NOAA FISHERIES
Alaska Fisheries Science Center

Preliminary assessment of the arrowtooth flounder stock in the Bering Sea and Aleutian Islands

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September 20, 2018

Comments from 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.”

Comments from 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.

New proposed models

- Length-based rather than age-based selectivity (so males and female selectivity can be combined).
- Alternative formulations for male and female natural mortality.
- Inclusion of an ageing error matrix.
- Smoothed length-age conversion matrix.
- Explore different ways to integrate the three surveys.

New Models:

Model 15.1c: Base Model.

Model 18.0: Selectivity at length for the three surveys.

Model 18.1: Same as 18.0 also incorporates logistic fishery selectivity (as opposed to non-parametric).

Model 18.2: Selectivity at length for three surveys and the fishery.

Model 18.3: Differs from base model by an ageing error matrix.

Model 18.4: Lorenzen natural mortality.

Model 18.5: Gislason natural mortality.

Model 18.6: Length-based survey selectivity, non-parametric fishery selectivity, ageing error matrix.

Extra Models:

Model 18.7: EBS shelf and slope only. Estimates catchability among two regions (shelf and slope).

Model 18.8: Aleutian Islands only. Length data only.

Plan Team and SSC: Consider smoothing the length age conversion matrix.

- All models presented here incorporate a smoothed length age conversion matrix.

Smoothed length age conversion matrix

- Based on age data from standard surveys (5,243 males, 2,547 females).

Bering Sea (shelf and slope).

1982	1991	1993	1994	1996	1998	2004	2010	2012	2014	2015
243	187	211	125	218	280	594	1482	1098	392	617

2016	2017
1214	530

Aleutian Islands

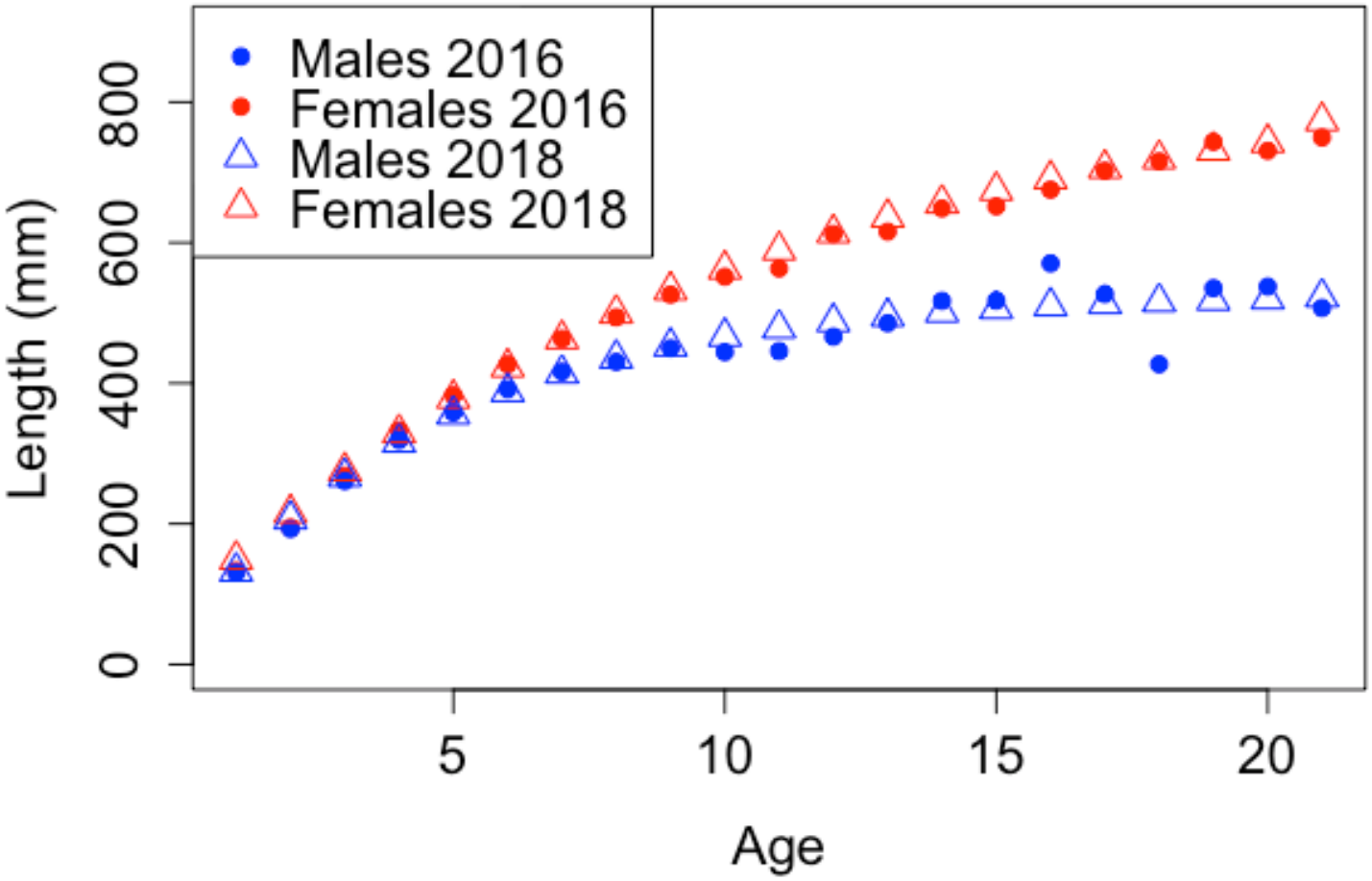
2010	2012	2014	2016
477	401	314	477

Age data is corrected for available length frequencies in the population

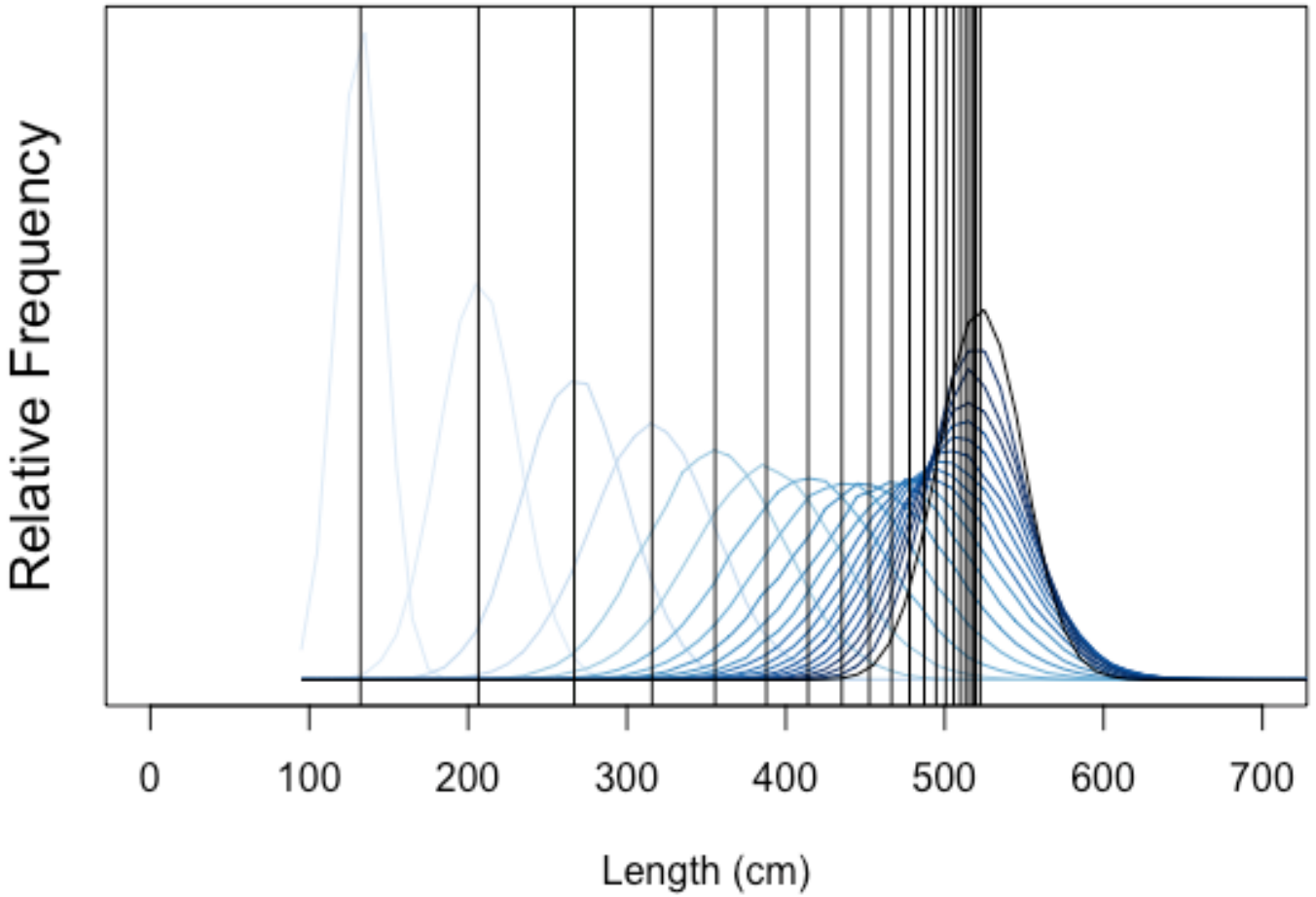
- More length data than aged specimens collected on each research survey
- Age data adjusted by dividing by length frequencies from survey data.
- Corrected for survey length frequencies.
- Fit to vonBertalanffy.
- The plus group (21+) weighted average of the vonBertalanffy mean length and the proportion estimated in upper age categories (M=0.2, M=0.35).

