4. Assessment of Northern and Southern rock sole (*Lepidopsetta polyxstra* and *bilineata*) stocks in the Gulf of Alaska

by

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Executive Summary

The Gulf of Alaska (GOA) northern and southern rock sole assessment has been moved to a 4-year assessment cycle per the stock assessment prioritization schedule. During years when a full assessment is not completed a partial assessment will be done. This year marks a full assessment year. The last full assessment was completed in 2017. The biomass, OFL and ABC values for northern and southern rock sole are added into the shallow-water flatfish complex values to estimate OFL and ABC for the complex.

Summary of Changes in Assessment Inputs

New data inputs:

1. 2017 catch data were updated to the final estimate from the catch accounting system, final catch estimates for 2018-2020 were also added to the model, and 2021 catch was extrapolated to include expected catch in October-December, 2021.
2. 2019 and 2021 GOA trawl survey biomass estimates were added to the model.
3. 2018-2021 fishery lengths were added to the model.
4. 2019 and 2021 GOA trawl survey length composition data were added to the model.
5. 2017 GOA trawl survey conditional-age-at-length (CAAL) data were added to the northern rock sole model. Northern rock sole otoliths were not collected in 2019. 2017 and 2019 GOA trawl survey conditional-age-at-length (CAAL) data were added to the southern rock sole model.

Changes to the assessment model:

1. The 2017 accepted assessment model was run assuming that fishery selectivity was asymptotic
2. Growth was poorly estimated in the 2017 assessment model, this was largely due to the overestimation of the coefficient of variation of the distribution of length at the maximum age. This was an estimated parameter that was fixed at a reasonable value determined through sensitivity analysis.
3. The authors demonstrated that there were growth differences in the central and western Gulf of Alaska for both northern and southern rock sole. The model was split into 2-areas that accounted for differences in growth between the western and central Gulf. A recruitment allocation parameter was estimated to distribute the population between the two areas. Growth was estimated in the model for each area. Catch, survey biomass, length composition data, and conditional age-at-length data were split between areas and used in the model. Survey catchability was assumed to be 1 in each area and area- and sex-specific survey selectivity was estimated. Area-and sex-specific fishery selectivity was also estimated.

Summary of Results

During the September Plan Team meeting, the authors showed that there is evidence that northern and southern rock sole growth differs in the central and western Gulf of Alaska. As such, several single area

and 2-area growth morph models were evaluated as part of this assessment. Given the more appropriate accounting of growth differences in the assessment model, and better estimation of growth for the central Gulf, the area where the majority of catch is taken, model 21.2 is the recommended model for this year's assessment of northern rock sole rather than model 17.1. The results were similar among the single area models and the 2-area, growth morph models for southern rock sole. Given the more appropriate accounting of growth differences in the western and central Gulf of Alaska model 21.1 is the recommended model for southern rock sole.

The northern rock sole models estimate an increasing trend in total and spawning biomass and relatively low fishing mortality rates in recent years. The 2021 northern rock sole SSB estimates were above $B_{35\%}$ and the 2021 fishing mortality estimates were below $F_{35\%}$. The southern rock sole models estimates the start of an increasing trend in total biomass and SSB, and fishing mortality rates have remained relatively low. The 2021 southern rock sole SSB estimates were above $B_{35\%}$ and the fishing mortality estimates were below $F_{35\%}$.

The key management results of the assessment, based on the author's preferred model (model 21.2 for northern rock sole and model 21.1 for southern rock sole), are compared to the 2020 projection results of the accepted 2017 update assessment in the tables below. The results are presented separately for each species and by area.

Northern Rock Sole

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022+	2023+
M (natural mortality rate; female, male)	0.2, 0.253*	0.2, 0.253*	See area specific estimates	
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	94,612	94,614	98,387	100,919
Projected Female spawning biomass (t)	47,694	46,330	35,474	39,682
$B_{100\%}$	51,387	51,387	See area specific estimates	
$B_{40\%}$	20,555	20,555		
$B_{35\%}$	17,985	17,985		
F_{OFL}	0.462	0.462		
$maxF_{ABC}$	0.382	0.382		
F_{ABC}	0.382	0.382		
OFL (t)	21,080	21,191	14,027	14,810
maxABC (t)	17,756	17,851	11,882	12,551
ABC (t)	17,756	17,851	11,882	12,551
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated. +Estimates represent the combined results from the area-specific model 21.2.

Northern rock sole: Central Gulf	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	This was not done in 2017-2020		0.2, 0.232	0.2, 0.232
Tier			3a	3a
Projected total (age 0+) biomass (t)			35,089	36,945
Projected Female spawning biomass (t)			11,694	13,861
$B_{100\%}$			21,622	21,622
$B_{40\%}$			8,649	8,649
$B_{35\%}$			7,568	7,568
F_{OFL}			0.187	0.187
$maxF_{ABC}$			0.157	0.157
F_{ABC}			0.157	0.157
OFL (t)			4,691	5,075
maxABC (t)			3,999	4,329
ABC (t)			3,999	4,329
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated. Estimates from the preferred model 21.2 for northern rock sole.

Northern rock sole: Western Gulf **Quantity**	As estimated or *specified last* year for: 2021 2022	As estimated or *recommended this* year for: 2022 2023
M (natural mortality rate; female, male)	This was not done in 2017-2020	0.2, 0.254 0.2, 0.254
Tier		3a 3a
Projected total (age 0+) biomass (t)		63,298 63,974
Projected Female spawning biomass (t)		23,780 25,821
$B_{100\%}$		28,656 28,656
$B_{40\%}$		11,462 11,462
$B_{35\%}$		10,030 10,030
F_{OFL}		0.270 0.270
$maxF_{ABC}$		0.225 0.225
F_{ABC}		0.225 0.225
OFL (t)		9,336 9,735
maxABC (t)		7,883 8,222
ABC (t)		7,883 8,222
Status	As determined *last* year for: 2019 2020	As determined *this* year for: 2020 2021
Overfishing	No n/a	No n/a
Overfished	n/a No	n/a No
Approaching overfished	n/a No	n/a No

*Male natural mortality was estimated. Estimates from the preferred model 21.2 for northern rock sole.

Southern Rock Sole

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	0.2, 0.248*	0.2, 0.248*	See area specific rates	
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	144,833	148,917	163,737	173,631
Projected Female spawning biomass (t)	72,973	73,930	73,114	83,900
$B_{100\%}$	93,518	93,518	See area specific estimates	
$B_{40\%}$	37,407	37,407		
$B_{35\%}$	32,731	32,731		
F_{OFL}	0.326	0.326		
$maxF_{ABC}$	0.271	0.271		
F_{ABC}	0.271	0.271		
OFL (t)	27,204	27,943	30,288	32,514
maxABC (t)	22,990	23,614	25,555	27,441
ABC (t)	22,990	23,614	25,555	27,441
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated. +Estimates represent the combined results from the area-specific model presented below.

Southern rock sole Central Gulf	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	This was not done in 2017-2020		0.2, 0.253	0.2, 0.253
Tier			3a	3a
Projected total (age 0+) biomass (t)			88,391	94,107
Projected Female spawning biomass (t)			37,555	43,470
$B_{100\%}$			54,439	54,439
$B_{40\%}$			21,376	21,376
$B_{35\%}$			18,703	18,703
F_{OFL}			0.268	0.268
$maxF_{ABC}$			0.224	0.224
F_{ABC}			0.224	0.224
OFL (t)			15,622	16,853
maxABC (t)			13,185	14,229
ABC (t)			13,185	14,229
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated. Estimates from the preferred model 21.1 for southern rock sole.

Southern rock sole Western Gulf	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	This was not done in 2017-2020		0.2, 0.271	0.2, 0.271
Tier			3a	3a
Projected total (age 0+) biomass (t)			75,346	79,524
Projected Female spawning biomass (t)			35,559	40,430
$B_{100\%}$			43,788	43,788
$B_{40\%}$			17,515	17,515
$B_{35\%}$			15,326	15,326
F_{OFL}			0.335	0.335
$maxF_{ABC}$			0.278	0.278
F_{ABC}			0.278	0.278
OFL (t)			14,666	15,661
maxABC (t)			12,370	13,212
ABC (t)			12,370	13,212
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated. Estimates from the preferred model 21.1 for southern rock sole.

Responses to SSC and Plan Team Comments on Assessments in General

NA

Responses to SSC and Plan Team Comments Specific to this Assessment

"In the next full assessment in four years, the author is requested to provide an equation and rationale for the input sample size calculation applied to the conditional age-at-length data; it was not clear how this calculation was performed or why this would be a function of the length samples and not purely the age samples."
An equation was provided.

"The SSC noted that the scale of the standardized residuals (particularly for the fishery length data) was large; further efforts to improve data weighting/model tuning are warranted. There appears to be a systematic lack of fit reflected in the comparison of variance about the conditional age-at-length data. The SSC supports the Plan Team's recommendation to explore spatially differing growth (similar to the "growth morph" analysis provided in the rex sole assessment) as a possible method for addressing this and other lack of fit in the length data. This model also showed a strong retrospective pattern, which represents a source of uncertainty not adequately captured in the results for management use and warrants additional investigation."

The growth morph model was explored to account for differences in growth in the central and western Gulf of Alaska for northern and southern rock sole. A systematic pattern in the residuals associated with the fit to the length data still exists and requires further investigation.

The models presented for northern rock sole still exhibit a strong retrospective pattern. The fit to survey biomass resulted in autocorrelated residuals, which indicate non-stationarity. In the future, the authors will evaluate whether survey catchability has changed over time.

"The partitioning of fishery catches into northern and southern rock sole components remains problematic, and the current approach of assigning 50% of the catch to each species represents a strong assumption that could be improved. The SSC supports a special project, or further analysis, to more accurately speciate catches in the historical time-series. Further, the mis-match between length composition data from the fishery and survey noted by the authors for northern rock sole suggests that mis-identification could be affecting some model parameters. Geographically explicit separation of these species on a biologically relevant scale could result in better fits by ensuring that datasets include only a single species. In addition, as noted by the author, further consideration of the best methods for modelling these species either separately or simultaneously are encouraged"

This is still an issue that will be addressed during the next full assessment.

"The authors also note that catch data used in the model do not currently incorporate estimates of error or variability, and the SSC supports efforts to rectify this."

This is still an issue that will be addressed during the next full assessment.

Introduction

Rock sole are demersal flatfish that can be found in shelf waters to 600 m depth (Allen and Smith, 1988). Two species of rock sole are known to occur in the north Pacific Ocean, northern rock sole (*Lepidopsetta polyxystra*) and southern rock sole (*L. bilineata*) (Orr and Matarese, 2000). Adult northern rock sole are found from Puget Sound through the Bering Sea and Aleutian Islands to the Kuril Islands, while southern rock sole range from the southeast Bering Sea to Baja California (Stark and Somerton, 2002). These species have an overlapping distribution in the Gulf of Alaska (Wilderbuer and Nichol, 2009). Rock sole are most abundant in the Kodiak and Shumagin areas. Northern rock sole spawns in midwinter and spring, and southern rock sole spawns in summer (Stark and Somerton, 2002). Northern rock sole spawning occurred in areas where bottom temperatures averaged 3°C in January, and southern rock sole spawned in areas where bottom temperatures averaged 6°C in June (Stark and Somerton, 2002). Rock soles grow to approximately 60 cm and can live in excess of 20 years (http://www.afsc.noaa.gov/race/behavioral/rocksole_fbe.htm).

Both rock sole species are managed as part of the shallow-water flatfish complex. They are often caught with the other shallow-water flatfish species which also includes yellowfin sole (*Pleuronectes asper*), starry flounder (*Platichthys stellatus*), butter sole (*Pleuronectes isolepis*), English sole (*Pleuronectes vetulus*), Alaska plaice (*Pleuronectes quadrituberculatus*), and sand sole (*Psettichthys melanostictus*),

Turnock et al., 2009).

Fishery

Northern and southern rock sole in the Gulf of Alaska are part of the shallow water flatfish complex. The fishery does not report rock sole by species, so the catch statistics represent total rock sole (Table 4.1). The fishery observer program began collecting differentiated northern and southern rock sole data in 1997. The observer data since 1997 lists species as northern (N), southern (S), or “undifferentiated” (U) rock sole because adult northern and southern rock sole are difficult to differentiate visually (Orr and Matarese, 2000). There is considerable uncertainty about the fraction of annual rock sole catch that is northern or southern rock sole.

Rock sole are not targeted specifically because they co-occur with several other species. They are primarily caught with bottom trawl gear in NMFS area 630 followed by areas 620 and 610 (Figure 4.1). Rock sole are primarily caught in the spring (March-May) and in the summer/fall (July-October). Rock sole discards by area reported in Table 4.2. Rock sole caught in the central GOA are generally retained. Discard rates in the western GOA have ranged from 10 percent to 100 percent depending on the year.

Data

The following data were used in the model.

Data source	Years
Fishery catch (assumed 50% NRS, 50% SRS)	1977-2021
NMFS GOA groundfish survey biomass and SE	1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021
Fishery length composition	1997-2021
NMFS GOA groundfish survey length composition	1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021
NMFS GOA groundfish survey CAAL (2019 age data were not available for NRS)	1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2017, 2019*

Fishery

Northern and southern rock sole catches are currently reported as rock sole by year and management area (Figure 4.1). These data are included in the assessment model as a total catch time-series. Rock sole catch has ranged from 1,765 t to 8,112 t since 1993 and has averaged 4,161 t (Table 4.1). Since 2010, rock sole catch has been below this average (Table 4.2).

It was assumed that 50% of the total rock sole catch was northern rock sole and 50% was southern rock sole. This catch split was used for the catch input for the single area models and catch was assumed to be known without error in the assessment models. For the 2-area model, the catch was also split by area, western and central GOA. On average, since 1993, 97% of rock sole catch has occurred in the central GOA and 3% in the western GOA (Figure 4.1).

Size composition data are available from the NMFS observer program from 1985 to present and obtained from the NORPAC length tables. Observations were recorded as rock sole until 1996. Northern and southern rock sole were differentiated after 1996. Fishery length composition data from 1997 through 2021 are included in the assessment model (Figure 4.2). The number of sampled hauls was used as the input sample size in the assessment model. The number of sampled hauls and the number of length samples by species and sex are summarized in Table 4.3. The number of lengths sampled and hauls sampled has varied over time and has been below the time series average since 2010. The majority of length samples have been collected in areas 630 and 620 with relatively few lengths collected from area 610 (Table 4.4).

Survey

Survey data are available from the NMFS Gulf of Alaska groundfish survey conducted by the AFSC's Resource Assessment and Conservation Engineering (RACE) division. Surveys were conducted triennially from 1984 until 1999 and biennially from 2001 until present. These data include biomass estimates by area, length composition data, age composition data, and conditional age-at-length data. Northern and southern rock sole were not differentiated until 1996. After 1996, observed rock sole were identified as northern, southern, or unidentified rock sole.

Estimates of total biomass and the associated standard errors were included in the northern and southern rock sole assessment model. The survey total biomass estimates are summarized in Table 4.5a and shown

in Figure 4.4. Area-specific biomass and standard errors were used as input for the 2-area model and summarized in Table 4.5b and shown in Figure 4.5.

Northern rock sole survey biomass declined between 1996 and 1999 and then increased to a peak of 102,641 t in 2007 (4.4, top panel). After 2007, survey biomass consistently declined to a low of 38,987 t in 2019. The northern rock sole biomass declined by 27% between 2017 and 2019, and increased by 29% in 2021. The peak in total northern rock sole biomass matches peak biomass in the western Gulf, where on average 63% of biomass is found (4.5, top panels). Biomass in the central Gulf peaked in 2009 and generally declined until 2019. Biomass in the central Gulf increased in 2021 and surpassed biomass in the western Gulf.

Southern rock sole total biomass declined between 1996 and 1999, increased to a peak in 2009, declined in 2011 and has remained relatively stable since (Figure 4.4., bottom panel). The southern rock sole biomass estimate declined by 14% from 2015 to 2017 and by 7% between 2017 and 2019 and increased by 29% in 2021. The peak in total biomass matches peak biomass in the central and western Gulf, where on average 56% and 44% of southern rock sole biomass is found, respectively (Figure 4.5, bottom panels). Trends in southern rock sole biomass are generally similar between the central and western Gulf, but there has been some divergence in recent years. Biomass declined in the west in 2017 and 2019, while biomass remained stable in the central Gulf. Southern rock sole biomass in the west increased in 2021 and is now higher than in the central Gulf. Biomass has been generally proportionally higher in the central Gulf, 56%, than western Gulf, 44% (Figure 4.5, bottom-right panel).

Survey length composition data and conditional age-at-length data were also included in the assessment models. The number of lengths and hauls per year, area, and species are summarized in Table 4.6. The number of hauls per year was used as the input sample size for the length composition data. The input sample size for the conditional age-at-length data was the ratio of the number of hauls and number of lengths sampled scaled by the number of age samples:

$$ISS_{l,y} = \frac{nhauls_y}{nlengths_y} nlengths_{l,y}$$

The number of ages by area are shown in Table 4.6c and d. Generally more northern rock sole lengths were collected from the western Gulf than the central Gulf. The opposite is true for southern rock sole.

The survey length composition data for northern and southern rock sole are shown in Figure 4.2 and Figure 4.3, respectively. The survey conditional age at length data aggregated over years are shown in Figures 4.6 and 4.7.

Analytic approach

General Model Structure

All models were configured using Stock Synthesis (SS3). SS3 equations can be found in Methot and Wetzel (2013) and further technical documentation is outlined in Methot (2009). The models covered ages 0 to 30, were sex-specific, and started in 1977. Age-0 individuals represent recruits to the population and the oldest age class represents as plus group. As mentioned in the data section, in model 17.1 (the last accepted assessment model), fishery catch (retained catch and discards) are reported as undifferentiated rock sole. Annual total catch was split evenly between northern and southern rock sole and included in the model as the catch time-series. Catch was assumed to be known without error.

Growth was assumed to follow the von Bertalanffy growth relationship and assumed constant over time. All growth parameters were estimated including two error terms describing the coefficient of variation of

young and old individuals in model 17.1. The coefficient of variation of the intermediate ages was interpolated from these two parameters and assumed to be a function of length and age.

Female natural mortality was fixed and set equal to 0.2. Male natural mortality was estimated. Age-based maturity was a fixed input vector and is shown in Figure 4.8. The length-weight relationship was assumed to be the same for females and males and are shown in Figure 4.9. Fecundity was assumed to be equivalent to spawning biomass.

The stock recruitment relationship was assumed to be an average level of recruitment unrelated to stock size. Two of the stock-recruit parameters were fixed. Steepness was fixed equal to 1 in all model configurations, recruitment variability σ_R was fixed equal to 0.6. Unfished recruitment (R_0) and the R1_offset parameter, which adjusts the starting recruitment relative to R_0, were estimated within the model. Annual recruitment deviations were estimated for the full time period.

Sex-specific, size-based selectivity functions were estimated for the fishery and survey and were assumed to be constant over time. A double normal selectivity pattern was used for the fishery and the survey. The double normal pattern is described by 6 parameters;

1. Peak- beginning size of the plateau,
2. Width of the plateau,
3. Width of the ascending limb,
4. Width of the descending limb,
5. Selectivity at the smallest length, and
6. Selectivity of the largest length.

The selectivity parameters for the fishery were estimated and allowed for a dome-shape relationship in model 17.1. It was assumed that the survey selectivity was asymptotic. The parameters associated with the descending side of the double normal curve and the selectivity of the final size bin were fixed to accommodate this assumption. Male selectivity was estimated as an offset of female selectivity. When using a double normal pattern, five additional parameters are required to differentiate from the opposite sex. These parameters offset the female peak, ascending and descending limbs, and the selectivity at the final length bin. An additional parameter represents the apical selectivity for males.

Catchability was fixed equal to 1 in all model configurations. This assumes that the survey biomass estimates reflect absolute abundance for fully selected individuals.

Description of Alternative Models

Several models are presented independently for northern and southern rock sole. A general summary of the models can be found in Tables 4.7-4.10.

Northern rock sole models

Model 17.1 was a re-run of the 2017 full assessment model with data updated through 2021. Models 17.1a-17.1c represent minor changes to the last accepted assessment. The descending limb of female and male fishery selectivity sharply changed and the curve became domed over length classes where there is little information and the model was effectively estimating parameters that had little influence on the results and therefore assuming asymptotic selectivity is justified. The fishery selectivity for both females and males was fixed to be asymptotic in 17.1a.

During the September Plan Team meeting, the team noted the poor fit to the length composition data and suggested that CV of the distribution of the length at maximum age parameter was too large. A sensitivity analysis was conducted to determine the impact this parameter had on the estimate of the growth curve.

The analysis was conducted assuming that the CV parameter was the same for females and males. The model runs were completed while fixing this parameter over a range of values from 0.01 to 0.25. The results are shown in Figure 4.10. The CV at maximum age is negatively correlated with asymptotic length, therefore, smaller CV values yield higher asymptotic growth and a somewhat lower growth coefficient. The results indicate that values of CV between 0.07 and 0.09 better describe the aggregate growth of northern rock sole. Given the confounding between this parameter with asymptotic length, the confounding between asymptotic length and the von Bertalanffy growth coefficient, the CV of distribution of length at maximum age was fixed in model 17.1b. This helps to constrain the model into a region where growth is better estimated. Model 17.1c represents a combination of models 17.1a and 17.1b

During the September Plan Team, the authors showed evidence for differing growth between the western and central Gulf of Alaska. This was initially evaluated based on recommendations made by the CIE reviewers during the 2021 CIE review. The conditional age at length data are shown by area in Figure 4.6 and demonstrate this difference. In addition, differences in growth were evaluated statistically using the fishmethods package (v4.0.5, Nelson, 2021) in Program R. More specifically, this package was used to externally estimate the von Bertalanffy growth parameters, evaluate several models, and for model selection. The data from Yakutat and SE were combined with Chirikof and Kodiak and considered as part of the central GOA. Several models were considered and included 1.) growth parameters were equal between the two areas, 2.) all growth parameters differed, 3.) asymptotic length was set equal, 4.) the growth coefficient was set equal, and 5.) the theoretical age at which length is zero (t_0) was set equal.

The results are presented in Table 4.11. The model where all growth parameters differ between areas has the lowest AIC for northern rock sole and given the delta AIC there is strong support for this model for northern rock sole females. Differences in growth are also supported for male northern rock sole, but a model with the von Bertalanffy growth coefficient set equal in both areas is also supported.

The 2-area, “growth morph” model similar to McGilliard *et al.* (2017) was explored for northern rock sole given the magnitude of difference in the growth relationship of this species. The two areas in the model represented the western GOA and central GOA and the survey and fishery data were split according to area and input separately in the model. Estimated fishery and survey selectivity were sex-specific and area-specific. Survey catchability was set equal to 1 for both areas and a time-invariant distribution parameter that specifies the proportion of recruits in each area was estimated.

Model 21.0 is the 2-area representation of model 17.1 (Table 4.7). Model 21.1 is similar to model 21.0 while assuming the CV of the distribution of length at maximum age was fixed. This parameter has a moderately strong negative correlation with asymptotic length in model 17.1. A sensitivity analysis was conducted to further demonstrate this parameters influence on the growth estimates. The analysis was conducted assuming that the CV parameter was the same for females and males and there was no difference in this parameter between areas. The model runs were completed while fixing this parameter over a range of values from 0.01 to 0.25. The outcome of this analysis and the influence of this CV parameter on the growth estimates is shown in Figure 4.11. Similar to the sensitivity analysis results for model 17.1, the CV of the distribution of length at maximum age is negatively correlated with asymptotic length where smaller CV values between 0.05 and 0.15 yield higher asymptotic growth and a somewhat lower growth coefficient. The results indicate that values of CV between 0.05 and 0.09 better describe the area-specific growth of northern rock sole. As such, this CV parameter was fixed in Model 21.1.

Model 21.2 is similar to model 21.1 while assuming fishery selectivity is asymptotic. This was done by fixing the descending limb and selectivity of the largest size bin parameters of the double normal selectivity pattern. Additionally, this change to the model was explored because the descending limb of female and male fishery selectivity sharply changed and the curve became domed over length classes

where there is little information. The model was effectively estimating parameters that had little influence on the results and therefore assuming asymptotic selectivity is justified. Model 21.3 is similar to model 21.2 while fixing the growth parameters. This run was done to further evaluate how well the 2-area, growth morph model is able to estimate growth.

Southern rock sole models
Model 17.1 was a re-run of the 2017 full assessment model with data updated through 2021. Model 17.1a represents a minor change to model 17.1. Similar to the northern rock sole assessment, the descending limb of female and male fishery selectivity sharply changed and the curve became domed over length classes where there is little information. In model 17.1a, female and male fishery selectivity was fixed to be asymptotic.

During the September Plan Team meeting, the team noted the poor fit to the length composition data and suggested that the CV of the distribution of the length at maximum age was too large. A sensitivity analysis was conducted to determine the impact this parameter had on the estimate of the growth curve, the results of which are presented in the Results section. As such, the maximum CV parameter was fixed in model 17.1b along with asymptotic fishery selectivity.

During the September Plan Team, the authors showed evidence for differing growth between the western and central Gulf of Alaska. The conditional age at length data are shown by area in Figure 4.7. The difference in growth is more subtle for southern rock sole than northern rock sole. The same statistical analysis conducted for northern rock sole using the fishmethods package in Program R was completed for southern rock sole. The data from Yakutat and SE were combined with Chirikof and Kodiak and considered part of the central GOA. The model with the lowest AIC for southern rock sole is the model where the t_0 parameter is set equal among areas (Table 4.10); however, the model with growth differences between areas and the model where the von Bertalanffy growth coefficient is set equal are also supported. This suggests there is some difference in growth between the areas for southern rock sole.

The 2-area, “growth morph” model was explored for southern rock sole. A summary of the models is in Table 4.9. Model 21.0 is similar to model 17.1 (Table 4.7). Model 21.1 is similar to model 21.0 while assuming fishery selectivity is asymptotic. This was done by fixing the descending limb and selectivity of the largest size bin parameters of the double normal selectivity pattern. Model 21.2 is similar to model 21.1 but the growth parameters were fixed to the externally estimated values.

Parameters estimated outside the assessment model

The initial values for the growth parameters used in the model are from the updated analysis done in September. The parameters for the weight-length relationship ($W = aL^b$, weight in kg and length in cm) for northern and southern rock sole are from Turnock et al. (2011) and are shown in Figure 4.9.

Species	Parameter	Female	Male
Northern rock sole			
All GOA	L_∞	45.14 cm	38.49 cm
	K	0.2007	0.2314
	t_0	0.2128	0.0940
Central	L_∞	50.29 cm	41.92 cm
	K	0.2039	0.2314
	t_0	0.4907	0.2558
West	L_∞	45.47 cm	37.72 cm
	K	0.1500	0.2078
	t_0	-0.47	-0.1039
All models	a	9.984×10^{-6}	9.984×10^{-6}
	b	3.0468	3.0468
Southern rock sole			
All GOA	L_∞	50.24 cm	39.58 cm
	K	0.1637	0.2112
	t_0	0.2875	0.1292
Central	L_∞	51.43 cm	39.86 cm
	K	0.1659	0.2199
	t_0	0.3285	0.2175
West	L_∞	48.67 cm	39.15 cm
	K	0.1553	0.1983
	t_0	0.1772	0.0199
All models	a	9.984×10^{-6}	9.984×10^{-6}
	b	3.0468	3.0468

Parameters Estimated Inside the Assessment Model

The parameters fixed and estimated in each model are summarized in Tables 4.7 and 4.8 for northern rock sole and Tables 4.9 and 4.10 for southern rock sole.

Results

Model evaluation

The resulting likelihoods, model fits to the data, and sensitivity results for several key parameters are presented to evaluate the northern and southern rock sole assessment models.

Northern rock sole
The northern rock sole assessment model fit to the survey conditional age-at-length, survey biomass, and the overall length composition data are shown in Figures 4.12 – 4.14. Model fit to annual CAAL and length composition and in Appendix A, Figures A.1 – A.13. The root mean square error values associated with the model fit to the survey data and the total likelihood and the data component likelihoods are reported in Tables 4.12 and 4.13.

All models were fit to the survey conditional age-at-length (CAAL) data that provide the model with information to estimate growth (Figure 4.12). Model 17.1-17.1c were fit to the aggregated GOA CAAL data and models 21.0-21.3 were fit to the area-specific CAAL. All single area models fit the CAAL data relatively well and similarly (see Figure A.1a-d). Models 17.1 and 17.1a estimated a lower asymptotic length and a higher growth coefficients and t_0 parameters than the external estimates (Table 4.13). Models

17.b and 17.1c estimated a higher asymptotic length, a lower growth coefficient, and higher t_0 parameter than the external estimates. This is not unexpected given the negative correlation between the growth parameters (Table 4.15). The distribution of the observed length at age seems better described by model 17.1b and 17.1c when the CV of the oldest individuals was fixed to a value of 0.1 (Figure 4.12).

The 2-area, growth morph model estimated the growth for the central GOA similarly among models and was similar to the externally estimated growth parameters for both females and males (Figure 4.12, Table 4.14). The models generally underestimated the asymptotic length for females and males while overestimating the growth coefficient and t_0 parameter when compared to the externally estimated parameter estimates, which were fixed in model 21.3. Correlation among parameters may help to explain why the growth of the western Gulf growth morph is not estimated as well as the growth in the central GOA by models 21.0-21.2.

Female asymptotic length in the western Gulf is negatively correlated with the recruitment distribution parameter and male natural mortality in the western Gulf (Table 4.15). The recruitment distribution parameter is estimated in the model and determines the proportion of the population found in the western Gulf. The range in estimates for the distribution parameter is between 0.69 and 0.73 (Table 4.15), which is slightly higher than the proportion of survey biomass from the western Gulf (63%). This parameter is positively correlated with male natural mortality in the western Gulf. The models are estimating a male natural mortality value that provides a fairly reasonable estimate distribution of the population. Given the negative correlation between male natural mortality and asymptotic length, for growth to be more reasonably estimated male natural mortality would have to be lower. The estimate of male mortality is further constrained by the fixed value of female natural mortality. Female and male natural mortality are generally positively correlated, therefore, the fixed value of female natural mortality will place a lower limit of male natural mortality.

The fits to survey biomass are shown in Figure 4.13. All single area models similarly fit the aggregate survey biomass data (Table 4.12). The fit to the area-specific survey biomass is similar among the growth morph models. Comparing across models is difficult, but when the expected area-specific biomass is summed over the areas and compared to the single area models expected values the fit to survey biomass before 2015 is similar among the models (Figure 4.13 bottom panel). All models consistently underestimate biomass from 2005 – 2013. Starting in 2015, the 2-area models better describe survey biomass; however, all models overestimate biomass between 2015 and 2021. This autocorrelation in the residuals indicates non-stationarity in survey biomass and in the future we will need to investigate whether survey catchability or selectivity has changed over time.

Figure 4.14 shows the model fits to the fishery and survey size composition data aggregated over year. Annual fits are in Appendix A (Figure A.2 - A.13). The fits to the fishery length composition data are similar among the models. The same is true for the model fits to the survey length composition data. The one notable exception is for model 21.3 when the growth parameters were fixed to the externally estimated values. This represents the trade-off in fitting the CAAL data and the length data. Model 21.3 better fits the CAAL data than the other 2-area models. It should be noted that the single area and 2-area models consistently underestimate the peak of the male survey length data, which is driven by the misfit of the peak of the male length distribution from the western Gulf. To some degree this is also true for the female survey length distribution, where the peak of the central GOA survey length distribution is underestimated.

Length-based selectivity was modeled using the double normal pattern for the fishery and survey. Survey selectivity was forced to be asymptotic for all models and was estimated consistently among the models (Figure 4.15). There are obvious differences in fishery selectivity among the models (Figure 4.15). Notably the descending limb was sensitive to small changes in the model and although is estimated to be

dome-shaped. Comparing the length distribution of the fishery and survey, the fishery length distribution is wider and includes larger individuals. Survey selectivity is assumed asymptotic; therefore, it seems reasonable to assume fishery selectivity is also asymptotic.

Tables 4.17- 4.19 summarize the model estimates of and uncertainty in SSB, age-0 recruits, and fishing mortality. Figure 4.16 shows the same results compared to the 2017 accepted assessment model and The estimated initial conditions of the model are similar among the models with considerable overlap in confidence regions. In general, the 2-area models estimates slightly lower SSB and higher F than the single area model. However, the annual SSB estimates fall within each other's confidence bounds for the majority of the time series. The greatest deviation among the single area and 2-area models is in the last several years where the single area model estimates higher SSB than the 2-area model. The single area models overestimate the increase in survey biomass more so than the 2-area model driving this trend in estimated SSB. It should also be noted estimated SSB between 2011-2017 for all models is lower than the last accepted assessment model. This is largely driven by higher estimated recruitment in the early 2000s by the last assessment model.

Figure 4.17 shows the estimated SSB and age-0 recruit time series by area. The 2-area, growth morph models estimated the proportion of recruitment in the western area to be between 69% and 73% depending on the model (Table 4.16). Therefore, recruitment in the central GOA was estimated to be between 21% and 27%. The estimated difference in SSB also reflects this difference. Over the bottom trawl survey times, on average, ~63% of biomass has been in the western area (Figure 4.5).

The authors recommend model 21.2 be used to provide management advice for northern rock sole because a) it explicitly models the differences in growth in the central and western Gulf by modeling growth separately, b) the model better estimates growth in the central Gulf, where the majority of rock sole catch occurs and therefore improved reference points reflecting the difference in productivity in the two areas, and c) there is a visible improvement in the fit to the survey biomass data.

Retrospective analysis

A retrospective analysis was conducted for all models to examine the consistency among parameter estimates as data were removed from the assessment model. The analysis extends back 10 years (2010-2020). A single peel of the data removed annual fishery catch and length composition data and every other year survey biomass estimates, survey length composition data, and survey CAAL data were removed.

The Mohn's rho results from the retrospective analysis are presented in Table 4.20. Figures 4.18 and 4.19 summarize the retrospective results for models 17.1c and 21.2. Model 17.1c was chosen as a comparison because it represents an improvement on the last accepted model by better estimating aggregate growth. SSB increased and fishing mortality declined with each successive peel of the data. R_0 generally increased with each peel of the data. The estimates of age-0 recruits did not have a clear pattern, but the 2011 peak increased with the first seven peels of the data and then declined with further removal of data.

The revised Mohn's ρ was calculated to indicate the direction and size of the retrospective bias. The revised Mohn's ρ statistic for SSB was equal to 0.27 and 0.25 for models 17.1c and 21.2, respectively. The Mohn's ρ statistic for SSB was similar across models. A positive bias indicates that previous assessments would have been more optimistic about stock size and would have resulted in more optimistic management advice. When models have a directional retrospective bias, this indicates that some aspect of the model that is assumed time-invariant may change over time (e.g., selectivity, natural mortality, catchability, etc.). Simulation results from Hurtado-Ferro *et al.* (2015) suggest that models with retrospective patterns with ρ values greater than 0.2 should explicitly address the cause of the retrospective pattern in the model. The residuals from the fit to the survey biomass suggests non-

stationarity. In the future, we will have to evaluate whether survey catchability has changed over time or some other biological progress such as, natural mortality has changed over time.

Southern rock sole

The southern rock sole assessment model fit to the survey conditional age-at-length, survey biomass estimates, and the length composition data are shown in Figures 4.20 – 4.22. The root mean square error values associated with the fit to the survey data and the total likelihood and the data component likelihoods are reported in Tables 4.24 and 4.25.

All models were fit to the survey conditional age-at-length (CAAL) data, which provide the model with information to estimate growth (Figure 4.27). Model 17.1-17.1b were fit to the aggregated GOA CAAL data and models 21.0-21.2 were fit to the area-specific CAAL. All single area models fit the CAAL data relatively well and similarly (Figures 4.20 and Appendix A.14 and Table 4.26). The same is true for the 2-area models. The fits to the area-specific data are similar to each other and the externally estimated growth curves. Given the negative correlation between asymptotic length and the growth coefficient, the 2-area models estimate slightly smaller asymptotic length and higher growth coefficients (Tables 4.26 and 4.27). Additionally the positive correlation between asymptotic length and the reference age for the first size-at-age (L_at_amin), t_0 is larger than expected when compared to the externally estimated growth parameters.

The fits to survey biomass were similar for all single area models (17.1-17.1b) and exhibit similar residual patterns (Figure 4.21). There is some degree of underestimating survey biomass starting in 2005 through 2015, except 2013, and the last two years of biomass are overestimated (Figure 4.21). Fits to the area-specific survey biomass exhibit similar trends as the single-area models. When the expected area-specific biomass is summed over area and compared to the single area models, the fit to survey biomass over the entire time series is similar among the models (Figure 4.21 bottom panel).

Figure 4.22 shows the model fits to the fishery and survey size composition data aggregated over year. The annual data and model fits are shown in Appendix A (Figures A.15-A.26). The fits to the fishery length composition data are similar among the models. The same is true for the model fits to the survey length composition data. The growth parameters in model 21.2 were fixed to the externally estimated values and does not fit the survey length composition from the western Gulf as well as the other 2-area models. This represents the trade-off in fitting the CAAL data and the length data. Model 21.2 has a slightly better fit to the western Gulf CAAL data than the other 2-area models. It should be noted that the single area and 2-area models consistently underestimate the peak of the female survey length data overall and in both areas.

Length-based selectivity was modeled using the double normal pattern for the fishery and survey. Survey selectivity was forced to be asymptotic for all models and was estimated consistently among the models (Figure 4.23). Fishery selectivity was allowed to be dome-shaped in model 21.0 and forced to be asymptotic in models 21.1 and 21.2. When estimated the descending limb dropped suddenly and sharply at the largest size classes and essentially estimated an asymptotic selectivity pattern. Given the model's estimation behavior, it is reasonable to assume fishery selectivity is asymptotic.

Male natural mortality was estimated by all models, while female natural mortality was fixed at 0.2. Male natural mortality was estimated to be ~0.27 by the single area models and ~0.27 in the western Gulf by the 2-area model (Table 4.26). Male natural mortality was estimated to be ~0.25 in the Central Gulf by the 2-area models.

A key estimated parameter of the 2-area growth morph model is the recruitment distribution parameter. This parameter essentially allocates the proportion of the population between the modeled areas. All 2-area growth morph models estimated that the population was evenly split between the central and western Gulf (Table 4.28 and Figure 4.25). The proportion of survey abundance and biomass in the central Gulf is ~ 56% and in the western Gulf 44% (Figure 4.5), therefore, the model's estimation of apportionment is similar to the apportionment of survey biomass.

Tables 4.29 – 4.31 summarize the model estimates of and uncertainty in SSB, age-0 recruits, and fishing mortality. Figures 4.25 show the estimates of annual age-0 recruits, fishing mortality, annual spawning biomass, and unfished recruitment on the log-scale. The initial conditions, measured as R_0, were similar among the models, with a somewhat lower estimate when the growth parameters were fixed (Figure 4.25). The trends in spawning biomass were similar among the models. Spawning stock biomass had been declining since 2007 and increased in 2021 (Table 4.29 and Figure 4.32). This increase corresponds to the 2010 cohort, which corresponds to average recruitment, becoming mature (Table 4.30). Model 21.2 estimates spawning biomass to be lower and fishing mortality to be higher than the other models with little overlap with the single area models' confidence regions. Models 171.-17.b, 21.0, and 21.1fishing mortality estimates are more similar.

The difference in southern rock sole growth in the central and western Gulf is of a smaller magnitude than northern rock sole. Growth models were compared in September and the AIC results suggest that southern rock sole growth differs in the two areas, but support was strongest for a model assuming the t_0 differ. There was also strong support for the model assuming all growth parameters differed and the model assuming the growth coefficient differed. Models 21.0-21.2 accounts for a full difference in growth in the central and western Gulf. The results presented in this report indicate that the 2-area growth morph model can estimate the area-specific, female and male southern rock sole growth curves fairly well and fit the data inputs as well as the single area models. This results in fairly similar estimates between the single-area and 2-area growth-morph models. Given that the 2-area model better accounts for differences in growth, the author recommends that model 21.1 be used to provide management advice.

Retrospective analysis

A retrospective analysis was conducted for all models. The analysis extends back 10 years (2011-2020). The results are summarized in Table 4.32 and indicate all models performed similarly. The retrospective pattern in spawning biomass for southern rock sole was not as obvious as northern rock sole and minimal (Figure 4.26a). The retrospective analysis showed little pattern in fishing mortality. The estimates of R_0 varied and became generally smaller with each peel. A clear pattern in the age-0 recruit estimates was not apparent.

The revised Mohn's ρ was calculated to indicate the direction and size of the retrospective bias. The revised Mohn's ρ statistic for SSB and range between 0.05 and 0.09 indicating a small, positive bias. Simulation results from Hurtado-Ferro *et al.* (2015) suggest that models with retrospective patterns with ρ values greater than 0.2 should explicitly address the cause of the retrospective pattern in the model. All models has a ρ value less than 0.2, suggesting that at this time the cause of the retrospective does not have to be explicitly modeled, but should be evaluated in the future.

Time Series Results

Northern rock sole

Tables 4.17-4.19 summarize spawning biomass, recruitment (age-0 recruits), and fishing mortality with uncertainty. Table 4.34 summarizes the spawning stock biomass and age-0 recruitment time series from

the 2017 assessment (model 17.1) and the author's preferred model (Model 21.2) for 2021 for northern rock sole. Spawning biomass is consistently lower while the difference in recruitment varies, but on average is also lower.

SSB has been above $SSB_{35\%}$ and fishing mortality has been below $F_{35\%}$ (Figure 4.27).

The estimated total numbers-at-age for northern rock sole by model 17.1c and 21.2 are summarized in Table 4.21 and 4.22. It shows that the model estimated strong year classes for 1987, the mid- to late-1990s, 2004, 2011 and 2015-2017.

Southern rock sole

Tables 4.29-4.31 summarize the spawning biomass and recruitment (age-0 recruits) time-series for southern rock sole with uncertainty (reported as CV). Table 4.35 includes estimated time-series from the previous full assessment model and the recommended model, model 21.1. Spawning biomass is similar between the two models. Recruitment is also similar, but with 4 more years of data the estimate of recruitment in years 2014-2017 are considerably higher than the 2017 assessment.

SSB has been well above $SSB_{35\%}$ and fishing mortality has been well below $F_{35\%}$ (Figure 4.28).

The estimated total numbers-at-age for northern rock sole by model 21.1 are summarized in Table 4.33. Model 21.1 estimated strong year classes in the late 1970s and early 1980s, 1998, 2003, 2010, and 2014. The length and age data start in 1997.

Harvest Recommendations

The GOA northern and southern rock sole stocks were moved from Tier 4 to Tier 3 of the NPFMC harvest guidelines in 2011. In Tier 3, reference mortality rates are based on the spawning biomass per recruit (SPR), while biomass reference levels are estimated by multiplying the SPR by average recruitment. Estimates of the FSPR harvest rates were obtained using the life history characteristics. Spawning biomass reference levels were based on average age-0 recruitment for 1977-2017. Female spawning biomass was calculated using the mean weight-at-age of mature females at the time of spawning. A summary of the projection results are presented here and in the executive summary table at the beginning of the report.

Projections were run for models 17.1c and 21.2 (preferred model) for northern rock sole. Inputs include, natural mortality, mature female weight-at-age, female and male weight-at-age, female and male age-based fishery selectivity, female and male numbers at age in the terminal year (2021), age-0 recruits from 1977 to 2017, and spawning biomass from 1977 to 2021. Projection results for model 21.2 are included in the executive summary. The projection results for model 17.1c, a single area model for comparison purposes, are shown below:

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	0.2, 0.253*	0.2, 0.253*	0.2, 0.239*	0.2, 0.239*
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	94,612	94,614	90,348	95,479
Projected Female spawning biomass (t)	47,694	46,330	41,784	46,494
$B_{100\%}$	51,387	51,387	50,155	50,155
$B_{40\%}$	20,555	20,555	20,062	20,062
$B_{35\%}$	17,985	17,985	17,554	17,554
F_{OFL}	0.462	0.462	0.25	0.25
$maxF_{ABC}$	0.382	0.382	0.21	0.21
F_{ABC}	0.382	0.382	0.21	0.21
OFL (t)	21,080	21,191	16,367	17,324
maxABC (t)	17,756	17,851	13,812	14,624
ABC (t)	17,756	17,851	13,812	14,624
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Projections were also completed for southern rock sole models 17.1 and 21.1. The results for the preferred model 21.1 are presented in the executive summary table and for model 17.1a they are presented below:

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2021	2022	2022	2023
M (natural mortality rate; female, male)	0.2, 0.248*	0.2, 0.248*	0.2, 0.271	0.2, 0.271
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	144,833	148,917	164,505	175,206
Projected Female spawning biomass (t)	72,973	73,930	76,194	87,589
$B_{100\%}$	93,518	93,518	99,661	99,661
$B_{40\%}$	37,407	37,407	39,864	39,864
$B_{35\%}$	32,731	32,731	34,881	34,881
F_{OFL}	0.326	0.326	0.383	0.383
$maxF_{ABC}$	0.271	0.271	0.319	0.319
F_{ABC}	0.271	0.271	0.319	0.319
OFL (t)	27,204	27,943	33,245	35,727
maxABC (t)	22,990	23,614	28,012	30,113
ABC (t)	22,990	23,614	28,012	30,113
	As determined *last* year for:		As determined *this* year for:	
Status	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Male natural mortality was estimated

Biomass projections
A standard set of projections is required for stocks managed under Tier 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2021 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2022 using the schedules of natural mortality and fishery selectivity described in the assessment and the best available estimate of total annual catch for 2021, 2022, and 2023. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2018, are as follows (“max FABC” refers to the maximum permissible value of FABC under Amendment 56):

Scenario 1: In all future years, F is set equal to max FABC. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction of max FABC, where this fraction is equal to the ratio of the FABC value for 2019 recommended in the assessment to the max FABC for 2020. (Rationale: When FABC is set at a value below max FABC, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to the average of the five most recent years. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of FTAC than FABC.)

Scenario 4: In all future years, the upper bound on FABC is set at F60%. (Rationale: This scenario provides a likely lower bound on FABC that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above its MSY level in 2021 and above its MSY level in 2035 under this scenario, then the stock is not overfished.)

Scenario 7: In 2022 and 2023, F is set equal to max FABC, and in all subsequent years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2035 under this scenario, then the stock is not approaching an overfished condition.)

The projections for northern rock sole in the central GOA can be found in Table 36. Under scenario 6, northern rock sole spawning biomass in 2021 in the central Gulf is 10,526 t and the year 2035 spawning biomass, 8,293 t, is above the $B_{35\%}$ level of 7,568 t. For scenario 7, the year 2035 spawning biomass is 8,297 t, is also above $B_{35\%}$.

The projections for northern rock sole in the western GOA can be found in Table 37. Under scenario 6, northern rock sole spawning biomass in 2021 in the western Gulf is 23,229 t and the year 2033 spawning biomass is 10,654 t, both are above the $B_{35\%}$ level of 10,030 t. For scenario 7, the year 2035 spawning biomass is 10,655 t, is also above $B_{35\%}$.

The projections for southern rock sole in the centralGOA can be found in Table 38. Under scenario 6, southern rock sole spawning biomass in 2021 in the central Gulf is 33,625 t and the year 2035 spawning biomass is 20,500 t, both are above the $B_{35\%}$ level of 18,701 t. For scenario 7, the year 2035 spawning biomass is 20,573 t, is also above $B_{35\%}$.

The projections for southern rock sole in the western GOA can be found in Table 39. Under scenario 6, southern rock sole spawning biomass in 2021 in the western Gulf is 32,477 t and the year 2035 spawning

biomass is 16,782 t, both are above the $B_{35\%}$ level of 15,326 t. For scenario 7, the year 2033 spawning biomass is 16,778 t, is also above $B_{35\%}$.

The authors recommendations for F_{ABC} and ABC for northern rock sole for 2021 in the central Gulf are 0.157 and 3,999 t and in the western Gulf are 0.225 and 7,883 t.

The authors recommendations for F_{ABC} and ABC for southern rock sole for 2021 in the central Gulf are 0.224 and 13,185 and in the western Gulf are 0.278 and 12,370 t.

Ecosystem Considerations

See the shallow water flatfish chapter for information on ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks.

Ecosystem Effects on the Stock

See the shallow water flatfish for information on ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks.

Fishery Effects on the Ecosystem

See the ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks.

Data Gaps and Research Priorities

Several data gaps and research priorities are still at large for this assessment.

1. The first is the split t of total rock sole catch, which has been a consistent concern over time. Potential future avenues to address this problem include determining the proportion of northern and southern catch from the observer and survey databases and compare the changes over time.
2. Future models should include a measure of uncertainty associated with the catch. Currently the model assumes that catch is known perfectly when in fact we know this is not true.
3. Given the retrospective pattern exhibited by the northern rock sole assessment model and the residual pattern from the fit to the survey data, time-varying catchability should be evaluated.
4. A formal data weighting approach should be re-evaluated.

Literature Cited

Allen, M.J., Smith, G.B. 1988. Atlas and Zoogeography of Common Fishes in the Bering Sea and Northeastern Pacific. NOAA Technical Report NMFS 66, 151 pp.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124-1138.

McAllister, M.K., Ianelli, J.N. 1997. Bayesian stock assessment using catch-at-age data nad sampling-importance resampling algorithm. Canadian Journal of Fisheries and Aquatic Sciences 54: 284-300.

Methot, R. D., Wetzell, C. R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142: 86-99.

Orr, J.W., Matarese, A.C. 2000. Revision of the genus Lepidopsetta Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fisheries Bulletin 98(3), 539-582.

Stark, J.W., Somerton, D.A. 2002. Maturation, spawning and growth of rock soles off Kodiak Island in the Gulf of Alaska. Journal of Fish Biology 61: 417 – 431.

Thorson, J., Johnson, K.F., Methot, R.D., Taylor, I.G. 2017. Model-based estimates of effective sample size in stock assessment models using the Dirichlet-multinomial distribution. Fisheries Research 192: 84-93.

Turnock, B.J., A'mar, Z.T., Wilderbuer, T.K. 2009. Assessment of the shallow-water flatfish stock assemblage in the Gulf of Alaska for 2010. In: Stock Assessment and Fishery Evaluation Report for Groundfish Resources in the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK, USA.

Turnock, B.J., A'mar, Z.T., Wilderbuer, T.K. 2011. Assessment of the shallow-water flatfish stock assemblage in the Gulf of Alaska for 2012. In: Stock Assessment and Fishery Evaluation Report for Groundfish Resources in the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK, USA.

Wilderbuer, T.K, Nichol, D.G. 2009. Assessment of northern rock sole in the eastern Bering Sea and Aleutian Islands for 2010. In: Stock Assessment and Fishery Evaluation Report for Groundfish Resources in the Eastern Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK, USA.

Tables

Table 4.1. Total rock sole catch from Alaska Fisheries Information Network (AKFIN) as of 2021-10. *Value represents an estimate of 2021 catch.

Year	Catch (t)
1993	8112.12
1994	3008.11
1995	3923.91
1996	6595.32
1997	5466.78
1998	2532.34
1999	1765.35
2000	5386.69
2001	4771.73
2002	5564.29
2003	3554.64
2004	2216.74
2005	4130.50
2006	5763.28
2007	6727.40
2008	7269.09
2009	6538.69
2010	3570.64
2011	3237.93
2012	2923.49
2013	4199.96
2014	3645.50
2015	2863.09
2016	3166.62
2017	2116.89
2018	2106.35
2019	2171.89
2020	3175.48
2021	1367.46*

Table 4.2. Discarded rates of rock sole (discard/total catch) by area for 1993-2020. Source: NMFS Alaska Regional Office via AKFIN, October 11, 2021.

Year	West Discard rate	Central Discard rate	East Discard rate
1993	1.0	0.3	1.0
1994	0.7	0.2	1.0
1995	0.9	0.2	0.8
1996	0.1	0.1	
1997	0.6	0.1	0.0
1998	0.6	0.0	0.0
1999	0.3	0.0	0.0
2000	0.6	0.0	0.0
2001	0.1	0.0	0.0
2002	0.3	0.0	0.0
2003	0.2	0.0	0.0
2004	0.3	0.1	0.0
2005	0.0	0.0	
2006	0.1	0.0	0.2
2007	0.2	0.0	0.0
2008	0.2	0.0	
2009	0.2	0.0	0.0
2010	0.6	0.1	0.2
2011	0.2	0.0	1.0
2012	0.3	0.0	1.0
2013	0.9	0.0	0.9
2014	0.9	0.0	1.0
2015	0.8	0.0	0.5
2016	1.0	0.0	1.0
2017	1.0	0.0	1.0
2018	0.4	0.0	1.0
2019	0.6	0.1	1.0
2020	0.9	0.0	1.0

Table 4.3. Number of lengths by year, species, and sex and hauls sampled by the NMFS fisheries observer program (data obtained from NORPAC length report).

	NORTHERN ROCK SOLE				SOUTHERN ROCK SOLE			
Year	F	M	U	Hauls	F	M	U	Hauls
1997	542	334		14	1020	587		20
1998	1807	1148	908	139	3168	2081	1094	157
1999	394	242	12	41	197	197	11	31
2000	1818	1482	16	204	1404	1121	22	186
2001	1913	1545	57	274	1828	1332	92	257
2002	3256	1929	11	368	1643	1162	30	320
2003	1293	1192	10	189	1041	779	32	168
2004	520	314	21	81	1242	719	4	140
2005	977	803	11	157	1120	681	7	157
2006	1979	1177	13	244	1113	634	28	217
2007	1978	1713	23	297	1731	1197	32	273
2008	1717	1087	31	224	1999	1455	14	273
2009	2273	1679	43	301	2218	1459	62	322
2010	1064	1093	7	174	1087	742	2	159
2011	314	327	4	65	479	275	6	59
2012	1036	657	2	141	1733	1202	7	189
2013	851	1154	30	114	669	498	25	84
2014	746	779	2	92	338	249		45
2015	520	547	5	60	104	90	34	27
2016	1174	1506	8	147	378	204	98	60
2017	256	343	1	43	264	183		50
2018	279	445	3	42	310	338		35
2019	392	322	41	72	524	462	44	86
2020	576	686	2	117	915	890	11	117
2021	23	16		2	10	7		2

Table 4.4. Number of lengths by year, species, sex and NMFS area collected by the NMFS fisheries observer program (data obtained from NORPAC length report).
a)

NORTHERN ROCK SOLE											
	610			620			630			640	
Year	F	M	U	F	M	U	F	M	U	F	M
1997				226	131		316	203			
1998				262	105	350	1482	987	744	10	1
1999	18	11					376	231	11		
2000	15	21		193	91	2	1601	1356	20	9	14
2001	76	23	1	66	53		1739	1450	91		
2002	157	31		1488	745	6	1593	1147	24		
2003	97	52		237	227		832	876	32		
2004	49	53	1	206	74	2	265	187	1		
2005	146	135		22	8		809	660	7		
2006	192	82		211	71		1576	1024	28		
2007	65	4		123	62	1	1790	1647	31		
2008	27	14		167	59	1	1523	1014	13		
2009	35	29		316	166	5	1913	1475	57	9	9
2010	2			11	6		1051	1087	2		
2011	1	4		7			306	323	6		
2012	17	9		88	53		931	595	7		
2013	3	14		10	6	14	838	1134	11		
2014				21			725	779			
2015				14	7		506	540	34		
2016	2	2		22	4		1150	1500	98		
2017	9	10		38	28		209	305			
2018							279	445			
2019	17	9		10	3		365	310	44		
2020				15	2		561	684	11		
2021				17	4		6	12			

Table 4.4 continued.
b)

SOUTHERN ROCK SOLE											
	610			620			630			640	
Year	F	M	U	F	M	U	F	M	U	F	M
1997				135	83		720	370			
1998				537	328	265	1371	812	534	6	3
1999	2	3					195	194	12		
2000	56	22		141	66	1	1194	1024	15		
2001	68	49	5	21	17		1689	1235	52		
2002	90	33		409	240	3	1122	874	8		
2003	39	37		201	145		722	554	10		
2004	35	34		111	17		1096	668	21		
2005	260	87		12	2		848	592	11		
2006	81	32		91	44		941	558	13		
2007				107	108		1624	1089	23		
2008	5	5		193	99	2	1801	1351	29		
2009	8	1		189	77	1	2016	1376	42	5	5
2010				38	25		1049	717	7		
2011				29	4		450	271	4		
2012	4			97	37		1632	1165	2		
2013	1						668	498	30		
2014		1			1		338	247	2		
2015					1		104	89	5		
2016	13	10		49	23		316	171	8		
2017	12	3		32	11		220	169	1		
2018				23	14		287	324	3		
2019	4	2					520	460	41		
2020	9	9		20	14		886	867	2		
2021	1	4					9	3			

Table 4.5. NMFS GOA bottom trawl survey total biomass estimates (in metric tons) and standard deviation.
a)

	NORTHERN ROCK SOLE			SOUTHERN ROCK SOLE	
AREA	Year	Biomass (t)	SD	Biomass (t)	SD
GOA	1996	78845	9929.9	127390	12580.0
GOA	1999	61543	15133.9	106235	10580.3
GOA	2001	64809	9887.3	122492	14643.1
GOA	2003	79648	9513.7	126819	12479.8
GOA	2005	91453	10123.2	147580	15092.8
GOA	2007	102641	12063.8	162358	11810.3
GOA	2009	95846	16067.7	191765	22591.3
GOA	2011	72875	12426.7	120573	10318.3
GOA	2013	74586	13586.8	131441	13993.3
GOA	2015	52370	7695.0	125518	9564.9
GOA	2017	55047	8260.6	107985	9568.1
GOA	2019	39875	7644.0	100698	8620.2
GOA	2021	51498	13704.1	129601	9933.9

Table 4.5. continued
b)

		NORTHERN ROCK SOLE		SOUTHERN ROCK SOLE	
AREA	Year	Biomass (t)	SD	Biomass (t)	SD
Central	1996	15962	3459.09	79970	11255.48
Central	1999	16366	4467.46	61136	8012.69
Central	2001	27535	5348.08	63181	9221.95
Central	2003	36521	6272.85	71703	11134.33
Central	2005	32871	6915.61	83628	12505.36
Central	2007	37078	7560.32	84153	8278.60
Central	2009	39660	9727.90	109045	18310.92
Central	2011	27812	5809.46	69254	8177.03
Central	2013	27139	8233.79	73340	12027.16
Central	2015	25413	6242.21	62070	6746.21
Central	2017	26227	7075.56	67498	8473.94
Central	2019	11931	2978.64	62924	6956.95
Central	2021	29270	9827.45	60185	6159.39
West	1996	62883	250.76	47420	5618.86
West	1999	45178	212.55	45098	6909.41
West	2001	37274	193.06	59311	11374.32
West	2003	43127	207.67	55116	5636.60
West	2005	58582	242.04	63952	8450.37
West	2007	65563	256.05	78205	8423.05
West	2009	56186	237.04	82720	13231.73
West	2011	45063	212.28	51319	6293.18
West	2013	47447	217.82	58101	7152.52
West	2015	26958	164.19	63448	6780.52
West	2017	28820	169.76	40487	4443.08
West	2019	27944	167.16	37775	5090.13
West	2021	22229	149.09	69416	7793.80

Table 4.6. NMFS GOA bottom trawl survey a-b) number of lengths collected and the number of hauls capturing each species by year and area. a) Northern rock sole and b) southern rock sole. c-d)Number of ages by area and sex, c) northern rock sole and d) southern rock sole.

a)

	Number of lengths						Number of hauls		
	Female			Male					
Year	Central	West	All GOA	Central	West	All GOA	Central	West	All GOA
1999	1087	2342	3429	611	1545	2156	11	20	31
2001	1648	2462	4110	1036	1133	2169	60	41	102
2003	2416	4135	6551	1799	2740	4539	32	33	67
2005	2037	2930	4967	1197	2418	3615	19	36	55
2007	1900	4675	6575	1216	3160	4376	36	41	78
2009	2232	3585	5817	1441	2559	4000	30	24	54
2011	1511	2309	3820	868	1402	2270	31	42	73
2013	964	1907	2871	542	1187	1729	26	35	61
2015	1343	2141	3484	1049	1537	2586	29	22	51
2017	1074	1721	2795	736	1231	1967	46	28	74
2019	568	1217	1785	404	1129	1533	22	36	59
2021	850	858	1708	587	664	1251	19	29	48

b)

	Number of lengths						Number of hauls		
	Female			Male					
Year	Central	West	All GOA	Central	West	All GOA	Central	West	All GOA
1996	3756	2908	6664	1152	781	1933	16	23	39
1999	3017	2029	5046	1102	916	2018	20	16	36
2001	3016	2318	5334	1311	662	1973	78	29	109
2003	3989	4348	8337	2113	2066	4179	44	23	68
2005	4877	3041	7918	1981	1311	3292	33	28	61
2007	4933	4699	9632	1939	2189	4128	46	29	76
2009	4455	4594	9049	2052	1889	3941	36	20	56
2011	3141	2774	5915	1329	832	2161	39	32	71
2013	2667	2312	4979	1248	915	2163	34	28	62
2015	3274	3503	6777	1388	1229	2617	24	22	46
2017	2078	2092	4170	1278	538	1816	54	27	81
2019	2618	1975	4593	1284	1045	2329	78	46	125
2021	2573	3019	5592	1382	1687	3069	69	69	138

Table 4.6. continued

c)

	Central		West		
Year	Female	Male	Female	Male	Total
1996	65	38	71	56	230
1999	64	45	163	110	382
2001	180	115	170	125	590
2003	114	77	184	129	504
2005	69	42	150	124	385
2007	77	49	180	146	452
2009	121	91	164	131	507
2011	78	56	162	114	410
2013	100	89	121	82	392
2015	129	105	124	93	451
2017	251	159	109	72	591

d)

	Central		West		
Year	Female	Male	Female	Male	Total
1996	98	59	83	28	268
1999	134	89	89	43	355
2001	339	204	91	63	697
2003	240	150	112	69	571
2005	150	78	108	73	409
2007	158	93	111	79	441
2009	192	142	98	75	507
2011	135	76	105	66	382
2013	152	101	114	77	444
2015	134	72	113	79	398
2017	314	216	111	77	718
2019	291	117	181	79	668

Table 4.7. Summary of data and model assumptions for the northern rock sole single area model alternatives. *In SS3v3.30 R1_offset parameter no longer exists. It is estimated as a SR regime parameter.

