Science, Service, Stewardship

Assessment of the Bering Sea and Aleutian Islands arrowtooth flounder

Ingrid Spies

November 15, 2018

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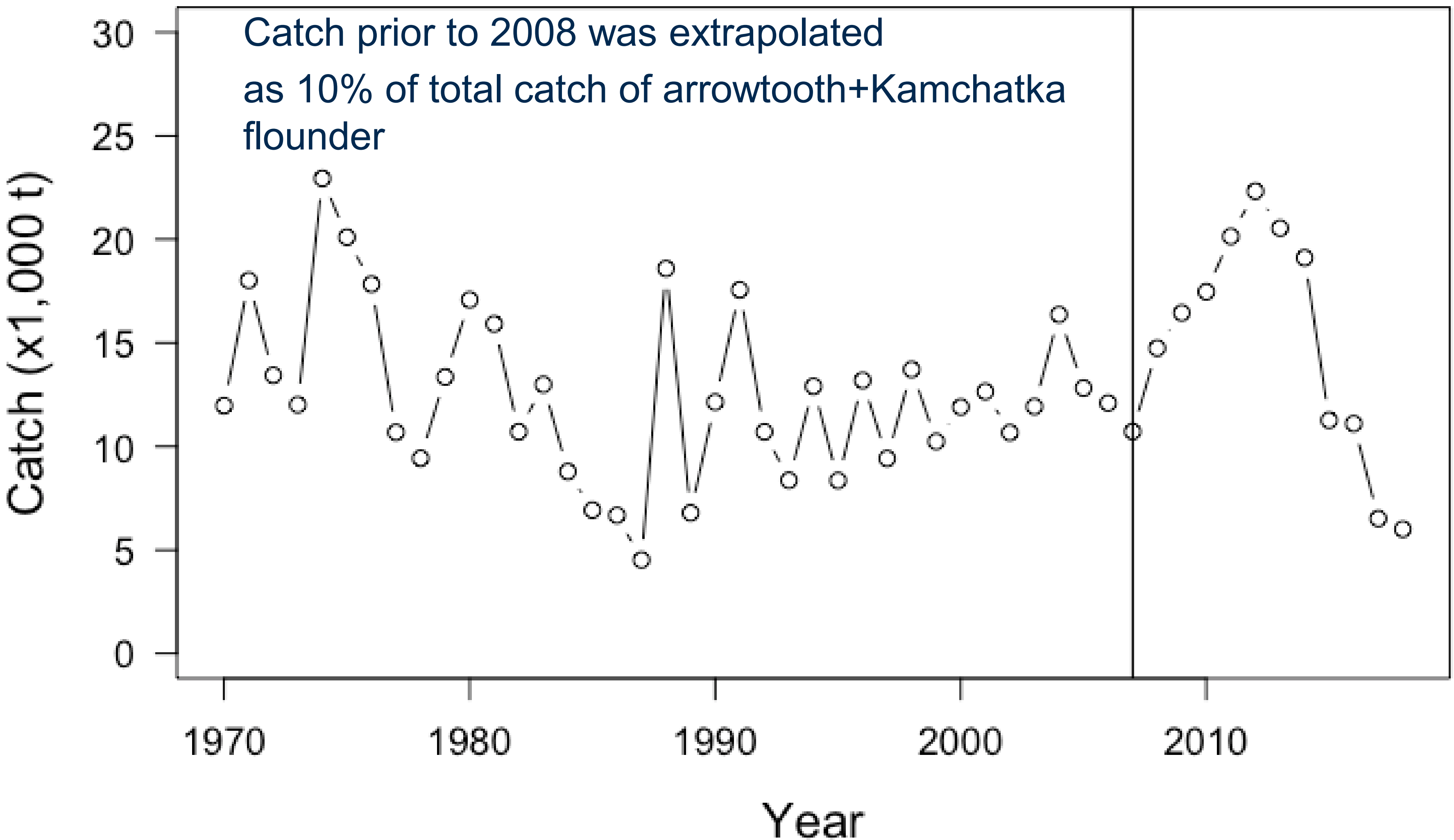
Changes in the input data

- Length compositions from the 2017 and 2018 Eastern Bering Sea shelf survey, and 2018 Aleutian Islands survey.
- Biomass point-estimates and standard errors from the 2017 and 2018 Eastern Bering Sea shelf surveys, and 2018 Aleutian Islands survey.
- Fishery size compositions for 2017 and 2018.
- Estimates of catch through October 19, 2018.
- Estimated total catch of 6,387 t for 2018 and 10,878 t for 2019.
- Age data from the 2016 and 2017 Bering Sea shelf and the 2012 and 2016 Aleutian Islands surveys.
- The final model did not include Bering Sea slope survey data for 1979-1991.

Changes in the assessment methodology

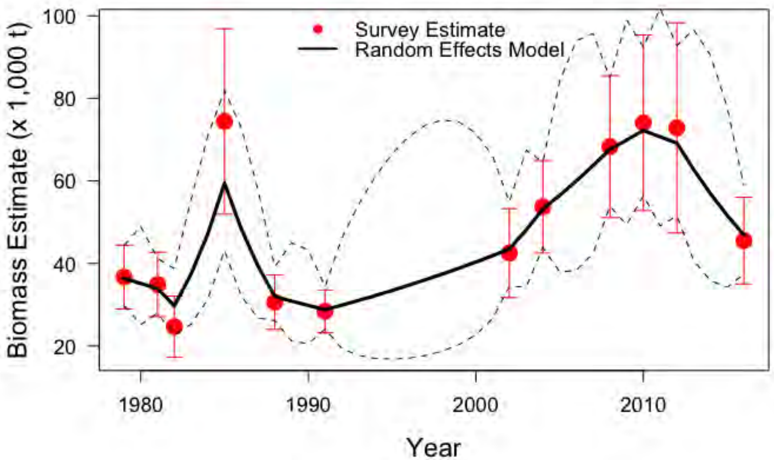
- The model uses a smoothed length-age conversion matrix that corrects for stratified sampling.
- The model uses an ageing error matrix to account for error in age reading.
- Eastern Bering Sea slope data from 1979-1991 was excluded based on concerns about methodology and species identification.

Arrowtooth flounder catch 1970-2018

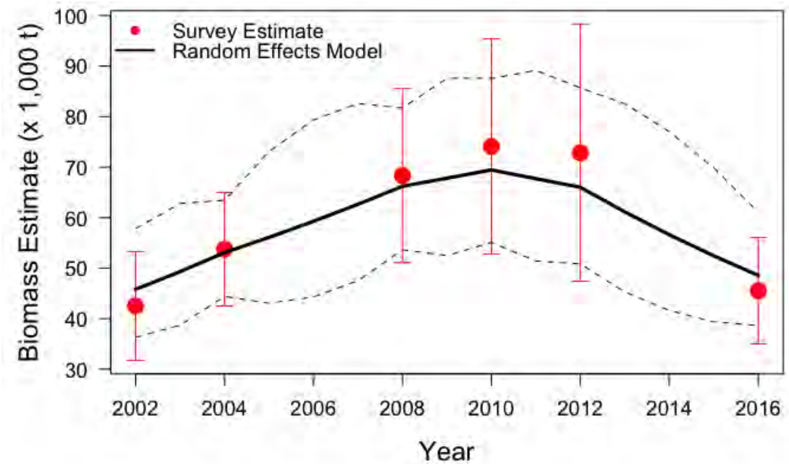


Random effects model fit to survey data

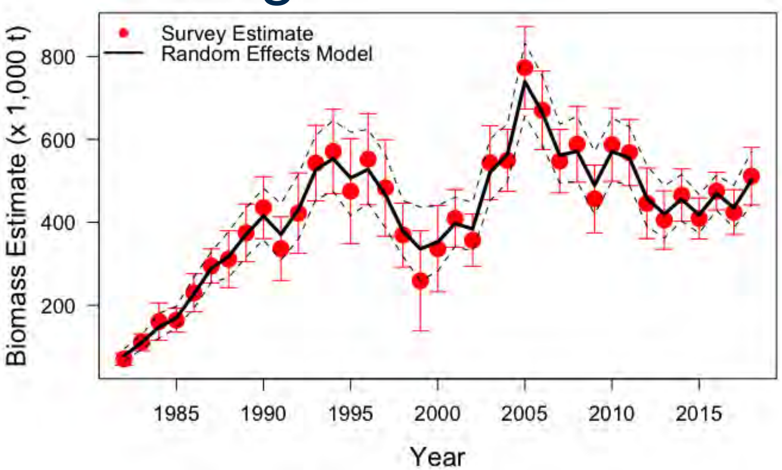
Bering Sea slope (all years)



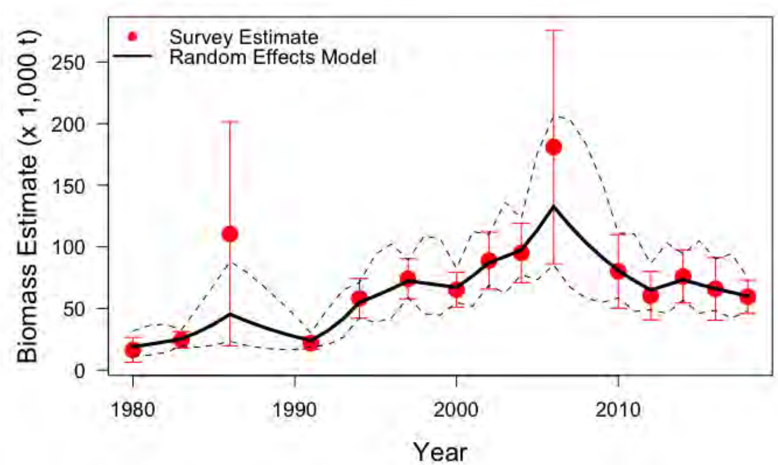
Bering Sea slope (2002-2018)



Bering Sea shelf

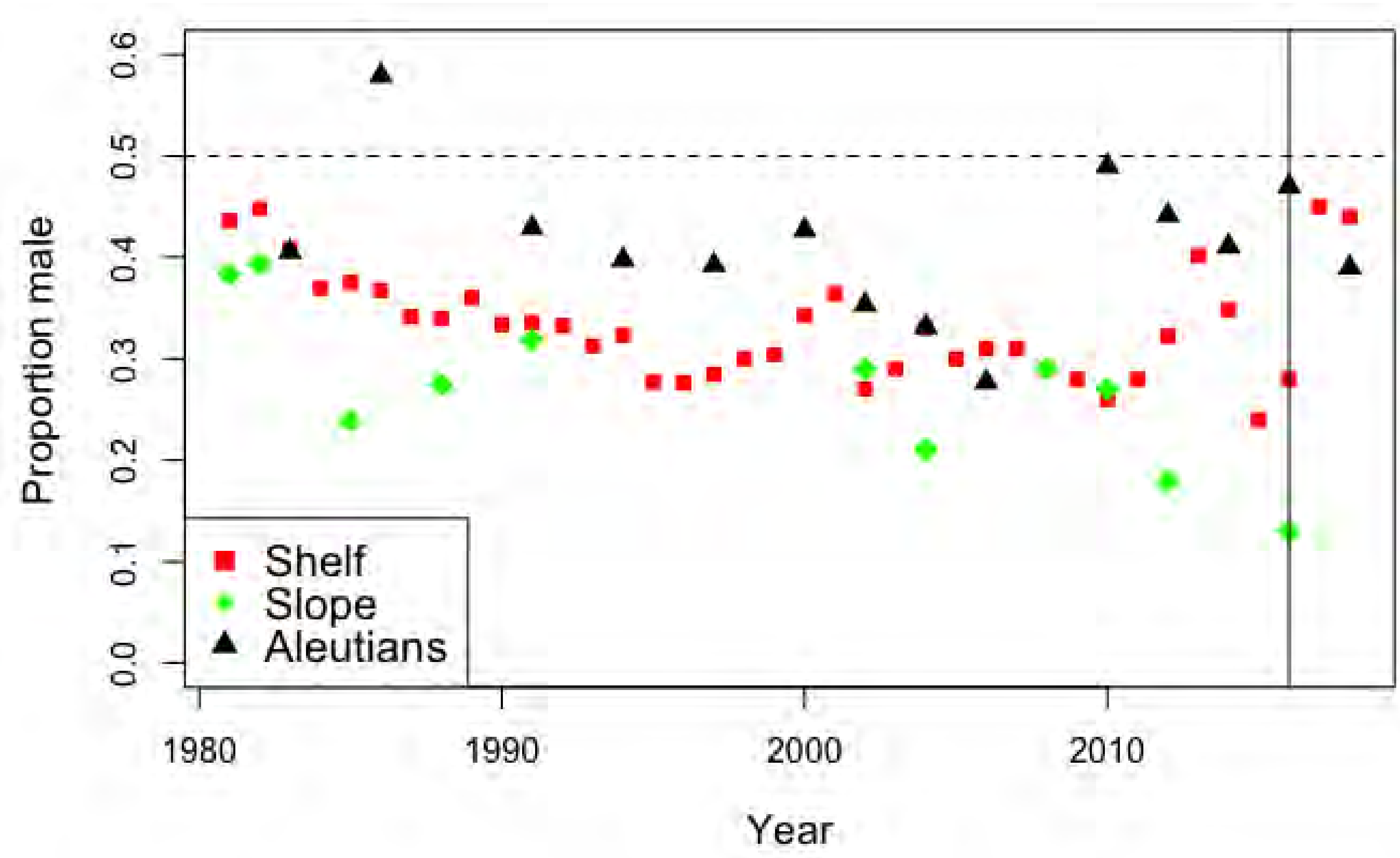


Aleutian Islands

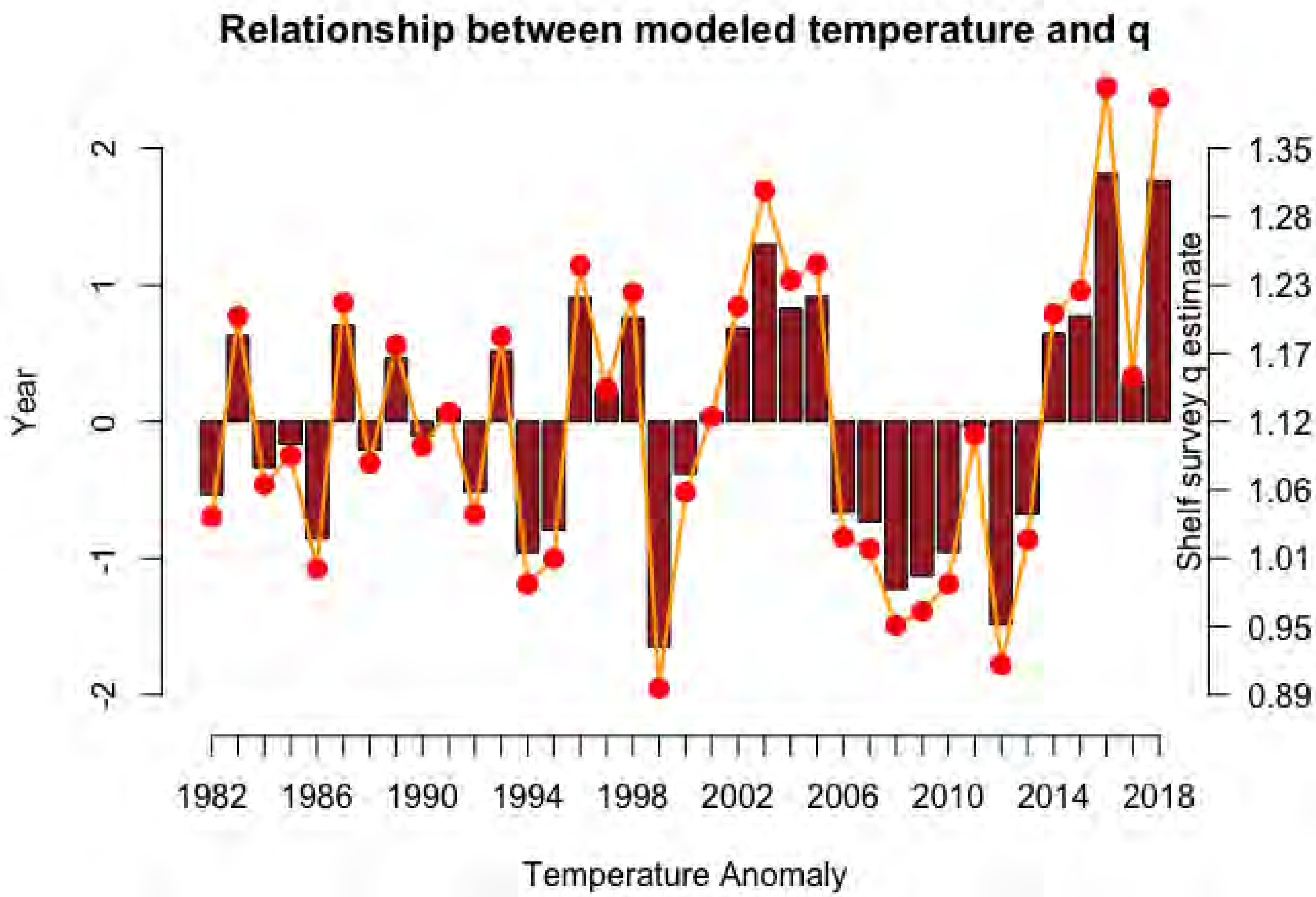


10% in the Aleutians, 82% on the Bering Sea shelf, and 8% on the Bering Sea slope no change when old slope data removed.

Sex ratio closest to 50% in the Aleutian Islands



Bottom temperature relationship to q on the shelf survey



Five models were evaluated, including 3 of the 6 presented in September

15.1b Base model – same as 2015 model.

15.1c Base model with smoothed length age conversion matrix and updated weight at age

18.3 Model 15.1c with an ageing error matrix.

18.6 Model 15.1c with length-based survey selectivity.

18.9 Model 18.3 with early years of slope survey removed (1979-1991).

Flatfish CIE Review April 2017

- Fewer parameters.
- More age data.
- Explore male/female natural mortality.
- Issues with integrating 3 surveys.
- Temperature relationship on EBS shelf catchability - significant?
- "The main weakness of the assessment in terms of assessing stock status is in understanding the stock dynamics immediately preceding the assessment period."

November 2016 Plan Team

- Consider smoothing the age length conversion matrix.
- Ensure that selectivity parameters are not on bounds without reason.

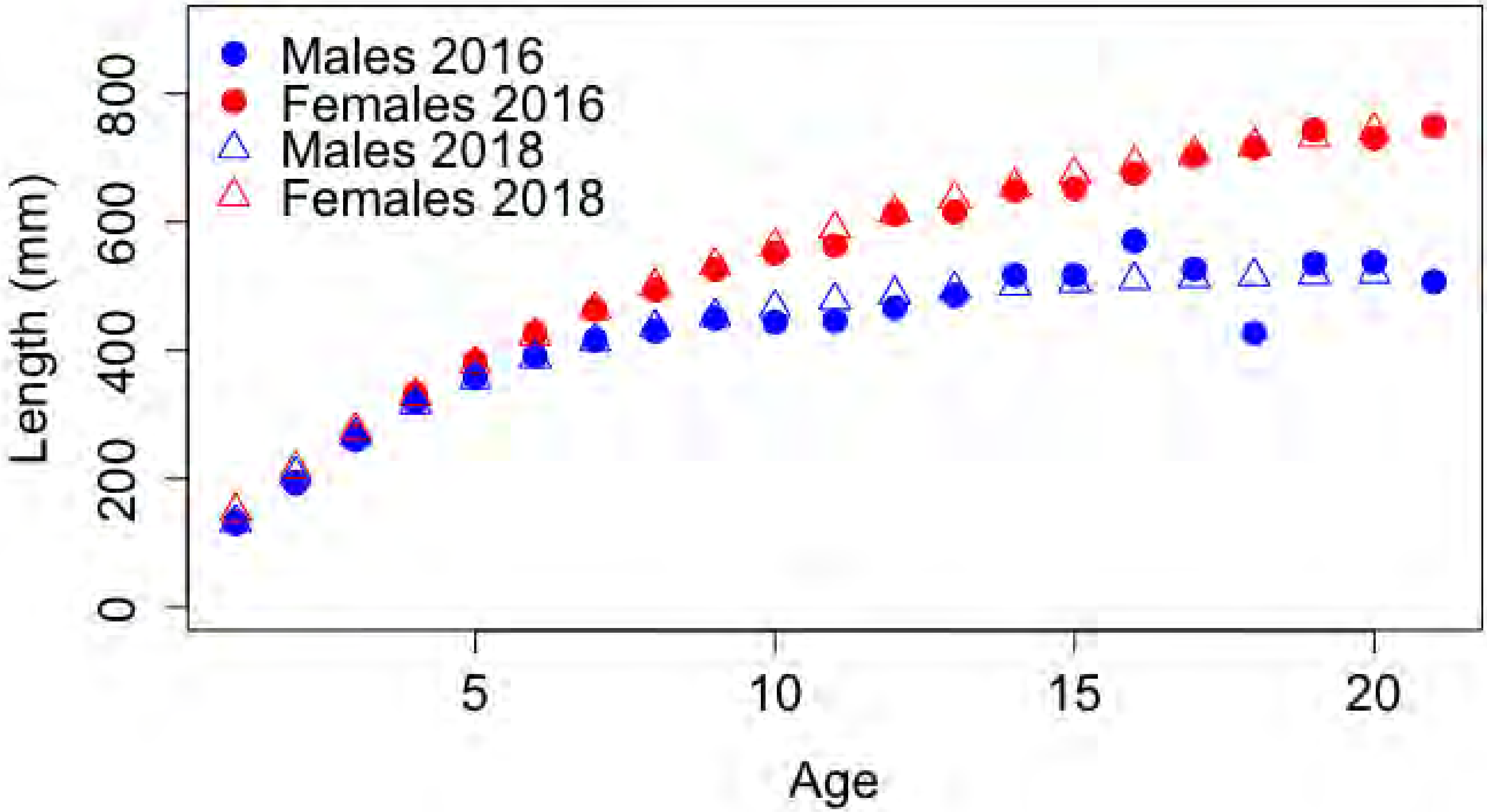
Comments from December 2016 SSC

- Some additional work is indicated for the preferred model for next year's assessment.
- Authors were concerned that some selectivity parameters may be at or near their boundaries.
- They suggested investigating this by considering alternatives for the degree of dome-shaped selectivity curves for the EBS survey.
- Consider smoothing the age-length conversion matrix.

Model 15.1c:

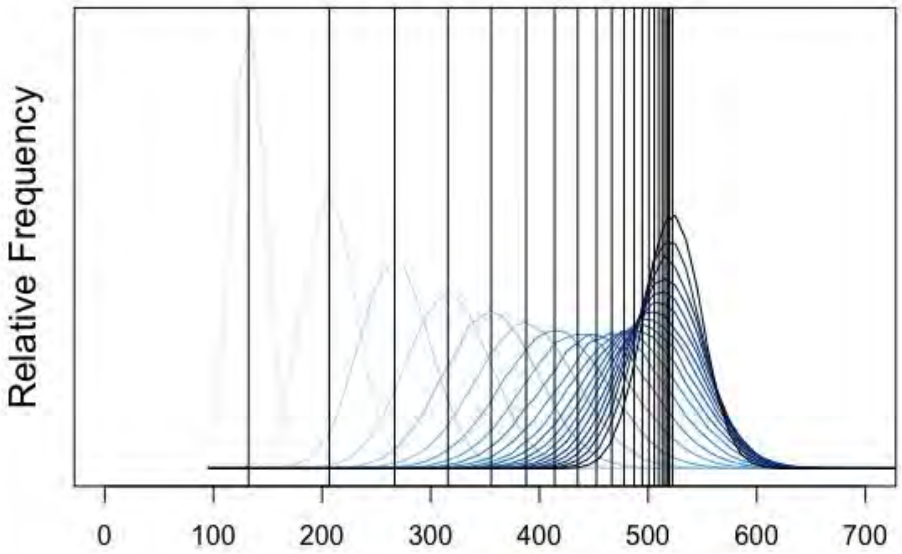
Base model with smoothed length age conversion matrix and updated weight at age

