Preliminary age structured assessment model of the Pacific cod stock in the Aleutian Islands

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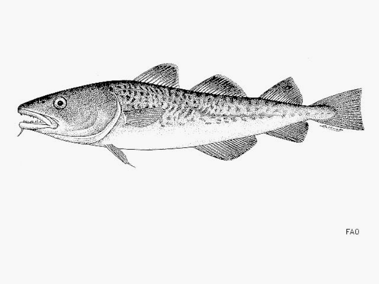
November 13, 2019



Responses to SSC and Plan Team Comments Specific to this Assessment

BSAI Plan Team Comments, September 2019

- The Team recommends that the authors report the fit of the maturity curve.

Authors' response The fit is now shown.

- The Team recommends that the authors report an exploration of how different reasonable M values impact reference points.

Authors' response The reference points associated with different values of natural mortality, M=0.4 and M=0.34, are presented Models 19.0 and 19.0a.

Responses to SSC and Plan Team Comments Specific to this Assessment

- The Team recommends that the authors report the general results of an existing model that was run without fishery lengths.

Authors' response

This is presented in Model 19.0c.

Responses to SSC and Plan Team Comments Specific to this Assessment

- The Team recommends that the authors report quantitative goodness of fit statistics.

Authors' response

The CV of the root mean squared error (RMSE) was reported for biomass estimates.

$$CV(RMSE) = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2}}{\bar{Y}_i}$$

The root sum of squared error was used for age composition data, and the standard deviation of normalized residuals (SDNRs) were reported for the biomass indices.

Responses to SSC and Plan Team Comments Specific to this Assessment

- The Team recommends that the authors communicate with Cindy Tribuzio of AFSC to obtain IPHC survey indices and cod lengths for possible inclusion in future years.

Authors' response

These indices have been obtained and will be considered for future years.

Model features

- One fishery, one gear type, one season per year.
- Single sex model, 1:1 male female ratio.
- Logistic age-based selectivity for both the fishery and survey.
- External estimation of a single growth curve (vonBertalanffy) for length at age, weight at age.
- An ageing error matrix for ages 1 through 10+.
- All parameters constant over time except for recruitment and fishing mortality.
- Internal estimation of fishing mortality, catchability, and selectivity parameters.
- Recruitment estimated as a mean with lognormally distributed deviations
- Natural mortality was fixed in the model using M=0.34 for consistency with previous Aleutian Islands Pacific cod assessments.
- Survey catchability was estimated within the model as a constant multiplier on survey selectivity.
- Maturity at age was estimated using observer data. This is consistent with the Gulf of Alaska Pacific cod assessment.

Data

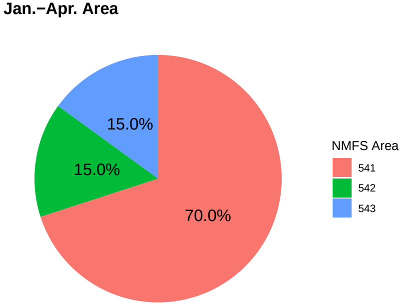
Source	Type	Years
Fishery	Catch biomass	1990-2019
Fishery	Size composition	1990-2019
AI bottom trawl survey	Biomass estimate	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018
AI bottom trawl survey	Age composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018

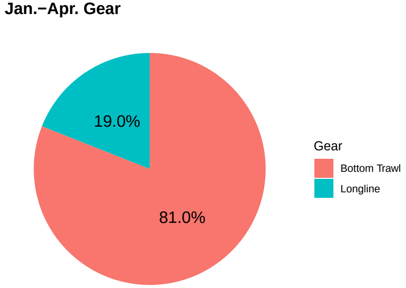
Four models:

- Model 19.0: Base model with M=0.34, maturity ogive derived from observer collections of maturity values from Aleutian Islands cod.
- Model 19.0a: Base model except M=0.40.
- Model 19.0b: Base model except Stark (2007) maturity ogive.
- Model 19.0c: Base model with no fishery length data likelihood.

AI cod winter fishery, 1990-2019

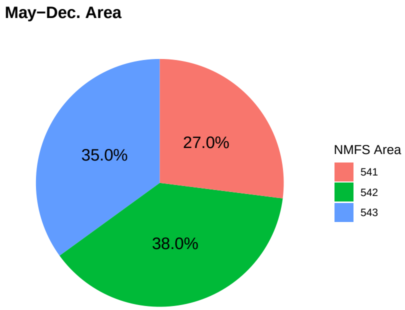
- Approximately 78% of catch takes place during winter months (January-April).
- The winter fishery mostly operates in NMFS area 541 (Adak is in 541): 70% in 541, 15% in 542, and 15% in 543.
- The winter fishery is predominantly (80%) bottom trawl gear, and 18% longline.

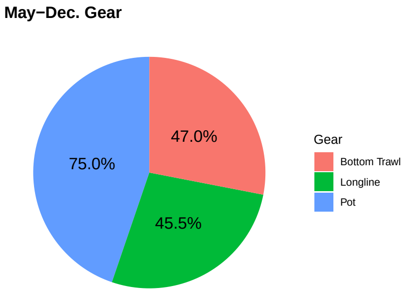




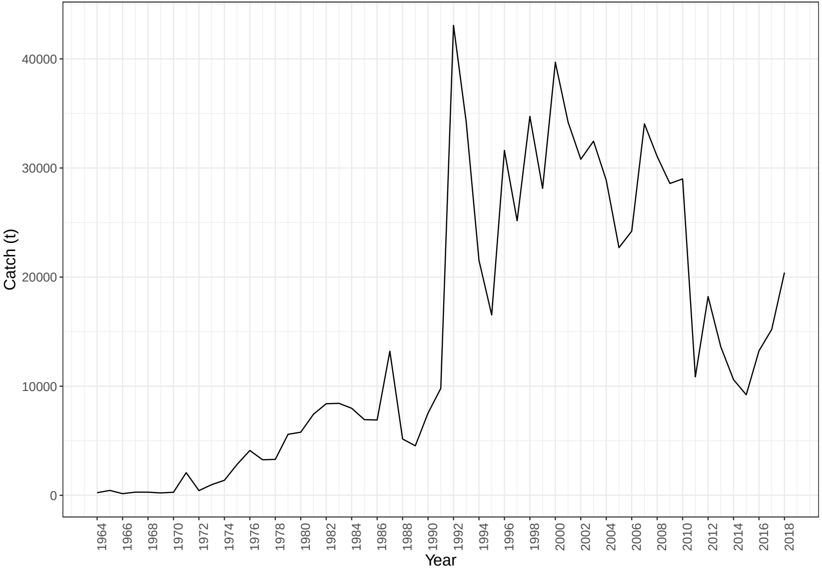
AI cod non-winter fishery, 1990-2019

- During May-December, catches are more equally distributed (27% in 541, 38% in 542, 35% in 543).
- Gear after April consists of 45% longline, 47% bottom trawl 7% pot.

