



**NOAA
FISHERIES**



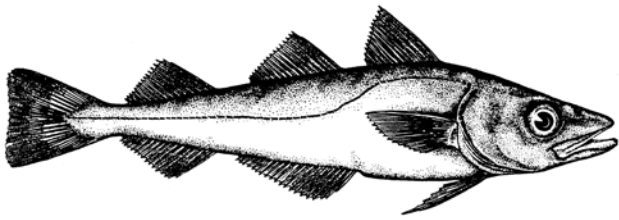
GOA Pollock

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November 2021 GOA Plan Team



Outline for today

- Overview of key results and current model
- New data updates for 2021
- Updated biology
- Model fits and diagnostics
- Results and risk table concerns
- Reference point calculations & Apportionment
- SE assessment
- Plan and priorities for 2022



Gulf of Alaska pollock

Overview of results

Changes to the assessment model

- None in 2020 or 2021 (model 19.1)

Author's 2022 ABC 133,081 t

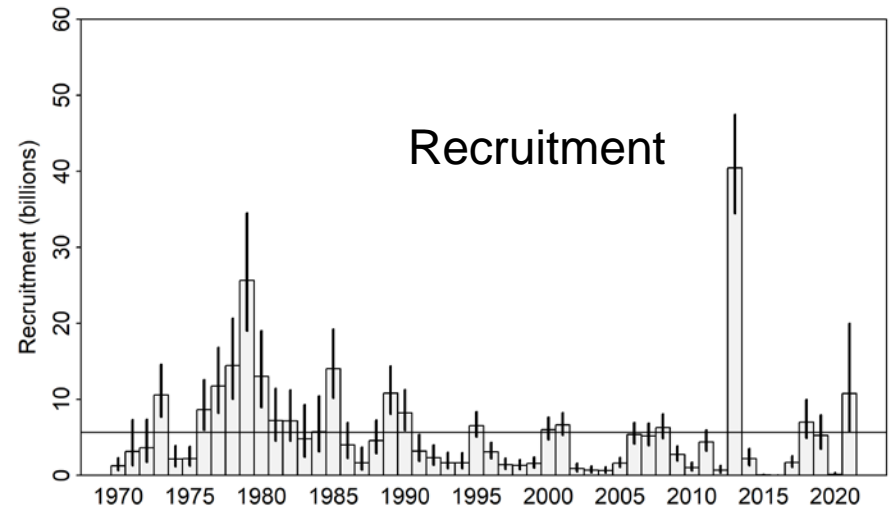
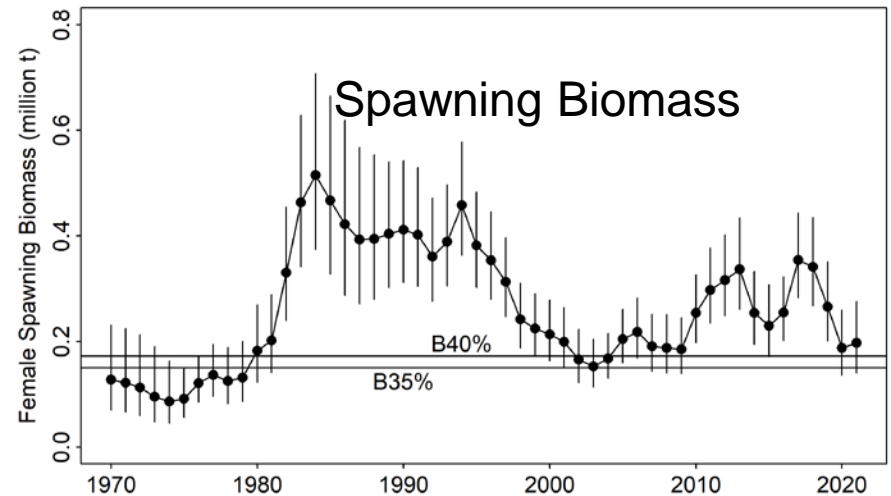
- Increase of 26% from 2021
- 2023 ABC decreases to 131,912 t

Concerns:

- Conflict in size of 2018 year class
- Unusual increase in spawning WAA after long decline
- Absolute stock scale driven by NMFS BT Q prior

Positives:

- Return to normal age diversity w/ decline in 2012 cohort
- Large 2020 cohort
- Environmental conditions favorable



Model overview

- Single-sex, single-fleet, ages 1-10+
- Empirical weight at age
 - No internal length dynamics, all processes age-based
 - Length compositions converted via specified matrices
- Fishery selectivity time-varying double-logistic
- Fitted to 4 surveys
 - NMFS winter (Shelikof) + summer (coast wide) acoustic
 - NMFS & ADF&G summer bottom trawl
- Time-varying catchability for Shelikof and ADF&G
- Recruits freely estimated, except initial and last two years ($\sigma_R=1$)
- Francis tuning used for compositional data

Response to PT/SSC comments

(Presented in Sep, reviewed here)

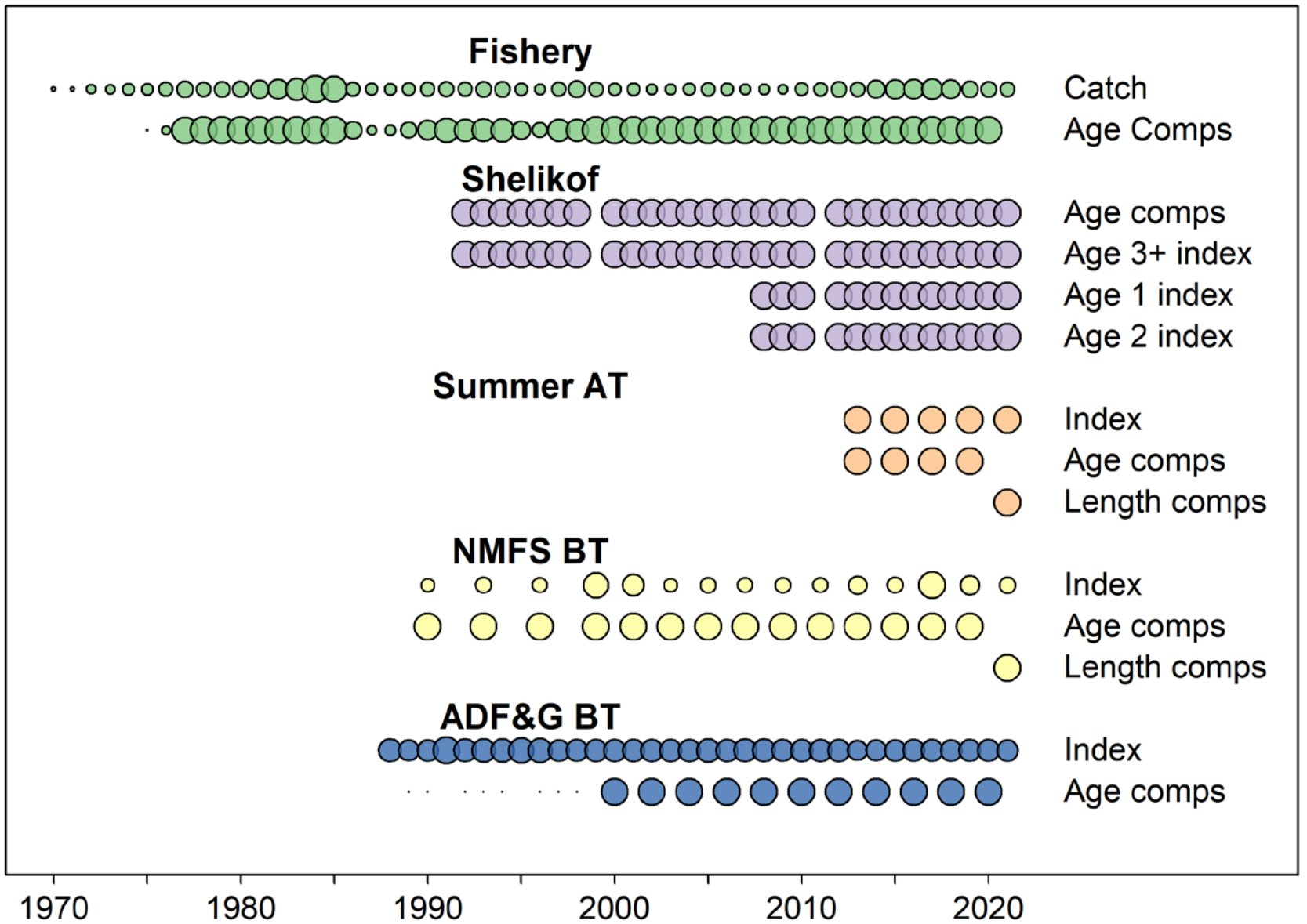
- GPT: Explore alternative fishery selectivity curves due to consistent positive age-4 residuals
 - Will explore in 2022
- GPT: Constrain time-varying Shelikof Q to be <1
 - Explored logistic transform, worked well but unexpected shift in scale
 - Will further explore in 2022 and address SSC comment about uniform implied prior
- GPT: Effect of dropping indices?
 - Explore and discovered trend insensitive, but scale sensitive to inclusion of NMFS BT survey (prior on Q)

Data used in assessment

Source	Data	Years
Fishery	Total catch	1970-2020
Fishery	Age composition	1975-2020
Shelikof Strait acoustic survey	Biomass	1992-2021
Shelikof Strait acoustic survey	Age composition	1992-2021
Summer acoustic survey	Biomass	2013-2021
Summer acoustic survey	Age composition	2013-2019
NMFS bottom trawl survey	Area-swept biomass	1990-2021
NMFS bottom trawl survey	Age composition	1990-2019
ADF&G trawl survey	Delta-GLM index	1988-2021
ADF&G survey	Age composition	2000-2020

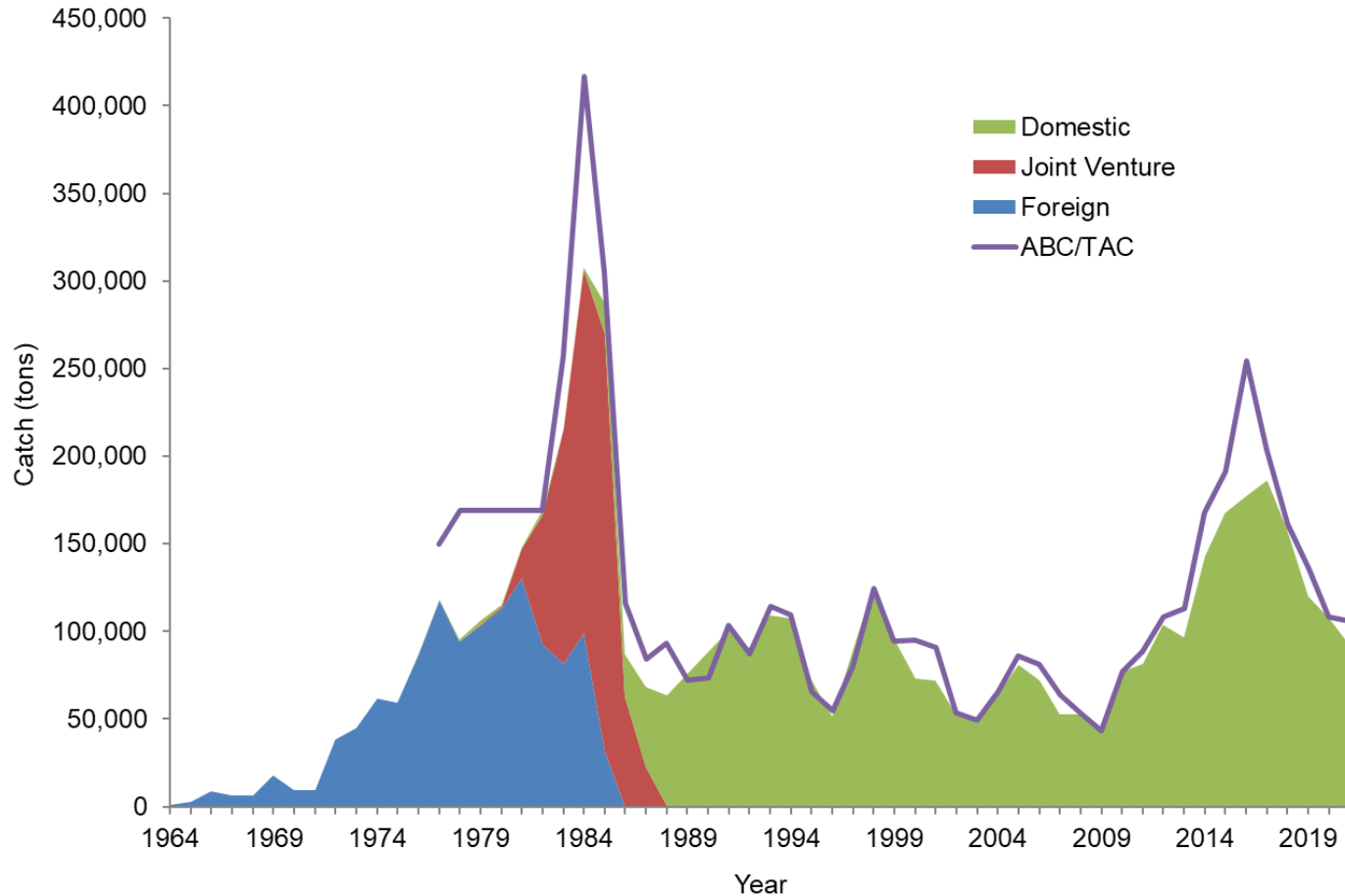
New model inputs

- **Fishery:** 2020 total catch, catch and weight at age.
- **Shelikof Strait acoustic survey:** 2021 biomass index and age composition.
- **NMFS bottom trawl survey:** 2021 biomass index and length composition
- **Summer acoustic survey:** 2021 biomass index and length composition
- **ADF&G bottom trawl survey:** 2021 biomass index and 2020 age composition

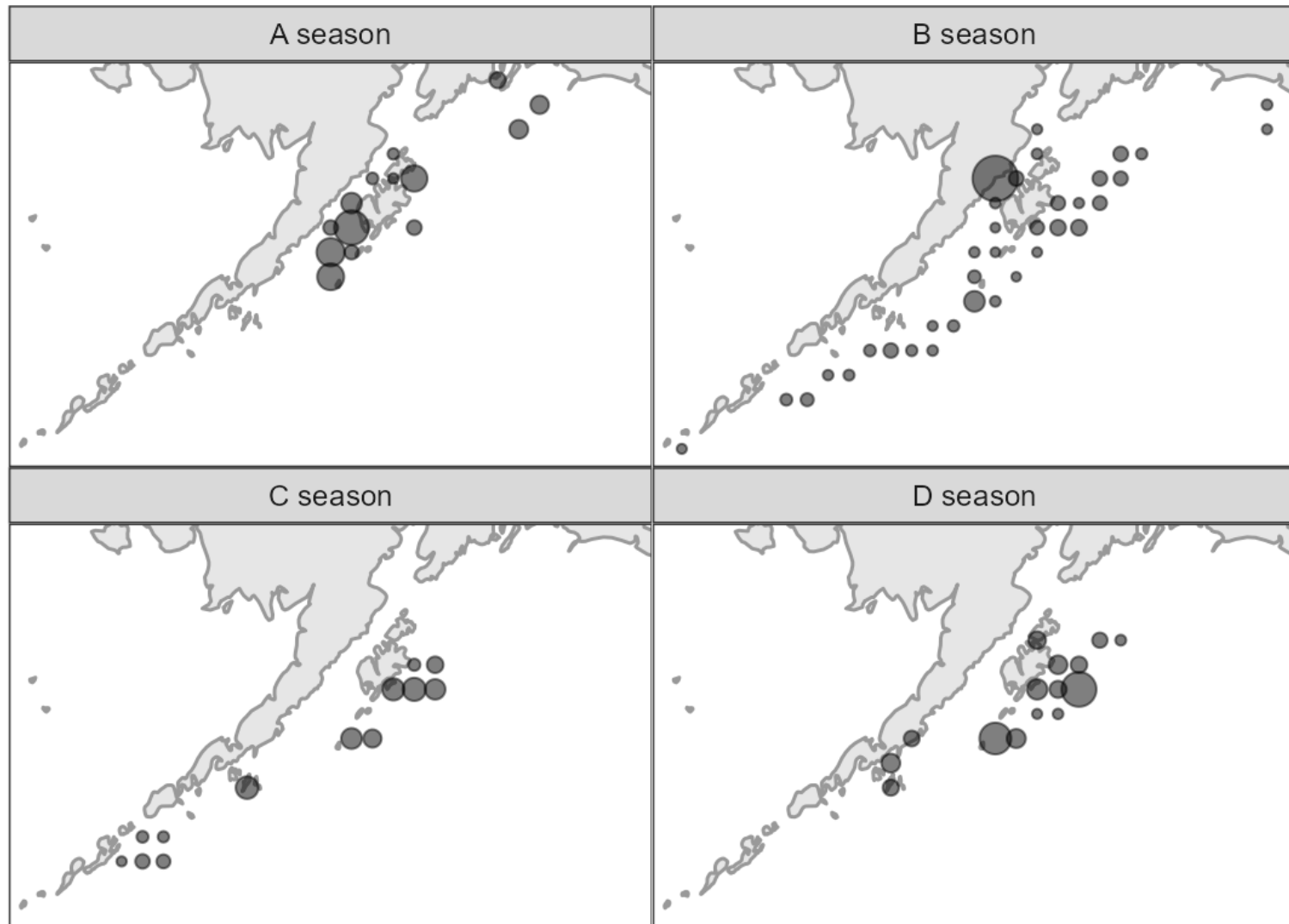


Catch history

- 2021 projected catch = 92,342 t
- 2021 ABC = 105,722 t



2020 fishery catch distribution



Survey overview

2021 is “on” year for surveys in the GOA.

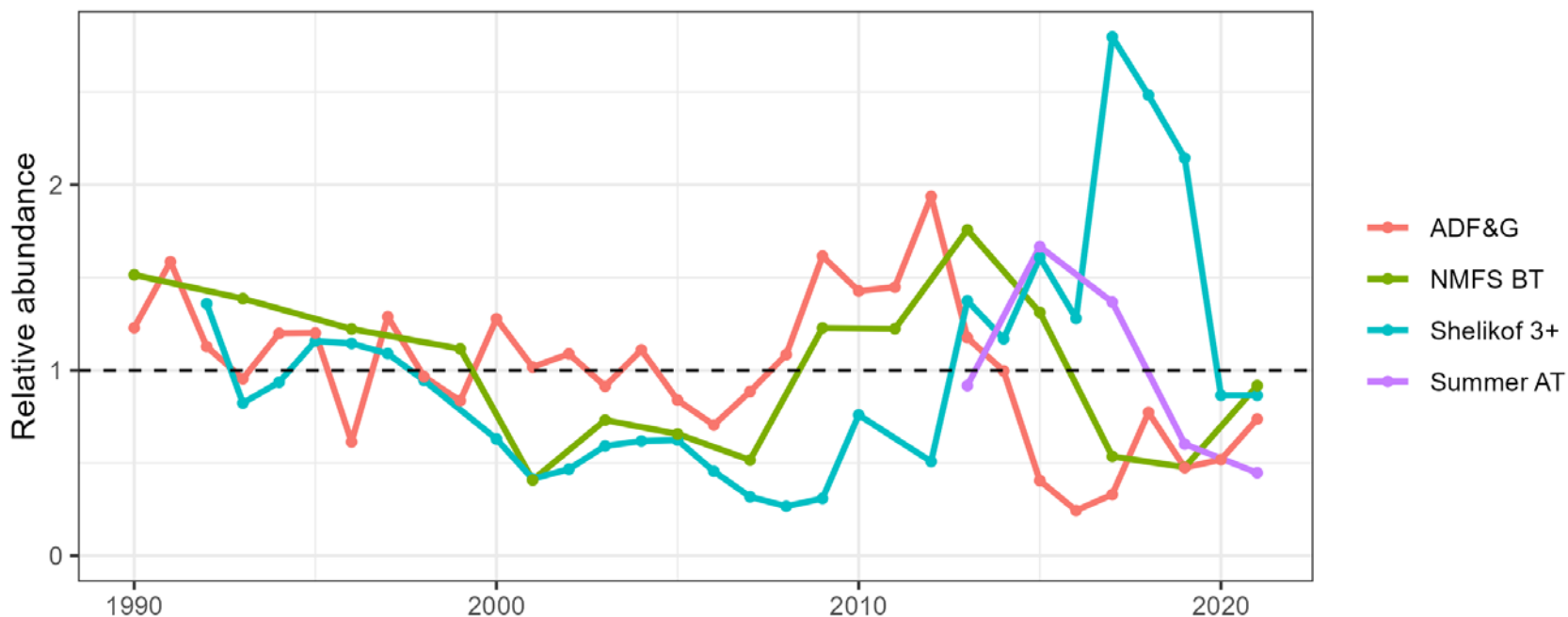
2021 biomass estimates:

Shelikof acoustic: 527 kt, **15% increase** from 2020.

