Assessment of the Arrowtooth Flounder Stock in the Gulf of Alaska

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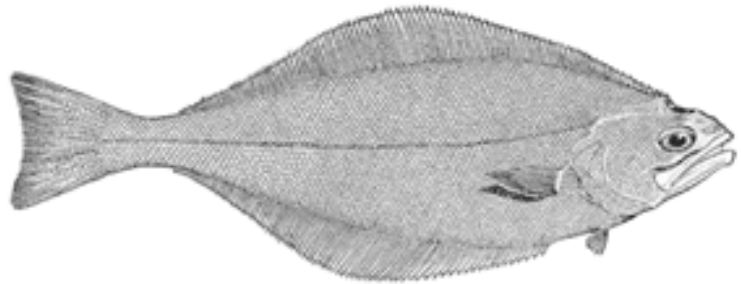
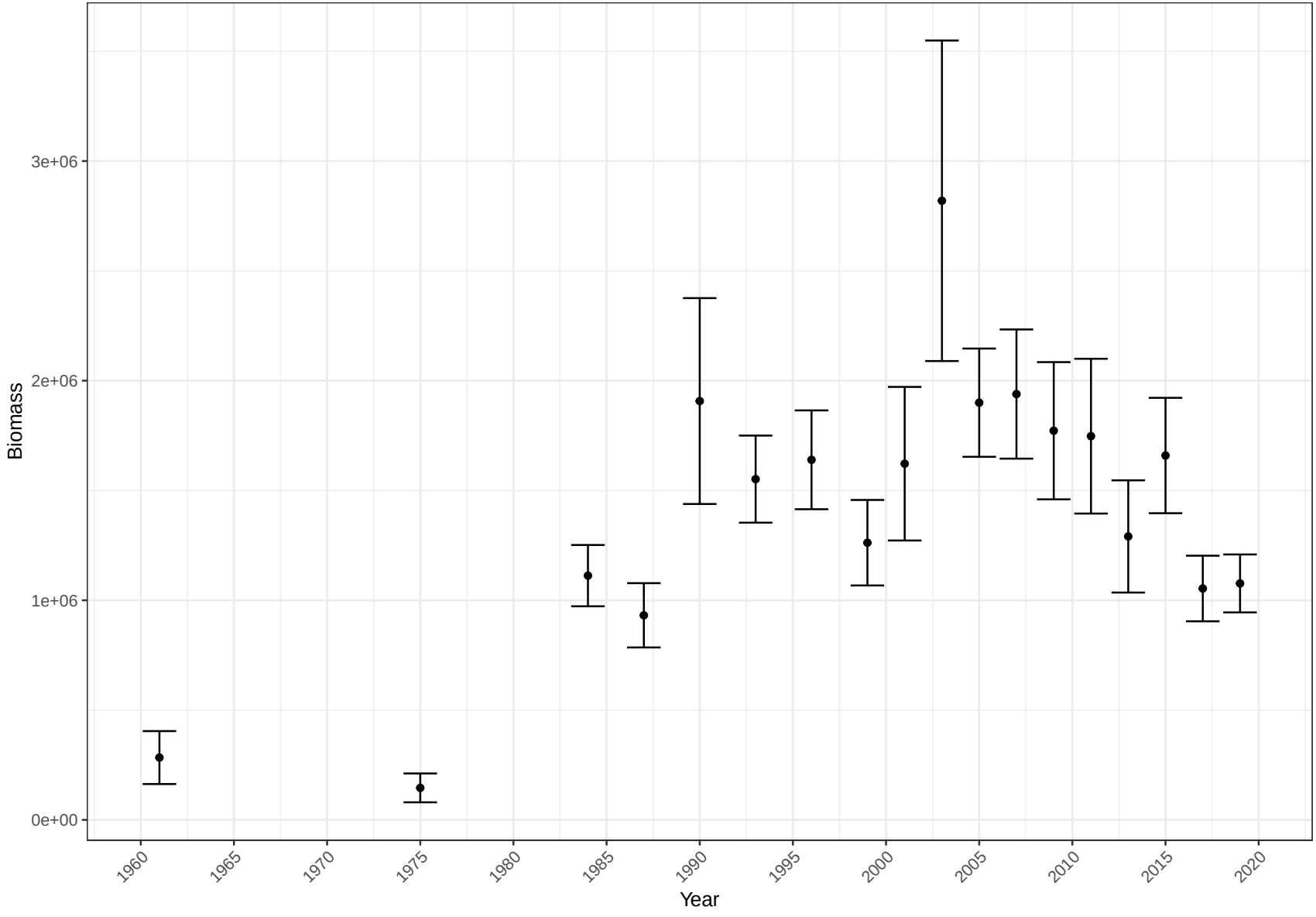
11/13/2019



Plan Team and SSC Comments

- Document survey design and spatial distribution in 1961 and 1975 to evaluate the comparability of these early surveys to recent surveys.
- Evaluate the cooperative US-Japan longline surveys, for stock trends from 1979 – 1992.
- Look at ADF&G bottom trawl surveys in the central and western Gulf of Alaska to see if any of them span the years in question.

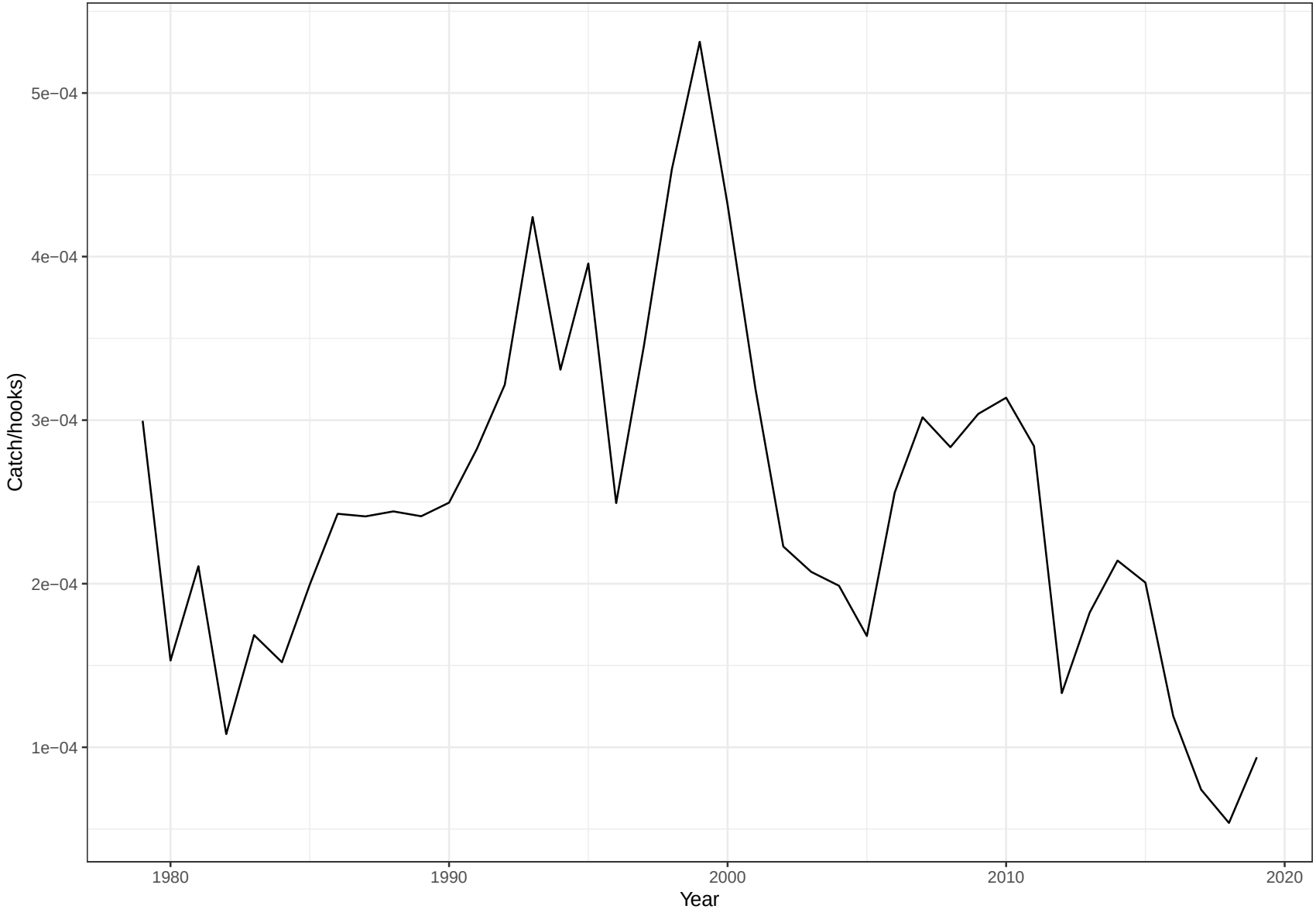
Two early nonstandard surveys, 1961-1962 (IPHC trawl survey) and 1973-1976 (NMFS exploratory trawl).



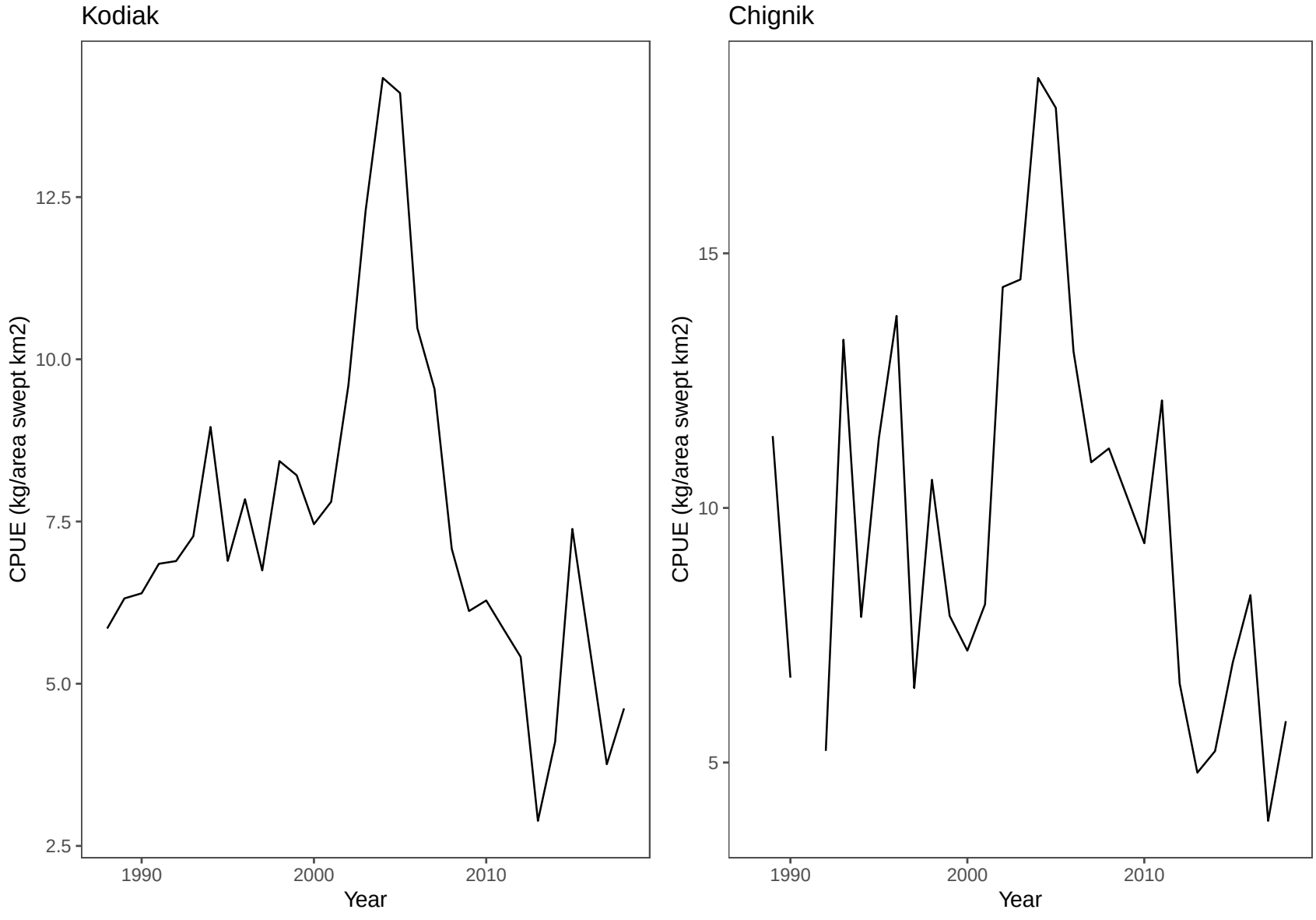
Early survey spatial distribution and methodology

- Biomass estimates from 1960's and 1970's surveys analyzed using the same strata, methods as current surveys.
- Selectivity of the different surveys assumed equal.
- Data from the 1961 and 1962 IPHC surveys combined for total coverage of the GOA.
- NMFS surveys in 1973 to 1976 were combined to provide total coverage of the GOA.
- Sample sizes lower in 1970's surveys (403 hauls); some strata had less than 3 hauls.
- IPHC and NMFS 1970's surveys used a 400 mesh Eastern trawl, current surveys use a nor' eastern trawl.
- The trawl used in the early surveys had no bobbin or roller gear, more in contact with bottom than current gear.
- Early survey net ~ 1.61 more efficient at catching Arrowtooth Flounder, estimates lowered by dividing by 1.61.

US-Japan longline surveys since 1979 indicate higher catch relative to the 1961-1962 and 1973-1976 surveys.



ADF&G surveys since 1988 CPUE reflects low biomass in 1990s followed by a peak in the early 2000s.



One new model is introduced in this assessment.

- Model 17.0e: The model used for the 2017 assessment.
- Model 17.1a. Model 17.0e with data from 1961 through 2019.
- Model 19.0: Same as Model 17.1a omitting 1961 and 1975 surveys and starts at 1977.

