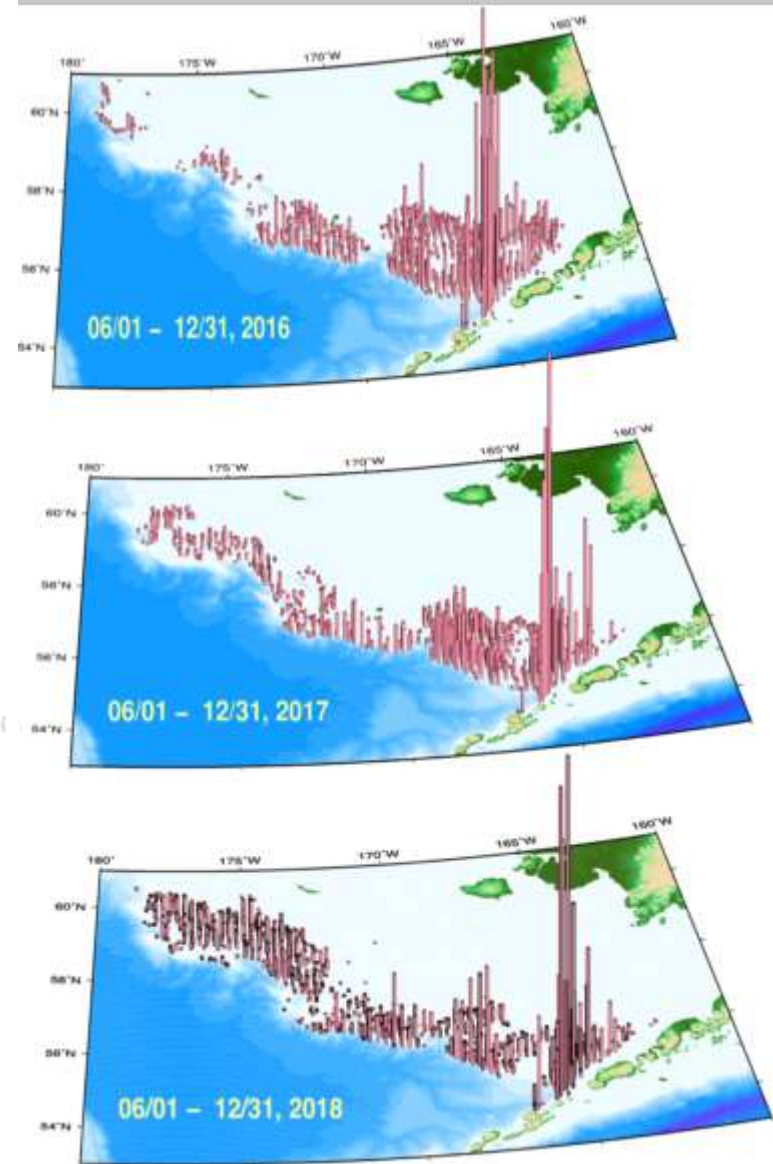
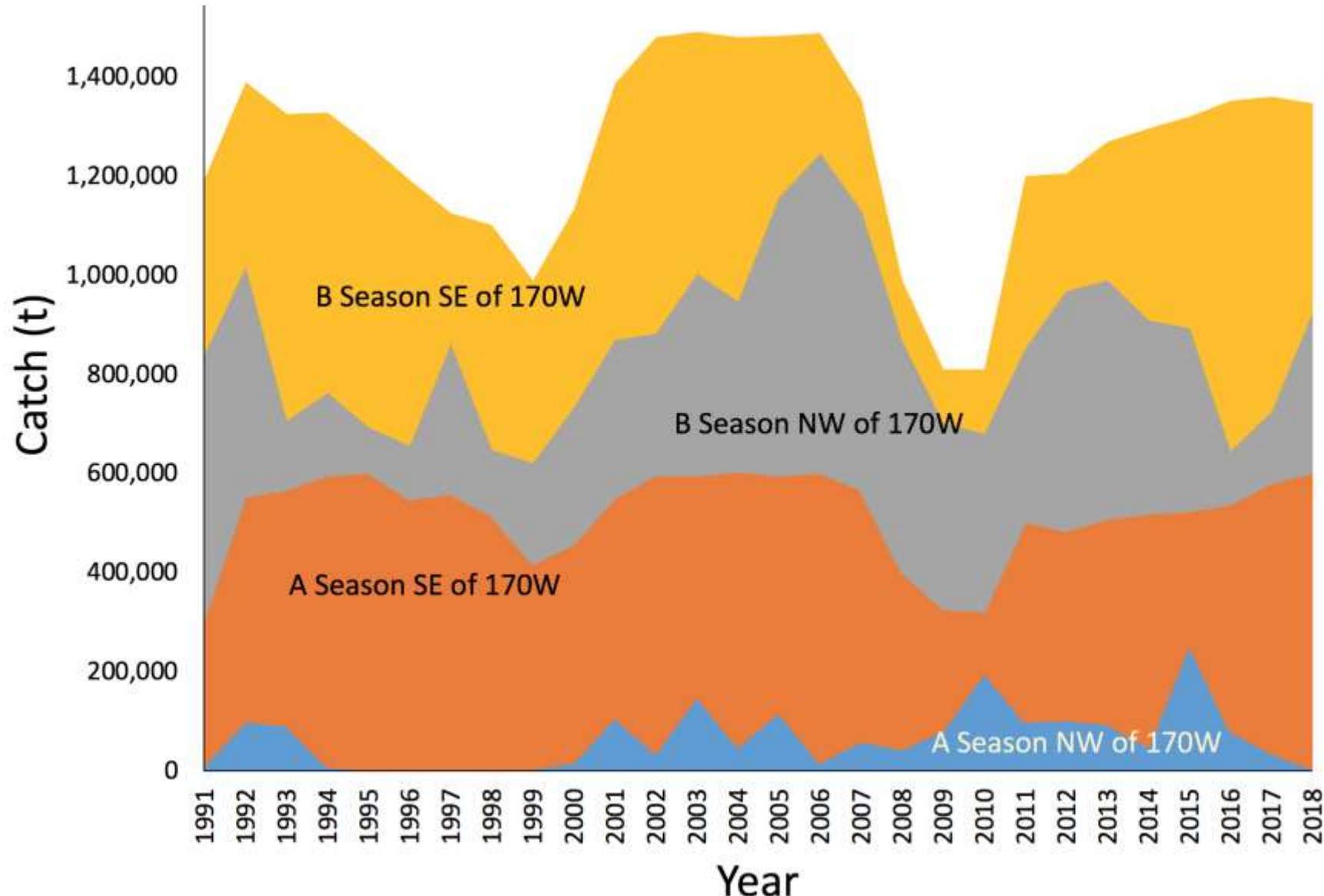
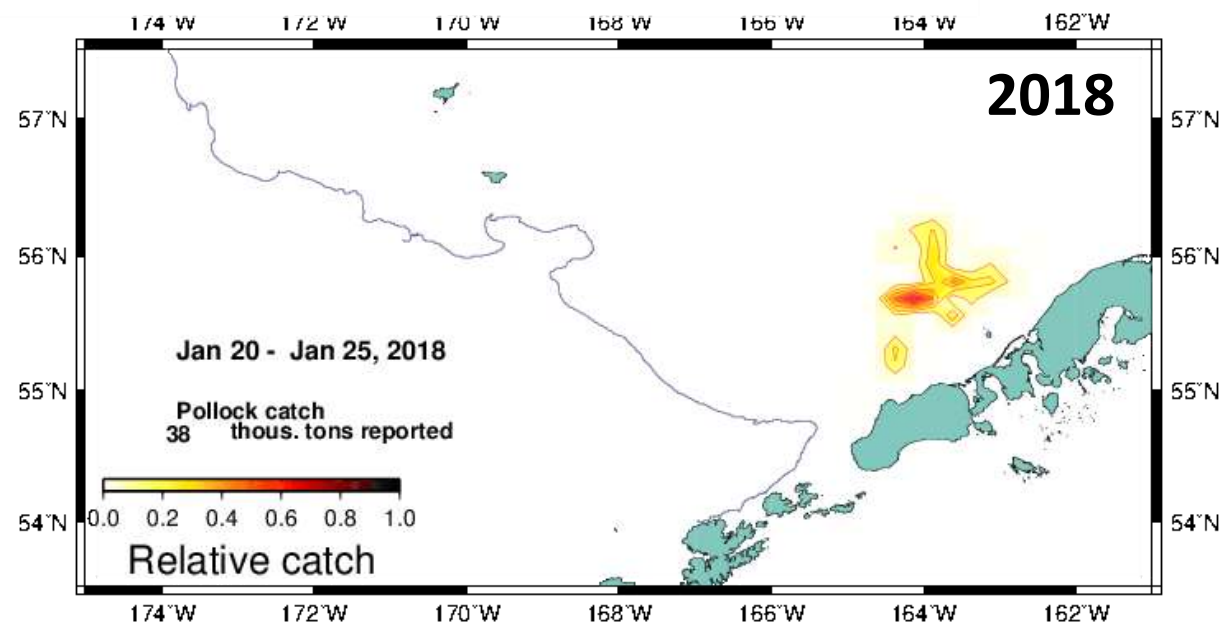
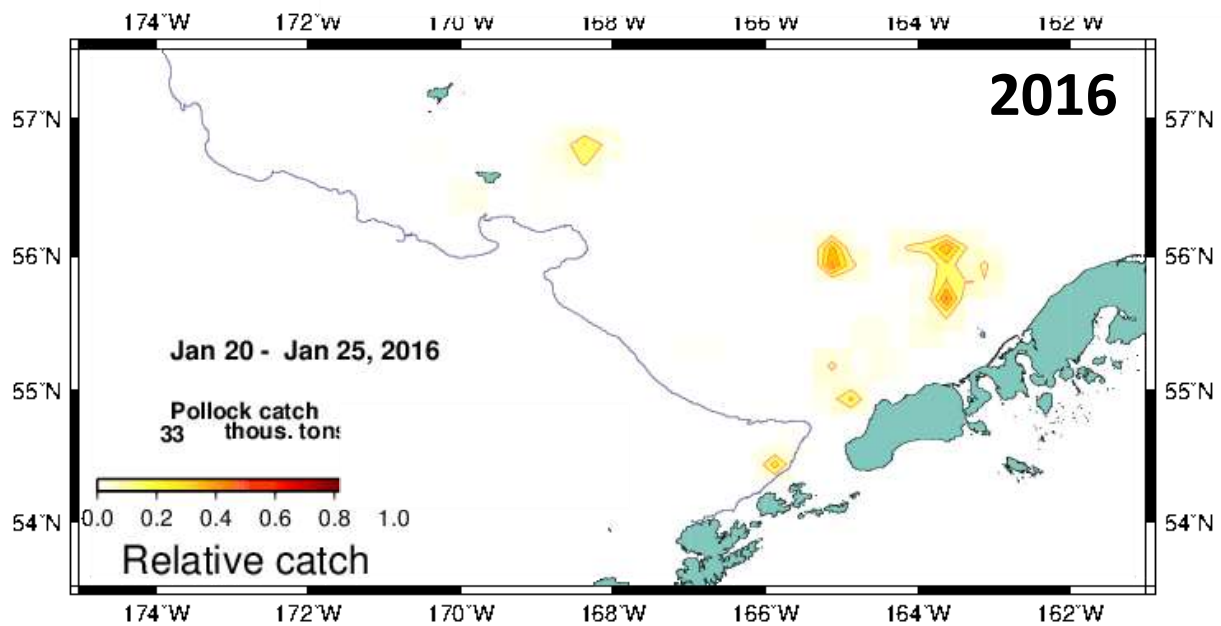
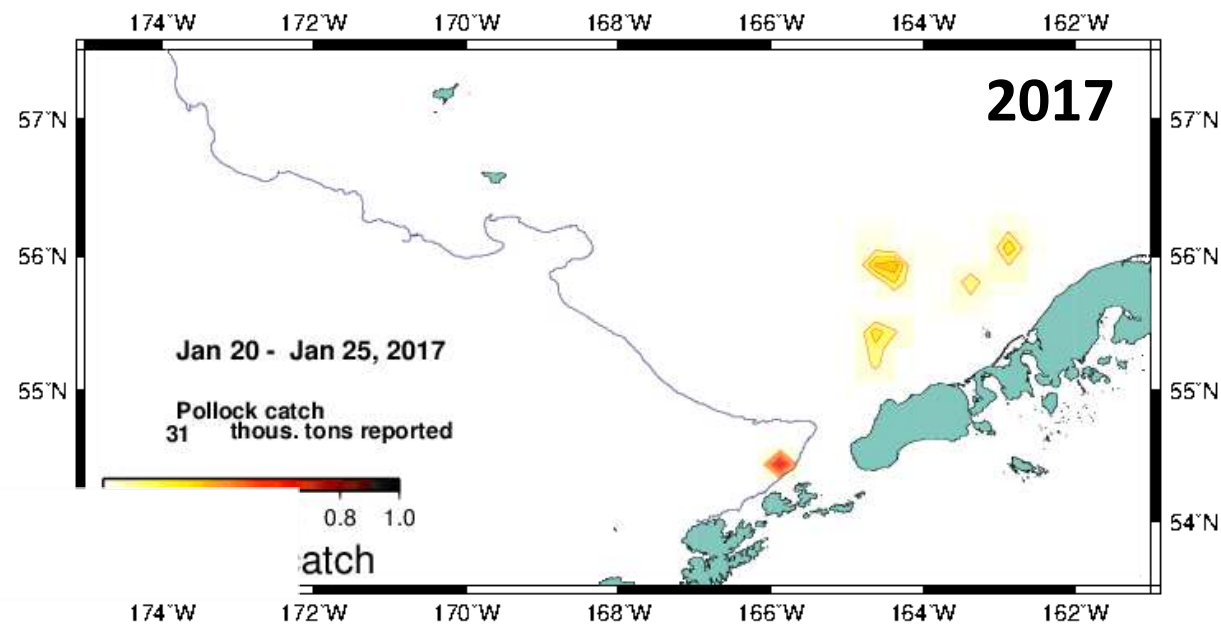
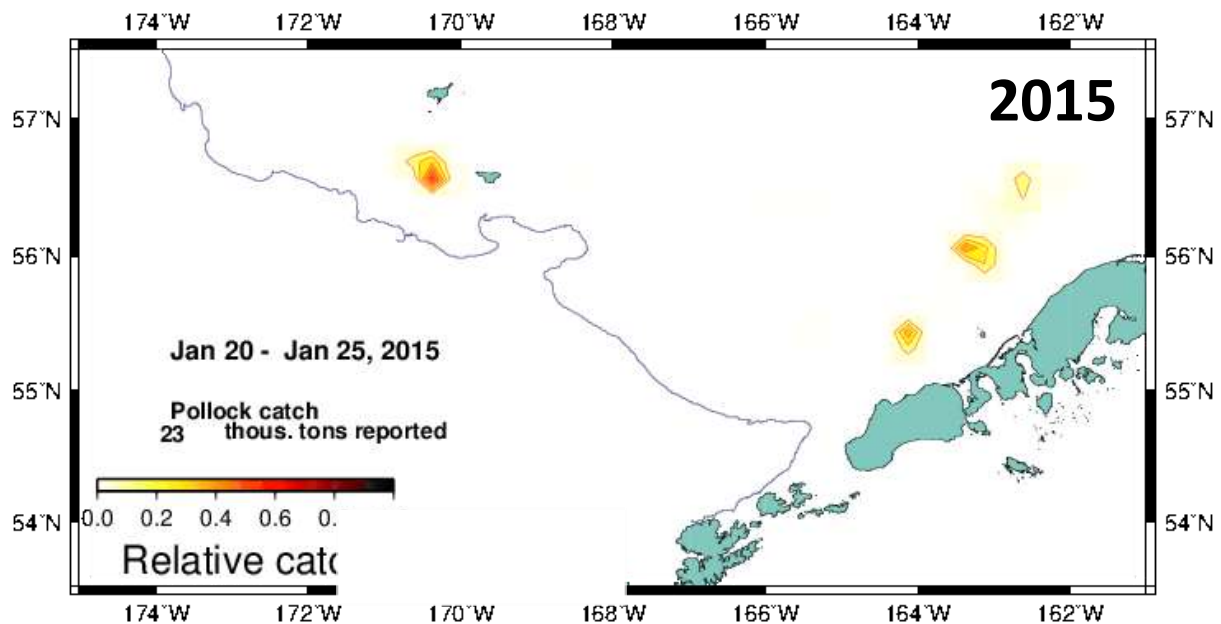


Seasonal and area catch patterns

Eastern Bering Sea pollock



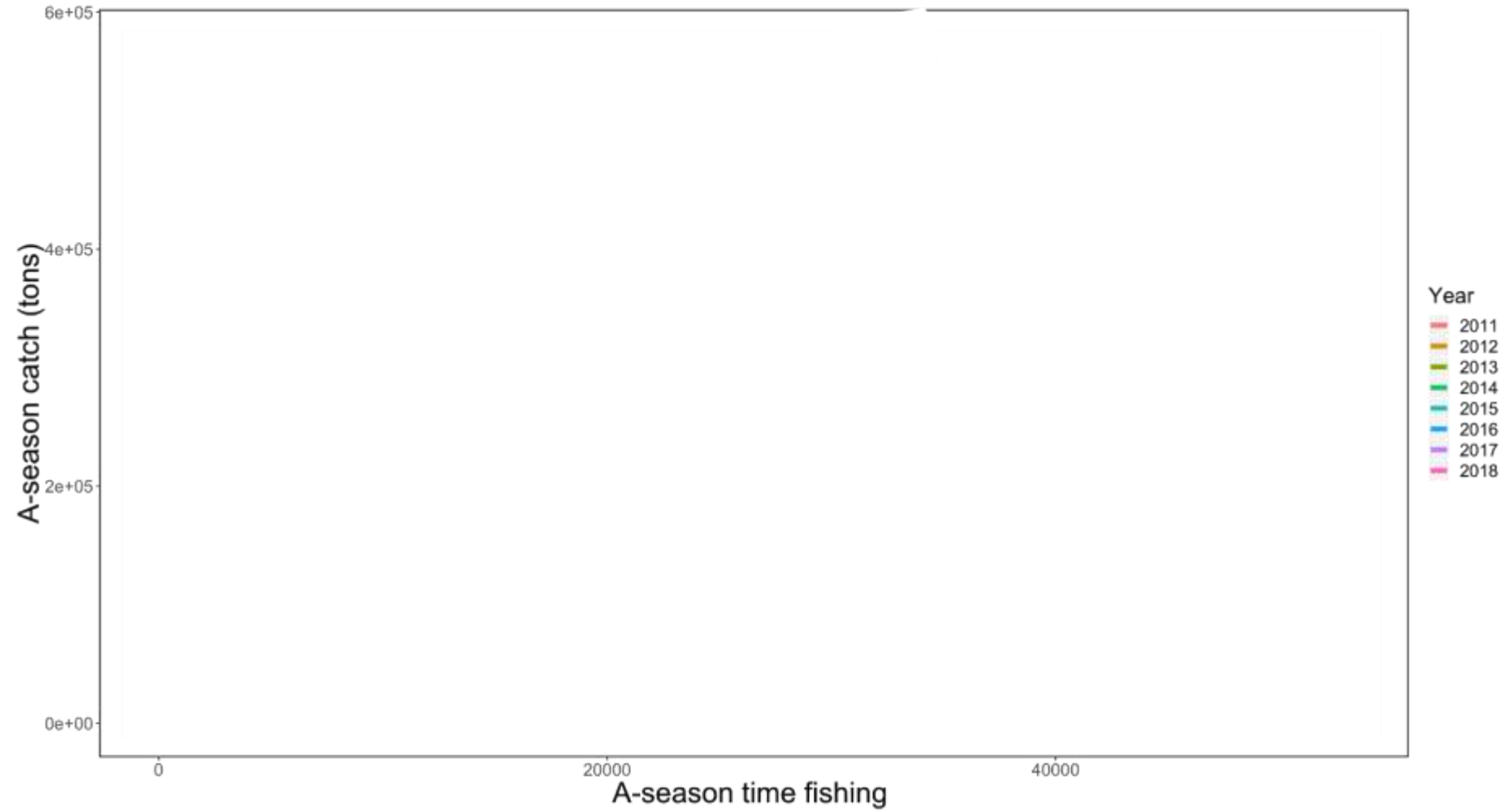
Winter season fishing patterns



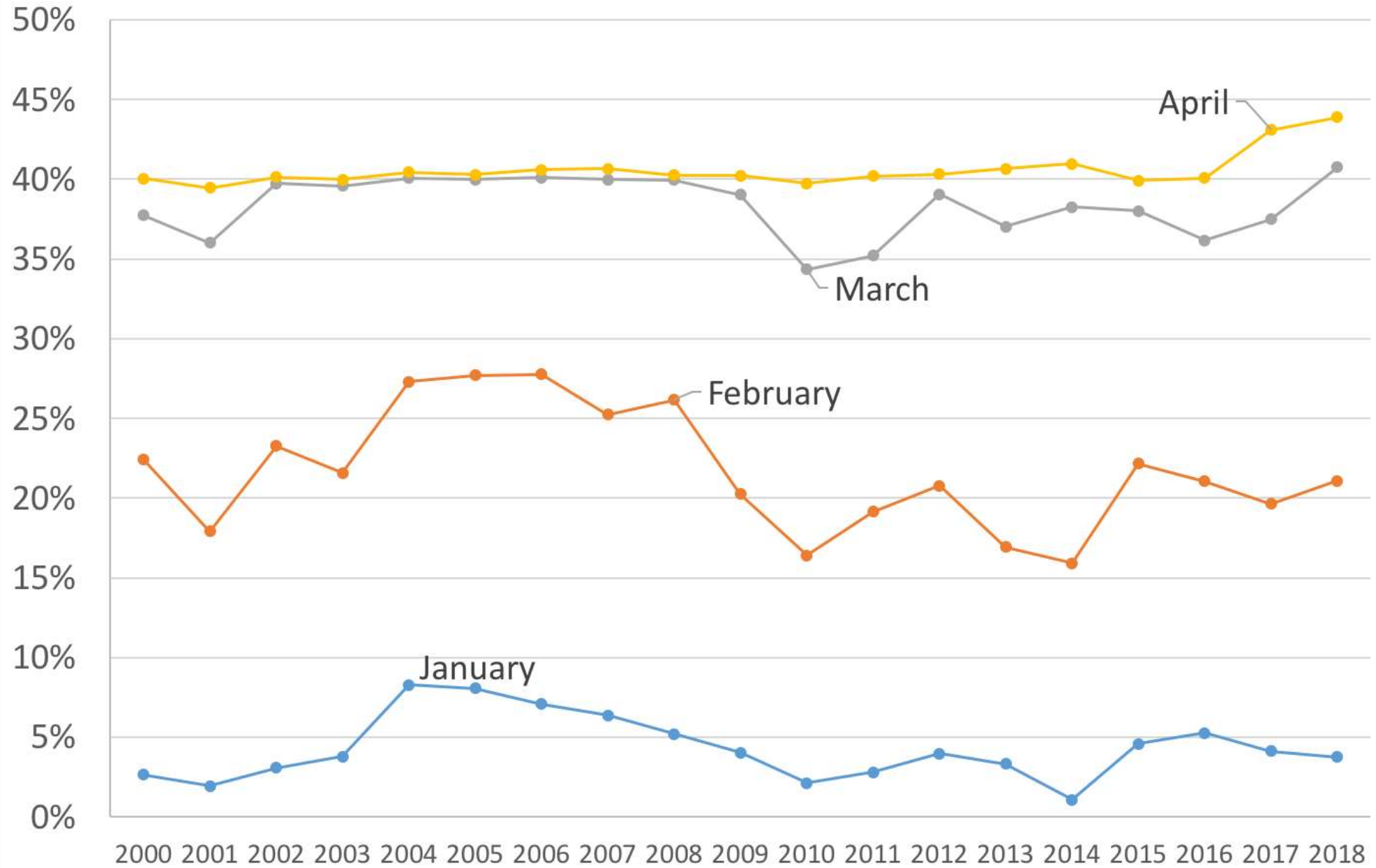
Winter fishing

Fishing conditions

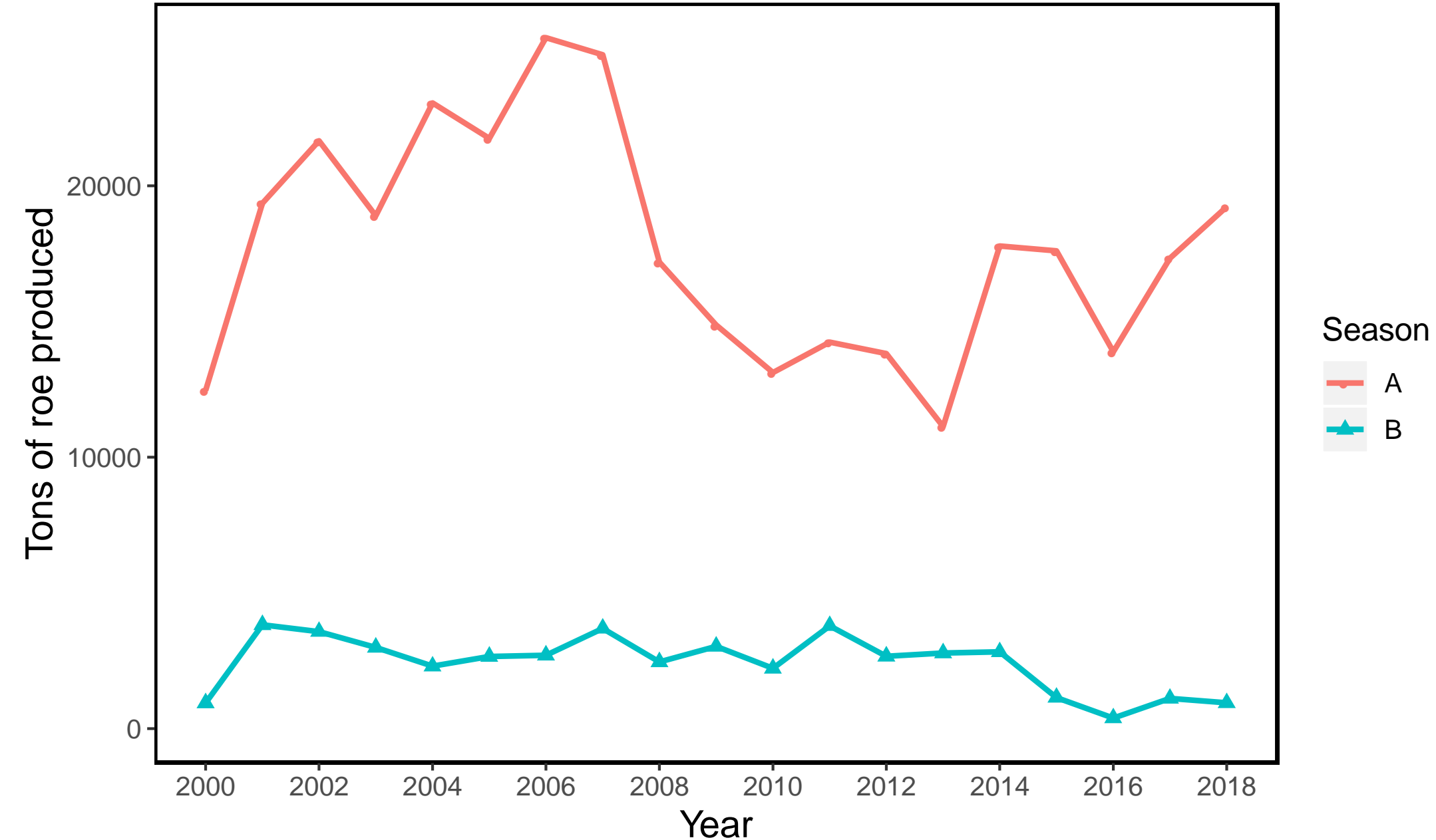
A-season



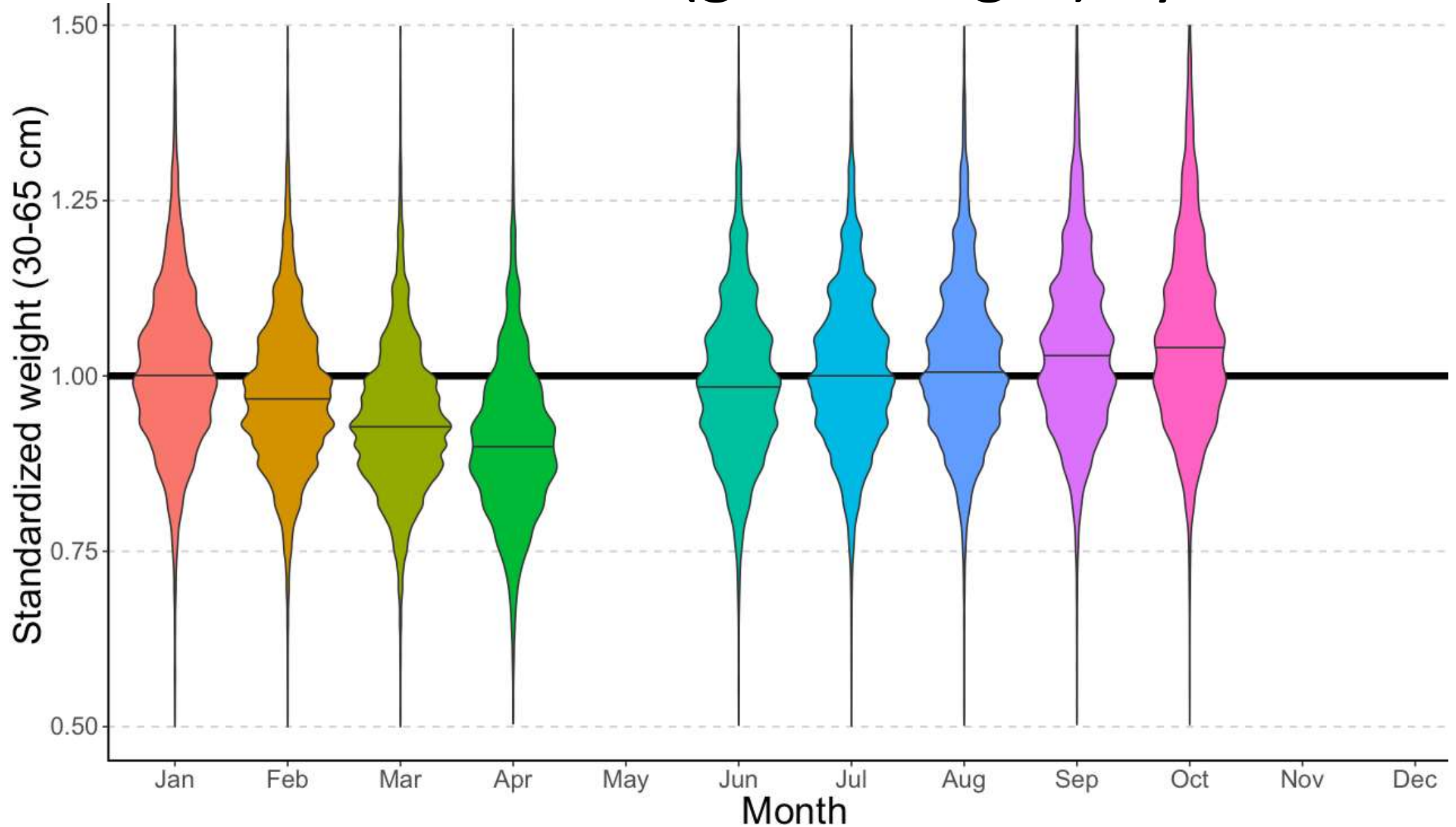
Cumulative pollock catch by month as proportion of TAC



