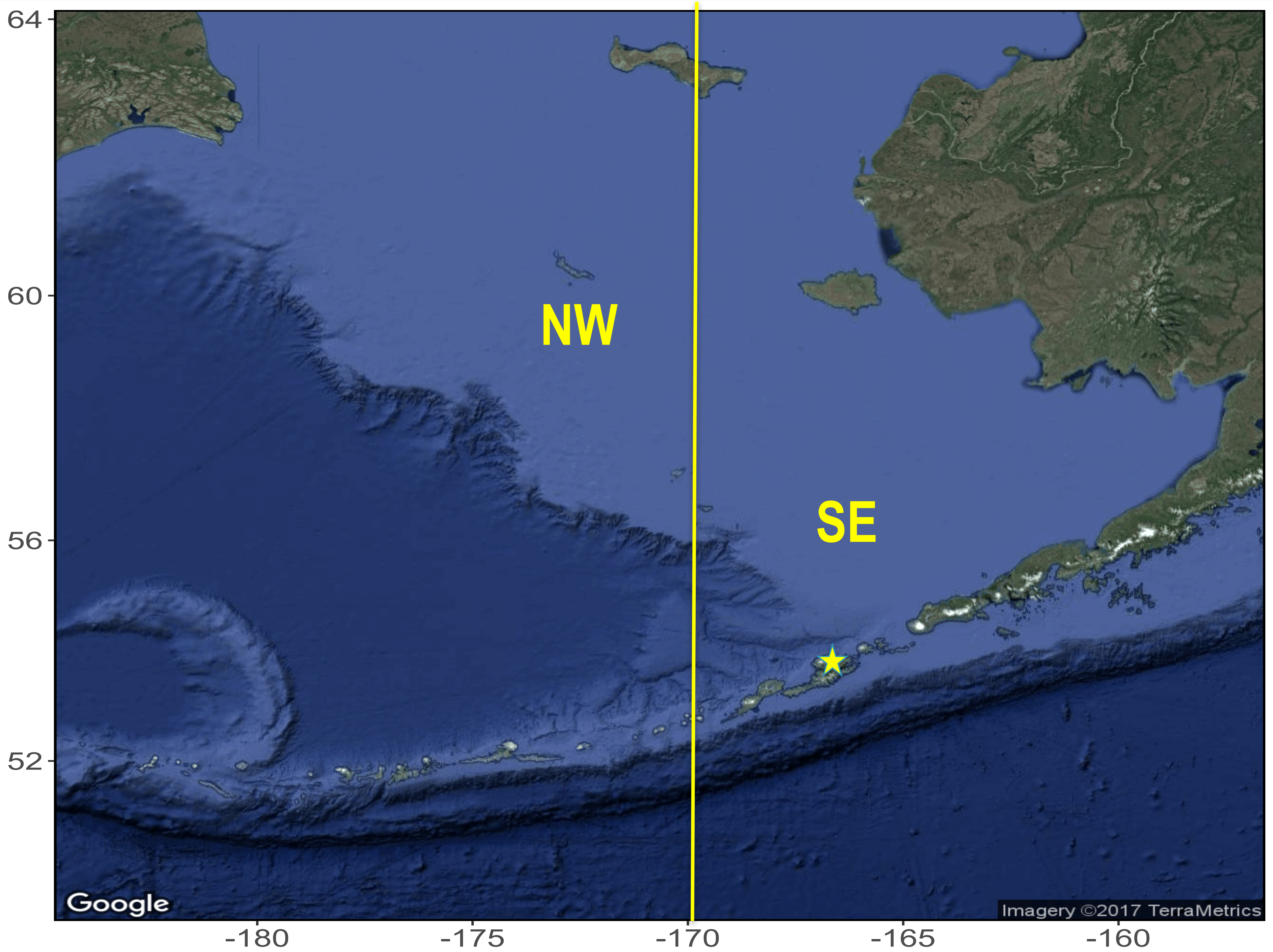
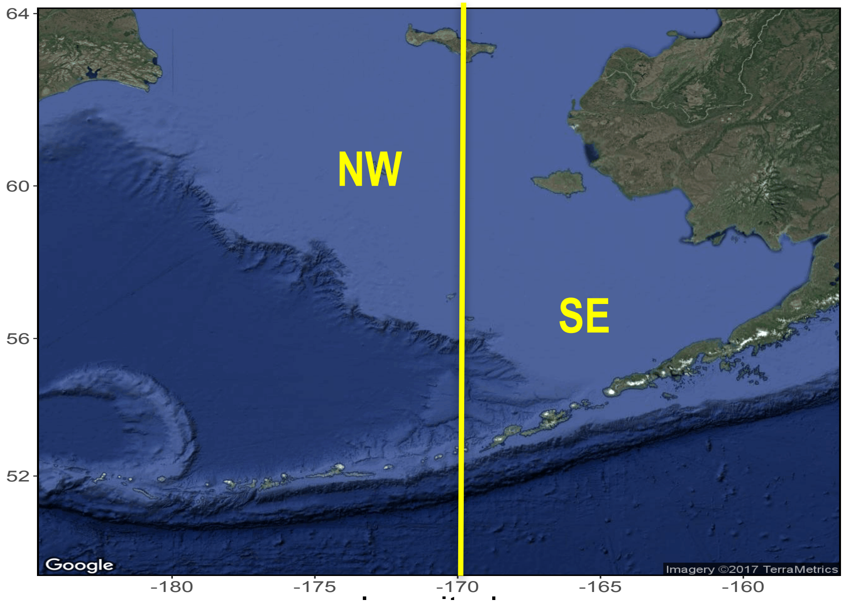
Eastern Bering Sea pollock

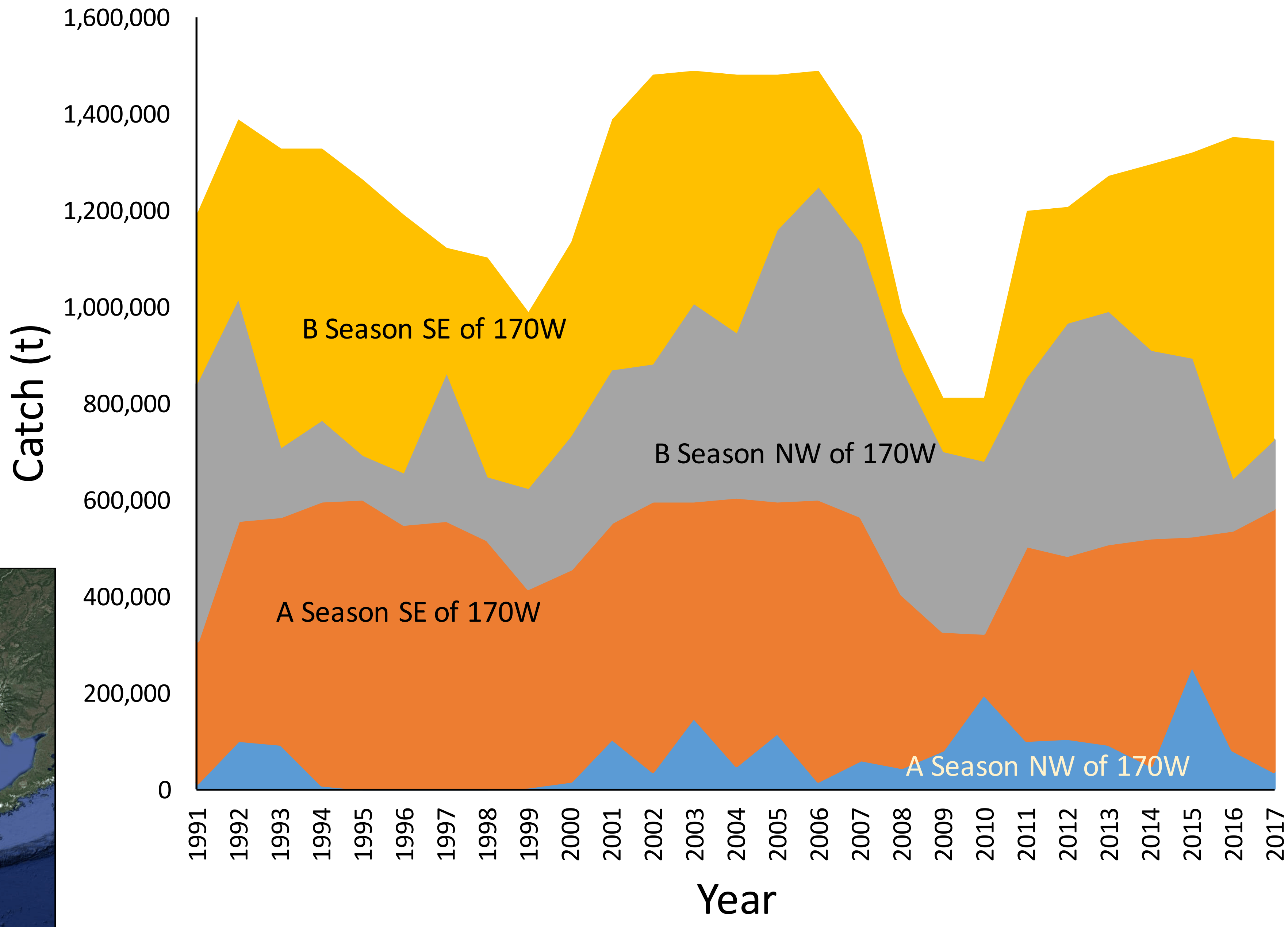
Jim Ianelli, Stan Kotwicki,
Taina Honkalehto, and Kirstin Holsman
Alaska Fisheries Science Center
NMFS/NOAA



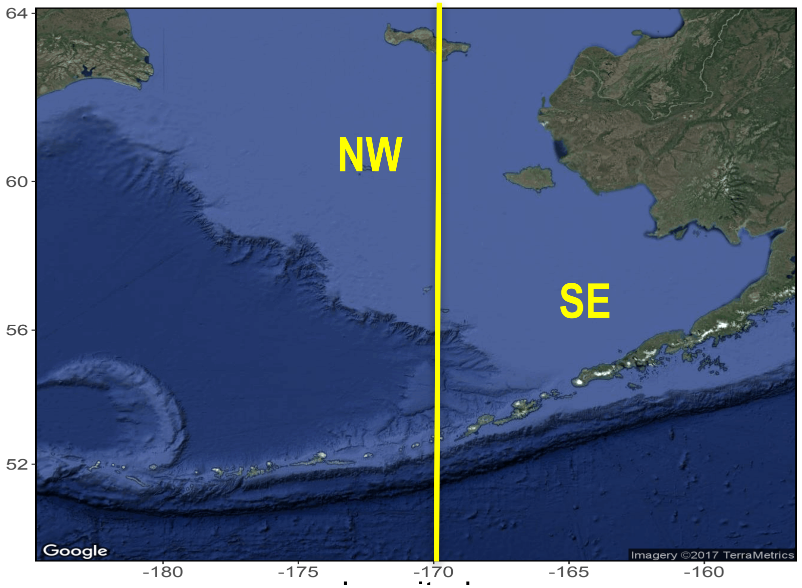
64
60
56
52
NW
SE
Google
Imagery ©2017 TerraMetrics
-180
-175
-170
-165
-160

