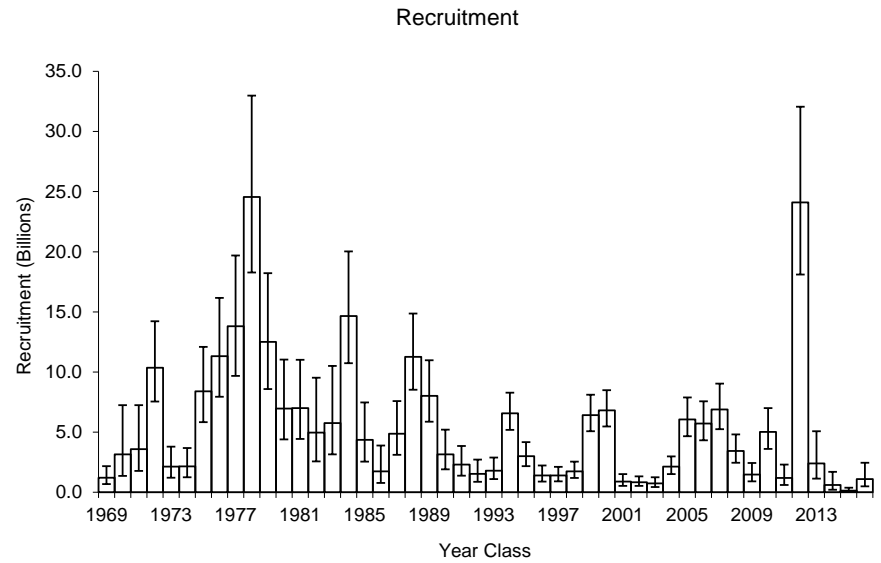
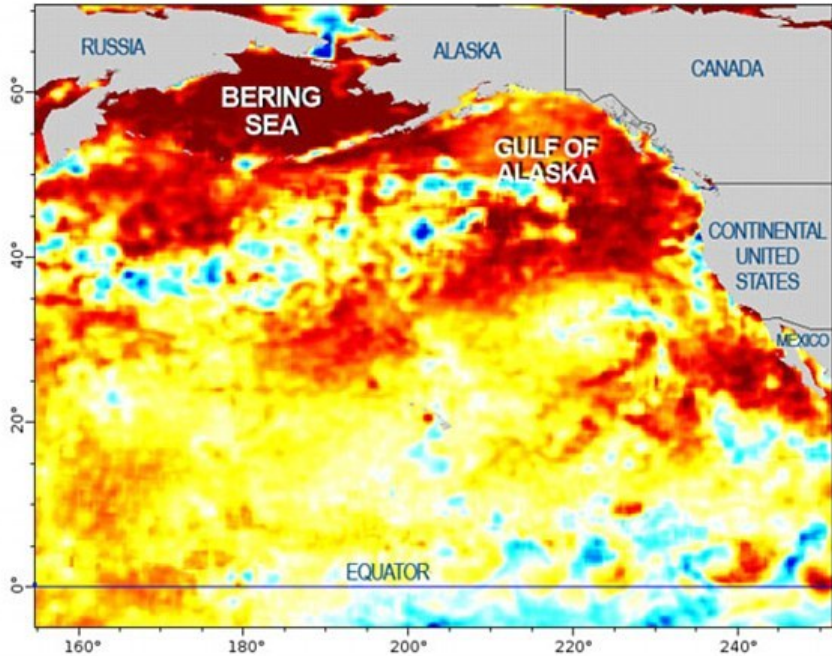




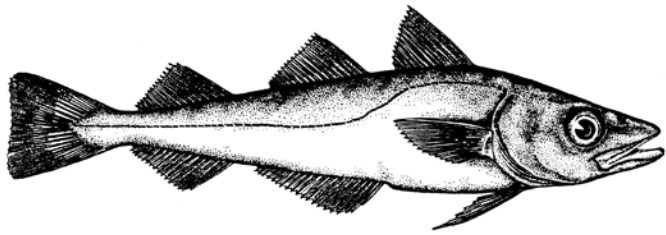
Gulf of Alaska pollock
Plan Team meeting
Nov 16, 2017
AFSC Seattle

Two extreme anomalies for GOA pollock



Anomalously warm waters
2014-2016

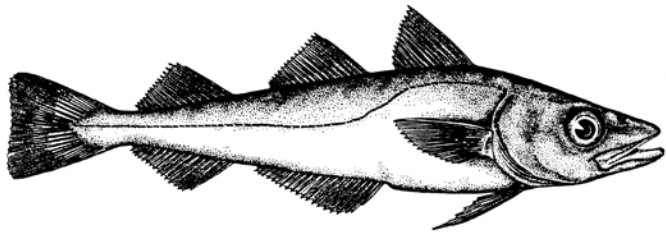
Largest year class in
over 30 years



Gulf of Alaska pollock

Overview: Surveys

- Dorn et al. 2016:
 - *In 2017, there will be full complement of assessment surveys in the Gulf of Alaska, so it is reasonable to expect that this uncertainty will be reduced when the results of these surveys are available.*
- **2017 Shelikof Strait acoustic survey biomass is 1.5 million t**
 - 124% percent increase from 2016 (largest estimate in over 30 years!).
- **2017 NMFS bottom trawl biomass is was 315,000 t,**
 - 58% **decrease** from 2015 estimate
(second lowest in the time series after 2001 !!!)
- **2017 ADFG survey biomass is 22,000 t**
 - close to historical lows.
- **2017 summer acoustic survey biomass is 1.3 million t**
 - 18% decrease from 2015 (but in line with model projections).



Gulf of Alaska pollock

Overview: Assessment

Changes to the assessment model

- Used Francis reweighting for composition data
- Random walk in catchability for
 - Shelikof Strait acoustic survey and the
 - ADFG bottom trawl survey
- Improved model but poor fit to 2017 data

Stock at 57.5% of unfished in 2018

Author's 2018 ABC 161,492 t

- Decrease of 21% from the 2017 ABC
- 2019 ABC drops by 1/3rd to ~106,000 t

Concerns:

- poor model fit
- decline in weight at age
- changes in maturation, sex ratios
- lack of recruitment (single very strong year class)

Positives:

- Reasonably strong evidence of 2017 year class
- Both summer acoustic and EcoFOCI surveys



Plan Team and SSC comments

- *The SSC in its December 2016 minutes continued to support a standard naming convention for different models presented in assessments.*

In this assessment, we used the naming convention supported by the SSC. The base model in last year's assessment was model 16.2. The recommended base model in this assessment is model 17.2.

- *The GOA plan team recommended in its November 2016 minutes that the summary information on economic performance be included in future assessments.*

A section on the economic performance of the GOA pollock fishery is again included in the assessment.

- *The GOA plan team recommended in its November 2016 minutes continued development of the ADFG survey delta-GLM model, examining interactions and the possible inclusion of environmental covariates.*

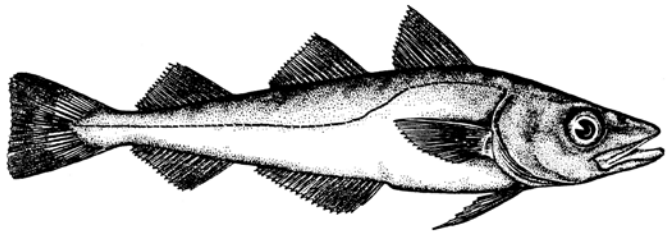
The delta-GLM model for the ADFG survey was included again included in the assessment. We were unable to explore interaction terms and environmental covariates in the model.

- *The GOA plan team recommended in its November 2016 minutes an evaluation of prediction error of the weight-at-age random effects model.*

We compare the predictions from last year's weight-at-age random effects model with this year's estimates.

Plan Team and SSC comments

- *The GOA plan team recommended in its November 2016 minutes a coordinated evaluation of annual change in ADFG survey biomass estimates relative to the NMFS bottom trawl survey for both Pacific cod and walleye pollock.*
We were unable to conduct this evaluation.
- *The SSC its December 2016 minutes noted that number of assessments are adopting the geostatistical approach for estimating survey biomass and its uncertainty. The SSC recommended further exploration of geostatistical estimates for GOA pollock.*
Work presented to the joint plan teams in September indicated the application of VAST models to Gulf of Alaska survey data was not straightforward, and that additional analyses were needed before being fully confident in the approach. We did not put forward a model in this assessment using the VAST approach pending additional analyses to be completed.
- *The SSC its December 2016 minutes looked forward to suggestions for model improvement during the CIE review in 2017.*
The CIE review for GOA pollock took place on May 22-25, 2017. Reviews were generally supportive of the current approach for the GOA pollock assessment. We summarized the reviews for the GOA plan team in September, and are developing a written response to the review that includes a work plan for the GOA pollock assessment moving forward. We will provide this plan to the GOA Plan Team and the SSC for consideration next year.

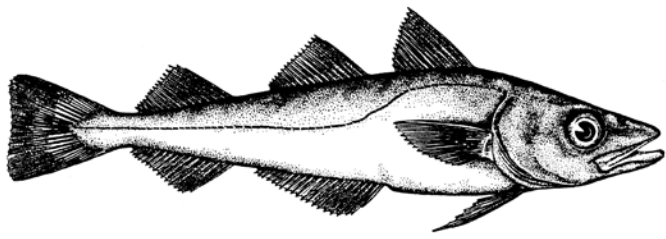


Gulf of Alaska pollock Economic Performance

Table 1. Pollock in the Gulf of Alaska ex-vessel market data. Total and retained catch (thousand metric tons), ex-vessel value (million US\$), price (US\$ per pound), the Central Gulf's share of value, and number of trawl vessels; 2005-2007 average, 2008-2010 average, 2011-2013 average, and 2014-2016.

	Avg 05-07	Avg 08-10	Avg 11-13	2014	2015	2016
Total Catch K mt	68.6	57.8	94.0	142.6	167.6	177.1
Retained Catch K mt	66.3	53.9	91.6	141.1	163.0	176.0
Ex-vessel Value M \$	\$ 19.7	\$ 21.4	\$ 34.3	\$ 37.9	\$ 43.6	\$ 32.3
Ex-vessel Price/lb \$	\$ 0.135	\$ 0.180	\$ 0.170	\$ 0.122	\$ 0.119	\$ 0.083
Central Gulf Share of Value	61%	62%	75%	88%	80%	63%
Vessels #	67.0	63.0	70.0	72	65	70

Source: NMFS Alaska Region Blend and Catch-accounting System estimates; and ADF&G Commercial Operators Annual Reports (COAR). Data compiled and provided by the Alaska Fisheries Information Network (AKFIN).



Gulf of Alaska pollock Economic Performance

Table 2. Pollock in the Gulf of Alaska first-wholesale market data. First-wholesale production (thousand metric tons), value (million US\$), price (US\$ per pound), and head and gut, fillet, surimi, and roe production volume (thousand metric tons), price (US\$ per pound), and value share; 2005-2007 average, 2008-2010 average, 2011-2013 average, and 2014-2016.

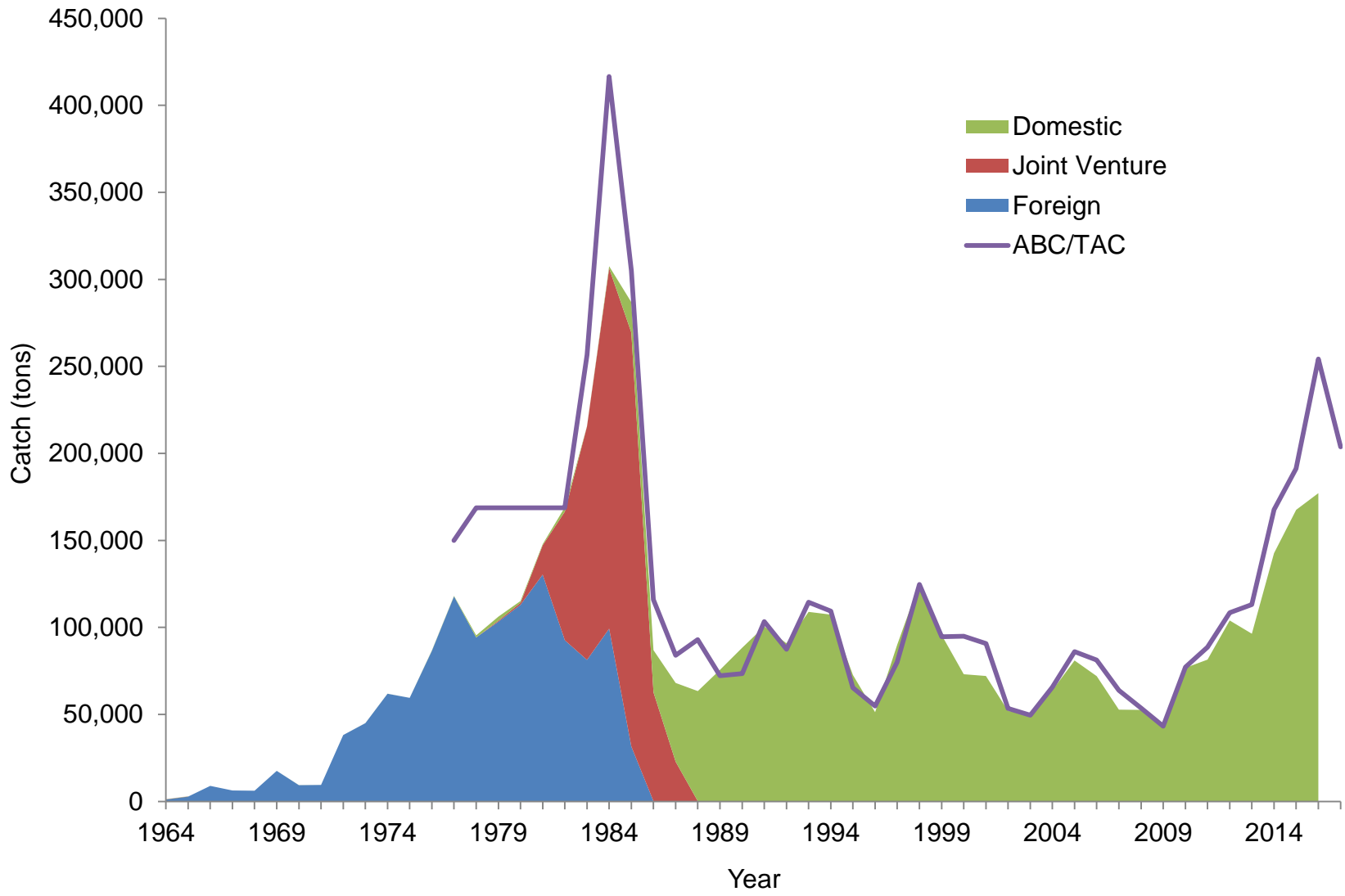
		Avg 05-07	Avg 08-10	Avg 11-13	2014	2015	2016
All Products	Volume K mt	23.5	17.6	36.1	54.7	59.8	75.1
All Products	Value M \$	\$ 53.4	\$ 48.9	\$ 84.5	\$ 105.8	\$ 105.4	\$ 105.2
All Products	Price lb \$	\$ 1.03	\$ 1.26	\$ 1.06	\$ 0.88	\$ 0.80	\$ 0.64
Head & Gut	Volume K mt	6.9	7.8	18.4	29.7	30.3	27.8
Head & Gut	Price lb \$	\$ 0.63	\$ 0.75	\$ 0.68	\$ 0.62	\$ 0.61	\$ 0.43
Head & Gut	Value share	18%	26%	33%	38%	39%	25%
Fillets	Volume K mt	4.6	3.2	5.8	8.2	9.1	14.3
Fillets	Price lb \$	\$ 1.30	\$ 1.82	\$ 1.59	\$ 1.35	\$ 1.30	\$ 1.11
Fillets	Value share	25%	26%	24%	23%	25%	33%
Surimi	Volume K mt	7.1	4.5	8.5	12.3	14.7	13.4
Surimi	Price lb \$	\$ 0.91	\$ 1.62	\$ 1.19	\$ 0.89	\$ 0.85	\$ 0.97
Surimi	Value share	27%	33%	27%	23%	26%	27%
Roe	Volume K mt	1.8	0.9	1.7	3.5	3.1	0.5
Roe	Price lb \$	\$ 3.36	\$ 2.92	\$ 3.04	\$ 2.03	\$ 1.30	\$ 1.34
Roe	Value share	25%	12%	14%	15%	8%	2%

Source: NMFS Alaska Region Blend and Catch-accounting System estimates; NMFS Alaska Region At-sea Production Reports; and ADF&G Commercial Operators Annual Reports (COAR). Data compiled and provided by the Alaska Fisheries Information Network (AKFIN).

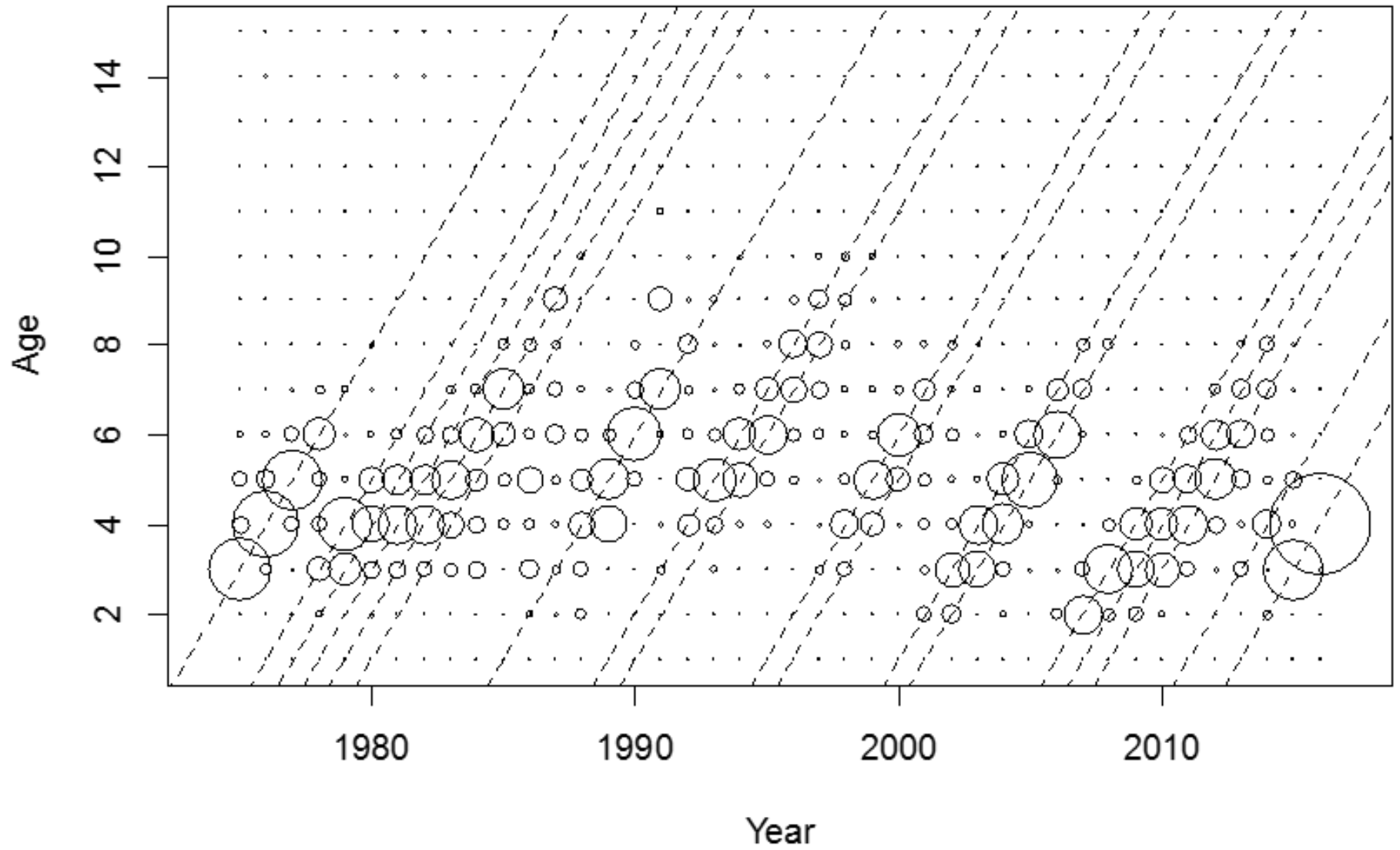
Data used in the assessment

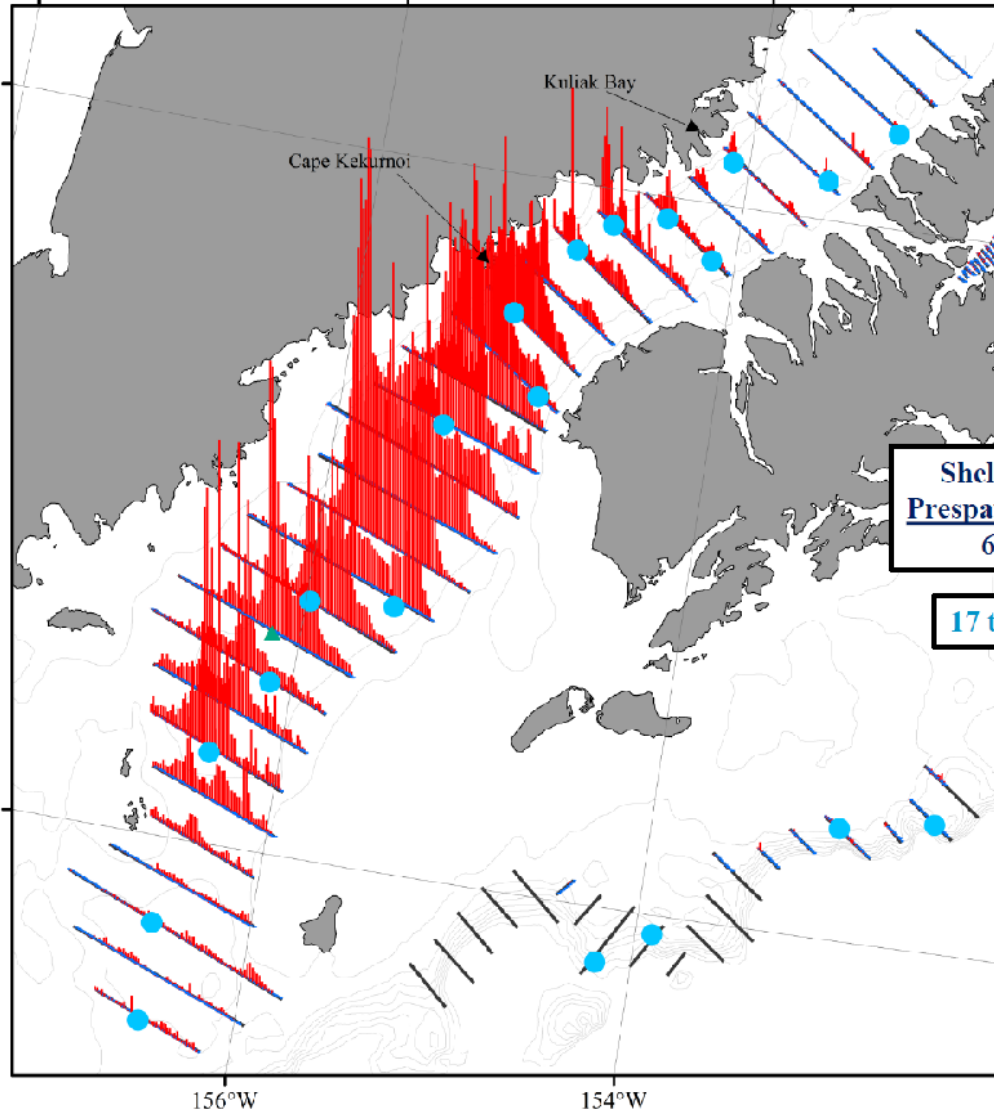
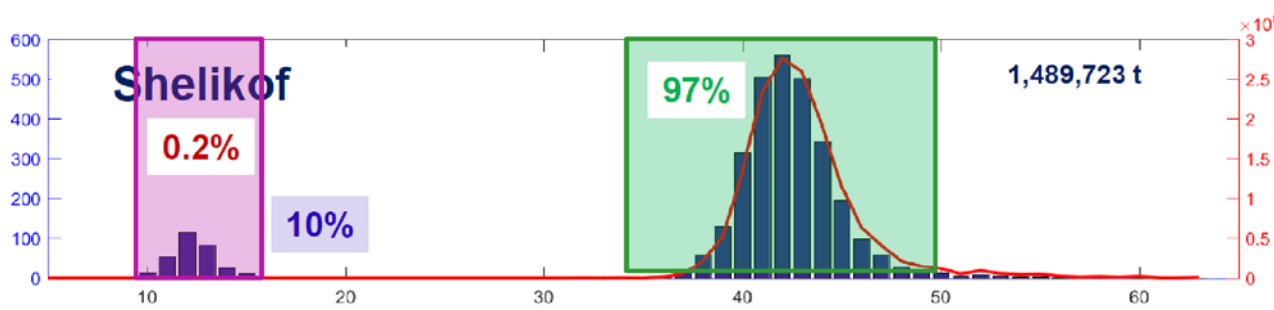
Source	Data	Years
Fishery	Total catch	1970-2016
Fishery	Age composition	1975-2016
Shelikof Strait acoustic survey	Biomass	1992-2017
Shelikof Strait acoustic survey	Age composition	1992-2017
Summer acoustic survey	Biomass	2013-2017
Summer acoustic survey	Age composition	2013,2015
Summer acoustic survey	Length composition	2017
NMFS bottom trawl survey	Area-swept biomass	1990-2017
NMFS bottom trawl survey	Age composition	1990-2015
NMFS bottom trawl survey	Length composition	2017
ADFG trawl survey	Area-swept biomass	1989-2017
ADFG survey	Age composition	2000-2016

Total catch 1964-2016



Catch at age, 1975-2016





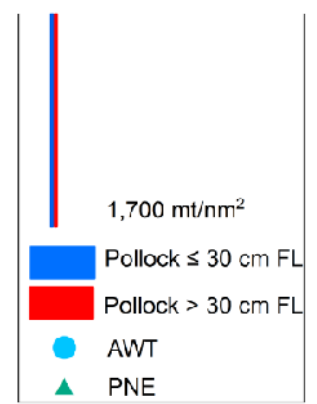
Shelikof Strait March 18-24

1,489,723 t

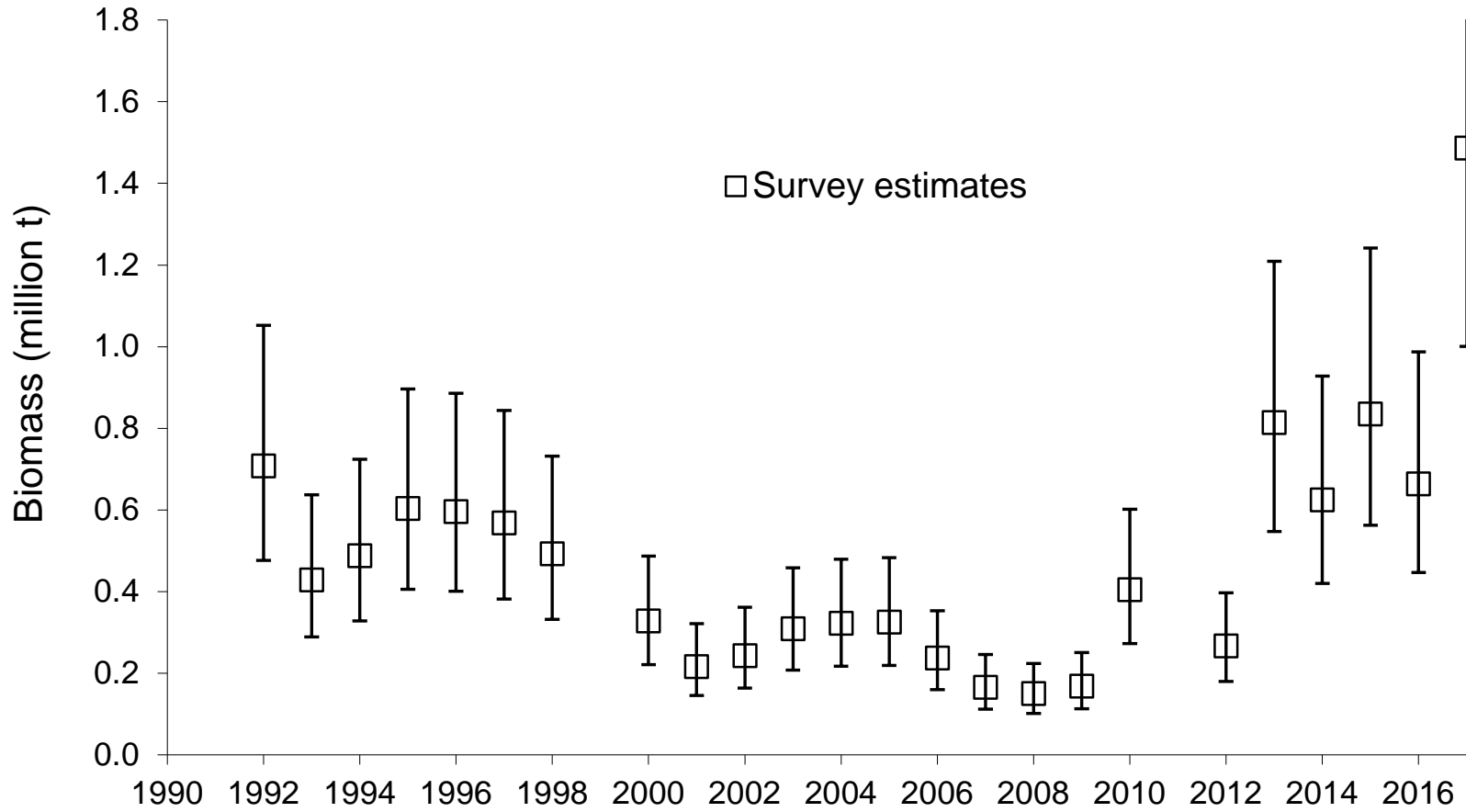
Shelikof Maturities (females > 40cm)

Prespawning	Spawning	Spent	n
63%	7%	26%	404

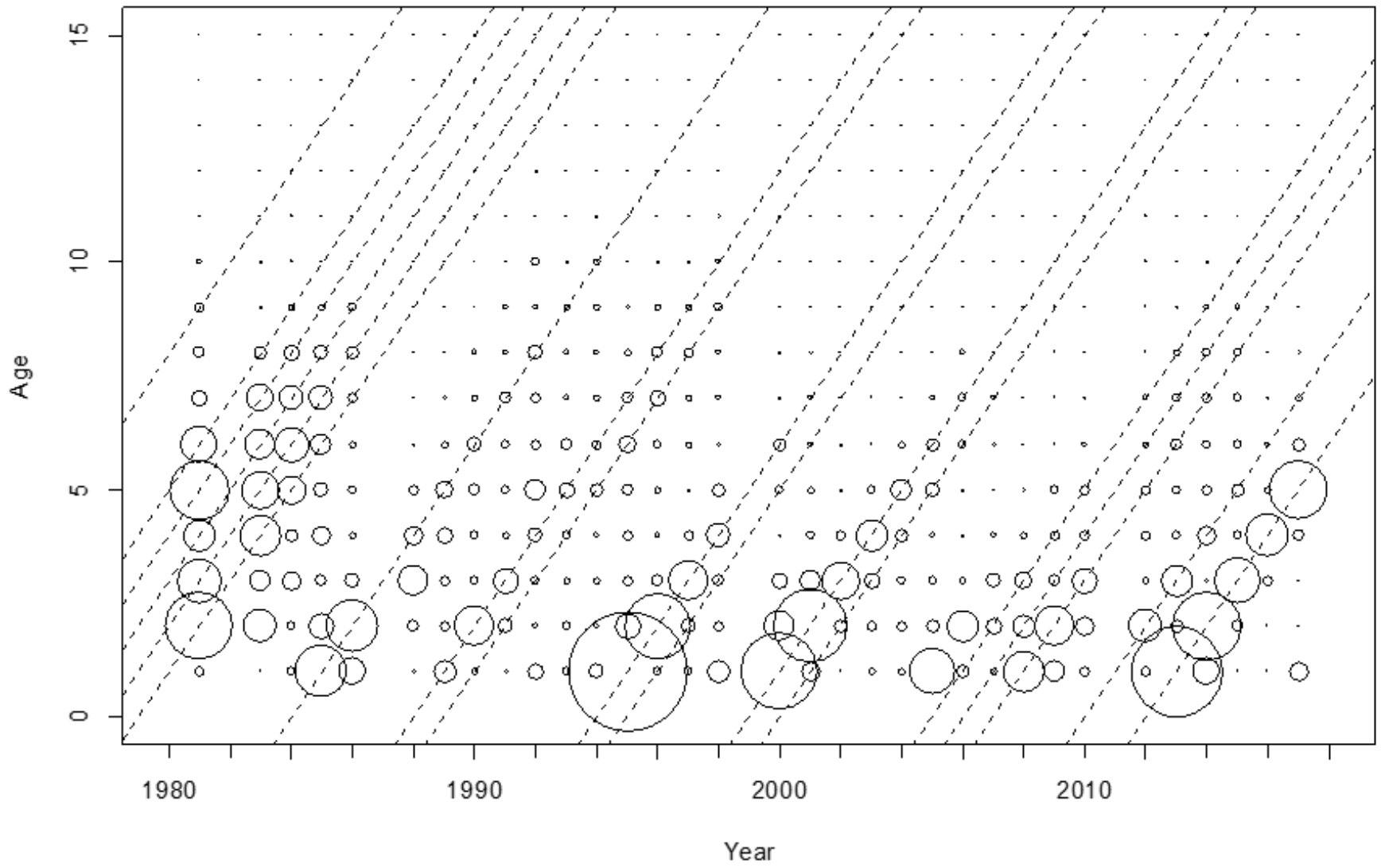
17 tows, 815 nautical miles of trackline



