Chapter 4.1: Assessment of the northern and southern rock sole (*Lepidopsetta polyxystra and bilineata*) stocks in the Gulf of Alaska for 2016

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Executive Summary

Summary of Changes in Assessment Inputs

Relative to last year's assessment, the following changes have been made in the current assessment:

New Input data

1. Fishery: 2014 and preliminary 2015 total (undifferentiated) rock sole catch, and 2014 and preliminary 2015 fishery observer undifferentiated (U), northern (N), and southern (S) rock sole catch-at-length data
2. Survey: 2015 N and S rock sole biomass and size composition from the NMFS GOA bottom trawl survey

Changes in assessment methodology

There were no changes in assessment methodology; Stock Synthesis was used for all model configurations in this analysis.

Summary of Results

The biomass estimate from the 2015 GOA NMFS bottom trawl survey for northern rock sole was a significant decrease (30.2%) from the estimate from the 2013 survey. The biomass estimate from the 2015 survey for southern rock sole was a slight decrease (4.7%) from the estimate from the 2013 survey.

Stock Synthesis was used for all model configurations in this analysis; Stock Synthesis models have been presented at the September Groundfish Plan Team meetings in 2013, 2014, and 2015. The 2012 final model was a two-species two-sex mixed-fishery statistical catch-at-age population dynamics ADMB (ADMB Project, 2009) model.

Northern Rock Sole

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2015	2016	2016	2017
M (natural mortality rate)	0.2,0.251*	0.2, 0.251*	0.2,0.250*	0.2, 0.250*
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	80,000	68,600	75,600	68,400
Projected Female spawning biomass	40,600	32,600	35,600	30,900
$B_{100\%}$	50,400	50,400	51,800	51, 800
$B_{40\%}$	20,100	20,100	20,700	20,700

$B_{35\%}$	17,600	17,600	18,100	18,100
F_{OFL}	0.452	0.452	0.299	0.299
$maxF_{ABC}$	0.374	0.374	0.248	0.248
F_{ABC}	0.374	0.374	0.248	0.248
OFL (t)	17,000	14,200	14,000	12,800
maxABC (t)	14,300	11,900	11,800	10,800
ABC (t)	14,300	11,900	11,800	10,800
	As determined *last* year for:		As determined *this* year for:	
Status	2013	2014	2014	2015
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	no
Approaching overfished	n/a	no	n/a	no

*Estimated in model for males

Southern Rock Sole

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2015	2016	2016	2017
M (natural mortality rate)	0.2, 0.259*	0.2, 0.259*	0.2, 0.248*	0.2, 0.248*
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	119,500	103,600	138,600	120,200
Projected Female spawning biomass	72,200	65,900	74,000	60,600
$B_{100\%}$	81,500	81,500	93,500	93,500
$B_{40\%}$	32,600	32,600	37,400	37,400
$B_{35\%}$	28,500	28,500	32,700	32,700
F_{OFL}	0.243	0.243	0.222	0.222
$maxF_{ABC}$	0.204	0.204	0.186	0.186
F_{ABC}	0.204	0.204	0.186	0.186
OFL (t)	19,600	16,600	22,700	19,600
maxABC (t)	16,700	14,100	19,200	16,600
ABC (t)	16,700	14,100	19,200	16,600
	As determined *last* year for:		As determined *this* year for:	
Status	2013	2014	2014	2015
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	no
Approaching overfished	n/a	no	n/a	no

*Estimated in model for males

Responses to SSC and Plan Team Comments Specific to this Assessment

Plan Team, Sept. 2015: "*The model for NRS was sensitive to specified lambda (lambda values affect recent recruitment estimates) and that the* ***team recommends that should this pattern remain when the 2015 GOA bottom trawl survey data are added, that options to stabilize the recent recruitment be used.***"

Response: Options used to stabilize recent recruitment estimates, specifically the large estimate for 2011, included changing the weighting on recent fishery length composition and survey age and length composition data.

Plan Team, Sept. 2015: "*The Team* ***recommends that for presentation purposes for the November meeting, the author favor the asymptotic survey selectivity at length option and provide estimates for each species separately.*** *The data fit better for these options.*"

Response: Each set of model configurations for northern, southern, and undifferentiated rock sole estimate survey selectivity-at-length by sex, and all model configurations are independent.

Plan Team, Sept. 2015: "*Finally, the Team* ***recommends that the 2016 rock sole assessment author revisit the PT and SSC comments and suggestions that will not be addressed in the 2015 assessment.***"

Response: This recommendation will be addressed in 2016.

SSC, Oct. 2015: "The only substantive change to the assessment models for rock sole over last year's assessment is that now an asymptotic selectivity is assumed. The 2015 GOA bottom trawl survey have not yet been added to the assessment. In its present state, the model for Northern Rock Sole is extremely sensitive to a specified model parameter that largely affects the recruitment estimates. The Plan Team recommends that, if this pattern persists after the data are updated, options to stabilize recruitment should be used. **In addition, the SSC also recommends identifying the source of information that is responsible for the large recruitment anomalies in the NRS model.**"

Response: The 1999 and 2011 estimates of age-0 NRS have been significantly larger than average. The 2001 and 2013 NRS bottom trawl survey age composition data have similar proportions of age-2 fish, both of which are larger than average, and the estimated survey selectivity-at-age for age-2 fish is low. Thus, the large estimates of age-0 NRS in 1999 and 2011 have some support given the survey age data. However, there does not appear to be a larger-than-average proportion of age-4 NRS present in the 2015 bottom trawl survey length composition data. The NRS fishery length composition data for 2013 – 2015 have a lower-than-average proportion of female fish (Fig. 4.1.8), which was not seen in the 2013 and 2015 survey length composition data (Fig. 4.1.9). Decreasing the weight on the recent fishery length composition data has decreased the 2011 estimate of age-0 NRS.

Introduction

Rock sole are demersal fish 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 the 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. The northern rock sole spawns in midwinter and spring, and the 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, 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*), as these species are caught in the shallow-water flatfish fishery (Turnock et al., 2009).

See the Chapter 4 for more information on the Gulf of Alaska northern and southern rock sole stocks

Fishery

Rock sole are caught in the shallow-water flatfish fishery and are not targeted specifically, as they co-occur with several other species. The rock sole species were differentiated in survey data beginning in 1996, and were differentiated in the fishery observer data beginning in 1997. Data for more recent years have the species listed as northern (N), southern (S), or “undifferentiated” (U) rock sole as 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.

See the Chapter 4 for more information on the Gulf of Alaska shallow-water flatfish fishery

Data

This section describes data used in the current assessment model. It does not attempt to summarize all available data pertaining to northern and southern rock sole in the GOA.

Data	Source	Type	Years included
Fishery catch	AKFIN	metric tonnes	1977 – 2015
Fishery catch-at-length[a]	AKFIN / FMA	number, by cm bin	1989 – 2015
GOA NMFS bottom trawl survey biomass and abundance estimates[b]	AFSC	metric tonnes, numbers	1984 – 2015
GOA NMFS bottom trawl survey length composition[b]	AFSC	number, by cm bin	1984 – 2015
GOA NMFS bottom trawl survey age composition[b]	AFSC	number, by age	1984 – 2013
GOA NMFS bottom trawl survey mean length-at-age[b]	AFSC	mean value and number	1984 – 2013

[a]Species-specific fishery observer catch-at-length data are available for 1997 – 2015
[b]Species-specific survey data are available for 1996 – 2015

The survey data for 1984, 1987, 1990, and 1993 are for U rock sole; the survey data for 1996 on are for N and S rock sole, and the fishery observer length composition data for 1997 on are for N, S, and U rock sole. The catch data are for U rock sole.

Fishery:

The fishery data available include total (undifferentiated) rock sole catch, retained and discarded, by year and area (Table 4.1.1, Figs. 4.1.1 and 4.1.2); fishery observer species-specific extrapolated haul-level data (Table 4.1.2, Fig. 4.1.3); and fishery observer catch-at-length data for 1989 through 2015 for U, N, and S rock sole. The fishery observer data for N and S rock sole are separated by species from 1997 on. Data for more recent years have the species listed as N, S, or U rock sole as adult northern and southern rock sole are difficult to differentiate visually (Orr and Matarese, 2000). More information on catches before 1991is available in Turnock et al. (2011).

Survey:

The survey data available include NMFS GOA bottom trawl survey biomass and population estimates by area for 1984, 1987, 1990, 1993, 1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015 (Table 4.1.3, Figs. 4.1.4, 4.1.5, 4.1.6, and 4.1.7); survey population length composition data for all survey years; survey population age composition for all survey years except for 2015; survey conditional age-at-length data for all survey years except 1984 and 2015; and survey estimates of mean length-at-age for all survey years except for 2015. The survey data for 1984, 1987, 1990, and 1993 are for U rock sole; the survey data for 1996 on are for N and S rock sole.

Analytic Approach

Model Structure

Three independent sets of Stock Synthesis model configurations were developed, for the undifferentiated (U), northern (N), and southern (S) rock sole stocks. Stock Synthesis version 3.24S (Methot, 2013) was used. Technical details of Stock Synthesis are described by Methot and Wetzell (2013). All model configurations covered ages 0 to 30, were sex-specific, and estimated male natural mortality; female natural mortality was fixed at 0.2. Values for other biological parameters came from Turnock et al. (2011). Survey age composition data were used in model fitting for years when both survey length and age composition data were available. All sets of time-varying parameters in the U model configurations, e.g., for selectivity or growth, were unconstrained; there were no time-varying parameters in the N and S model configurations. All length and age composition data are sex-specific. All models start in 1977 and used a σ_R value of 0.6.

The main difference between the 2014 and 2015 model configurations is the assumption of asymptotic survey selectivity for 1990 on, as that assumption is made in the GOA shallow-water flatfish stock assessment (Turnock et al., 2011) and other GOA flatfish assessments.

The U model configurations used all fishery and survey data for U, N, and S rock sole; the species-specific model configurations used species-specific fishery length composition and survey data.

For the U models configurations, the data were split into 3 periods to account for changes in the ratio of northern and southern rock sole. The data from the NMFS GOA bottom trawl survey were divided into three periods, 1984 – 1993, 1996 – 2006, and 2007 on, with respect to catchability and selectivity. Catchability is set to 1.0 for the latter two survey periods and estimated for the first period, as Thompson et al. (2009) note that "the [NMFS GOA bottom trawl] survey used 30-minute tows during that period [1984-1993], but 15-minute tows thereafter [from 1996 on]".

All fishery catch-at-length data were used in model fitting for the U model configurations; the three fishery selectivity curves correspond to three periods, 1977 – 1996, 1997 – 2005, and 2006 on, so that each period had at least 8 years of data. Survey length composition data for all survey years and survey conditional age-at-length data for 1990 on were used in model fitting. The conditional age-at-length data for 1984 and 1987 were not used, as Boldt and Zador (2009) state that "…the gears used by the Japanese vessels in the [NMFS GOA bottom trawl] surveys prior to 1990 were quite different from the survey gear used aboard American vessels in subsequent surveys and likely resulted in different catch rates for many of these groups."

For the species-specific model configurations, the species-specific survey data (1996 on) and the fishery length composition data (1997 on) were used in all model configurations. Constant growth and fishery and survey selectivity were estimated. The time series of catch in the species-specific models was ½ of the total (undifferentiated) rock sole catch (Fig. 4.1.10); there is considerable uncertainty about what fraction of the catch is northern and southern rock sole. Other data for undifferentiated rock sole were not used in the species-specific model configurations.

The sample sizes for the fishery and survey length composition data were the number of hauls or trips with U, N, and/or S rock sole. The sample sizes for the survey conditional age-at-length data were the number of samples in that length bin multiplied by the total number of hauls with U/N/S rock sole in that survey year divided by the total number of U/N/S rock sole samples in that survey year. This sample size adjustment results in the sum of the conditional age-at-length sample sizes for each survey year being the number of hauls in that survey year.

The undifferentiated rock sole data model configurations, designated "URS", included

- 3 periods of sex-specific double normal fishery selectivity-at-length, 1977-1996, 1997-2005, and 2006-2015;
- 4 periods of sex-specific double normal survey selectivity-at-length, 1977-1989, 1990-1995, 1996-2006, and 2007-2015, with the latter 3 periods being asymptotic;
- 3 periods of sex-specific von Bertalanffy growth, 1977-1995, 1996-2004, and 2005-2015, which allows for the changing ratio of northern to southern rock sole;
- Fit to fishery length composition and survey length and age composition and conditional age-at-length data; and
- Estimated natural mortality for males.

The URS model configurations are for reference only, as many of their characteristics, like growth and maturity, are a combination of northern and southern rock sole characteristics. The URS model configurations use all of the data for undifferentiated, northern, and southern rock sole, in order to compare and contrast the model results which use aggregated data to the species-specific model results.

The northern and southern rock sole model configurations, designated "NRS" and "SRS", respectively, each included

- 1 period of sex-specific double normal fishery selectivity-at-length;
- 1 period of sex-specific asymptotic double normal survey selectivity-at-length;
- 1 period of sex-specific von Bertalanffy growth;
- Fit to fishery length composition and survey length and age composition and conditional age-at-length data; and
- Estimated natural mortality for males.

Parameters Estimated Outside the Assessment Model

The initial values for the growth and maturity parameters used in the model are from Stark and Somerton, 2002.

Northern rock sole

- Males: L_∞=382 mm, k=0.261, t_0=0.160;
- Females: L_∞=429 mm, k=0.236, t_0=0.387, L_{T50} = 328 mm.

Southern rock sole

- Males: L_∞=387 mm, k=0.182, t_0=-0.962;
- Females: L_∞=520 mm, k=0.120, t_0=-0.715, L_{T50} = 347 mm.

The growth parameters for weight-at-length ($W = aL^b$, weight in kg and length in cm) for northern and southern rock sole males and females are 9.984×10^{-6} and 3.0468 for *a* and *b*, respectively (Turnock et al., 2011). A_{min} is age 2 for NRS, and age 3 for SRS and URS. Natural mortality was fixed at 0.2 for females in all model configurations.

See the Chapter 4 for more information on growth, maturity, and natural mortality for GOA northern and southern rock sole

Parameters Estimated Inside the Assessment Model

Parameters that were estimated in the model configurations included:

- median and initial age-0 recruitment;
- annual recruitment deviations for 1977 – 2014;
- natural mortality for males;
- annual fishing mortality;
- initial fishing mortality;
- fishery selectivity-at-length by sex, and fishery period for U models;
- survey catchability for the early survey period for U models;
- survey selectivity-at-length by sex, and survey period for U models;
- length-at-age growth parameters by sex, and growth period for U models;
- CVs for length-at-age at A_{min}, by sex; and
- CVs for length-at-age at A_{max} (A_∞, corresponding to L_∞)

The stock-recruitment relationship in all model configurations is an average level of recruitment unrelated to stock size. Recruitment variability, σ_R, was fixed at 0.6. Catchability for the survey for 1996 on was fixed at 1.0 in all model configurations.

Results

Model Evaluation

Model comparisons included fit to the catch, fishery length composition, survey biomass indices, and survey length and age composition and conditional age-at-length data; reasonable curves for fishery and survey selectivity; the total negative log likelihood (NLL) value and its components; and that the model estimated the variance-covariance matrix. Survey selectivity was length-based and fitted to age composition data.

Three model configurations are presented for each of the NRS, SRS, and URS model configurations. Model 0 is the 2014 model with the 2014 data (no new data), Model 1 is the 2014 model with data through 2015, and Model 2 is the 2015 model with data through 2015.

Models 0, 1, and 2 for NRS have similar overall patterns for spawning biomass (Fig. 4.1.11) and age-0 recruits (Fig. 4.1.12), although there are differences in the values for recent years. Model 2 for NRS, the 2015 model, fits the survey biomass better than Models 0 and 1 (Fig. 4.1.13). Models 0, 1, and 2 for SRS also has a similar pattern for spawning biomass (Fig. 4.1.14); the age-0 recruits are very similar across the three models (Fig. 4.1.15). Model 2 for SRS also fits the survey biomass better than Models 0 and 1 (Fig. 4.1.16). Models 0, 1, and 2 for URS also have similar patterns for spawning biomass (Fig 4.1.17) and age-0 recruits (Fig. 4.1.18). Model 2 for URS fits the survey biomass better than Models 0 and 1 (Fig. 4.1.19) due mainly to the early survey period, 1984 – 1993, split into two 2-year periods in Model 2.

