NOAA FISHERIES

Alaska Fisheries Science Center

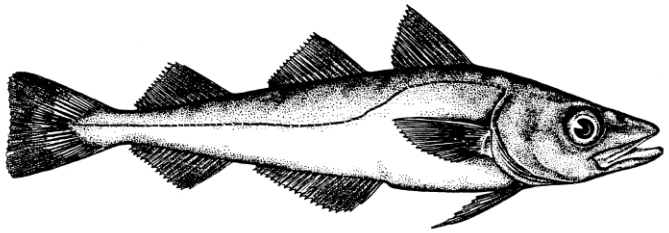
Gulf of Alaska pollock

Martin Dorn

Gulf of Alaska Plan Team meeting

Nov 13, 2019

AFSC Seattle



Gulf of Alaska pollock Overview of assessment results

Changes to the assessment model

- Assessment is an update except…
- New approach to estimating maturity
- Stronger penalty of random walk variation in catchability for Shelikof Strait acoustic survey

Author's 2020 ABC 108,494 t

- Decrease of 20% from the 2019 ABC
- 2021 ABC stabilizes ~110,000 t

•**Concerns:**

- Conflicting input data
- Poor model fit
- Large assessment uncertainty

•**Positives**:

- Strong 2018 year class
- Catches and SSB projected to stabilize
- Environmental condition OK for adults

Plan Team and SSC comments

Responses to SSC and Plan Team Comments in General

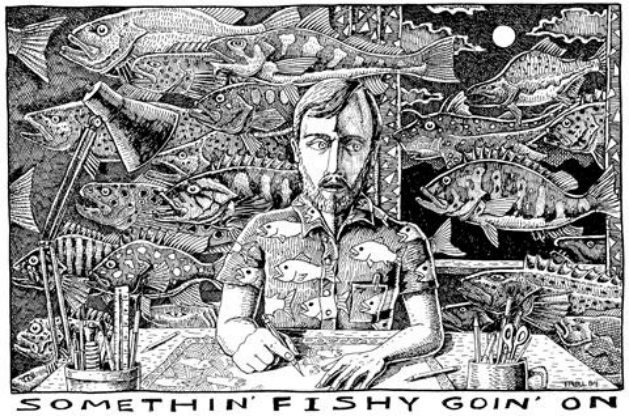
The SSC in its December 2019 minutes recommended that all assessment authors use the risk table below when determining whether to recommend an ABC lower than the maximum permissible. The SSC also requested the addition of a fourth column on fishery performance

- In this assessment, we have used the risk matrix table to evaluate stock assessment, population dynamics, ecosystem, and fishery performance concerns relevant to Gulf of Alaska pollock.

Responses to SSC and Plan Team Comments Specific to this Assessment

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

- The acoustic survey group produced as series of plots of pollock vertical distribution during the summer acoustic survey that are included in the assessment.



Plan Team and SSC comments (continued)

Responses to SSC and Plan Team Comments Specific to this Assessment

The GOA plan team in its November 2018 minutes recommended the author investigate the use of alternative maturity at age estimation procedures.

- In this assessment we provide maturity estimates for Shelikof Strait acoustic survey from 2003 to the present with GLM approach that uses local abundance to weight the maturity data collected in a haul.

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The GOA plan team in its November 2018 minutes recommended investigating model behavior sensitivity to abundance indices by incrementally dropping survey indexes to clarify how the data affect the model(s).

- We did not do this in this assessment due to lack of time, but will plan to do so in future assessments.

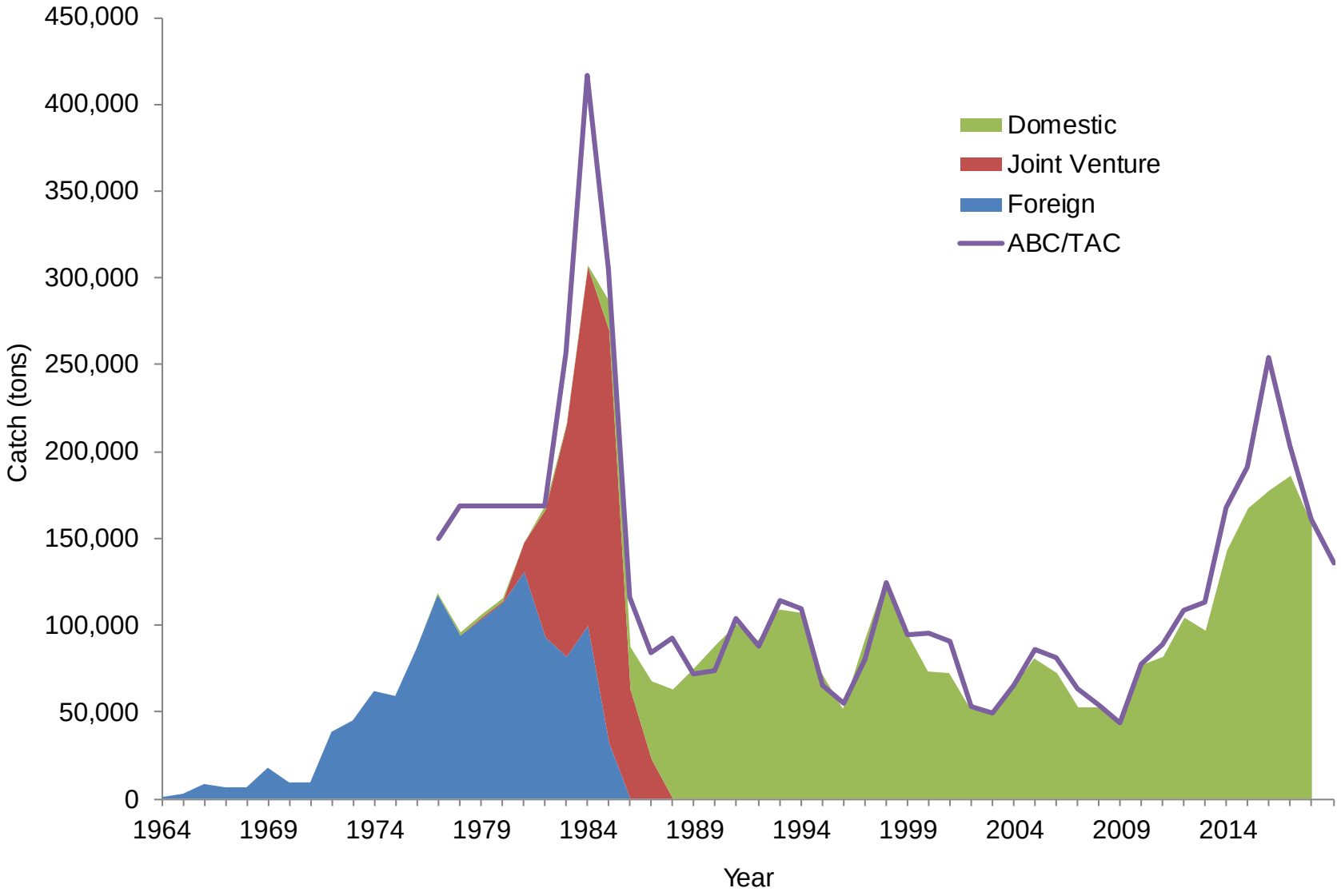
The GOA plan team in its November 2018 minutes recommended the author check recent year estimates of fishery selectivity, specifically the rising edge of the selectivity curves, which appear overly static given the single cohort state of the population.

- We checked those selectivity estimates and they appear to be estimated appropriately. Selectivity in the final year of the assessment set equal to the previous year because no fish age composition data are available in the final year.

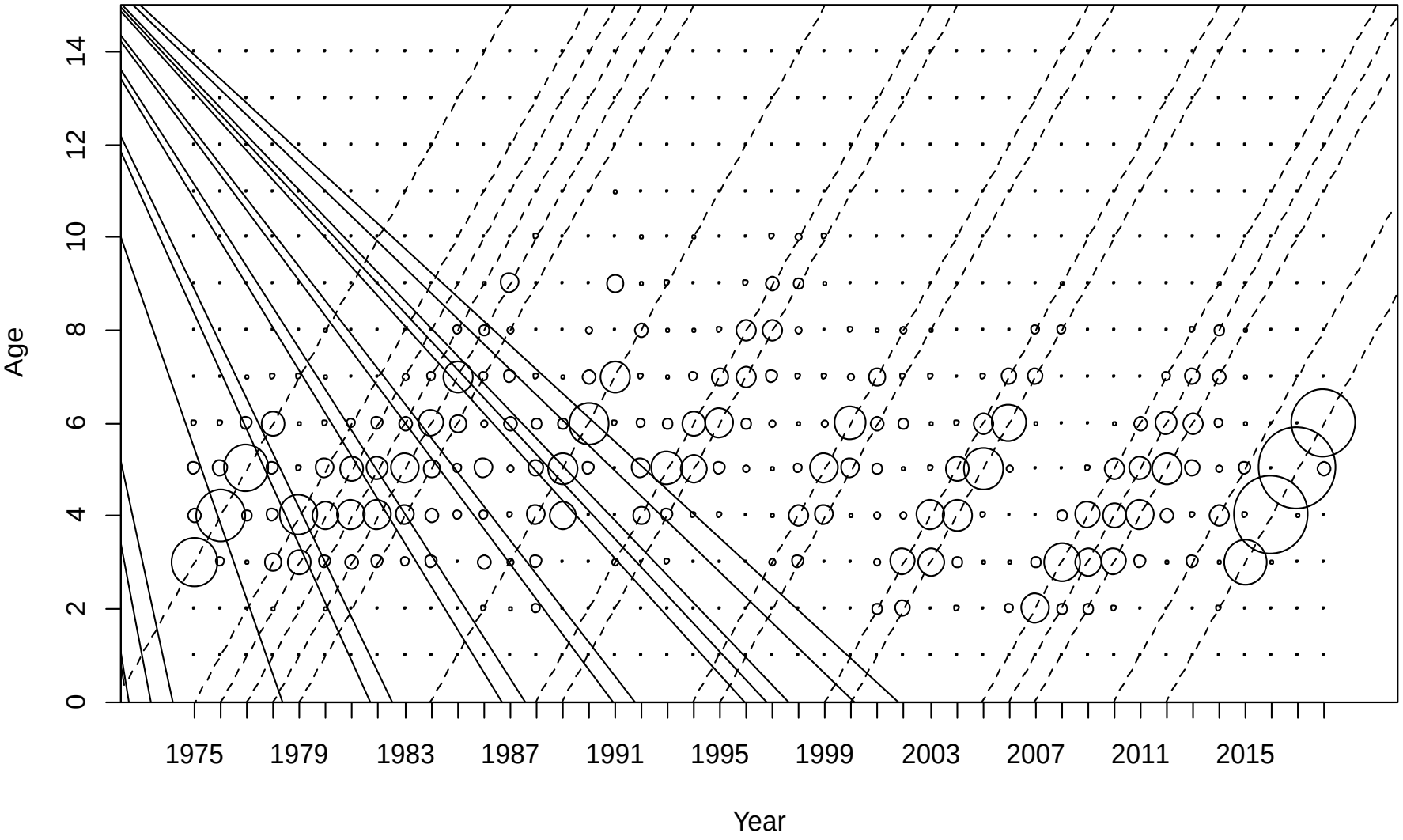
Data used in the assessment

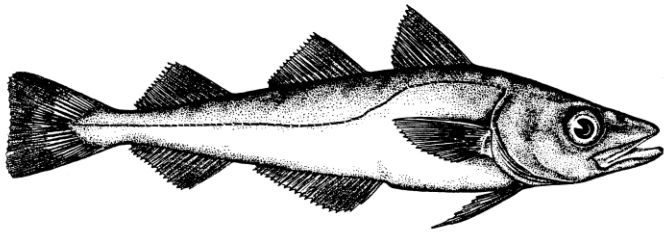
Source	Data	Years
Fishery	Total catch	1970-2018
Fishery	Age composition	1975-2018
Shelikof Strait acoustic survey	Biomass	1992-2019
Shelikof Strait acoustic survey	Age composition	1992-2019
Summer acoustic survey	Biomass	2013-2019
Summer acoustic survey	Age composition	2013-2017
Summer acoustic survey	Length composition	2019
NMFS bottom trawl survey	Area-swept biomass	1990-2019
NMFS bottom trawl survey	Age composition	1990-2017
NMFS bottom trawl survey	Length composition	2019
ADF&G trawl survey	Delta-GLM index	1988-2019
ADF&G survey	Age composition	2000-2016

Total catch 1970-2018



Catch at age, 1975-2018





Gulf of Alaska pollock
Overview of surveys

- **2019 is an on year for surveys in the GOA. A comprehensive set of winter acoustic surveys had been planned, many were cancelled due to the Govt shutdown**

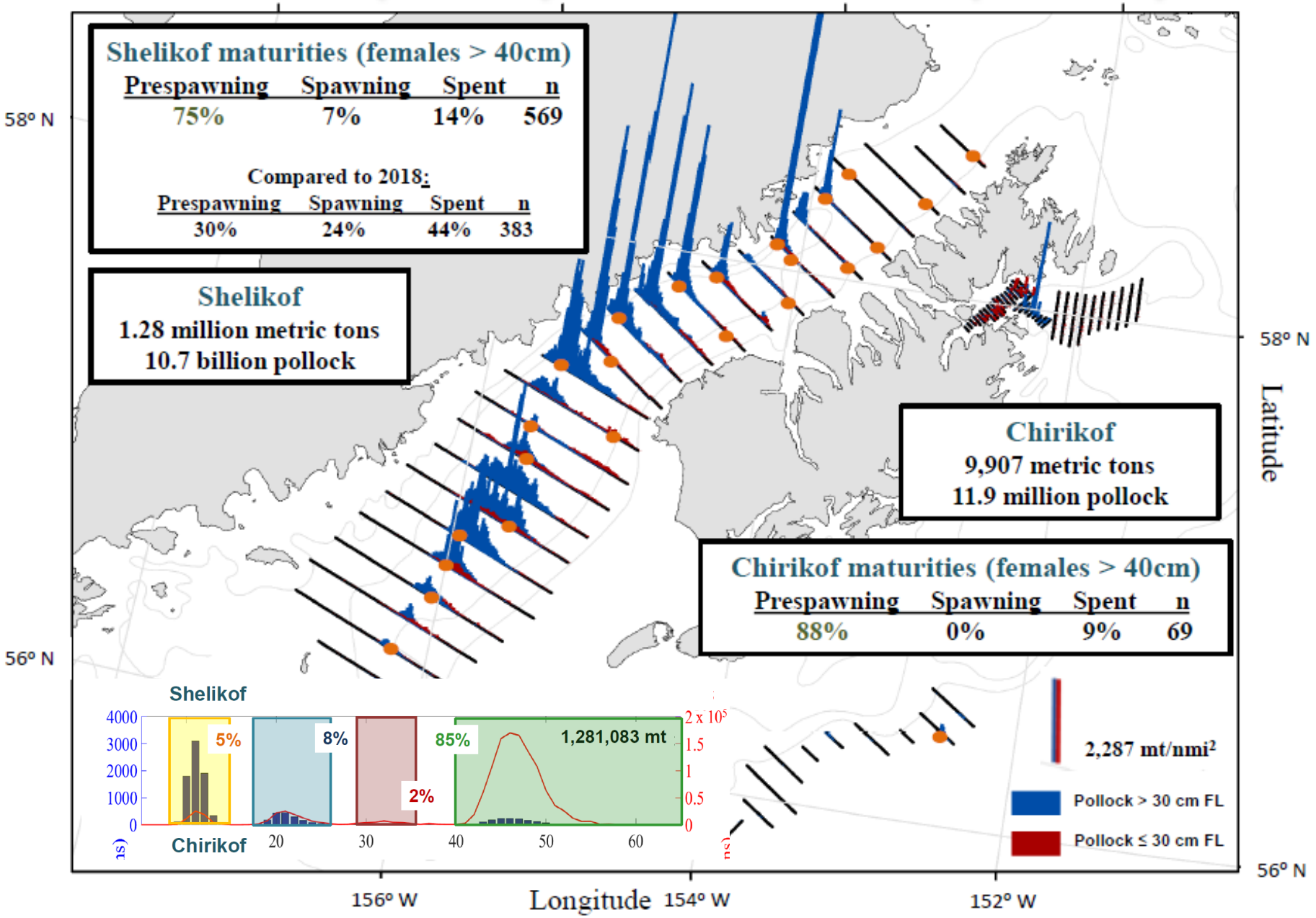
- **2019 Shelikof Strait acoustic survey biomass is 1.3 million t**
  - 3% percent decrease from 2019 (but third largest estimate in over 30 years!).

- **2019 Summer acoustic biomass is 580,000 t**
  - 56% drop from 2017

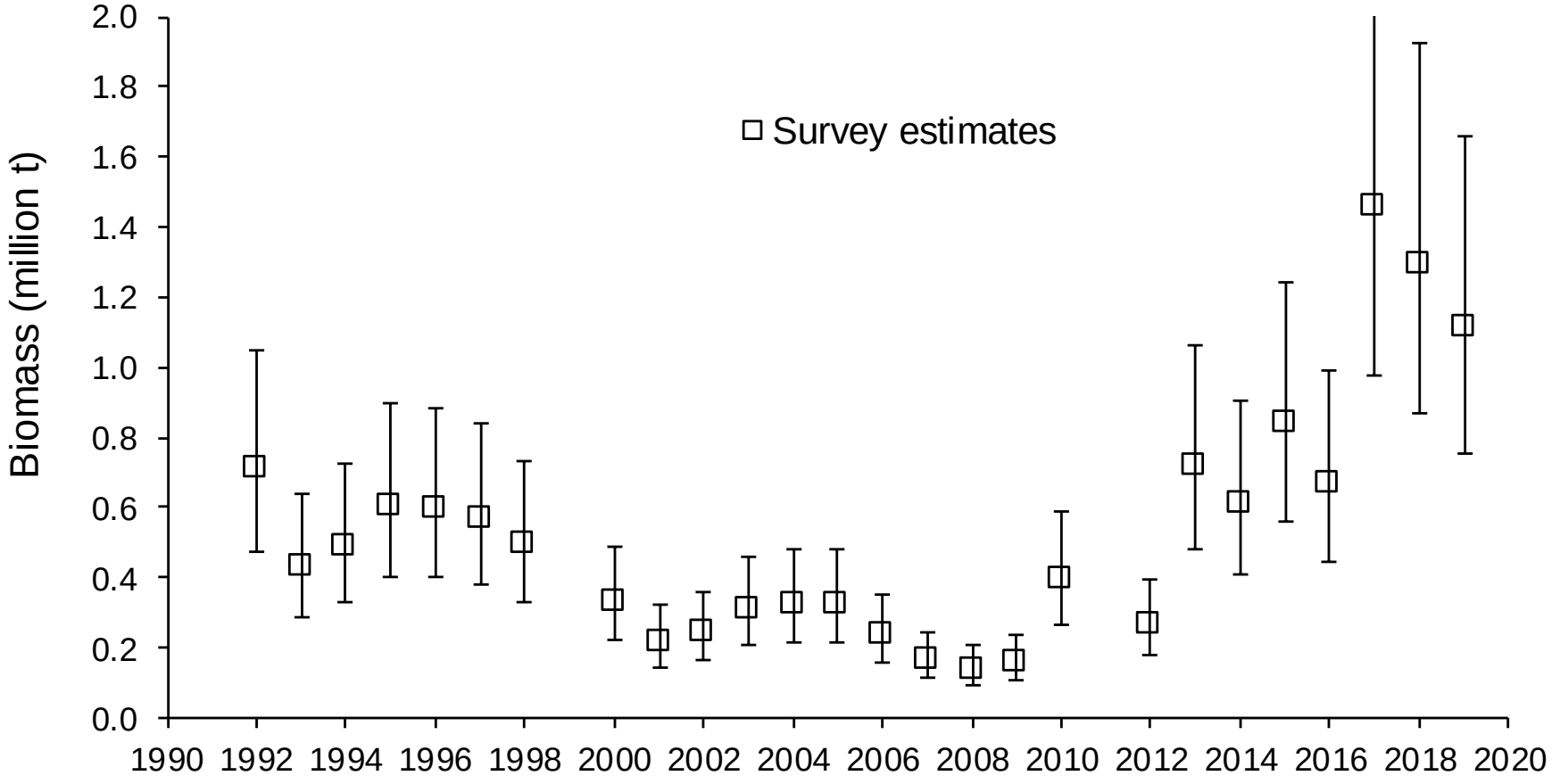
- **2019 NMFS bottom trawl 260,000 t**
  - About the same as last year (but second lowest in the time series)

- **2019 ADFG survey biomass is 50,000 t**
  - Almost the same as last year(but still about half the long-term average)

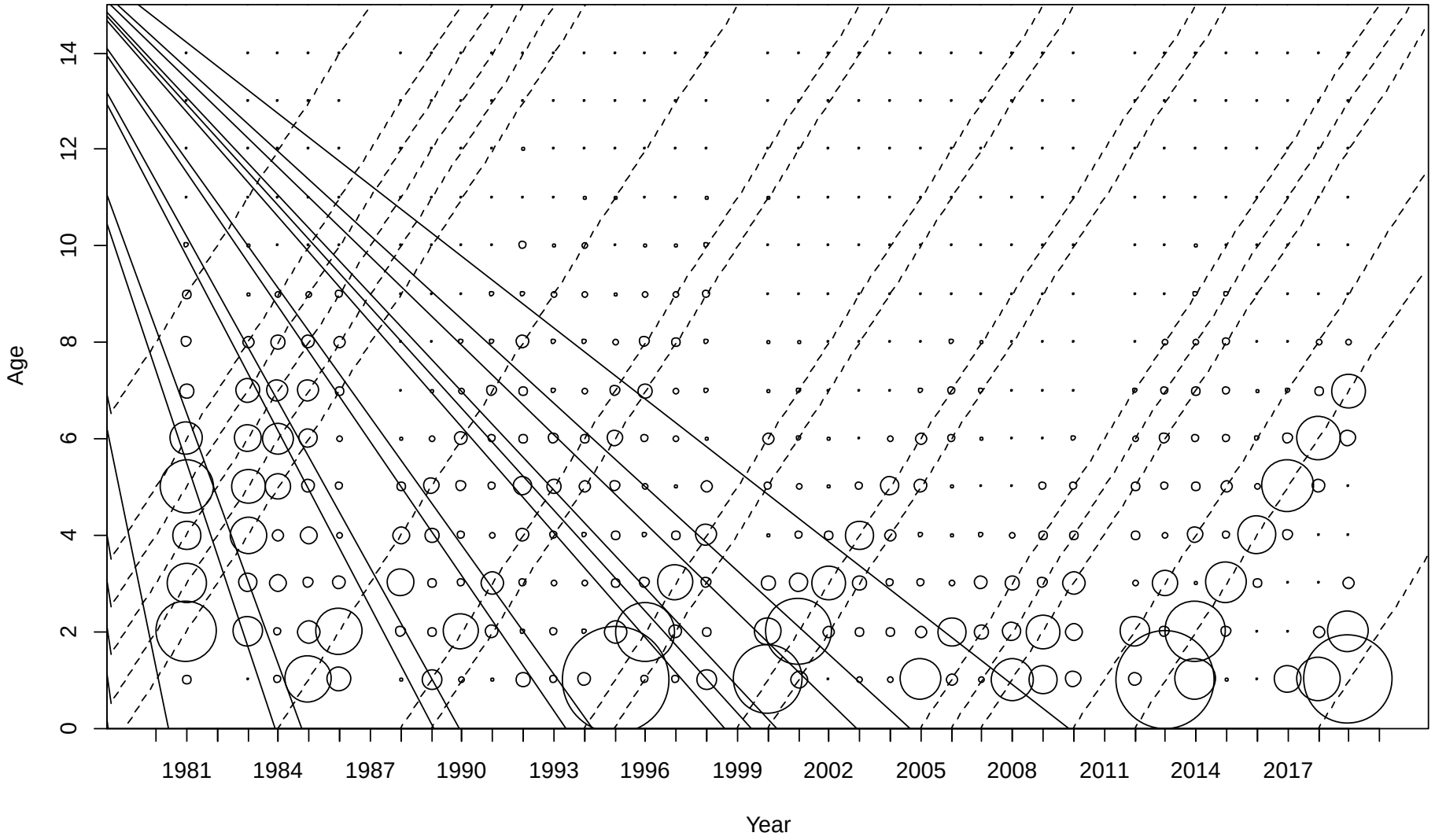
Shelikof Strait (7-16 Mar) and Chirikof Shelfbreak (16-18 Mar)