The following data sources (and years of availability) were used in the preferred model:

Data source	Year
Fishery catch	1977 - 2019
NMFS trawl survey biomass and S.E.	1984,1987,1990,1993,1996,1999,2001,2003, 2005,2007,2009,2011,2013,2015,2017,2019
Fishery size compositions	1977-1993,1995-2019
NMFS survey size compositions	1985,1986,1989,2019
NMFS trawl survey age composition data	1984,1987,1990,1993,1996,1999,2001, 2003,2005,2007,2009,2011,2013,2015,2017

Note: Fishery size composition data is available for all years from which NMFS trawl surveys occurred. For years in which age compositions were not available, length composition was used directly in the model.

Model parameterization

The model is split by sex with different natural mortality for males and females, 0.2 females and 0.35 males.

Selectivity

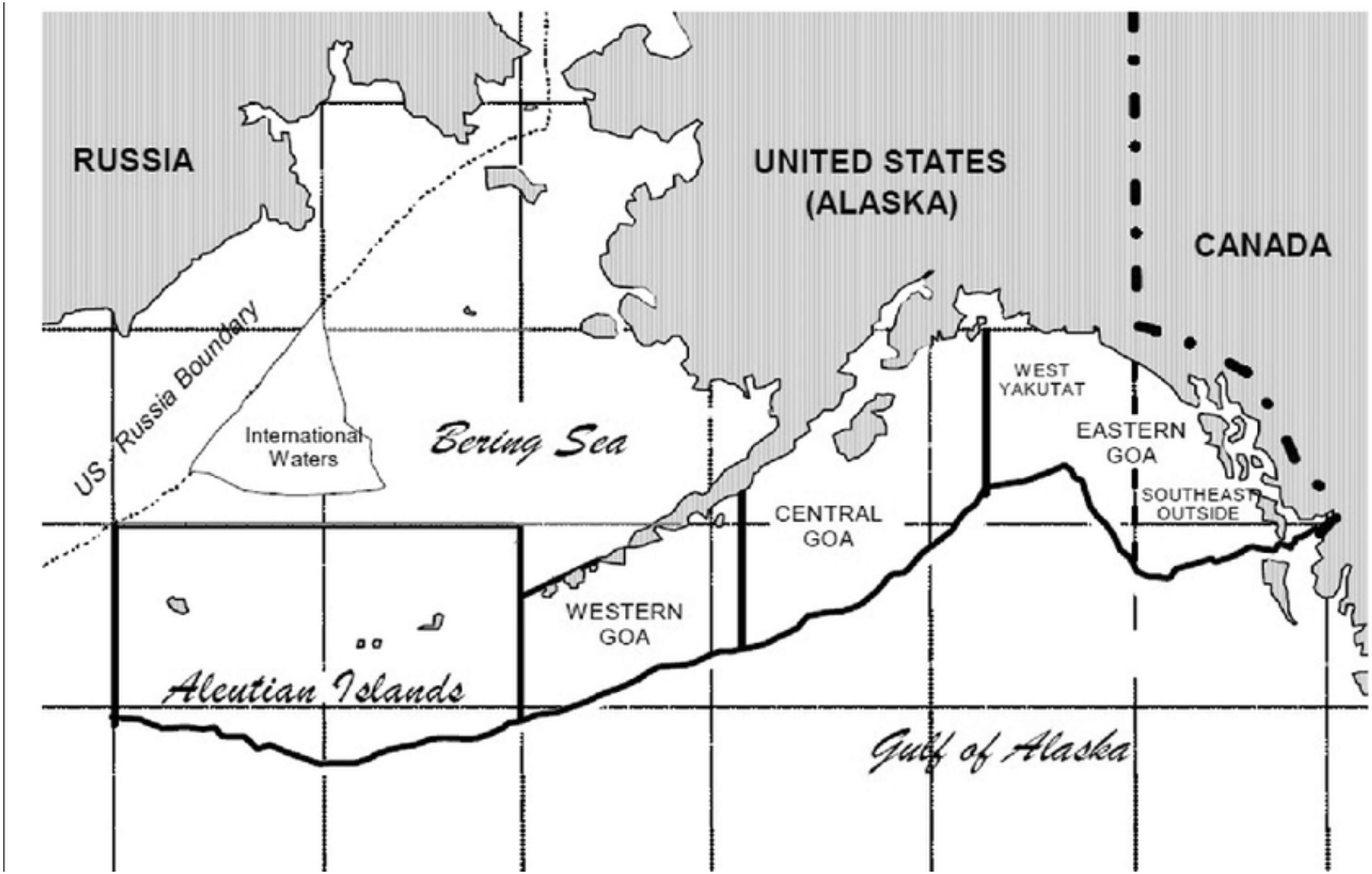
- Fishery selectivity was estimated non-parametrically for each age, by sex, up to age 19, and the shape of the selectivity curve was constrained to be a smooth function.
- Survey selectivity was estimated as a 2 parameter logistic function, separately for males and females.

Model parameterization

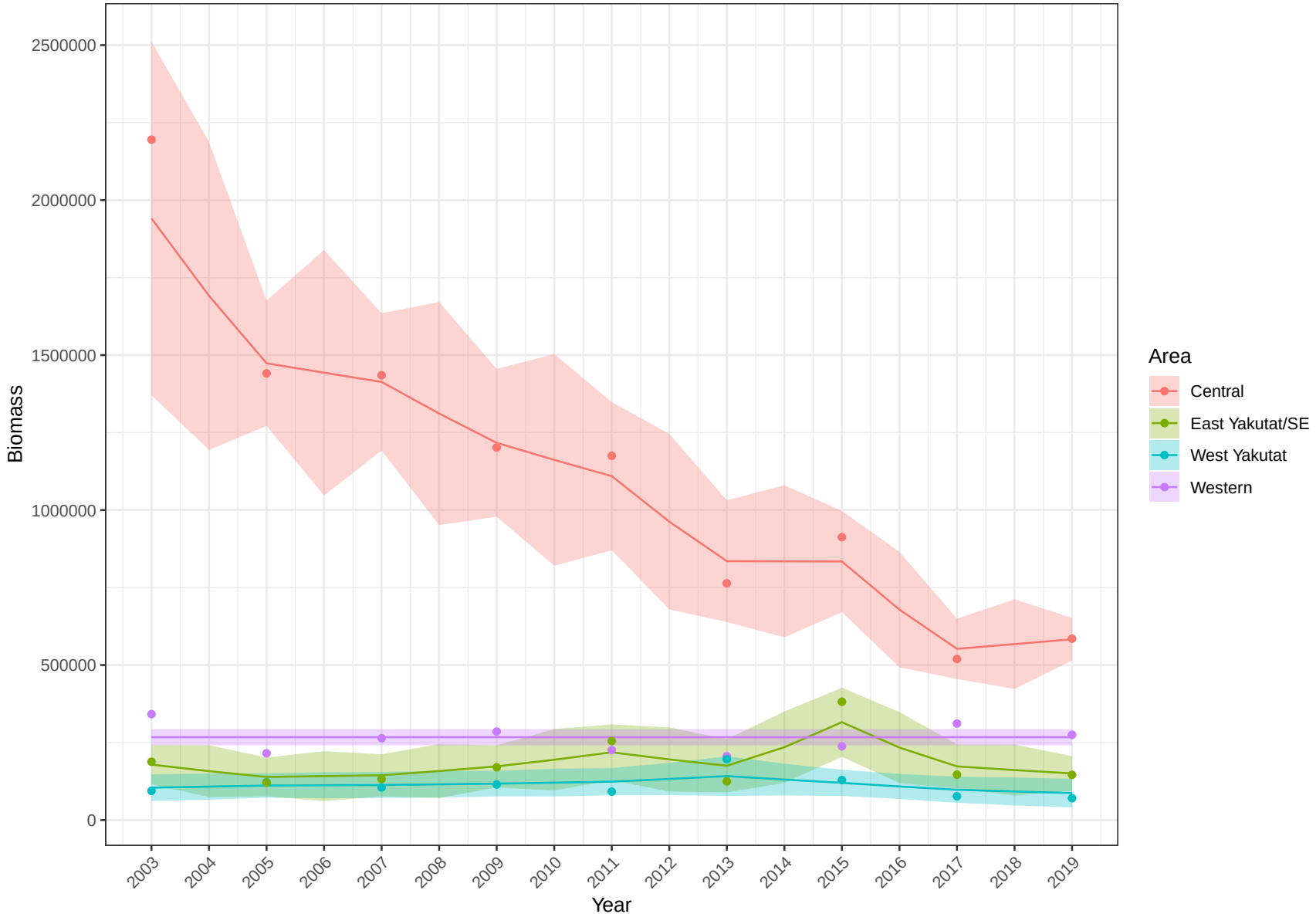
Maturity

- A maturity study by Stark (2008) has been used in the model since 2015.
- Parameter estimates were based on sample of 301 fish was taken in February 2002 from central GOA, because Arrowtooth Flounder spawn during winter months.
- The estimate of logistic 50% maturity was 7 years.

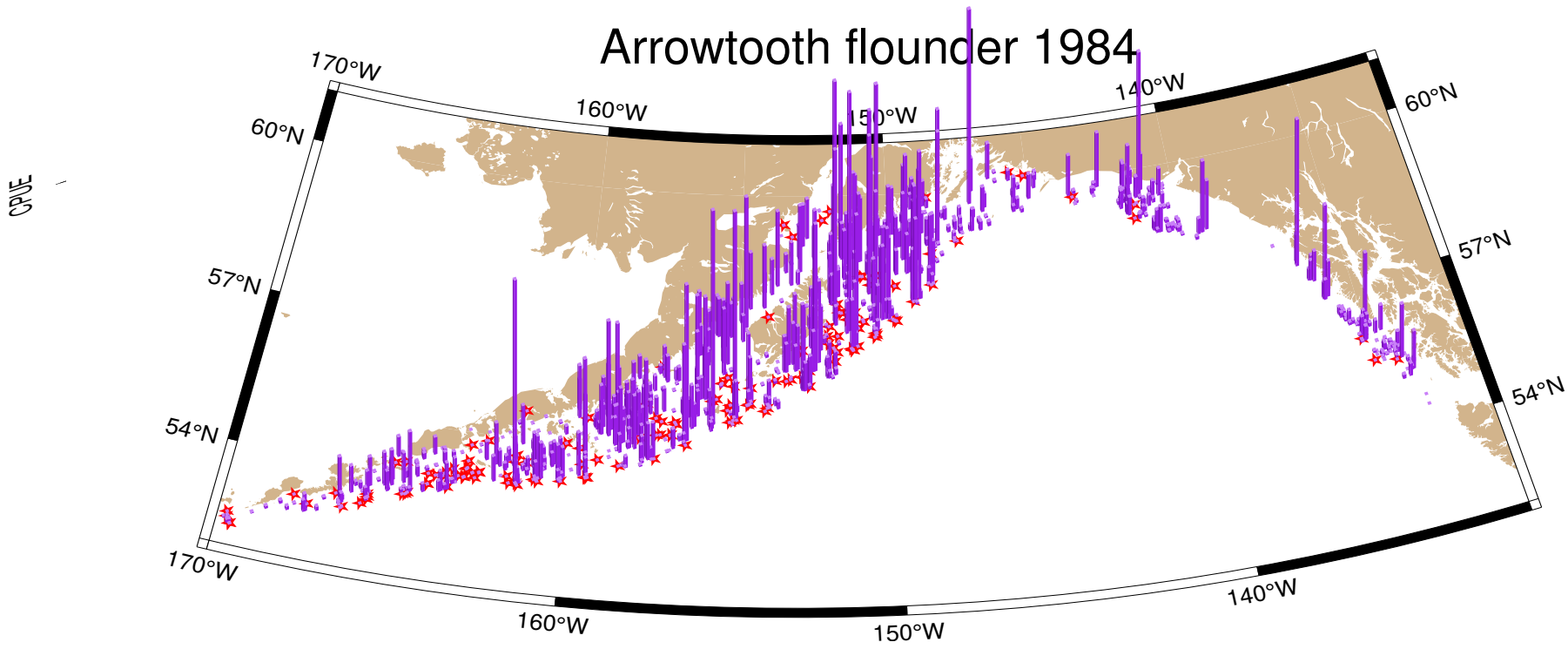
Apportionment in the GOA defined for Western, Central, West Yakutat & East Yakutat/SE



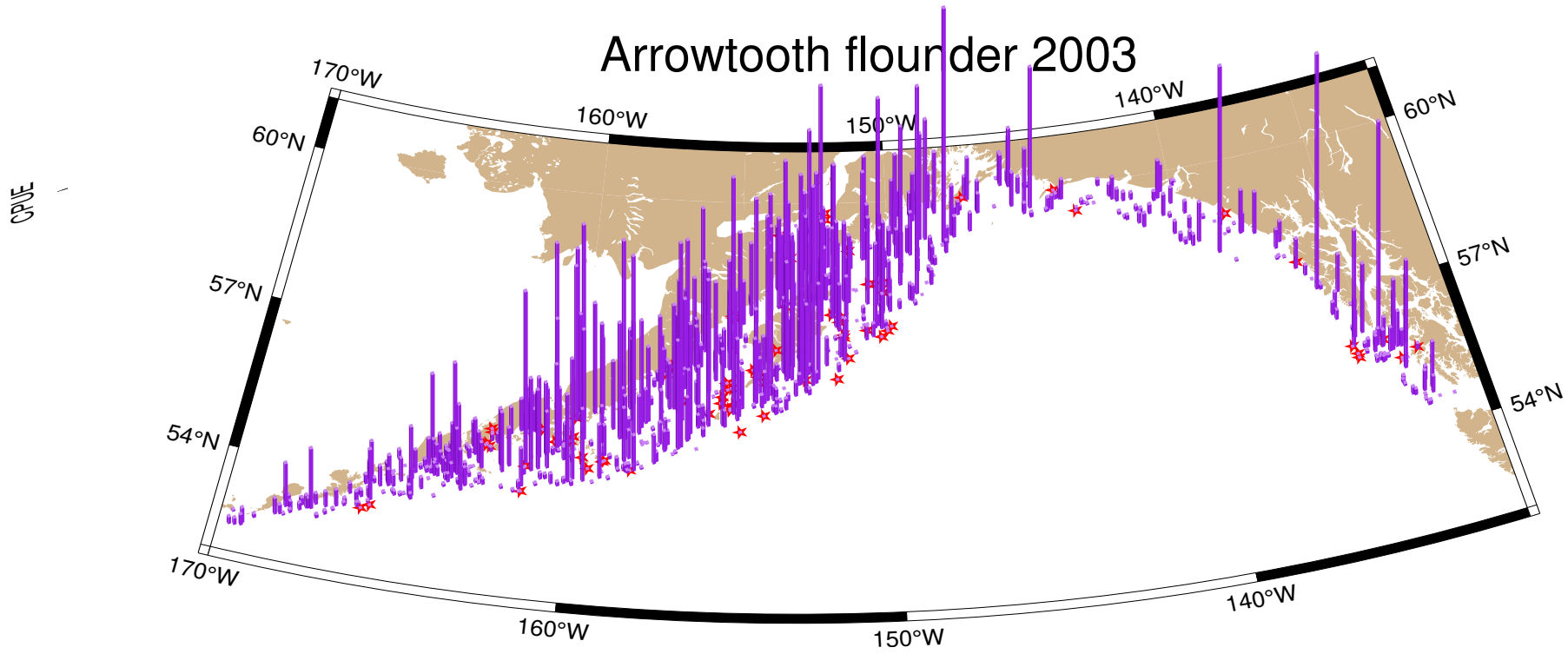
Central area (NMFS area 620 and 630) shows greatest decline in biomass of Arrowtooth Flounder