Summer acoustic: 431 kt, **26% decrease** from 2019

NMFS bottom trawl: 494 kt, **92% increase** from 2019

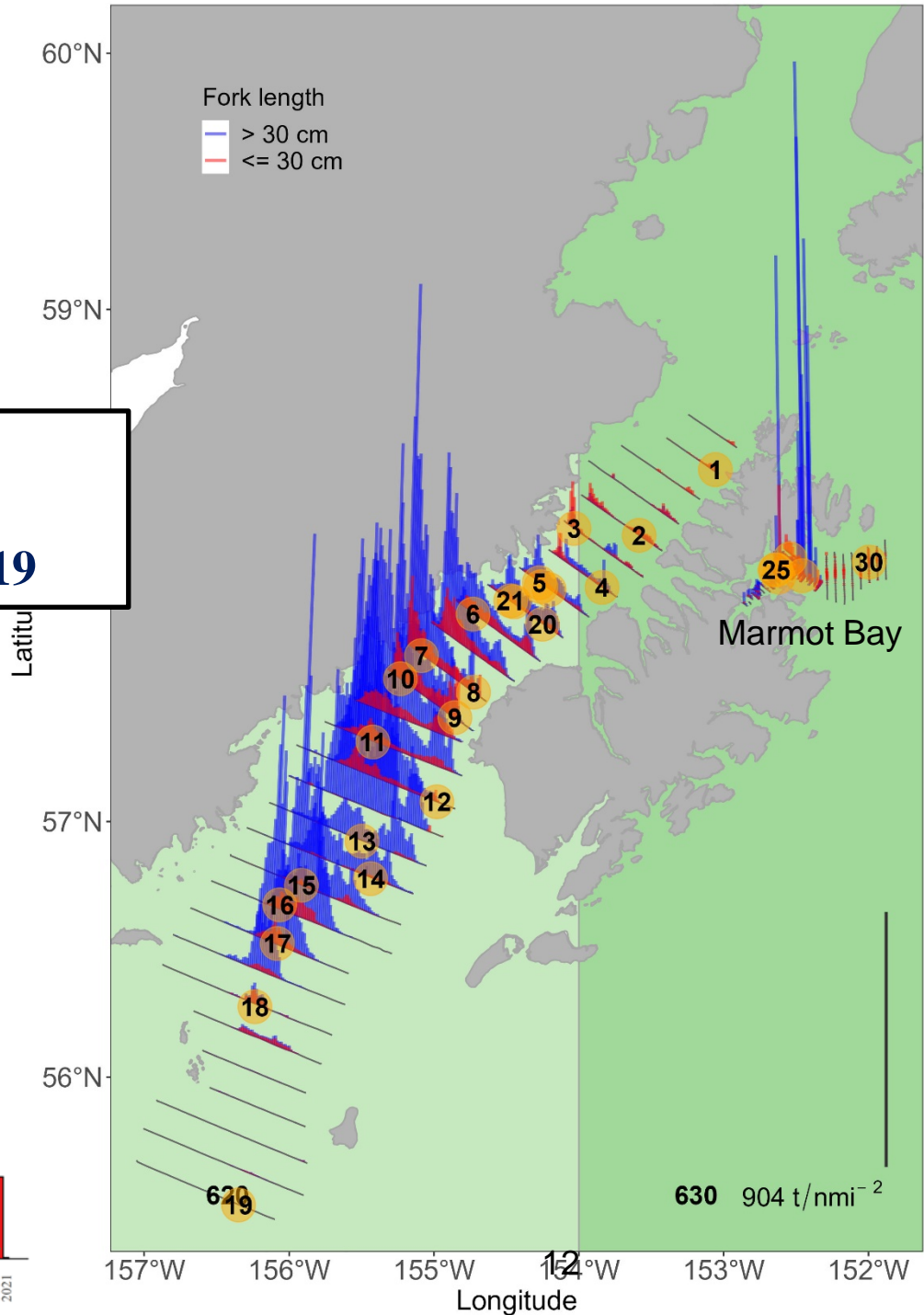
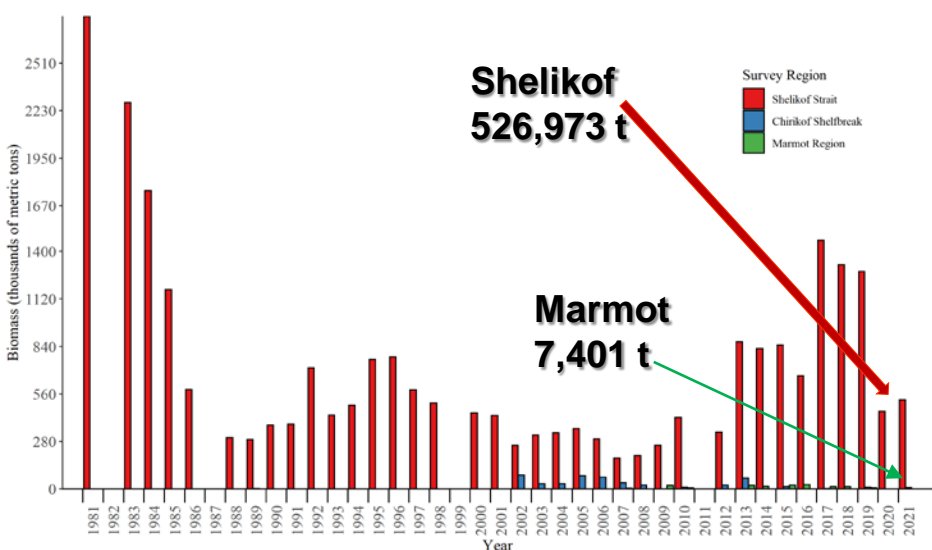
ADF&G bottom trawl: 65 kt, **9% increase** from 2020



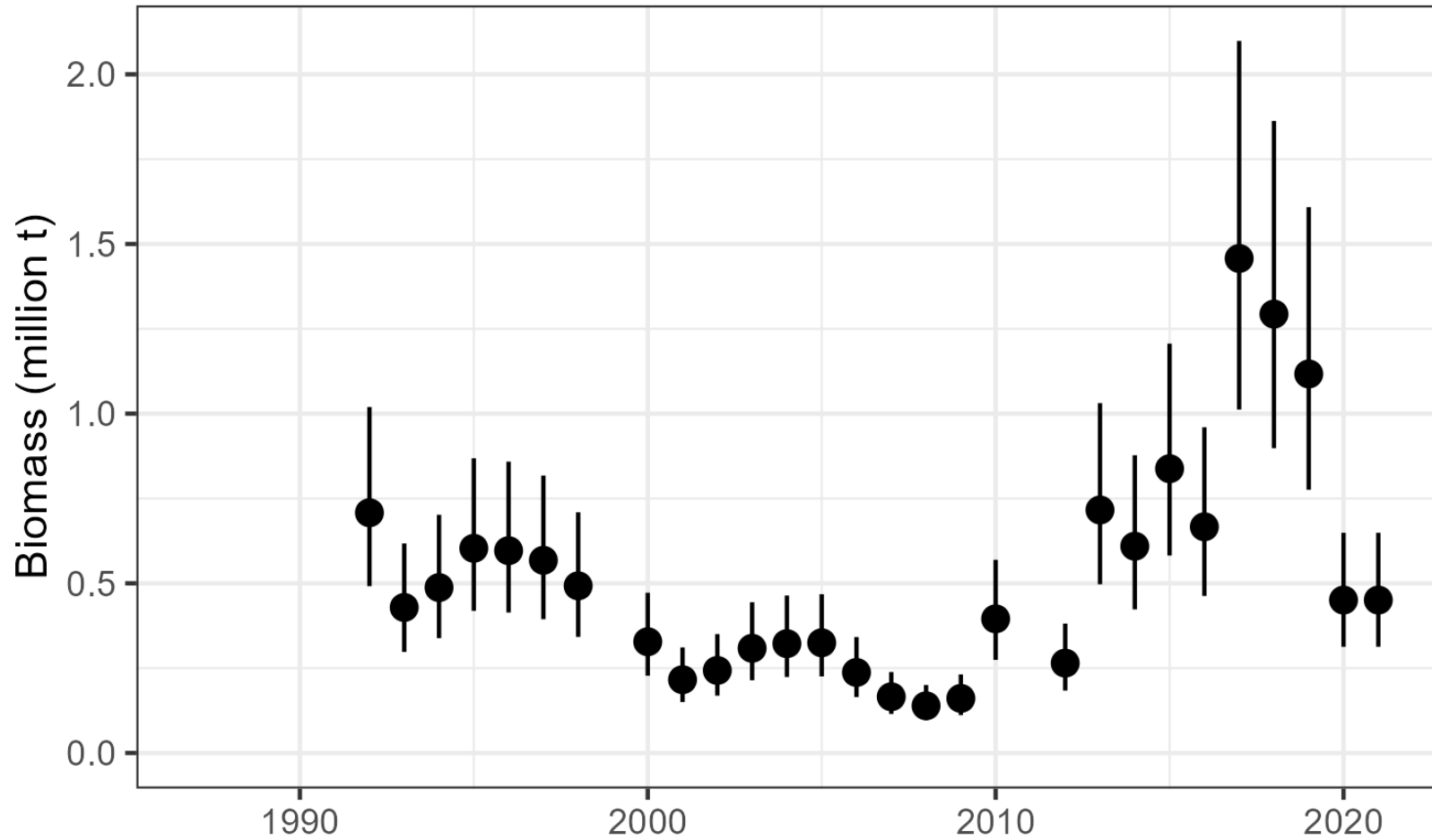
8,364.7 million fish
527.0 thousand t

Shelikof maturities (females > 40cm)			
Prespawning	Spawning	Spent	n
88%	2%	0%	219

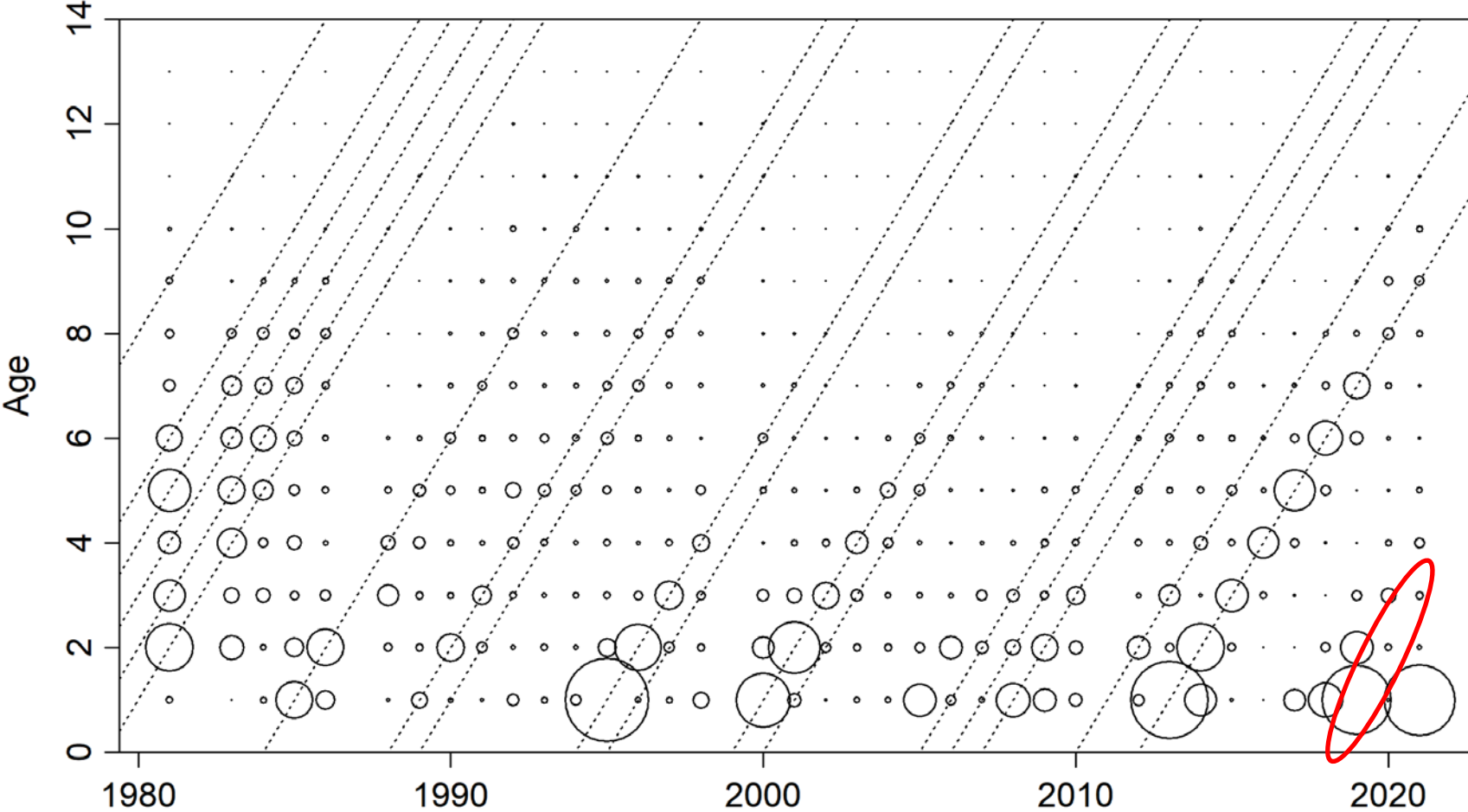
2021 Shelikof Acoustic Trawl Survey



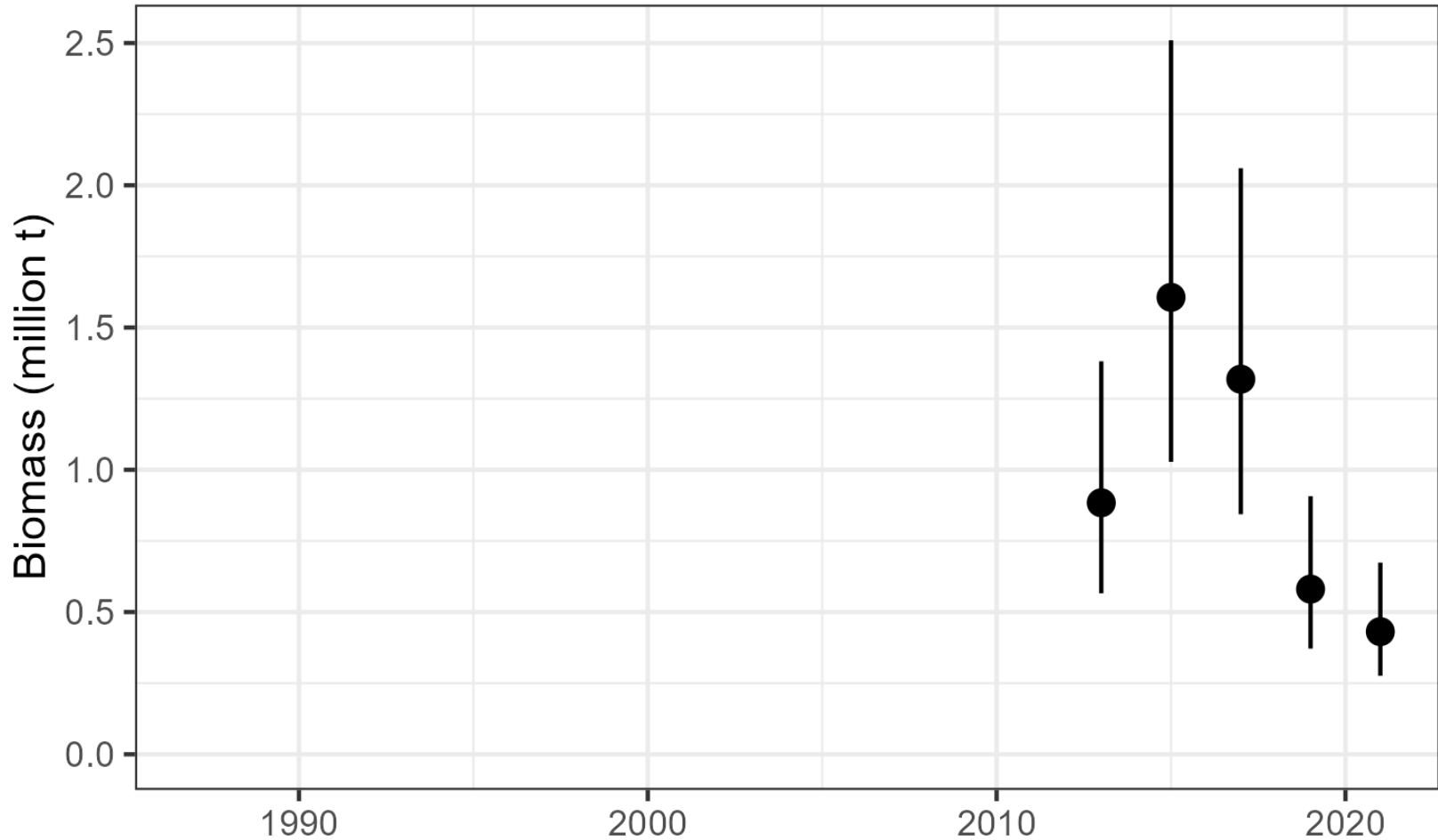
Shelikof Strait acoustic index, 1922-2021



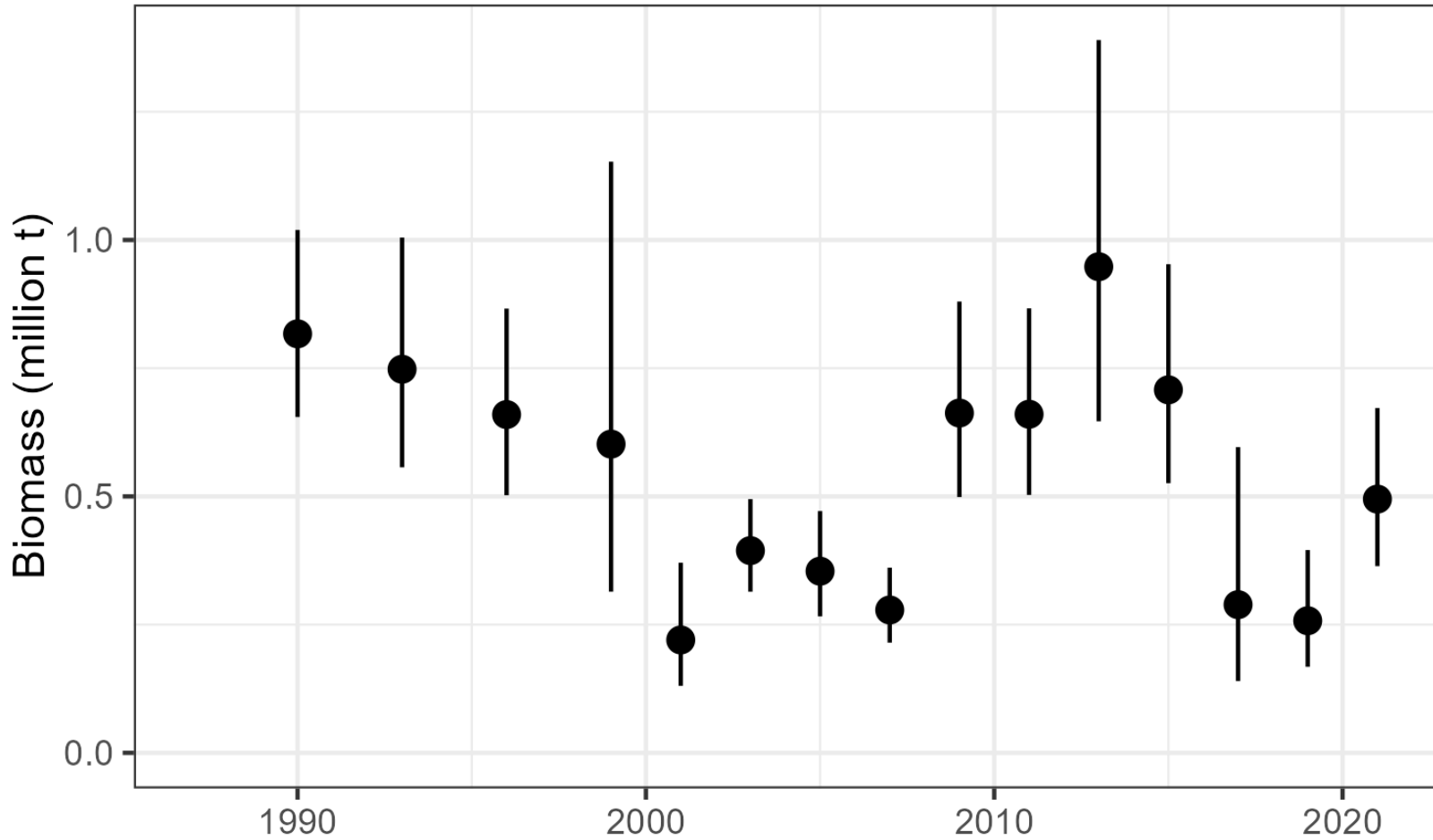
Shelikof Strait acoustic ages, 1922-2021



