

Eastern Bering Sea pollock and multi-species assessment

Photo: Mark Holsman

Overview

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Kirstin Holsman and Kerim Aydin



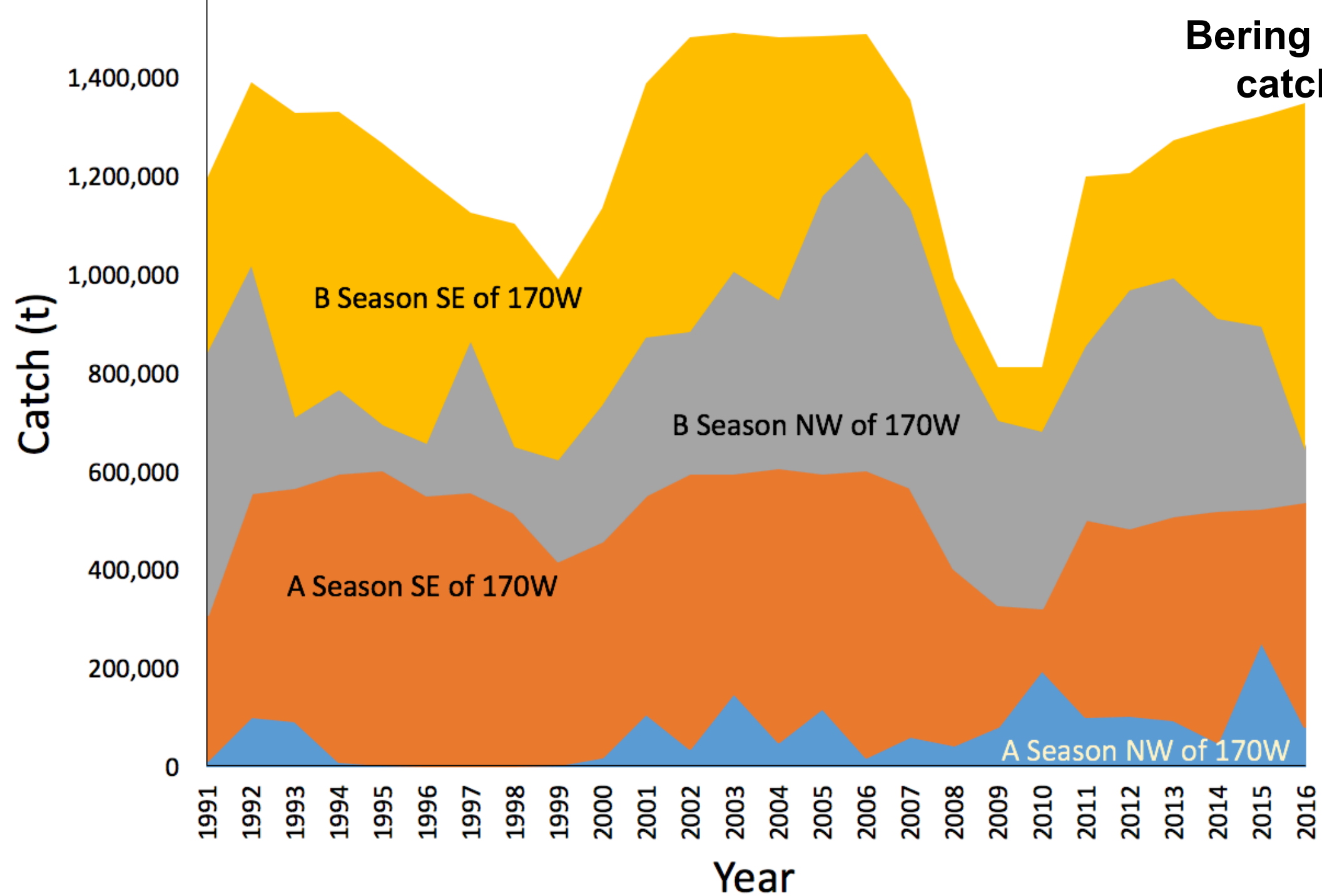
NOAA FISHERIES

Outline

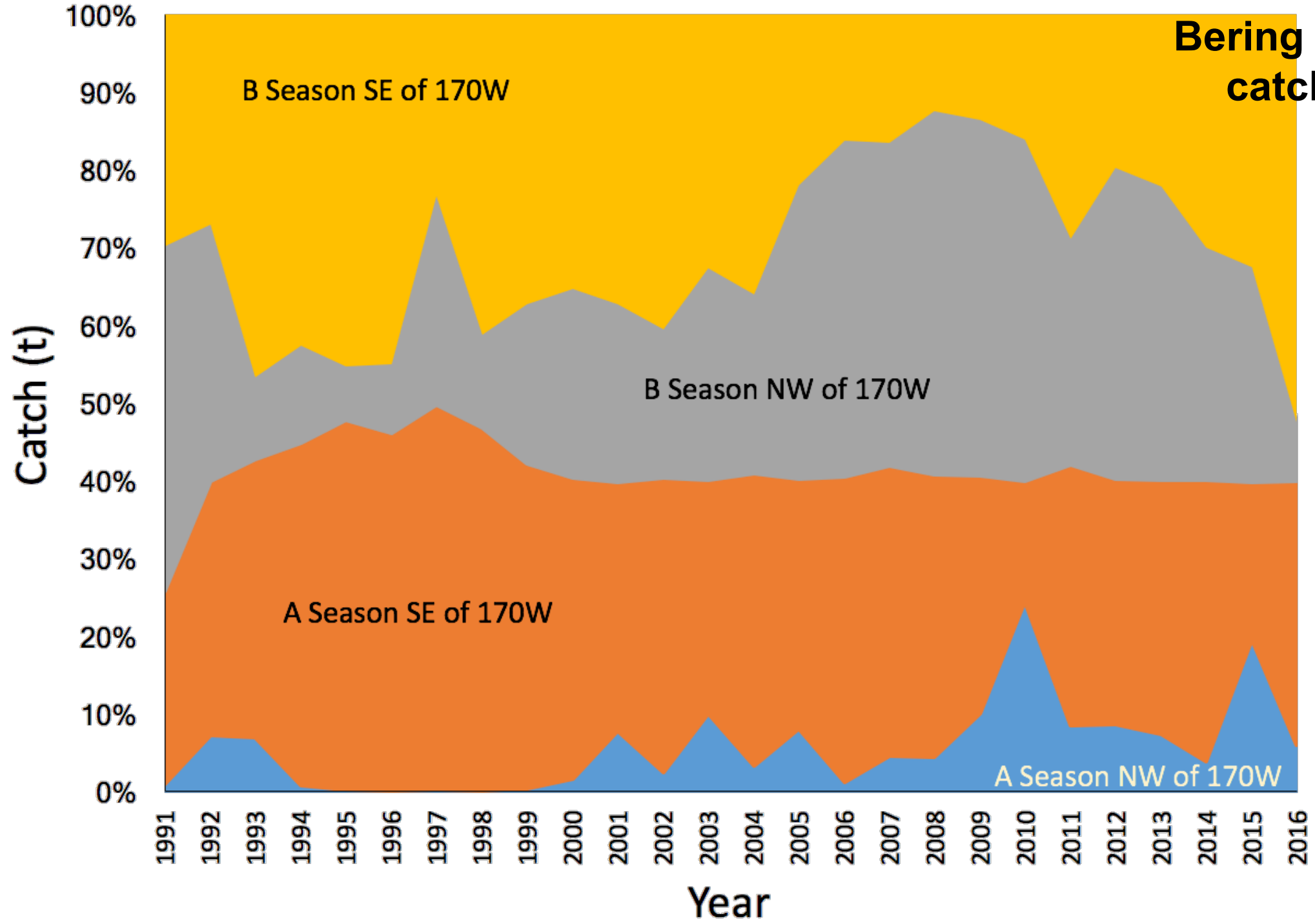
- Background
- Pollock
 - Fishing
 - Surveys
 - Assessment

- Multi-species modeling

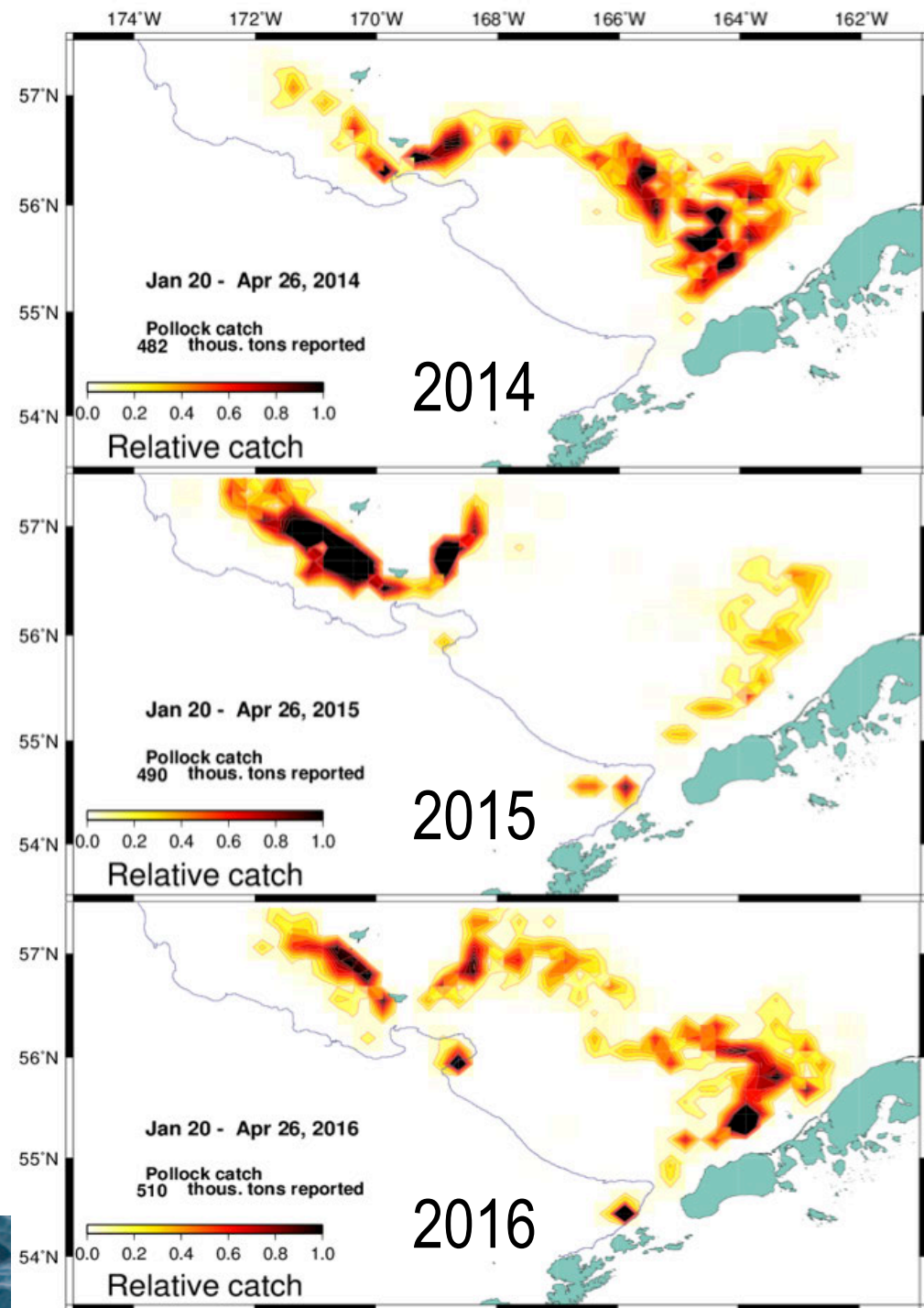
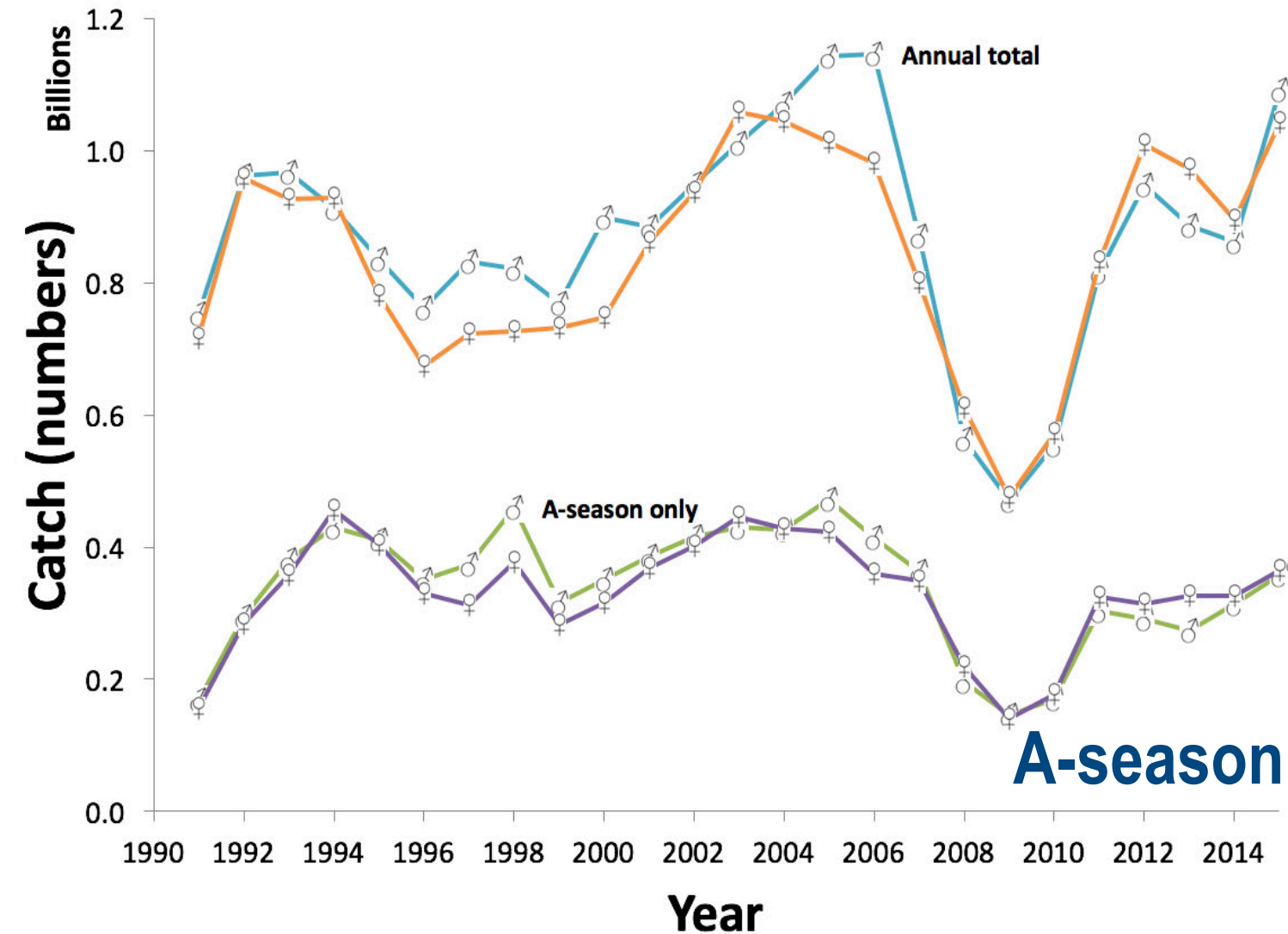
Bering Sea Pollock catch by season and area



Bering Sea Pollock catch by season and area

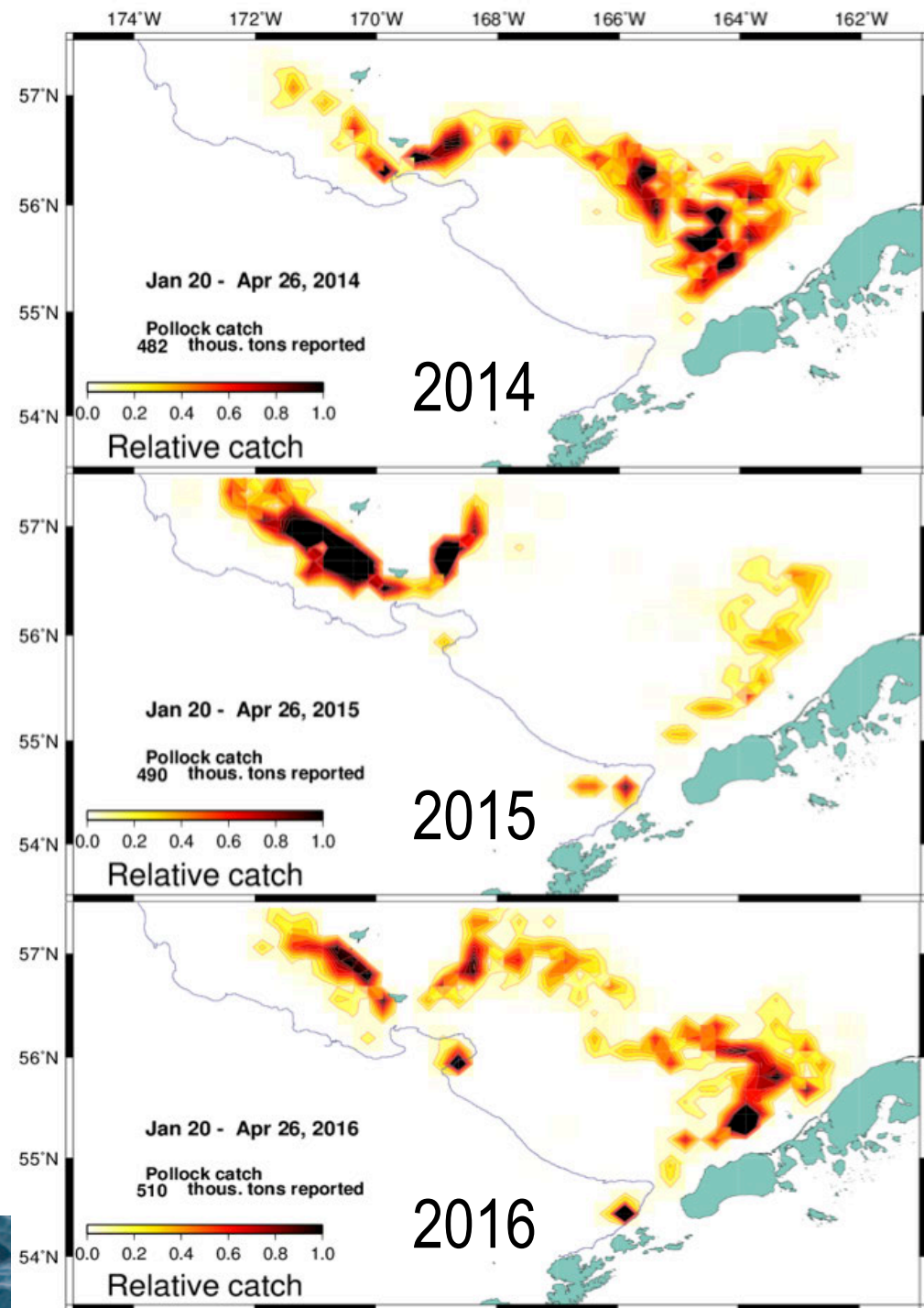
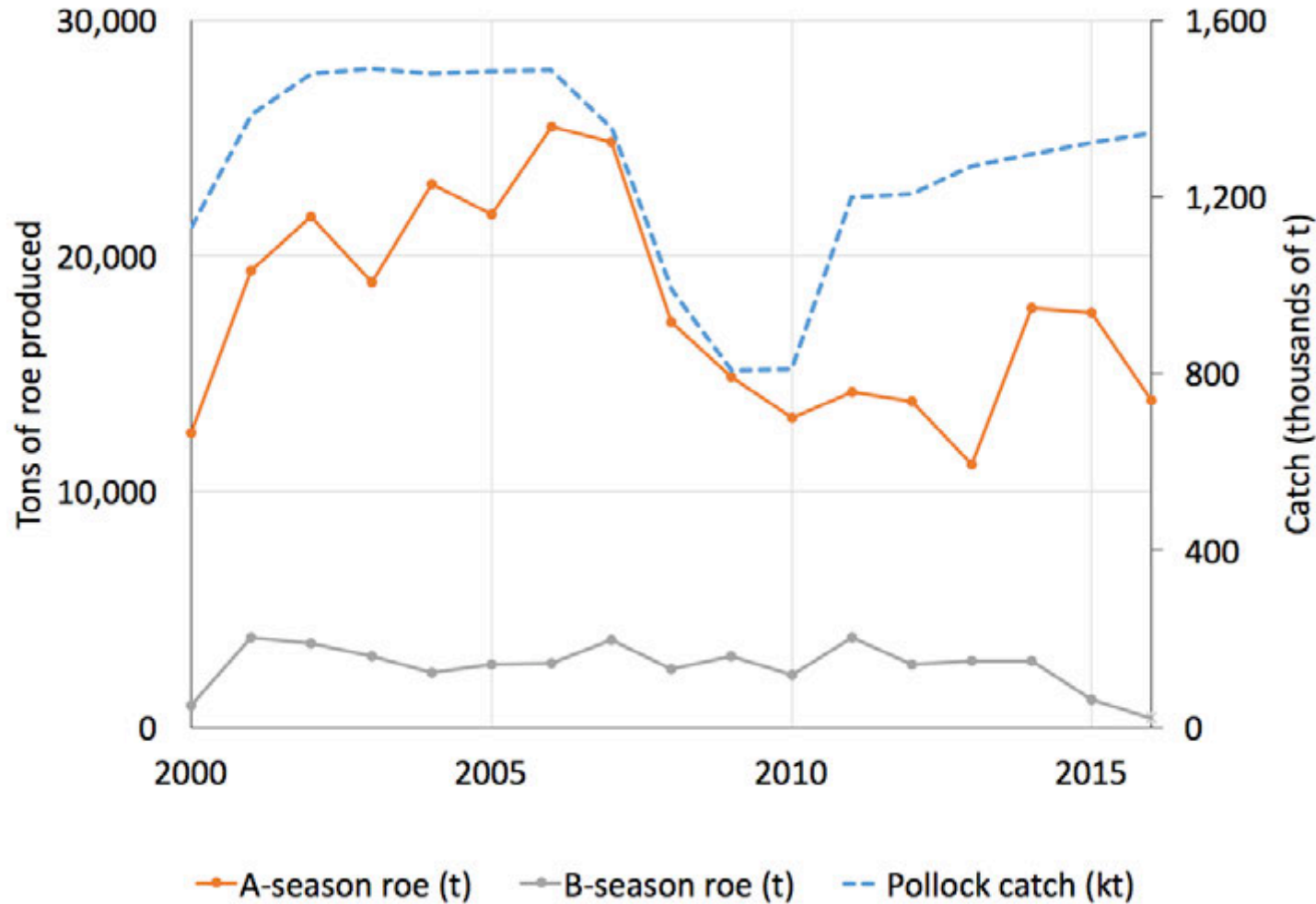


Fishing conditions



Fishing conditions

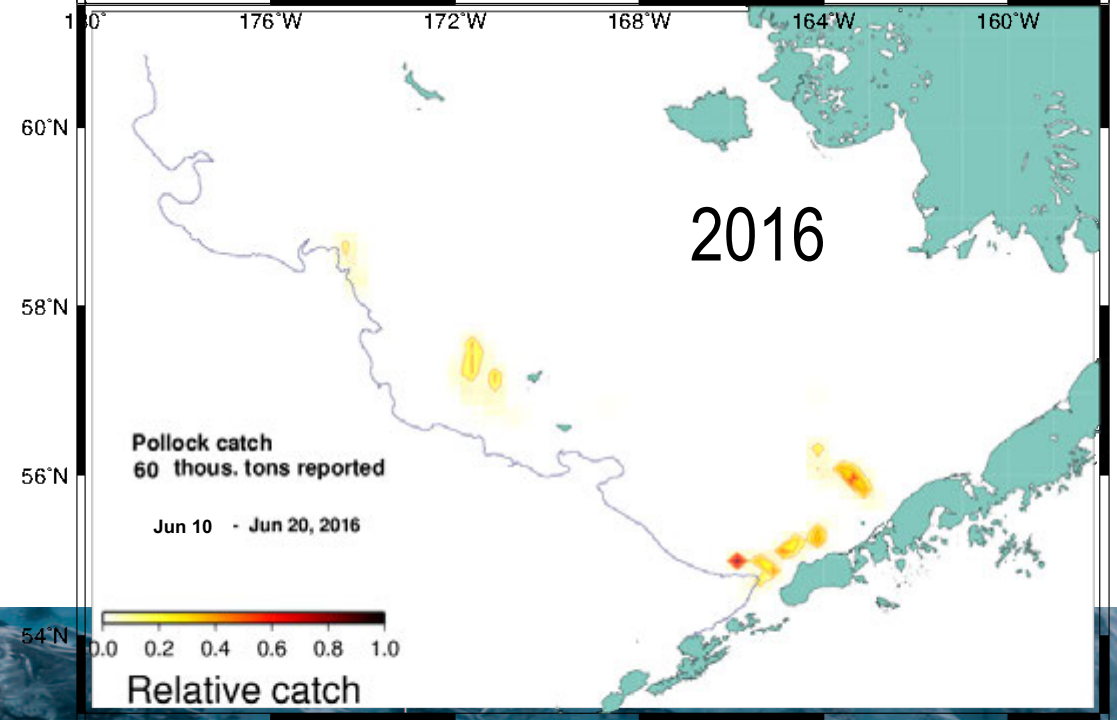
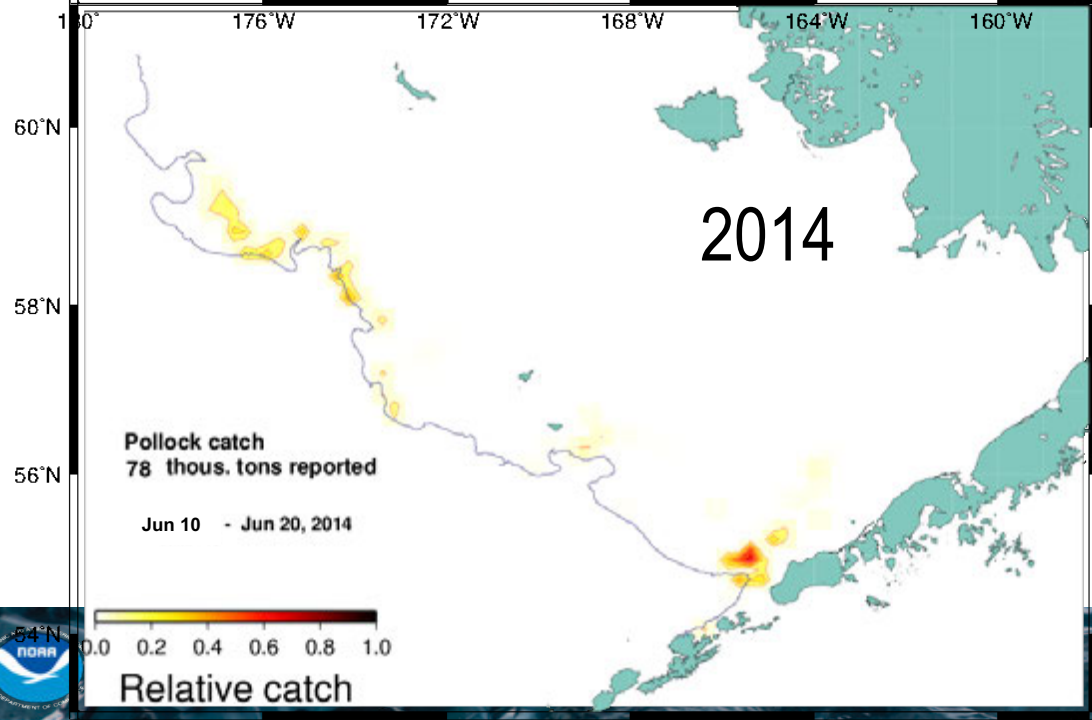
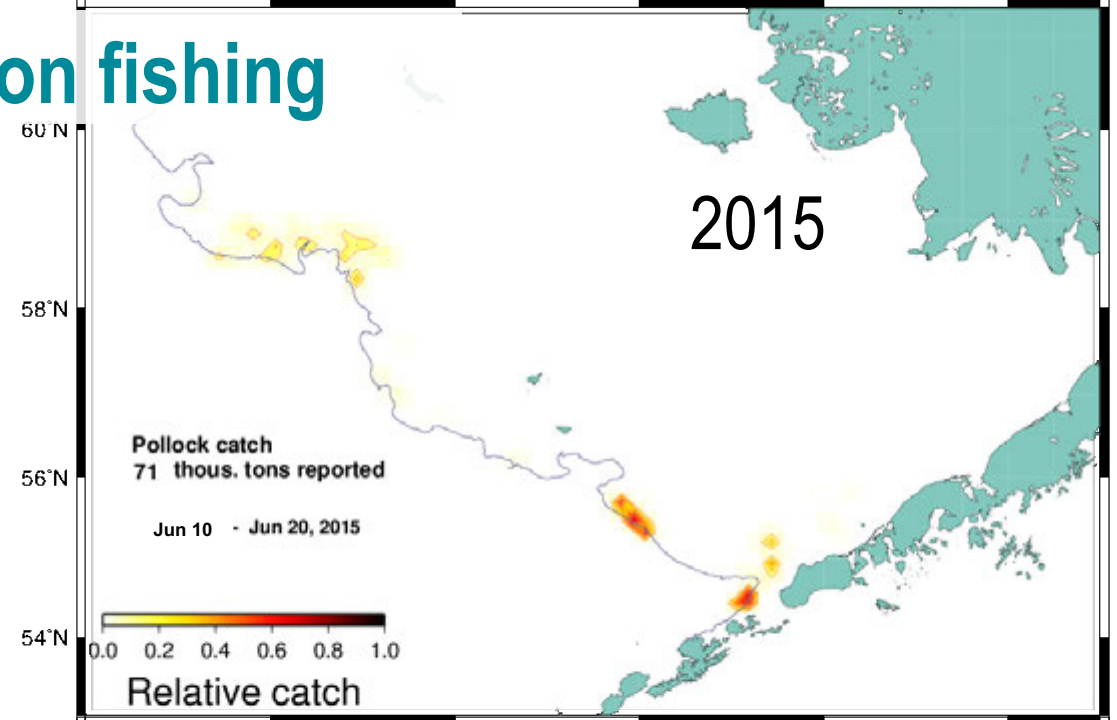
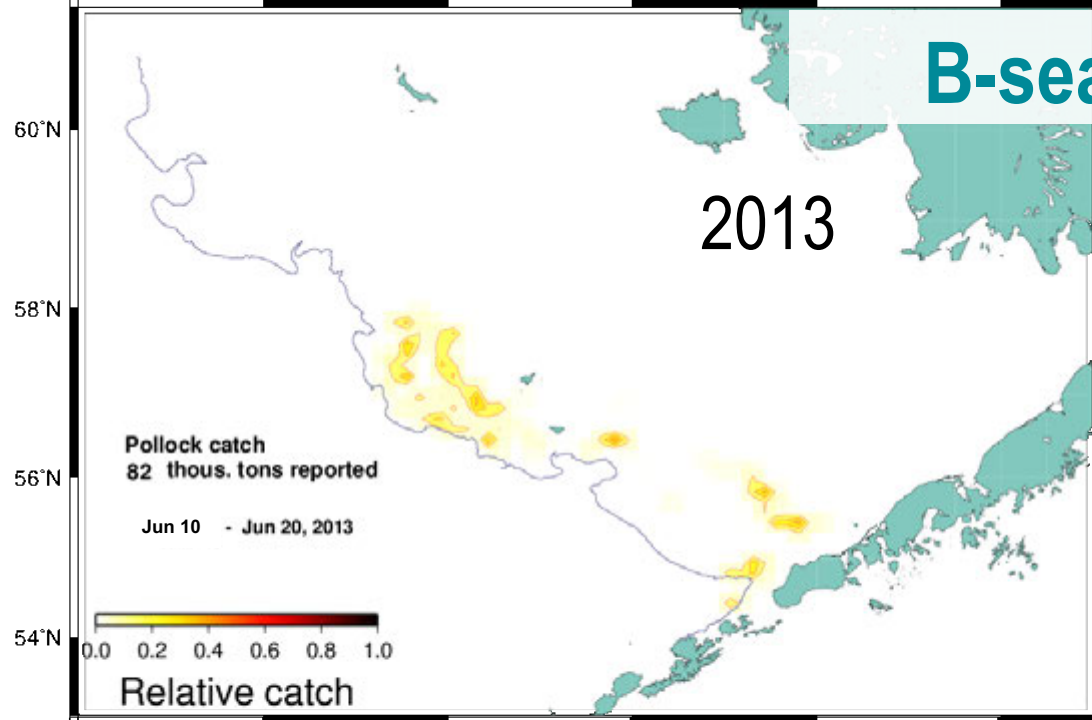
Roe production



