Bering Sea Aleutian Islands arrowtooth flounder

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- *December 2013:*
  - *SSC accepted the author's and Plan Team's recommended ABCs and OFLs for 2014 and 2015 under Tier 3a using the current model updated with female maturity information based on research by Stark (2011).*
  - *The SSC looks forward to a full analysis of the model results with the old and new data in next year's stock assessment. The assessment should compare the alternative maturity curves, along with their uncertainty.*

- *September 2014, BSAI Plan Team recommended:*
  - *a model that explores selectivity shapes for both the survey and the fishery, including a model with non-parametric selectivity-by-age as an alternative to the logistic model.*
  - *For the selectivity-by-age model, the weightings used in the smoothing penalties should also be explored.*

Changes to Assessment Inputs

1. Survey size composition, biomass, standard deviations: 2013 and 2014 EBS shelf survey, and 2014 AI survey.
2. Fishery size compositions for 2012, 2013, and 2014. Fishery size composition data was also added for 1992-1999.
3. Estimates of catch through October 10, 2014.
4. Age data from the 2010 EBS shelf and 2010 AI surveys, as well as the 2004 shelf survey, which was not previously included.

Changes to Assessment Methodology

1. Fishery selectivity estimated non-parametrically rather than using a 2-parameter logistic function.
2. An additional likelihood component was added to incorporate new Aleutian Islands age data that had not been included in the past.

Summary of Results

	Last year		This year	
Quantity/Status	2014	2015	2015	2016
M (natural mortality – Male, Female)	0.35, 0.2	0.35, 0.2	0.35, 0.2	0.35, 0.2
Specified/recommended Tier	3a	3a	3a	3a
Projected biomass (ages 1+)	1,023,440	995,494	908,379	911,652
Female spawning biomass (t)				
Projected	626,319	632,319	533,731	528,020
$B_{100\%}$	577,538	577,538	555,049	555,049
$B_{40\%}$	231,015	231,015	222,019	222,019
$B_{35\%}$	202,138	202,138	194,267	194,267
F_{OFL}	0.186	0.186	0.180	0.180
$maxF_{ABC}$ (maximum allowable = $F_{40\%}$)	0.156	0.156	0.153	0.153
Specified/recommended F_{ABC}	0.156	0.156	0.153	0.153
Specified/recommended OFL (t)	125,642	125,025	93,856	91,663
Specified/recommended ABC (t)	106,599	106,089	80,547	78,661
Is the stock being subjected to overfishing?	no	no	no	no
Is the stock currently overfished?	no	no	no	no
Is the stock approaching a condition of being overfished?	no	no	no	no

Model Structure

- Length-based model in ADMB.
- Survey and fishery length composition observations used to calculate numbers-at-age using length-age (growth) matrix.
- Age composition can be used.
- Catchability increases with temperature.

Fishing mortality	Selectivity	Temp-q	Year class strength	Total
40	58	5	59	162

Two models for fishery selectivity

- Model 1: Non-parametric; Selectivity is estimated separately for each age, and the shape is constrained to be a smooth function.
- Model 2: Logistic; selectivity is modeled as a two parameter ascending logistic function.

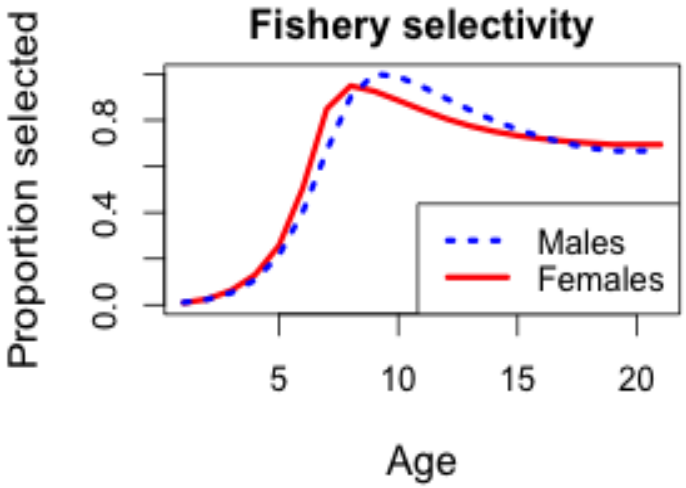
Model 1 is preferred over model 2

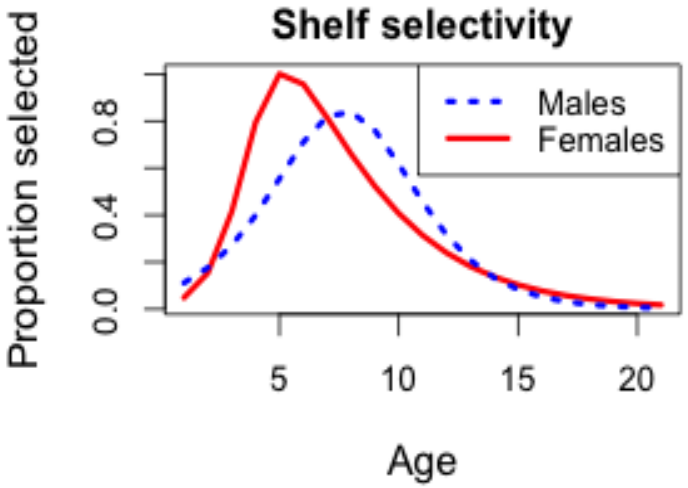
- Lower AIC.
- There are fewer effective parameters than incorporated into the AIC calculation.
- Greatest improvement is in fit to fishery lengths.

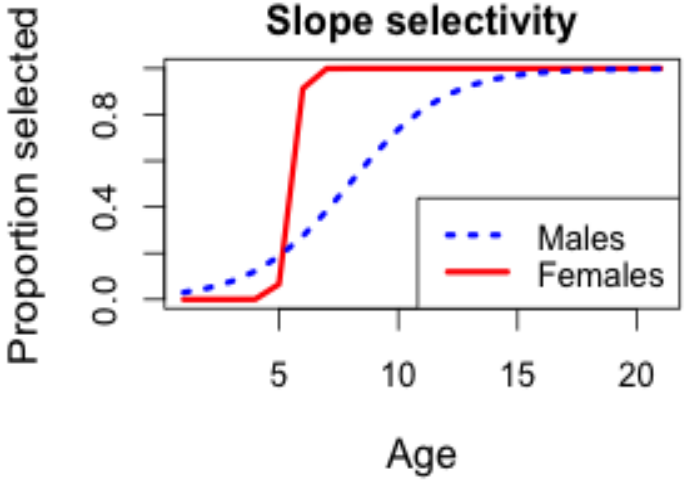
Likelihood components for BSAI ATF model run with Models 1 and 2 (green lower, red higher)

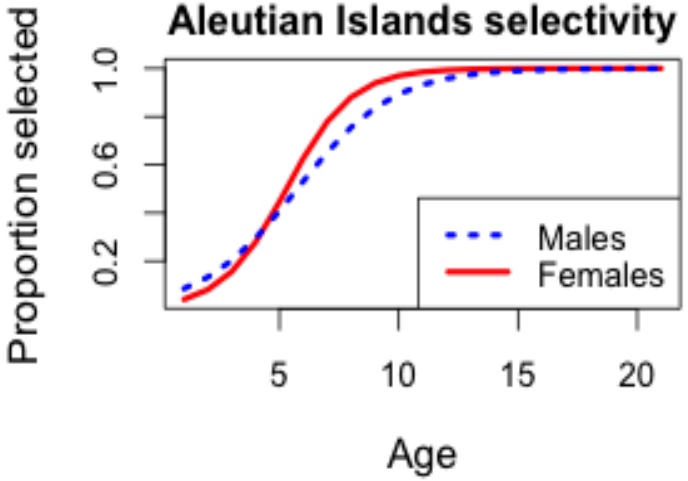
	Non-parametric selectivity (Model 1)	Logistic fishery selectivity (Model 2)
Shelf survey biomass	133.9	134.4
Slope survey biomass	62.6	64.0
AI biomass	47.6	47.2
Shelf survey lengths	1852.0	1854.1
Slope survey lengths	1046.0	1042.5
AI survey lengths	1087.3	1083.0
Fishery lengths	280.114	301.2
Recruitment	27.4	27.8
Catch	0.001106	0.001257
Sex ratio	46.6	46.7
Shelf survey ages	140.4	140.4
Total Obj. Fun. value	4753.54	4759.74
Number of Parameters	158	120
AIC	9818.488	9990.455