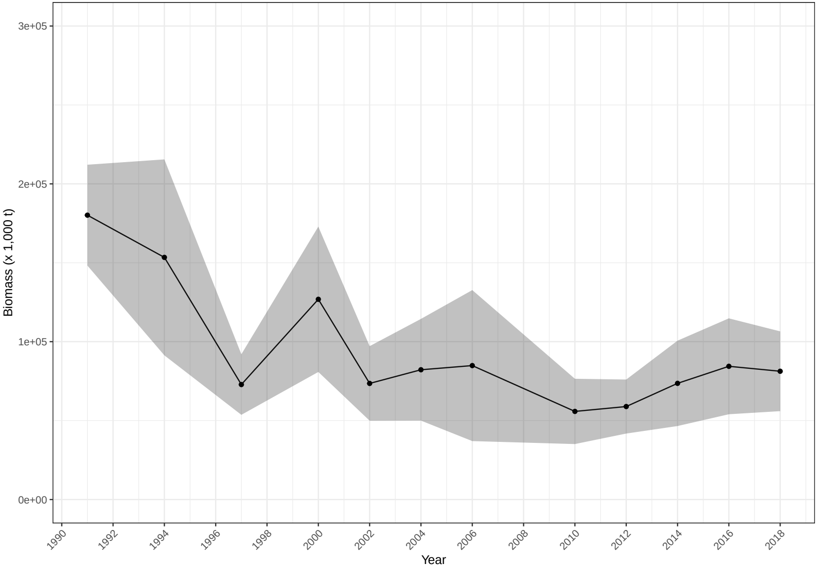




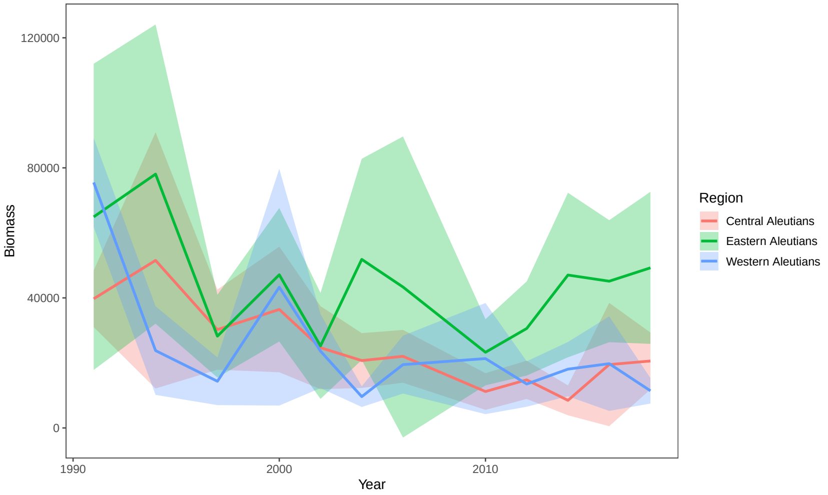
Catches increased in 1990 and have declined since 2010.



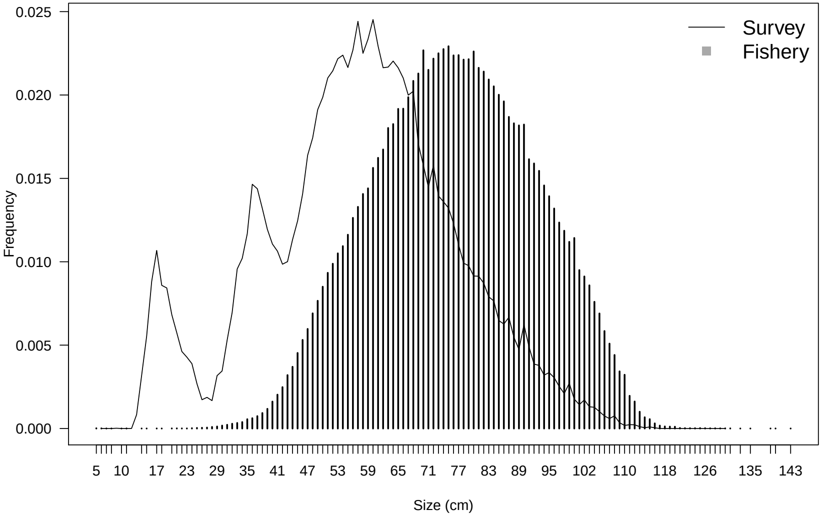
Survey biomass in the Aleutian Islands declined after 1990, stabilized since 2010.



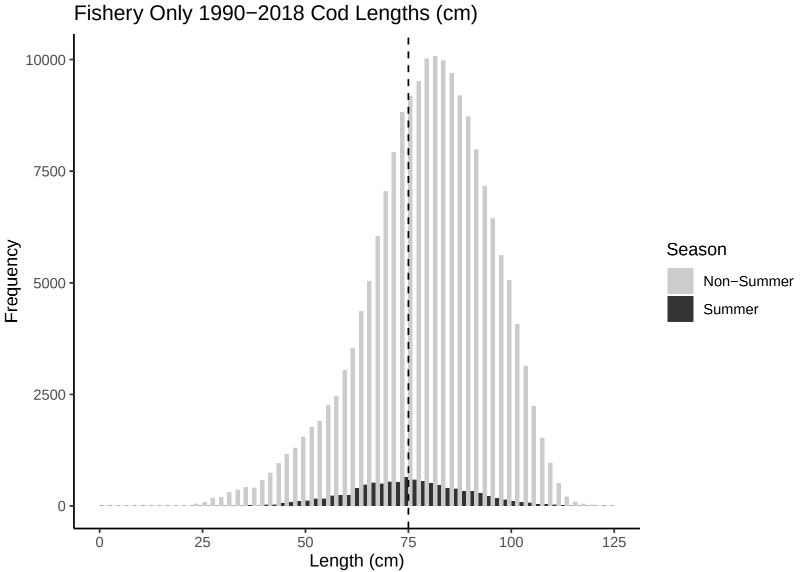
Eastern Aleutian Islands region (541) has shown most increase since 2010.



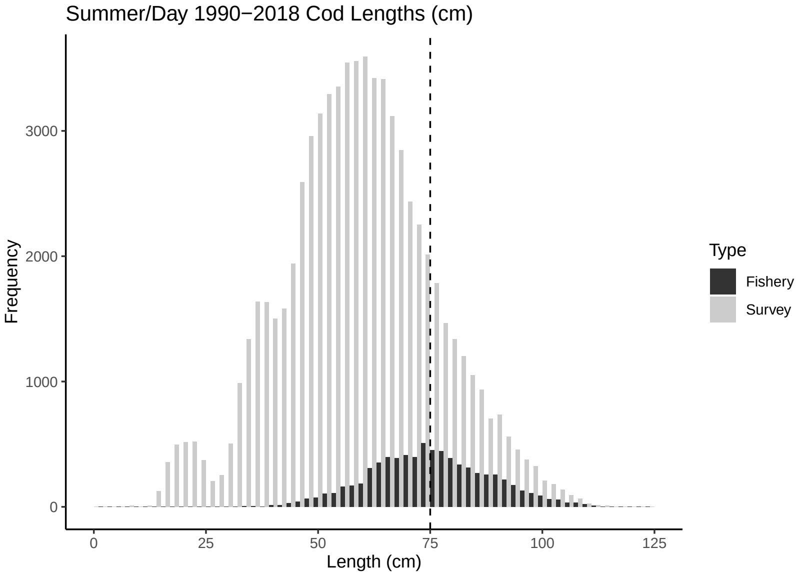
Length frequencies for Pacific cod caught in the Aleutian Islands - fishery 1990-2019, survey, 1991-2018.



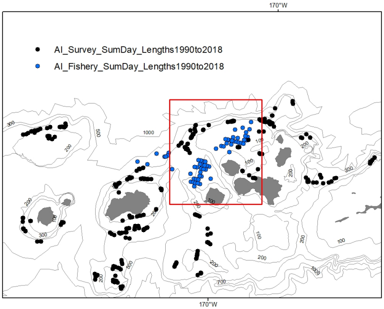
Within the fishery, larger fish caught in non-summer months (summer defined as May-August).