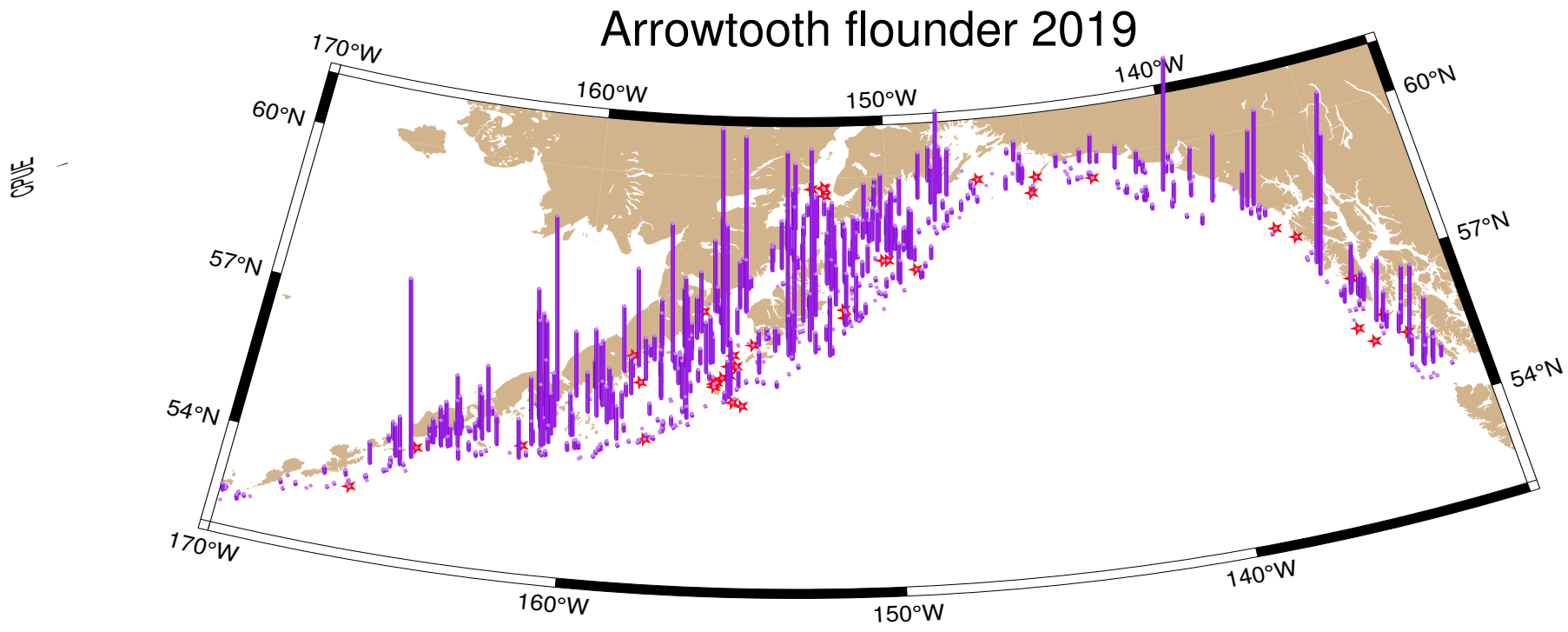
Distribution 1984



Distribution 2003



Distribution 2019



Likelihood components for Model 19.0 and 17.1a.

	Survey Biomass	Fishery Length	Survey Length	Survey Age	Recruitment	Fishery Selectivity
Model 17.1a	50.5932	808.392	105.1390	244.234	20.7069	1.42204
Model 19.0	28.4486	796.457	92.2046	250.048	4.9668	1.46121

	Survey selectivity	SDNR	N. Parameters	Total Likelihood	ADSB	Objective Function
Model 17.1a	5.5239	2.4509	193	1254.011	-	223.355
Model 19.0	5.5941	1.9397	161	1197.180	0.178	183.487

Calculating AIC from the hessian and objective function value (ADMB output)

- Transformed in the Hessian parameters were backtransformed into the original parameter space.
- Marginal likelihood was estimated (Thorson et al. 2014):

$$Likelihood_{mar} = -0.5 Hess_T - OFV$$

- AIC was calculated using this marginal likelihood.

Model 17.1a AIC = 1568.33

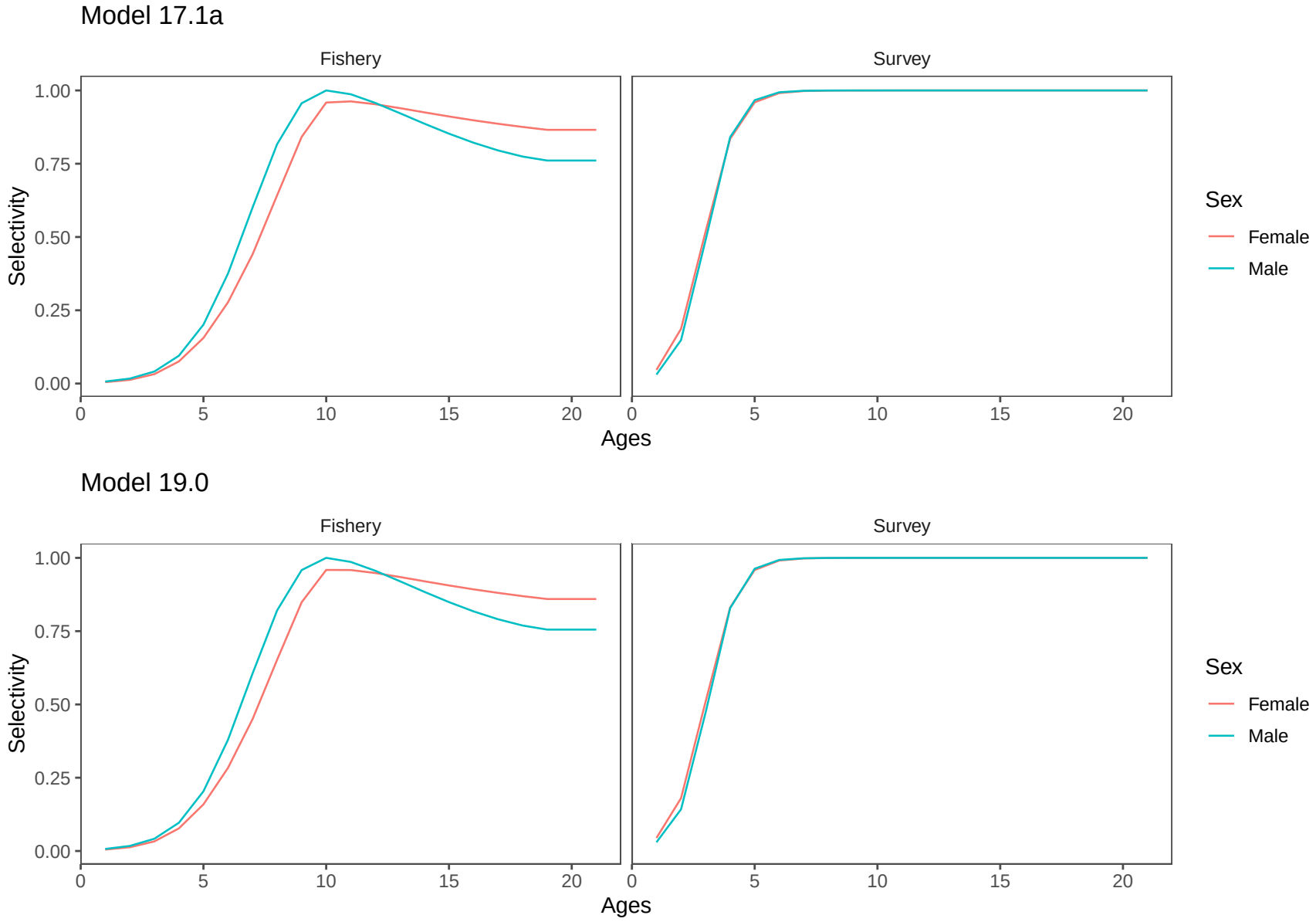
Model 19.0 AIC = 1258.94

Thorson, J., Hicks, A.C., and Methot, R. 2014. Random effect estimation of time-varying factors in Stock Synthesis. ICES Journal of Marine Science; doi: 10.1093/icesjms/fst211.

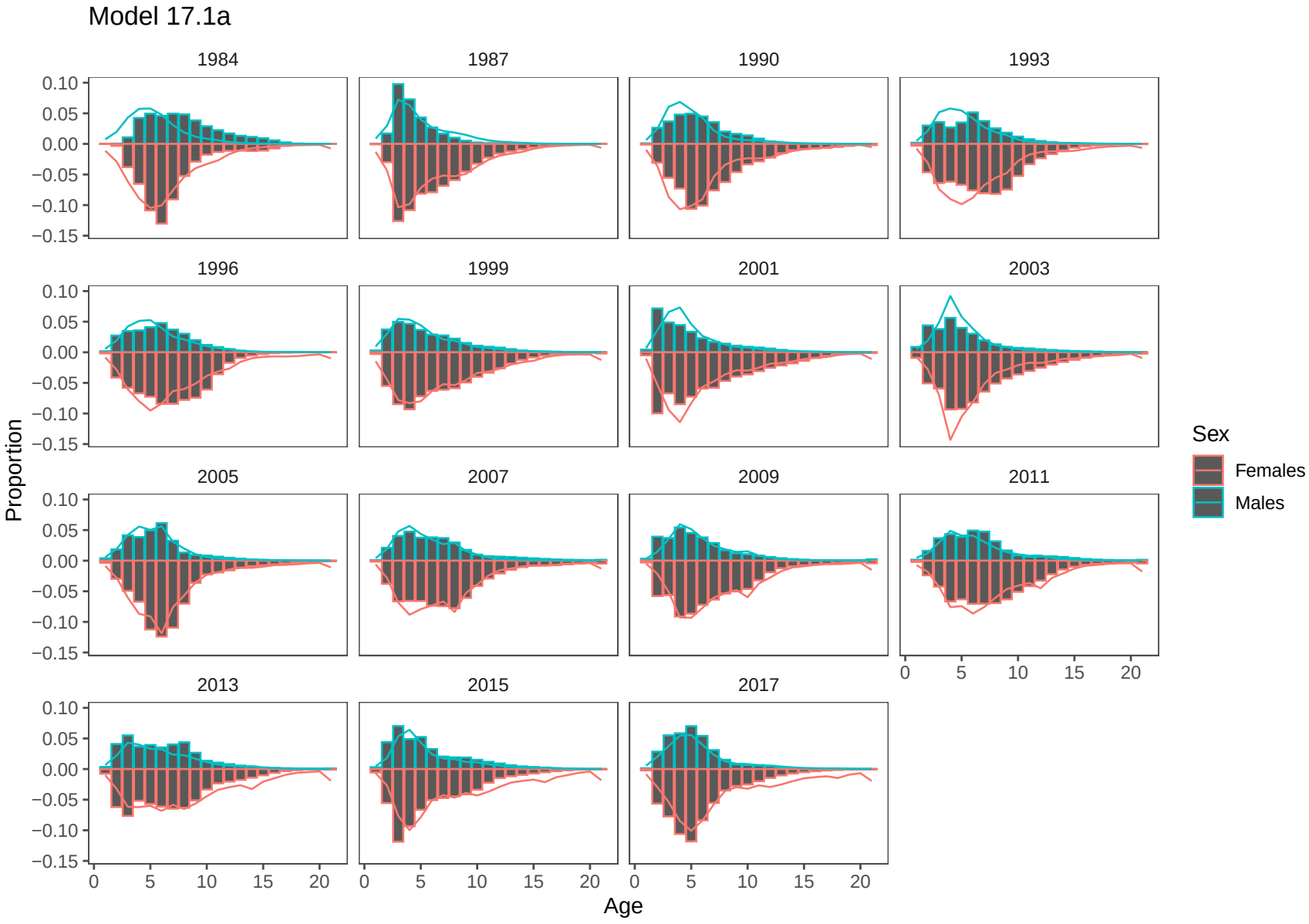
Comparison of results for Model 17.1a and Model 19.0.