Non-parametric fishery selectivity

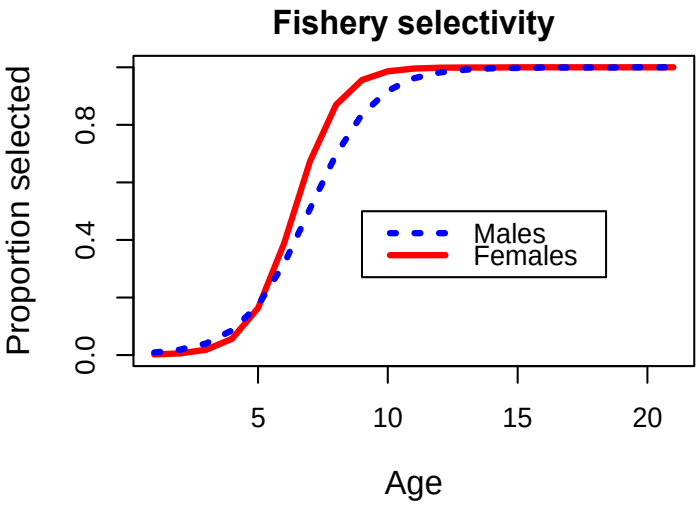


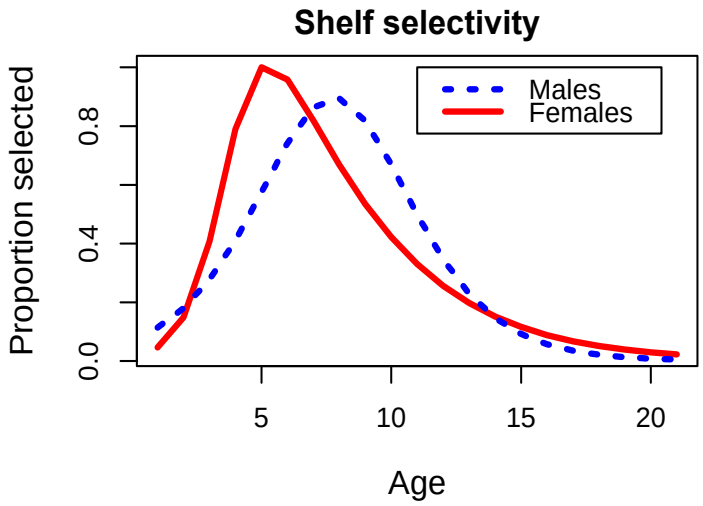


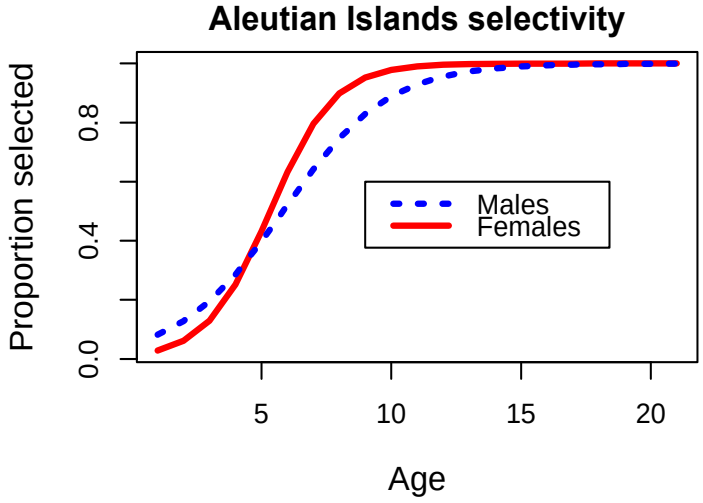




Logistic fishery selectivity



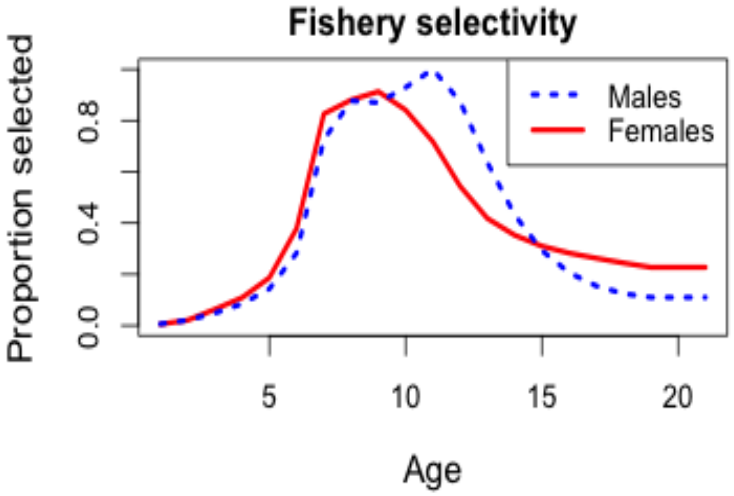


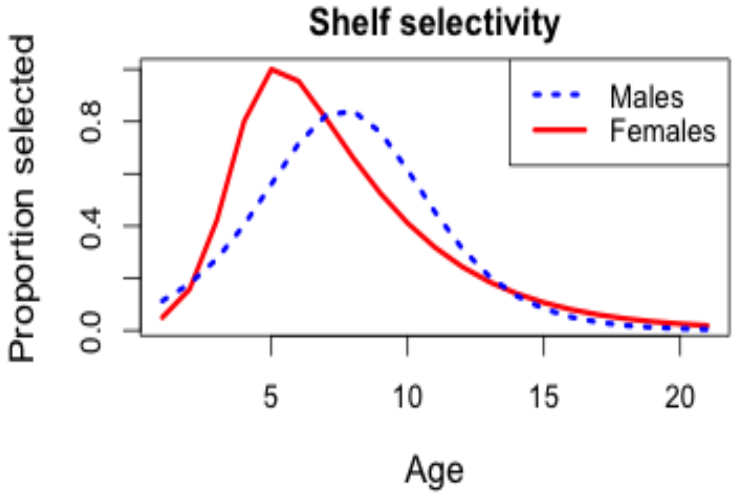


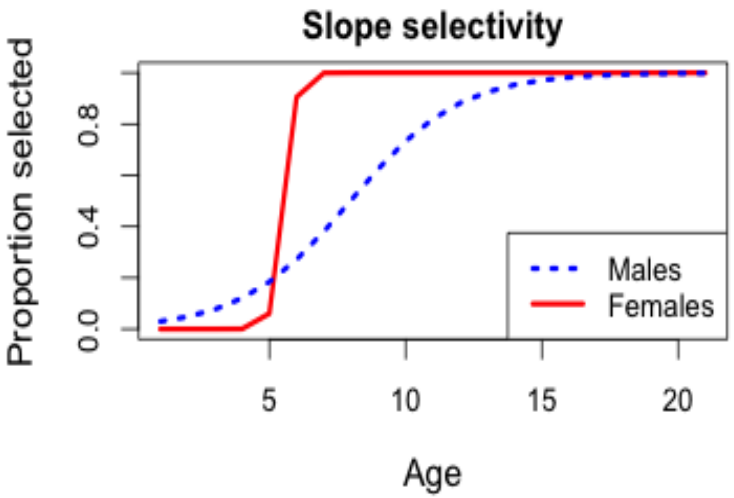
Weightings used in the smoothing and monotonicity penalties (equal weights shown in parentheses)

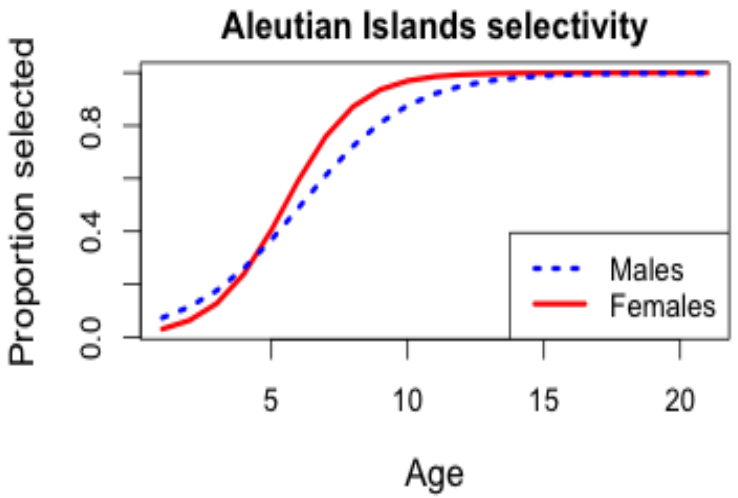
	Fishery female	Fishery male
Smooth selectivity likelihoods	10 (1)	40 (1)
Monotonicity constraint	200 (1)	100 (1)

Non-parametric fishery selectivity with equal weights on likelihood components









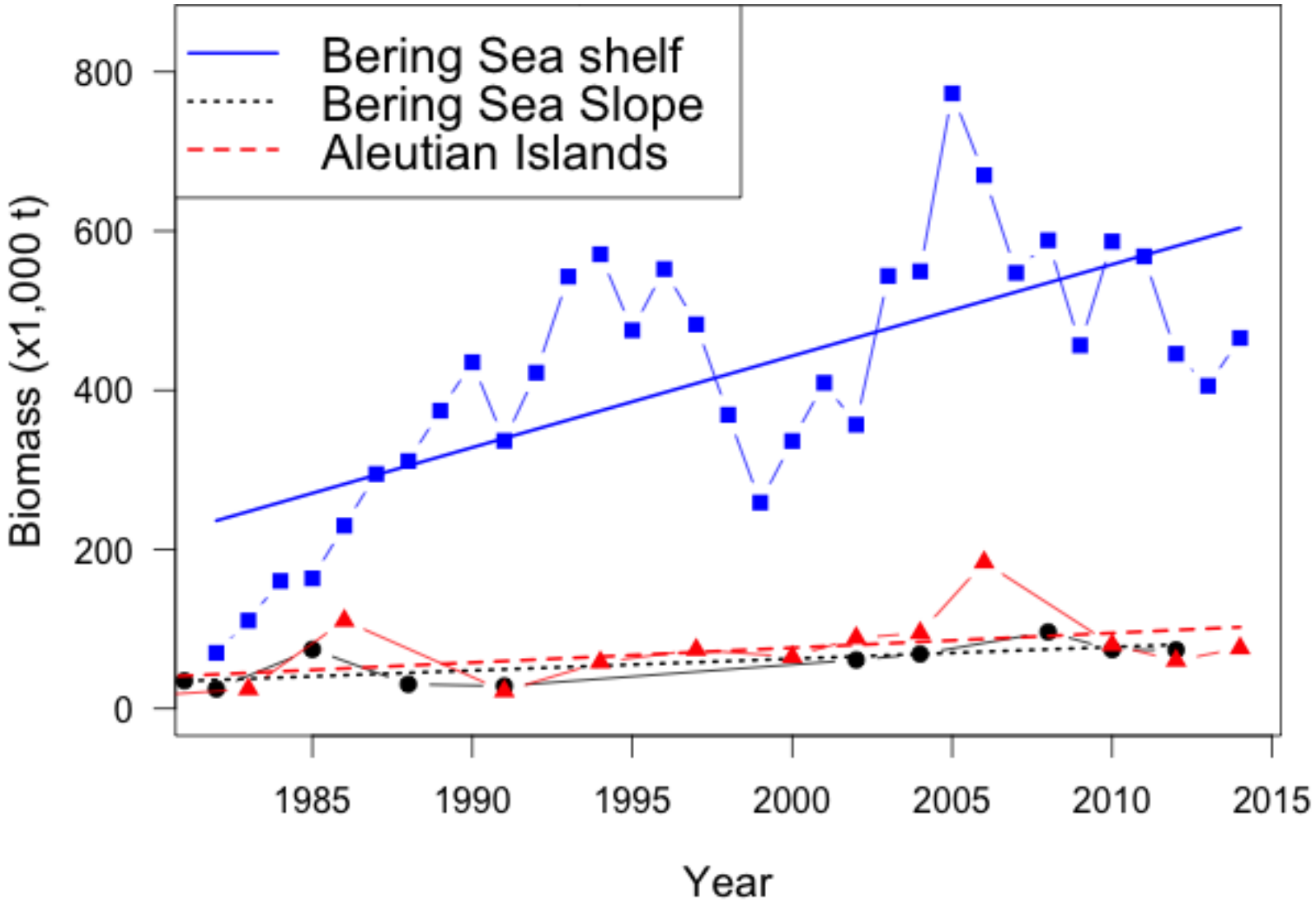
Summary of results for both selectivity models