Length-age conversion matrix: Smoothed relationship between age and length data

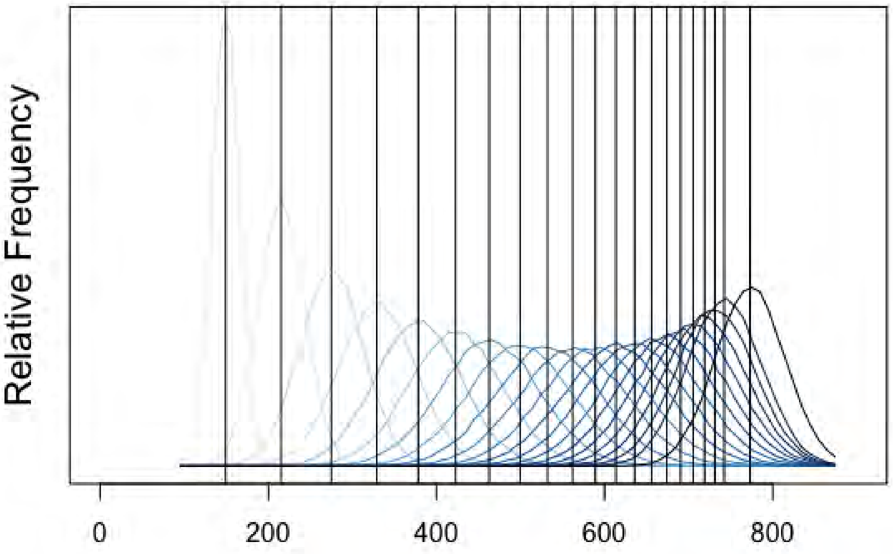


Length-Age conversion matrix

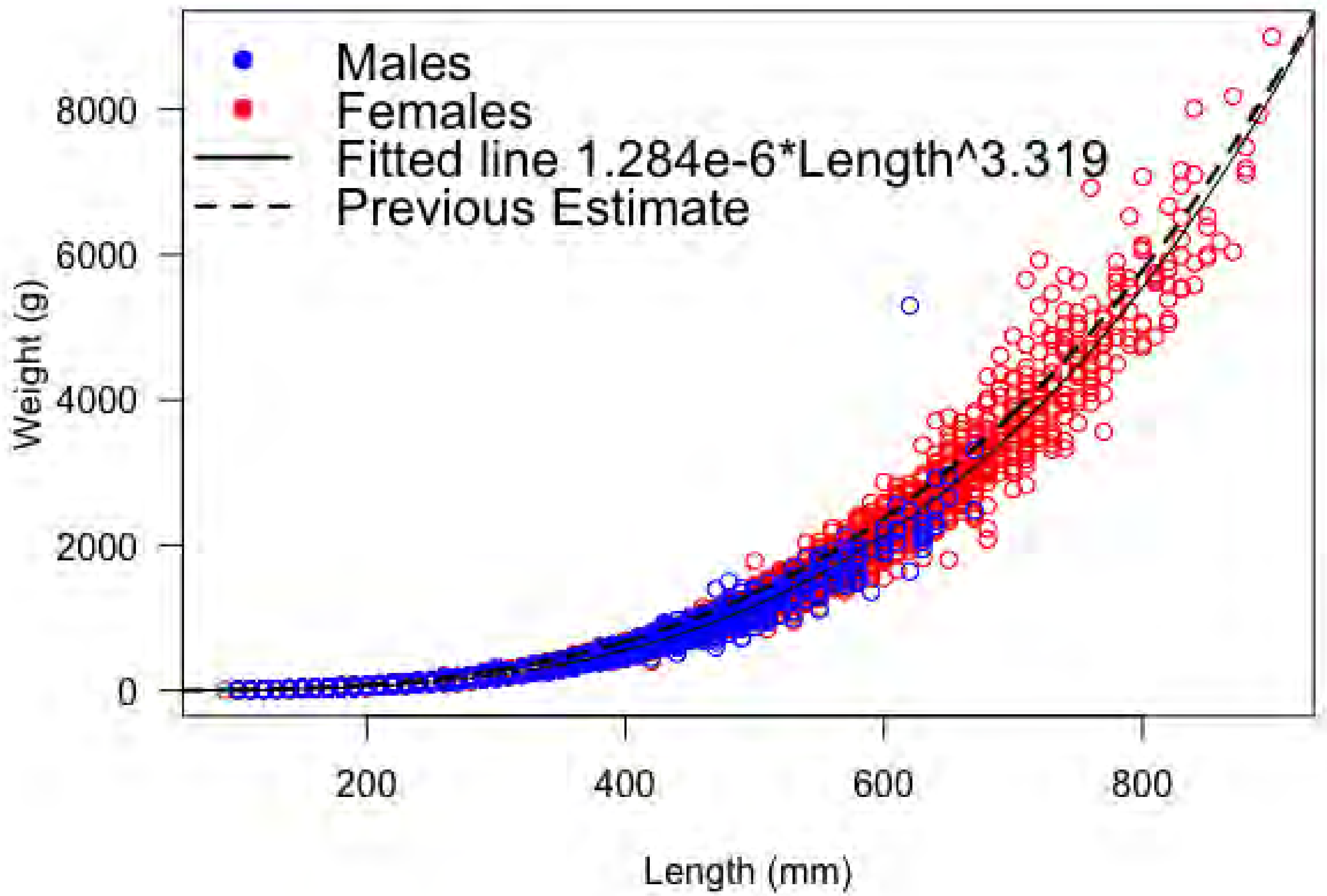
Males



Females



Updated length-weight relationship



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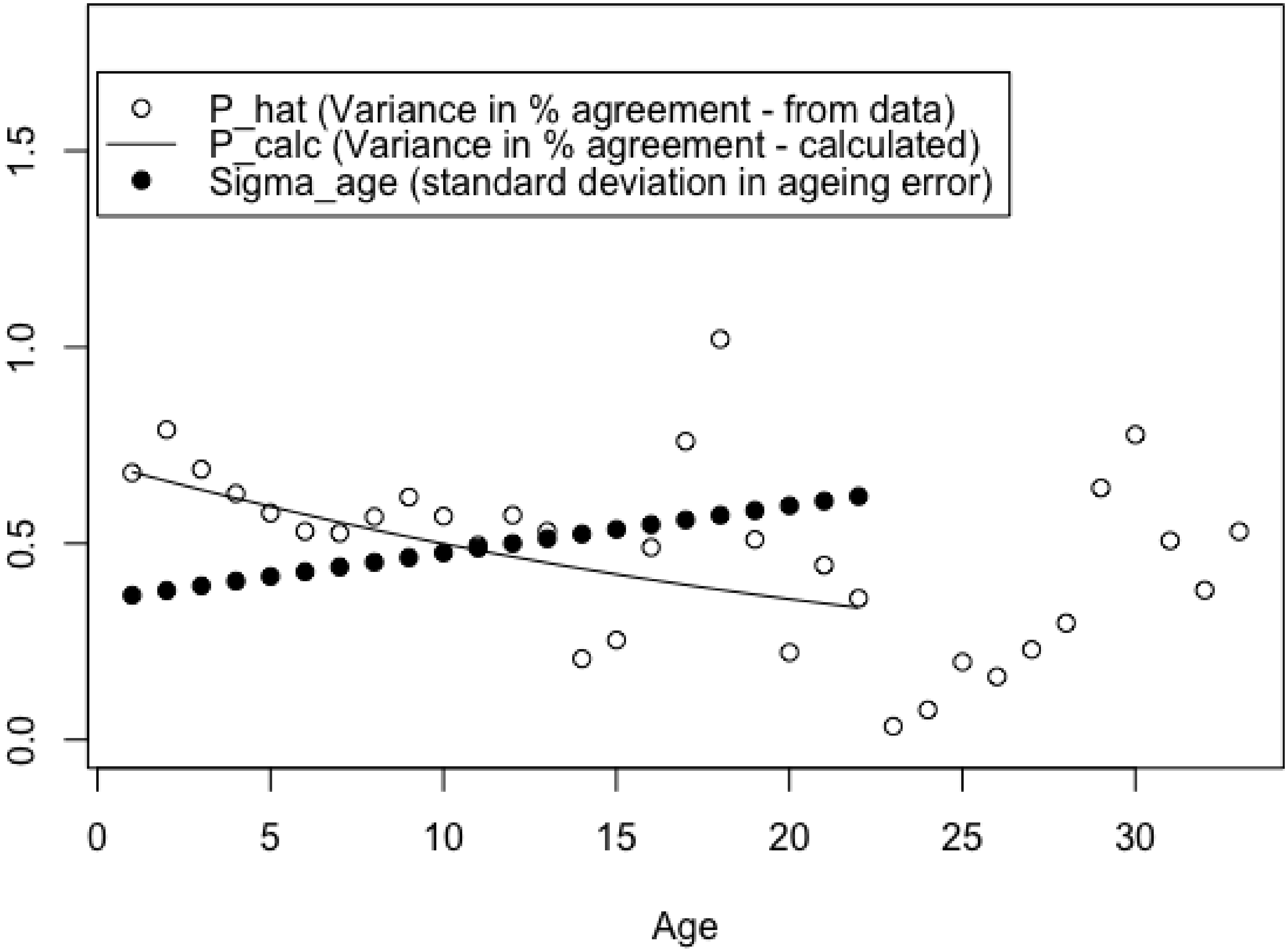
Model 18.3:

Model 15.1c with an ageing error matrix.

Ageing error matrix



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Model 18.6:

Model 15.1c with length-based survey selectivity.

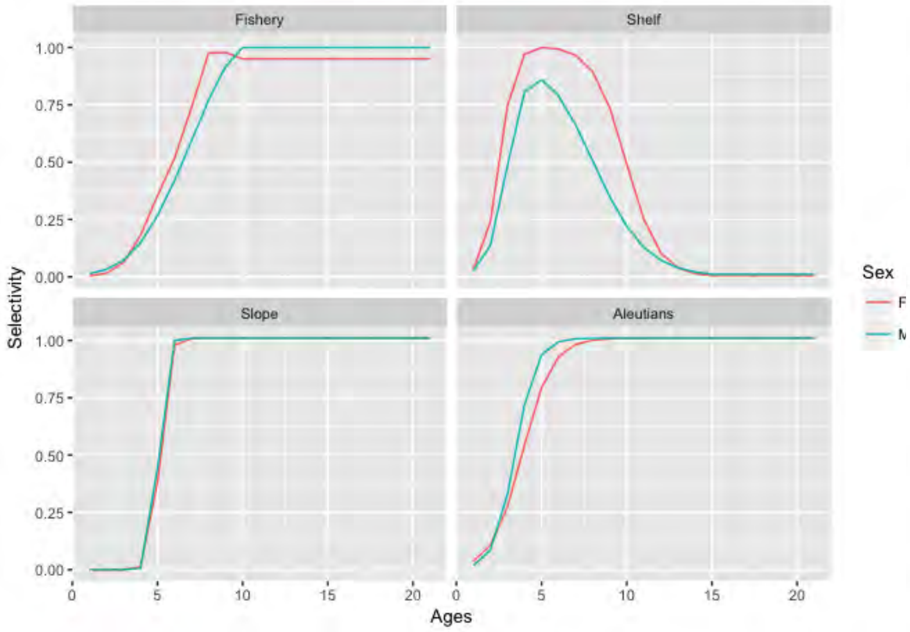
Length-based selectivity

Only two/four parameters were required for the selectivity curve for each survey (rather than four/eight if selectivity is by sex and age).

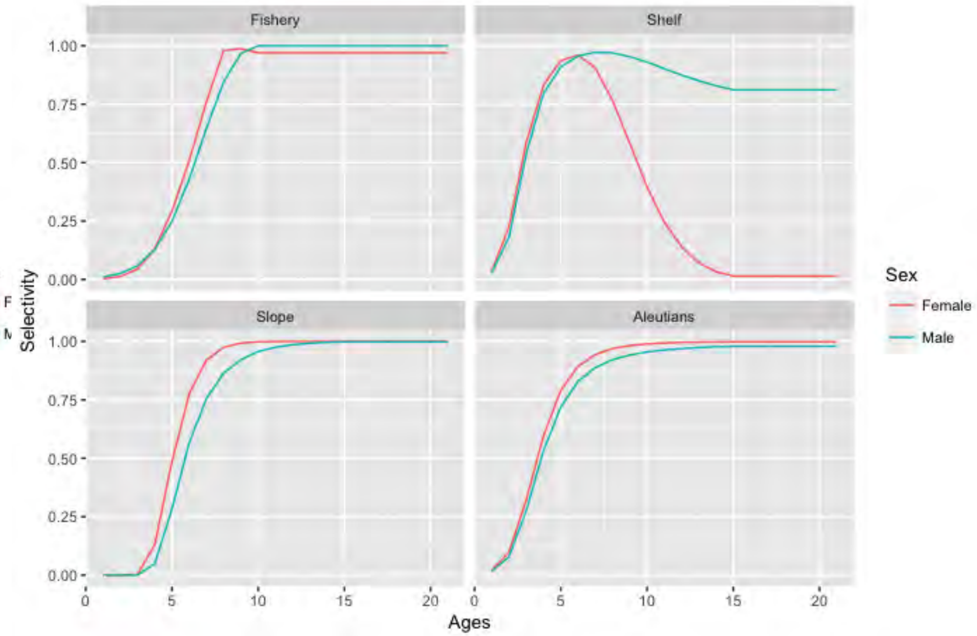
Logistic selectivity was then converted back to selectivity by age using the length age conversion matrix, separately for each sex.

Selectivity

Models 15.1b, 15.1c, 18.3, 18.9



Model 18.6



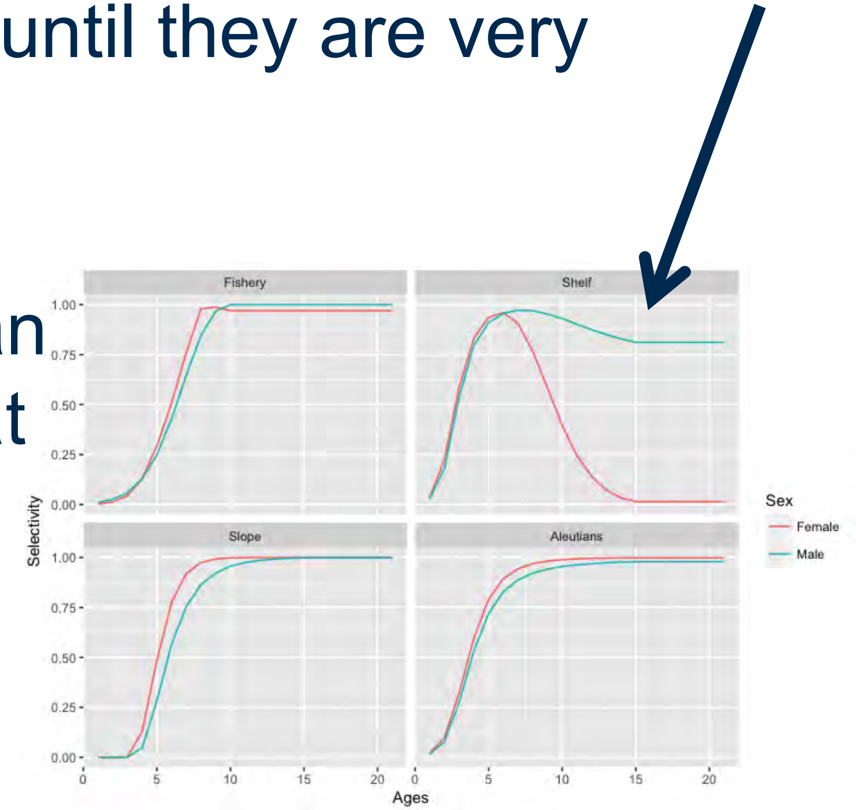
Length-based selectivity

Pros: Fewer parameters.

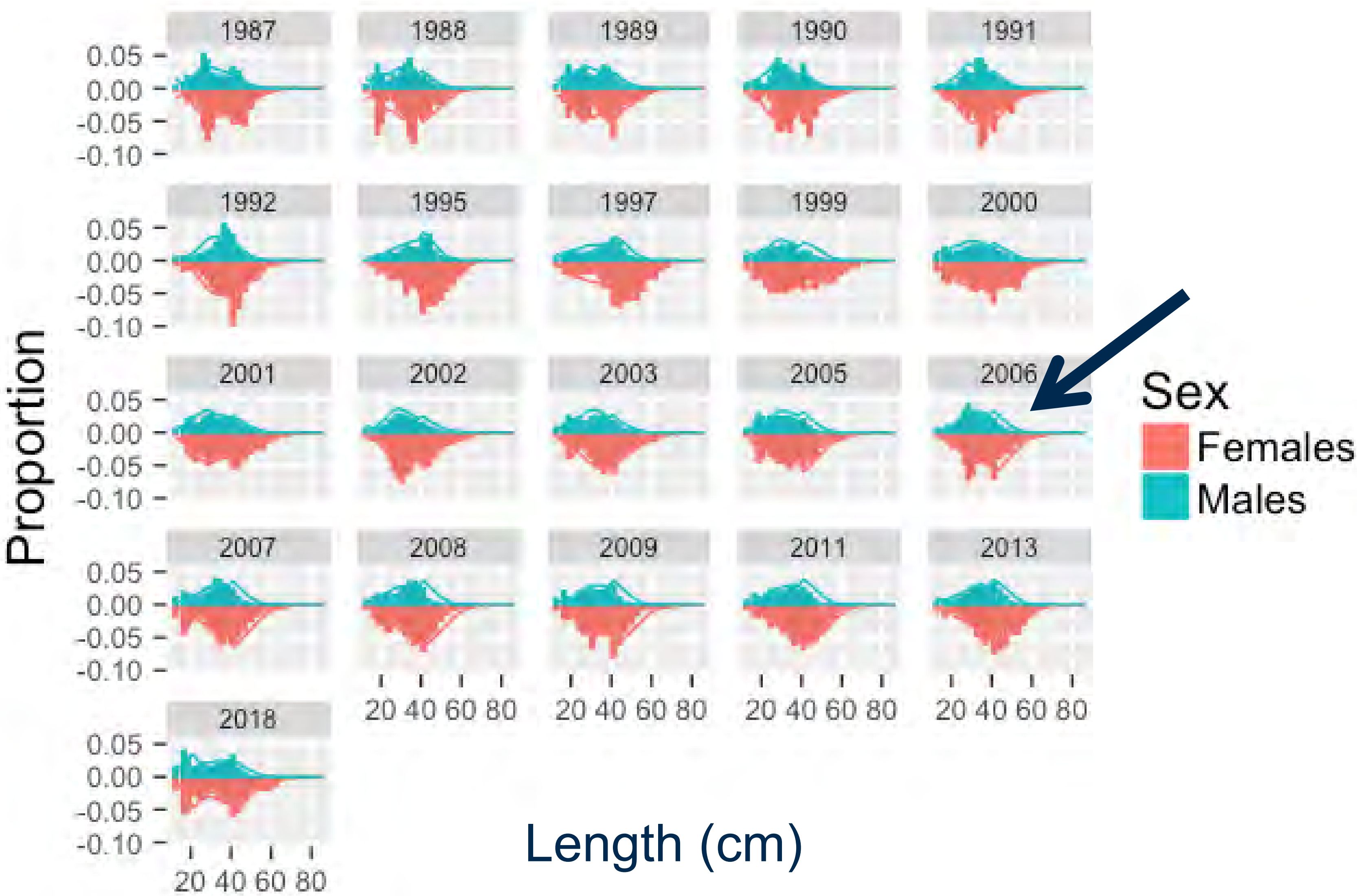
Cons:

- The size-based algorithm predicts that males will not move off the shelf until they are very large.

- Unrealistically predicts more males on the shelf than females. It is more likely that movement off the shelf occurs at older ages and is associated with spawning.



Model 18.6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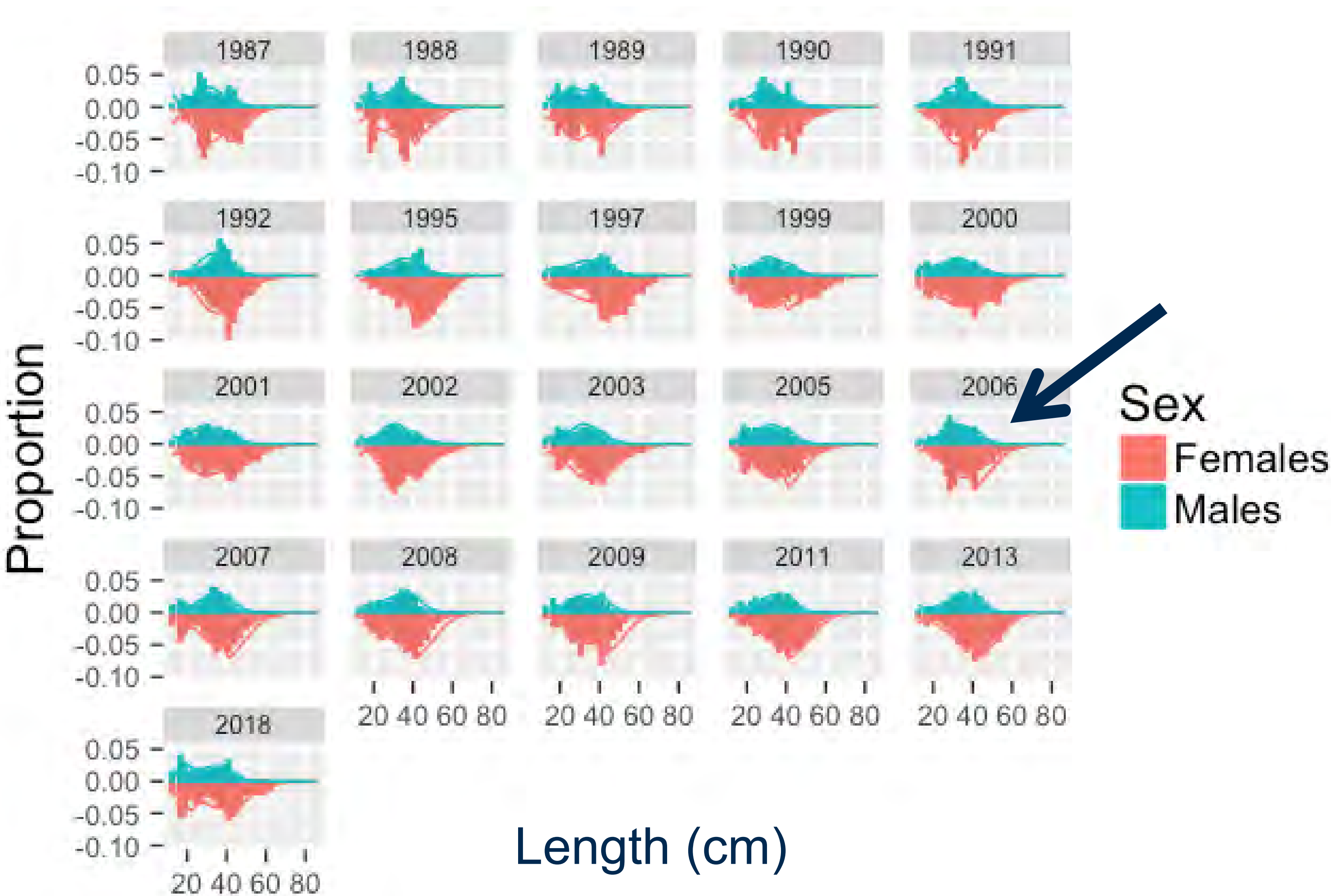
Proportion
Sex
Females
Males
Length (cm)

Model 18.9



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20 40 60 80
Proportion
Length (cm)
Sex
Females
Males

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Model 18.9:

Model 18.3 with early years of slope survey removed (1979-1991).

Age-based selectivity.

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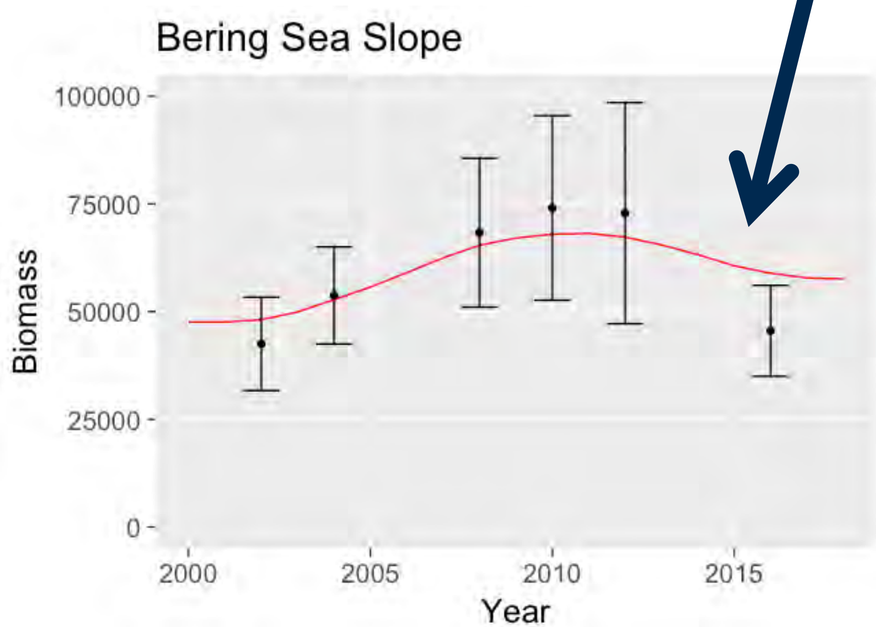
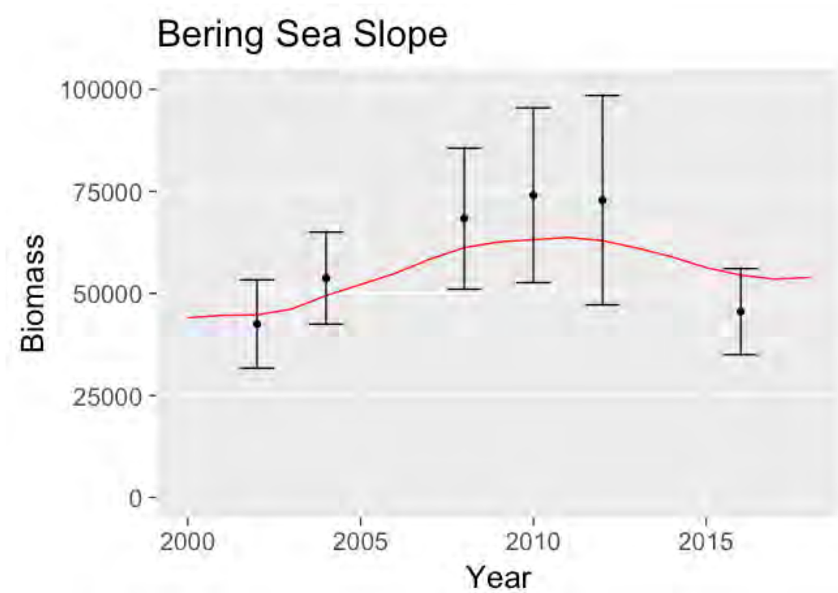
Higher fit to slope survey data.

