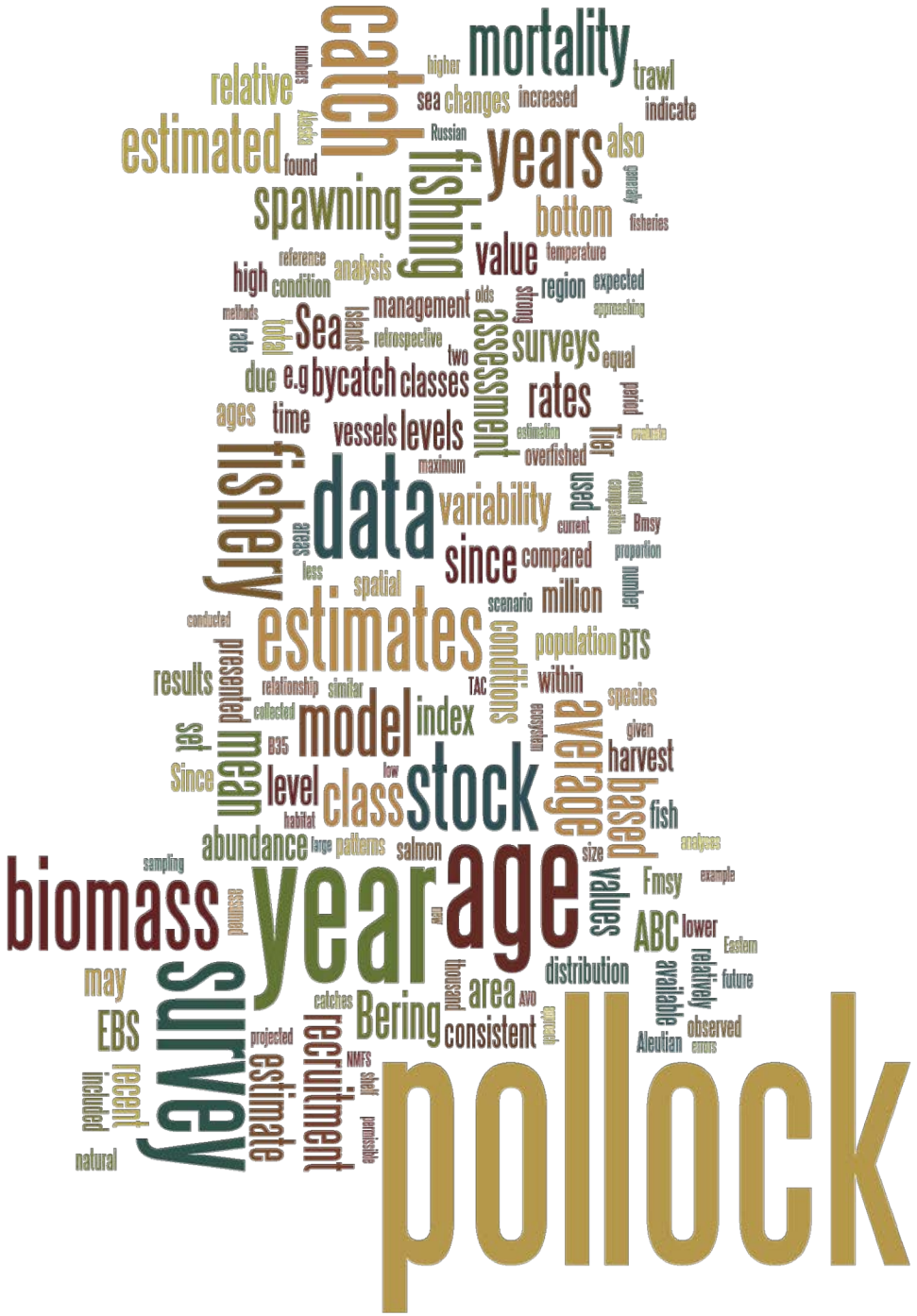


Eastern Bering Sea pollock stock assessment

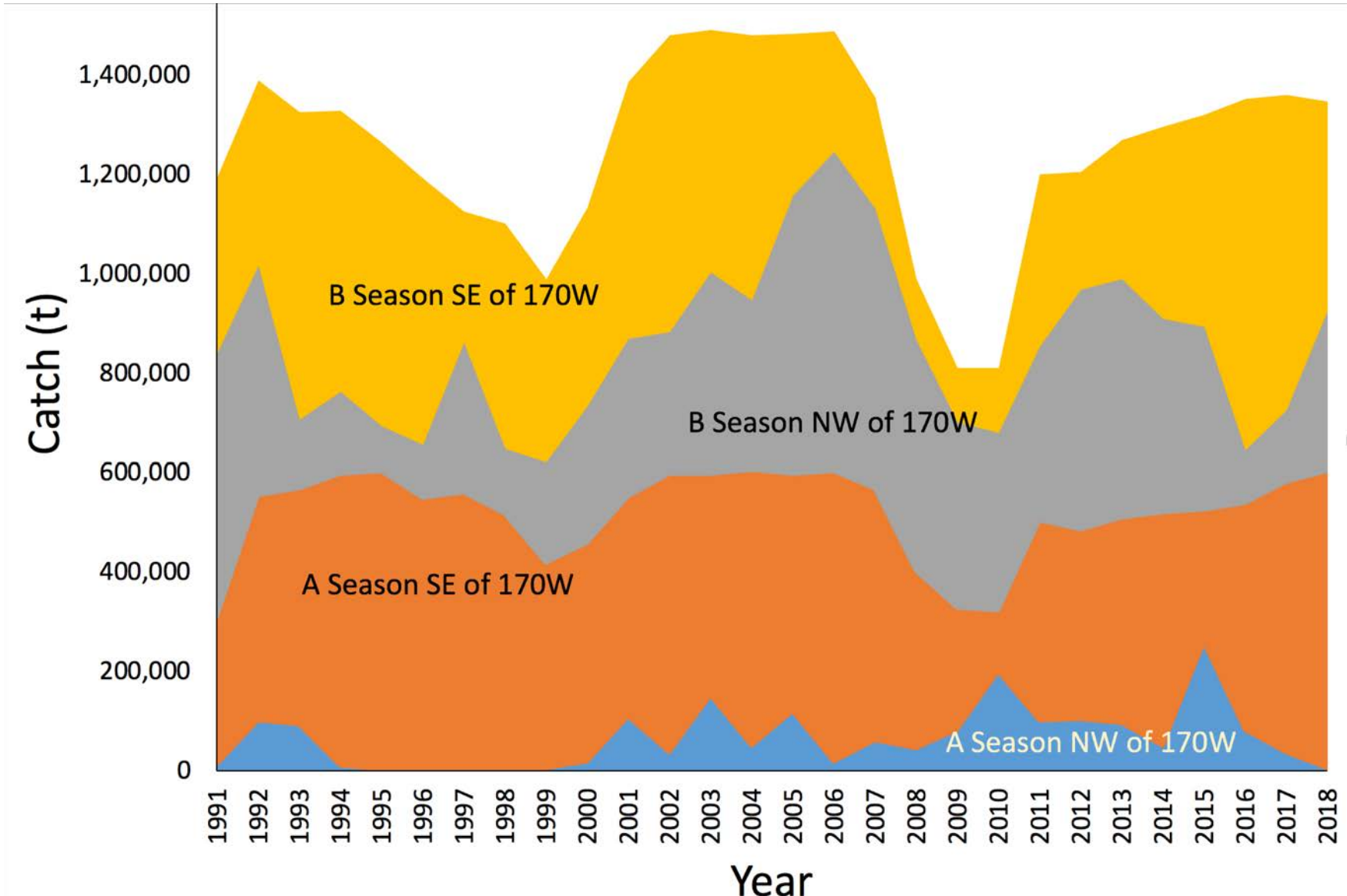
James Ianelli
Taina Honkalehto,
Abigail McCarthy,
Sarah Stienessen,
Kirstin Holsman,
Elizabeth Siddon and
Ben Fissel
Alaska Fisheries Science Center
NMFS/NOAA

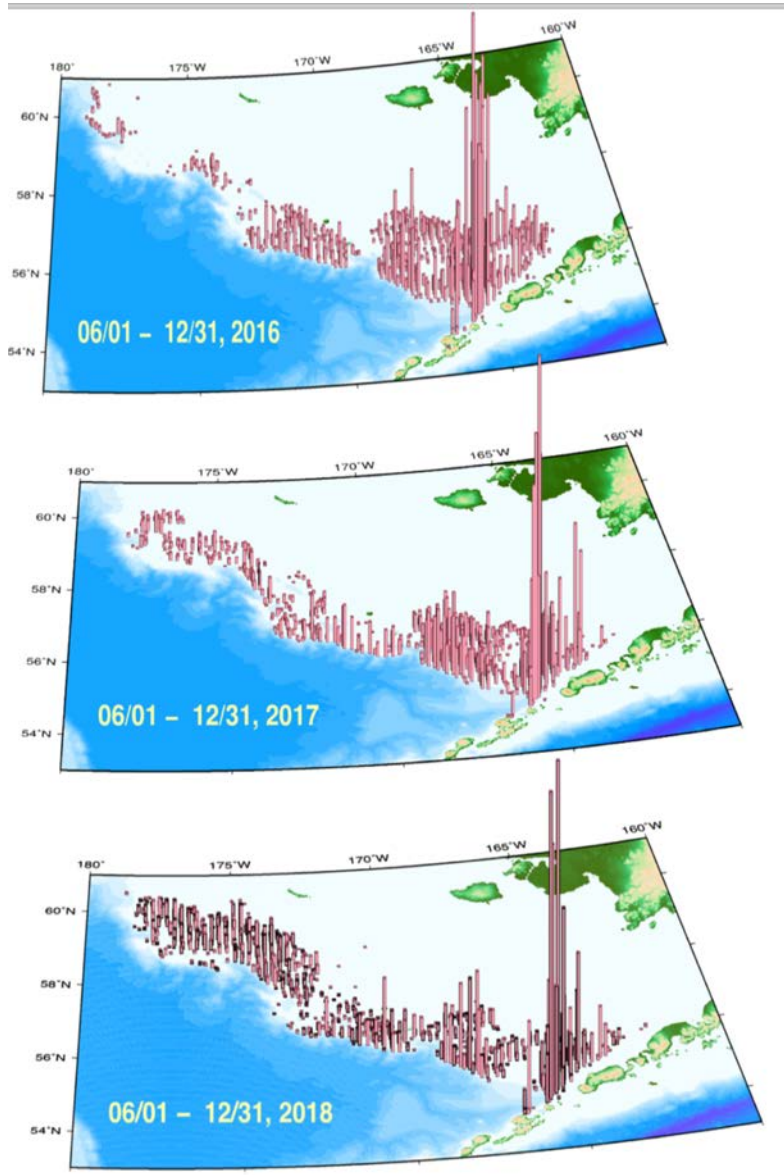
December 2018

www.tinyurl.com/gfplanteam

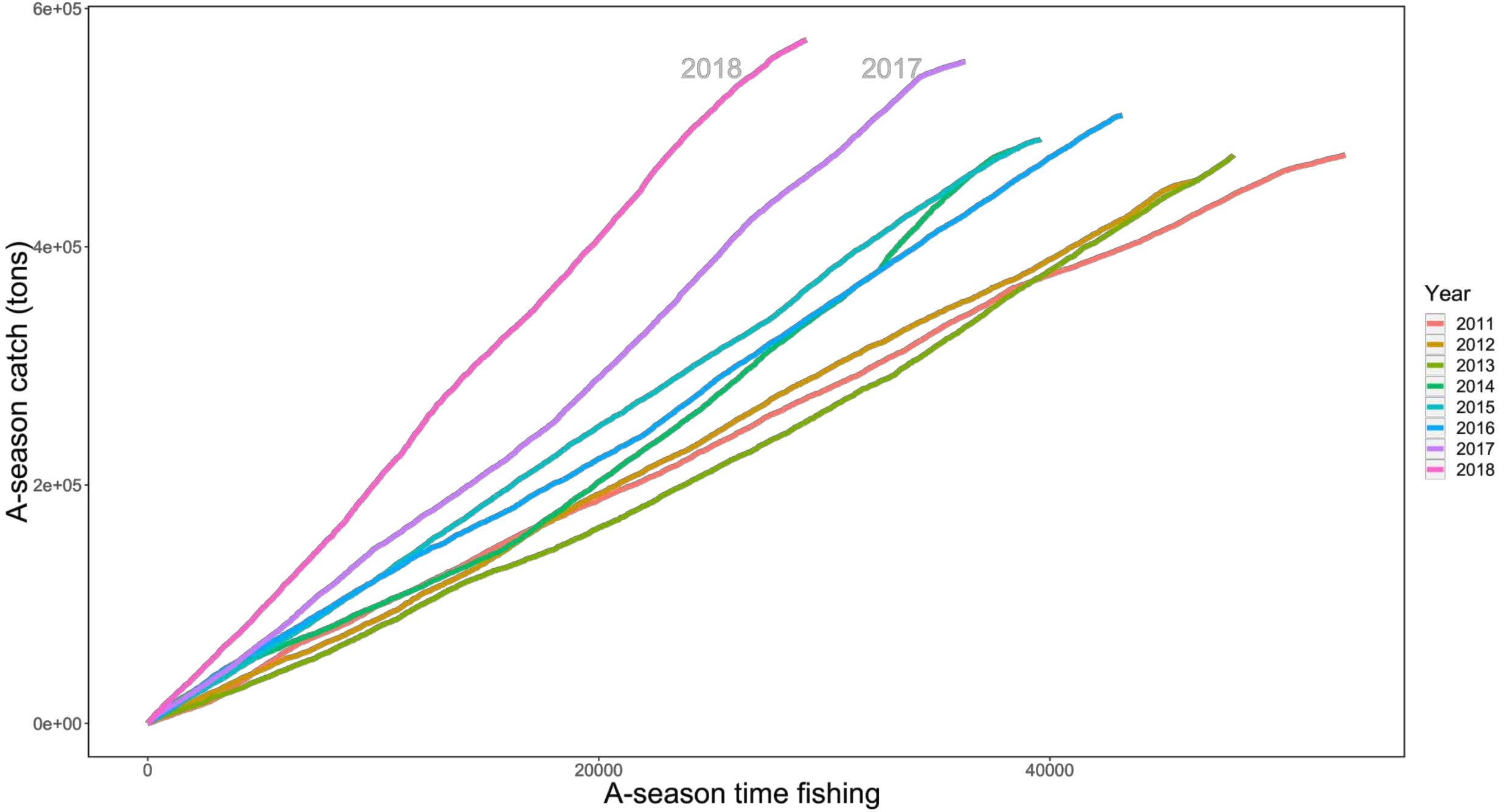
Seasonal and area catch patterns

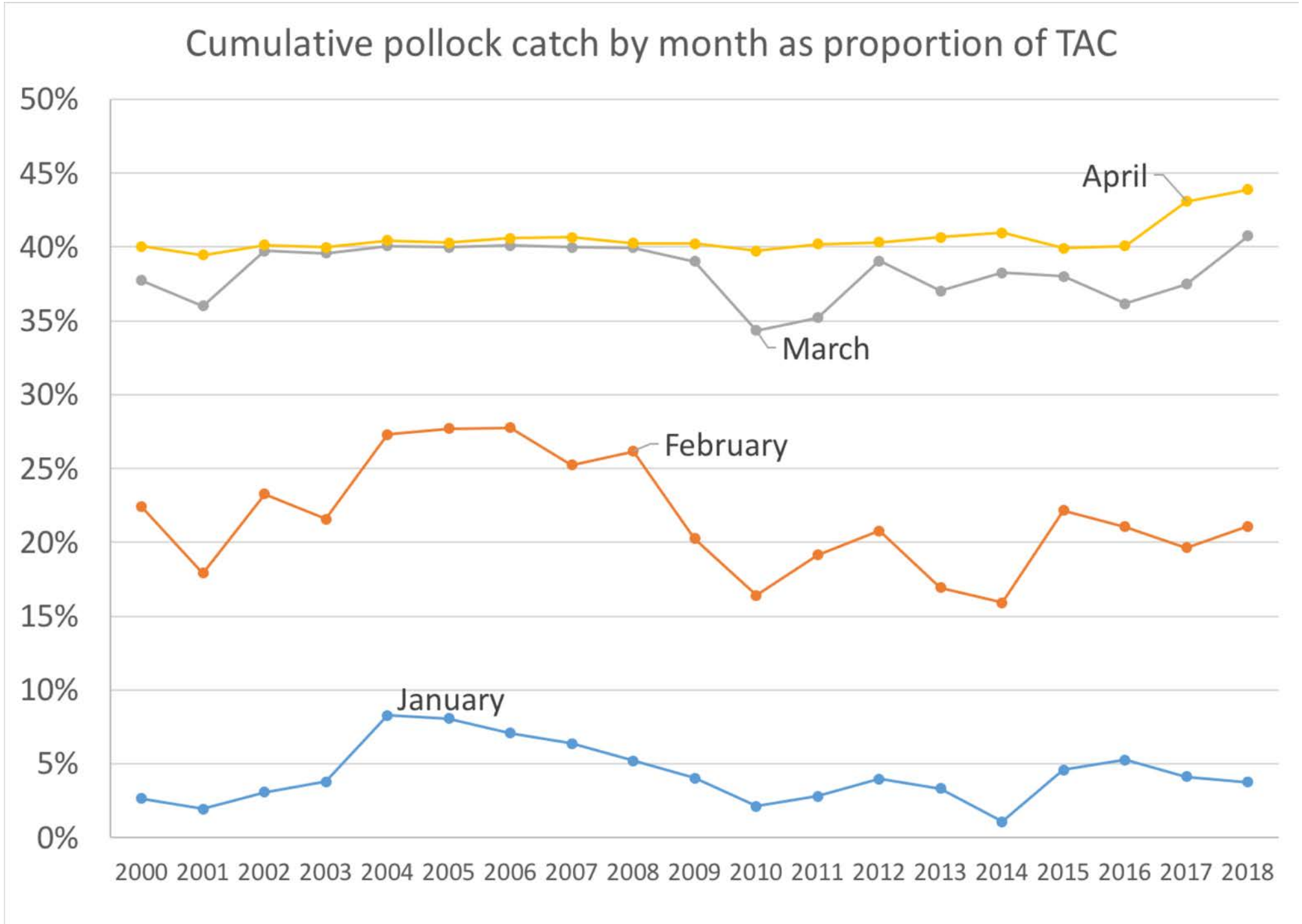
Eastern Bering Sea pollock



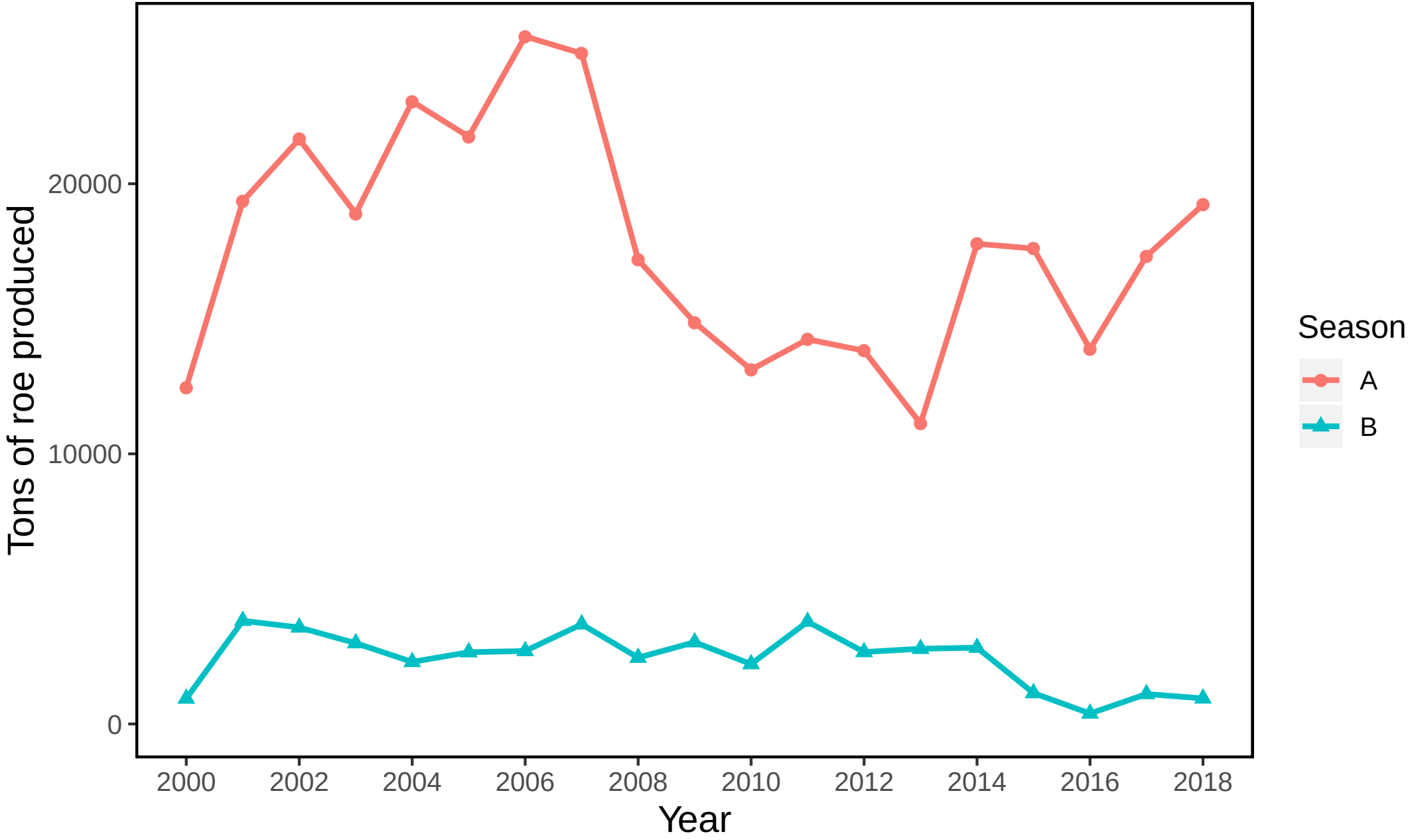


Winter fishing

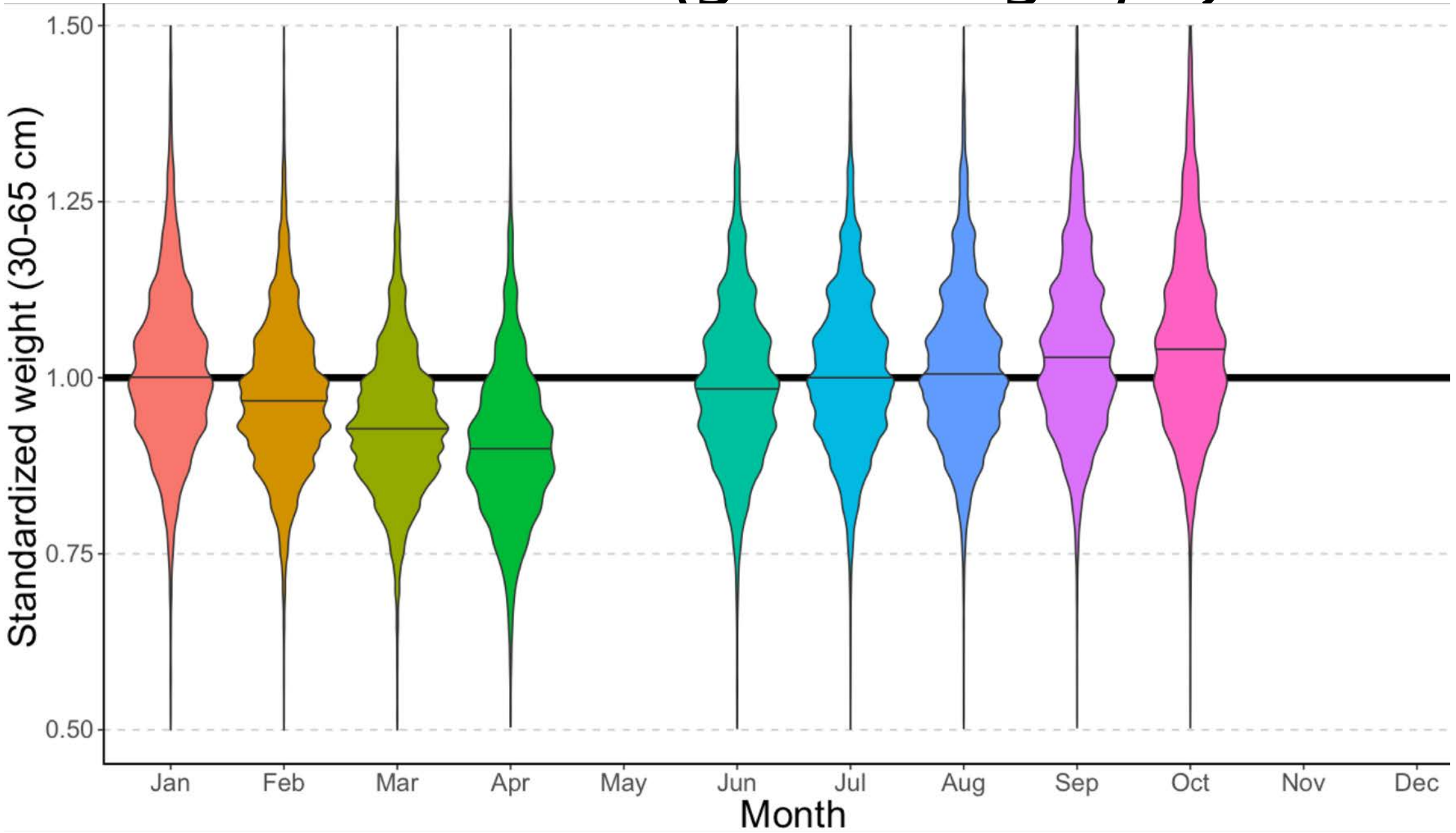


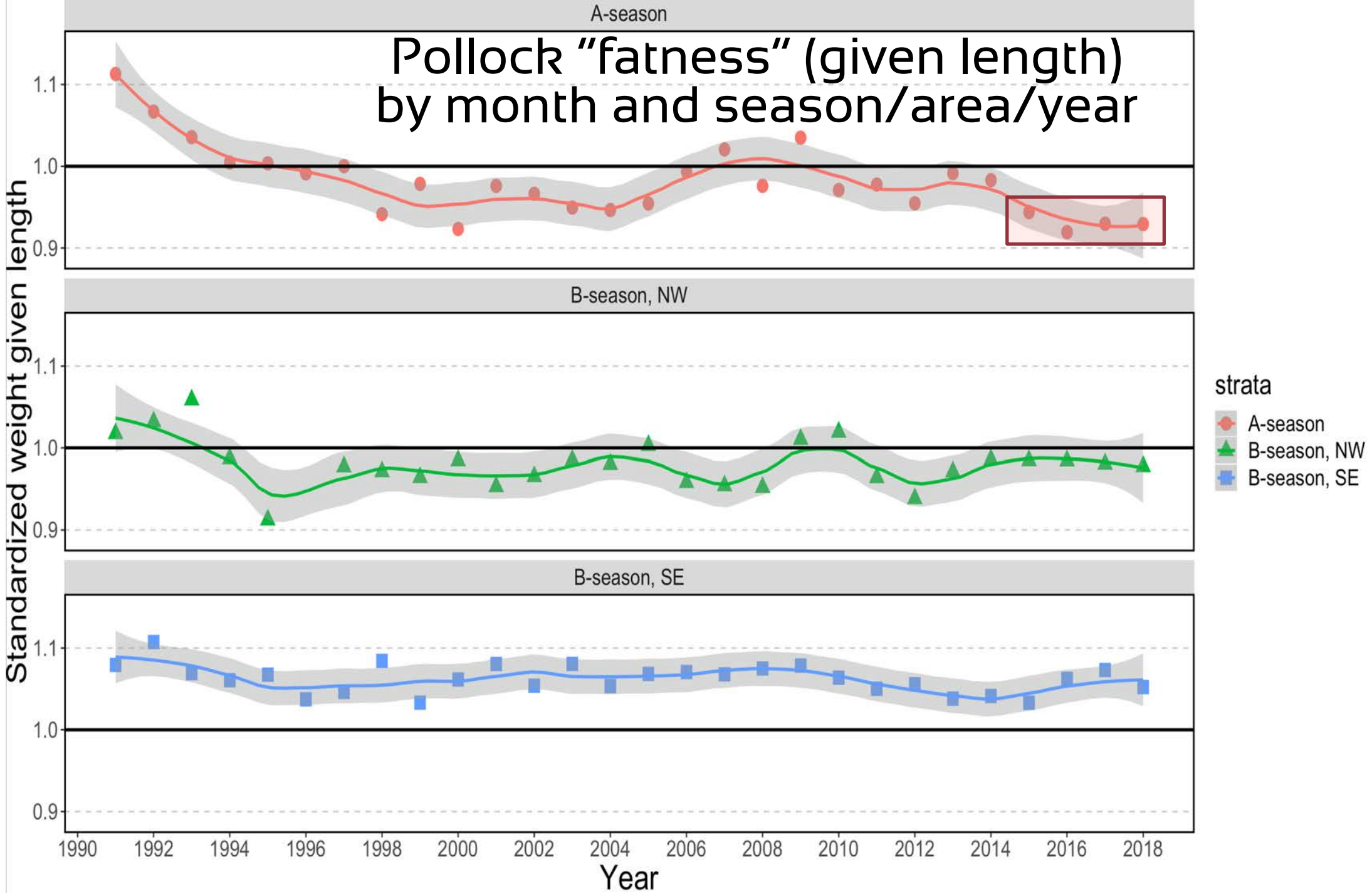

Cumulative pollock catch by month as proportion of TAC
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
April
March
February
January
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

