



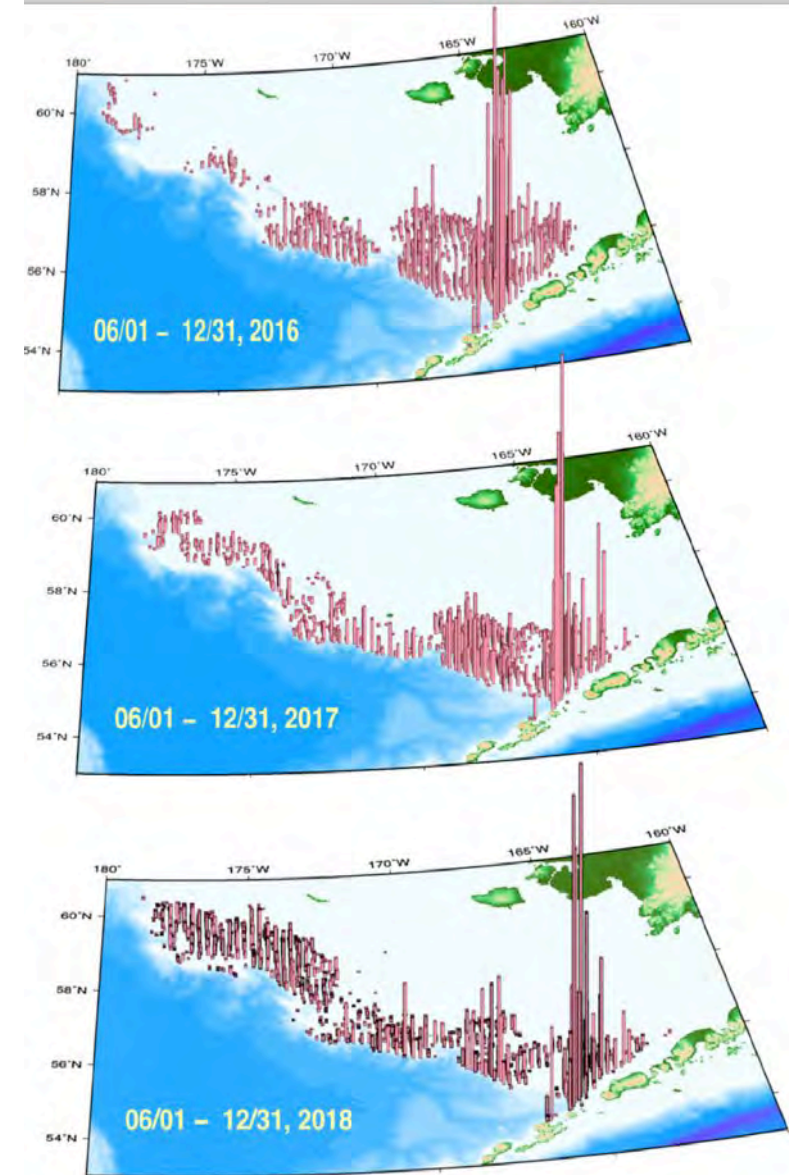
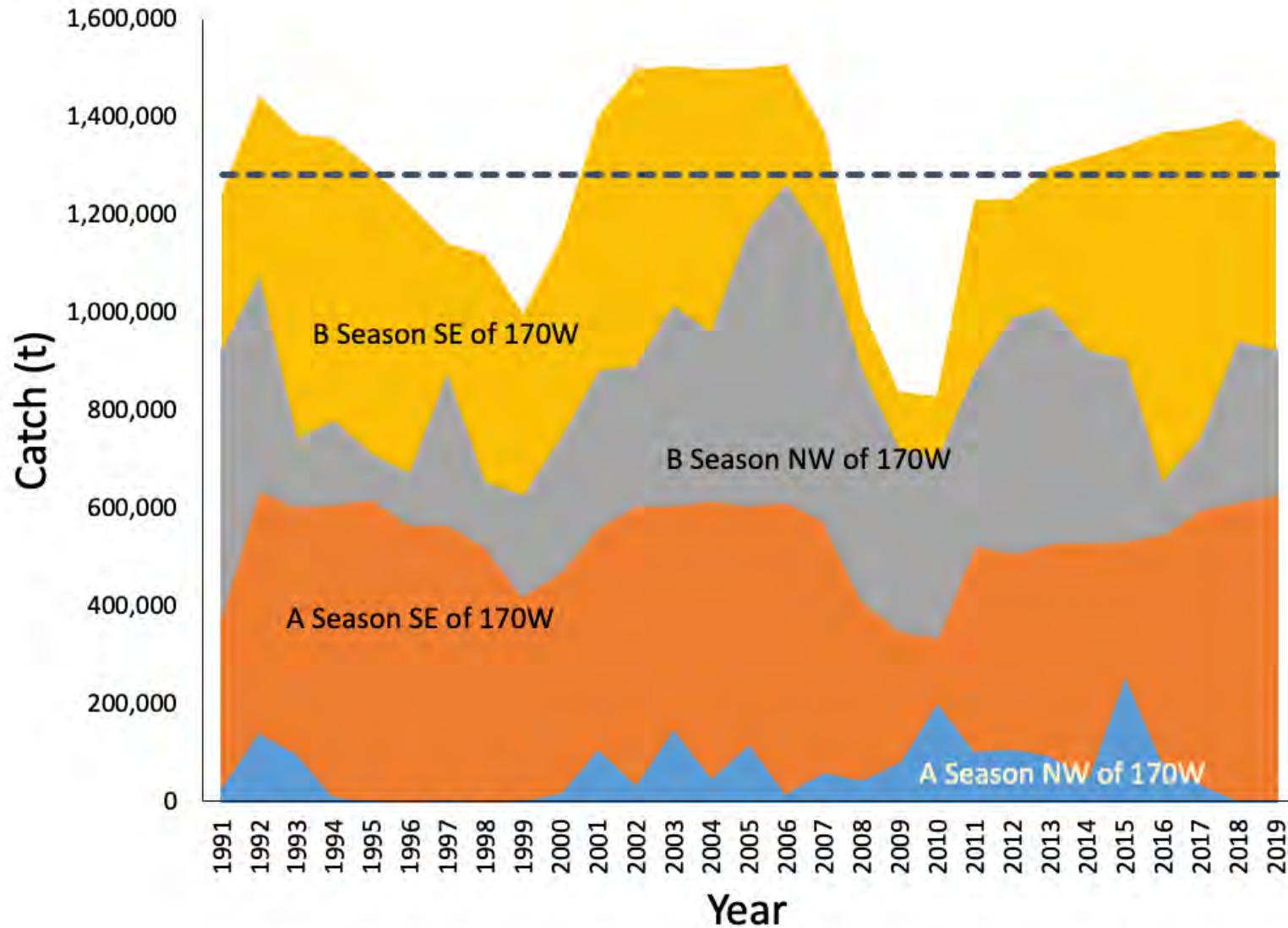
NOAA
FISHERIES

EBS Pollock stock assessment

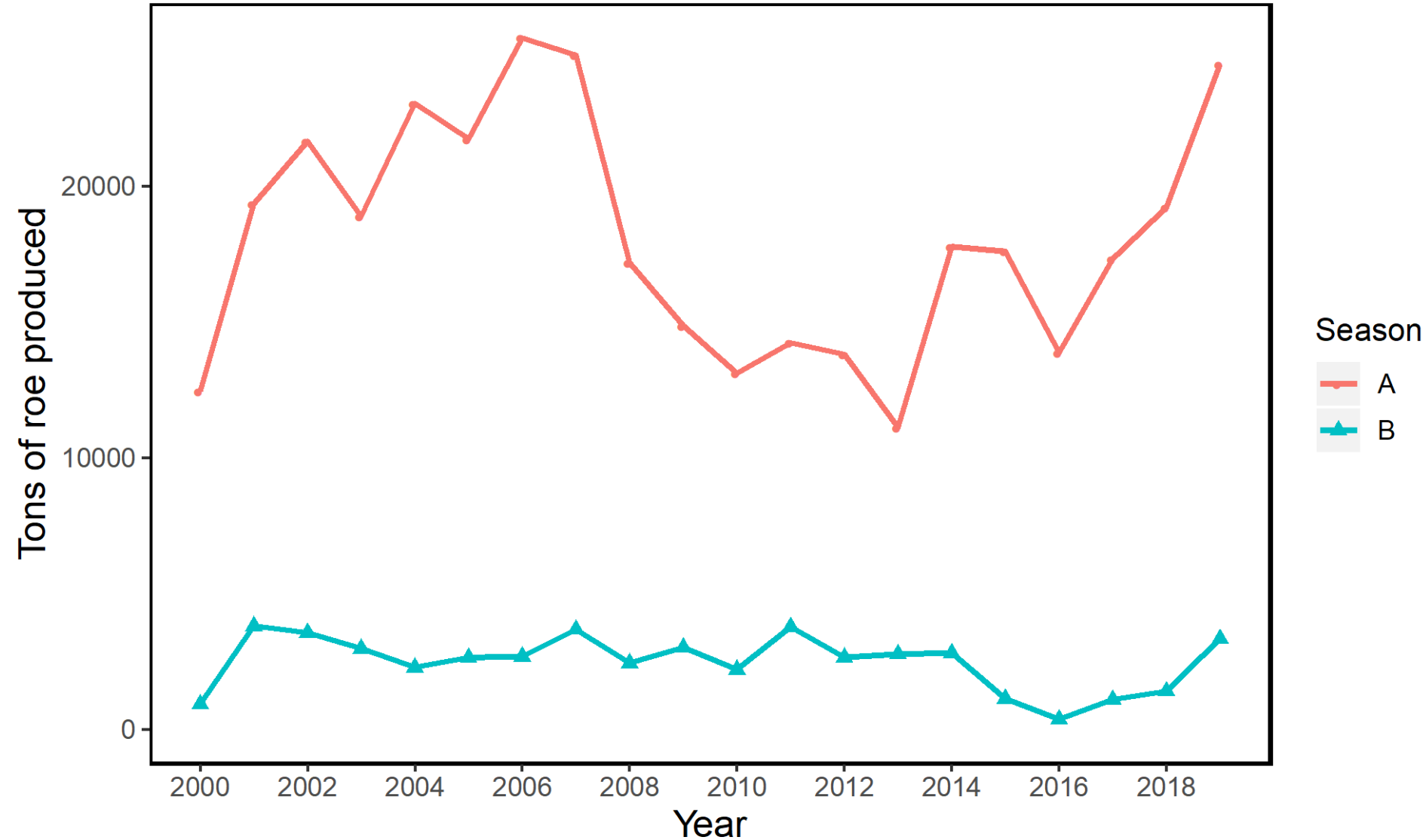
2019 BSAI Plan Team meeting

Seasonal and area catch patterns

Eastern Bering Sea pollock

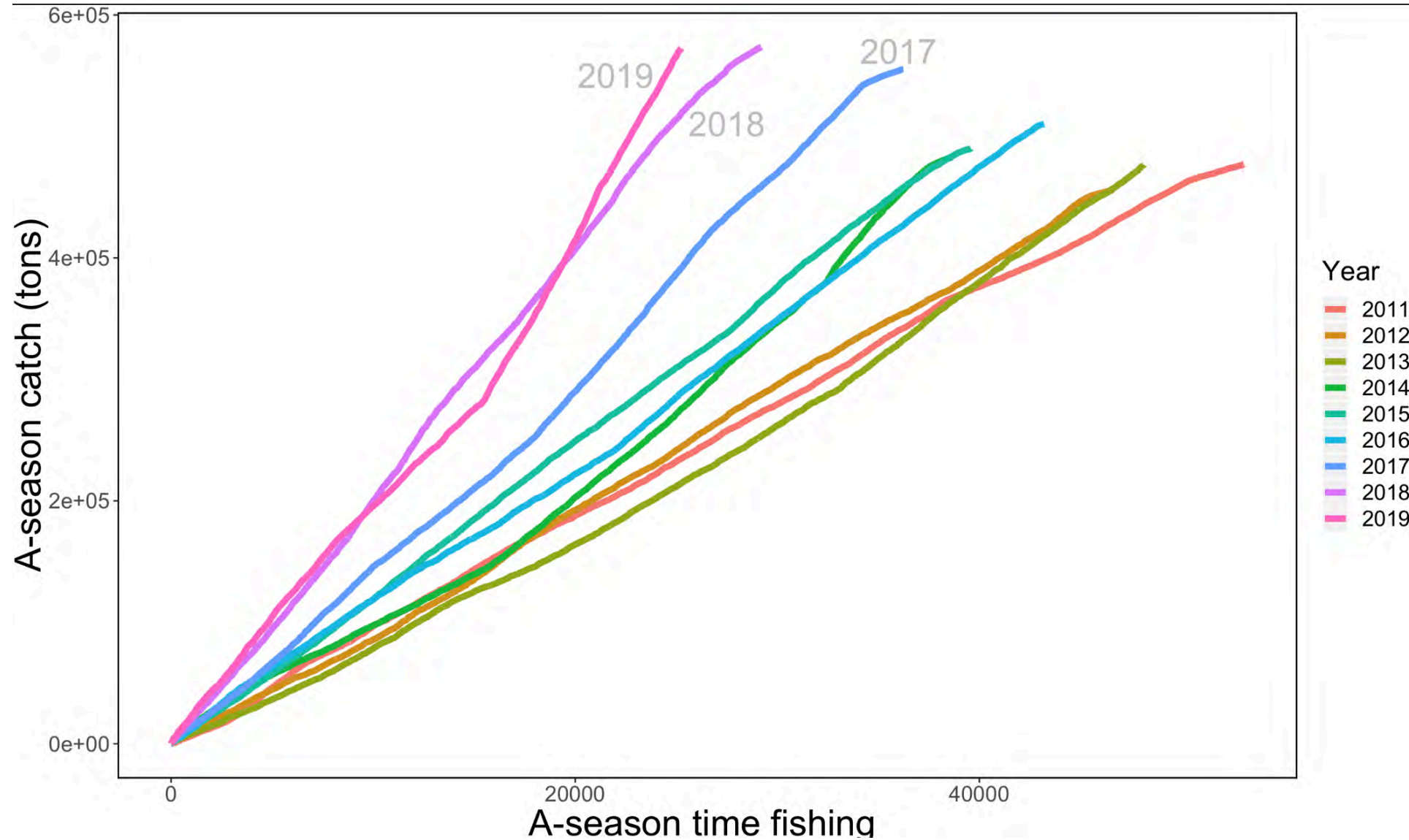
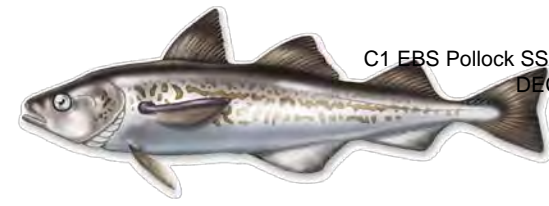


Fishing: Seasonal roe production



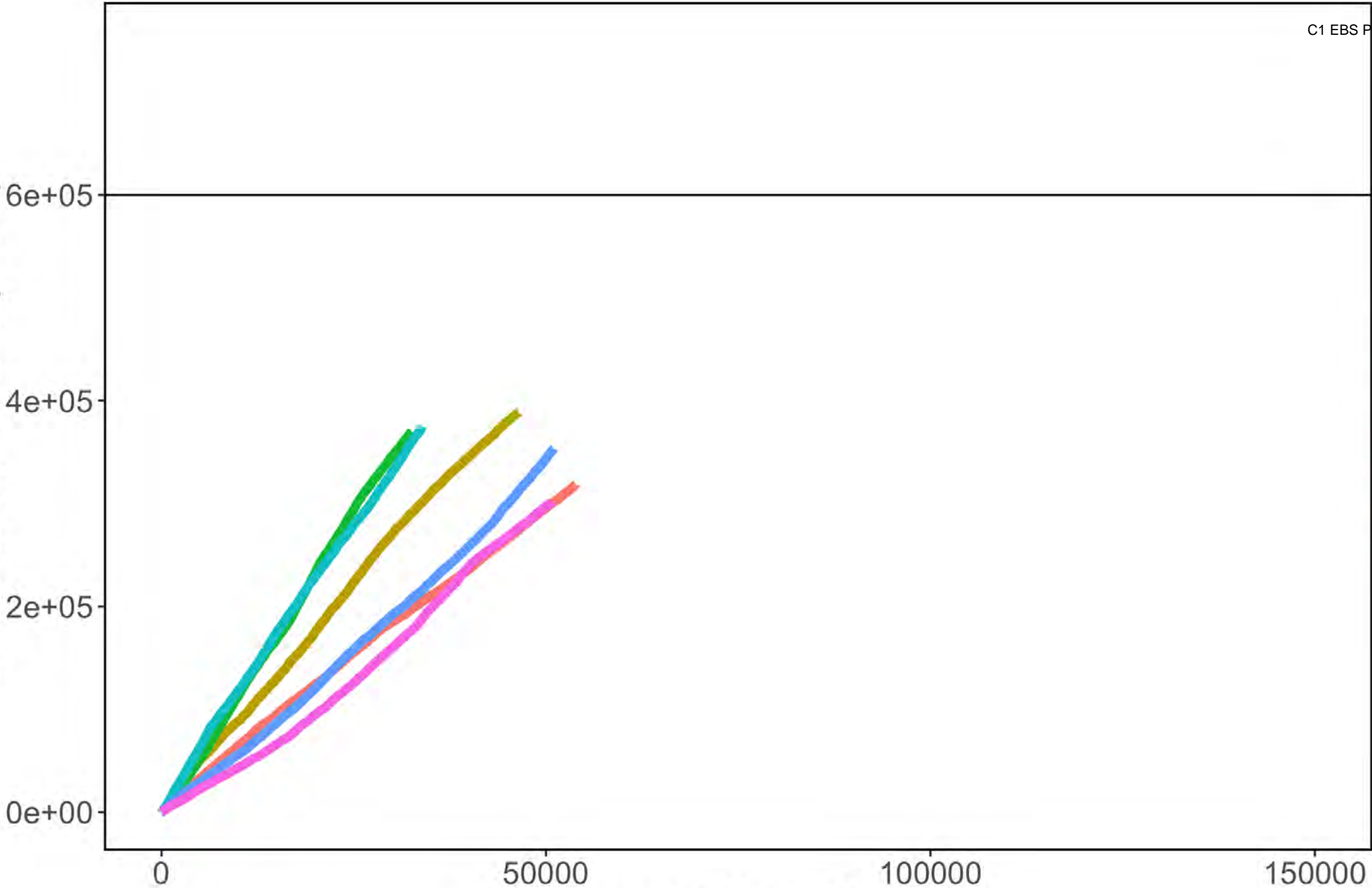
A-season

Fishing conditions



Compare to B-season (summer) conditions...

B-season catch (tons)

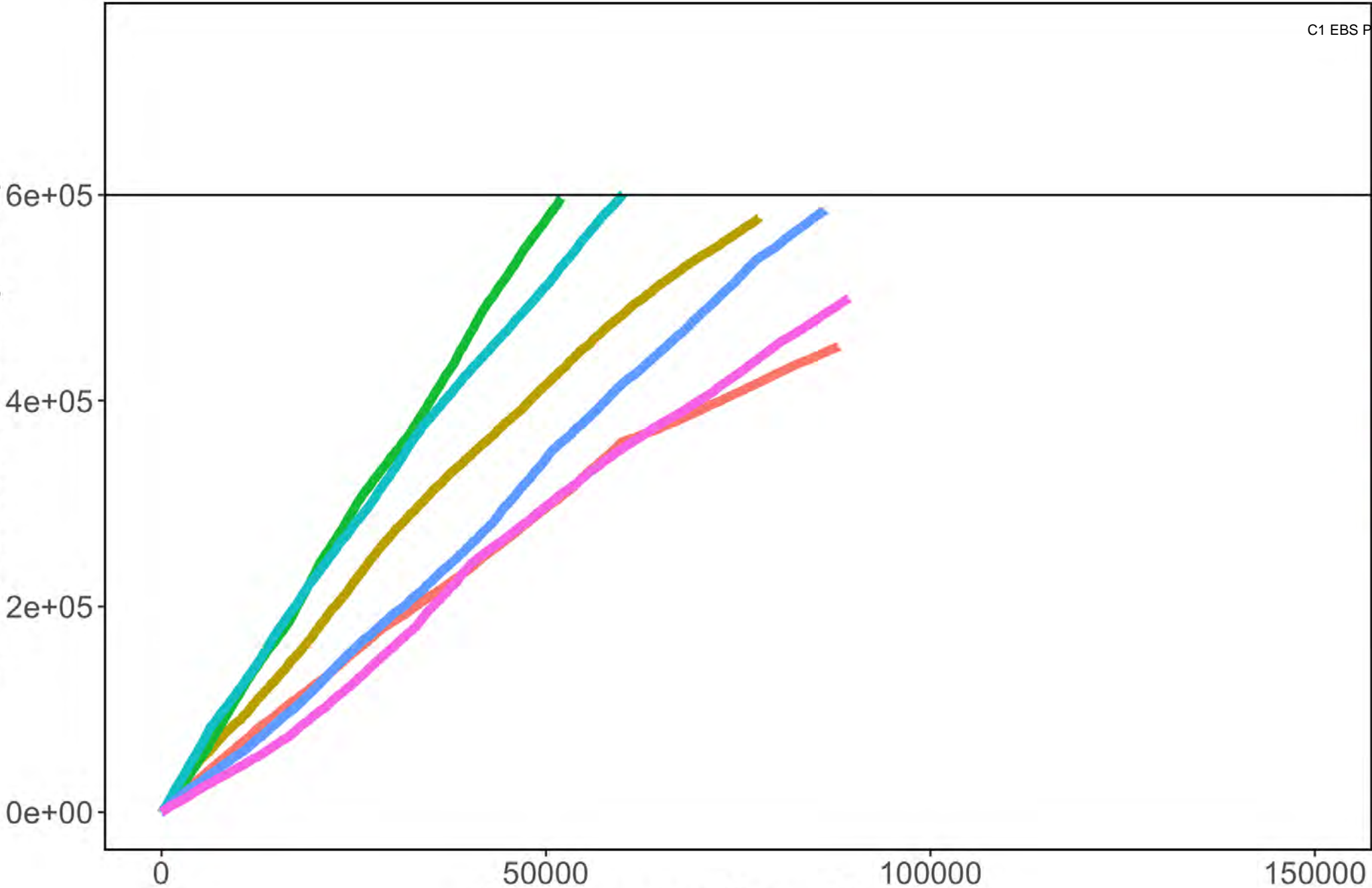


Year

- 2011
- 2013
- 2016
- 2017
- 2018
- 2019

B-season time fishing

B-season catch (tons)

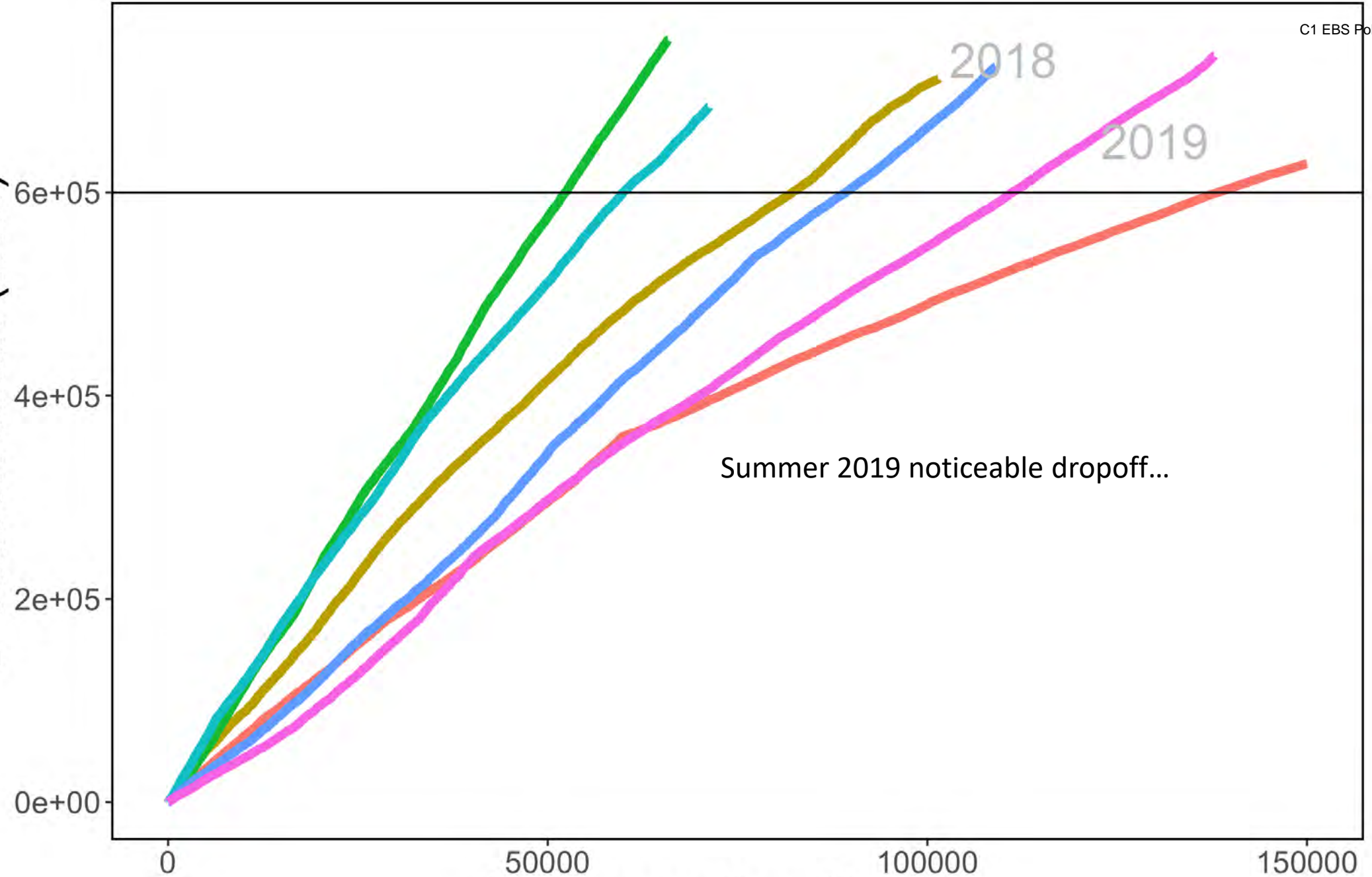


Year

- 2011
- 2013
- 2016
- 2017
- 2018
- 2019

B-season time fishing

B-season catch (tons)



Summer 2019 noticeable dropoff...

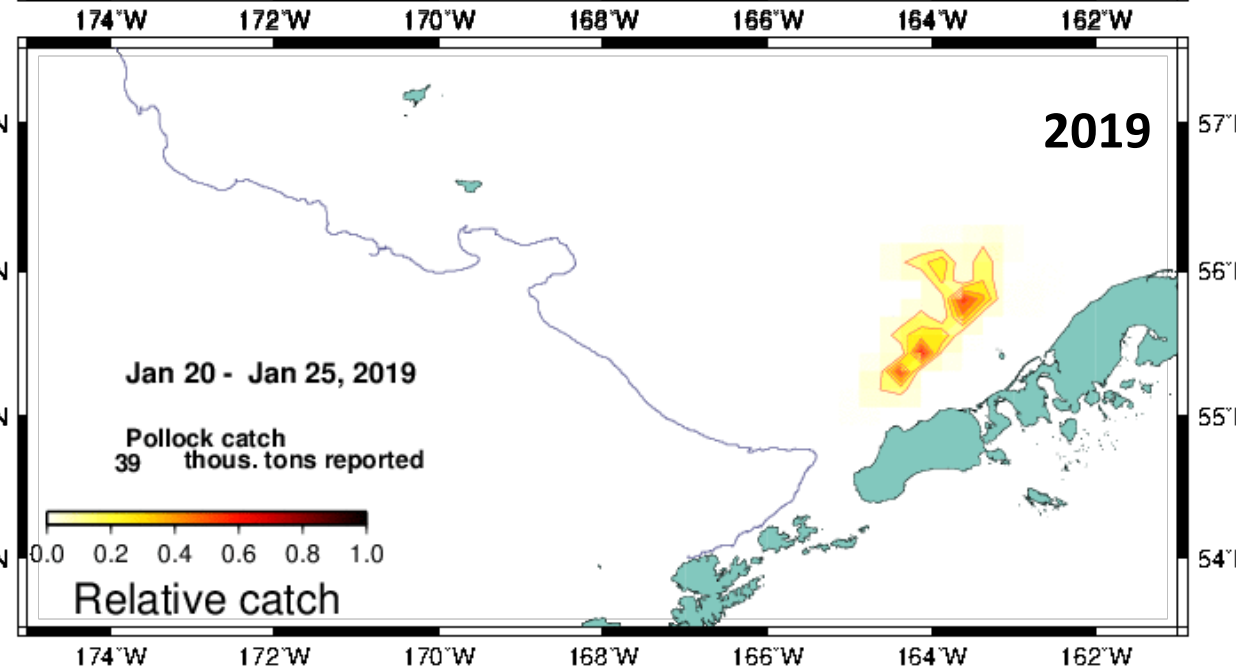
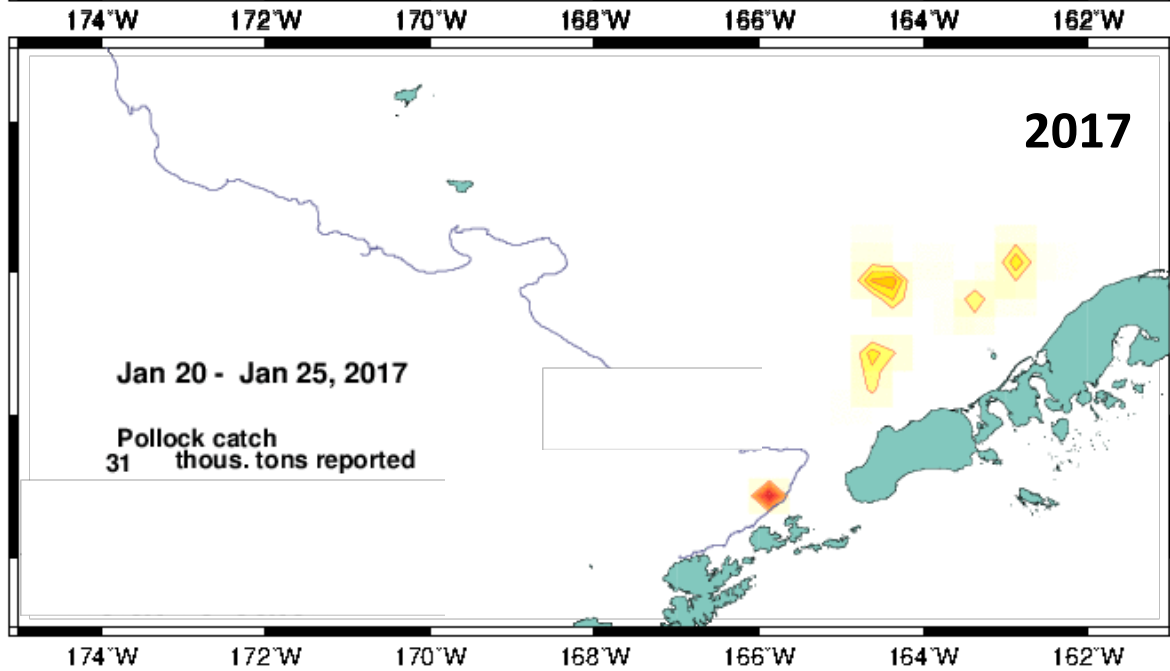
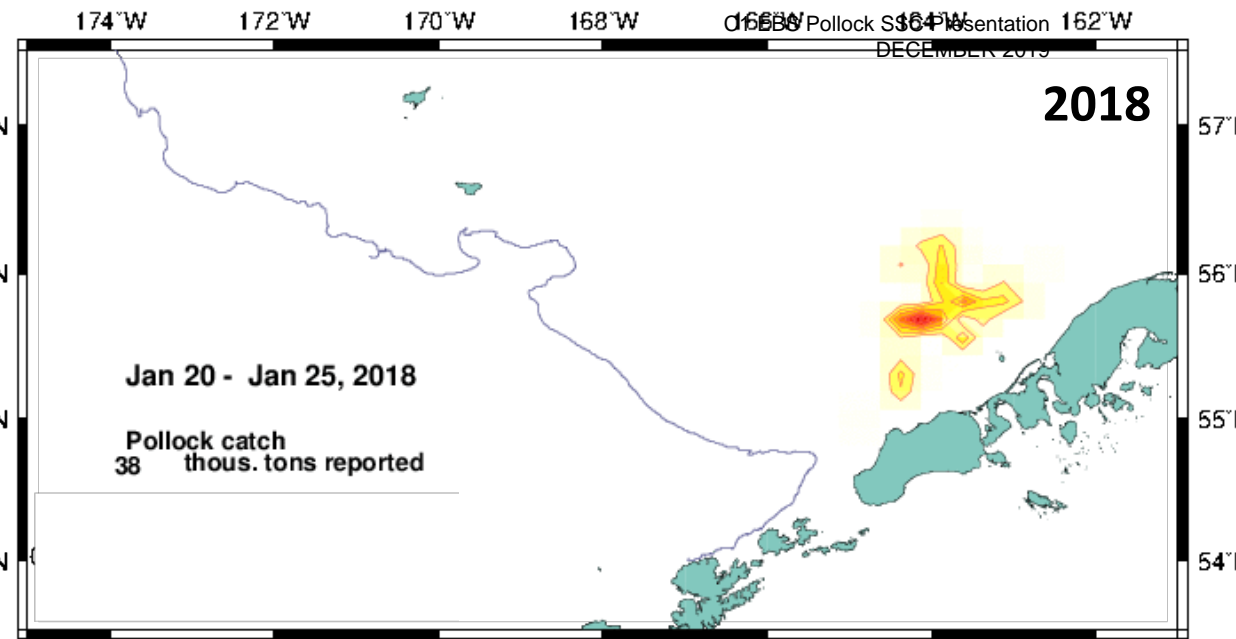
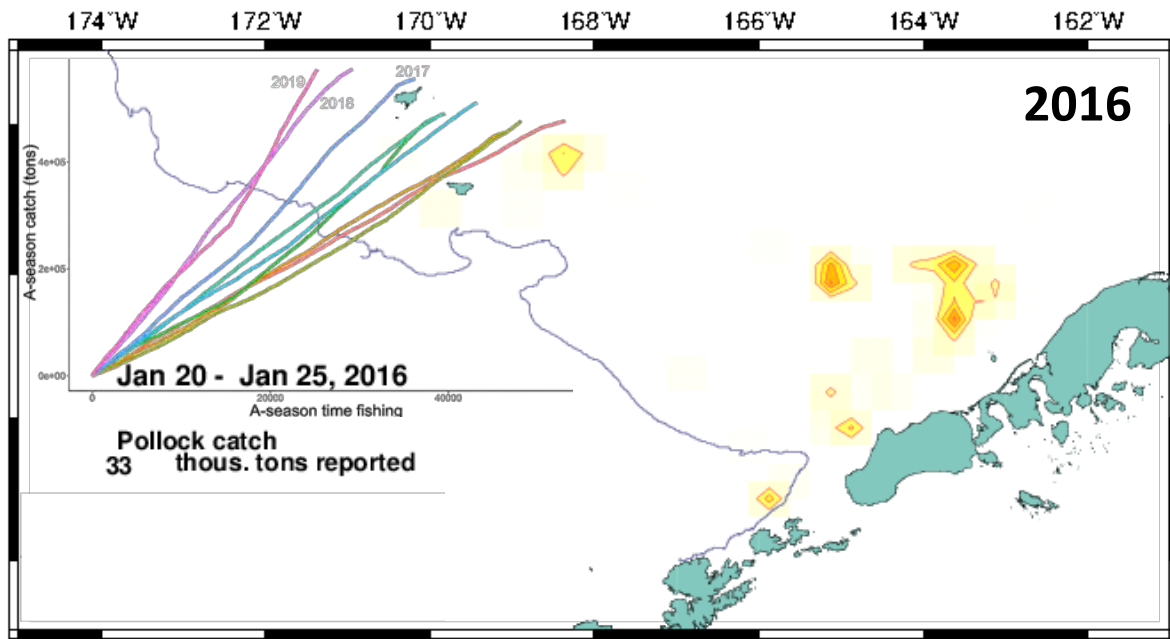
2018

