Gulf of Alaska pollock

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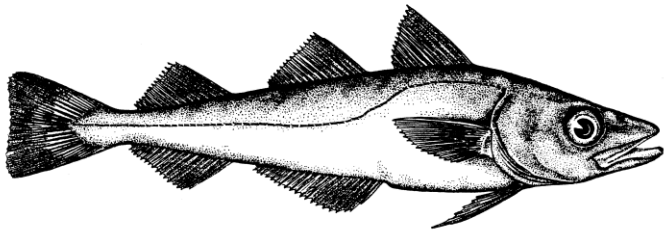
NOAA FISHERIES

Alaska Fisheries Science Center

Plan Team meeting

Nov 14, 2018

AFSC Seattle



Gulf of Alaska pollock
Overview of assessment results

Changes to the assessment model

- Assessment is an update except…
- Net-selectivity corrected acoustic estimates

Author's 2019 ABC 134,740 t

- Decrease of 17% from the 2018 ABC
- 2020 ABC drops by 22% to 105,290 t

•**Concerns:**

- Poor model fit
- Population dominated by single year class
- Lack of recruitment
- Unfavorable environmental conditions

•**Positives**:

- No retrospective pattern
- Evidence of moderately large 2017 year class
- Full suite of surveys will occur next year

Plan Team and SSC comments

Responses to SSC and Plan Team Comments in General

The SSC in its October 2018 minutes recommended that assessment authors and plan teams use the risk matrix table developed last summer by a plan team working group when determining whether to recommend an ABC lower than the maximum permissible.

- In this assessment, we have used the risk matrix table to evaluate stock assessment, population dynamics and ecosystem concerns relevant to Gulf of Alaska pollock. Substantially increased concerns were identified, leading to a recommendation to reduce the ABC from the maximum permissible.

Responses to SSC and Plan Team Comments Specific to this Assessment

The GOA plan team in its November 2017 minutes recommended that trawl survey catchability relative to age structure be examined. That is, evaluate the extent that pollock of different ages vary in availability to bottom gear.

- Acoustic data are routinely collected during the NMFS bottom trawl survey, but these data have never been processed. We are exploring options for processing these data, which could potentially be used to evaluate pollock catchability. This project would need to obtain outside funding since the GOA/AI survey group currently does not have the resources to analyze these data.

Plan Team and SSC comments (continued)

Responses to SSC and Plan Team Comments Specific to this Assessment

The GOA plan team in its November 2017 minutes recommended that when using the Francis weighting approach that age/length composition data sets with small numbers of years be paired with other similar data sources with increased number of years in order to estimate data weights.

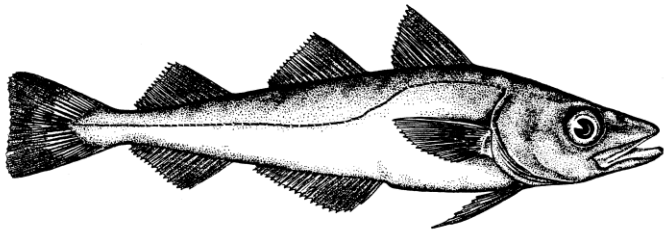
- Since we were able reasonable results were obtained using the Francis approach for all age composition data sets, this did not seem to be a problem with pollock assessment. The ADFG survey has the fewest years of age composition data (9 years), but the Francis tuning procedure seemed to work appropriately.

The GOA plan team in its November 2017 minutes recommended that pollock vertical distribution in the water column be evaluated.

- We plan to work with acoustic survey group to produce statistics on pollock vertical distribution during the summer acoustic survey. Such an index could potentially be used to inform catchability for bottom trawl surveys conducted during the summer.

The GOA plan team recommended in its November 2017 minutes that assessment authors to continue examining environmental covariates in the delta-GLMM survey abundance estimate.

- The delta-GLM model for the ADFG survey was included again included in the assessment. We were unable to explore environmental covariates in the model. The model fit to this index was much improved in the current assessment, which may make this less of an issue.

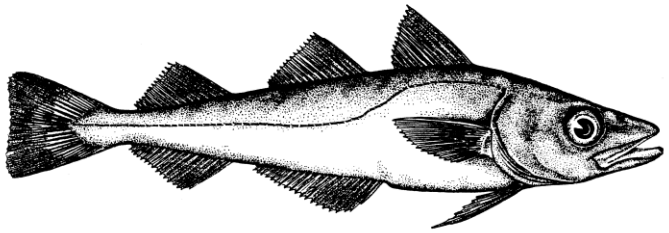


Gulf of Alaska pollock
Economic Performance

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 2014-2017.

	Avg 05-07	Avg 08-10	Avg 11-13	2014	2015	2016	2017
Total Catch K mt	68.6	57.8	94.0	142.6	167.6	177.1	186.2
Retained Catch K mt	66.3	53.9	91.6	141.1	163.0	176.0	184.3
Ex-vessel Value M $	$ 19.6	$ 21.4	$ 34.3	$ 37.8	$ 43.8	$ 32.5	$ 35.6
Ex-vessel Price/lb $	$ 0.134	$ 0.180	$ 0.170	$ 0.122	$ 0.119	$ 0.084	$ 0.088
Central Gulf Share of Value	61%	62%	75%	88%	80%	63%	72%
Vessels #	67.0	63.0	70.0	72.0	65.0	70.0	67.0

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 2014-2017.

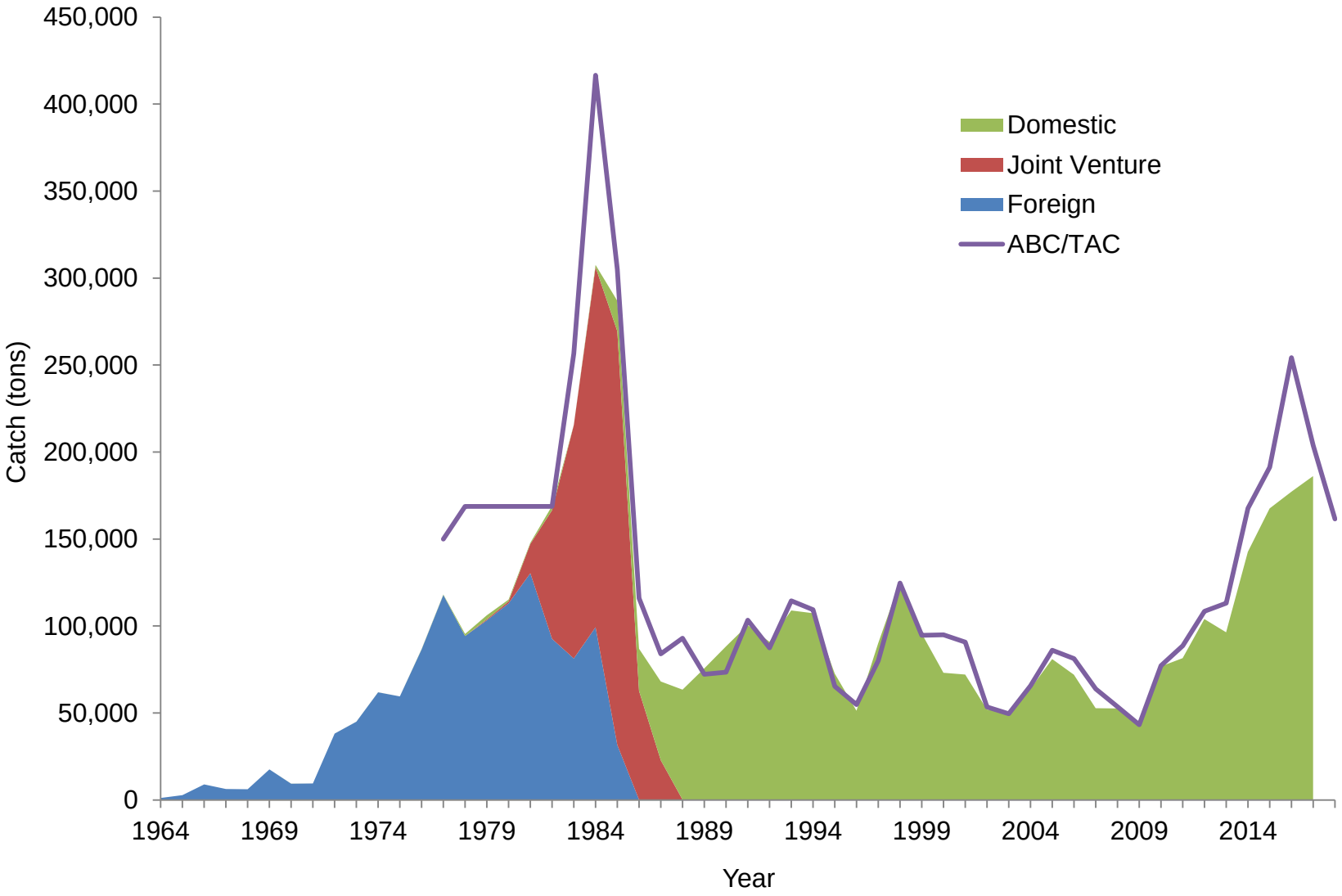
		Avg 05-07	Avg 08-10	Avg 11-13	2014	2015	2016	2017
All Products	Volume K mt	23.5	17.6	36.1	54.7	59.8	75.1	78.1
All Products	Value M $	$ 53.4	$ 48.9	$ 84.5	$ 105.8	$ 105.4	$ 105.3	$ 92.7
All Products	Price lb $	$ 1.03	$ 1.26	$ 1.06	$ 0.88	$ 0.80	$ 0.64	$ 0.54
Head & Gut	Volume K mt	6.9	7.8	18.4	29.7	30.3	27.8	37.4
Head & Gut	Price lb $	$ 0.63	$ 0.75	$ 0.68	$ 0.62	$ 0.61	$ 0.43	$ 0.40
Head & Gut	Value share	18%	26%	33%	38%	39%	25%	36%
Fillets	Volume K mt	4.6	3.2	5.8	8.2	9.1	14.3	15.7
Fillets	Price lb $	$ 1.30	$ 1.82	$ 1.59	$ 1.35	$ 1.30	$ 1.11	$ 0.86
Fillets	Value share	25%	26%	24%	23%	25%	33%	32%
Surimi	Volume K mt	7.1	4.5	8.5	12.3	14.7	13.4	10.6
Surimi	Price lb $	$ 0.91	$ 1.62	$ 1.19	$ 0.89	$ 0.85	$ 0.97	$ 0.70
Surimi	Value share	27%	33%	27%	23%	26%	27%	18%
Roe	Volume K mt	1.8	0.9	1.7	3.5	3.1	0.5	1.1
Roe	Price lb $	$ 3.36	$ 2.92	$ 3.04	$ 2.03	$ 1.30	$ 1.34	$ 1.68
Roe	Value share	25%	12%	14%	15%	8%	2%	4%

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).

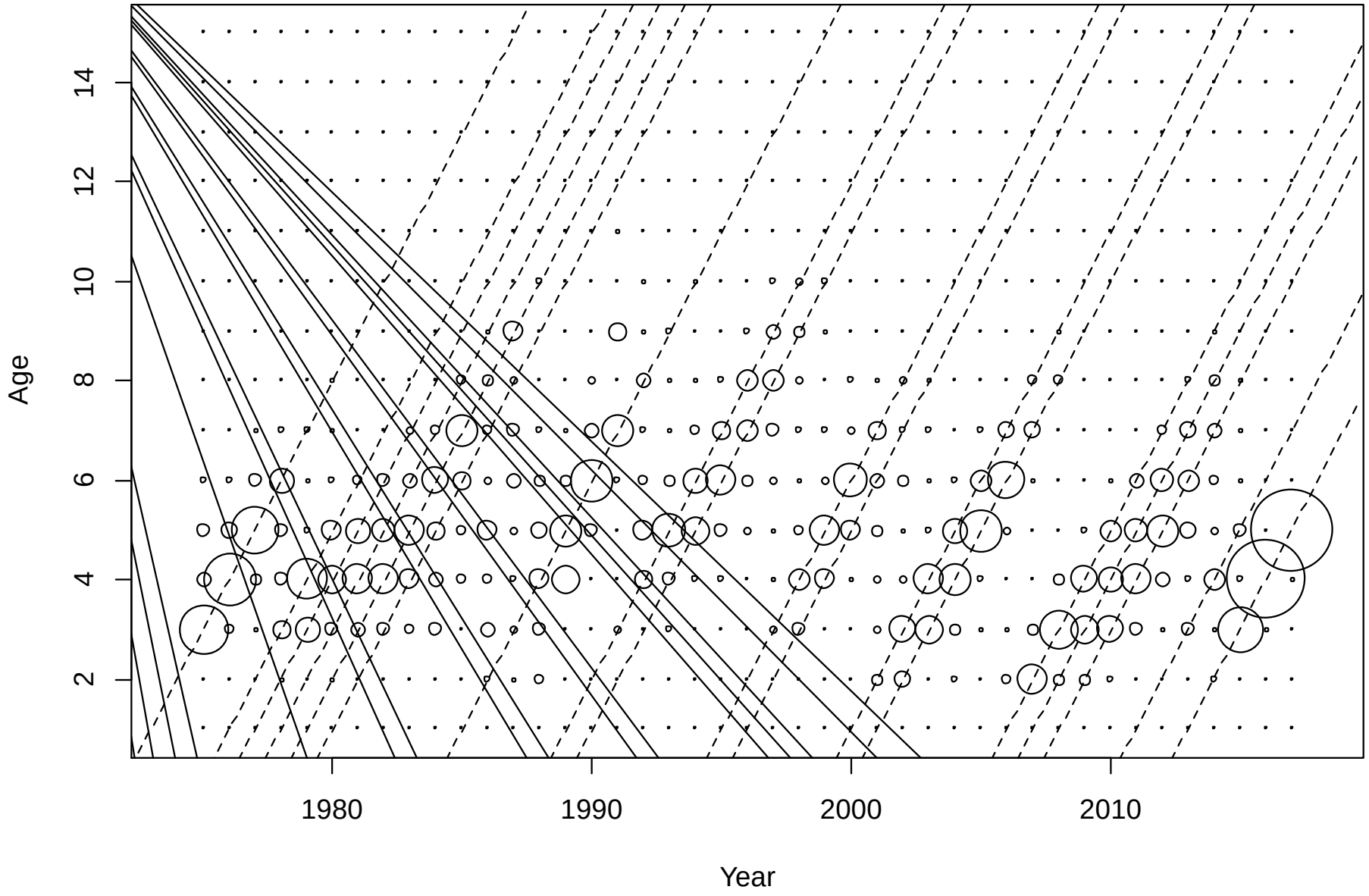
Data used in the assessment

Source	Data	Years
Fishery	Total catch	1970-2017
Fishery	Age composition	1975-2017
Shelikof Strait acoustic survey	Biomass	1992-2018
Shelikof Strait acoustic survey	Age composition	1992-2018
Summer acoustic survey	Biomass	2013-2017
Summer acoustic survey	Age composition	2013-2017
NMFS bottom trawl survey	Area-swept biomass	1990-2017
NMFS bottom trawl survey	Age composition	1990-2017
ADFG trawl survey	Delta GLM index	1989-2018
ADFG survey	Age composition	2000-2016

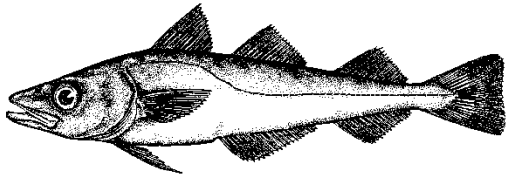
Total catch 1964-2017



Catch at age, 1975-2017



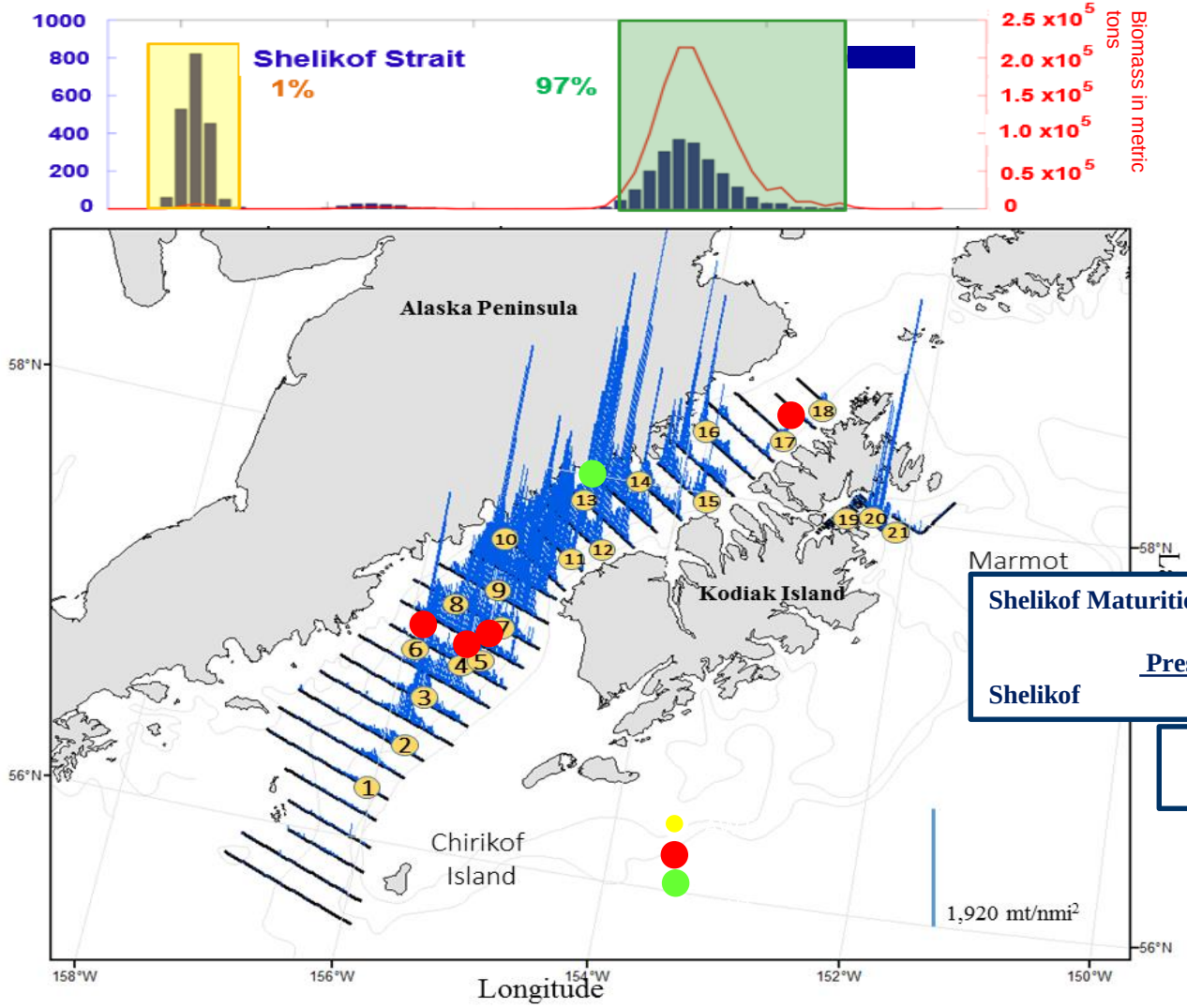
Gulf of Alaska pollock
Overview new surveys



- **2018 is an off year for surveys in the GOA**

- **2018 Shelikof Strait acoustic survey biomass is 1.3 million t**
  - 10% percent decrease from 2017 (but second largest estimate in over 30 years!).

- **2018 ADFG survey biomass is 50,000 t**
  - 128% percent increase from 2017 (but still about half the long-term average)



Shelikof Strait

March 15-21

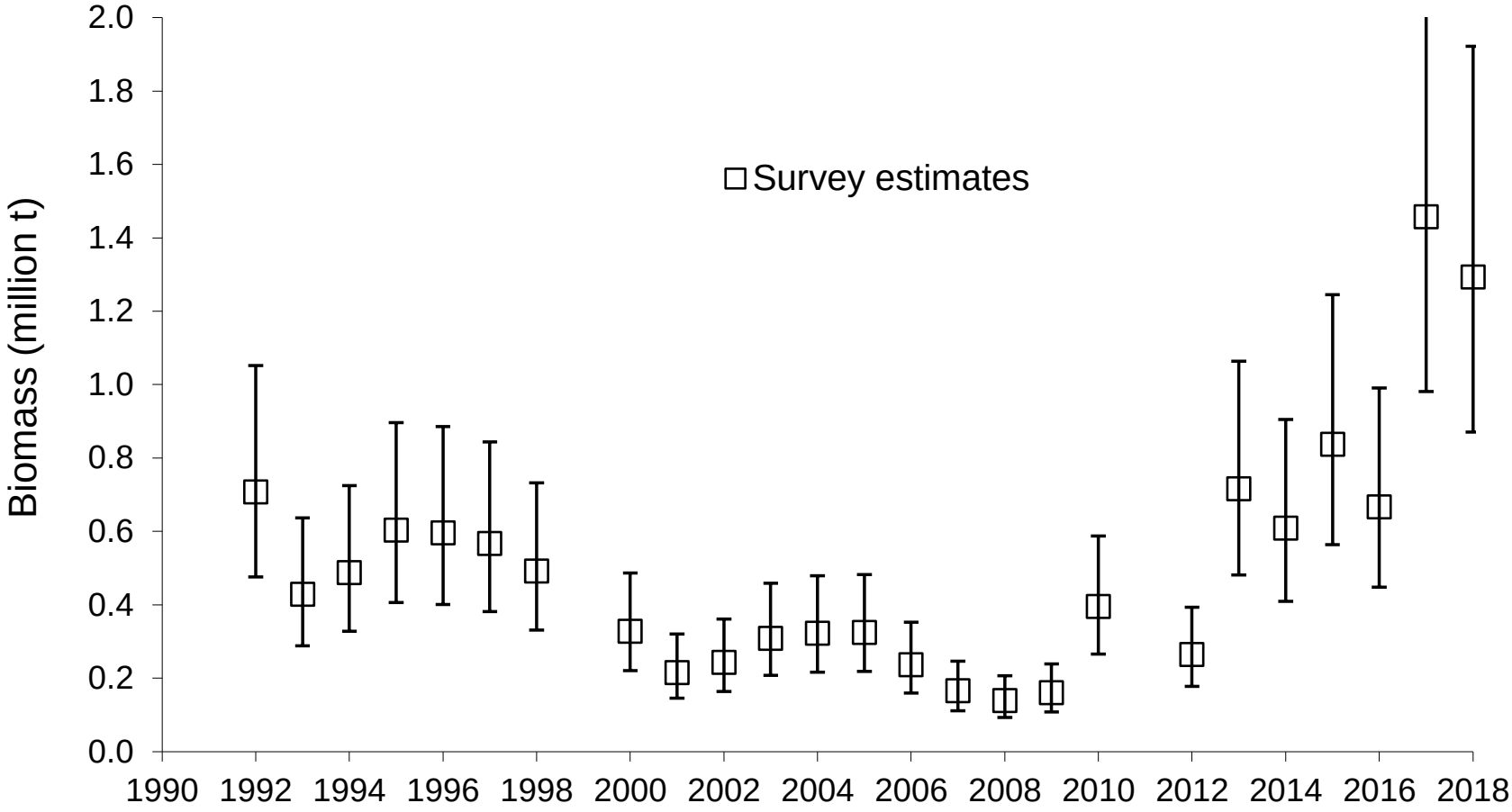
1,320,867 t

Shelikof Maturities (females > 40cm)

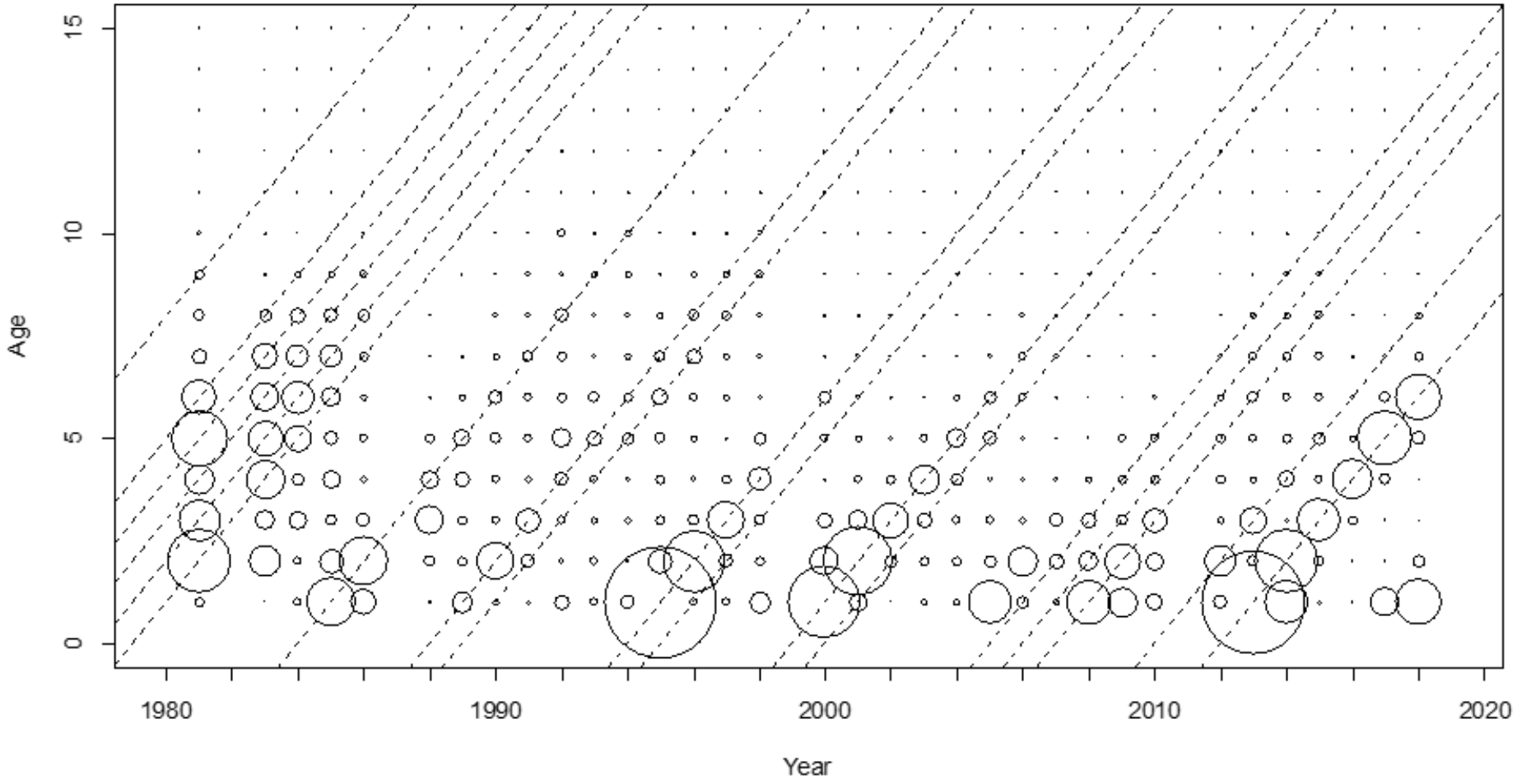
	Prespawning	Spawning	Spent	n
Shelikof	30%	24%	44%	383