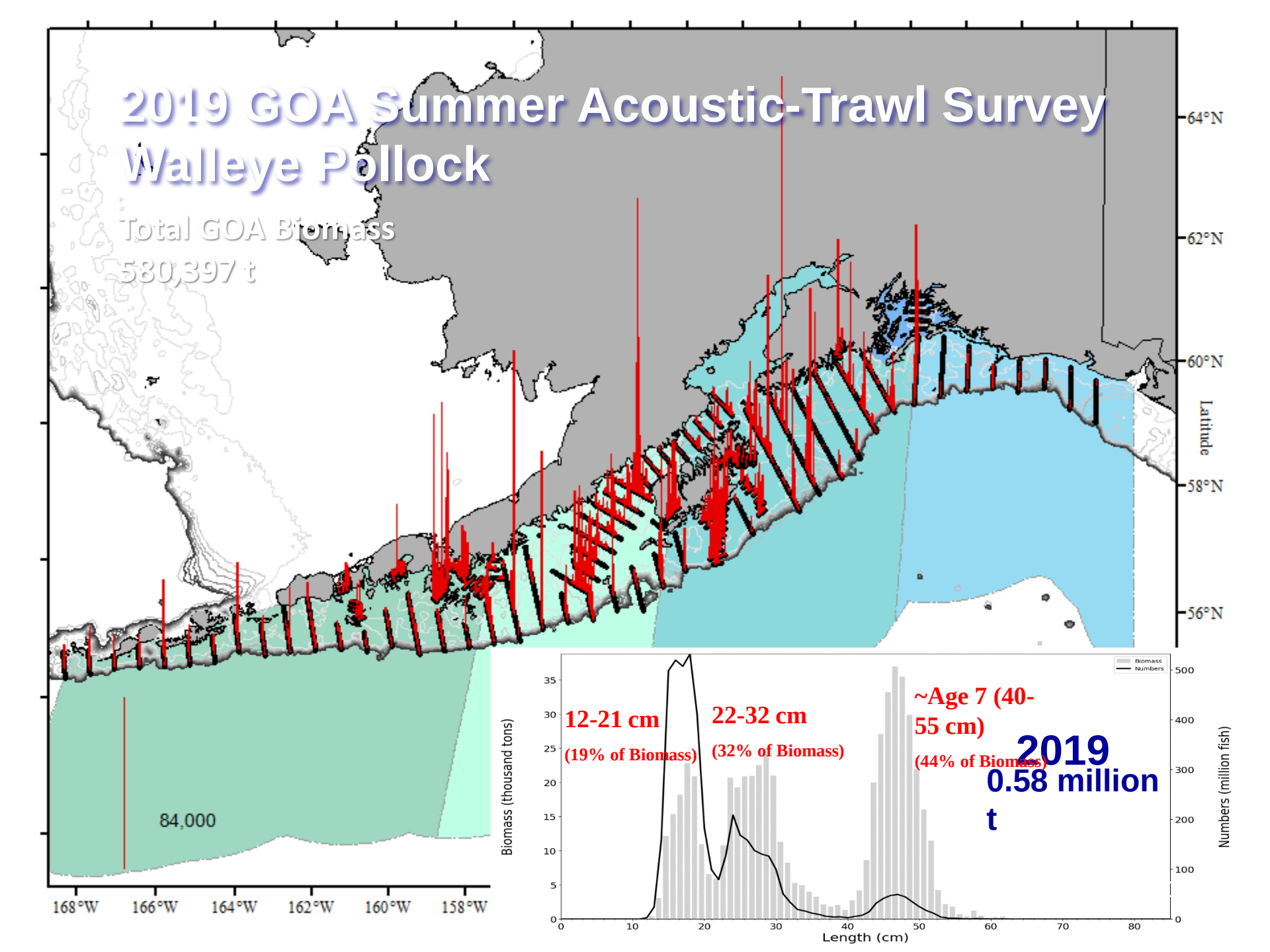


Shelikof Strait acoustic survey, 1992-2019

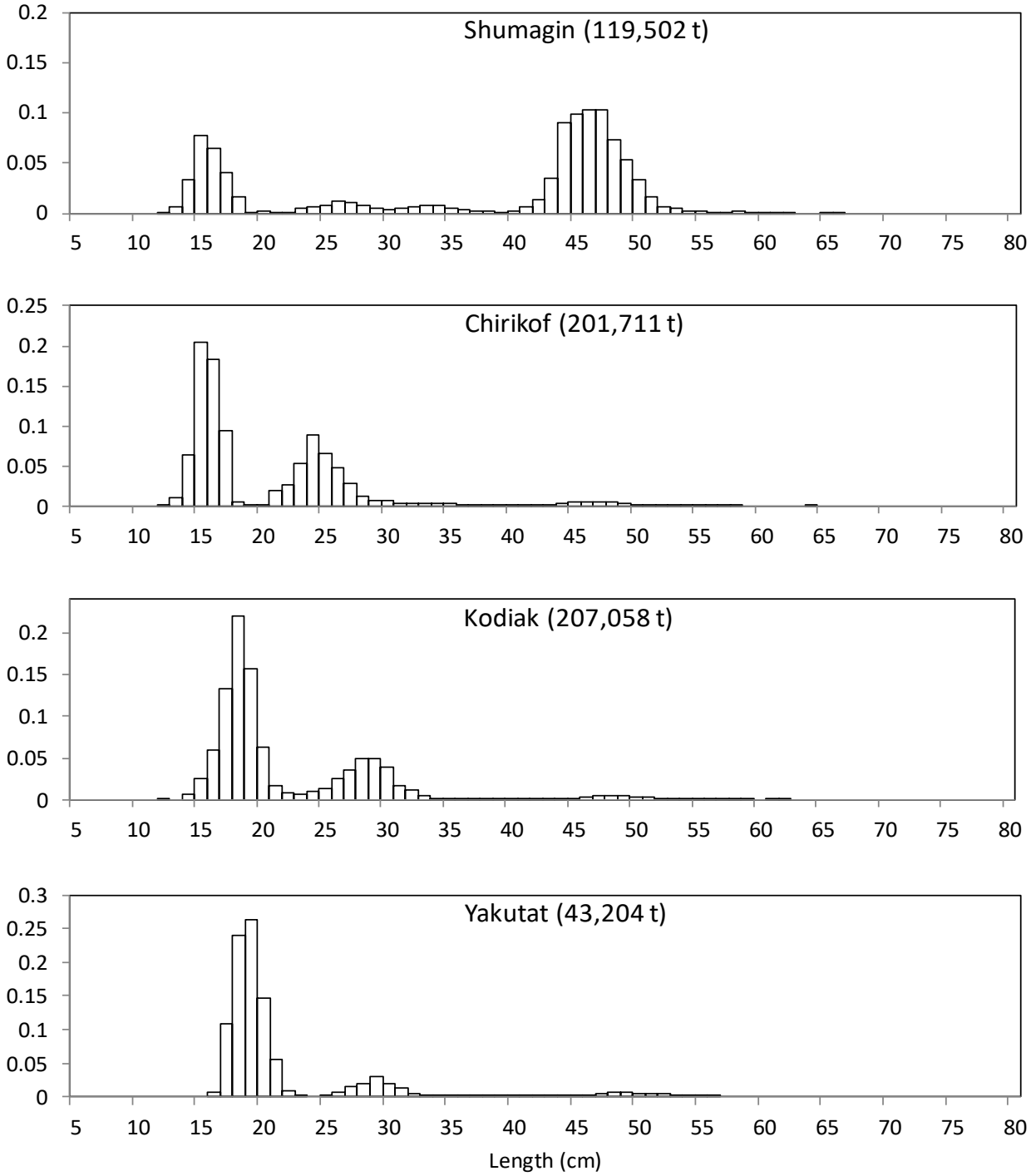


Shelikof Strait survey age comp, 1992-2019

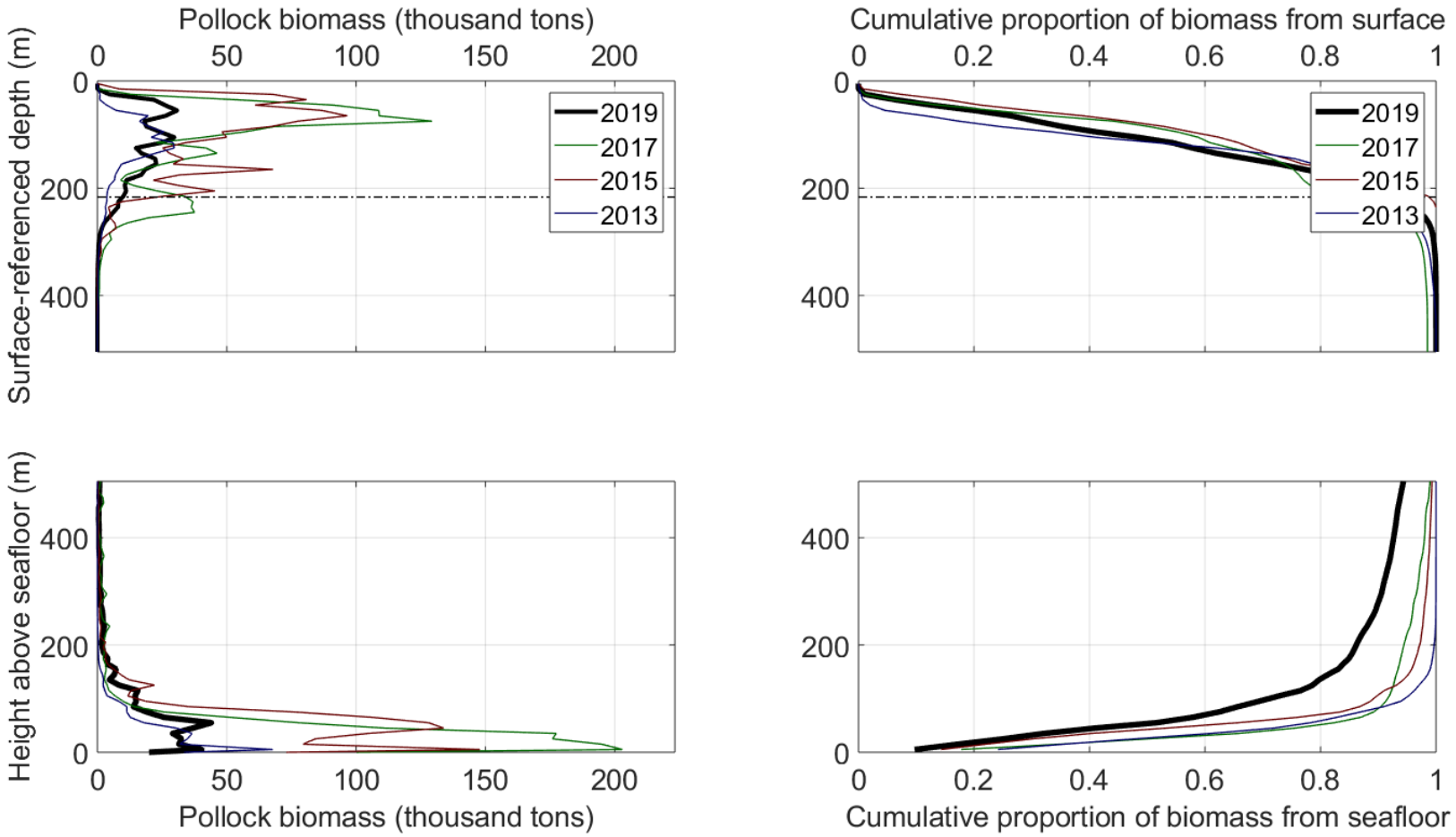



2019 GOA Summer Acoustic-Trawl Survey
Walleye Pollock
Total GOA Biomass
580,397 t
84,000
64°N
62°N
60°N
58°N
56°N
Latitude
168°W
166°W
164°W
162°W
160°W
158°W
Biomass (thousand tons)
Numbers (million fish)
Length (cm)
Biomass
Numbers
12-21 cm
(19% of Biomass)
22-32 cm
(32% of Biomass)
~Age 7 (40-55 cm)
(44% of Biomass)
2019
0.58 million t

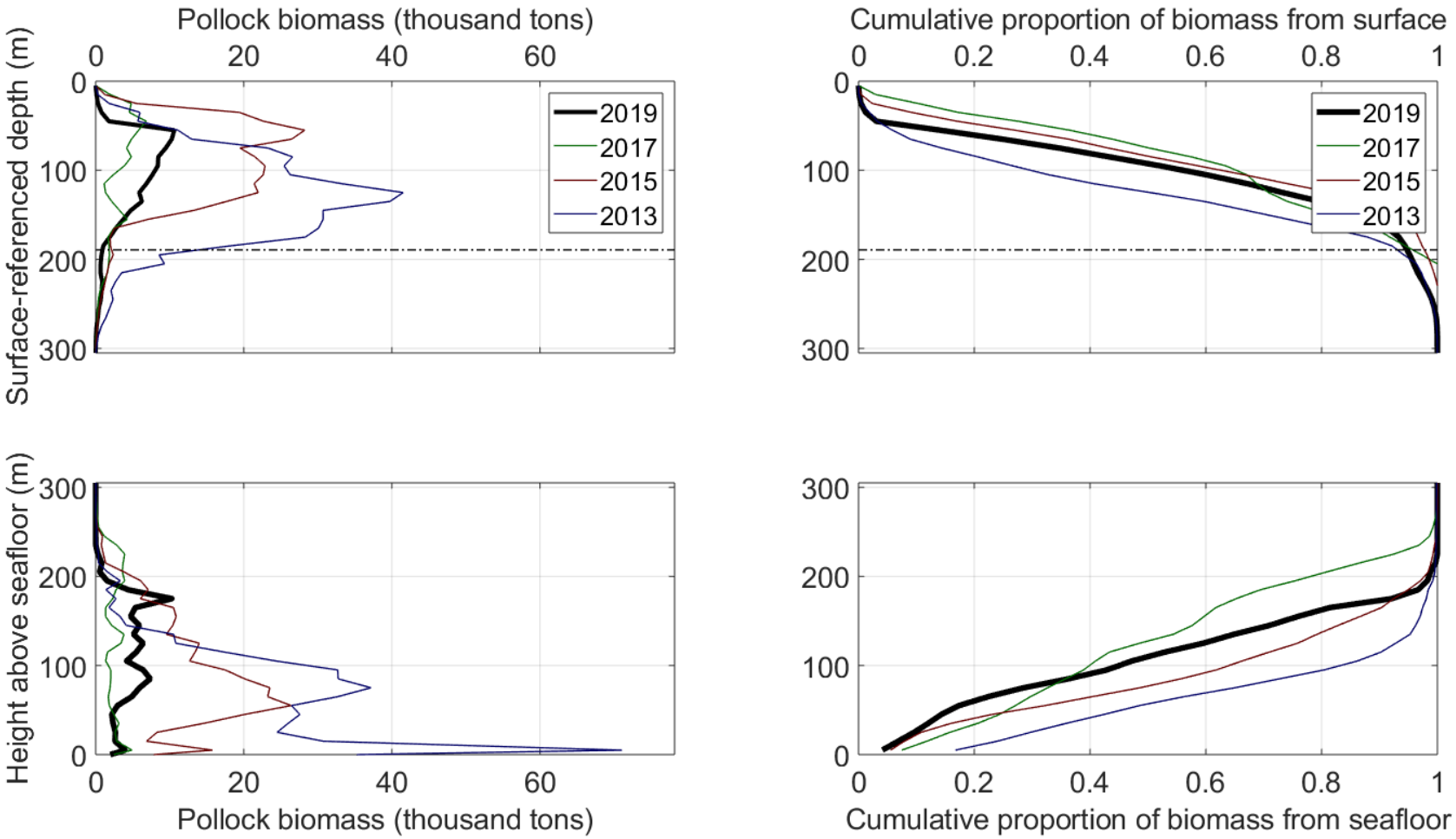
2019 Summer acoustic survey



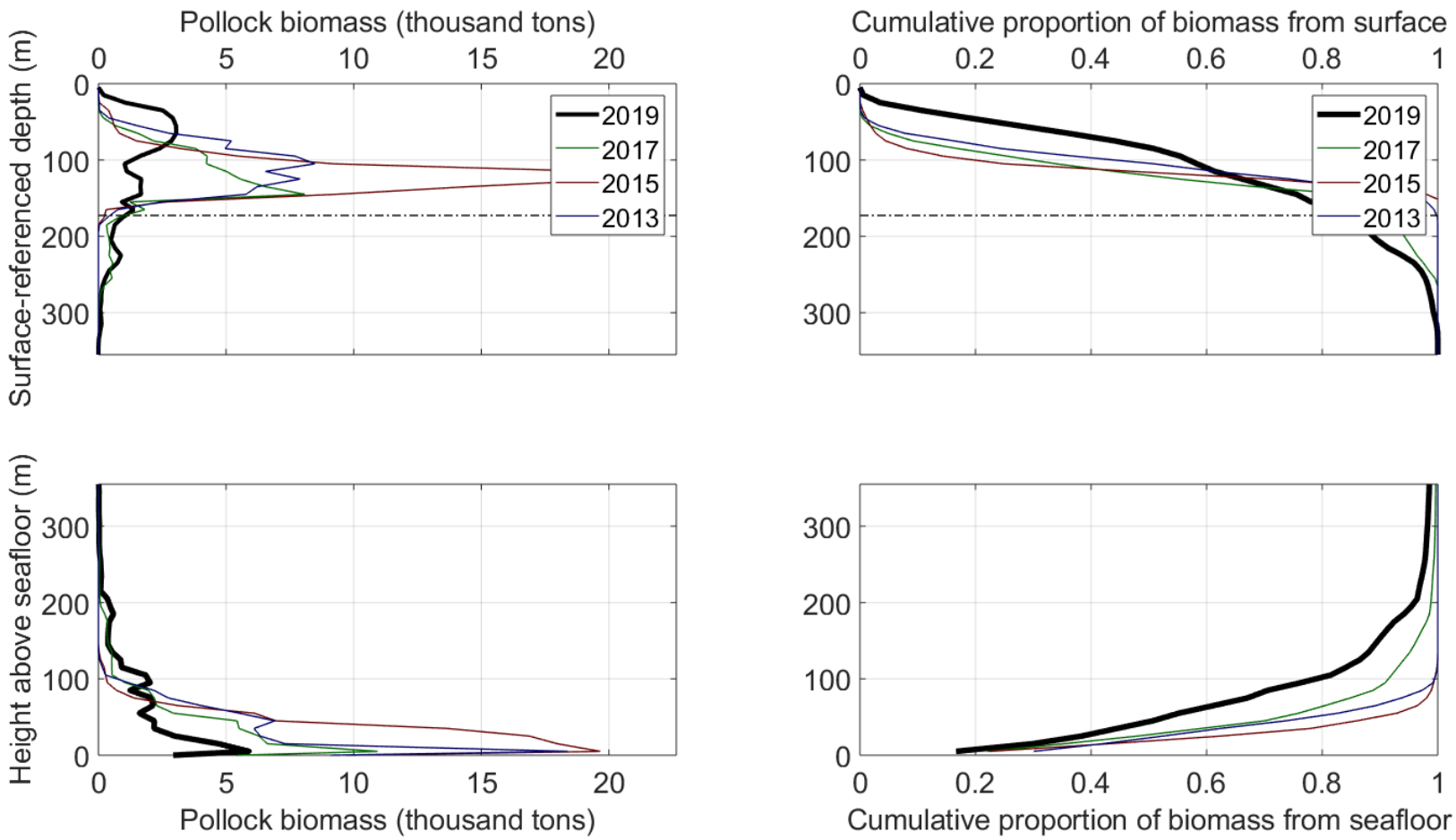
Surface and bottom referenced biomass distribution—Shelf transects



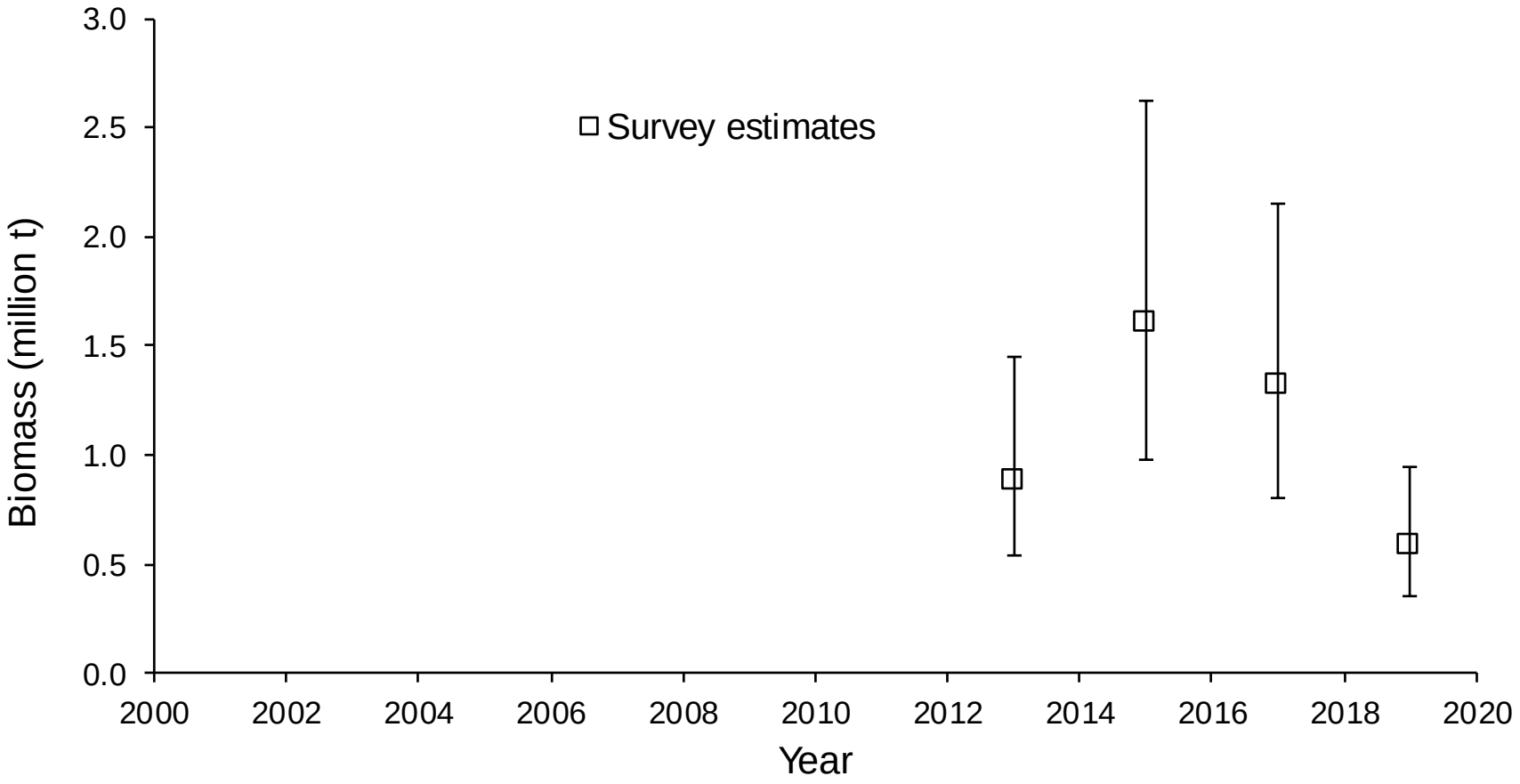
Surface and bottom referenced biomass distribution—Shelikof Strait

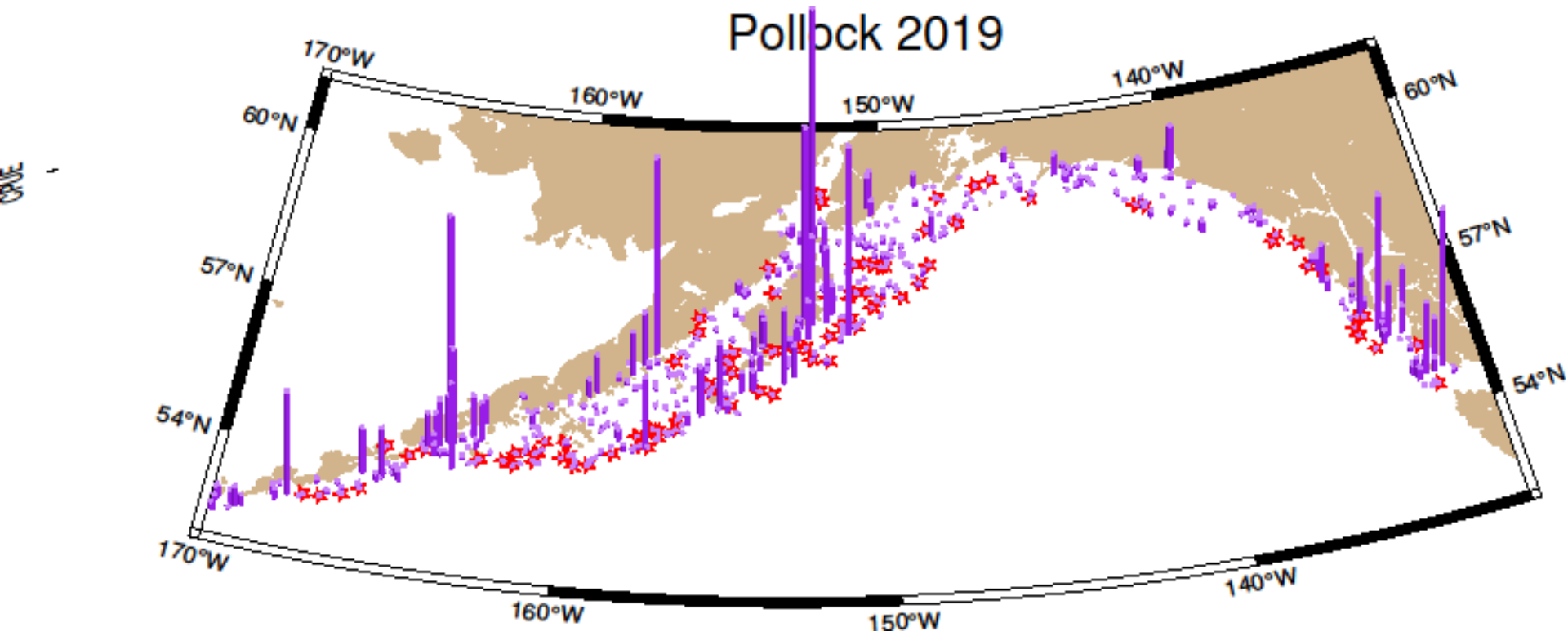


Surface and bottom referenced biomass distribution—Barnabus Gully

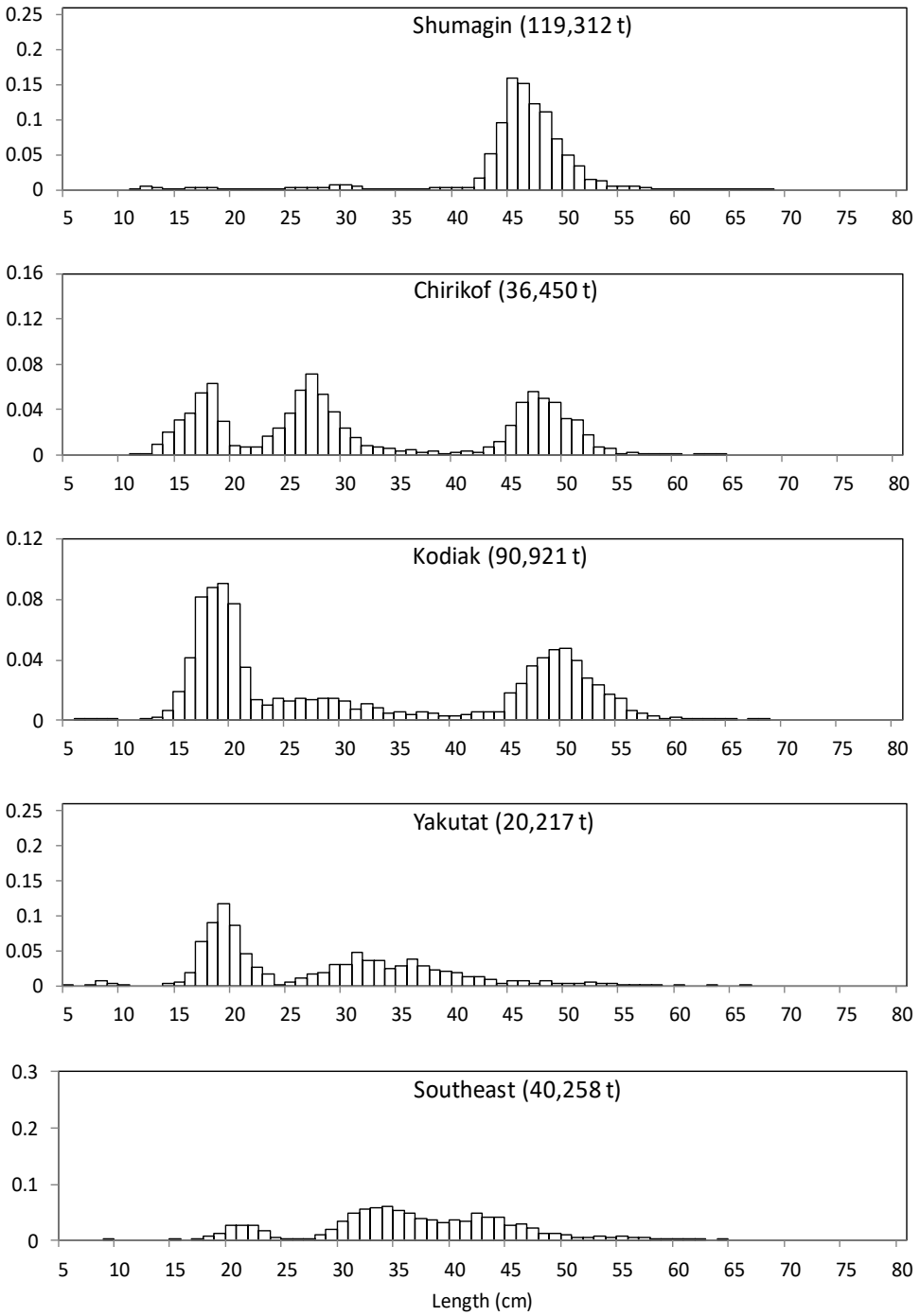


Summer acoustic survey, 2013-2019

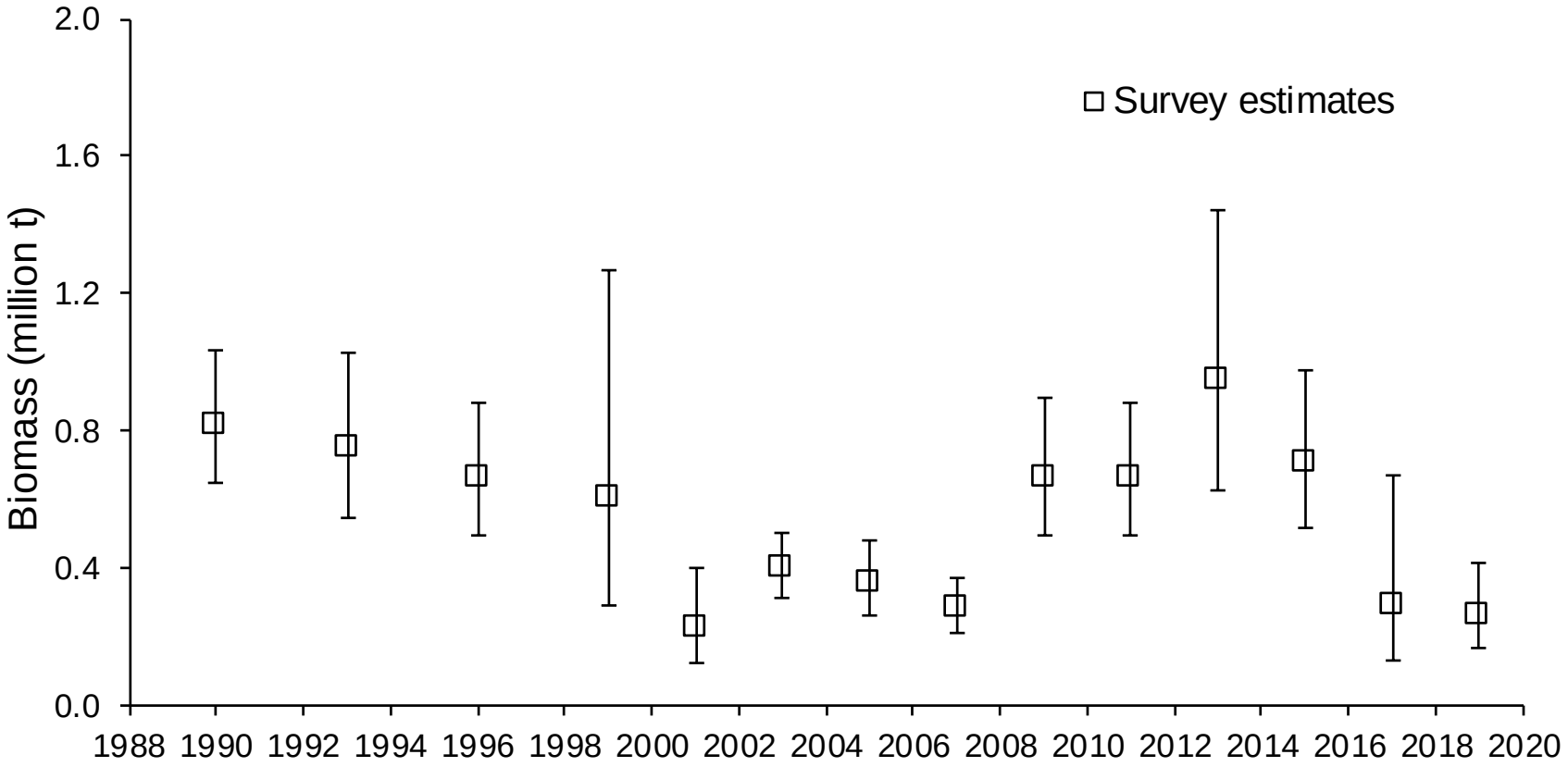



Pollock 2019
170°W
160°W
150°W
140°W
60°N
57°N
54°N

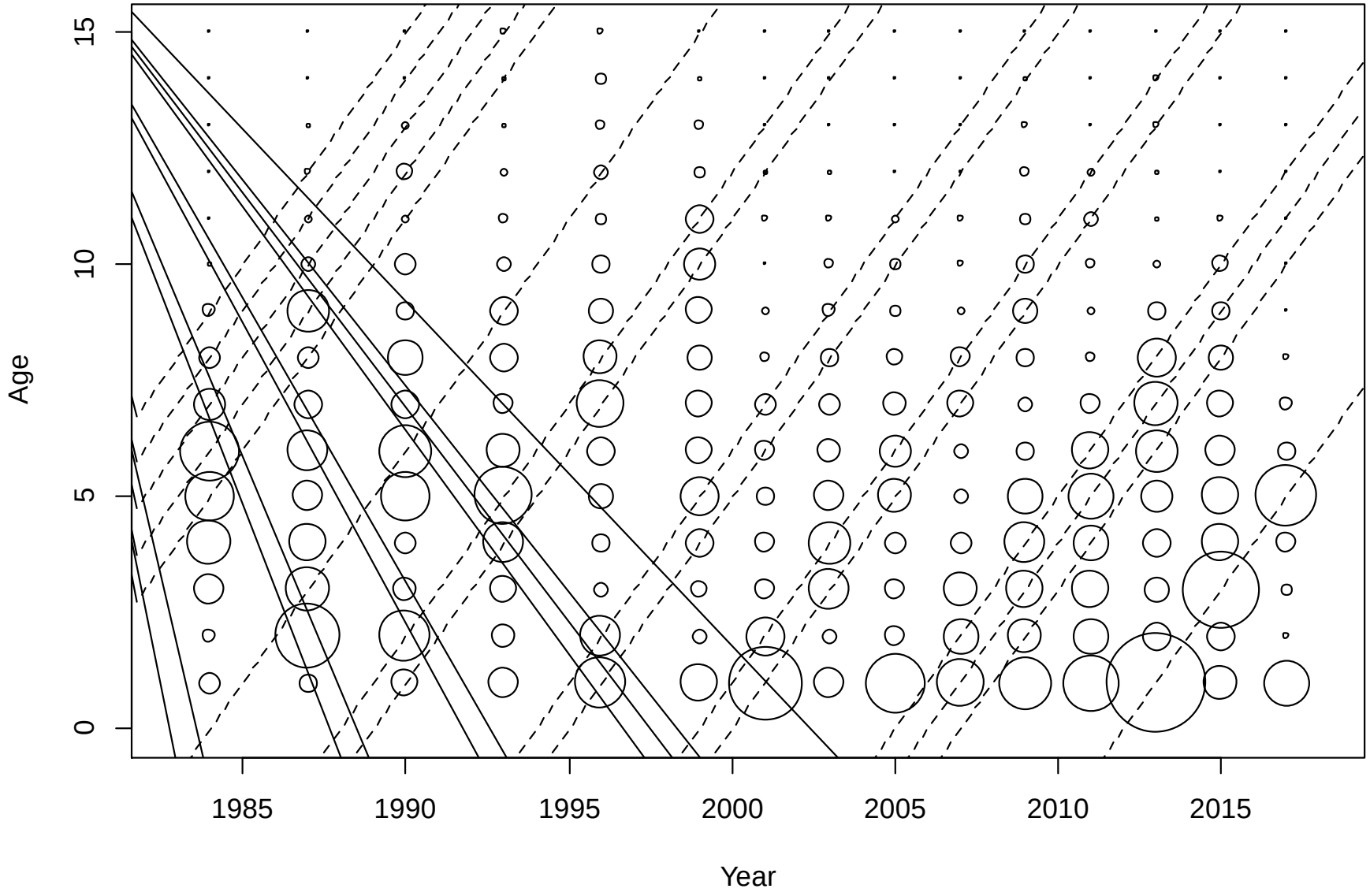
2019 NMFS bottom trawl survey



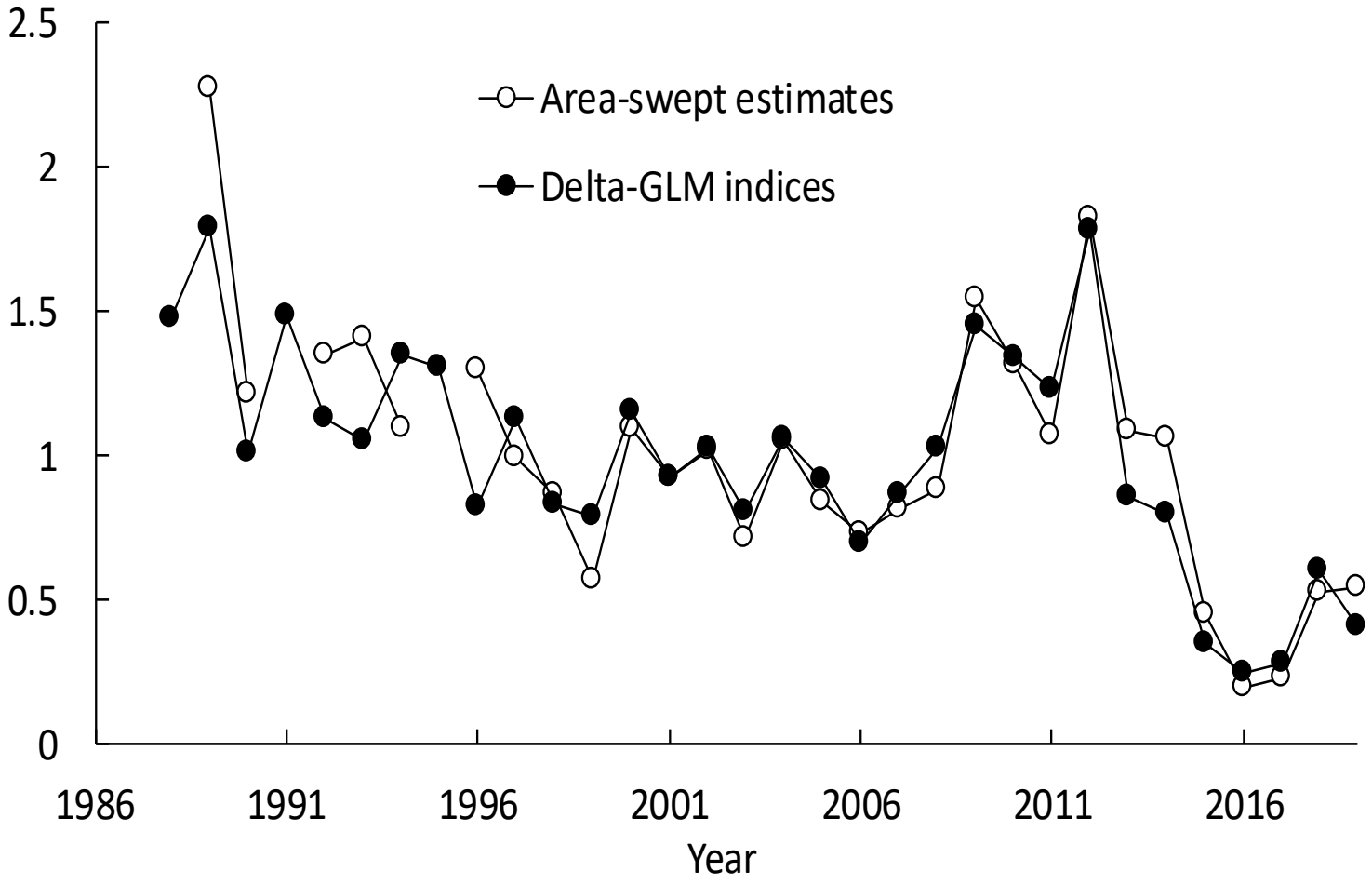
NMFS bottom trawl survey (1990-2017)