- Bayes Theorem: P(Age|Length)=P(Length|Age)*P(Age)/P(Length)

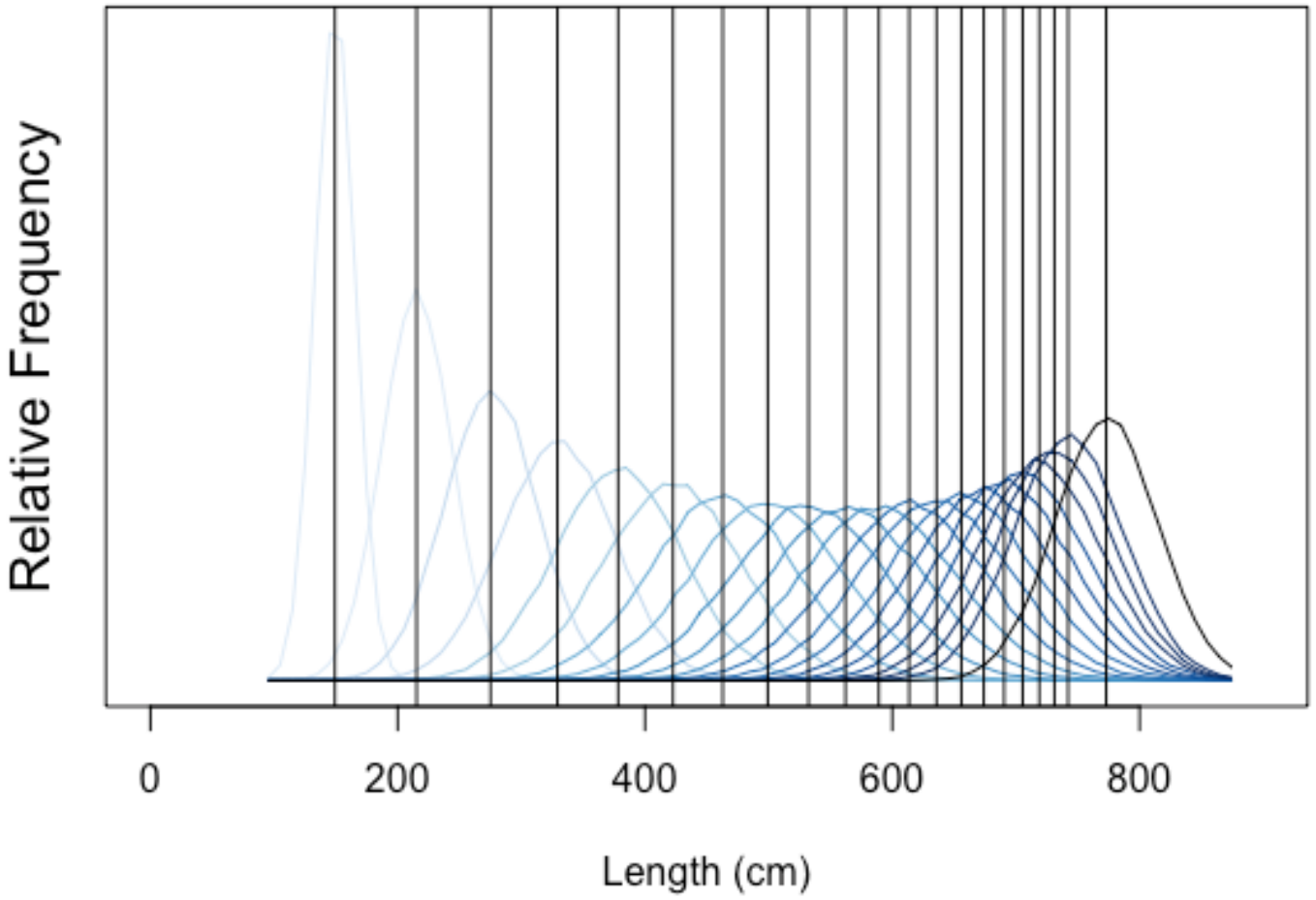
Smoothed length age conversion matrix



Male Length Age conversion matrix



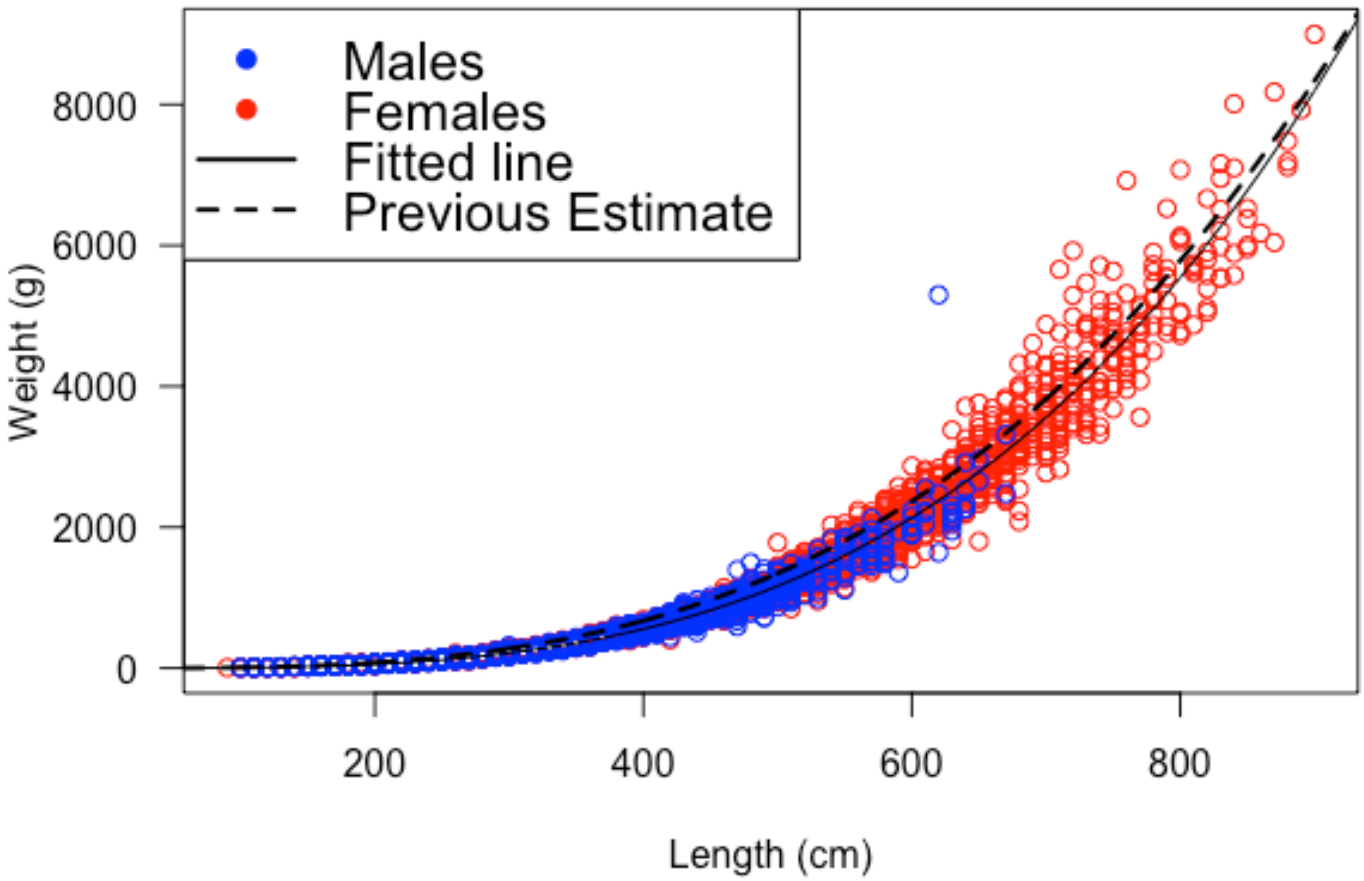
Female Length Age conversion matrix



Weight at age

- Weight at age is available from the length age conversion matrix.
- Mean length at age is converted to weight at age using the fitted length weight relationship.
- Weight~1.284e-06*Length^3.319.

Weight at length – calculated from available data (5,761 records)



Plan Team and SSC: Ensure that selectivity parameters are not on bounds without reason.

- All models are tuned so that parameters are not on the bounds (without reason).

- Model 18.7 female decreasing slope selectivity parameter is on lower bound (decreases quickly).

CIE Review: Reduce parameters and combine male and female selectivity when possible.

Models 18.0, 18.1, 18.2

Model 18.0: Selectivity at length for the three surveys.