Summer fishing (B-season)

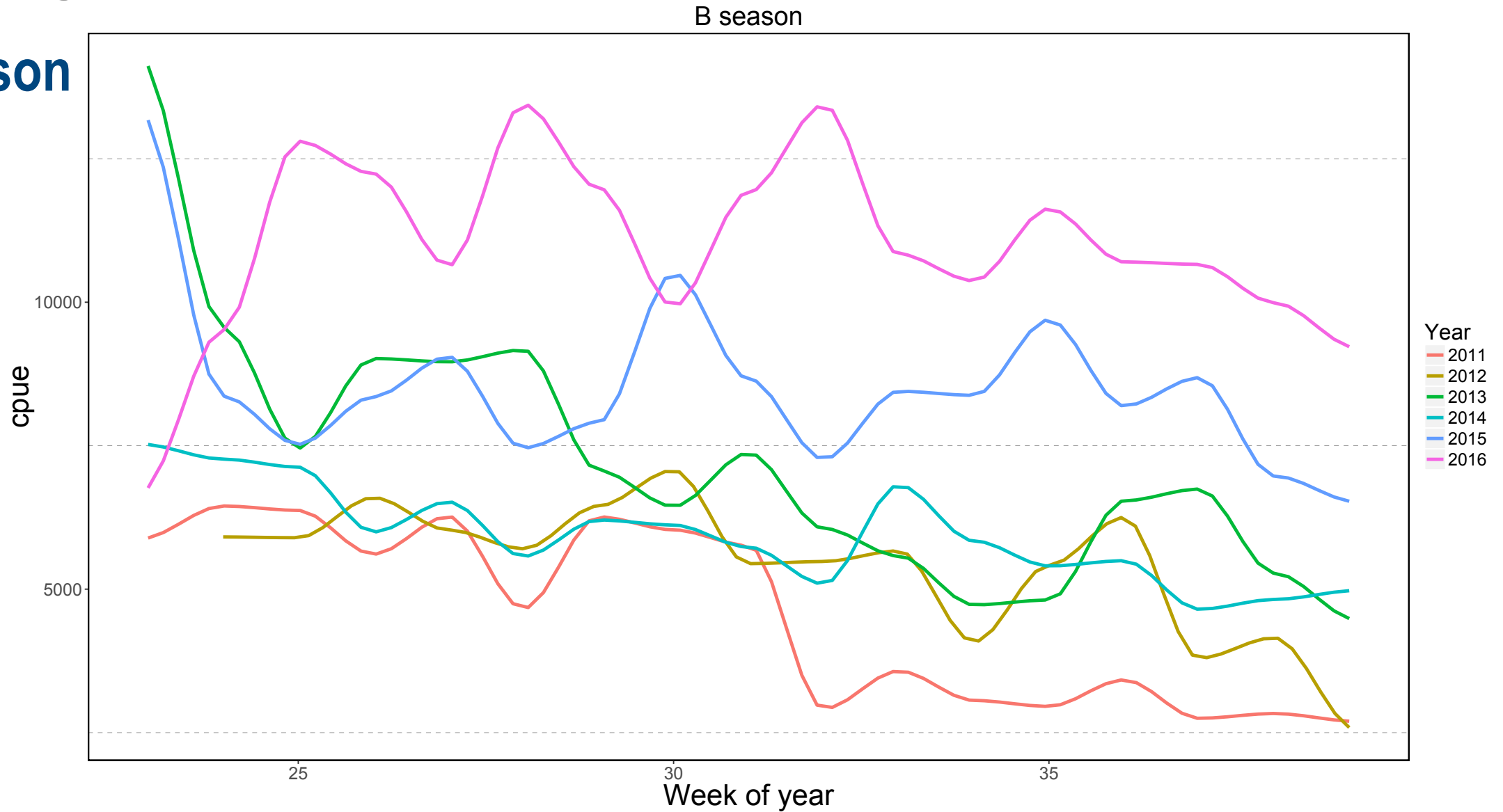


B-season fishing



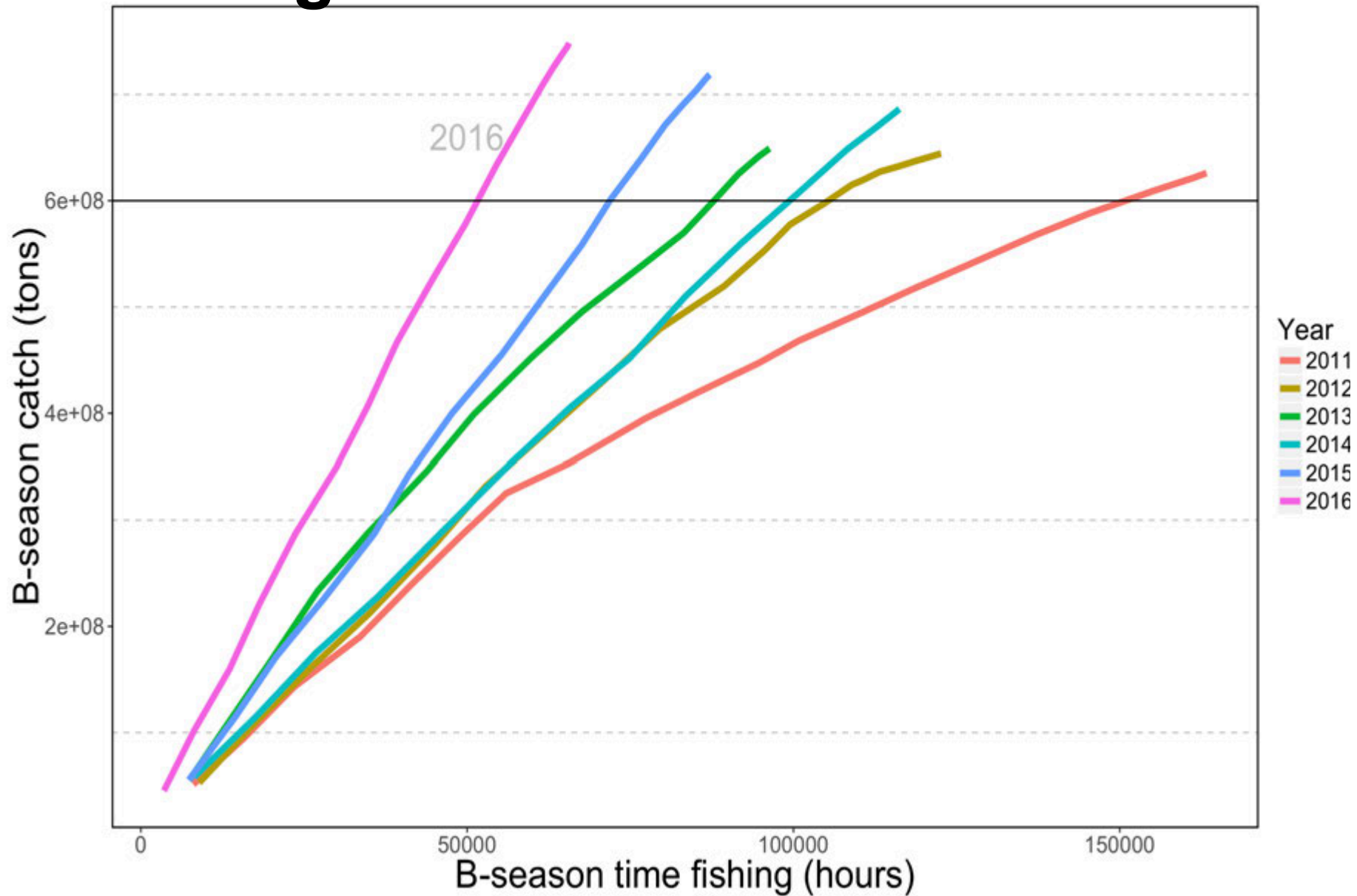
Fishing conditions

B-Season catch rates



Fishing conditions

B-season

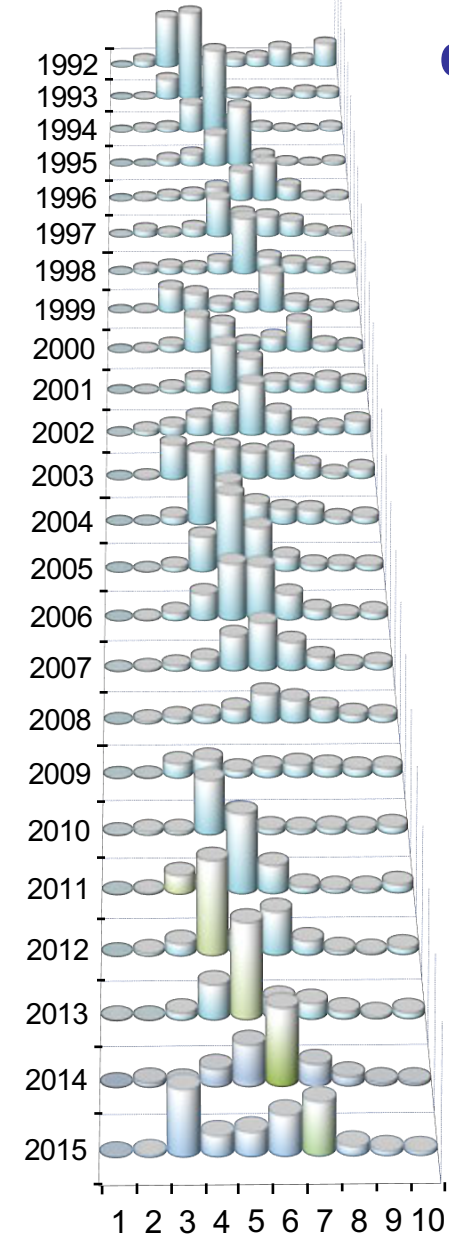


Fishing conditions

Catch and weight at age

1991	0.26	0.44	0.62	0.78	0.86	0.91	0.98	1.06	1.11	1.17	1.21	1.19	1.34
1992	0.39	0.45	0.62	0.79	0.92	0.97	1.00	1.05	1.11	1.15	1.20	1.23	1.21
1993	0.41	0.59	0.65	0.81	0.94	1.05	1.07	1.07	1.10	1.15	1.18	1.22	1.25
1994	0.35	0.56	0.75	0.79	0.92	1.04	1.12	1.12	1.11	1.13	1.17	1.20	1.23
1995	0.21	0.45	0.66	0.84	0.87	0.98	1.09	1.15	1.15	1.13	1.15	1.18	1.21
1996	0.23	0.35	0.59	0.79	0.95	0.96	1.05	1.14	1.19	1.18	1.15	1.17	1.20
1997	0.33	0.43	0.56	0.78	0.95	1.07	1.05	1.13	1.19	1.24	1.21	1.18	1.18
1998	0.27	0.42	0.52	0.64	0.84	1.00	1.11	1.08	1.15	1.21	1.25	1.22	1.18
1999	0.34	0.45	0.61	0.69	0.78	0.96	1.09	1.18	1.14	1.19	1.24	1.27	1.24
2000	0.30	0.49	0.61	0.74	0.80	0.87	1.03	1.14	1.22	1.17	1.21	1.26	1.28
2001	0.26	0.45	0.64	0.74	0.86	0.89	0.94	1.08	1.18	1.25	1.19	1.23	1.27
2002	0.37	0.48	0.67	0.84	0.91	0.99	1.00	1.02	1.14	1.23	1.28	1.21	1.25
2003	0.41	0.53	0.64	0.82	0.96	1.01	1.07	1.05	1.07	1.18	1.25	1.30	1.23
2004	0.39	0.56	0.69	0.78	0.94	1.06	1.08	1.12	1.10	1.10	1.20	1.27	1.31
2005	0.33	0.49	0.66	0.78	0.86	1.00	1.11	1.12	1.15	1.12	1.11	1.21	1.28
2006	0.29	0.45	0.61	0.77	0.87	0.93	1.06	1.15	1.15	1.18	1.14	1.13	1.22
2007	0.38	0.52	0.68	0.82	0.94	1.01	1.04	1.14	1.21	1.20	1.21	1.16	1.14
2008	0.29	0.53	0.67	0.81	0.93	1.04	1.08	1.10	1.18	1.24	1.22	1.23	1.17
2009	0.31	0.51	0.75	0.87	0.98	1.06	1.14	1.16	1.16	1.23	1.28	1.25	1.25
2010	0.35	0.50	0.71	0.92	1.02	1.10	1.16	1.21	1.21	1.20	1.25	1.30	1.26
2011	0.28	0.53	0.67	0.86	1.05	1.12	1.18	1.22	1.26	1.25	1.22	1.27	1.31
2012	0.30	0.42	0.67	0.80	0.97	1.14	1.19	1.23	1.26	1.29	1.27	1.24	1.29
2013	0.29	0.46	0.58	0.82	0.92	1.07	1.22	1.25	1.27	1.29	1.31	1.29	1.25
2014	0.29	0.46	0.64	0.74	0.95	1.03	1.15	1.28	1.29	1.31	1.32	1.33	1.30
2015	0.36	0.48	0.66	0.81	0.89	1.06	1.12	1.22	1.33	1.33	1.34	1.34	1.35
2016	0.34	0.52	0.64	0.80	0.93	0.99	1.14	1.18	1.26	1.36	1.36	1.36	1.35
2017	0.21	0.53	0.71	0.81	0.95	1.05	1.07	1.21	1.23	1.30	1.39	1.38	1.37
2018	0.21	0.39	0.72	0.88	0.95	1.06	1.14	1.14	1.26	1.27	1.33	1.41	1.39
2016	2%	1%	1%	1%	1%	1%	1%	0%	0%	1%	1%	1%	1%
2017	14%	14%	11%	8%	6%	4%	3%	2%	2%	1%	1%	1%	1%
2018	14%	20%	15%	11%	9%	7%	5%	4%	3%	2%	2%	1%	1%

Fishery catch-at-age



Age

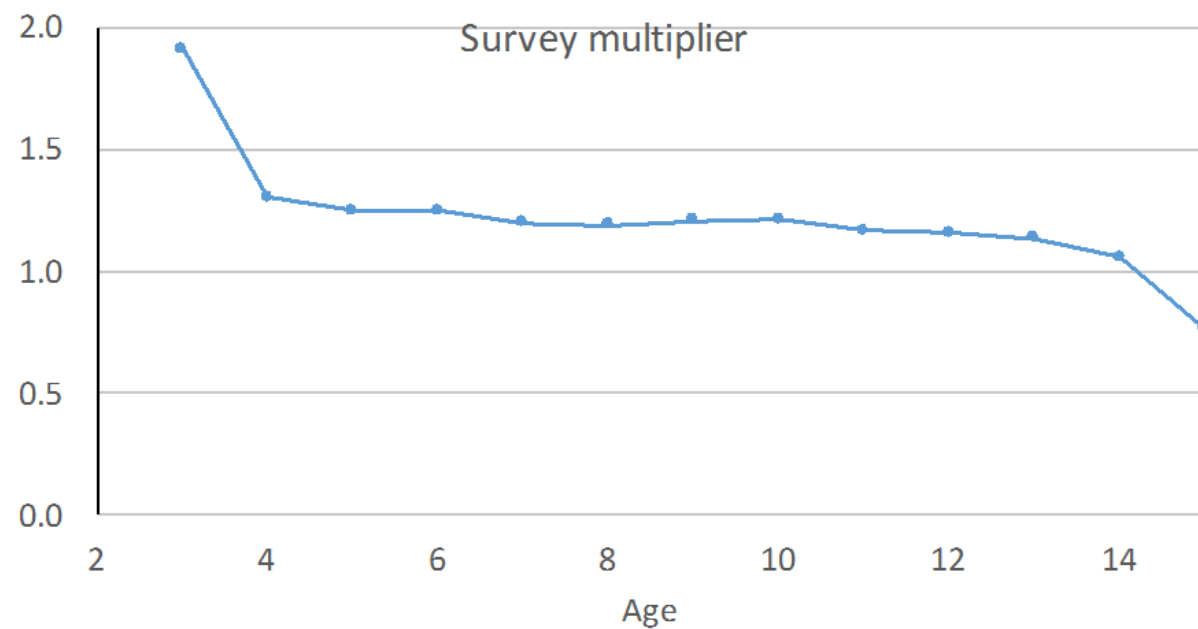
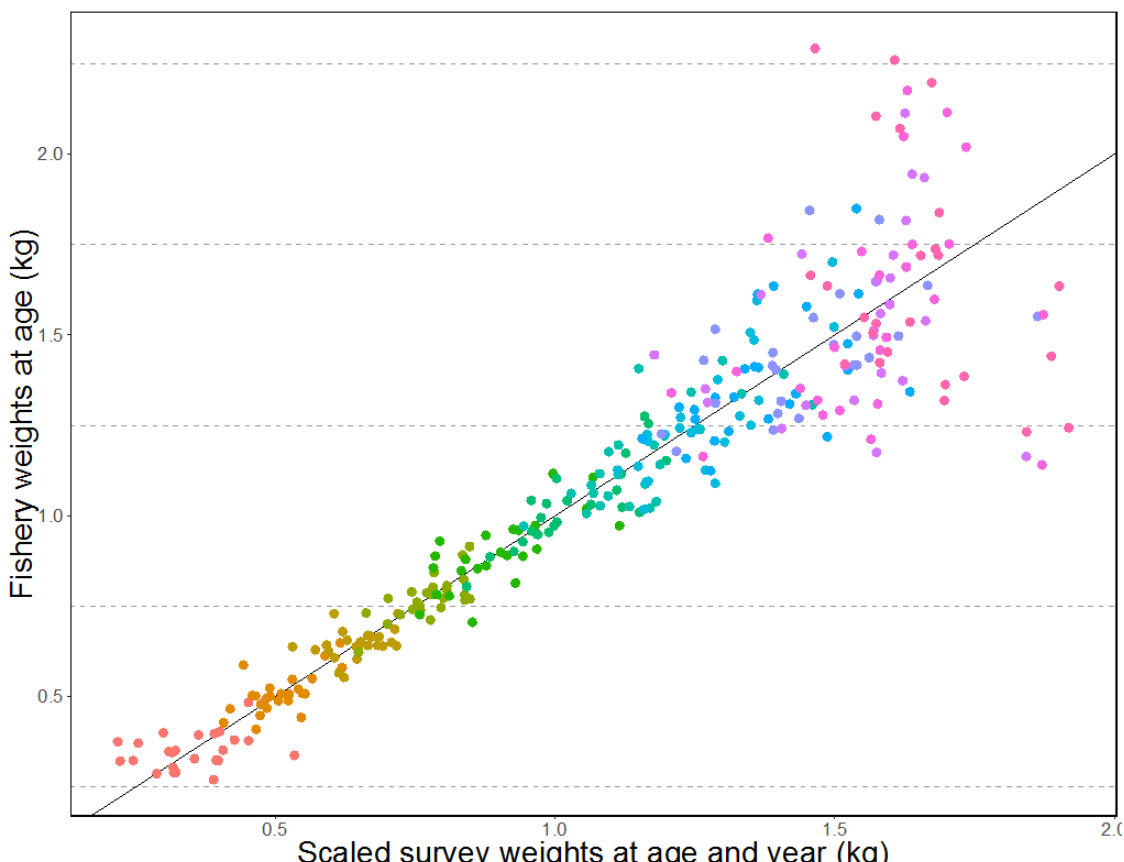


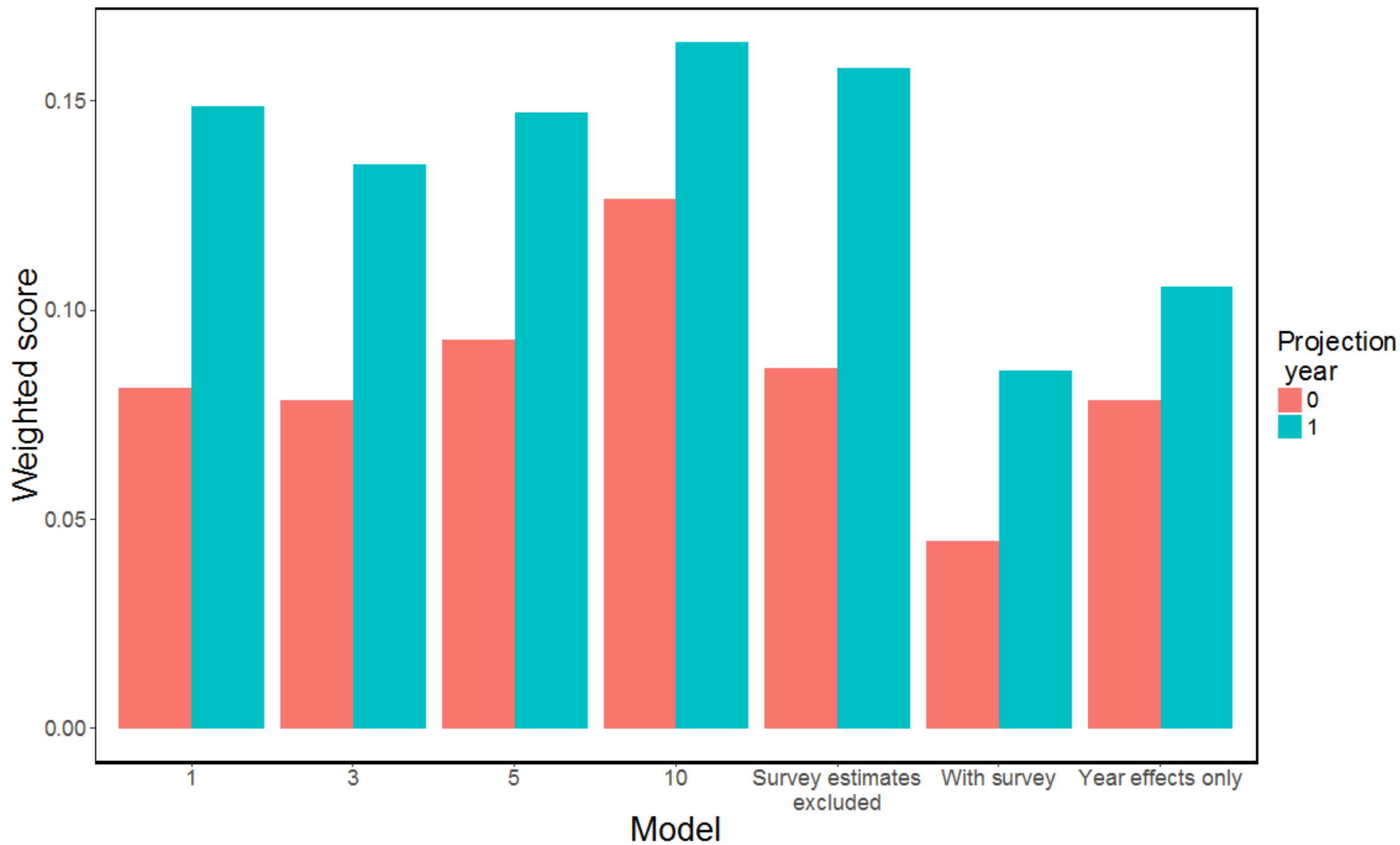
Table 1a.1. Equations and model parameters for growth estimation

Symbol	Description
$\hat{w}_{ij} = \mu_j e^{\delta_i} \quad j = 1, i \geq 1$	Growth model
$\hat{w}_{ij} = \hat{w}_{i-1,j-1} + \Delta_j e^{\zeta_i} \quad j > 1, i > 1$	
$\Delta_j = \mu_{j-1} - \mu_j \quad j < J$	
$\mu_j = \alpha \left[L_1 + (L_2 - L_1) \left(\frac{1 - K^{j-1}}{1 - K^{J-1}} \right) \right]^3$	Expected mean weight-at-age j in year i Index for year and age Mean length age j Mean growth increment Constant to scale lengths Cohort and year effects Parameters of the von Bertalanffy growth
\hat{w}_{ij}	
i, j	
μ_j	
Δ_j	
α	
δ_i, ζ_i	
$K, L_1, \text{ and } L_2$	

Table 1a.2. Alternative methods evaluated for computing mean weight-at-age for EBS pollock.

