

Coastwide sablefish maturity examination

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1 Background

2 Methods

2.1 Sample collection

Ovary samples were collected from Alaska waters in 2011 and 2015 and from Washington, Oregon, and California waters in 2011, 2015, 2016, and 2018.

Metrics:

- length
- weight
- otolith (age)
- macroscopic maturity estimate
- histological maturity estimate
- location (lat, long)
- depth
- date

2.2 Sample size

2.3 Histology

2.4 Analysis

2.4.1 Exploratory data analysis

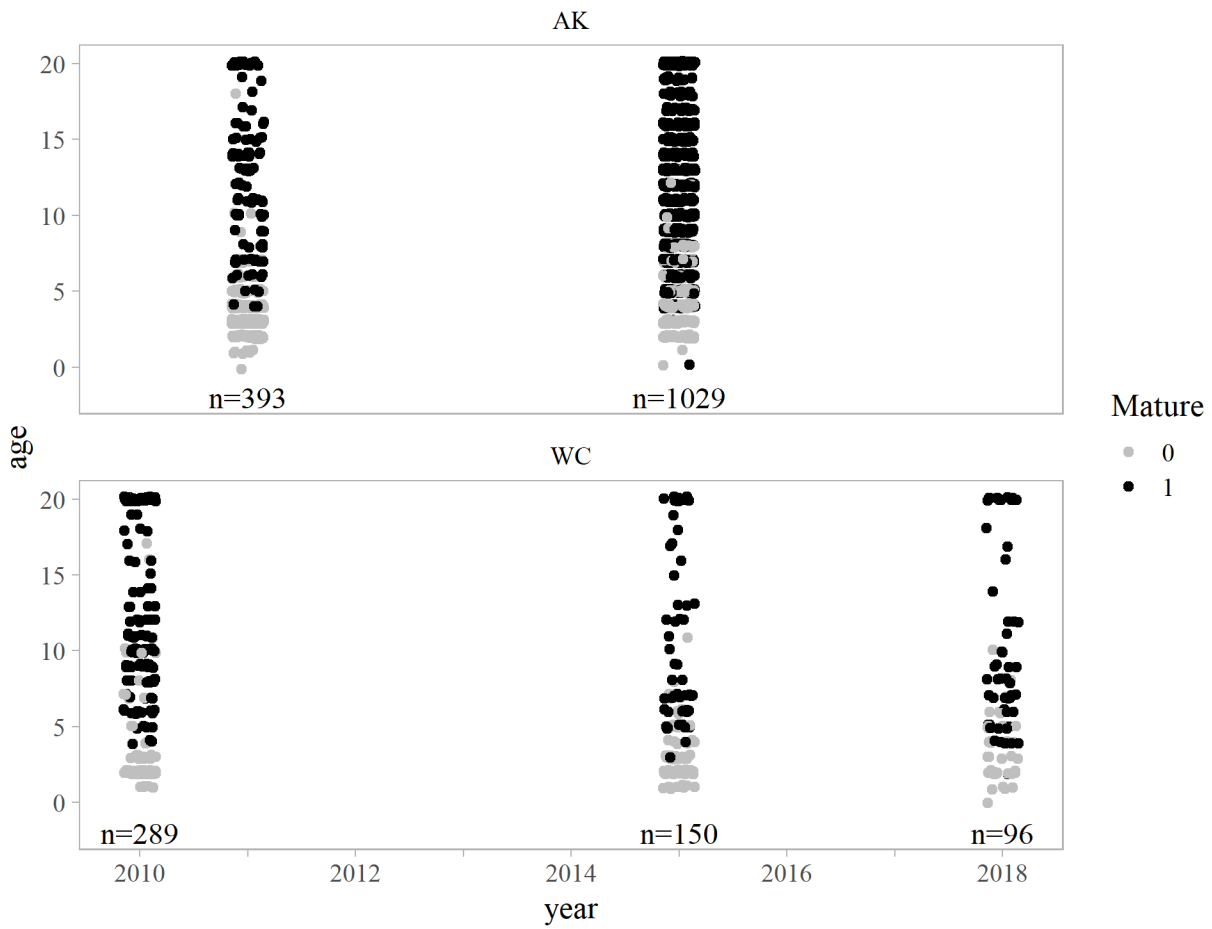


Figure 1: Sablefish histological maturity status by age and year for each region. Sample sizes are listed for each year and region.

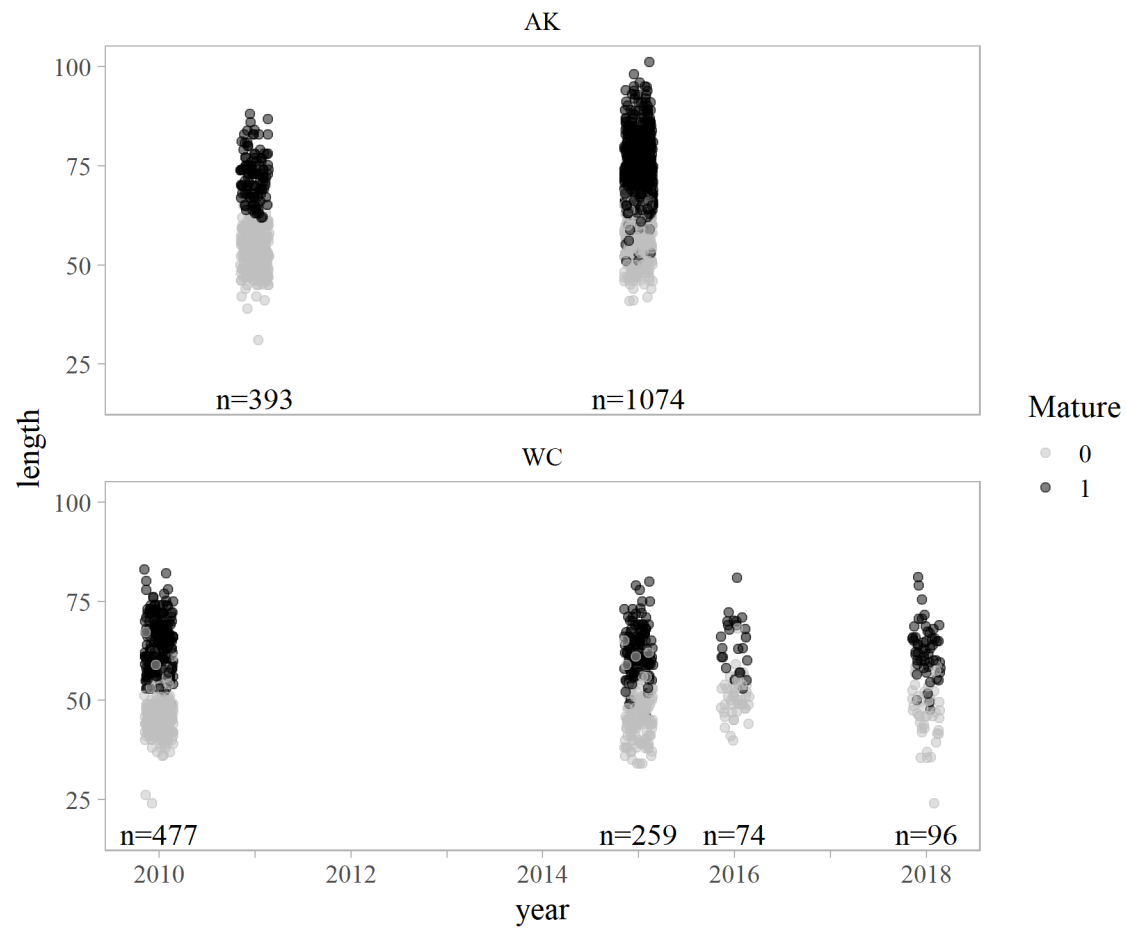


Figure 2: Sablefish histological maturity status by length and year for each region. Sample sizes are listed for each year and region.