Quantity	Model 17.1a *this* year for: 2020	2021	Model 19.0 *this* year for: 2020	2021
M (natural mortality rate)	0.35, 0.2	0.35, 0.2	0.35, 0.2	0.35, 0.2
Tier	3a	3a	3a	3a
Projected total (age 1+) biomass (t)	1,270,359 t	1,251,117 t	1,325,867 t	1,321,075 t
Projected female spawning biomass (t)	746,658 t	706,966 t	756,100 t	718,325 t
$B_{100\%}$	867,147 t	867,147 t	1,028,329 t	1,028,329 t
$B_{40\%}$	346,859 t	346,859	411,332 t	411,332 t
$B_{35\%}$	303,501 t	303,501	359,915 t	359,915 t
F_{OFL}	0.236	0.236	0.234	0.234
$maxF_{ABC}$	0.194	0.194	0.193	0.193
F_{ABC}	0.194	0.194	0.193	0.193
OFL	151,702 t	146,554 t	153,017 t	127,773 t
$maxABC$	126,872 t	122,568 t	128,060 t	124,357 t
ABC	126,872 t	122,568 t	128,060 t	124,357 t

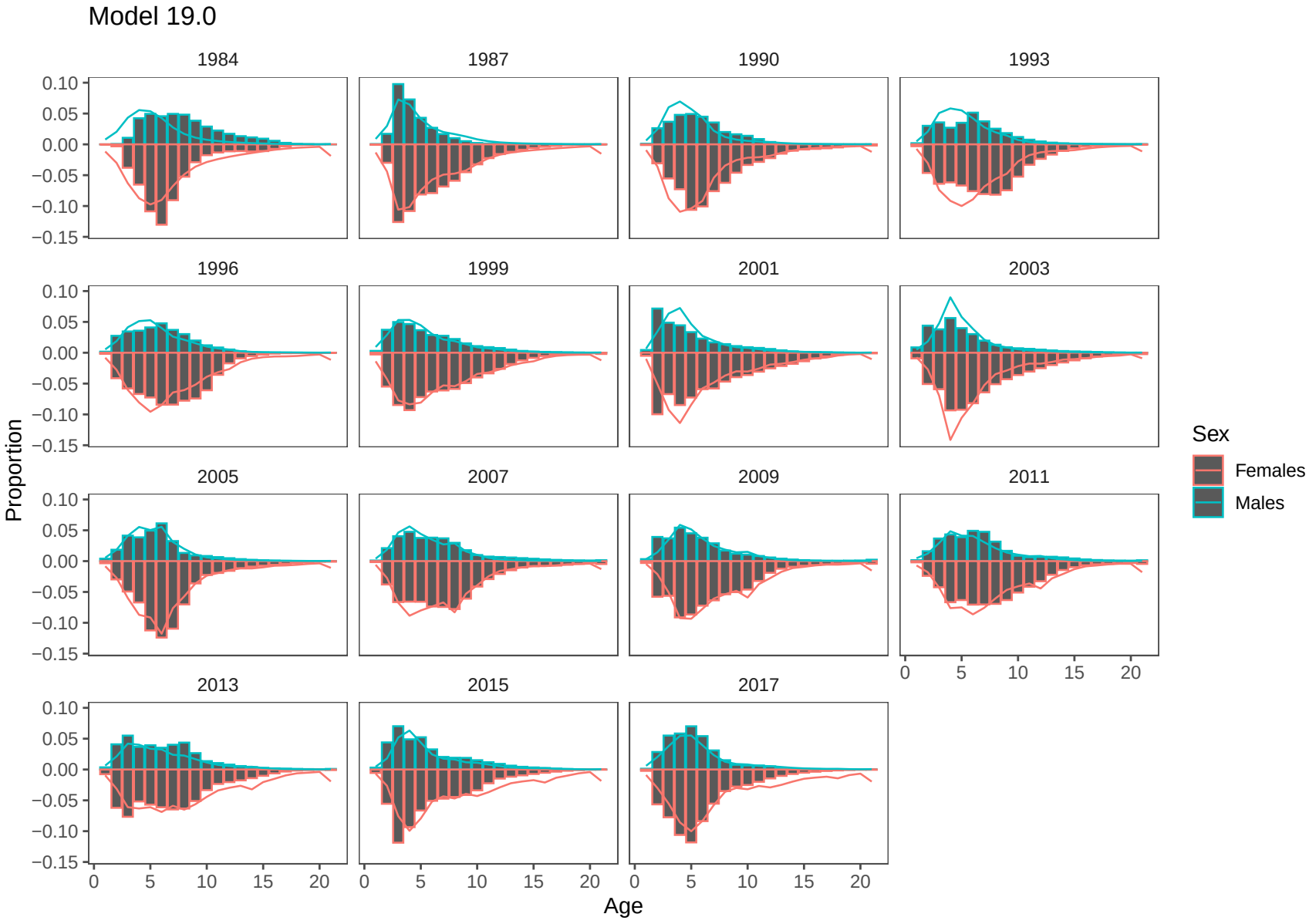
Selectivities for fishery and survey estimated by Model 17.1a and Model 19.0.



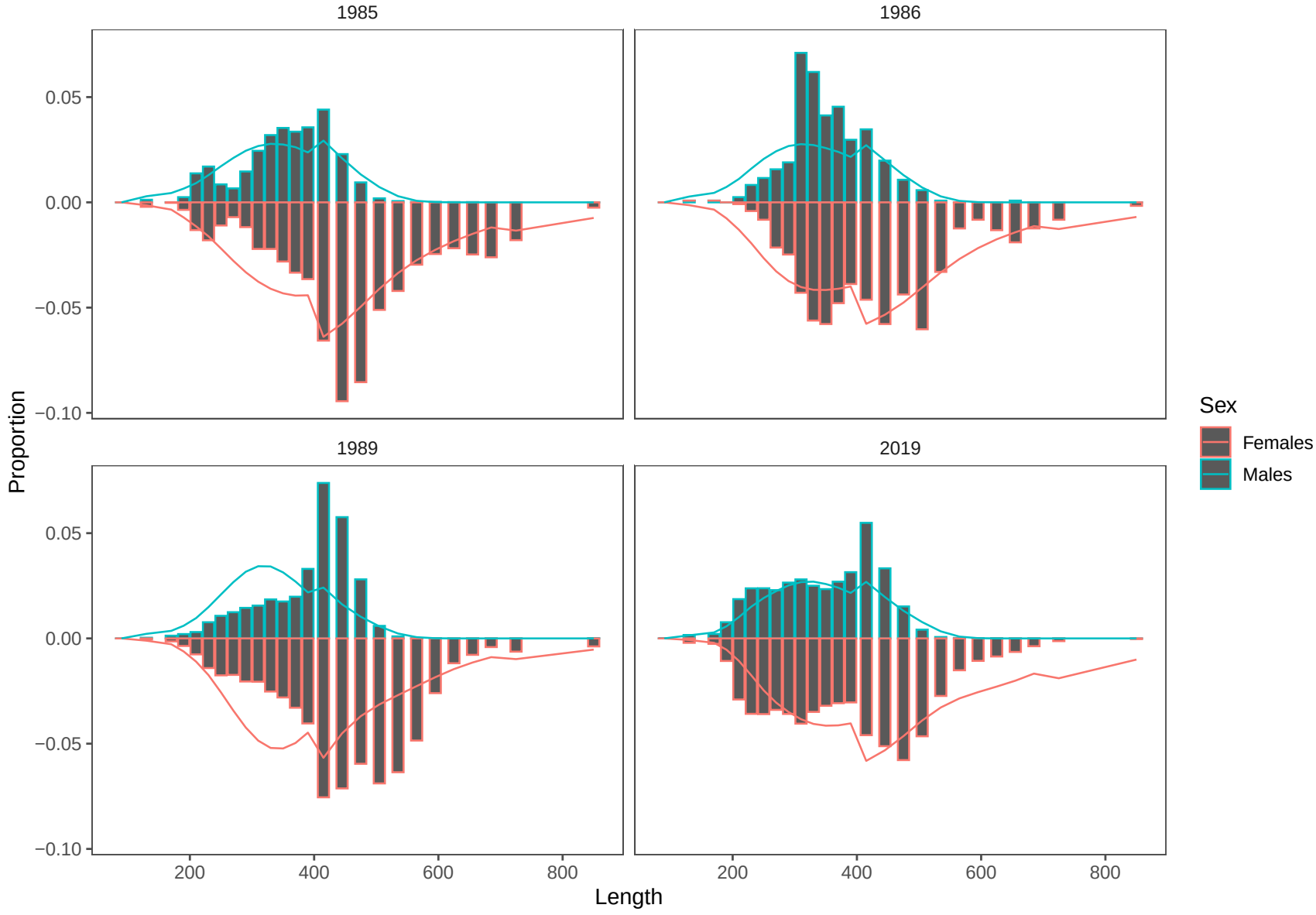
Survey age frequency fit to model, males above, females below, solid line is predicted, for Model 17.1a.



Survey age frequency fit to model, males above, females below, solid line is predicted, for Model 19.0.