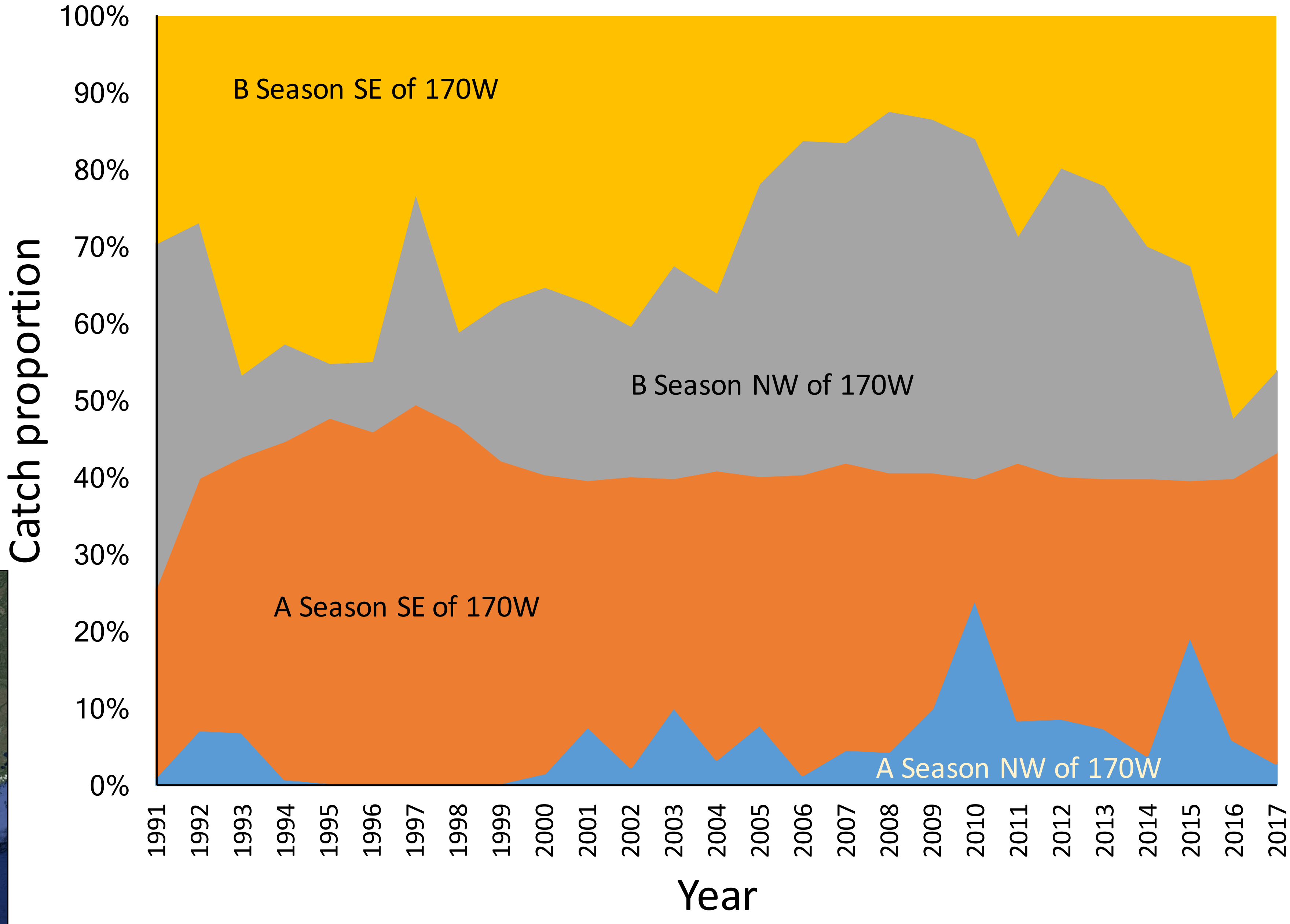
Fishery catches





Fishery catches



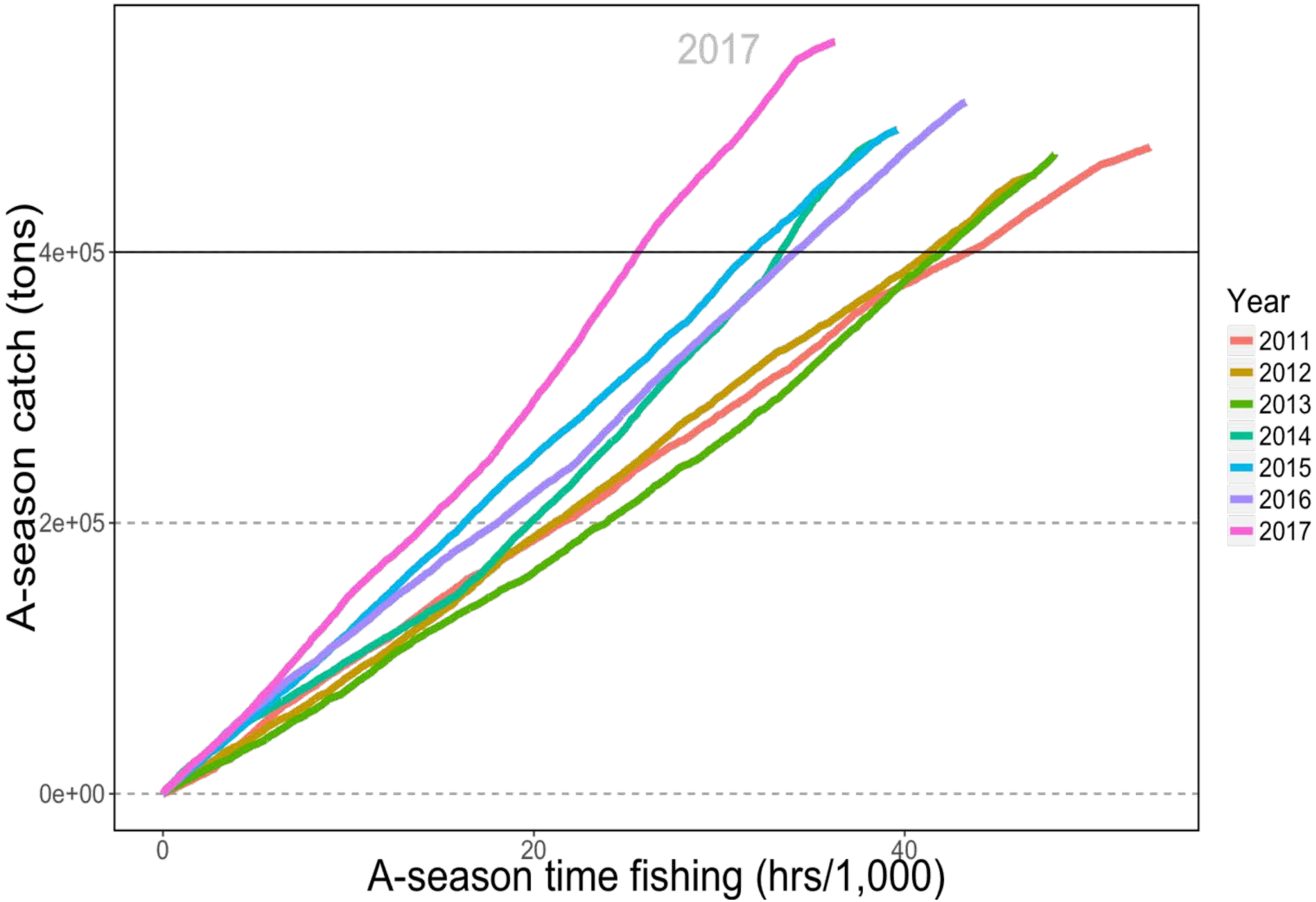


Fishing conditions

B-season

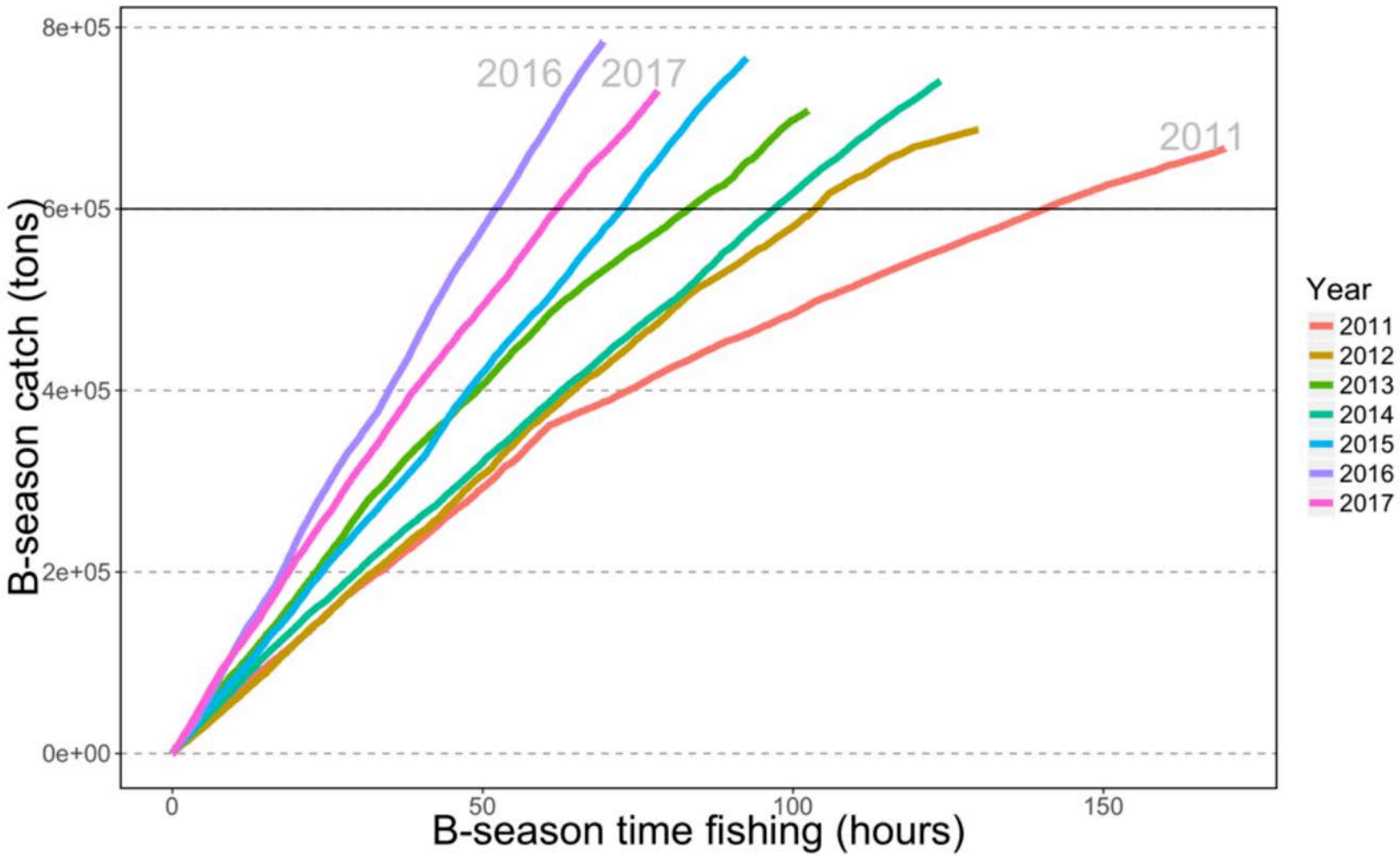
Fishing conditions

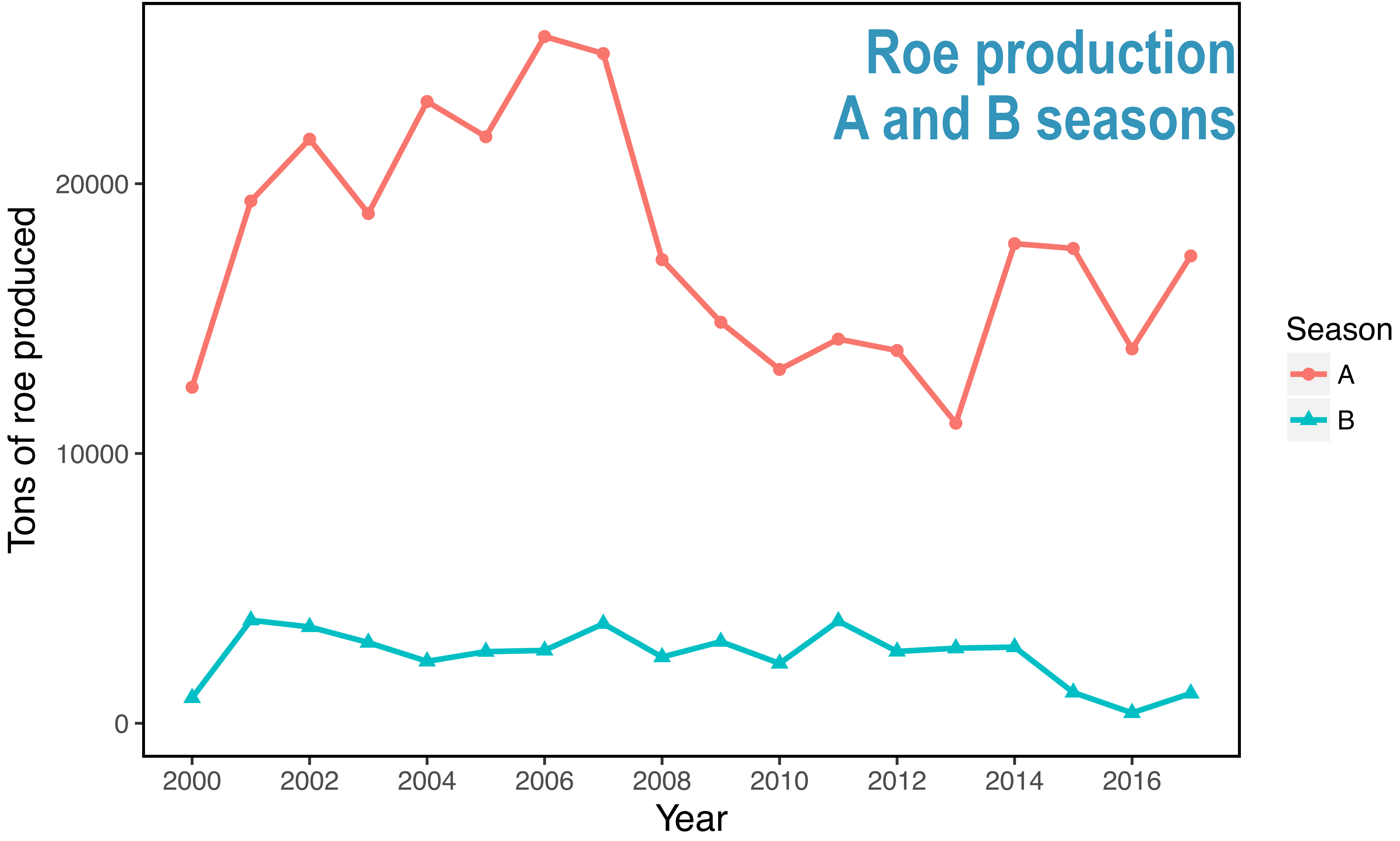
A-season



Fishing conditions

B-season…updated





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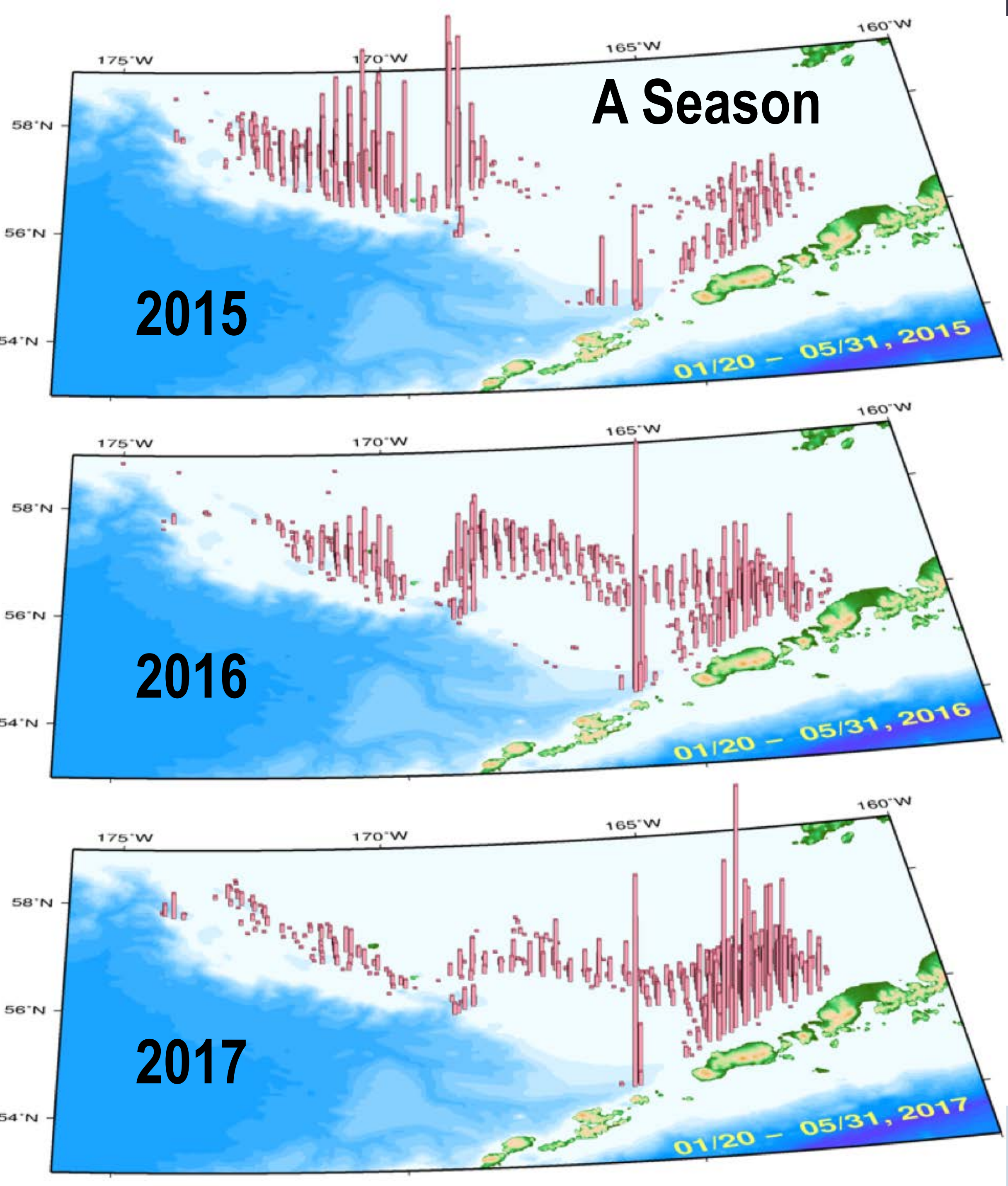
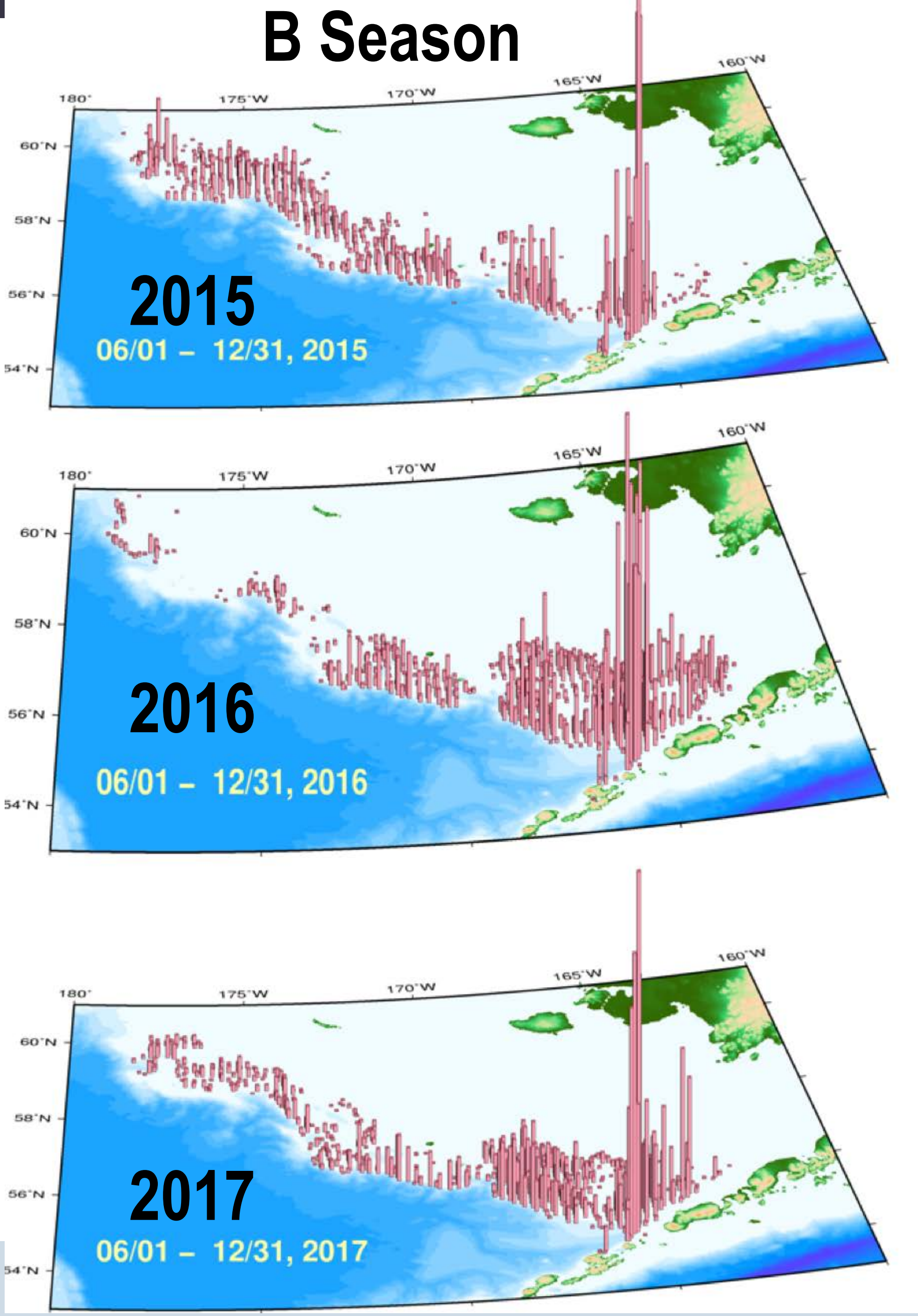
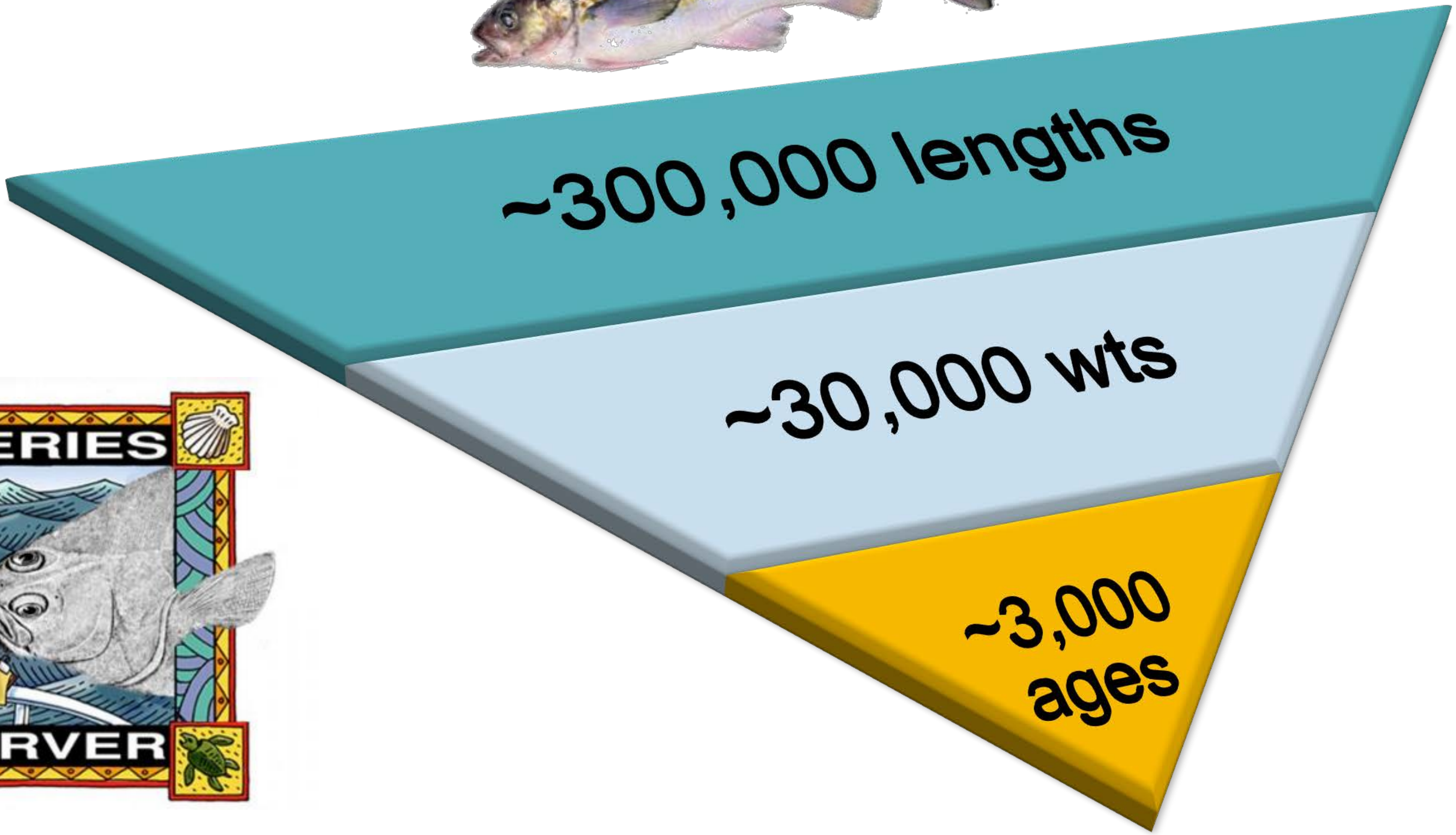

A Season
2015
01/20 – 05/31, 2015
2016
01/20 – 05/31, 2016
2017
01/20 – 05/31, 2017
175°W
170°W
165°W
160°W
58°N
56°N
54°N


B Season
2015
06/01 – 12/31, 2015
2016
06/01 – 12/31, 2016
2017
06/01 – 12/31, 2017
180°
175°W
170°W
165°W
160°W
60°N
58°N
56°N
54°N

Fishery data from scientific observers

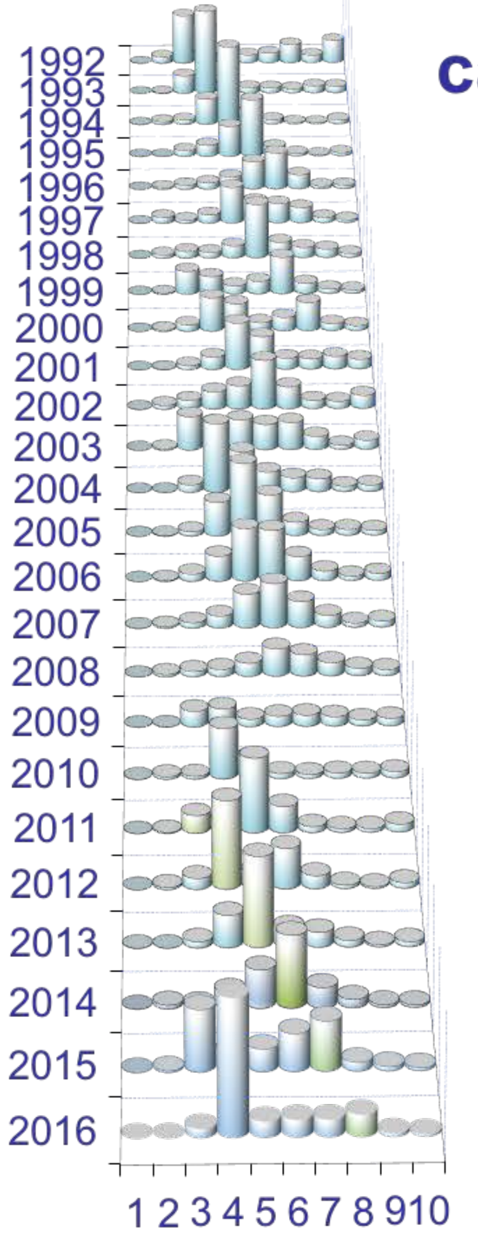


Fishery weight-at-age

Year

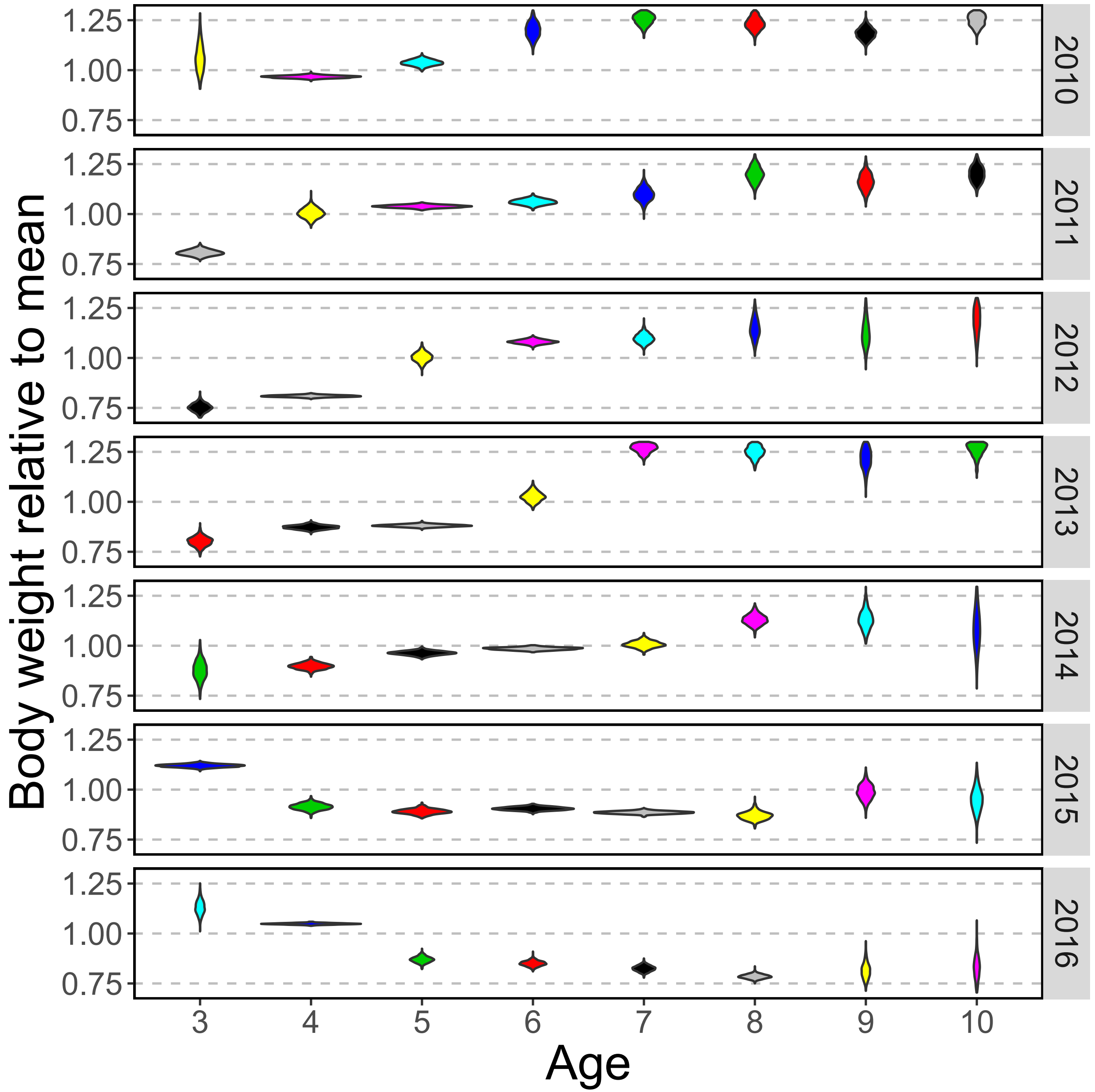
Year	3	4	5	6	7	8	9	10	11	12	13	14	15
1991	0.286	0.476	0.604	0.728	0.839	0.873	1.014	1.127	1.129	1.251	1.240	1.308	1.249
1992	0.394	0.462	0.647	0.701	0.812	0.982	1.031	1.210	1.226	1.272	1.199	1.340	1.430
1993	0.497	0.610	0.650	0.754	0.904	1.039	1.211	1.232	1.391	1.538	1.610	1.646	1.584
1994	0.405	0.651	0.728	0.747	0.707	1.057	1.395	1.347	1.347	1.391	1.394	1.301	1.341
1995	0.377	0.498	0.735	0.840	0.856	0.986	1.220	1.315	1.388	1.477	1.390	1.297	1.341
1996	0.323	0.427	0.679	0.794	0.949	0.953	1.020	1.096	1.362	1.500	1.520	1.710	1.598
1997	0.315	0.471	0.559	0.747	0.893	1.072	1.091	1.243	1.346	1.443	1.668	1.423	1.383
1998	0.368	0.589	0.627	0.621	0.775	1.029	1.169	1.253	1.327	1.452	1.414	1.523	1.537
1999	0.405	0.507	0.643	0.701	0.728	0.891	1.037	1.250	1.248	1.431	1.429	1.444	1.236
2000	0.353	0.526	0.629	0.731	0.782	0.806	0.966	1.007	1.242	1.321	1.453	1.165	1.466
2001	0.327	0.503	0.669	0.788	0.958	0.987	1.063	1.115	1.314	1.435	1.563	1.433	1.467
2002	0.386	0.509	0.666	0.795	0.910	1.029	1.104	1.095	1.288	1.448	1.597	1.343	1.683
2003	0.489	0.547	0.649	0.767	0.862	0.953	1.081	1.200	1.200	1.206	1.362	1.377	1.699
2004	0.409	0.583	0.640	0.758	0.889	0.924	1.035	1.162	1.110	1.160	1.333	1.281	1.213
2005	0.346	0.508	0.642	0.741	0.882	0.954	1.062	1.096	1.225	1.276	1.251	1.174	1.373
2006	0.305	0.447	0.606	0.755	0.853	0.952	1.065	1.114	1.219	1.234	1.282	1.399	1.462
2007	0.346	0.506	0.641	0.781	0.962	1.098	1.182	1.275	1.304	1.477	1.500	1.738	1.520
2008	0.330	0.520	0.652	0.774	0.903	1.049	1.119	1.282	1.421	1.524	1.553	1.921	1.660
2009	0.340	0.526	0.704	0.879	1.002	1.125	1.399	1.490	1.563	1.614	1.814	1.996	2.230
2010	0.383	0.489	0.664	0.915	1.119	1.261	1.371	1.587	1.659	1.924	1.923	2.079	2.316
2011	0.290	0.509	0.665	0.808	0.976	1.225	1.346	1.518	1.585	1.621	2.176	1.754	2.287
2012	0.270	0.410	0.643	0.824	0.974	1.172	1.306	1.519	1.614	1.644	1.717	2.040	2.086
2013	0.289	0.442	0.564	0.782	1.131	1.284	1.426	1.692	1.834	1.806	1.960	2.187	2.207
2014	0.316	0.455	0.617	0.751	0.894	1.154	1.310	1.370	1.692	1.815	1.733	1.658	2.236
2015	0.403	0.463	0.571	0.690	0.786	0.887	1.145	1.201	1.378	1.892	1.452	1.603	2.627
2016	0.407	0.531	0.557	0.648	0.732	0.801	0.943	1.047	1.201	1.486	1.541	1.870	1.638
2017	*0.369*	*0.565*	*0.707*	*0.756*	*0.849*	*0.980*	*1.094*	*1.269*	*1.448*	*1.594*	*1.758*	*1.870*	*1.935*
2018	*0.395*	*0.496*	*0.696*	*0.837*	*0.882*	*0.969*	*1.093*	*1.199*	*1.365*	*1.536*	*1.673*	*1.830*	*1.935*
2019	*0.395*	*0.523*	*0.627*	*0.826*	*0.963*	*1.002*	*1.082*	*1.198*	*1.296*	*1.454*	*1.616*	*1.746*	*1.895*

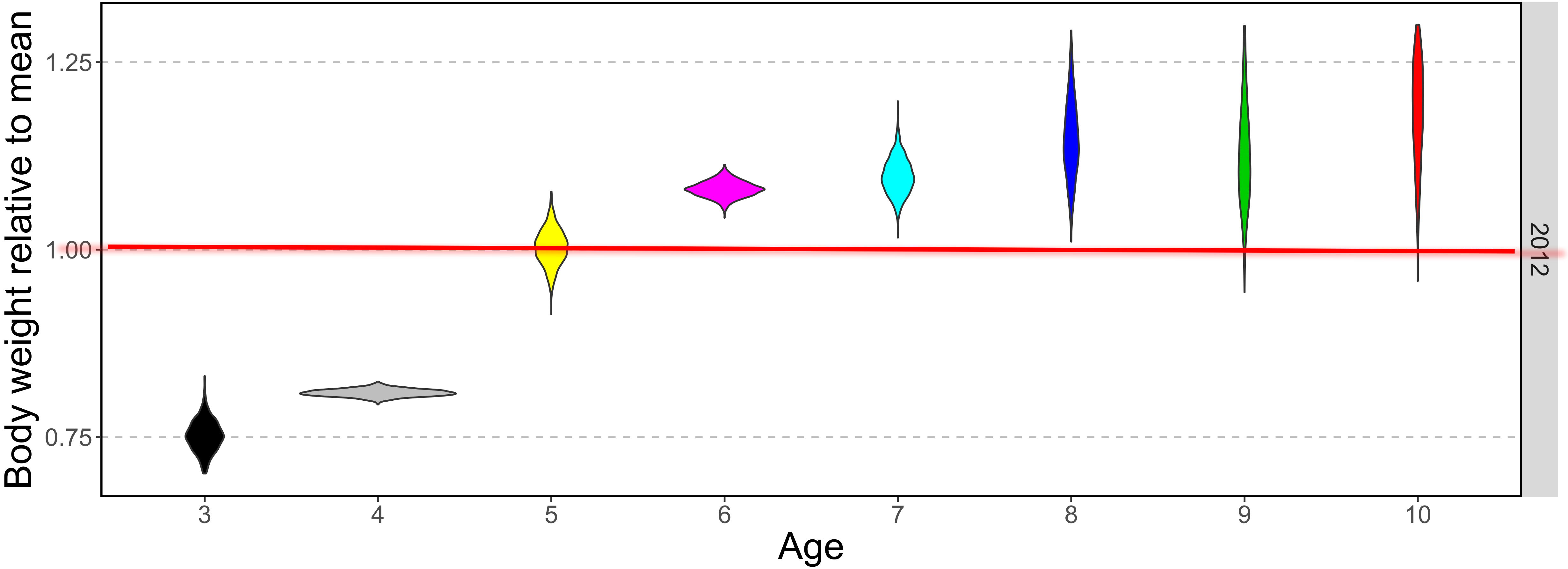
Fishery catch-at-age

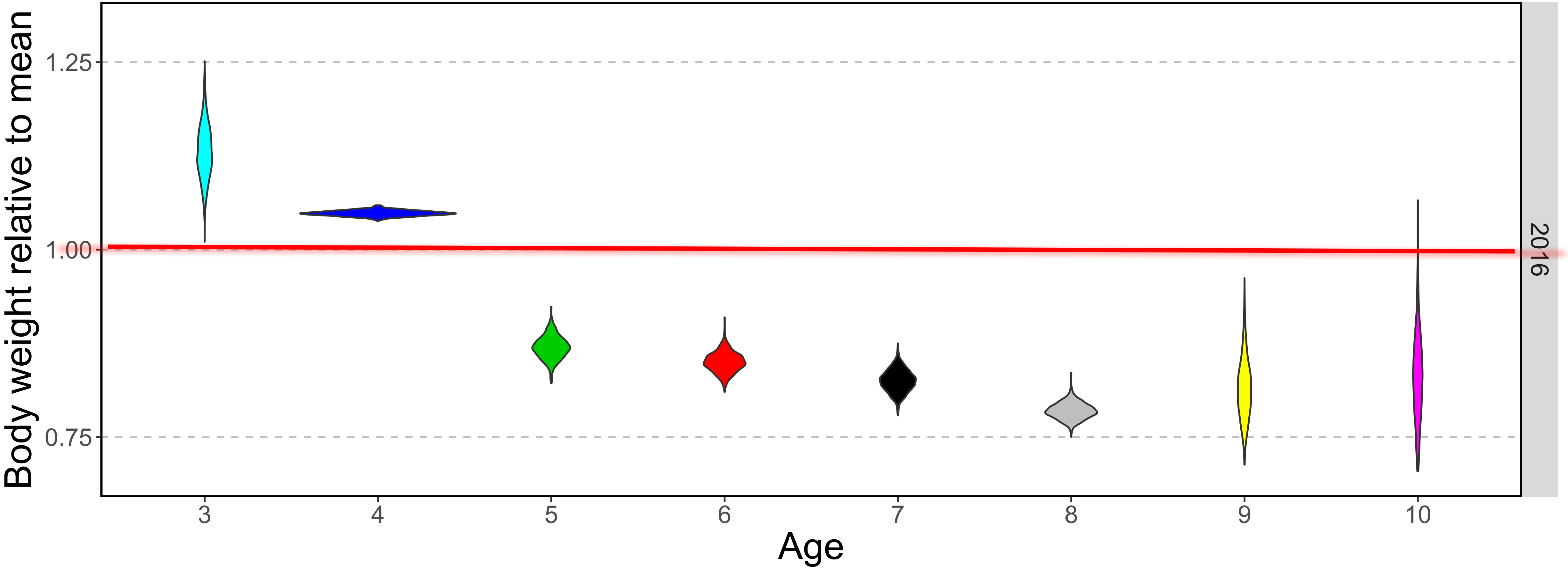


Age

Average weight at age anomalies




Body weight relative to mean
1.25
1.00
0.75
3
4
5
6
7
8
9
10
Age
2012



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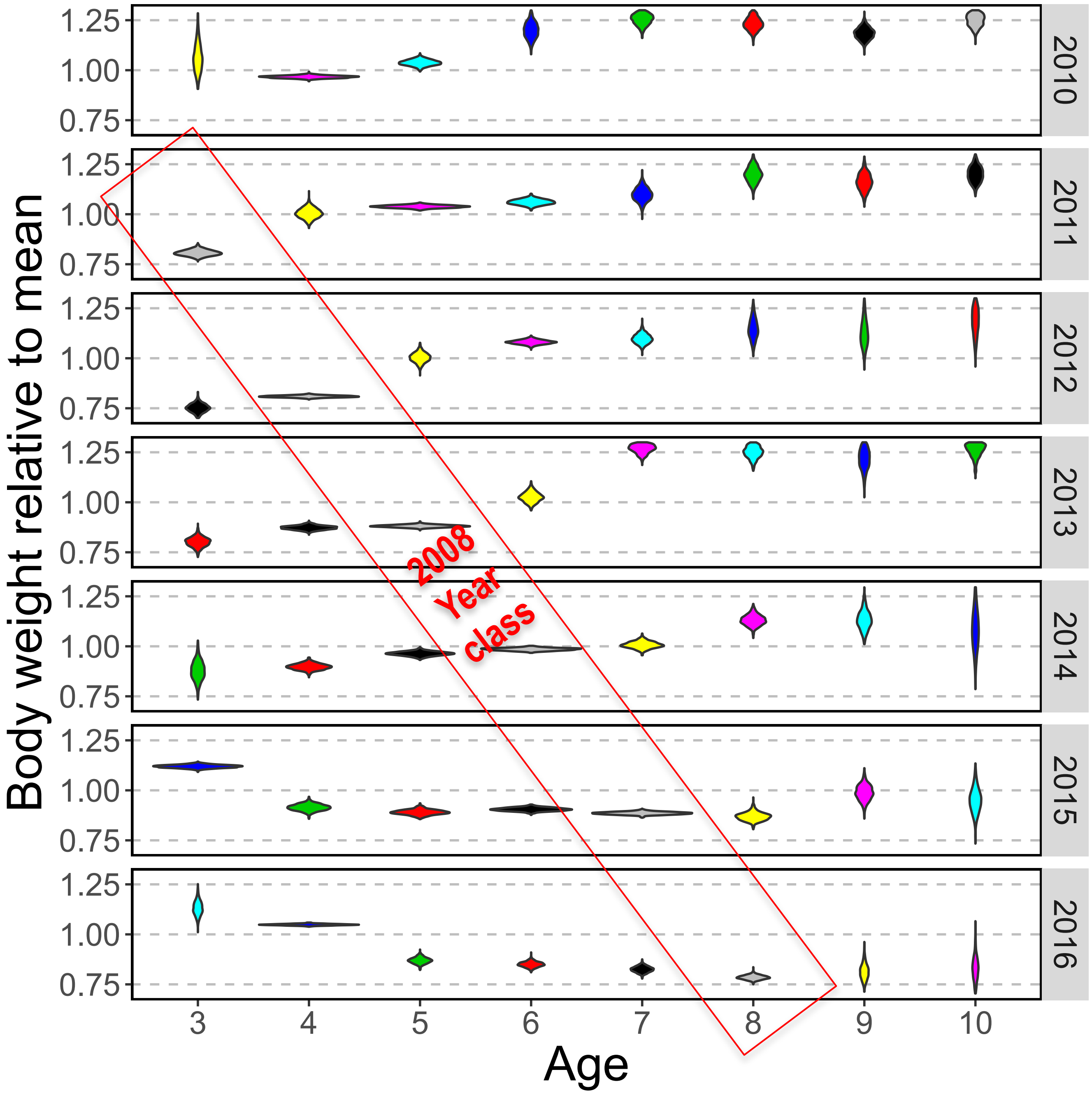
Average weight at age anomalies