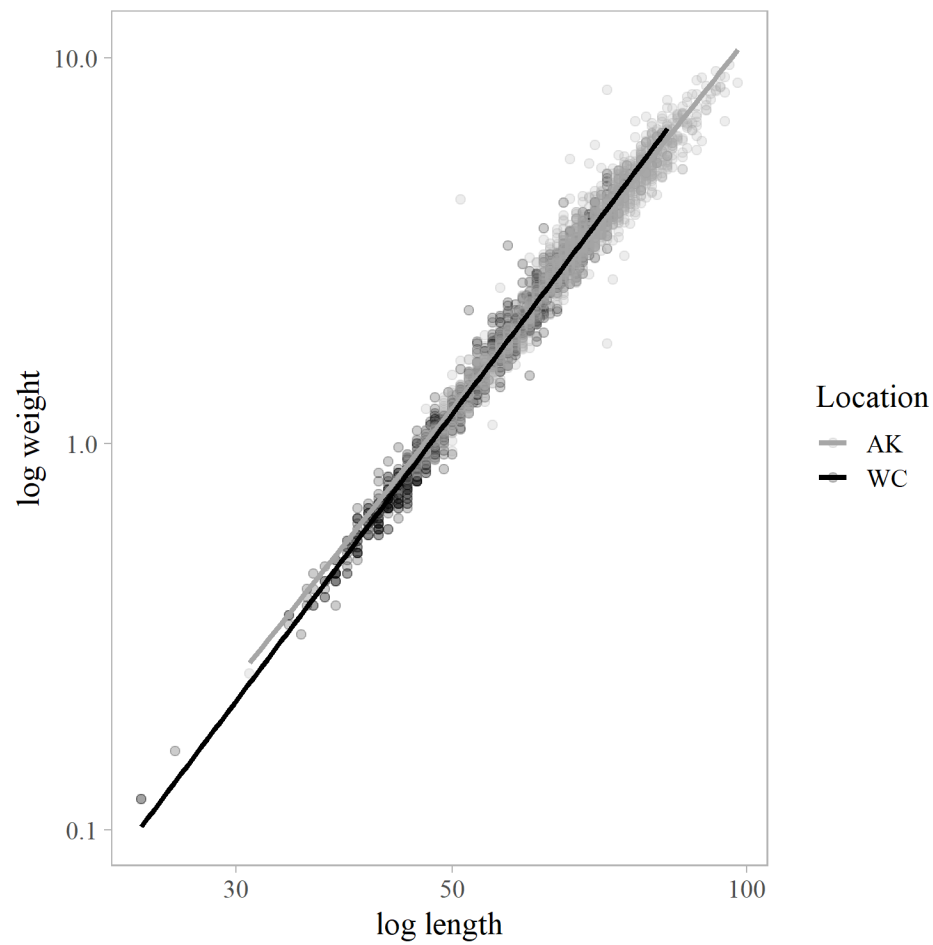


Figure 3: Log length-weight relationships for samplefish used in maturity analysis by region.

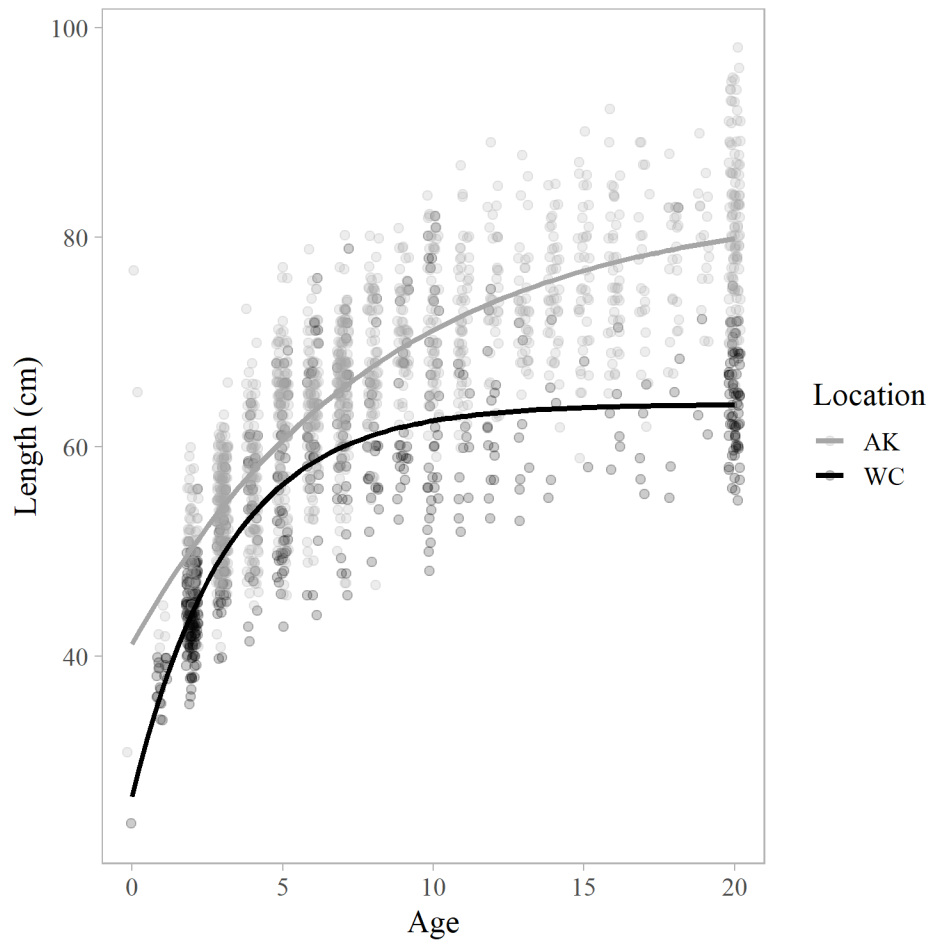


Figure 4: Sablefish vonBertalanffy growth curves for data used to determine maturity status, by region.

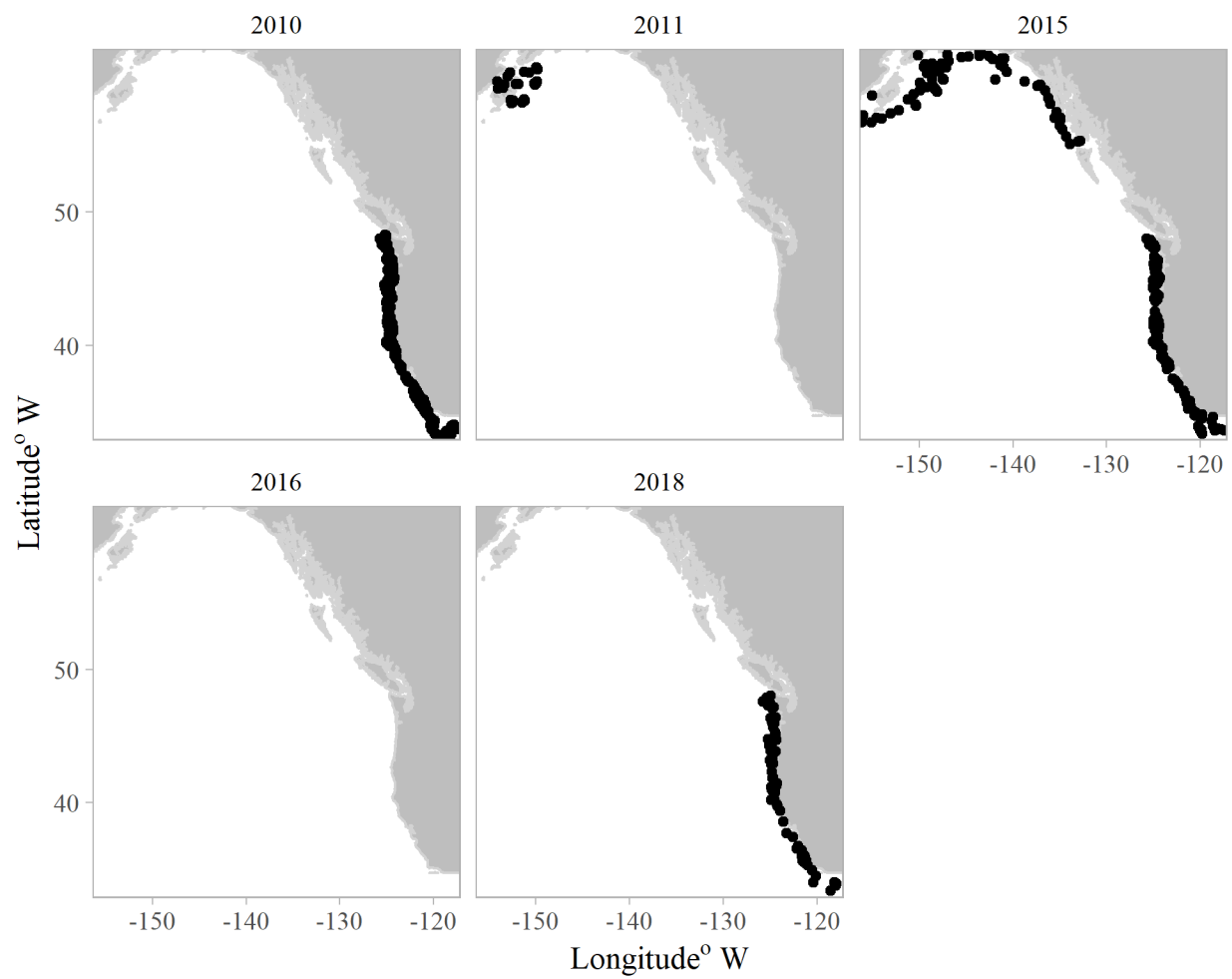


Figure 5: Coastwide sablefish maturity sample locations by year.