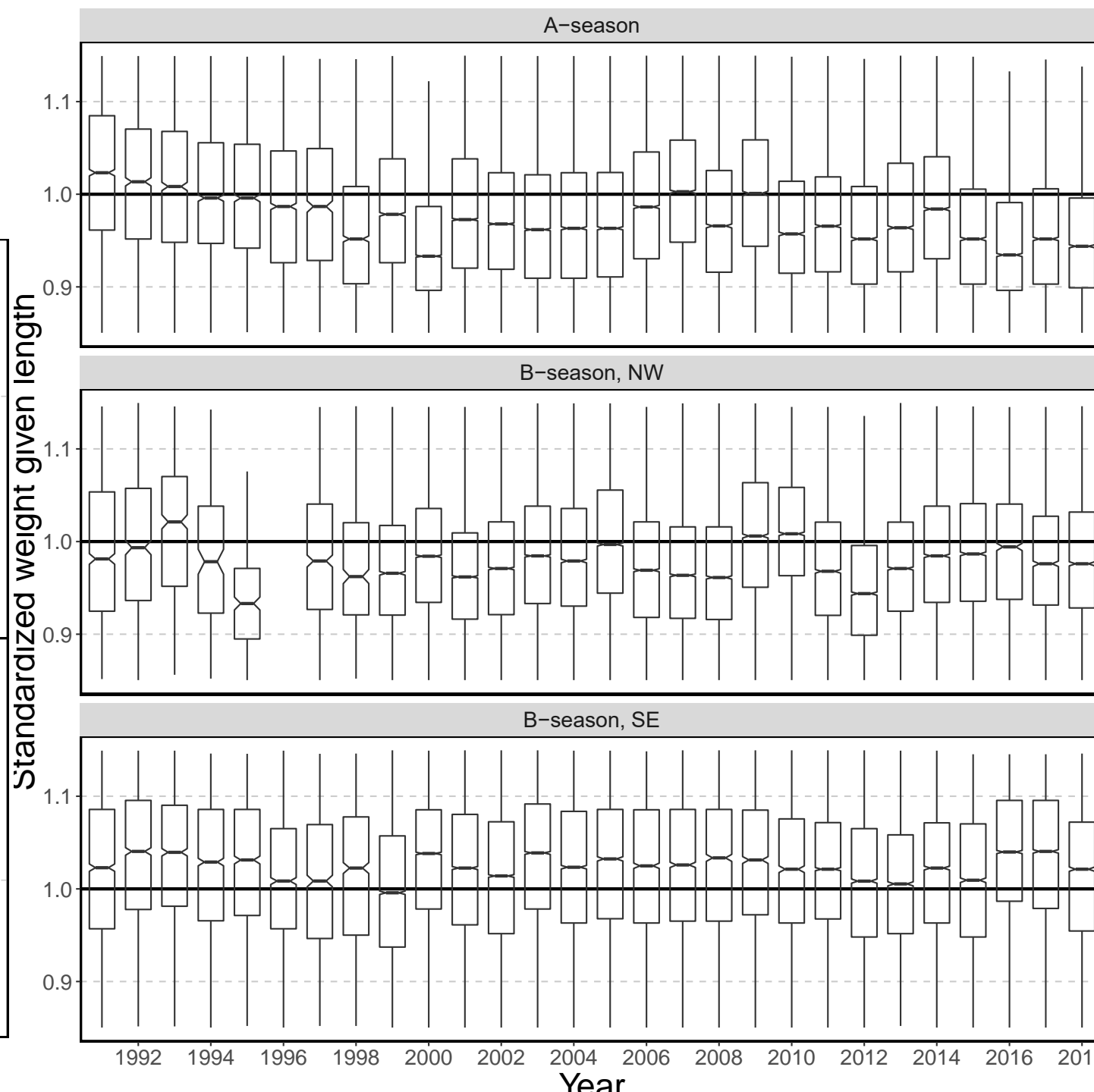
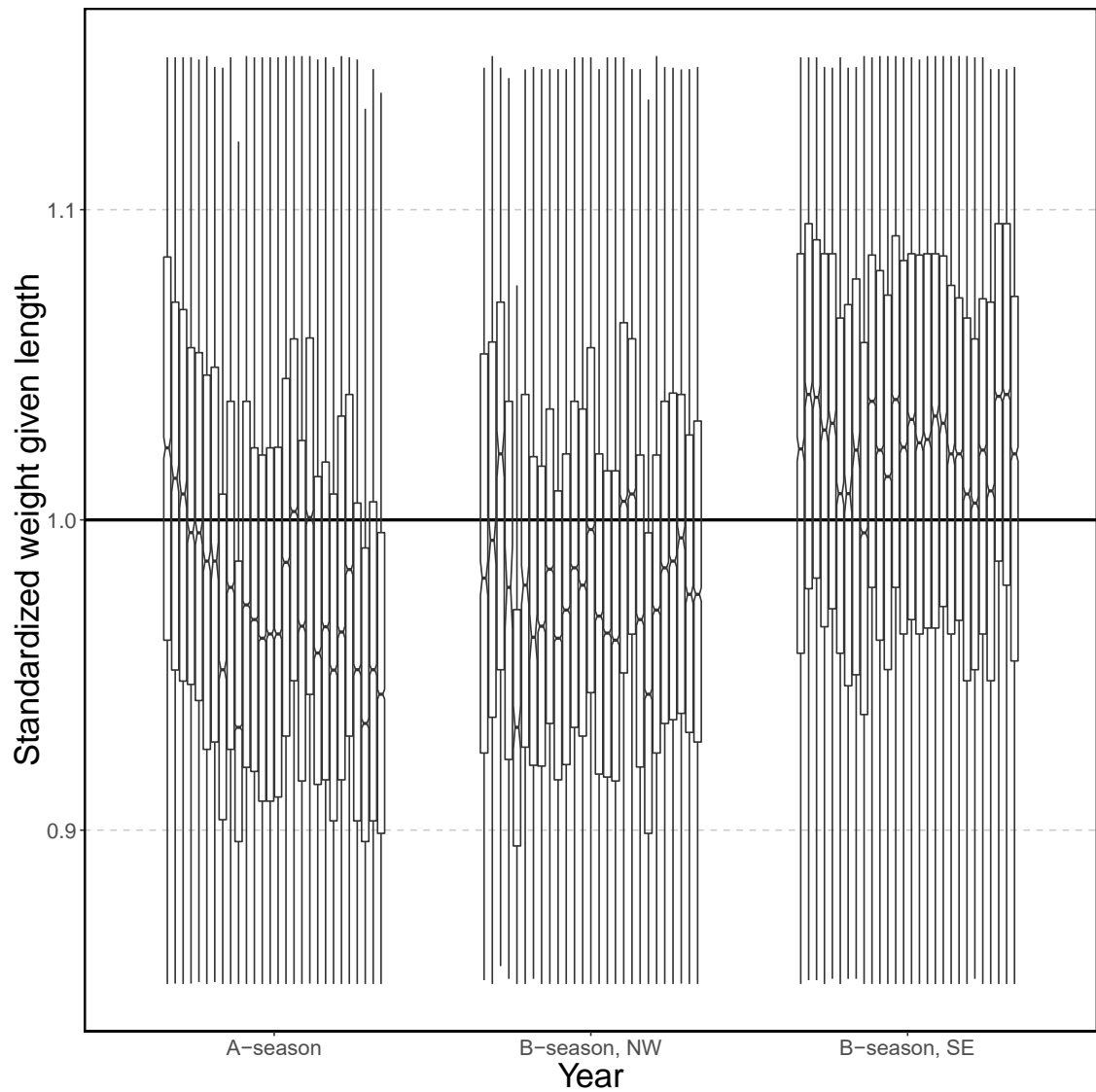
Fishing: Seasonal roe production

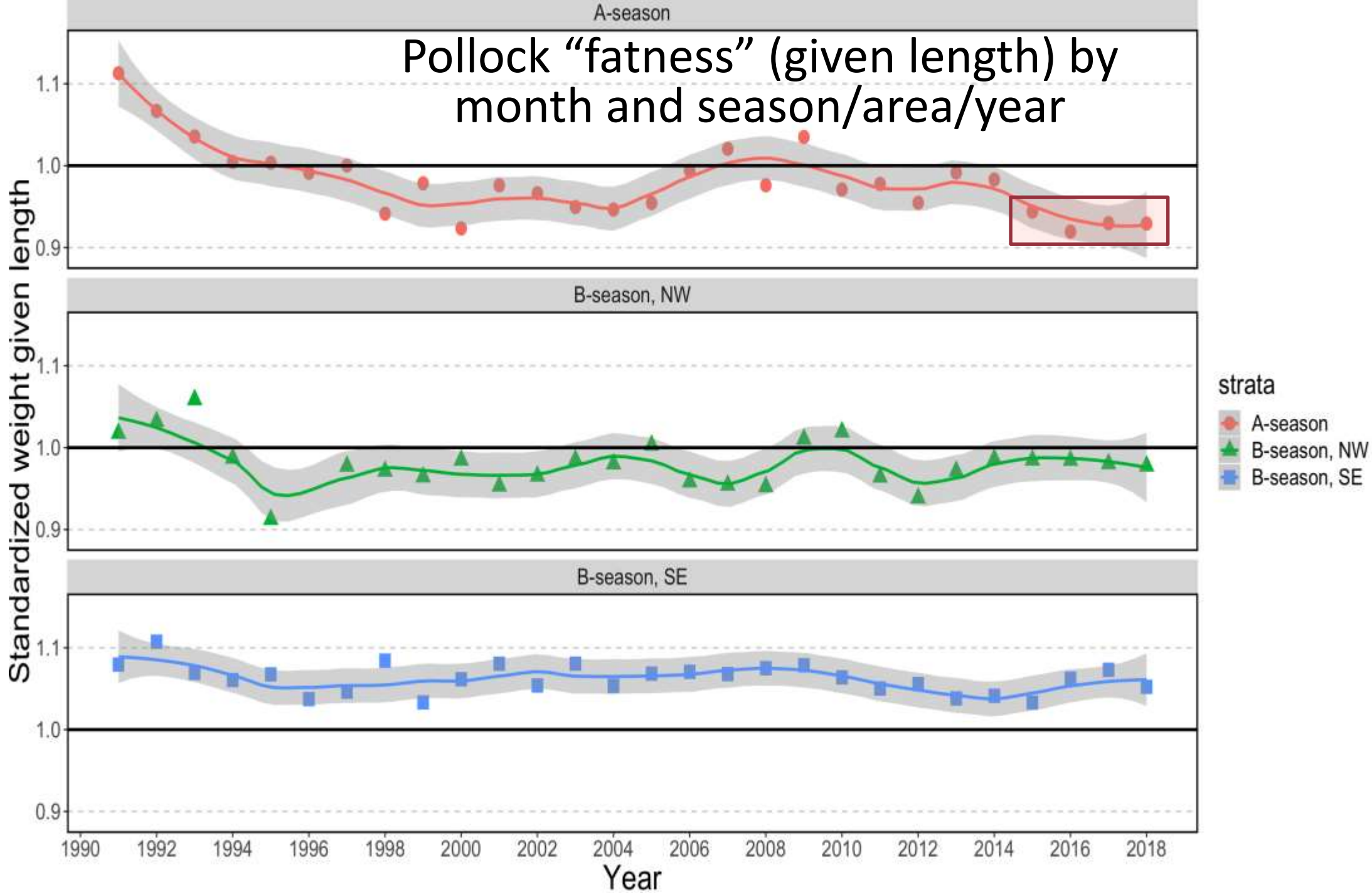


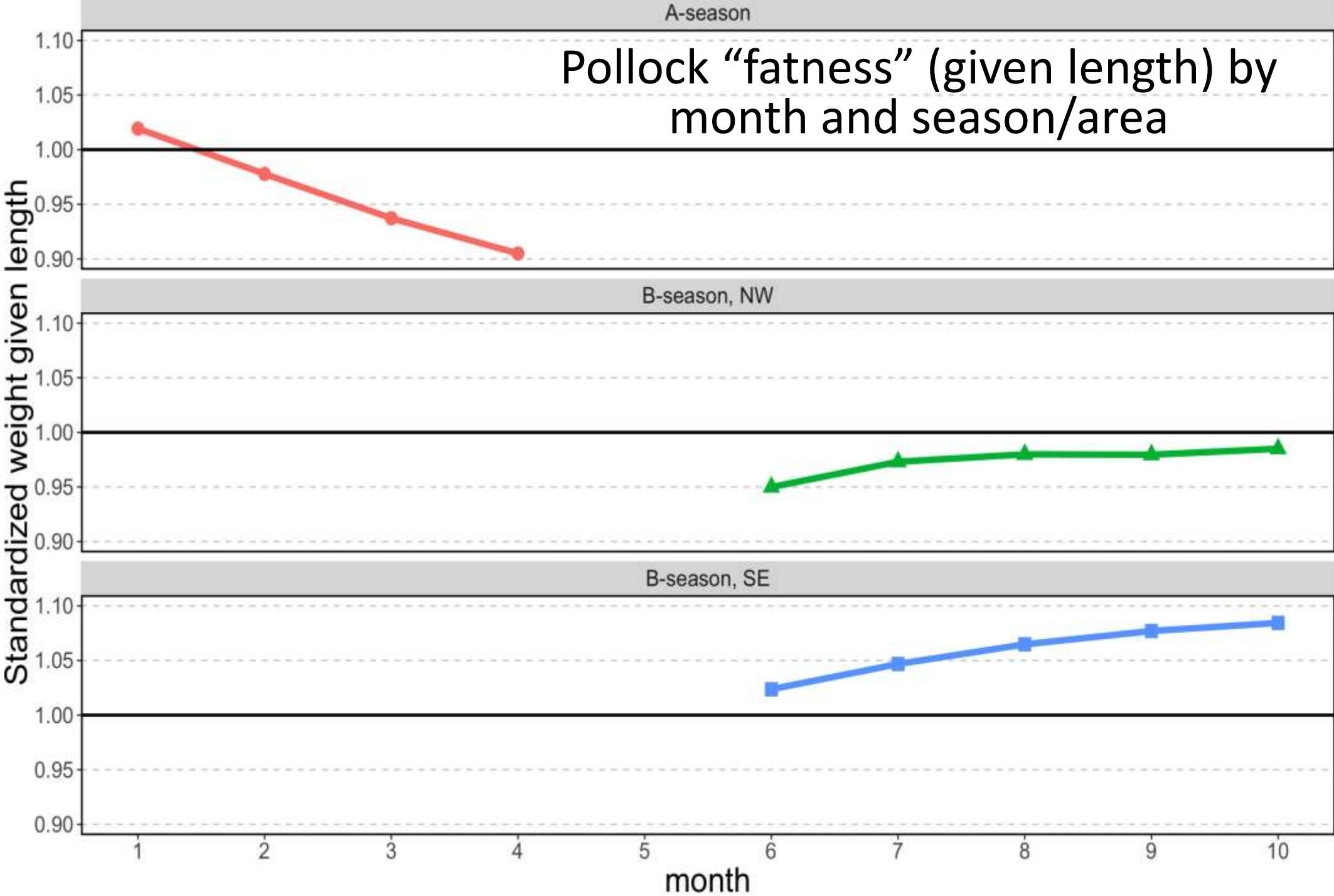
Pollock "fatness" (given length) by month



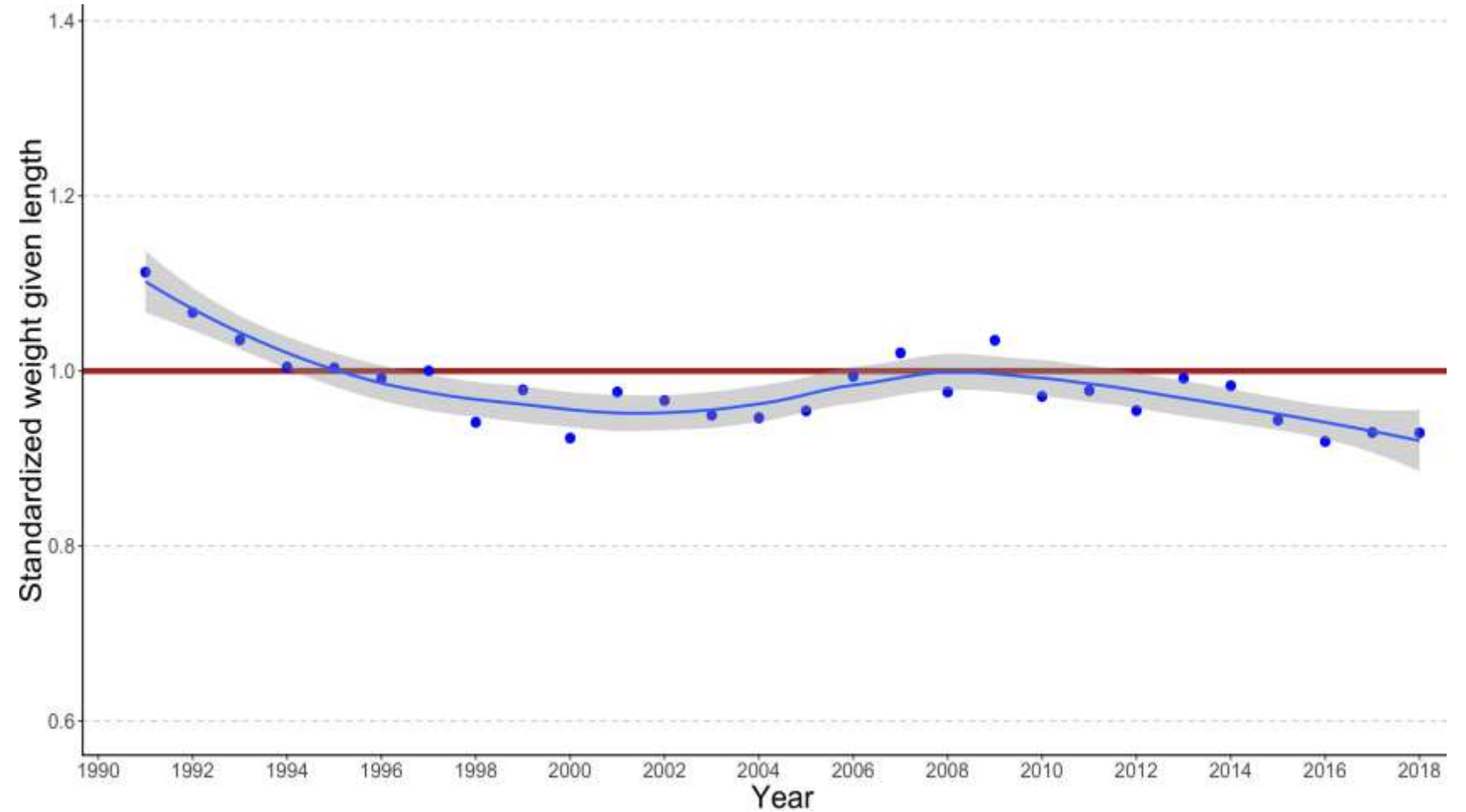
Pollock "fatness" (given length) by year and season