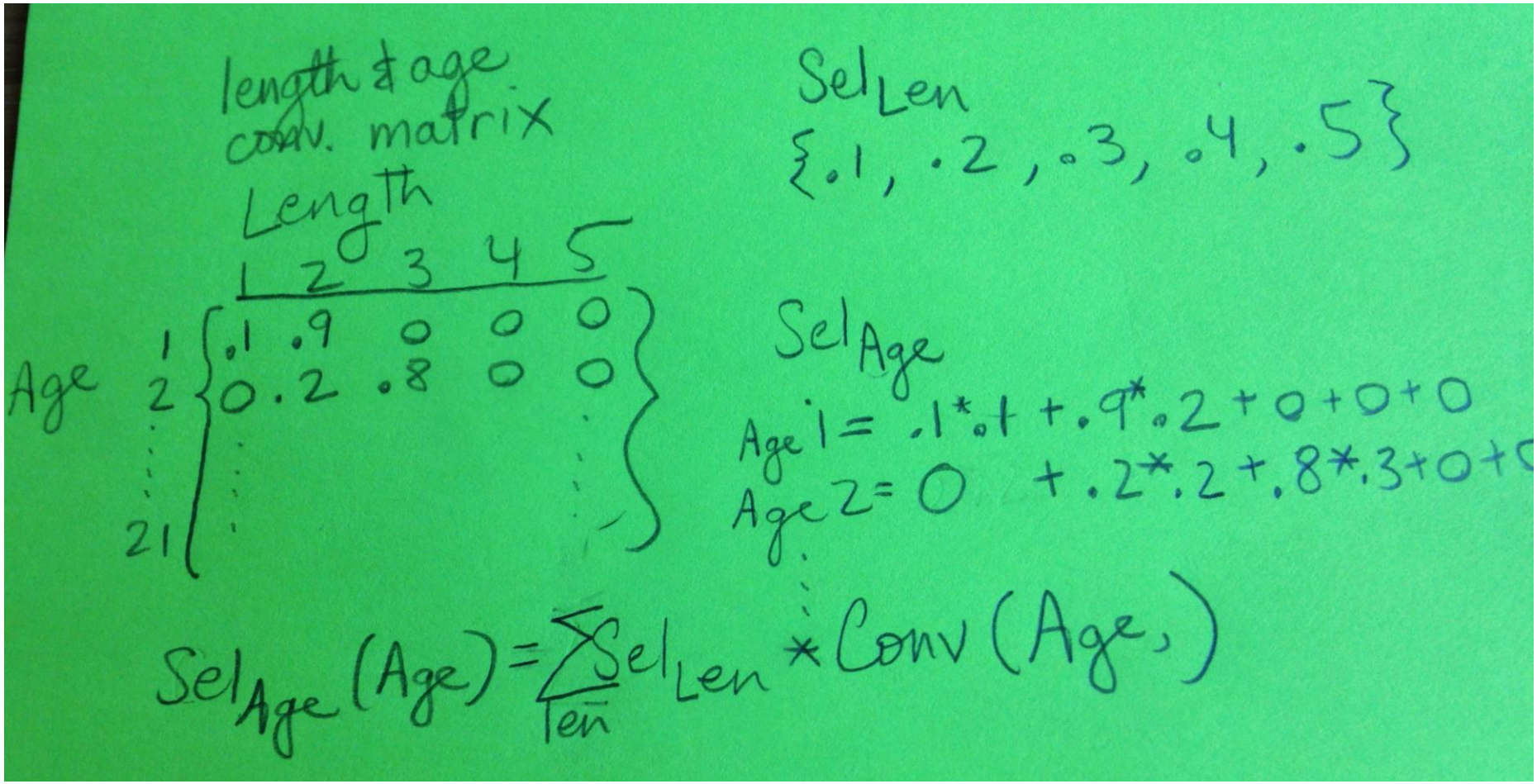
Model 18.1: Same as 18.0 also incorporates logistic fishery selectivity (as opposed to non-parametric).

Model 18.2: Selectivity at length for three surveys and the fishery.

Models 18.0, 18.1, 18.2

- 2 parameter logistic (slope and Aleutians survey).
- 4 parameter dome shaped logistic (shelf survey).
- Male and female selectivity combined.
- Converted back to selectivity at age via the length age conversion matrix.

Conversion from Selectivity at length to selectivity at age.



Models 18.0, 18.1, 18.2

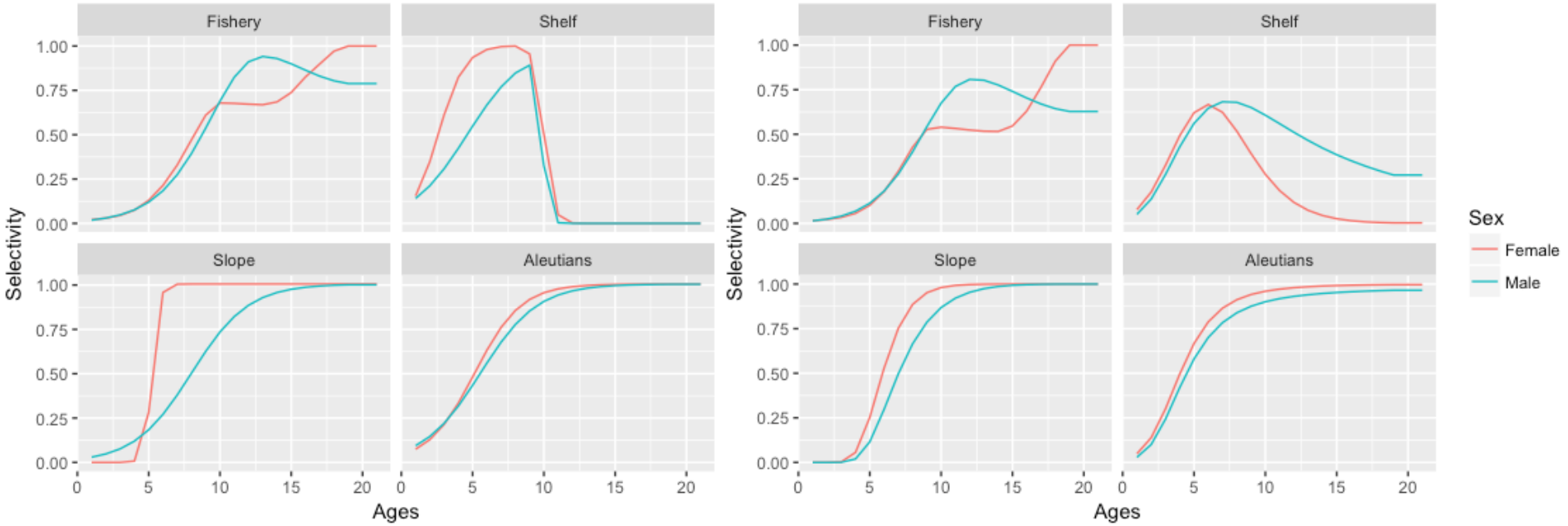
- Did not improve the survey biomass likelihoods, but they did improve the survey age and length likelihoods, as well as the recruitment likelihood.
- More biologically plausible.

Model Number	EBS. Surv. Biom. Like.	Slope Surv. Biom. Like.	AI Surv. Biom. Like.	Fish. Length Like.	Surv. Length Like.	Surv. Age Like.	Rec. Like.	Fish. sel. Like.	Surv. sel. Like.	Number of Parameters	Total Like.	ADSB	Obj. fun.
15.1c	24.4	34.8	45.7	479.9	593.8	444.6	50.8	0.83	3.96	167	1674.8	-	3824.5
18.0	34.9	71.3	45.9	493.2	544.8	341.0	29.9	1.43	5.53	159	1562.5	0.193	3831.7
18.1	35.0	71.4	46.0	498.1	544.9	339.7	29.7	0.00	0.00	121	1564.9	0.194	3831.5
18.2	35.1	71.7	46.3	546.9	548.0	343.4	29.8	0.00	0.00	119	1621.2	0.198	3876.1

Model comparison - selectivity

Model 15.1c (Base Model)

Model 18.0

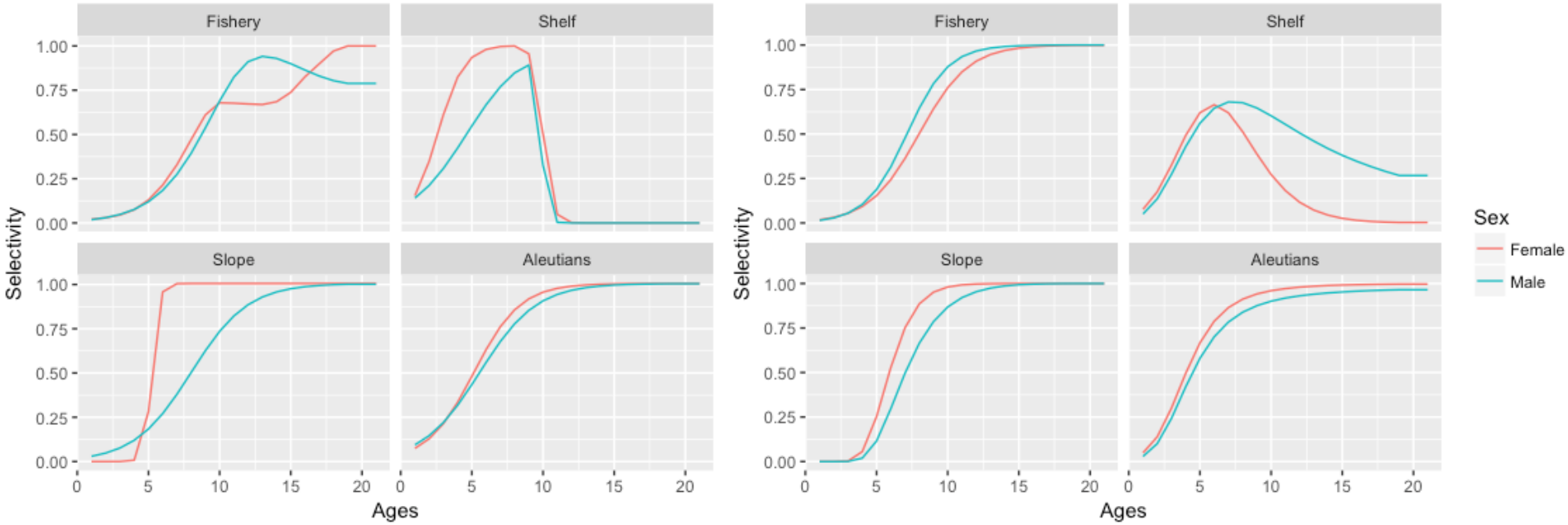


- Model 18.0: Selectivity at length rather than age for the three surveys.