NORTHERN ROCK SOLE				
Model Number	17.1	17.1a	17.1b	17.1c
SS version				
Model dimensions				
Start and end year	1977, 2021			
Data				
Fishery catch	1977-2021			
Survey biomass	1996-2001 (triennial), 2003-2021 (biennial)			
Fishery length composition	1977-2021			
Survey age composition	1977-2017			
Survey CAAL	1977-2017			
Growth	von Bertalanffy			
L_at_Amin (female and male)	Estimated			
L_at_Amax (female and male)	Estimated			
K (female and male)	Estimated			
CV_young (female and male)	Estimated			
CV_old (female and male)	Estimated	0.1	0.1	0.1
Natural mortality	0.2 (female), Estimated (male)			
Maturity	Fixed input			
Stock-recruitment				
Ln(R0)	Estimated			
Steepness	1			
σ_R	0.6			
R1_offset*	Estimated			
Recruitment devs	Estimated (1977-2021)			
Catchability	1			
Selectivity	Double normal pattern			
P1: Peak (Fem)	Estimated			
P2: top (Fem)	Estimated, prior~N(0,5)			
P3:Ascend width (Fem)	Estimated			
P4: Descend width (Fem)	Estimated, prior~N(0,5)	0	Estimated, prior~N(0,5)	0
P5:Selex first bin (Fem)	Estimated	-10	Estimated	-10
P6: Selex last bin (Fem)	Estimated, prior~N(0,5)	10	Estimated, prior~N(0,5)	10
P1: Peak (Male)	Estimated			
P2: Ascend width (Male)	Estimated			
P3: Descend width (Male)	0			
P4: Selex last bin (Male)	0			
P5: Scale (Male)	1			
Survey	Double normal pattern			
P1: Peak (Fem)	Estimated			
P2: top (Fem)	0			
P3:Ascend width (Fem)	Estimated			
P4: Descend width (Fem)	0			
P5:Selex first bin (Fem)	-10			
P6: Selex last bin (Fem)	10			
P1: Peak (Male)	Estimated			
P2: Ascend width (Male)	Estimated			
P3: Descend width (Male)	0			
P4: Selex last bin (Male)	0			
P5: Scale (Male)	1			

Table 4.8. Summary of data and model assumptions for the northern rock sole 2-area model alternatives.

NORTHERN ROCK SOLE				
Model Number	21.0	21.1	21.2	21.3
SS version				
Model dimensions				
Start and end year	1977, 2021			
Data (Central and western GOA split)				
Fishery catch	1977-2021 (97% Central, 3% West)			
Survey biomass	1996-2001 (triennial), 2003-2021 (biennial)			
Fishery length composition	1977-2021			
Survey CAAL	1977-2017			
Growth				
Central				
L_at_Amin (female, male)	Estimated	Estimated	Estimated	15.73, 15.99
L_at_Amax (female, male)	Estimated	Estimated	Estimated	50.29, 41.92
K (female, male)	Estimated	Estimated	Estimated	0.2039, 0.2558
CV_young (female, male)	Estimated	Estimated	Estimated	0.2, 0.2
CV_old (female, male)	Estimated	Estimated	0.08	0.09, 0.09
West				
L_at_Amin (female, male)	Estimated	Estimated	Estimated	15.6, 14.97
L_at_Amax (female, male)	Estimated	Estimated	Estimated	45.47, 37.72
K (female, male)	Estimated	Estimated	Estimated	0.15, 0.11
CV_young (female, male)	Estimated	Estimated	Estimated	0.18, 0.18
CV_old (female, male)	Estimated	0.08	0.08	0.09, 0.09
Natural mortality	0.2 (female), Estimated (male) for both areas			
Maturity	Fixed input			
Stock-recruitment				
Ln(R0)	Estimated			
Steepness	1			
σ_R	0.6			
R1_offset*	Estimated			
Recruitment devs	Estimated (1977-2021)			
Catchability	1 (central and west survey)			
Selectivity	Double normal (same assumptions for central and western area)			
P1: Peak (Fem)	Estimated			
P2: top (Fem)	Estimated, prior~N(0,5)			
P3:Ascend width (Fem)	Estimated			
P4: Descend width (Fem)	Estimated, prior~N(0,5)	Estimated, prior~N(0,	0	0
P5:Selex first bin (Fem)	Estimated	Estimated	-10	-10
P6: Selex last bin (Fem)	Estimated, prior~N(0,5)	Estimated, prior~N(0,	10	10
P1: Peak (Male)	Estimated			
P2: Ascend width (Male)	Estimated			
P3: Descend width (Male)	0			
P4: Selex last bin (Male)	0			
P5: Scale (Male)	1			
Survey	Double normal (same assumptions for central and western area)			
P1: Peak (Fem)	Estimated			
P2: top (Fem)	0			
P3:Ascend width (Fem)	Estimated			
P4: Descend width (Fem)	0			
P5:Selex first bin (Fem)	-10			
P6: Selex last bin (Fem)	10			
P1: Peak (Male)	Estimated			
P2: Ascend width (Male)	Estimated			
P3: Descend width (Male)	0			
P4: Selex last bin (Male)	0			
P5: Scale (Male)	1			

Table 4.9. Summary of data and model assumptions for the southern rock sole single area model alternatives.

SOUTHERN ROCK SOLE			
Model Number	17.1	17.1a	17.1b
SS version			
Model dimensions			
Start and end year		1977, 2021	
Data			
Fishery catch		1977-2021	
Survey biomass		1996-2001 (triennial), 2003-2021 (biennial)	
Fishery length composition		1977-2021	
Survey age composition		1977-2019	
Survey CAAL		1977-2019	
Growth		von Bertalanffy	
L_at_Amin (female and male)		Estimated	
L_at_Amax (female and male)		Estimated	
K (female and male)		Estimated	
CV_young (female and male)		Estimated	
CV_old (female and male)	Estimated	Estimated	0.1
Natural mortality		0.2 (female), Estimated (male)	
Maturity		Fixed input	
Stock-recruitment			
Ln(R0)		Estimated	
Steepness		Fixed = 1	
σ_R		Fixed = 0.6	
R1_offset*		Estimated	
Recruitment devs		Estimated (1977-2021)	
Catchability		Fixed =1	
Selectivity		Double normal pattern	
P1: Peak (Fem)		Estimated	
P2: top (Fem)		Estimated	
P3:Ascend width (Fem)		Estimated	
P4: Descend width (Fem)	Estimated	0	0
P5:Selex first bin (Fem)	Estimated	-10	-10
P6: Selex last bin (Fem)	Estimated	10	10
P1: Peak (Male)		Estimated	
P2: Ascend width (Male)		Estimated	
P3: Descend width (Male)		Fixed =0	
P4: Selex last bin (Male)		Fixed=0	
P5: Scale (Male)		Fixed = 1	
Survey		Double normal pattern	
P1: Peak (Fem)		Estimated	
P2: top (Fem)		0	
P3:Ascend width (Fem)		Estimated	
P4: Descend width (Fem)		0	
P5:Selex first bin (Fem)		-10	
P6: Selex last bin (Fem)		10	
P1: Peak (Male)		Estimated	
P2: Ascend width (Male)		Estimated	
P3: Descend width (Male)		0	
P4: Selex last bin (Male)		0	
P5: Scale (Male)		1	

Table 4.10. Summary of data and model assumptions for the southern rock sole 2-area model alternatives.

Model Number	21.0	21.1	21.3
SS version			
Model dimensions			
Start and end year		1977, 2021	
Data (Central and western GOA split)			
Fishery catch		1977-2021 (97% Central, 3% West)	
Survey biomass		1996-2001 (triennial), 2003-2021 (biennial)	
Fishery length composition		1977-2021	
Survey CAAL		1977-2019	
Growth			
Central			
L_at_Amin (female, male)	Estimated	Estimated	18.86, 18.63
L_at_Amax (female, male)	Estimated	Estimated	51.43, 39.858
K (female, male)	Estimated	Estimated	0.1658, 0.2199
CV_young (female, male)	Estimated	Estimated	0.16, 0.19
CV_old (female, male)	Estimated	Estimated	0.09, 0.04
West			
L_at_Amin (female, male)	Estimated	Estimated	17.68, 17.82
L_at_Amax (female, male)	Estimated	Estimated	48.67, 39.15
K (female, male)	Estimated	Estimated	0.1553, 0.1983
CV_young (female, male)	Estimated	Estimated	0.13,0.17
CV_old (female, male)	Estimated	Estimated	0.13, 0.08
Natural mortality		0.2 (female), Estimated (male) for both areas	
Maturity		Fixed input (same for both areas)	
Stock-recruitment			
Ln(R0)		Estimated	
Steepness		1	
σ_R		0.6	
R1_offset*		Estimated	
Recruitment devs		Estimated (1977-2021)	
Catchability		1 (both areas)	
Selectivity		Double normal (same assumptions for central and western area)	
P1: Peak (Fem)		Estimated	
P2: top (Fem)		Estimated, prior~N(0,5)	
P3:Ascend width (Fem)		Estimated	
P4: Descend width (Fem)	Estimated, prior~N(0,5)	0	0
P5:Selex first bin (Fem)	Estimated	-10	-10
P6: Selex last bin (Fem)	Estimated, prior~N(0,5)	10	10
P1: Peak (Male)		Estimated	
P2: Ascend width (Male)		Estimated	
P3: Descend width (Male)		0	
P4: Selex last bin (Male)		0	
P5: Scale (Male)		1	
Survey		Double normal (same assumptions for central and western area)	
P1: Peak (Fem)		Estimated	
P2: top (Fem)		0	
P3:Ascend width (Fem)		Estimated	
P4: Descend width (Fem)		0	
P5:Selex first bin (Fem)		-10	
P6: Selex last bin (Fem)		10	
P1: Peak (Male)		Estimated	
P2: Ascend width (Male)		Estimated	
P3: Descend width (Male)		0	
P4: Selex last bin (Male)		0	
P5: Scale (Male)		1	

Table 4.11. AIC results comparing growth models externally estimated from the assessment model. NRS is northern rock sole and SRS is southern rock sole.

Species	Sex	model	rss	AIC	Delta AIC
NRS	Female	**Growth ≠**	**52659.9**	**16395.1**	**-**
		vbK =	53165.0	16420.2	25.2
		t0 =	53256.3	16425.1	30.0
		L∞ =	53258.7	16425.2	30.2
		Growth =	72864.6	17313.3	918.2
NRS	Male	**Growth ≠**	**23270.6**	**10803.3**	**-**
		vbK =	23298.6	10803.7	0.5
		t0 =	23316.7	10805.3	2.0
		L∞ =	23668.6	10836.0	32.7
		Growth =	28958.4	11245.1	441.8
SRS	Female	**t0 =**	**57082.5**	**20420.7**	**-**
		Growth ≠	57069.1	20421.8	1.1
		vbK =	57103.5	20422.0	1.3
		L∞ =	57479.0	20446.0	25.3
		Growth =	63012.7	20777.7	357.1
SRS	Male	**t0 =**	**22945.2**	**11434.5**	**-**
		Growth ≠	22935.9	11435.6	1.1
		L∞ =	22957.6	11435.7	1.2
		vbK =	22965.3	11436.4	1.9
		Growth =	23804.6	11511.6	77.1

Table 4.12. Root mean square error from model fit to the northern rock sole models.

Model	All GOA	Central	West
17.1	0.27	-	-
17.1a	0.27	-	-
17.1b	0.27	-	-
17.1c	0.27	-	-
21.0	-	0.35	0.26
21.1	-	0.35	0.27
21.2	-	0.35	0.27
21.3	-	0.36	0.26

Table 4.13. Total likelihood and likelihood components for the northern rock sole models.

NORTHERN ROCK SOLE					
Model	Age_comp	Length_comp	Survey	Total	Npars
17.1	780.17	527.73	-9.40	1296.47	92
17.1a	780.18	527.70	-9.40	1296.43	90
17.1b	786.63	558.05	-8.14	1333.94	90
17.1c	786.63	558.04	-8.14	1333.87	88
21	628.81	556.17	-15.61	1174.54	116
21.1	624.64	569.99	-14.55	1184.61	112
21.2	624.64	569.97	-14.55	1184.54	108
21.3	736.50	605.82	-14.75	1332.56	92

Table 4.14. Biological parameter estimates for northern rock sole by model, sex, and area. *Female natural mortality (M) was not estimated and fixed to 0.2.

Model	Sex	Area	L_a_Amin	Linfinity	K	t0	CVmin	CVmax	M*
External	Female	All GOA	15.63	45.14	0.2007	0.213	-	-	-
17.1	Female	All GOA	10.83	42.51	0.2383	1.10	0.18	0.17	0.200
17.1a	Female	All GOA	10.82	42.48	0.2387	1.10	0.18	0.17	0.200
17.1b	Female	All GOA	10.22	48.06	0.1832	1.03	0.27	0.10	0.200
17.1c	Female	All GOA	10.22	48.06	0.1832	1.03	0.27	0.10	0.200
External	Male	All GOA	15.55	38.49	0.2310	0.094	-	-	-
17.1	Male	All GOA	10.86	37.60	0.2679	1.06	0.17	0.14	0.253
17.1a	Male	All GOA	10.86	37.59	0.2679	1.06	0.17	0.14	0.253
17.1b	Male	All GOA	10.48	39.92	0.2430	1.08	0.21	0.10	0.239
17.1c	Male	All GOA	10.48	39.92	0.2430	1.08	0.21	0.10	0.239
External	Female	Central	15.73	50.29	0.2039	0.49	-	-	-
21	Female	Central	10.37	49.61	0.2364	1.34	0.23	0.09	0.200
21.1	Female	Central	10.38	50.38	0.2250	1.31	0.23	0.08	0.200
21.2	Female	Central	10.38	50.38	0.2250	1.31	0.23	0.08	0.200
21.3	Female	Central	15.73	50.29	0.2039	0.49	0.20	0.09	0.200
External	Male	Central	15.99	41.92	0.2315	0.26	-	-	-
21	Male	Central	10.91	39.97	0.3145	1.32	0.18	0.11	0.228
21.1	Male	Central	10.95	41.27	0.2849	1.25	0.20	0.08	0.232
21.2	Male	Central	10.95	41.27	0.2849	1.25	0.20	0.08	0.232
21.3	Male	Central	15.96	41.92	0.2315	0.26	0.20	0.08	0.229
External	Female	West	15.60	45.47	0.1500	-0.47	-	-	-
21	Female	West	10.42	39.50	0.2389	1.05	0.19	0.10	0.200
21.1	Female	West	10.07	40.40	0.2273	1.07	0.22	0.08	0.200
21.2	Female	West	10.07	40.40	0.2273	1.07	0.22	0.08	0.200
21.3	Female	West	15.60	45.47	0.1500	-0.47	0.20	0.08	0.200
External	Male	West	14.97	37.72	0.2078	-0.10	-	-	-
21	Male	West	9.62	33.12	0.3454	1.34	0.18	0.09	0.256
21.1	Male	West	9.37	33.36	0.3423	1.37	0.20	0.08	0.254
21.2	Male	West	9.37	33.36	0.3423	1.37	0.20	0.08	0.254
21.3	Male	West	14.97	37.72	0.2078	-0.10	0.20	0.08	0.264

Table 4.15. Parameter correlation tables for northern rock sole models a) 17.1, b) 17.1c, and c) 21.0.

a) Model 17.1

Model 17.1																													
Number	Parameter name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	L_at_Amin female	10.83	0.42	1																								
2	L_at_Amax female	42.51	0.87	0.05	1																							
3	K female	0.24	0.01	-0.42	-0.78	1																						
4	CV min female	0.18	0.02	-0.46	0.23	-0.12	1																					
5	CV max female	0.17	0.01	0.26	-0.62	0.28	-0.47	1																				
6	M male	0.25	0.01	0.08	-0.55	0.28	-0.12	0.27	1																			
7	L_at_Amin male	10.86	0.43	0.04	-0.11	0.04	-0.02	0.03	0.00	1																		
8	L_at_Amax male	37.60	0.82	0.02	0.22	-0.20	0.02	-0.03	0.22	0.11	1																	
9	K male	0.27	0.02	-0.05	-0.03	0.09	0.02	-0.02	-0.17	-0.49	-0.79	1																
10	CV min male	0.17	0.02	0.00	0.10	-0.07	0.02	-0.01	0.05	-0.44	0.23	-0.11	1															
11	CV max male	0.14	0.01	-0.01	-0.20	0.15	-0.02	0.04	-0.15	0.17	-0.71	0.40	-0.44	1														
12	R0	11.71	0.07	0.13	-0.55	0.19	-0.14	0.34	0.63	0.09	-0.03	-0.12	-0.03	0.07	1													
13	SR_regime	-0.07	0.13	0.00	-0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-0.05	1												
14	init_F	0.05	0.01	0.00	-0.27	0.20	-0.03	0.03	0.20	0.08	-0.18	0.04	-0.08	0.14	0.06	-0.65	1											
15	Size_DblN_peak_Fishery(1)	52.34	2.54	-0.09	-0.63	0.53	-0.04	0.01	0.58	0.16	-0.31	0.03	-0.15	0.26	0.47	0.00	0.39	1										
16	Size_DblN_top_logit_Fishery(1)	0.37	0.82	-0.02	0.05	-0.02	0.03	-0.05	-0.03	0.00	0.06	-0.04	0.01	-0.01	-0.04	0.00	-0.04	-0.07	1									
17	Size_DblN_ascend_se_Fishery(1)	5.74	0.14	-0.22	-0.48	0.52	0.06	-0.15	0.45	0.12	-0.28	0.06	-0.13	0.22	0.31	0.01	0.35	0.94	-0.05	1								
18	Size_DblN_descend_se_Fishery(1)	-0.10	6.42	-0.04	-0.07	0.08	0.02	-0.05	0.07	0.02	-0.03	-0.01	-0.02	0.04	0.05	0.00	0.05	0.13	0.05	0.13	1							
19	Size_DblN_end_logit_Fishery(1)	0.87	3.41	-0.03	-0.03	0.04	0.03	-0.06	0.03	0.01	-0.02	0.00	-0.01	0.02	0.02	0.00	0.02	0.06	-0.15	0.07	-0.08	1						
20	SzSel_Male_Peak_Fishery(1)	-13.42	1.98	0.13	0.52	-0.49	0.00	0.05	-0.68	-0.14	0.00	0.19	0.06	-0.12	-0.43	-0.01	-0.30	-0.88	0.02	-0.87	-0.13	-0.06	1					
21	SzSel_Male_Ascend_Fishery(1)	-1.01	0.15	0.20	0.23	-0.33	-0.09	0.17	-0.45	-0.17	-0.19	0.31	0.03	-0.04	-0.21	-0.01	-0.14	-0.56	-0.03	-0.65	-0.10	-0.05	0.86	1				
22	Size_DblN_peak_Survey(2)	36.84	1.72	0.12	-0.44	0.22	-0.18	0.27	0.46	0.07	-0.01	-0.10	-0.02	0.06	0.52	0.00	0.10	0.37	-0.03	0.26	0.04	0.02	-0.35	-0.19	1			
23	Size_DblN_ascend_se_Survey(2)	5.10	0.20	0.00	-0.32	0.23	-0.10	0.15	0.29	0.04	-0.03	-0.05	-0.02	0.05	0.33	0.00	0.07	0.28	-0.02	0.22	0.04	0.02	-0.27	-0.16	0.89	1		
24	SzSel_Male_Peak_Survey(2)	-6.85	1.87	-0.09	0.37	-0.21	0.15	-0.22	-0.46	0.00	-0.09	0.12	-0.05	0.05	-0.41	0.00	-0.09	-0.31	0.02	-0.22	-0.04	-0.01	0.33	0.20	-0.84	-0.78	1	
25	SzSel_Male_Ascend_Survey(2)	-0.79	0.27	0.00	0.24	-0.18	0.07	-0.11	-0.28	-0.05	-0.08	0.12	-0.02	0.03	-0.24	0.00	-0.06	-0.21	0.01	-0.17	-0.03	-0.01	0.24	0.17	-0.64	-0.72	0.88	1

Table 4.15. continued
b) Model 17.1c

Model 17.1c																												
Number	Parameter name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	L_at_Amin female	10.22	0.46	1																								
2	L_at_Amax female	48.06	0.49	**0.40**	1																							
3	K female	0.18	0.01	**-0.58**	**-0.75**	1																						
4	CV min female	0.27	0.02	**-0.54**	-0.31	0.13	1																					
5	-	-	-																									
6	M male	0.24	0.01	0.15	0.04	-0.35	0.06		1																			
7	L_at_Amin male	10.48	0.45	0.05	0.03	-0.07	-0.01		-0.11	1																		
8	L_at_Amax male	39.92	0.44	0.06	0.05	-0.14	0.00		0.14	**0.44**	1																	
9	K male	0.24	0.01	-0.08	-0.07	0.18	0.02		0.10	**-0.67**	**-0.80**	1																
10	CV min male	0.21	0.02	-0.02	-0.01	0.02	0.02		0.01	**-0.51**	-0.29	0.23	1															
11	-	-	-																									
12	R0	11.57	0.06	0.11	0.01	-0.34	0.07		**0.44**	0.02	0.11	-0.13	0.00		1													
13	SR_regime	-0.07	0.13	0.00	-0.02	0.02	0.00		0.00	0.00	-0.01	0.01	0.00		-0.08	1												
14	init_F	0.04	0.01	0.04	0.01	-0.04	-0.01		0.04	0.03	0.02	-0.04	-0.01		-0.13	**-0.71**	1											
15	Size_DblN_peak_Fishery(1)	43.70	1.25	0.20	-0.17	-0.18	-0.06		**0.45**	0.10	0.19	-0.24	-0.03		0.29	-0.01	0.11	1										
16	Size_DblN_top_logit_Fishery(1)	0.02	4.66	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	1									
17	Size_DblN_ascend_se_Fishery(1)	5.26	0.11	0.06	-0.27	0.03	-0.02		**0.32**	0.07	0.12	-0.16	-0.02		0.17	0.00	0.09	**0.92**	0.00	1								
18	-	-	-																									
19	-	-	-																									
20	SzSel_Male_Peak_Fishery(1)	-8.36	1.20	-0.14	0.21	0.05	0.06		**-0.49**	0.02	-0.27	0.17	-0.03		-0.23	0.00	-0.06	**-0.80**	0.00	**-0.79**			1					
21	SzSel_Male_Ascend_Fishery(1)	-0.81	0.14	0.00	0.22	-0.09	0.01		-0.29	-0.04	-0.27	0.18	0.00		-0.11	0.00	-0.03	**-0.54**	0.00	**-0.65**			**0.89**	1				
22	Size_DblN_peak_Survey(2)	33.35	1.65	0.17	0.08	-0.24	-0.06		0.25	0.02	0.11	-0.11	0.00		0.32	-0.01	-0.02	0.21	0.00	0.12			-0.16	-0.07	1			
23	Size_DblN_ascend_se_Survey(2)	4.77	0.23	0.07	0.01	-0.10	-0.03		0.15	0.01	0.06	-0.06	0.01		0.19	0.00	-0.02	0.13	0.00	0.08			-0.10	-0.05	**0.91**	1		
24	SzSel_Male_Peak_Survey(2)	-4.02	1.86	-0.14	-0.04	0.16	0.06		-0.25	0.07	-0.06	0.00	-0.05		-0.19	0.00	0.00	-0.15	0.00	-0.09			0.15	0.08	**-0.79**	**-0.75**	1	
25	SzSel_Male_Ascend_Survey(2)	-0.51	0.30	-0.05	0.00	0.06	0.03		-0.13	0.00	-0.06	0.04	-0.02		-0.11	0.00	0.00	-0.09	0.00	-0.06			0.09	0.06	**-0.64**	**-0.72**	**0.90**	1

Table 4.15. continued
c) Model 21.0

Numbe	Parameter name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	L_at_Amin female 1	10.37	0.61	1.00																										
2	L_at_Amax female 1	49.61	0.68	0.36	1.00																									
3	K female 1	0.24	0.01	-0.60	-0.82	1.00																								
4	CV min female 1	0.23	0.02	-0.62	-0.17	0.28	1.00																							
5	CV max female 1	0.09	0.01	0.10	-0.55	0.29	-0.35	1.00																						
6	L_at_Amin female 2	10.42	0.81	0.00	0.01	-0.01	0.00	0.00	1.00																					
7	L_at_Amax female 2	39.50	0.93	0.00	0.01	-0.01	0.00	0.00	0.11	1.00																				
8	K female 2	0.24	0.02	-0.01	-0.02	0.02	0.00	0.01	-0.50	-0.79	1.00																			
9	CV min female 2	0.19	0.03	0.00	0.00	0.00	0.00	0.00	-0.62	0.16	0.07	1.00																		
10	CV max female 2	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.28	-0.51	0.23	-0.56	1.00																	
11	M male 1	0.23	0.01	0.13	0.07	-0.25	-0.08	0.11	0.00	0.00	0.00	0.00	0.00	1.00																
12	L_at_Amin male 1	10.91	0.65	0.07	0.06	-0.10	-0.04	0.00	0.01	0.00	-0.01	0.00	0.00	-0.14	1.00															
13	L_at_Amax male 1	39.97	0.60	0.06	0.13	-0.17	-0.05	-0.02	0.00	0.01	-0.01	0.00	0.00	0.19	0.34	1.00														
14	K male 1	0.31	0.02	-0.10	-0.16	0.23	0.09	0.02	-0.01	-0.01	0.02	0.00	0.00	0.12	-0.64	-0.79	1.00													
15	CV min male 1	0.18	0.02	-0.04	-0.03	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.12	-0.62	-0.13	0.28	1.00												
16	CV max male 1	0.11	0.01	0.01	-0.03	0.03	0.00	0.02	0.00	0.00	0.01	0.00	0.00	-0.25	0.08	-0.60	0.29	-0.29	1.00											
17	M male 2	0.26	0.01	0.00	0.01	-0.01	0.00	0.00	0.13	-0.32	0.08	-0.17	0.28	0.01	0.00	0.01	-0.01	0.00	0.00	1.00										
18	L_at_Amin male 2	9.62	0.90	0.01	0.01	-0.01	0.00	0.00	0.02	-0.04	0.00	-0.02	0.04	0.00	0.00	0.01	-0.01	0.00	0.00	0.02	1.00									
19	L_at_Amax male 2	33.12	0.66	0.00	0.01	-0.01	0.00	-0.01	0.03	-0.03	-0.01	-0.03	0.05	0.01	0.00	0.01	-0.01	0.00	0.00	0.29	0.29	1.00								
20	K male 2	0.35	0.03	-0.01	-0.02	0.02	0.00	0.01	-0.04	0.08	0.00	0.05	-0.08	-0.01	-0.01	-0.02	0.02	0.00	0.01	-0.20	-0.65	-0.79	1.00							
21	CV min male 2	0.18	0.03	0.00	0.00	0.00	0.00	0.00	-0.01	0.02	0.00	0.01	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	-0.62	-0.08	0.26	1.00						
22	CV max male 2	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.15	0.22	-0.30	0.07	-0.46	1.00					
23	Rec Dist	1.01	0.13	-0.02	0.06	0.03	0.02	-0.05	0.17	-0.51	0.16	-0.23	0.37	-0.11	0.01	0.04	-0.03	-0.01	0.01	0.65	0.08	0.09	-0.18	-0.04	-0.01	1.00				
24	R0	11.69	0.09	0.02	-0.01	-0.04	-0.01	0.00	0.17	-0.51	0.16	-0.22	0.38	0.06	0.01	0.02	-0.02	0.00	-0.02	0.66	0.08	0.10	-0.19	-0.04	-0.01	0.82	1.00			
25	SR_regime	-0.02	0.13	0.00	-0.02	0.01	0.00	0.00	0.00	-0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.05	1.00		
26	init_F[1]	0.10	0.03	0.03	0.08	-0.07	-0.03	0.00	0.00	0.01	-0.01	0.00	-0.01	0.02	0.02	0.05	-0.05	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-0.05	-0.72	1.00	
27	init_F[2]	0.00	0.00	-0.01	0.01	0.00	0.00	0.00	-0.01	-0.33	0.24	-0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.02	-0.07	0.06	0.01	-0.01	-0.01	-0.03	-0.47	0.36	1.00

Number	Parameter name	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
23	Rec Dist	1.00																										
24	R0	0.82	1.00																									
25	SR_regime	0.01	-0.05	1.00																								
26	init_F[1]	0.05	-0.05	-0.72	1.00																							
27	init_F[2]	-0.01	-0.03	-0.47	0.36	1.00																						
28	Size_DblN_peak_Fishery(1)	0.02	0.05	0.00	0.11	-0.01	1.00																					
29	Size_DblN_top_logit_Fishery(1)	-0.01	-0.02	0.00	-0.04	0.00	-0.38	1.00																				
30	Size_DblN_ascend_se_Fishery(1)	0.01	0.04	0.00	0.08	-0.01	0.94	-0.35	1.00																			
31	Size_DblN_descend_se_Fishery(1)	0.00	0.00	0.00	0.00	0.00	-0.03	-0.24	-0.02	1.00																		
32	Size_DblN_end_logit_Fishery(1)	0.01	0.00	0.00	-0.02	0.00	-0.08	-0.04	-0.06	-0.08	1.00																	
33	SzSel_Male_Peak_Fishery(1)	0.03	-0.04	0.00	-0.05	0.00	-0.79	0.30	-0.78	0.02	0.06	1.00																
34	SzSel_Male_Ascend_Fishery(1)	0.02	-0.02	0.00	-0.03	0.00	-0.59	0.22	-0.67	0.01	0.03	0.91	1.00															
35	Size_DblN_peak_Fishery(2)	0.28	0.27	0.00	0.00	0.66	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.00														
36	Size_DblN_top_logit_Fishery(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00													
37	Size_DblN_ascend_se_Fishery(2)	0.19	0.19	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	1.00												
38	Size_DblN_descend_se_Fishery(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00											
39	Size_DblN_end_logit_Fishery(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00										
40	SzSel_Male_Peak_Fishery(2)	-0.30	-0.30	0.00	0.00	-0.14	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	-0.51	0.00	-0.53	0.00	0.00	1.00									
41	SzSel_Male_Ascend_Fishery(2)	-0.22	-0.22	0.00	0.00	-0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.61	0.00	-0.68	0.00	0.00	0.94	1.00								
42	Size_DblN_peak_Survey(1)	-0.01	0.02	0.00	0.01	0.00	0.11	-0.04	0.07	0.00	-0.01	-0.08	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00							
43	Size_DblN_ascend_se_Survey(1)	-0.01	0.02	0.00	0.01	0.00	0.06	-0.02	0.04	0.00	-0.01	-0.04	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	1.00						
44	SzSel_Male_Peak_Survey(1)	0.02	-0.01	0.00	0.00	0.00	-0.04	0.02	-0.02	0.00	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.71	-0.67	1.00					
45	SzSel_Male_Ascend_Survey(1)	0.01	0.00	0.00	0.00	0.00	-0.01	0.01	-0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.61	-0.67	0.93	1.00				
46	Size_DblN_peak_Survey(2)	0.71	0.71	0.00	-0.01	0.04	0.03	-0.01	0.02	0.00	0.00	-0.01	-0.01	0.29	0.00	0.22	0.00	0.00	-0.28	-0.22	0.01	0.00	0.00	0.00	1.00			
47	Size_DblN_ascend_se_Survey(2)	0.53	0.53	0.00	-0.01	0.04	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.25	0.00	0.20	0.00	0.00	-0.23	-0.18	0.00	0.00	0.00	0.00	0.91	1.00		
48	SzSel_Male_Peak_Survey(2)	-0.62	-0.62	0.00	0.01	-0.03	-0.02	0.01	-0.01	0.00	0.00	0.01	0.00	-0.26	0.00	-0.19	0.00	0.00	0.26	0.19	0.00	0.00	0.00	0.00	-0.90	-0.84	1.00	
49	SzSel_Male_Ascend_Survey(2)	-0.42	-0.43	0.00	0.00	-0.02	-0.01	0.00	-0.01	0.00	0.00	0.01	0.00	-0.19	0.00	-0.15	0.00	0.00	0.19	0.15	0.00	0.00	0.00	0.00	-0.71	-0.77	0.88	1.00

Table 4.16. The estimated proportion of northern rock sole abundance in the western Gulf of Alaska. On average since 1996, 63% of survey biomass is in the western Gulf.

Model	Rec Dist gm2	Proportion
17.1	-	-
17.1a	-	-
17.1b	-	-
17.1c	-	-
21.0	1.01	0.73
21.1	0.96	0.72
21.2	0.96	0.72
21.3	0.81	0.69

Table 4.17. Spawning biomass (SSB) and associated CV estimates from the northern rock sole assessment models.

	17.1		17.1a		17.1b		17.1c		21		21.1		21.2		21.3	
Year	SSB	CV	SSB	CV	SSB	CV	SSB	CV	SSB	CV	SSB	CV	SSB	CV	SSB	CV
1977	42,282	0.2	42,316	0.2	39,962	0.2	39,960	0.2	40,874	0.2	39,778	0.24	39,777	0.2	39,583	0.2
1978	41,793	0.2	41,827	0.2	39,476	0.2	39,474	0.2	40,698	0.2	39,588	0.24	39,586	0.2	39,429	0.2
1979	41,310	0.2	41,344	0.2	38,999	0.2	38,997	0.2	40,563	0.2	39,435	0.24	39,433	0.2	39,315	0.2
1980	40,774	0.2	40,807	0.2	38,455	0.2	38,453	0.2	40,382	0.2	39,232	0.24	39,230	0.2	39,159	0.2
1981	40,243	0.2	40,276	0.2	37,930	0.2	37,928	0.2	40,262	0.2	39,088	0.24	39,086	0.2	39,064	0.2
1982	39,566	0.2	39,598	0.2	37,244	0.2	37,242	0.2	40,027	0.2	38,828	0.24	38,826	0.2	38,862	0.2
1983	39,922	0.2	39,953	0.2	37,654	0.2	37,651	0.2	40,668	0.2	39,461	0.23	39,459	0.2	39,475	0.2
1984	40,502	0.2	40,534	0.2	38,128	0.2	38,126	0.2	40,975	0.2	39,762	0.22	39,760	0.2	39,705	0.2
1985	42,091	0.2	42,124	0.2	39,569	0.2	39,566	0.2	41,734	0.2	40,514	0.21	40,512	0.2	40,345	0.2
1986	44,018	0.2	44,051	0.2	41,414	0.2	41,411	0.2	42,729	0.2	41,502	0.20	41,499	0.2	41,220	0.2
1987	45,171	0.2	45,203	0.2	42,649	0.2	42,646	0.2	43,551	0.2	42,321	0.19	42,319	0.2	41,953	0.2
1988	45,499	0.2	45,530	0.2	43,017	0.1	43,014	0.1	43,607	0.2	42,367	0.18	42,364	0.2	41,974	0.2
1989	45,550	0.1	45,579	0.1	43,239	0.1	43,237	0.1	43,940	0.2	42,680	0.17	42,677	0.2	42,274	0.2
1990	44,901	0.1	44,929	0.1	42,684	0.1	42,682	0.1	43,888	0.2	42,572	0.16	42,569	0.2	42,197	0.2
1991	44,800	0.1	44,829	0.1	42,435	0.1	42,434	0.1	44,272	0.2	42,822	0.14	42,819	0.1	42,495	0.1
1992	45,604	0.1	45,634	0.1	42,894	0.1	42,893	0.1	45,505	0.1	43,820	0.13	43,817	0.1	43,546	0.1
1993	46,646	0.1	46,680	0.1	43,452	0.1	43,452	0.1	47,093	0.1	45,109	0.11	45,106	0.1	44,913	0.1
1994	47,813	0.1	47,850	0.1	44,067	0.1	44,067	0.1	48,616	0.1	46,319	0.10	46,318	0.1	46,225	0.1
1995	48,414	0.1	48,449	0.1	44,707	0.1	44,708	0.1	49,501	0.1	47,105	0.09	47,104	0.1	47,076	0.1
1996	47,286	0.1	47,319	0.1	43,833	0.1	43,834	0.1	48,684	0.1	46,310	0.08	46,310	0.1	46,426	0.1
1997	45,157	0.1	45,188	0.1	41,881	0.1	41,883	0.1	46,609	0.1	44,328	0.08	44,328	0.1	44,660	0.1
1998	43,442	0.1	43,472	0.1	40,380	0.1	40,382	0.1	44,571	0.1	42,459	0.07	42,459	0.1	43,006	0.1
1999	42,130	0.1	42,158	0.1	39,493	0.1	39,494	0.1	42,994	0.1	41,152	0.07	41,153	0.1	41,789	0.1
2000	41,238	0.1	41,264	0.1	39,038	0.1	39,040	0.1	42,112	0.1	40,508	0.07	40,509	0.1	40,995	0.1
2001	40,749	0.1	40,778	0.1	38,630	0.1	38,631	0.1	41,453	0.1	39,860	0.07	39,861	0.1	40,293	0.1
2002	41,475	0.1	41,507	0.1	39,372	0.1	39,373	0.1	41,153	0.1	39,596	0.07	39,598	0.1	40,289	0.1
2003	42,842	0.1	42,879	0.1	40,582	0.1	40,583	0.1	41,459	0.1	39,973	0.07	39,974	0.1	40,309	0.1
2004	45,347	0.1	45,388	0.1	42,709	0.1	42,710	0.1	43,855	0.1	42,343	0.06	42,344	0.1	42,144	0.1
2005	48,773	0.1	48,816	0.1	45,572	0.0	45,572	0.0	47,548	0.1	45,966	0.06	45,967	0.1	45,711	0.1
2006	51,639	0.1	51,684	0.1	47,733	0.0	47,733	0.0	51,836	0.1	50,034	0.06	50,035	0.1	48,944	0.1
2007	51,028	0.1	51,071	0.1	47,020	0.0	47,020	0.0	52,645	0.1	50,698	0.06	50,700	0.1	49,544	0.1
2008	47,593	0.1	47,632	0.1	44,001	0.0	44,001	0.0	49,632	0.1	47,796	0.06	47,797	0.1	46,934	0.1
2009	43,553	0.1	43,589	0.1	40,466	0.1	40,465	0.1	45,216	0.1	43,677	0.06	43,678	0.1	42,961	0.1
2010	41,052	0.1	41,087	0.1	38,278	0.1	38,277	0.1	42,060	0.1	40,860	0.06	40,861	0.1	39,885	0.1
2011	40,701	0.1	40,737	0.1	38,071	0.1	38,069	0.1	41,056	0.1	40,097	0.06	40,097	0.1	38,949	0.1
2012	40,505	0.1	40,542	0.1	37,938	0.1	37,936	0.1	40,658	0.1	39,800	0.06	39,800	0.1	38,514	0.1
2013	39,032	0.1	39,067	0.1	36,768	0.1	36,766	0.1	39,096	0.1	38,322	0.07	38,321	0.1	37,457	0.1
2014	36,274	0.1	36,306	0.1	34,433	0.1	34,431	0.1	35,976	0.1	35,350	0.07	35,350	0.1	34,896	0.1
2015	33,825	0.1	33,855	0.1	32,394	0.1	32,392	0.1	32,860	0.1	32,436	0.07	32,436	0.1	32,087	0.1
2016	33,087	0.1	33,118	0.1	31,885	0.1	31,882	0.1	31,242	0.1	31,070	0.07	31,069	0.1	30,245	0.1
2017	34,667	0.1	34,701	0.1	33,247	0.1	33,244	0.1	31,987	0.1	31,992	0.08	31,992	0.1	30,187	0.1
2018	37,833	0.1	37,873	0.1	35,982	0.1	35,980	0.1	34,532	0.1	34,438	0.08	34,437	0.1	32,024	0.1
2019	39,869	0.1	39,910	0.1	37,887	0.1	37,884	0.1	35,466	0.1	35,354	0.08	35,353	0.1	33,288	0.1
2020	40,611	0.1	40,650	0.1	38,791	0.1	38,787	0.1	34,919	0.1	34,903	0.09	34,902	0.1	32,974	0.1
2021	41,806	0.1	41,845	0.1	40,096	0.1	40,093	0.1	34,447	0.1	34,605	0.09	34,604	0.1	32,023	0.1

Table 4.18. Estimates of age-0 recruits and associated CVs from the northern rock sole assessment models.

	17.1		17.1a		17.1b		17.1c		21		21.1		21.2		21.3	
Year	Rec	CV	Rec	CV	Rec	CV	Rec	CV	Rec	CV	Rec	CV	Rec	CV	Rec	CV
1977	113,697	0.5	113,829	0.5	97,413	0.5	97,403	0.5	115,078	0.6	110,247	0.58	110,238	0.6	96,443	0.6
1978	126,293	0.5	126,439	0.5	107,939	0.5	107,927	0.5	118,343	0.6	113,088	0.58	113,078	0.6	99,337	0.6
1979	141,723	0.5	141,884	0.5	120,941	0.5	120,928	0.5	119,178	0.6	113,638	0.57	113,628	0.6	100,342	0.6
1980	99,767	0.5	99,877	0.5	85,679	0.5	85,671	0.5	113,801	0.6	108,460	0.56	108,450	0.6	96,031	0.6
1981	120,146	0.5	120,279	0.5	102,451	0.5	102,443	0.5	110,916	0.6	105,647	0.55	105,638	0.6	93,523	0.6
1982	98,474	0.5	98,586	0.5	83,987	0.5	83,981	0.5	111,572	0.6	105,817	0.54	105,808	0.5	94,122	0.5
1983	90,015	0.5	90,116	0.5	77,405	0.5	77,400	0.5	110,706	0.5	104,717	0.54	104,709	0.5	93,086	0.5
1984	114,859	0.4	114,984	0.4	97,207	0.4	97,203	0.4	127,328	0.6	120,188	0.54	120,180	0.5	106,286	0.6
1985	144,297	0.4	144,452	0.4	120,920	0.4	120,918	0.4	157,124	0.5	146,158	0.54	146,151	0.5	131,624	0.5
1986	133,782	0.4	133,934	0.4	113,698	0.4	113,697	0.4	158,222	0.6	147,955	0.56	147,950	0.6	132,527	0.6
1987	187,914	0.3	188,119	0.3	156,387	0.3	156,391	0.3	212,947	0.4	197,299	0.44	197,305	0.4	180,774	0.4
1988	107,658	0.3	107,776	0.3	92,214	0.3	92,216	0.3	121,837	0.5	114,163	0.48	114,168	0.5	104,635	0.5
1989	84,262	0.3	84,354	0.3	70,938	0.3	70,938	0.3	102,705	0.4	95,433	0.43	95,440	0.4	87,637	0.4
1990	86,610	0.3	86,706	0.3	73,193	0.3	73,194	0.3	102,935	0.4	97,278	0.38	97,287	0.4	88,361	0.4
1991	100,654	0.2	100,772	0.2	86,913	0.2	86,913	0.2	102,110	0.3	97,276	0.33	97,285	0.3	89,763	0.3
1992	79,437	0.2	79,530	0.2	69,924	0.2	69,922	0.2	82,965	0.3	81,053	0.32	81,057	0.3	74,547	0.3
1993	74,154	0.3	74,231	0.3	69,258	0.2	69,254	0.2	84,431	0.3	85,635	0.29	85,635	0.3	72,168	0.3
1994	117,902	0.2	118,060	0.2	102,271	0.2	102,266	0.2	136,181	0.2	125,667	0.21	125,669	0.2	102,171	0.2
1995	127,131	0.2	127,302	0.2	114,822	0.2	114,814	0.2	111,249	0.2	105,726	0.20	105,727	0.2	115,808	0.2
1996	139,839	0.2	140,034	0.2	125,265	0.2	125,253	0.2	113,208	0.2	111,920	0.19	111,916	0.2	89,376	0.2
1997	156,105	0.2	156,312	0.2	130,019	0.2	130,010	0.2	190,836	0.2	181,730	0.14	181,725	0.1	134,868	0.2
1998	157,746	0.2	157,920	0.2	132,677	0.2	132,669	0.2	151,290	0.2	146,864	0.17	146,862	0.2	167,797	0.1
1999	207,256	0.1	207,465	0.1	165,085	0.1	165,075	0.1	266,041	0.1	252,705	0.13	252,714	0.1	182,189	0.1
2000	94,816	0.2	94,950	0.2	76,278	0.2	76,270	0.2	141,792	0.2	129,503	0.18	129,506	0.2	133,670	0.2
2001	50,972	0.2	51,054	0.2	43,927	0.2	43,921	0.2	63,294	0.2	59,257	0.22	59,255	0.2	56,550	0.2
2002	47,299	0.2	47,367	0.2	42,669	0.2	42,662	0.2	43,804	0.2	43,697	0.24	43,694	0.2	40,032	0.2
2003	86,969	0.2	87,095	0.2	78,330	0.2	78,318	0.2	86,906	0.2	89,054	0.18	89,047	0.2	57,062	0.2
2004	118,065	0.2	118,225	0.2	104,939	0.2	104,923	0.2	110,692	0.2	110,430	0.17	110,424	0.2	100,745	0.2
2005	118,368	0.2	118,534	0.2	99,493	0.2	99,480	0.2	135,609	0.2	130,629	0.16	130,622	0.2	101,121	0.2
2006	64,547	0.2	64,638	0.2	55,473	0.2	55,466	0.2	74,575	0.2	70,192	0.20	70,191	0.2	80,422	0.2
2007	46,275	0.2	46,348	0.2	42,202	0.2	42,196	0.2	47,052	0.2	45,928	0.22	45,926	0.2	43,900	0.2
2008	45,979	0.3	46,046	0.3	41,455	0.2	41,449	0.2	36,478	0.3	36,917	0.24	36,914	0.2	31,561	0.2
2009	73,608	0.2	73,723	0.2	69,857	0.2	69,847	0.2	60,095	0.2	61,832	0.23	61,827	0.2	42,860	0.2
2010	130,348	0.2	130,511	0.2	115,586	0.2	115,570	0.2	112,731	0.2	119,672	0.20	119,664	0.2	78,569	0.2
2011	170,533	0.2	170,783	0.2	144,749	0.2	144,732	0.2	184,980	0.2	173,354	0.18	173,350	0.2	135,188	0.2
2012	122,297	0.2	122,451	0.2	105,373	0.2	105,358	0.2	90,997	0.2	89,313	0.21	89,309	0.2	107,689	0.2
2013	73,220	0.3	73,306	0.3	66,419	0.3	66,411	0.3	60,509	0.3	59,653	0.26	59,651	0.3	47,669	0.3
2014	128,202	0.3	128,347	0.3	111,755	0.3	111,737	0.3	73,533	0.3	76,027	0.28	76,022	0.3	63,278	0.3
2015	130,527	0.4	130,699	0.4	126,949	0.4	126,929	0.4	123,992	0.3	125,801	0.32	125,787	0.3	51,574	0.4
2016	238,571	0.4	238,882	0.4	195,707	0.4	195,675	0.4	183,324	0.3	184,163	0.33	184,141	0.3	117,196	0.3
2017	184,427	0.5	184,472	0.5	180,703	0.5	180,699	0.5	255,062	0.3	248,679	0.36	248,683	0.4	214,679	0.3
2018	120,591	0.5	120,696	0.5	101,262	0.6	101,253	0.6	98,057	0.5	95,889	0.51	95,887	0.5	108,624	0.5
2019	107,878	0.6	107,979	0.6	96,419	0.6	96,411	0.6	109,820	0.6	106,621	0.58	106,619	0.6	91,706	0.5
2020	117,613	0.6	117,752	0.6	102,603	0.6	102,594	0.6	118,537	0.6	114,129	0.60	114,126	0.6	93,124	0.6
2021	121,294	0.6	121,442	0.6	105,371	0.6	105,361	0.6	119,728	0.6	115,216	0.60	115,213	0.6	101,569	0.6

Table 4.19. Fishing mortality estimates from the northern rock sole assessment models.

	17.1		17.1a		17.1b		17.1c		21		21.1		21.2		21.3	
Year	F	CV	F	CV	F	CV	F	CV	F	CV	F	CV	F	CV	F	CV
1977	0.05	0.2	0.05	0.2	0.04	0.2	0.04	0.2	0.11	0.3	0.11	0.3	0.11	0.3	0.11	0.3
1978	0.05	0.2	0.05	0.2	0.04	0.2	0.04	0.2	0.10	0.3	0.10	0.3	0.10	0.3	0.10	0.3
1979	0.05	0.2	0.05	0.2	0.04	0.2	0.04	0.2	0.11	0.3	0.11	0.3	0.11	0.3	0.11	0.3
1980	0.05	0.2	0.05	0.2	0.04	0.2	0.04	0.2	0.10	0.3	0.10	0.3	0.10	0.3	0.10	0.3
1981	0.06	0.2	0.06	0.2	0.04	0.2	0.04	0.2	0.11	0.3	0.12	0.3	0.12	0.3	0.11	0.3
1982	0.02	0.2	0.02	0.2	0.01	0.2	0.01	0.2	0.03	0.3	0.03	0.3	0.03	0.3	0.03	0.3
1983	0.04	0.2	0.04	0.2	0.03	0.2	0.03	0.2	0.07	0.3	0.07	0.3	0.07	0.3	0.07	0.3
1984	0.02	0.2	0.02	0.2	0.02	0.2	0.02	0.2	0.04	0.2	0.04	0.3	0.04	0.3	0.04	0.2
1985	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.02	0.2	0.02	0.2	0.02	0.2	0.02	0.2
1986	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2
1987	0.03	0.2	0.03	0.2	0.02	0.1	0.02	0.1	0.05	0.2	0.06	0.2	0.06	0.2	0.06	0.2
1988	0.01	0.2	0.01	0.2	0.01	0.1	0.01	0.1	0.03	0.2	0.03	0.2	0.03	0.2	0.03	0.2
1989	0.03	0.2	0.03	0.2	0.03	0.1	0.03	0.1	0.06	0.2	0.06	0.2	0.06	0.2	0.06	0.2
1990	0.04	0.2	0.04	0.2	0.03	0.1	0.03	0.1	0.08	0.1	0.08	0.1	0.08	0.1	0.08	0.1
1991	0.05	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.08	0.1	0.09	0.1	0.09	0.1	0.08	0.1
1992	0.07	0.1	0.07	0.1	0.05	0.1	0.05	0.1	0.12	0.1	0.12	0.1	0.12	0.1	0.12	0.1
1993	0.08	0.1	0.08	0.1	0.06	0.1	0.06	0.1	0.14	0.1	0.15	0.1	0.15	0.1	0.15	0.1
1994	0.03	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.06	0.1
1995	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.07	0.1	0.08	0.1	0.08	0.1	0.07	0.1
1996	0.07	0.1	0.07	0.1	0.05	0.1	0.05	0.1	0.13	0.1	0.14	0.1	0.14	0.1	0.13	0.1
1997	0.06	0.1	0.06	0.1	0.05	0.1	0.05	0.1	0.12	0.1	0.12	0.1	0.12	0.1	0.12	0.1
1998	0.03	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.06	0.1
1999	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.04	0.1	0.04	0.1	0.04	0.1	0.04	0.1
2000	0.06	0.1	0.06	0.1	0.05	0.1	0.05	0.1	0.12	0.1	0.12	0.1	0.12	0.1	0.12	0.1
2001	0.05	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.10	0.1	0.11	0.1	0.11	0.1	0.10	0.1
2002	0.06	0.1	0.06	0.1	0.05	0.1	0.05	0.1	0.12	0.1	0.12	0.1	0.12	0.1	0.11	0.1
2003	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.07	0.1	0.07	0.1	0.07	0.1	0.07	0.1
2004	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.04	0.1	0.04	0.1	0.04	0.1	0.04	0.1
2005	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.07	0.1	0.07	0.1	0.07	0.1	0.07	0.1
2006	0.05	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.10	0.1	0.10	0.1	0.10	0.1	0.11	0.1
2007	0.07	0.1	0.07	0.1	0.05	0.1	0.05	0.1	0.13	0.1	0.13	0.1	0.13	0.1	0.13	0.1
2008	0.08	0.1	0.08	0.1	0.06	0.1	0.06	0.1	0.16	0.1	0.16	0.1	0.16	0.1	0.16	0.1
2009	0.07	0.1	0.07	0.1	0.06	0.1	0.06	0.1	0.15	0.1	0.16	0.1	0.16	0.1	0.16	0.1
2010	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.09	0.1	0.09	0.1	0.09	0.1	0.09	0.1
2011	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.08	0.1	0.09	0.1	0.09	0.1	0.09	0.1
2012	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.08	0.1	0.08	0.1	0.08	0.1	0.08	0.1
2013	0.05	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.13	0.1	0.13	0.1	0.13	0.1	0.13	0.1
2014	0.05	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.12	0.1	0.12	0.1	0.12	0.1	0.12	0.1
2015	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.09	0.1	0.09	0.1	0.09	0.1	0.09	0.1
2016	0.04	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.09	0.1	0.09	0.1	0.09	0.1	0.10	0.1
2017	0.03	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.06	0.1
2018	0.03	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.06	0.1
2019	0.03	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.06	0.1
2020	0.03	0.1	0.03	0.1	0.03	0.1	0.03	0.1	0.08	0.1	0.08	0.1	0.08	0.1	0.08	0.1
2021	0.01	0.1	0.01	0.1	0.01	0.1	0.01	0.1	0.06	0.1	0.06	0.1	0.06	0.1	0.07	0.1

Table 4.20. AFSC Mohn's rho statistics from the northern rock sole retrospective analyses.

Model	ρ SSB	ρ Recruitment	ρ Fishing mortality
17.1	0.24	-0.13	-0.20
17.1b	0.27	-0.13	-0.19
17.1a	0.25	-0.12	-0.18
17.1c	0.27	-0.13	-0.19
21.0	0.24	0.16	-0.22
21.1	0.25	0.13	-0.24
21.2	0.25	0.13	-0.24
21.3	0.15	0.16	-0.17

Table 4.21. Numbers of northern rock sole females at age from model 17.1c.