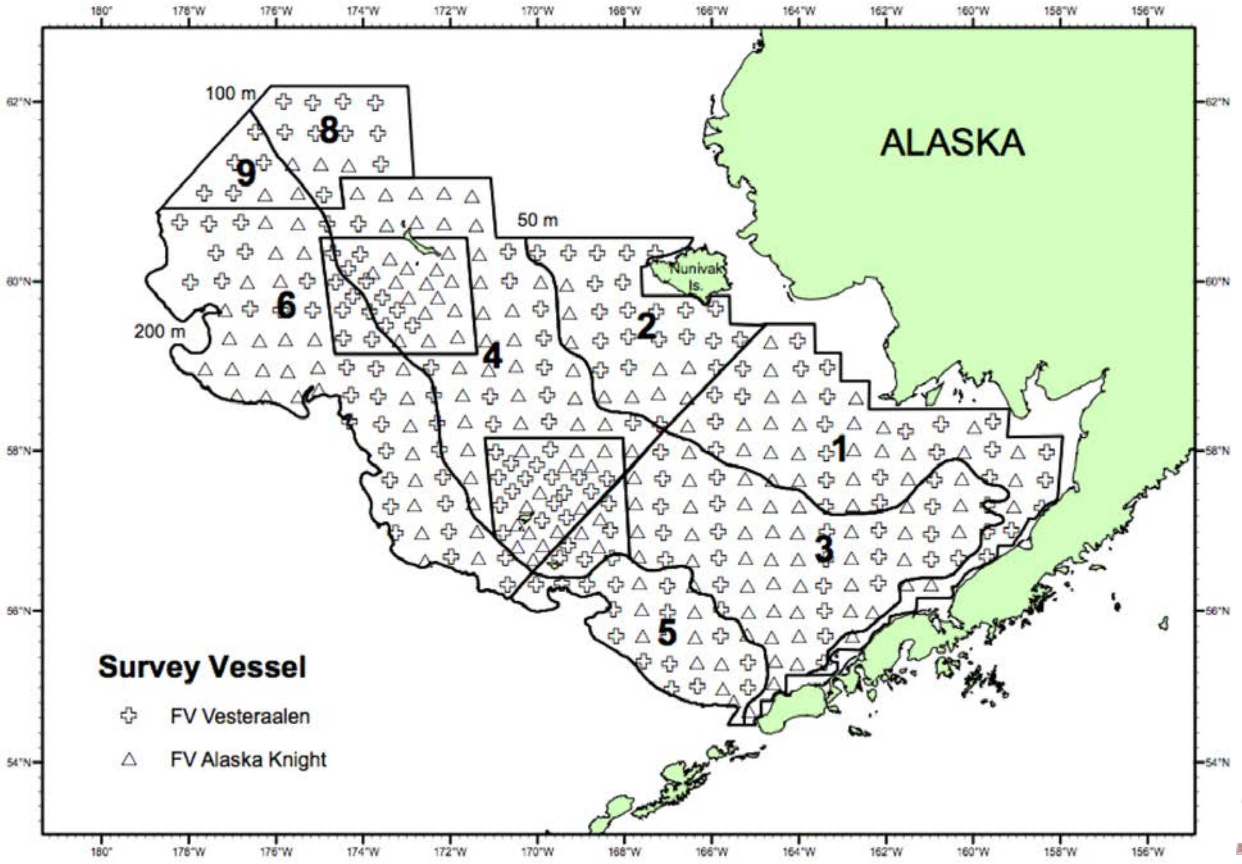


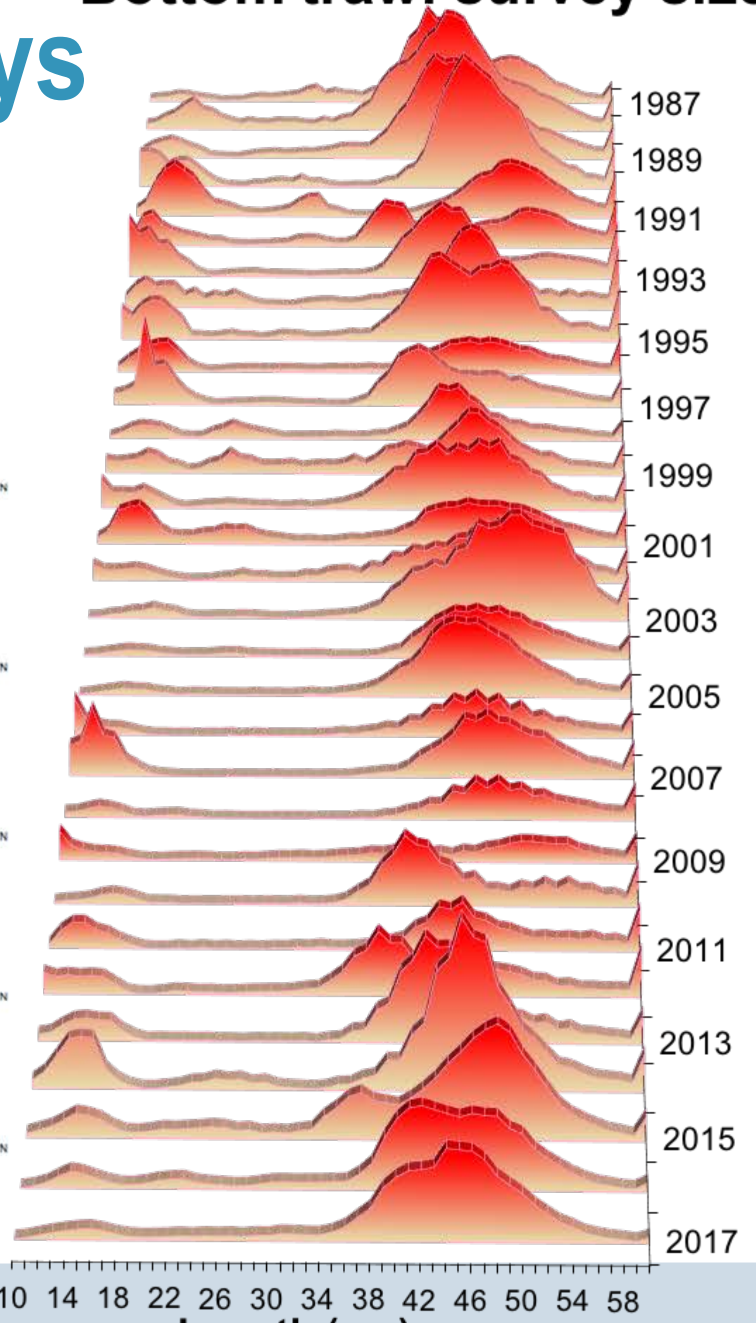
Procedure for fishery weight-age estimation (near term projections)

1. Run separate random effects model
    - Observation errors specified (available from bootstraps)
    - **Estimate the process error variances**:
        - Year and cohort effects
2. Use same estimation procedure in full assessment model
    - Year and cohort effects **treated as fixed effects because:**
    - Variances available from step 1

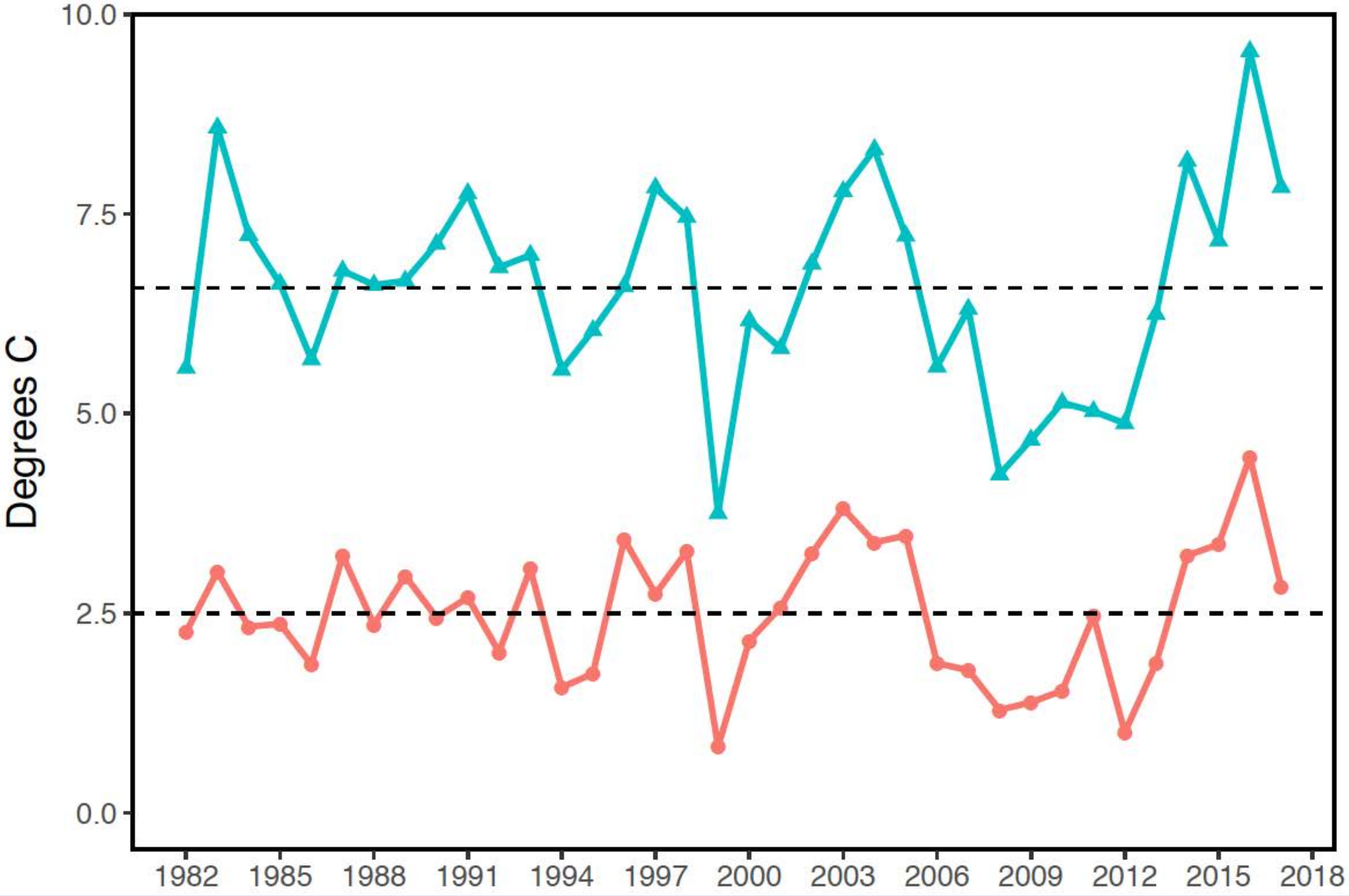
Scientific research surveys

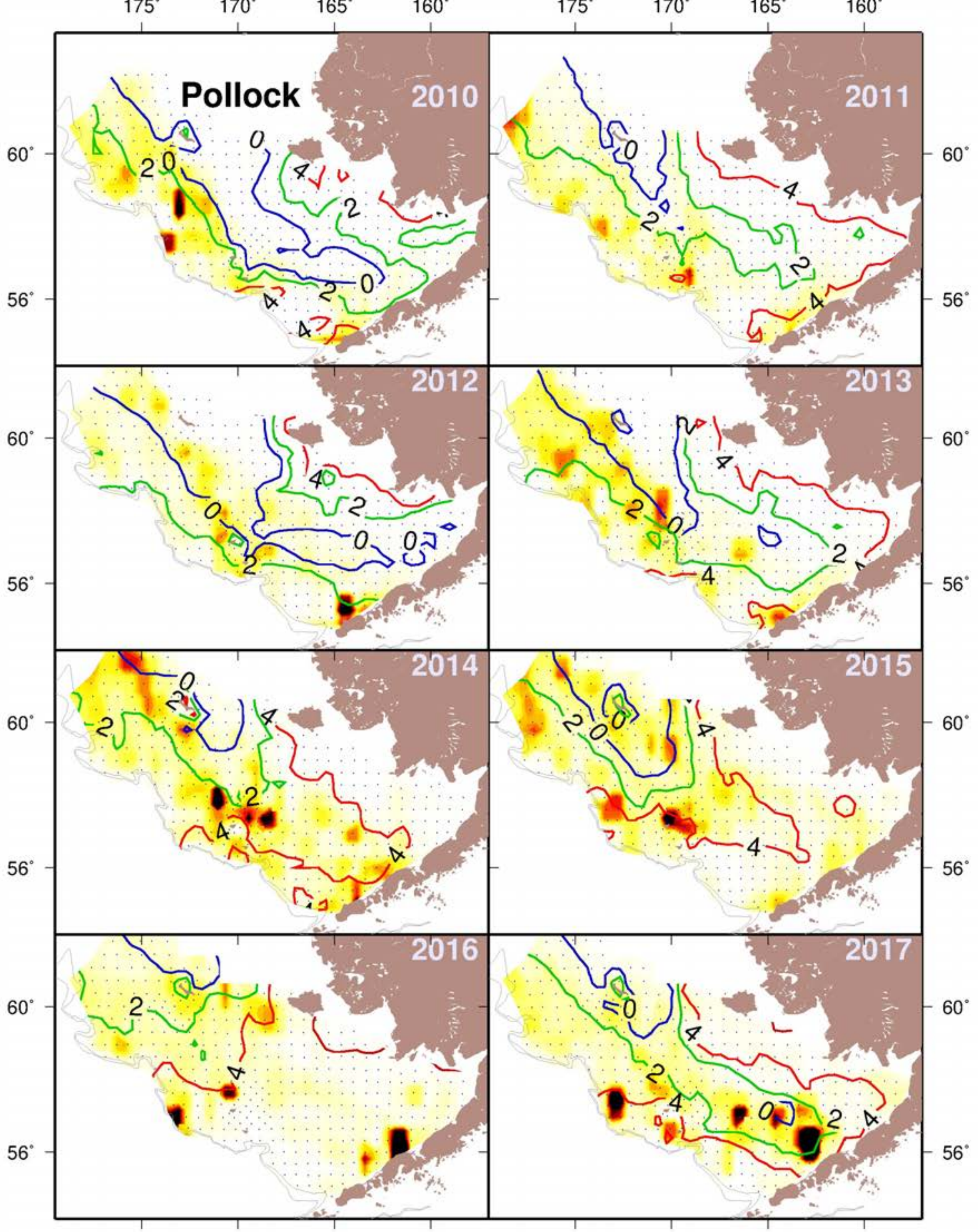
Independent from fishery data—
designed sampling