Quantity/Status	Non-parametric fishery selectivity 2015	Non-parametric fishery selectivity 2016	Logistic fishery selectivity 2015	Logistic fishery selectivity 2016
M (natural mortality – Male, Female)	0.35, 0.2	0.35, 0.2	0.35, 0.2	0.35, 0.2
Specified/recommended Tier	3a	3a	3a	3a
Projected biomass (ages 1+)	908,379	911,652	908,644	912,220
Female spawning biomass (t)				
Projected	533,731	528,020	533,246	527,257
$B_{100\%}$	555,049	555,049	551,587	551,587
$B_{40\%}$	222,019	222,019	220,635	220,635
$B_{35\%}$	194,267	194,267	193,055	193,055
F_{OFL}	0.180	0.180	0.163	0.163
$maxF_{ABC}$ (maximum allowable = $F_{40\%}$)	0.153	0.153	0.138	0.138
Specified/recommended F_{ABC}	0.153	0.153	0.138	0.138
Specified/recommended OFL (t)	93,856	91,663	97,286	98,757
Specified/recommended ABC (t)	80,547	78,661	84,300	83,043
Is the stock being subjected to overfishing?	no	no	no	no
Is the stock currently overfished?	no	no	no	no
Is the stock approaching a condition of being overfished?	no	no	no	no

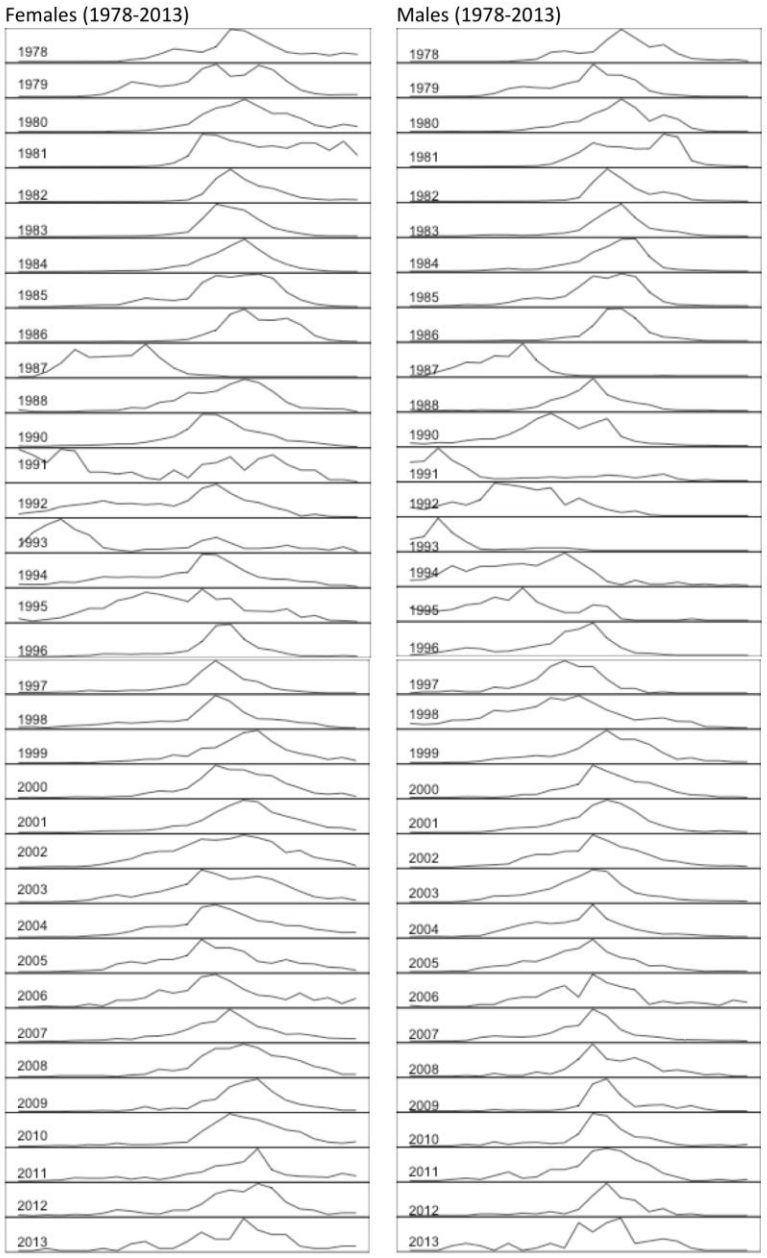
Trends

- Total biomass has declined slightly since 2006 in the EBS slope and shelf surveys, and the Aleutian Islands survey.
- Model indicates female spawning biomass increasing.
- Size composition appears stable.