Yr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1977	48706.7	33446.5	27012.7	22947	19217	15716.4	13023	10718.2	8736.69	7075.71	5699.42	4570.49	3653.99	2914.12	2319.45	1843.32	1463.15	1160.29	919.459	728.196	576.459	457.886	361.958	286.113	226.151	178.75	141.281	111.663	88.2536	69.7506	55.1262
1978	53969.7	39877.7	27381.8	22110.9	18754.9	15647.5	12726.3	10481.9	8579.75	6962.61	5620	4515.82	3615.07	2886.64	2300.18	1829.7	1453.48	1153.36	914.42	724.501	573.722	454.131	360.694	285.112	225.359	178.123	140.785	111.272	87.9436	69.5055	54.9325
1979	60470.7	44186.6	32646.9	22413.3	18072.7	15274.3	12675.8	10249.6	8397.66	6844.45	5536.45	4458.36	3576.45	2859.72	2281.62	1817.03	1444.77	1147.37	910.254	721.565	571.632	452.626	358.253	284.527	224.896	177.757	140.495	111.042	87.7623	69.3622	54.8192
1980	42839.7	49509.2	36174.5	26722.7	18318.4	14715.2	12367.4	10201.3	8203.45	6691.27	5435.26	4385.77	3525.6	2824.73	2256.71	1799.43	1432.4	1138.6	904.01	717.071	568.356	450.216	356.461	282.122	224.054	177.091	139.968	110.625	87.4325	69.1013	54.6129
1981	51225.7	35074.2	40532.1	29610.4	21842.2	14918.9	11920.6	9960.76	8173	6544.41	5320.82	4311.92	3473.55	2789.02	2232.76	1782.74	1420.91	1130.76	898.632	713.373	565.788	448.408	355.176	281.198	222.545	176.734	139.685	110.401	87.2554	68.9612	54.5021
1982	41993.6	41940.1	28714.2	33176.4	24197.5	17777.2	12069.8	9581.41	7958.96	6499.25	5185.32	4204.73	3401.09	2736.21	2194.97	1756.04	1401.47	1116.65	888.414	705.909	560.306	444.343	352.131	278.9	220.798	174.738	138.763	109.672	86.6783	68.5049	54.1413
1983	38702.6	34381.5	34336.9	23507.4	27147	19775.6	14502.1	9826.73	7786.79	6458.82	5268.43	4199.96	3403.78	2752.12	2213.49	1775.3	1420.09	1133.24	902.867	718.288	570.708	452.978	359.219	284.667	225.463	178.492	141.255	112.173	88.6559	70.0683	55.3772
1984	48603.6	31687	28147.8	28107.9	19222.2	22138.7	16063.2	11728.7	7916.29	6252.99	5174.09	4213.09	3354.48	2716.2	2194.84	1764.51	1414.77	1131.45	902.754	719.152	572.08	454.51	360.731	286.055	226.68	179.531	142.126	112.474	89.3168	70.5906	55.7901
1985	60460.1	39793.2	25942.4	23043.3	22996.9	15703.5	18046.3	13062.5	9516.99	6412.18	5058.15	4181.35	3402.39	2707.69	2191.74	1770.62	1423.23	1140.99	912.415	727.944	579.866	461.262	366.456	290.839	230.627	182.755	144.741	114.583	90.6771	72.0069	56.9097
1986	56848.9	49500.5	32579.6	21239	18860.6	18810.6	12832.7	14731.9	10653.4	7755.91	5222.62	4118.06	3403.21	2768.64	2203.01	1783.04	1440.34	1157.69	928.074	742.134	592.077	471.63	375.16	298.048	236.545	187.572	148.636	117.719	93.1911	73.7479	58.5633
1987	78193.3	46544	40527.2	26673	17384.5	15429.2	15375.6	10479.9	12021.2	8687.38	6321.44	4255.14	3354.34	2771.56	2254.48	1793.74	1451.7	1172.63	942.481	755.531	604.148	481.985	383.93	305.396	242.622	192.555	152.689	120.994	95.8259	75.8597	60.0324
1988	46107.1	64019.3	38105.5	33176.3	21816.1	14188.2	12552	12464.8	8469.12	9689.77	6988.95	5078.4	3414.99	2690.15	2221.67	1806.56	1437	1162.78	939.13	754.738	604.984	483.74	385.908	307.389	244.505	194.244	154.158	122.24	96.8642	76.7148	60.7301
1989	35468.8	37749.3	52413.5	31196	27149	17833.4	11579.6	10226.5	10139.6	6880.48	7864.57	5668.52	4116.88	2767.45	2179.52	1799.66	1463.21	1163.79	941.644	760.492	611.153	489.876	391.692	312.471	248.891	197.973	157.275	124.818	98.974	78.4277	62.1132
1990	36596.6	29039.4	30905.1	42905.7	25511.2	22145.6	14492.5	9372.09	8246.51	8151.96	5519.21	6298.23	4534.26	3290.4	2210.6	1740.27	1436.55	1167.74	928.643	751.299	606.715	487.542	390.776	312.442	249.243	198.523	157.906	125.443	99.5538	78.9403	62.5524
1991	43456.7	29962.7	23774	25297.7	35075.2	20787.4	17958.1	11690.6	7524.21	6595.06	6500.41	4391.71	5004.04	3598.73	2609.57	1752.28	1378.95	1137.98	924.867	735.39	594.888	480.365	385.986	309.361	247.339	197.302	157.148	124.994	99.2956	78.8017	62.4845
1992	34962.2	35579.3	24529.8	19460.2	20678	28568.3	16842.4	14467.1	9369.32	6004.93	5246.67	5159.43	3480.02	3960.68	2846.08	2062.62	1384.46	1089.17	898.653	730.244	580.572	469.607	379.176	304.662	244.171	195.212	155.716	124.023	98.6451	78.363	62.1887
1993	34629	28624.6	29127.3	20077.1	15896.5	16808.8	23054.9	13485.2	11500.8	7405.18	4725.29	4115.46	4037.88	2719.22	3091.34	2219.64	1607.73	1078.7	848.378	699.828	568.587	451.992	365.569	295.151	237.135	190.043	151.932	121.189	96.5214	76.7692	60.984
1994	51135.6	28351.8	23433.3	23838.5	16392.7	12902.4	13523.6	18372.6	10653.8	9022.47	5778.6	3673.14	3190.34	3124.18	2101.07	2386.33	1712.27	1239.63	831.427	653.733	539.159	437.984	348.131	281.541	227.294	182.606	146.337	116.986	93.312	74.3168	59.1075
1995	57411	41866.3	23211.6	19182.9	19497.3	13377.6	10494.8	10960.8	14842.6	8584.22	7255.35	4640.11	2946.43	2557.31	2503.01	1682.72	1910.7	1370.74	992.243	665.437	523.18	431.463	350.483	278.572	225.281	181.87	146.111	117.089	93.6033	74.6604	59.4616
1996	62632.5	47004.1	34275.4	19000.5	15684.4	15894.8	10858.8	8478.7	8817.44	11899	6863.73	5790.16	3698.05	2346.01	2034.82	1990.69	1337.85	1518.74	1089.36	788.456	528.718	415.659	342.772	278.426	221.291	178.954	144.467	116.06	93.0053	74.3497	59.3027
1997	65009.3	51279.1	38480.2	28053.4	15519.9	12746.4	12821	8687.66	6733.5	6960.65	9350.71	5376.04	4524.56	2884.99	1828.11	1584.33	1549.07	1040.63	1180.97	846.898	612.865	410.919	323.018	266.356	216.342	171.939	139.039	112.24	90.1681	72.2554	57.761
1998	66338.7	53225.1	41980.5	31496.2	22921.7	12625.5	10302.4	10290	6928.3	5342.16	5500.77	7368.55	4227.88	3553.21	2263.38	1433.21	1241.47	1213.41	814.926	924.654	662.99	479.726	321.624	252.808	208.451	169.303	134.551	108.801	87.8293	70.5562	56.5389
1999	82542.5	54313.6	43575.4	34366.2	25762.2	18709.8	10274	8355.62	8320.3	5588.35	4300.97	4422.69	5918.73	3393.73	2850.82	1815.36	1149.24	995.327	972.707	653.21	741.113	531.361	384.467	257.751	202.596	167.046	135.672	107.822	87.1869	70.3805	56.5387
2000	38138.8	67580.1	44467	35673.3	28117.8	21047.7	15253.3	8356.46	6781.82	6741.61	4522.16	3477.12	3573.14	4779.57	2739.64	2300.84	1464.9	927.267	803.012	784.712	526.939	597.828	428.617	310.12	207.904	163.414	134.738	109.431	86.9667	70.3226	56.7668
2001	21963.4	31225.4	55325.5	36396.5	29147.7	22874.1	17012	12242.1	6664.12	5380.45	5327.63	3563.52	2734.49	2806.01	3749.69	2147.82	1802.91	1147.46	726.143	628.718	614.301	412.462	467.911	335.451	242.698	162.698	127.878	105.435	85.6298	68.0504	55.0258
2002	21334.4	17982.1	25563.4	45285.8	29746.3	23731.3	18518.6	13688.4	9795.7	5308.38	4271.23	4218.8	2816.88	2158.88	2213.42	2956.01	1692.46	1420.23	903.7	571.789	495.01	483.614	324.69	368.319	264.04	191.026	128.055	100.646	82.9812	67.3929	53.5568
2003	39165.2	17467.2	14721.4	20923.9	37002.8	24200.8	19184.1	14866.5	10919.9	7774.64	4196.87	3367.41	3319.44	2213.28	1694.61	1736.22	2317.57	1326.45	1112.81	707.95	447.87	387.69	378.732	254.258	288.408	206.746	149.57	100.262	78.8009	64.9689	52.7636
2004	52469.7	32065.8	14300.2	12050.8	17110.1	30178.4	19660.4	15518.8	11979.8	8772.02	6230.65	3357.62	2690.73	2650.13	1765.95	1351.53	1384.31	1847.42	1057.2	886.815	564.129	356.861	308.894	301.745	202.567	229.769	164.707	119.155	79.8732	62.7755	51.756
2005	49746.2	42958.6	26252.5	11706.9	9859.21	13976.3	24593.9	15981.7	12586.1	9697.87	7091.1	5031.56	2709.47	2170.21	2136.7	1423.46	1089.22	1115.49	1488.53	851.762	714.452	454.466	287.481	248.833	243.07	163.176	185.085	132.675	95.9812	64.3386	50.566
2006	27736.7	40728.8	35169.7	21489.8	9572.04	8038.22	11346.7	19874.5	12861	10094.1	7757.75	5661.9	4012.13	2158.51	1727.78	1700.32	1132.37	866.278	887.019	1183.51	677.157	567.954	361.258	228.511	197.784	193.198	129.693	147.105	105.448	76.2834	51.1343
2007	21101	22708.9	33343.4	28787.1	17561.2	7790.31	6502.65	9119.02	15877.9	10225.3	7996.18	6129.11	4464.84	3159.69	1698.32	1358.53	1336.32	889.662	680.437	696.603	929.318	531.666	445.891	283.601	179.381	155.254	151.65	101.8	115.464	82.7658	59.874
2008	20727.6	17276.1	18590.8	27290.7	23514.5	14273.4	6285.27	5204.44	7245.57	12541.6	8040.75	6267.49	4793.01	3485.9	2464.11	1323.39	1058.02	1040.3	692.375	529.43	541.919	722.869	413.516	346.777	220.548	139.493	120.727	117.921	79.1559	89.7792	64.3535
2009	34928.5	16970.3	14143	15215.4	22284.9	19092.3	11491.9	5014.27	4117.65	5694.05	9805.89	6263.55	4869.39	3716.96	2699.8	1906.69	1023.36	817.767	803.795	534.836	408.89	418.476	558.146	319.26	267.715	170.256	107.679	93.1904	91.0217	61.0983	69.2969
2010	57793.1	28597	13892.8	11575.4	12426.4	18102.5	15386.4	9181.49	3974.9	3243.45	4463.64	7660.13	4880.81	3787.82	2887.83	2095.76	1479.2	793.563	633.934	622.955	414.434	316.798	324.192	432.359	247.294	207.358	131.866	83.3969	72.1734	70.4924	47.3171
2011	72374.4	47317	23412	11372.3	9463.86	10128.9	14689.7	12425	7381.7	3184.3	2591.31	3559.14	6099.37	3882.52	3011.02	2294.48	1664.58	1174.58	630.027	503.227	494.462	328.926	251.421	257.277	343.105	196.239	164.544	104.637	66.1755	57.269	55.9346
2012	52686.4	59255.2	38737.9	19164.7	9298.7	7716.47	8224.37	11873.7	10001.9	5922.34	2548.33	2069.97	2839.38	4861.46	3092.56	2397.29	1826.22	1324.57	934.495	501.188	400.281	393.281	261.605	199.954	204.604	272.854	156.055	130.849	83.2086	52.6228	45.5399
2013	33209.7	43136	48511.7	31710.6	15671.6	7583.78	6268.84	6653.13	9568.32	8034.82	4746.37	2038.81	1654.08	2266.96	3879.06	2466.57	1911.47	1455.81	1055.74	744.749	399.388	318.956	313.363	208.436	159.31	163.011	217.383	124.327	104.244	66.2897	41.9226
2014	55877.5	27189.8	35314.2	39708.1	25914.8	12756.5	6137.03	5040.65	5318.78	7613.47	6370.59	3753.56	1609.4	1304.01	1785.58	3053.42	1940.7	1503.45	1144.79	830.042	585.459	313.934	250.692	246.282	163.809	125.196	128.101	170.825	97.6977	81.9148	52.0897
2015	63474.6	45748.6	22259.7	28906.3	32456.7	21107.1	10335.4	4943.85	4039.61	4244.59	6056.51	5056.07	2974.15	1273.74	1031.22	1411.24	2412.29	1532.76	1187.17	903.819	655.248	462.129	247.786	197.859	194.37	129.276	98.8013	101.092	134.805	77.0961	64.6407
2016	97853.4	51968.6	37453.9	18221.5	23636.1	26465.5	17140.2	8355.51	3980.61	3241.86	3397.89	4839.6	4034.99	2371.38	1014.95	821.334	1123.65	1920.27	1219.93	944.762	719.2	521.368	367.687	197.139	157.412	154.632	102.845	78.5993	80.4203	107.239	61.3302
2017	90351.4	80115.6	42546	30658.9	14898	19267.6	21479.4	13844.7	6719.78	3190.1	2591.15	2710.61	3855.42	3211.33	1886.04	806.841	652.702	892.733	1525.37	968.929	750.301	571.124	414	291.955	156.529	124.982	122.772	81.6535	62.4029	63.848	85.139
2018	50631.2	73973.5	65590.9	34829.5	25079.3	12163.5	15686.8	17434.1	11206	5426.83	2571.9	2086.43	2180.7	3099.79	2580.83	1515.27	648.088	524.196	716.887	1224.81	777.96	602.393	458.521	332.366	234.381	125.659	100.332	98.5574	65.548	50.0941	51.2538
2019	48209.3	41453.3	60562.3	53695.1	28492	20478.7	9905.57	12737.6	14118.9	9055.66	4378.32	2072.53	1679.92	1754.79	2493.34	2075.3	1218.21	520.957	421.323	576.152	984.304	625.17	484.067	368.445	267.068	188.33	100.968	80.6173	79.1903	52.6671	40.2498
2020	51301.6	39470.4	33938	49578.7	43925.5	23266.3	16678.6	8044.24	10317.1	11411.8	7307.65	3529.06	1669.15	1352.16	1411.85	2005.49	1668.91	979.517	418.836	338.706	463.147	791.21	502.511	389.082	296.142	214.655	151.368	81.1512	64.7939	63.6465	42.3292
2021	52685.3	42002.2	32314.2	27781.8	40545.3	35833.6	18911.1	13502.8	6489.15	8298.41	9158.6	5855.39	2824.51	1334.85	1080.74	1128	1601.85	1332.74	782.095	334.383	270.388	369.707	631.552	401.095	310.549	236.363	171.322	120.809	64.7672	51.7118	50.7957

Table 4.22 Numbers at age (northern rock sole) from model 21.2 a) female, central Gulf, b) female, western Gulf. The sex ratio was assumed 50%, so male estimates are not shown.

a)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1977	15267.3	12169.3	9945.25	8171.97	6663.3	5321.18	4144.93	3164.57	2385.17	1784.72	1330.29	989.552	735.255	545.931	405.17	300.601	222.962	165.342	122.593	90.884	67.3694	50.0255	37.0641	27.4608	20.3458	15.0742	11.1684	8.27468	6.13069	4.54222	3.36532
1978	15660.6	12499.8	9961.65	8136.19	6627.34	5281.84	4104.06	3129.47	2358.58	1765.63	1316.79	979.985	728.443	541.059	401.67	298.078	221.137	164.018	121.629	90.1803	66.8546	49.557	36.7986	27.2642	20.2	14.9662	11.0884	8.21542	6.08679	4.50969	3.34122
1979	15736.7	12821.8	10232.3	8149.87	6600.98	5260.53	4084.02	3109.25	2341.7	1753.4	1308.45	974.379	724.652	538.47	399.888	296.843	220.276	163.413	121.202	89.877	66.638	49.4015	36.6194	27.1918	20.1464	14.9265	11.059	8.1936	6.07062	4.49771	3.33234
1980	15019.7	12884.1	10495.8	8371.02	6609.76	5233.35	4058.58	3084.82	2318.52	1734.39	1294.4	964.442	717.684	533.562	396.408	294.362	218.498	162.134	120.279	89.2083	66.1519	49.0472	36.3605	26.9526	20.0136	14.8281	10.9861	8.1396	6.03062	4.46807	3.31038
1981	14630.2	12297.1	10546.9	8586.98	6792.48	5249.15	4050.19	3078.58	2311.59	1726.26	1287.33	959.353	714.312	531.377	394.988	293.43	217.883	161.725	120.005	89.0241	66.027	48.9618	36.3017	26.9118	19.9486	14.8128	10.9748	8.1312	6.02439	4.46346	3.30697
1982	14653.8	11978.2	10066.2	8628.04	6960.38	5374.95	4035.62	3044.75	2283.01	1701.98	1266.6	943.007	702.215	522.662	388.738	288.933	214.633	159.368	118.29	87.7736	65.1133	48.2927	35.8109	26.5512	19.6833	14.5904	10.8341	8.02696	5.94716	4.40623	3.26457
1983	14501.5	11997.5	9806.37	8239.47	7042.98	5641.08	4318.87	3221.06	2420.34	1810.94	1348.66	1003.17	746.707	555.979	413.795	307.758	228.74	169.917	126.166	93.6453	69.4866	51.5473	38.2312	28.3499	21.0194	15.5824	11.5506	8.57684	6.35456	4.70808	3.48821
1984	16644.1	11872.8	9821.56	8024.6	6702.82	5641.95	4436.29	3348.03	2475.32	1851.47	1382.22	1028.3	764.505	568.926	423.558	315.22	234.436	174.241	129.431	96.1034	71.3316	52.9293	39.2645	29.1213	21.5945	16.0107	11.8693	8.79822	6.53309	4.84035	3.58621
1985	20241	13627.1	9720.01	8038.91	6546.9	5422.48	4518.22	3524.78	2647.42	1952.41	1458.56	1088.27	809.398	601.68	447.727	333.316	248.056	184.482	137.113	101.851	75.6248	56.1315	41.6505	30.8975	22.9157	16.9929	12.5989	9.34003	6.92337	5.14092	3.8089
1986	20490.1	16571.9	11156.6	7957.11	6571.9	5333.02	4398.16	3652.49	2843.62	2133.53	1572.61	1174.54	876.256	651.68	484.425	360.469	268.354	199.71	148.526	110.389	81.9997	60.8851	45.1911	33.5325	24.8754	18.4493	13.6808	10.1433	7.51959	5.57395	4.13892
1987	27325.5	16775.9	13567.6	9133.3	6506.5	5357.52	4331.76	3562.31	2953.26	2297.17	1722.77	1269.58	948.128	707.308	526.02	391.011	290.956	216.604	161.197	119.884	89.1007	66.1863	49.1436	36.4761	27.0658	20.0782	14.8914	11.0425	8.1872	6.06945	4.49903
1988	15811.6	22372.3	13733.7	11103.9	7441.48	5239.77	4254.55	3402.73	2779.86	2296.59	1783.37	1336.39	984.476	735.079	548.324	407.766	303.101	225.538	167.901	124.952	92.9273	69.0659	51.3039	38.0932	28.2742	20.9798	15.5634	11.5429	8.55949	6.34623	4.70467
1989	13217.8	12945.4	18316.1	11242	9069.51	6043.55	4226.44	3413.54	2721.3	2219.39	1832.05	1422.08	1065.46	784.825	585.98	437.096	325.046	241.612	179.783	133.839	99.6022	74.0747	55.0542	40.8956	30.3651	22.538	16.7235	12.406	9.20113	6.82297	5.05873
1990	13473.6	10821.8	10597.8	14989.3	9154.03	7288.65	4780.98	3302.77	2647.76	2102.56	1711.52	1411.55	1095.23	820.411	604.259	451.139	336.506	250.238	186.004	138.404	103.034	76.6774	57.0253	42.3825	31.4828	23.376	17.3505	12.8743	9.55051	7.08331	5.25253
1991	13473.3	11031.2	8859.02	8671.8	12187	7319.22	5712.02	3688.78	2524.23	2013.55	1595.08	1296.95	1069.07	829.286	621.121	457.445	341.516	254.732	189.426	140.801	104.768	77.9939	58.0424	43.1663	32.0822	23.8314	17.6948	13.1337	9.74538	7.22939	5.36181
1992	11225.8	11031	9030.35	7248.74	7046.88	9726.82	5717.02	4387.37	2804.59	1908.92	1518.77	1201.66	976.5	804.707	624.132	467.431	344.242	256.996	191.687	142.543	105.952	78.8373	58.6895	43.6762	32.482	24.1414	17.9327	13.3151	9.8829	7.33325	5.44
1993	11859.8	9190.93	9029.73	7387.17	5873.3	5568.74	7459.5	4283.28	3240.85	2056.31	1394.55	1107.65	875.681	711.331	586.078	454.518	340.384	250.67	187.136	139.578	103.793	77.1484	57.405	42.7344	31.8024	23.6515	17.5783	13.0575	9.69522	7.19612	5.33962
1994	17404.3	9710.02	7523.1	7385.05	5969.38	4599.03	4199.08	5462.06	3080.92	2309.35	1458.62	987.099	783.237	618.913	502.635	414.079	321.107	240.464	177.081	132.197	98.6002	73.3202	54.4982	40.5512	30.1877	22.4653	16.7074	12.4173	9.22384	6.8487	5.08333
1995	14642.4	14249.5	7949.15	6156.86	6015.9	4804.06	3647.77	3293.06	4254.19	2390.95	1789.03	1129.05	763.771	605.92	478.754	388.79	320.283	248.367	185.99	136.965	102.248	76.2629	56.7098	42.1518	31.3644	23.3487	17.3758	12.9224	9.60417	7.13418	5.29713
1996	15499.7	11988.2	11665	6504.67	5007.08	4814.19	3770.8	2820.46	2523.04	3243.8	1818.84	1359.46	857.508	579.94	460.026	363.456	295.147	243.136	188.54	141.188	103.972	77.6176	57.8916	43.0487	31.9976	23.8088	17.7241	13.19	9.8094	7.29054	5.41557
1997	25167.7	12690.1	9812.97	9541.21	5262.01	3935.38	3655.16	2786.96	2050.79	1818.83	2328.68	1303.17	973.139	613.559	414.865	329.046	259.956	211.092	173.889	134.841	100.974	74.3576	55.5097	41.4021	30.7869	22.8835	17.0272	12.6756	9.43299	7.0153	5.21391
1998	20339.4	20605.6	10387.7	8027.12	7727.71	4152.63	3010.5	2729.22	2050.58	1497.29	1322.96	1690.83	945.432	705.722	444.866	300.771	238.54	188.447	153.022	126.052	97.745	73.195	53.9008	40.2381	30.0117	22.3168	16.5878	12.3426	9.18827	6.83778	5.08525
1999	34999.3	16652.5	16868.8	8501.15	6538.2	6216.72	3291.35	2358.65	2123.3	1589.44	1158.49	1022.75	1306.62	730.466	545.208	343.666	232.344	184.268	145.571	118.205	97.3711	75.5048	56.5406	41.6365	31.0825	23.1829	17.2389	12.8135	9.53423	7.09759	5.28193
2000	17935.8	28655	13633	13807.1	6935.69	5289.3	4978.51	2615.09	1865.07	1674.75	1252.13	912.119	805.026	1028.34	574.853	429.047	270.441	182.836	145.004	114.552	93.0167	76.6221	59.4152	44.4922	32.764	24.4589	18.2428	13.5654	10.083	7.50253	5.58513
2001	8206.4	14684.6	23456.1	11152.1	11184.6	5476.59	4050.51	3722.68	1927.32	1364.13	1220.4	910.857	662.977	584.909	747.016	417.55	311.625	196.42	132.791	105.312	83.1952	67.5547	55.6477	43.1509	32.3128	23.7951	17.7635	13.2489	9.85194	7.3228	5.44875
2002	6051.39	6718.83	12020.7	19189.7	9045.61	8870.49	4228.06	3062.25	2778.81	1429.07	1008.19	900.592	671.683	488.725	431.103	550.534	307.71	229.643	144.744	97.8536	77.6042	61.3059	49.7804	41.0061	31.7973	23.8109	17.5342	13.0896	9.76291	7.25974	5.39606
2003	12332.5	4954.46	5499.86	9833.31	15547.3	7146.36	6799.5	3165.66	2260.3	2035.75	1043.12	734.653	655.723	488.867	355.638	313.676	400.554	223.875	167.074	105.305	71.1908	56.4586	44.6011	36.216	29.8325	23.1329	17.3227	12.7564	9.52284	7.10262	5.28153
2004	15293	10097	4055.91	4500.64	8001.21	12464.1	5628.05	5281.21	2438.18	1733.19	1557.66	797.34	561.288	500.872	373.377	271.607	239.552	305.894	170.966	127.588	80.4175	54.3654	43.1149	34.0599	27.6565	22.7817	17.6656	13.2285	9.74142	7.27214	5.42393
2005	18090.4	12520.8	8266.17	3319.76	3671.96	6473.45	9983.24	4472.69	4177.15	1923.65	1365.78	1226.76	627.79	441.877	394.288	293.915	213.799	188.565	240.785	134.576	100.431	63.3002	42.7934	33.9376	26.81	21.7696	17.9324	13.9053	10.4127	7.66788	5.7242
2006	9720.93	14811.1	10250	6764.34	2701.1	2943.27	5096.49	7750.7	3443.14	3201.31	1471.07	1043.39	936.737	479.264	337.297	300.954	224.333	163.181	143.92	183.775	102.712	76.6512	48.3122	32.6608	25.9019	20.4619	16.615	13.6864	10.6128	7.94718	5.85227
2007	6360.49	7958.83	12124.3	8385.82	5488.28	2144.42	2276.56	3862.9	5802.74	2561.14	2373.78	1089.2	772.001	692.861	354.431	249.421	222.536	165.875	120.657	106.414	135.881	75.944	56.6748	35.7212	24.1489	19.1514	15.1292	12.2848	10.1194	7.84688	5.87598
2008	5112.36	5207.53	6514.75	9917.19	6786.55	4319.55	1632.31	1688.43	2820.08	4201.23	1846.83	1708.49	783.236	554.906	497.917	254.68	179.213	159.89	119.178	86.6879	76.4541	97.6249	54.5623	40.7182	25.664	17.3497	13.7593	10.8695	8.82598	7.27028	5.63757
2009	8562.69	4185.65	4262.47	5327.77	8006.84	5298.4	3239.34	1186.37	1204.05	1991.03	2951.78	1294.62	1196.37	548.183	388.278	348.355	178.168	125.368	111.848	83.3669	60.6391	53.48	68.2888	38.1663	28.4823	17.9518	12.1361	9.62456	7.60316	6.17372	5.08551
2010	16572.7	7010.54	3426.05	3485.92	4302.42	6255.73	3978.82	2358.73	847.839	852.039	1402.22	2074.19	908.766	839.376	384.51	272.313	244.297	124.942	87.9131	78.431	58.4587	42.5212	37.5009	47.8849	26.7626	19.972	12.588	8.50989	6.7488	5.33138	4.32904
2011	24007.8	13568.6	5738.91	2803.22	2831.58	3429.15	4873.89	3045.57	1786.18	638.419	639.823	1051.62	1554.63	680.936	628.852	288.05	203.991	182.999	93.5907	65.8529	58.7499	43.7892	31.8509	28.0904	35.8685	20.0467	14.9601	9.42908	6.37437	5.05522	3.99349
2012	12368.6	19655.9	11107.5	4695.78	2278.07	2260.38	2679.4	3745.31	2316.78	1351.54	481.823	482.297	792.258	1170.9	512.789	473.533	216.896	153.598	137.791	70.4691	49.5837	44.2353	32.9707	23.9818	21.1503	27.0068	15.0939	11.264	7.09949	4.79949	3.80625
2013	8261.27	10126.6	16090.8	9088.78	3817.25	1820.4	1769.52	2064.28	2857.6	1758.66	1023.41	364.419	364.58	598.73	884.762	387.452	357.778	163.873	116.047	104.103	53.2404	37.461	33.4202	24.9096	18.1184	15.9792	20.4038	11.4035	8.51003	5.3637	3.62604
2014	10528.5	6763.76	8289.26	13162.1	7358.92	3009.2	1389.79	1317.68	1514.06	2079.31	1274.73	740.453	263.44	263.448	432.56	639.141	279.874	258.431	118.366	83.8207	75.193	38.4549	27.0576	24.1388	17.9918	13.0866	11.5415	14.7372	8.23651	6.14661	3.87408
2015	17420.7	8620.02	5536.66	6781.06	10667.2	5820.04	2311.21	1043.36	975.626	1112.9	1522.99	932.126	541.025	192.415	192.386	315.852	466.671	204.345	188.685	86.4205	61.1978	54.8985	28.0759	19.7546	17.6236	13.1357	9.55442	8.42633	10.7595	6.01341	4.48759
2016	25502.4	14262.9	7056.48	4530.2	5509.31	8507.88	4540.18	1772.13	791.674	736.21	837.555	1144.74	700.215	406.305	144.482	144.45	237.142	350.37	153.417	141.659	64.8814	45.9449	41.2155	21.0782	14.8309	13.231	9.86166	7.17302	6.3261	8.07775	4.51459
2017	34440.9	20879.6	11675.8	5773.62	3679.63	4390.19	6626.09	3473.49	1341.18	595.751	552.483	627.722	857.429	524.319	304.196	108.164	108.135	177.521	262.277	114.843	106.04	48.5676	34.3924	30.8521	15.7782	11.1017	9.90414	7.38198	5.36939	4.73542	6.04662
2018	13279.7	28197.9	17093.2	9555.35	4703.12	2961.06	3481.62	5195.37	2704.74	1040.57	461.404	427.54	485.575	663.143	405.475	235.235	83.6411	83.6177	137.27	202.808	88.8028	81.996	37.5549	26.5939	23.8564	12.2004	8.58439	7.65836	5.7081	4.15186	3.66165
2019	14766.1	10872.5	23084.4	13989.1	7785.09	3787.04	2350.96	2734.12	4052.87	2102.58	807.529	357.785	331.402	376.321	513.89	314.201	182.278	64.8105	64.7918	106.364	157.146	68.8087	63.5343	29.0993	20.6062	18.485	9.45344	6.65157	5.93403	4.42288	3.21705
2020	15805.7	12089.5	8900.85	18892.4	11397.9	6269.61	3007.54	1846.87	2133.76	3151.97	1632.45	626.473	277.464	256.958	291.76	398.399	243.582	141.307	50.2427	50.2279	82.4555	121.822	53.3415	49.2527	22.5581	15.9742	14.3298	7.32842	5.15637	4.60013	3.42867
2021	15956.3	12940.6	9896.81	7283.5	15366.3	9125.17	4925.17	2328.01	1416.84	1629.22	2401.18	1242.27	476.497	210.989	195.373	221.82	302.885	185.181	107.427	38.1958	38.1844	62.6843	92.6113	40.5511	37.4427	17.149	12.1438	10.8937	5.57117	3.91995	3.49708

Table 4.22 continued
b)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1977	39851.8	31765.2	25964.1	21349.9	17563.3	14454.3	11901.2	9794.35	8051.3	6610.39	5421.85	4443.56	3639.63	2979.77	2438.65	1995.19	1631.97	1334.6	1091.24	892.125	729.262	597.164	487.905	398.635	325.697	266.103	217.413	177.632	145.13	118.574	96.8777
1978	40878.5	32627.9	26007.2	21257.6	17479.7	14378.6	11831	9738.22	8011.48	6583.62	5403.98	4431.48	3631.37	2974.08	2434.71	1992.47	1630.09	1333.3	1090.33	891.494	728.821	595.766	487.846	398.586	325.657	266.071	217.387	177.61	145.112	118.56	96.8658
1979	41077.1	33468.5	26713.5	21292.9	17404.1	14310.2	11769.1	9681.04	7965.92	6551.45	5382.48	4417.23	3621.82	2967.6	2430.3	1989.45	1628.02	1331.89	1089.38	890.845	728.381	595.467	486.754	398.579	325.651	266.066	217.383	177.607	145.109	118.557	96.864
1980	39205.6	33631.1	27401.7	21871.1	17433	14248.2	11713	9630.24	7918.9	6513.92	5355.91	4399.41	3609.95	2959.61	2424.84	1985.7	1625.44	1330.11	1088.15	890.002	727.798	595.064	486.474	397.658	325.621	266.042	217.363	177.591	145.096	118.547	96.8552
1981	38188.8	32098.8	27534.8	22434.6	17906.4	14271.9	11662.5	9584.63	7877.74	6475.91	5325.66	4378.09	3595.74	2950.22	2418.57	1981.47	1622.57	1328.16	1086.82	889.105	727.194	594.658	486.202	397.476	324.907	266.049	217.369	177.596	145.1	118.55	96.8578
1982	38250.4	31266.4	26280.3	22543.6	18367.7	14659.4	11681.6	9542.68	7839.65	6441.38	5293.72	4352.57	3577.61	2937.99	2410.37	1975.9	1618.74	1325.51	1084.97	887.814	726.292	594.025	485.756	397.161	324.682	265.403	217.323	177.559	145.069	118.525	96.8375
1983	37852.9	31316.8	25598.7	21516.5	18457.1	15037.9	12001.1	9562.3	7810.57	6416.01	5271.23	4331.78	3561.49	2927.28	2403.88	1972.15	1616.65	1324.41	1084.49	887.689	726.376	594.223	486.007	397.425	324.94	265.641	217.141	177.804	145.27	118.689	96.9717
1984	43445.7	30991.3	25640	20958.5	17616.1	15110.6	12309.6	9821.57	7823.76	6389.06	5247.34	4310.47	3541.9	2911.85	2393.21	1965.23	1612.23	1321.59	1082.67	886.532	725.649	593.78	485.748	397.285	324.874	265.62	217.146	177.5	145.344	118.75	97.0212
1985	52834.6	35570.4	25373.5	20992.3	17159.3	14422.4	12370.1	10075.9	8038.19	6402.31	5227.73	4293.19	3526.48	2897.58	2382.08	1957.75	1607.62	1318.85	1081.08	885.64	725.191	593.586	485.714	397.343	324.98	265.747	217.277	177.625	145.195	118.891	97.137
1986	53484.9	43257.4	29122.6	20774.1	17187	14048.7	11807.5	10126.8	8248.05	6579.64	5240.35	4278.79	3513.8	2886.23	2371.47	1949.55	1602.26	1315.7	1079.36	884.769	724.817	593.503	485.795	397.512	325.188	265.965	217.489	177.821	145.369	118.828	97.3013
1987	71327.2	43789.7	35416.1	23843.5	17008.4	14071.3	11501.6	9666.25	8289.85	6751.58	5385.65	4289.26	3502.14	2875.96	2362.28	1940.95	1595.62	1311.37	1076.83	883.399	724.135	593.222	485.748	397.595	325.34	266.148	217.677	178.002	145.536	118.976	97.2536
1988	41272.6	58397.8	35852	28996.3	19521.3	13924.6	11518.7	9413.22	7909.41	6781.8	5522.46	4404.65	3507.66	2863.79	2351.64	1931.54	1587.01	1304.62	1072.2	880.431	722.271	592.053	485.016	397.145	325.071	265.995	217.6	177.97	145.532	118.988	97.2734
1989	34502.1	33791.1	47812	29353.1	23740.1	15982.3	11399.5	9428.96	7704.64	6473.12	5549.83	4518.98	3604.13	2870.06	2343.18	1924.1	1580.36	1298.46	1067.41	877.246	720.341	590.938	484.397	396.823	324.929	265.961	217.627	178.031	145.608	119.068	97.3513
1990	35169.7	28247.9	27665.8	39145.2	24032.2	19435.6	13082.6	9329.12	7714.44	6302.16	5293.8	4538.06	3694.75	2946.54	2346.28	1915.48	1572.85	1291.84	1061.38	872.514	717.065	588.807	483.03	395.943	324.359	265.593	217.393	177.885	145.52	119.018	97.3246
1991	35169.1	28794.5	23127.4	22650.9	32049.1	19674.5	15908.4	10705.2	7631.25	6308.51	5152.35	4327.15	3708.9	3019.38	2407.77	1917.18	1565.11	1285.12	1055.5	867.191	712.868	585.858	481.065	394.642	323.489	265.004	216.991	177.611	145.333	118.89	97.2379
1992	29302.5	28794.1	23574.9	18935.1	18544.8	26237.6	16103.6	13016.9	8756.26	6239.9	5156.95	4210.98	3536.04	3030.5	2466.92	1967.12	1566.25	1278.59	1049.84	862.239	708.403	582.333	478.577	392.971	322.373	264.249	216.474	177.253	145.085	118.718	97.1175
1993	30957.5	23990.9	23574.6	19301.5	15502.6	15181.6	21473.4	13173.8	10643.5	7156.54	5098.07	4212.14	3438.8	2887.22	2474.2	2013.93	1605.82	1278.53	1043.68	856.94	703.801	578.226	475.319	390.627	320.752	263.127	215.684	176.689	144.676	118.42	96.8984
1994	45430.1	25345.8	19642.1	19301.2	15802.6	12690.9	12424.2	17564.3	10769.5	8696.51	5844.93	4162.39	3438.27	2806.55	2356.1	2018.89	1643.22	1310.18	1043.11	851.488	699.122	574.177	471.725	387.769	318.674	261.669	214.658	175.954	144.141	118.026	96.6054
1995	38220.8	37195.1	20751.4	16081.6	15802.4	12937.5	10388.8	10168.6	14372.5	8810.81	7113.76	4780.6	3404.16	2811.78	2295.07	1926.65	1650.87	1343.66	1071.32	852.934	696.242	571.653	469.487	385.715	317.065	260.569	213.957	175.518	143.871	117.859	96.5048
1996	40458.4	31292.6	30452.7	16989.8	13166.4	12937.2	10590.1	8501.82	8319.38	11756	7205.35	5816.65	3908.49	2782.94	2298.53	1876.06	1574.87	1349.41	1098.28	875.664	697.157	569.079	467.243	383.736	315.263	259.152	212.975	174.877	143.458	117.592	96.3309
1997	65694.6	33124.6	25620.2	24932.6	13909.9	10778.7	10588.3	8663.88	6952.29	6800.27	9606.1	5886.18	4750.85	3191.91	2272.5	1876.82	1531.79	1285.82	1101.71	896.666	714.904	569.163	464.595	381.454	313.278	257.377	211.568	173.869	142.766	117.116	95.9992
1998	53091.4	53786.2	27120.1	20976	20412.9	11387.6	8822.2	8663.46	7086.13	5684.23	5558.36	7850.08	4809.42	3881.34	2607.51	1856.33	1533.05	1251.18	1050.25	899.857	732.37	583.907	464.868	379.459	311.552	255.869	210.211	172.796	142.006	116.602	95.6534
1999	91357.8	43467.6	44036.4	22204	17173.6	16712	9322.02	7220.81	7089.59	5797.84	4650.19	4546.75	6420.9	3933.61	3174.42	2132.54	1518.16	1253.75	1023.23	858.895	735.901	598.928	477.515	380.164	310.317	254.783	209.246	171.907	141.31	116.13	95.3556
2000	46817.4	74797.4	35588.2	36054	18179.1	14060.2	13681.3	7630.57	5909.85	5801.76	4744.2	3804.83	3720	5253.17	3218.14	2596.99	1744.6	1241.98	1025.66	837.07	702.632	602.014	489.96	390.635	310.996	253.857	208.427	171.175	140.63	115.6	95.0007
2001	21421	38330.9	61238.9	29137.2	29518.2	14882.5	11507.9	11193.7	6240.65	4831.57	4741.78	3876.56	3108.47	3038.81	4290.88	2628.47	2121.04	1424.83	1014.31	837.633	683.605	573.81	491.635	400.124	319.009	253.972	207.309	170.209	139.787	114.843	94.4024
2002	15795.8	17538	31382.7	50138.2	23855.3	24165.6	12181.3	9416.2	9155.81	5102.81	3949.58	3875.4	3167.8	2539.88	2482.77	3505.55	2147.32	1732.73	1163.96	828.584	684.251	558.423	468.73	401.602	326.848	260.587	207.46	169.343	139.037	114.186	93.8103
2003	32191.2	12932.5	14358.9	25693.9	41049.3	19529.3	19778.7	9966.28	7700.75	7484.95	4170.29	3227.06	3165.9	2587.53	2074.46	2027.69	2862.87	1753.6	1414.99	950.497	676.621	558.753	455.999	382.755	327.938	266.895	212.788	169.405	138.28	113.533	93.2405
2004	39918.8	26355.9	10588.2	11756.1	21036.3	33606.4	15986	16186.4	8154.06	6298.99	6121.29	3410.02	2638.47	2588.27	2115.32	1695.81	1657.53	2340.21	1433.43	1156.63	776.942	553.07	456.723	372.731	312.861	268.053	218.157	173.93	138.47	113.028	92.7999
2005	47220.8	32682.8	21578.4	8668.92	9625.03	17222.5	27511.3	13084.9	13246.9	6672.29	5153.73	5007.91	2789.61	2158.33	2117.21	1730.29	1387.12	1355.79	1914.17	1172.46	946.056	635.491	452.376	373.569	304.869	255.899	219.249	178.437	142.262	113.258	92.4488
2006	25374.3	38661.1	26758.4	17666.9	7097.47	7879.84	14097.6	22514	10705.1	10834.9	5456.31	4213.85	4094.16	2280.43	1764.28	1730.59	1414.29	1133.76	1108.14	1564.51	958.284	773.229	519.396	369.732	305.321	249.171	209.147	179.193	145.837	116.271	92.5662
2007	16602.6	20774.7	31653.1	21907.9	14464.3	5810.45	6449.59	11534.9	18414.5	8752.87	8856.52	4459.07	3443.17	3345	1863.01	1441.26	1413.68	1155.27	926.101	905.16	1277.92	782.734	631.576	424.242	301.995	249.384	203.521	170.829	146.363	119.118	94.9689
2008	13344.7	13593.1	17008.9	25915.3	17936.5	11841.2	4755.57	5276.61	9432.92	15052.8	7152.65	7235.56	3642.31	2812.13	2731.71	1521.33	1176.88	1154.32	943.292	756.161	739.052	1043.39	639.081	515.661	346.378	246.567	203.612	166.166	139.474	119.498	97.254
2009	22351	10925.7	11129.1	13925.7	21217.4	14683.6	9691.13	3890.37	4314.52	7709.58	12298.3	5842.19	5908.75	2973.98	2295.9	2230.08	1241.91	960.684	942.245	769.972	617.214	603.242	851.651	521.634	420.893	282.719	201.252	166.19	135.626	113.84	97.5355
2010	43259.4	18299.4	8945.2	9111.71	11401.3	17369.7	12017.7	7928.45	3181.33	3526.72	6299.75	10046.8	4771.76	4825.49	2428.53	1874.69	1820.86	1013.98	784.351	769.282	628.623	503.903	492.492	695.29	425.861	343.615	230.81	164.3	135.676	110.724	92.9377
2011	62667	35417.8	14982.3	7323.71	7460	9334.08	14218.3	9835.11	6486.86	2602.28	2884.26	5151.4	8214.57	3901.24	3944.96	1985.31	1532.51	1488.48	828.877	641.158	628.835	513.853	411.901	402.572	568.342	348.105	280.876	188.667	134.301	110.903	90.5067
2012	32285.6	51307.4	28997.6	12266.5	5996.11	6107.42	7640.69	11636.3	8047.19	5306.47	2128.38	2358.69	4212.3	6716.59	3189.67	3225.3	1623.1	1252.89	1216.87	677.624	524.156	514.079	420.078	336.731	329.103	464.619	284.575	229.615	154.235	109.79	90.6628
2013	21564.2	26433.2	42007	23741.2	10042.9	4908.97	4999.46	6253.33	9521.34	6583.21	4340.37	1740.67	1928.85	3444.44	5491.97	2608.02	2637.09	1327.07	1024.36	994.91	554.018	428.541	420.301	343.446	275.303	269.067	379.86	232.661	187.727	126.098	89.7614
2014	27482.3	17655.3	21641.7	34392.4	19437.5	8221.83	4018.07	4090.91	5115.19	7785.99	5382.01	3547.74	1422.59	1576.23	2814.56	4487.44	2130.91	2154.61	1084.25	836.92	812.846	452.632	350.116	343.381	280.591	224.918	219.823	310.339	190.079	153.369	103.019
2015	45472.9	22500.6	14454.9	17718.7	28157.9	15913	6729.84	3288.02	3346.59	4183.32	6366.1	4399.76	2899.89	1162.71	1288.2	2300.13	3667.14	1741.34	1760.68	886.001	683.888	664.211	369.862	286.091	280.588	229.279	183.787	179.623	253.585	155.318	125.321
2016	66568.3	37230	18422	11834.7	14506.8	23052.5	13025.9	5507.6	2690.18	2737.47	3421.26	5205.68	3597.39	2370.87	950.55	1053.1	1880.31	2997.75	1423.46	1439.25	724.249	559.031	542.944	302.335	233.857	229.358	187.417	150.231	146.827	207.285	126.96
2017	89900.4	54501.5	30481.4	15082.6	9689.36	11876.4	18869.6	10659.7	4505.82	2200.29	2238.49	2797.2	4255.63	2940.62	1937.91	776.932	860.728	1536.79	2450.04	1163.37	1176.27	591.908	456.878	443.729	247.086	191.122	187.445	153.168	122.777	119.995	169.404
2018	34663.7	73604.2	44622	24956	12348.6	7932.65	9722.14	15444.2	8722.99	3686.55	1799.97	1831.03	2287.86	3480.53	2404.93	1584.84	635.369	703.887	1256.75	2003.56	951.363	961.903	484.036	373.613	362.86	202.055	156.29	153.282	125.253	100.4	98.1253
2019	38543.6	28380.2	60262	36533.4	20432.2	10109.7	6493.76	7957.32	12638.3	7136.97	3015.84	1472.34	1497.63	1871.17	2846.52	1966.8	1296.09	519.599	575.626	1027.74	1638.45	777.992	786.609	395.826	305.526	296.731	165.232	127.807	125.348	102.426	82.1029
2020	41257.2	31556.8	23235.7	49338.4	29910.9	16727.8	8275.9	5314.92	6511.54	10340.2	5838.37	2466.83	1204.21	1224.83	1530.27	2327.86	1608.4	1059.89	424.903	470.716	840.422	1339.83	636.191	643.236	323.679	249.837	242.646	135.114	104.511	102.5	83.7563
2021	41650.4	33778.6	25836.5	19023.8	40394.6	24487.5	13692.5	6772.56	4348.23	5325.84	8455.58	4773.5	2016.67	984.382	1001.18	1250.79	1902.66	1314.58	866.261	347.275	384.714	686.868	1095.02	519.948	525.704	264.535	204.186	198.308	110.426	85.4142	83.7705

Table 4.23. Comparison of time series estimates from the 2017 assesssment and the author's preferred model for 2021.

	2017 assessment				21.2 (2021 preferred assessment)			
Year	SSB	CV	Rec	CV	SSB	CV	Rec	CV
1977	45,484	0.218	106,962	0.562	39,778	0.235	110,247	0.583
1978	44,900	0.218	119,916	0.574	39,588	0.237	113,088	0.582
1979	44,267	0.218	127,793	0.566	39,435	0.238	113,638	0.575
1980	43,499	0.217	113,071	0.556	39,232	0.239	108,460	0.564
1981	42,727	0.215	104,665	0.529	39,088	0.239	105,647	0.552
1982	41,845	0.213	98,061	0.513	38,828	0.238	105,817	0.542
1983	41,932	0.205	89,764	0.508	39,461	0.231	104,717	0.541
1984	41,985	0.197	109,819	0.501	39,762	0.223	120,188	0.544
1985	42,912	0.186	139,528	0.484	40,514	0.212	146,158	0.537
1986	44,280	0.173	136,307	0.498	41,502	0.200	147,955	0.558
1987	45,258	0.162	208,062	0.33	42,321	0.188	197,299	0.438
1988	45,183	0.153	100,840	0.417	42,367	0.178	114,163	0.484
1989	45,009	0.144	86,682	0.36	42,680	0.166	95,433	0.427
1990	44,231	0.136	93,963	0.296	42,572	0.156	97,278	0.376
1991	43,938	0.126	100,920	0.247	42,822	0.144	97,276	0.328
1992	44,601	0.116	82,595	0.241	43,820	0.130	81,053	0.316
1993	45,865	0.105	72,409	0.248	45,109	0.114	85,635	0.292
1994	47,526	0.094	107,671	0.212	46,319	0.099	125,667	0.208
1995	48,314	0.087	139,538	0.178	47,105	0.088	105,726	0.201
1996	47,388	0.081	137,186	0.177	46,310	0.080	111,920	0.192
1997	45,522	0.078	153,088	0.168	44,328	0.076	181,730	0.144
1998	43,958	0.075	171,682	0.162	42,459	0.073	146,864	0.169
1999	42,715	0.072	221,981	0.137	41,152	0.070	252,705	0.129
2000	41,683	0.069	107,992	0.184	40,508	0.068	129,503	0.184
2001	40,959	0.067	62,825	0.218	39,860	0.067	59,257	0.222
2002	41,742	0.065	62,512	0.229	39,596	0.067	43,697	0.239
2003	43,038	0.063	112,056	0.195	39,973	0.066	89,054	0.183
2004	45,532	0.06	139,592	0.18	42,343	0.064	110,430	0.175
2005	49,351	0.056	126,834	0.178	45,966	0.061	130,629	0.156
2006	52,827	0.054	71,533	0.213	50,034	0.059	70,192	0.202
2007	52,878	0.055	59,389	0.225	50,698	0.058	45,928	0.216
2008	50,103	0.056	58,535	0.249	47,796	0.060	36,917	0.241
2009	46,819	0.058	98,832	0.242	43,677	0.062	61,832	0.226
2010	45,188	0.061	157,376	0.237	40,860	0.064	119,672	0.202
2011	45,555	0.062	226,533	0.223	40,097	0.064	173,354	0.179
2012	45,612	0.064	138,936	0.275	39,800	0.065	89,313	0.213
2013	44,204	0.067	84,364	0.383	38,322	0.066	59,653	0.261
2014	41,590	0.07	127,100	0.45	35,350	0.069	76,027	0.275
2015	39,428	0.073	113,609	0.567	32,436	0.071	125,801	0.315
2016	39,284	0.077	122,753	0.583	31,070	0.073	184,163	0.328
2017	41,831	0.083	131,118	0.604	31,992	0.076	248,679	0.359
2018	-	-	-	-	34,438	0.079	95,889	0.510
2019	-	-	-	-	35,354	0.083	106,621	0.578
2020	-	-	-	-	34,903	0.087	114,129	0.601
2021	-	-	-	-	34,605	0.093	115,216	0.604

Table 4.24. Root mean square error from model fit to the southern rock sole models.

Model	All GOA	Central	West
17.1	0.13	-	-
17.1a	0.13	-	-
17.1b	0.13	-	-
21	-	0.14	0.18
21.1	-	0.14	0.18
21.2	-	0.14	0.20

Table 4.25. Total likelihood and likelihood components for the southern rock sole models.

Model	Age_comp	Length_comp	Survey	Total	Npars
17.1	572.53	569.69	-19.74	1122.06	95
17.1a	572.82	568.73	-19.68	1125.39	95
17.1b	568.17	578.64	-19.58	1130.31	92
21	776.26	622.73	-31.39	1371.69	119
21.1	776.24	622.78	-31.39	1371.73	111
21.2	917.33	637.80	-29.97	1527.99	95

Table 4.26. Biological parameter estimates for southern rock sole by model, sex, and area. *Female natural mortality (M) was not estimated and fixed at 0.2.

Model	Sex	Area	L_a_A1	L_a_A2	K	A_a_L0	CVmin	CVmax	M_nages
External	Female	All GOA	18.45	50.24	0.1637	0.2875	-	-	-
17.1	Female	All GOA	14.25	49.04	0.174	1.12	0.20	0.10	0.200
17.1a	Female	All GOA	14.62	49.10	0.172	1.03	0.14	0.10	0.200
17.1b	Female	All GOA	14.67	50.17	0.163	0.96	0.16	0.09	0.200
External	Male	All GOA	18.37	39.58	0.211	0.13	-	-	-
17.1	Male	All GOA	15.11	40.75	0.190	0.64	2.15	5.23	0.271
17.1a	Male	All GOA	15.14	40.58	0.194	0.68	0.12	0.13	0.271
17.1b	Male	All GOA	14.95	41.49	0.188	0.71	0.14	0.11	0.270
External	Female	Central	18.86	51.43	0.166	0.33	-	-	-
21	Female	Central	15.38	51.57	0.158	0.84	0.16	0.09	0.200
21.1	Female	Central	15.37	51.57	0.158	0.84	0.16	0.09	0.200
21.2	Female	Central	18.86	51.43	0.166	0.33	0.16	0.09	0.200
External	Male	Central	18.63	39.86	0.220	0.22	-	-	-
21	Male	Central	16.03	41.48	0.181	0.39	0.13	0.13	0.253
21.1	Male	Central	16.03	41.48	0.181	0.39	0.13	0.13	0.253
21.2	Male	Central	18.63	39.86	0.220	0.22	0.13	0.13	0.249
External	Female	West	17.68	48.67	0.155	0.18	-	-	-
21	Female	West	12.39	46.02	0.201	1.52	0.19	0.05	0.200
21.1	Female	West	12.38	46.01	0.201	1.52	0.19	0.05	0.200
21.2	Female	West	17.68	48.67	0.155	0.18	0.19	0.04	0.200
External	Male	West	17.82	39.15	0.198	0.02	-	-	-
21	Male	West	12.92	37.17	0.267	1.49	0.18	0.06	0.271
21.1	Male	West	12.92	37.17	0.267	1.49	0.18	0.06	0.271
21.2	Male	West	17.82	39.15	0.198	0.02	0.17	0.08	0.274

Table 4.27. Parameter correlation tables for southern rock sole models a) 17.1, b) 17.1a, and c) 21.1.

a) Model 17.1

Number	Parameter name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	L_at_Amin female	14.25	0.61	1																								
2	L_at_Amax female	49.04	0.61	0.26	1																							
3	K female	0.17	0.01	**-0.67**	**-0.77**	1																						
4	CV min female	2.84	0.26	**-0.44**	0.15	0.05	1																					
5	CV max female	5.13	0.22	0.18	**-0.38**	0.07	**-0.45**	1																				
6	M male	0.27	0.01	0.15	-0.30	0.01	-0.09	0.07	1																			
7	L_at_Amin male	15.11	0.59	0.03	-0.06	0.00	-0.02	0.01	-0.20	1																		
8	L_at_Amax male	40.75	0.87	0.00	0.03	-0.03	0.01	0.00	0.21	0.23	1																	
9	K male	0.19	0.02	-0.04	0.06	0.02	0.02	-0.02	0.04	**-0.67**	**-0.76**	1																
10	CV min male	2.15	0.26	-0.01	0.02	0.00	0.01	0.00	0.08	-0.34	0.25	-0.09	1															
11	CV max male	5.23	0.34	0.03	-0.07	0.00	-0.02	0.02	-0.10	0.33	-0.20	-0.18	**-0.45**	1														
12	R0	12.41	0.06	0.25	-0.31	-0.14	-0.14	0.18	**0.49**	0.09	0.03	-0.15	-0.01	0.09	1													
13	SR_regime	-0.07	0.13	-0.02	-0.03	0.04	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.09	1												
14	init_F	0.03	0.01	0.05	-0.16	0.05	-0.03	-0.01	0.24	0.07	-0.04	-0.06	-0.03	0.07	0.12	**-0.66**	1											
15	Size_DblN_peak_Fishery(1)	57.98	2.26	0.04	**-0.48**	0.24	-0.06	-0.06	**0.57**	0.15	-0.05	-0.16	-0.05	0.16	**0.45**	-0.01	**0.40**	1										
16	Size_DblN_top_logit_Fishery(1)	2.77	46.41	0.00	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1									
17	Size_DblN_ascend_se_Fishery(1)	5.97	0.11	-0.12	**-0.45**	0.36	0.02	-0.14	**0.46**	0.11	-0.05	-0.11	-0.04	0.12	0.30	0.00	0.34	**0.94**	0.00	1								
18	Size_DblN_descend_se_Fishery(1)	0.09	216.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.27	0.00	1							
19	Size_DblN_end_logit_Fishery(1)	-2.42	83.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	1						
20	SzSel_Male_Peak_Fishery(1)	-18.16	1.92	-0.01	**0.44**	-0.26	0.04	0.07	**-0.66**	-0.07	-0.13	0.22	0.00	-0.17	**-0.42**	0.00	-0.34	**-0.91**	0.00	**-0.89**	0.00	0.00	1					
21	SzSel_Male_Ascend_Fishery(1)	-1.29	0.13	0.12	0.29	-0.27	-0.03	0.11	**-0.43**	-0.14	-0.26	0.32	0.00	-0.22	-0.22	0.00	-0.18	**-0.60**	0.00	**-0.68**	0.00	0.00	**0.85**	1				
22	Size_DblN_peak_Survey(2)	44.24	1.38	0.20	-0.24	-0.03	-0.13	0.13	0.33	0.07	0.03	-0.12	-0.01	0.09	0.60	-0.01	0.07	0.34	0.00	0.24	0.00	0.00	-0.32	-0.18	1			
23	Size_DblN_ascend_se_Survey(2)	5.40	0.12	0.02	-0.22	0.12	-0.05	0.05	0.19	0.04	0.01	-0.06	-0.01	0.05	0.36	0.00	0.03	0.23	0.00	0.20	0.00	0.00	-0.22	-0.15	**0.86**	1		
24	SzSel_Male_Peak_Survey(2)	-7.46	1.72	-0.15	0.24	-0.05	0.11	-0.07	**-0.49**	0.10	-0.15	0.09	-0.07	-0.05	-0.37	0.01	-0.12	-0.36	0.00	-0.29	0.00	0.00	0.42	0.29	**-0.68**	**-0.64**	1	
25	SzSel_Male_Ascend_Survey(2)	-0.65	0.20	-0.02	0.21	-0.12	0.04	-0.02	-0.31	0.01	-0.15	0.14	-0.04	-0.07	-0.19	0.00	-0.10	-0.27	0.00	-0.24	0.00	0.00	0.32	0.26	**-0.49**	**-0.59**	**0.90**	1

Table 4.27 continued
b) Model 17.1a

Number	name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	L_at_Amin female	14.62	0.52	1.00																						
2	L_at_Amax female	49.10	0.64	**0.31**	1.00																					
3	K female	0.17	0.01	**-0.65**	**-0.80**	1.00																				
4	CV min female	0.14	0.01	**-0.29**	0.15	-0.11	1.00																			
5	CV max female	0.10	0.01	-0.03	**-0.65**	**0.41**	**-0.41**	1.00																		
6	M male	0.27	0.01	0.13	**-0.31**	0.04	-0.08	0.15	1.00																	
7	L_at_Amin male	15.14	0.53	0.03	-0.06	0.00	-0.01	0.02	-0.18	1.00																
8	L_at_Amax male	40.58	0.88	0.00	0.04	-0.03	0.01	-0.01	0.23	0.21	1.00															
9	K male	0.19	0.02	-0.03	0.05	0.02	0.00	-0.03	0.00	**-0.61**	**-0.78**	1.00														
10	CV min male	0.12	0.01	-0.01	0.01	-0.01	0.01	0.00	0.09	-0.35	0.22	-0.15	1.00													
11	CV max male	0.13	0.01	0.02	-0.07	0.01	-0.01	0.03	-0.16	0.18	**-0.53**	0.19	-0.43	1.00												
12	R0	12.43	0.06	0.21	-0.31	-0.10	-0.09	0.23	**0.49**	0.09	0.01	-0.14	0.00	0.07	1.00											
13	SR_regime	-0.08	0.13	-0.02	-0.04	0.04	0.00	0.01	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.08	1.00										
14	init_F[1]	0.03	0.01	0.04	-0.17	0.06	-0.04	0.04	0.24	0.06	-0.05	-0.04	-0.02	0.07	0.11	**-0.66**	1.00									
15	Size_DblN_peak_Fishery(1)	57.76	2.25	0.03	**-0.50**	**0.27**	-0.10	0.12	**0.58**	0.13	-0.07	-0.12	-0.03	0.15	**0.44**	-0.01	**0.40**	1.00								
16	Size_DblN_top_logit_Fishery(1)	0.61	102.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00							
17	Size_DblN_ascend_se_Fishery(1)	5.96	0.11	-0.11	**-0.46**	0.36	-0.05	0.05	**0.47**	0.10	-0.06	-0.09	-0.03	0.12	**0.30**	0.00	0.34	**0.94**	0.00	1.00						
18	SzSel_Male_Peak_Fishery(1)	-17.87	1.91	0.00	**0.45**	-0.28	0.09	-0.10	**-0.67**	-0.05	-0.12	0.21	-0.05	-0.09	**-0.41**	0.00	-0.33	**-0.91**	0.00	**-0.89**	1.00					
19	SzSel_Male_Ascend_Fishery(1)	-1.26	0.13	0.11	**0.30**	-0.27	0.02	-0.02	**-0.45**	-0.11	-0.26	**0.31**	-0.05	-0.08	-0.22	0.00	-0.18	**-0.60**	0.00	**-0.68**	**0.85**	1.00				
20	Size_DblN_peak_Survey(2)	44.15	1.37	0.17	-0.26	0.02	-0.13	0.19	**0.32**	0.06	0.02	-0.11	0.00	0.07	**0.61**	-0.01	0.06	**0.34**	0.00	0.24	-0.32	-0.18	1.00			
21	Size_DblN_ascend_se_Survey(2)	5.39	0.12	0.01	-0.23	0.14	-0.08	0.13	0.19	0.03	0.01	-0.05	0.00	0.03	**0.35**	0.00	0.03	0.23	0.00	0.20	-0.22	-0.15	**0.86**	1.00		
22	SzSel_Male_Peak_Survey(2)	-7.28	1.73	-0.12	0.26	-0.09	0.11	-0.15	**-0.49**	0.11	-0.17	0.12	-0.12	0.04	-0.35	0.01	-0.12	-0.36	0.00	-0.30	**0.42**	**0.30**	**-0.67**	**-0.63**	1.00	
23	SzSel_Male_Ascend_Survey(2)	-0.62	0.20	-0.01	0.22	-0.14	0.06	-0.10	-0.32	0.01	-0.17	0.15	-0.08	0.02	-0.18	0.00	-0.10	-0.27	0.00	-0.24	**0.32**	0.26	**-0.48**	**-0.59**	**0.90**	1.00

Table 4.27. continued
c) Model 21.1

Number	name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	L_at_Amin female 1	15.37	0.61	1.00																										
2	L_at_Amax female 1	51.57	0.89	0.11	1.00																									
3	K female 1	0.16	0.01	-0.54	-0.76	1.00																								
4	CV min female 1	0.16	0.01	-0.54	0.19	0.00	1.00																							
5	CV max female 1	0.09	0.01	0.13	-0.73	0.42	-0.44	1.00																						
6	L_at_Amin female 2	12.38	0.82	0.01	0.01	-0.01	-0.01	0.00	1.00																					
7	L_at_Amax female 2	46.01	0.50	0.01	0.02	-0.02	0.00	0.00	0.28	1.00																				
8	K female 2	0.20	0.01	-0.01	-0.02	0.03	0.01	0.00	-0.66	-0.75	1.00																			
9	CV min female 2	0.19	0.02	-0.01	-0.01	0.01	0.00	0.00	-0.60	-0.06	0.26	1.00																		
10	CV max female 2	0.05	0.01	0.00	-0.01	0.01	0.00	0.00	0.10	-0.42	0.21	-0.40	1.00																	
11	M male 1	0.25	0.01	0.27	-0.32	-0.04	-0.20	0.29	0.00	0.01	-0.01	0.00	0.00	1.00																
12	L_at_Amin male 1	16.03	0.66	0.05	-0.05	-0.01	-0.03	0.05	0.00	0.00	0.00	0.00	0.00	-0.24	1.00															
13	L_at_Amax male 1	41.48	1.15	0.03	-0.04	-0.01	-0.02	0.03	0.00	0.00	-0.01	0.00	0.00	0.26	0.28	1.00														
14	K male 1	0.18	0.02	-0.08	0.10	0.03	0.06	-0.09	0.00	0.00	0.01	0.00	0.00	0.04	-0.65	-0.79	1.00													
15	CV min male 1	0.13	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.11	-0.39	0.16	-0.07	1.00												
16	CV max male 1	0.13	0.01	0.05	-0.06	-0.01	-0.04	0.06	0.00	0.01	-0.01	0.00	0.00	-0.23	0.14	-0.59	0.23	-0.39	1.00											
17	M male 2	0.27	0.02	-0.01	0.00	0.01	0.00	0.00	0.03	0.01	-0.04	-0.02	0.01	-0.01	-0.01	-0.01	0.02	0.00	-0.01	1.00										
18	L_at_Amin male 2	12.92	0.91	0.00	0.00	-0.01	0.00	0.00	0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.09	1.00									
19	L_at_Amax male 2	37.18	0.68	0.00	0.00	0.01	0.00	0.00	-0.02	0.02	0.01	0.02	-0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.50	0.23	1.00								
20	K male 2	0.27	0.02	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.27	-0.61	-0.78	1.00							
21	CV min male 2	0.18	0.02	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	-0.61	-0.03	0.21	1.00						
22	CV max male 2	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.12	0.03	-0.37	0.23	-0.28	1.00					
23	Rec Dist	0.02	0.11	-0.17	0.19	0.07	0.11	-0.19	0.19	-0.15	-0.18	-0.15	0.14	-0.28	-0.03	-0.03	0.07	0.00	-0.03	0.07	0.03	-0.11	0.04	-0.03	0.00	1.00				
24	R0	12.43	0.06	0.17	-0.16	-0.11	-0.11	0.17	0.17	-0.14	-0.18	-0.14	0.14	0.25	0.05	0.05	-0.11	0.00	0.04	0.03	0.03	-0.12	0.03	-0.03	0.00	0.37	1.00			
25	SR_regime	-0.09	0.13	-0.02	-0.03	0.04	0.00	0.01	-0.01	-0.03	0.03	0.01	0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.09	1.00		
26	init_F[1]	0.04	0.01	0.11	-0.13	0.00	-0.09	0.11	0.01	0.02	-0.02	-0.01	-0.01	0.17	0.03	0.02	-0.06	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.03	-0.69	1.00	
27	init_F[2]	0.00	0.00	0.01	0.02	-0.01	0.00	-0.01	-0.02	0.10	-0.03	0.03	-0.06	0.01	0.00	-0.01	0.01	0.00	0.00	0.11	0.00	0.09	-0.06	0.01	-0.01	-0.29	-0.27	-0.63	0.45	1.00

Table 4.27. continued
c)

Number	name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
28	Size_DblN_peak_Fishery(1)	52.48	2.23	0.33	-0.59	0.15	-0.32	0.44	0.00	0.01	-0.02	0.00	0.00	0.58	0.10	0.08	-0.21	0.00	0.13	-0.02	0.01	-0.01	0.00	-0.01	0.00	-0.28	0.29	-0.01	0.29	0.00	1.00																	
29	Size_DblN_top_logit_Fishery(1	0.95	215.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00																
30	Size_DblN_ascend_se_Fishery(	5.71	0.12	0.19	-0.59	0.27	-0.25	0.38	0.00	0.01	-0.01	0.00	0.00	0.49	0.08	0.07	-0.17	0.00	0.10	-0.01	0.01	0.00	0.00	0.00	0.00	-0.23	0.22	0.00	0.26	0.00	0.95	0.00	1.00															
31	SzSel_Male_Peak_Fishery(1)	-13.60	2.01	-0.30	0.55	-0.17	-0.30	-0.40	0.00	-0.01	0.01	0.00	0.00	-0.68	0.02	-0.22	0.22	-0.09	-0.02	0.01	-0.01	0.00	0.00	0.00	0.00	0.27	-0.26	0.01	-0.25	0.00	-0.92	0.00	-0.90	1.00														
32	SzSel_Male_Ascend_Fishery(1)	-1.08	0.15	-0.14	0.46	-0.23	0.19	-0.29	0.00	0.00	0.01	0.00	0.00	-0.51	-0.06	-0.30	0.31	-0.07	-0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.19	-0.18	0.00	-0.18	0.00	-0.72	0.00	-0.77	0.90	1.00													
33	Size_DblN_peak_Fishery(2)	38.94	2.41	0.00	0.00	0.00	0.00	0.01	0.08	-0.04	-0.04	-0.08	0.05	0.00	0.01	0.00	-0.01	0.00	0.00	0.11	0.01	0.03	-0.04	-0.01	0.00	0.06	0.06	0.00	0.01	0.22	0.01	0.00	0.01	-0.01	-0.01	1.00												
34	Size_DblN_top_logit_Fishery(2	-0.72	17.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	1.00											
35	Size_DblN_ascend_se_Fishery(	3.87	0.54	0.00	0.00	0.00	0.00	0.00	0.03	-0.05	0.01	-0.04	0.03	0.00	0.01	0.00	-0.01	0.00	0.00	0.07	0.01	0.02	-0.02	0.00	0.00	0.03	0.03	0.00	0.00	0.15	0.01	0.00	0.01	0.00	0.00	0.92	-0.01	1.00										
36	SzSel_Male_Peak_Fishery(2)	-1.01	3.57	0.00	0.00	-0.01	0.00	0.00	-0.04	0.04	-0.01	0.04	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	-0.44	-0.03	-0.30	0.25	-0.02	0.04	-0.03	-0.01	0.00	0.00	-0.07	0.00	0.00	0.00	0.00	0.00	-0.58	0.01	-0.56	1.00									
37	SzSel_Male_Ascend_Fishery(2)	0.34	0.74	0.00	0.00	0.00	0.00	0.00	-0.01	0.04	-0.02	0.02	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	-0.27	-0.06	-0.19	0.19	0.02	0.01	-0.02	-0.01	0.00	0.00	-0.07	0.00	0.00	0.00	0.00	0.00	-0.64	0.01	-0.71	0.91	1.00								
38	Size_DblN_peak_Survey(1)	43.16	2.12	0.31	-0.24	-0.07	-0.23	0.26	0.00	0.01	-0.02	0.00	0.00	0.31	0.06	0.05	-0.13	0.00	0.06	-0.03	0.00	-0.01	0.00	0.00	0.00	-0.32	0.37	-0.01	0.01	-0.01	0.38	0.00	0.31	-0.36	-0.25	0.01	0.00	0.01	0.01	0.00	1.00							
39	Size_DblN_ascend_se_Survey(	5.42	0.18	0.18	-0.21	0.03	-0.16	0.19	0.00	0.01	-0.01	0.00	0.00	0.20	0.04	0.04	-0.08	0.00	0.03	-0.02	0.00	-0.01	0.00	0.00	0.00	-0.23	0.25	-0.01	0.00	-0.01	0.27	0.00	0.23	-0.25	-0.19	0.01	0.00	0.00	0.01	0.00	0.90	1.00						
40	SzSel_Male_Peak_Survey(1)	-5.96	2.54	-0.26	0.25	0.00	0.22	-0.23	0.00	-0.01	0.01	0.00	0.00	-0.48	0.16	-0.17	0.06	-0.14	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.20	-0.20	0.01	-0.09	0.00	-0.38	0.00	-0.33	0.44	0.34	0.00	0.00	0.00	0.00	0.00	-0.68	-0.66	1.00					
41	SzSel_Male_Ascend_Survey(1)	-0.55	0.28	-0.14	0.21	-0.06	0.14	-0.17	0.00	0.00	0.00	0.00	0.00	-0.33	0.09	-0.16	0.10	-0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.12	-0.11	0.00	-0.07	0.00	-0.28	0.00	-0.25	0.33	0.27	0.00	0.00	0.00	0.00	0.00	-0.51	-0.60	0.92	1.00				
42	Size_DblN_peak_Survey(2)	44.87	2.40	0.01	0.01	-0.03	0.00	0.00	0.14	-0.24	0.00	-0.14	0.17	0.01	0.01	0.01	-0.02	0.00	0.01	0.01	0.02	-0.10	0.04	-0.03	0.00	0.65	0.62	-0.01	0.01	-0.31	0.03	0.00	0.02	-0.02	-0.01	0.05	0.00	0.03	-0.01	-0.01	0.04	0.03	-0.01	0.00	1.00			
43	Size_DblN_ascend_se_Survey(	5.38	0.20	0.01	0.01	-0.02	0.00	0.00	-0.01	-0.26	0.14	-0.04	0.12	0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.02	-0.06	0.03	-0.02	0.00	0.45	0.41	-0.01	0.01	-0.23	0.01	0.00	0.01	-0.01	-0.01	0.03	0.00	0.02	-0.01	-0.01	0.02	0.02	-0.01	0.00	0.89	1.00		
44	SzSel_Male_Peak_Survey(2)	-3.61	4.44	0.00	0.00	-0.01	0.00	0.00	-0.02	0.08	-0.06	0.03	-0.04	0.01	0.01	0.00	-0.01	0.00	0.01	-0.77	0.00	-0.48	0.38	-0.05	0.07	-0.03	0.00	-0.01	0.01	-0.09	0.02	0.00	0.01	-0.01	-0.01	-0.09	0.00	-0.06	0.38	0.24	0.03	0.02	-0.01	0.00	-0.22	-0.28	1.00	
45	SzSel_Male_Ascend_Survey(2)	-0.20	0.44	0.01	0.00	-0.02	0.00	0.00	0.04	0.08	-0.10	-0.01	-0.02	0.01	0.01	0.00	-0.01	0.00	0.01	-0.68	-0.07	-0.45	0.40	0.00	0.06	0.02	0.05	-0.01	0.01	-0.10	0.02	0.00	0.01	-0.01	-0.01	-0.08	0.00	-0.05	0.34	0.22	0.03	0.02	-0.01	0.00	-0.18	-0.32	0.96	1

Table 4.28. The estimated proportion of southern rock sole abundance in the western Gulf of Alaska. On average since 1996, 56% of survey biomass has been in the western Gulf.