Model comparison - selectivity

Model 15.1c (Base Model)

Model 18.1

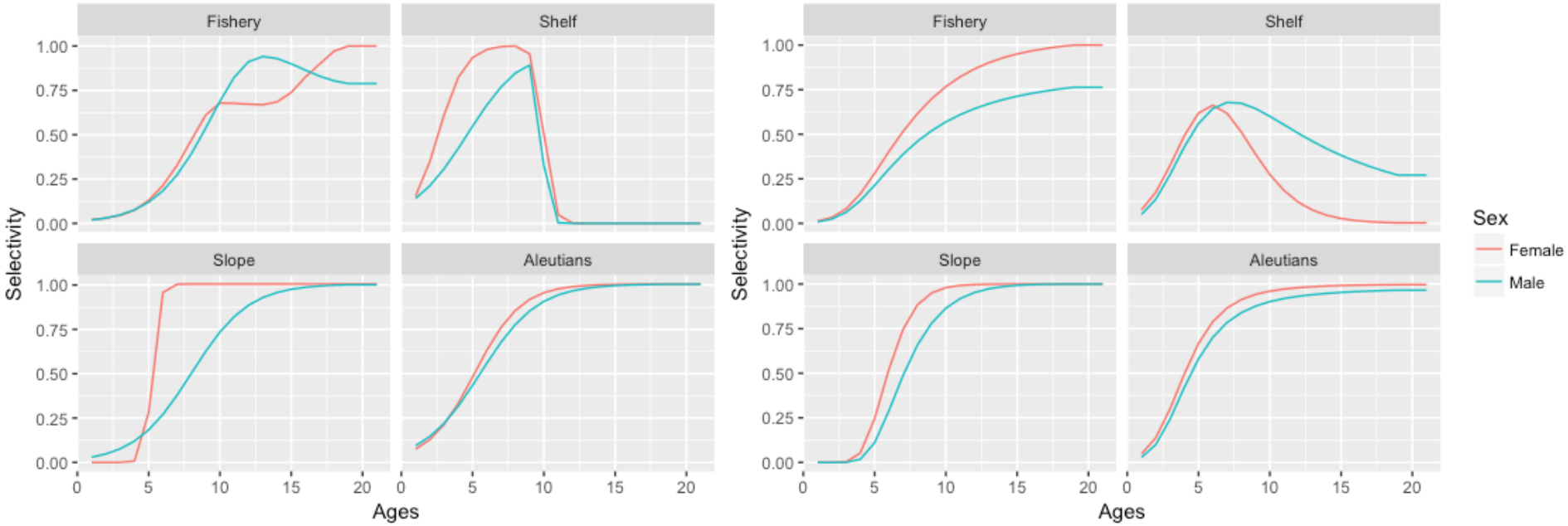


- Model 18.1: Selectivity at length rather than age for the three surveys and logistic selectivity by age for the fishery.

Model comparison - selectivity

Model 15.1c (Base Model)

Model 18.2



- Model 18.2: Selectivity at length rather than age for the three surveys and the fishery.

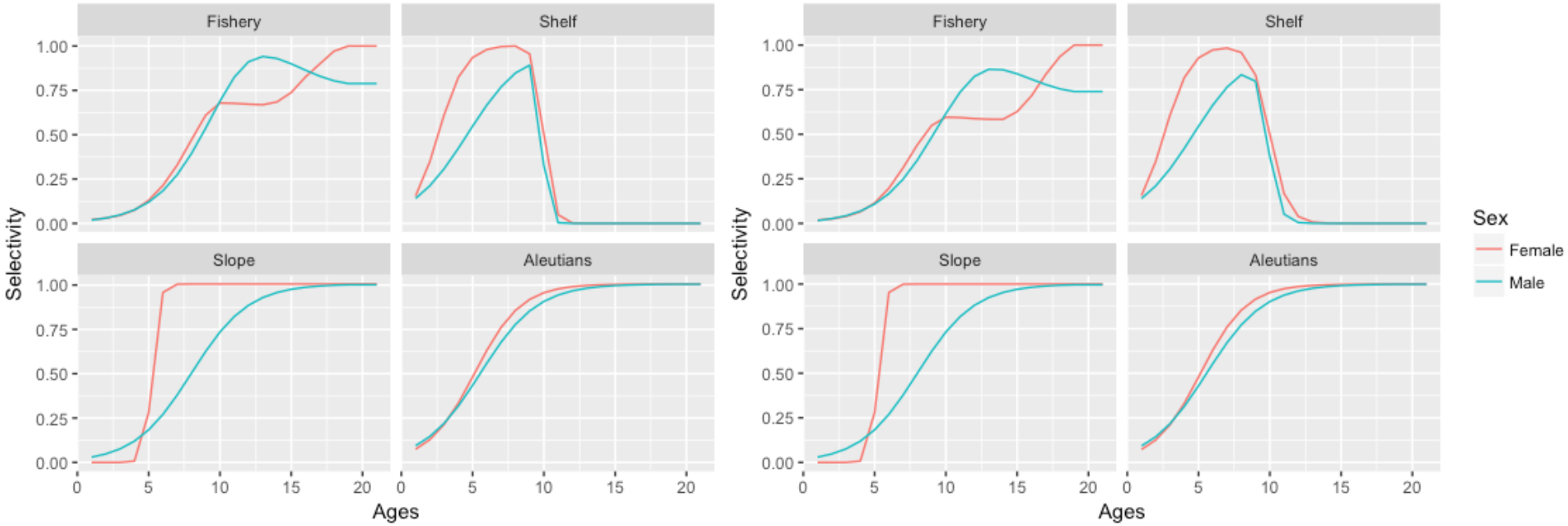
Ageing error matrix

- The model incorporates a linear increase in the standard deviation of ageing error.
- Assumes that ageing error is normally distributed (Dorn et al. 2003, Methot 2000).
- Percent agreement is predicted by the sum probability that both readers are correct, that both readers are off by one year in the same direction, and the probability that both age readers are off by two years in the same direction (Methot 2000).

Model comparison - selectivity

Model 15.1c (Base Model)

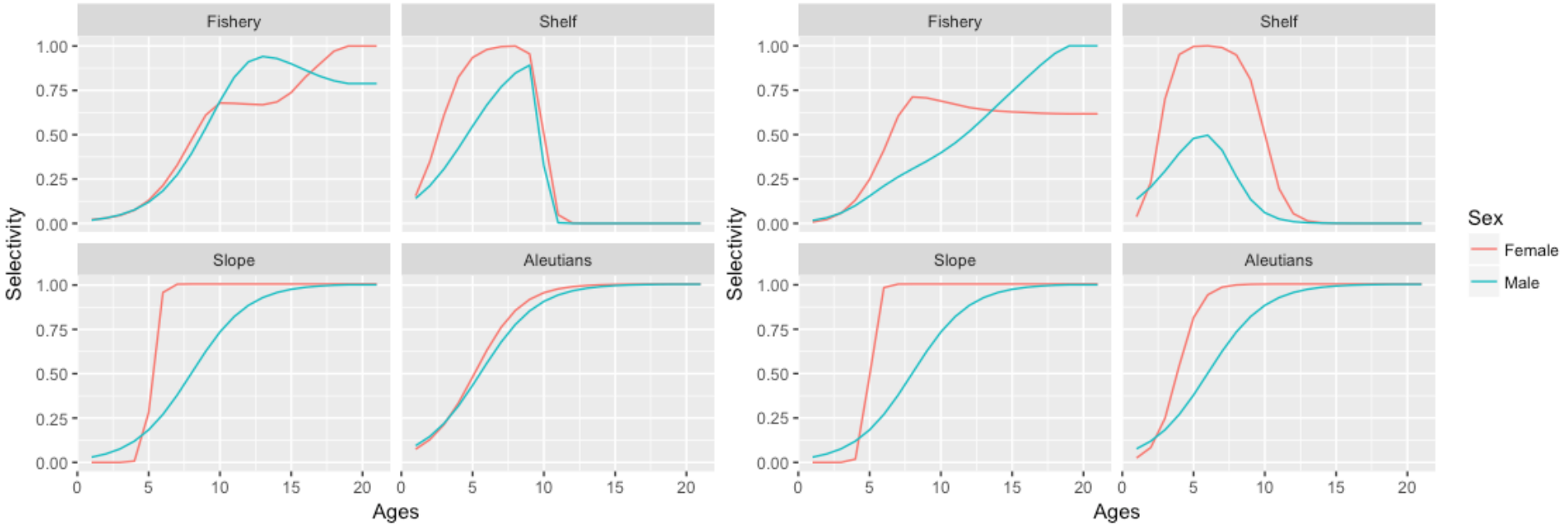
Model 18.3



- Model 18.3: Same as base model but incorporates ageing error matrix.