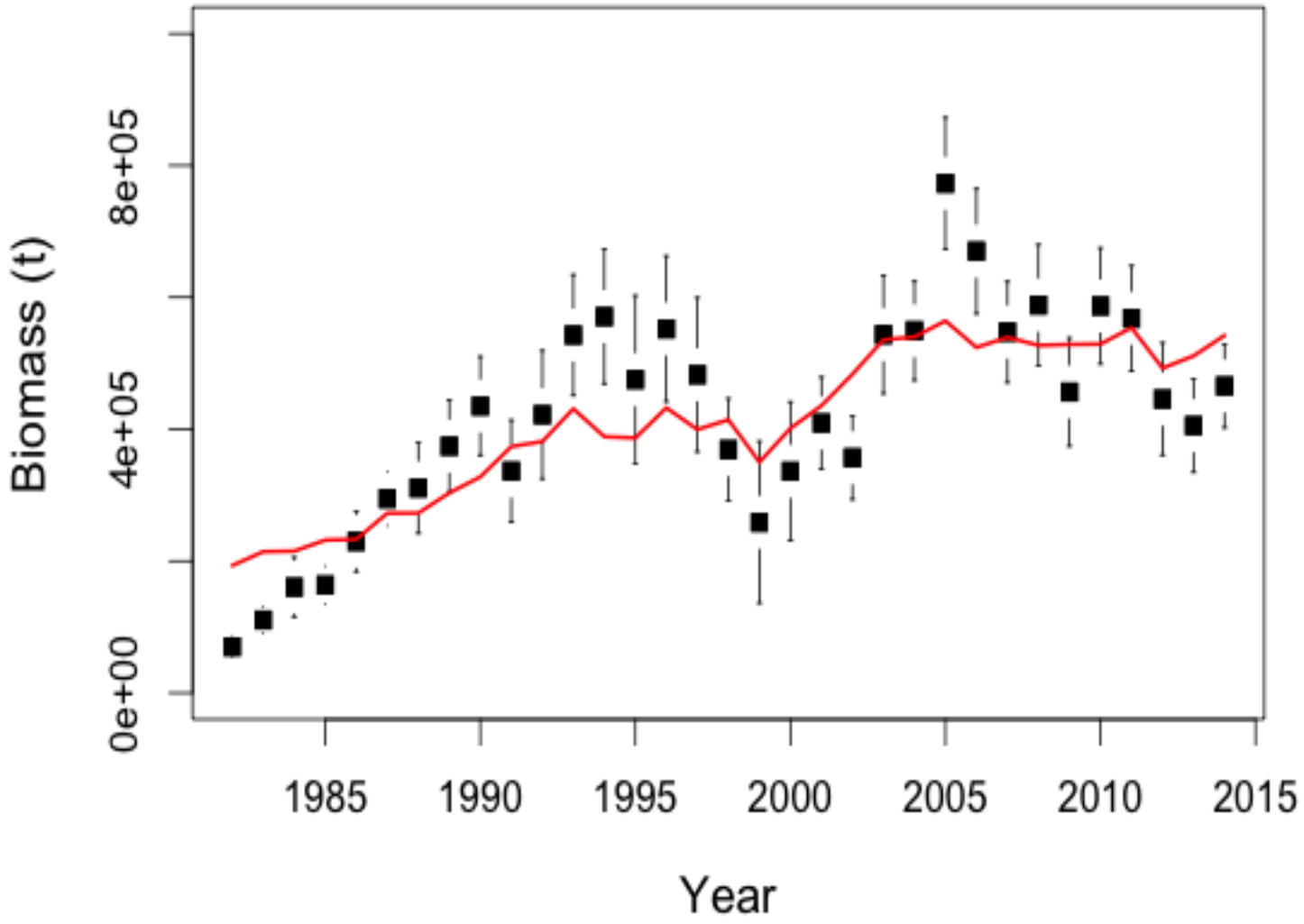
Survey biomass



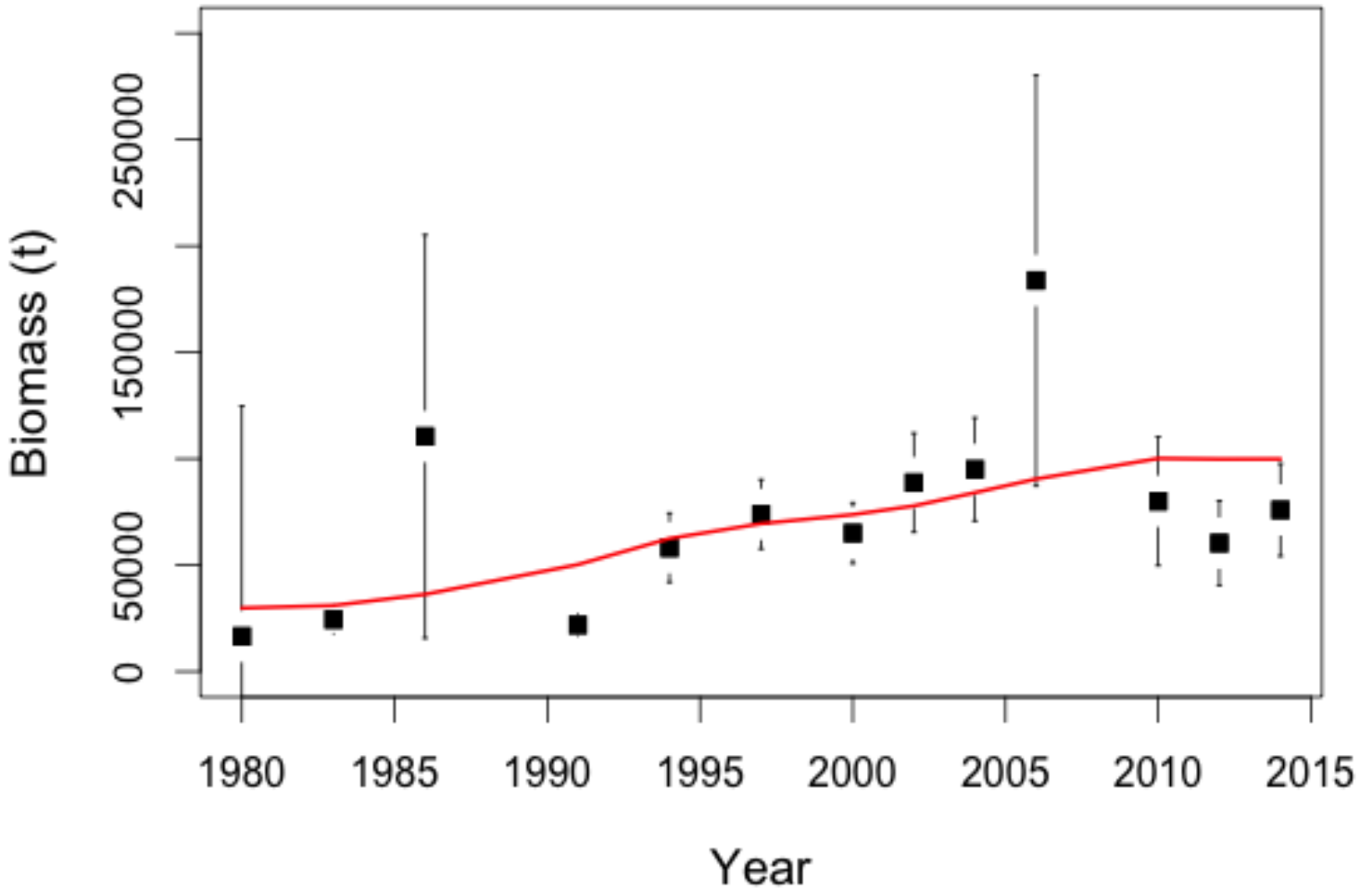
Fishery size compositions



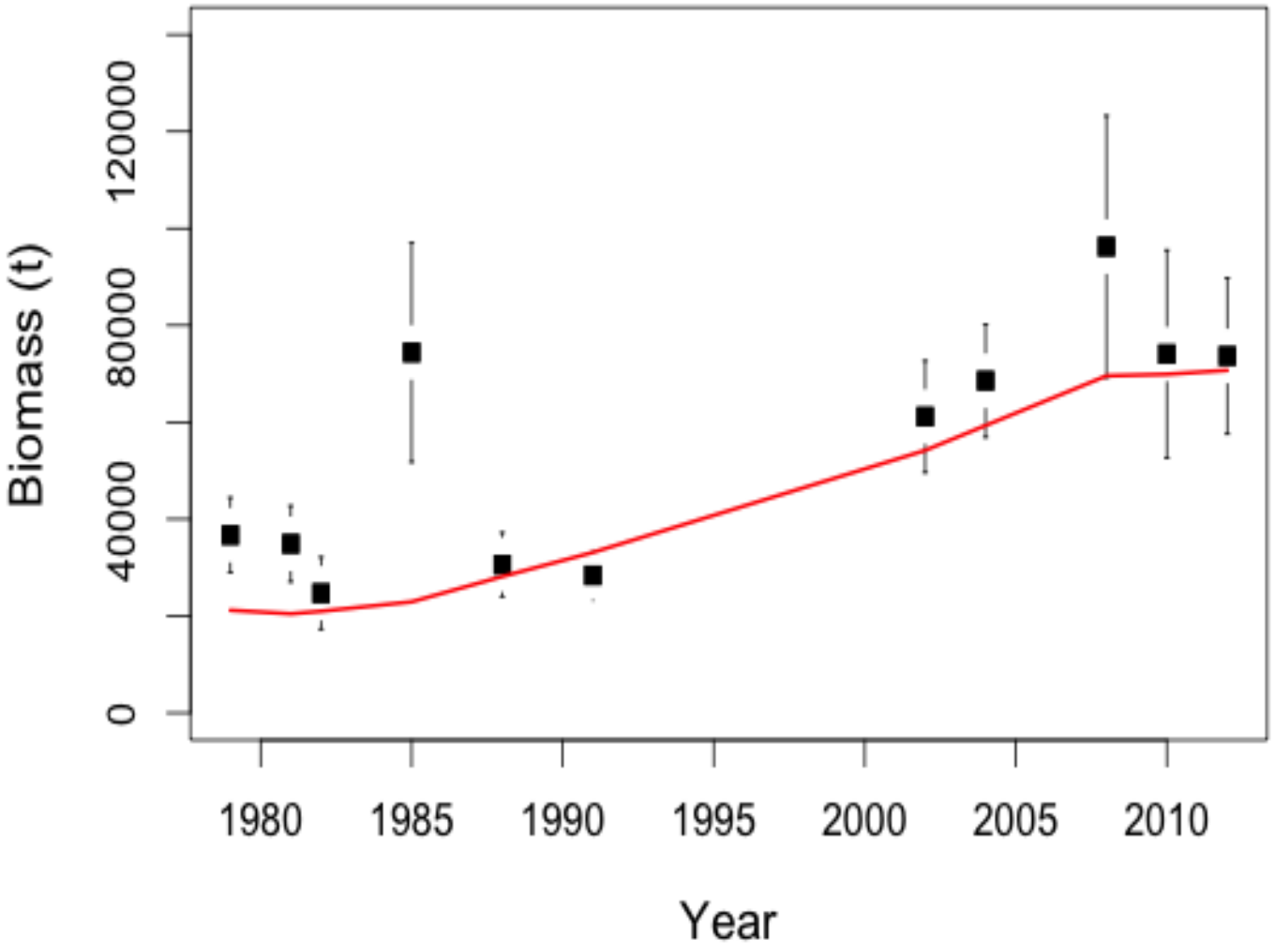
Fit to Bering Sea shelf survey biomass



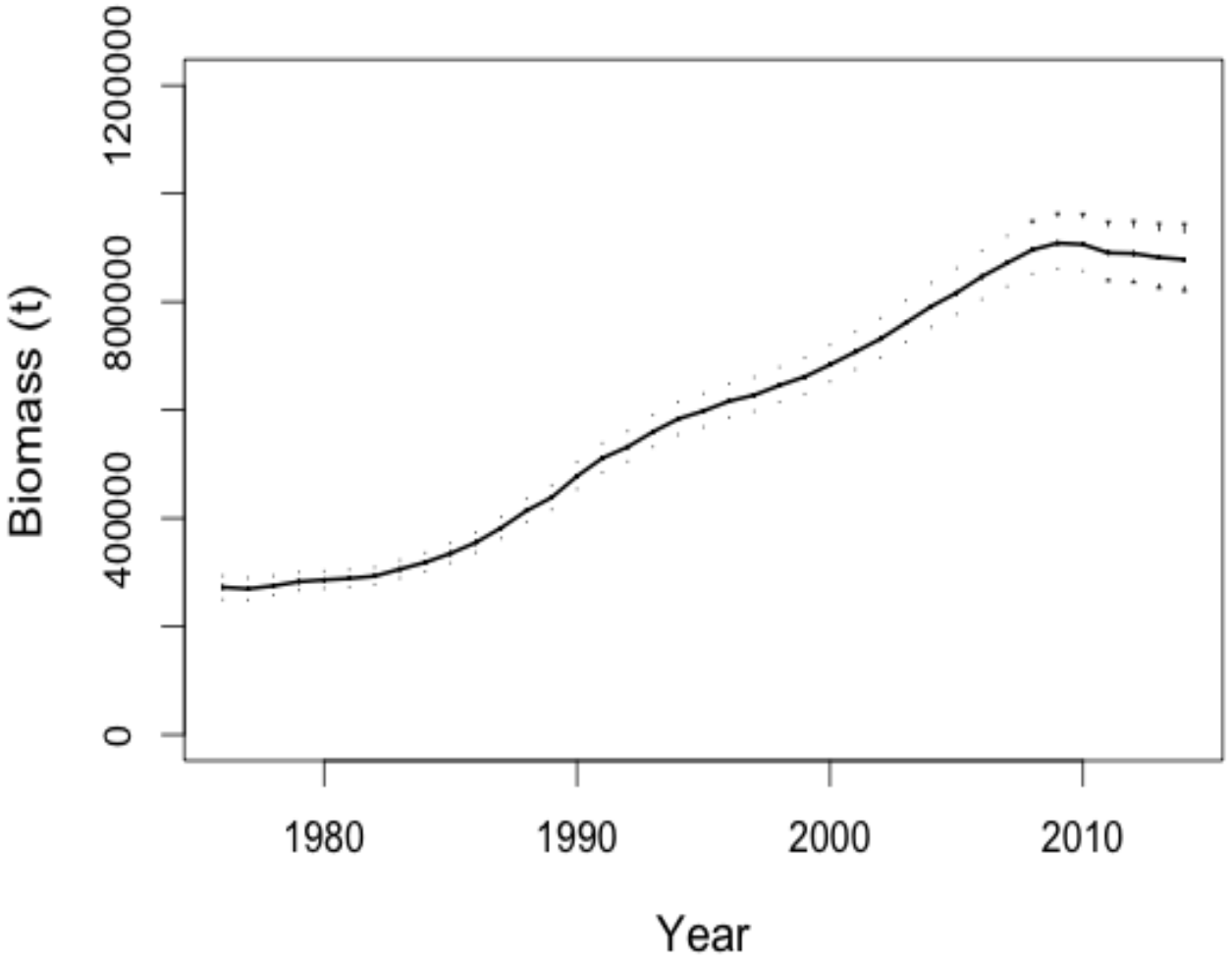
Fit to Aleutian Islands survey biomass