Model 18.6



Model 18.9



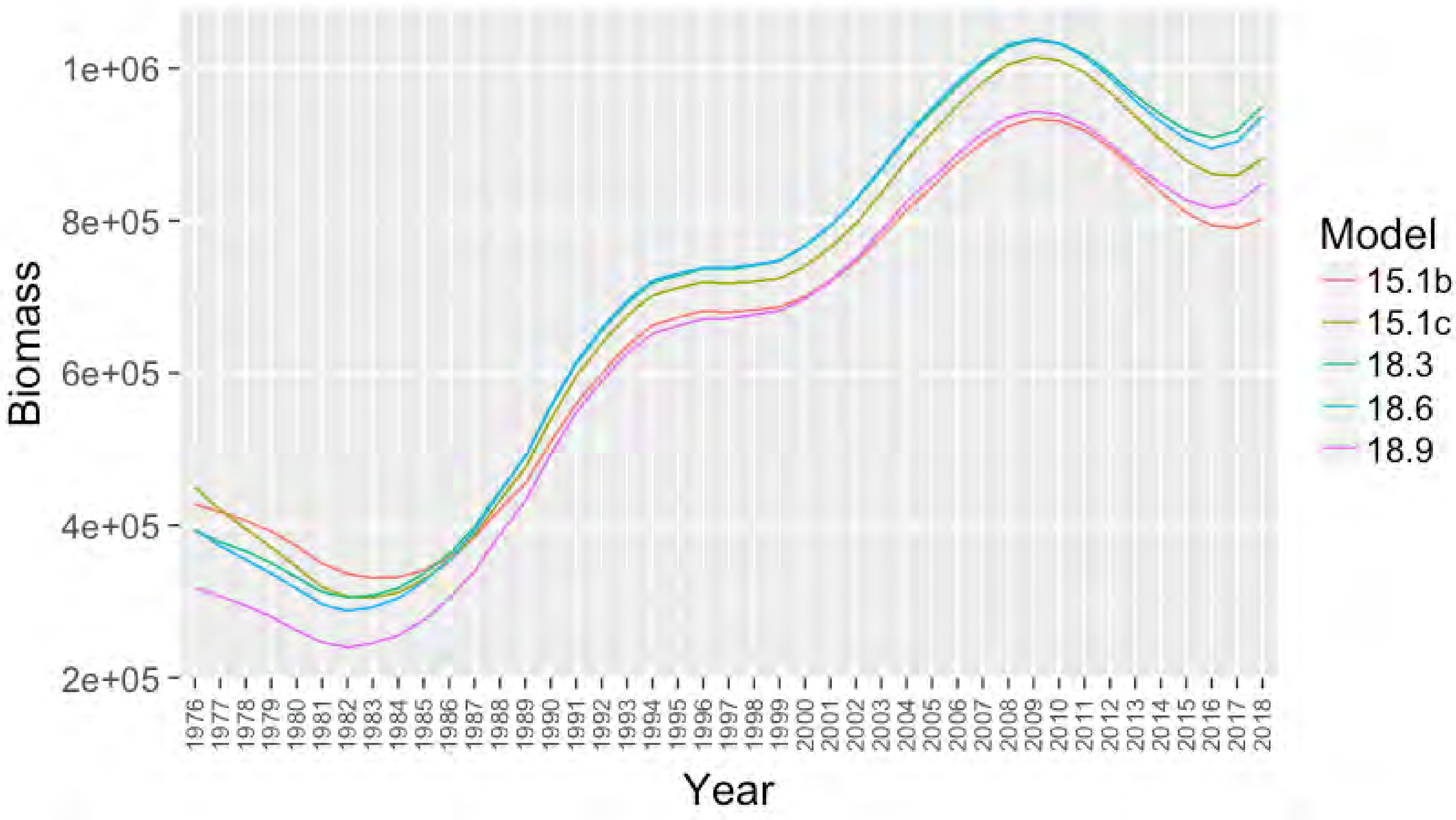
Statistics for evaluating the models

	Model 15.1b	*Model 15.1c*	*Model 18.3*	*Model 18.6*	*Model 18.9*
Total -log(Likelihood)					
Catch	0.012	0.014	0.011	0.015	0.008
Recruitment	52.27	32.55	45.30	28.97	40.35
EBS shelf survey biomass	31.12	34.59	34.79	40.36	30.08
EBS slope survey biomass	45.32	61.01	64.66	75.08	2.89
Aleutian survey biomass	44.63	43.99	42.47	43.65	41.25
EBS shelf survey age comp	347.32	317.65	274.06	317.96	255.68
EBS slope survey age comp	43.96	42.15	54.79	36.43	37.10
Aleutian survey age comp	160.74	163.43	130.08	134.88	125.52
Survey length comp	402.88	387.10	437.36	494.57	433.67
Fishery length comp	667.13	669.84	596.98	597.83	605.72
Priors/Penalties	0.83	0.95	1.09	1.12	1.31
Fishery selectivity	13.88	14.81	13.96	14.96	14.04
Number of parameters	153	153	153	145	153
Total likelihood	1,987.70	1,957.96	1,887.58	1,982.21	1,789.18
ADSB	-	0.12	0.09	0.12	0.19
Objective function	3,567.92	3,629.12	3,315.00	3,620.89	2,690.25
Mohn's rho	0.08615	0.1004	0.07749	0.1066	0.02918
Stock status (t)					
2018 Spawning biomass	494,638	534,625	554,216	547,940	853,048
2018 Total biomass	801,623	881,880	950,576	937,500	498,263

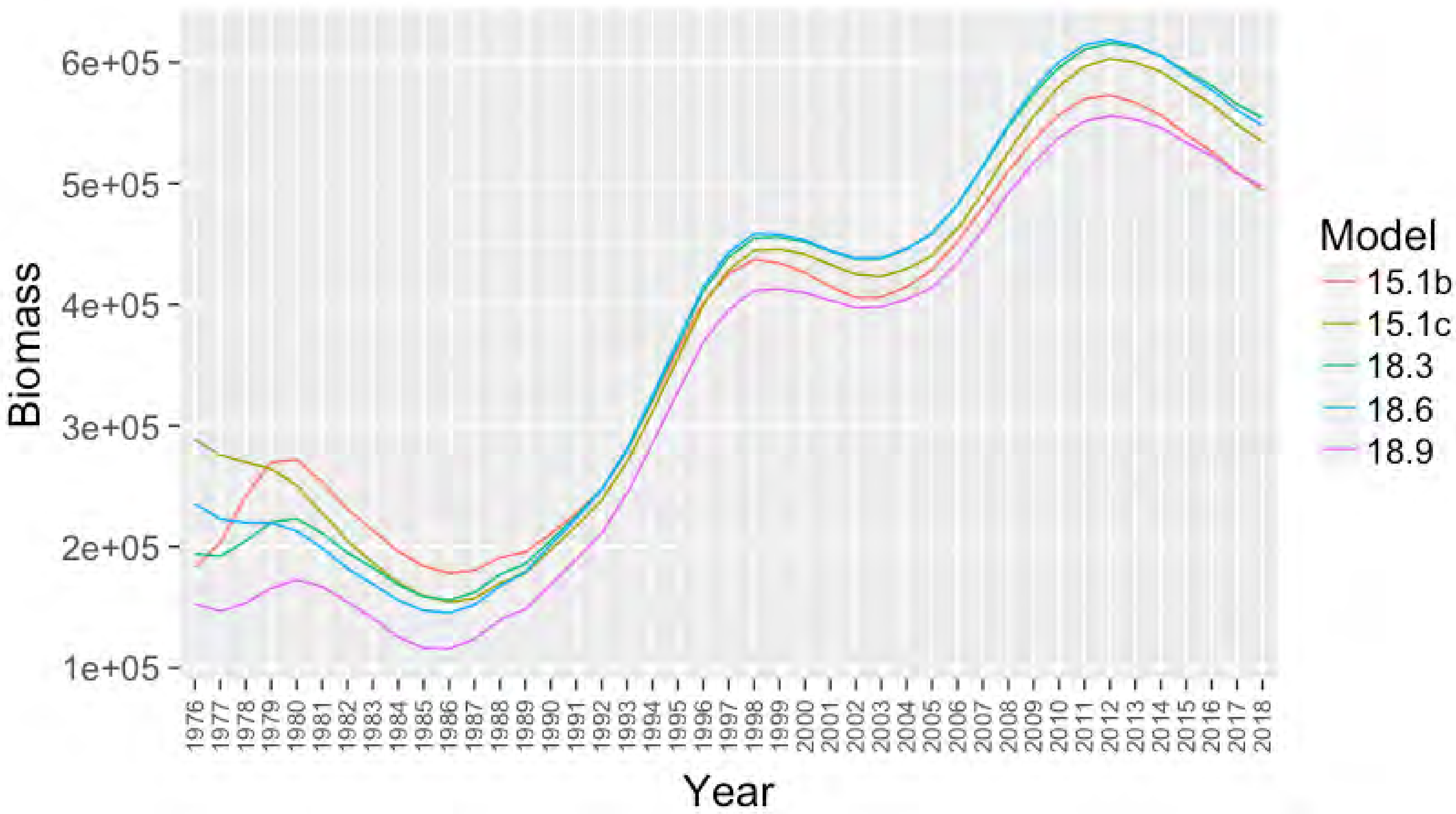
Brief model descriptions (see text for details):

Model 15.1b - Base model from 2016 assessment.
Model 15.1c - Model 15.1b with smoothed length at conversion matrix.
Model 18.3 - Model 15.1c with ageing error matrix.
Model 18.6 - Model 18.3 with length-based survey selectivity and non-parametric fishery selectivity.
Model 18.9 - Model 18.3 with slope survey years 1979-1991 removed.