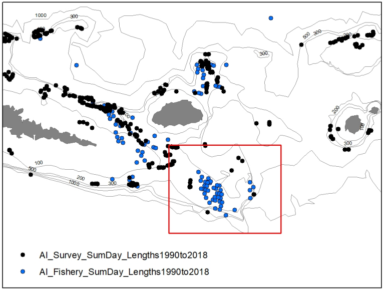


NMFS survey catches the same distribution of lengths as the fishery during summer daytime hours.



Areas of highest summer fishing effort, Islands of the Four Mountains (left) and Seguam Pass (right)





Selectivity

- The fishery catches larger fish than the survey, but only in the winter.

Two parameter logistic growth curve fit (separately) for survey and fishery:

$$Selectivity_{age} = \frac{1}{1 + e^{-(slope * age - a_{50})}},$$

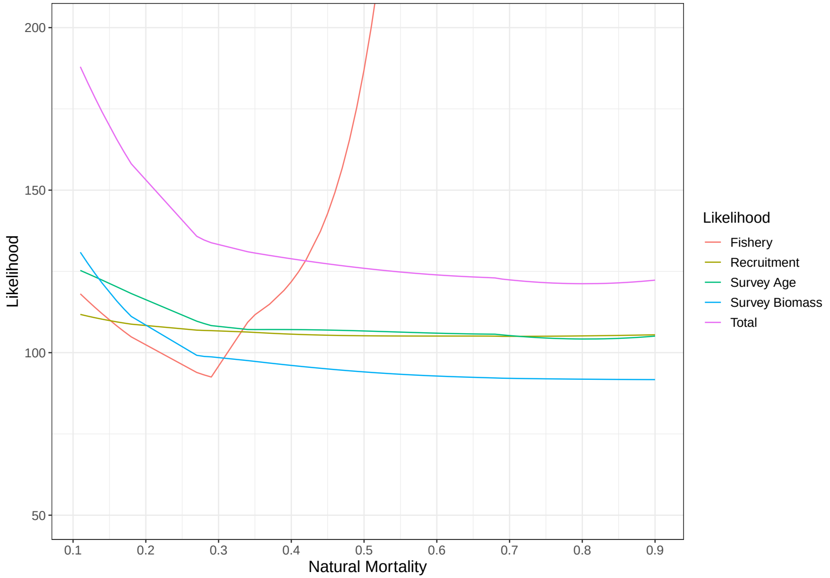
where the two parameters estimated were *slope* and a_{50}.

An additional parameter for survey catchability was estimated by the model.

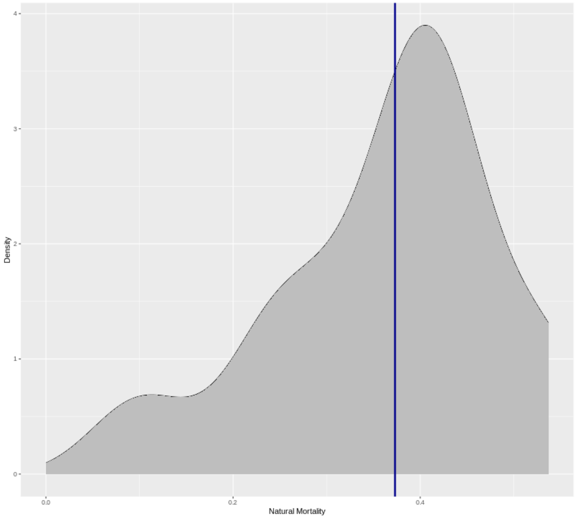
Natural mortality

- Estimated several ways.
- Sensitivity tested in Model 19.0a.
- Value of M=0.34 used for consistency with Bering Sea assessment.

Likelihood profile for natural mortality, with age, fishery length, recruitment, and survey biomass.



Median value of M=0.36 for Aleutian Islands Pacific cod estimated using the Cope composite method.



Maturity

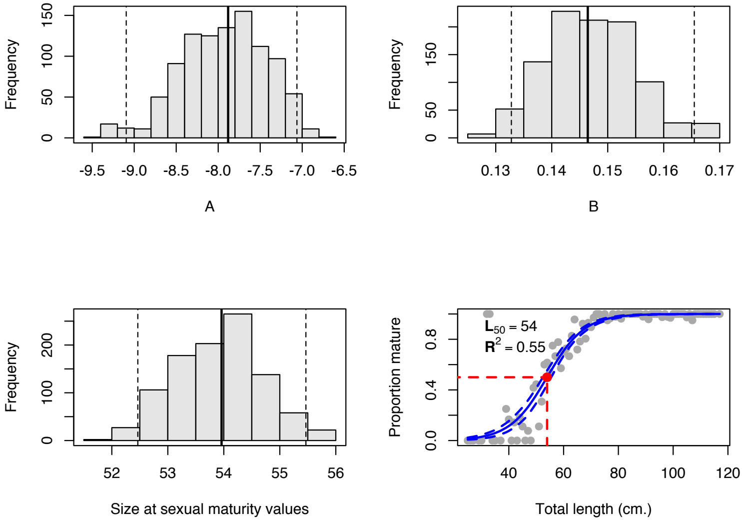
Stark (2007) maturity ogive based on 129 female fish February, 2003, from the Unimak Pass area,

- 50% of female fish become mature at approximately 4.88 years and 58.0 cm.

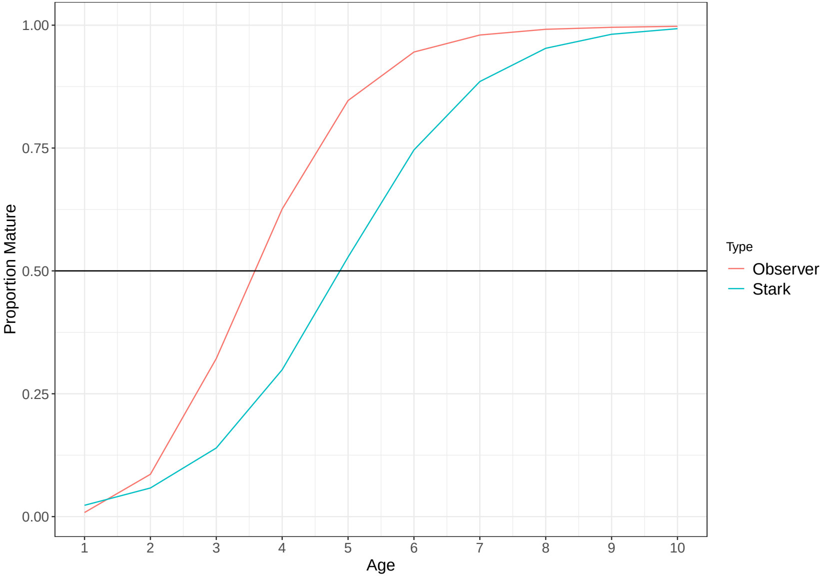
An alternative maturity curve based on observer records of maturity from the Aleutian Islands (2,098 records January – March since 2008).

- $L_{50\%}$ was estimated to be 53.8 cm (age 4).

Parameter estimation for A and B, size at maturity, and fit to samples January-March, 2008-2019.