2019

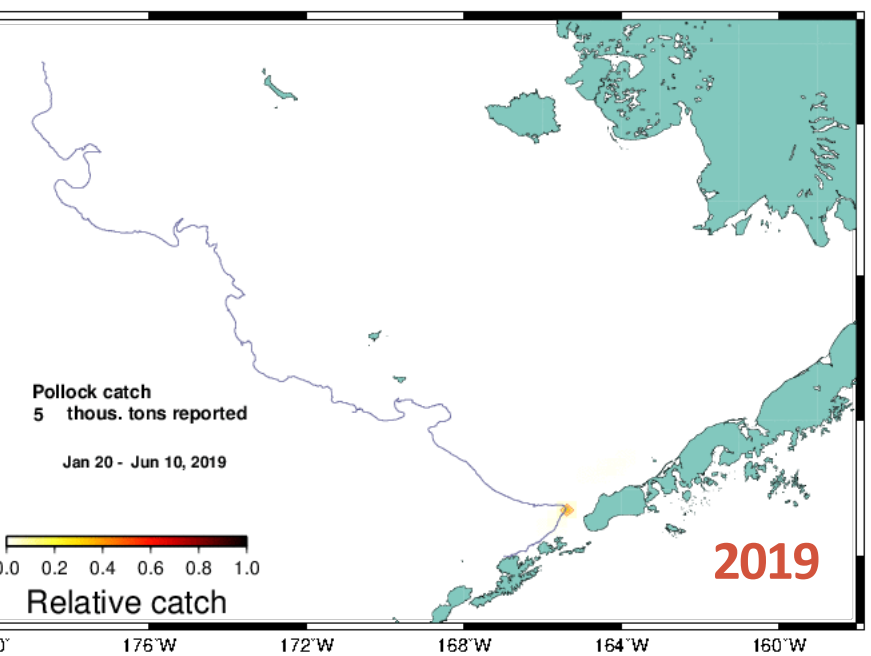
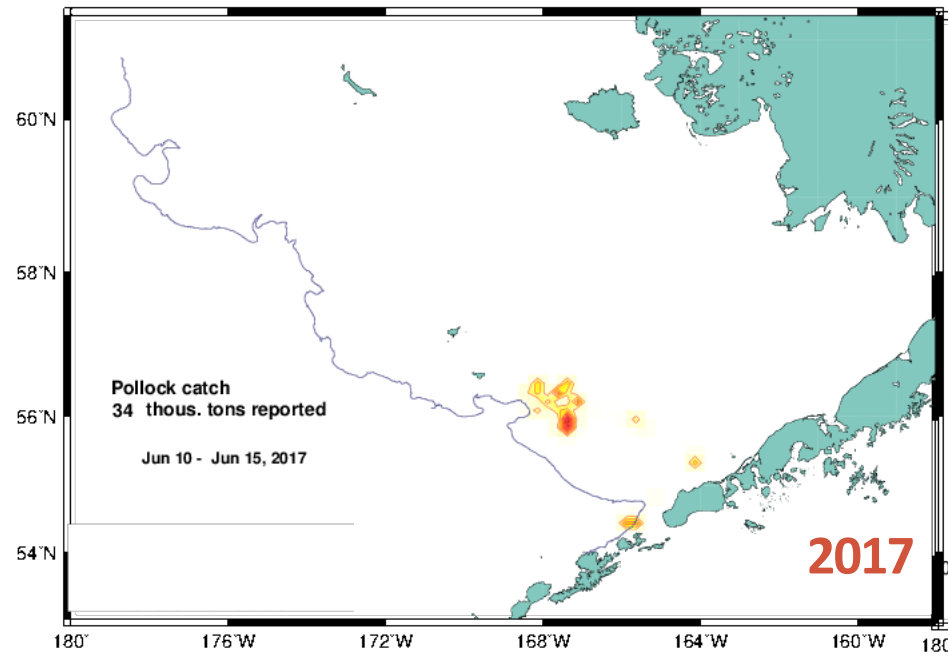
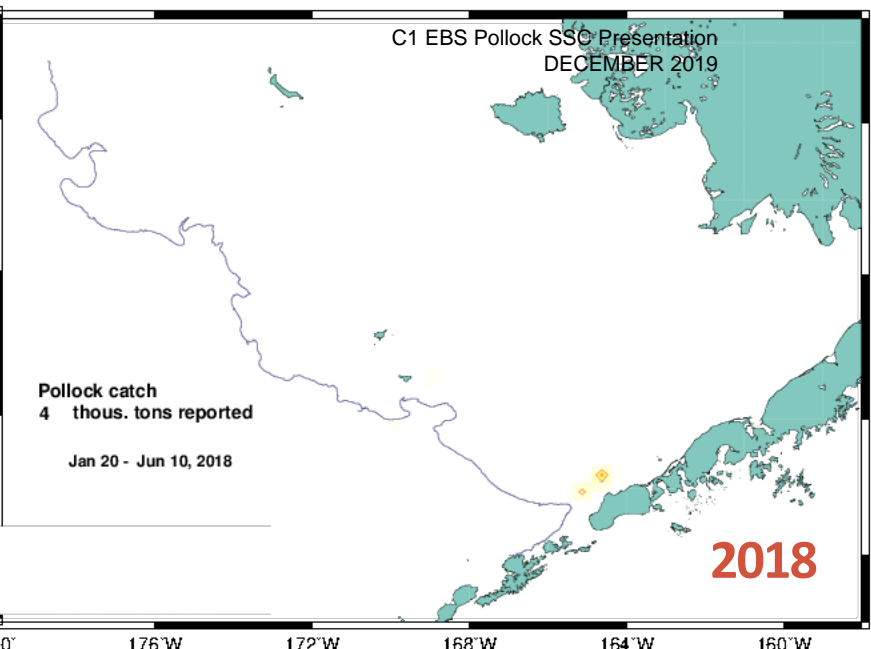
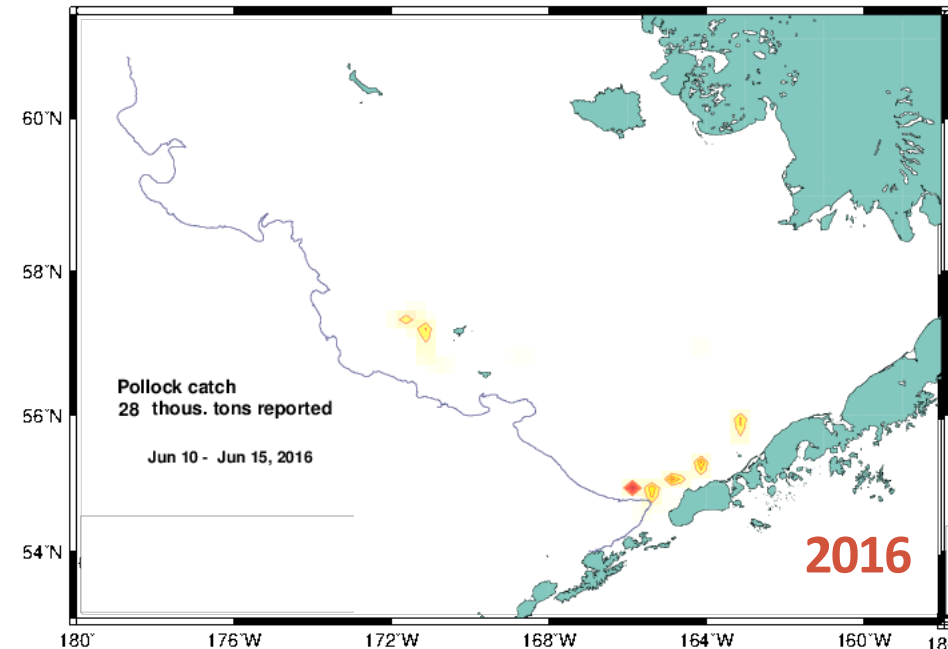
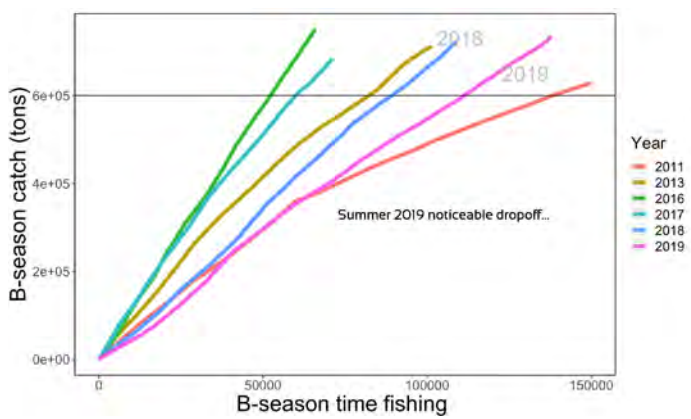
Year

- 2011
- 2013
- 2016
- 2017
- 2018
- 2019

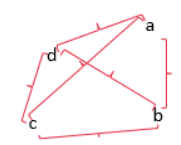
B-season time fishing



Winter season fishing patterns

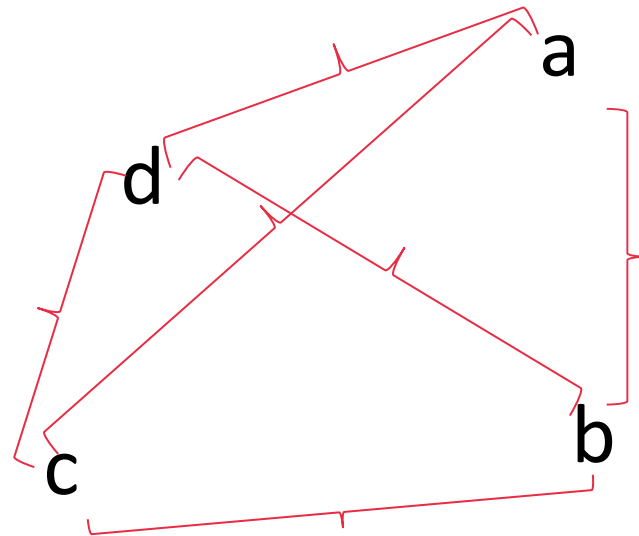


Summarizing spatial fishery patterns

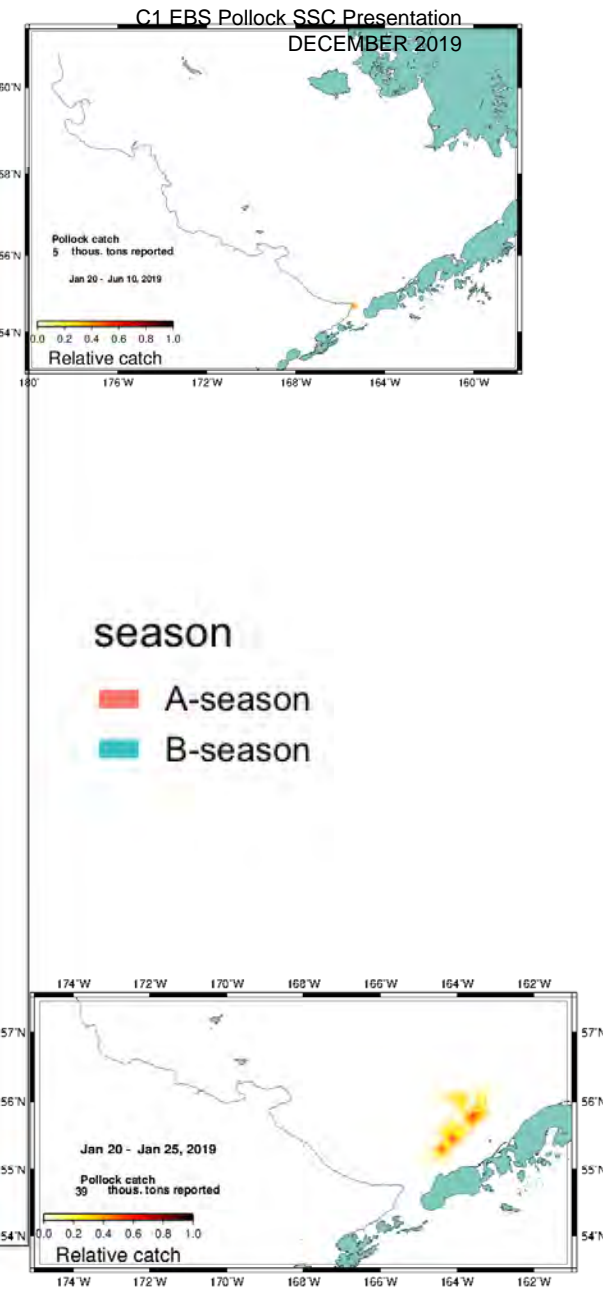
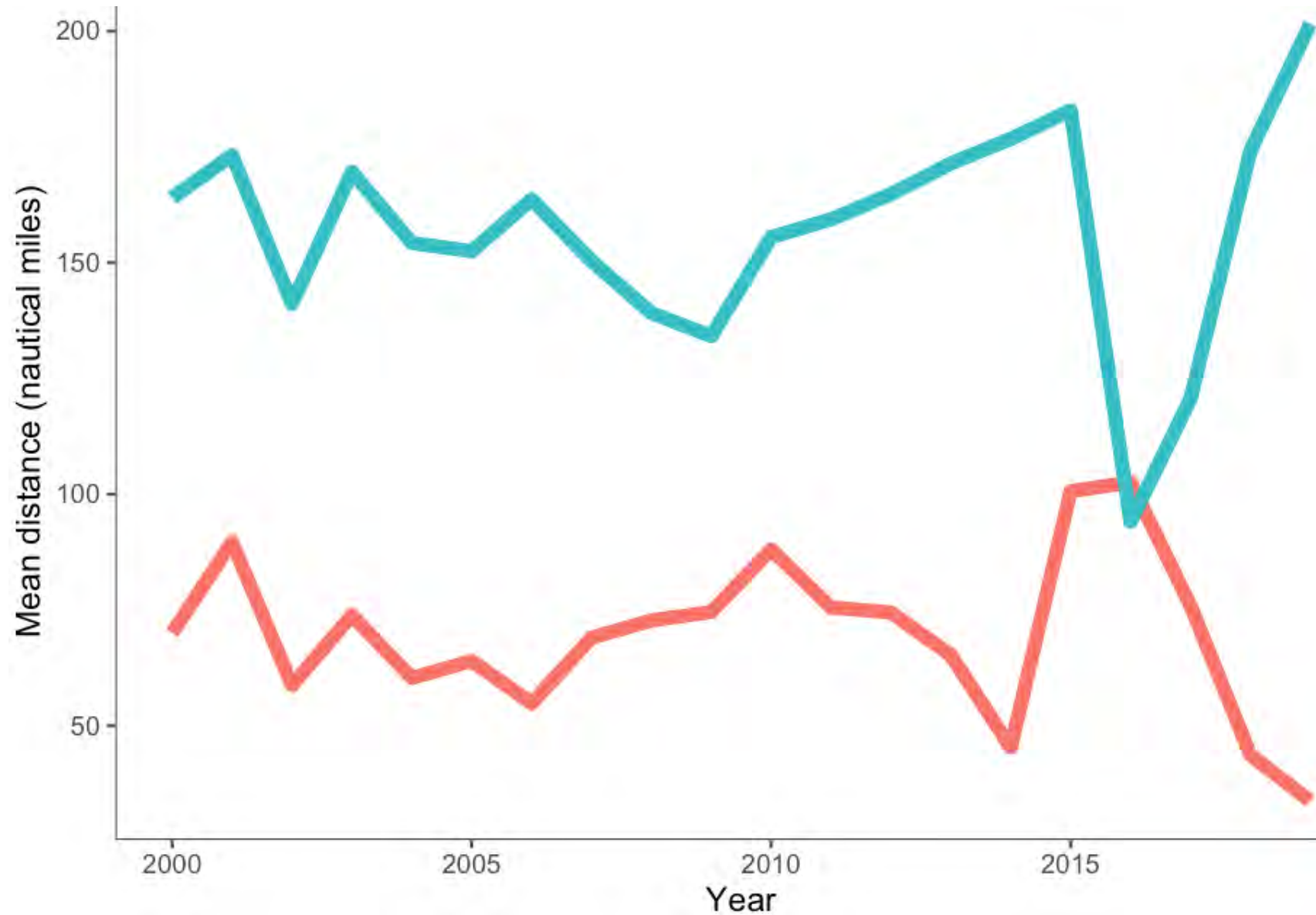


Summer fishing distributions

Summarizing spatial fishery patterns

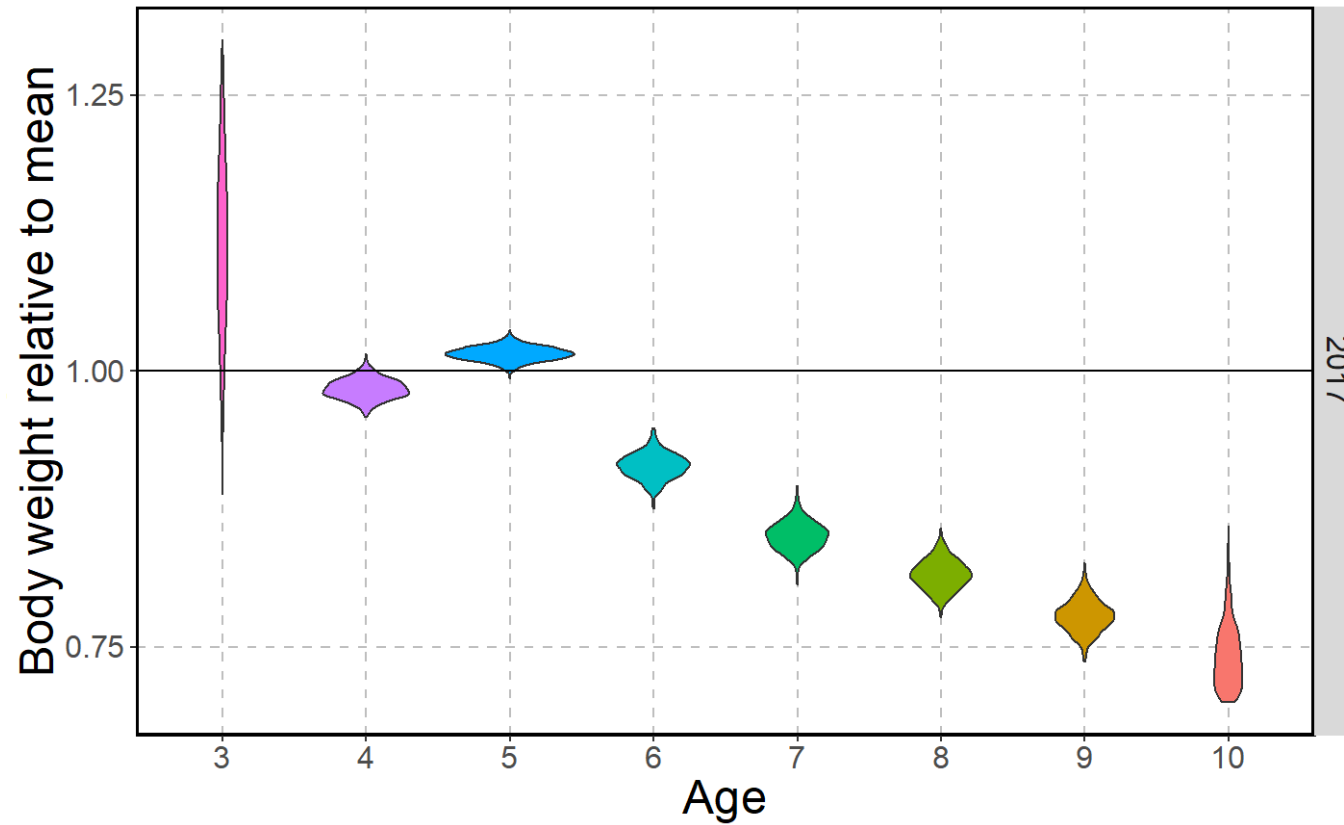


All pollock boats combined...



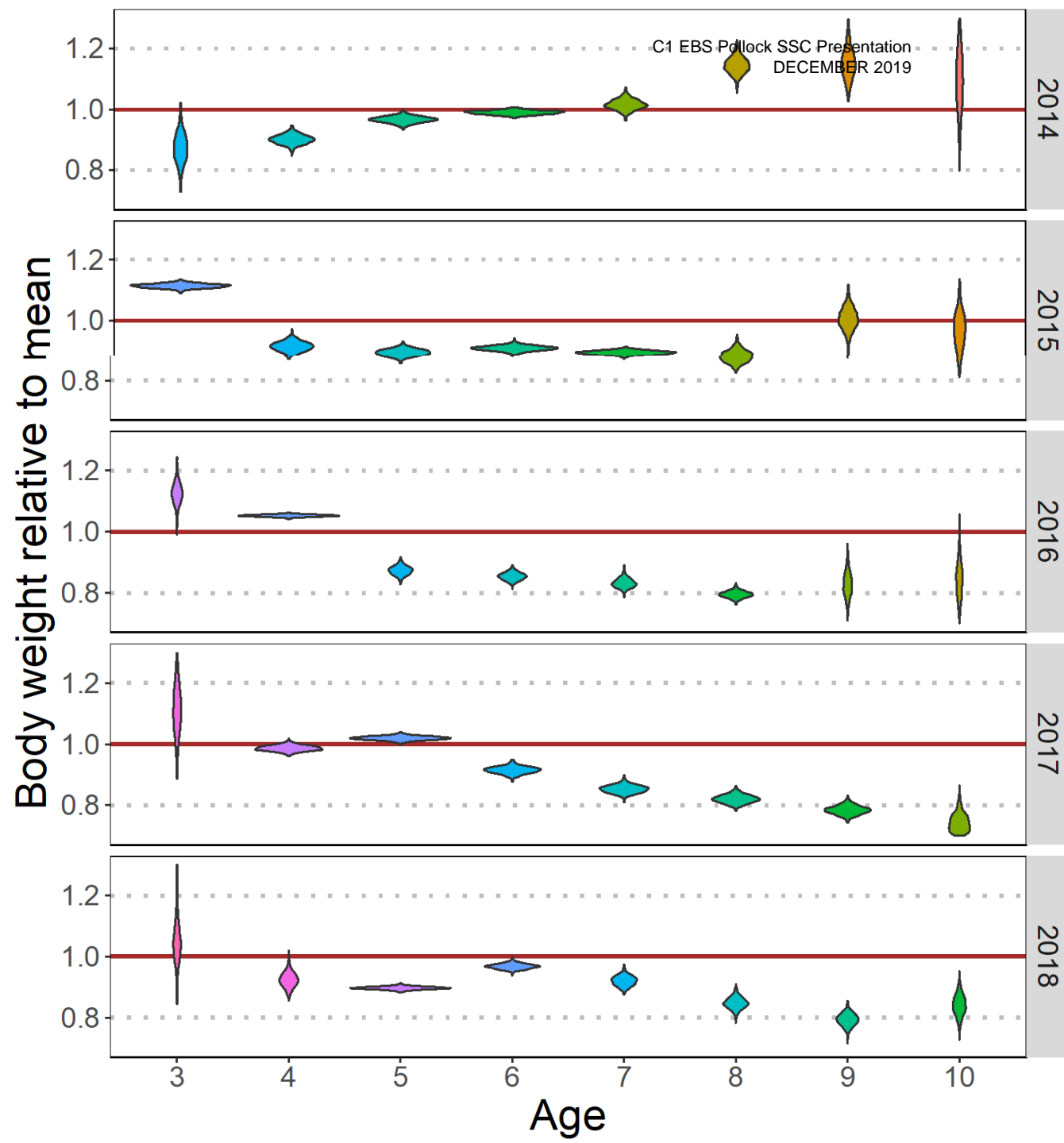
- Fishery observer sampling...
 - Patterns in pollock growth

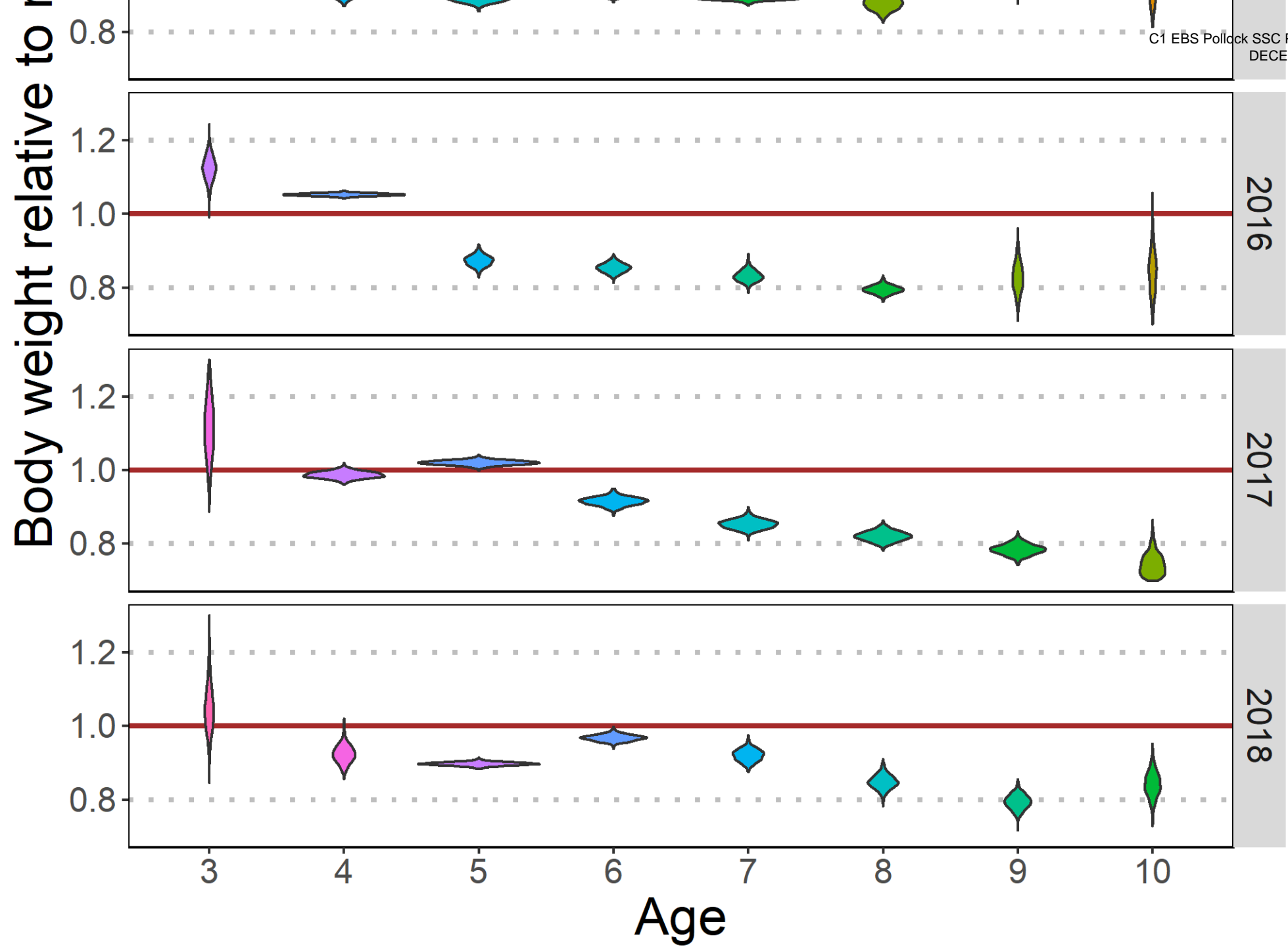
Looking at weight-at-age



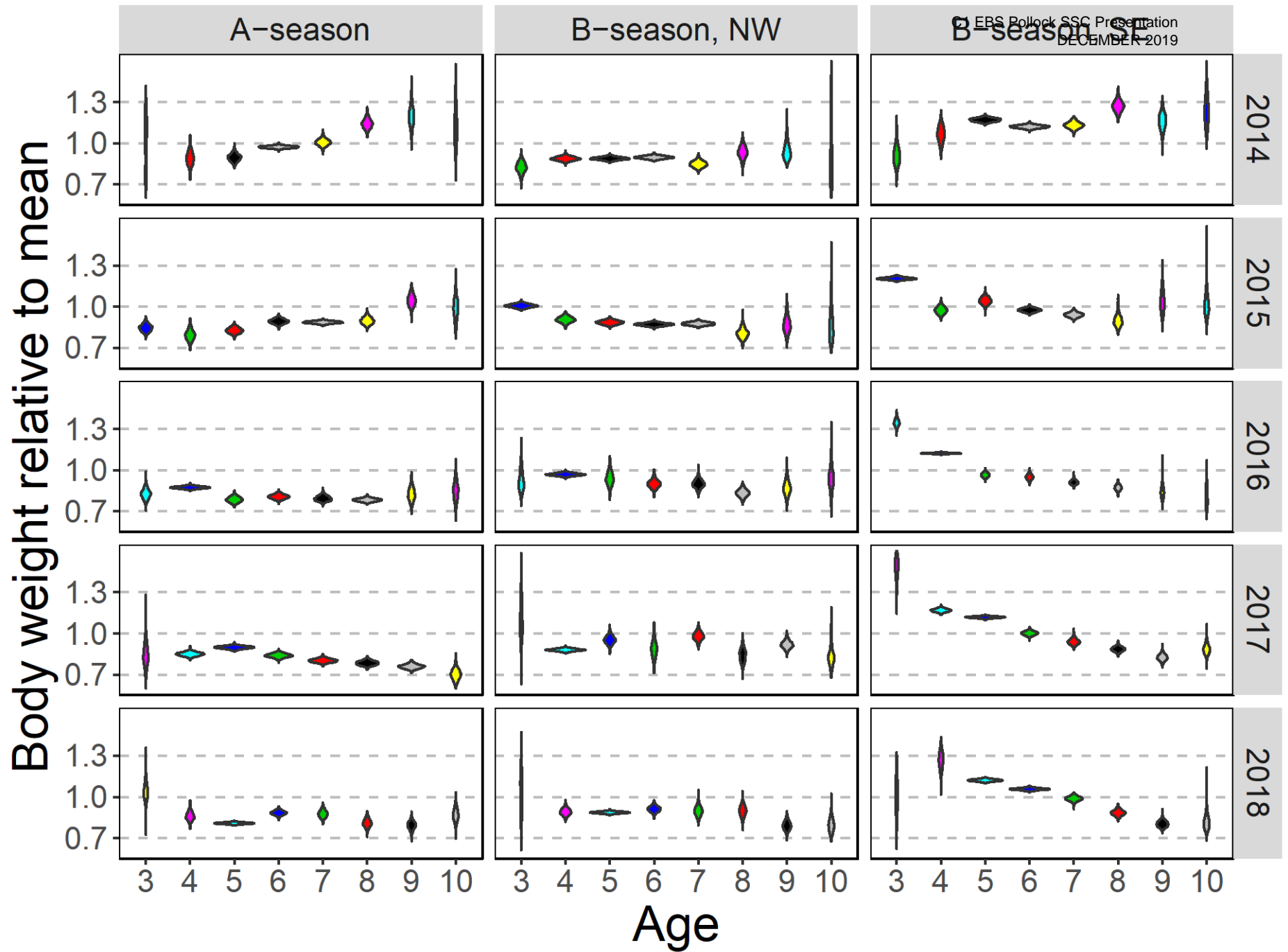
Are pollock smaller at age than normal???