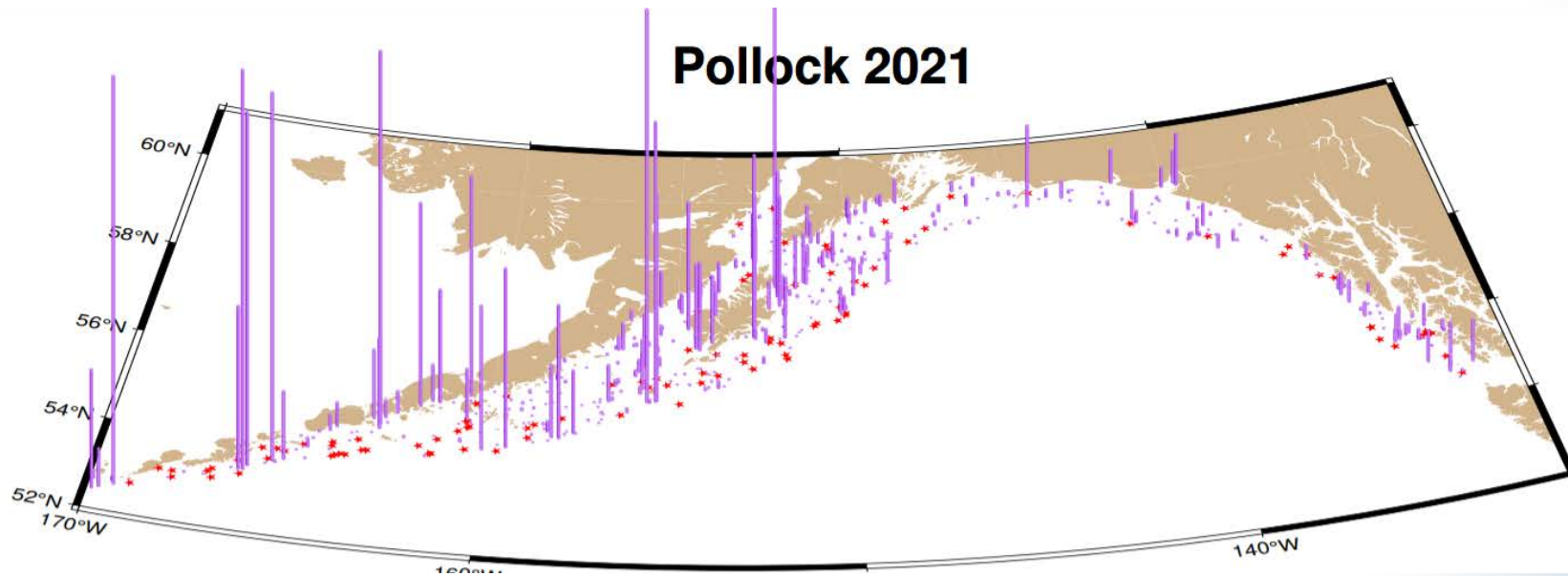
NMFS summer acoustic survey, 2013-2021



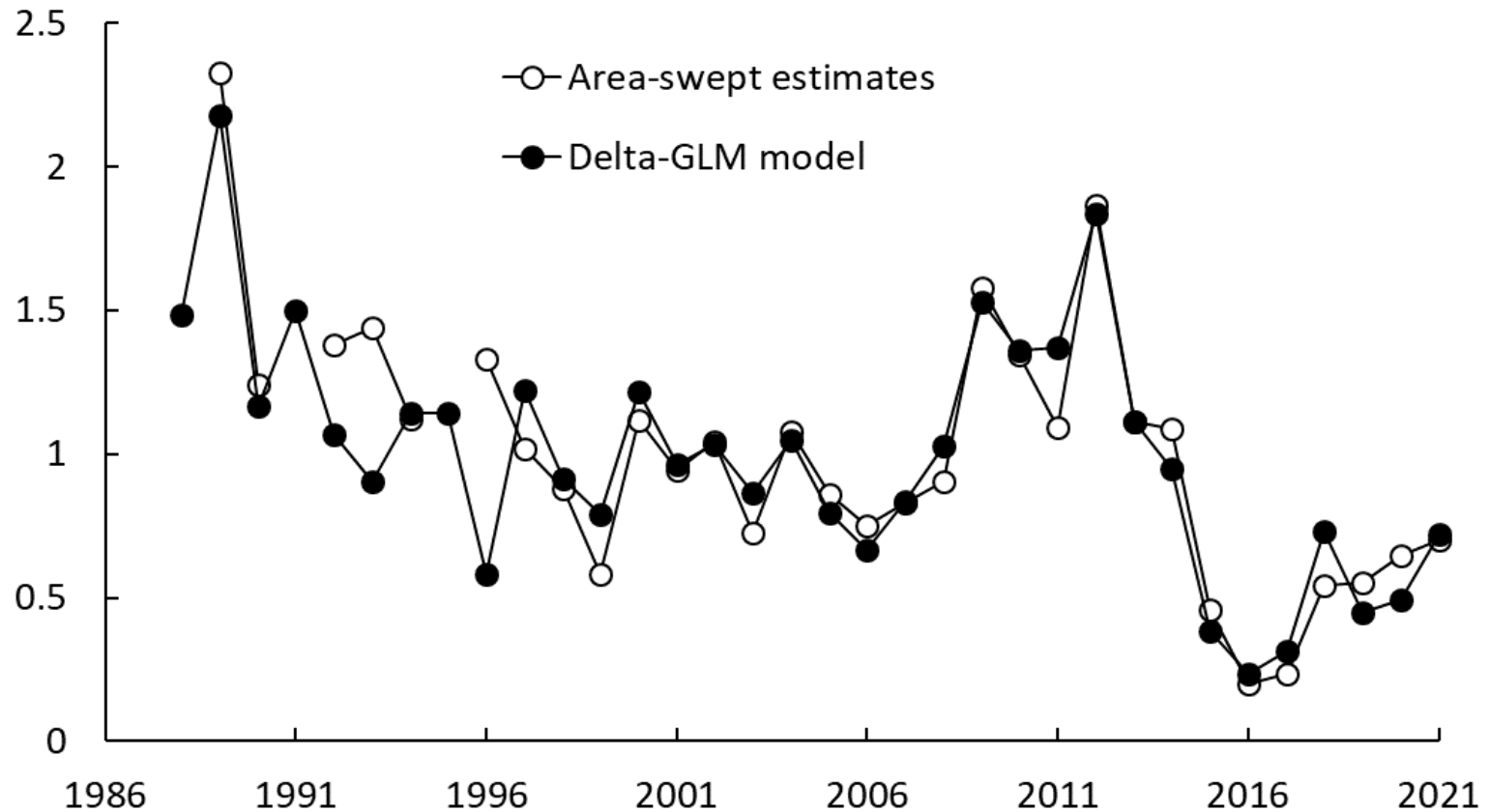
NMFS bottom trawl index, 1990-2021



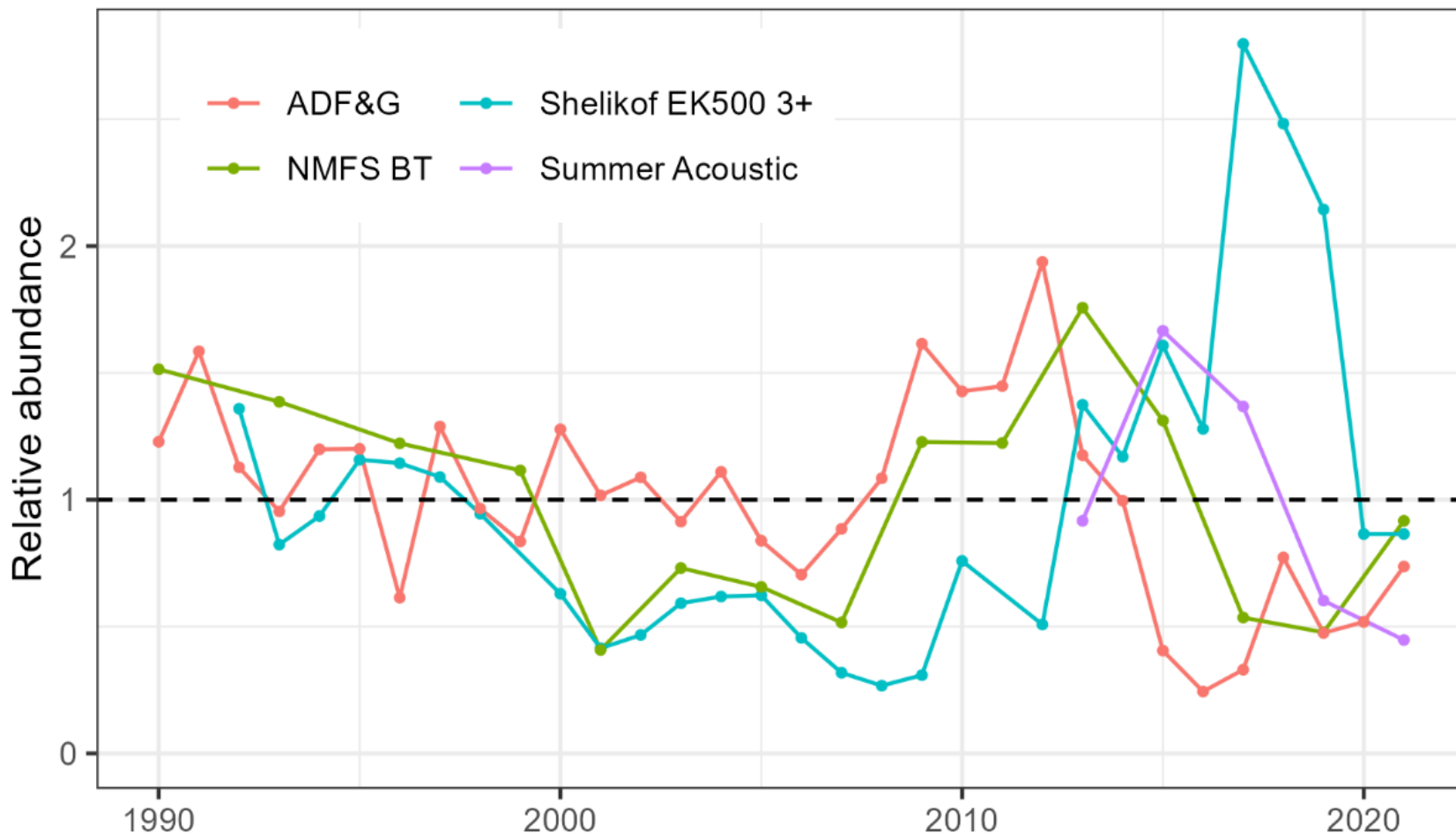
NMFS bottom trawl catch distribution



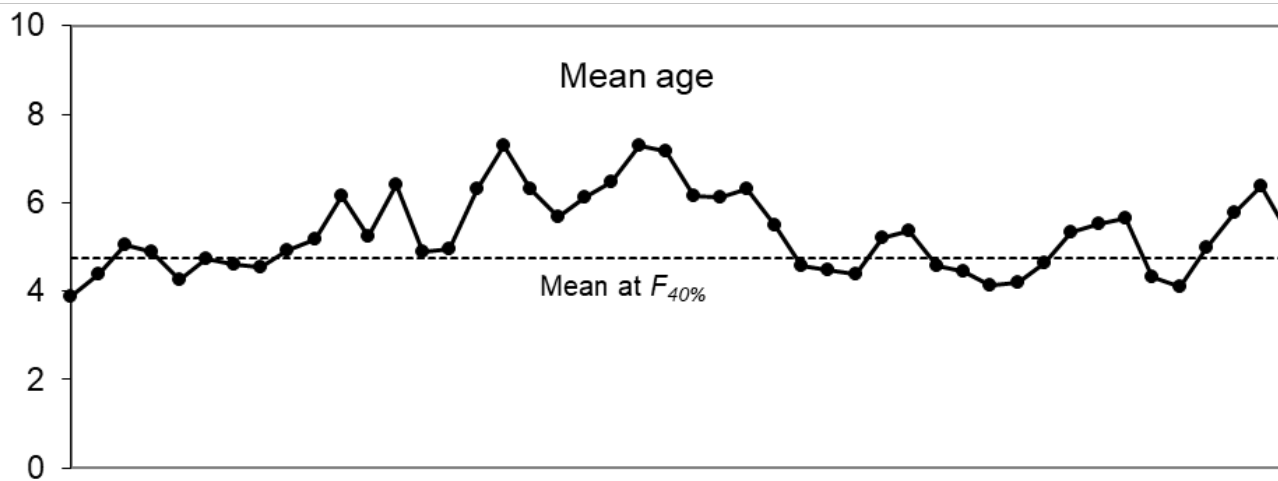
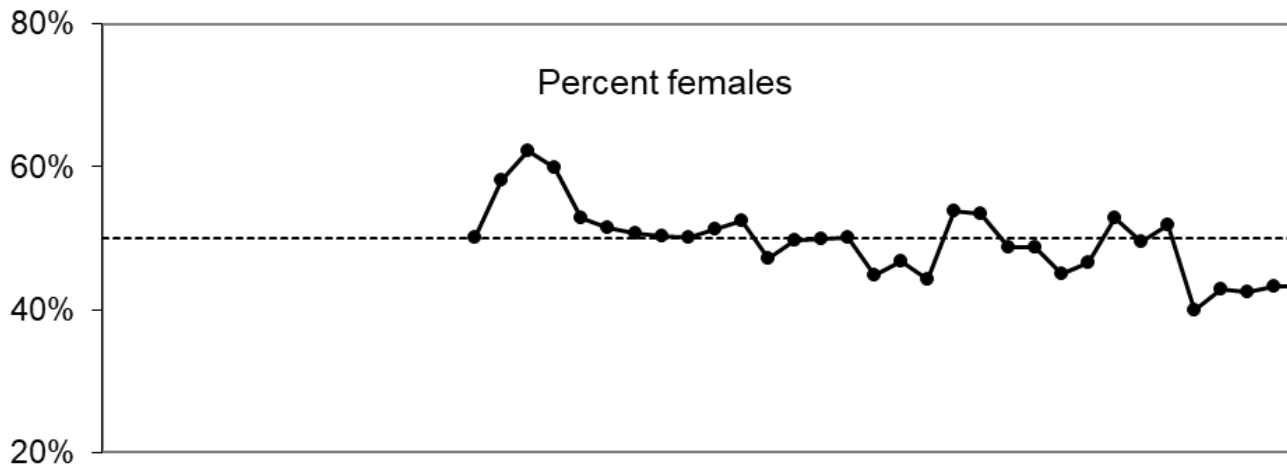
Comparison between area-swept and delta-GLM estimates of ADF&G index



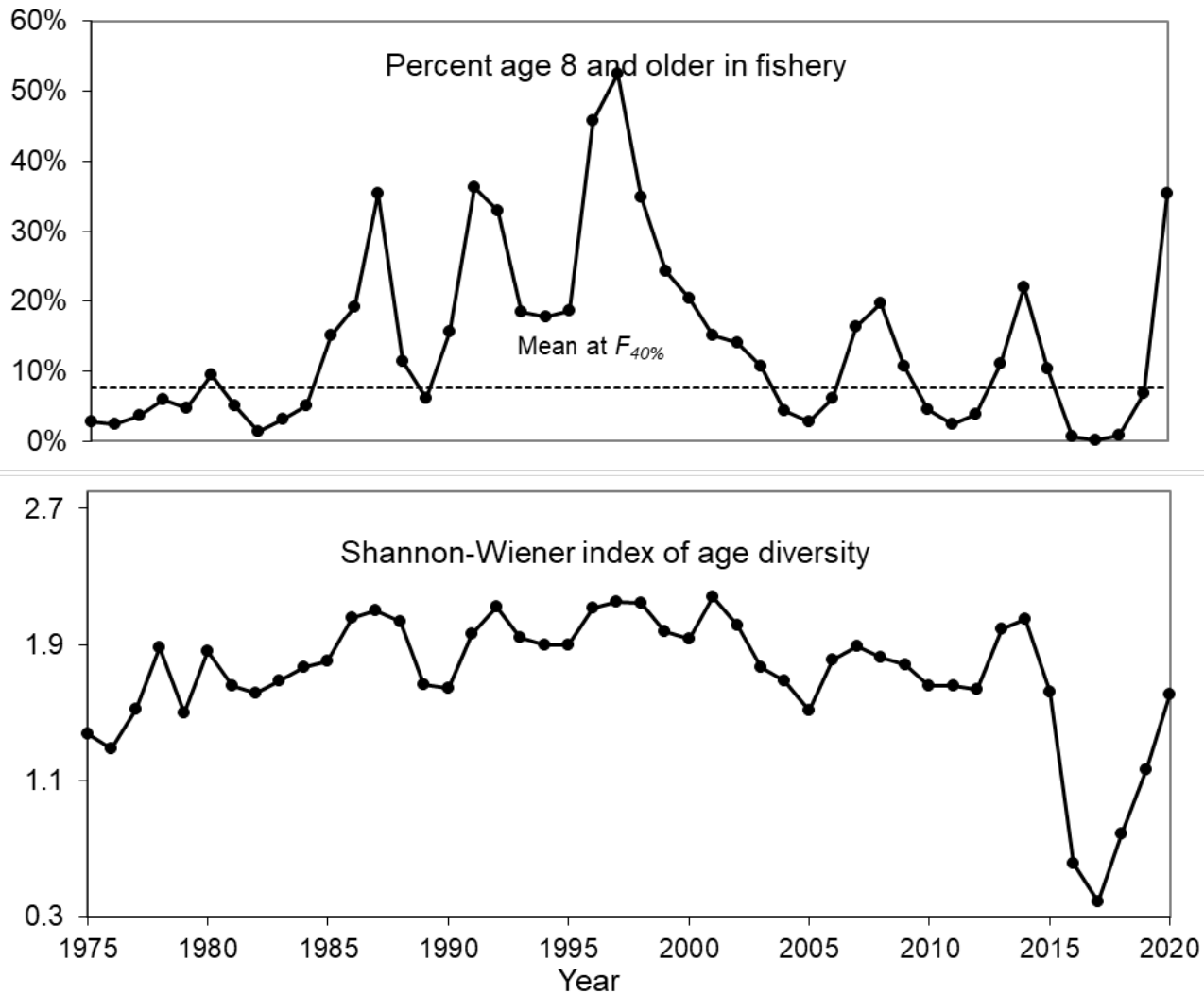
Relative trends in abundance indices



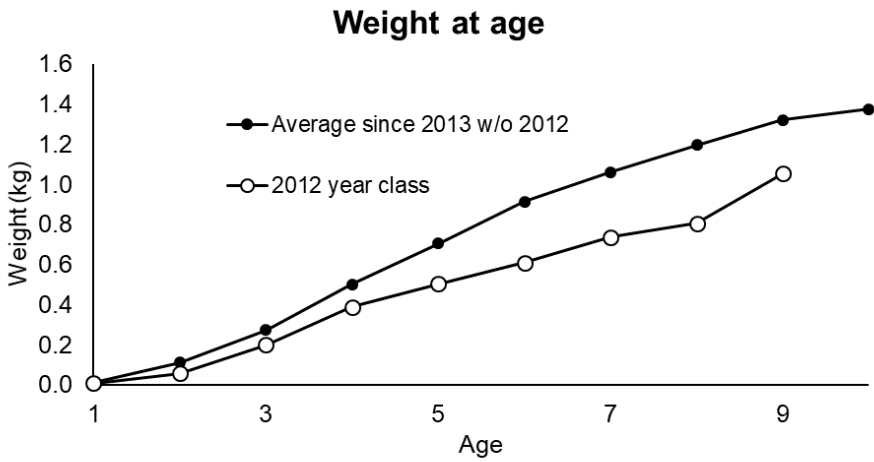
Fishery catch indicators



Fishery catch indicators



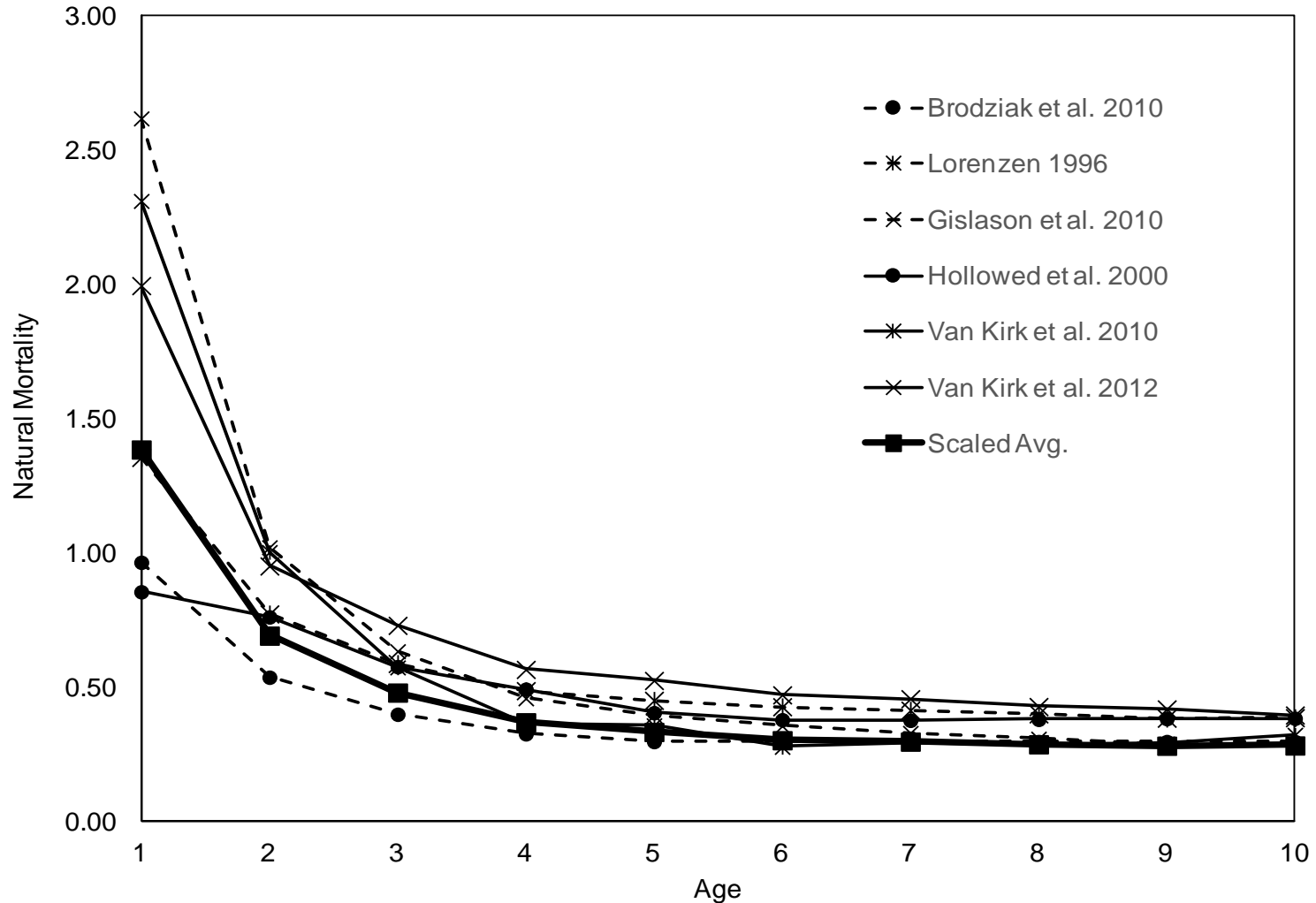
Unusual life history of the 2012 cohort



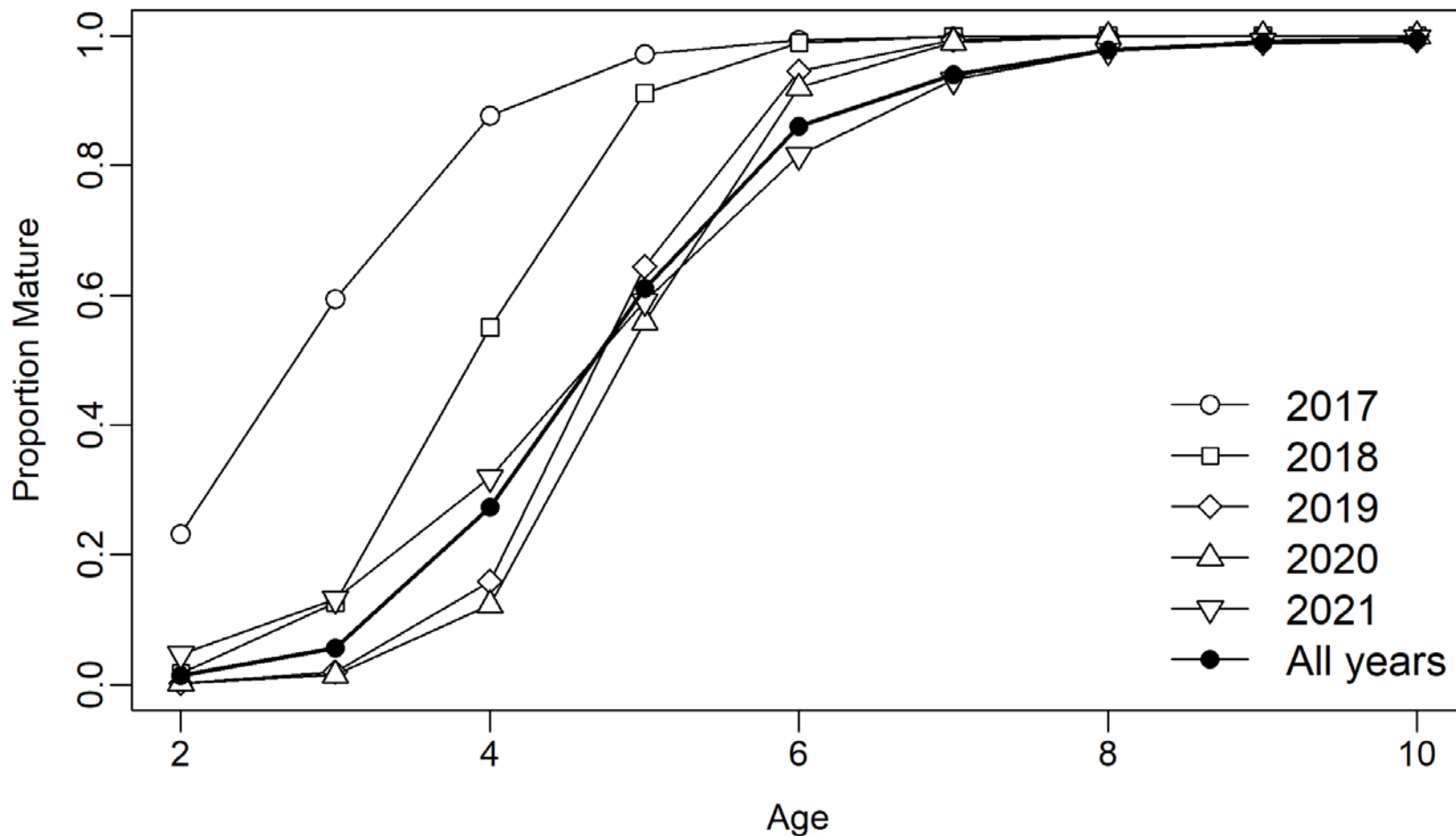
Parameters estimated externally

- Natural mortality: age-specific pattern
- Fishery weight at age
 - Data used through 2020
 - A RE model used for 2021
 - 5-year average used for projections
- Spawning weight at age
 - Annual data exclusively from Shelikof Strait
 - 5-year average for projections
- Population weight at age
 - Projections use average of last 3 NMFS BT surveys
- Proportion mature at age
 - Long-term (1983-present) average used throughout