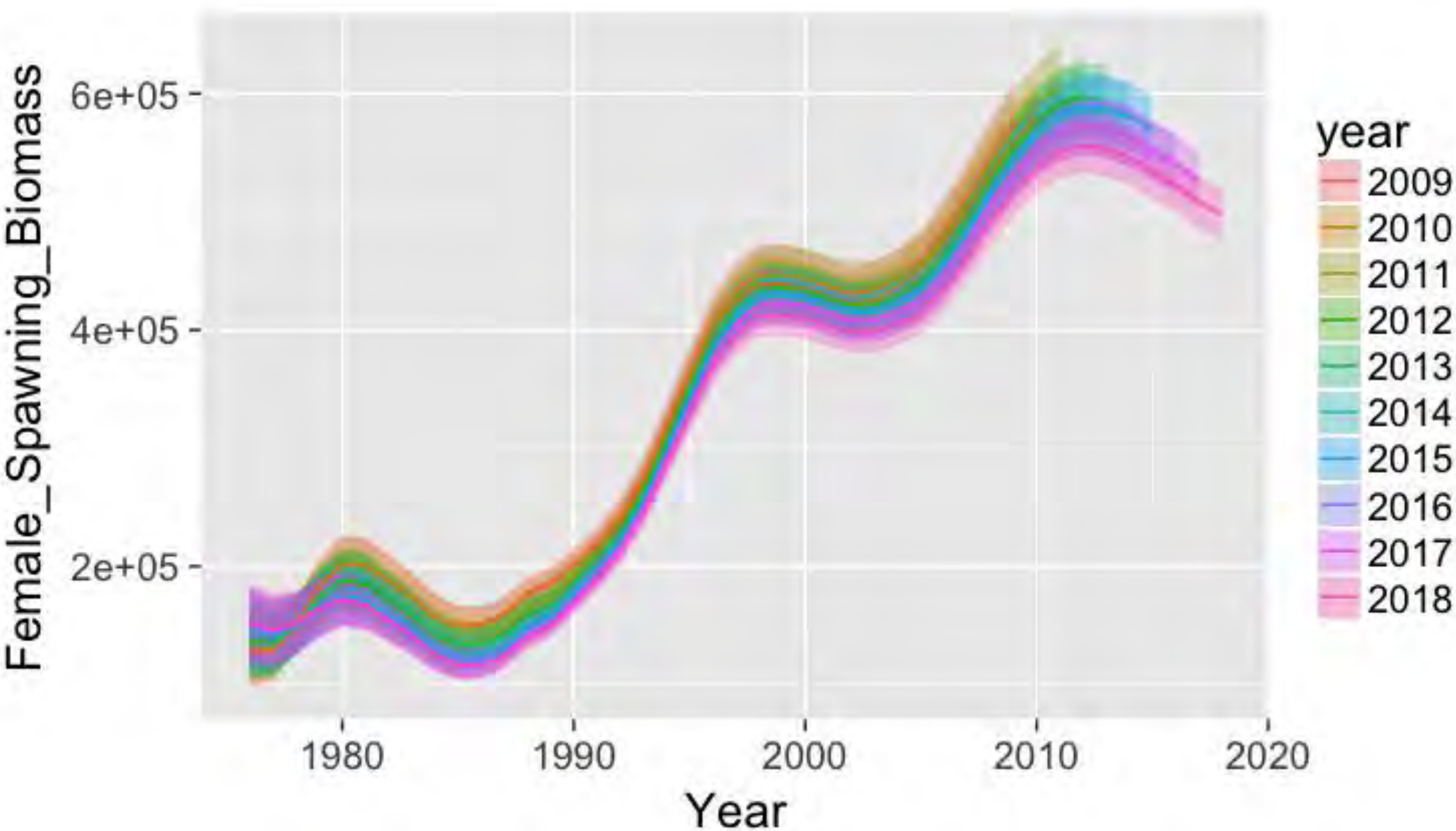
Biomass time series by Model



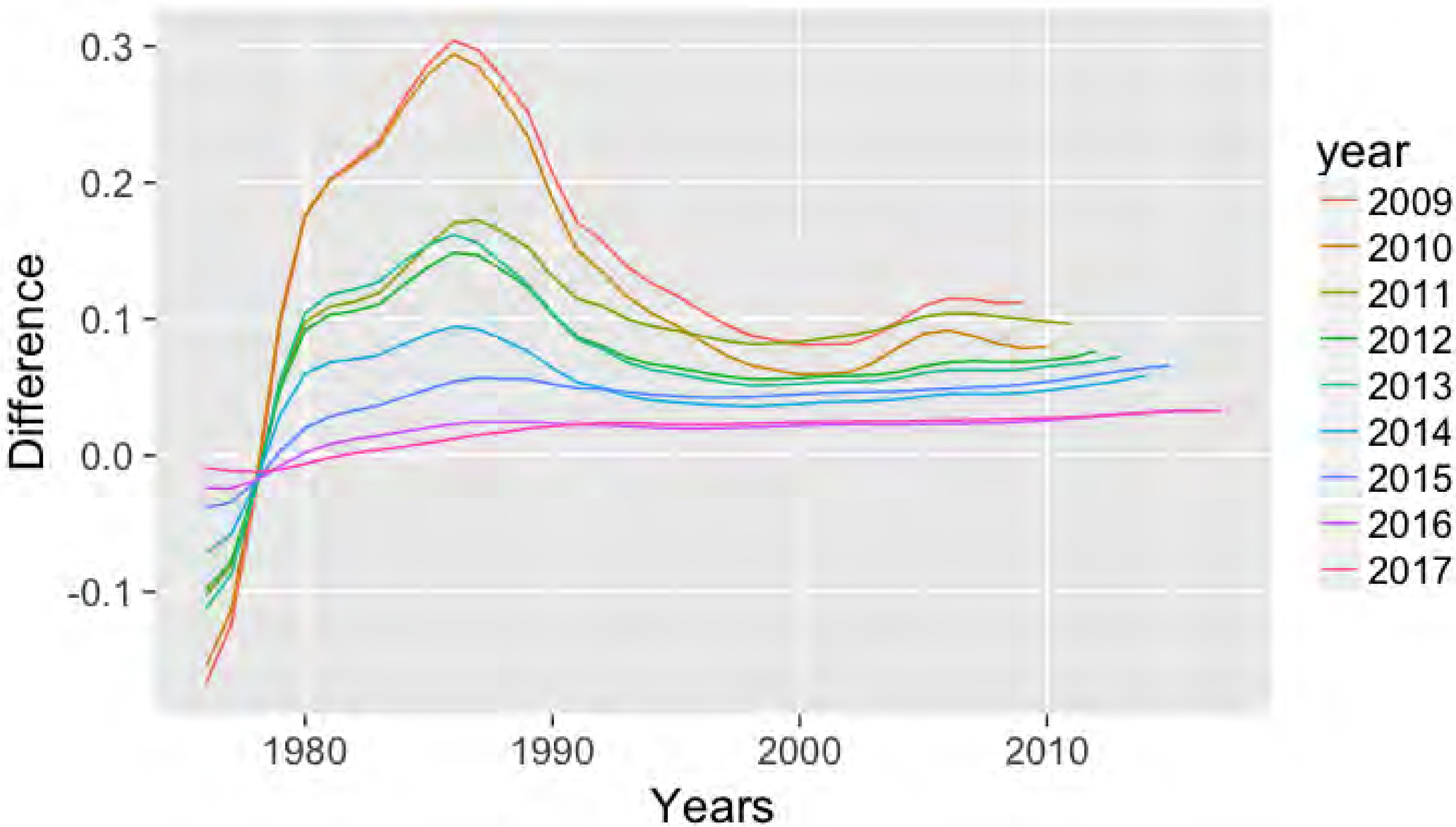
Biomass time series by Model



Retrospective plot Model 18.9

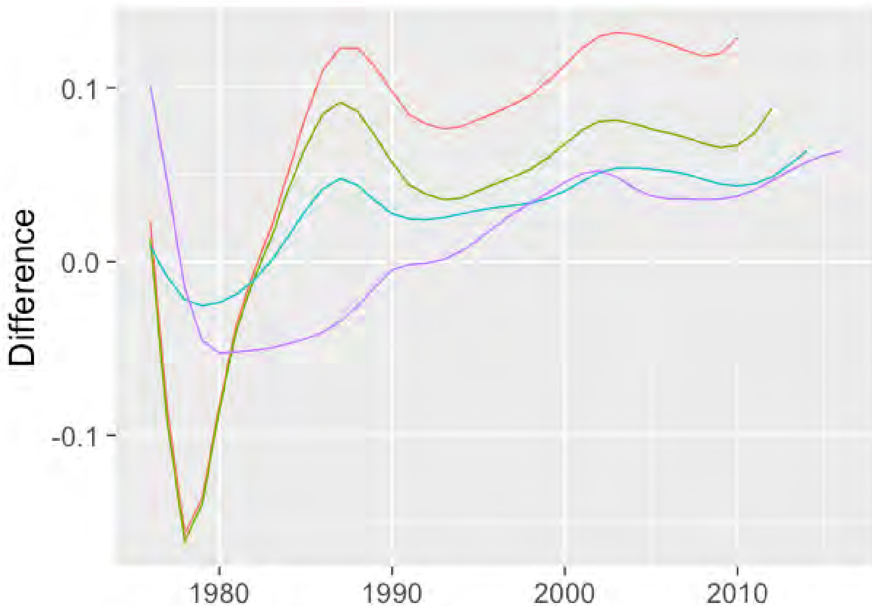


Retrospective difference

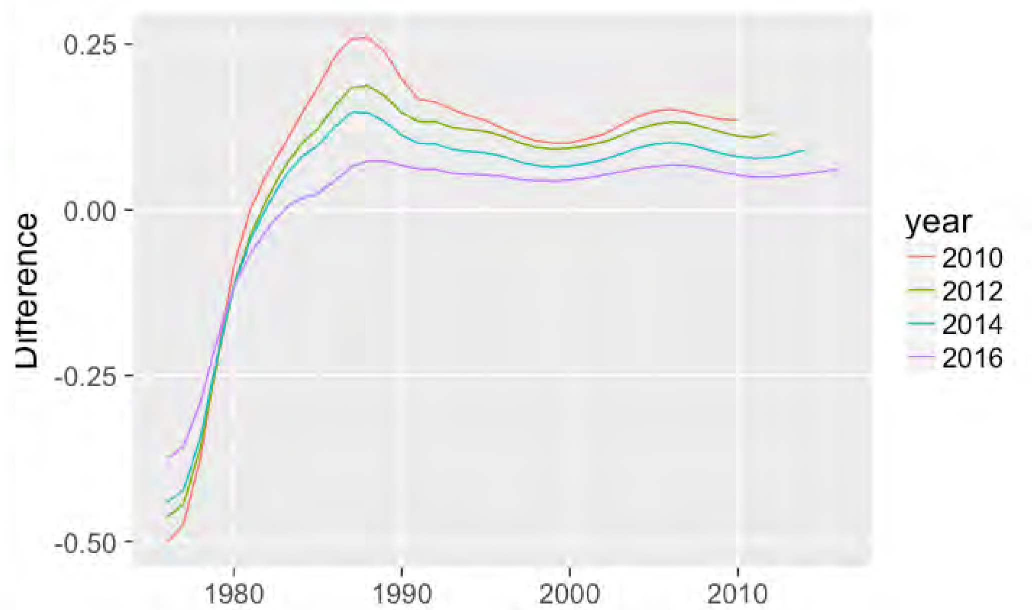


Rho: 0.02918

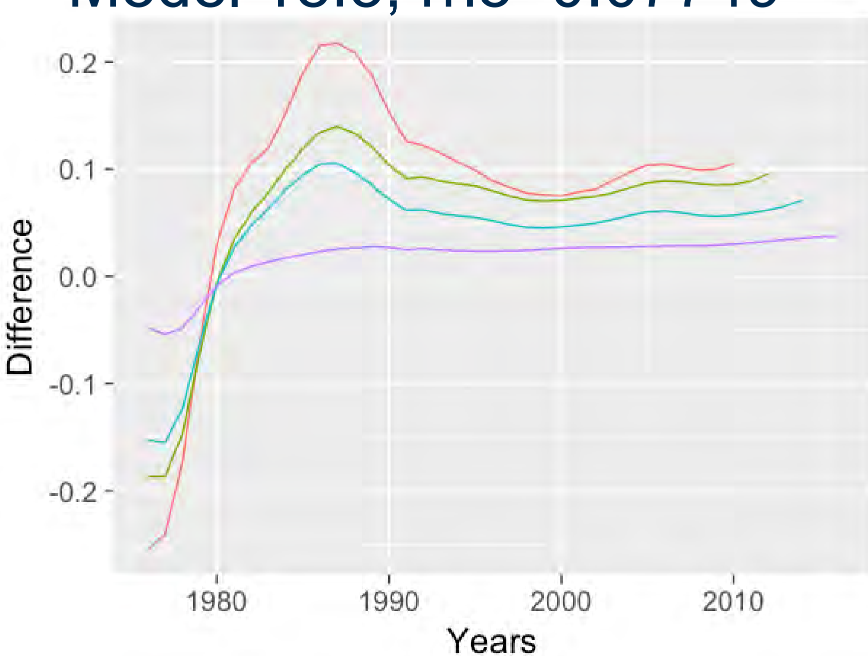
Model 15.1b, rho=0.08615



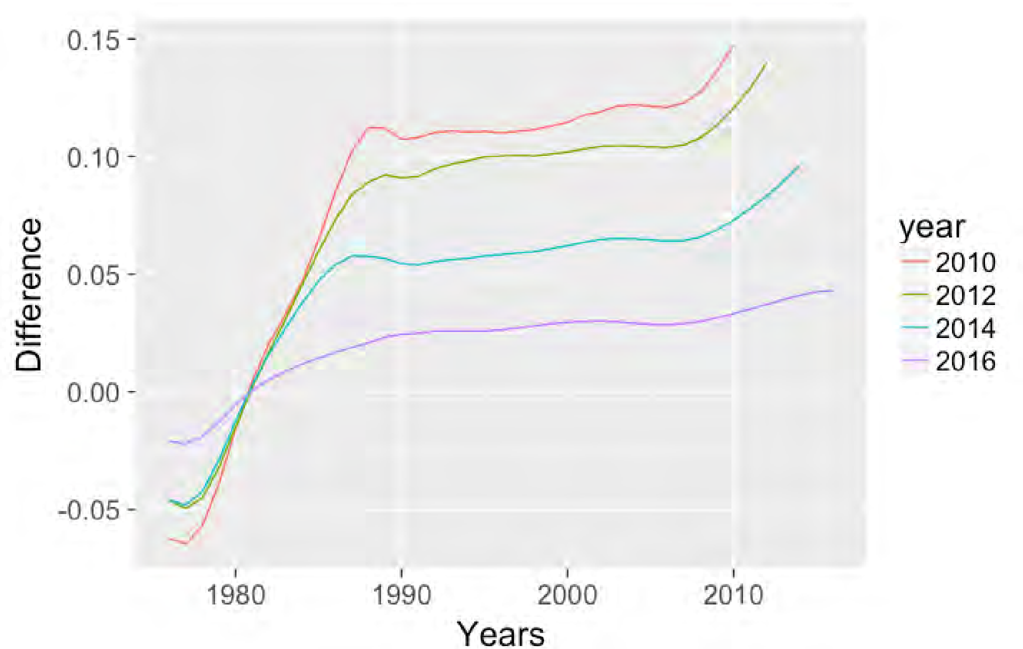
Model 15.1c, rho=0.1004



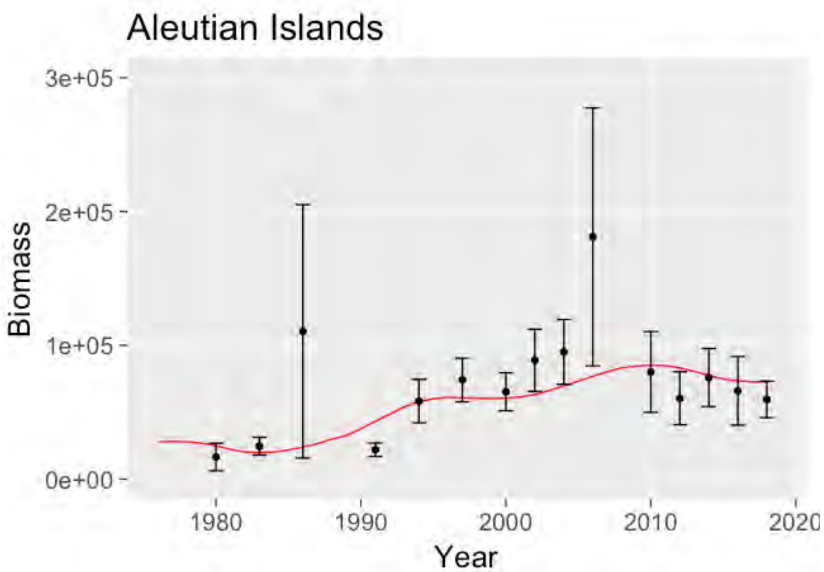
Model 18.3, rho=0.07749

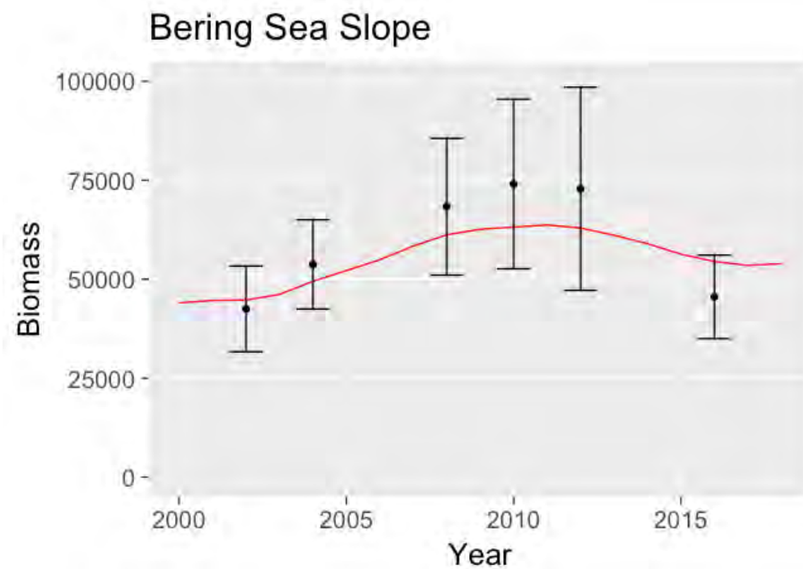


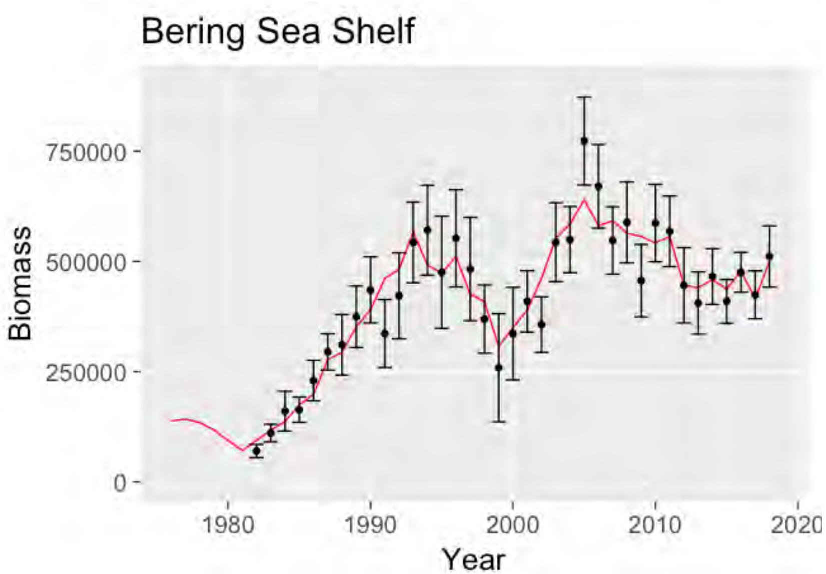
Model 18.6 rho=0.1066



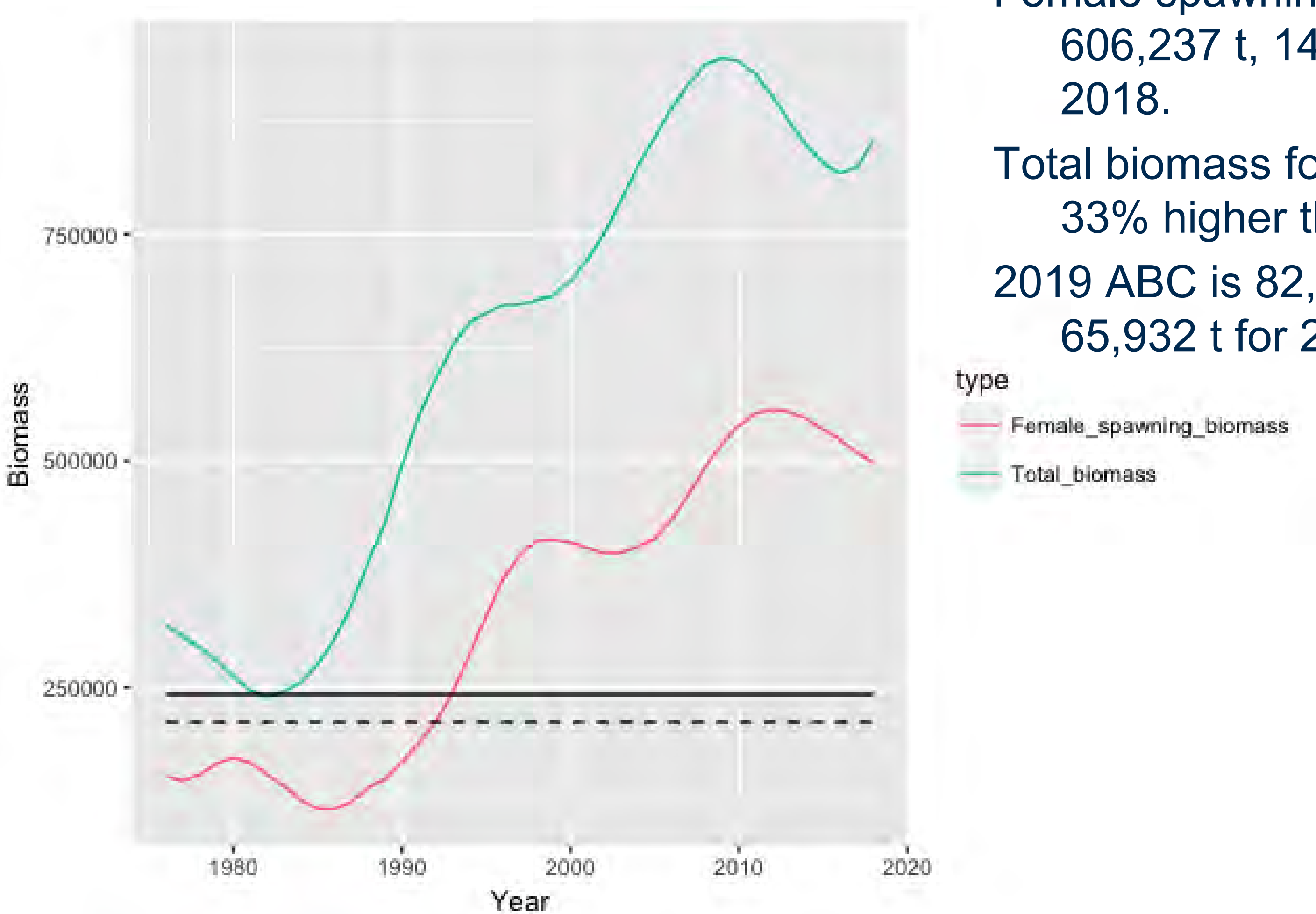
Fit to survey data







Overall trends are fairly stable

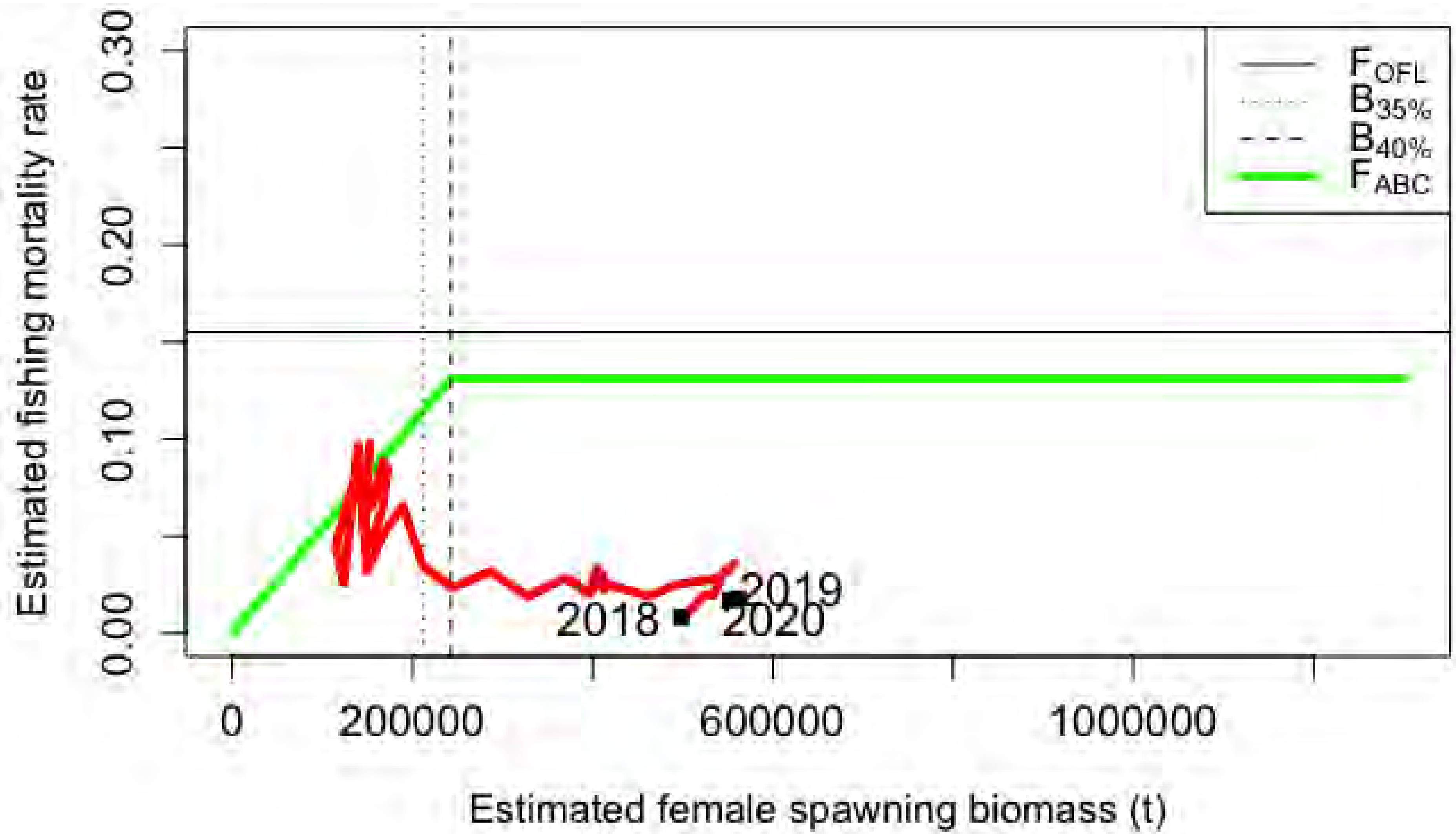


- Female spawning biomass in 2019: 606,237 t, 14% higher than 2018.
- Total biomass for 2019: 1,041,250 t, 33% higher than 2018.
- 2019 ABC is 82,034 t, up from 65,932 t for 2018.

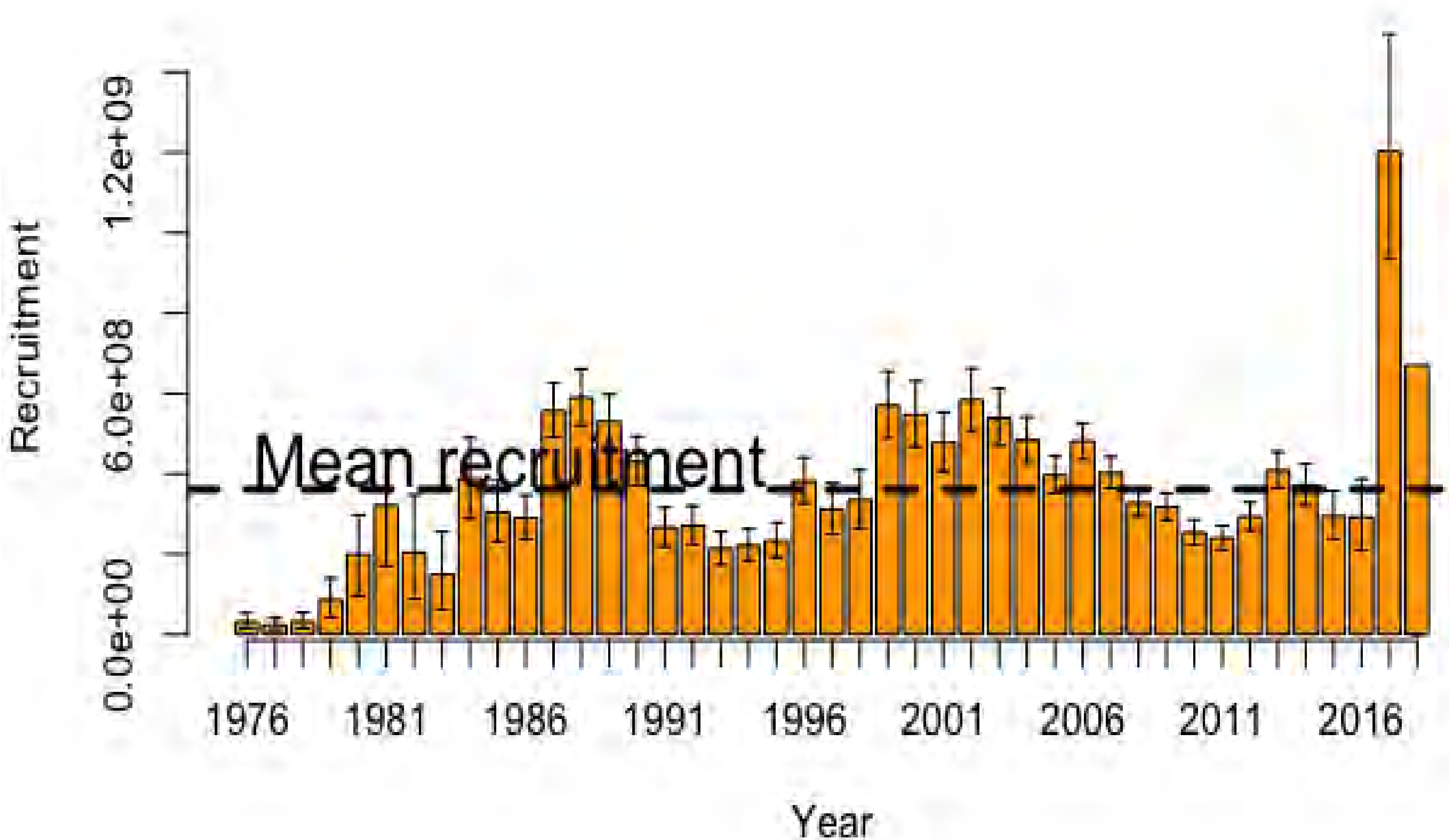
Summary

Quantity/Status	Last year 2018	Last year 2019	This year 2019	This year 2020
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+)	785,141	782,840	1,041,250	1,086,260
Female spawning biomass (t)				
Projected	490,663	472,562	561,174	552,101
$B_{100\%}$	530,135	530,135	606,237	606,237
$B_{40\%}$	212,054	212,054	242,495	242,495
$B_{35\%}$	185,547	185,547	212,183	212,183
F_{OFL}	0.151	0.151	0.155	0.155
$maxF_{ABC}$ (maximum allowable = $F_{40\%}$)	0.129	0.129	0.131	0.131
Specified/recommended F_{ABC}	0.129	0.129	0.131	0.131
Specified/recommended OFL (t)	76,757	75,084	96,257	86,772
Specified/recommended ABC (t)	65,932	64,494	82,034	75,467
Status	As determined *last* year for: 2015	As determined *last* year for: 2016	As determined *this* year for: 2016	As determined *this* year for: 2017
Is the stock being subjected to overfishing?	no	na	no	na
Is the stock currently overfished?	na	no	na	no
Is the stock approaching a condition of being overfished?	na	no	na	no

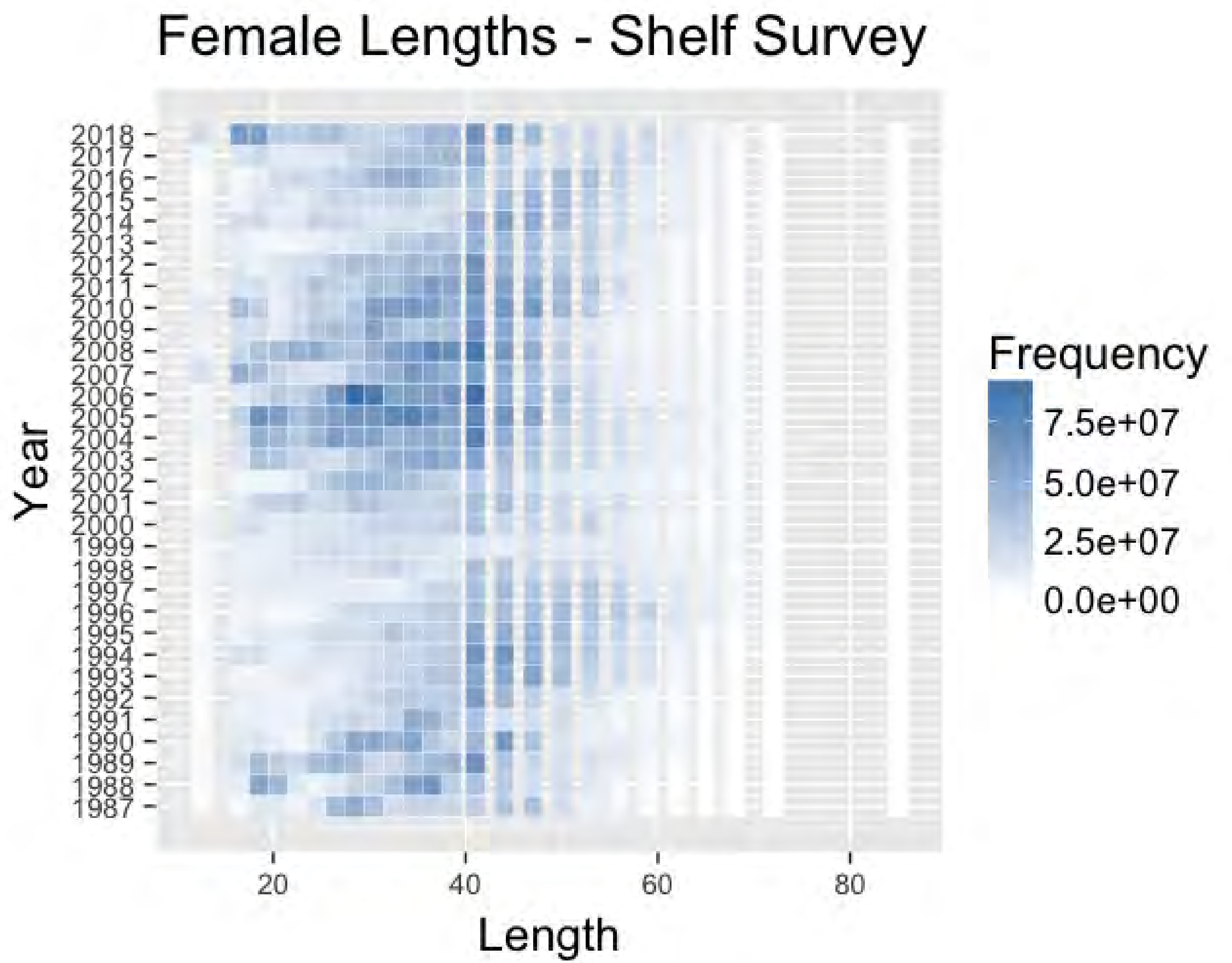
Arrowtooth flounder continue to be lightly exploited



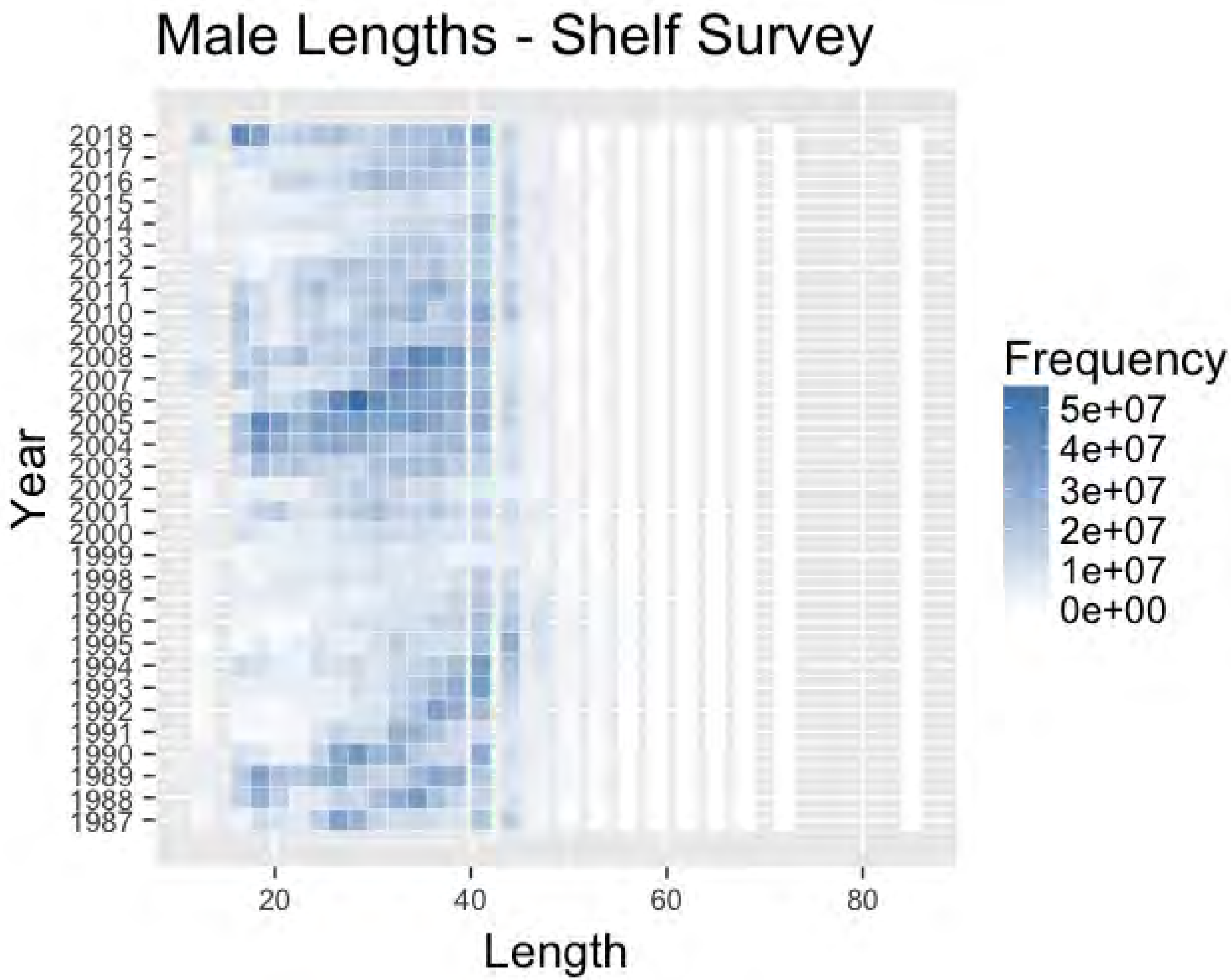
Estimated age 1 recruitment



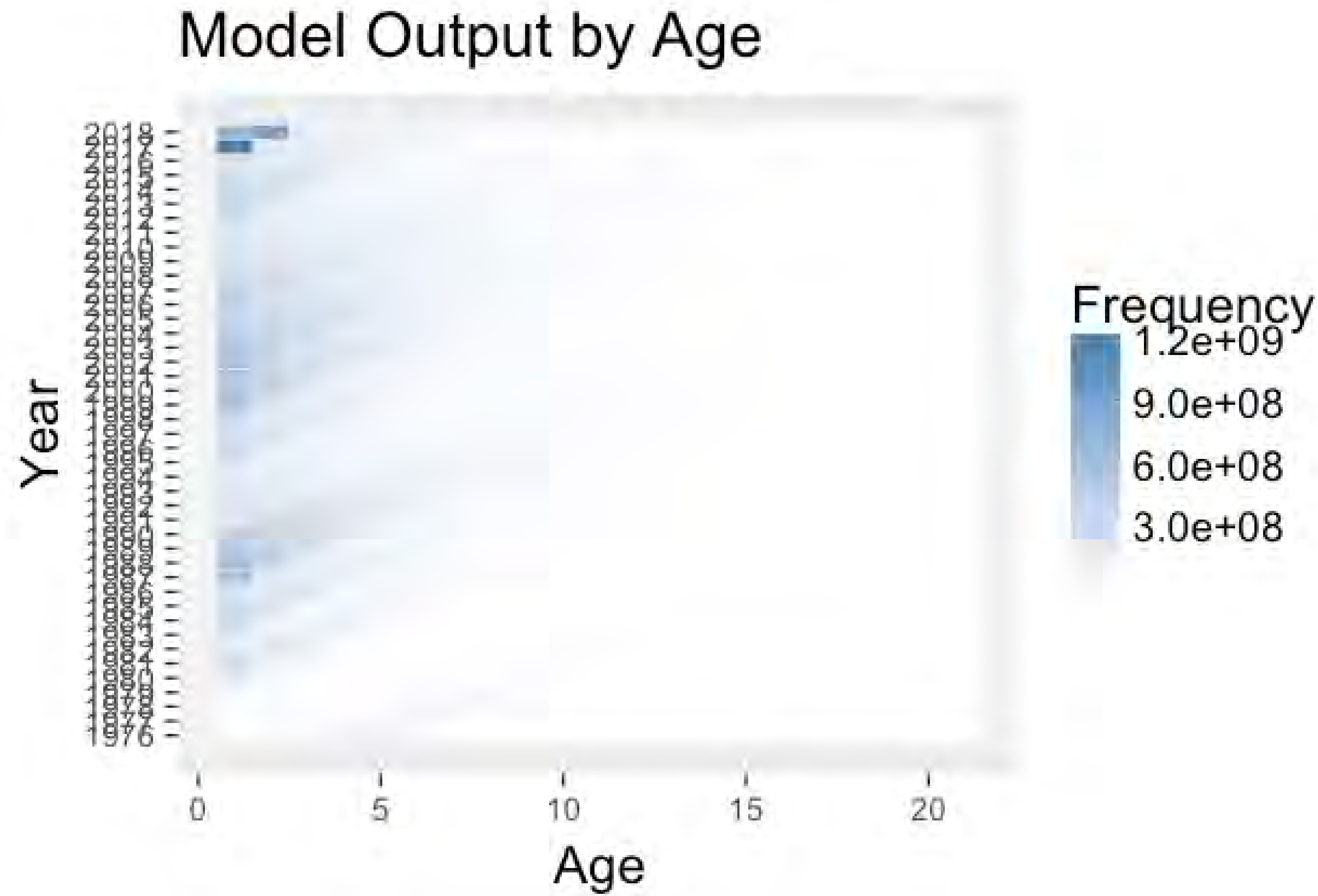
Strong 2016 year class (Bering Sea shelf)