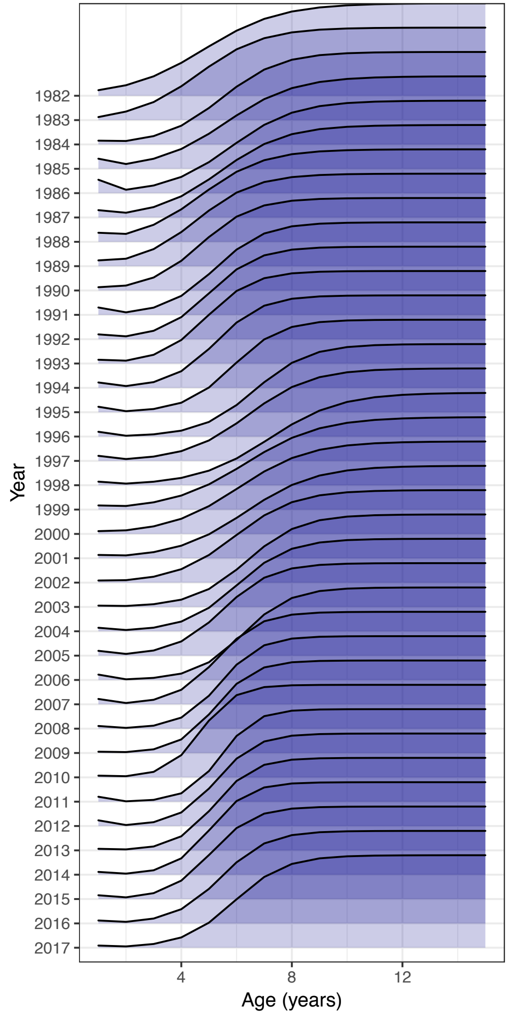




Pollock density and environment

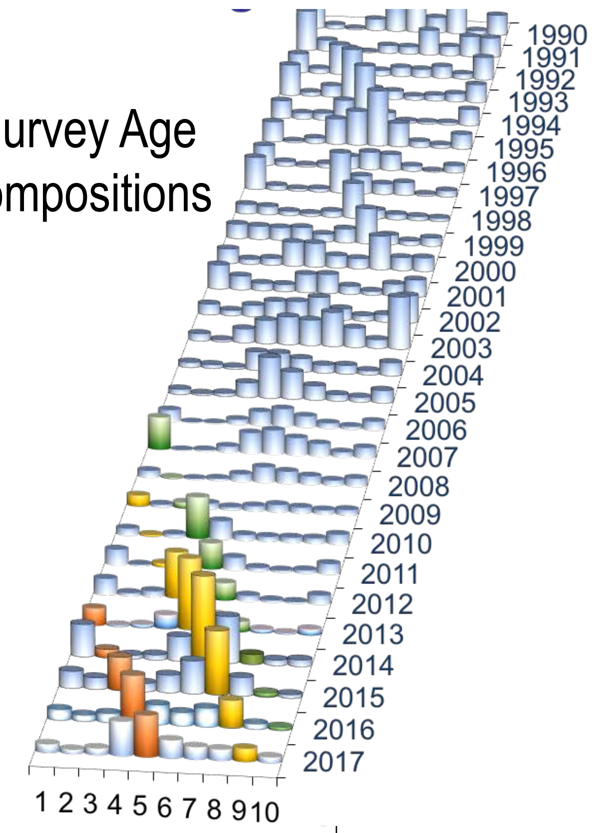


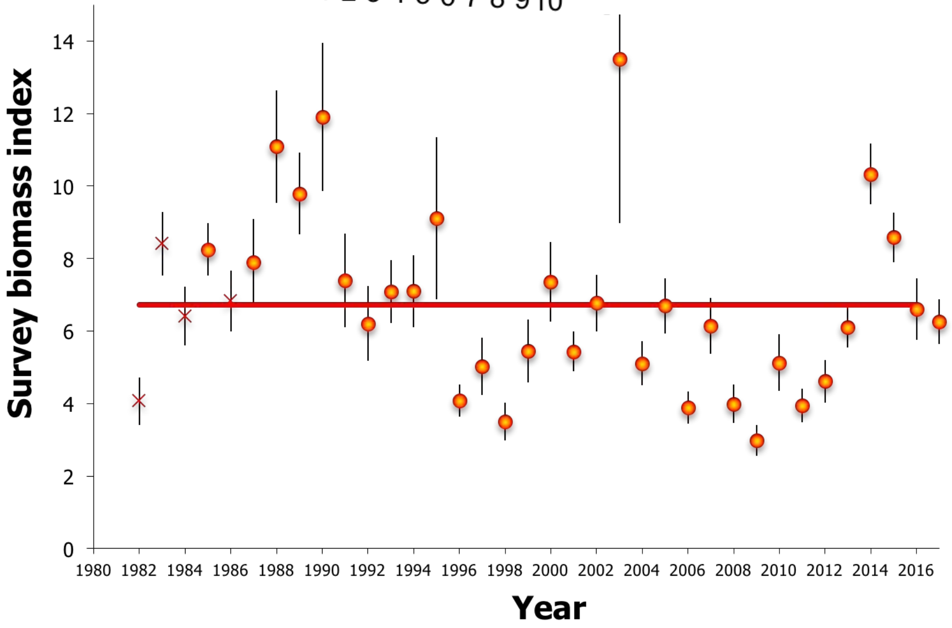




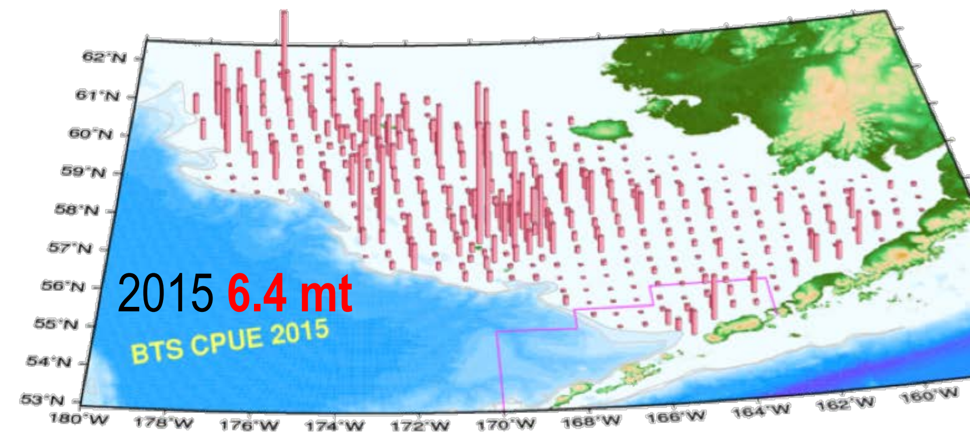
Survey selectivity

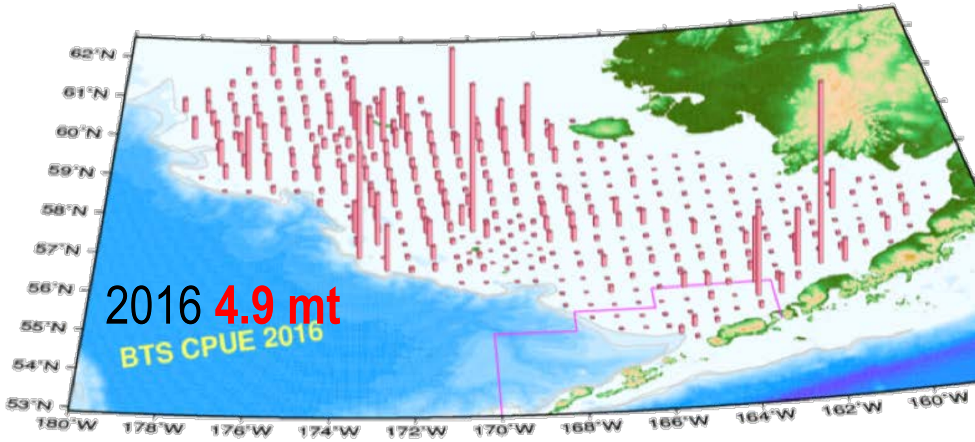
Survey Age compositions

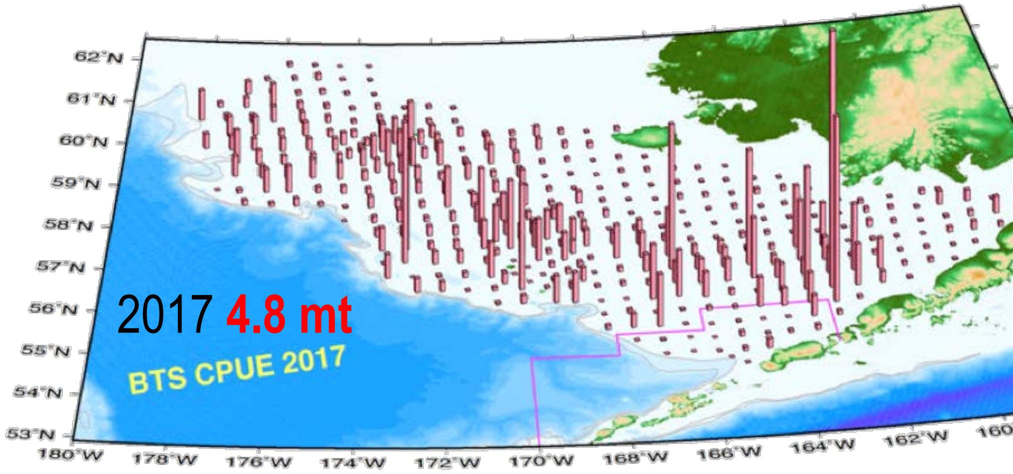




Bottom-trawl surveys

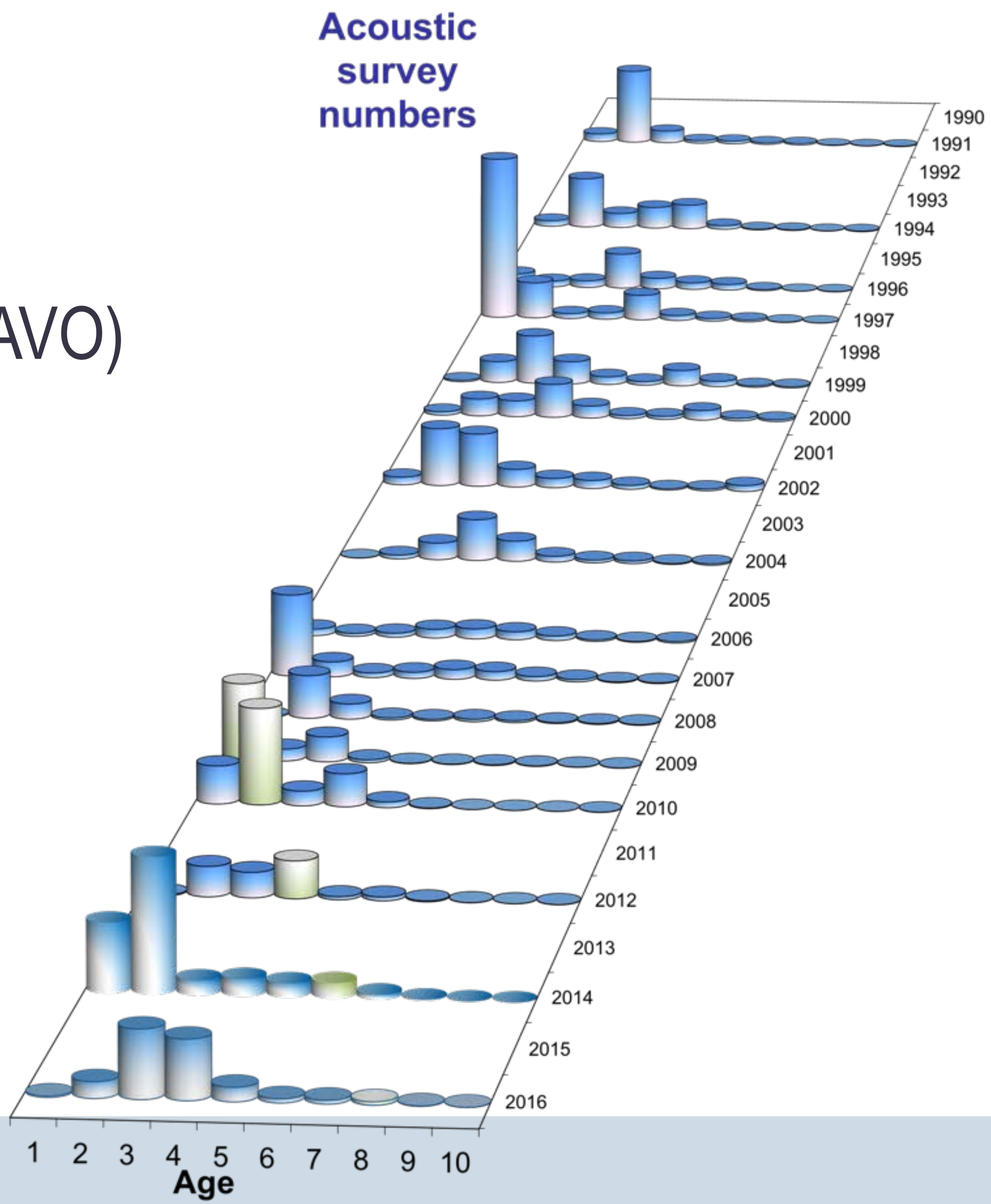






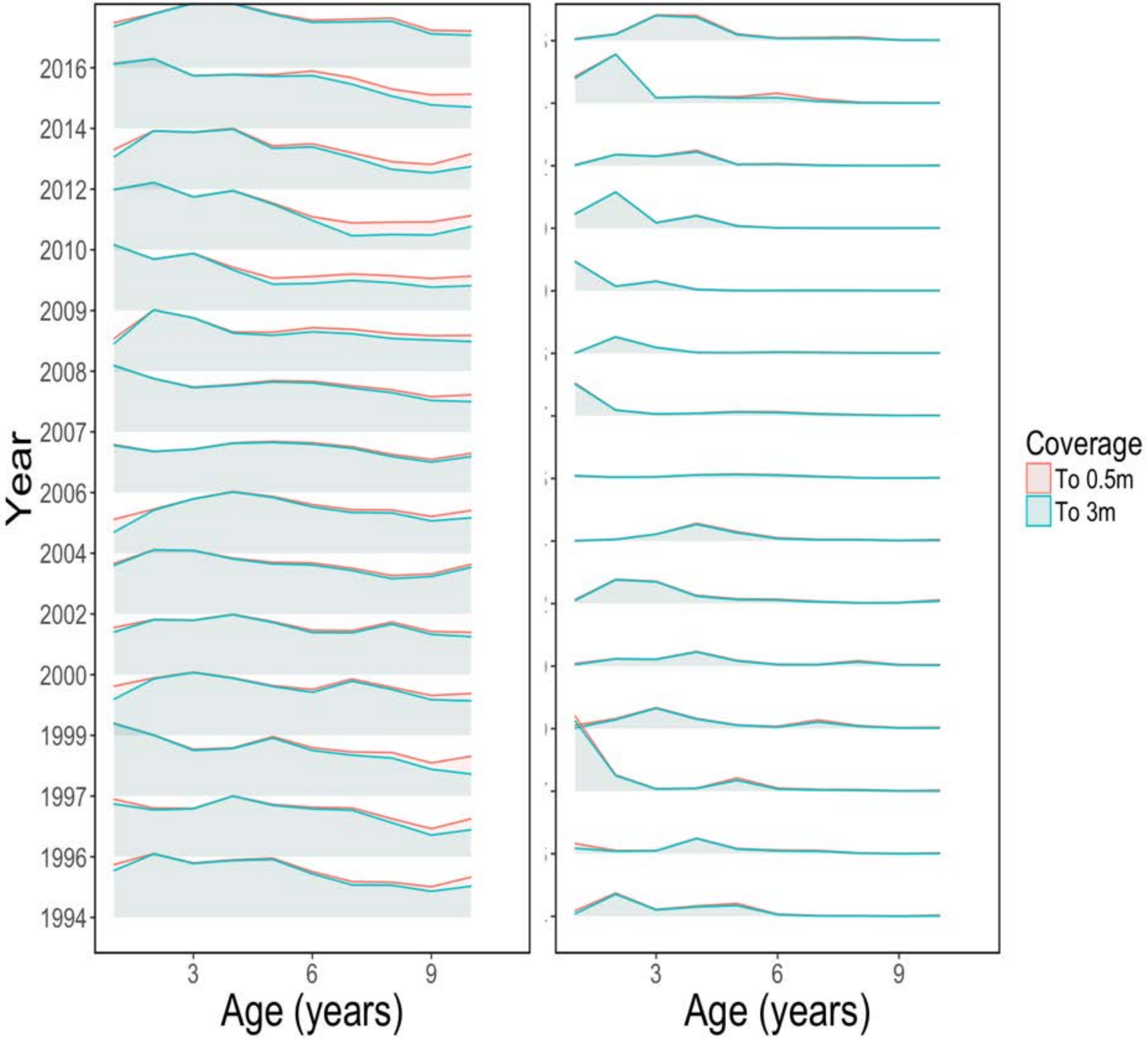
New data

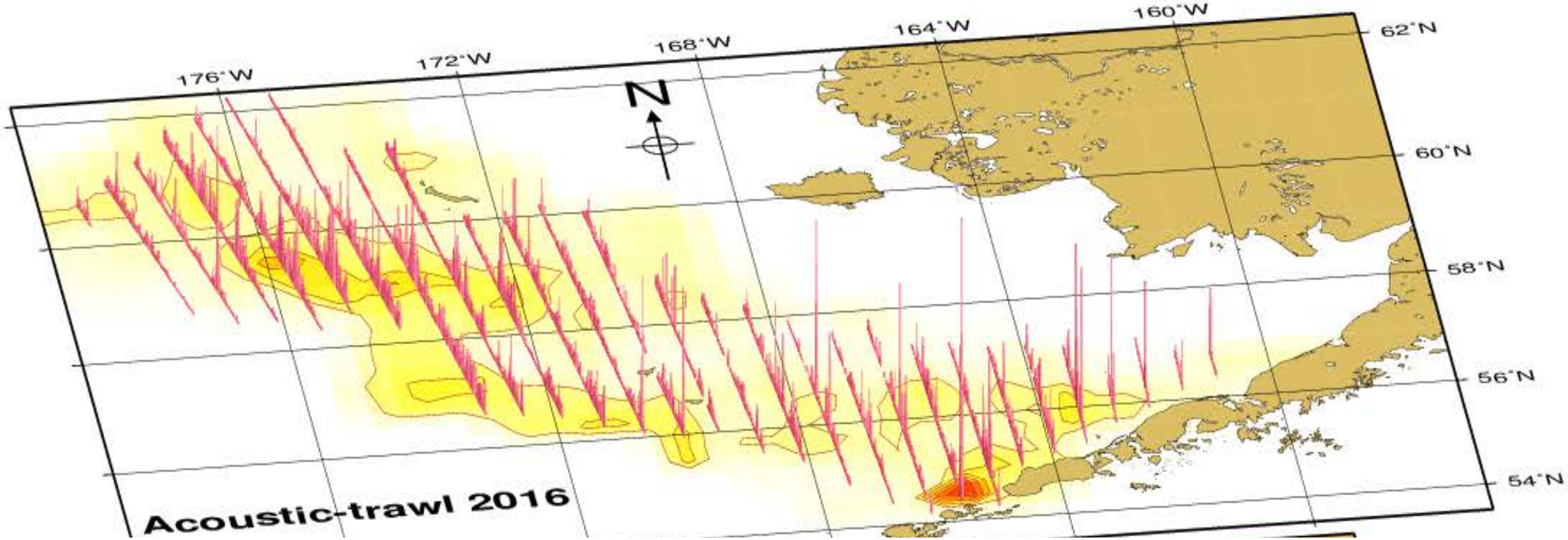
Updated acoustics to 0.5m from bottom
Acoustics from vessels of opportunity (AVO)
Fishery and bottom trawl survey



Acoustic trawl survey age compositions

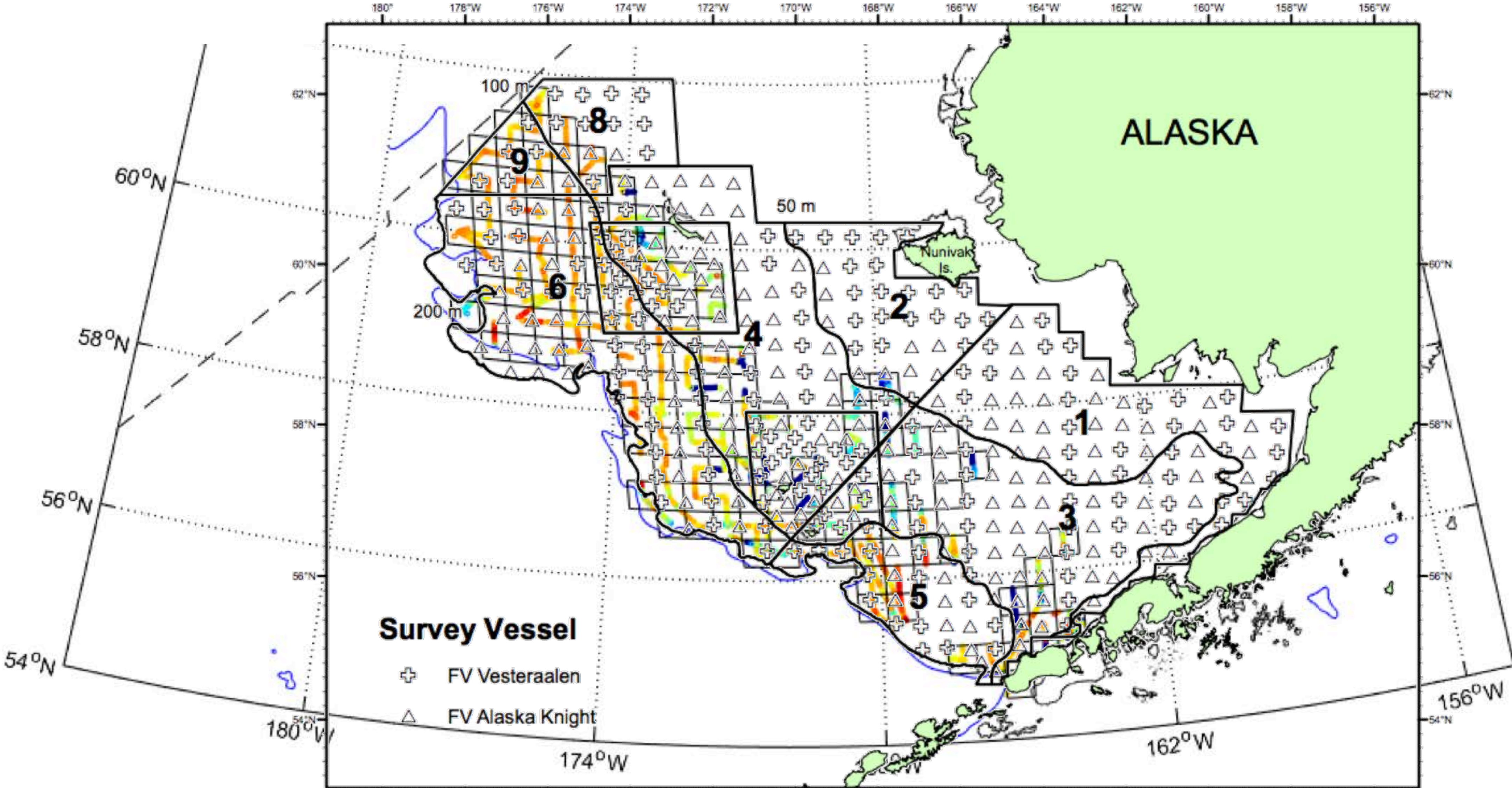
Change w/ bottom layer added

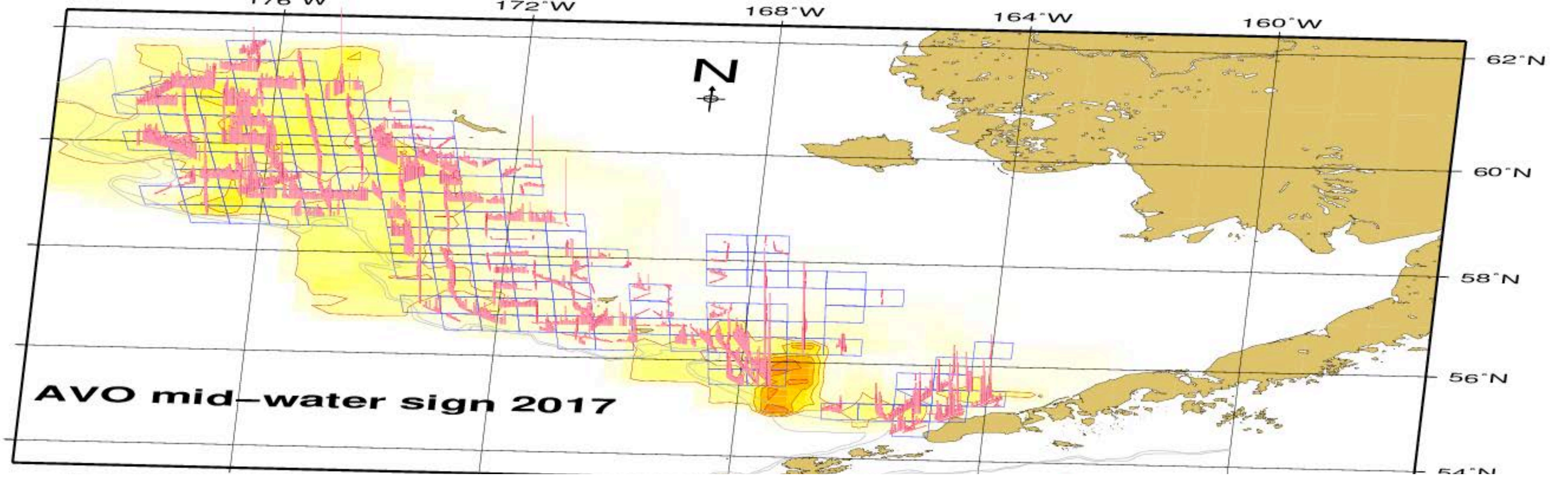




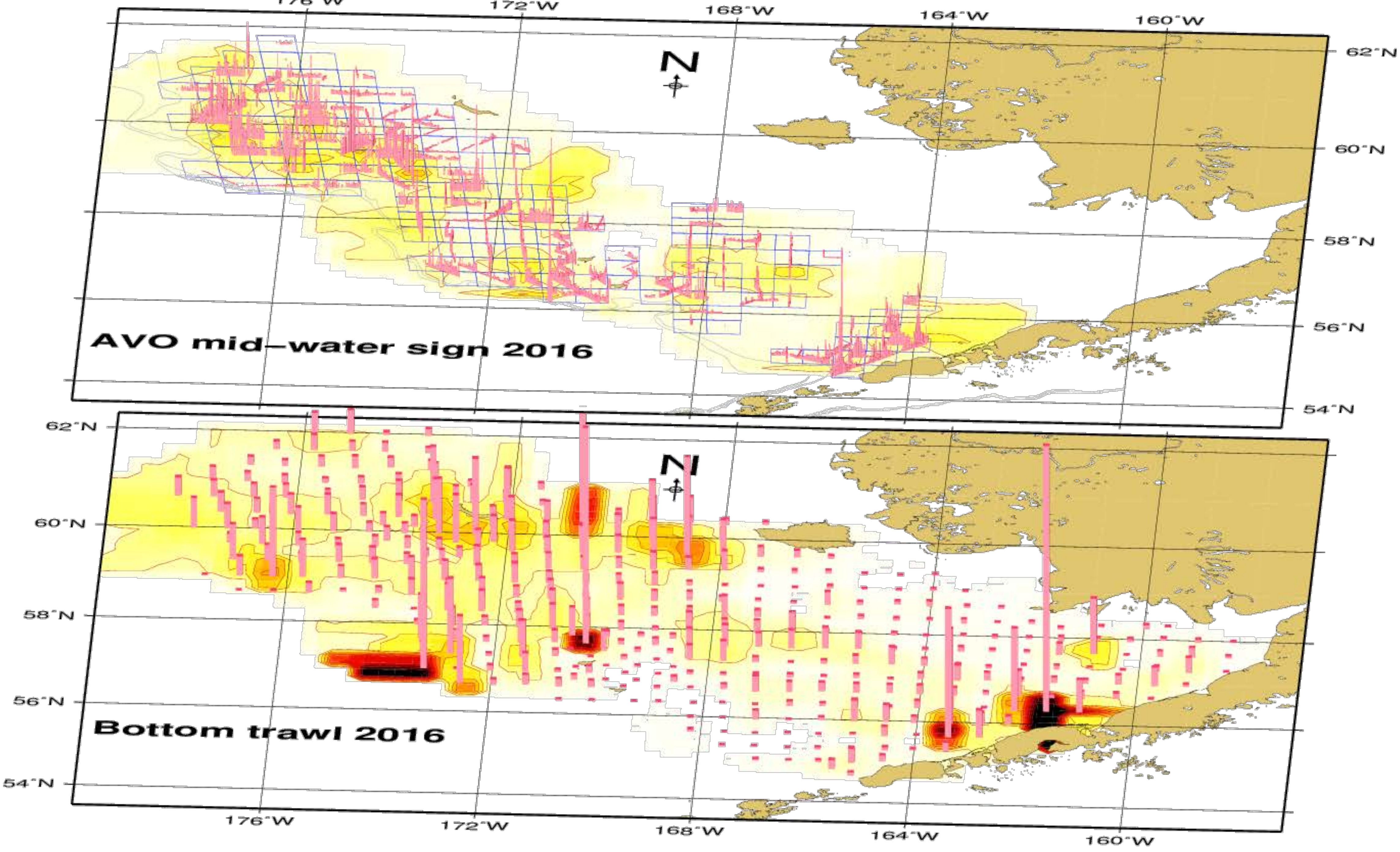
Comparing 2016 Surveys

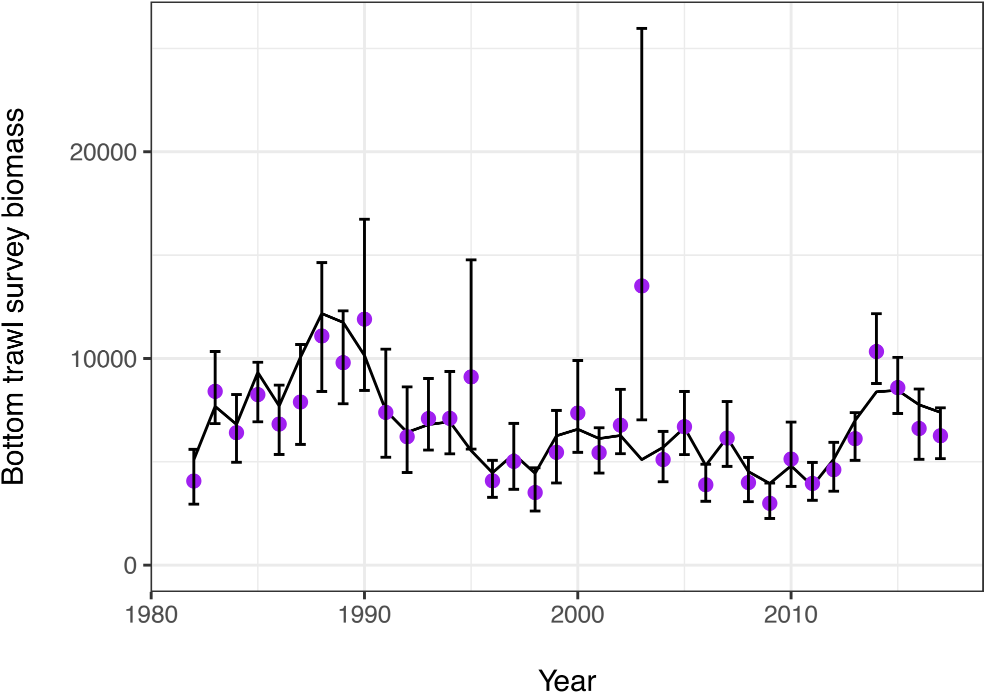
New Data in 2017—two years of AVO

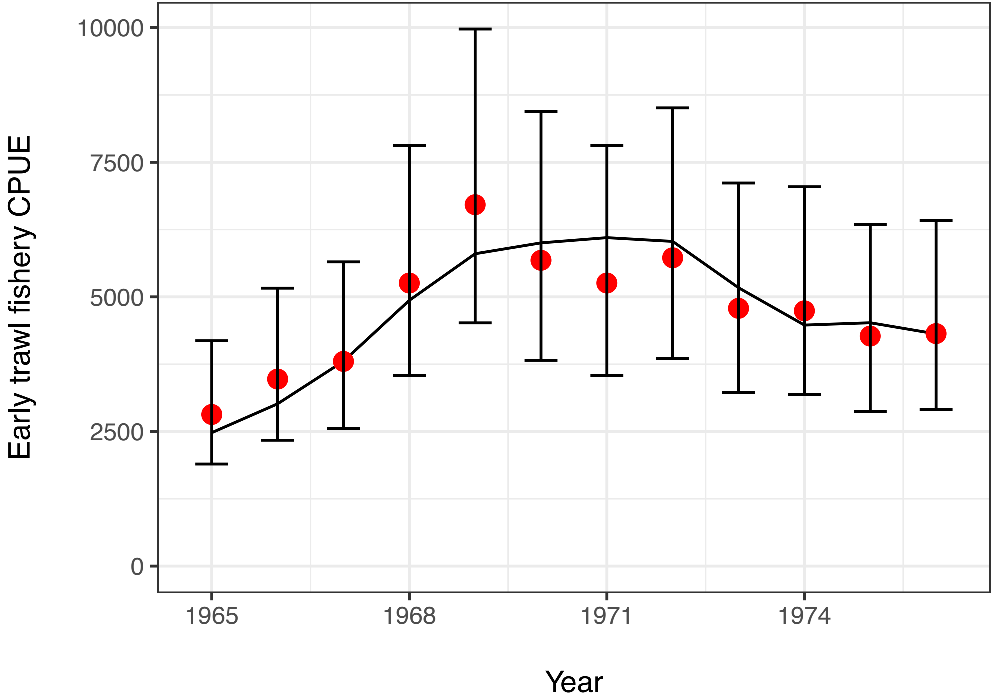


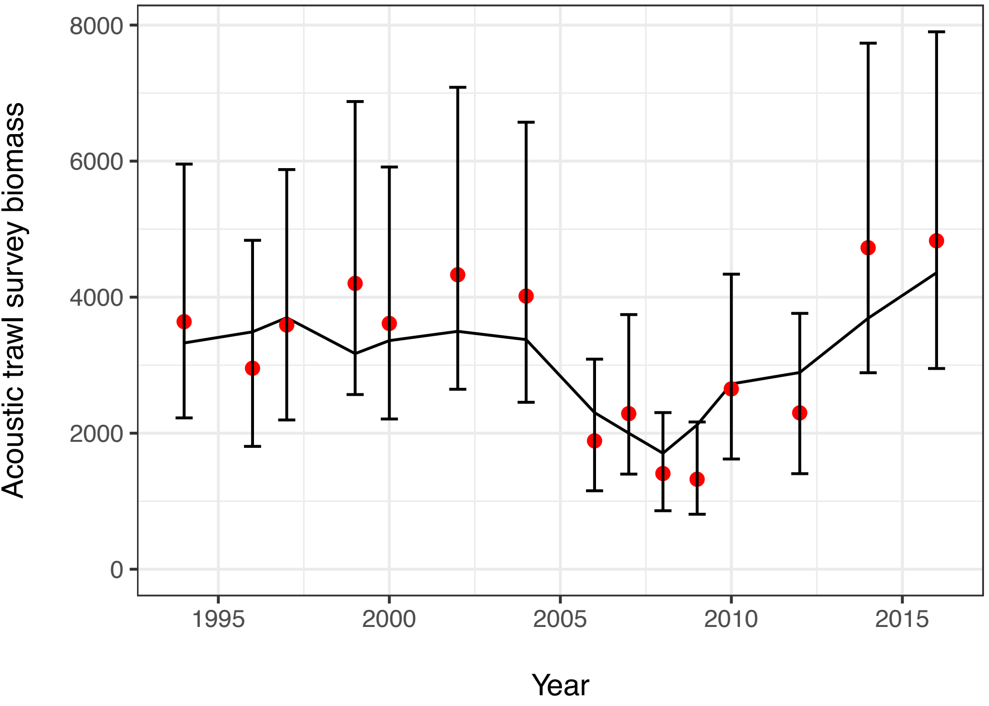


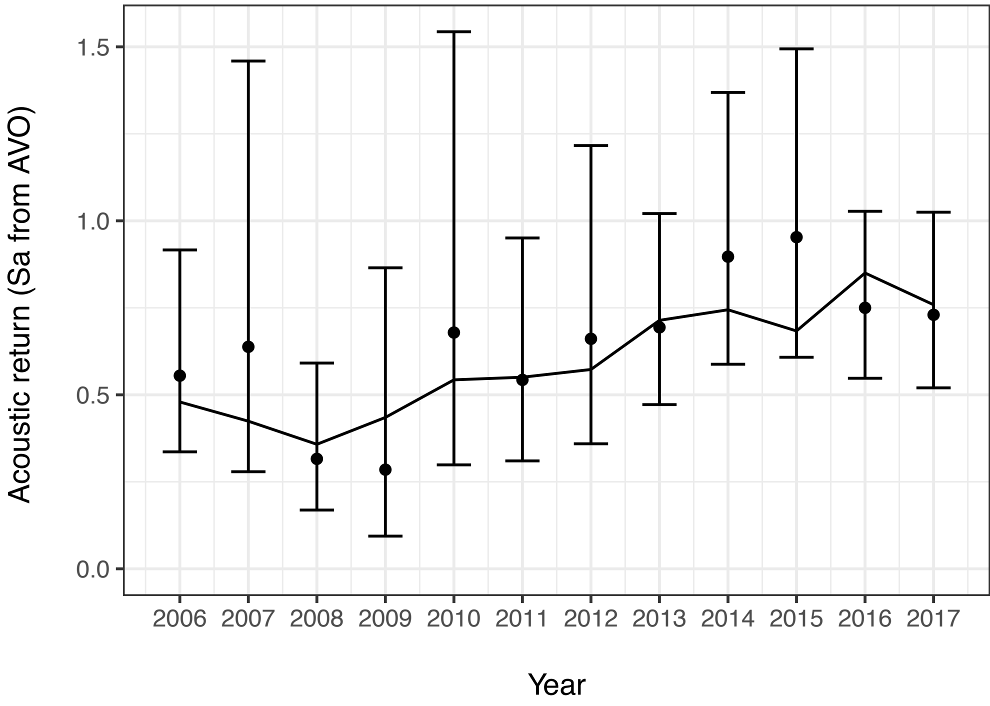
172°W
168°W
164°W
160°W
62°N
60°N
58°N
56°N
N
AVO mid-water sign 2017

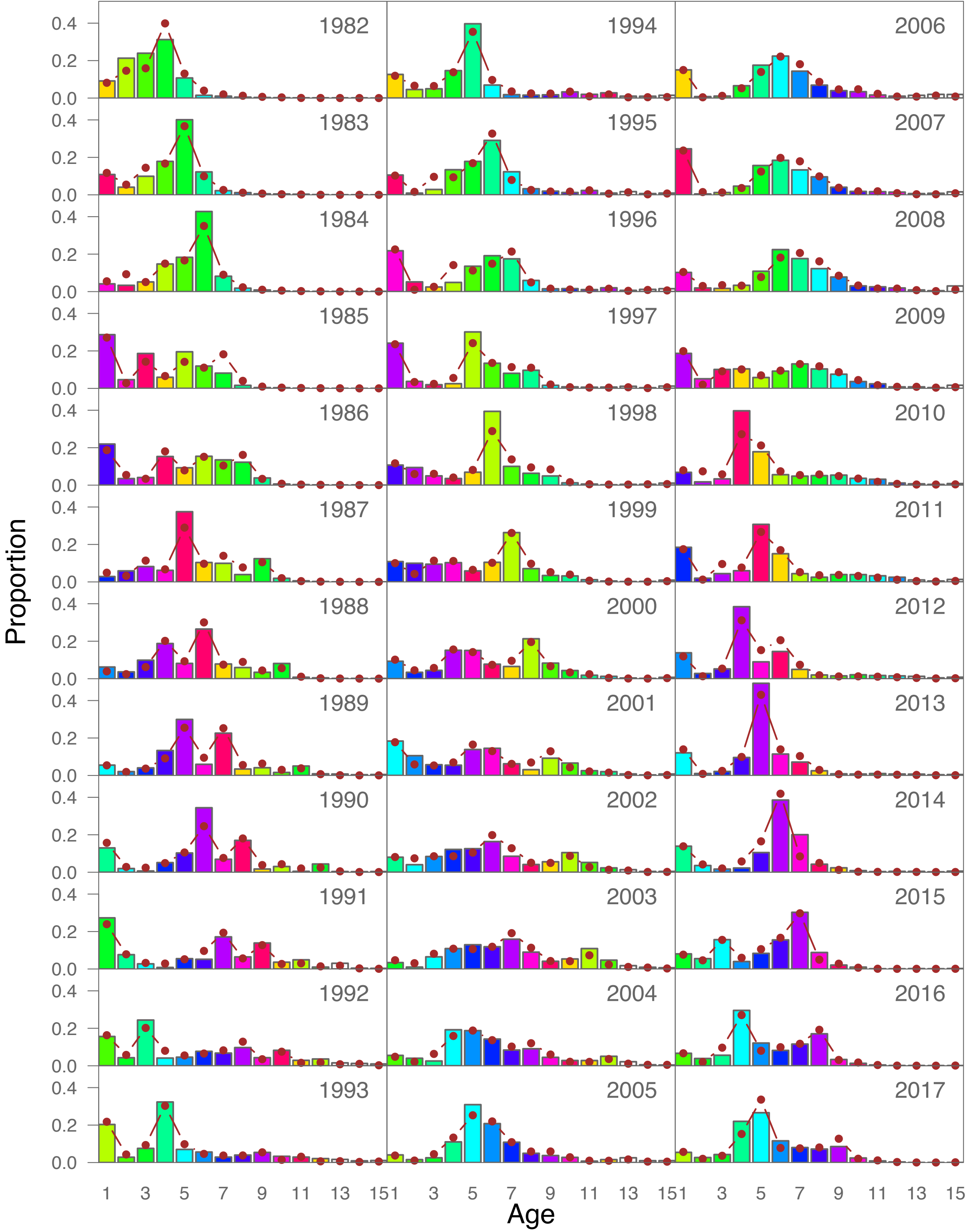

176°W
172°W
168°W
164°W
160°W
62°N
60°N
58°N
56°N
54°N
N
AVO mid-water sign 2016
Bottom trawl 2016