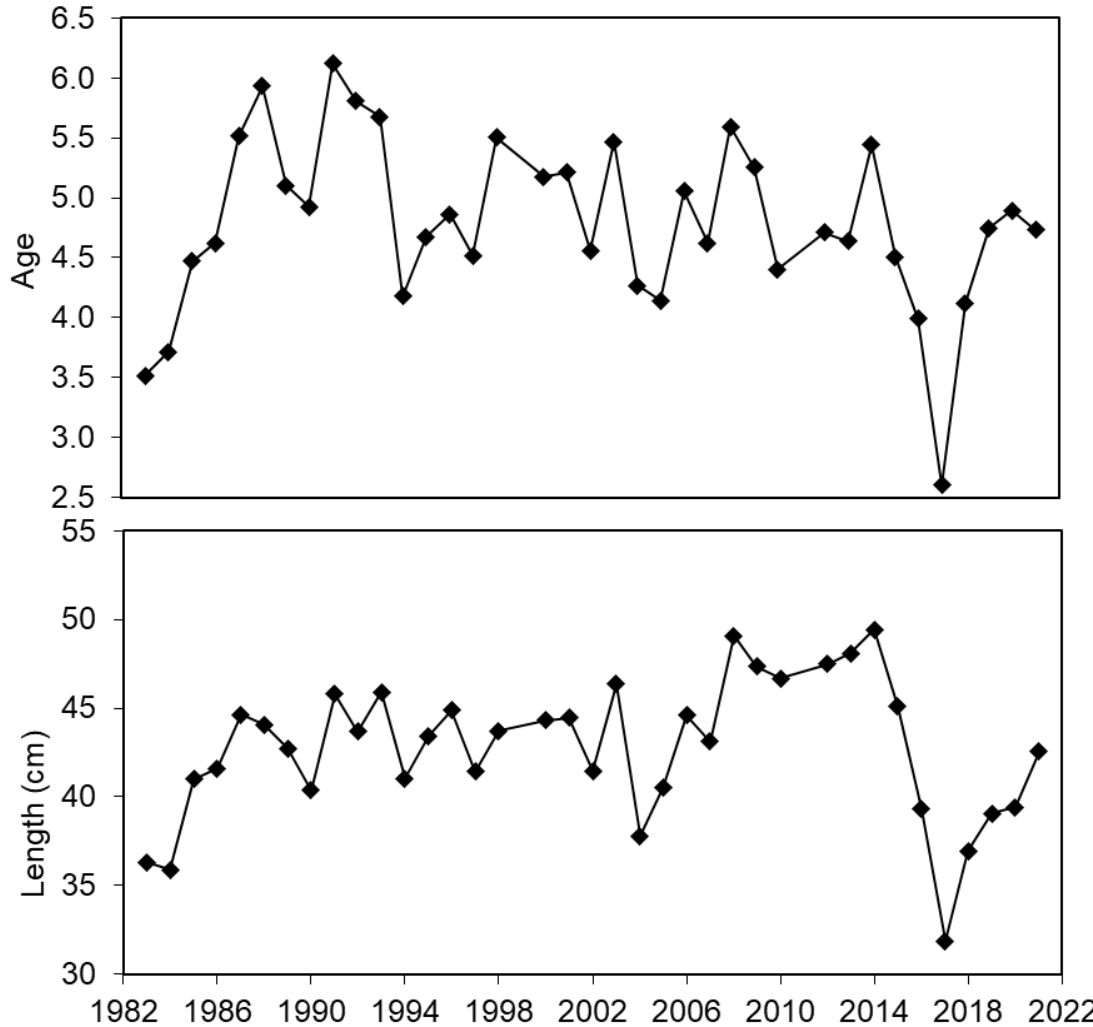
Natural mortality estimates (since 2014)



Maturity



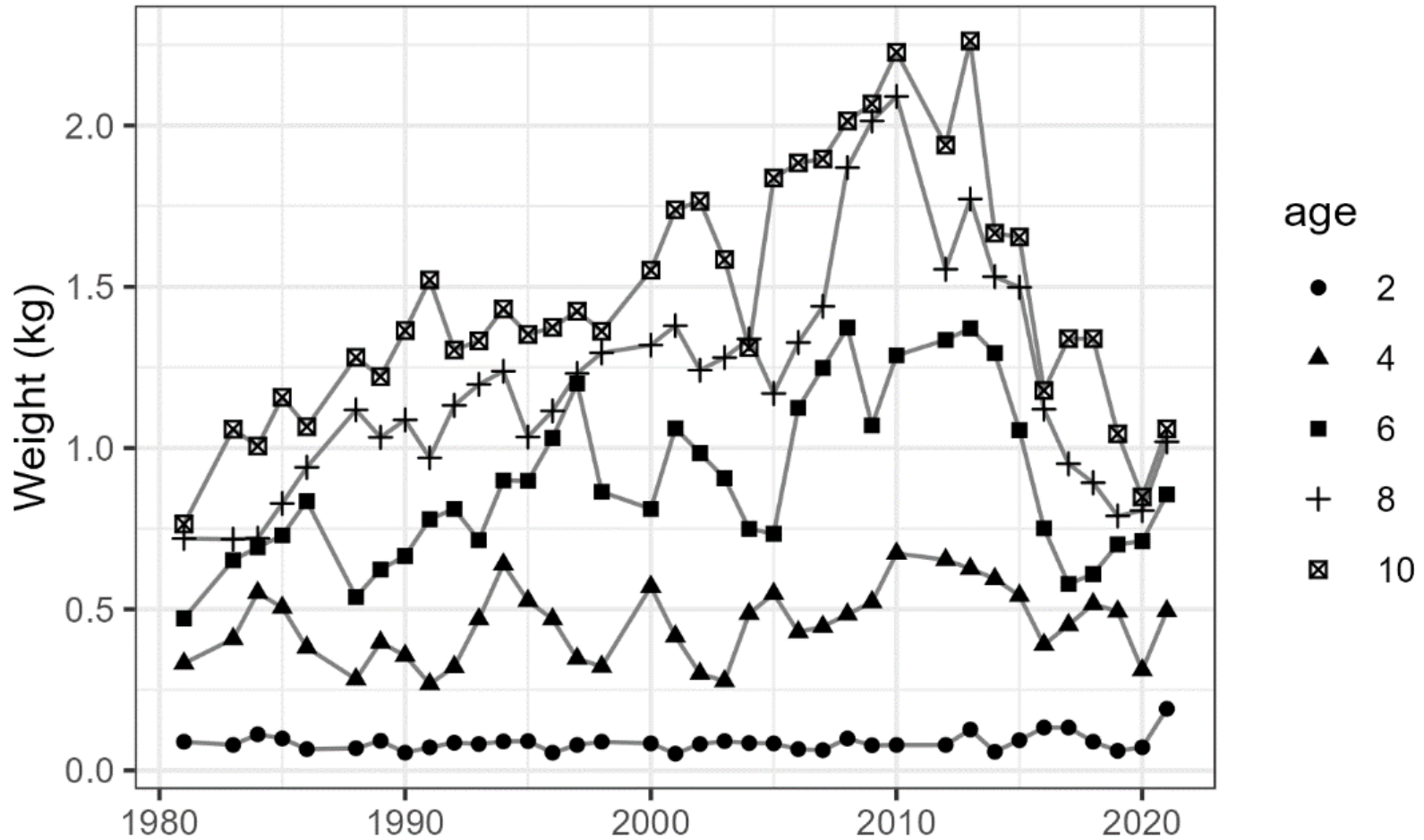
Changes in maturity



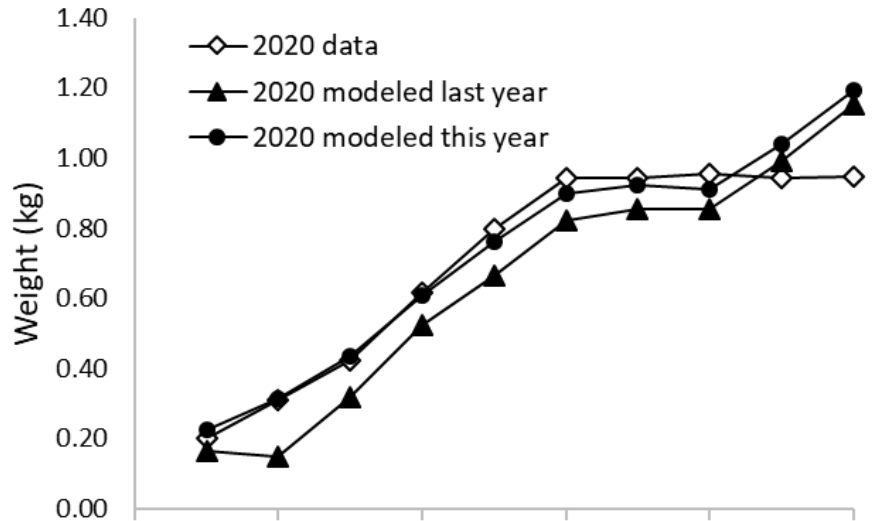
Annual GLM estimates of age and length at 50% mature

Data after 2003 use local abundance weighting

Shelikof weight at age

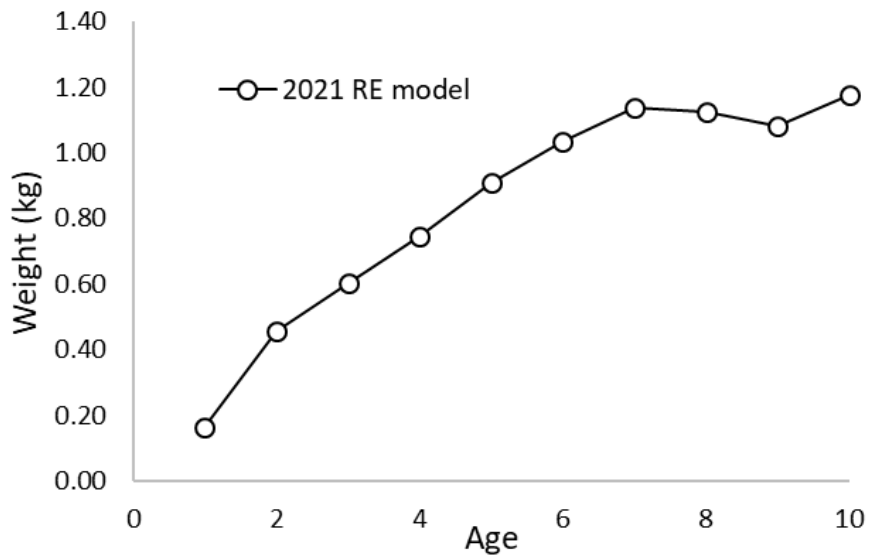


Fishery weight at age



Did the RE model accurately predict the 2020 fishery WAA last year?

..... no



Likelihood components

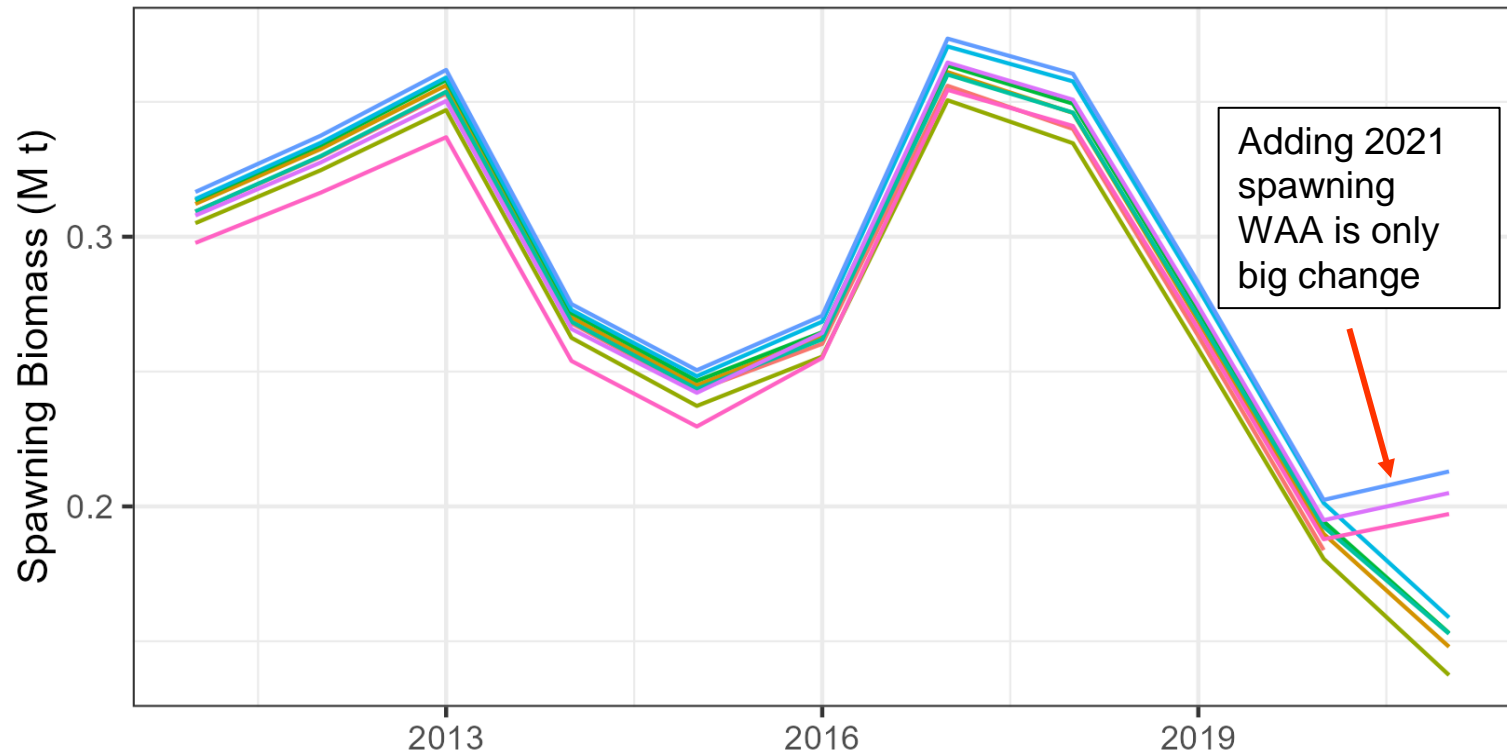
Likelihood component	Likelihood	Variance assumption
Fishery total catch (1970-2020)	Log-normal	CV = 0.05, 2021 catch is projected
Fishery age comp. (1975-2019)	Multinomial	Initial sample size: 200 or the number of tows/deliveries if less than 200
Shelikof acoustic biomass (1992-2020)	Log-normal	CV = 0.20
Shelikof acoustic age comp. (1992-2020)	Multinomial	Initial sample size = 60
Shelikof acoustic age-1 and age-2 indices (1994-2020)	Log-normal	Tuned CVs = 0.45 and 0.55
Summer acoustic biomass (2013-2019)	Log-normal	CV = 0.25
Summer acoustic age comp. (2013, 2015, 2017, 2019)	Multinomial	Initial sample size = 10
NMFS bottom trawl biom. (1990-2019)	Log-normal	Survey-specific CV from random-stratified design = 0.12-0.38
NMFS bottom trawl age comp. (1990-2019)	Multinomial	Initial sample size = 60
ADF&G trawl index (1989-2020)	Log-normal	Survey-specific CV from delta GLM model rescaled so mean is 0.25=0.20-0.35
ADF&G survey age comp. (2000-2018)	Multinomial	Initial sample size = 30
Recruit process error (1970-1977, 2019, 2020)	Log-normal	$\sigma_R = 1.0$

Likelihood components

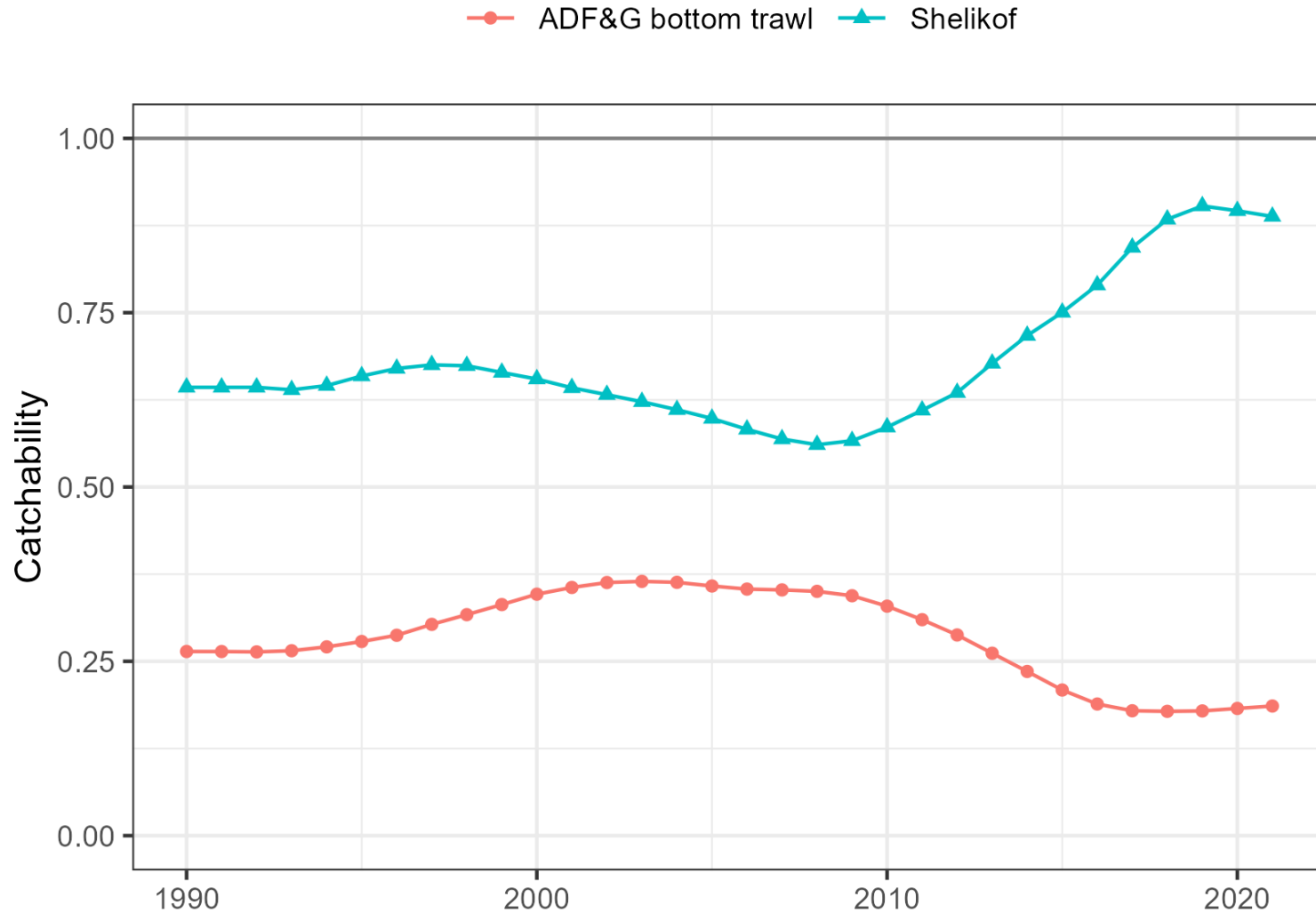
Population process	Number of parameters	Estimation details
Recruitment	Years 1970-2021 = 52	Estimated as log deviances from the log mean; recruitment in 1970-77, and 2018 and 2019 constrained by random deviation process error.
Natural mortality	Age-specific= 10	Not estimated in the model
Fishing mortality	Years 1970-2021 = 52	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	$2 * (\text{No. years}-1) = 102$	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	$2 * (\text{No. years}-1) = 102$	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 (2 each for 3 surveys)	Slope parameters estimated on a log scale.
Total	120 estimated parameters + 204 process error parameters + 10 fixed parameters = 334	

Sequential addition of data

- 19.1 (2020)
- + ADF&G bottom trawl survey
- + Shelikof 2021 WAA
- + 2020 fishery data
- + NMFS bottom trawl survey
- + updated catch projec
- + summer acoustic
- + Shelikof survey w/o 2021 WAA
- 19.1 (2021) final