The NRS model configurations estimated significantly larger than average values for age-0 recruits in 1999 and 2011. The survey age composition data for 2001 and 2013 both have larger than average proportions for age-2 fish, which supports the larger than average age-0 recruit estimates for 1999 and 2011. However, there does not appear to be a larger than average proportion of age-4 fish in the 2015 survey length composition data (Fig. 4.1.28, bottom panel). The average fraction of females for NRS in the fishery length composition data for 1997 – 2014 is 0.562 (Fig. 4.1.8) and 0.577 for the survey length composition data for 1996 – 2015 (Fig 4.1.9); the fraction of females for NRS in the fishery length composition data for 2013 and 2014 are 0.425 and 0.489, respectively, which are significantly lower than average. Since the fishery length composition data for 2013 and 2014 are anomalous relative to the data from previous years, they have been downweighted to decrease the influence of the lower than average fraction female. The 2015 NRS model configurations estimated the 2015 survey biomass within the uncertainty intervals only when the sample sizes on the fishery length composition data for 2013 and 2014 were less than ¼ of their original values. The sample sizes were decreased to 1/8 of their original values in the final 2015 NRS model configuration, and ¼ in the final 2015 URS model configuration.

The negative log likelihood (NLL) components for the final 2015 NRS, SRS, and URS model configurations (Model 2) are in Table 4.1.4. The estimated growth parameters for the NRS and SRS model configurations are in Table 4.1.5, and in Table 4.1.6 for URS. Parameter estimates with standard deviations for the NRS, SRS, and URS model configurations are in Table 4.1.12.

Time Series Results

The pattern of spawning biomass for the final 2015 URS and SRS model configurations are similar (Fig. 4.1.20), as are the age-0 recruits (Fig. 4.1.21). None of the final 2015 model configurations fit the survey biomass well (Fig. 4.1.22), as there appear to be factors other than fishing influencing the NRS and SRS stocks which are not accounted for in the model configurations.

The time series of spawning biomass and age-0 recruits, with standard deviations, for NRS and SRS model configurations are in Table 4.1.7. The estimates of numbers-at-age for northern rock sole females and males are in Tables 4.1.8 and 4.1.9, respectively, and in Tables 4.1.10 and 4.1.11 for southern rock sole. Female maturity-at-age and derived fishery and survey selectivity-at-age for the N and S model configurations are in Table 4.1.13.

The time series of annual catches used for the N and S model configurations, which is ½ of the total (undifferentiated) rock sole catch, is in Figure 4.1.10.

Total and spawning biomass for NRS were stable over most of the historical period, with the highest value in 2007 and spawning biomass decreasing moderately through 2015 (Figs. 4.1.23 and 4.1.24). Age-0 recruits are moderately variable for the recent period, with lower uncertainty on estimates for the 1990s and 2000s (Fig. 4.1.25). The fits to the survey biomass are reasonable, given the uncertainty intervals (Fig. 4.1.26). The fishery and survey selectivity-at-length curves for females and males are in Figure 4.1.27. The summary of the fits to the fishery and survey length composition data are in Figures 4.1.28; the 2015 survey length composition data are the only data in the bottom panel. The fits to the fishery length composition data are in Figure 4.1.29. The estimates of the survey length composition data are in Figure 4.1.30; these data are not used in model fitting. The fits to the survey age composition data are in Figure 4.1.31. The survey conditional age-at-length data and the estimated relationships are in Figure 4.1.32. Females are larger than males on average at all ages (Fig. 4.1.33).

Total and spawning biomass for SRS has been more variable than that for NRS, with the highest spawning biomass in 1990 and decreasing moderately through 2015 (Figs. 4.1.34 and 4.1.35). Age-0 recruits were significantly lower than average in 2006 through 2009, and have increased since the lowest level in 2006, with lower uncertainty on estimates for the 1990s and 2000s (Fig. 4.1.36). The fit to the survey index is reasonable, although few, if any, model configurations were able to estimate the 2009 value well (Fig. 4.1.37). The fishery and survey selectivity-at-length curves for males and females are in Figure 4.1.38. The summary of the fits to the fishery and survey length composition data are in Figure 4.1.39; the 2015 survey length composition data are the only data in the bottom panel. The fits to the fishery length composition are in Figure 4.1.40. The estimates of the survey length composition data are in Figure 4.1.41; these data are not used in model fitting. The fits to the survey age composition data are in Figure 4.1.42. The survey conditional age-at-length data and the estimated relationships are in Figure 4.1.43. Females are larger than males on average for ages 4 and older (Fig. 4.1.44).

The spawning biomass and fits to survey biomass from the retrospective model runs for the final 2015 NRS and SRS model configurations are in Figures 4.1.45, 4.1.46, 4.1.47, and 4.1.48, respectively. Both NRS and SRS have consistent patterns, although the SRS model configurations fit the survey biomass better than the NRS model configurations do and both the NRS and SRS runs for 2006 have lower estimates for the recent period than all other models do.

The results for the final 2015 URS model configuration are similar to those from the SRS model configuration (Figs. 4.1.49 – 4.1.65), which is expected as there is over 1½ times more SRS biomass than NRS biomass in all survey years, although on average the abundance of SRS is only somewhat higher than NRS. The survey selectivity-at-length for the early period 1984 and 1987 is dome shaped and significantly different than the survey selectivity-at-length for the other periods (Figs. 4.1.55 and 4.1.56), due to the smaller fish seen in those survey years.

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 1977-2014. Spawning was assumed to occur on 1 April and 15 July for northern and southern rock sole, respectively, and female spawning biomass was calculated using the mean weight-at-age at the time of spawning.

	Northern	Southern
SB_{2016}	35,600	74,000
$SB_{40\%}$	20,700	37,400

$SB_{35\%}$	18,100	32,700
F_{ABC}	0.248	0.186
ABC	11,800	19,200
F_{OFL}	0.299	0.222
OFL	14,000	22,700

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 2015 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2016 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total annual catch for 2015. 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 2016, are as follows ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, *F* is set equal to *max* F_{ABC}. (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* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2015 recommended in the assessment to the *max* F_{ABC} for 2016. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, *F* is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, *F* is set equal to the 2010-2014 average *F*. (Rationale: For some stocks, TAC can be well below ABC, and recent average *F* may provide a better indicator of F_{TAC} than F_{ABC}.)

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 F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above its MSY level in 2015 and above its MSY level in 2028 under this scenario, then the stock is not overfished.)

Scenario 7: In 2016 and 2017, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2026 under this scenario, then the stock is not approaching an overfished condition.)

Simulation results indicate the northern (Table 4.1.14) and southern (Table 4.1.15) rock sole are not overfished currently and are not approaching an overfished condition.

The authors' recommendations for F_{ABC} and ABC for northern and southern rock sole for 2016 are 0.248 and 11,800 mt and 0.186 and 19,200 mt, respectively.

Ecosystem Considerations

See the Chapter 4 for information on ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks

Ecosystem Effects on the Stock

See the Chapter 4 for information on ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks

Fishery Effects on the Ecosystem

See the Chapter 4 for information on ecosystem considerations for the Gulf of Alaska shallow-water flatfish fishery and stocks

Data Gaps and Research Priorities

There is considerable uncertainty about the fractions, by mass, of the shallow-water flatfish catch that is northern or southern rock sole. The fishery observer program samples on average 20% of the shallow-water flatfish catch by mass (A'mar and Palsson, 2013), and U/N/S rock sole is on average 70-80% of the observed shallow-water flatfish catch by mass (Table 4.1.1; Fig. 4.1.1; A'mar and Palsson, 2013).

The increase in random fishery observer samples throughout the year and across the entire GOA may provide more information about the distribution of northern and southern rock sole throughout the year. The NMFS bottom trawl survey takes place in the summer, when southern rock sole are spawning, so that the distribution of northern and southern rock sole determined by the survey may not represent the distribution of northern and southern rock sole at different times. The annual shallow-water flatfish catches come primarily from INPFC area 630 (Fig. 4.1.1); the fishery observer data for shallow-water flatfish come primarily from INPFC area 630 as well (A'mar and Palsson, 2013). However, the survey data suggest that, in the summer, northern rock sole are located primarily in INPFC area 610 (Fig. 4.1.4) and southern rock sole are distributed more widely across the GOA (Fig. 4.1.5).

Another research question is how well the northern and southern rock sole animals are differentiated by fishery observers and survey personnel. Future sampling and genetic analysis of tissue samples would provide more information on the rates of misidentification.

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Tables

Table 4.1.1 – Estimated catch (in metric tonnes) for shallow water flatfish (SWFF) and total (undifferentiated) rock sole catch from the Alaska Fisheries Information Network (AKFIN) (as of 2015-10-15).

Year	SWFF catch (AKFIN)	U/N/S rock sole catch (AKFIN)	% U/N/S rock sole
1991	5,224.6	0.1	-
1992	8,333.8	42.0	-
1993	9,113.7	8,112.1	89.0
1994	3,843.0	3,008.1	78.3
1995	5,436.9	3,923.9	72.2
1996	9,372.4	6,595.3	70.4
1997	7,779.6	5,466.8	70.3
1998	3,567.3	2,532.3	71.0
1999	2,578.4	1,765.4	68.5
2000	6,928.7	5,386.7	77.7
2001	6,163.3	4,771.7	77.4
2002	7,177.3	5,564.3	77.5
2003	4,648.5	3,554.6	76.5
2004	3,094.1	2,216.7	71.6
2005	4,805.1	4,130.5	86.0
2006	7,651.6	5,763.3	75.3
2007	8,692.3	6,727.4	77.4
2008	9,721.0	7,269.1	74.8
2009	8,485.4	6,538.7	77.1
2010	5,533.8	3,285.3	59.4
2011	3,998.4	3,094.5	77.4
2012	4,015.5	2,828.6	70.4
2013	5,523.1	4,058.3	73.5
2014	4,750.4	3,440.3	72.4
2015	2,685.8	2,146.9	79.9

Table 4.1.2 – Totals of fishery observer extrapolated haul-level rock sole catch (in metric tonnes), by species (as of 2015-10-05)

Year	URS	NRS	SRS	Total		% URS	% NRS	% SRS
1997	1,057.9	37.9	46.0	1,141.8		92.7	3.3	4.0
1998	135.7	171.7	223.0	530.4		25.6	32.4	42.0
1999	117.9	122.1	122.0	362.1		32.6	33.7	33.7
2000	220.8	359.8	328.8	909.4		24.3	39.6	36.2
2001	179.3	404.4	425.6	1,009.4		17.8	40.1	42.2
2002	247.5	551.0	335.3	1,133.8		21.8	48.6	29.6
2003	112.0	254.3	265.6	632.0		17.7	40.2	42.0
2004	91.6	84.8	225.6	401.9		22.8	21.1	56.1
2005	39.4	209.9	224.3	473.6		8.3	44.3	47.4
2006	79.2	492.3	177.5	748.9		10.6	65.7	23.7
2007	208.3	644.2	429.6	1,282.1		16.2	50.2	33.5
2008	211.4	551.5	606.3	1,369.2		15.4	40.3	44.3
2009	161.1	498.0	441.8	1,100.8		14.6	45.2	40.1
2010	56.8	374.9	368.2	799.9		7.1	46.9	46.0
2011	76.5	149.5	303.1	529.1		14.5	28.3	57.3
2012	115.5	375.4	705.2	1,196.2		9.7	31.4	59.0
2013	115.9	519.1	476.9	1,111.8		10.4	46.7	42.9
2014	177.3	670.7	312.4	1,160.5		15.3	57.8	26.9
2015	70.9	232.0	99.2	402.0		17.6	57.7	24.7

Table 4.1.3 – GOA NMFS bottom trawl survey biomass (in mt) and population estimates

Year	Species	Total biomass	std dev	Total numbers	std dev
1984	URS	137,623	12,208	404,285,245	43,401,215
1987	URS	123,393	20,329	281,015,223	37,864,353
1990	URS	156,032	19,472	329,427,129	40,836,229
1993	URS	173,044	14,570	346,198,094	29,291,722
1996	NRS	78,845	9,930	208,492,467	30,477,247
1999	NRS	61,543	15,134	151,313,021	34,652,753
2001	NRS	64,809	9,887	140,508,433	17,513,605
2003	NRS	79,648	9,514	203,049,571	26,460,258
2005	NRS	91,453	10,123	216,795,375	23,769,399
2007	NRS	102,641	12,064	226,849,649	26,637,966
2009	NRS	95,846	16,068	257,075,774	51,973,203
2011	NRS	72,875	12,427	148,039,674	24,568,593
2013	NRS	74,586	13,587	152,326,011	31,004,369
2015	NRS	52,069	7,613	143,333,149	20,891,720
1996	SRS	127,390	12,580	186,116,865	16,990,673
1999	SRS	106,235	10,580	154,084,268	15,292,879
2001	SRS	122,492	14,643	174,732,258	20,118,997
2003	SRS	126,819	12,480	199,376,622	15,983,336
2005	SRS	147,580	15,093	239,871,739	25,620,458
2007	SRS	162,358	11,810	257,947,143	19,199,840
2009	SRS	191,765	22,591	300,479,225	33,990,620
2011	SRS	120,573	10,318	174,623,722	15,912,209
2013	SRS	131,441	13,993	182,199,716	16,748,495
2015	SRS	125,234	9,531	183,930,520	15,502,979

Table 4.1.4 – Negative log likelihood components

	NRS		SRS		URS
Parameters	89		89		131
TOTAL	877.643		934.539		1,111.040
Survey	-14.668		-15.325		-22.116
Fsh length comp	176.588		158.441		228.291
Srv length comp	6.666		5.556		13.073
Srv age comp	716.264		787.163		896.372
Recruitment	-10.808		-6.888		-9.124

Table 4.1.5 – Growth parameter estimates for the northern and southern model configurations; A_{min} is 2.33333 for NRS and 3.08333 for SRS

	NRS		SRS
Female L-at-Amin	10.33		11.84
Female L-at-Amax	45.83		49.61
Female k	0.206		0.194
Female CV Amin	2.34		3.27
Female CV Amax	7.96		4.94
Male M	0.250		0.248
Male L-at-Amin	10.08		13.11
Male L-at-Amax	39.22		40.40
Male k	0.254		0.228
Male CV Amin	2.41		2.33
Male CV Amax	5.48		4.59
$Ln(R_0)$	11.65		12.35

Table 4.1.6 – Growth parameter estimates for the undifferentiated model configuration; A_{min} is 3.20333 for URS

	Early period		Middle period		Later period
Female L-at-Amin	13.69		15.19		14.09
Female L-at-Amax	44.15		49.39		49.96
Female k	0.208		0.186		0.168
Female CV Amin	3.22		-		-
Female CV Amax	5.64		-		-
Male M	0.250		-		-
Male L-at-Amin	14.97		14.59		13.81
Male L-at-Amax	37.13		41.67		40.98
Male k	0.239		0.223		0.227
Male CV Amin	2.82		-		-
Male CV Amax	4.63		-		-
$Ln(R_0)$	12.76		-		-
Q for early survey period (1984 – 1993)	0.858		-		-

Table 4.1.7 – Estimated annual spawning biomass (in metric tonnes) and age-0 recruits (in thousands) with standard deviations for NRS and SRS