18 tows, 871 nmi of trackline

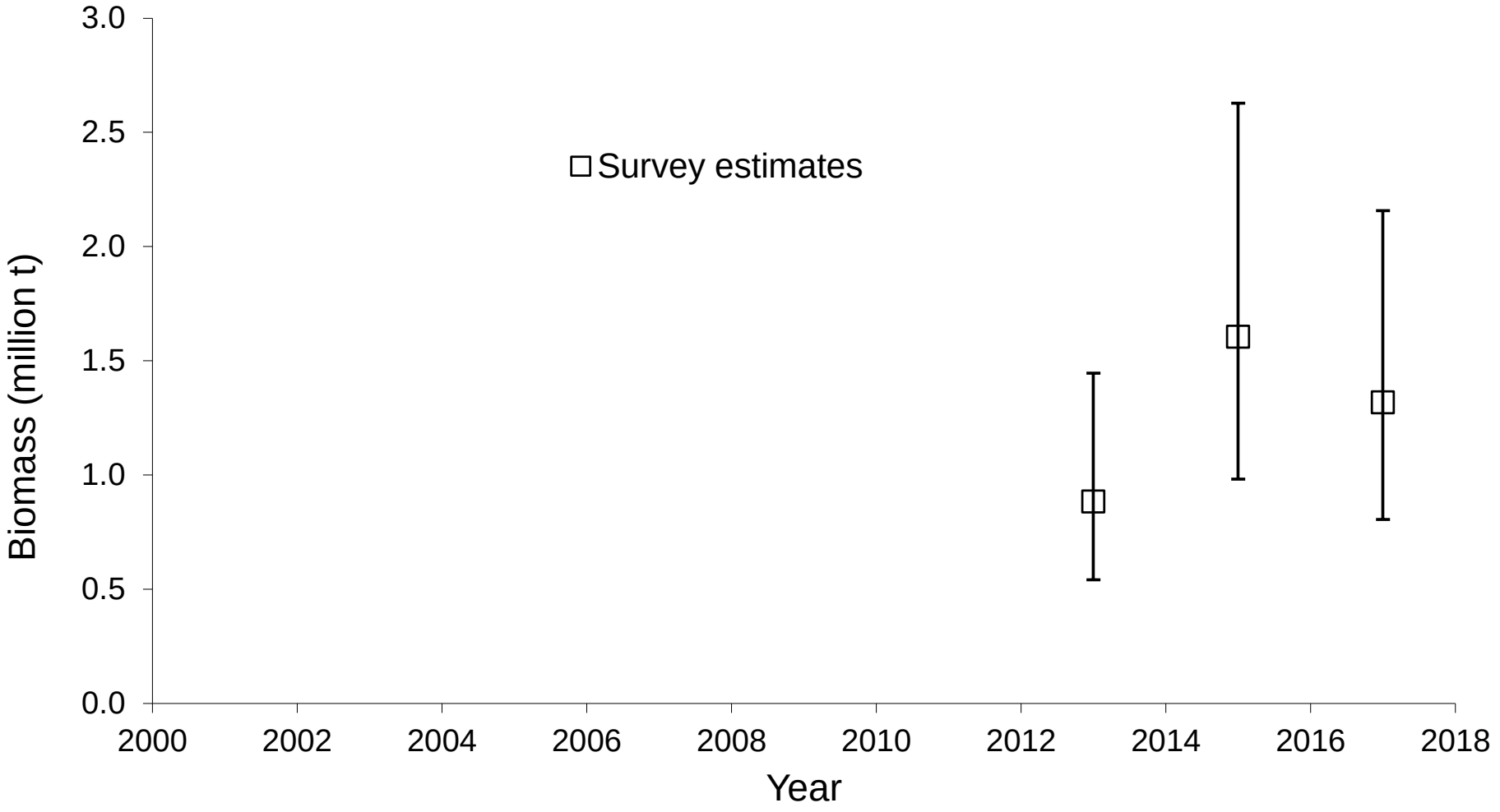
Shelikof Strait acoustic survey, 1992-2018



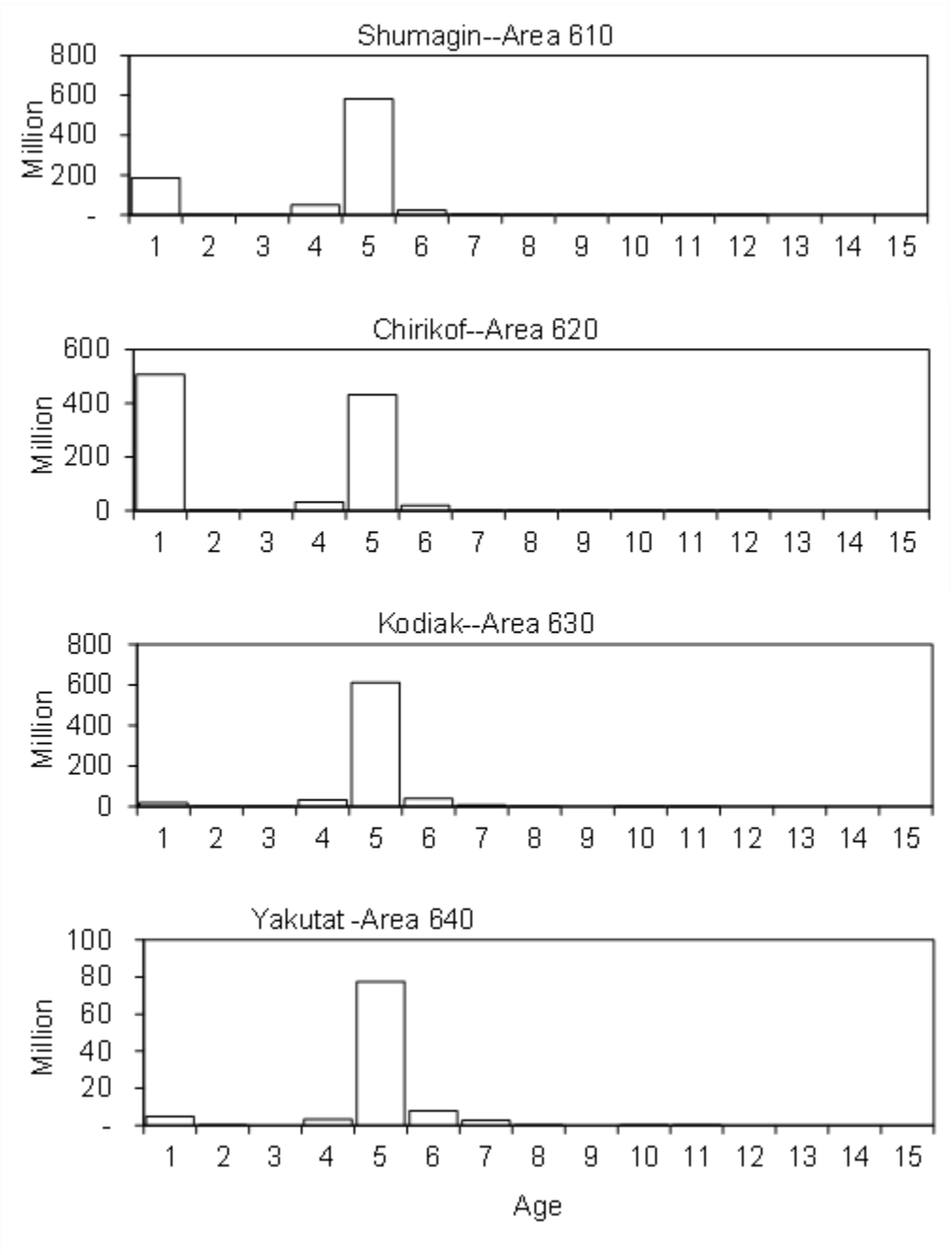
Shelikof Strait survey age comp, 1992-2018



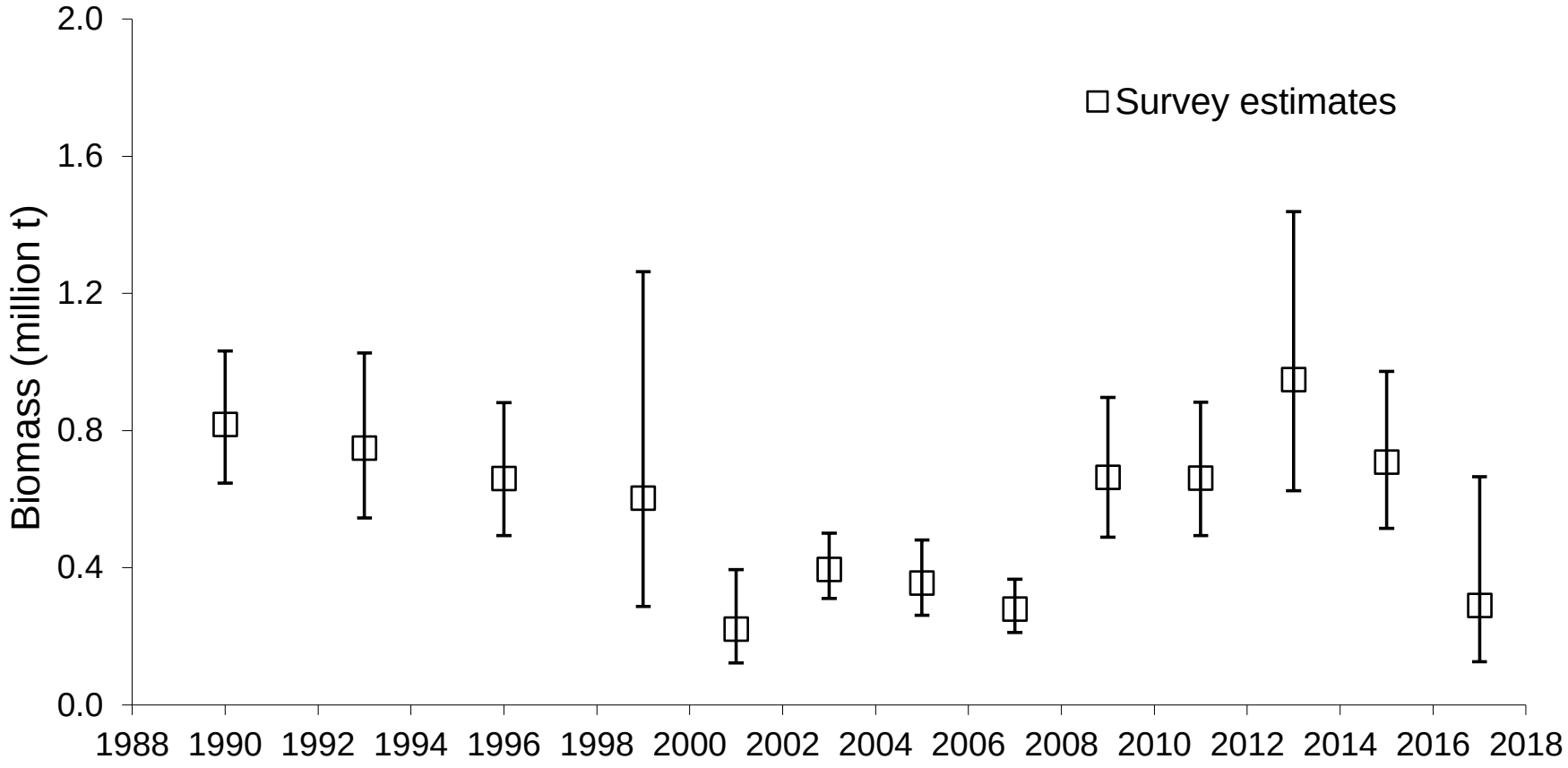
Summer acoustic survey, 2013-2017



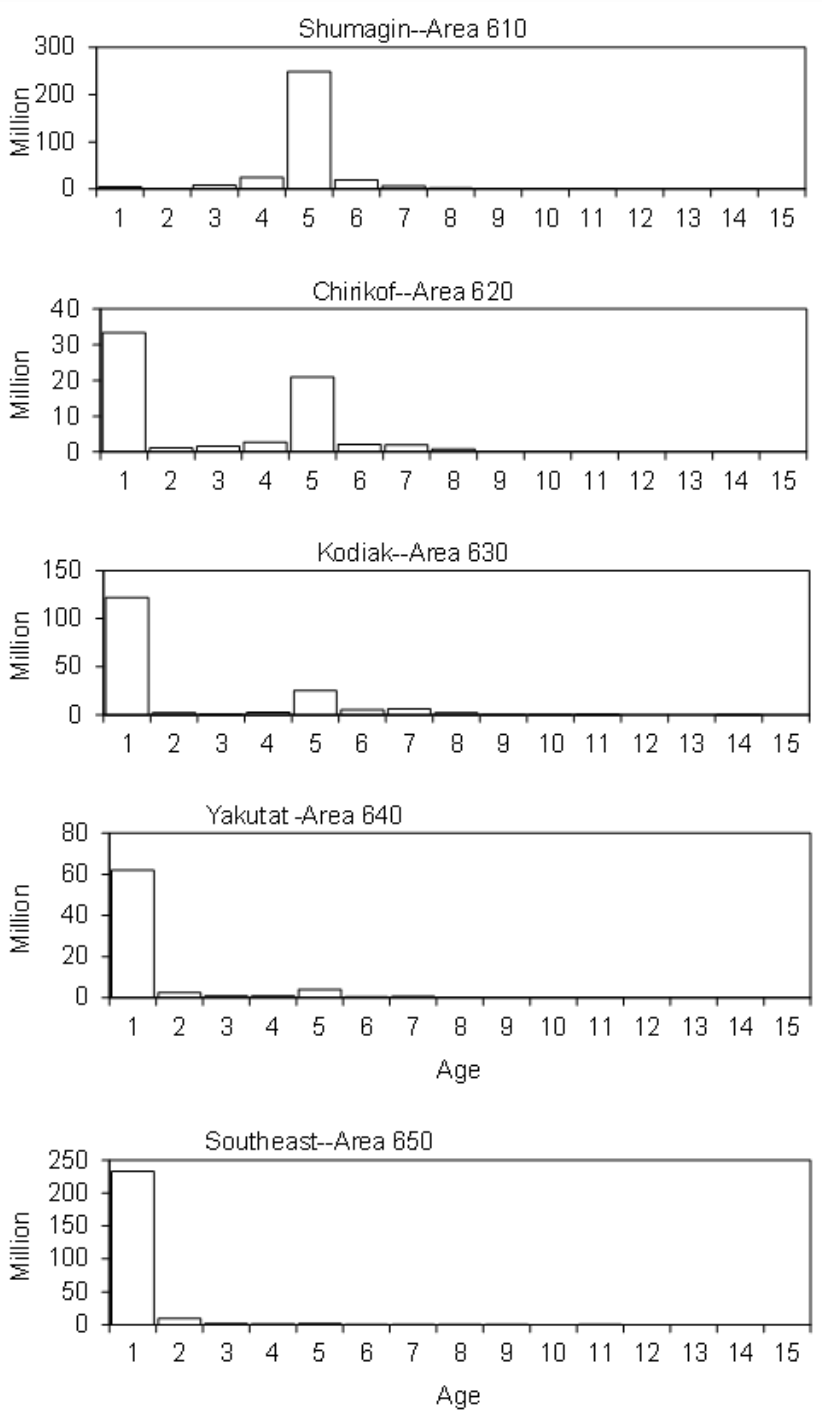
2017 Summer acoustic survey



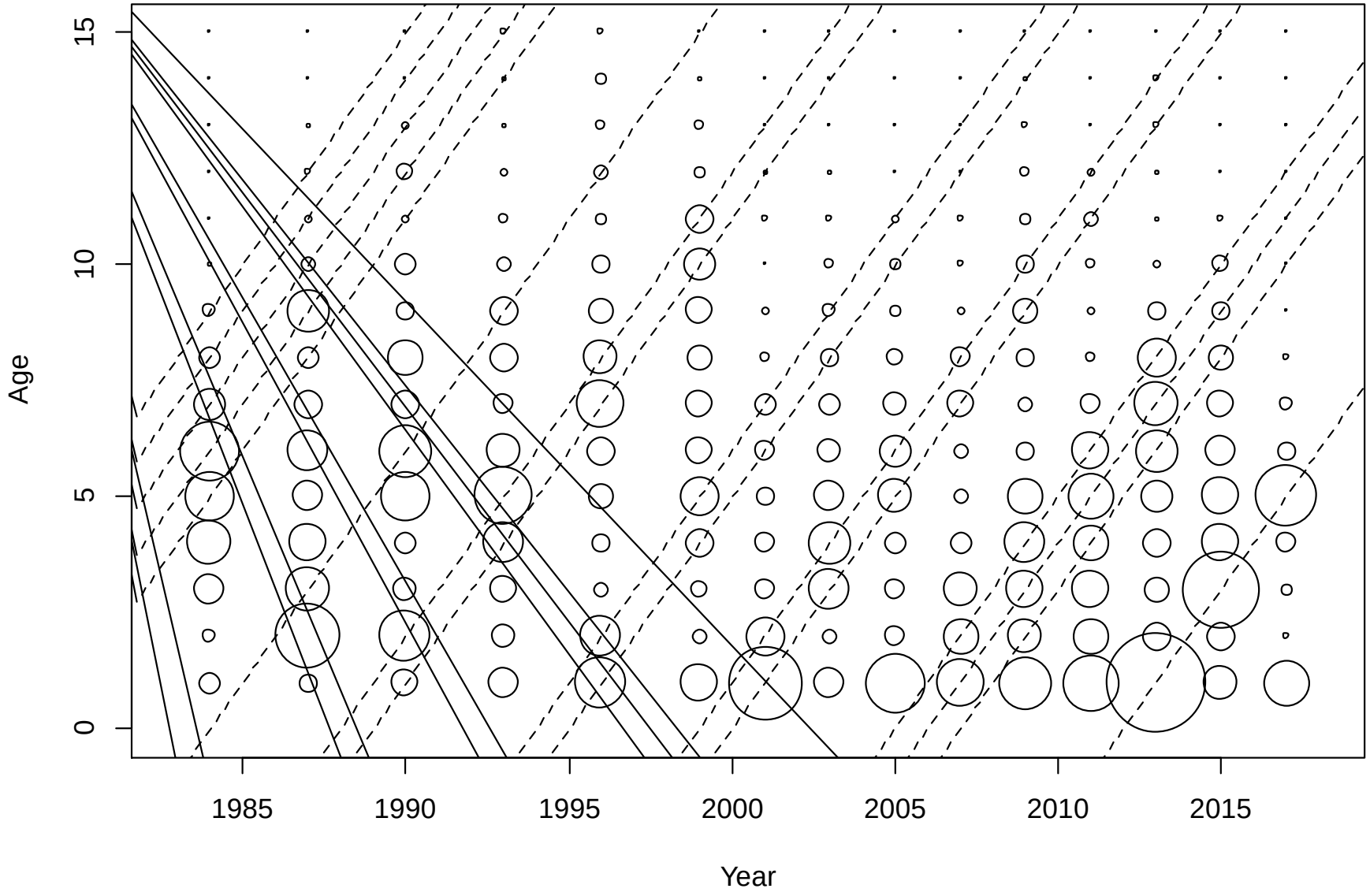
NMFS bottom trawl survey (1990-2017)



2017 NMFS bottom trawl survey



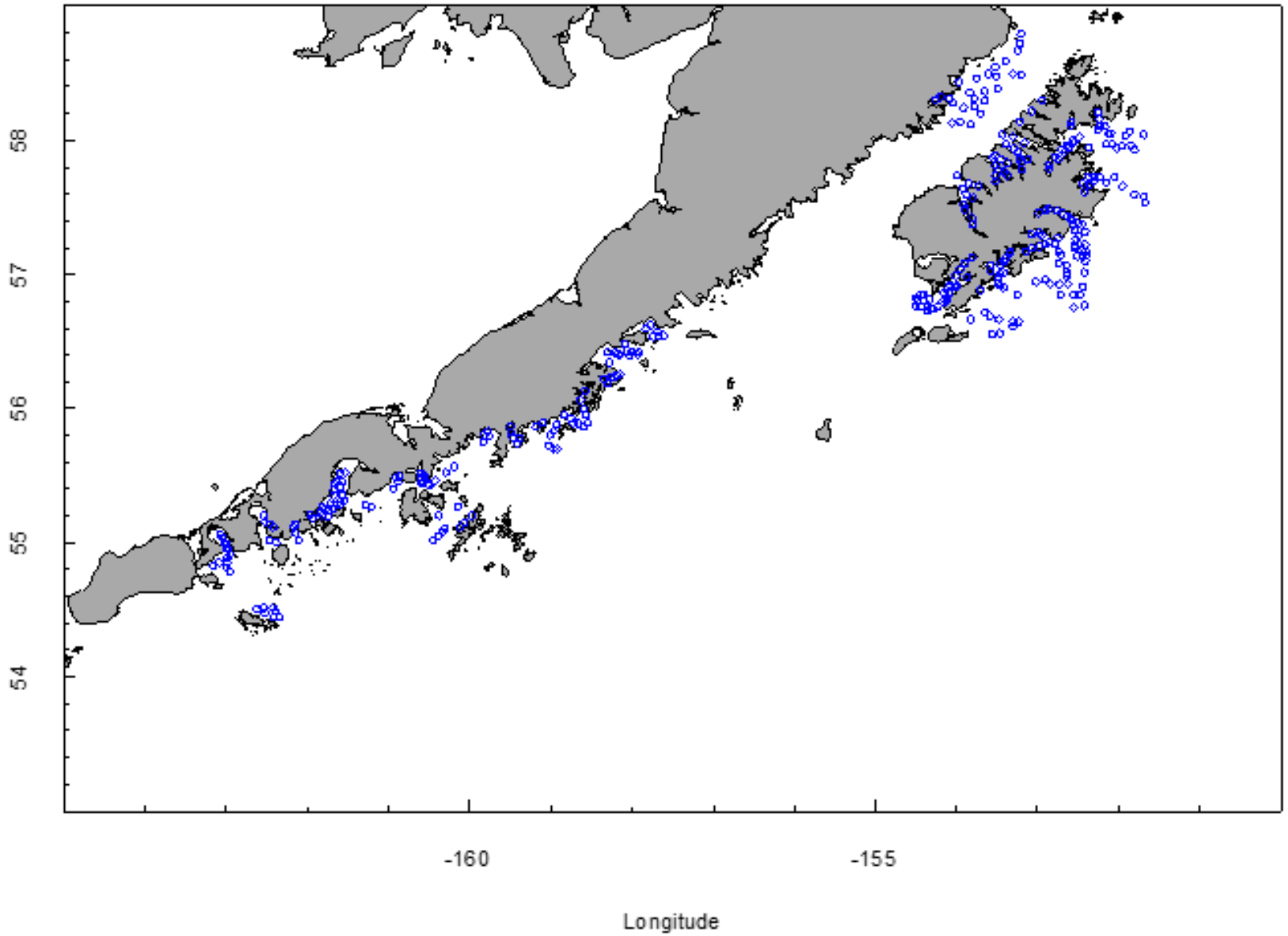
NMFS Bottom trawl survey age comp (1990-2017)