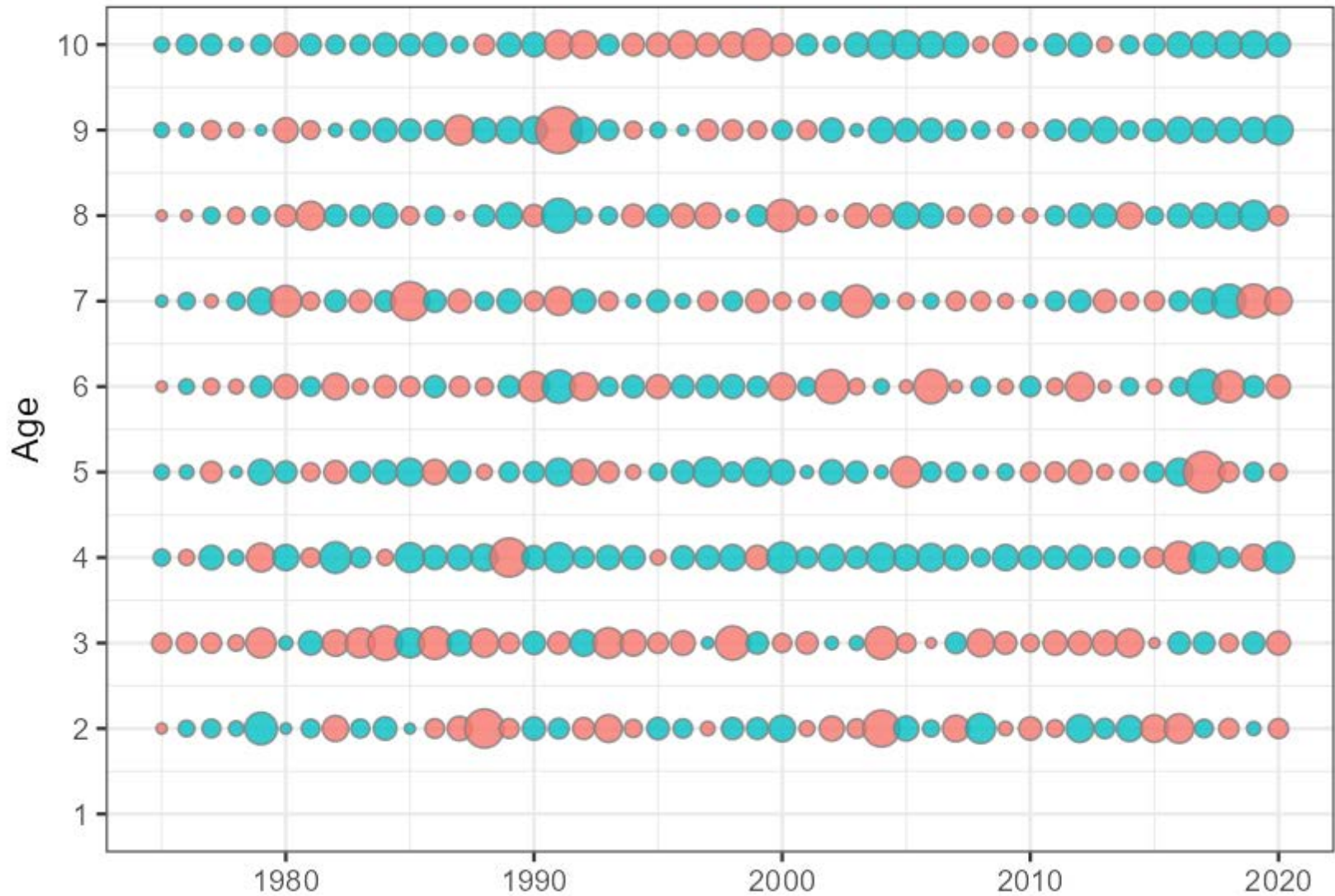


Time-varying catchabilities



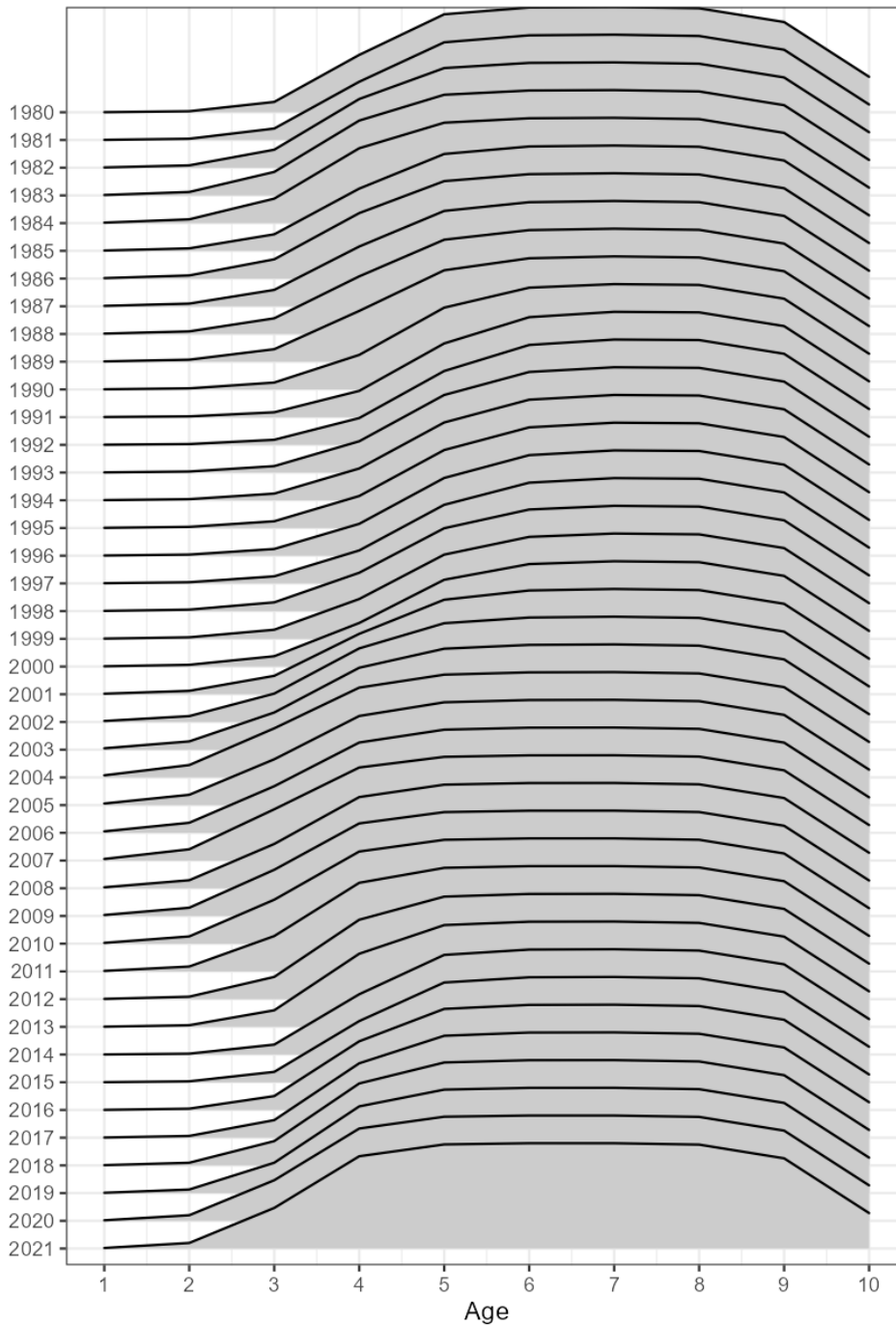
Fishery age residuals

Pearson residual range: -2.1 to 4.6



Fishery selectivity

Double-logistic with
time varying
ascending slope and
inflection



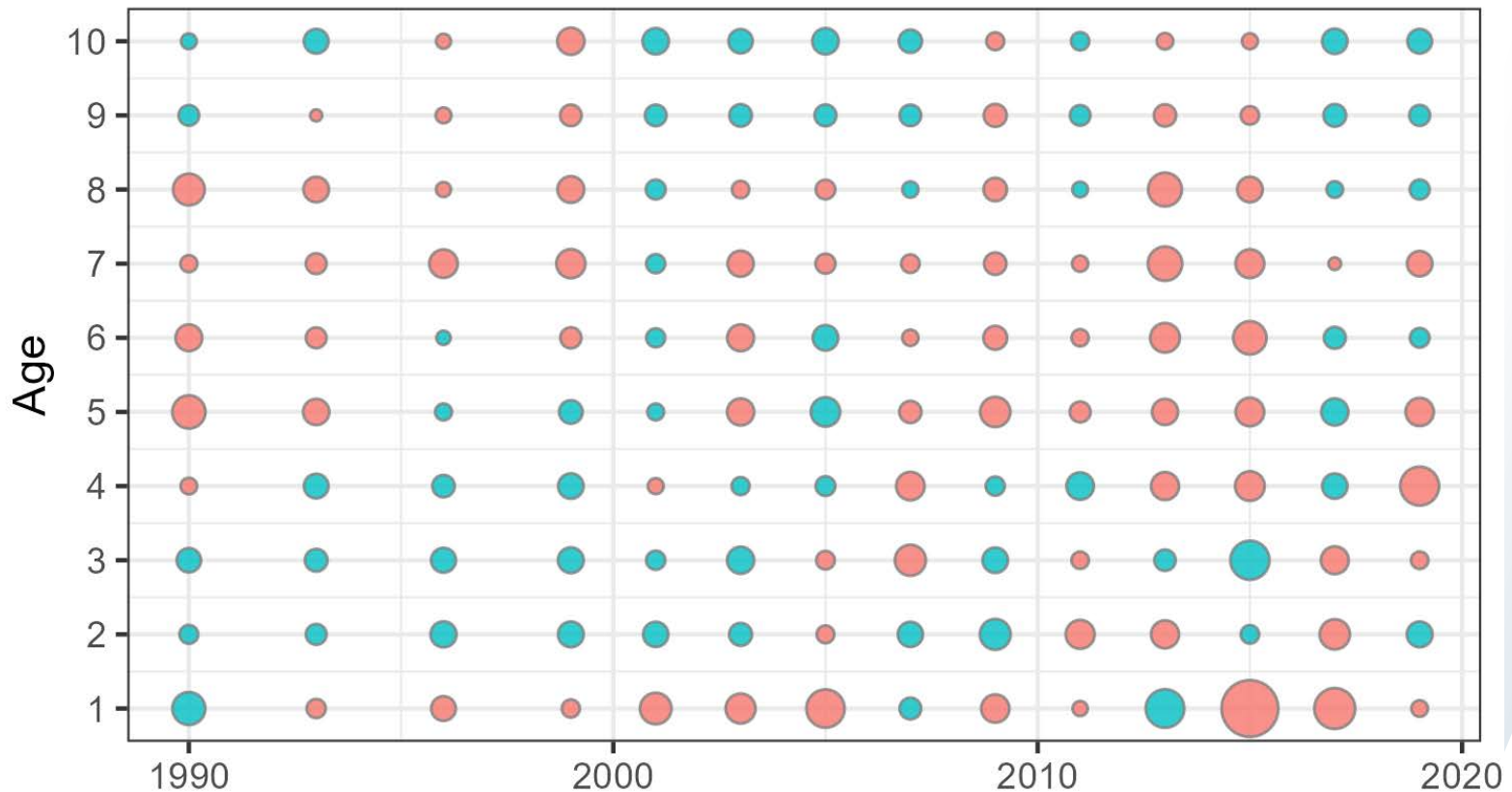
Shelikof age residuals

Pearson residual range: -1.9 to 2.7



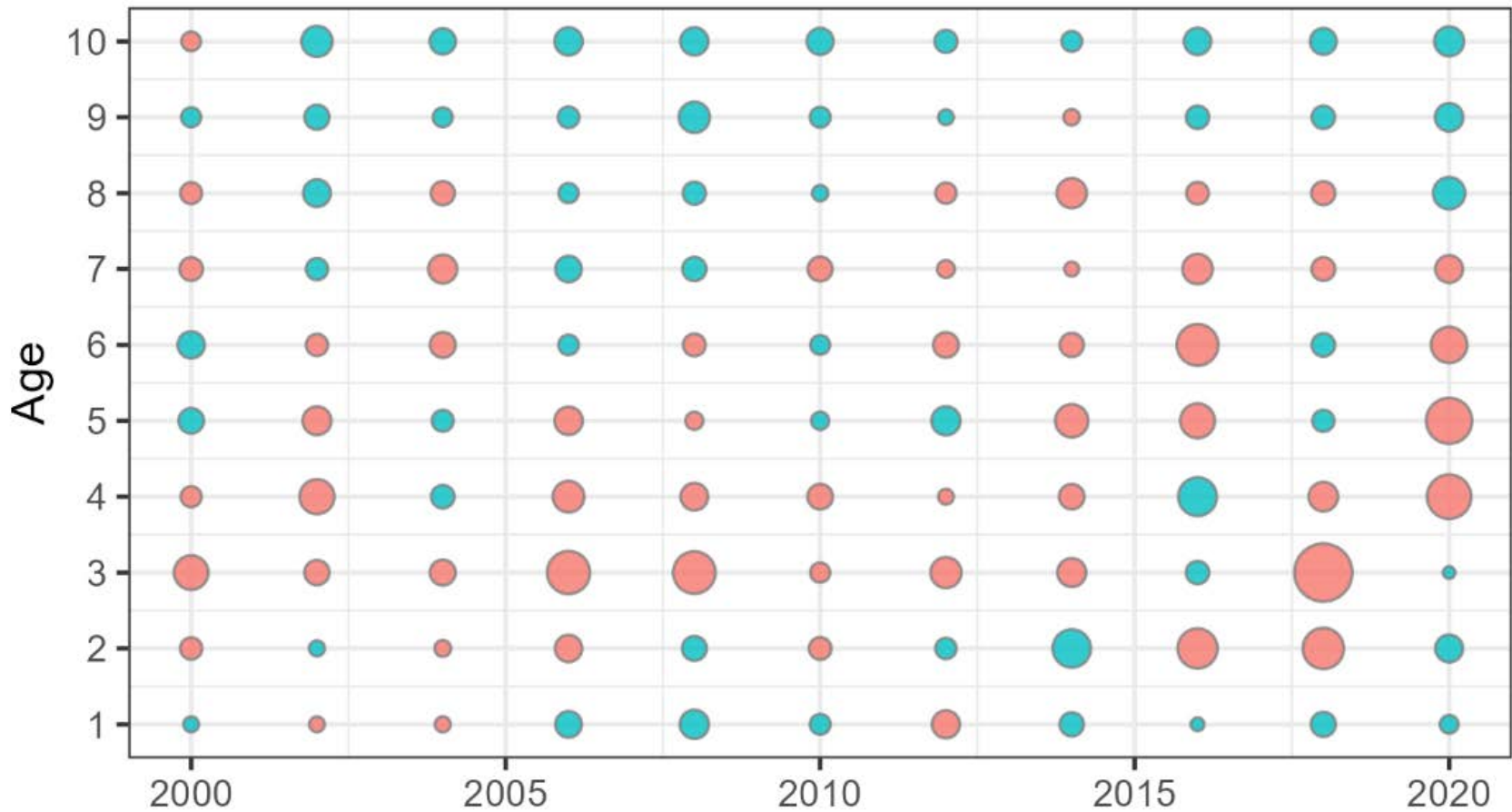
NMFS BT age residuals

Pearson residual range: -2 to 5.4

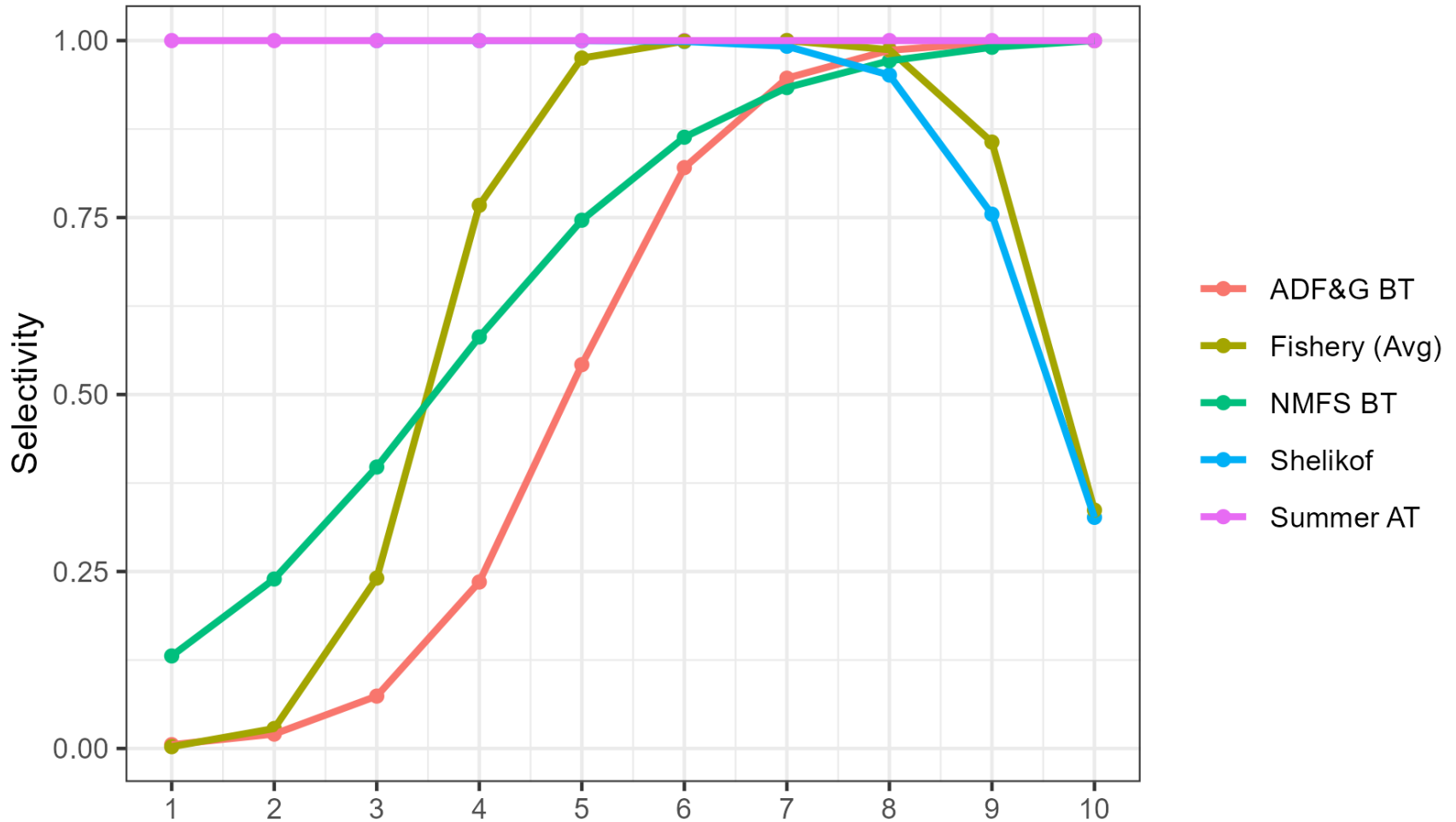


ADF&G BT age residuals

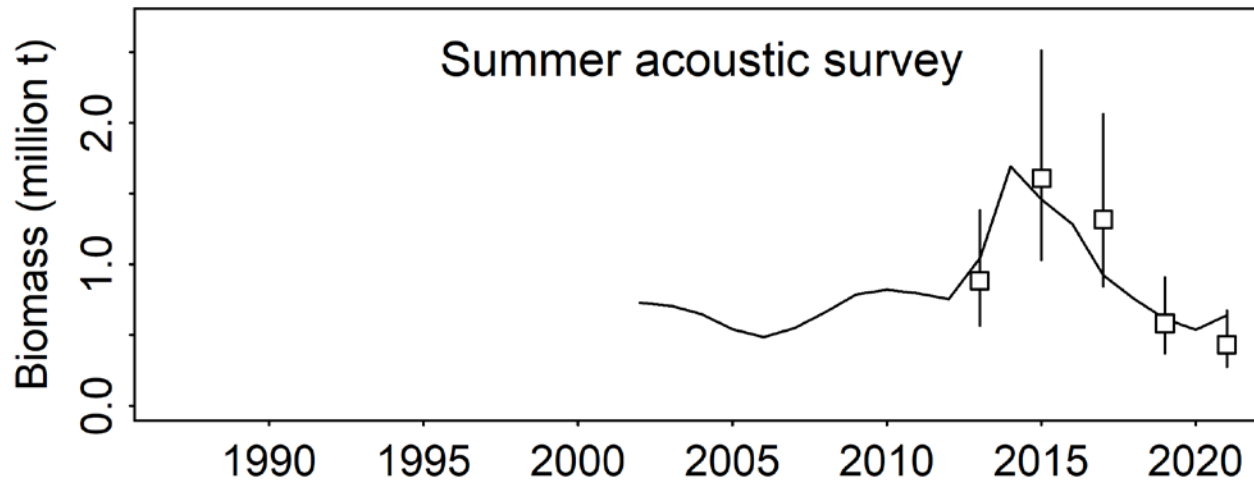
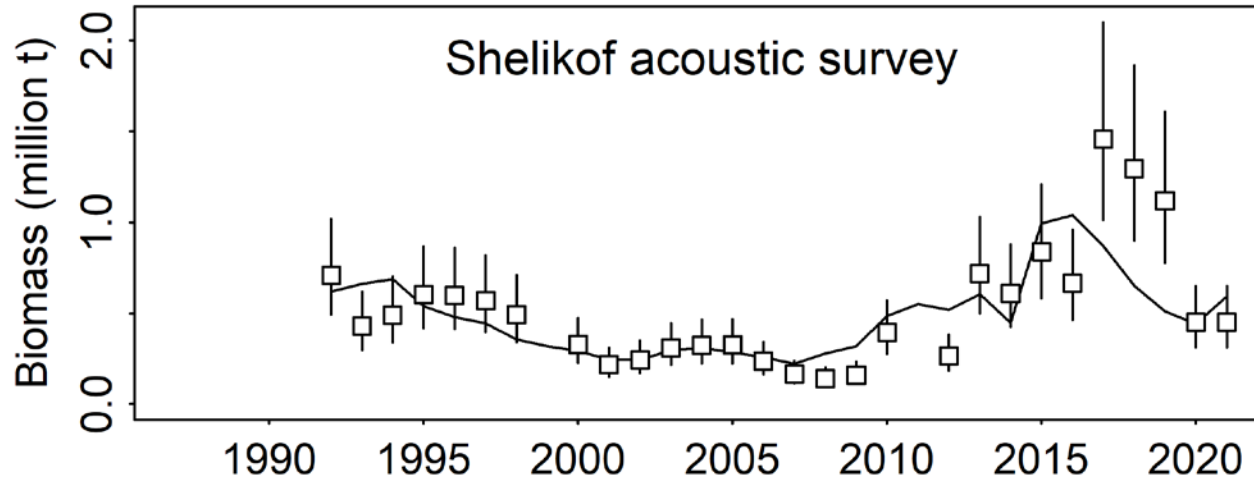
Pearson residual range: -2.3 to 6.9