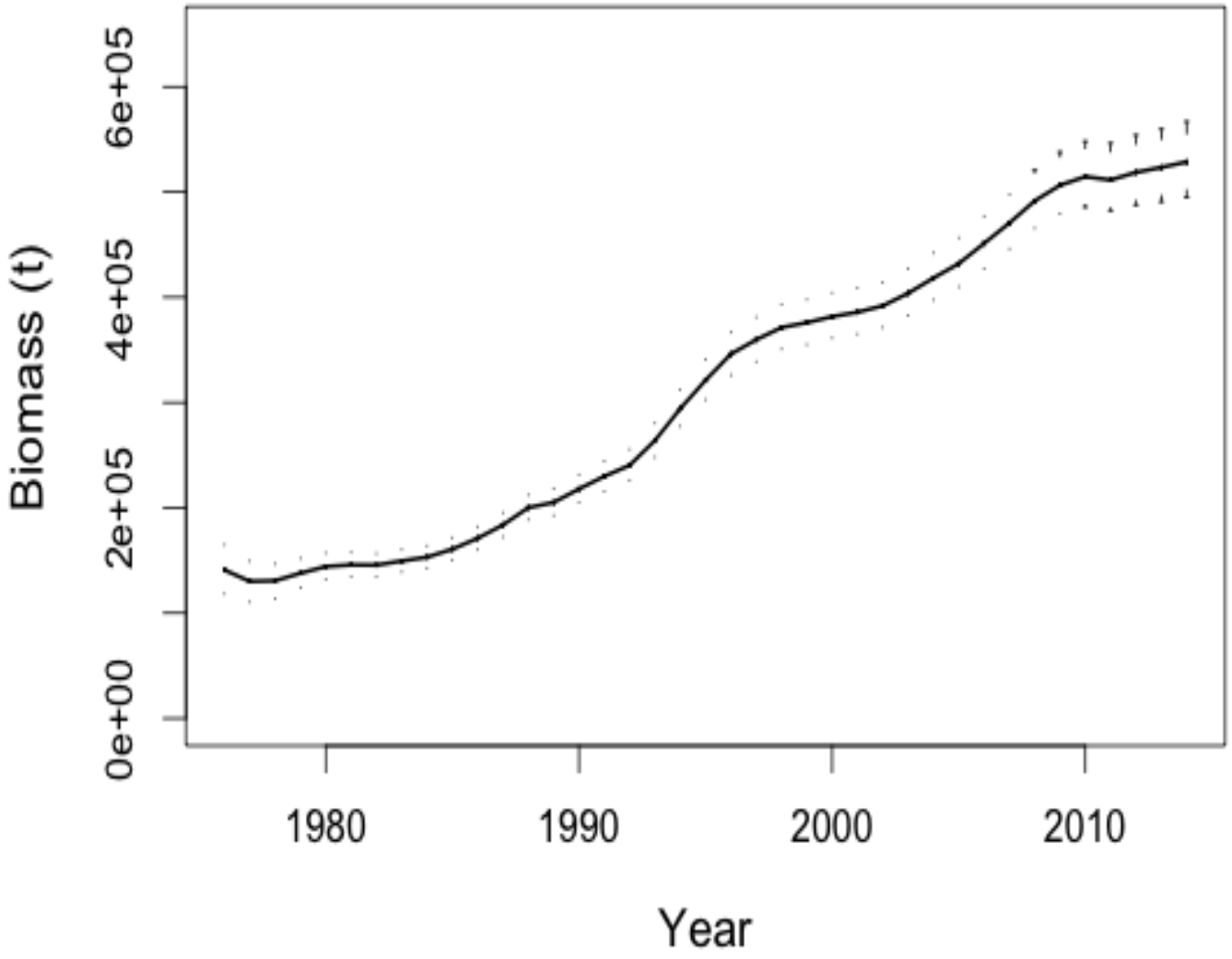
Fit to slope survey biomass



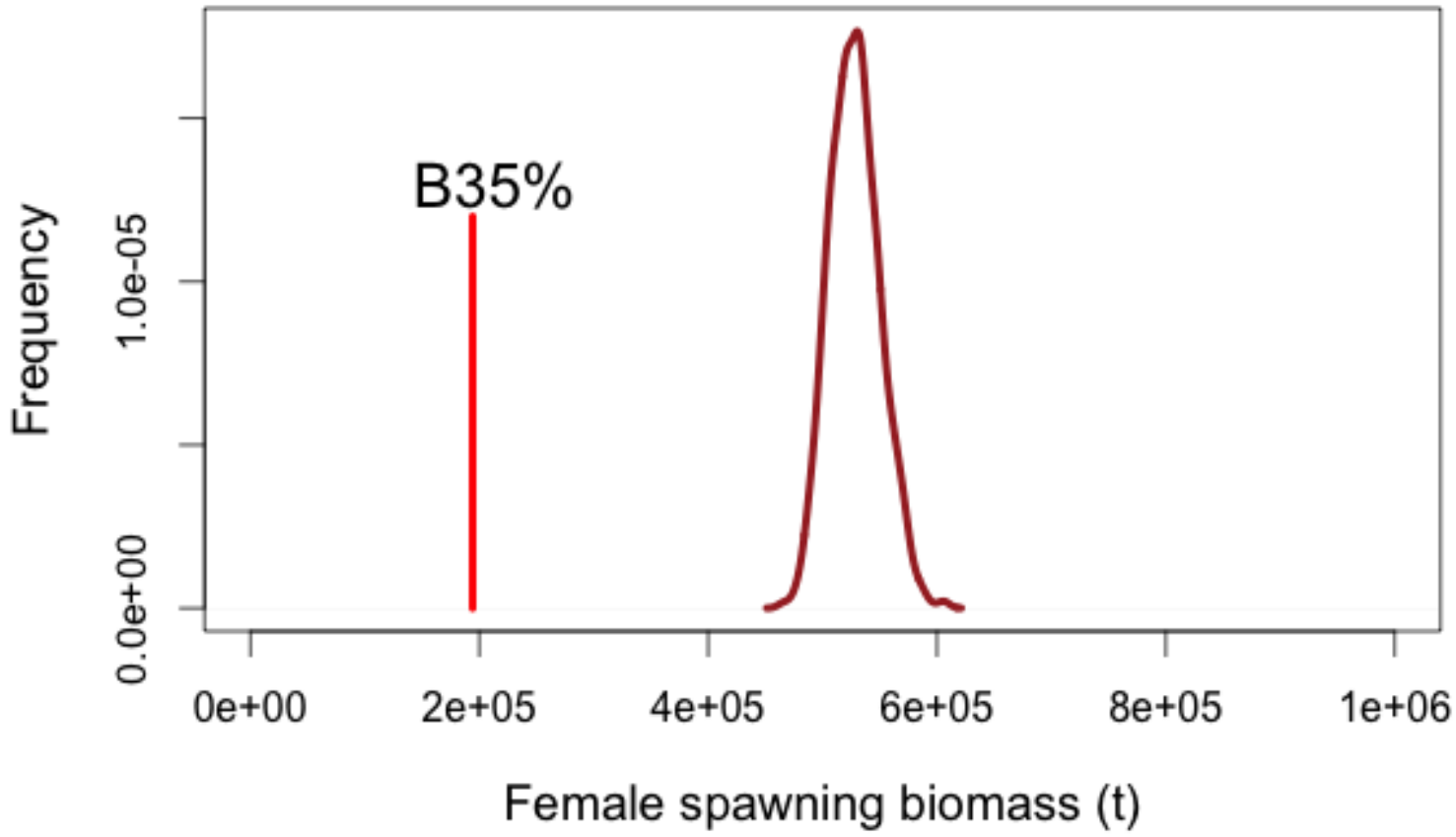
Estimated Total Biomass

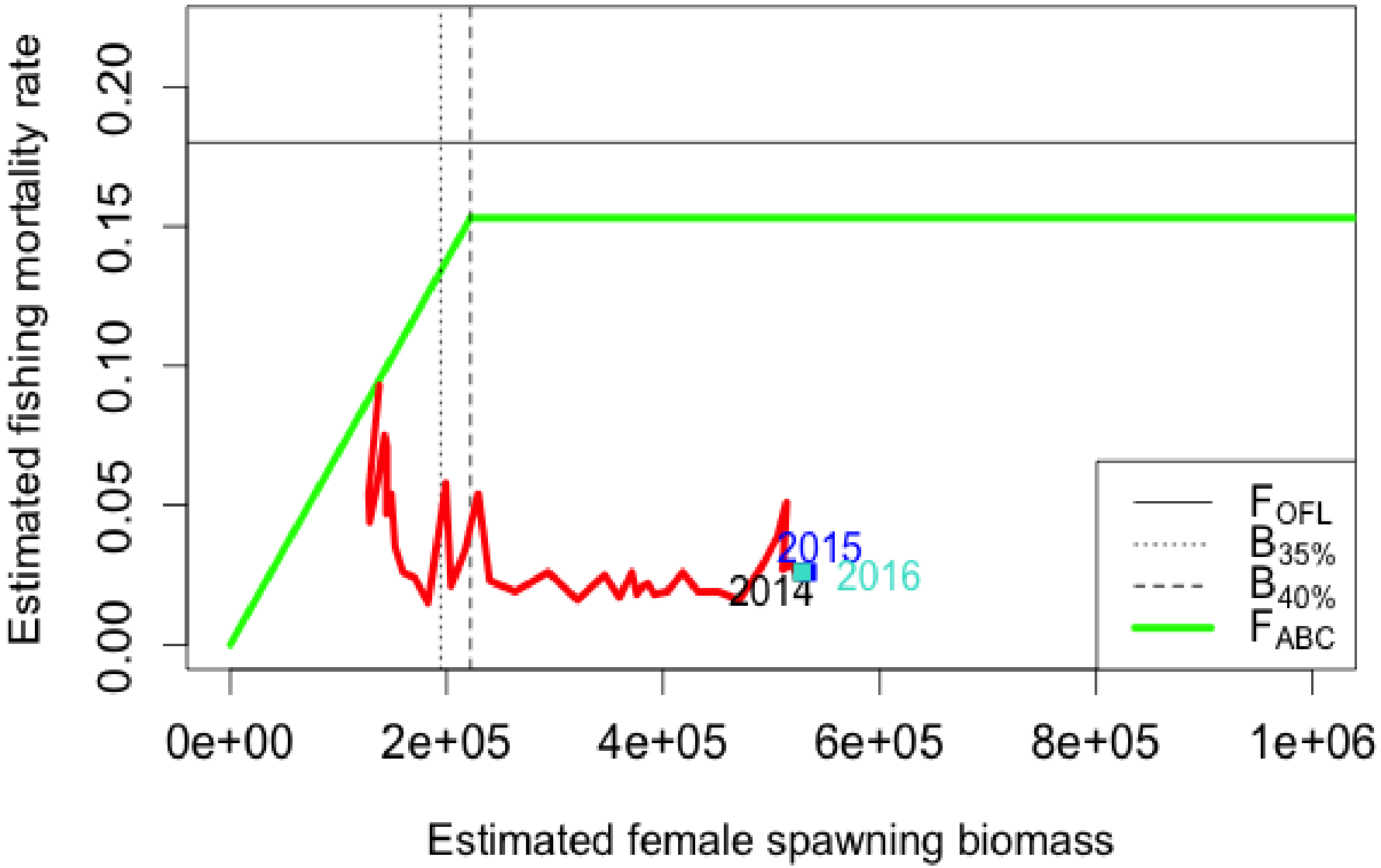


Estimated female spawning biomass



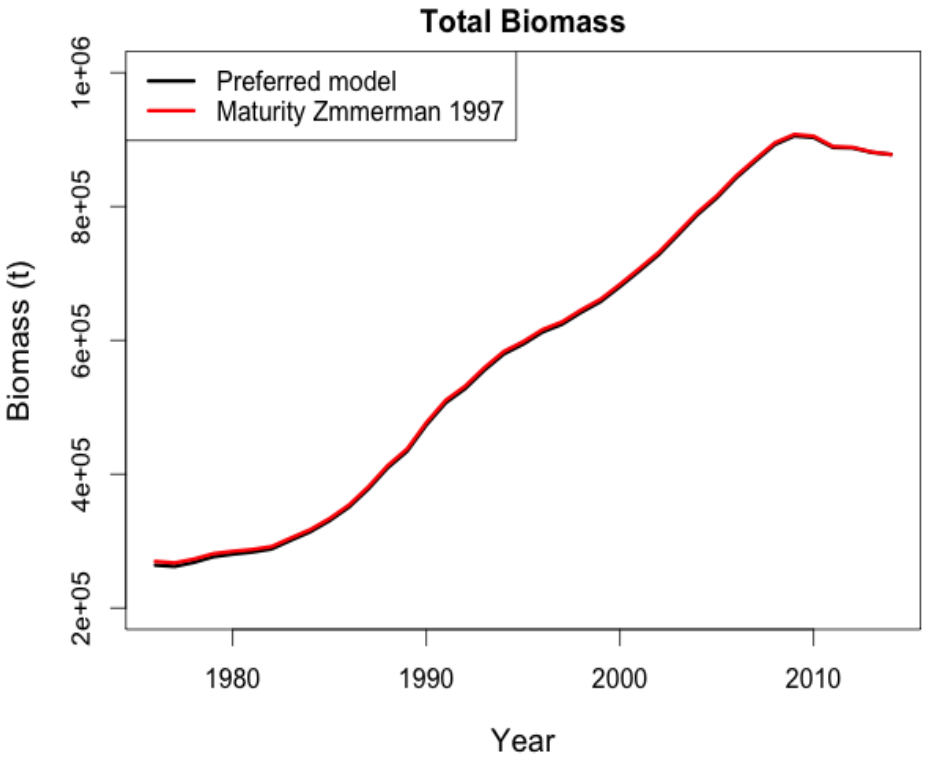