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



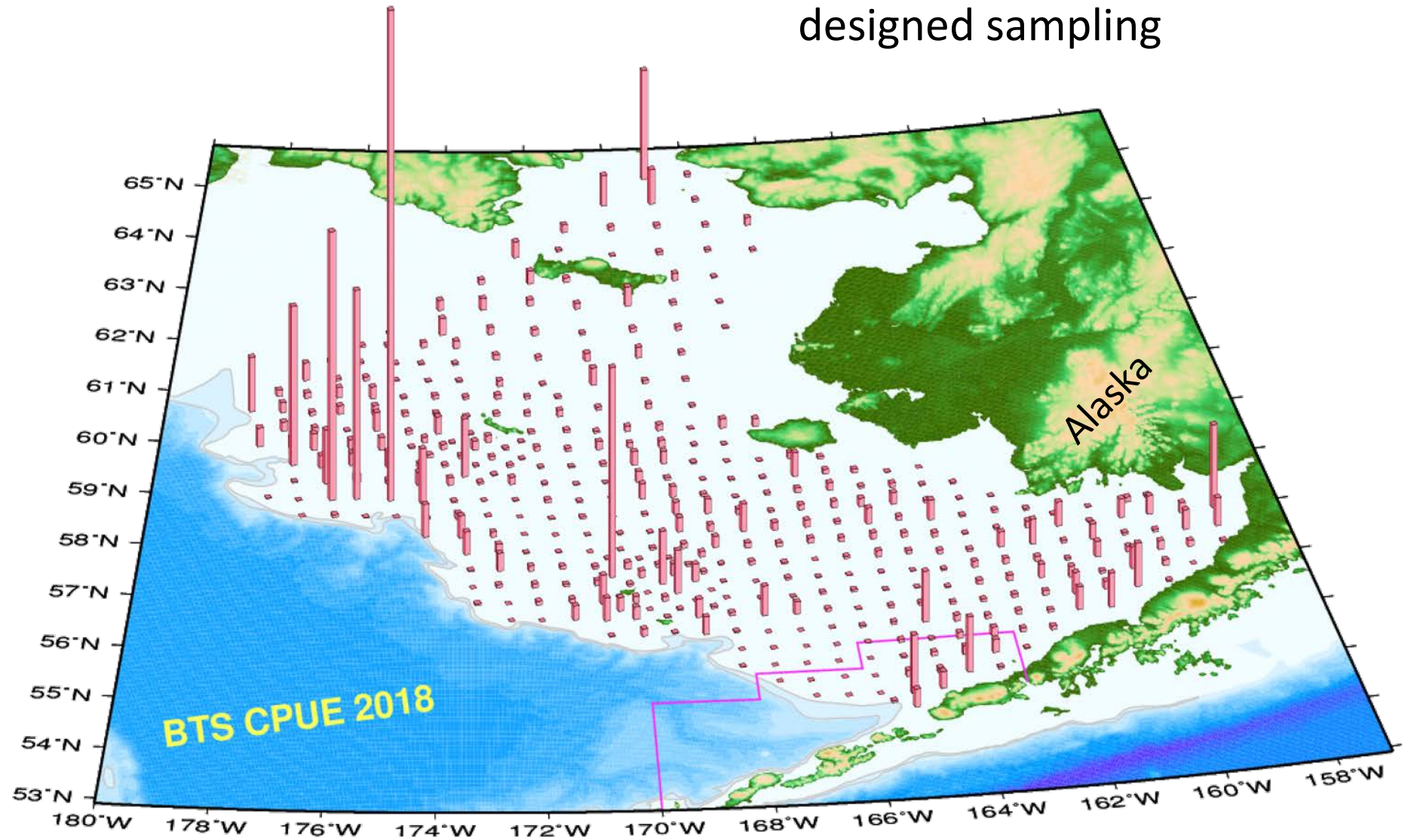


Average fishery weight-at-age by season and year...

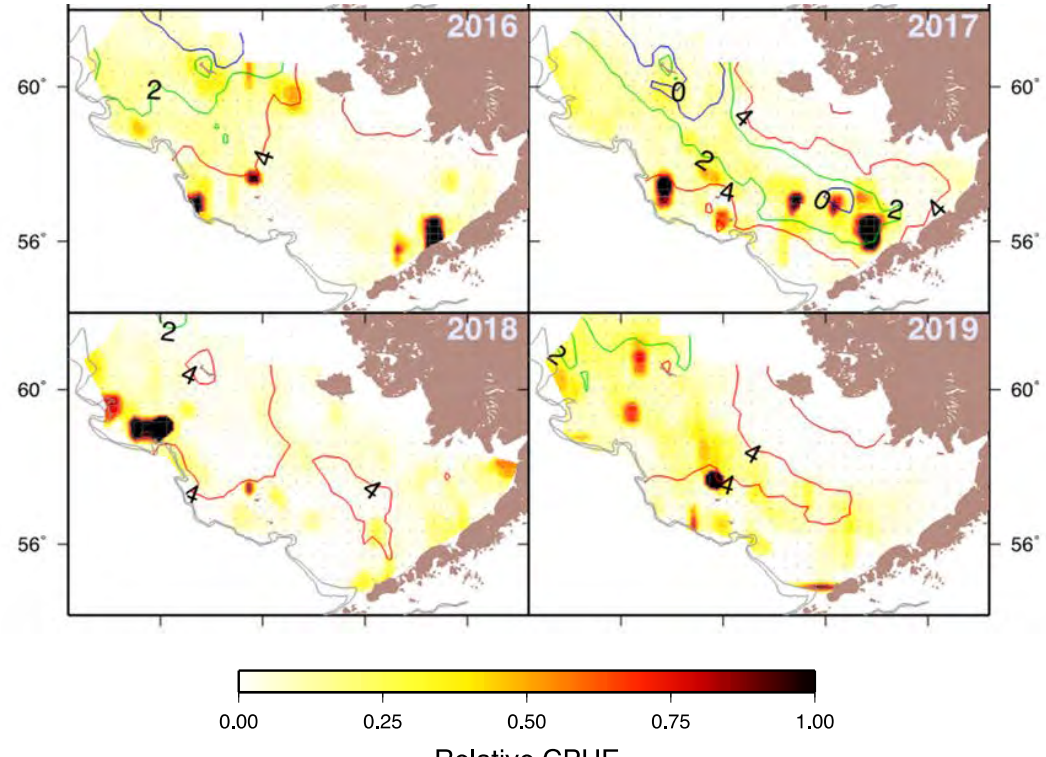


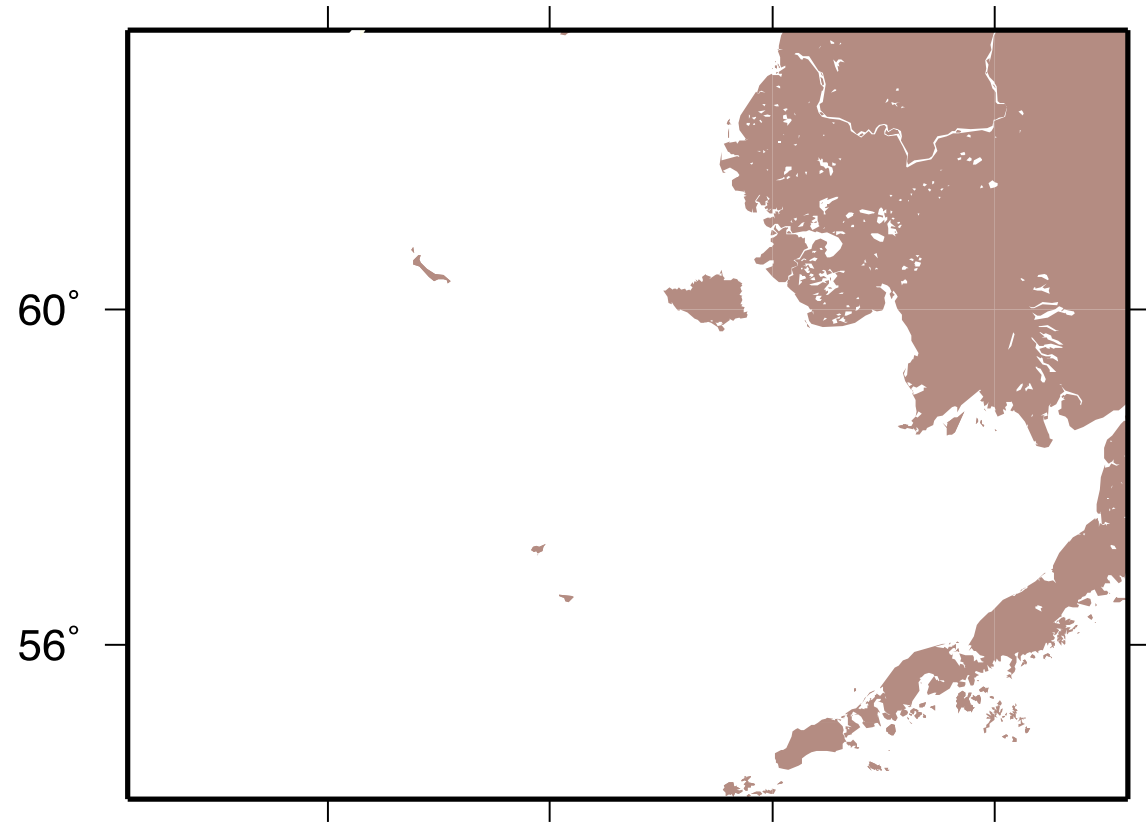
Scientific research survey

Independent from fishery data—
designed sampling



Pollock density and temperature



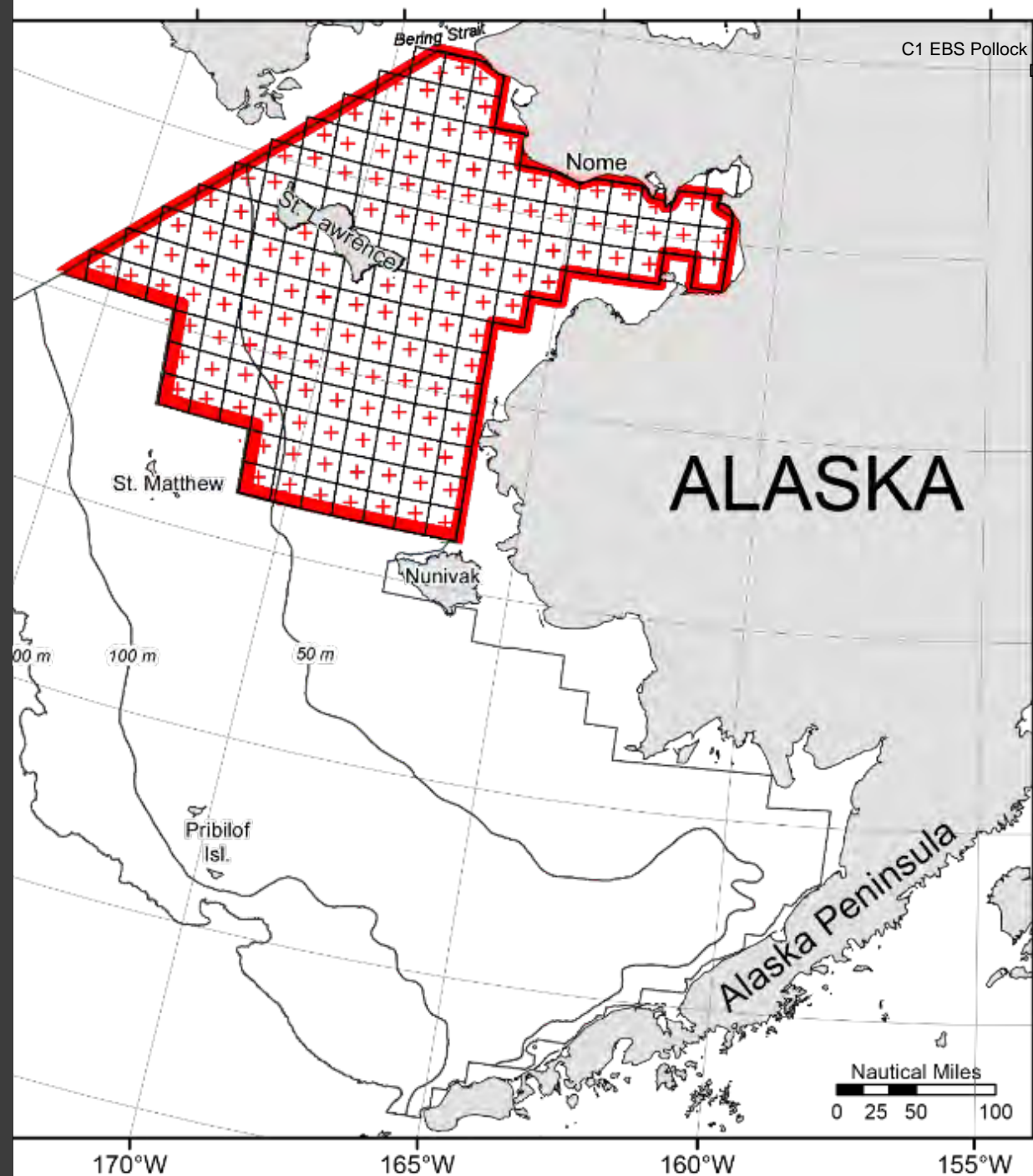


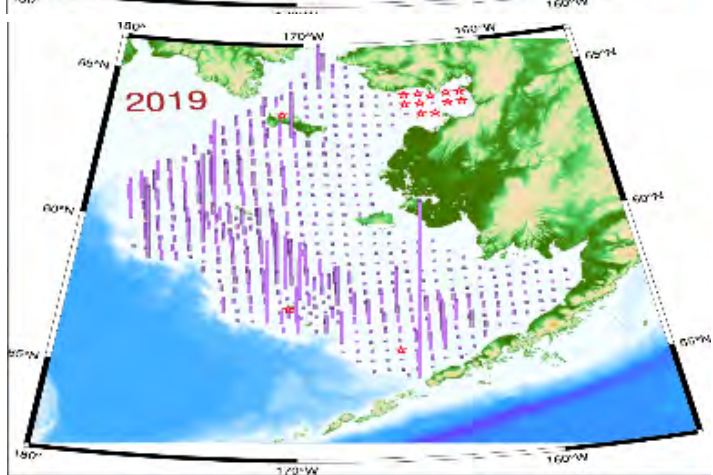
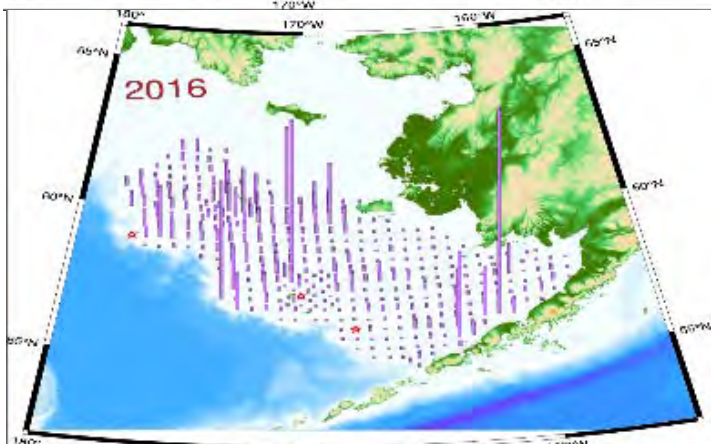
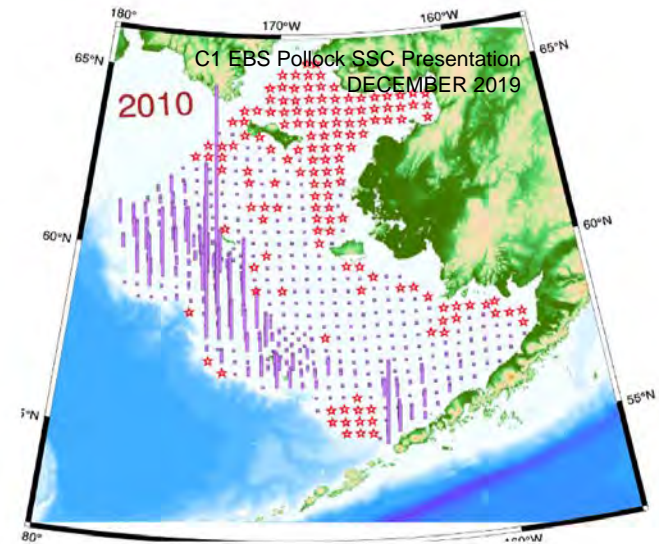
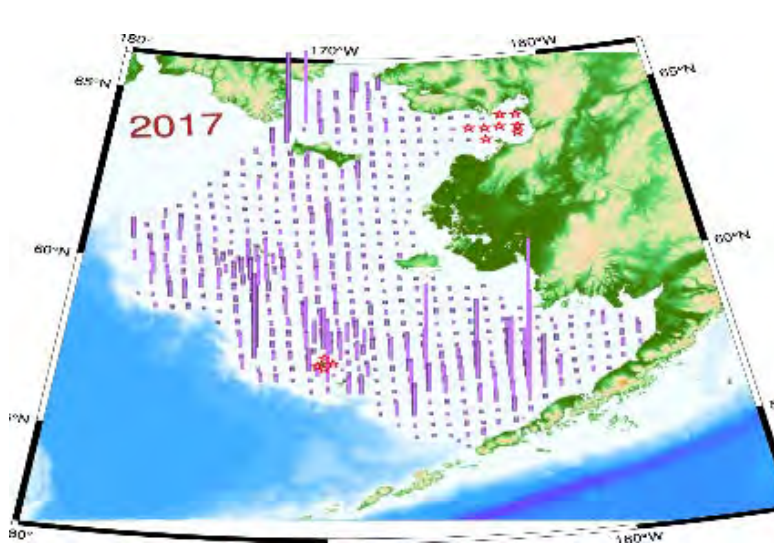
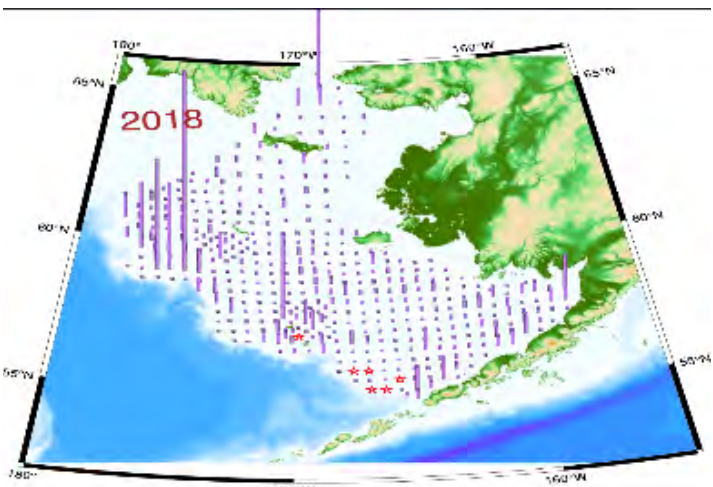
Survey stations in northern area... "NBS"

Formally surveyed in 2010 and
2017

2018 an "emergency"

2019 a "full" Nbs

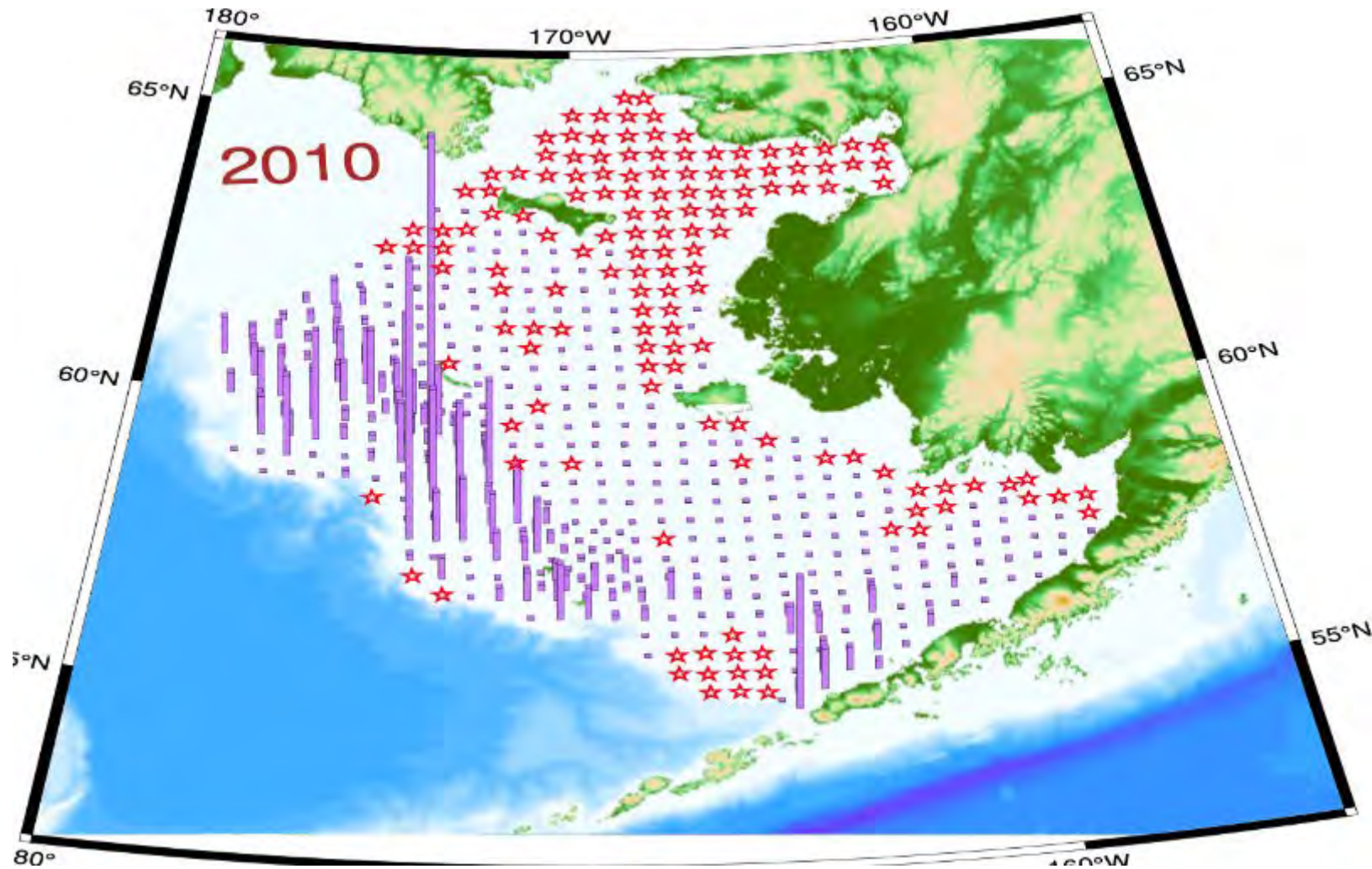




Northern area: trace amounts

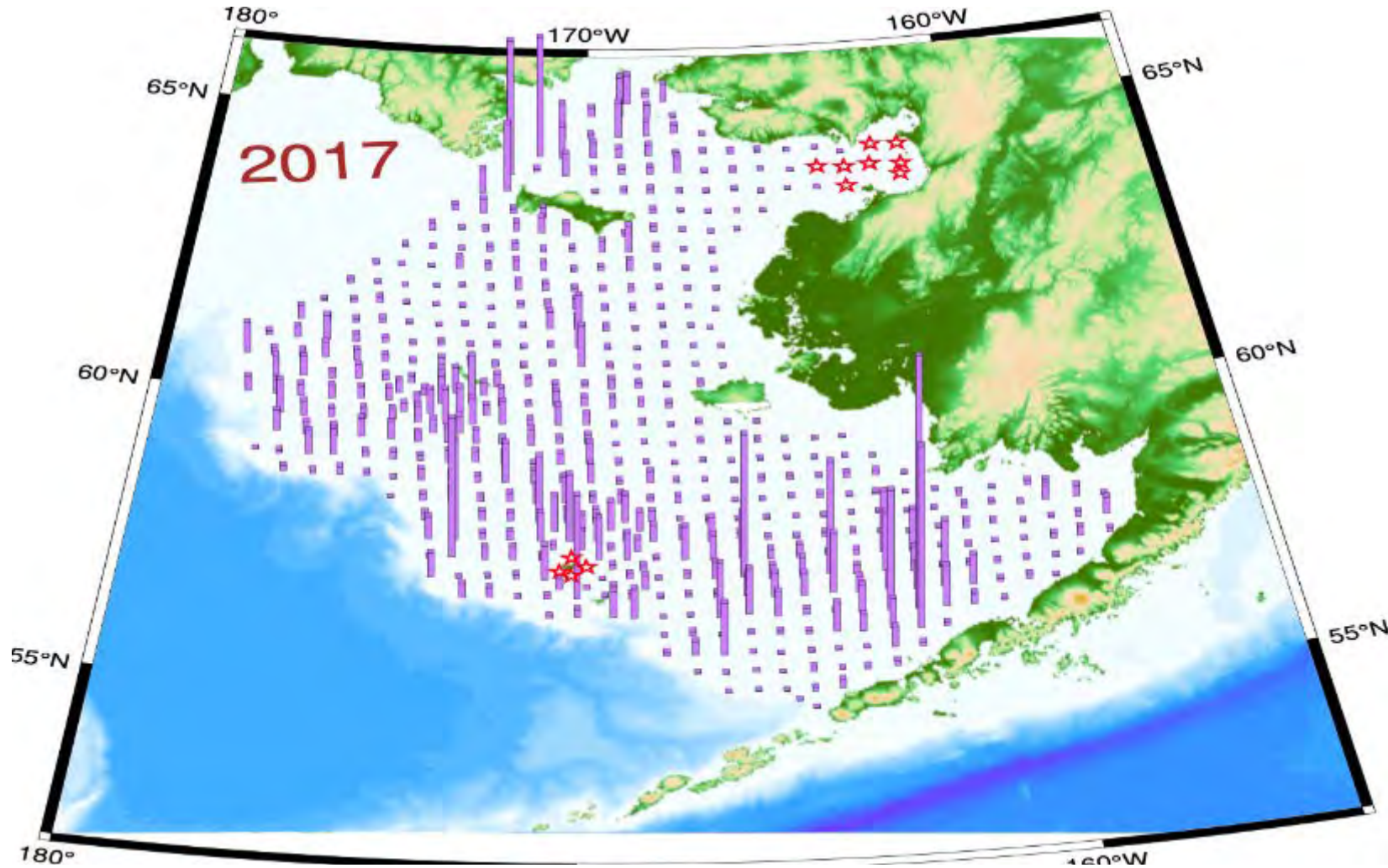
Bottom trawl survey spatial patterns

2010 standard survey (3.74 million t pollock estimated)



Northern area: trace amounts

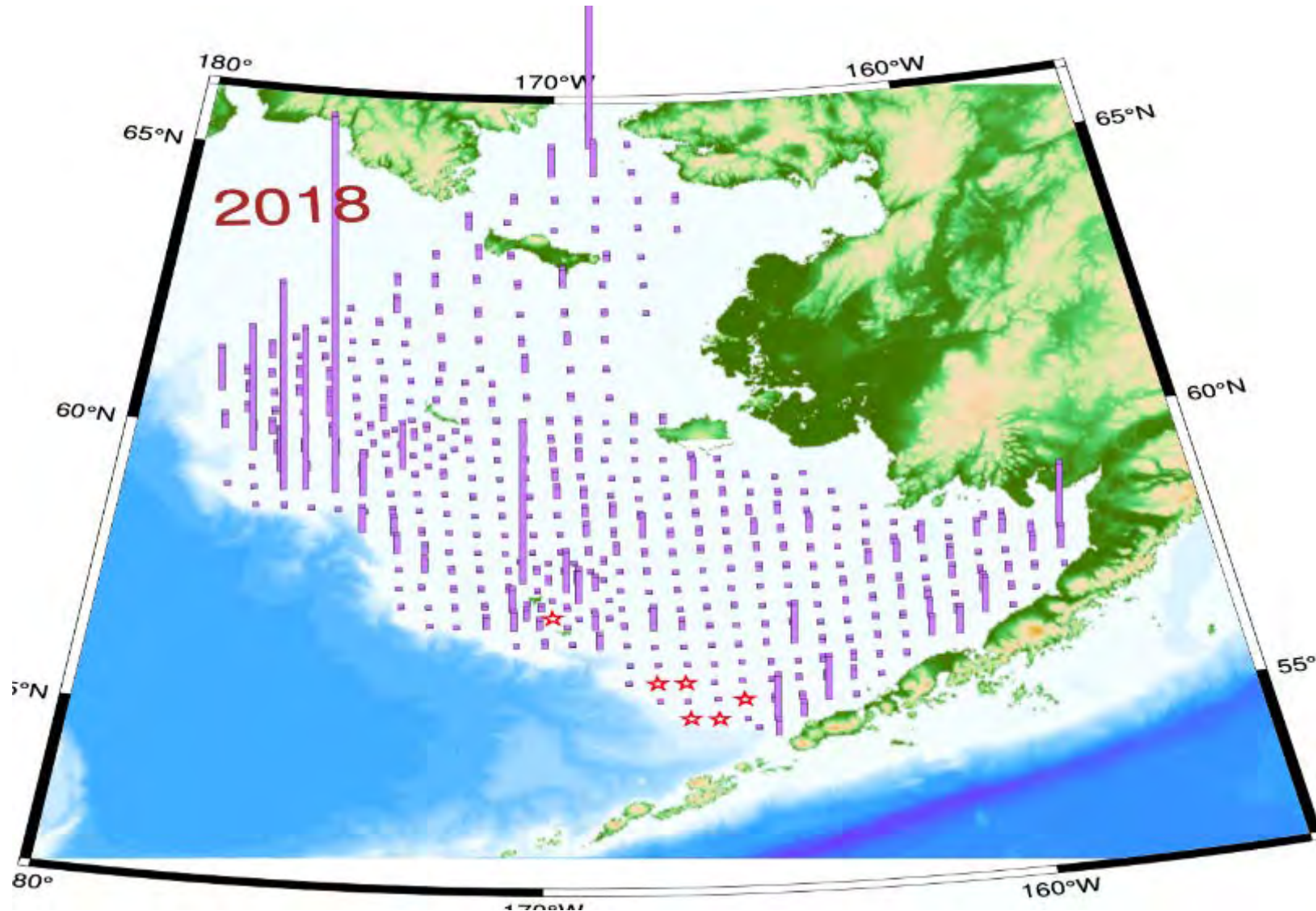
2017 standard survey (4.81 million t pollock estimated)



Northern area: 1.34 million t

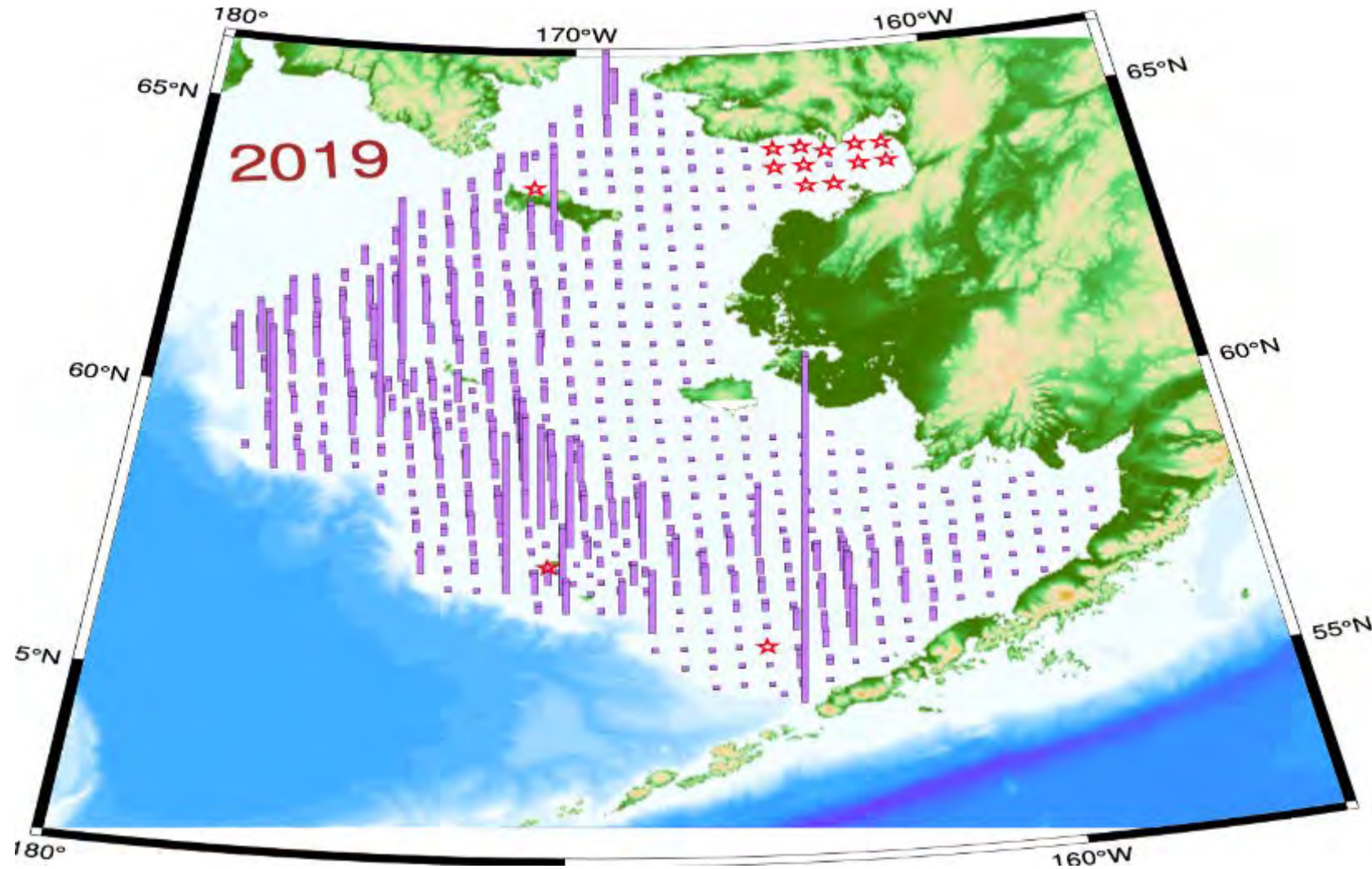
2018 standard survey (3.1 million t pollock estimated)