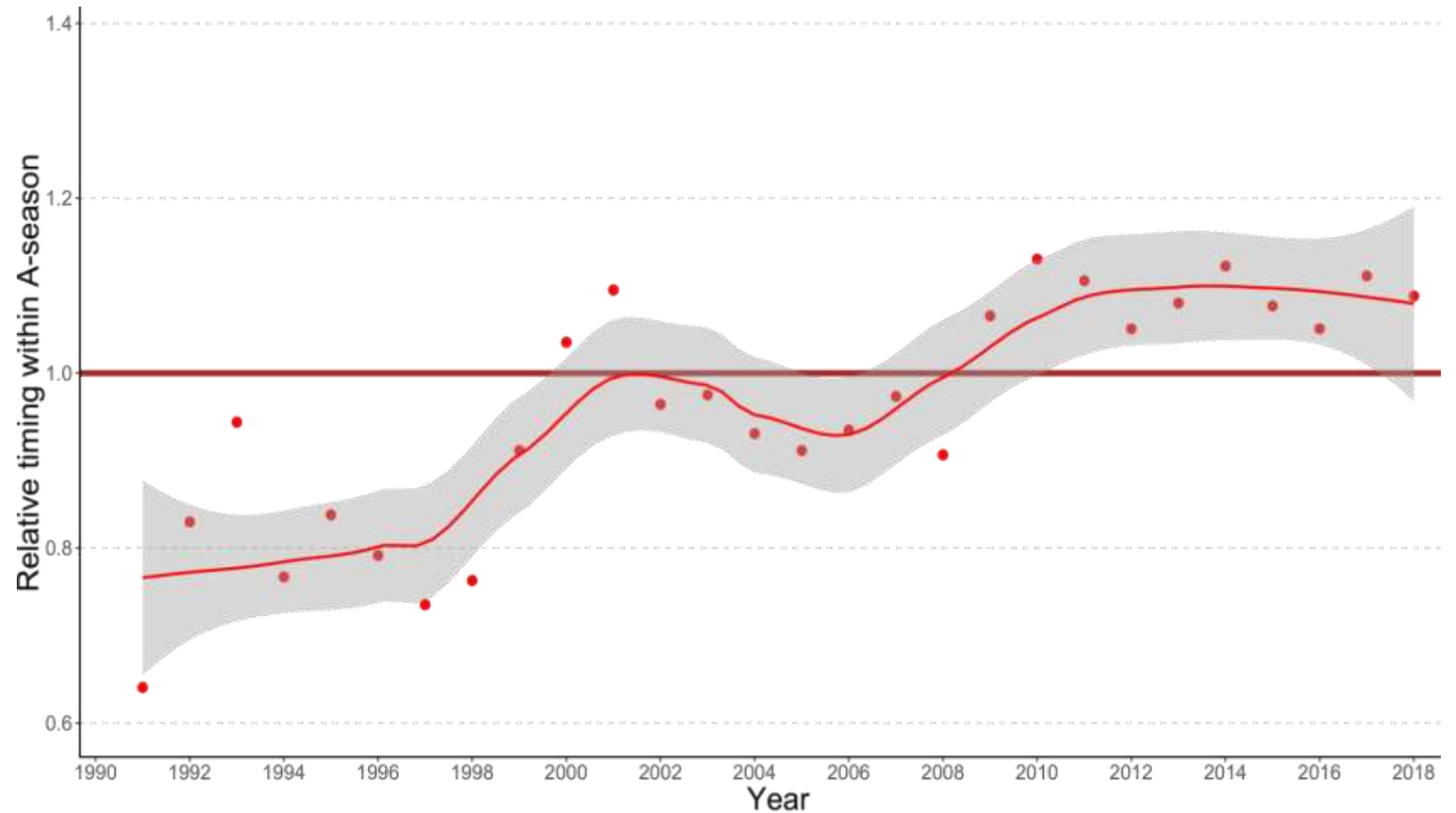


Closer look at A-season “fatness” trend



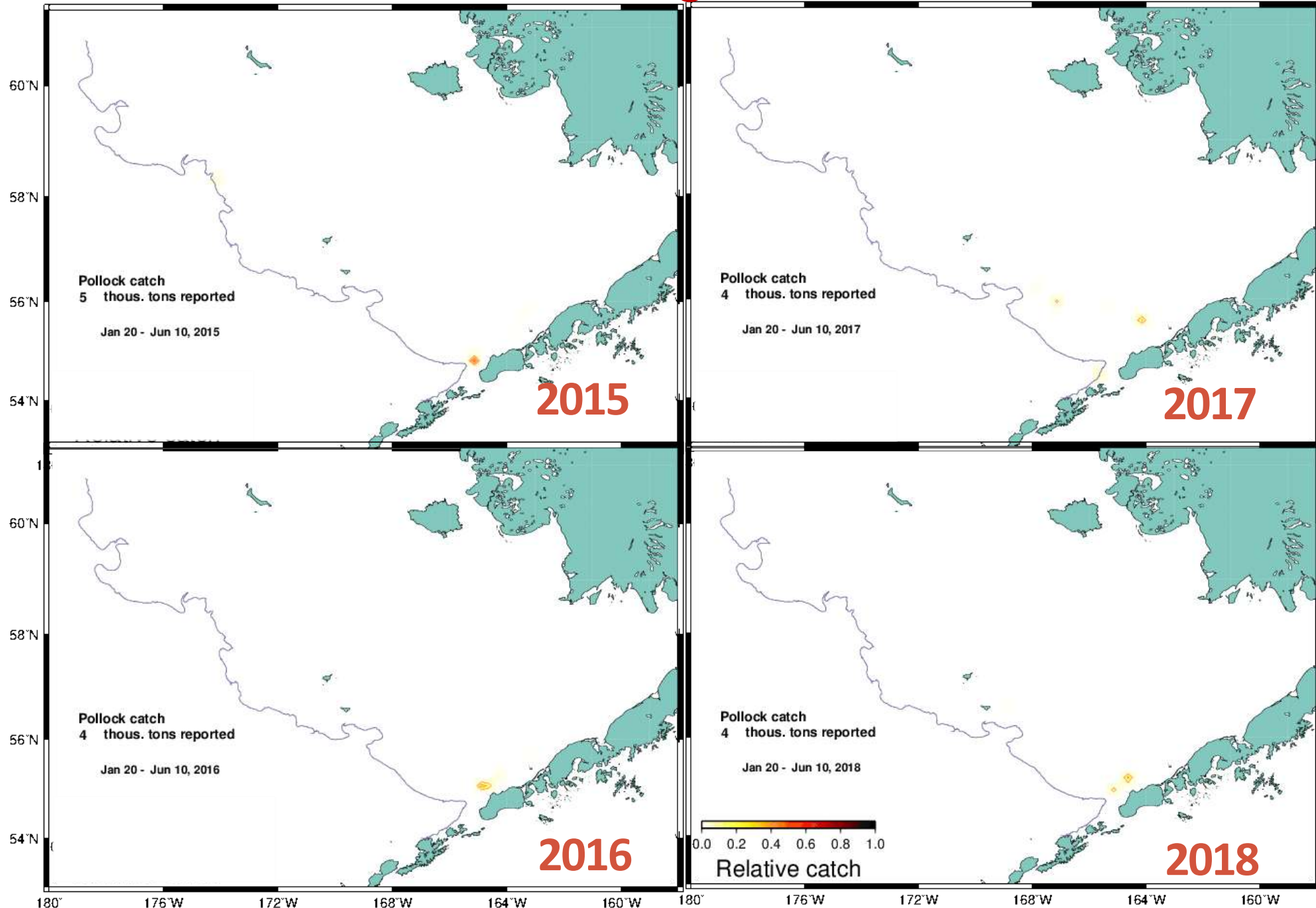
Closer look at A-season “fatness” trend

Early on
race-for-fish
meant earlier
in season



Spatial patterns in the summer fishery

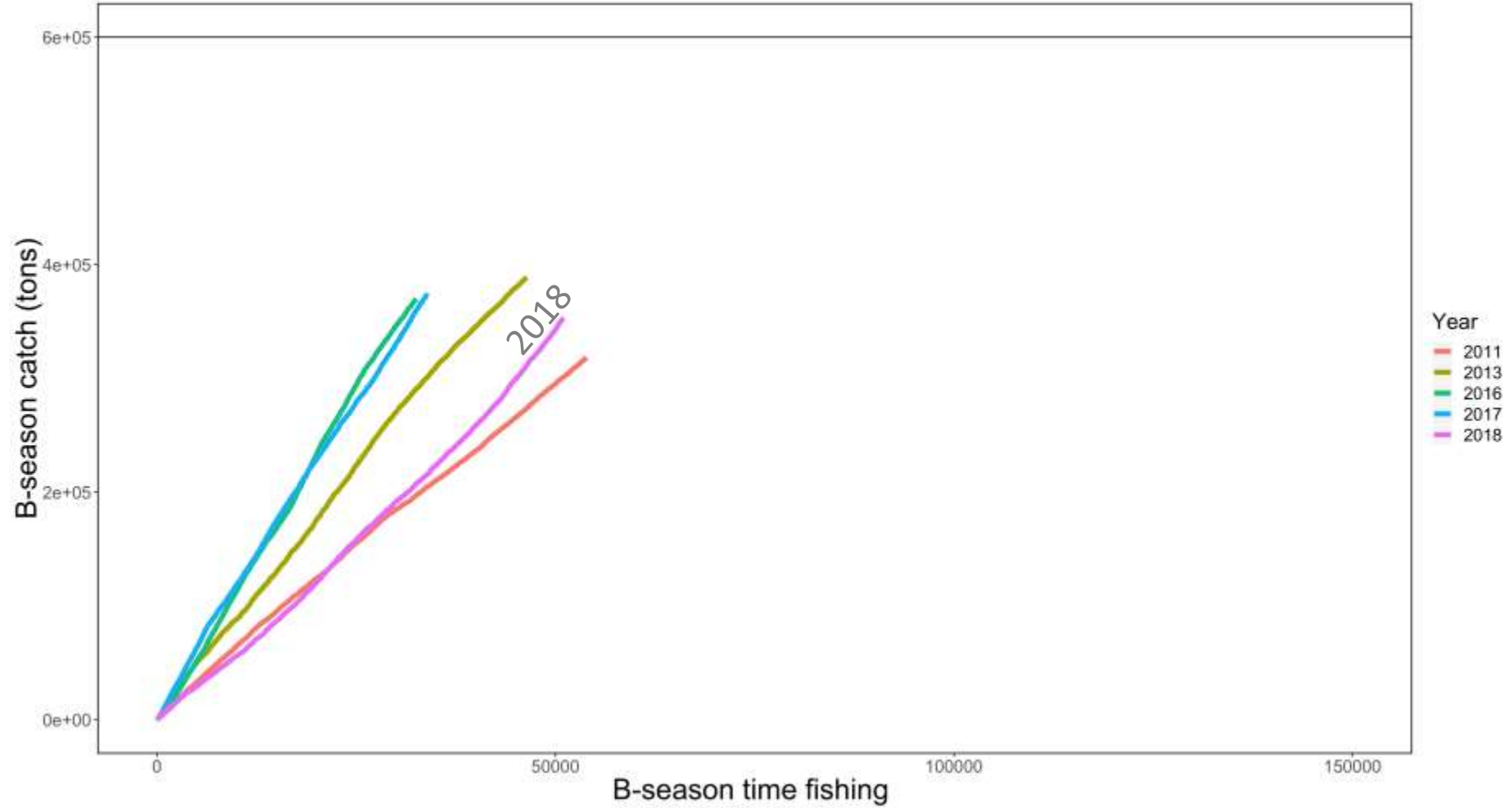
Summer fishing distributions



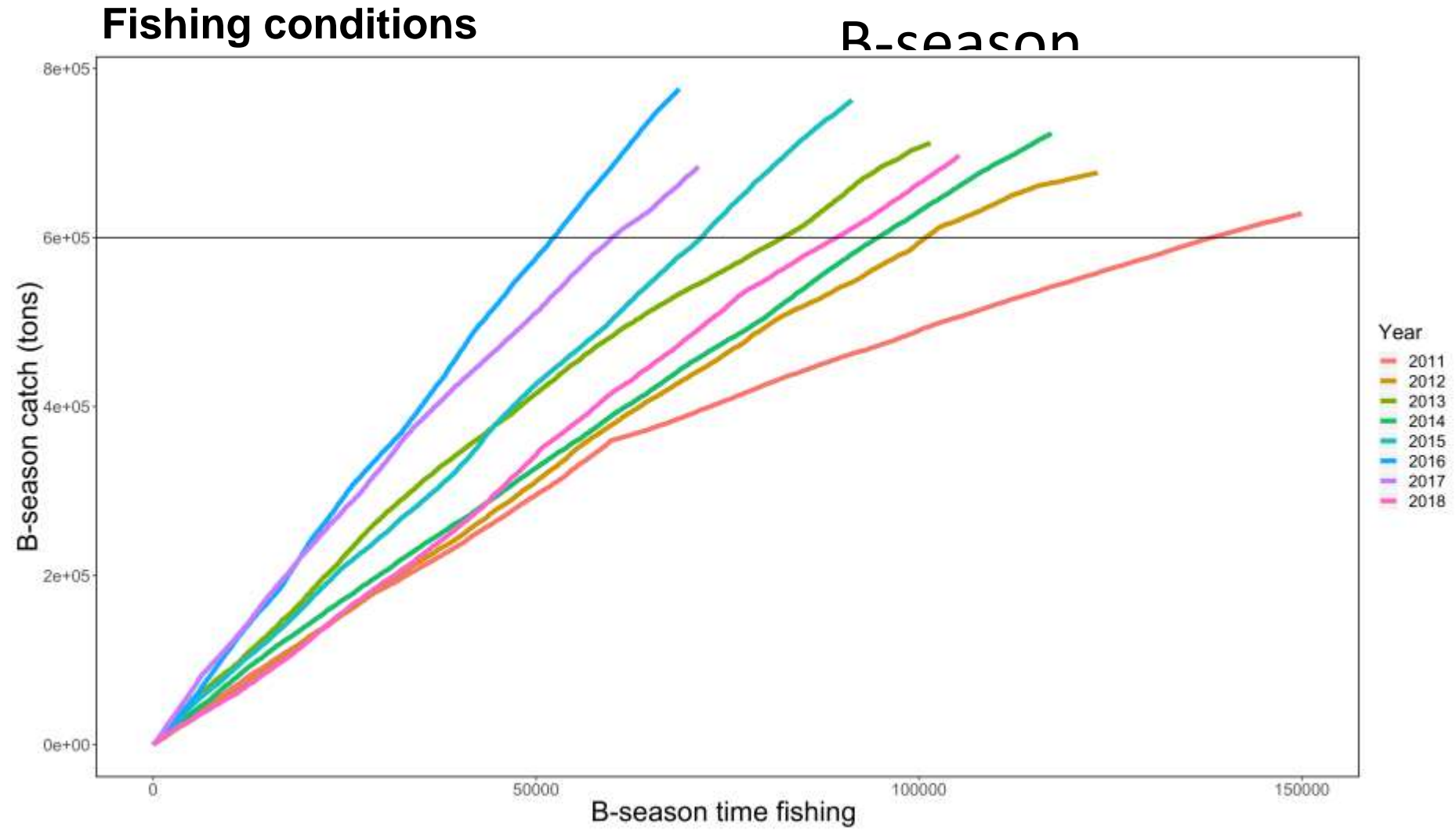
Summer fishing conditions

Fishing conditions

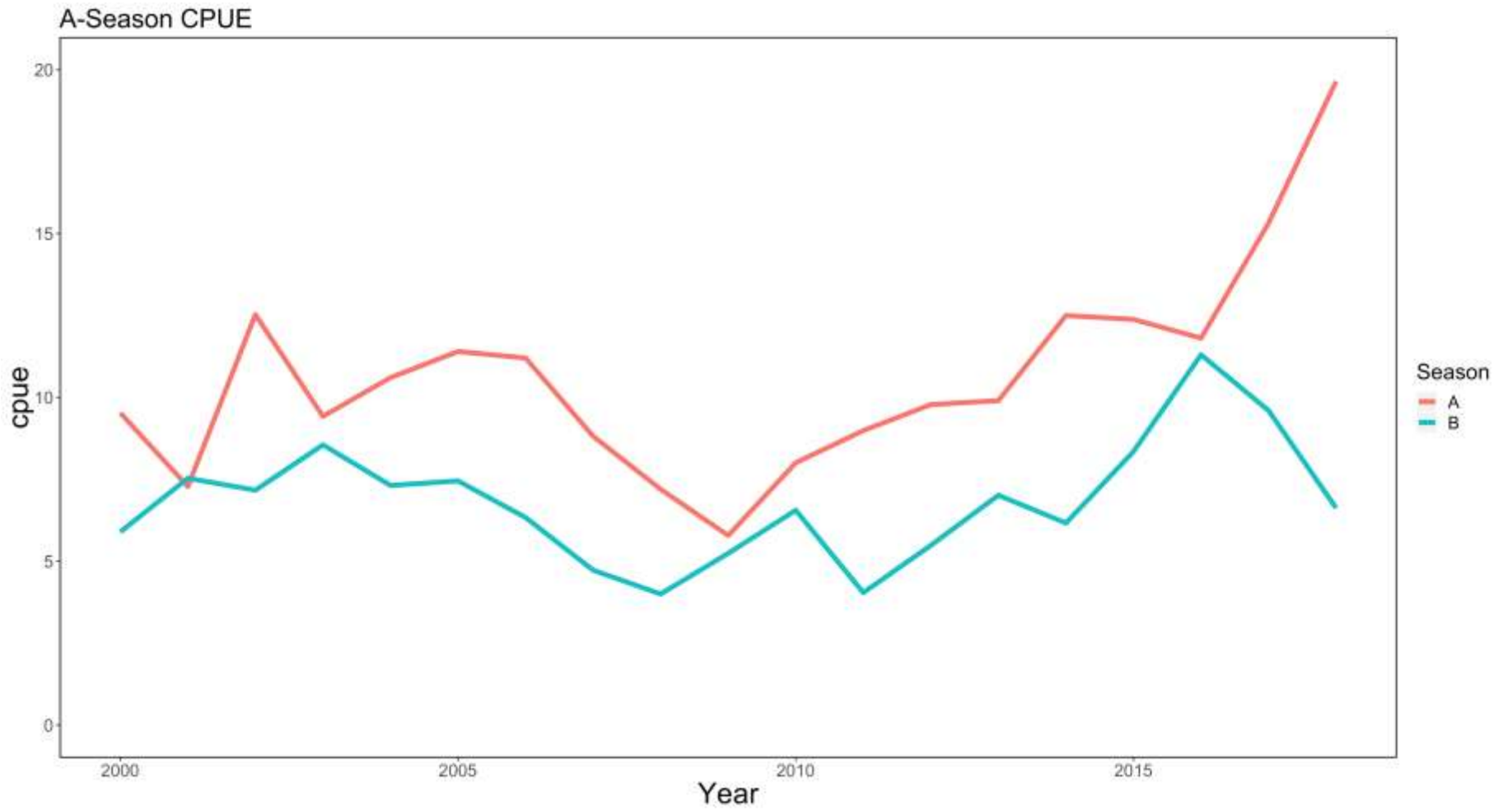
B-season



Summer fishing conditions

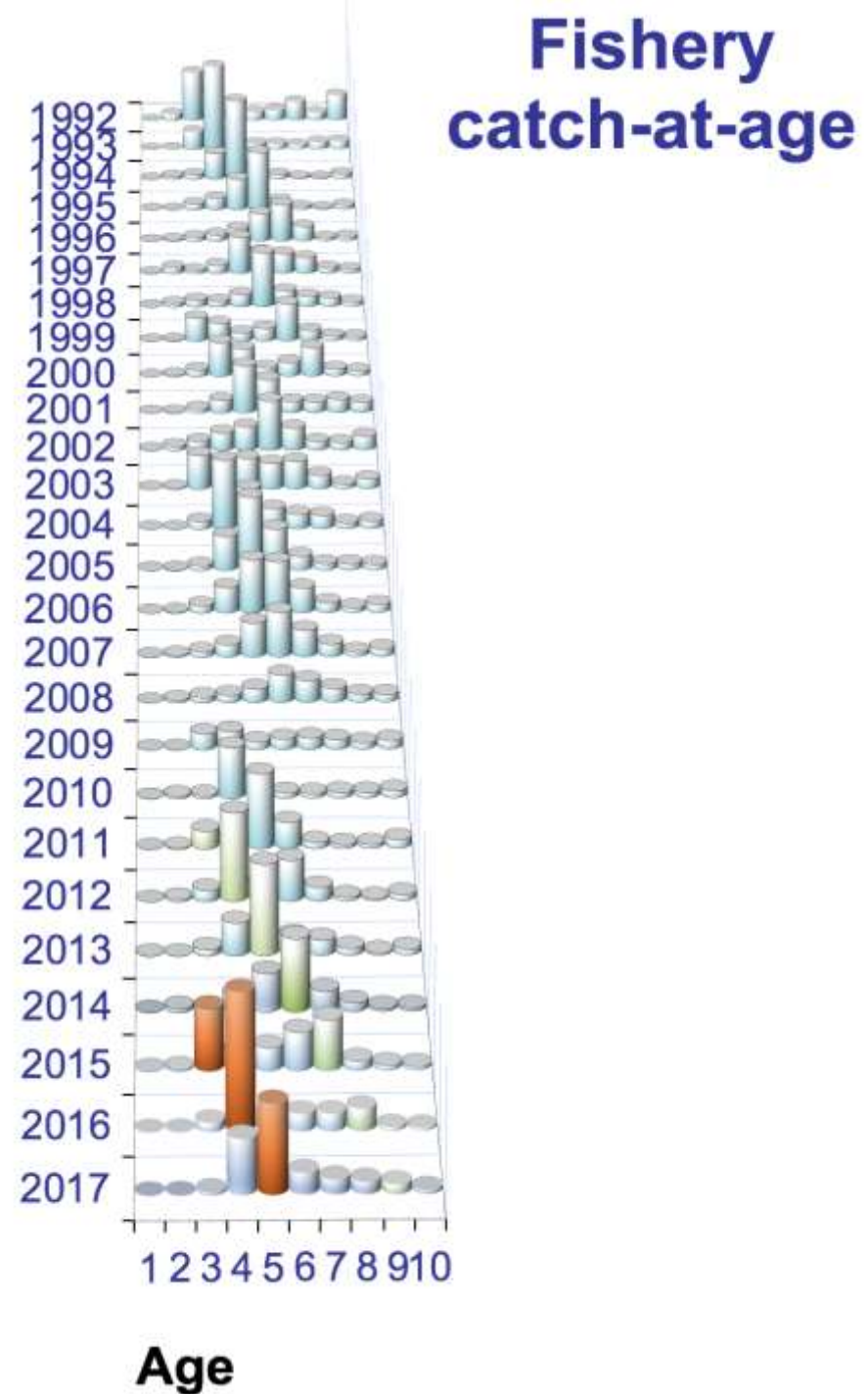


Fishing conditions



What ages of pollock are caught?

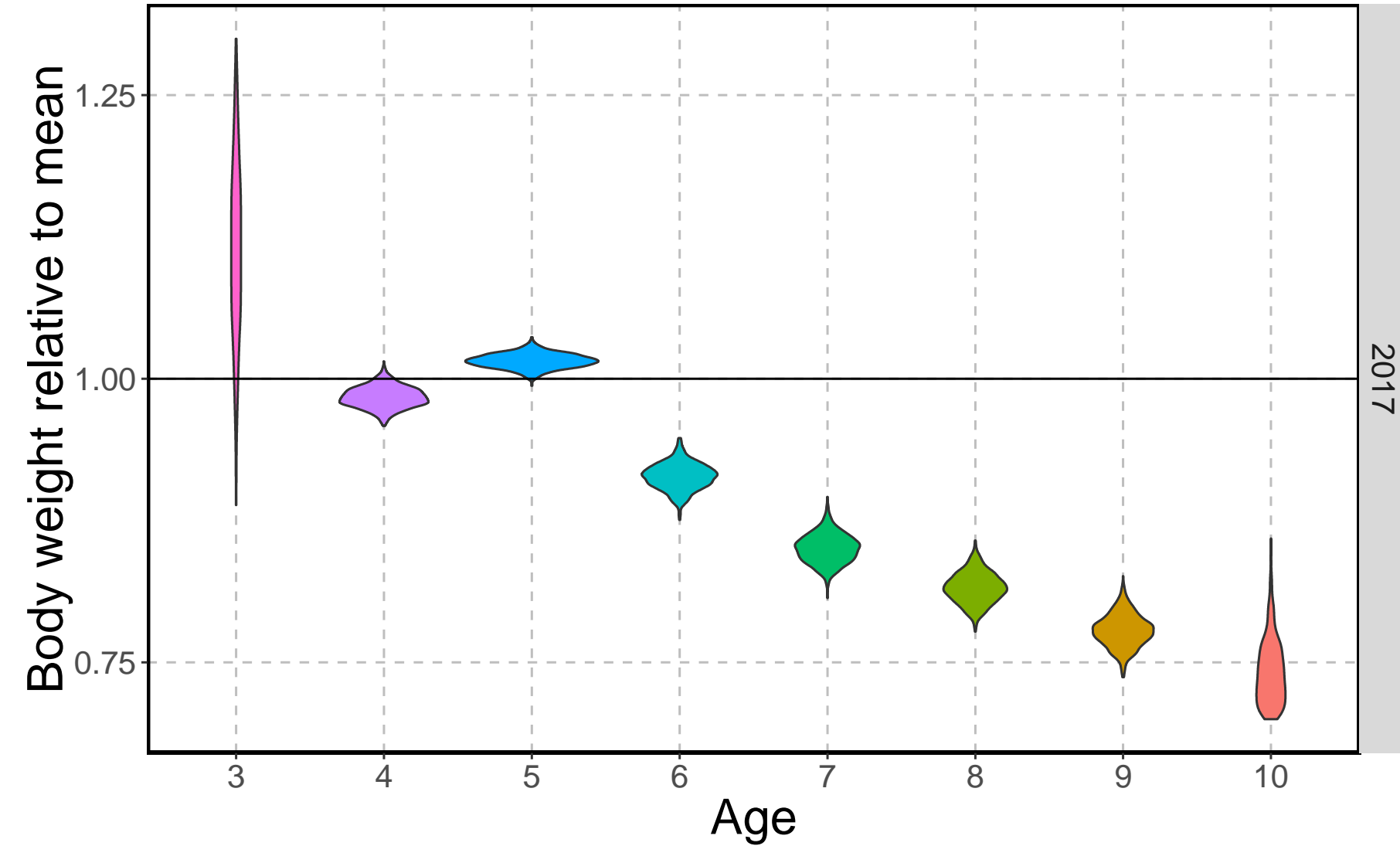
- New 2017 catch-age data



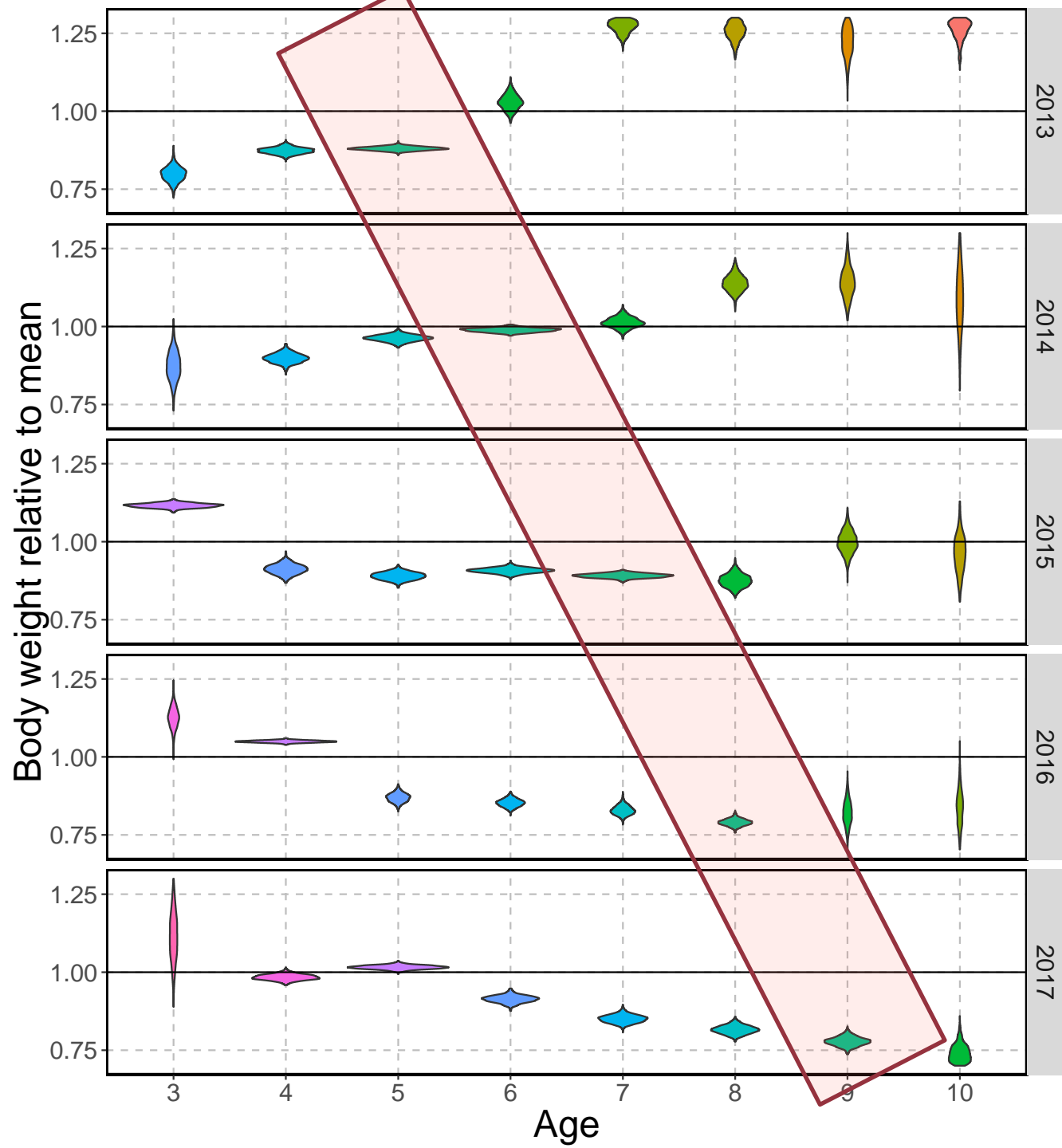
Looking at weight-at-age



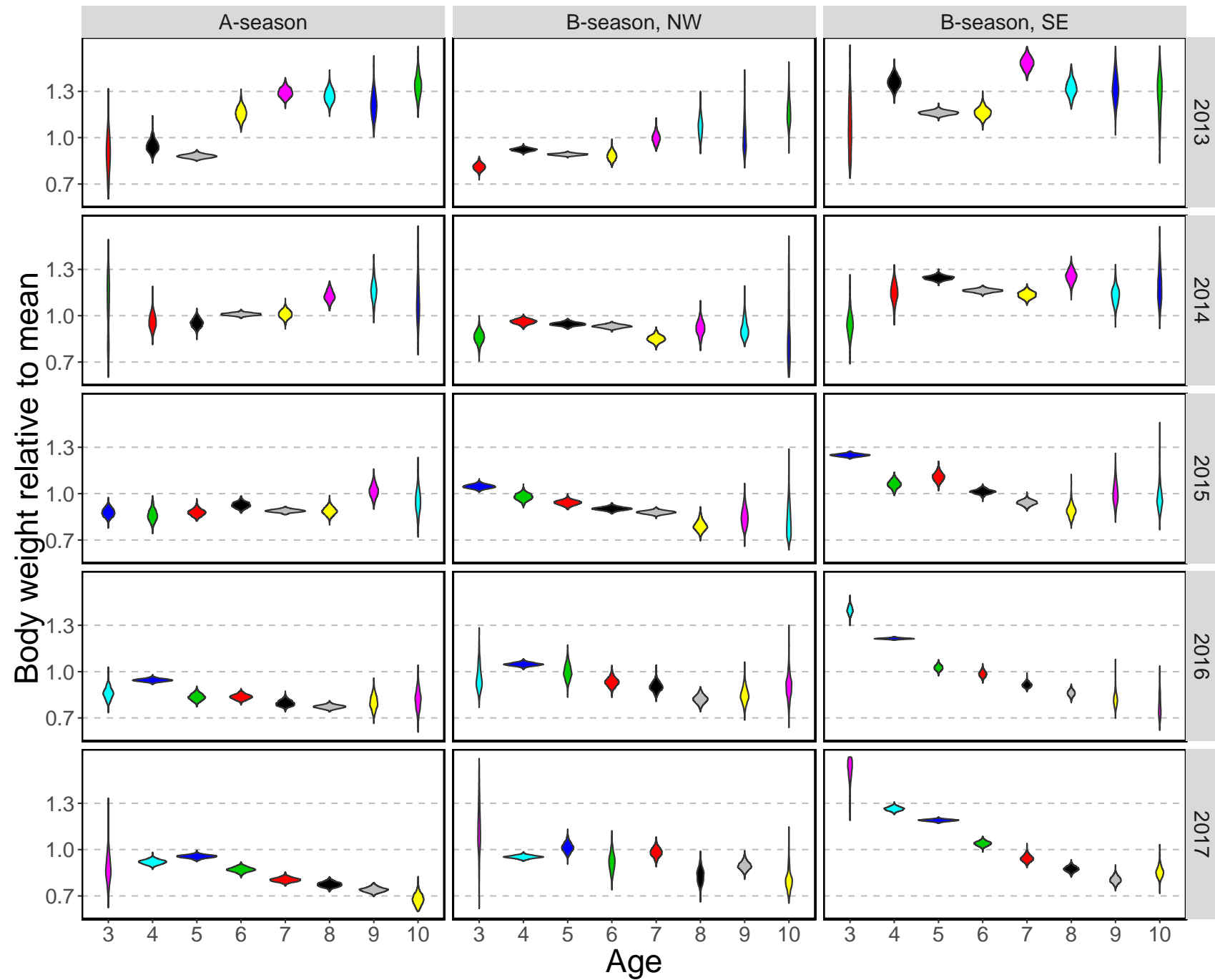
Are pollock smaller at age than normal???