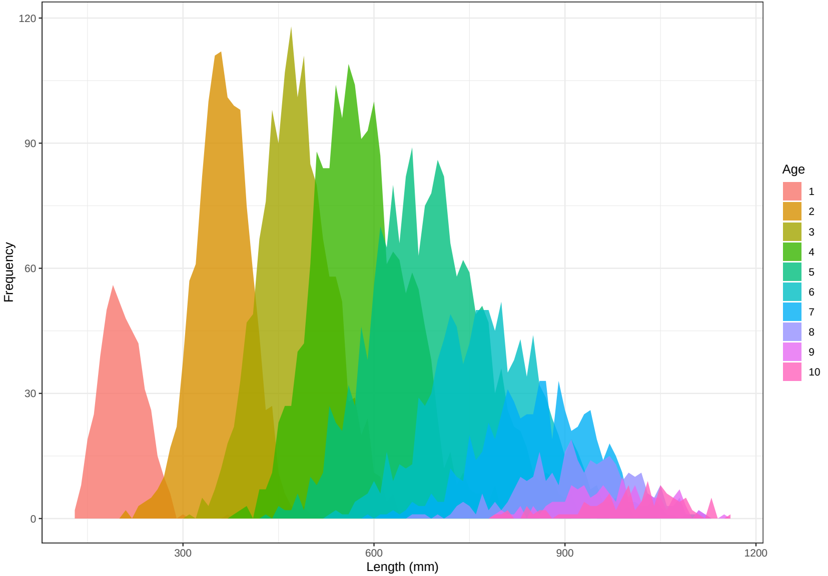
Proportion mature by age, as measured using Stark (2007) parameters and observer maturity at length data.



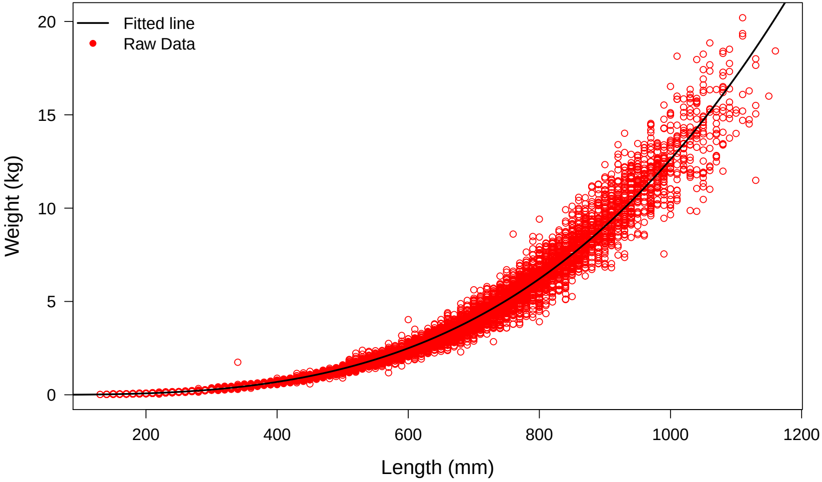
Length-age conversion matrix was prepared based on data from 1990-2018 and was used to:

- convert fishery data to ages,
- convert length-based maturity curve to age-based.

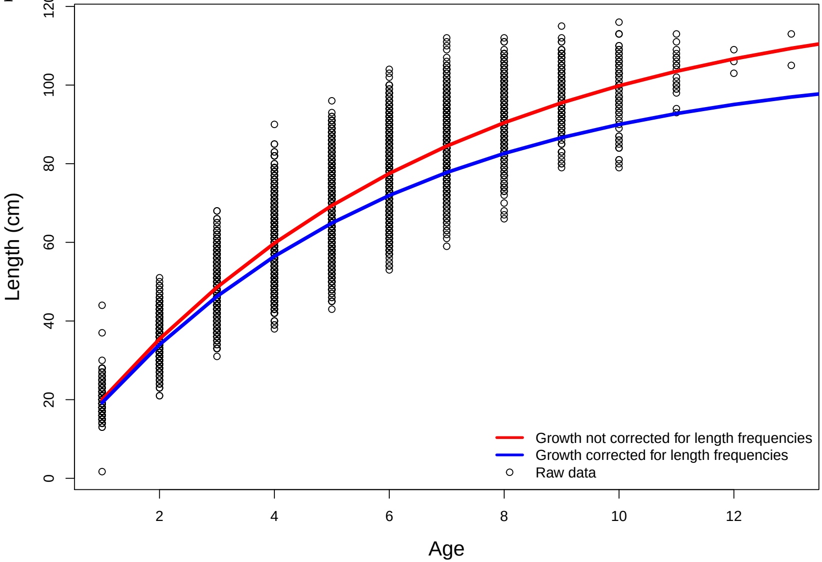
Length frequency by age of cod collected from surveys from 1990-2018.



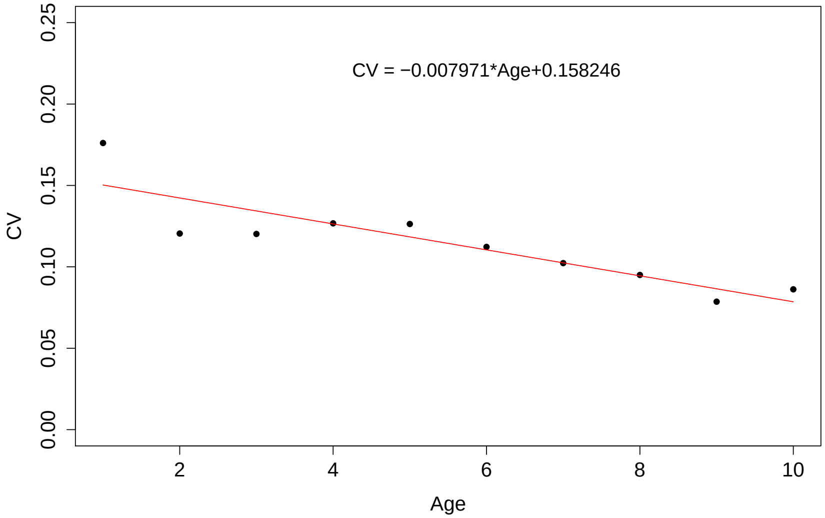
Length-weight relationship for Aleutian Islands Pacific cod, males and females combined (1990-2018). The fit to weight-at-length is shown as a black line.



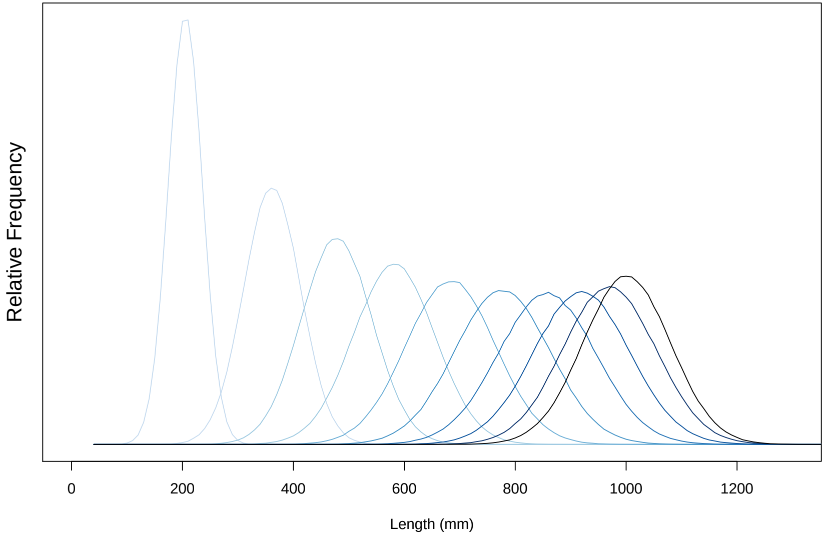
Raw lengths at age and vonBertalanffy growth curves, corrected vs. not corrected for population length frequencies.