Fishing: Seasonal roe production

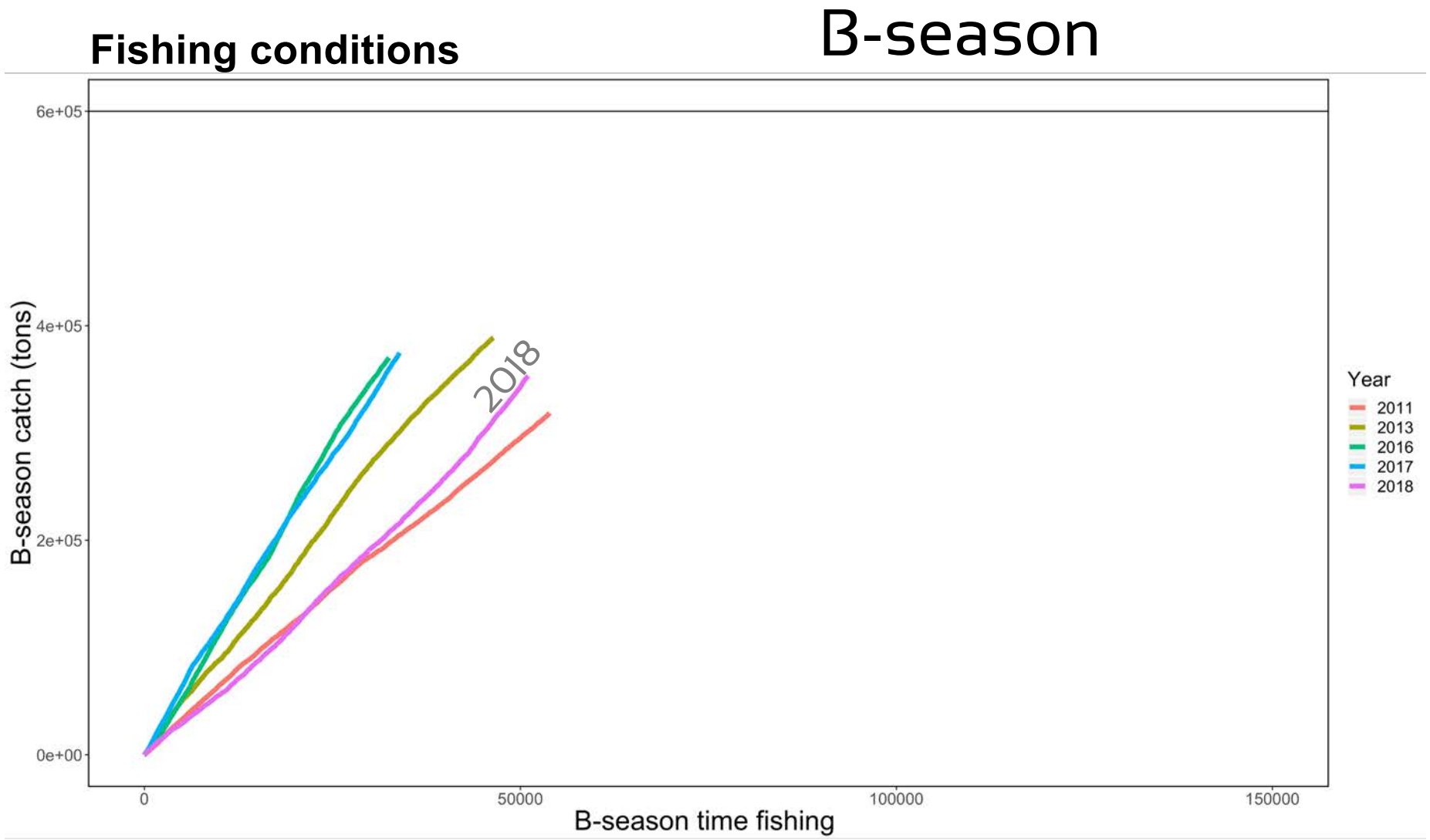


Pollock “fatness” (given length) by month



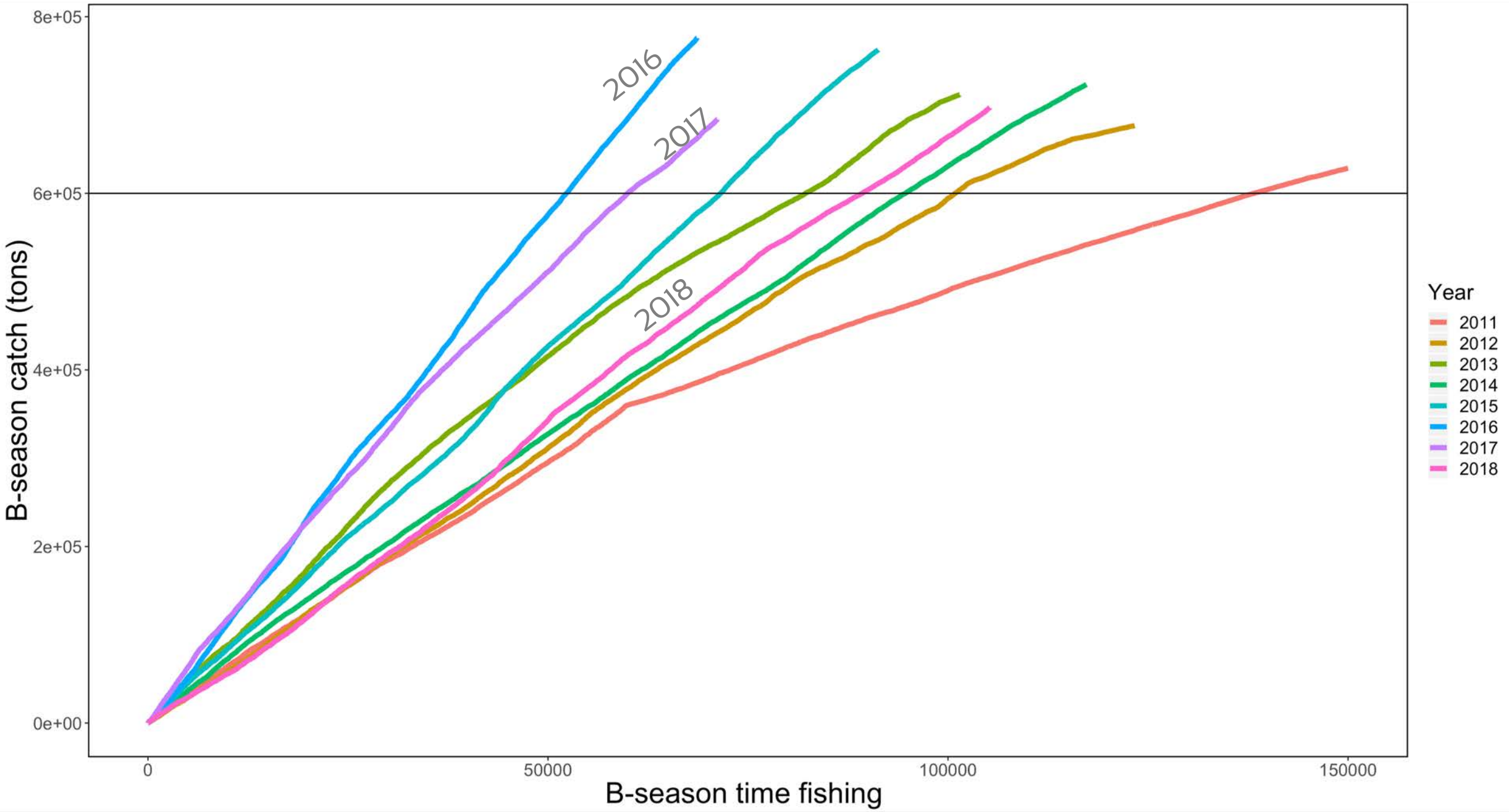

Pollock “fatness” (given length)
by month and season/area/year
A-season
B-season, NW
B-season, SE
Standardized weight given length
1.1
1.0
0.9
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year
strata
A-season
B-season, NW
B-season, SE

Summer fishing conditions



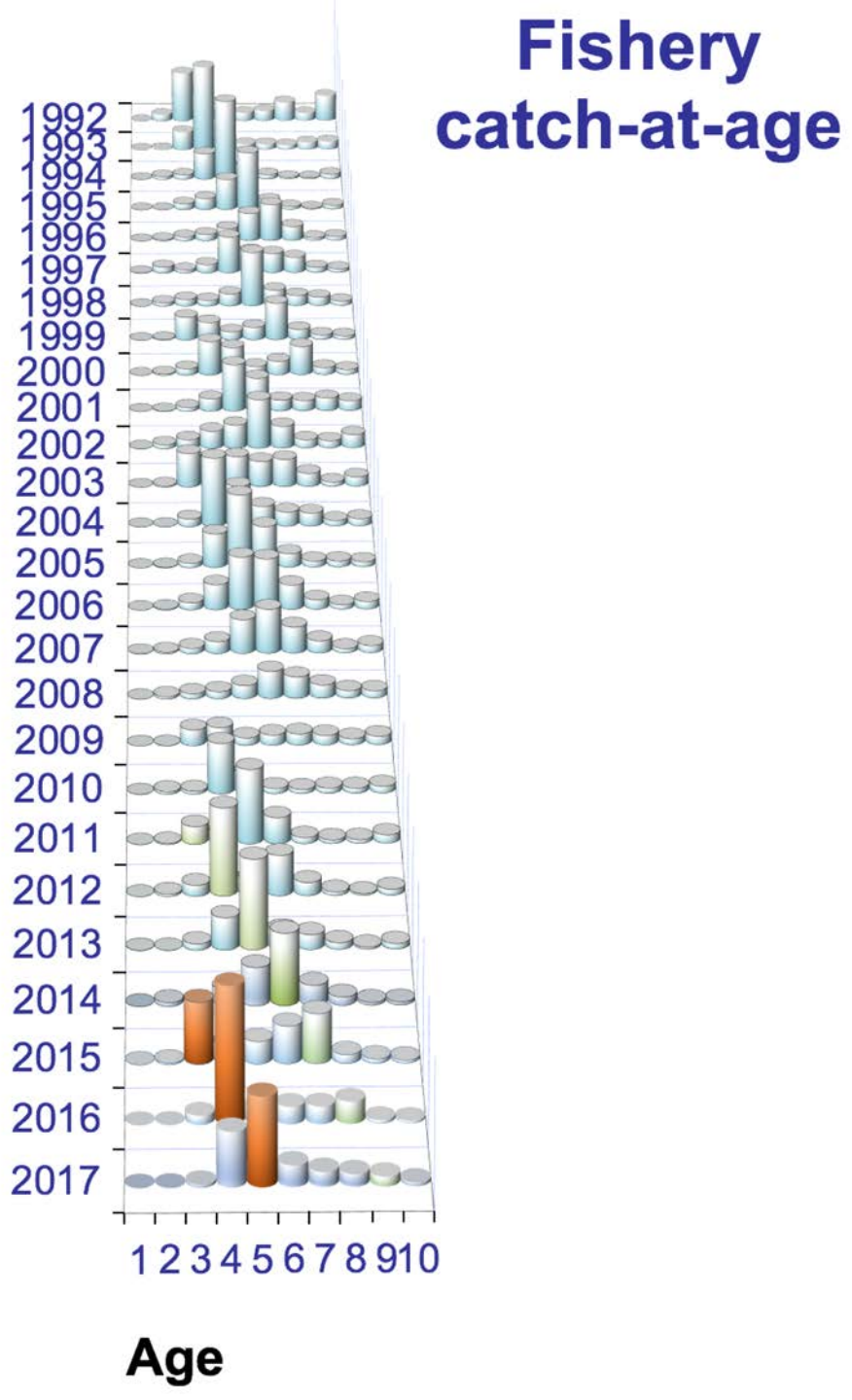
Summer fishing conditions

B-season

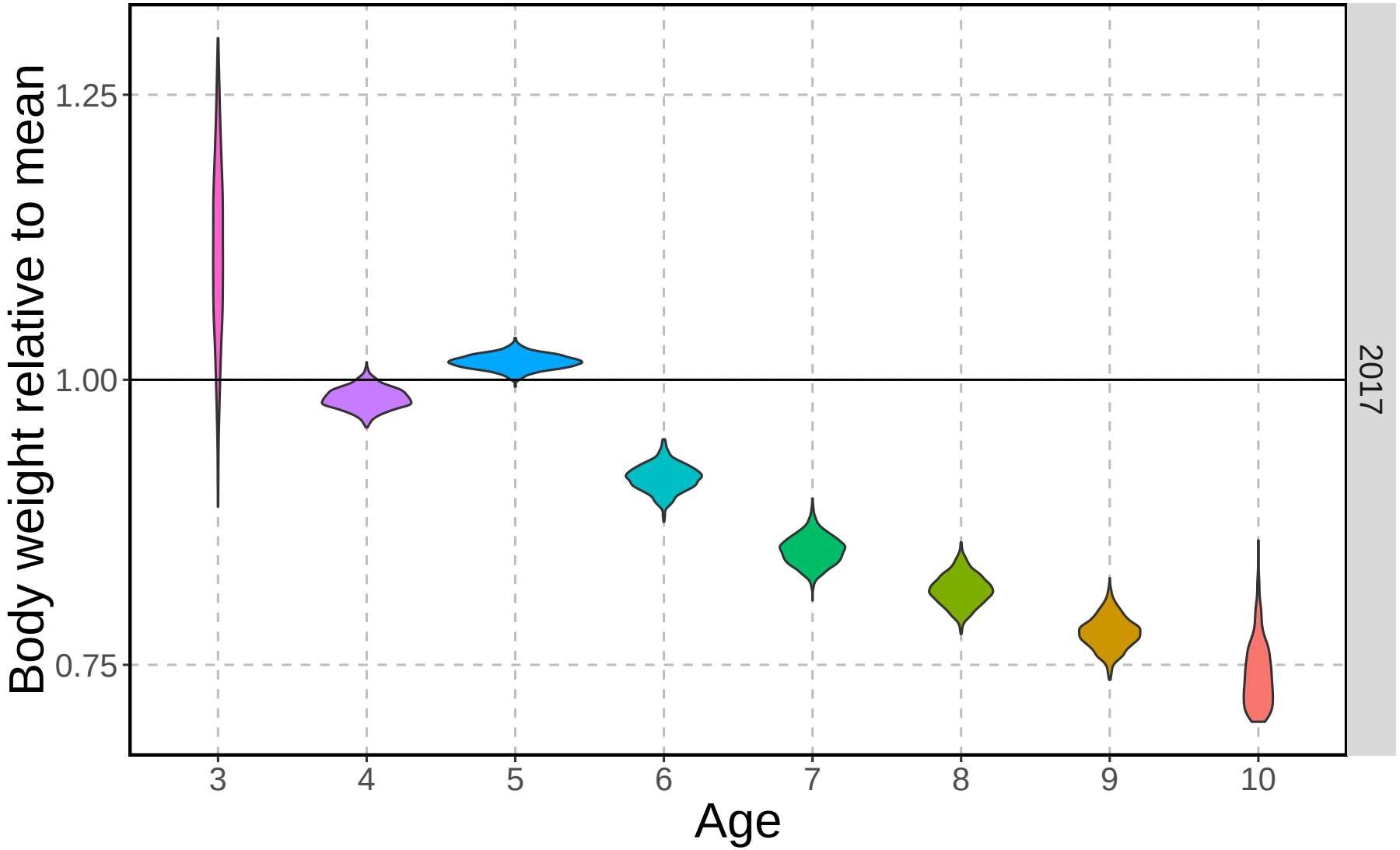


What ages of pollock are caught?

- New 2017 catch-age data

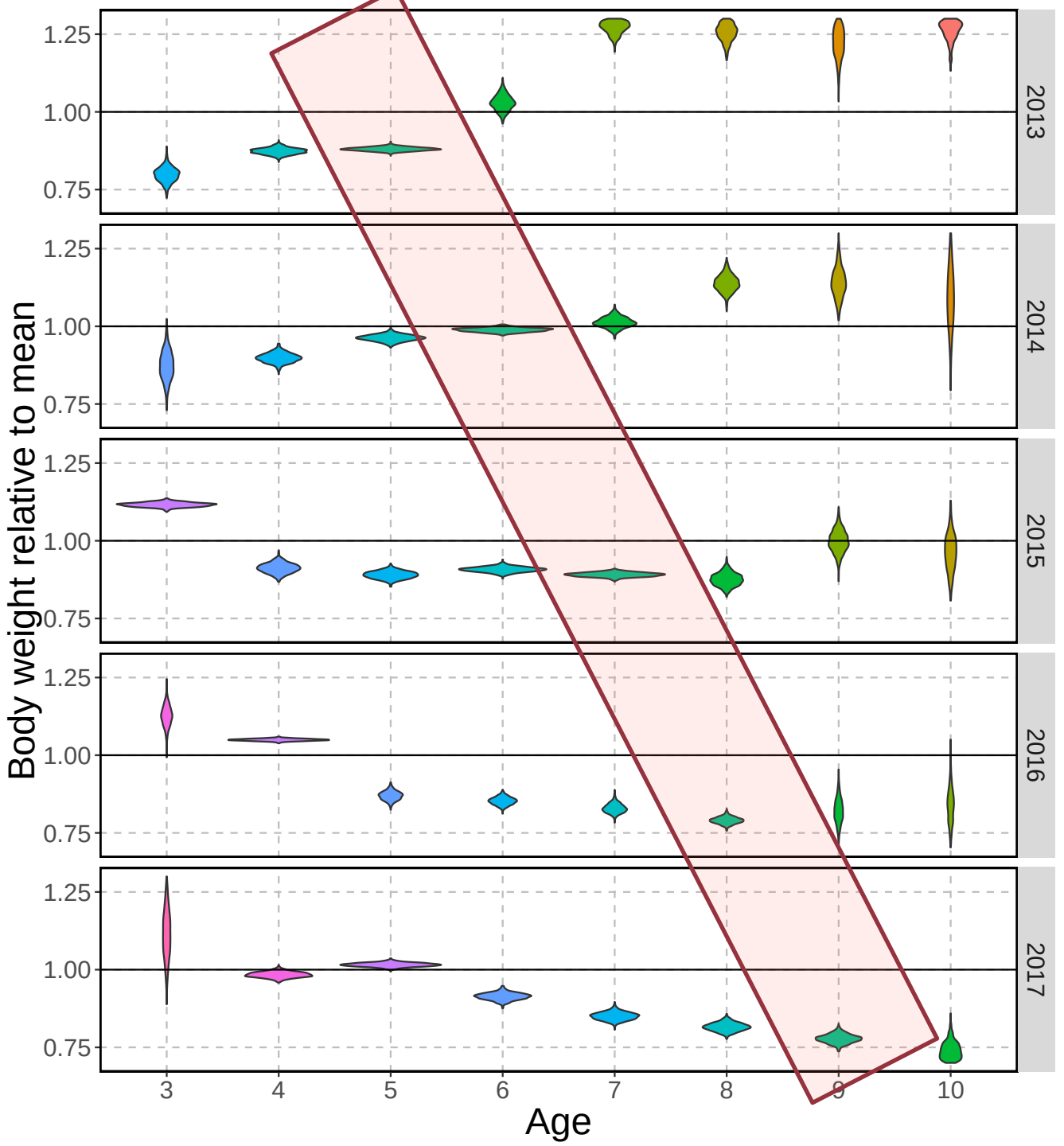


Looking at weight-at-age

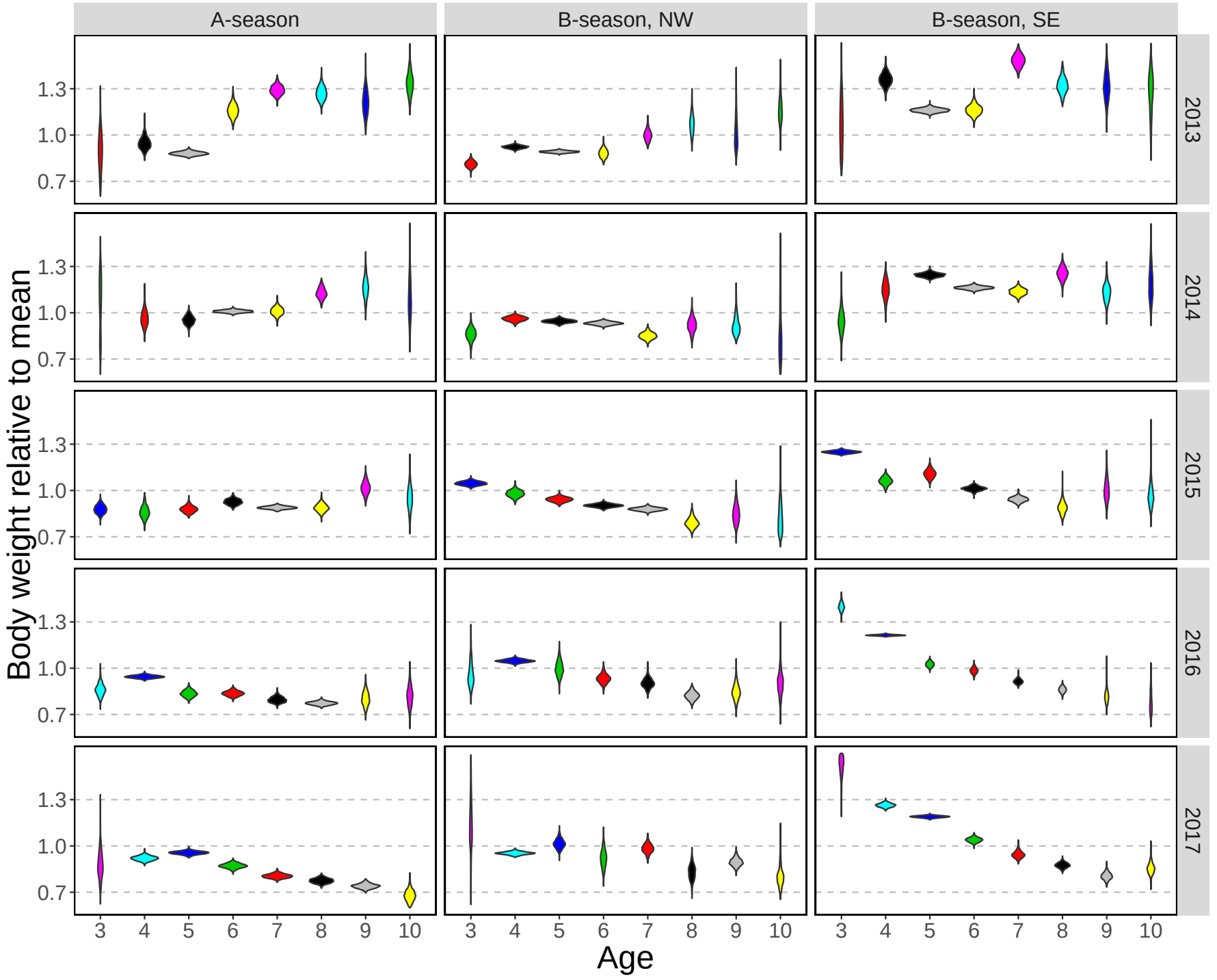


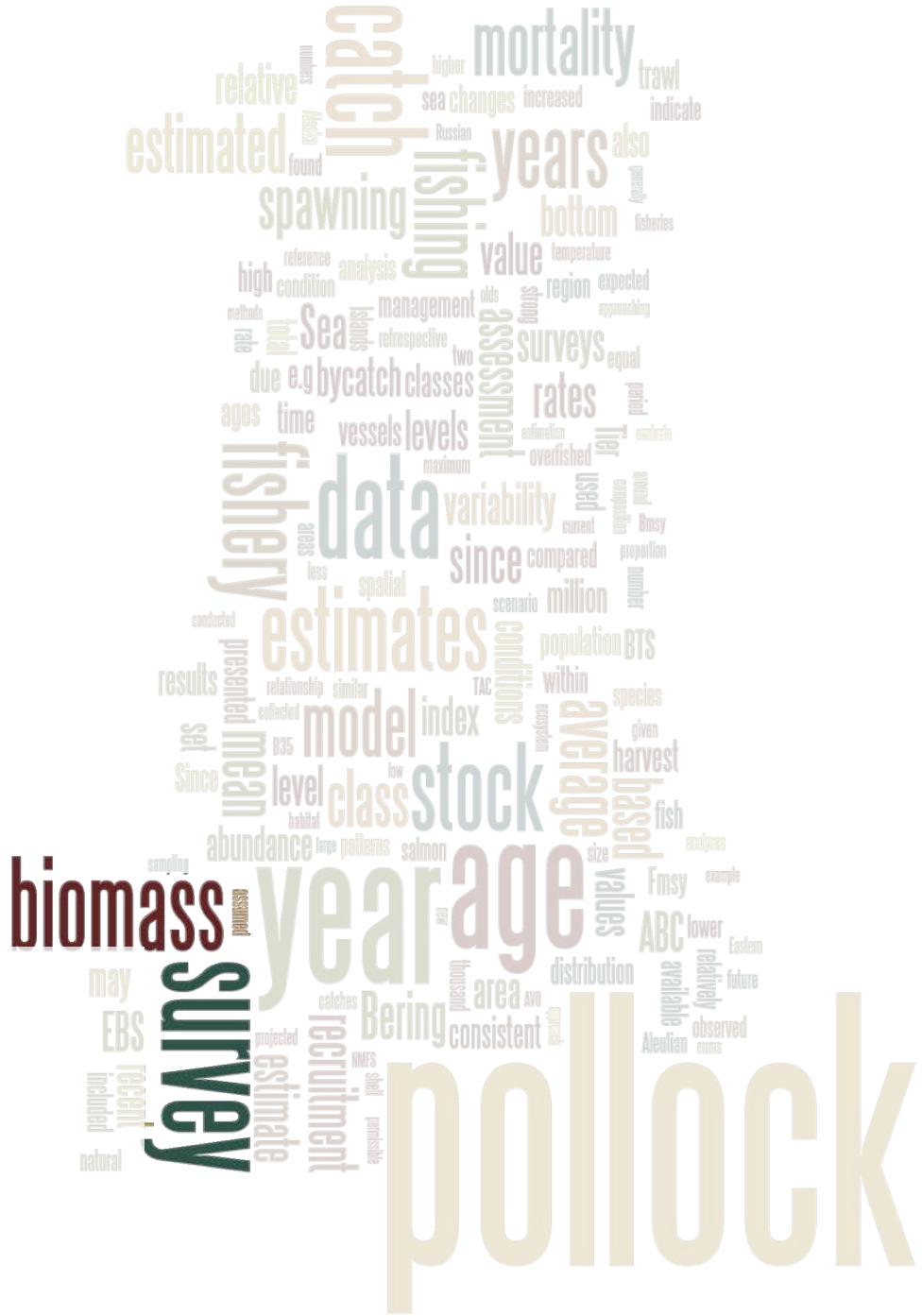
Are pollock smaller at age than normal???