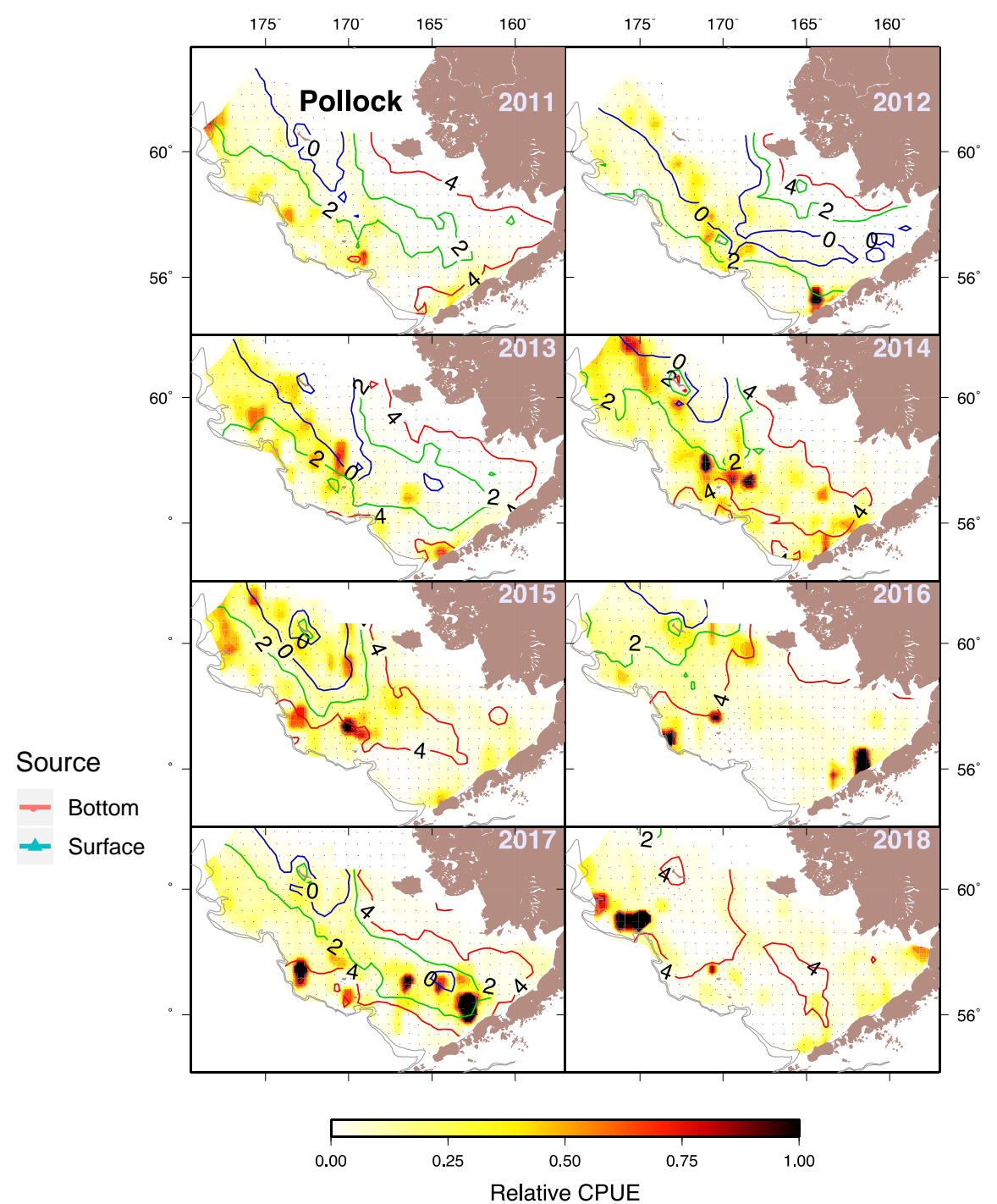
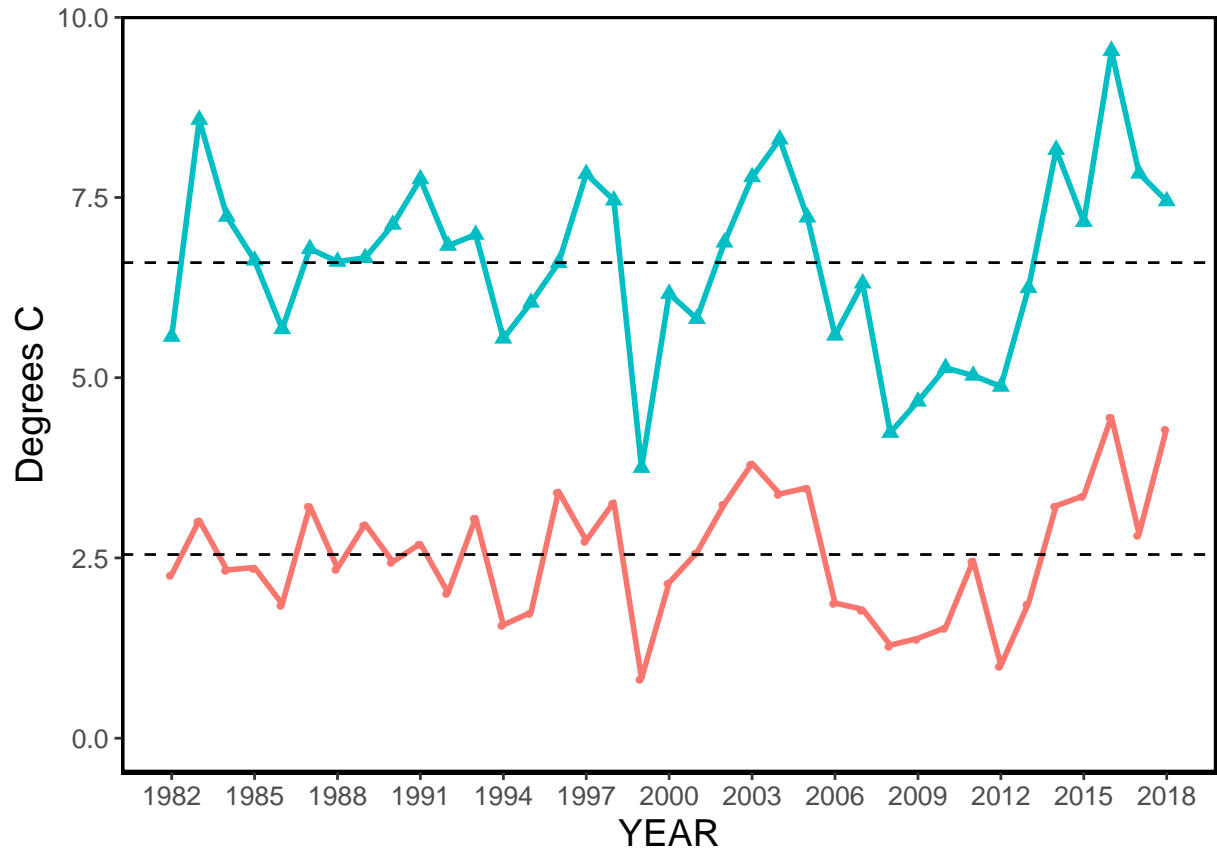
- 2008 year class generally small at age
- 2012 looks better!



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



Pollock density and temperature

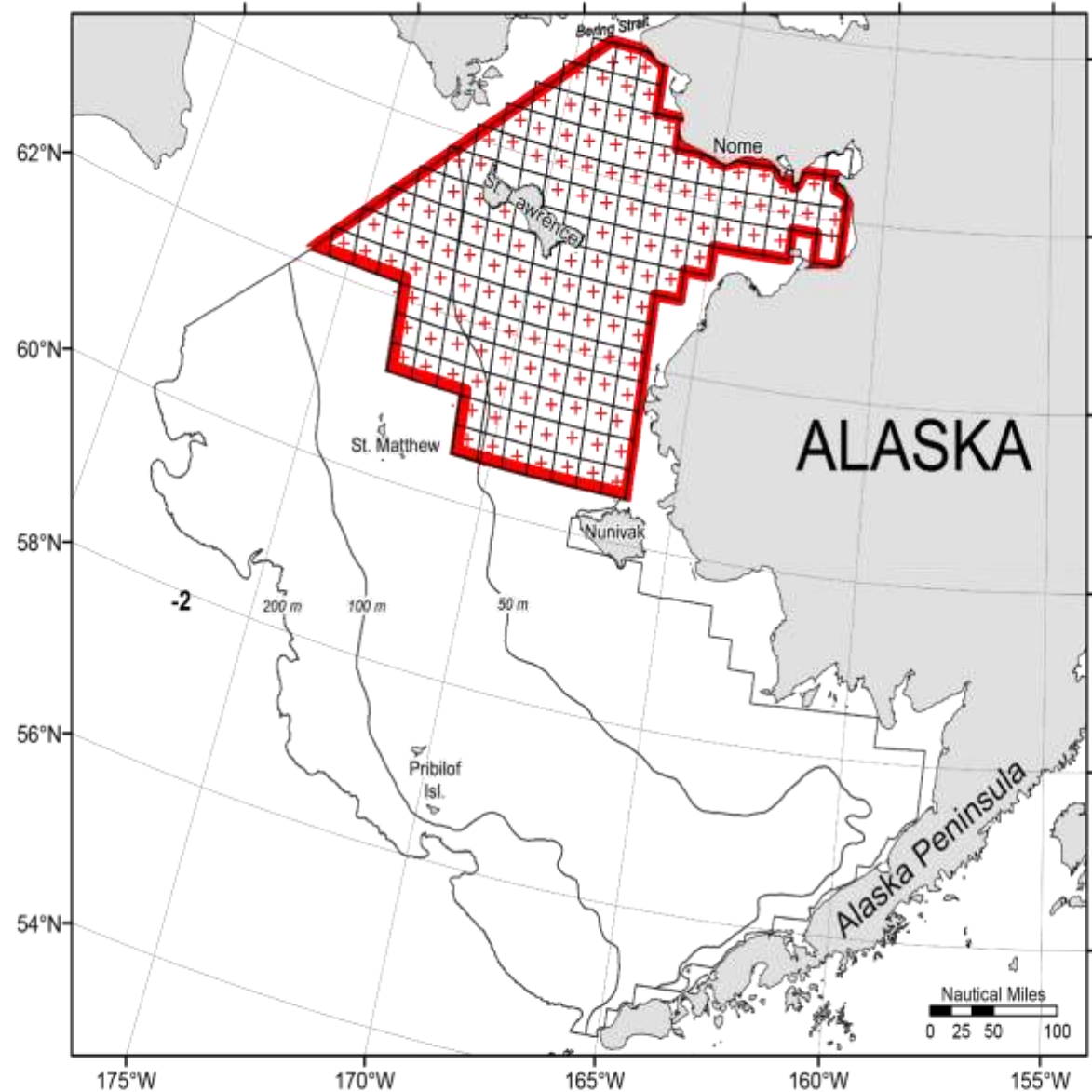


Added survey stations in northern area...

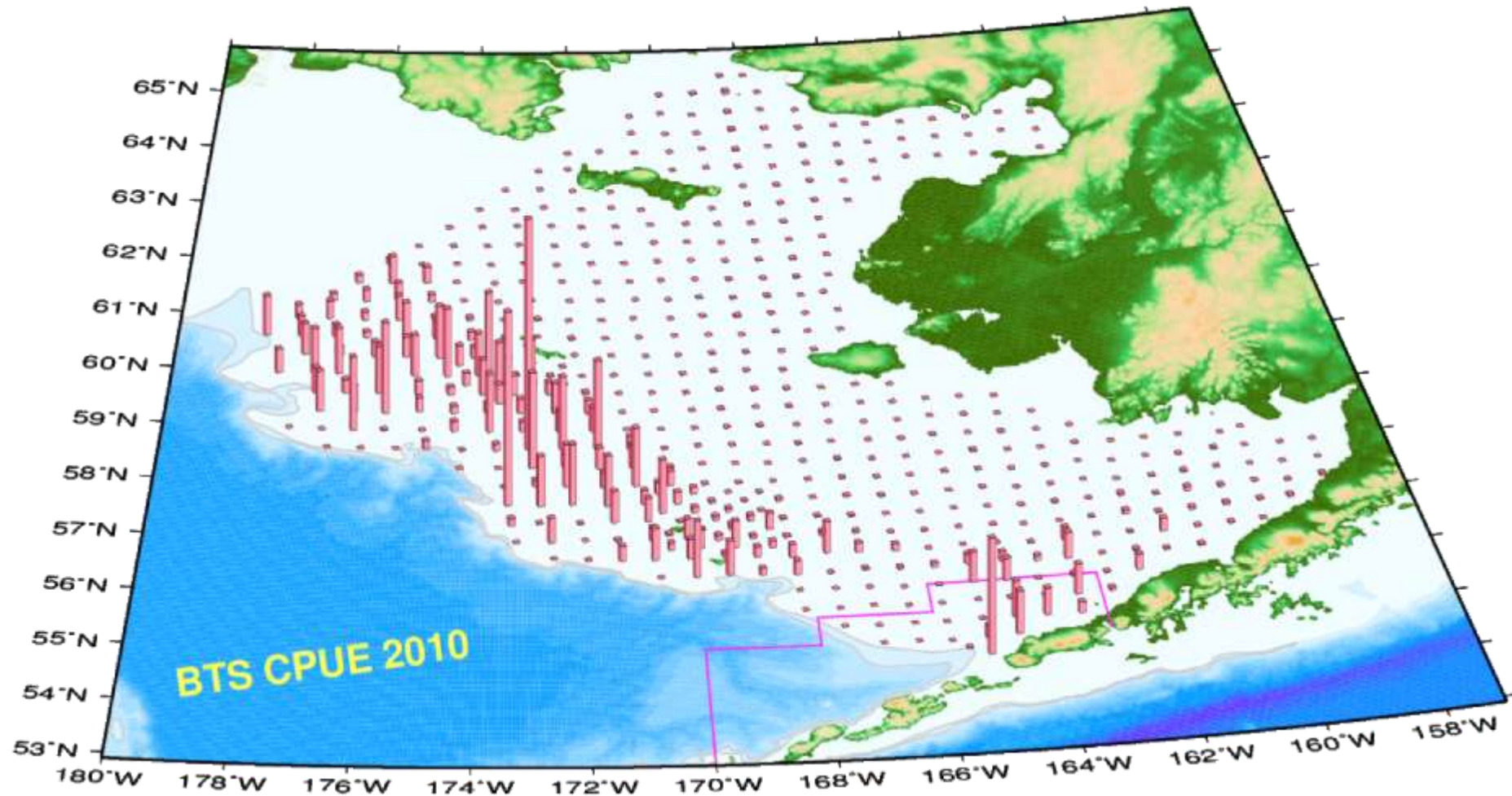
Surveyed in 2010 and 2017

- Extra stations done in 2018 as an “emergency”

Thought to have low abundances of pollock and cod...until 2017

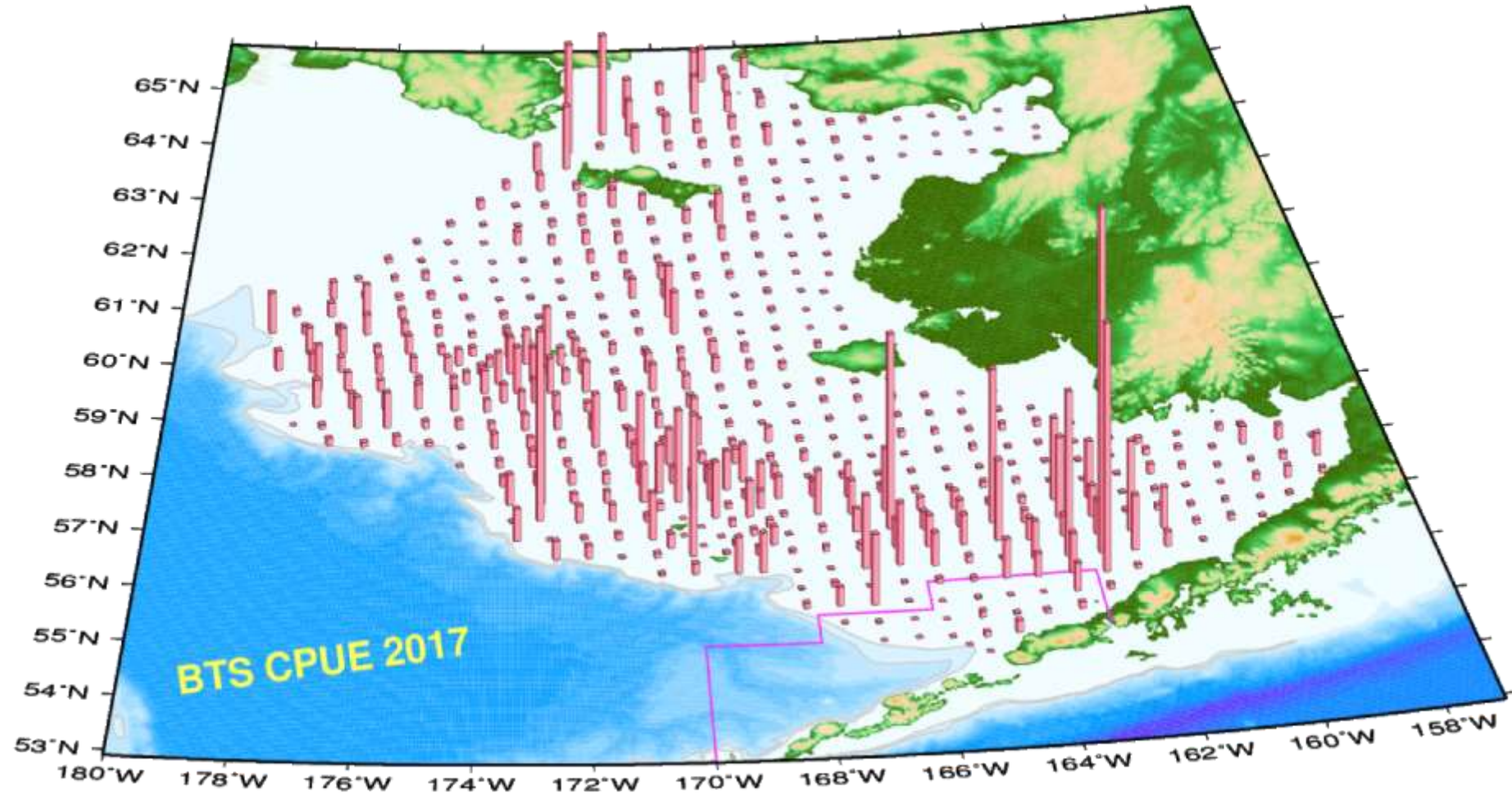


2010 standard survey (3.74 million t pollock estimated)



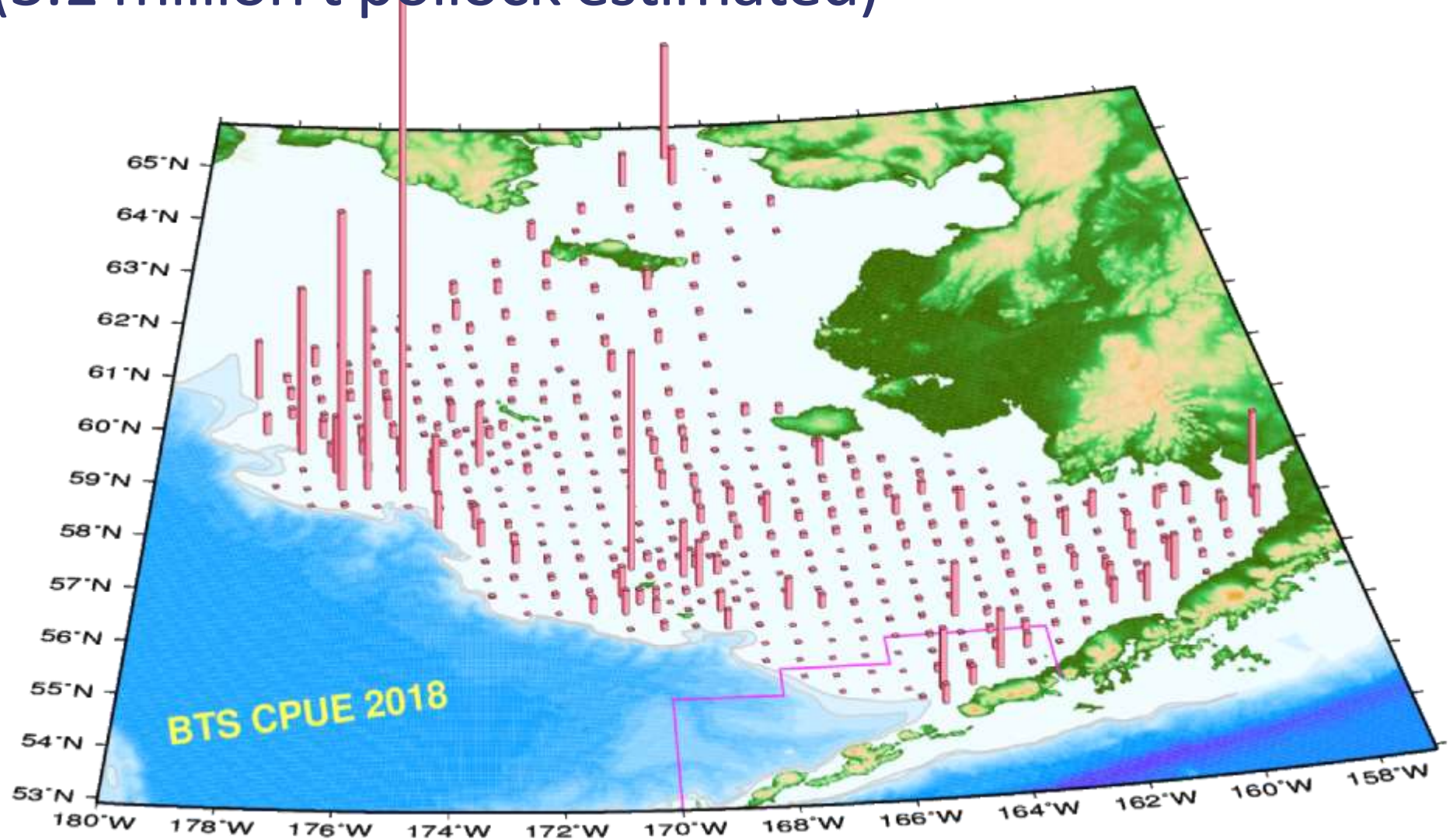
Northern area: trace amounts

2017 standard survey (4.81 million t pollock estimated)



Northern area: 1.34 million t

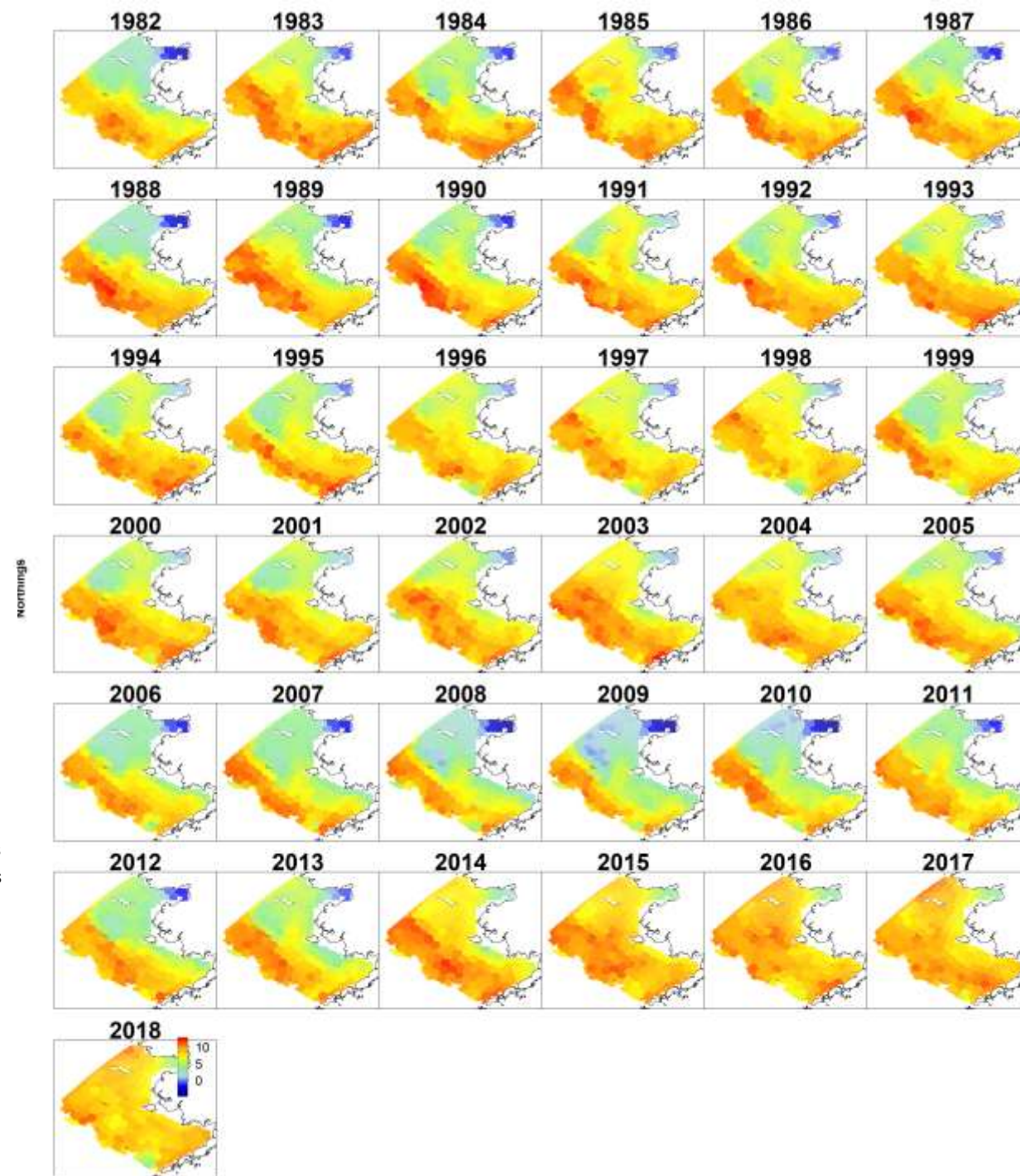
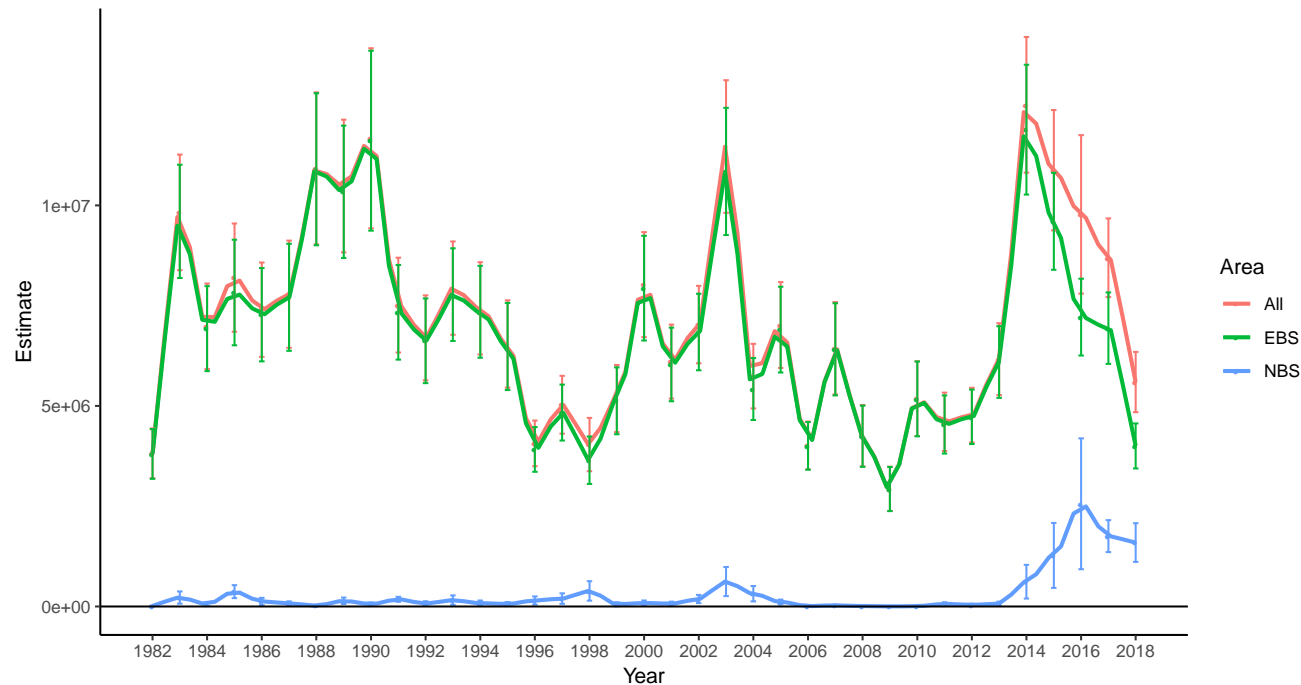
2018 standard survey (3.1 million t pollock estimated)