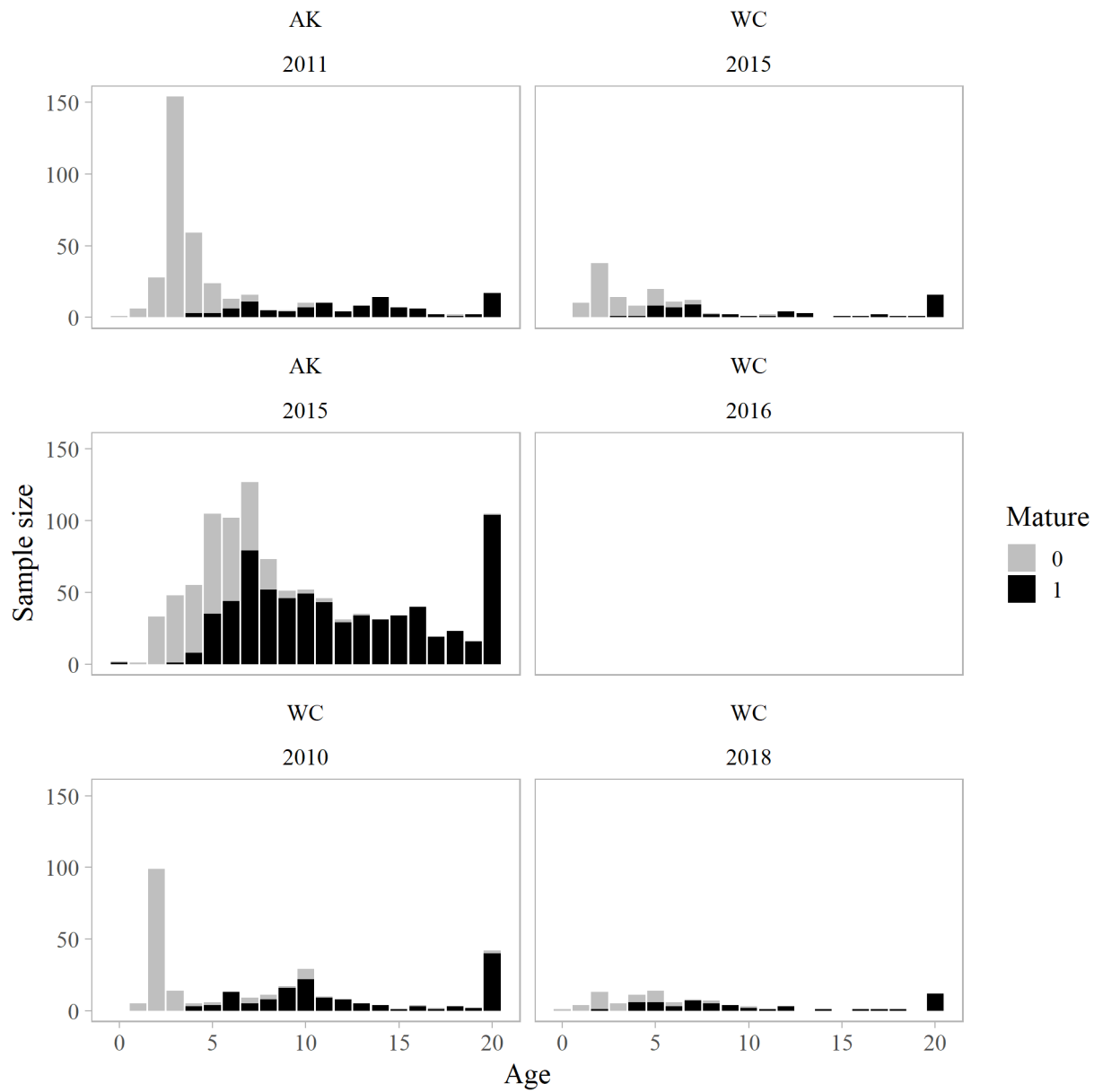


Figure 6: Sablefish samples sizes by age class for maturity status determination, by region.

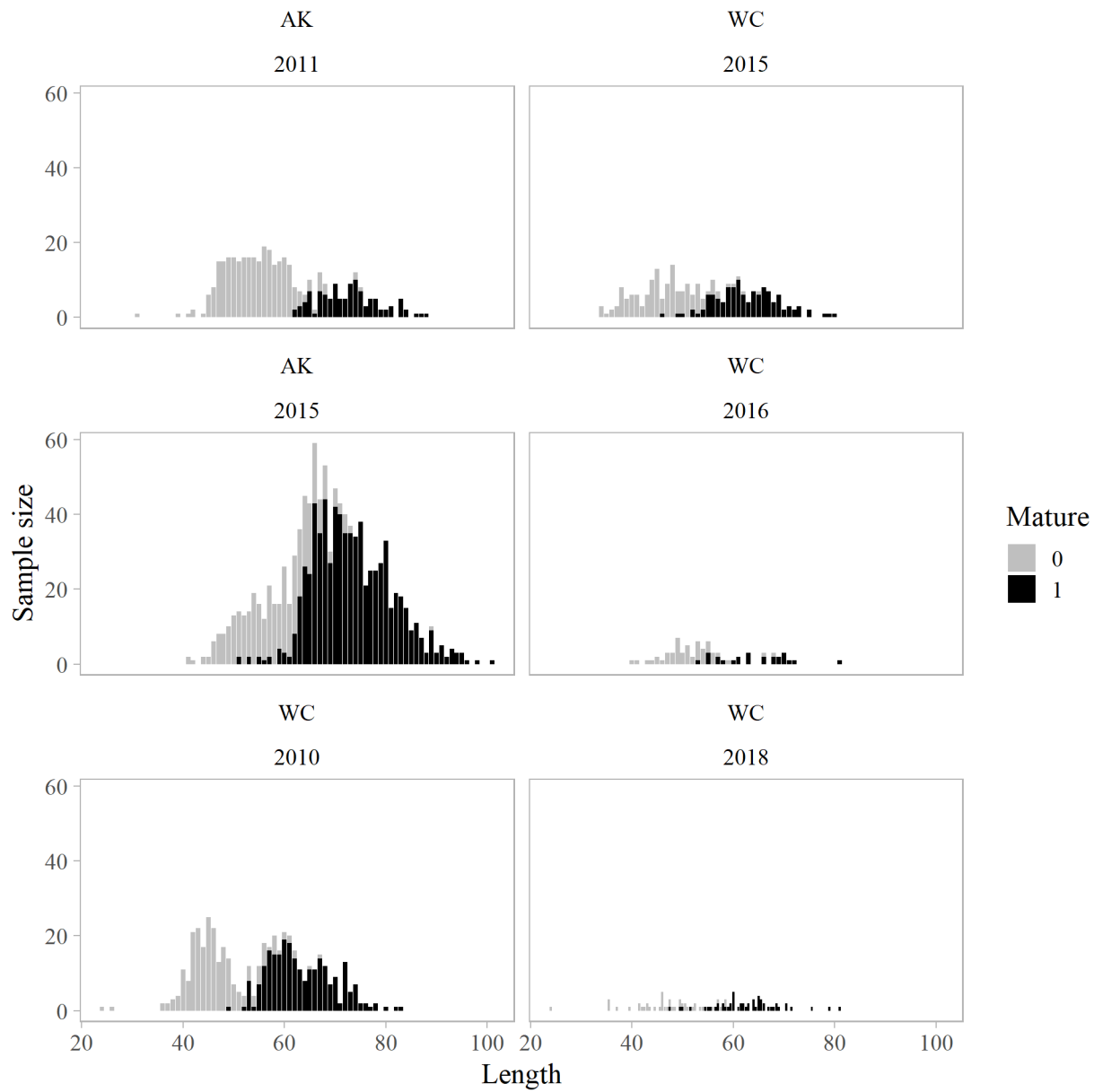


Figure 7: Sablefish samples sizes by length (cm) for maturity status determination, by region.