C1 EBS Pollock SSC Presentation
DECEMBER 2019



Northern area: 1.15 million t

2019 standard survey (5.4 million t pollock estimated)



Northern area: 1.2xx million t

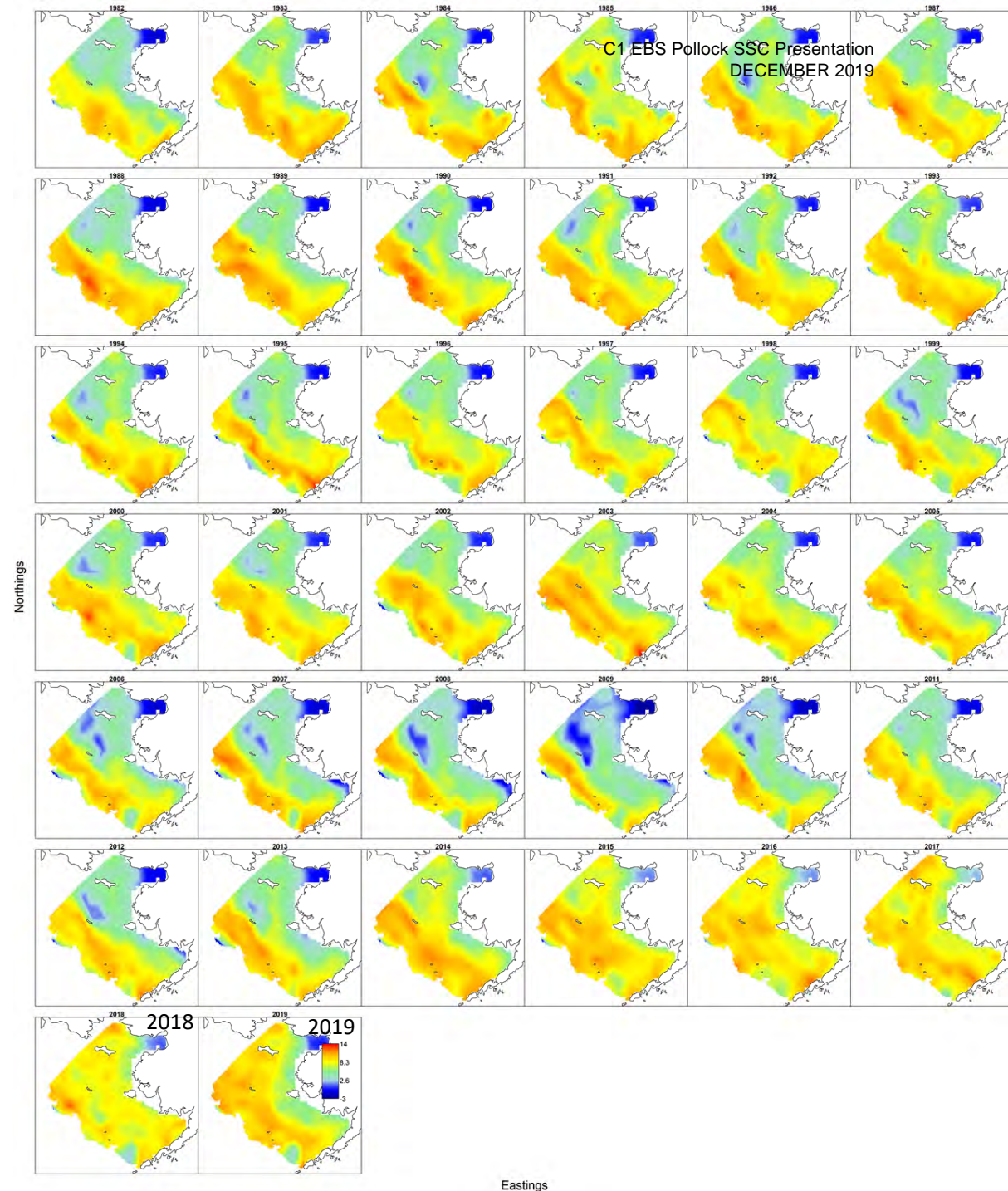
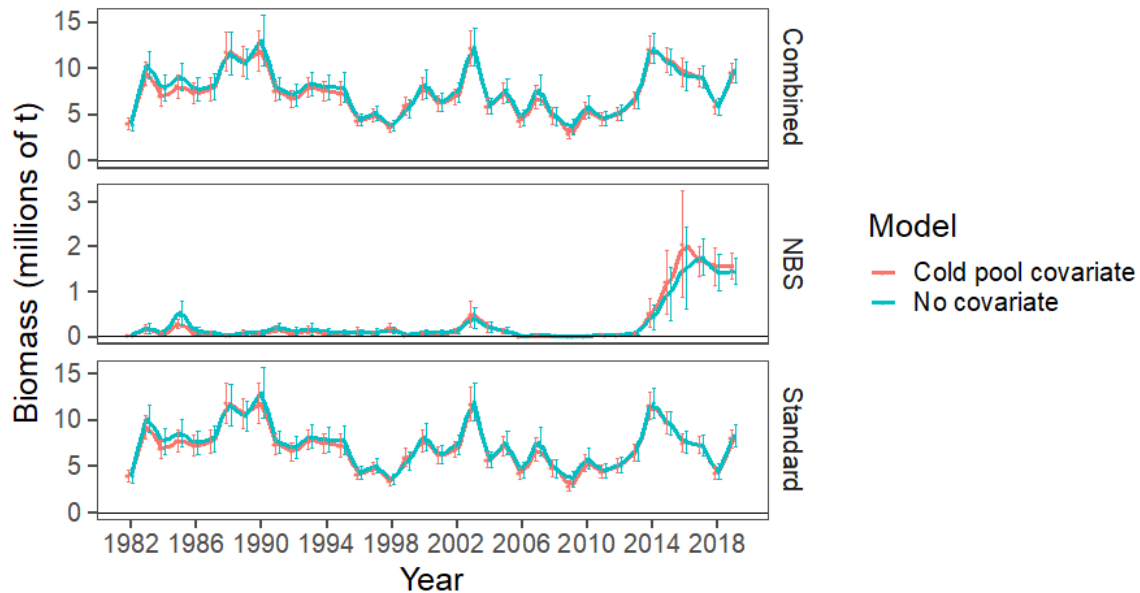
New this year

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

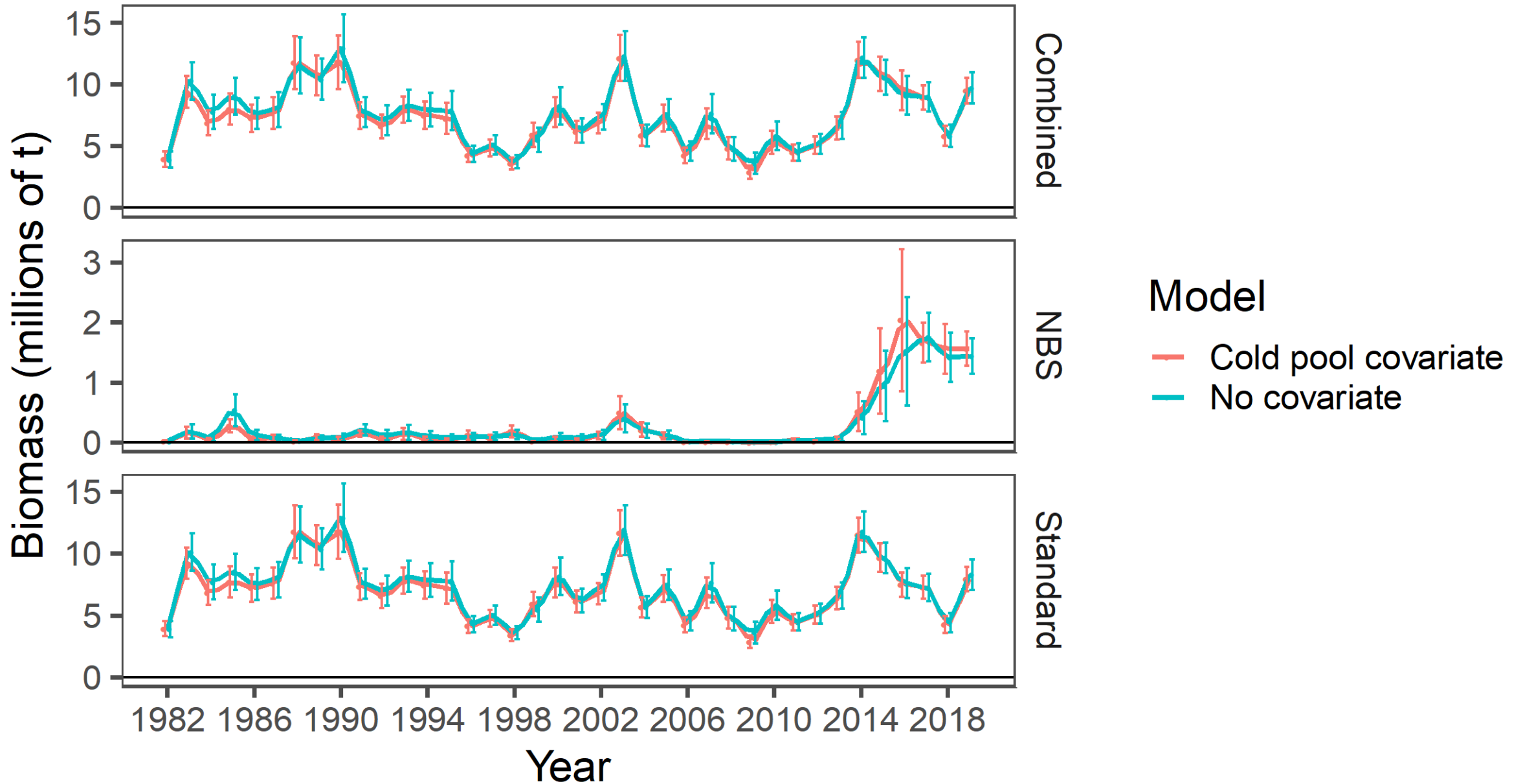
Modeling surveys

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

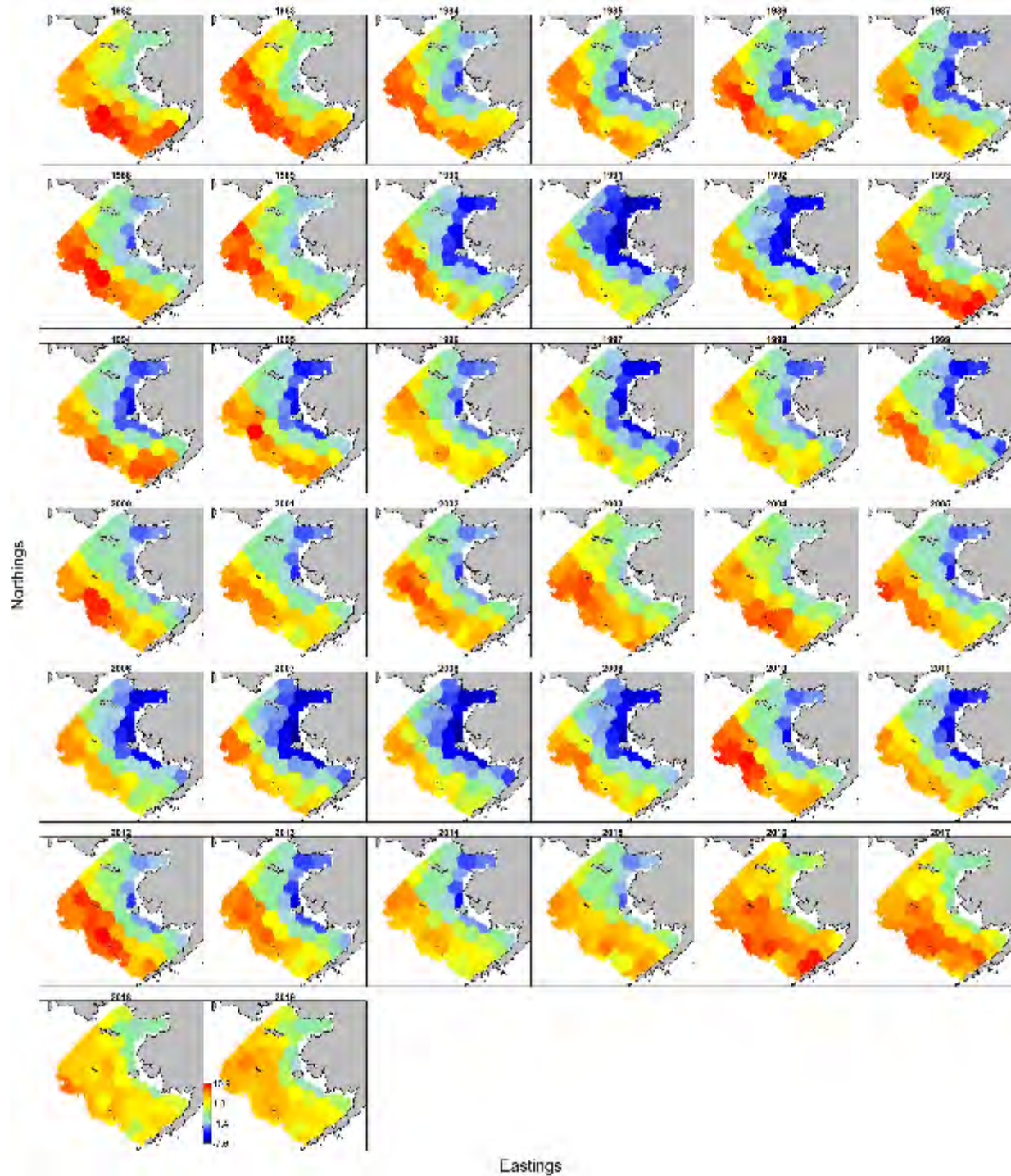
Pollock biomass by regions—VAST run



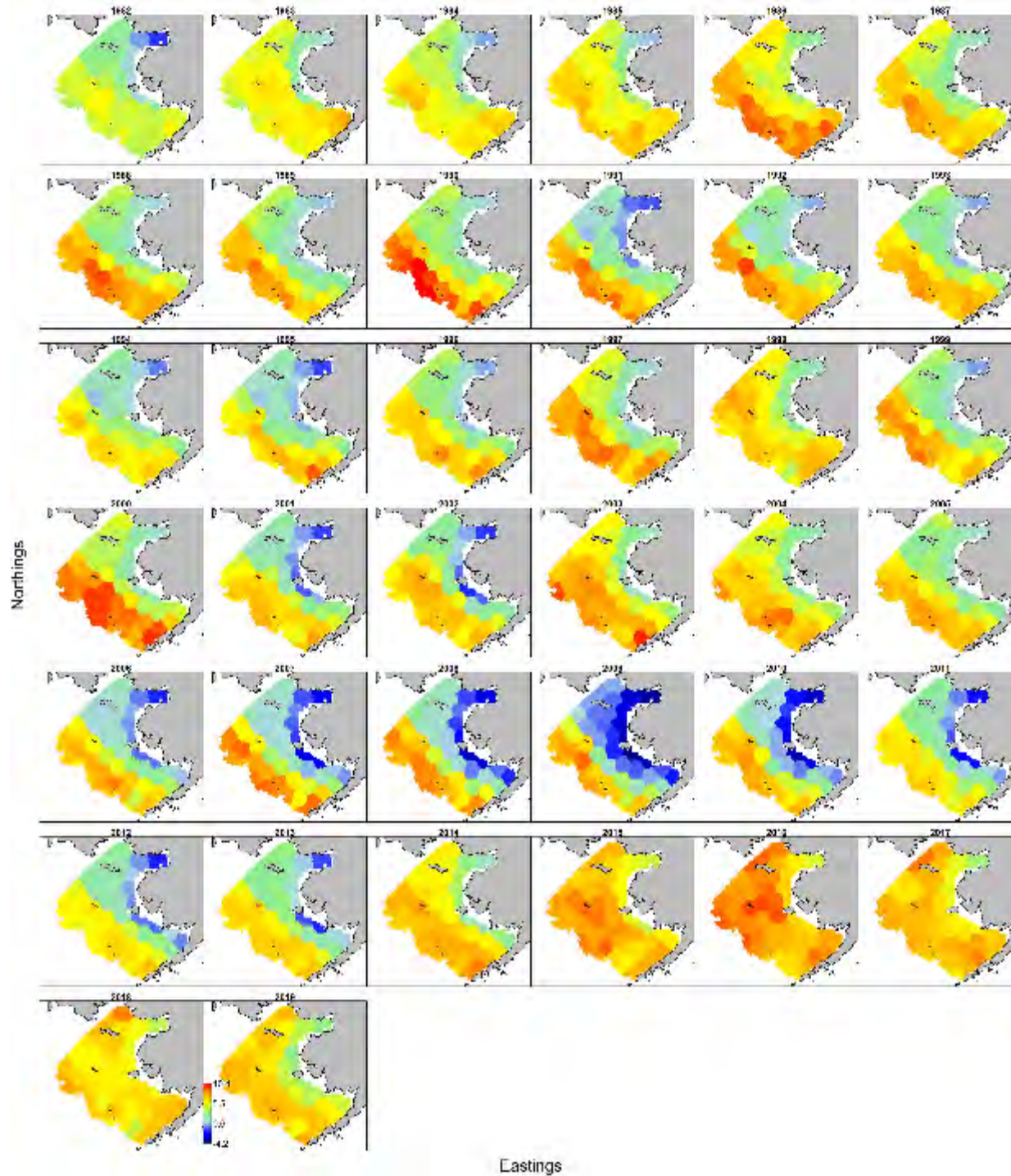
Pollock biomass by regions—VAST run

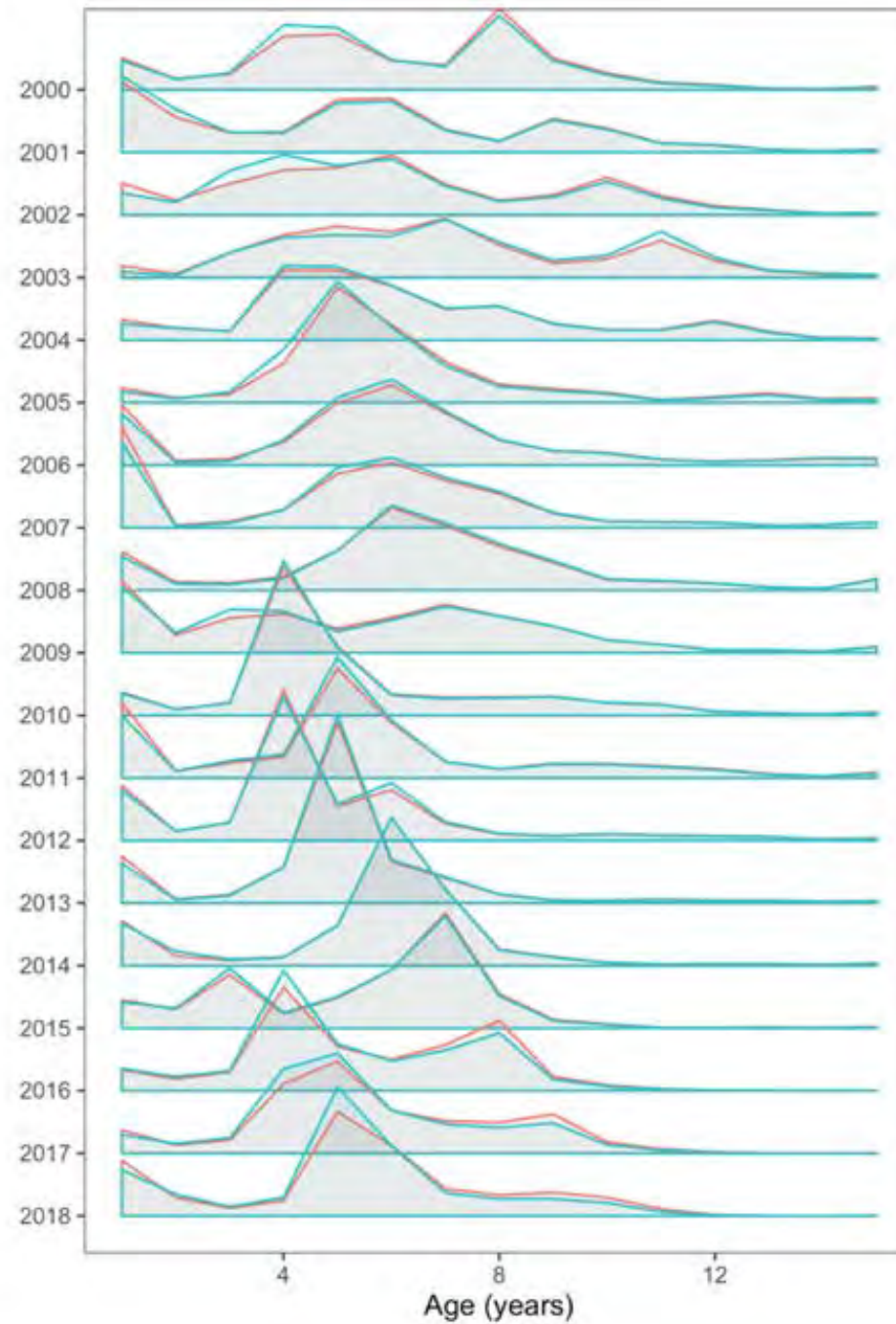
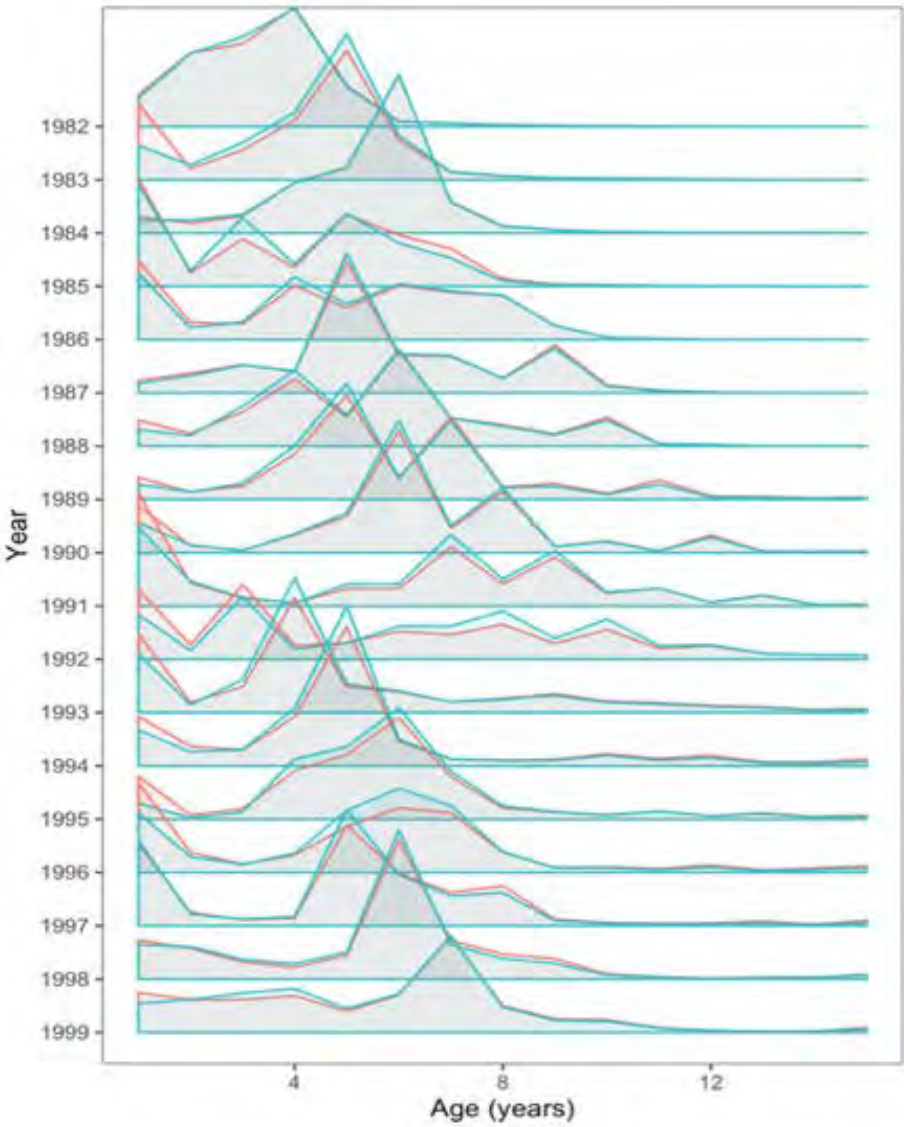


4 Year olds



8 Year olds





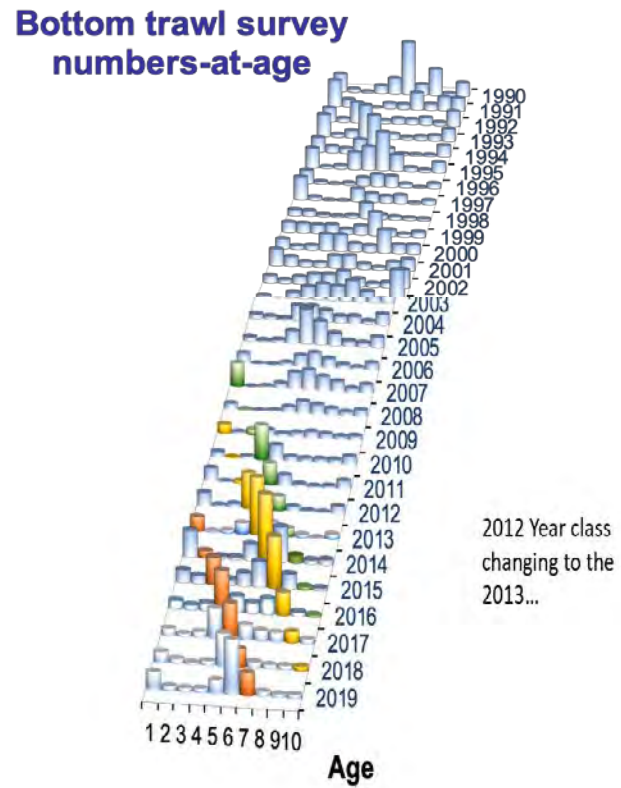
Source
VAST
DB

**VAST Age
compositions**
*compared to
design-based*

Model configurations

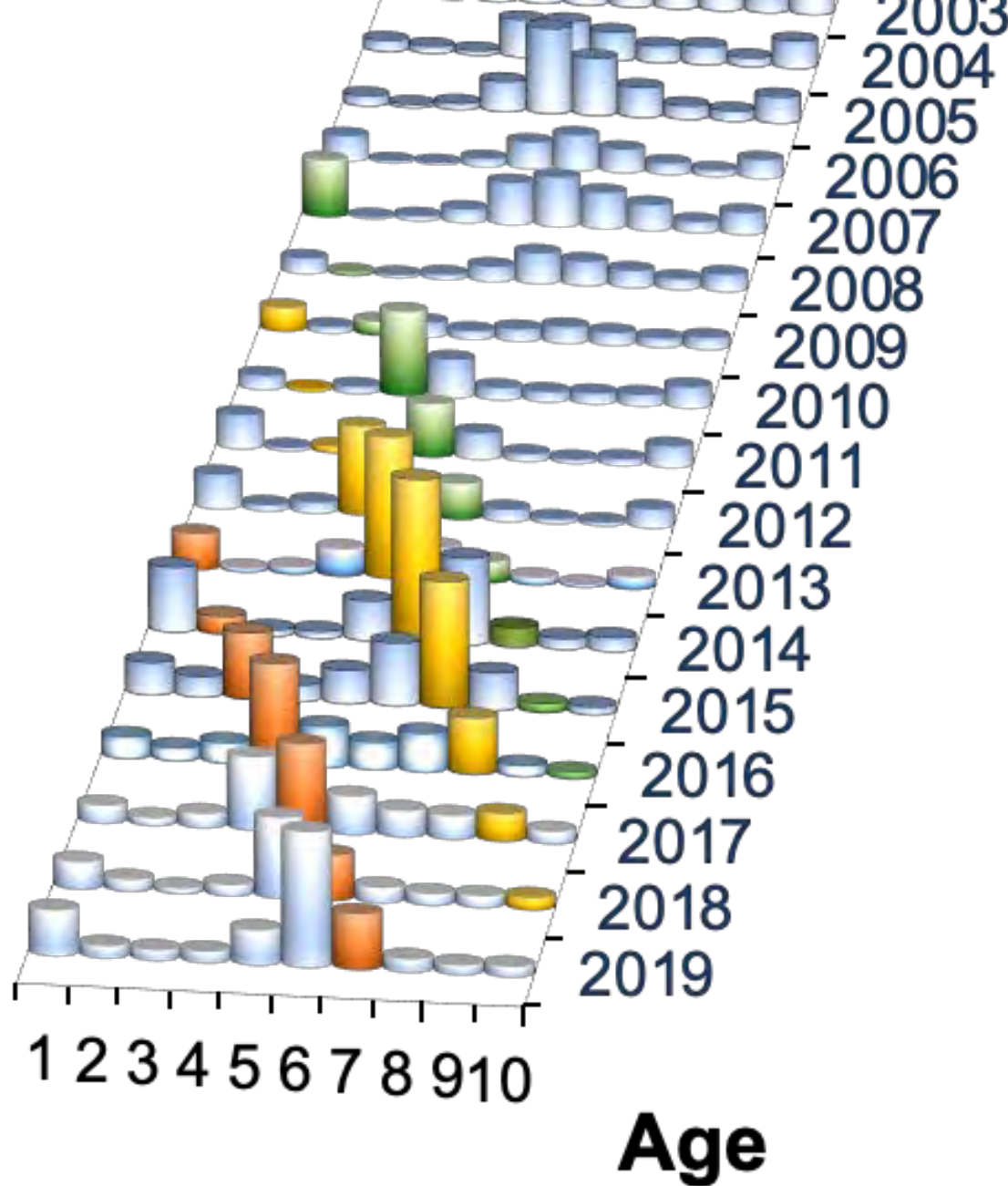
- Base (as in 2018)
- VAST indices—account for Northern Bering Sea biomass
- New work on space-time modeling of survey data
 - Layers of water column
 - Led to an evaluation of effective “catchability”

Population numbers of fish



Scientific Research
Survey
Results





2012 Year class
changing to the
2013...

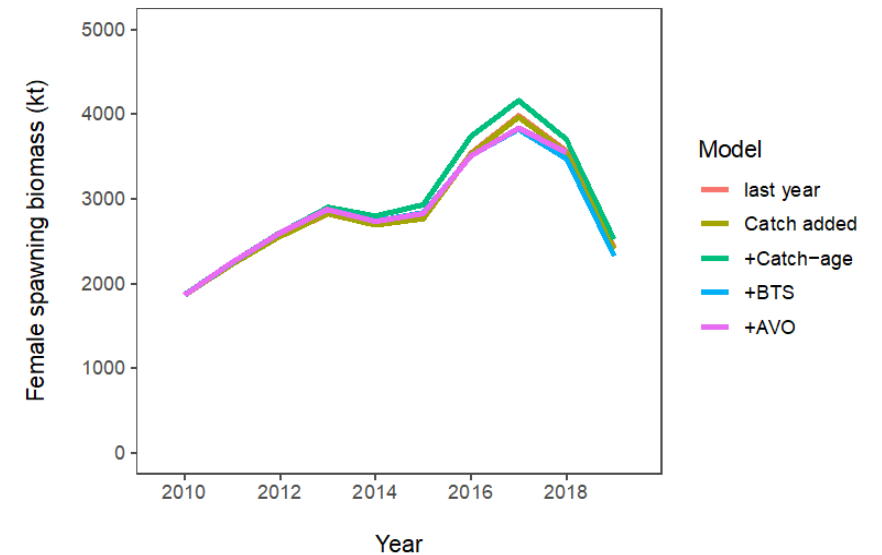
Data Impact on Model

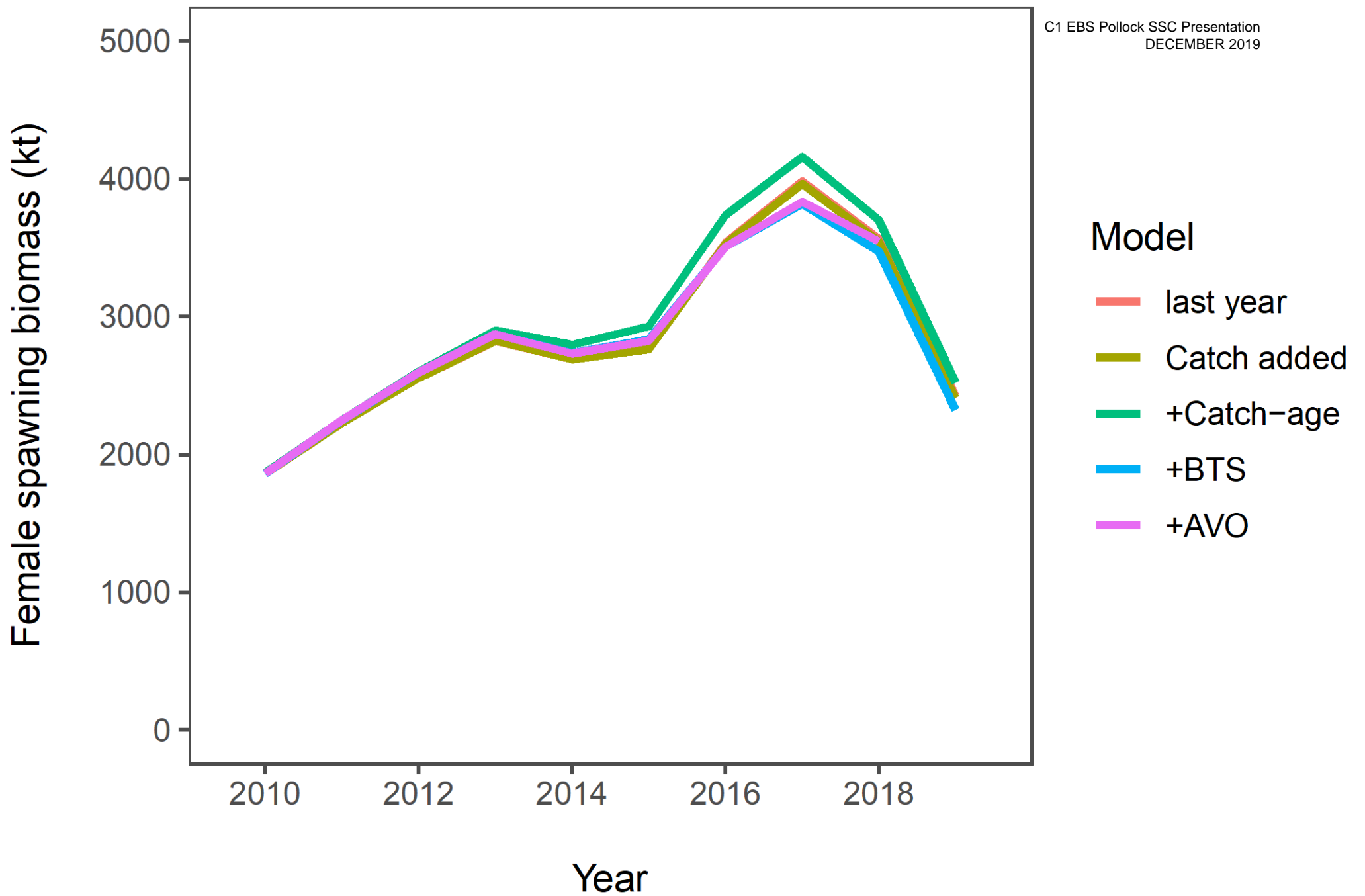
New data impact on model...