Female spawning biomass is higher than $B_{35\%}$

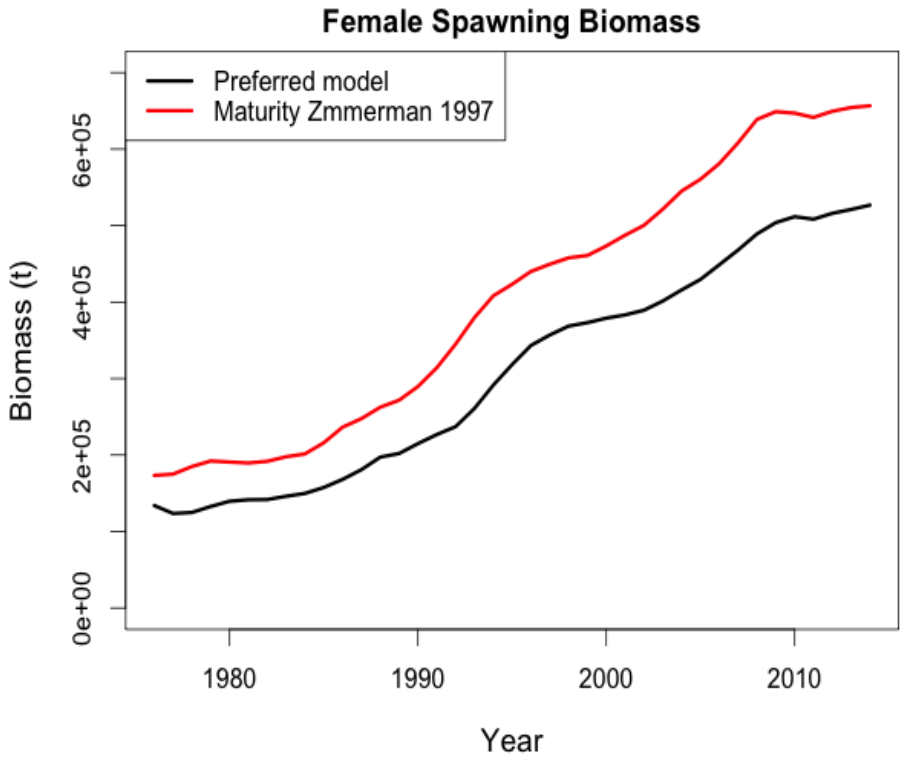



Estimated fishing mortality rate
0.00
0.05
0.10
0.15
0.20
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
Estimated female spawning biomass
2014
2015
2016
F OFL
B 35%
B 40%
F ABC