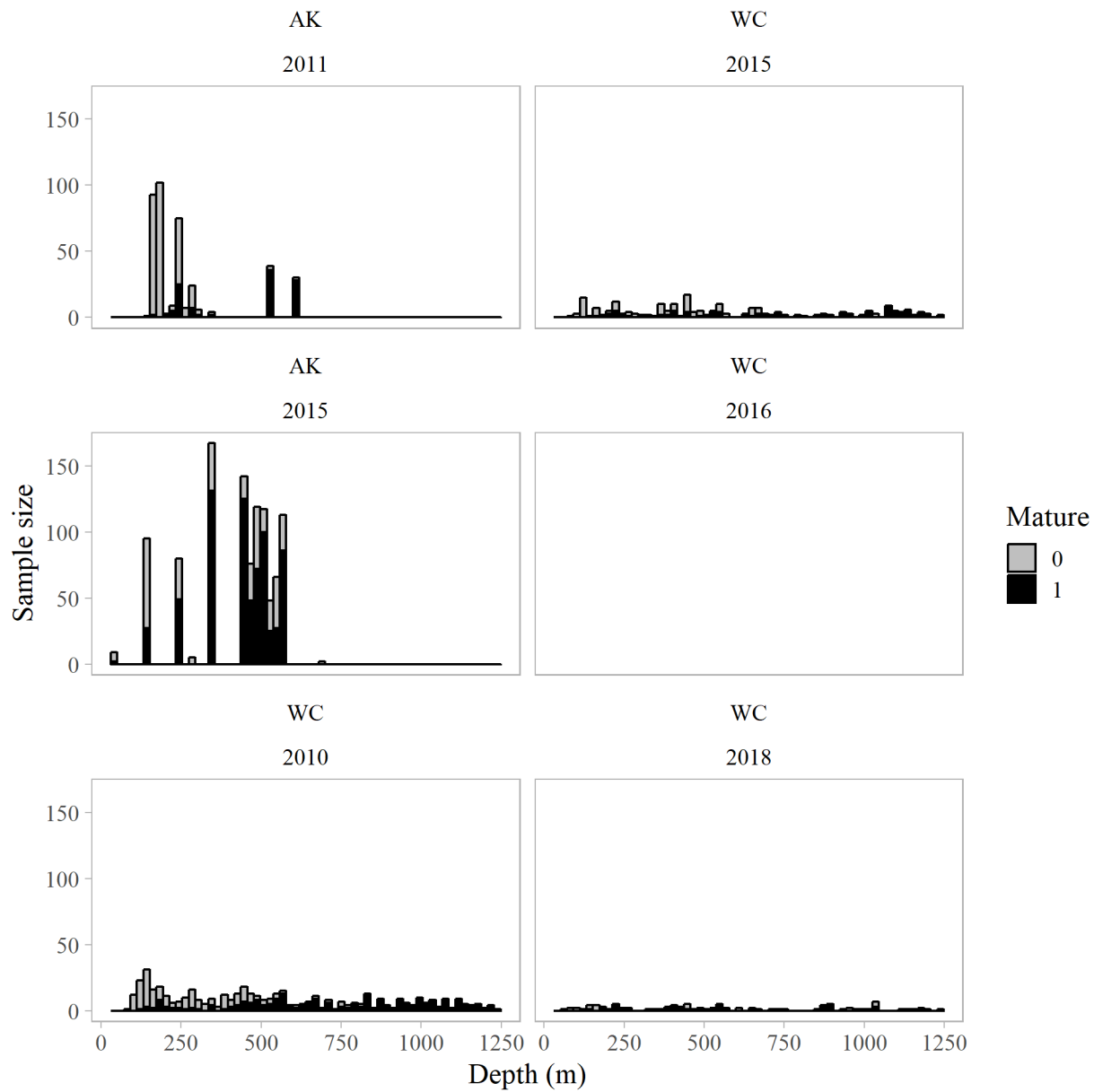


Figure 8: Sablefish samples sizes by depth (m) for maturity status determination, by region.

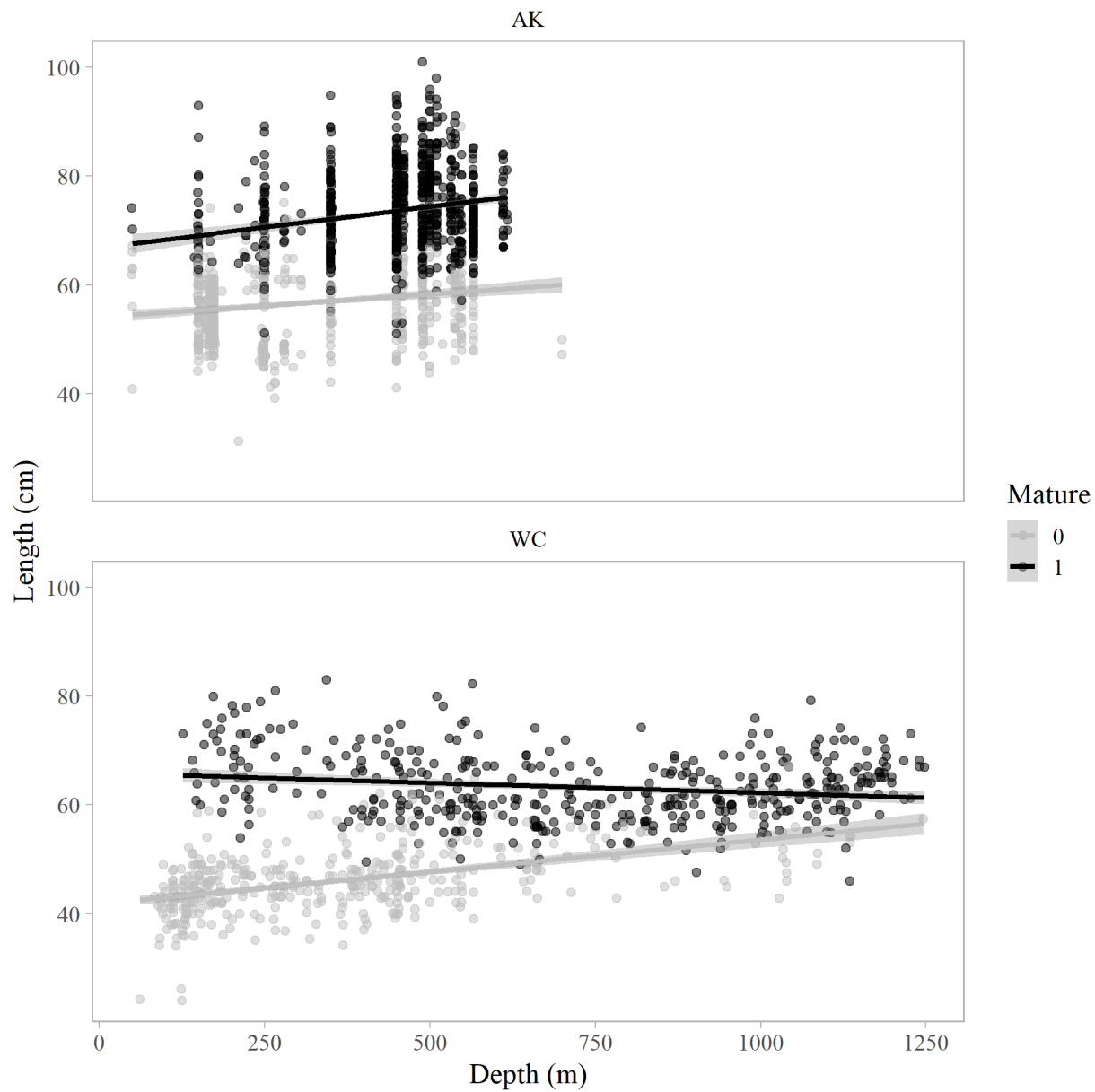


Figure 9: Sablefish length (cm) at depth by region.

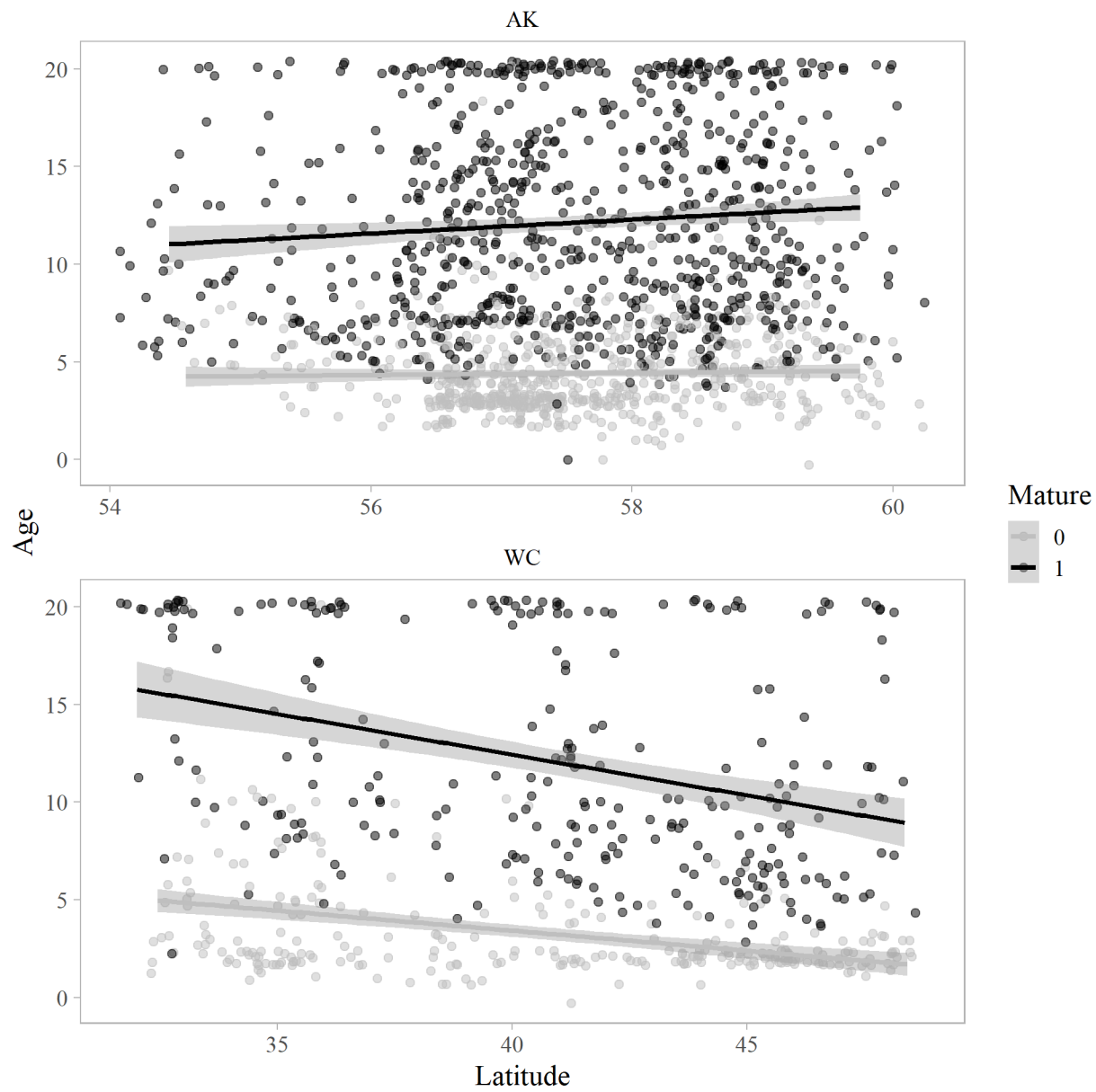


Figure 10: Sablefish age by latitude by region.