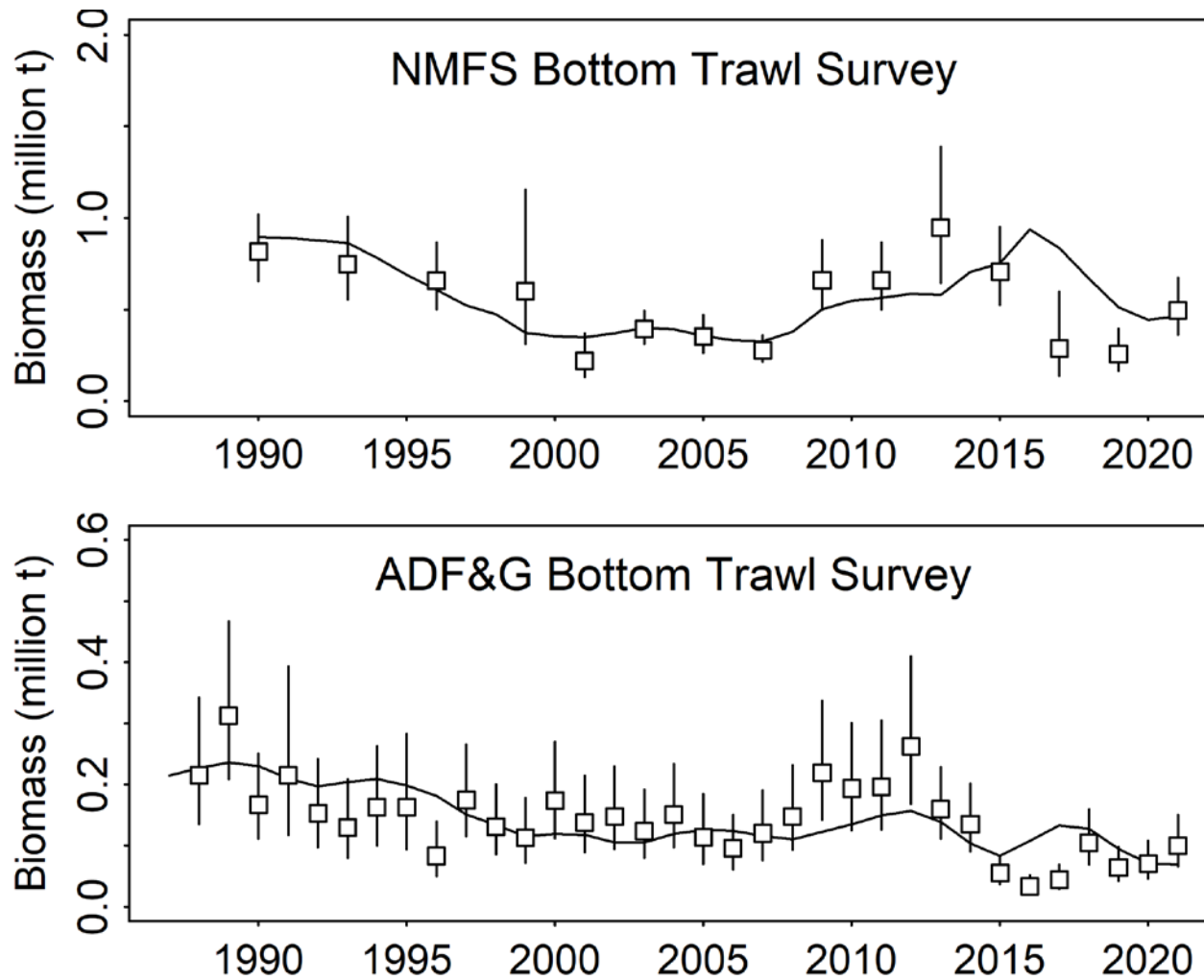
Estimated survey selectivities



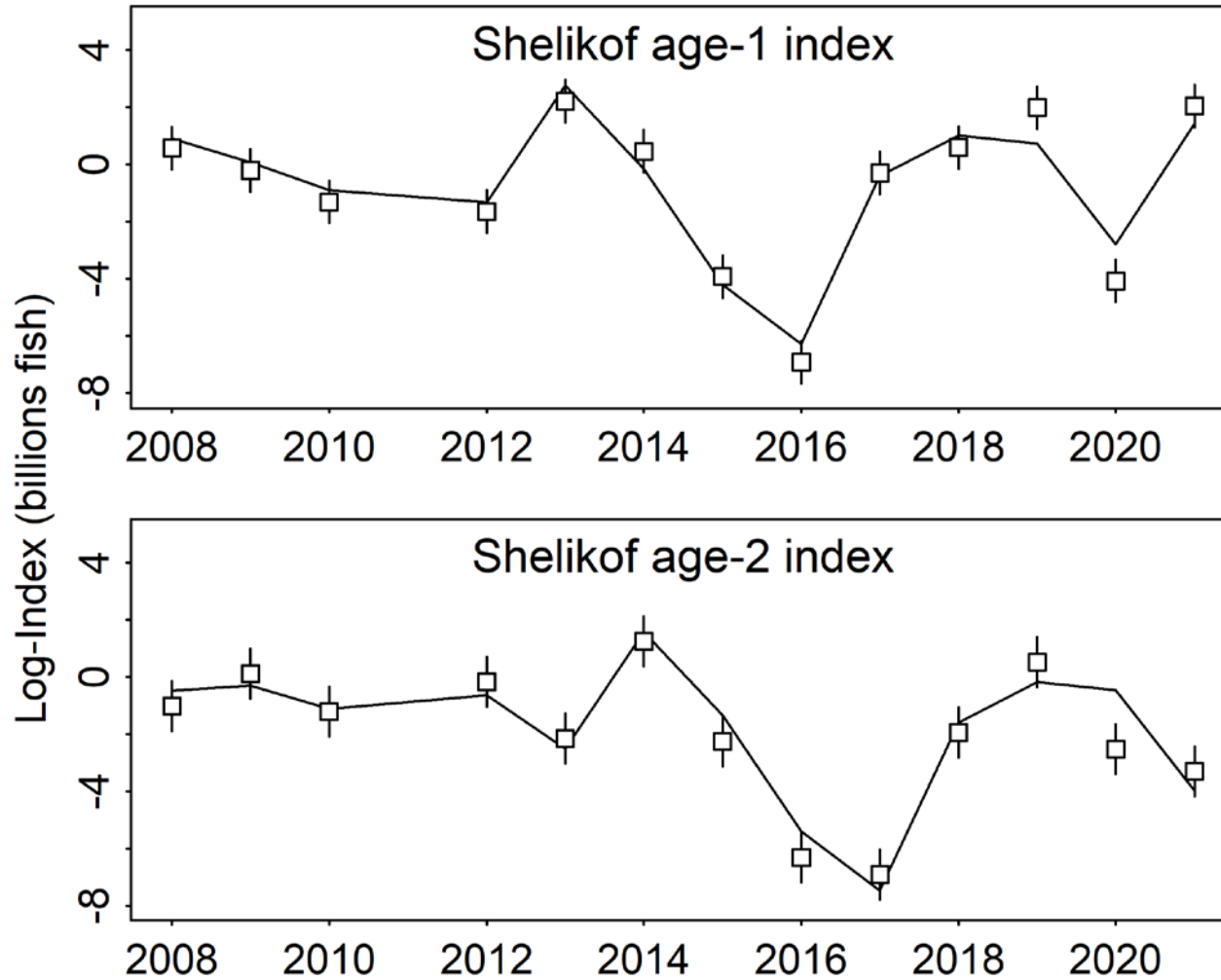
Fits to acoustic indices

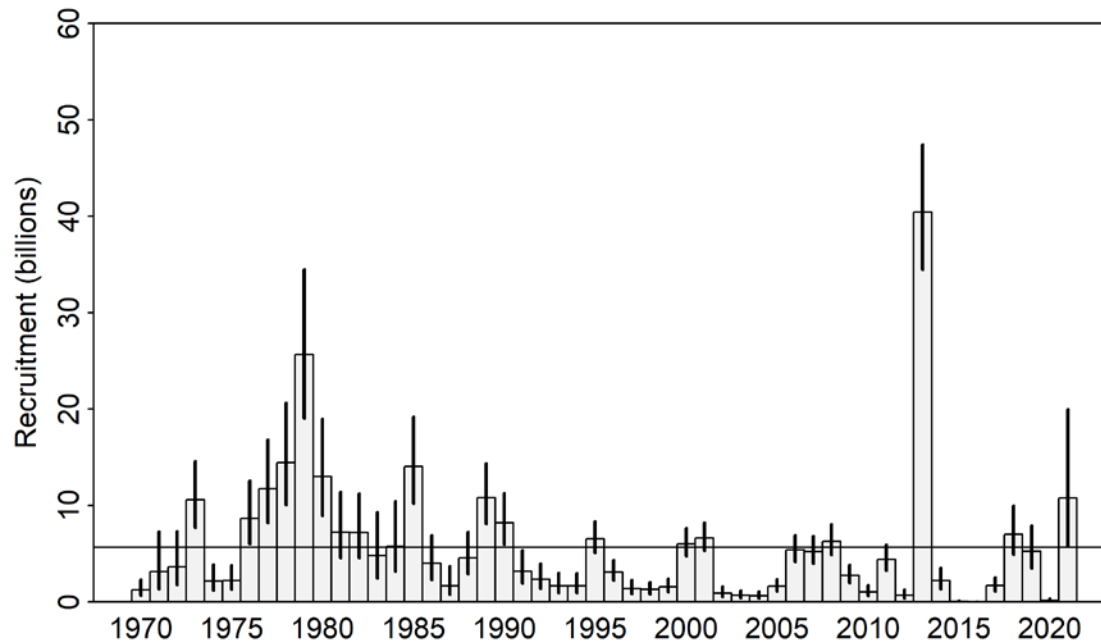
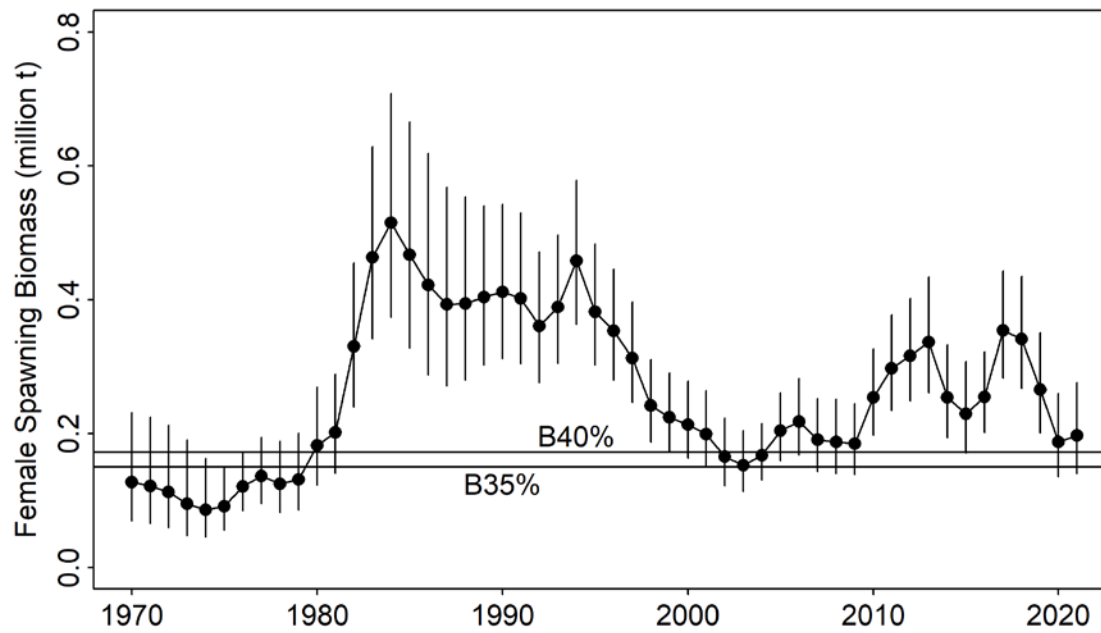


Fits to BT indices

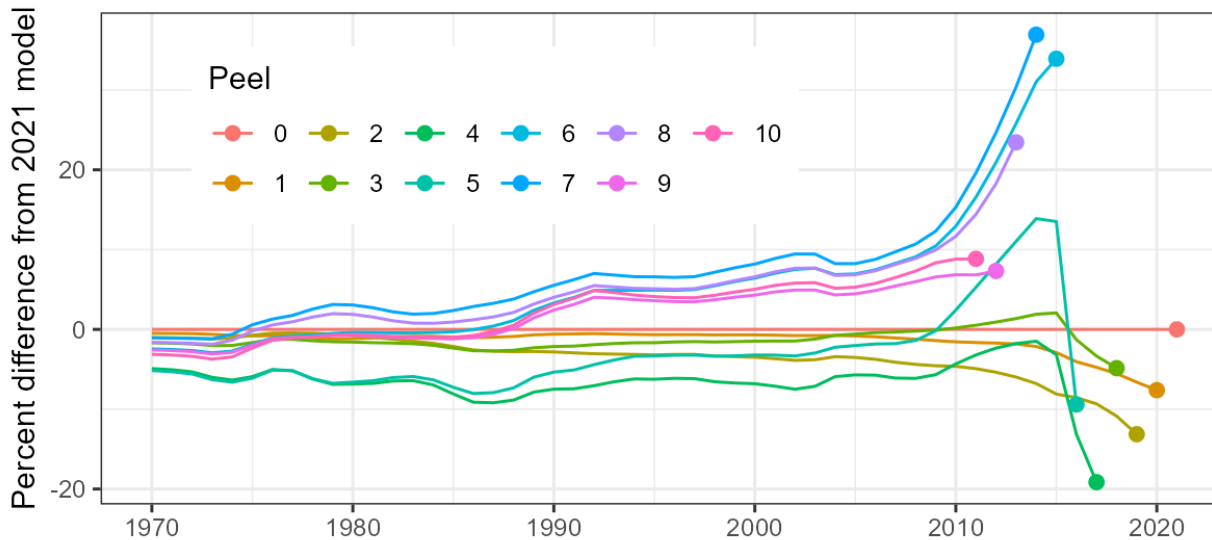
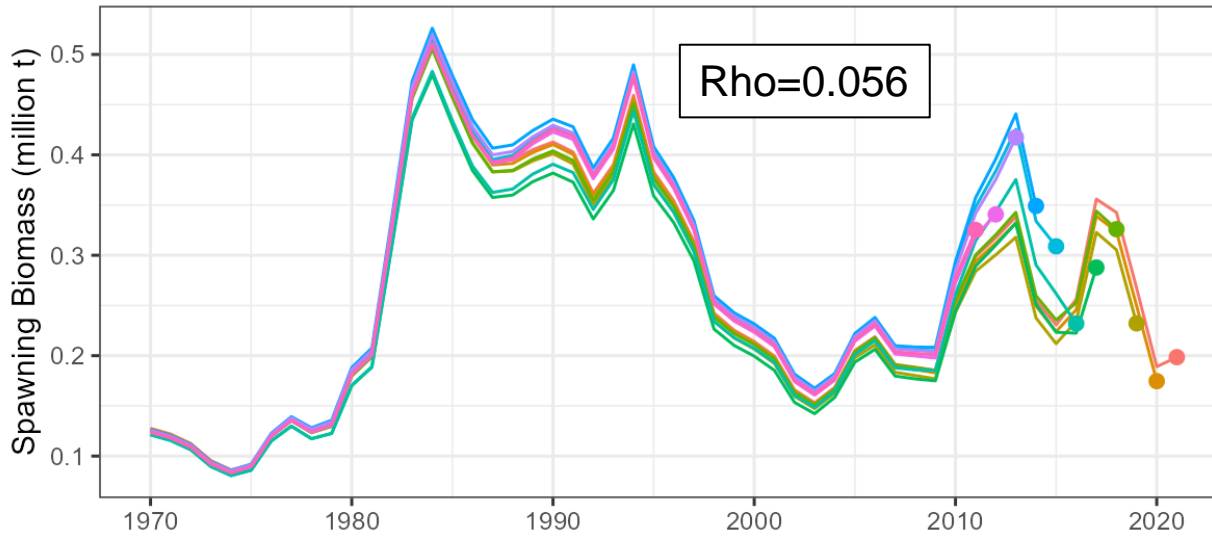