Maturity-at-age

Total biomass, female spawning biomass



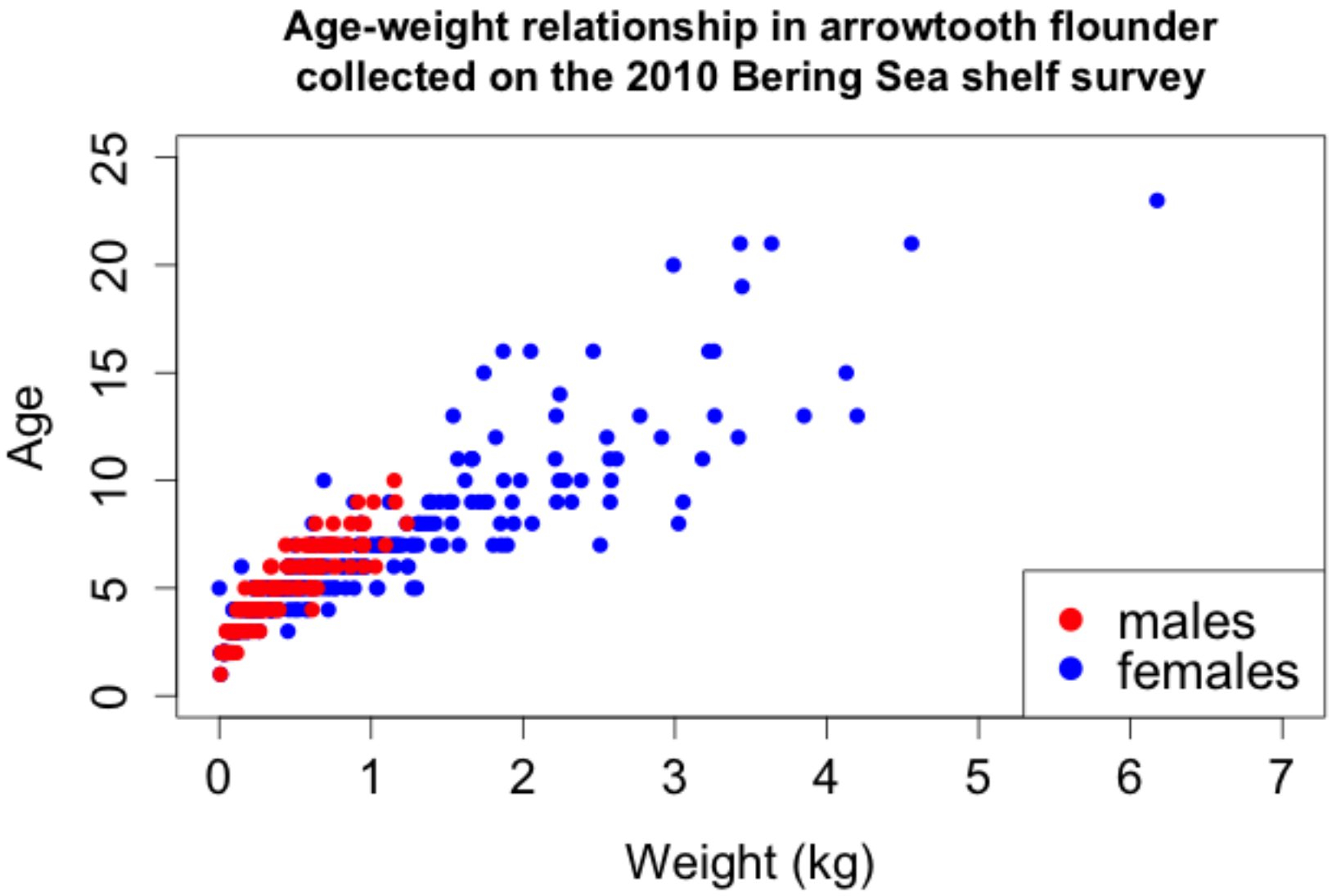


Sex-specific mortality in ATF

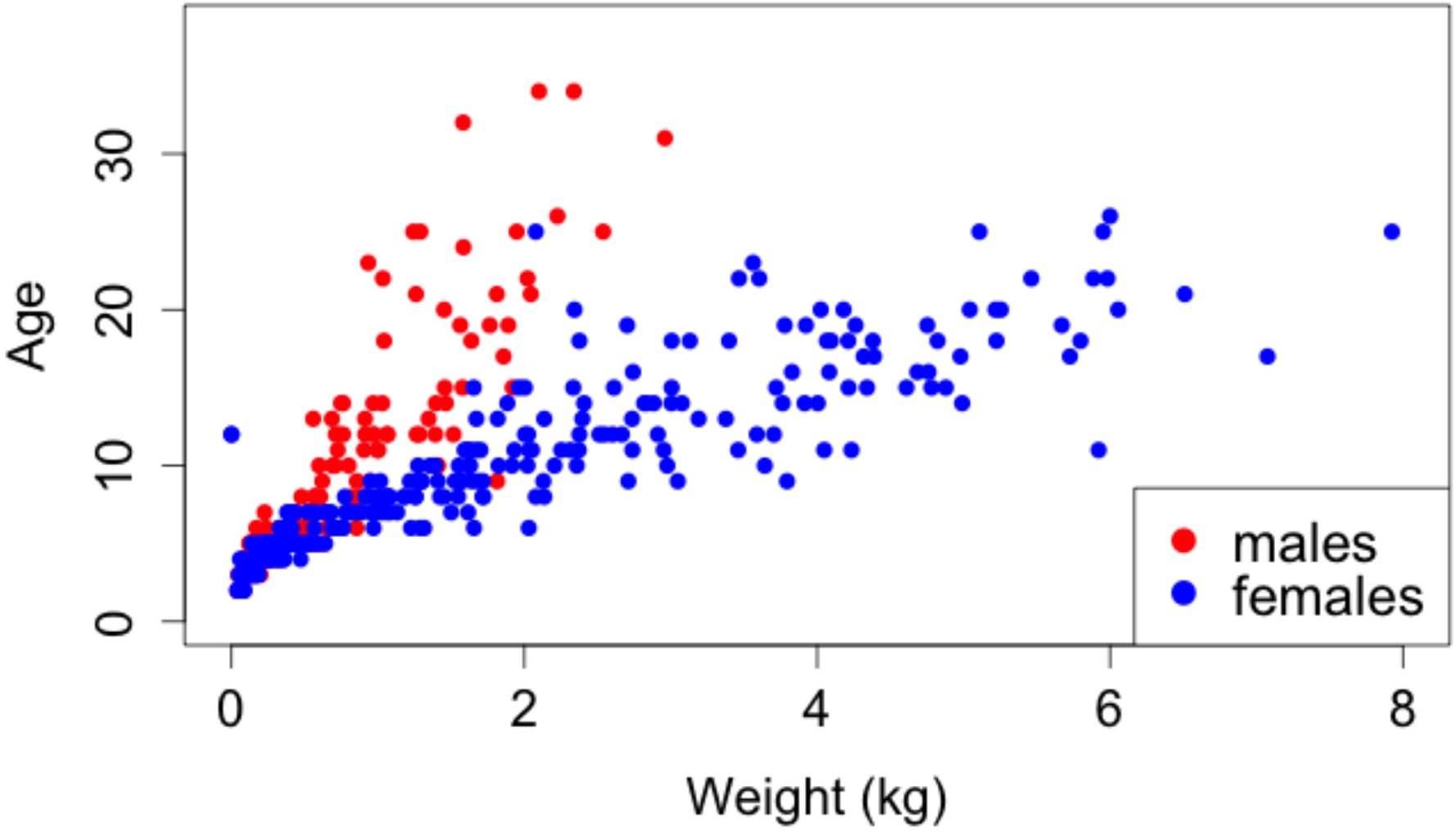
Male estimates for M ranged from 0.24-0.51, female ranged from 0.14-0.33 (Wilderbuer and Turnock 2009).

- Wilderbuer, T., and Turnock, B. 2009. Sex-specific natural mortality of arrowtooth flounder in Alaska: implications of a skewed sex ratio on exploitation and management. N. American Journal of Fisheries Management.29:2, 306-322.

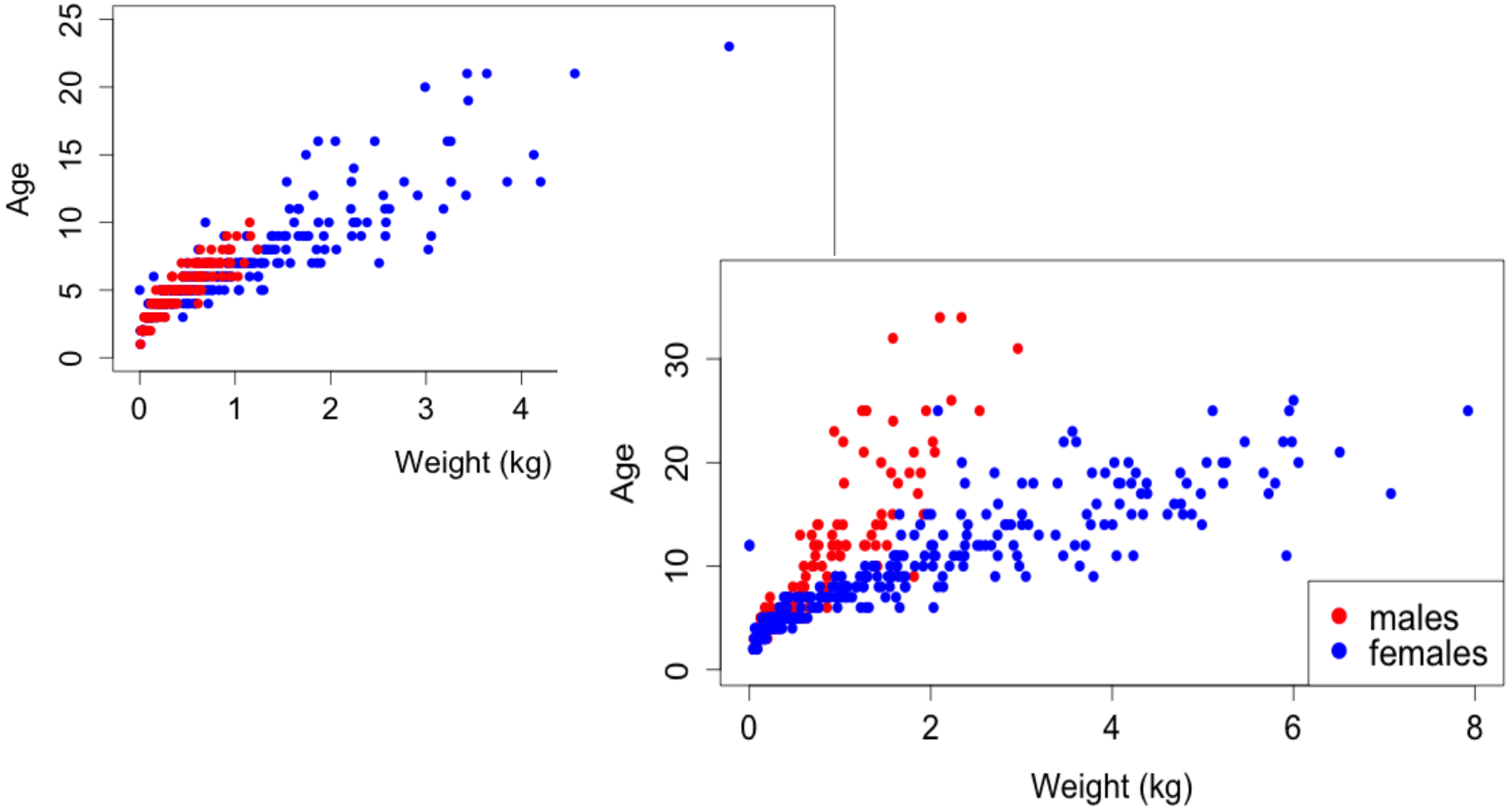
Age-weight relationship from the 2010



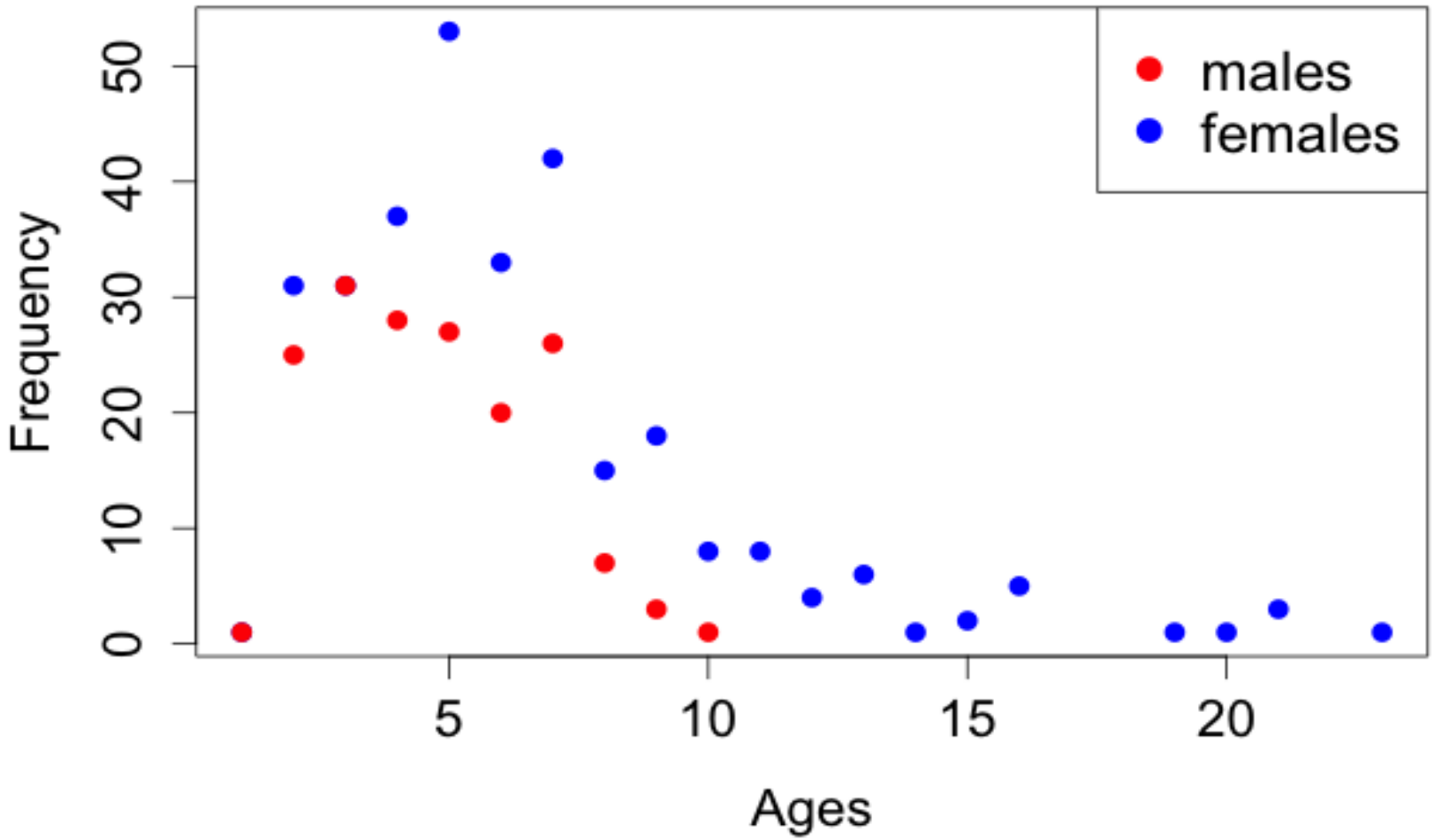
Age-weight relationship in arrowtooth flounder collected on the 2010 Aleutian Islands survey