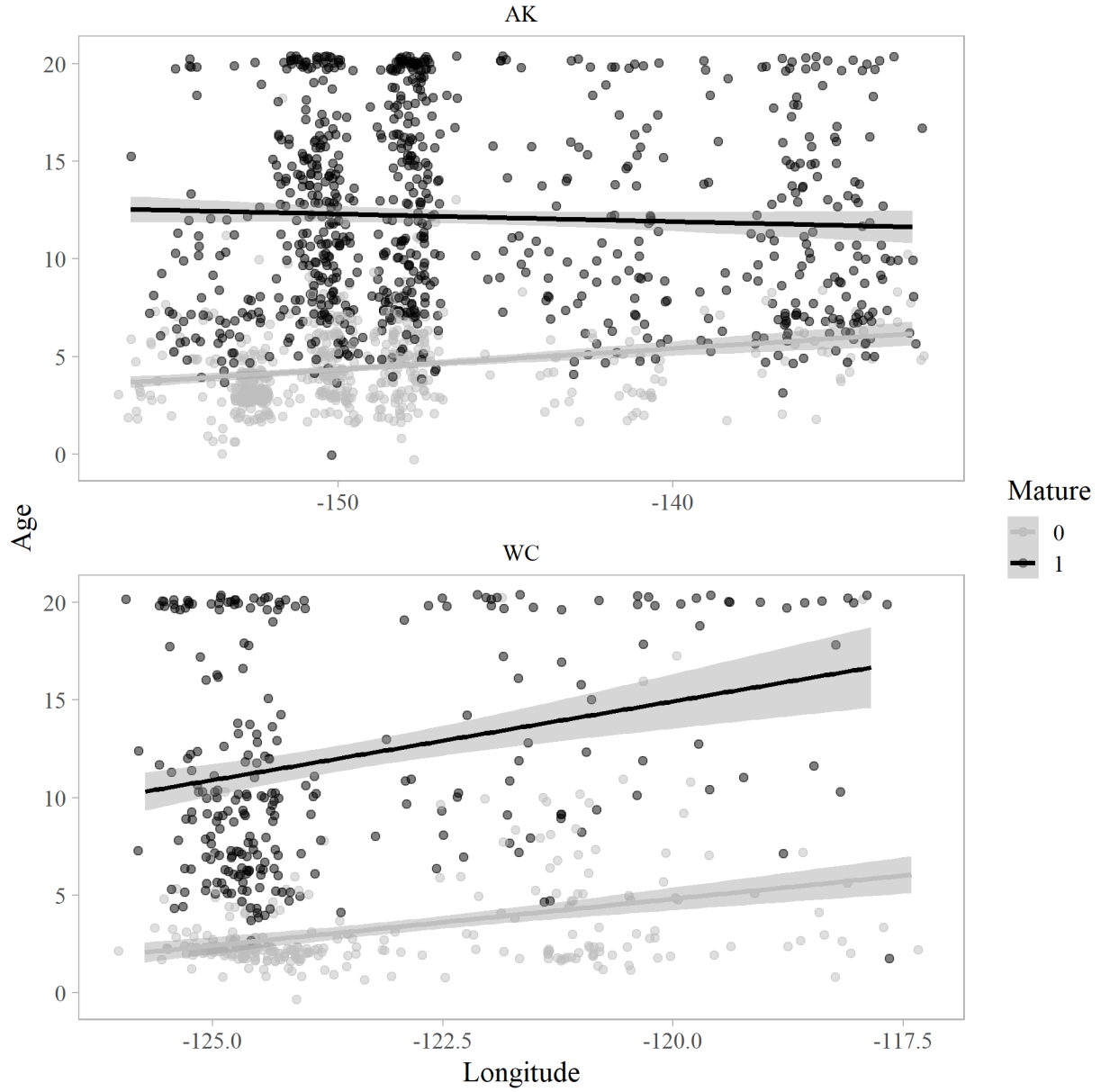


Figure 11: Sablefish age by longitude by region.

Note that figures 9-11 are only representative of the samples collected. If the location of the population as a whole is substantially different then these figures can be highly misleading.

2.4.2 Maturity models

Each region (Alaska and west coast) were modeled separately using the following generalized additive model:

$$\hat{M}_a = f_1(\text{Length}) \cdot \text{Age} + f_2(\text{Location}) + f_3(\text{depth}) + \text{Age} + \text{Year} + \epsilon. \quad (1)$$

The “joint” model combined both datasets and had the addition of a “region” variable.

$$\hat{M}_a = f_1(\text{Length}) \cdot \text{Age} + f_2(\text{Location}) + f_3(\text{depth}) + \text{Age} + \text{Year} + \text{Region} + \epsilon. \quad (2)$$

Length, location (lat/long), and depth were included as continuous variables. The “knots” for length and depth were constrained to a maximum of 4. All other variables were included as factors.

2.4.2.1 Model predictions

Prediction data were established so that lengths were binned in two-centimeter increments between 10 and 80 cm and filtered for the minimum and maximum sizes by both age and region. Latitude and longitude were in one-degree increments between the minimum and maximum for each region. Ages 1 through 20 were included in the prediction dataset. Depth was set as the median depth in each location.

Model predictions presented are the mean of the observed response e.g., the proportion mature at length by the mean length at age, mean depth, etc. This differs from the usual presentation of median values for predictions. However, it is unclear what the median location indicates, perhaps the mode would be more informative?

3 Results

Overall the joint model does a reasonably good job of describing the data in hand, with 74.1% of explained deviance (Table 1). The joint and separate models do a similar job of estimating maturity at age and length (Figures 1 & 2).

Family: binomial

Link function: logit

Formula:

Mature ~ s(depth, k = 4) + s(long, lat) + s(length, by = Age) +
Age + Year + Location

Parametric coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-4.136e+01	3.131e+06	0.000	1.0000
Age1	6.038e+00	1.108e+08	0.000	1.0000
Age2	3.643e+01	3.131e+06	0.000	1.0000
Age3	3.652e+01	3.131e+06	0.000	1.0000
Age4	3.911e+01	3.131e+06	0.000	1.0000
Age5	3.914e+01	3.131e+06	0.000	1.0000
Age6	3.958e+01	3.131e+06	0.000	1.0000
Age7	3.993e+01	3.131e+06	0.000	1.0000
Age8	4.035e+01	3.131e+06	0.000	1.0000
Age9	4.113e+01	3.131e+06	0.000	1.0000
Age10	4.079e+01	3.131e+06	0.000	1.0000
Age11	4.182e+01	3.131e+06	0.000	1.0000
Age12	4.411e+01	3.131e+06	0.000	1.0000
Age13	4.263e+01	3.131e+06	0.000	1.0000
Age14	7.825e+01	1.853e+07	0.000	1.0000
Age15	7.875e+01	2.057e+07	0.000	1.0000

Age16	1.412e+02	3.656e+06	0.000	1.0000
Age17	4.454e+01	3.131e+06	0.000	1.0000
Age18	4.261e+01	3.131e+06	0.000	1.0000
Age19	7.790e+01	3.348e+07	0.000	1.0000
Age20	4.001e+01	3.131e+06	0.000	1.0000
Year2011	3.893e-01	6.808e-01	0.572	0.5675
Year2015	4.825e-01	5.430e-01	0.889	0.3742
Year2018	9.601e-01	5.458e-01	1.759	0.0786
LocationWC	5.082e+00	3.199e+00	1.588	0.1122

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:

	edf	Ref.df	Chi.sq	p-value	
s(depth)	1.5885	1.9000	18.905	0.000339	***
s(long,lat)	9.6637	12.7194	66.410	3.17e-09	***
s(length):Age0	0.9710	0.9809	0.000	0.999997	
s(length):Age1	1.0000	1.0000	0.000	1.000000	
s(length):Age2	1.0000	1.0000	0.685	0.408037	
s(length):Age3	1.0000	1.0000	1.560	0.211634	
s(length):Age4	1.0000	1.0000	21.685	3.21e-06	***
s(length):Age5	1.0000	1.0000	50.265	1.34e-12	***
s(length):Age6	1.1998	1.3727	10.282	0.001545	**
s(length):Age7	1.5361	1.8930	34.649	2.11e-08	***
s(length):Age8	1.0000	1.0000	28.108	1.15e-07	***
s(length):Age9	1.0000	1.0000	9.303	0.002287	**
s(length):Age10	1.0000	1.0000	24.307	8.21e-07	***
s(length):Age11	1.0000	1.0000	13.787	0.000205	***
s(length):Age12	1.6325	1.9736	1.522	0.417771	
s(length):Age13	1.0000	1.0000	1.711	0.190857	
s(length):Age14	1.0000	1.0000	0.000	1.000000	
s(length):Age15	1.0000	1.0000	0.000	1.000000	
s(length):Age16	0.8926	0.9838	0.000	0.999953	
s(length):Age17	1.0000	1.0000	1.487	0.222717	
s(length):Age18	1.0000	1.0000	0.190	0.663214	
s(length):Age19	1.0000	1.0000	0.000	1.000000	
s(length):Age20	2.3524	2.8897	14.481	0.001753	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = 0.776 Deviance explained = 74.1%
fREML = 2214.3 Scale est. = 1 n = 1957