Fits to acoustic indices

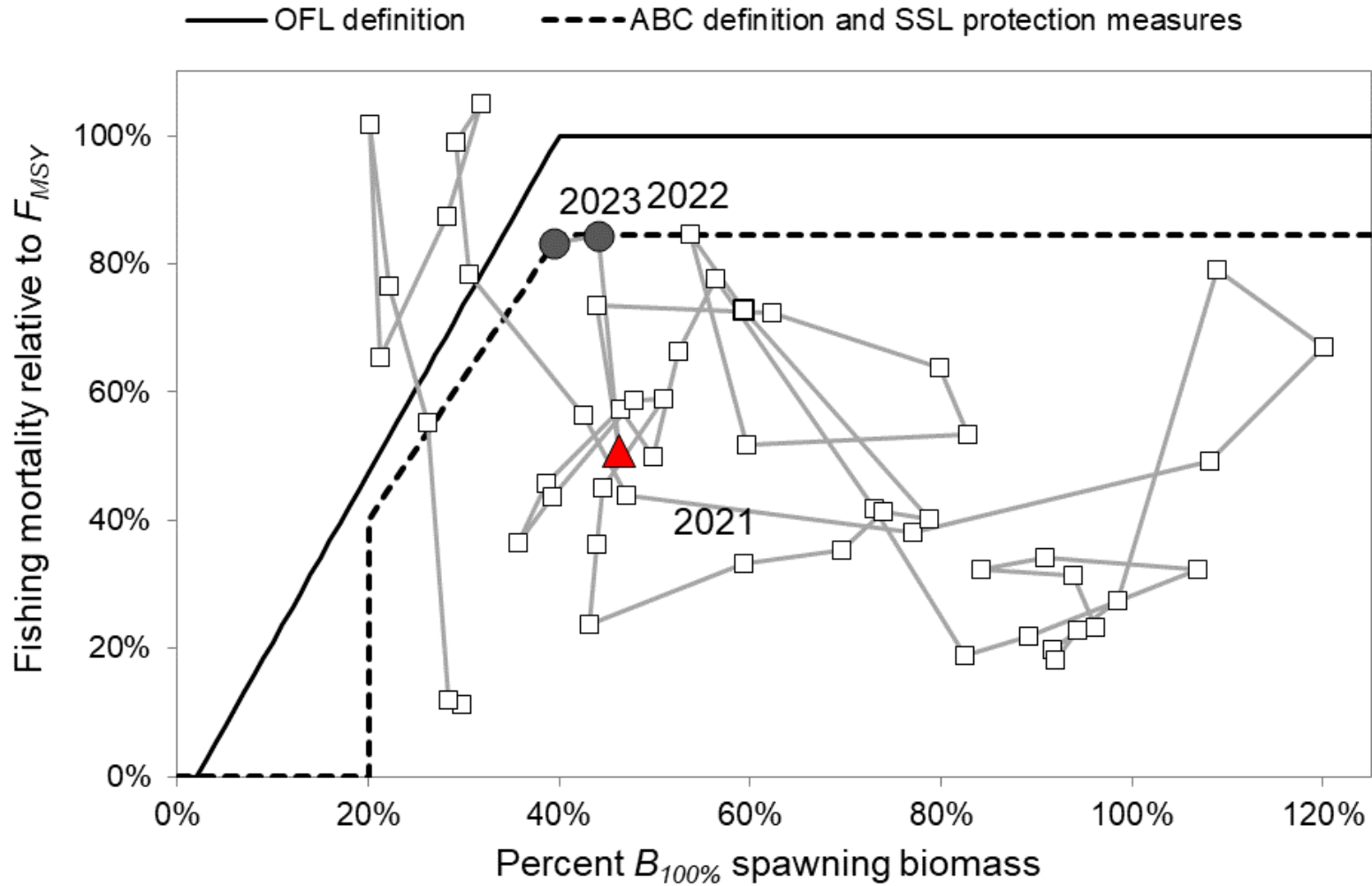




Retrospective analysis

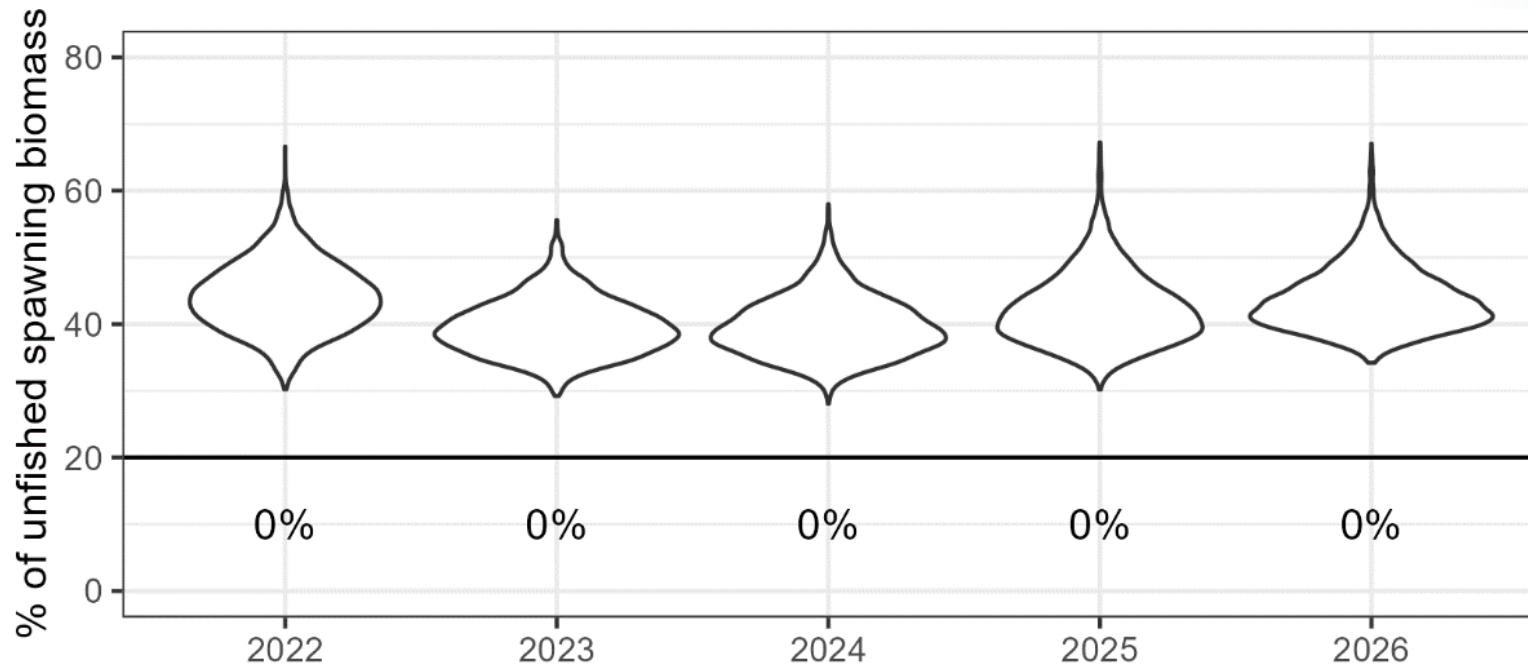


SSB vs fishing mortality



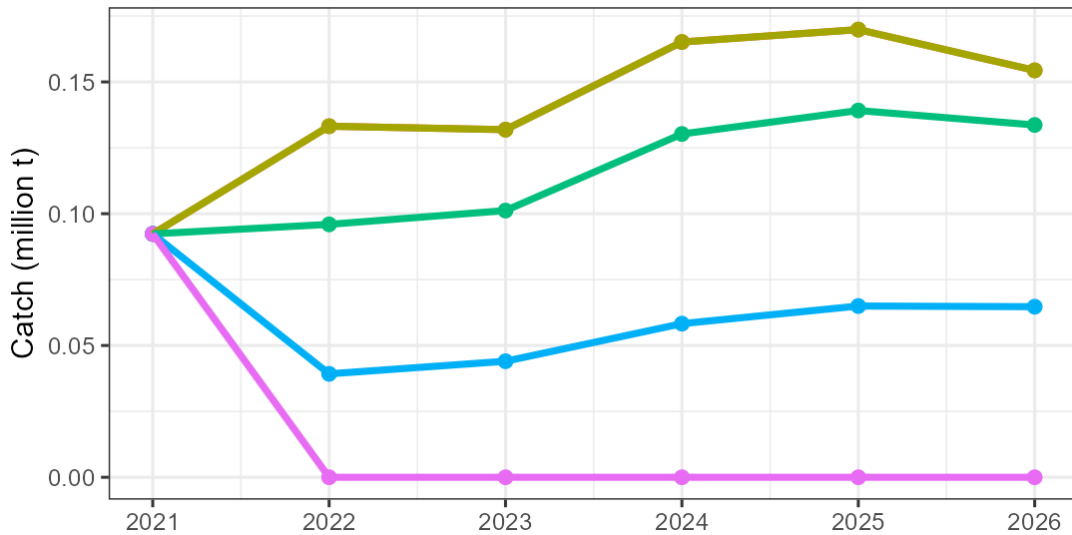
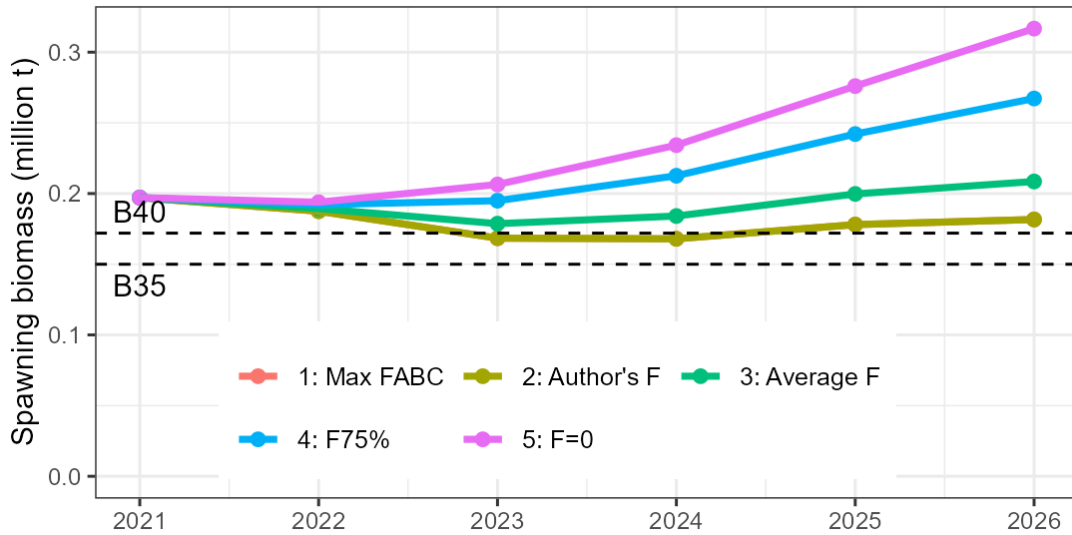
Probability of falling below B20%

Run MCMC samples through an internal projection module to calculate $\Pr(\text{SSB} < \text{B20}\%)$ for SSL measures



5-year
projections

Mean spawning
biomass



Mean yield

Risk matrix

<i>Assessment-related considerations</i>	<i>Population dynamics considerations</i>	<i>Environmental/ecosystem considerations</i>	<i>Fishery Performance</i>
<p>2021 survey indices showed consistent relative trends and were fit well. Minimal retrospective pattern and generally good fits. Continued uncertainty in size of 2018 cohort. Issue with scale and catchability prior.</p>	<p>Age diversity has returned to normal as extremely dominant 2012 cohort ages out. Strong 2017, 2018 and 2020 cohorts suggest continued diversity in near term.</p>	<p>Improved egg/larval habitat conditions, and average-adequate prey resources for larvae, juveniles and adults. Unknown recruitment potential due to loss of summer survey.</p> <p>Overall 2021 ecosystem indicators were average to above average and socioeconomic indicators were good to poor.</p>	<p>Fishery CPUE is either above or close to long-term average, and is very consistent with abundance trends from the model.</p>
Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns

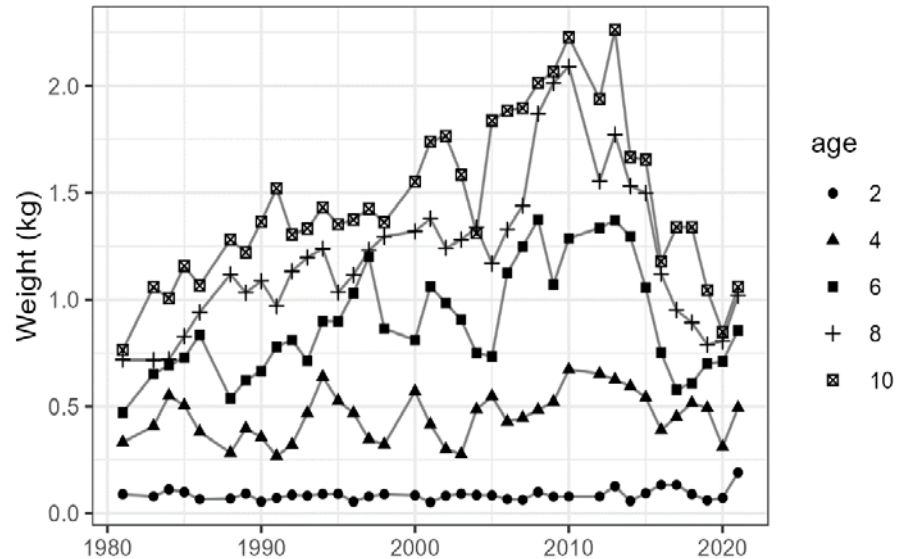
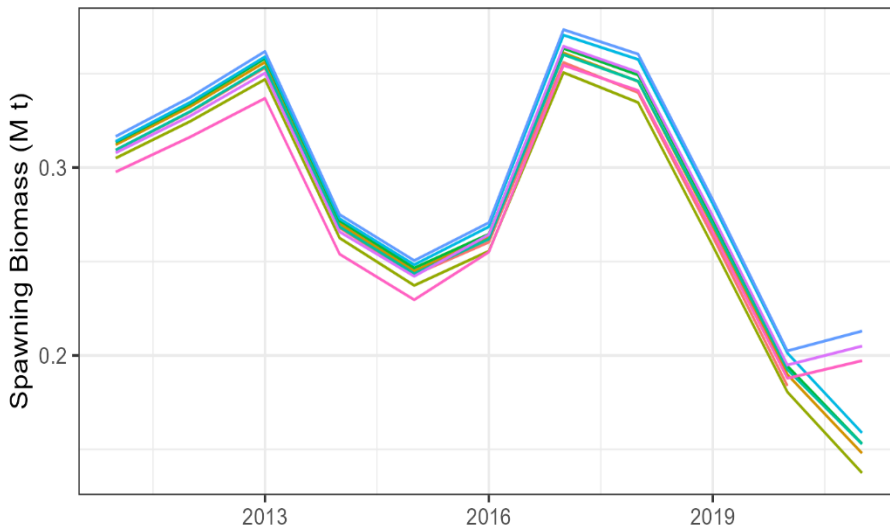
Author's recommended 2022 ABC = maximum permissible ABC (no additional buffer recommended).

2021 model concerns

- Increase in spawning WAA has large impact
- Scale of population driven largely by prior on Q for NMFS BT
- The size of the 2018 remains unclear

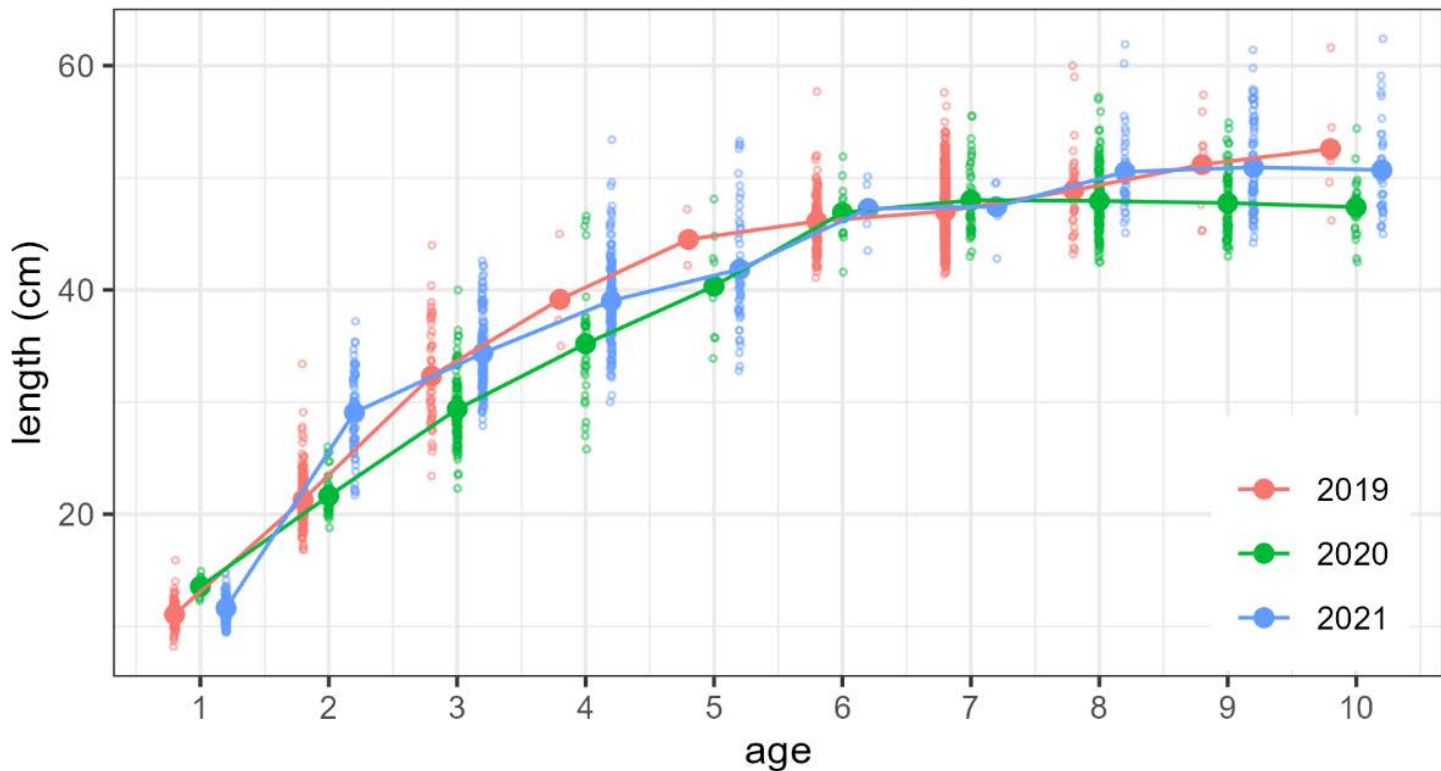
Unusual spawning WAA

- 2021 had abrupt increase spawning WAA
- Largest age 2 fish to date, 4th largest age 3 fish
- If 2020 WAA used, 2022 ABC increases 8%



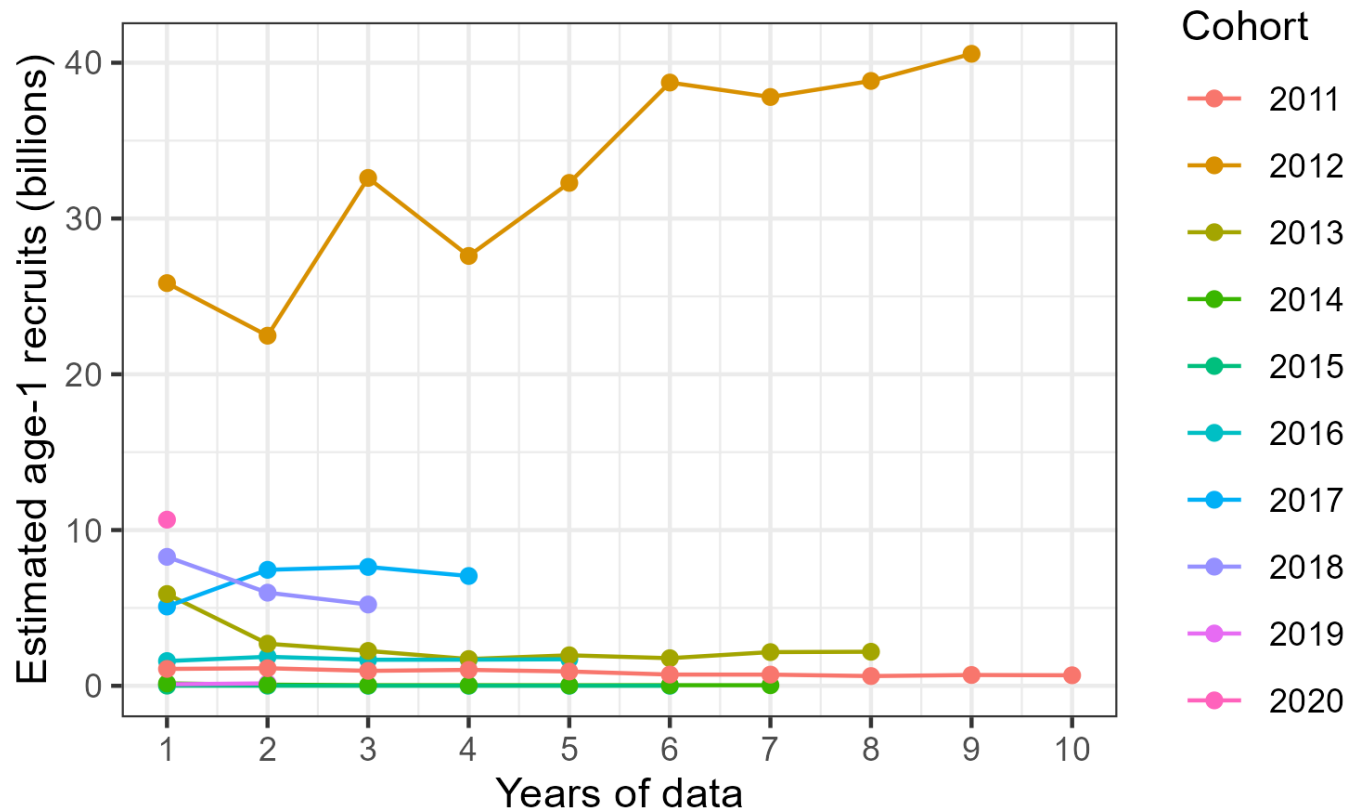
Unusual spawning WAA

- Differences are actually in length, not age
- Nothing apparent in survey design, execution, or data processing to explain this (it appears real)
- Is 2020 the anomaly?



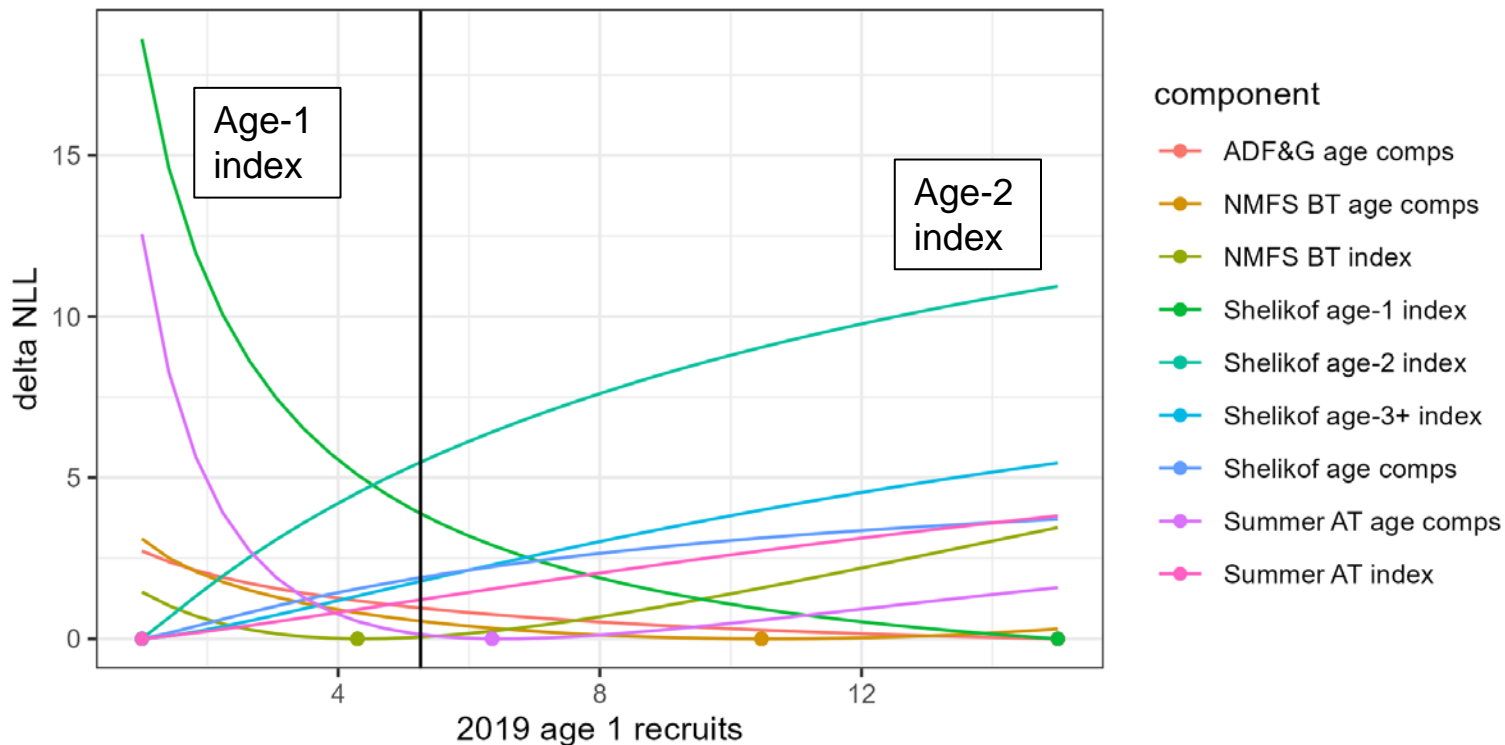
Size of the 2018 cohort

- Huge decrease in winter survey from 2019 to 2020
- But, not an abnormal change in estimated size as more data are added



Size of the 2018 cohort

- Why not? Because there is conflict in the data
- Can profile over 2019 recruit size (**warning: huge grain of salt**)
- Shelikof age-1 suggests >15 billion
- Shelikof age-2 and age-3+ suggest <1 billion
- Summer AT suggests ~6 billion

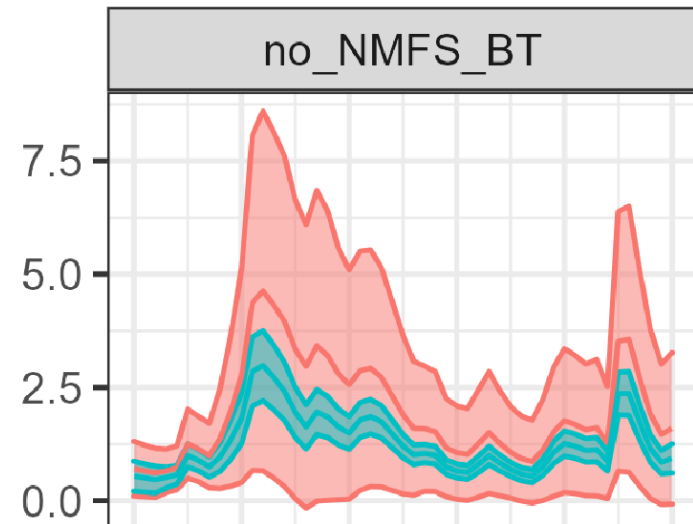
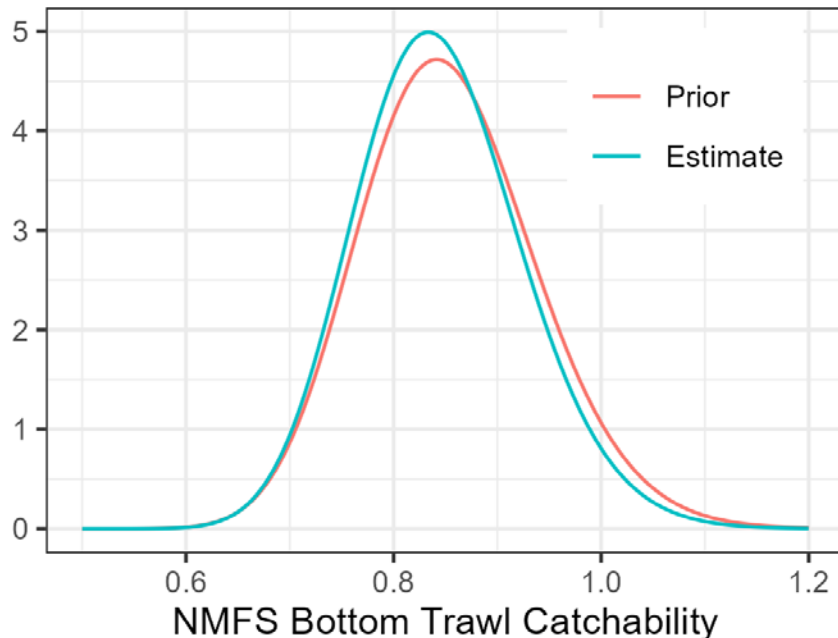