Year	NRS				SRS			
	Spawning	Std dev	Recruits	Std dev	Spawning	Std dev	Recruits	Std dev
1977	42,786	9,313	89,705	49,129	76,687	15,129	380,305	266,229
1978	42,151	9,199	100,753	56,232	75,474	14,834	394,784	282,461
1979	41,482	9,043	107,934	59,160	74,146	14,467	331,533	234,064
1980	40,685	8,839	94,561	50,963	72,706	14,040	369,959	239,907
1981	39,890	8,590	87,327	44,744	71,537	13,591	311,801	180,137
1982	38,951	8,306	82,407	40,864	70,896	13,174	195,164	104,738
1983	39,030	8,000	75,108	37,147	72,418	12,881	207,962	106,618
1984	38,997	7,651	96,645	48,162	75,586	12,715	288,539	131,620
1985	39,839	7,330	146,112	65,458	81,730	12,703	234,340	102,458
1986	41,161	7,017	126,503	62,992	90,144	12,795	145,209	67,848
1987	42,147	6,669	222,418	61,559	99,075	12,802	280,160	73,011
1988	42,077	6,275	95,663	37,139	106,538	12,565	128,252	47,364
1989	41,999	5,857	77,367	25,124	112,368	12,122	128,415	36,376
1990	41,329	5,428	81,702	20,988	114,867	11,491	110,931	30,798
1991	41,395	5,025	90,527	18,678	114,617	10,716	169,108	33,712
1992	42,851	4,685	73,835	15,112	113,164	9,886	128,676	28,552
1993	44,989	4,384	60,304	13,130	110,632	9,079	212,065	34,037
1994	47,806	4,138	94,232	16,176	107,012	8,323	177,670	30,761
1995	49,445	3,926	132,216	18,062	104,230	7,629	180,934	30,666
1996	48,860	3,664	116,508	16,643	100,456	7,011	241,559	36,182
1997	46,945	3,398	134,732	17,887	94,851	6,458	316,856	42,210
1998	45,266	3,168	151,632	19,759	88,952	5,950	410,749	47,294
1999	43,910	2,962	220,746	24,390	84,335	5,519	206,070	33,516
2000	42,657	2,775	119,571	17,094	80,859	5,181	147,705	27,324
2001	41,614	2,637	61,266	11,117	77,630	4,952	232,602	34,781
2002	42,174	2,572	60,008	11,194	75,814	4,824	236,560	36,982
2003	43,058	2,540	94,559	15,523	75,026	4,793	331,563	44,613
2004	45,195	2,546	115,387	17,894	76,402	4,864	204,014	34,131
2005	48,977	2,613	113,649	17,569	80,368	5,067	177,730	30,214
2006	53,132	2,760	62,498	11,883	85,454	5,371	61,890	15,448
2007	54,211	2,862	55,178	11,295	89,478	5,659	72,520	18,033
2008	52,099	2,857	46,687	11,151	90,973	5,829	118,466	28,742
2009	48,965	2,816	67,154	17,150	90,737	5,908	147,424	41,266
2010	46,924	2,836	83,793	24,883	90,923	6,019	218,871	71,477
2011	46,720	2,937	187,763	66,381	92,538	6,201	193,941	85,872
2012	46,419	3,055	131,347	70,129	93,736	6,397	132,196	70,190
2013	44,881	3,105	101,836	60,670	93,051	6,497	180,518	102,771
2014	42,143	3,099	103,266	61,604	89,325	6,426	197,647	115,022
2015	39,468	3,081	109,799	66,252	83,979	6,218	221,642	133,738
2016	37,981	3,156	114,853	69,302	78,724	5,983	231,844	139,894

Table 4.1.8 – Numbers-at-age for northern rock sole females

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	44.9	33.5	27.4	23.0	19.4	16.3	13.6	11.2	9.2	7.5	6.1	4.9	3.9	3.2	2.5	2.0	1.6	1.3	1.0	0.8	3.1
1978	50.4	36.7	27.4	22.4	18.8	15.8	13.2	11.0	9.0	7.3	6.0	4.8	3.9	3.1	2.5	2.0	1.6	1.3	1.0	0.8	3.1
1979	54.0	41.2	30.1	22.5	18.4	15.3	12.8	10.6	8.8	7.2	5.9	4.7	3.8	3.1	2.5	2.0	1.6	1.3	1.0	0.8	3.1
1980	47.3	44.2	33.8	24.6	18.4	15.0	12.4	10.3	8.5	7.0	5.7	4.6	3.8	3.0	2.4	2.0	1.6	1.2	1.0	0.8	3.1
1981	43.7	38.7	36.2	27.6	20.1	15.0	12.1	10.0	8.3	6.8	5.6	4.5	3.7	3.0	2.4	1.9	1.5	1.2	1.0	0.8	3.1
1982	41.2	35.7	31.7	29.6	22.6	16.4	12.1	9.8	8.0	6.6	5.4	4.4	3.6	2.9	2.3	1.9	1.5	1.2	1.0	0.8	3.0
1983	37.6	33.7	29.3	25.9	24.2	18.5	13.4	9.9	7.9	6.5	5.3	4.4	3.6	2.9	2.4	1.9	1.5	1.2	1.0	0.8	3.1
1984	48.3	30.7	27.6	24.0	21.2	19.8	15.0	10.8	8.0	6.4	5.2	4.3	3.5	2.9	2.3	1.9	1.5	1.2	1.0	0.8	3.1
1985	73.1	39.6	25.2	22.6	19.6	17.3	16.1	12.2	8.8	6.4	5.2	4.2	3.4	2.8	2.3	1.9	1.5	1.2	1.0	0.8	3.1
1986	63.3	59.8	32.4	20.6	18.5	16.0	14.2	13.2	10.0	7.2	5.2	4.2	3.4	2.8	2.3	1.9	1.5	1.2	1.0	0.8	3.2
1987	111.2	51.8	49.0	26.5	16.9	15.1	13.1	11.6	10.7	8.1	5.8	4.3	3.4	2.8	2.3	1.9	1.5	1.2	1.0	0.8	3.2
1988	47.8	91.1	42.4	40.1	21.7	13.8	12.3	10.6	9.3	8.7	6.5	4.7	3.4	2.7	2.2	1.8	1.5	1.2	1.0	0.8	3.2
1989	38.7	39.2	74.5	34.7	32.8	17.7	11.2	10.0	8.6	7.6	7.0	5.3	3.8	2.8	2.2	1.8	1.5	1.2	1.0	0.8	3.3
1990	40.9	31.7	32.1	61.0	28.4	26.8	14.4	9.1	8.1	6.9	6.1	5.6	4.2	3.0	2.2	1.8	1.4	1.2	1.0	0.8	3.3
1991	45.3	33.4	25.9	26.2	49.9	23.1	21.7	11.6	7.3	6.5	5.5	4.8	4.5	3.4	2.4	1.8	1.4	1.1	0.9	0.8	3.2
1992	36.9	37.1	27.4	21.2	21.5	40.7	18.8	17.5	9.3	5.8	5.1	4.4	3.8	3.5	2.7	1.9	1.4	1.1	0.9	0.7	3.1
1993	30.2	30.2	30.3	22.4	17.3	17.5	32.8	15.0	13.9	7.4	4.6	4.0	3.4	3.0	2.8	2.1	1.5	1.1	0.9	0.7	3.0
1994	47.1	24.7	24.7	24.8	18.3	14.1	14.1	26.2	11.9	11.0	5.8	3.6	3.2	2.7	2.3	2.1	1.6	1.2	0.8	0.7	2.9
1995	66.1	38.6	20.2	20.3	20.3	14.9	11.5	11.4	21.2	9.6	8.8	4.7	2.9	2.5	2.2	1.9	1.7	1.3	0.9	0.7	2.9
1996	58.3	54.1	31.6	16.5	16.6	16.6	12.1	9.3	9.2	17.1	7.7	7.1	3.7	2.3	2.0	1.7	1.5	1.4	1.0	0.7	2.8
1997	67.4	47.7	44.3	25.9	13.5	13.5	13.4	9.7	7.4	7.3	13.5	6.1	5.6	2.9	1.8	1.6	1.3	1.2	1.1	0.8	2.8
1998	75.8	55.2	39.0	36.3	21.1	11.0	10.9	10.8	7.8	5.9	5.8	10.7	4.8	4.4	2.3	1.4	1.2	1.1	0.9	0.8	2.8
1999	110.4	62.1	45.2	32.0	29.7	17.3	9.0	8.9	8.7	6.3	4.8	4.7	8.6	3.9	3.5	1.8	1.1	1.0	0.9	0.7	2.9
2000	59.8	90.4	50.8	37.0	26.2	24.3	14.1	7.3	7.2	7.1	5.1	3.8	3.8	6.9	3.1	2.8	1.5	0.9	0.8	0.7	3.0
2001	30.6	48.9	74.0	41.6	30.2	21.3	19.6	11.3	5.8	5.7	5.6	4.0	3.0	3.0	5.5	2.5	2.2	1.2	0.7	0.6	2.9
2002	30.0	25.1	40.1	60.6	34.0	24.6	17.3	15.8	9.1	4.7	4.6	4.5	3.2	2.4	2.4	4.3	1.9	1.8	0.9	0.6	2.8
2003	47.3	24.6	20.5	32.8	49.5	27.7	19.9	13.9	12.6	7.2	3.7	3.6	3.5	2.5	1.9	1.8	3.4	1.5	1.4	0.7	2.6
2004	57.7	38.7	20.1	16.8	26.8	40.4	22.5	16.1	11.2	10.2	5.8	3.0	2.9	2.8	2.0	1.5	1.5	2.7	1.2	1.1	2.7
2005	56.8	47.2	31.7	16.5	13.8	21.9	32.9	18.3	13.1	9.1	8.2	4.7	2.4	2.3	2.3	1.6	1.2	1.2	2.2	1.0	3.1
2006	31.2	46.5	38.7	25.9	13.5	11.2	17.8	26.7	14.8	10.5	7.3	6.6	3.7	1.9	1.9	1.8	1.3	1.0	1.0	1.7	3.2
2007	27.6	25.6	38.1	31.7	21.2	11.0	9.1	14.4	21.4	11.8	8.4	5.8	5.2	3.0	1.5	1.5	1.4	1.0	0.8	0.8	3.9
2008	23.3	22.6	20.9	31.2	25.9	17.3	8.9	7.3	11.5	17.0	9.3	6.6	4.6	4.1	2.3	1.2	1.2	1.1	0.8	0.6	3.7
2009	33.6	19.1	18.5	17.1	25.5	21.0	13.9	7.1	5.8	9.1	13.4	7.3	5.2	3.6	3.2	1.8	0.9	0.9	0.9	0.6	3.3
2010	41.9	27.5	15.6	15.1	14.0	20.7	17.0	11.2	5.7	4.6	7.2	10.5	5.8	4.1	2.8	2.5	1.4	0.7	0.7	0.7	3.1
2011	93.9	34.3	22.5	12.8	12.4	11.4	16.9	13.8	9.0	4.6	3.7	5.8	8.5	4.6	3.3	2.2	2.0	1.1	0.6	0.6	3.0
2012	65.7	76.9	28.1	18.4	10.5	10.1	9.3	13.7	11.1	7.3	3.7	3.0	4.6	6.8	3.7	2.6	1.8	1.6	0.9	0.5	2.9
2013	50.9	53.8	62.9	23.0	15.1	8.6	8.2	7.5	11.1	9.0	5.9	3.0	2.4	3.7	5.4	3.0	2.1	1.4	1.3	0.7	2.7
2014	51.6	41.7	44.0	51.5	18.8	12.3	6.9	6.6	6.1	8.9	7.2	4.7	2.4	1.9	2.9	4.3	2.4	1.7	1.1	1.0	2.7
2015	54.9	42.3	34.1	36.0	42.1	15.3	10.0	5.6	5.3	4.9	7.1	5.7	3.7	1.9	1.5	2.3	3.4	1.9	1.3	0.9	3.0

Table 4.1.9 – Numbers-at-age for northern rock sole males

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	44.9	31.9	24.8	19.8	15.8	12.6	10.0	7.8	6.1	4.7	3.6	2.7	2.1	1.6	1.2	0.9	0.7	0.5	0.4	0.3	0.9
1978	50.4	34.9	24.8	19.3	15.4	12.2	9.7	7.6	5.9	4.6	3.5	2.7	2.0	1.6	1.2	0.9	0.7	0.5	0.4	0.3	0.9
1979	54.0	39.2	27.2	19.3	15.0	11.9	9.4	7.4	5.8	4.5	3.4	2.6	2.0	1.5	1.2	0.9	0.7	0.5	0.4	0.3	0.9
1980	47.3	42.0	30.5	21.2	15.0	11.6	9.1	7.2	5.6	4.4	3.4	2.6	2.0	1.5	1.2	0.9	0.7	0.5	0.4	0.3	0.9
1981	43.7	36.8	32.7	23.8	16.5	11.6	8.9	7.0	5.4	4.2	3.3	2.5	1.9	1.5	1.1	0.9	0.7	0.5	0.4	0.3	0.9
1982	41.2	34.0	28.7	25.5	18.5	12.7	8.9	6.8	5.3	4.1	3.2	2.5	1.9	1.4	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1983	37.6	32.1	26.5	22.3	19.8	14.4	9.9	6.9	5.2	4.1	3.1	2.4	1.9	1.5	1.1	0.9	0.7	0.5	0.4	0.3	0.9
1984	48.3	29.2	25.0	20.6	17.4	15.4	11.1	7.5	5.2	4.0	3.1	2.4	1.8	1.4	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1985	73.1	37.6	22.8	19.4	16.0	13.5	11.9	8.5	5.8	4.0	3.0	2.4	1.8	1.4	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1986	63.3	56.9	29.3	17.7	15.1	12.5	10.5	9.2	6.6	4.5	3.1	2.4	1.8	1.4	1.1	0.8	0.7	0.5	0.4	0.3	0.9
1987	111.2	49.2	44.3	22.8	13.8	11.8	9.7	8.1	7.1	5.1	3.5	2.4	1.8	1.4	1.1	0.8	0.7	0.5	0.4	0.3	0.9
1988	47.8	86.6	38.3	34.5	17.7	10.7	9.1	7.4	6.2	5.5	3.9	2.7	1.8	1.4	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1989	38.7	37.2	67.4	29.8	26.8	13.8	8.3	7.0	5.7	4.8	4.2	3.0	2.0	1.4	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1990	40.9	30.1	29.0	52.5	23.2	20.8	10.6	6.4	5.4	4.4	3.6	3.2	2.3	1.5	1.1	0.8	0.6	0.5	0.4	0.3	0.9
1991	45.3	31.8	23.4	22.6	40.8	18.0	16.0	8.1	4.8	4.1	3.3	2.7	2.4	1.7	1.2	0.8	0.6	0.5	0.4	0.3	0.9
1992	36.9	35.2	24.8	18.3	17.5	31.6	13.8	12.2	6.1	3.6	3.0	2.5	2.1	1.8	1.3	0.9	0.6	0.5	0.4	0.3	0.9
1993	30.2	28.7	27.4	19.3	14.2	13.5	24.1	10.4	9.1	4.6	2.7	2.3	1.8	1.5	1.3	0.9	0.6	0.4	0.3	0.3	0.9
1994	47.1	23.5	22.4	21.4	15.0	10.9	10.3	18.1	7.8	6.8	3.4	2.0	1.7	1.3	1.1	1.0	0.7	0.5	0.3	0.2	0.8
1995	66.1	36.7	18.3	17.4	16.6	11.6	8.4	7.9	13.9	5.9	5.2	2.6	1.5	1.3	1.0	0.8	0.7	0.5	0.4	0.2	0.8
1996	58.3	51.5	28.6	14.2	13.5	12.9	8.9	6.5	6.0	10.6	4.5	3.9	2.0	1.1	1.0	0.8	0.6	0.6	0.4	0.3	0.8
1997	67.4	45.4	40.1	22.2	11.1	10.5	9.8	6.8	4.9	4.5	7.9	3.4	2.9	1.4	0.9	0.7	0.6	0.5	0.4	0.3	0.8
1998	75.8	52.4	35.3	31.2	17.3	8.5	8.0	7.5	5.1	3.7	3.4	5.9	2.5	2.2	1.1	0.6	0.5	0.4	0.4	0.3	0.8
1999	110.4	59.0	40.8	27.5	24.3	13.4	6.6	6.2	5.7	3.9	2.8	2.6	4.5	1.9	1.7	0.8	0.5	0.4	0.3	0.3	0.9
2000	59.8	85.9	46.0	31.8	21.4	18.8	10.4	5.1	4.8	4.4	3.0	2.1	2.0	3.5	1.5	1.3	0.6	0.4	0.3	0.3	0.9
2001	30.6	46.5	66.9	35.8	24.7	16.5	14.4	7.9	3.8	3.6	3.3	2.2	1.6	1.5	2.6	1.1	0.9	0.5	0.3	0.2	0.8
2002	30.0	23.8	36.2	52.1	27.8	19.1	12.7	11.0	6.0	2.9	2.7	2.5	1.7	1.2	1.1	1.9	0.8	0.7	0.4	0.2	0.8
2003	47.3	23.4	18.6	28.2	40.5	21.5	14.6	9.6	8.3	4.5	2.2	2.0	1.9	1.3	0.9	0.8	1.4	0.6	0.5	0.3	0.7
2004	57.7	36.8	18.2	14.5	21.9	31.4	16.6	11.2	7.4	6.3	3.4	1.6	1.5	1.4	1.0	0.7	0.6	1.1	0.5	0.4	0.8
2005	56.8	44.9	28.7	14.2	11.2	17.0	24.3	12.8	8.6	5.7	4.8	2.6	1.3	1.2	1.1	0.7	0.5	0.5	0.8	0.4	0.9
2006	31.2	44.2	35.0	22.3	11.0	8.7	13.1	18.6	9.8	6.6	4.3	3.7	2.0	1.0	0.9	0.8	0.6	0.4	0.4	0.6	0.9
2007	27.6	24.3	34.4	27.2	17.3	8.5	6.7	10.0	14.1	7.4	4.9	3.2	2.8	1.5	0.7	0.7	0.6	0.4	0.3	0.3	1.2
2008	23.3	21.5	18.9	26.8	21.2	13.4	6.5	5.1	7.5	10.6	5.5	3.7	2.4	2.1	1.1	0.5	0.5	0.5	0.3	0.2	1.1
2009	33.6	18.2	16.7	14.7	20.8	16.3	10.2	4.9	3.8	5.6	7.9	4.1	2.7	1.8	1.5	0.8	0.4	0.4	0.3	0.2	1.0
2010	41.9	26.1	14.1	13.0	11.5	16.1	12.5	7.8	3.7	2.9	4.2	5.9	3.0	2.0	1.3	1.1	0.6	0.3	0.3	0.2	0.9
2011	93.9	32.6	20.4	11.0	10.1	8.9	12.4	9.6	5.9	2.8	2.2	3.2	4.5	2.3	1.5	1.0	0.9	0.5	0.2	0.2	0.9
2012	65.7	73.1	25.4	15.8	8.6	7.9	6.9	9.5	7.3	4.5	2.2	1.7	2.4	3.4	1.8	1.2	0.8	0.7	0.3	0.2	0.8
2013	50.9	51.1	56.9	19.8	12.3	6.6	6.1	5.3	7.3	5.6	3.5	1.6	1.3	1.9	2.6	1.3	0.9	0.6	0.5	0.3	0.7
2014	51.6	39.6	39.8	44.3	15.4	9.5	5.1	4.6	4.0	5.5	4.2	2.6	1.2	0.9	1.4	1.9	1.0	0.7	0.4	0.4	0.8
2015	54.9	40.2	30.9	31.0	34.4	11.9	7.3	3.9	3.5	3.0	4.2	3.2	2.0	0.9	0.7	1.1	1.5	0.8	0.5	0.3	0.9