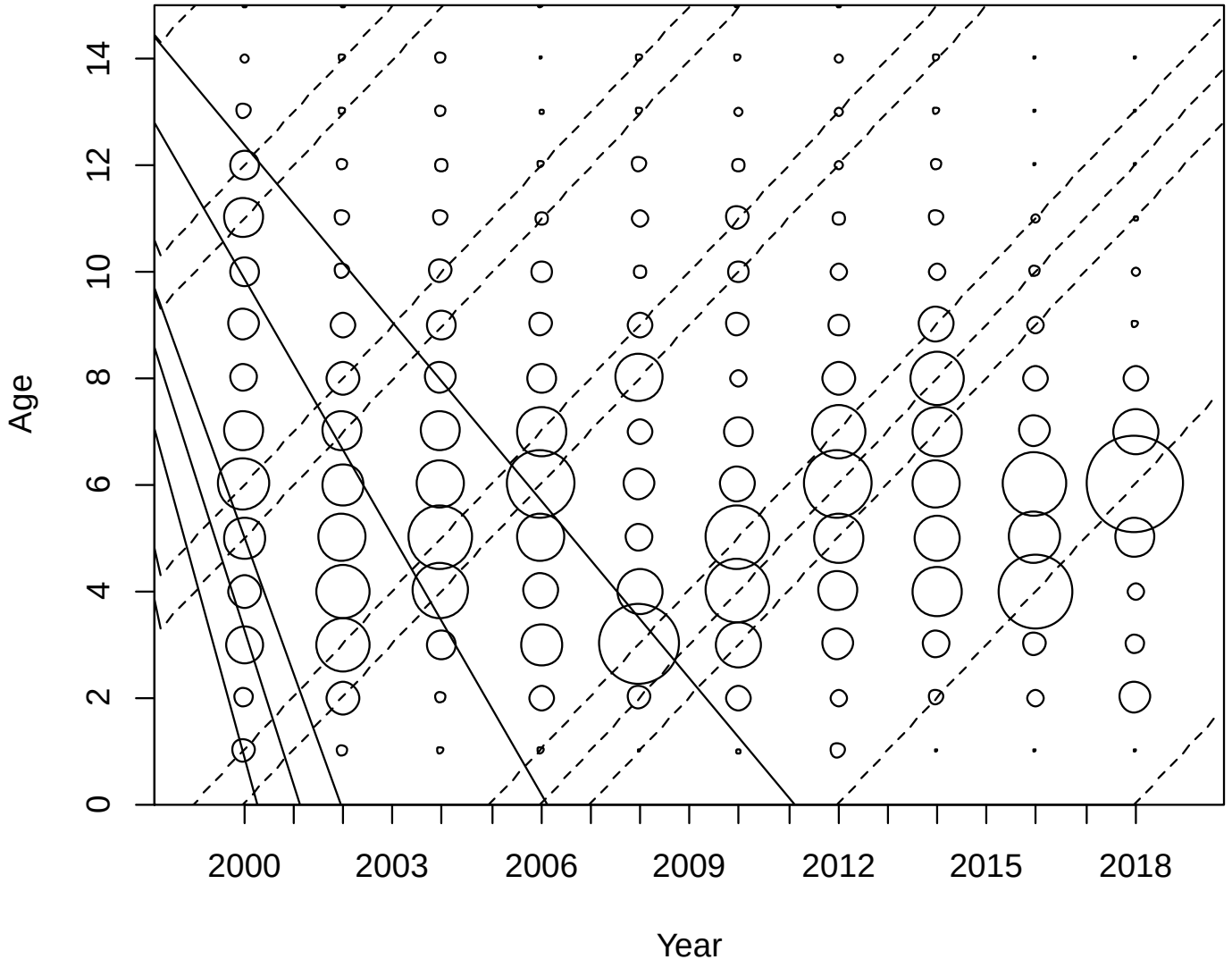
NMFS Bottom trawl survey age comp (1990-2017)



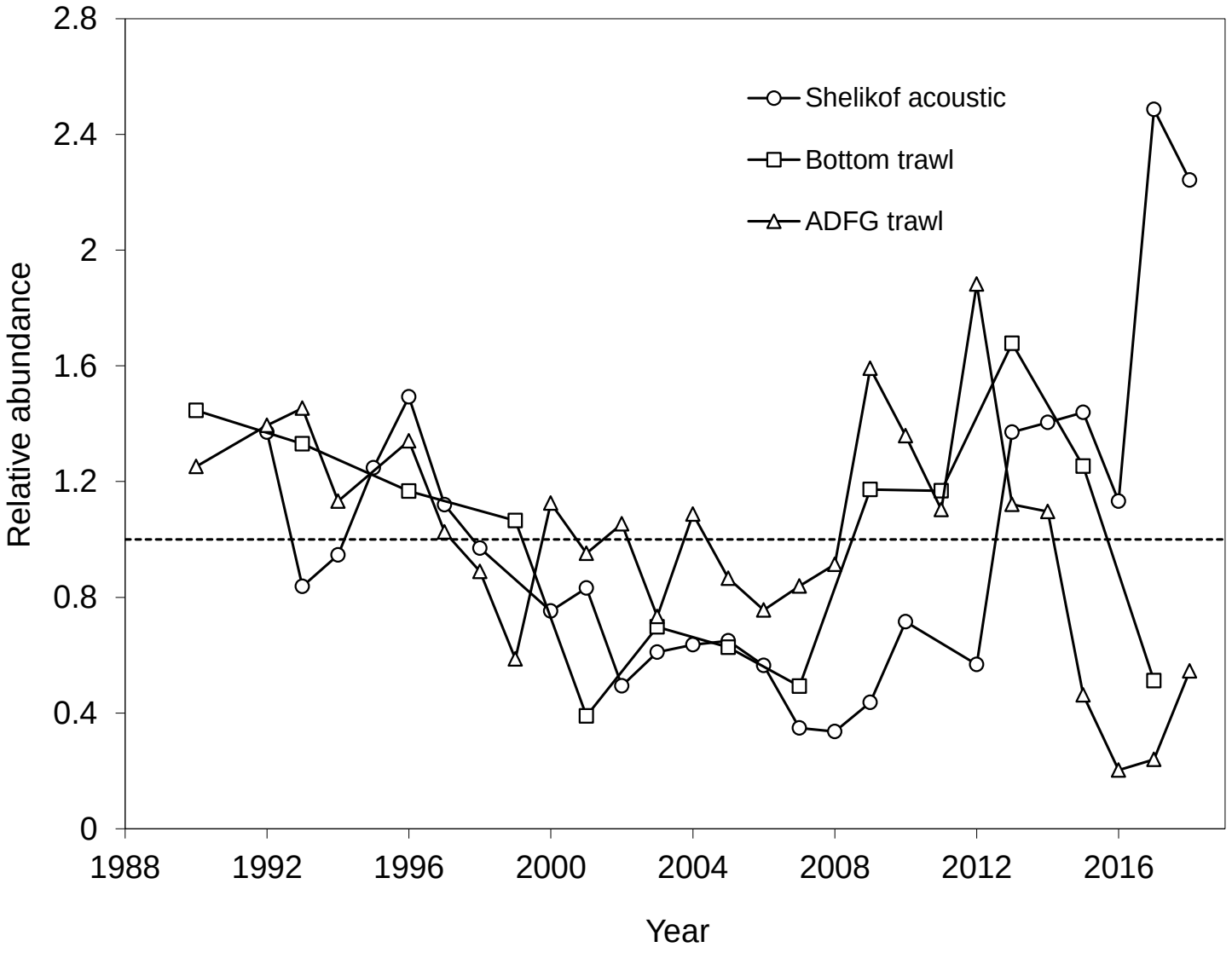
Comparison between area-swept estimates and delta-GLM estimates



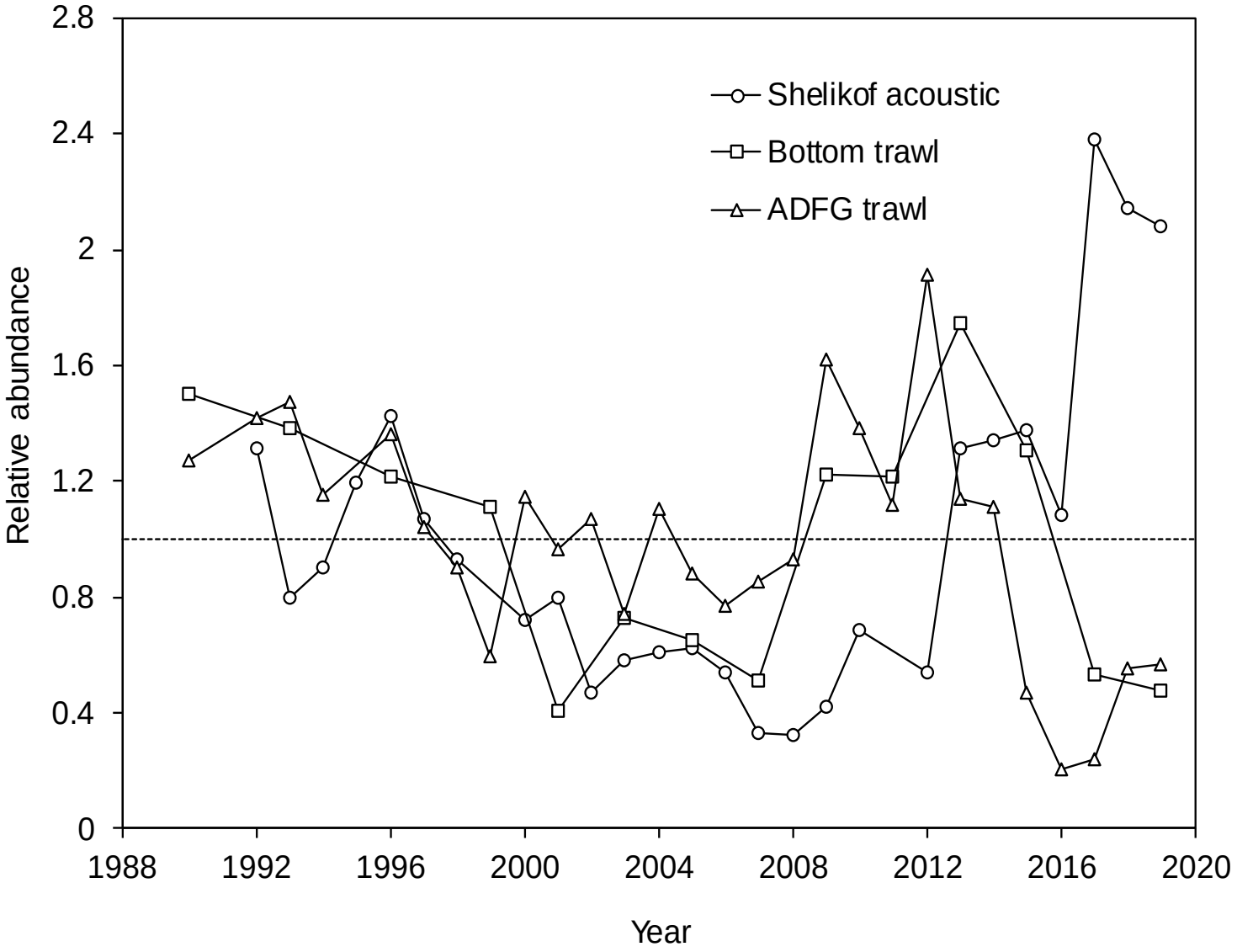
ADFG crab/groundfish trawl survey age comp (2000-2018)



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



Relative trends in abundance indices this year (1990-2019)



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

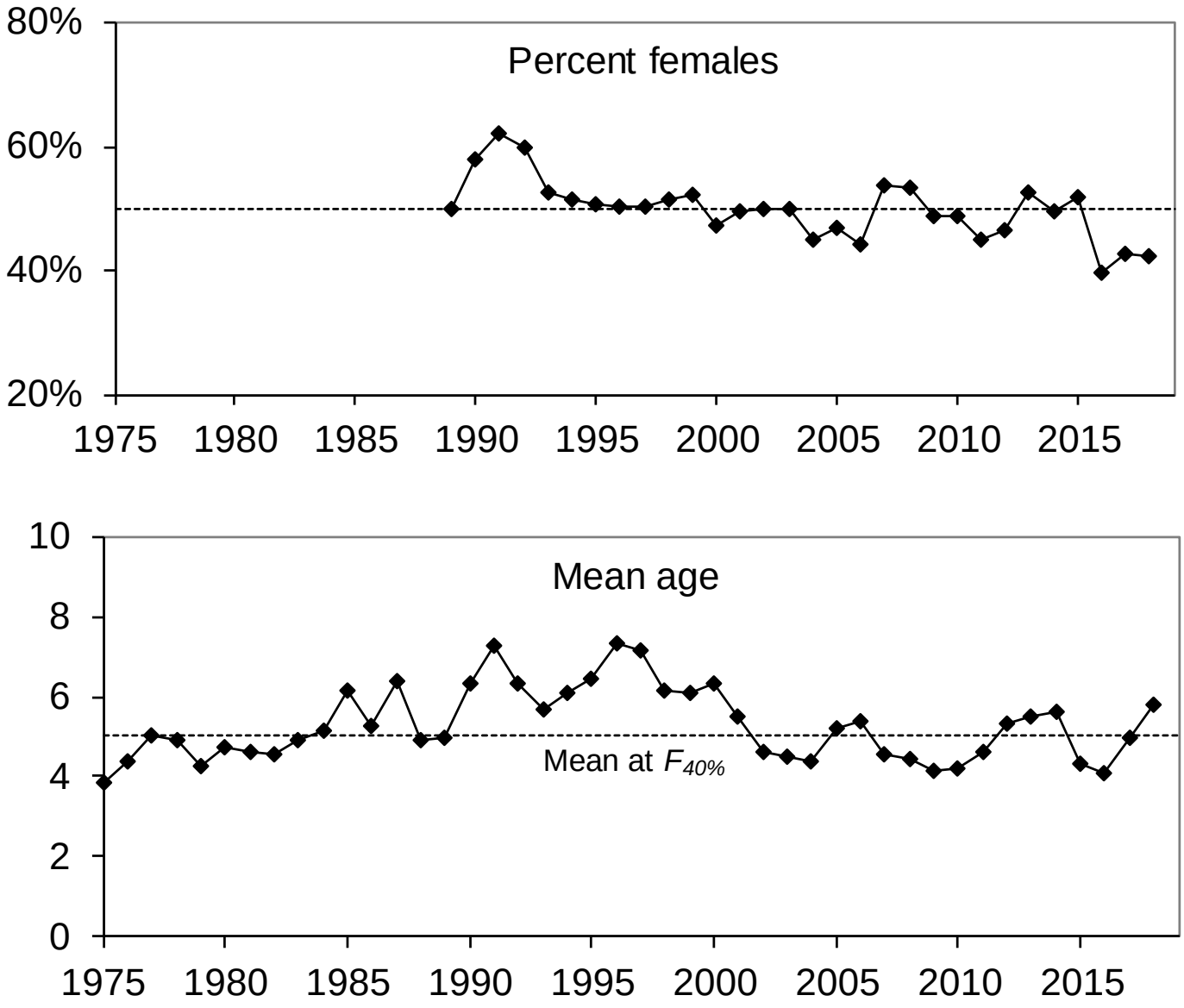
"Apparent data conflict in modern integrated stock assessment models can occur for three reasons:

1) Random sampling error.

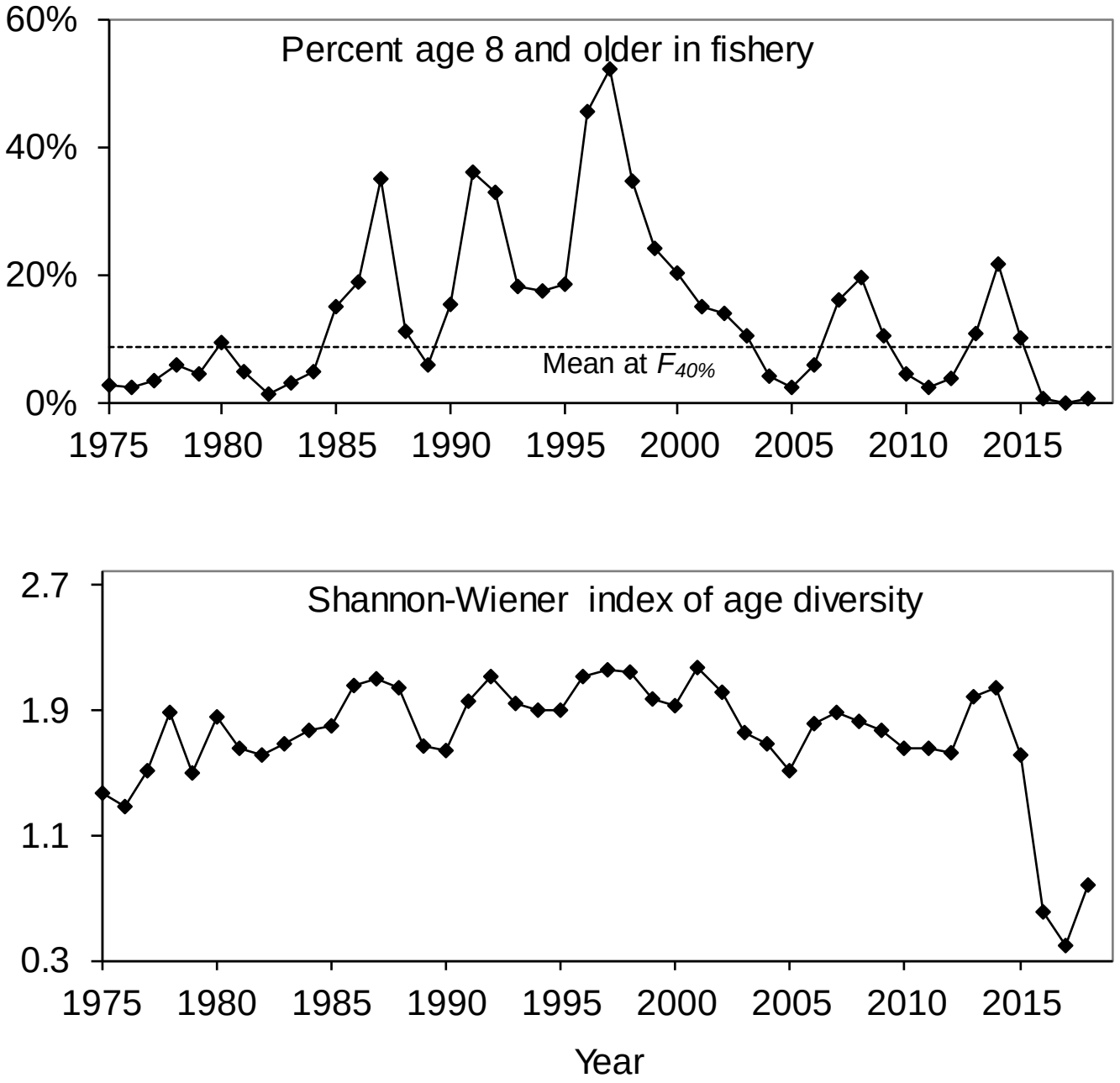
2) Misspecification of the observation model (model processes relating dynamics or states to data).

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

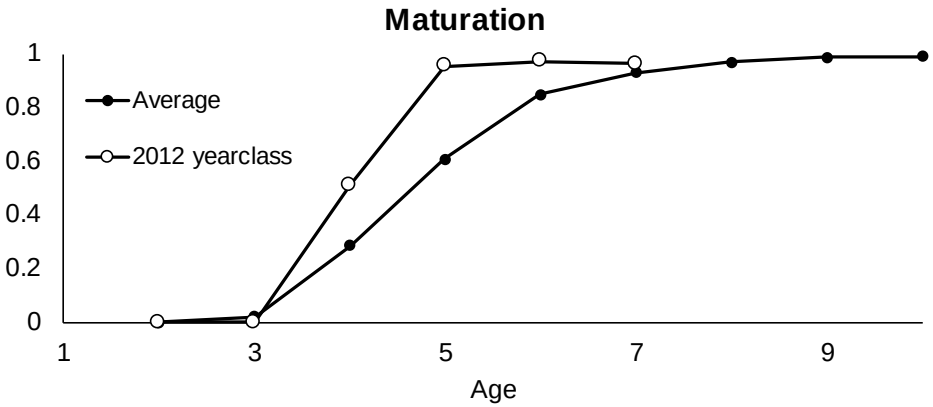
Fishery catch indicators



Fishery catch indicators



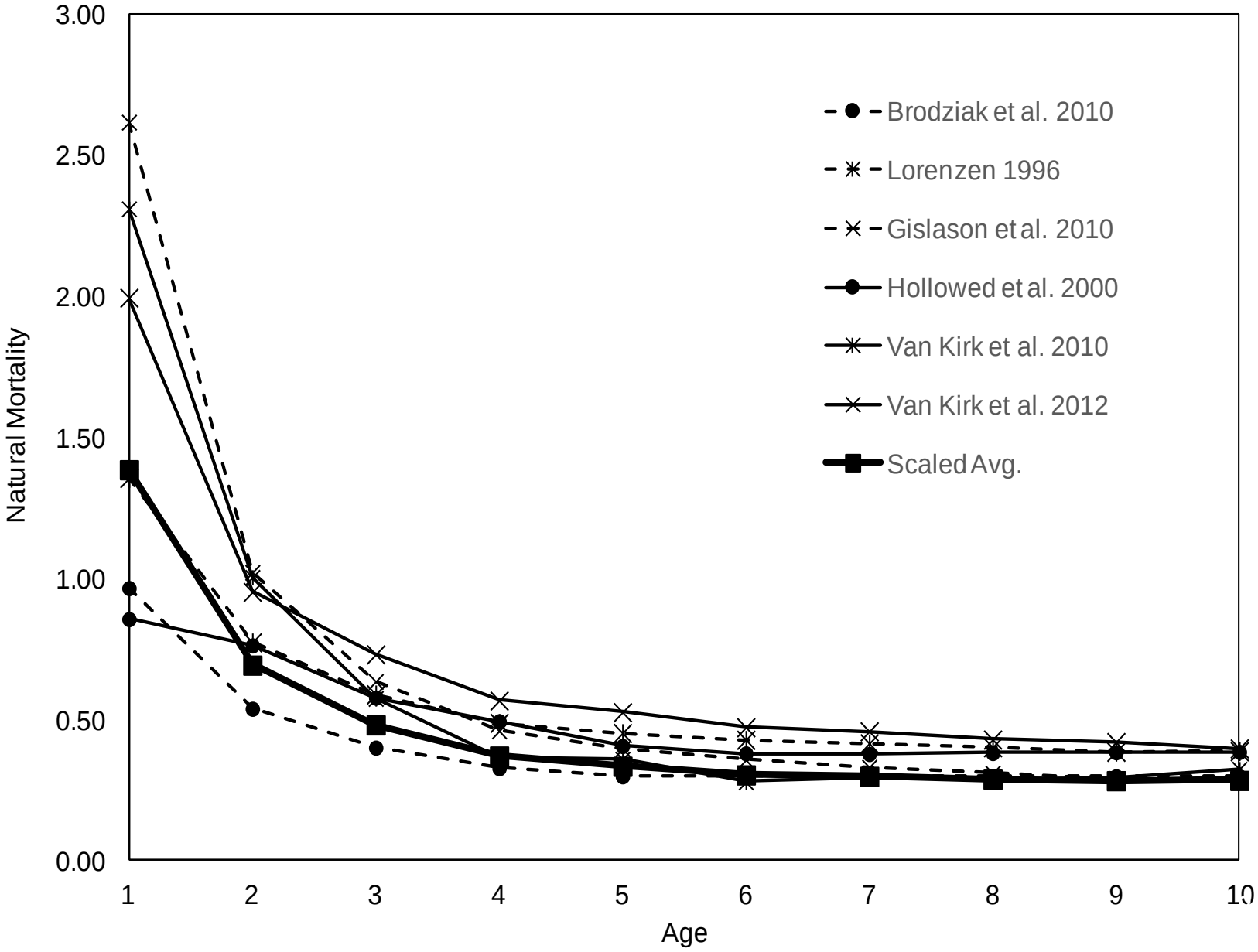
Unusual features of the 2012 year class life history characteristics



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 2019 and 2020.
- Proportion mature at age (new method)