Coefficient of variation (CV) fitted to age, based on raw data (black points.



Length age conversion matrix for Aleutian Islands Pacific cod, ages 1-10, where 10 represents ages 10+.



Responses to SSC and Plan Team Comments Specific to this Assessment

- The SSC noted the wide variety of otolith sampling strategies that have been employed over time. The SSC requests that the authors elaborate on how different otolith sampling strategies were combined into one length-at-age curve.

Authors' response

- Typically age data is corrected for using survey length frequencies.
- Here the length frequency distribution did not match the observed lengths in the fishery, and resulted in an unrealistic growth curve.
- Therefore, no correction was made for length frequency in the population.
- Future models could consider other sources for length frequency distributions of the Aleutian Islands cod stock.

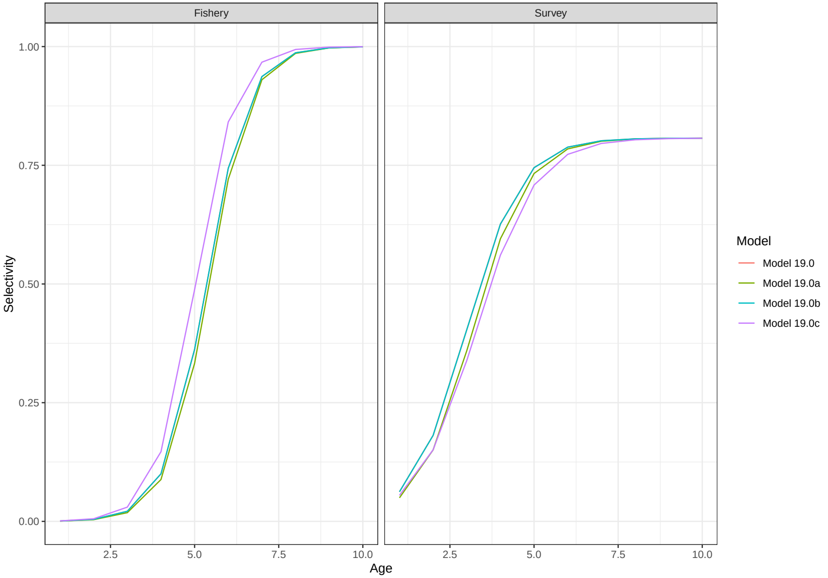
Data weighting

- Models were sensitive to the relative weight of the age composition data.
- Higher age composition likelihood weights decreased survey catchability and reduced biomass estimates.
- Data weighting for age composition likelihood component performed using McAllister and Ianelli (2007).
- The weight factor converged to 94 after 3 iterations.
- Ad hoc value of 10 used for fishery length composition.

Survey catchability

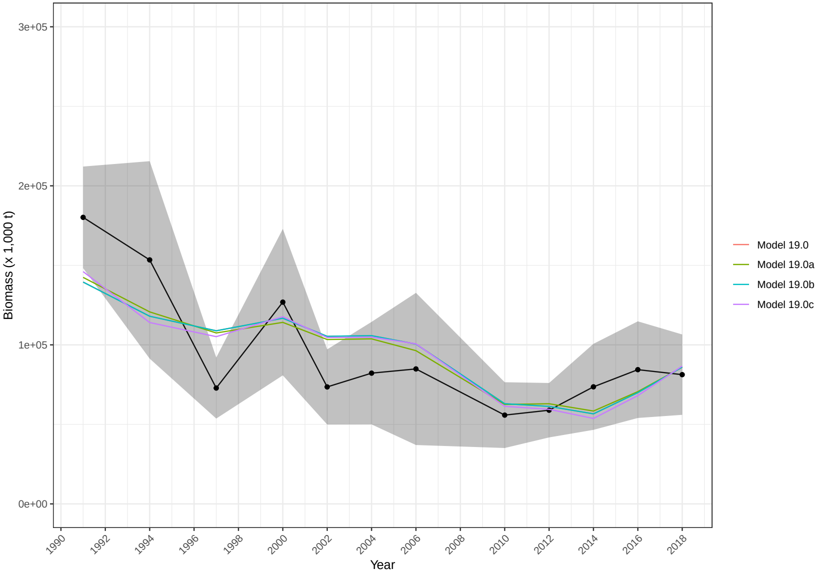
Model 19.0 Base	Model 19.0a M=0.40	Model 19.0b Stark mat.	Model 19.0c No fishery
0.807	0.696	0.807	0.967

Model estimates for selectivity for survey and fishery.

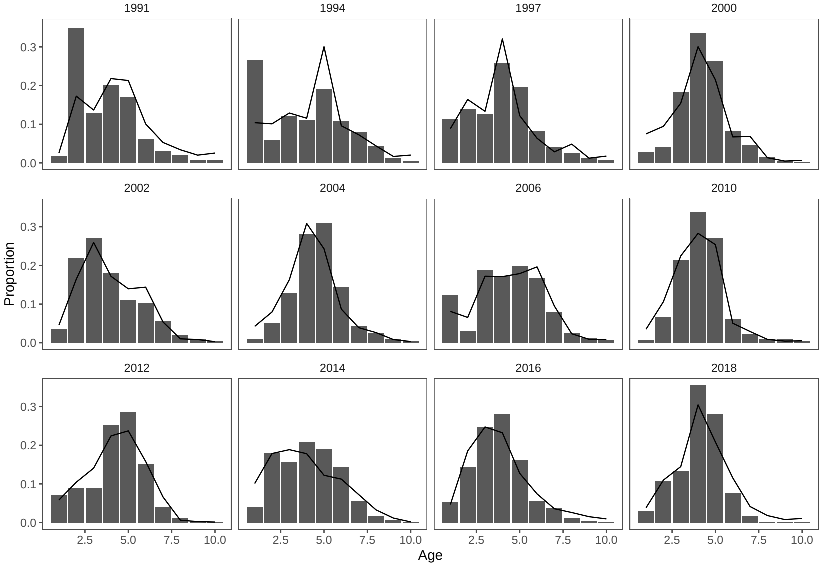


Survey selectivity includes catchability.

NMFS Aleutian Islands survey biomass estimates and model estimates of survey biomass.



Survey age frequency fit to model 19.0, solid line is predicted.



Model comparison

Quantity	Model 19.0a M=0.40 2020	Model 19.0a M=0.40 2021	Model 19.0 Base 2020	Model 19.0 Base 2021
M (natural mortality rate)	0.40	0.40	0.34	0.34
Tier	3b	3b	3b	3b
Projected total (age 1+) biomass (t)	152,919	133,219	127,146 t	119,180 t
Projected female spawning biomass (t)	47,907	37,065	42,009 t	36,743 t
$B_{100\%}$	99,221	99,221	103,330 t	103,330 t
$B_{40\%}$	39,688	39,688	41,332 t	41,332 t
$B_{35\%}$	34,727	34,727	36,165 t	36,165 t
F_{OFL}	1.155	1.155	0.787	0.787
$maxF_{ABC}$	0.863	0.863	0.605	0.605
F_{ABC}	0.863	0.863	0.605	0.605
OFL	47,159	32,143	33,008 t	25,419 t
$maxABC$	38,482	26,278	26,957 t	20,781 t
ABC	38,482	26,278	26,957 t	20,781 t
	Model 19.0b Stark maturity		Model 19.0c No fish lengths	
Quantity	2020	2021	2020	2021
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	3b	3b	3b	3b
Projected total (age 1+) biomass (t)	127,152	125,482	116,010 t	115,421 t
Projected female spawning biomass (t)	42,009	32,647	42,009 t	35,341 t
$B_{100\%}$	91,688	91,688	101,934 t	101,934 t
$B_{40\%}$	36,675	36,675	40,773 t	40,773 t
$B_{35\%}$	32,091	32,091	35,677 t	35,677 t
F_{OFL}	0.609	0.609	0.651	0.651
$maxF_{ABC}$	0.483	0.483	0.511	0.511
F_{ABC}	0.483	0.483	0.511	0.511
OFL	25,458	22,825	24,942 t	22,344 t
$maxABC$	21,134	18,926	20,591 t	18,404 t
ABC	21,134	18,926	20,591 t	18,404 t