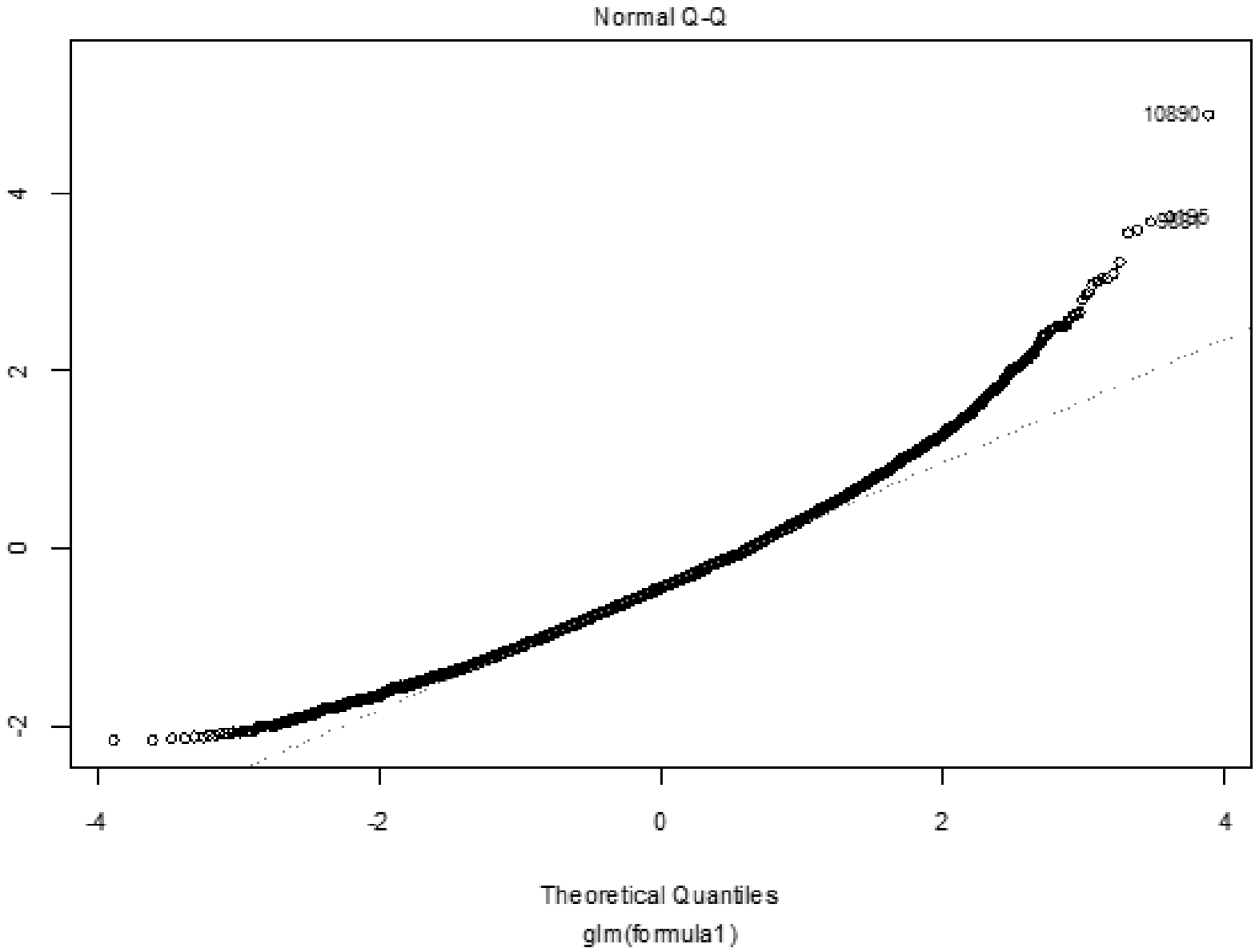
Delta-GLM for ADFG survey

- 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

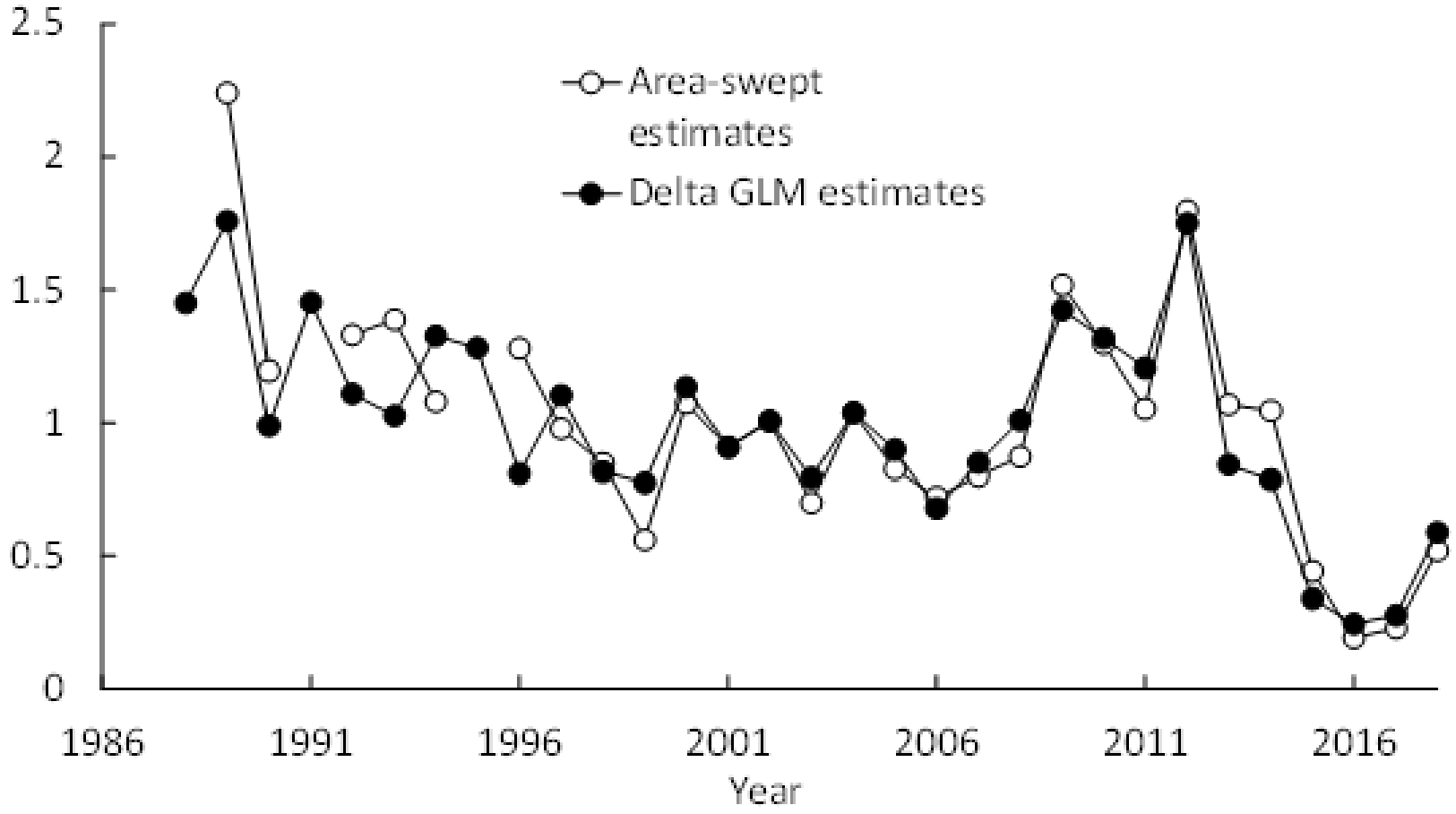
2018 ADFG survey stations



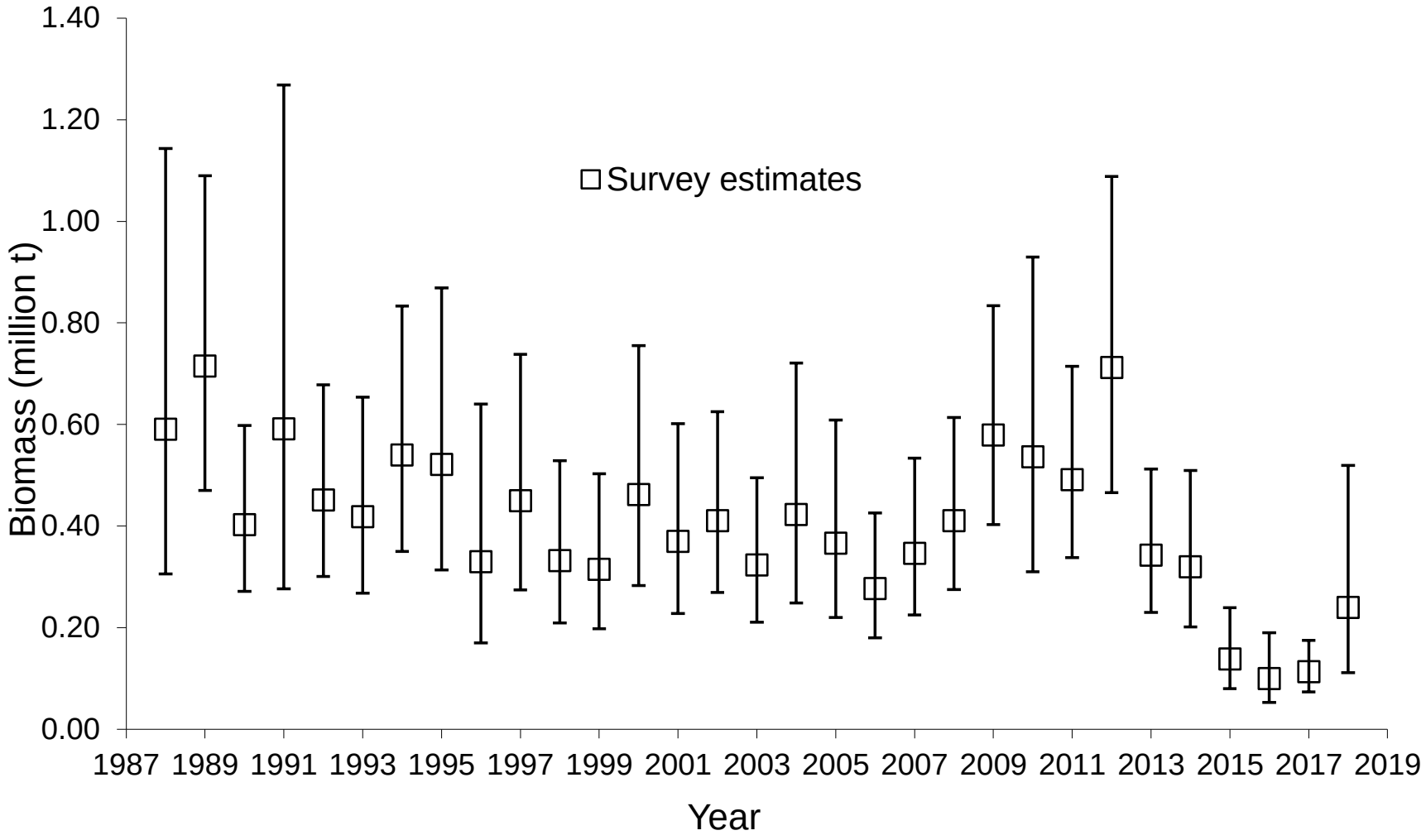
QQ plot for gamma error assumption



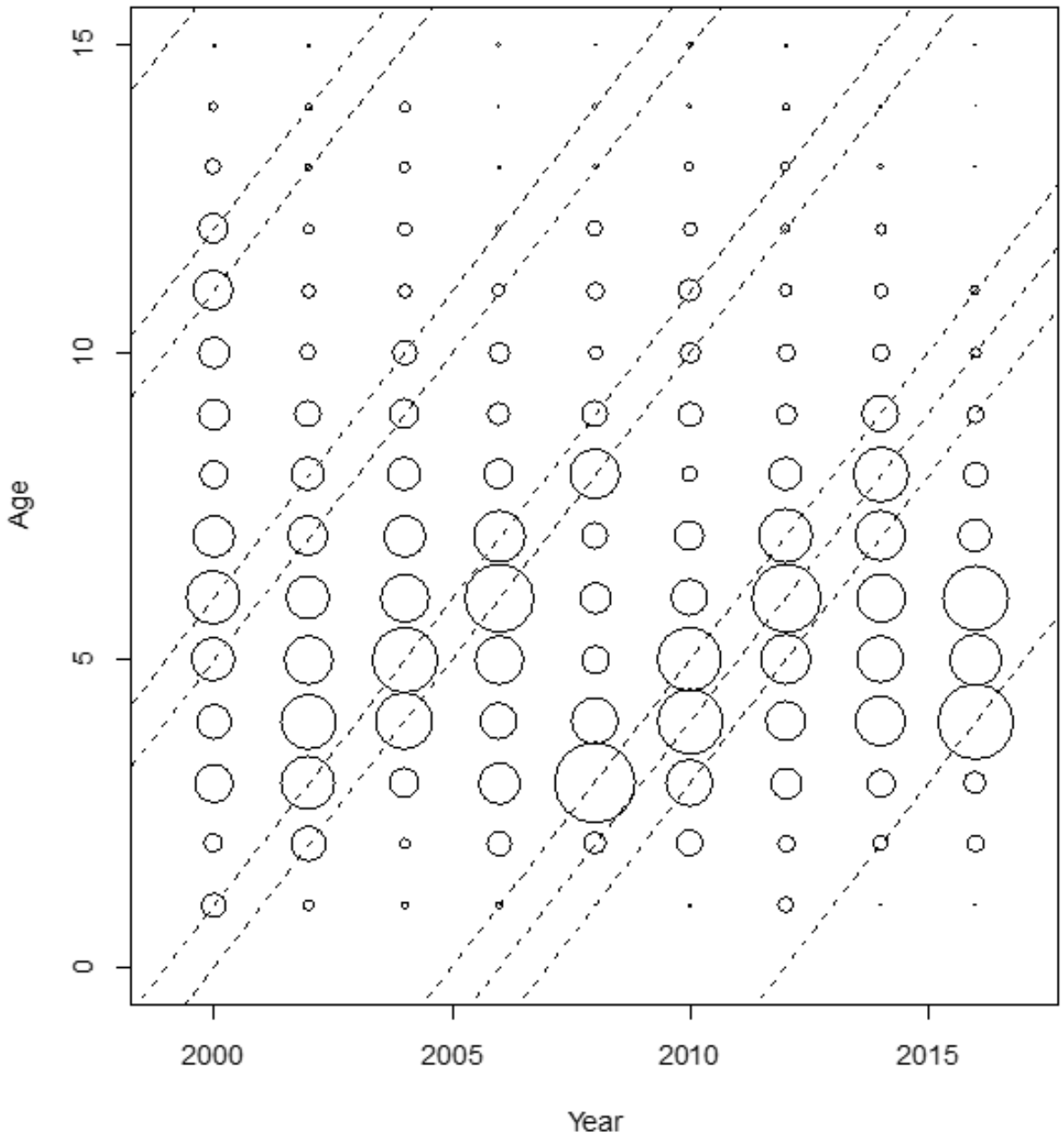
Comparison between area-swept estimates and delta-GLM estimates



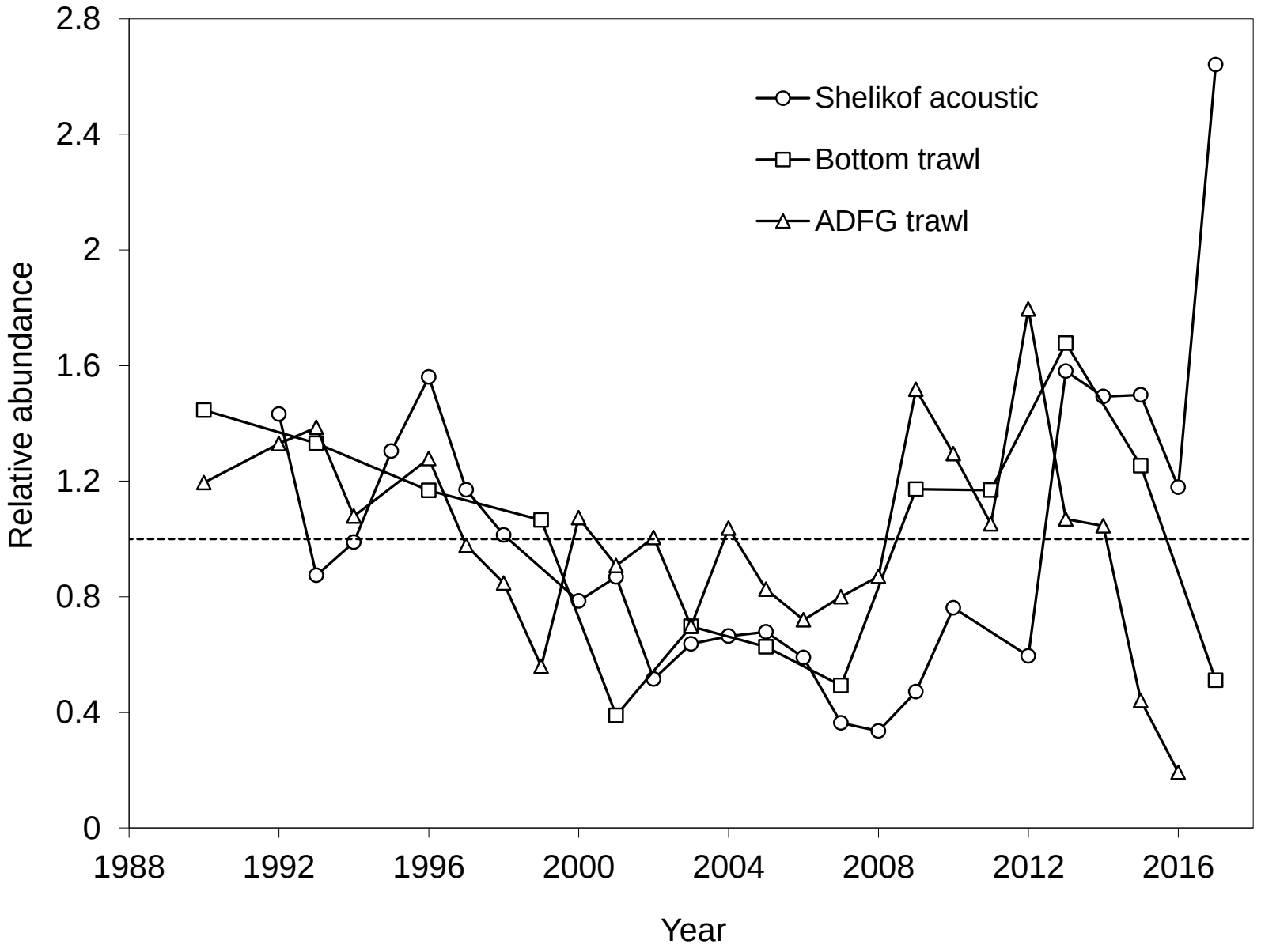
ADFG crab/groundfish trawl survey (1989-2018)



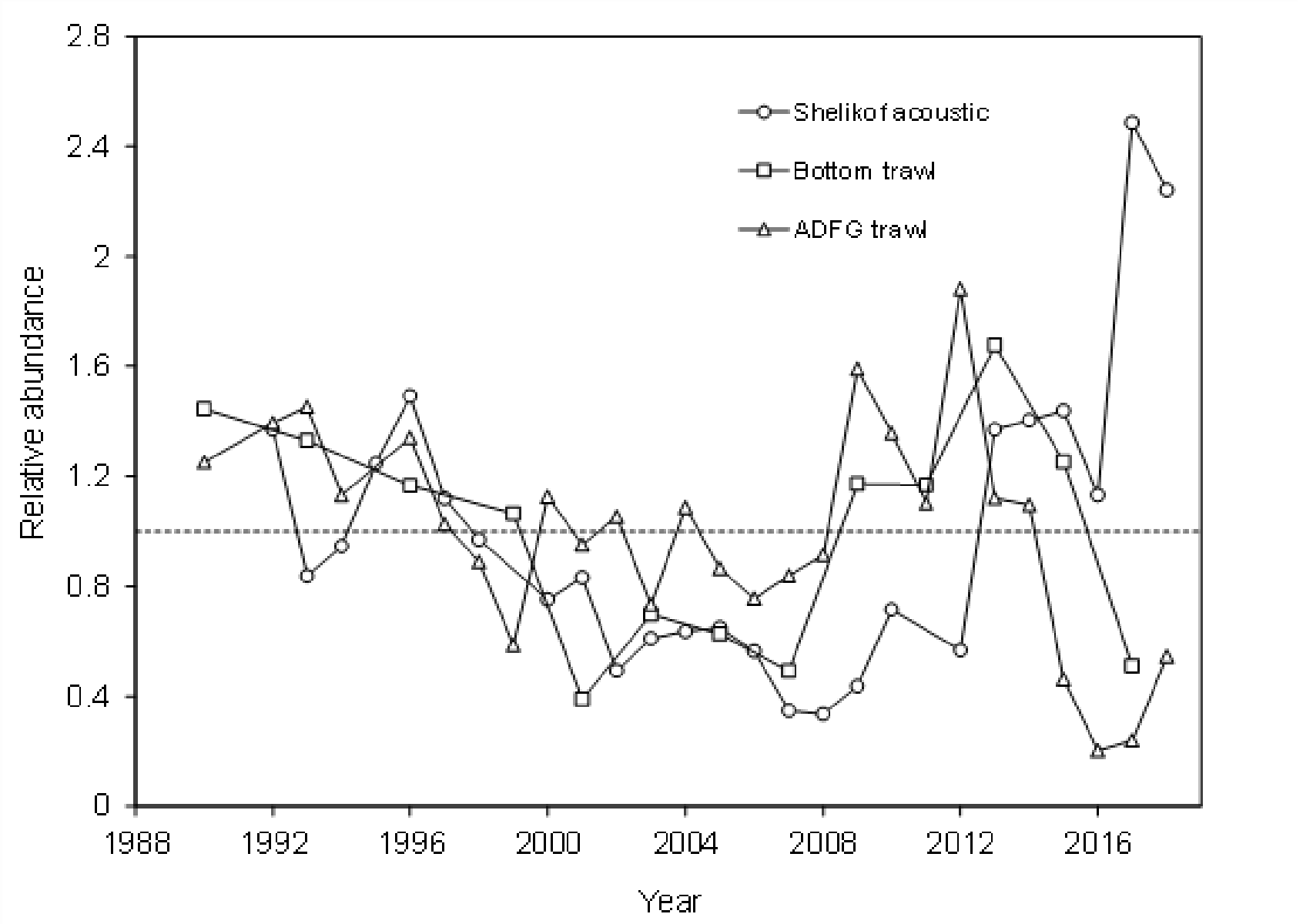
ADFG crab/groundfish trawl survey age comp (2000-2016)



Relative trends in abundance indices last year (1990-2017)



Relative trends in abundance indices this year (1990-2018)



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

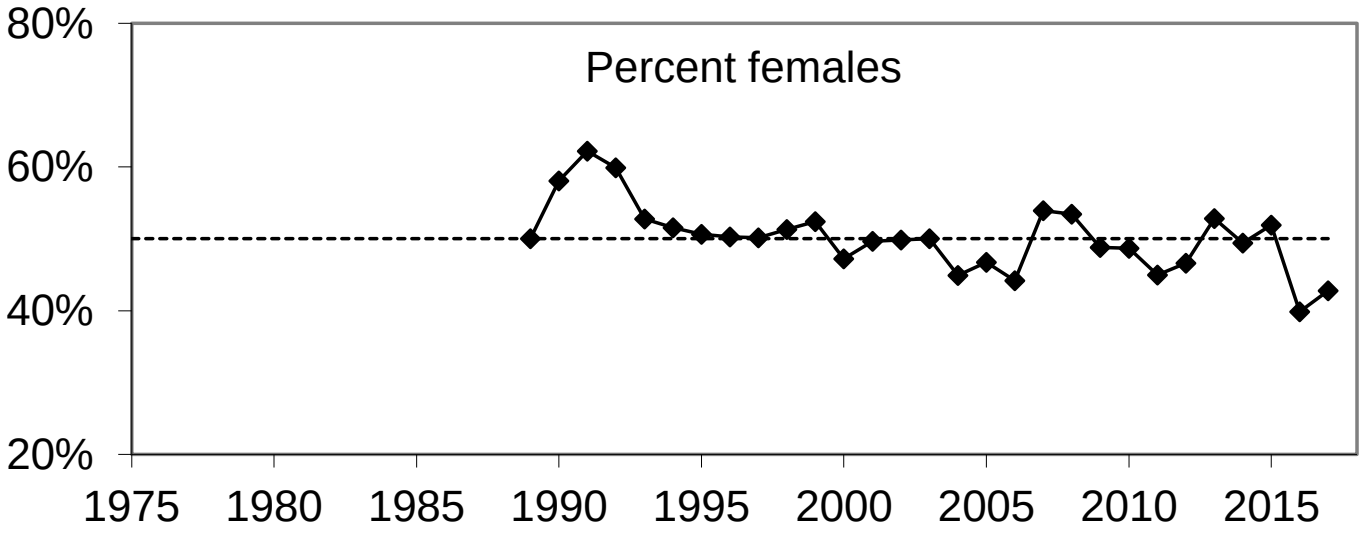
"Apparent data conflict in modern integrated stock assessment models can occur for three reasons:

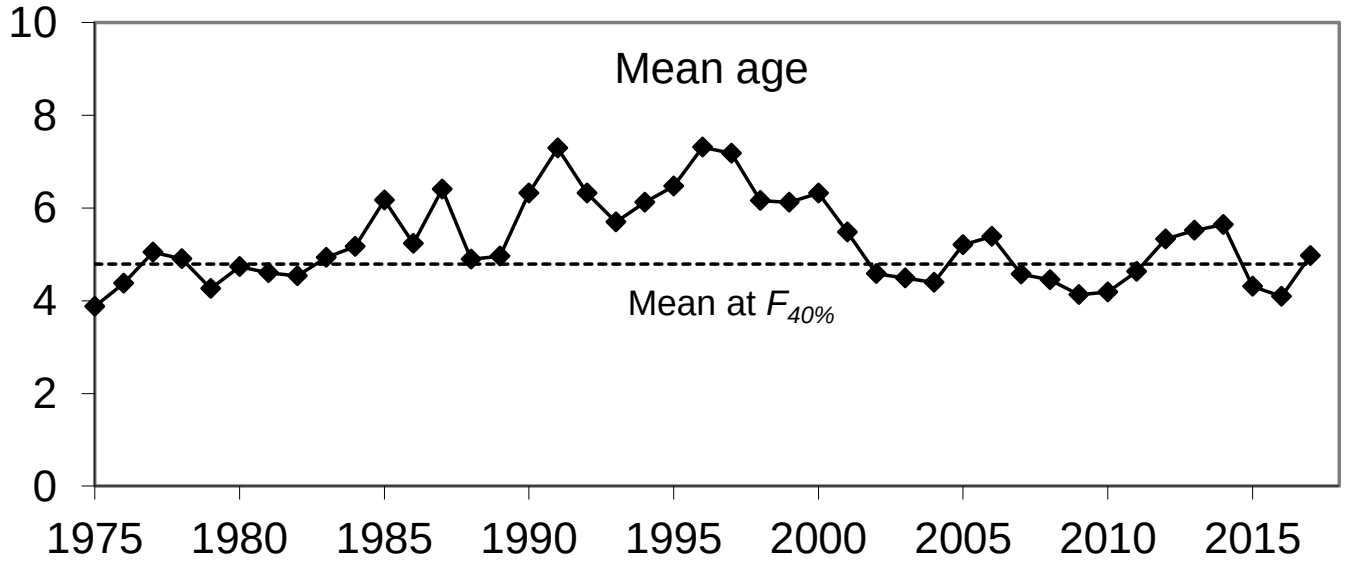
1) Random sampling error.

2) Misspecification of the observation model (model processes relating dynamics or states to data).

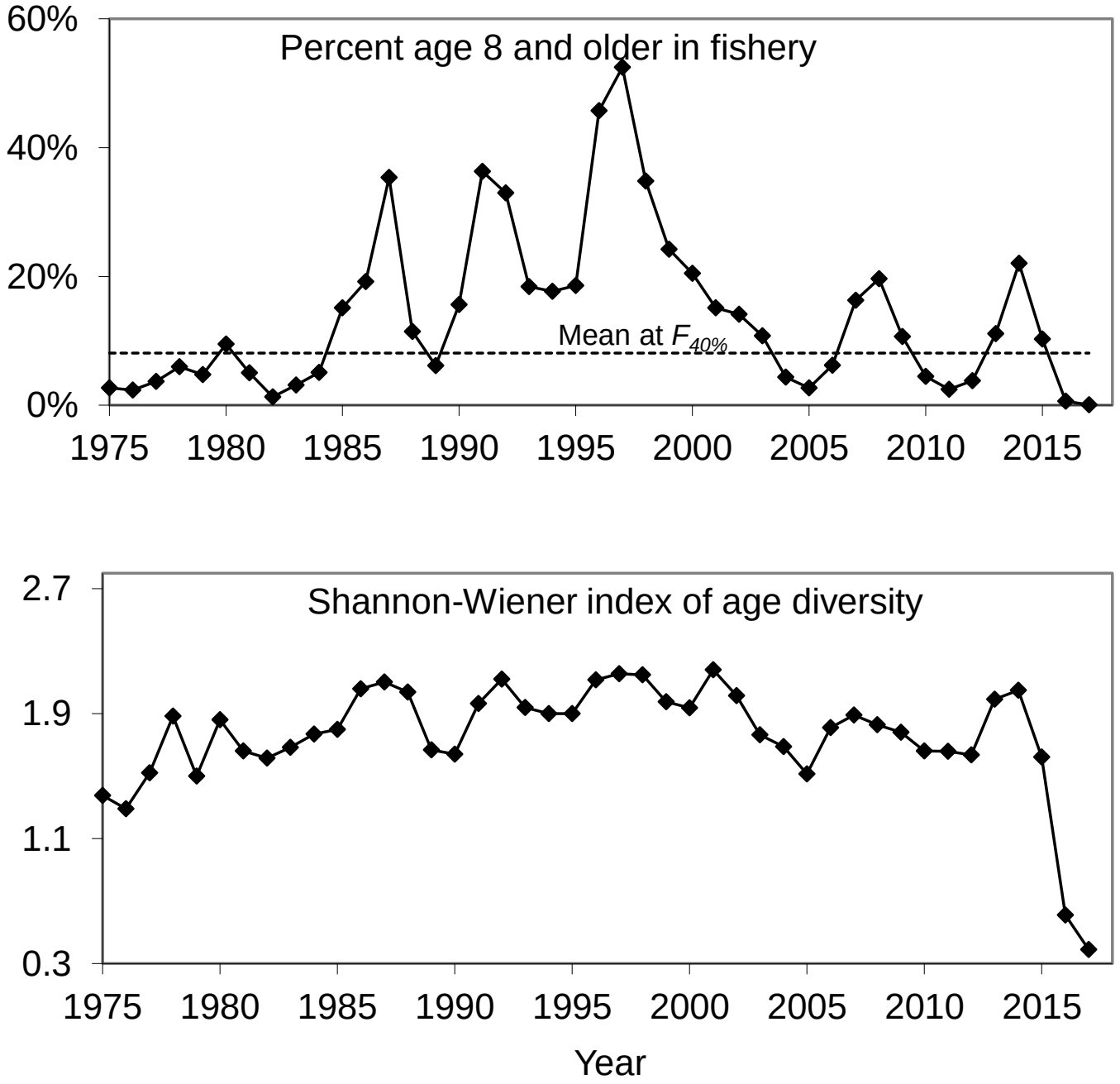
3) Misspecification of the system dynamics model (the population dynamics model)."