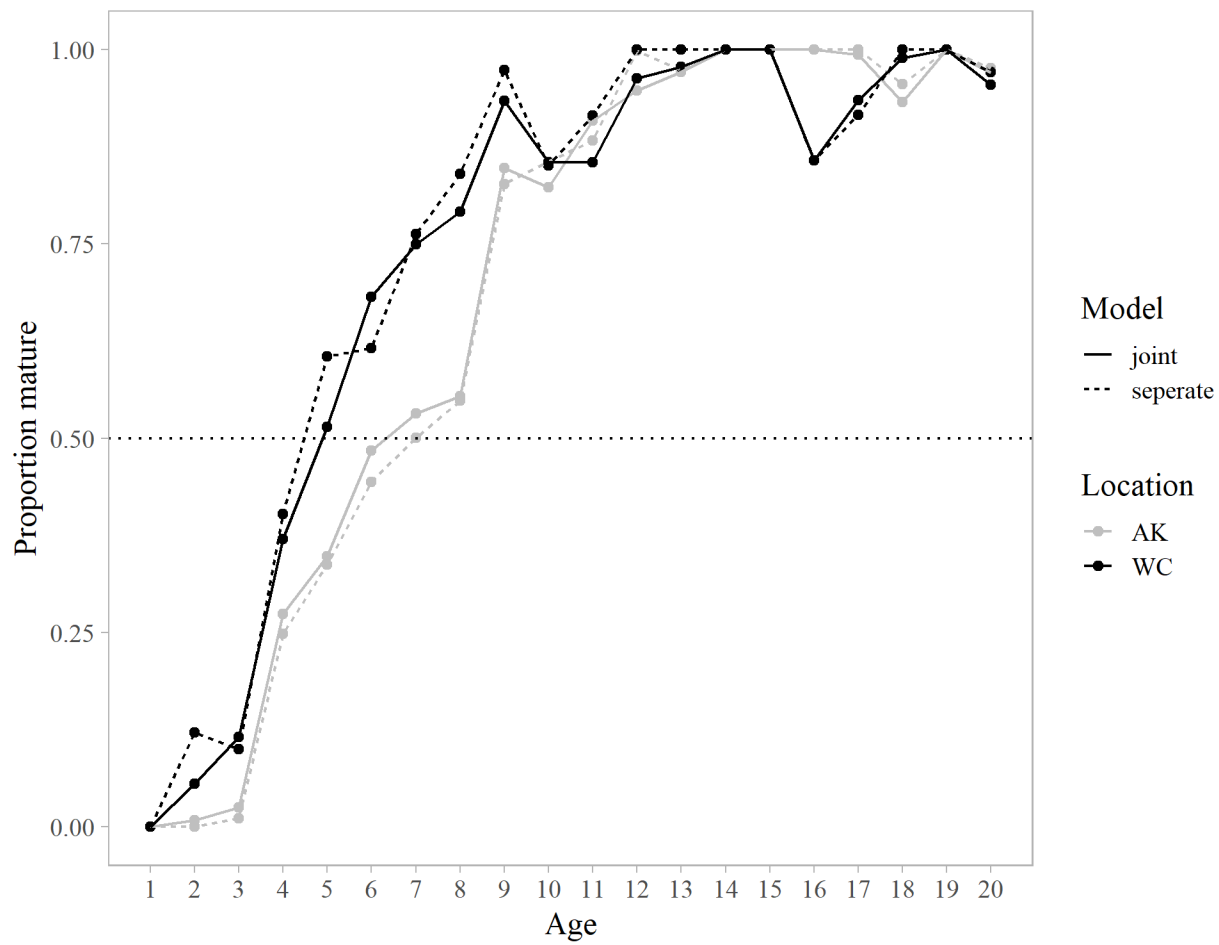


Figure 12: Sablefish maturity at age schedules for the joint and seperate models, by region.

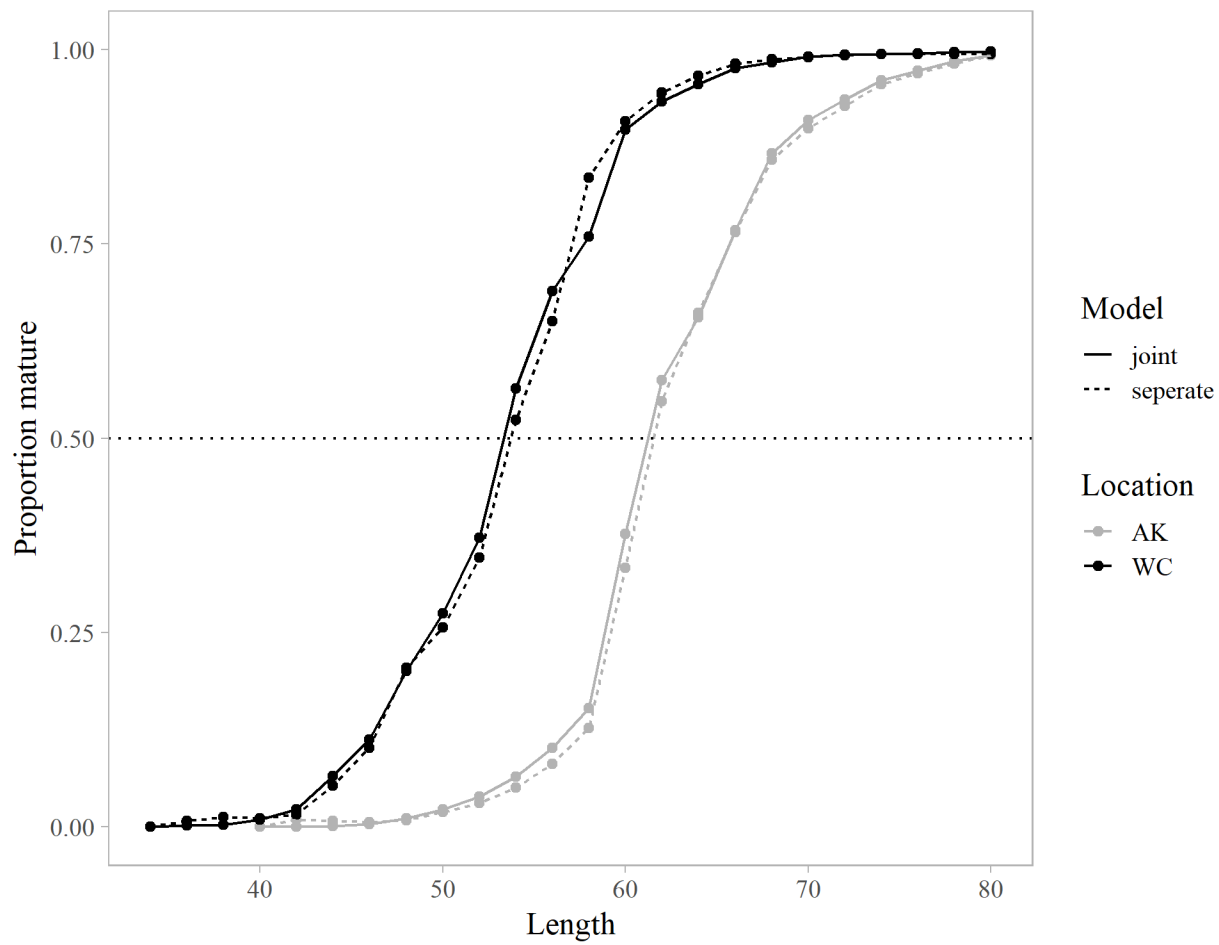


Figure 13: Sablefish maturity at length schedules for the joint and seperate models, by region.