Model comparison - selectivity

Model 15.1c (Base Model) Model 18.6



Model 18.6: Length-based survey selectivity and non-parametric fishery selectivity by age. It also incorporates the ageing error matrix.

Model evaluation – statistics for Models 15.1c-18.6

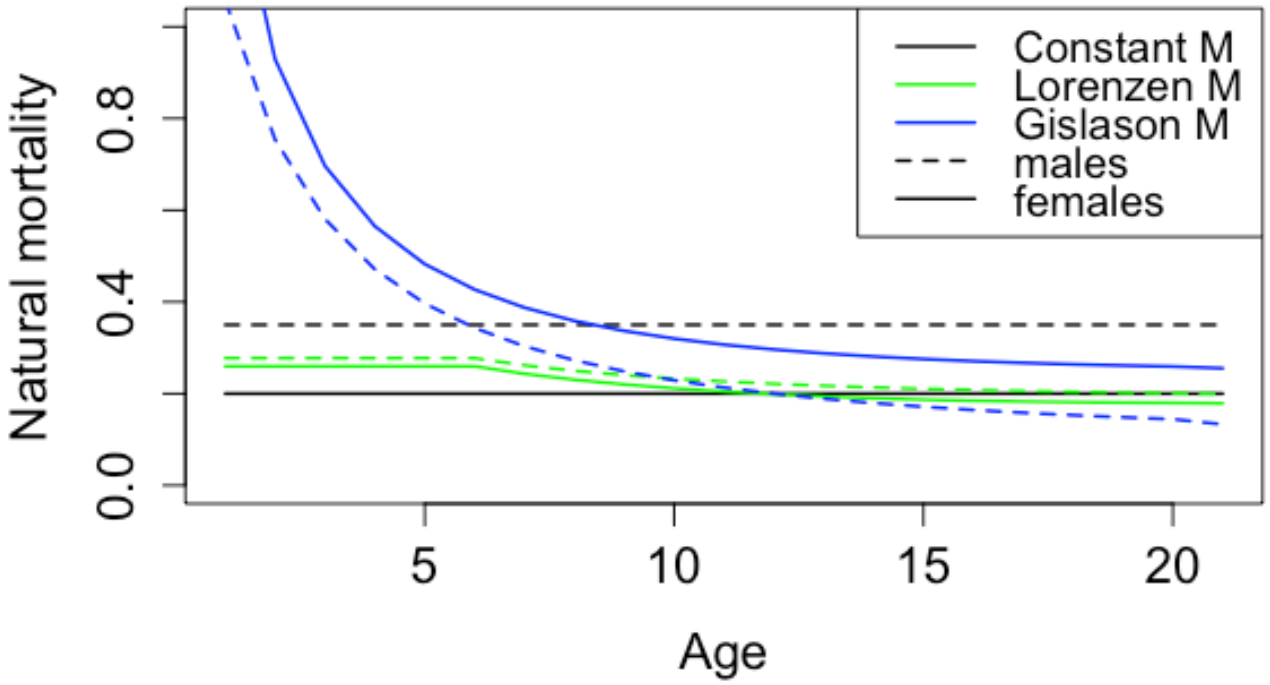
Model Number	EBS. Surv. Biom. Like.	Slope Surv. Biom. Like.	AI Surv. Biom. Like.	Fish. Length Like.	Surv. Length Like.	Surv. Age Like.	Rec. Like.	Fish. sel. Like.	Surv. sel. Like.	Number of Parameters	Total Like.	ADSB	Obj. fun.	AIC*
15.1c	24.4	34.8	45.7	479.9	593.8	444.6	50.8	0.83	3.96	167	1674.8	-	3824.5	8078.4
18.0	34.9	71.3	45.9	493.2	544.8	341.0	29.9	1.43	5.53	159	1562.5	0.193	3831.7	8406.3
18.1	35.0	71.4	46.0	498.1	544.9	339.7	29.7	0.00	0.00	121	1564.9	0.194	3831.5	8384.0
18.2	35.1	71.7	46.3	546.9	548.0	343.4	29.8	0.00	0.00	119	1621.2	0.198	3876.1	8459.2
18.3	32.5	62.7	45.6	437.5	538.2	368.5	20.4	2.32	5.93	167	1507.7	0.062	3801.6	7817.8
18.4	37.3	48.7	50.8	498.1	1623.5	898.0	43.9	3.48	17.51	167	3203.7	0.290	6473.3	-Inf
18.5	35.6	71.4	46.0	498.5	532.4	270.3	28.7	0.00	0.00	121	1482.9	0.145	3730.2	-Inf
18.6	35.5	71.2	45.9	493.9	532.2	271.6	28.9	1.47	5.45	159	1480.8	0.196	3730.3	8208.4

CIE Review: Investigate size-based estimates of natural mortality

- Model 18.4: Lorenzen natural mortality.
- Model 18.5 Gislason natural mortality.

Lorenzen natural mortality

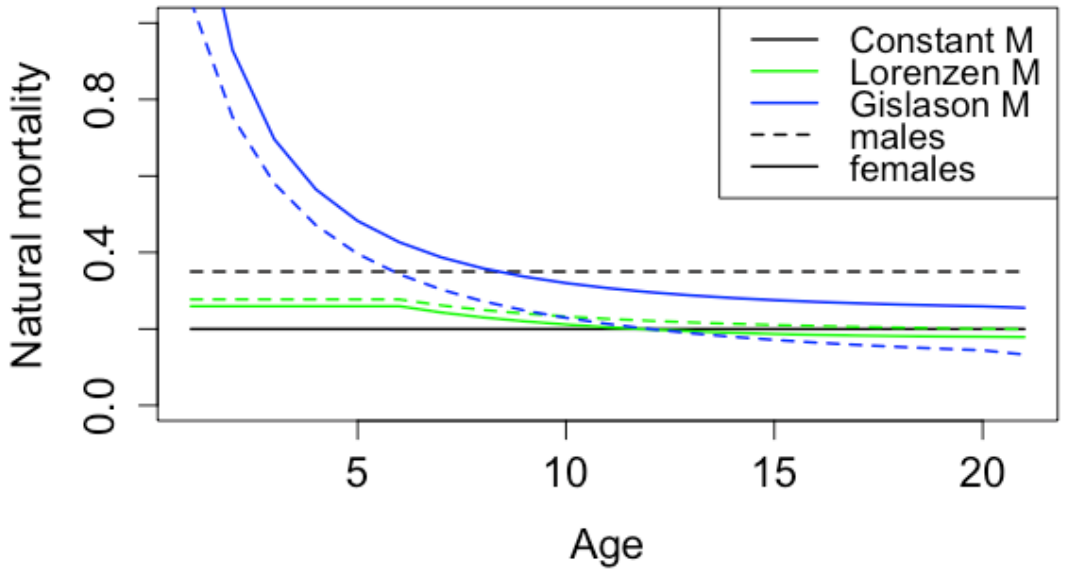
The Lorenzen (1996) natural mortality equation is as follows:
(1) $M_{age} = aWt_{age}^{b}$, where a and b are estimated parameters, and Wt_{age} is based on emprirical data.