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



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

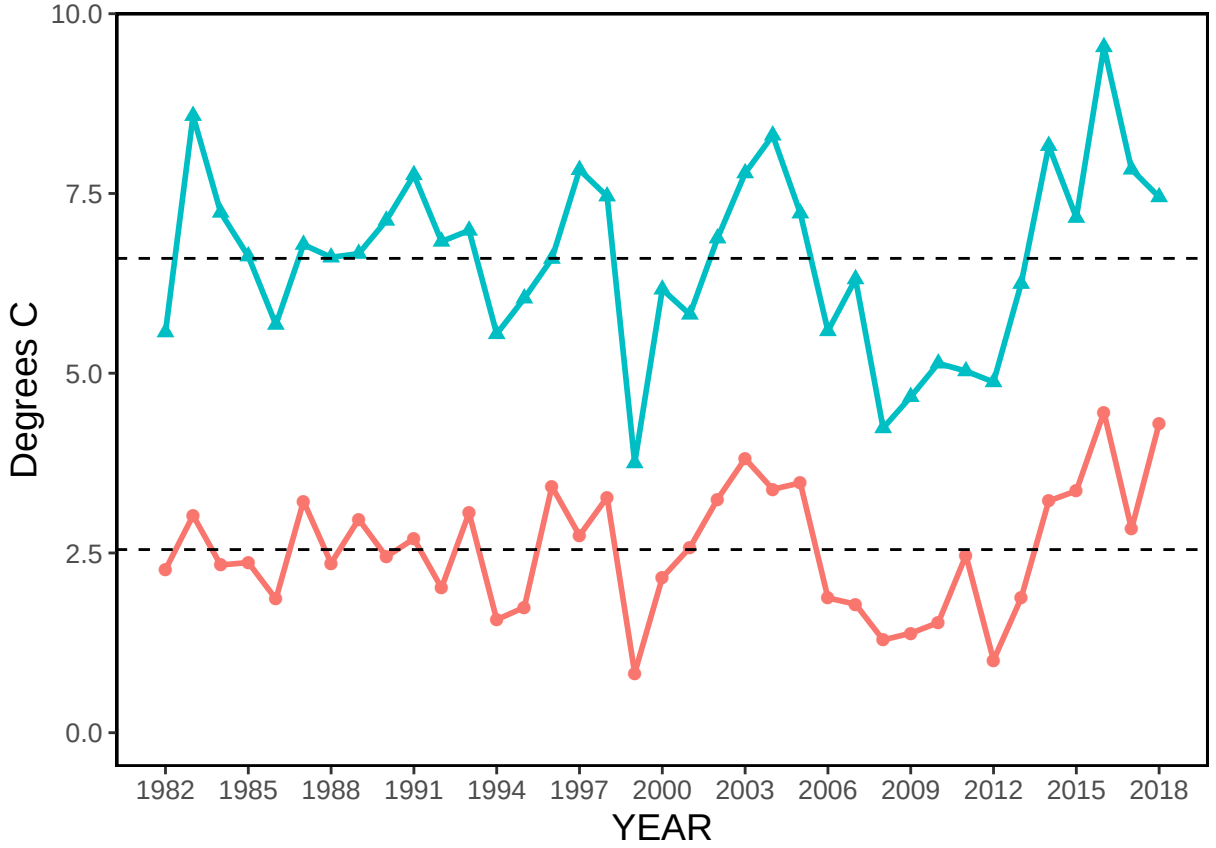


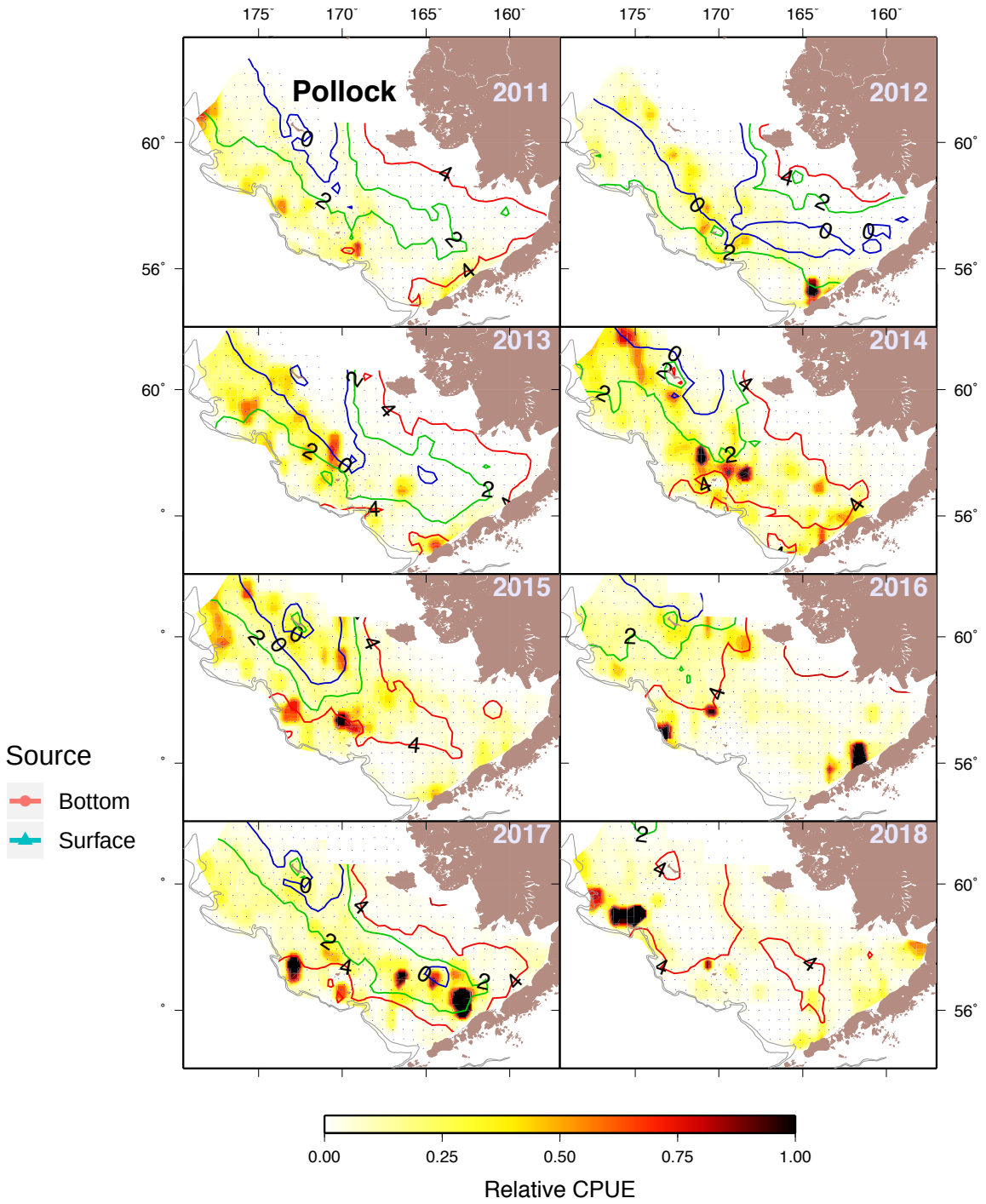


Eastern Bering Sea pollock

surveys

Pollock density and temperature



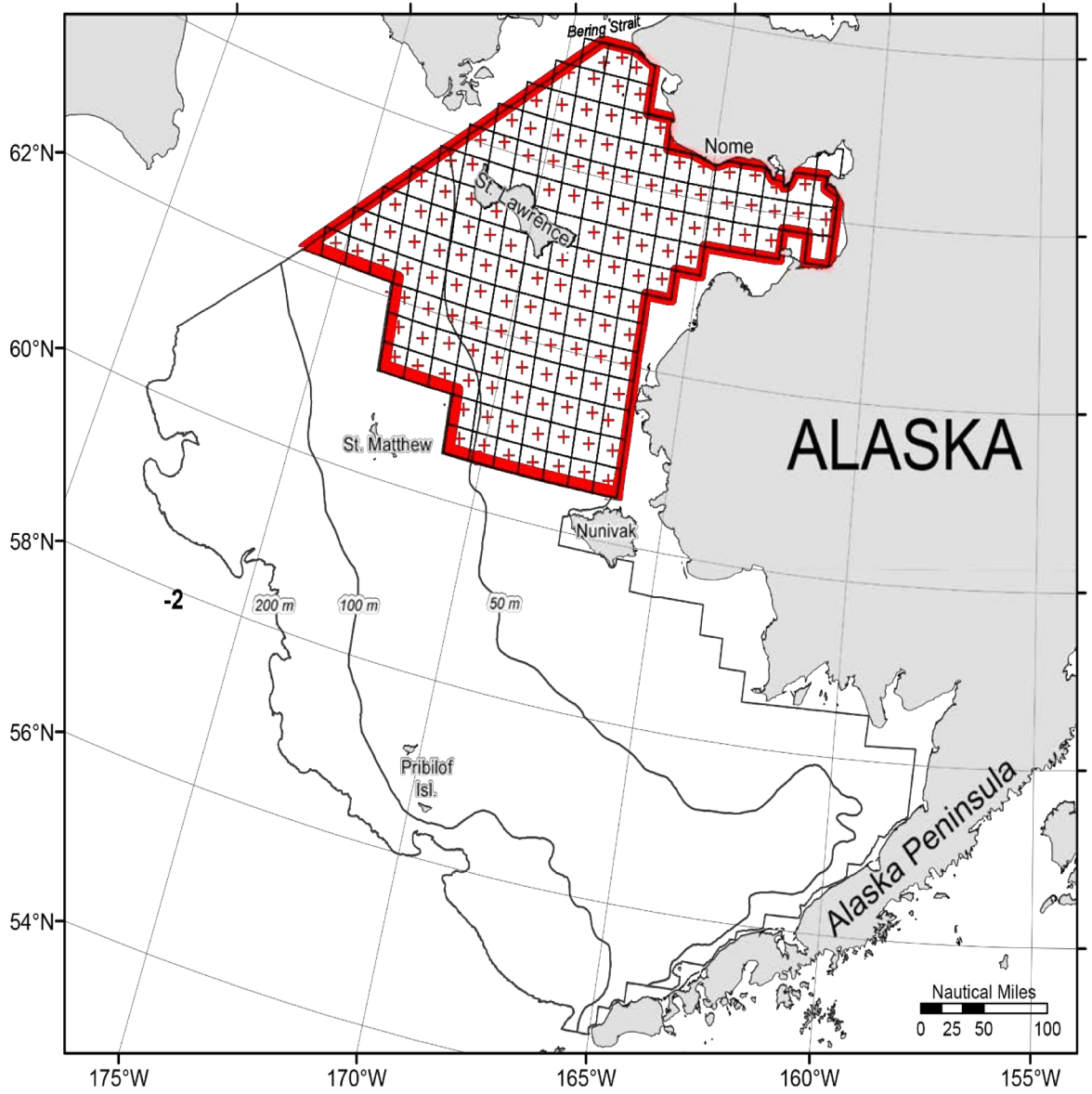


Added survey stations in northern area…

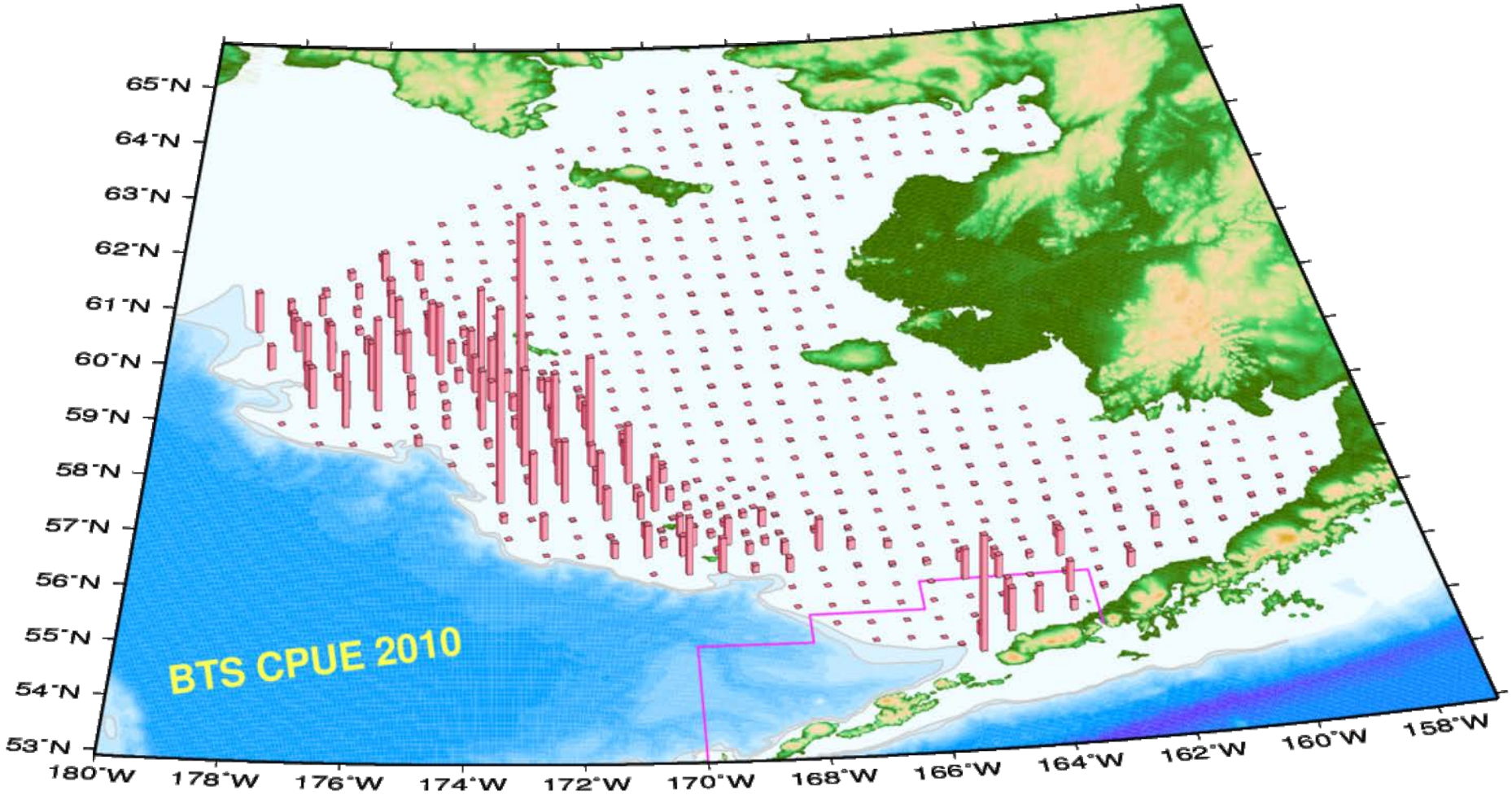
Surveyed in 2010 and 2017

- Extra stations done in 2018 as an "emergency"

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

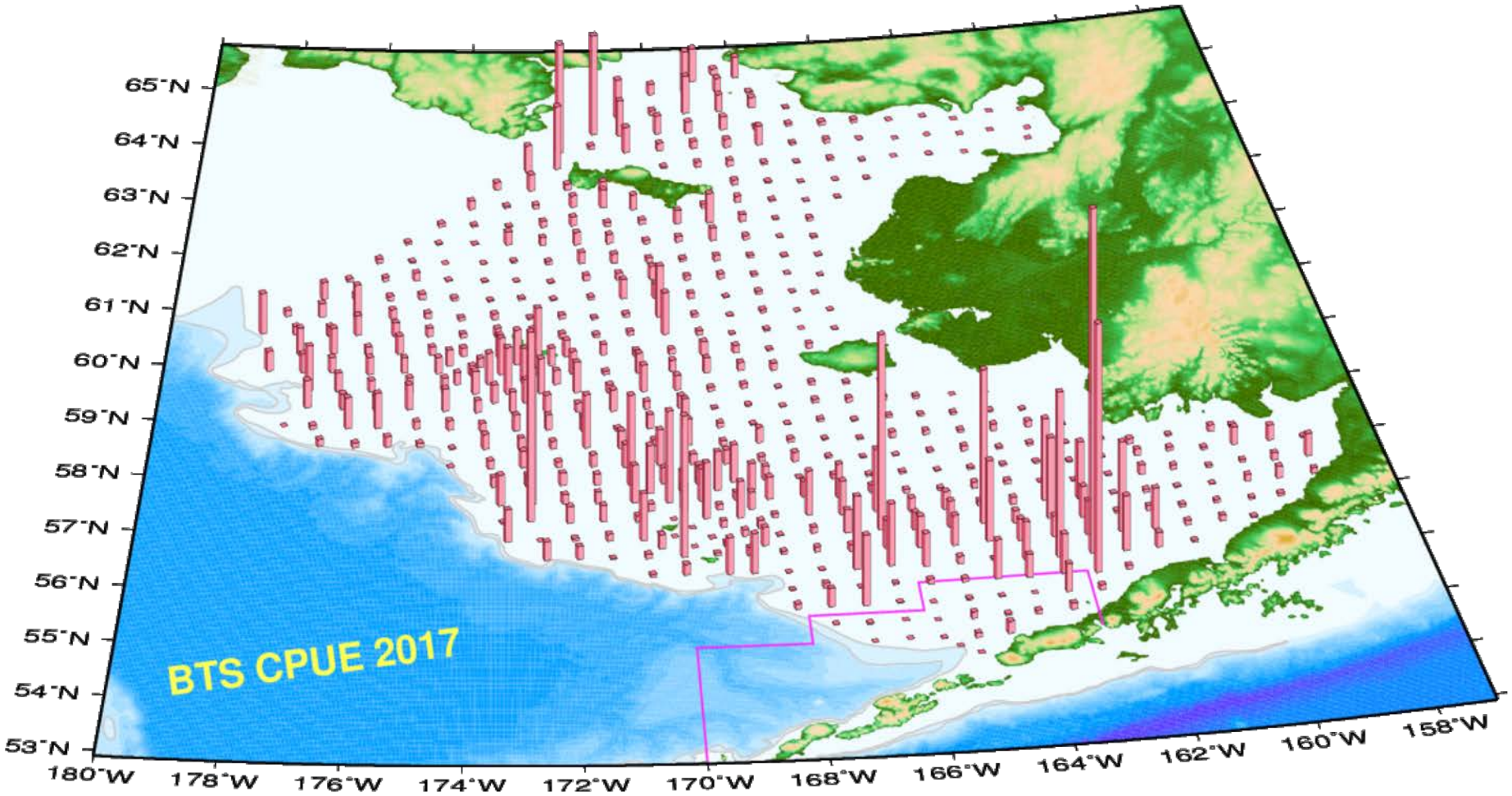


2010 standard survey
(3.74 million t pollock estimated)



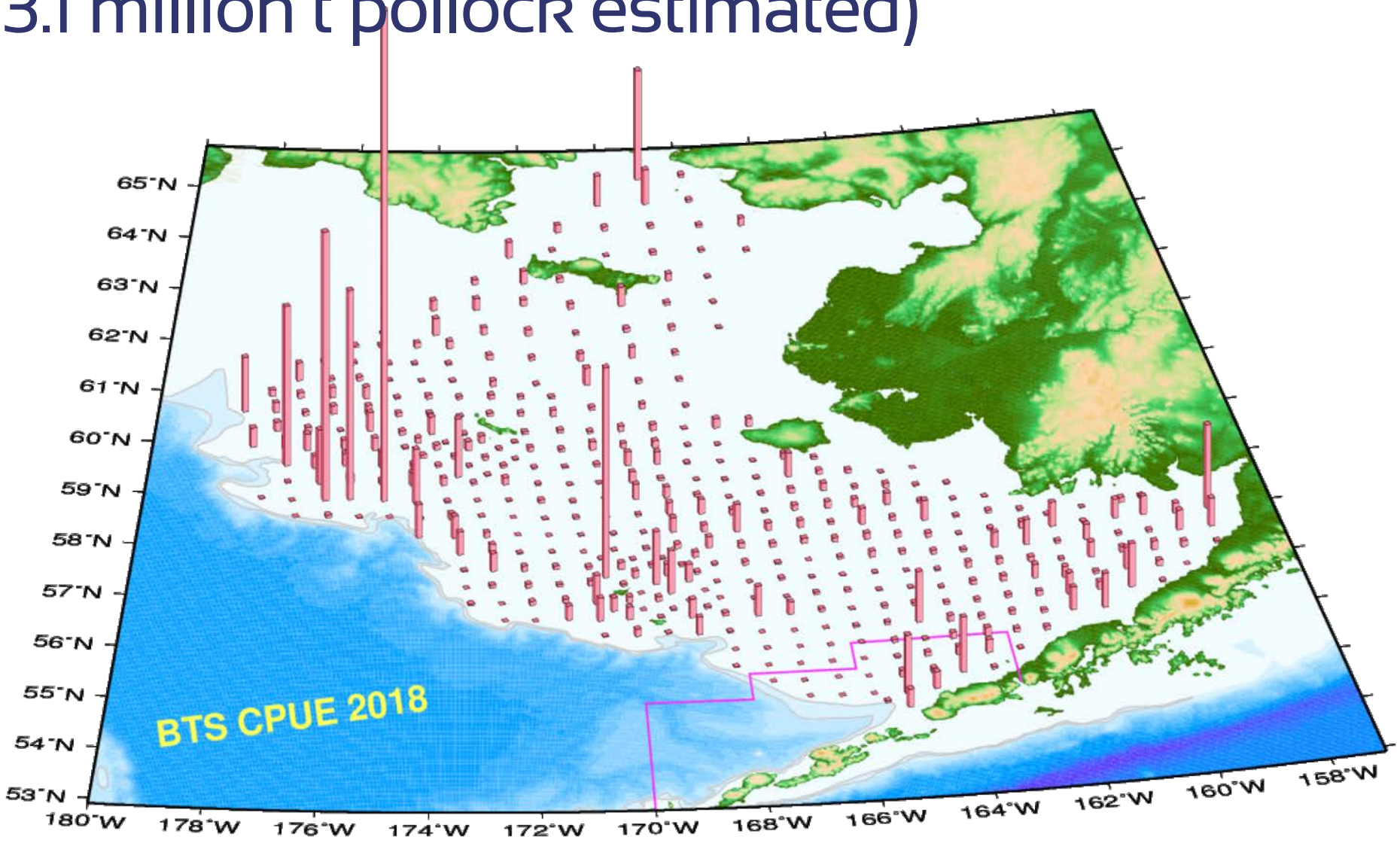
Northern area: trace amounts

2017 standard survey
(4.81 million t pollock estimated)



Northern area: 1.34 million t

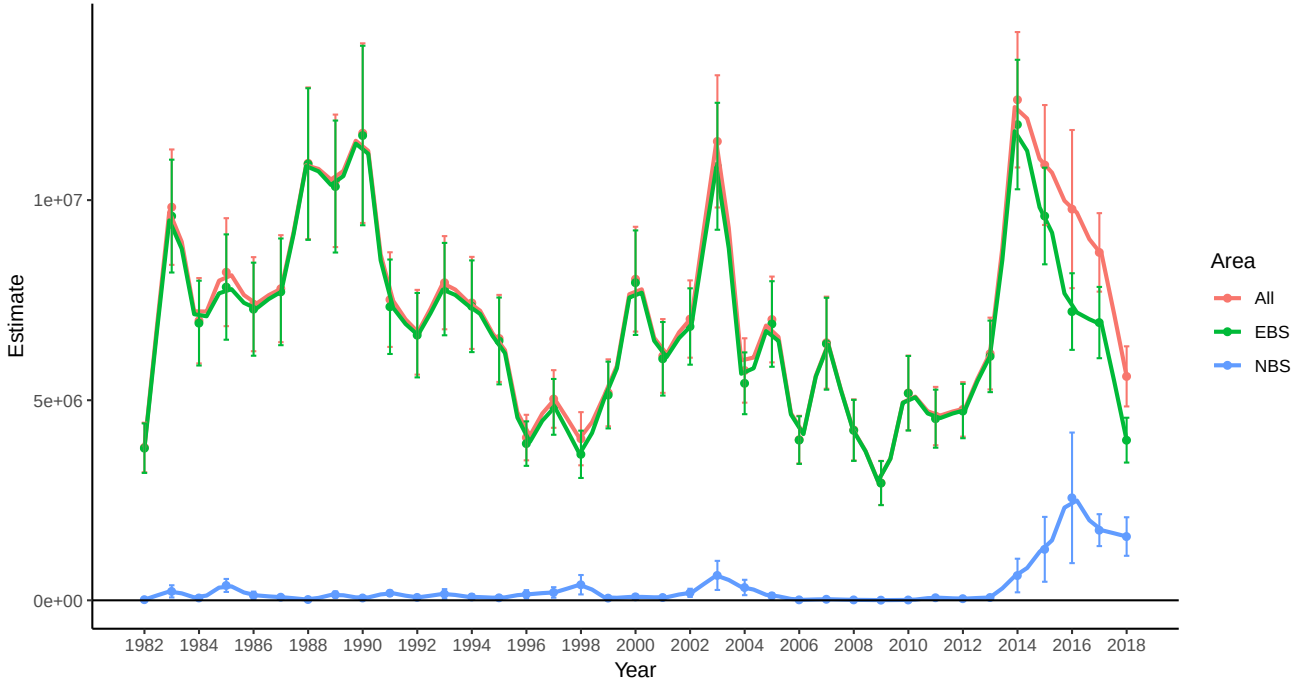
2018 standard survey (3.1 million t pollock estimated)