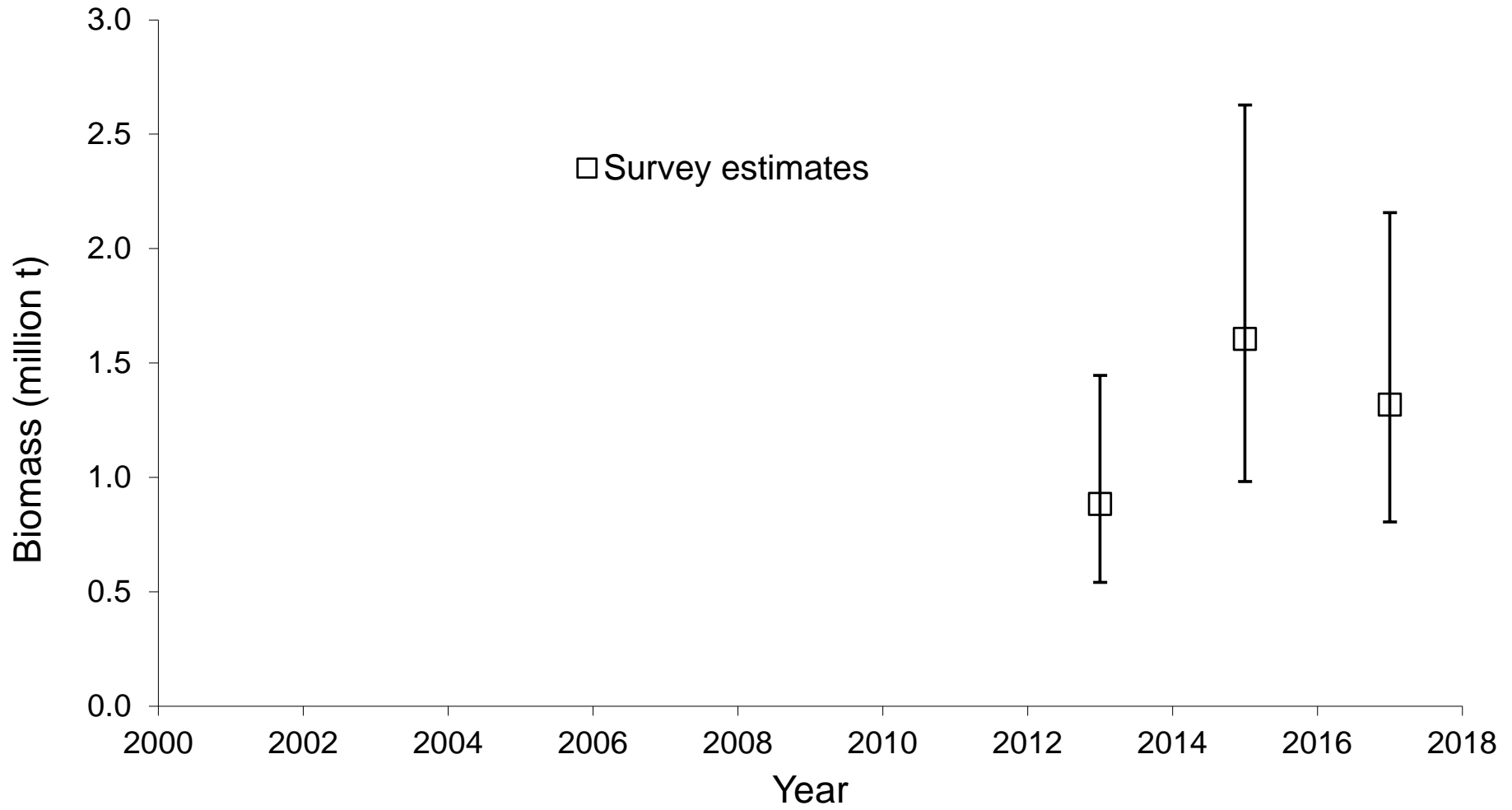
Shelikof Strait acoustic survey, 1992-2017



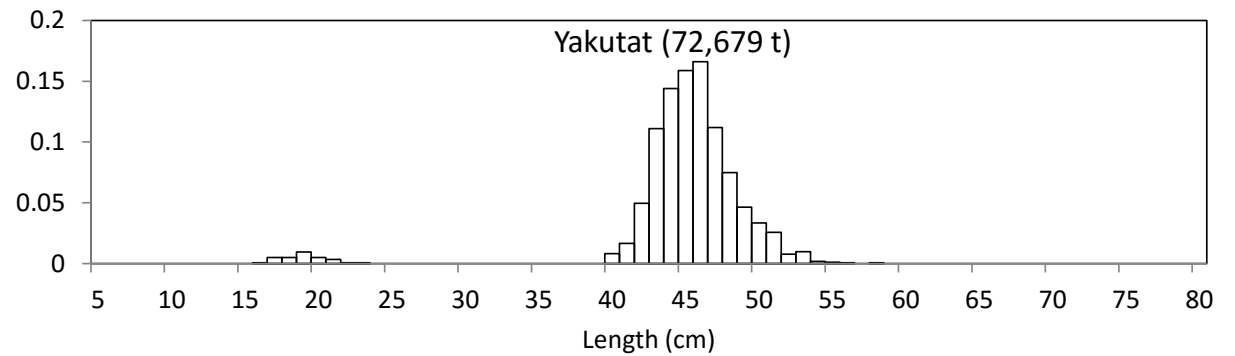
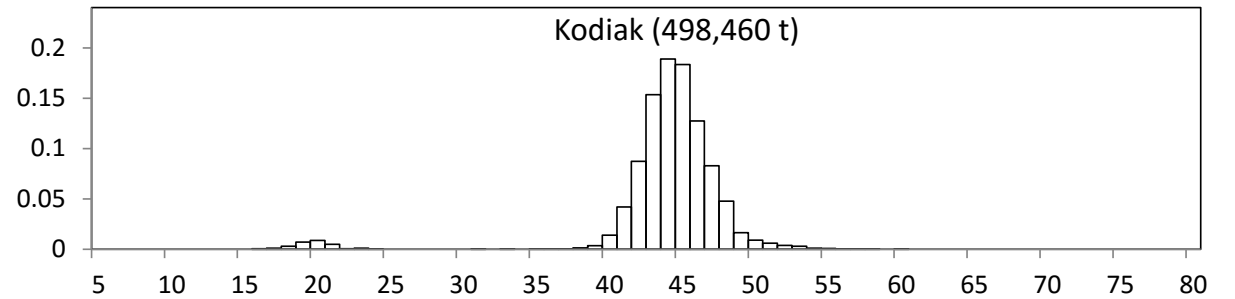
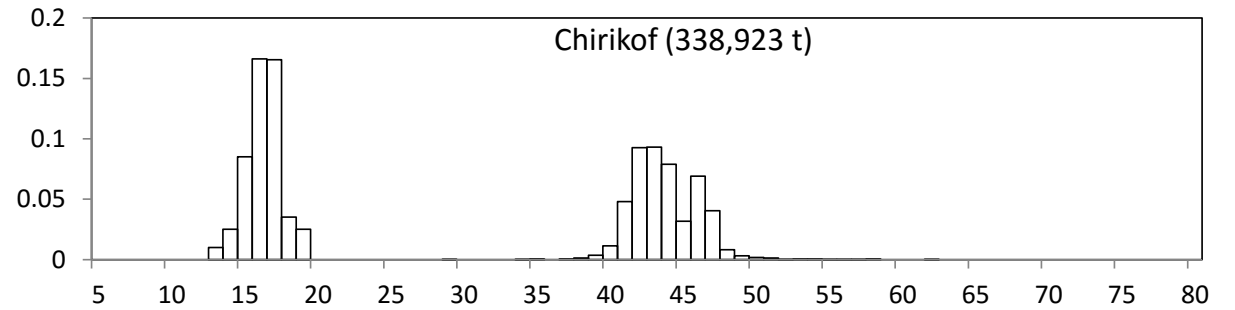
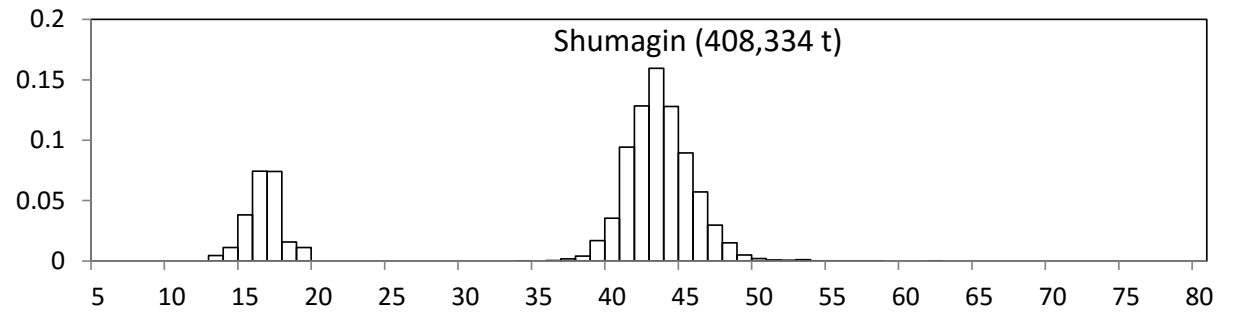
Shelikof Strait survey age comp, 1992-2017



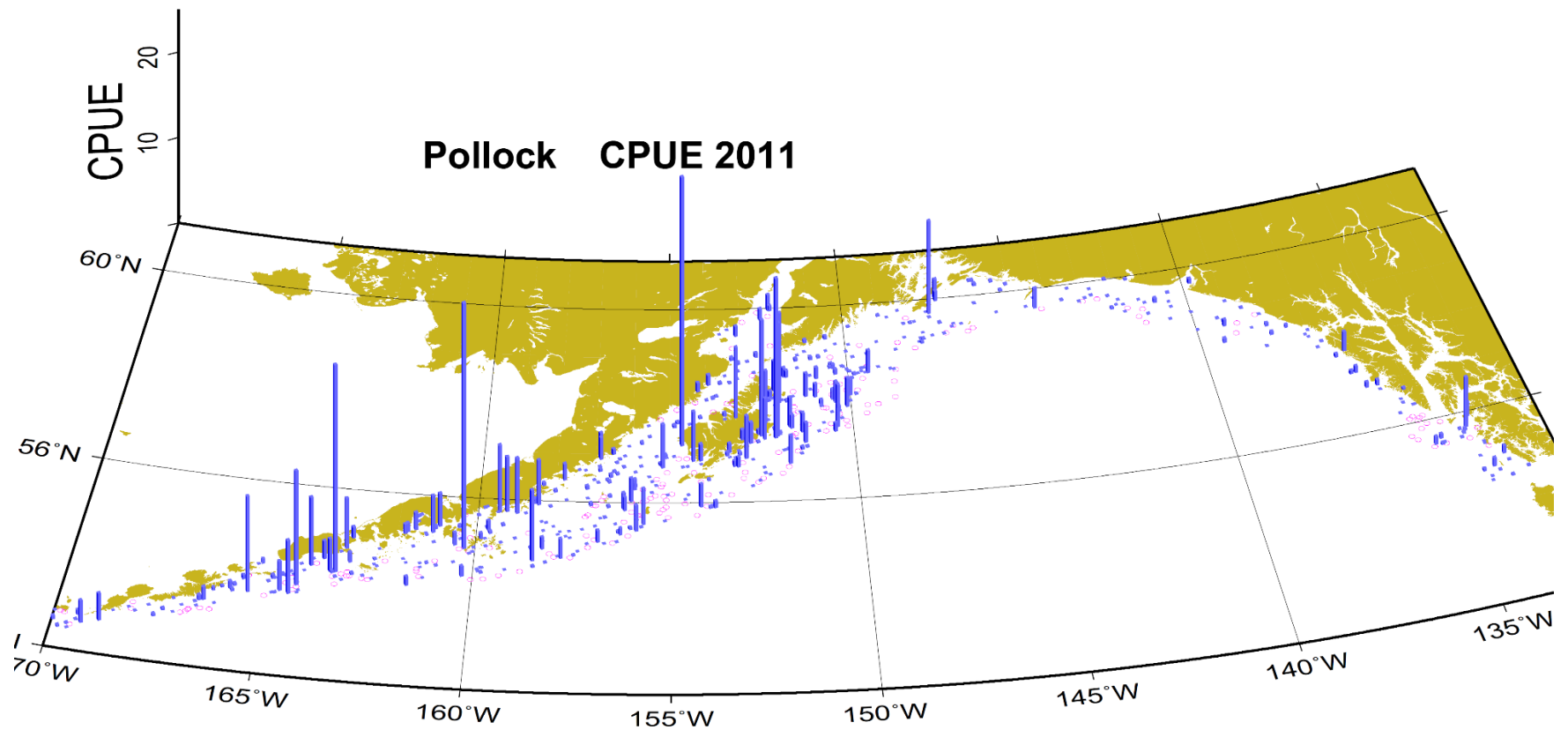
Summer acoustic survey, 2013-2017



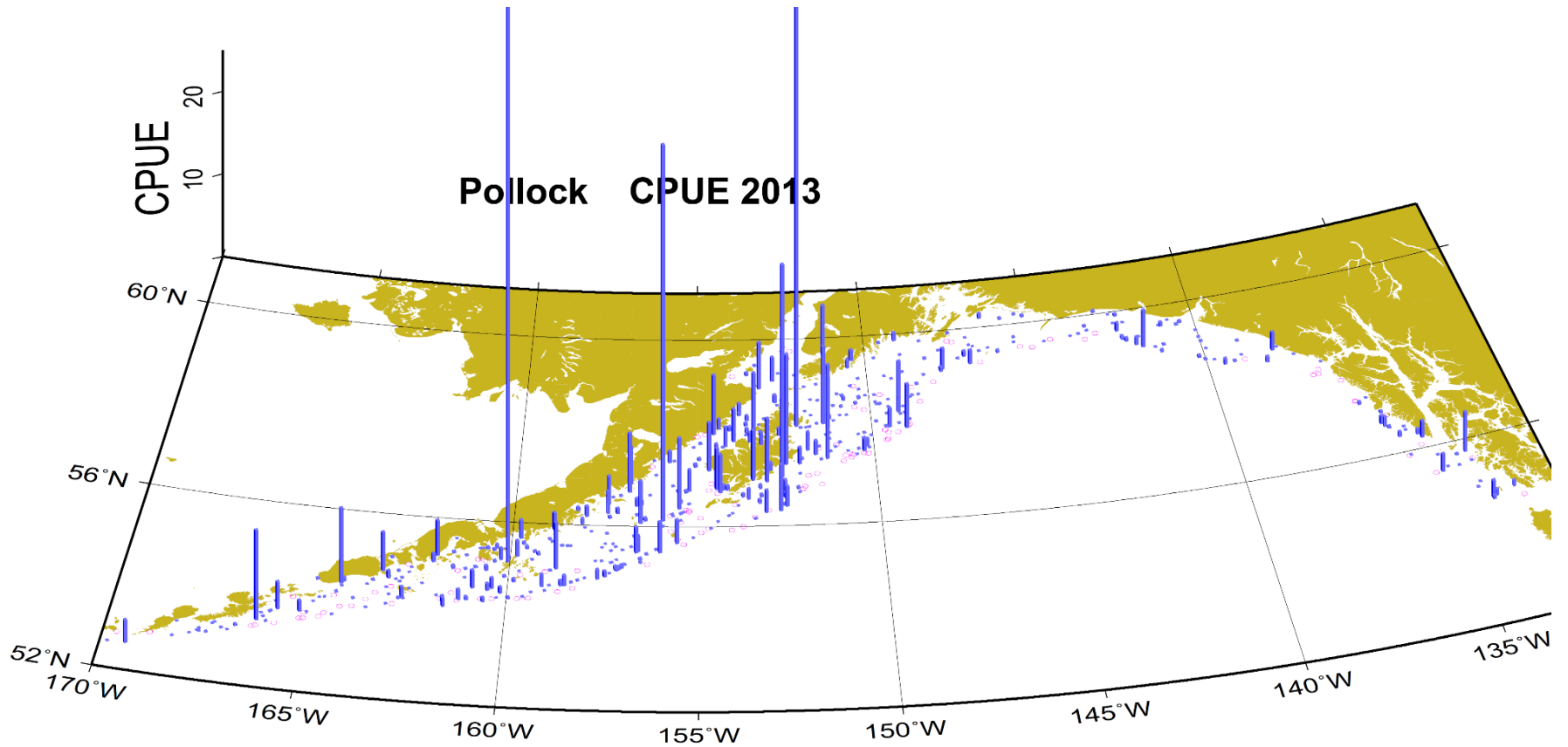
2017 Summer acoustic survey



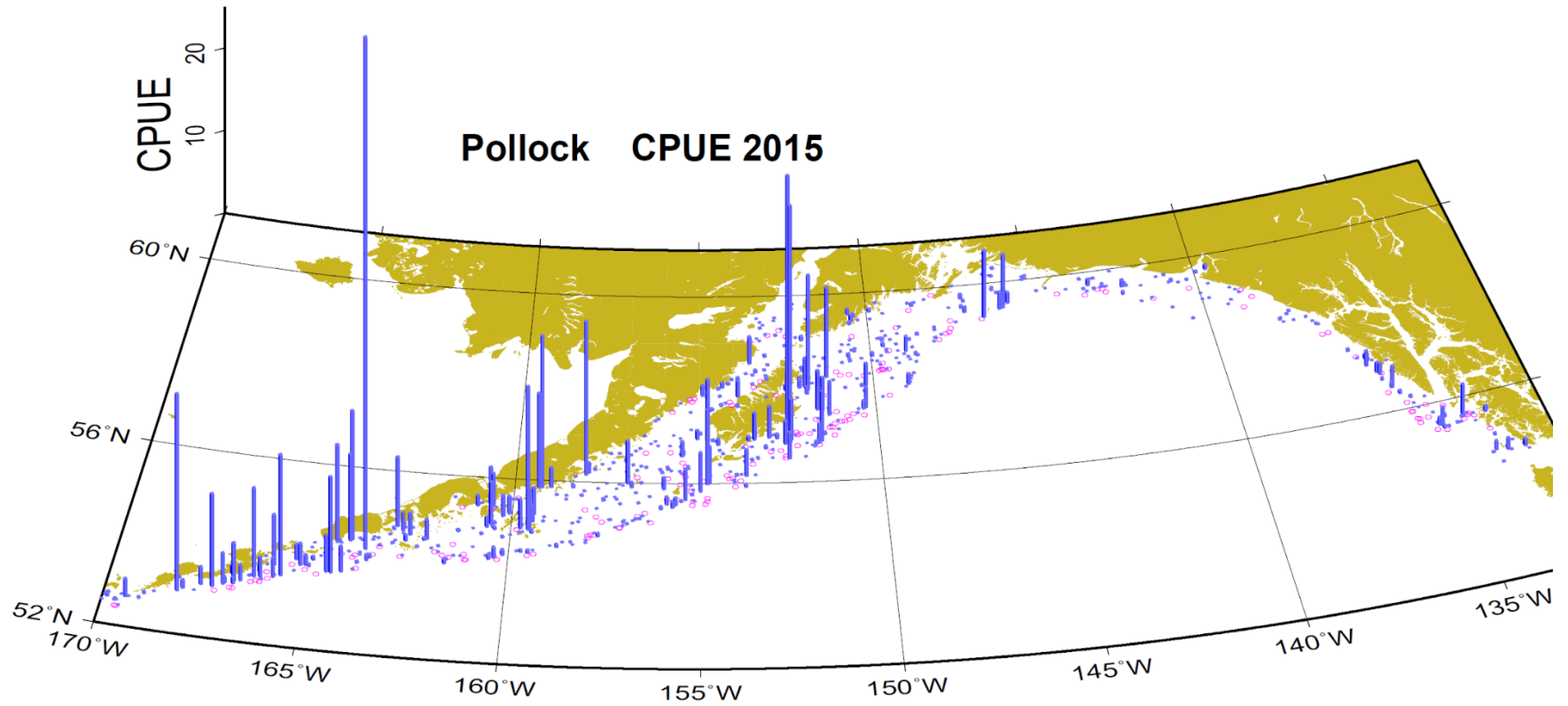
2011 NMFS bottom trawl survey



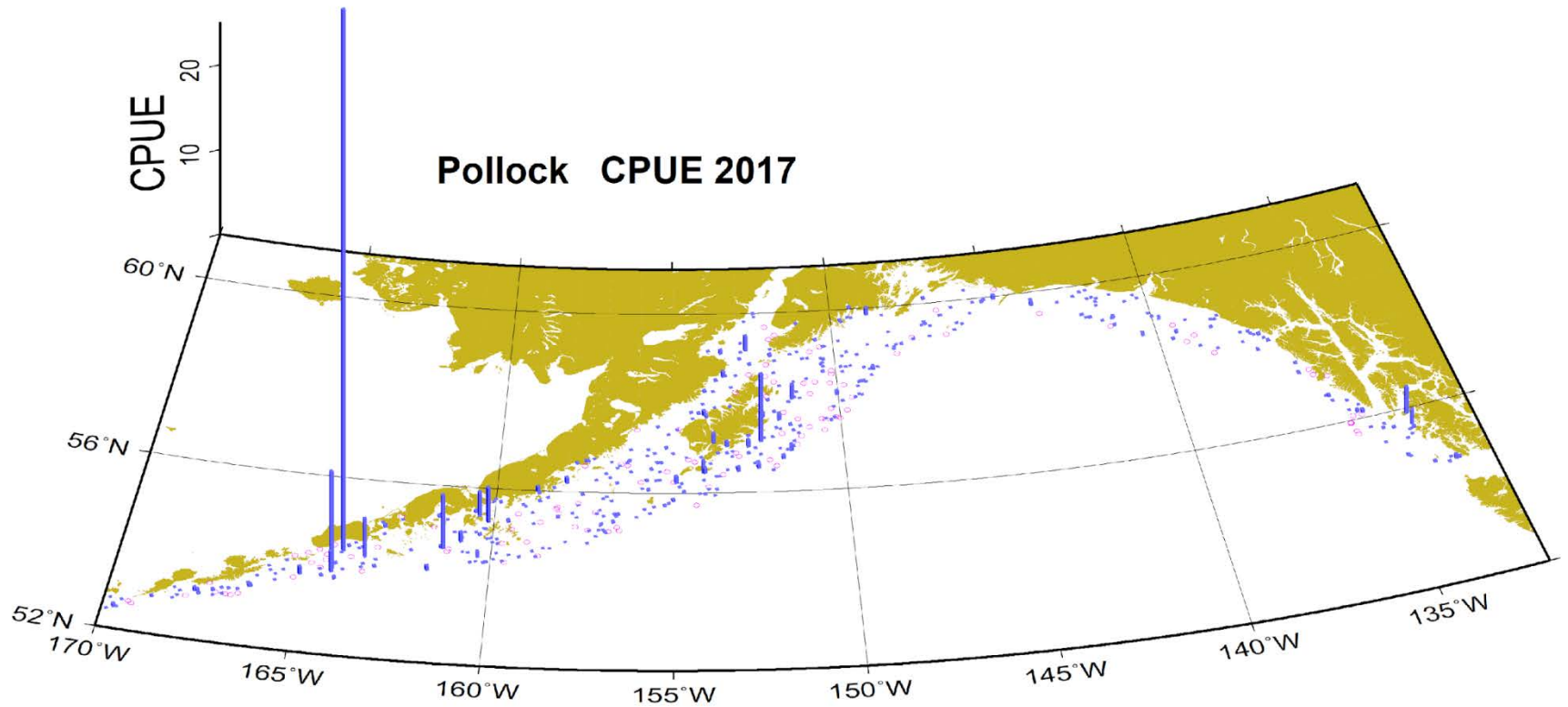
2013 NMFS bottom trawl survey



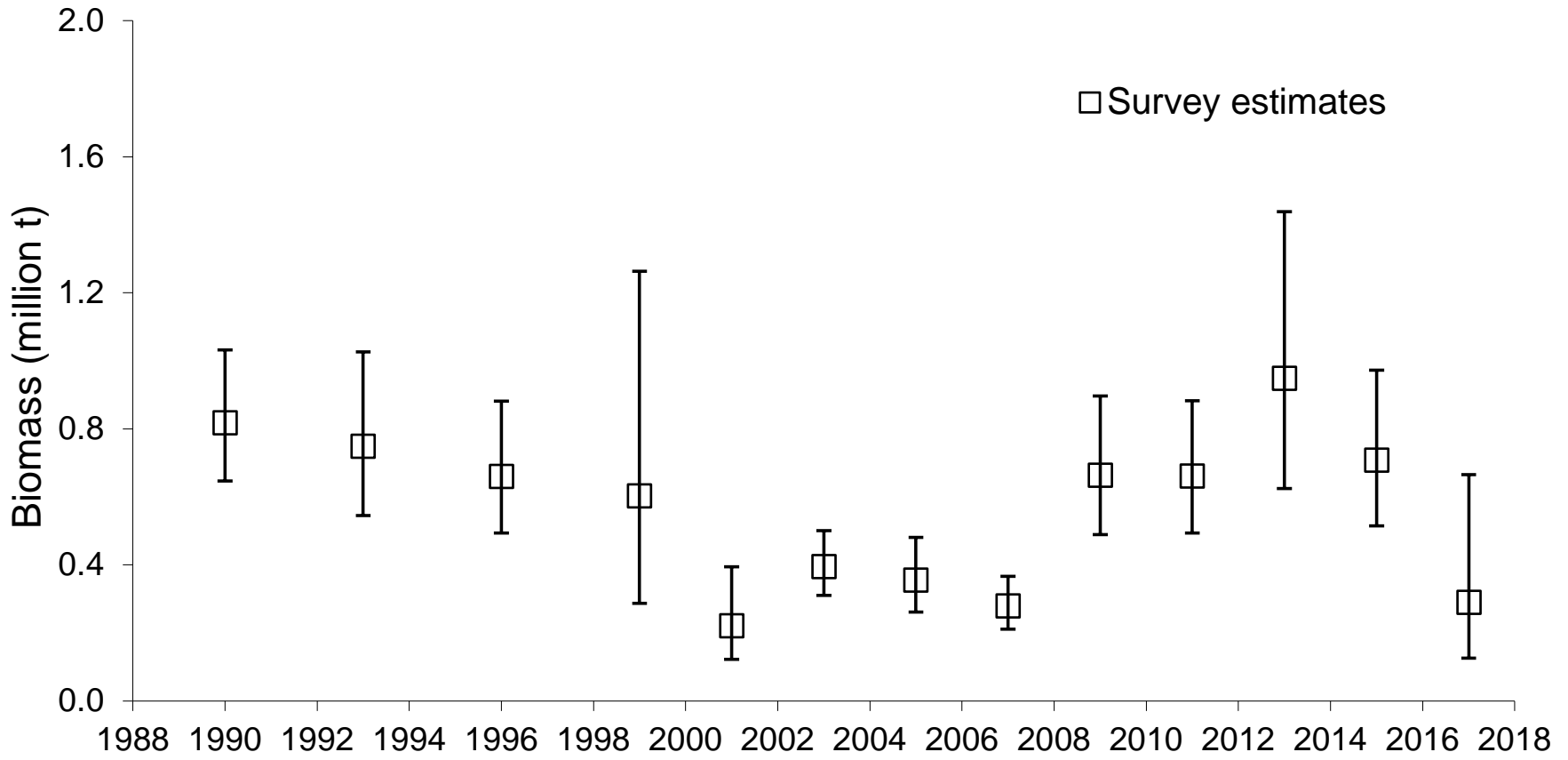
2015 NMFS bottom trawl survey



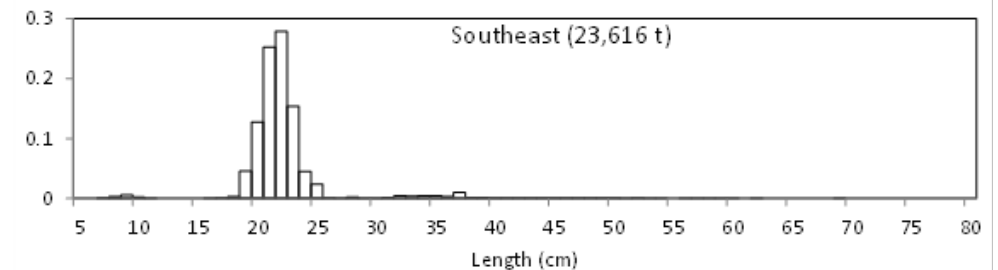
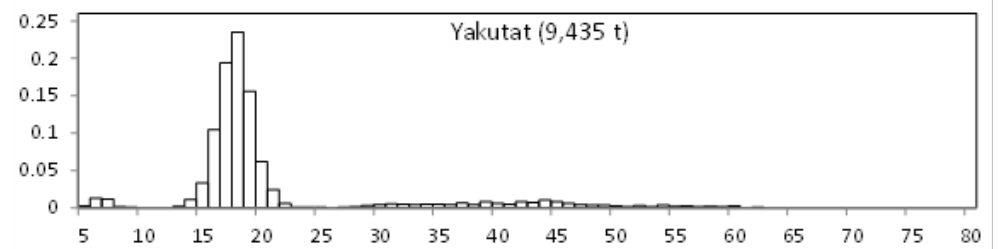
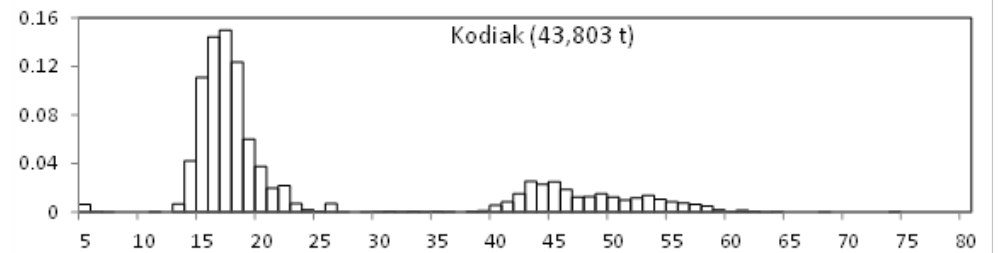
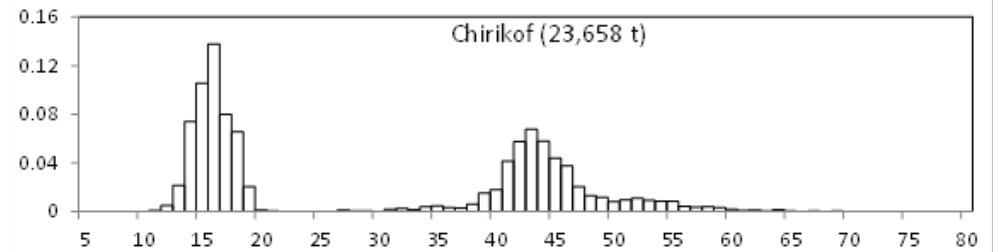
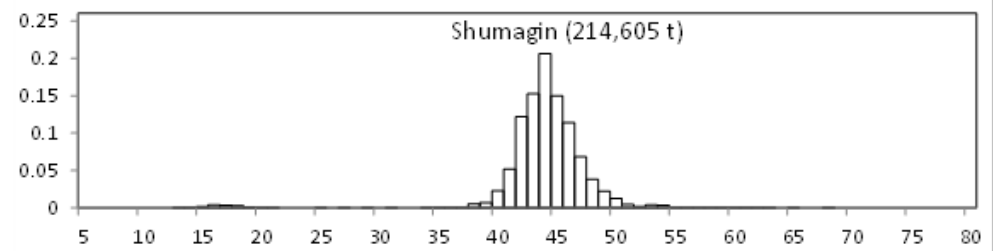
2017 NMFS bottom trawl survey



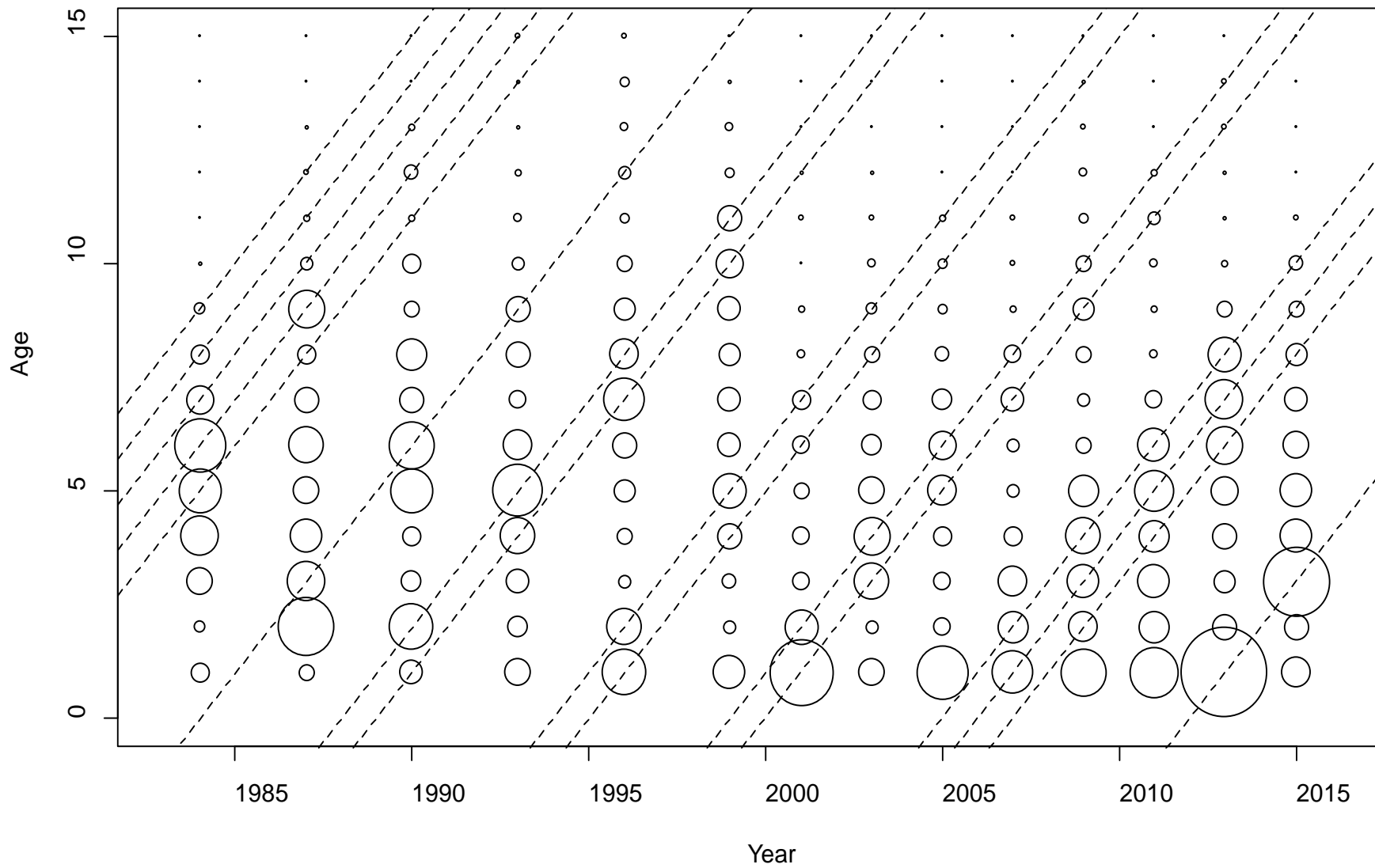
NMFS bottom trawl survey (1990-2017)