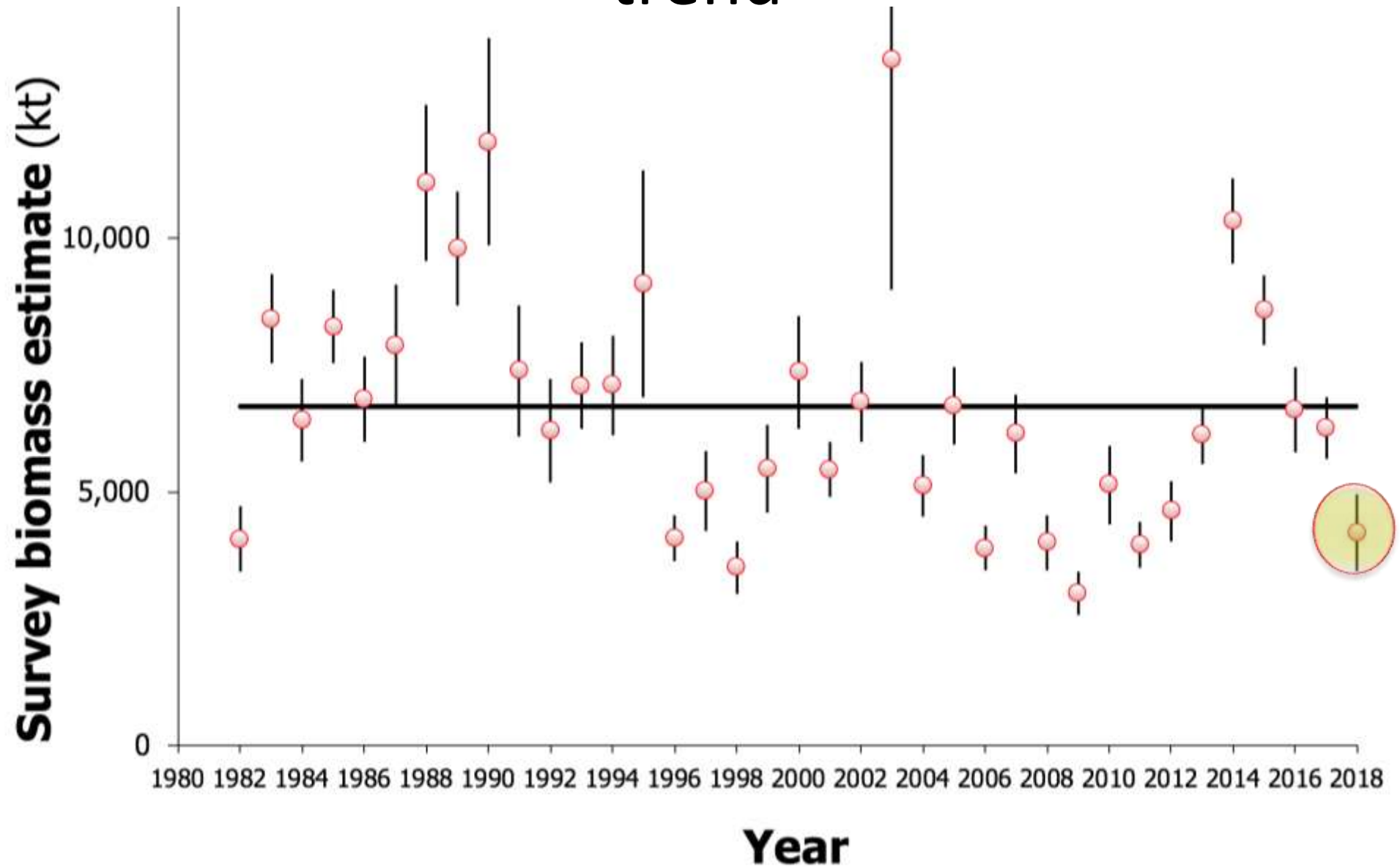
Northern area: 1.15 million t

Modeling surveys

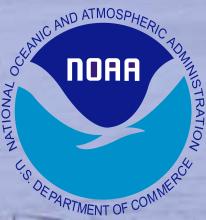
- To account for missed areas/years...
- VAST model of Thorson

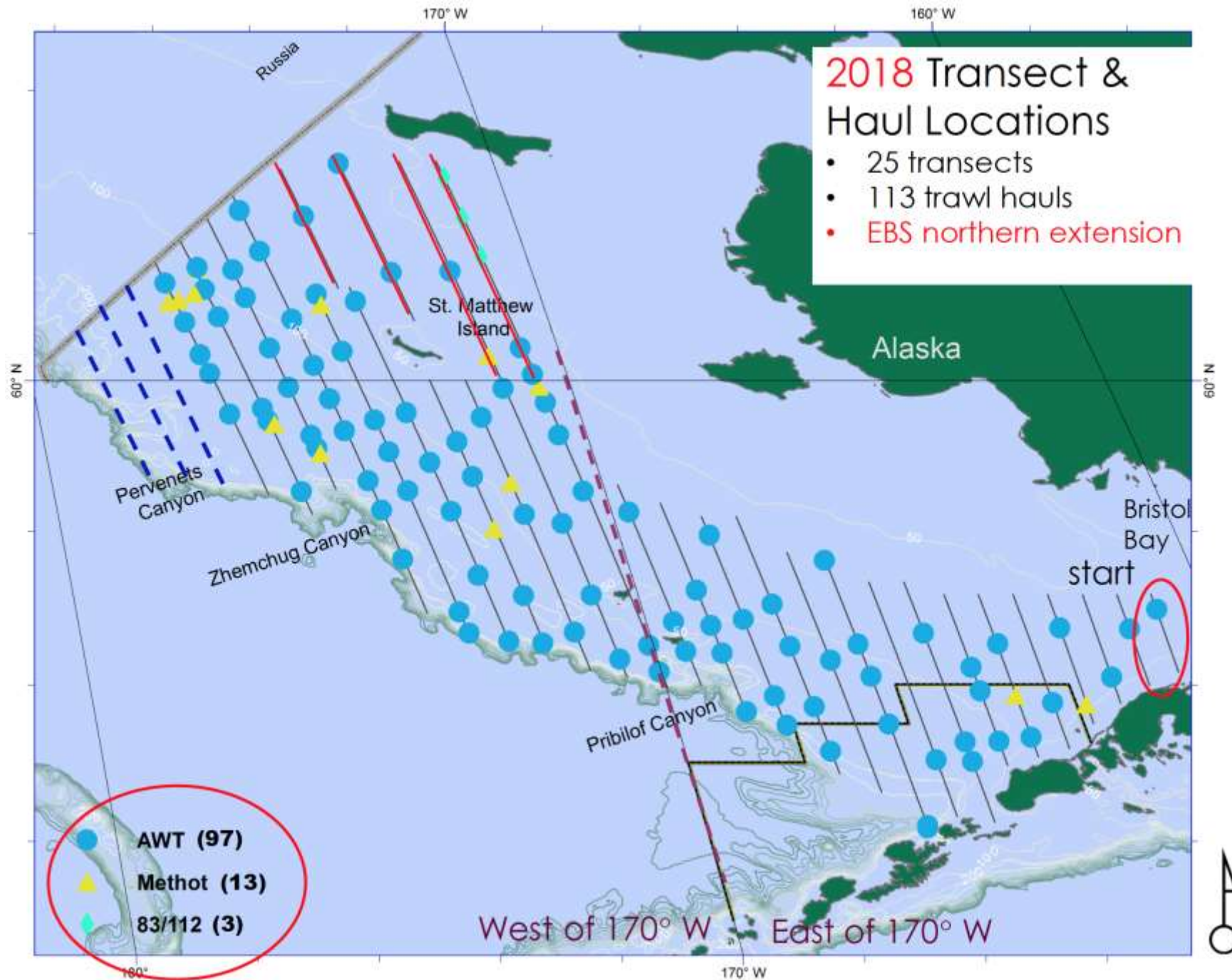


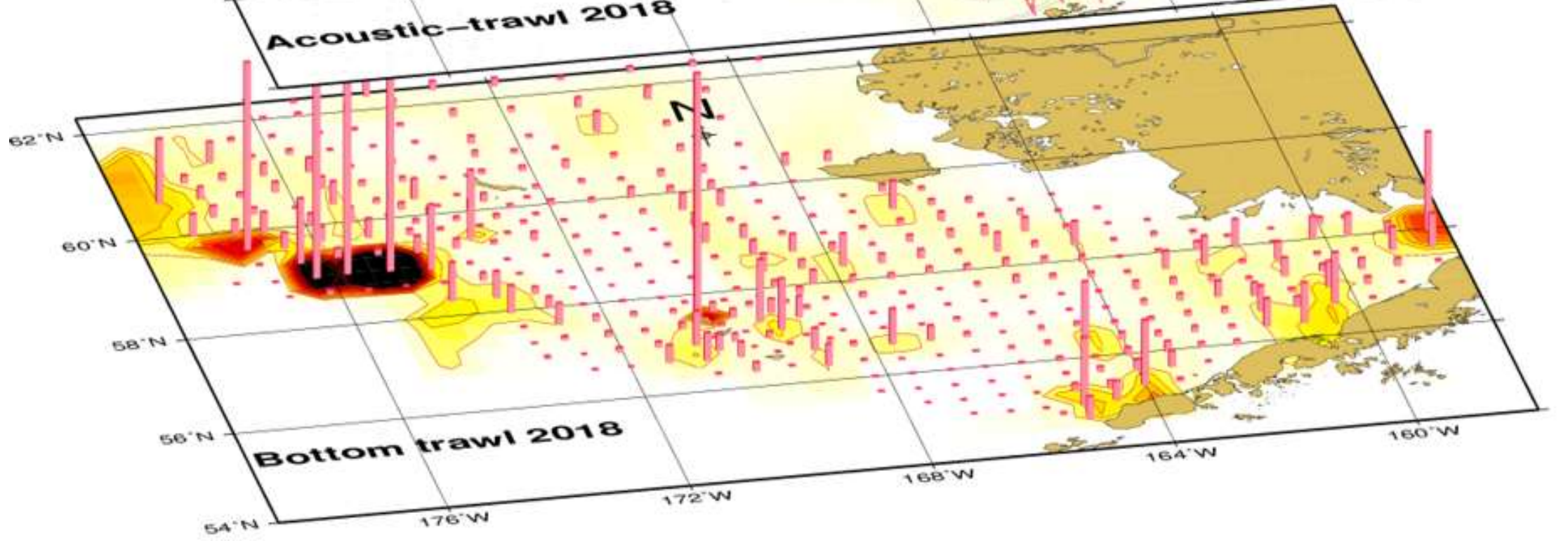
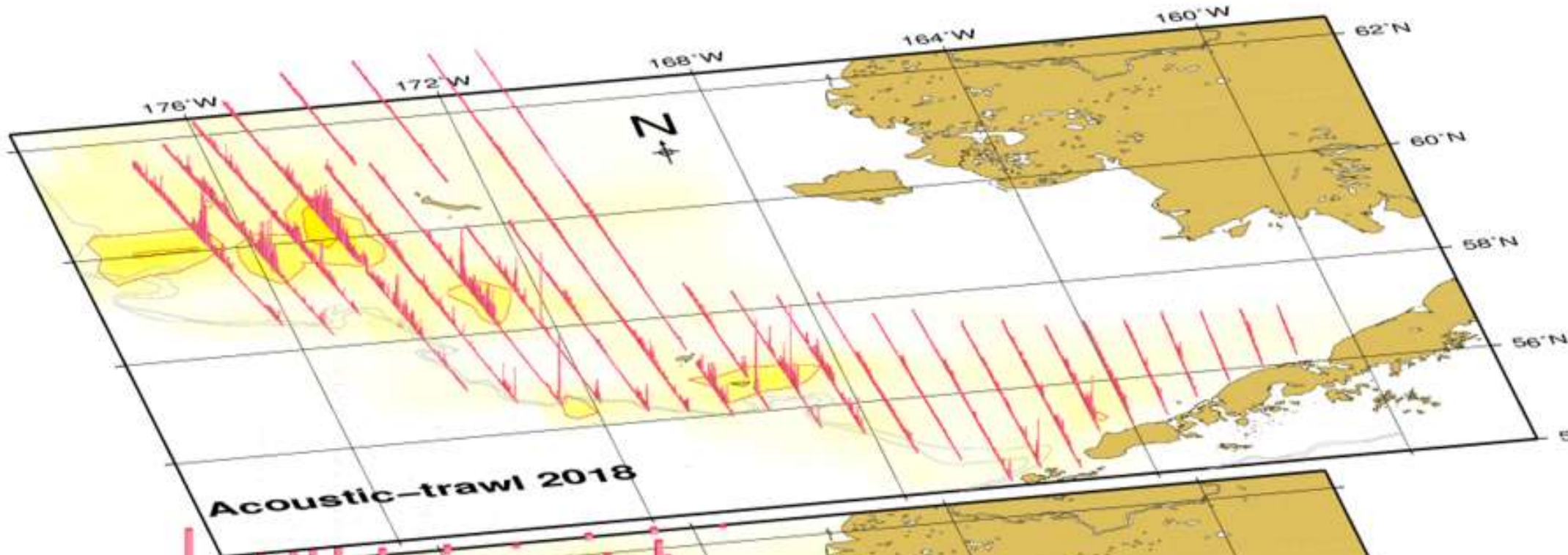
Pollock bottom trawl survey biomass trend

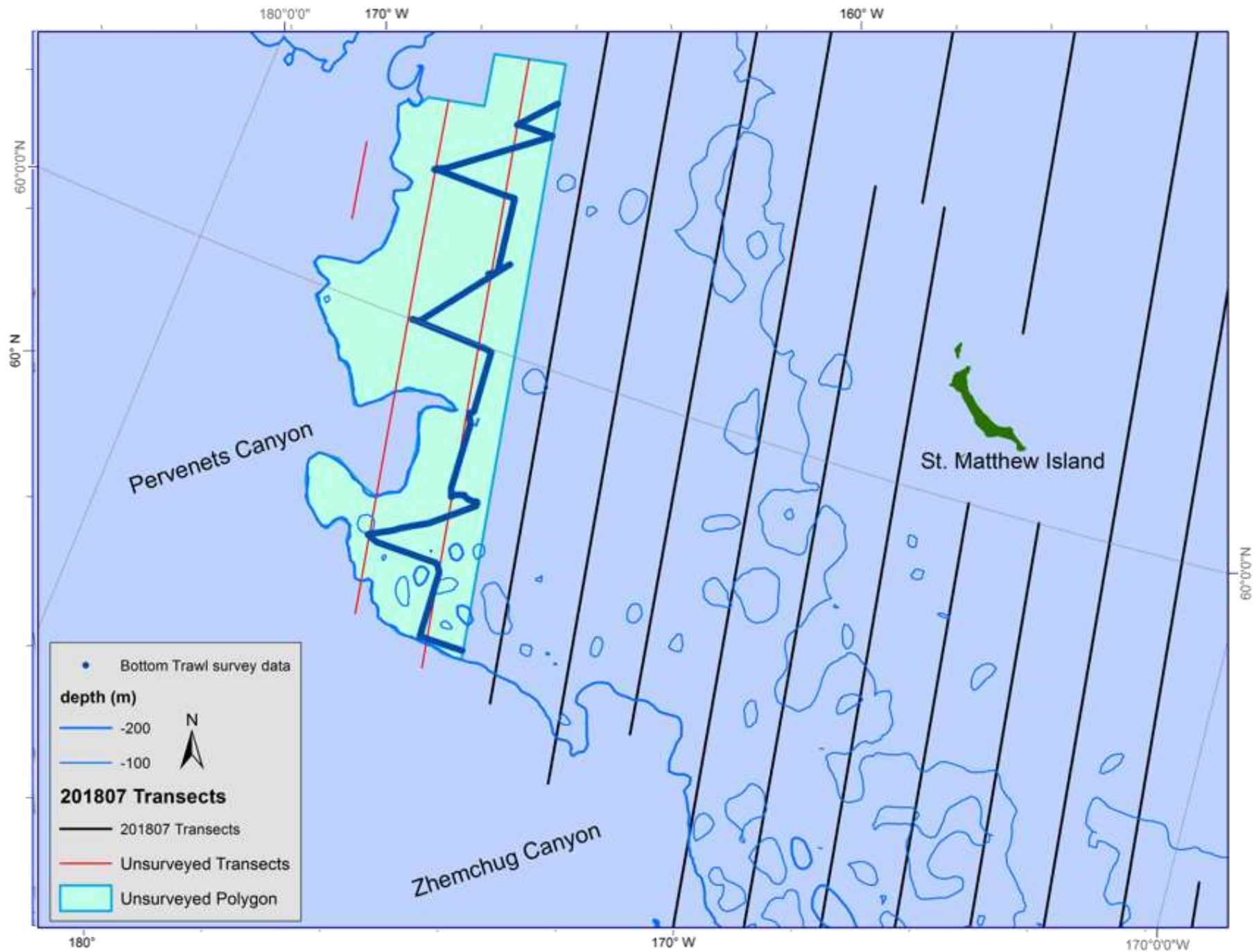


Biennial mid-water acoustic-trawl survey



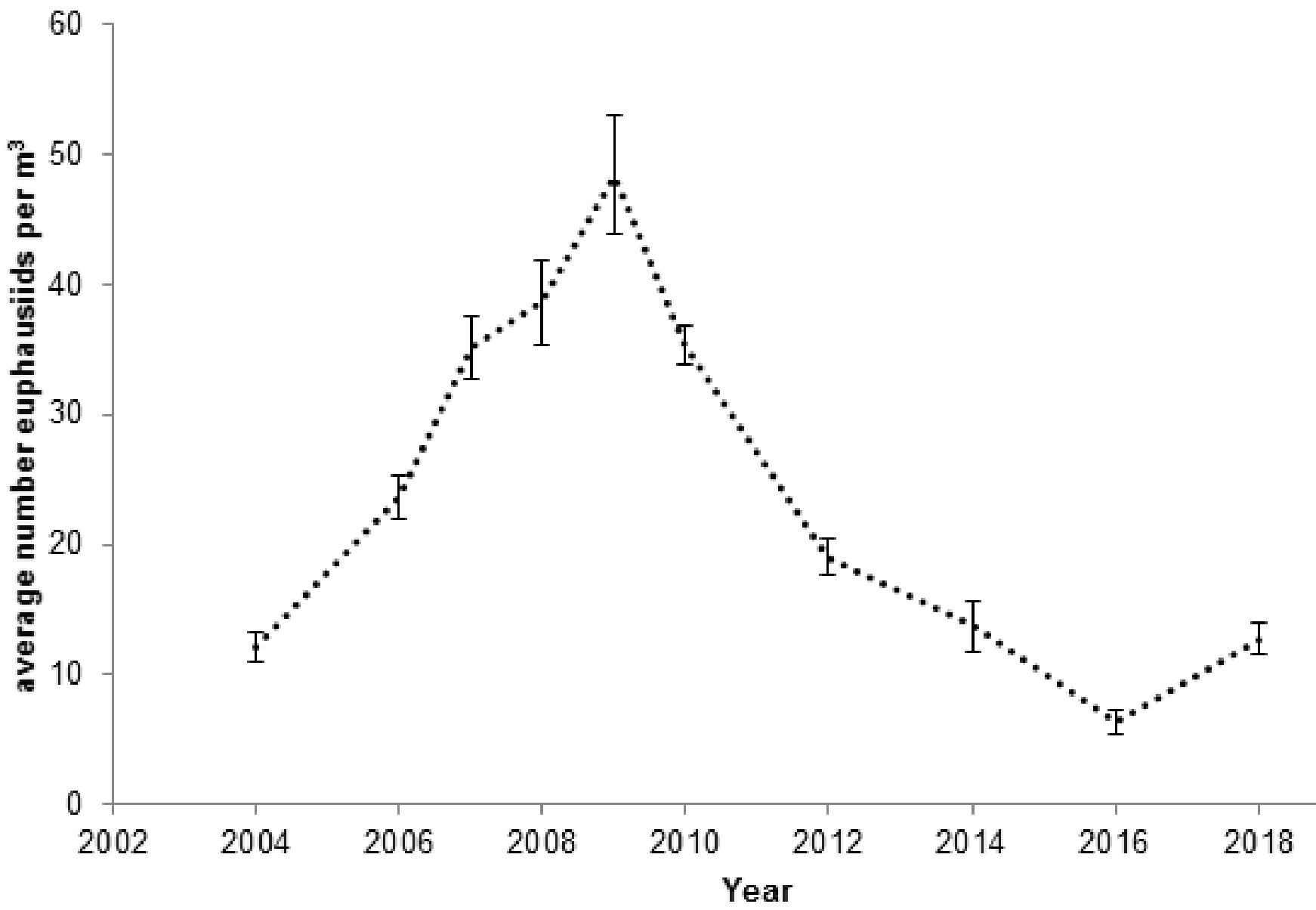
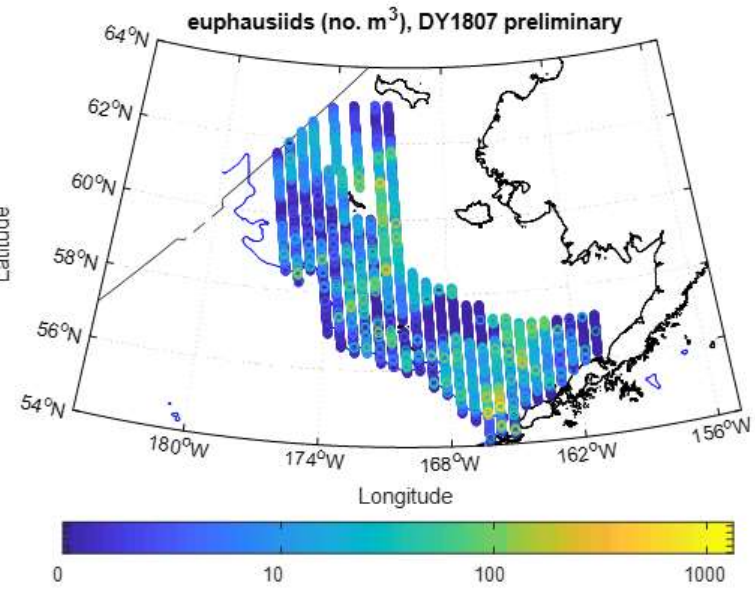




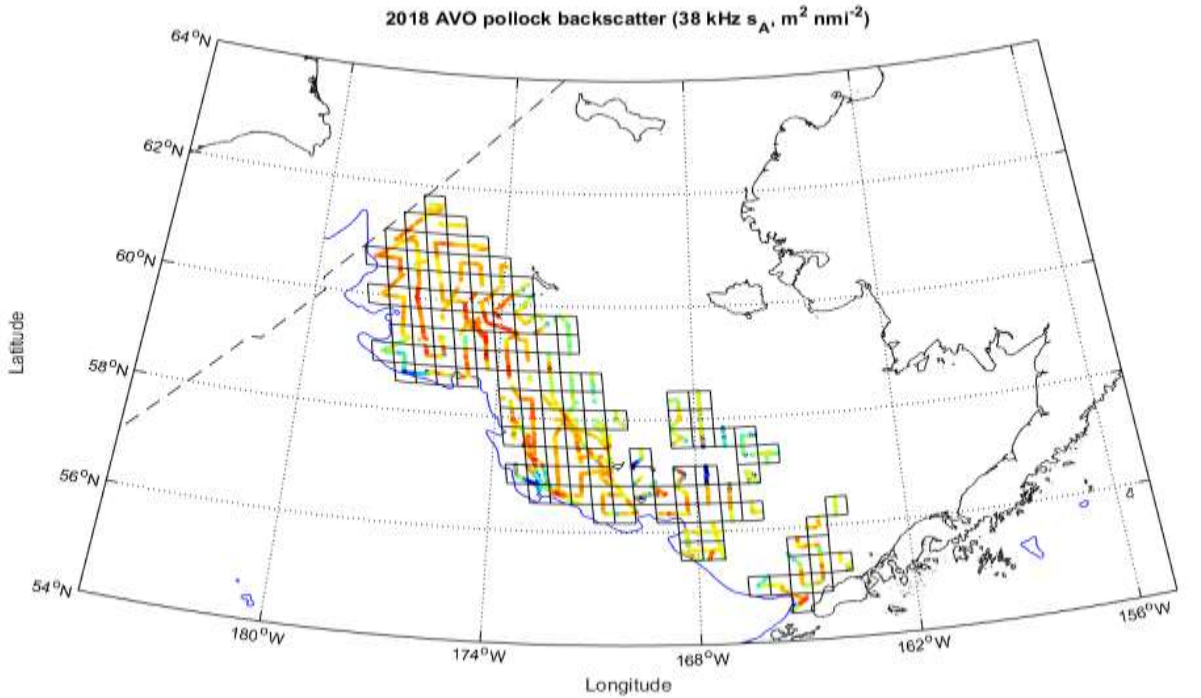
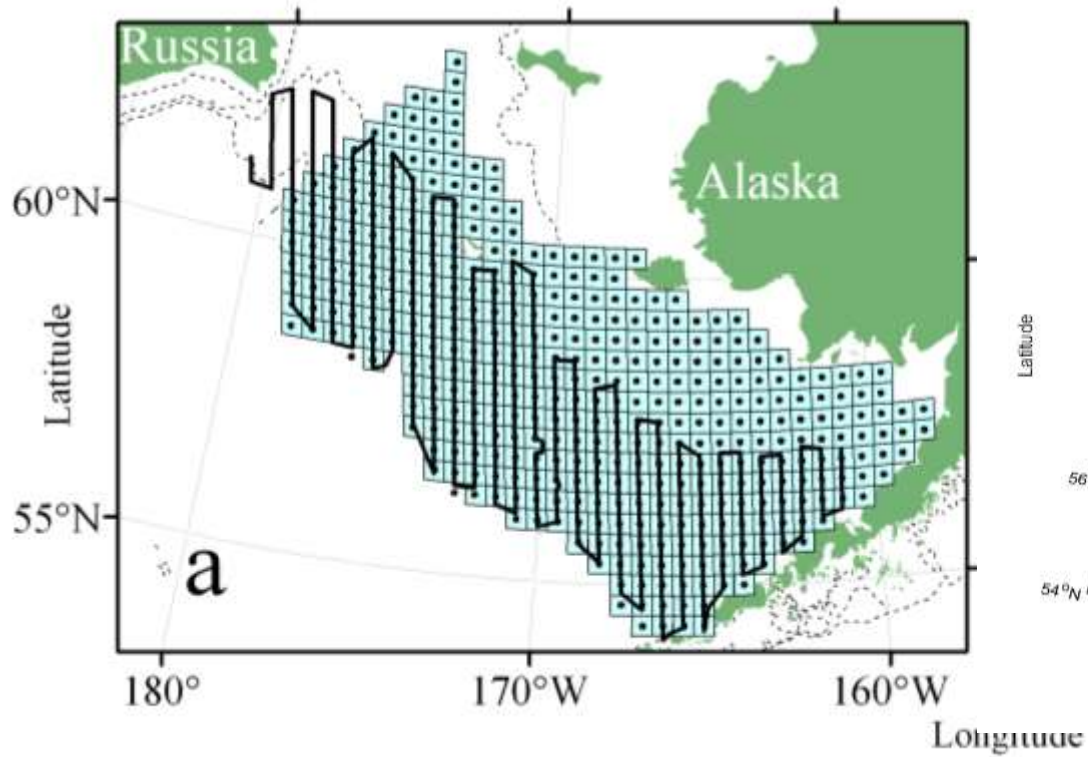


Zooplankton

Courtesy Patrick Ressler

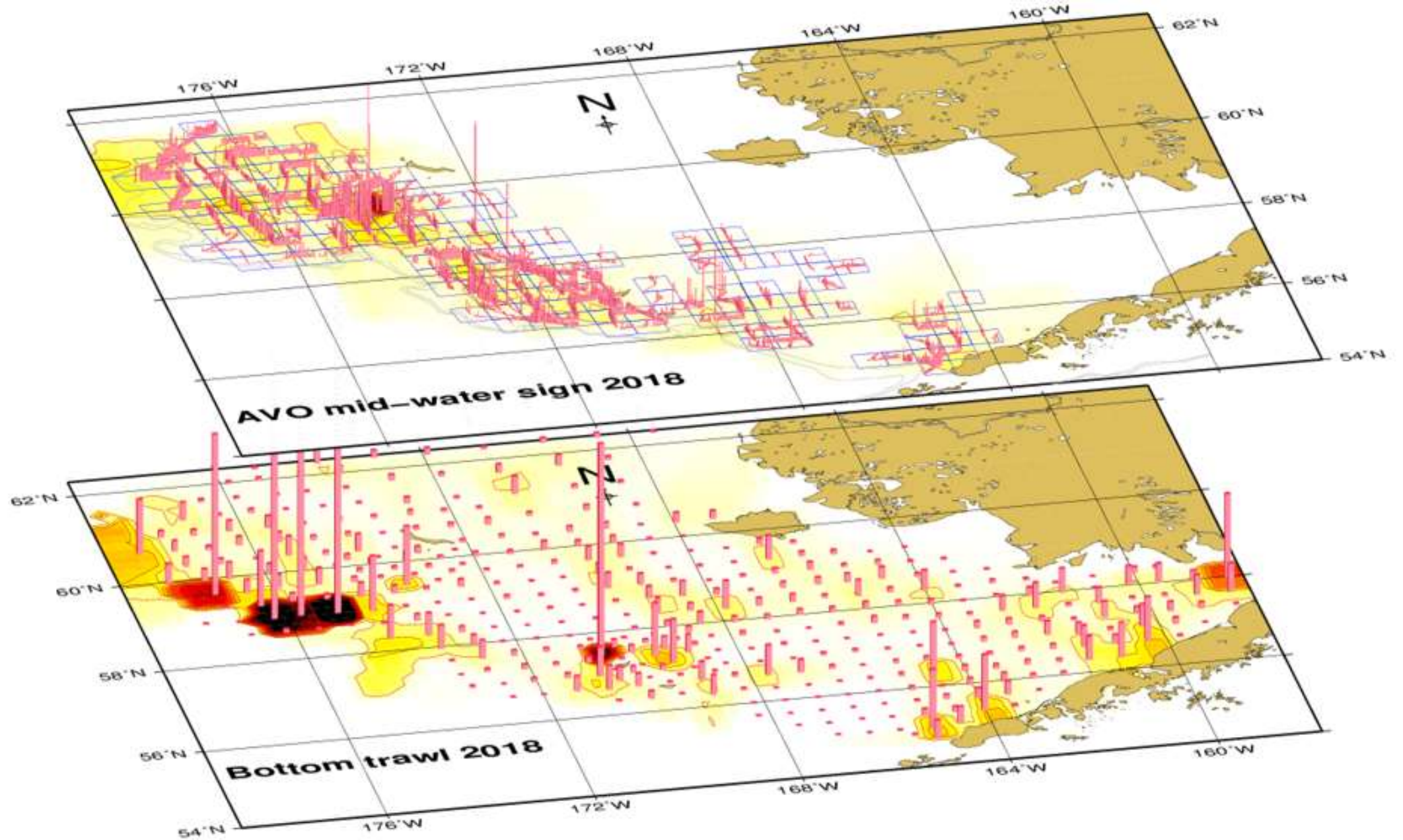


Mid-water acoustic surveys...