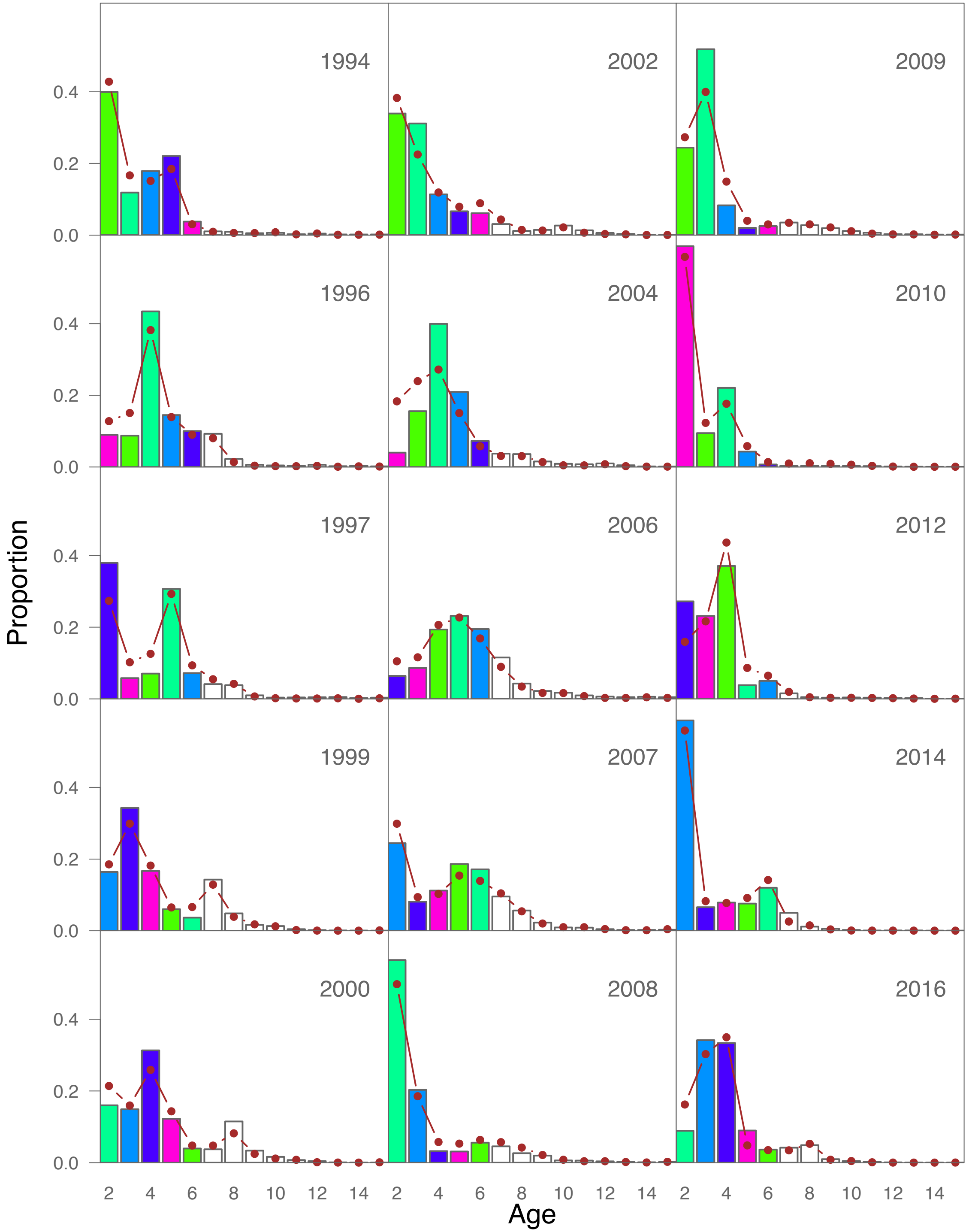

Bottom trawl survey biomass
20000
10000
0
1980
1990
2000
2010
Year

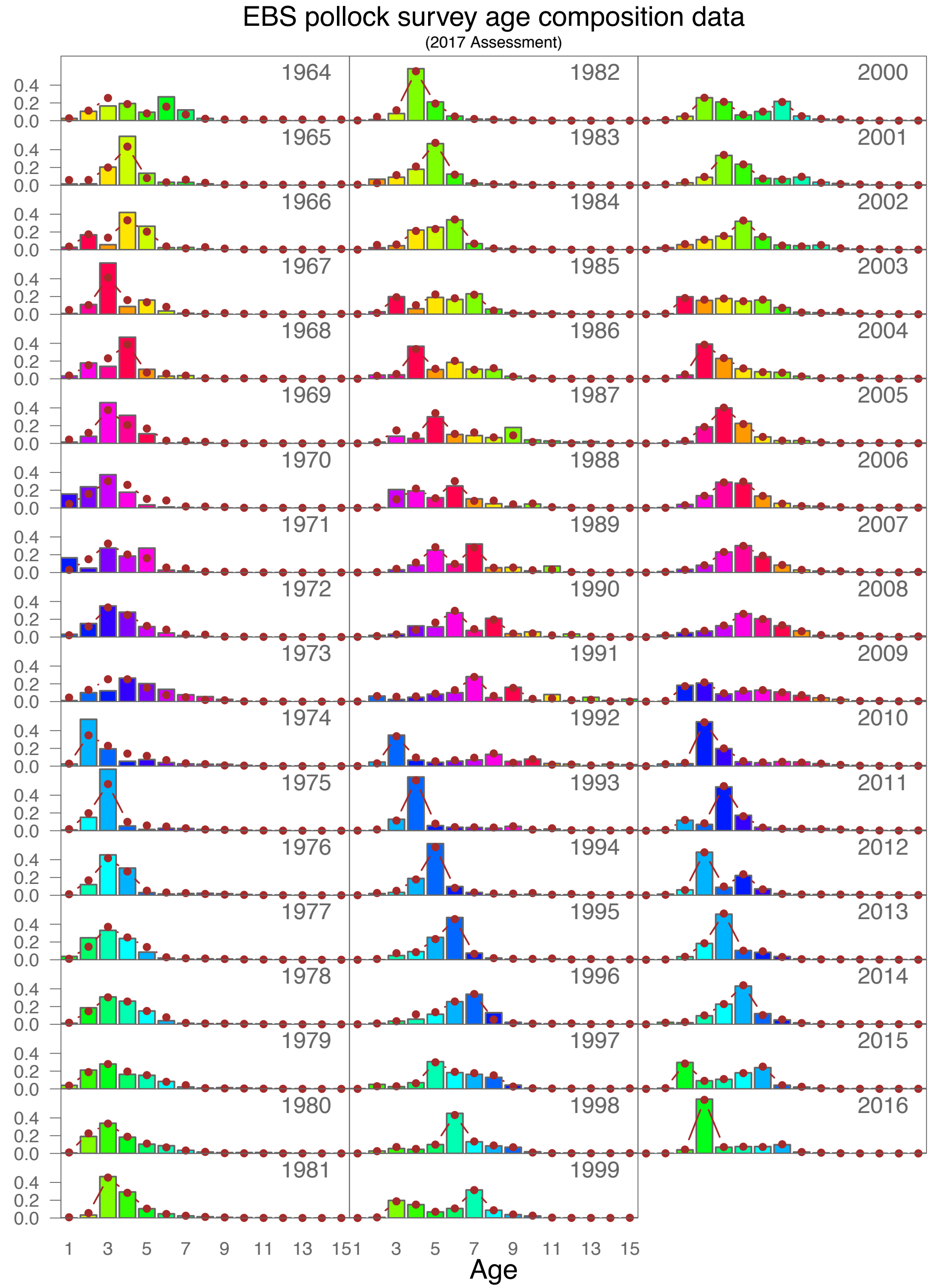

Early trawl fishery CPUE
10000
7500
5000
2500
0
1965
1968
1971
1974
Year

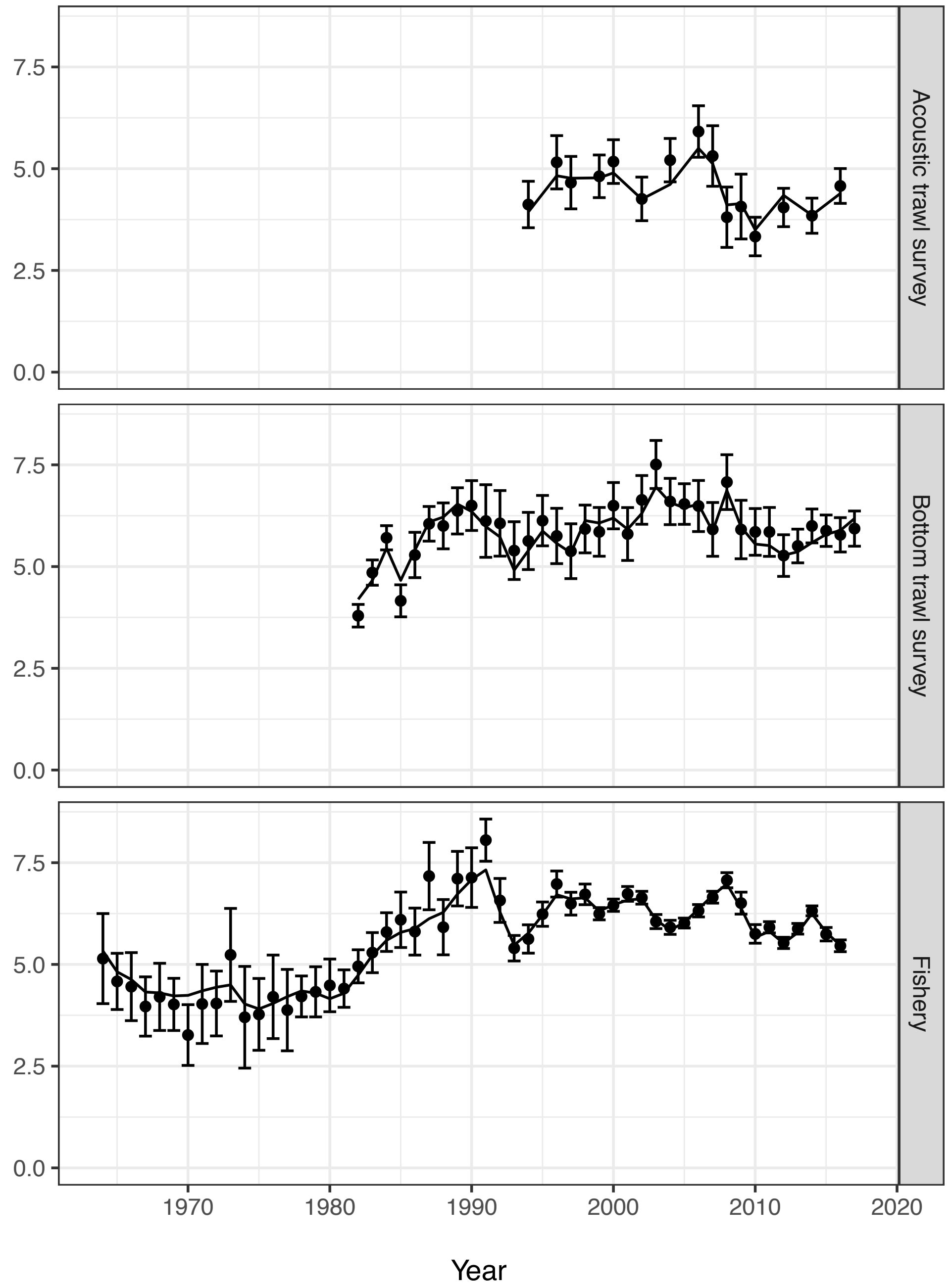

Acoustic trawl survey biomass
8000
6000
4000
2000
0
1995
2000
2005
2010
2015
Year

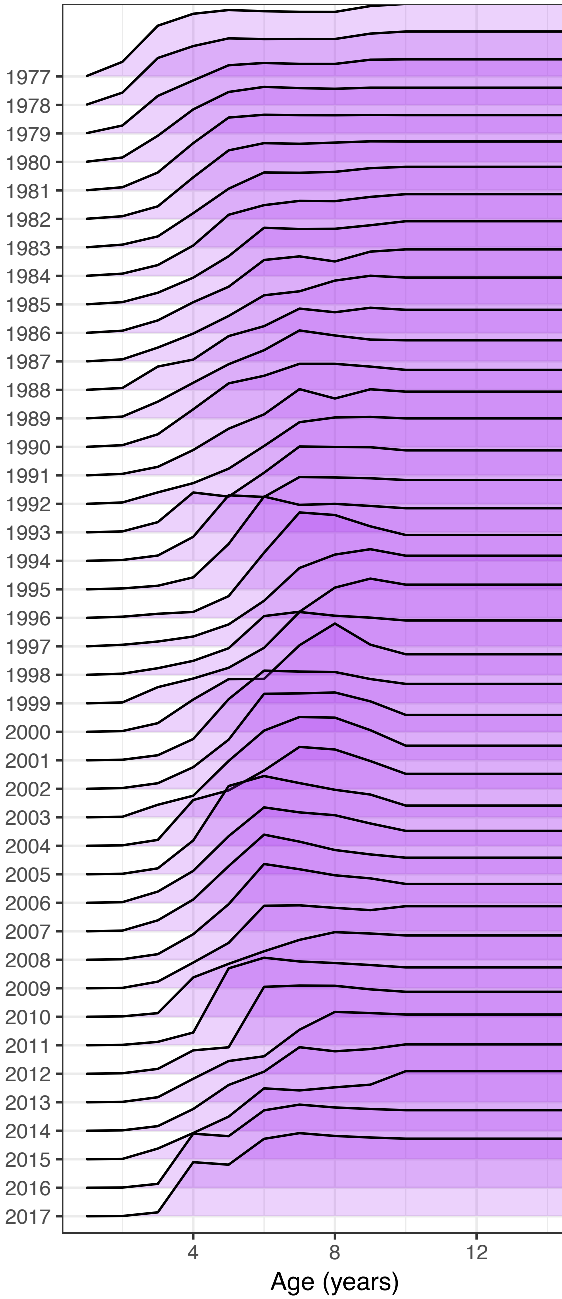

Acoustic return (Sa from AVO)
1.5
1.0
0.5
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year

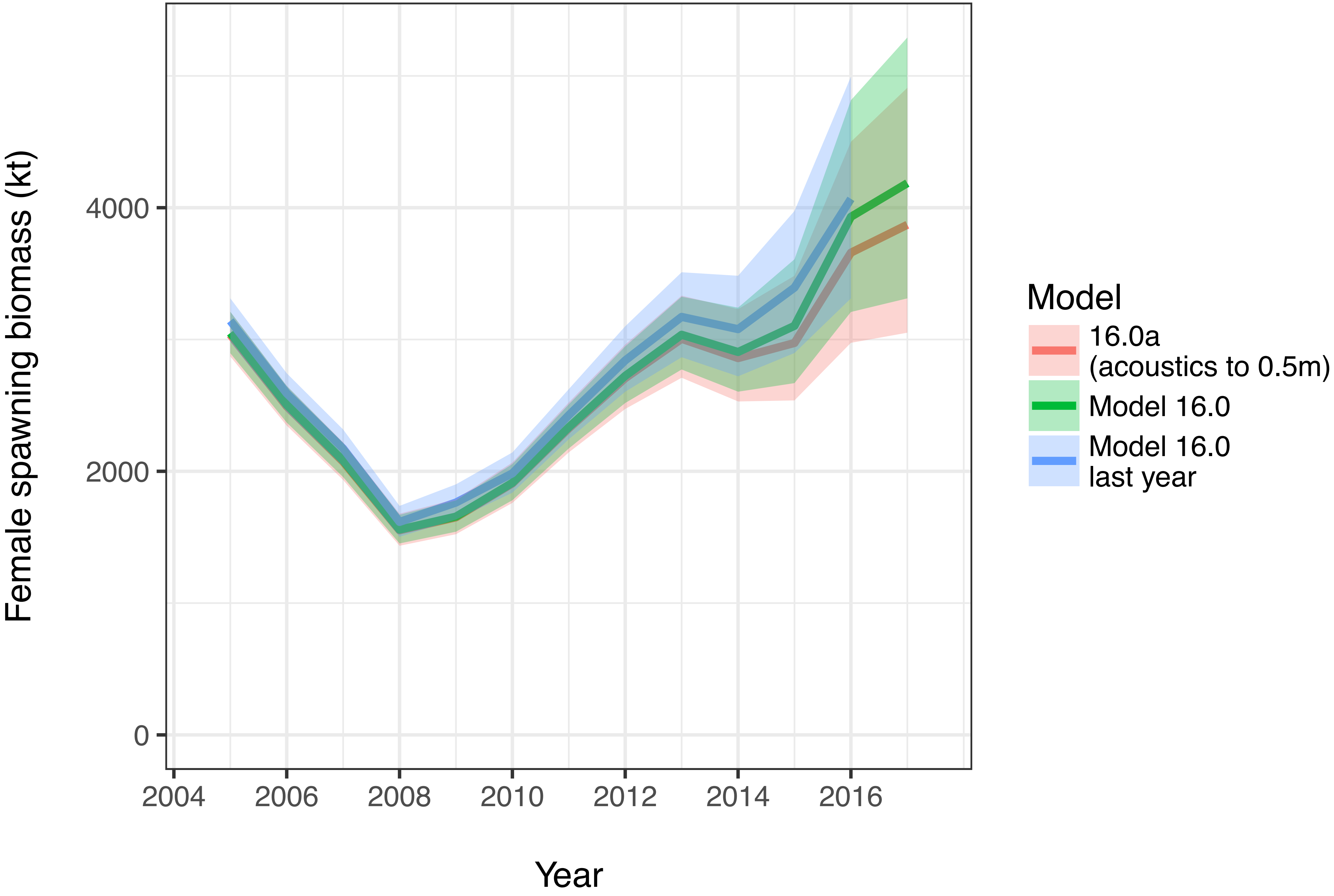

Proportion
Age
0.0
0.2
0.4
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
1
3
5
7
9
11
13
15


Proportion
Age
0.0
0.2
0.4
1994
2002
2009
1996
2004
2010
1997
2006
2012
1999
2007
2014
2000
2008
2016
2
4
6
8
10
12
14


EBS pollock survey age composition data
(2017 Assessment)
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
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
0.0
0.2
0.4
1 3 5 7 9 11 13 15
Age


Acoustic trawl survey
Bottom trawl survey
Fishery
0.0
2.5
5.0
7.5
1970
1980
1990
2000
2010
2020
Year

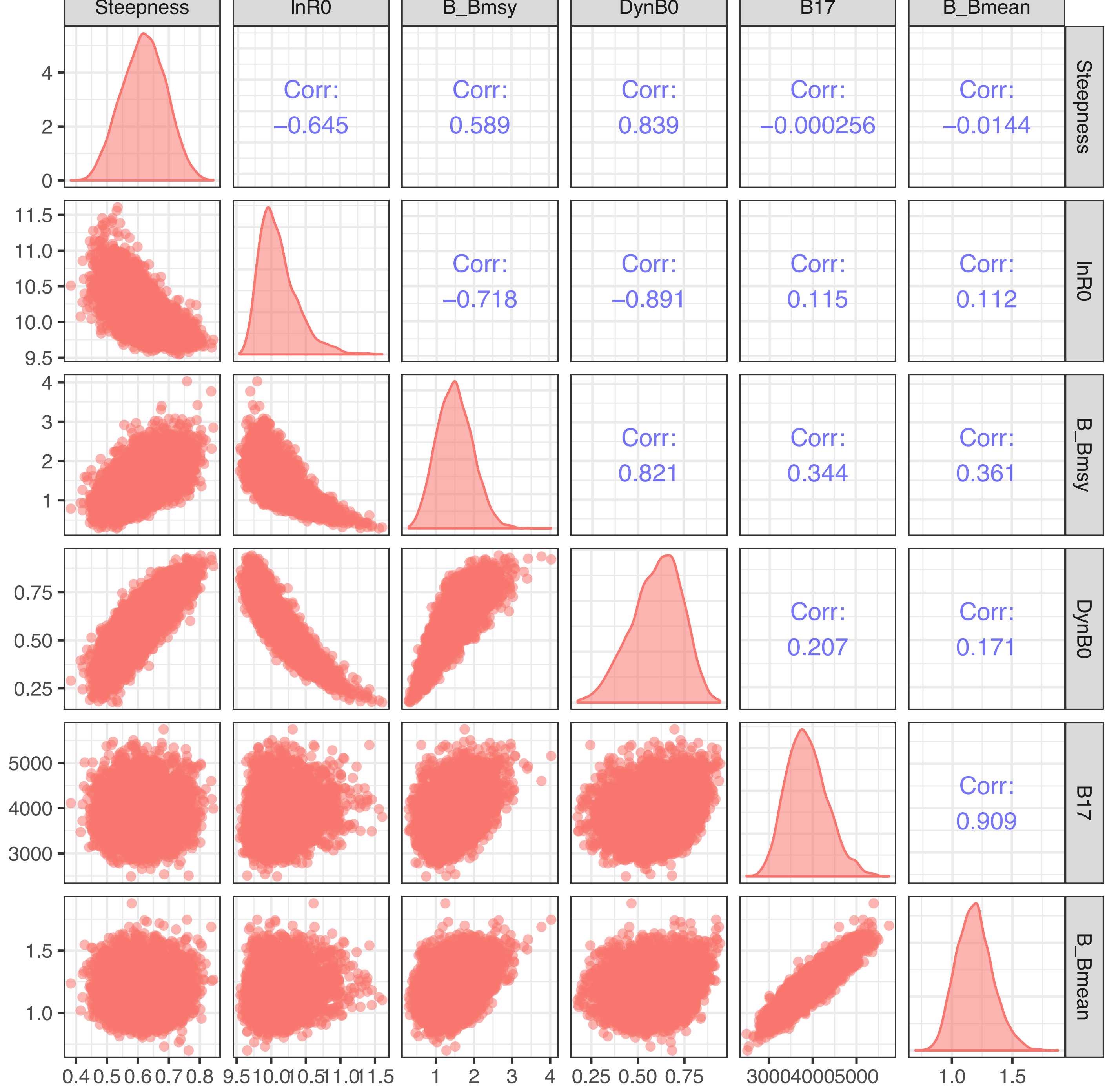

1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
4
8
12
Age (years)



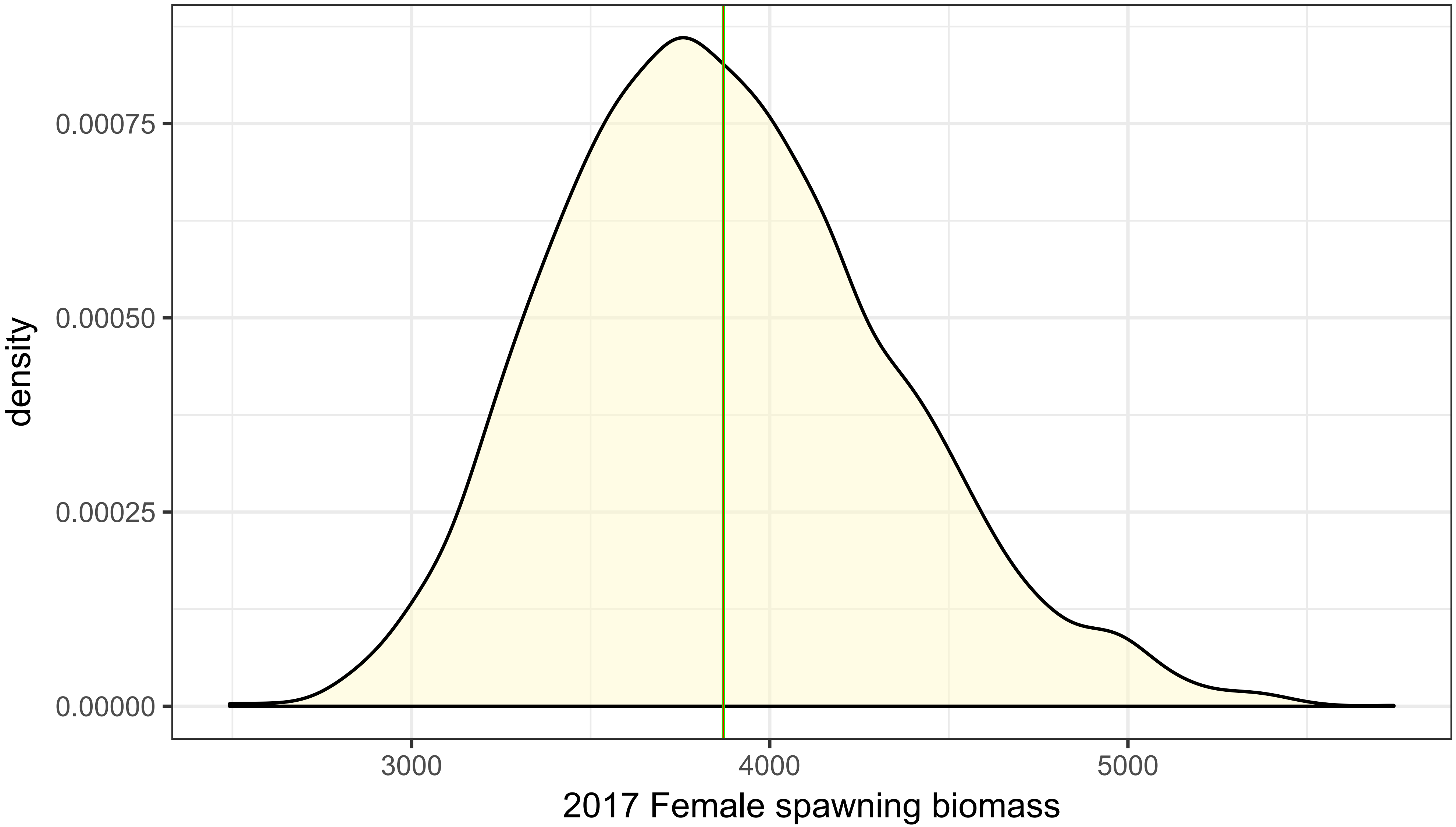
Female spawning biomass (kt)
4000
2000
0
2004
2006
2008
2010
2012
2014
2016
Year
Model
16.0a
(acoustics to 0.5m)
Model 16.0
Model 16.0
last year

MCMC posterior

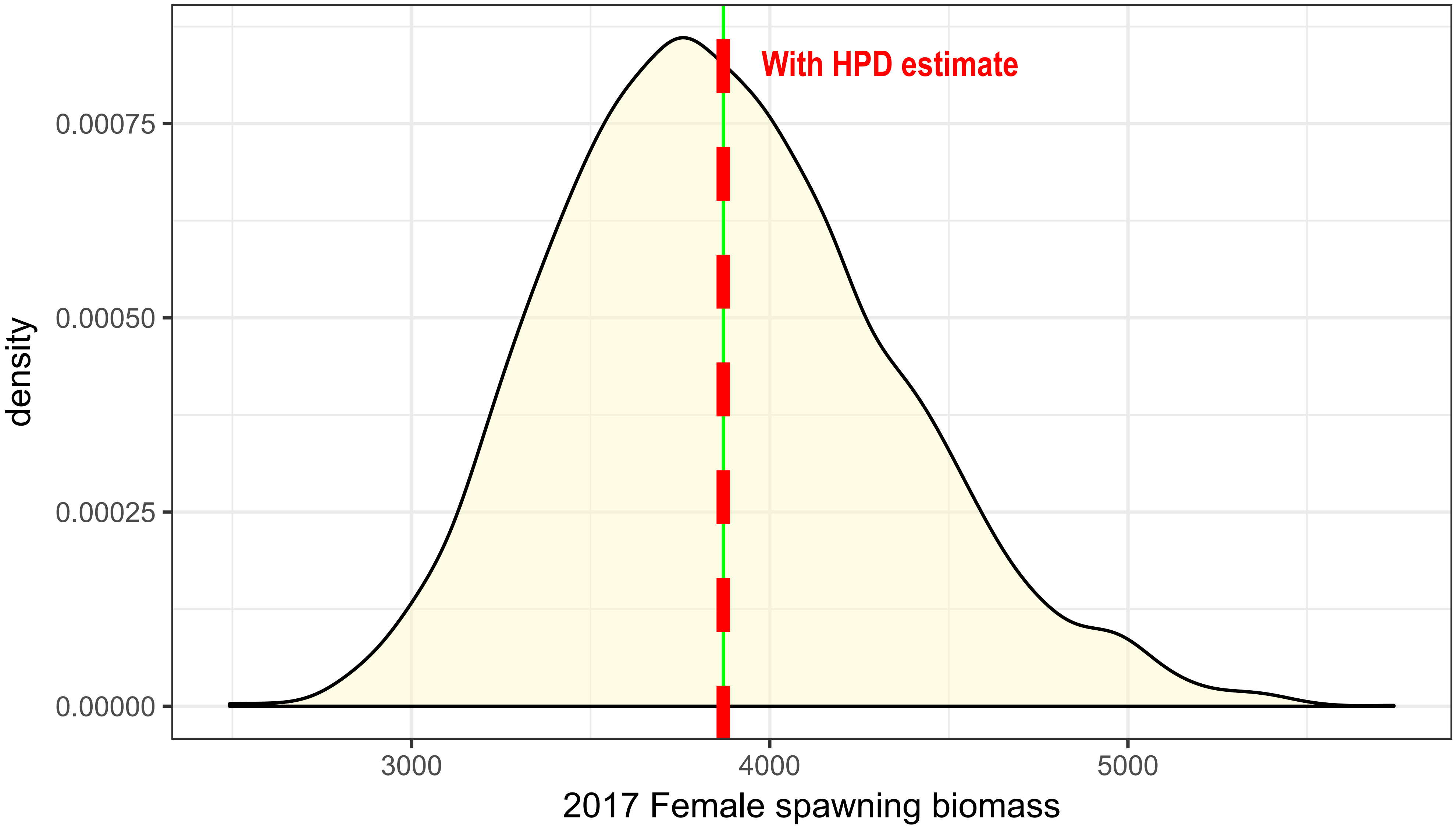
- Added to draft
- Consistent with asymptotic approximations