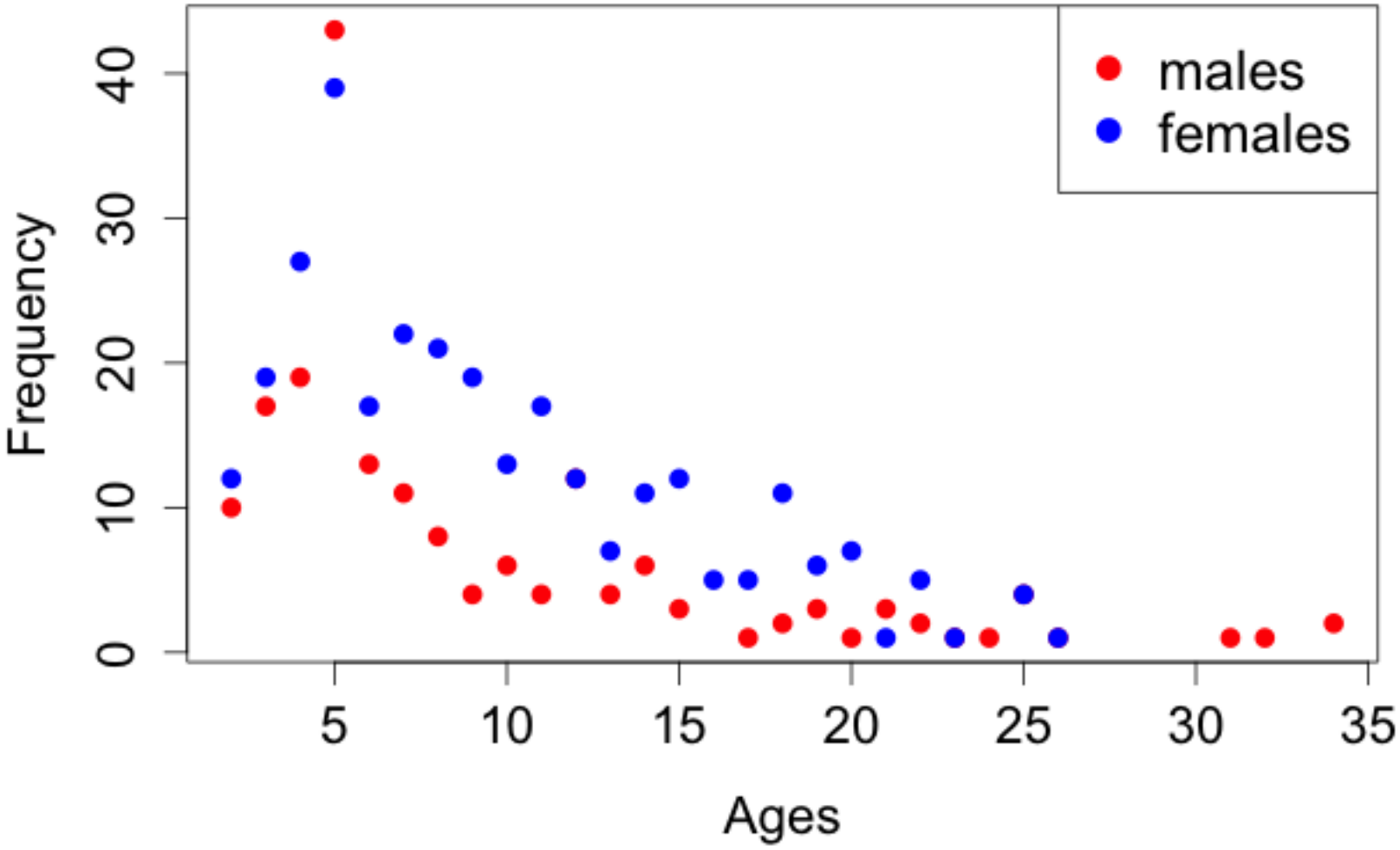
Bering Sea shelf (left), Aleutian Islands (right), 2010 sample



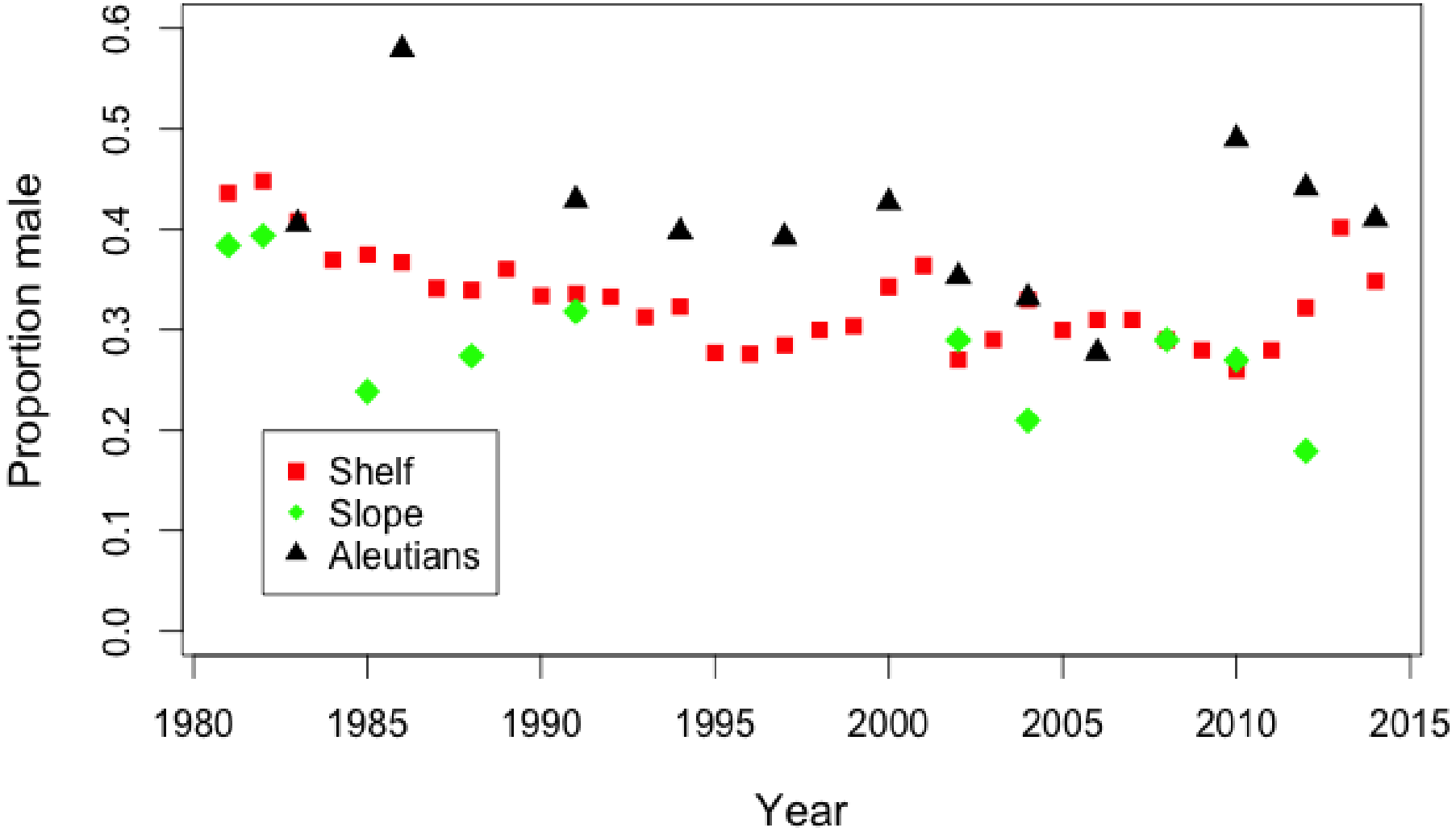
Age frequency data for 2010 EBS shelf sample



Age frequency data for 2010 Aleutian Island sample



Sex ratio in surveys



Summary

- Non-parametric fishery selectivity recommended (little change in reference points).
- Current likelihood weightings are best (in a limited exploration of alternatives).
- Maturity based on Stark (2011) better than Zimmerman (1997).
- New Aleutian Islands age data indicates males may not have higher natural mortality.

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Is the stock being subjected to overfishing?	no	no	no	no
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Is the stock approaching a condition of being overfished?	no	no	no	no

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):

$$\text{likelihood}_{MAR} = -0.5 Hess_T - OFV$$

- AIC was calculated using this marginal likelihood.

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.

Catchability

BSAI

- Catchablity (*q*) has been found to vary with shelf survey bottom temperature (*T*):

$$q = e^{-a+bT},$$

where α and β are a parameters estimated by the model.