Acoustic
Vessels of
Oportunity

Acoustic vessels of opportunity (AVO)



Acoustic
Vessels of
Opportunity

Models

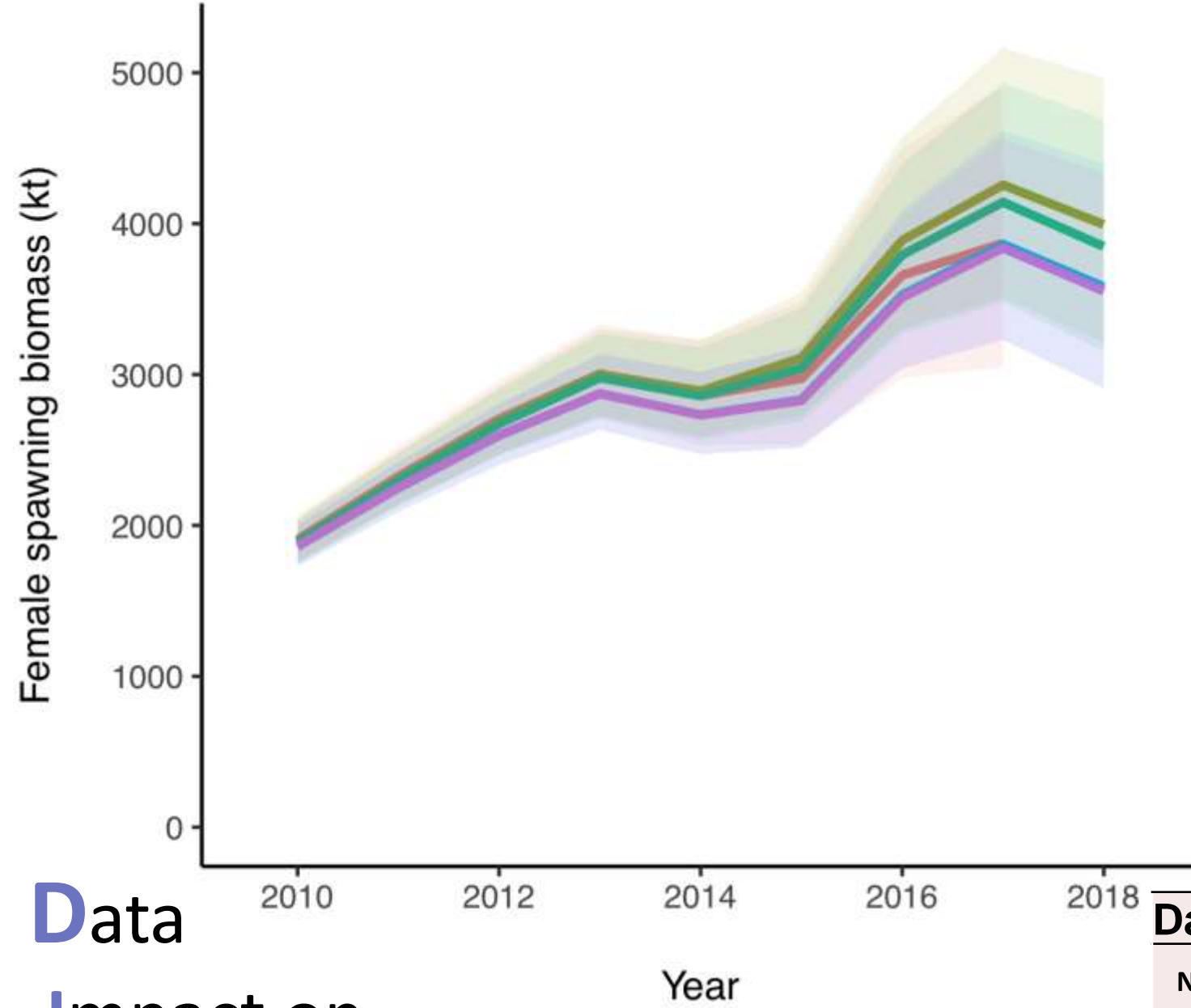
Data considerations

Name	Updated catch to 2018	2018 ATS data	2018 Bottom trawl data	AVO 2018
Catch	X			
+ATS	X	X		
+BTS	X	X	X	
+AVO	X	X	X	X

Data

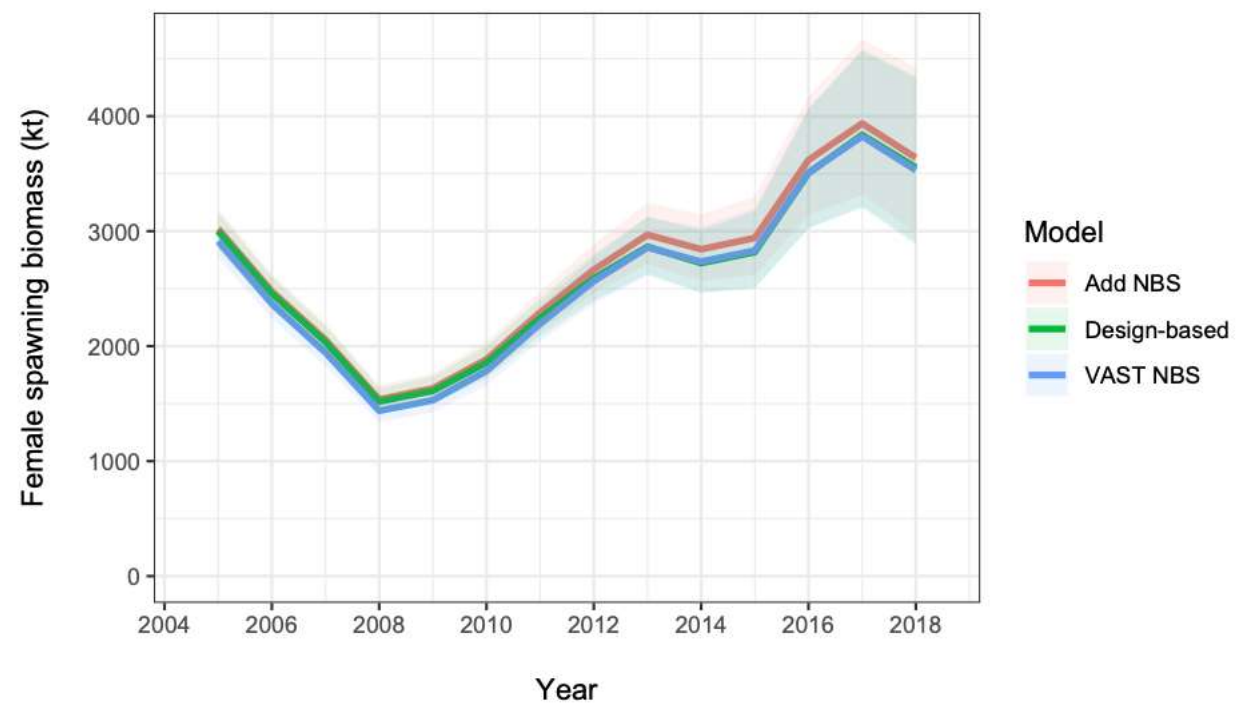
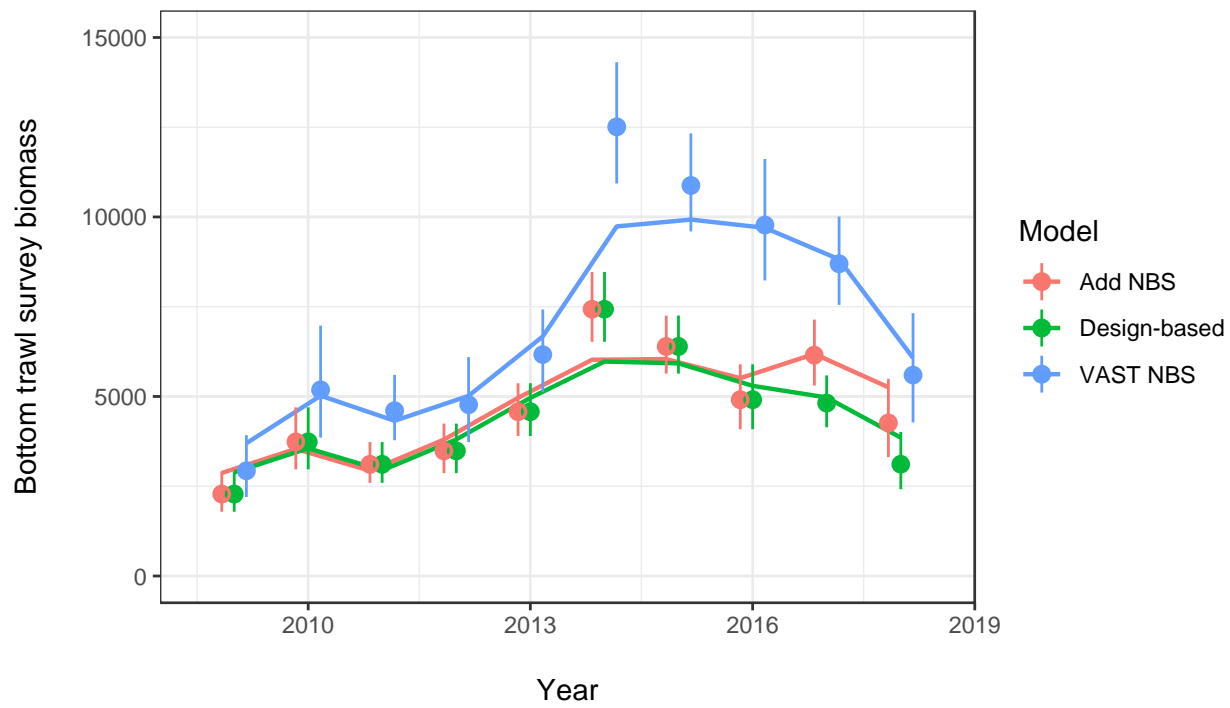
Impact on

Model



Data
Impact on
Model

Data considerations				
Name	Updated catch to 2018	2018 ATS data	2018 Bottom trawl data	AVO 2018
Catch	X			
+ATS	X	X		
+BTS	X	X	X	
+AVO	X	X	X	X



Model details (1 of 2)

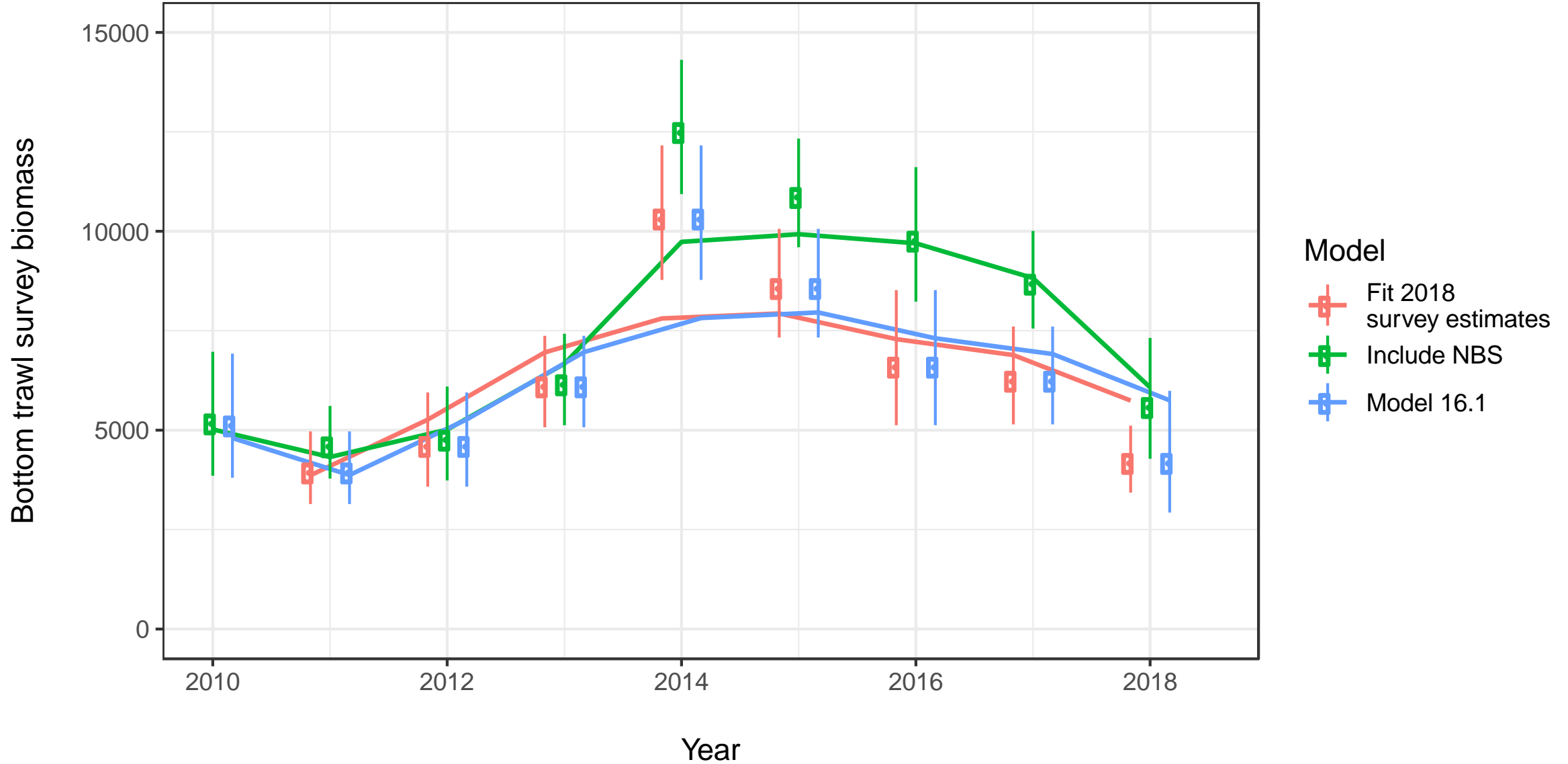
- Tuning indices
 - Acoustic Trawl survey
 - Available biennially (usually)
 - Annual fixed-station bottom trawl survey
 - Tested including northern Bering Sea from VASt
 - Acoustic vessel of opportunity (AVO index)
 - Two new years of data every other year
 - Old foreign trawler CPUE (in 1970s)
- Fishery data
 - Total catch
 - Catch-at-age
 - Mean fishery weights-at-age

Model details (2 of 2)

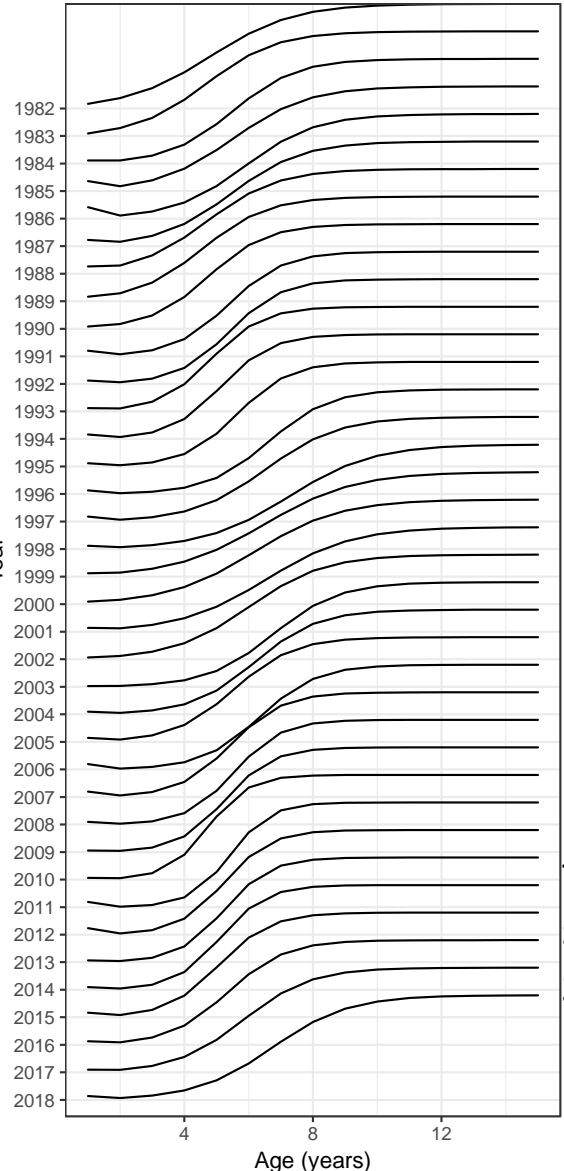
- Age specific schedules
 - Natural mortality
 - Ages 1 and 2 higher, other ages fixed at 0.3
 - Maturity
 - Fixed, 50% at ~ age 3.5 years
- Other
 - Conditioned on catch biomass (F's estimated)
 - Selectivity varies in fishery
 - Slightly in surveys
 - Stock recruitment model Ricker, affects ABC values,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

Alternative models for bottom-trawl survey

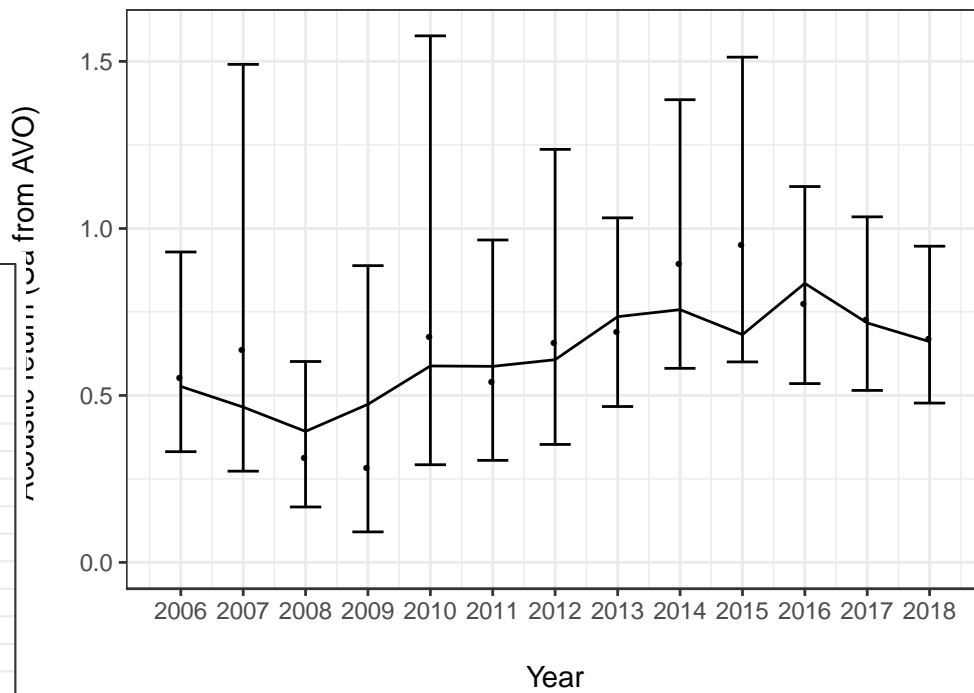
EBS pollock
Assessment
Results



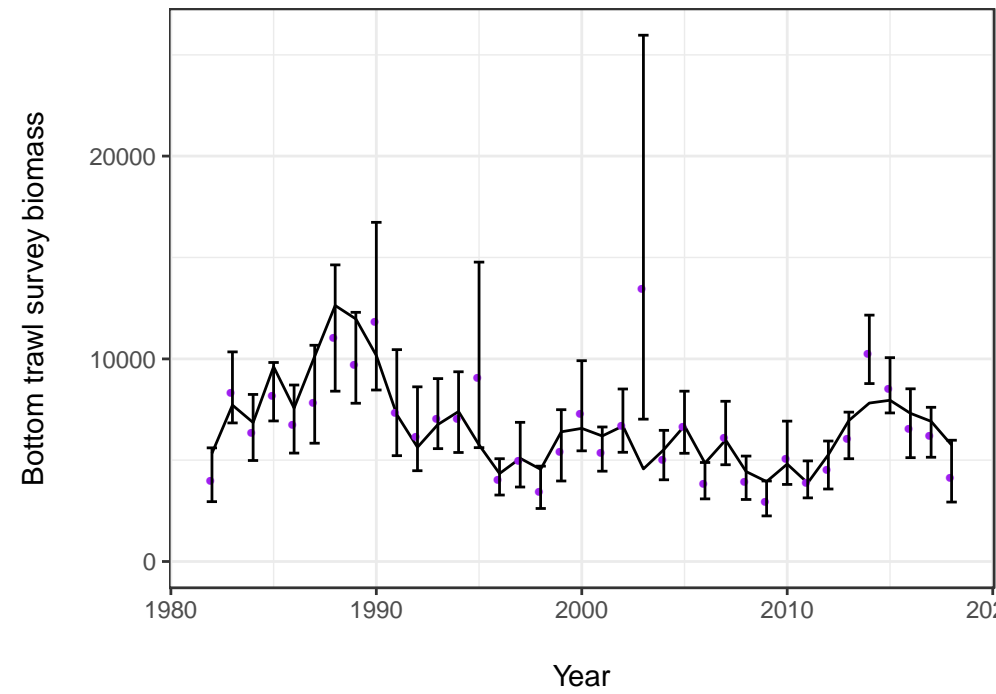
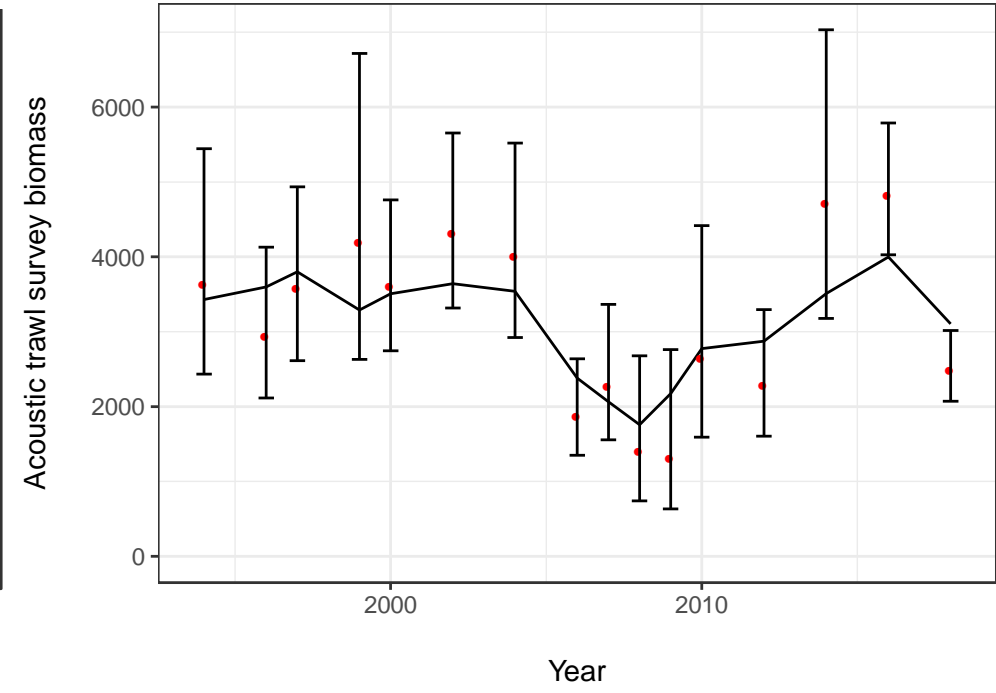
EBS pollock
Assessment
Results



Bottom
trawl
survey
Selectivity...

