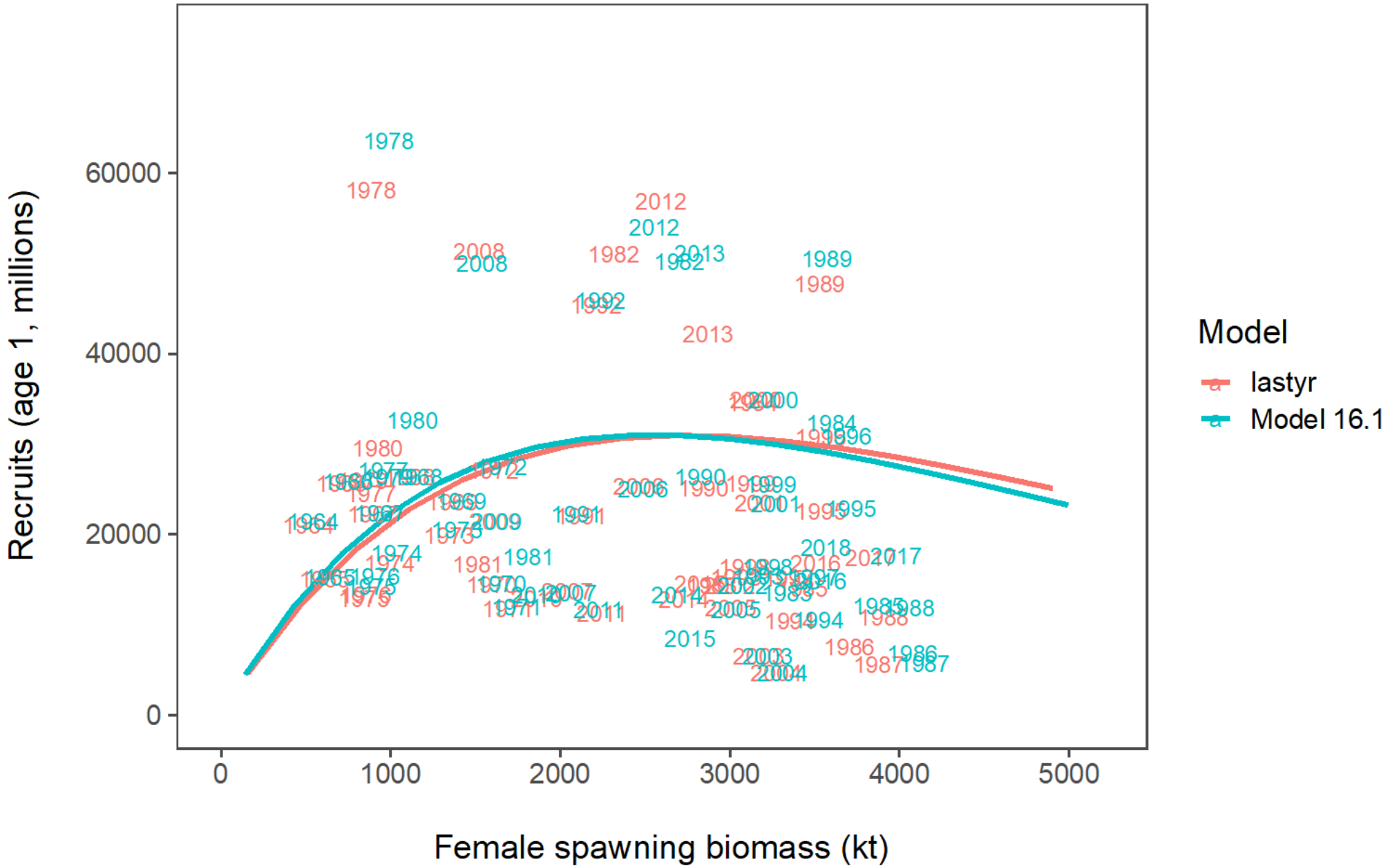
Tables provided for VAST as well

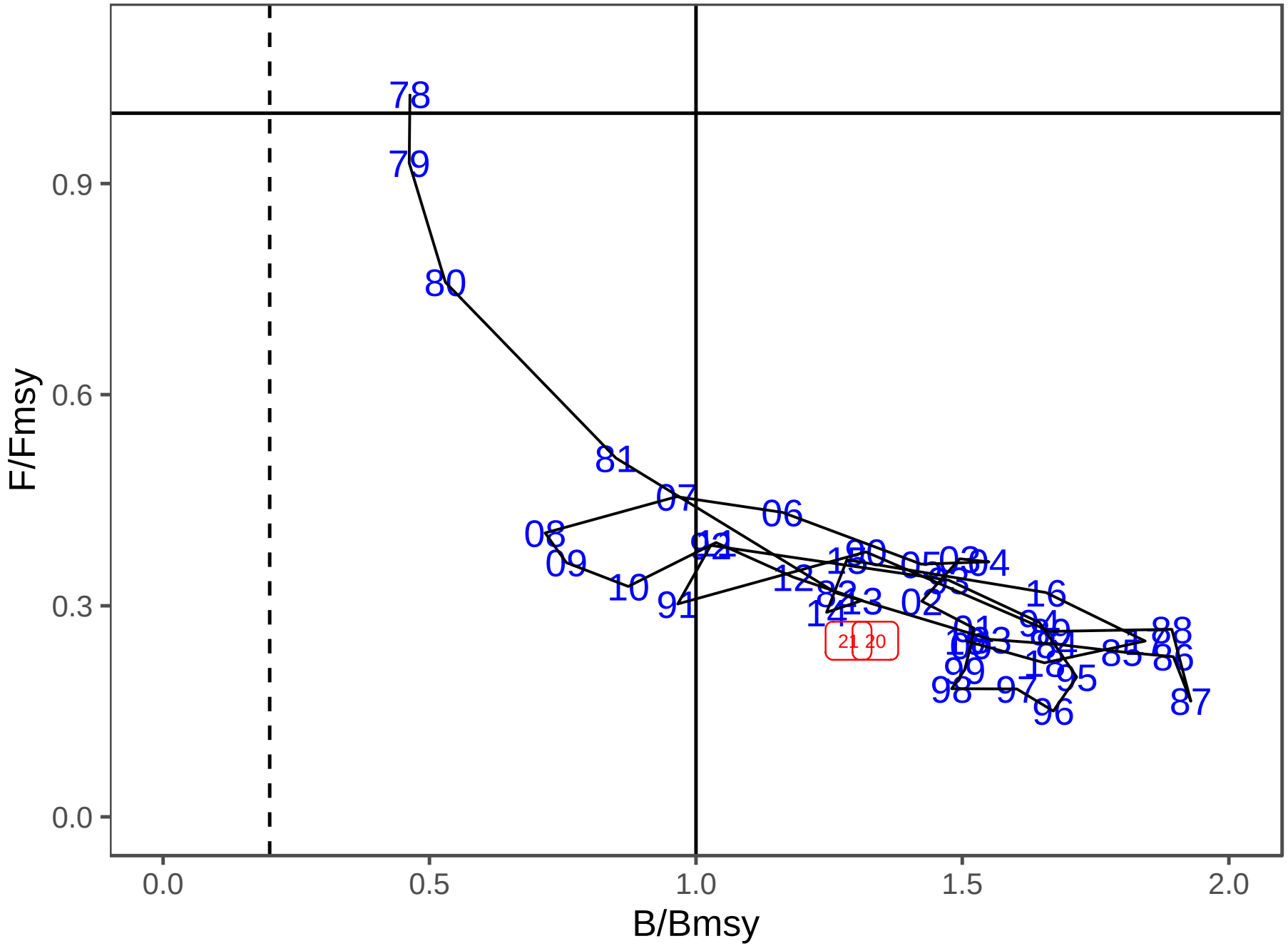




EBS pollock
Assessment
Results

2019 Stock recruitment




F/Fmsy
B/Bmsy
0.0
0.3
0.6
0.9
0.0
0.5
1.0
1.5
2.0
78
79
80
81
07
06
08
09
10
91
16
88
87
96
98
97
21
20

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.