Fishery catch indicators

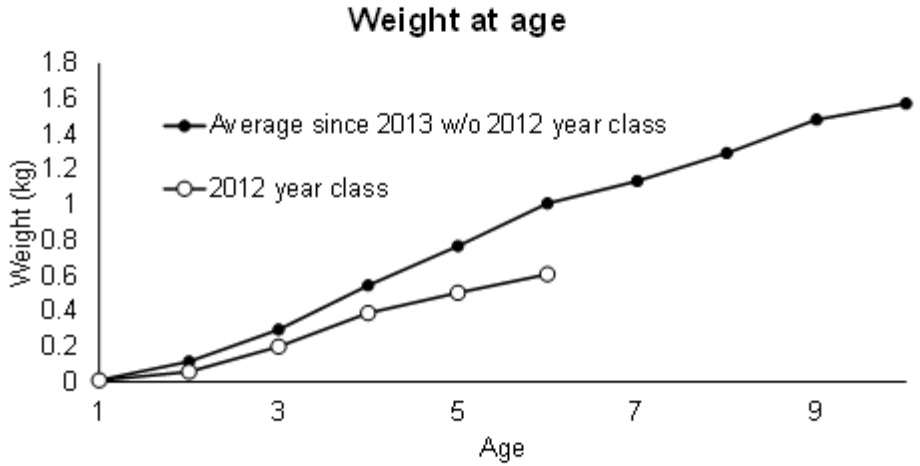




Fishery catch indicators



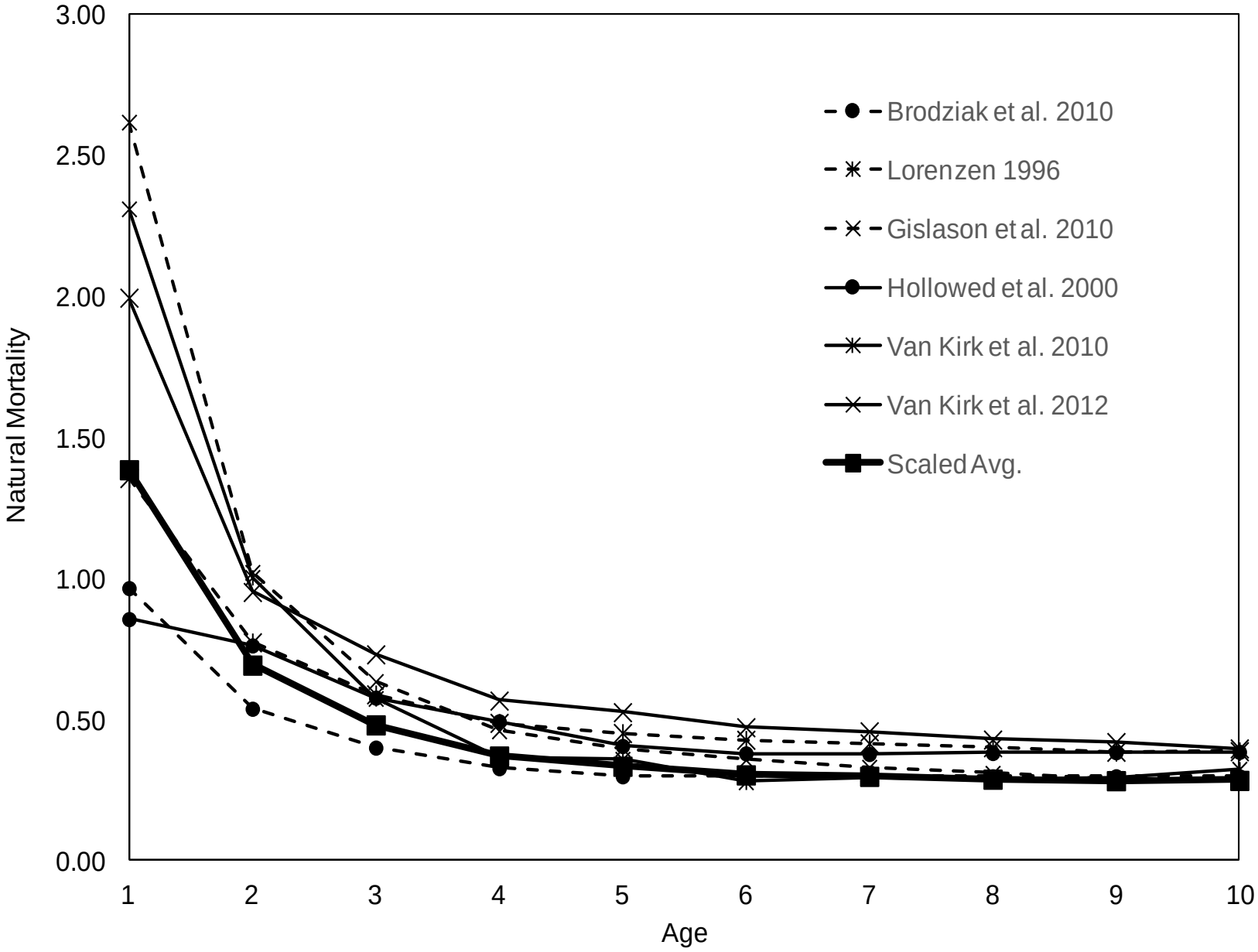
Unusual features of the 2012 year class life history characteristics



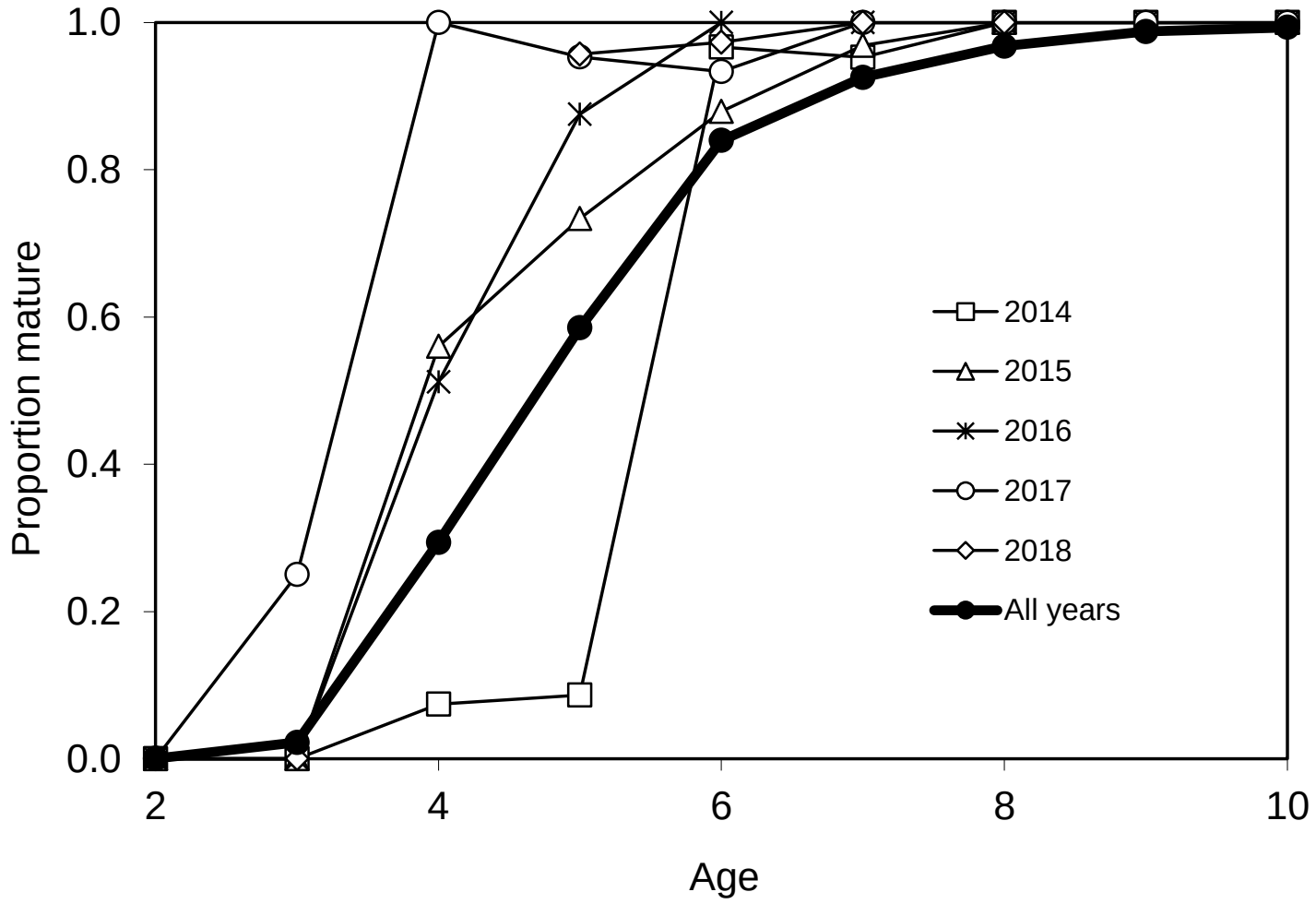
Parameters estimated independently

- Natural mortality: age-specific pattern (in 2014 assessment)
- Weight at age by fishery and survey
- RE model fishery weights at age in 2018 and 2019.
- Proportion mature at age

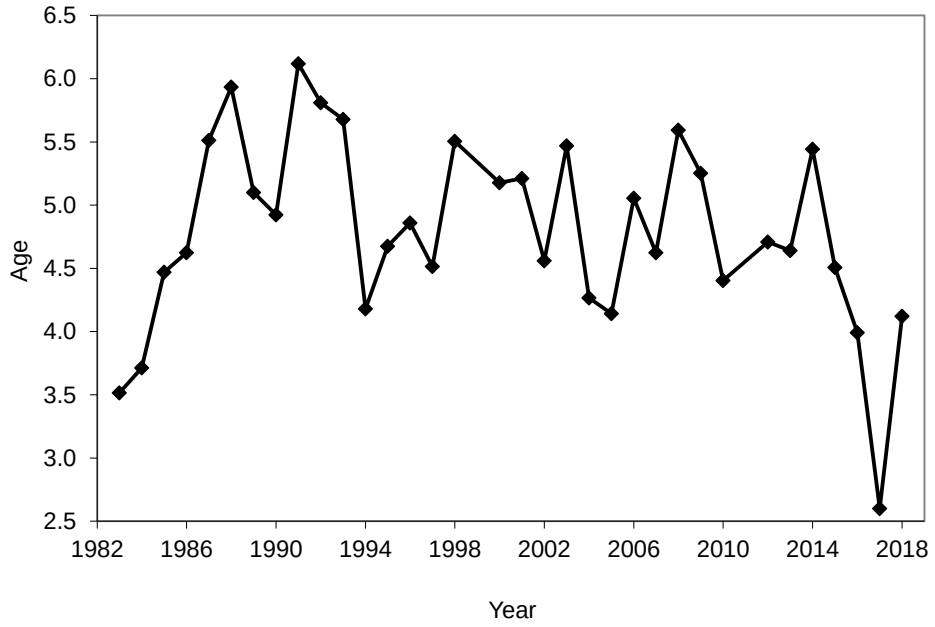
Natural mortality estimates

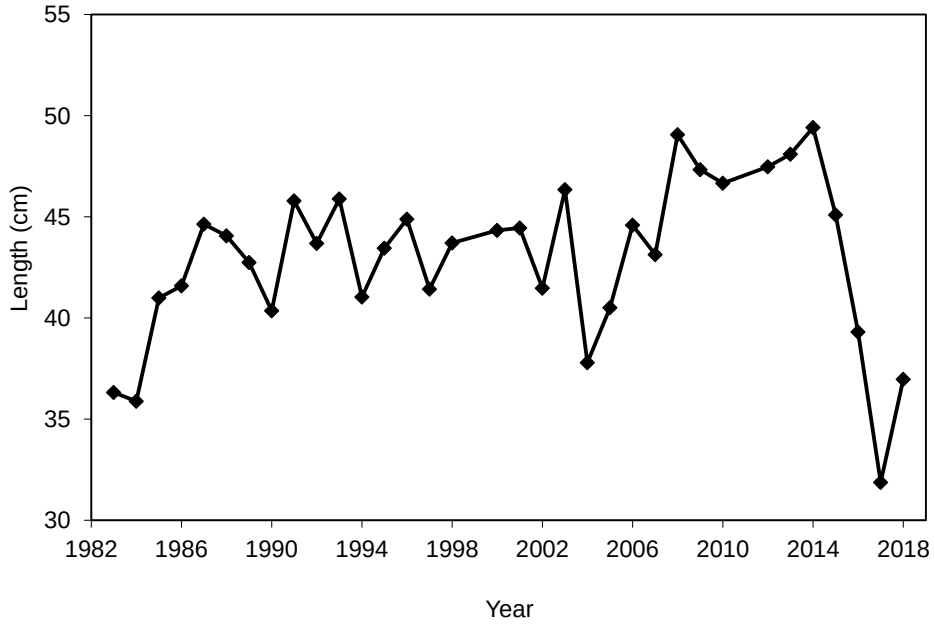


Recent maturity curves

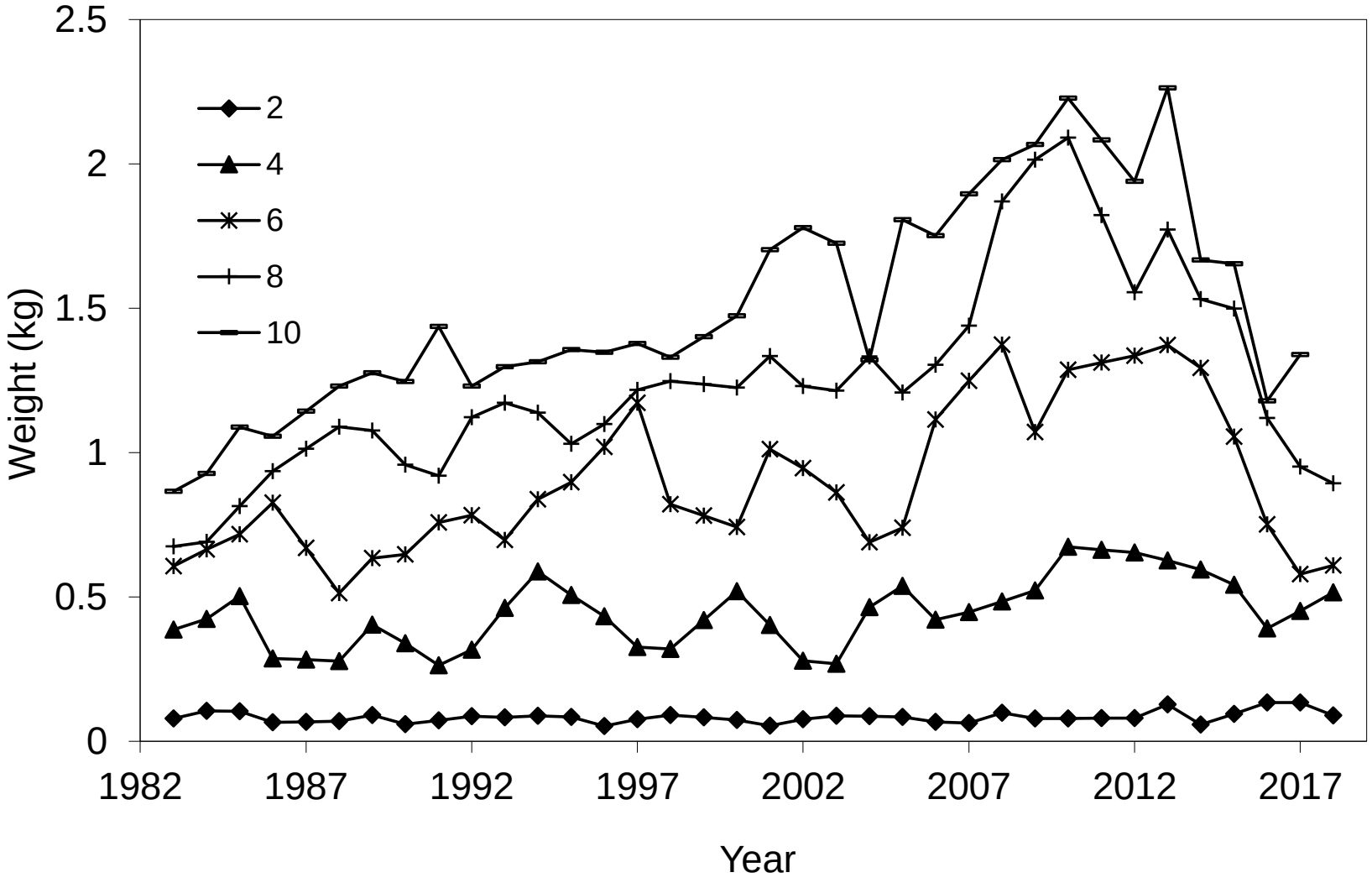


Changes in maturity





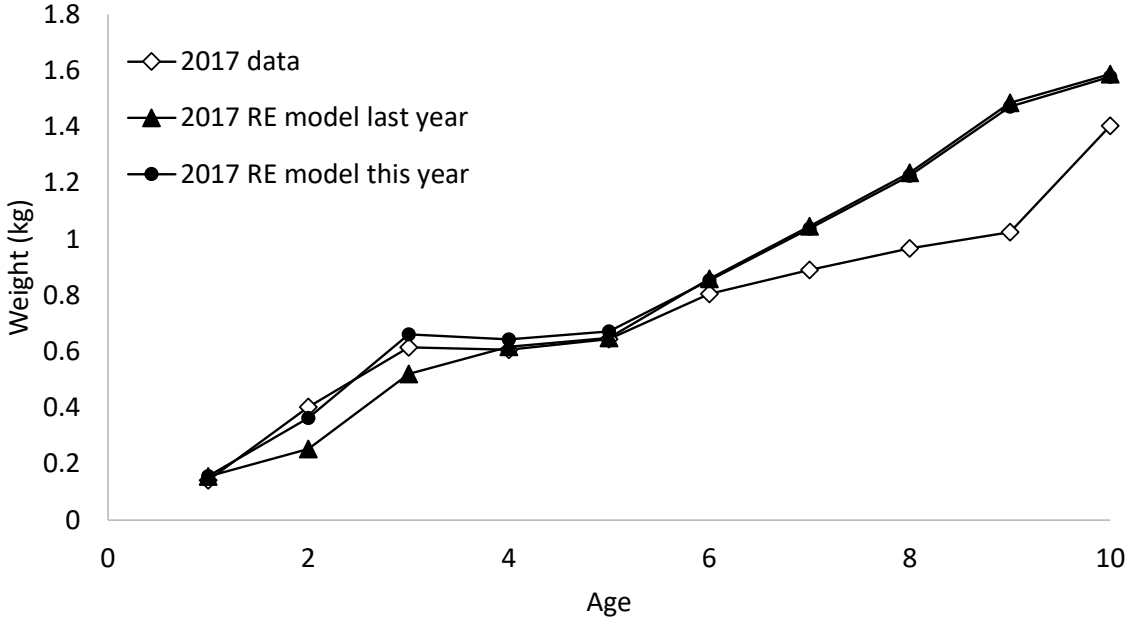
Shelikof survey changes in weight at age

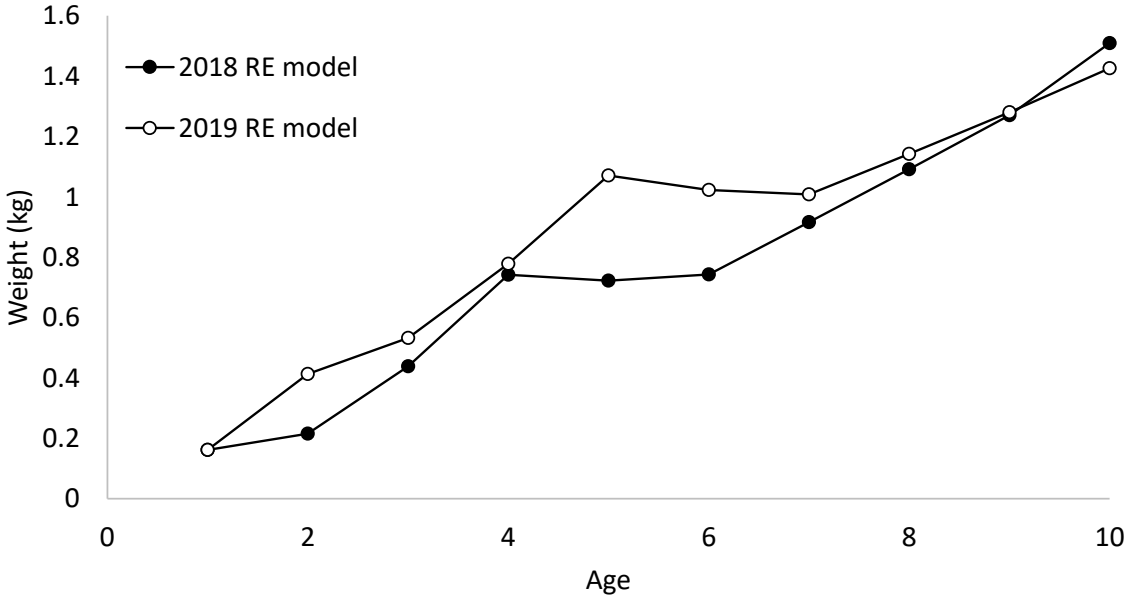


Random effects model for weight at age

- Developed in the EBS pollock stock assessesment (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 2018 (Shelikof Strait survey ageing data available but not fishery) and in 2019 (including F_{SPR} calcs).

RE model for fishery weight at age





Likelihood components

Likelihood component	Statistical model for error	Variance assumption
Fishery total catch (1970-2018)	Log-normal	CV = 0.05
Fishery age comp. (1975-2017)	Multinomial	Initial sample size: 200 or the number of tows/deliveries if less than 200
Shelikof acoustic survey biomass (1992-2018)	Log-normal	CV = 0.20
Shelikof acoustic survey age comp. (1992-2018)	Multinomial	Initial sample size = 60
Winter acoustic survey age-1 and age-2 indices (1994-2018)	Log-normal	Tuned CVs = 0.45
Summer acoustic survey biomass (2013-2015)	Log-normal	CV = 0.25
Summer acoustic survey age comp. (2013, 2015, 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. (1990-2017)	Multinomial	Initial sample size = 60
ADFG trawl survey biomass (1989-2018)	Log-normal	CV = 0.25
ADFG survey age comp. (2000-2016)	Multinomial	Initial sample size = 30
Recruit process error (1970-1977, 2017, 2018)	Log-normal	σ_R =1.0

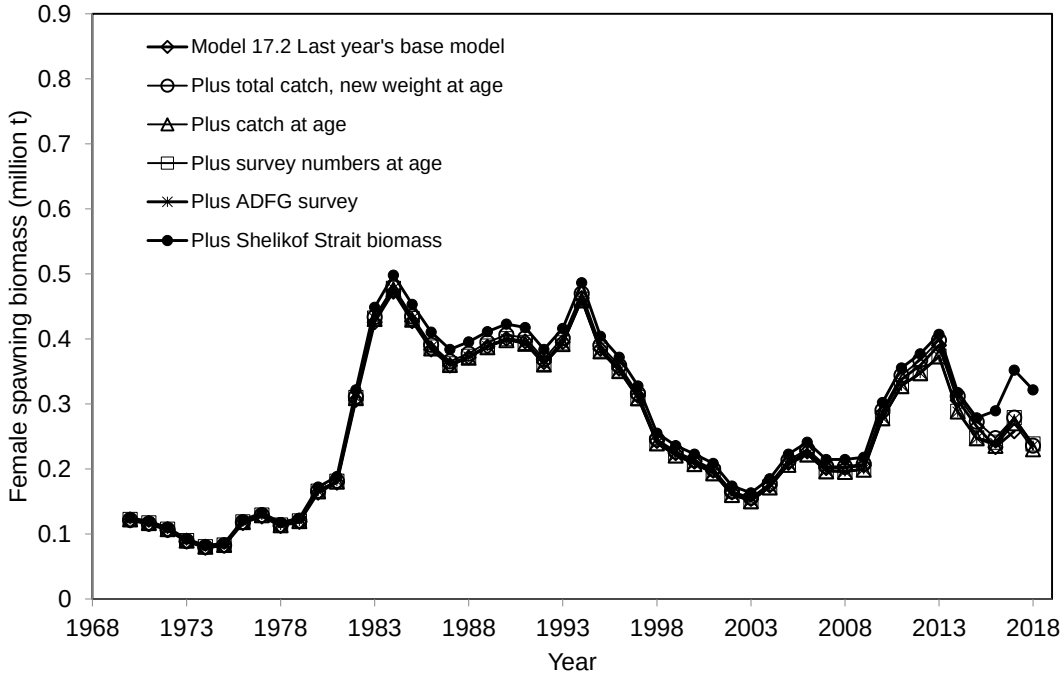
Model parameters

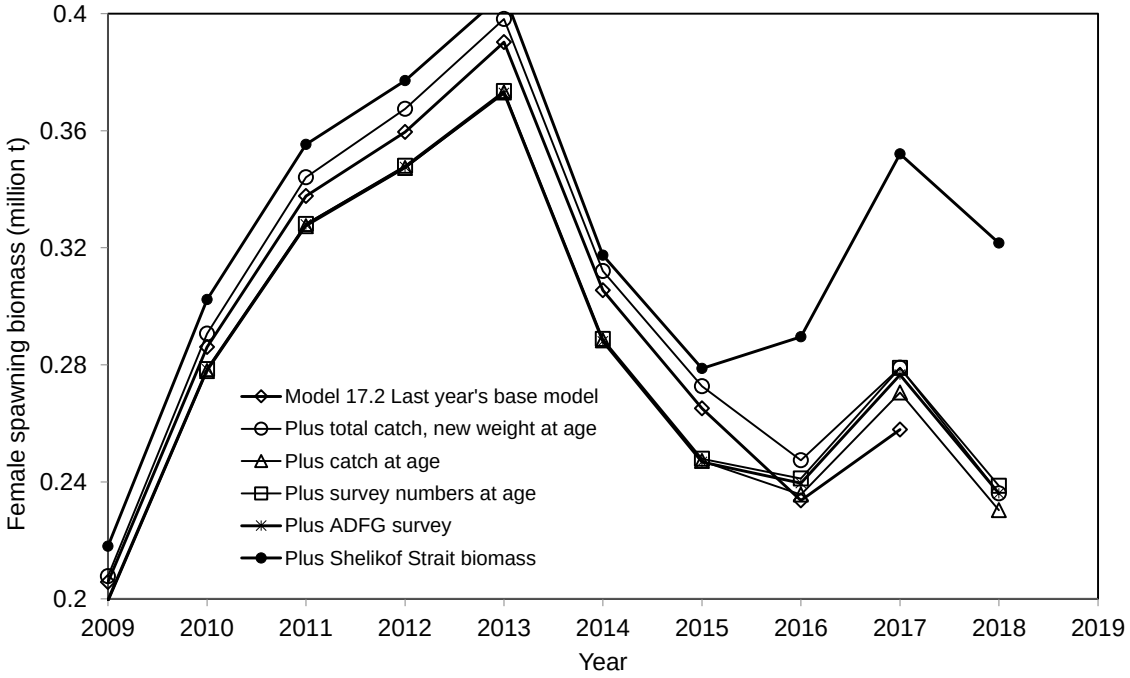
Population process modeled	Number of parameters	Estimation details
Recruitment	Years 1970-2018 = 49	Estimated as log deviances from the log mean; recruitment in 1970-77, and 2017 and 2018 constrained by random deviation process error.
Natural mortality	Age-specific= 10	Not estimated in the model
Fishing mortality	Years 1970-2017 = 49	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 * (No. years-1) = 96	Estimated as deviations from mean selectivity and constrained by random walk process error
Mean survey catchability	No. of surveys = 6	Catchabilities estimated on a log scale. Separate catchabilities were also estimated for age-1 and age-2 winter acoustic indices.
Annual changes in survey catchability	2 * (No. years-1) = 96	Annual catchability for winter acoustic surveys and ADF&G surveys estimated as deviations from mean catchability and constrained by random walk process error
Survey selectivity	6 (Shelikof acoustic survey: 2, BT survey: 2, ADFG survey: 2)	Slope parameters estimated on a log scale.
Total	110 estimated parameters + 192 process error parameters + 10 fixed parameters = 312	

Model input changes

- Fishery: 2017 total catch and catch at age.
- Shelikof Strait acoustic survey: 2018 biomass and age composition.
- NMFS bottom trawl survey: 2017 age composition.
- Summer acoustic survey: 2017 age composition.
- ADFG crab/groundfish trawl survey: 2018 biomass.

Sequential addition of new data





Alternative Models

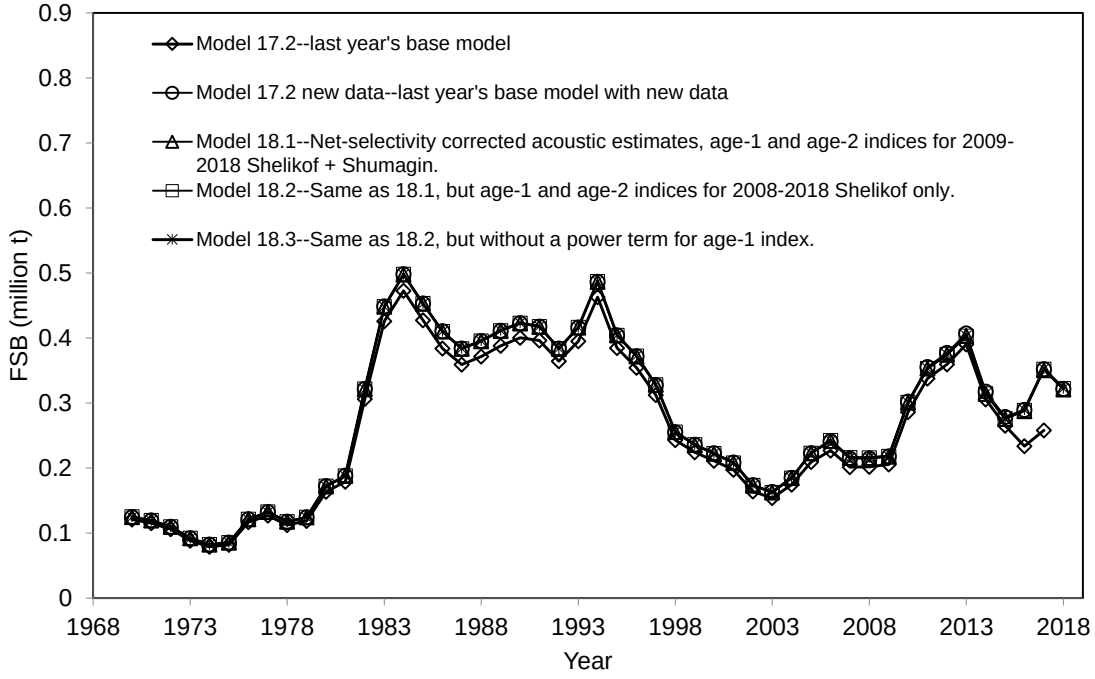
Model 17.2--last year's base model.

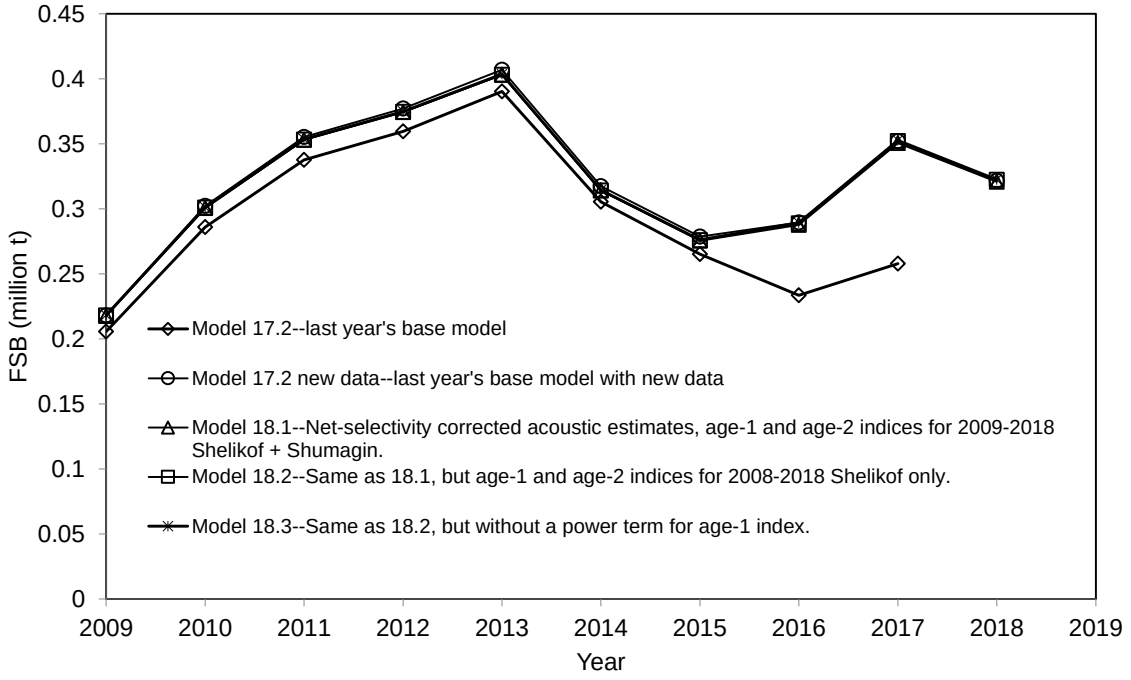
Model 17.2 new data--last year's base model with new data.