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

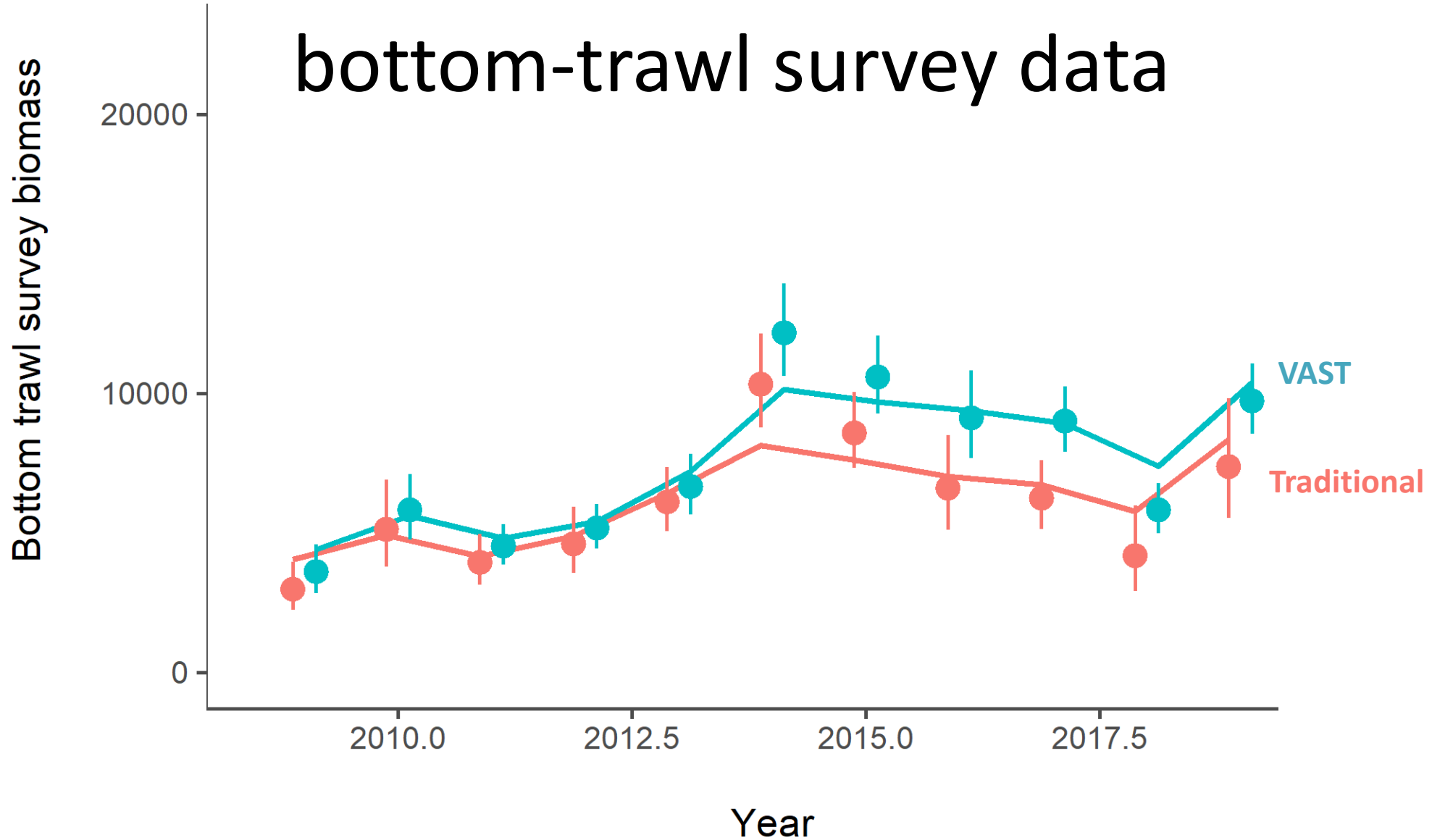




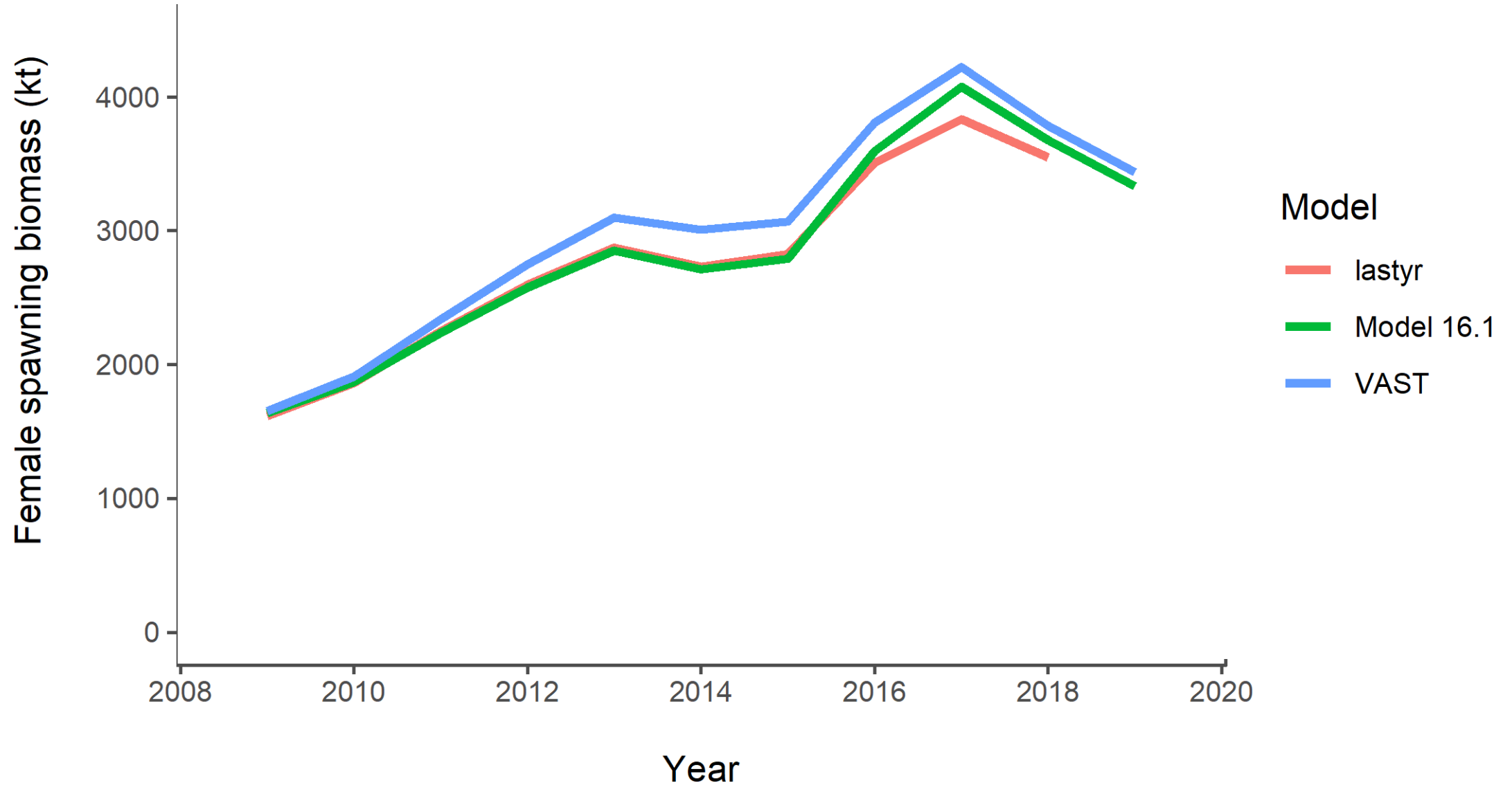
Data
Impact on
Model

Alternative treatments of bottom-trawl survey data

Alternative treatments of bottom-trawl survey data



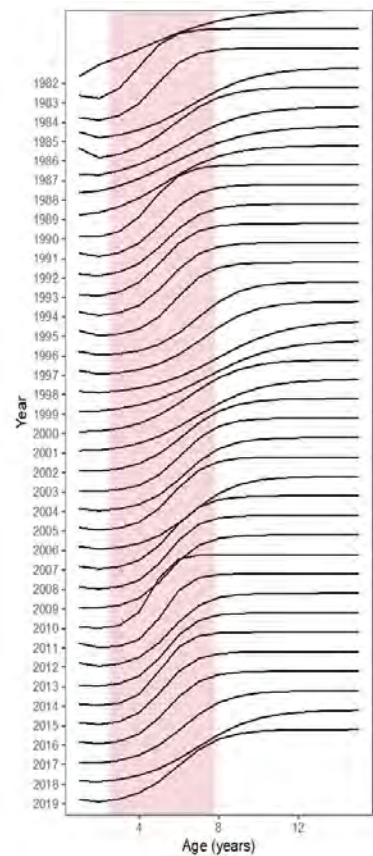
Alternative models for bottom-trawl survey



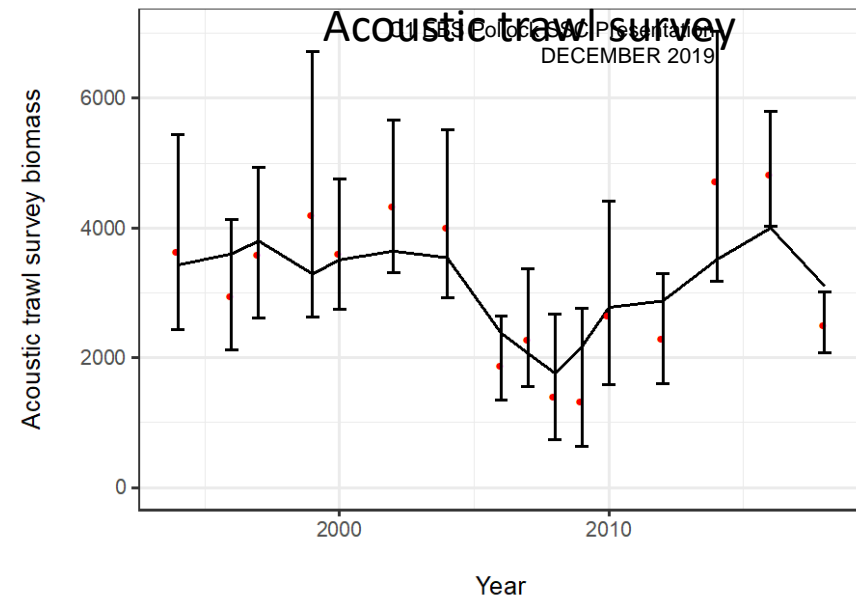
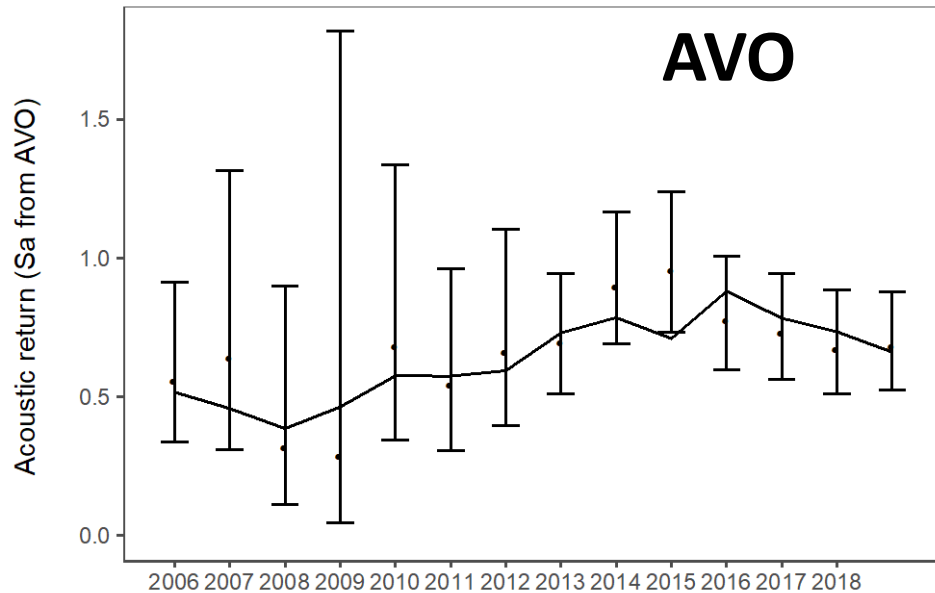
New stuff

- Layers
- Spatial-temporal survey age compositions

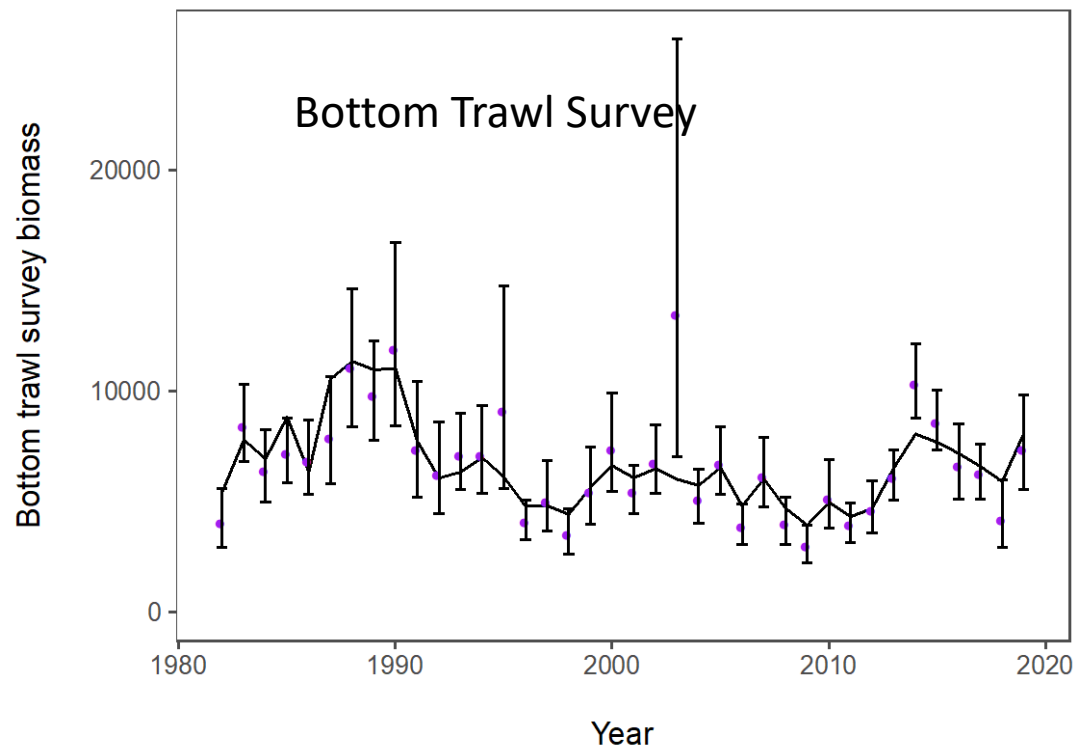
EBS pollock
Assessment
Results

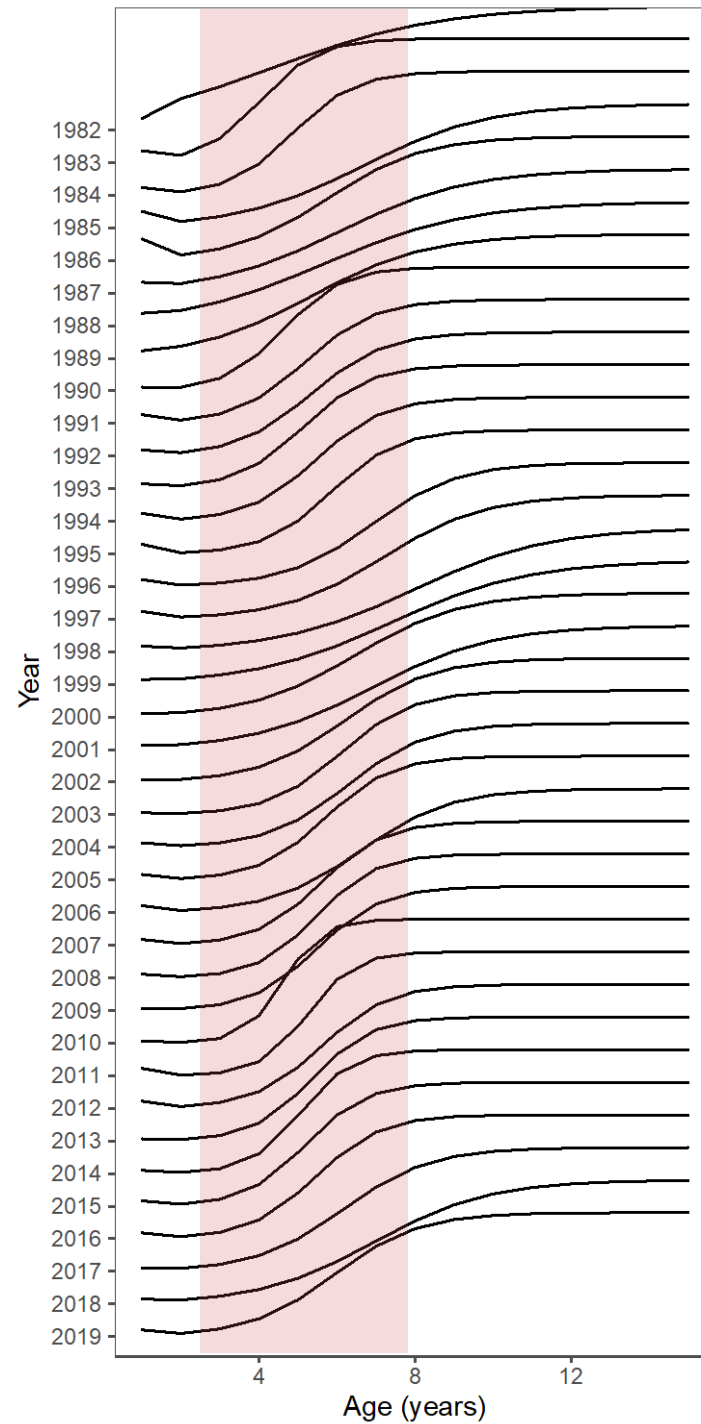


Bottom
trawl
survey
Selectivity
...



**Model
fits to
indices**



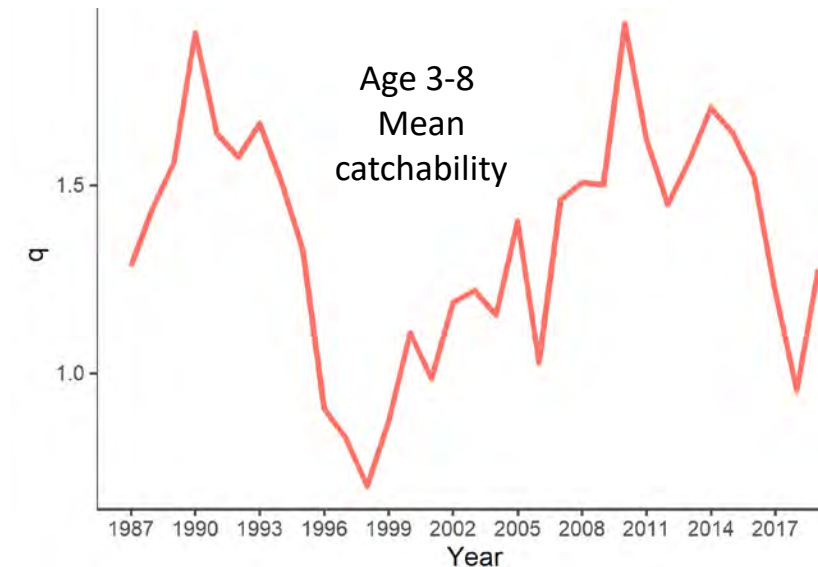


Bottom
trawl
survey
Selectivity
...

Rationale...

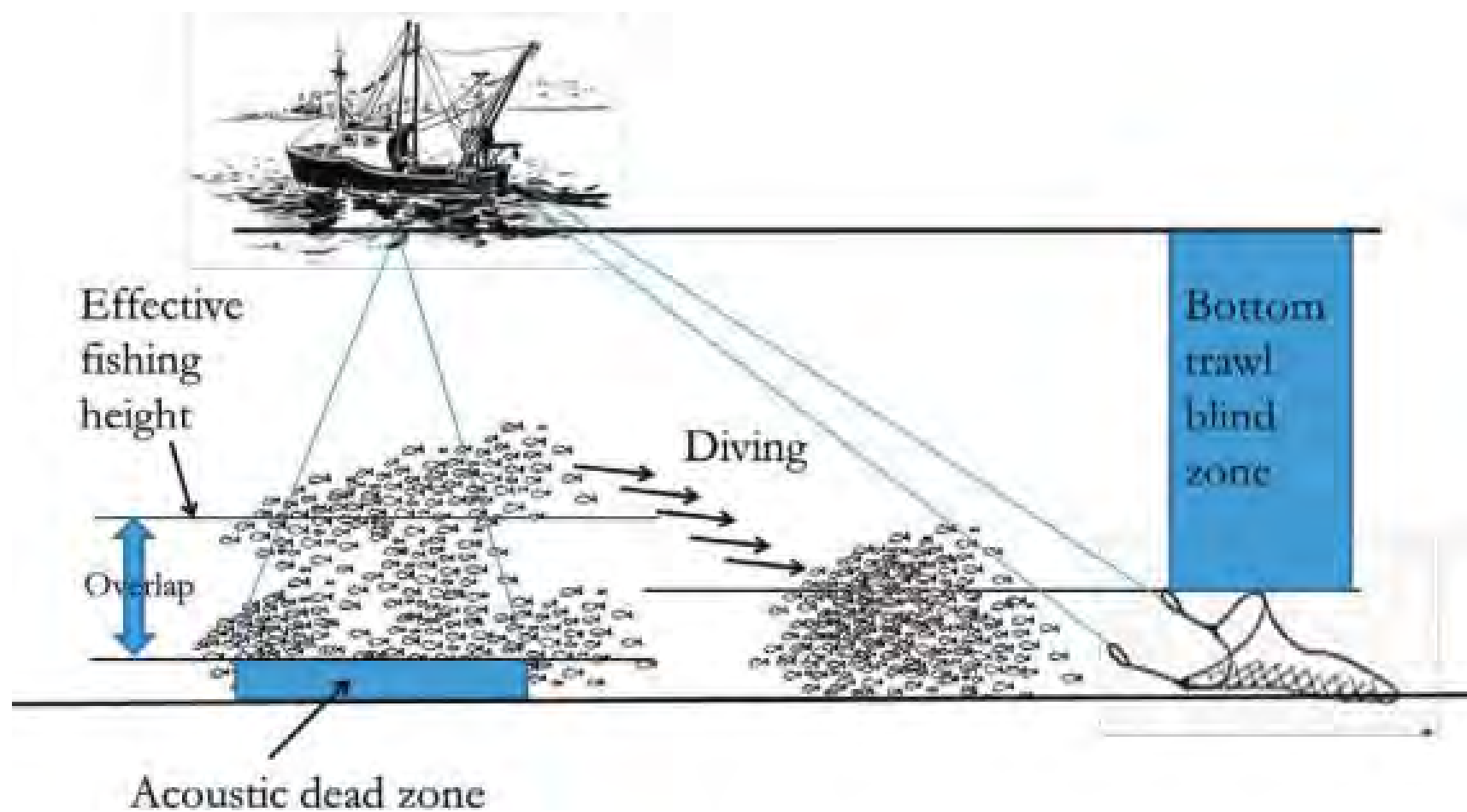
...time varying “catchability” for rigorously conducted scientific fishery-independent survey...

- 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

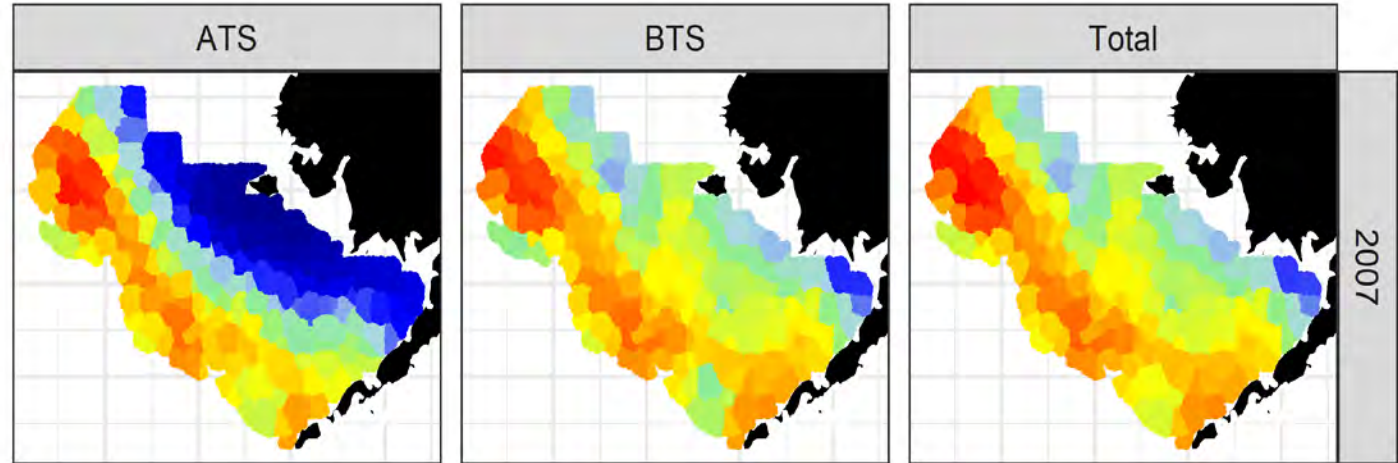
Cole Monnahan



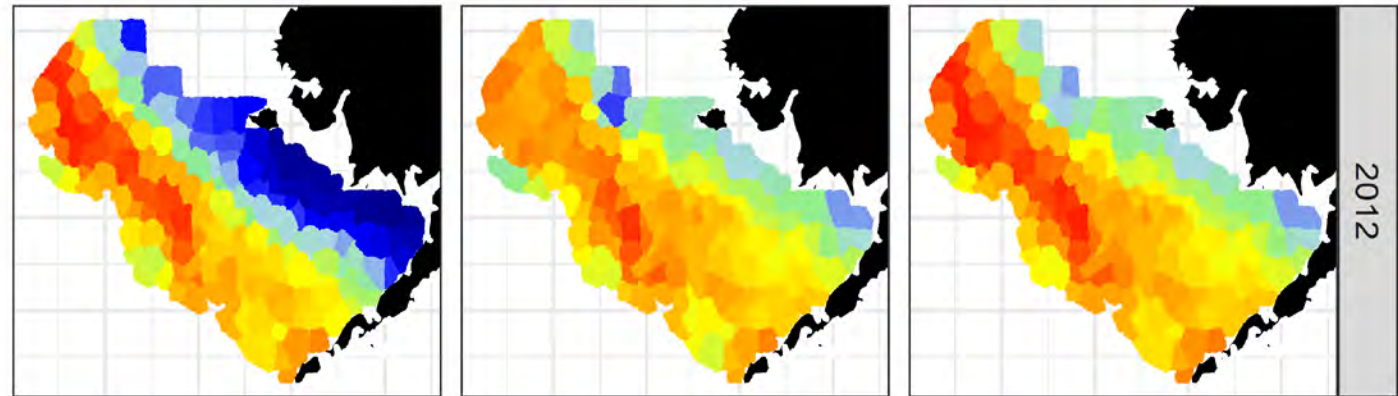
Acoustic Bottom *Combined*

EBS Pollock SSC Presentation
DECEMBER 2019

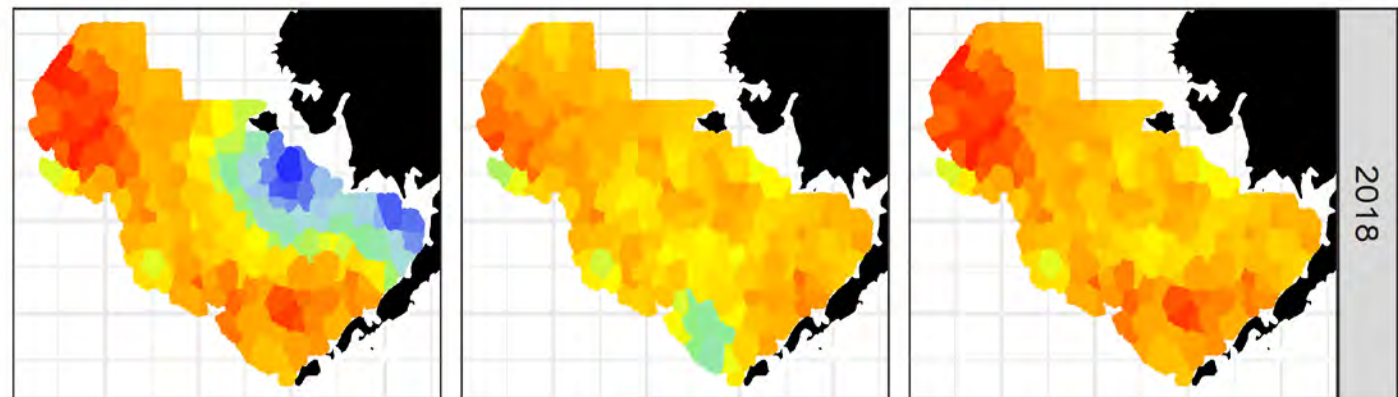
2007



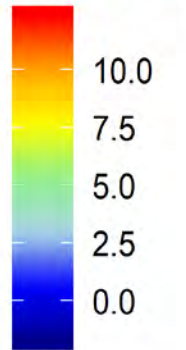
2012



2018



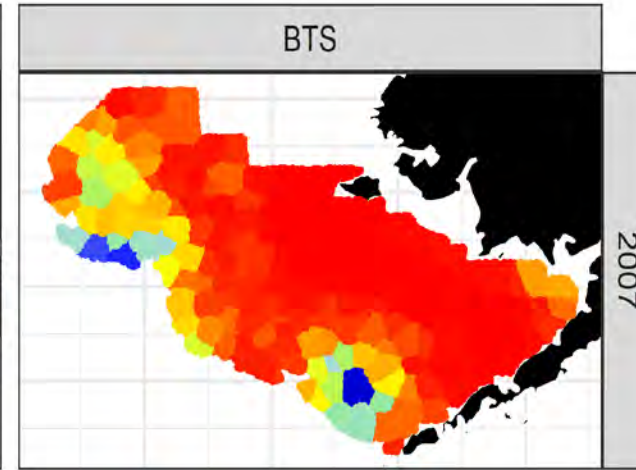
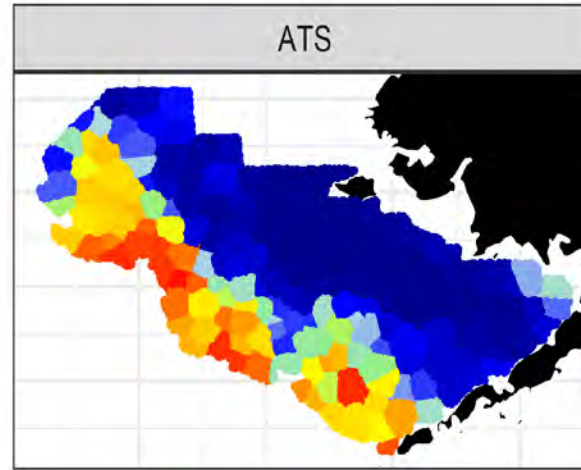
log(density)