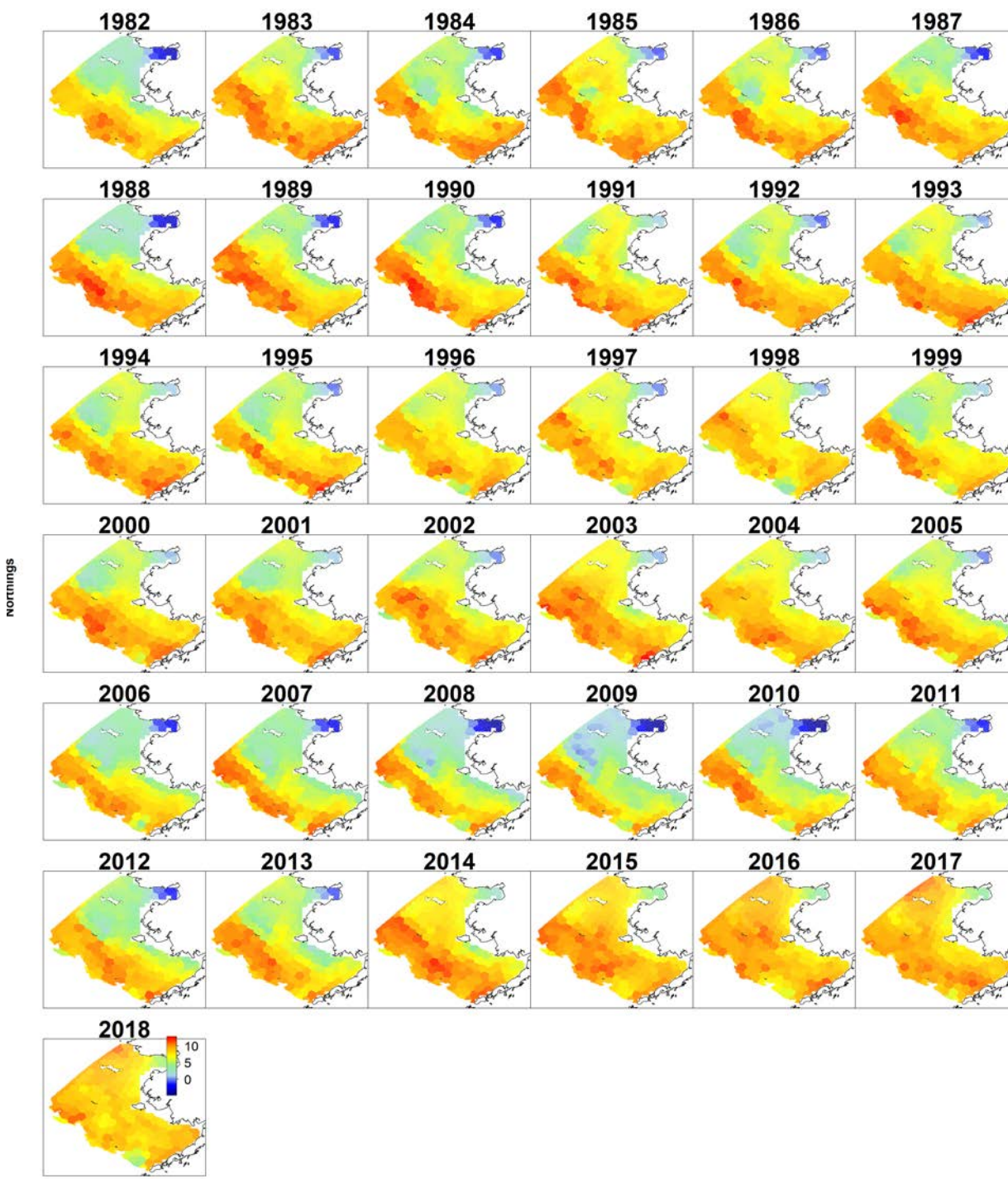


Northern area: 1.15 million t

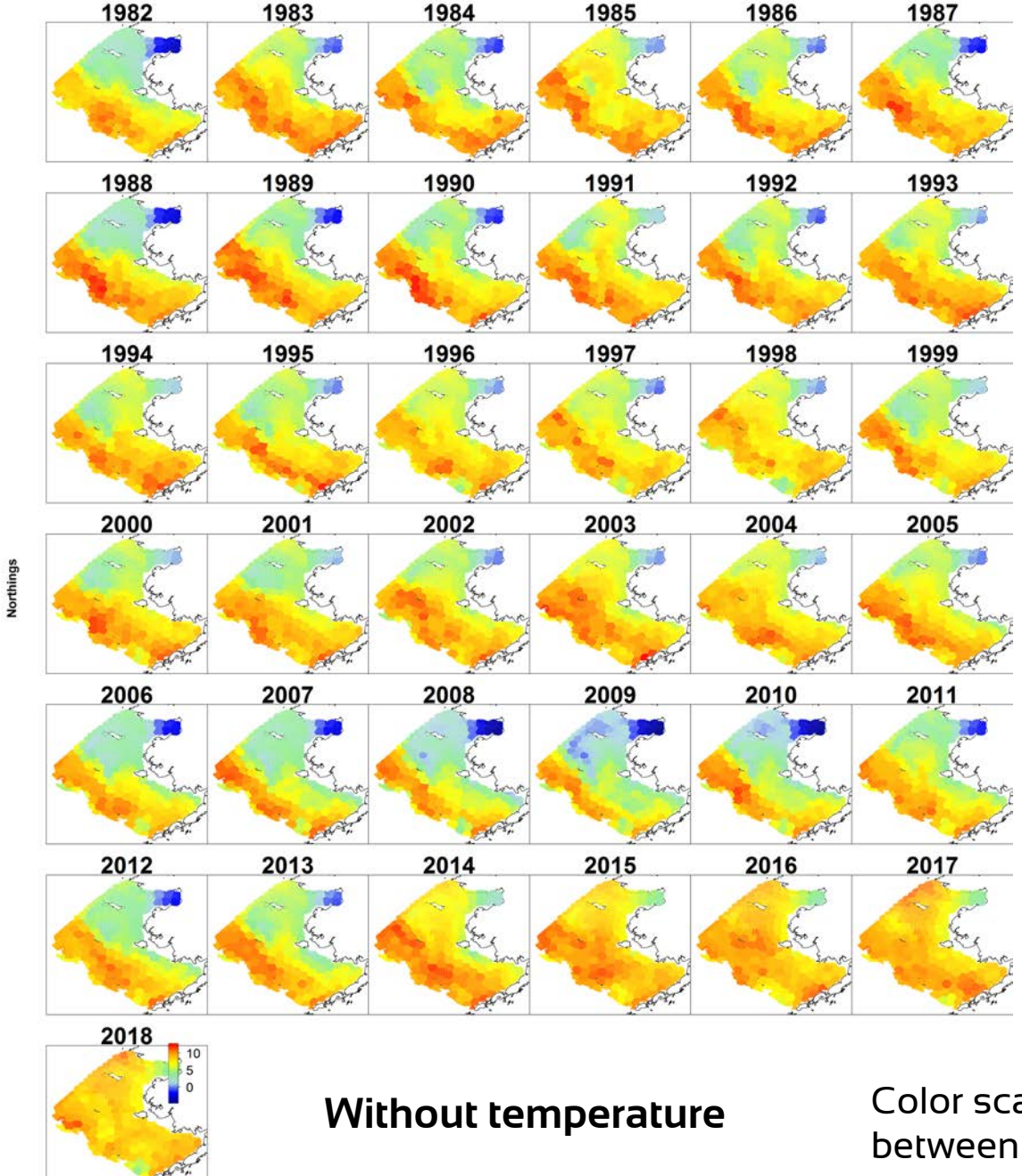
Modeling surveys

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



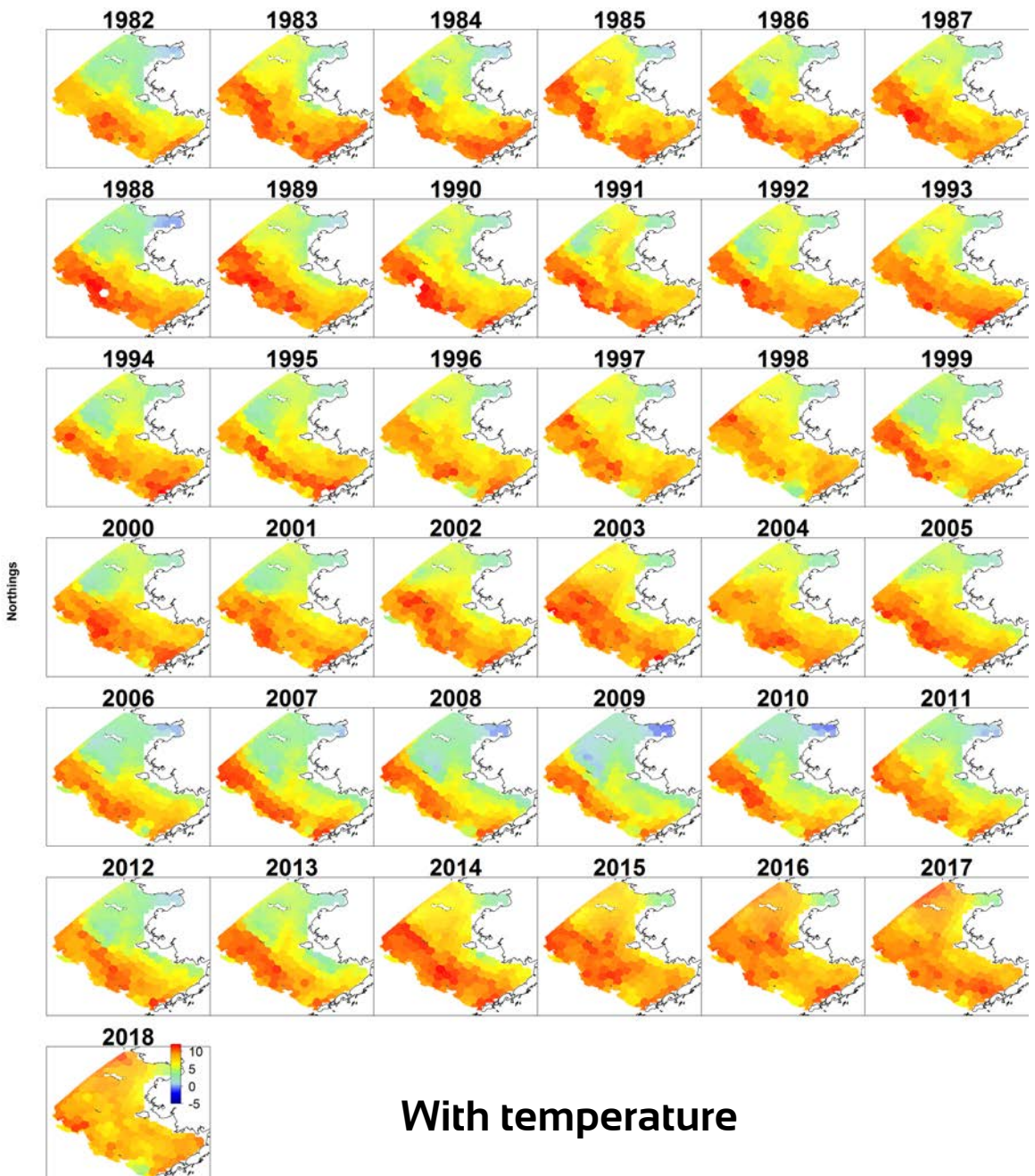


Pollock distribution - Comparing with vs. without temperature



Without temperature

Color scale differs between analyses

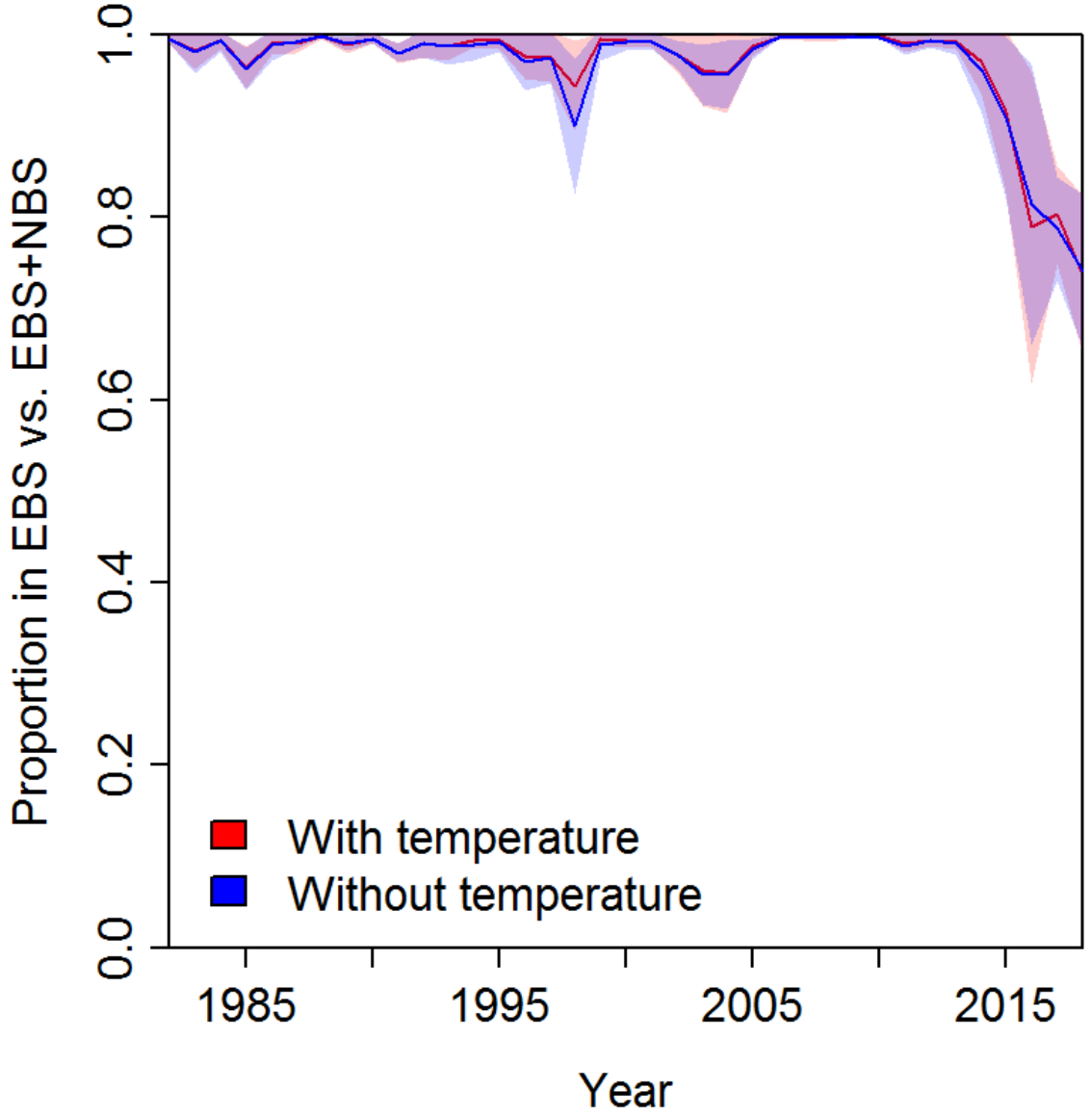


With temperature

EBS pollock distribution
Comparing with vs. without temperature

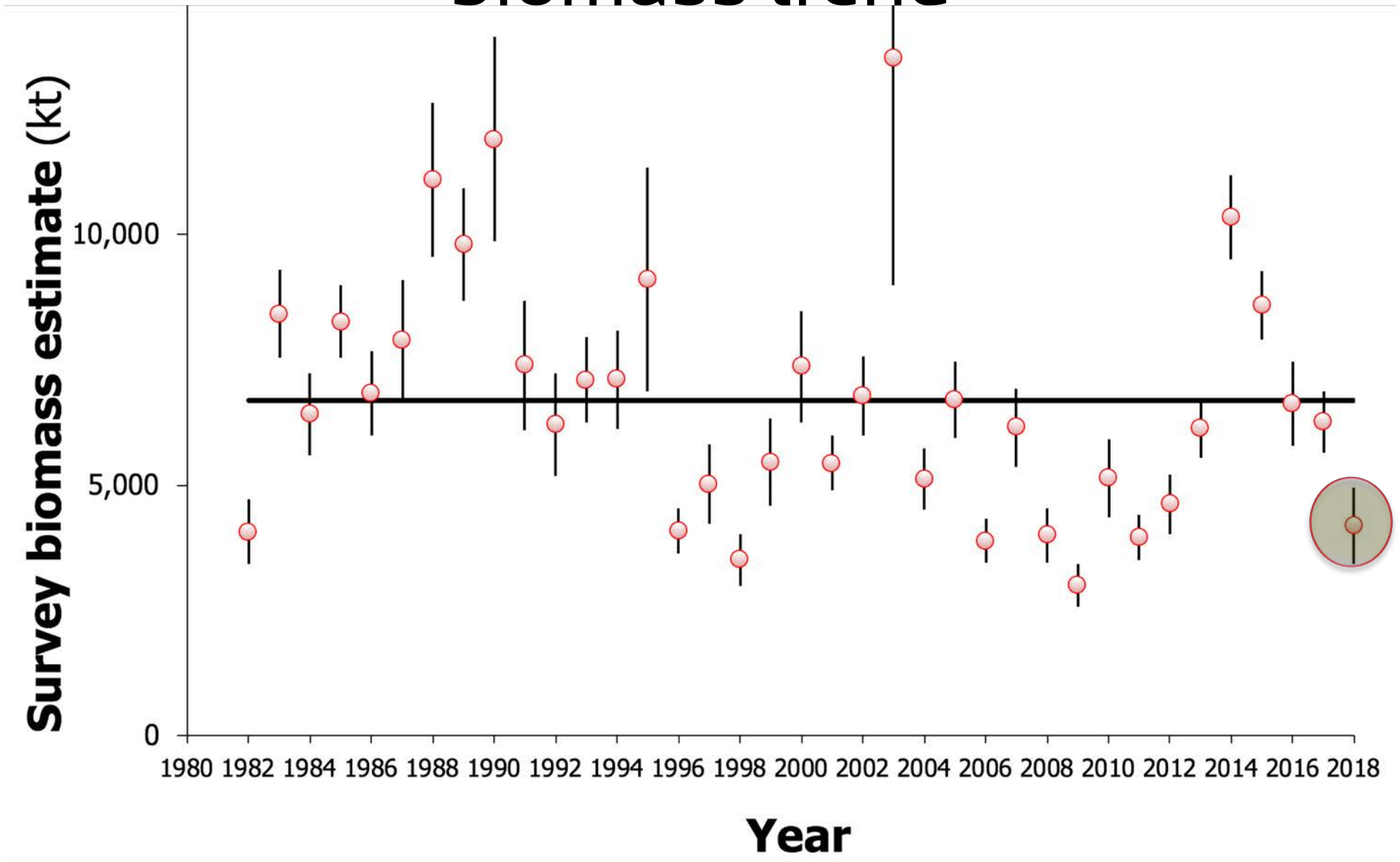
Preliminary conclusion

Including temperature has relatively little impact on relative biomass in NBS vs. total



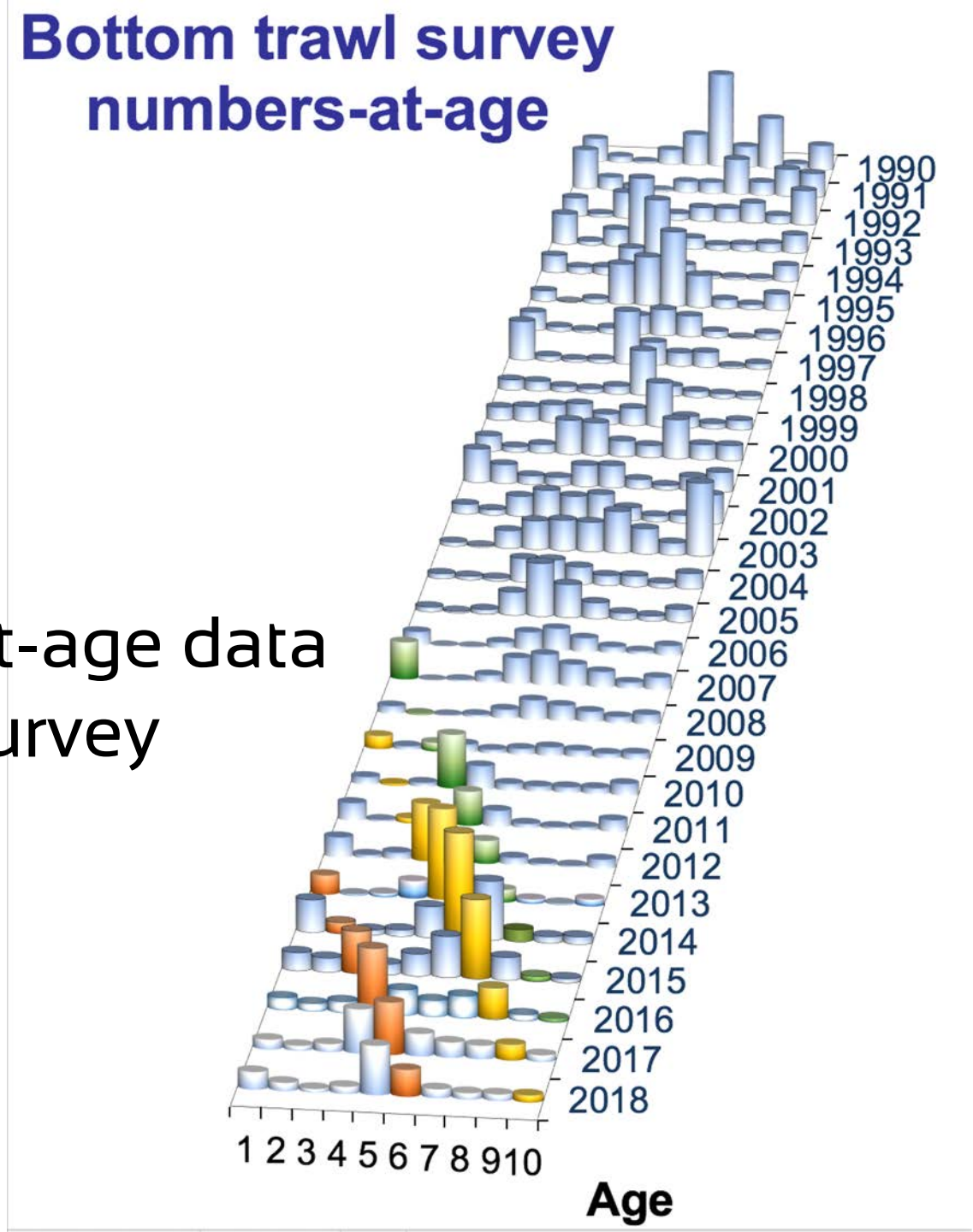
Courtesy Kerim Aydin and Jim Thorson

Pollock bottom trawl survey biomass trend



What are the EBS pollock abundance-at-age estimates like?

- New 2018 abundance-at-age data from the bottom trawl survey



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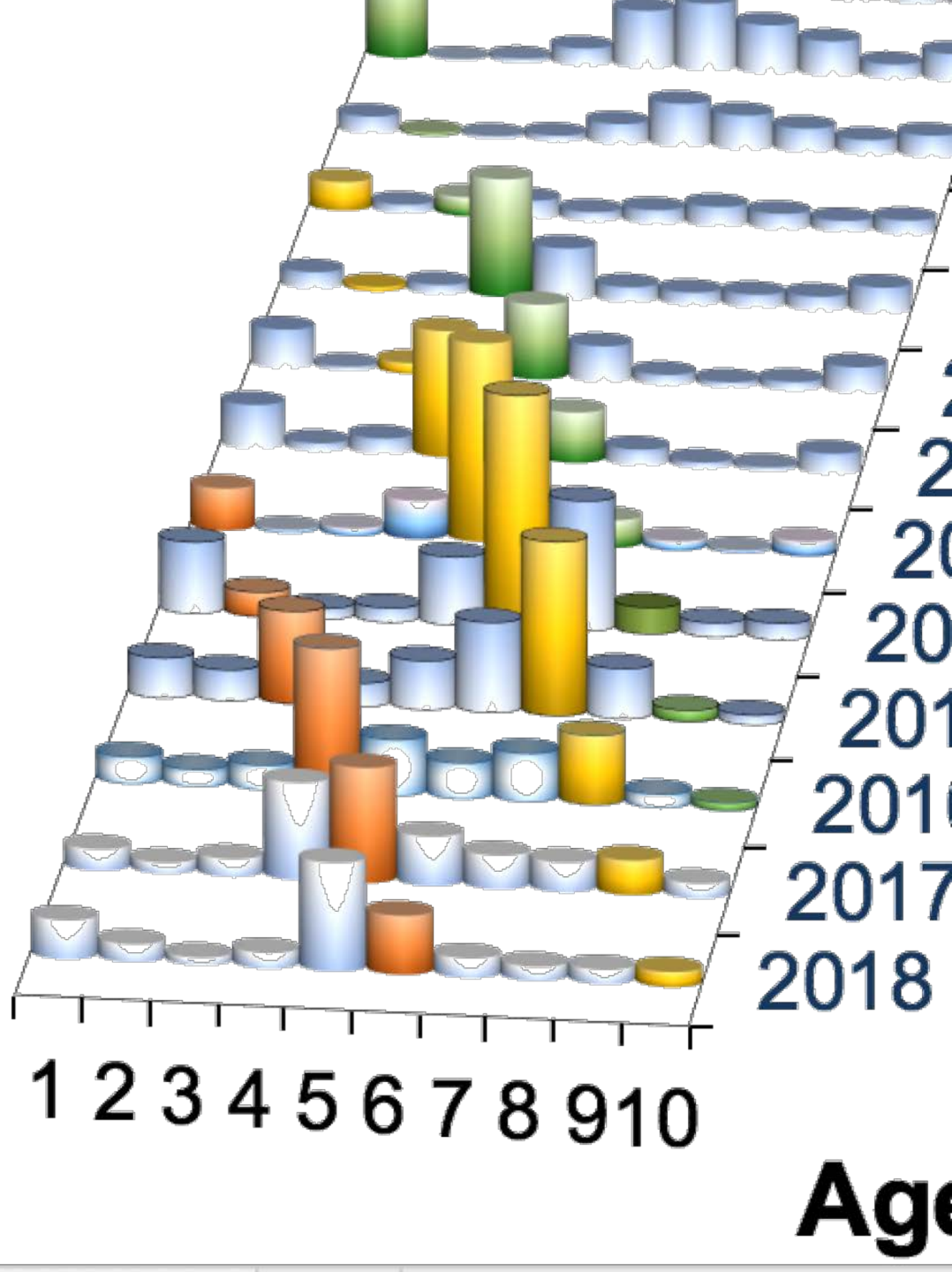
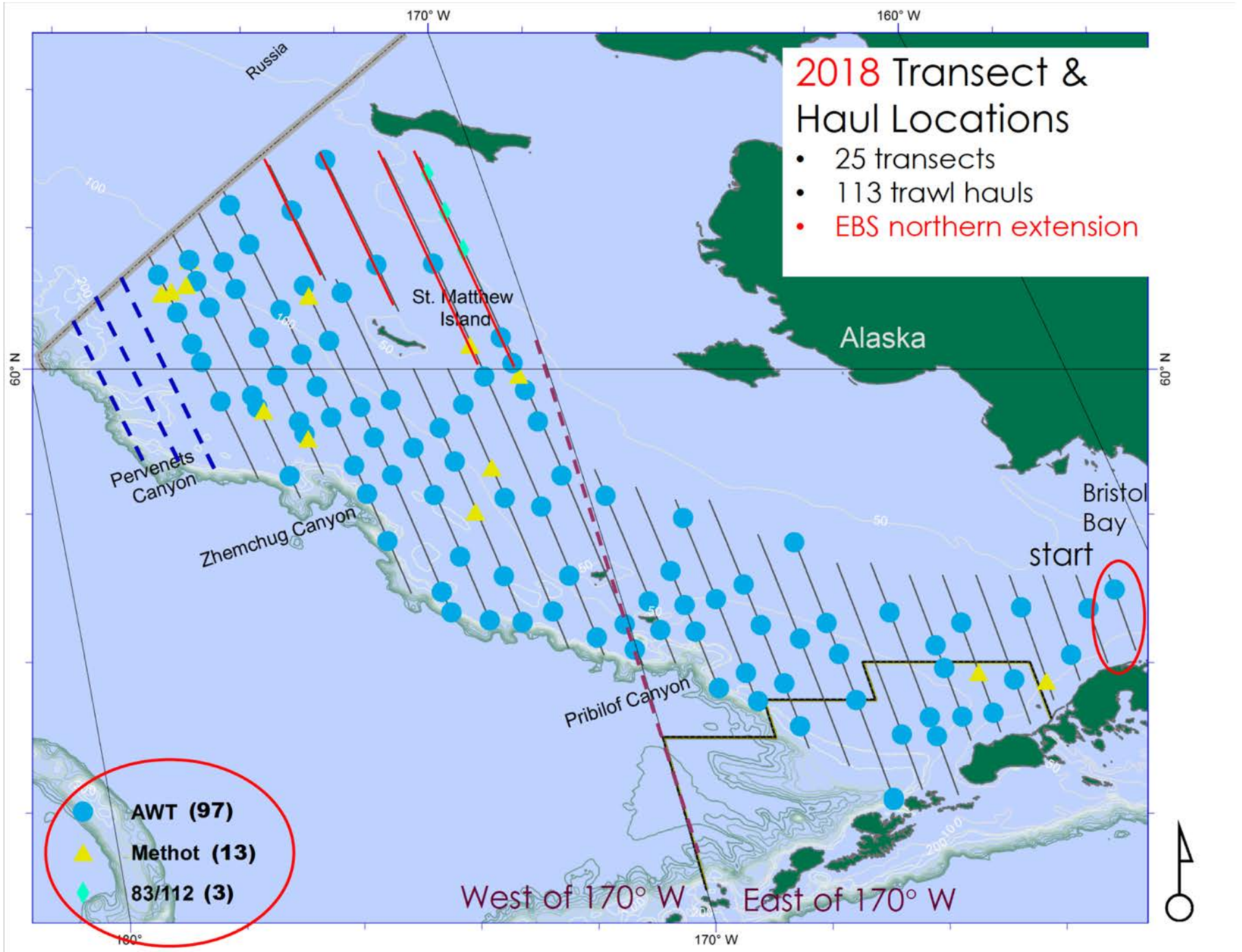


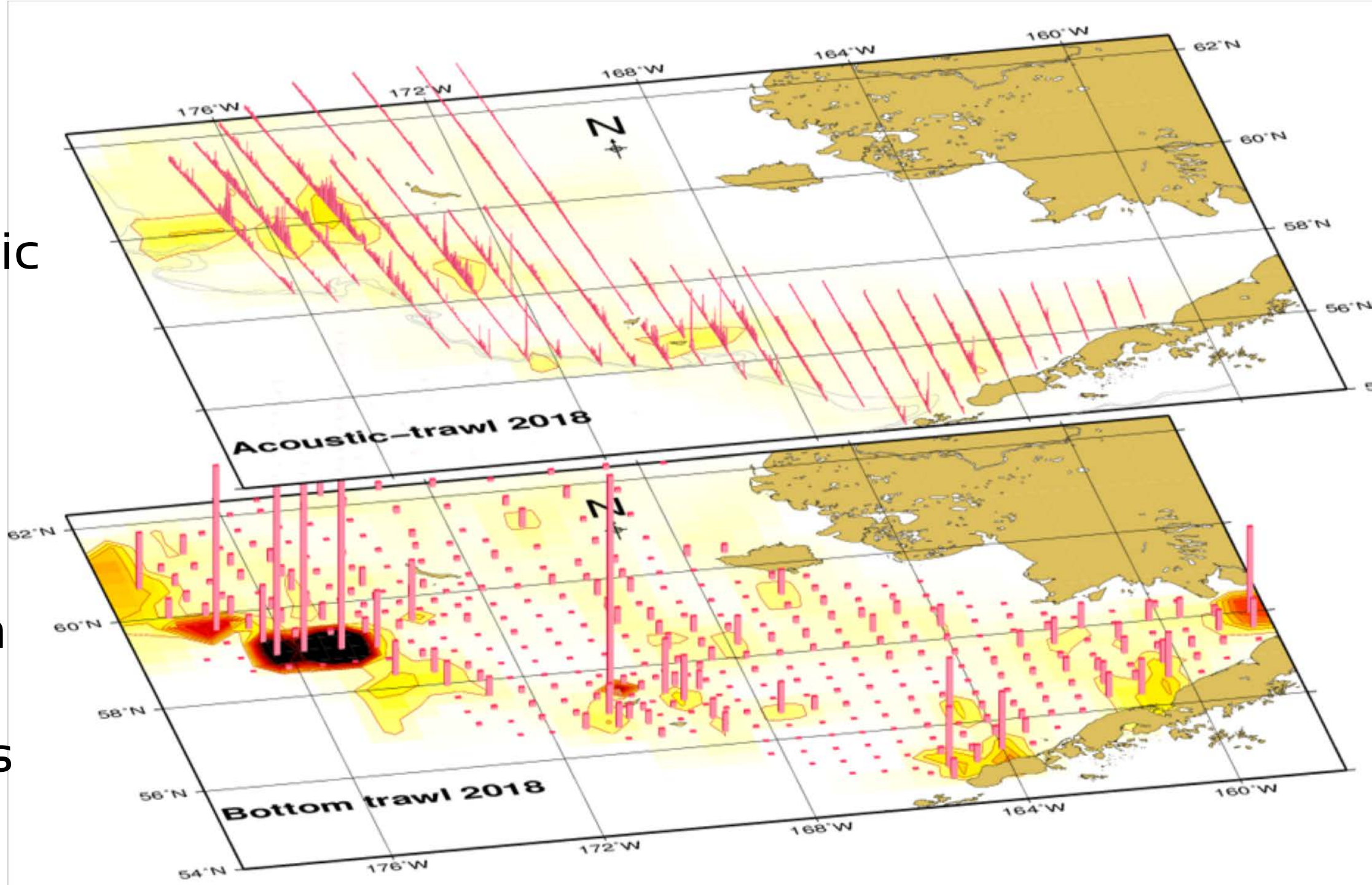
Biennial mid-water acoustic-trawl survey

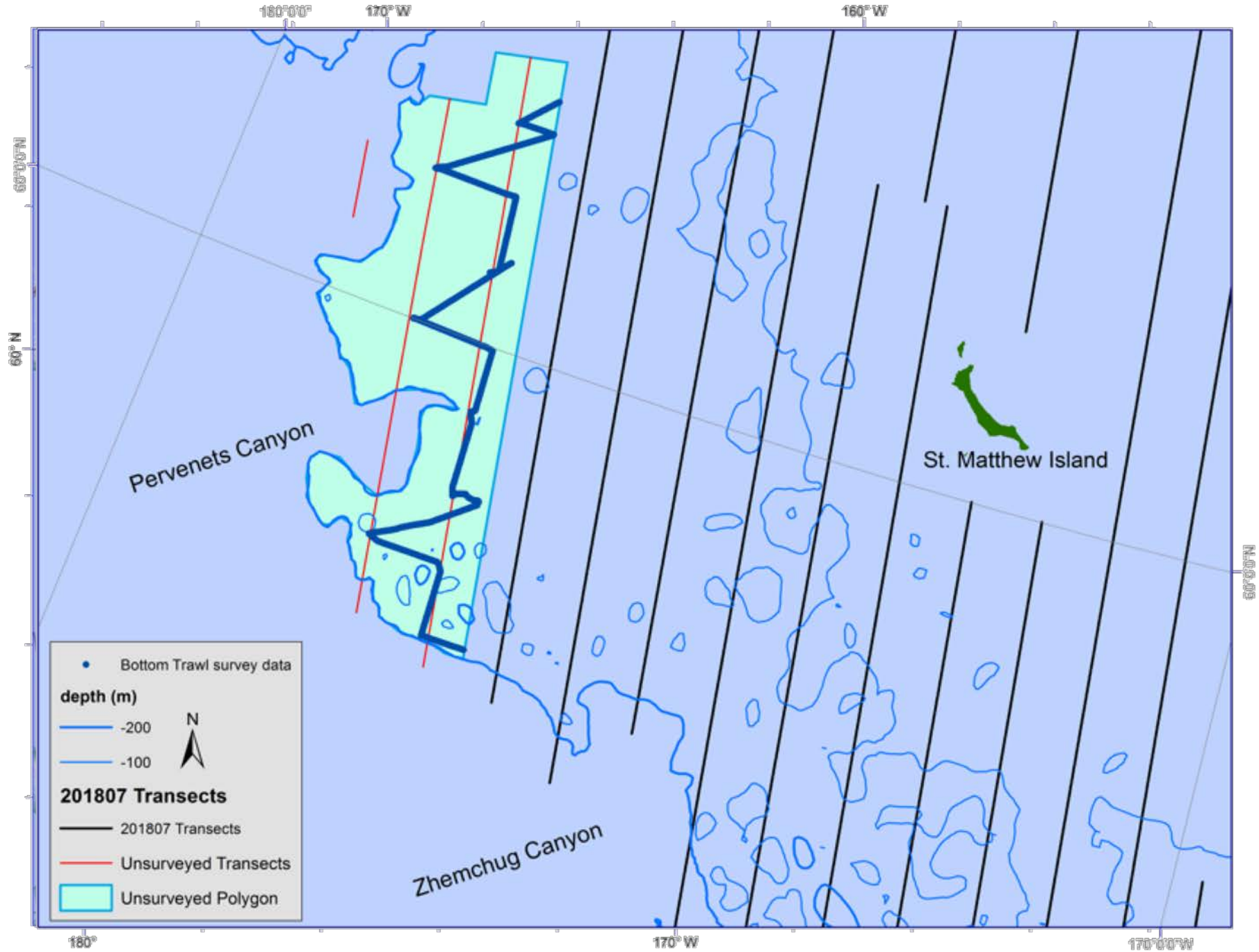

2018 Transect & Haul Locations
• 25 transects
• 113 trawl hauls
• EBS northern extension
170° W
160° W
60° N
Russia
St. Matthew Island
Alaska
Pervenets Canyon
Zhemchug Canyon
Pribilof Canyon
Bristol Bay
start
AWT (97)
Methot (13)
83/112 (3)
West of 170° W
East of 170° W
180°
170° W