Posterior marginal distribution



Posterior marginal distribution



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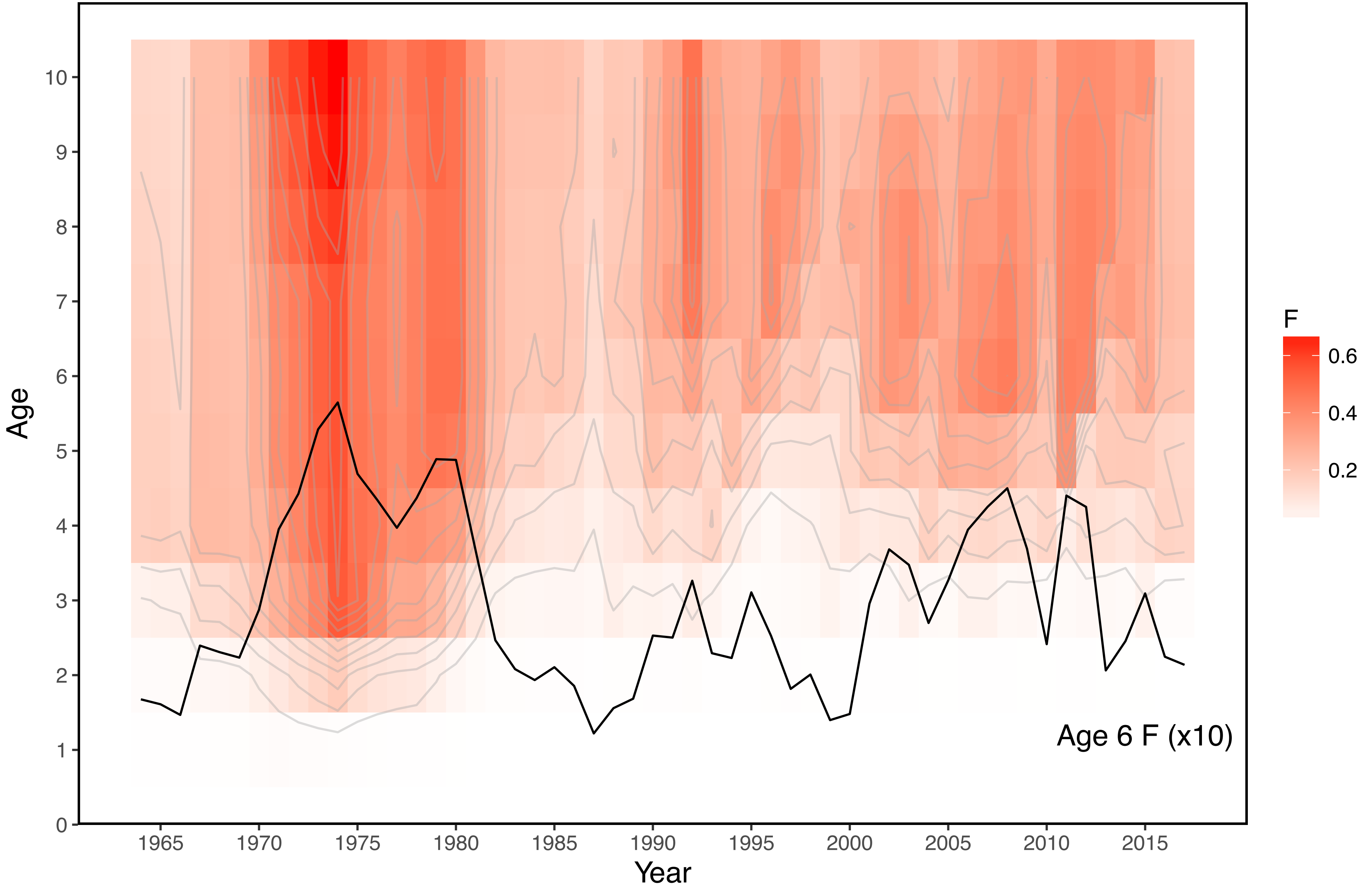
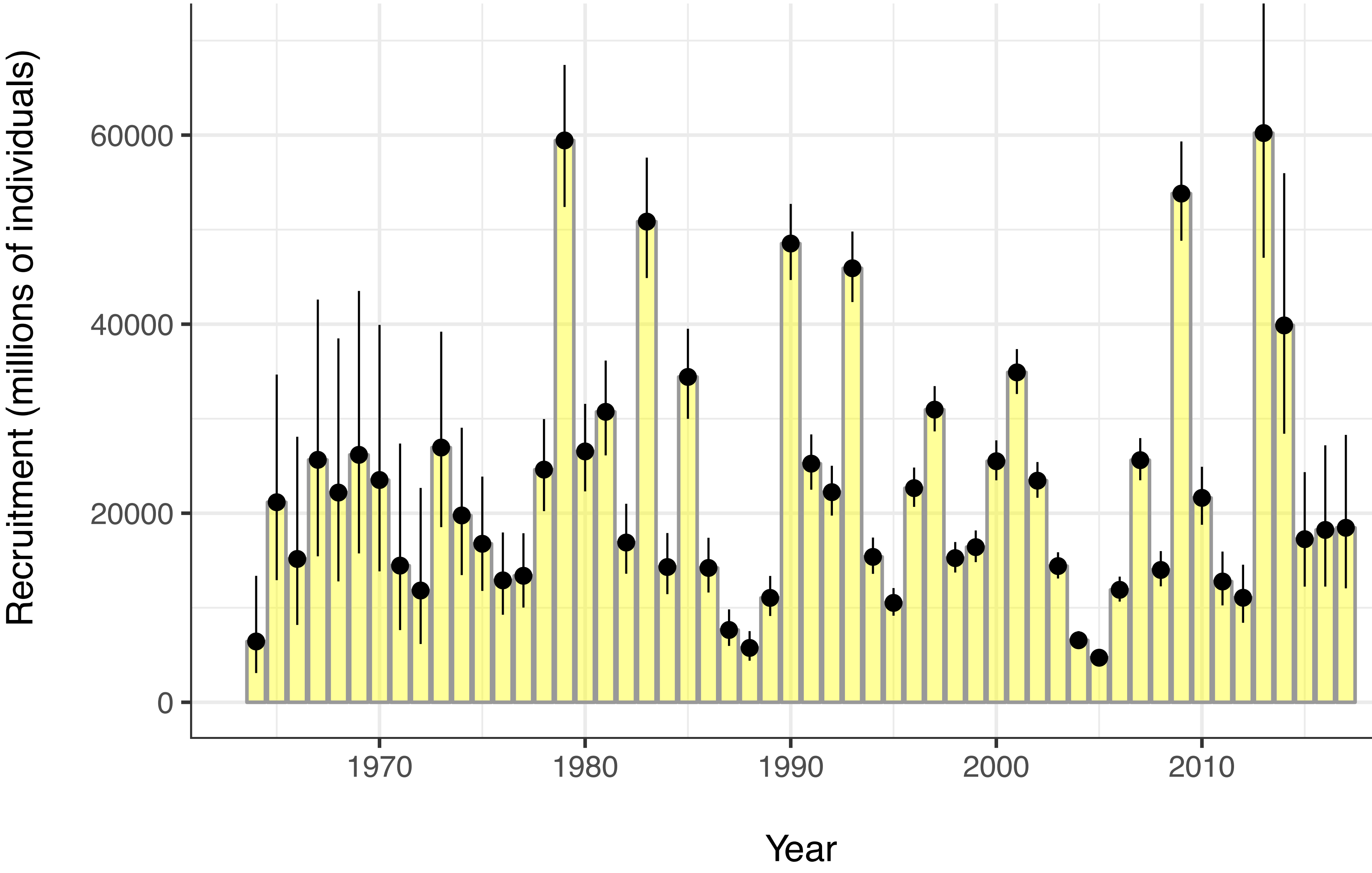
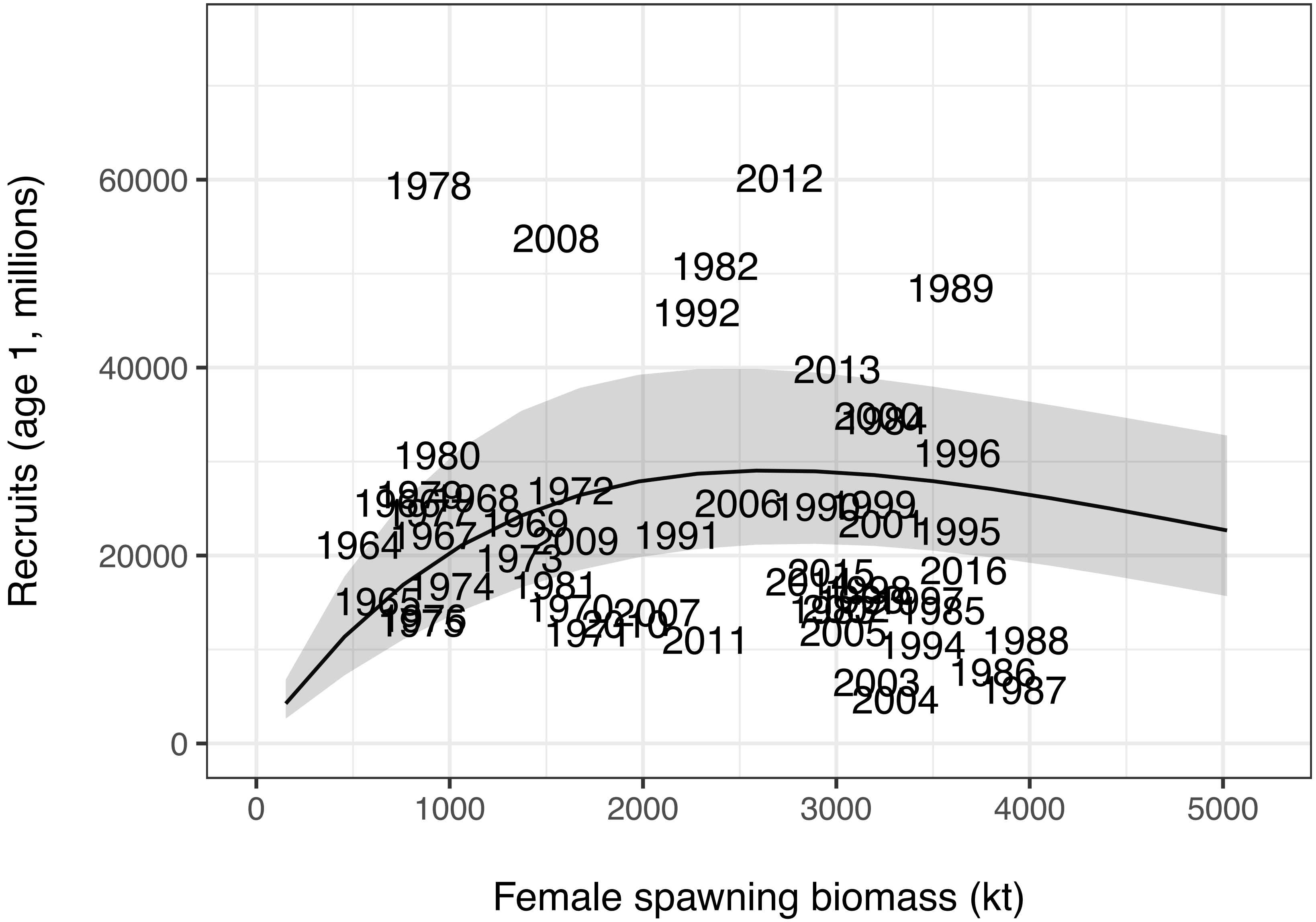


Age
Year
F
0.6
0.4
0.2
Age 6 F (x10)
0
1
2
3
4
5
6
7
8
9
10
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

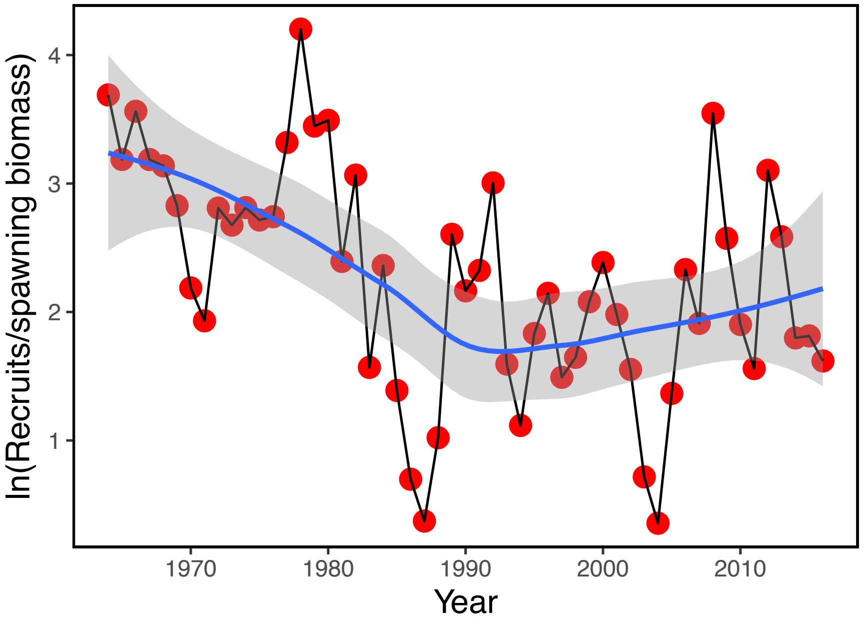
NOAA



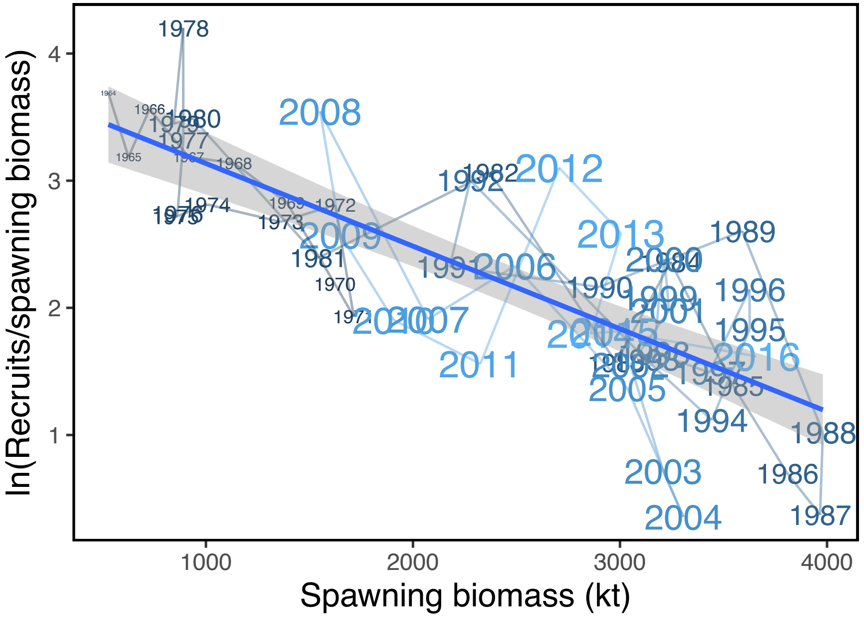
NOAA FISHERIES



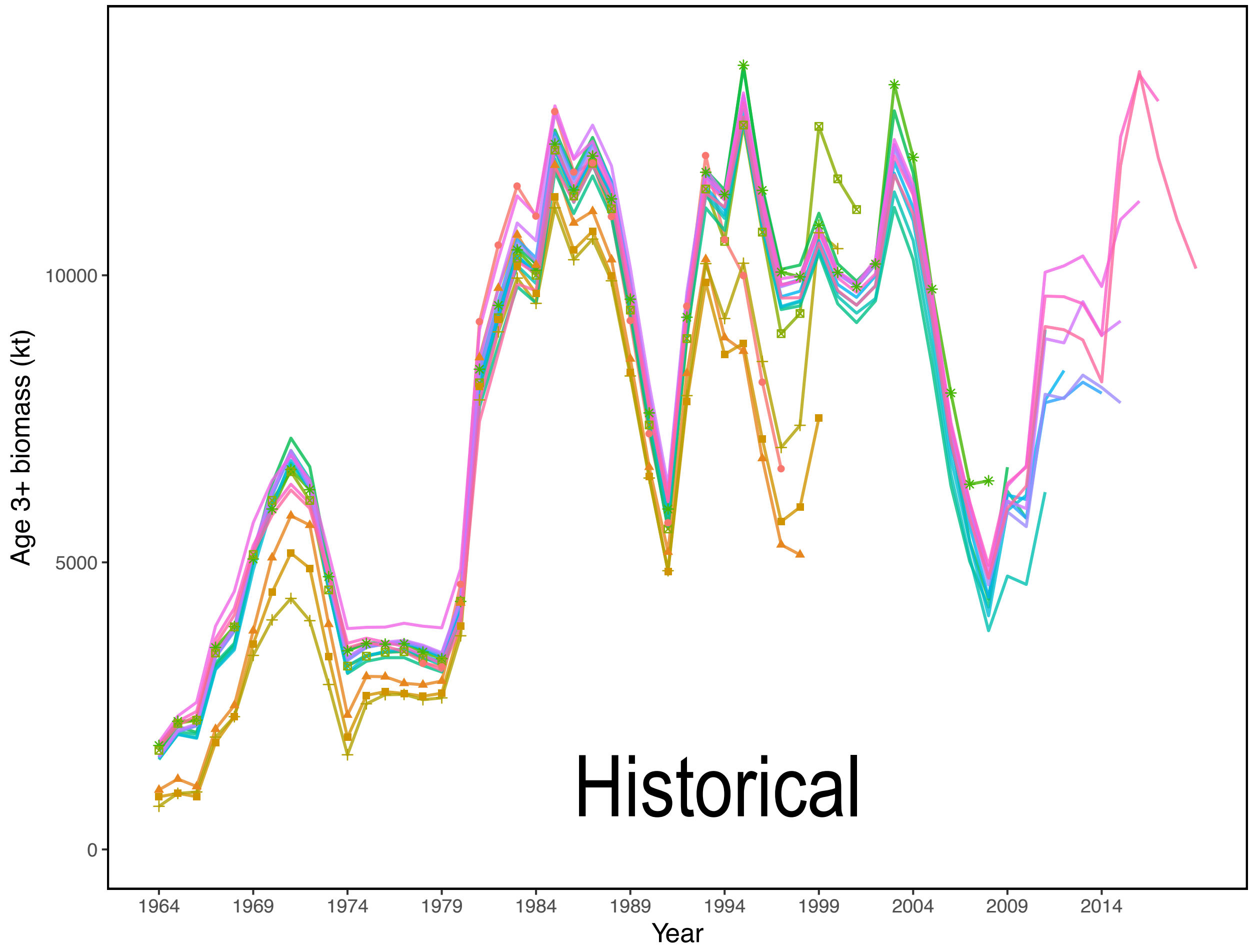
Recruits (age 1, millions)
0
20000
40000
60000
0
1000
2000
3000
4000
5000
Female spawning biomass (kt)



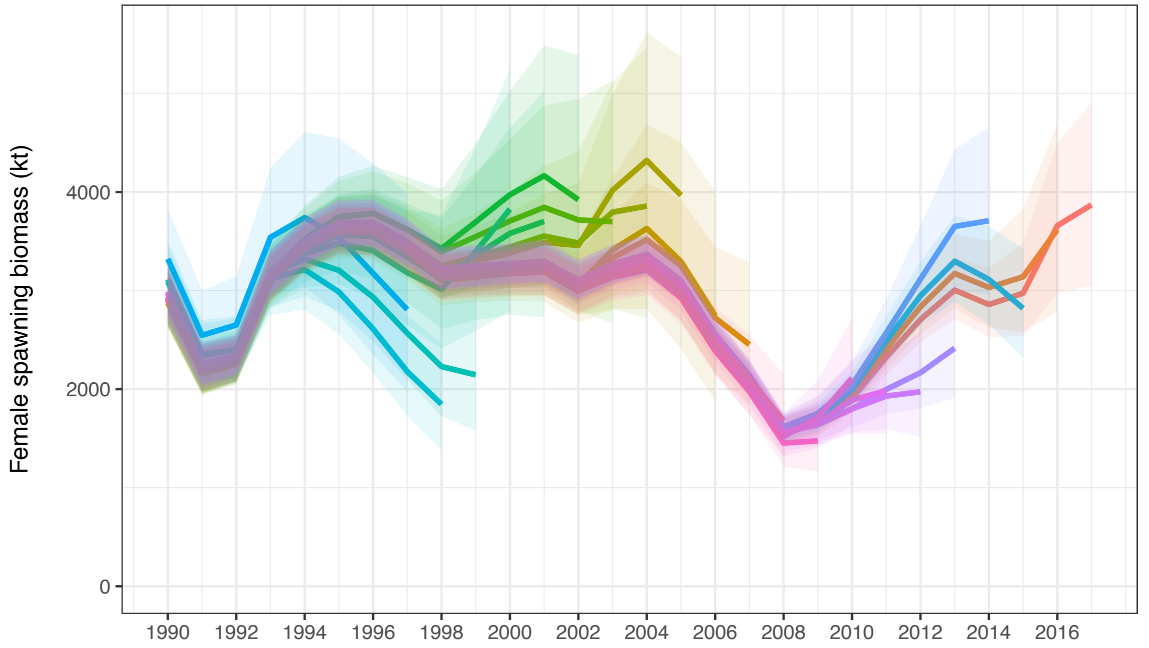
ln(Recruits/spawning biomass)
1
2
3
4
1970
1980
1990
2000
2010
Year



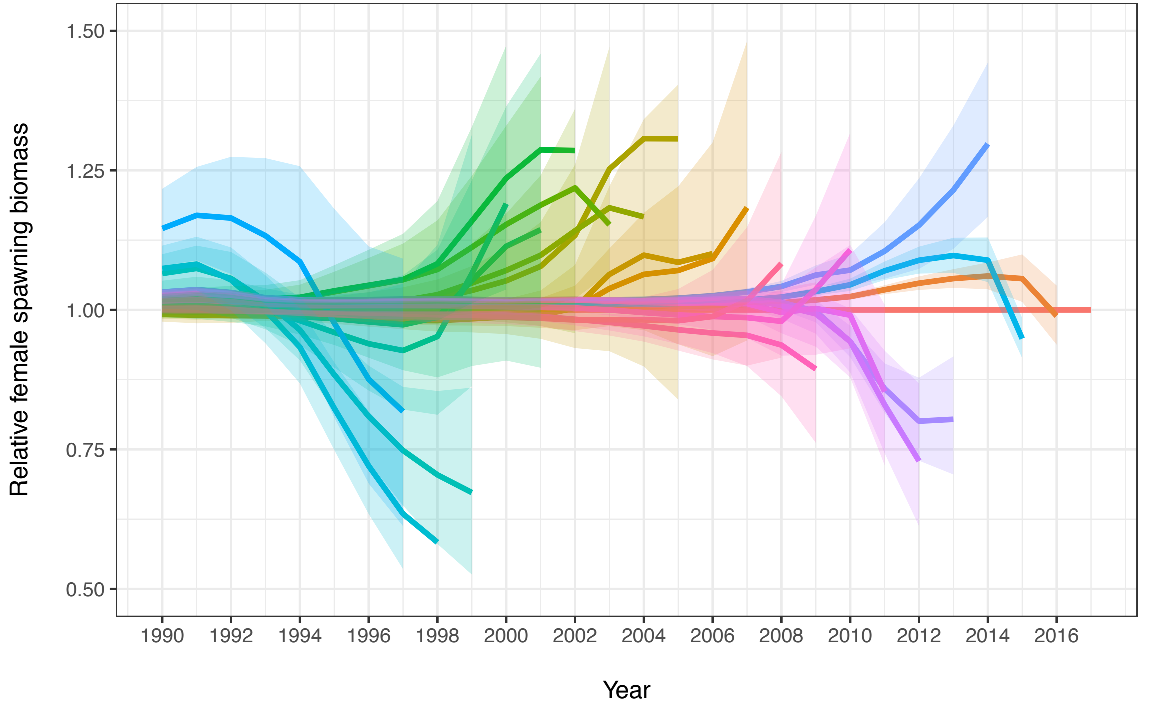
ln(Recruits/spawning biomass)
1
2
3
4
1000
2000
3000
4000
Spawning biomass (kt)



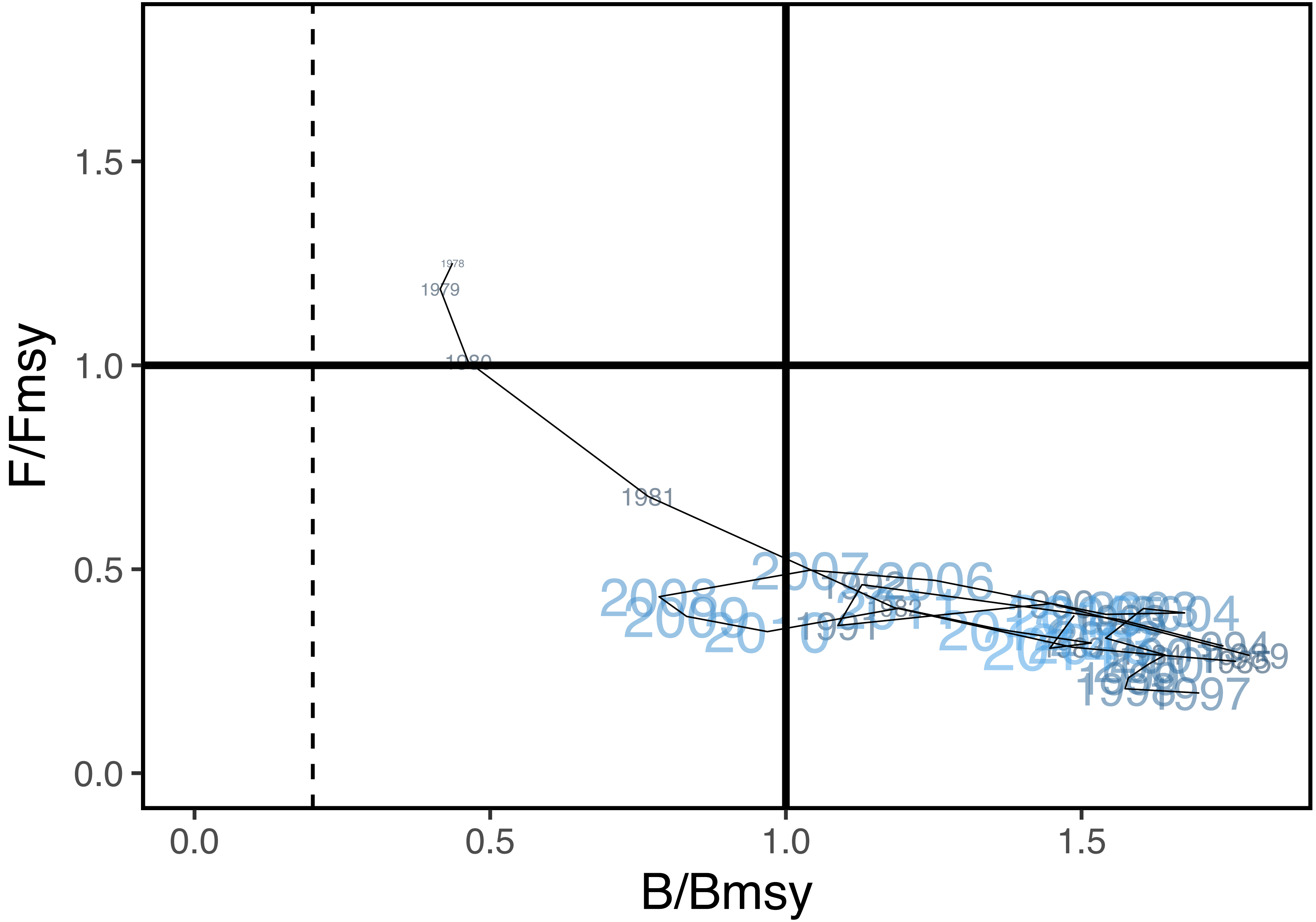
Retrospective patterns



2017 model



Relative trend



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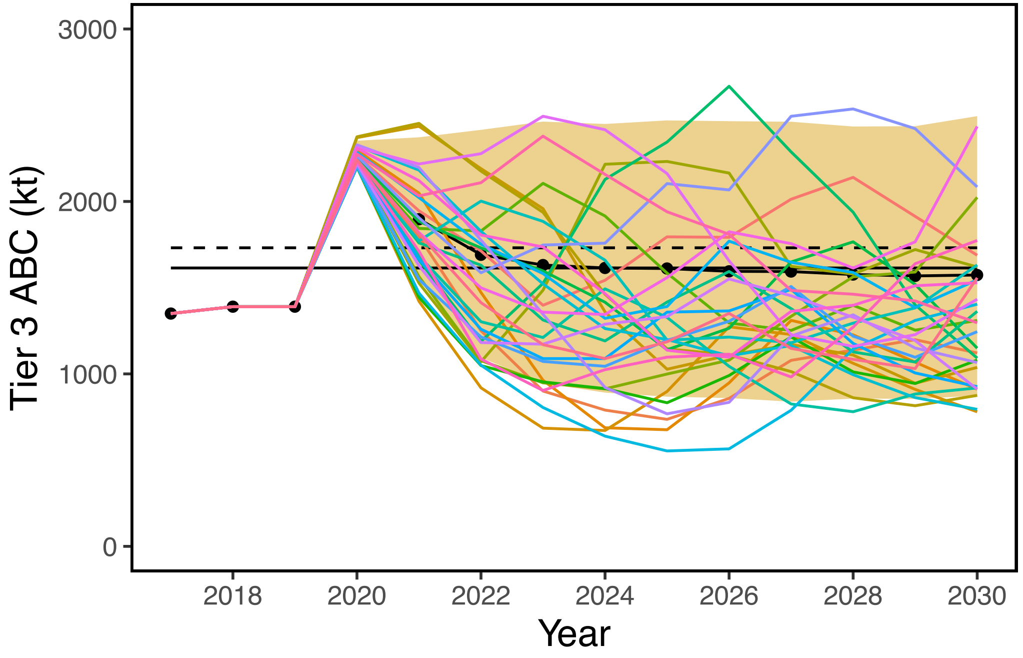
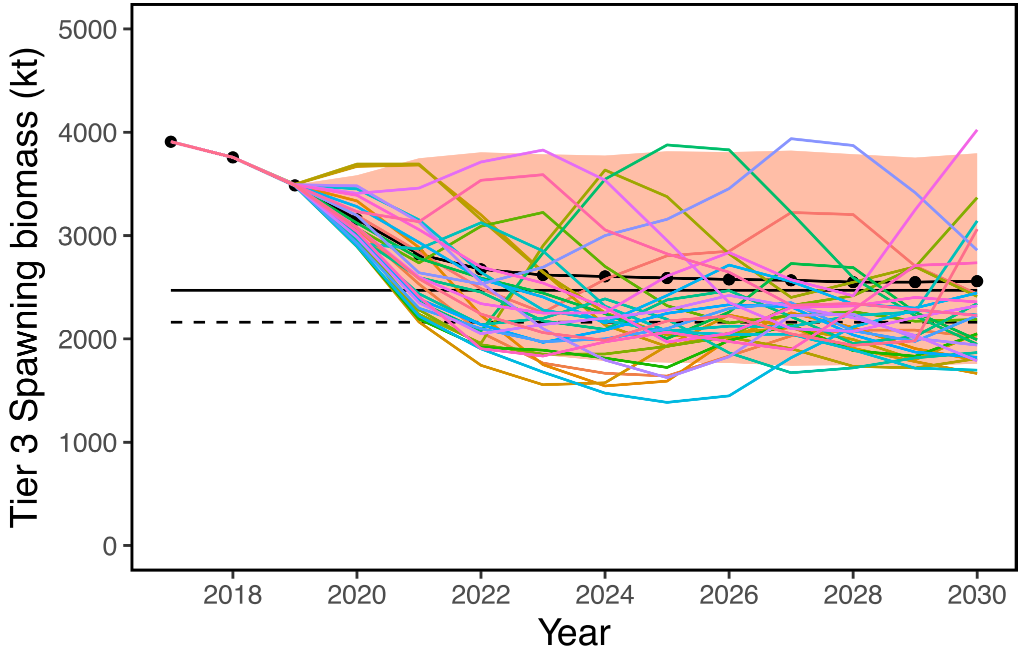
Quantity	As estimated or *recommended this* year for: 2018	2019
M (natural mortality rate, ages 3+)	0.3	0.3
Tier	1a	1a
Projected total (age 3+) biomass (t)	10,967,000 t	10,119,000 t
Projected female spawning biomass (t)	3,679,000 t	3,365,000 t
B_0	5,394,000 t	5,394,000 t
B_{msy}	2,043,000 t	2,043,000 t
F_{OFL}	0.622	0.622
$maxF_{ABC}$	0.466	0.466
F_{ABC}	0.336	0.336
OFL	4,797,000 t	4,592,000 t
$maxABC$	3,598,000 t	3,445,000 t
ABC	2,592,000 t	2,467,000 t
Status	2016	2017
Overfishing	No	n/a
Overfished	n/a	No
Approaching overfished	n/a	No