Acoustic

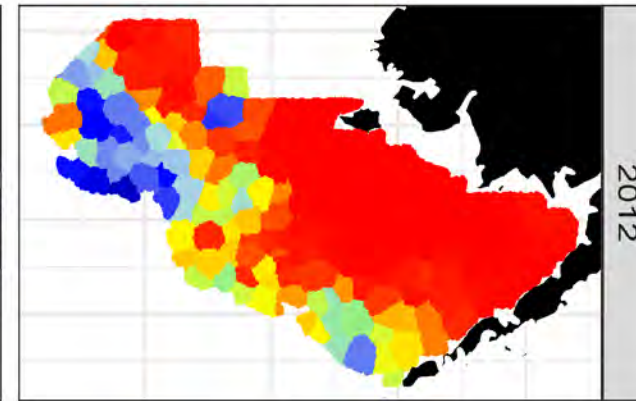
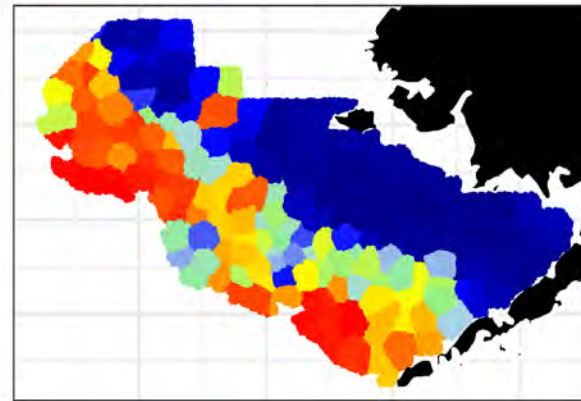
Bottom

2007



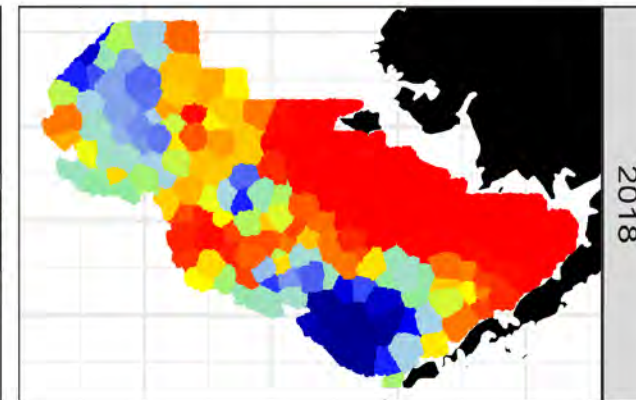
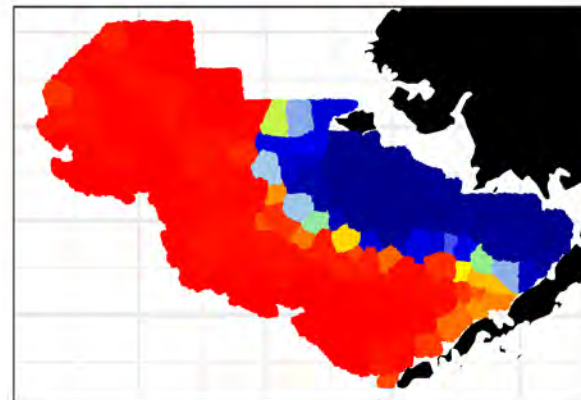
2007

2012

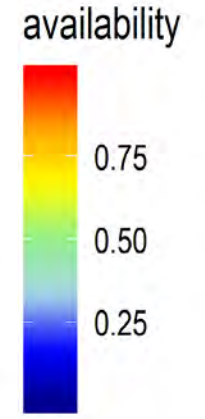


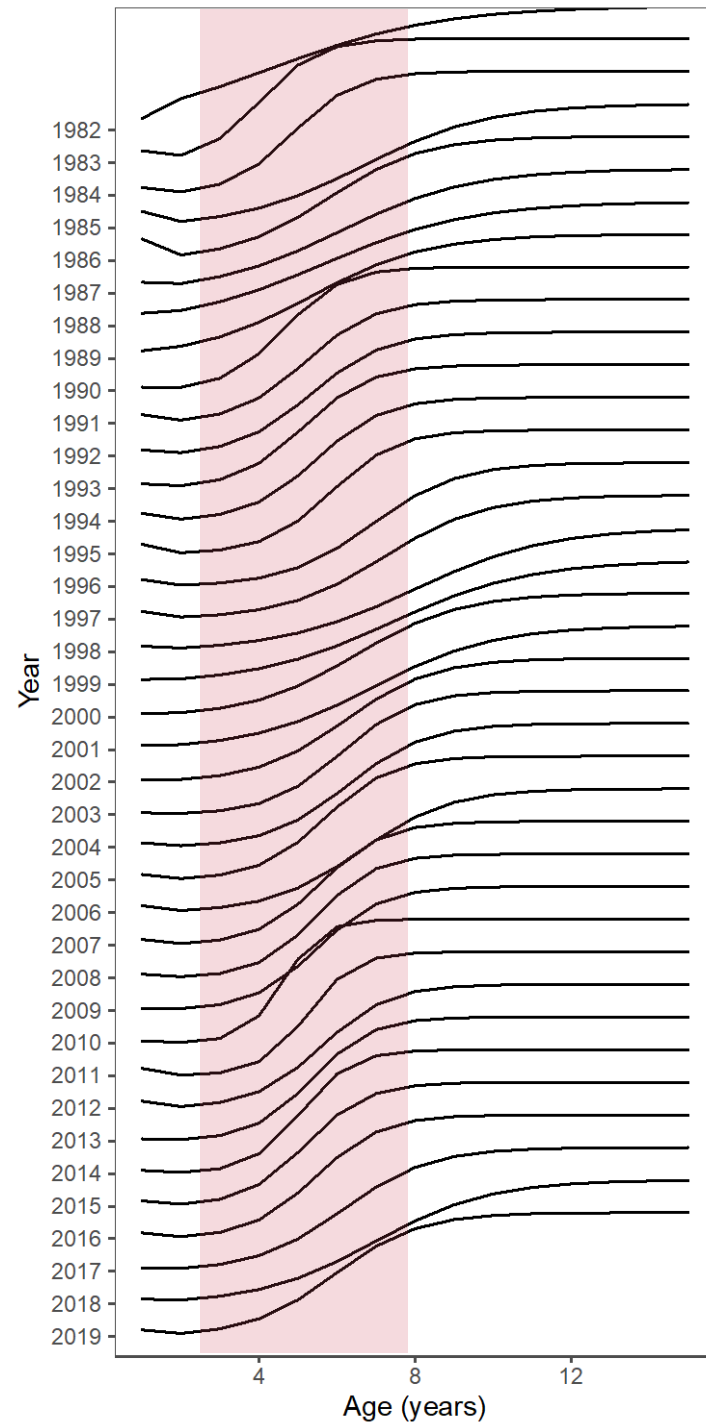
2012

2018



2018



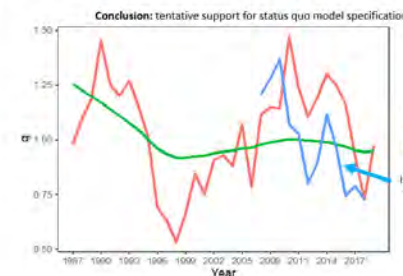


Bottom
trawl
survey
Selectivity
...

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. CV EBS Pollock SSC Presentation
DECEMBER 2019

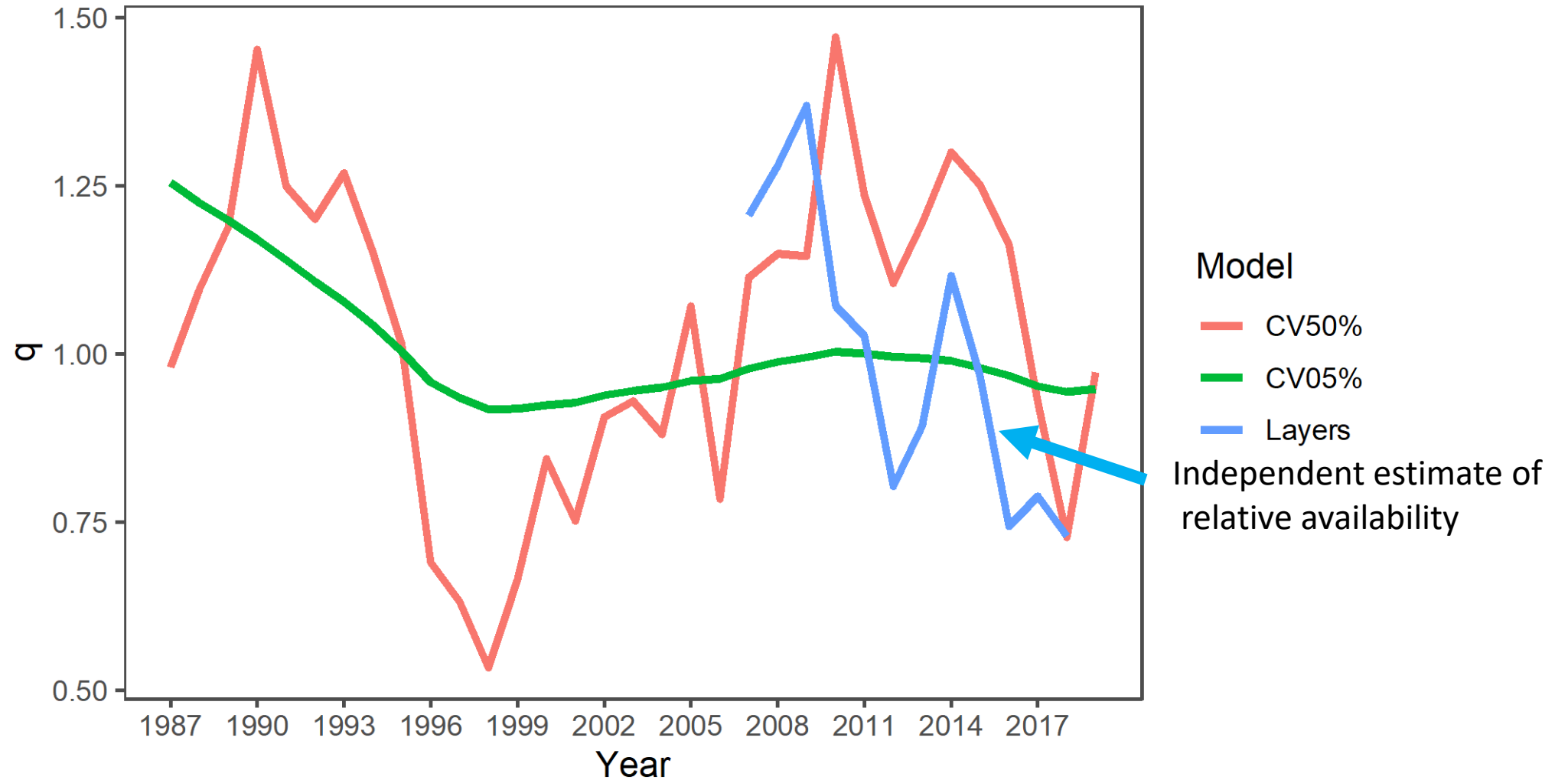
Component	Less flexibility in survey "catchability"				
	CV70%	CV50%	CV20%	CV10%	CV05%
RMSE BTS	0.19	0.20	0.25	0.29	0.31
RMSE ATS	0.22	0.22	0.22	0.23	0.25
RMSE AVO	0.20	0.20	0.20	0.20	0.20
RMSE CPUE	0.09	0.09	0.09	0.09	0.09
SDNR BTS	1.02	1.19	1.79	2.23	2.47
SDNR ATS	1.10	1.10	1.11	1.14	1.22
SDNR AVO	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 trawl

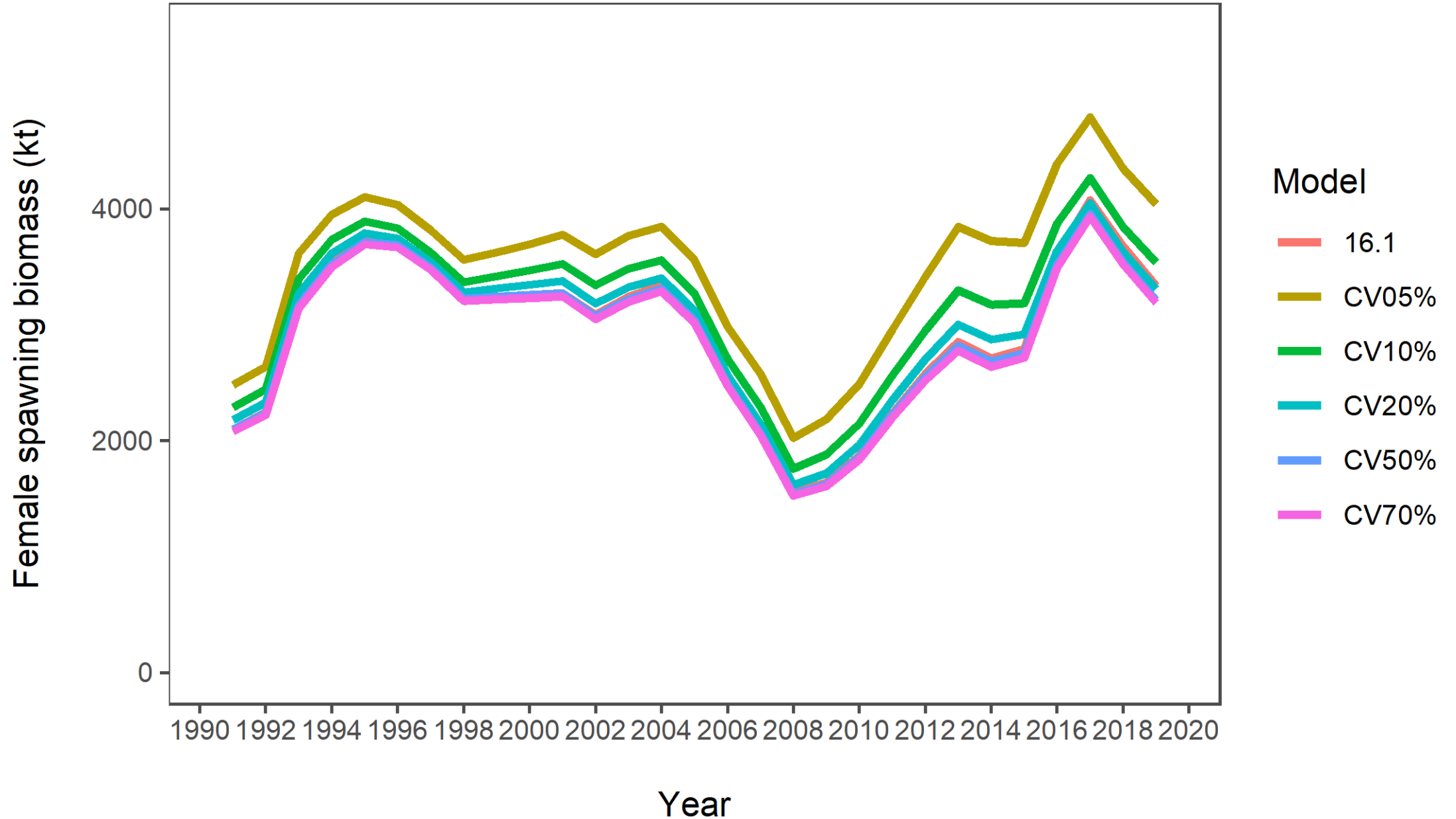


Age 3-8 relative “availability” to bottom trawl survey

Conclusion: tentative support for status quo model specification...



Impact of constraining availability assumption..





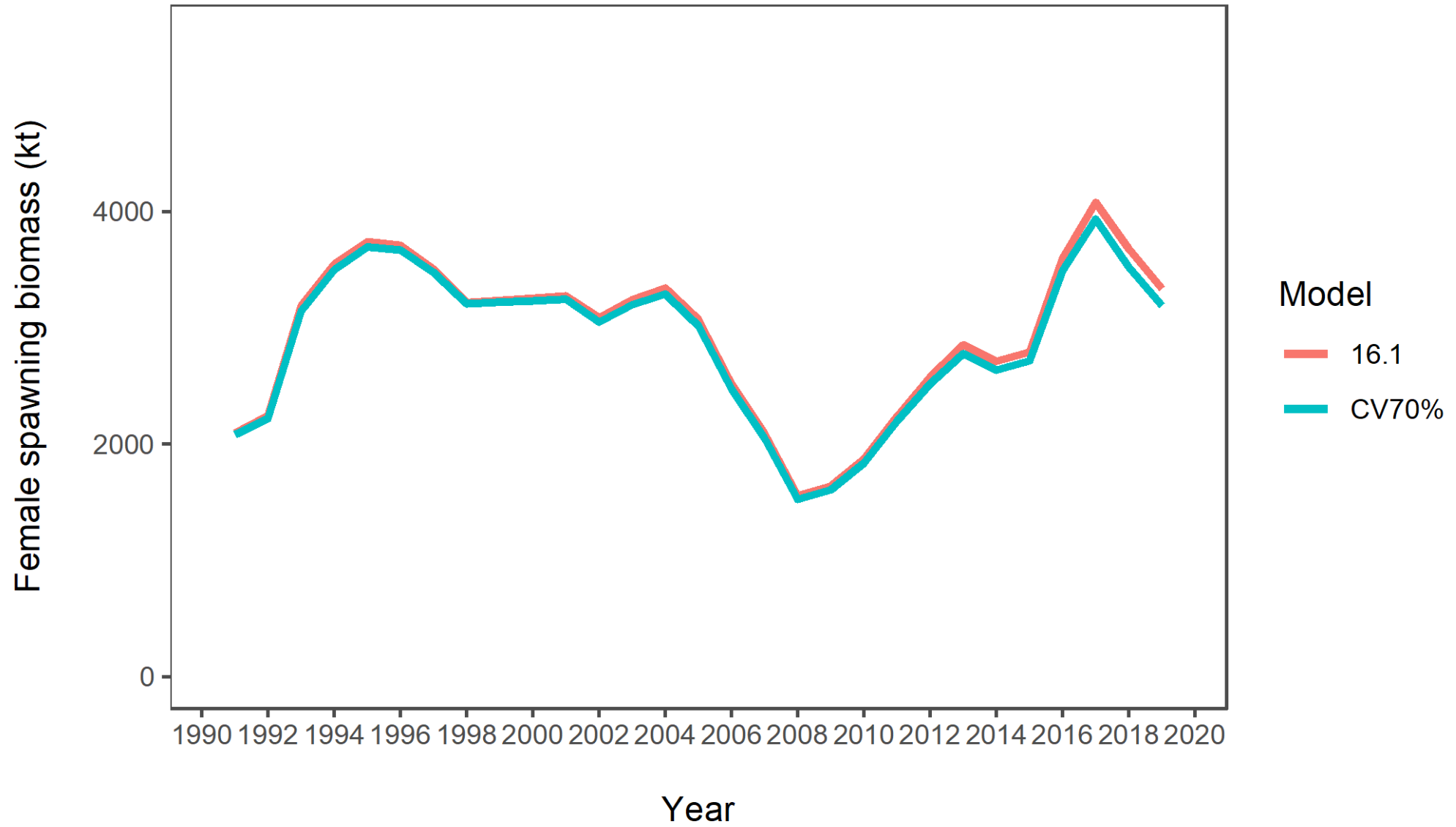
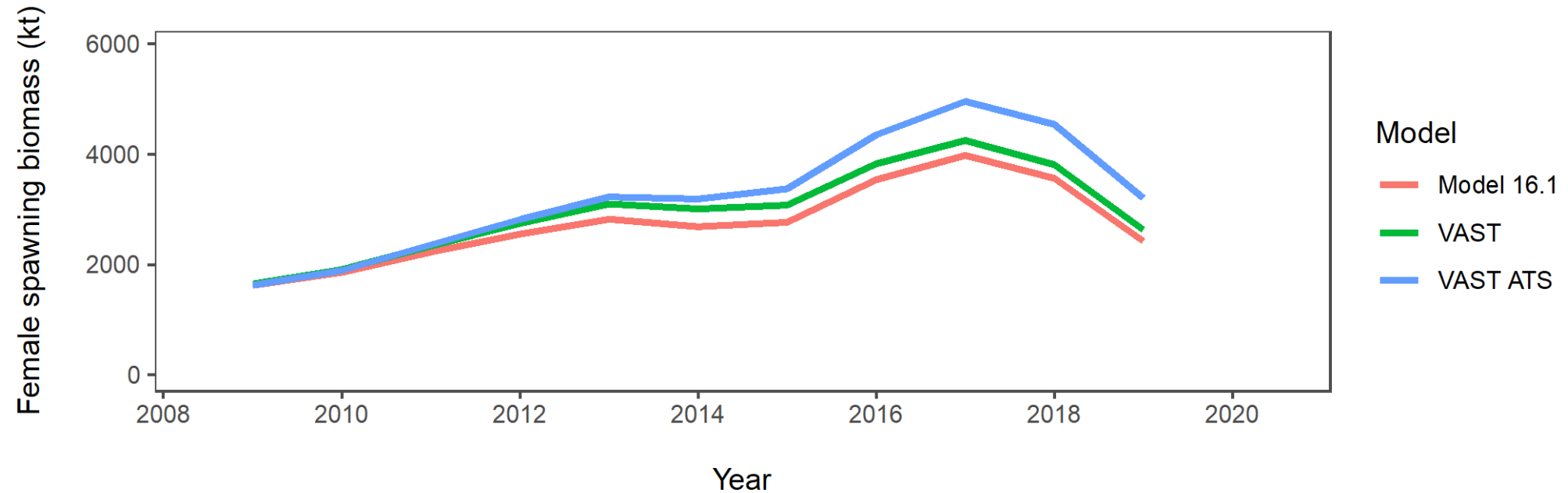
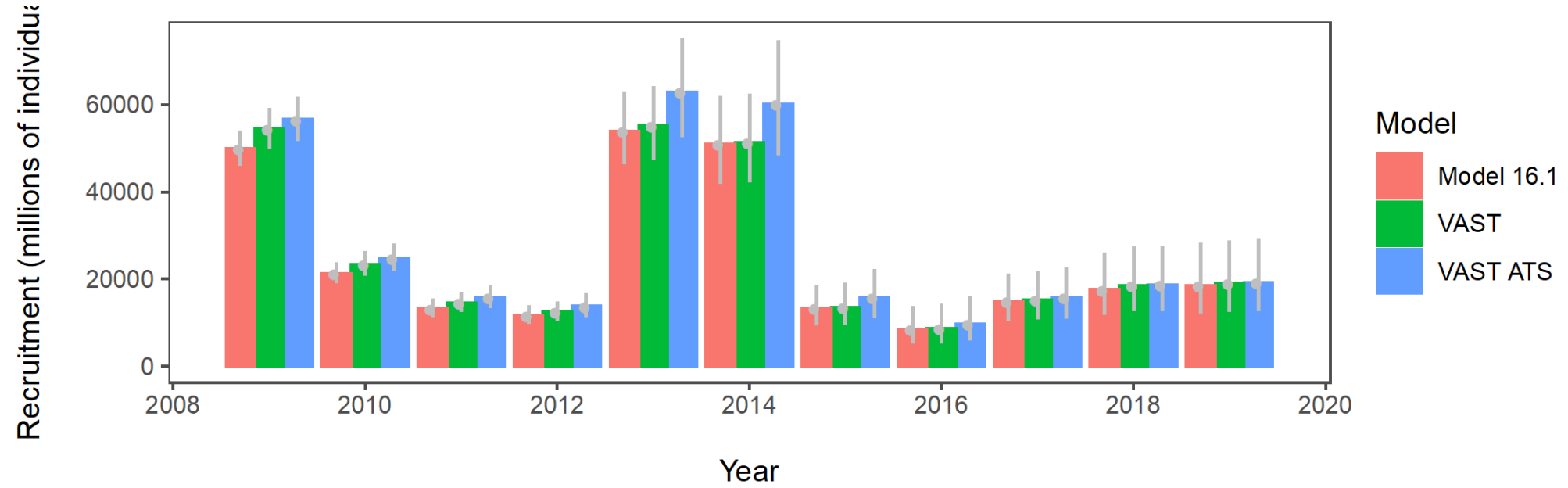


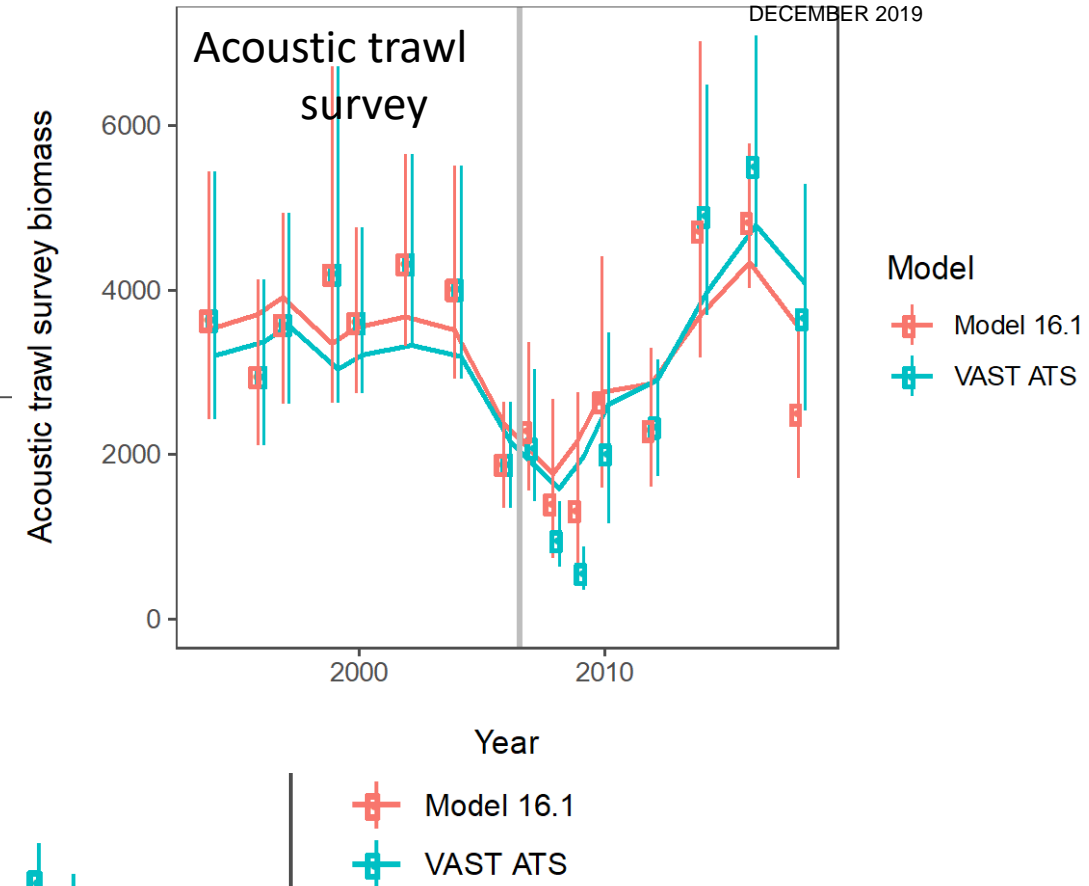
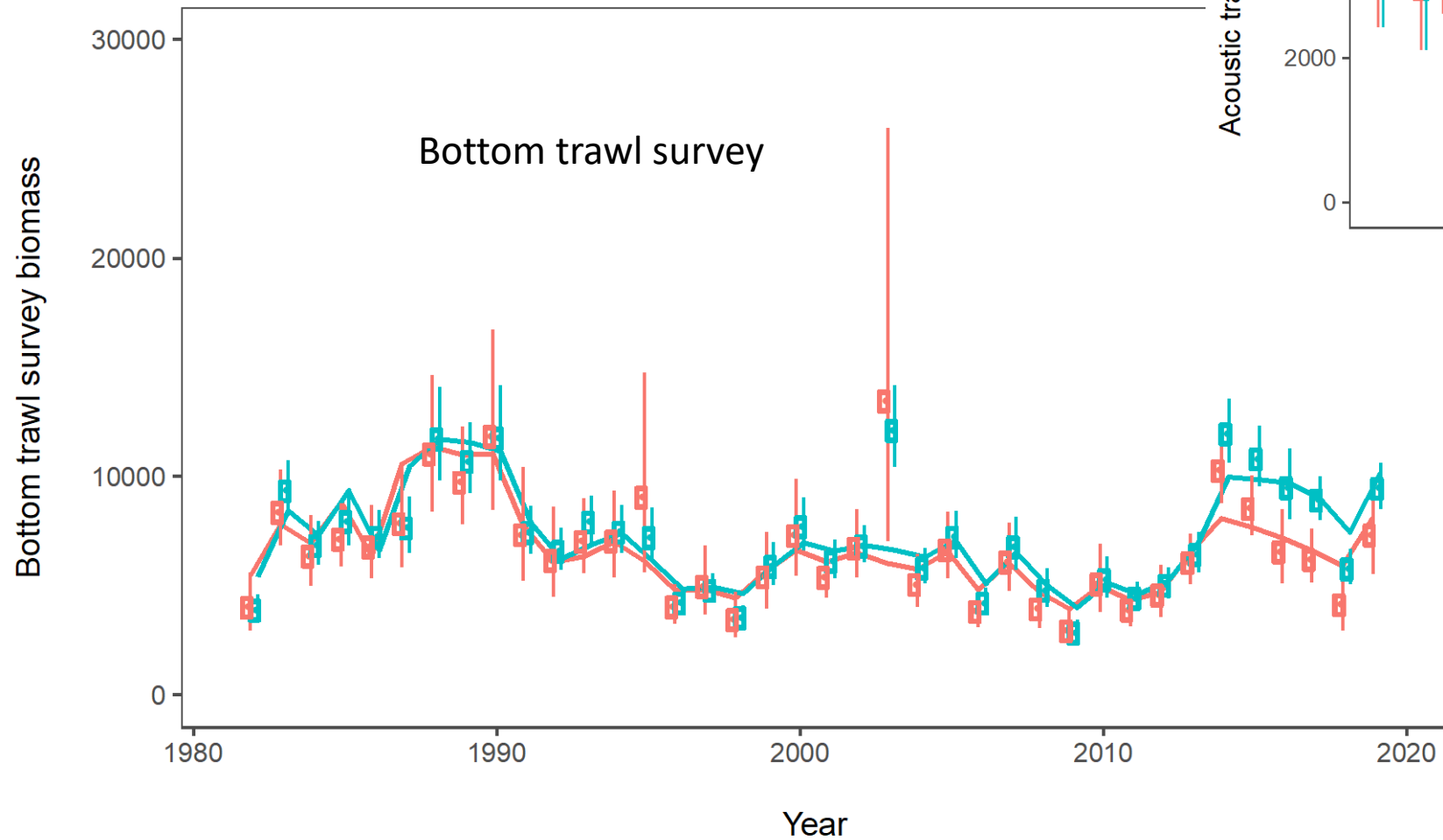
Table 27: Goodness of fit to primary data used for assessment model parameter estimation for different model configurations, EBS pollock.

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...

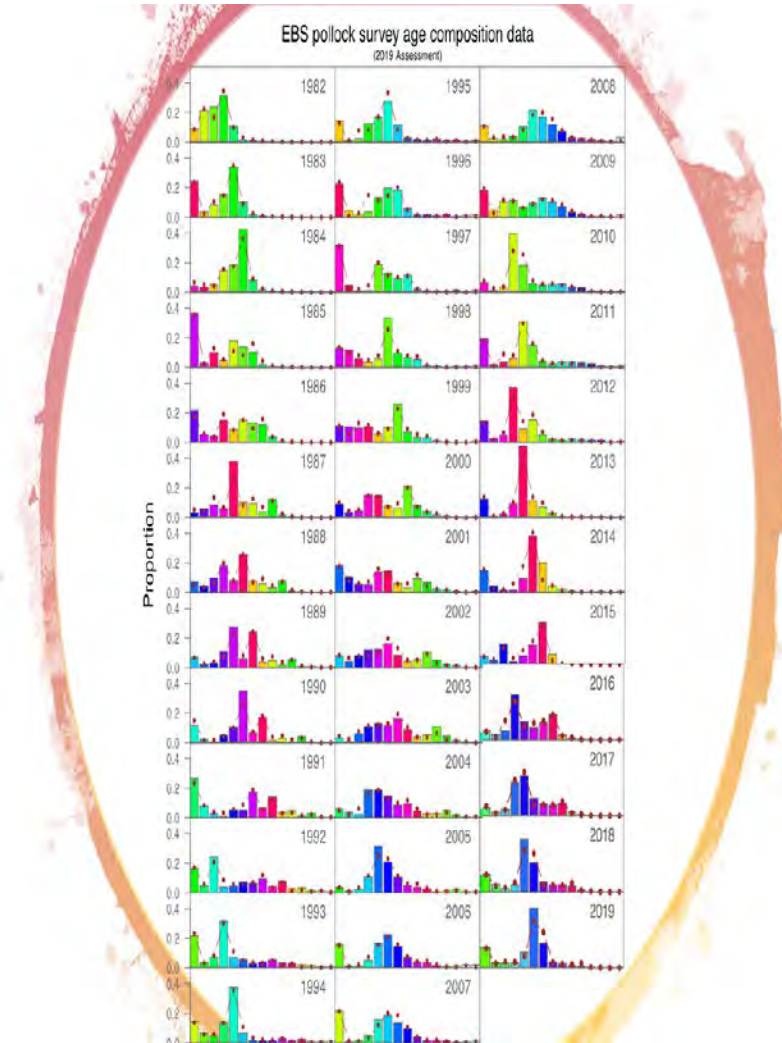


Other model contrasts...