Table 4.1.10 – Numbers-at-age for southern rock sole females

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	190.2	110.3	70.1	48.8	36.5	29.0	24.1	20.6	17.5	14.6	11.9	9.7	7.9	6.5	5.3	4.3	3.5	2.9	2.3	1.9	8.0
1978	197.4	155.7	90.3	57.4	39.9	29.9	23.7	19.6	16.7	14.2	11.8	9.6	7.8	6.4	5.2	4.3	3.5	2.8	2.3	1.9	7.9
1979	165.8	161.6	127.5	73.9	47.0	32.6	24.4	19.3	15.9	13.5	11.5	9.5	7.7	6.3	5.1	4.2	3.4	2.8	2.3	1.9	7.9
1980	185.0	135.7	132.3	104.3	60.5	38.4	26.6	19.8	15.6	12.9	10.9	9.2	7.6	6.2	5.0	4.1	3.4	2.7	2.2	1.8	7.8
1981	155.9	151.4	111.1	108.3	85.4	49.5	31.4	21.7	16.1	12.7	10.4	8.8	7.4	6.2	5.0	4.1	3.3	2.7	2.2	1.8	7.7
1982	97.6	127.6	124.0	91.0	88.7	69.8	40.4	25.5	17.6	13.0	10.2	8.4	7.1	6.0	4.9	4.0	3.3	2.6	2.2	1.8	7.6
1983	104.0	79.9	104.5	101.5	74.5	72.6	57.1	33.0	20.8	14.3	10.6	8.3	6.8	5.8	4.9	4.0	3.3	2.6	2.2	1.8	7.7
1984	144.3	85.1	65.4	85.6	83.1	60.9	59.3	46.6	26.9	16.9	11.6	8.6	6.7	5.5	4.7	3.9	3.3	2.6	2.1	1.7	7.6
1985	117.2	118.1	69.7	53.6	70.0	68.0	49.8	48.4	38.0	21.9	13.8	9.5	7.0	5.5	4.5	3.8	3.2	2.6	2.1	1.7	7.6
1986	72.6	95.9	96.7	57.1	43.8	57.3	55.7	40.8	39.6	31.1	17.9	11.3	7.7	5.7	4.5	3.7	3.1	2.6	2.2	1.8	7.6
1987	140.1	59.4	78.5	79.2	46.7	35.9	46.9	45.5	33.3	32.4	25.4	14.6	9.2	6.3	4.7	3.7	3.0	2.5	2.1	1.8	7.7
1988	64.1	114.7	48.7	64.3	64.8	38.2	29.3	38.3	37.1	27.2	26.4	20.7	11.9	7.5	5.1	3.8	3.0	2.4	2.1	1.7	7.7
1989	64.2	52.5	93.9	39.8	52.6	53.1	31.3	24.0	31.3	30.3	22.2	21.5	16.9	9.7	6.1	4.2	3.1	2.4	2.0	1.7	7.7
1990	55.5	52.6	43.0	76.9	32.6	43.1	43.4	25.5	19.6	25.5	24.7	18.0	17.5	13.7	7.9	5.0	3.4	2.5	2.0	1.6	7.6
1991	84.6	45.4	43.0	35.2	62.9	26.7	35.2	35.4	20.8	15.9	20.7	20.0	14.6	14.1	11.1	6.4	4.0	2.7	2.0	1.6	7.4
1992	64.3	69.2	37.2	35.2	28.8	51.5	21.8	28.7	28.8	16.9	12.9	16.7	16.2	11.8	11.4	8.9	5.1	3.2	2.2	1.6	7.3
1993	106.0	52.7	56.7	30.4	28.8	23.6	42.0	17.7	23.3	23.3	13.6	10.4	13.5	13.0	9.5	9.2	7.2	4.1	2.6	1.8	7.2
1994	88.8	86.8	43.1	46.4	24.9	23.6	19.2	34.1	14.4	18.8	18.7	10.9	8.3	10.8	10.4	7.6	7.3	5.7	3.3	2.1	7.1
1995	90.5	72.7	71.1	35.3	38.0	20.4	19.3	15.7	27.8	11.7	15.3	15.2	8.9	6.8	8.8	8.4	6.1	6.0	4.7	2.7	7.5
1996	120.8	74.1	59.5	58.2	28.9	31.1	16.7	15.7	12.8	22.6	9.5	12.4	12.3	7.2	5.5	7.1	6.8	5.0	4.8	3.8	8.2
1997	158.4	98.9	60.6	48.7	47.6	23.6	25.3	13.5	12.7	10.3	18.2	7.6	9.9	9.9	5.8	4.4	5.7	5.5	4.0	3.8	9.6
1998	205.4	129.7	81.0	49.6	39.9	38.9	19.3	20.6	11.0	10.3	8.3	14.7	6.1	8.0	7.9	4.6	3.5	4.5	4.4	3.2	10.8
1999	103.0	168.1	106.2	66.3	40.6	32.6	31.8	15.7	16.8	8.9	8.4	6.8	11.9	5.0	6.5	6.4	3.7	2.8	3.7	3.6	11.3
2000	73.9	84.4	137.7	86.9	54.3	33.3	26.7	26.0	12.8	13.7	7.3	6.8	5.5	9.7	4.0	5.3	5.2	3.0	2.3	3.0	12.1
2001	116.3	60.5	69.1	112.7	71.2	44.4	27.1	21.7	21.1	10.4	11.0	5.9	5.5	4.4	7.8	3.2	4.2	4.2	2.4	1.9	12.1
2002	118.3	95.2	49.5	56.5	92.2	58.2	36.2	22.1	17.6	17.0	8.4	8.9	4.7	4.4	3.5	6.2	2.6	3.4	3.4	2.0	11.2
2003	165.8	96.8	78.0	40.5	46.3	75.4	47.5	29.4	17.9	14.2	13.7	6.7	7.1	3.8	3.5	2.8	5.0	2.1	2.7	2.7	10.5
2004	102.0	135.7	79.3	63.8	33.2	37.9	61.6	38.7	23.9	14.5	11.5	11.1	5.4	5.8	3.1	2.8	2.3	4.0	1.7	2.2	10.6
2005	88.9	83.5	111.1	64.9	52.2	27.1	31.0	50.3	31.6	19.5	11.8	9.4	9.0	4.4	4.7	2.5	2.3	1.9	3.3	1.4	10.4
2006	30.9	72.8	68.4	91.0	53.1	42.7	22.2	25.2	40.9	25.6	15.8	9.6	7.6	7.3	3.6	3.8	2.0	1.9	1.5	2.6	9.5
2007	36.3	25.3	59.6	56.0	74.5	43.4	34.9	18.0	20.5	33.1	20.7	12.7	7.7	6.1	5.9	2.9	3.0	1.6	1.5	1.2	9.7
2008	59.2	29.7	20.7	48.8	45.8	60.9	35.4	28.4	14.6	16.5	26.6	16.6	10.2	6.2	4.9	4.7	2.3	2.4	1.3	1.2	8.7
2009	73.7	48.5	24.3	17.0	39.9	37.5	49.6	28.8	22.9	11.8	13.3	21.4	13.3	8.2	4.9	3.9	3.7	1.8	1.9	1.0	7.9
2010	109.4	60.4	39.7	19.9	13.9	32.6	30.6	40.4	23.3	18.5	9.5	10.7	17.2	10.7	6.5	3.9	3.1	3.0	1.5	1.6	7.2
2011	97.0	89.6	49.4	32.5	16.3	11.4	26.7	24.9	32.9	19.0	15.0	7.7	8.7	13.9	8.6	5.3	3.2	2.5	2.4	1.2	7.1
2012	66.1	79.4	73.4	40.5	26.6	13.3	9.3	21.8	20.3	26.7	15.4	12.2	6.2	7.0	11.3	7.0	4.3	2.6	2.0	2.0	6.7
2013	90.3	54.1	65.0	60.1	33.1	21.8	10.9	7.6	17.7	16.5	21.7	12.5	9.9	5.1	5.7	9.1	5.7	3.5	2.1	1.7	7.0
2014	98.8	73.9	44.3	53.2	49.2	27.1	17.8	8.9	6.2	14.4	13.4	17.6	10.1	8.0	4.1	4.6	7.4	4.6	2.8	1.7	7.0
2015	110.8	80.9	60.5	36.3	43.6	40.2	22.1	14.5	7.2	5.0	11.7	10.8	14.2	8.2	6.5	3.3	3.7	6.0	3.7	2.3	7.0

Table 4.1.11 – Numbers-at-age for southern rock sole males

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	190.2	105.2	63.7	42.2	30.2	22.8	18.0	14.6	11.9	9.4	7.3	5.7	4.4	3.4	2.7	2.1	1.6	1.3	1.0	0.7	2.5
1978	197.4	148.4	82.1	49.7	33.0	23.5	17.7	14.0	11.3	9.1	7.2	5.6	4.3	3.4	2.6	2.0	1.6	1.2	1.0	0.7	2.5
1979	165.8	154.0	115.8	64.0	38.8	25.7	18.3	13.7	10.8	8.7	7.0	5.5	4.3	3.3	2.6	2.0	1.6	1.2	0.9	0.7	2.5
1980	185.0	129.4	120.2	90.4	50.0	30.2	20.0	14.1	10.6	8.3	6.7	5.4	4.2	3.3	2.5	2.0	1.5	1.2	0.9	0.7	2.5
1981	155.9	144.4	101.0	93.8	70.5	38.9	23.5	15.4	10.9	8.1	6.4	5.1	4.1	3.3	2.5	1.9	1.5	1.2	0.9	0.7	2.4
1982	97.6	121.7	112.7	78.8	73.2	54.9	30.2	18.2	11.9	8.4	6.2	4.9	3.9	3.2	2.5	1.9	1.5	1.2	0.9	0.7	2.4
1983	104.0	76.2	94.9	87.9	61.5	57.1	42.8	23.5	14.1	9.3	6.5	4.8	3.8	3.0	2.5	1.9	1.5	1.2	0.9	0.7	2.4
1984	144.3	81.1	59.4	74.1	68.6	47.9	44.4	33.2	18.2	10.9	7.1	5.0	3.7	2.9	2.3	1.9	1.5	1.2	0.9	0.7	2.4
1985	117.2	112.6	63.3	46.4	57.8	53.5	37.3	34.6	25.8	14.2	8.5	5.5	3.9	2.9	2.3	1.8	1.5	1.2	0.9	0.7	2.4
1986	72.6	91.4	87.9	49.4	36.2	45.1	41.7	29.1	26.9	20.1	11.0	6.6	4.3	3.0	2.3	1.8	1.4	1.1	0.9	0.7	2.4
1987	140.1	56.7	71.4	68.6	38.6	28.2	35.2	32.5	22.7	21.0	15.7	8.6	5.1	3.4	2.4	1.8	1.4	1.1	0.9	0.7	2.4
1988	64.1	109.3	44.2	55.7	53.5	30.1	22.0	27.4	25.3	17.6	16.3	12.1	6.6	4.0	2.6	1.8	1.4	1.1	0.9	0.7	2.4
1989	64.2	50.0	85.3	34.5	43.5	41.7	23.5	17.1	21.3	19.7	13.7	12.6	9.4	5.2	3.1	2.0	1.4	1.1	0.8	0.7	2.4
1990	55.5	50.1	39.1	66.6	26.9	33.9	32.5	18.2	13.3	16.5	15.2	10.6	9.8	7.3	4.0	2.4	1.6	1.1	0.8	0.6	2.4
1991	84.6	43.3	39.1	30.5	51.9	21.0	26.4	25.2	14.1	10.3	12.8	11.7	8.2	7.5	5.6	3.1	1.8	1.2	0.8	0.6	2.3
1992	64.3	66.0	33.8	30.5	23.8	40.5	16.3	20.5	19.5	10.9	7.9	9.8	9.1	6.3	5.8	4.3	2.4	1.4	0.9	0.7	2.3
1993	106.0	50.2	51.5	26.4	23.8	18.5	31.5	12.6	15.8	15.0	8.4	6.1	7.5	6.9	4.8	4.4	3.3	1.8	1.1	0.7	2.2
1994	88.8	82.7	39.2	40.2	20.6	18.5	14.4	24.3	9.7	12.1	11.5	6.4	4.6	5.7	5.3	3.7	3.4	2.5	1.4	0.8	2.2
1995	90.5	69.3	64.6	30.6	31.4	16.0	14.4	11.2	18.9	7.5	9.4	8.9	4.9	3.6	4.4	4.1	2.8	2.6	2.0	1.1	2.4
1996	120.8	70.6	54.1	50.4	23.9	24.4	12.5	11.2	8.7	14.6	5.8	7.2	6.9	3.8	2.8	3.4	3.1	2.2	2.0	1.5	2.6
1997	158.4	94.3	55.1	42.2	39.3	18.6	19.0	9.6	8.6	6.6	11.2	4.4	5.5	5.2	2.9	2.1	2.6	2.4	1.7	1.5	3.2
1998	205.4	123.6	73.6	43.0	32.9	30.6	14.4	14.7	7.4	6.6	5.1	8.6	3.4	4.2	4.0	2.2	1.6	2.0	1.8	1.3	3.6
1999	103.0	160.3	96.5	57.4	33.5	25.7	23.9	11.2	11.4	5.8	5.1	3.9	6.6	2.6	3.3	3.1	1.7	1.2	1.5	1.4	3.8
2000	73.9	80.4	125.1	75.3	44.8	26.2	20.0	18.6	8.7	8.8	4.5	4.0	3.1	5.1	2.0	2.5	2.4	1.3	1.0	1.2	4.0
2001	116.3	57.6	62.7	97.6	58.7	34.9	20.3	15.5	14.3	6.7	6.8	3.4	3.0	2.3	3.9	1.6	1.9	1.8	1.0	0.7	4.0
2002	118.3	90.8	45.0	49.0	76.2	45.8	27.1	15.7	11.9	11.0	5.1	5.2	2.6	2.3	1.8	3.0	1.2	1.5	1.4	0.8	3.6
2003	165.8	92.3	70.8	35.1	38.2	59.3	35.5	21.0	12.1	9.2	8.4	3.9	4.0	2.0	1.8	1.4	2.3	0.9	1.1	1.1	3.3
2004	102.0	129.4	72.0	55.3	27.4	29.8	46.2	27.6	16.2	9.3	7.1	6.5	3.0	3.1	1.5	1.4	1.0	1.8	0.7	0.9	3.4
2005	88.9	79.6	101.0	56.2	43.1	21.4	23.2	35.9	21.4	12.6	7.2	5.5	5.0	2.3	2.4	1.2	1.1	0.8	1.4	0.5	3.3
2006	30.9	69.3	62.1	78.8	43.9	33.6	16.6	18.0	27.8	16.5	9.7	5.6	4.2	3.9	1.8	1.8	0.9	0.8	0.6	1.0	3.0
2007	36.3	24.1	54.1	48.5	61.5	34.2	26.1	12.9	13.9	21.3	12.7	7.4	4.3	3.2	3.0	1.4	1.4	0.7	0.6	0.5	3.1
2008	59.2	28.3	18.8	42.2	37.8	47.9	26.5	20.2	9.9	10.6	16.3	9.7	5.7	3.3	2.5	2.3	1.1	1.1	0.5	0.5	2.7
2009	73.7	46.2	22.1	14.7	32.9	29.5	37.2	20.5	15.5	7.6	8.1	12.5	7.4	4.3	2.5	1.9	1.7	0.8	0.8	0.4	2.4
2010	109.4	57.5	36.1	17.2	11.5	25.7	22.9	28.7	15.8	11.9	5.8	6.2	9.5	5.6	3.3	1.9	1.4	1.3	0.6	0.6	2.1
2011	97.0	85.4	44.9	28.2	13.4	8.9	20.0	17.8	22.3	12.2	9.2	4.5	4.8	7.4	4.4	2.5	1.5	1.1	1.0	0.5	2.1
2012	66.1	75.7	66.6	35.0	22.0	10.5	7.0	15.5	13.8	17.2	9.4	7.1	3.5	3.7	5.7	3.4	2.0	1.1	0.9	0.8	2.0
2013	90.3	51.6	59.1	52.0	27.3	17.1	8.2	5.4	12.0	10.7	13.3	7.3	5.5	2.7	2.9	4.4	2.6	1.5	0.9	0.7	2.2
2014	98.8	70.4	40.3	46.1	40.6	21.3	13.3	6.3	4.2	9.3	8.2	10.3	5.6	4.2	2.1	2.2	3.4	2.0	1.2	0.7	2.2
2015	110.8	77.1	55.0	31.4	36.0	31.6	16.6	10.3	4.9	3.2	7.2	6.3	7.9	4.3	3.3	1.6	1.7	2.6	1.5	0.9	2.2