Model 18.1--Net-selectivity corrected acoustic estimates, age-1 and age-2 indices for 2009-2018 Shelikof + Shumagin.

Model 18.2--Same as 18.1, but age-1 and age-2 indices for 2008-2018 Shelikof only.

Model 18.3--Same as 18.2, but without a power term for age-1 index.





Model 17.2--last year's base model.

Model 17.2 new data--last year's base model with new data.

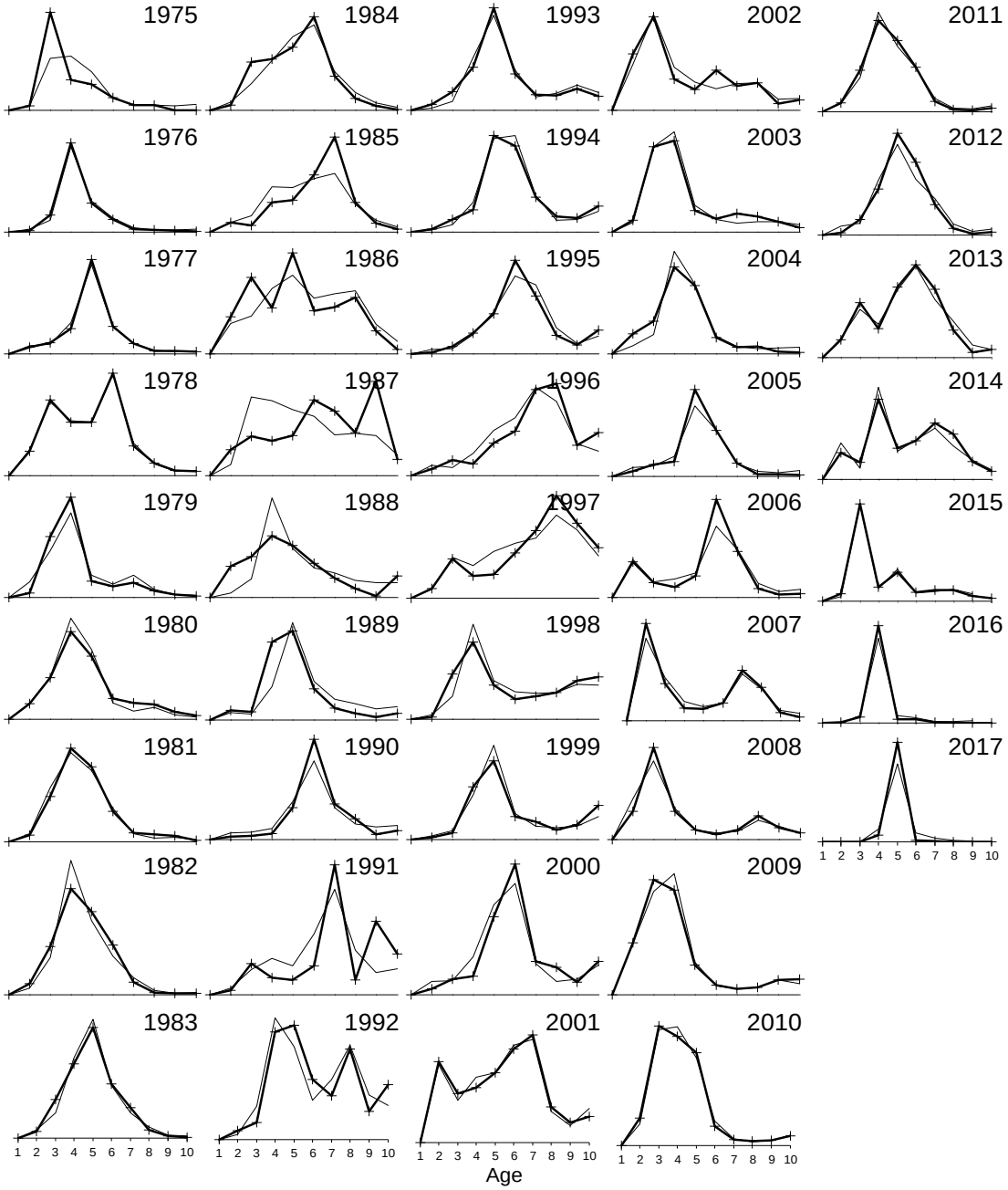
Model 18.1--Net-selectivity corrected acoustic estimates, age-1 and age-2 indices for 2009-2018 Shelikof + Shumagin.

Model 18.2--Same as 18.1, but age-1 and age-2 indices for 2008-2018 Shelikof only.

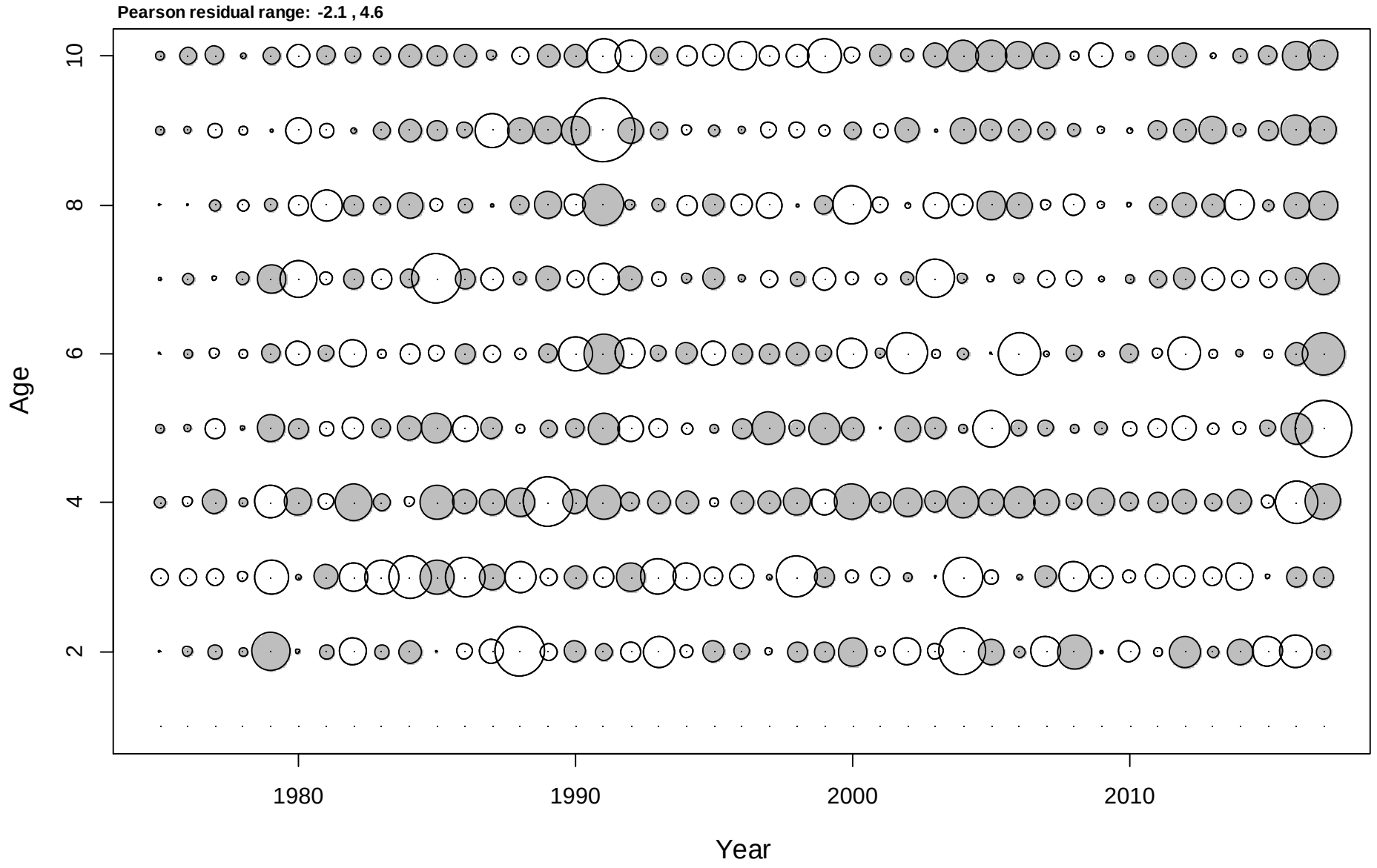
Model 18.3--Same as 18.2, but without a power term for age-1 index.

	Model 17.2 last year	*Model 17.2 new data*	*Model 18.1*	*Model 18.2*	*Model 18.3*
Model fits					
Total log(Likelihood)	-312.18	-342.15	-333.19	-333.04	-333.33
Catch	-0.07	-0.08	-0.08	-0.08	-0.08
Fishery age	-96.98	-105.39	-104.46	-104.47	-104.36
Acoustic survey biomass	-35.93	-40.20	-40.03	-40.00	-40.07
Age-1 and age-2 indices	-17.25	-11.91	-2.77	-2.42	-2.49
Acoustic survey age	-27.57	-34.16	-34.62	-34.64	-34.53
Bottom trawl survey biomass	-8.51	-9.06	-9.21	-9.23	-9.22
Bottom trawl survey age and length comp	-20.80	-25.48	-25.67	-25.73	-25.99
ADFG trawl survey biomass	-30.90	-35.95	-36.04	-36.13	-36.14
ADFG trawl survey age	-23.52	-32.68	-32.78	-32.75	-32.85
Summer acoustic biomass	-2.34	-1.78	-1.76	-1.74	-1.75
Summer acoustic age and length comp.	-5.48	-2.56	-2.58	-2.64	-2.56
Priors/Penalties	-42.85	-42.88	-43.20	-43.21	-43.28
Composition data					
Fishery age comp. effective N	90	76	77	77	78
Shelikof Strait acoustic age comp. effective N	10	11	11	11	11
NMFS bottom trawl age comp. effective N	23	18	18	18	18
ADF&G trawl age comp. effective N	30	18	18	18	18
Survey abundance					
Shelikof Strait Acoustic RMSE					
EK500	0.35	0.36	0.36	0.36	0.36
Age-1 index	1.37	1.19	0.64	0.58	0.62
Age-2 index	1.49	1.13	0.94	0.83	0.81
NMFS bottom trawl RMSE	0.31	0.34	0.34	0.34	0.34
ADFG trawl RMSE	0.36	0.37	0.37	0.37	0.37
Summer acoustic RMSE	0.31	0.27	0.27	0.27	0.27
Catchability estimates					
NMFS trawl	0.87	0.85	0.85	0.85	0.85
Shelikof Strait acoustic					
3+ Biomass	0.63	0.61	0.61	0.61	0.61
Age-1 index linear term	0.08	0.31	0.81	0.53	0.63
Age-1 index power term	1.21	0.30	0.28	0.20	0.00
Age-2 index	1.03	1.15	0.98	0.87	0.95
Summer acoustic	1.03	0.82	0.83	0.82	0.82
ADFG trawl	0.68	0.64	0.64	0.64	0.64
Stock status (t)					
2018 Spawning biomass	342,683	321,620	320,869	322,342	322,564
Depletion (B2018/B0)	58%	58%	58%	58%	58%
$B_{40\%}$	238,000	222,693	222,456	222,835	222,914
2019 yield (t)					
Maximum permissible ABC	113,153	156,065	155,693	156,889	156,523

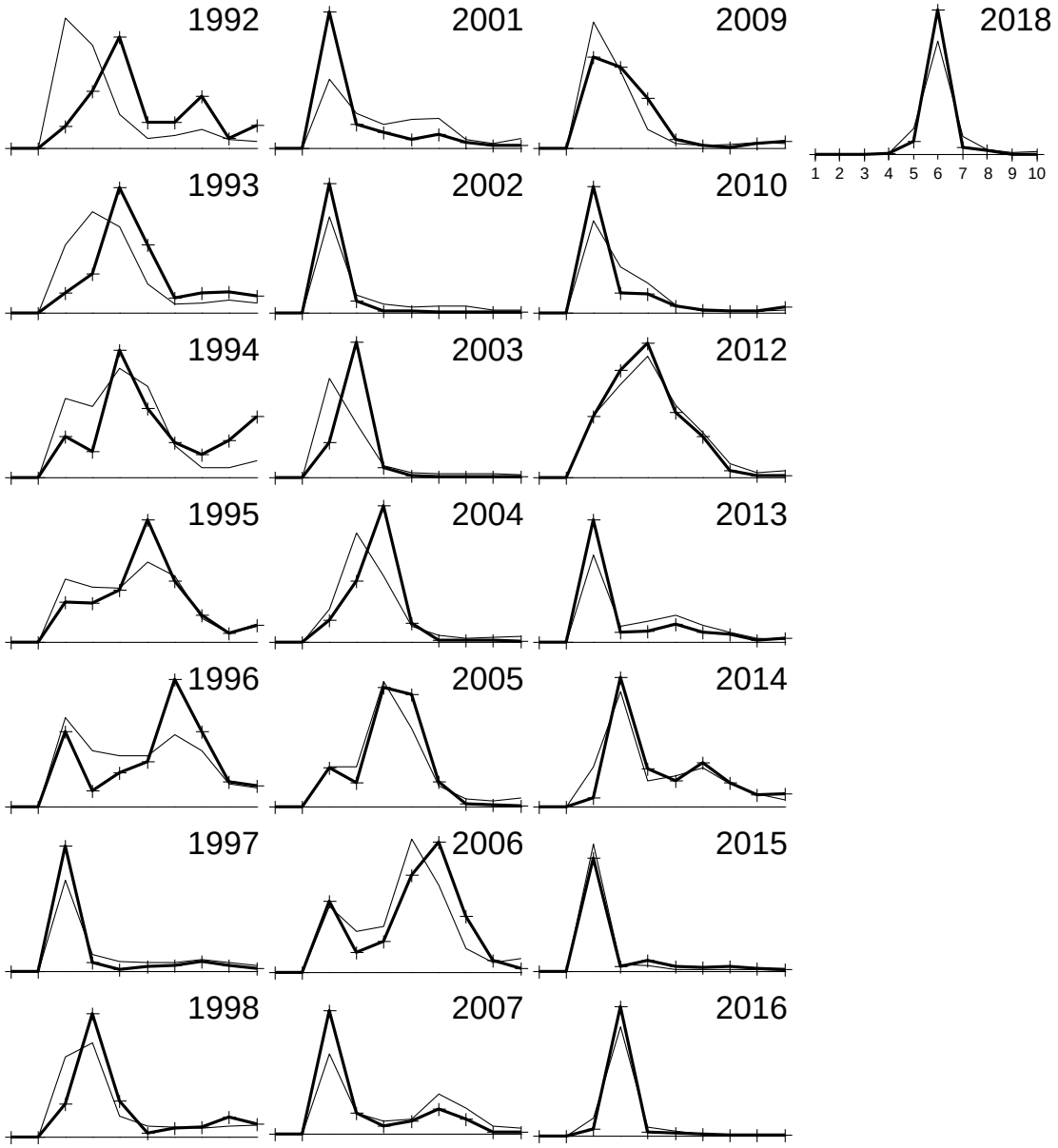
Fishery age composition (predicted vs observed)



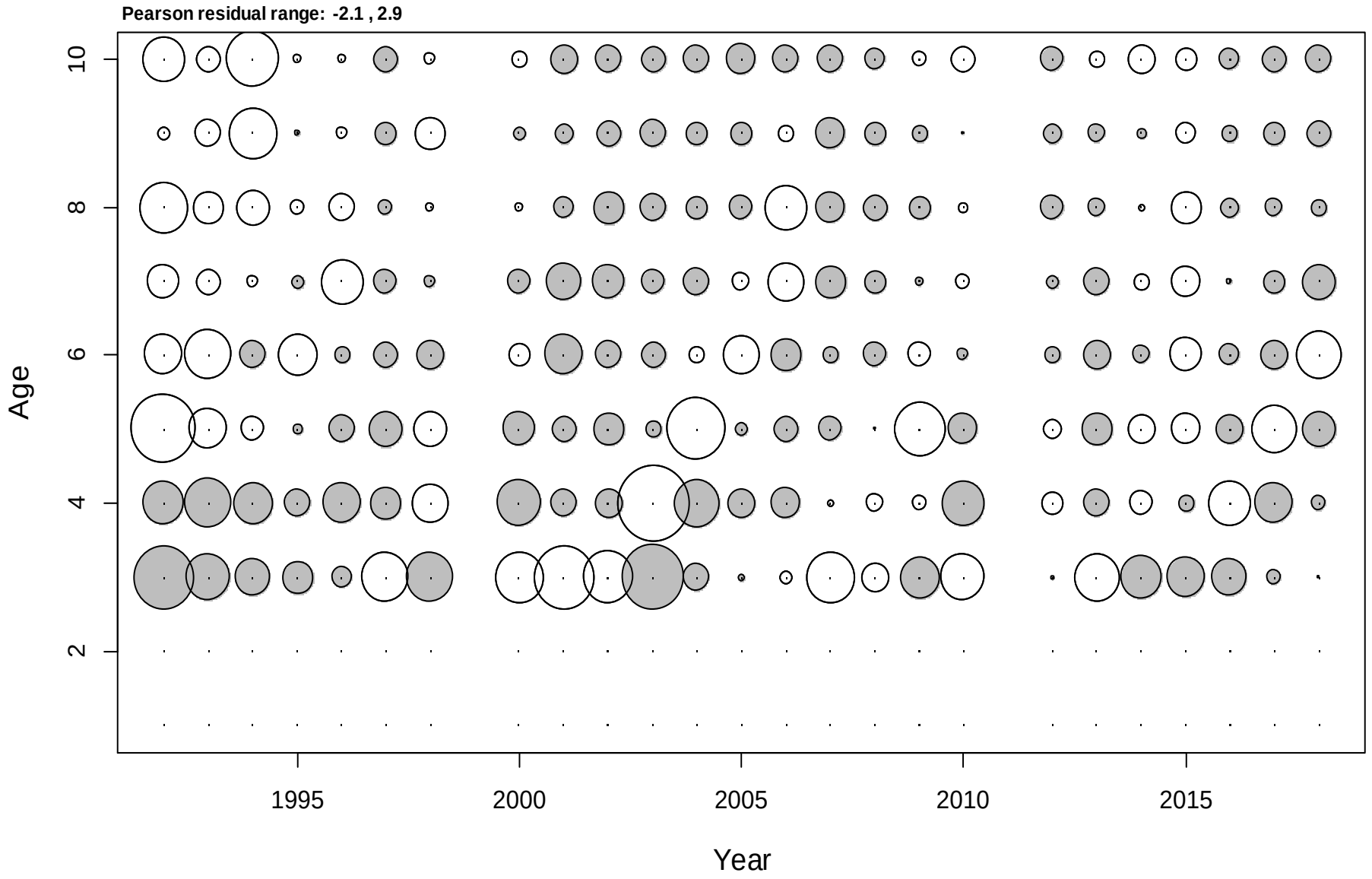
Fishery age composition (residuals)



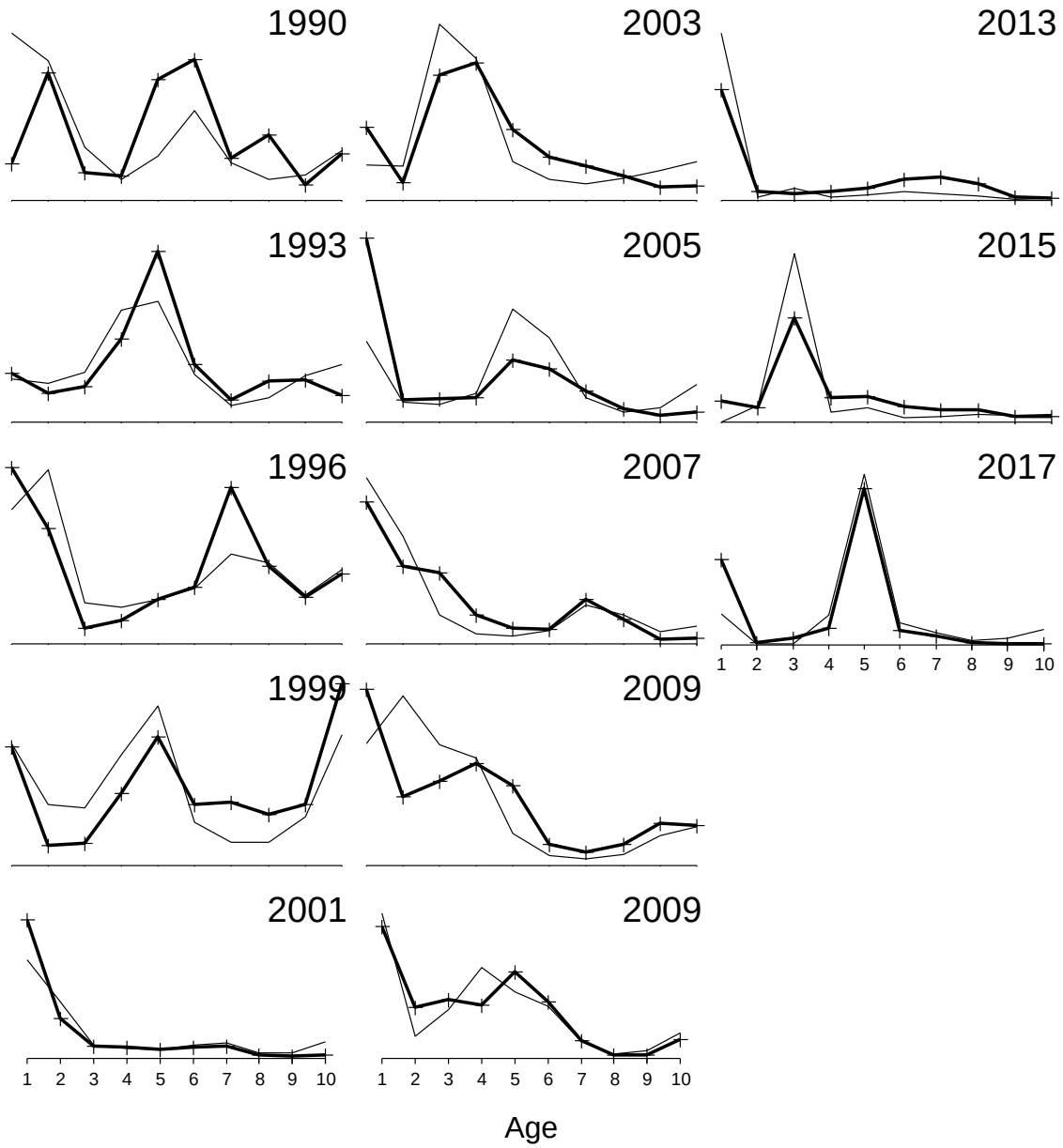
Shelikof Strait EIT age composition (predicted vs observed)



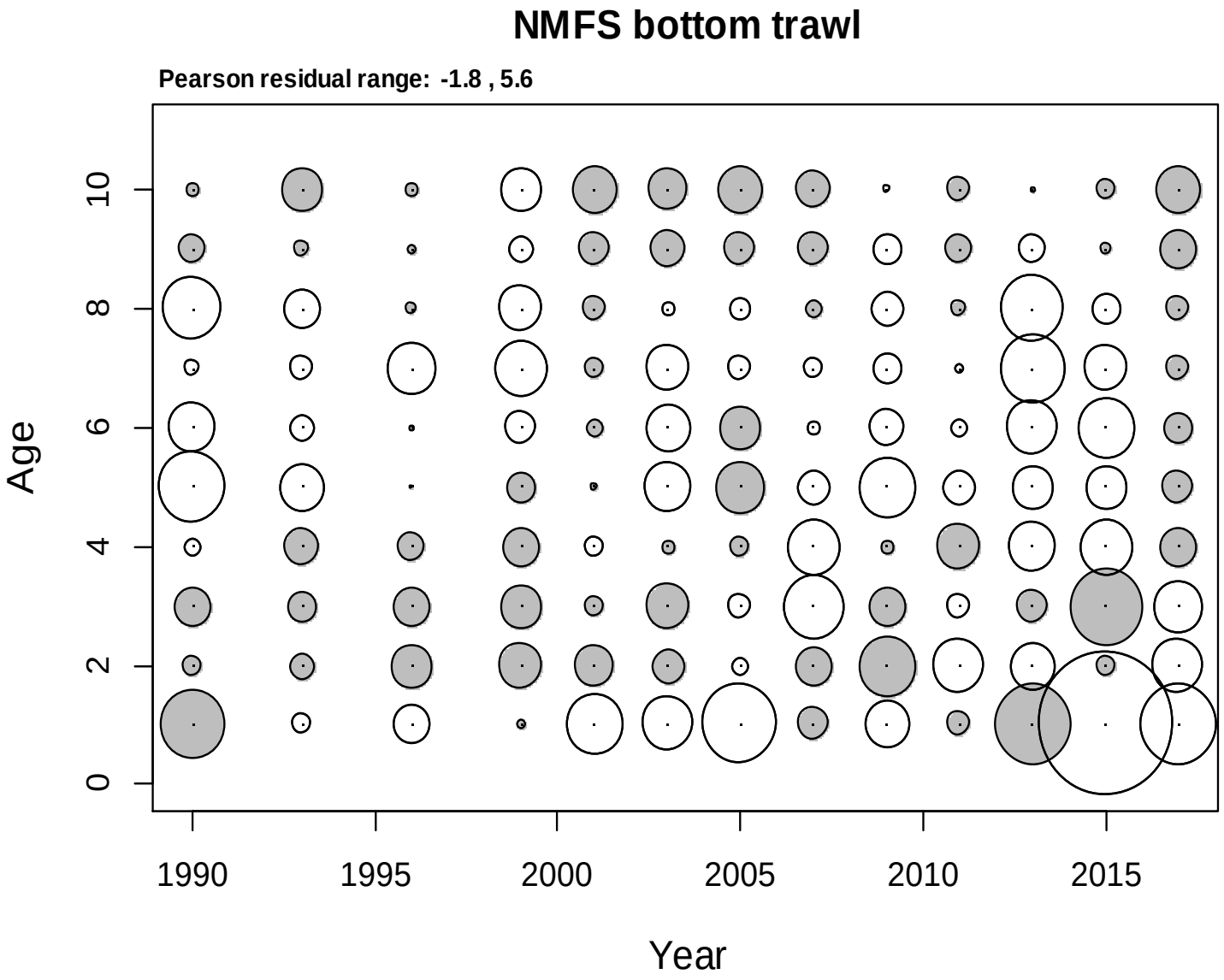
Shelikof Strait EIT age composition (residuals)