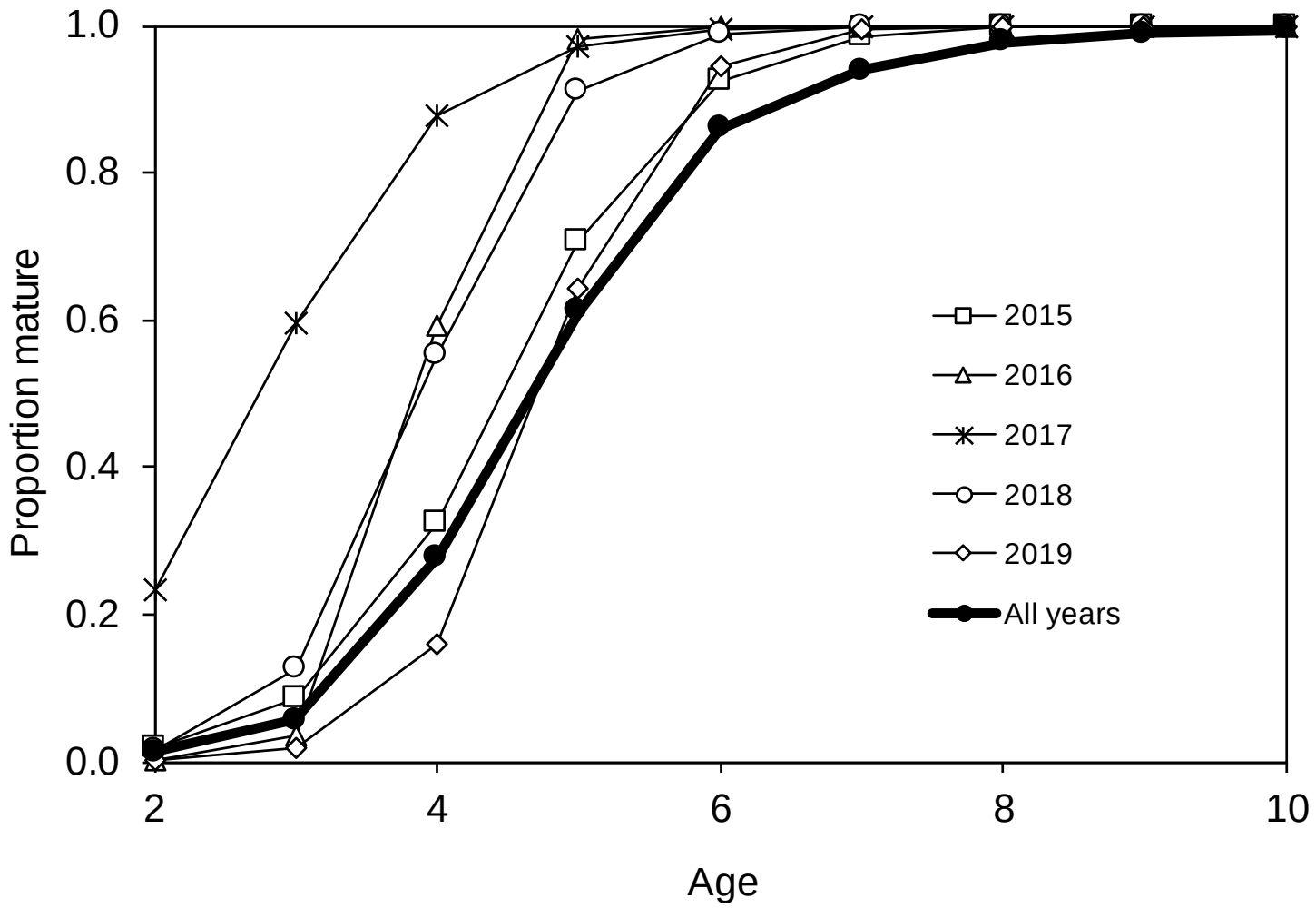
Natural mortality estimates



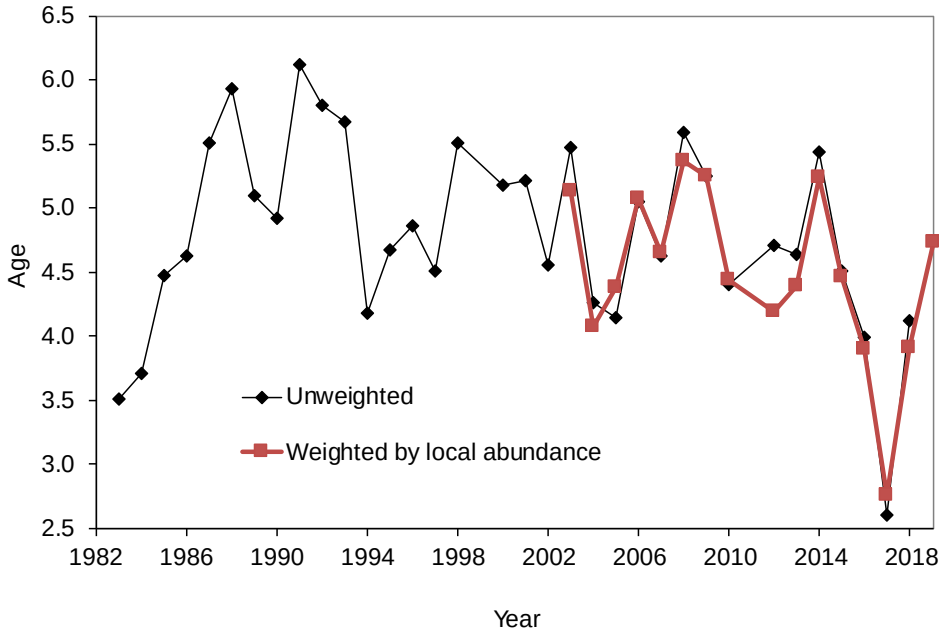
New maturity estimates

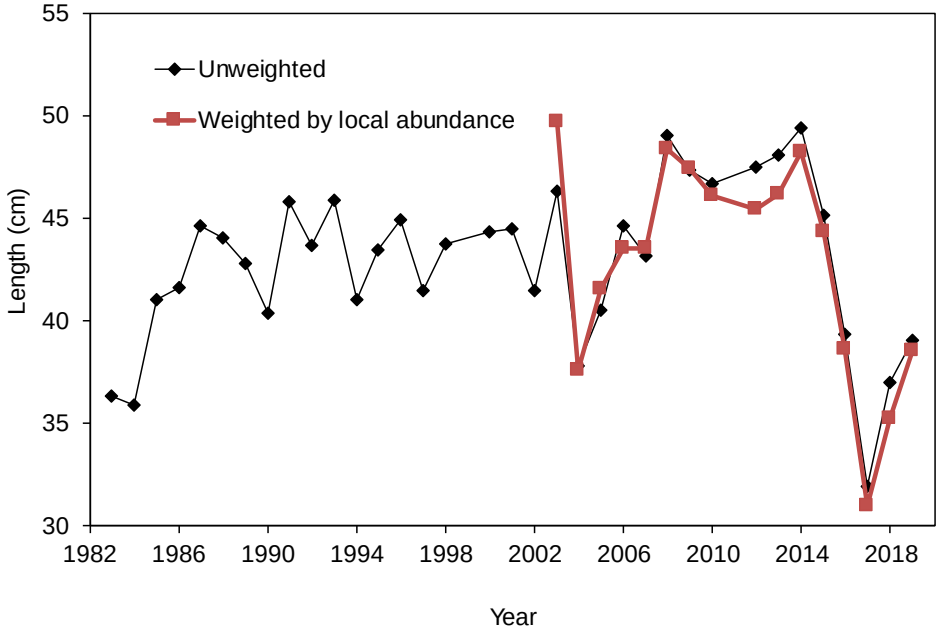
- Maturity estimates from 2003 onwards were revised
- Weights obtained dividing abundance >30cm in a haul-stratum by the mean abundance per haul-stratum
- Weights range from 0.05 to 6, as some hauls were placed in light sign while others sampled very dense aggregations.
- Maturity-at-age was estimated using logistic regression
- Weighted generalized linear model was used where data from each haul weighted by the appropriate values as computed above.

Recent maturity curves

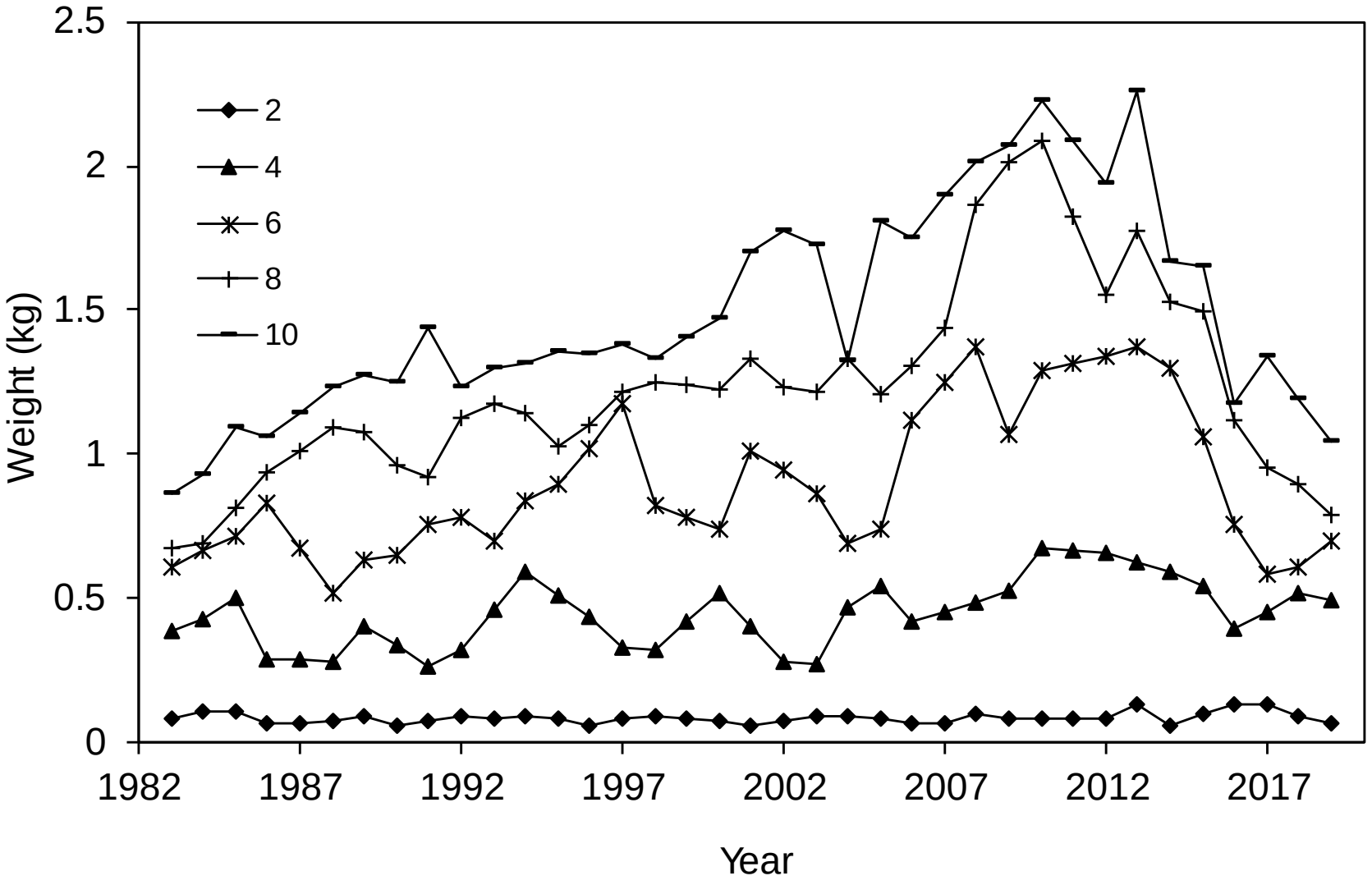


Changes in maturity

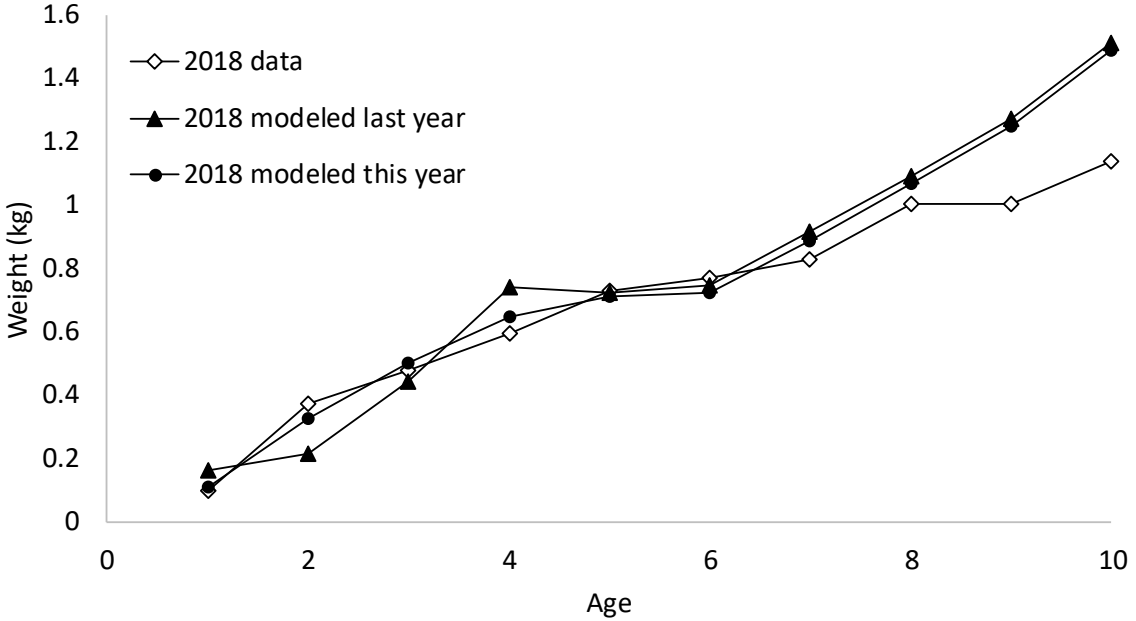


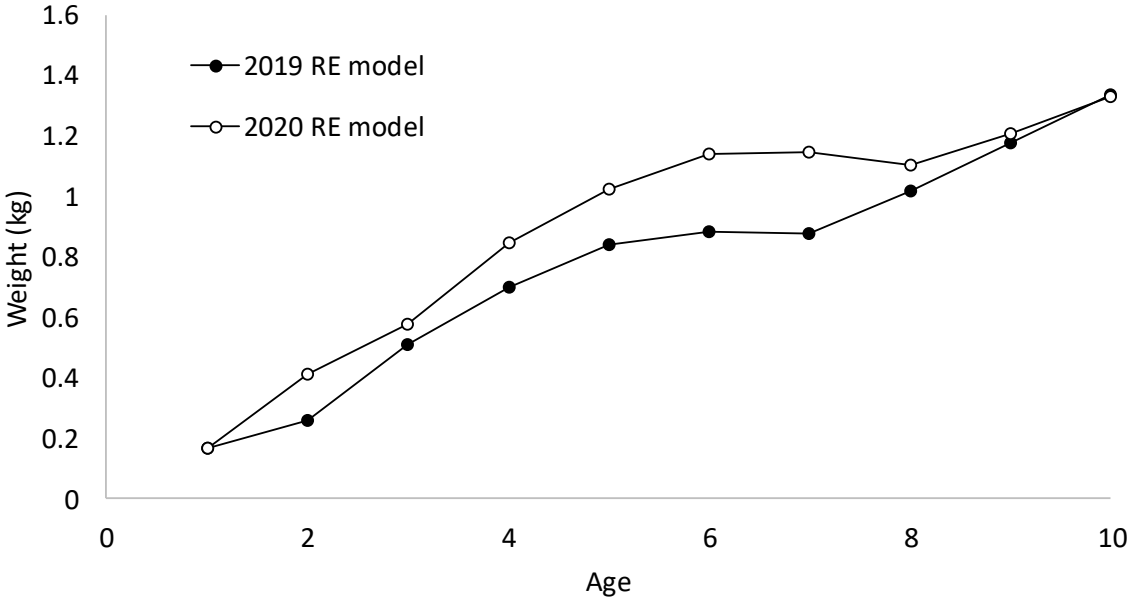


Shelikof survey changes in weight at age



RE model for fishery weight at age





Likelihood components

Likelihood component	Statistical model for error	Variance assumption
Fishery total catch (1970-2019)	Log-normal	CV = 0.05
Fishery age comp. (1975-2018)	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. (1992-2019)	Multinomial	Initial sample size = 60
Shelikof acoustic survey age-1 and age-2 indices (1994-2019)	Log-normal	Tuned CVs = 0.45 and 0.45
Summer acoustic survey biomass (2013-2019)	Log-normal	CV = 0.25
Summer acoustic survey age comp. (2013, 2015, 2017)	Multinomial	Initial sample size = 10
Summer acoustic survey length comp. (2019)	Multinomial	Initial sample size = 10
NMFS bottom trawl survey biom. (1990-2019)	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
NMFS bottom trawl survey length comp. (2019)	Multinomial	Initial sample size = 10
ADF&G trawl survey index (1989-2019)	Log-normal	Survey-specific CV from delta GLM model x 2= 0.18-0.40
ADF&G survey age comp. (2000-2018)	Multinomial	Initial sample size = 30
Recruit process error (1970-1977, 2018, 2019)	Log-normal	σ_R =1.0

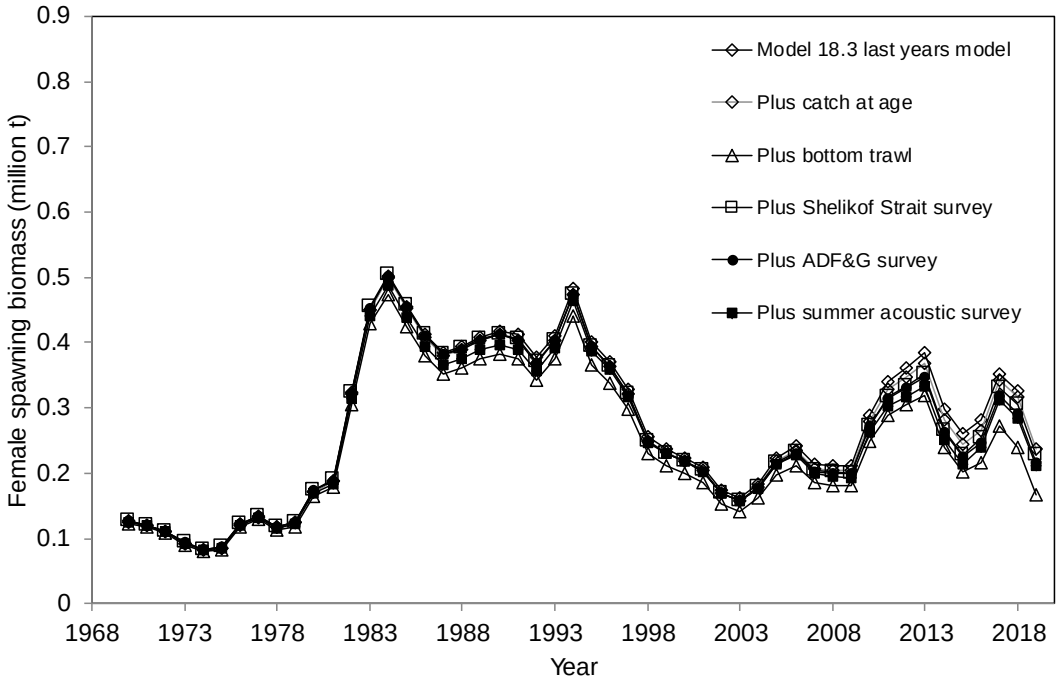
Model parameters

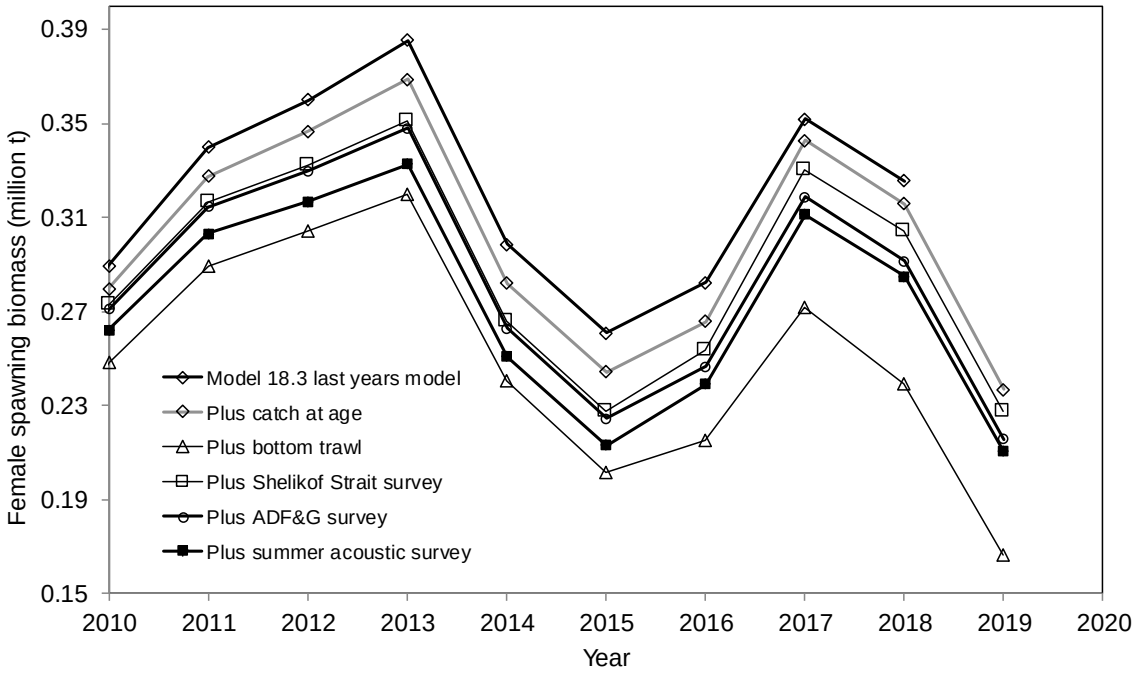
Population process modeled	Number of parameters	Estimation details
Recruitment	Years 1970-2019 = 50	Estimated as log deviances from the log mean; recruitment in 1970-77, and 2018 and 2019 constrained by random deviation process error.
Natural mortality	Age-specific= 10	Not estimated in the model
Fishing mortality	Years 1970-2019 = 50	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) = 98	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) = 98	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, ADF&G survey: 2)	Slope parameters estimated on a log scale.
Total	116 estimated parameters + 196 process error parameters + 10 fixed parameters = 322	

Model input changes

- Fishery: 2018 total catch and catch at age.
- Shelikof Strait acoustic survey: 2019 biomass and age composition.
- NMFS bottom trawl survey: 2019 biomass and size composition.
- Summer acoustic survey: 2019 biomass and size composition.
- ADF&G crab/groundfish trawl survey: 2019 biomass and 2018 age composition

Sequential addition of new data



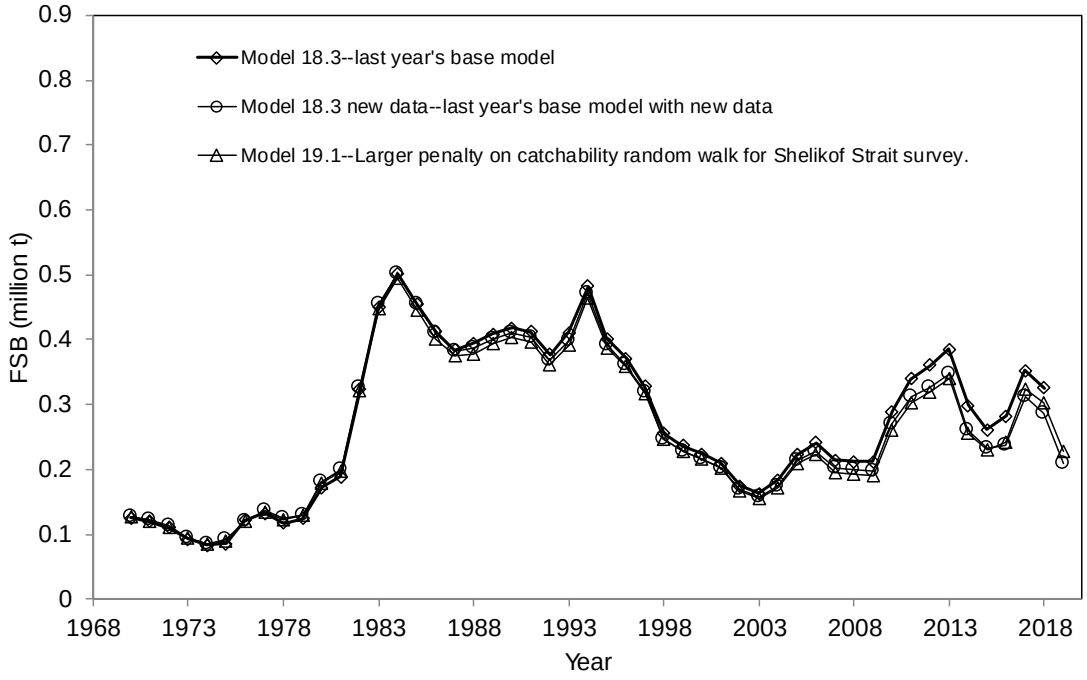


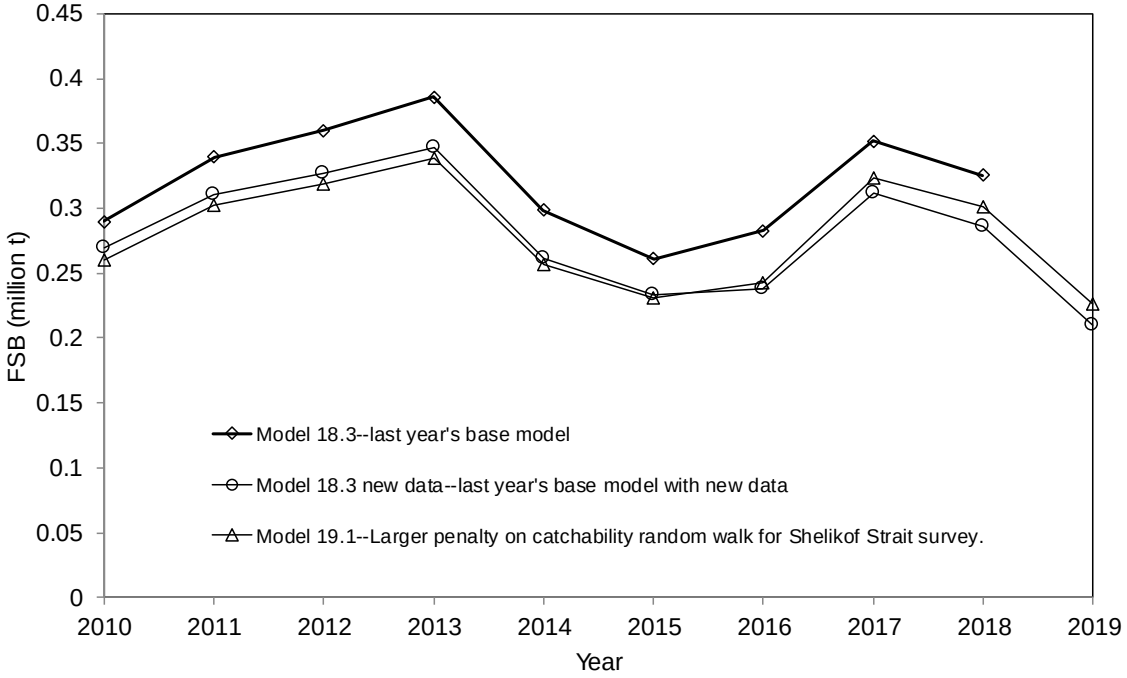
Alternative Models

Model 18.3--last year's base model.

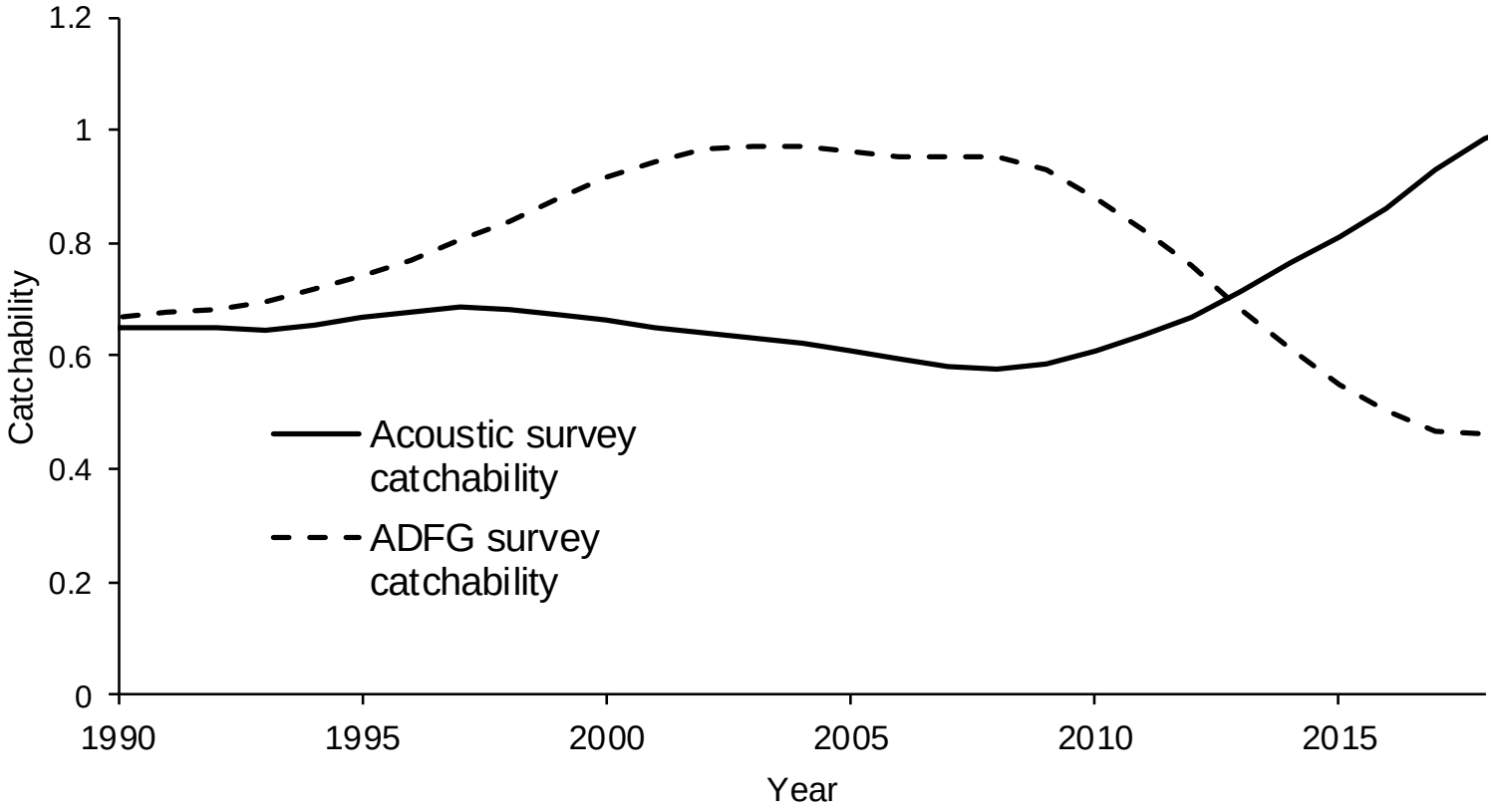
Model 18.3 new data--last year's base model with new data.

Model 19.1--Larger penalty on catchability random walk for Shelikof Strait survey.