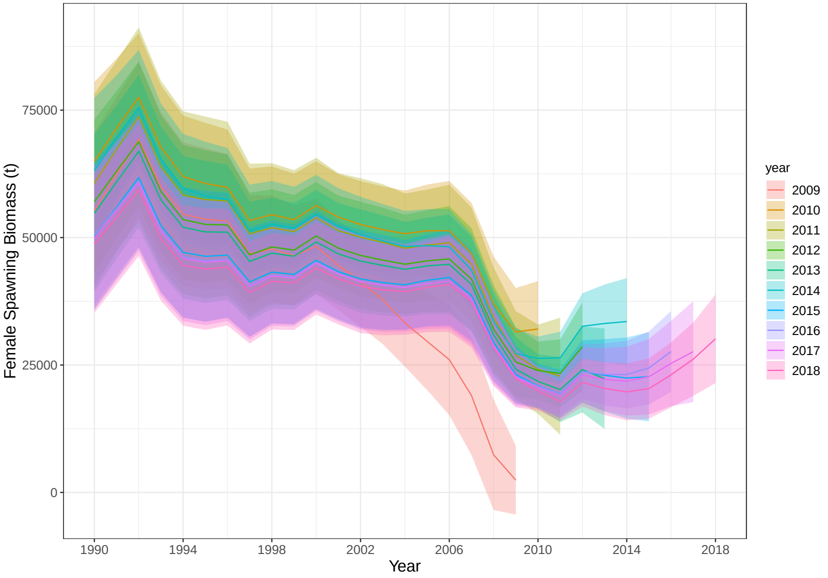
Likelihood components and total likelihood for the four models and statistical goodness of fit test results

	Model 19.0 Base	Model 19.0a M=0.40	Model 19.0b Stark mat.	Model 19.0c No fishery
Recruitment	5.994	5.587	5.994	5.494
Survey age	0.66	0.653	0.66	0.639
Survey biomass	14.558	12.911	14.557	13.061
Catch	0.001	0.001	0.001	0.001
Fishery length	20.93	20.299	20.93	-
Total	42.143	39.45	42.142	52.476
CV of RMSE for biomass	0.251	0.251	0.251	0.253
RSSD for survey age	0.402	0.404	0.402	0.392
RSSD for fishery lengths	0.203	0.2	0.203	"-"
SDNR	1.632	1.535	1.632	1.549

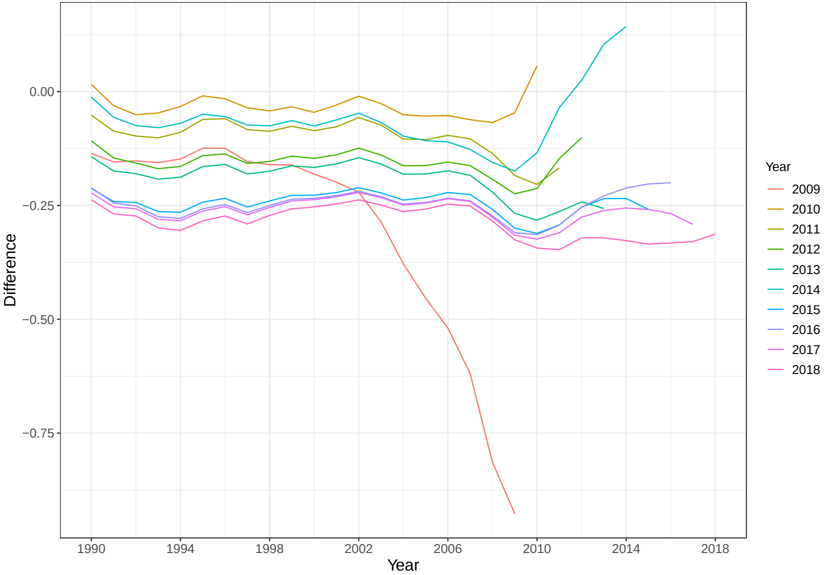
Retrospective results

- Retrospective estimates of female spawning biomass were typically higher for retrospective runs.
- Rho = -0.232.
- Past trends indicate that the model may be overestimating spawning biomass for the current year.

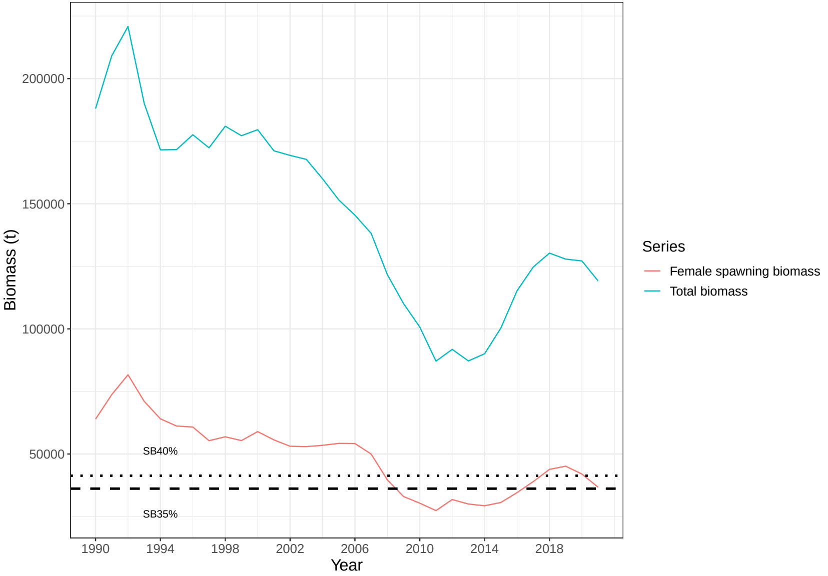
Retrospective plot of female spawning biomass.



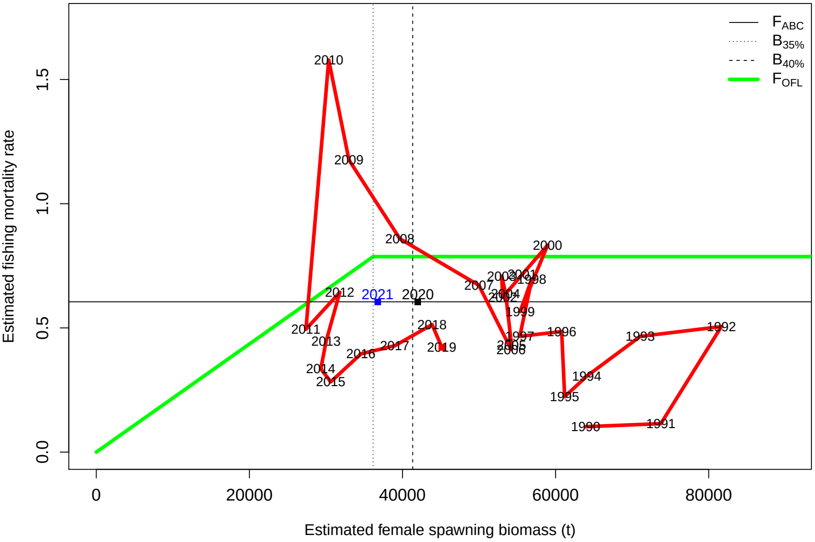
Relative differences in estimates of spawning biomass between the 2019 preferred model and 2009-2018.