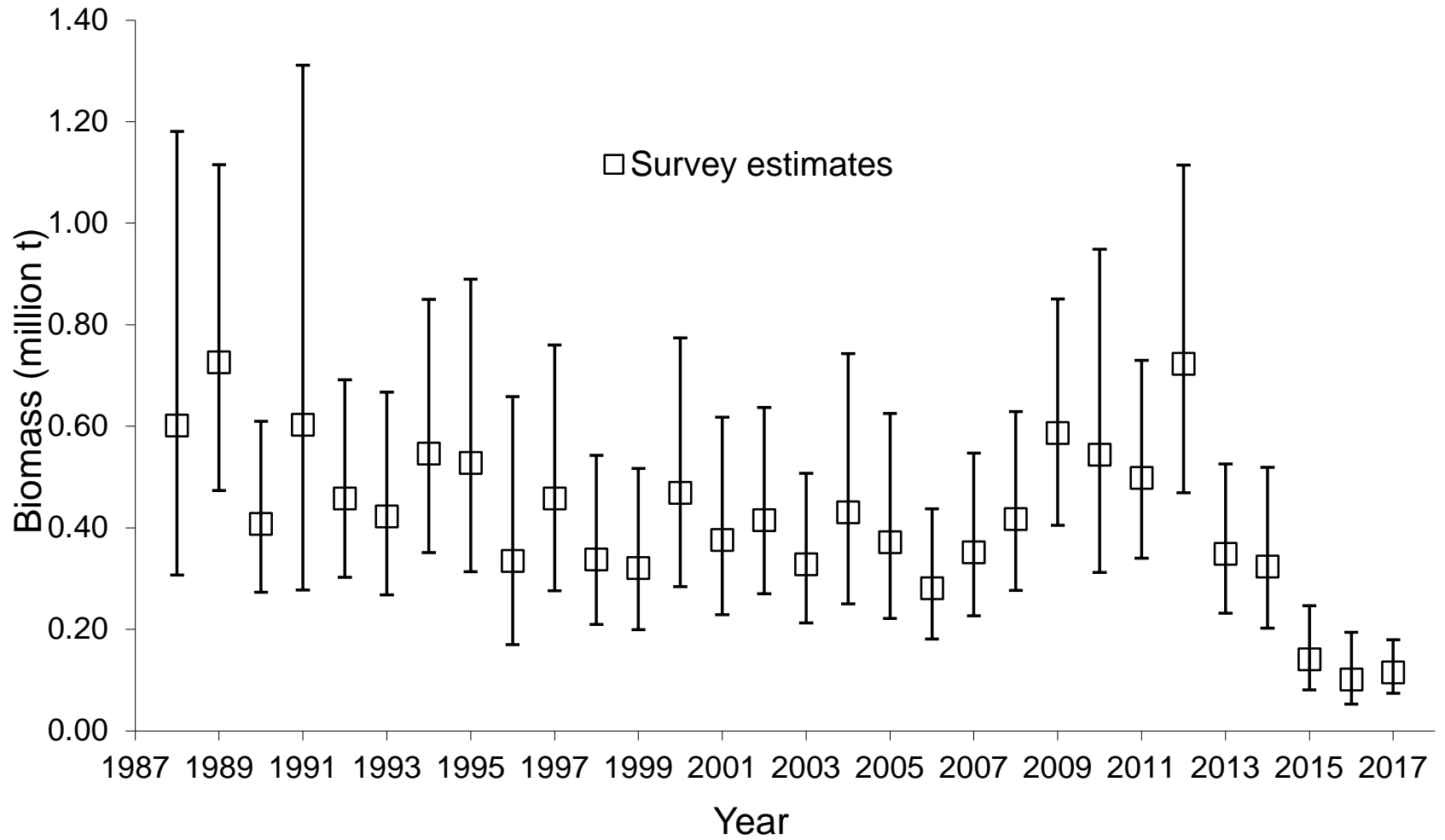
2017 NMFS bottom trawl survey



NMFS Bottom trawl survey age comp (1990-2015)



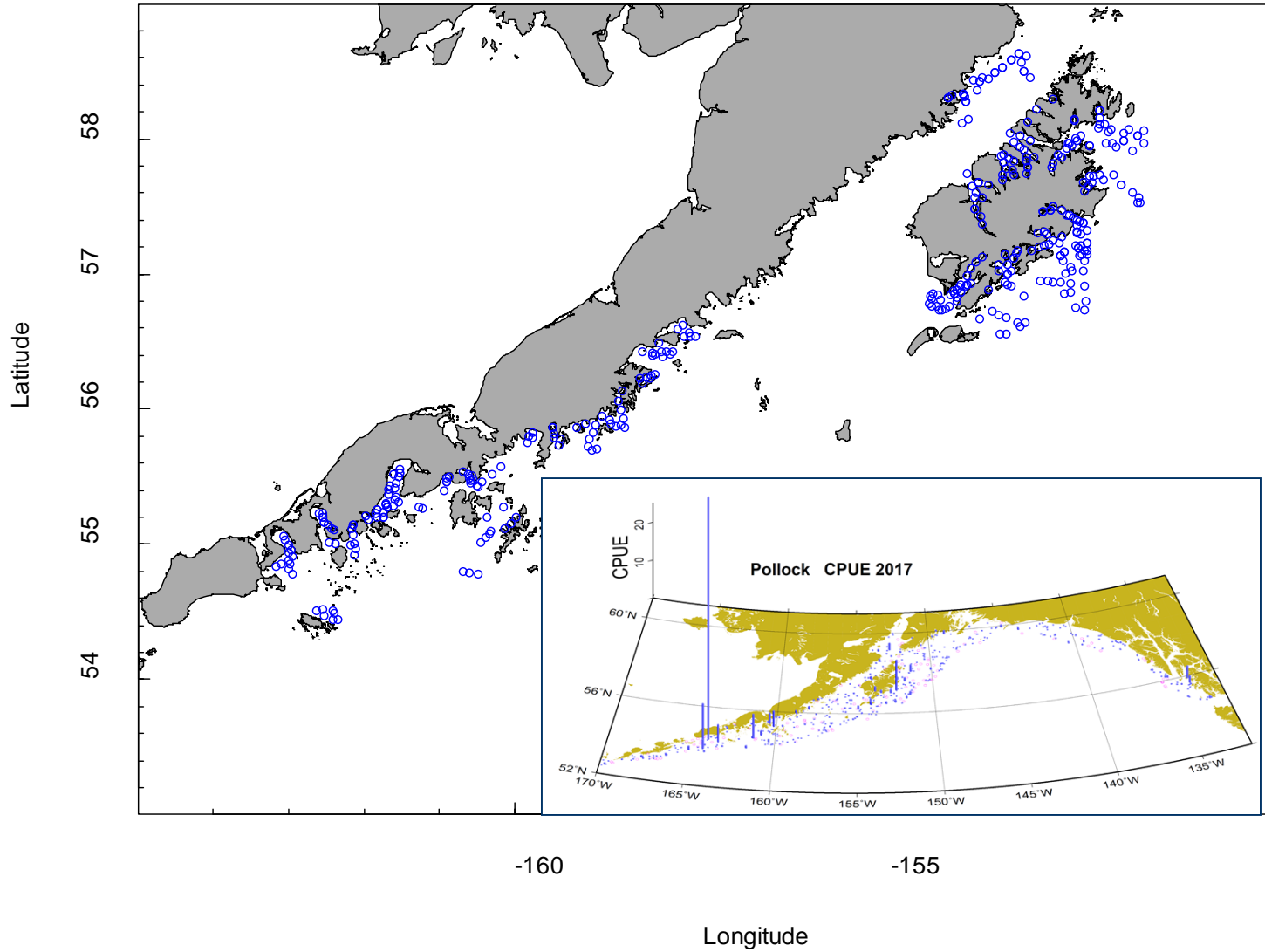
ADFG crab/groundfish trawl survey (1989-2017)



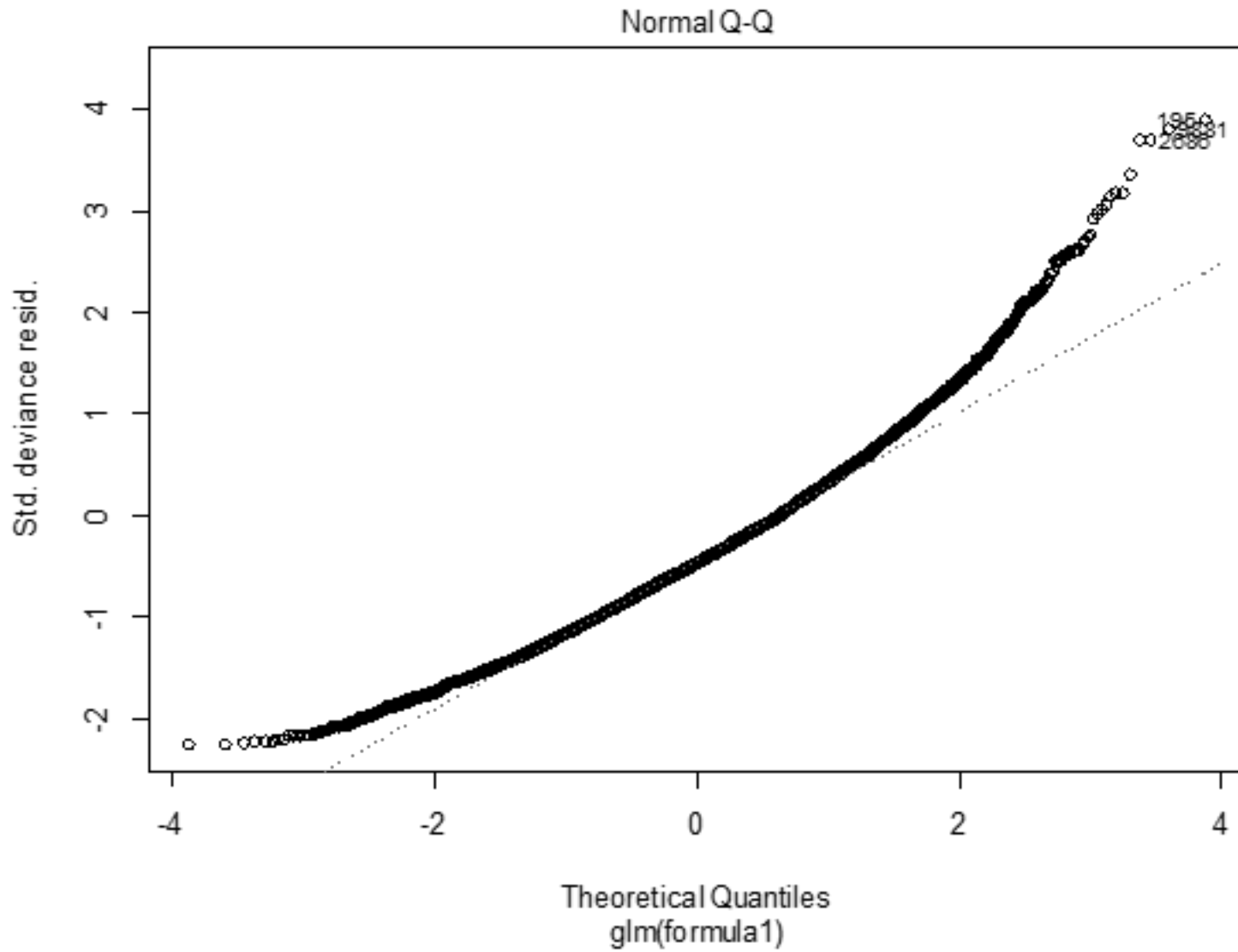
Delta-GLM for ADFG survey

- Excluded data: no location (1 tow), no depth (14 tows), lower Shelikof Strait stations (157).
- Fixed effects model with area (ADFG districts Kodiak, Chignik, and South Peninsula) and depth (<30 fm, 30-100 fm, > 100 fm)
- Evaluated log normal and gamma error assumptions.
- AIC strongly preferred gamma error assumption ($\Delta AIC = 494.2$).
- CVs ranged from 0.09 to 0.20. Multiplied by 2X to make them comparable to previous weights

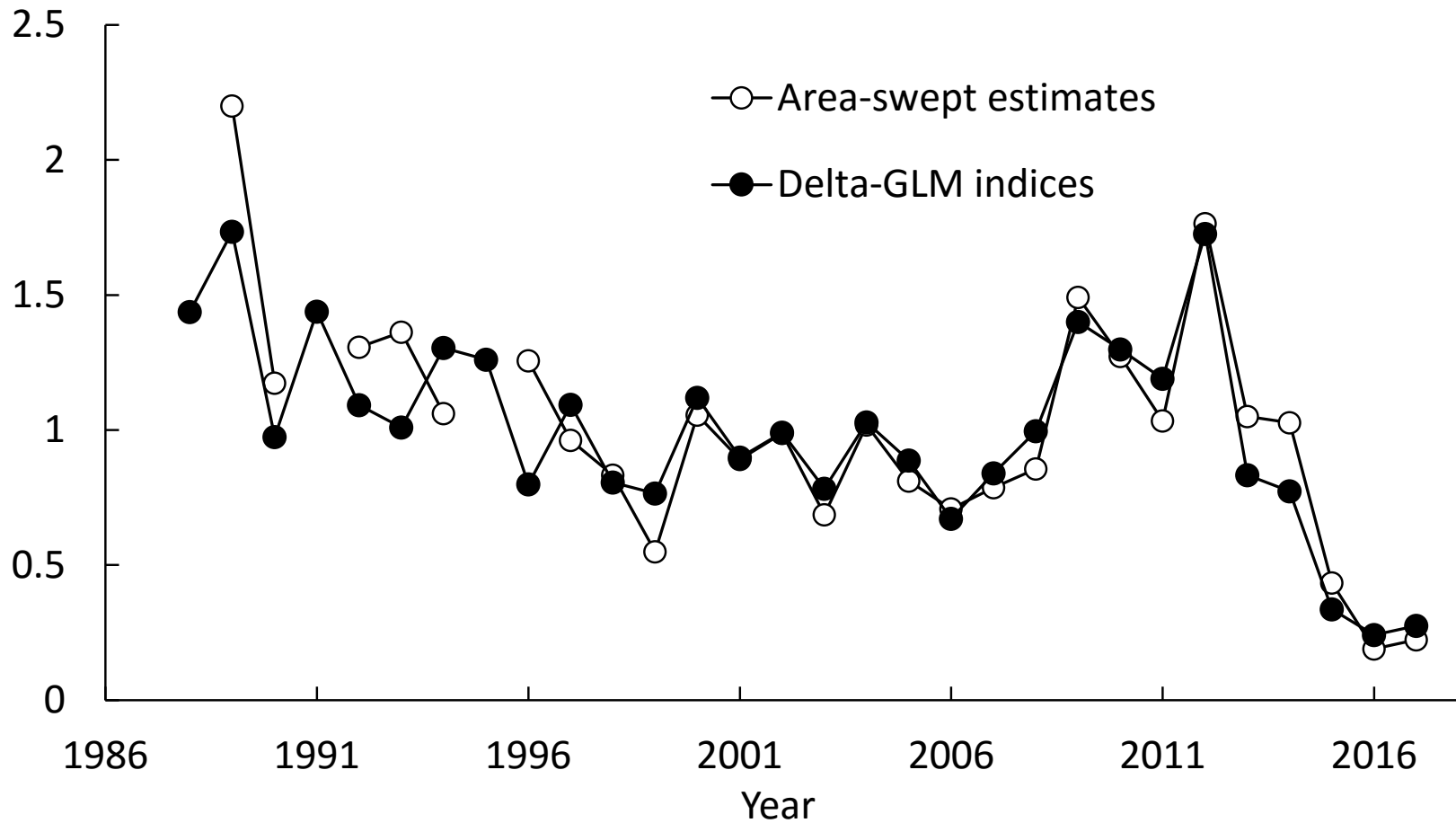
2017 ADFG survey stations



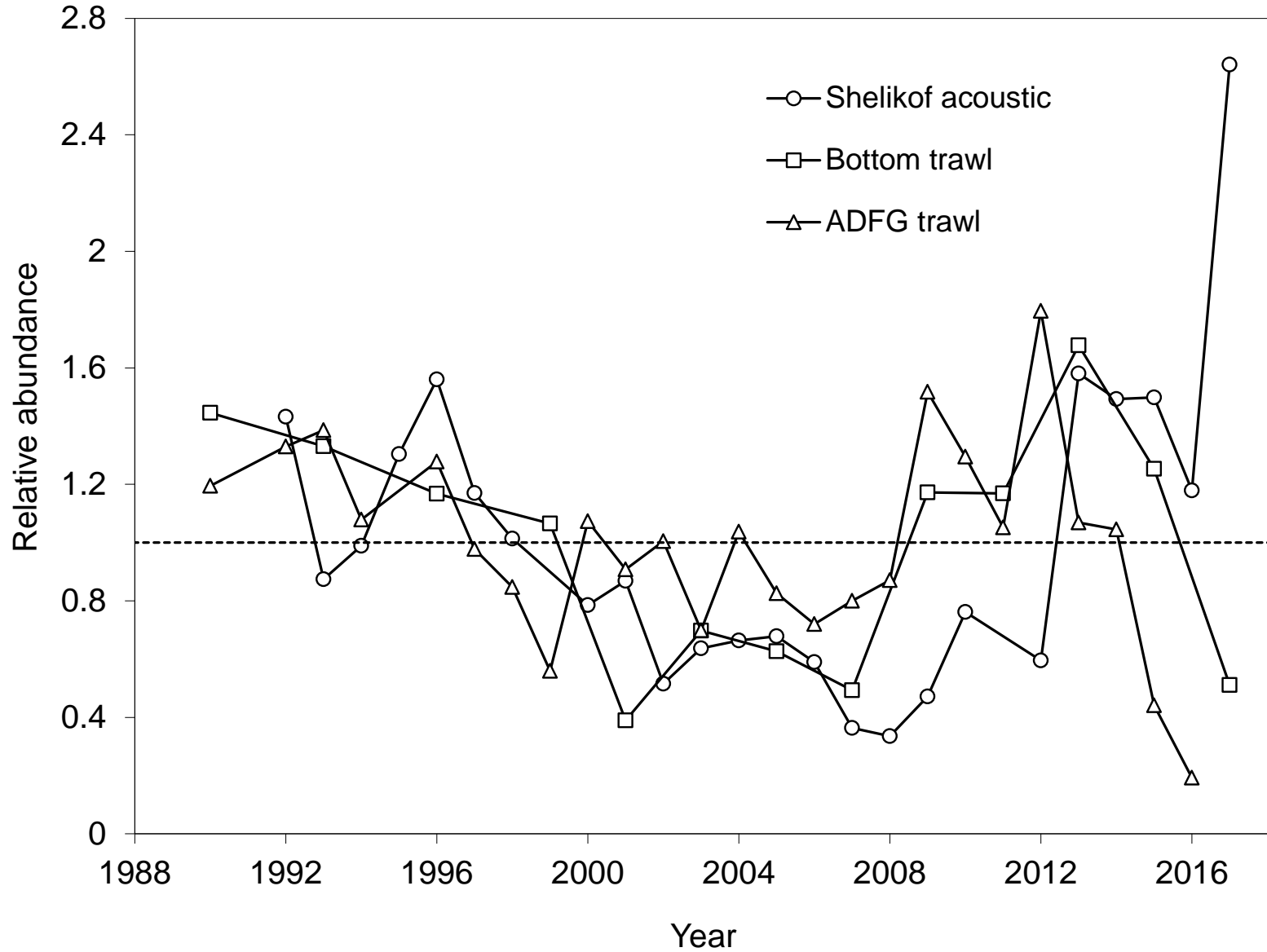
QQ plot for gamma error assumption



Comparison between area-swept estimates and delta-GLM estimates



Relative trends in abundance indices (1990-2017)



Maunder and Piner (2017) *Dealing with data conflicts in statistical inference of population assessment models that integrate information from multiple diverse data sets.*

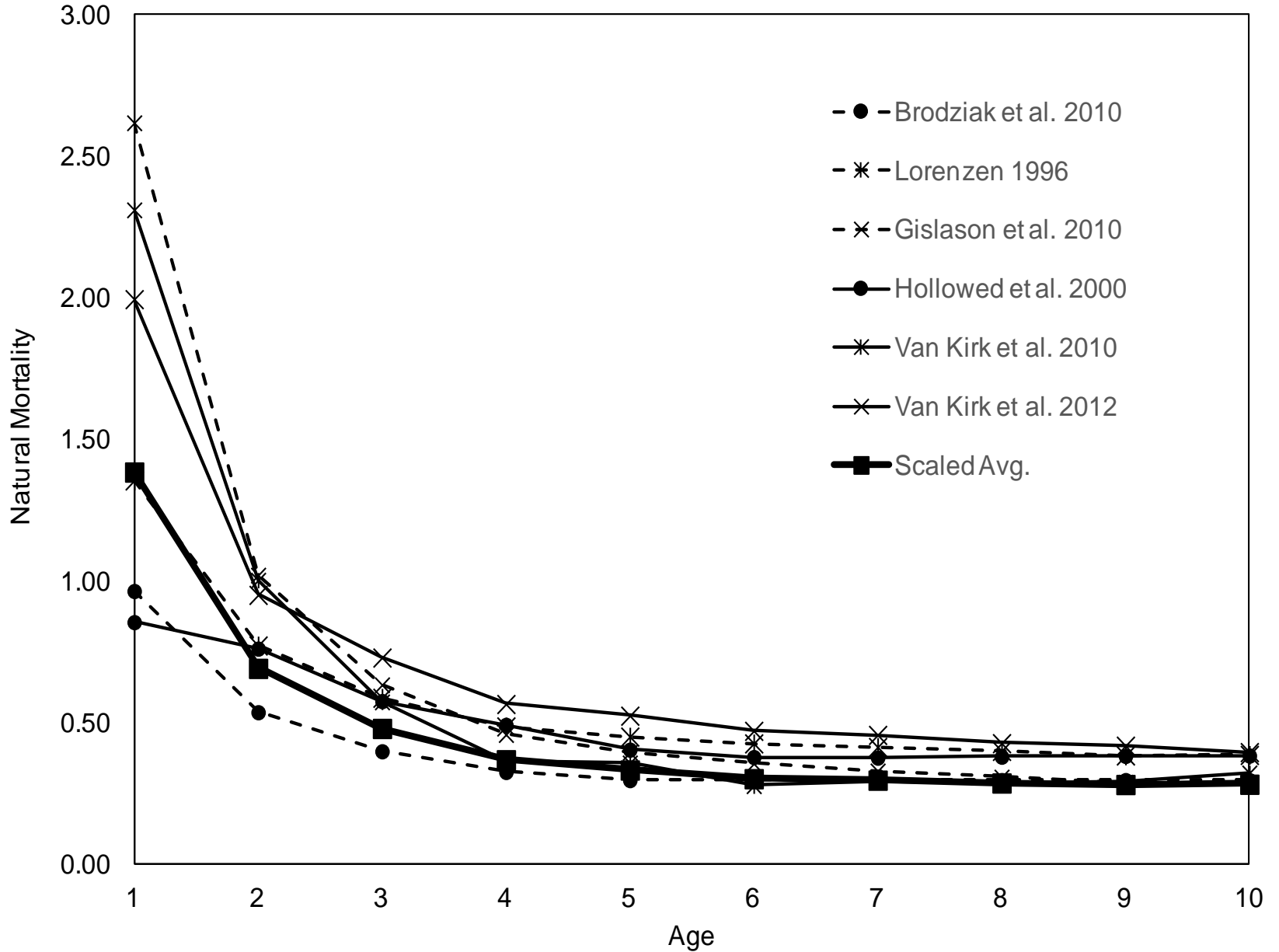
“Apparent data conflict in modern integrated stock assessment models can occur for three reasons:

- 1) Random sampling error.
- 2) Misspecification of the observation model (model processes relating dynamics or states to data).
- 3) Misspecification of the system dynamics model (the population dynamics model).”

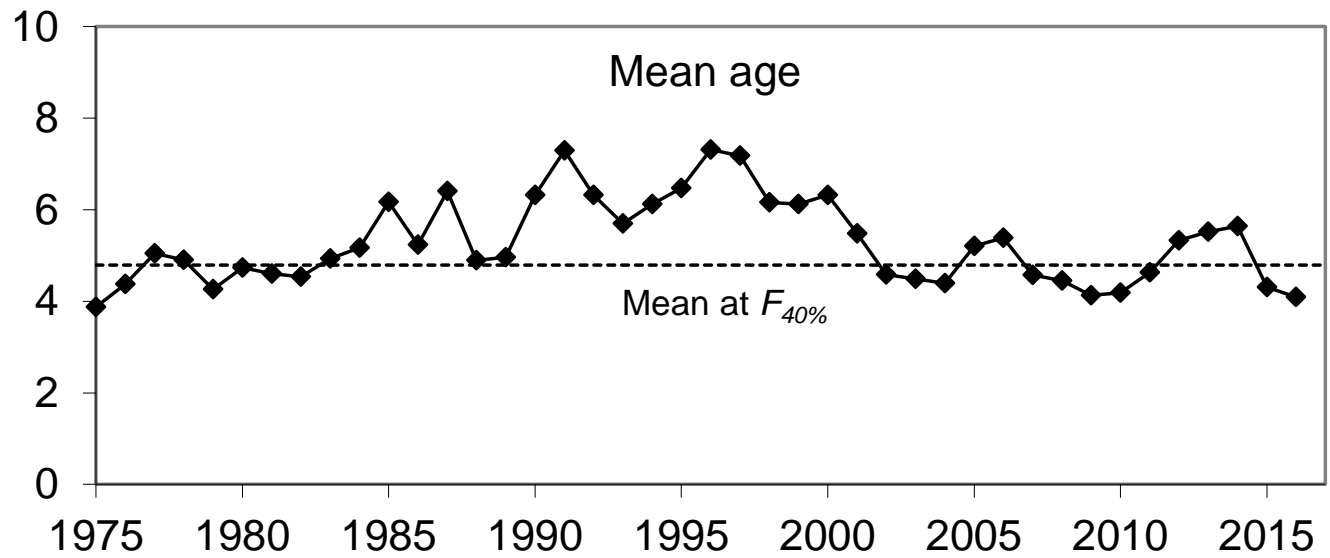
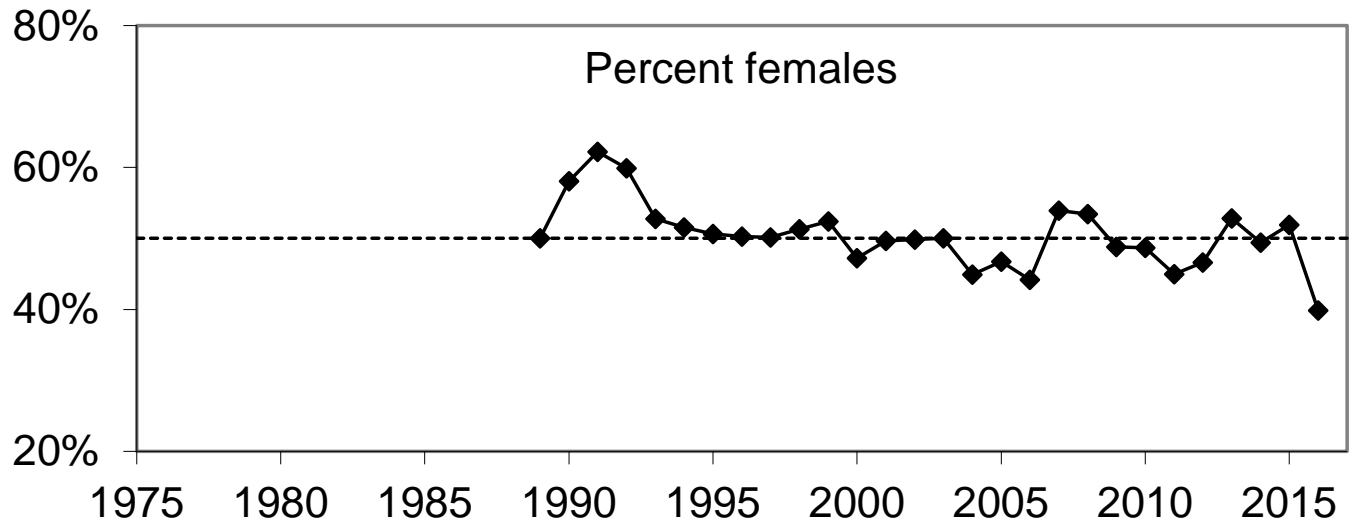
Parameters estimated independently

- Natural mortality: age-specific pattern from the 2014 assessment
- Weight at age by fishery and survey
- RE model fishery weights at age in 2017 and 2018.
- Proportion mature at age

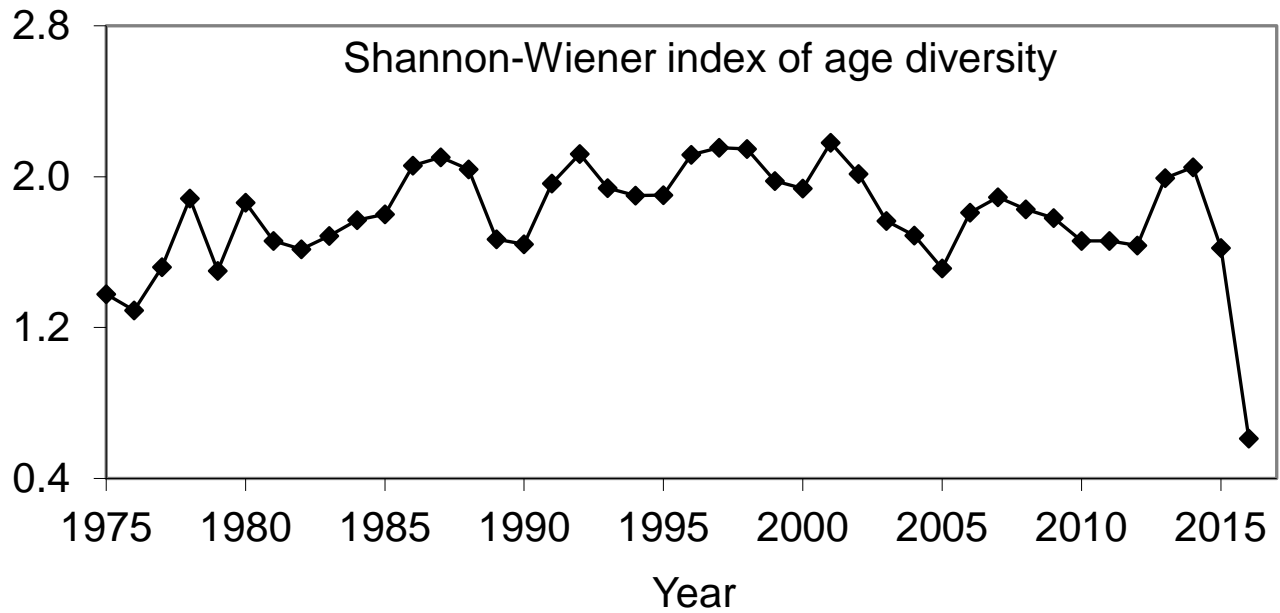
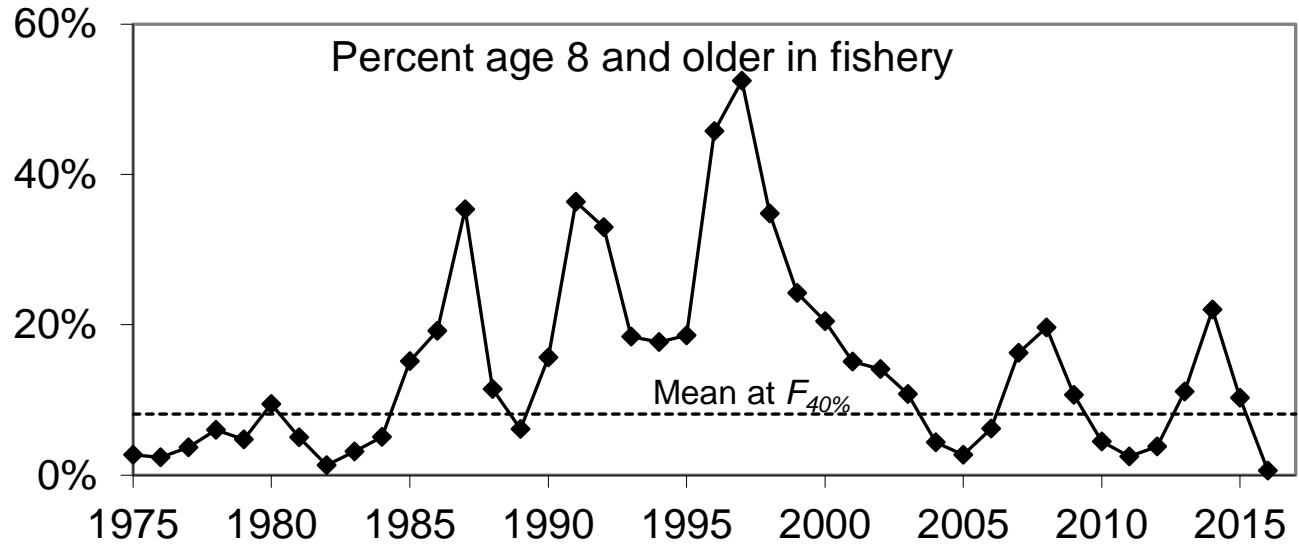
Natural mortality estimates