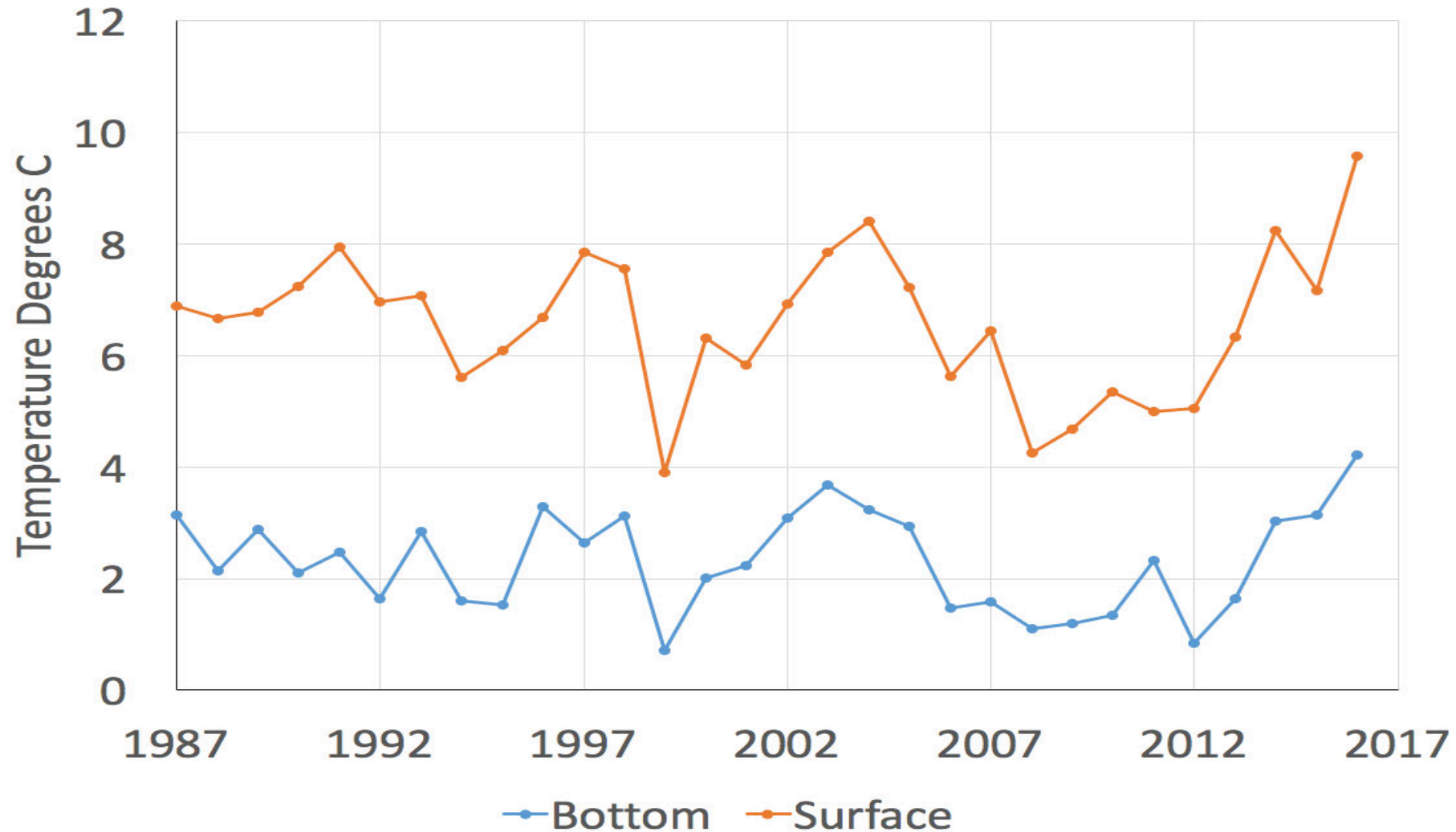
Method	Description
Means	Mean fishery weights-at-age of most recent n years of data ($n = 1, 3, 5,$ and 10)
Year and Cohort	Year and cohort effect model
Year and Cohort with scaled survey data	Include scaled survey weights-at-age ($\hat{w}_{i,j}^{k-2} = \lambda_j w_{i,j}^{survey}$)
Year effect only (with scaled survey data)	Year effect model (a random effect parameter for each annual growth increment)





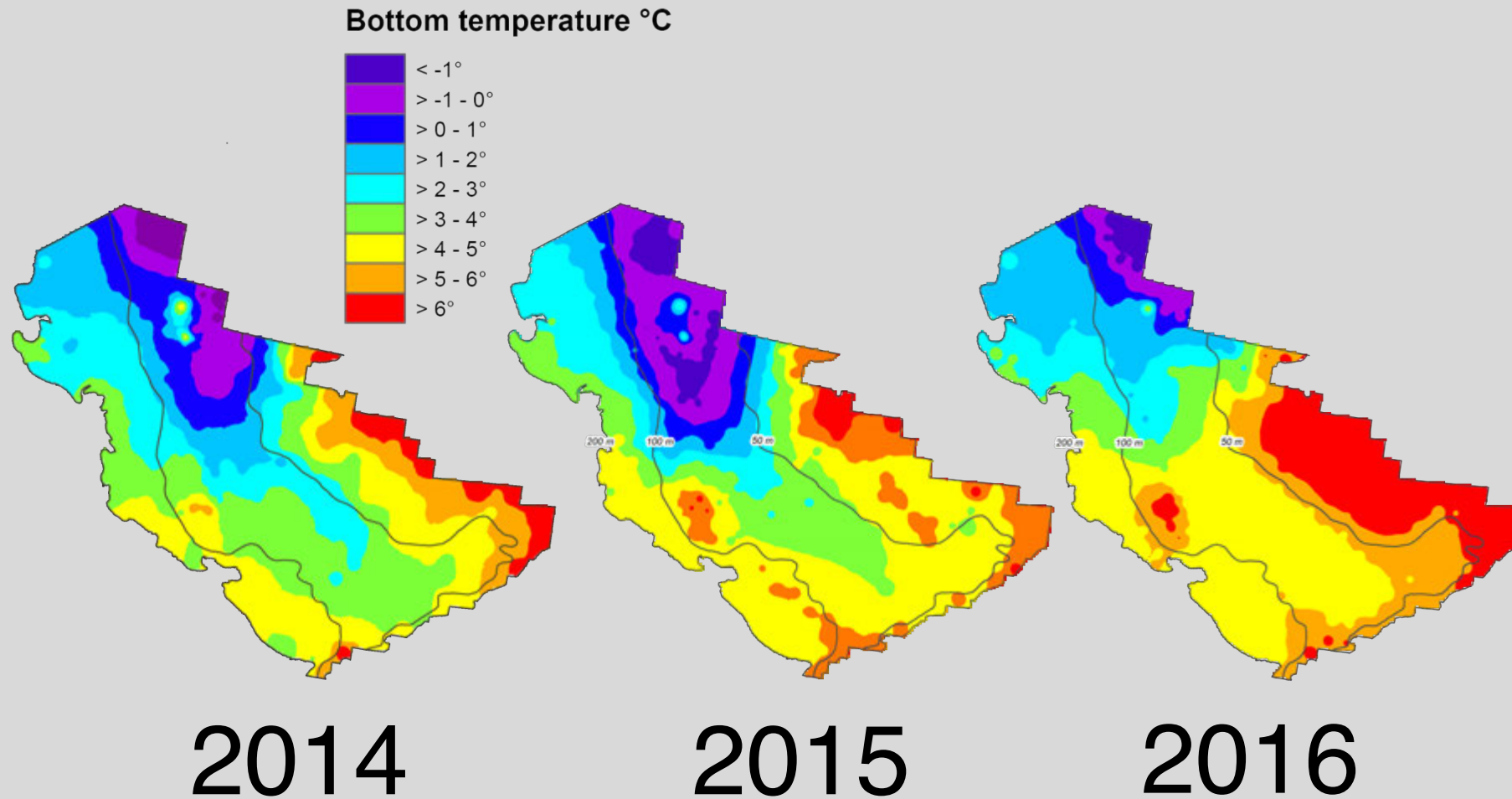
Survey data and environmental conditions

Warm year...warmest?



EBS shelf environment

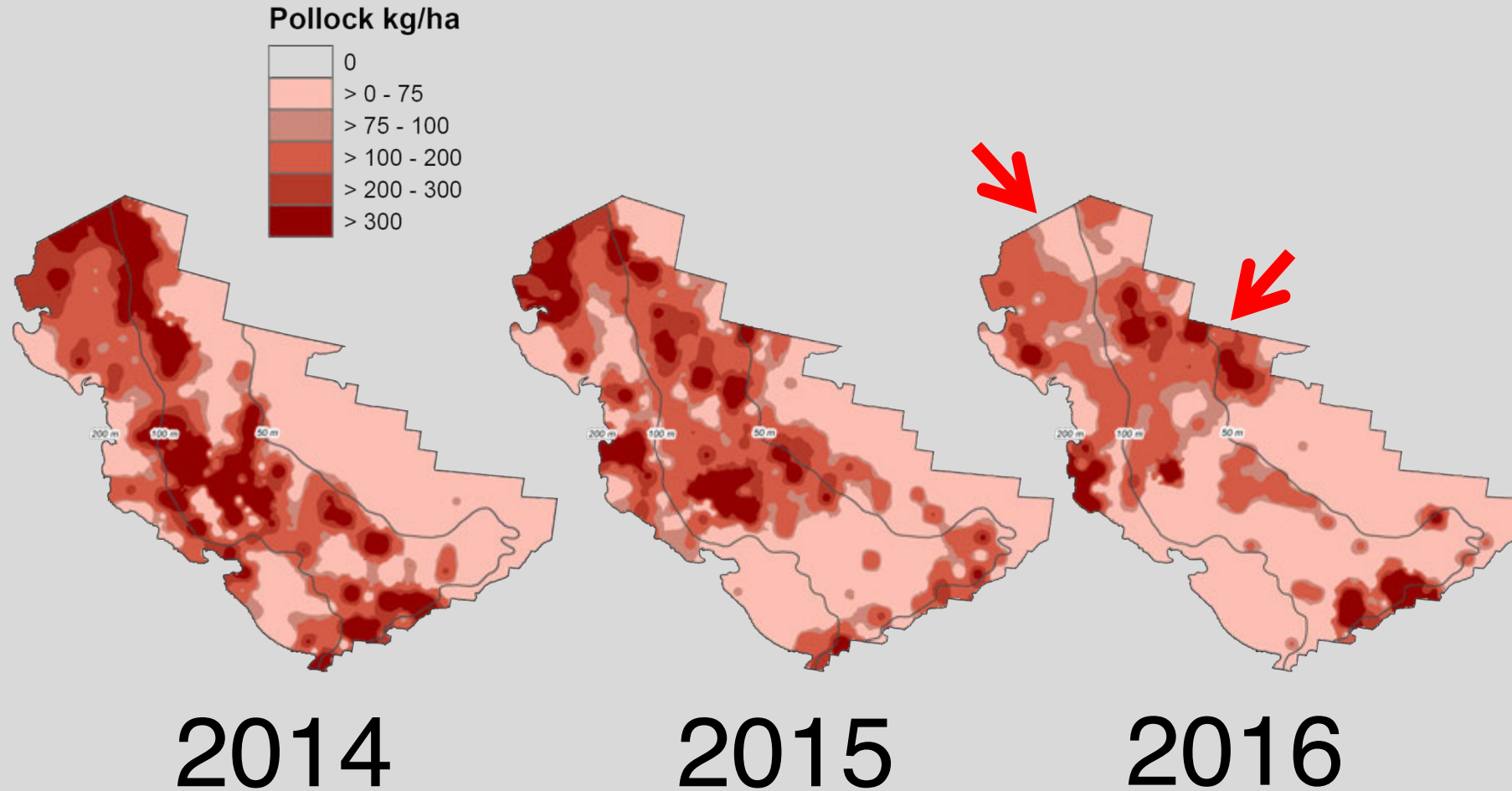
Bottom temperatures



Courtesy Bob Lauth, AFSC RACE Division

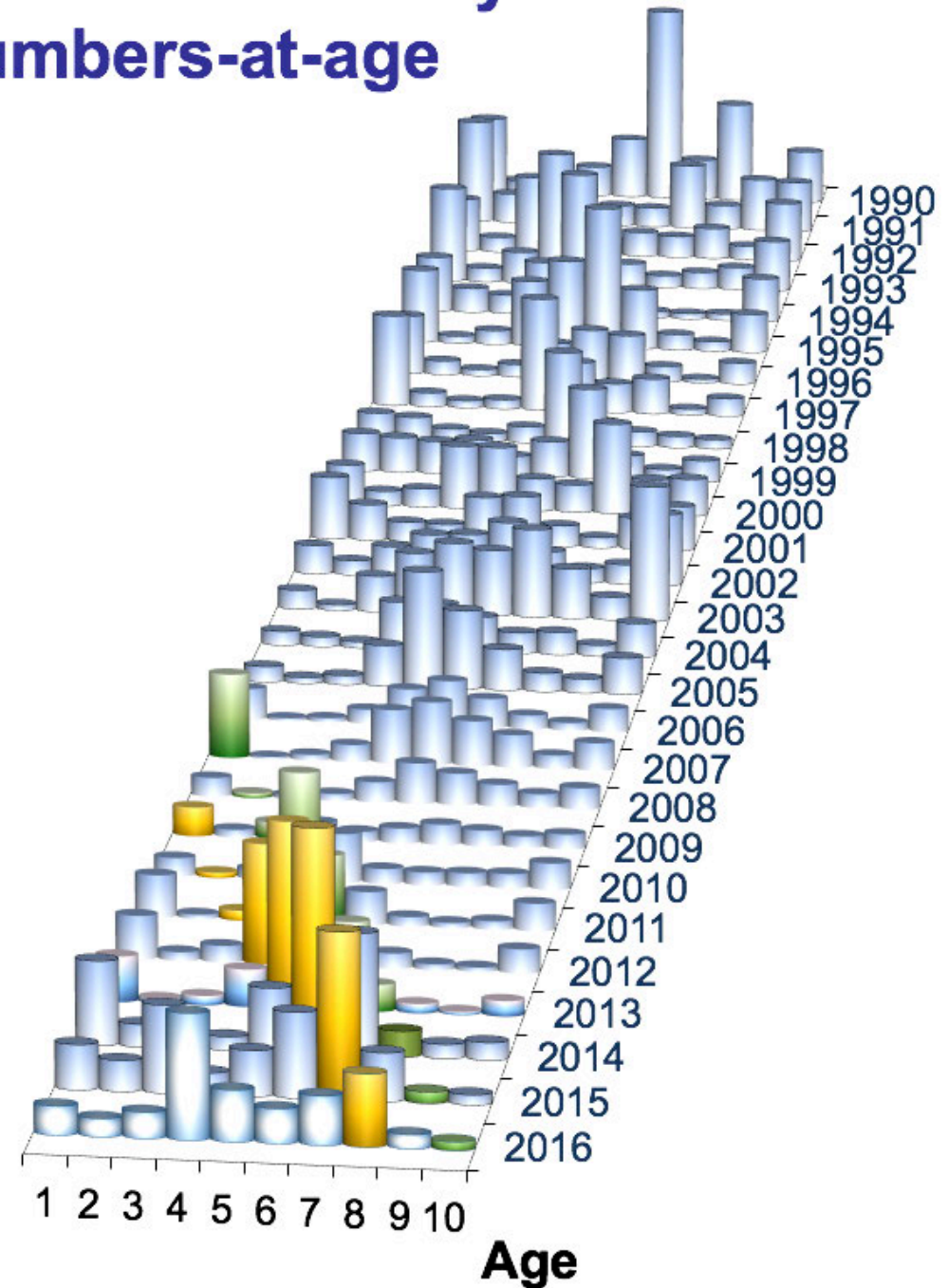
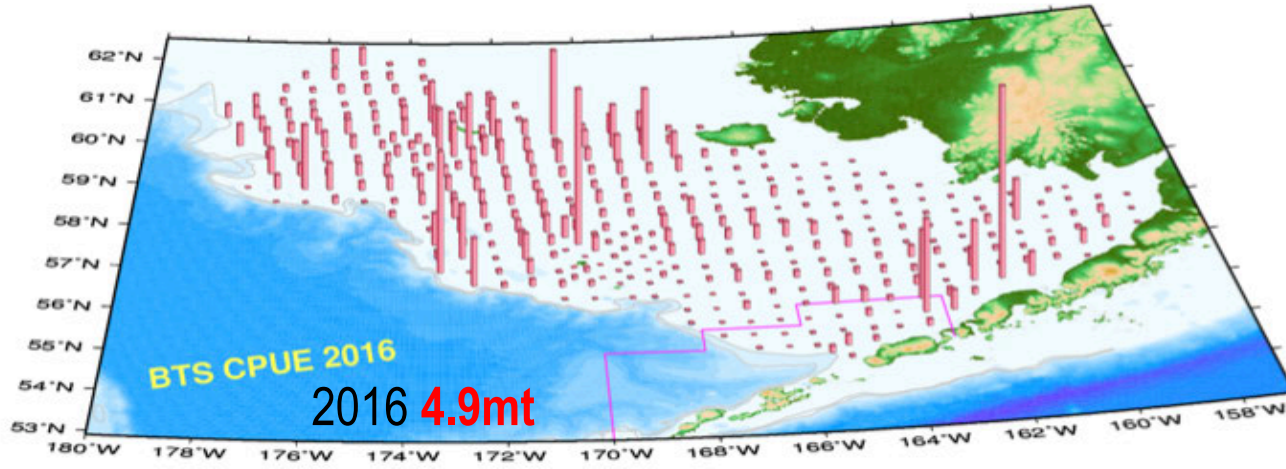
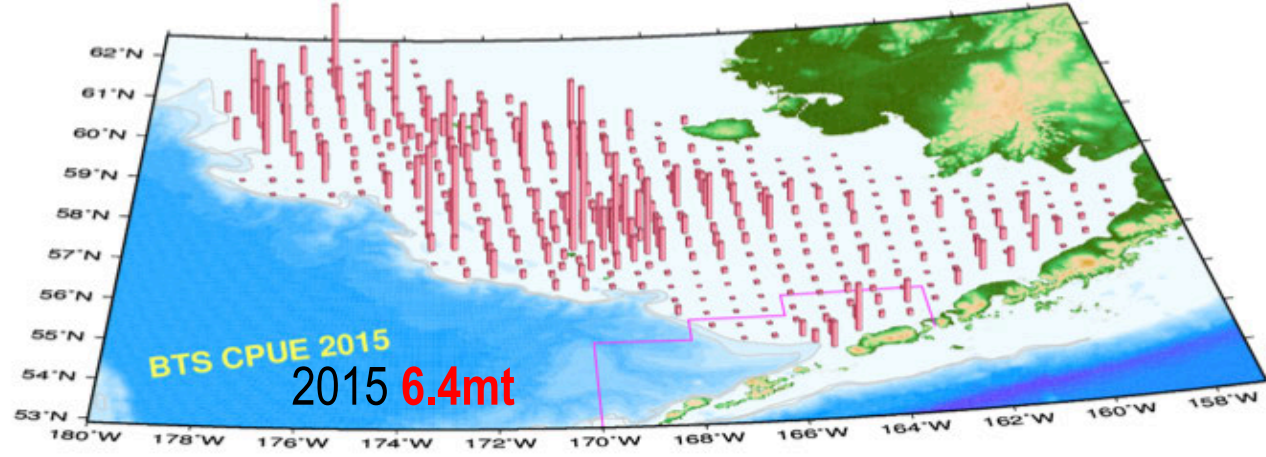
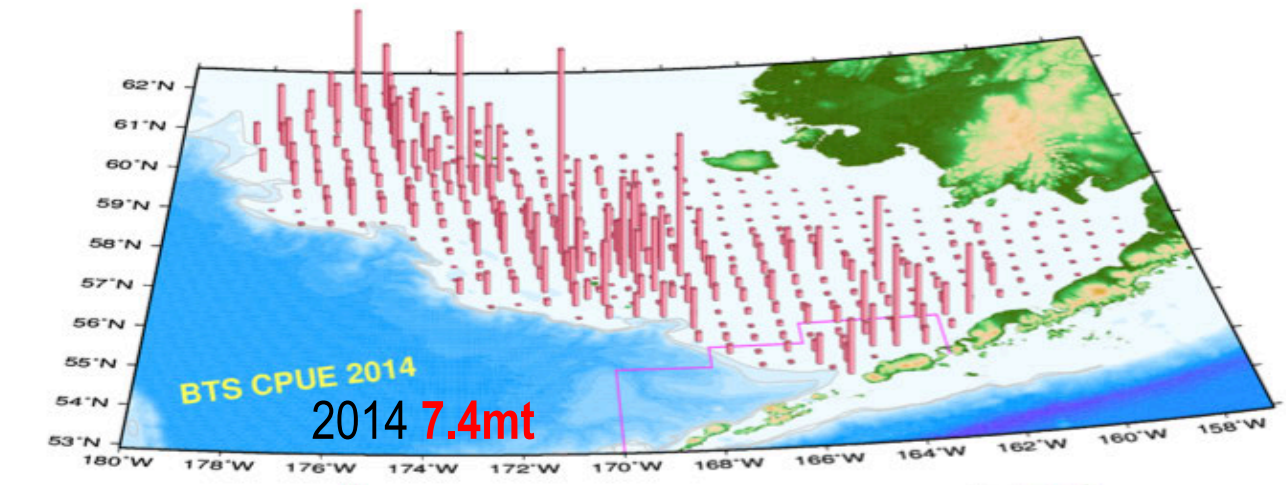
Walleye pollock