Acoustic

&

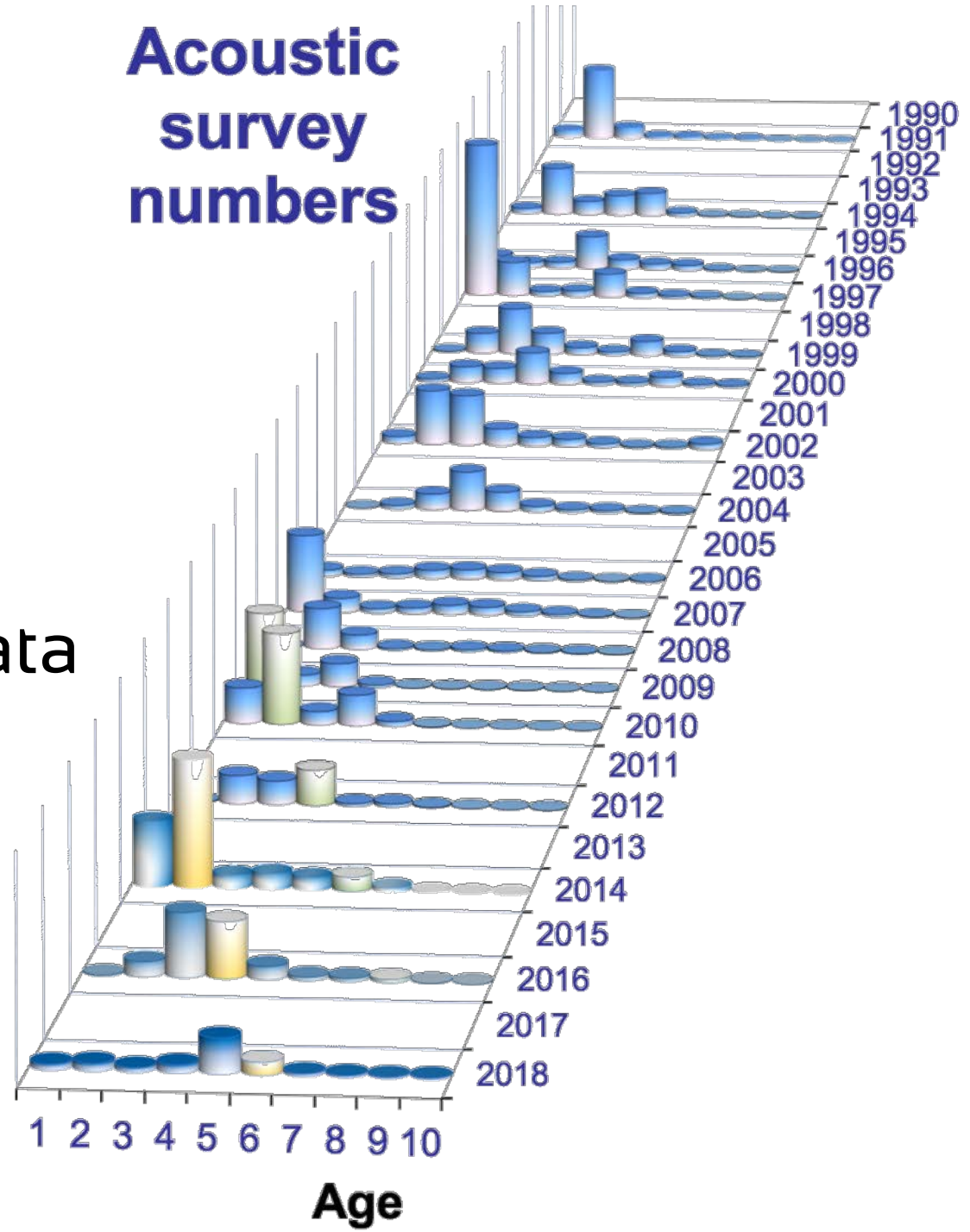
Bottom trawl surveys

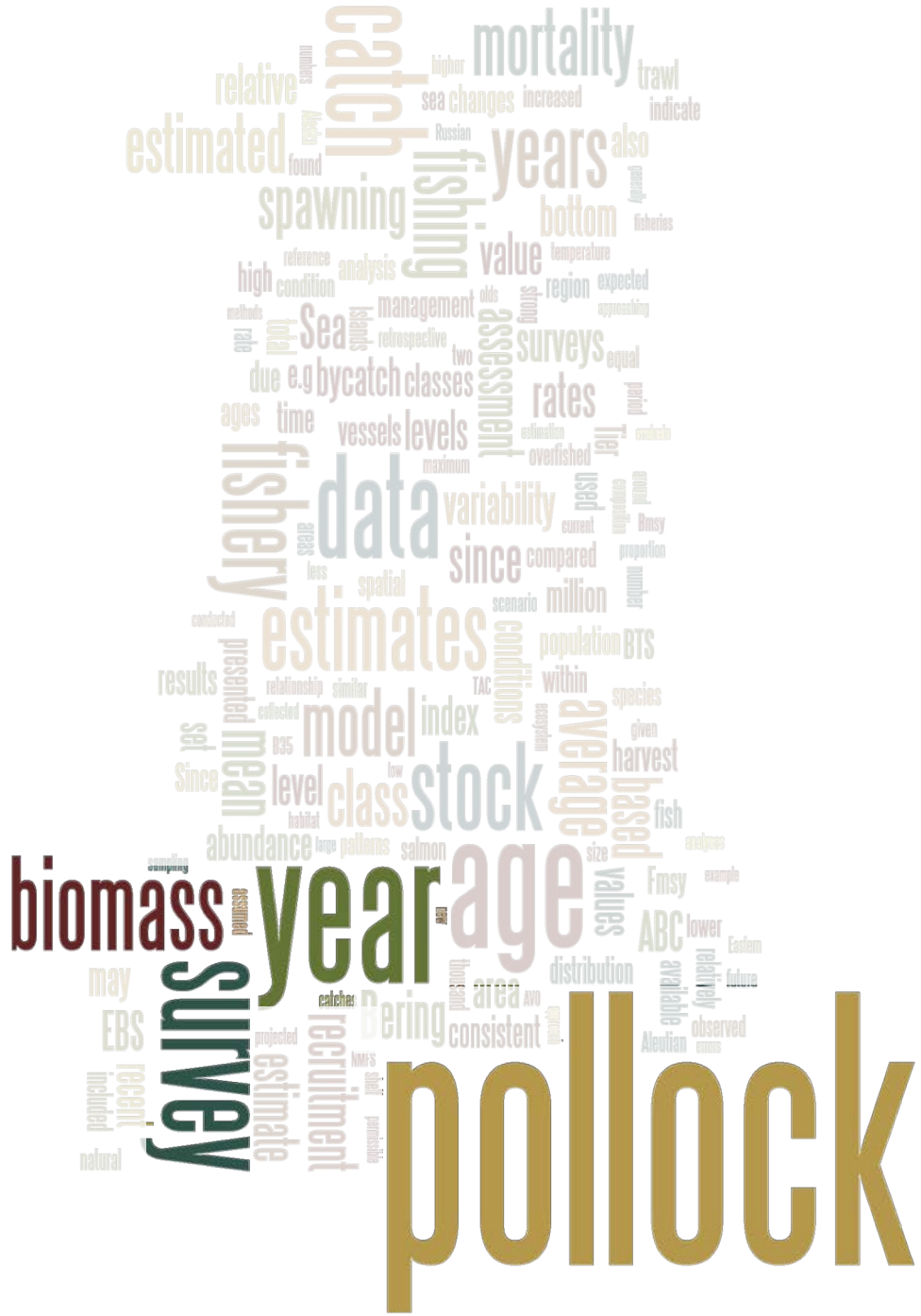



180°00'
170° W
160° W
60°10'N
60° N
59°50'N
Pervenets Canyon
St. Matthew Island
Zhemchug Canyon
Bottom Trawl survey data
depth (m)
-200
-100
N
201807 Transects
201807 Transects
Unsurveyed Transects
Unsurveyed Polygon
180°
170° W
170°10'W

What are the EBS pollock abundance-at-age estimates like?

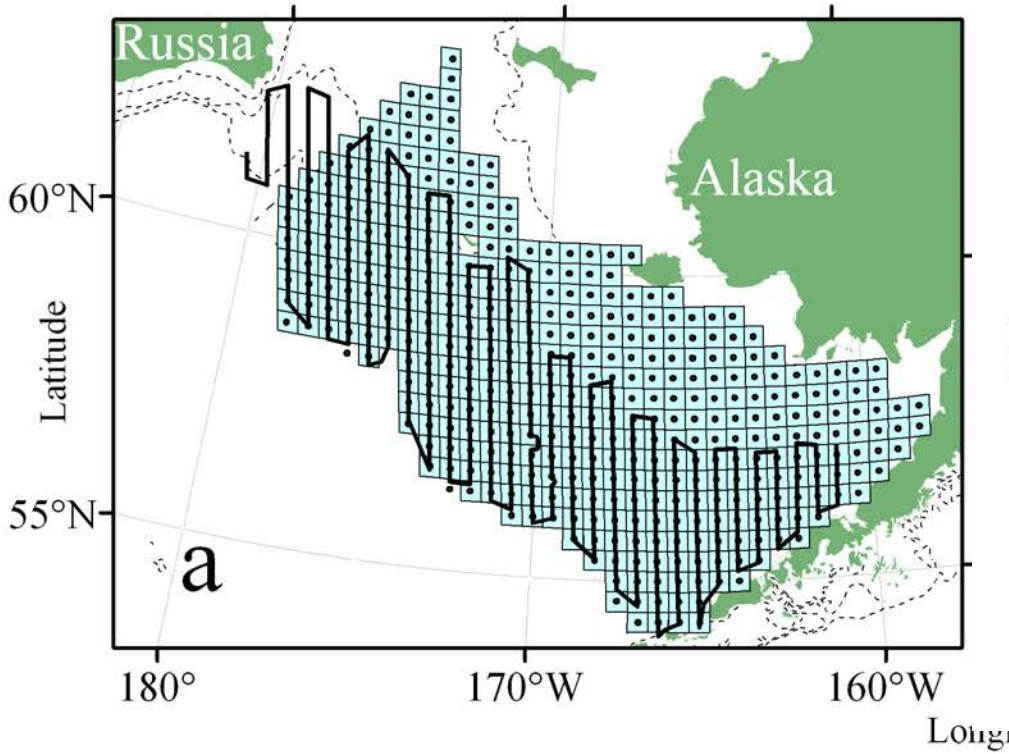
- New 2018 abundance-at-age data from the acoustic trawl survey

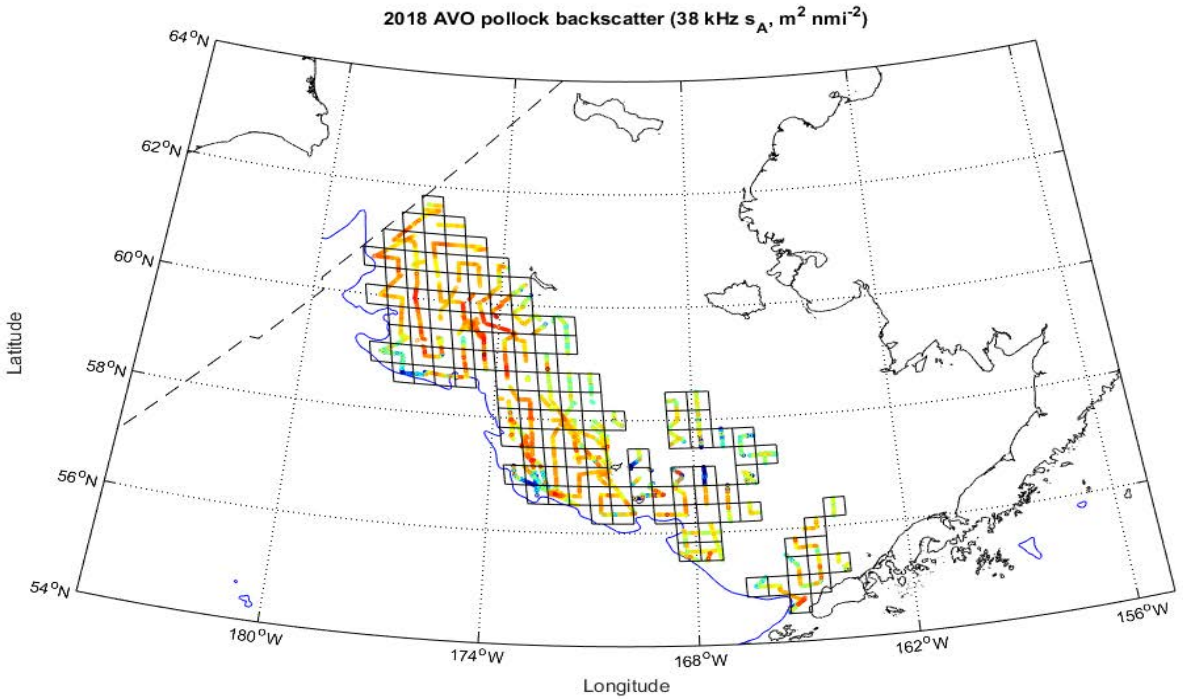




Acoustic Vessels of Oportunity

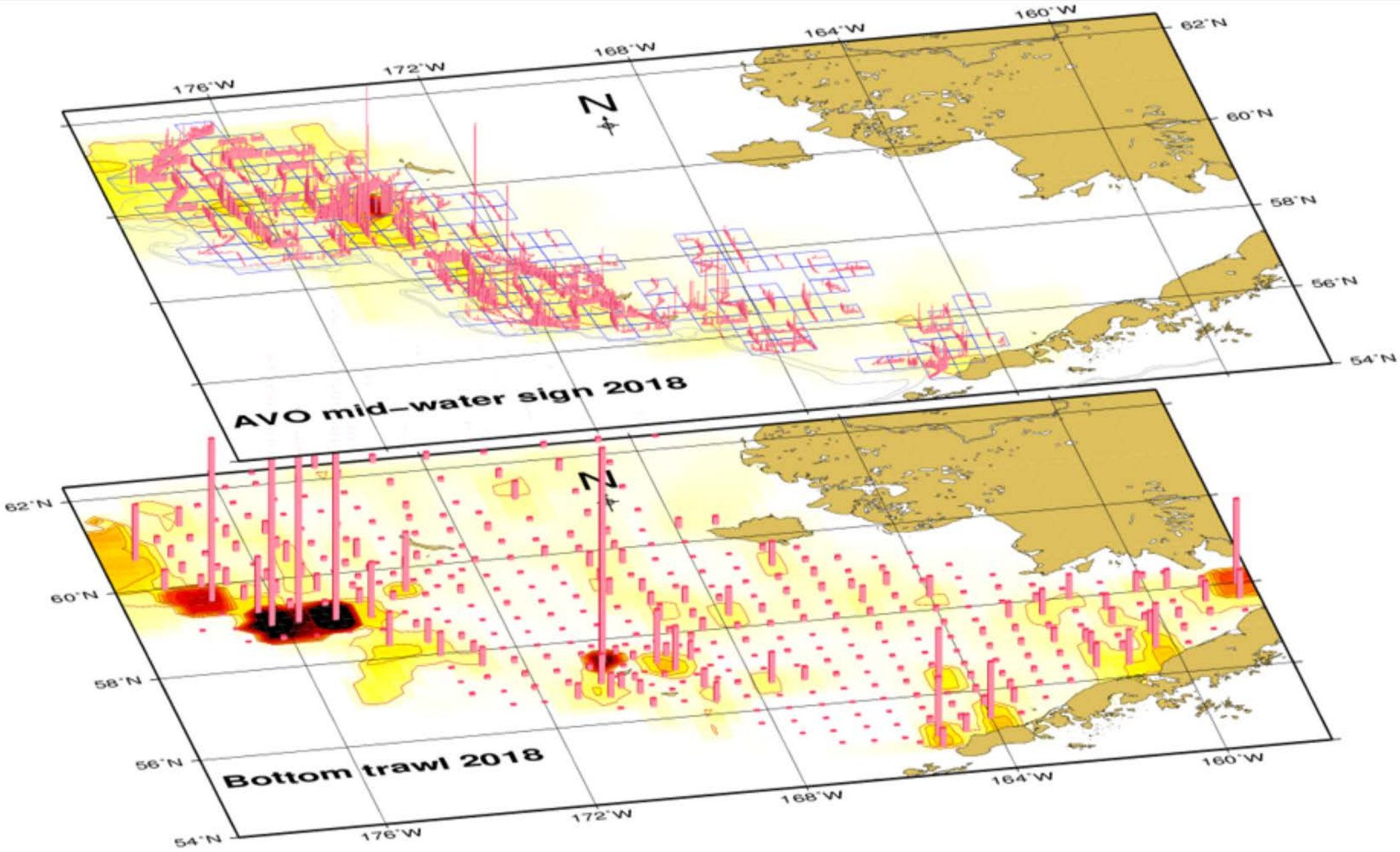
Mid-water acoustic surveys…



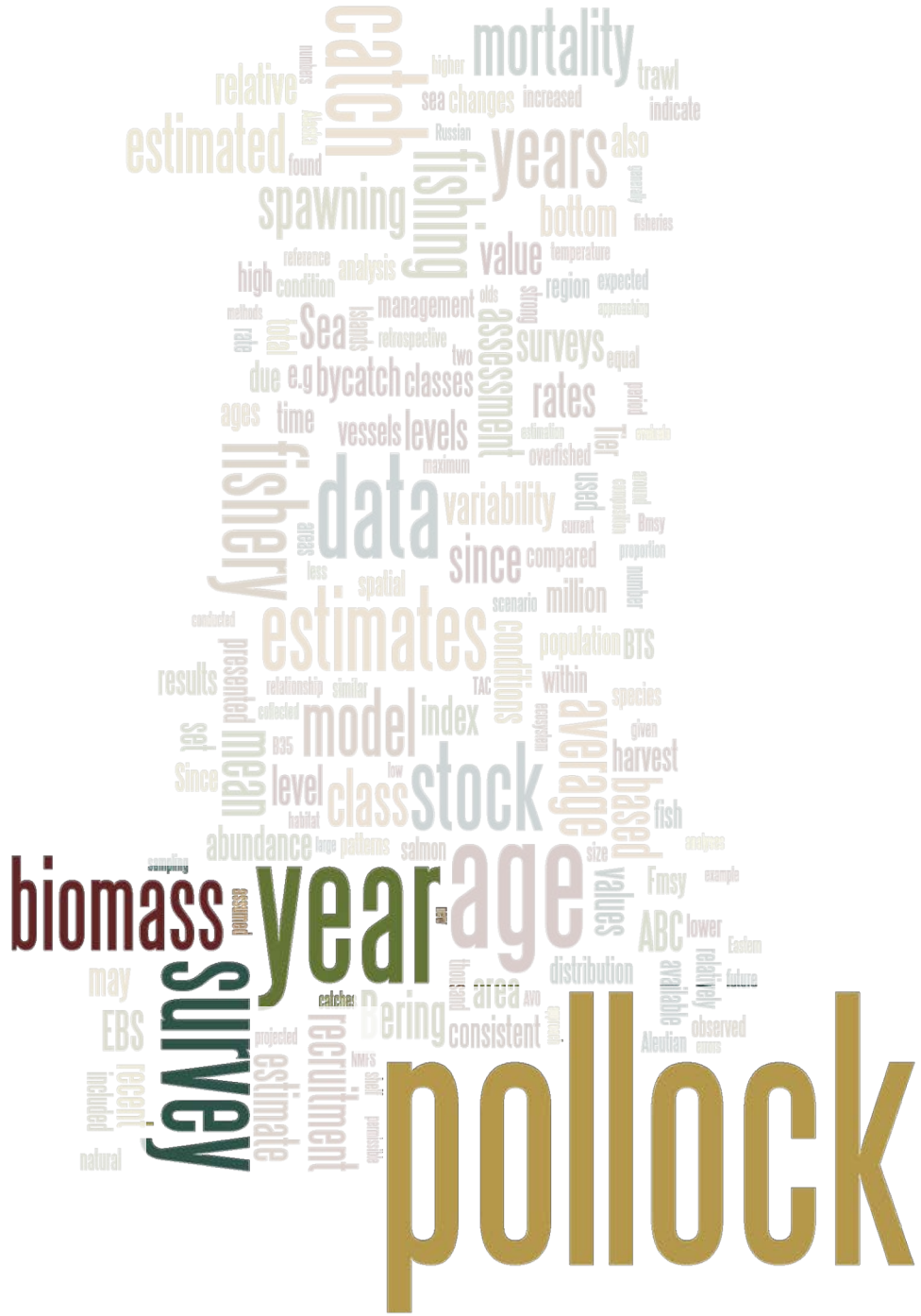


Acoustic
Vessels of
Oportunity

Acoustic vessels of opportunity (AVO)



Acoustic
Vessels of
Oportunity



Data Impact on Model

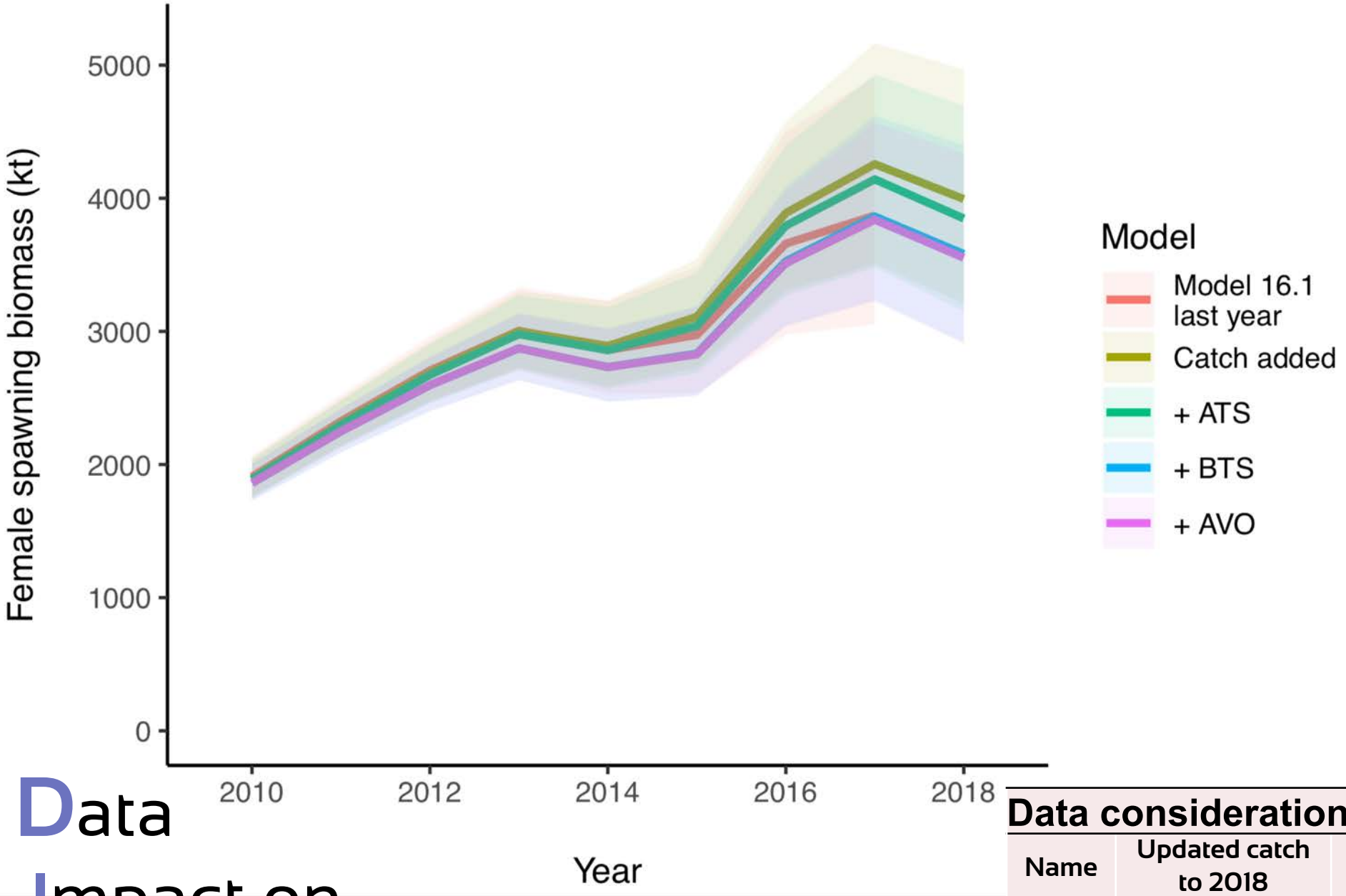
Models

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

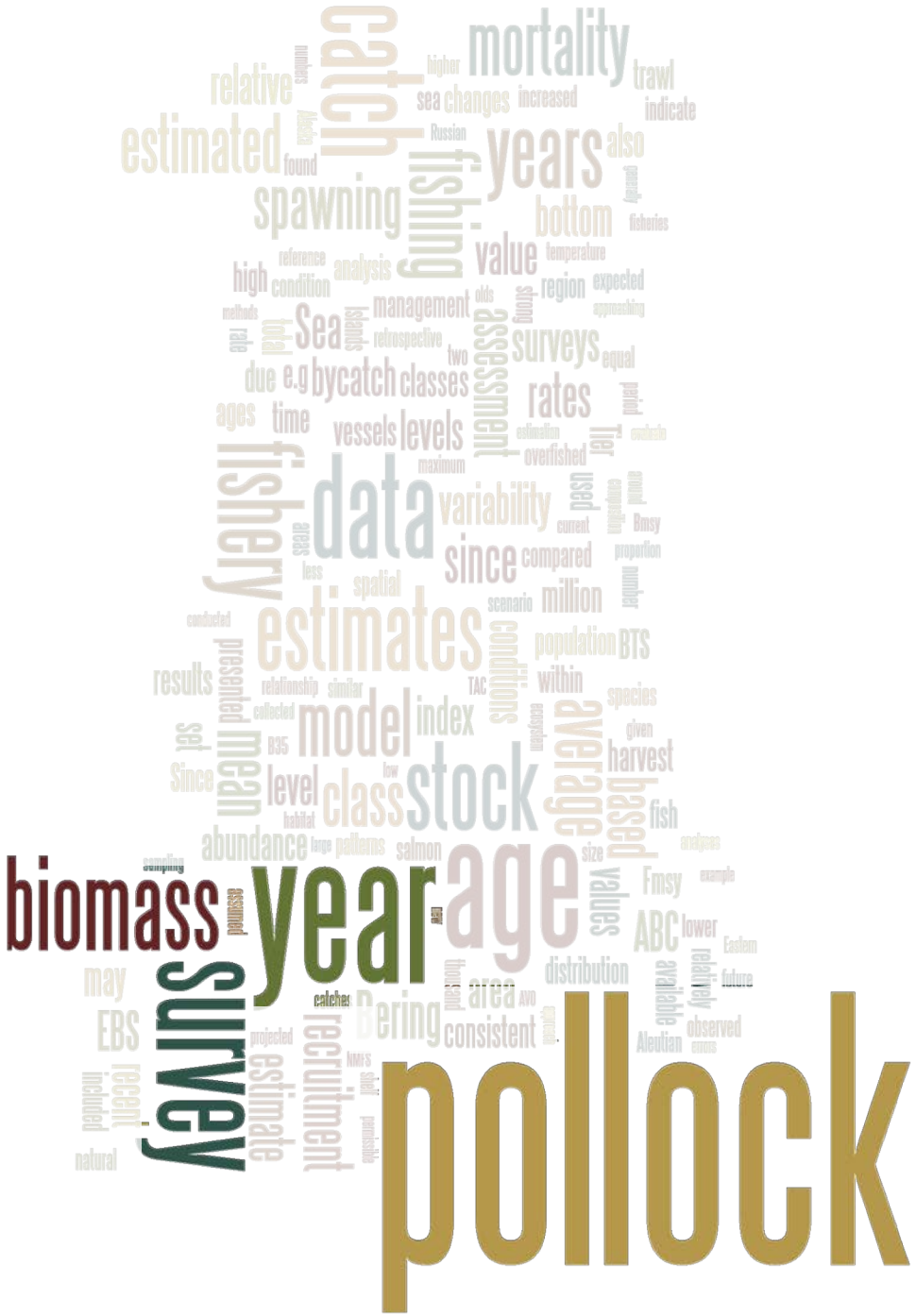
Model



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



EBS pollock Assessment Results

EBS pollock
Assessment
Results

Model details (1 of 2)