Model	Recruitment distribution parameter	Distribution
17.1	-	-
17.1a	-	-
17.1b	-	-
21	0.02	0.51
21.1	0.02	0.51
21.2	0.02	0.50

Table 4.29. Spawning biomass (SSB in tons) estimates and associated CVs from the southern rock sole assessment models.

	17.1		17.1a		21		21.1		21.2	
Year	SSB	CV	SSB	CV	SSB	CV	SSB	CV	SSB	CV
1977	81,276	0.2	83,012	0.2	79,315	0.2	79,299	0.2	69,809	0.2
1978	80,386	0.2	82,058	0.2	78,319	0.2	78,302	0.2	68,923	0.2
1979	79,475	0.2	81,052	0.2	77,284	0.2	77,267	0.2	68,005	0.2
1980	78,491	0.2	79,957	0.2	76,163	0.2	76,146	0.2	67,010	0.2
1981	77,652	0.2	79,014	0.2	75,176	0.2	75,159	0.2	66,154	0.2
1982	76,938	0.2	78,226	0.2	74,300	0.2	74,281	0.2	65,425	0.2
1983	77,614	0.2	78,868	0.2	74,780	0.2	74,761	0.2	65,981	0.2
1984	78,708	0.2	79,973	0.2	75,575	0.2	75,555	0.2	66,882	0.2
1985	81,504	0.2	82,818	0.2	77,874	0.2	77,854	0.2	69,206	0.2
1986	85,944	0.2	87,302	0.2	81,640	0.2	81,618	0.2	72,910	0.2
1987	91,247	0.2	92,581	0.1	86,247	0.2	86,224	0.2	77,418	0.2
1988	95,919	0.1	97,105	0.1	90,371	0.1	90,348	0.1	81,508	0.1
1989	99,967	0.1	100,852	0.1	94,122	0.1	94,099	0.1	85,281	0.1
1990	102,062	0.1	102,570	0.1	96,186	0.1	96,164	0.1	87,529	0.1
1991	102,778	0.1	103,030	0.1	97,114	0.1	97,093	0.1	88,789	0.1
1992	102,931	0.1	103,158	0.1	97,693	0.1	97,674	0.1	89,831	0.1
1993	102,294	0.1	102,595	0.1	97,634	0.1	97,617	0.1	90,348	0.1
1994	100,852	0.1	101,161	0.1	96,827	0.1	96,811	0.1	90,176	0.1
1995	100,245	0.1	100,495	0.1	96,834	0.1	96,820	0.1	90,726	0.1
1996	98,511	0.1	98,696	0.1	95,658	0.1	95,644	0.1	90,065	0.1
1997	94,826	0.1	94,969	0.1	92,447	0.1	92,434	0.1	87,324	0.1
1998	90,621	0.1	90,722	0.1	88,623	0.1	88,612	0.1	83,887	0.1
1999	87,269	0.1	87,339	0.1	85,562	0.1	85,552	0.1	81,120	0.1
2000	84,595	0.1	84,668	0.1	83,091	0.1	83,082	0.1	78,884	0.1
2001	81,544	0.1	81,626	0.1	80,114	0.1	80,106	0.1	76,107	0.0
2002	79,359	0.1	79,415	0.1	77,814	0.1	77,806	0.1	73,751	0.0
2003	78,073	0.1	78,084	0.1	76,215	0.1	76,207	0.1	71,595	0.0
2004	79,377	0.1	79,386	0.1	77,148	0.1	77,139	0.1	71,186	0.0
2005	83,701	0.1	83,681	0.1	81,285	0.1	81,276	0.1	73,571	0.0
2006	89,073	0.1	88,943	0.0	86,725	0.1	86,714	0.1	77,669	0.0
2007	93,018	0.0	92,747	0.0	90,822	0.1	90,809	0.1	81,228	0.0
2008	94,211	0.0	93,868	0.0	92,155	0.1	92,142	0.1	82,612	0.0
2009	93,465	0.0	93,112	0.0	91,585	0.1	91,572	0.1	82,231	0.0
2010	92,669	0.0	92,304	0.0	90,963	0.1	90,950	0.1	81,663	0.0
2011	92,916	0.0	92,530	0.0	91,314	0.1	91,302	0.1	81,836	0.0
2012	92,853	0.0	92,429	0.0	91,317	0.1	91,305	0.1	81,839	0.0
2013	91,352	0.0	90,902	0.0	89,877	0.1	89,865	0.1	80,847	0.0
2014	87,300	0.0	86,837	0.0	85,854	0.1	85,843	0.1	77,633	0.0
2015	81,842	0.1	81,384	0.1	80,332	0.1	80,322	0.1	72,912	0.0
2016	76,351	0.1	75,897	0.1	74,666	0.1	74,656	0.1	67,661	0.0
2017	72,092	0.1	71,688	0.1	70,207	0.1	70,198	0.1	63,107	0.0
2018	69,866	0.1	69,528	0.1	67,838	0.1	67,830	0.1	60,256	0.0
2019	68,791	0.1	68,525	0.1	66,679	0.1	66,671	0.1	58,485	0.0
2020	68,640	0.1	68,414	0.1	66,373	0.1	66,364	0.1	57,355	0.0
2021	71,111	0.1	70,876	0.1	68,408	0.1	68,399	0.1	57,548	0.1

Table 4.30. Age-0 recruit estimates (in 1000s) and associated CVs from the southern rock sole assessment models.

	17.1		17.1a		21		21.1		21.2	
Year	Rec	CV	Rec	CV	Rec	CV	Rec	CV	Rec	CV
1977	295,010	0.6	300,409	0.6	271,966	0.6	271,885	0.6	229,884	0.6
1978	327,459	0.6	331,701	0.6	305,798	0.6	305,688	0.6	259,875	0.6
1979	334,197	0.6	334,100	0.6	317,087	0.6	317,023	0.6	271,332	0.6
1980	323,176	0.6	323,860	0.6	311,265	0.6	311,206	0.6	269,722	0.6
1981	282,821	0.6	272,546	0.5	277,472	0.6	277,428	0.6	243,877	0.6
1982	238,301	0.6	223,678	0.5	235,865	0.5	235,840	0.5	206,241	0.6
1983	248,824	0.5	256,554	0.5	248,490	0.5	248,467	0.5	216,810	0.6
1984	292,685	0.5	303,040	0.5	299,968	0.5	299,969	0.5	270,246	0.5
1985	265,821	0.5	267,855	0.5	275,485	0.5	275,460	0.5	251,903	0.5
1986	214,011	0.5	207,559	0.5	221,766	0.5	221,741	0.5	199,529	0.5
1987	288,819	0.4	289,045	0.4	297,355	0.4	297,311	0.4	277,127	0.4
1988	180,994	0.4	180,814	0.4	186,309	0.4	186,297	0.4	169,598	0.4
1989	161,041	0.4	161,596	0.4	168,781	0.4	168,779	0.4	152,545	0.4
1990	143,076	0.4	143,452	0.4	145,394	0.4	145,393	0.4	127,692	0.4
1991	191,780	0.3	186,458	0.3	195,456	0.3	195,450	0.3	174,989	0.3
1992	168,053	0.3	176,980	0.3	171,486	0.3	171,465	0.3	152,046	0.3
1993	206,078	0.2	202,260	0.3	206,269	0.2	206,237	0.2	186,350	0.2
1994	171,591	0.2	168,332	0.3	166,389	0.2	166,365	0.2	146,449	0.2
1995	188,999	0.2	188,888	0.3	175,021	0.2	174,996	0.2	133,809	0.2
1996	276,641	0.2	279,466	0.2	259,391	0.2	259,357	0.2	166,994	0.2
1997	407,715	0.2	409,615	0.2	423,492	0.1	423,405	0.1	304,250	0.1
1998	408,877	0.1	392,444	0.2	423,669	0.1	423,580	0.1	408,031	0.1
1999	229,139	0.2	235,048	0.2	222,663	0.2	222,622	0.2	190,524	0.2
2000	171,171	0.2	168,650	0.3	179,426	0.2	179,410	0.2	164,650	0.2
2001	229,337	0.2	233,440	0.2	239,150	0.2	239,126	0.2	211,679	0.2
2002	227,902	0.2	218,668	0.2	228,043	0.2	228,021	0.2	173,409	0.2
2003	319,447	0.2	328,404	0.2	324,602	0.2	324,555	0.2	264,075	0.1
2004	201,982	0.2	187,443	0.2	201,365	0.2	201,354	0.2	180,734	0.2
2005	195,329	0.2	204,414	0.2	204,027	0.2	203,998	0.2	198,710	0.2
2006	65,252	0.3	60,129	0.3	65,045	0.3	65,036	0.3	73,094	0.3
2007	77,069	0.2	76,612	0.3	72,356	0.2	72,347	0.2	59,769	0.2
2008	106,720	0.2	105,449	0.3	97,401	0.2	97,392	0.2	71,036	0.2
2009	153,093	0.2	153,325	0.2	147,083	0.2	147,069	0.2	94,097	0.2
2010	252,123	0.2	255,342	0.2	253,591	0.2	253,561	0.2	196,354	0.2
2011	127,974	0.2	124,337	0.3	129,322	0.3	129,296	0.3	106,189	0.2
2012	127,588	0.3	132,580	0.3	124,635	0.3	124,611	0.3	95,074	0.2
2013	238,077	0.2	229,290	0.2	221,941	0.2	221,889	0.2	147,430	0.2
2014	636,305	0.2	643,918	0.2	597,184	0.2	597,058	0.2	346,511	0.2
2015	530,240	0.2	492,311	0.3	499,815	0.2	499,709	0.2	272,688	0.2
2016	414,769	0.4	417,000	0.4	434,557	0.3	434,447	0.3	328,864	0.3
2017	316,014	0.5	309,151	0.4	313,666	0.4	313,584	0.4	325,239	0.4
2018	213,864	0.5	215,152	0.5	195,784	0.5	195,741	0.5	181,929	0.5
2019	209,769	0.6	205,453	0.5	201,212	0.5	201,178	0.5	163,032	0.5
2020	228,788	0.6	236,698	0.6	232,503	0.6	232,467	0.6	177,297	0.6
2021	244,002	0.6	250,172	0.6	249,820	0.6	249,785	0.60	206,391	0.6

Table 4.31. Fishing mortality estimates from the southern rock sole assessment models.

	17.1		17.1a		21.0		21.1		21.2	
Year	F	CV	F	CV	F	CV	F	CV	F	CV
1977	0.03	0.2	0.03	0.2	0.04	0.2	0.04	0.2	0.04	0.2
1978	0.03	0.2	0.03	0.2	0.04	0.2	0.04	0.2	0.04	0.2
1979	0.03	0.2	0.03	0.2	0.05	0.2	0.05	0.2	0.04	0.2
1980	0.03	0.2	0.03	0.2	0.04	0.2	0.04	0.2	0.04	0.2
1981	0.03	0.2	0.01	0.2	0.05	0.2	0.05	0.2	0.05	0.2
1982	0.01	0.2	0.02	0.2	0.01	0.2	0.01	0.2	0.01	0.2
1983	0.02	0.2	0.01	0.2	0.03	0.2	0.03	0.2	0.03	0.2
1984	0.01	0.2	0.00	0.2	0.02	0.2	0.02	0.2	0.02	0.2
1985	0.00	0.2	0.00	0.2	0.01	0.2	0.01	0.2	0.01	0.2
1986	0.00	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.1
1987	0.02	0.2	0.01	0.1	0.02	0.2	0.02	0.2	0.02	0.1
1988	0.01	0.1	0.02	0.1	0.01	0.1	0.01	0.1	0.01	0.1
1989	0.02	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.02	0.1
1990	0.02	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1
1991	0.02	0.1	0.03	0.1	0.04	0.1	0.04	0.1	0.03	0.1
1992	0.03	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1
1993	0.04	0.1	0.02	0.1	0.06	0.1	0.06	0.1	0.06	0.1
1994	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1
1995	0.02	0.1	0.04	0.1	0.03	0.1	0.03	0.1	0.03	0.1
1996	0.04	0.1	0.03	0.1	0.05	0.1	0.05	0.1	0.05	0.1
1997	0.03	0.1	0.01	0.1	0.05	0.1	0.05	0.1	0.04	0.1
1998	0.01	0.1	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1
1999	0.01	0.1	0.03	0.1	0.02	0.1	0.02	0.1	0.01	0.1
2000	0.03	0.1	0.03	0.1	0.05	0.1	0.05	0.1	0.05	0.1
2001	0.03	0.1	0.03	0.1	0.05	0.1	0.05	0.1	0.04	0.1
2002	0.03	0.1	0.02	0.1	0.05	0.1	0.05	0.1	0.05	0.1
2003	0.02	0.1	0.01	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2004	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1
2005	0.02	0.1	0.03	0.1	0.04	0.1	0.04	0.1	0.03	0.1
2006	0.03	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.04	0.1
2007	0.04	0.1	0.04	0.1	0.06	0.1	0.06	0.1	0.05	0.1
2008	0.04	0.1	0.04	0.1	0.06	0.1	0.06	0.1	0.06	0.1
2009	0.04	0.1	0.02	0.1	0.05	0.1	0.05	0.1	0.05	0.1
2010	0.02	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2011	0.02	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2012	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2013	0.03	0.1	0.02	0.1	0.04	0.1	0.04	0.1	0.04	0.1
2014	0.02	0.1	0.02	0.1	0.04	0.1	0.04	0.1	0.04	0.1
2015	0.02	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2016	0.02	0.1	0.01	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2017	0.02	0.1	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1
2018	0.02	0.1	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1
2019	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1
2020	0.02	0.1	0.01	0.1	0.03	0.1	0.03	0.1	0.03	0.1
2021	0.01	0.1			0.02	0.1	0.02	0.1	0.02	0.1

Table 4.32. AFSC Mohn's rho statistics from the southern rock sole retrospective analyses.

Model	ρ SSB	ρ Recruitment	ρ Fishing mortality
17.1	0.06	-0.06	-0.11
17.1a	0.06	-0.10	-0.12
17.1b	0.05	-0.11	-0.12
21.0	0.08	-0.07	-0.11
21.1	0.09	-0.07	-0.11
21.2	0.05	0.00	-0.01

Table 4.33. Numbers of southern rock sole females at age from model 21.1. Sex ratio was assumed 50%.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1977	67247	45970	34103	26428	21082	17175	14192	11796	9773	8032	6548	5308	4285	3448	2765	2212	1764	1405	1117	886	703	563	445	351	277	219	173	137	108	85	67
1978	75608	55057	37633	27914	21618	17214	13982	11507	9521	7853	6427	5220	4219	3398	2729	2185	1746	1391	1107	879	698	553	443	350	276	218	172	136	107	85	67
1979	78411	61902	45073	30803	22834	17654	14017	11341	9293	7655	6289	5129	4154	3350	2693	2159	1727	1378	1098	873	693	550	436	348	275	217	172	135	107	84	67
1980	76972	64198	50677	36892	25197	18644	14371	11365	9153	7466	6124	5013	4076	3293	2650	2127	1704	1361	1086	864	687	545	432	342	274	216	171	135	106	84	66
1981	68618	63020	52556	41480	30179	20576	15182	11657	9178	7360	5979	4888	3989	3236	2610	2097	1681	1345	1074	856	681	541	430	341	270	216	170	134	106	84	66
1982	58332	56180	51591	43017	33928	24638	16745	12301	9400	7365	5880	4758	3877	3156	2555	2057	1651	1322	1057	844	672	535	425	337	267	211	169	133	105	83	66
1983	61455	47758	45995	42236	35209	27754	20135	13666	10025	7649	5985	4773	3859	3142	2556	2068	1664	1335	1069	855	682	543	432	343	272	216	171	137	108	85	67
1984	74193	50315	39099	37650	34558	28773	22633	16373	11078	8101	6163	4810	3828	3089	2512	2041	1650	1327	1064	852	681	543	432	344	273	217	172	136	109	86	68
1985	68131	60744	41193	32008	30814	28265	23506	18462	13333	9005	6575	4995	3894	3096	2497	2029	1648	1332	1071	859	687	549	438	349	277	220	175	138	110	88	69
1986	54845	55781	49732	33725	26202	25218	23120	19215	15080	10883	7346	5360	4070	3172	2521	2032	1651	1341	1084	871	698	559	447	356	284	225	179	142	113	89	71
1987	73536	44903	45669	40716	27608	21445	20631	18904	15702	12315	8882	5992	4371	3318	2585	2054	1656	1345	1092	883	710	569	455	364	290	231	184	146	116	92	73
1988	46078	60206	36762	37385	33320	22572	17506	16807	15364	12732	9964	7173	4832	3520	2669	2078	1650	1330	1080	877	708	569	456	365	292	233	185	147	117	93	73
1989	41745	37725	49291	30096	30602	27262	18455	14298	13712	12521	10364	8104	5830	3925	2858	2166	1686	1338	1078	875	711	574	461	370	296	236	188	150	119	95	75
1990	35961	34178	30885	40350	24628	25016	22248	15026	11611	11106	10117	8357	6524	4686	3151	2292	1737	1351	1072	863	701	569	459	369	296	237	189	151	120	95	76
1991	48342	29442	27981	25282	33014	20124	20396	18085	12174	9376	8940	8123	6695	5217	3742	2514	1827	1383	1075	853	687	557	452	365	293	235	188	150	120	95	76
1992	42409	39579	24104	22904	20684	26971	16401	16569	14637	9817	7535	7164	6493	5341	4156	2977	1998	1451	1098	853	676	544	442	358	289	232	186	149	119	95	75
1993	51010	34722	32401	19728	18733	16883	21940	13281	13347	11731	7830	5986	5672	5126	4208	3268	2338	1567	1137	860	668	529	426	345	280	226	182	145	116	93	74
1994	41148	41763	28425	26518	16131	15280	13714	17721	10659	10645	9302	6178	4703	4441	4003	3279	2542	1816	1216	882	666	517	410	330	267	217	175	140	112	90	72
1995	43283	33689	34191	23269	21700	13189	12473	11170	14400	8641	8610	7509	4979	3786	3571	3216	2633	2040	1457	976	707	534	415	328	264	214	174	140	113	90	72
1996	64148	35437	27581	27988	19039	17734	10755	10142	9054	11635	6961	6919	6022	3986	3026	2852	2566	2099	1626	1161	777	563	425	330	261	210	170	138	111	89	72
1997	#####	52520	29010	22573	22889	15537	14418	8701	8160	7244	9262	5517	5463	4741	3131	2372	2232	2007	1640	1269	906	606	439	331	257	204	164	133	108	87	70
1998	#####	85740	42996	23745	18464	18687	12644	11684	7017	6549	5788	7372	4377	4324	3744	2468	1868	1756	1577	1288	997	711	475	344	260	202	160	128	104	84	68
1999	55062	85775	70195	35197	19431	15096	15256	10301	9497	5691	5300	4676	5946	3526	3479	3010	1984	1501	1410	1266	1034	800	570	381	276	208	162	128	103	83	68
2000	44374	45081	70225	57465	28807	15894	12335	12446	8390	7723	4621	4298	3787	4812	2852	2812	2432	1602	1212	1138	1022	834	645	460	308	223	168	130	103	83	67
2001	59144	36331	36906	57477	47000	23515	12929	9988	10027	6725	6161	3671	3403	2991	3791	2243	2209	1908	1256	949	891	800	653	505	360	241	174	131	102	81	65
2002	56398	48423	29743	30207	47014	38376	19141	10481	8060	8054	5378	4909	2916	2696	2365	2993	1769	1740	1502	988	746	701	629	513	396	283	189	137	103	80	63
2003	80274	46175	39642	24343	24705	38370	31208	15491	8437	6453	6416	4267	3880	2298	2120	1856	2346	1385	1361	1174	772	583	547	491	400	309	220	147	107	80	62
2004	49802	65723	37802	32449	19917	20187	31284	25369	12551	6813	5195	5152	3418	3103	1835	1691	1479	1869	1102	1083	934	614	463	435	390	318	246	175	117	85	64
2005	50456	40774	53807	30946	26557	16288	16487	25505	20641	10192	5522	4204	4163	2759	2503	1479	1363	1191	1504	887	872	752	494	373	350	314	256	198	141	94	68
2006	16086	41310	33381	44044	25318	21697	13276	13396	20650	16653	8196	4428	3363	3324	2200	1993	1177	1083	947	1195	704	692	596	392	296	277	249	203	157	112	75
2007	17894	13170	33819	27322	36025	20670	17657	10757	10802	16570	13303	6522	3512	2661	2625	1734	1569	926	851	743	938	553	543	468	307	232	217	195	159	123	87
2008	24089	14650	10782	27679	22344	29397	16804	14283	8652	8639	13184	10538	5147	2763	2088	2056	1356	1226	723	664	579	731	430	422	364	239	180	169	152	124	95
2009	36376	19722	11993	8824	22634	18228	23885	13579	11471	6907	6858	10414	8290	4036	2161	1630	1602	1056	953	561	515	450	567	334	327	282	185	140	131	117	96
2010	62715	29782	16145	9816	7216	18470	14820	19324	10925	9178	5498	5435	8223	6526	3170	1694	1276	1253	825	744	438	402	350	442	260	255	220	144	109	102	91
2011	31979	51346	24382	13216	8032	5898	15064	12055	15670	8832	7399	4421	4362	6589	5222	2534	1353	1018	999	658	593	349	320	279	352	207	203	175	115	87	81
2012	30821	26183	42037	19959	10814	6565	4812	12260	9783	12681	7129	5959	3554	3501	5282	4182	2028	1082	814	799	525	474	279	256	223	281	165	162	140	92	69
2013	54881	25234	21435	34411	16332	8840	5357	3917	9955	7923	10245	5748	4796	2856	2810	4237	3352	1624	867	652	639	420	379	223	205	178	225	132	130	112	73
2014	#####	44933	20658	17546	28151	13341	7202	4349	3168	8018	6358	8196	4586	3818	2270	2231	3359	2656	1286	686	516	505	332	300	176	162	141	177	104	102	88
2015	#####	#####	36785	16910	14355	22999	10873	5851	3520	2555	6445	5096	6553	3659	3042	1807	1774	2669	2109	1021	544	409	401	263	237	140	128	112	141	83	81
2016	#####	#####	98983	30112	13836	11732	18759	8845	4745	2847	2060	5184	4091	5252	2929	2433	1444	1416	2130	1683	814	434	326	319	210	189	111	102	89	112	66
2017	77560	87976	82843	81023	24636	11305	9564	15246	7163	3830	2290	1653	4150	3269	4190	2334	1937	1149	1126	1693	1337	647	345	259	254	167	150	88	81	71	89
2018	48414	63501	72026	67816	66305	20142	9228	7790	12389	5807	3098	1849	1332	3341	2629	3368	1875	1555	922	903	1358	1072	518	276	207	203	134	120	71	65	57
2019	49759	39638	51988	58961	55497	54211	16443	7518	6331	10045	4698	2502	1491	1073	2688	2113	2705	1505	1248	739	725	1089	860	416	221	166	163	107	96	57	52
2020	57497	40739	32451	42558	48251	45375	44255	13395	6110	5134	8128	3795	2018	1201	863	2161	1698	2173	1208	1002	593	581	873	689	333	178	133	131	86	77	45
2021	61781	47075	33352	26564	34822	39432	37005	35991	10860	4938	4137	6534	3044	1616	960	690	1725	1354	1732	963	798	473	463	695	549	265	141	106	104	68	62

Table 4.34. GOA northern rock sole SSB (t) and age-0 recruit estimates from the 2017 assessment and the preferred model 21.2.

	2017 assessment				21.2 (2021 preferred assessment)			
Year	SSB	CV	Rec	CV	SSB	CV	Rec	CV
1977	45,484	0.218	106,962	0.562	39,778	0.235	110,247	0.583
1978	44,900	0.218	119,916	0.574	39,588	0.237	113,088	0.582
1979	44,267	0.218	127,793	0.566	39,435	0.238	113,638	0.575
1980	43,499	0.217	113,071	0.556	39,232	0.239	108,460	0.564
1981	42,727	0.215	104,665	0.529	39,088	0.239	105,647	0.552
1982	41,845	0.213	98,061	0.513	38,828	0.238	105,817	0.542
1983	41,932	0.205	89,764	0.508	39,461	0.231	104,717	0.541
1984	41,985	0.197	109,819	0.501	39,762	0.223	120,188	0.544
1985	42,912	0.186	139,528	0.484	40,514	0.212	146,158	0.537
1986	44,280	0.173	136,307	0.498	41,502	0.200	147,955	0.558
1987	45,258	0.162	208,062	0.33	42,321	0.188	197,299	0.438
1988	45,183	0.153	100,840	0.417	42,367	0.178	114,163	0.484
1989	45,009	0.144	86,682	0.36	42,680	0.166	95,433	0.427
1990	44,231	0.136	93,963	0.296	42,572	0.156	97,278	0.376
1991	43,938	0.126	100,920	0.247	42,822	0.144	97,276	0.328
1992	44,601	0.116	82,595	0.241	43,820	0.130	81,053	0.316
1993	45,865	0.105	72,409	0.248	45,109	0.114	85,635	0.292
1994	47,526	0.094	107,671	0.212	46,319	0.099	125,667	0.208
1995	48,314	0.087	139,538	0.178	47,105	0.088	105,726	0.201
1996	47,388	0.081	137,186	0.177	46,310	0.080	111,920	0.192
1997	45,522	0.078	153,088	0.168	44,328	0.076	181,730	0.144
1998	43,958	0.075	171,682	0.162	42,459	0.073	146,864	0.169
1999	42,715	0.072	221,981	0.137	41,152	0.070	252,705	0.129
2000	41,683	0.069	107,992	0.184	40,508	0.068	129,503	0.184
2001	40,959	0.067	62,825	0.218	39,860	0.067	59,257	0.222
2002	41,742	0.065	62,512	0.229	39,596	0.067	43,697	0.239
2003	43,038	0.063	112,056	0.195	39,973	0.066	89,054	0.183
2004	45,532	0.06	139,592	0.18	42,343	0.064	110,430	0.175
2005	49,351	0.056	126,834	0.178	45,966	0.061	130,629	0.156
2006	52,827	0.054	71,533	0.213	50,034	0.059	70,192	0.202
2007	52,878	0.055	59,389	0.225	50,698	0.058	45,928	0.216
2008	50,103	0.056	58,535	0.249	47,796	0.060	36,917	0.241
2009	46,819	0.058	98,832	0.242	43,677	0.062	61,832	0.226
2010	45,188	0.061	157,376	0.237	40,860	0.064	119,672	0.202
2011	45,555	0.062	226,533	0.223	40,097	0.064	173,354	0.179
2012	45,612	0.064	138,936	0.275	39,800	0.065	89,313	0.213
2013	44,204	0.067	84,364	0.383	38,322	0.066	59,653	0.261
2014	41,590	0.07	127,100	0.45	35,350	0.069	76,027	0.275
2015	39,428	0.073	113,609	0.567	32,436	0.071	125,801	0.315
2016	39,284	0.077	122,753	0.583	31,070	0.073	184,163	0.328
2017	41,831	0.083	131,118	0.604	31,992	0.076	248,679	0.359
2018	-	-	-	-	34,438	0.079	95,889	0.510
2019	-	-	-	-	35,354	0.083	106,621	0.578
2020	-	-	-	-	34,903	0.087	114,129	0.601
2021	-	-	-	-	34,605	0.093	115,216	0.604

Table 4.35. GOA southern rock sole SSB (t) and age-0 recruit estimates from the 2017 assessment and the preferred model 21.1.

	2017 assessment				21.1 (2021 preferred assessment)			
Year	SSB	CV	Rec	CV	SSB	CV	Rec	CV
1977	80,187	0.198	353,516	0.644	79,299	0.2	271,885	0.6
1978	79,183	0.197	349,040	0.647	78,302	0.2	305,688	0.6
1979	77,997	0.196	324,754	0.636	77,267	0.2	317,023	0.6
1980	76,598	0.195	329,571	0.608	76,146	0.2	311,206	0.6
1981	75,351	0.192	295,131	0.555	75,159	0.2	277,428	0.6
1982	74,497	0.188	211,277	0.535	74,281	0.2	235,840	0.5
1983	75,638	0.181	217,254	0.516	74,761	0.2	248,467	0.5
1984	78,045	0.173	274,107	0.484	75,555	0.2	299,969	0.5
1985	82,781	0.162	228,800	0.475	77,854	0.2	275,460	0.5
1986	89,110	0.15	173,086	0.482	81,618	0.2	221,741	0.5
1987	95,648	0.139	269,195	0.331	86,224	0.2	297,311	0.4
1988	100,839	0.128	151,365	0.4	90,348	0.1	186,297	0.4
1989	104,865	0.118	148,586	0.324	94,099	0.1	168,779	0.4
1990	106,318	0.11	138,637	0.306	96,164	0.1	145,393	0.4
1991	105,771	0.102	182,132	0.238	97,093	0.1	195,450	0.3
1992	104,319	0.095	148,282	0.251	97,674	0.1	171,465	0.3
1993	101,946	0.088	233,209	0.191	97,617	0.1	206,237	0.2
1994	98,747	0.082	197,183	0.207	96,811	0.1	166,365	0.2
1995	96,617	0.075	199,522	0.204	96,820	0.1	174,996	0.2
1996	93,695	0.069	272,032	0.18	95,644	0.1	259,357	0.2
1997	89,208	0.066	353,310	0.162	92,434	0.1	423,405	0.1
1998	84,628	0.063	431,113	0.14	88,612	0.1	423,580	0.1
1999	81,255	0.06	211,436	0.202	85,552	0.1	222,622	0.2
2000	78,874	0.058	158,301	0.225	83,082	0.1	179,410	0.2
2001	76,594	0.057	259,935	0.177	80,106	0.1	239,126	0.2
2002	75,608	0.057	251,328	0.191	77,806	0.1	228,021	0.2
2003	75,558	0.056	320,438	0.163	76,207	0.1	324,555	0.2
2004	77,632	0.056	215,800	0.191	77,139	0.1	201,354	0.2
2005	82,221	0.054	183,365	0.188	81,276	0.1	203,998	0.2
2006	87,656	0.053	76,569	0.258	86,714	0.1	65,036	0.3
2007	91,658	0.053	96,840	0.242	90,809	0.1	72,347	0.2
2008	92,952	0.053	141,588	0.23	92,142	0.1	97,392	0.2
2009	92,549	0.053	190,688	0.234	91,572	0.1	147,069	0.2
2010	92,502	0.054	254,480	0.229	90,950	0.1	253,561	0.2
2011	93,645	0.054	122,900	0.324	91,302	0.1	129,296	0.3
2012	94,210	0.054	163,649	0.351	91,305	0.1	124,611	0.3
2013	93,032	0.054	349,492	0.376	89,865	0.1	221,889	0.2
2014	89,178	0.056	280,872	0.555	85,843	0.1	597,058	0.2
2015	84,110	0.057	219,759	0.577	80,322	0.1	499,709	0.2
2016	79,374	0.058	231,224	0.582	74,656	0.1	434,447	0.3
2017	76,053	0.06	247,039	0.603	70,198	0.1	313,584	0.4
2018	-	-	-	-	67,830	0.1	195,741	0.5
2019	-	-	-	-	66,671	0.1	201,178	0.5
2020	-	-	-	-	66,364	0.1	232,467	0.6
2021	-	-	-	-	68,399	0.1	249,785	0.60

Table 4.36. Northern rock sole projection alternatives for model 21.2, Central area.

Scenarios 1 and 2, max ABC is permissible						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	3,532
2022	35,089	11,694	0.025	663	4,691	3,999
2023	36,945	13,861	0.023	663	5,075	4,329
2024	38,268	16,299	0.158	4,529	5,309	4,529
2025	35,509	15,424	0.158	4,160	4,875	4,160
2026	33,144	14,059	0.158	3,832	4,491	3,832
2027	31,230	12,809	0.158	3,569	4,184	3,569
2028	29,756	11,808	0.158	3,368	3,948	3,368
2029	28,632	11,056	0.158	3,217	3,772	3,217
2030	27,795	10,499	0.158	3,106	3,642	3,106
2031	27,182	10,078	0.157	3,017	3,537	3,017
2032	26,736	9,778	0.156	2,938	3,445	2,938
2033	26,457	9,556	0.155	2,878	3,376	2,878
2034	26,309	9,403	0.154	2,840	3,331	2,840
2035	26,234	9,303	0.153	2,823	3,311	2,823
Scenario 3, Harvest average F over past 5 years						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	1,497
2022	35,089	11,694	0.025	663	4,691	1,697
2023	36,945	13,861	0.023	663	5,075	1,839
2024	38,268	16,299	0.065	1,926	5,309	1,926
2025	38,001	16,805	0.065	1,909	5,261	1,909
2026	37,583	16,628	0.065	1,880	5,182	1,880
2027	37,116	16,319	0.065	1,851	5,101	1,851
2028	36,680	16,024	0.065	1,824	5,028	1,824
2029	36,280	15,778	0.065	1,801	4,966	1,801
2030	35,935	15,576	0.065	1,782	4,912	1,782
2031	35,648	15,396	0.065	1,765	4,866	1,765
2032	35,405	15,253	0.065	1,751	4,828	1,751
2033	35,233	15,120	0.065	1,739	4,796	1,739
2034	35,124	15,009	0.065	1,732	4,774	1,732
2035	35,050	14,919	0.065	1,727	4,763	1,727

Table 4.36. Northern rock sole projection alternatives for model 21.2, Central area. continued.

	Scenario 4, the upper bound on FABC is set at F60%.					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	981
2022	35,089	11,694	0.025	663	4,691	1,112
2023	36,945	13,861	0.023	663	5,075	1,206
2024	38,268	16,299	0.042	1,263	5,309	1,263
2025	38,636	17,159	0.042	1,275	5,359	1,275
2026	38,771	17,320	0.042	1,277	5,367	1,277
2027	38,766	17,311	0.042	1,275	5,359	1,275
2028	38,705	17,271	0.042	1,272	5,345	1,272
2029	38,603	17,232	0.042	1,268	5,329	1,268
2030	38,492	17,198	0.042	1,264	5,312	1,264
2031	38,387	17,149	0.042	1,260	5,294	1,260
2032	38,283	17,110	0.042	1,256	5,277	1,256
2033	38,217	17,056	0.042	1,252	5,262	1,252
2034	38,188	17,005	0.042	1,250	5,253	1,250
2035	38,173	16,961	0.042	1,250	5,251	1,250
	Scenario 5, No fishing					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	0
2022	35,089	11,694	0.025	663	4,691	0
2023	36,945	13,861	0.023	663	5,075	0
2024	38,268	16,299	0.000	0	5,309	0
2025	39,847	17,833	0.000	0	5,547	0
2026	41,102	18,681	0.000	0	5,730	0
2027	42,091	19,319	0.000	0	5,879	0
2028	42,890	19,862	0.000	0	5,999	0
2029	43,519	20,332	0.000	0	6,098	0
2030	44,021	20,734	0.000	0	6,177	0
2031	44,424	21,053	0.000	0	6,238	0
2032	44,739	21,321	0.000	0	6,287	0
2033	45,015	21,522	0.000	0	6,325	0
2034	45,264	21,680	0.000	0	6,359	0
2035	45,476	21,808	0.000	0	6,392	0

Table 4.36. Northern rock sole projection alternatives for model 21.2, Central area. continued.

	Scenario 6, Determination of whether SRS is currently overfished					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	4,144
2022	35,089	11,694	0.187	4,691	4,691	4,691
2023	33,067	11,998	0.187	4,482	4,482	4,482
2024	30,966	12,339	0.187	4,175	4,175	4,175
2025	29,122	11,617	0.187	3,873	3,873	3,873
2026	27,659	10,625	0.187	3,628	3,628	3,628
2027	26,551	9,808	0.187	3,449	3,449	3,449
2028	25,753	9,215	0.187	3,321	3,321	3,321
2029	25,171	8,811	0.184	3,178	3,178	3,178
2030	24,805	8,558	0.178	3,039	3,039	3,039
2031	24,631	8,416	0.175	2,969	2,969	2,969
2032	24,552	8,352	0.173	2,936	2,936	2,936
2033	24,551	8,313	0.173	2,921	2,921	2,921
2034	24,600	8,298	0.172	2,921	2,921	2,921
2035	24,657	8,293	0.173	2,932	2,932	2,932
	Scenario 7, Determination of whether SRS are approaching overfished condition					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	32,616	10,526	0.028	663	4,144	4,144
2022	35,089	11,694	0.158	4,000	4,691	4,691
2023	33,731	12,316	0.158	3,910	4,584	4,584
2024	32,139	12,971	0.187	4,357	4,357	4,357
2025	30,031	12,162	0.187	4,016	4,016	4,016
2026	28,341	11,062	0.187	3,736	3,736	3,736
2027	27,051	10,142	0.187	3,528	3,528	3,528
2028	26,113	9,462	0.187	3,377	3,377	3,377
2029	25,426	8,989	0.185	3,245	3,245	3,245
2030	24,958	8,673	0.179	3,083	3,083	3,083
2031	24,716	8,485	0.176	2,995	2,995	2,995
2032	24,595	8,390	0.174	2,950	2,950	2,950
2033	24,570	8,333	0.173	2,927	2,927	2,927
2034	24,606	8,307	0.173	2,923	2,923	2,923
2035	24,658	8,297	0.173	2,932	2,932	2,932

Table 4.37 Northern rock sole projection alternatives for model 21.2, Western area. continued.

Scenarios 1 and 2, max ABC is permissible						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0.02	663	8,815	7,444
2022	63,298	23,780	0.02	663	9,336	7,883
2023	63,974	25,821	0.02	663	9,735	8,222
2024	64,109	27,525	0.22	8,403	9,947	8,403
2025	56,985	24,249	0.22	7,348	8,697	7,348
2026	51,531	20,943	0.22	6,475	7,665	6,475
2027	47,497	18,290	0.22	5,803	6,872	5,803
2028	44,625	16,327	0.22	5,311	6,291	5,311
2029	42,589	14,941	0.22	4,962	5,879	4,962
2030	41,181	13,978	0.22	4,718	5,591	4,718
2031	40,219	13,300	0.22	4,536	5,374	4,536
2032	39,562	12,850	0.22	4,388	5,197	4,388
2033	39,191	12,541	0.22	4,285	5,074	4,285
2034	39,022	12,346	0.22	4,221	4,998	4,221
2035	38,953	12,225	0.22	4,193	4,964	4,193
Scenario 3, Harvest average F over past 5 years						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0.019	663	8,815	51
2022	63,298	23,780	0.018	663	9,336	54
2023	63,974	25,821	0.017	663	9,735	57
2024	64,109	28,343	0.001	58	9,947	58
2025	64,526	29,435	0.001	59	10,116	59
2026	64,736	29,656	0.001	60	10,193	60
2027	64,799	29,699	0.001	60	10,224	60
2028	64,802	29,717	0.001	60	10,231	60
2029	64,738	29,730	0.001	60	10,226	60
2030	64,658	29,740	0.001	60	10,215	60
2031	64,572	29,717	0.001	60	10,199	60
2032	64,471	29,697	0.001	60	10,181	60
2033	64,421	29,650	0.001	60	10,162	60
2034	64,415	29,601	0.001	60	10,149	60
2035	64,417	29,555	0.001	59	10,144	59

Table 4.37. Northern rock sole projection alternatives for model 21.2, Western area. continued.

Scenario 4, the upper bound on FABC is set at F60%.						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0.02	663	8,815	1,960
2022	63,298	23,780	0.02	663	9,336	2,074
2023	63,974	25,821	0.02	663	9,735	2,165
2024	64,109	28,142	0.06	2,215	9,947	2,215
2025	62,572	28,073	0.06	2,173	9,748	2,173
2026	61,111	27,226	0.06	2,118	9,497	2,118
2027	59,787	26,334	0.06	2,063	9,248	2,063
2028	58,665	25,563	0.06	2,013	9,025	2,013
2029	57,704	24,930	0.06	1,970	8,834	1,970
2030	56,917	24,416	0.06	1,934	8,676	1,934
2031	56,281	23,978	0.06	1,905	8,545	1,905
2032	55,753	23,630	0.06	1,880	8,438	1,880
2033	55,375	23,327	0.06	1,861	8,351	1,861
2034	55,119	23,080	0.06	1,846	8,285	1,846
2035	54,931	22,881	0.06	1,835	8,240	1,835
Scenario 5, No fishing						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0	663	8,815	0
2022	63,298	23,780	0	663	9,336	0
2023	63,974	25,821	0	663	9,735	0
2024	64,109	28,349	0	0	9,947	0
2025	64,578	29,472	0	0	10,126	0
2026	64,836	29,724	0	0	10,212	0
2027	64,940	29,794	0	0	10,251	0
2028	64,978	29,837	0	0	10,265	0
2029	64,943	29,871	0	0	10,266	0
2030	64,886	29,898	0	0	10,260	0
2031	64,821	29,891	0	0	10,248	0
2032	64,736	29,883	0	0	10,234	0
2033	64,699	29,847	0	0	10,218	0
2034	64,704	29,806	0	0	10,207	0
2035	64,715	29,767	0	0	10,204	0

Table 4.37. Northern rock sole projection alternatives for model 21.2, Western area. continued.

	Scenario 6, Determination of whether SRS is currently overfished					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0.02	663	8,815	8,815
2022	63,298	22,976	0.27	9,336	9,336	9,336
2023	56,107	20,791	0.27	8,289	8,289	8,289
2024	50,249	19,539	0.27	7,343	7,343	7,343
2025	45,775	17,355	0.27	6,532	6,532	6,532
2026	42,539	15,190	0.27	5,897	5,897	5,897
2027	40,276	13,564	0.27	5,439	5,439	5,439
2028	38,763	12,450	0.27	5,125	5,125	5,125
2029	37,740	11,737	0.27	4,844	4,844	4,844
2030	37,134	11,320	0.26	4,579	4,579	4,579
2031	36,873	11,101	0.25	4,452	4,452	4,452
2032	36,765	11,009	0.25	4,396	4,396	4,396
2033	36,778	10,958	0.25	4,373	4,373	4,373
2034	36,862	10,940	0.25	4,371	4,371	4,371
2035	36,948	10,934	0.25	4,385	4,385	4,385
	Scenario 7, Determination of whether SRS are approaching overfished condition					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	61,826	23,229	0.02	663	8,815	8,815
2022	63,298	23,119	0.22	7,883	9,336	9,336
2023	57,422	21,613	0.22	7,202	8,530	8,530
2024	52,397	20,738	0.27	7,744	7,744	7,744
2025	47,306	18,279	0.27	6,827	6,827	6,827
2026	43,602	15,868	0.27	6,108	6,108	6,108
2027	40,999	14,044	0.27	5,585	5,585	5,585
2028	39,246	12,781	0.27	5,224	5,224	5,224
2029	38,058	11,957	0.27	4,944	4,944	4,944
2030	37,310	11,450	0.26	4,642	4,642	4,642
2031	36,960	11,173	0.25	4,487	4,487	4,487
2032	36,802	11,045	0.25	4,412	4,412	4,412
2033	36,791	10,975	0.25	4,379	4,379	4,379
2034	36,864	10,946	0.25	4,373	4,373	4,373
2035	36,946	10,936	0.25	4,386	4,386	4,386

Table 4.38. Southern rock sole projection alternatives for model 21.1 central Gulf

Scenarios 1 and 2, max ABC is permissible						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	11,928
2022	88,391	37,555	0.01	663	15,622	13,185
2023	94,107	43,470	0.01	663	16,853	14,229
2024	99,800	48,388	0.22	14,948	17,697	14,948
2025	92,562	46,137	0.22	13,530	16,014	13,530
2026	84,992	42,312	0.22	12,164	14,396	12,164
2027	77,699	37,727	0.22	10,977	12,992	10,977
2028	71,514	33,437	0.22	10,025	11,866	10,025
2029	66,815	30,036	0.22	9,304	11,017	9,304
2030	63,507	27,604	0.22	8,782	10,401	8,782
2031	61,291	25,960	0.22	8,413	9,966	8,413
2032	59,824	24,853	0.22	8,146	9,649	8,146
2033	58,873	24,110	0.22	7,912	9,368	7,912
2034	58,298	23,623	0.22	7,740	9,164	7,740
2035	57,962	23,305	0.22	7,638	9,043	7,638
Scenario 3, Harvest average F over past 5 years						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	1,367
2022	88,391	37,555	0.01	663	15,622	1,512
2023	94,107	43,470	0.01	663	16,853	1,634
2024	99,800	49,491	0.02	1,720	17,697	1,720
2025	103,041	53,496	0.02	1,755	18,010	1,755
2026	104,181	55,323	0.02	1,762	18,055	1,762
2027	103,579	55,325	0.02	1,754	17,948	1,754
2028	102,172	54,432	0.02	1,738	17,778	1,738
2029	100,699	53,383	0.02	1,721	17,593	1,721
2030	99,488	52,518	0.02	1,704	17,420	1,704
2031	98,616	51,907	0.02	1,688	17,265	1,688
2032	97,966	51,445	0.02	1,675	17,132	1,675
2033	97,478	51,078	0.02	1,664	17,017	1,664
2034	97,094	50,762	0.02	1,654	16,923	1,654
2035	96,764	50,476	0.02	1,647	16,850	1,647

Table 4.38. SRS Projection alternatives continued

	Scenario 4, the upper bound on FABC is set at F60%.					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	3,138
2022	88,391	37,555	0.01	663	15,622	3,469
2023	94,107	43,470	0.01	663	16,853	3,749
2024	99,800	49,313	0.06	3,945	17,697	3,945
2025	101,270	52,240	0.06	3,948	17,673	3,948
2026	100,761	52,981	0.06	3,893	17,402	3,893
2027	98,727	51,993	0.06	3,810	17,018	3,810
2028	96,144	50,258	0.06	3,721	16,614	3,721
2029	93,737	48,526	0.06	3,637	16,240	3,637
2030	91,799	47,117	0.06	3,564	15,916	3,564
2031	90,361	46,073	0.06	3,502	15,646	3,502
2032	89,278	45,273	0.06	3,452	15,424	3,452
2033	88,464	44,646	0.06	3,410	15,243	3,410
2034	87,836	44,134	0.06	3,377	15,098	3,377
2035	87,328	43,704	0.06	3,352	14,989	3,352
	Scenario 5, No fishing					
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	0
2022	88,391	37,555	0.01	663	15,622	0
2023	94,107	43,470	0.01	663	16,853	0
2024	99,800	49,627	0.00	0	17,697	0
2025	104,412	54,472	0.00	0	18,271	0
2026	106,878	57,177	0.00	0	18,569	0
2027	107,477	58,012	0.00	0	18,696	0
2028	107,104	57,859	0.00	0	18,730	0
2029	106,494	57,443	0.00	0	18,720	0
2030	105,995	57,111	0.00	0	18,693	0
2031	105,708	56,949	0.00	0	18,658	0
2032	105,534	56,857	0.00	0	18,622	0
2033	105,431	56,794	0.00	0	18,586	0
2034	105,353	56,725	0.00	0	18,554	0
2035	105,266	56,636	0.00	0	18,532	0

Table 4.38. SRS Projection alternatives continued

Scenario 6, Determination of whether SRS is currently overfished						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	14,134
2022	88,391	36,448	0.27	15,622	15,622	15,622
2023	82,804	36,079	0.27	14,685	14,685	14,685
2024	78,327	35,915	0.27	13,578	13,578	13,578
2025	73,663	34,504	0.27	12,386	12,386	12,386
2026	68,693	31,816	0.27	11,264	11,264	11,264
2027	63,889	28,542	0.27	10,327	10,327	10,327
2028	59,927	25,569	0.27	9,618	9,618	9,618
2029	57,091	23,356	0.27	9,118	9,118	9,118
2030	55,261	21,920	0.27	8,728	8,728	8,728
2031	54,210	21,103	0.26	8,252	8,252	8,252
2032	53,808	20,731	0.25	8,006	8,006	8,006
2033	53,749	20,593	0.25	7,909	7,909	7,909
2034	53,836	20,559	0.25	7,882	7,882	7,882
2035	53,958	20,565	0.25	7,892	7,892	7,892
Scenario 7, Determination of whether SRS are approaching overfished condition						
	Total biomass	SSB	F	Catch	OFL	ABC
2021	84,046	33,628	0.01	663	14,134	14,134
2022	88,391	36,637	0.22	13,185	15,622	15,622
2023	84,631	37,252	0.22	12,691	15,036	15,036
2024	81,564	37,751	0.27	14,199	14,199	14,199
2025	76,209	36,044	0.27	12,875	12,875	12,875
2026	70,631	33,052	0.27	11,637	11,637	11,637
2027	65,317	29,492	0.27	10,604	10,604	10,604
2028	60,951	26,272	0.27	9,818	9,818	9,818
2029	57,808	23,861	0.27	9,260	9,260	9,260
2030	55,754	22,272	0.27	8,862	8,862	8,862
2031	54,517	21,329	0.26	8,360	8,360	8,360
2032	53,975	20,864	0.25	8,068	8,068	8,068
2033	53,832	20,667	0.25	7,941	7,941	7,941
2034	53,871	20,596	0.25	7,896	7,896	7,896
2035	53,969	20,581	0.25	7,898	7,898	7,898

Table 4.39. Southern rock sole projection alternatives for model 21.2 continued western Gulf

Scenarios 1 and 2, max ABC is permissible						
Year	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	11,325
2022	75,346	35,559	0.00	41	14,667	12,370
2023	79,524	40,429	0.00	41	15,662	13,213
2024	83,780	44,197	0.28	13,749	16,289	13,749
2025	75,696	40,891	0.28	12,059	14,284	12,059
2026	68,036	36,539	0.28	10,558	12,507	10,558
2027	61,138	31,847	0.28	9,333	11,057	9,333
2028	55,574	27,707	0.28	8,401	9,956	8,401
2029	51,540	24,567	0.28	7,729	9,163	7,729
2030	48,822	22,415	0.28	7,263	8,613	7,263
2031	47,087	21,022	0.28	6,947	8,241	6,947
2032	45,984	20,127	0.28	6,717	7,966	6,717
2033	45,312	19,560	0.27	6,517	7,727	6,517
2034	44,957	19,210	0.27	6,387	7,573	6,387
2035	44,773	18,994	0.27	6,316	7,488	6,316
Scenario 3, Harvest average F over past 5 years						
	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	33
2022	75,346	35,559	0.00	41	14,667	36
2023	79,524	40,429	0.00	41	15,662	39
2024	83,780	45,440	0.00	40	16,289	40
2025	86,690	49,002	0.00	41	16,579	41
2026	87,802	50,639	0.00	41	16,634	41
2027	87,390	50,663	0.00	41	16,561	41
2028	86,279	49,906	0.00	41	16,437	41
2029	85,127	49,029	0.00	41	16,302	41
2030	84,205	48,329	0.00	40	16,175	40
2031	83,574	47,859	0.00	40	16,063	40
2032	83,118	47,519	0.00	40	15,965	40
2033	82,787	47,255	0.00	40	15,880	40
2034	82,544	47,028	0.00	39	15,808	39
2035	82,329	46,817	0.00	39	15,753	39

Table 4.39. Southern rock sole projection alternatives for model 21.2 continued western Gulf

	Scenario 4, the upper bound on FABC is set at F60%.					
	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	2,955
2022	75,346	35,559	0.00	41	14,667	3,226
2023	79,524	40,429	0.00	41	15,662	3,450
2024	83,780	45,132	0.07	3,597	16,289	3,597
2025	83,822	46,867	0.07	3,535	15,980	3,535
2026	82,329	46,708	0.07	3,431	15,490	3,431
2027	79,706	45,123	0.07	3,313	14,947	3,313
2028	76,816	43,024	0.07	3,200	14,433	3,200
2029	74,282	41,075	0.07	3,101	13,988	3,101
2030	72,301	39,534	0.07	3,018	13,620	3,018
2031	70,860	38,405	0.07	2,951	13,322	2,951
2032	69,791	37,556	0.07	2,897	13,084	2,897
2033	69,001	36,905	0.07	2,854	12,894	2,854
2034	68,420	36,388	0.07	2,820	12,745	2,820
2035	67,961	35,966	0.07	2,794	12,634	2,794
	Scenario 5, No fishing					
	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	0
2022	75,346	35,559	0.00	41	14,667	0
2023	79,524	40,429	0.00	41	15,662	0
2024	83,780	45,443	0.00	0	16,289	0
2025	86,722	49,027	0.00	0	16,586	0
2026	87,865	50,685	0.00	0	16,647	0
2027	87,481	50,729	0.00	0	16,580	0
2028	86,393	49,989	0.00	0	16,461	0
2029	85,260	49,127	0.00	0	16,330	0
2030	84,353	48,439	0.00	0	16,207	0
2031	83,736	47,980	0.00	0	16,098	0
2032	83,290	47,647	0.00	0	16,002	0
2033	82,967	47,391	0.00	0	15,919	0
2034	82,730	47,169	0.00	0	15,848	0
2035	82,521	46,963	0.00	0	15,795	0

Table 4.39. Southern rock sole projection alternatives for model 21.2 continued western Gulf

	Scenario 6, Determination of whether SRS is currently overfished					
	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	13,427
2022	75,346	34,347	0.34	14,667	14,667	14,667
2023	68,306	32,642	0.34	13,299	13,299	13,299
2024	63,103	31,517	0.34	11,938	11,938	11,938
2025	58,319	29,554	0.34	10,628	10,628	10,628
2026	53,666	26,690	0.34	9,484	9,484	9,484
2027	49,419	23,523	0.34	8,586	8,586	8,586
2028	46,074	20,802	0.34	7,943	7,943	7,943
2029	43,798	18,873	0.34	7,513	7,513	7,513
2030	42,408	17,693	0.33	7,137	7,137	7,137
2031	41,712	17,091	0.32	6,765	6,765	6,765
2032	41,515	16,863	0.31	6,601	6,601	6,601
2033	41,552	16,811	0.31	6,553	6,553	6,553
2034	41,686	16,824	0.31	6,551	6,551	6,551
2035	41,815	16,852	0.31	6,570	6,570	6,570
	Scenario 7, Determination of whether SRS are approaching overfished condition					
	Total Biomass	SSB	F	Catch	OFL	ABC
2021	72,453	32,477	0.00	41	13,427	13,427
2022	75,346	34,549	0.28	12,370	14,667	14,667
2023	70,049	33,831	0.28	11,525	13,666	13,666
2024	66,068	33,299	0.34	12,561	12,561	12,561
2025	60,548	30,990	0.34	11,096	11,096	11,096
2026	55,293	27,800	0.34	9,827	9,827	9,827
2027	50,570	24,345	0.34	8,829	8,829	8,829
2028	46,865	21,389	0.34	8,111	8,111	8,111
2029	44,329	19,279	0.34	7,627	7,627	7,627
2030	42,758	17,963	0.33	7,262	7,262	7,262
2031	41,903	17,248	0.32	6,841	6,841	6,841
2032	41,608	16,949	0.31	6,641	6,641	6,641
2033	41,591	16,854	0.31	6,570	6,570	6,570
2034	41,697	16,843	0.31	6,557	6,557	6,557
2035	41,815	16,858	0.31	6,571	6,571	6,571

Figures

Figure 4.1. Total rock sole catch (retained + discards, top-left panel), proportion of catch by gear type (top-right panel), catch by NMFS area (middle-left panel), proportion of catch by area (middle-right panel), and total catch by month and NMFS area (bottom-left panel). Area 610 represents the western GOA and areas 620 and 630 represent the Central GOA.

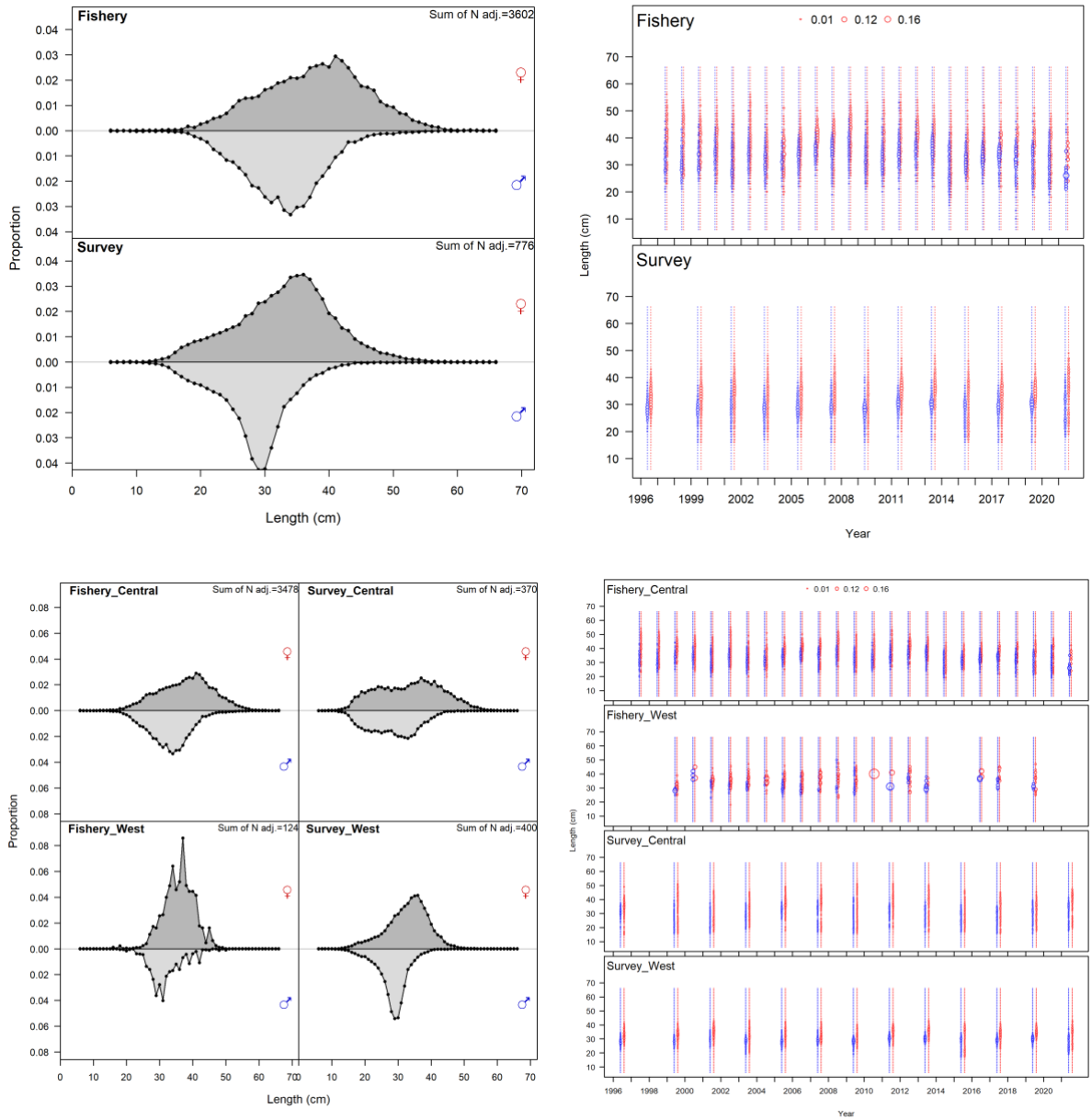


Figure 4.2. Northern rock sole fleet specific total length composition data in centimeters (top-left), fleet specific annual length composition data (top-right), fleet and area specific total length composition data (bottom-left), and fleet and area specific annual length composition data (bottom-right). The red bubbles represent females and the blue bubbles represent males.