High ABC and OFL…but as always caveats…

- **Shift in distribution?**
  - Ecosystem survey in Northern Bering Sea this summer found increases in pollock
- **Relative few one-year-old pollock** in 2017 trawl survey

- Relatively few old fish in survey (not unexpected)

- Future catches near current levels will require more effort
  - Biomass expected to decline, quite quickly
  - Even higher salmon bycatch?

Figure added and text edit (page 25)

8. Finally, given the same estimated aggregate fishing effort in 2017, the estimated stock trend is downwards except at low catch levels (a replacement yield of 590 kt is the amount that would maintain the spawning stock constant). Furthermore, the ability to catch the same amount as in 2017 through to 2020 will require about 35% more effort with a decline in spawning biomass of about 28% compared to the current level (based on expected average recruitment).

8. Finally, given the same estimated aggregate fishing effort in 2017, the estimated stock trend is downwards except at low catch levels (a replacement yield of 560 kt is the amount that would maintain the spawning stock constant). Furthermore, the ability to catch the same amount as in 2017 through to 2021 will require about 25% more effort with a decline in spawning biomass of about 20% compared to the current level (based on expected average recruitment; Fig. 41).

New Figure (41) to support last bullet point…

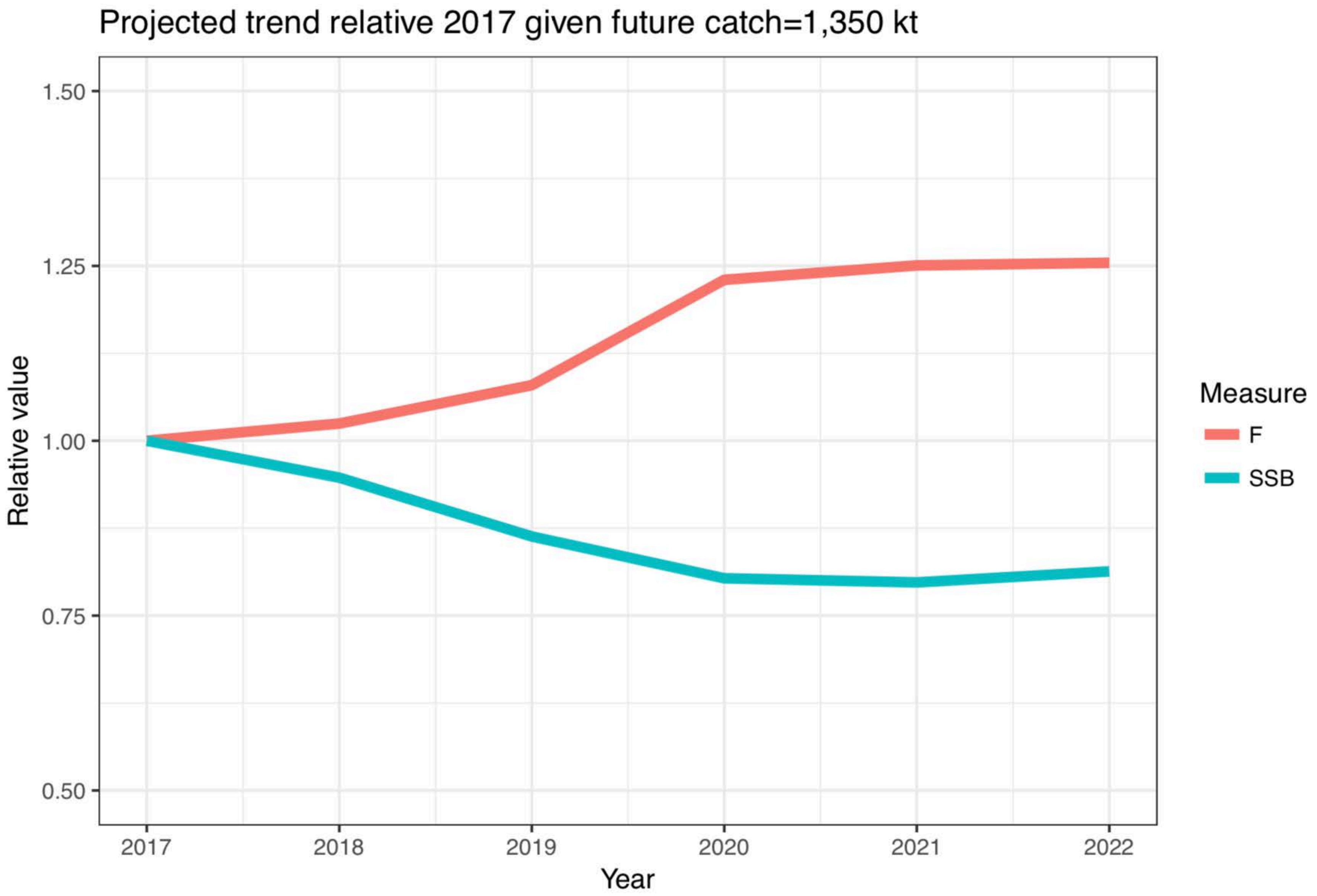
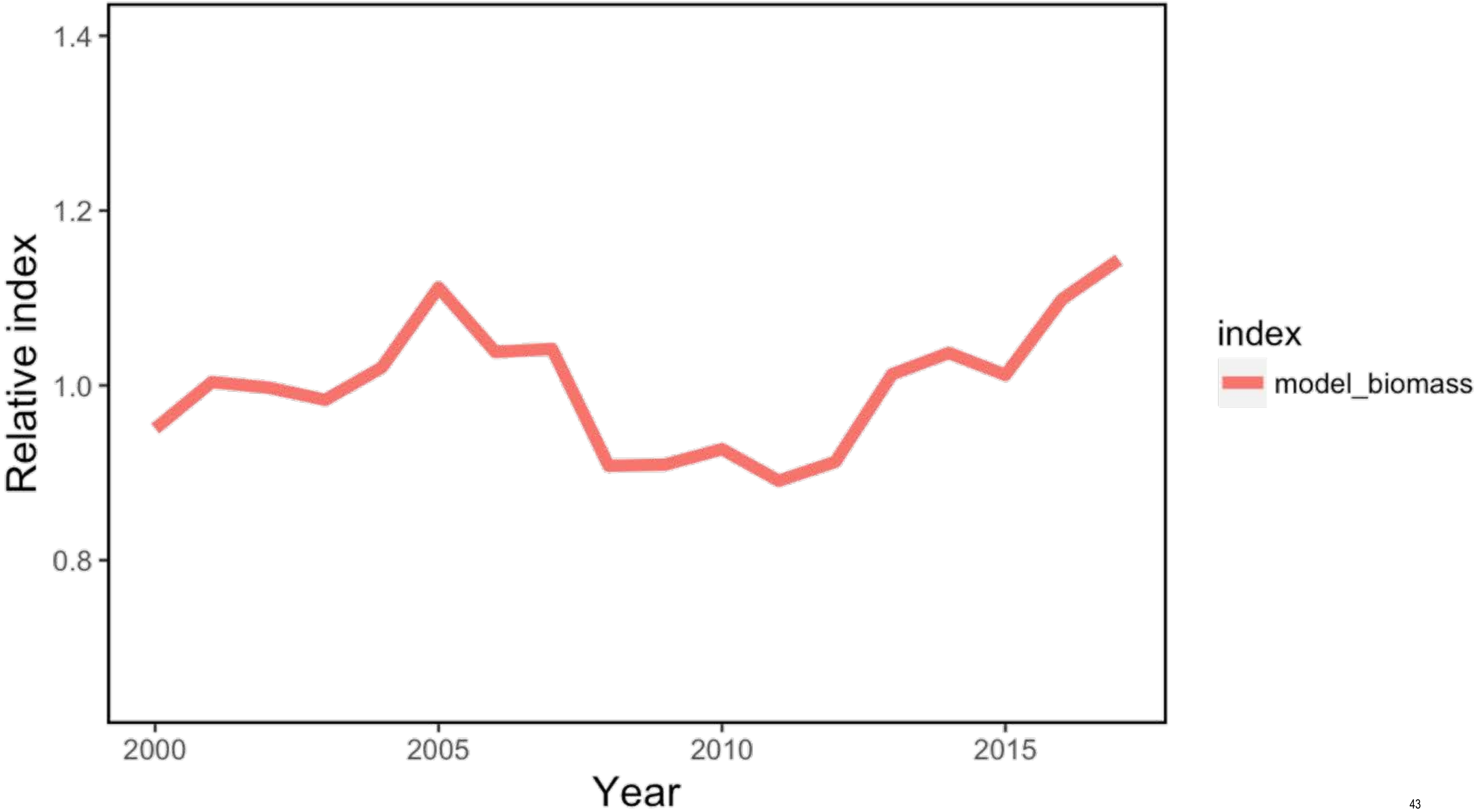
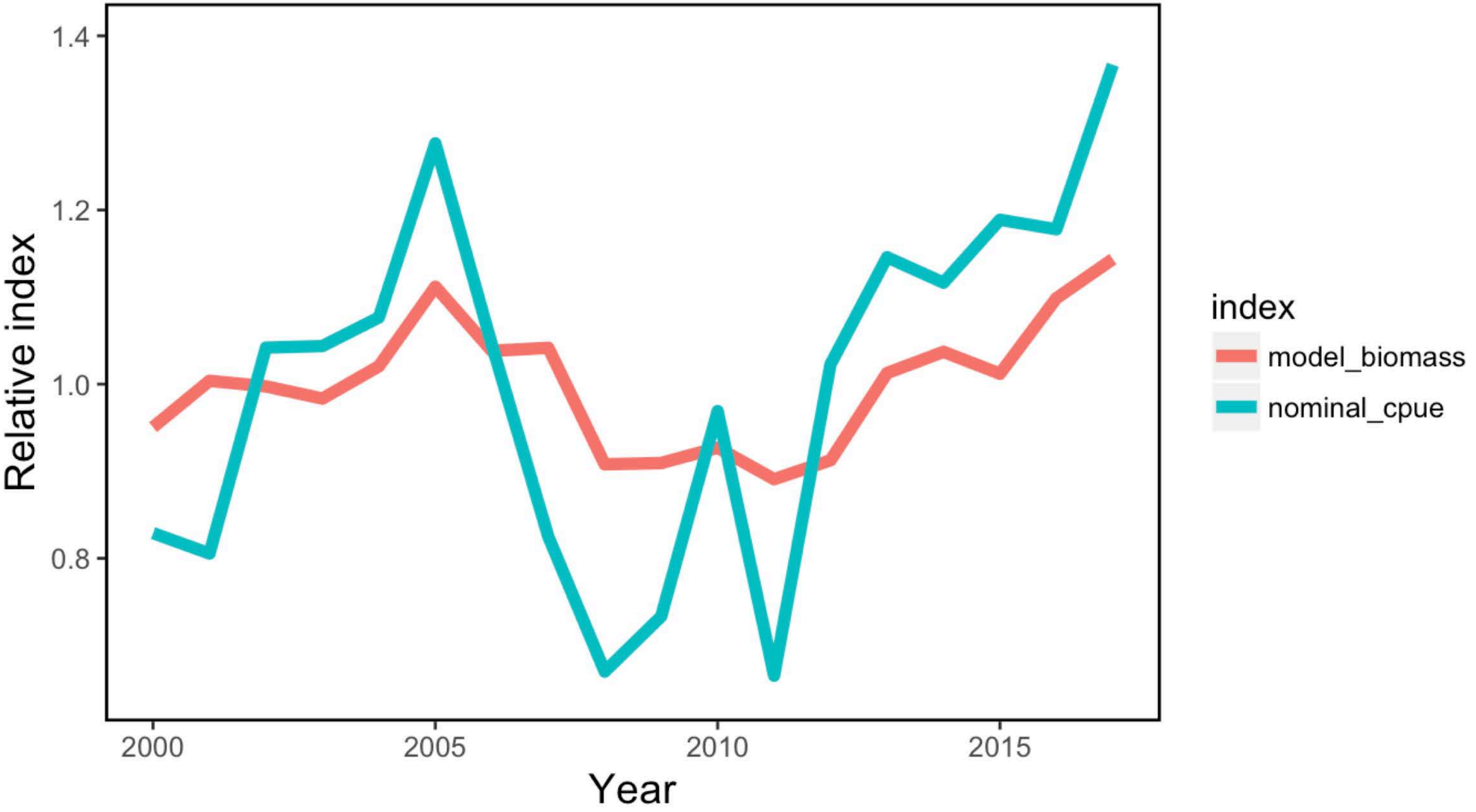
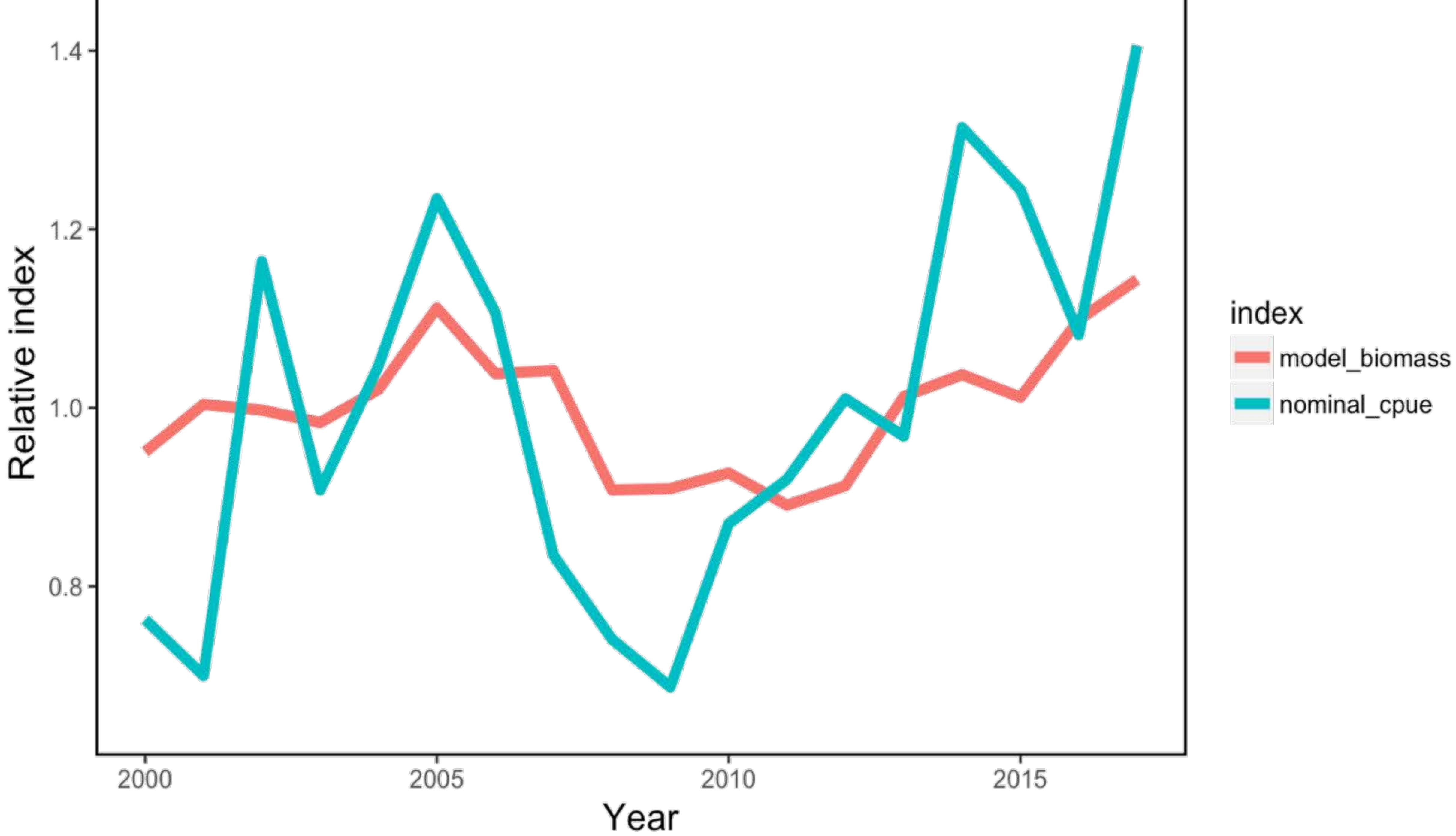


Figure 41: Projected fishing mortality and spawning biomass relative to 2017 values under constant catch of 1.35 million t


Relative index
1.4
1.2
1.0
0.8
2000
2005
2010
2015
Year
index
model_biomass



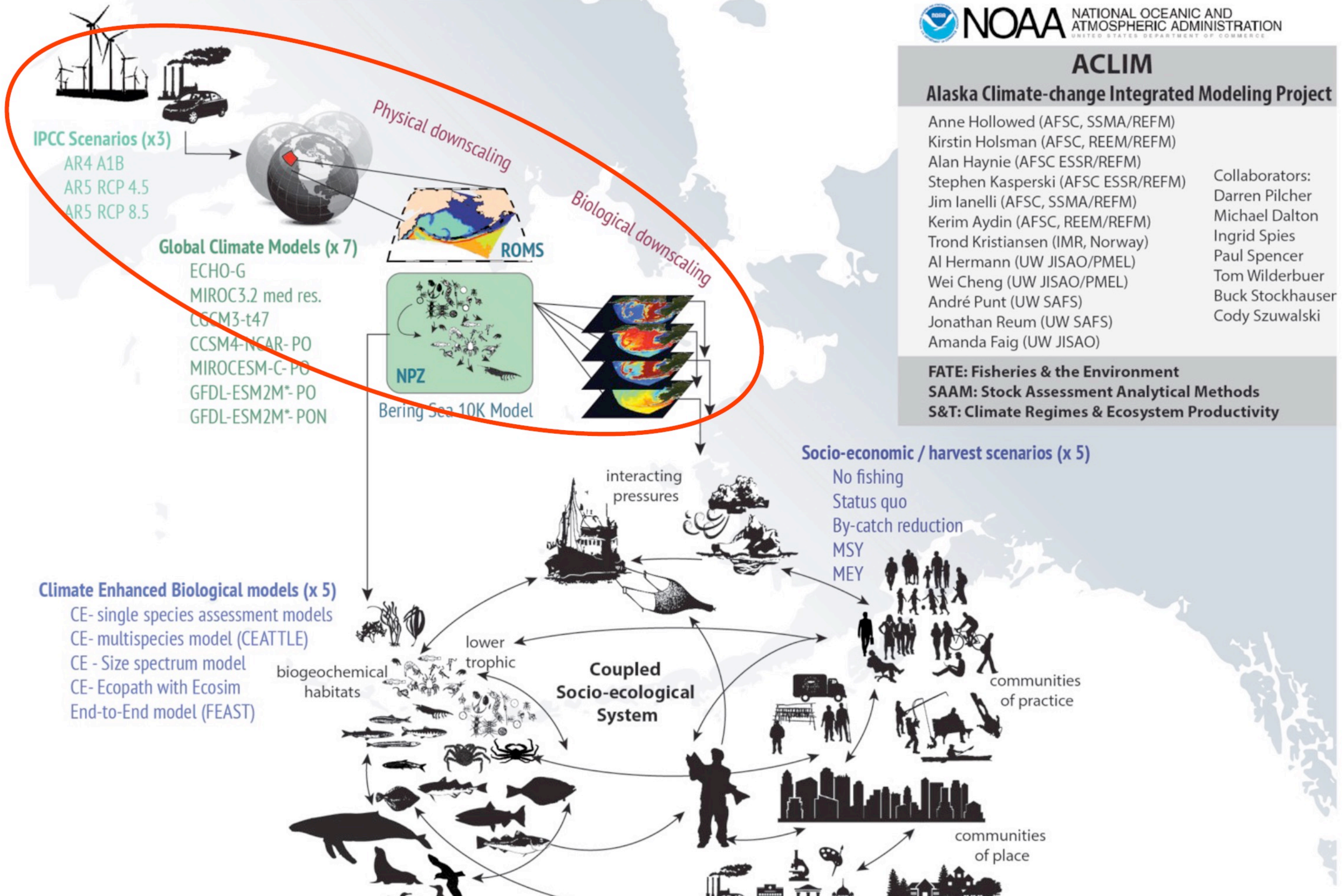
1.4
1.2
1.0
0.8
Relative index
2000
2005
2010
2015
Year
index
model_biomass
nominal_cpue



Relative index
1.4
1.2
1.0
0.8
2000
2005
2010
2015
Year
index
model_biomass
nominal_cpue

Other research

- Genetics sampling
- Multi-species modeling/prediction under climate change


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE
ACLIM
Alaska Climate-change Integrated Modeling Project
Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
Alan Haynie (AFSC ESSR/REFM)
Stephen Kasperski (AFSC ESSR/REFM)
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Trond Kristiansen (IMR, Norway)
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)
Jonathan Reum (UW SAFS)
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Collaborators:
Darren Pilcher
Michael Dalton
Ingrid Spies
Paul Spencer
Tom Wilderbuer
Buck Stockhauser
Cody Szuwalski
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity
IPCC Scenarios (x3)
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5
Physical downscaling
Biological downscaling
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
ROMS
NPZ
Bering Sea 10K Model
Socio-economic / harvest scenarios (x 5)
No fishing
Status quo
By-catch reduction
MSY
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

2017 Multi-species Stock Assessment for walleye pollock, Pacific cod, and arrowtooth flounder in the Eastern Bering Sea

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November 2017

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Executive Summary

This is a three species stock assessment for walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*) and arrowtooth flounder (*Atheresthes stomias*), from the Eastern Bering Sea (EBS), Alaska updated from Holsman et al.(2016). Results are presented from models estimated and projected without trophic interactions (single-species mode, SSM) and with trophic interactions (multi-species mode, MSM).