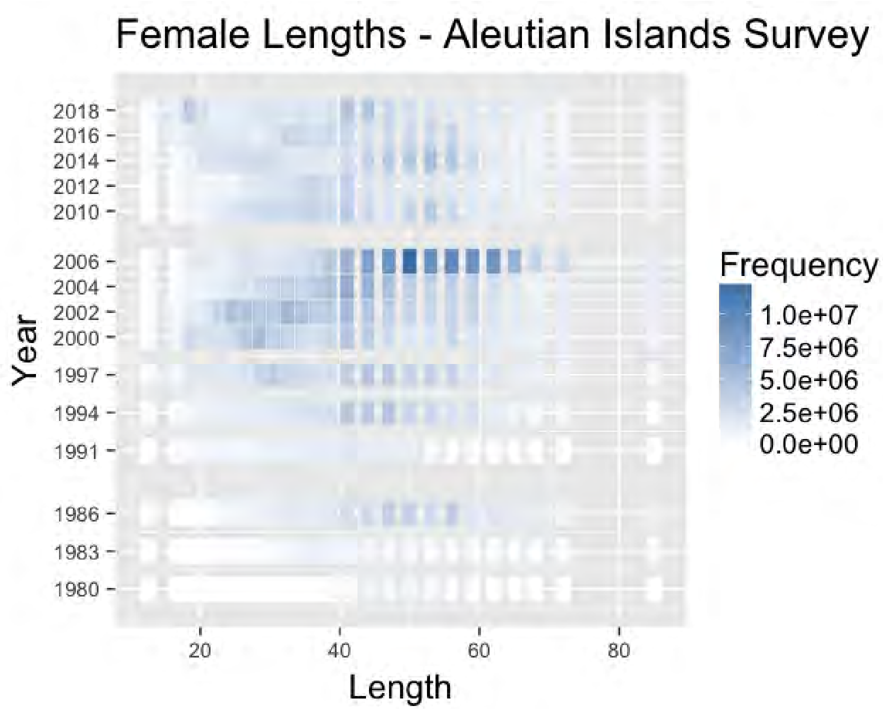
Strong 2016 year class (Bering Sea shelf)

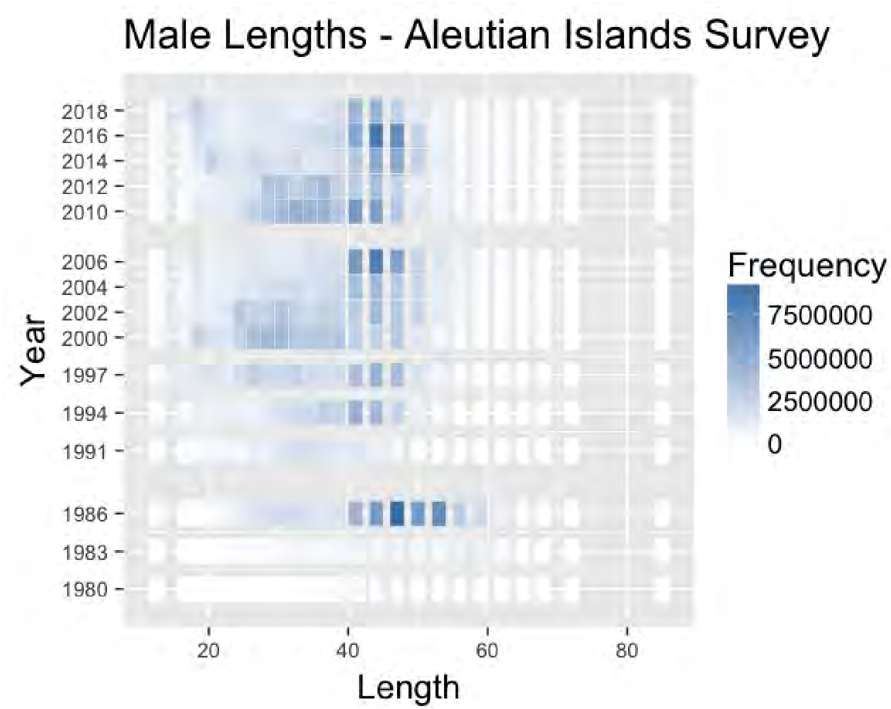


Strong 2016 year class (model output)

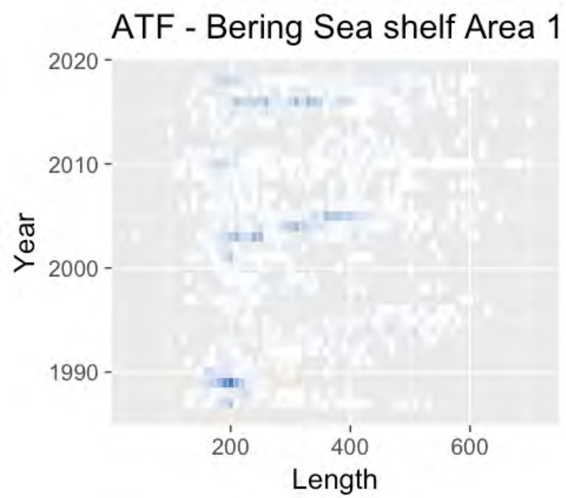


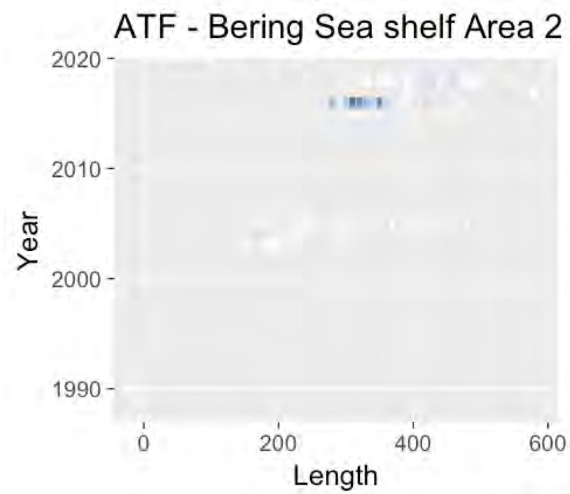
Aleutian Islands length frequencies

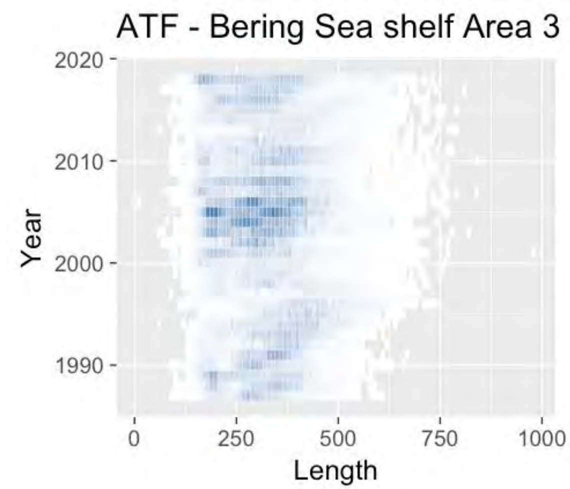


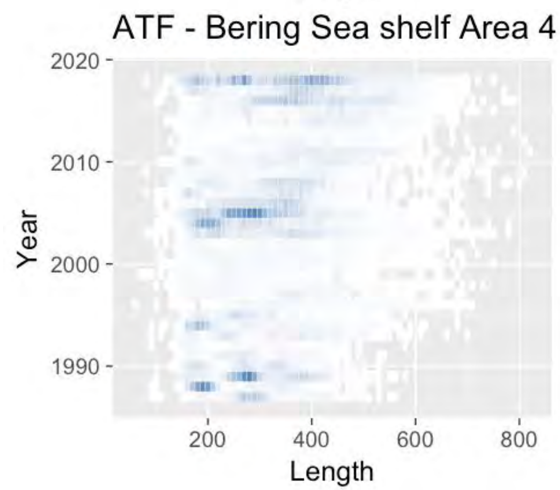


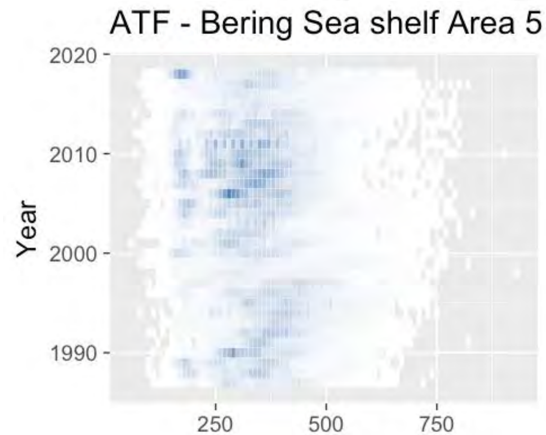
Length frequency data by area

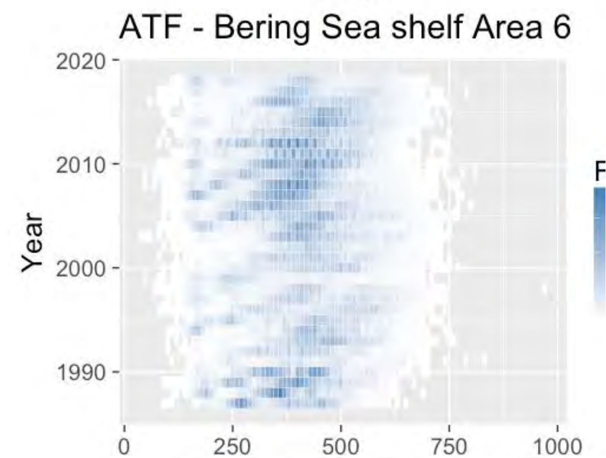


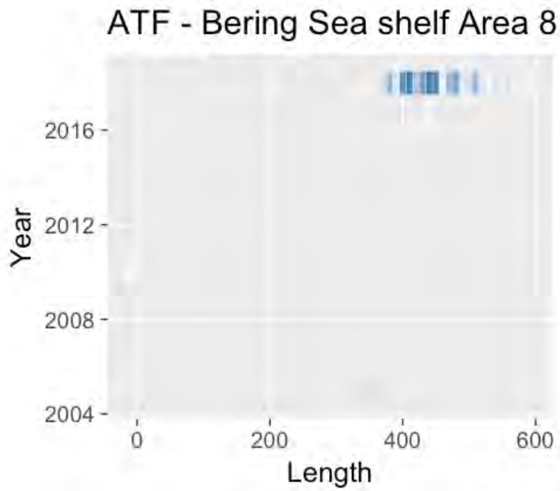


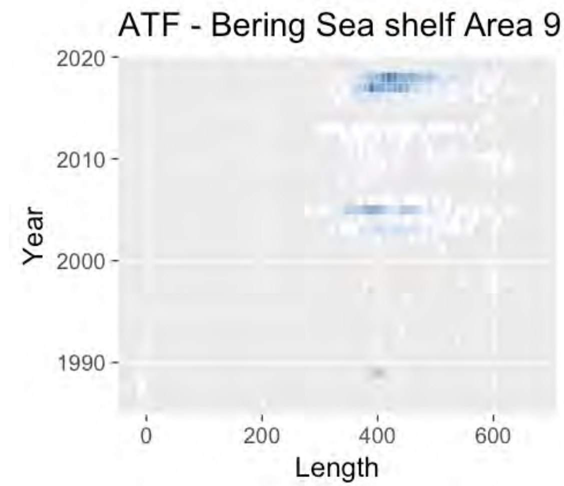


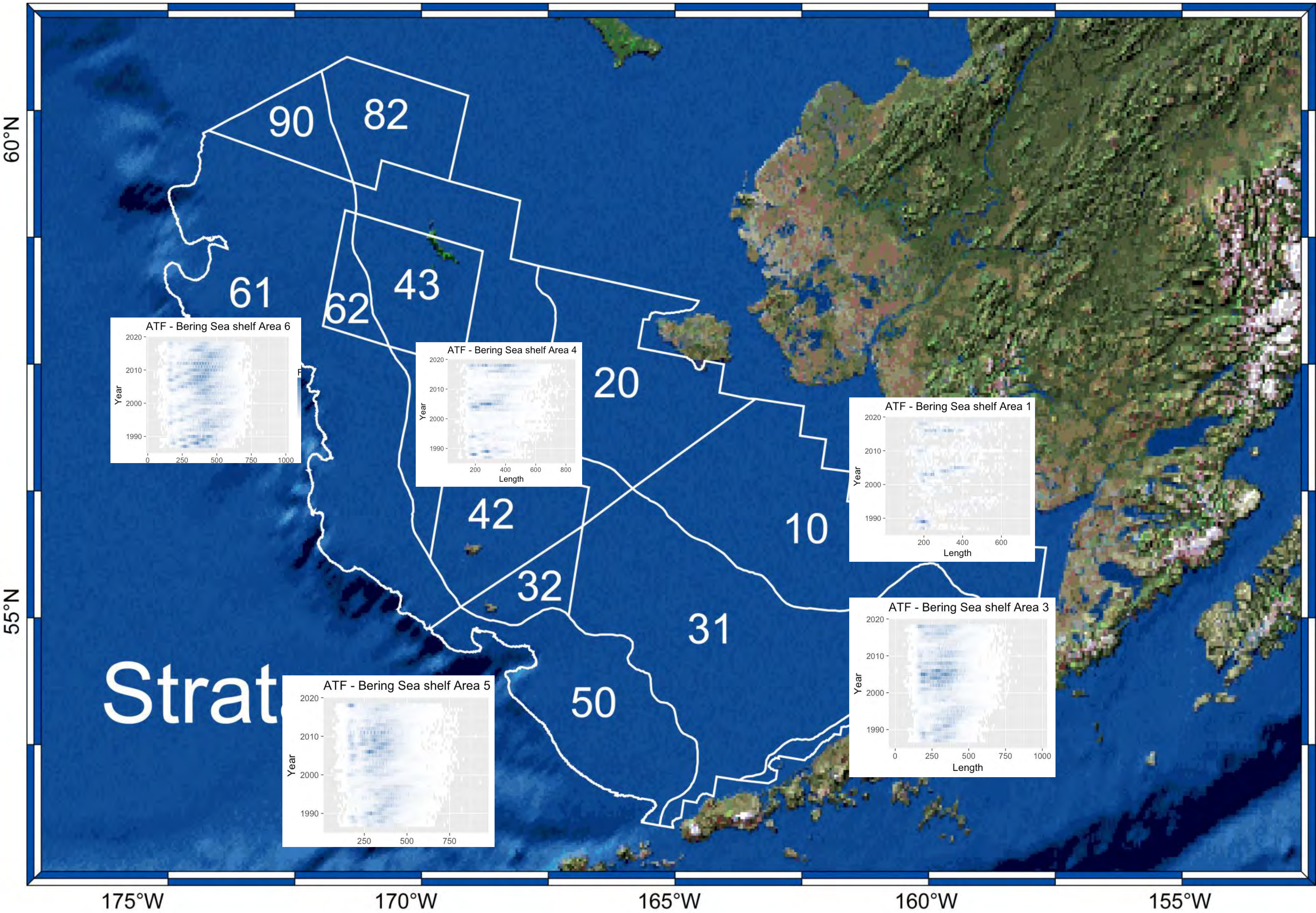












90
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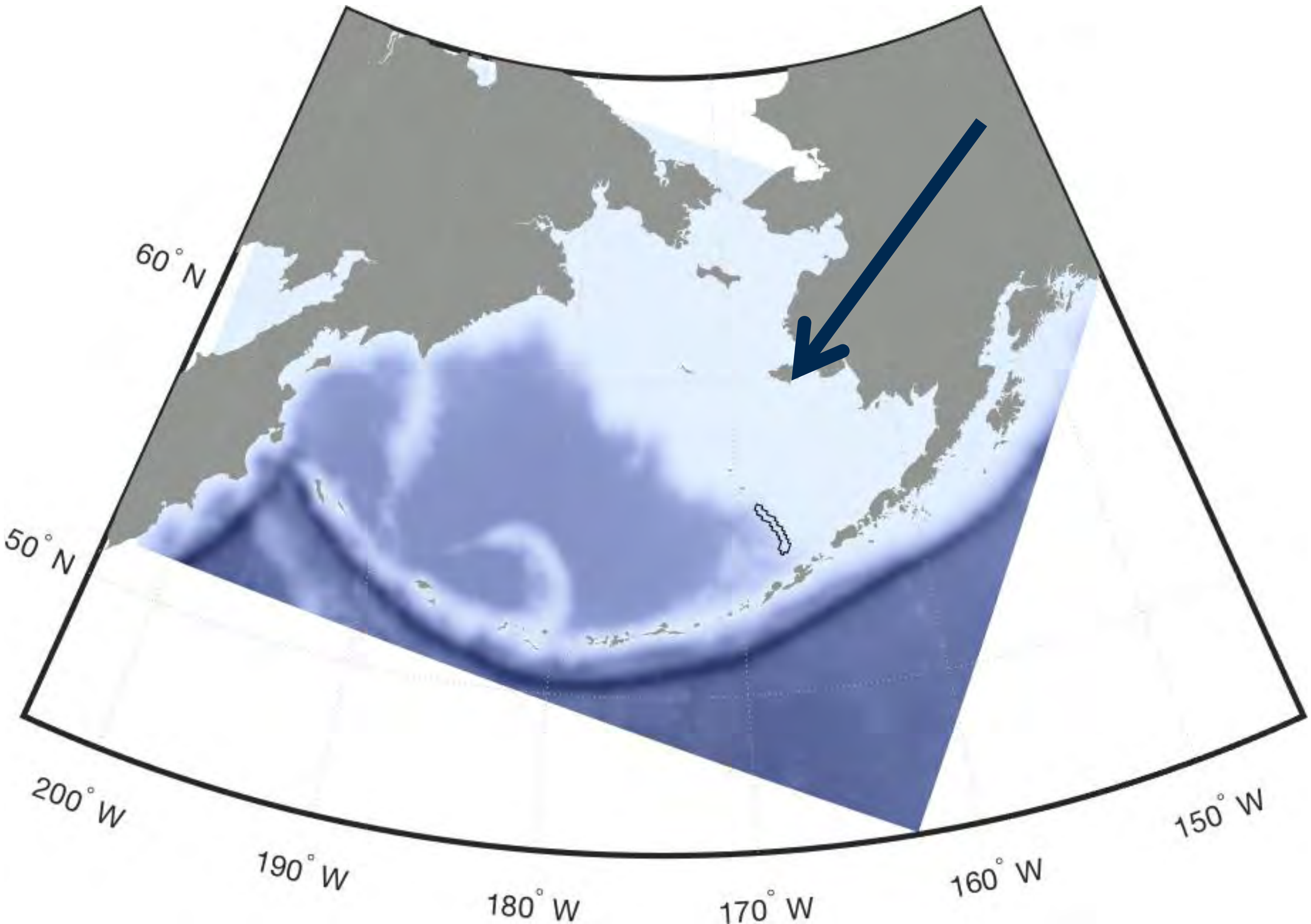
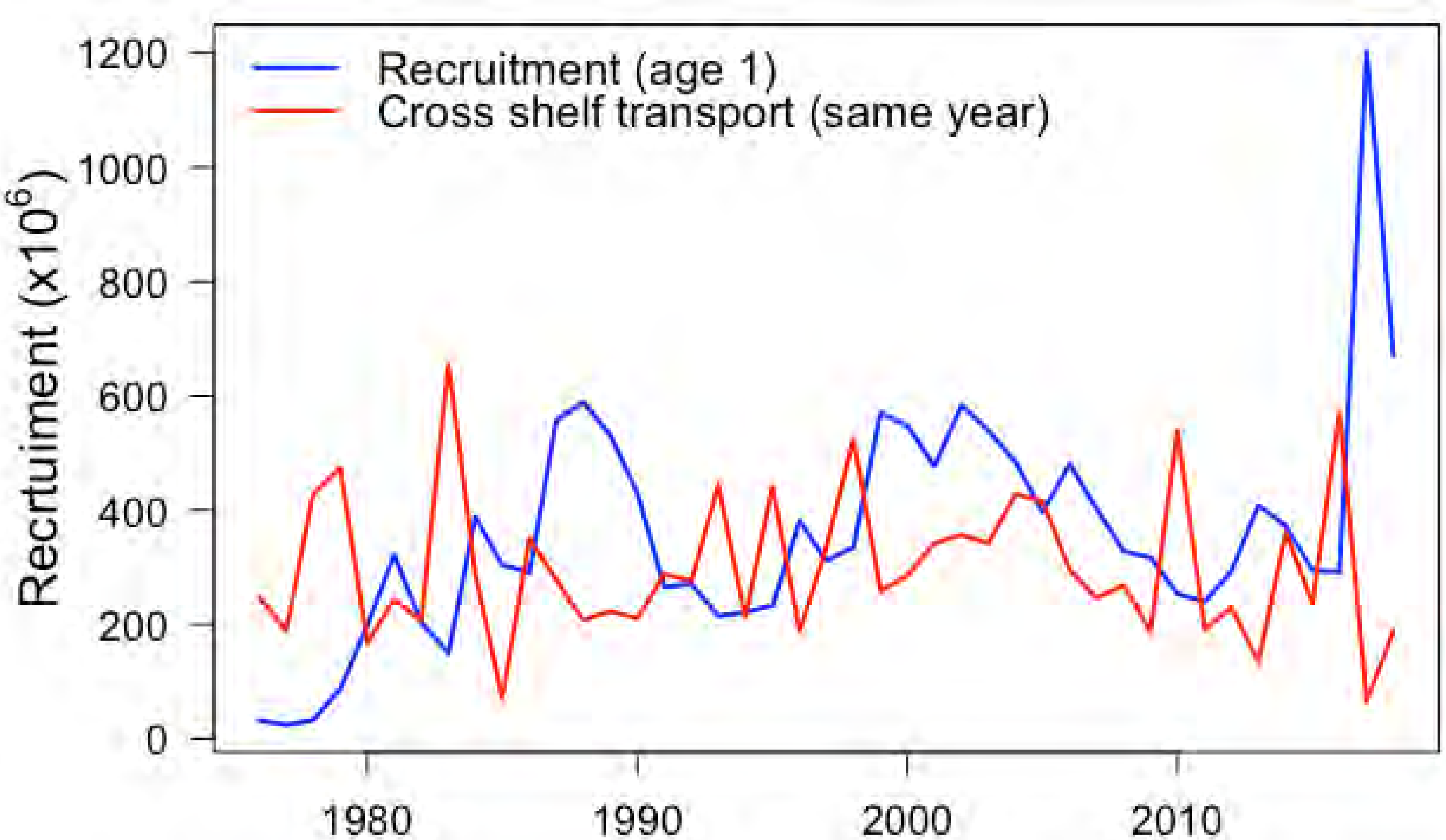
32
31
50
Strat
ATF - Bering Sea shelf Area 6
ATF - Bering Sea shelf Area 4
ATF - Bering Sea shelf Area 1
ATF - Bering Sea shelf Area 3
ATF - Bering Sea shelf Area 5
Year
Length
60°N
55°N
175°W
170°W
165°W
160°W
155°W

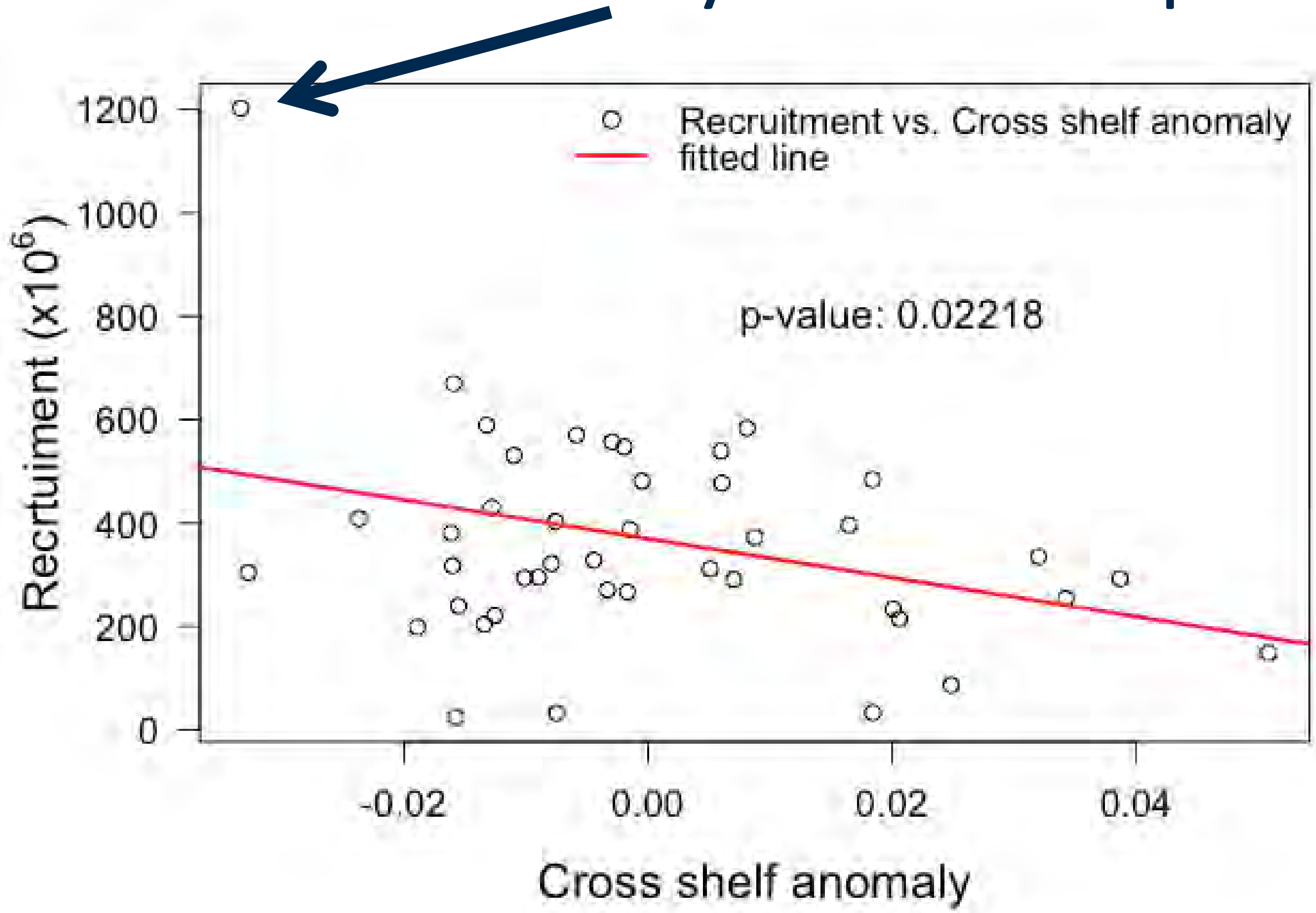
Physical data taken from southern EBS shelf near arrowtooth spawning areas