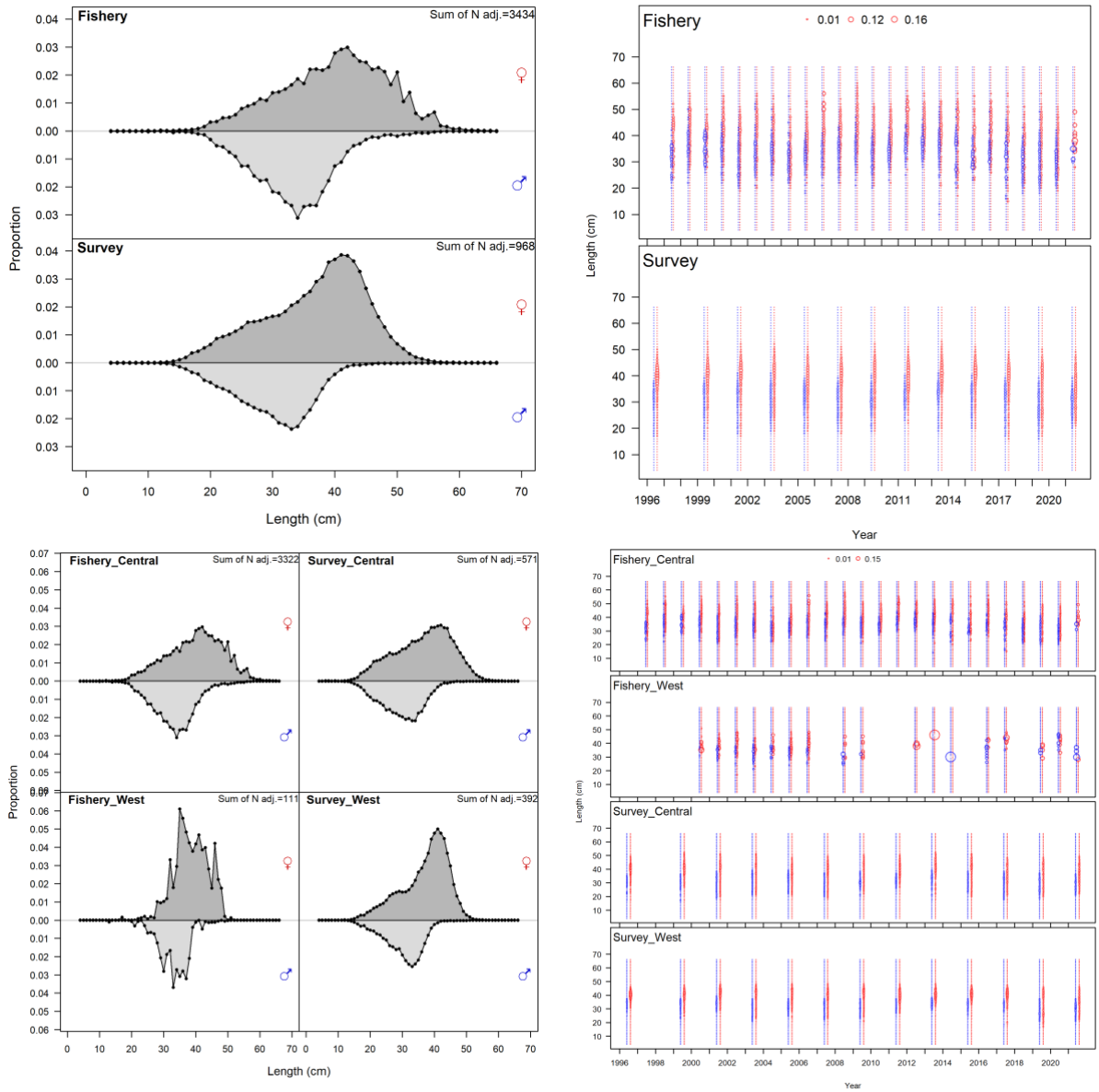


Figure 4.3 Southern rock sole fleet specific total length composition data in centimeters (top-left), fleet specific annual length composition data (top-right), fleet and area specific total length composition data (bottom-left), and fleet and area specific annual length composition data (bottom-right). The red bubbles represent females and the blue bubbles represent males.

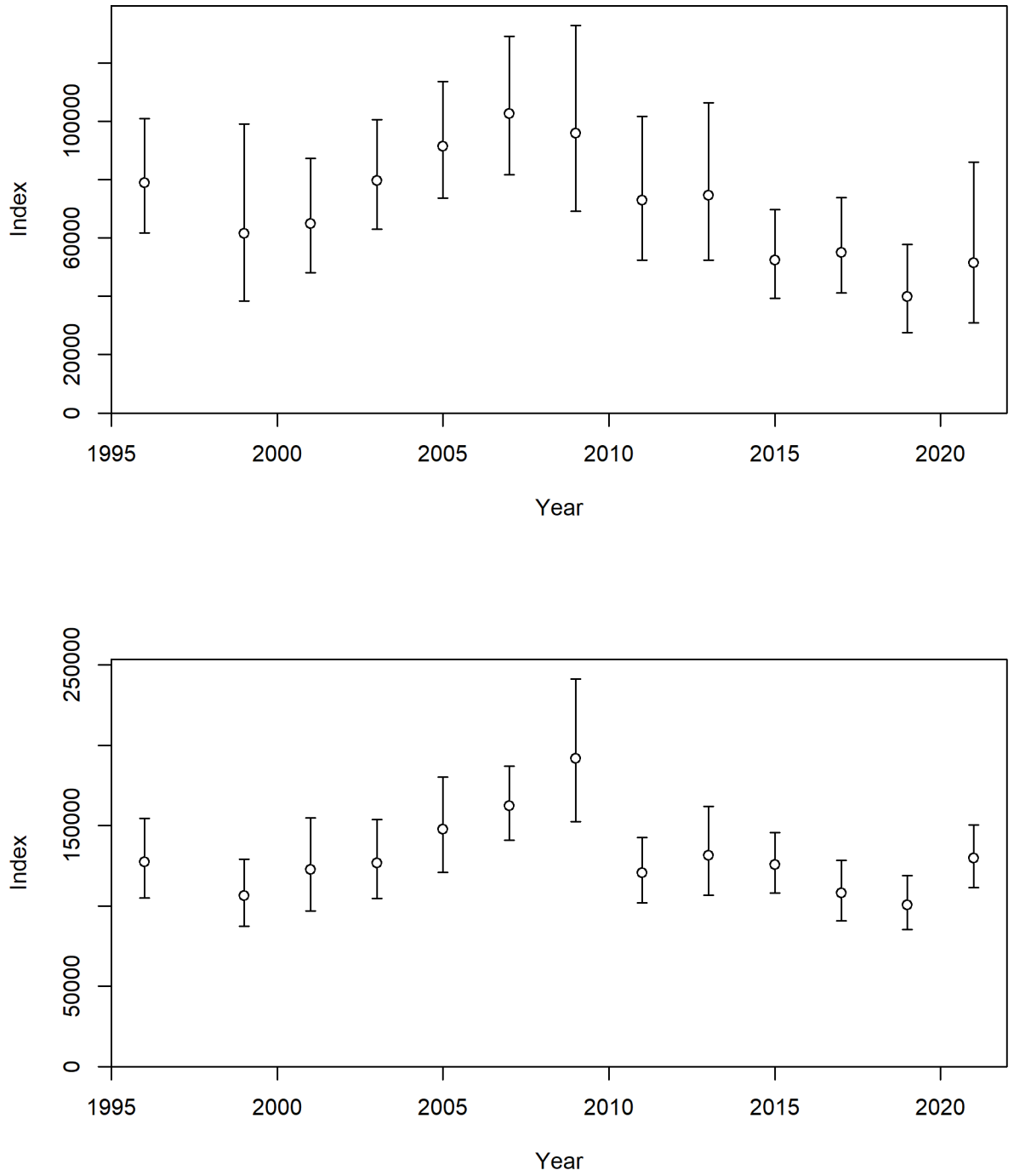


Figure 4.4. Total biomass estimates from the NMFS GOA bottom trawl survey for northern (top panel) and southern rock sole (bottom panel).

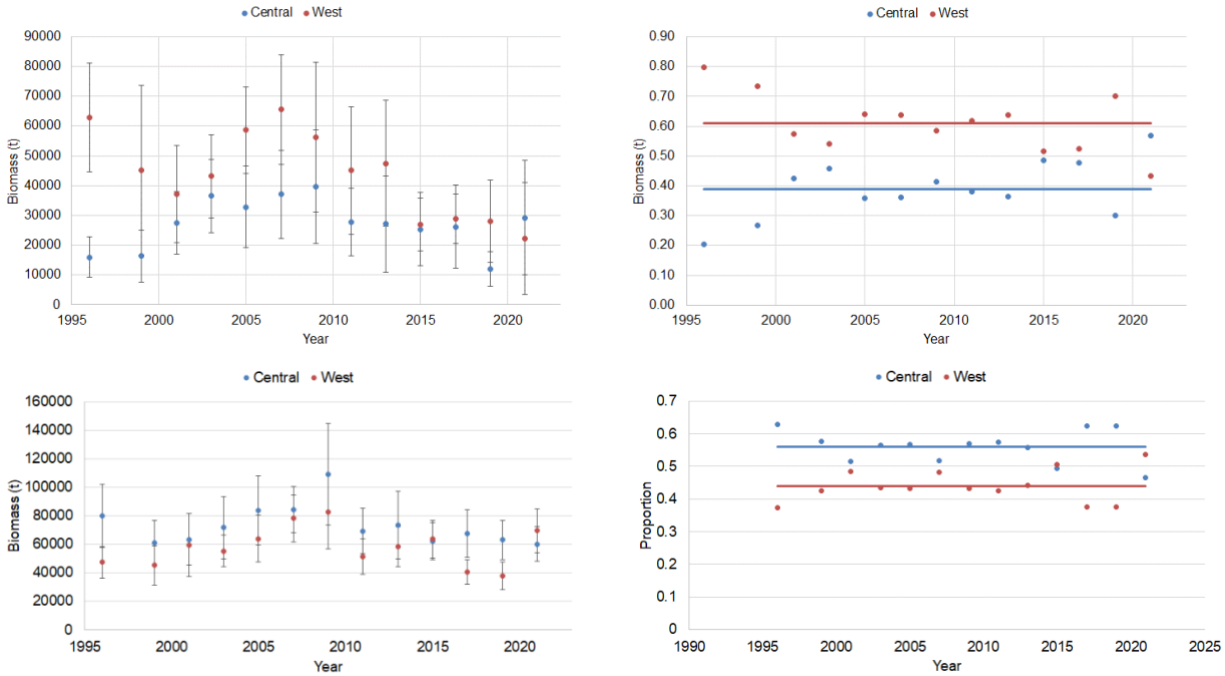


Figure 4.5. Total biomass estimates and proportion of biomass from the NMFS GOA bottom trawl survey by species and area; northern rock sole (top panels) and southern rock sole (bottom panels).

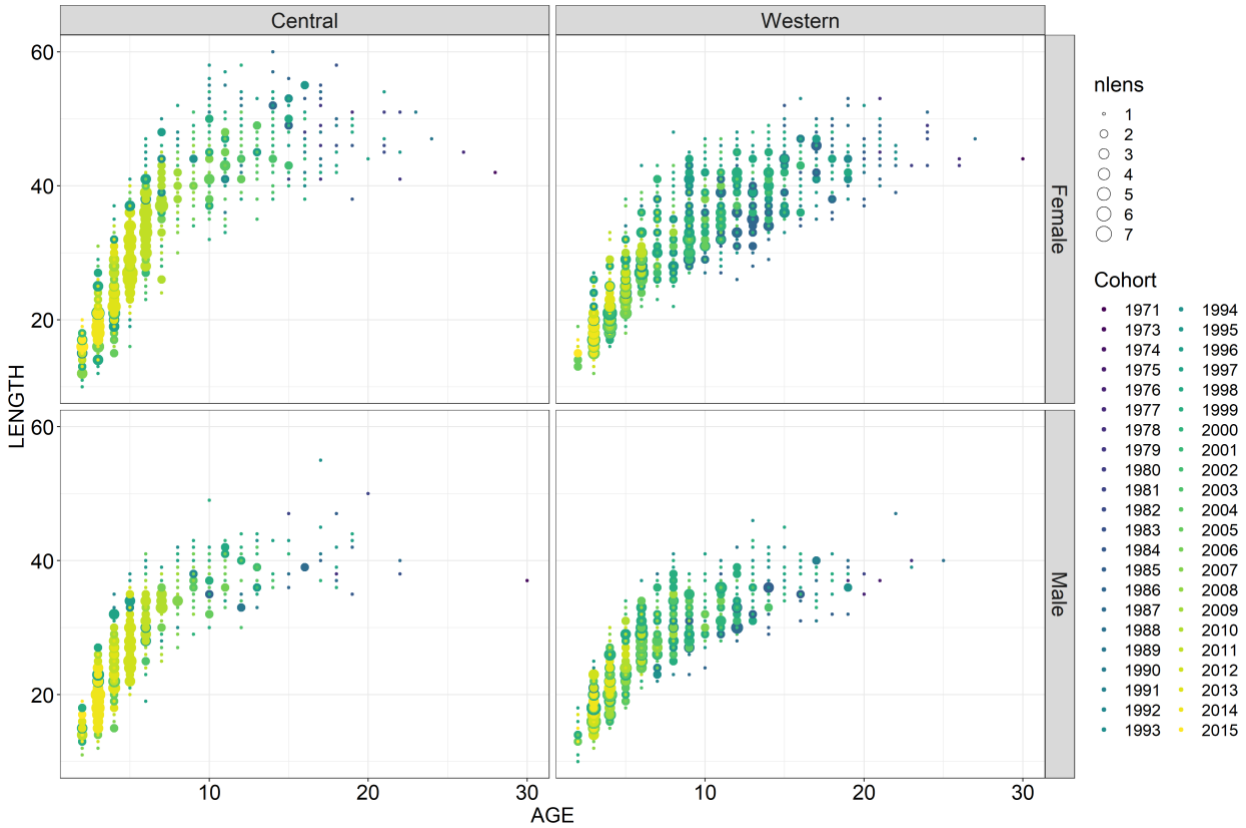


Figure 4.6. NMFS bottom trawl survey conditional age-at-length data for northern rock sole by area and sex. The size of the bubbles represents the number of lengths per age bin and the color represents cohort. The central Gulf represents Chirikof and Kodiak regions.

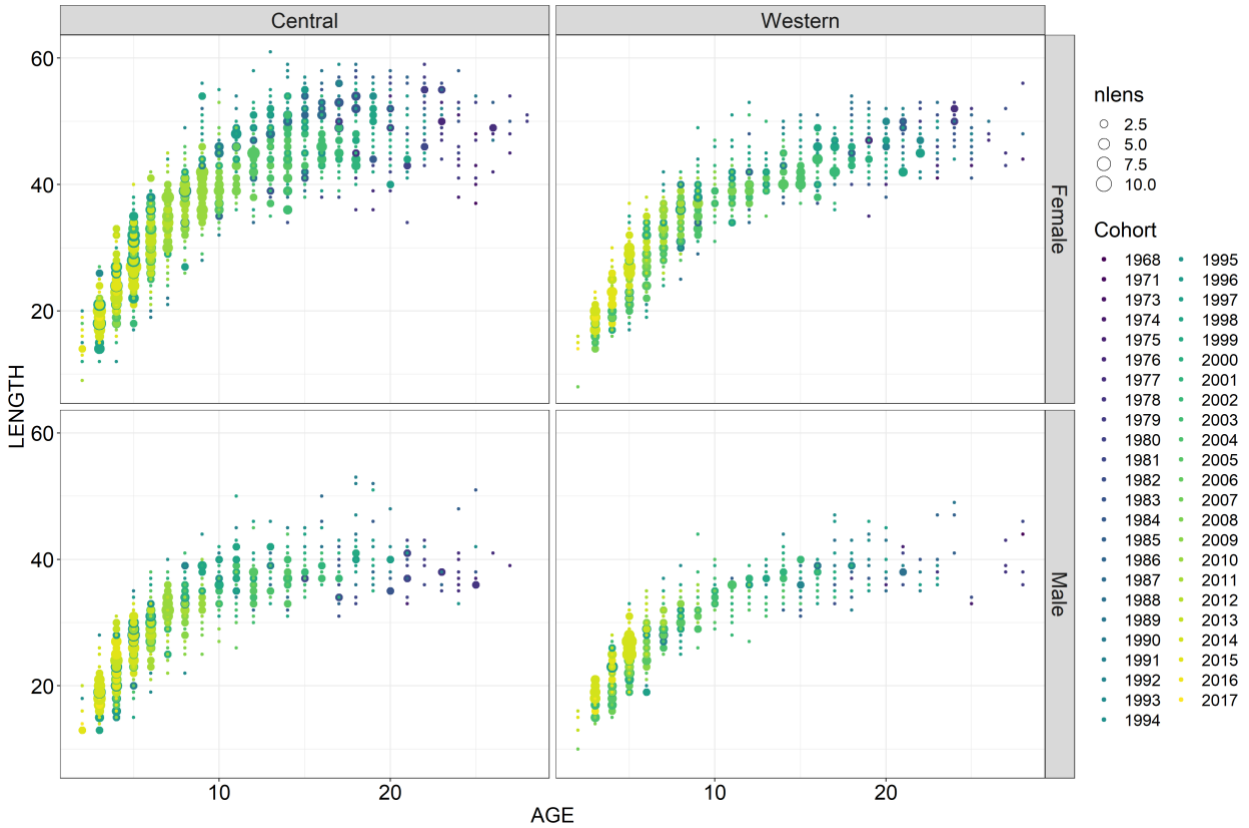


Figure 4.7. NMFS bottom trawl survey conditional age-at-length data for southern rock sole by area and sex. The size of the bubbles represents the number of lengths per age bin and the color represents cohort. The central Gulf represents Chirikof and Kodiak regions.

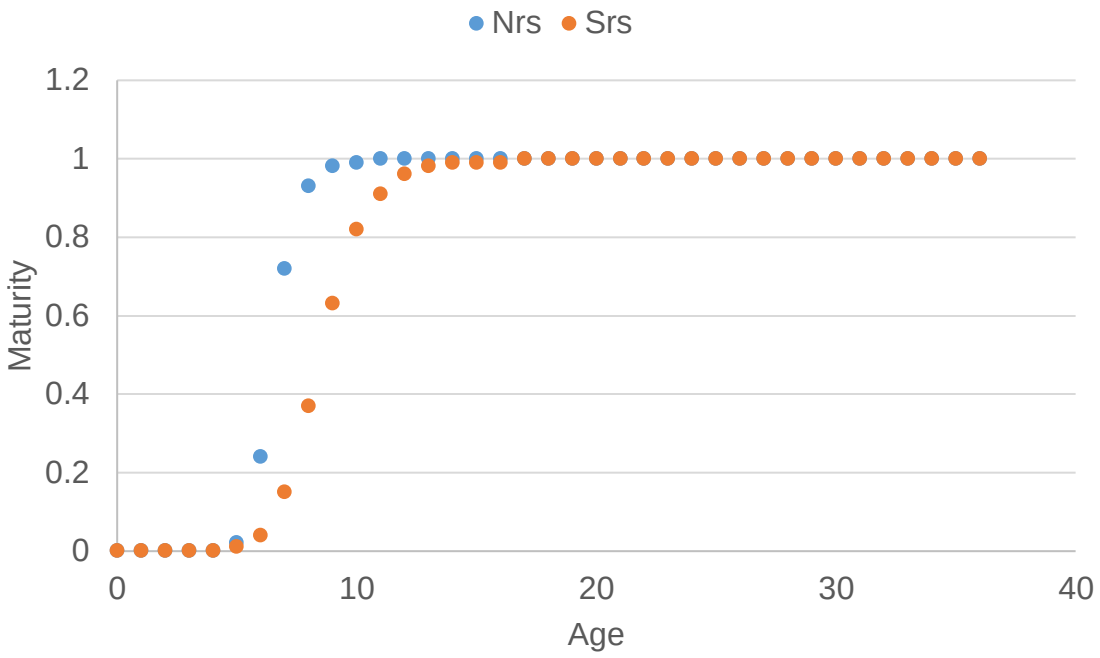
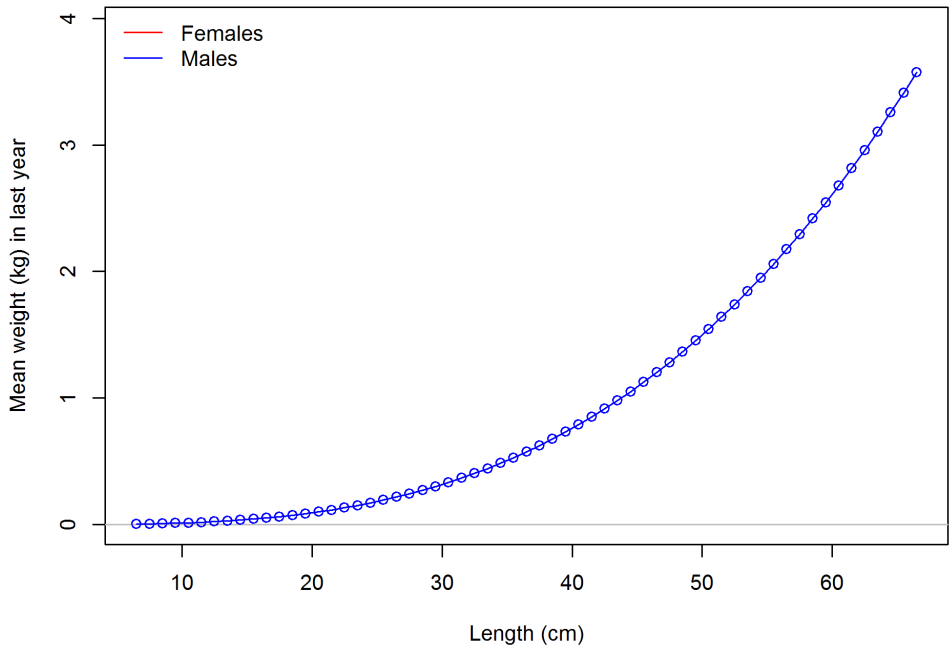


Figure 4.8. Northern and southern rock sole maturity curves.

a)



b)

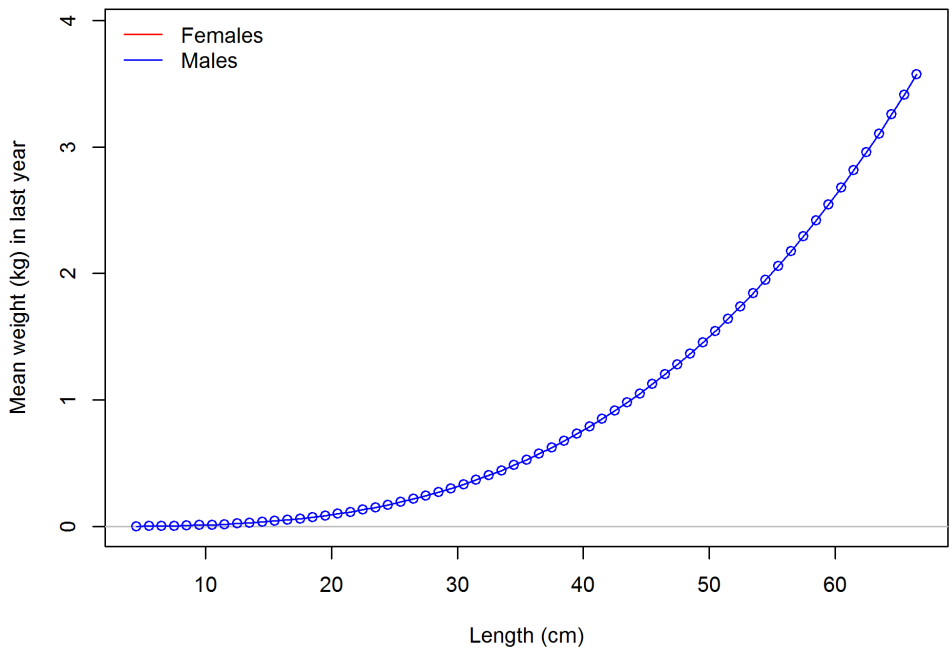


Figure 4.9. a) Northern and b) southern rock sole length-weight relationships.

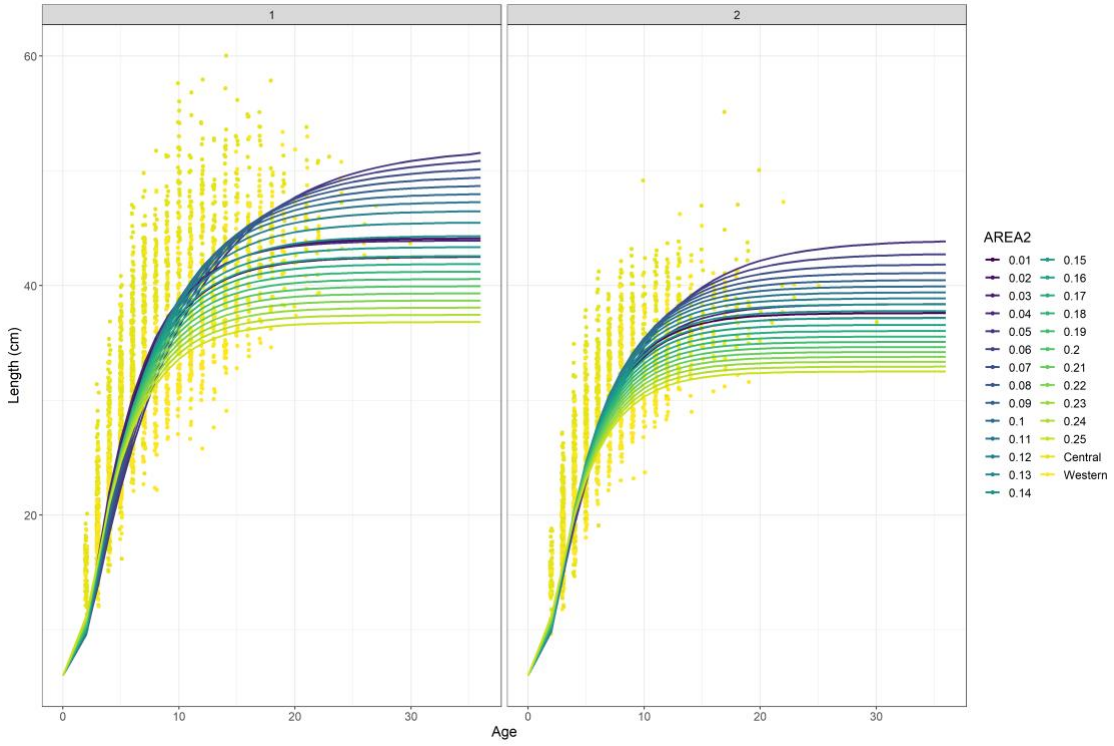


Figure 4.10. Estimated growth curves over a range of values for the CV at the oldest age parameter. The dots are the conditional age-at-length data by area. The colored lines represent the range of CV values explored. The female data and growth estimates are in the left panel and the male data and growth estimates are in the right panel. The dotted lines signify the uncertainty region associated with the mean (solid lines).

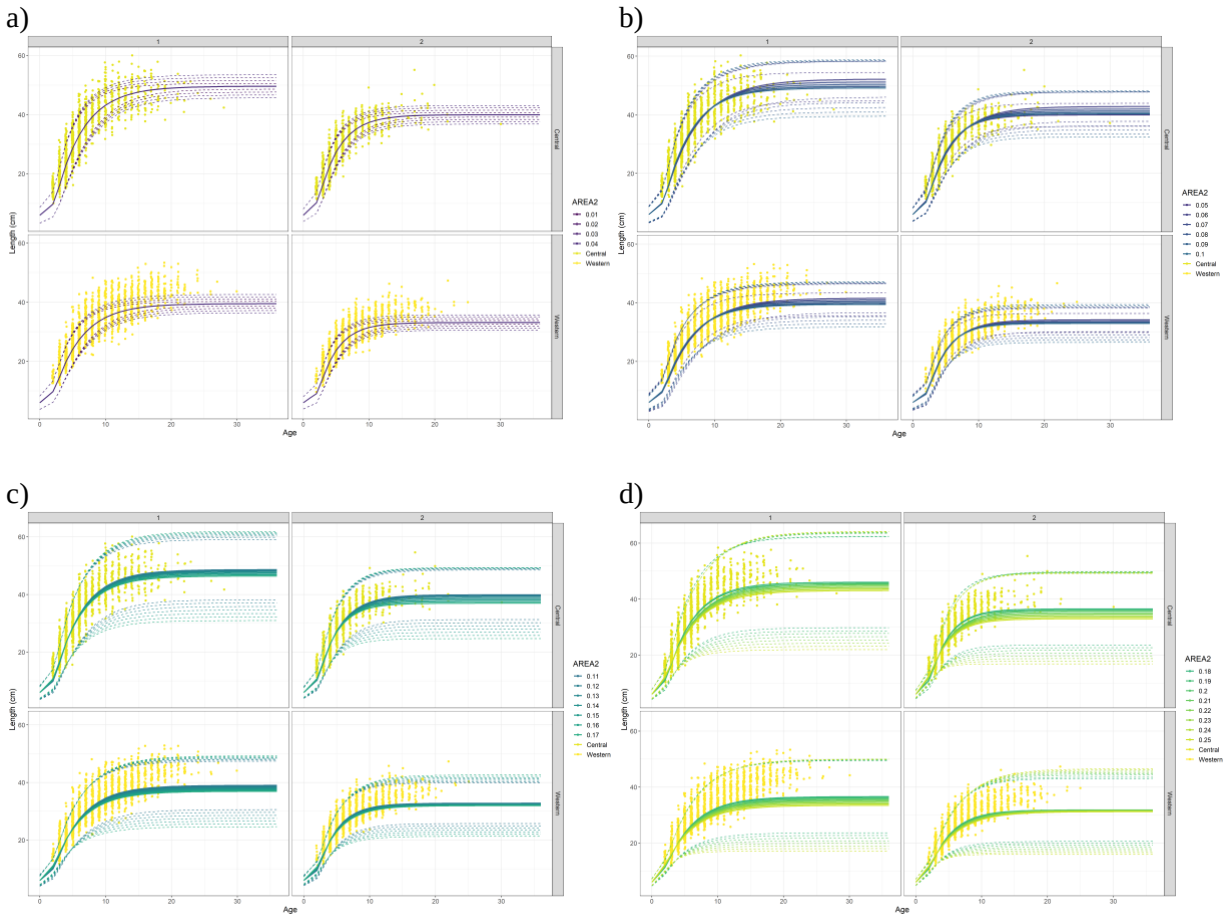


Figure 4.11. Estimated growth curves over a range of values for the CV at the oldest age parameter. The colored lines represent the range of CV values explored. a) CV is between 0.01 and 0.04, b) CV is between 0.05 and 0.09, c) CV is between 0.11 and 0.17, and d) CV is between 0.18 and 0.25. The female data and growth estimates are in the left panels and the male data and growth estimates are in the right panels.

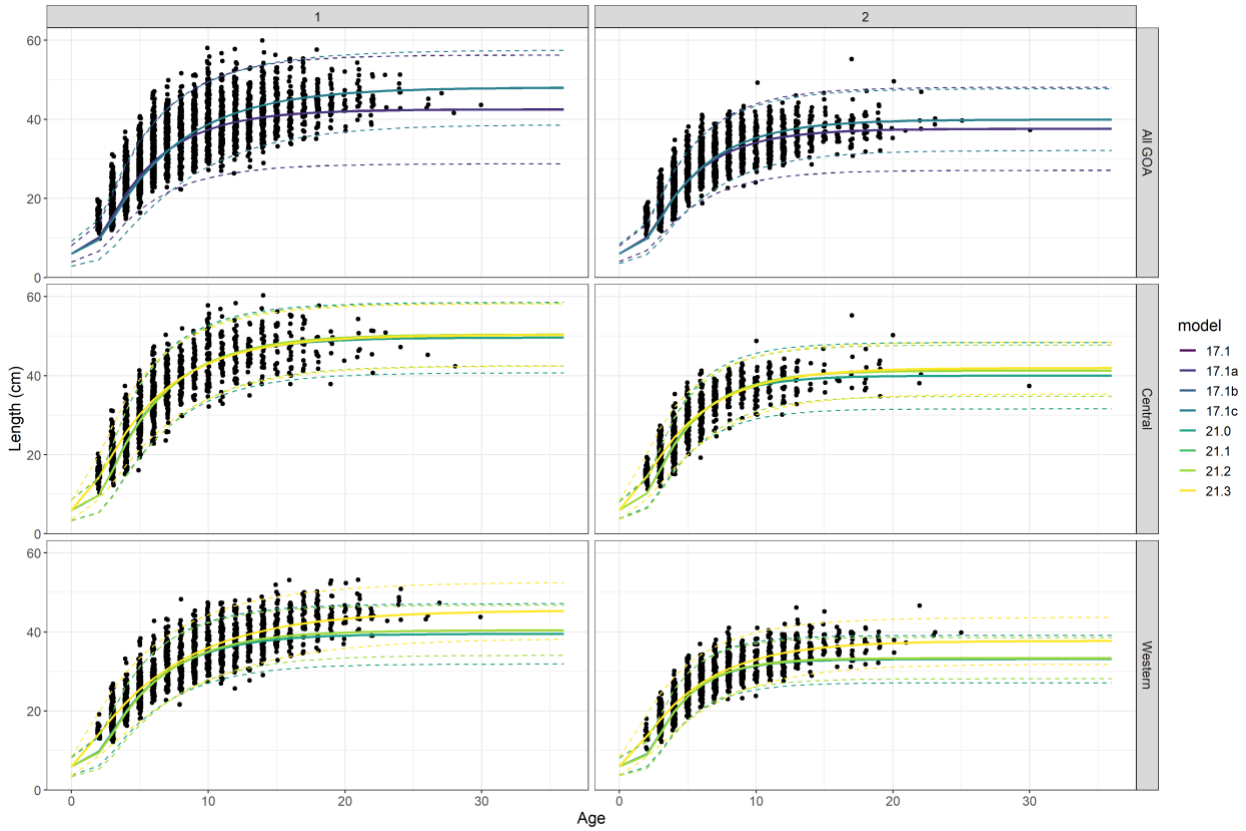


Figure 4.12. Mean northern rock sole growth curve estimates (solid lines) and associated uncertainty (area between the dashed lines) from each model. The single area models (17.1, 17.1a-c) were fit to the aggregated conditional age-at-length data and the growth morphs models were fit to area-specific conditional age-at-length. Female data are shown in the first column and the male data are shown in the second column.

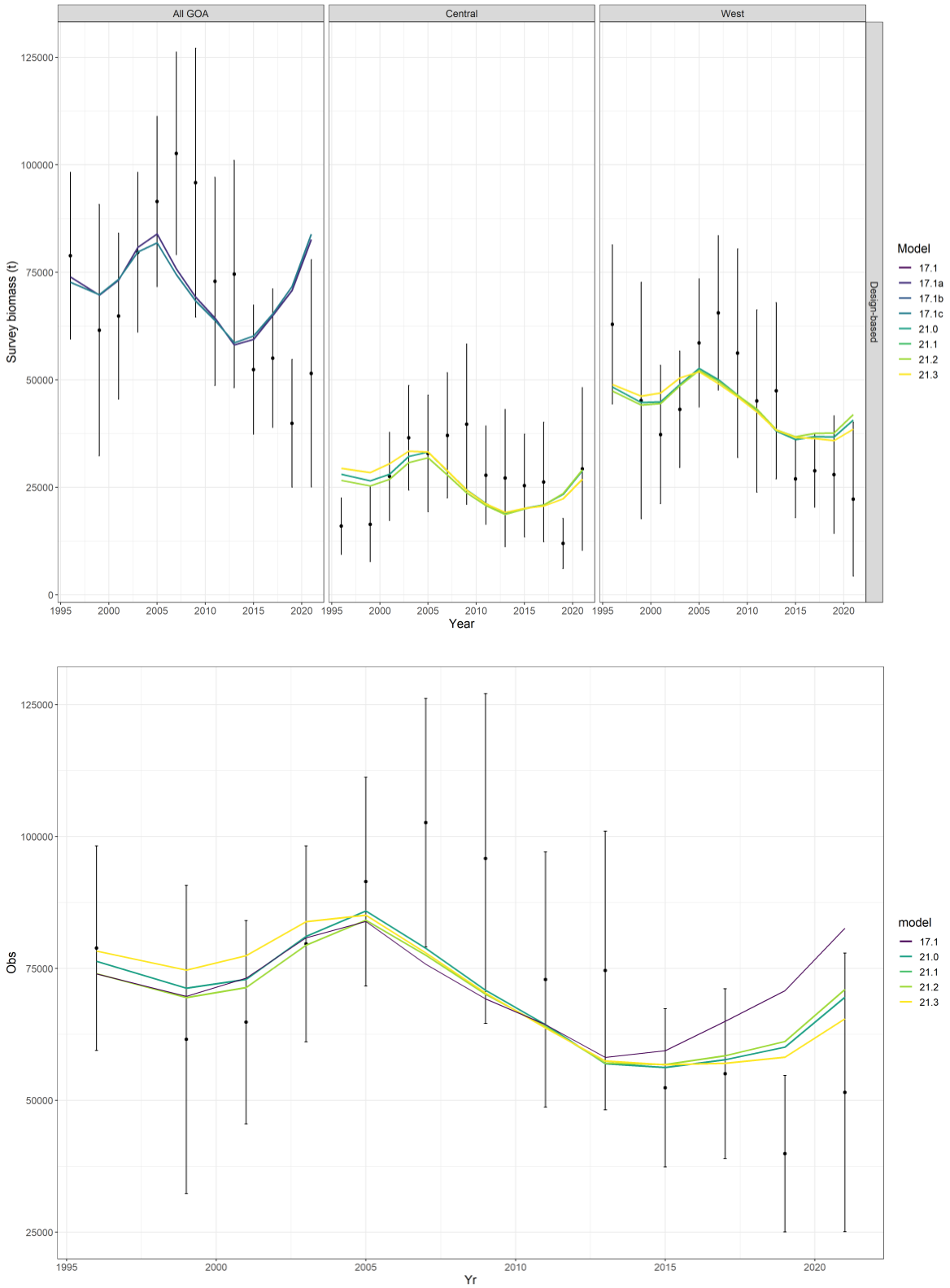


Figure 4.13. NMFS GOA bottom trawl survey northern rock sole index and model fit comparison by area and model (top panel) and a comparison of model fit to aggregate survey biomass (t) by model 17.1 (single are model) and the growth morph models.

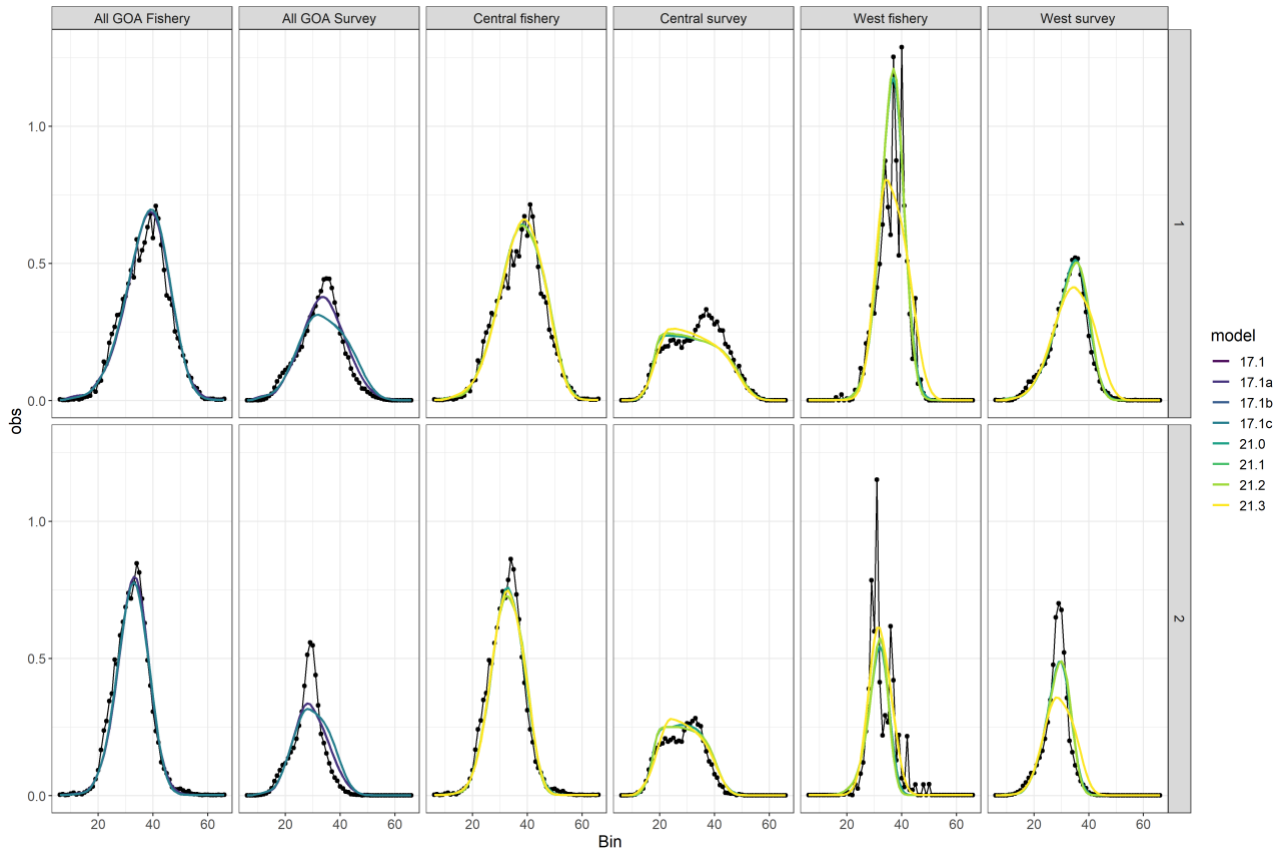


Figure 4.14. Model fit to the northern rock sole fishery and survey size length composition data by fleet, sex, and area aggregated over years. Line color reflects model, data are shown as black dots and lines. Females are shown in the first row and males are shown in the second row.

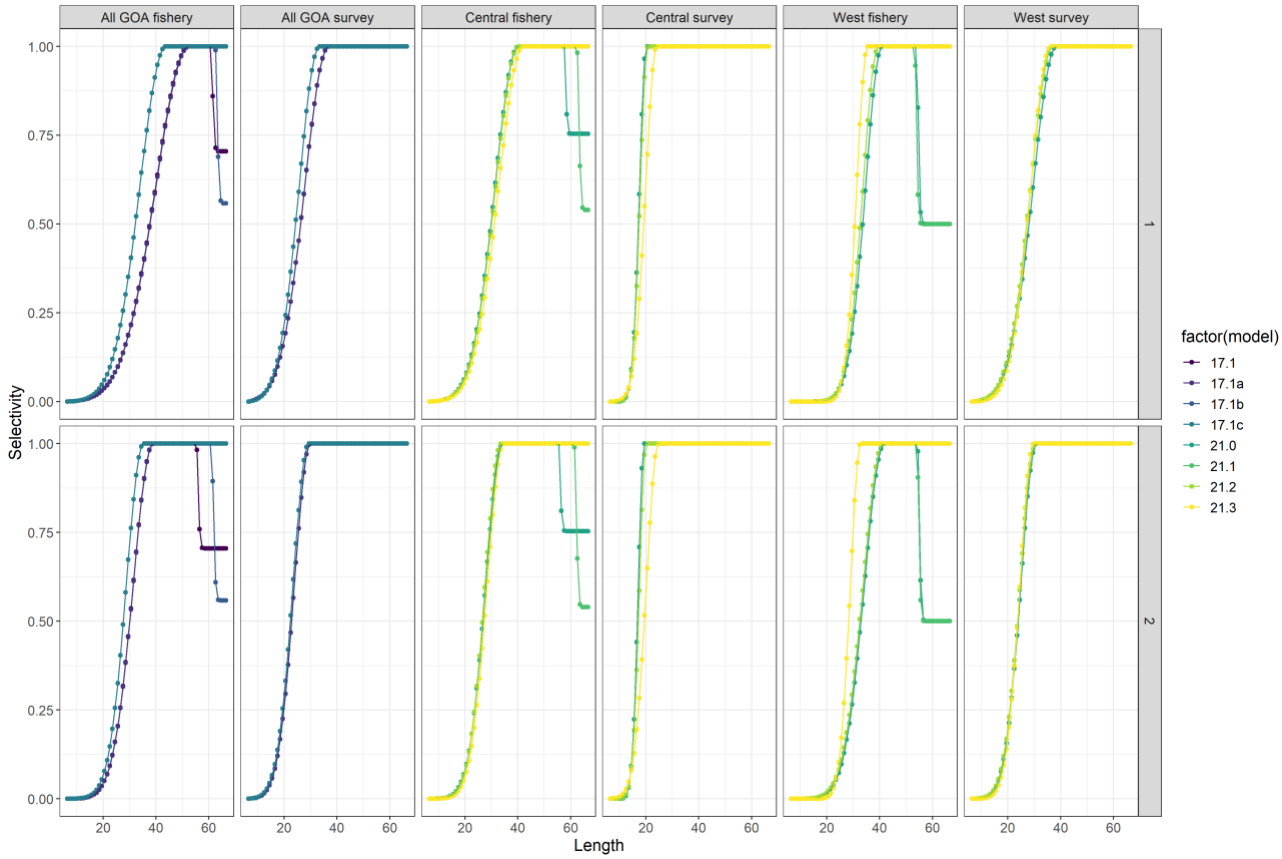


Figure 4.15. Estimated selectivity by model, area, and sex. Female selectivity is shown in the top row and male selectivity is shown in the bottom row. Line color reflects the model.

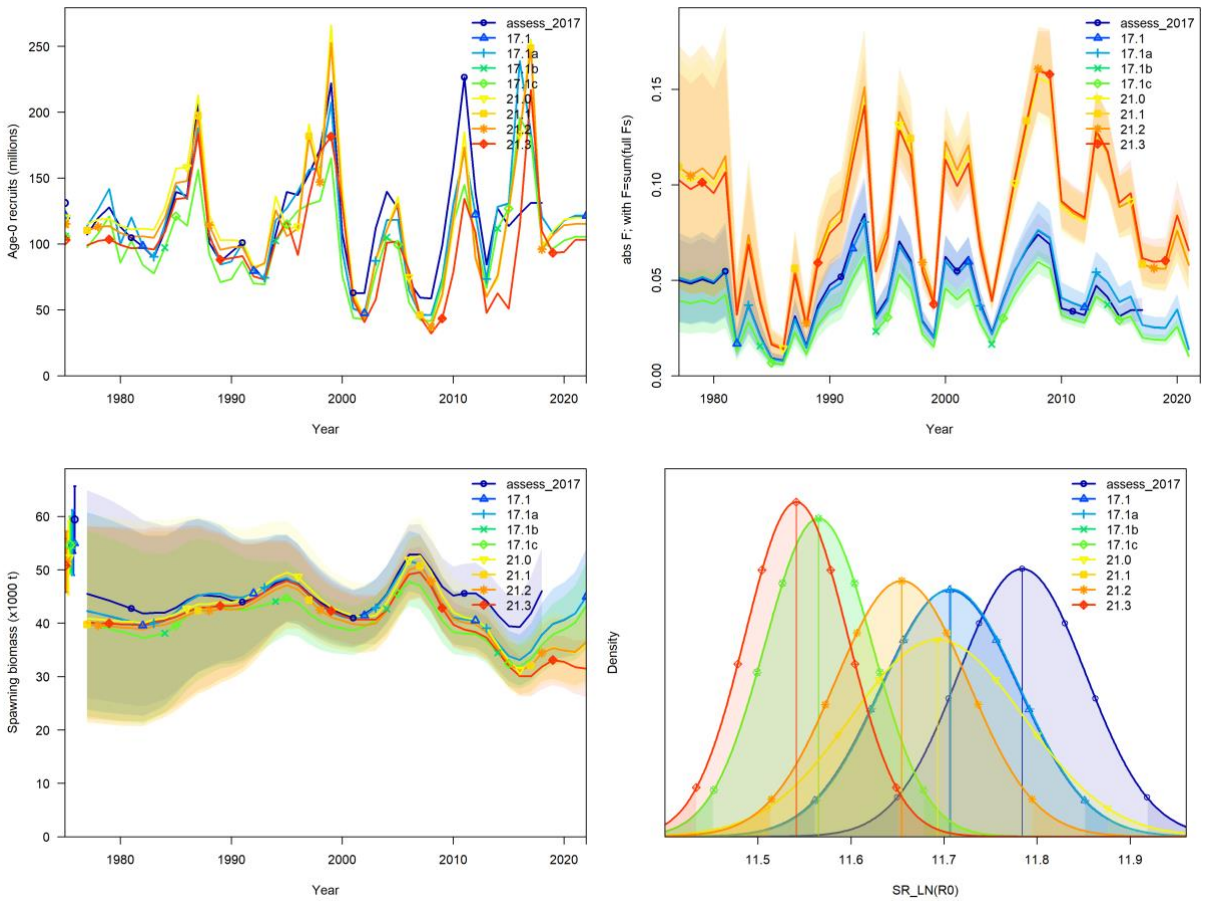


Figure 4.16. Northern rock sole age-0 recruits (top left), fishing mortality (top right) and spawning stock biomass (middle left) with uncertainty, and ln(R_0) density (bottom left).

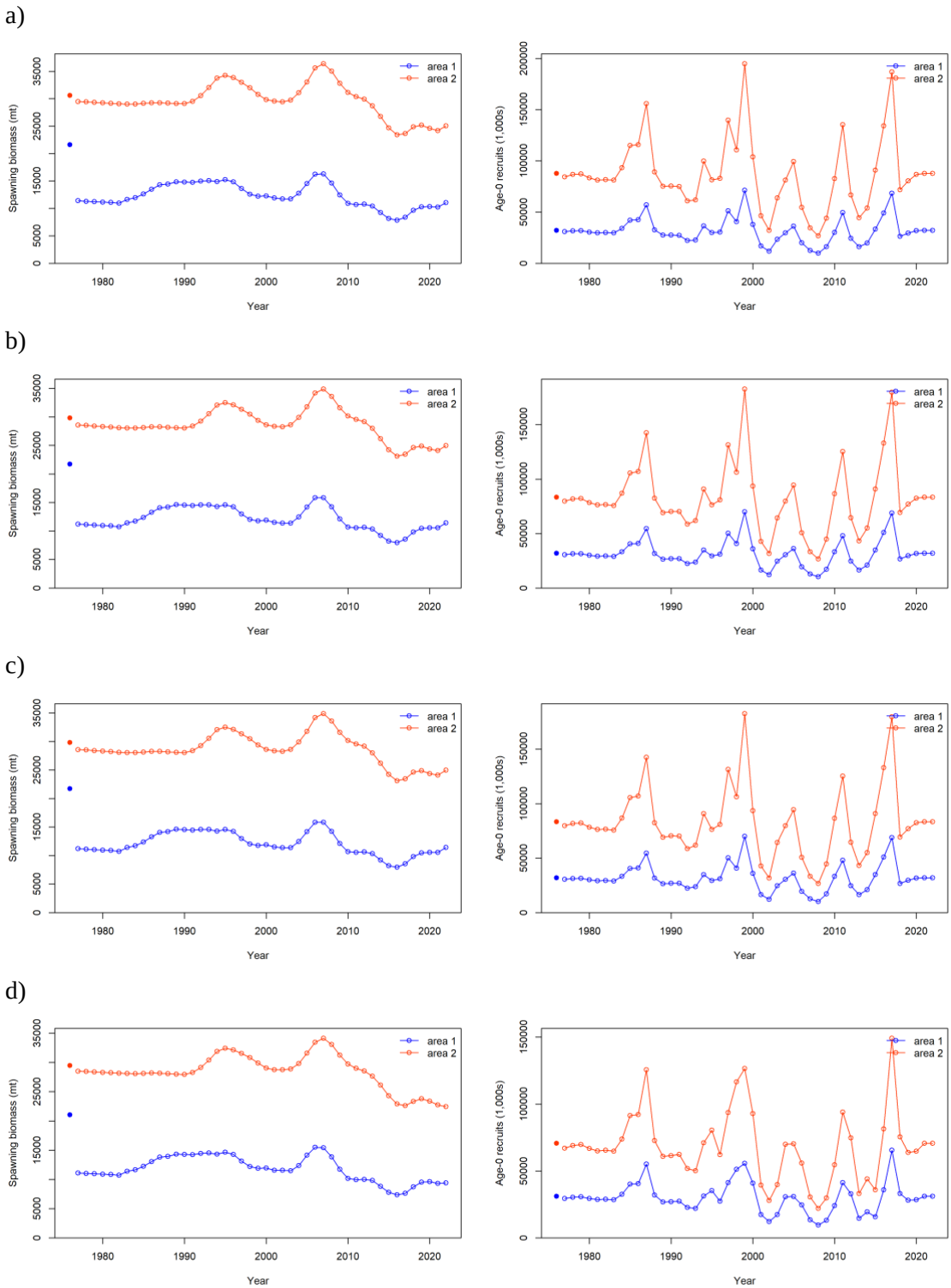


Figure 4.17. Northern rock sole SSB and age-0 recruits by area from models a) 21.0, b) 21.1, c) 21.2, and c) 21.3. Area 1 represents the central Gulf and area 2 represents the western Gulf.

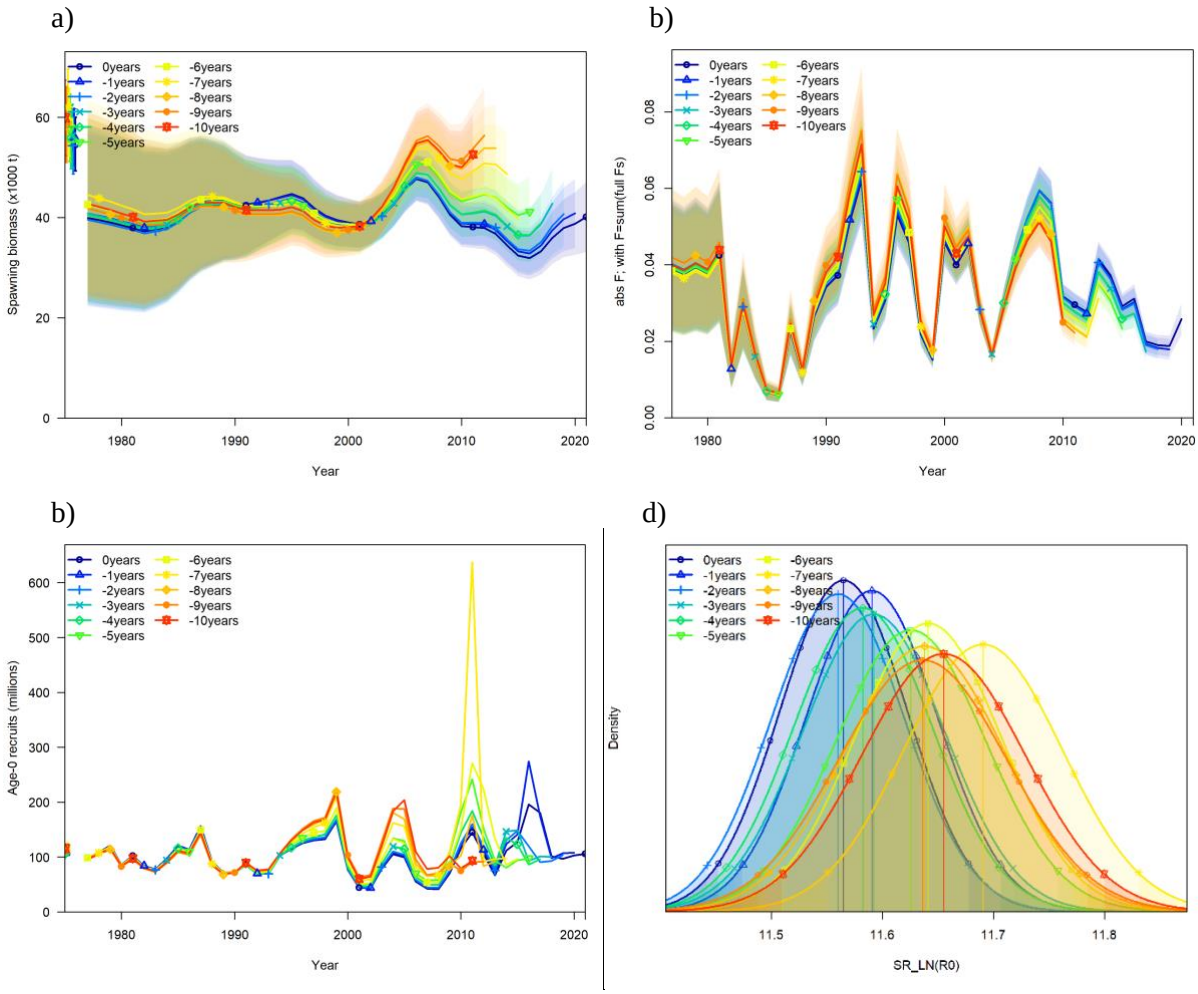


Figure 4.18. Northern rock sole retrospective analysis results for model 17.1c. a) spawning biomass, b) fishing mortality, c) age-0 recruits, and d) density of $LN(R_0)$

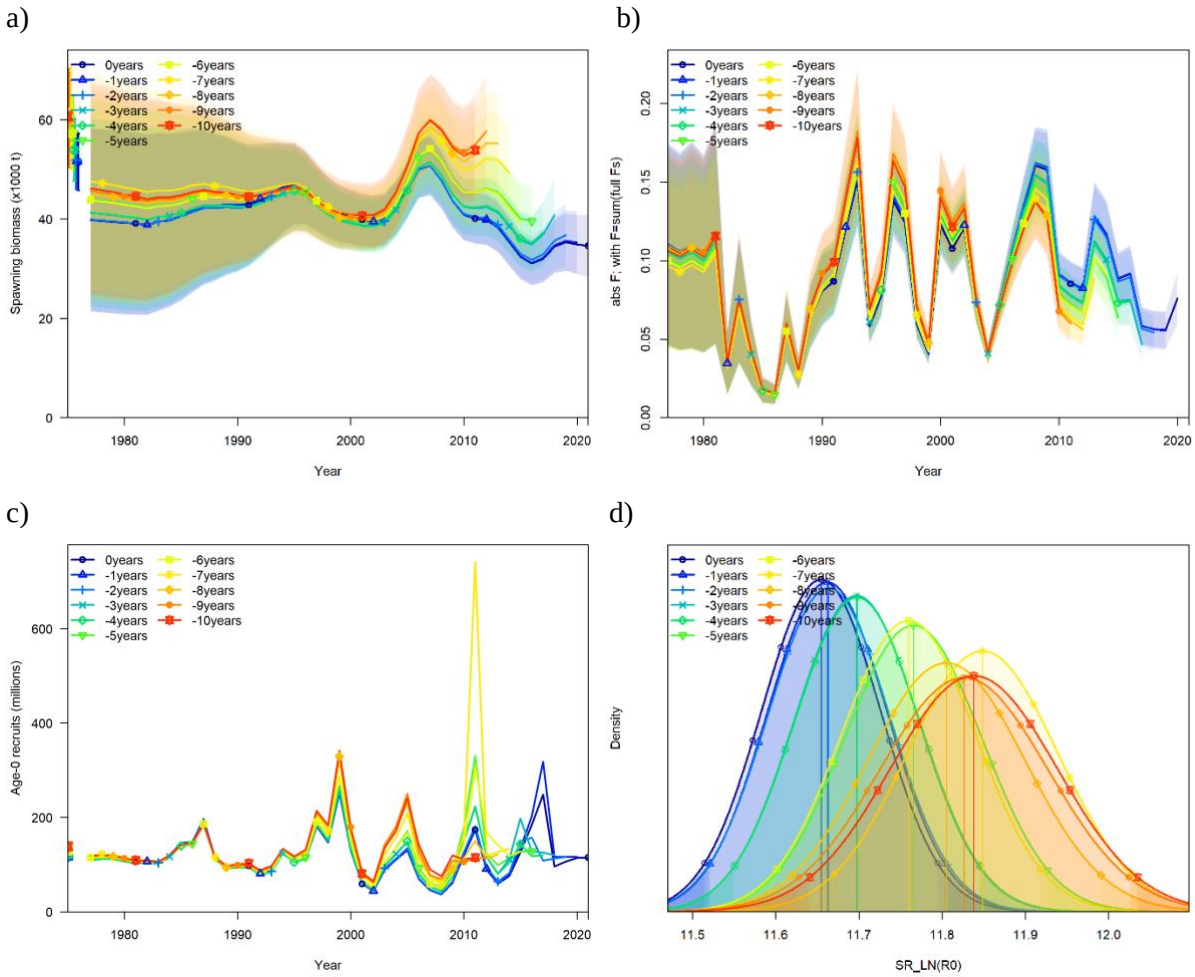


Figure 4.19. Northern rock sole retrospective analysis results for model 21.2. a) spawning biomass, b) fishing mortality, c) age-0 recruits, and d) density of $LN(R_0)$

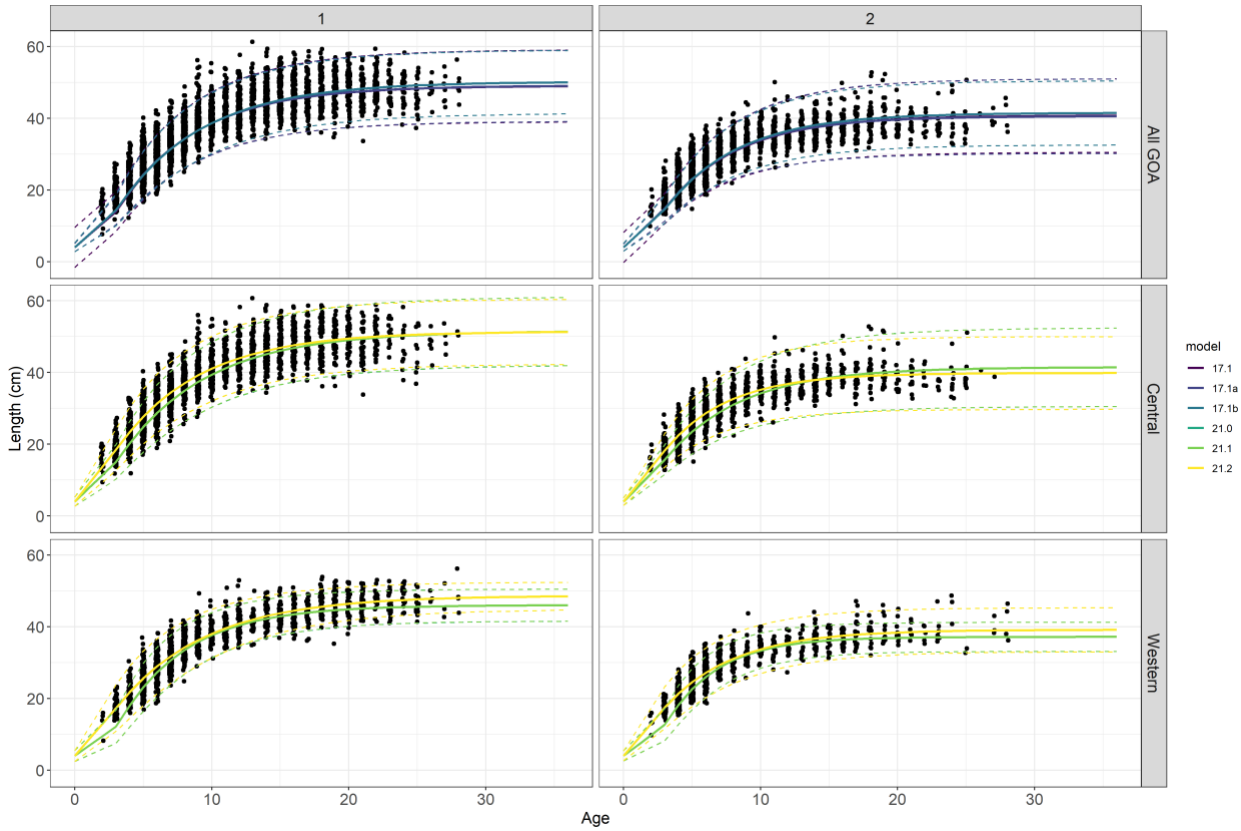


Figure 4.20. Mean southern rock sole growth curve estimates (solid lines) and associated uncertainty (area between the dashed lines) from each model. The single are models (17.1, 17.1a-b) were fit to the aggregated conditional age-at-length data and the growth morphs models were fit to area-specific conditional age-at-length. Female data and estimates are shown in the left column and the male data and estimates are shown in the right column.