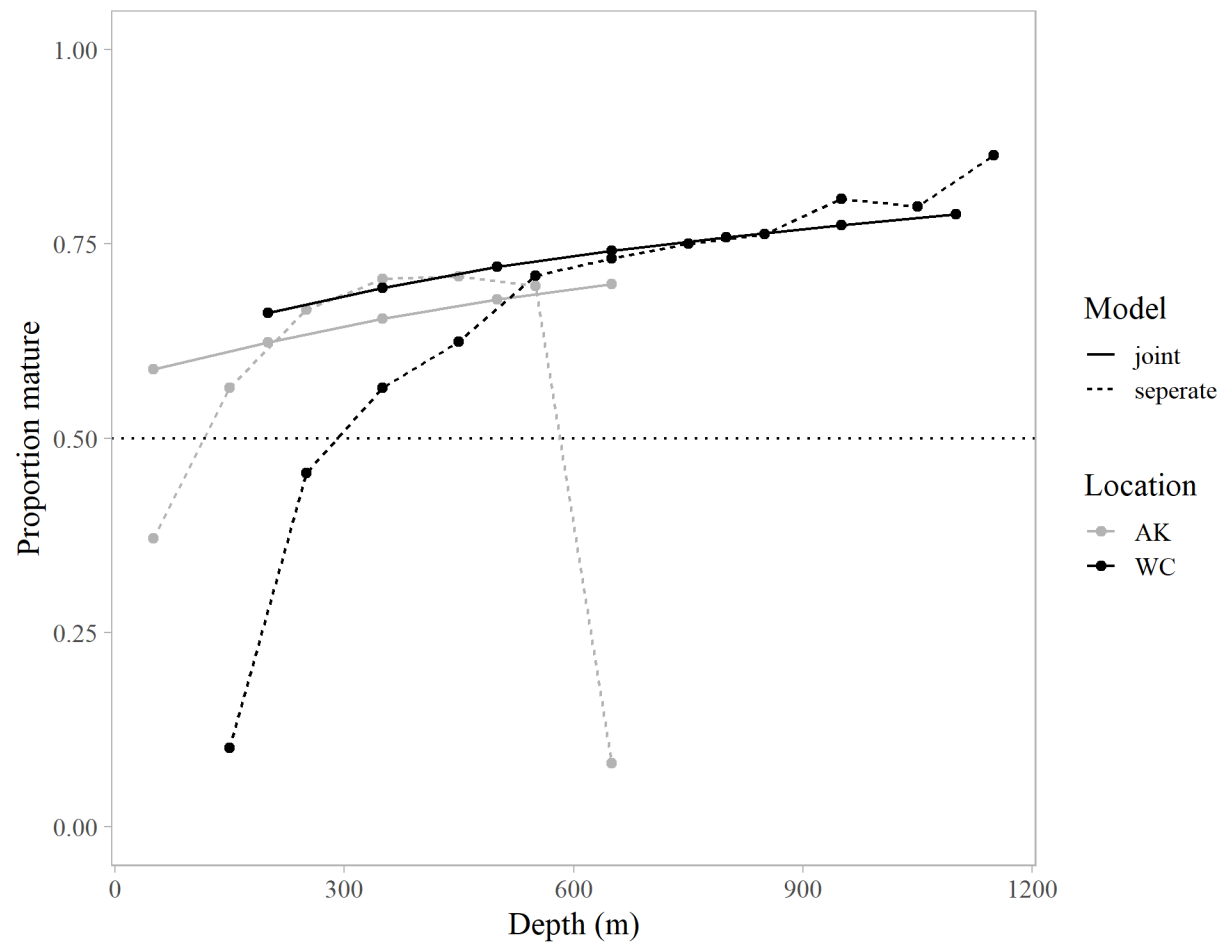


Figure 14: Modeled sablefish maturity at depth for the joint and seperate models, by region.

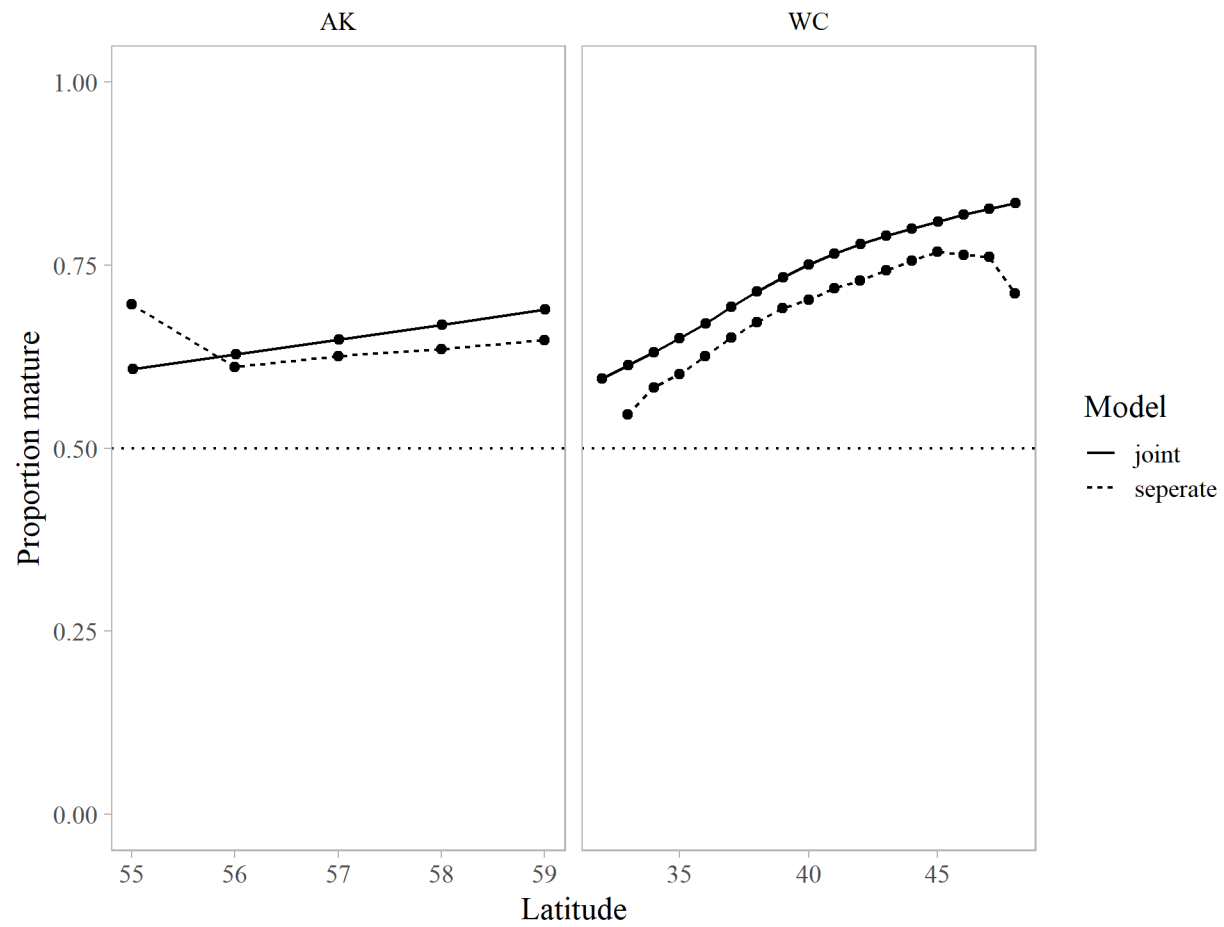


Figure 15: Modeled sablefish maturity by latitude for the joint and seperate models, by region.

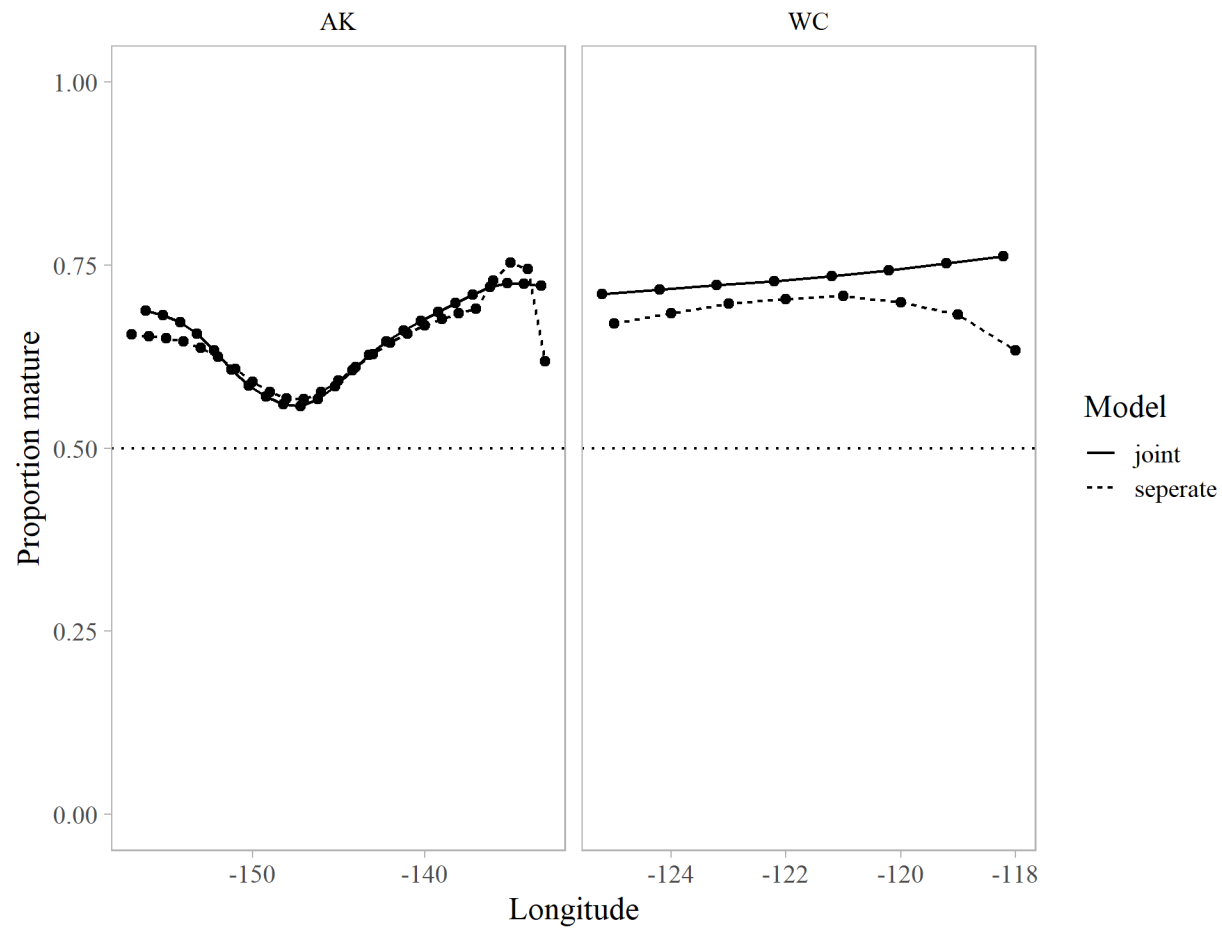


Figure 16: Modeled sablefish maturity by longitude for the joint and seperate models, by region.