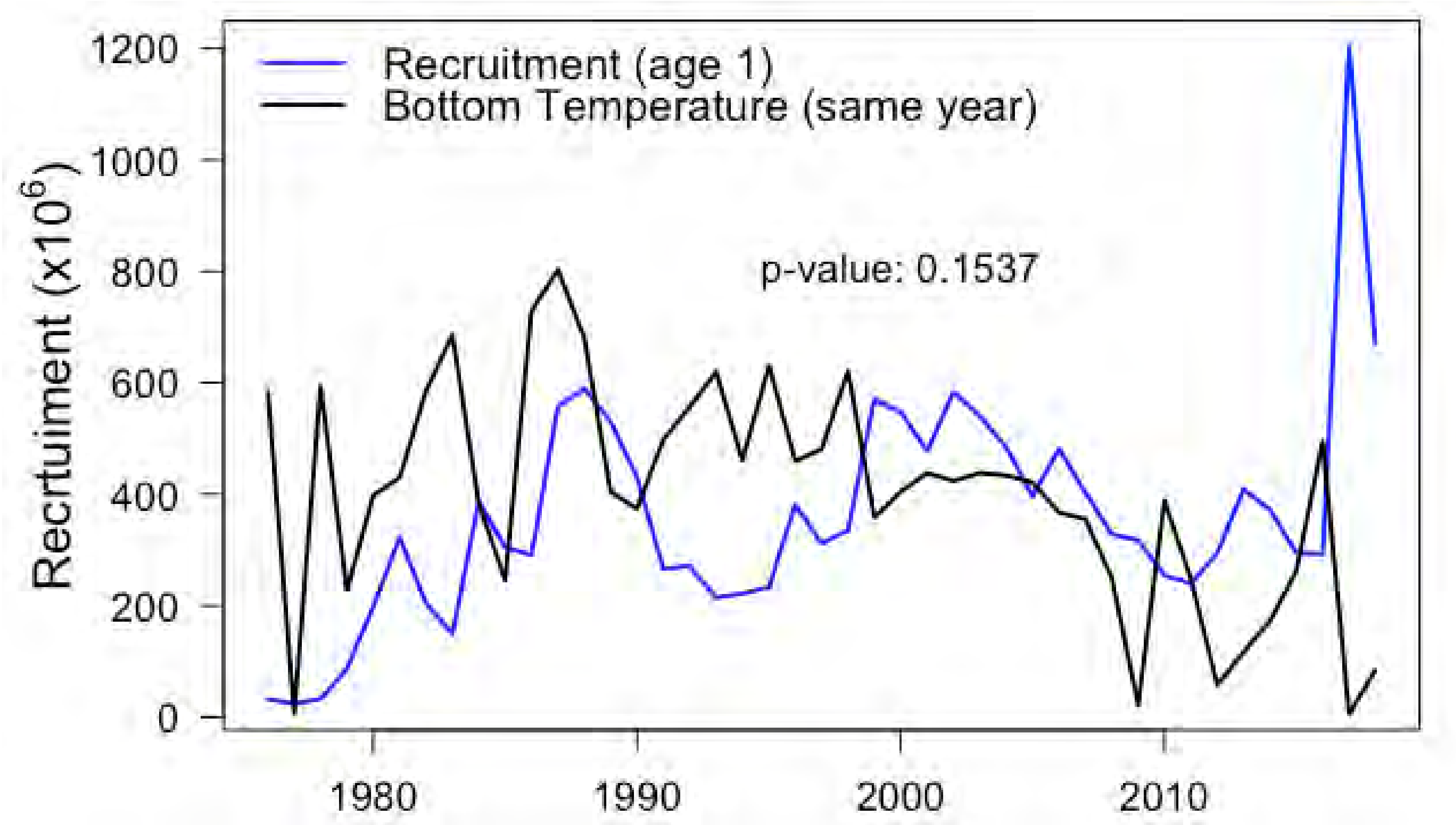
Relationship between cross-shelf transport anomalies (same year) and recruitment is significant



..but it is driven by 2017 data point



Relationship between bottom temperature anomalies (same year) and recruitment is not significant

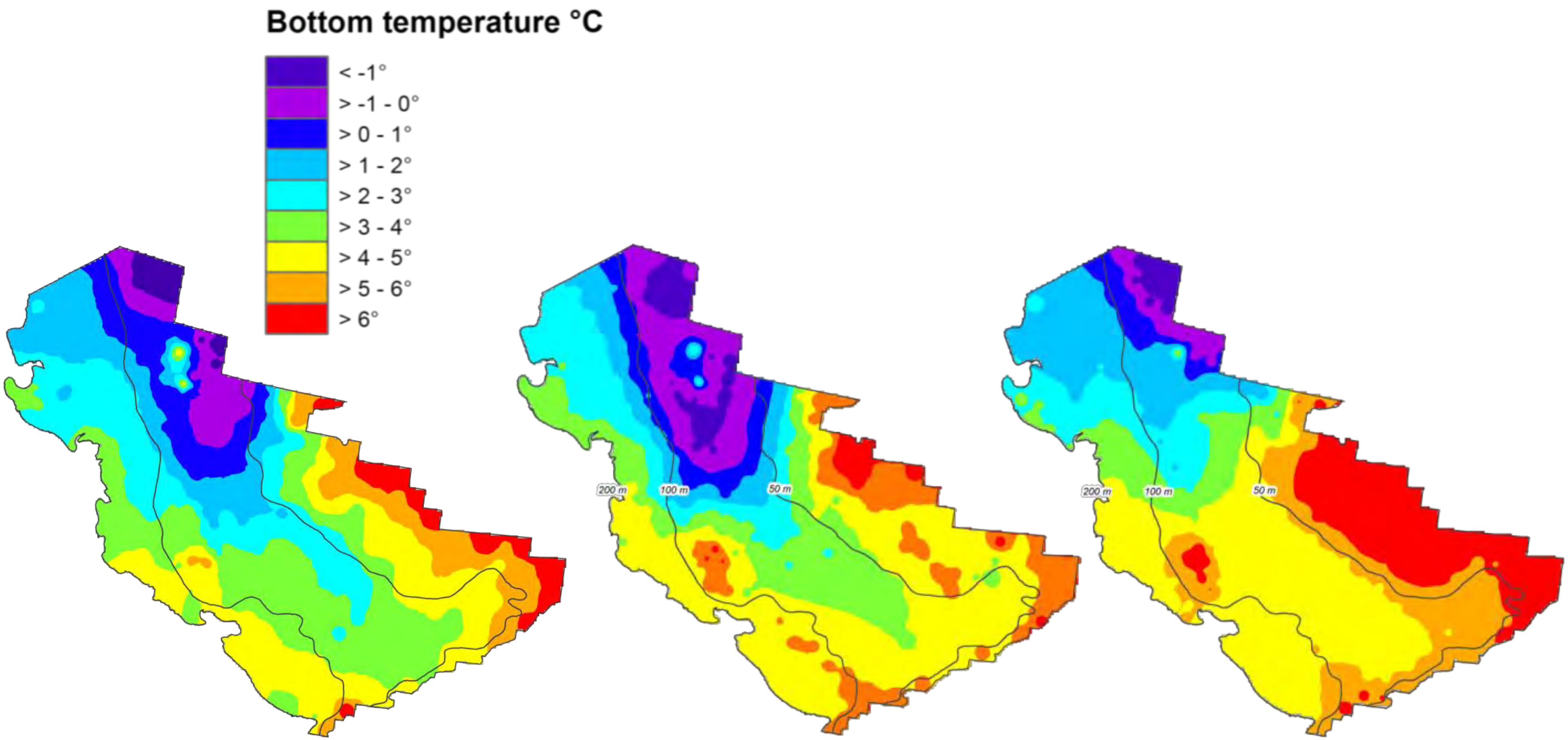


Conclusions – Questions?

Quantity/Status	Last year 2018	2019	This year 2019	2020
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+)	785,141	782,840	1,041,250	1,086,260
Female spawning biomass (t) Projected	490,663	472,562	561,174	552,101
$B_{100\%}$	530,135	530,135	606,237	606,237
$B_{40\%}$	212,054	212,054	242,495	242,495
$B_{35\%}$	185,547	185,547	212,183	212,183
F_{OFL}	0.151	0.151	0.155	0.155
$maxF_{ABC}$ (maximum allowable = $F_{40\%}$)	0.129	0.129	0.131	0.131
Specified/recommended F_{ABC}	0.129	0.129	0.131	0.131
Specified/recommended OFL (t)	76,757	75,084	96,257	86,772
Specified/recommended ABC (t)	65,932	64,494	82,034	75,467
Status	As determined *last* year for: 2015	2016	As determined *this* year for: 2016	2017
Is the stock being subjected to overfishing?	no	na	no	na
Is the stock currently overfished?	na	no	na	no
Is the stock approaching a condition of being overfished?	na	no	na	no

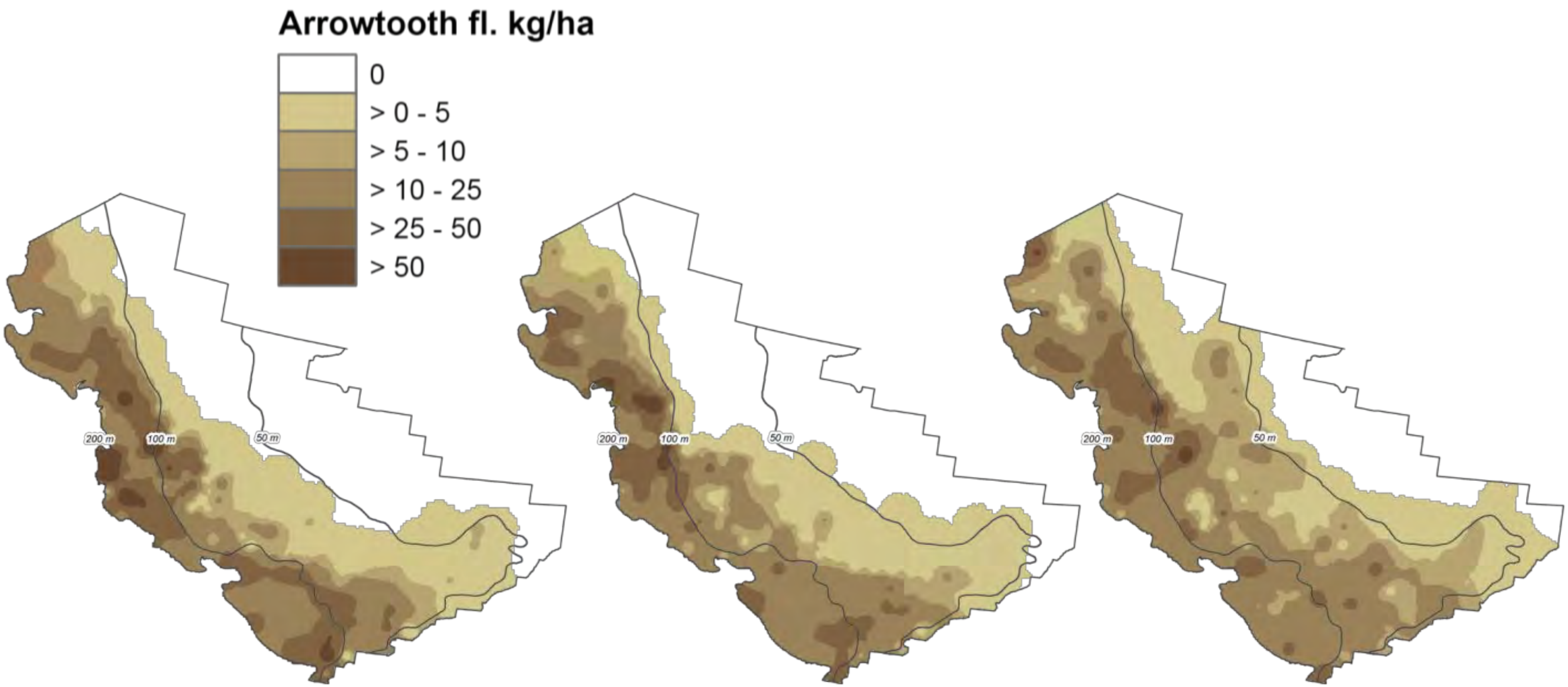
EBS shelf environment

Bottom temperatures – 3 warm years



Arrowtooth flounder

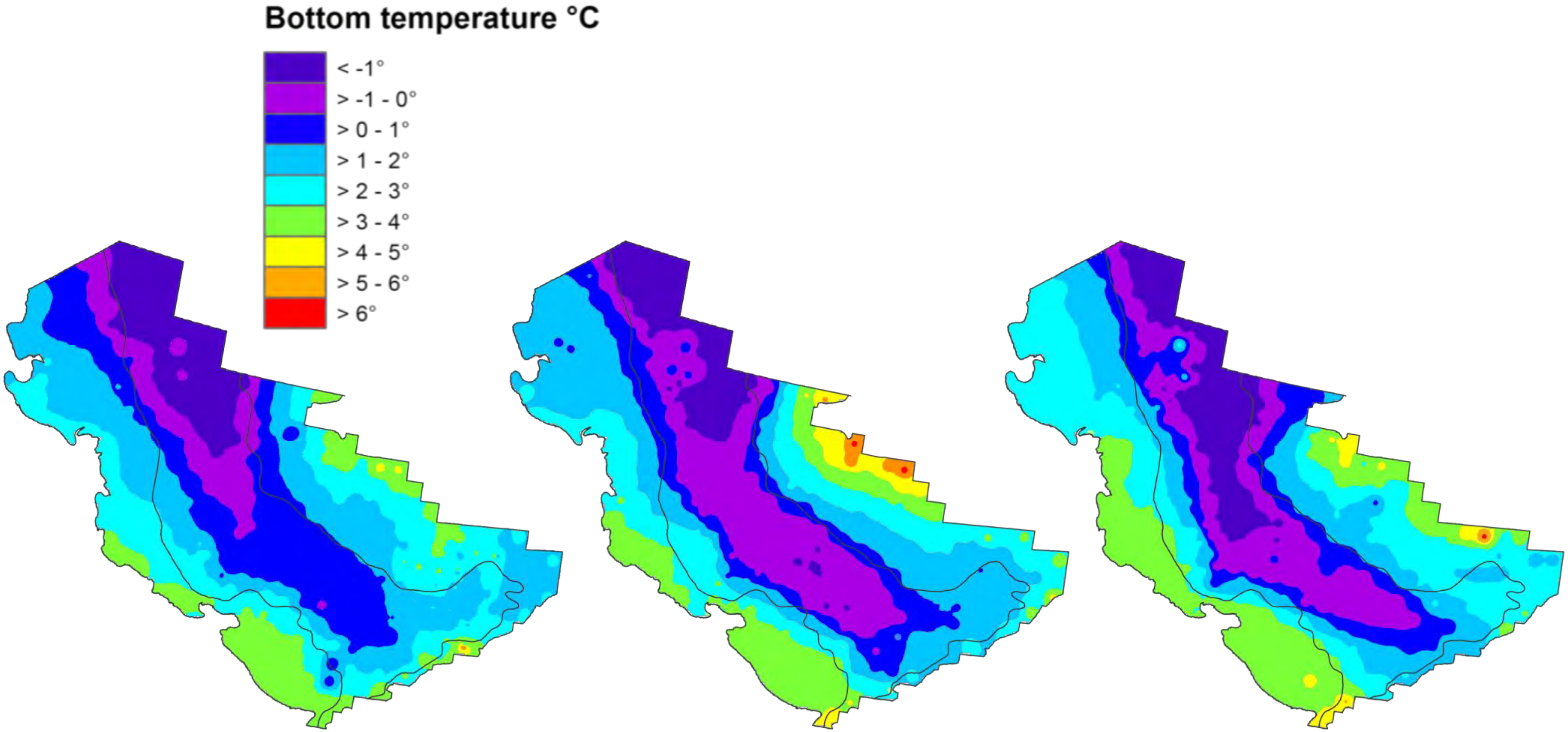
Survey distribution and abundance – 3 warm years



2014 2015 2016

EBS shelf environment

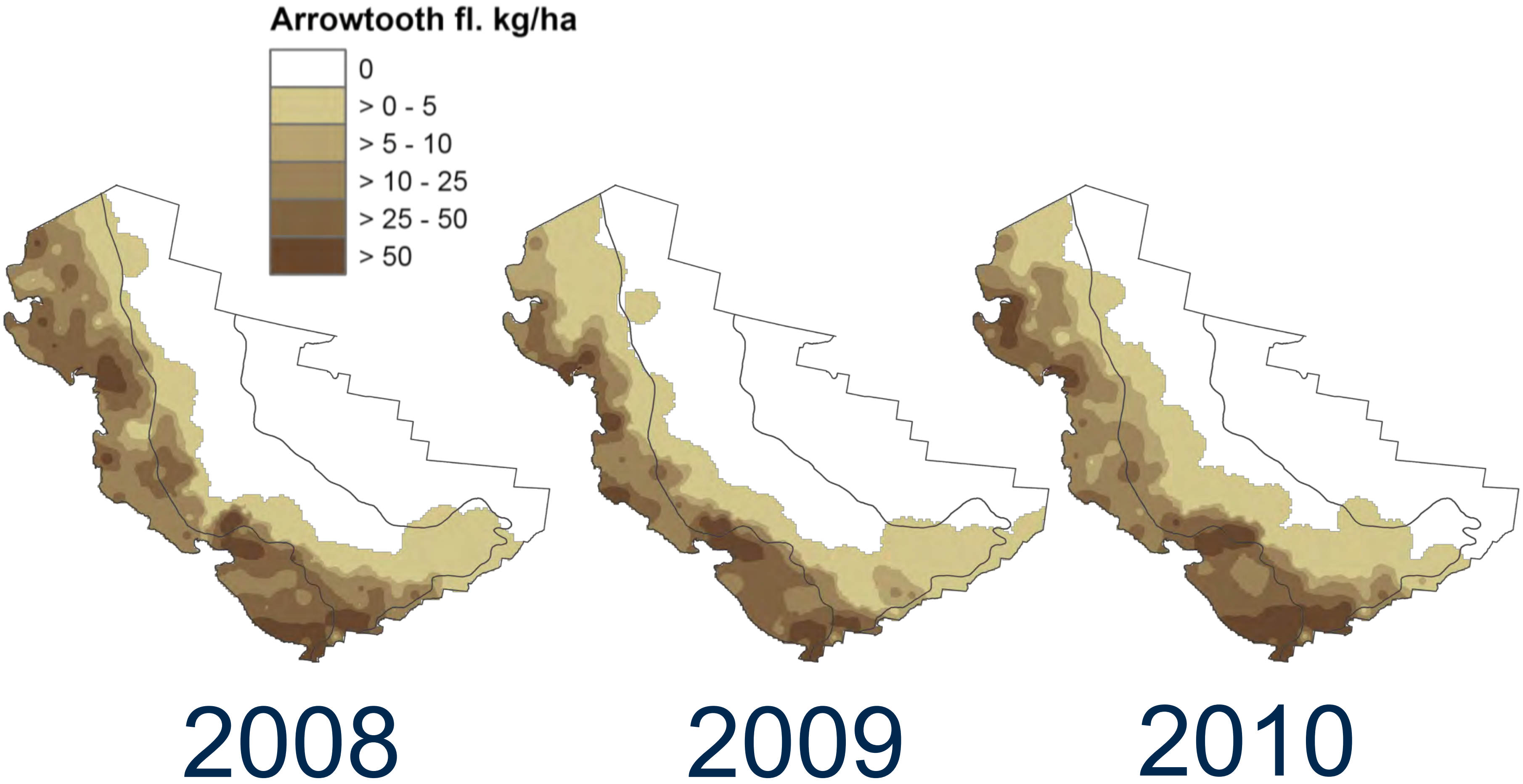
Bottom temperatures – 3 cold years



2008 2009 2010

Arrowtooth flounder

Survey distribution and abundance – 3 cold years



Length-age conversion matrix

Estimation of mean length-at-age

An unbiased estimate of $\bar{l}_j$ is given by

$$\bar{l}_j = \sum_i l_i q_{ij},$$

where q_{ij} is the probability of length i given age j. An expression for q_{ij} is obtained using Bayes theorem,

$$q_{ij} = \frac{q_i q'_{ij}}{\sum_i q_i q'_{ij}}.$$

Dorn, M.W., 1992. Detecting environmental covariates of Pacific whiting Merluccius productus growth using a growth-increment regression model. Fishery Bulletin 90: 260-275.

P(Length|Age)=P(Age|lLength)*P(Length)/P(Age)

Bering Sea shelf catchability

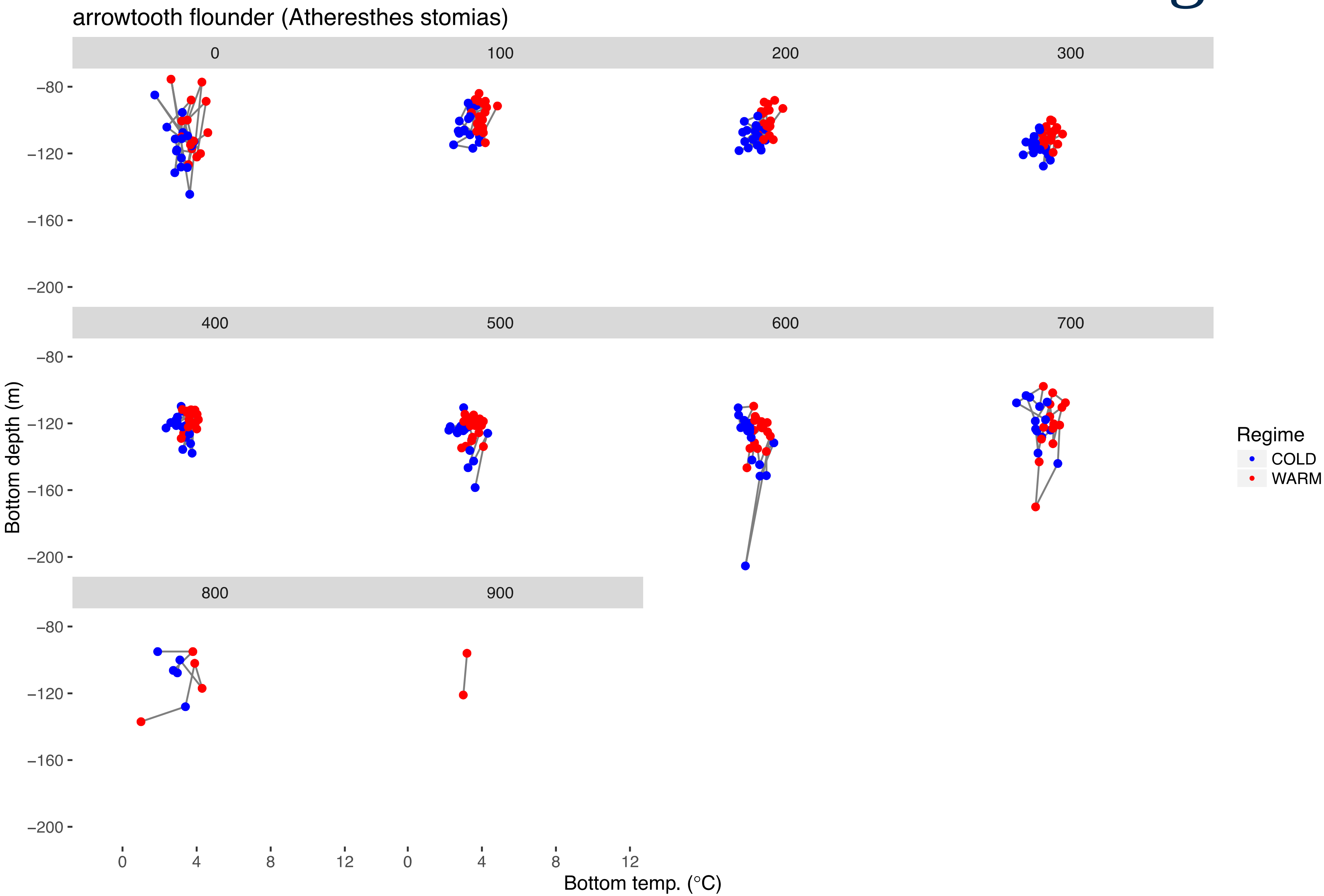
In the Bering Sea, catchablity (*q*) has been found to vary with shelf survey bottom temperature (*T*):

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

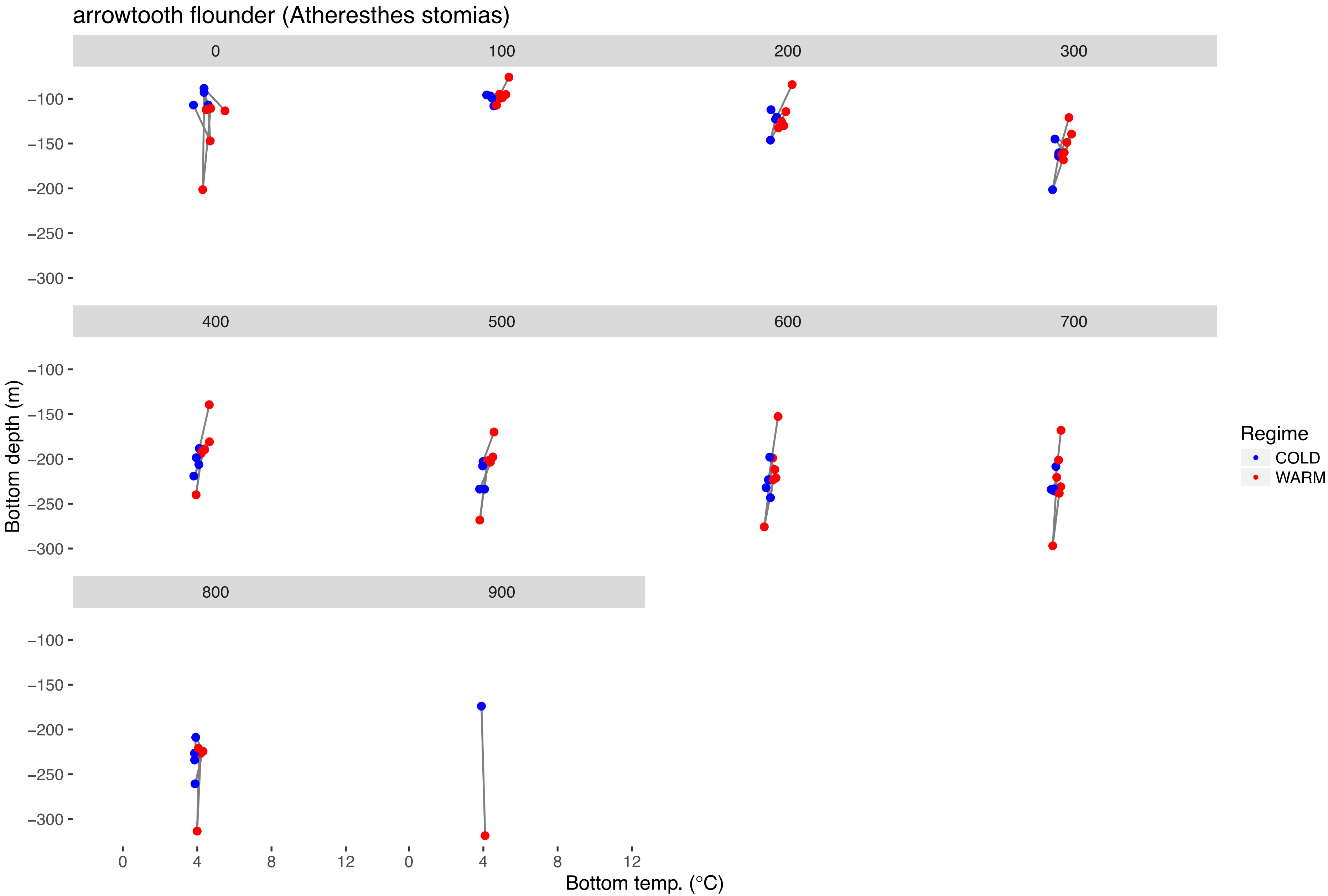
where *α* and β are a parameters estimated by the model.