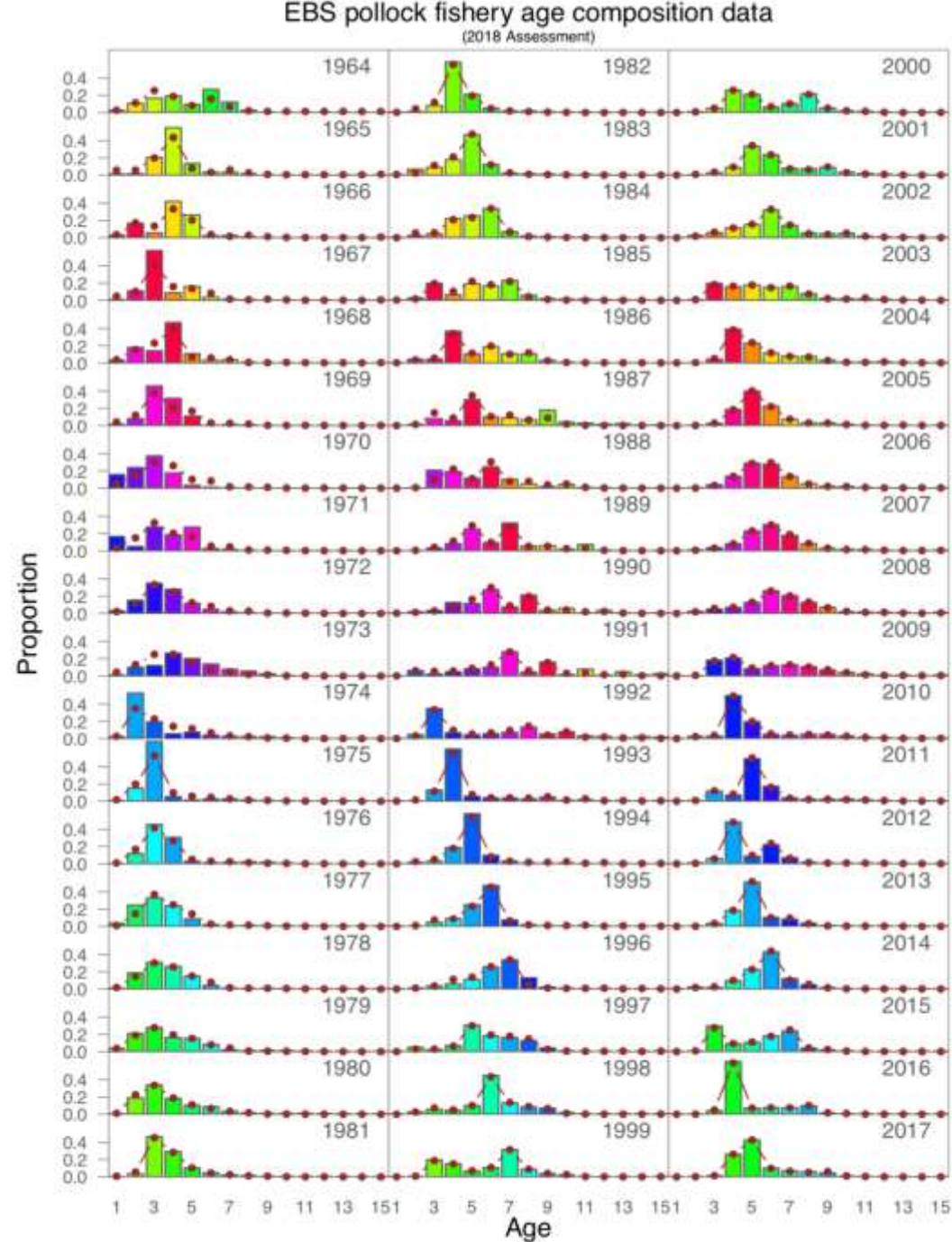


**Model
fits to indices**



EBS pollock
Assessment
Results

Bering Sea
pollock
fishery
age data and
fits

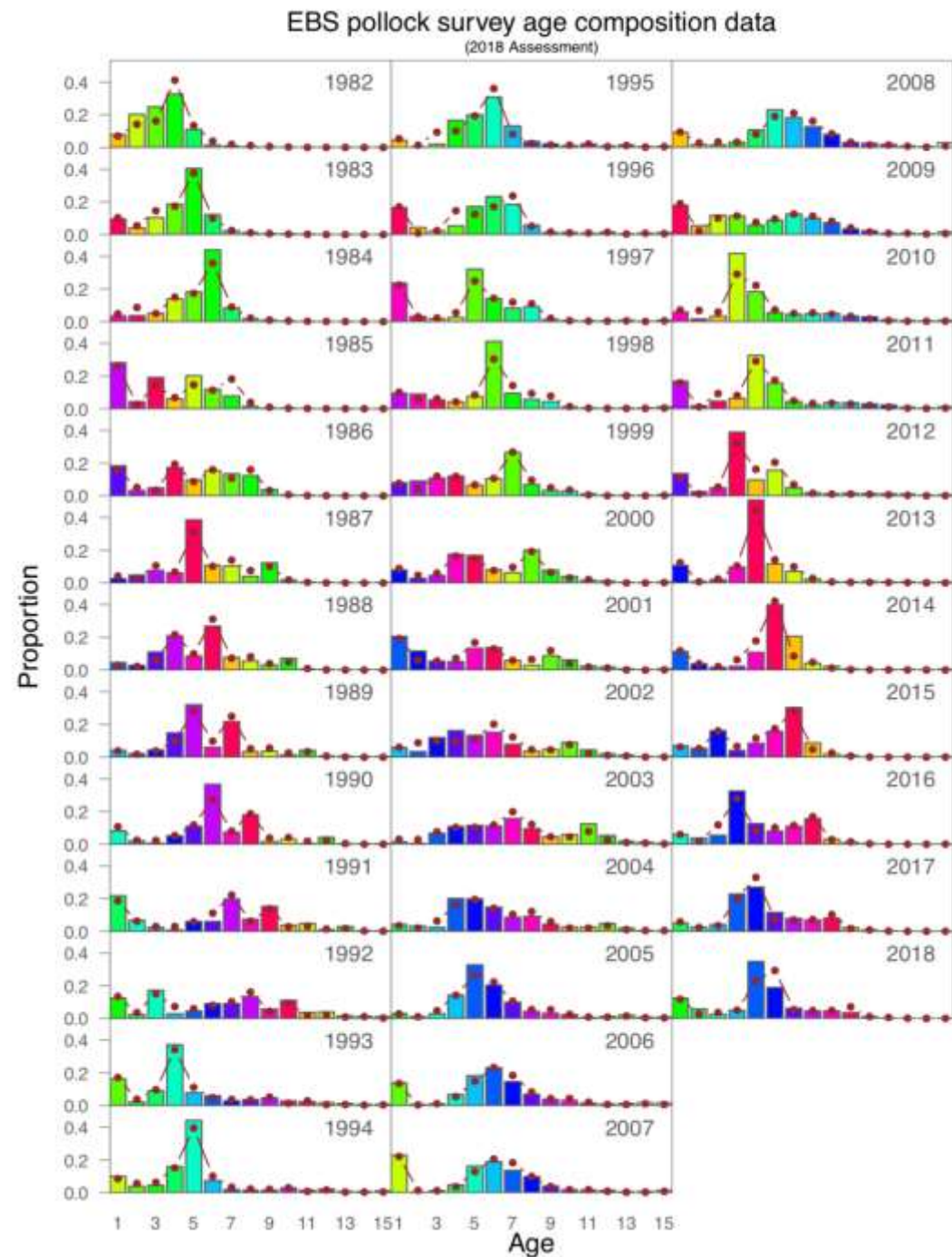


EBS pollock
Assessment
Results

Bering Sea
pollock

Bottom trawl survey

age data and
fits

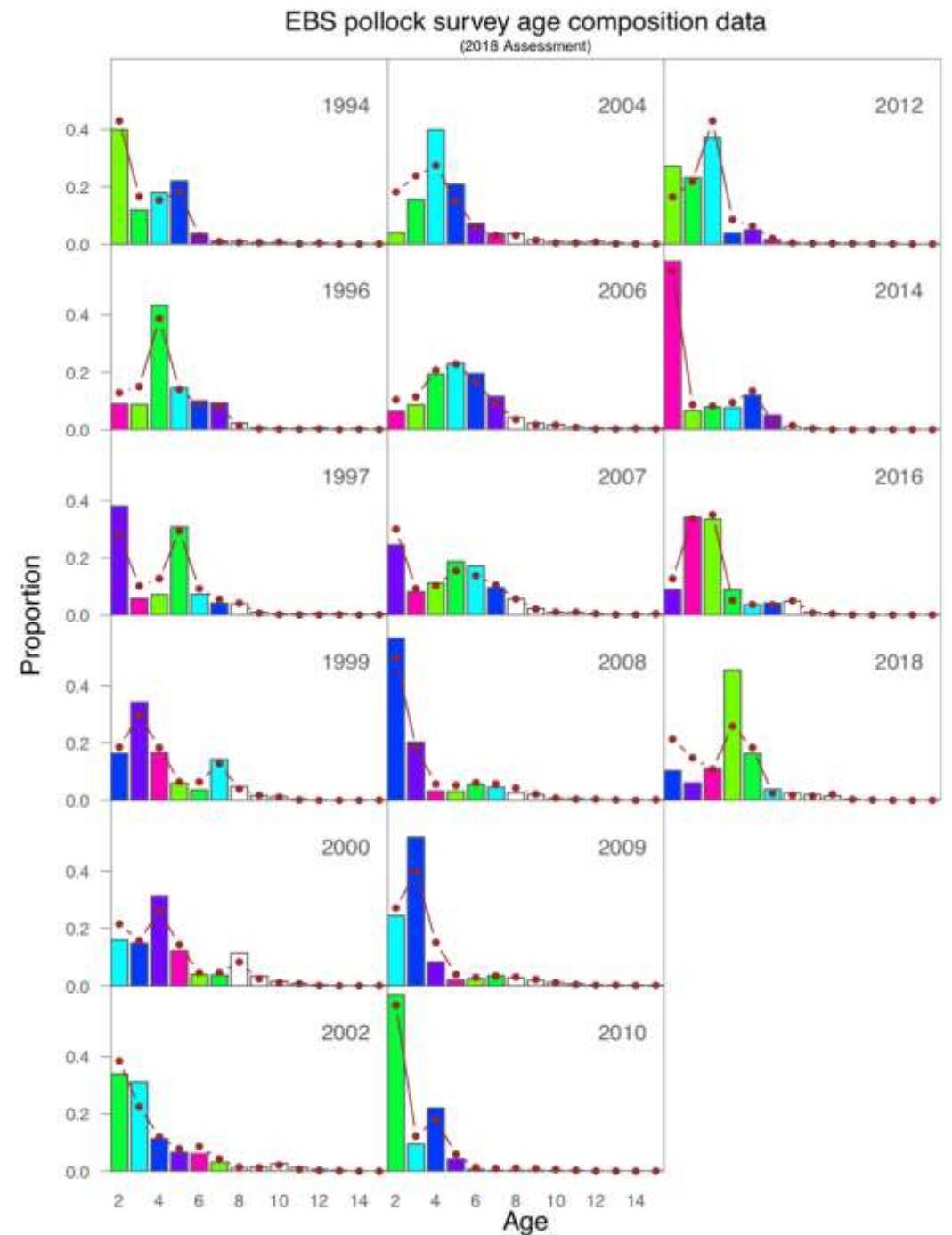


EBS pollock
Assessment
Results

Bering Sea
pollock

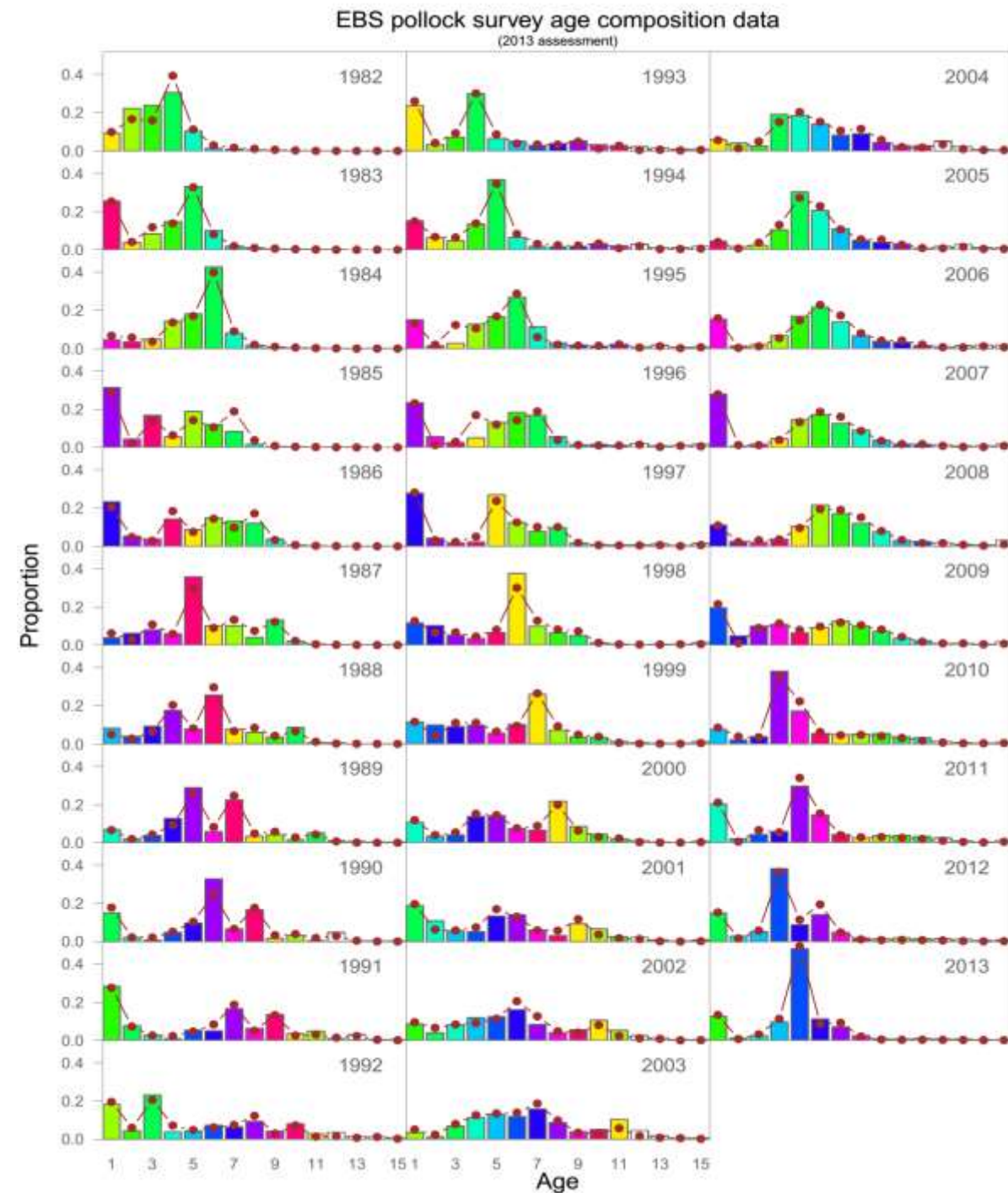
Acoustic survey

age data and
fits



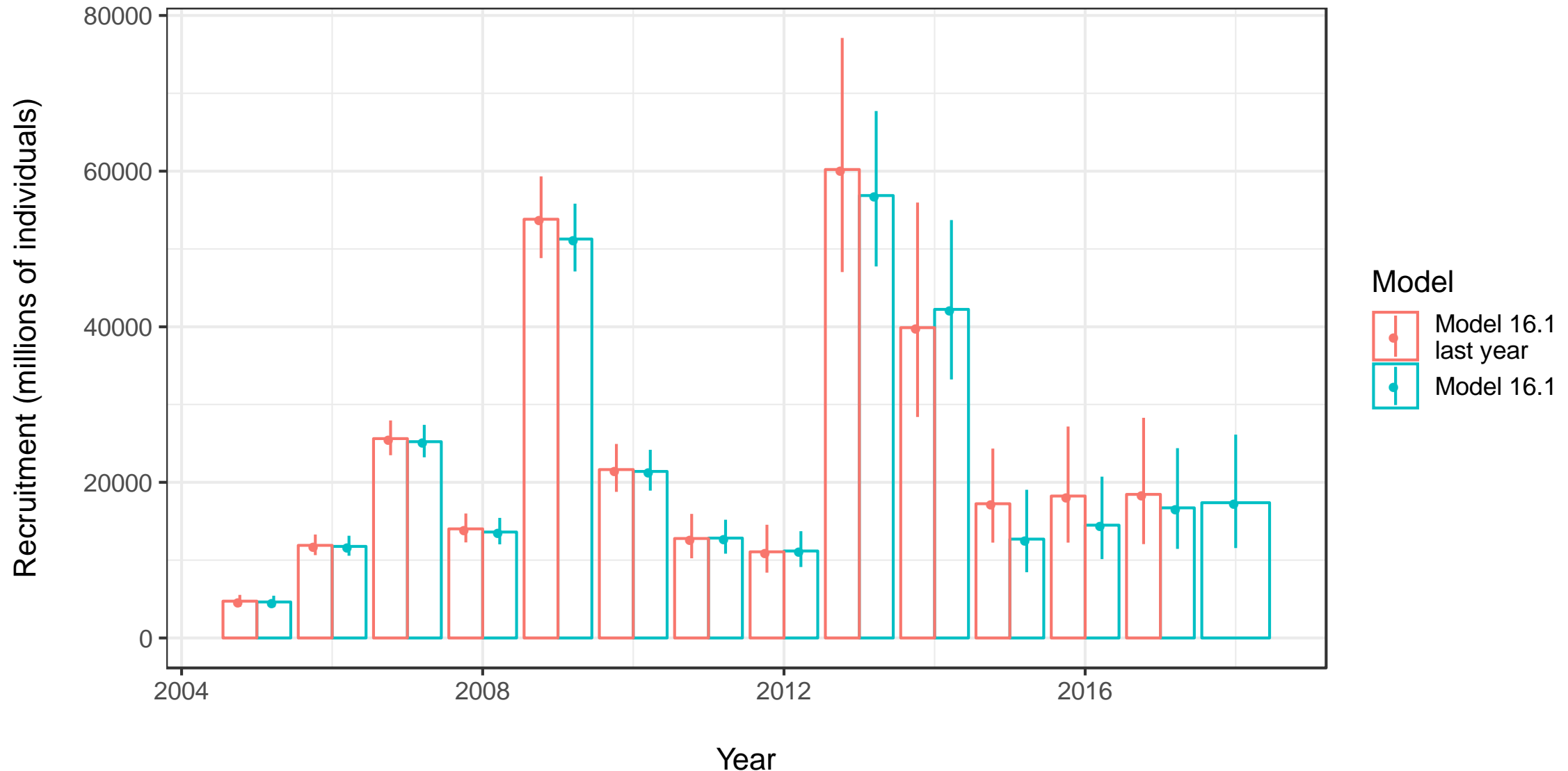
EBS pollock
Assessment
Results

Bering Sea
pollock
survey
age data and
fits



EBS pollock
Assessment
Results

EBS pollock recruitment estimates

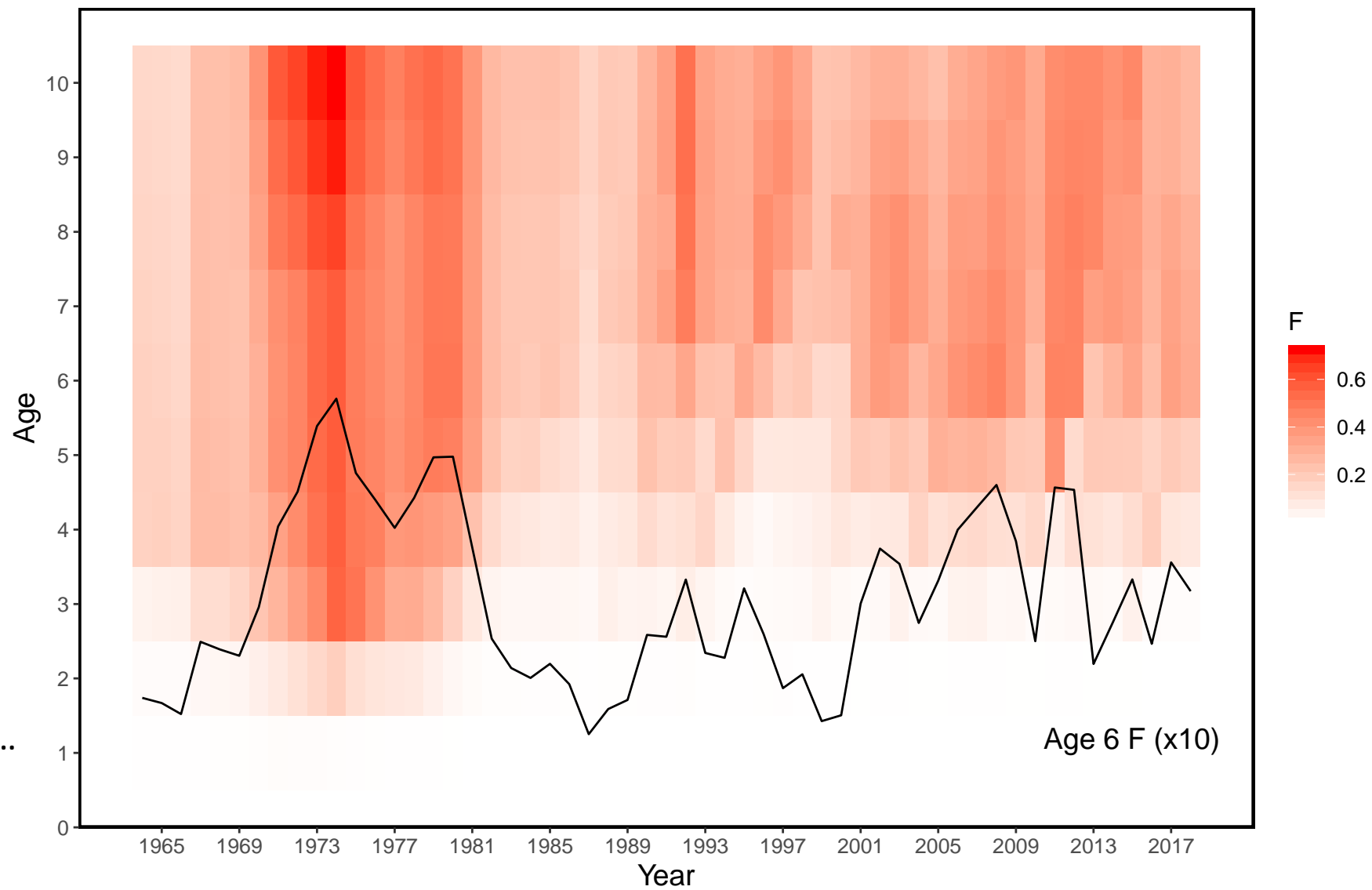
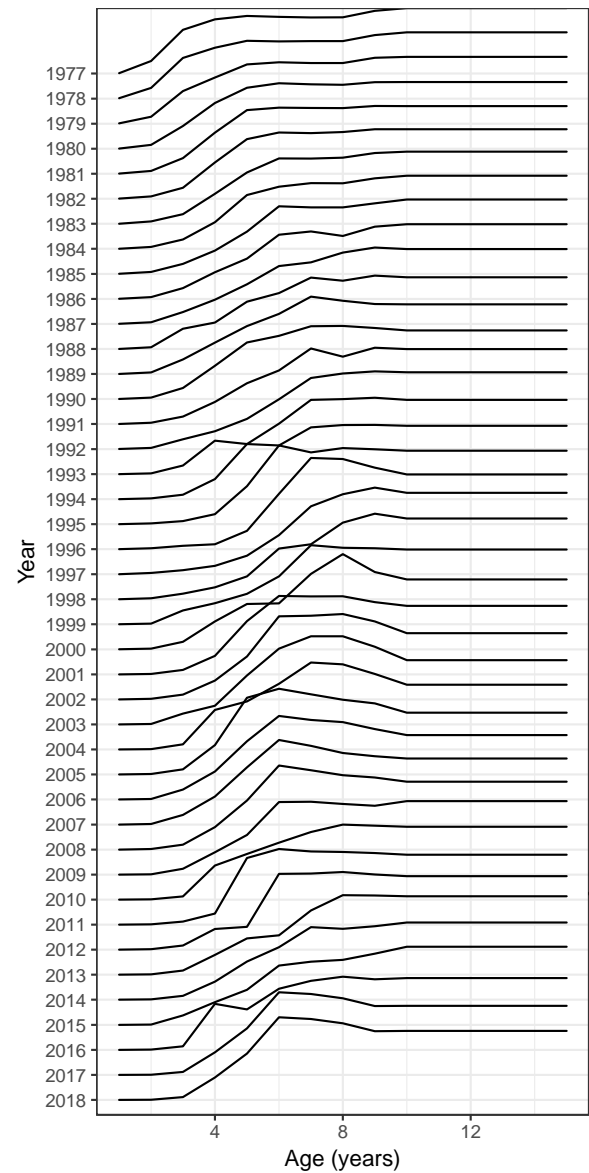