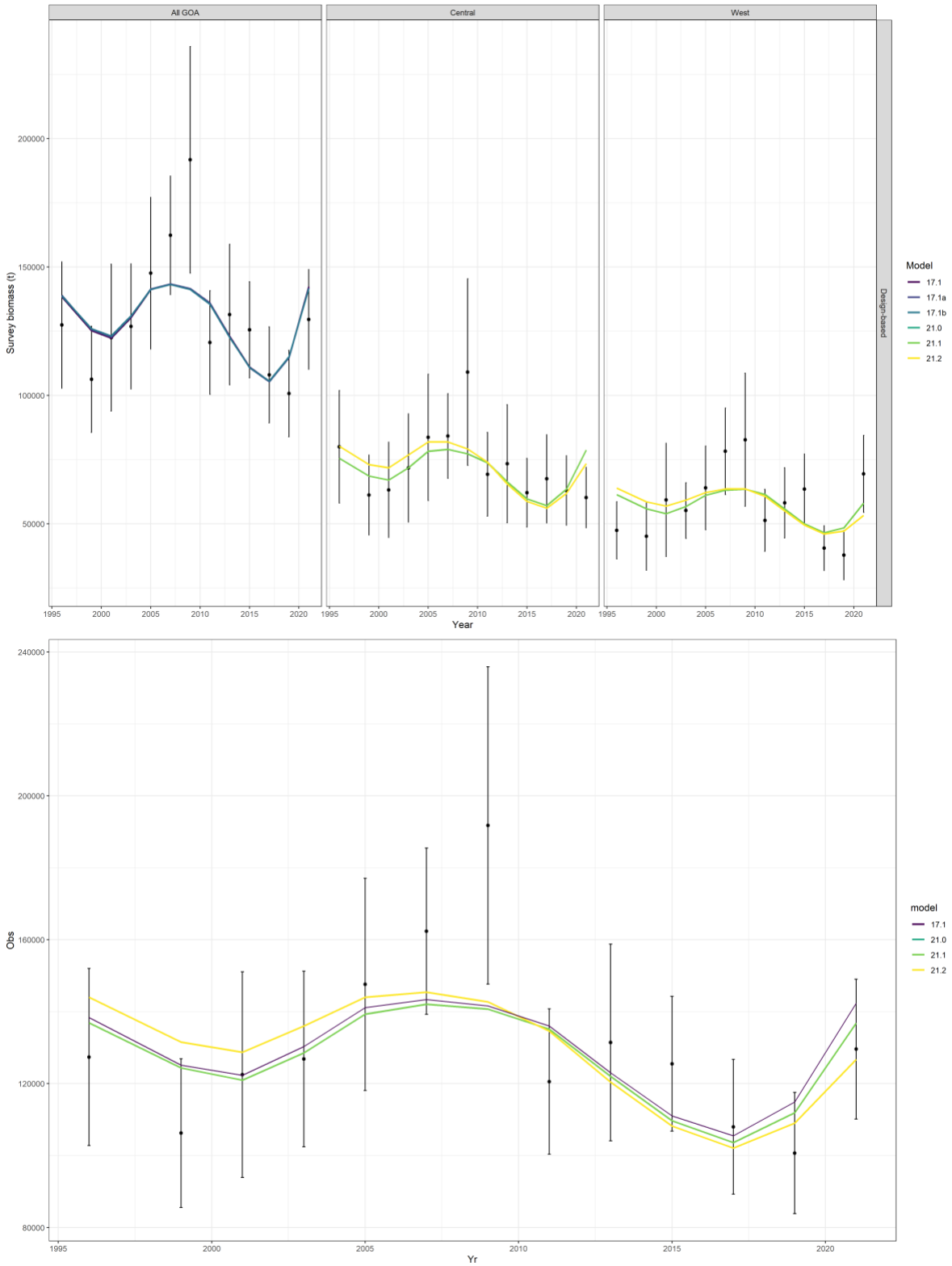


Figure 4.21. NMFS GOA bottom trawl survey southern rock sole index and model fit comparison.

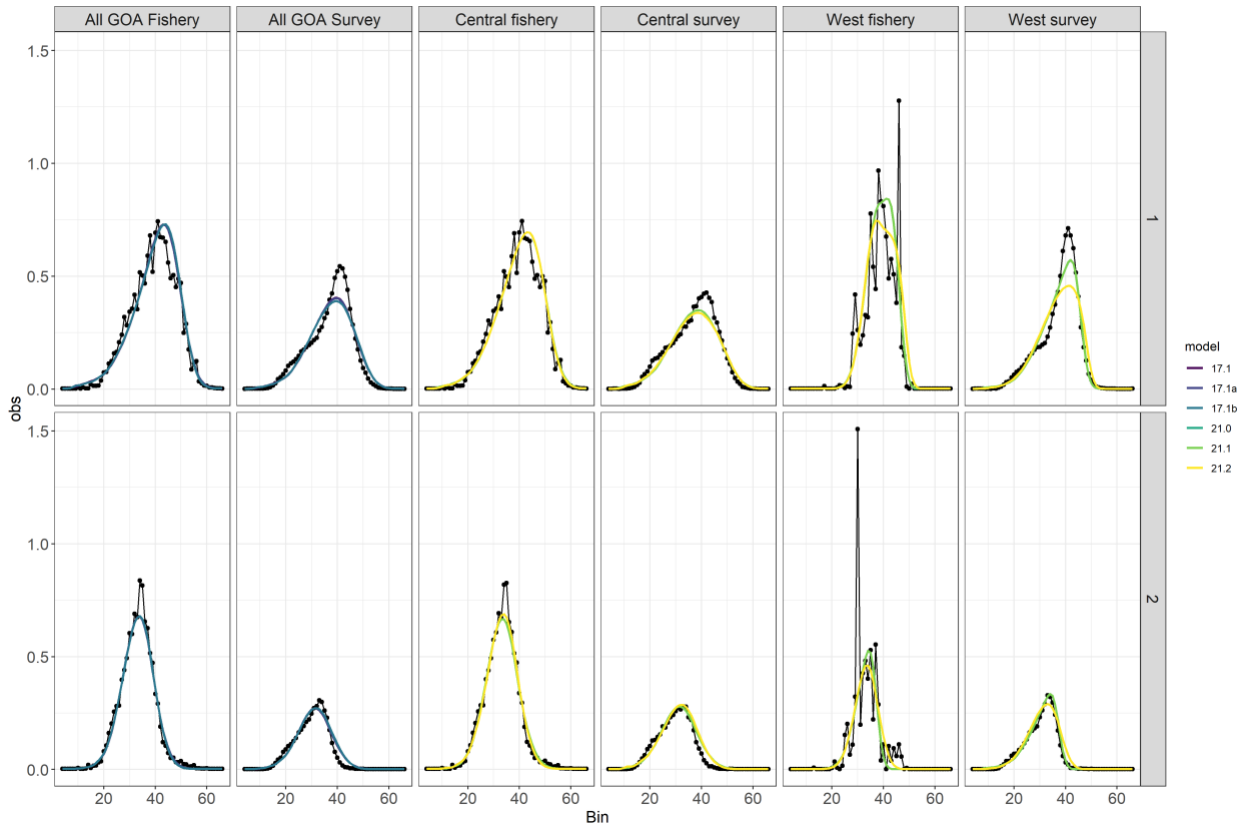


Figure 4.22. Fits to the southern rock sole fishery and survey size composition data aggregated over years by sex (female, top row; males, bottom row) and area.

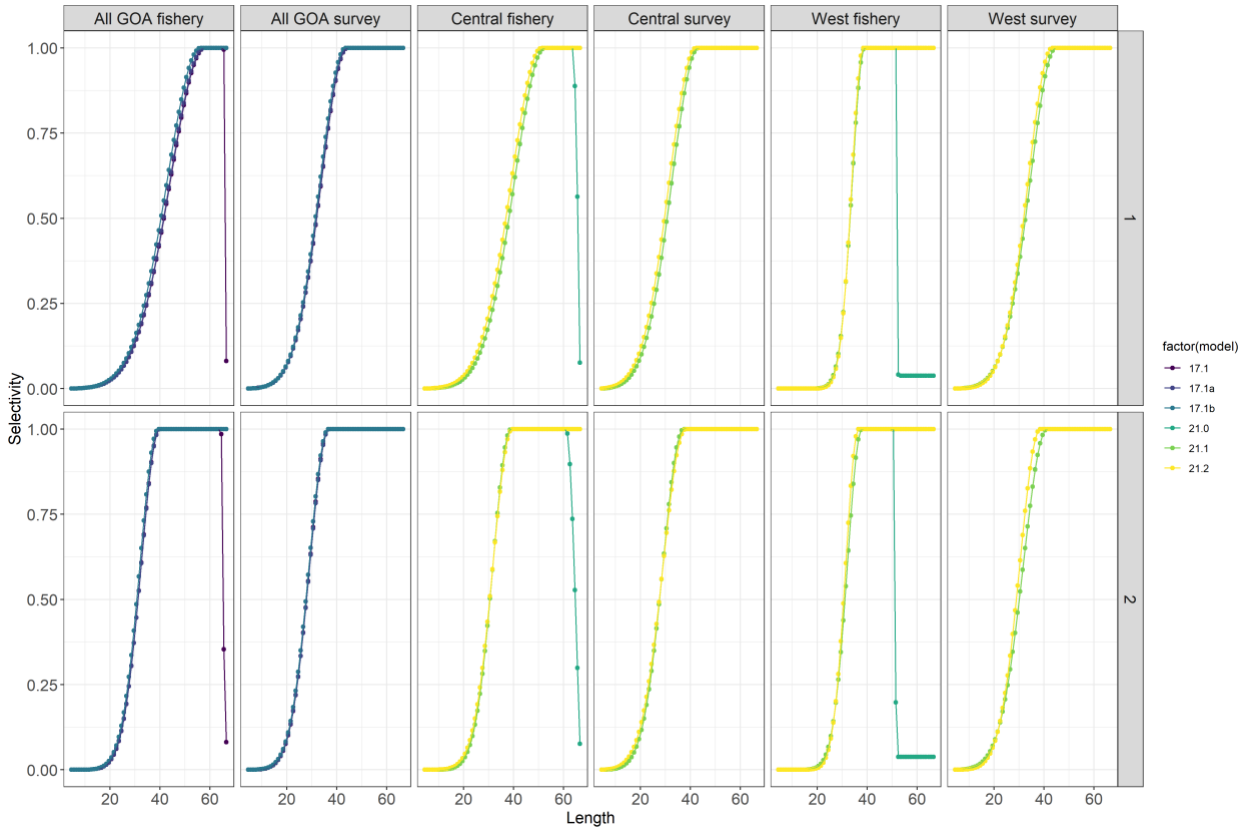
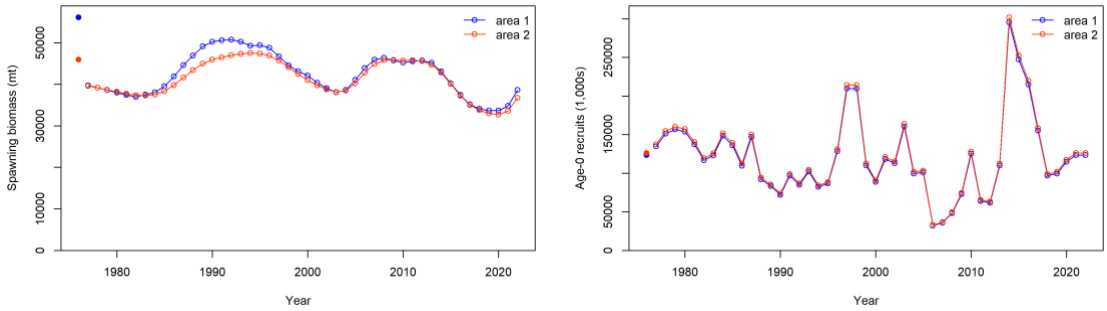
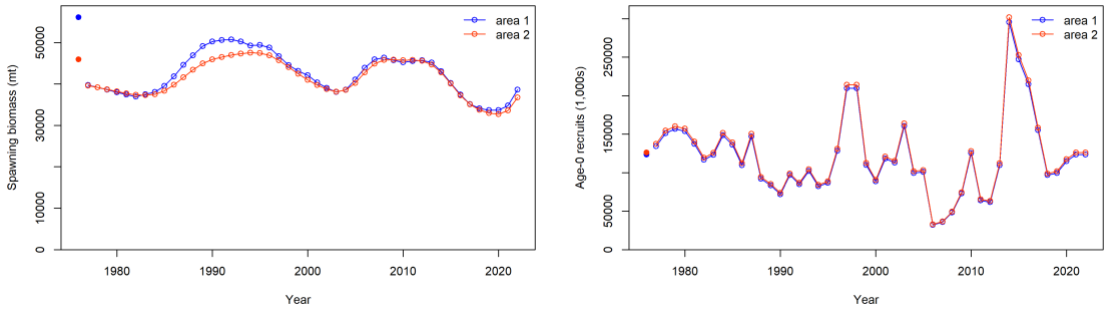


Figure 4.23. Estimated southern rock sole fishery and survey estimated selectivity by area and sex (females, top row and males, bottom row).

a)



b)



c)

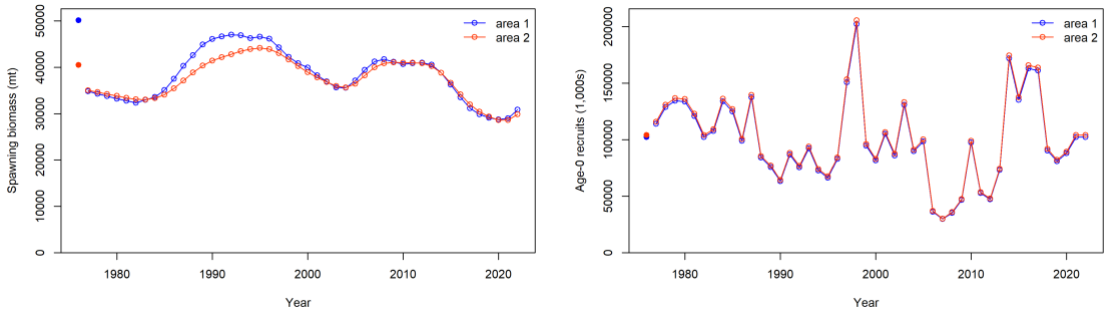


Figure 4.24. Northern rock sole SSB and age-0 recruits by area from models a) 21.0, b) 21.1, c) 21.2, and c) 21.3. Area 1 represents the central Gulf and area 2 represents the western Gulf.

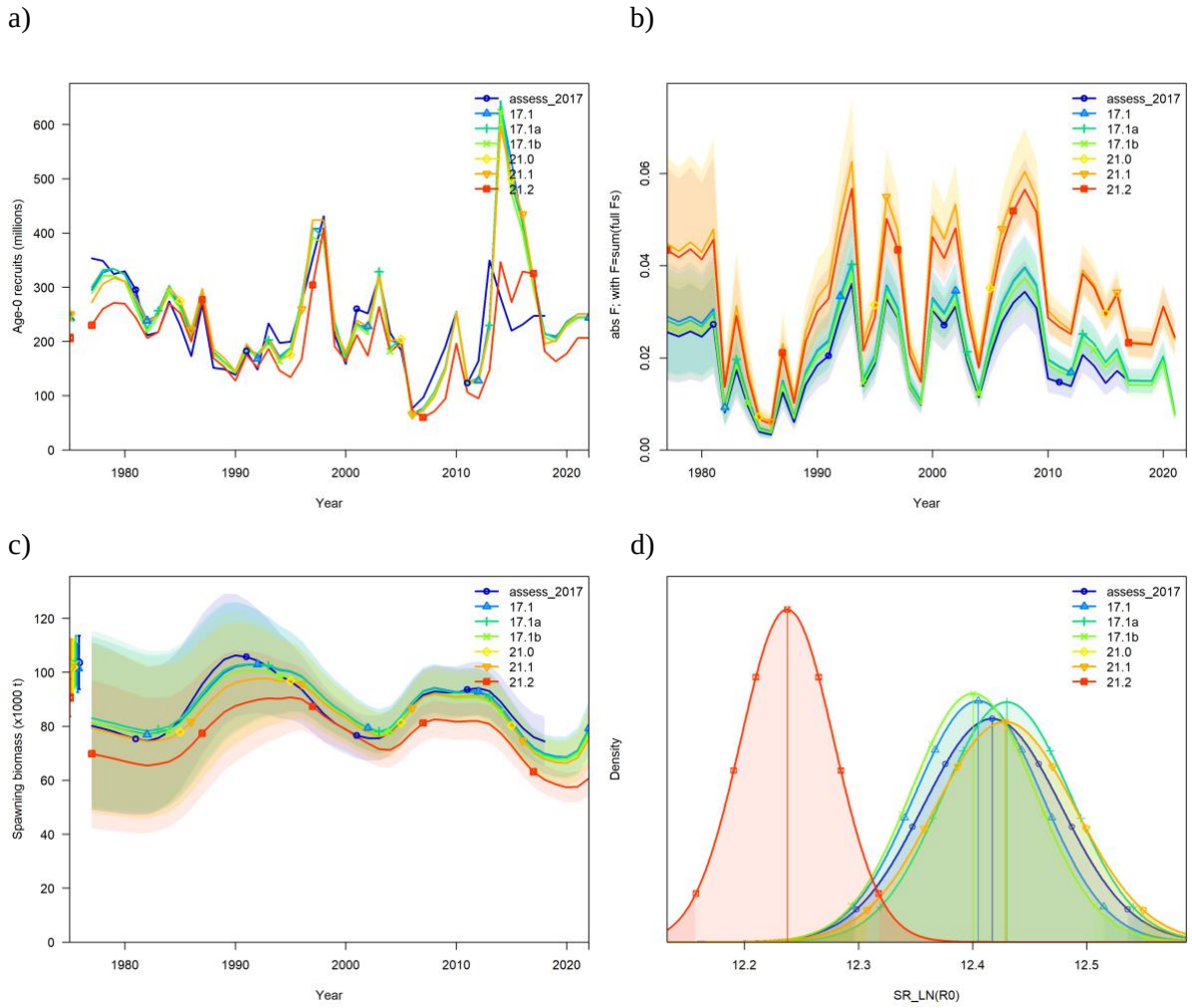


Figure 4.25. Southern rock sole a) age-0 recruits, b) fishing mortality with uncertainty, c) spawning stock biomass with uncertainty, and d) Ln(R_0) density.

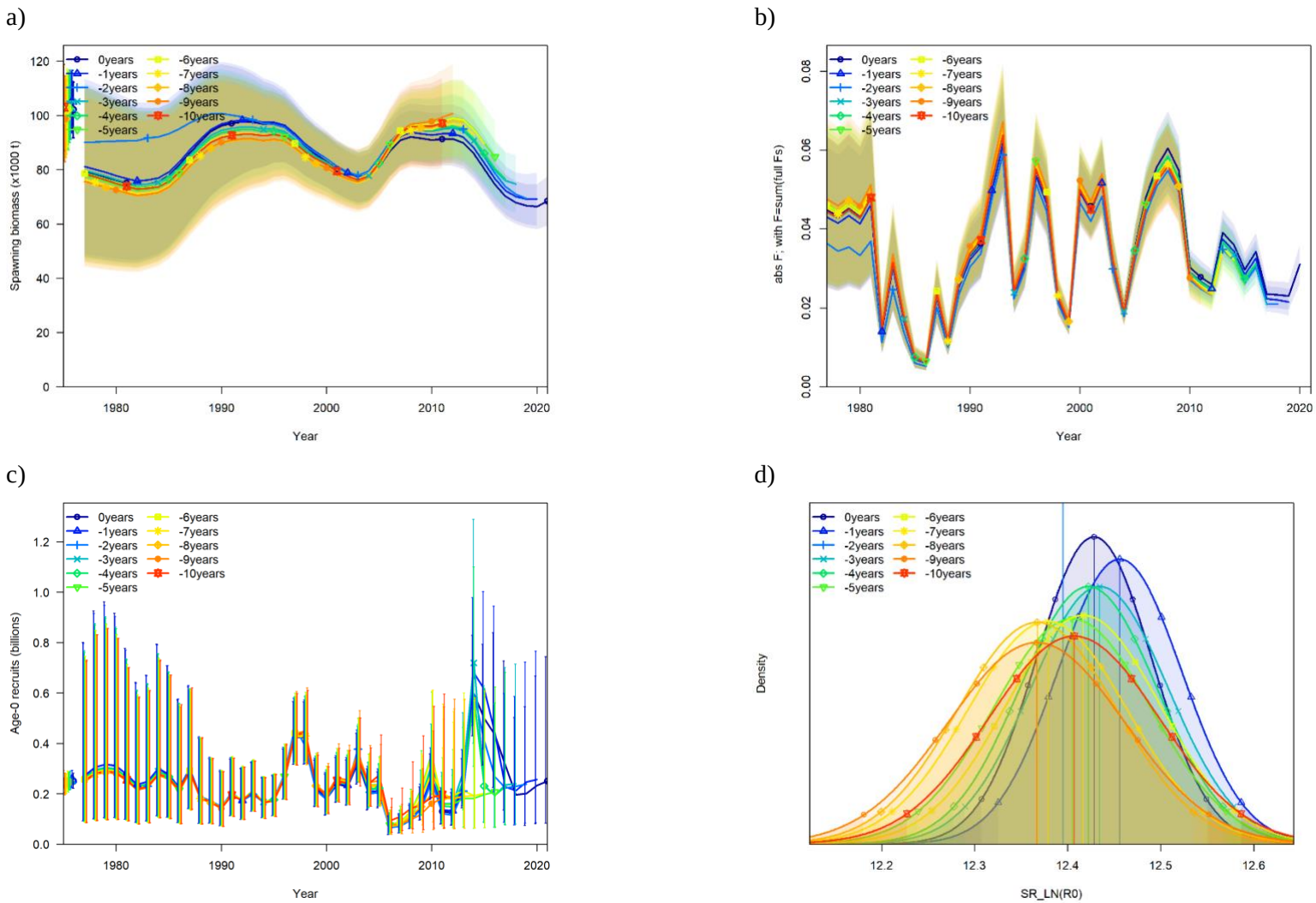


Figure 4.26. Southern rock sole retrospective analysis for model 21.1. a) spawning biomass, b) fishing mortality, c) age-0 recruits, and d) density of LN(R_0).

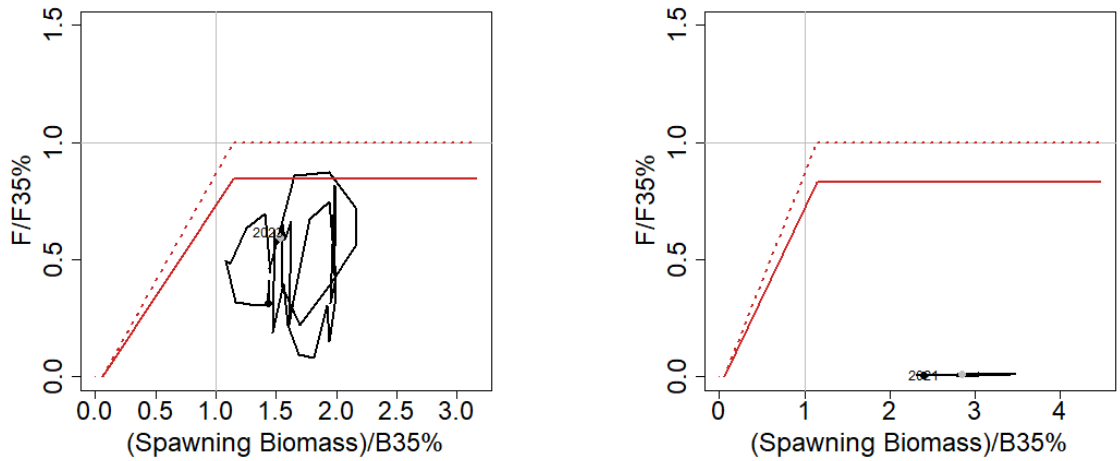


Figure 4.27. Northern rock sole spawning stock biomass relative to B35% and fishing mortality relative to F35% from 1977-2021 (solid black line), OFL control rule (dotted red line), the maxABC control rul (solid red line), B35% (vertical gray line), and F35% (horizontal gray line). The dot represents the 1977 values, the beginning of the time series. Central GOA (left panel) and western GOA (right panel).

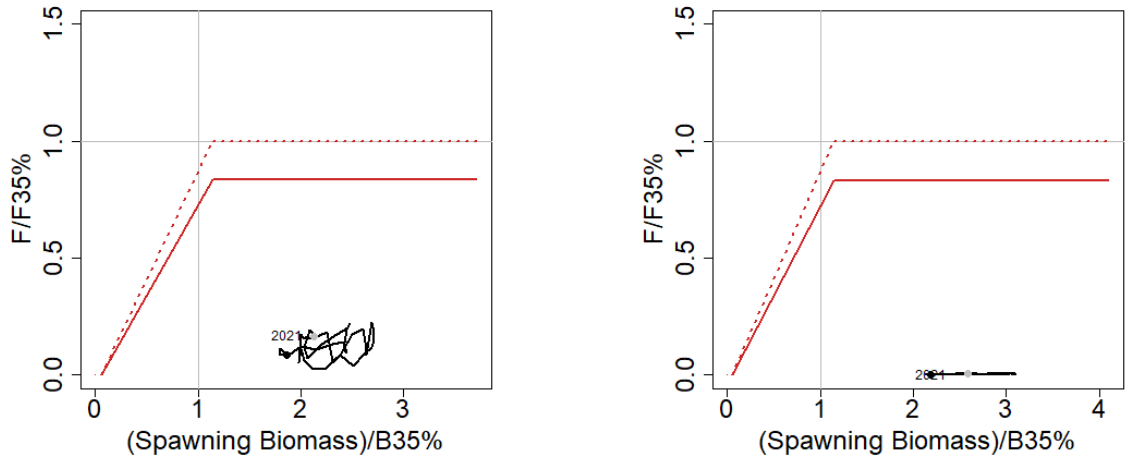


Figure 4.28. Southern rock sole spawning stock biomass relative to B35% and fishing mortality relative to F35% from 1977-2021 (solid black line), OFL control rule (dotted red line), the maxABC control rul (solid red line), B35% (vertical gray line), and F35% (horizontal gray line). The dot represents the 1977 values, the beginning of the time series. Central GOA (left panel) and western GOA (right panel).