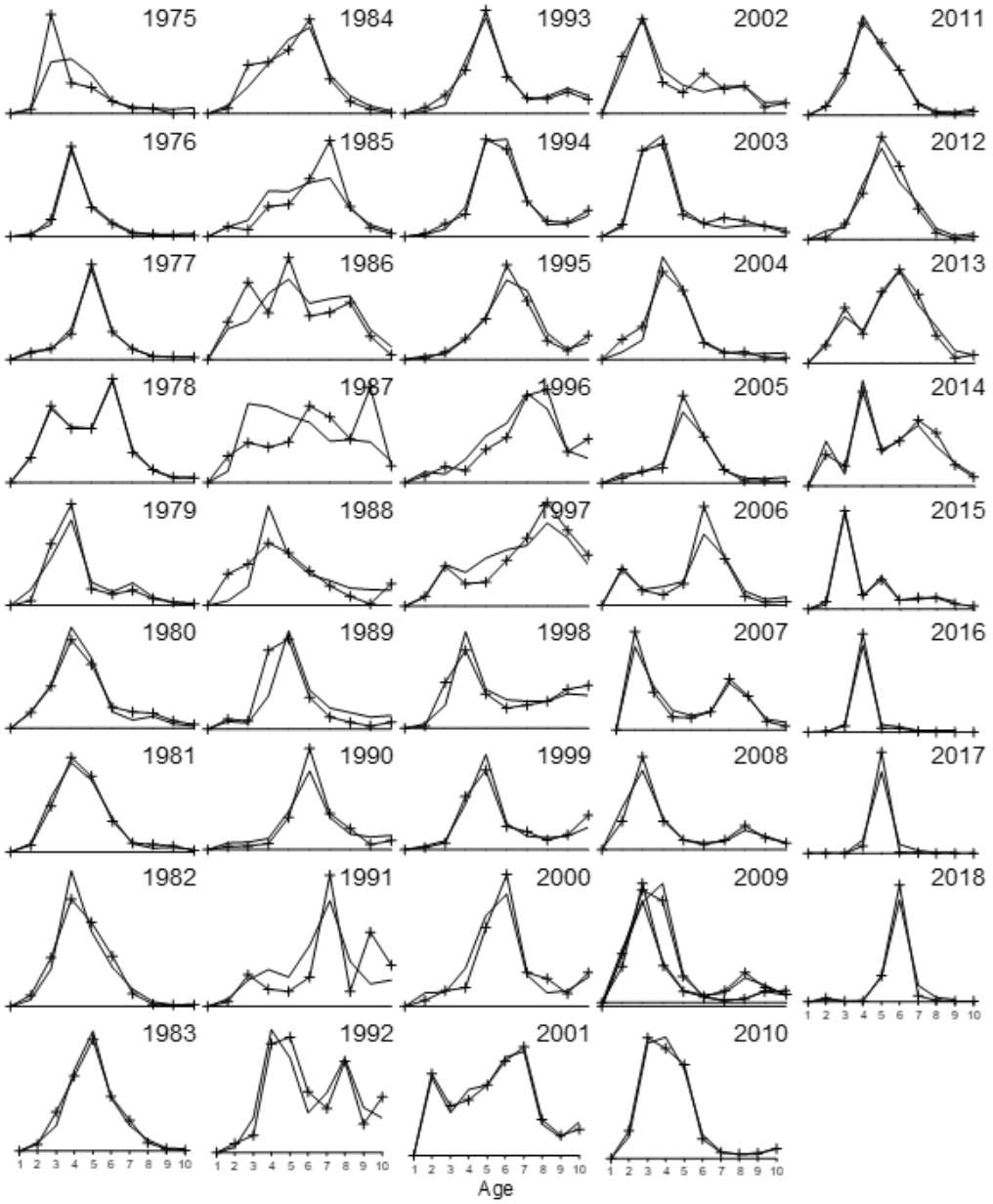




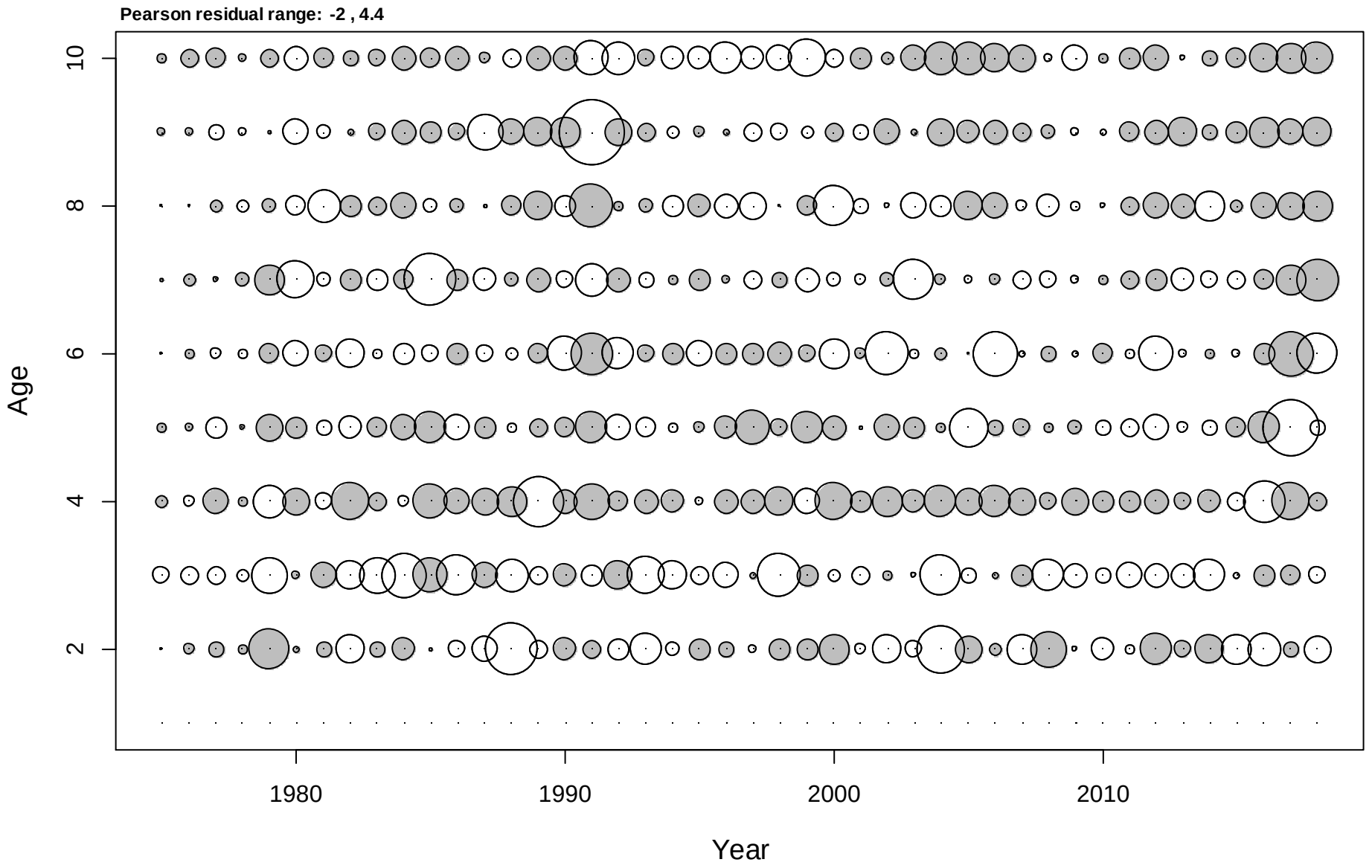
Random walk in catchability for Shelikof Strait survey and ADFG survey



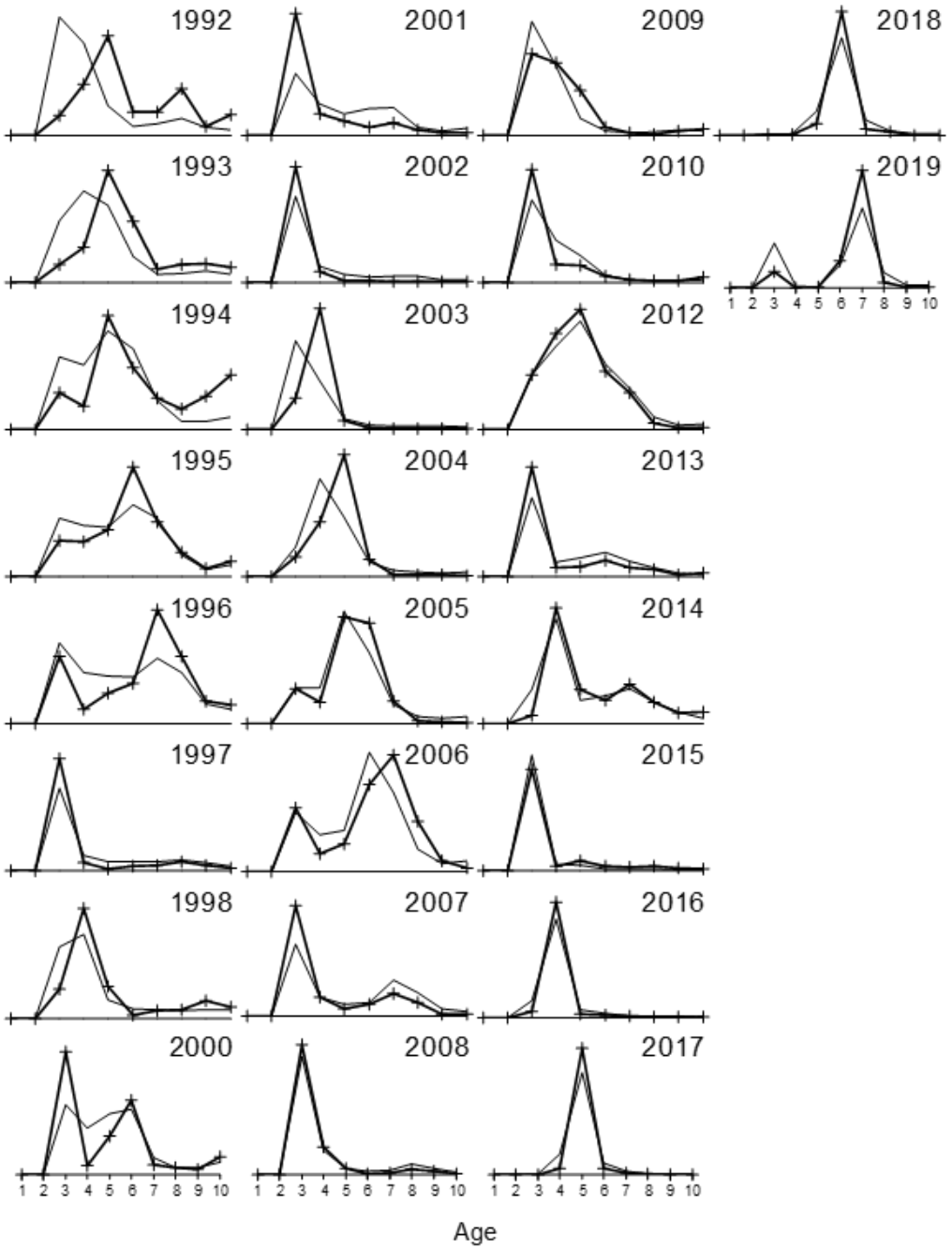
Fishery age composition (predicted vs observed)



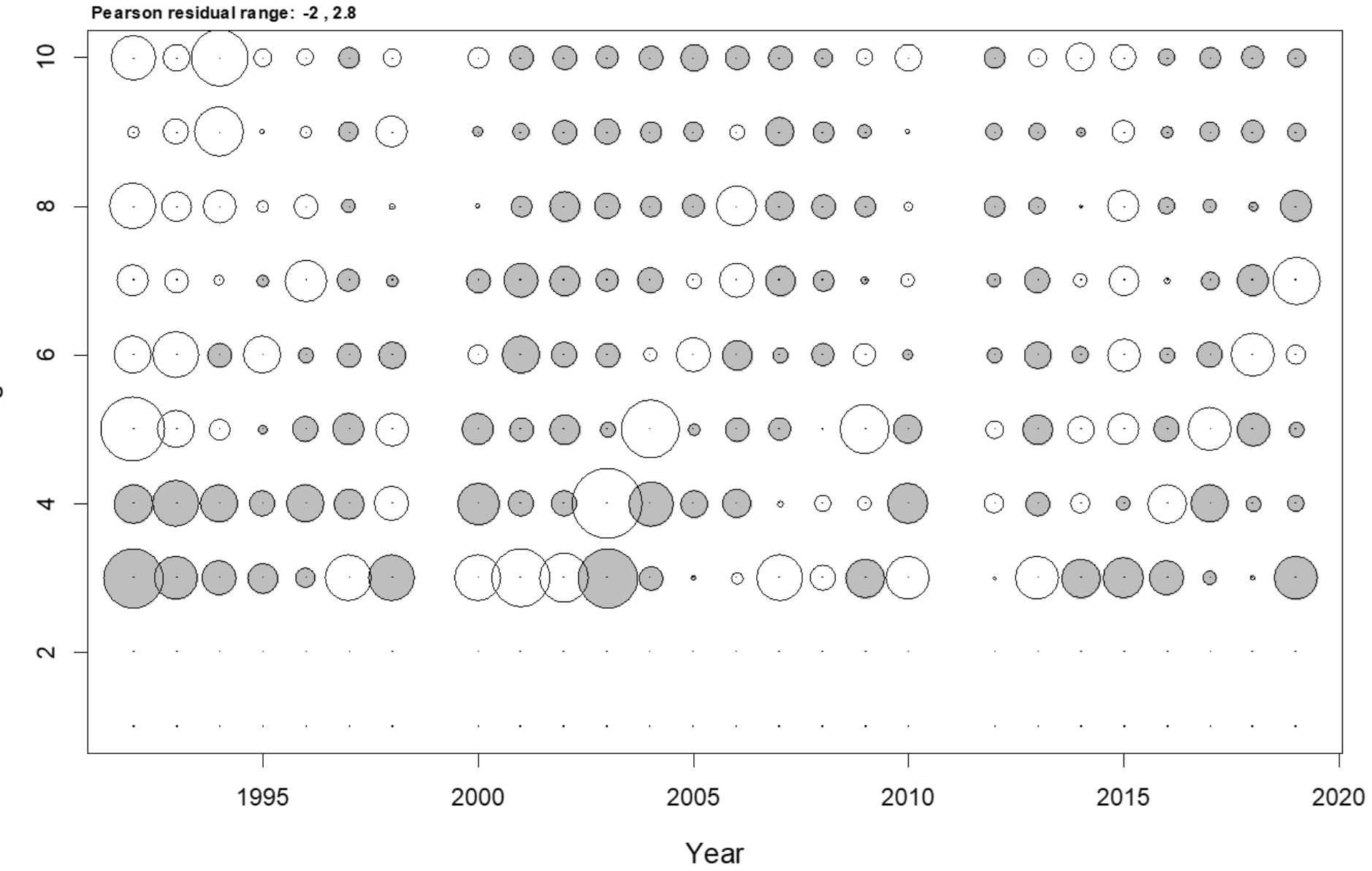
Fishery age composition (residuals)



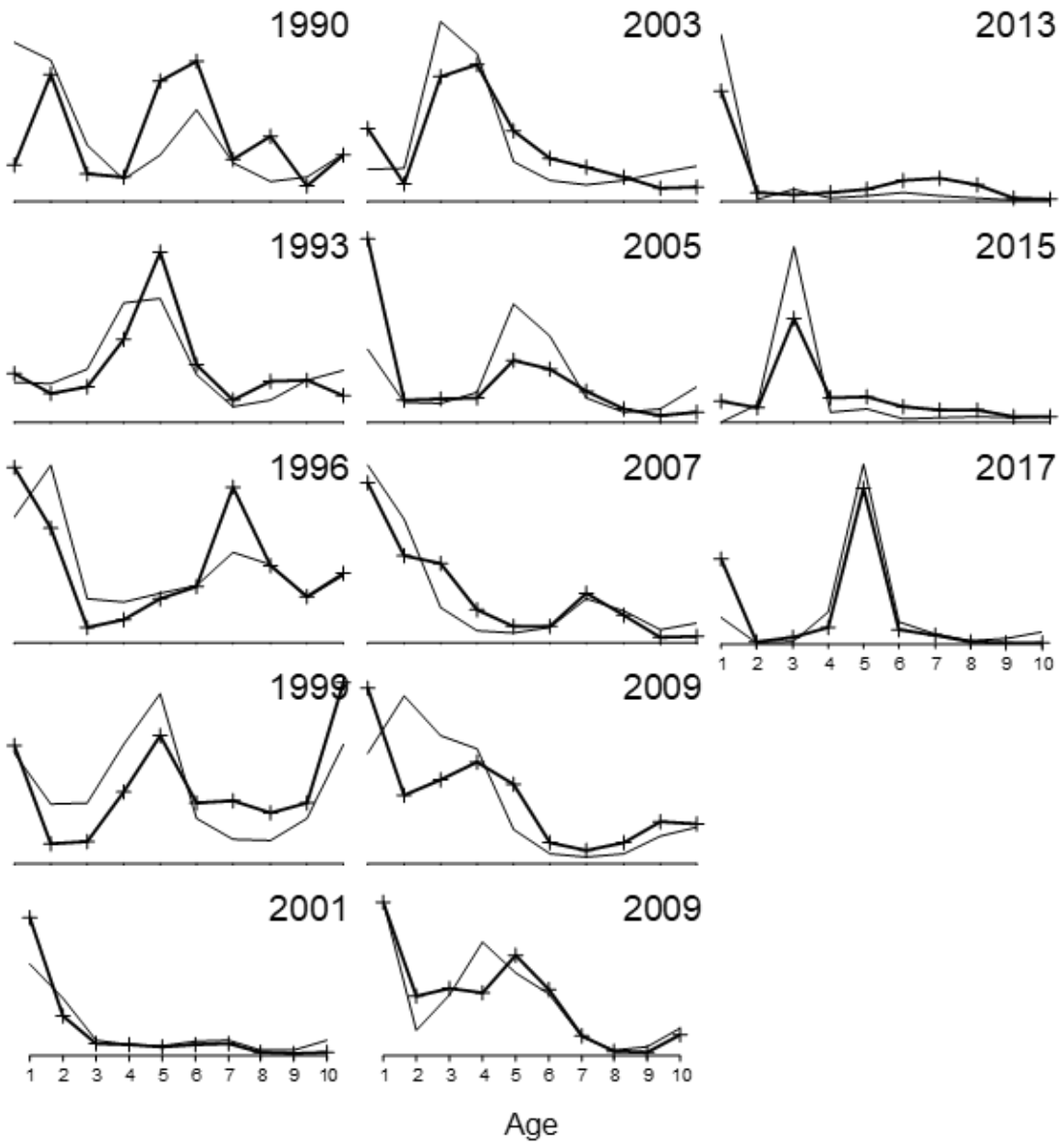
Shelikof Strait EIT age composition (predicted vs observed)



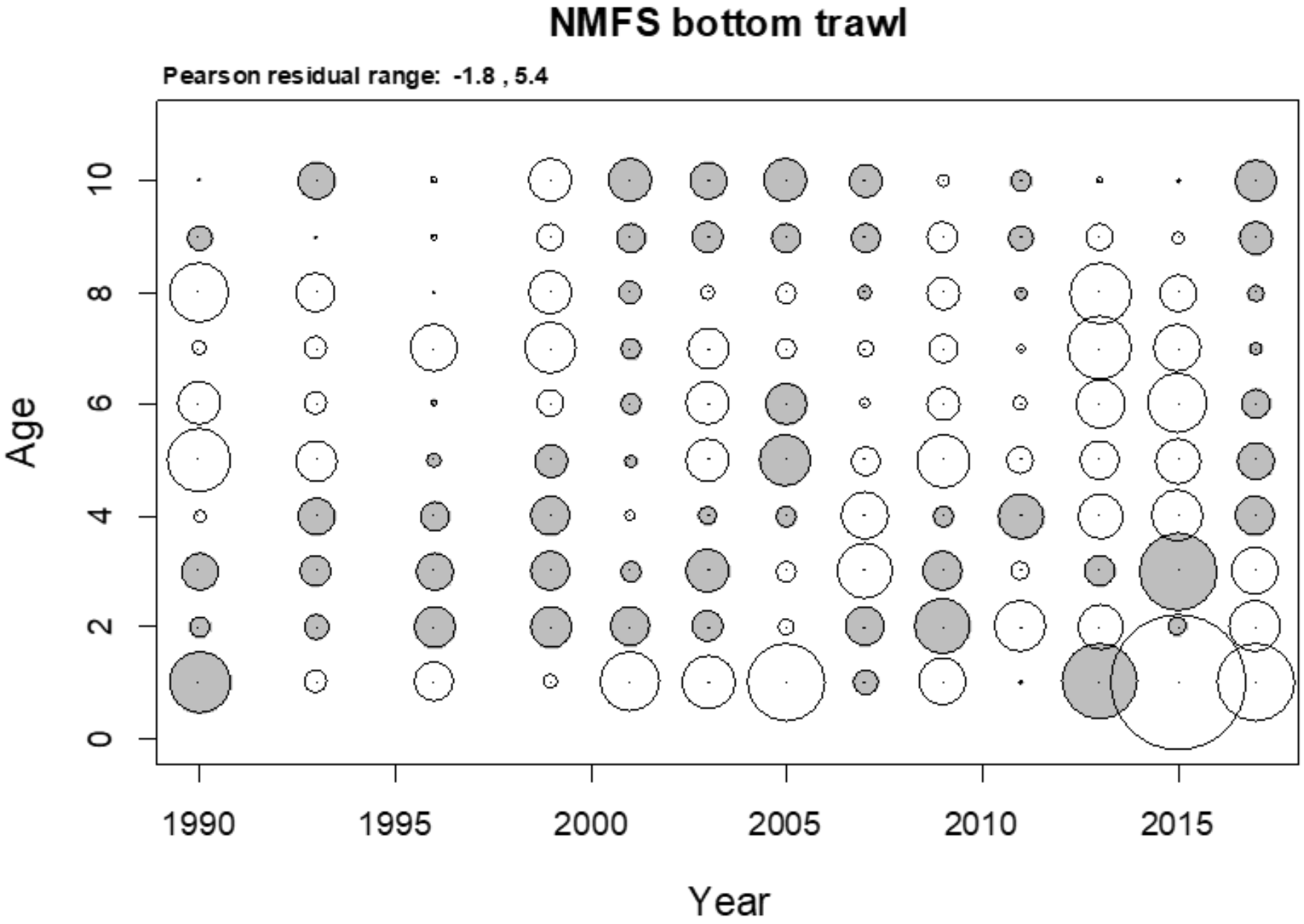
Shelikof Strait EIT age composition (residuals)



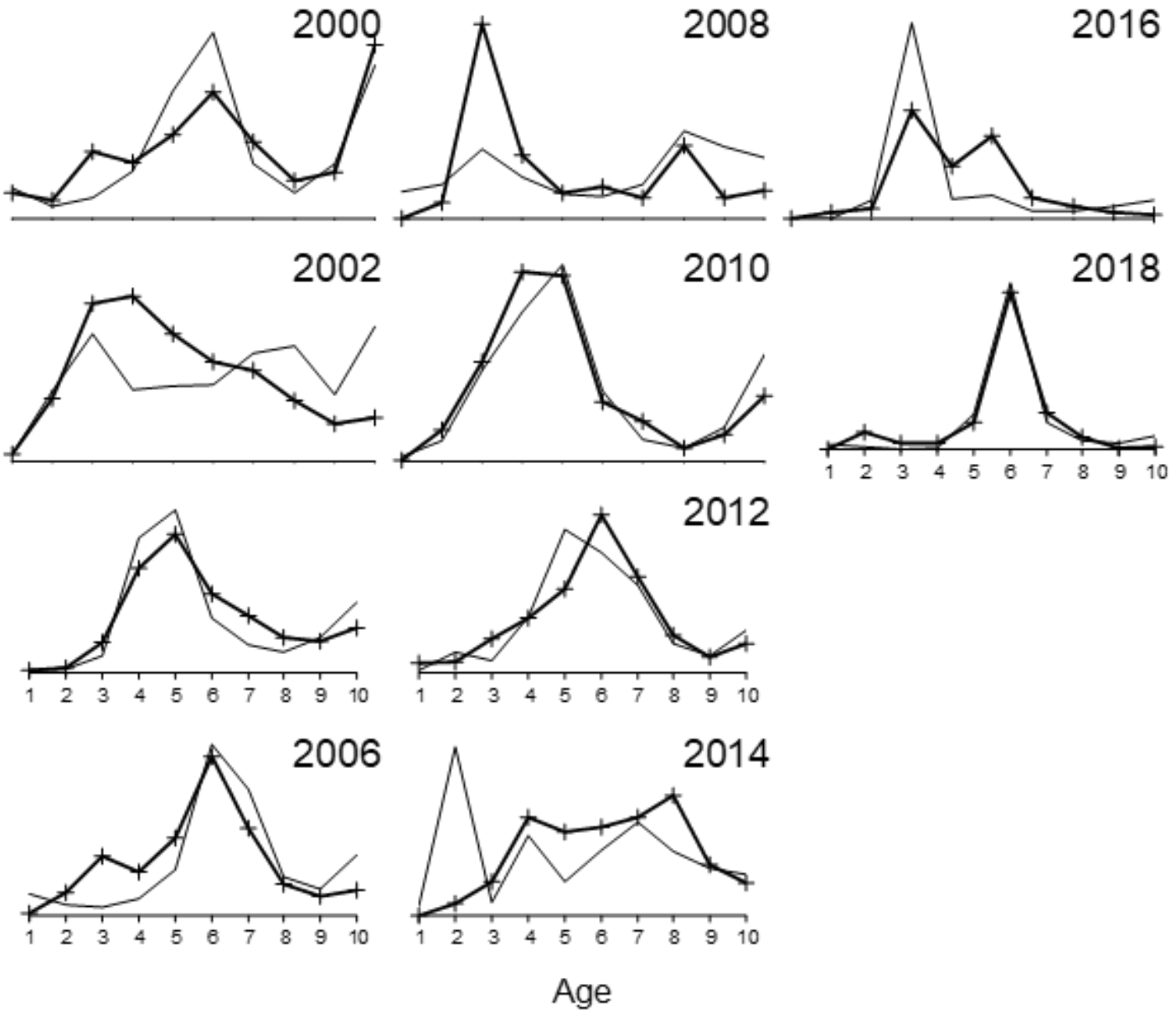
NMFS bottom trawl age composition (predicted vs observed)



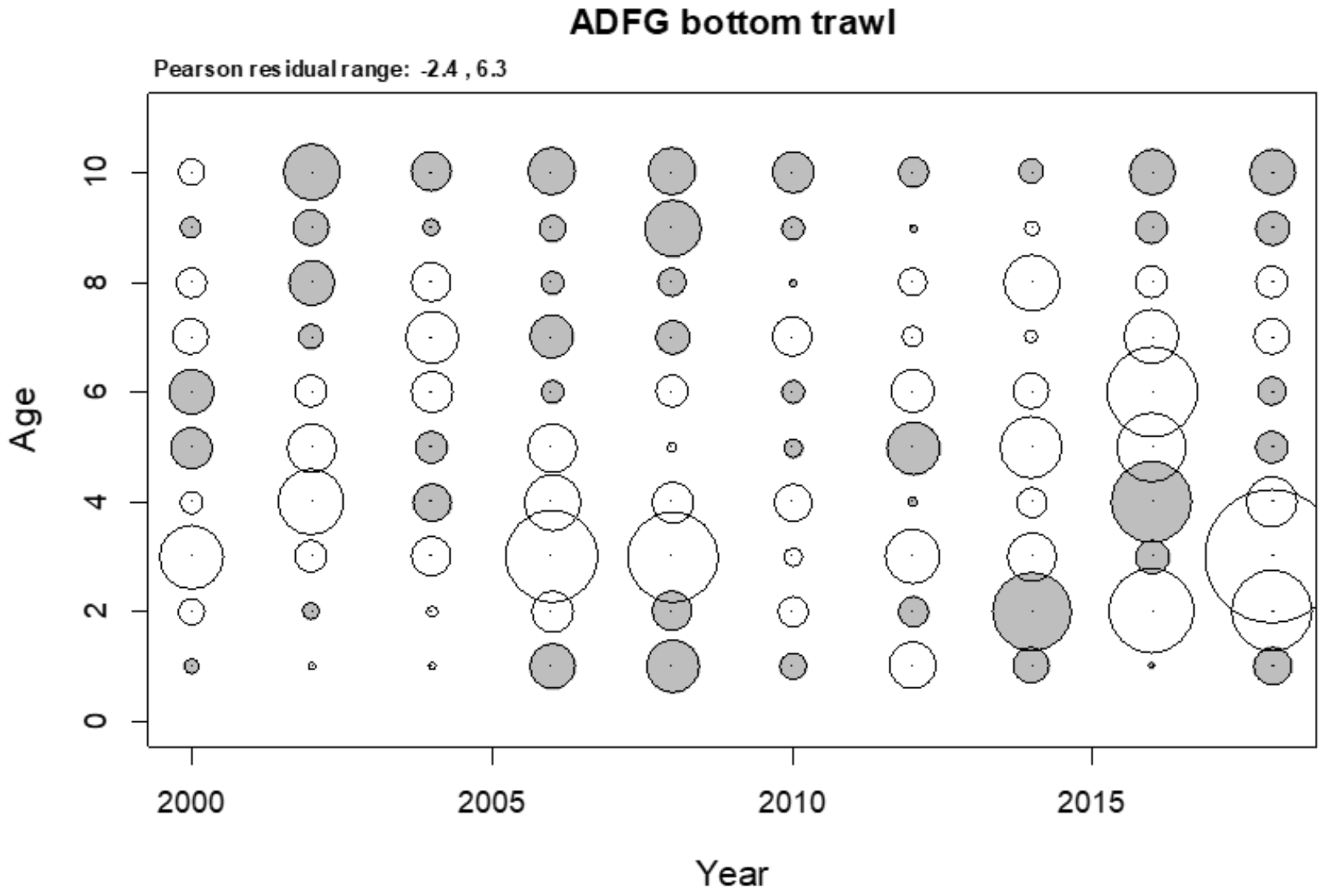
NMFS bottom trawl age composition (residuals)



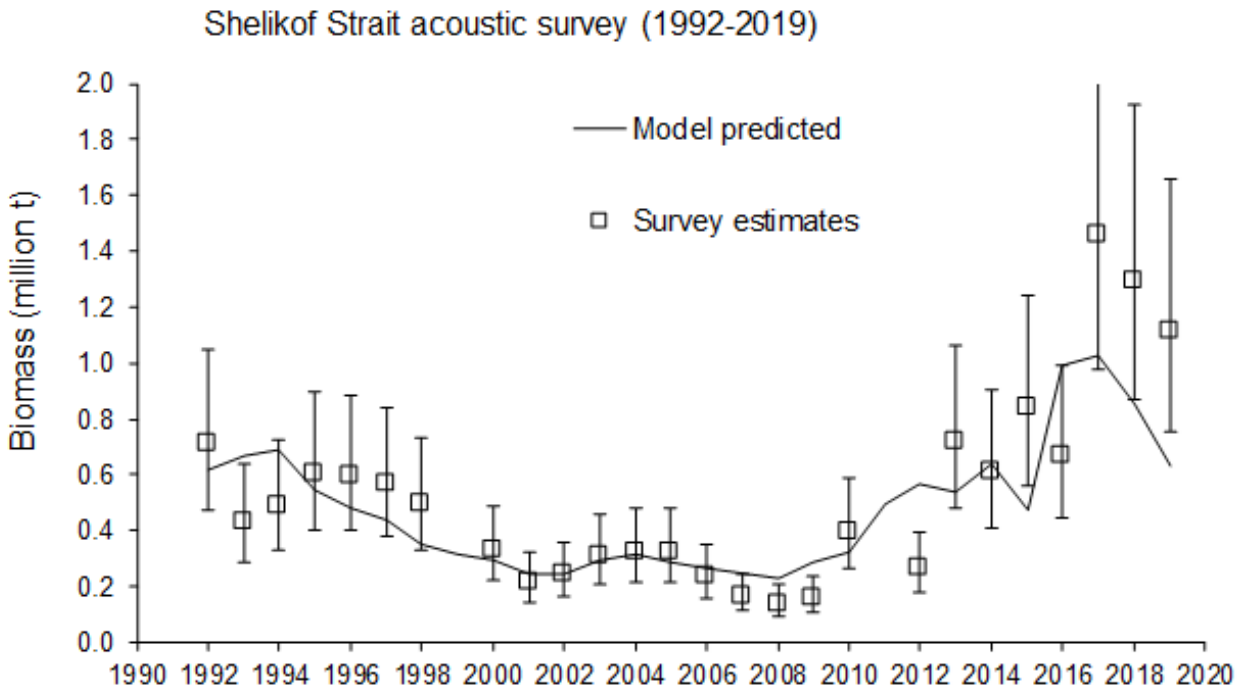
ADFG bottom trawl age composition (predicted vs observed)