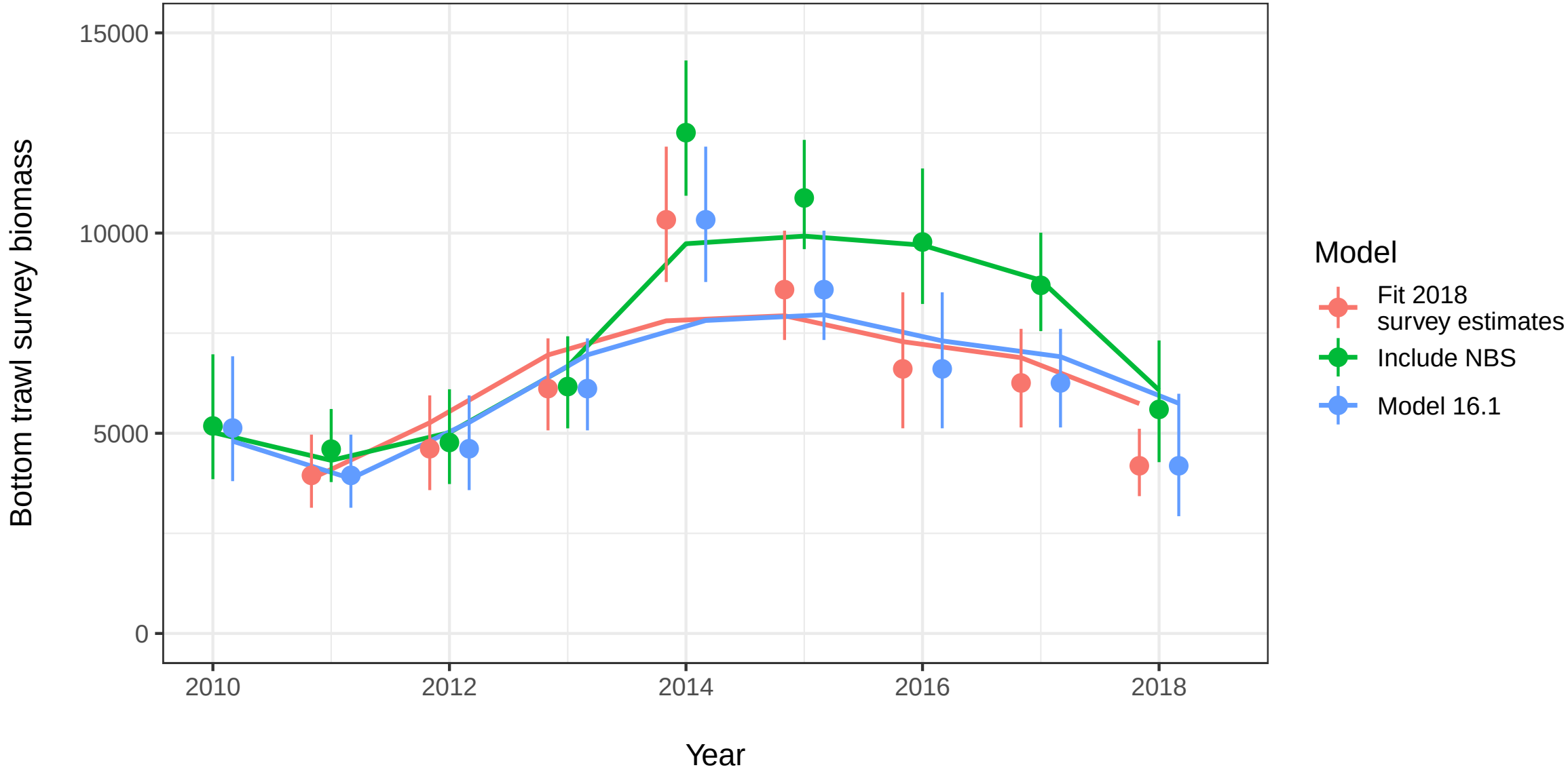
- Tuning indices
  - Acoustic Trawl survey
    - Available biennially (usually)
  - Annual fixed-station bottom trawl survey
    - Tested including northern Bering Sea from VASt
  - Acoustic vessel of opportunity (AVO index)
    - Two new years of data every other year
  - Old foreign trawler CPUE (in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

Model details (2 of 2)

- 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

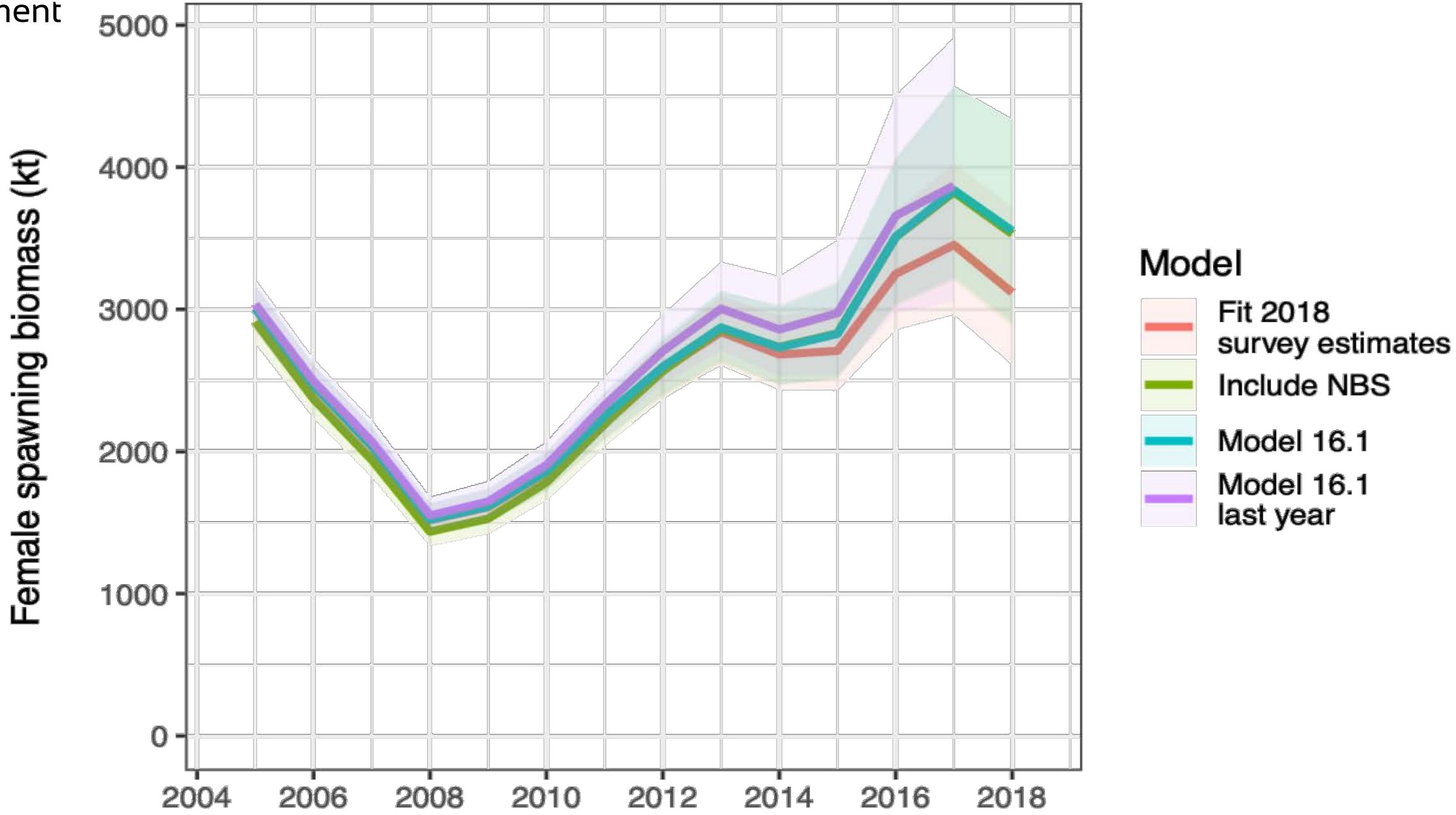
EBS pollock
Assessment
Results

Alternative models for bottom-trawl survey

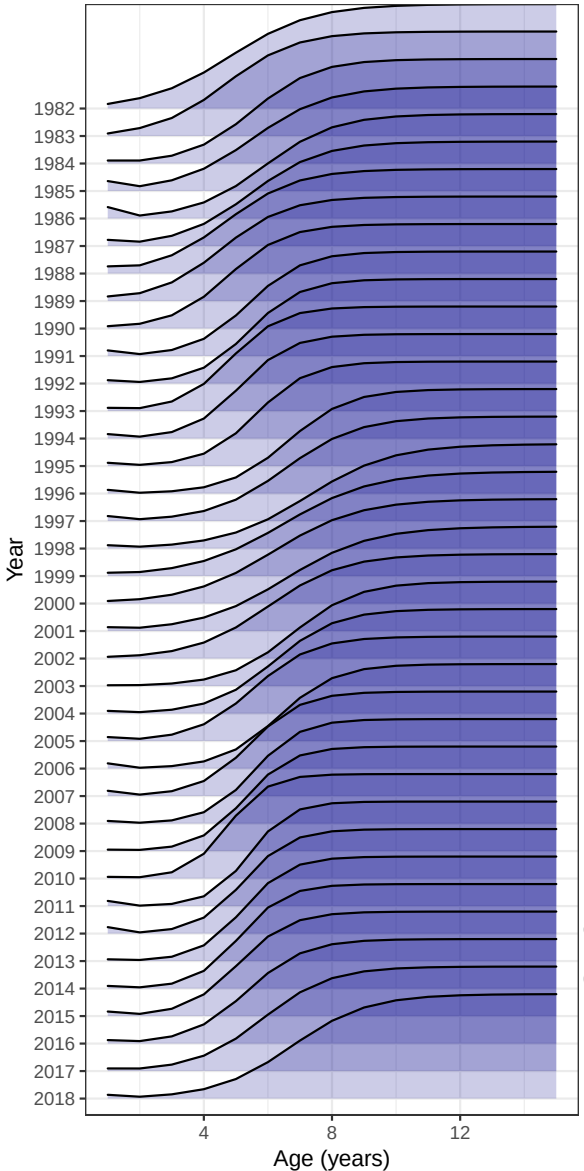


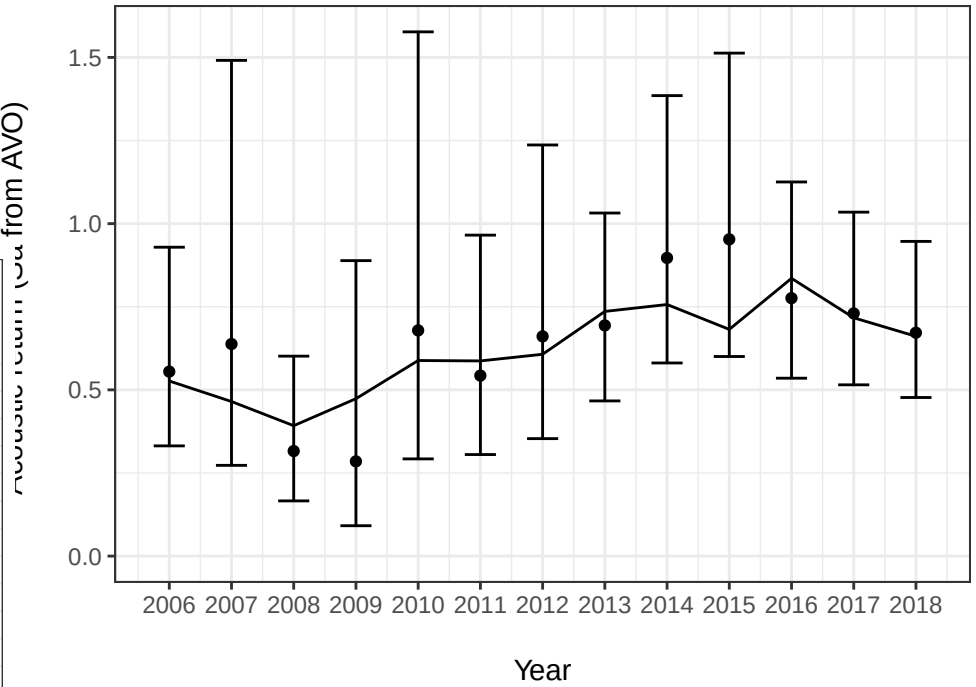
EBS pollock
Assessment
Results

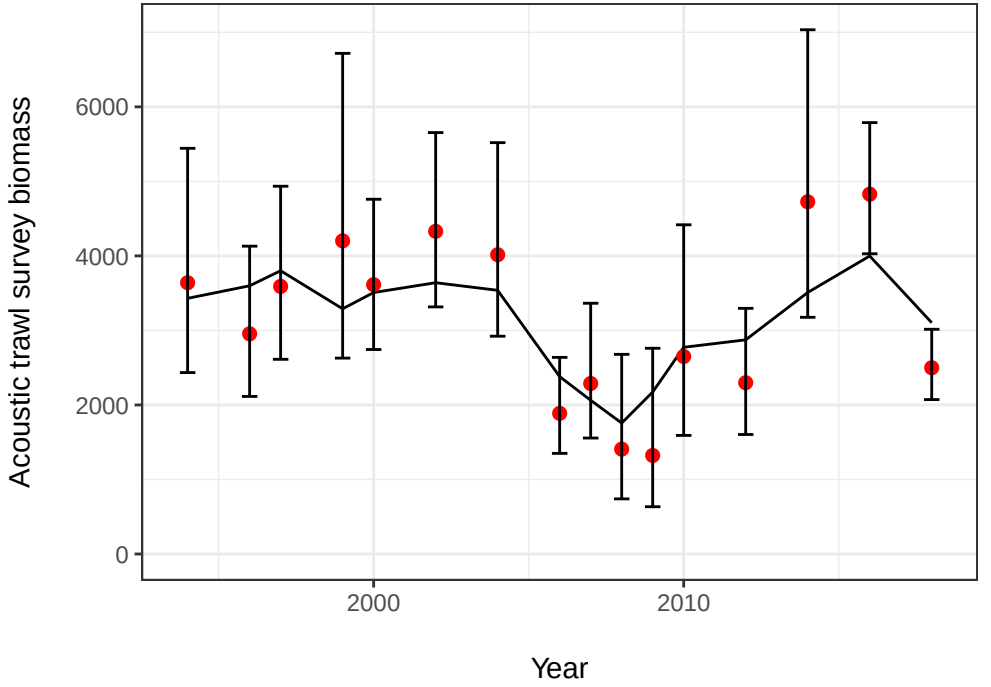
Spawning biomass



EBS pollock Assessment Results

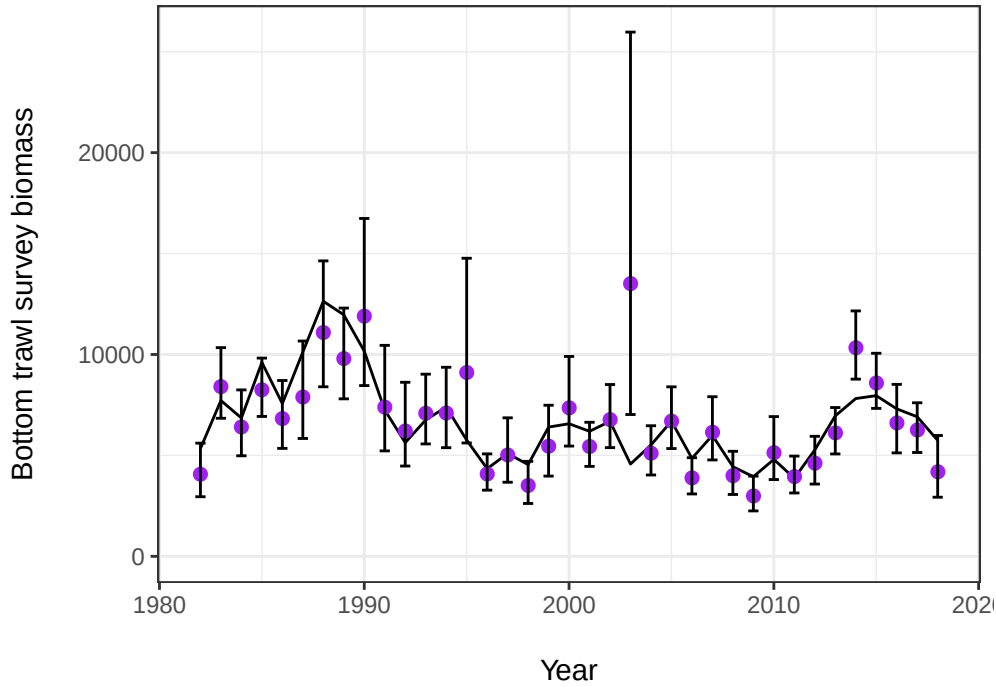






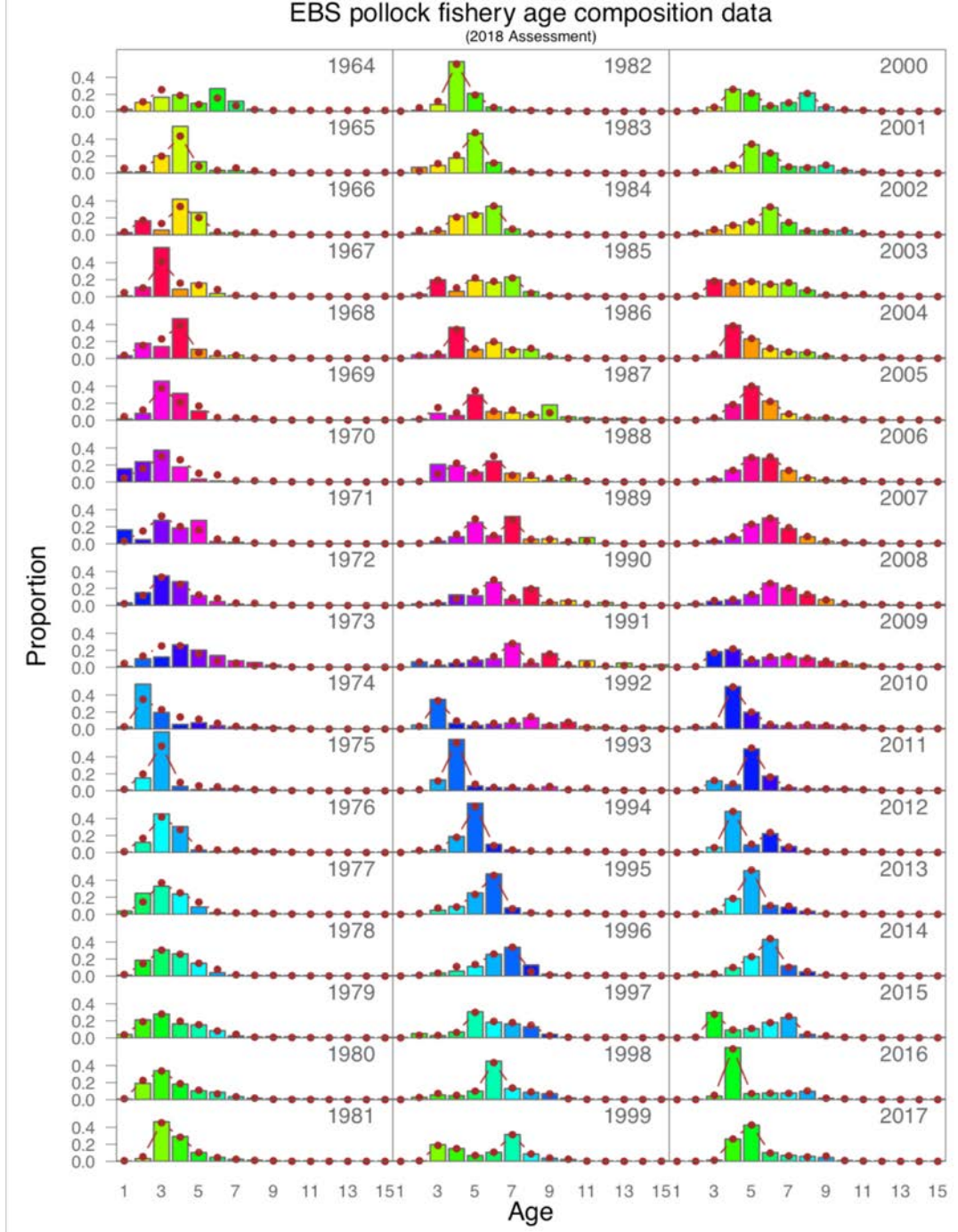
Model fits to indices

Bottom trawl survey Selectivity...