Decision table diagnostics included

Table 49: Outcomes of decision (expressed as chances out of 100) given different 2020 catches (first row, in kt). Note that for the 2018 and later year-classes average values were assumed. Constant Fs based on the 2020 catches were used for subsequent years.

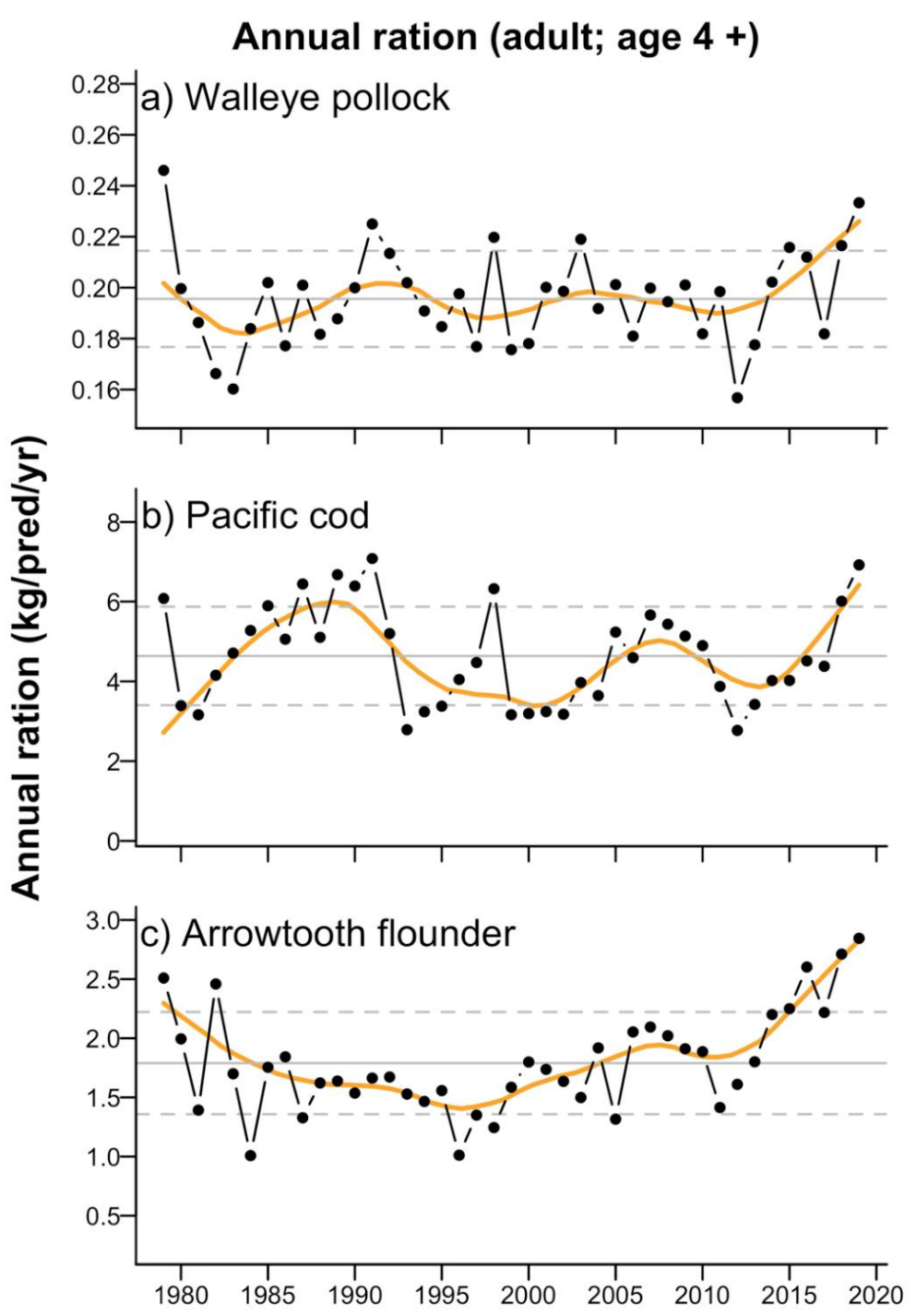
	10	500	1000	1250	1387	1500	1750	2000
$P\left[F_{2020} > F_{MSY}\right]$	0	0	0	0	0	1	4	12
$P\left[B_{2021} < B_{MSY}\right]$	10	16	23	28	31	34	40	48
$P\left[B_{2022} < B_{MSY}\right]$	6	10	19	25	28	31	39	48
$P\left[B_{2021} < \bar{B}\right]$	15	44	77	88	92	94	98	99
$P\left[B_{2024} < \bar{B}\right]$	3	11	24	31	36	39	47	55
$P\left[B_{2024} < B_{2020}\right]$	4	11	22	28	32	34	40	46
$P\left[B_{2022} < B_{20\%}\right]$	0	0	0	1	1	1	2	3
$P\left[p_{a_5,2022} > \bar{p}_{a_5}\right]$	17	44	68	75	79	81	85	88
$P\left[D_{2021} < D_{1994}\right]$	0	0	0	0	0	0	0	0
$P\left[D_{2024} < D_{1994}\right]$	0	1	5	9	12	15	24	35
$P\left[E_{2020} > E_{2019}\right]$	0	0	13	95	100	100	100	100