Fishing mortality rates

EBS pollock

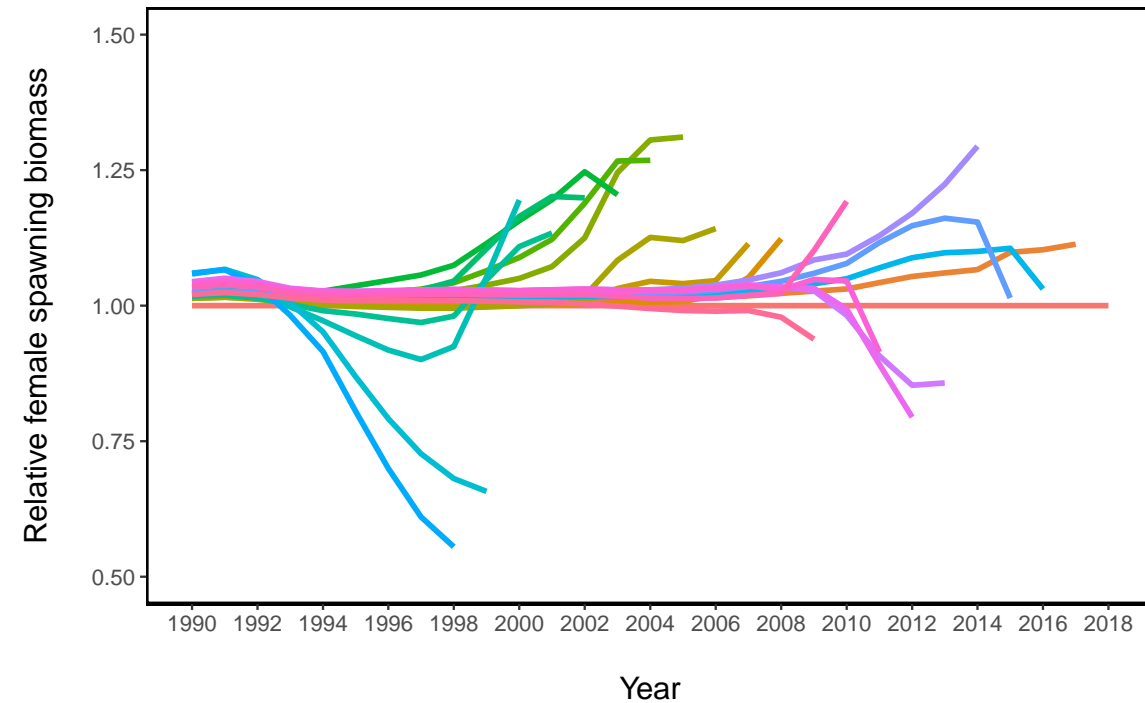
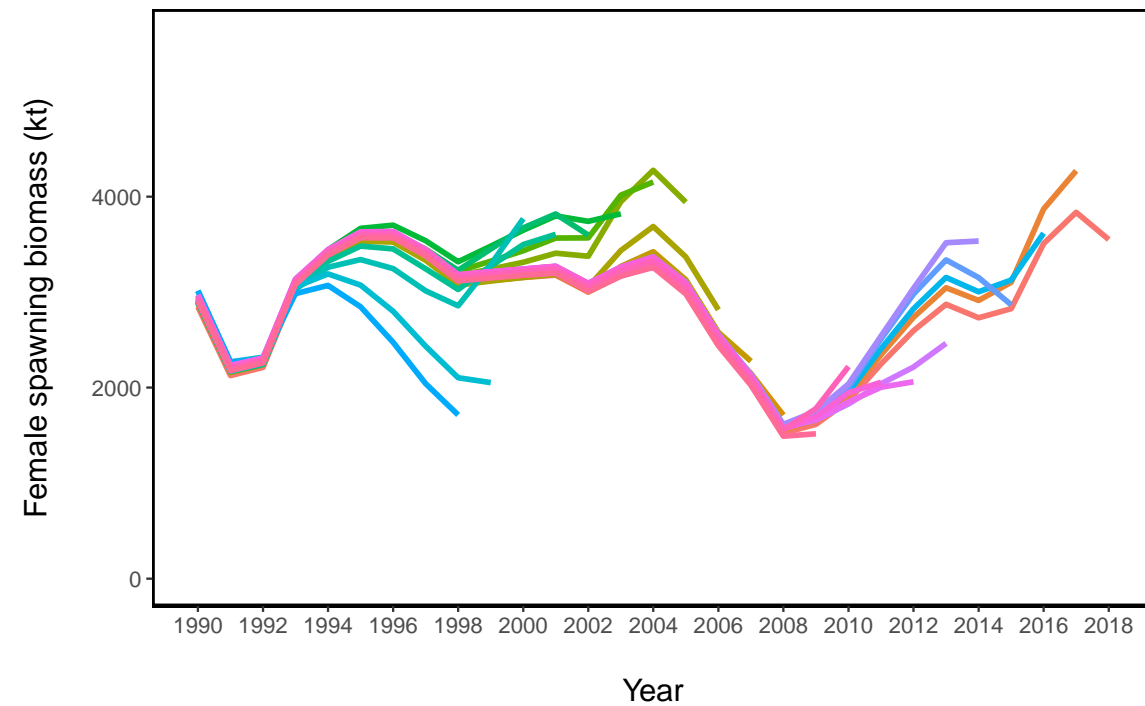
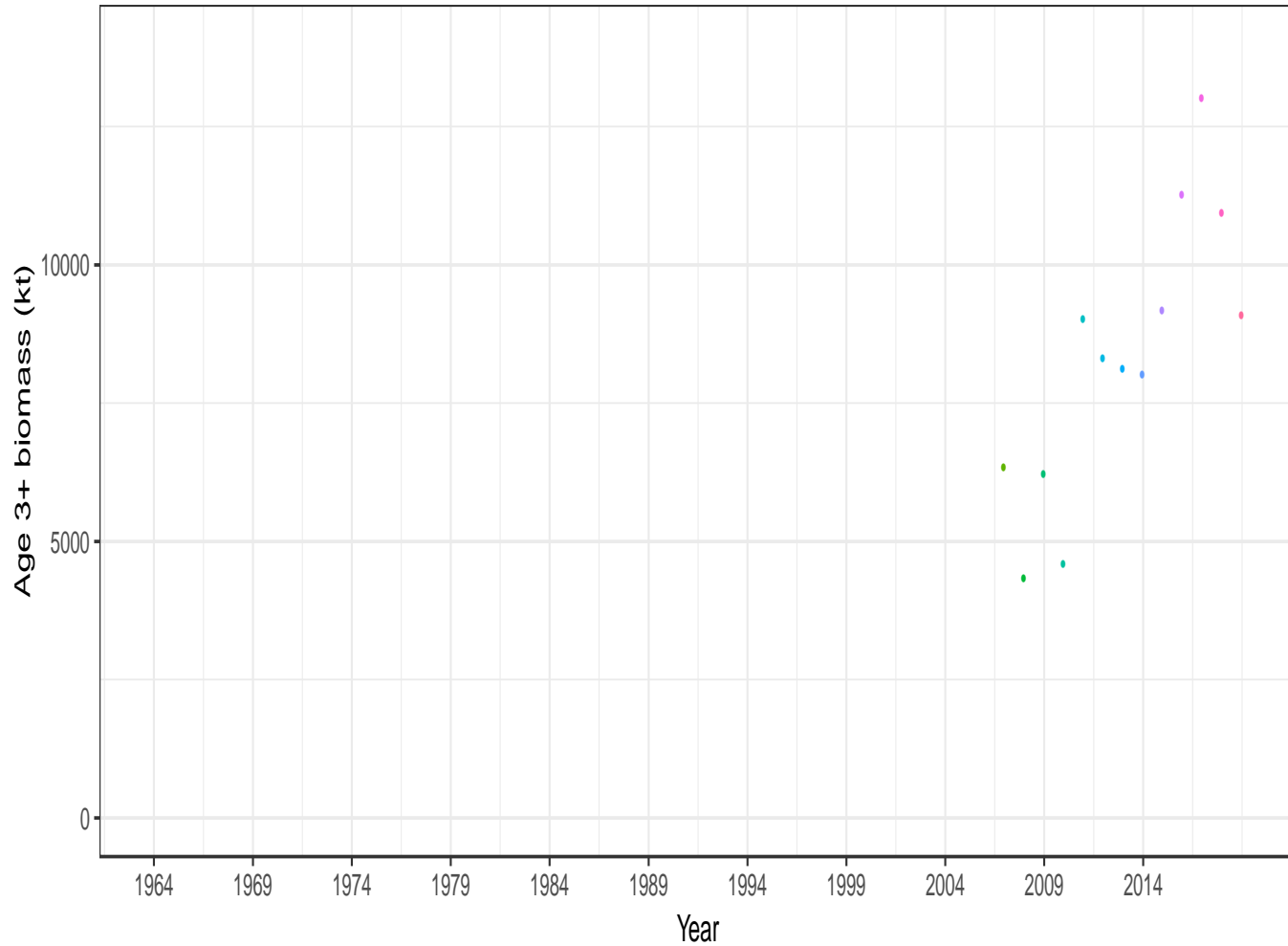
Assessment

Results

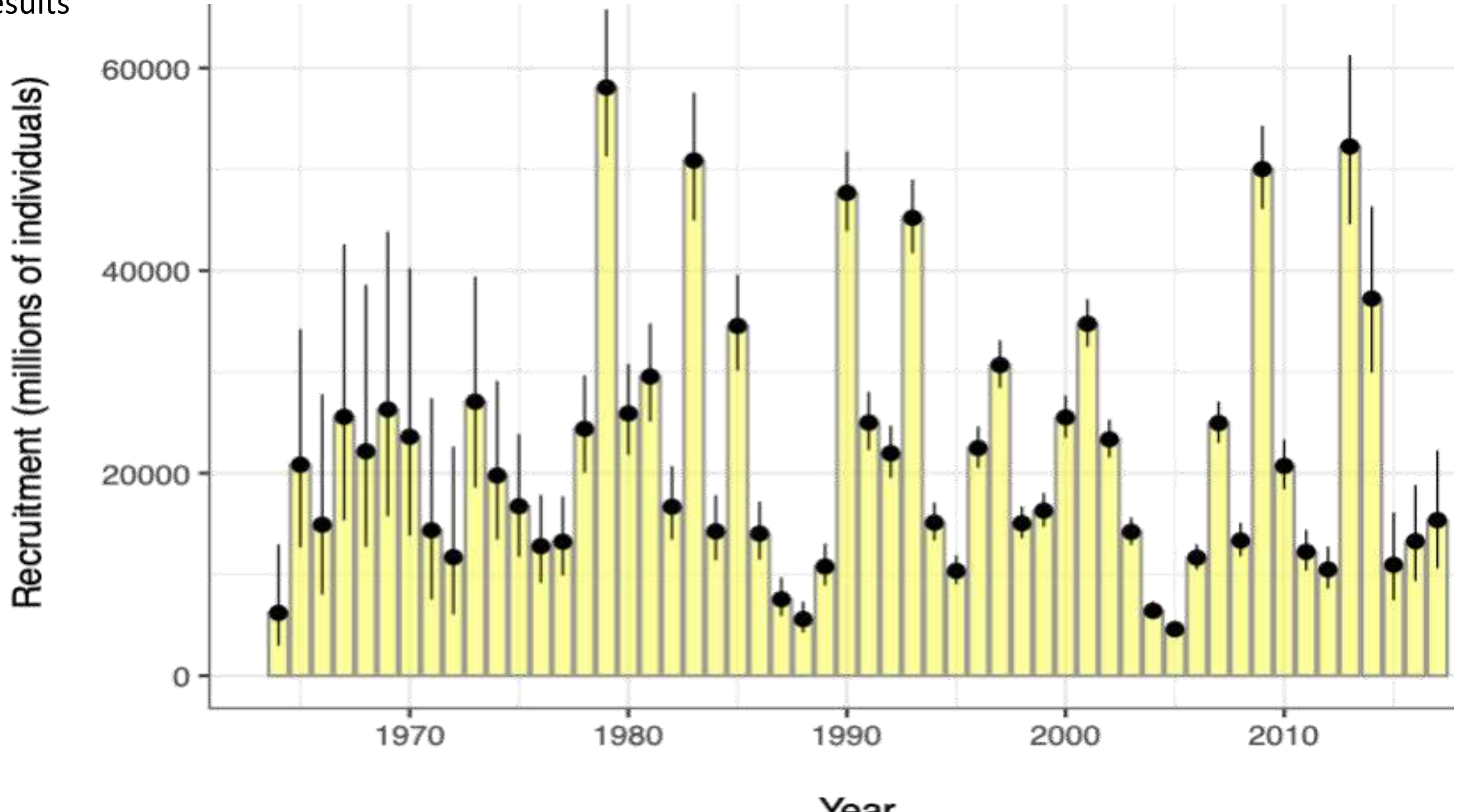


EBS pollock
Assessment
Results

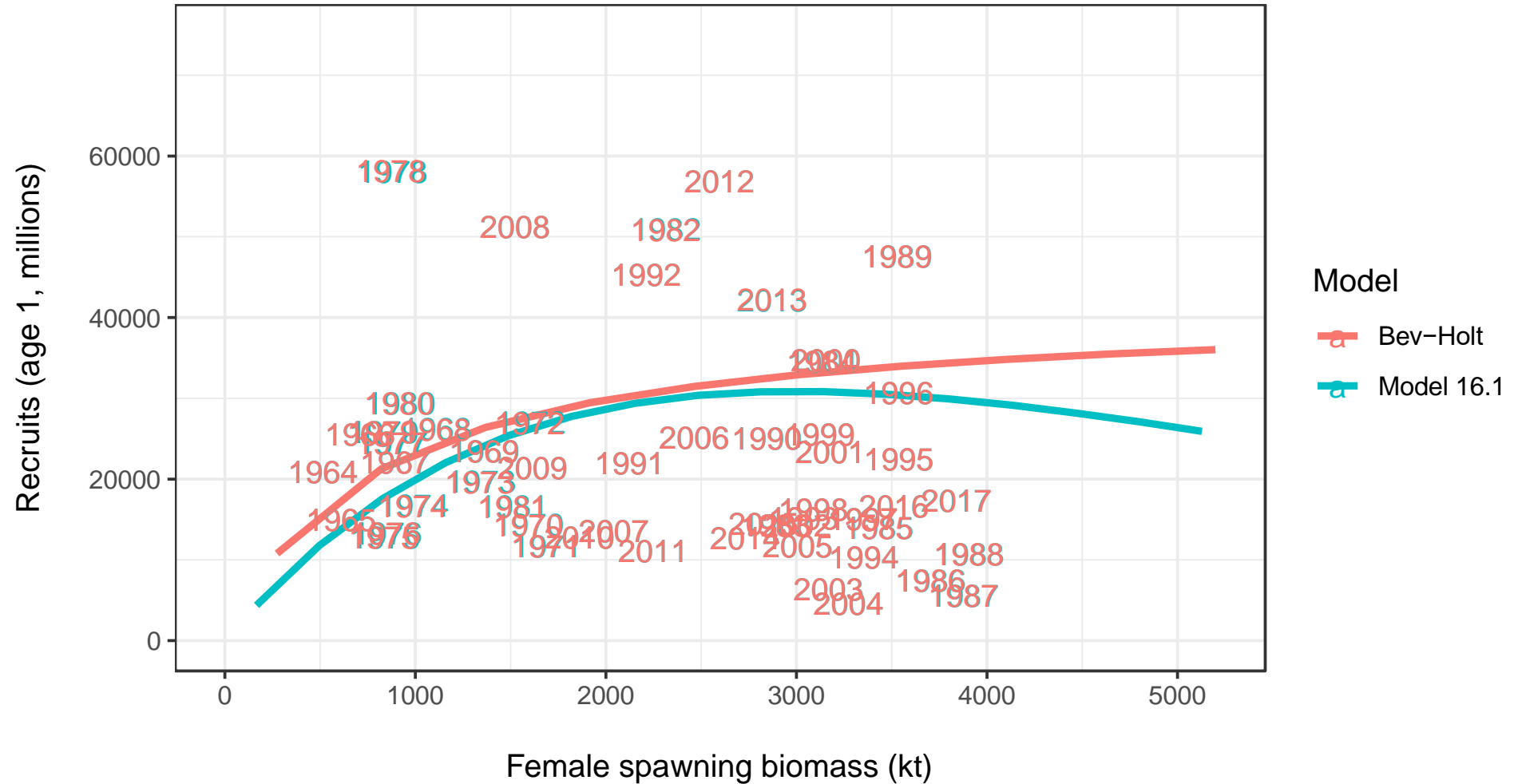
Retrospective



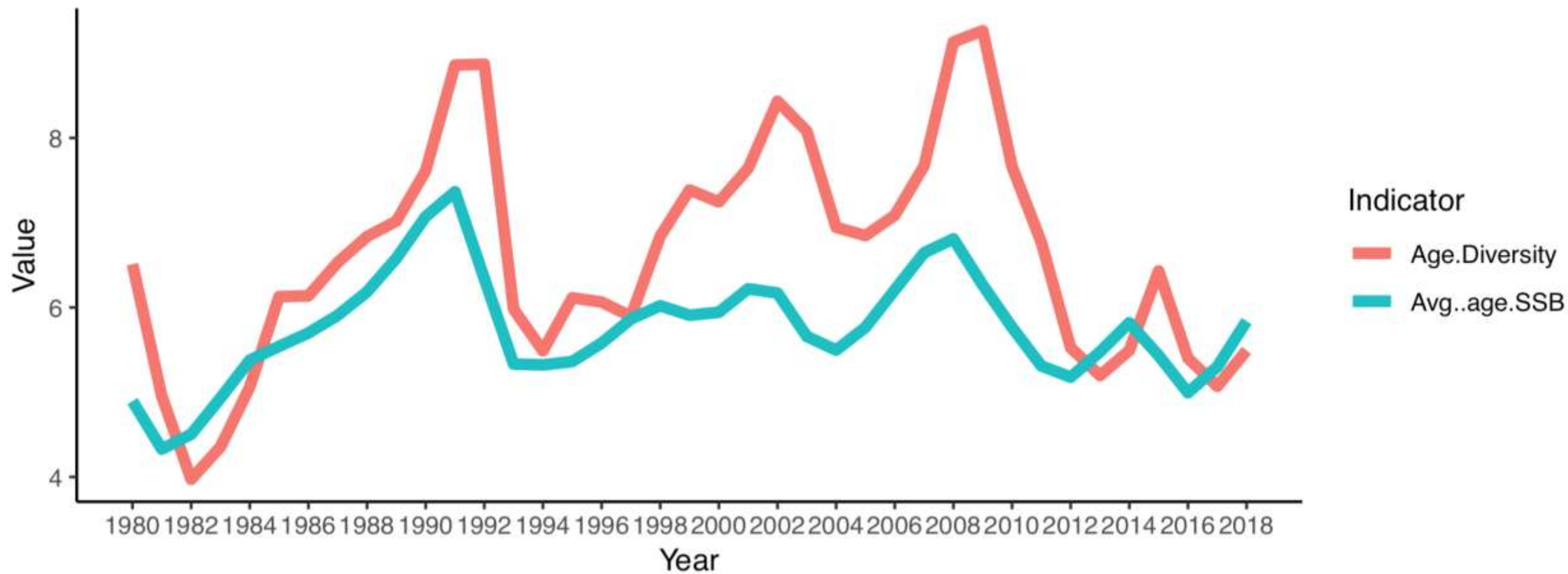
EBS pollock
Assessment
Results



2018 Stock recruitment evaluation

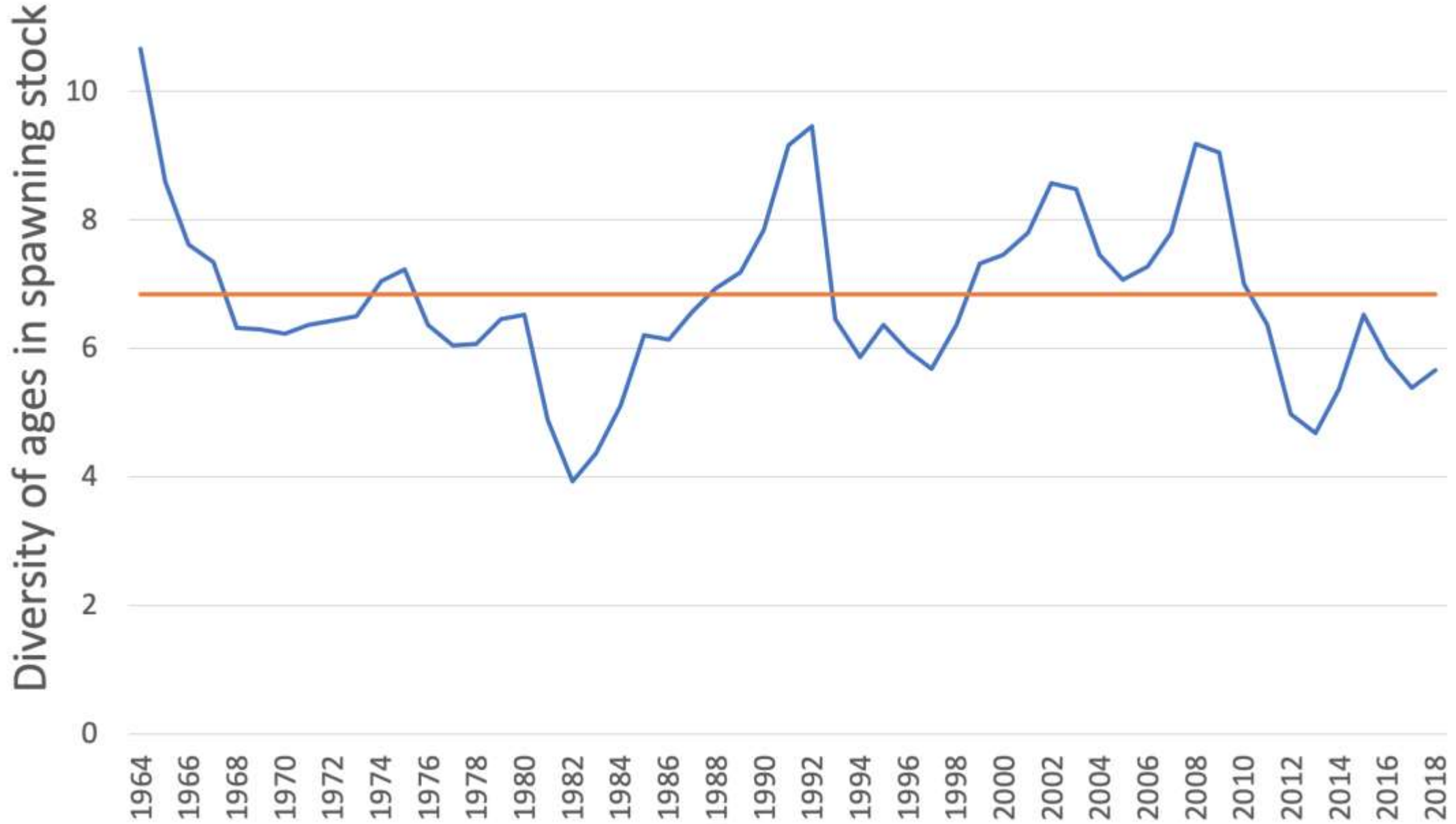


EBS pollock
Assessment
Results



Diversity of age groups in spawning biomass

EBS pollock
Assessment
Results



Decision table diagnostics included

Table 44: Outcomes of decision (expressed as chances out of 100) given different 2019 catches (first row, in kt). Note that for the 2017 and later year-classes average values were assumed. Constant F's based on the 2019 catches were used for subsequent years.

	10	500	1000	1250	1374	1500	1750	2000
$P [F_{2019} > F_{MSY}]$	0.0	0.0	0.0	0.0	0.2	0.7	3.7	10.1
$P [B_{2020} < B_{MSY}]$	13.3	17.7	23.9	27.7	29.8	32.1	37.2	42.8
$P [B_{2021} < B_{MSY}]$	8.5	13.6	21.6	26.9	29.9	33.2	40.4	48.3
$P [B_{2020} < \bar{B}]$	1.4	8.8	30.2	45.6	53.5	61.5	75.5	86.0
$P [B_{2023} < B]$	2.1	7.6	18.1	24.7	28.2	31.8	39.1	46.4
$P [B_{2023} < B_{2019}]$	6.9	16.9	30.8	38.1	41.7	45.2	51.8	57.8
$P [B_{2021} < B_{20\%}]$	0.3	0.6	1.0	1.4	1.6	1.9	2.6	3.5
$P [p_{a_5,2021} > \bar{p}_{a_5}]$	10.7	30.9	53.6	62.9	66.8	70.4	76.2	80.6
$P [D_{2020} < D_{1994}]$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$P [D_{2023} < D_{1994}]$	0.0	0.6	3.1	5.7	7.4	9.4	14.6	21.3
$P [E_{2019} > E_{2018}]$	0.0	0.0	3.8	41.7	63.7	79.4	93.8	98.1

Factors for reducing ABC

	Considerations		
	Assessment-related	Population dynamics	Environmental & ecosystem
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
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.
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)
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

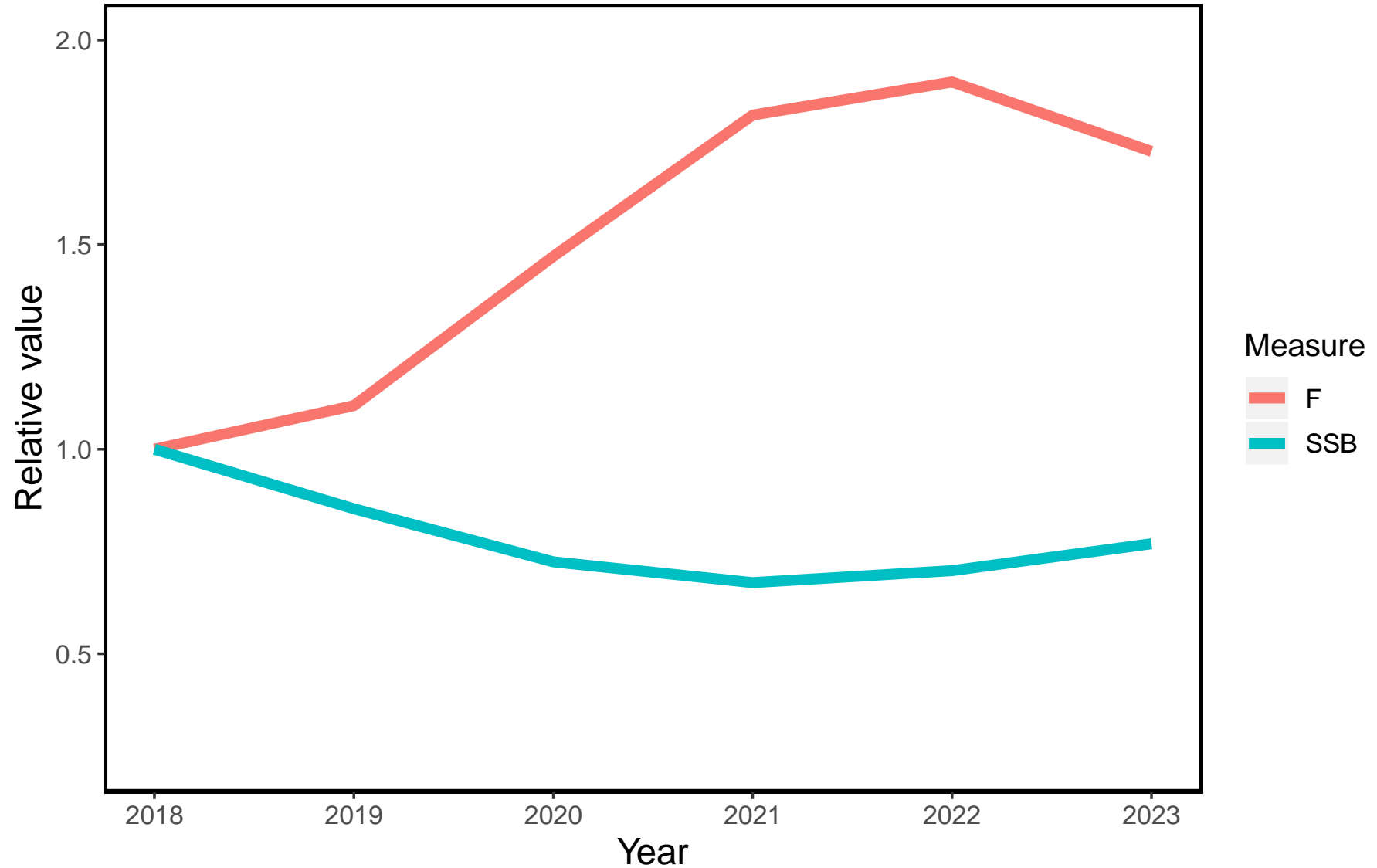
- Unprecedented warm conditions in 2018 resulted in reduced primary and secondary production
- The cold pool prediction for summer 2019 is for continued warm conditions and reduced cold pool extent
- Weak, delayed phytoplankton bloom, reduced biomass, and reduced energy transfer to upper trophic levels (i.e., zooplankton prey base and juvenile pollock)
- Zooplankton prey base reduced (small, lipid-poor taxa, few euphausiids)
- Adult pollock condition index is negative in both SEBS and NBS and has been trending downwards in SEBS since 2010.
- Unprecedented seabird die-off event and broad reproductive failures indicate, in part, a lack of sufficient prey resources

We therefore rated the Ecosystem concern as Level 2, substantially increased concern.
 These results are summarized as:

Assessment-related	Considerations		Score (max of individual)
	Population dynamics	Environmental or ecosystem	
Level 1: No concern	Level 2: Substantially increased concerns	Level 2: Substantially increased concerns	Level 2: Substantially increased concerns

Fishery effort relative to SSB impact

Projected trend relative to 2018 given future catch=1,350 kt





EBS pollock summary

- Outlook
 - Spawning biomass projected to decline from high levels
 - Decision table may help with TAC considerations

Summary of EBS pollock results

85% of Tier 1 maxABC

Quantity	As estimated or <i>specified</i> last year for:		As estimated or <i>recommended</i> this year for:	
	2018	2019	2019	2020
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)	10,965,000 t	10,117,000 t	9,110,000 t	8,156,000 t
Projected female spawning biomass (t)	3,678,000 t	3,365,000 t	3,107,000 t	2,725,000 t
B_0	5,394,000 t	5,394,000 t	5,866,000 t	5,866,000 t
B_{msy}	2,042,000 t	2,042,000 t	2,280,000 t	2,280,000 t
F_{OFL}	0.621	0.621	0.645	0.645
$maxF_{ABC}$	0.466	0.466	0.51	0.51
F_{ABC}	0.336	0.336	0.433	0.433
OFL	4,797,000 t	4,592,000 t	3,914,000 t	3,082,000 t
$maxABC$	3,603,000 t	3,448,000 t	3,096,000 t	2,437,000 t
ABC	2,592,000 t	2,467,000 t	2,631,000 t	2,072,000 t
Status	2016	2017	2017	2018
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Summary of EBS pollock results

Re-done w/ ABC=Tier 3

Quantity	As estimated or <i>specified</i> last year for:		As estimated or <i>recommended</i> this year for:	
	2018	2019	2019	2020
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)	10,965,000 t	10,117,000 t	9,110,000 t	8,156,000 t
Projected female spawning biomass (t)	3,678,000 t	3,365,000 t	3,107,000 t	2,725,000 t
B_0	5,394,000 t	5,394,000 t	5,866,000 t	5,866,000 t
B_{msy}	2,042,000 t	2,042,000 t	2,280,000 t	2,280,000 t
F_{OFL}	0.621	0.621	0.645	0.645
$maxF_{ABC}$	0.466	0.466	0.51	0.51
F_{ABC}	0.336	0.336	0.356	0.356
OFL	4,797,000 t	4,592,000 t	3,914,000 t	3,082,000 t
$maxABC$	3,603,000 t	3,448,000 t	3,096,000 t	2,437,000 t
ABC	2,592,000 t	2,467,000 t	2,163,000 t	1,792,000 t
Status	2016	2017	2017	2018
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Work plan

- Survey data treatment
 - Joining acoustics with bottom trawl (funded proposal)
 - Refining composition data treatment
 - More AVO work
- New data collection methods
 - Sea-floor mounted echo-sounders
- Genetics work
 - For Bogoslof treatment