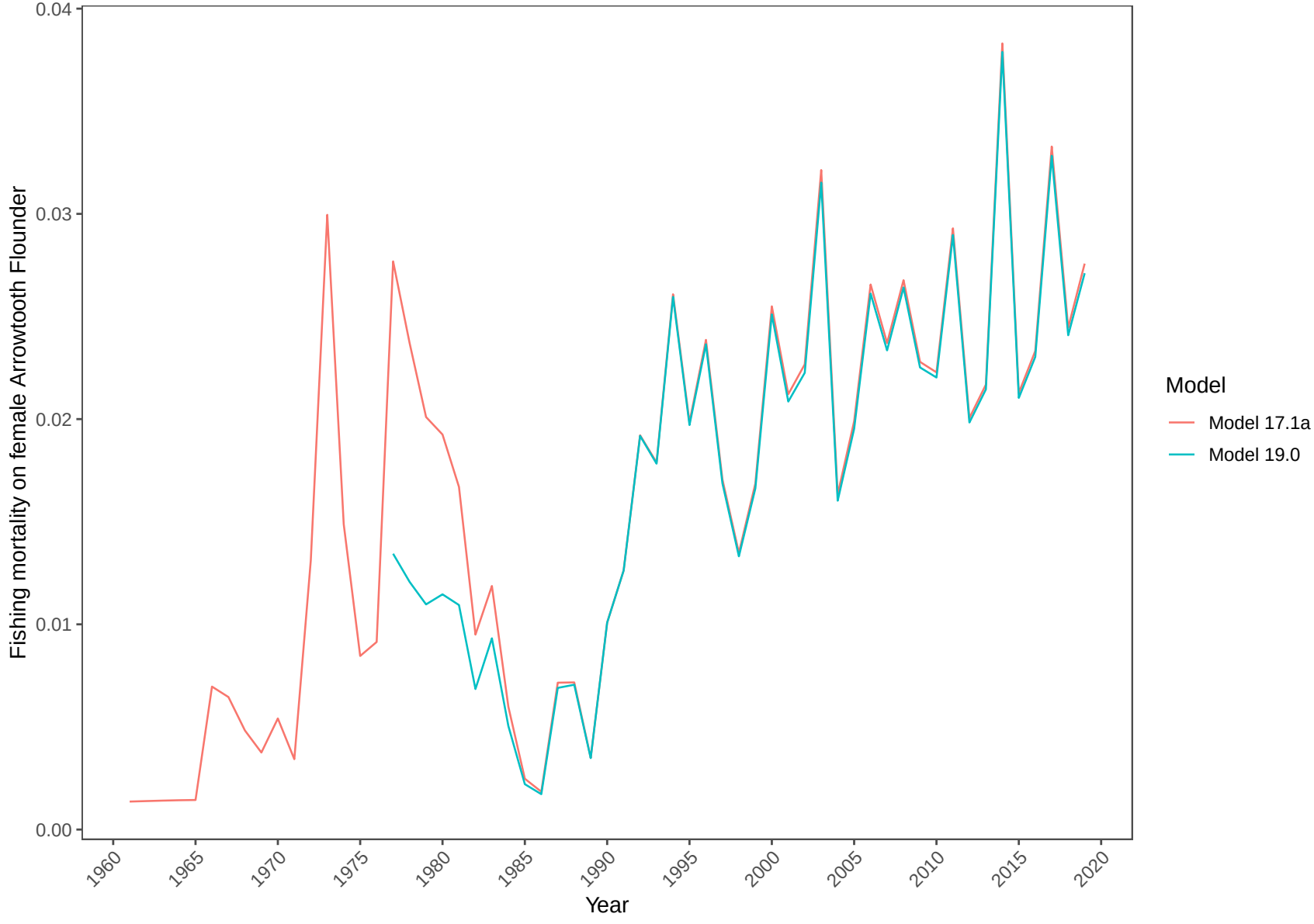


Survey length frequency fit to model 19.0, males above, females below

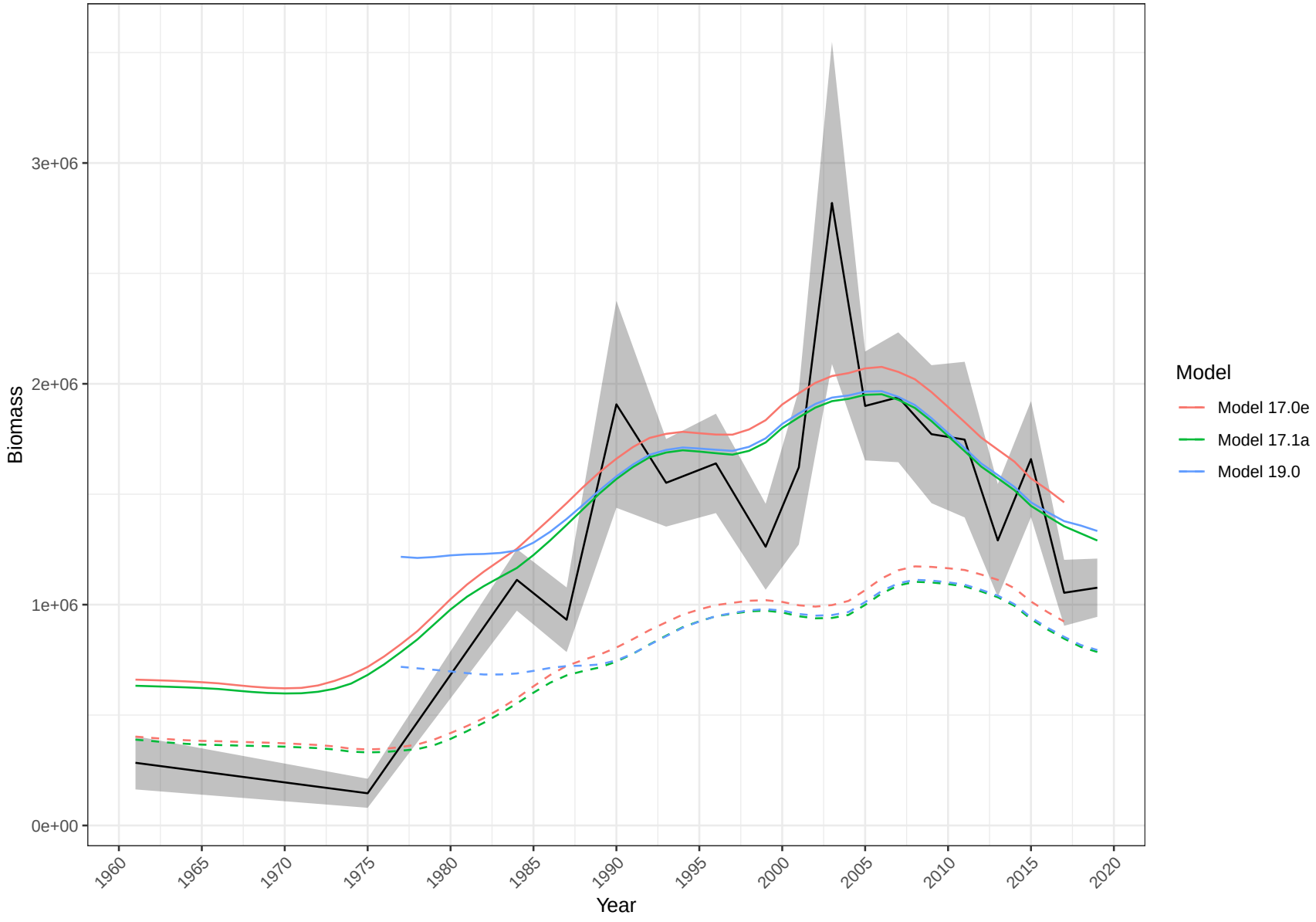


Fit to the male and female fishery length composition data for Model 19.0, solid line is predicted.

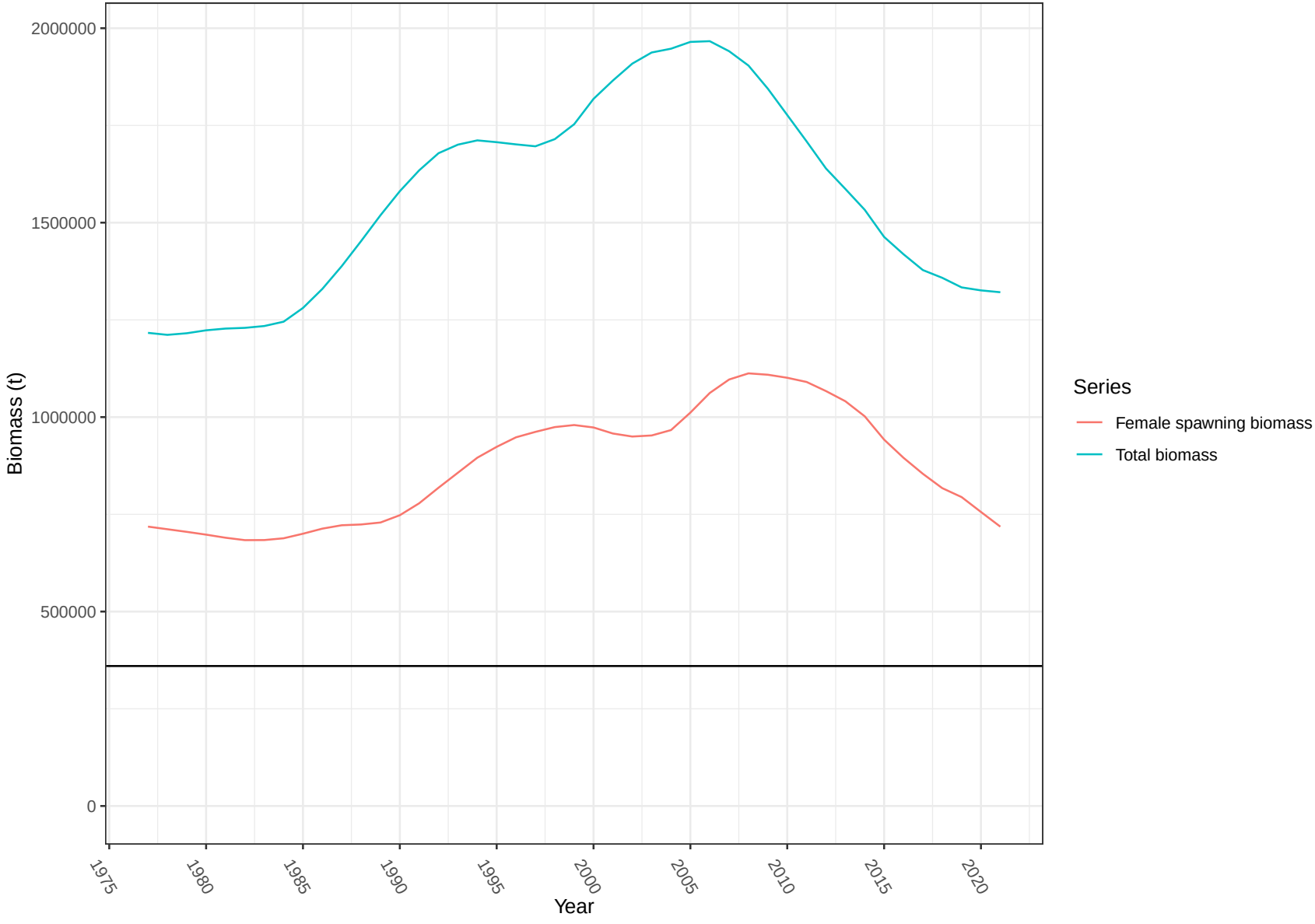
Natural mortality estimated by the Model 17.1a and 19.0, 1961-2019.



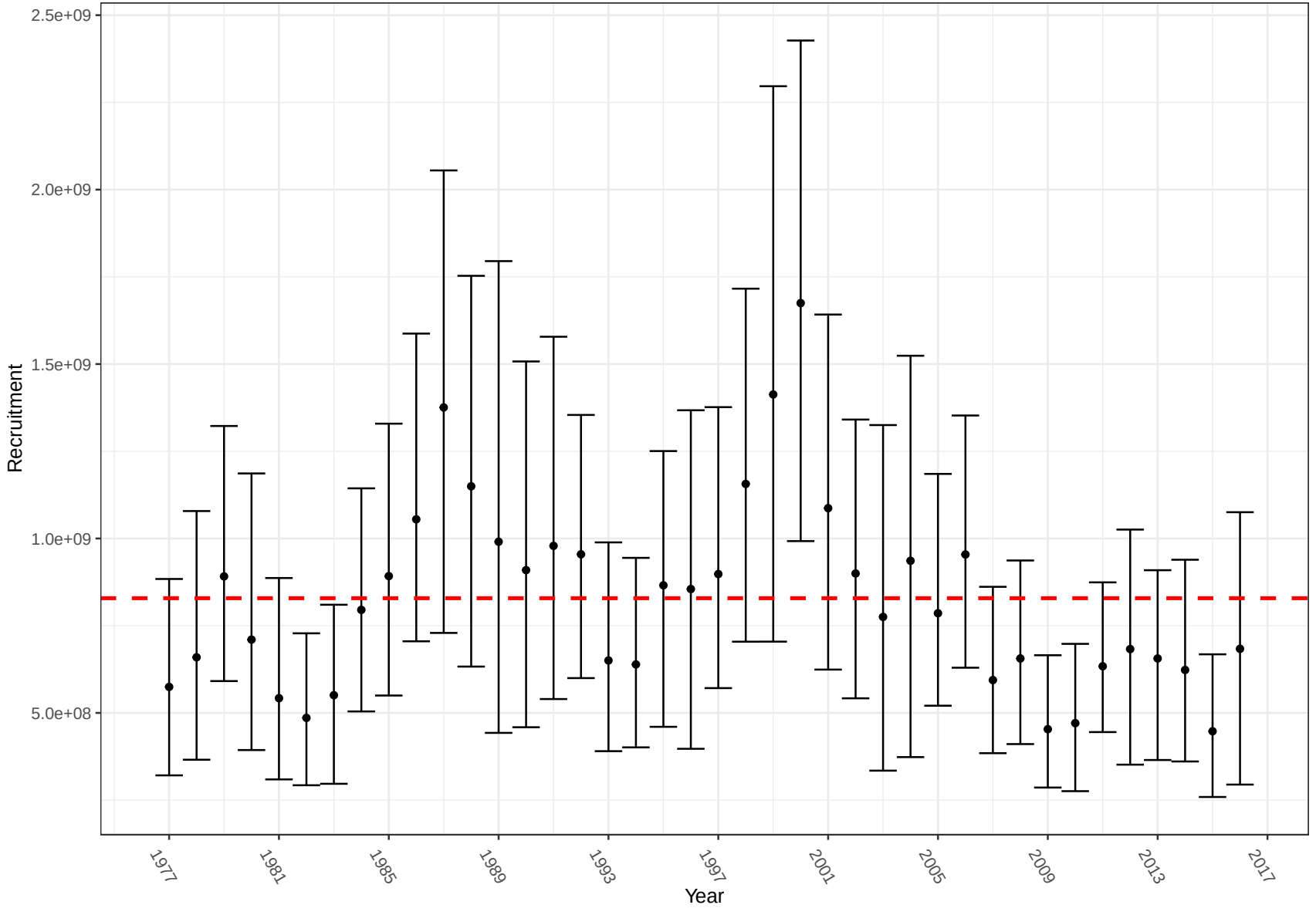
Predicted and observed survey biomass, 1961-2019 for Models 17.0e, 17.1a, and 19.0.



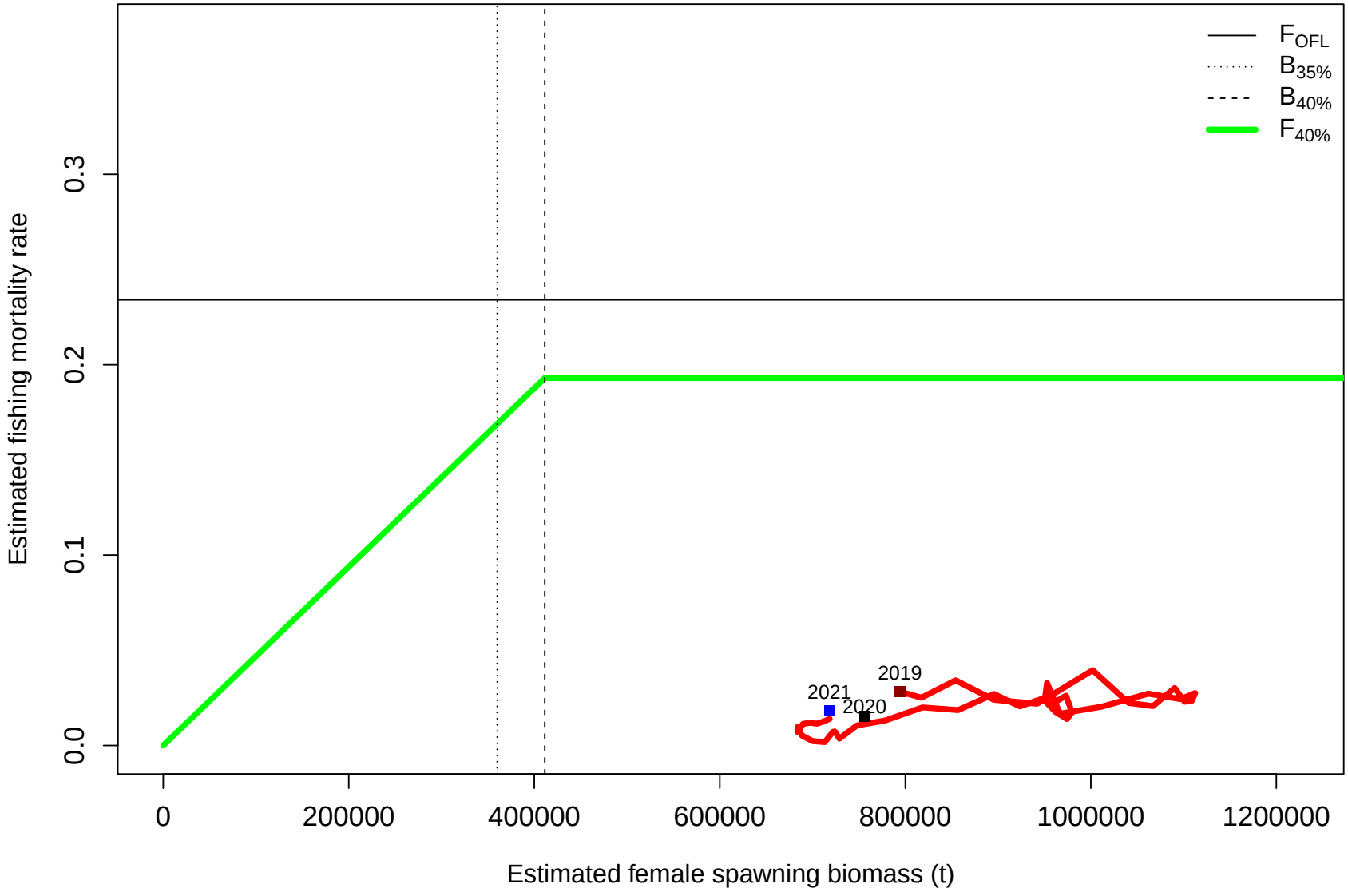
Predicted female spawning biomass, total biomass (age 1+) and B35% for Model 19.0, 1977-2021.