Table 4.1.12 – Parameter estimates for the NRS and SRS model configurations

	NRS			SRS	
Label	**Value**	**Std Dev**		**Value**	**Std Dev**
NatM_p_1_Fem_GP_1	0.200	_		0.200	_
L_at_Amin_Fem_GP_1	10.329	0.655		11.838	0.694
L_at_Amax_Fem_GP_1	45.829	0.897		49.615	0.571
VonBert_K_Fem_GP_1	0.206	0.013		0.194	0.009
CV_young_Fem_GP_1	2.337	0.317		3.267	0.310
CV_old_Fem_GP_1	7.961	0.424		4.935	0.240
NatM_p_1_Mal_GP_1	0.250	0.005		0.248	0.007
L_at_Amin_Mal_GP_1	10.076	0.658		13.110	0.584
L_at_Amax_Mal_GP_1	39.218	0.777		40.405	0.654
VonBert_K_Mal_GP_1	0.254	0.017		0.228	0.015
CV_young_Mal_GP_1	2.410	0.317		2.329	0.253
CV_old_Mal_GP_1	5.481	0.297		4.593	0.279
SR_LN(R0)	11.651	0.064		12.354	0.064
SR_BH_steep	1.000	_		1.000	_
SR_sigmaR	0.600	_		0.600	_
SR_envlink	0.000	_		0.000	_
SR_R1_offset	-0.087	0.127		-0.108	0.123
SR_autocorr	0.000	_		0.000	_
Early_InitAge_20	-0.007	0.598		-0.023	0.593
Early_InitAge_19	-0.009	0.597		-0.028	0.592
Early_InitAge_18	-0.011	0.597		-0.035	0.590
Early_InitAge_17	-0.014	0.596		-0.043	0.587
Early_InitAge_16	-0.017	0.595		-0.053	0.585
Early_InitAge_15	-0.021	0.594		-0.065	0.581
Early_InitAge_14	-0.027	0.592		-0.079	0.578
Early_InitAge_13	-0.034	0.590		-0.095	0.574
Early_InitAge_12	-0.042	0.588		-0.110	0.570
Early_InitAge_11	-0.052	0.585		-0.122	0.566
Early_InitAge_10	-0.064	0.581		-0.128	0.563
Early_InitAge_9	-0.079	0.577		-0.137	0.559
Early_InitAge_8	-0.096	0.573		-0.164	0.552
Early_InitAge_7	-0.116	0.567		-0.213	0.542
Early_InitAge_6	-0.137	0.562		-0.260	0.533
Early_InitAge_5	-0.157	0.556		-0.276	0.529
Early_InitAge_4	-0.175	0.551		-0.247	0.531
Early_InitAge_3	-0.191	0.546		-0.158	0.543
Early_InitAge_2	-0.204	0.542		0.005	0.572
Early_InitAge_1	-0.191	0.542		0.258	0.630

Main_RecrDev_1977	-0.175	0.535		0.513	0.691
Main_RecrDev_1978	-0.047	0.549		0.568	0.715
Main_RecrDev_1979	0.034	0.542		0.412	0.702
Main_RecrDev_1980	-0.086	0.533		0.539	0.650
Main_RecrDev_1981	-0.154	0.507		0.386	0.578
Main_RecrDev_1982	-0.200	0.491		-0.064	0.531
Main_RecrDev_1983	-0.281	0.489		0.017	0.508
Main_RecrDev_1984	-0.017	0.495		0.363	0.460
Main_RecrDev_1985	0.409	0.453		0.173	0.436
Main_RecrDev_1986	0.277	0.493		-0.288	0.460
Main_RecrDev_1987	0.841	0.287		0.369	0.266
Main_RecrDev_1988	-0.003	0.384		-0.412	0.364
Main_RecrDev_1989	-0.215	0.324		-0.411	0.280
Main_RecrDev_1990	-0.161	0.257		-0.557	0.272
Main_RecrDev_1991	-0.058	0.206		-0.136	0.196
Main_RecrDev_1992	-0.262	0.202		-0.409	0.216
Main_RecrDev_1993	-0.464	0.214		0.091	0.155
Main_RecrDev_1994	-0.018	0.170		-0.086	0.165
Main_RecrDev_1995	0.321	0.133		-0.068	0.160
Main_RecrDev_1996	0.194	0.138		0.221	0.140
Main_RecrDev_1997	0.340	0.128		0.492	0.124
Main_RecrDev_1998	0.458	0.125		0.752	0.108
Main_RecrDev_1999	0.833	0.107		0.062	0.156
Main_RecrDev_2000	0.220	0.137		-0.271	0.177
Main_RecrDev_2001	-0.448	0.174		0.183	0.141
Main_RecrDev_2002	-0.469	0.177		0.200	0.147
Main_RecrDev_2003	-0.014	0.156		0.538	0.124
Main_RecrDev_2004	0.185	0.145		0.052	0.156
Main_RecrDev_2005	0.169	0.143		-0.086	0.157
Main_RecrDev_2006	-0.429	0.176		-1.141	0.236
Main_RecrDev_2007	-0.553	0.189		-0.982	0.233
Main_RecrDev_2008	-0.720	0.221		-0.491	0.227
Main_RecrDev_2009	-0.357	0.238		-0.273	0.265
Main_RecrDev_2010	-0.135	0.279		0.122	0.313
Main_RecrDev_2011	0.672	0.342		0.001	0.428
Main_RecrDev_2012	0.314	0.517		-0.382	0.515
Late_RecrDev_2013	0.015	0.593		-0.115	0.567
Late_RecrDev_2014	-0.016	0.593		-0.070	0.579
Late_RecrDev_2015	0.000	0.600		0.000	0.600
InitF_1Fishery	0.038	0.008		0.018	0.003
SizeSel_1P_1_Fishery	46.379	0.717		47.604	1.662

SizeSel_1P_2_Fishery	0.191	0.068		2.463	10.211
SizeSel_1P_3_Fishery	5.396	0.060		5.430	0.116
SizeSel_1P_4_Fishery	-9.542	12.954		-1.331	103.957
SizeSel_1P_5_Fishery	-10.000	_		-10.000	_
SizeSel_1P_6_Fishery	-0.295	0.813		2.095	70.036
SzSel_1Male_Peak_Fishery	-8.806	0.374		-9.845	1.584
SzSel_1Male_Ascend_Fishery	-0.778	0.095		-0.855	0.155
SzSel_1Male_Descend_Fishery	0.000	_		0.000	_
SzSel_1Male_Final_Fishery	0.000	_		0.000	_
SzSel_1Male_Scale_Fishery	1.000	_		1.000	_
SizeSel_2P_1_Survey	33.491	2.822		42.393	2.868
SizeSel_2P_2_Survey	0.000	_		0.000	_
SizeSel_2P_3_Survey	4.796	0.383		5.345	0.268
SizeSel_2P_4_Survey	0.000	_		0.000	_
SizeSel_2P_5_Survey	-10.000	_		-10.000	_
SizeSel_2P_6_Survey	10.000	_		10.000	_
SzSel_2Male_Peak_Survey	-6.043	2.986		2.915	4.266
SzSel_2Male_Ascend_Survey	-0.841	0.527		0.359	0.393
SzSel_2Male_Descend_Survey	0.000	_		0.000	_
SzSel_2Male_Final_Survey	0.000	_		0.000	_
SzSel_2Male_Scale_Survey	1.000	_		1.000	_

Table 4.1.13 – Maturity-at-age (fixed), and derived survey and fishery selectivity-at-age for males and females for NRS and SRS

	NRS						SRS				
Age	Maturity	Srv F	Srv M	Fsh F	Fsh M		Maturity	Srv F	Srv M	Fsh F	Fsh M
0	0	0.003	0.001	0.000	0.000		0	0.002	0.003	0.000	0.000
1	0	0.007	0.003	0.002	0.001		0	0.004	0.009	0.001	0.000
2	0	0.024	0.016	0.005	0.002		0	0.010	0.021	0.003	0.002
3	0	0.171	0.221	0.034	0.034		0	0.035	0.055	0.013	0.011
4	0	0.441	0.597	0.113	0.150		0	0.133	0.140	0.058	0.072
5	0.02	0.680	0.834	0.236	0.333		0.01	0.303	0.254	0.154	0.214
6	0.24	0.823	0.931	0.372	0.512		0.04	0.500	0.375	0.291	0.402
7	0.72	0.897	0.968	0.496	0.649		0.15	0.673	0.485	0.441	0.575
8	0.93	0.935	0.983	0.594	0.742		0.37	0.798	0.577	0.578	0.704
9	0.98	0.956	0.990	0.667	0.803		0.63	0.878	0.649	0.688	0.792
10	0.99	0.968	0.993	0.720	0.842		0.82	0.926	0.704	0.771	0.849
11	1	0.975	0.995	0.757	0.869		0.91	0.953	0.745	0.830	0.886
12	1	0.980	0.996	0.783	0.886		0.96	0.969	0.776	0.871	0.910
13	1	0.983	0.997	0.802	0.899		0.98	0.979	0.799	0.899	0.926
14	1	0.985	0.997	0.814	0.907		0.99	0.985	0.817	0.919	0.937
15	1	0.987	0.997	0.823	0.914		0.99	0.988	0.830	0.933	0.945
16	1	0.988	0.998	0.829	0.918		0.99	0.991	0.840	0.944	0.950
17	1	0.989	0.998	0.834	0.922		1	0.993	0.848	0.951	0.954
18	1	0.990	0.998	0.837	0.924		1	0.994	0.854	0.957	0.958
19	1	0.990	0.998	0.839	0.926		1	0.995	0.859	0.961	0.960
20	1	0.991	0.998	0.841	0.927		1	0.995	0.863	0.964	0.962
21	1	0.991	0.998	0.842	0.929		1	0.996	0.866	0.966	0.963
22	1	0.991	0.998	0.843	0.929		1	0.996	0.868	0.968	0.964
23	1	0.991	0.998	0.844	0.930		1	0.996	0.870	0.970	0.965
24	1	0.991	0.998	0.844	0.930		1	0.996	0.871	0.971	0.965
25	1	0.992	0.998	0.845	0.931		1	0.997	0.872	0.972	0.966
26	1	0.992	0.998	0.845	0.931		1	0.997	0.873	0.973	0.966
27	1	0.992	0.998	0.845	0.931		1	0.997	0.874	0.973	0.967
28	1	0.992	0.998	0.845	0.932		1	0.997	0.874	0.974	0.967
29	1	0.992	0.998	0.846	0.932		1	0.997	0.875	0.974	0.967
30	1	0.992	0.998	0.846	0.932		1	0.997	0.875	0.975	0.967

Table 4.1.14 – Results for the projections scenarios for northern rock sole

Scenarios 1 and 2, Maximum tier 3 ABC harvest permissible						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	11,558	13,677	1,088	38,071	0.022	75,363
2016	11,842	14,021	11,842	35,622	0.248	75,613
2017	10,838	12,840	10,838	30,933	0.248	68,456
2018	10,148	12,026	10,148	29,566	0.248	65,219
2019	9,584	11,358	9,584	28,432	0.248	62,546
2020	9,107	10,794	9,107	26,806	0.248	59,675
2021	8,716	10,332	8,716	25,296	0.248	57,251
2022	8,410	9,970	8,410	24,191	0.248	55,426
2023	8,176	9,693	8,176	23,322	0.248	53,978
2024	7,966	9,440	7,966	22,671	0.247	52,834
2025	7,733	9,158	7,733	22,233	0.244	52,016
2026	7,540	8,927	7,540	21,842	0.242	51,408
2027	7,435	8,801	7,435	21,498	0.241	50,970
2028	7,355	8,707	7,355	21,216	0.240	50,671
Scenario 3, F_{ABC} at average F over the past 5 years						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	1,501	13,677	1,088	38,071	0.022	75,363
2016	1,534	14,021	1,534	36,599	0.030	75,613
2017	1,594	14,594	1,594	36,823	0.030	76,894
2018	1,659	15,189	1,659	39,558	0.030	80,463
2019	1,713	15,670	1,713	41,957	0.030	83,373
2020	1,753	16,021	1,753	43,170	0.030	84,849
2021	1,780	16,262	1,780	43,844	0.030	85,674
2022	1,798	16,421	1,798	44,417	0.030	86,252
2023	1,810	16,519	1,810	44,790	0.030	86,530
2024	1,815	16,561	1,815	45,032	0.030	86,593
2025	1,814	16,550	1,814	45,224	0.030	86,590
2026	1,809	16,503	1,809	45,226	0.030	86,445
2027	1,803	16,441	1,803	45,088	0.030	86,198
2028	1,796	16,385	1,796	44,885	0.030	85,935
Scenario 4, $F_{ABC} = F_{60\%}$						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	5,788	13,677	1,088	38,071	0.022	75,363
2016	5,922	14,021	5,922	36,197	0.119	75,613
2017	5,838	13,845	5,838	34,285	0.119	73,290
2018	5,810	13,784	5,810	35,080	0.119	73,695
2019	5,770	13,687	5,770	35,690	0.119	73,806
2020	5,710	13,542	5,710	35,354	0.119	72,924
2021	5,639	13,371	5,639	34,739	0.119	71,833

2022	5,566	13,198	5,566	34,241	0.119	70,871
2023	5,497	13,036	5,497	33,755	0.119	69,942
2024	5,430	12,877	5,430	33,320	0.119	69,078
2025	5,362	12,715	5,362	32,980	0.119	68,370
2026	5,295	12,557	5,295	32,579	0.119	67,708
2027	5,236	12,418	5,236	32,148	0.119	67,098
2028	5,190	12,311	5,190	31,742	0.119	66,593
Scenario 5, No fishing (F_{ABC} = 0)						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	0	13,677	1,088	38,071	0.022	75,363
2016	0	14,021	0	36,736	0.000	75,613
2017	0	14,857	0	37,721	0.000	78,158
2018	0	15,701	0	41,204	0.000	82,930
2019	0	16,418	0	44,342	0.000	86,984
2020	0	16,988	0	46,242	0.000	89,499
2021	0	17,426	0	47,536	0.000	91,241
2022	0	17,757	0	48,663	0.000	92,619
2023	0	18,002	0	49,520	0.000	93,580
2024	0	18,167	0	50,178	0.000	94,218
2025	0	18,259	0	50,724	0.000	94,695
2026	0	18,296	0	51,024	0.000	94,944
2027	0	18,301	0	51,130	0.000	95,012
2028	0	18,298	0	51,123	0.000	94,997
Scenario 6, Whether N rock sole are overfished – $SB_{35\%}$ = 18,100						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	13,677	13,677	1,088	38,071	0.022	75,363
2016	14,021	14,021	14,021	35,400	0.299	75,613
2017	12,471	12,471	12,471	29,722	0.299	66,685
2018	11,418	11,418	11,418	27,684	0.299	62,285
2019	10,593	10,593	10,593	26,078	0.299	58,841
2020	9,932	9,932	9,932	24,158	0.299	55,513
2021	9,418	9,418	9,418	22,493	0.299	52,858
2022	9,034	9,034	9,034	21,318	0.299	50,939
2023	8,511	8,511	8,511	20,457	0.289	49,481
2024	8,142	8,142	8,142	19,946	0.281	48,565
2025	7,917	7,917	7,917	19,704	0.276	48,087
2026	7,764	7,764	7,764	19,492	0.273	47,784
2027	7,688	7,688	7,688	19,302	0.272	47,593
2028	7,653	7,653	7,653	19,146	0.272	47,492
Scenario 7, Whether N rock sole are approaching overfished condition						
Year	ABC	OFL	Catch	SSB	F	Total Bio