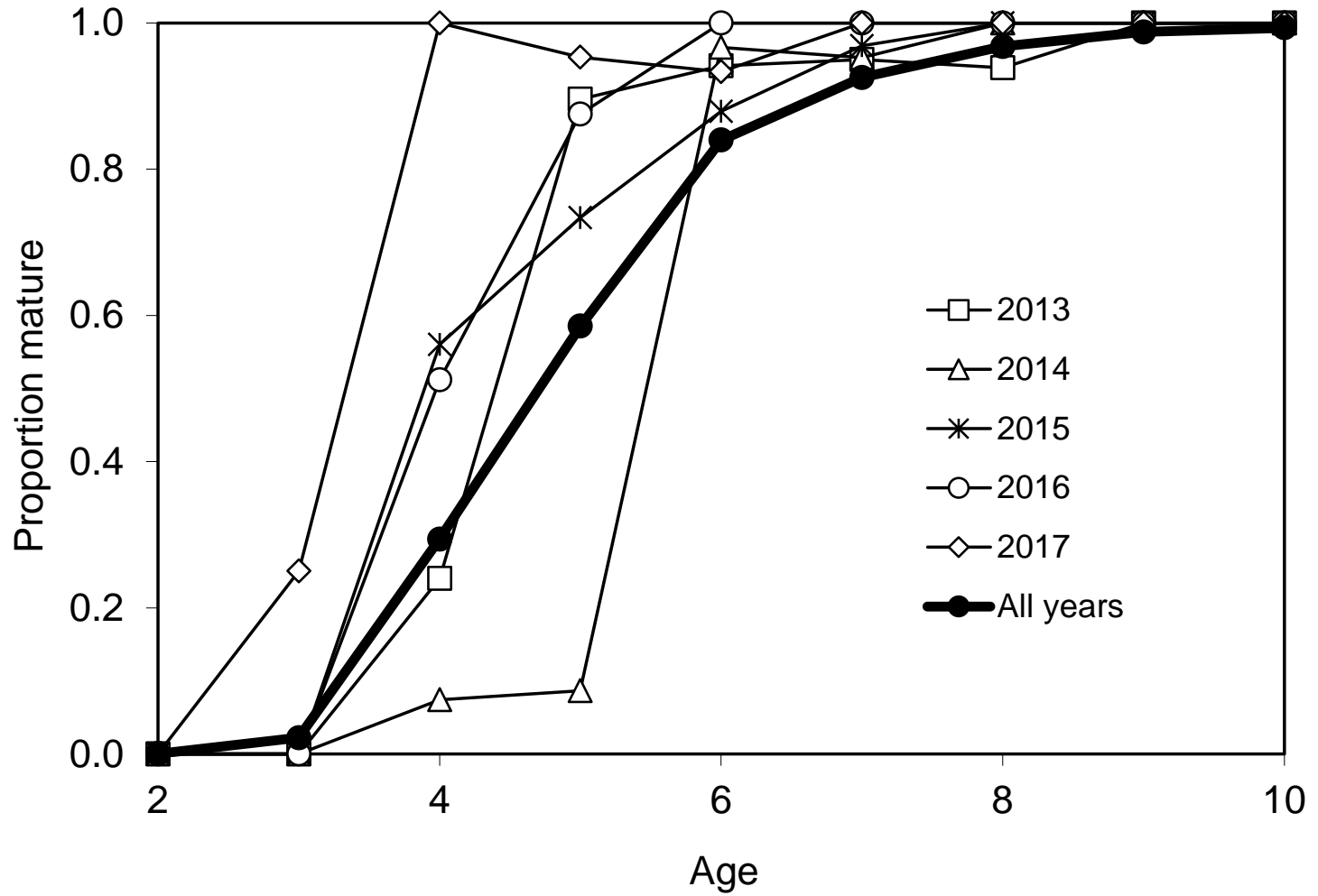
Fishery catch indicators



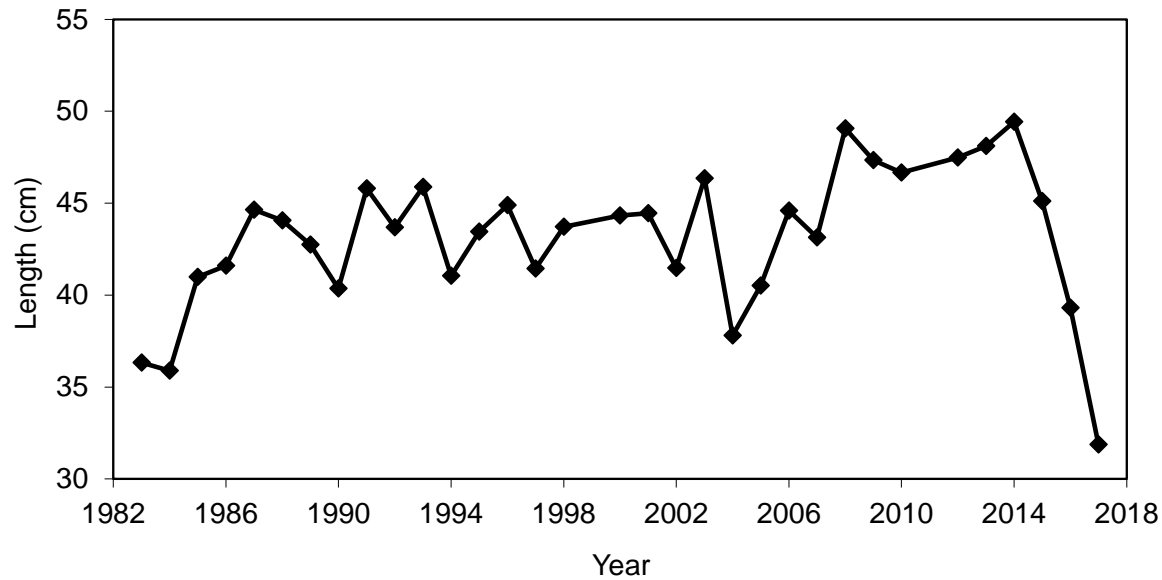
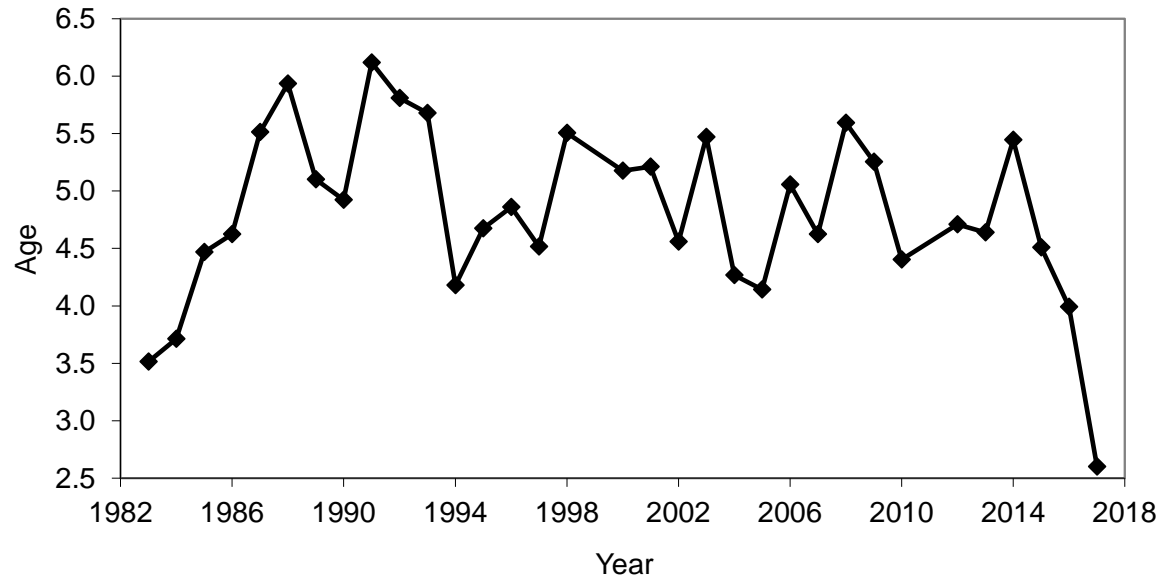
Fishery catch indicators



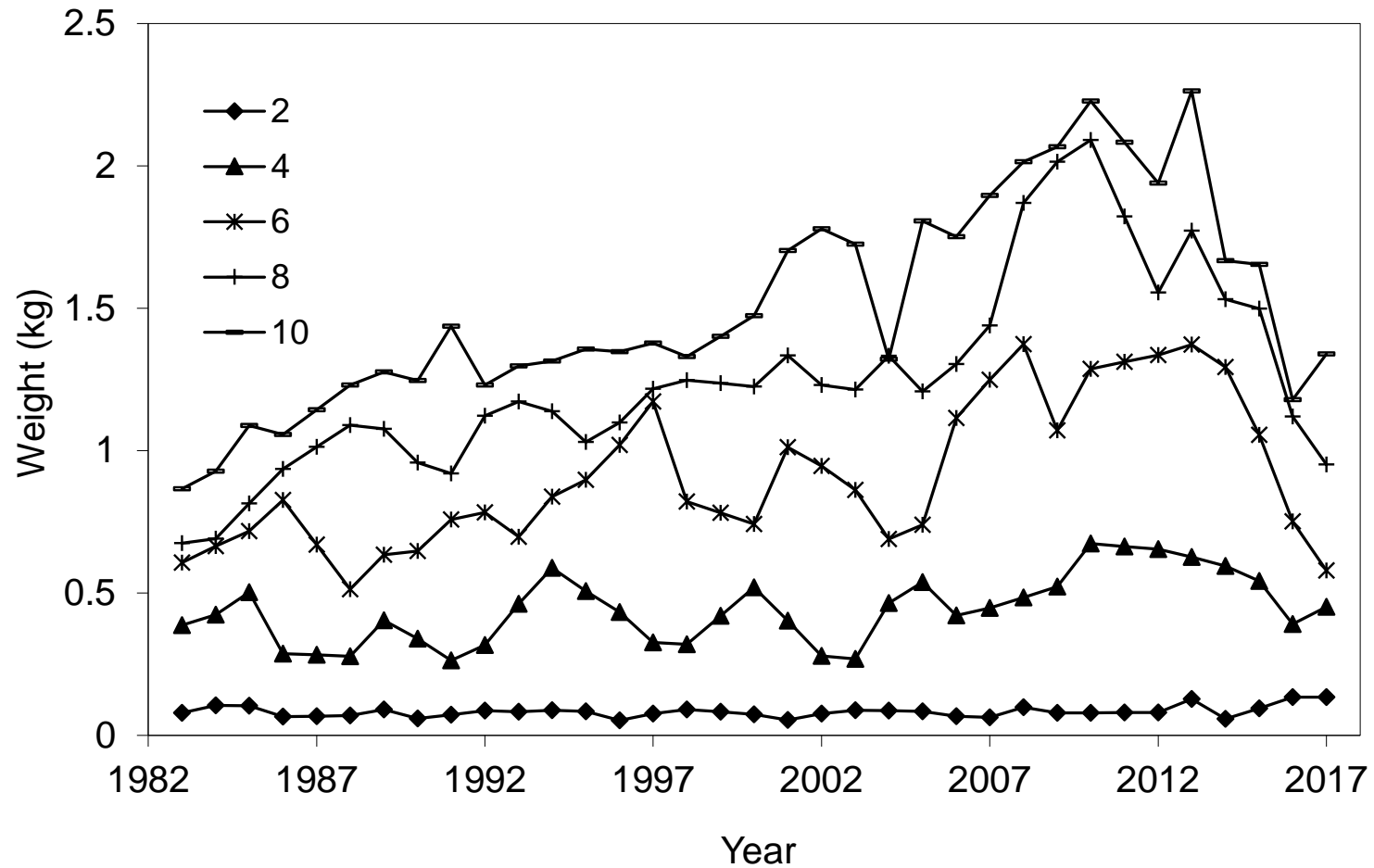
Recent maturity curves



Changes in maturity



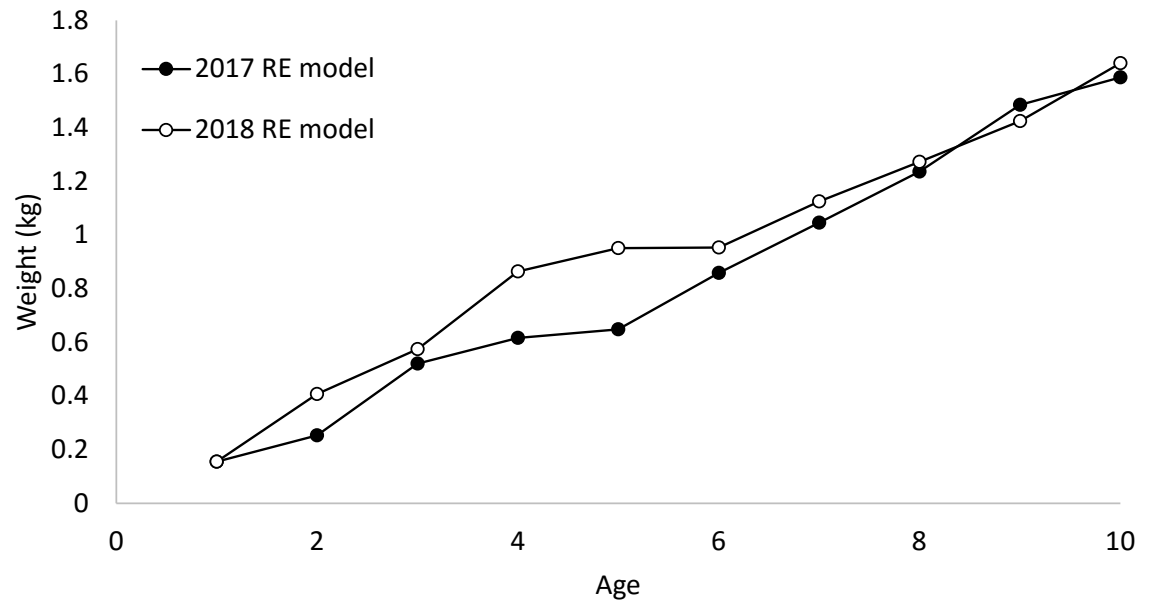
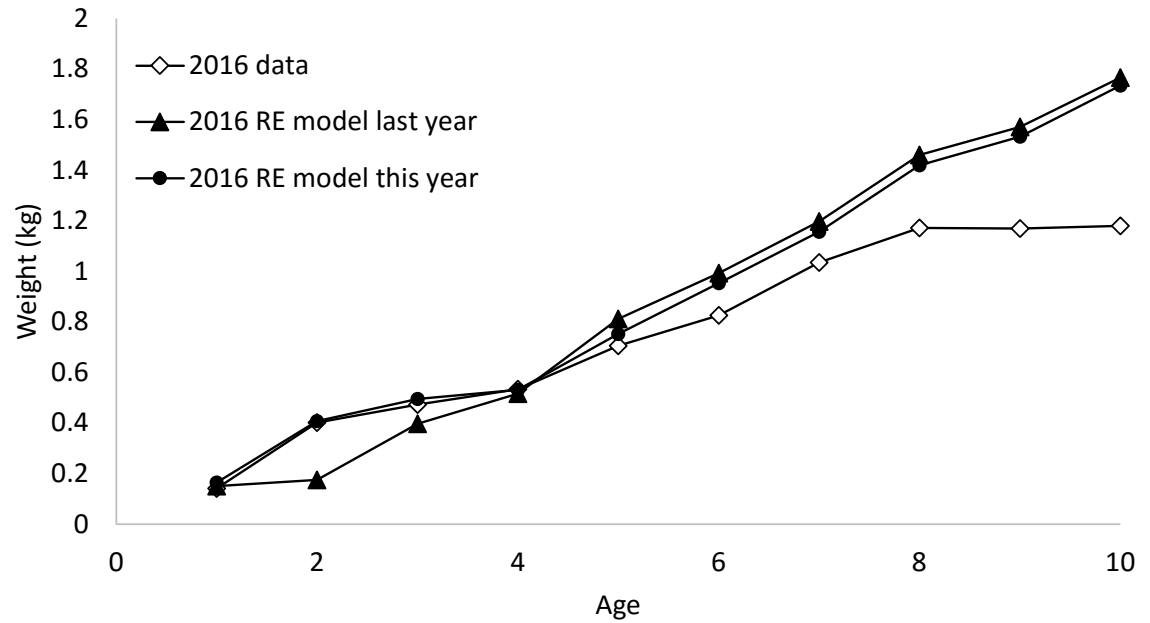
Shelikof survey changes in weight at age



Random effects model for weight at age

- Developed in the EBS pollock stock assessment (see Appendix 1.A in Ianelli et al. 2016)
- Underlying LVB growth curve
- Cohort and year RE effects on growth increments.
- Survey data incorporated with an offset (used both NMFS bottom trawl and Shelikof Strait acoustic survey weight-at-age estimates).
- Used to predict fishery WAA in 2017 (Shelikof Strait survey ageing data available but not fishery) and in 2018 (including F_{SPR} calcs).

RE model for fishery weight at age



Likelihood components

Likelihood component	Statistical model for error	Variance assumption
Fishery total catch (1970-2017)	Log-normal	CV = 0.05
Fishery age comp. (1975-2016)	Multinomial	Initial sample size: 200 or the number of tows/deliveries if less than 200
Shelikof acoustic survey biomass (1992-2017)	Log-normal	CV = 0.20
Shelikof acoustic survey age comp. (1992-2017)	Multinomial	Initial sample size = 60
Winter acoustic survey age-1 and age-2 indices (1994-2017)	Log-normal	Tuned CVs = 1.20 and 0.89
Summer acoustic survey biomass (2013-2015)	Log-normal	CV = 0.25
Summer acoustic survey age comp. (2013, 2015)	Multinomial	Initial sample size = 10
Summer acoustic survey length comp. (2017)	Multinomial	Initial sample size = 10
NMFS bottom trawl survey biom. (1990-2015)	Log-normal	Survey-specific CV from random-stratified design = 0.12-0.38
NMFS bottom trawl survey age comp. (1990-2015)	Multinomial	Initial sample size = 60
NMFS bottom trawl survey length comp. (2017)	Multinomial	Initial sample size = 60
ADFG trawl survey biomass (1989-2017)	Log-normal	CV = 0.25
ADFG survey age comp. (2000-2016)	Multinomial	Initial sample size = 30
Recruit process error (1970-1977, 2016, 2017)	Log-normal	$\sigma_R = 1.0$

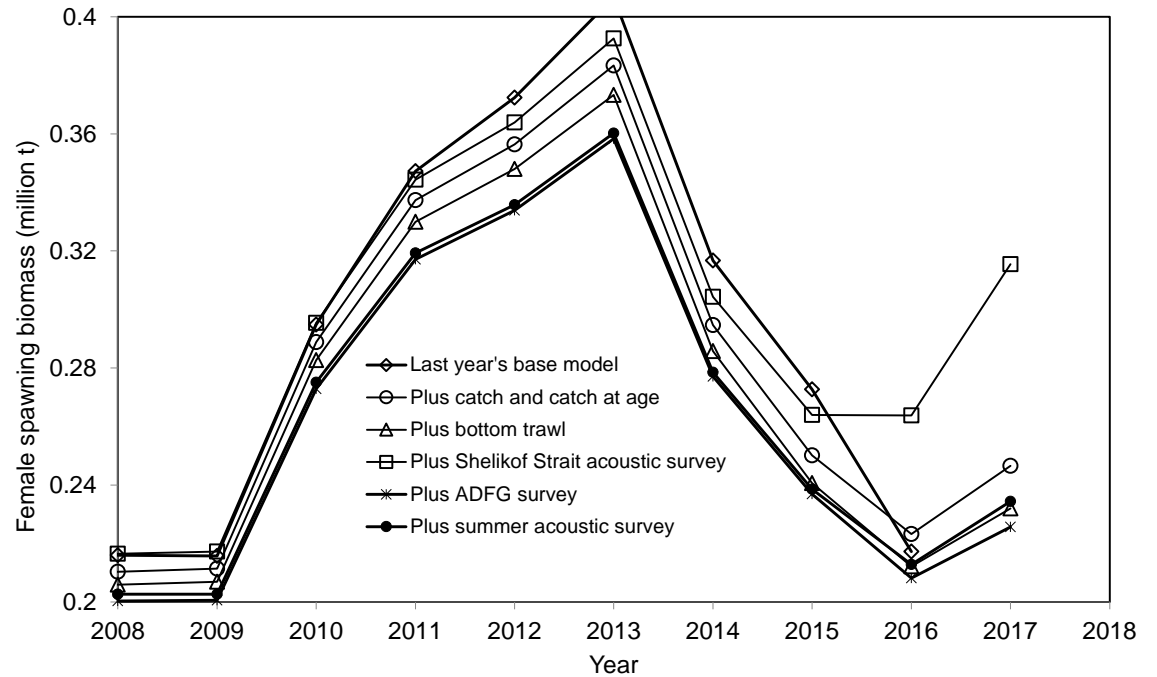
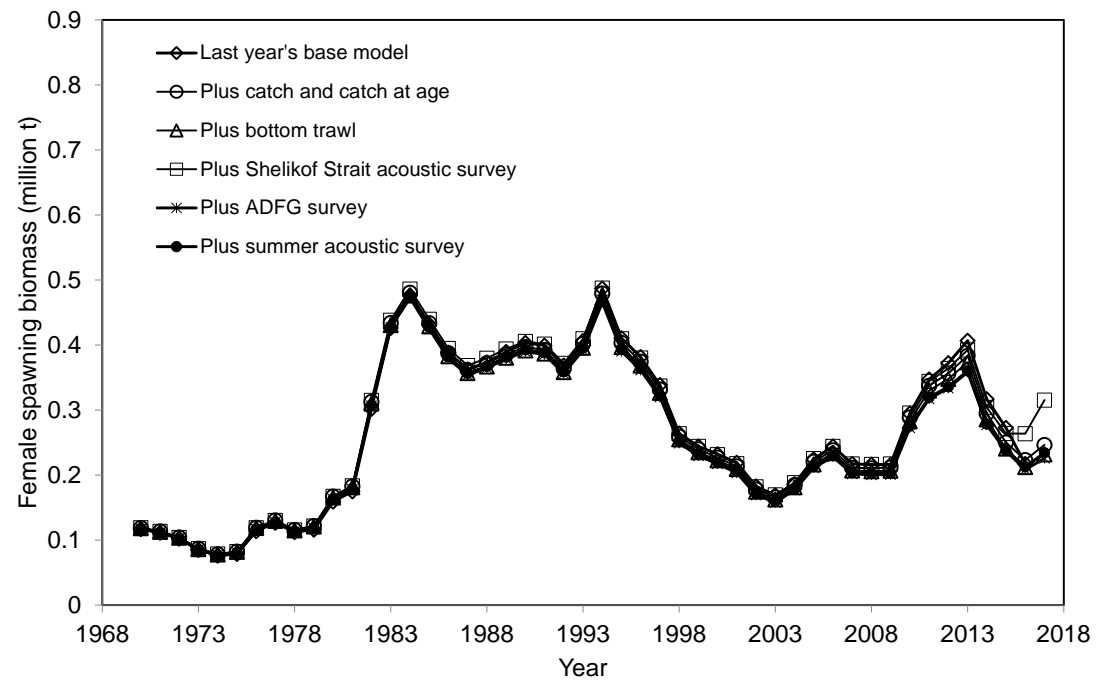
Model parameters

Population process modeled	Number of parameters	Estimation details
Recruitment	Years 1970-2017 = 48	Estimated as log deviances from the log mean; recruitment in 1970-77, and 2016 and 2017 constrained by random deviation process error.
Natural mortality	Age-specific= 10	Not estimated in the model
Fishing mortality	Years 1970-2017 = 48	Estimated as log deviances from the log mean
Mean fishery selectivity	4	Slope parameters estimated on a log scale, intercept parameters on an arithmetic scale
Annual changes in fishery selectivity	$2 * (\text{No. years}-1) = 94$	Estimated as deviations from mean selectivity and constrained by random walk process error
Survey catchability	No. of surveys + 1 = 7	Catchabilities estimated on a log scale. Two catchability periods were estimated for the Shelikof Strait acoustic survey. Separate catchabilities were also estimated for age-1 and age-2 winter acoustic indices.
Survey selectivity	6 (Shelikof acoustic survey: 2, BT survey: 2, ADFG survey: 2)	Slope parameters estimated on a log scale.
Total	113 estimated parameters + 94 process error parameters + 10 fixed parameters = 217	

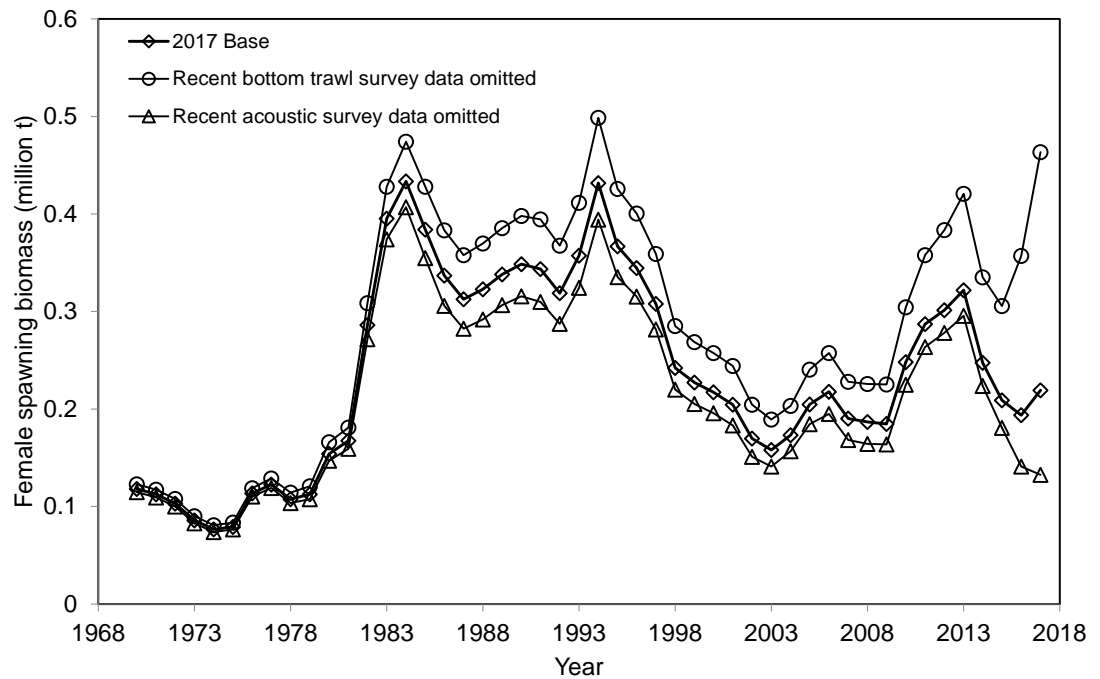
Model input changes

- Fishery: 2016 total catch and catch at age.
- NMFS bottom trawl survey: 2017 biomass and length composition.
- Shelikof Strait acoustic survey: 2017 biomass and age composition.
- ADFG crab/groundfish trawl survey: 2017 biomass and 2016 age composition.
- Summer acoustic survey: 2017 biomass and length composition.

Sequential addition of new data

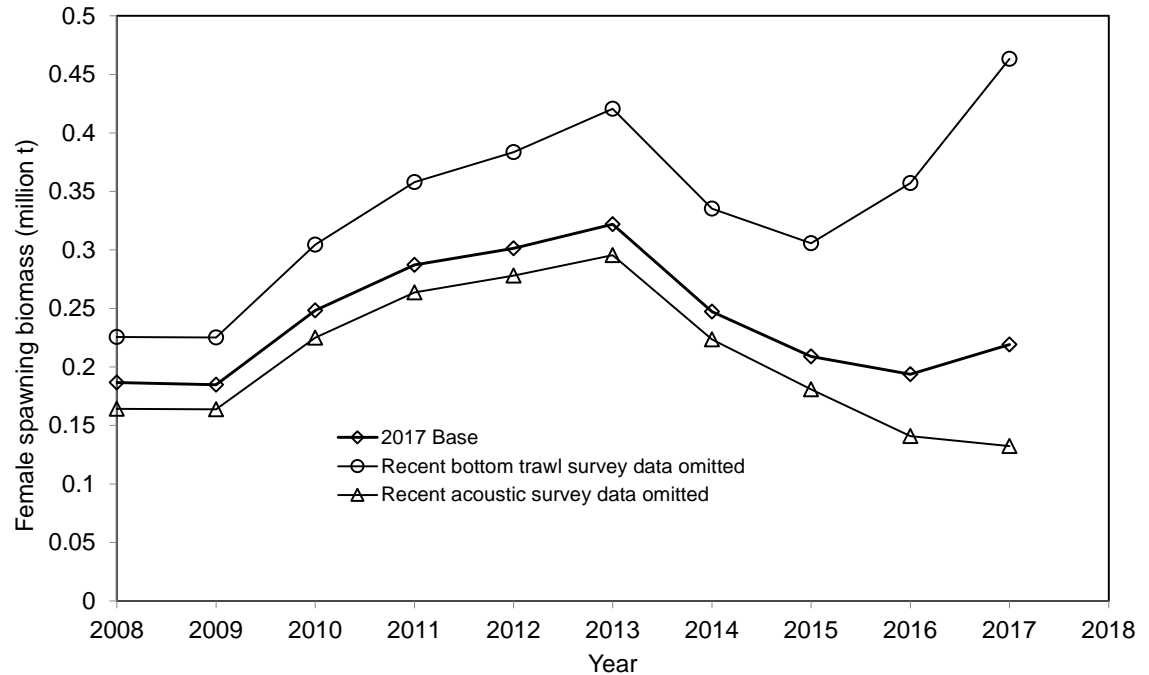


Omitting Acoustic vs Bottom Trawl Data



Acoustic: 2017 Shelikof Strait, 2017 summer acoustic

Bottom trawl: 2017 NMFS, 2015-2017 ADFG



Alternative Models

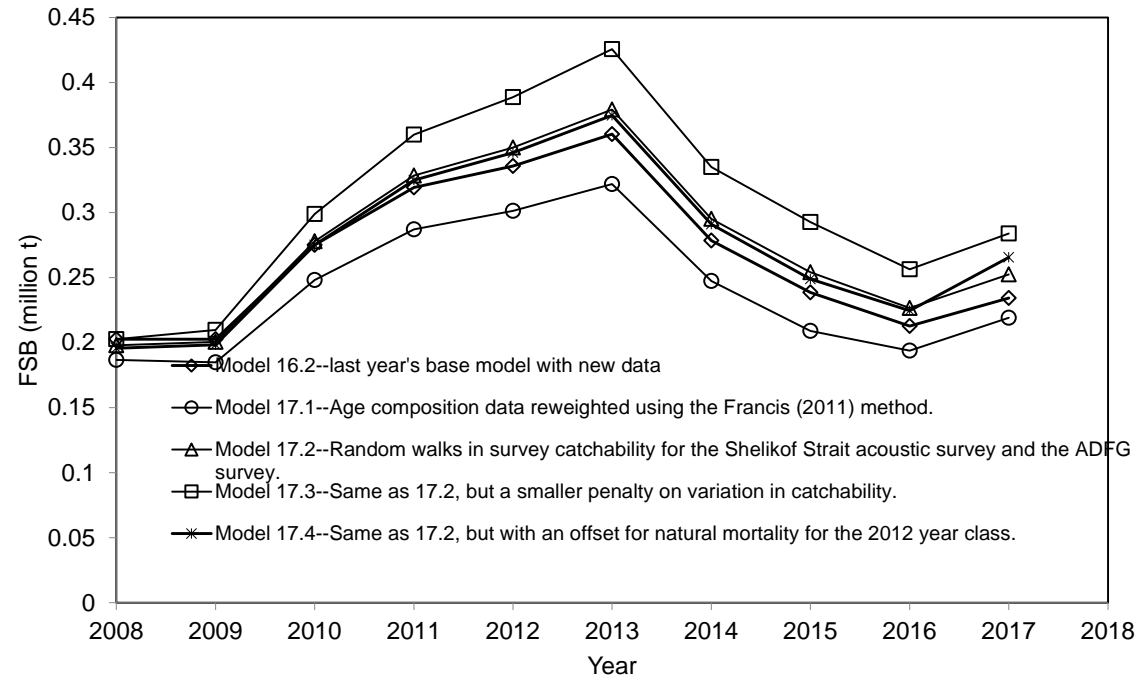
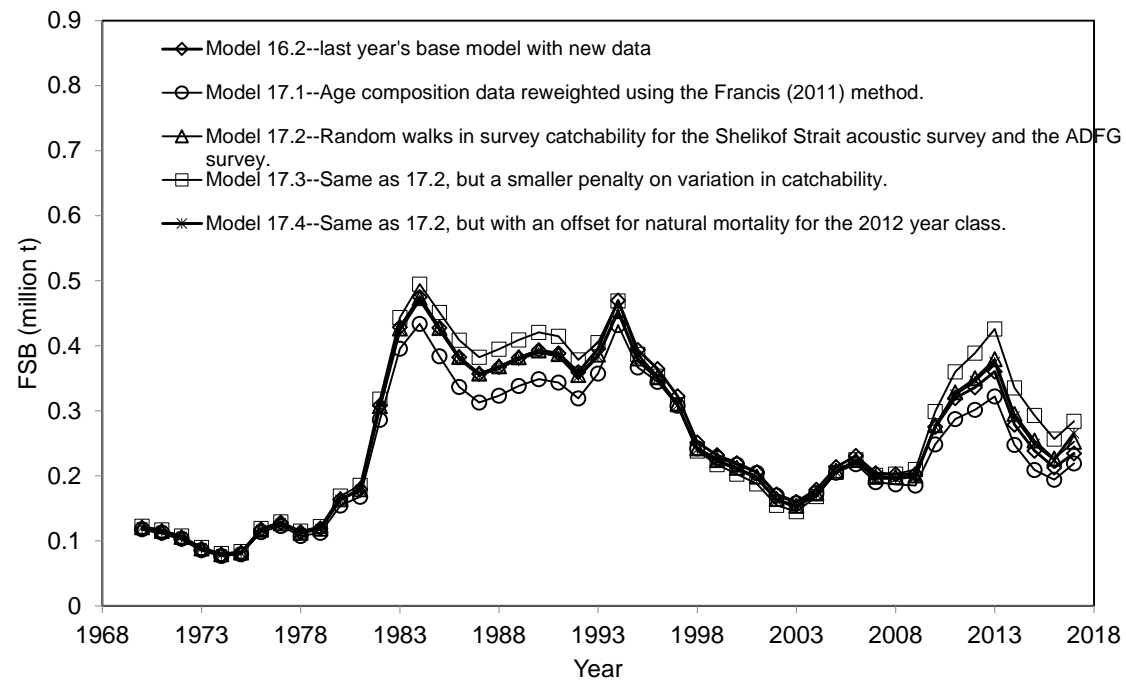
Model 16.2--last year's base model with new data

Model 17.1--Age composition data reweighted using the Francis (2011) method.