Age 1 estimated recruitment from 1977 to 2016, based on 1 million MCMC iterations, thinning every 100



Fishing mortality rate vs. female spawning biomass from 1977 to 2019 compared to the F35% and F40% control rules.



Mohn's rho measures the severity of retrospective patterns.

Relative bias is defined as

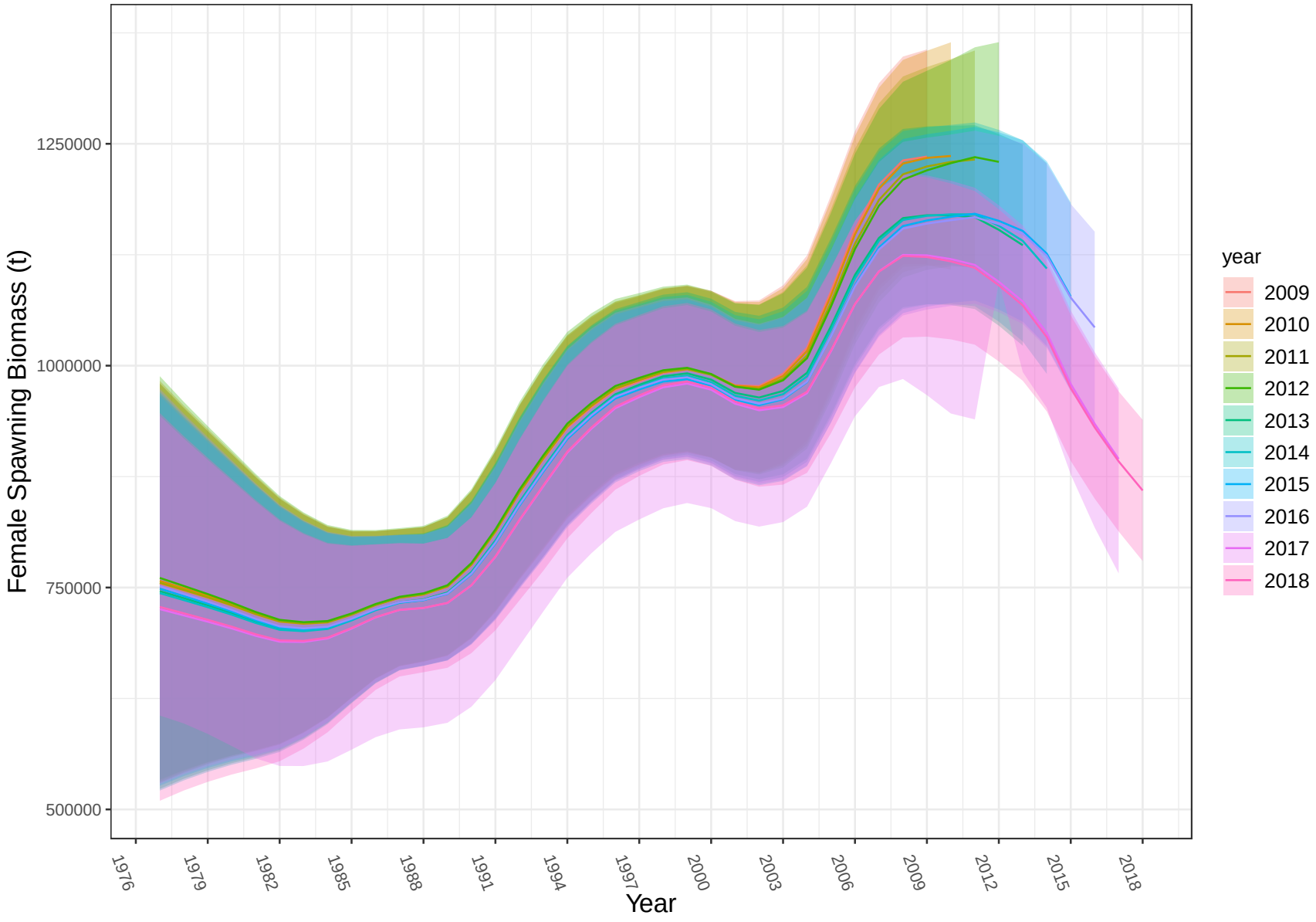
$relbias = (retro - base)/base$

and Mohn's rho is the average relative bias:

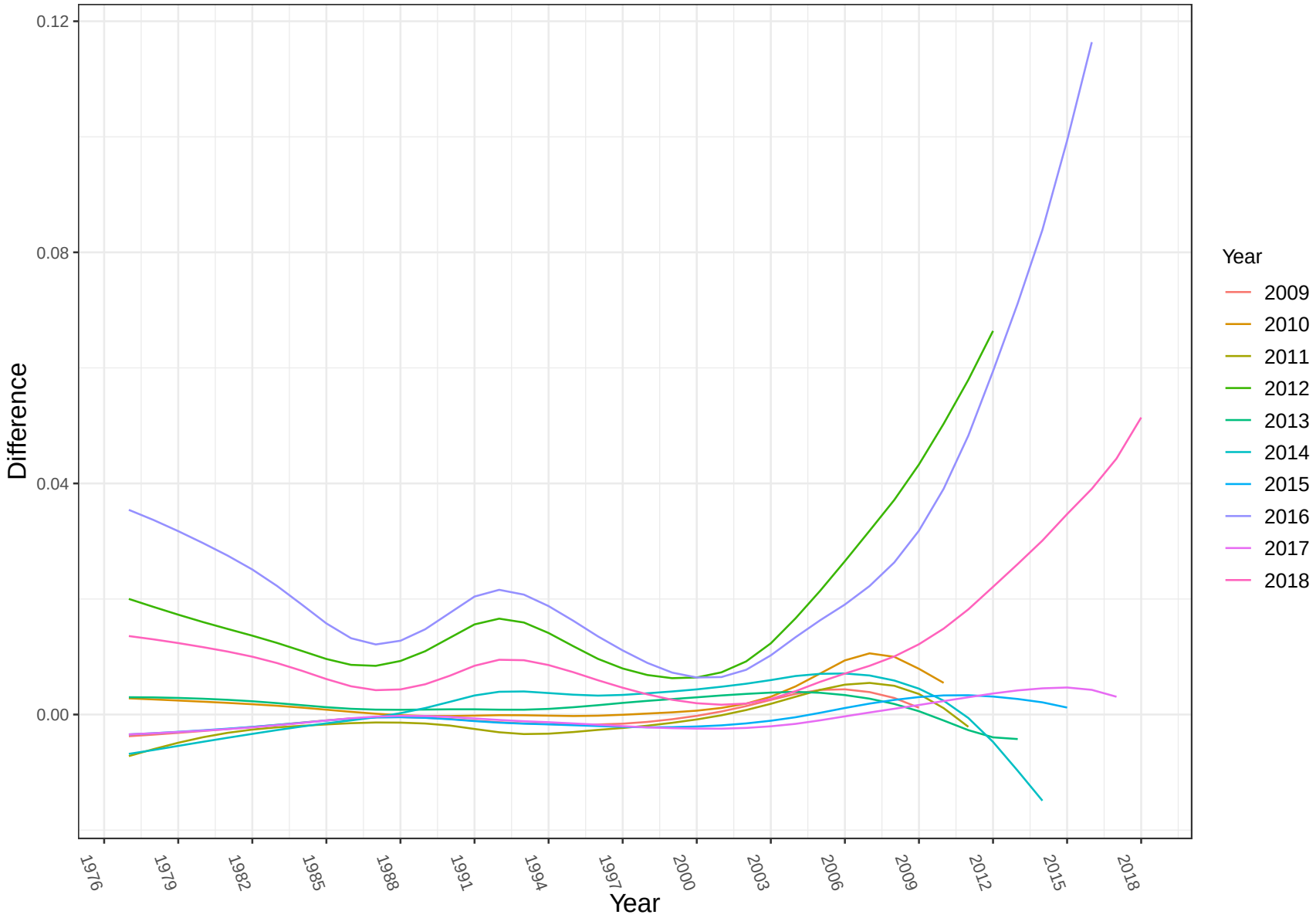
$rho = mean(relbias)$.

- Mohn's rho for Model 17.1a was calculated to be 0.131,
- The 2017 value was 0.092.
- Both in the range of other Alaska groundfish assessment models.
- The effect of the bias is small.
- Mohn's rho significantly improved under Model 19.0, to 0.022.

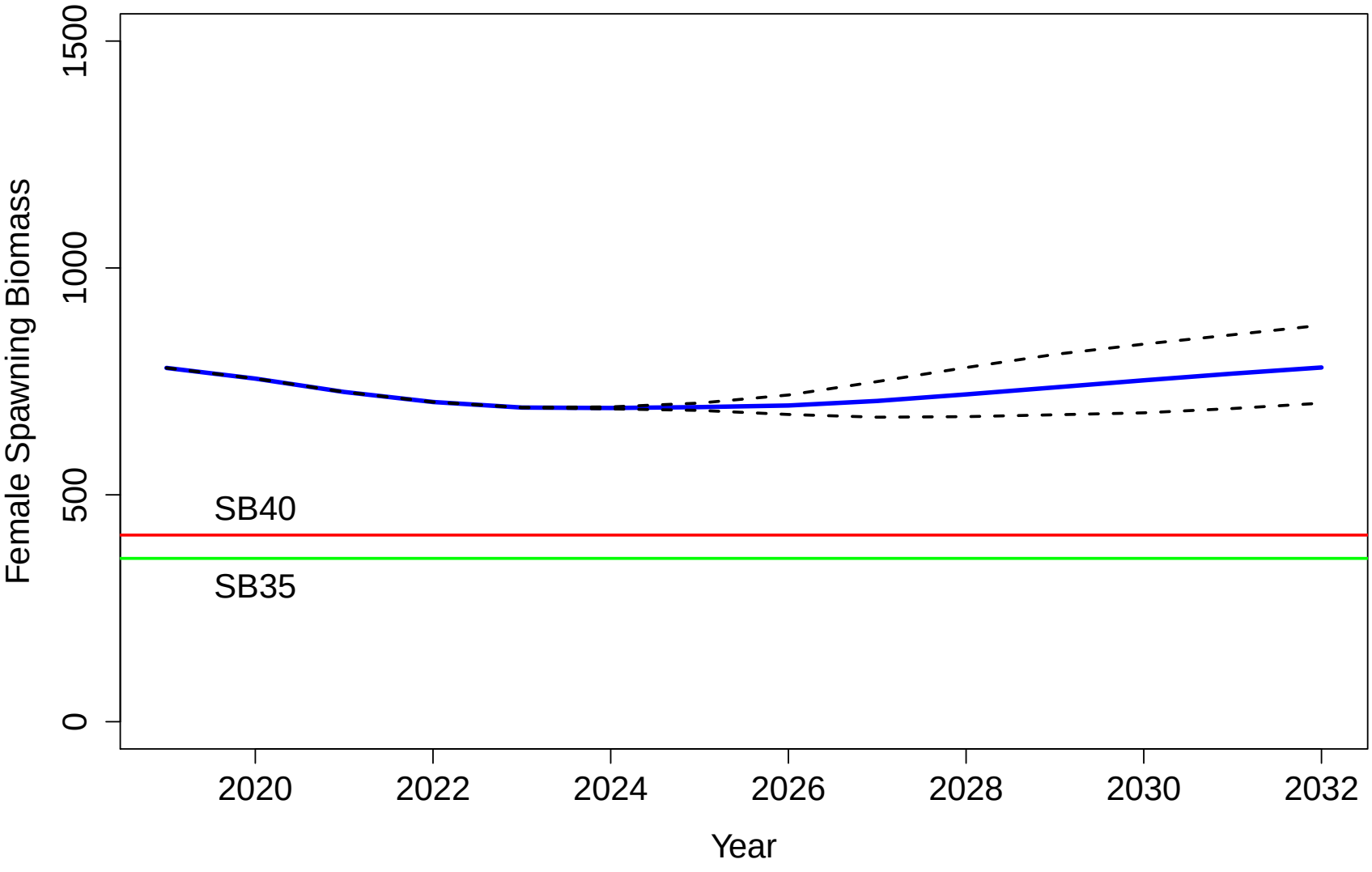
Retrospective plot of female spawning biomass, Model 19.0 through 2017.



Relative differences in estimates of spawning biomass between Model 19.0 and 10 retrospective runs.



Projected female spawning biomass, fishing at average rate over the past 5 years (Model 19.0).



Risk Assessment, Level 1: Normal.

Assessment-related Considerations

- The GOA Arrowtooth Flounder assessment is based on a time series of all standard NMFS groundfish surveys dating back to 1984.
- Ages from NMFS surveys are available for most of those years, and in years for which there is no survey, length composition data is used from the survey.
- The model exhibits good fits to abundance and composition data.
- The retrospective pattern from the current assessment is good, and Mohn's rho was calculated to be 0.022 for Model 19.0, indicating that there is little effect due to retrospective bias.

Risk Assessment, Level 1: Normal.

Population dynamics considerations

- Stock assessment model results that Arrowtooth Flounder biomass (age 1+) was at low levels during the 1960s and 1970s, although surveys used during that time period used unconventional methods.
- The population increased throughout the 1980's and reached a peak in the 2000's at which time biomass was estimated at approximately 2 million tons.
- The biomass has recently declined over roughly the past 10 years, and is now in the vicinity of 1 million metric tons, and still well above reference points.
- Population dynamics are not a concern for this assessment.

Risk Assessment, Level 2: Substantially increased concerns.

Ecosystem/environmental considerations

- Condition (defined as weight-length residuals) average during 2019 bottom trawl survey.
- Condition was low and record low in 2015 and 2017, likely related to the 2014-2016 marine heatwave.
- Potential for regional variation in Arrowtooth Flounder prey abundance.
- Both juvenile and adult Arrowtooth Flounder eat euphausiids.
- Euphausiids were at record abundance during the September 2018 Seward Line sampling.
- Moderate to low euphausiid abundance during 2019.