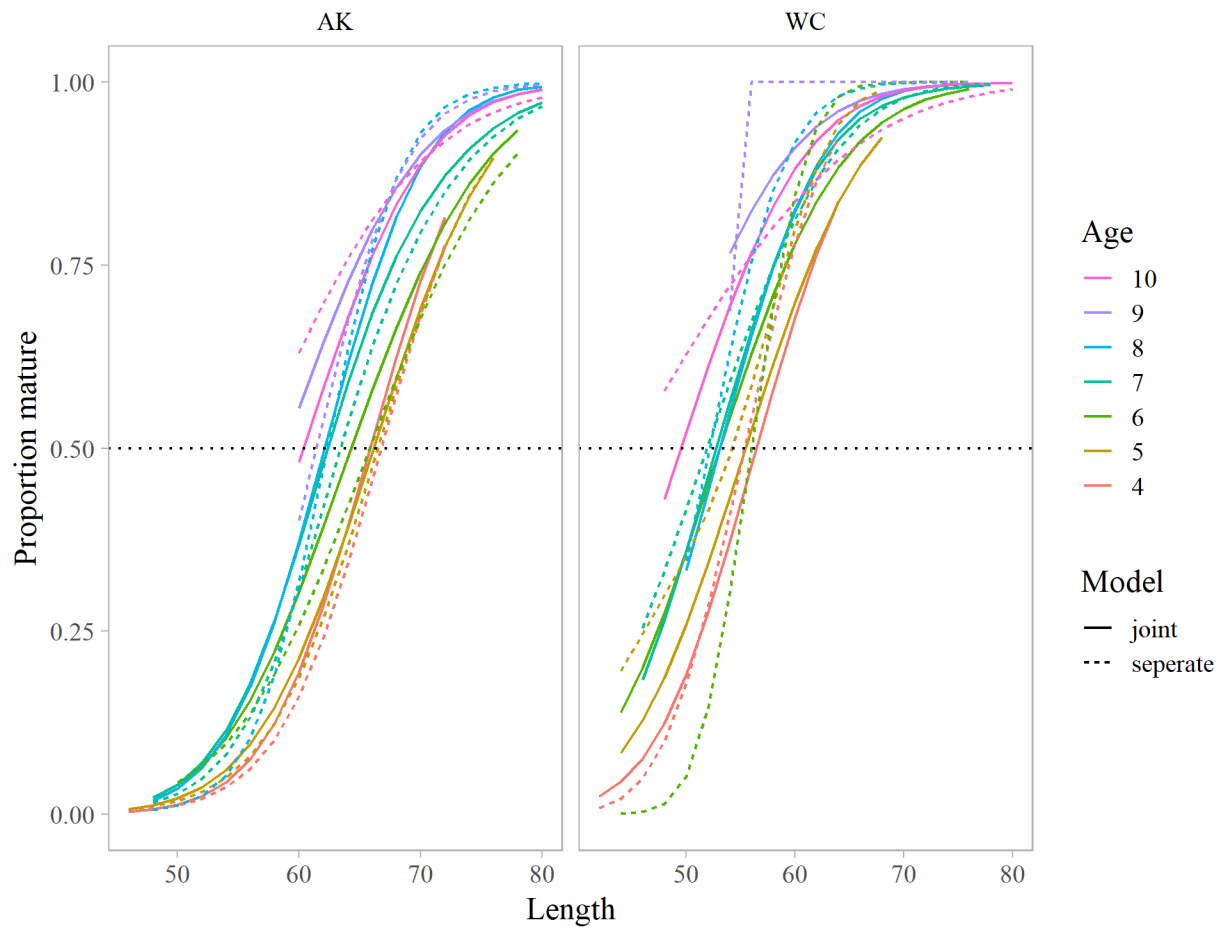


Figure 17: Modeled sablefish length at maturity by age for the joint and separate models, by region.

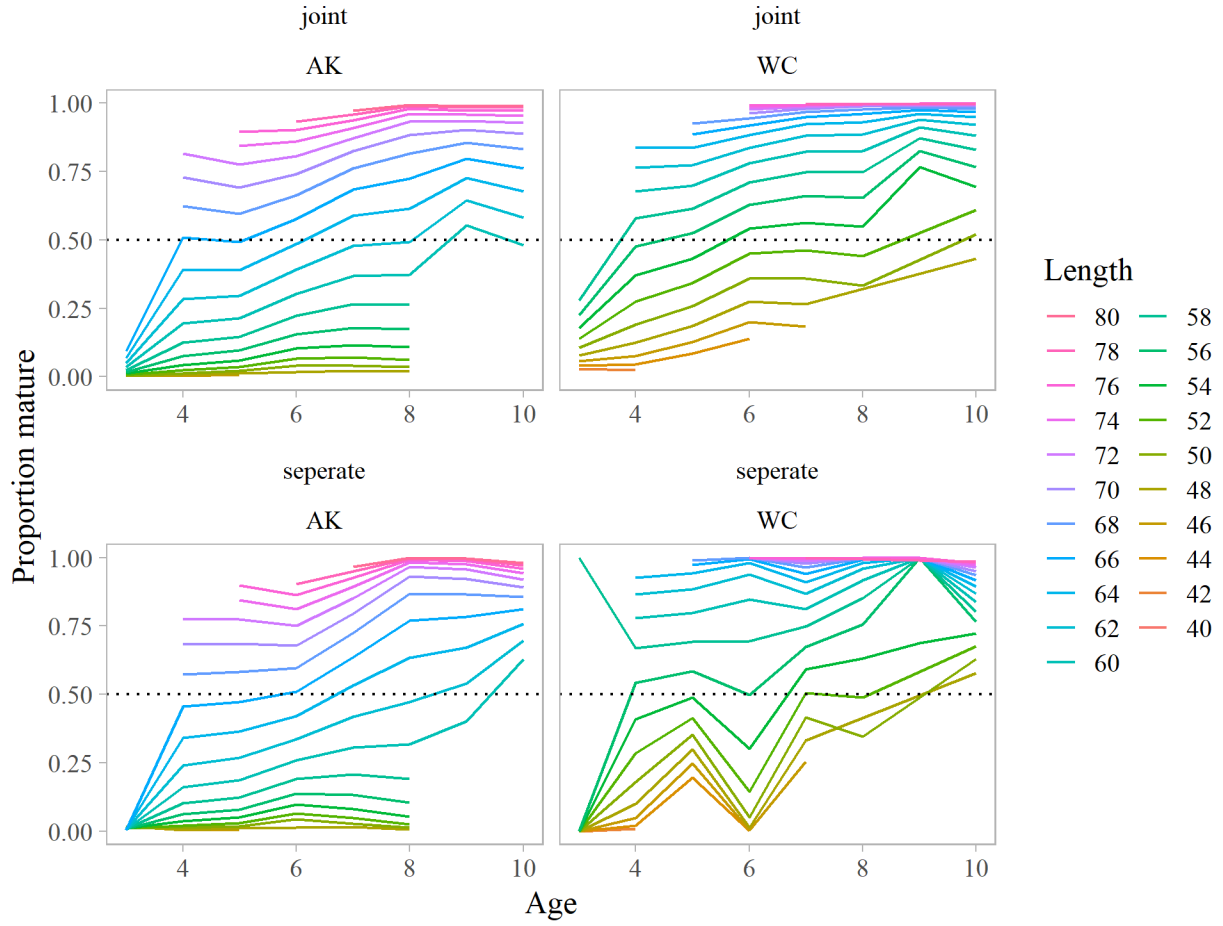


Figure 18: Modeled sablefish age at maturity maturity by length (2 cm bins) for the joint and seperate models, by region.

4 Discussion

General thoughts:

- There are some substantial differences in the sample sizes by location, depth, age, etc. that need to be considered when examining a coastwide model; therefore I utilized generalized additive models as they deal with missing data fairly well.
- Given the spatial differences in sablefish maturity, on both coastwide and regional scales, it is imperative to incorporate spatial abundance estimates into the estimated maturity schedule.
- Length at maturity is a more precise descriptor (no surprise there).
- For the coastwide analysis it would likely be easiest to implement either a strait age at maturity schedule or a von Bertalanffy estimated conditional length at maturity.
- It may be desirable to incorporate some of the spatial aspects that are found within each region (not fully detailed here).

5 References