Model 17.2--Random walks in survey catchability for the Shelikof Strait acoustic survey and the ADFG survey.

Model 17.3--Same as 17.2, but a smaller penalty on variation in catchability.

Model 17.4--Same as 17.2, but with an offset for natural mortality for the 2012 year class.



Model 16.2--last year's base model with new data

Model 17.1--Age composition data reweighted using the Francis (2011) method.

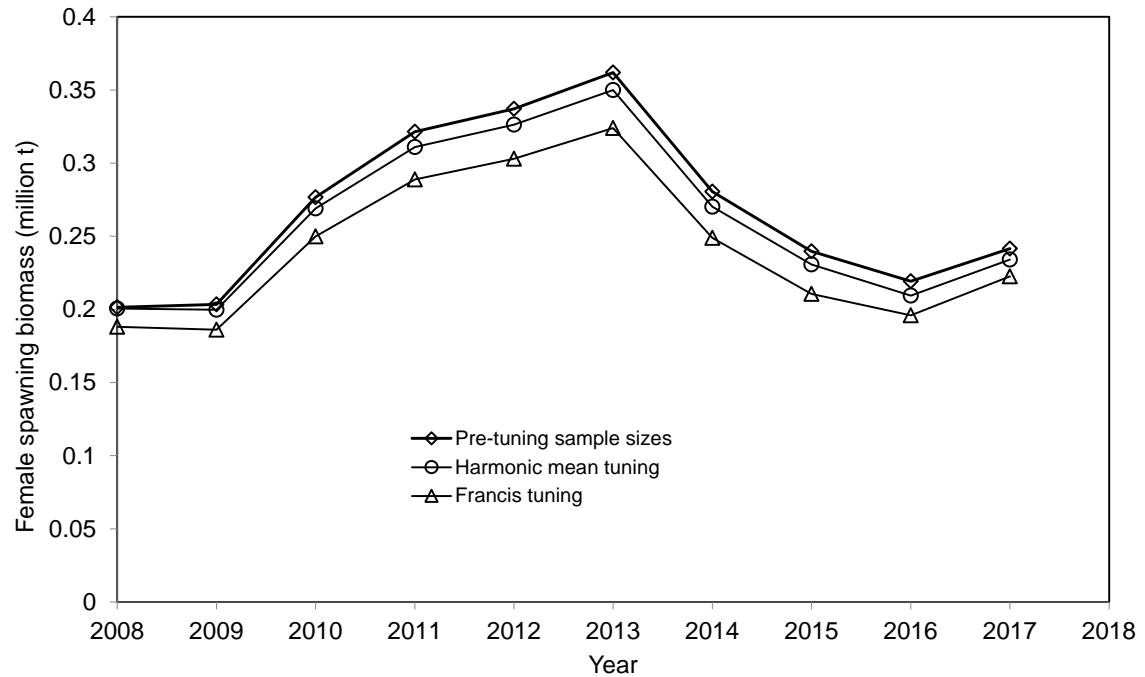
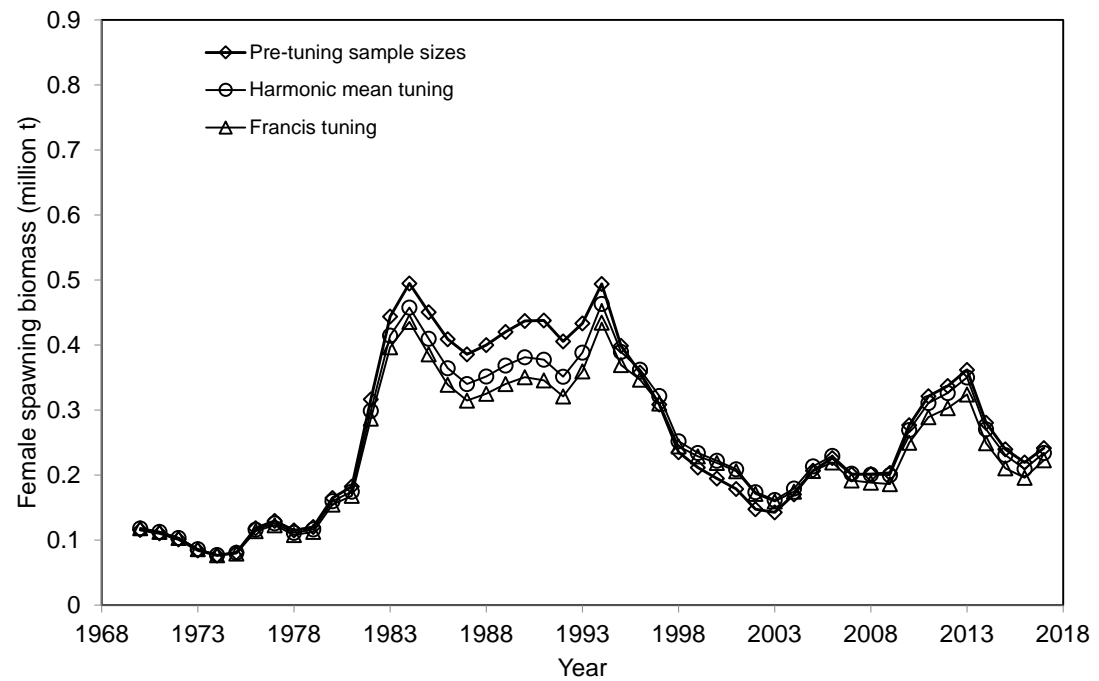
Model 17.2--Random walks in survey catchability for the Shelikof Strait acoustic survey and the ADFG survey.

Model 17.3--Same as 17.2, but a smaller penalty on variation in catchability.

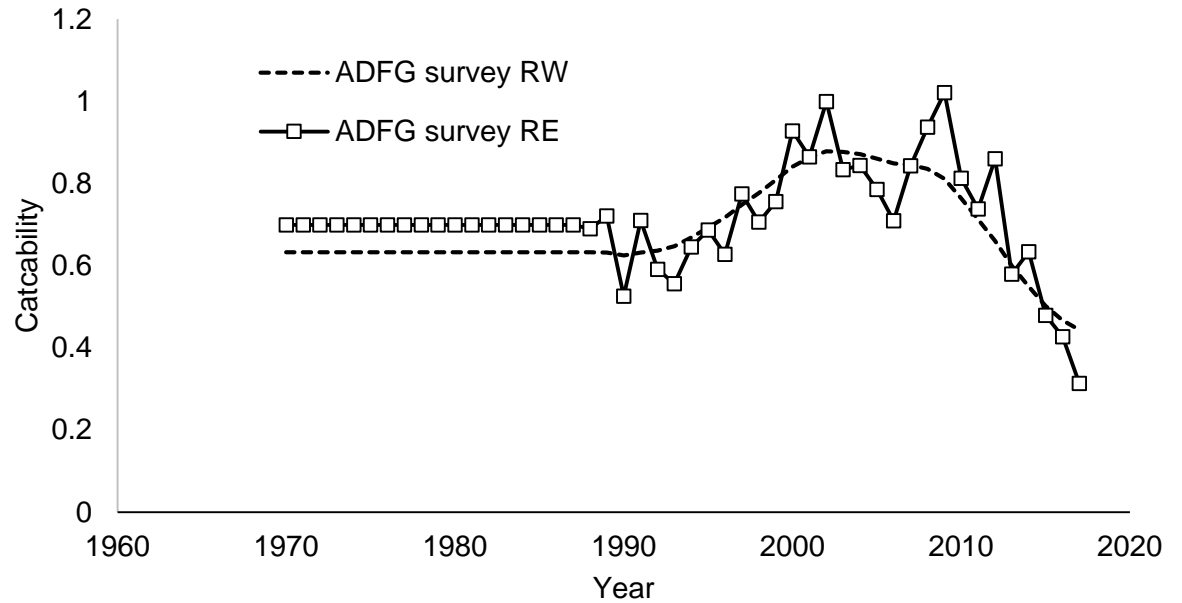
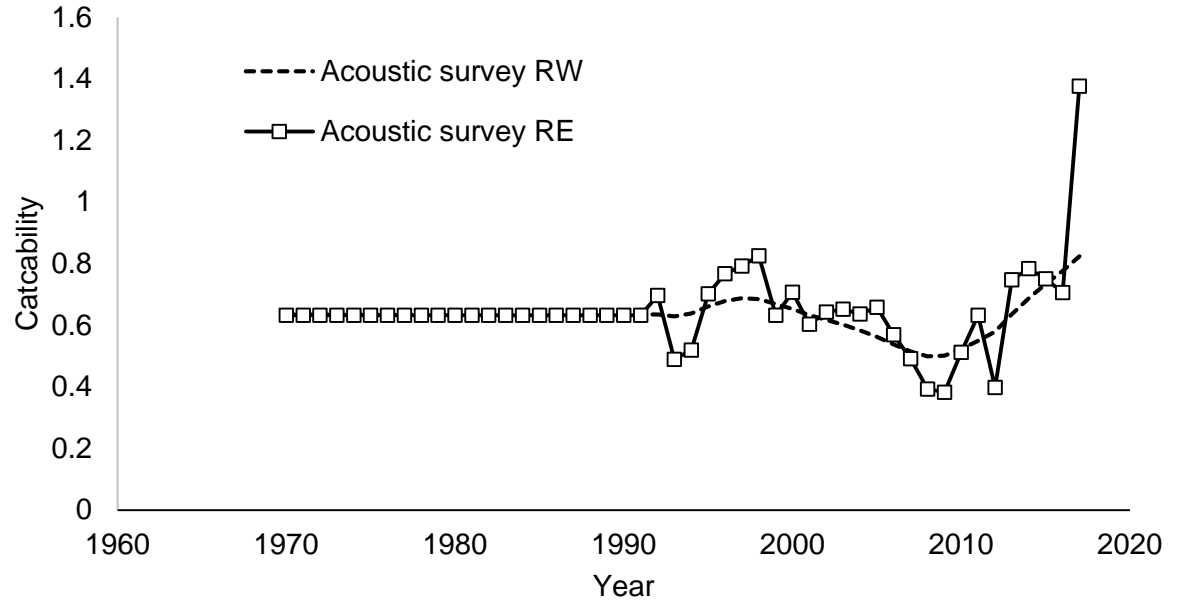
Model 17.4--Same as 17.2, but with an offset for natural mortality for the 2012 year class.

	Model 16.2	Model 17.1	Model 17.2	Model 17.3	Model 17.4
Model fits					
Total log(Likelihood)	-466.58	-344.74	-312.18	-278.74	-310.67
Catch	-0.12	-0.11	-0.07	-0.04	-0.07
Fishery age	-153.53	-98.45	-96.98	-96.33	-96.65
Acoustic survey biomass	-62.10	-56.70	-35.93	-20.01	-34.69
Age-1 and age-2 indices	-20.08	-17.18	-17.25	-17.43	-17.23
Acoustic survey age	-38.50	-28.95	-27.57	-26.62	-27.22
Bottom trawl survey biomass	-10.20	-10.51	-8.51	-7.69	-9.18
Bottom trawl survey age and length comp	-44.27	-22.09	-20.80	-20.26	-20.23
ADFG trawl survey biomass	-58.94	-54.36	-30.90	-14.49	-32.41
ADFG trawl survey age	-40.47	-26.92	-23.52	-22.20	-23.53
Summer acoustic biomass	-2.51	-1.68	-2.34	-2.38	-1.39
Summer acoustic age and length comp.	-5.64	-5.30	-5.48	-5.54	-5.62
Priors/Penalties	-30.22	-22.51	-42.85	-45.74	-42.43
Composition data					
Fishery age comp. effective N	97	91	90	90	92
Shelikof Strait acoustic age comp. effective N	10	9	10	10	10
NMFS bottom trawl age comp. effective N	24	20	23	25	26
ADF&G trawl age comp. effective N	30	26	30	32	31
Survey abundance					
Shelikof Strait Acoustic RMSE					
EK500	0.26	0.24	0.35	0.26	0.34
Dyson	0.66	0.64	NA	NA	NA
Age-1 index	1.36	1.35	1.37	1.40	1.35
Age-2 index	1.52	1.51	1.49	1.48	1.52
NMFS bottom trawl RMSE					
ADFG trawl RMSE	0.31	0.32	0.31	0.31	0.33
ADFG trawl RMSE	0.49	0.47	0.36	0.24	0.36
Summer acoustic RMSE	0.32	0.34	0.31	0.31	0.24
Catchability estimates					
NMFS trawl	0.89	0.89	0.87	0.86	0.87
Shelikof Strait acoustic					
EK500	0.61	0.65	0.63	0.61	0.64
Dyson	0.68	0.73	NA	NA	NA
Age-1 index linear term	0.08	0.09	0.08	0.08	0.08
Age-1 index power term	1.23	1.22	1.21	1.18	1.39
Age-2 index	0.81	1.10	1.03	0.99	1.06
Summer acoustic	1.09	1.06	1.03	0.94	1.06
ADFG trawl	0.70	0.83	0.68	0.64	0.70
Stock status (t)					
2017 Spawning biomass	310,480	296,531	338,239	379,115	383,965
Depletion (B2017/B0)	53%	53%	57%	62%	69%
B _{40%}	235,401	224,669	236,511	244,550	222,110
2018 yield (t)					
Author's recommended ABC	145,693	143,318	159,129	174,480	180,092

Francis tuning vs harmonic mean of effective N

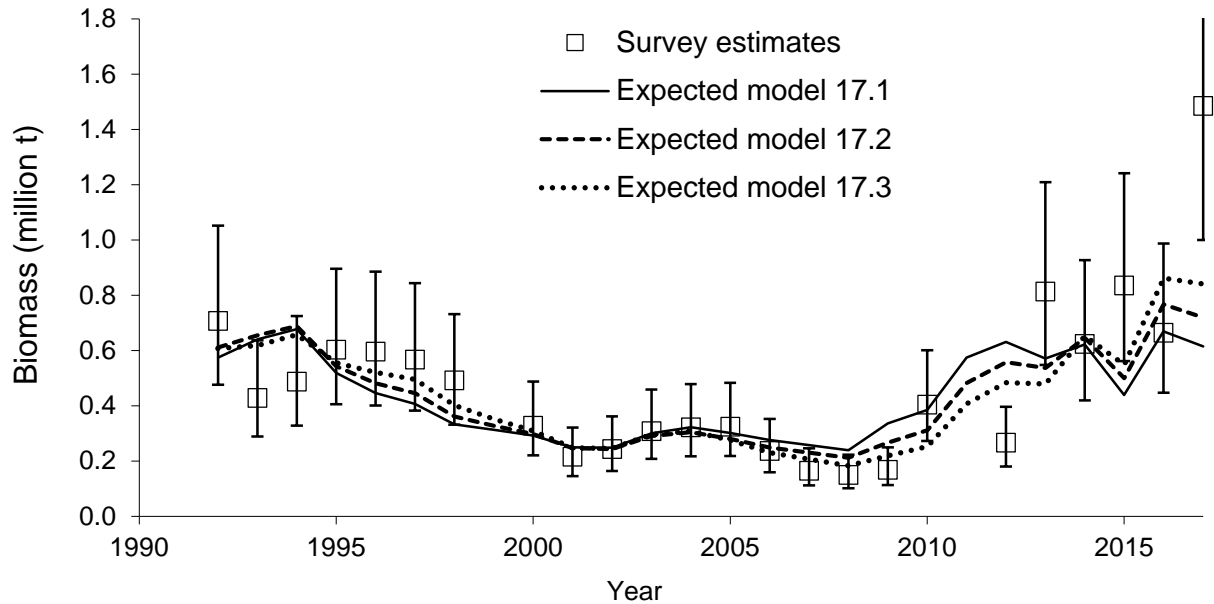
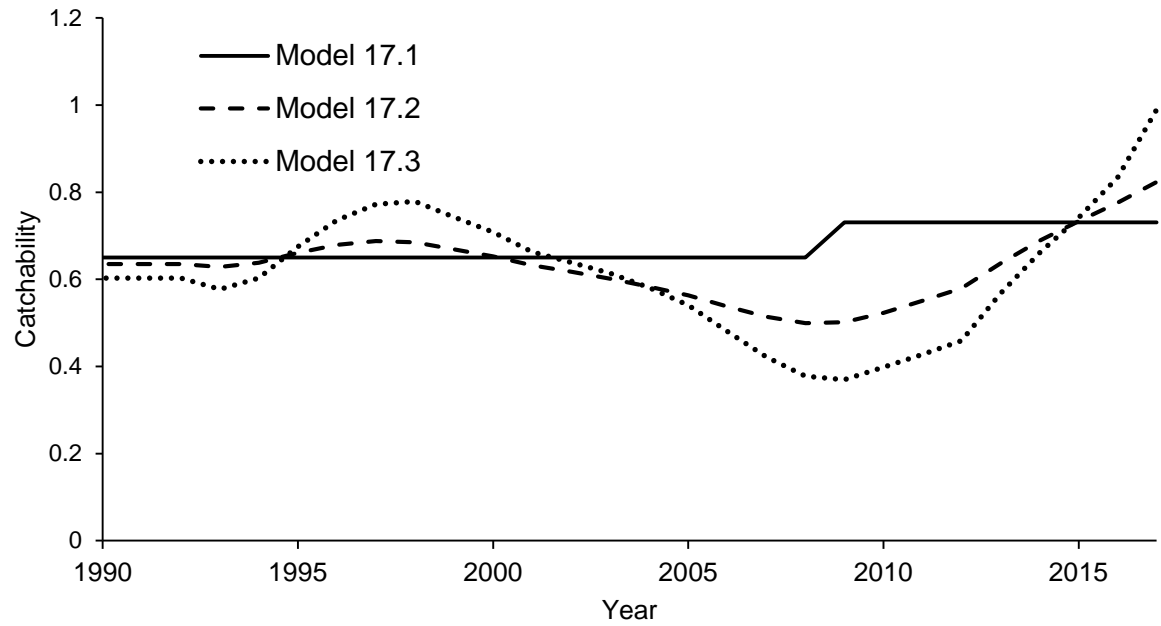


Random walk vs Random error



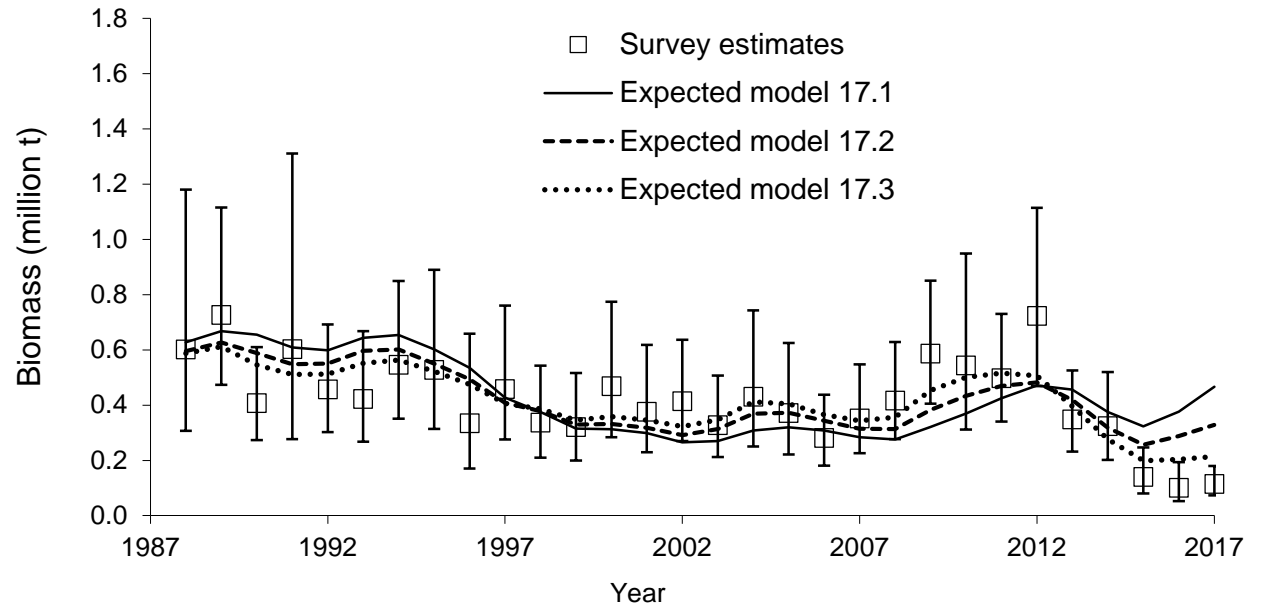
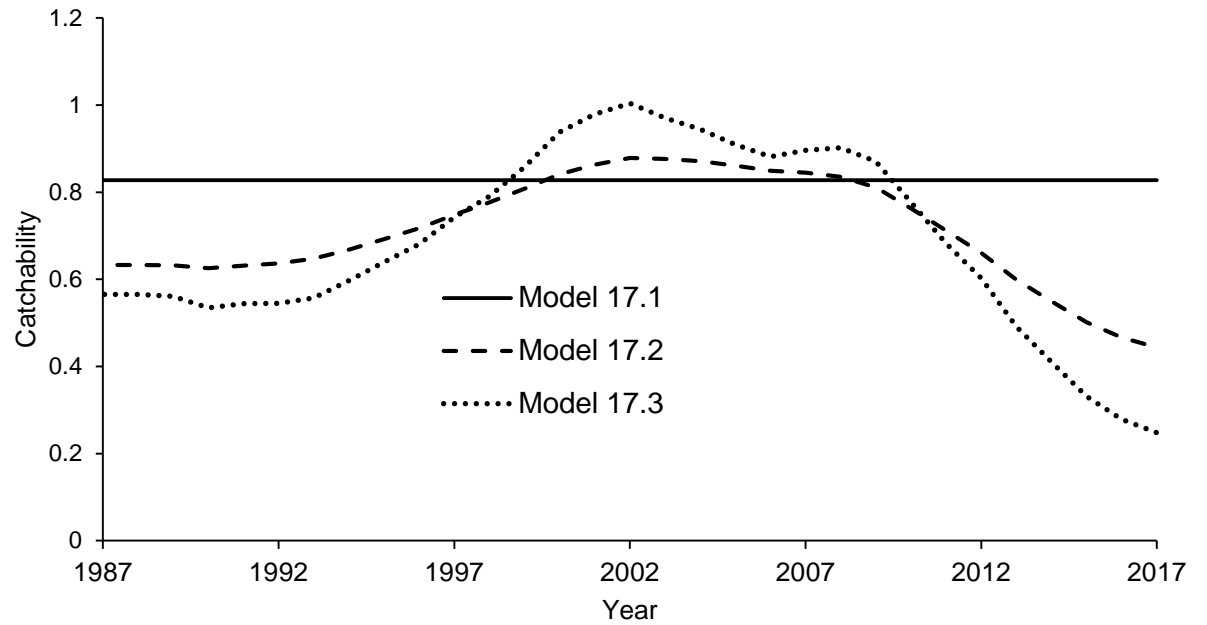
Small RW penalty vs large RW penalty

Shelikof Strait

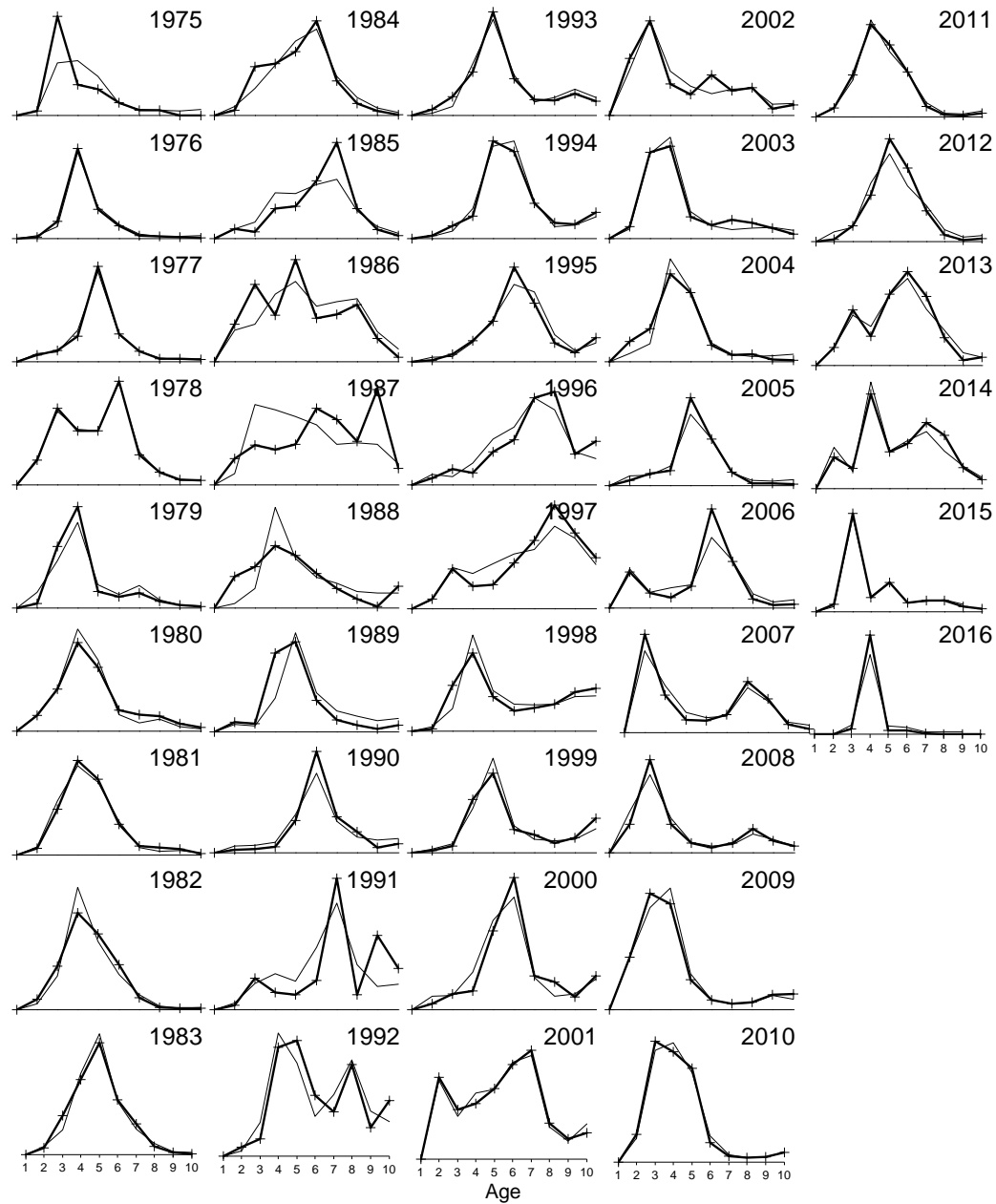


**Small RW
penalty
vs
large RW
penalty**

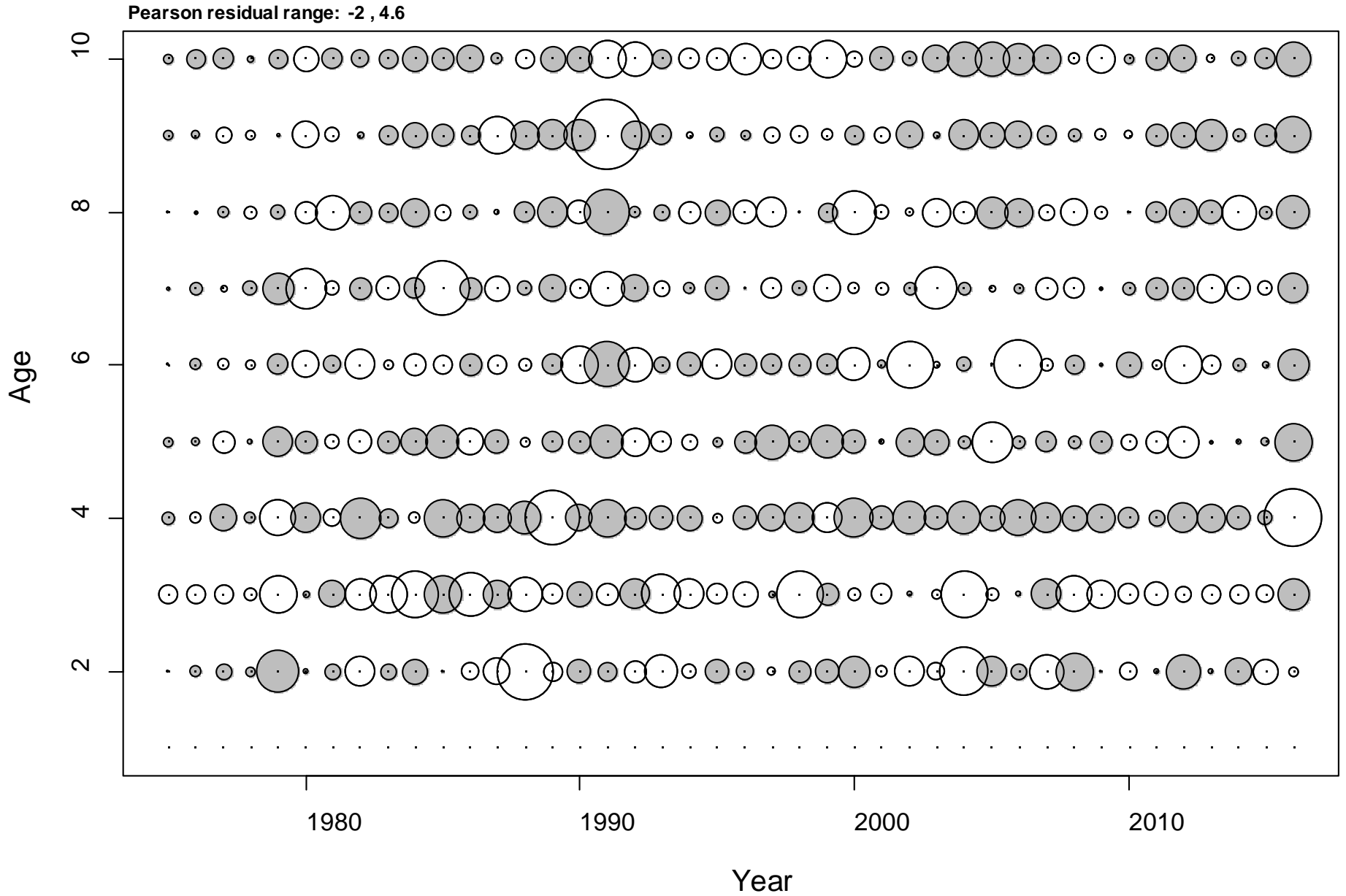
ADFG survey



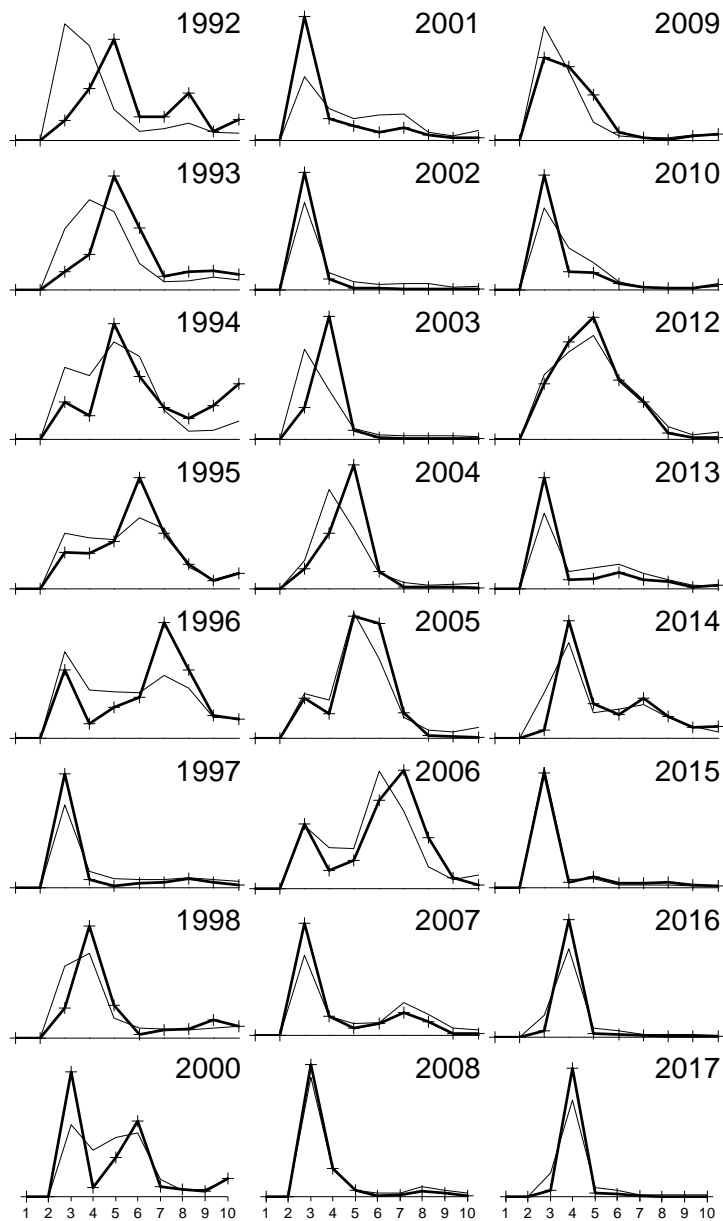
Fishery age composition (predicted vs observed)