2015	13,677	13,677	1,088	38,071	0.022	75,363
2016	14,021	14,021	11,842	35,622	0.248	75,613
2017	12,840	12,840	10,838	30,933	0.248	68,456
2018	12,026	12,026	12,026	29,395	0.299	65,219
2019	11,046	11,046	11,046	27,408	0.299	61,019
2020	10,259	10,259	10,259	25,152	0.299	57,077
2021	9,648	9,648	9,648	23,209	0.299	53,948
2022	9,192	9,192	9,192	21,820	0.299	51,681
2023	8,700	8,700	8,700	20,794	0.292	49,978
2024	8,246	8,246	8,246	20,138	0.283	48,826
2025	7,968	7,968	7,968	19,806	0.277	48,210
2026	7,787	7,787	7,787	19,543	0.274	47,835
2027	7,696	7,696	7,696	19,323	0.272	47,607
2028	7,654	7,654	7,654	19,153	0.272	47,490

Table 4.1.15 – Results for the projections scenarios for southern rock sole

Scenarios 1 and 2, Maximum tier 3 ABC harvest permissible						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	19,872	23,391	1,088	81,113	0.010	143,697
2016	19,299	22,722	19,299	74,078	0.186	138,624
2017	16,658	19,619	16,658	60,645	0.186	120,276
2018	14,762	17,391	14,762	51,567	0.186	108,443
2019	13,456	15,859	13,456	45,480	0.186	101,175
2020	12,654	14,919	12,654	41,063	0.186	96,473
2021	12,251	14,448	12,251	37,849	0.186	93,447
2022	11,667	13,708	11,667	36,011	0.179	91,924
2023	11,595	13,628	11,595	35,524	0.176	91,850
2024	11,770	13,844	11,770	35,778	0.177	92,446
2025	11,901	14,005	11,901	36,308	0.177	93,205
2026	11,949	14,067	11,949	36,848	0.176	93,953
2027	11,997	14,127	11,997	37,243	0.176	94,621
2028	12,088	14,235	12,088	37,418	0.177	95,077
Scenario 3, F_{ABC} at average F over the past 5 years						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	1,463	23,391	1,088	81,113	0.010	143,697
2016	1,419	22,722	1,419	75,999	0.013	138,624
2017	1,389	22,272	1,389	72,023	0.013	135,060
2018	1,372	22,010	1,372	69,891	0.013	134,013
2019	1,366	21,932	1,366	69,103	0.013	134,789
2020	1,374	22,066	1,374	68,765	0.013	136,160
2021	1,393	22,400	1,393	68,575	0.013	137,673
2022	1,422	22,879	1,422	68,986	0.013	139,644
2023	1,457	23,433	1,457	70,162	0.013	142,102
2024	1,491	23,987	1,491	71,854	0.013	144,832
2025	1,522	24,483	1,522	73,758	0.013	147,589
2026	1,548	24,896	1,548	75,605	0.013	150,184
2027	1,570	25,236	1,570	77,224	0.013	152,508
2028	1,588	25,527	1,588	78,471	0.013	154,387
Scenario 4, $F_{ABC} = F_{60\%}$						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	10,137	23,391	1,088	81,113	0.010	143,697
2016	9,839	22,722	9,839	75,120	0.092	138,624
2017	9,093	21,019	9,093	66,604	0.092	128,078
2018	8,538	19,751	8,538	60,834	0.092	121,498
2019	8,149	18,866	8,149	57,035	0.092	117,802
2020	7,922	18,355	7,922	54,192	0.092	115,528
2021	7,835	18,169	7,835	51,986	0.092	114,106

2022	7,852	18,218	7,852	50,758	0.092	113,676
2023	7,929	18,404	7,929	50,543	0.092	114,092
2024	8,027	18,632	8,027	50,991	0.092	115,012
2025	8,115	18,834	8,115	51,748	0.092	116,134
2026	8,181	18,986	8,181	52,538	0.092	117,255
2027	8,229	19,095	8,229	53,185	0.092	118,261
2028	8,269	19,187	8,269	53,580	0.092	119,003
Scenario 5, No fishing (F_{ABC} = 0)						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	0	23,391	1,088	81,113	0.010	143,697
2016	0	22,722	0	76,143	0.000	138,624
2017	0	22,484	0	72,947	0.000	136,240
2018	0	22,406	0	71,494	0.000	136,206
2019	0	22,487	0	71,315	0.000	137,868
2020	0	22,759	0	71,523	0.000	140,018
2021	0	23,212	0	71,811	0.000	142,207
2022	0	23,797	0	72,639	0.000	144,769
2023	0	24,446	0	74,189	0.000	147,755
2024	0	25,087	0	76,225	0.000	150,966
2025	0	25,661	0	78,450	0.000	154,167
2026	0	26,147	0	80,599	0.000	157,170
2027	0	26,552	0	82,497	0.000	159,866
2028	0	26,902	0	83,996	0.000	162,077
Scenario 6, Whether S rock sole are overfished – $SB_{35\%}$ = 28,500						
Year	ABC	OFL	Catch	SSB	F	Total Bio
2015	23,391	23,391	1,088	81,113	0.010	143,697
2016	22,722	22,722	22,722	73,685	0.222	138,624
2017	19,114	19,114	19,114	58,525	0.222	117,465
2018	16,583	16,583	16,583	48,445	0.222	103,979
2019	14,876	14,876	14,876	41,779	0.222	95,755
2020	13,709	13,709	13,709	37,057	0.220	90,523
2021	12,093	12,093	12,093	33,860	0.200	87,338
2022	11,605	11,605	11,605	32,500	0.191	86,617
2023	11,774	11,774	11,774	32,416	0.191	87,214
2024	12,215	12,215	12,215	32,943	0.194	88,240
2025	12,596	12,596	12,596	33,601	0.197	89,177
2026	12,749	12,749	12,749	34,132	0.199	89,872
2027	12,798	12,798	12,798	34,444	0.199	90,375
2028	12,864	12,864	12,864	34,521	0.200	90,662
Scenario 7, Whether S rock sole are approaching overfished condition						
Year	ABC	OFL	Catch	SSB	F	Total Bio

2015	23,391	23,391	1,088	81,113	0.010	143,697
2016	22,722	22,722	19,299	74,078	0.186	138,624
2017	19,619	19,619	16,658	60,645	0.186	120,276
2018	17,391	17,391	17,391	51,301	0.222	108,443
2019	15,479	15,479	15,479	43,963	0.222	99,083
2020	14,285	14,285	14,285	38,698	0.222	92,973
2021	12,772	12,772	12,772	34,994	0.207	89,006
2022	11,981	11,981	11,981	33,164	0.196	87,505
2023	11,968	11,968	11,968	32,776	0.193	87,632
2024	12,297	12,297	12,297	33,111	0.195	88,387
2025	12,614	12,614	12,614	33,658	0.198	89,184
2026	12,741	12,741	12,741	34,134	0.199	89,823
2027	12,782	12,782	12,782	34,423	0.199	90,315
2028	12,848	12,848	12,848	34,496	0.200	90,608

Figures

Figure 4.1.1 – Total shallow-water flatfish (SWFF) and rock sole (RS) catch (as of 2015-10-15)

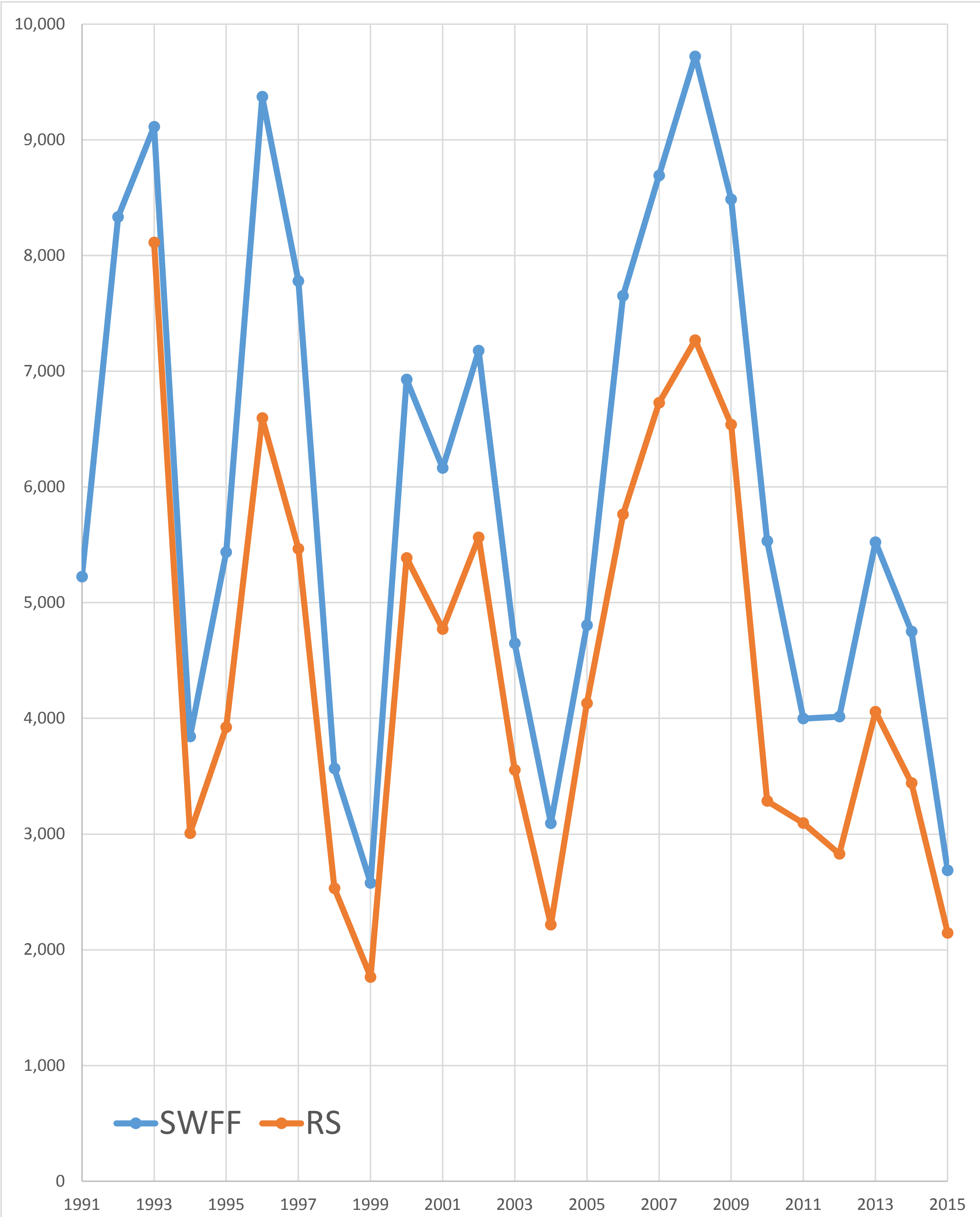


Figure 4.1.2 – Total rock sole catch by area (as of 2015-10-16)

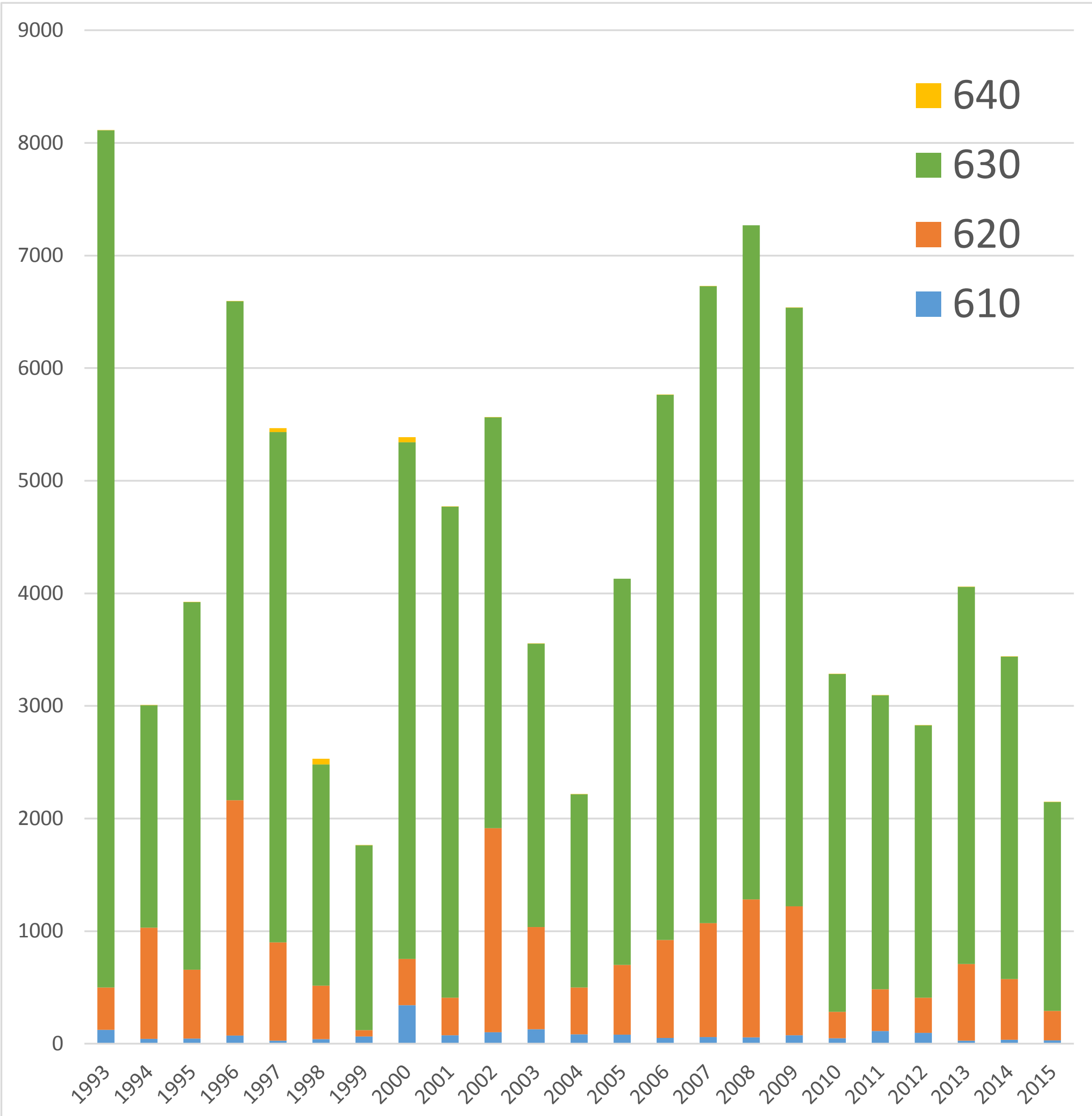


Figure 4.1.3 – Percent of the observed rock sole catch that is URS, NRS, or SRS (based on fishery observer extrapolated haul-level data; as of 2015-10-05)