In the GOA catchability q=1.

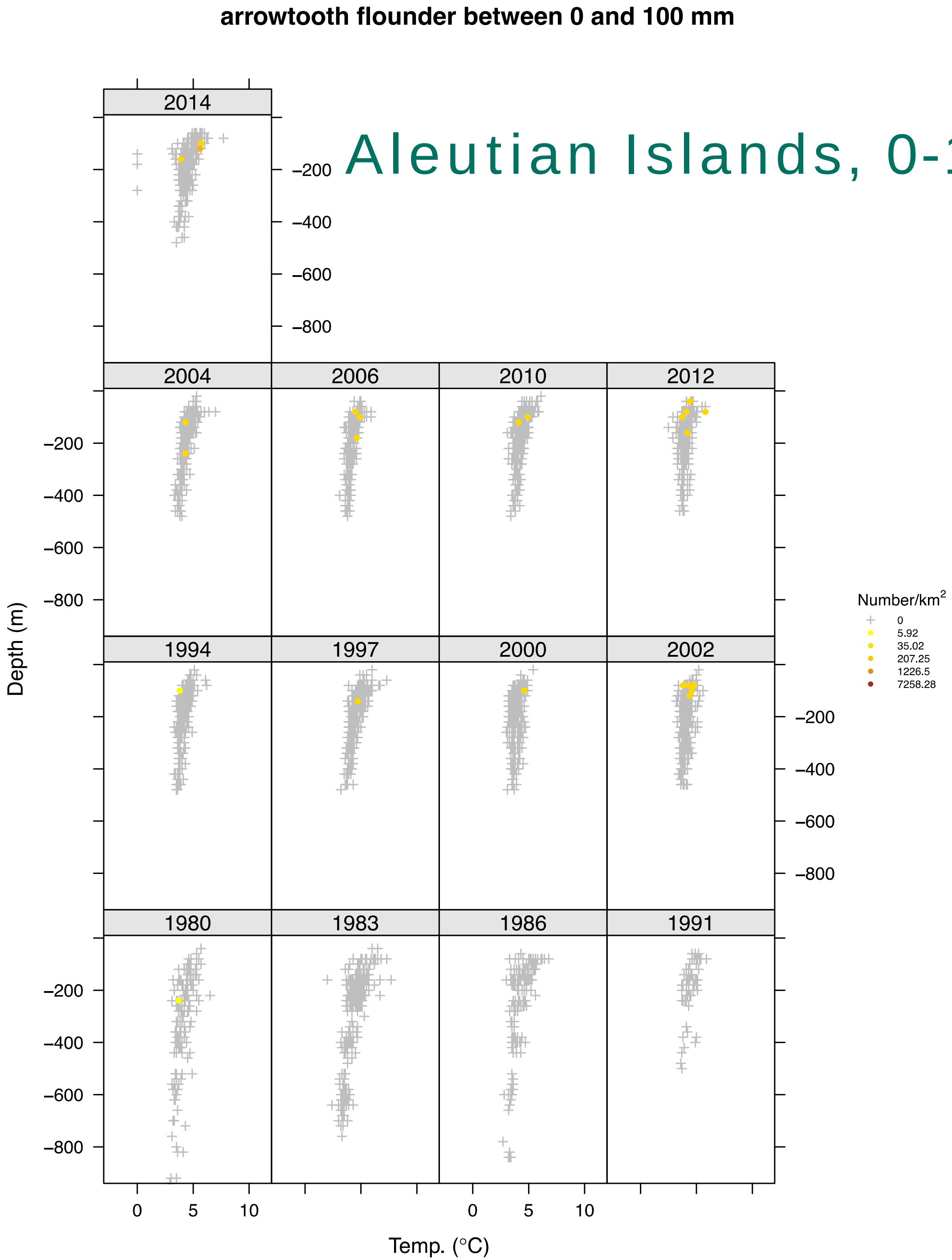
Eastern Bering Sea



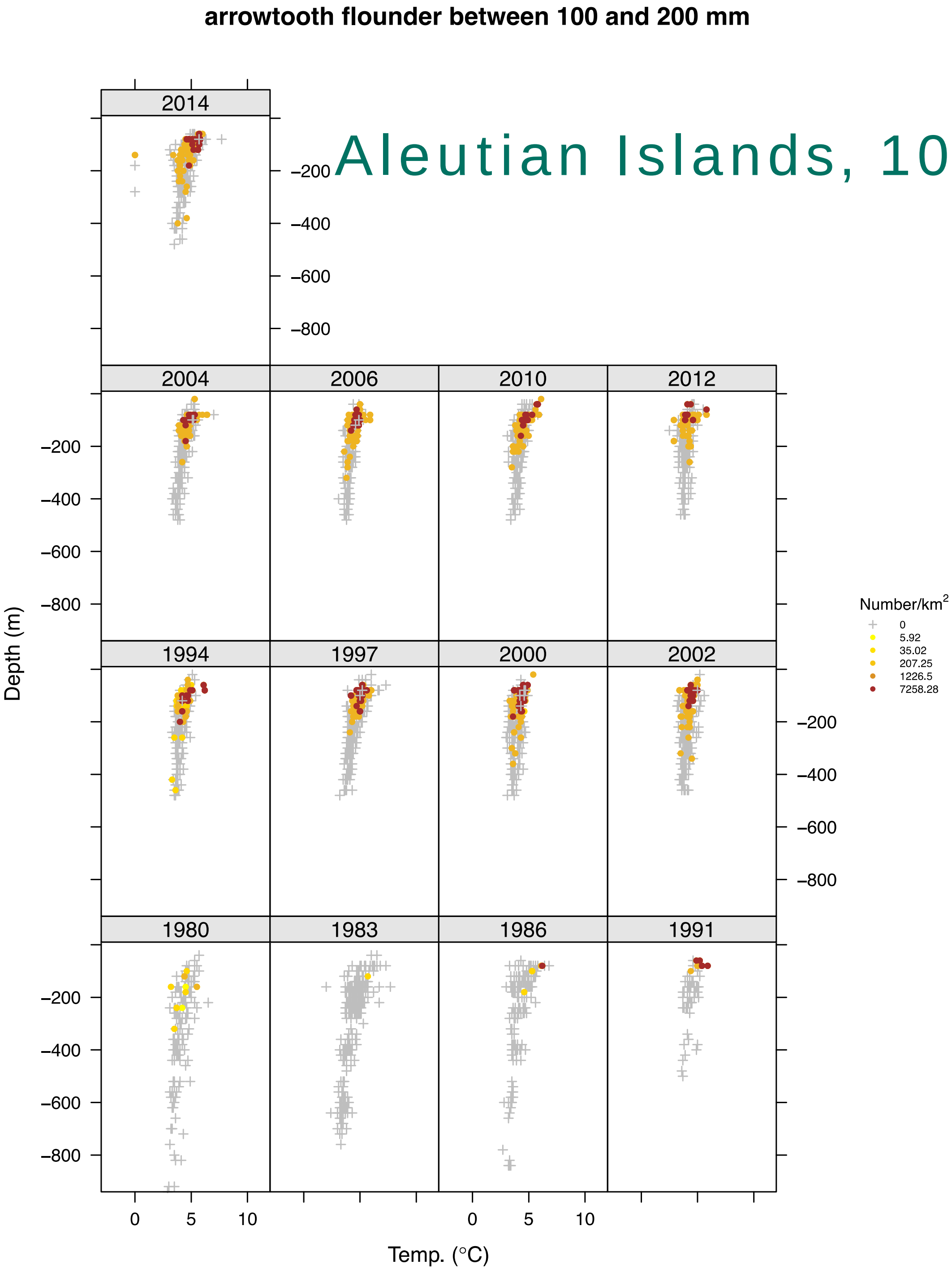
Aleutian Islands



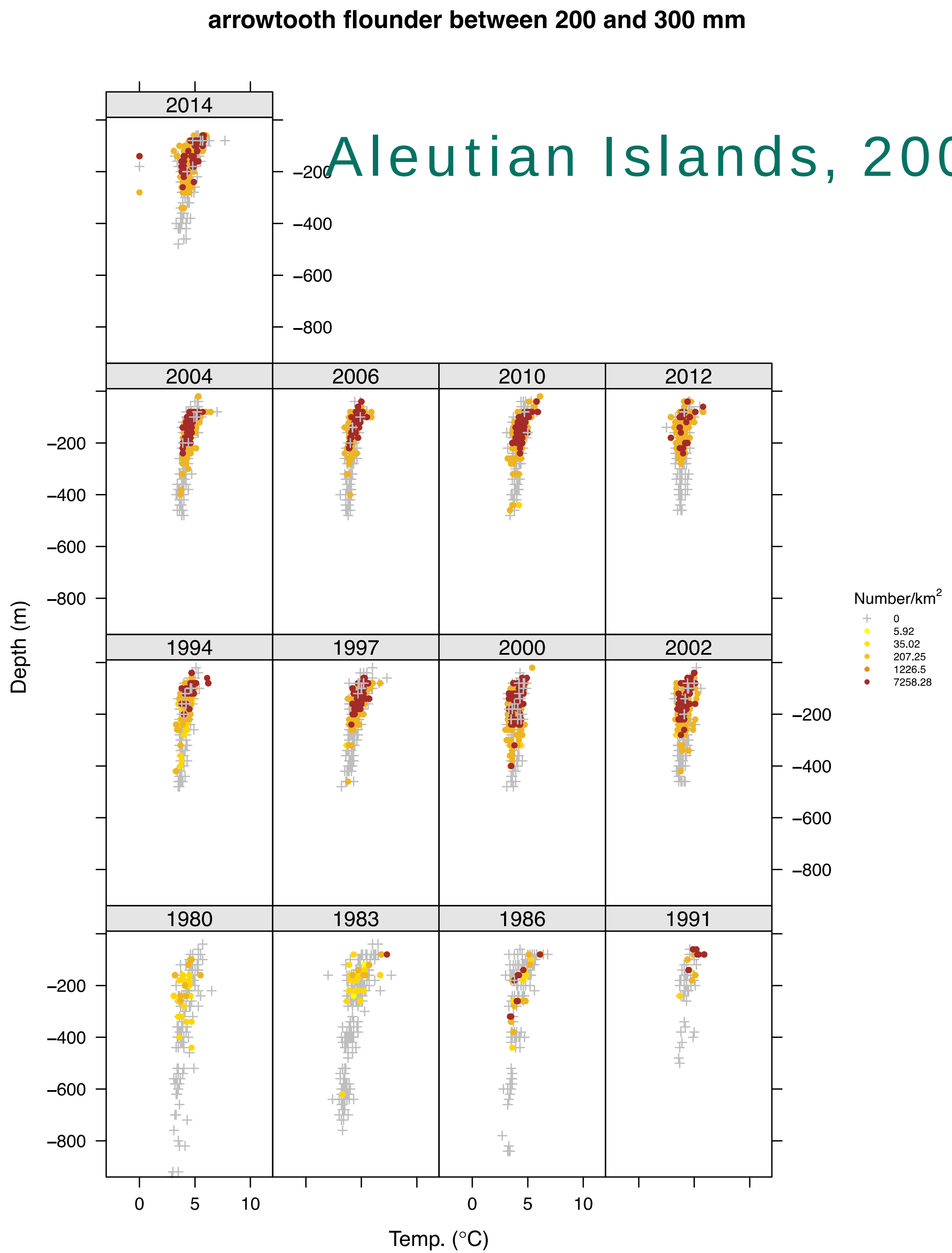
Aleutian Islands, 0-100mm



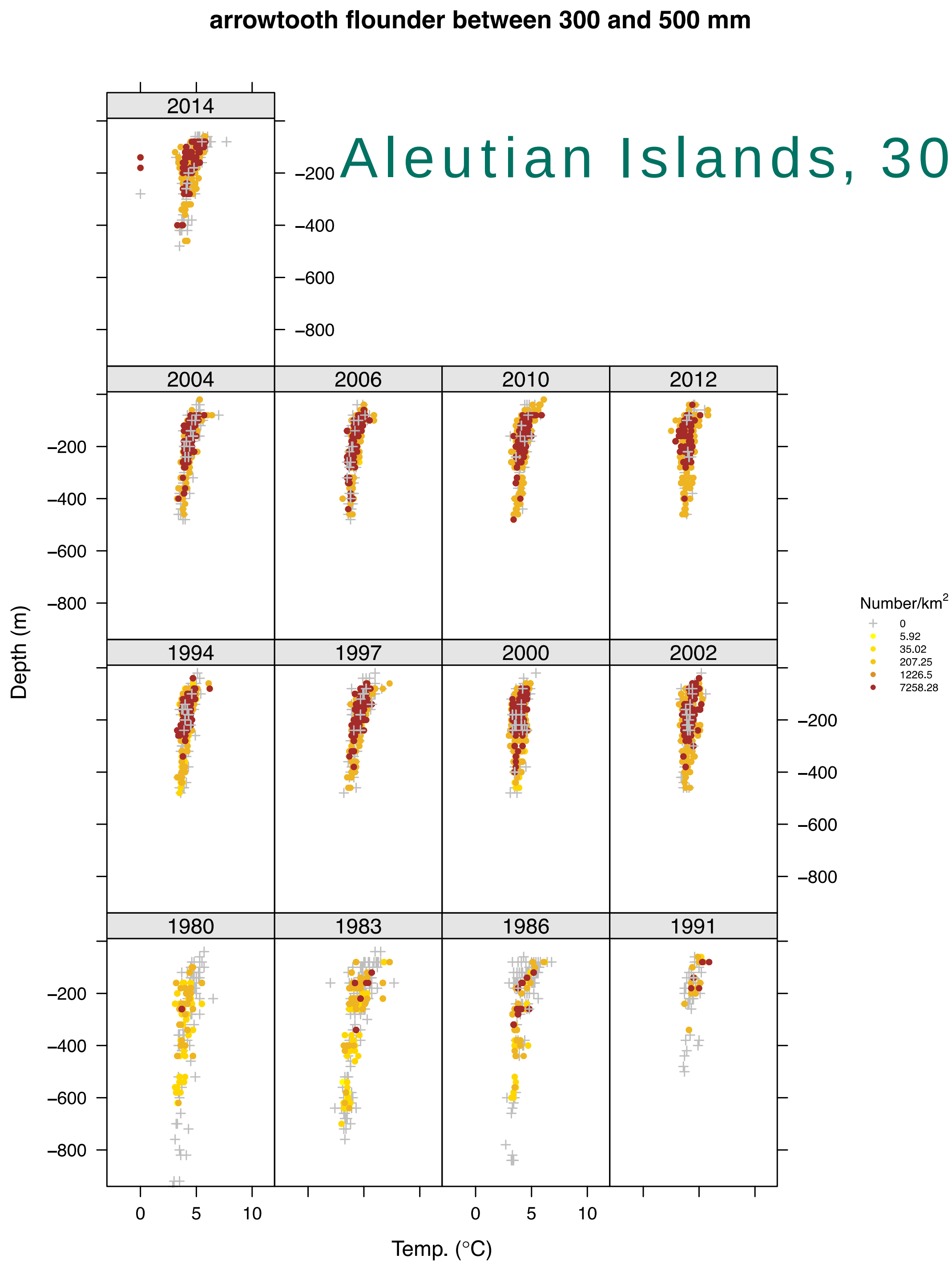
Aleutian Islands, 100-200mm



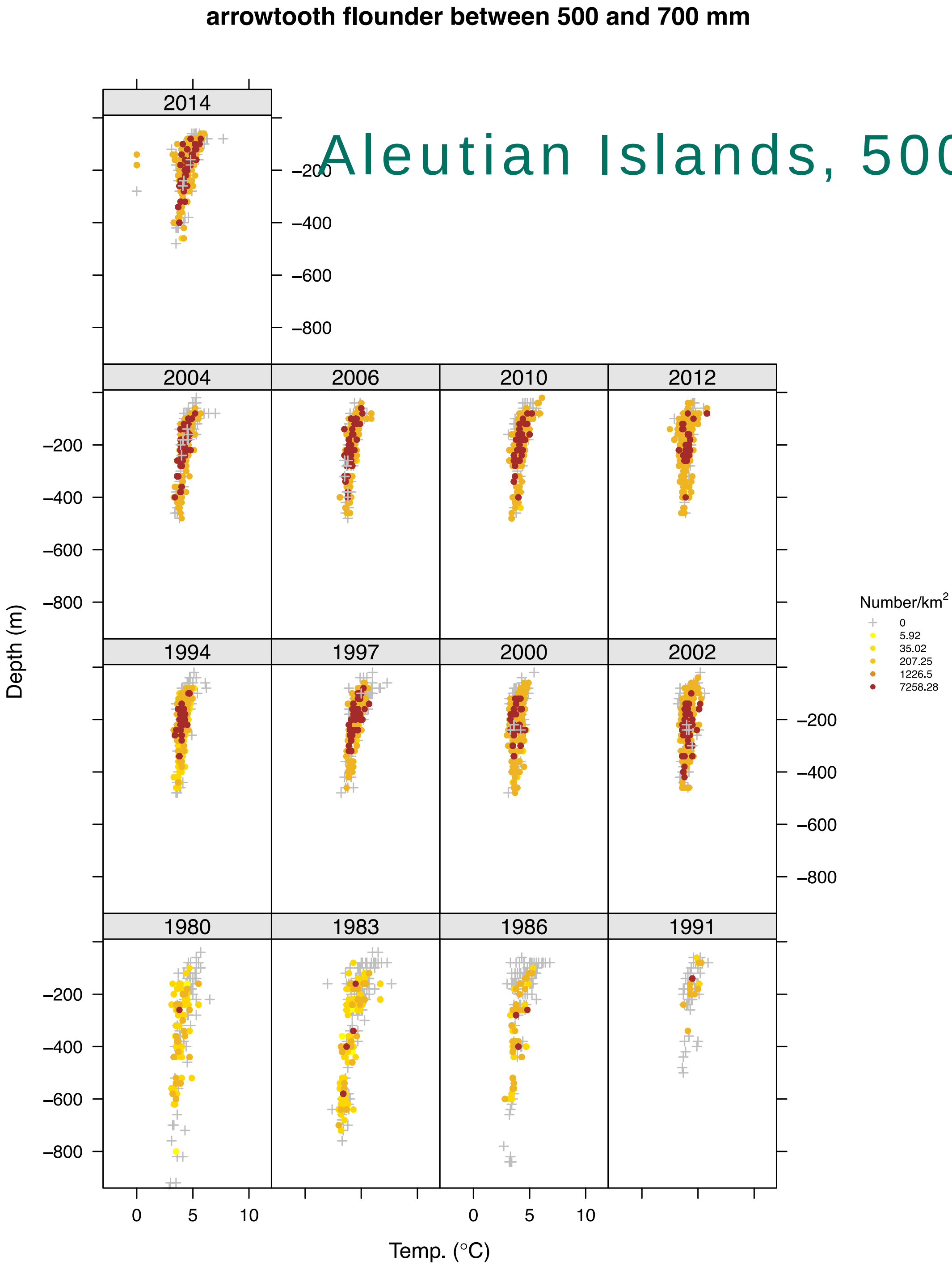
Aleutian Islands, 200-300m



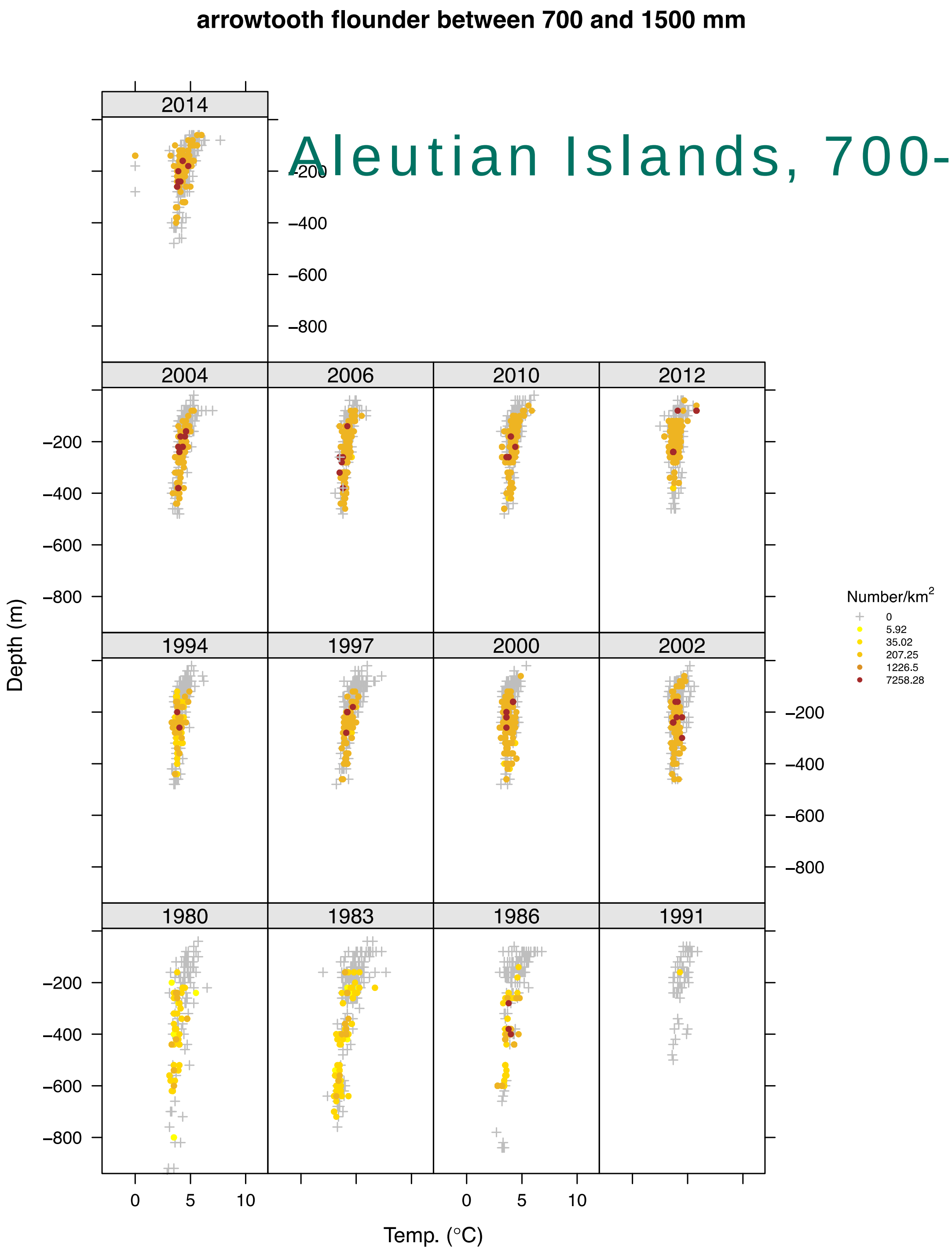
Aleutian Islands, 300-500mm



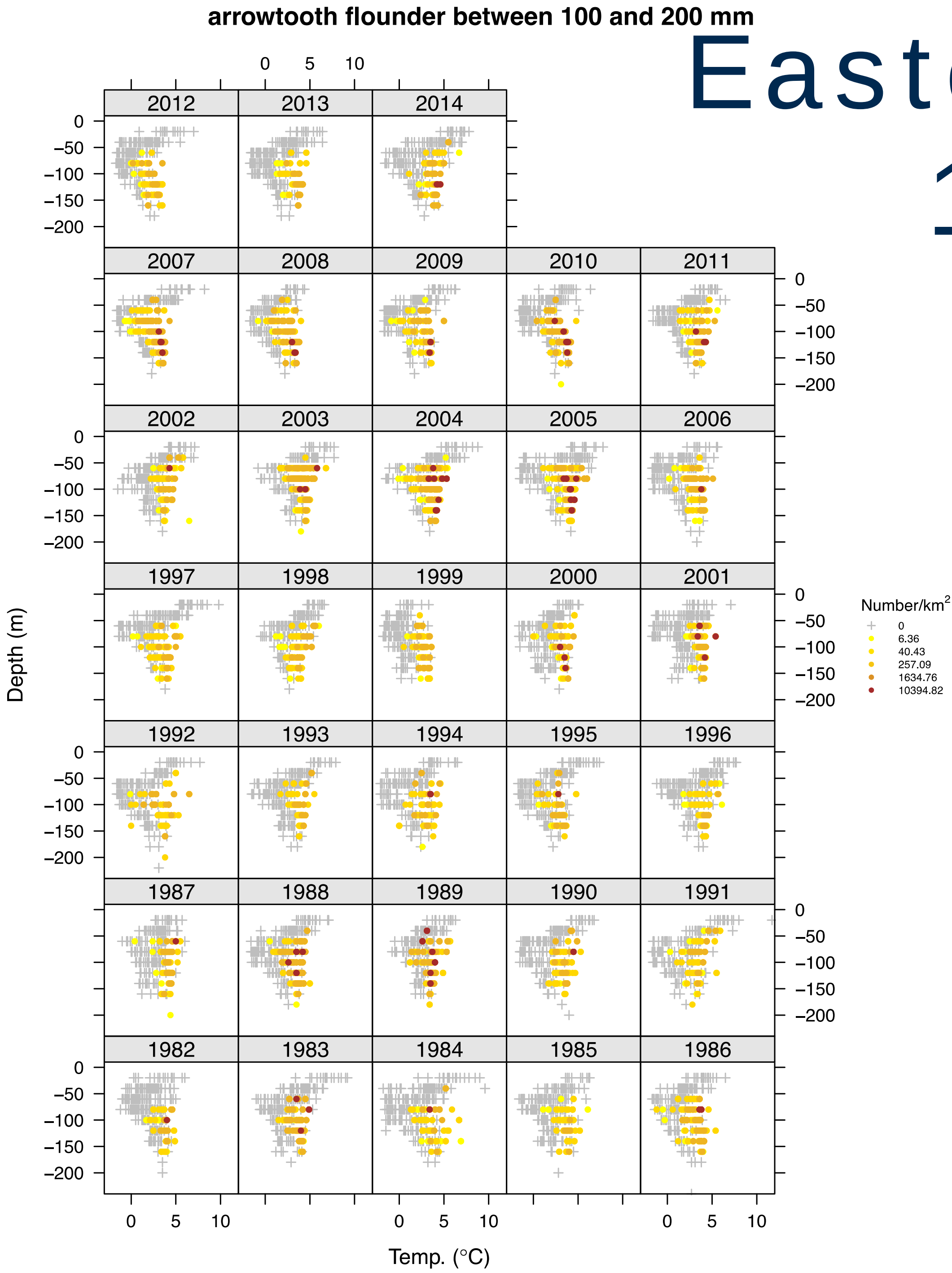
Aleutian Islands, 500-700mm



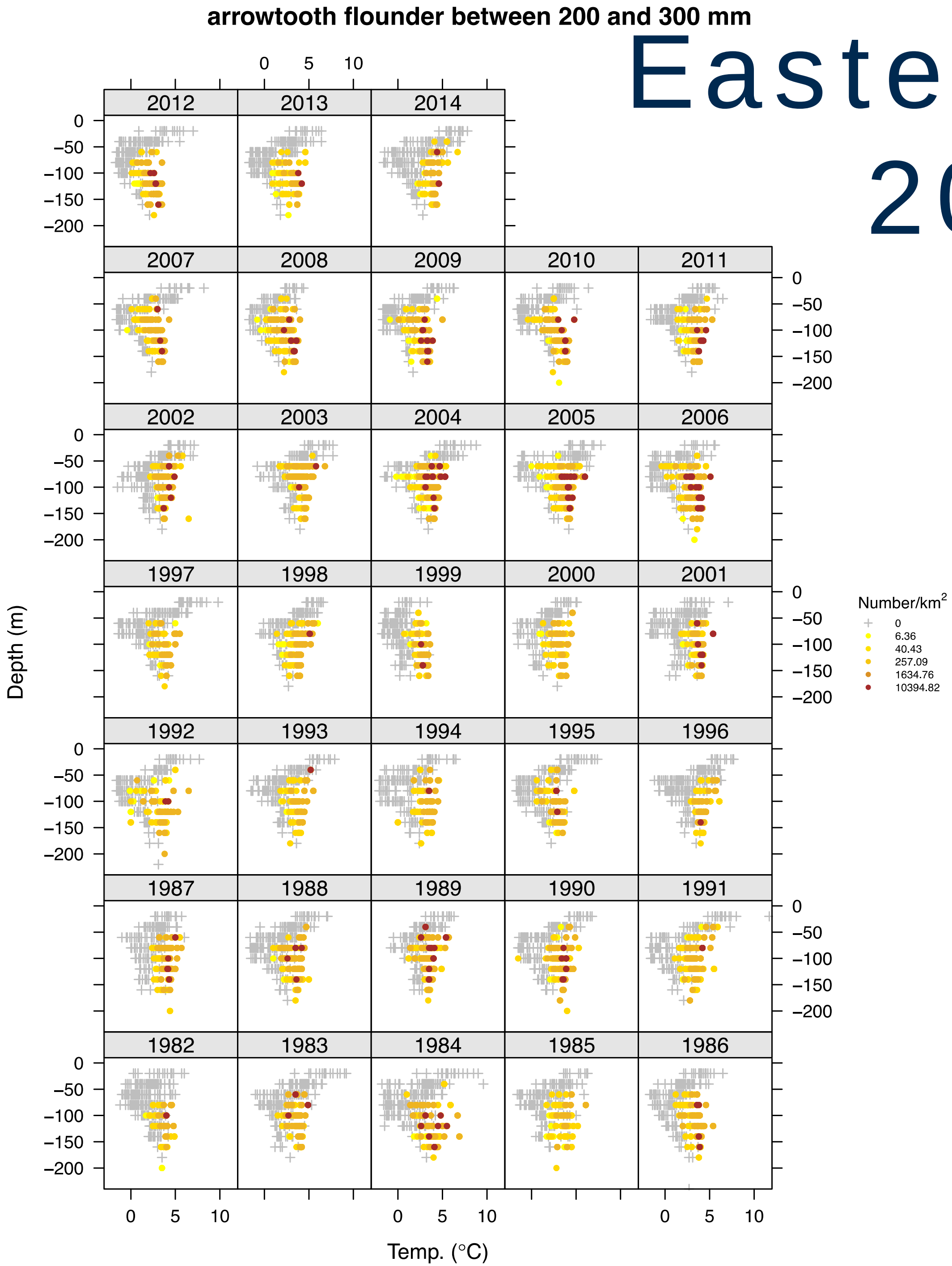
Aleutian Islands, 700-1,500mm



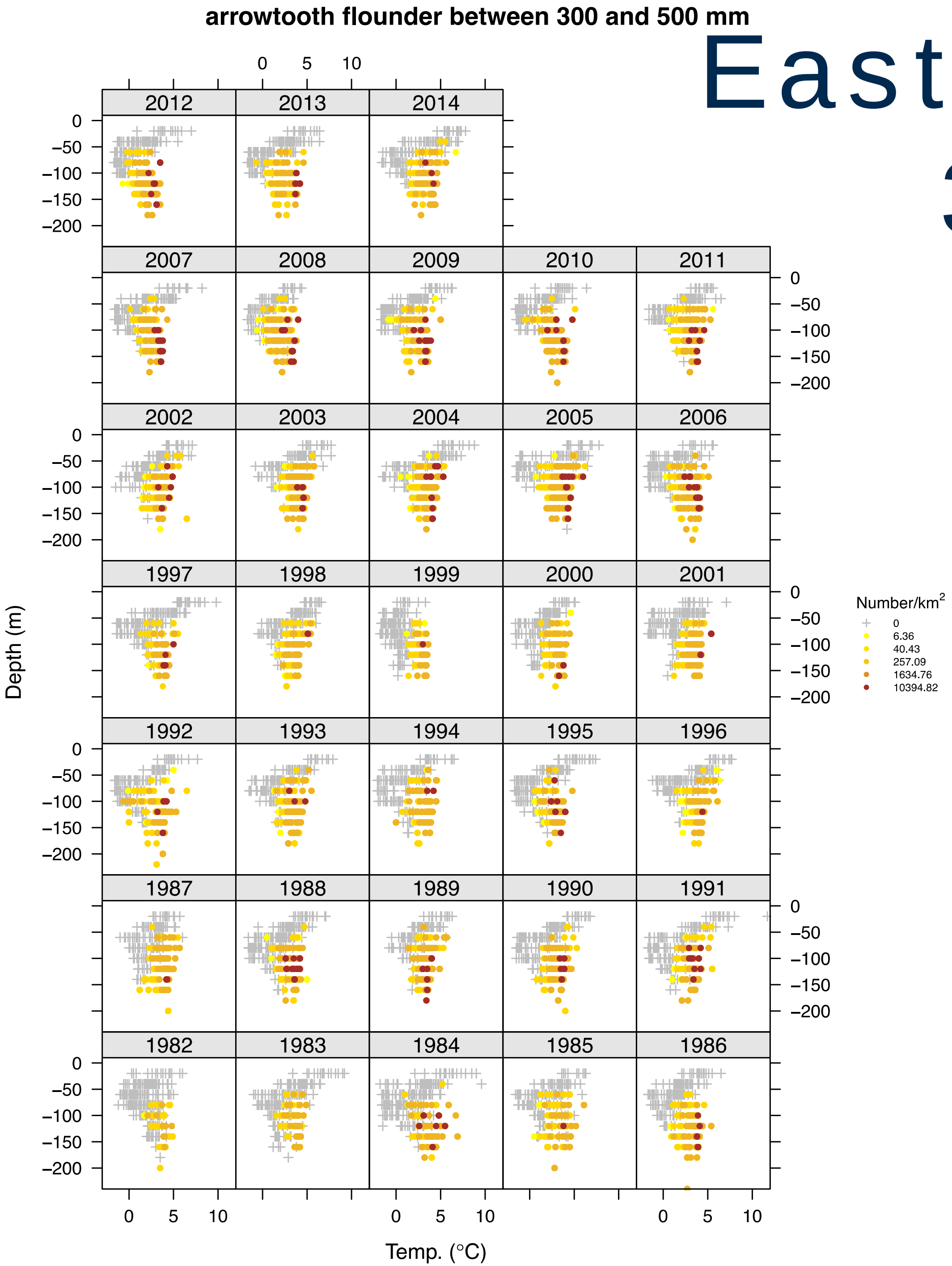
Eastern Bering Se
100-200mm



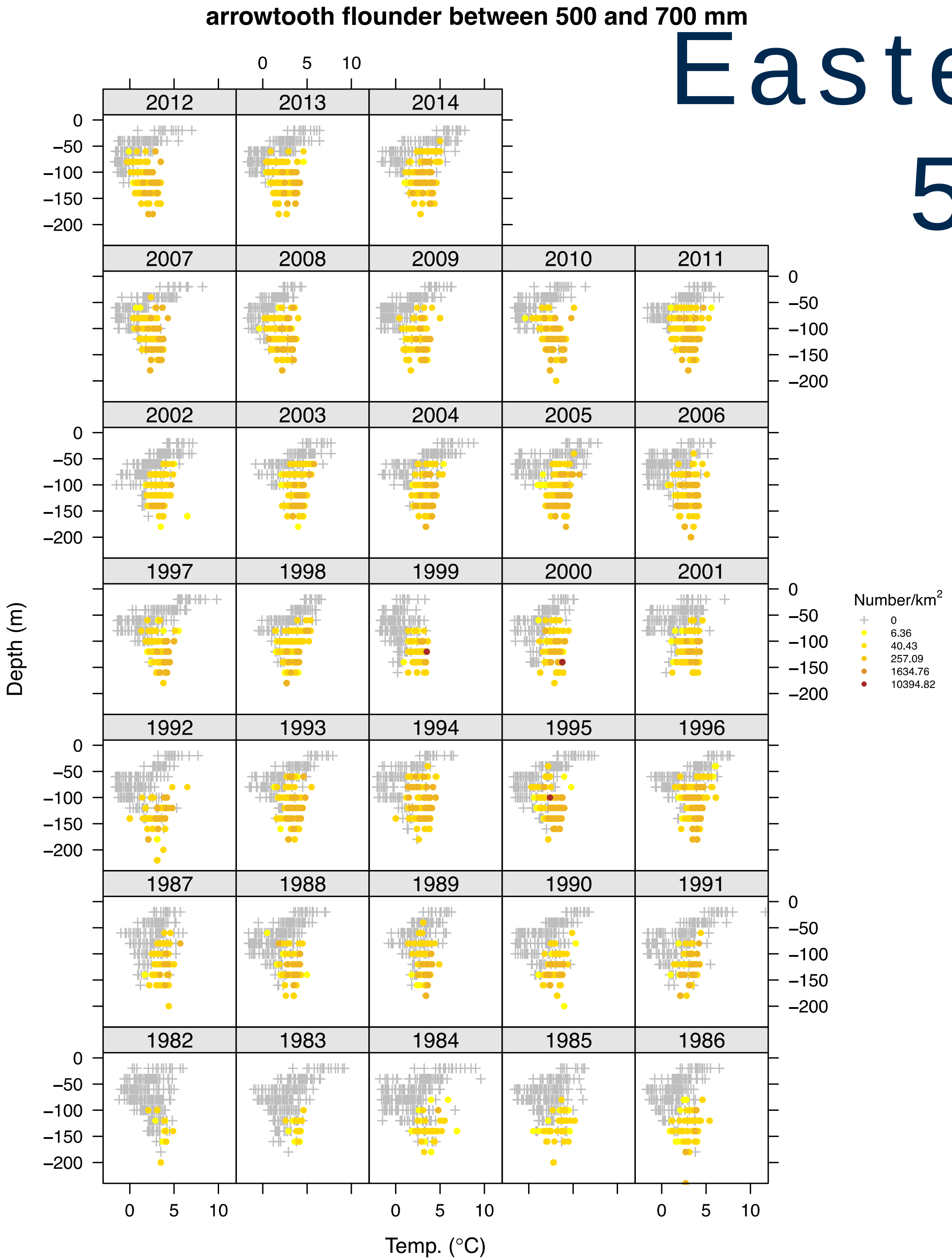
Eastern Bering Sea 200-300mm



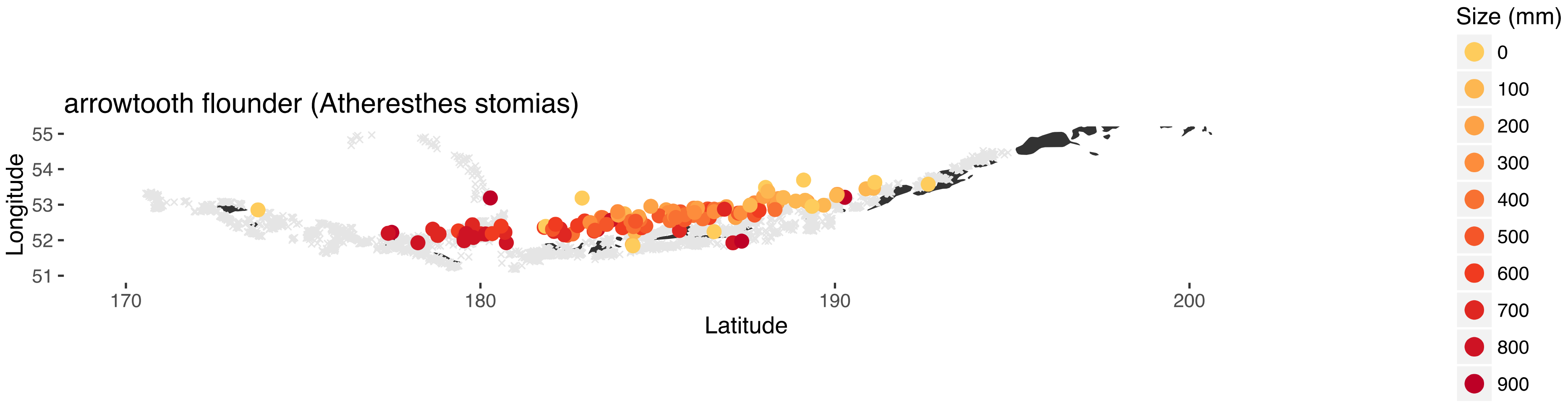
Eastern Bering Se
300-500mm



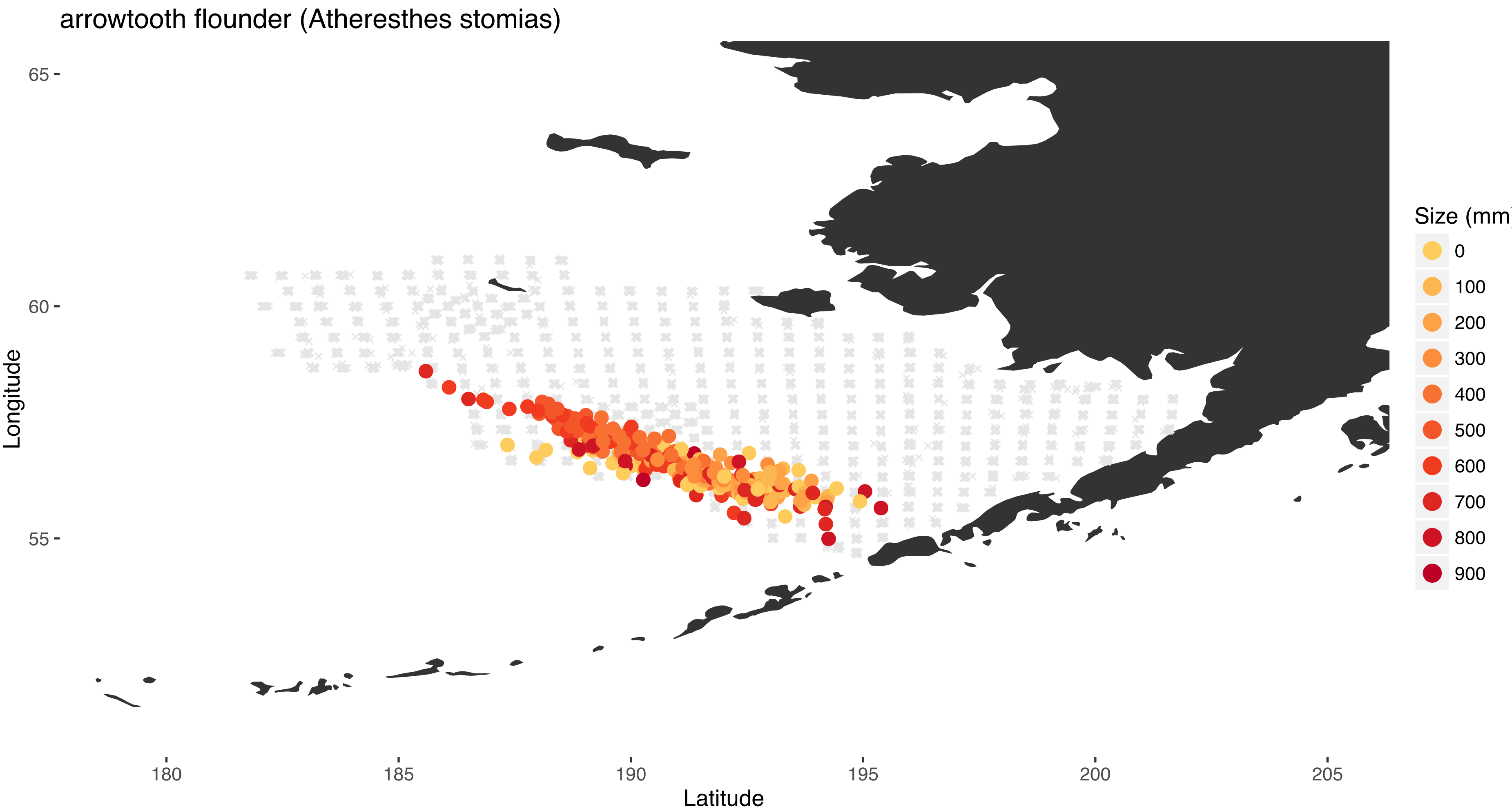
Eastern Bering Sea 500-700mm



Aleutian Islands



Eastern Bering Sea



Spencer et al. ICES Journal of Marine Science. 2016.