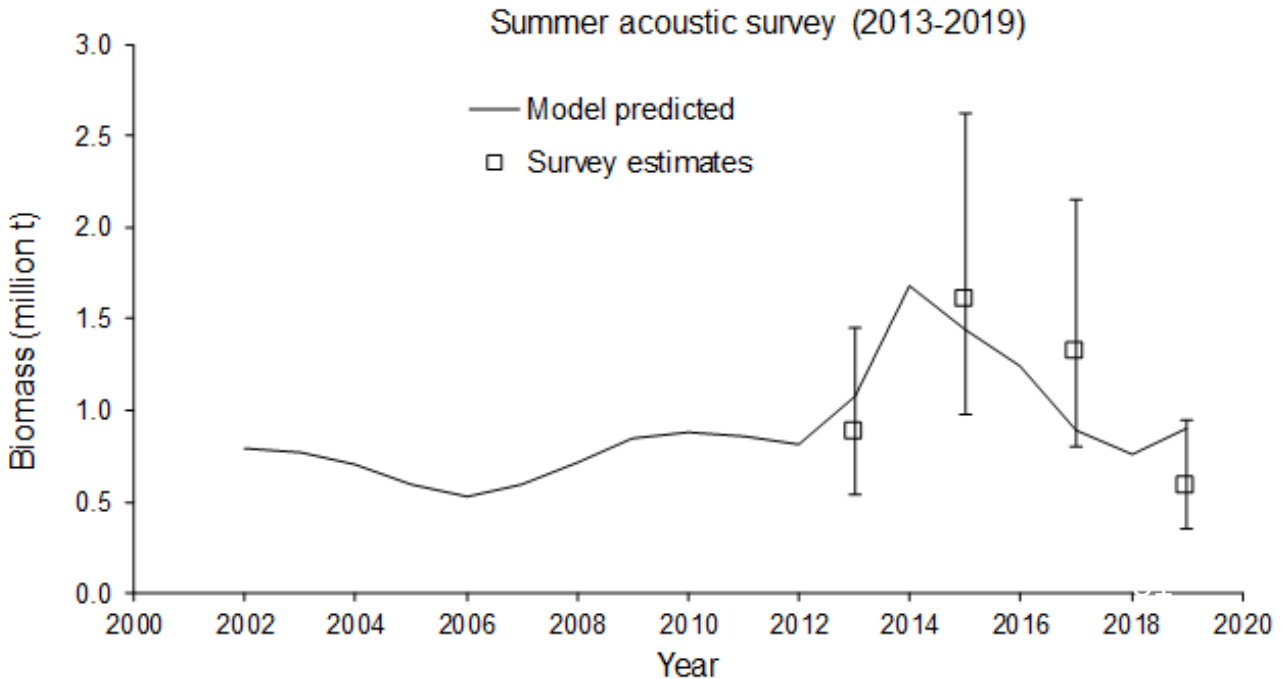
ADFG bottom trawl age composition (residuals)