Size of the 2018 cohort

- Have 2020 fishery age data, but selectivity is low (and flexible) for age 2, so not extremely informative
- Same for 2020 ADF&G
- Next year will have new ages for 2021 fishery, NMFS BT survey, and summer AT survey
- Bottom line: it's not conclusive that the 2018 has disappeared.. we will see next year

Scale and the prior on catchability

- The prior drives the estimate of catchability
- This catchability drives the scale of the assessment
- **Suggestions on reforming the prior?**



PT/SSC proposed updates

- **Suggestions on how to prioritize these?**
- Constrained catchabilities (logistic) and priors
- Investigate trends in weight at age
- Shelikof survey timing effects on catchability, maturity, selectivity
- General investigation of scale
- Data weighting and input CVs
- Combining BT and AT to estimate vertical availability (long-term)
- New selectivity forms

Other ideas

- Revisit process errors
 - Estimate them w/ MCMC or Laplace approximation?
- Explore alternative modeling frameworks:
 - SS, WHAM, bespoke-TMB, CEATTLE single-species
- VAST indices and age expansions
- Split fishery into A and B seasons
- Revisit likelihood on age-1 and age-2 indices
- Update ageing error matrix using Punt et al. 20

Status Summary for Gulf of Alaska Pollock in W/C/WYK Areas

Quantity/Status	As estimated or specified <i>last</i> year for		As estimated or recommended <i>this</i> year for	
	2021	2022	2022	2023
<i>M</i> (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	3a	3b	3a	3b
Projected total (age 3+) biomass (t)	1,097,340	812,182	848,878	1,205,850
Female spawning biomass (t)	184,530	169,577	186,481	167,840
<i>B</i> _{100%}	443,000	443,000	430,000	430,000
<i>B</i> _{40%}	177,000	177,000	172,000	172,000
<i>B</i> _{35%}	155,000	155,000	150,000	150,000
<i>F</i> _{OFL}	0.33	0.30	0.31	0.29
<i>maxF</i> _{ABC}	0.28	0.26	0.26	0.26
<i>F</i> _{ABC}	0.28	0.26	0.26	0.26
OFL (t)	123,455	106,767	154,983	153,097
maxABC (t)	105,722	91,934	133,081	131,912
ABC (t)	105,722	91,934	133,081	131,912
Status	As determined <i>last</i> year for		As determined <i>this</i> year for	
	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Summer acoustic estimates

Year	Biomass (t)			
	Area 610	Area 620	Area 630	Area 640
2017	408,334	338,923	498,460	72,679
2019	119,502	201,711	207,058	43,204
2021	78,468	131,625	197,118	23,937

Year	Percent			
	Area 610	Area 620	Area 630	Area 640
2017	30.97%	25.71%	37.81%	5.51%
2019	20.91%	35.30%	36.23%	7.56%
2021	18.20%	30.53%	45.72%	5.55%

Bottom trawl estimates

Year	Biomass (t)			
	Area 610	Area 620	Area 630	Area 640
2017	214,605	23,658	43,803	6,878
2019	119,312	36,450	90,921	10,921
2021	252,827	113,737	108,813	19,367

Year	Percent			
	Area 610	Area 620	Area 630	Area 640
2017	74.27%	8.19%	15.16%	2.38%
2019	46.32%	14.15%	35.29%	4.24%
2021	51.10%	22.99%	21.99%	3.91%

Options for allocation

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

Area 610	Area 620	Area 630	Area 640
346,535	260,050	337,421	51,575
34.81%	26.12%	33.89%	5.18%

Summer apportionment: Weights of 1.0, 0.5, and 0.25 for 2021, 2019, and 2017, respectively

Winter apportionment (example calculations)

<i>Survey</i>	<i>Year</i>	<i>Model estimates</i>		<i>Percent by management area</i>			
		<i>of total 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	2018	827,716	1,306,107	157.8%	0.0%	93.9%	6.1%
Shelikof	2019	701,356	1,219,160	173.8%	0.0%	97.1%	2.9%
Shelikof	2020	622,300	456,457	73.3%	0.0%	97.7%	2.3%
Shelikof	2021	757,993	526,974	69.5%	0.0%	96.6%	3.4%
Shelikof	Average			118.6%	0.0%	96.3%	3.7%
	Percent of total biomass				0.0%	114.3%	4.4%

Winter apportionment (summary)

<i>Survey</i>	<i>Year</i>	<i>Percent</i>	<i>Percent by management area</i>		
			<i>Area 610</i>	<i>Area 620</i>	<i>Area 630</i>
Shelikof	Average	118.6%	0.0%	96.3%	3.7%
	Percent of total biomass	0.0%	0.0%	114.3%	4.4%
Chirikof	Average	2.2%	0.0%	33.3%	66.7%
	Percent of total biomass	0.0%	0.0%	0.7%	1.4%
Marmot	Average	1.1%	0.0%	0.0%	100.0%
	Percent of total biomass	0.0%	0.0%	0.0%	1.1%
Shumagin	Average	1.5%	80.9%	19.1%	0.0%
	Percent of total biomass	0.0%	1.2%	0.3%	0.0%
Sanak	Average	0.4%	100.0%	0.0%	0.0%
	Percent of total biomass	0.0%	0.4%	0.0%	0.0%
Mozhovoi	Average	0.0%	0.0%	0.4%	100.0%
	Percent of total biomass	0.0%	0.0%	0.0%	0.4%
Pavlof	Average	0.0%	0.0%	0.3%	100.0%
	Percent of total biomass	0.0%	0.0%	0.0%	0.3%
Total		124.5%	2.3%	115.3%	6.9%
Rescaled total		100.0%	1.8%	92.6%	5.6%

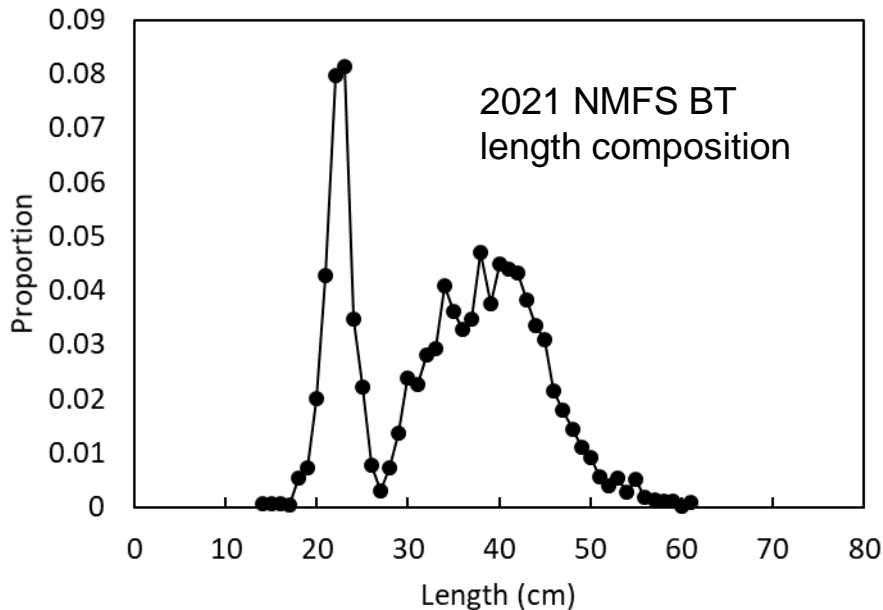
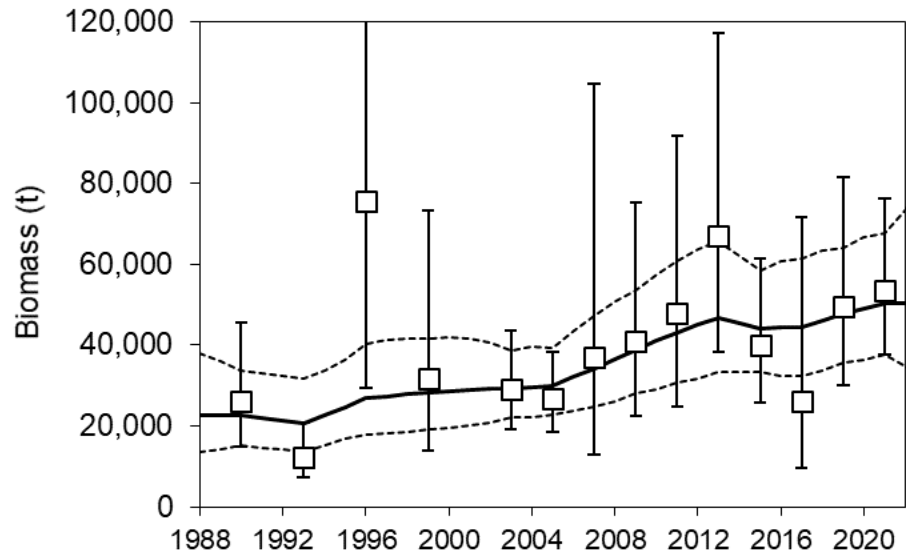
Final 2022 apportionment if TAC=133,081 t

Area	TAC (t)		Percent	
	Season A	Season B	Season A	Season B
610	1,138	22,582	0.9%	17.4%
620	52,313	16,946	40.3%	13.1%
630	8,065	21,988	6.2%	16.9%
640	6,722		5.2%	

Differences (2022-2021)

Area	TAC (t)		Percent	
	Season A	Season B	Season A	Season B
610	338	4,905	0.1%	0.3%
620	10,576	3,813	-0.2%	0.3%
630	1,768	3,965	0.1%	-0.5%
640	1,310		-0.1%	

Southeast Alaska Assessment



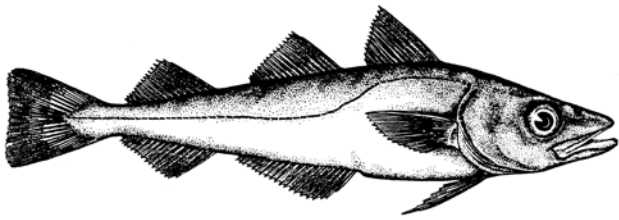
- Tier 5 model used for East Yakutat and SE.
- RE model fitted to biomass estimates from NMFS BT.
- $M=0.3$ assumed.
- $ABC=11,363$ t for 2022 and 2023

Status Summary for Pollock in the Southeast Outside Area

Quantity	As estimated or <i>specified last year for:</i>		As estimated or <i>recommended this year for:</i>	
	2021	2022	2022	2023
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	5	5	5	5
Biomass (t)	45,103	45,103	50,500	50,500
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)	13,531	13,531	15,150	15,150
maxABC (t)	10,148	10,148	11,363	11,363
ABC (t)	10,148	10,148	11,363	11,363
Status	As determined <i>last year for:</i>		As determined <i>this year for:</i>	
	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a

Questions/comments?

- **Thanks!**
- **Coauthors:**
Alison Deary, Bridget Ferriss, Benjamin Fissel, Taina Honkalehto, Darin Jones, Mike Levine, Lauren Rogers, Kalei Shotwell
- **Thanks to Kally Springer and Wayne Palsson for providing data**



Gulf of Alaska pollock

Overview of results

Changes to the assessment model

- None in 2020 or 2021 (model 19.1)

Author's 2022 ABC 133,081 t

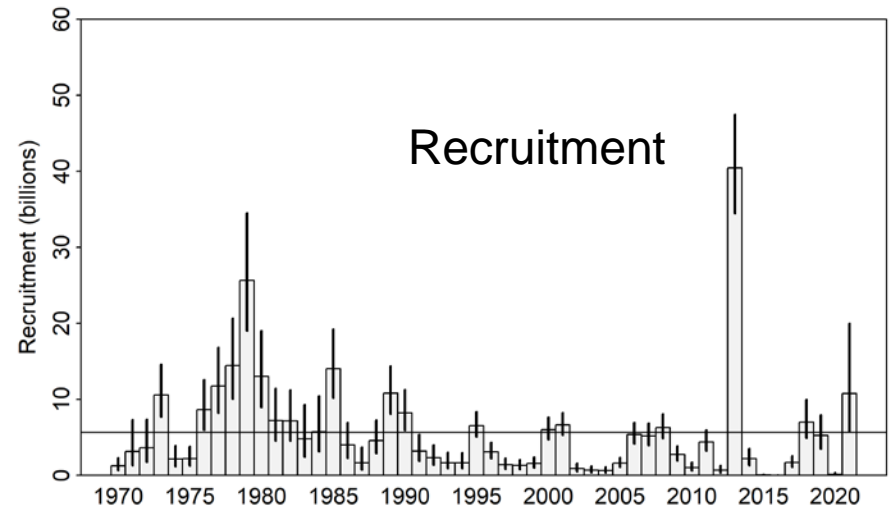
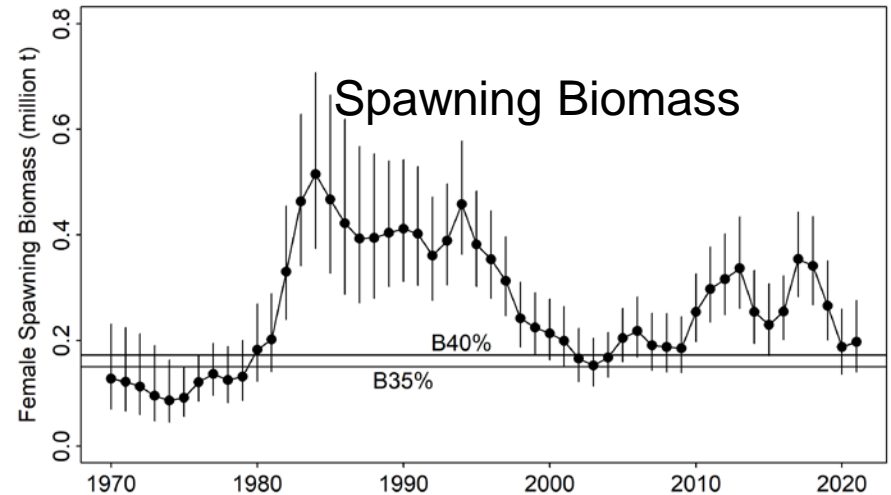
- Increase of 26% from 2021
- 2023 ABC decreases to 131,912 t

Concerns:

- Conflict in size of 2018 year class
- Unusual increase in spawning WAA after long decline
- Absolute stock scale driven by NMFS BT Q prior

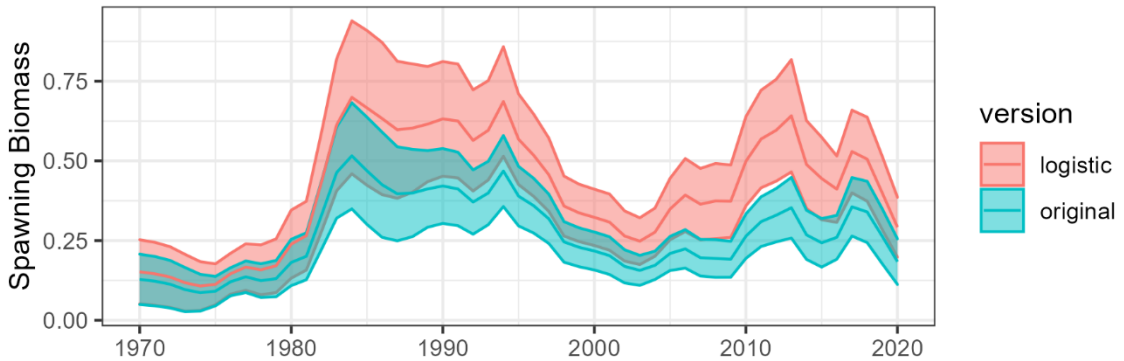
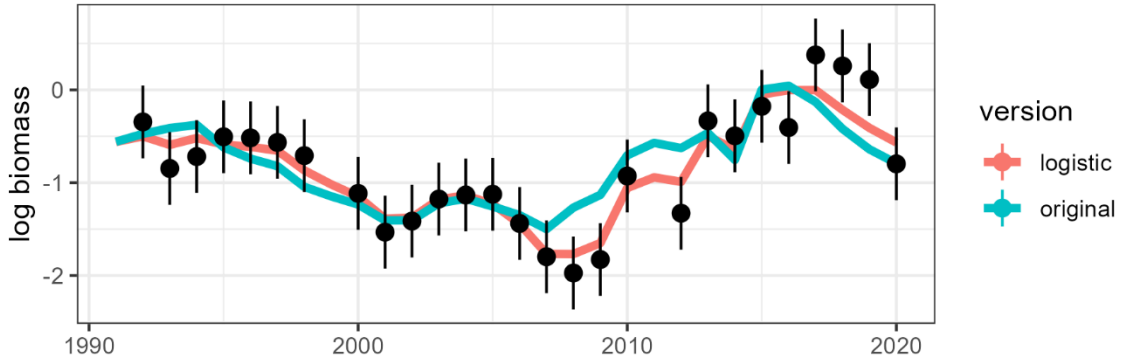
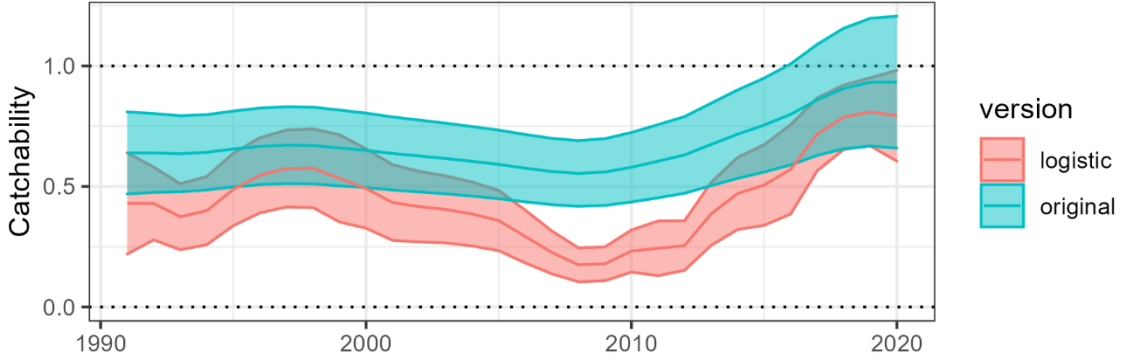
Positives:

- Return to normal age diversity w/ decline in 2012 cohort
- Large 2020 cohort
- Environmental conditions favorable

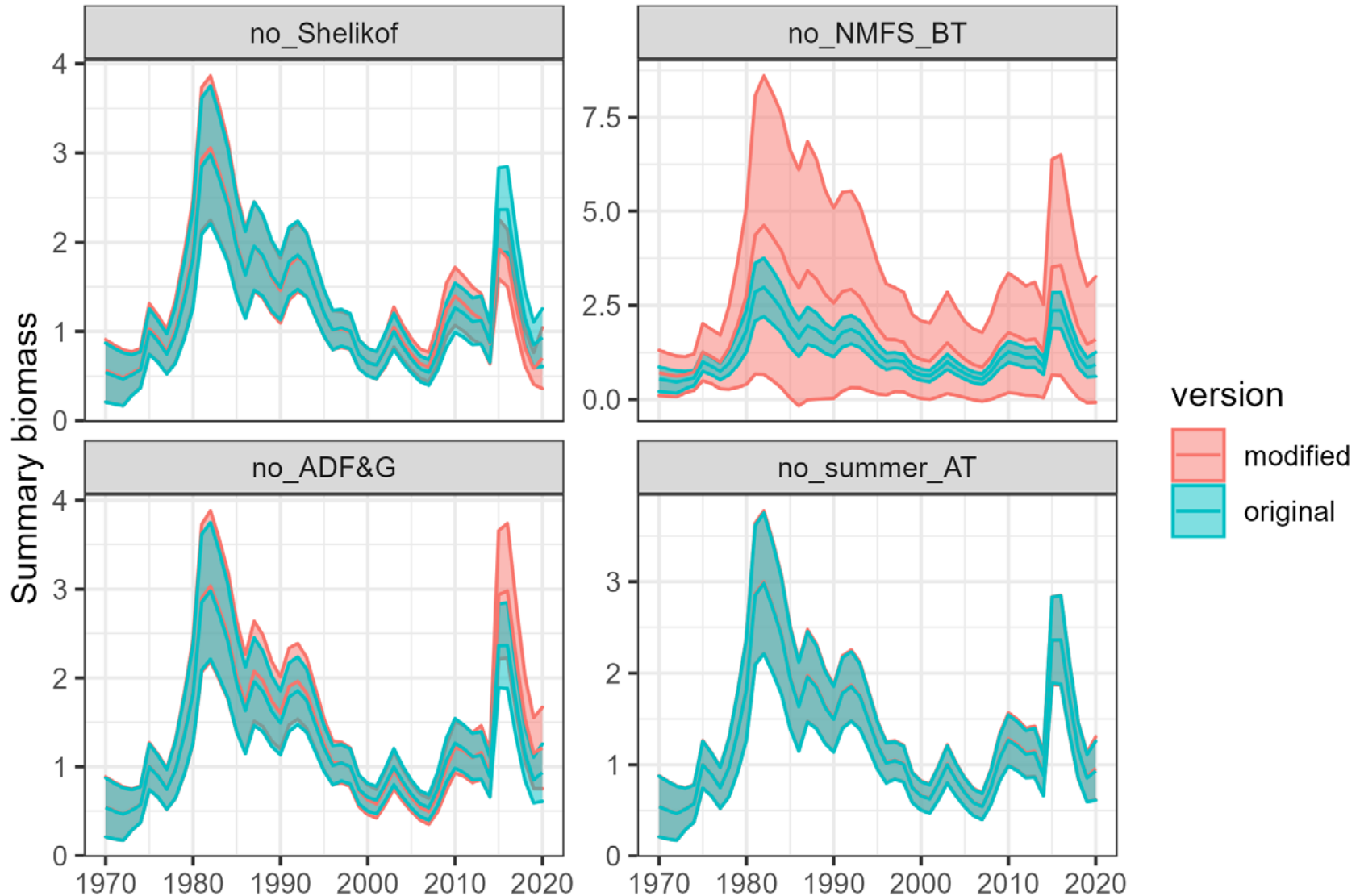


Extras

Constraining Shelikof catchability



Effect of dropping single surveys



Investigating population scale

- NMFS BT catchability driven entirely by prior