- Arrowtooth flounder avoid cool pool water in BSAI <2C.
- Arrowtooth are an important predator of juvenile walleye pollock.
- Models suggest that a decline in walleye pollock biomass would be made worse by an increase in relative distribution of arrowtooth in the eastern Bering Sea middle shelf.

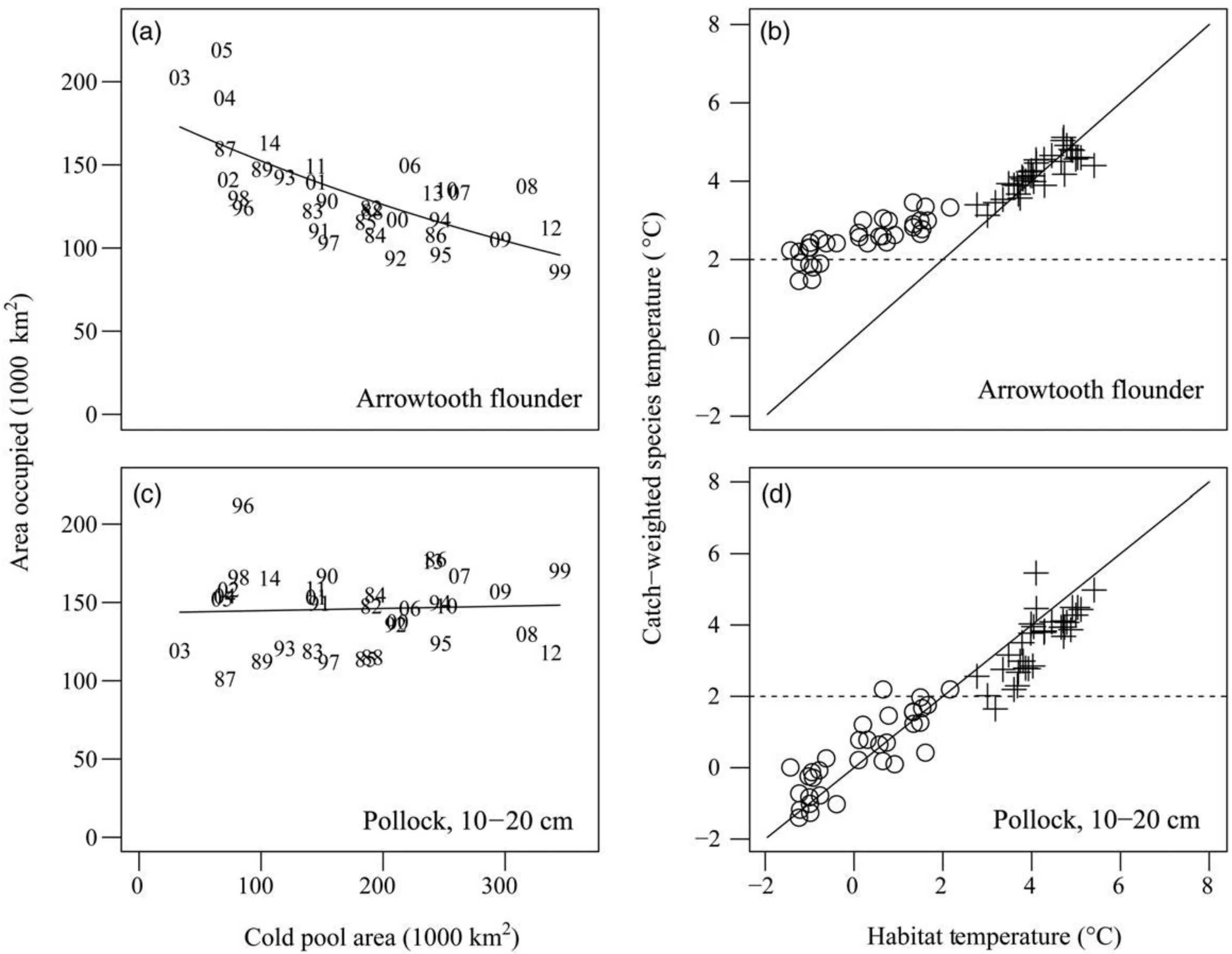


Figure 2. The relationship between the area occupied and cold pool area for arrowtooth flounder and juvenile walleye pollock (a and c, labelled by year). Scatterplots of the bottom temperatures for the tenth (W) and 90th (+) percentiles of the distributions of available temperatures and the catch-weighted temperature distributions are in (b) and (d). Temperature preference in indicated by deviations from the 1:1 line, and points below the horizontal lines indicate species occurrence within the cold pool. Spencer et al. 2016.

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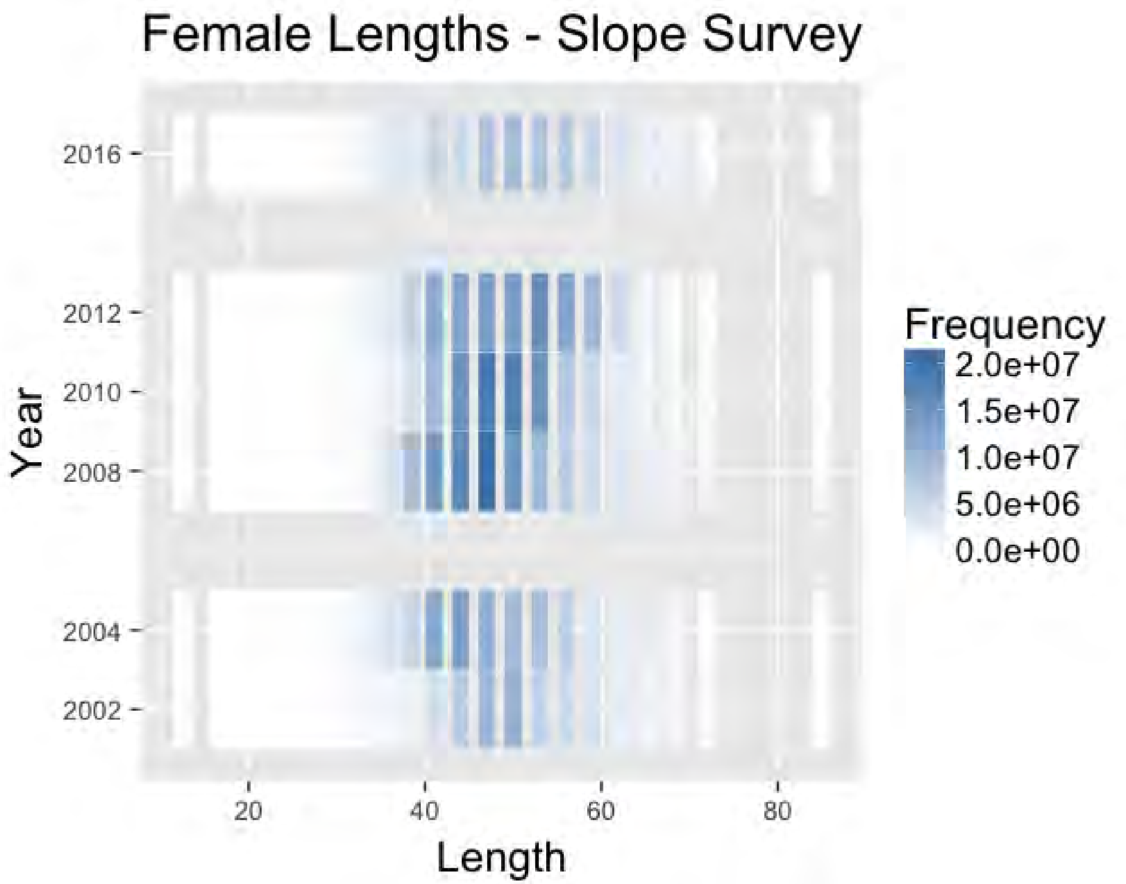
Fit to survey data



Updated age-weight relationship