Appendix

a) Model 17.1

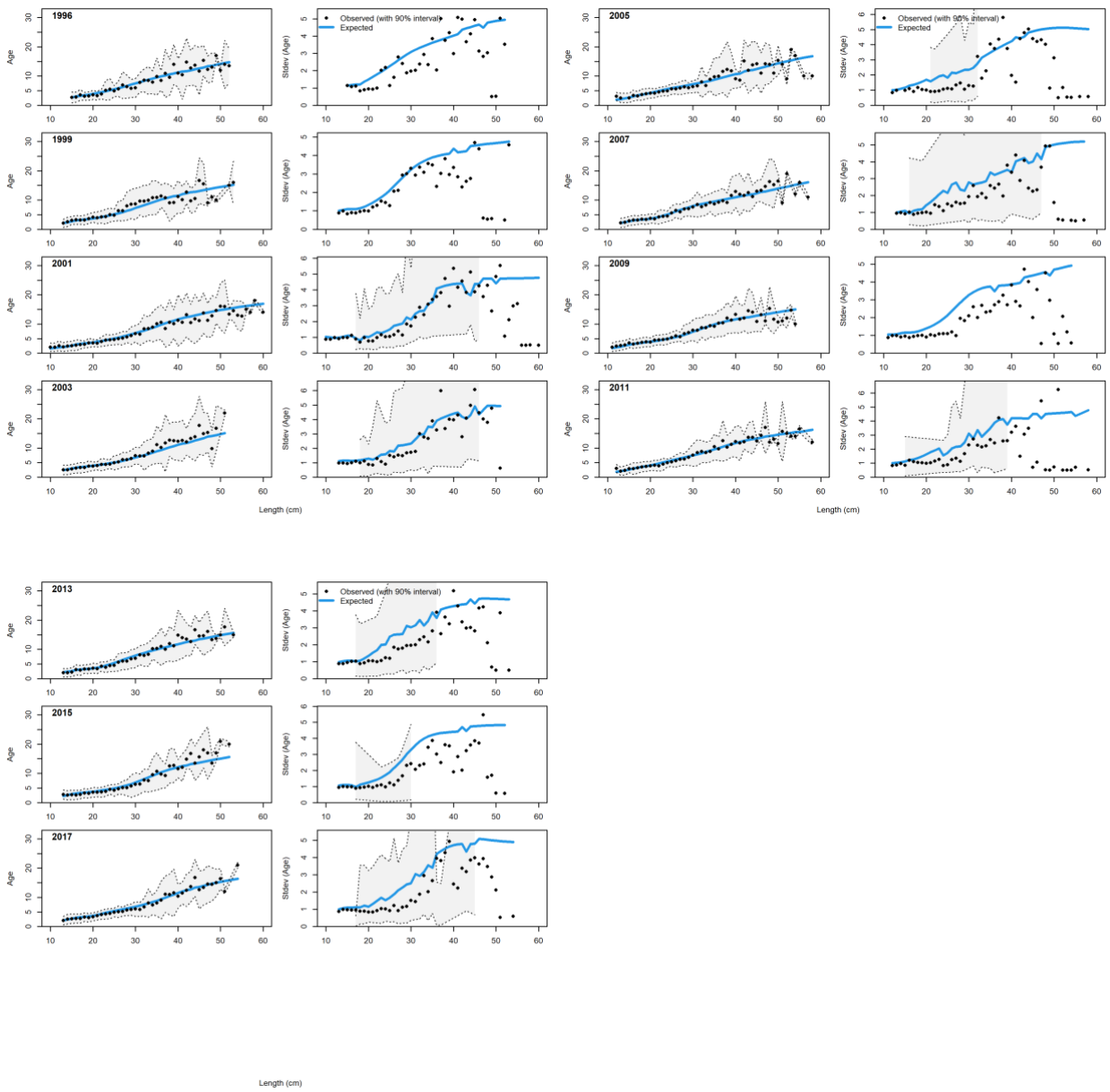


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

b) Model 17.1a

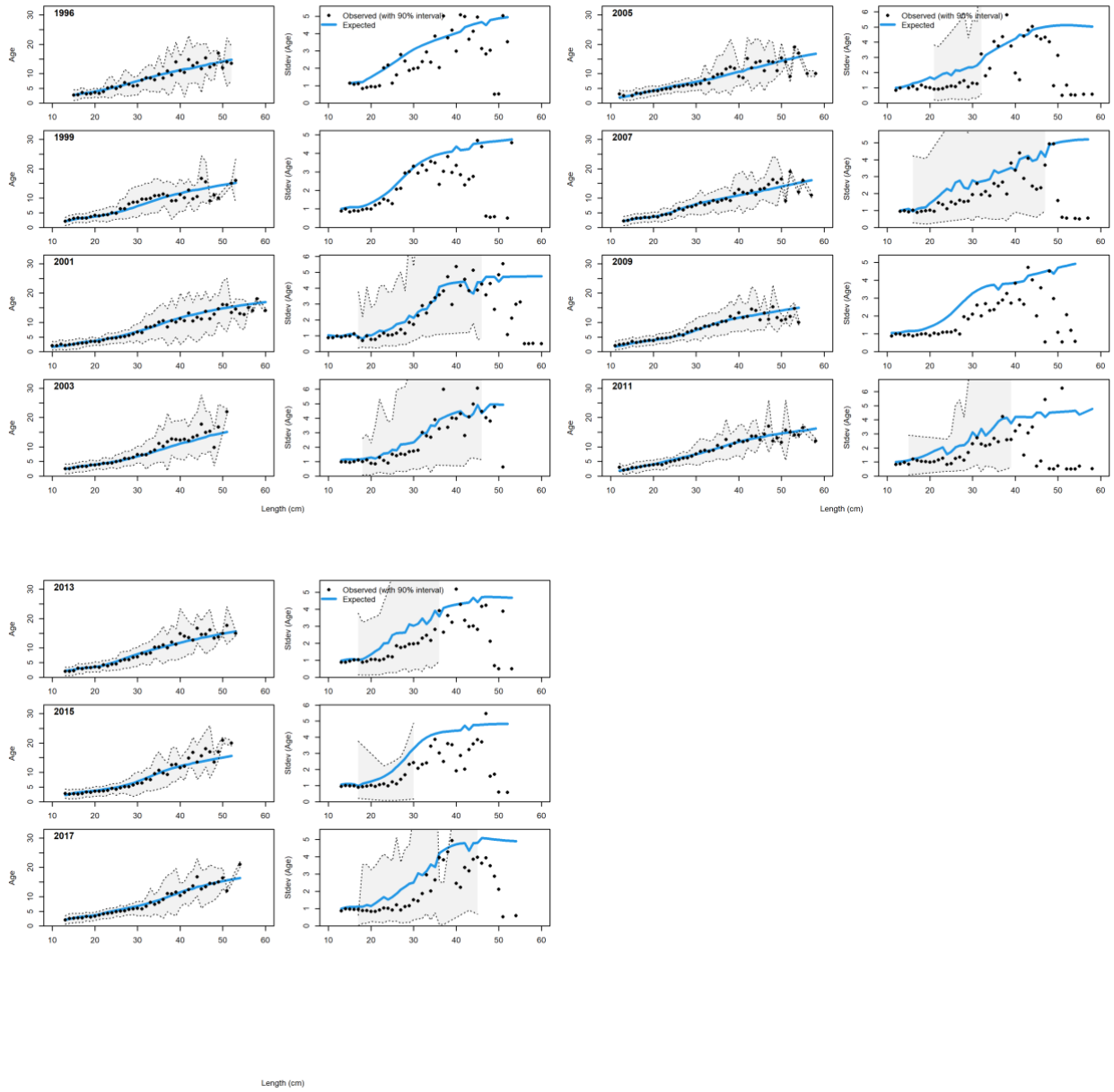


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

c) Model 17.1b

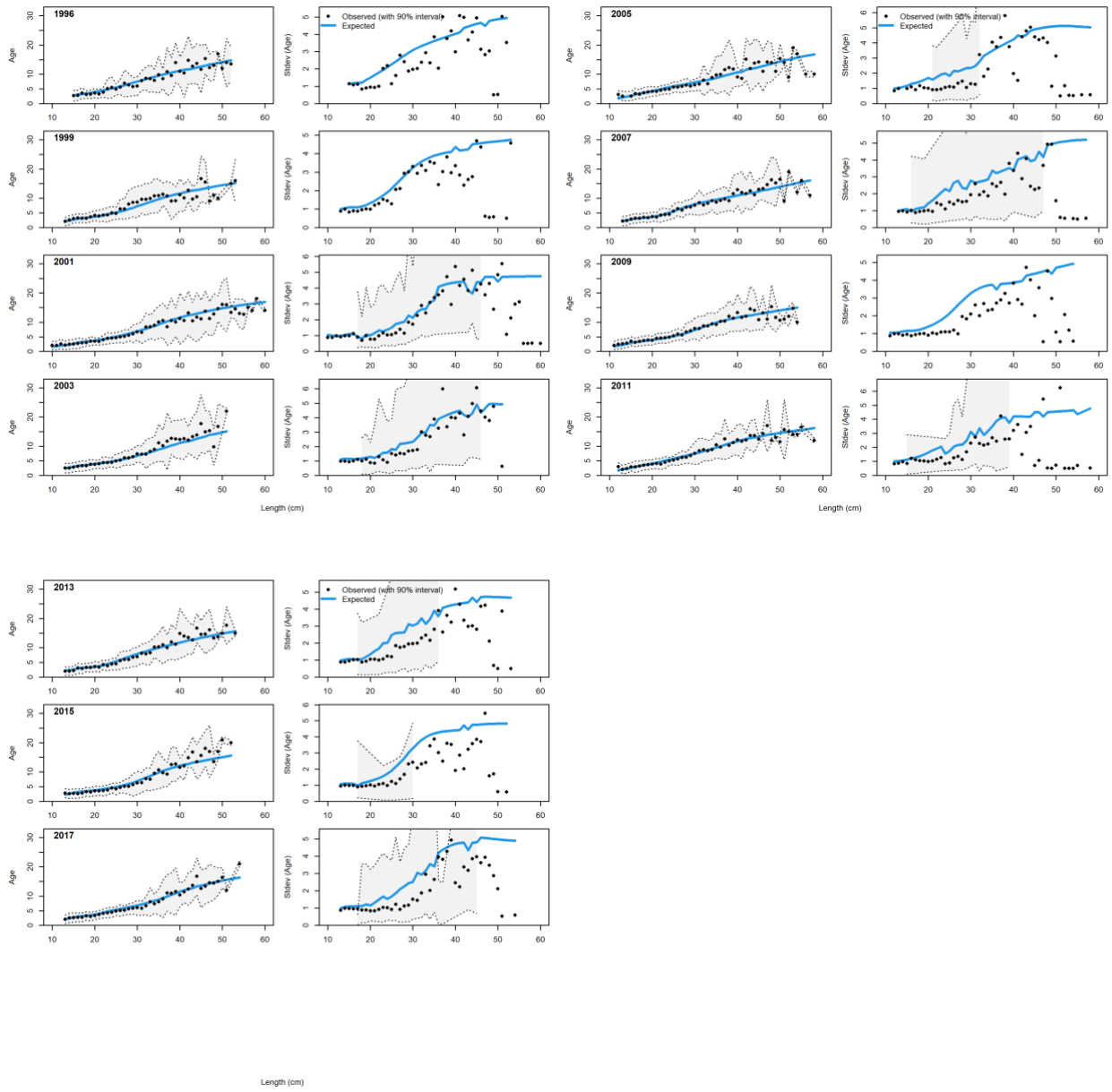


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

d) Model 17.1c

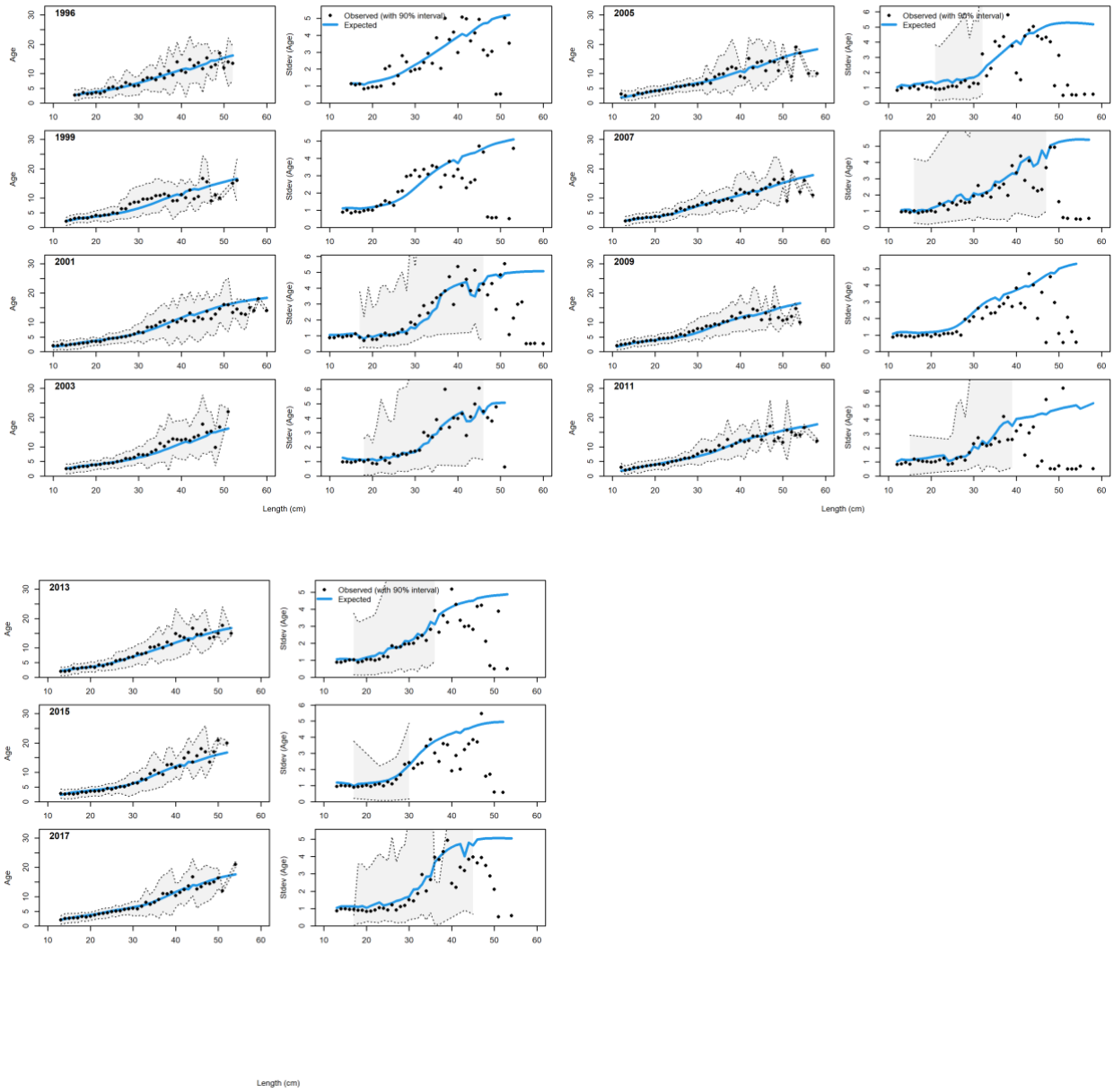


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

e) Model 21.0 central GOA

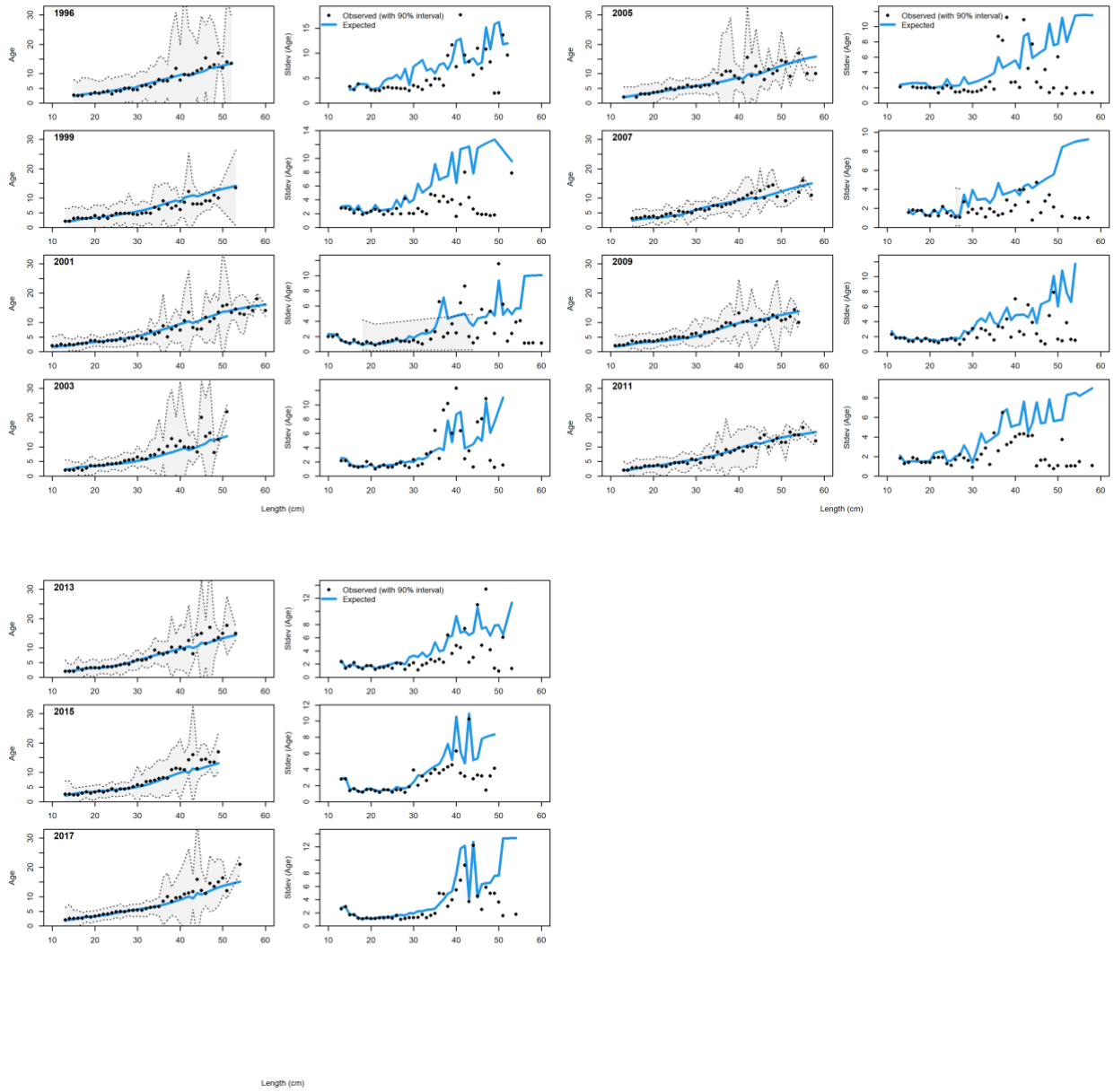


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

f) Model 21.1 central GOA

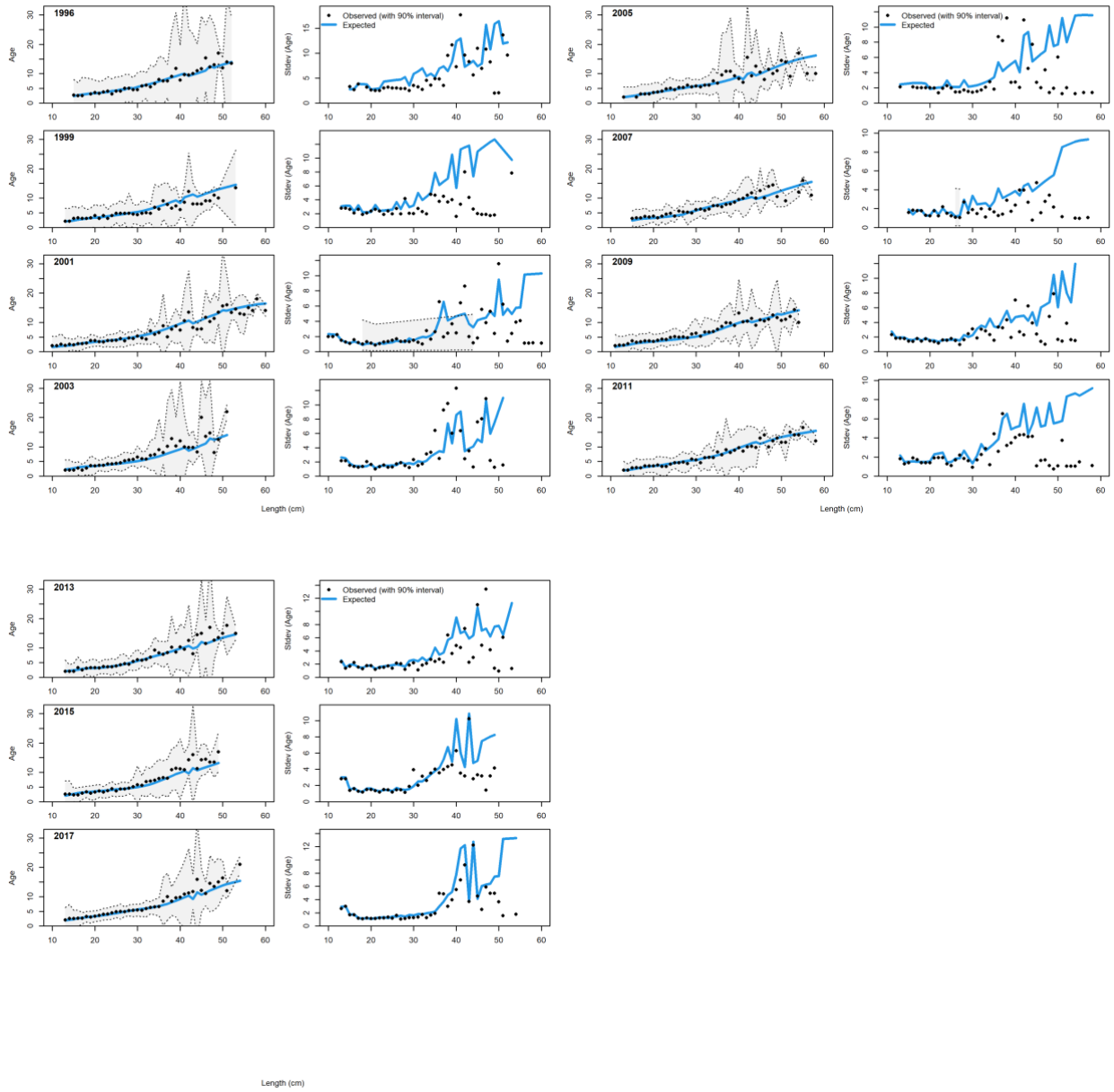


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

g) Model 21.2 central GOA

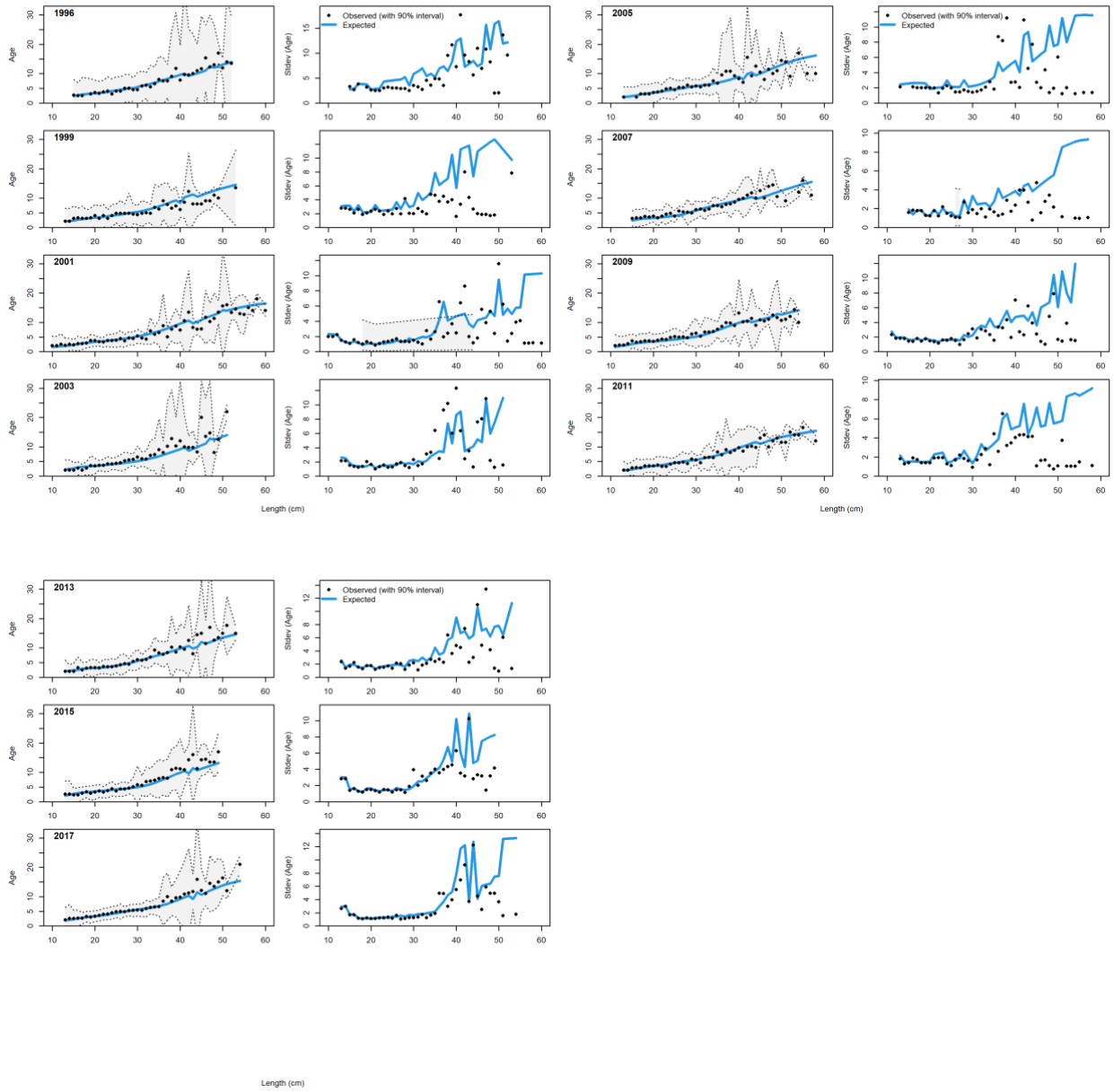


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

h) Model 21.3 central GOA

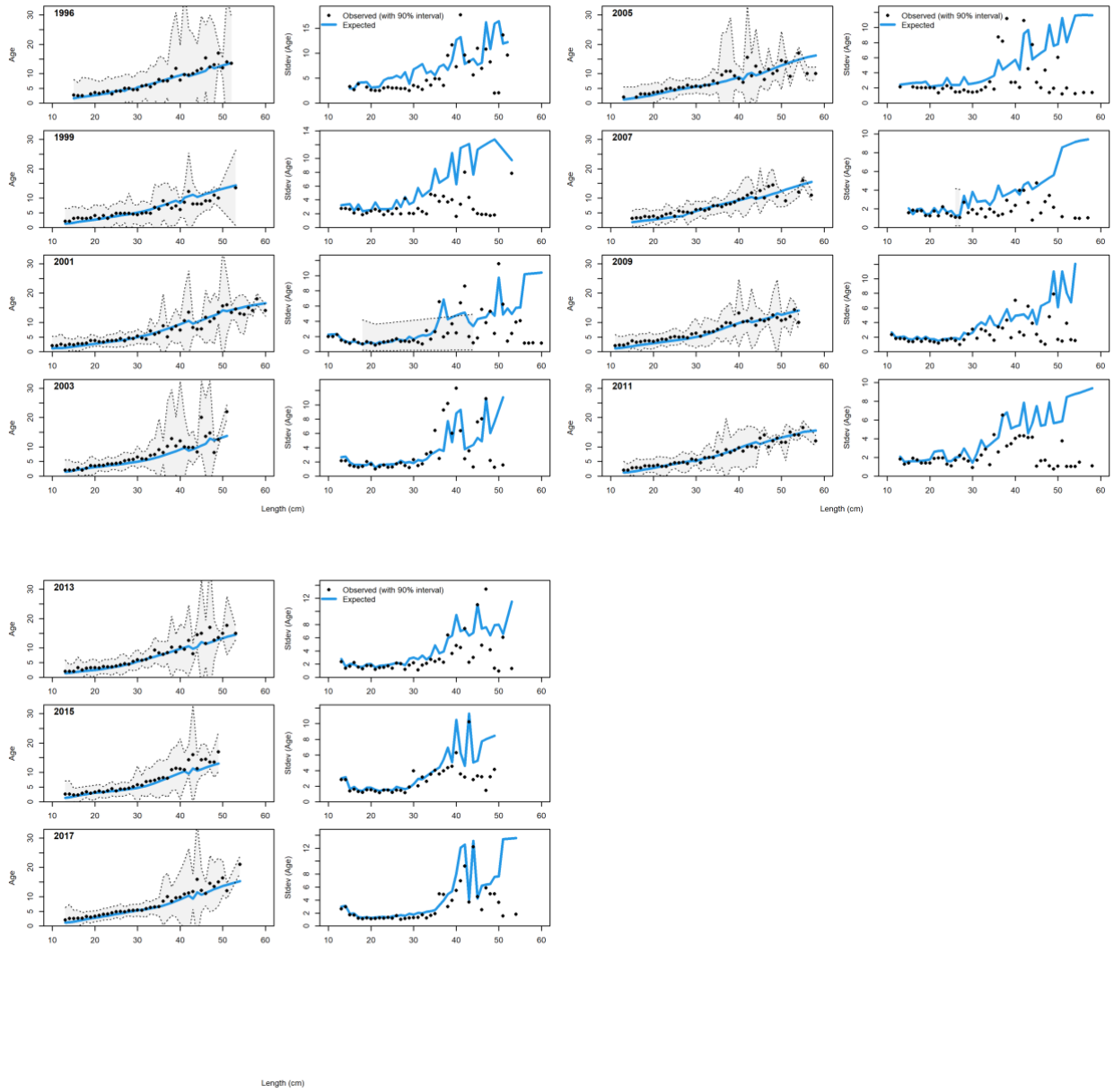


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

i) Model 21.0 western GOA

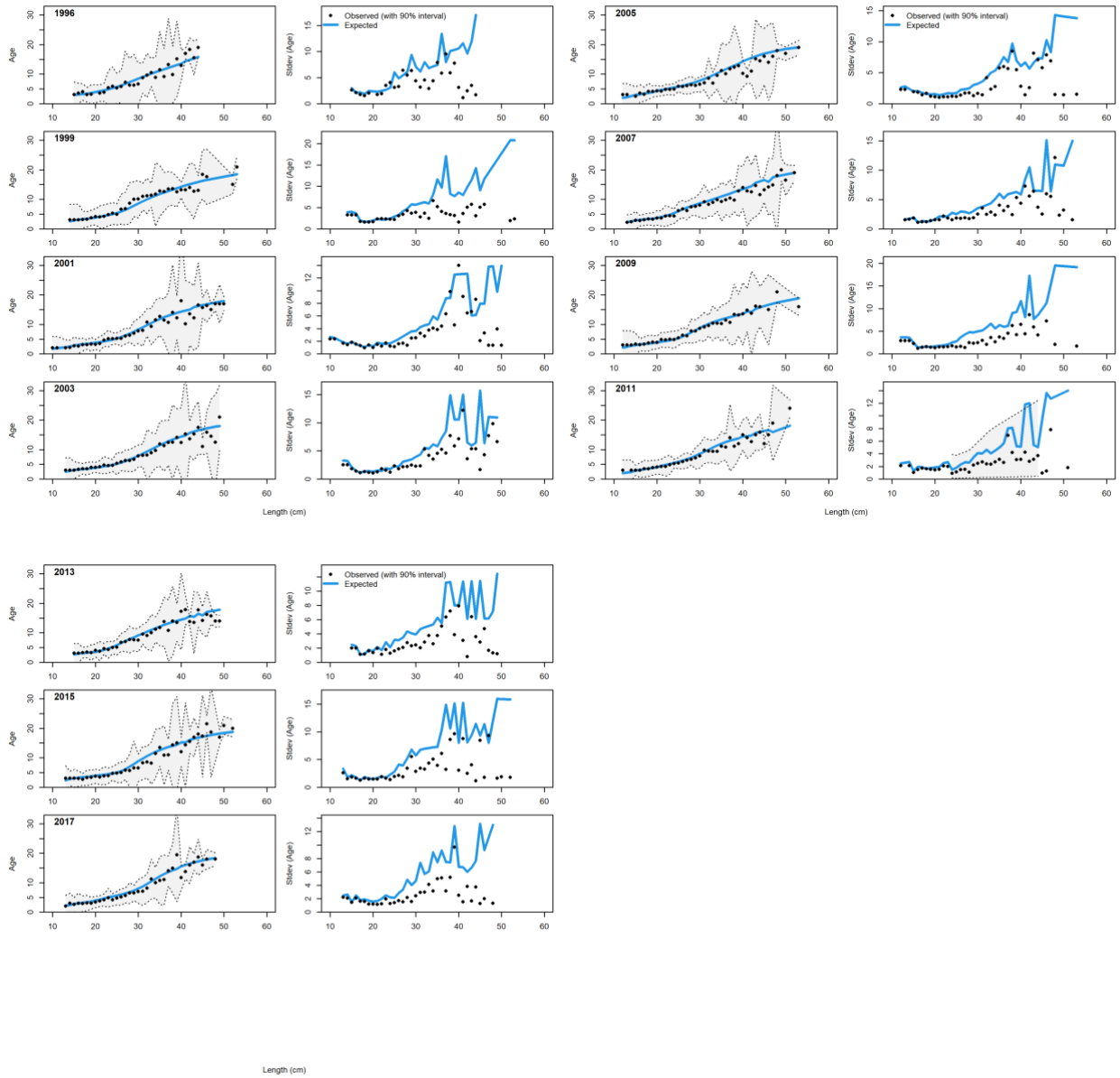


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

j) Model 21.1 western GOA

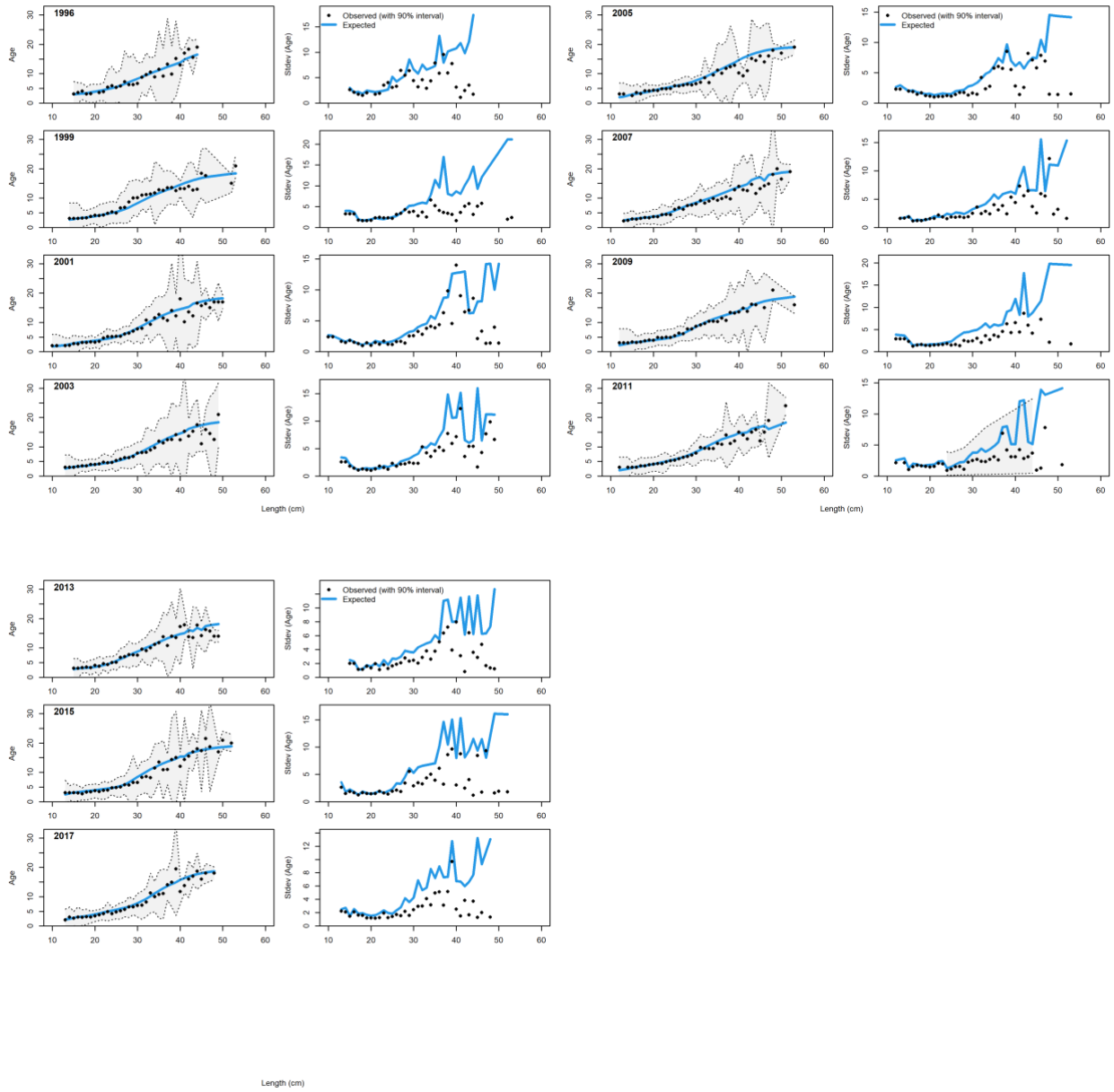


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

k) Model 21.2 western GOA

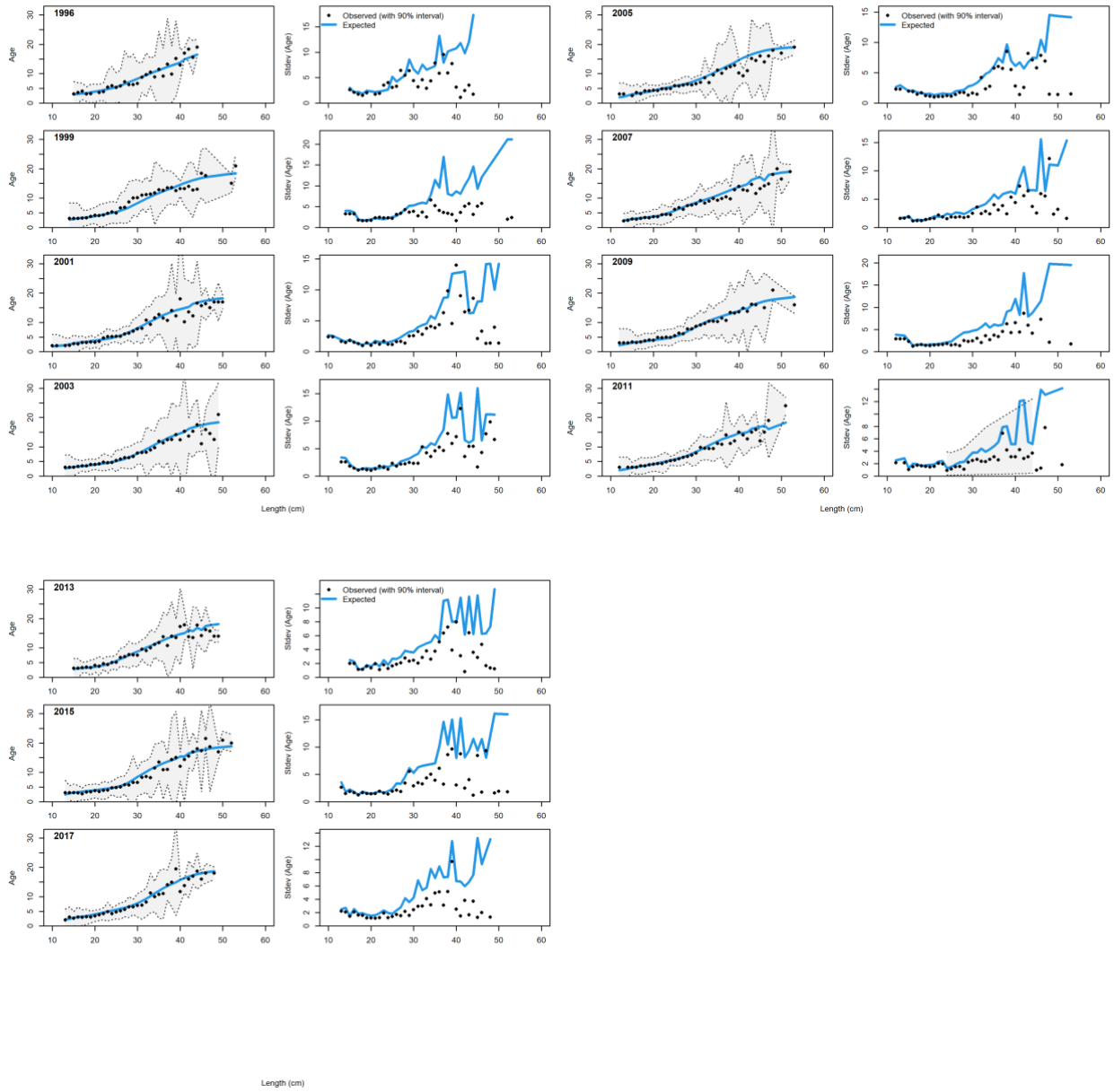


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

l) Model 21.3 western GOA

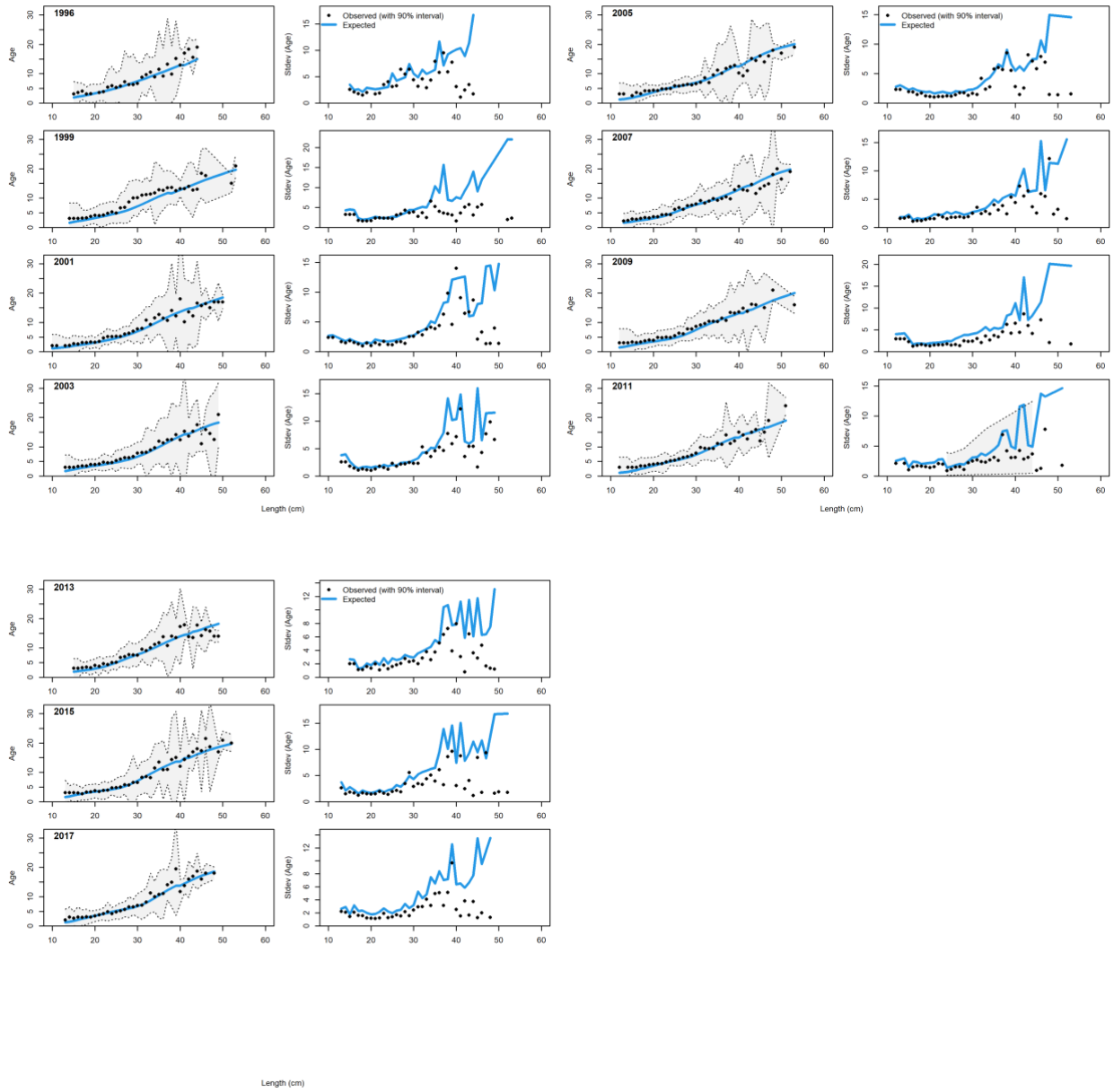


Figure A.1. Model fit to the northern rock sole survey conditional age at length data. a-l) Represent the model fits by model, sex, and area. Each panel is labelled with model, sex, and area.

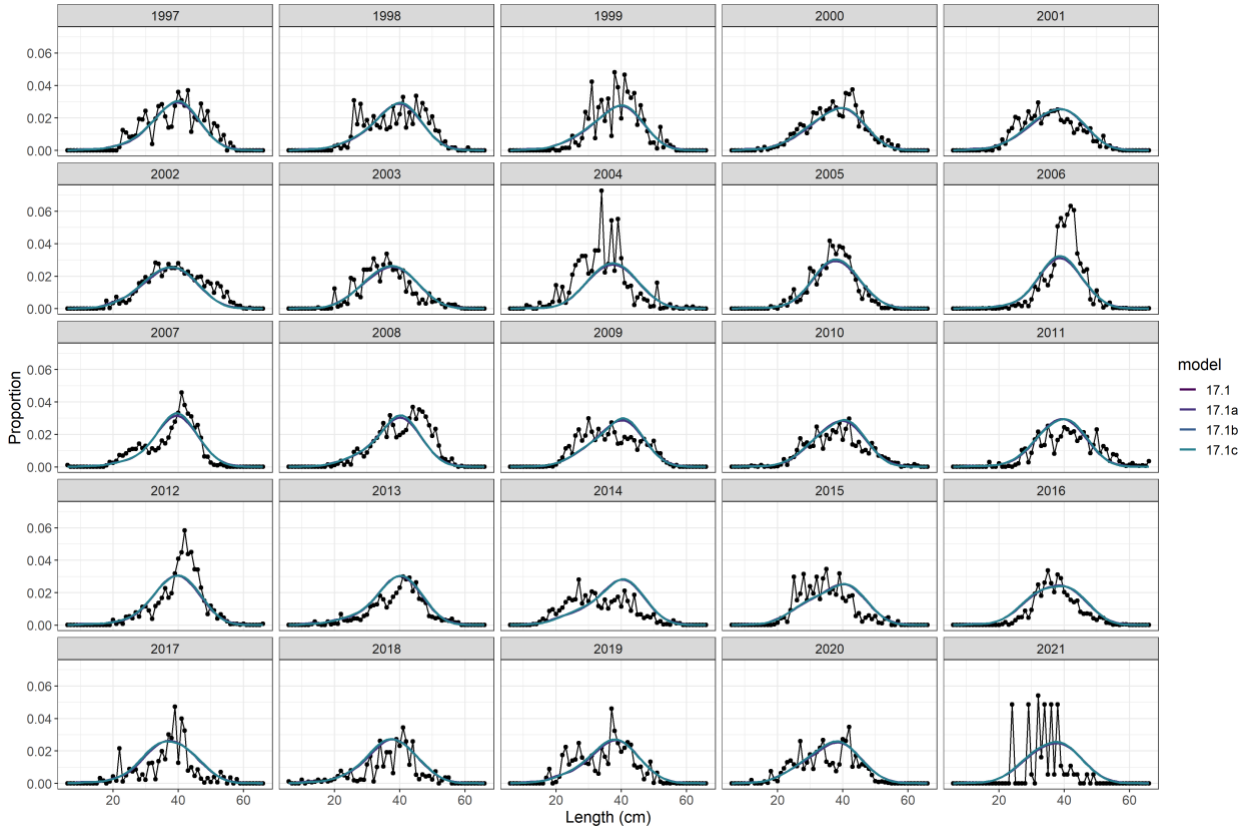


Figure A.2. Single area model fit to the female, northern rock sole fishery length composition data.

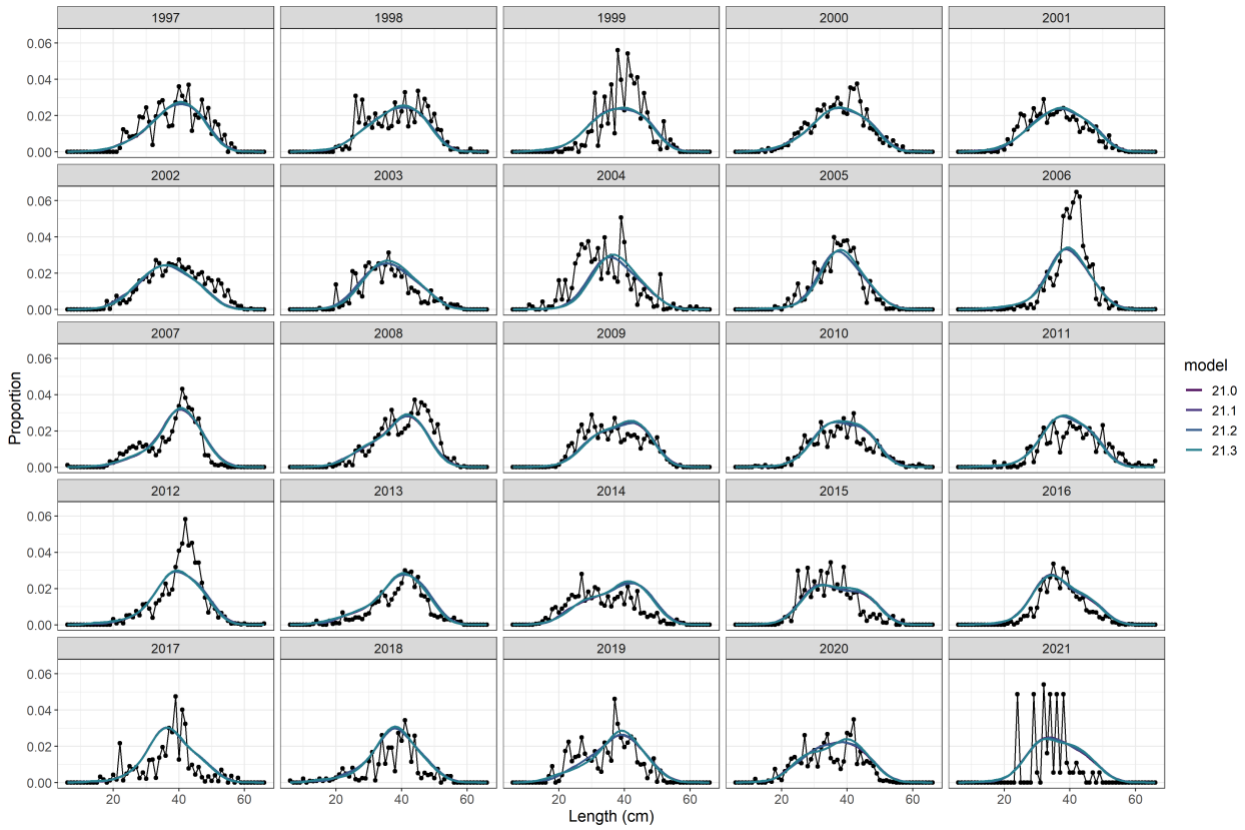


Figure A.3. 2-area model fit to the female, northern rock sole fishery length composition data from central GOA.

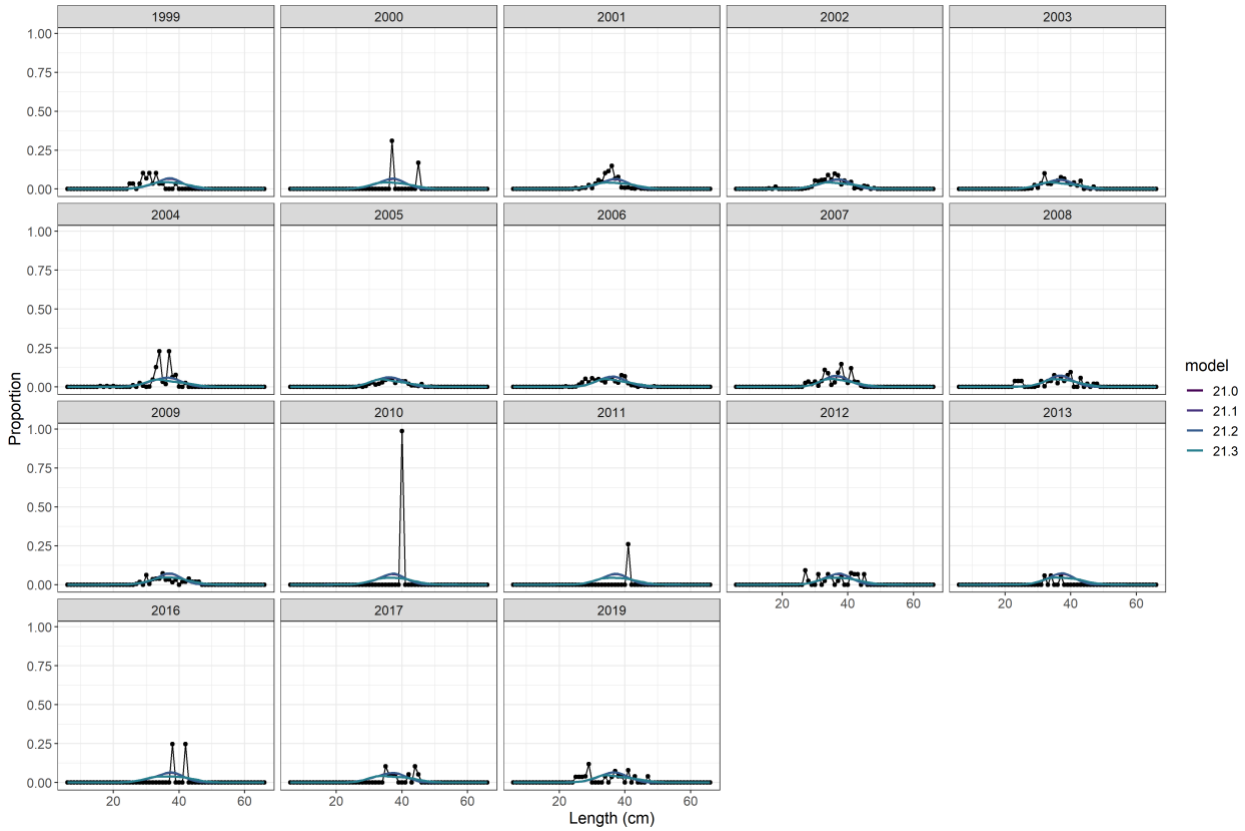


Figure A.4. 2-area model fit to the female, northern rock sole fishery length composition data from westGOA.

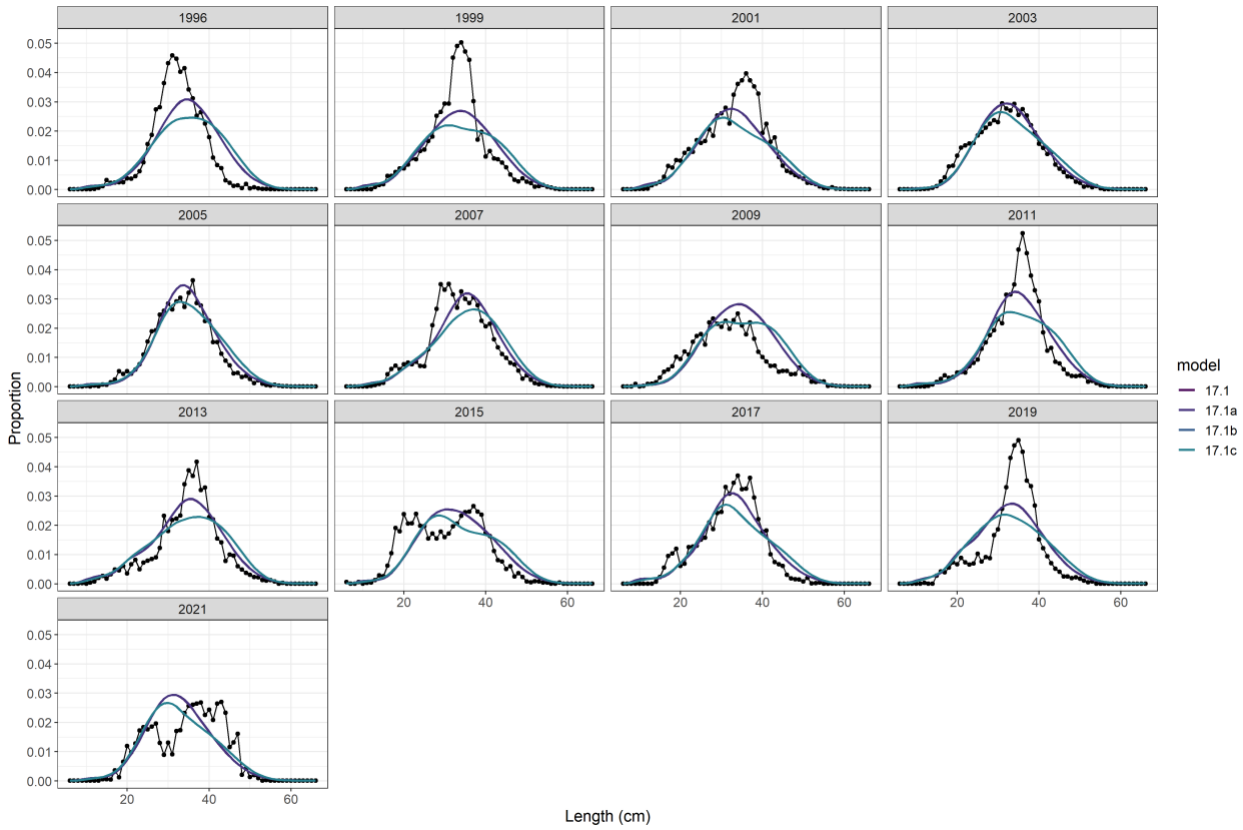


Figure A.5. 2-area model fit to the female, northern rock sole survey length composition data.

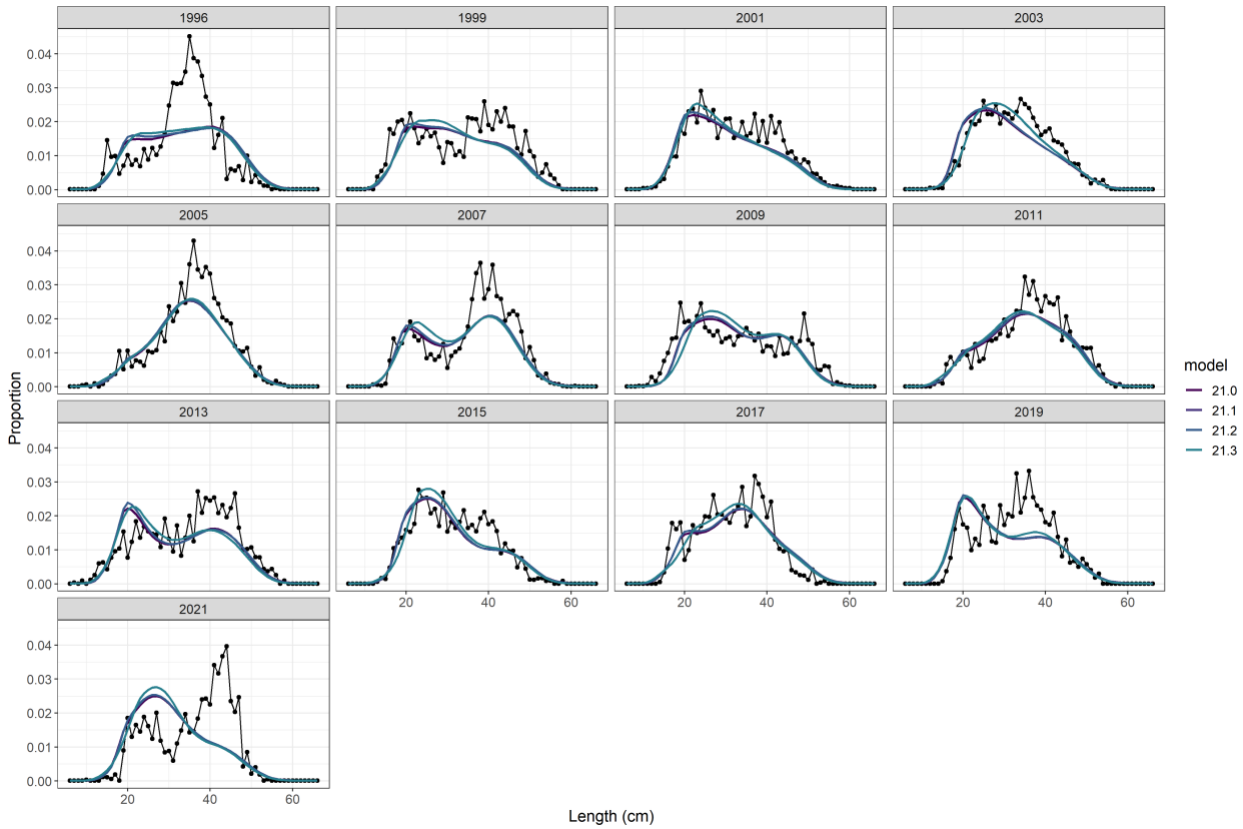


Figure A.6. 2-area model fit to the female, northern rock sole survey length composition data from the central GOA.

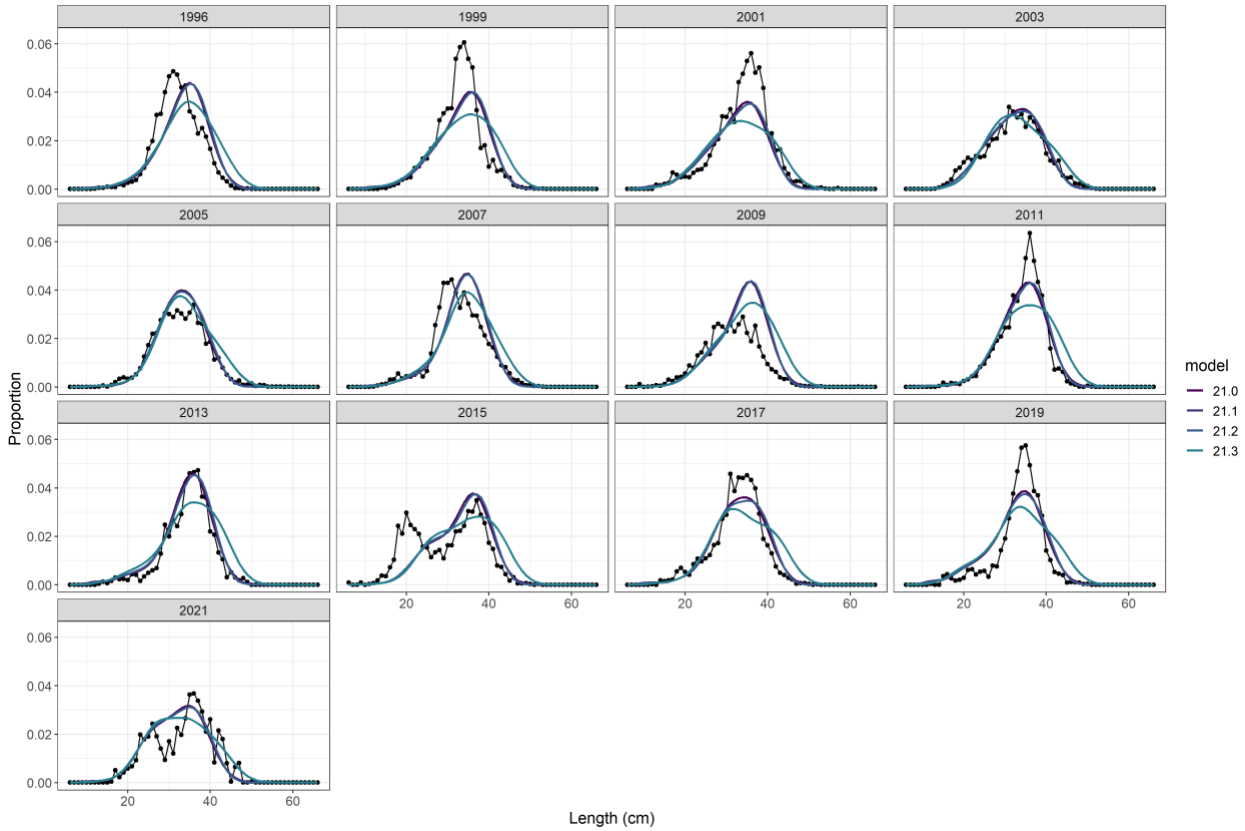


Figure A.7. 2-area model fit to the female, northern rock sole survey length composition data from the western GOA.

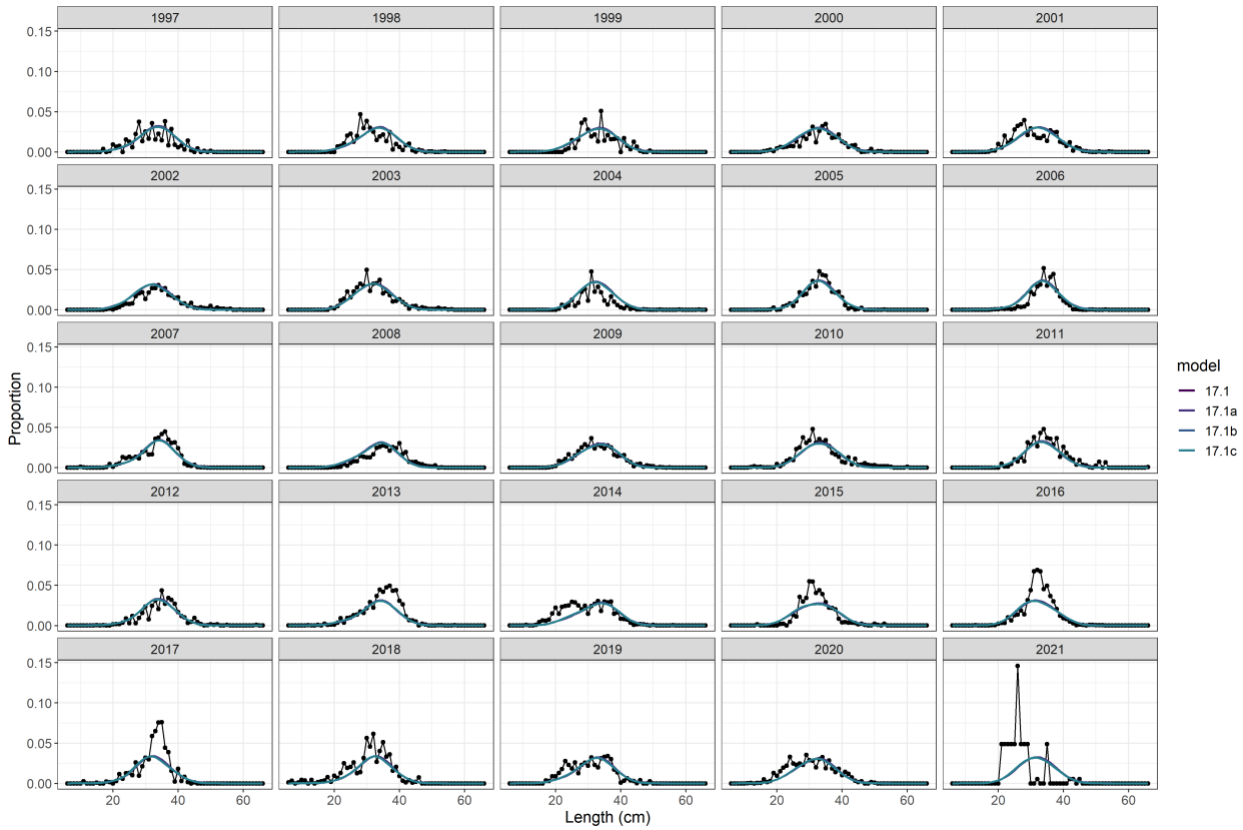


Figure A.8. Single area model fit to the male, northern rock sole fishery length composition data.

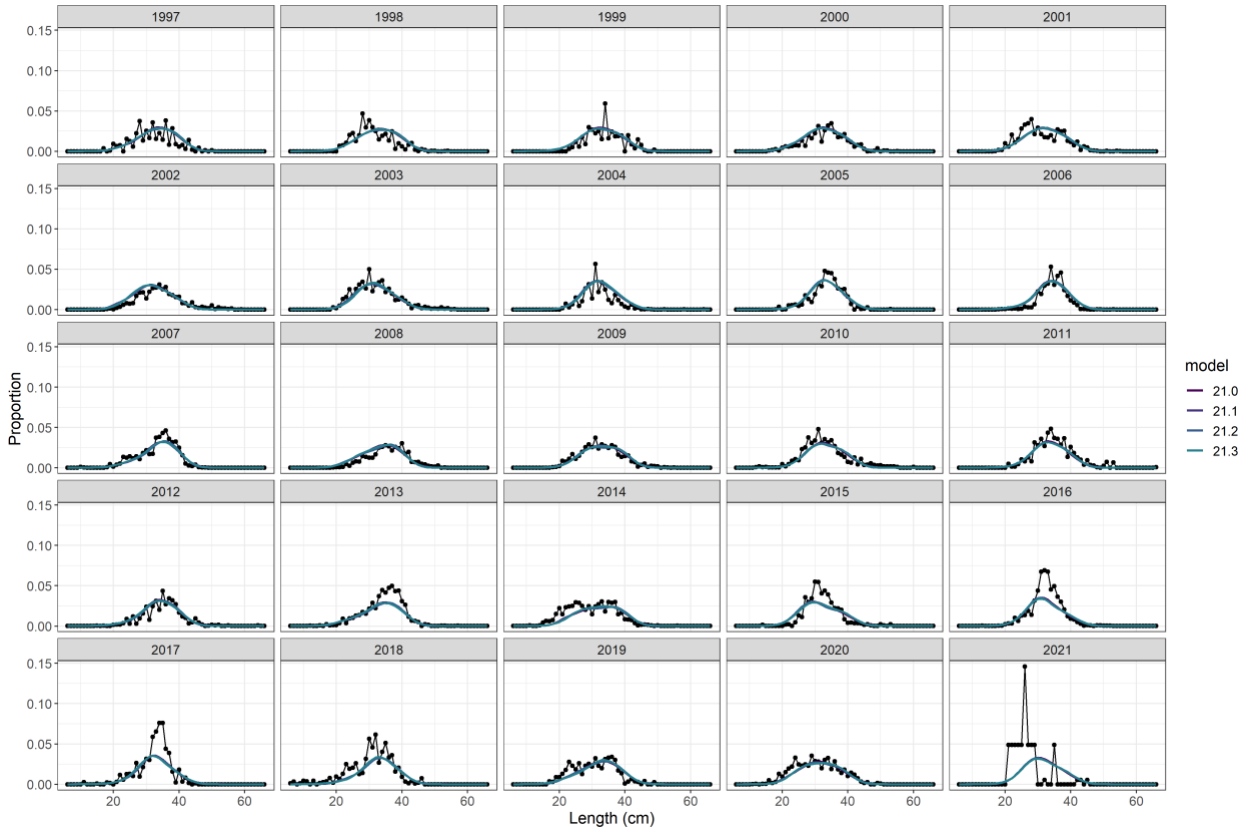


Figure A.9. 2-area model fit to the male, northern rock sole fishery length composition data from central GOA.

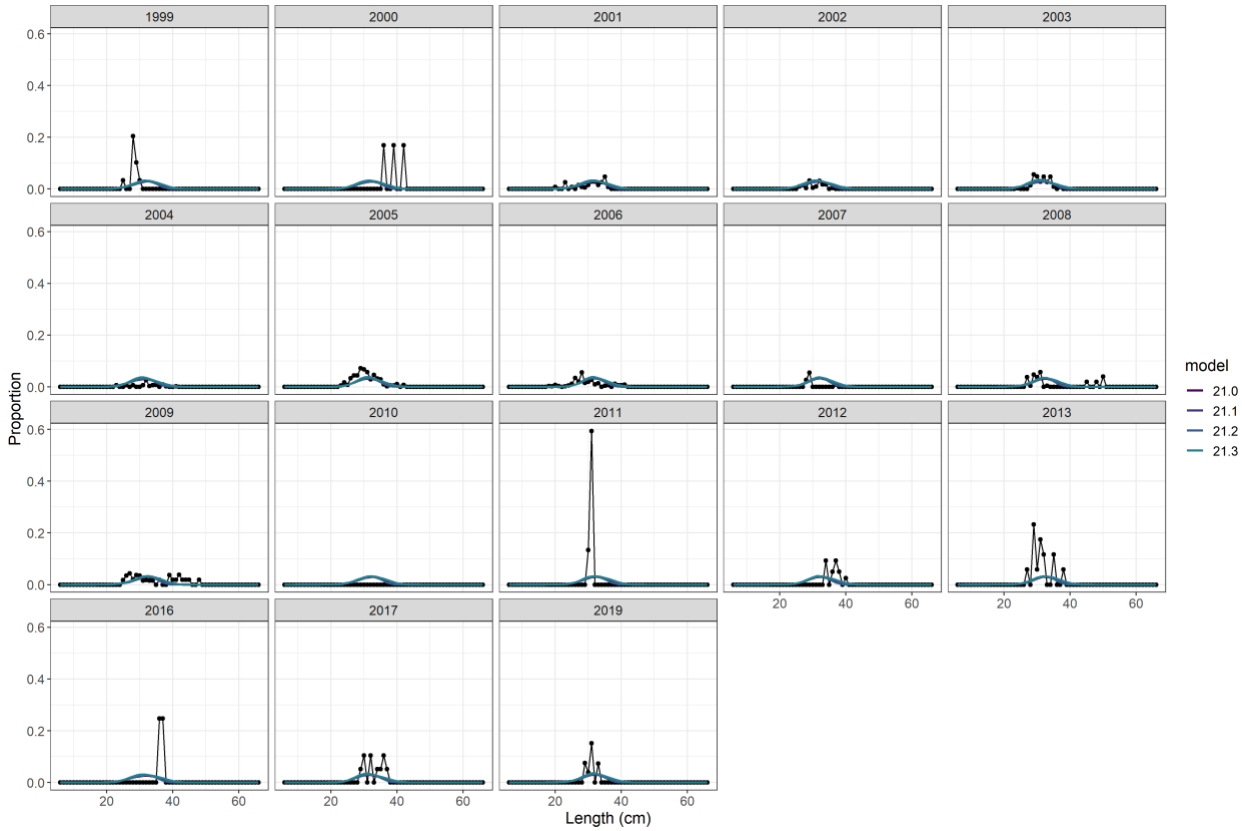


Figure A.10. 2-area model fit to the male, northern rock sole fishery length composition data from western GOA.

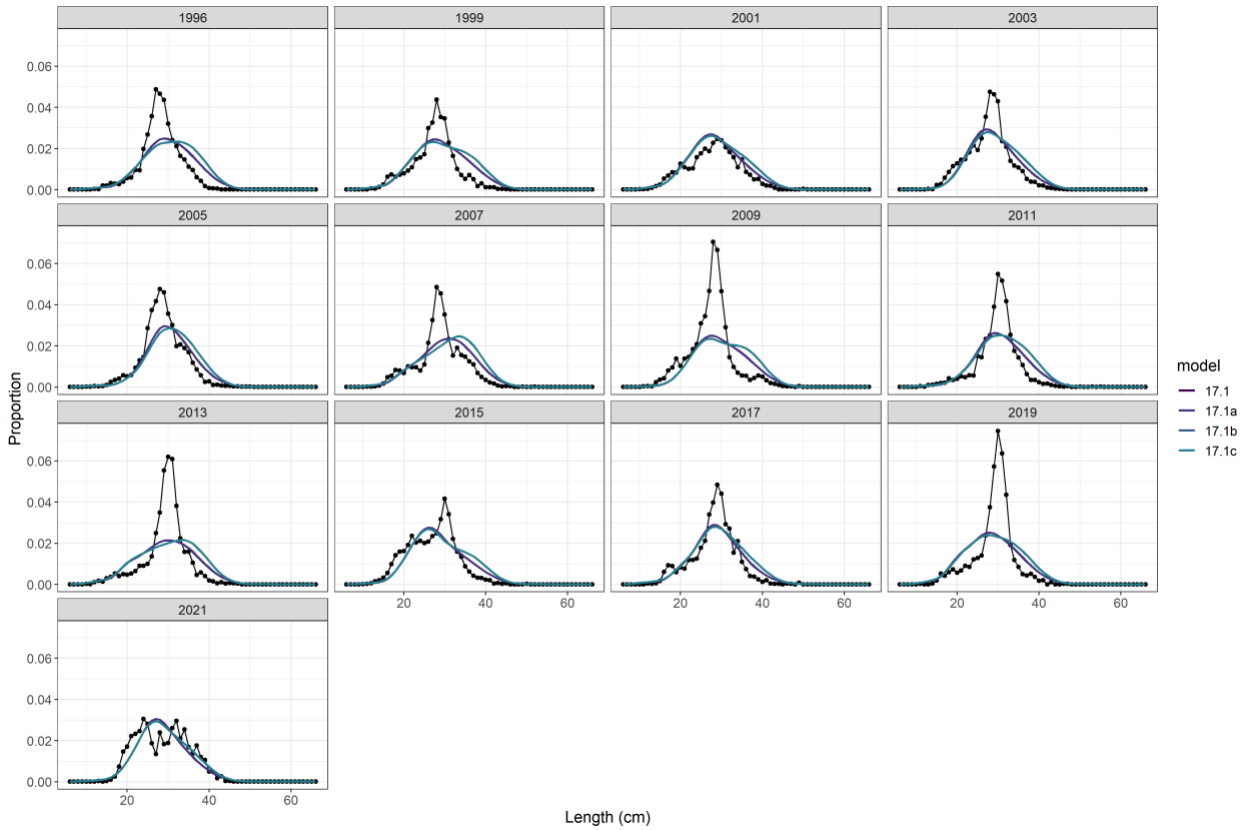


Figure A.11. Single area model fit to the male, northern rock sole survey length composition data.

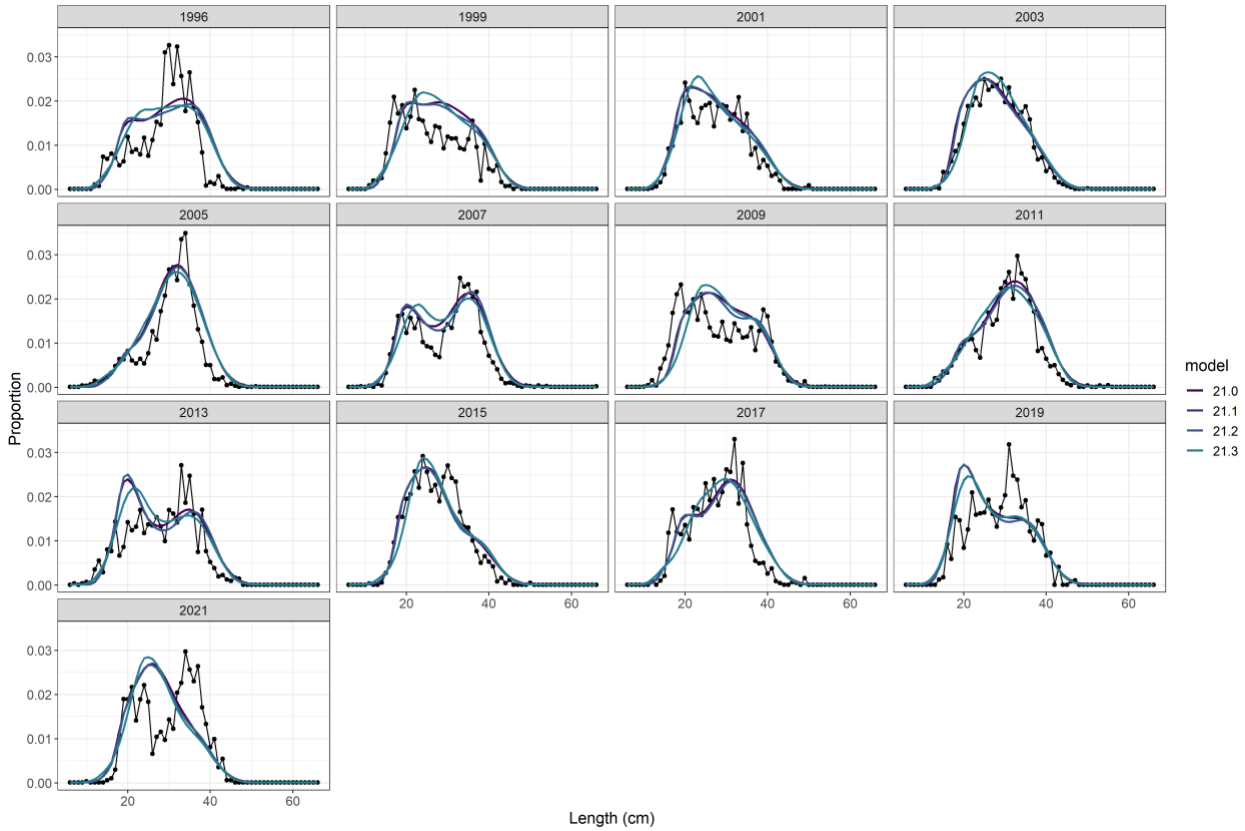


Figure A.12. 2-area model fit to the male, northern rock sole survey length composition data from central GOA.

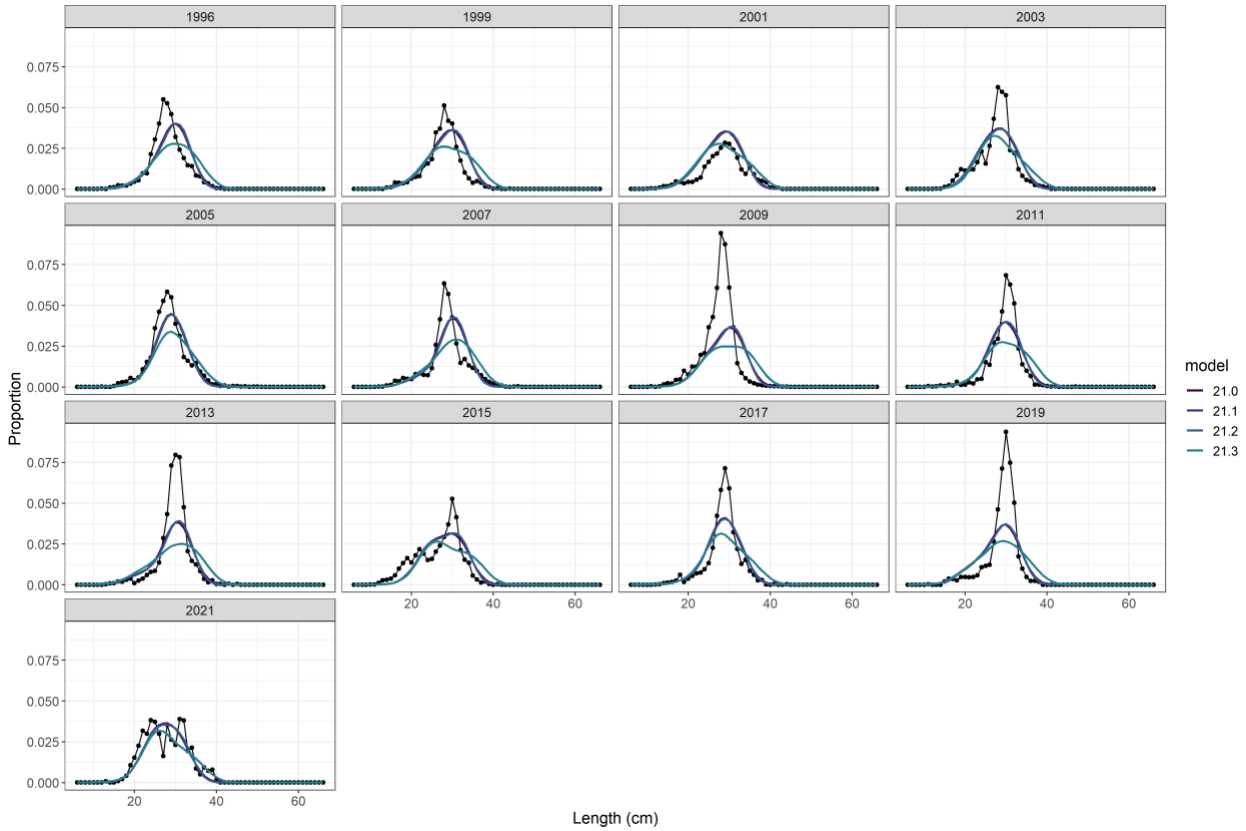


Figure A.13. 2-area model fit to the male, northern rock sole survey length composition data from western GOA.