Distribution and Abundance

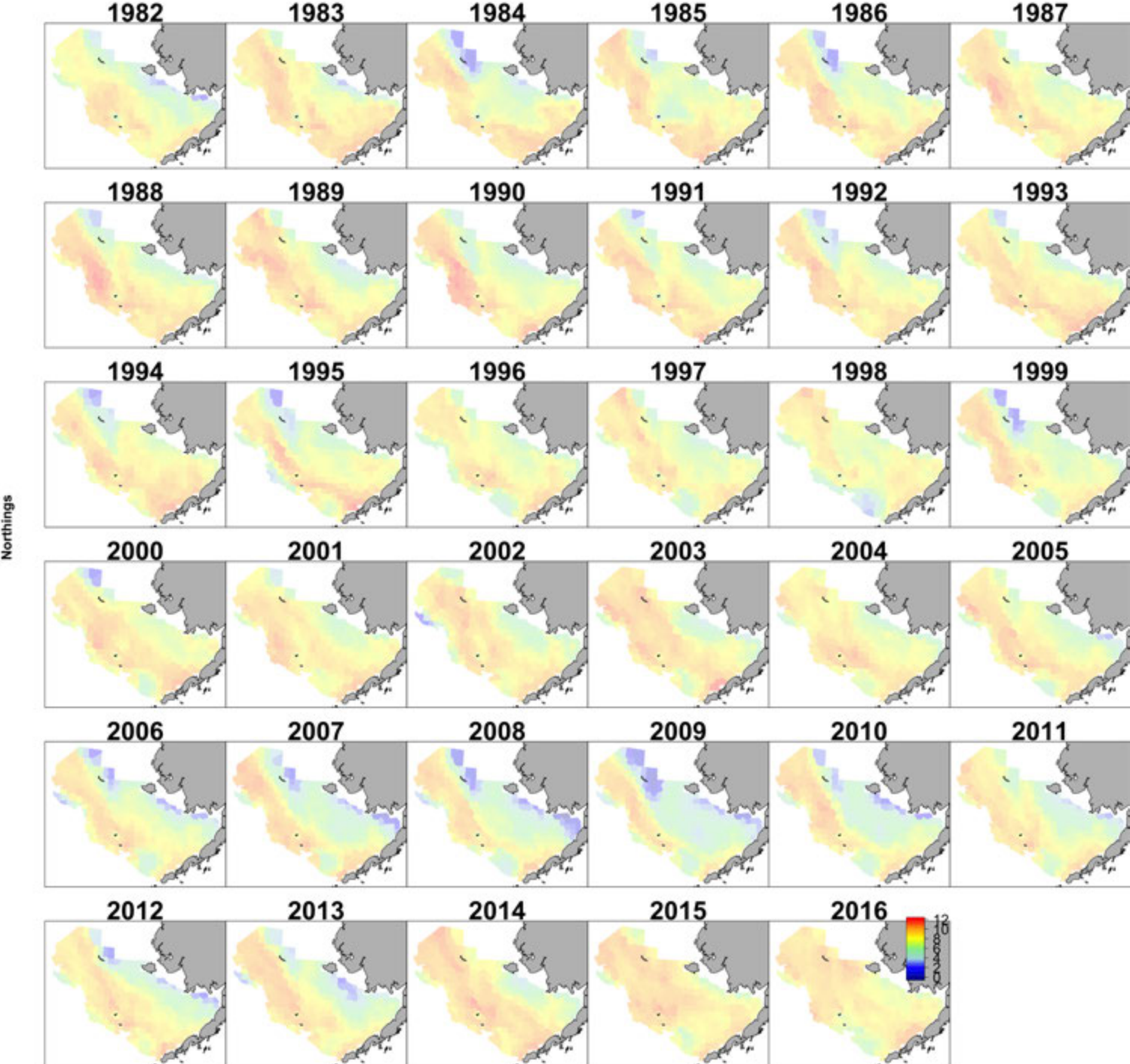


Courtesy Bob Lauth, AFSC RACE Division

Bottom trawl survey numbers-at-age

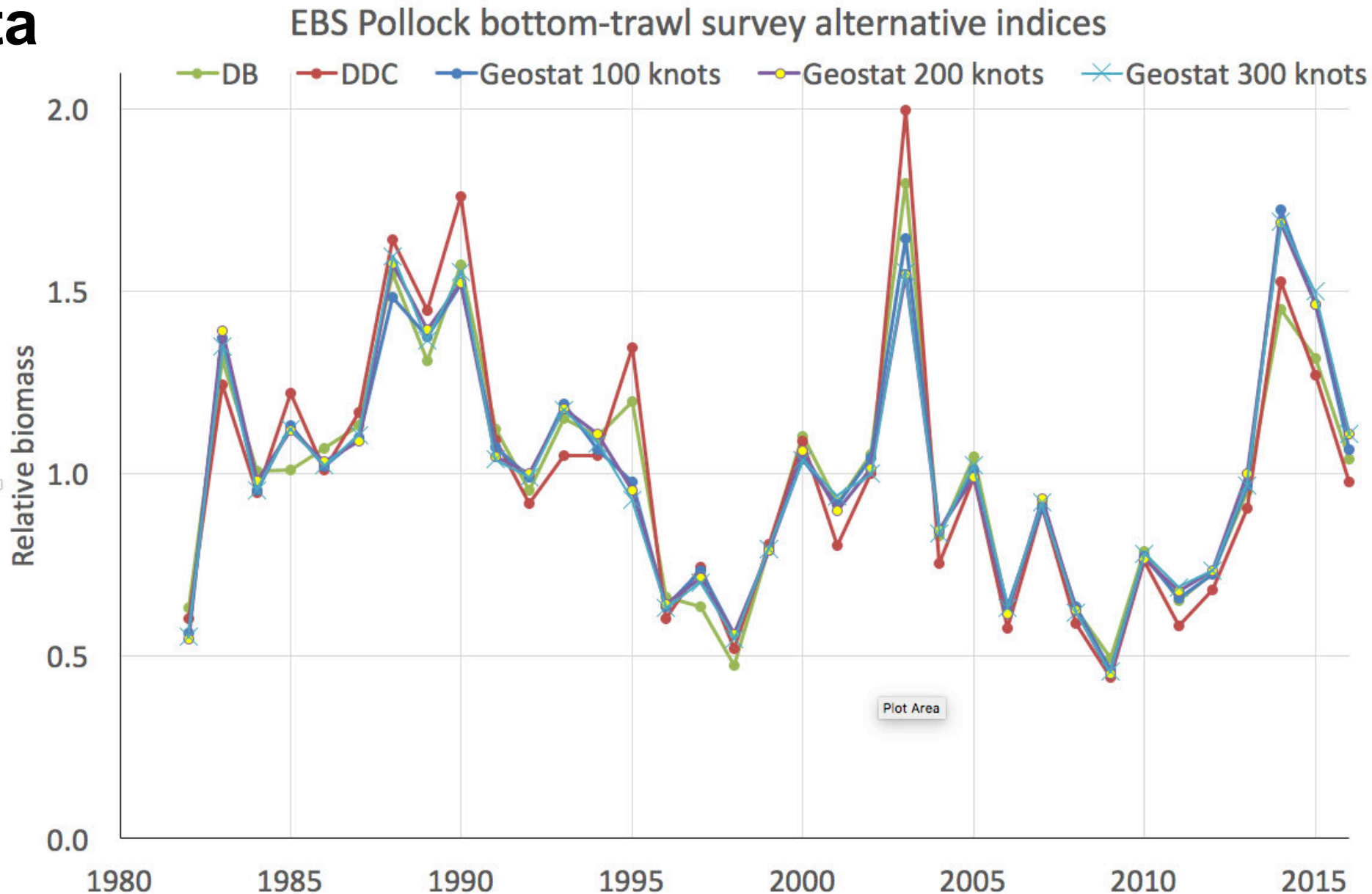


Geostatistical modeling of survey data



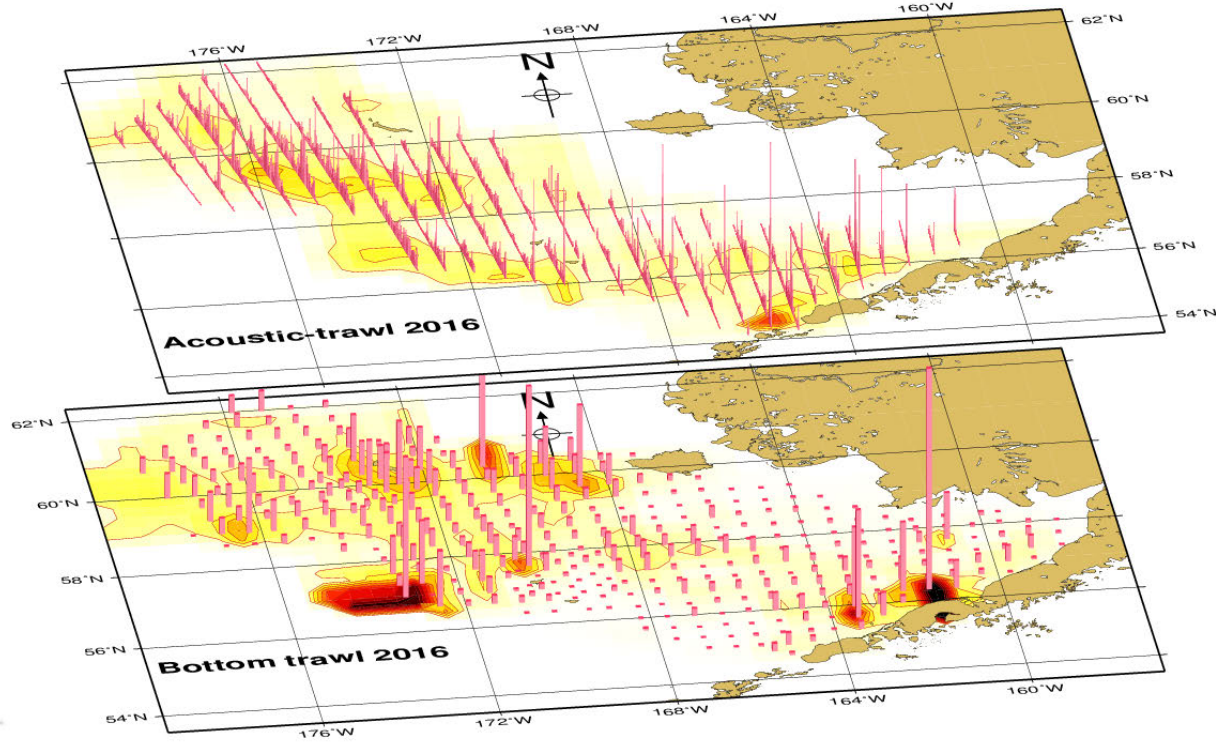
Courtesy
J. Thorson
NMFS/NOAA

Geostatistical modeling of survey data

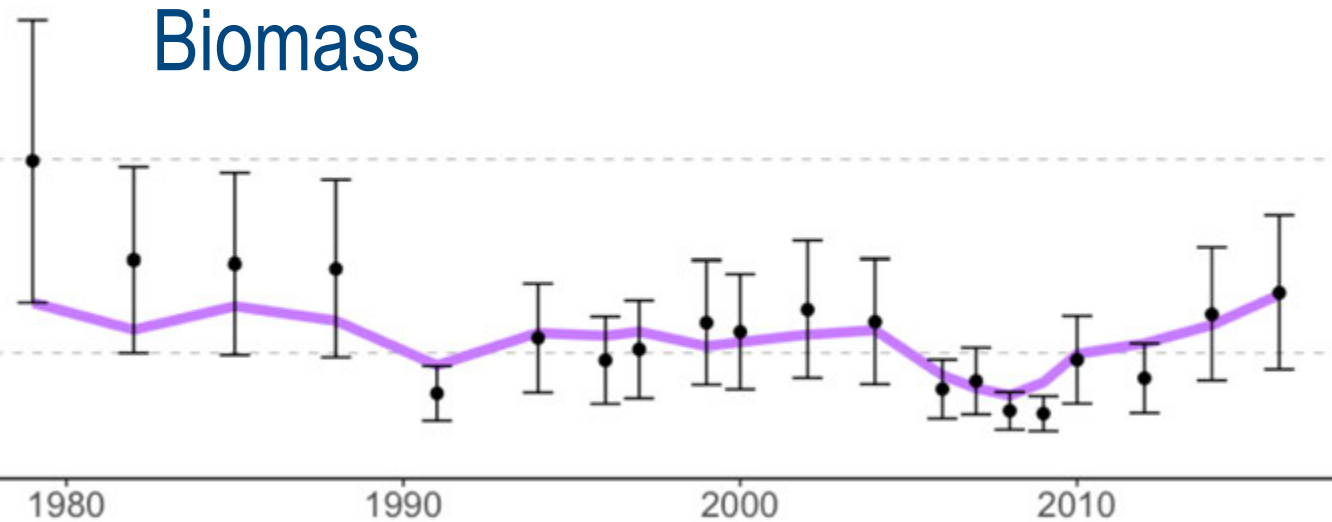


Courtesy
J. Thorson
NMFS/NOAA

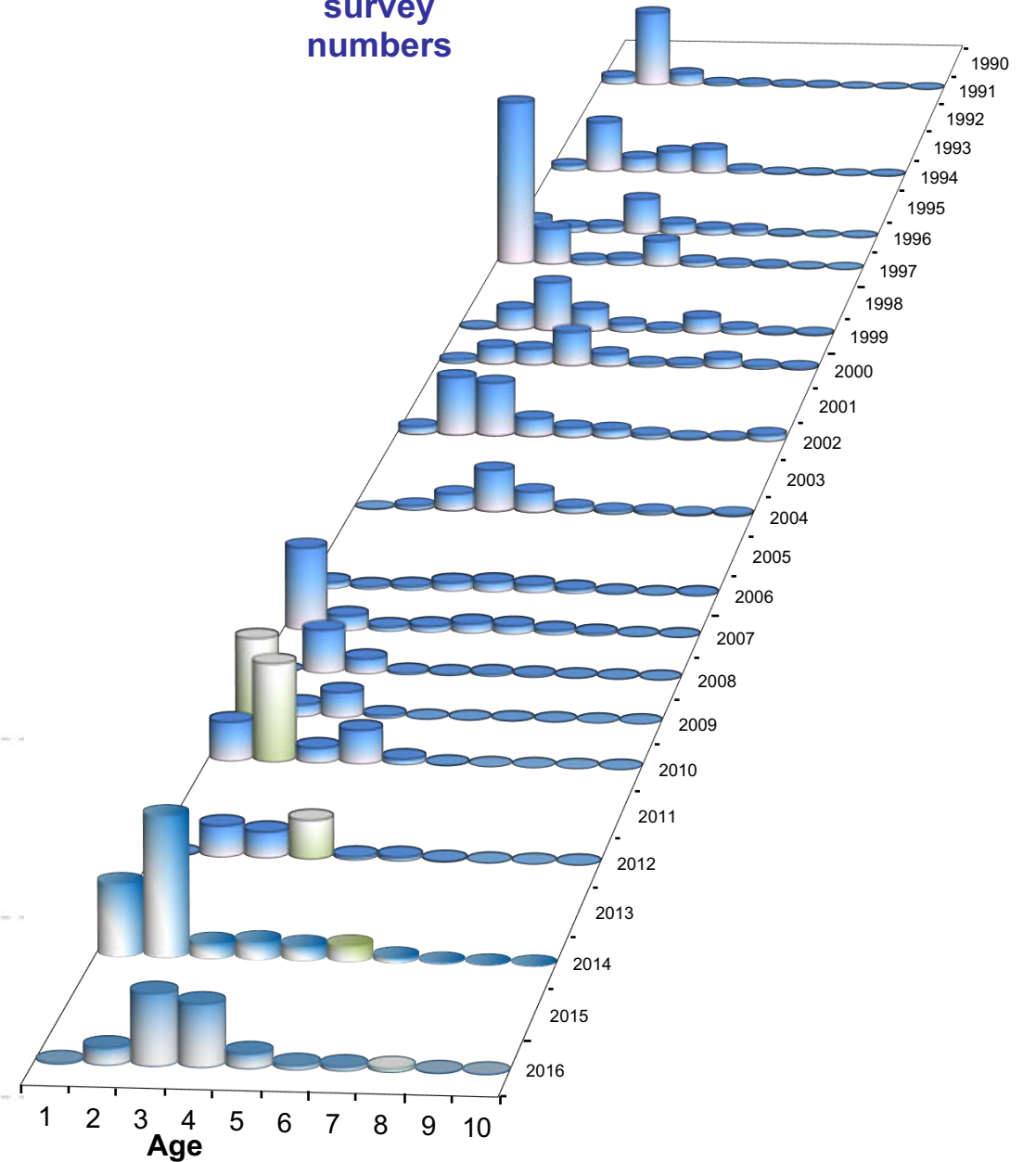
Acoustic trawl survey data

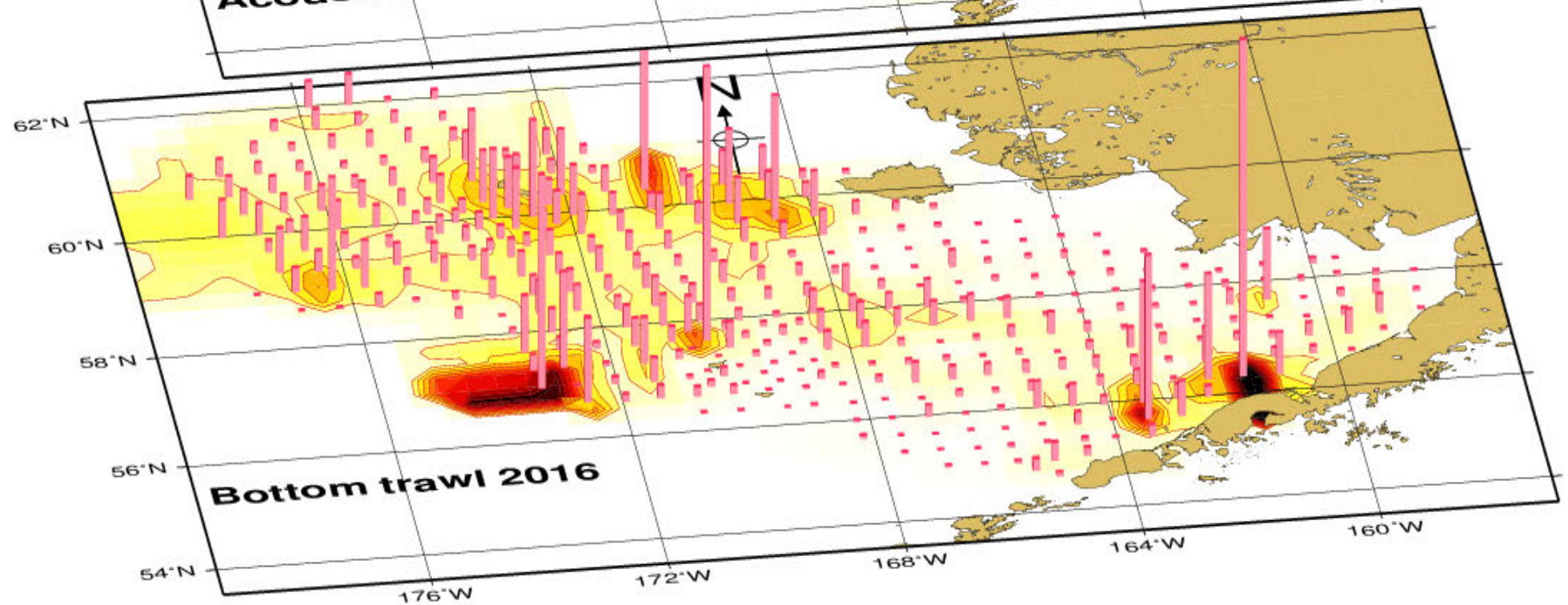
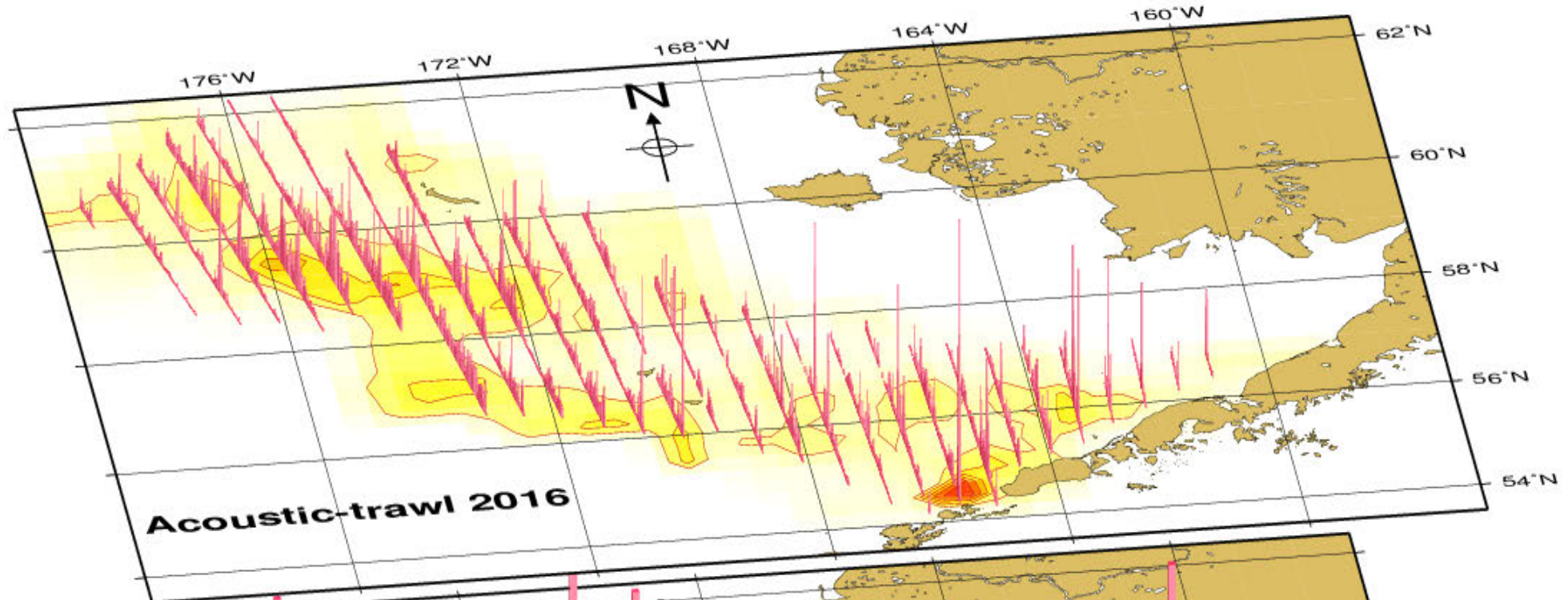


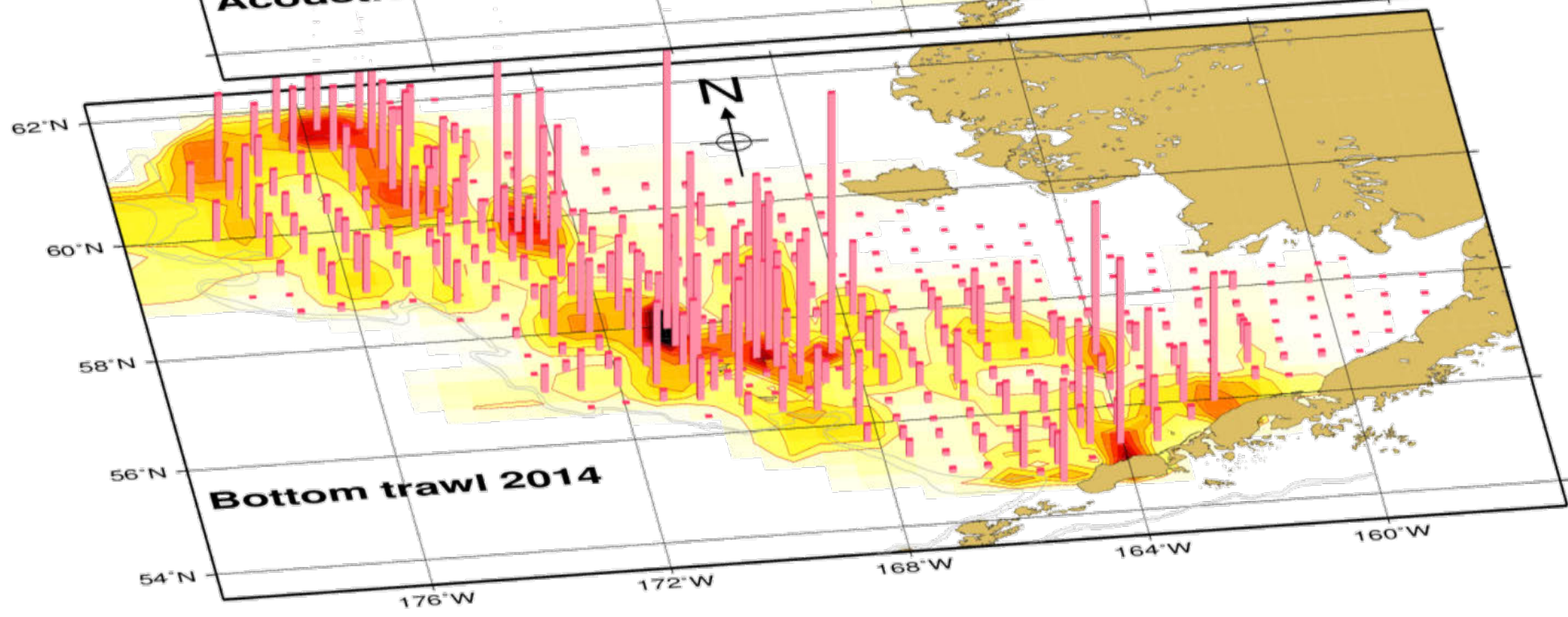
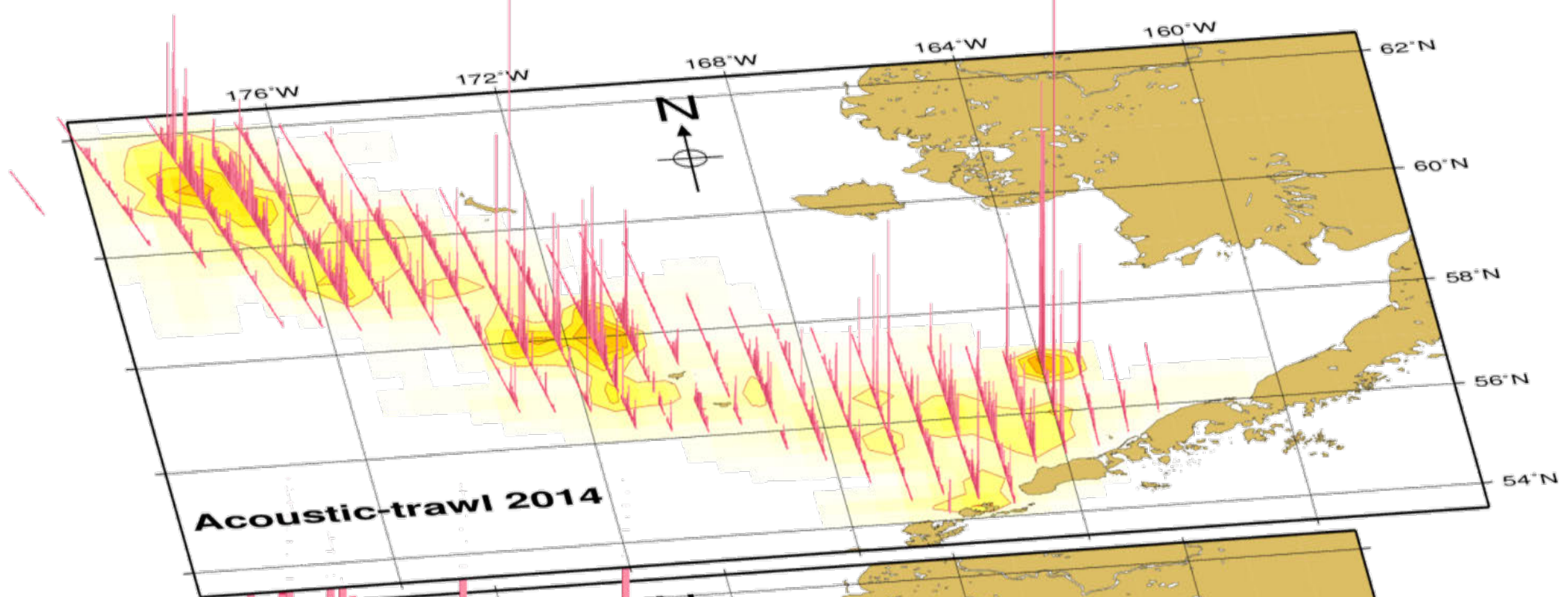
Biomass



Acoustic survey numbers







Model evaluation

Models	BTS				ATS		Fishery			Description	
	Standard survey method	Dens. Dep. Correction	Numbers	Biomass	Numbers	Biomass	15.1 Input sample sizes	Revised input sample sizes	Weight-age as 15.1		Revised weight age
14.1	x		x		x		x		x		2014 model
15.1		x	x		x		x		x		2015 model (alternative BTS abundance index)
16.01	x			x		x	x		x		Transition to biomass (standard indices)
16.02		x		x		x	x		x		Alternative BTS biomass index
16.03		x		x		x		x	x		Input sample size adjustment
16.1		x		x		x		x		x	Proposed model