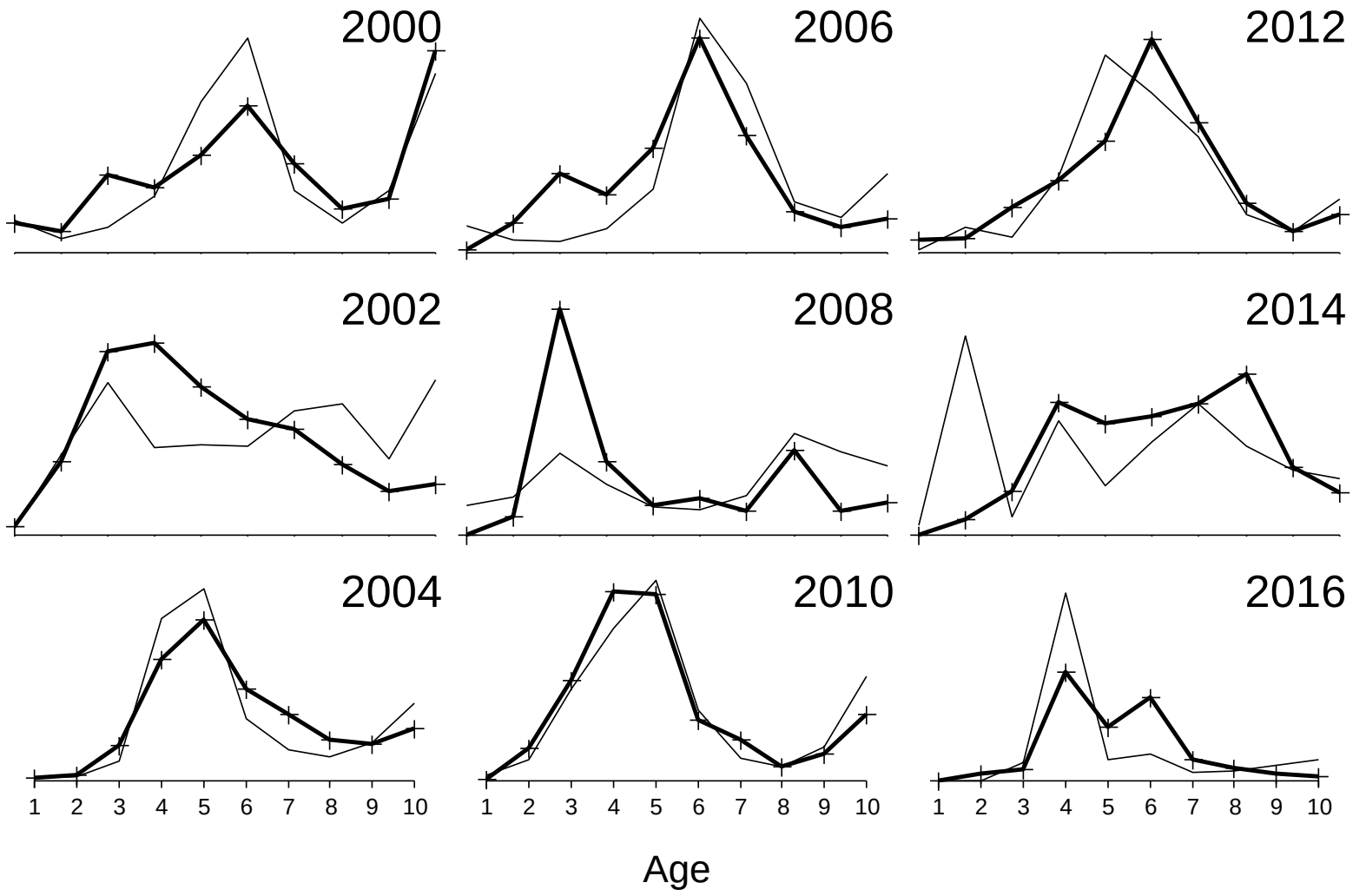
NMFS bottom trawl age composition (predicted vs observed)



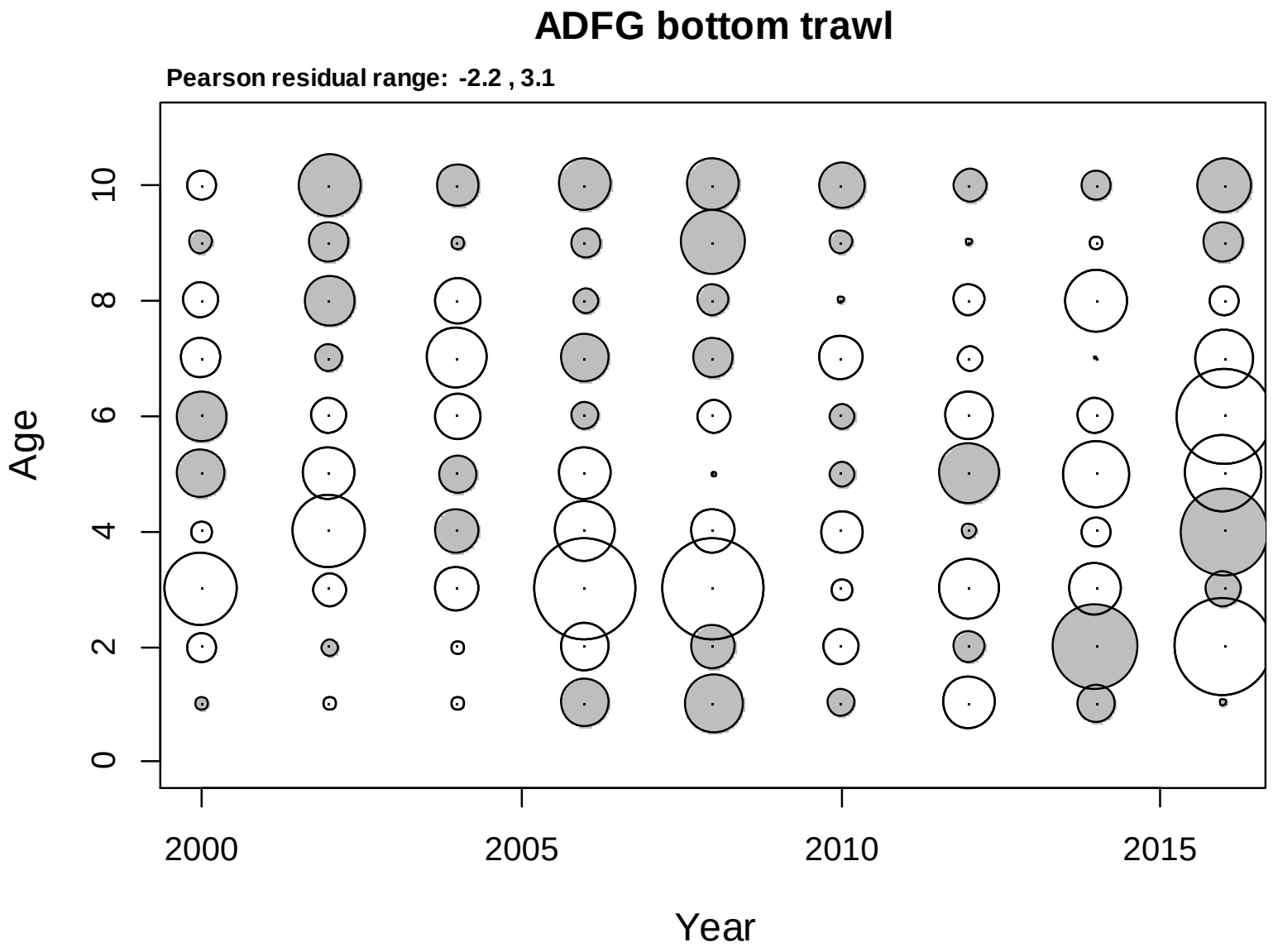
NMFS bottom trawl age composition (residuals)



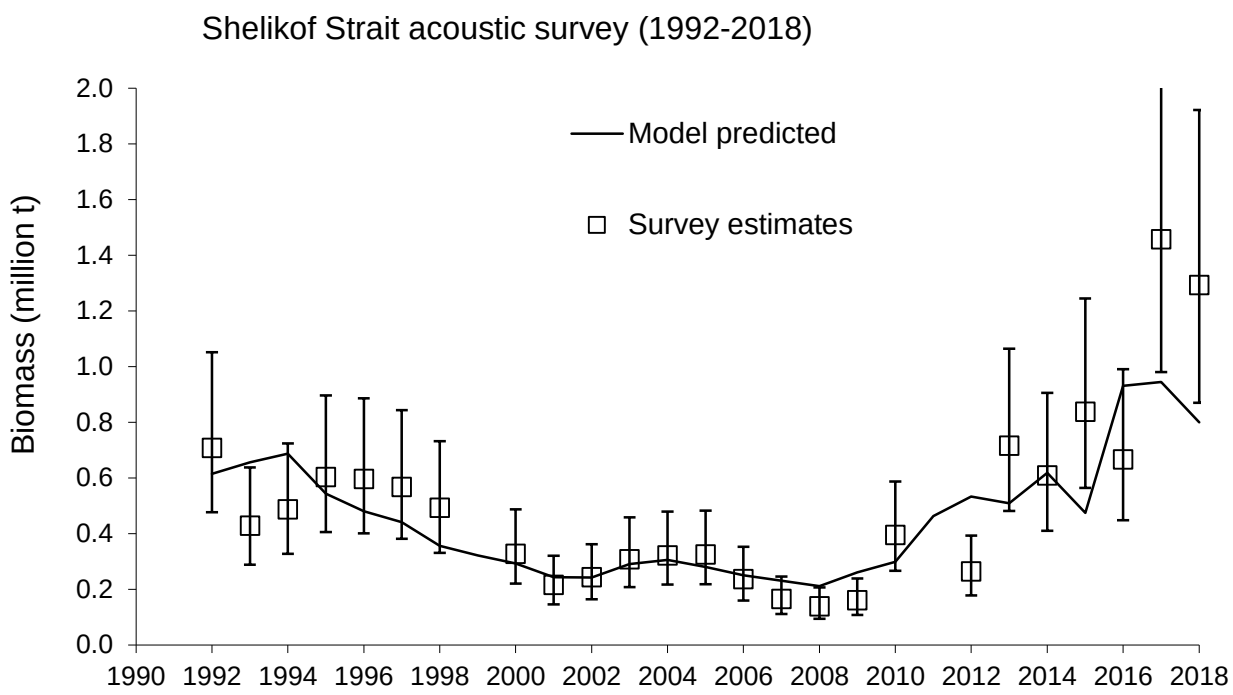
ADFG bottom trawl age composition (predicted vs observed)



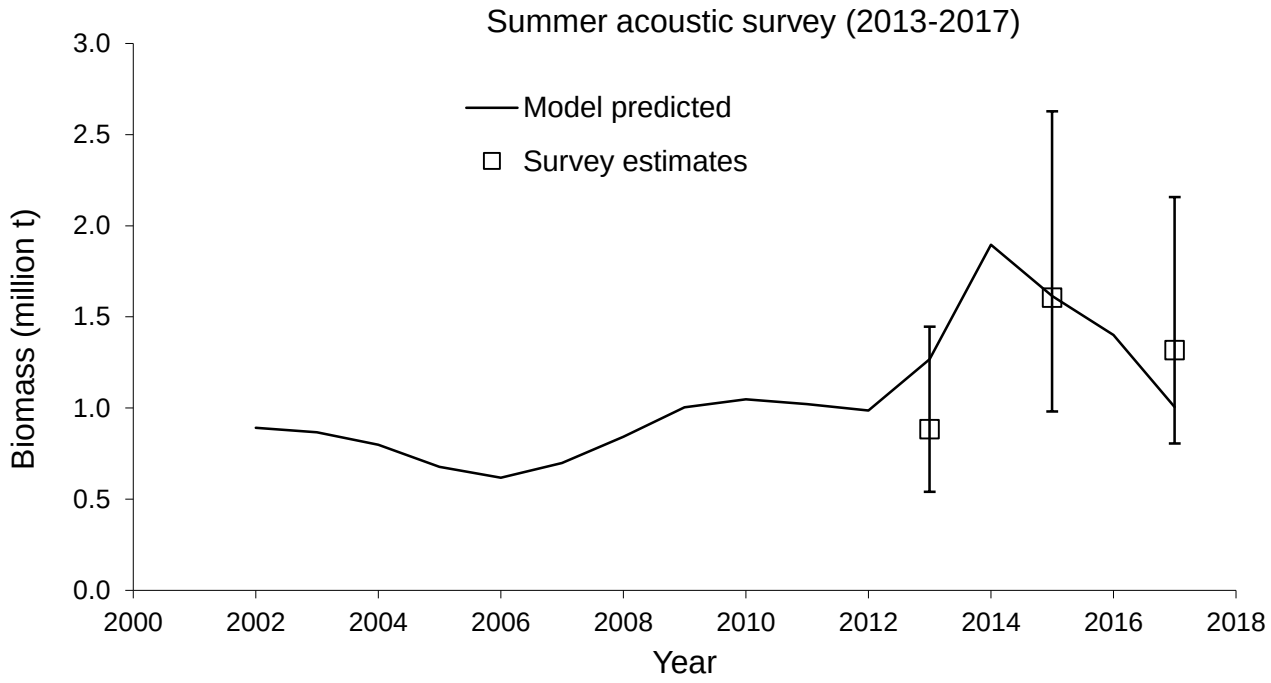
ADFG bottom trawl age composition (residuals)



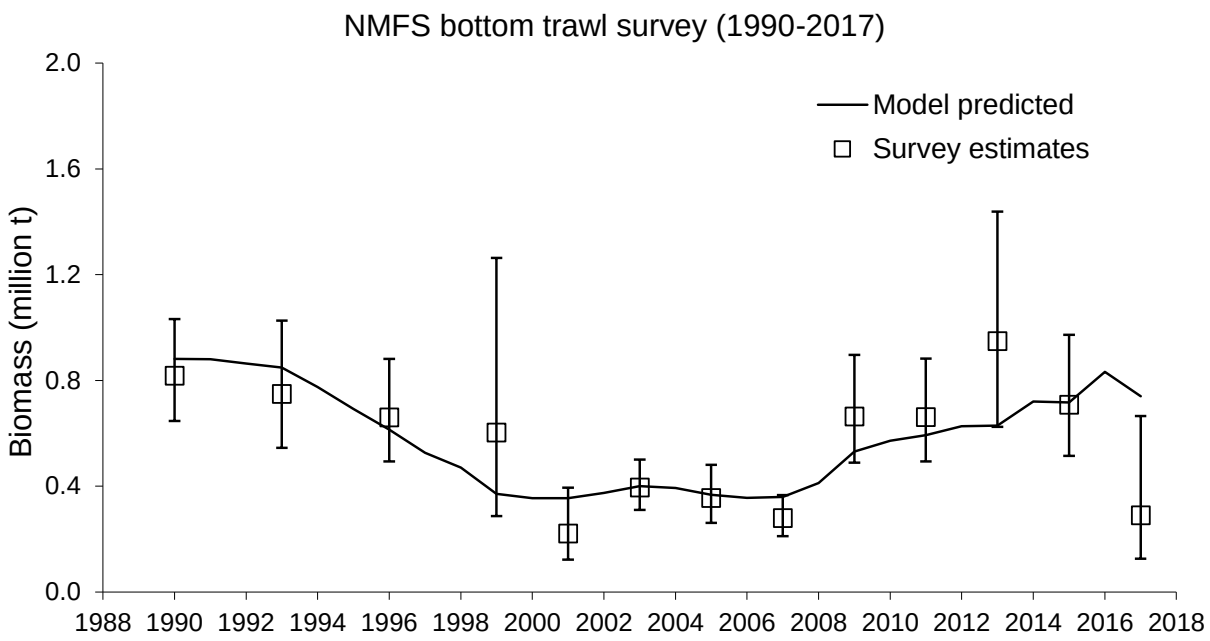
Fit to Shelikof Strait acoustic survey



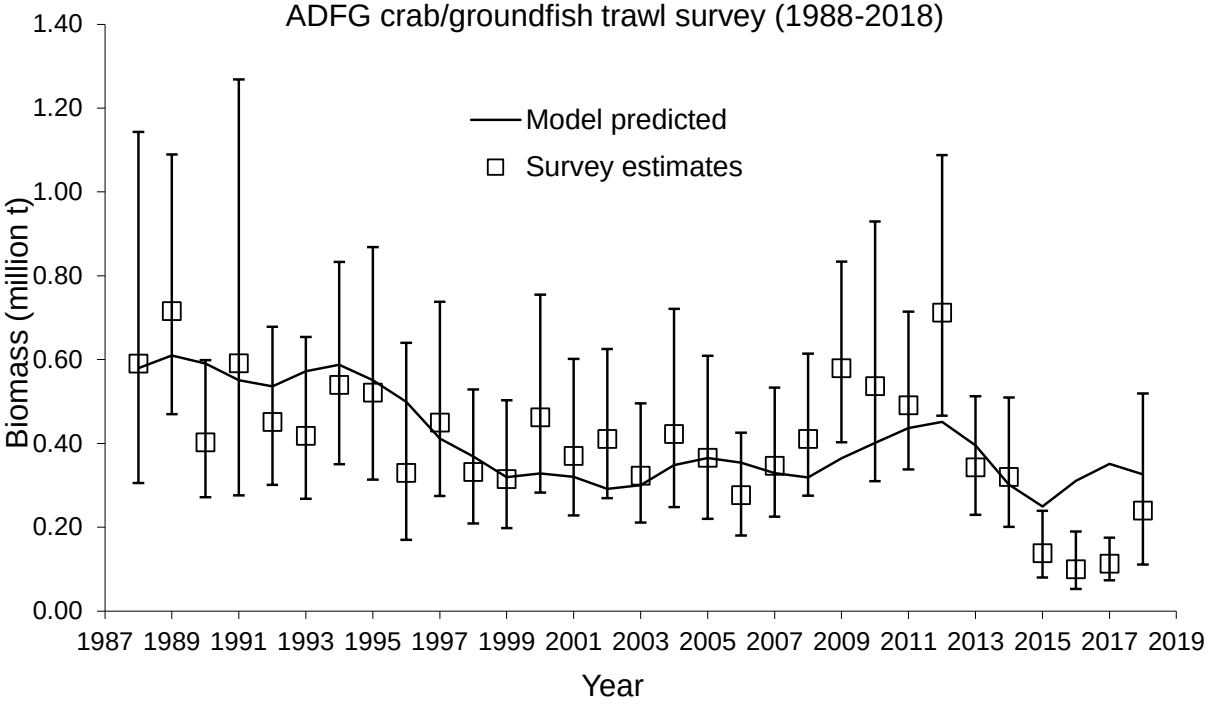
Fit to summer Acoustic survey



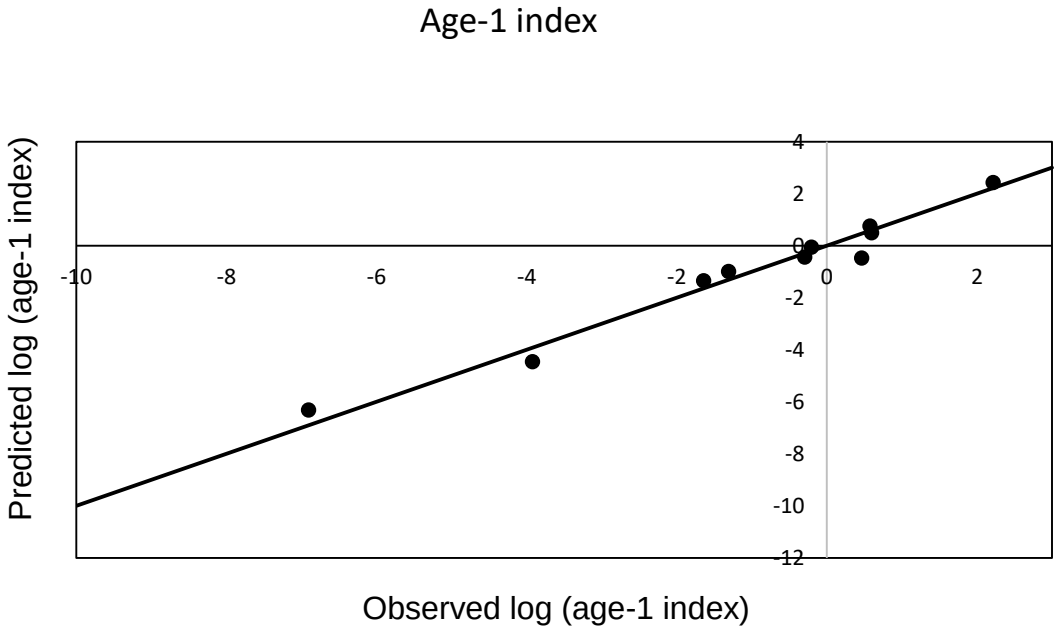
Fit to NMFS bottom trawl survey



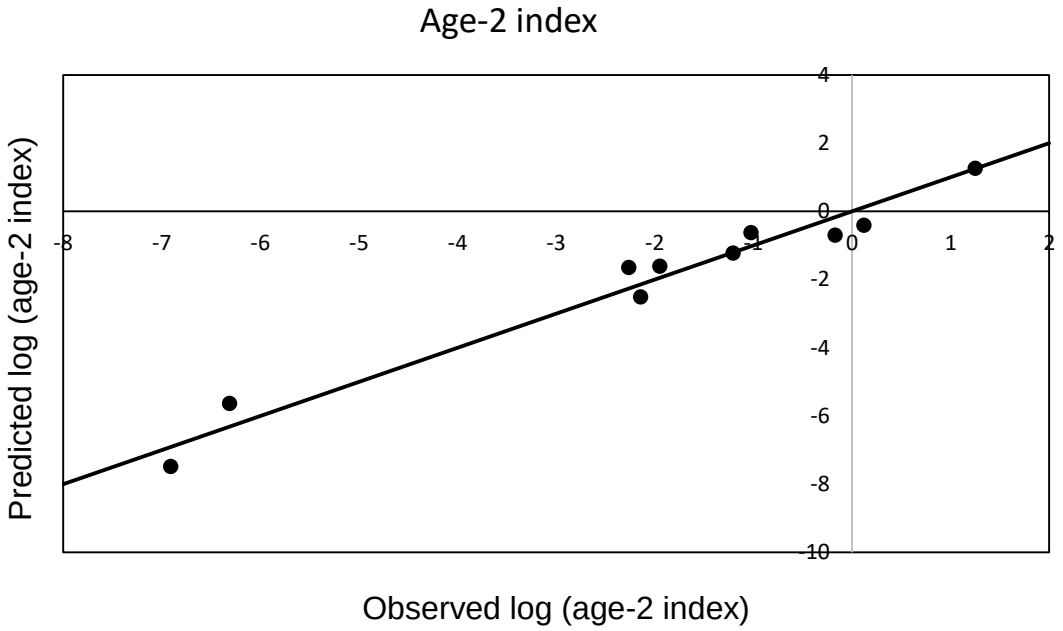
Fit to ADFG survey



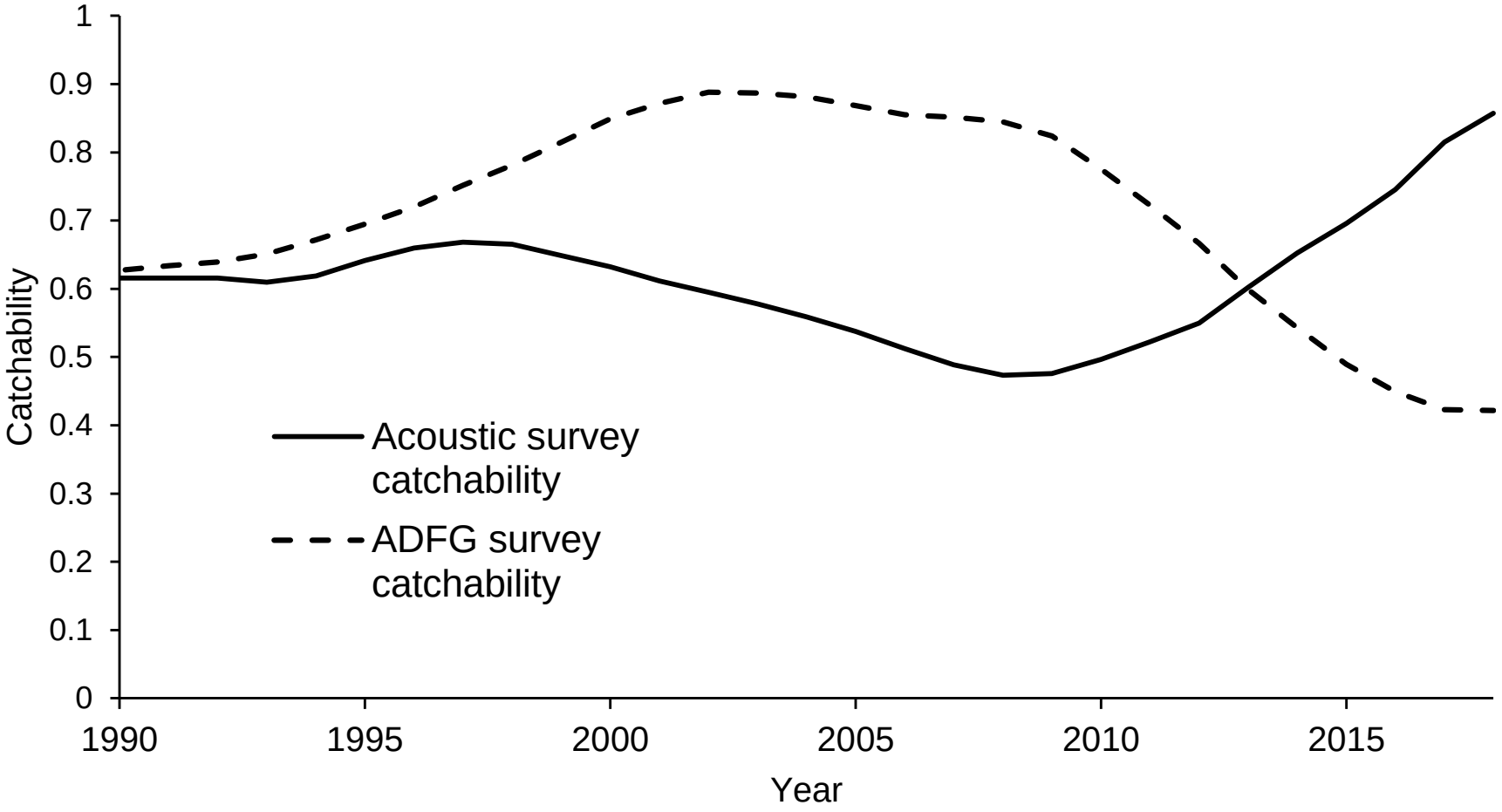
Fit to Age-1 index



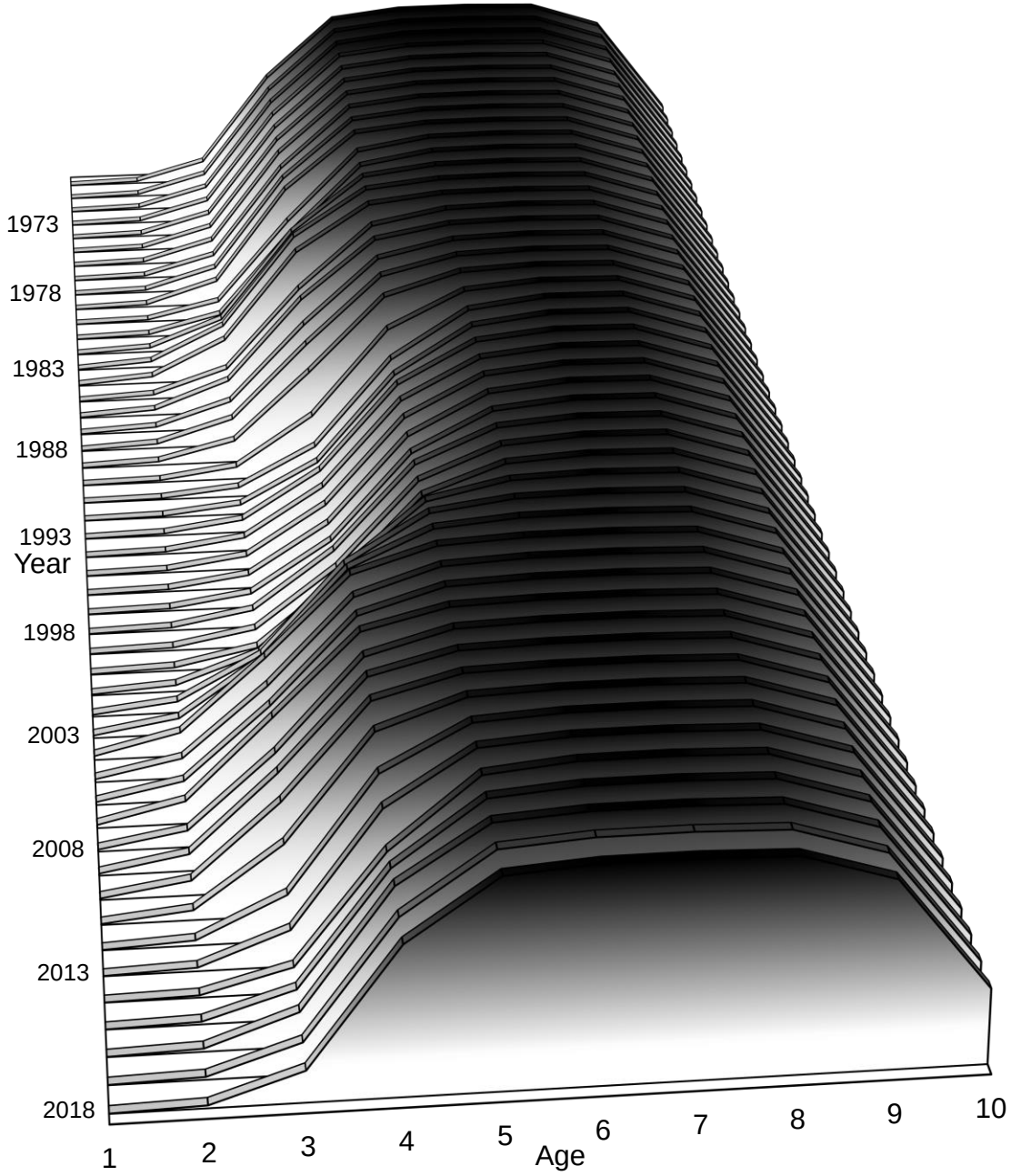
Fit to Age-2 index



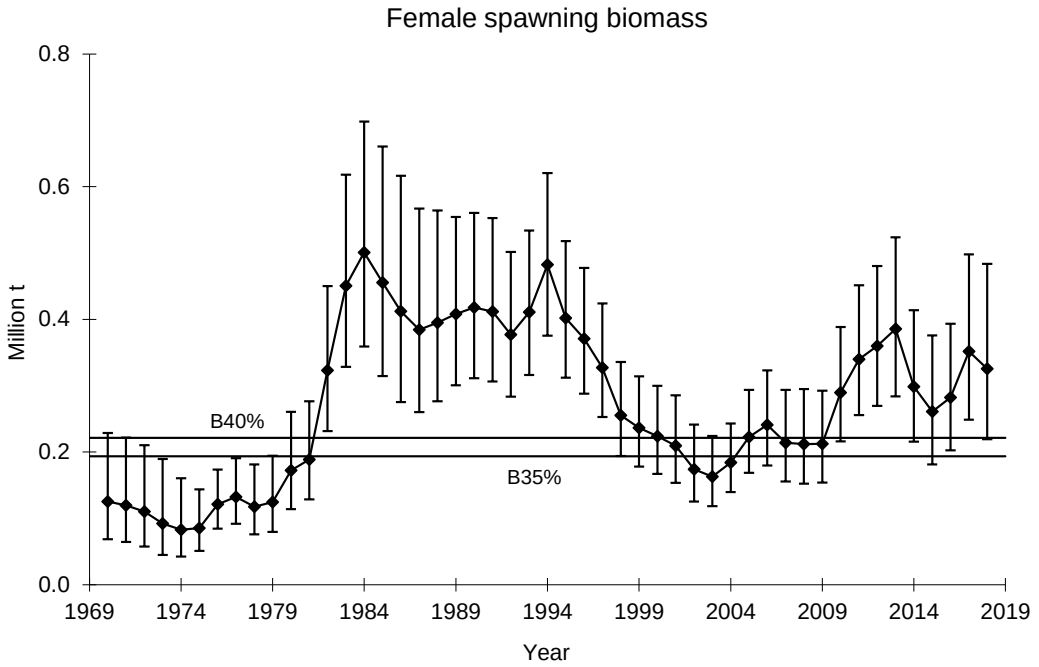
Random walk in catchability for Shelikof Strait survey and ADFG survey