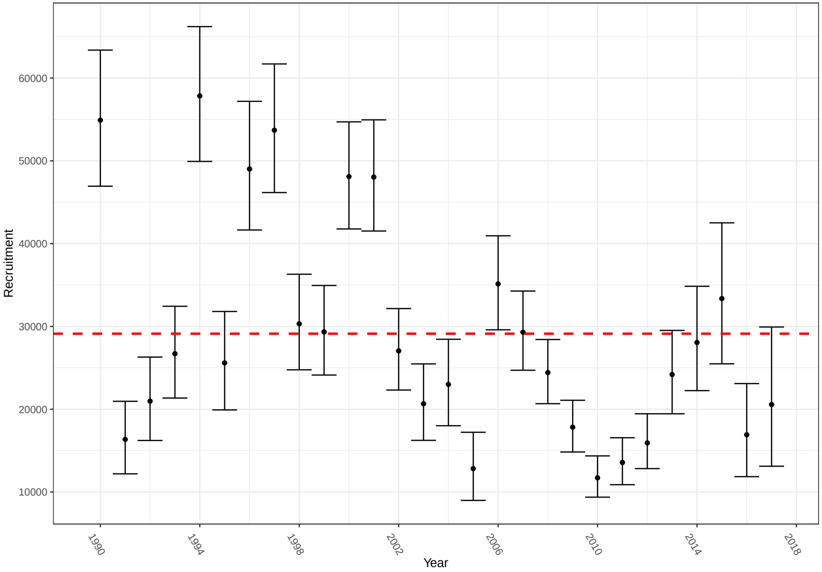
Model estimates for total (age 1+) biomass and FSB, plus projections for 2020 and 2021, B40% and B35%.



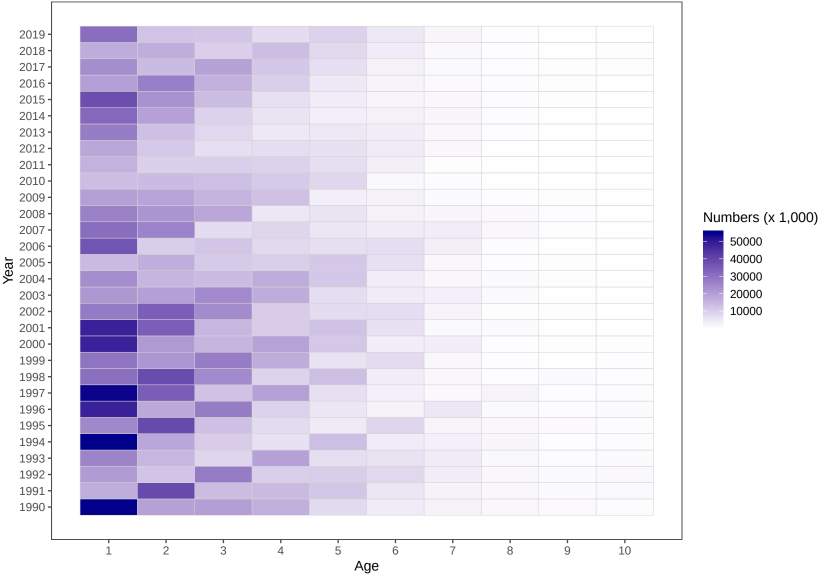
Time-series of model estimates of female spawning biomass relative to the harvest control rule.



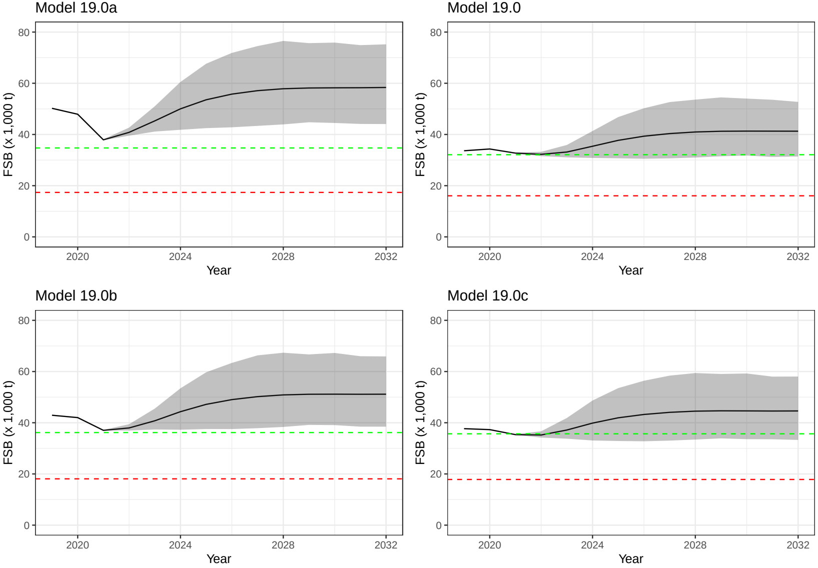
Age 1 estimated recruitment (x 1,000) from 1990-2019 with 95% credible intervals.



Estimated numbers at age of Aleutian Islands cod (x 1,000), based on Model 19.0.



Projected female spawning biomass and fishing at the 5-year (2014-2018) average, B35%, half of B35%.

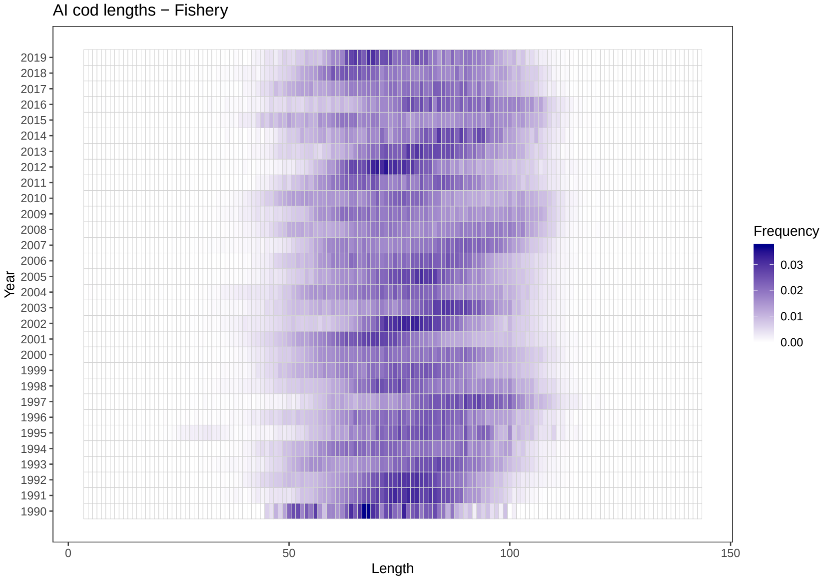


Harvest Specifications for Model 19.0

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2019	2020	2020	2021
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	5	5	3a	3a
Projected total (age 1+) biomass	80,700 t	80,700 t	127,146 t	119,180 t
Projected female spawning biomass	-	-	42,009 t	36,743 t
$B_{100\%}$	-	-	103,330 t	103,330 t
$B_{40\%}$	-	-	41,332 t	41,332 t
$B_{35\%}$	-	-	36,165 t	36,165 t
F_{OFL}	-	-	0.787	0.787
$maxF_{ABC}$	-	-	0.605	0.605
F_{ABC}	-	-	0.605	0.605
OFL	27,400 t	27,400 t	33,008 t	25,419 t
$maxABC$	20,600 t	20,600 t	26,957 t	20,781 t
ABC	20,600 t	20,600 t	26,957 t	20,781 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	-	-	n/a	No
Approaching overfished	-	-	n/a	No