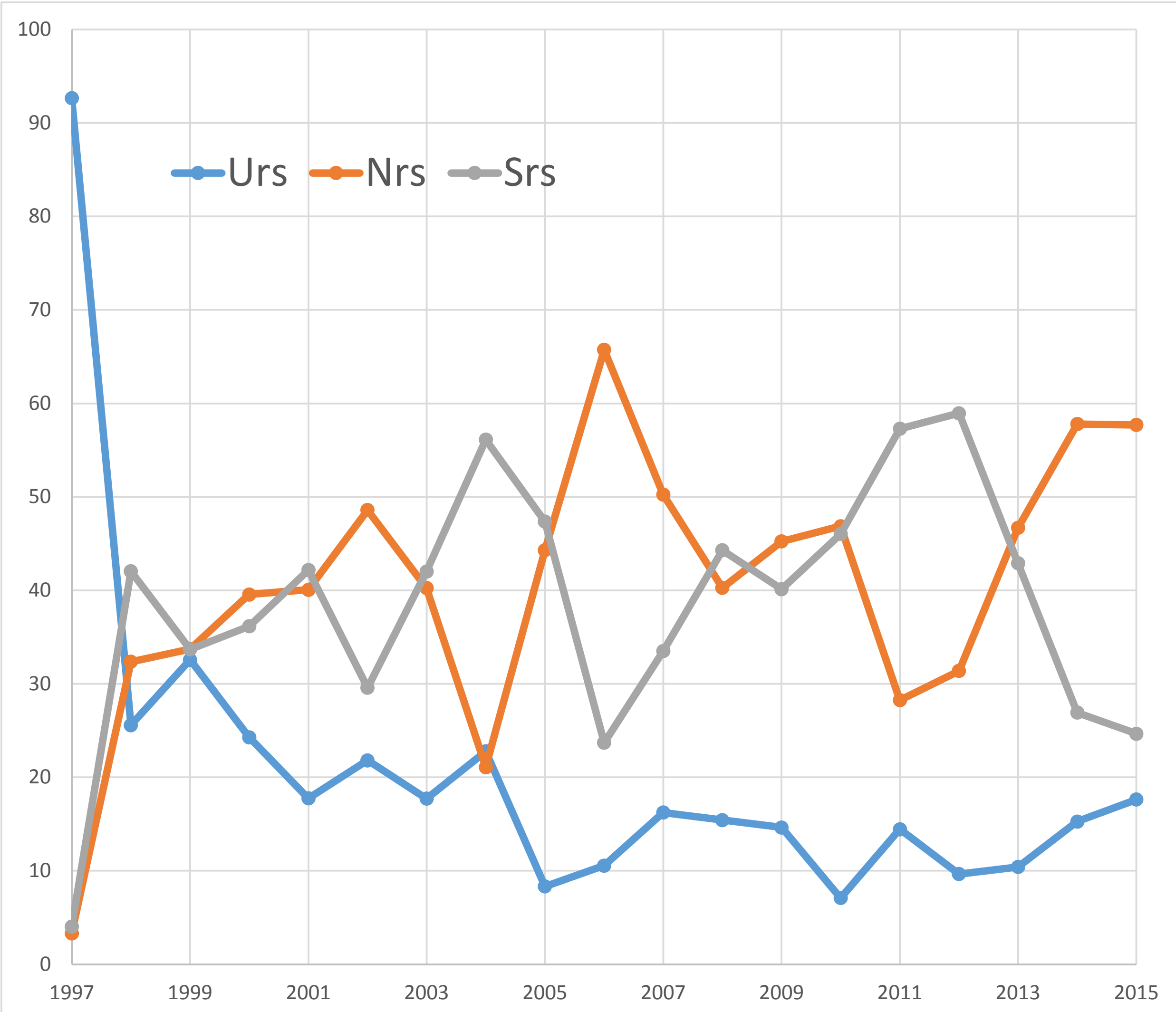


Figure 4.1.4 – GOA NMFS bottom trawl survey estimates for URS by area

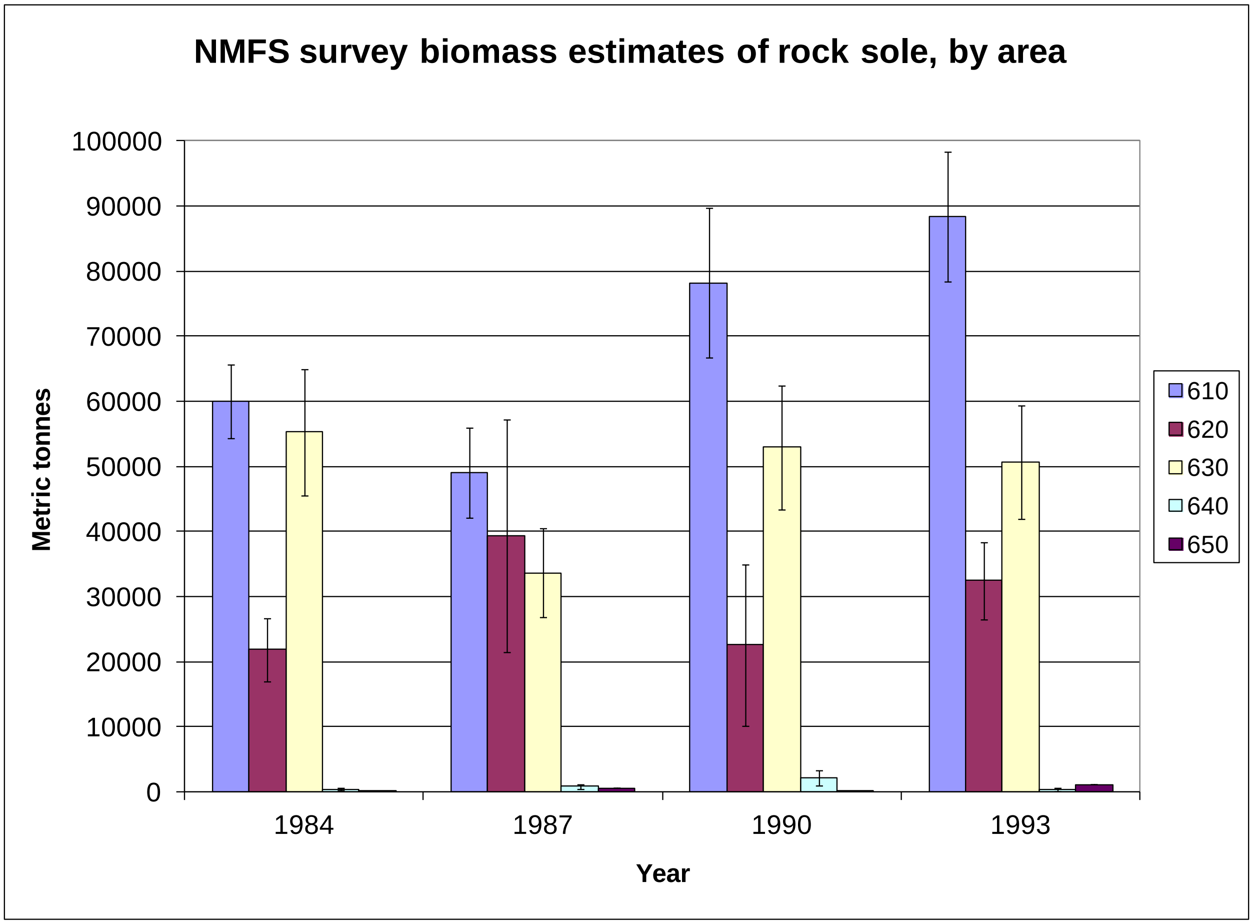


Figure 4.1.5 – GOA NMFS bottom trawl survey estimates for NRS by area

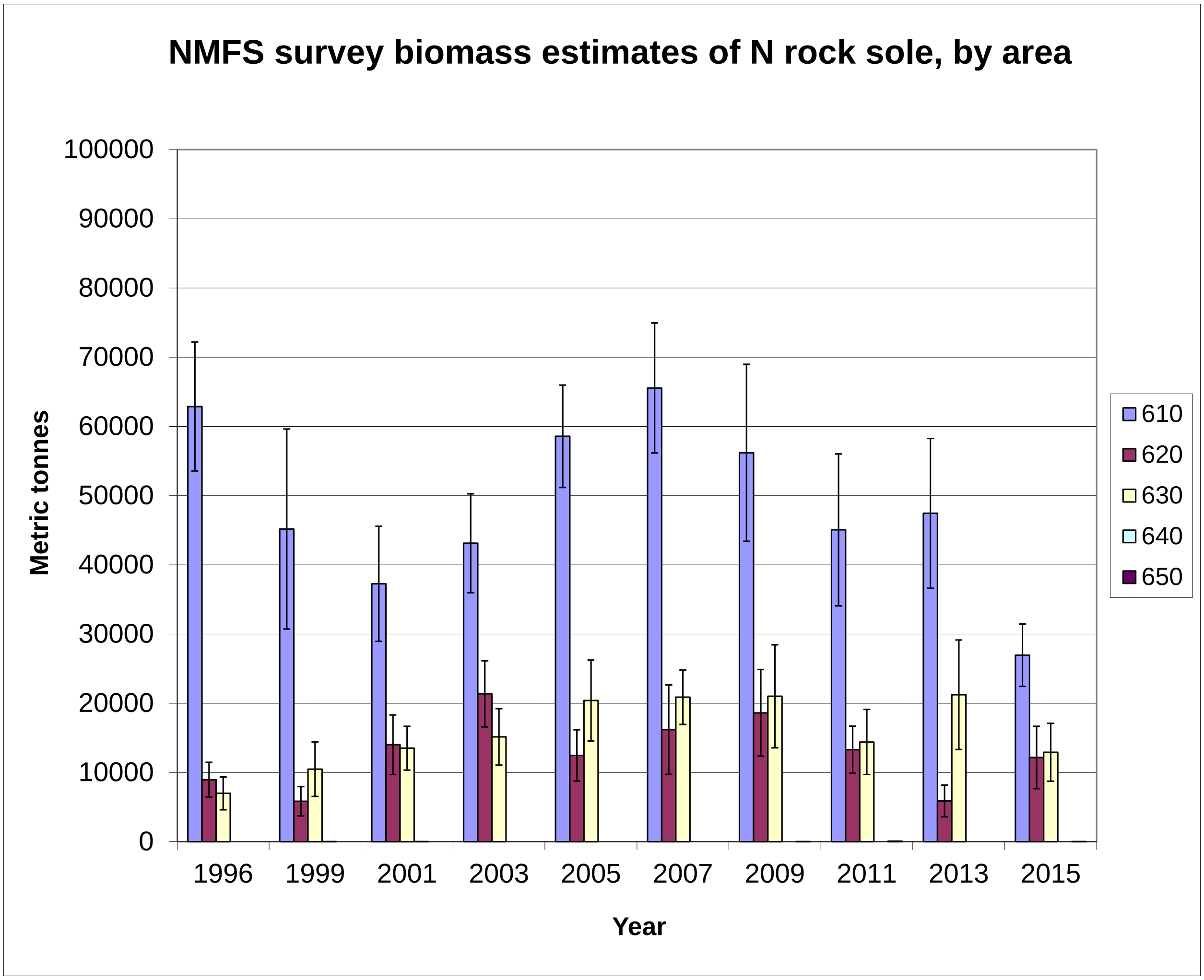


Figure 4.1.6 – GOA NMFS bottom trawl survey estimates for SRS by area

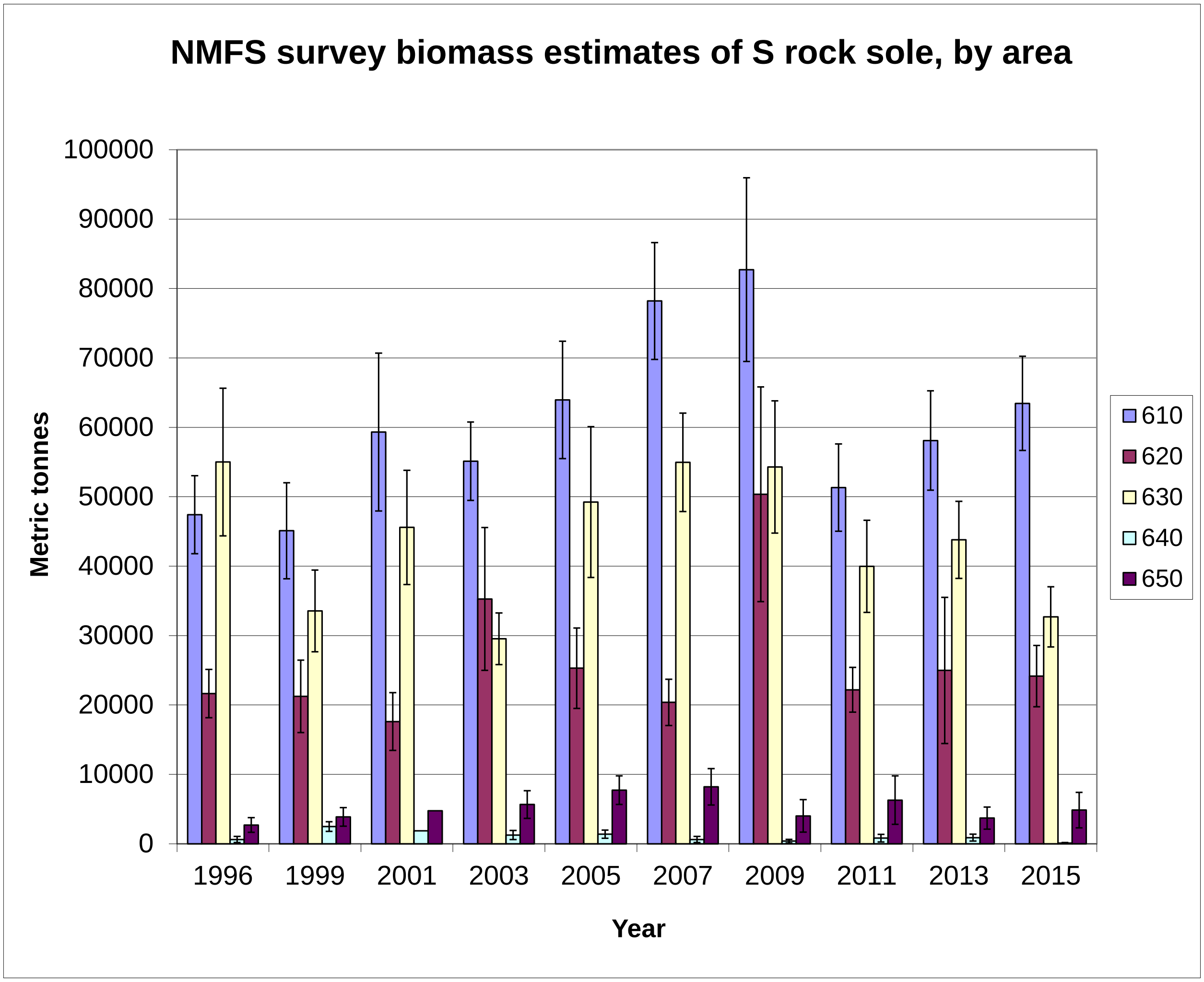


Figure 4.1.7 – GOA NMFS bottom trawl survey estimates for URS, NRS, and SRS

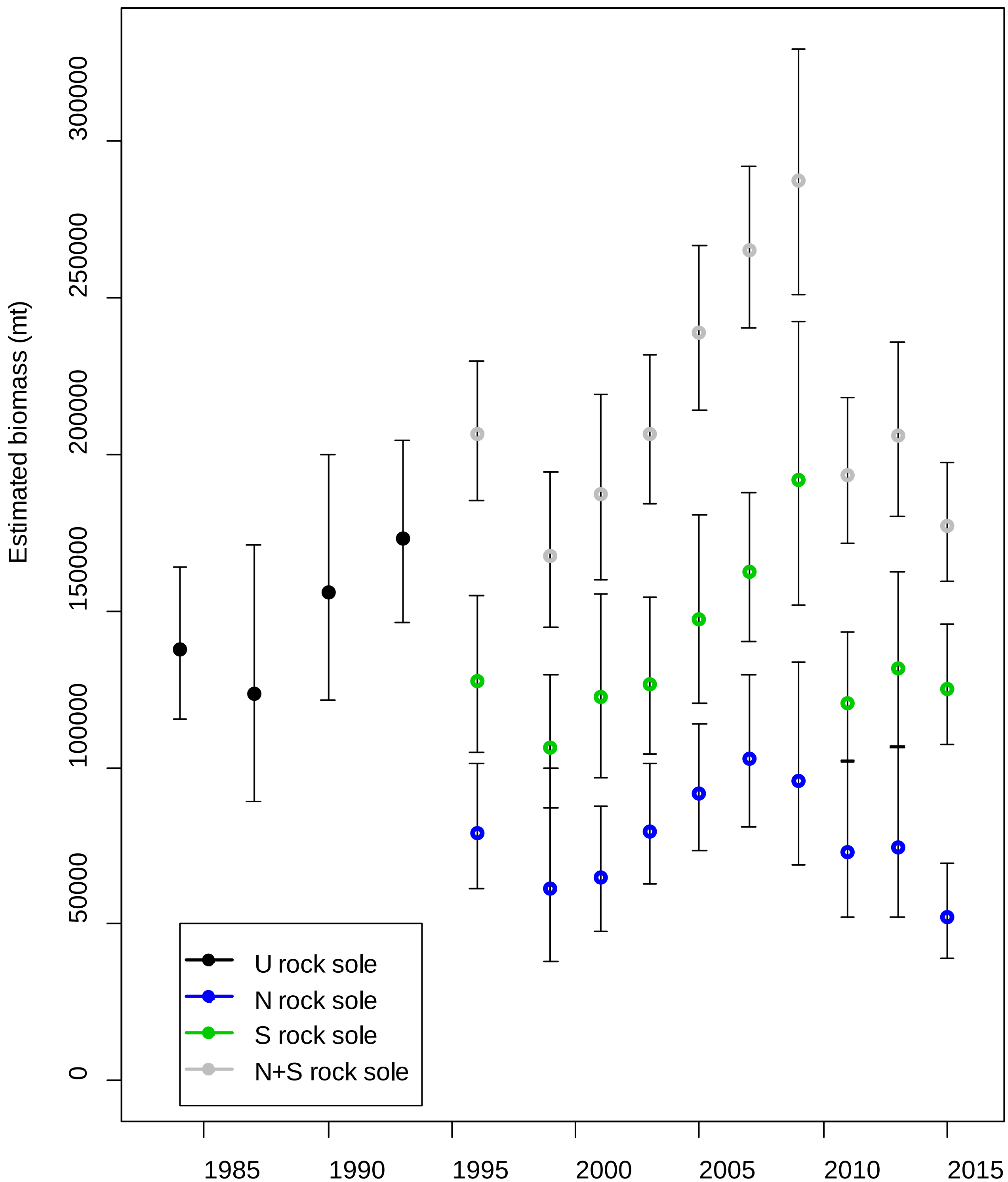


Figure 4.1.8 – Fraction of the URS, NRS, and SRS fishery length composition data that is female