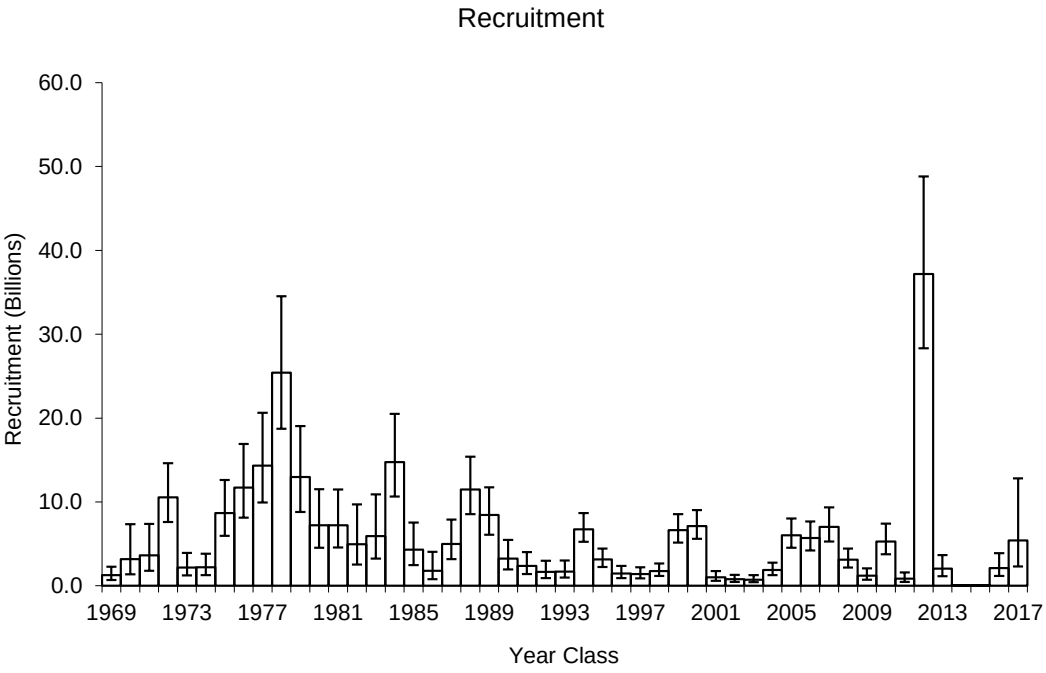
Fishery selectivity



Spawning biomass

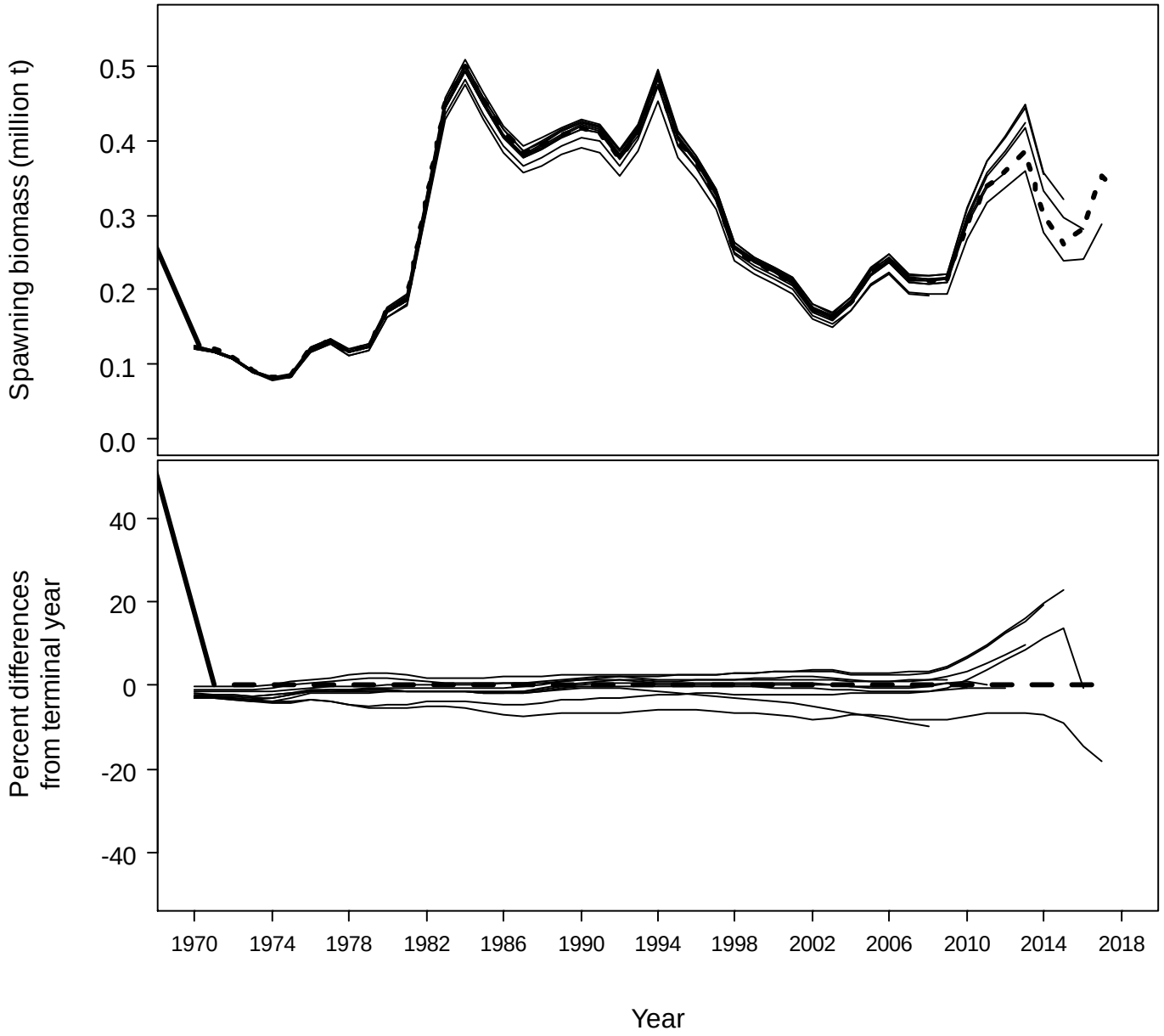


Recruitment

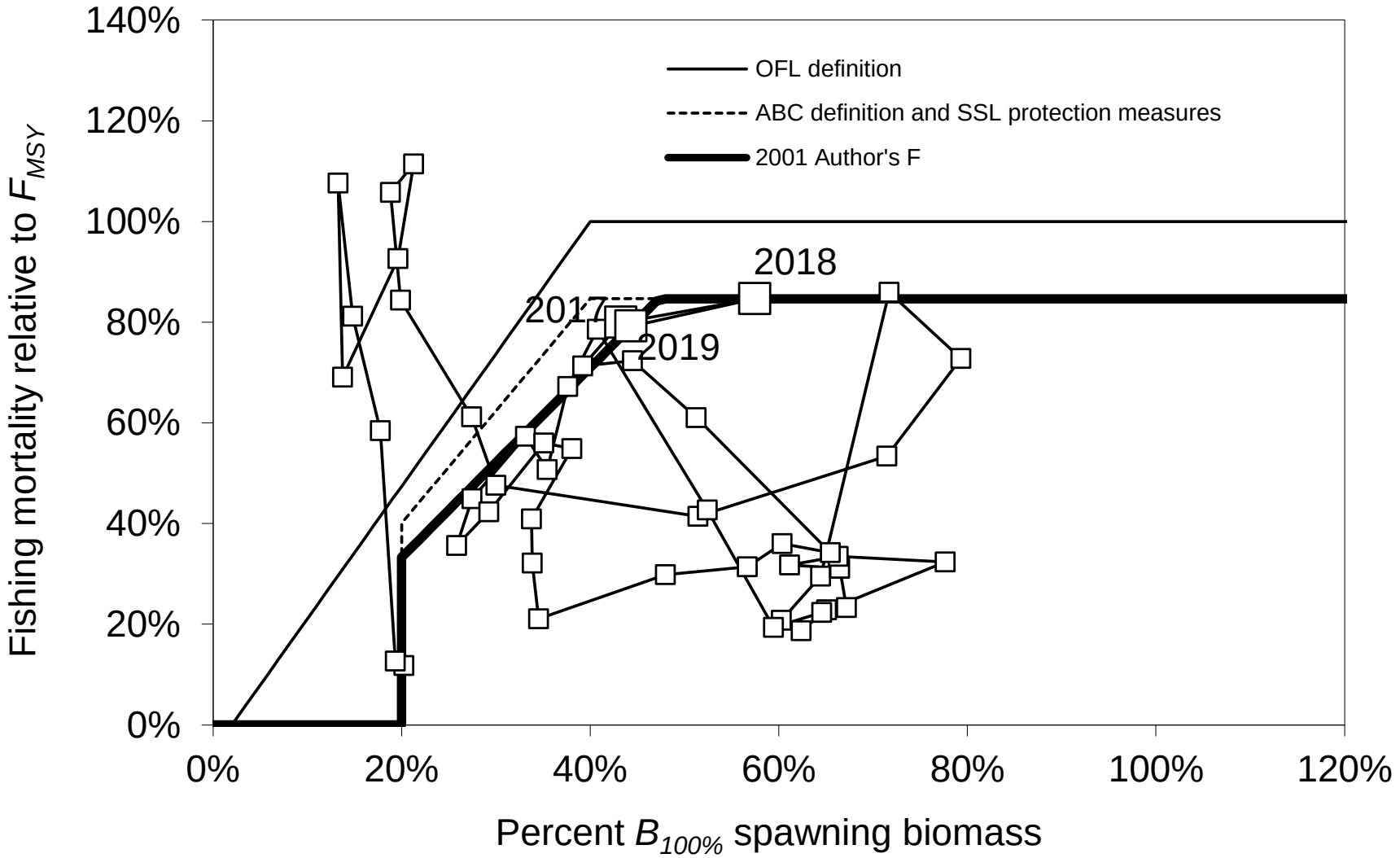


Retrospective plot

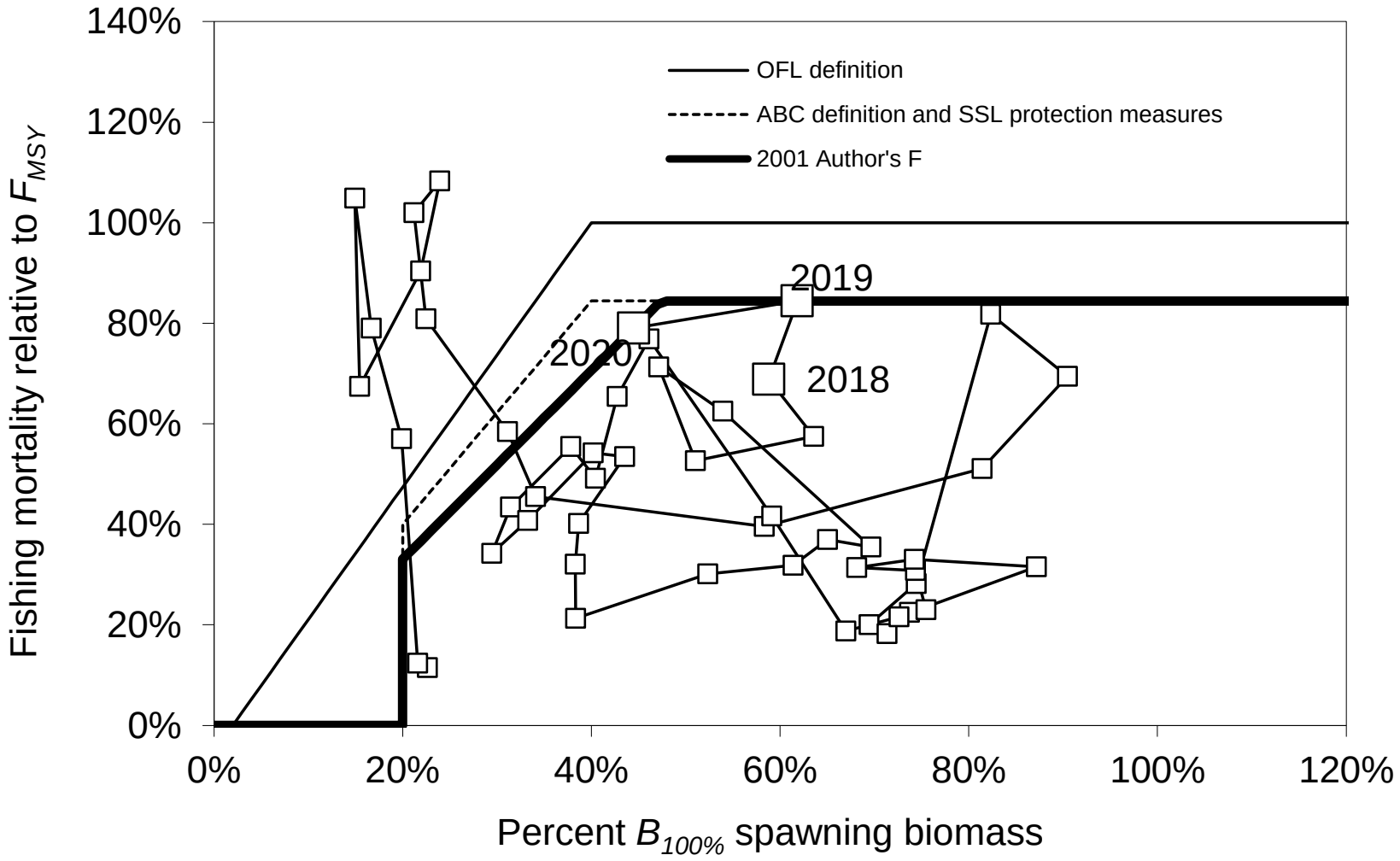
Mohn's ρ = 0.024



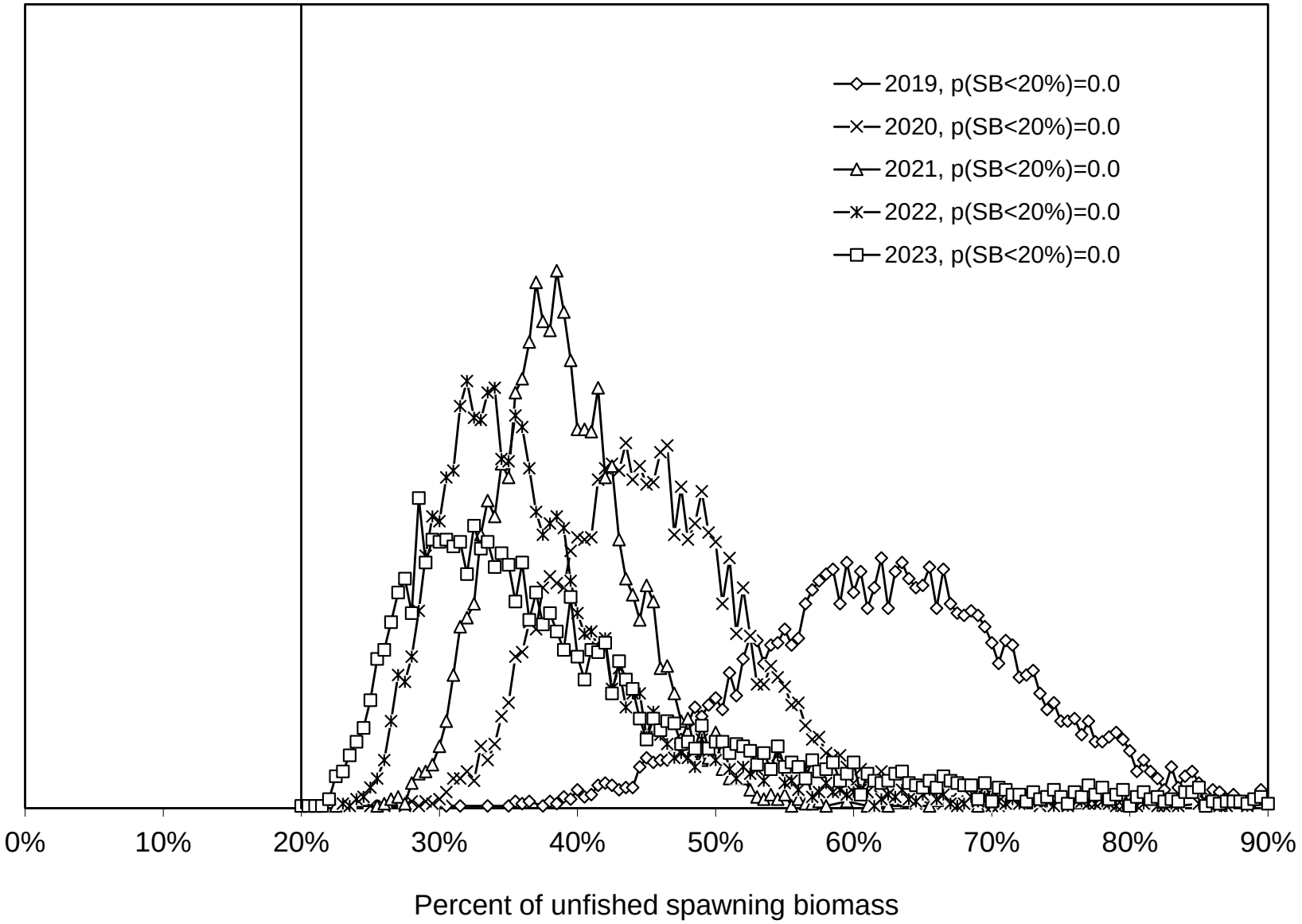
Spawning biomass vs fishing mortality (last year)



Spawning biomass vs fishing mortality (this year)

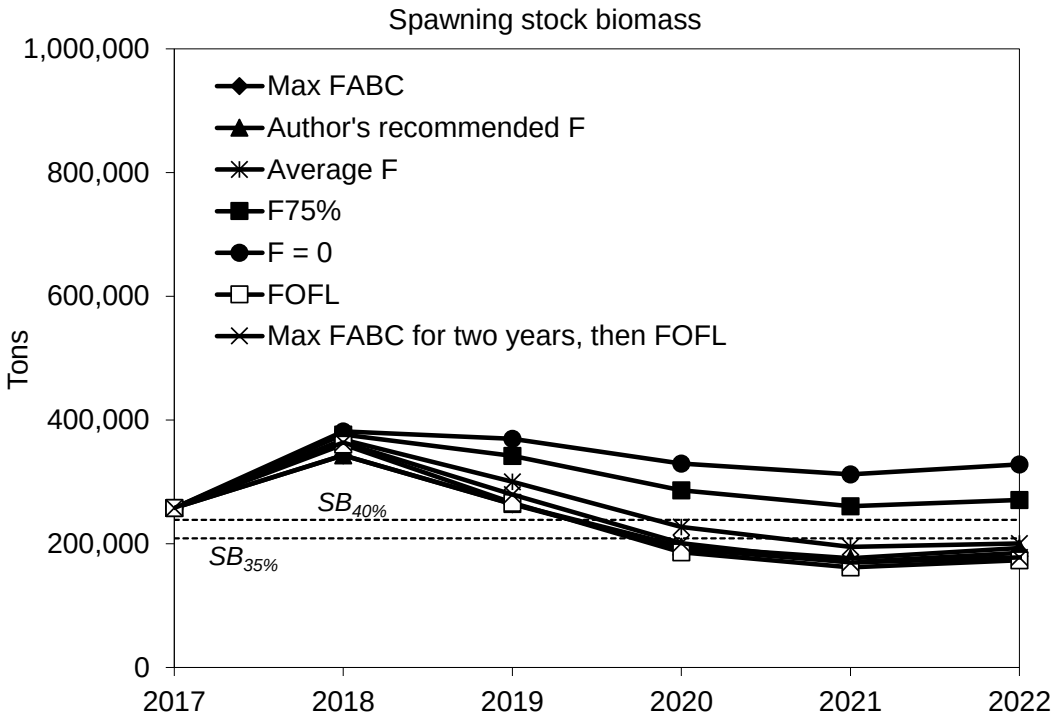


5-year pr(SB<B20%)

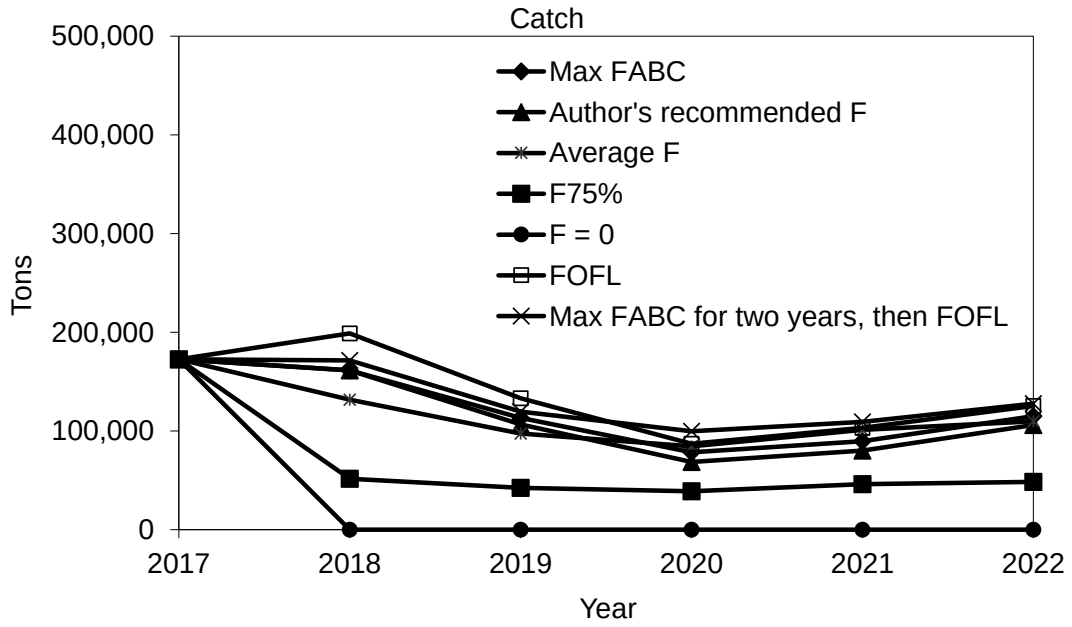


5-year projections

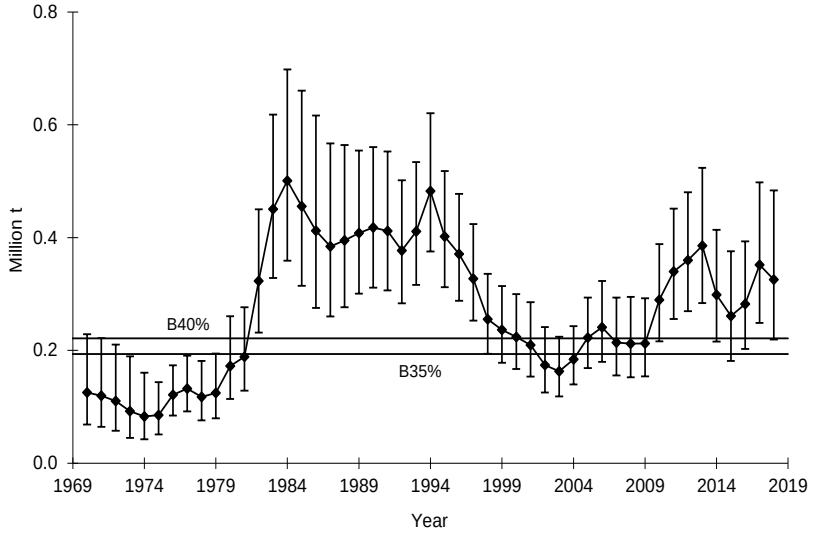
Mean spawning biomass



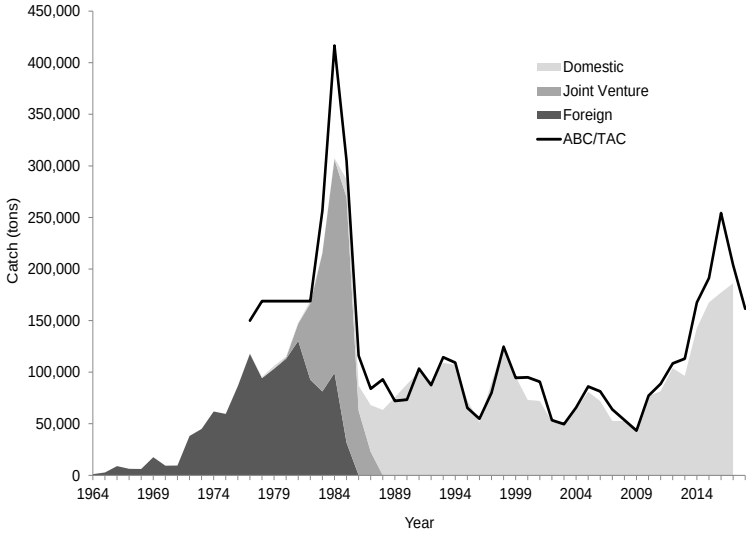
Mean yield



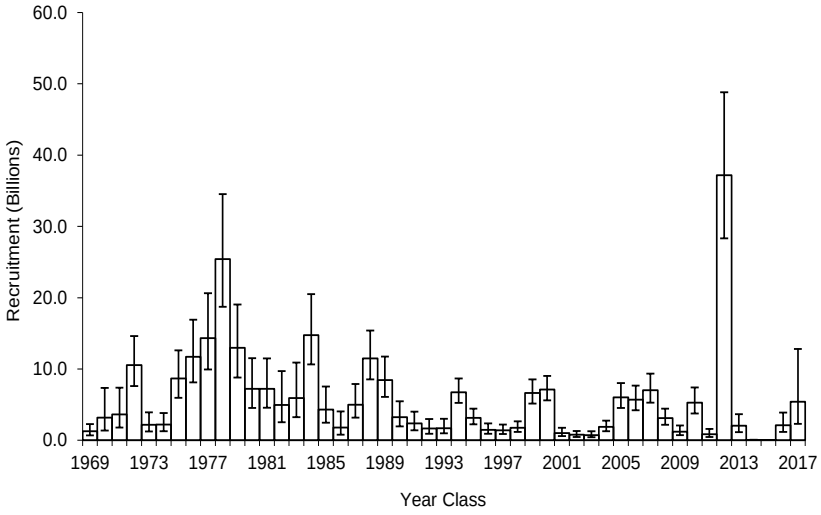
Spawning biomass



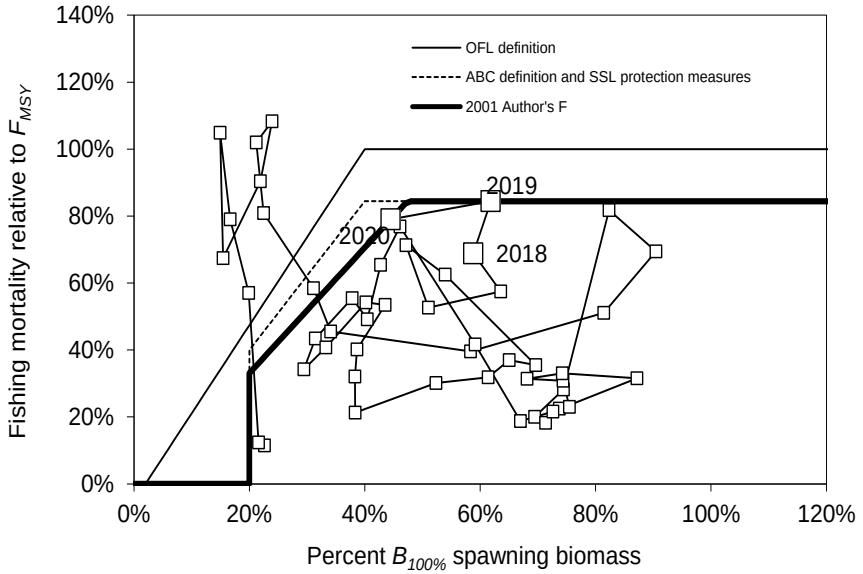
Catch



Recruitment



Status phase plot

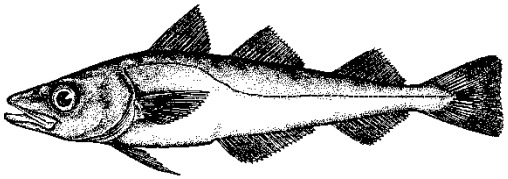


Summary table

Quantity/Status	As estimated or specified *last* year for 2018	2019	As estimated or recommended *this* year for 2019	2020
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass (t)	1,124,930	804,586	1,126,750	1,068,760
Female spawning biomass (t)	342,683	264,349	345,352	257,794
$B_{100\%}$	596,000	596,000	553,000	553,000
$B_{40\%}$	238,000	238,000	221,000	221,000
$B_{35\%}$	209,000	209,000	194,000	194,000
F_{OFL}	0.30	0.30	0.32	0.32
$maxF_{ABC}$	0.26	0.26	0.27	0.27
F_{ABC}	0.26	0.24	0.22	0.22
OFL (t)	187,059	131,170	194,230	148,968
maxABC (t)	161,492	113,153	158,518	123,870
ABC (t)	161,492	106,568	134,740	105,290

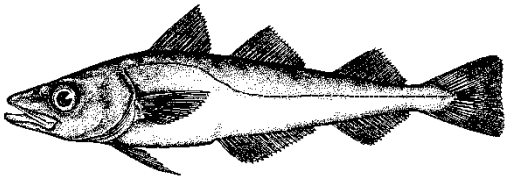
Status	As determined *last* year for 2016	2017	As determined *this* year for 2017	2018
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Gulf of Alaska pollock
Risk Matrix Criteria



	Assessment-related considerations	**Population dynamics considerations**	**Environmental/ecosystem considerations**
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals but the pattern is not consistent across all indicators.
Level 3: Major Concern	Major problems with the stock assessment, very poor fits to data, high level of uncertainty, strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock)
Level 4: Extreme concern	Severe problems with the stock assessment, severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented. More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock. Potential for cascading effects on other ecosystem components

Gulf of Alaska pollock
Risk Matrix Evaluation



Assessment-related considerations	**Population dynamics considerations**	**Environmental/ecosystem considerations**
Contradictory data, very poor model fits to recent survey indices. But model seems robust, no retrospective pattern.	Stock dominated by a single year class, Four years of very weak recruitment. There have been similar patterns in the past, but never this extreme.	Onset of a marine heatwave and projections of a weak El Niño are not conducive for winter survival for age-0 pollock. Zooplankton prey for adult pollock has increased, but planktivorous parakeet auklets in the central GOA had poor reproductive success in 2018
Conclusion: Level 2, substantially increased concerns	**Conclusion: Level 2: substantially increased concerns**	**Conclusion: Level 2: substantially increased concerns**

Overall score is Level 2: Substantially increased concerns. Author's recommended ABC = 85% of maximum permissible (15% buffer) based on mode of historical buffers.