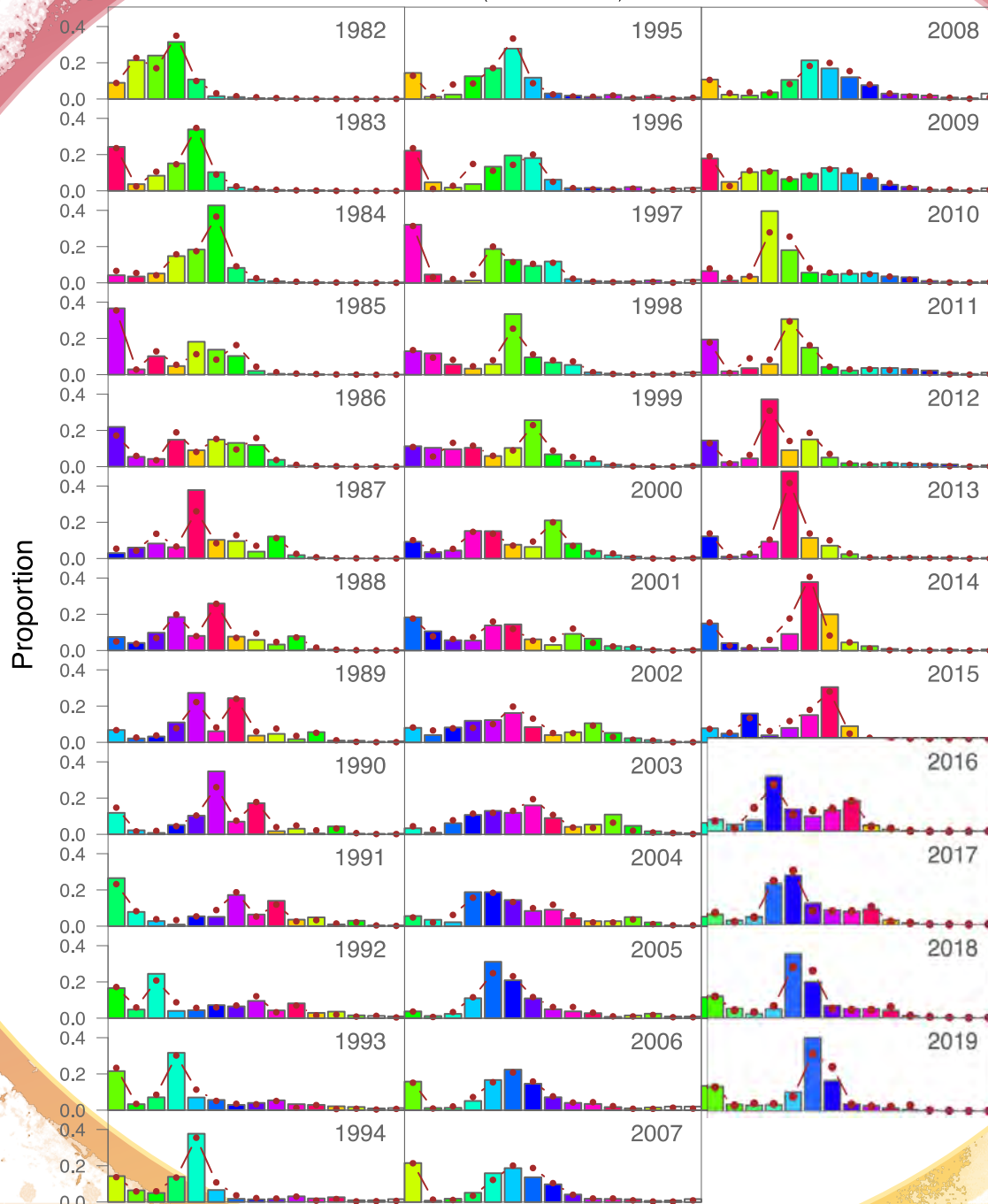
Model results...fit to data

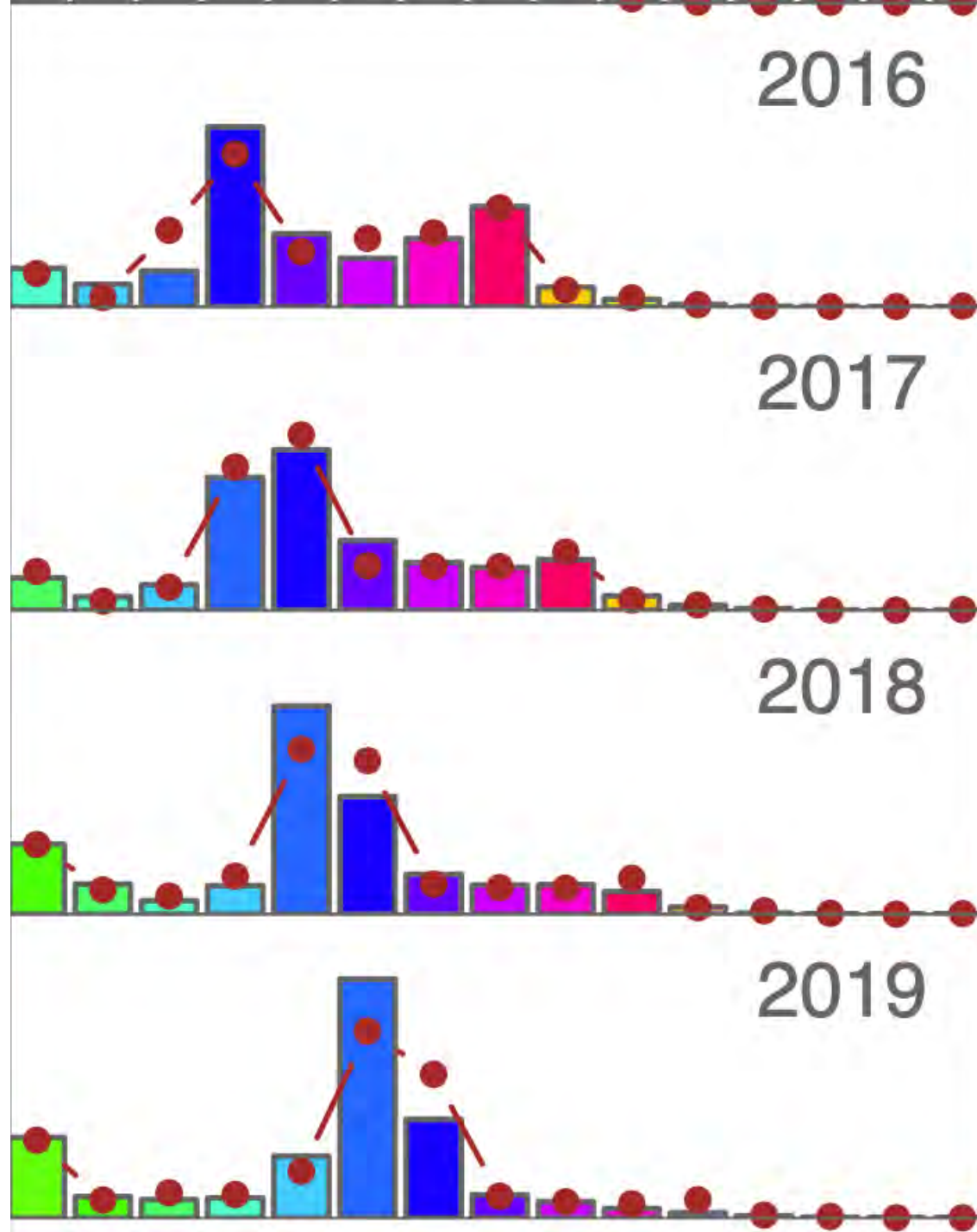
Bering Sea
pollock
Bottom trawl survey
age data and
fits



EBS pollock survey age composition data

(2019 Assessment)

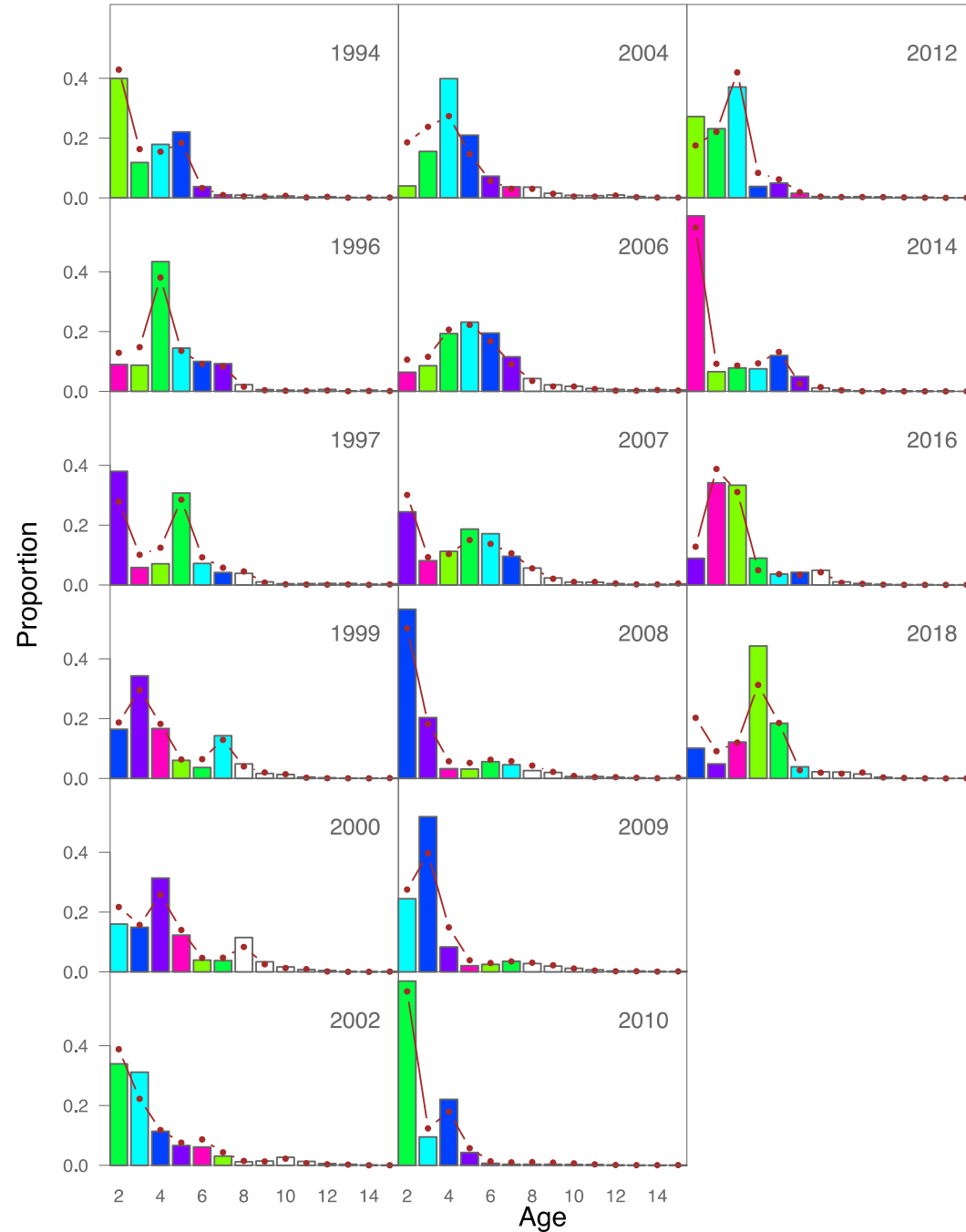




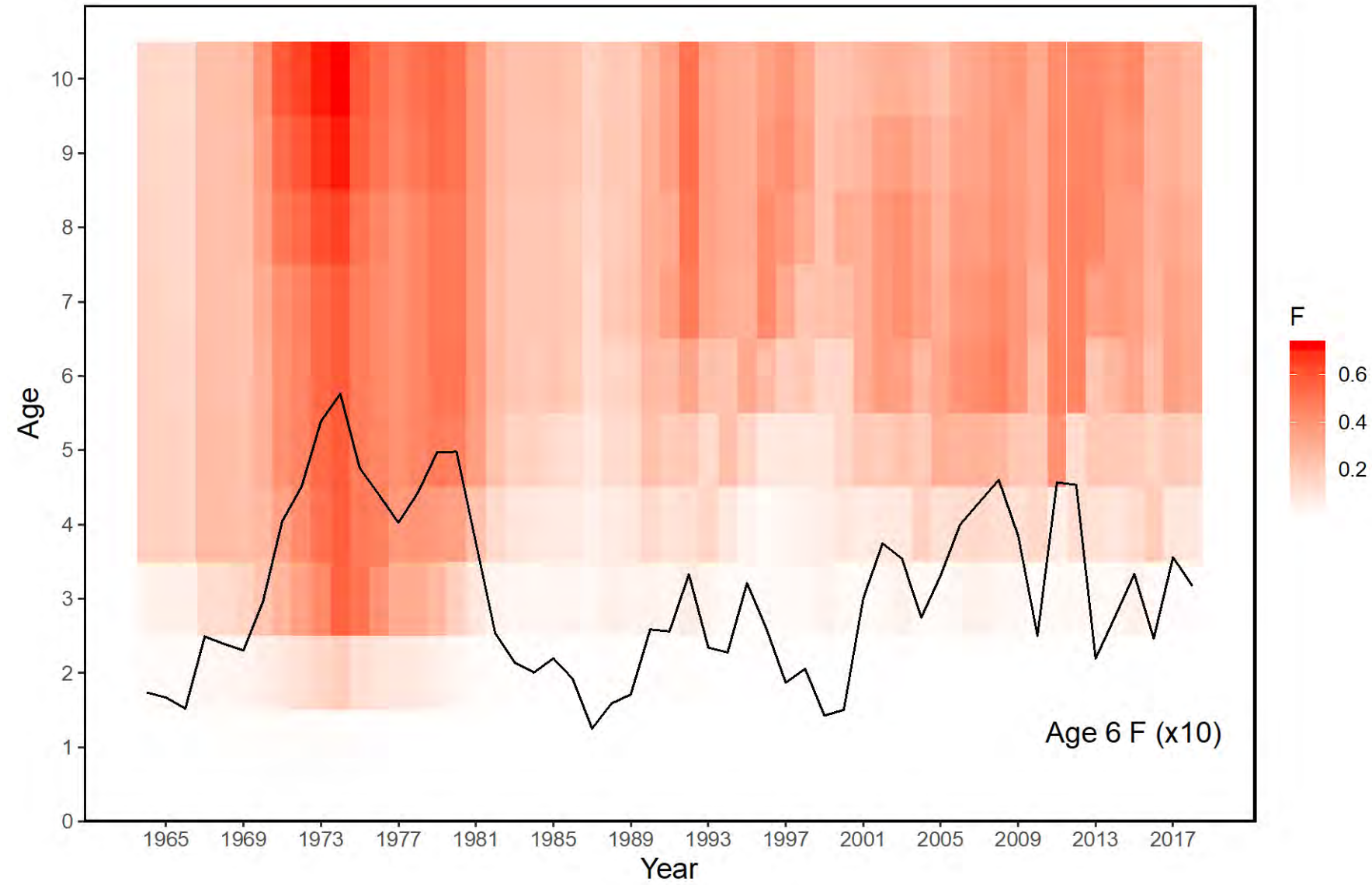
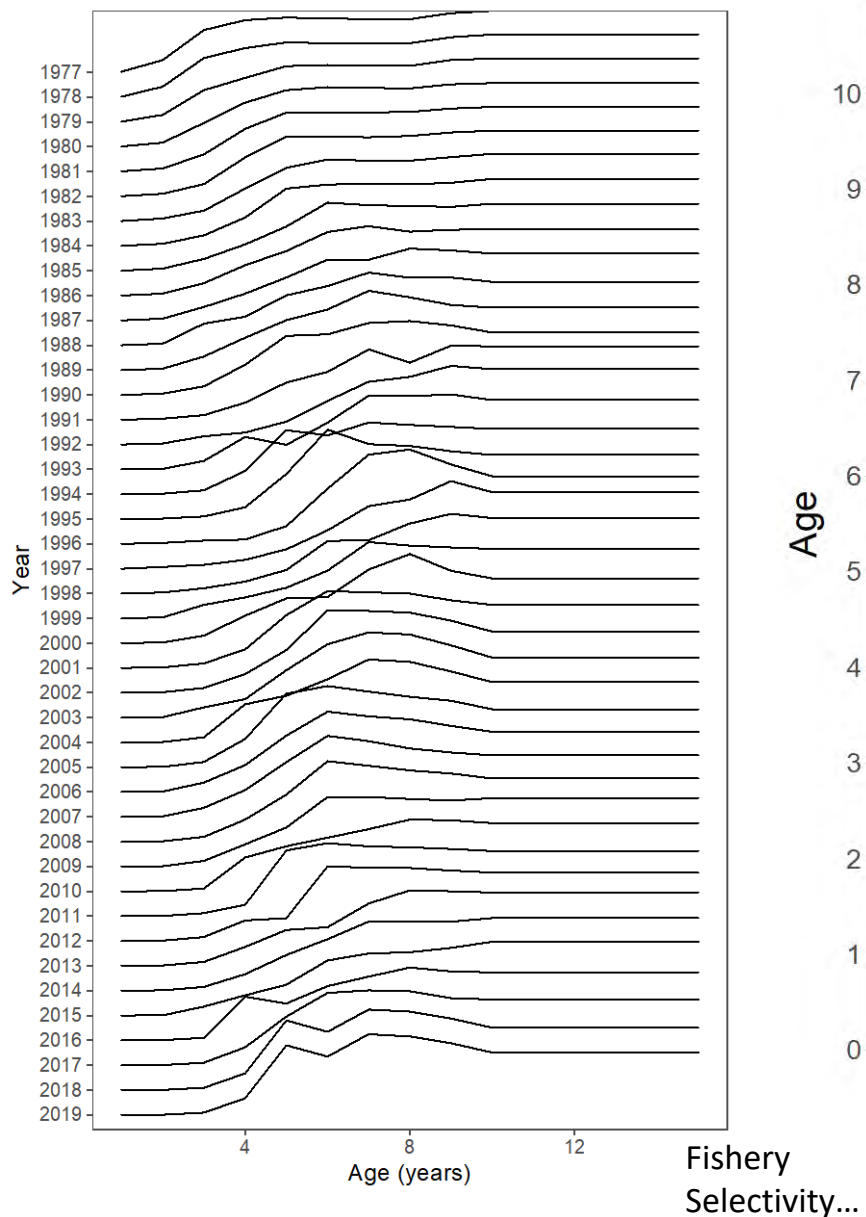
EBS pollock
Assessment
Results

Bering Sea
pollock
Acoustic survey
age data and
fits

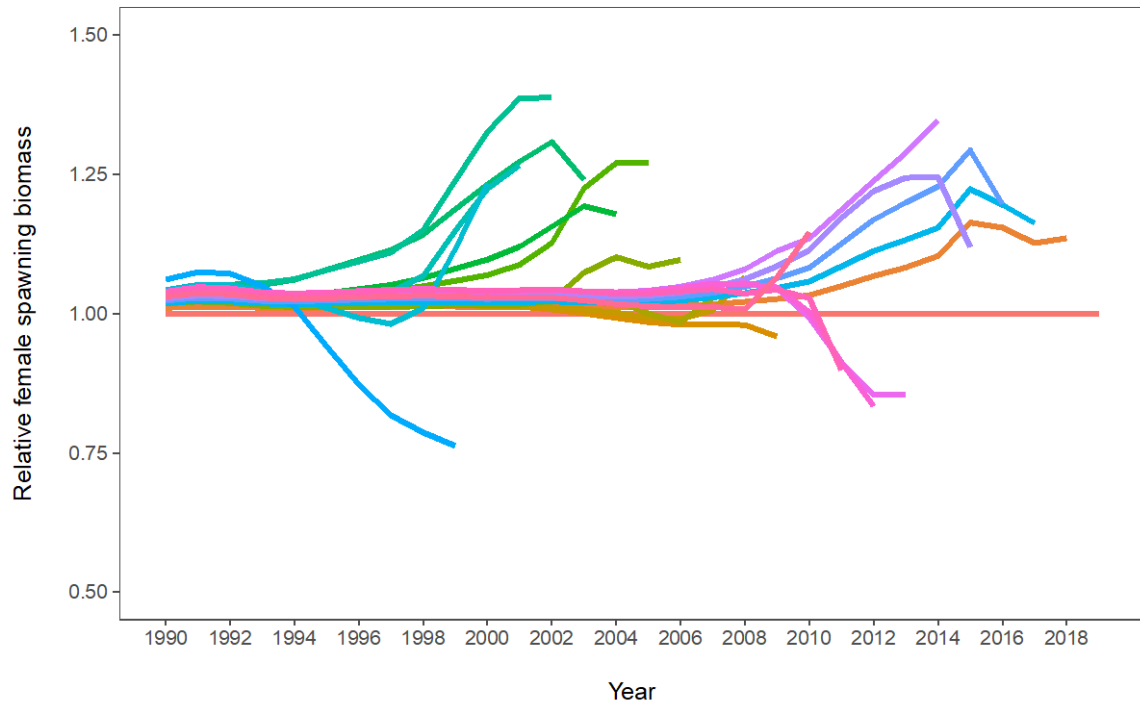
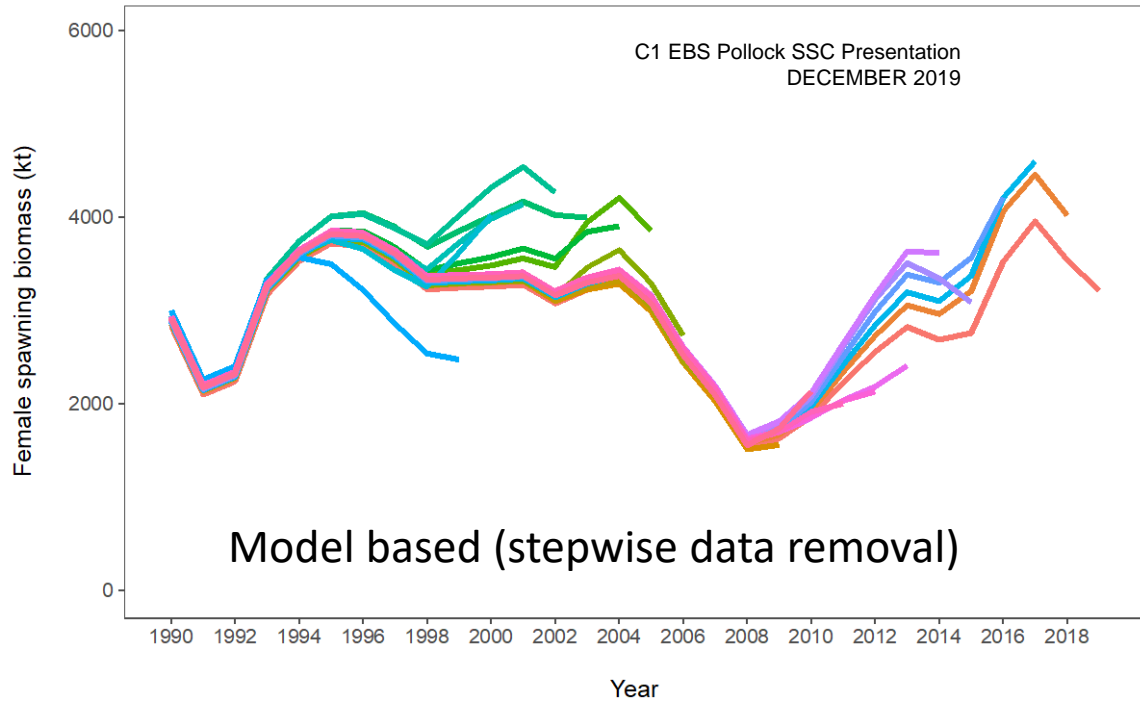
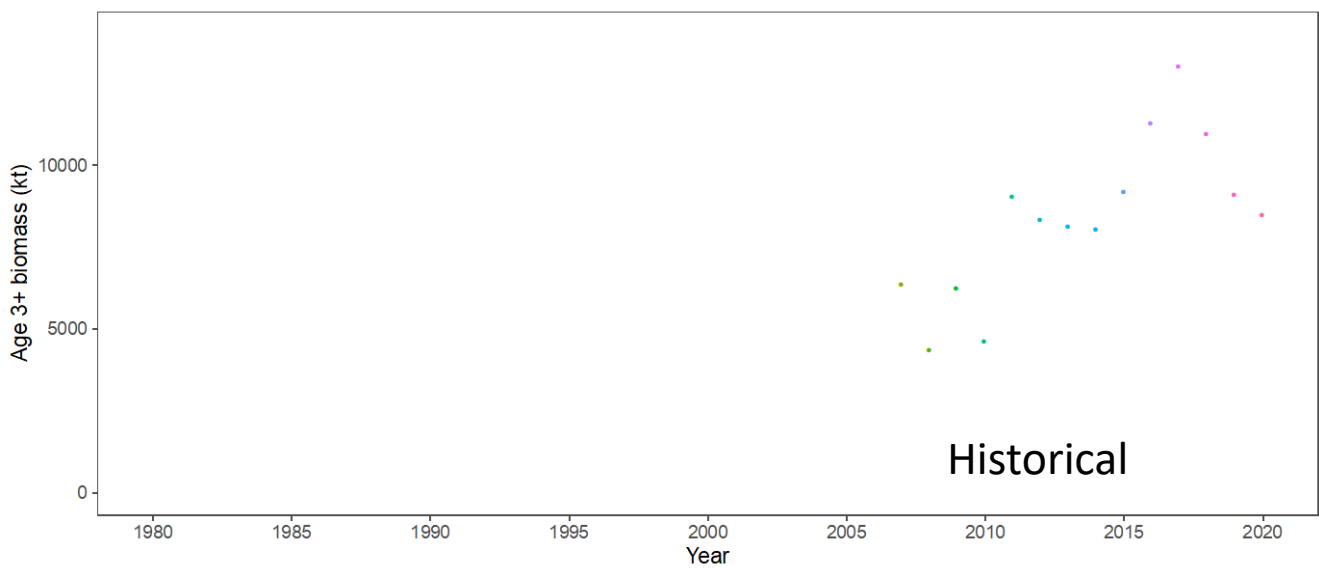
EBS pollock survey age composition data
(2018 Assessment)