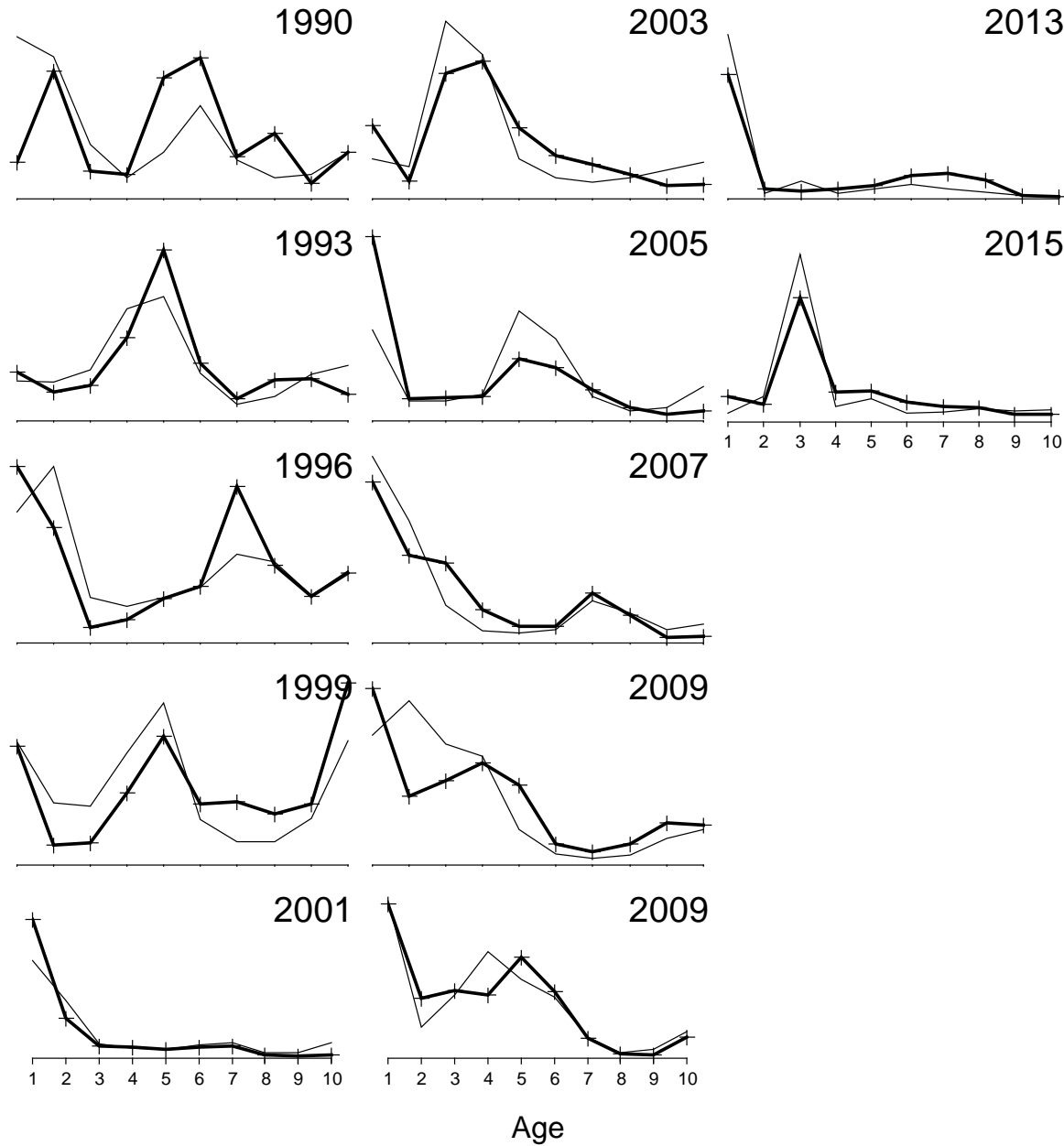
Fishery age composition (residuals)



Shelikof Strait EIT age composition (predicted vs observed)

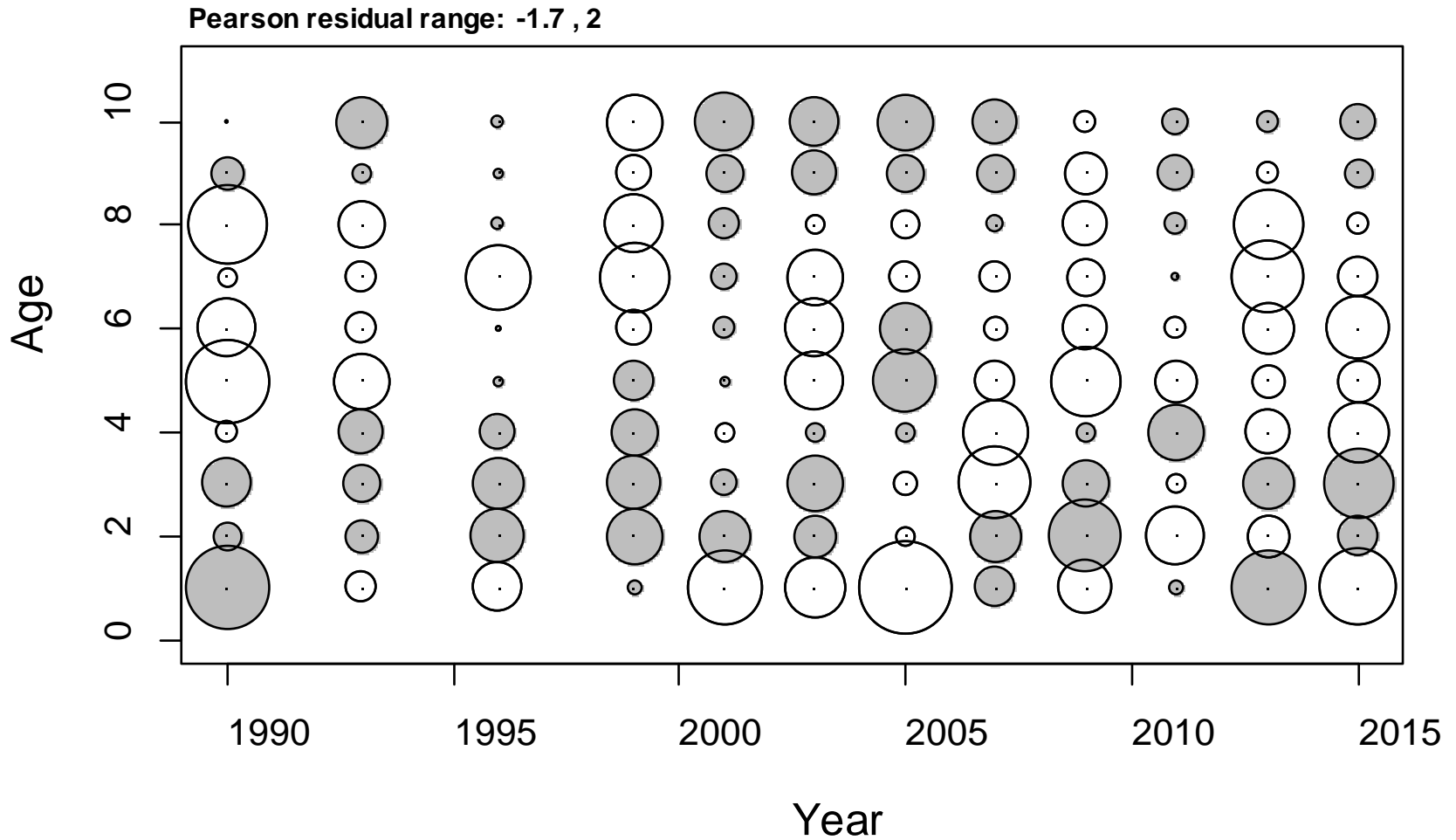


NMFS bottom trawl age composition (predicted vs observed)

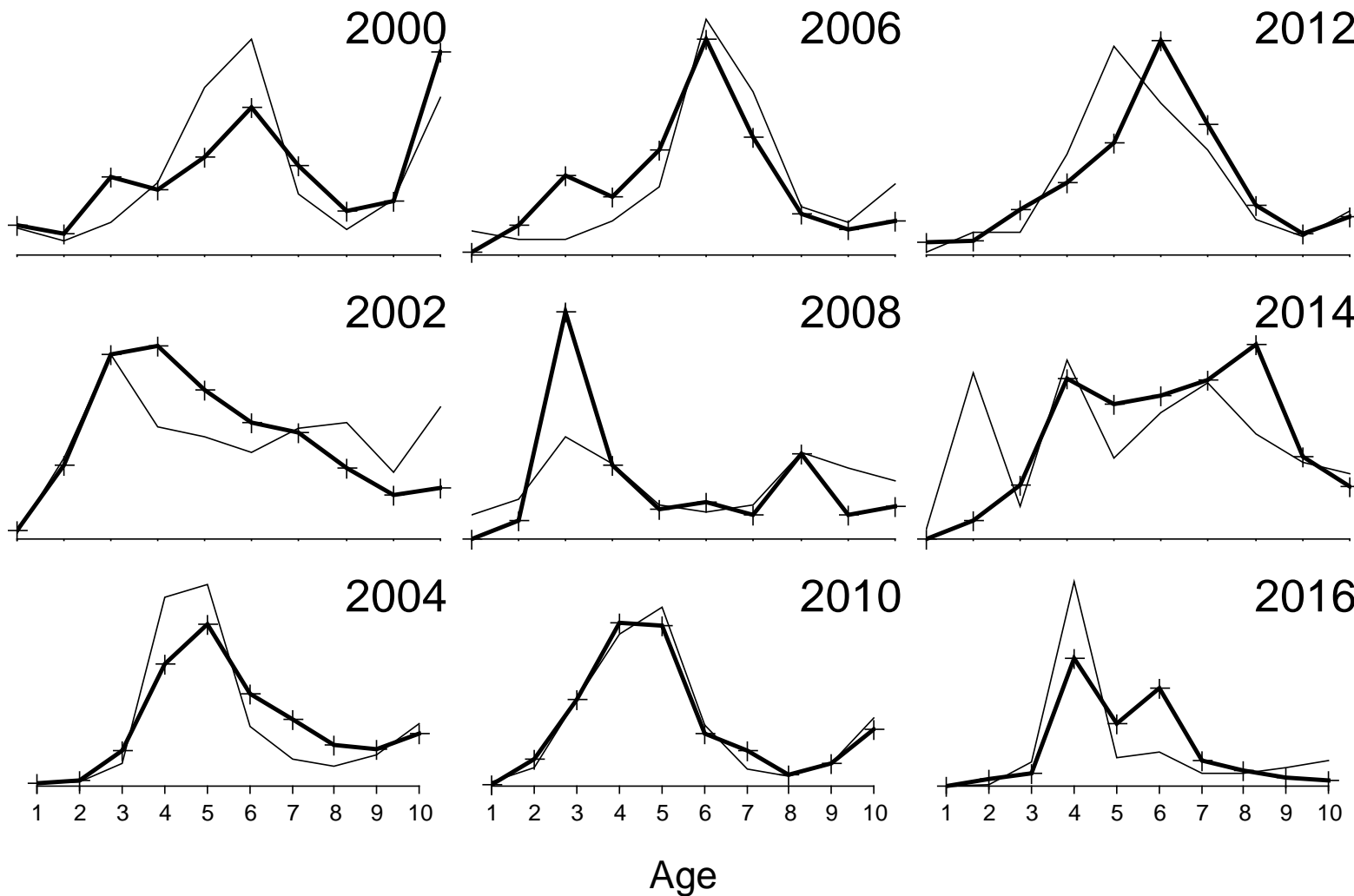


NMFS bottom trawl age composition (residuals)

NMFS bottom trawl



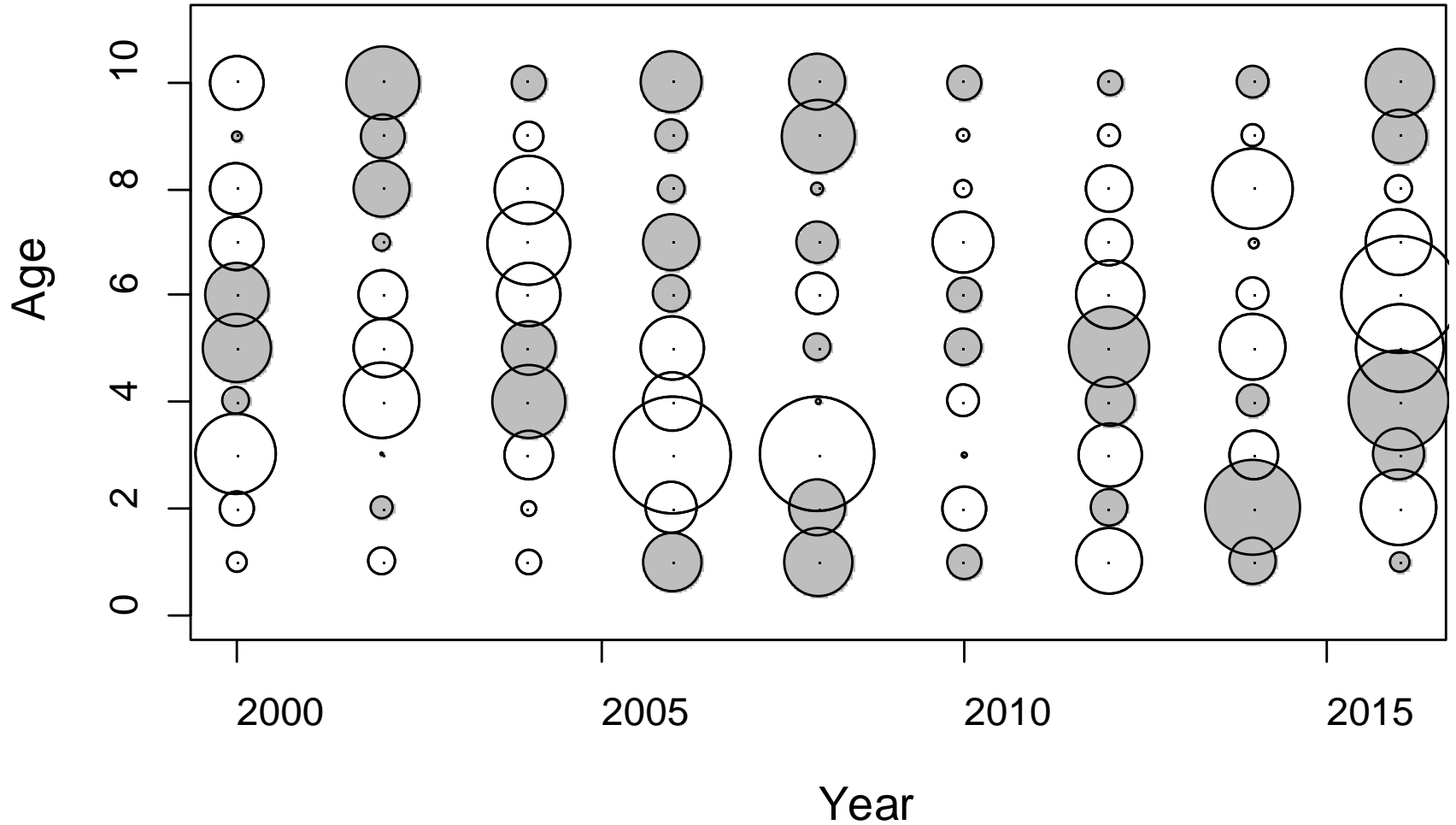
ADFG bottom trawl age composition (predicted vs observed)



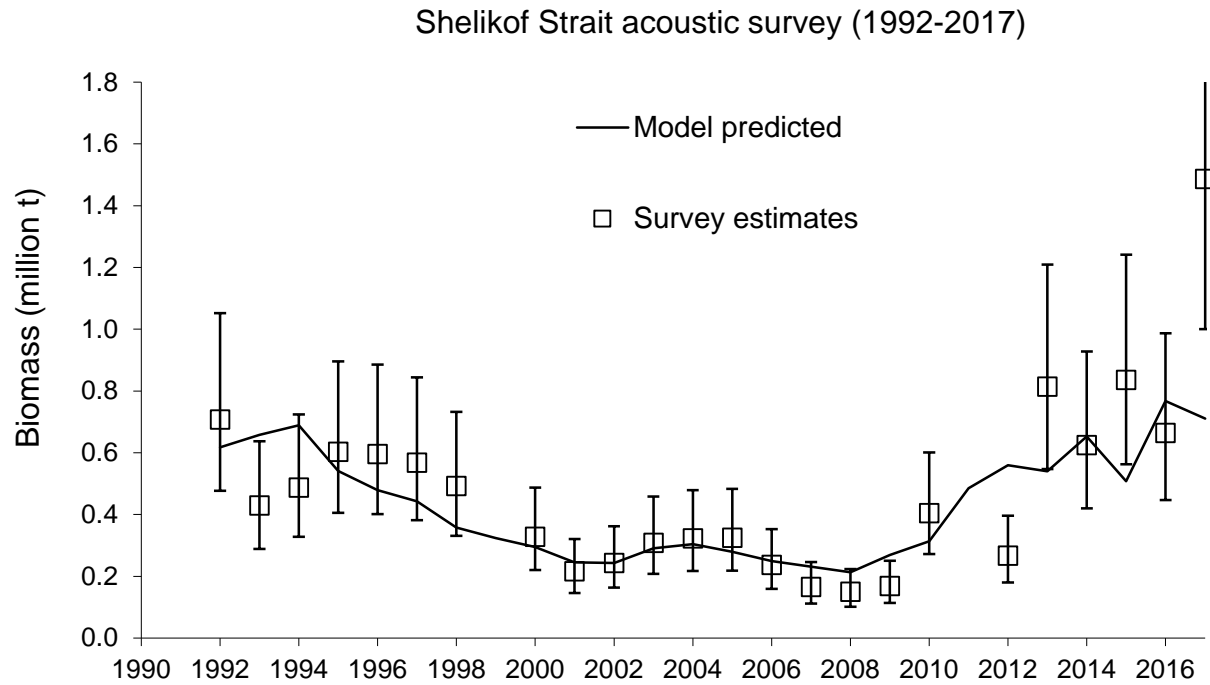
ADFG bottom trawl age composition (residuals)