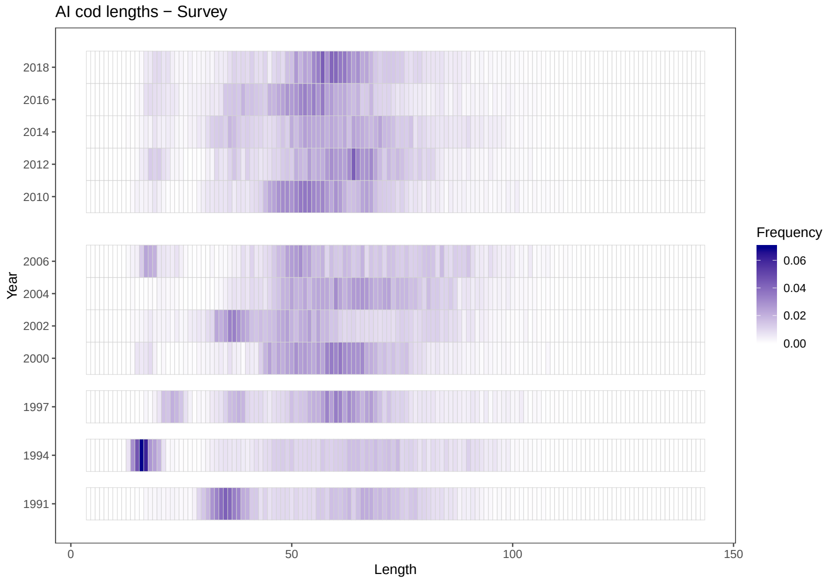
Questions?

Length compositions (cm) from the Aleutian Islands Pacific cod fishery, 1990-2019.

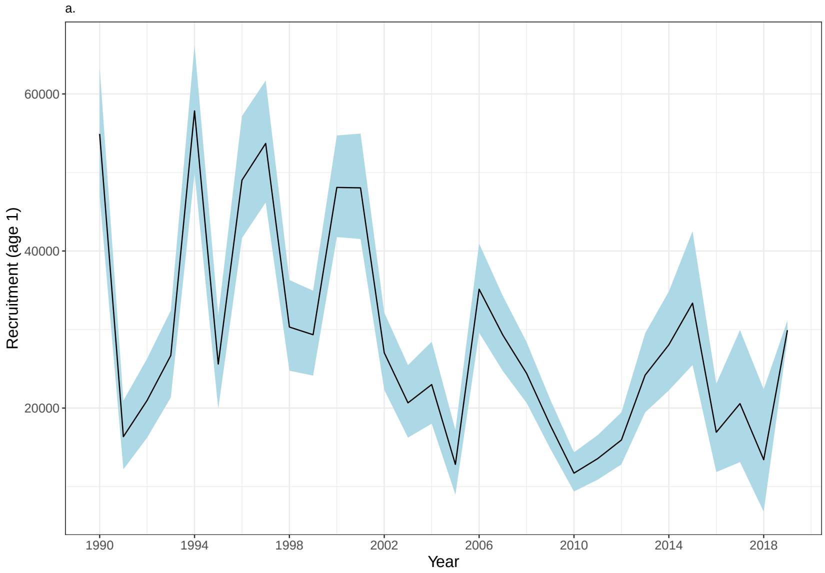


Age composition from the NMFS Aleutian Islands surveys, 1991-2018.

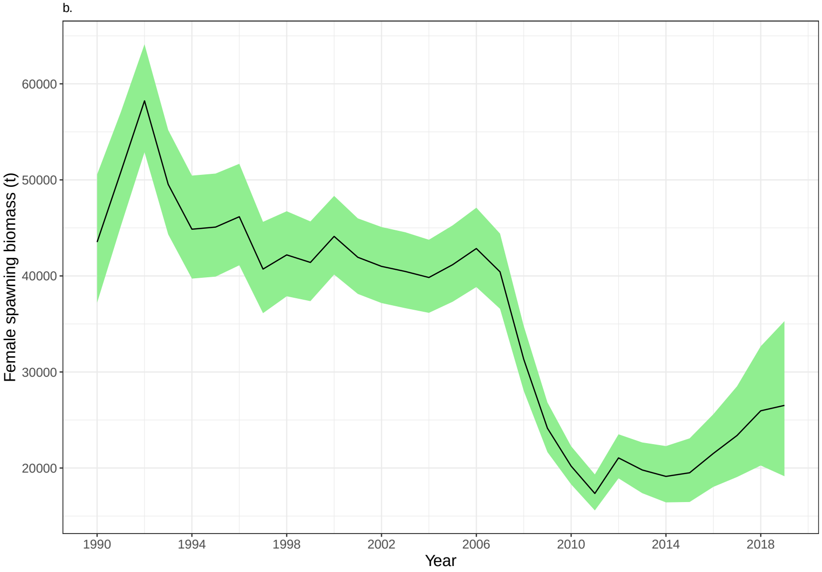
Length compositions (cm) from the NMFS Aleutian Islands surveys, 1991-2018.



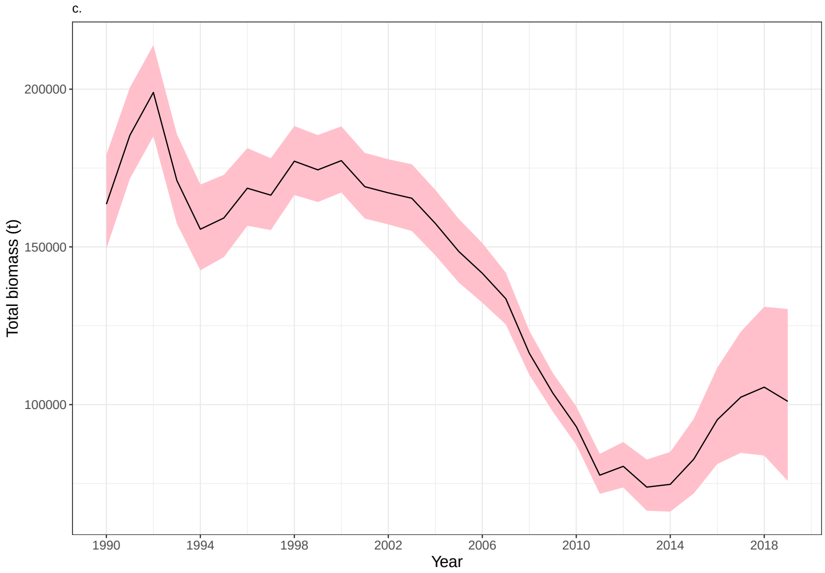
Mean and 95% credible intervals for age 1 recruitment.



Mean and 95% credible intervals for female spawning biomass (t).



Mean and 95% credible intervals for total biomass (t).



Proportion of fishery lengths taken by month for each gear type, 1990-2018.