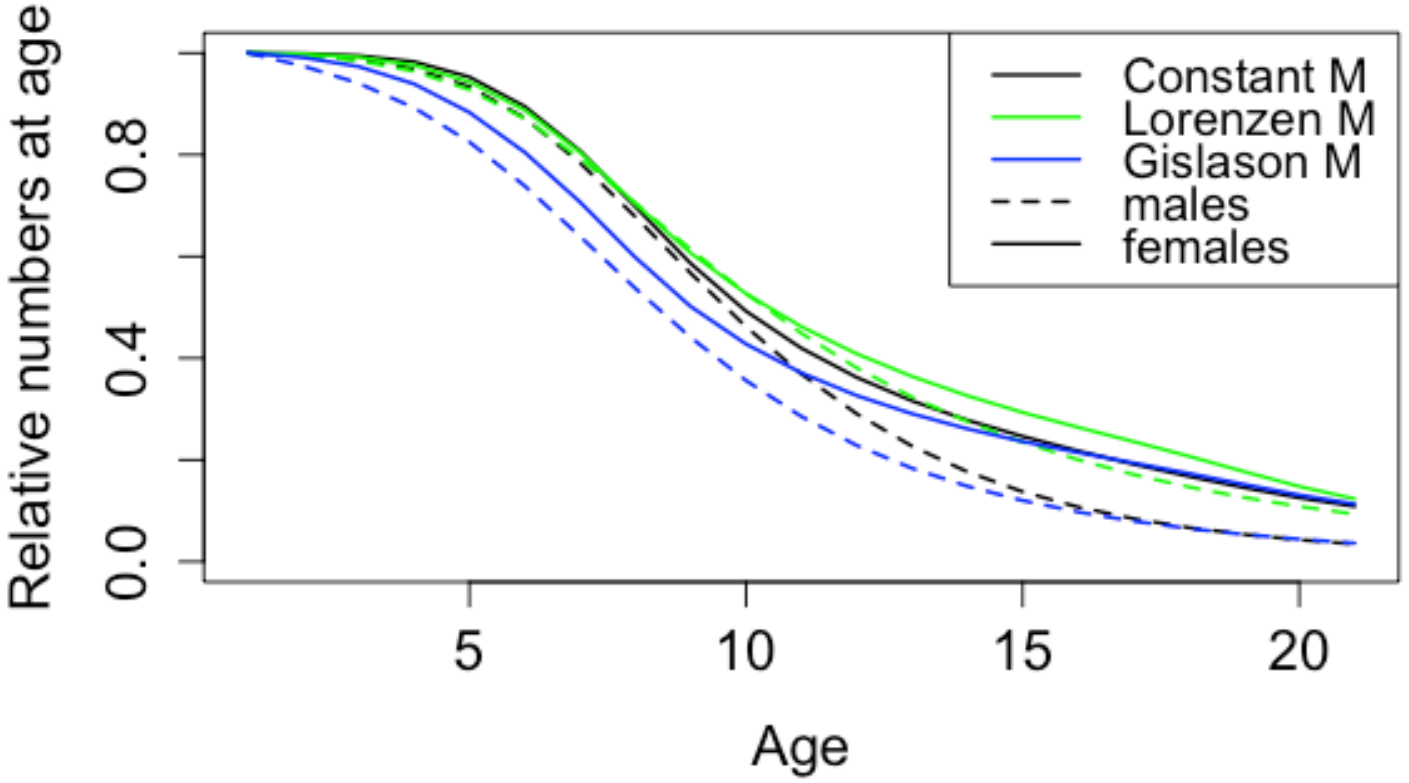
Gislason natural mortality

Model 18.5: Gislason natural mortality; the natural mortality equation of Gislason et al. (2010) is as follows:

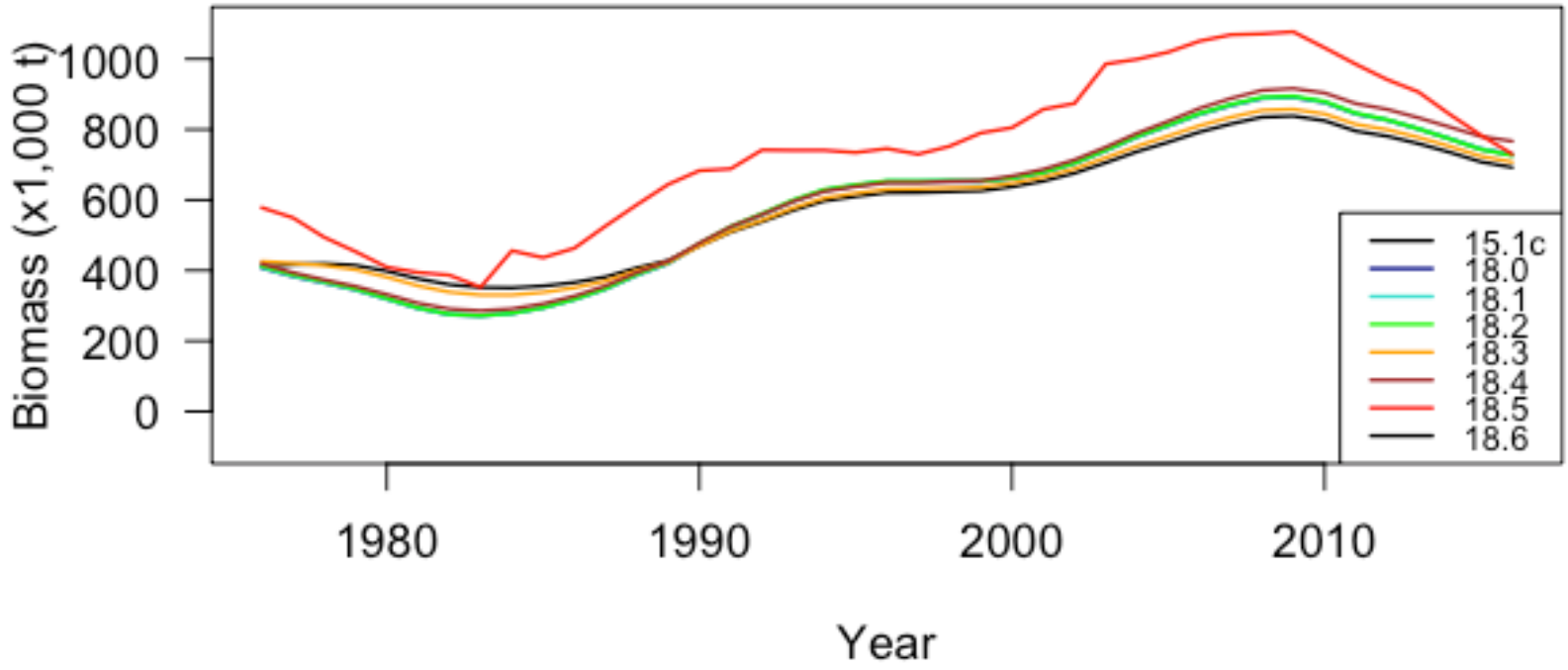
(2) $\ln(M_{age}) = 0.55 - 1.61\ln(L_{age}) + 1.44\ln(L_{\infty}) + \ln(K)$, where L_{age} is length at age, and L_{∞} and K are parameters from the sex-specific von-Bertalanffy fit to length at age. The mortality in equation 2 is multiplied by W=3 to match the natural mortalities previously established for ATF.



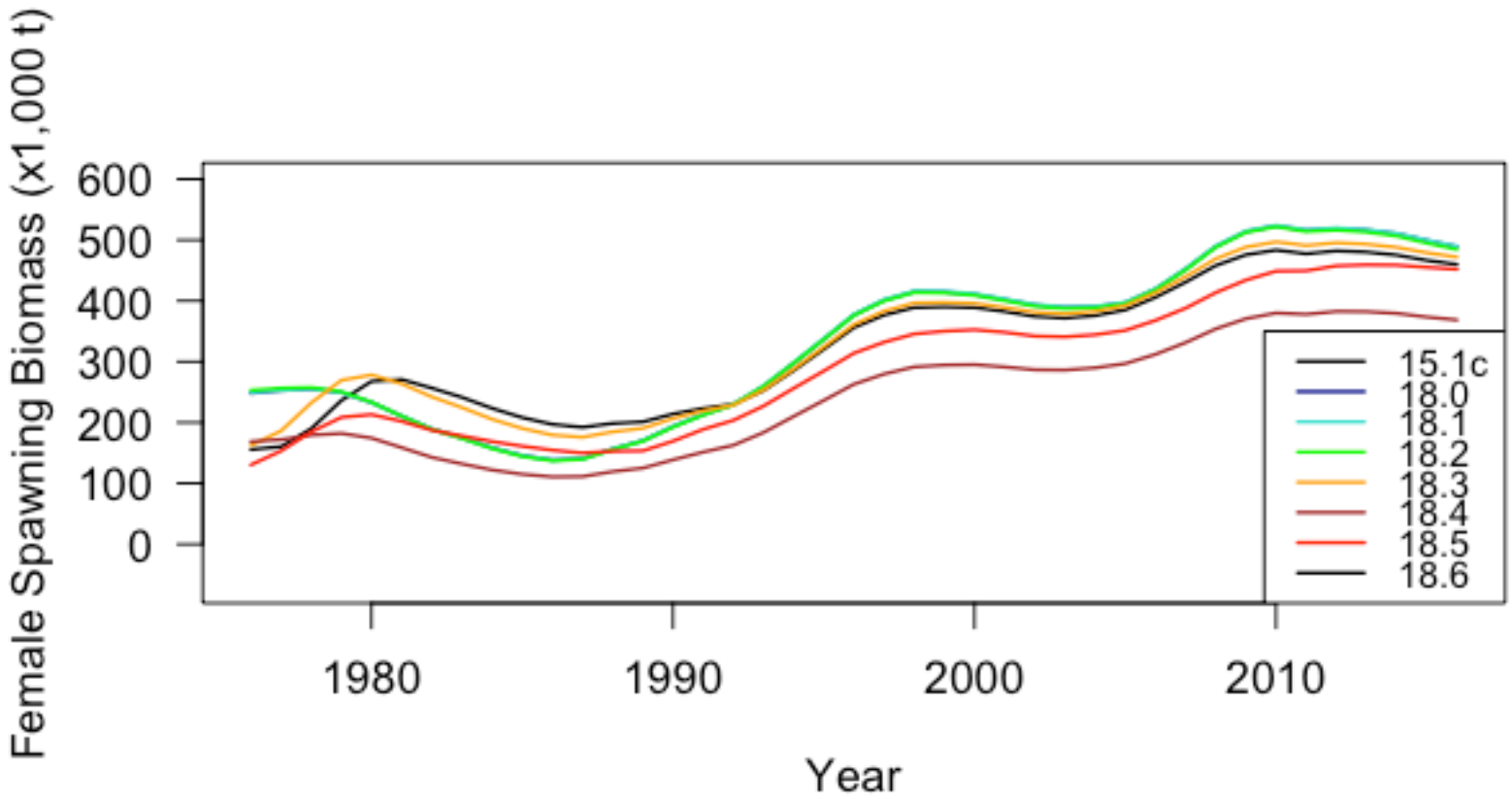
Reparameterization of natural mortality follows observations of more females than males



Total biomass for models 15.1c-18.6



Female spawning biomass for models 15.1c-18.6



CIE Review: Investigate other ways to integrate surveys.