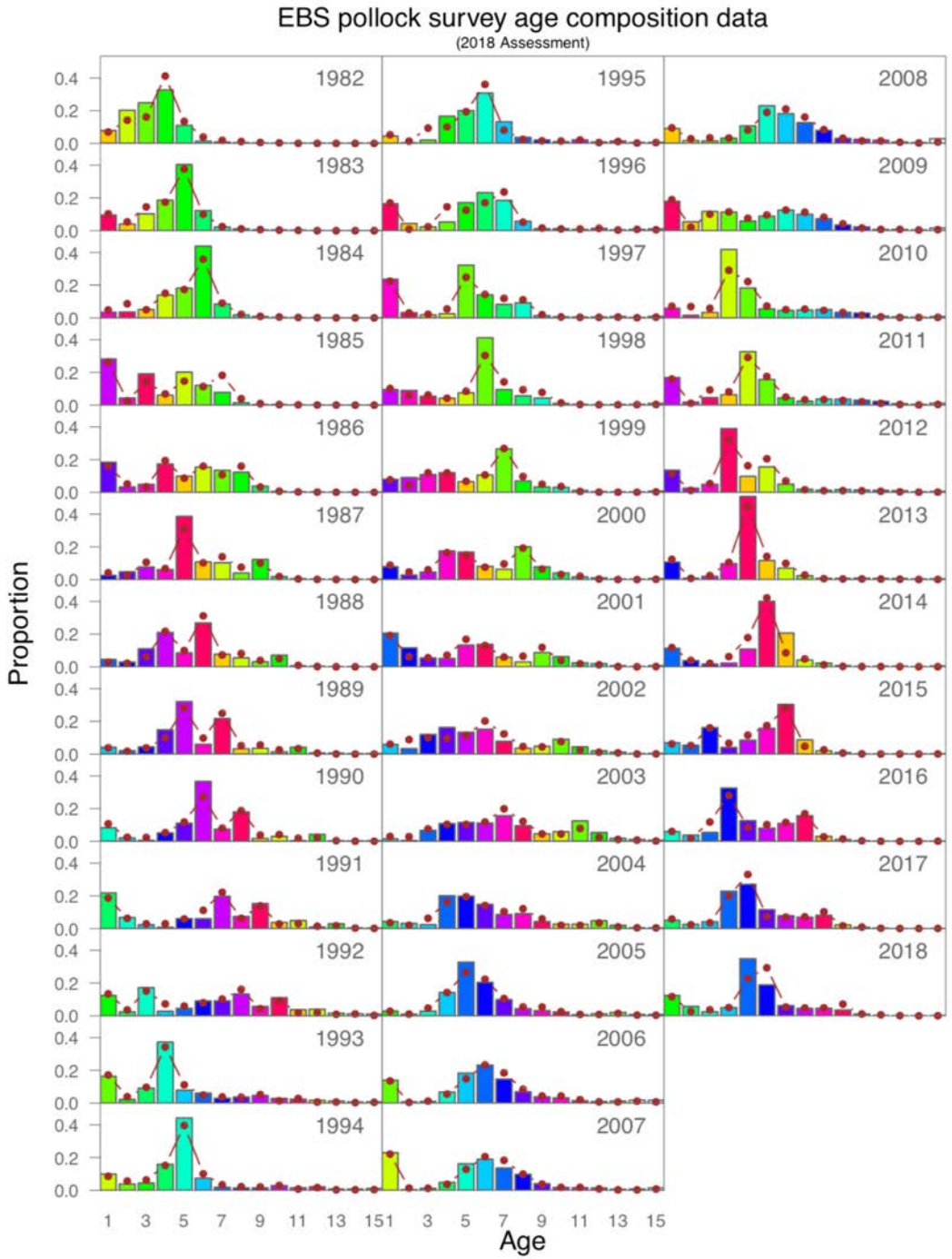
EBS pollock
Assessment
Results

Bering Sea pollock **fishery** age data and fits



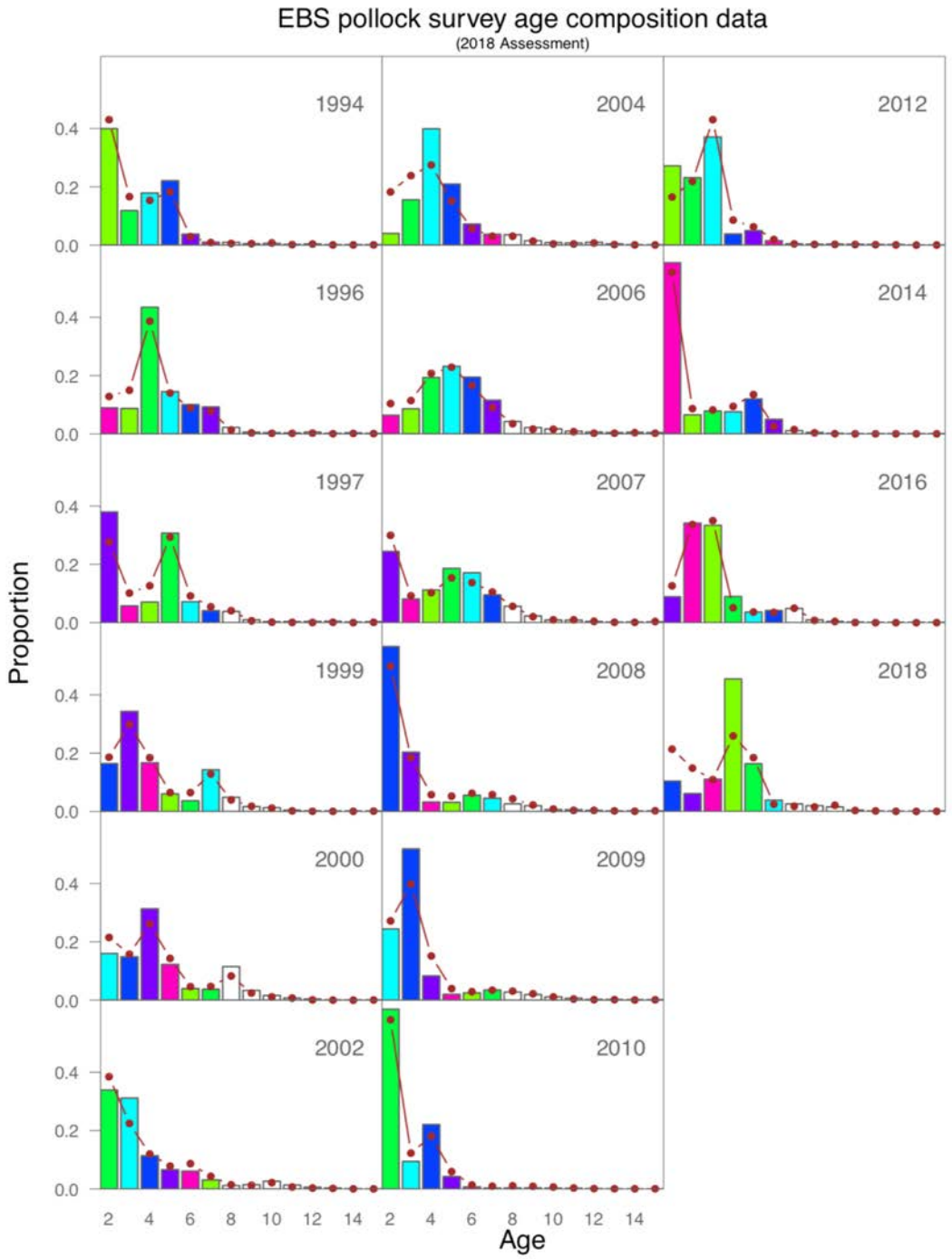
EBS pollock
Assessment
Results

Bering Sea pollock **Bottom trawl survey** age data and fits



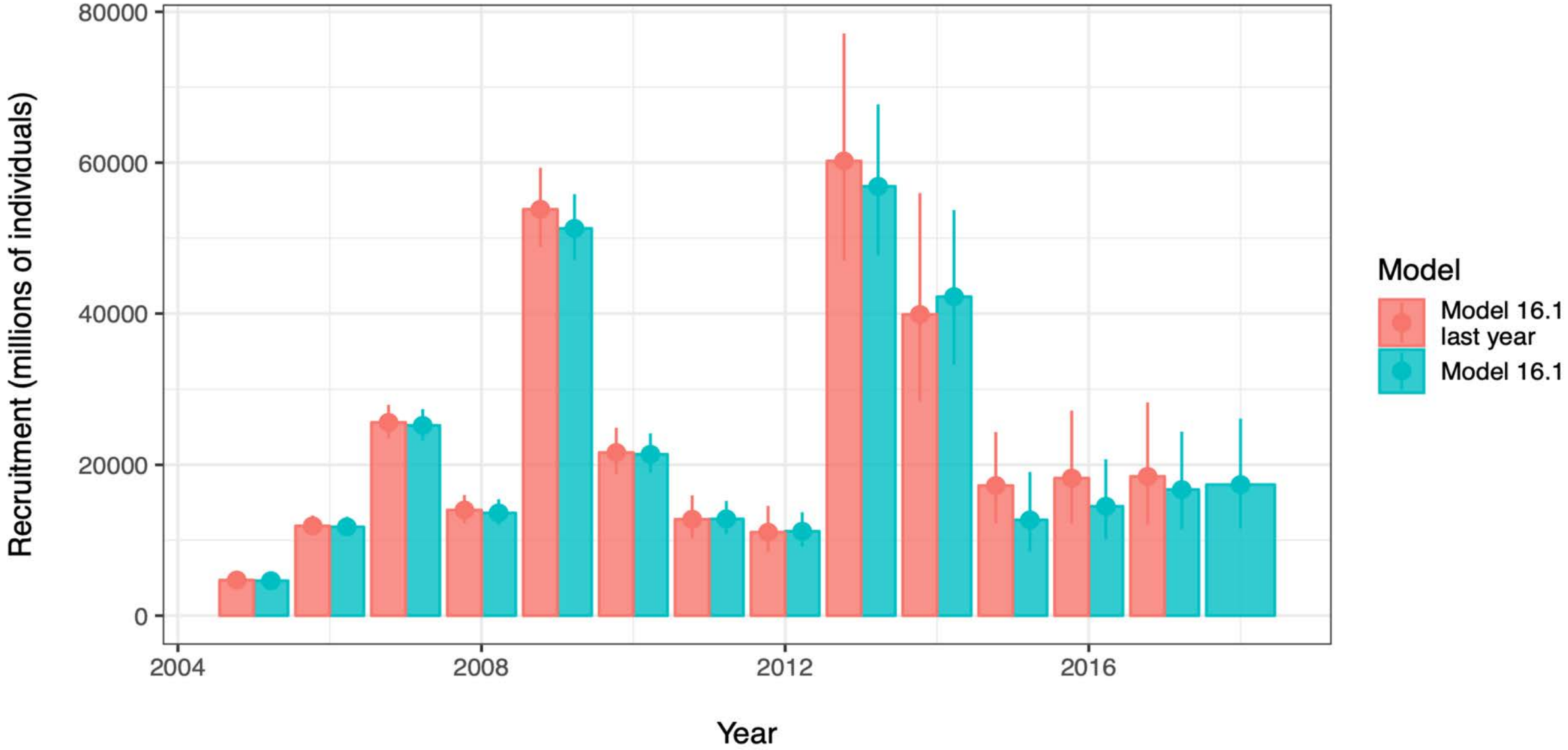
EBS pollock
Assessment
Results

Bering Sea pollock **Acoustic survey** age data and fits

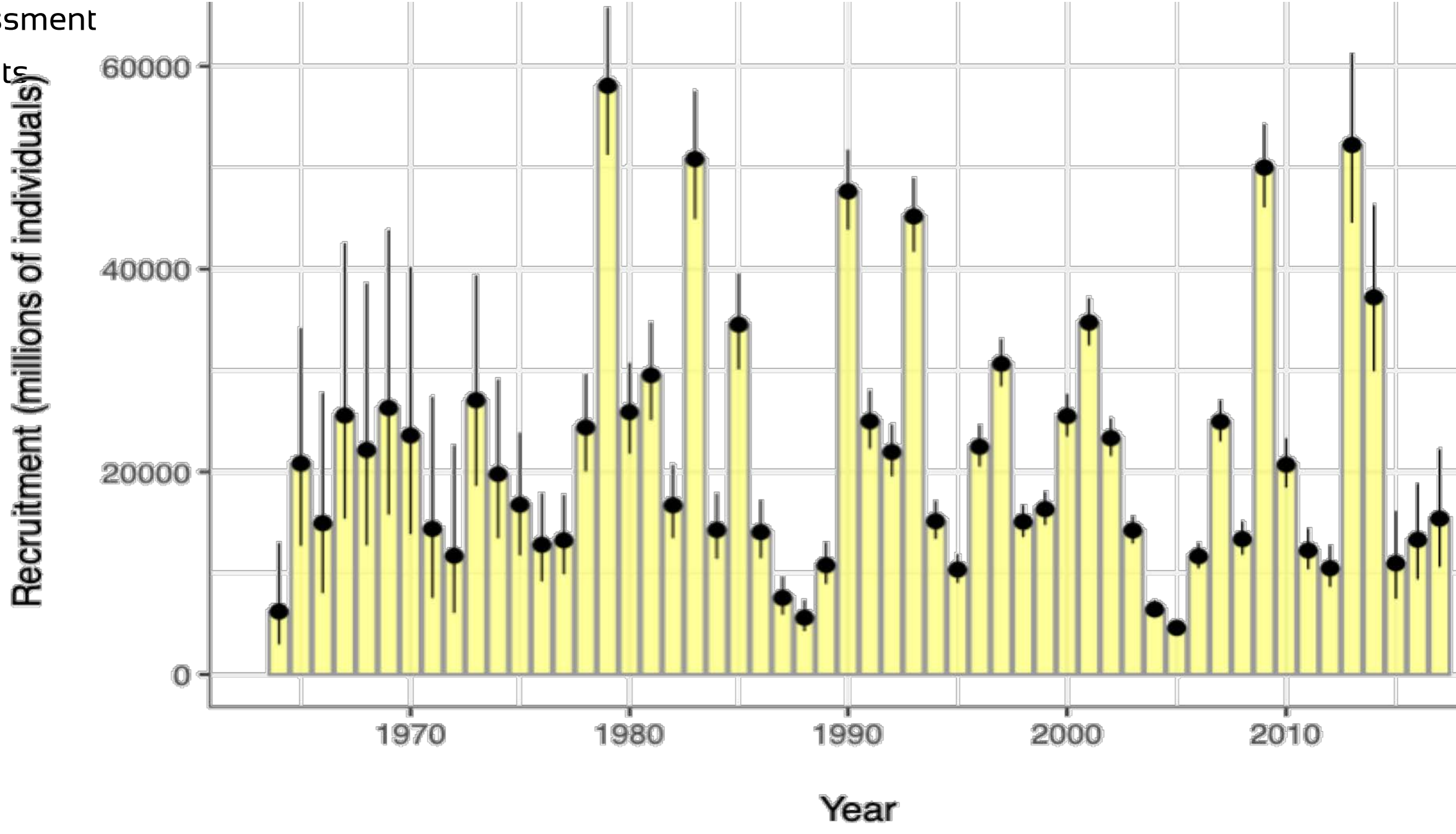


EBS pollock
Assessment
Results

EBS pollock recruitment estimates

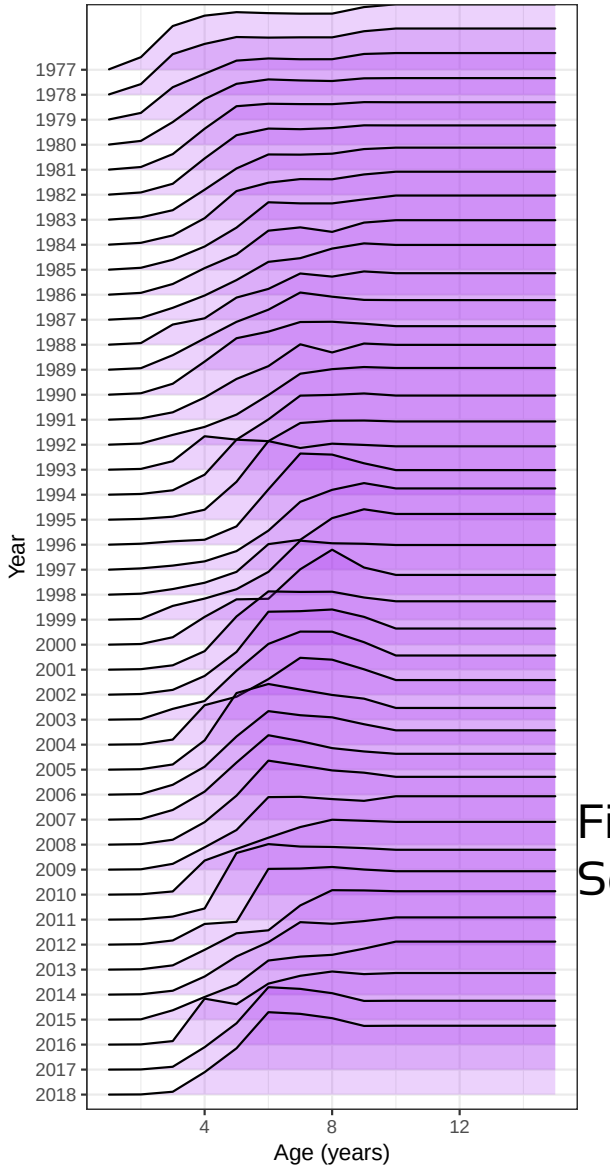


EBS pollock
Assessment
Results

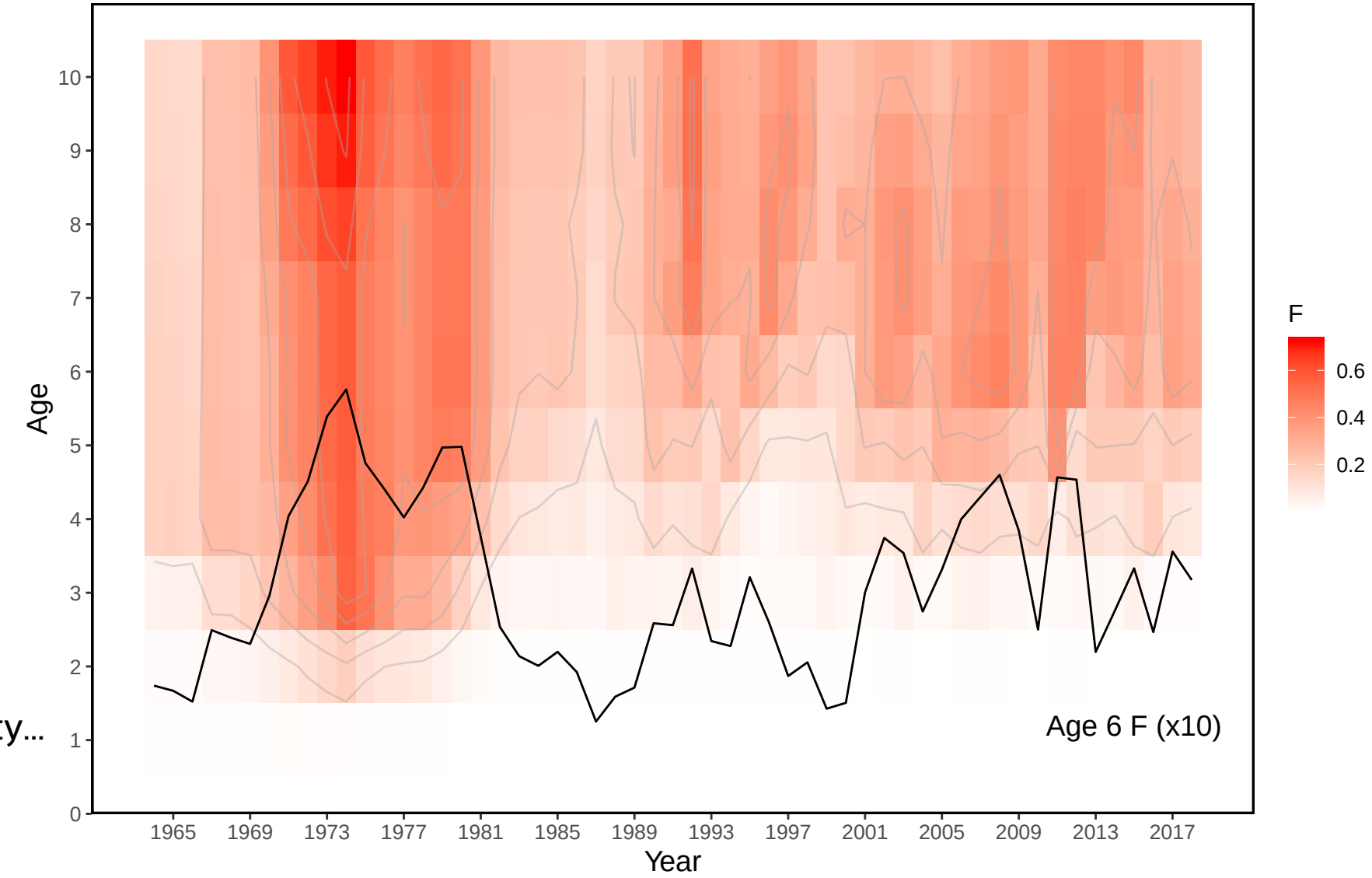


EBS pollock
Assessment
Results

Fishing mortality rates

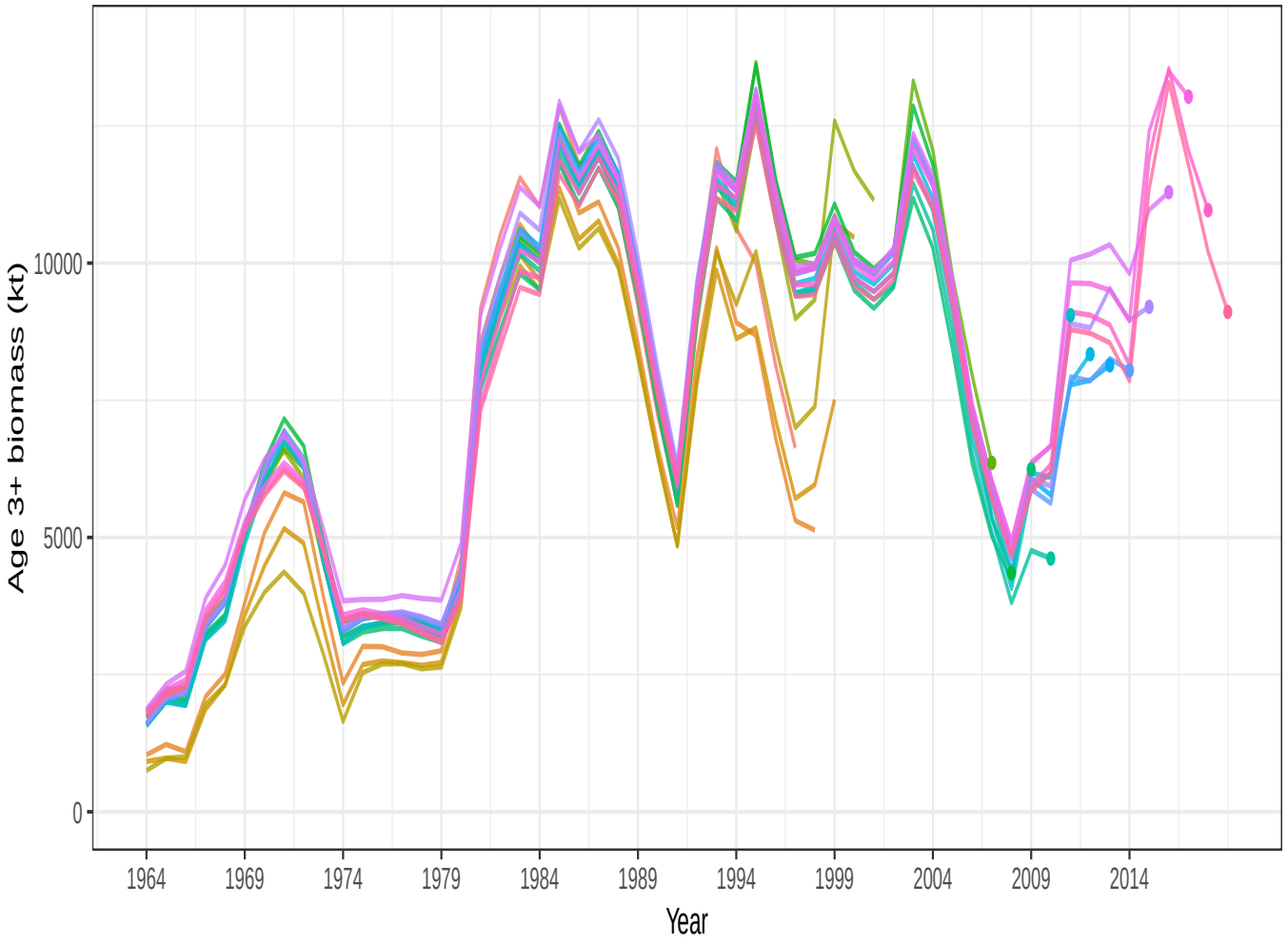


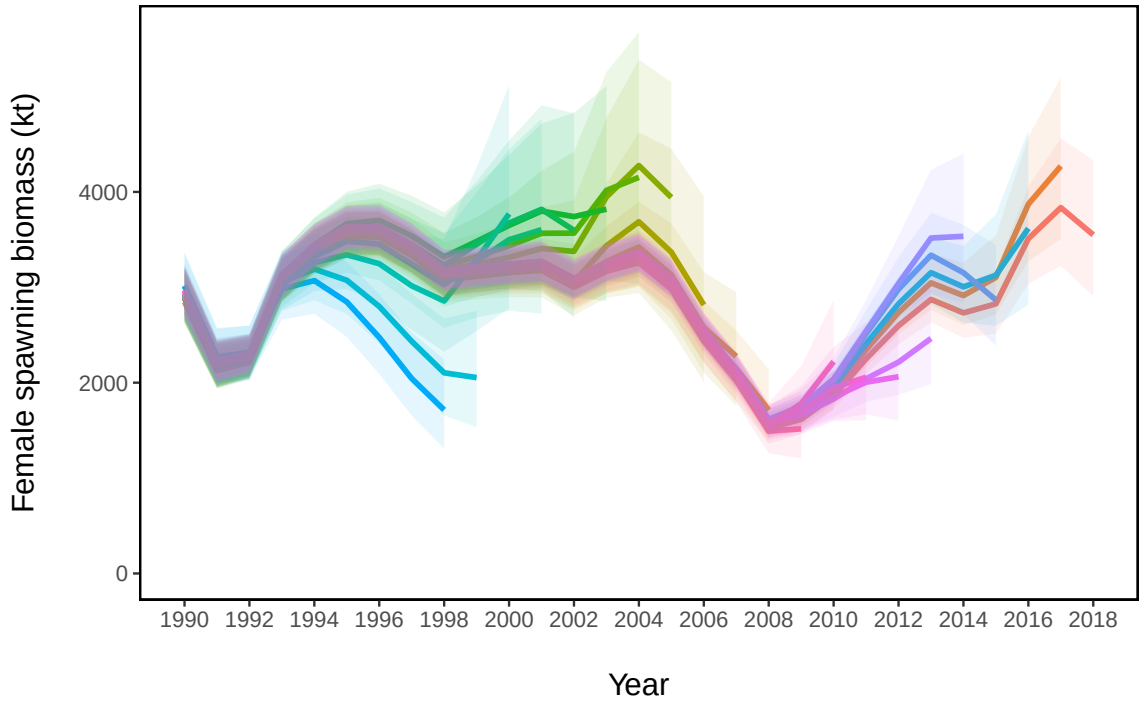
Fishery Selectivity...