Model evaluation

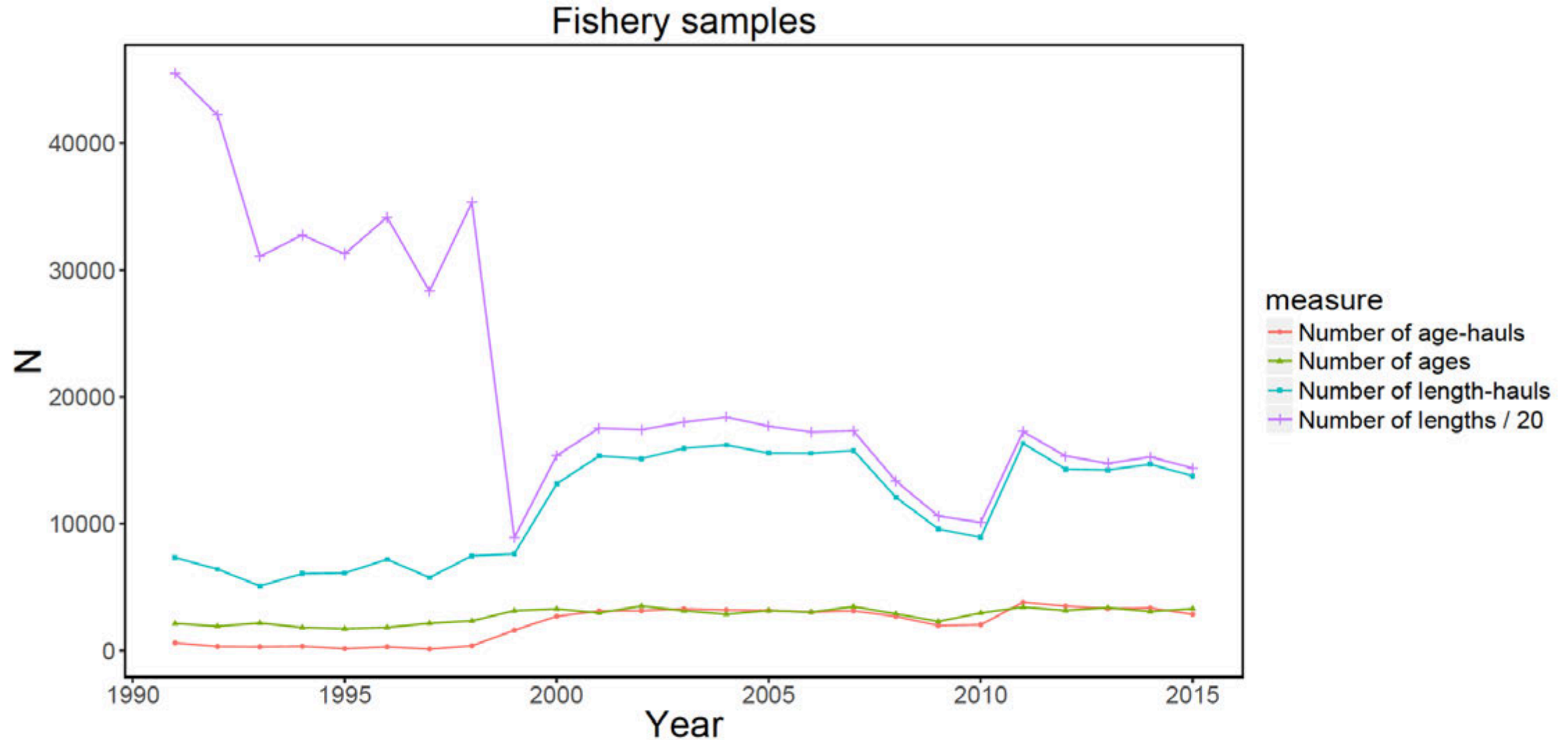
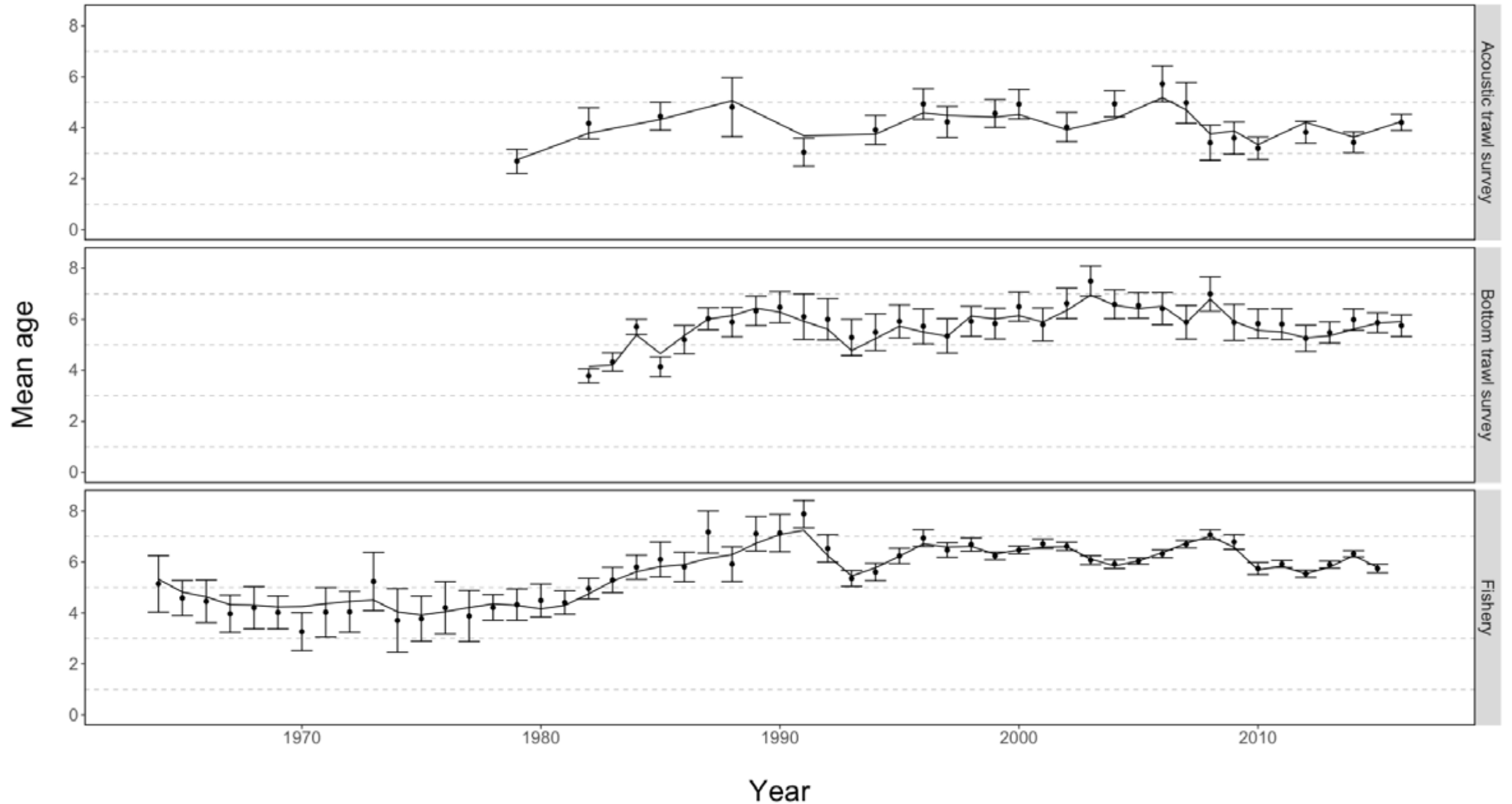
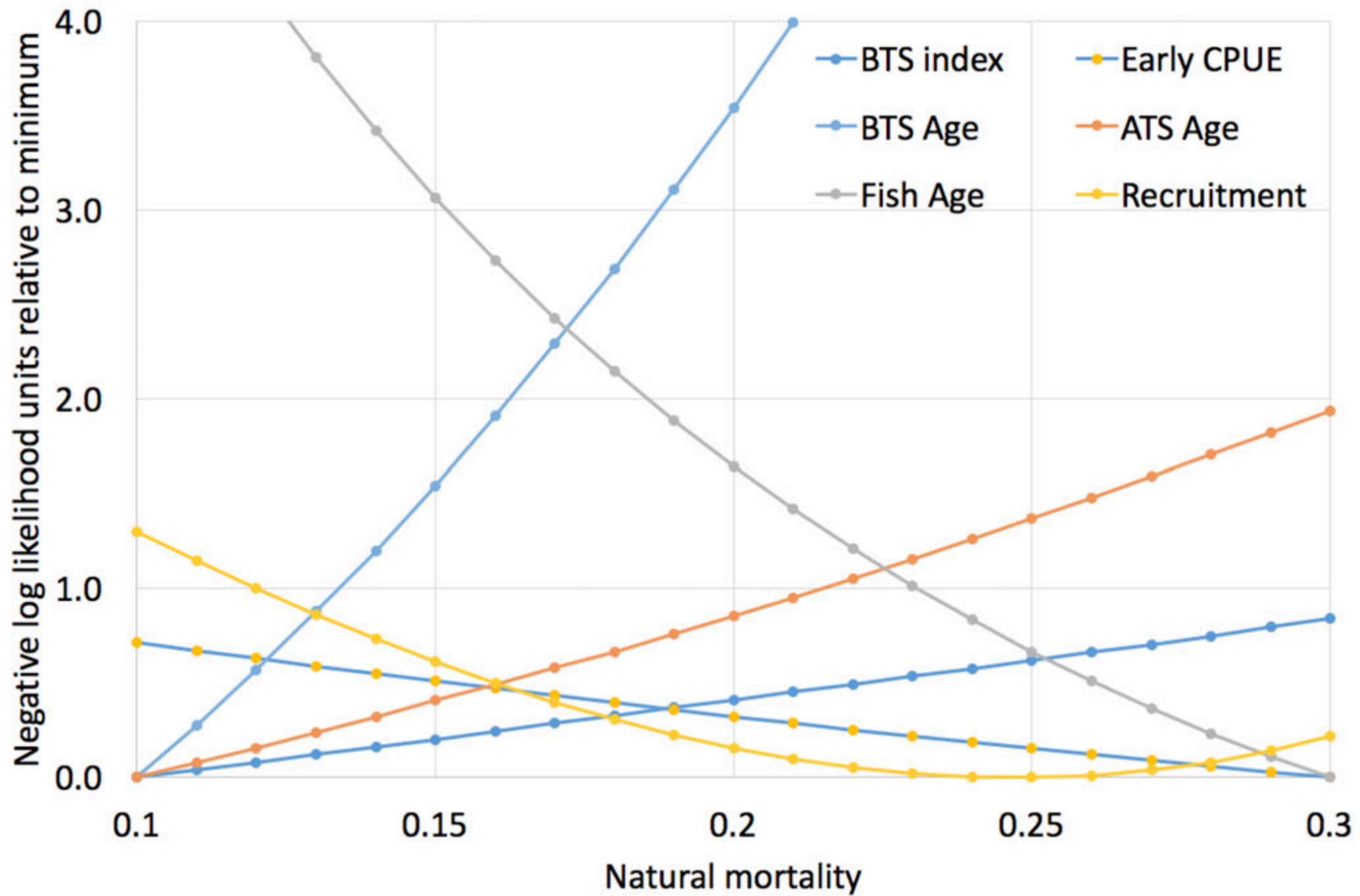


Figure 1.8. EBS pollock observer sampling summarized for number of ages, hauls from which ages were collected, and lengths (total measured and hauls sampled), 1991-2015.

Model evaluation





Model evaluation

- RMSE

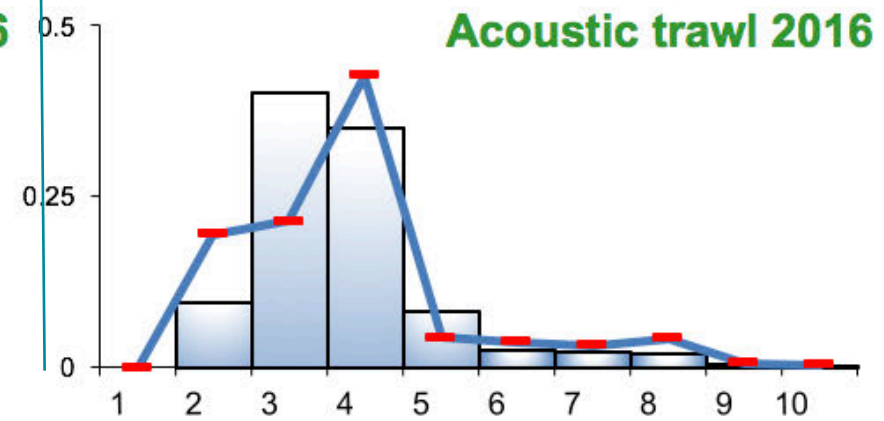
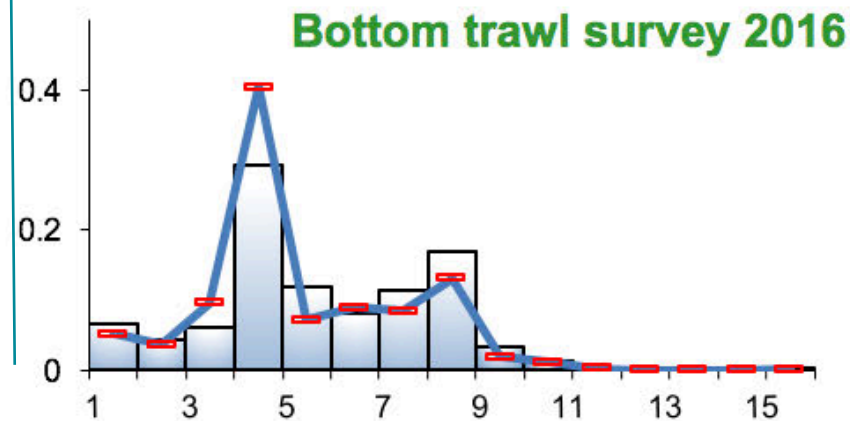
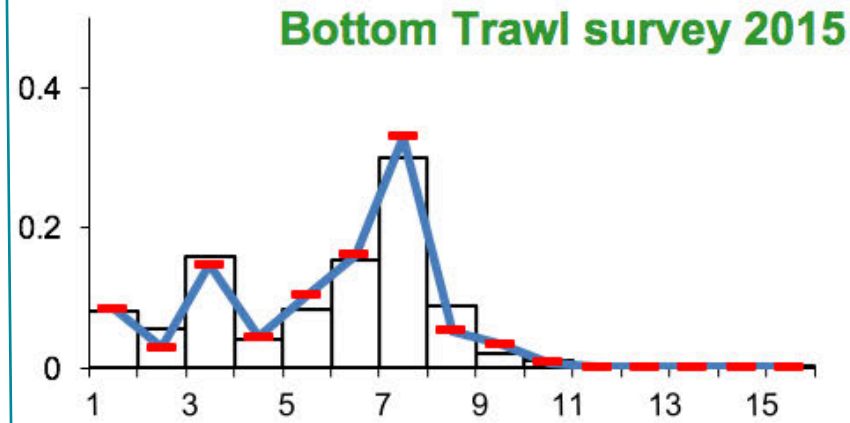
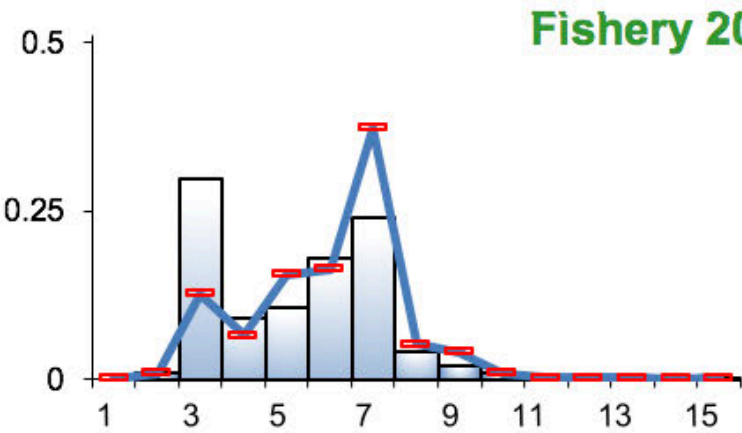
Model	BTS Biomass	BTS Abundance	ATS Biomass	ATS Abundance
15.1	0.3471	0.8377	0.3441	0.3594
16.1	0.2451	0.8465	0.3103	0.3080

Influence of new data

- Age compositions
Incremental addition of new data in 2016

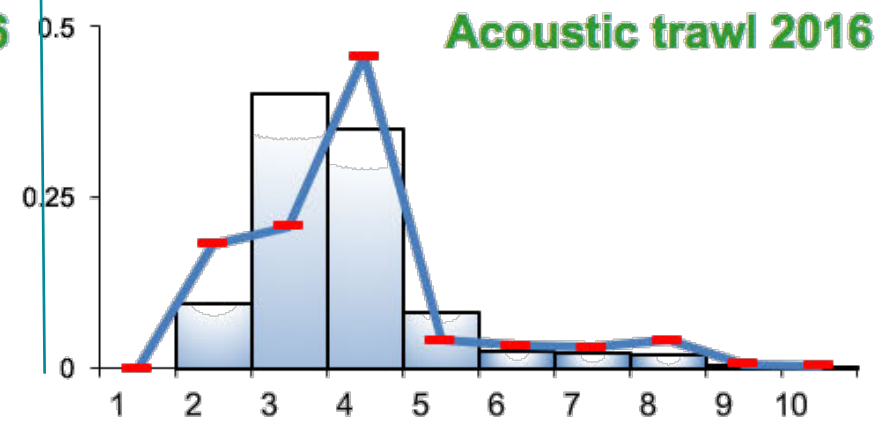
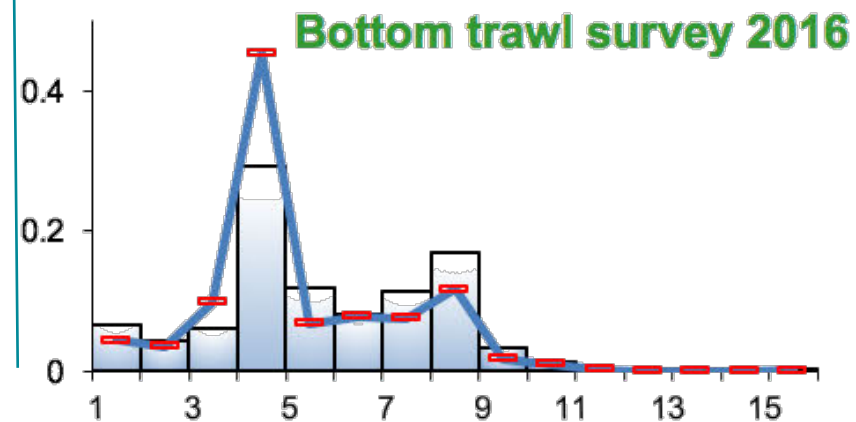
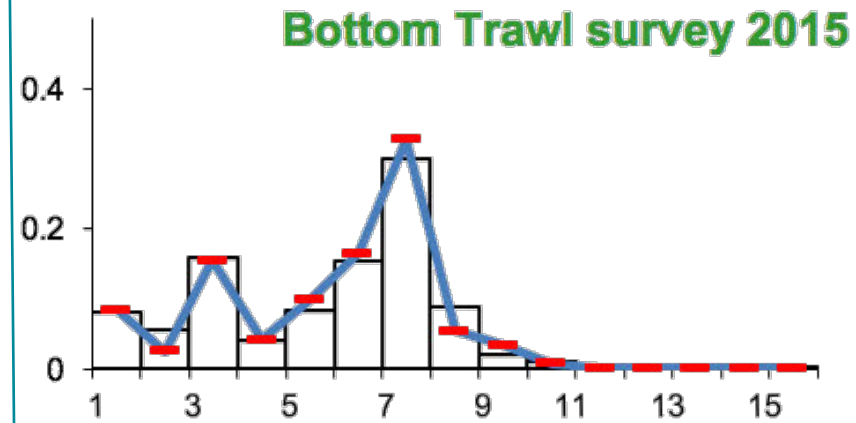
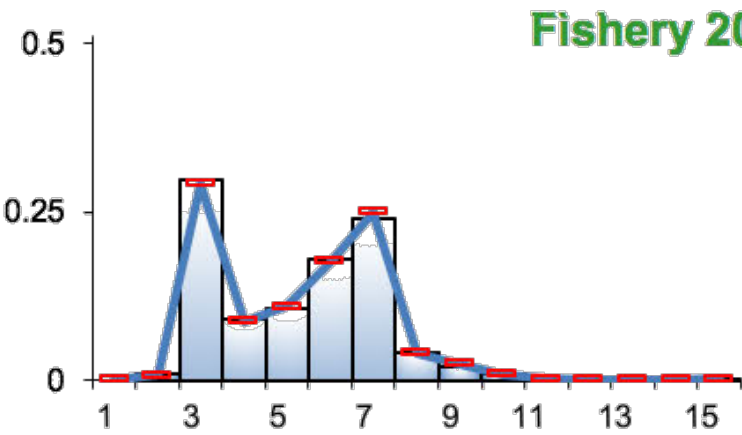
Catch biomass only updated (no new age data in fitting)

C



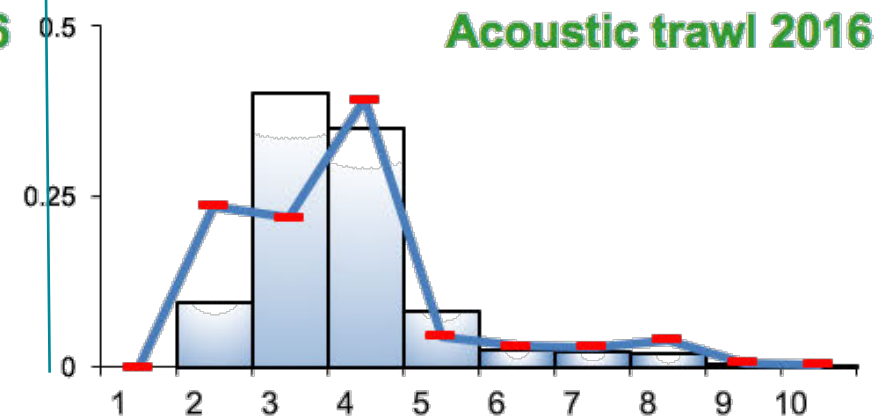
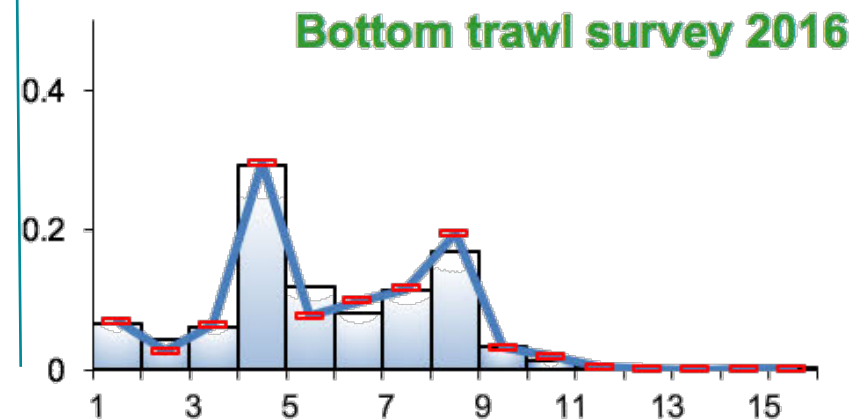
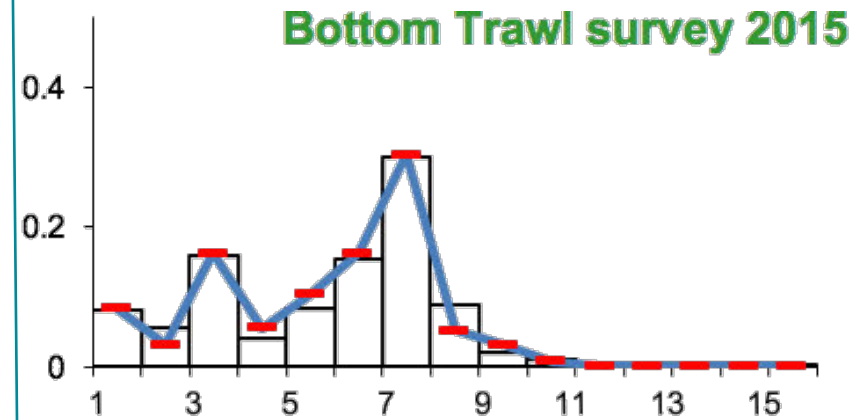
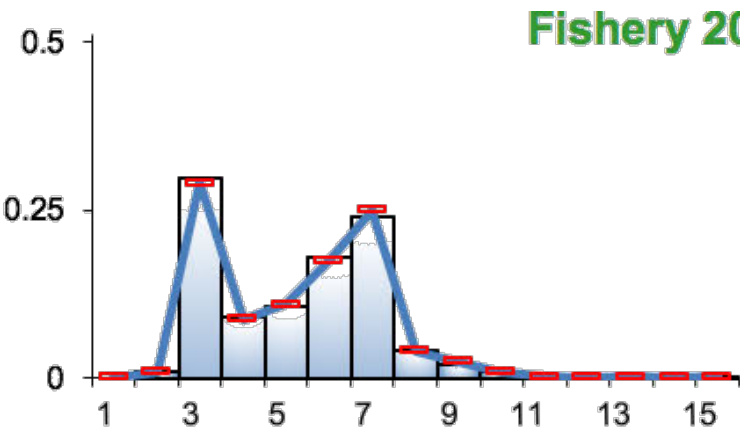
Catch and fishery age data updated

CA



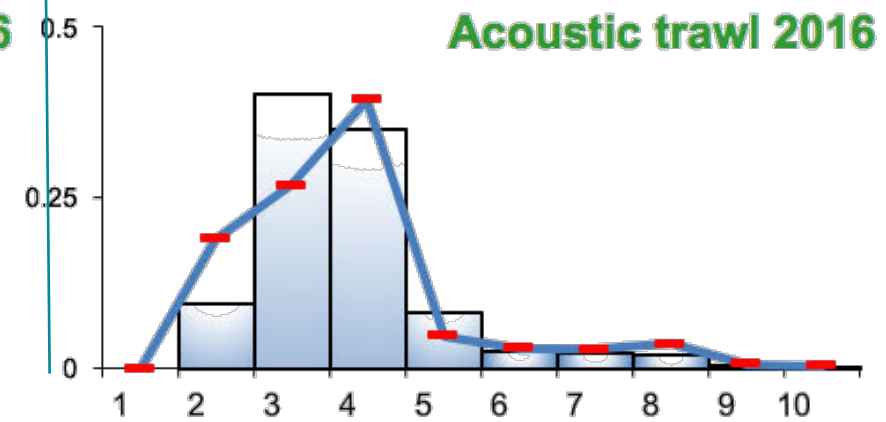
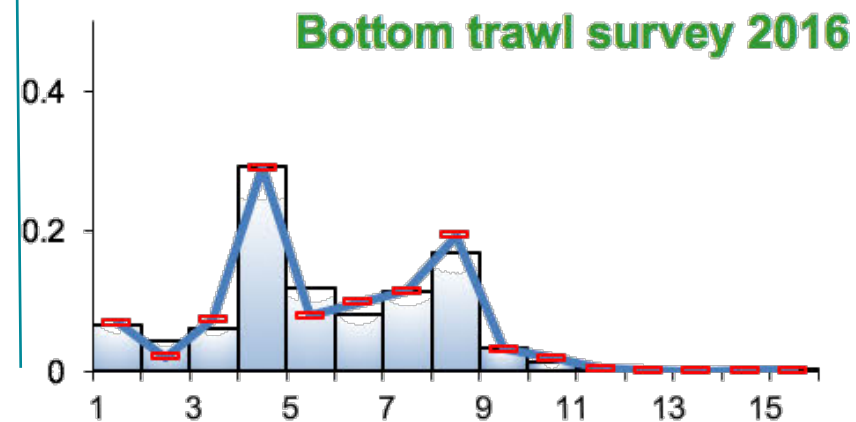
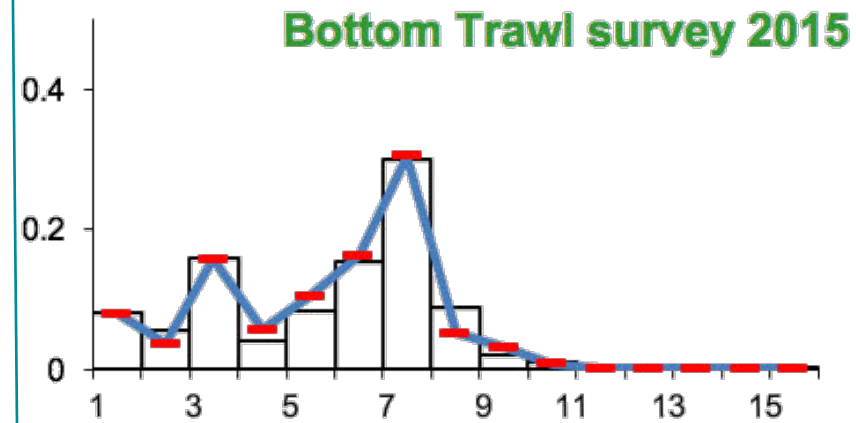
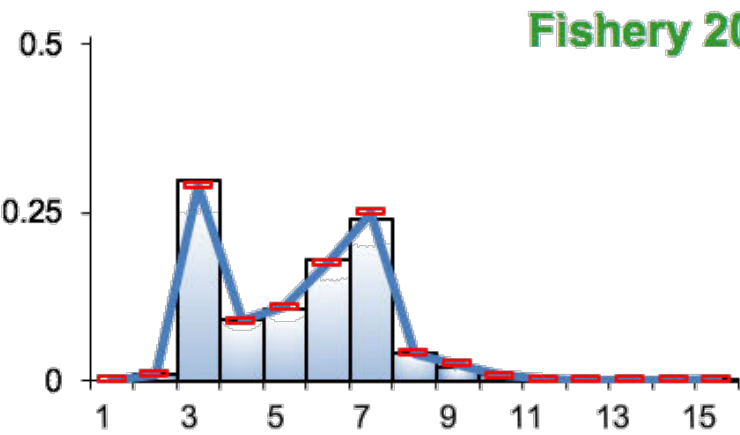
Catch, fishery age data, and bottom trawl survey data updated

CAB



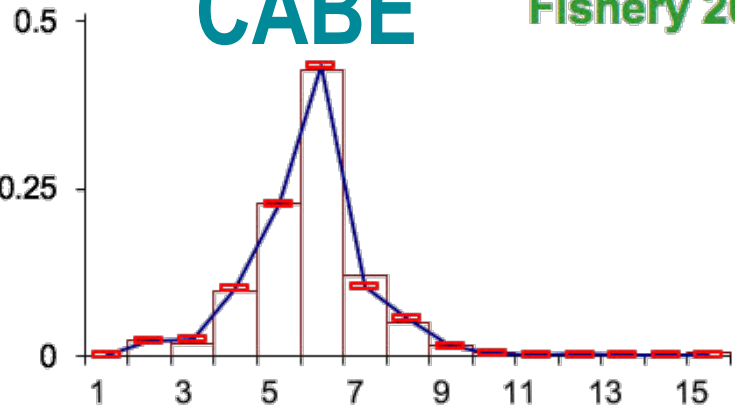
CABE

All new data in...