ADFG bottom trawl

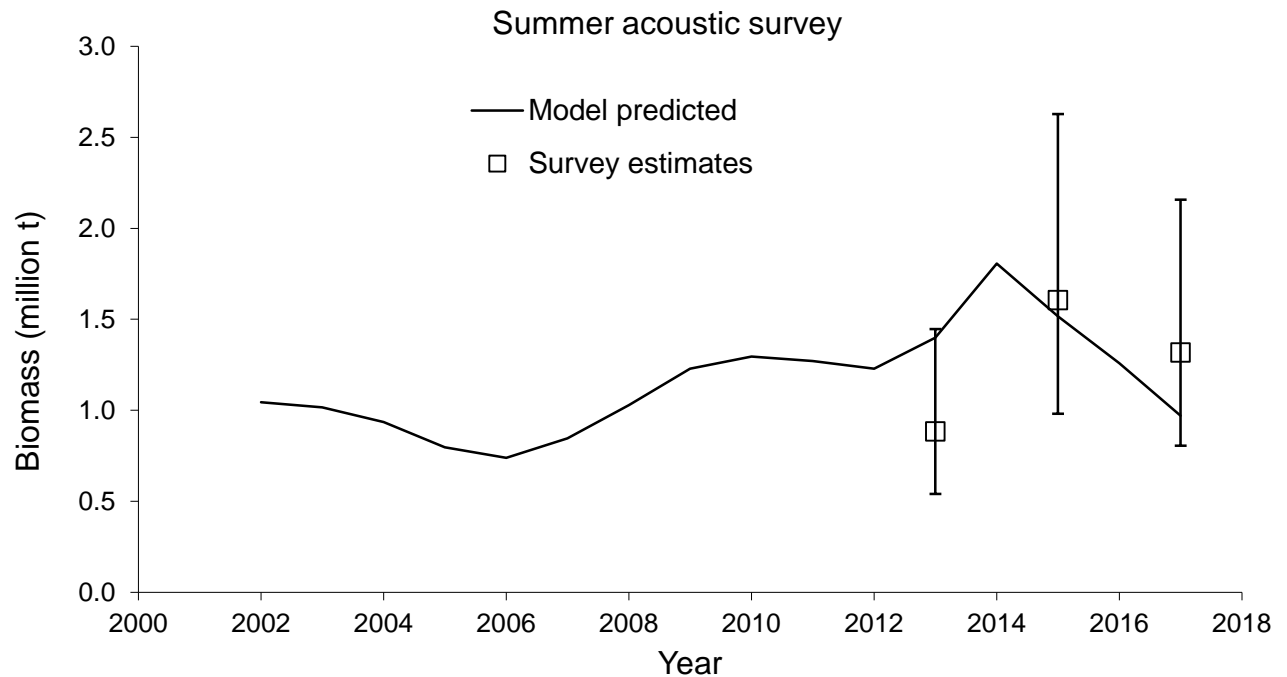
Pearson residual range: -2.1 , 2.9



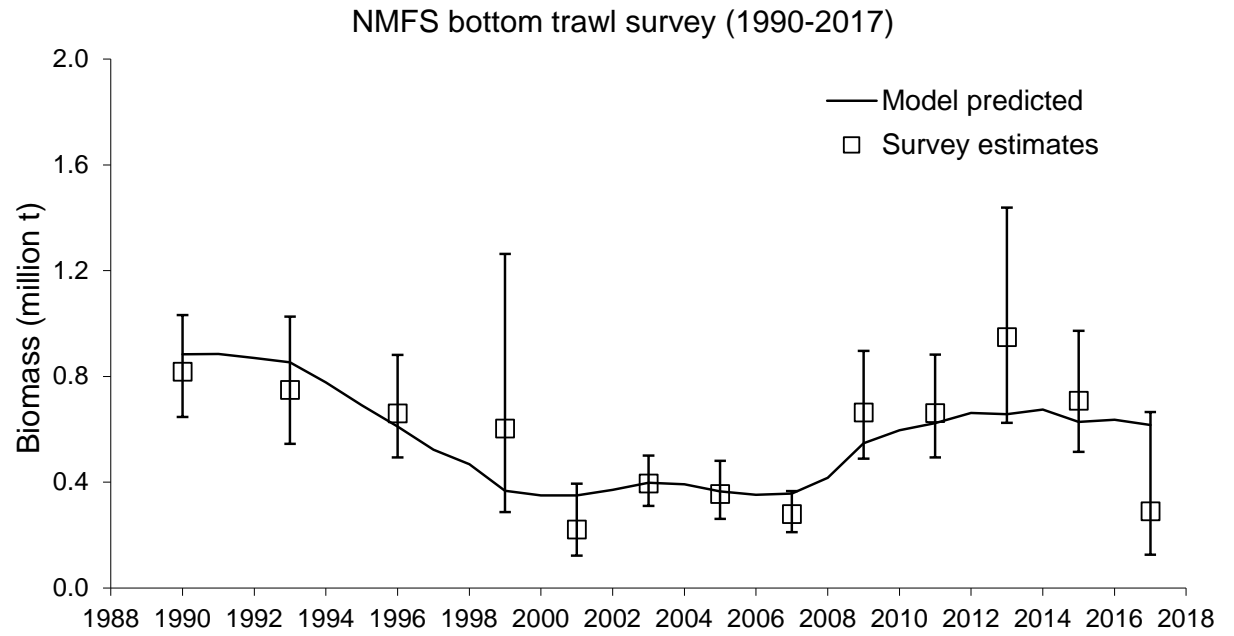
Fit to Shelikof Strait acoustic survey



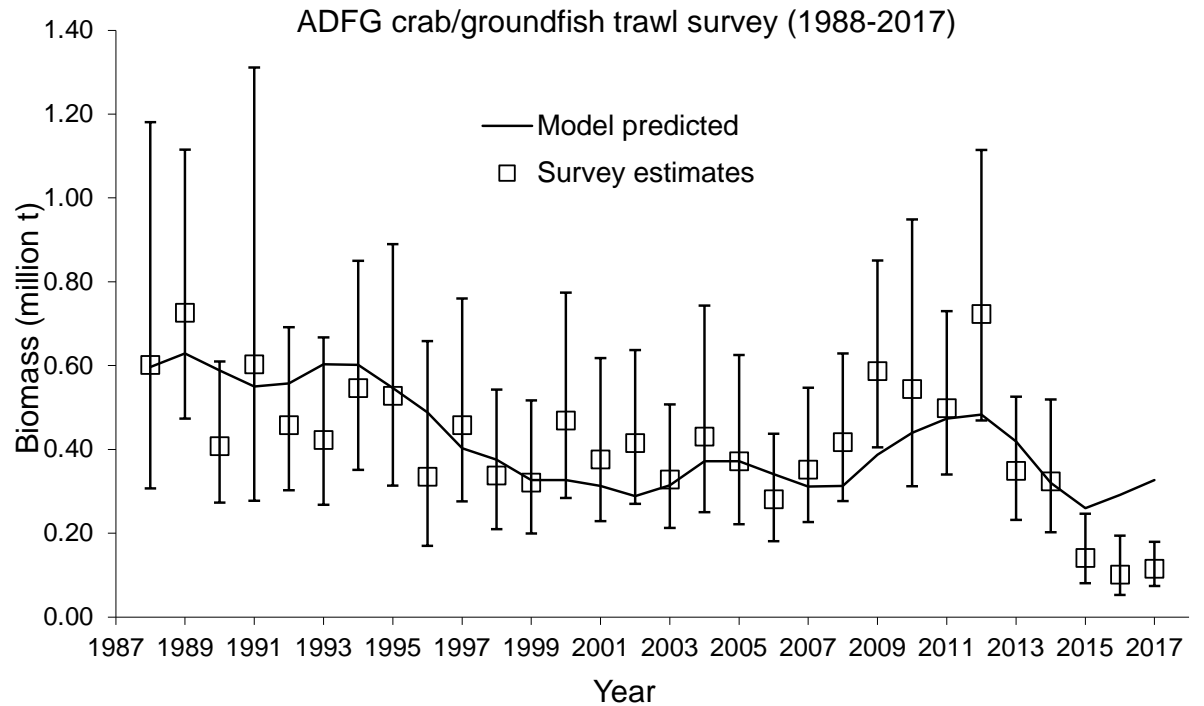
Fit to summer Acoustic survey



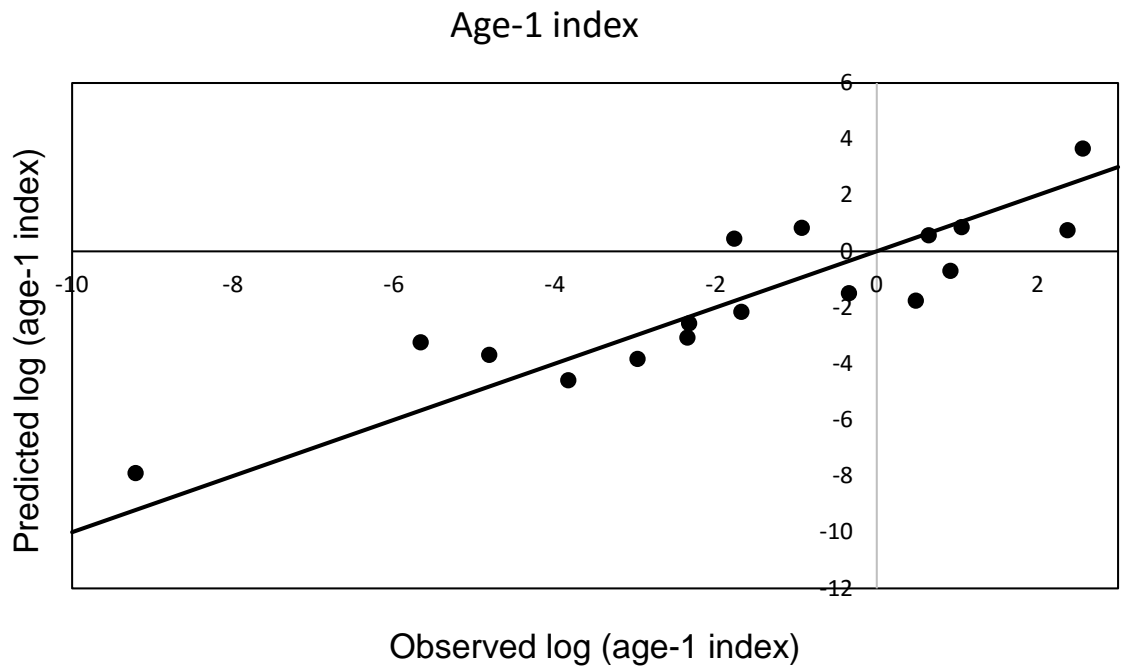
Fit to NMFS bottom trawl survey



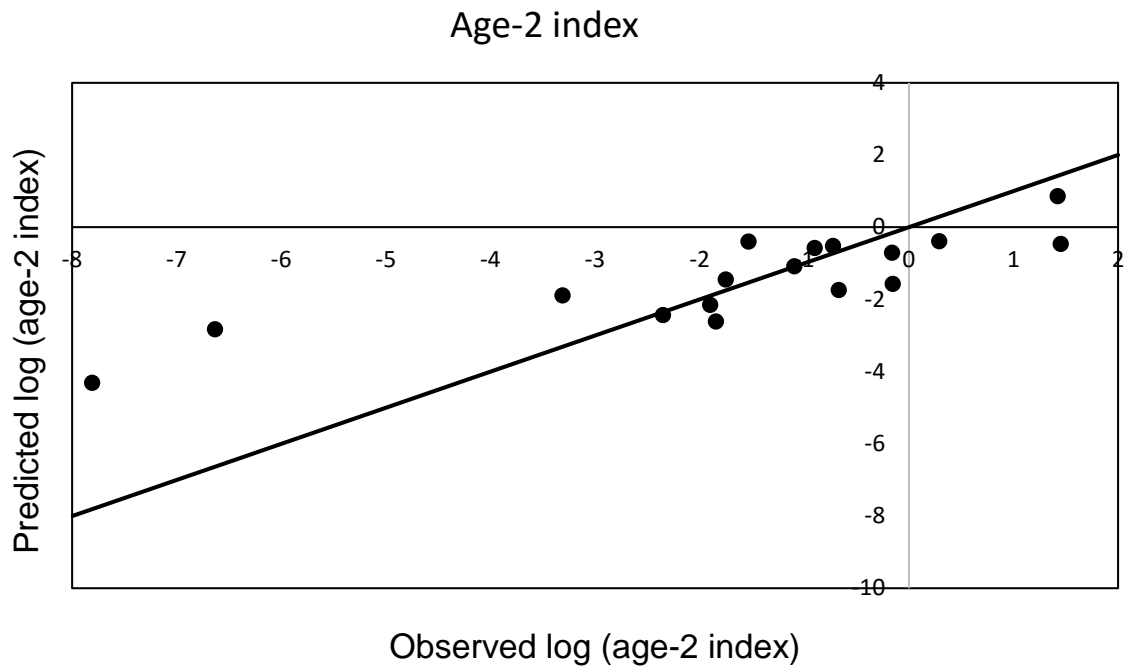
Fit to ADFG survey



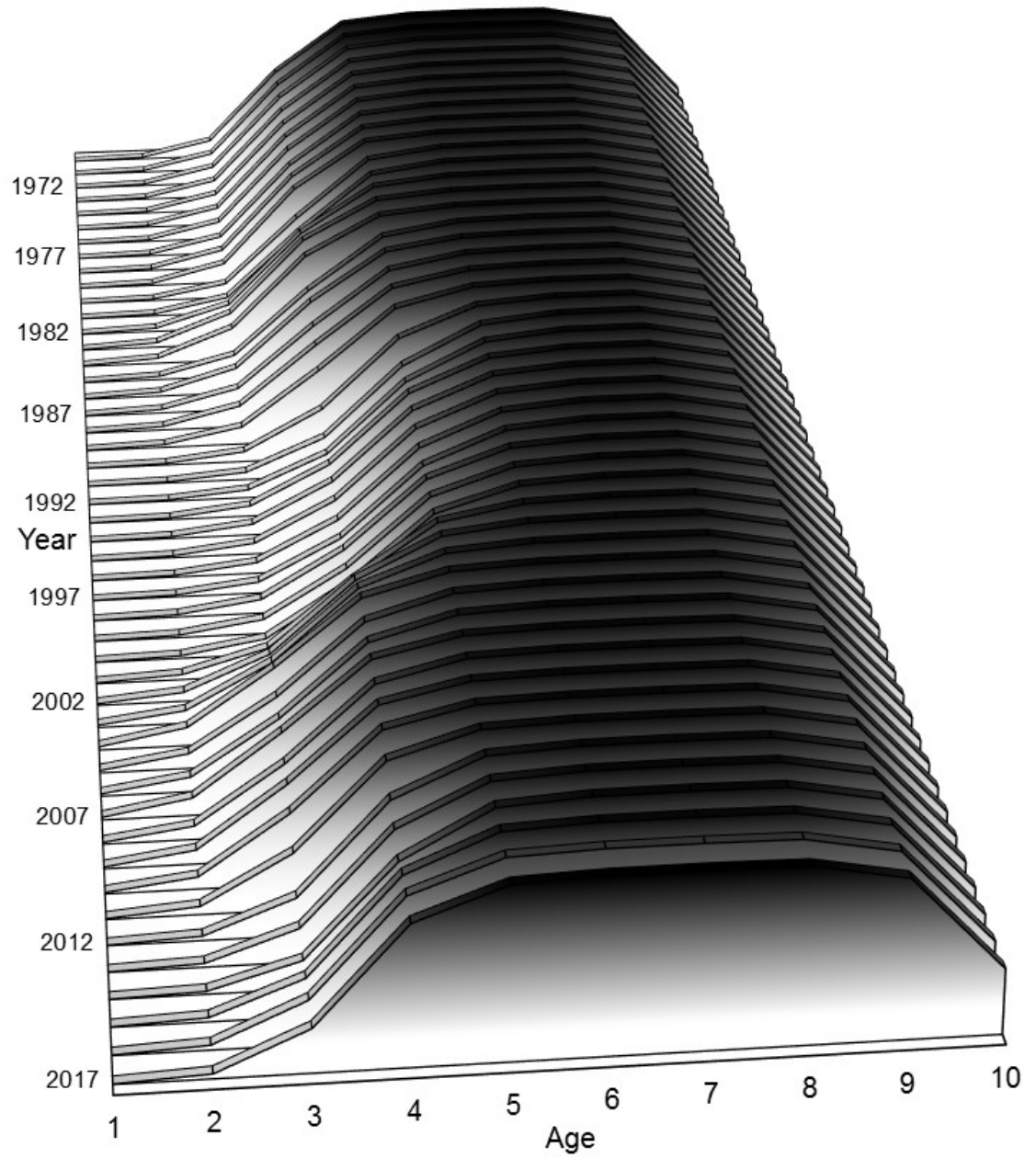
Fit to Age-1 index



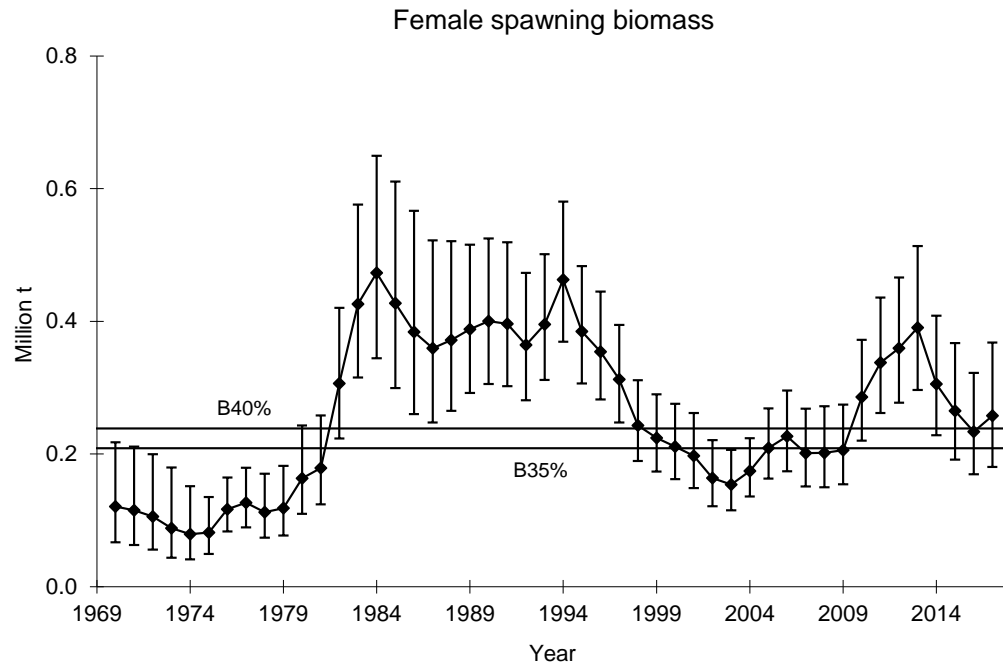
Fit to Age-2 index



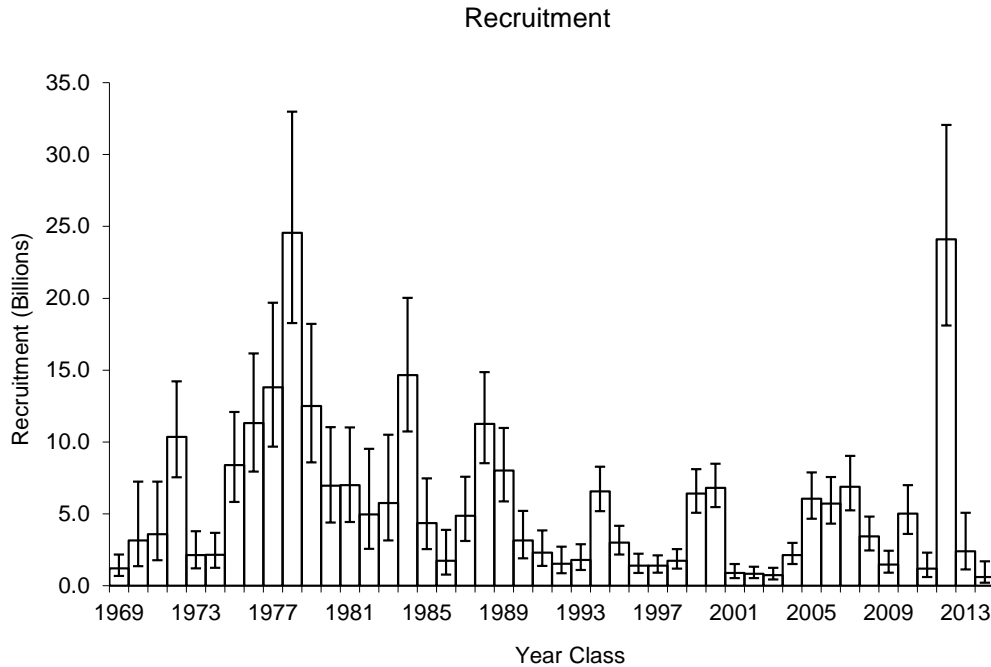
Fishery selectivity



Spawning biomass

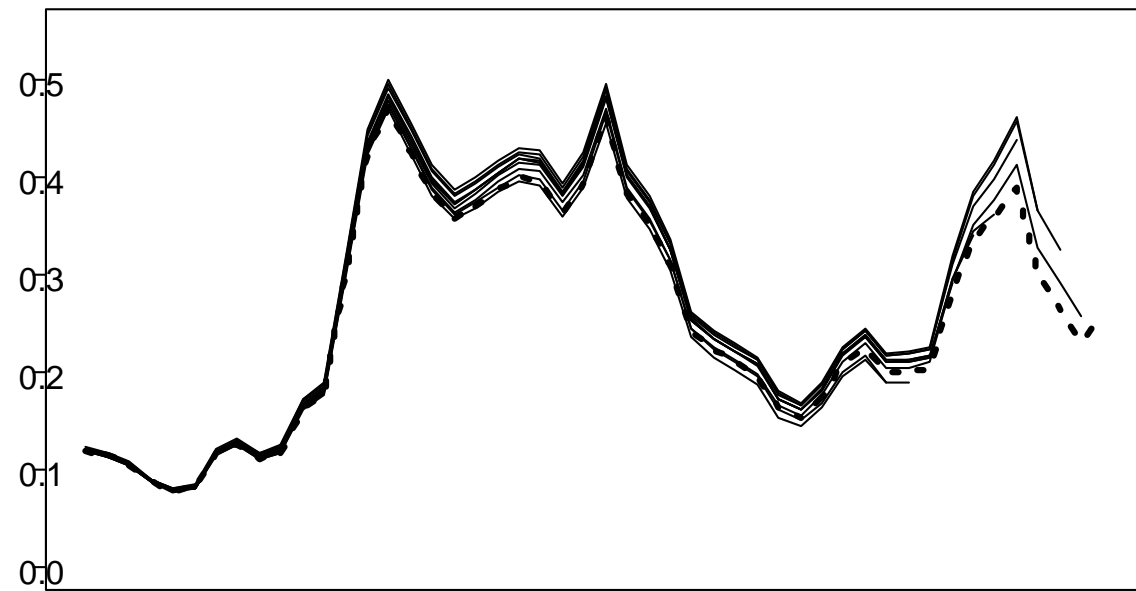


Recruitment

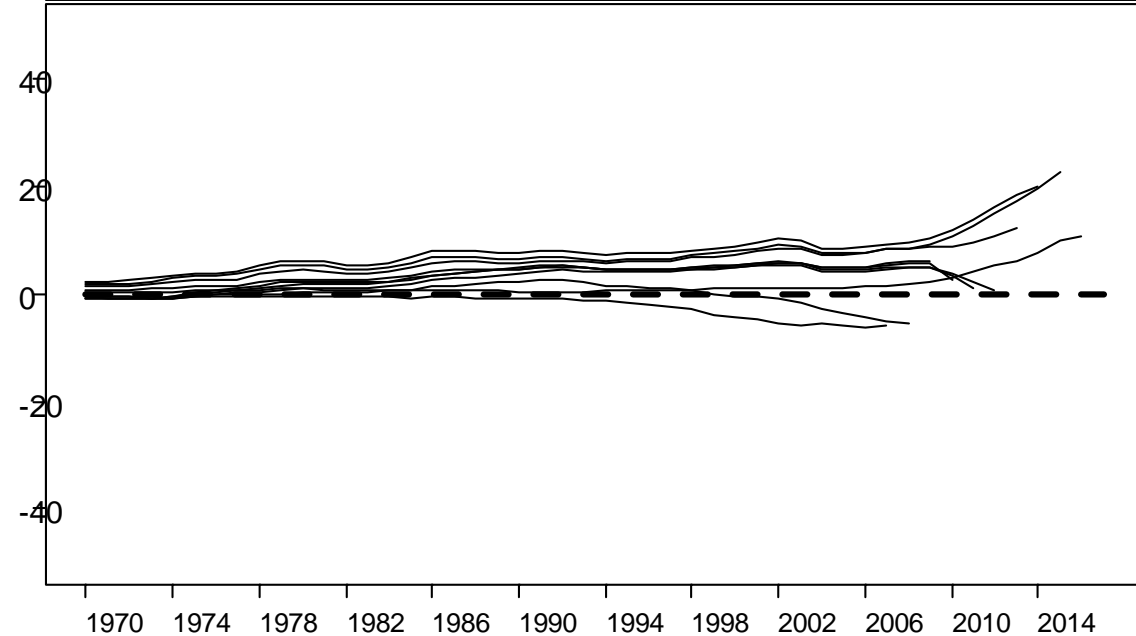


Retrospective plot

Spawning biomass (million)



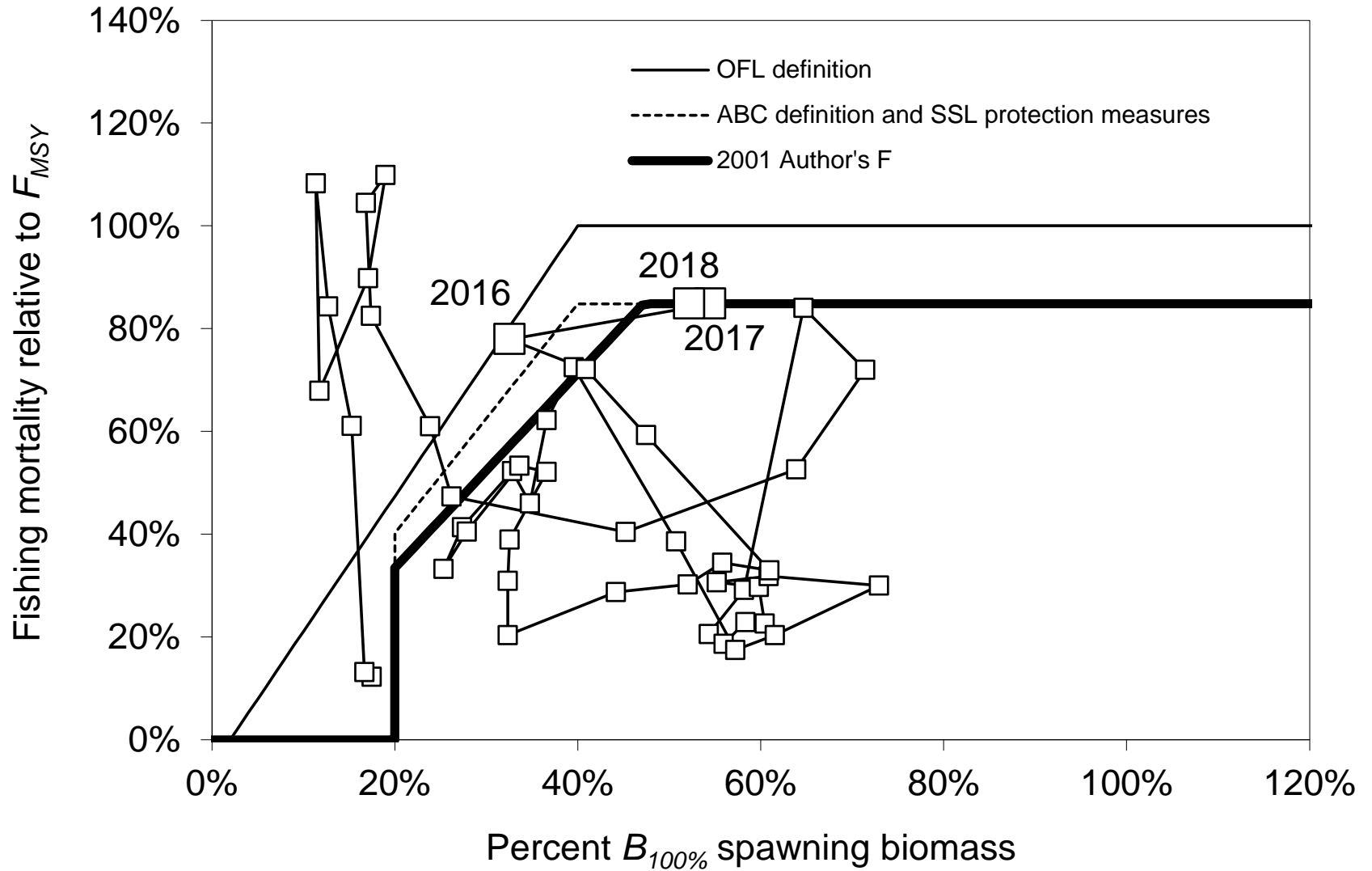
Percent differences from terminal year



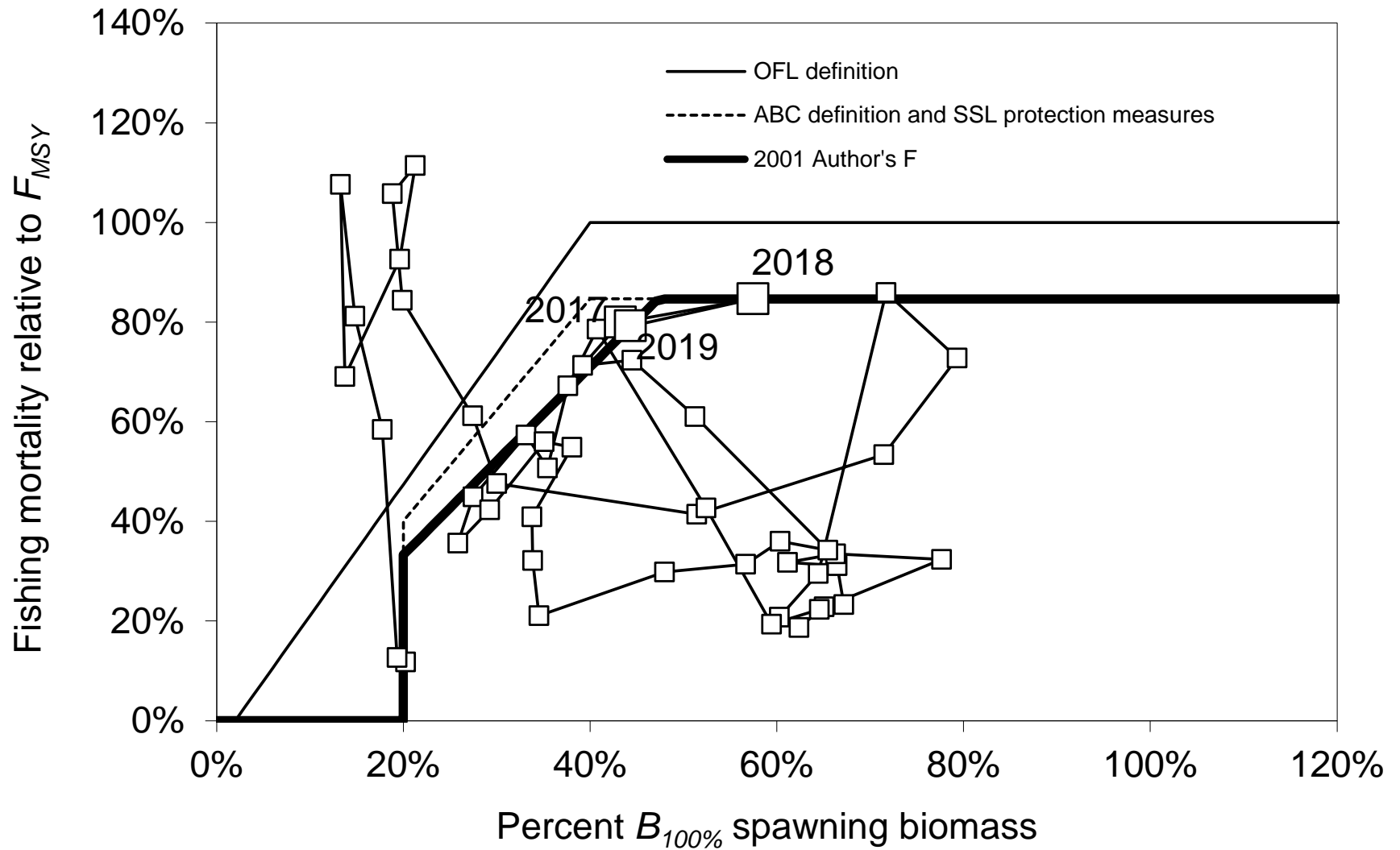
Mohn's $\rho = 0.066$

Year

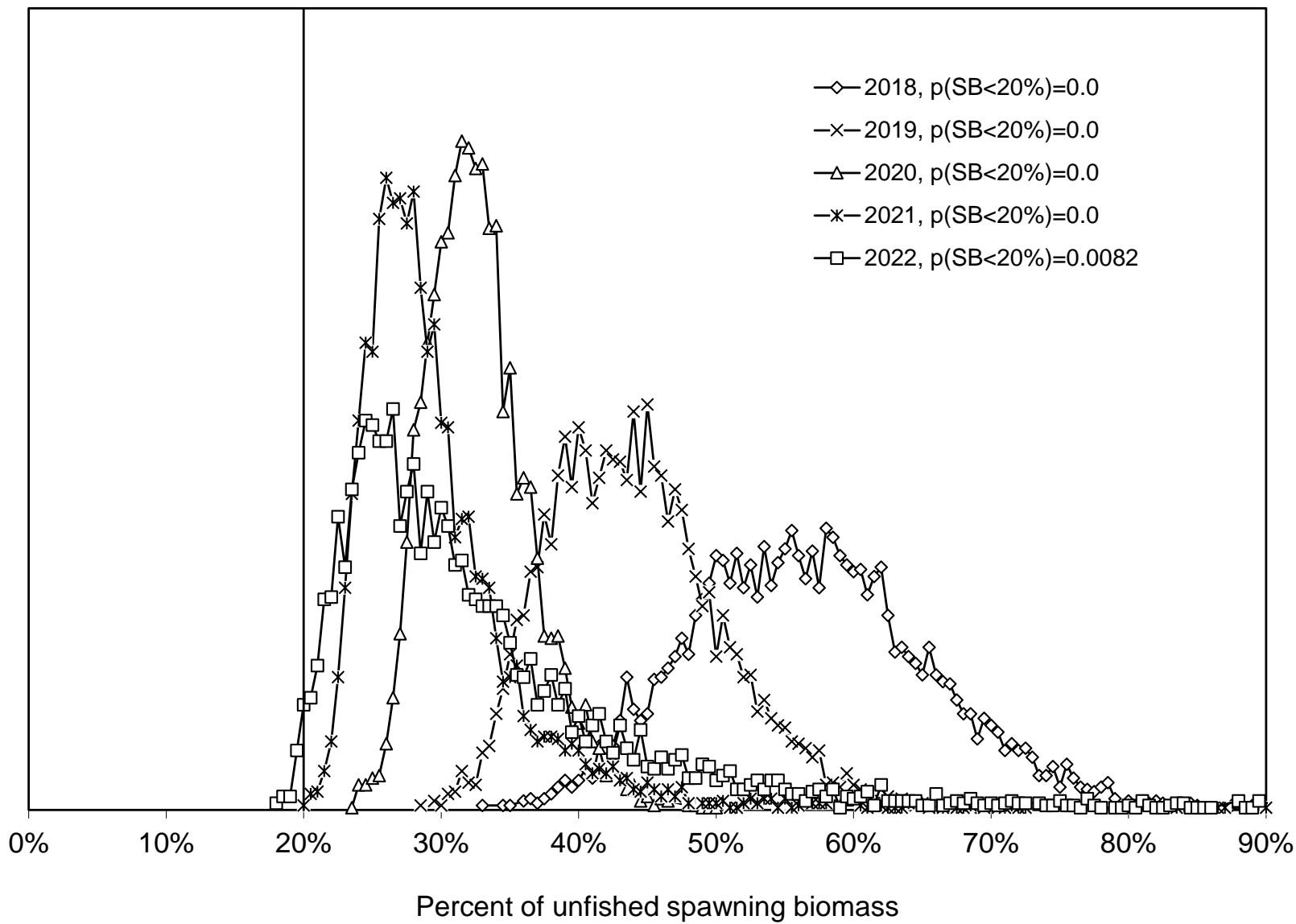
Spawning biomass vs fishing mortality (last year)



Spawning biomass vs fishing mortality (this year)

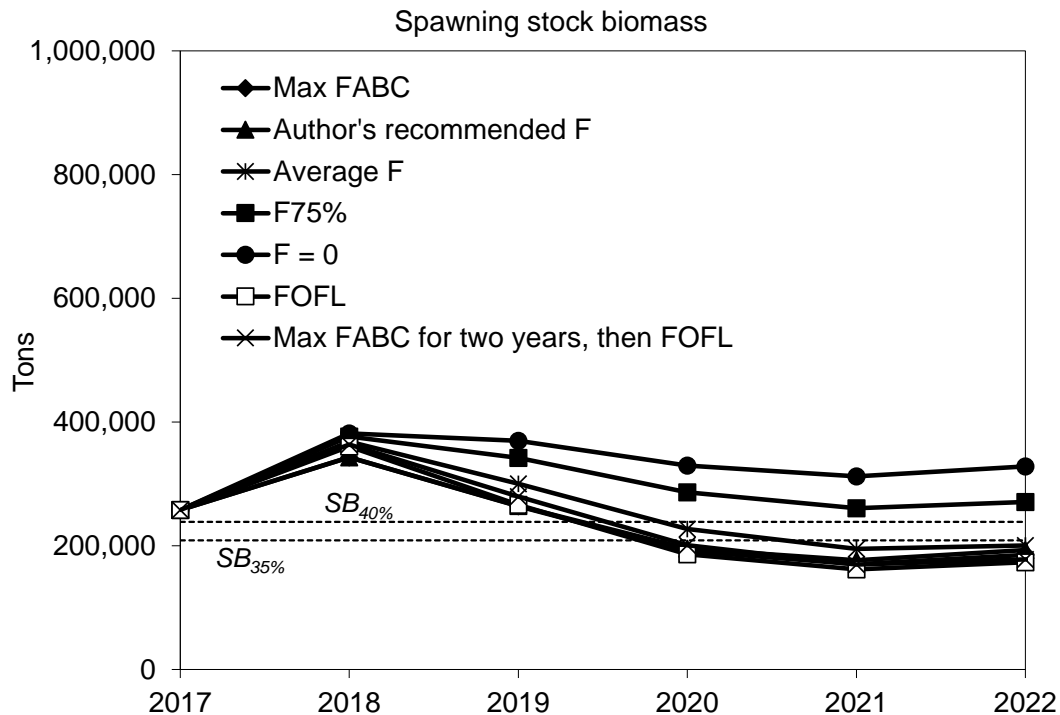


5-year pr(SB<B20%)

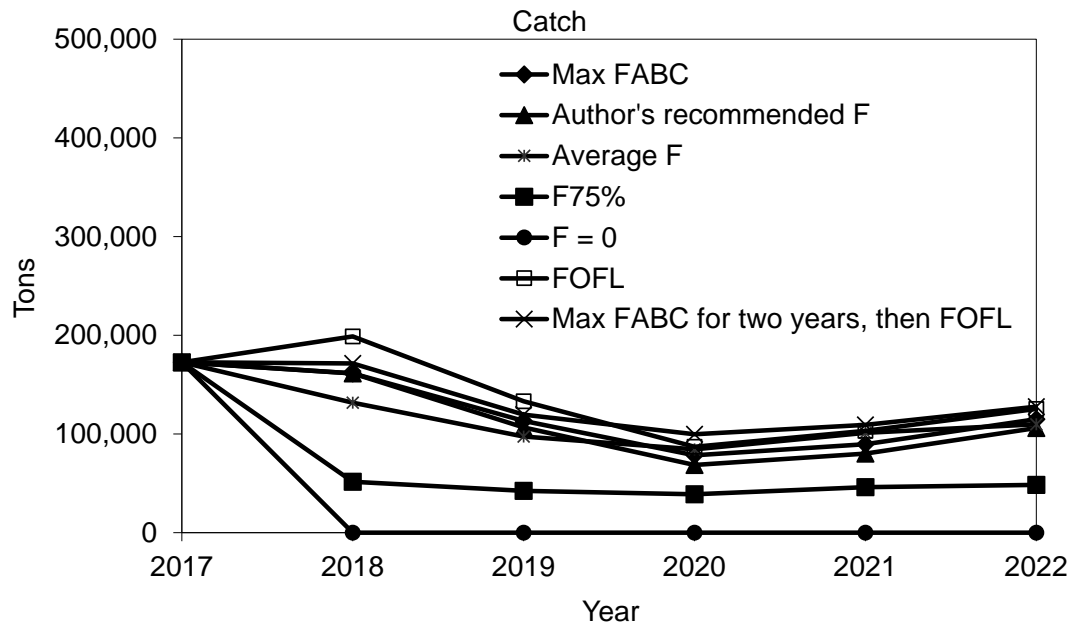


5-year projections

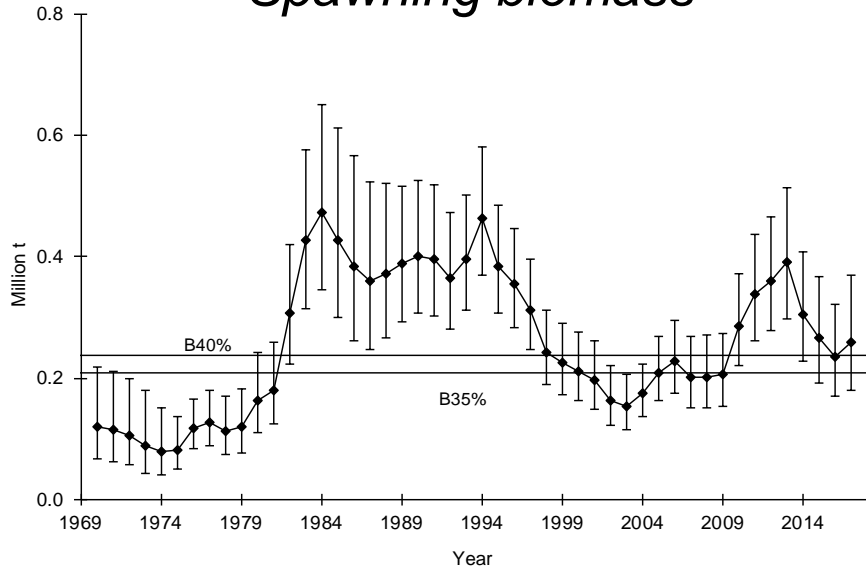
Mean spawning biomass



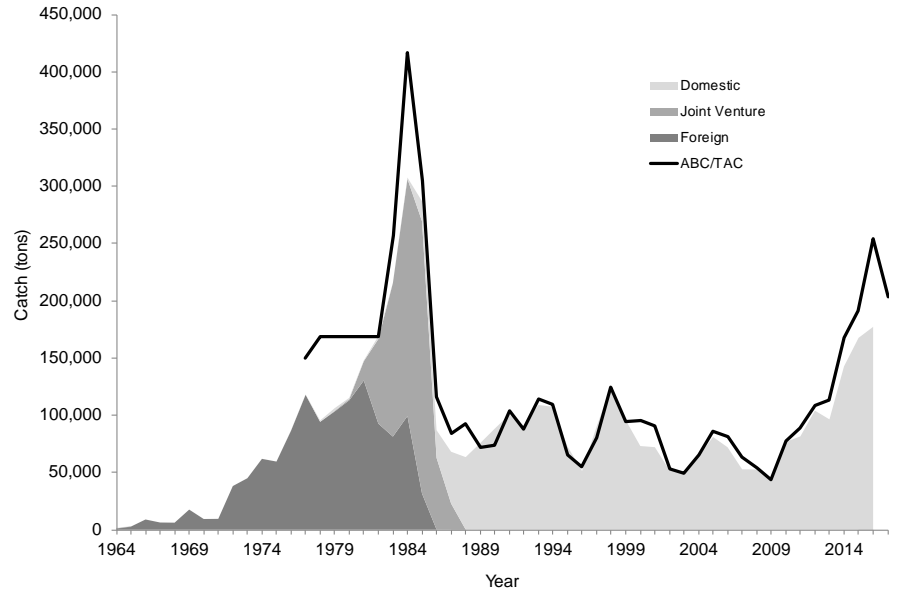
Mean yield



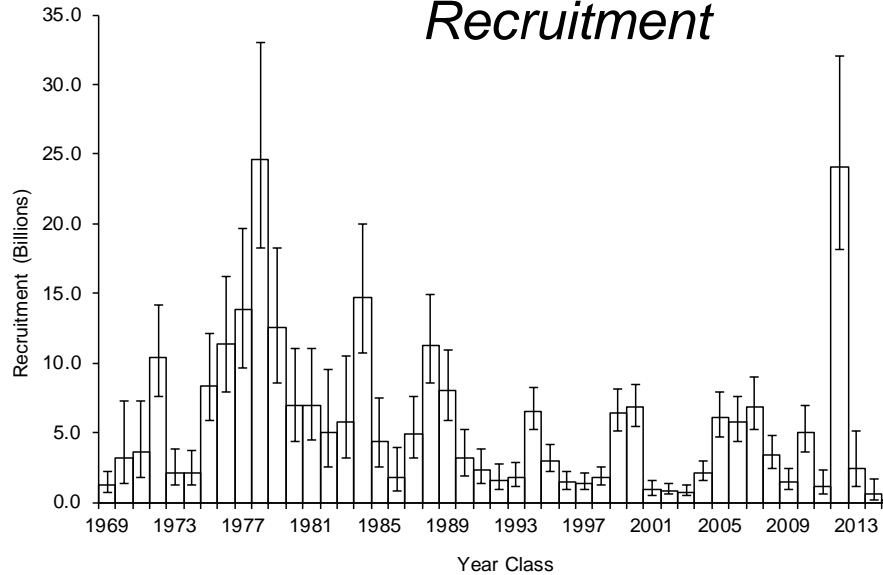
Spawning biomass



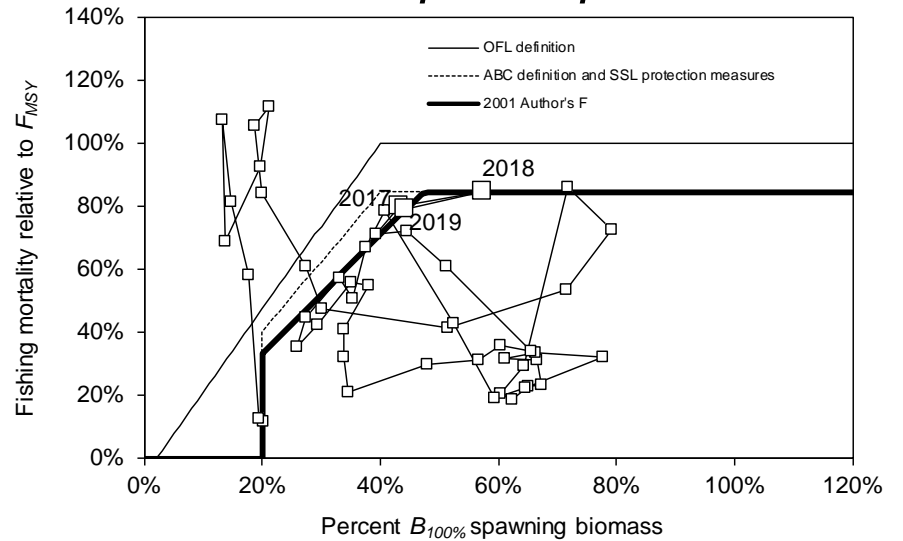
Catch



Recruitment



Status phase plot

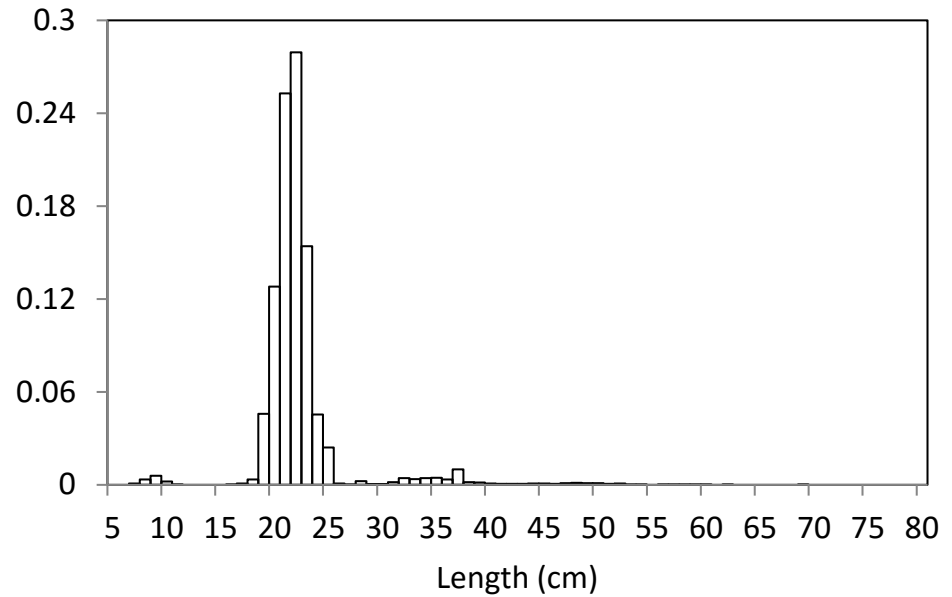


Summary table

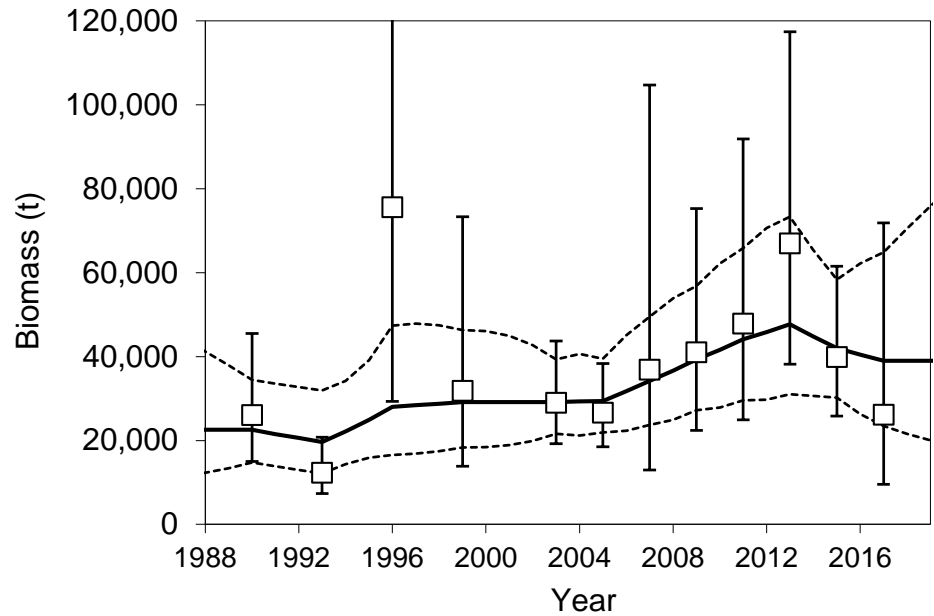
Quantity/Status	As estimated or specified <i>last year for</i>		As estimated or specified <i>this year for</i>	
	2017	2018	2018	2019
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	3a	3a	3a	3b
Projected total (age 3+) biomass (t)	1,391,290	991,030	1,124,930	804,586
Female spawning biomass (t)	363,800	348,330	342,683	264,349
$B_{100\%}$	667,000	667,000	596,000	596,000
$B_{40\%}$	267,000	267,000	238,000	238,000
$B_{35\%}$	234,000	234,000	209,000	209,000
F_{OFL}	0.30	0.30	0.30	0.30
$maxF_{ABC}$	0.25	0.25	0.26	0.26
F_{ABC}	0.25	0.25	0.26	0.24
OFL (t)	235,807	182,204	187,059	131,170
maxABC (t)	203,769	157,496	161,492	113,153
ABC (t)	203,769	157,496	161,492	106,568
Status	As determined <i>last</i> year for		As determined <i>this</i> year for	
	2015	2016	2016	2017
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Southeast Alaska Assessment