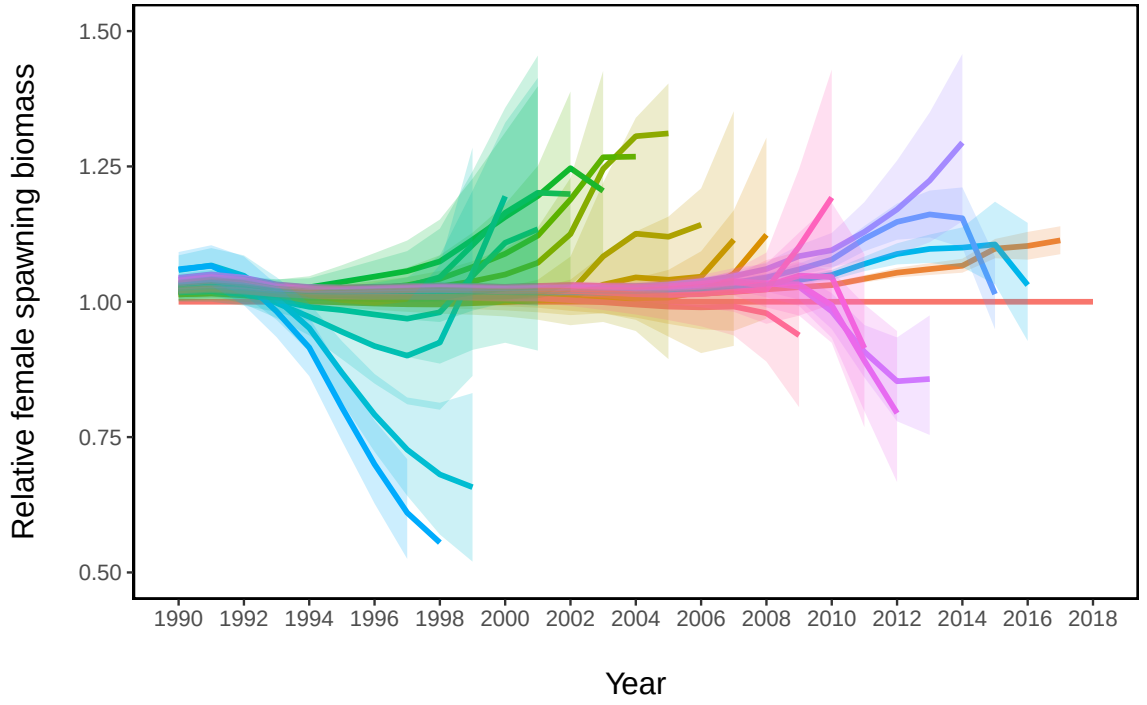


EBS pollock
Assessment
Results

Retrospective

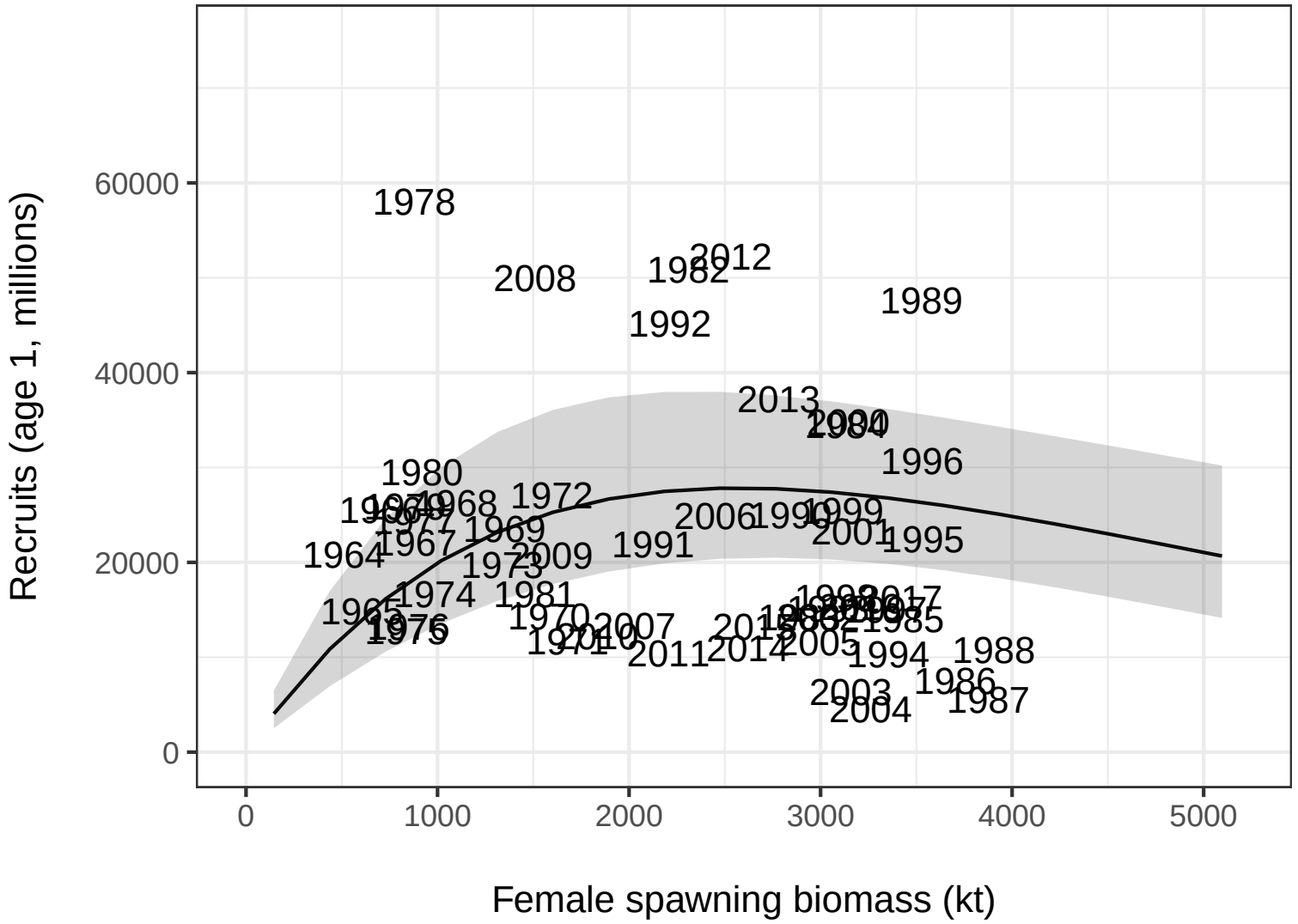


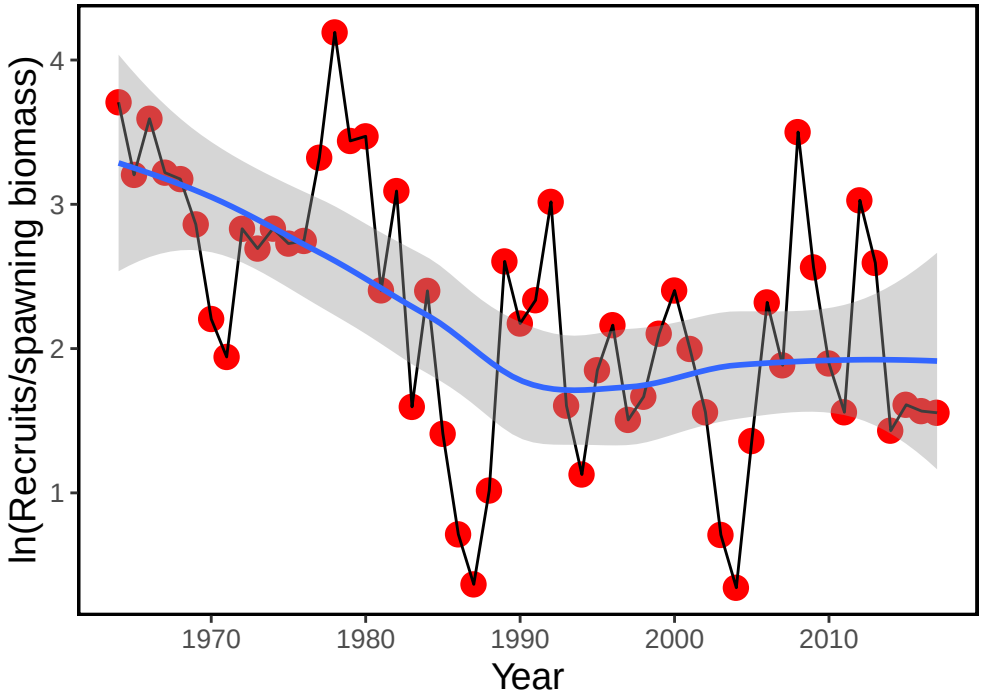


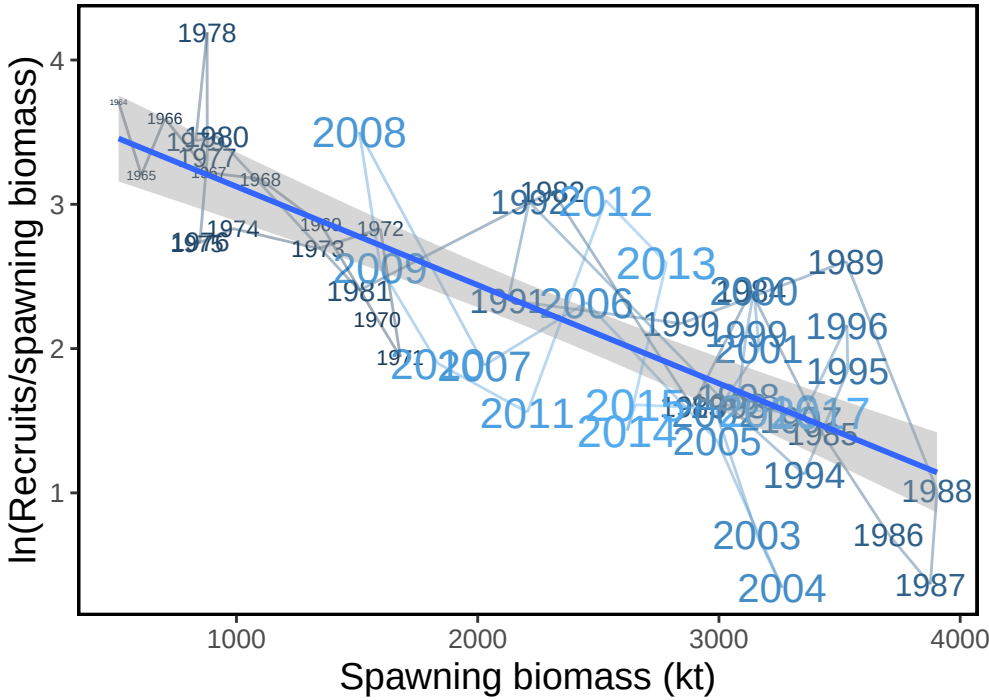


EBS pollock
Assessment
Results

2018 Stock recruitment evaluation

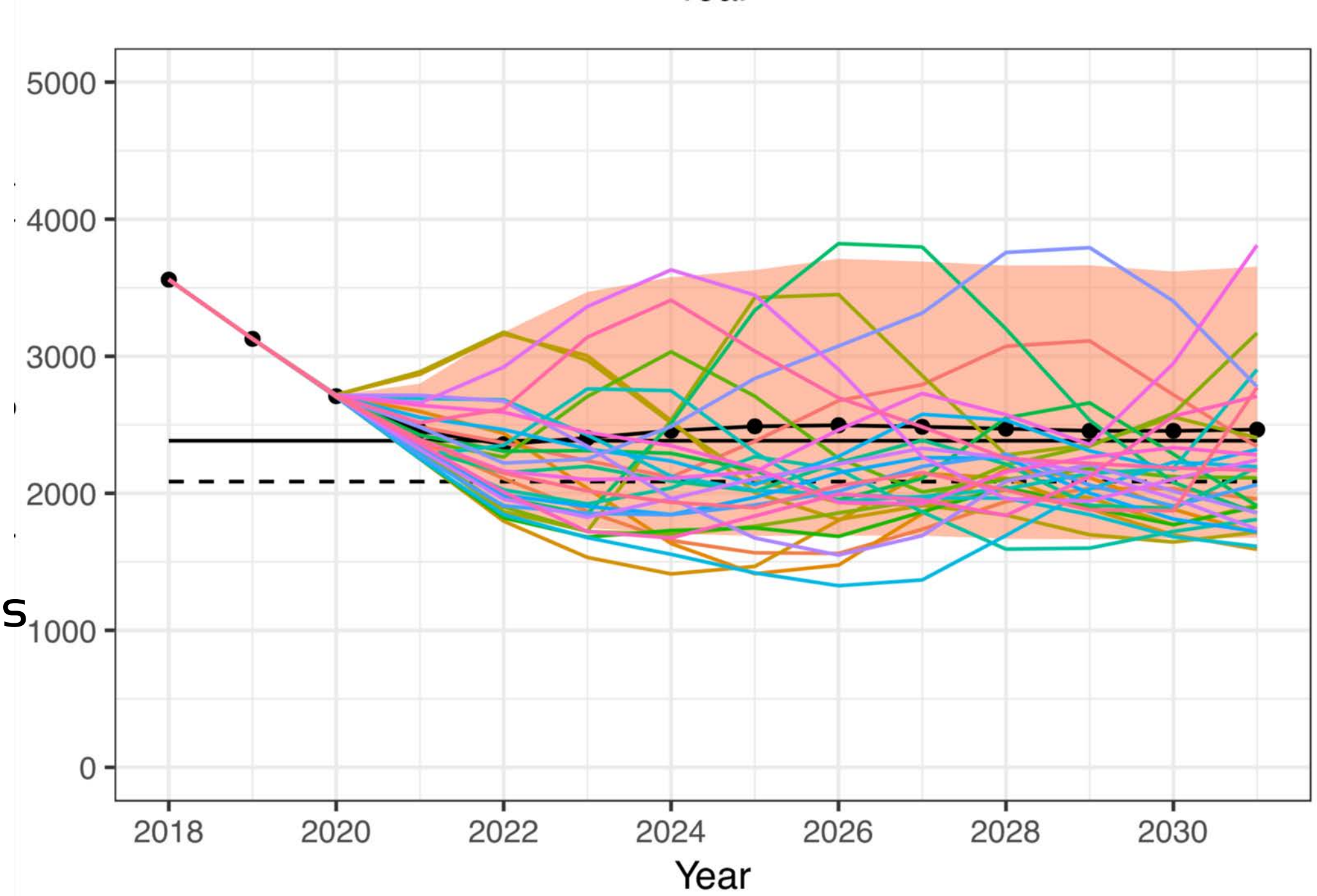




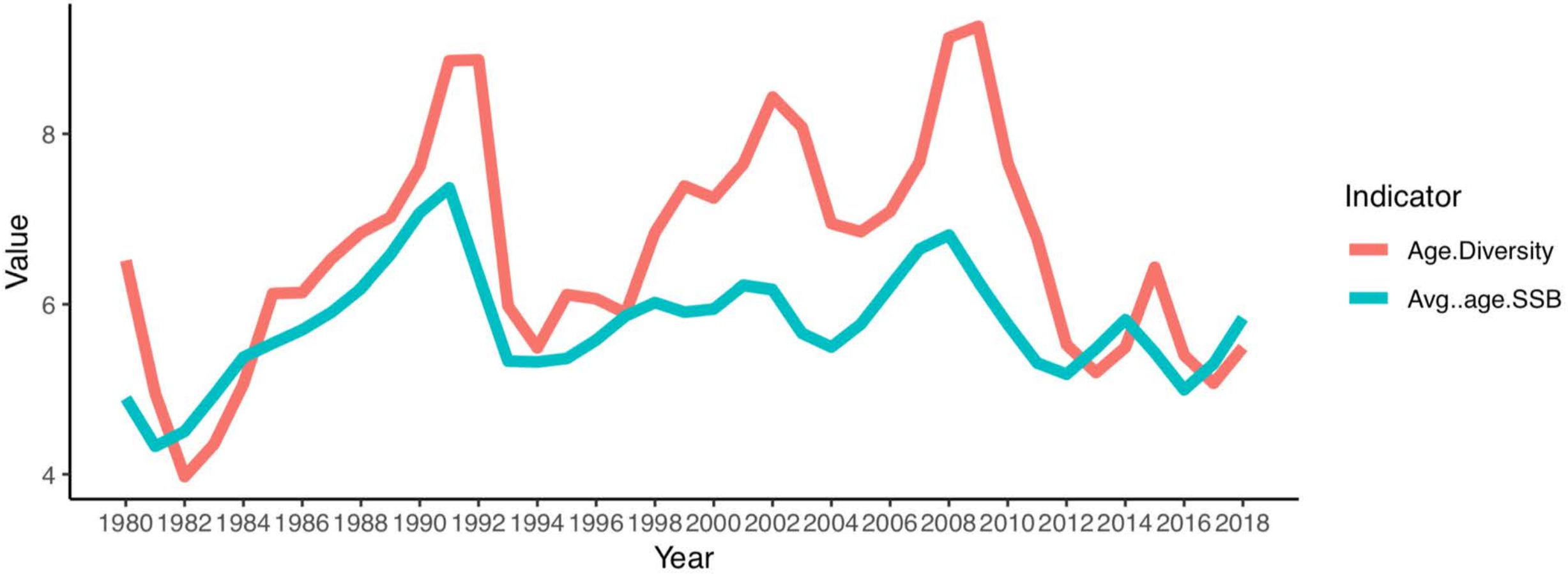


EBS pollock
Assessment
Results

Female spawning biomass projections



EBS pollock Assessment Results



Decision table diagnostics included

- Responds to SSC request for fixed future catch
- Relates to realistic future catches
- Allows comparisons with history
  - Less reliance on things like stock-recruit relationship

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

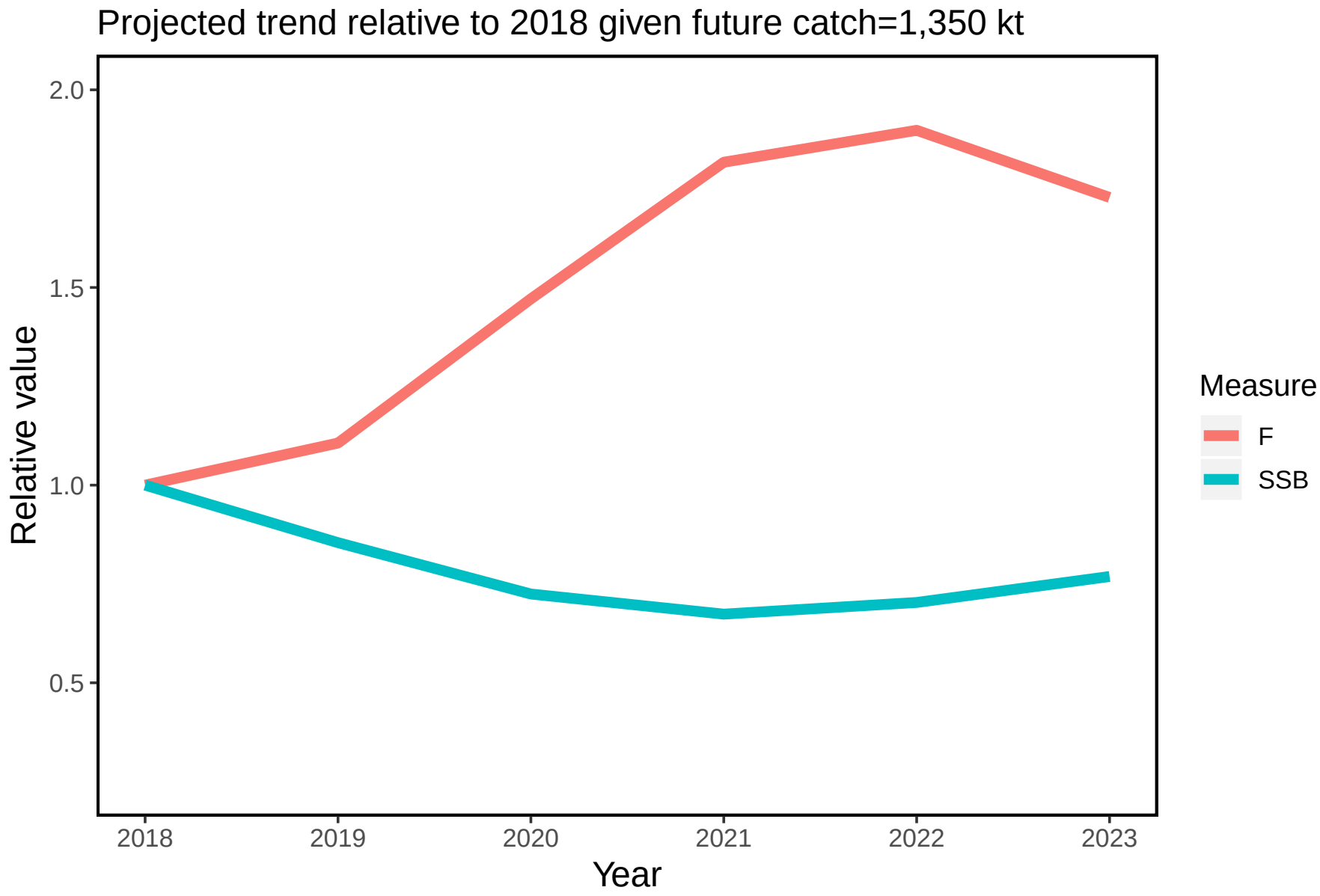
- Unprecedented warm conditions in 2018 resulted in reduced primary and secondary production
- The cold pool prediction for summer 2019 is for continued warm conditions and reduced cold pool extent
- Weak, delayed phytoplankton bloom, reduced biomass, and reduced energy transfer to upper trophic levels (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:

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

EBS pollock
Assessment
Results

Fishery effort relative to SSB impact



EBS pollock summary

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

85% of Tier 1 maxABC

Summary of EBS pollock results

Quantity	As estimated or *specified last* year for: 2018	2019	As estimated or *recommended this* year for: 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

Re-done w/ ABC=Tier 3

Summary of EBS pollock results

Quantity	As estimated or *specified last* year for: 2018	2019	As estimated or *recommended this* year for: 2019	2020
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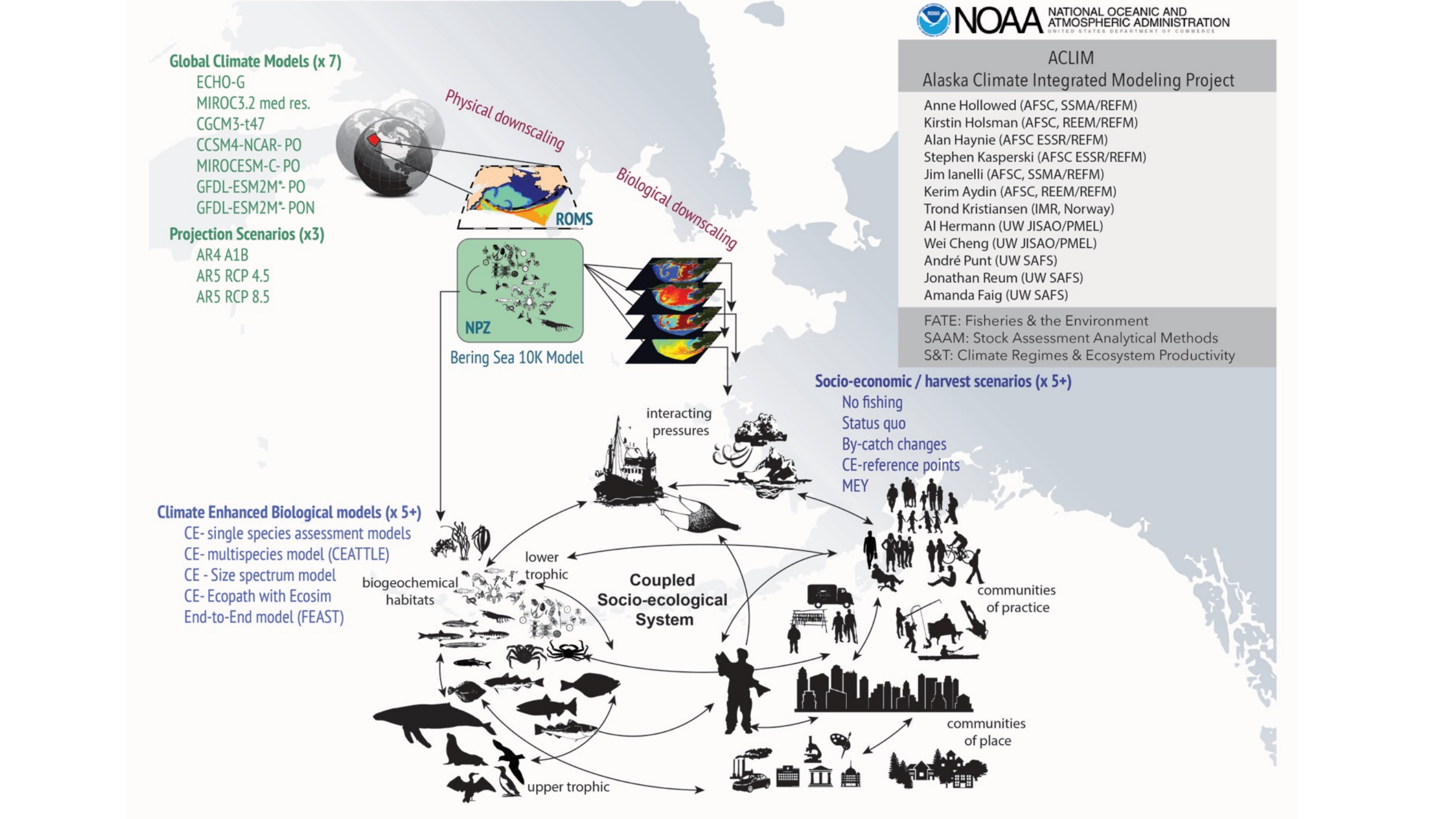
B_{msy}	2,042,000 t	2,042,000 t	2,280,000 t	2,280,000 t
F_{OFL}	0.621	0.621	0.645	0.645
$maxF_{ABC}$	0.466	0.466	0.51	0.51
F_{ABC}	0.336	0.336	0.356	0.356
OFL	4,797,000 t	4,592,000 t	3,914,000 t	3,082,000 t
$maxABC$	3,603,000 t	3,448,000 t	3,096,000 t	2,437,000 t
ABC	2,592,000 t	2,467,000 t	2,163,000 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


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE
ACLIM
Alaska Climate Integrated Modeling Project
Anne Hollowed (AFSC, SSMA/REFM)
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Alan Haynie (AFSC ESSR/REFM)
Stephen Kasperski (AFSC ESSR/REFM)
Jim Ianelli (AFSC, SSMA/REFM)
Kerim Aydin (AFSC, REEM/REFM)
Trond Kristiansen (IMR, Norway)
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)
Jonathan Reum (UW SAFS)
Amanda Faig (UW SAFS)
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity
Global Climate Models (x 7)
ECHO-G
MIROC3.2 med res.
CGCM3-t47
CCSM4-NCAR- PO
MIROCESM-C- PO
GFDL-ESM2M*- PO
GFDL-ESM2M*- PON
Projection Scenarios (x3)
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5
Physical downscaling
ROMS
Biological downscaling
NPZ
Bering Sea 10K Model
Socio-economic / harvest scenarios (x 5+)
No fishing
Status quo
By-catch changes
CE-reference points
MEY
interacting pressures
Climate Enhanced Biological models (x 5+)
CE- single species assessment models
CE- multispecies model (CEATTLE)
CE - Size spectrum model
CE- Ecopath with Ecosim
End-to-End model (FEAST)
lower trophic
biogeochemical habitats
Coupled Socio-ecological System
communities of practice
communities of place
upper trophic

The ACLIM Team


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Amanda Faig


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Andy Whitehouse


Darren Pilcher


Cody Szuwalski

Buck Stockhausen

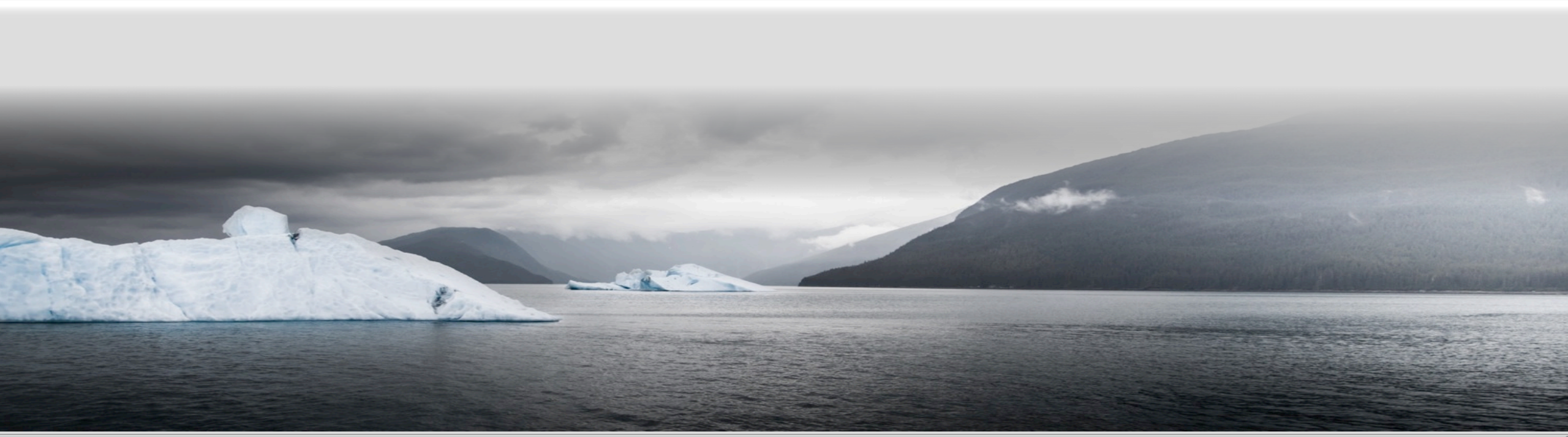

Tom Wilderbuer


Michael Dalton

Jim Thorson

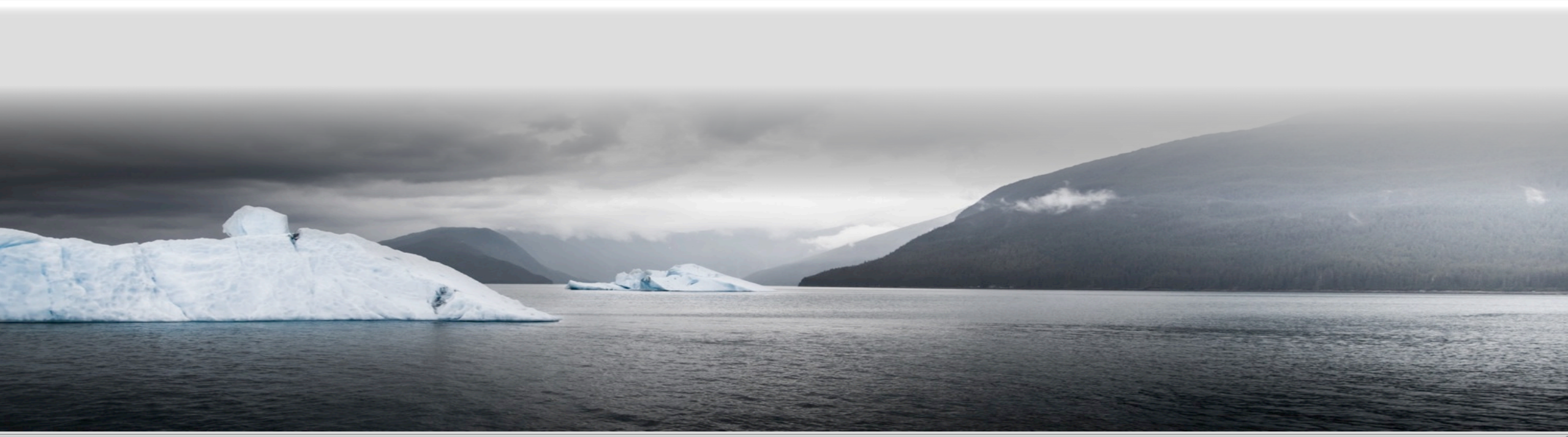
Ingrid Spies

Jeremy Sterling



Improve management **foresight** in a changing climate

Protect **adaptive capacity** in fish and fisheries



Project changes in Bering Sea ocean conditions and fish populations

Physical, biological, & socioeconomic change; now - 2100

Evaluate how management can adapt to minimize negative impacts of future changes

gradual change & sudden shocks;

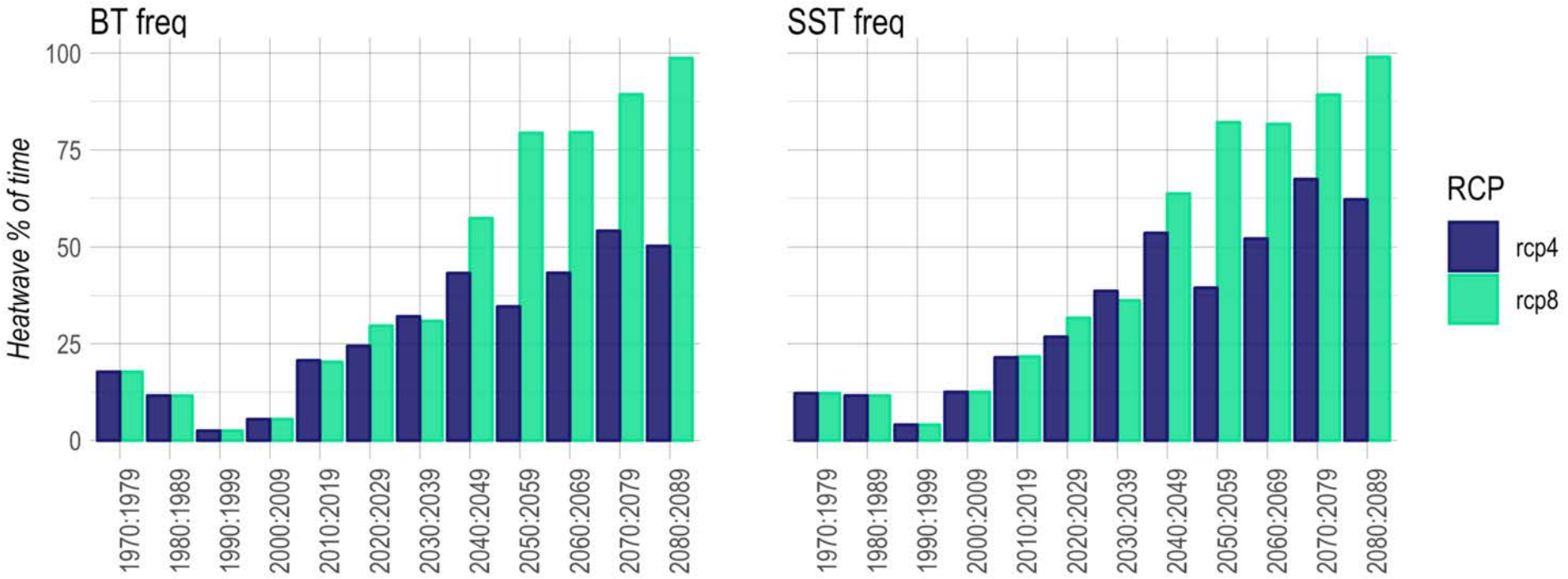
test existing & new tools; estimate risk

Marine heatwaves will likely increase in frequency and duration

Heatwaves
Now ~ 21% of the time
2050 ~ 30-77% of the time
2100 ~ 60-90% of the time

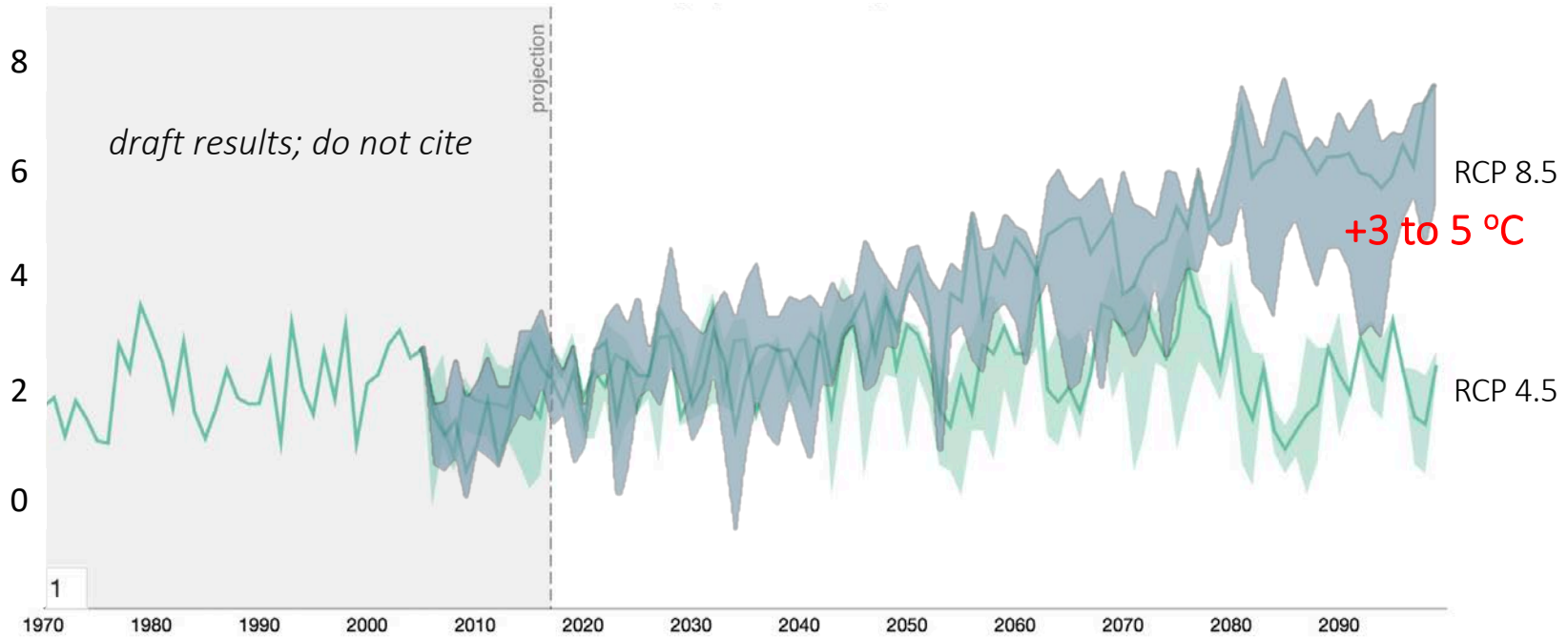
Duration

Marine heatwave analysis based on downscaled ROMSNPZ hindcast + projections, and 1970-2000 climatology.



ROMSNPZ: K. Kearney, A. Hermann, W. Cheng, K. Aydin, 2018
Heatwave analysis: K. Holsman, 2018, based on Hobday et al. (2016)
Data source: NOAA PMEL, AFSC REEM Program, IEA, MAPP Bering Seasons,ACLIM

Summer Bottom Temperature (°C)



Based on Hermann et al. in review

Downscaling is needed	GCMs may underestimate variance in projections
Account for trophic interactions	Accounting for predation changed the direction of projections from increases (single-sp model) to declines (multi-sp)
Mitigation is lower risk	**Most pollock and cod scenarios crashed under business as usual (RCP8.5) by 2100; carbon mitigation (RCP 4.5) may lessen or prevent declines**
Adaptation through fisheries management	**Changing harvest rates through management can help lessen climate impacts, to a point. Considering regional management policies is important.**

Holsman et al. in prep