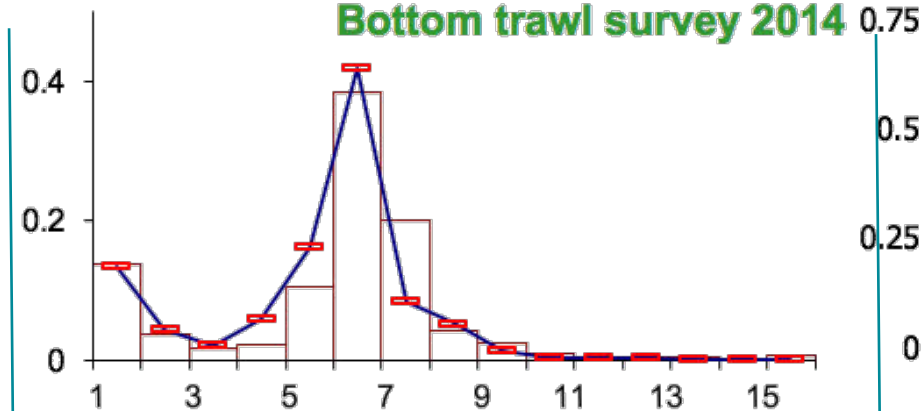


CABE

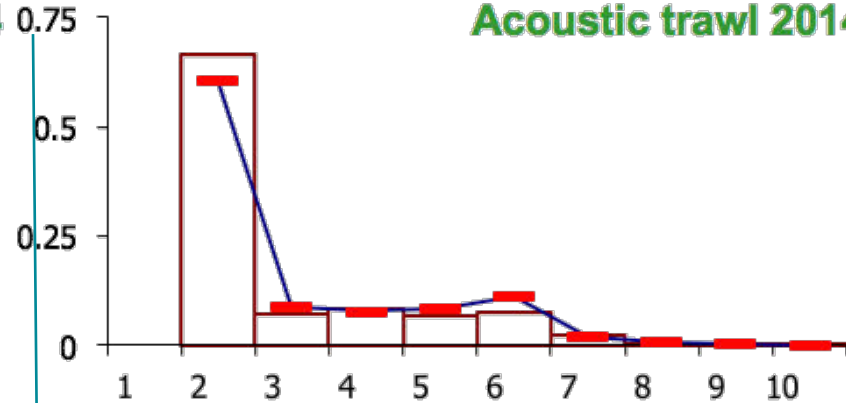
Fishery 2014



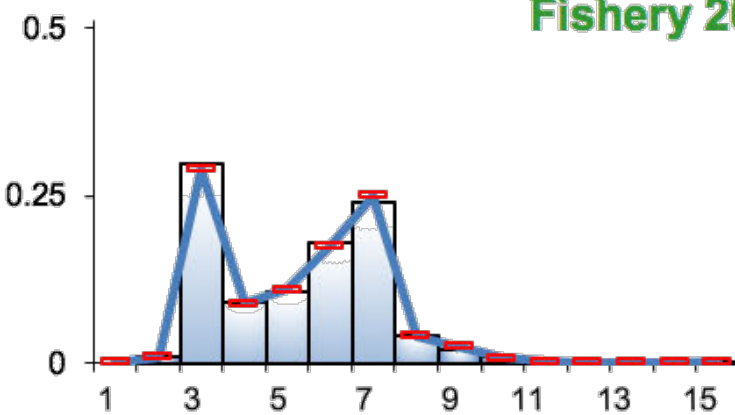
Bottom trawl survey 2014



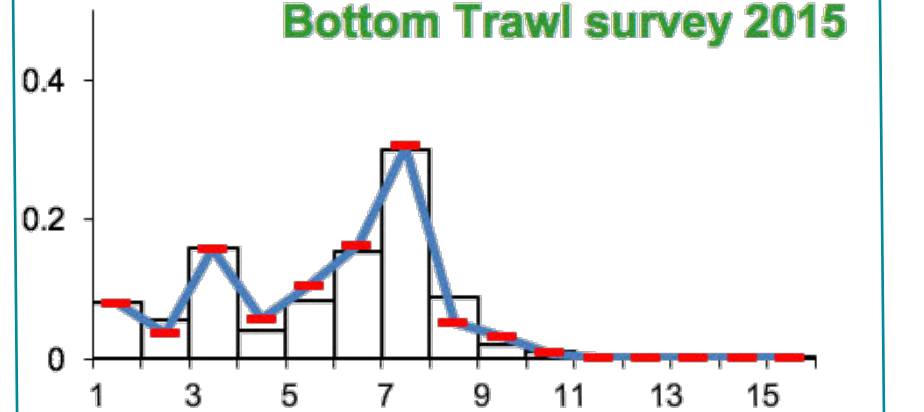
Acoustic trawl 2014



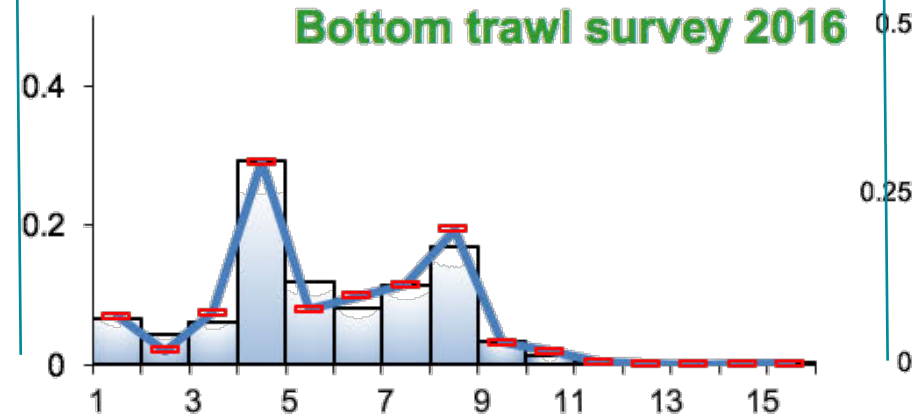
Fishery 2015



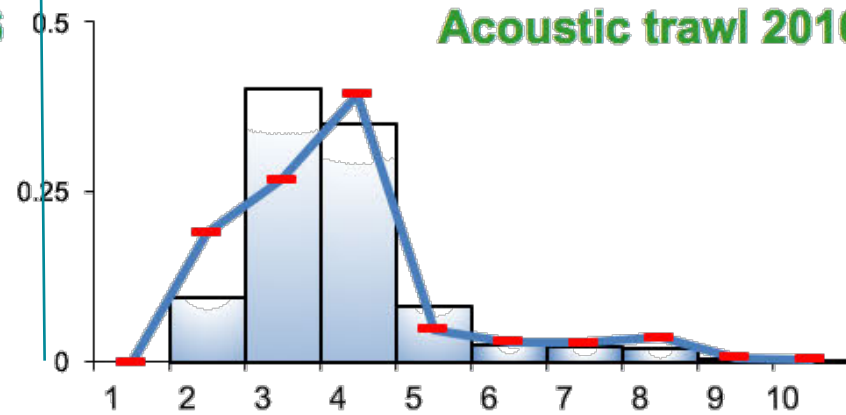
Bottom Trawl survey 2015



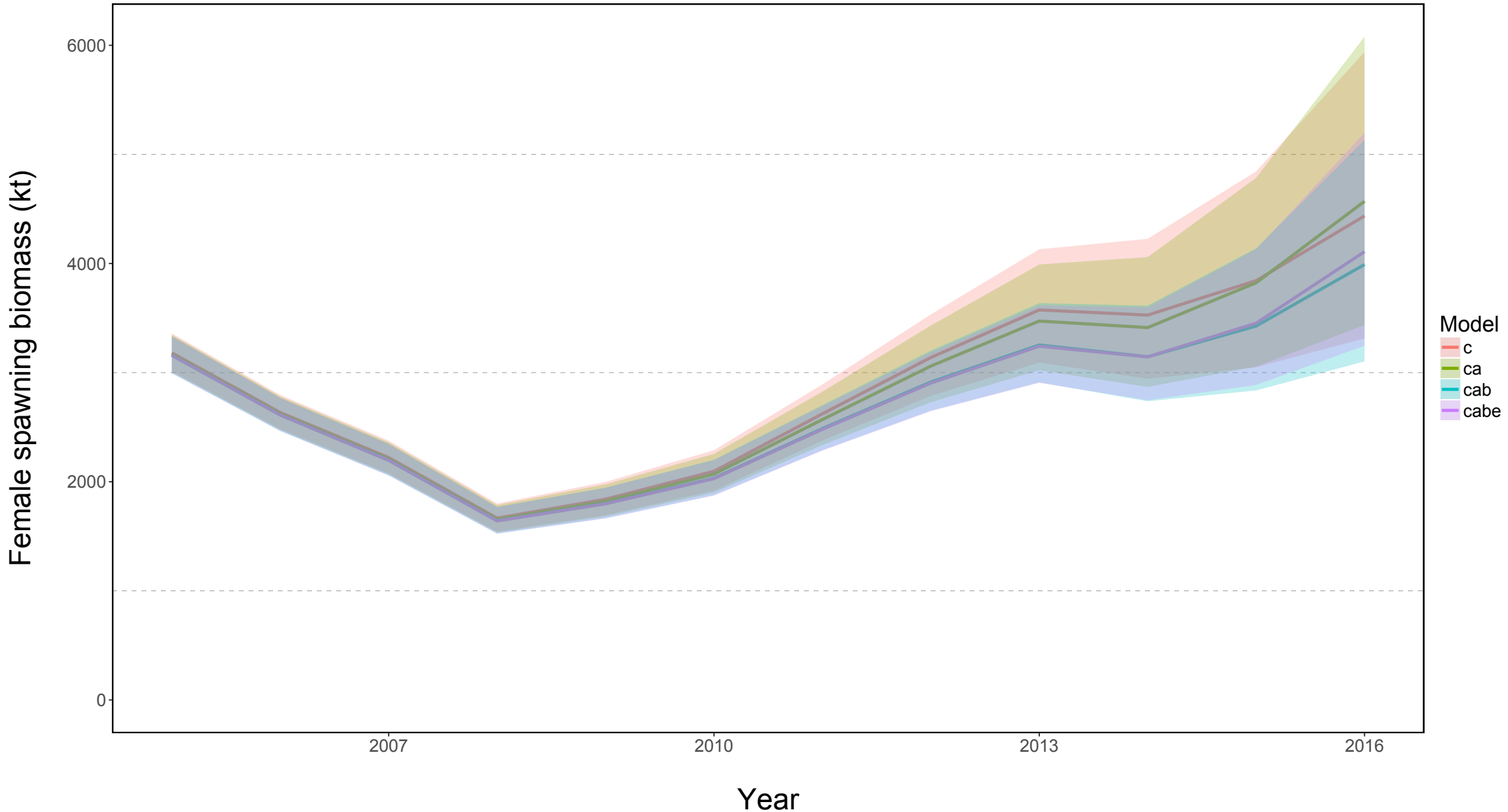
Bottom trawl survey 2016



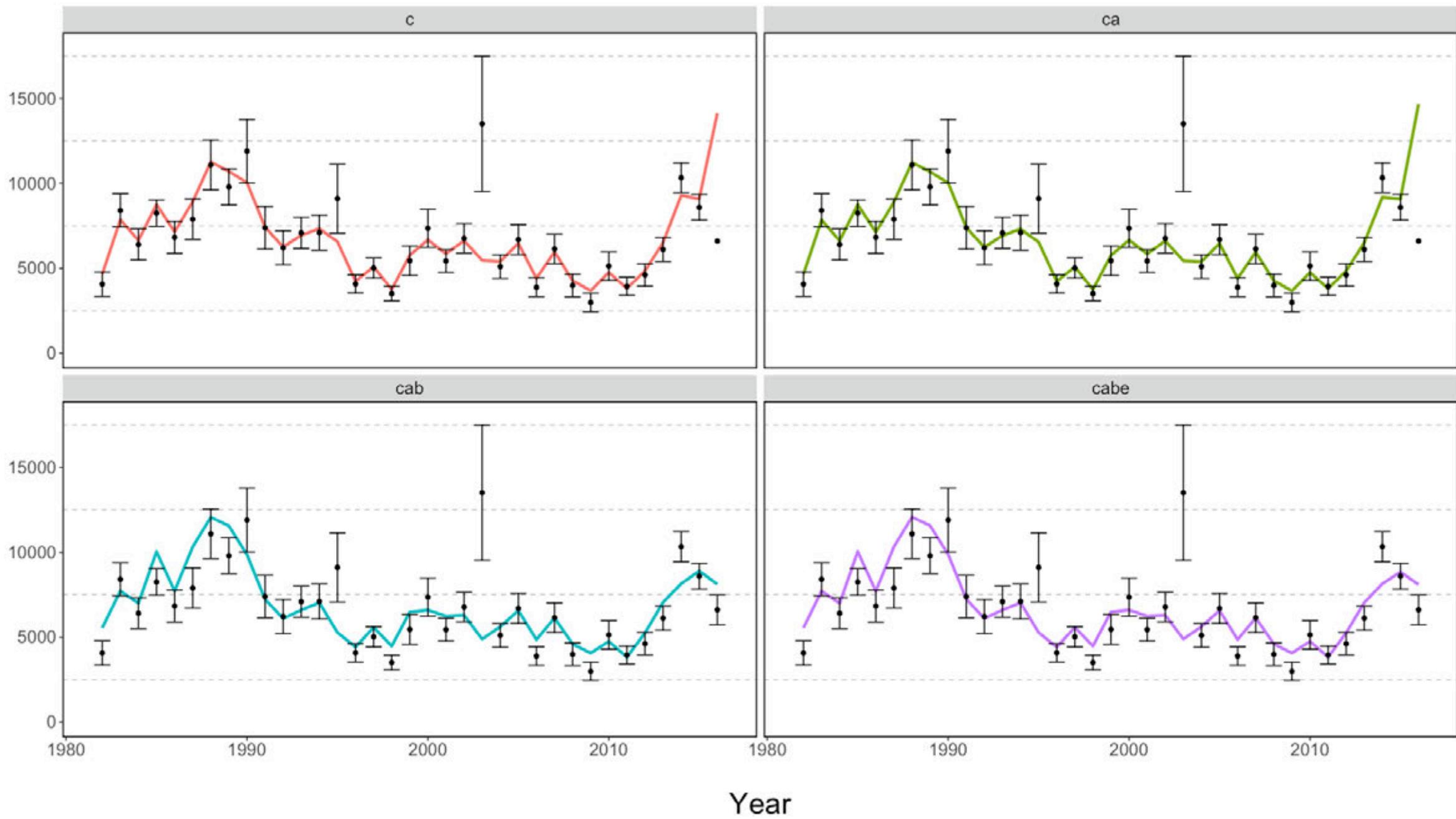
Acoustic trawl 2016



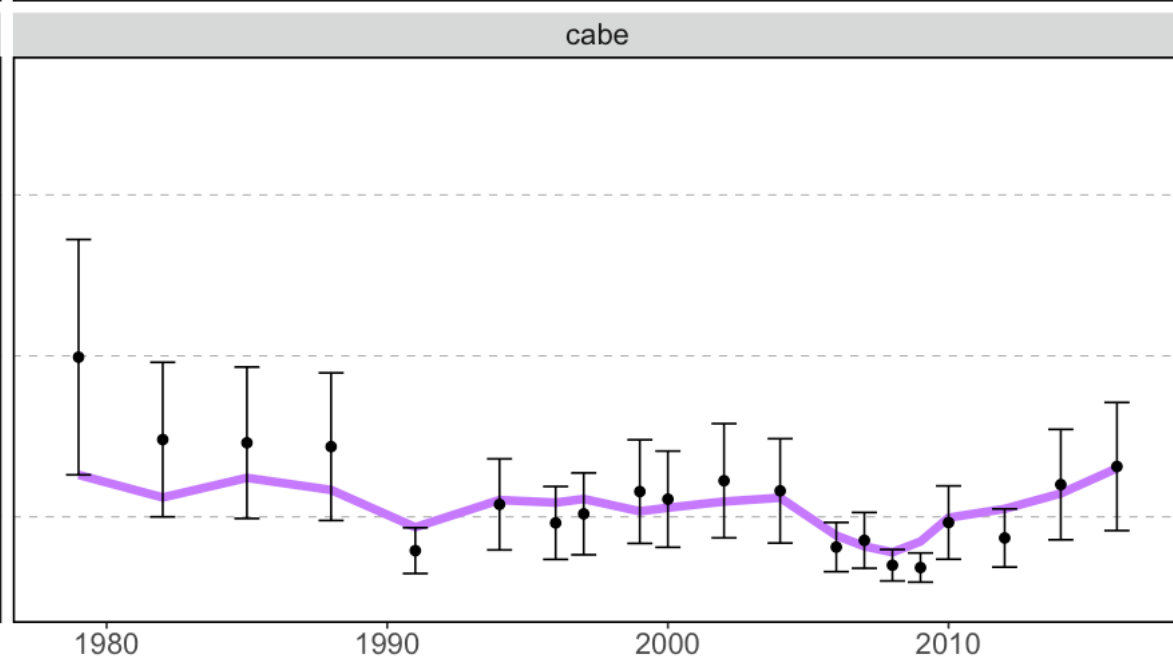
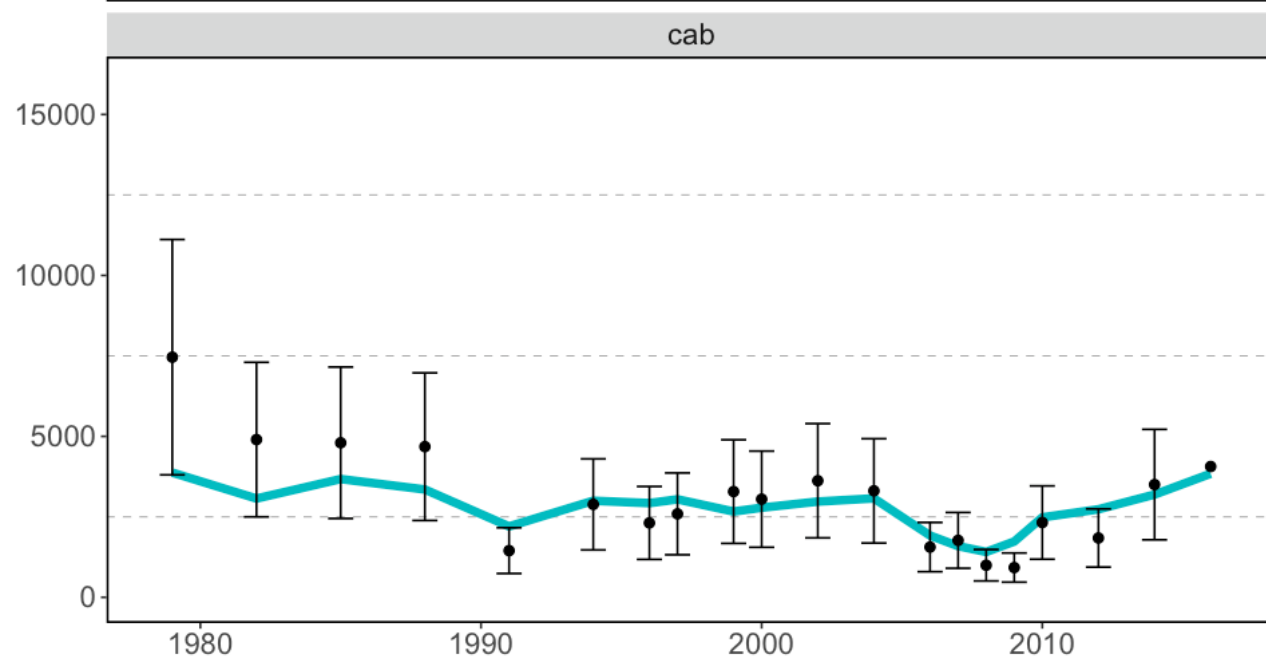
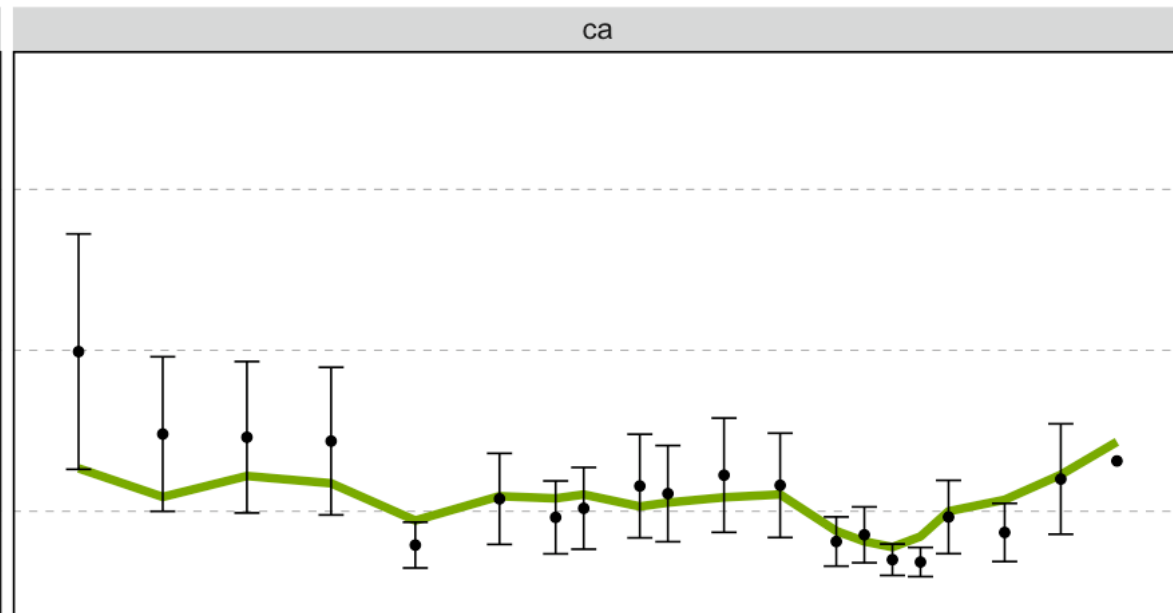
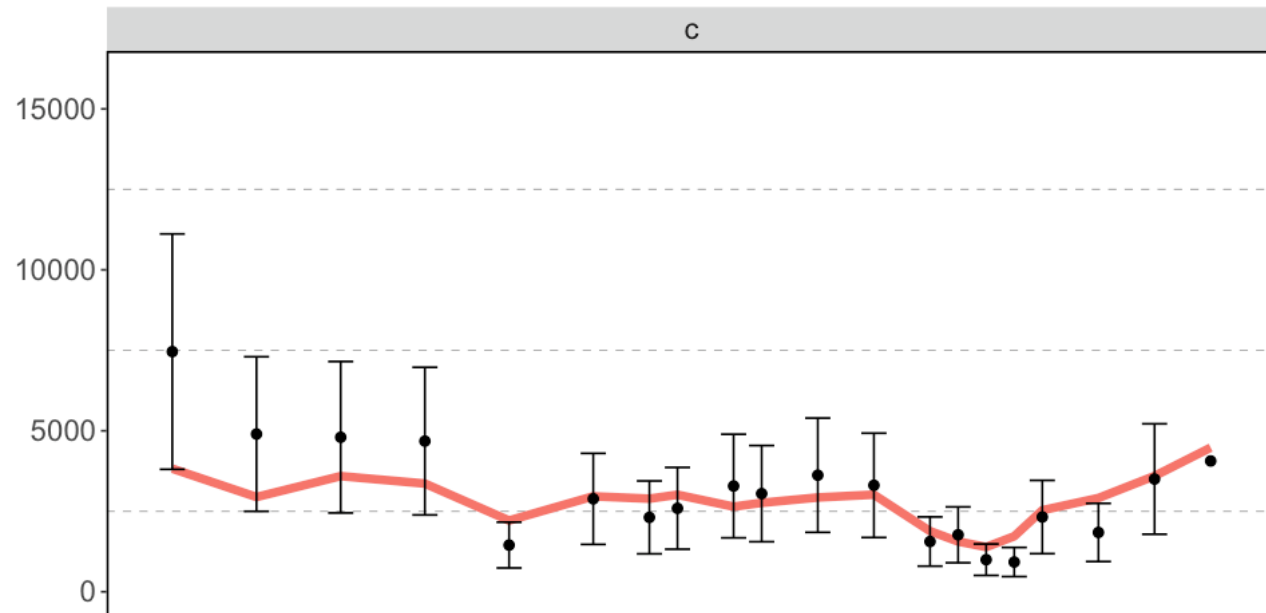
New data affects spawning biomass