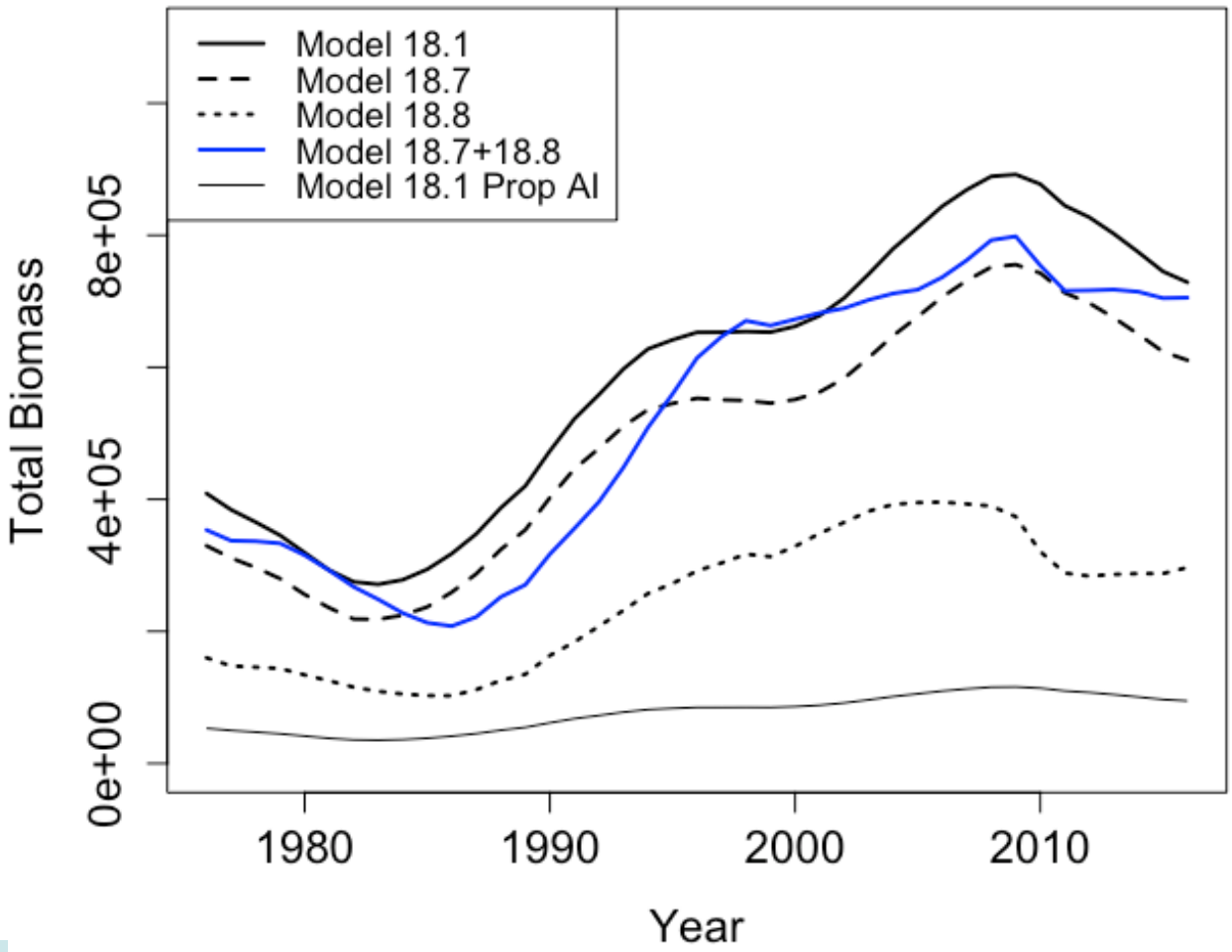
- Typically catchability adds to 1 among the 3 surveys.
- Relative proportions are based on the random effects model.
- Model cannot estimate catchability when 3 surveys are included.

CIE Review: Investigate other ways to integrate surveys.

- EBS shelf and slope only (Model 18.7). Model estimated catchability.
- Aleutian Islands – This model included only data from the Aleutian Islands. Age data was not included because there was only 2 years (Model 18.8).

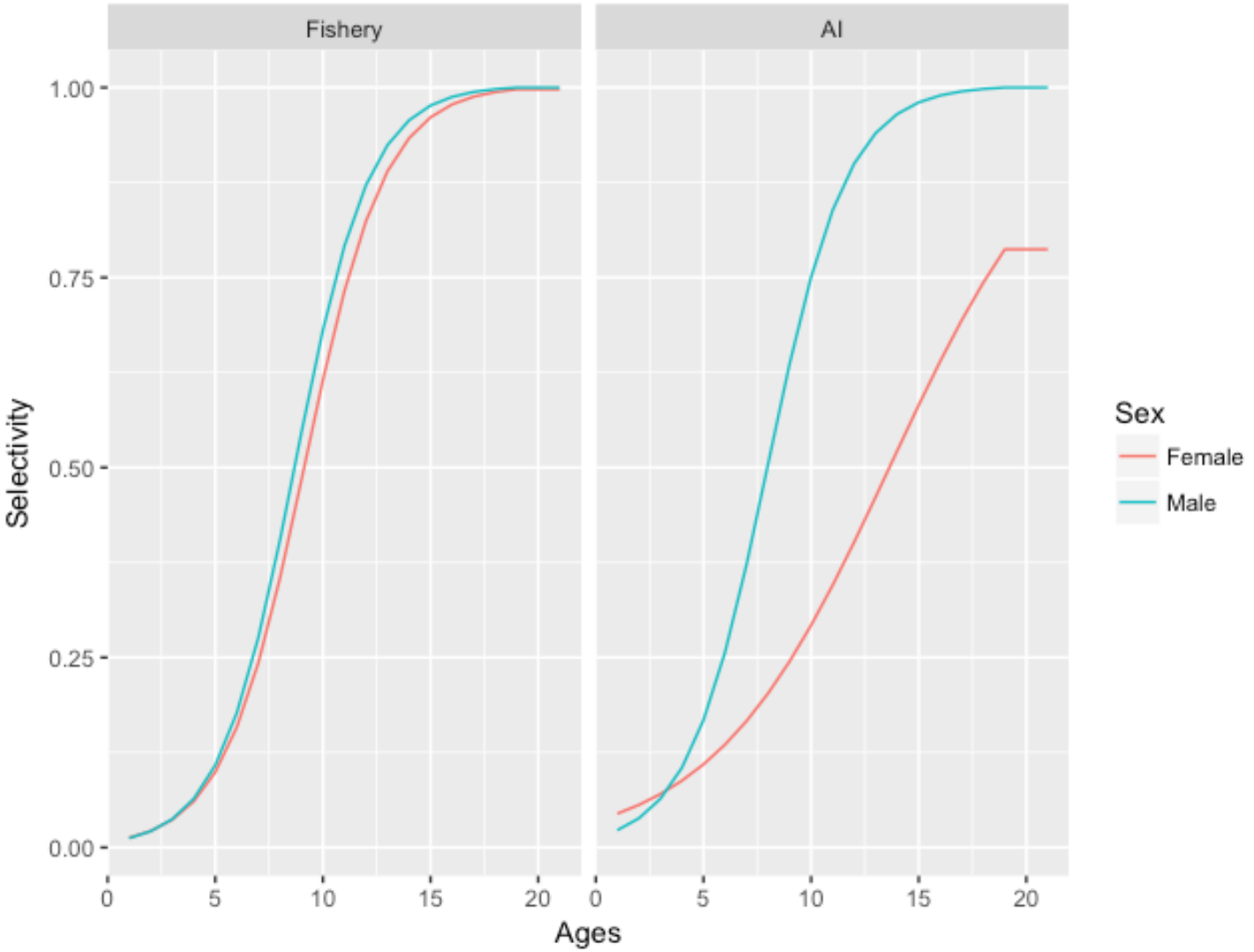
Aleutian Islands-only model (18.8) calculated higher biomass than random effects approach.