2017 length composition



Biomass trend



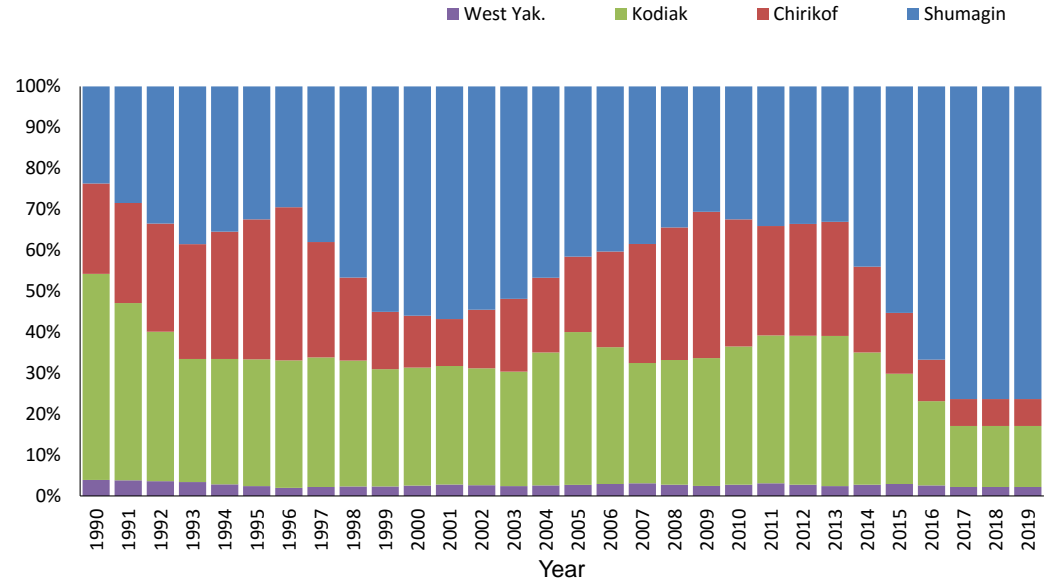
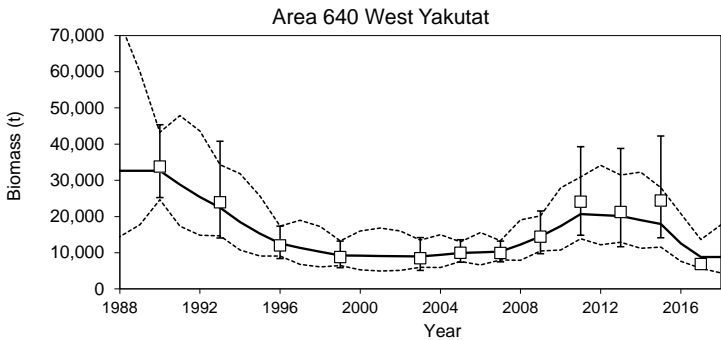
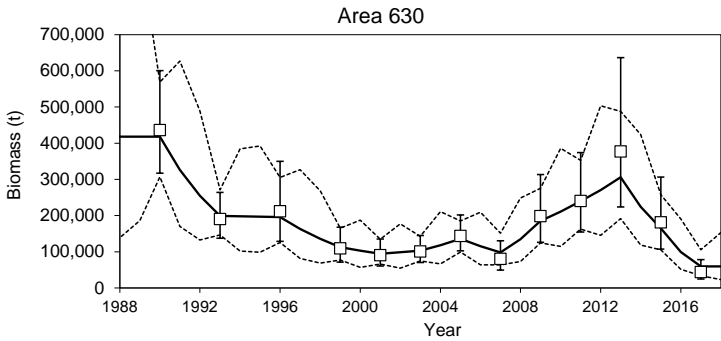
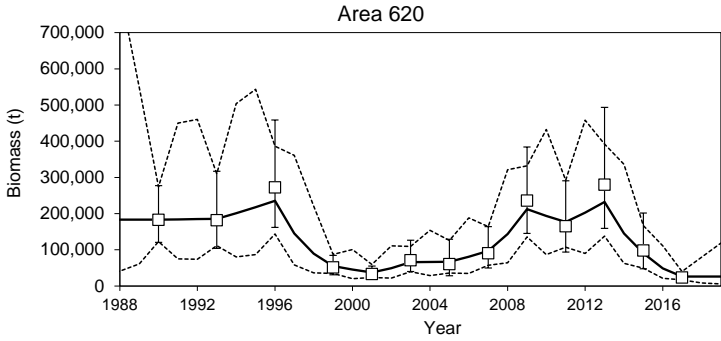
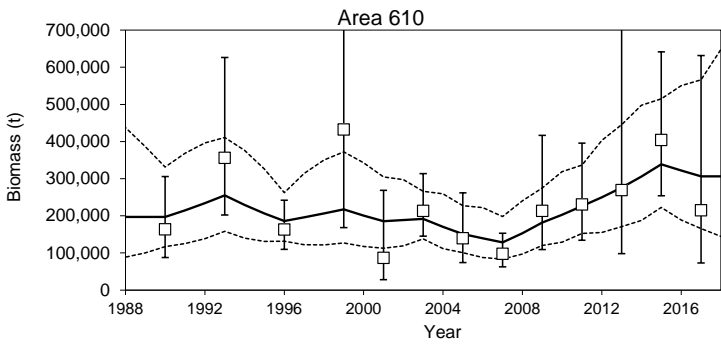
Winter apportionment table (example calculations for one area)

<i>Survey</i>	<i>Year</i>	<i>Model estimates</i>			<i>Percent by management area</i>		
		<i>oftotal 2+ biomass at spawning</i>	<i>Survey biomass estimate</i>	<i>Percent</i>	<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>
Shelikof	2014	1,146,870	883,177	77.0%	0.0%	96.7%	3.3%
Shelikof	2015	1,251,160	845,210	67.6%	0.0%	91.9%	8.1%
Shelikof	2016	1,079,920	665,059	61.6%	0.0%	79.3%	20.7%
Shelikof	2017	842,006	1,486,342	176.5%	0.0%	98.9%	1.1%
Shelikof	Average			95.7%	0.0%	91.7%	8.3%
	Percent of total 2+ biomass				0.0%	87.7%	7.9%

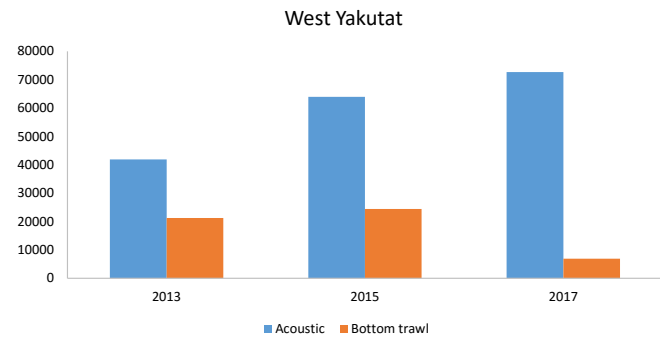
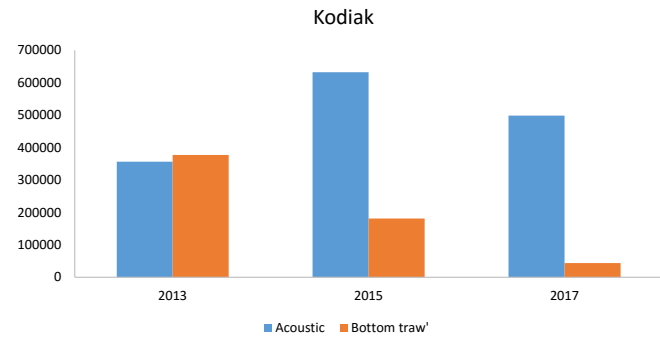
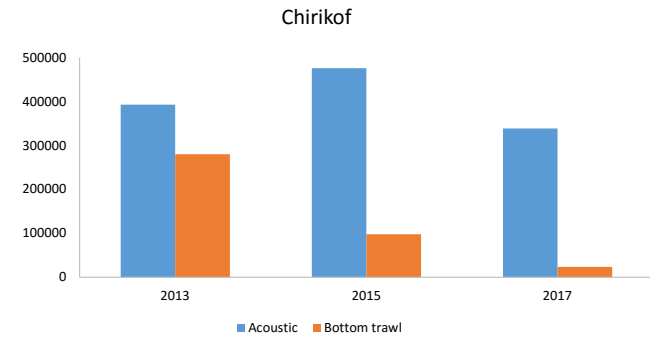
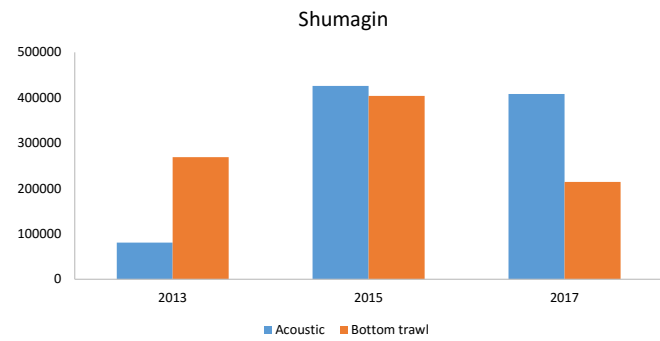
Winter apportionment table

<i>Survey</i>	<i>Year</i>	<i>Model estimates of total 2+ biomass at spawning</i>	<i>Survey biomass estimate</i>	<i>Percent by management area</i>			
				<i>Percent</i>	<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>
Shelikof	Average			95.7%	0.0%	91.7%	8.3%
	Percent of total 2+ biomass				0.0%	87.7%	7.9%
Chirikof	Average			2.2%	0.0%	27.8%	72.2%
	Percent of total 2+ biomass				0.0%	0.6%	1.6%
Marmot	Average			2.0%	0.0%	0.0%	100.0%
	Percent of total 2+ biomass				0.0%	0.0%	2.0%
Shumagin	Average			3.4%	76.3%	23.7%	0.0%
	Percent of total 2+ biomass				2.6%	0.8%	0.0%
Sanak	Average			0.6%	100.0%	0.0%	0.0%
	Percent of total 2+ biomass				0.6%	0.0%	0.0%
Mozhovoi	Average			0.5%	100.0%	0.0%	0.0%
	Percent of total 2+ biomass				0.5%	0.0%	0.0%
Total				104.40%	3.65%	89.15%	11.60%
Rescaled total				100.00%	3.50%	85.39%	11.11%

Summer Area Allocation: RE model output



Summer Area Allocation: Acoustic and bottom trawl comparison



Summer Area Allocation: Options

Options for allocation

Option 1: RE from Bottom Trawl

<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>	<i>Area 640</i>
76.34%	6.57%	14.89%	2.20%

Option 2: Weighted average from acoustic survey (2013-2017)

<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>	<i>Area 640</i>
26.64%	29.64%	38.75%	4.98%

Option 3: Average of RE Bottom trawl and 2017 Acoustic survey (2015 approach)

<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>	<i>Area 640</i>
53.65%	16.14%	26.35%	3.85%

Option 4: Average of RE Bottom trawl and weighted average of 2013-2015 acoustic

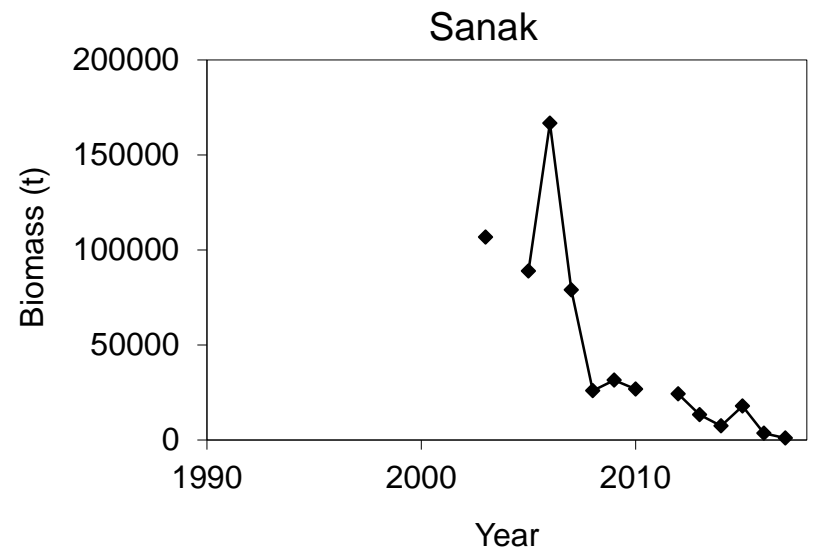
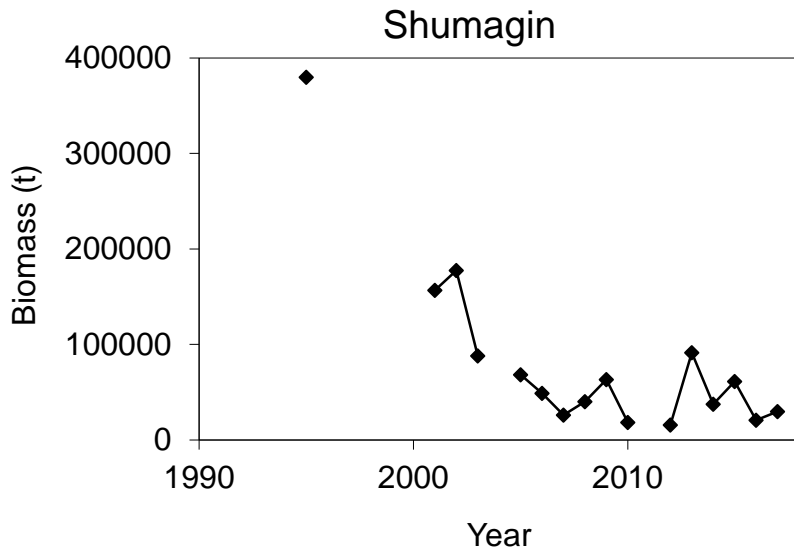
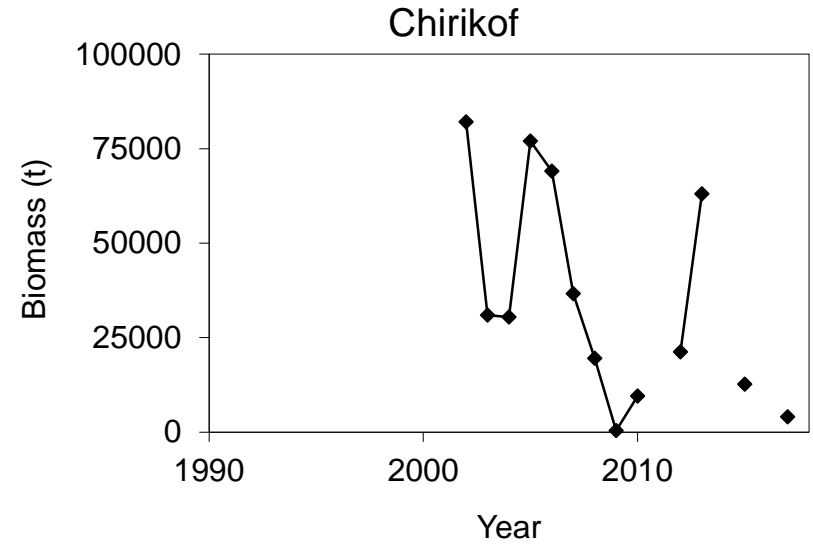
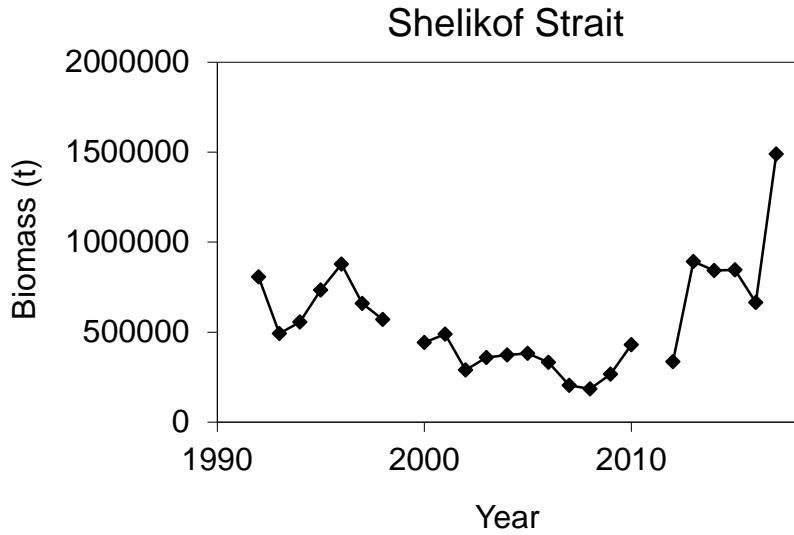
<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>	<i>Area 640</i>
51.49%	18.10%	26.82%	3.59%

Option 5: Weighted average of acoustic plus bottom trawl biomass (2013-2017)

<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>	<i>Area 640</i>
643,068	467,377	647,185	79,732
35.00%	25.44%	35.22%	4.34%

Extras

Acoustic surveys outside Shelikof Strait

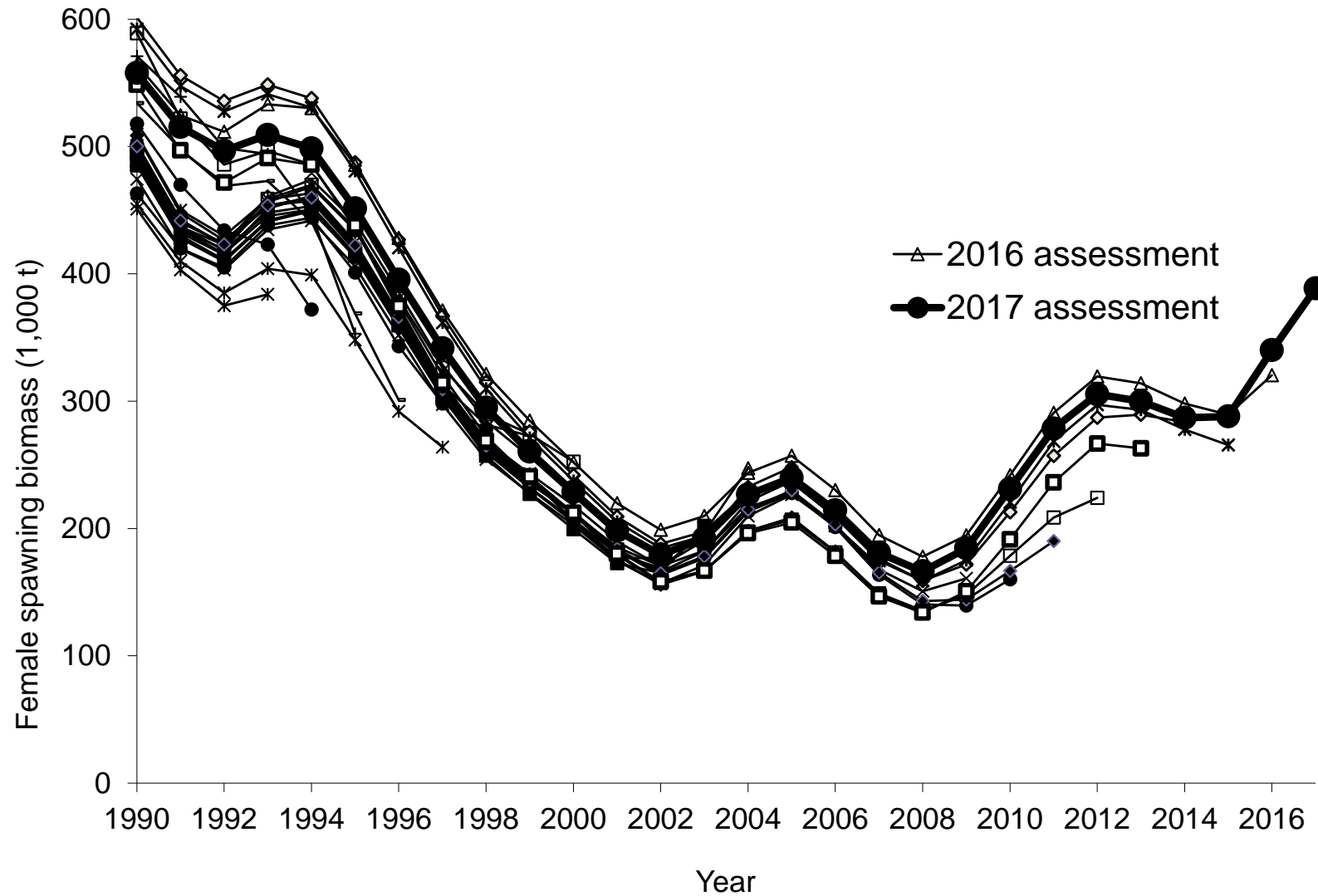


Total for all winter acoustic surveys = 1,761,603 t (84.6% in Shelikof Strait)

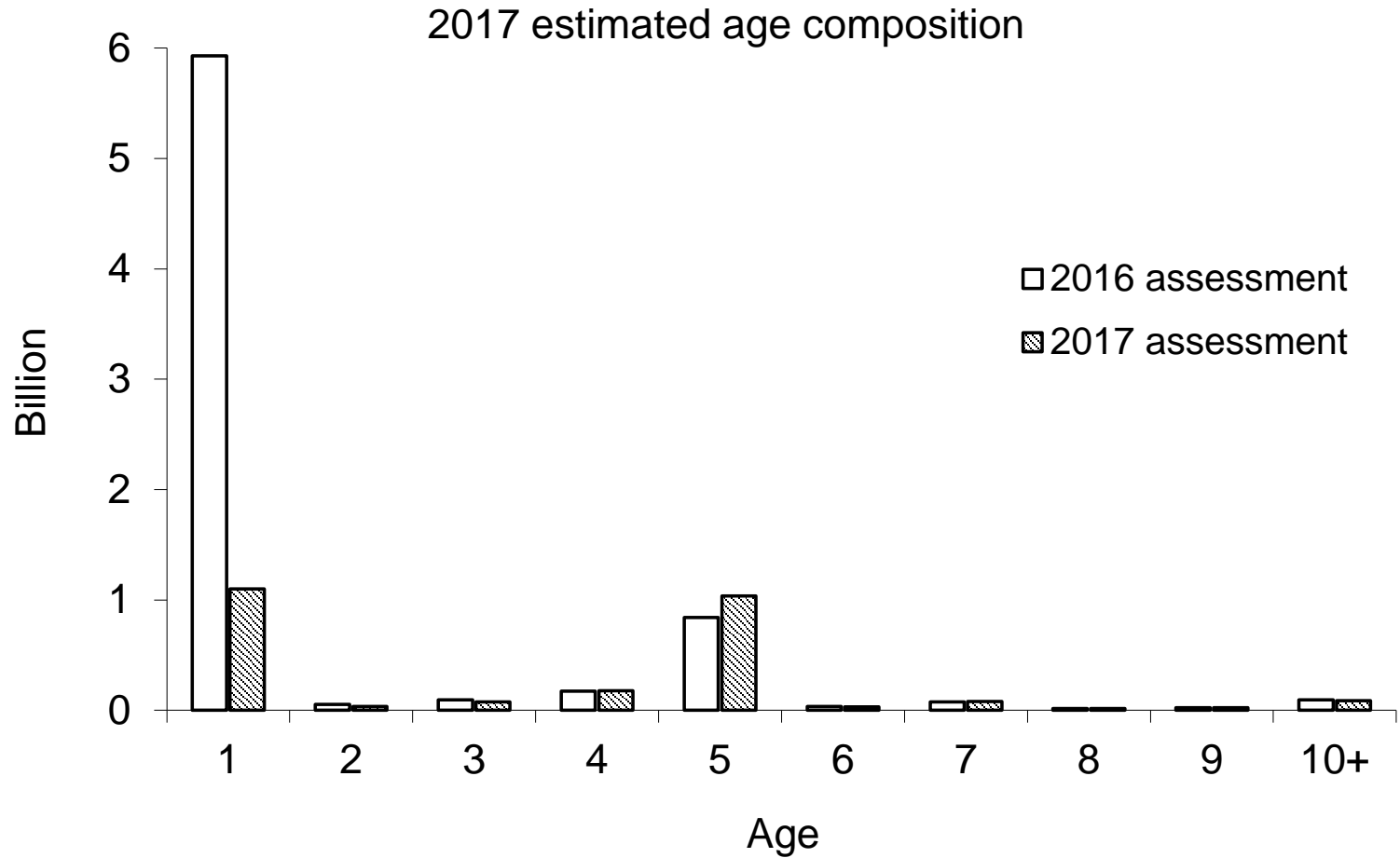
Southeast Pollock Summary Table

Quantity	As estimated or <i>specified last year for:</i>		As estimated or <i>recommended this year for:</i>	
	2017	2018	2018	2019
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	5	5	5	5
Biomass (t)				
Upper 95% confidence interval	76,781	83,089	76,781	83,089
Point estimate	44,087	44,087	38,989	38,989
Lower 95% confidence interval	25,315	23,393	25,315	23,393
F_{OFL}	0.30	0.30	0.30	0.30
$maxF_{ABC}$	0.23	0.23	0.23	0.23
F_{ABC}	0.23	0.23	0.23	0.23
OFL (t)	13,226	13,226	11,697	11,697
maxABC (t)	9,920	9,920	8,773	8,773
ABC (t)	9,920	9,920	8,773	8,773
Status	As determined <i>last year for:</i>		As determined <i>this year for:</i>	
	2015	2016	2016	2017
Overfishing	No	n/a	No	n/a

Retrospective patterns



Changes in estimated age composition



Natural mortality estimates

Age	Length (cm)	Weight (g)	<i>Brodziak et al.</i> 2010	<i>Lorenzen</i> 1996	<i>Gislason et al.</i> 2010	<i>Hollowed et al.</i> 2000	<i>Van Kirk et al.</i> 2010	<i>Van Kirk et al.</i> 2012	Average	Rescaled Avg.
1	15.3	26.5	0.97	1.36	2.62	0.86	2.31	2.00	1.69	1.39
2	27.4	166.7	0.54	0.78	1.02	0.76	1.01	0.95	0.84	0.69
3	36.8	406.4	0.40	0.59	0.64	0.58	0.58	0.73	0.59	0.48
4	44.9	752.4	0.33	0.49	0.46	0.49	0.37	0.57	0.45	0.37
5	49.2	966.0	0.30	0.45	0.40	0.41	0.36	0.53	0.41	0.34
6	52.5	1154.2	0.30	0.43	0.36	0.38	0.28	0.47	0.37	0.30
7	55.1	1273.5	0.30	0.42	0.33	0.38	0.30	0.46	0.36	0.30
8	57.4	1421.7	0.30	0.40	0.31	0.38	0.29	0.43	0.35	0.29
9	60.3	1624.8	0.30	0.39	0.29	0.39	0.29	0.42	0.35	0.28
10	61.1	1599.6	0.30	0.39	0.28	0.39	0.33	0.40	0.35	0.29

Clay Porch's rescaling equation:

$$M(t) = M_{target} \frac{nL(t)}{\sum_{t_c}^{t_{max}} L(t)}$$

Tuning details—Initial and ending input N

Fishery age composition:

Initial N: Use the number of tows/deliveries for the age composition sample if number of tows < 200, otherwise use 200

Ending N harmonic mean: 93.0.3

Ending N Francis = 71.8

Bottom trawl survey

Initial N = 60

Ending N harmonic mean = 23.6

Ending N Francis = 14.5

Acoustic survey

Initial N = 60

Ending N harmonic mean = 9.7

Ending N Francis = 9.3

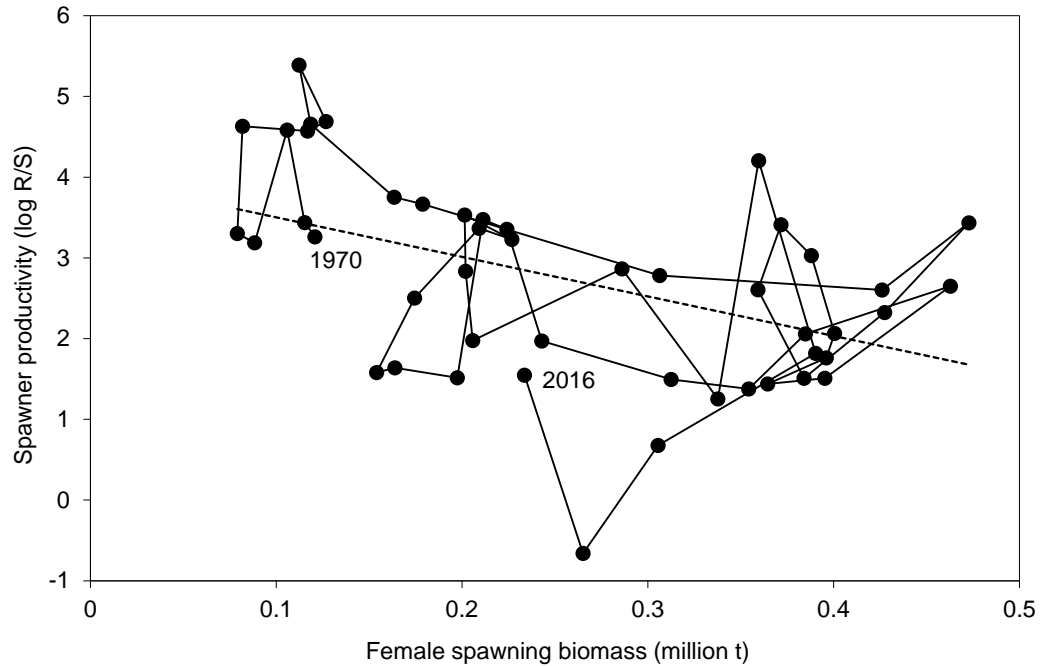
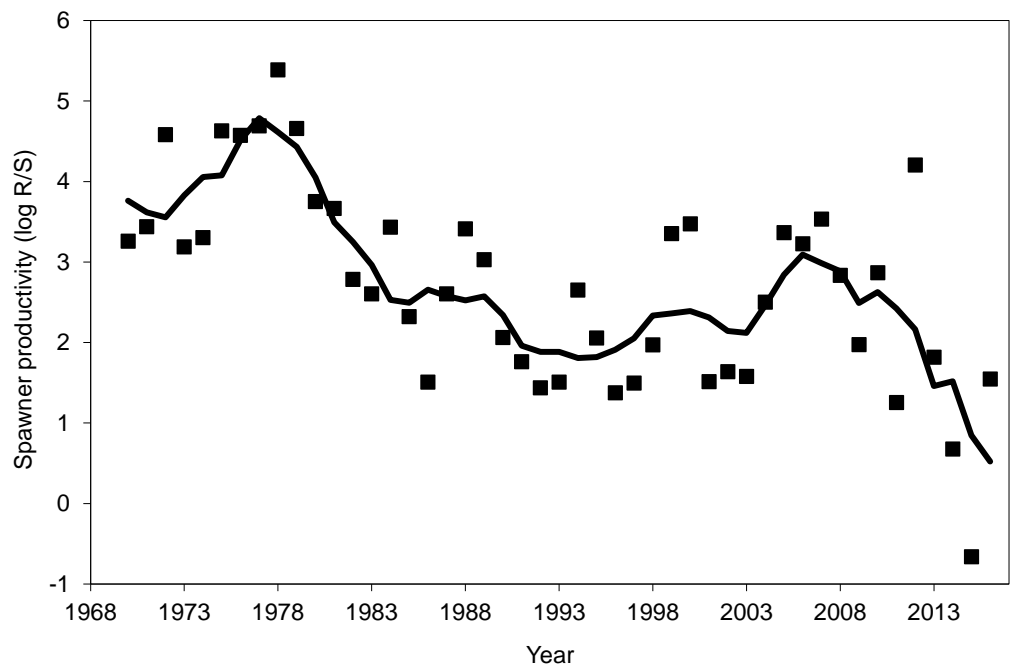
ADFG survey

Initial N = 30

Ending N harmonic mean = 21.6

Francis = 23.0

Spawner productivity



Annual SPR rate

Annual SPR rate