Bottom trawl survey biomass

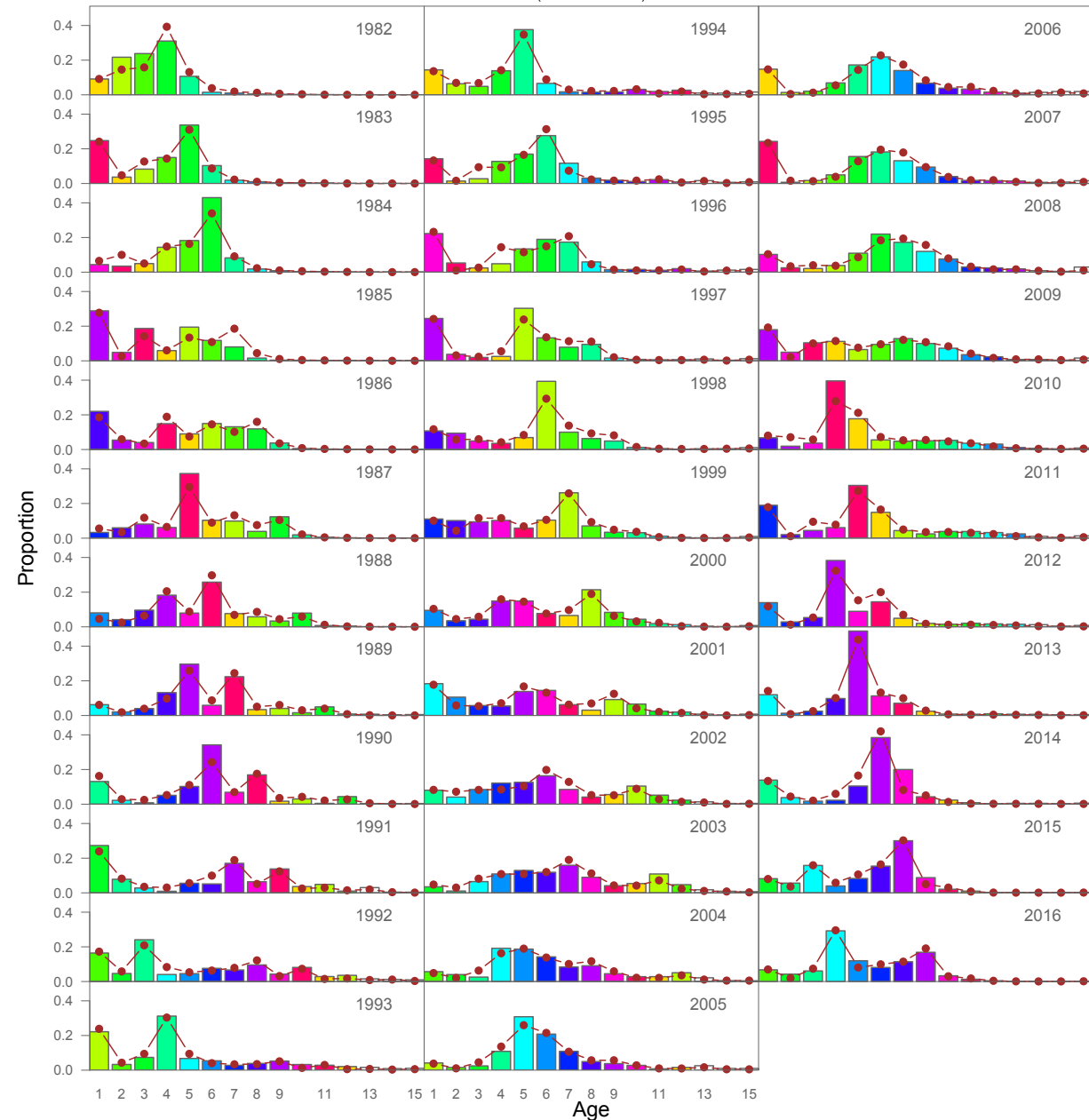


Acoustic trawl survey biomass

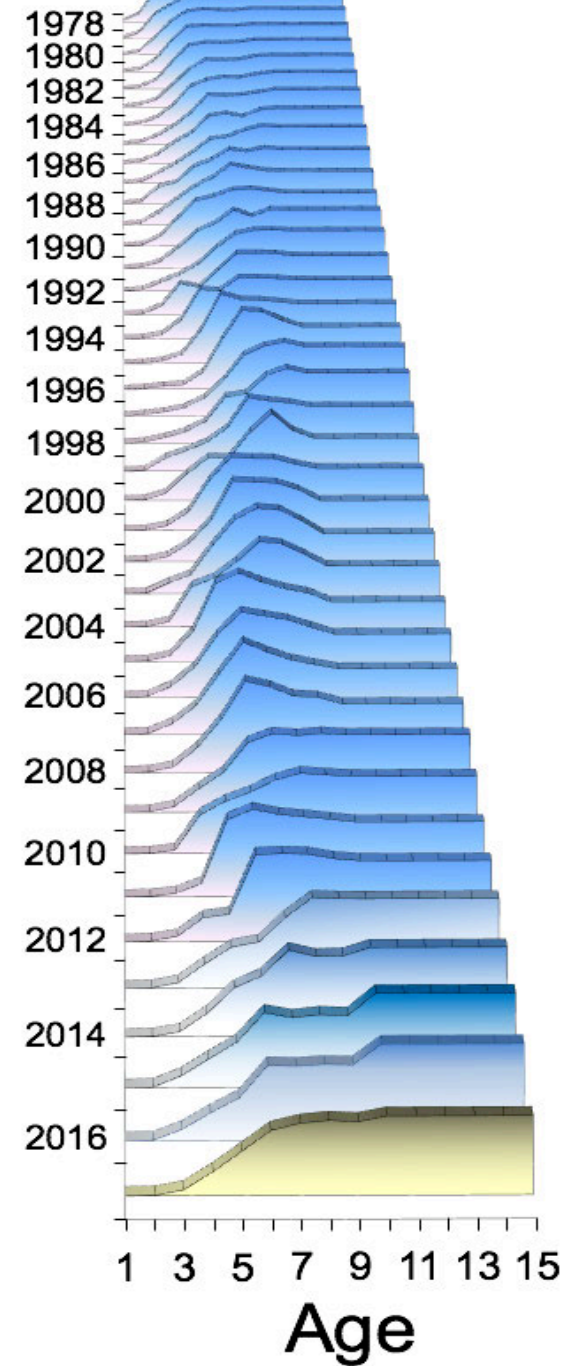
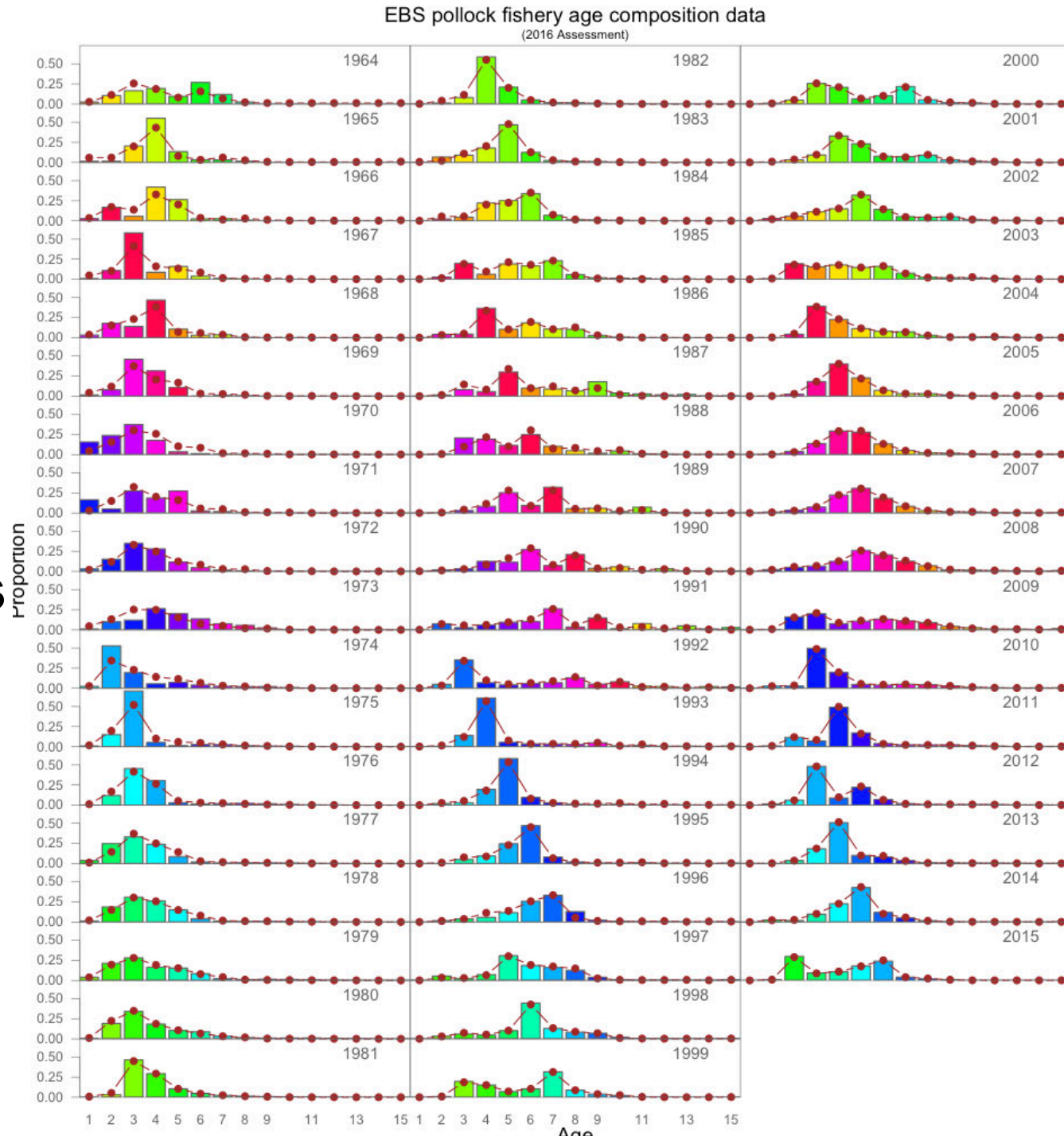


Fit to survey age compositions

EBS pollock survey age composition data
(2016 Assessment)

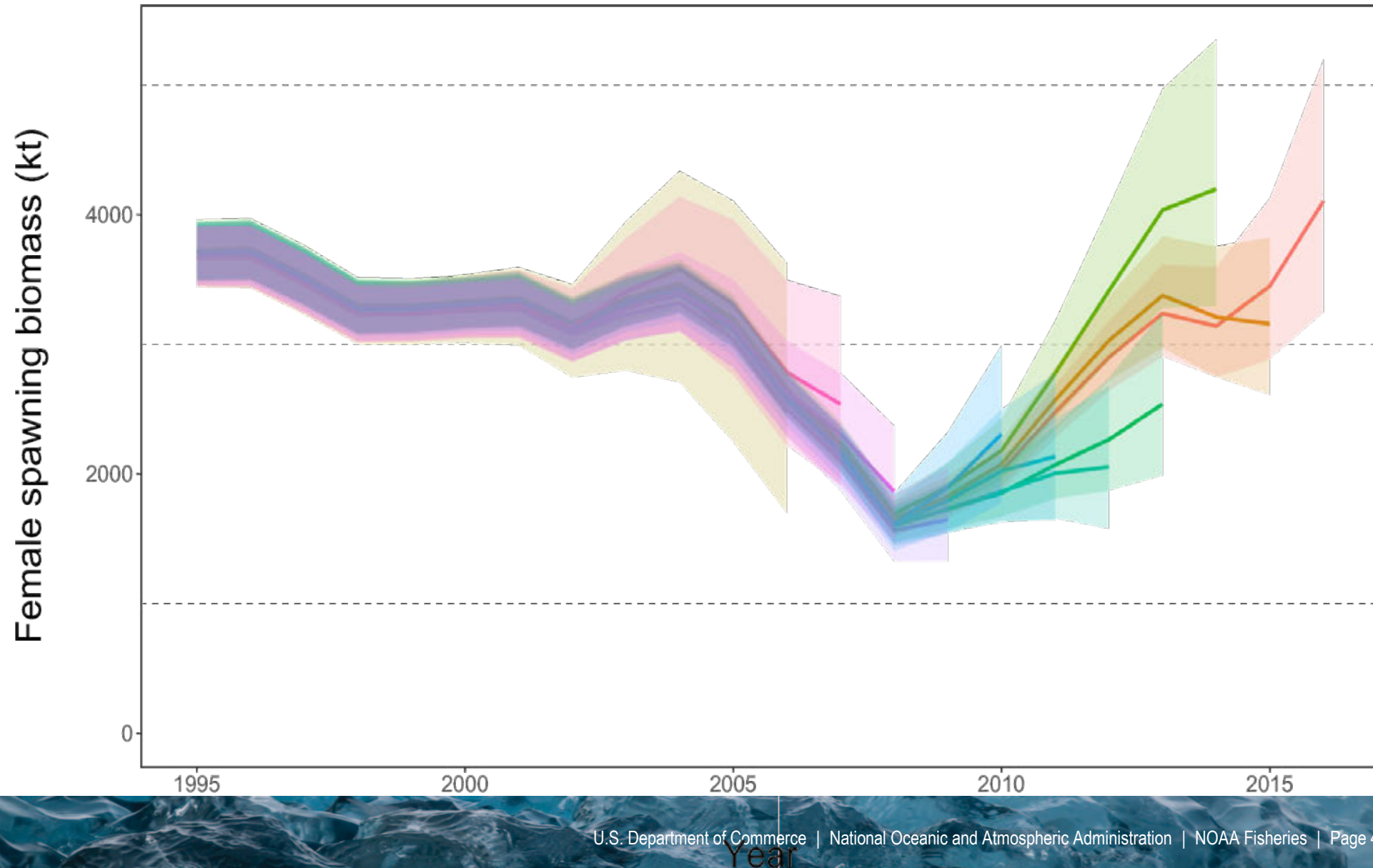


Fishery selectivity and fits to age compositions



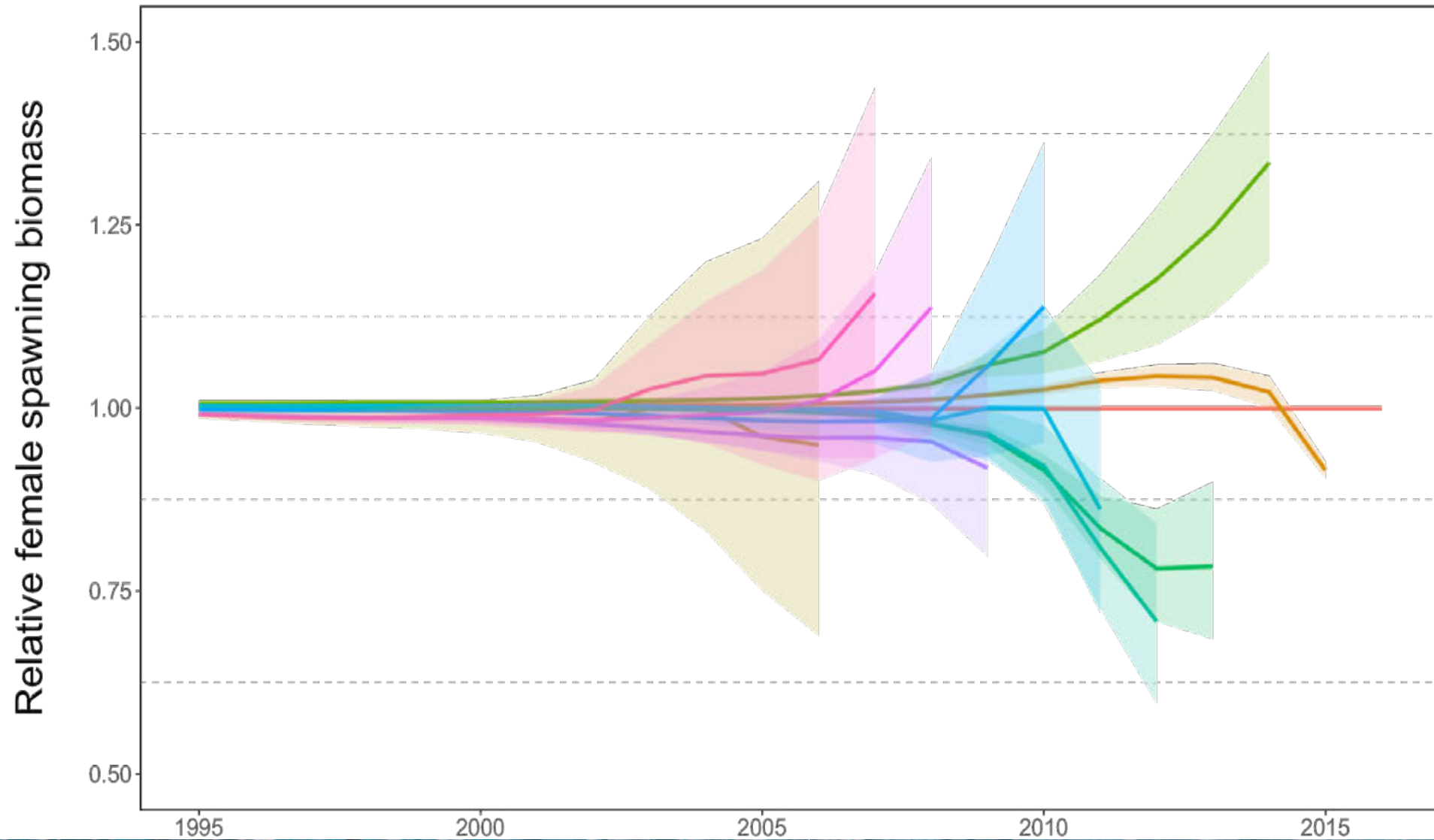
Diagnostics: retrospectives

Given model,
impact of
removing
recent
data

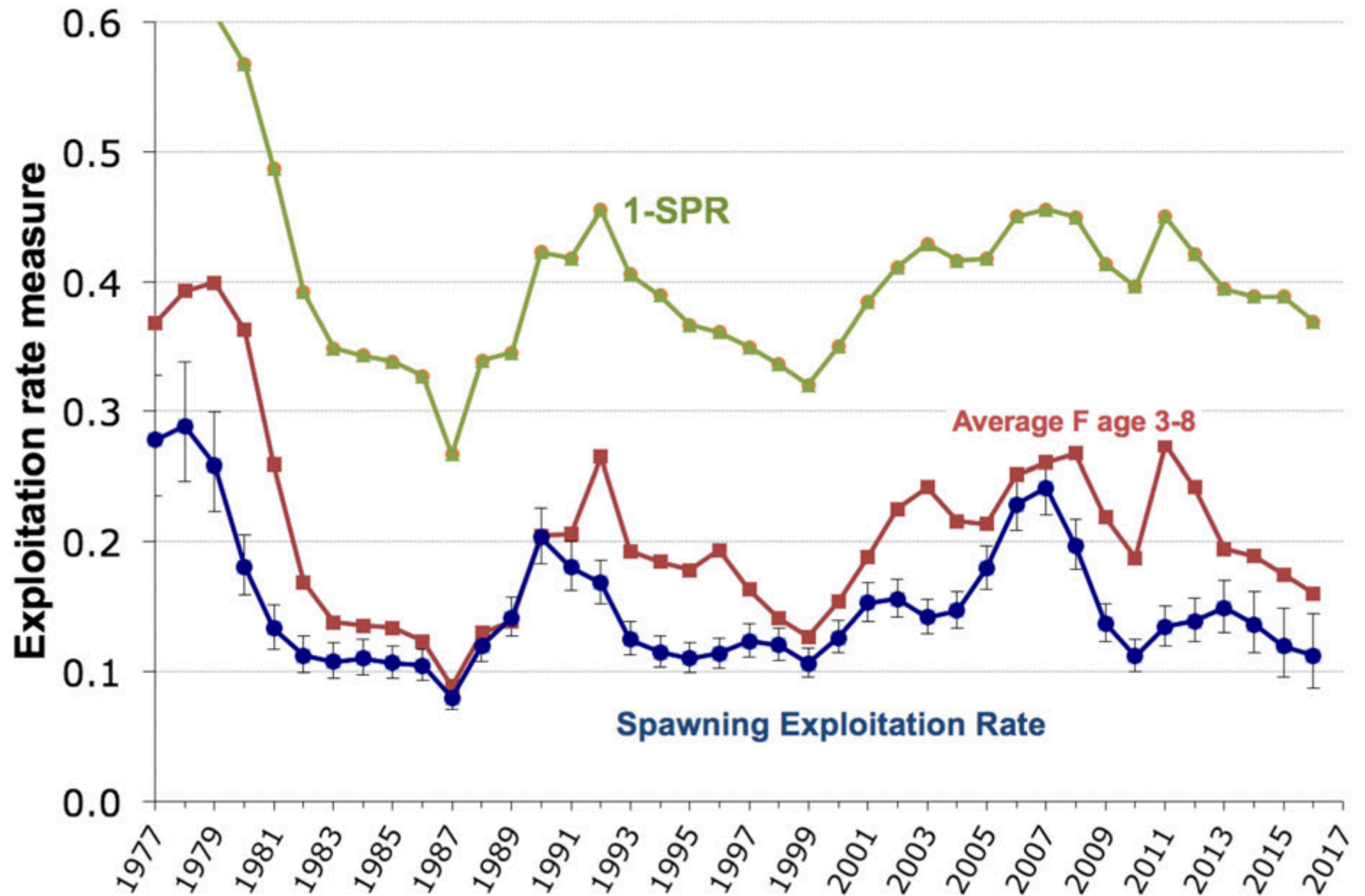


Diagnostics: retrospectives

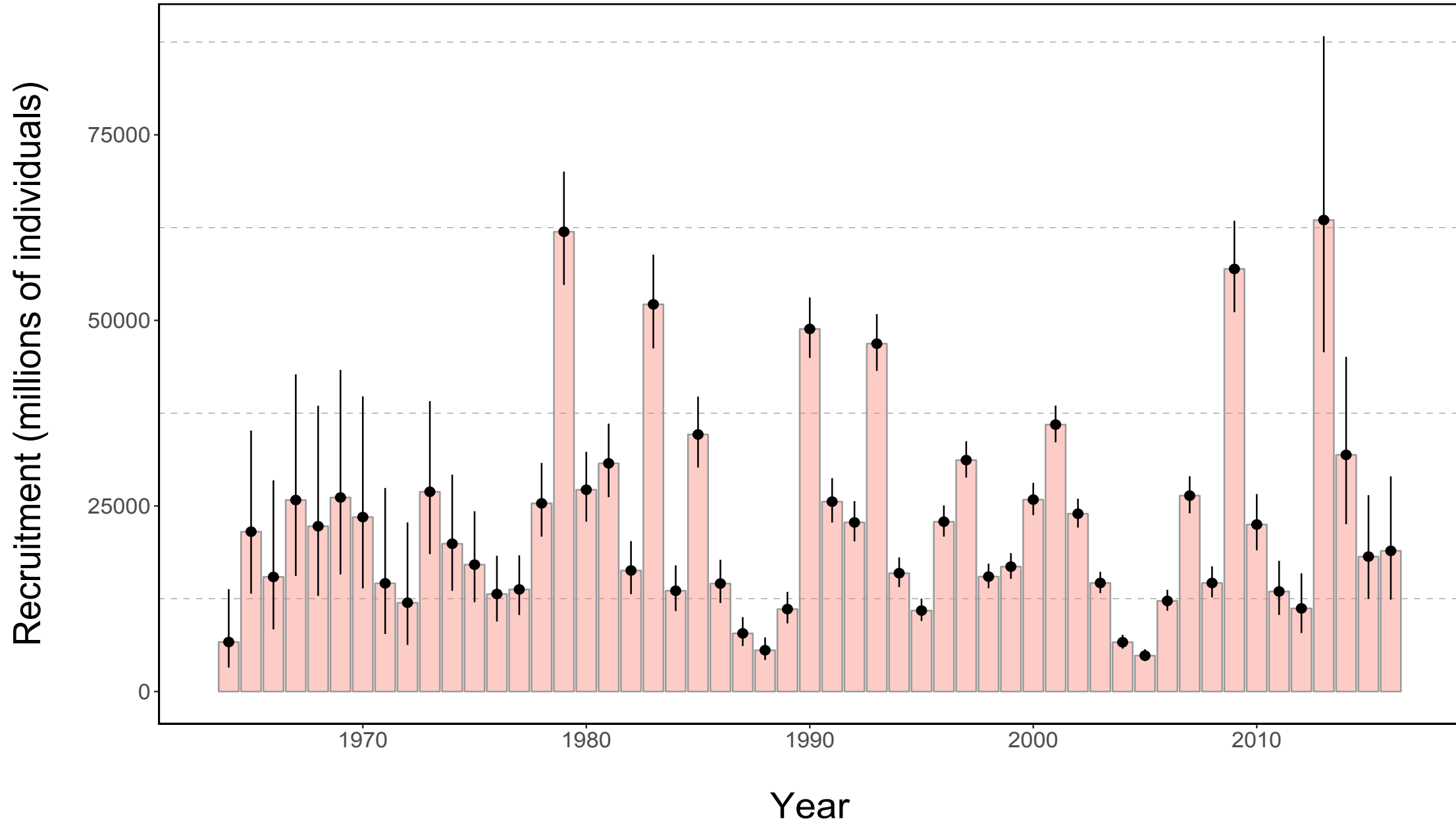
Given model,
impact of
removing
recent
data



Model 16.1 fishing intensity metrics

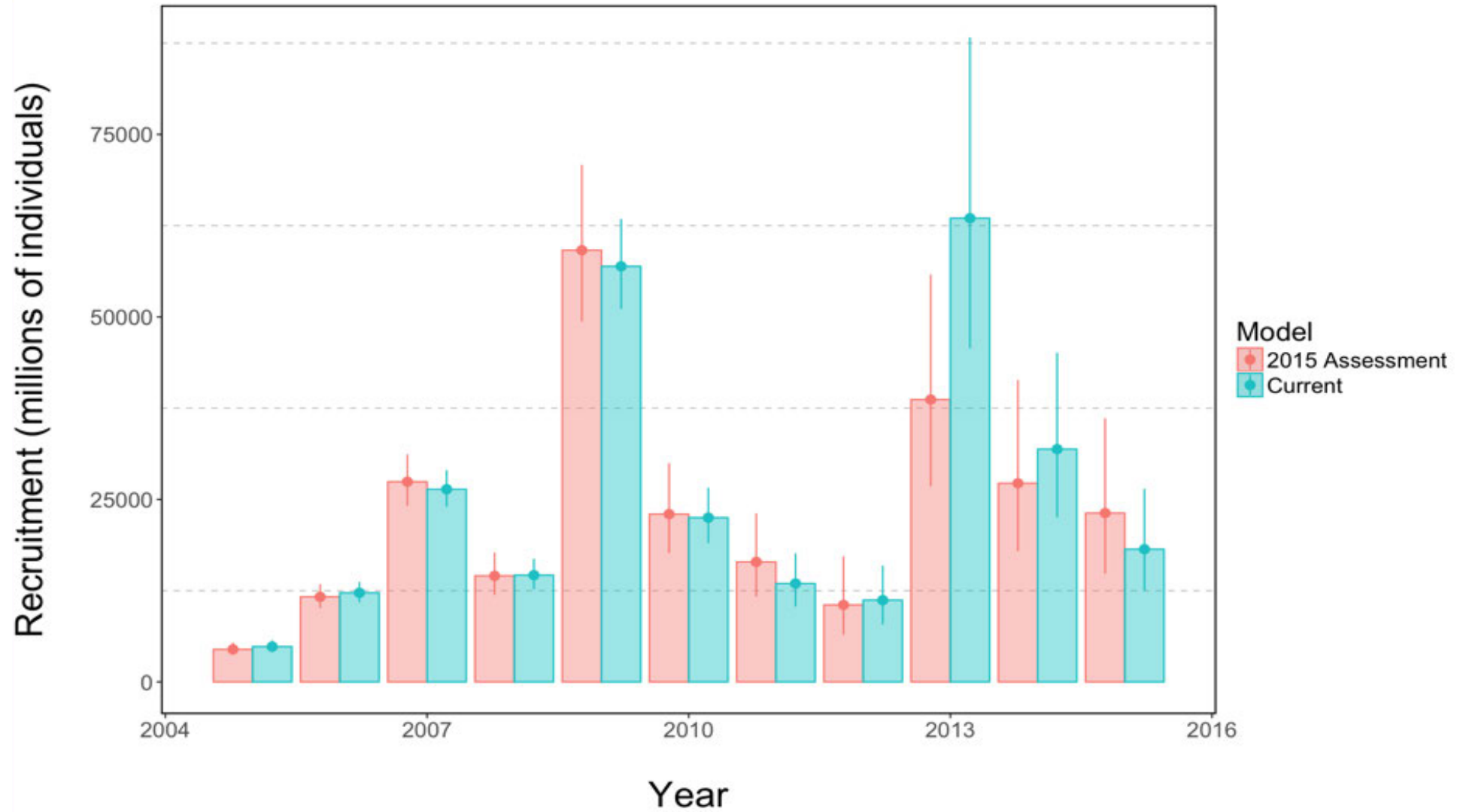


Recruitment estimates



Recruitment estimates

Change
from
last
year



Female spawning biomass (kt)