Winter apportionment table (example calculations for one area)

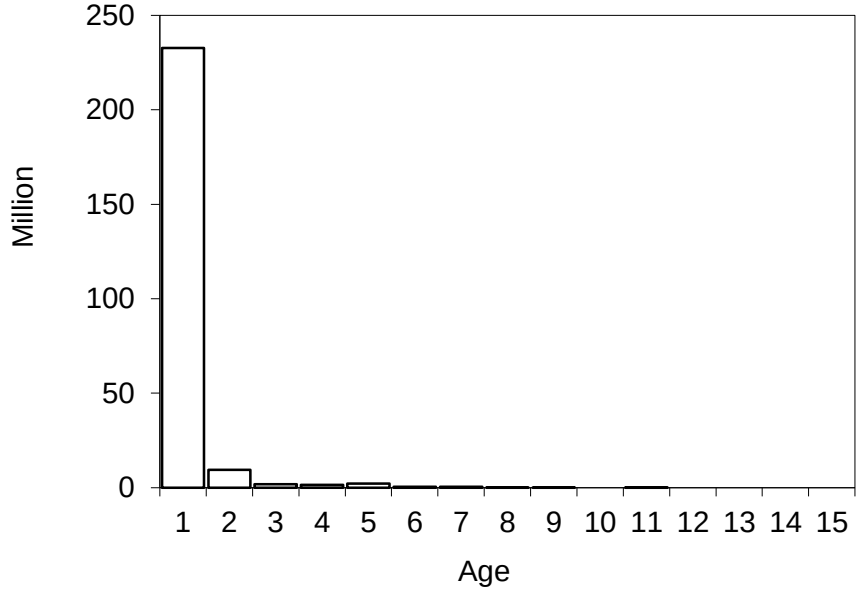
Survey	*Year*	*Model estimates of total 2+ biomass at spawning*	*Survey biomass estimate*	*Percent*	*Percent by management area*		
					Area 610	*Area 620*	*Area 630*
Shelikof	2015	1,491,680	847,542	56.8%	0.0%	91.9%	8.1%
Shelikof	2016	1,350,790	666,801	49.4%	0.0%	79.3%	20.7%
Shelikof	2017	1,070,970	1,457,295	136.1%	0.0%	99.1%	0.9%
Shelikof	2018	801,084	1,306,107	163.0%	0.0%	93.9%	6.1%
Shelikof	Average			101.3%	0.0%	91.1%	8.9%
	Percent of total biomass				0.0%	92.3%	9.1%

Winter apportionment table

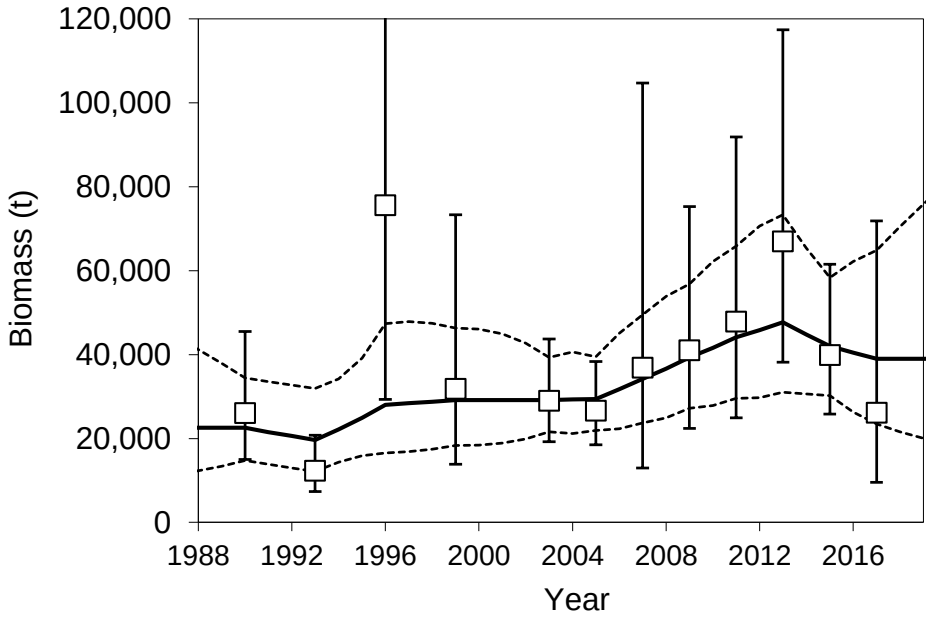
Survey	Year	Model estimates of total 2+ biomass at spawning	Survey biomass estimate	Percent	Percent by management area: Area 610	Area 620	Area 630
Shelikof	Average			101.3%	0.0%	91.1%	8.9%
	Percent of total biomass				0.0%	92.3%	9.1%
Chirikof	Average			2.1%	0.0%	30.9%	69.1%
	Percent of total biomass				0.0%	0.7%	1.5%
Marmot	Average			1.5%	0.0%	0.0%	100.0%
	Percent of total biomass				0.0%	0.0%	1.5%
Shumagin	Average			2.3%	74.6%	25.4%	0.0%
	Percent of total biomass				1.7%	0.6%	0.0%
Sanak	Average			0.4%	100.0%	0.0%	0.0%
	Percent of total biomass				0.4%	0.0%	0.0%
Mozhovoi	Average			0.4%	100.0%	0.0%	0.0%
	Percent of total biomass				0.4%	0.0%	0.0%
Pavlof	Average			0.3%	100.0%	0.0%	0.0%
	Percent of total biomass				0.3%	0.0%	0.0%
Total				108.49%	2.90%	93.52%	12.06%
Rescaled total				100.00%	2.68%	86.20%	11.12%

Southeast Alaska Assessment
(no changes)

2017 age composition

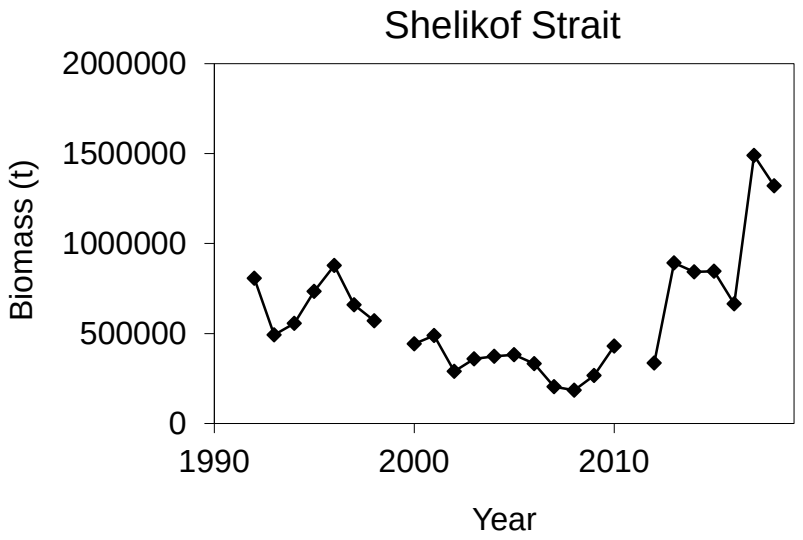


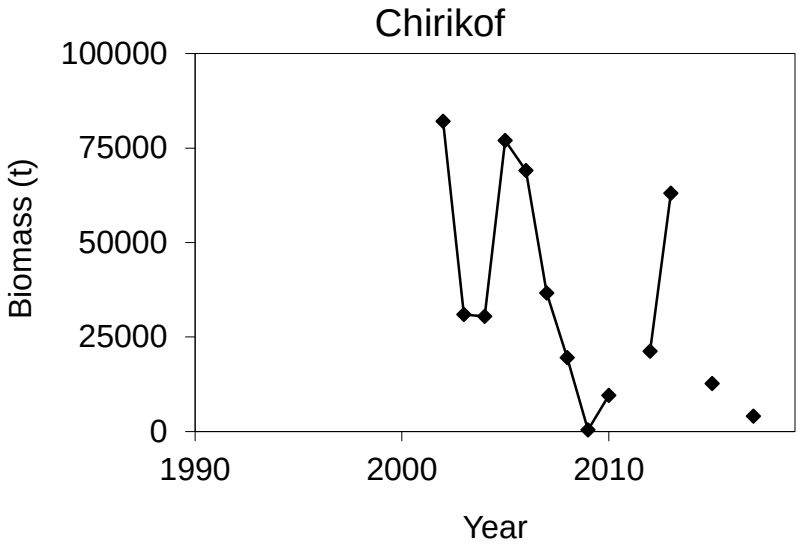
Biomass trend

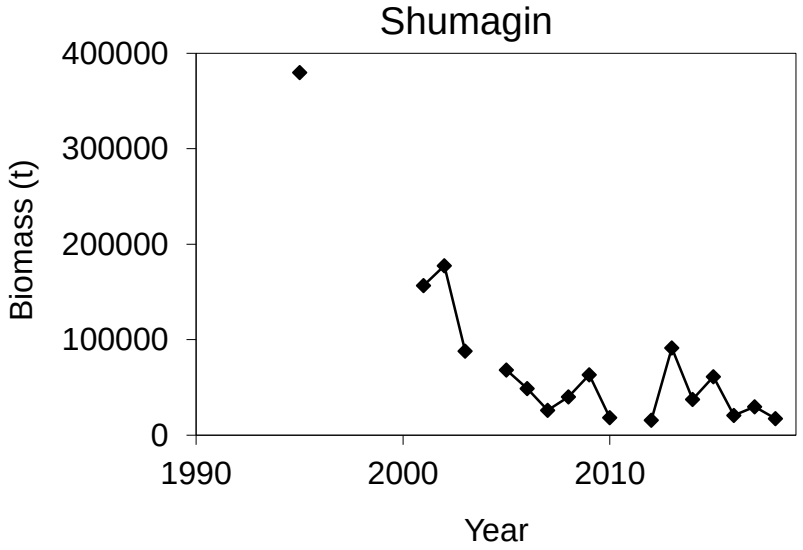


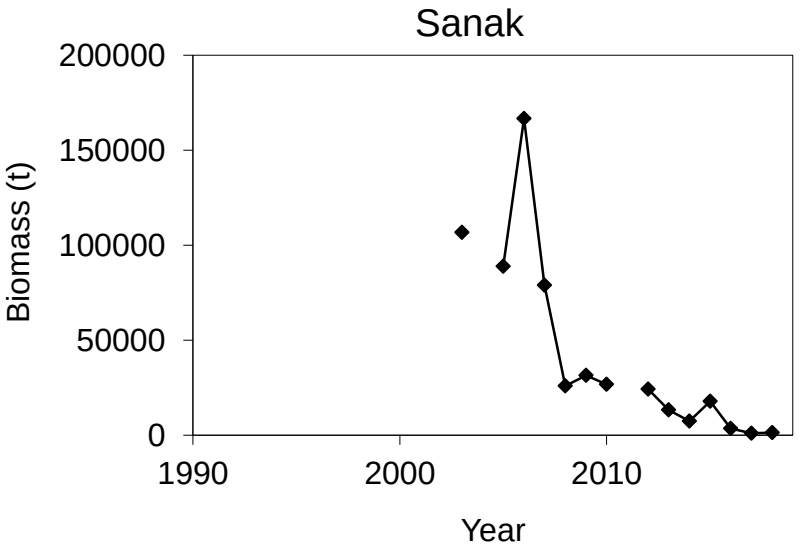
Extras

Acoustic surveys outside Shelikof Strait







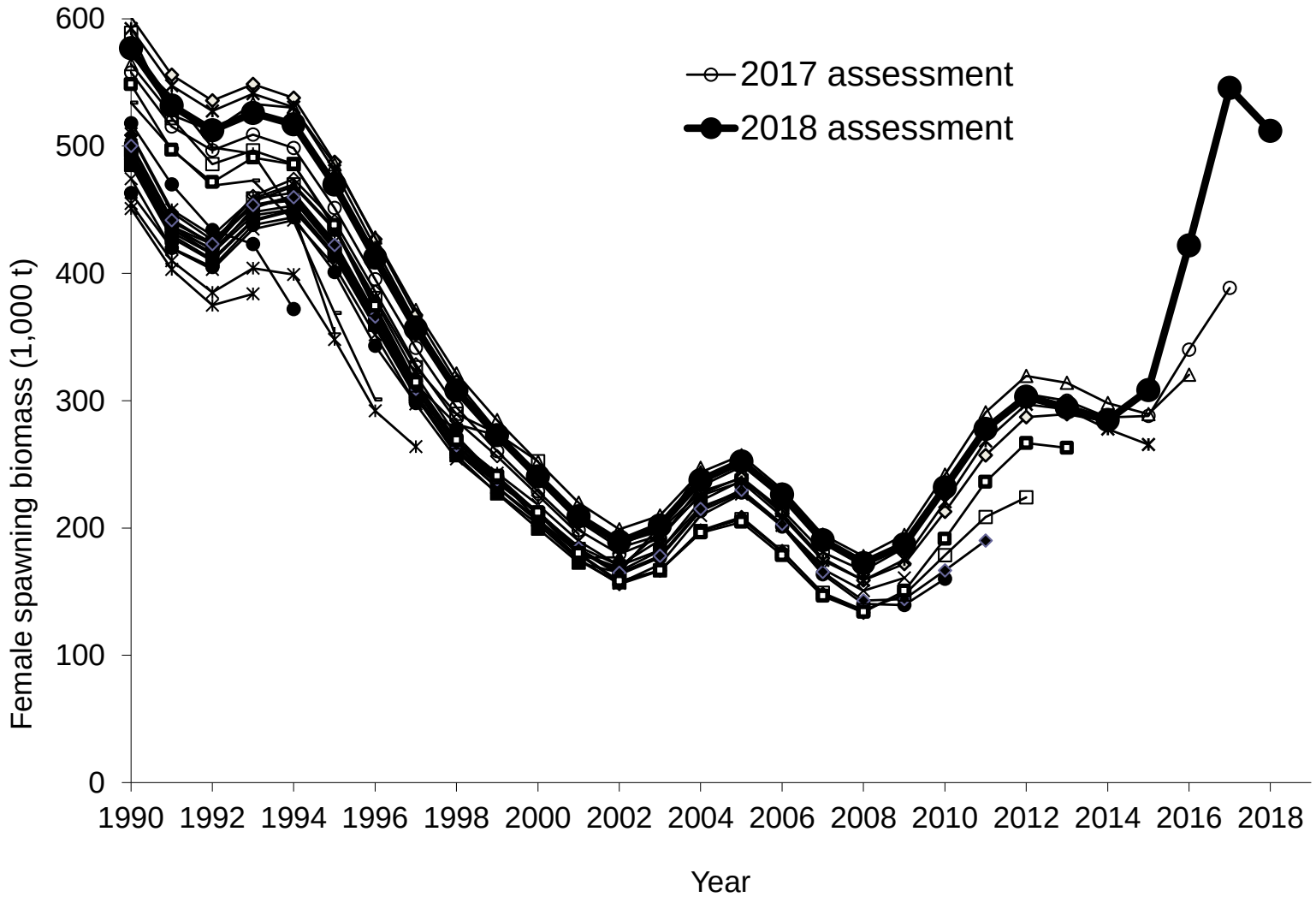


Total for all winter acoustic surveys = 1,361,461 t (97% in Shelikof Strait)

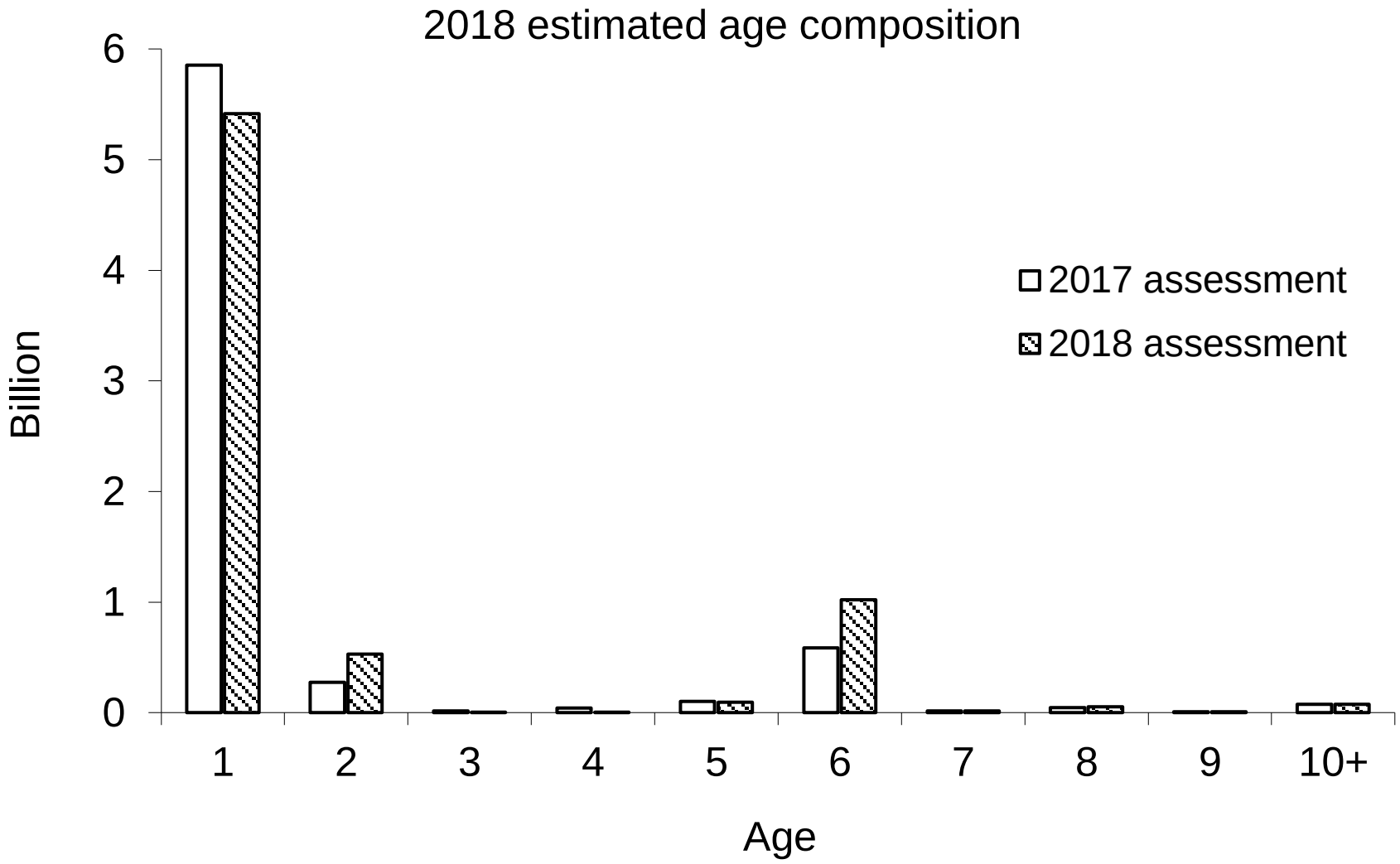
Southeast Pollock Summary Table

Quantity	As estimated or *specified last* year for: 2018	2019	As estimated or *recommended this* year for: 2019	2020
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	5	5	5	5
Biomass (t)				
Upper 95% confidence interval	70,502	75,820	75,820	80,954
Point estimate	38,989	38,989	38,989	38,989
Lower 95% confidence interval	21,562	20,050	20,050	18,778
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)	11,697	11,697	11,697	11,697
maxABC (t)	8,773	8,773	8,773	8,773
ABC (t)	8,773	8,773	8,773	8,773
Status	As determined *last* year for: 2016	2017	As determined *this* year for: 2017	2018
Overfishing	No	n/a	No	n/a

Retrospective pattern of historical assessments



Changes in estimated age composition



Natural mortality estimates

Age	*Length (cm)*	*Weight (g)*	*Brodziak et al. 2010*	*Lorenzen 1996*	*Gislason et al. 2010*	*Hollowed et al. 2000*	*Van Kirk et al. 2010*	*Van Kirk et al. 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 Francis = 70.9

Acoustic survey

Initial N = 60

Ending N Francis = 8.9

Bottom trawl survey

Initial N = 60

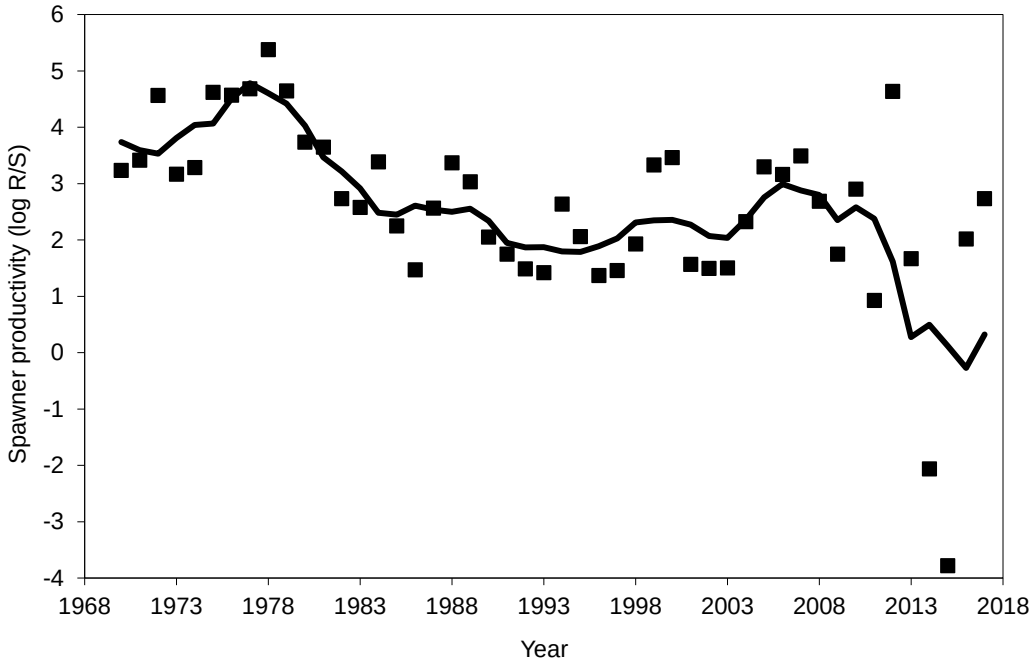
Ending N Francis = 8.7

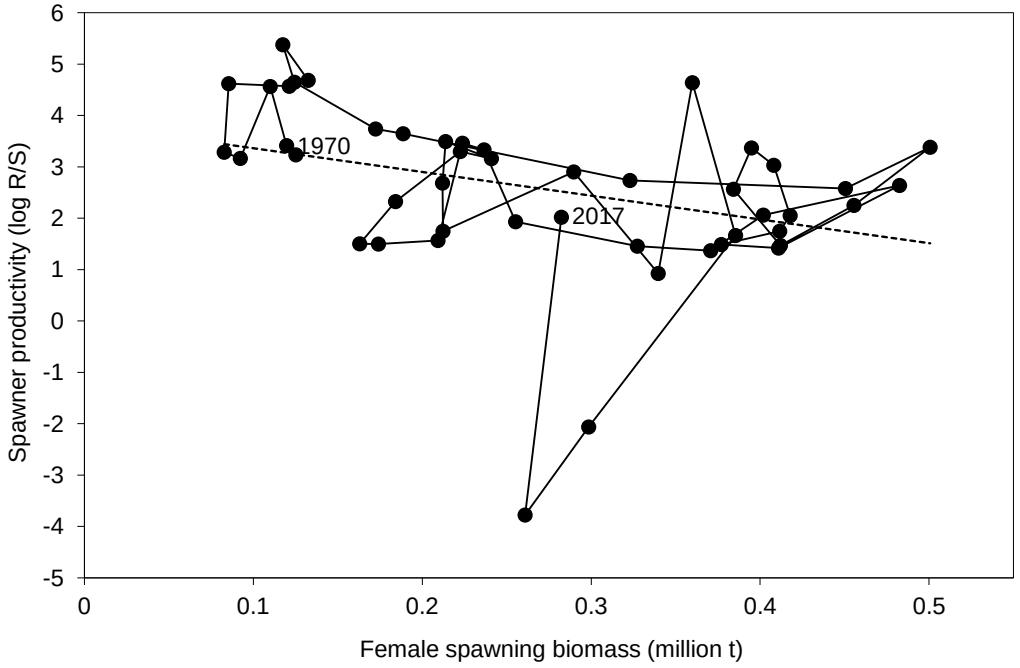
ADFG survey

Initial N = 30

Francis = 16.8

Spawner productivity





Annual SPR rate