a) Model 17.1

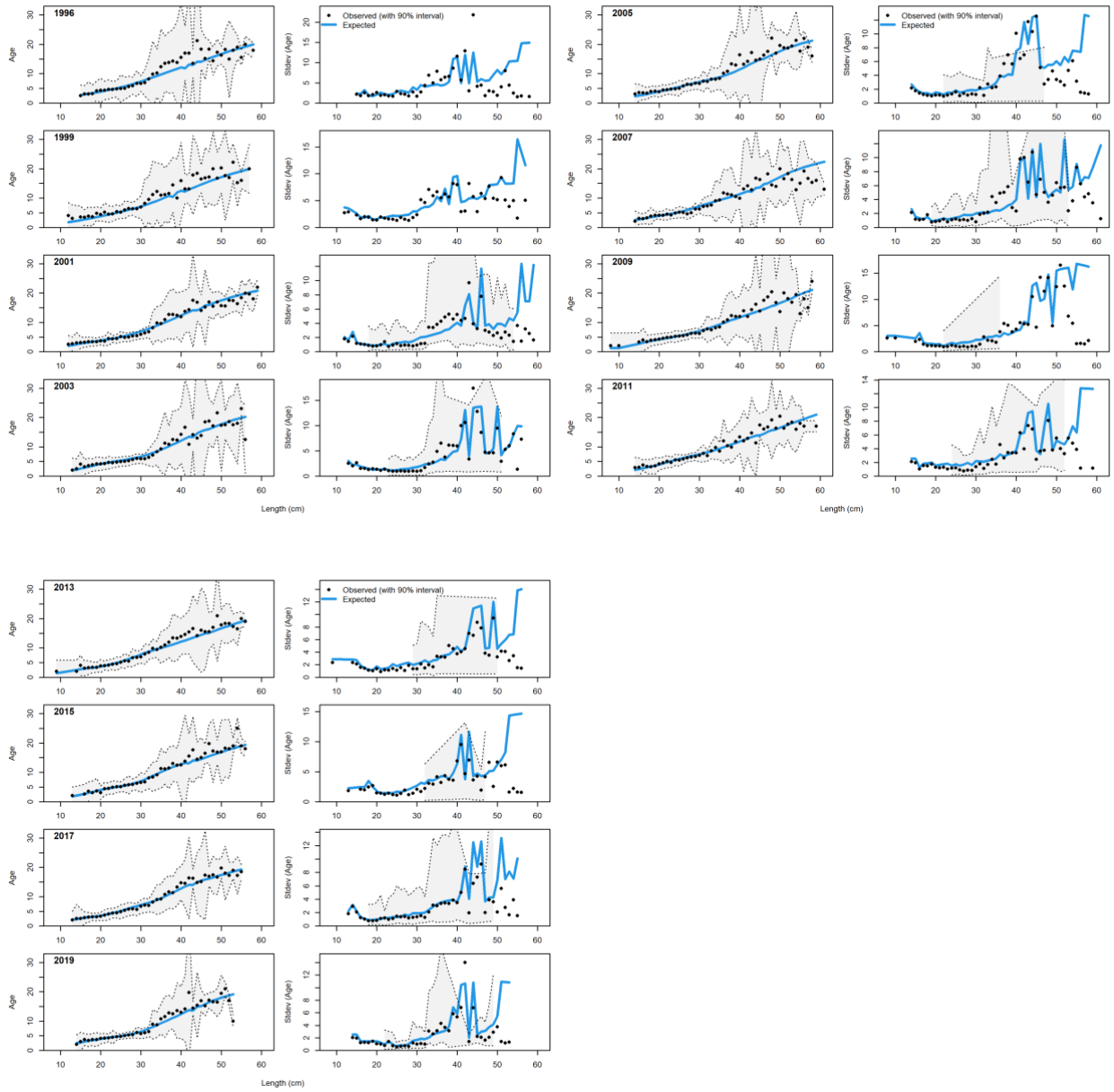


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

b) Model 17.1a

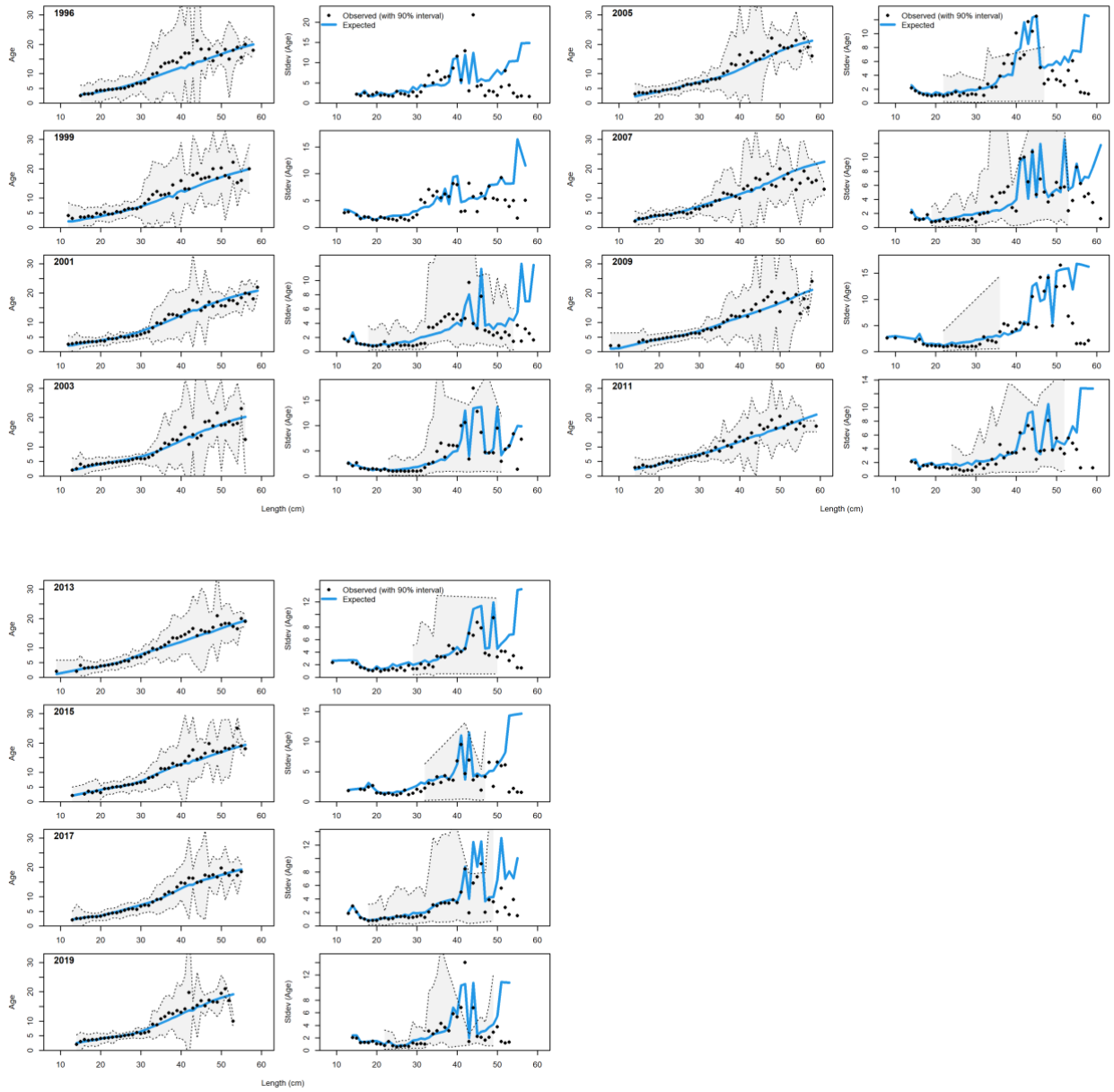


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

c) Model 17.1b

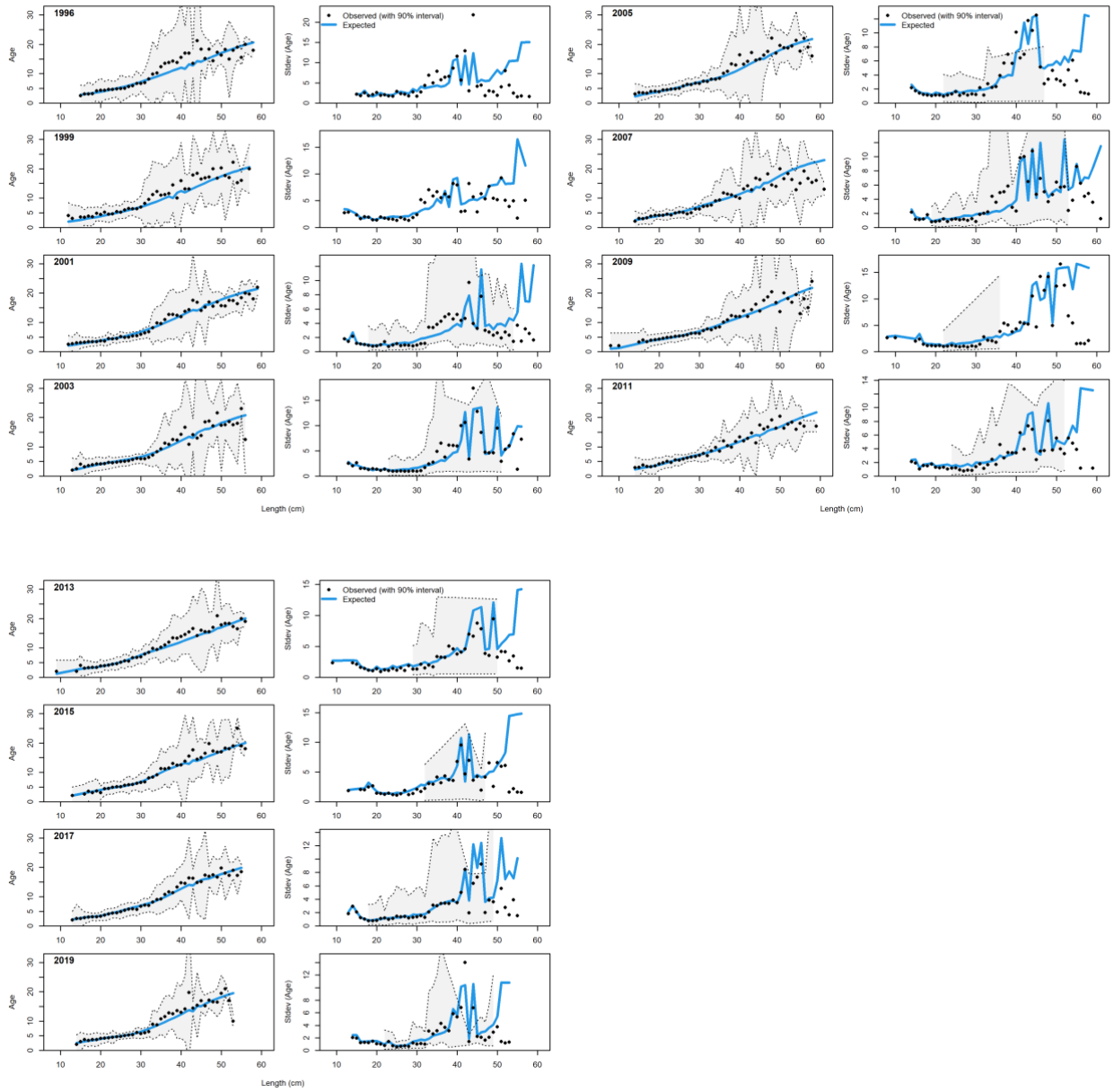


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

d) Model 21.0, central GOA

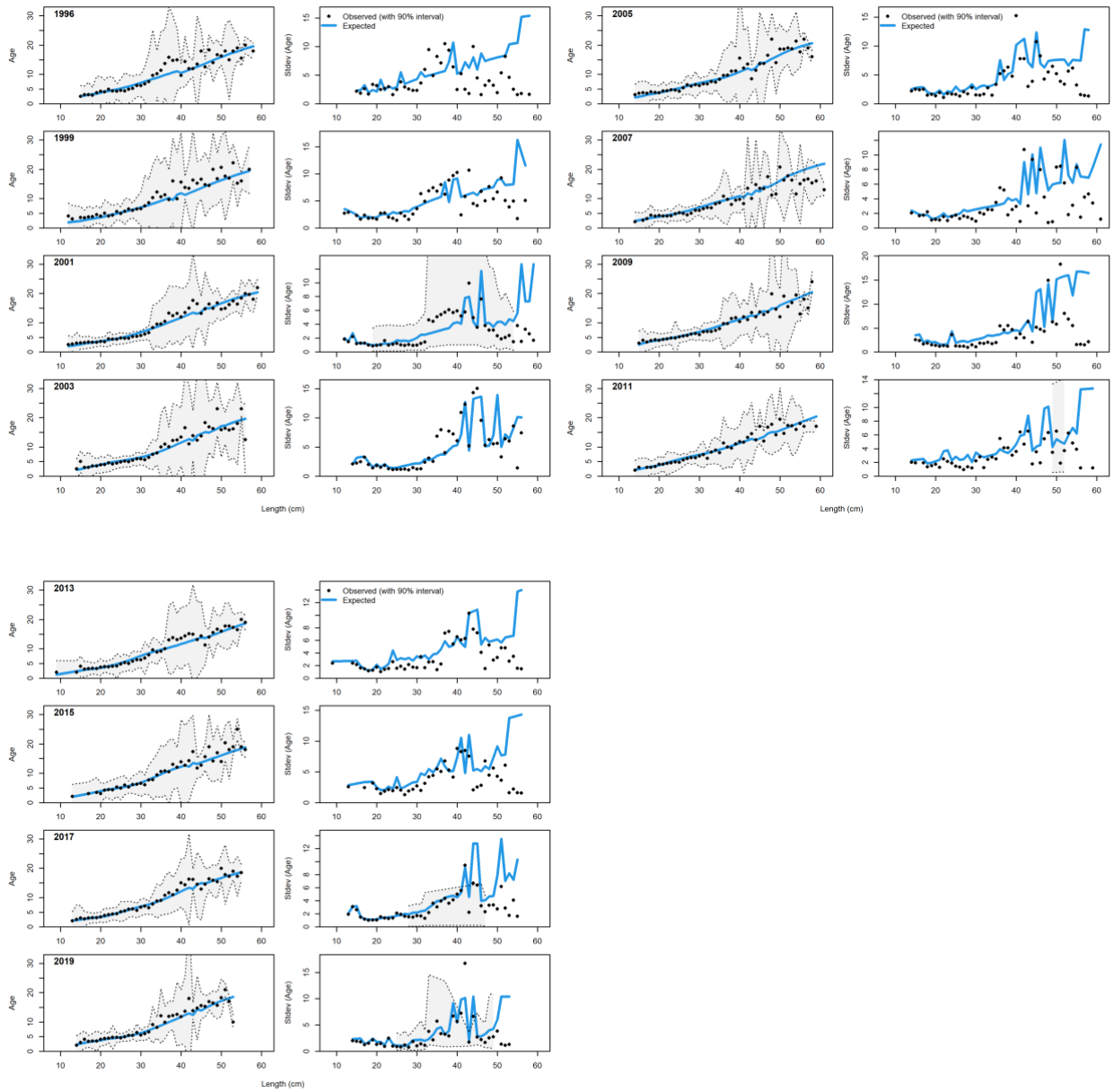


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

e) Model 21.1, central GOA

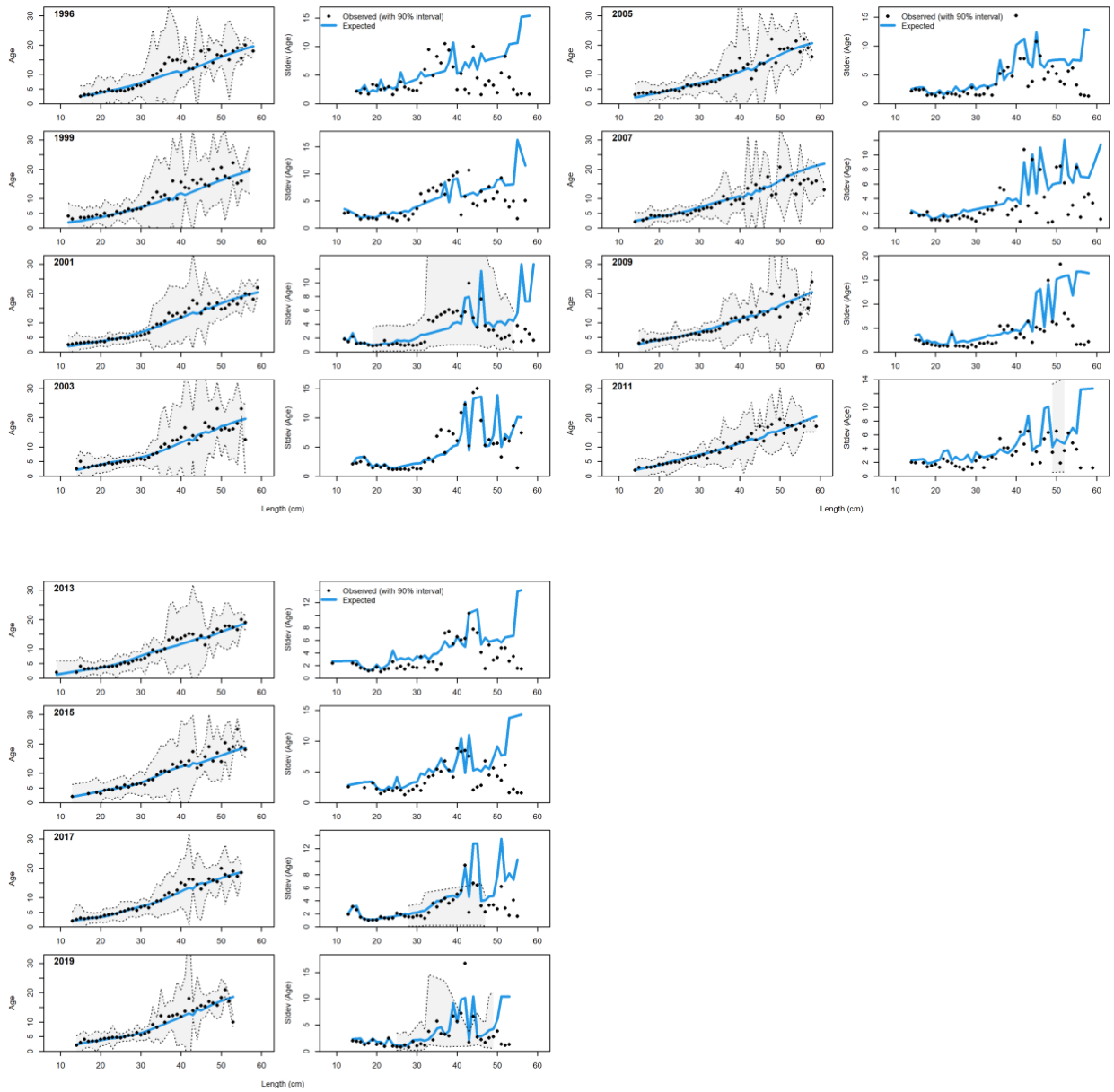


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

f) Model 21.2, central GOA

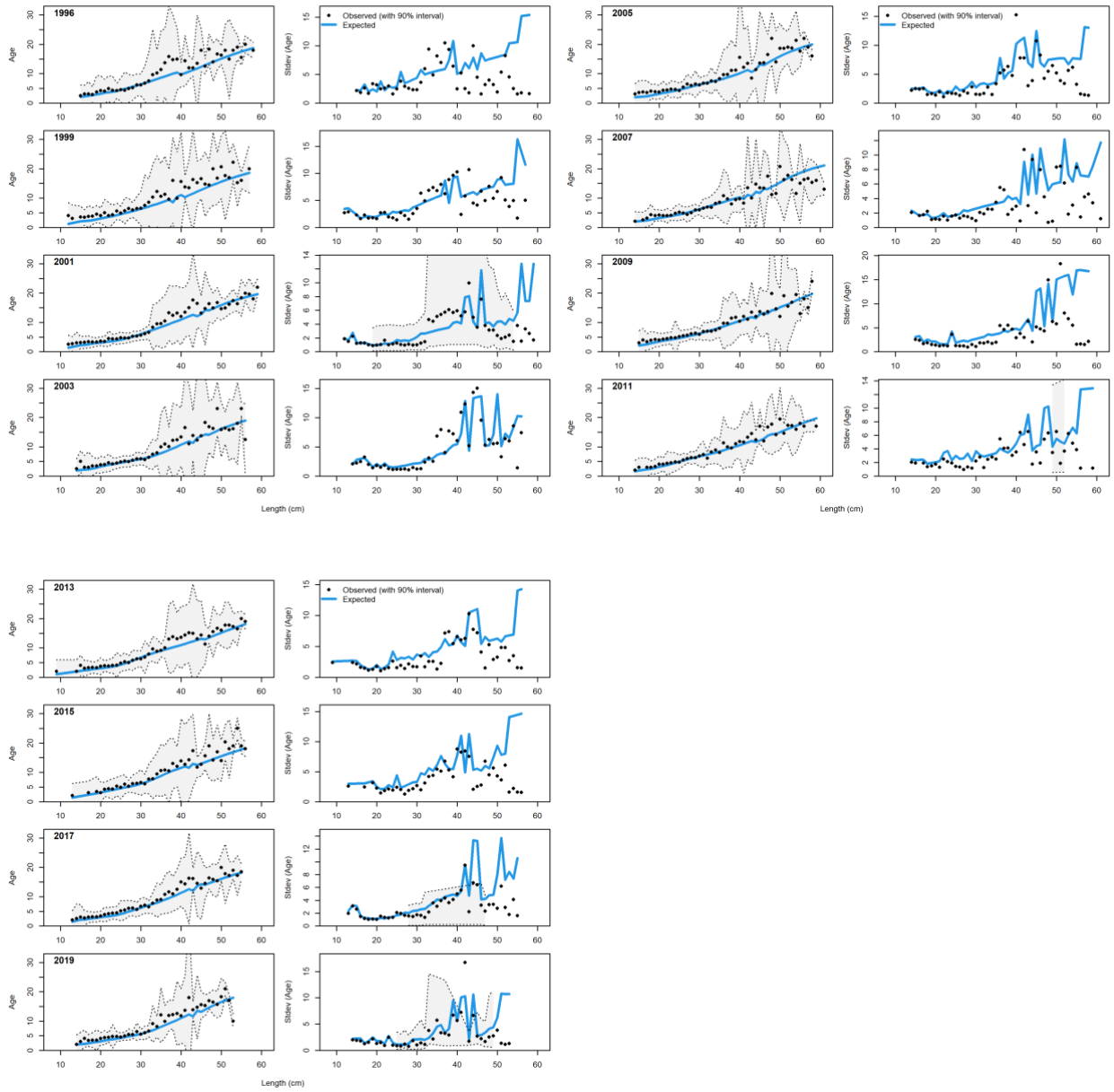


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

g) Model 21.0, western GOA

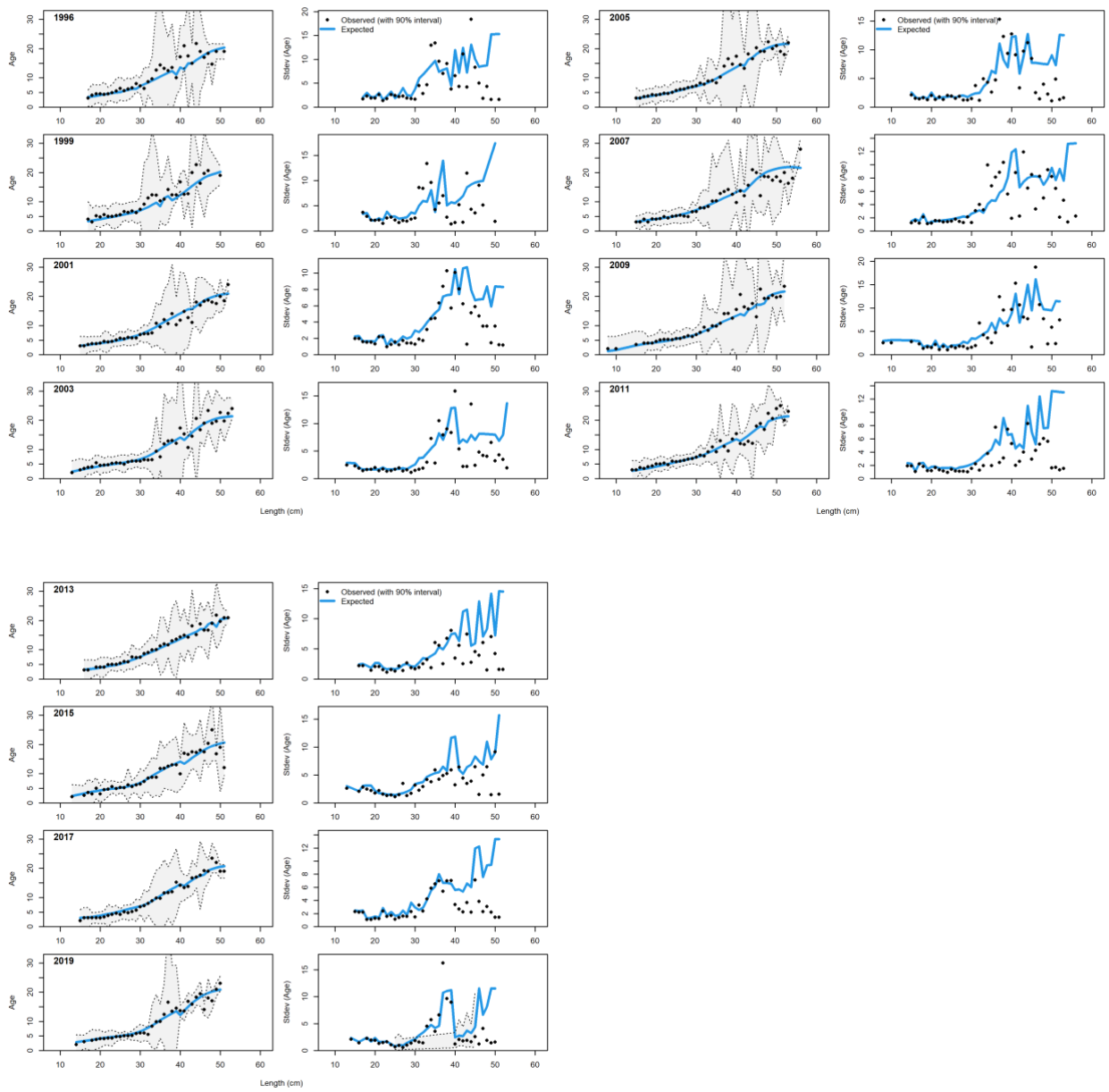


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

h) Model 21.1, western GOA

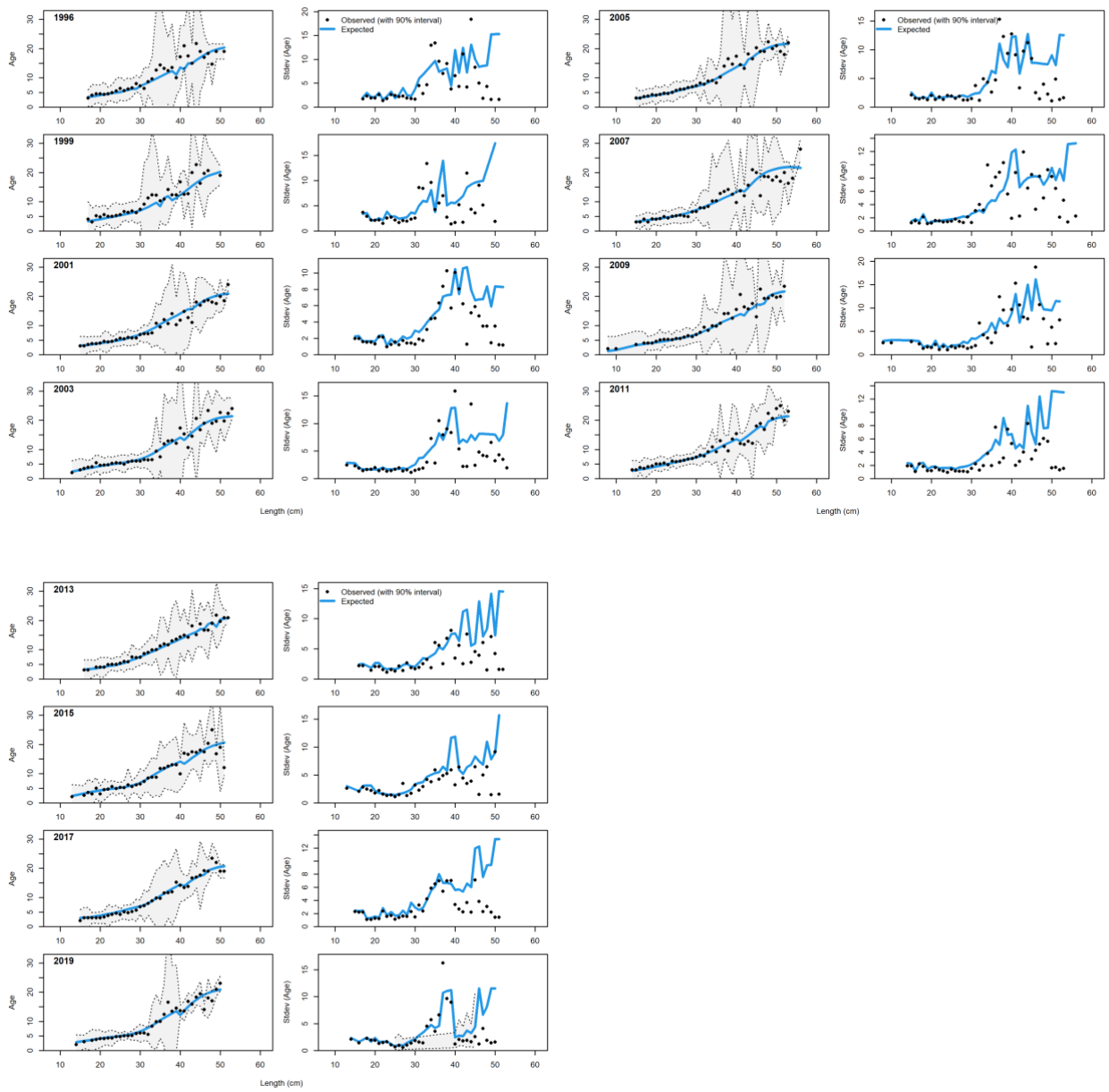


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

i) Model 21.2, western GOA

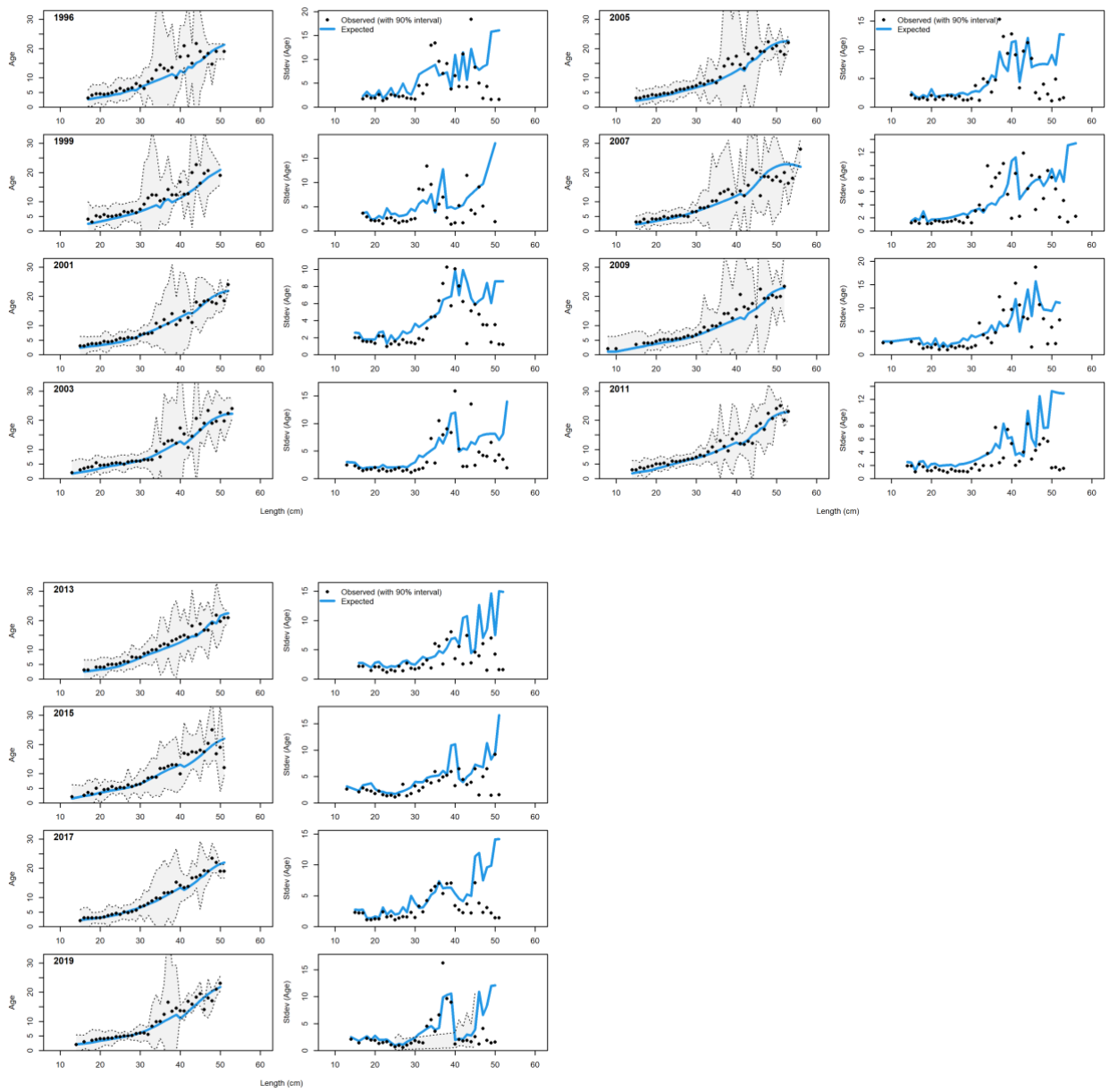


Figure A.14. Model fit to the southern rock sole survey conditional age at length data. a-i) Represent the fit by model, sex, and area. Each panel is labelled with model, sex, and area.

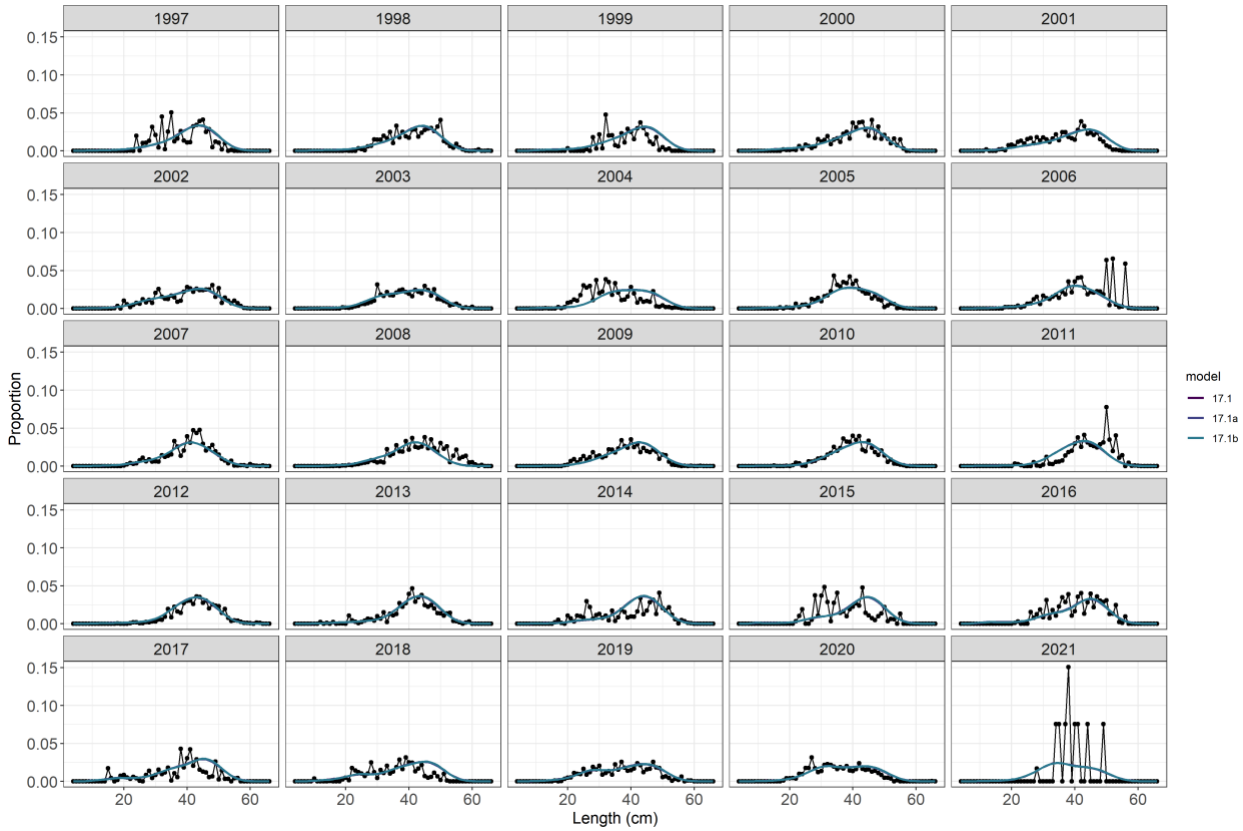


Figure A.15. Single area model fit to the female southern rock sole fishery length composition data.

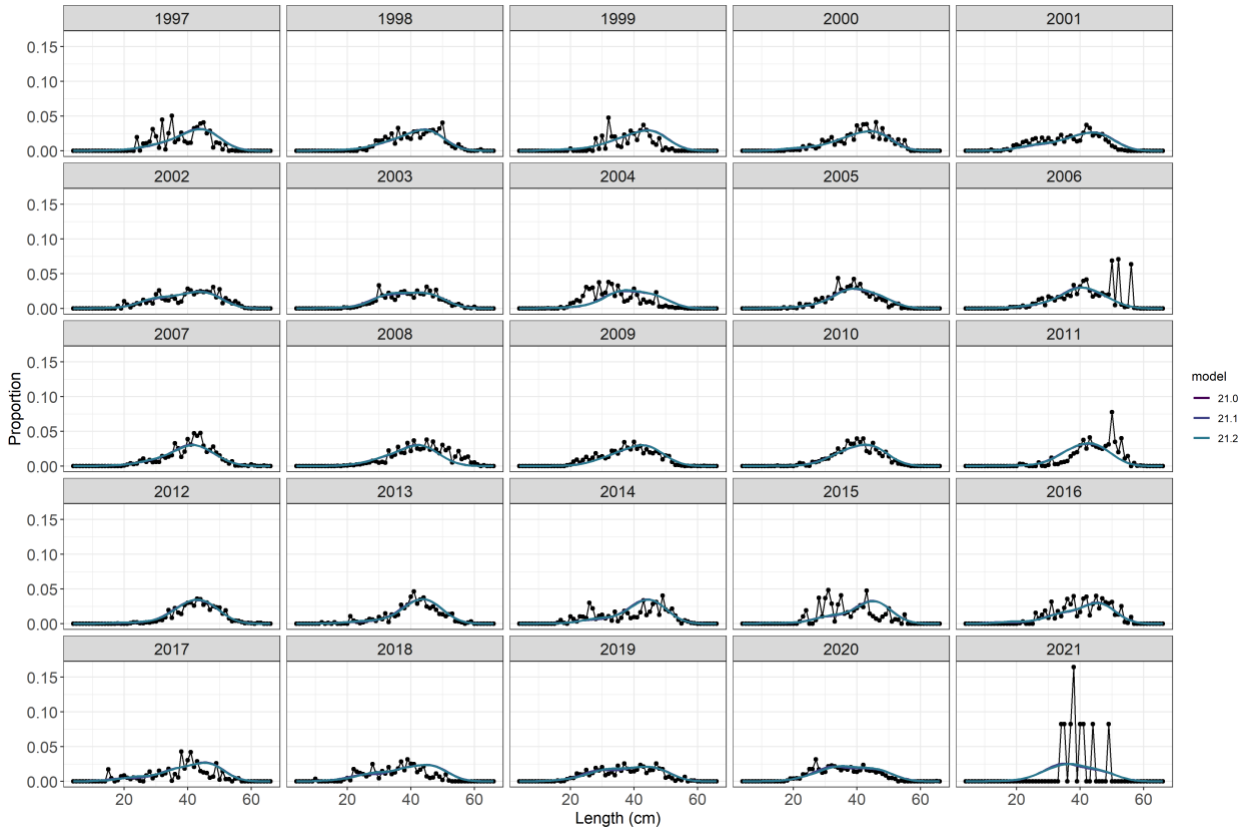


Figure A.16. 2-area model fit to the female southern rock sole fishery length composition data from the central GOA.

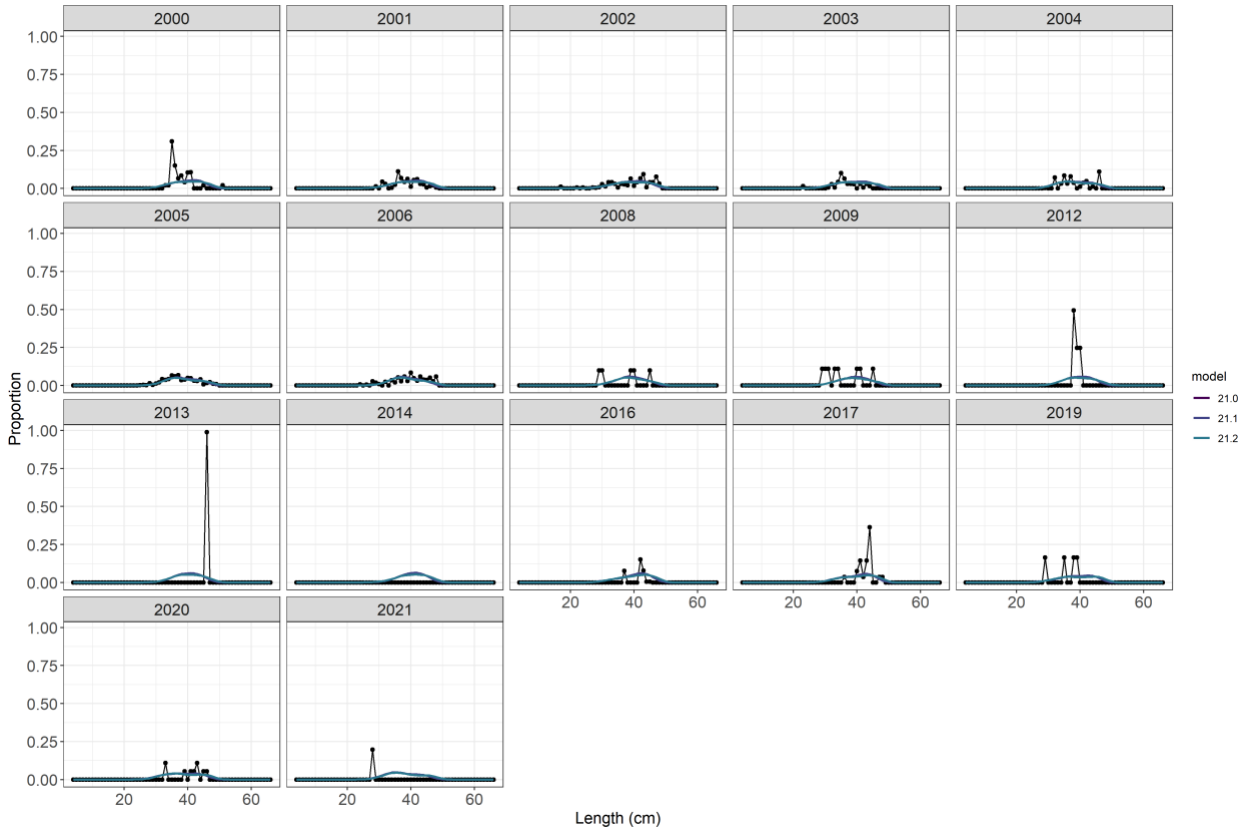


Figure A.17. 2-area model fit to the female southern rock sole fishery length composition data from the western GOA.

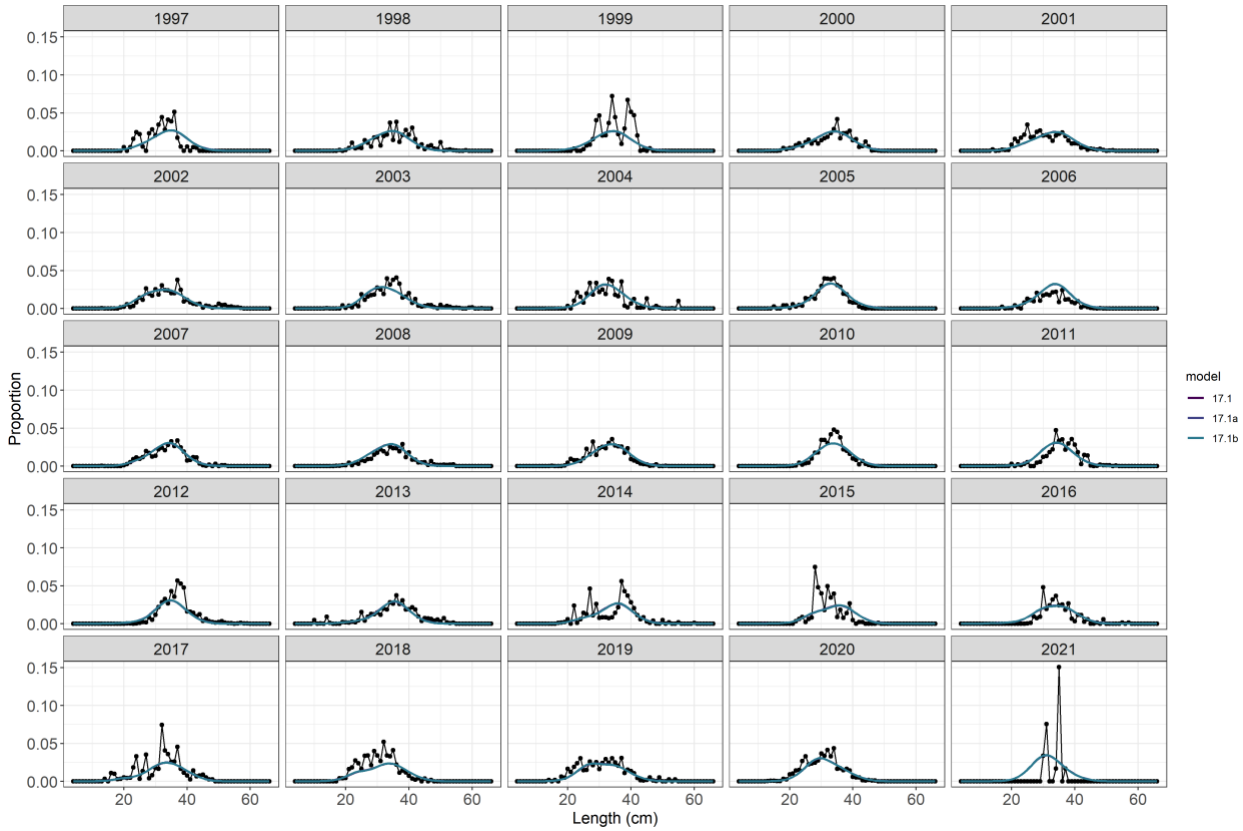


Figure A.18. Single area model fit to the male southern rock sole fishery length composition data.

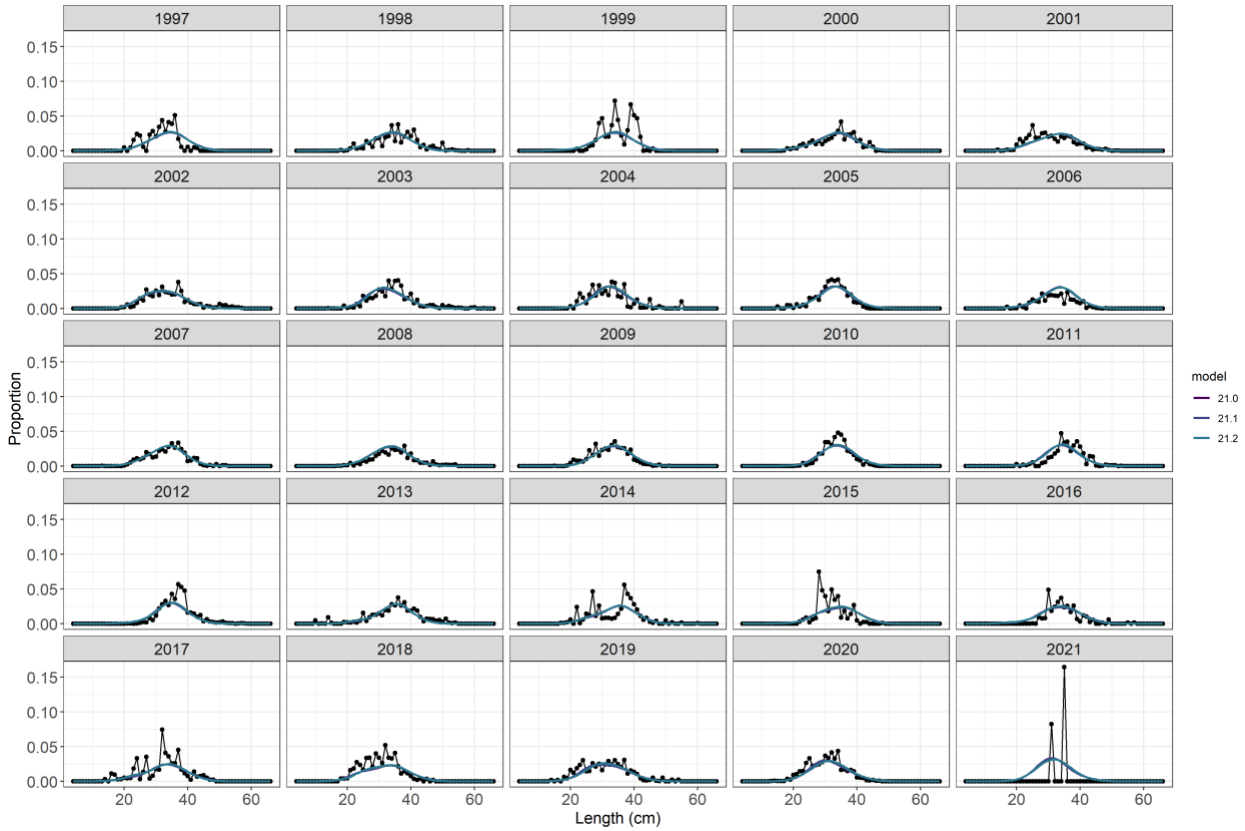


Figure A.19. 2-area model fit to the male southern rock sole fishery length composition data from the central GOA.

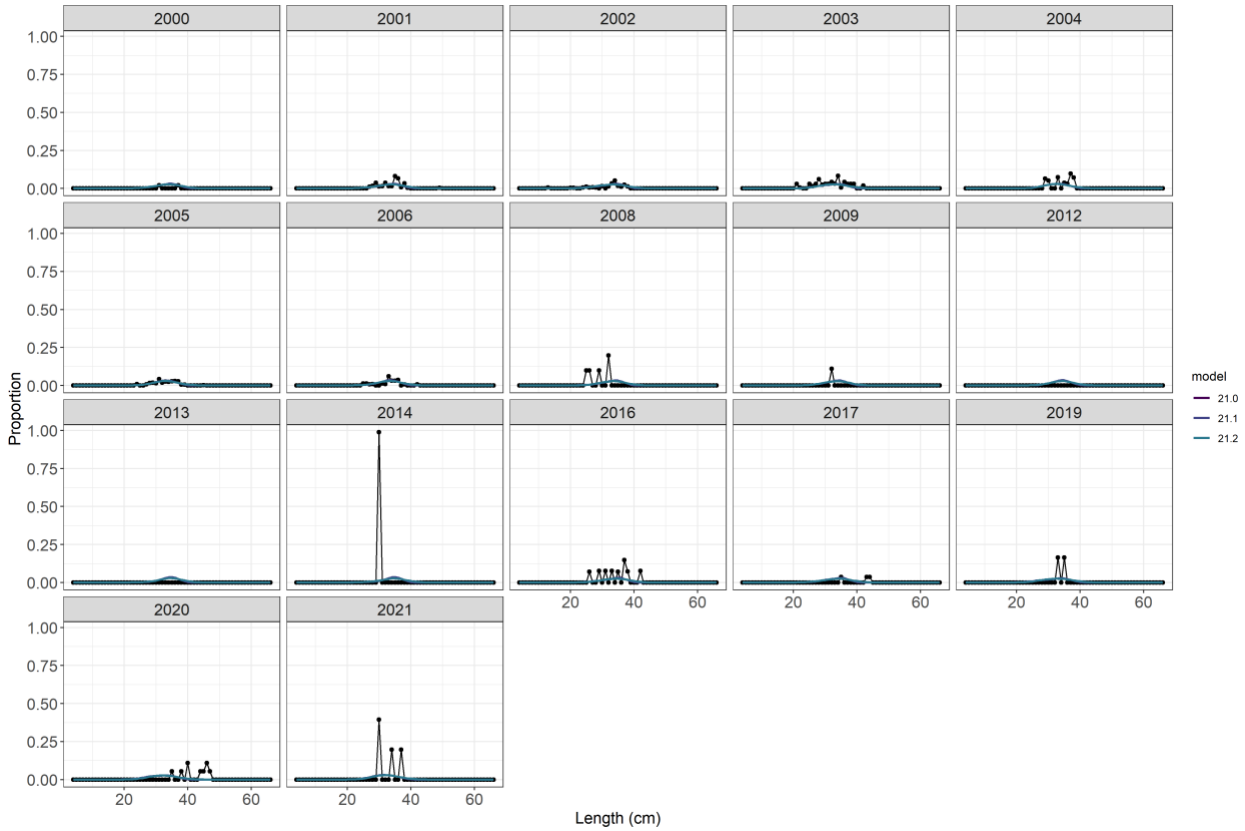


Figure A.20. 2-area model fit to the male southern rock sole fishery length composition data from the western GOA.

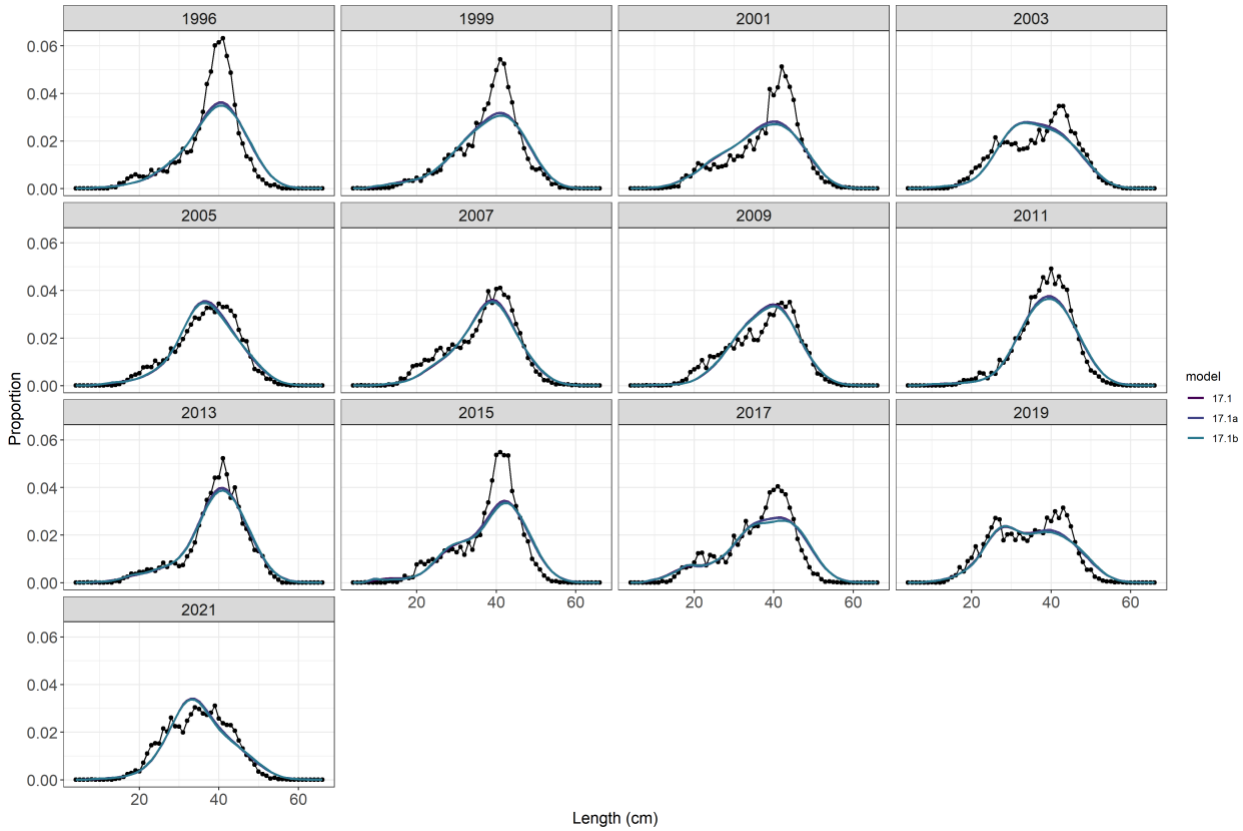


Figure A.21. Single area model fit to the female southern rock sole survey length composition data.

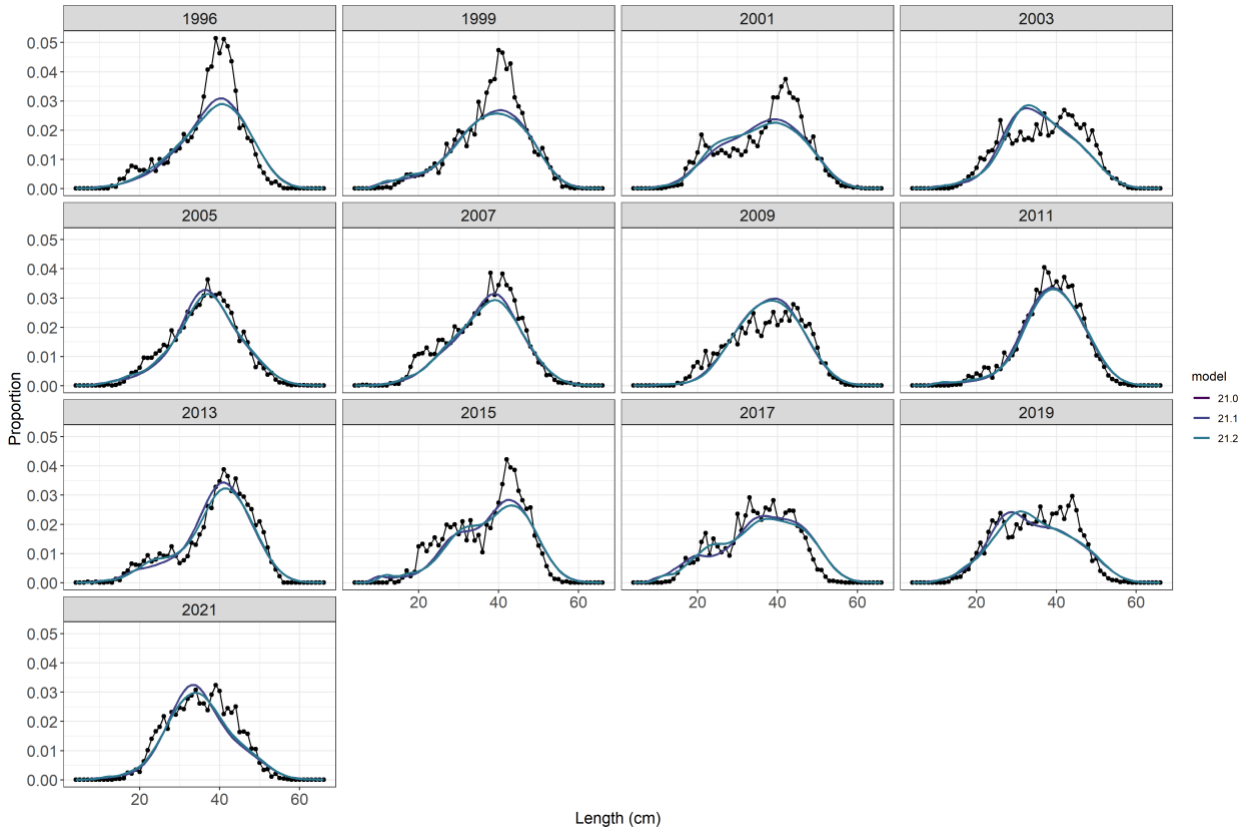


Figure A.22. 2-area model fit to the female southern rock sole survey length composition data from the central GOA.

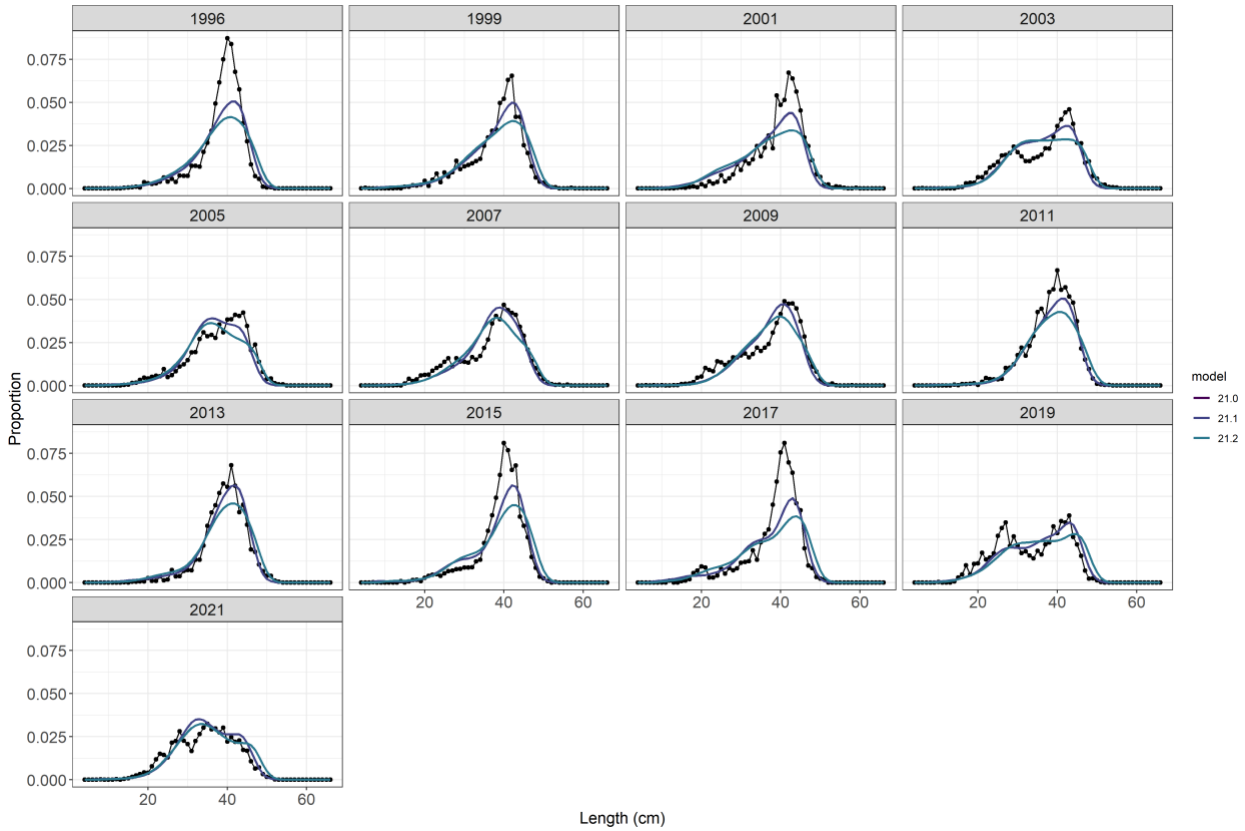


Figure A.23. 2-area model fit to the female southern rock sole survey length composition data from the western GOA.

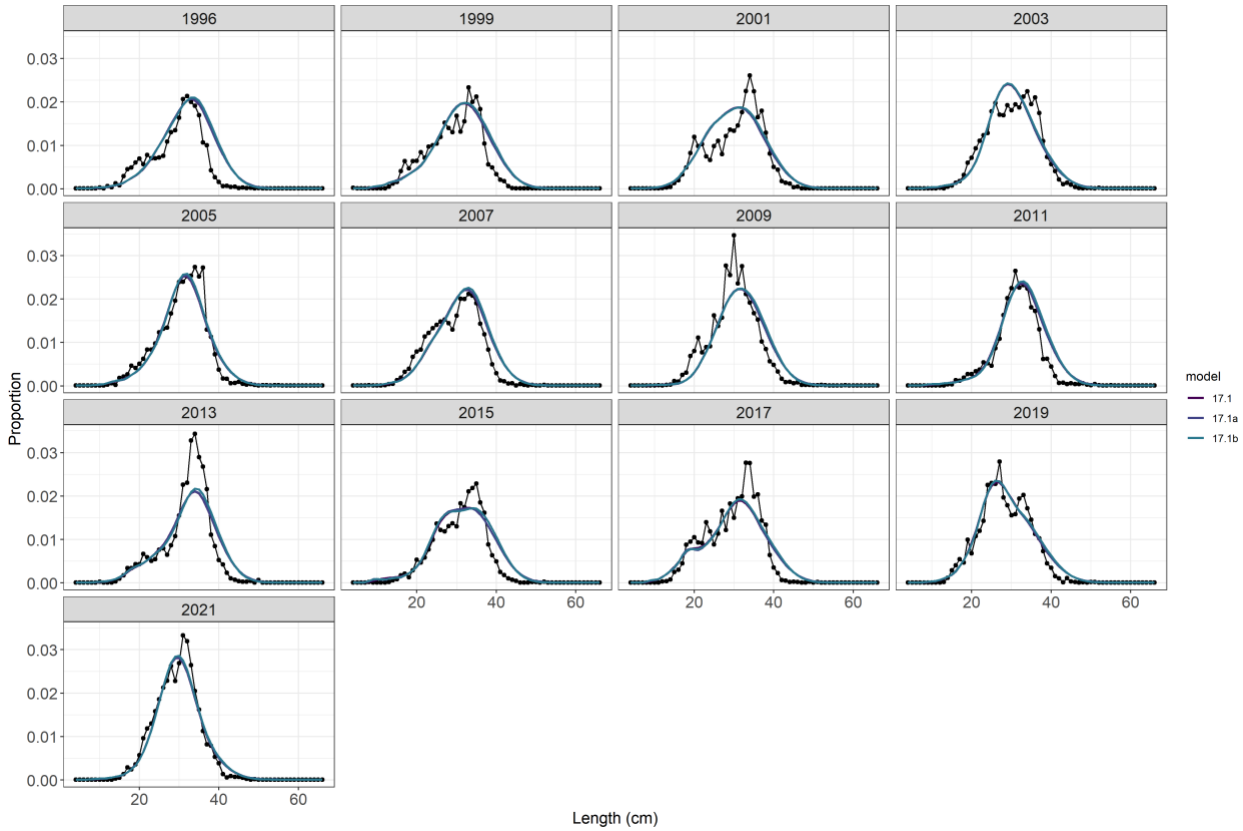


Figure A.24. Single area model fit to the male southern rock sole survey length composition data.

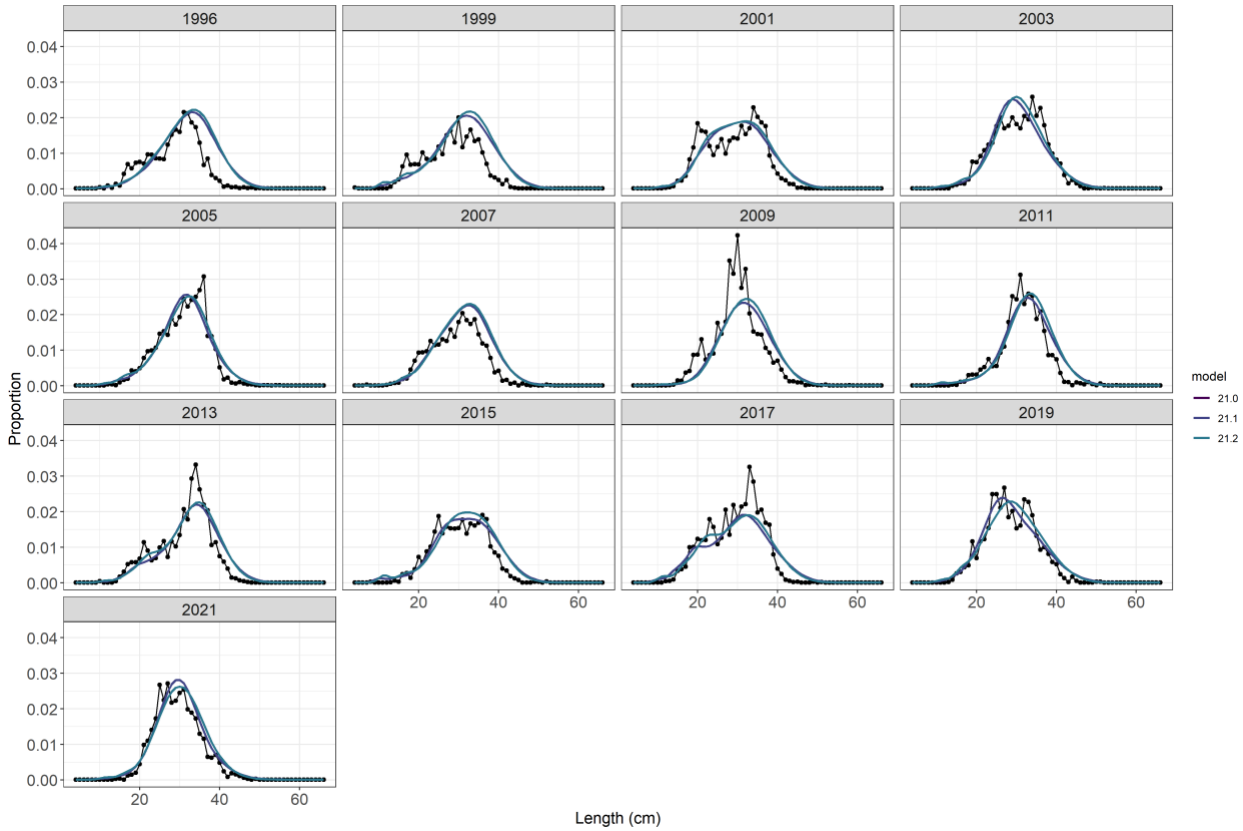


Figure A.25. 2-area model fit to the male southern rock sole survey length composition data from the central GOA.

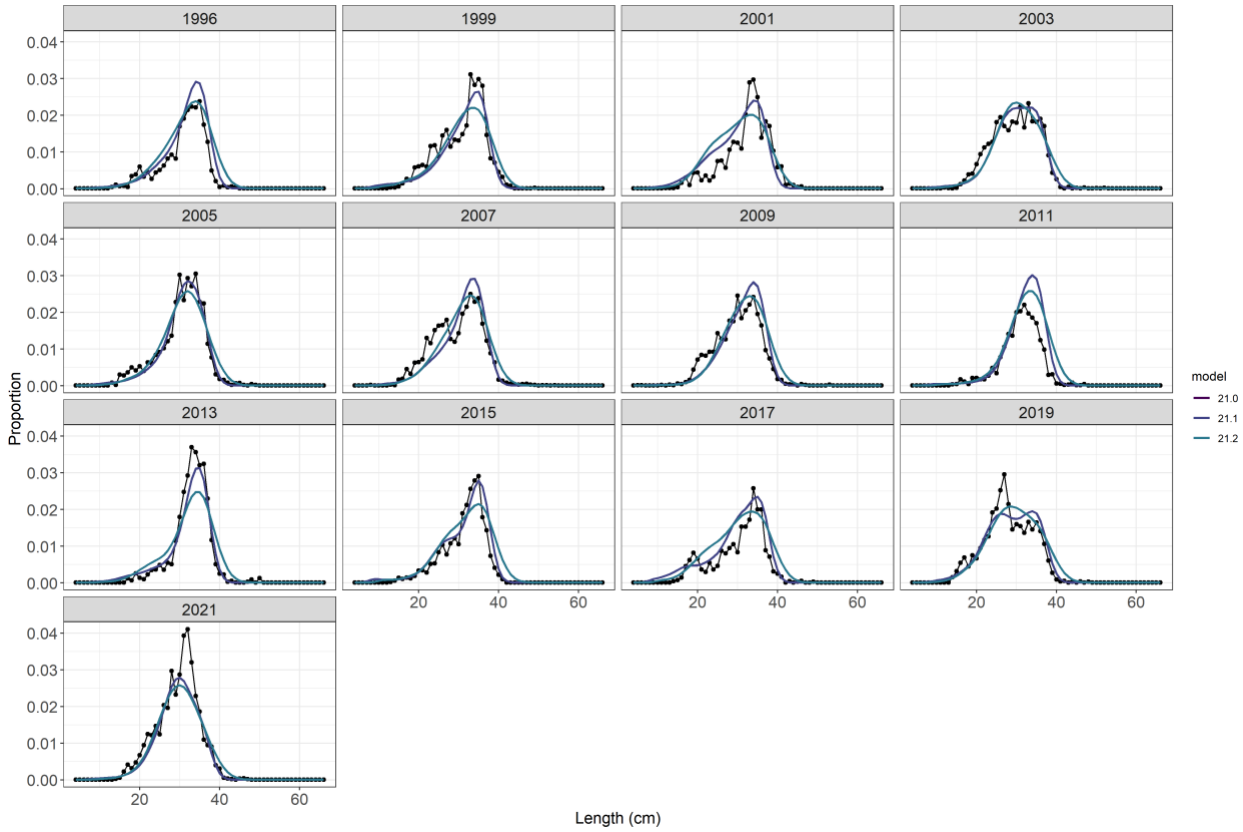


Figure A.26. 2-area model fit to the male southern rock sole survey length composition data from the western GOA.