5000
4000
3000
2000
1000
0

1980

1990

2000

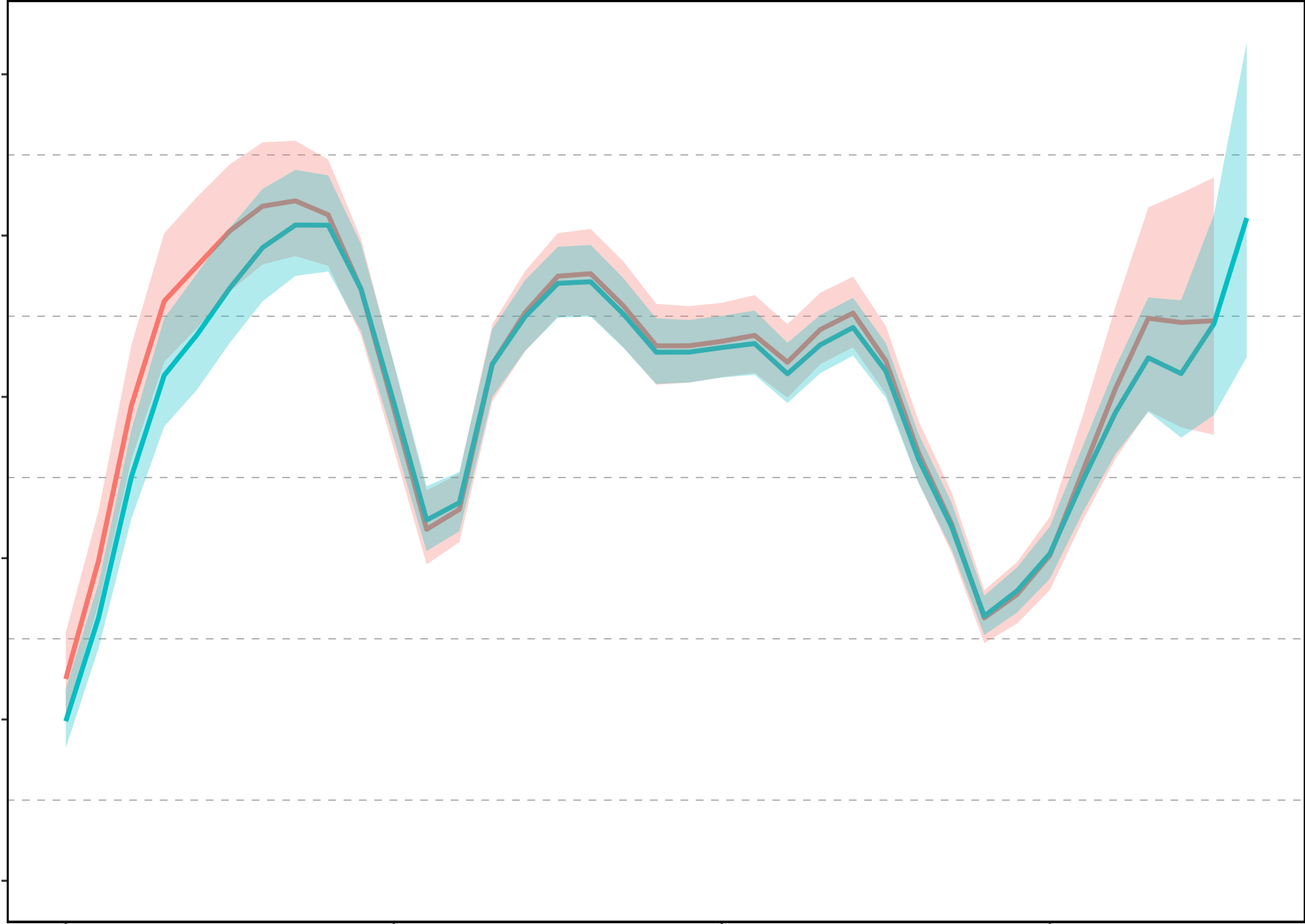
2010

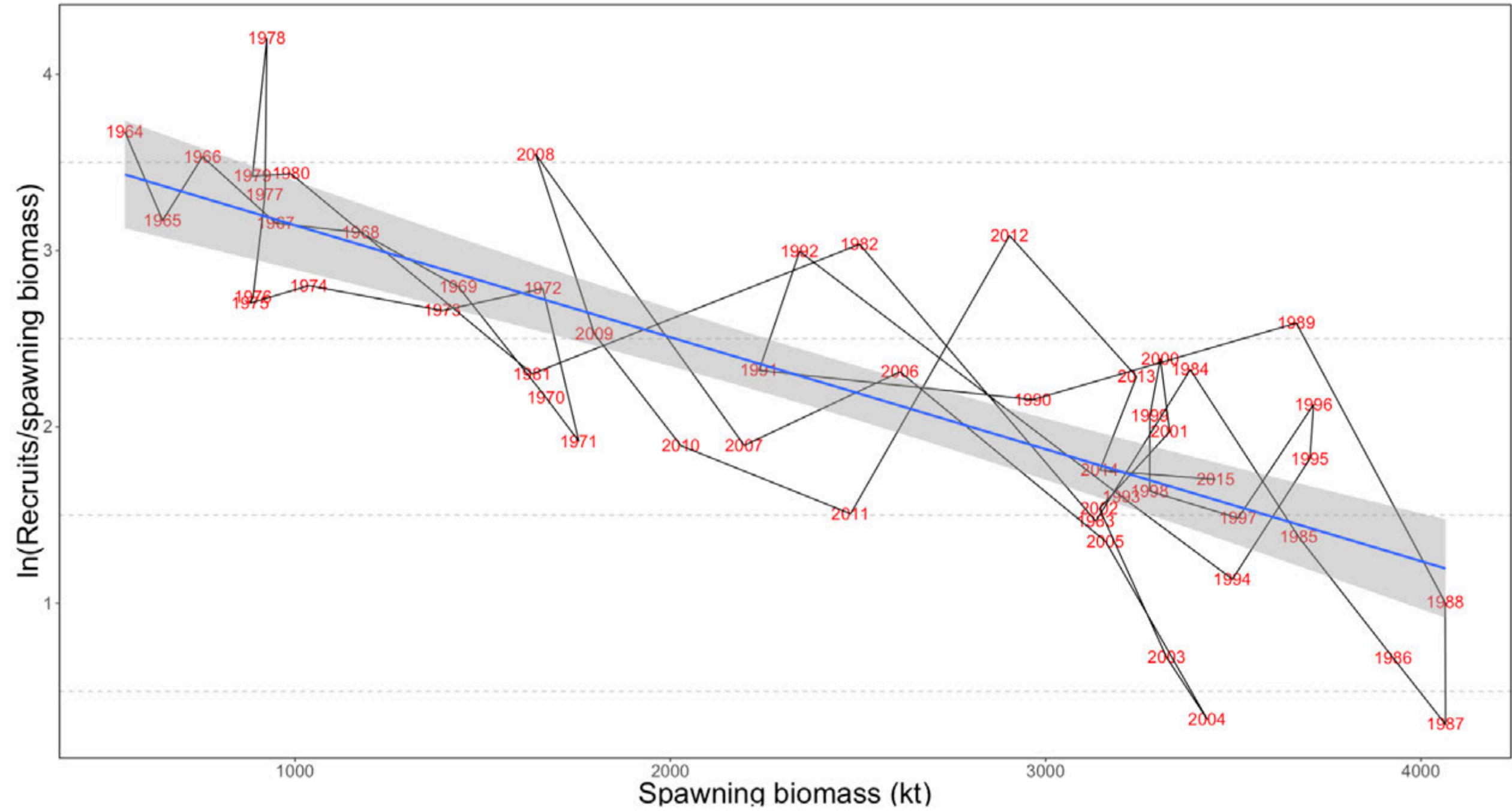
Year

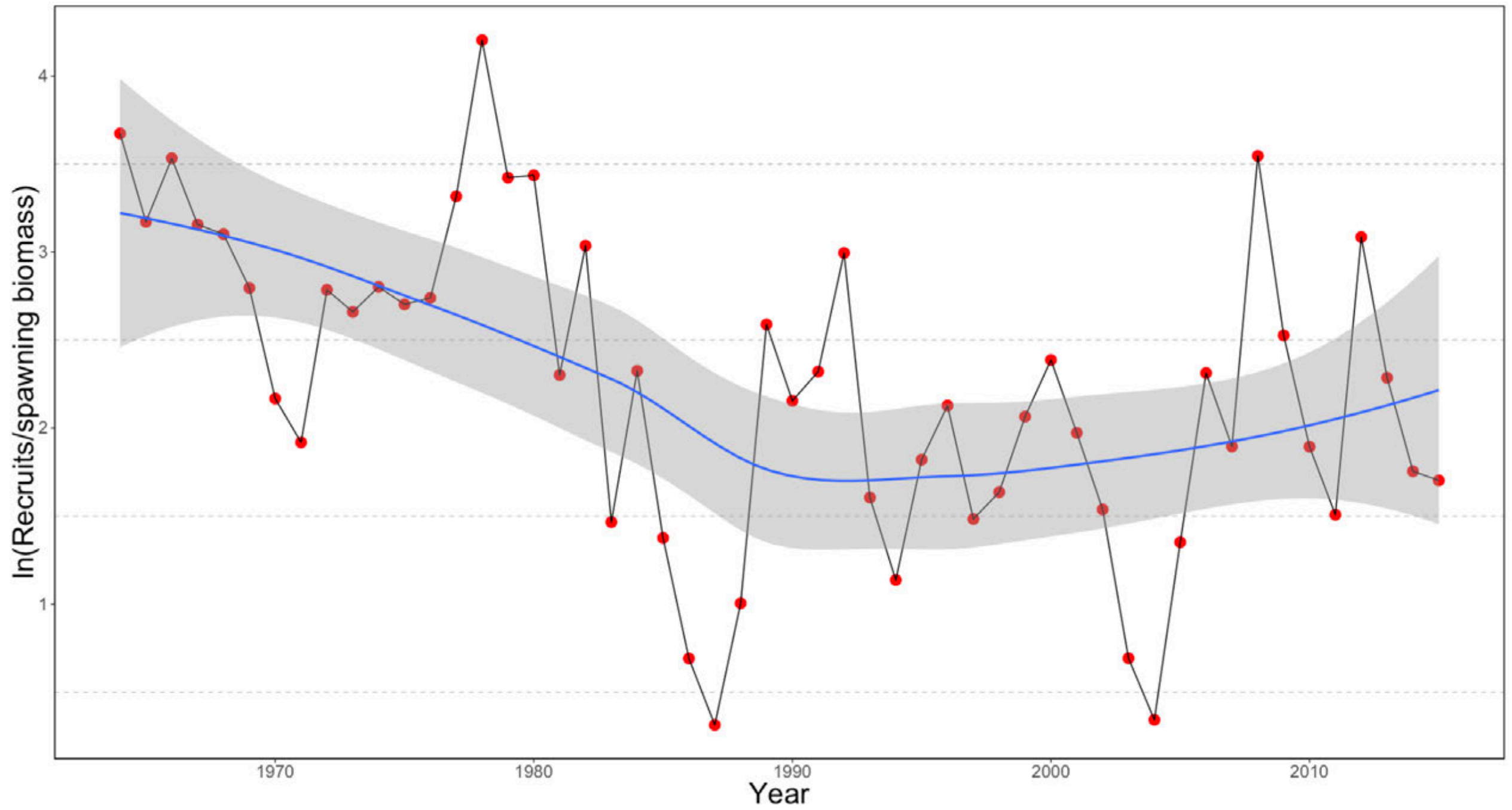
Model

2015 Assessment

Current

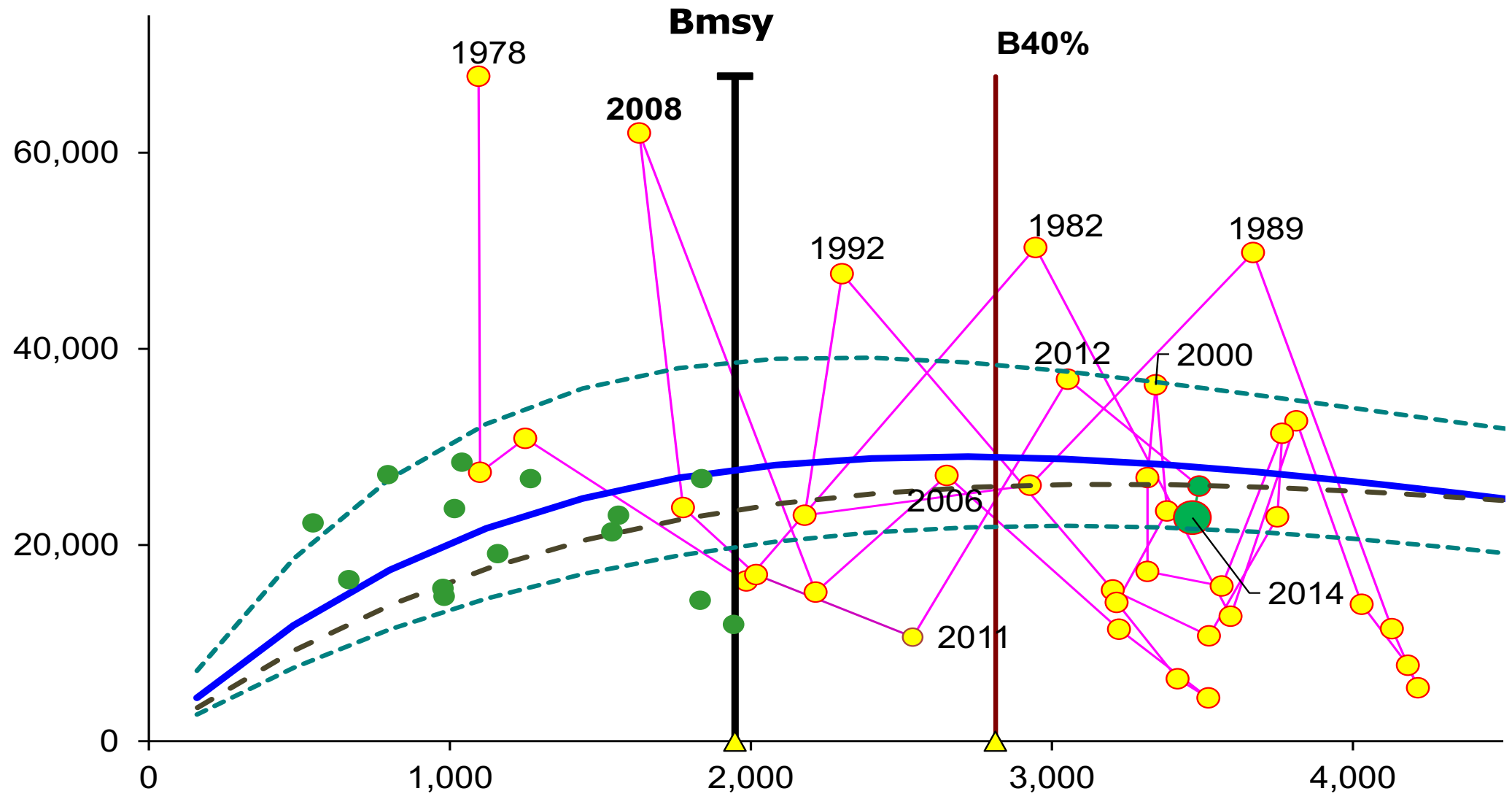






Age 1 Recruitment (millions)

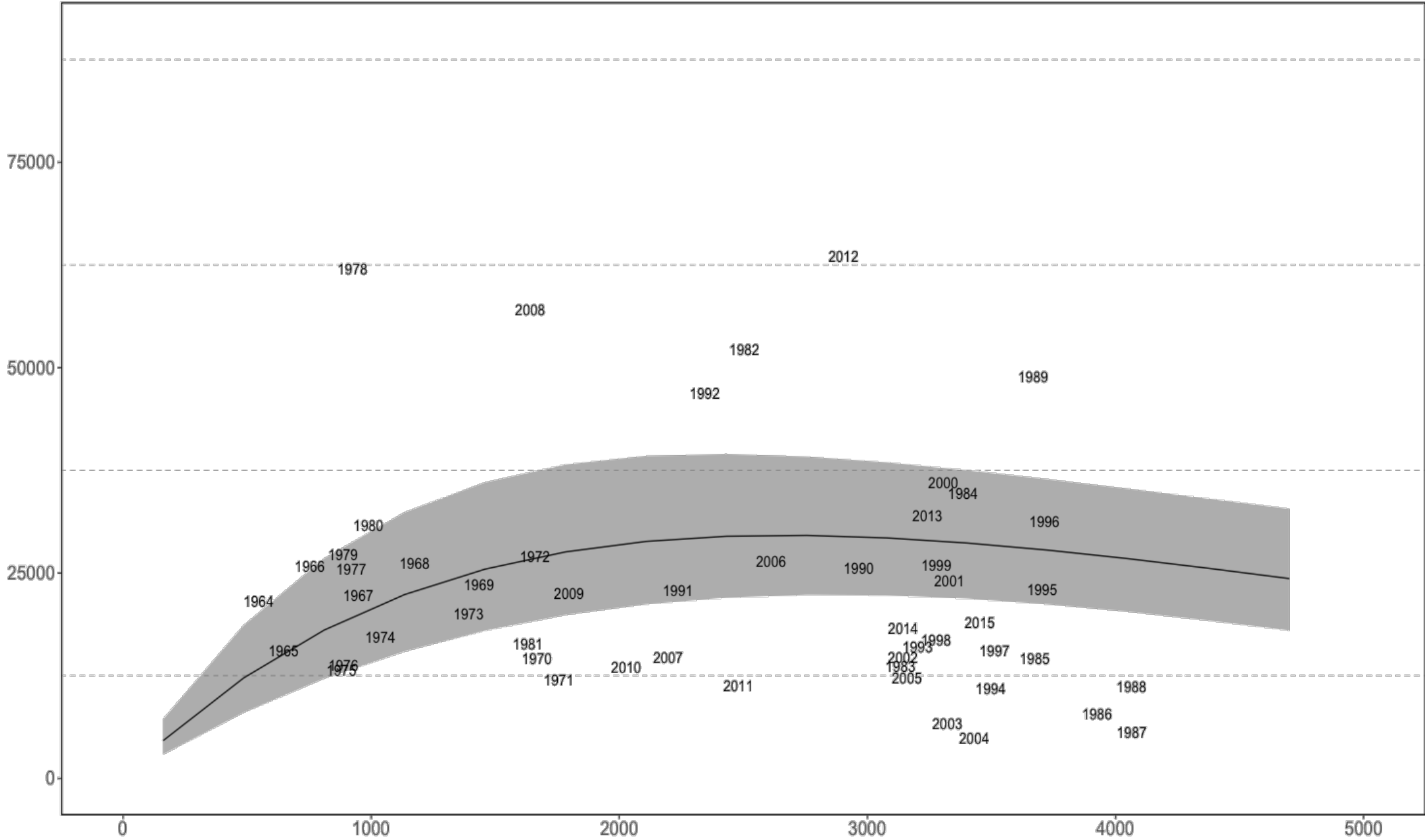
- Used in stock-recruit estimation
- Excluded in stock-recruit estimation
- Model estimate (1978-2011 YC included)
- - - SR curve confidence interval
- - - Curve at mode of prior on steepness



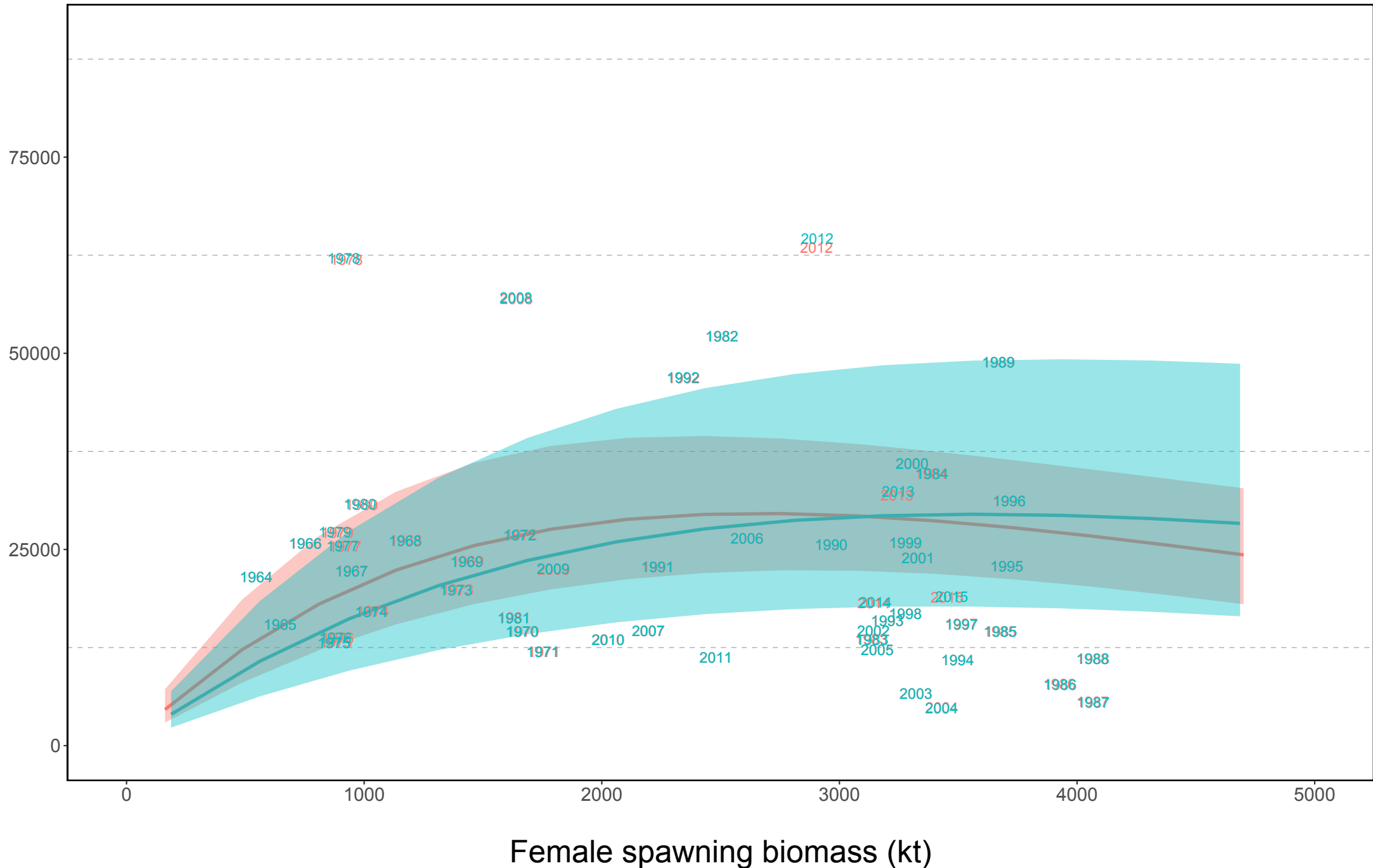
Female spawning biomass (thousands of t)



Recruits (age 1, millions)



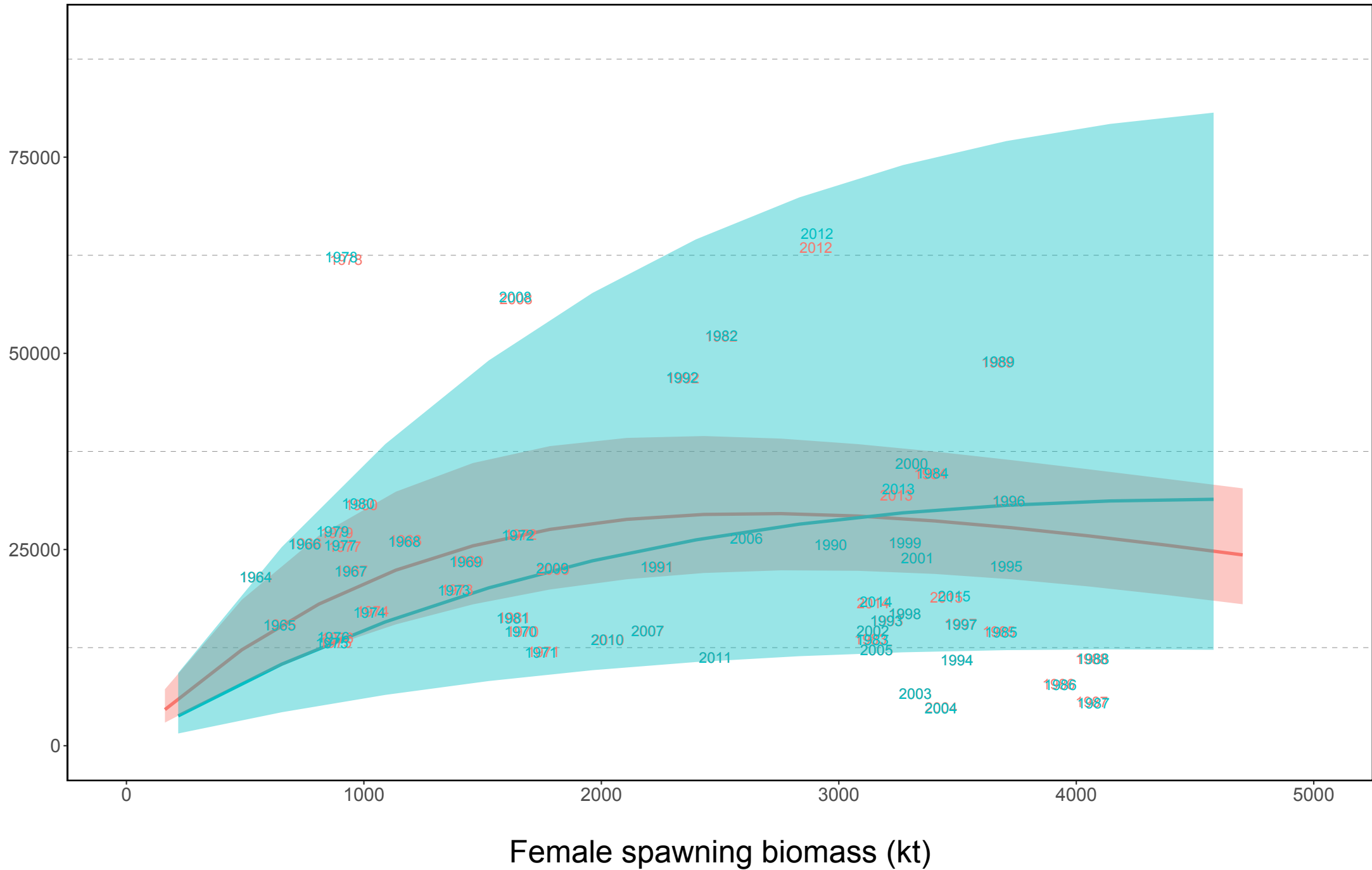
Recruits (age 1, millions)



Model
base condition
Mod condition



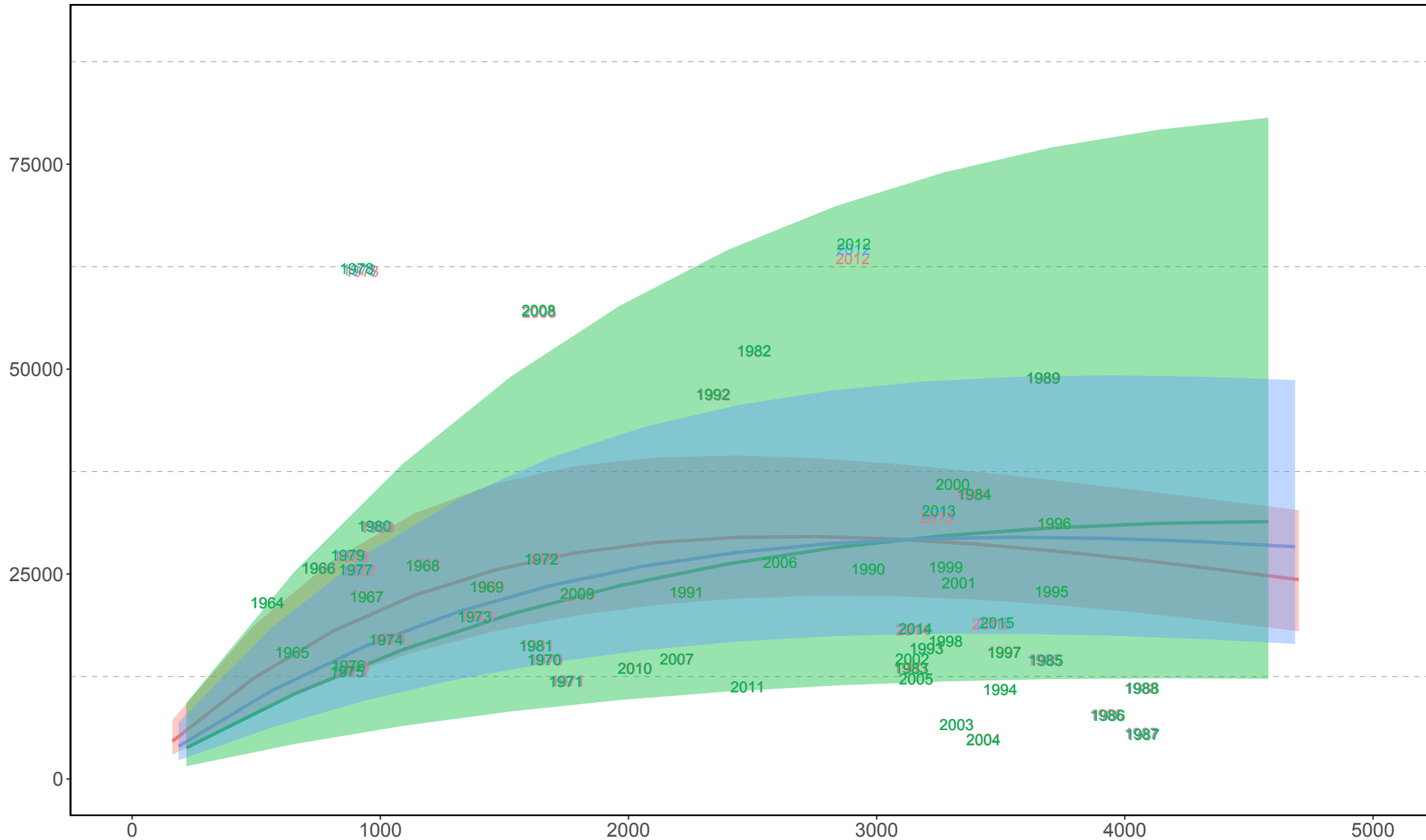
Recruits (age 1, millions)



Model
base condition
Low condition



Recruits (age 1, millions)



Female spawning biomass (kt)

High ABC and OFL...but some caveats...

- **Warm** conditions in summer 2016
 - Thought to negatively affect the survival of larval and juvenile pollock.
- **Few one-year-old pollock** in summer 2016 Acoustic survey
- **Low abundances of pollock aged 10 and older**
- **Patchier concentrations** of pollock compared to recent years
- **Roe production dropped**
 - In 2015 in the B-season.
- **Structural uncertainty underestimated**
- **Euphausiid index** declined since the 2009 peak.
- **2.5% decline in the overall Eastern Stock fur seal population.**

Eastern Bering Sea Bottom Trawl Survey
Major Strata Correspond to Panels (A-G)