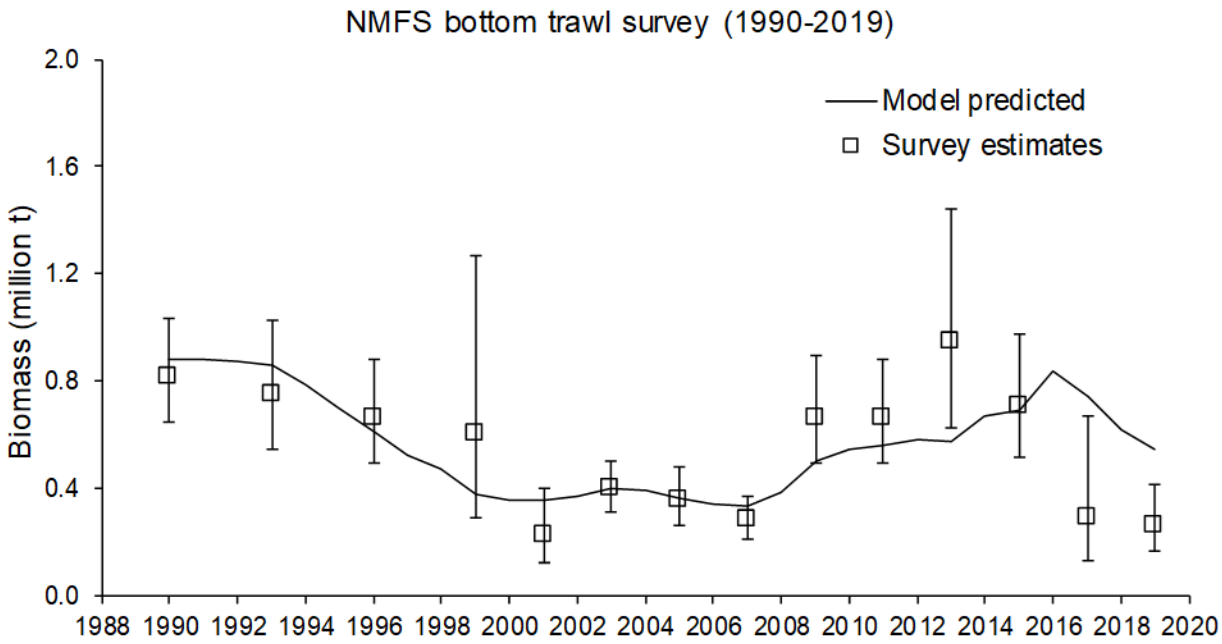
Fit to Shelikof Strait acoustic survey



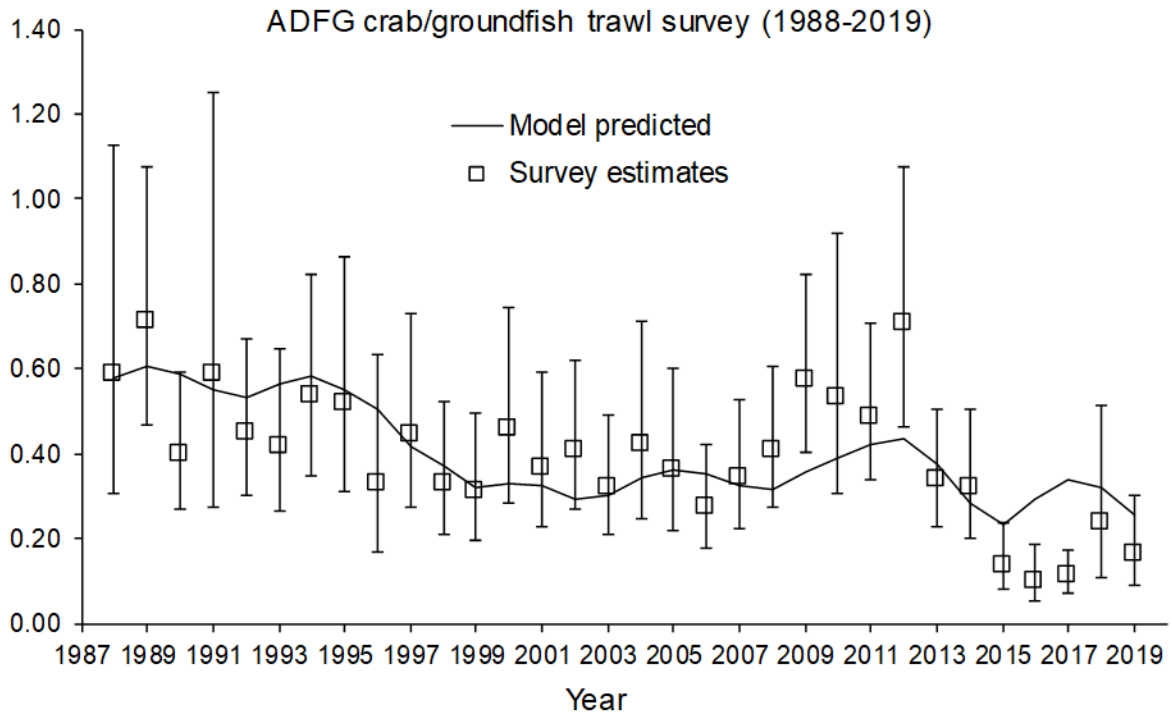
Fit to summer Acoustic survey



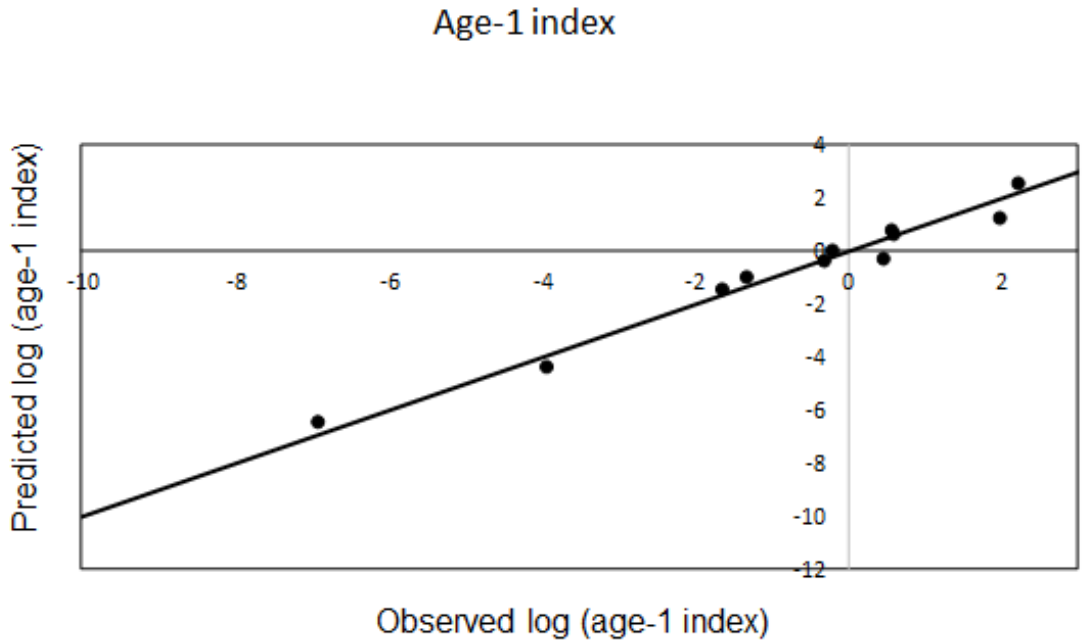
Fit to NMFS bottom trawl survey



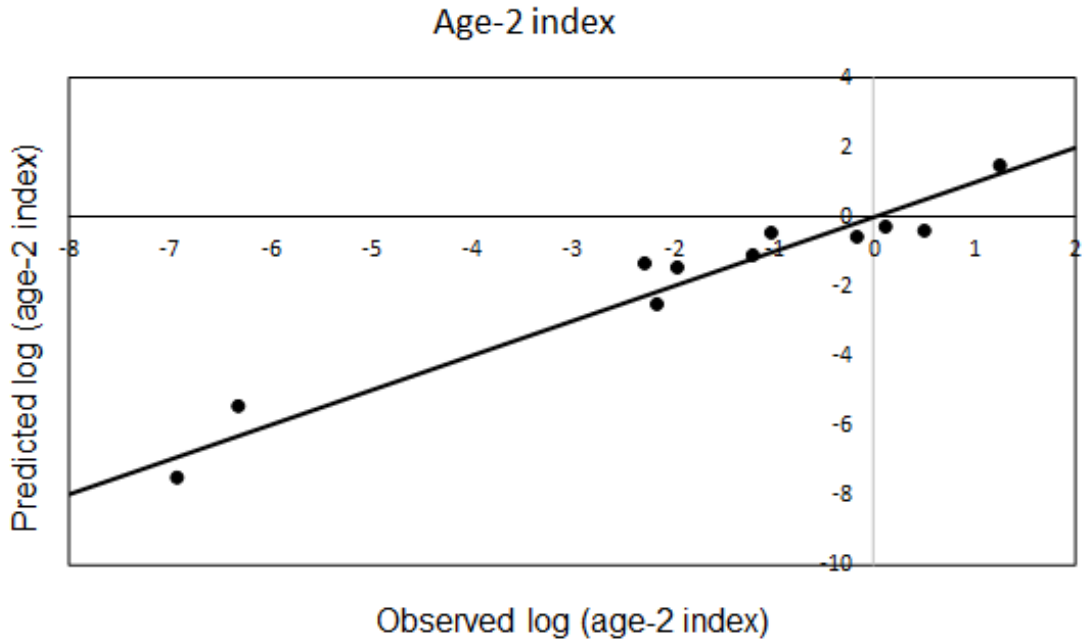
Fit to ADFG survey



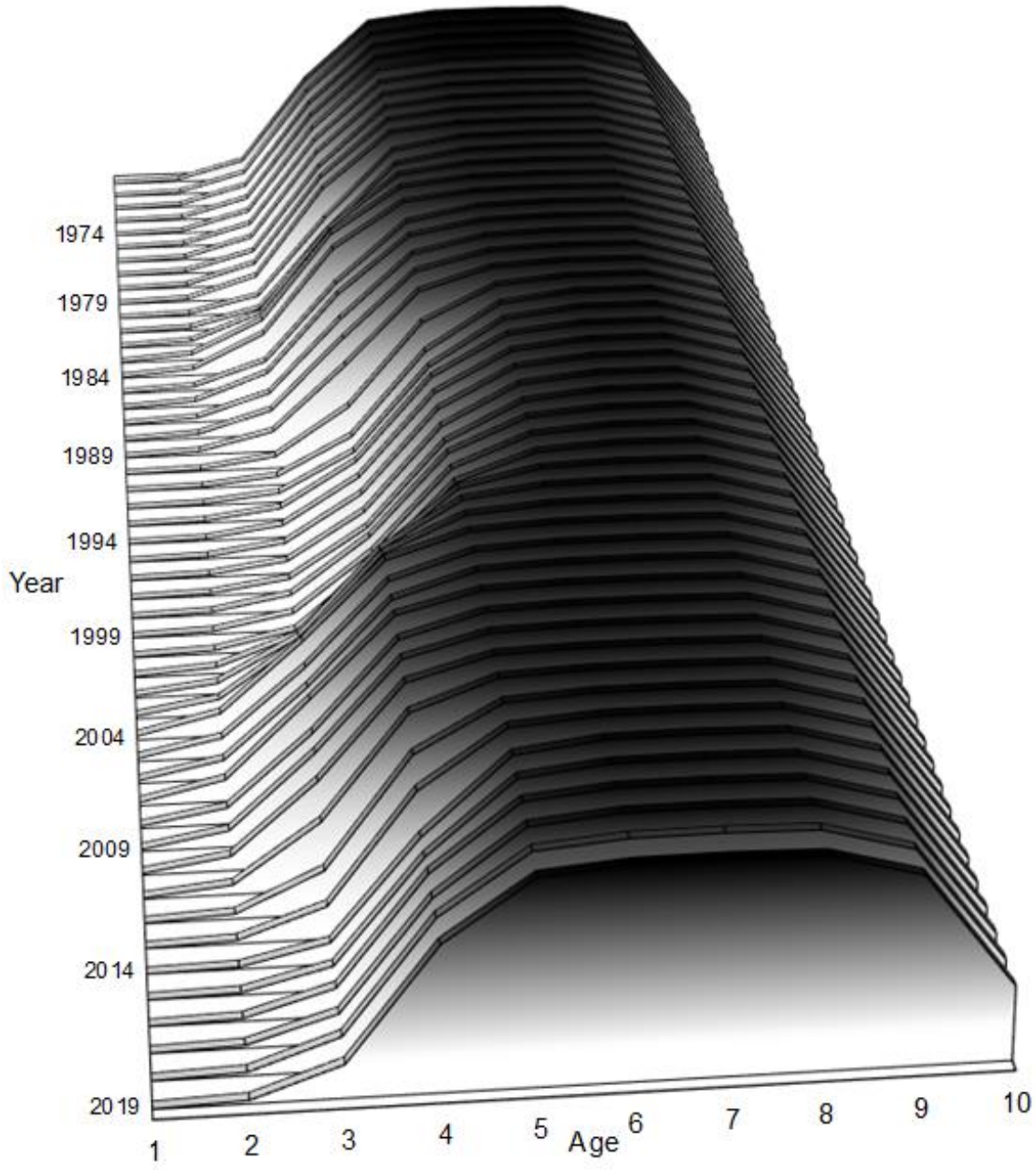
Fit to Age-1 index



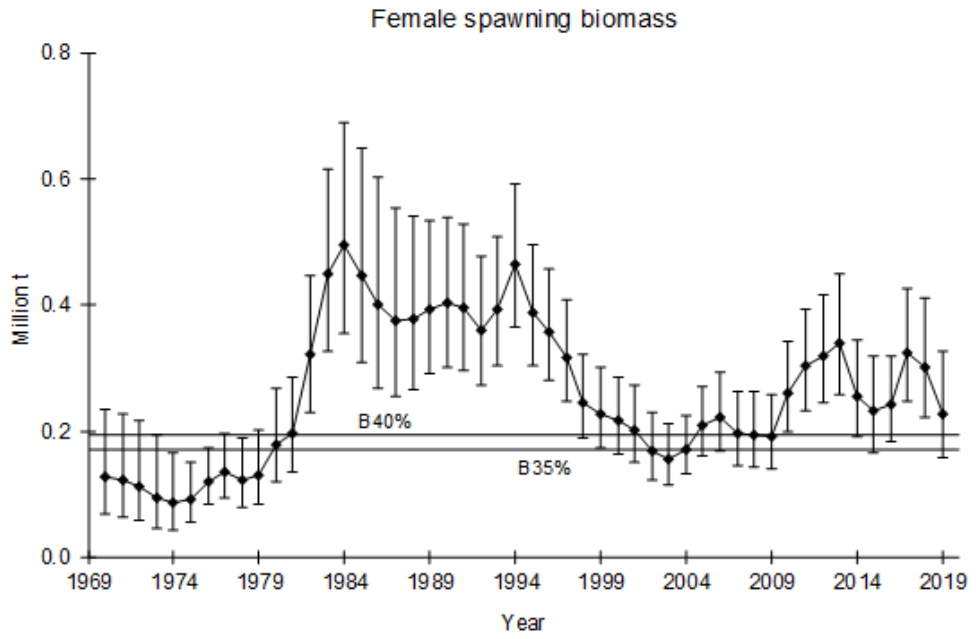
Fit to Age-2 index



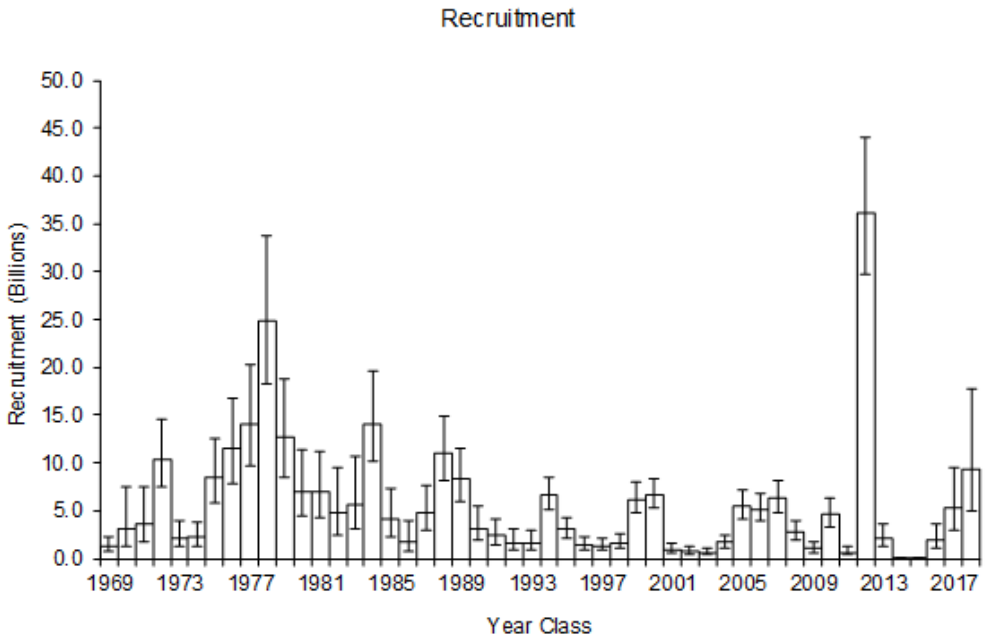
Fishery selectivity



Spawning biomass

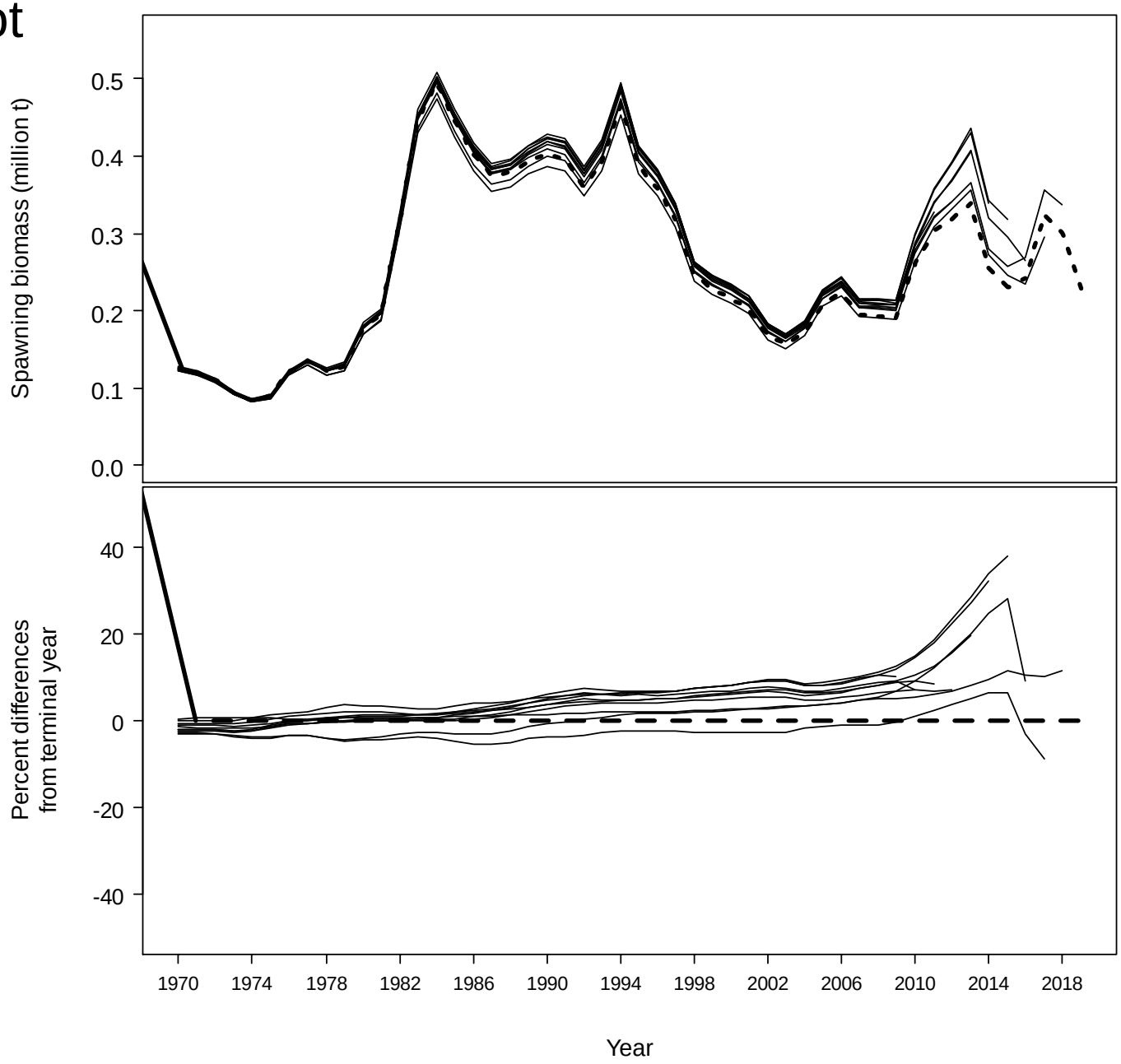


Recruitment

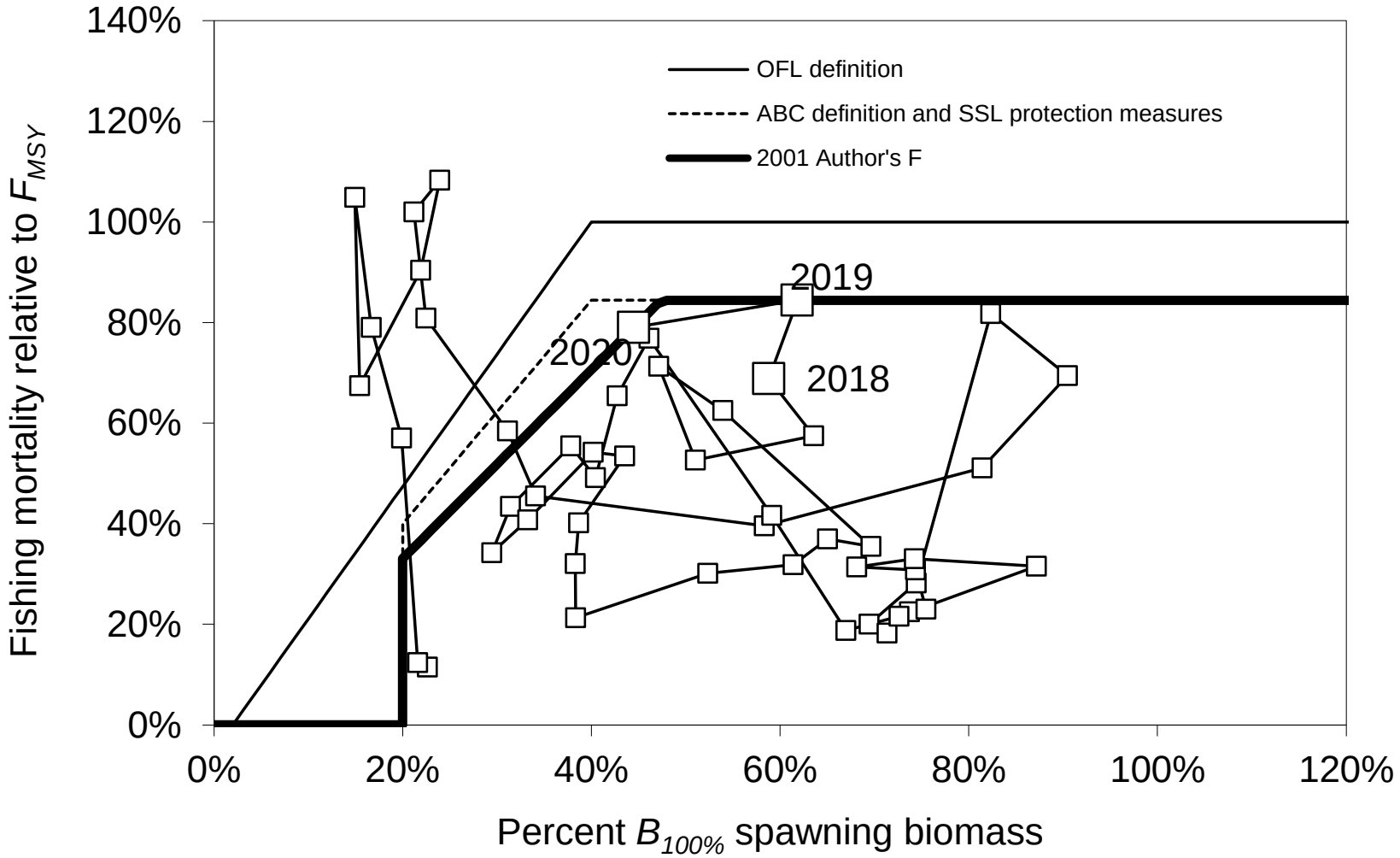


Retrospective plot

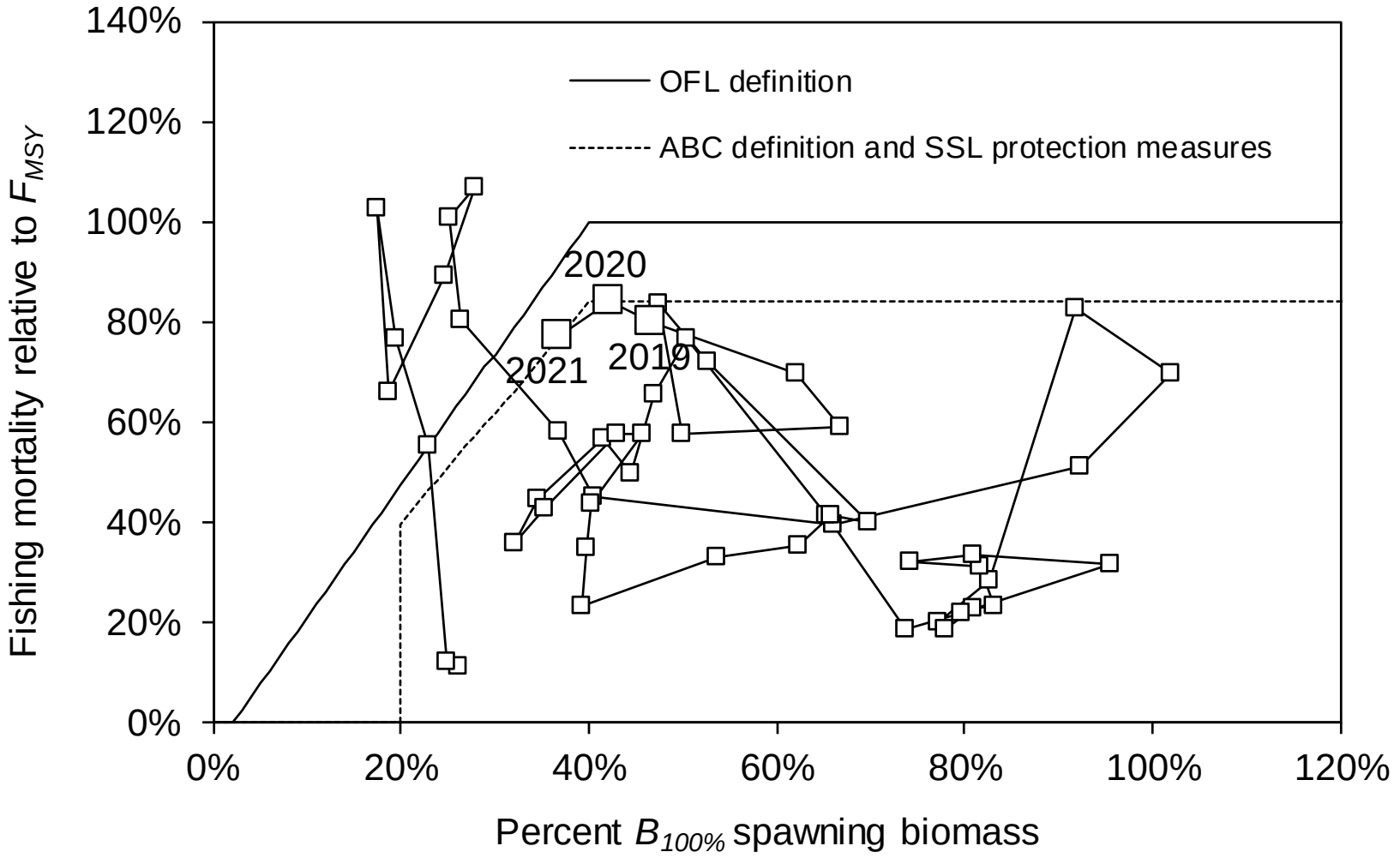
Mohn's ρ = 0.134



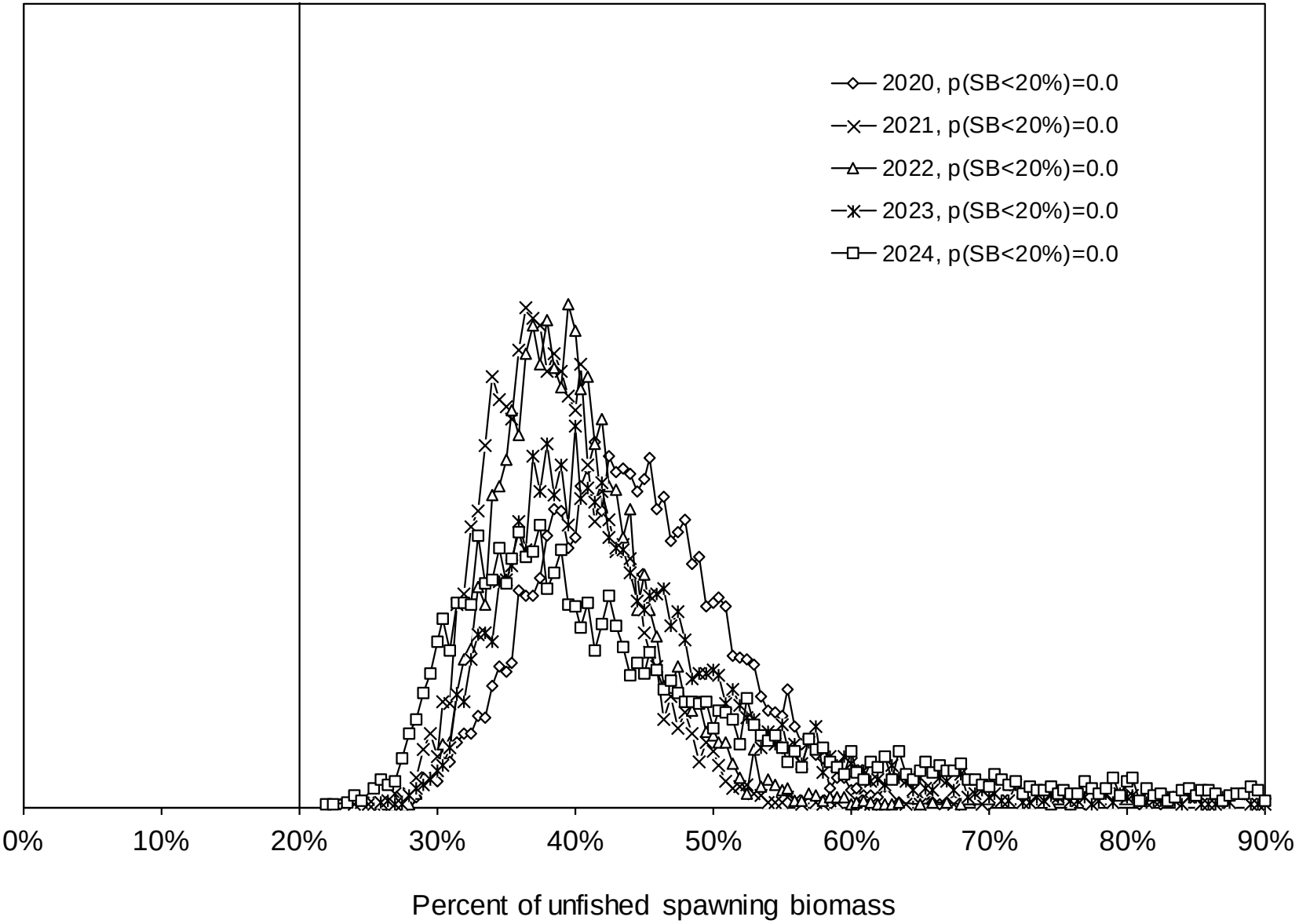
Spawning biomass vs fishing mortality (last year)



Spawning biomass vs fishing mortality (this year)

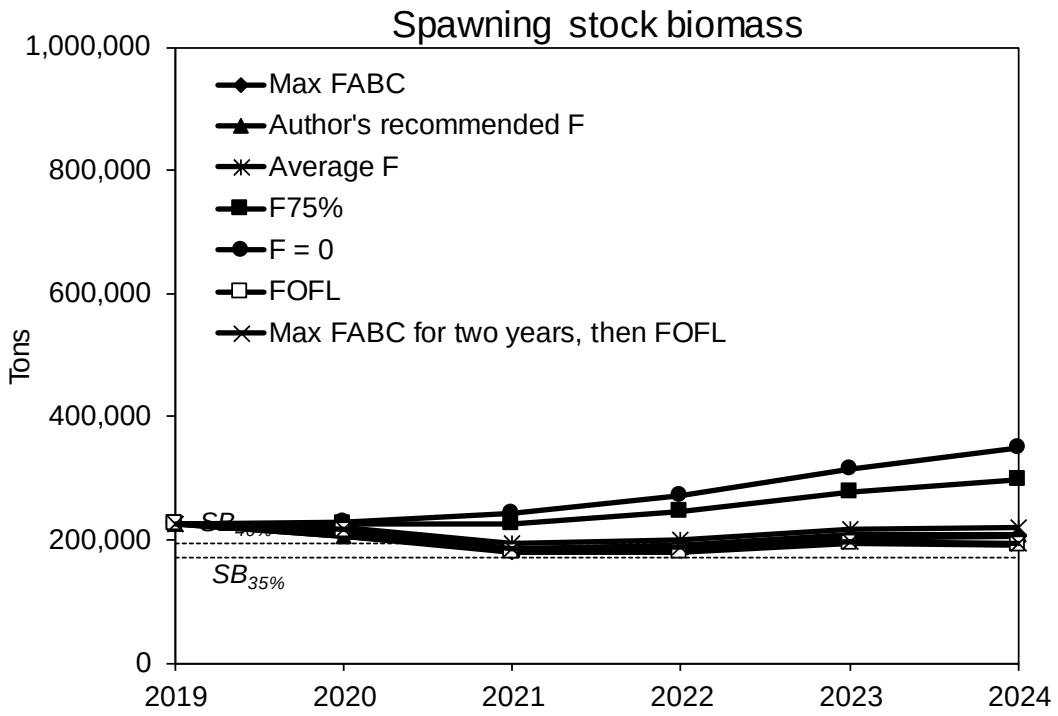


5-year pr(SB<B20%)

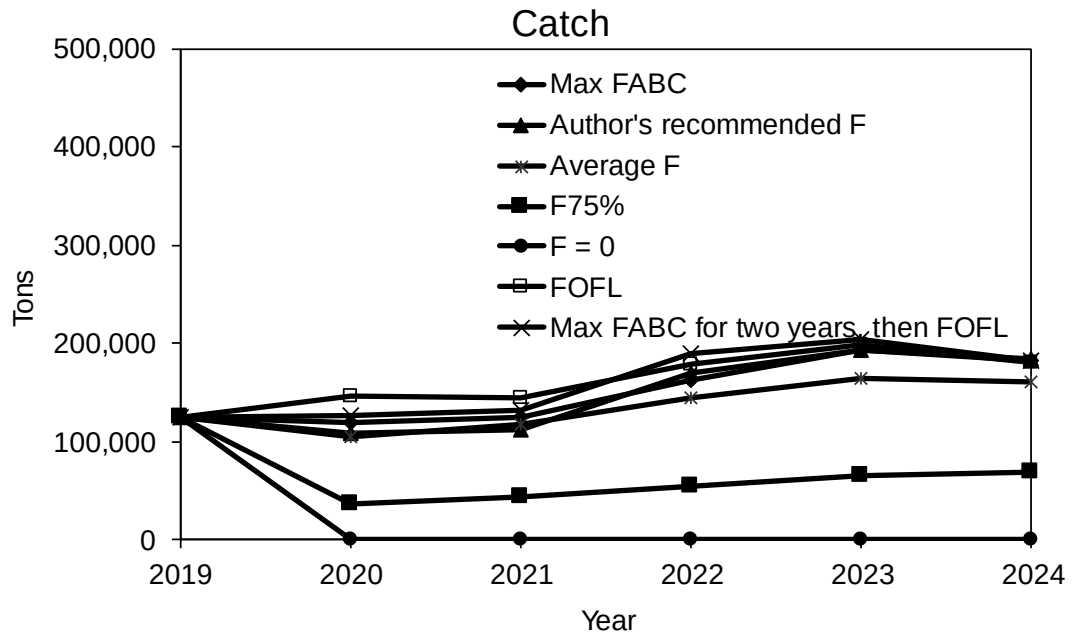


5-year projections

Mean spawning biomass



Mean yield



ESP Report

Appendix in SAFE report

1) Intro: justification, data
2) Metrics assessment: national, processes
3) Indicators assessment: time series, analyses
4) Recommendations; data gaps, future priorities

Appendix 1A. Ecosystem and Socioeconomic Profile of the Walleye Pollock stock in the Gulf of Alaska

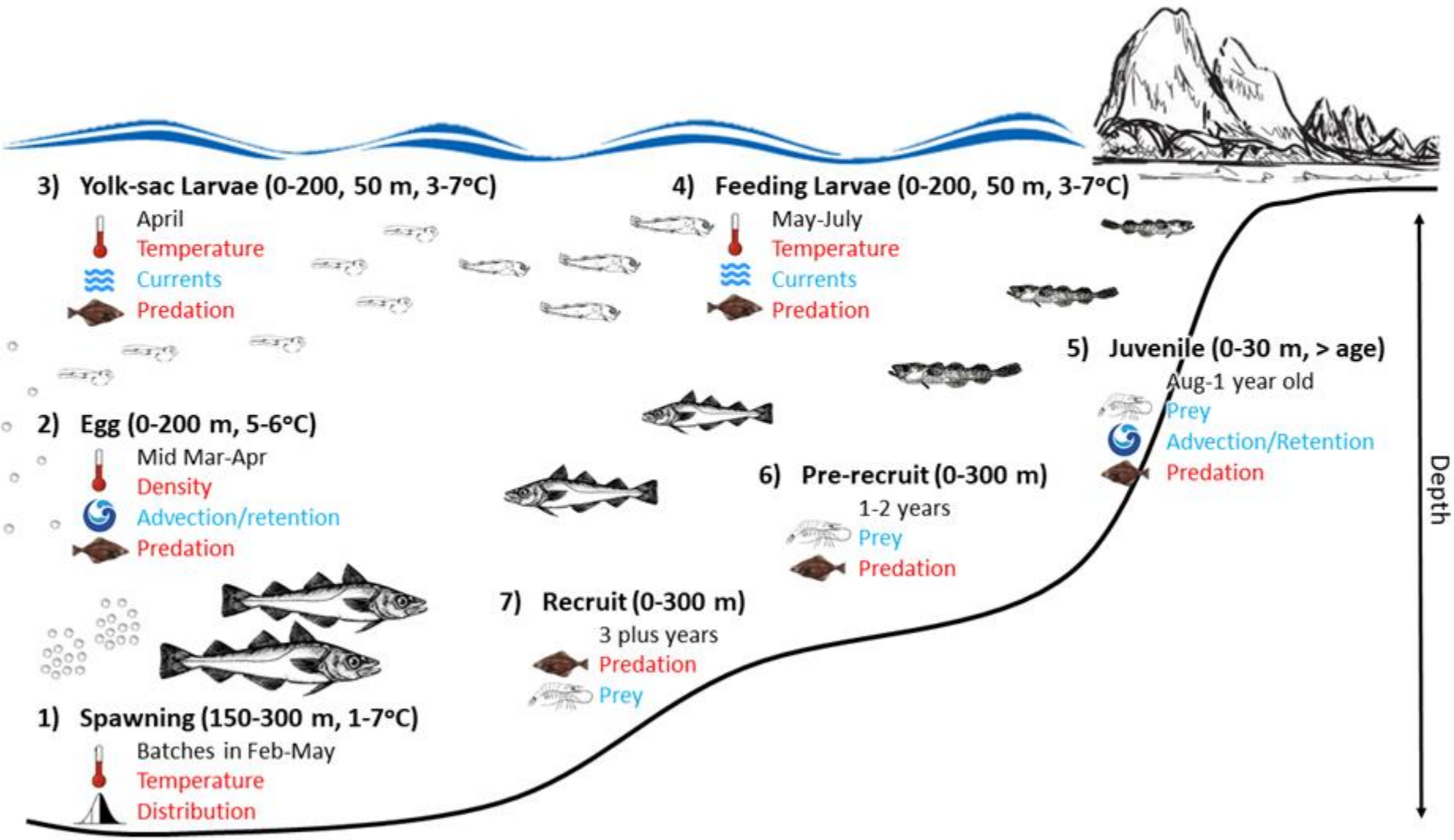
S. Kalei Shotwell, Martin Dorn, Alison L. Deary, Ben Fissel, Lauren Rogers, and Stephani Zador

November 2019

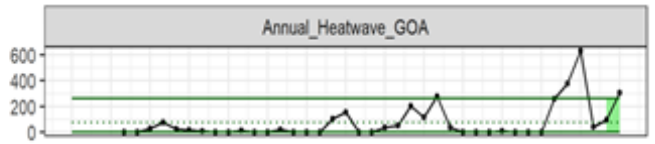
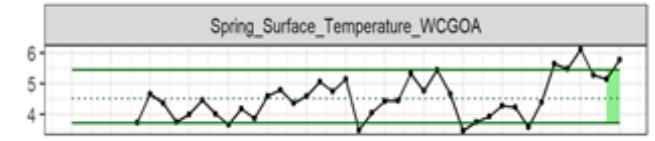
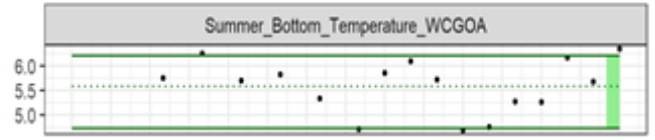
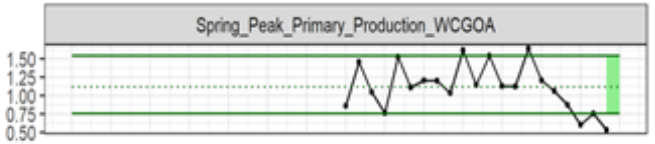
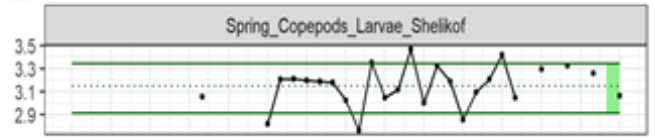
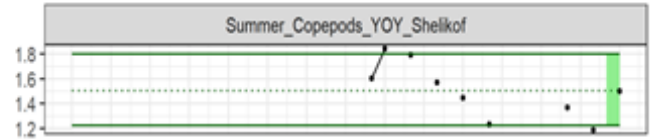
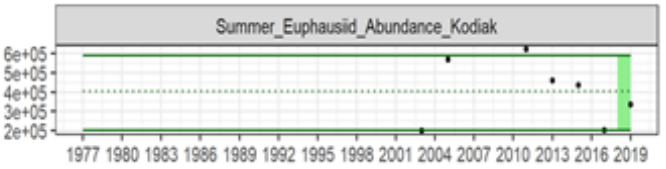
With Contributions from:

Grant Adams, Mayumi Arimitsu, Kerim Aydin, Steve Barbeaux, Lewis Barnett, Curry Cunningham, Dana Hanselman, Kirstin Holsman, David Kimmel, Ben Laurel, Jodi Pirtle, Patrick Ressler, Dale Robinson, Rob Suryan, James Thorson, Johanna Vollenweider, Cara Wilson, Sarah Wise

Ecosystem Processes



Ecosystem Traffic Light

Title	Description	Time series	Recent
Annual Heatwave GOA	Regional daily mean sea surface temperatures from NOAA climate model processed following Hobday et al., 2016 to obtain marine heatwave cumulative intensity (Barbeaux, 2019)		+
Spring Sea Surface Temperature WCGOA	Western/central GOA spring (Apr-May) sea surface temperature from Pathfinder v5.3 gridded monthly dataset (Casey et al., 2010, GHRSST, CoastWatch)		+
Summer Bottom Temperature WCGOA	Average summer bottom temperature (°C) over all hauls of the RACE GOA shelf bottom trawl survey. Available from AKFIN or online survey database.		+
Spring Peak Phytoplankton Production WCGOA	Western/central GOA peak (May) derived chlorophyll *a* from Ocean Colour CCI v4.0 gridded monthly dataset (Jackson et at., 2017, European Space Agency, CoastWatch)		-
Spring Copepods Larvae Shelikof	Mean abundance of small copepods (< 2 mm) in core Shelikof area measured in log scale numbers per meter cubed with associated rapid zooplankton assessment (Kimmel et al., 2019)		•
Summer Copepods YOY Shelikof	Mean abundance of large copepods (> 2 mm) in core Shelikof area measured in log scale numbers per meter cubed with associated rapid zooplankton assessment (Kimmel et al., 2019)		•
Summer Euphausiid Abundance Kodiak	Acoustic backscatter per unit area classified as euphausiids and integrated over the water column and across Kodiak core survey area from MACE summer survey (Ressler et al., 2019)		•

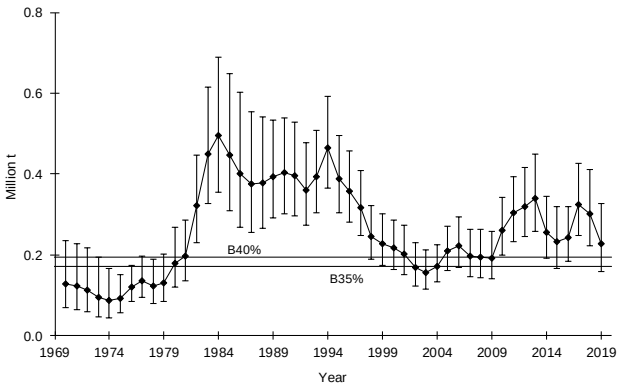
Recommendations

- Ecosystem Considerations
  - Return to heatwave conditions, high temp surface to bottom, zooplankton prey base return to average
  - Early survey indicators suggest weak 2019 year class, Adult condition low since 2015, improved in 2019
- Socioeconomic Considerations
  - Fishery CPUE above average since 2016, consistent with stock biomass levels
  - Drop in roe/unit catch, possibly due to poor condition

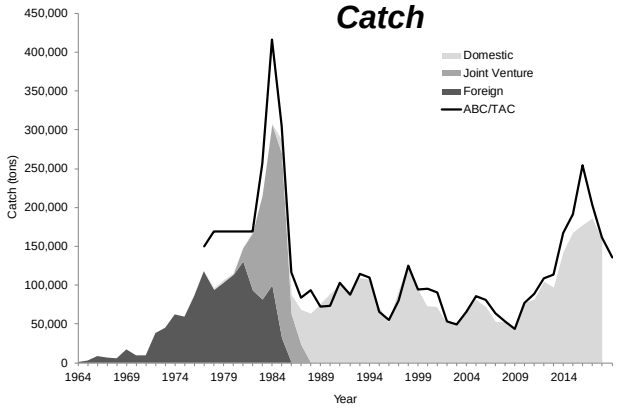
Gulf of Alaska pollock
Summary

- **Changes to the assessment model**
  - Stiffer random walk for Shelikof Strait catchability
- **Author's 2020 ABC 108,494 t**
  - Stiffer random walk for Shelikof Strait catchability
  - Decrease of 20% from the 2019 ABC
  - 2021 ABC stabilizes ~111,888 t
- **Concerns:**
  - Conflicting input data
  - Poor model fit
  - Large assessment uncertainty
- **Positives**:
  - Strong 2018 year class
  - Catches and SSB projected to stabilize
  - Environmental conditions OK for adults

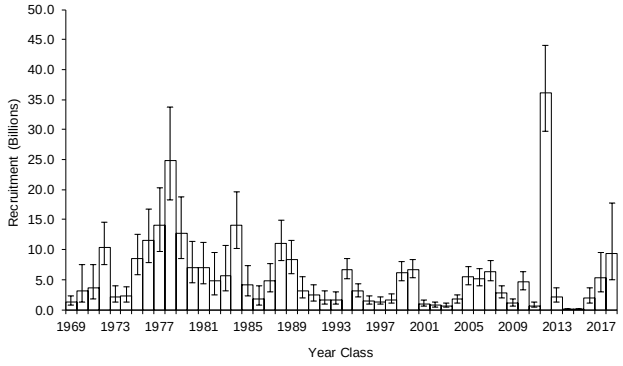
Spawning biomass



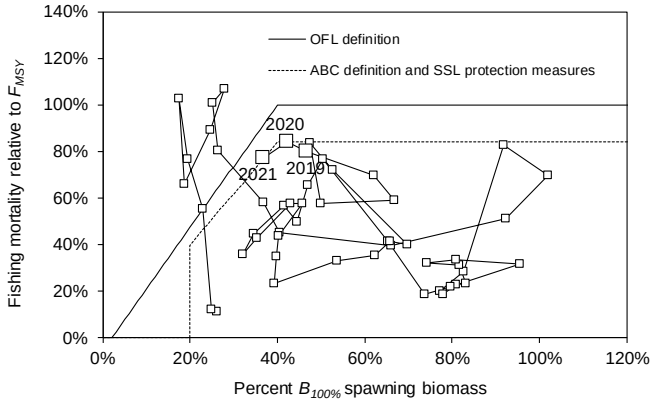
Catch



Recruitment



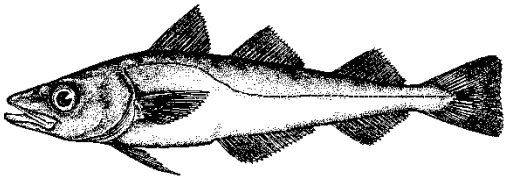
Status phase plot



Summary table

Quantity/Status	As estimated or specified *last* year for 2019	2020	As estimated or recommended *this* year for 2020	2021
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass (t)	1,126,750	1,068,760	1,007,850	1,270,080
Female spawning biomass (t)	345,352	257,794	206,664	184,094
$B_{100\%}$	553,000	553,000	485,000	485,000
$B_{40\%}$	221,000	221,000	194,000	194,000
$B_{35\%}$	194,000	194,000	170,000	170,000
F_{OFL}	0.32	0.32	0.33	0.30
$maxF_{ABC}$	0.27	0.27	0.28	0.26
F_{ABC}	0.22	0.22	0.23	0.28
OFL (t)	194,230	148,968	140,674	149,988
maxABC (t)	158,518	128,108	120,549	124,320
ABC (t)	135,850	108,892	108,494	111,888
Status	As determined *last* year for 2017	2018	As determined *this* year for 2018	2019
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	Fishery Performance
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	No apparent fishery/resource-use performance and/or behavior 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 relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing 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 as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
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	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

Gulf of Alaska pollock
Risk Matrix Evaluation

Assessment-related considerations	**Population dynamics considerations**	**Environmental/ecosystem considerations**	**Fishery performance**
Contradictory data, very poor model fits to recent survey indices. But model seems robust, small positive retrospective pattern. **Conclusion: Level 2, substantially increased concerns**	Level 2 last year, strong 2018 year class alleviates concerns about series of weak recruitments, and stock being dominated by a single year class. **Conclusion: Level 1: no increased concerns**	2019 year class evident failure, but recruitment failure not unusual. Foraging conditions neither strong nor week, but slightly below average. Planktivorous parakeet auklets had moderate reproductive success in 2019. Marine heatwave has abated, but a warm winter is forecasted **Conclusion: Level 1: no increased concerns**	Recent fishery CPUE high, consistent with trends in exploitable biomass in the assessment **Conclusion: Level 1: No increased concerns**

Overall score is Level 2: Substantially increased concerns. Author's recommended ABC = 90% of maximum permissible (10% buffer). Regard as a starting point for plan team and SSC deliberation.

Summer apportionment table:

Weights of 1.0, 0.5, and 0.25 for 2019, 2017, and 2015, respectively

Summer acoustic estimates

Biomass (t)

Year	*Area 610*	*Area 620*	*Area 630*	*Area 640*
2015	425,952	476,006	632,316	63,955
2017	408,334	338,923	498,460	72,679
2019	119,502	201,711	207,058	43,204

Percent

	Area 610	*Area 620*	*Area 630*	*Area 640*
2015	26.65%	29.78%	39.56%	4.00%
2017	30.97%	25.71%	37.81%	5.51%
2019	20.91%	35.30%	36.23%	7.56%

Bottom trawl estimates

Biomass (t)

Year	*Area 610*	*Area 620*	*Area 630*	*Area 640*
2015	403,884	98,001	181,482	24,408
2017	214,605	23,658	43,803	6,878
2019	119,312	36,450	90,921	10,921

Percent

	Area 610	*Area 620*	*Area 630*	*Area 640*
2015	57.06%	13.85%	25.64%	3.45%
2017	74.27%	8.19%	15.16%	2.38%
2019	46.32%	14.15%	35.29%	4.24%

Options for allocation

Option 5: Weighted average of acoustic plus bottom trawl biomass (2015-2019)

Area 610	*Area 620*	*Area 630*	*Area 640*
432,996	321,688	441,463	66,282
34.30%	25.48%	34.97%	5.25%

Winter apportionment table (example calculations for one area)

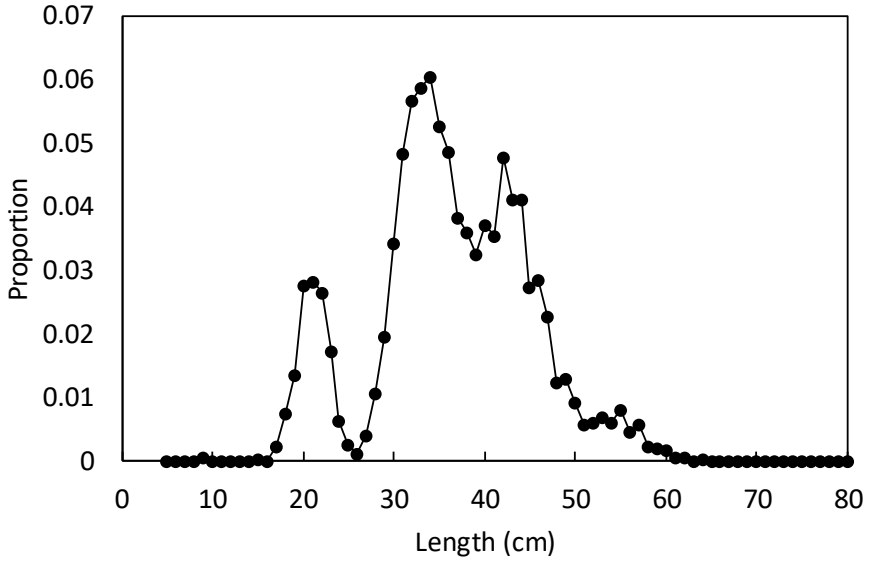
Survey	*Year*	*Model estimates of total 2+ biomass at spawning*	*Survey biomass estimate*	*Percent*	*Percent by management area*		
					Area 610	*Area 620*	*Area 630*
Shelikof	2016	1,258,720	666,801	53.0%	0.0%	79.3%	20.7%
Shelikof	2017	990,320	1,457,295	147.2%	0.0%	99.1%	0.9%
Shelikof	2018	734,861	1,306,107	177.7%	0.0%	93.9%	6.1%
Shelikof	2019	597,124	1,219,160	204.2%	0.0%	97.1%	2.9%
Shelikof	Average			145.5%	0.0%	92.3%	7.7%
	Percent of total biomass				0.0%	134.4%	11.1%

Winter apportionment table

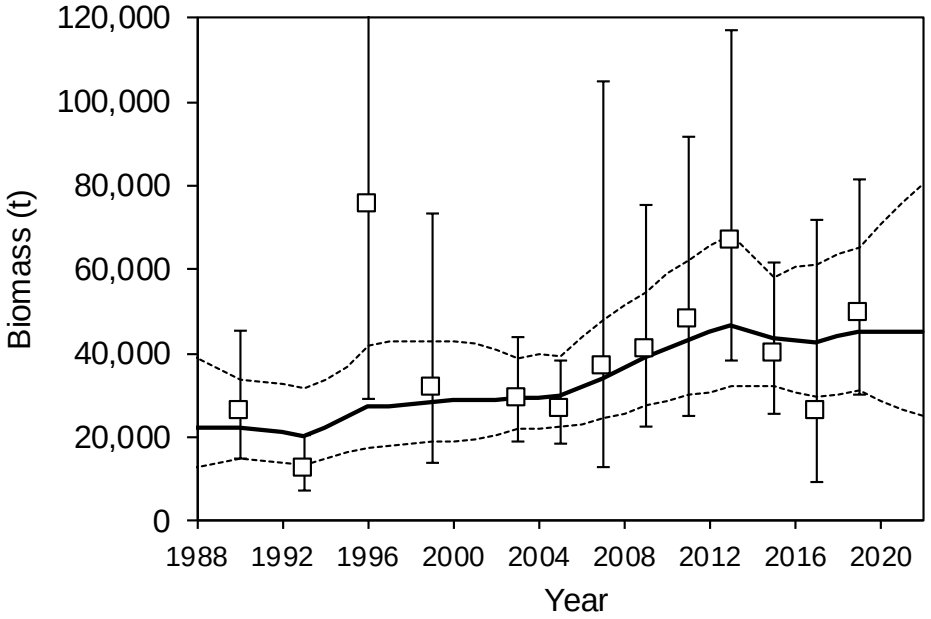
Survey	*Year*	*Model estimates of total 2+ biomass at spawning*	*Survey biomass estimate*	*Percent*	*Percent by management area* *Area 610*	*Area 620*	*Area 630*
Shelikof	Average			145.5%	0.0%	92.3%	7.7%
	Percent of total biomass				0.0%	134.4%	11.1%
Chirikof	Average			2.3%	0.0%	33.3%	66.7%
	Percent of total biomass				0.0%	0.8%	1.5%
Marmot	Average			1.5%	0.0%	0.0%	100.0%
	Percent of total biomass				0.0%	0.0%	1.5%
Shumagin	Average			2.5%	74.6%	25.4%	0.0%
	Percent of total biomass				1.9%	0.6%	0.0%
Sanak	Average			0.5%	100.0%	0.0%	0.0%
	Percent of total biomass				0.5%	0.0%	0.0%
Mozhovoi	Average			0.5%	100.0%	0.0%	0.0%
	Percent of total biomass				0.5%	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				153.11%	3.16%	135.78%	14.16%
Rescaled total				100.00%	2.06%	88.68%	9.25%