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2019	2020	2020	2021
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)	9,110,000 t	8,156,000 t	8,580,000 t	7,987,000 t
Projected female spawning biomass (t)	3,107,000 t	2,725,000 t	2,781,000 t	2,476,000 t
B_0	5,866,000 t	5,866,000 t	5,748,000 t	5,748,000 t
B_{msy}	2,280,000 t	2,280,000 t	2,147,000 t	2,147,000 t
F_{OFL}	0.645	0.645	0.528	0.528
$maxF_{ABC}$	0.510	0.51	0.442	0.442
F_{ABC}	0.356	0.375		
OFL	3,913,000 t	3,082,000 t	4,273,000 t	3,456,000 t
$maxABC$	3,096,000 t	2,437,000 t	3,578,000 t	2,894,000 t
ABC	2,163,000 t	1,792,000 t	2,045,000 t	1,716,000 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2019	2020	2020	2021
M (natural mortality rate, ages 3+)	0.3	0.3	0.3	0.3
Tier	1a	1a	3a	3a
Projected total (age 3+) biomass (t)	9,110,000 t	8,156,000 t	8,580,000 t	7,987,000 t
Projected female spawning biomass (t)	3,107,000 t	2,725,000 t	2,781,000 t	2,476,000 t
$B_0 or B_{100}$	5,866,000 t	5,866,000 t	6,165,000 t	6,165,000 t
B_{msy}	2,280,000 t	2,280,000 t	2,158,000 t	2,158,000 t
F_{OFL}	0.645	0.645	0.314	0.321
$maxF_{ABC}$	0.510	0.51	0.253	0.262
F_{ABC}	0.356	0.375	0.253	0.262
OFL	3,913,000 t	3,082,000 t	4,273,000 t	3,456,000 t
$maxABC$	3,096,000 t	2,437,000 t	2,045,000 t	1,716,000 t
ABC	2,163,000 t	1,792,000 t	2,045,000 t	1,716,000 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2019	2020	2020	2021
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)	9,110,000 t	8,156,000 t	9,128,000 t	8,494,000 t
Projected female spawning biomass (t)	3,107,000 t	2,725,000 t	2,991,000 t	2,674,000 t
B_0	5,866,000 t	5,866,000 t	5,777,000 t	5,777,000 t
B_{msy}	2,280,000 t	2,280,000 t	2,148,000 t	2,148,000 t
F_{OFL}	0.645	0.645	0.449	0.449
$maxF_{ABC}$	0.510	0.51	0.383	0.383
F_{ABC}	0.356	0.375		
OFL	3,913,000 t	3,082,000 t	4,085,000 t	3,385,000 t
$maxABC$	3,096,000 t	2,437,000 t	3,485,000 t	2,888,000 t
ABC	2,163,000 t	1,792,000 t	2,045,000 t	1,716,000 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Multi-species model



EBS pollock summary

- Outlook
  - Spawning biomass declining
    - From high levels
    - Fishing challenges likely to increase
  - Stock likely drop below mean by 2021
    - Age 1-abundance in 2019 survey seems good…