Fishing mortality rates



Retrospectives



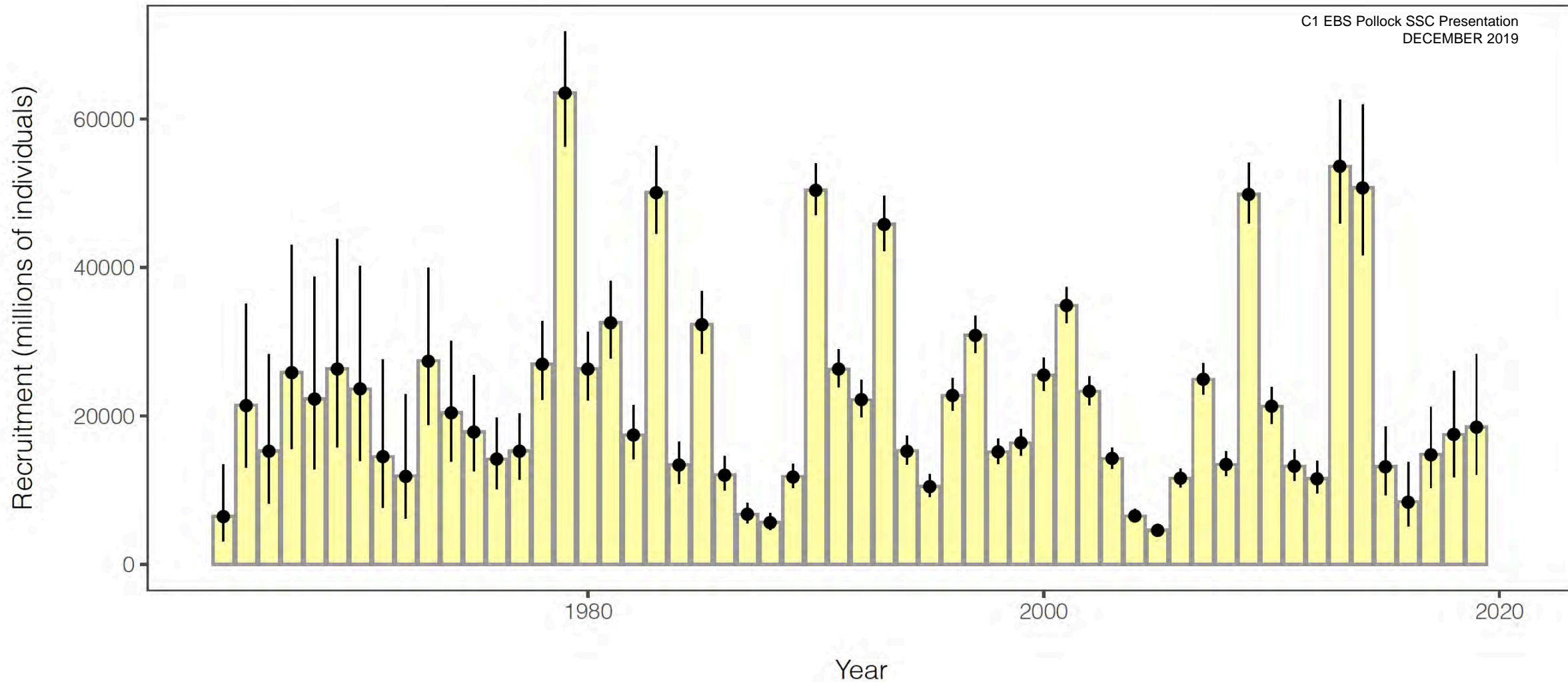
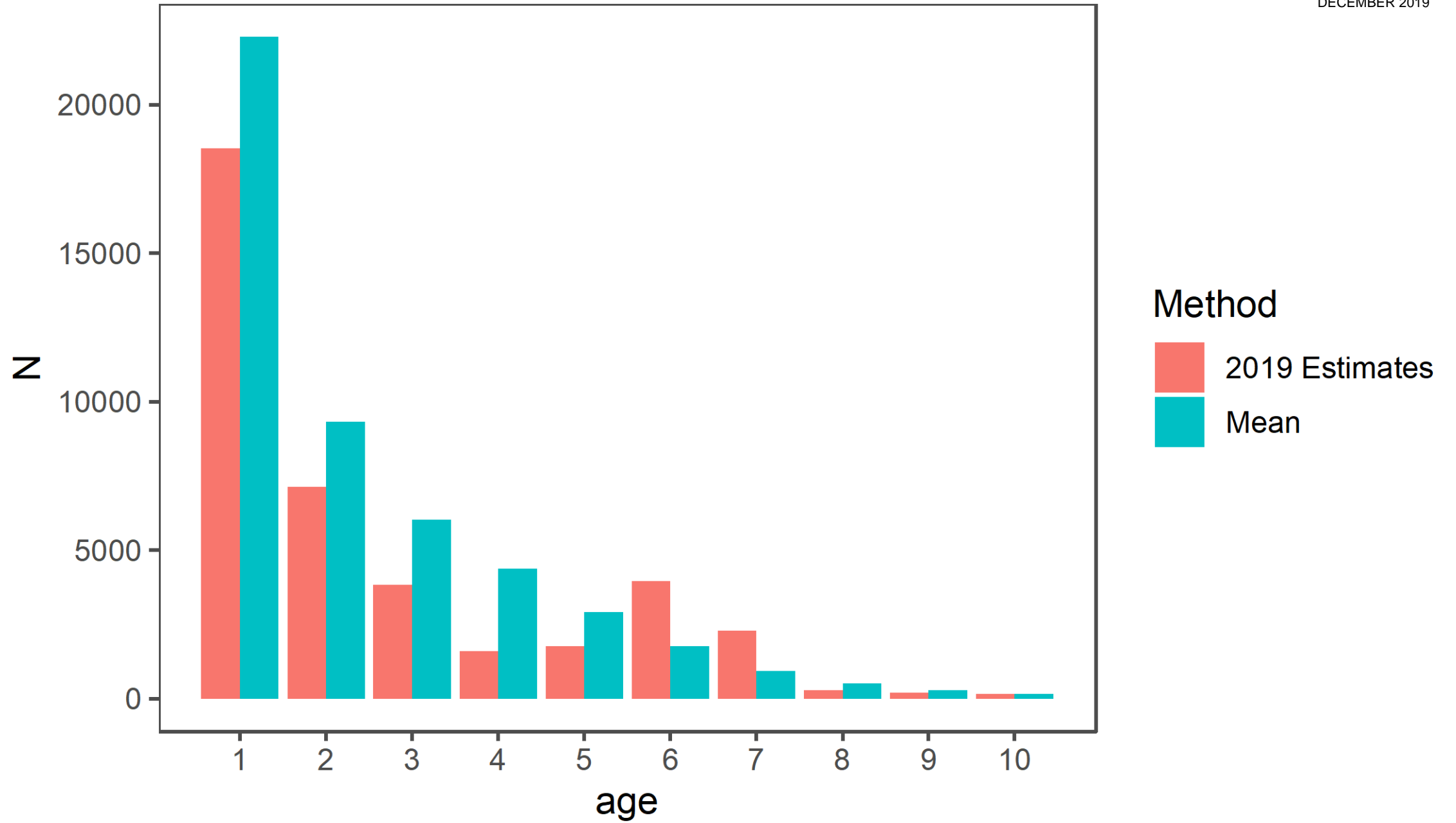
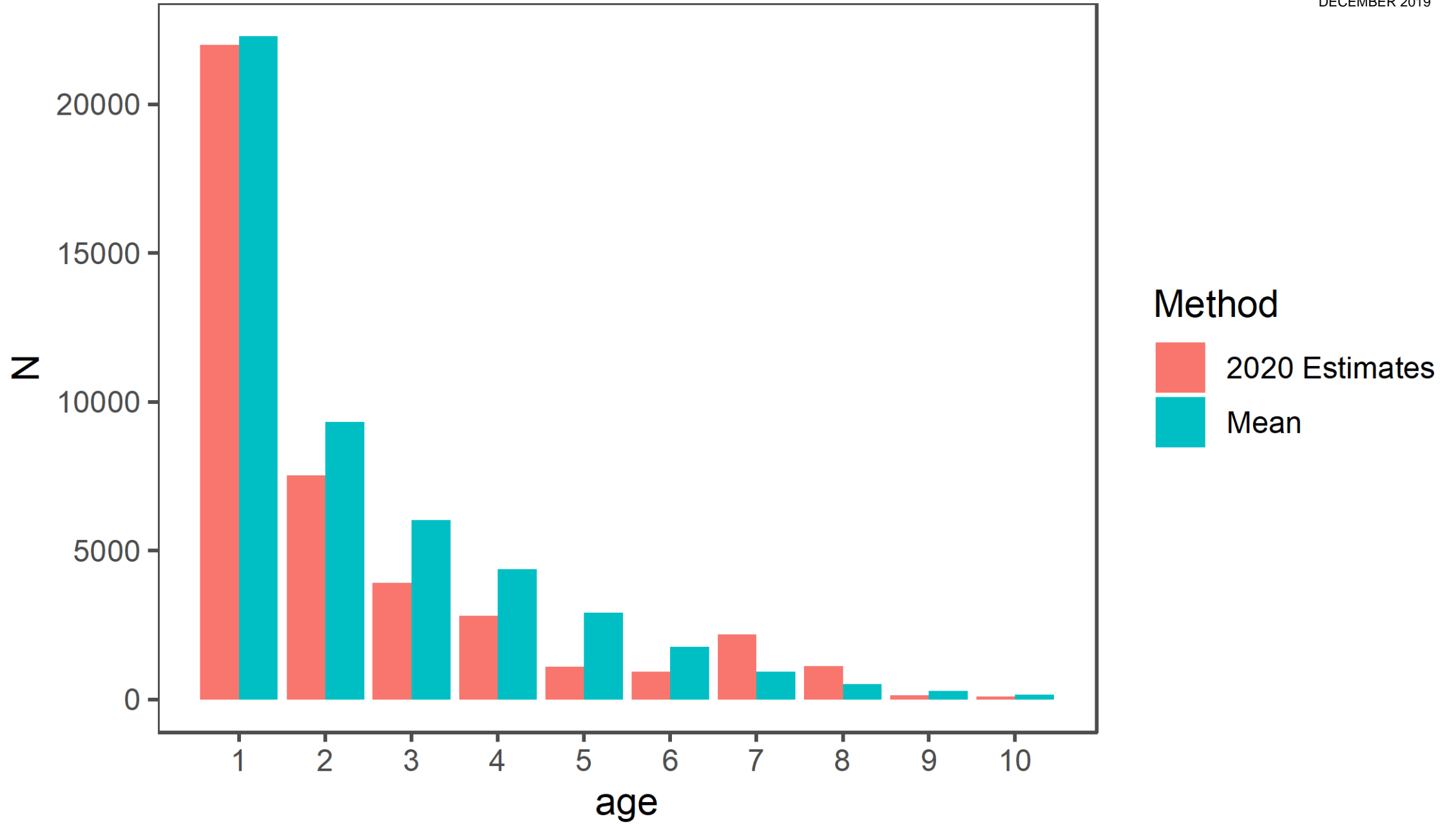
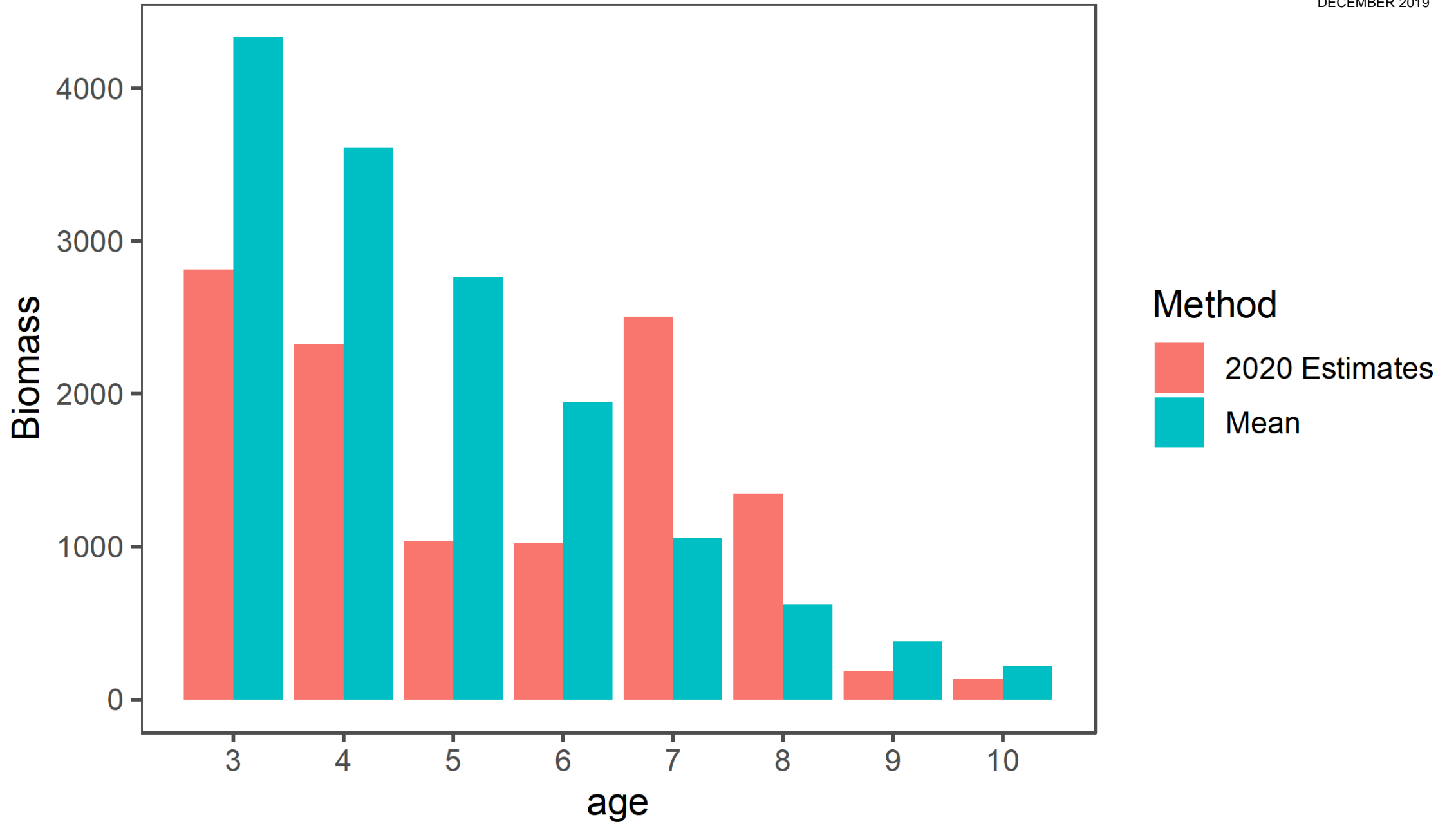
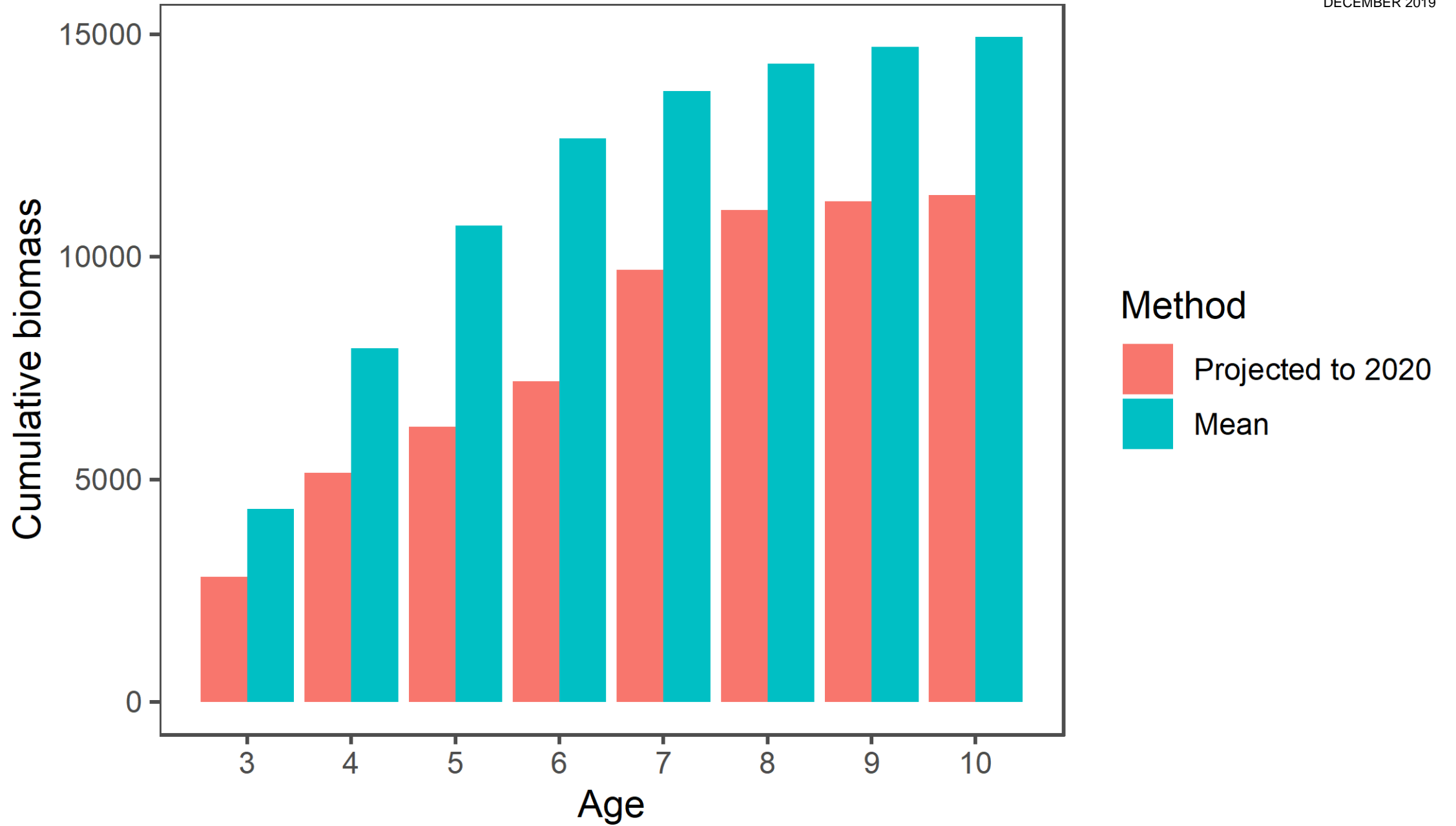


Figure 51: Recruitment estimates (age-1 recruits) for EBS pollock for all years since 1964 (1963–2017 year classes) for Model 16.1. Error bars reflect 90% credible intervals based on model estimates of uncertainty.



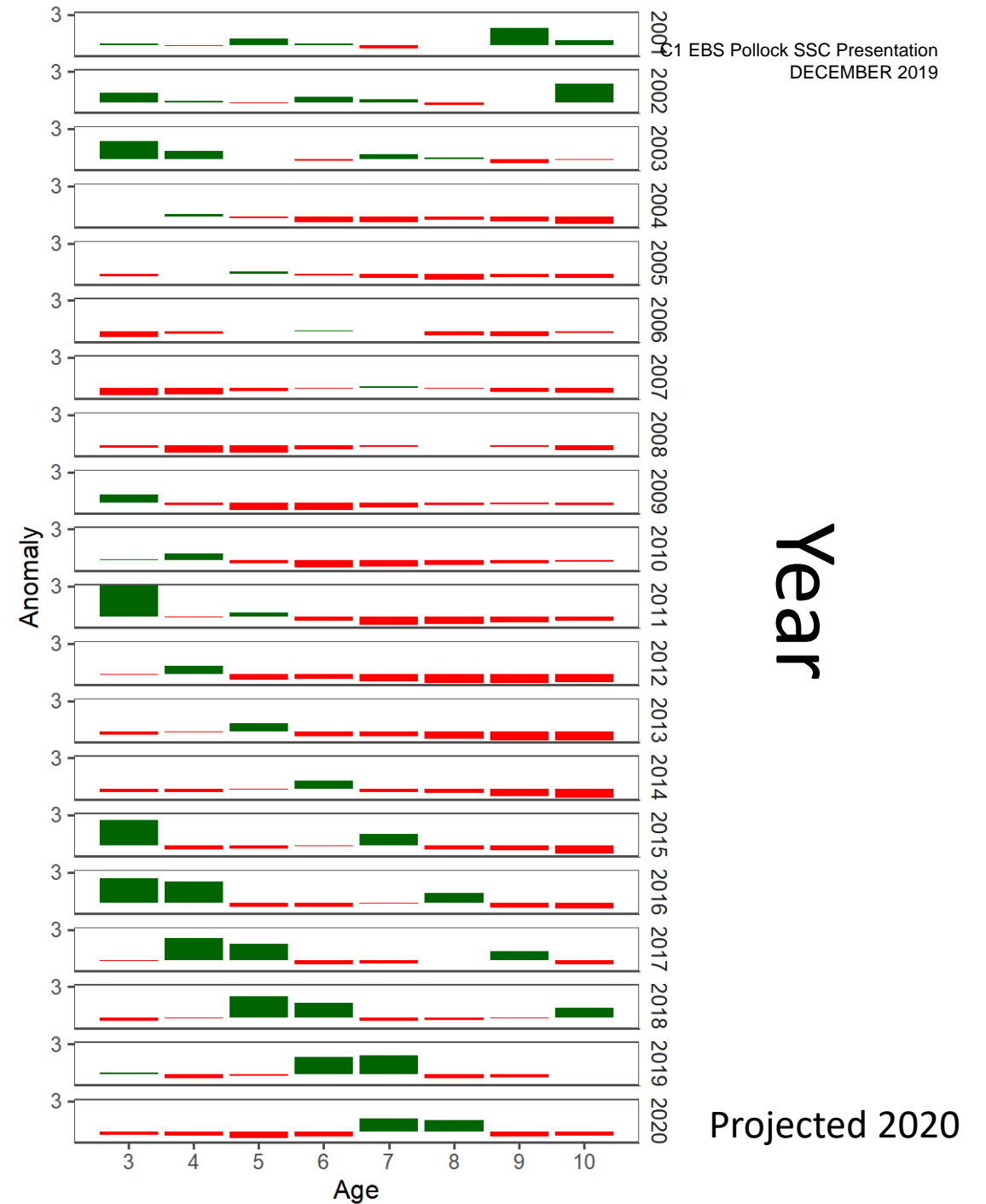




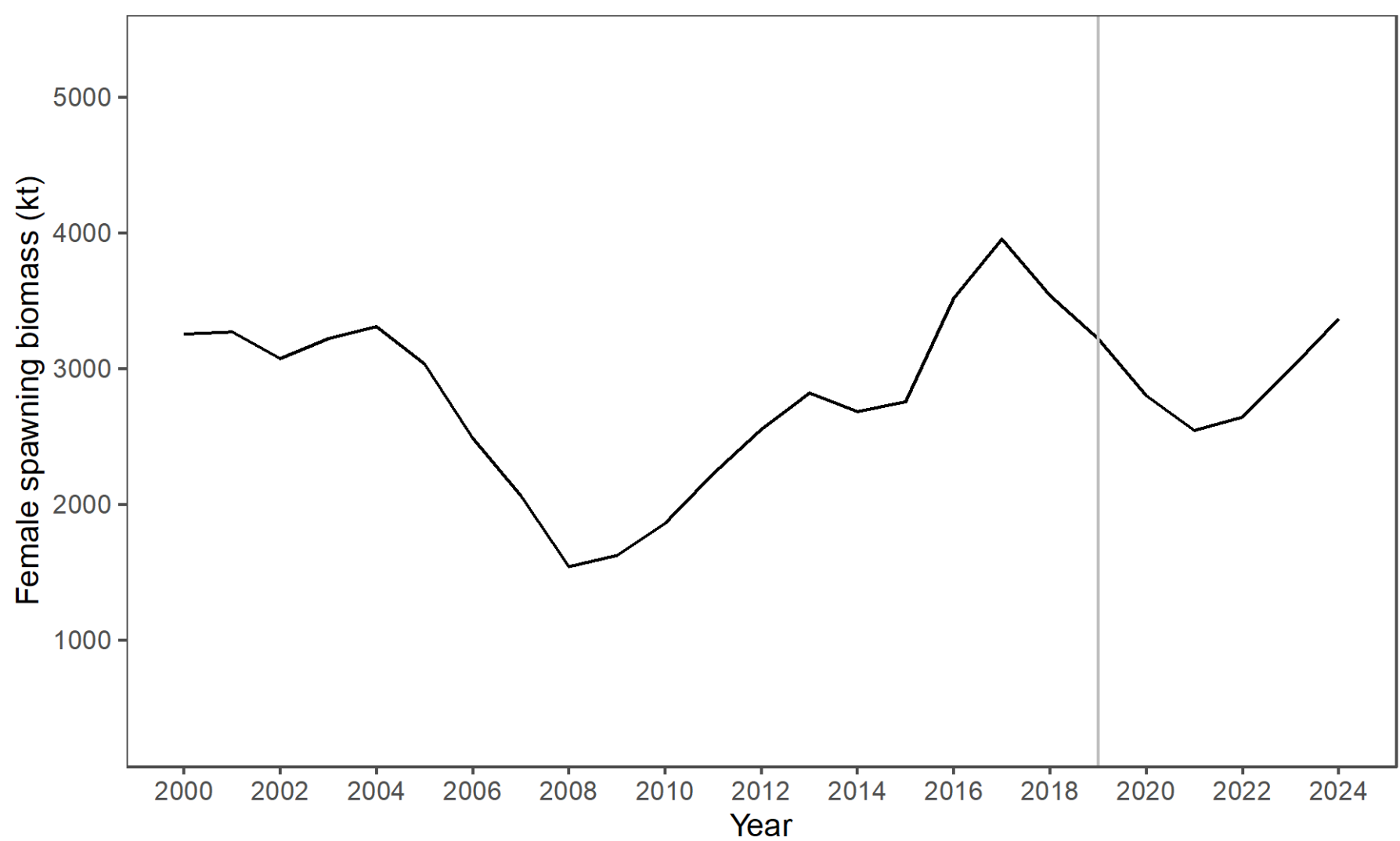


Age structured anomalies

- Biomass at age relative to mean



Spawning biomass projection

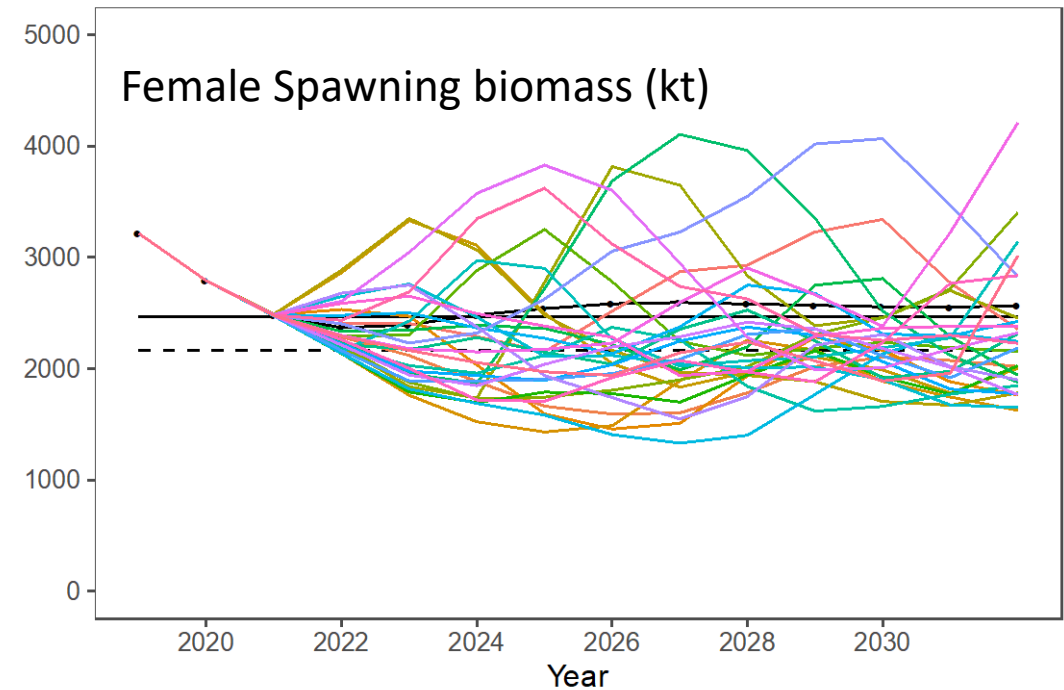
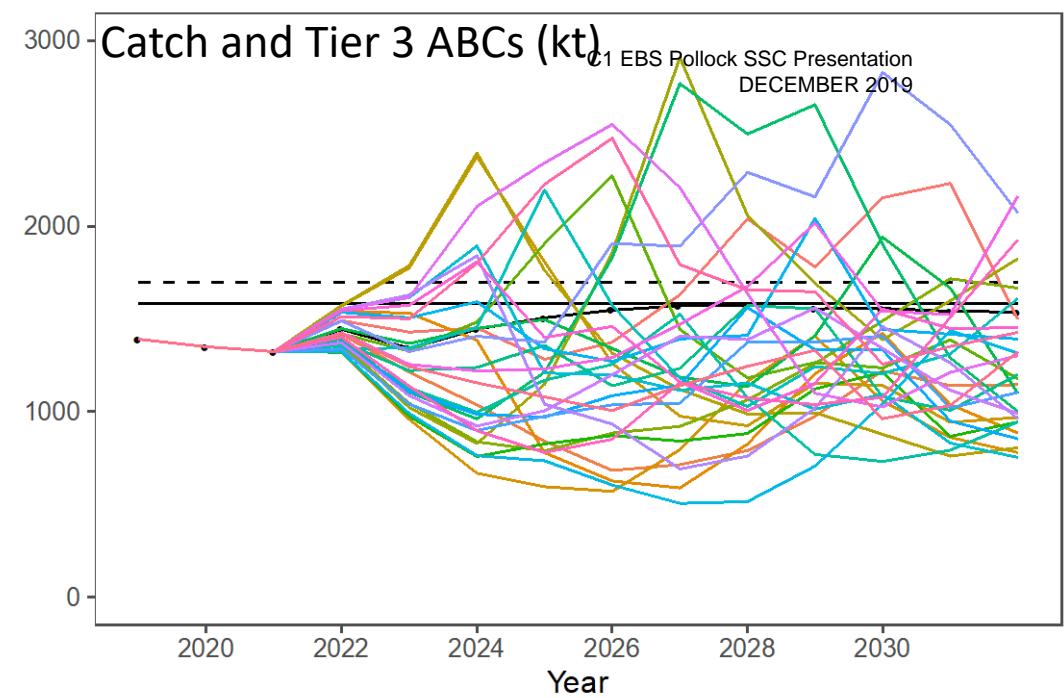


Projections

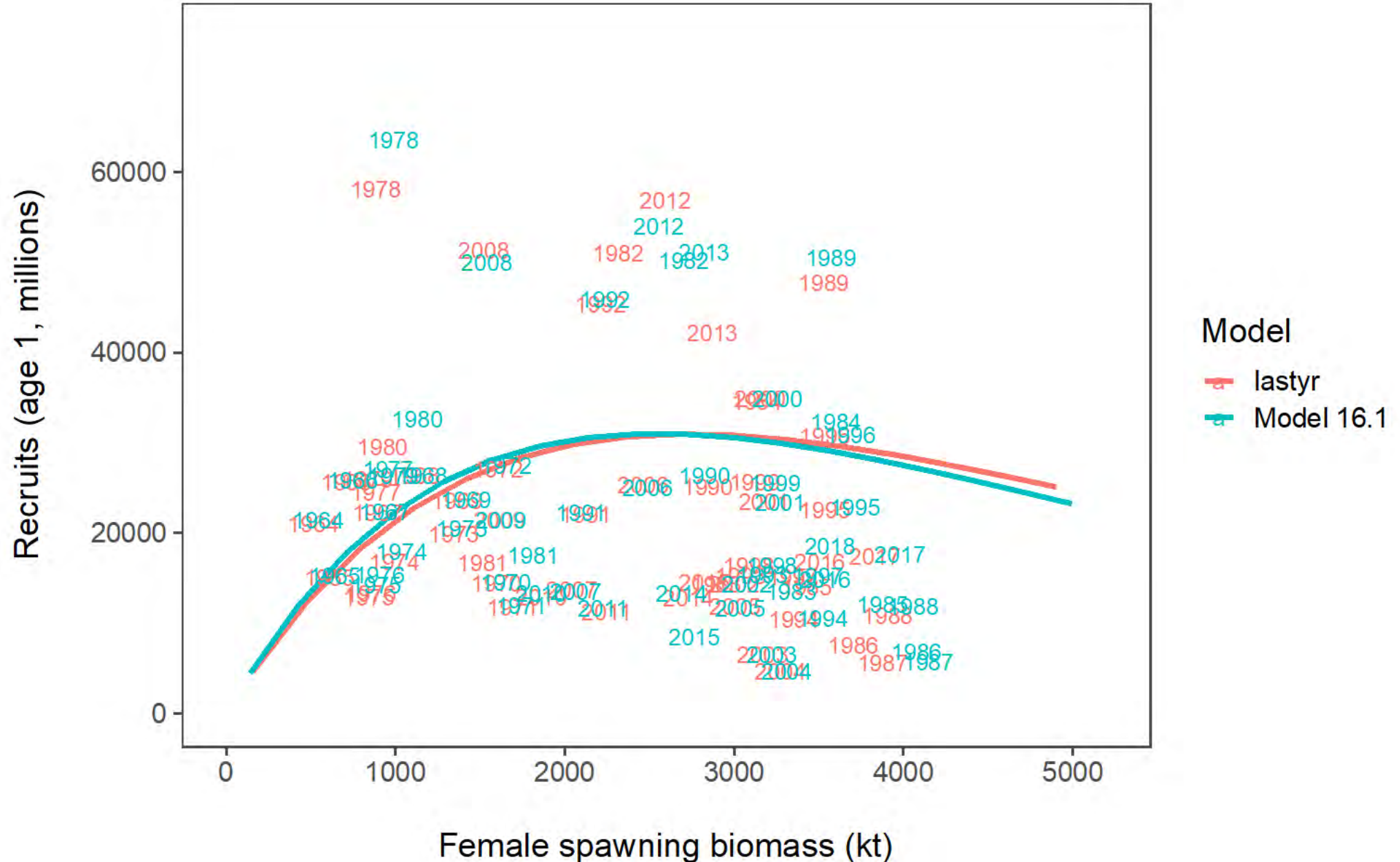
Cautions:

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

Tables provided for VAST as well



2019 Stock recruitment



Factors for reducing ABC

		Considerations			C1 EBS Pollock SSC Presentation DECEMBER 2019
	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 likely 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 F s based on the 2020 catches were used for subsequent years.

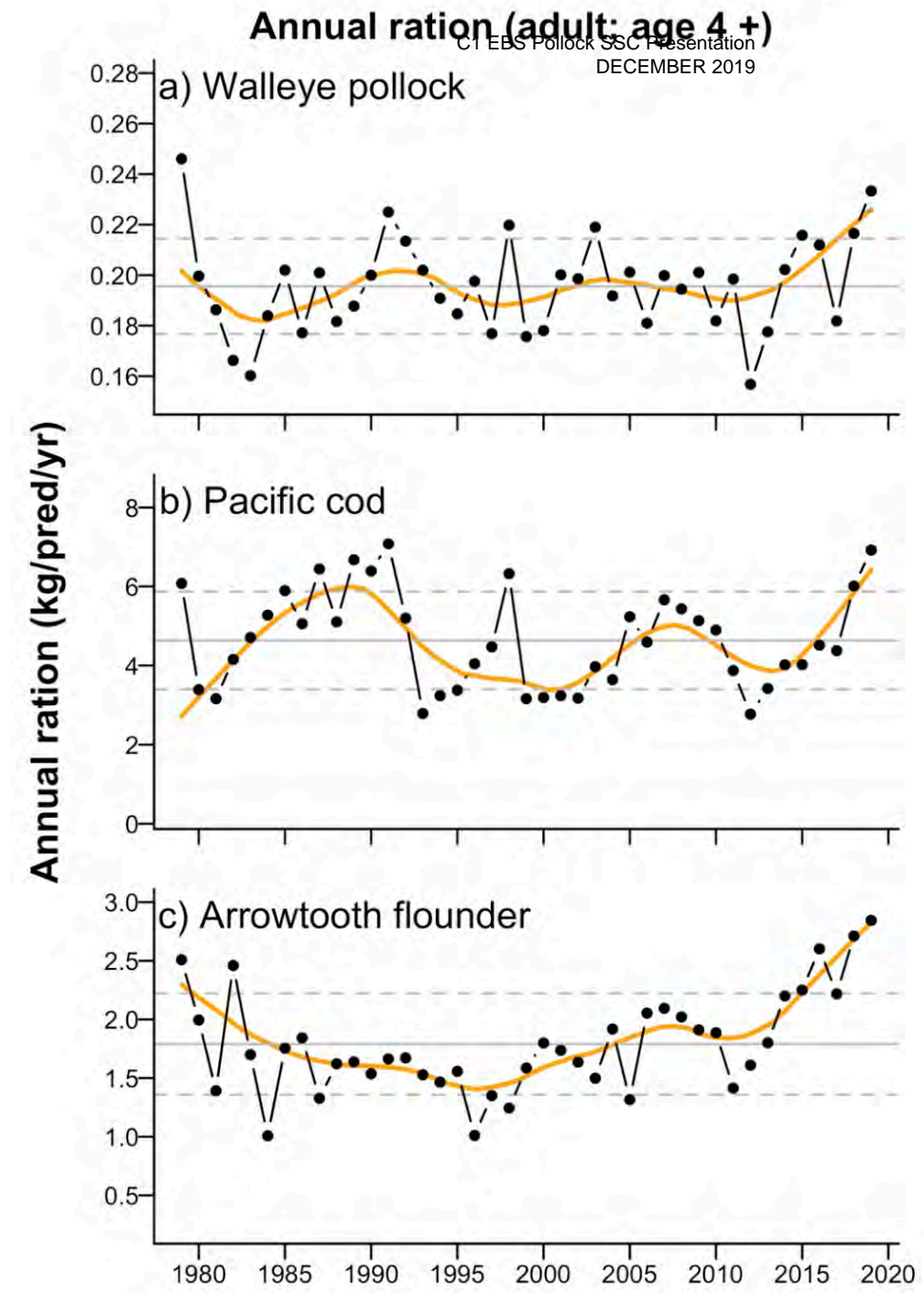
	10	500	1000	1250	1387	1500	1750	2000
$P [F_{2020} > F_{MSY}]$	0	0	0	0	0	1	4	12
$P [B_{2021} < B_{MSY}]$	10	16	23	28	31	34	40	48
$P [B_{2022} < B_{MSY}]$	6	10	19	25	28	31	39	48
$P [B_{2021} < \bar{B}]$	15	44	77	88	92	94	98	99
$P [B_{2024} < \bar{B}]$	3	11	24	31	36	39	47	55
$P [B_{2024} < B_{2020}]$	4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

Quantity	As estimated or <i>specified</i> <i>last year for:</i>		As estimated or <i>recommended</i> <i>this year for:</i>	
	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
$max F_{ABC}$	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
$max ABC$	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

Quantity	As estimated or <i>specified</i> <i>last year for:</i>		As estimated or <i>recommended</i> <i>this year for:</i>	
	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
$max F_{ABC}$	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
$max ABC$	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

Quantity	As estimated or <i>specified</i> <i>last year for:</i>		As estimated or <i>recommended</i> <i>this year for:</i>	
	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
$max F_{ABC}$	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
$max ABC$	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...