Southeast Alaska Assessment

2019 size composition



Biomass trend

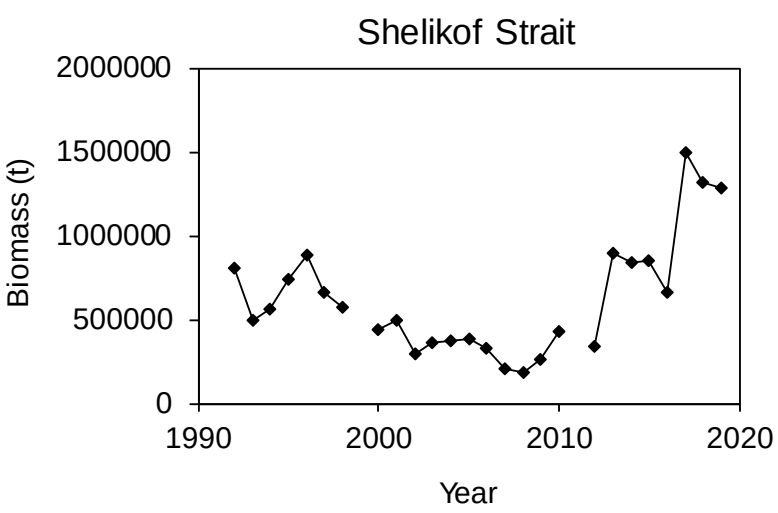


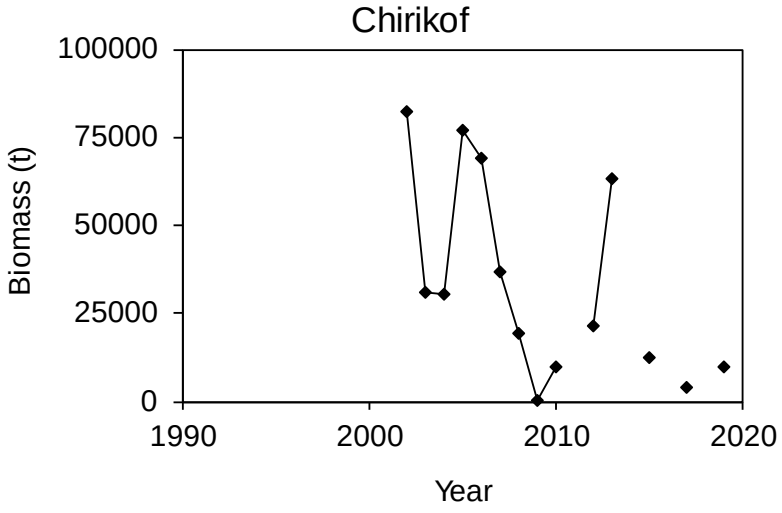
Southeast Pollock Summary Table

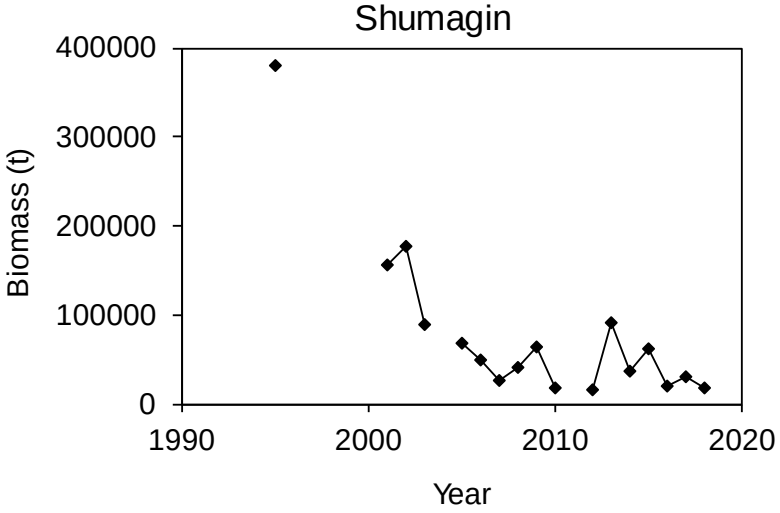
Quantity	As estimated or *specified last* year for: 2019	2020	As estimated or *recommended this* year for: 2020	2021
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	5	5	5	5
Biomass (t)				
Upper 95% confidence interval	75,820	80,954	70,914	75,826
Point estimate	38,989	38,989	45,103	45,103
Lower 95% confidence interval	20,050	18,778	28,687	26,828
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	13,531	13,531
maxABC (t)	8,773	8,773	10,148	10,148
ABC (t)	8,773	8,773	10,148	10,148
Status	As determined *last* year for: 2017	2018	As determined *this* year for: 2018	2019
Overfishing	No	n/a	No	n/a

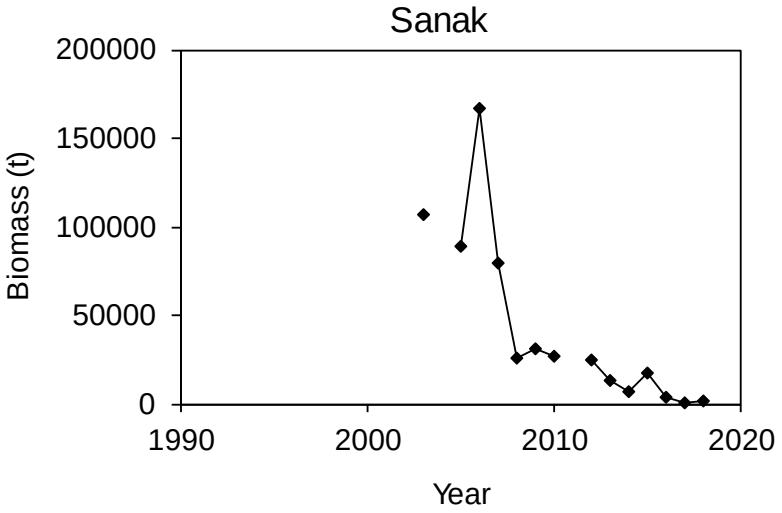
Extras

Acoustic surveys outside Shelikof Strait



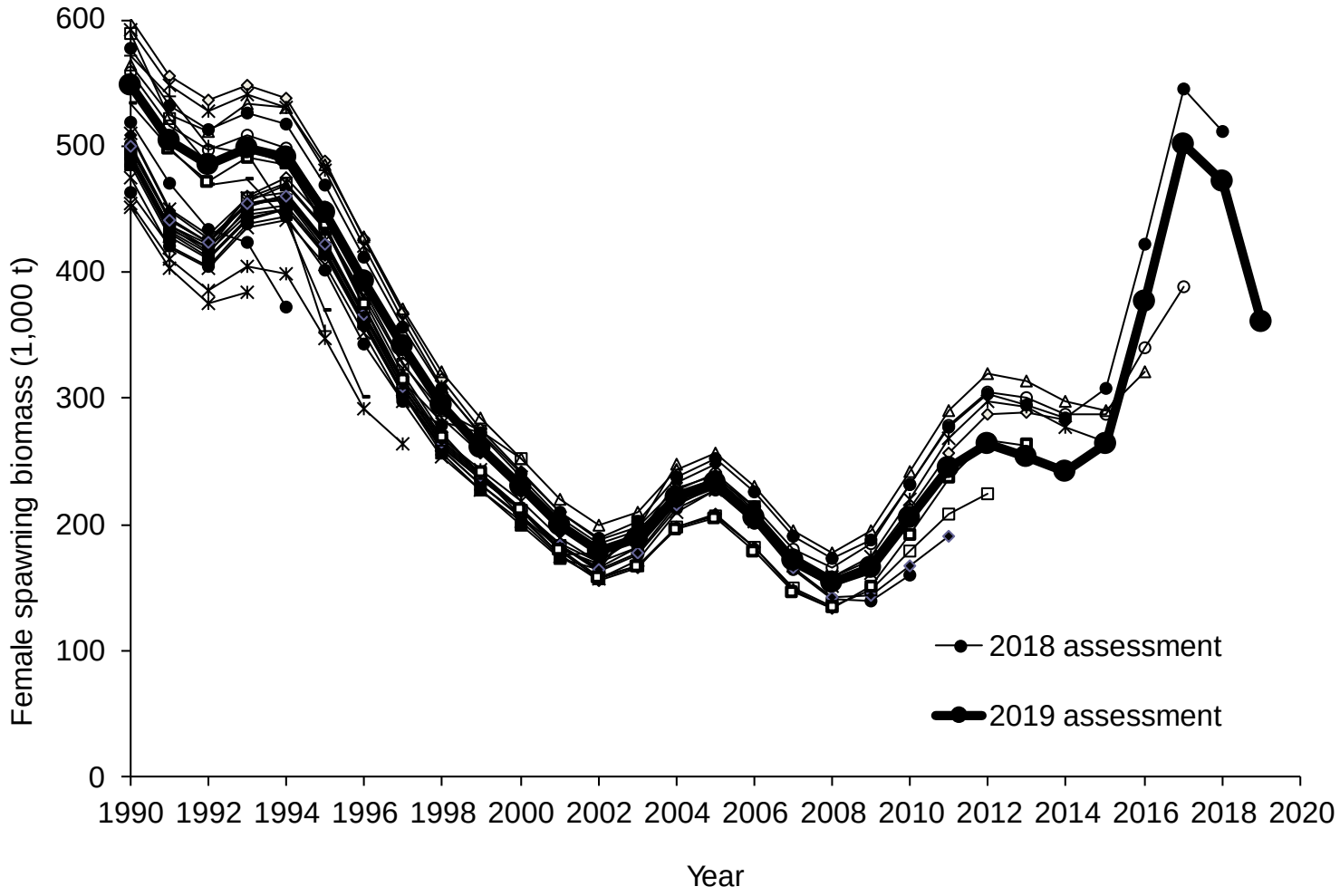




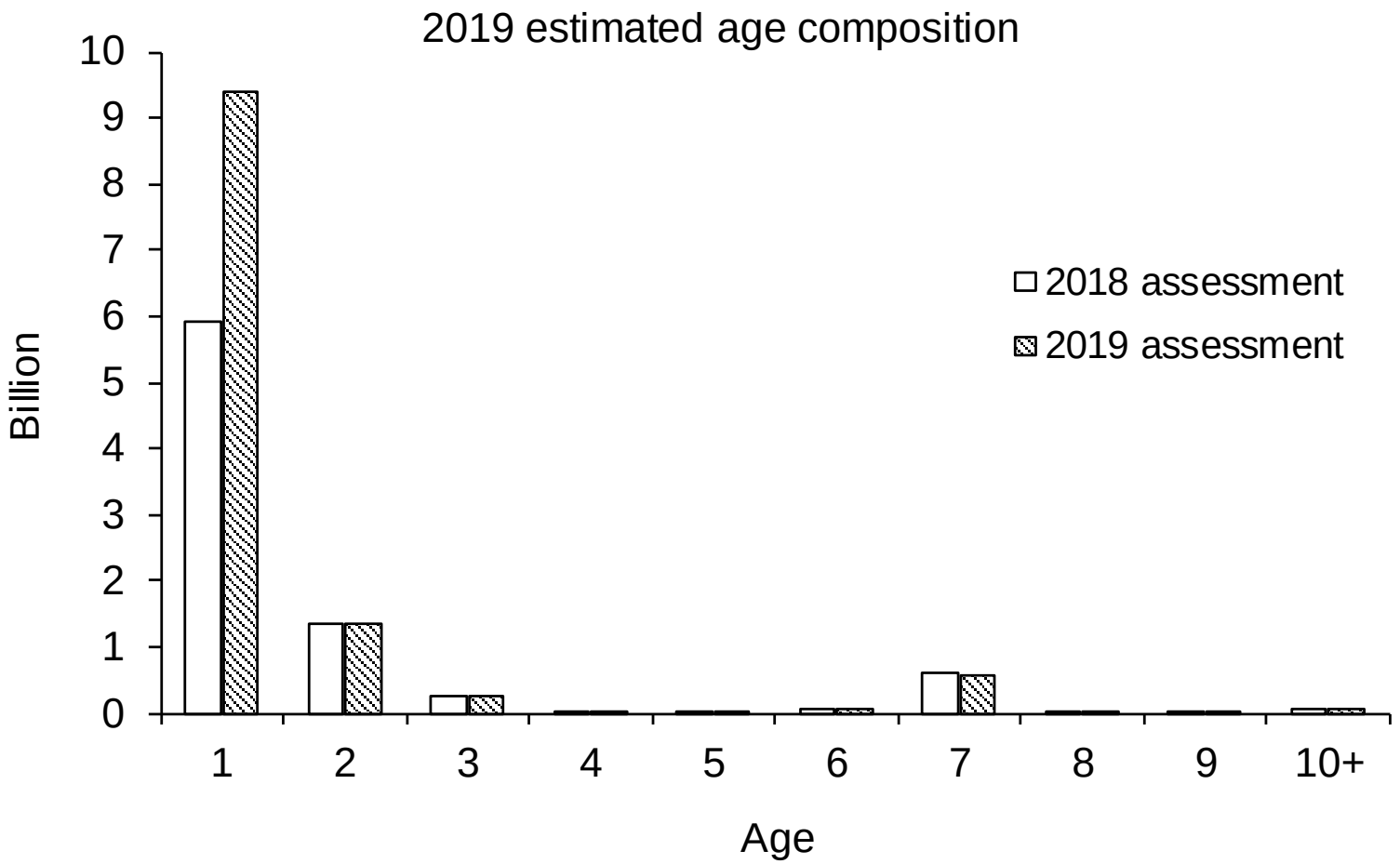


Total for all winter acoustic surveys = 1,297,265 t (99% in Shelikof Strait)

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 = 65.8

Acoustic survey

Initial N = 60

Ending N Francis = 8.4

Bottom trawl survey

Initial N = 60

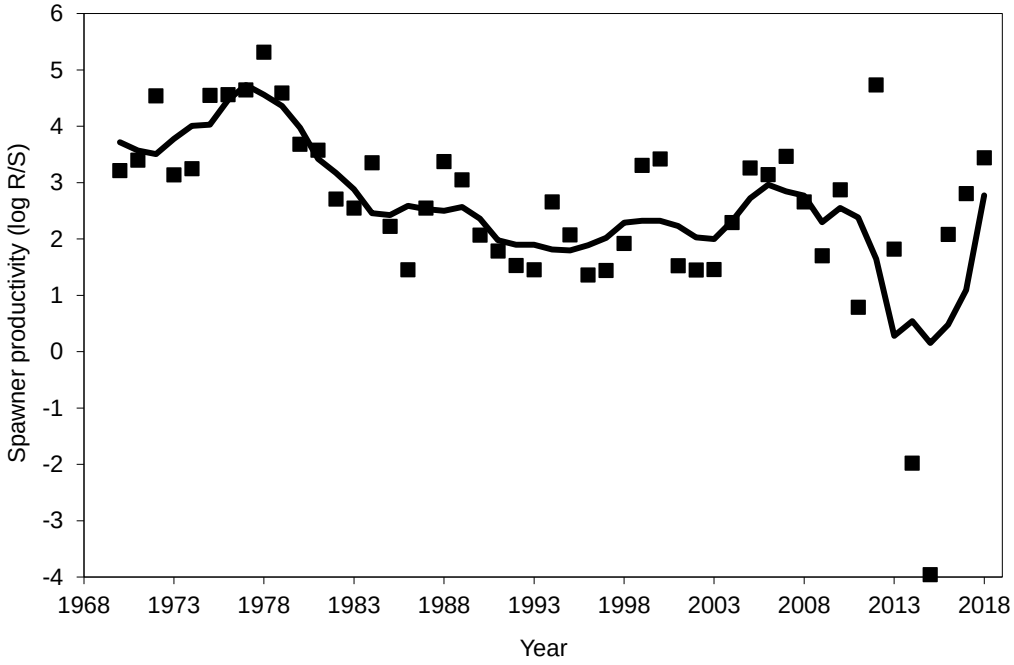
Ending N Francis = 7.4

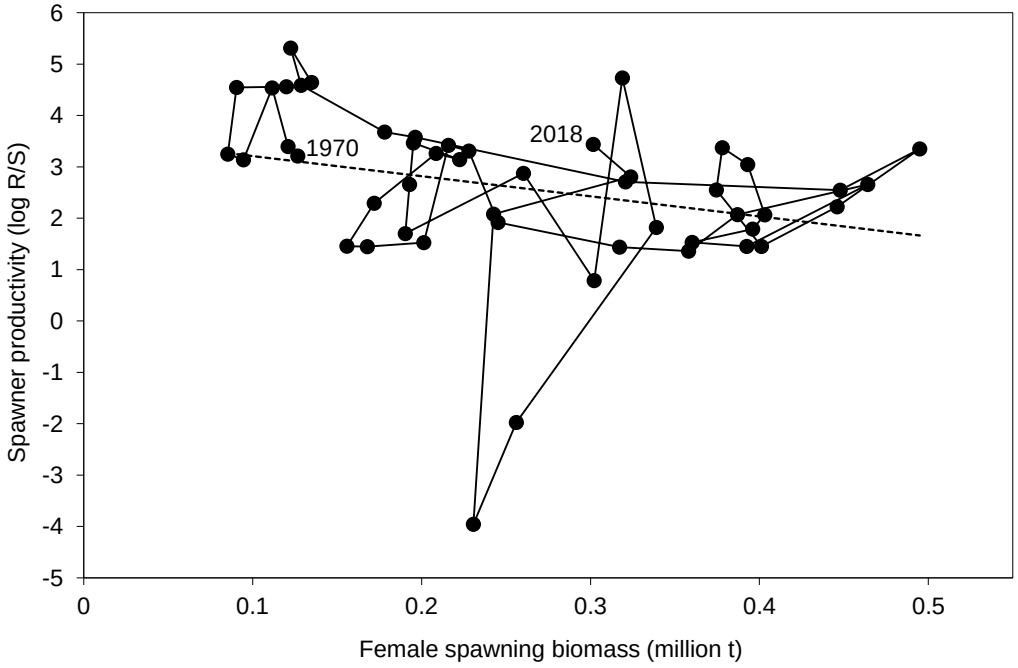
ADFG survey

Initial N = 30

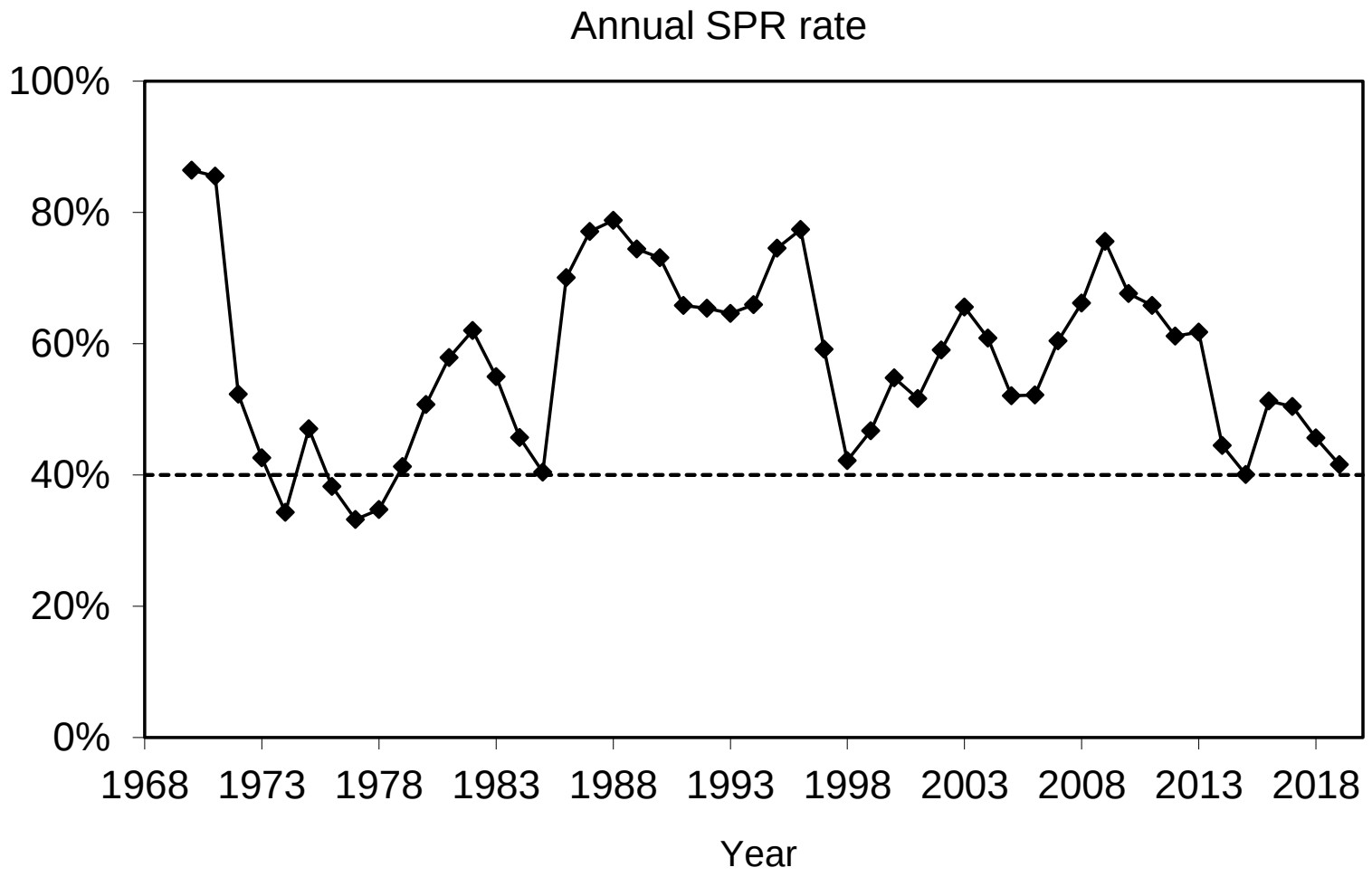
Francis = 15.8

Spawner productivity





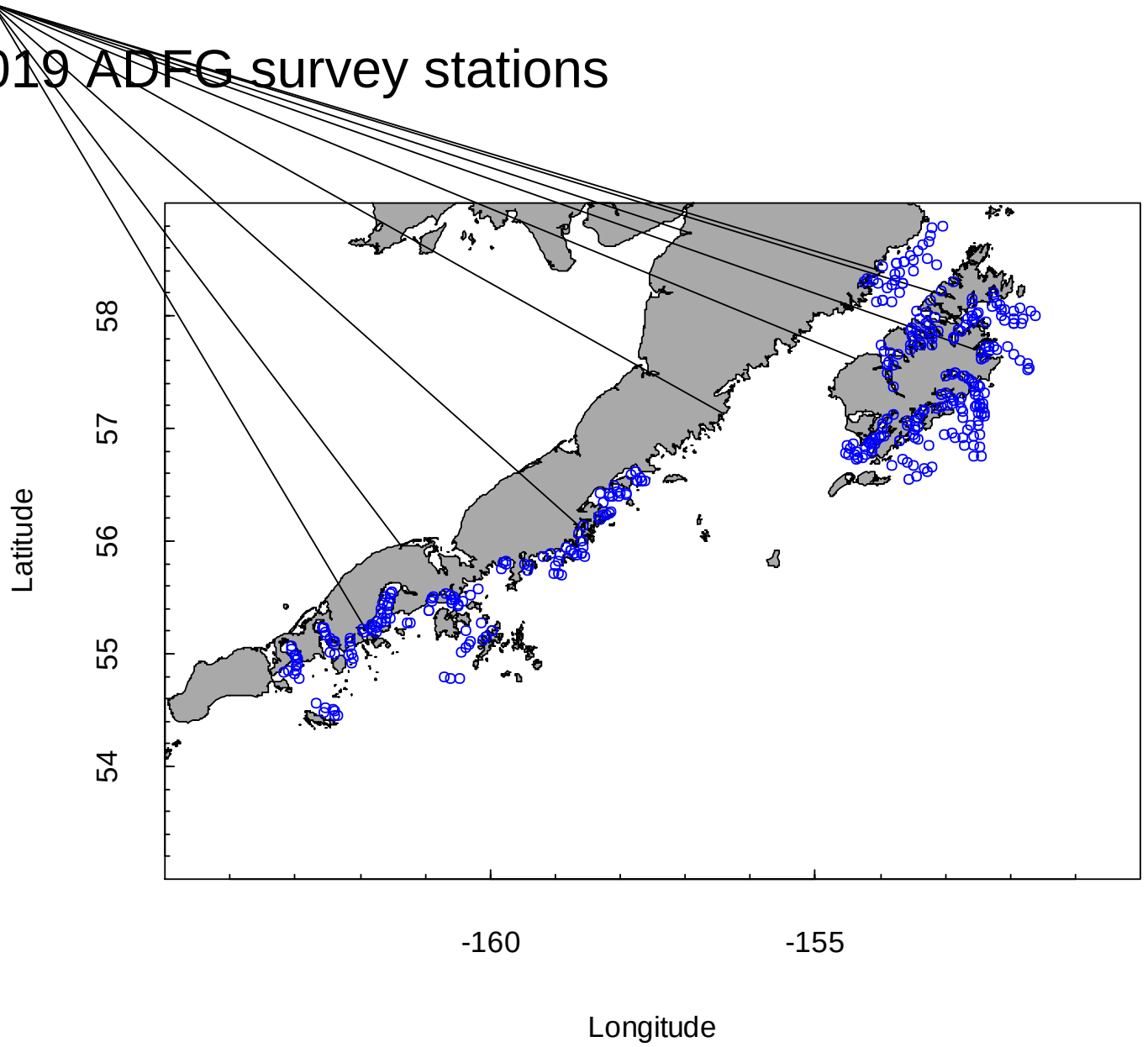
Annual SPR rate



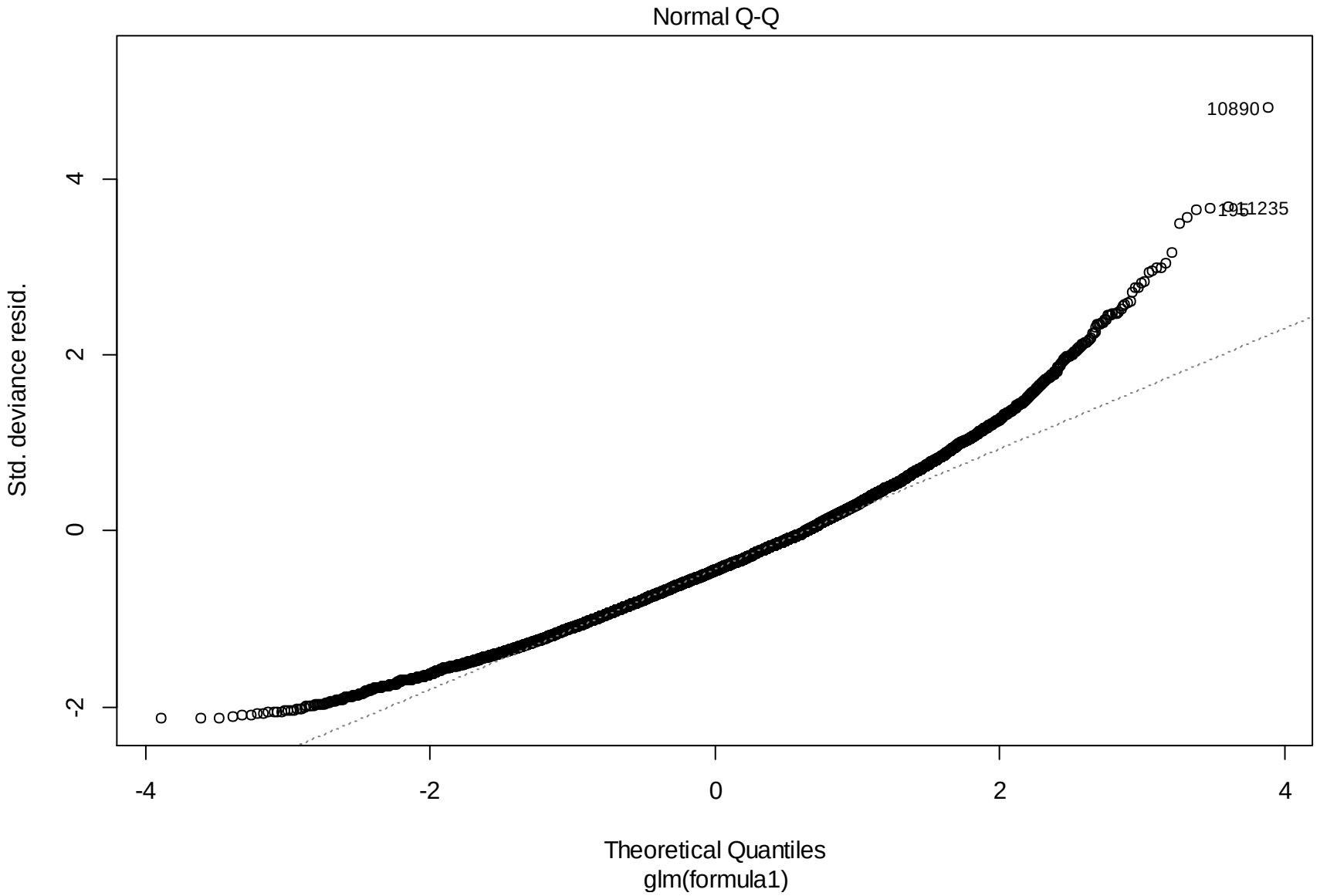
Delta-GLM for ADFG survey

- 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

2019 ADFG survey stations



QQ plot for gamma error assumption



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 2019 (Shelikof Strait survey ageing data available but not fishery) and in 2020 (including F_{SPR} calcs).