Definition	Equation	
Predation mortality	$\mathrm{M2}_{ij,y} = \sum_{pa} \left(\frac{N_{pa,y} \delta_{pa,y} \bar{S}_{paij}}{\left(\sum_{ij} \bar{S}_{paij} B_{ij,y}\right) + B_p^{other} \left(1 - \sum_{ij} \left(\bar{S}_{paij}\right)\right)} \right)$	T2.1
Predator-pery suitability	$\bar{S}_{paij} = \frac{1}{n_y} \sum_y \left(\frac{\frac{U_{paij}}{B_{ij,y}}}{\sum_{ij} \left(\frac{U_{paij}}{B_{ij,y}}\right) + \frac{1 + \sum_{ij} U_{paij}}{B_p^{other}}} \right)$	T2.2
Mean gravimetric diet proportion	$\bar{U}_{paij} = \frac{U_{paij}}{n_y}$	T2.3
Individual specific ration (kg $\mathrm{kg}^{-1}\mathrm{yr}^{-1}$)	$\delta_{pa,y} = \hat{\varphi}_p \alpha_\delta W_{pa,y}^{(1+\beta_\delta)} f\left(T_y\right)_p$	T2.3
Temperature scaling consumption algorithm	$f\left(T_y\right)_p = V^X e^{(X(1-V))}$	T2.5
	$V = \left(T_p^{cm} - T_y\right) / \left(T_p^{cm} - T_p^{co}\right)$	T2.5a
	$X = \left(Z^2 \left(1 + (1 + 40/Y)^{0.5}\right)^2\right) / 400$	T2.5b
	$Z = ln\left(Q_p^c\right)\left(T_p^{cm} - T_p^{co}\right)$	T2.5c
	$Y = ln\left(Q_p^c\right)\left(T_p^{cm} - T_p^{co} + 2\right)$	T2.5d

Table 4.	*SSM*	*MSM*
Total survey biomass		
Pollock	0.52	0.52
P. cod	0.81	0.82
Arrowtooth	0.66	0.65
Survey age composition		
Pollock	0.86	0.85
P. cod	0.89	0.88
Arrowtooth	0.54	0.56

Definition	Equation		
Recruitment	$N_{i,1,y} = R_{i,y} = R_{0,i} e^{\tau_{i,y}}$	$\tau_{i,y} \sim N(0, \sigma^2)$	T1.1
Catch (numbers)	$C_{ij,y} = \frac{F_{ij,y}}{Z_{ij,y}} \left(1 - e^{-Z_{ij,y}}\right) N_{ij,y}$		T1.2
Total yield (kg)	$Y_{i,y} = \sum_j^{A_i} \left(\frac{F_{ij,y}}{Z_{ij,y}} \left(1 - e^{-Z_{ij,y}}\right) N_{ij,y} W_{ij,y} \right)$		T1.3
Biomass at age (kg)	$B_{ij,y} = N_{ij,y} W_{ij,y}$		T1.4
Spawning biomass at age (kg)	$SSB_{ij,y} = B_{ij,y} \rho_{ij}$		T1.5
Total mortality at age	$Z_{ij,y} = \mathrm{M1}_{ij} + \mathrm{M2}_{ij} + F_{ij}$		T1.6
Total mortality at age	$F_{ij,y} = F_{0,i} e^{\epsilon_{i,y} S_{ij}^f}$	$\epsilon_{i,y} \sim N\left(0, \sigma_{\mathrm{F},i}^2\right)$	T1.7
Weight at age (kg)	$W_{ij,y} = W_{\infty,iy} \left(1 - e^{(-K_i(1-d_{i,y})(j-t_{0,i}))}\right)^{\frac{1}{1-d_{i,y}}}$		T1.8a
	$d_{i,y} = e^{(\alpha_{d,i,y} + \alpha_{0,d,i} + \beta_{d,i} T_y)}$		T1.8b
	$W_{\infty,iy} = \left(\frac{H_i}{K_i}\right)^{1/(1-d_{i,y})}$		T1.8c
Bottom trawl survey biomass (kg)	$\hat{\beta}_{i,y}^s = \sum_j^{A_i} \left(N_{ij,y} e^{-0.5 Z_{ij,y}} W_{ij,y} S_{ij}^{\mathrm{S}}\right)$		T1.9
Acoustic survey biomass (kg)	$\hat{\beta}_y^{eit} = \sum_j^{A_i} \left(N_{1j,y} e^{-0.5 Z_{1j,y}} W_{1j,y} S_{1j}^{eit} q_{1,j}^{eit}\right)$	(pollock only)	T1.10
Fishery age composition	$\hat{O}_{ij,y}^f = \frac{C_{ij,y}}{\sum_j C_{ij,y}}$		T1.11
Bottom trawl age composition	$\hat{O}_{ij,y}^s = \frac{N_{ij,y} e^{0.5(-Z_{ij,y})} S_{ij}^{\mathrm{S}}}{\sum_j \left(N_{ij,y} e^{0.5(-Z_{ij,y})} S_{ij}^{\mathrm{S}}\right)}$		T1.12
Acoustic trawl age composition	$\hat{O}_{1j,y}^{eit} = \frac{N_{1j,y} e^{-0.5 Z_{1j,y}} S_{1j}^{eit} q_{1,j}^{eit}}{\sum_j \left(N_{1j,y} e^{-0.5 Z_{1j,y}} S_{1j}^{eit} q_{1,j}^{eit}\right)}$	(pollock only)	T1.13
Bottom trawl selectivity	$S_{ij}^{s} = \frac{1}{1 + e^{\left(-b_i^{\mathrm{S}} \cdot j - a_i^{\mathrm{S}}\right)}}$		T1.14
Fishery selectivity	$S_{ij}^f = e^{\eta_{ij}} \quad j \leq A_{\eta,i}$	$\eta_{ij} \sim N\left(0, \sigma_{f,i}^2\right)$	T1.15
	$S_{ij}^f = e^{\eta_{ij} A_{\eta,i}} \quad j > A_{\eta,i}$		
Proportion female	$\omega_{ij} = \frac{e^{-j M_{\mathrm{fem}}}}{e^{-j M_{\mathrm{fem}}} + e^{-j M_{\mathrm{male}}}}$		T1.16
Proportion of mature females	$\rho_{ij} = \omega_{ij} \phi_{ij}$		T1.17
Adjusted weight at age (kg)	$W_{ij,y} = W_{ij,y}^{\mathrm{fem}} \omega_{ij} + (1 - \omega_{ij}) W_{ij,y}^{\mathrm{male}}$		T1.18
Adjusted residual natural mortality (kg)	$\mathrm{M1}_{ij} = \mathrm{M1}_{ij}^{\mathrm{fem}} \omega_{ij} + (1 - \omega_{ij}) \mathrm{M1}_{ij,y}^{\mathrm{male}}$		T1.19

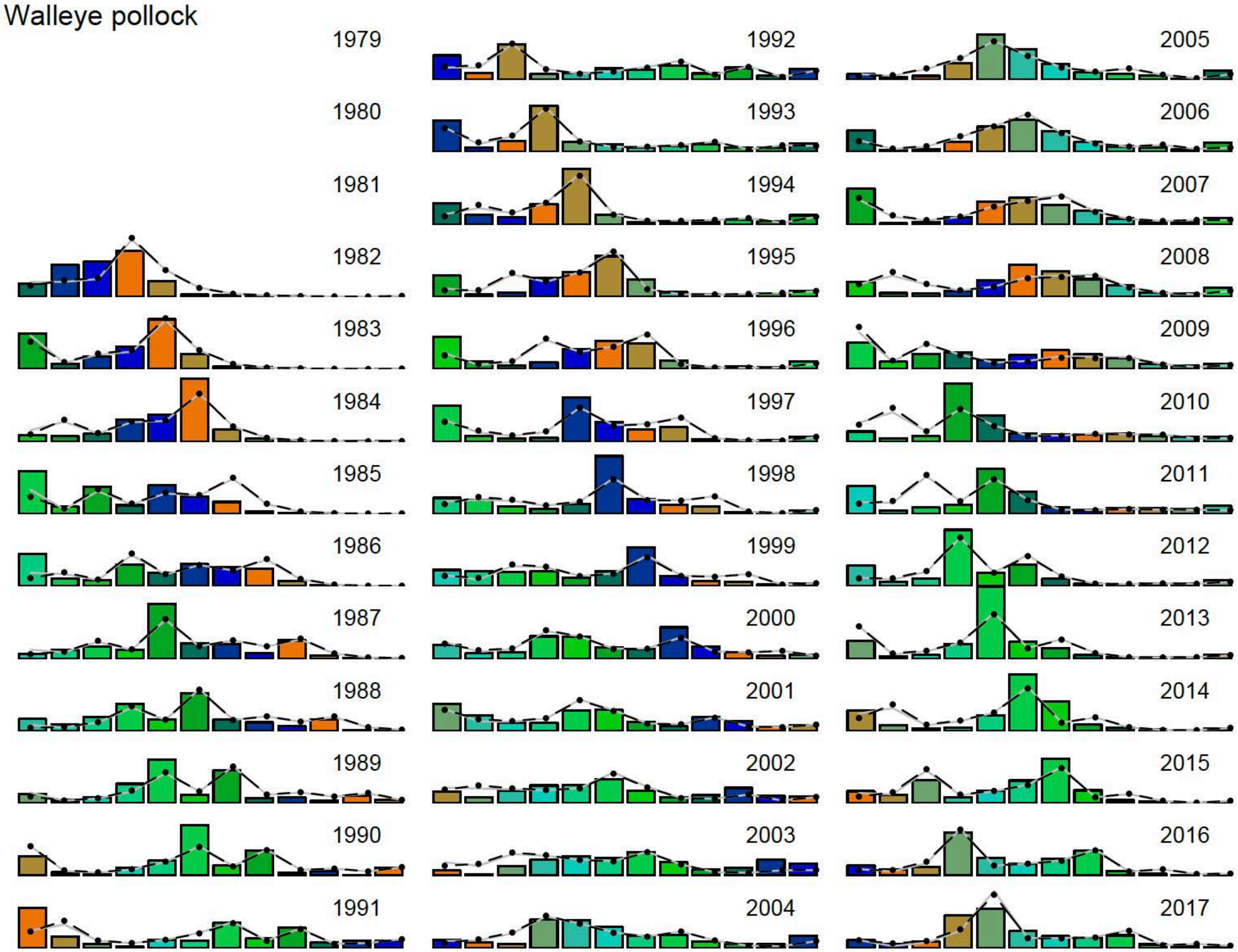

Figure 10: Survey age compostitions for walleye pollock. Colored bars represent observed values, black and gray points represent single- and multi-species fits to the data, respectively.

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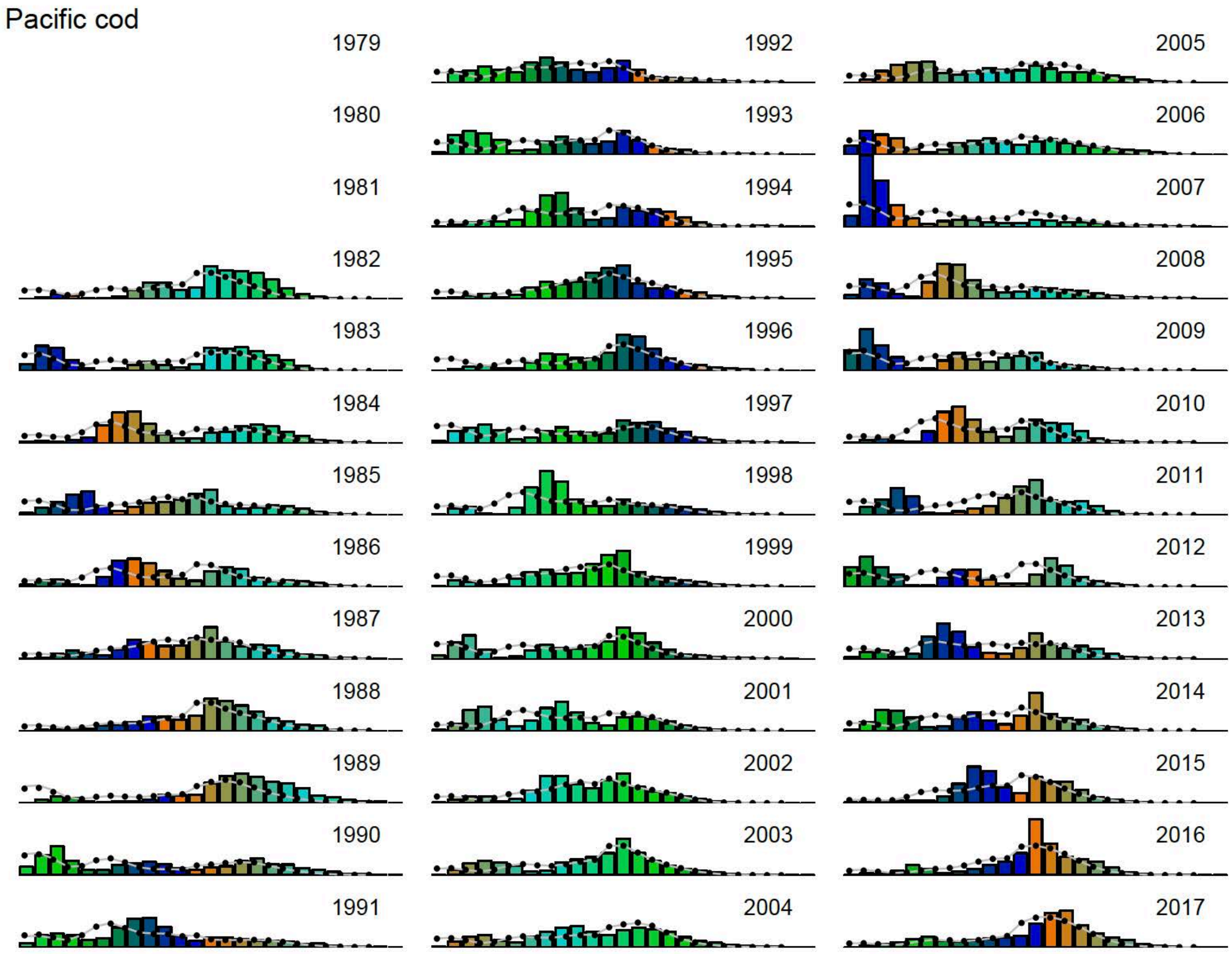
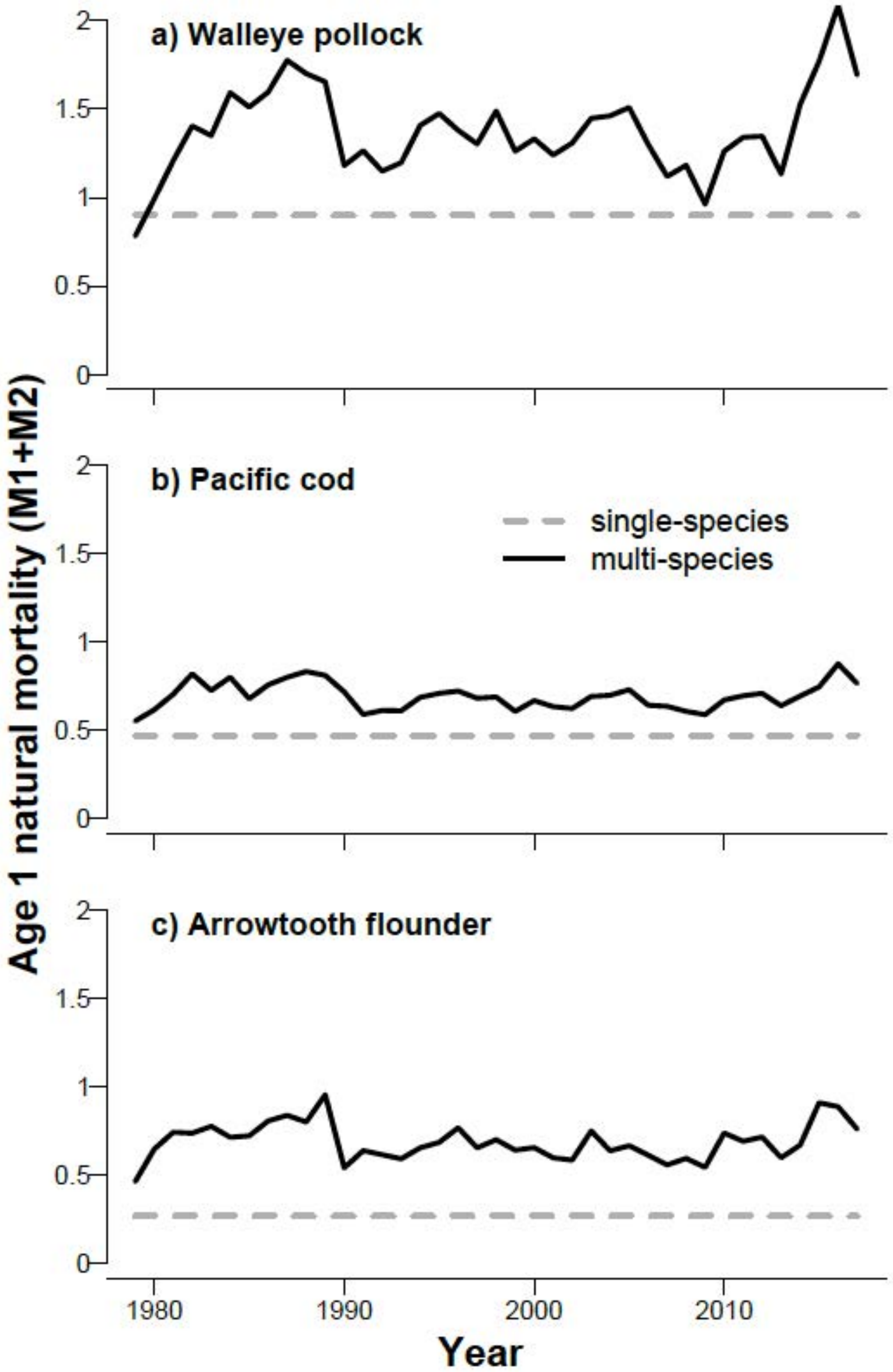
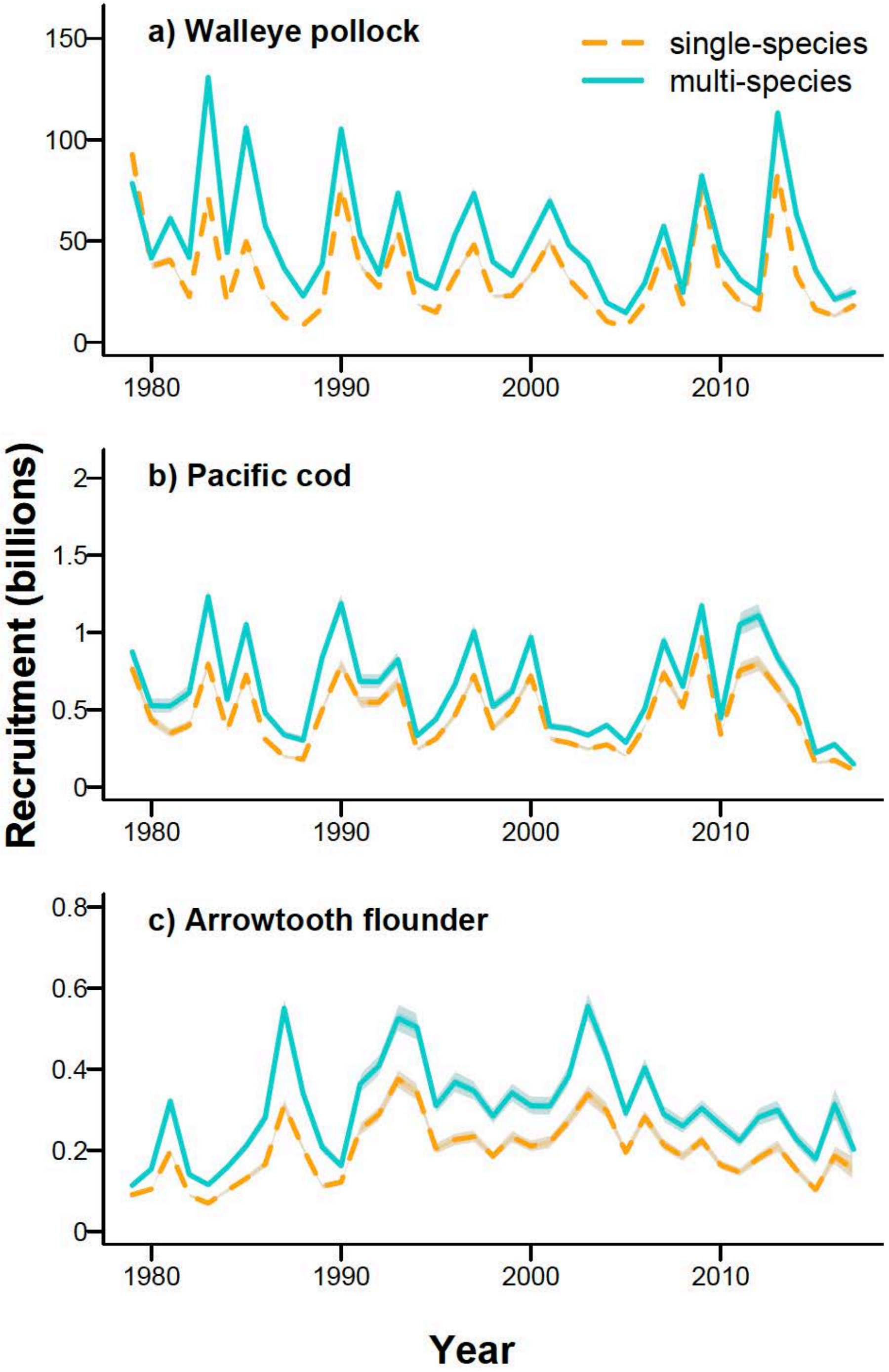


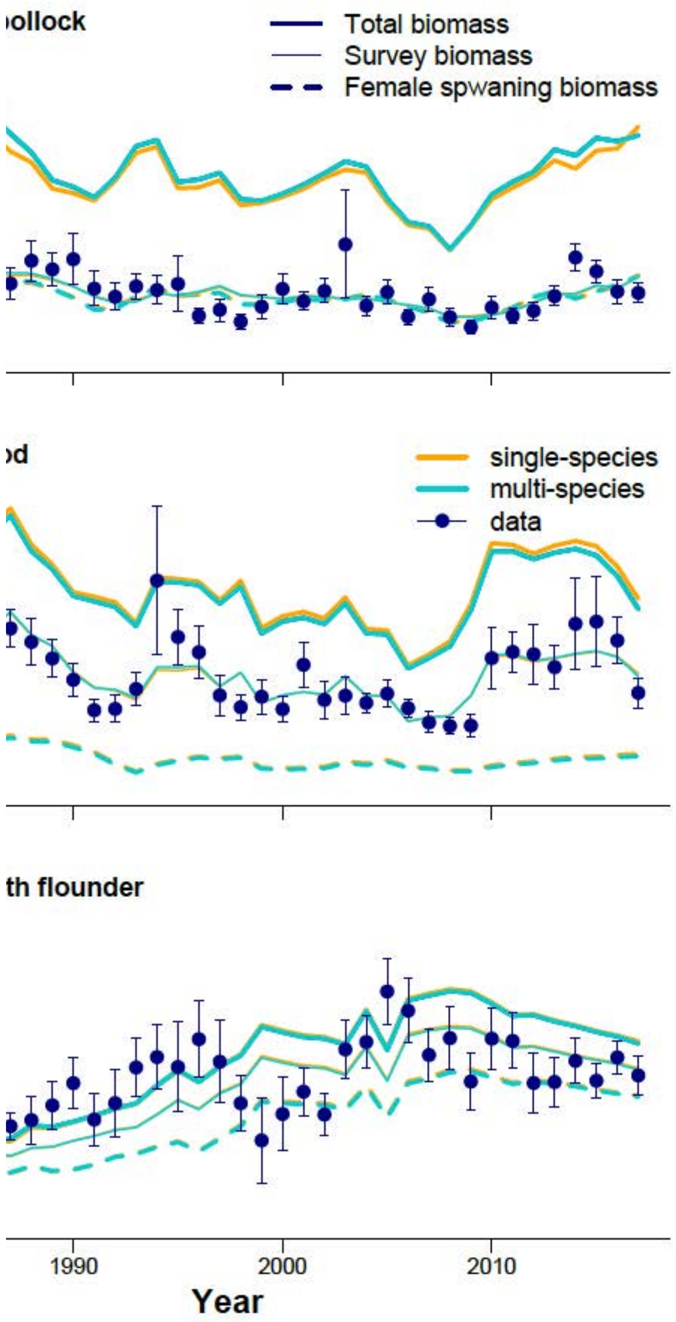
Figure 12: Survey length compostitions for Pacific cod Colored bars represent observed values, black and gray points represent single- and multi-species fits to the data, respectively.



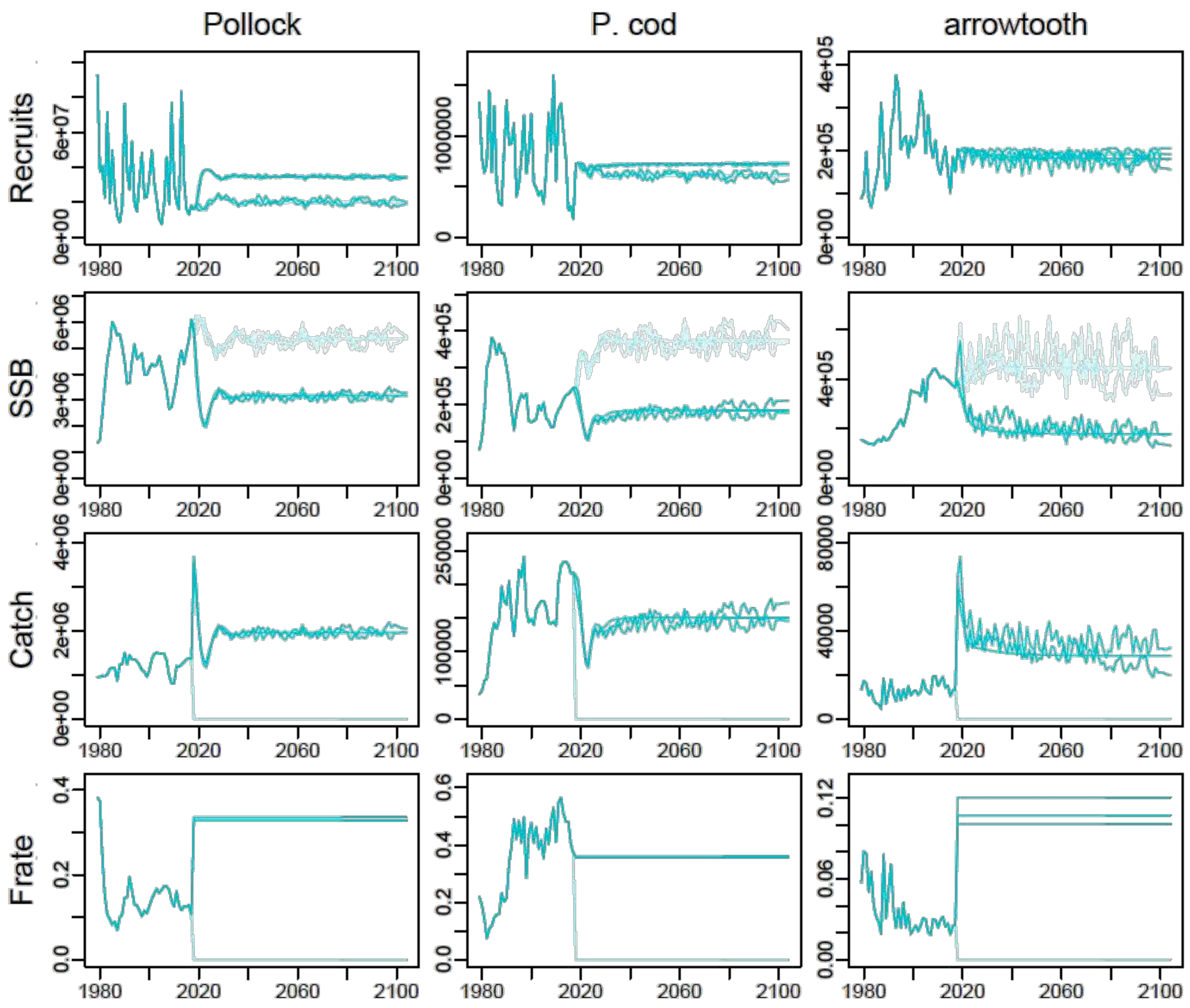
Age 1 natural mortality (M1+M2)
a) Walleye pollock
b) Pacific cod
single-species
multi-species
c) Arrowtooth flounder
0
0.5
1
1.5
2
1980
1990
2000
2010
Year



Recruitment (billions)
a) Walleye pollock
single-species
multi-species
0
50
100
150
b) Pacific cod
0
0.5
1
1.5
2
c) Arrowtooth flounder
0
0.2
0.4
0.6
0.8
1980
1990
2000
2010
Year



ollock
Total biomass
Survey biomass
Female spwaning biomass
od
single-species
multi-species
data
th flounder
1990
2000
2010
Year



Pollock
P. cod
arrowtooth
Recruits
SSB
Catch
Frate
1980
2020
2060
2100
0e+00
6e+07
0
1000000
2e+05
4e+05
3e+06
6e+06
2e+05
4e+05
2e+06
4e+06
100000
250000
40000
80000
0.0
0.2
0.4
0.6
0.00
0.06
0.12

11/13/17

Multi-species supplement

As estimated or recommended this year (2017) for:

Quantity	Walleye pollock		Pacific cod		Arrowtooth flounder	
	SSM	MSM	SSM	MSM	SSM	MSM
2017 M (age 1)	0.9	1.692	0.38	0.801	0.269	0.746
2017 Average 3+ M	0.3	0.311	0.38	0.38	0.226	0.227
Projected (age 3+) B_{2018} (t)	13,464,854	12,313,165	869,106	842,670	495,141	486,705
Projected SSB_{2018}(t)	5,831,610	5,852,470	231,702	226,771	395,277	391,310
*Projected $SSB_{0,target}$(t)	5,354,407	3,833,194	394,392	368,614	445,020	417,477
*Projected SSB_{target}(t)	3,173,340	3,101,376	197,965	190,330	178,019	167,000
**Target 2100 B/B_0	0.593	0.809	0.502	0.516	0.4	0.4
F_{target}	0.329	0.366	0.263	0.268	0.107	0.117
$F_{ABC,2018}$	0.161	0.168	0.202	0.202	0.053	0.055
ABC_{target}	3,657,230	3,978,190	185,006	184,317	55,944	59,904
ABC	1,954,180	2,034,666	147,374	144,210	28,695	29,398

** SSB is based on the projected SSB at 2100 (equilibrium)*

*** Target biomass ratios at year 2100 are based on Fmsy proxy of B/B_0=0.4, given the constraint that $B/B_0 > 0.35$ for every projection year.*

Pacific cod comparative BRPs

	2016 Assmnt	2016 CEATTLE-SSM	2016 CEATTLE-MSM	2017 Assmnt	2017 CEATTLE-SSM	2017 CEATTLE-MSM	
Projected total (age 0+) biomass (t)	1,110,000	*1,313,105*	*1,308,217*	807,000	*869,106*	*842,670*	*CEATTLE is age 3 + biomass*
Change between years				-27.3%	-33.8%	-35.6%	
2018 Projected female spawning biomass (t)	340,000	241,631	239,855	217,000	231,702	226,771	Maybe not comparable between CEATTLE and assmnt
Change between years				-36.2%	-4.1%	-5.5%	
B100%	620,000	435,039	415,105	548,000	394,392	368,614	
Change between years				-11.6%	-9.3%	-11.2%	
SSB40%	248000	174,503	166,030	219,000			
Change between years				-11.7%			
ABC	255,000	172,224	174,966	172,000	147,374	144,210	
Change between years				-32.5%	-14.4%	-17.6%	

Thanks!