Model estimates of biomass (18.1, 18.7, 18.8)

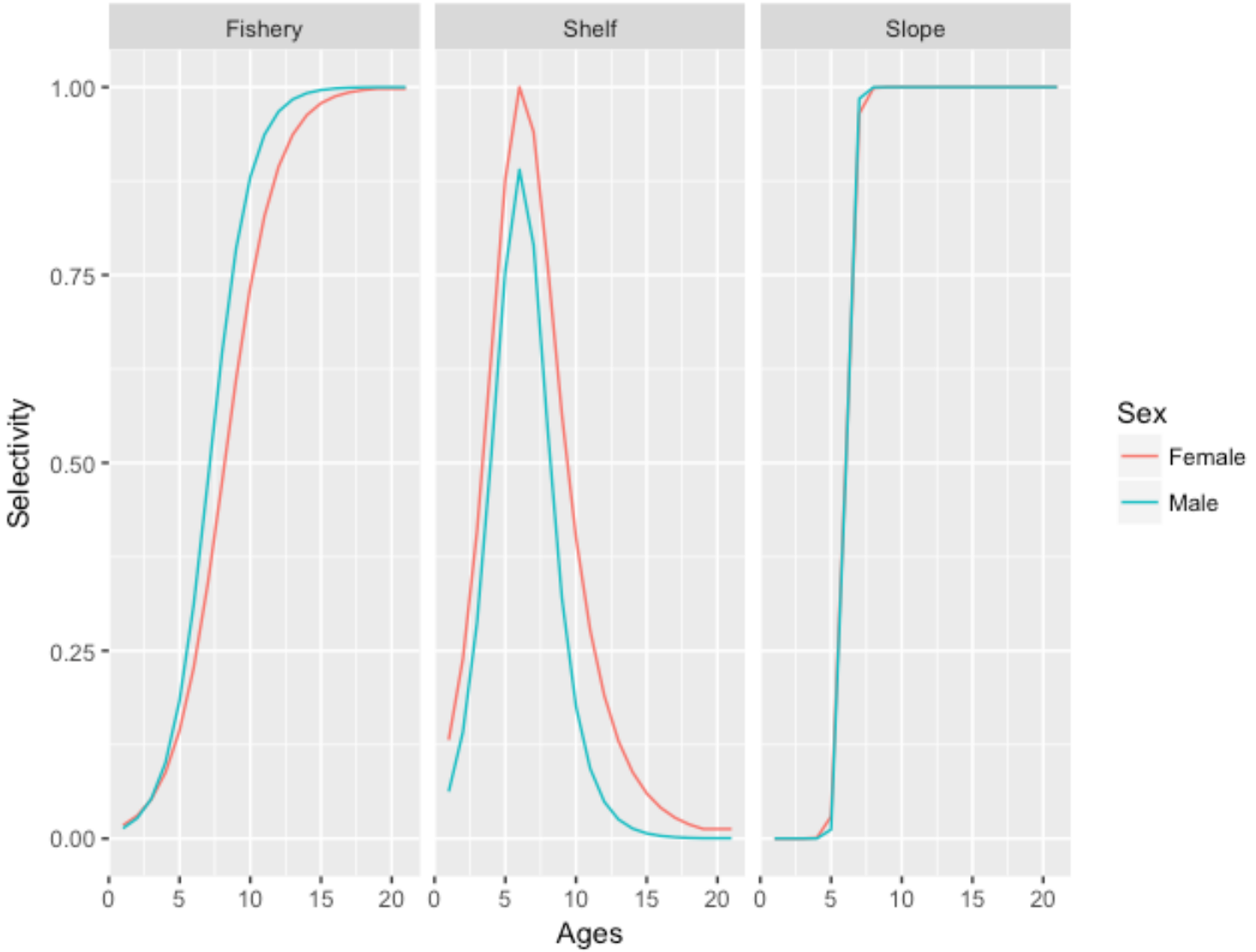


- Model 18.1: 3 surveys
- Model 18.7: EBS only
- Model 18.8: AI only
- Model 18.1: Prop AI (based on RE model.

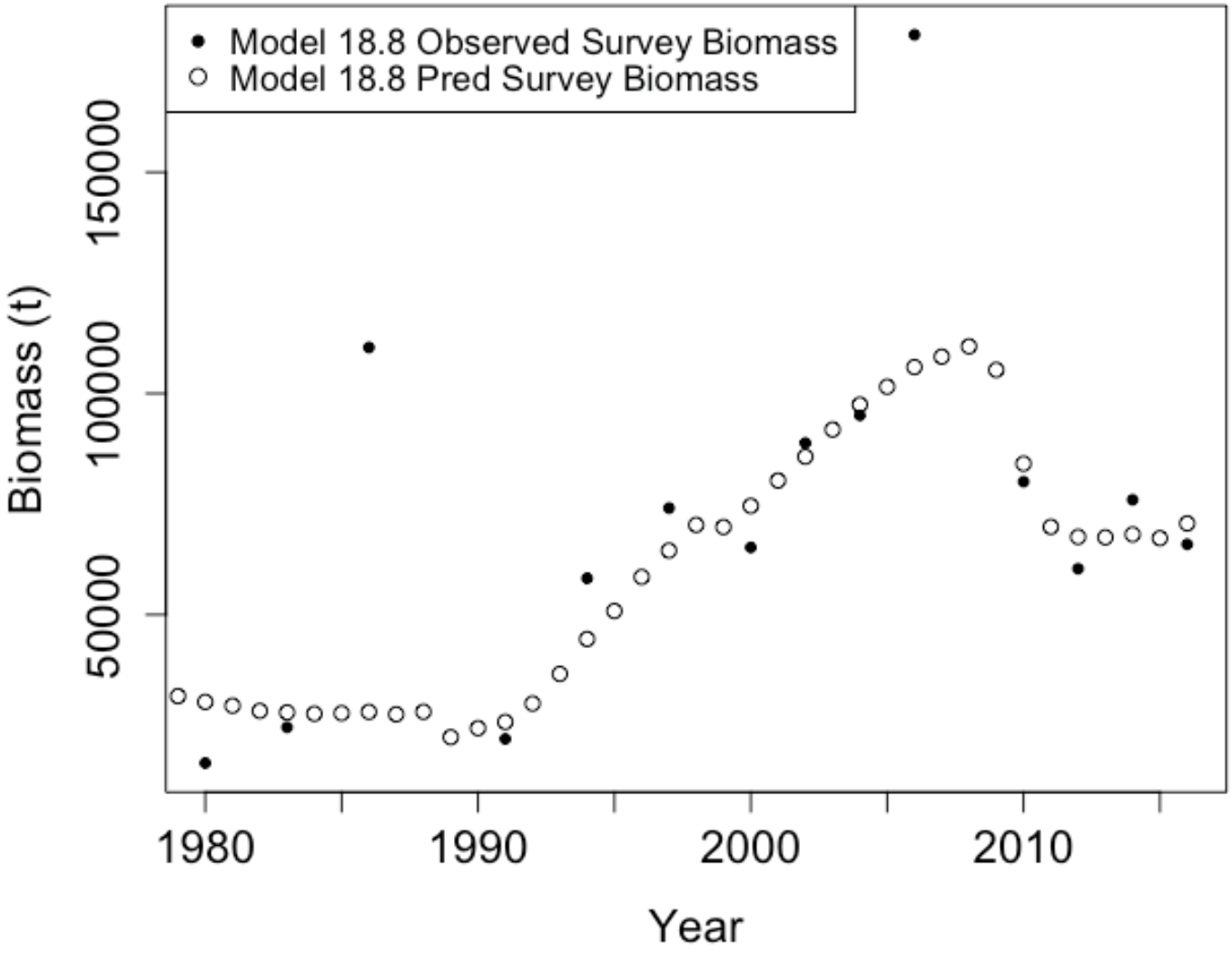
Aleutian Islands-only model (18.8) selectivity.



EBS-only (shelf and slope) model (18.7) selectivity.



Aleutian Islands-only model (18.8): fit to survey data



Models 18.8 and 18.7 indicate changes in proportion among survey areas.

Estimated total biomass in the Aleutian Islands, EBS shelf, and slope

	Model 18.1	Model 18.7	Model 18.8
Aleutian Islands	94,740 t		296,778 t
EBS shelf	517,425 t	531,351 t	
EBS slope	65,589 t	79,397 t	
Total	728,768 t	907,526 t	

Estimated proportions in the Aleutian Islands, EBS shelf, and slope

	Model 18.1	Model 18.7 + 18.8
Aleutian Islands	0.13	0.33
EBS shelf	0.79	0.59
EBS slope	0.09	0.09

Conclusions

- Fewer parameters (length-based selectivity and logistic rather than non-parametric).
- More age data (ongoing process).
- Explore male/female natural mortality (these models need some work).
- Issues with integrating 3 surveys (Models 18.7, 18.8).
- Temperature relationship on EBS shelf catchability - significant? (Yes).
- “The main weakness of the assessment in terms of assessing stock status is in understanding the stock dynamics immediately preceding the assessment period.” (GOA – incorporating more early surveys).

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.

GOA

- Catchability q=1.

Stachura et al (2014) ATF abundance recruitment associated with cross-shelf transport not SST.

Model evaluation

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

The hessian, the matrix of second mixed derivatives in transformed space, is created as output from each ADMB model run. The hessian was transformed back into the original parameter space ($Hess_T$) by taking the log of the determinant of the hessian, and the marginal likelihood ($Likelihood_{MAR}$) was estimated (Thorson et al. 2014) as follows, where OFV is the objective function value from the ADMB .par file:

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

The marginal likelihood can be used to calculate AIC, as follows:

$AIC = 2k - 2 * likelihood_{MAR}$, where k is the number of parameters used in the model.