Risk Assessment, Level 2: Substantially increased concerns.

Ecosystem/environmental considerations

- Poor forage fish prey abundance.
- Predators of juvenile Arrowtooth Flounder appear to be stable or declining (Steller sea lions, Pacific cod).
- The western GOA shelf area has experienced heatwave conditions since late September 2018.
- We consider this unfavorable for arrowtooth as the prolonged increased temperatures likely increased their metabolic demands as well as the metabolic demands of their groundfish predators.
- Concern level to be 2 - some indicators showing adverse signals relevant to the stock but the pattern not consistent across all indicators.

Fishery performance considerations, Level 1: Normal.

- There is no concern regarding the ability of the fishery to catch Arrowtooth Flounder.
- Fishery CPUE is not showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, or changes in the percent of TAC taken, changes in the duration of fishery openings.

Overall Level 2: Substantially increased concerns.

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: Only minor, low level of concern	Level 1: Stock trends are typical for the stock and expected given stock dynamics; recent recruitment is within the normal range.	Level 2: Some indicators showing adverse signals relevant to the stock but pattern not consistent across all indicators.	Level 1: Low level of concern.

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)	0.35, 0.2	0.35, 0.2	0.35, 0.2	0.35, 0.2
Tier	3a	3a	3a	3a
Total (age 1+) biomass (t)	1,391,460 t	1,367,620 t	1,325,867 t	1,321,075 t
Female spawning biomass (t)	869,399 t	810,159 t	756,100 t	718,325 t
$B_{100\%}$	924,644 t	924,644	1,028,329 t	1,028,329 t
$B_{40\%}$	369,858 t	369,858	411,332 t	411,332 t
$B_{35\%}$	323,625 t	323,625	359,915 t	359,915 t
F_{OFL}	0.238	0.238	0.234	0.234
$maxF_{ABC}$	0.196	0.196	0.193	0.193
F_{ABC}	0.196	0.196	0.193	0.193
OFL	174,598 t	168,634 t	153,017 t	148,597 t
$maxABC$	145,841 t	140,865 t	128,060 t	124,357 t
ABC	145,841 t	140,865 t	128,060 t	124,357 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Projections based on estimated 20,554 t for 2019, estimated from an average of 97.6% of the catch caught by October 5 over the years 2014-2018, and 24,186 for 2020 based on the 5 year average (2014-2018) used in place of maximum ABC for and 2021.

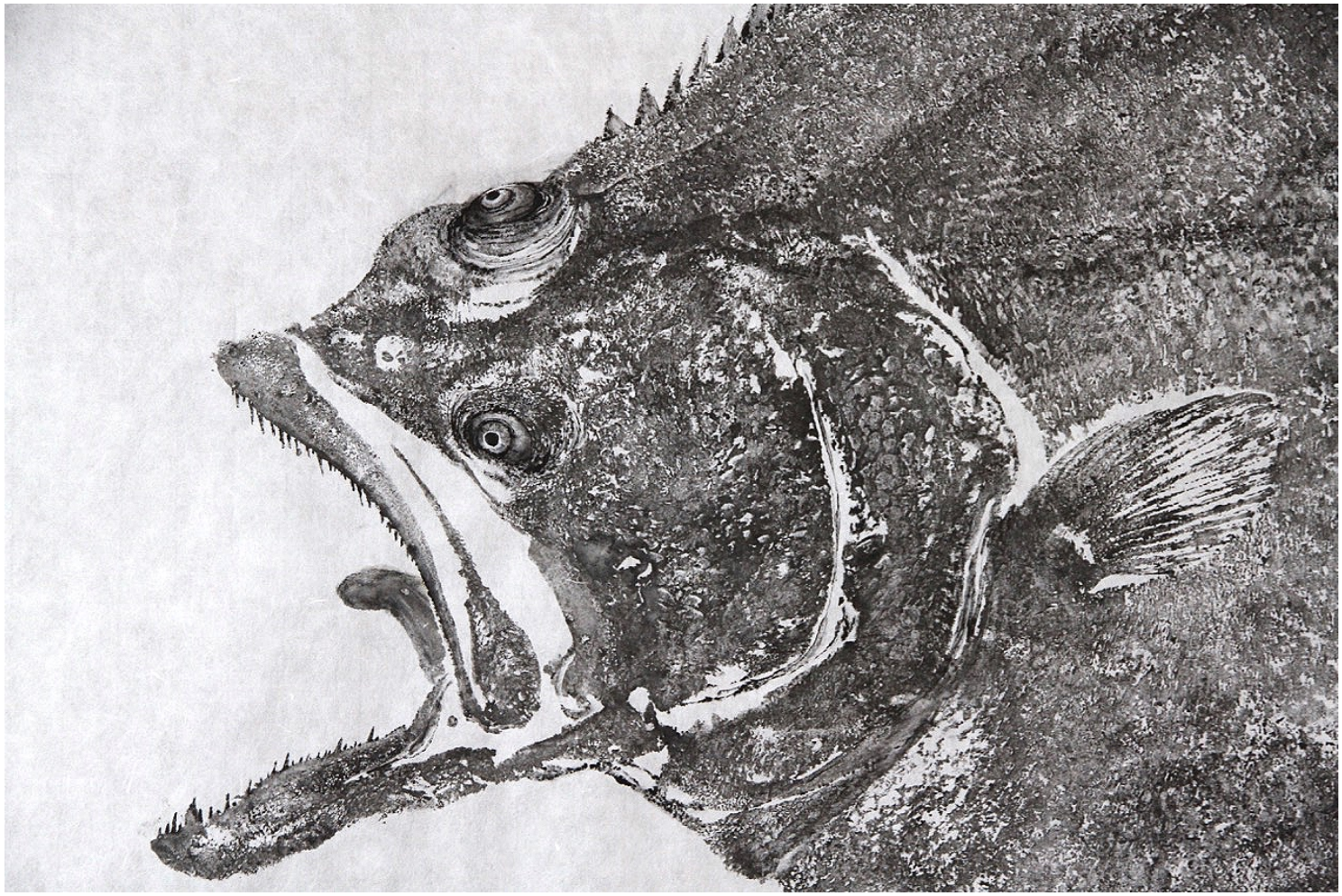
Area Apportionment

The fraction of the biomass in the four areas was determined by applying a time series of survey biomass estimates and their coefficients of variation to a random effects model.

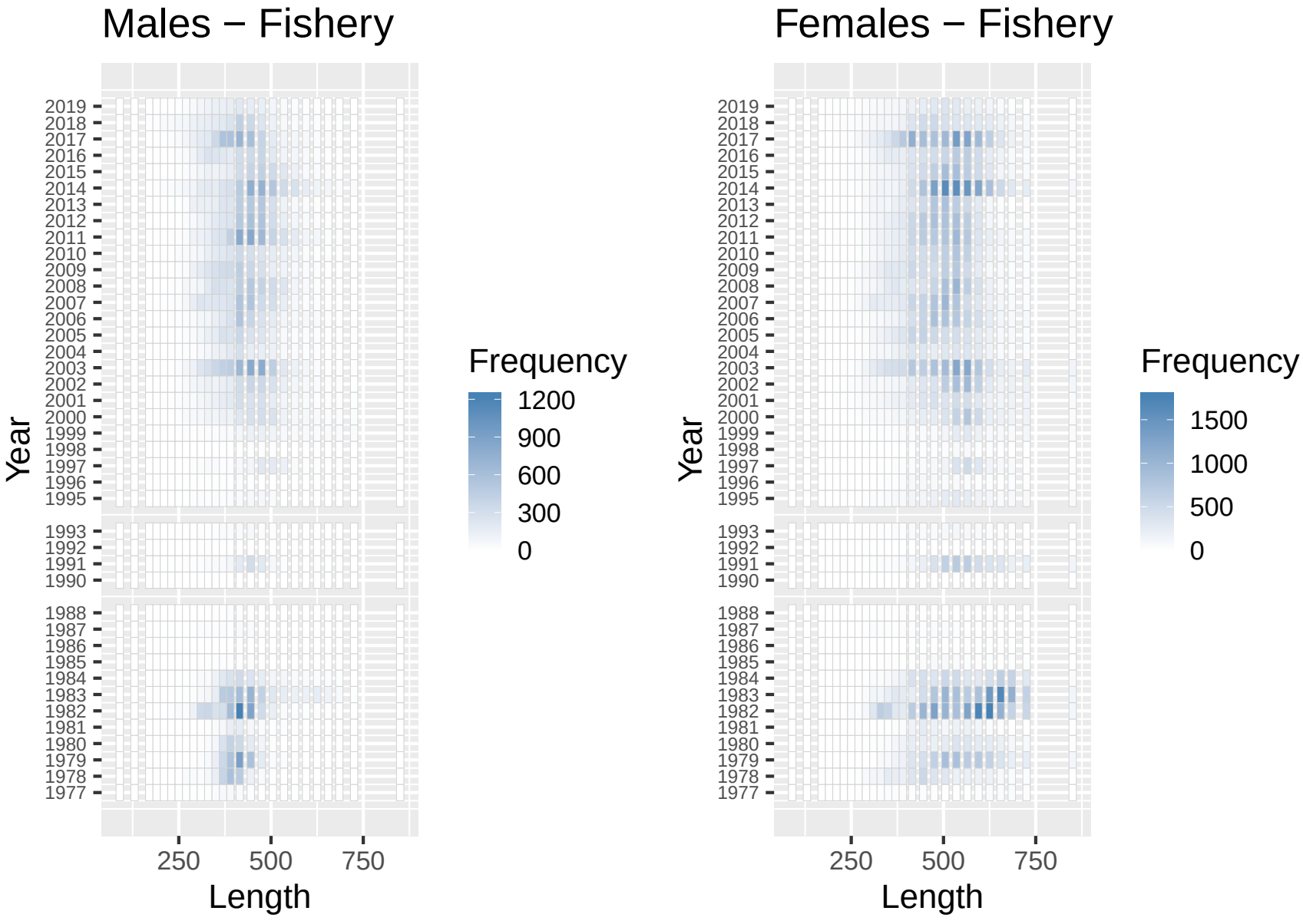
ABC by area

	Western	Central	West Yakutat	East YakutatSE	Total
2017 survey	24.68%	48.68%	10.91%	15.73%	100%
2018 ABC	37,253	73,480	16,468	23,744	150,945
2019 ABC	35,844	70,700	15,845	22,845	145,234
2019 survey	25.54 %	54.35 %	6.56%	13.54%	100%
2020 ABC	32,709	69,605	8,406	17,338	128,060
2021 ABC	31,764	67,592	8,163	16,837	124,357

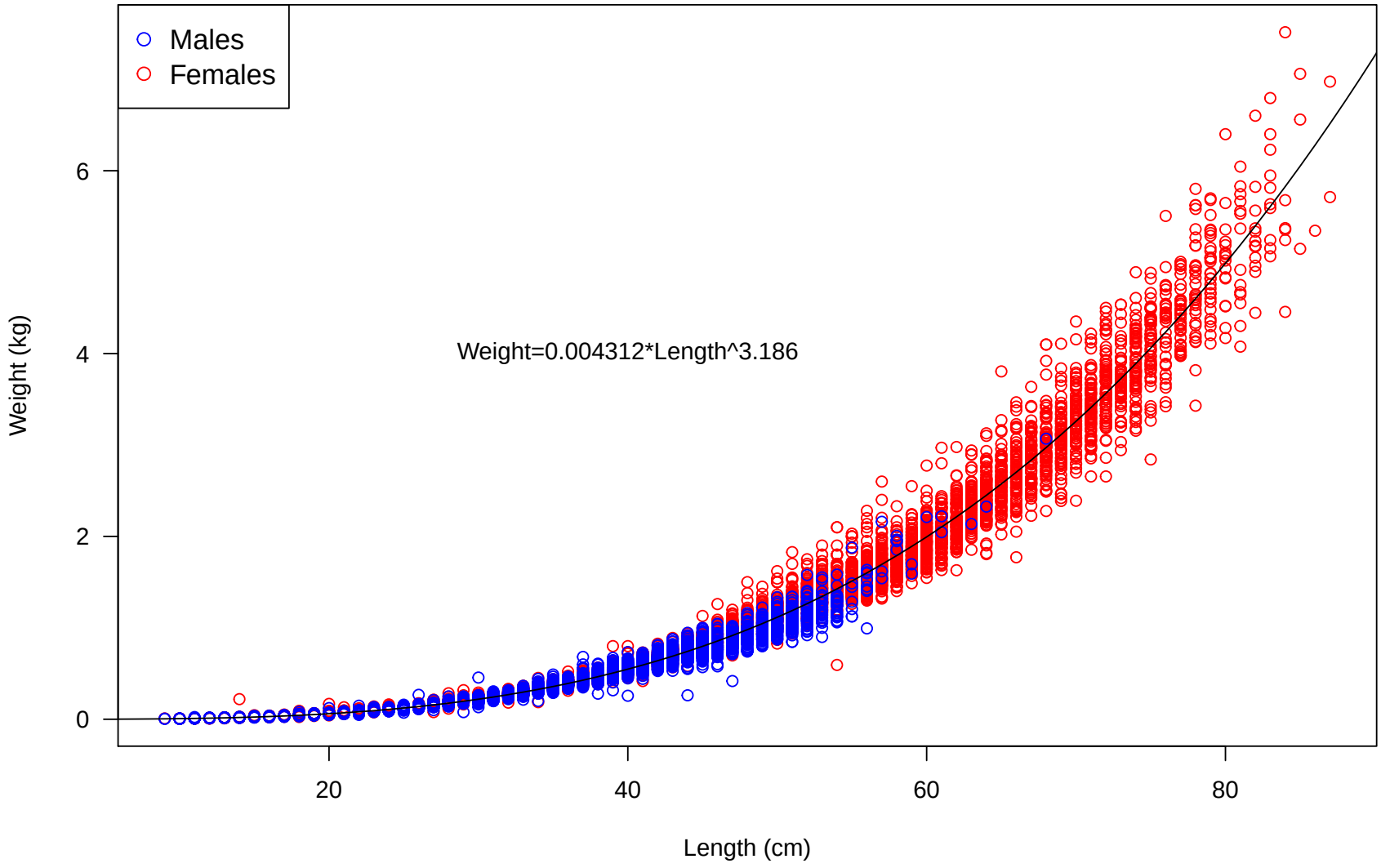
Questions?



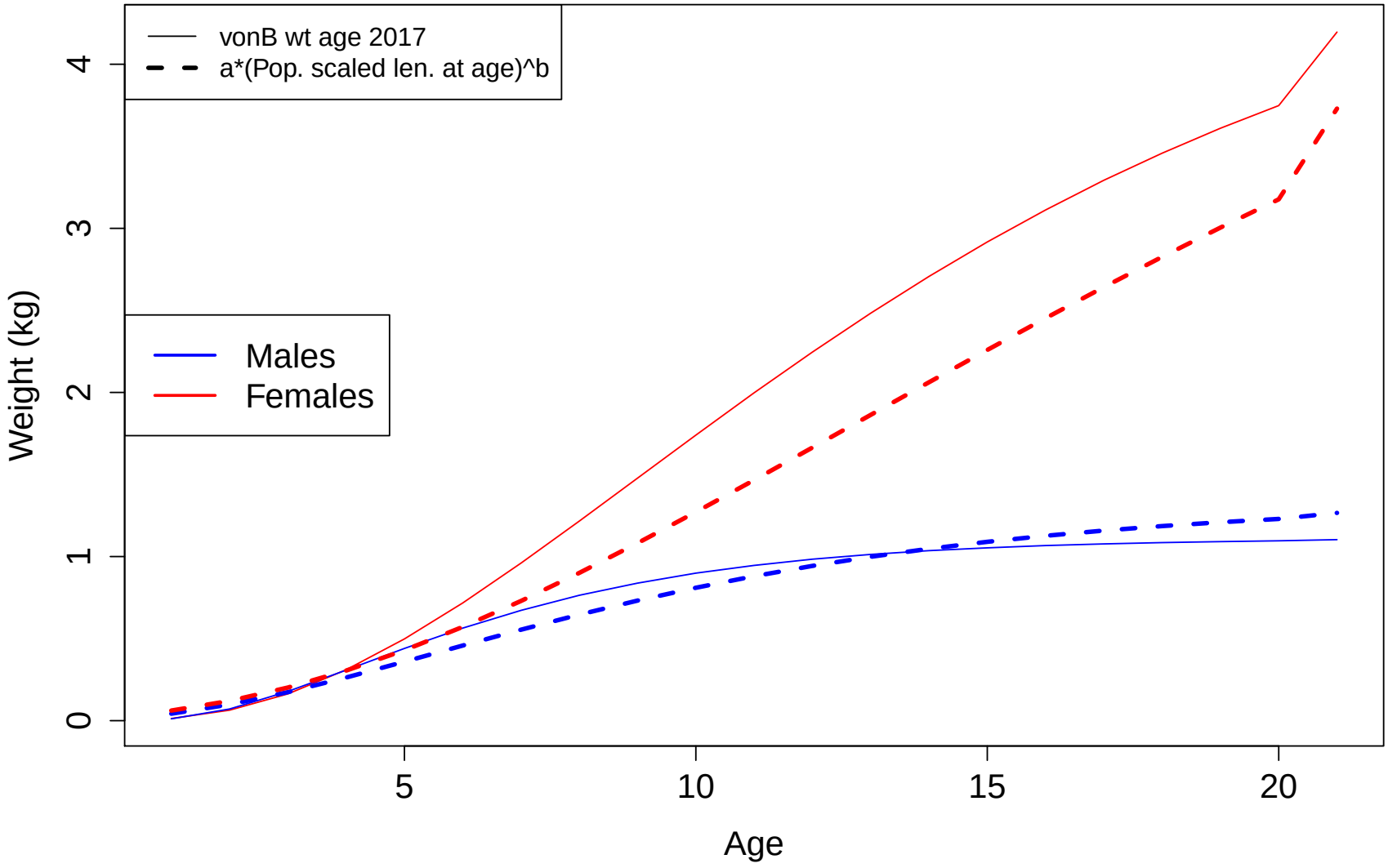
Fishery length frequency distribution



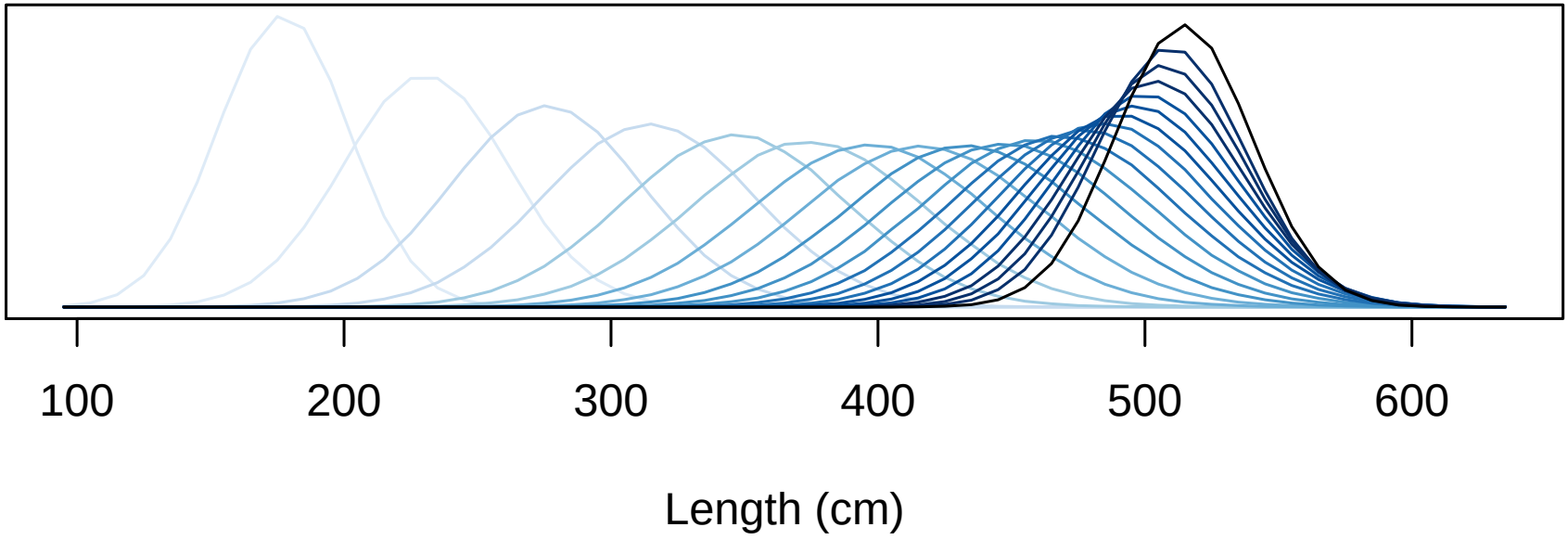
Length-weight relationship of Arrowtooth Flounder.

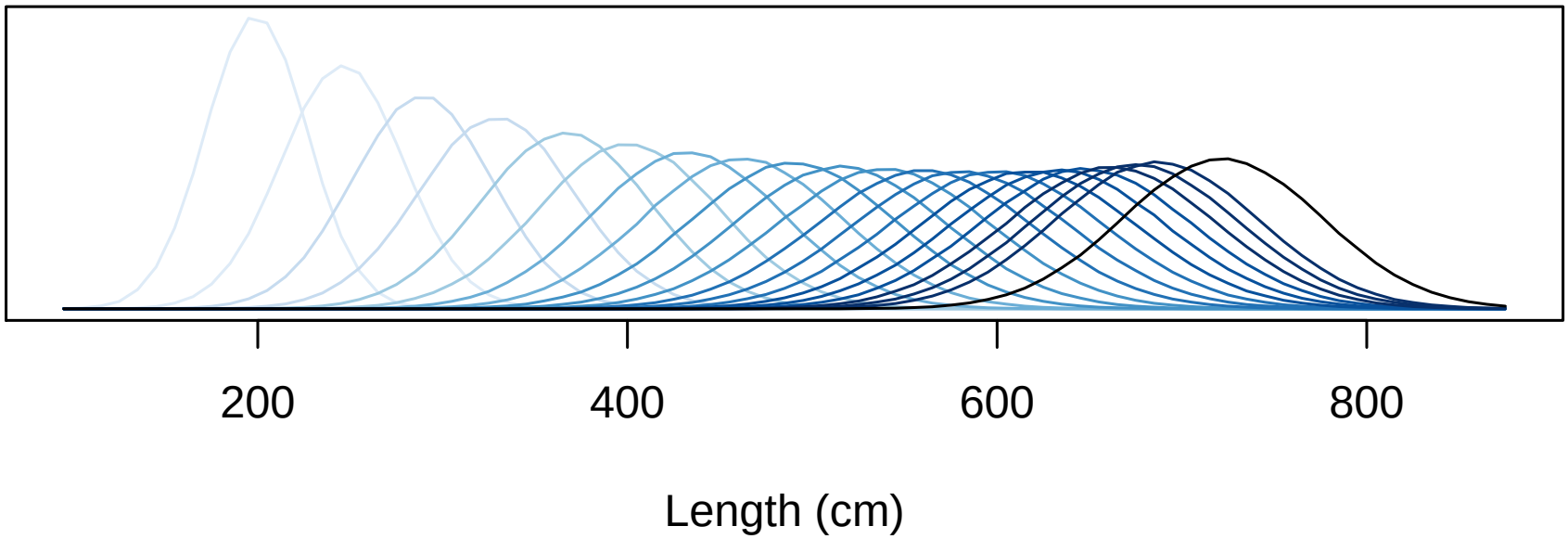


Weight at age used in the model is based on length at age corrected by survey length frequencies.

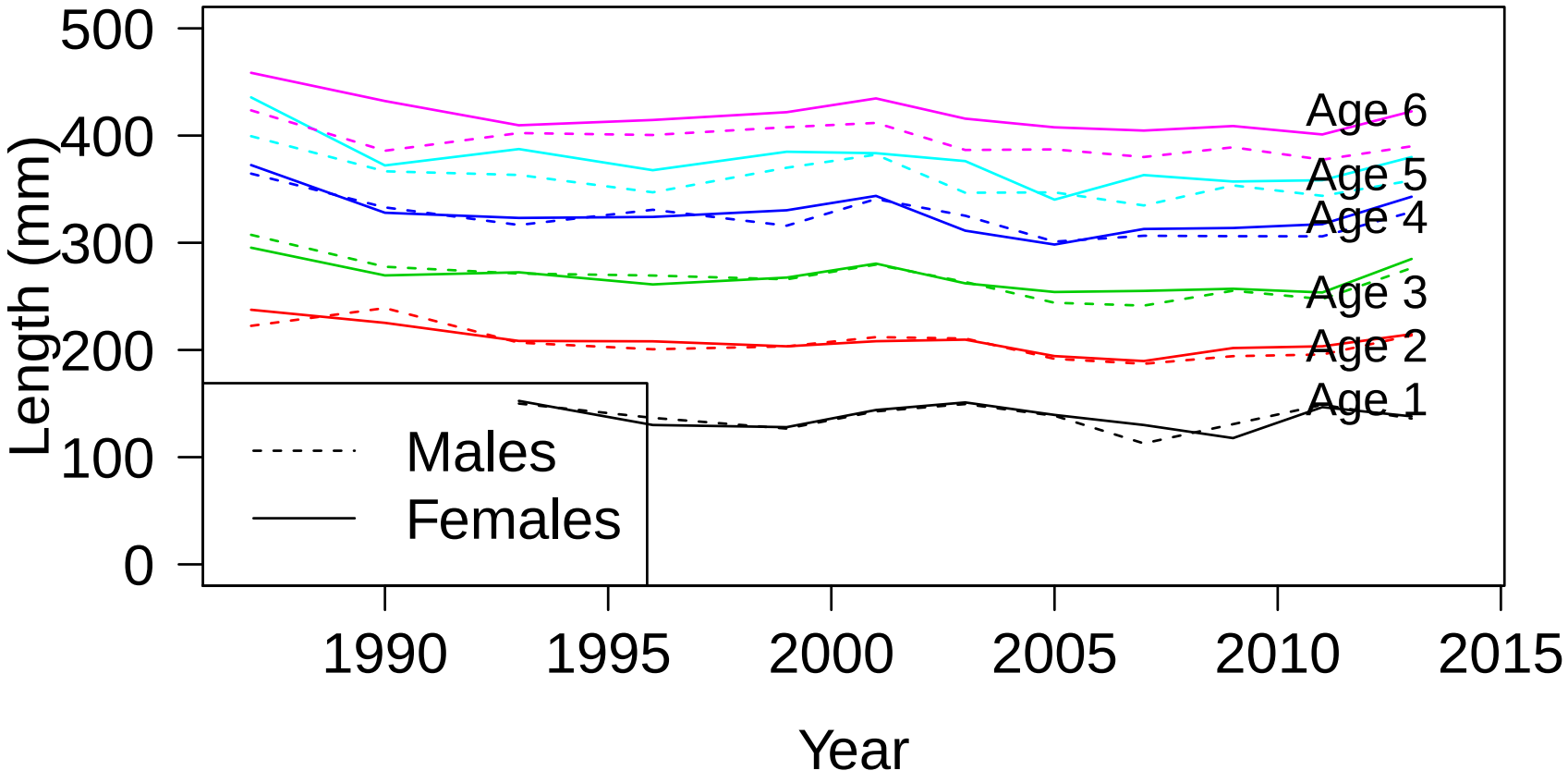


Visual representation of the length age conversion matrix used in the model, males above, females below





Growth differences among males and females start to appear around age 6. Age at 50% maturity is age 7 in females.



Trends in percent agreement in reader-tester evaluations for Arrowtooth Flounder, sample size 3,173.