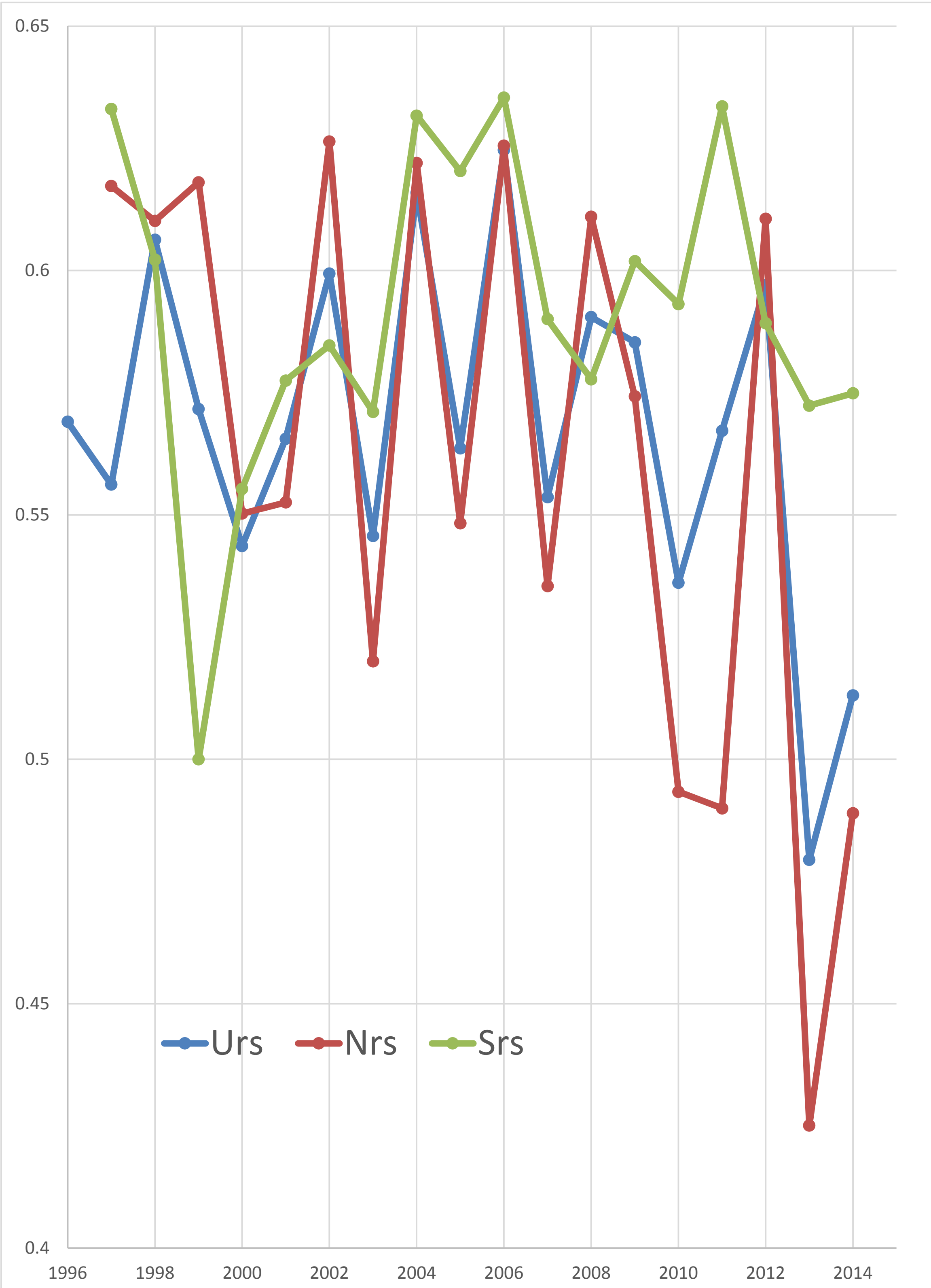


Figure 4.1.9 – Fraction of the URS, NRS, and SRS bottom trawl survey length composition data that is female

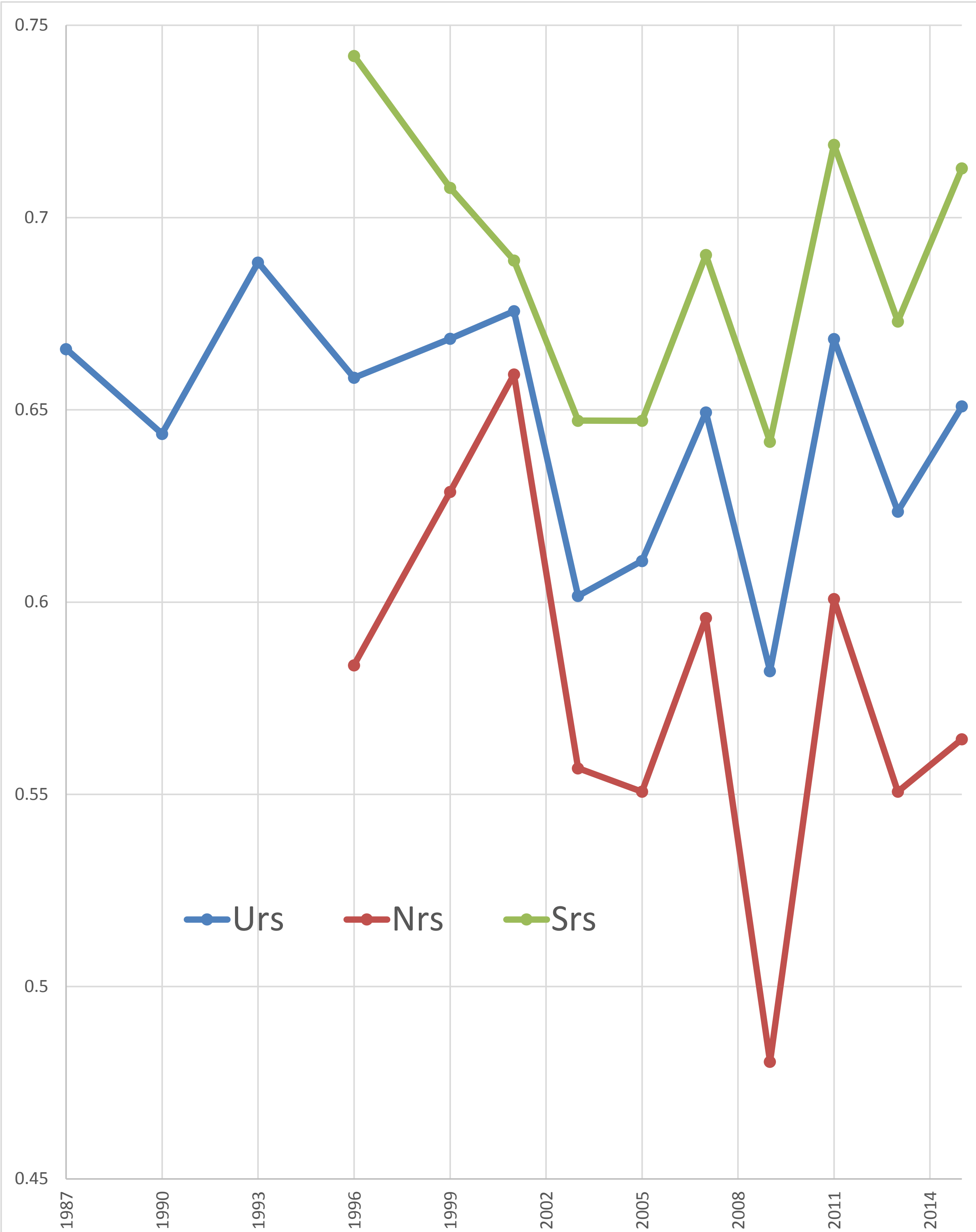


Figure 4.1.10 – Species-specific catch (½ of total [undifferentiated] rock sole catch)

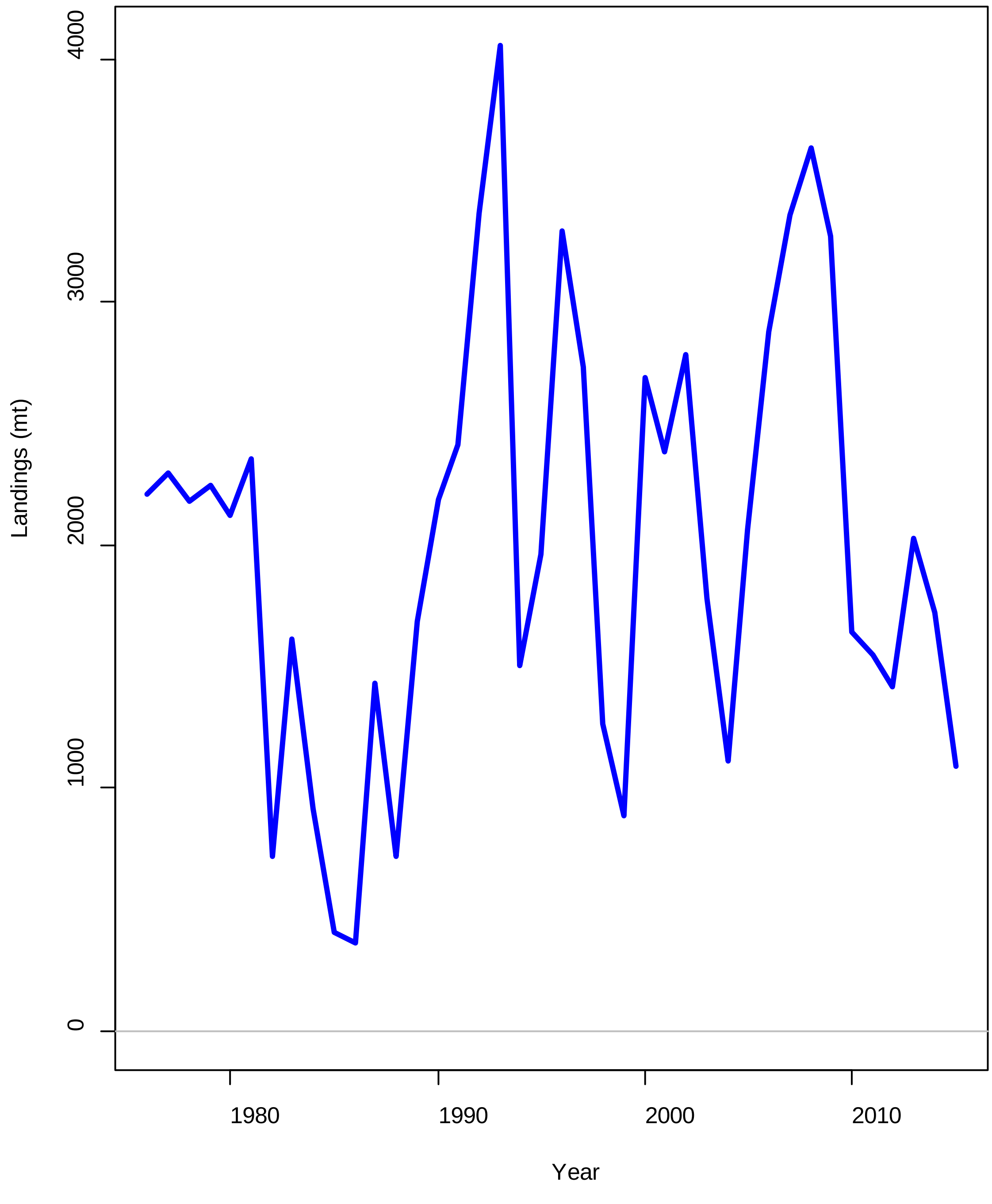


Figure 4.1.11 – Estimates of spawning biomass for NRS for Models 0, 1, and 2

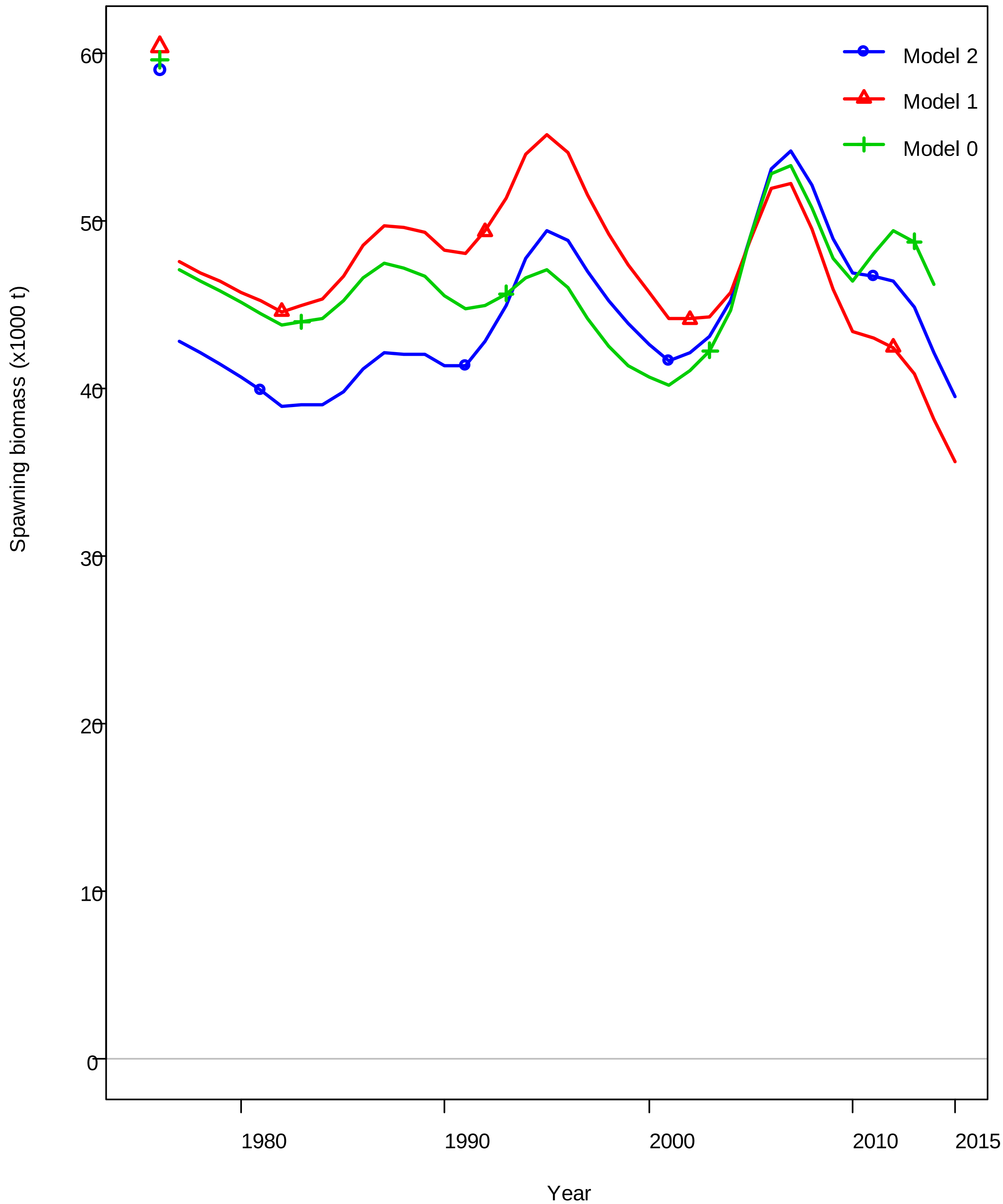


Figure 4.1.12 – Estimates of age-0 recruits for NRS for Models 0, 1, and 2

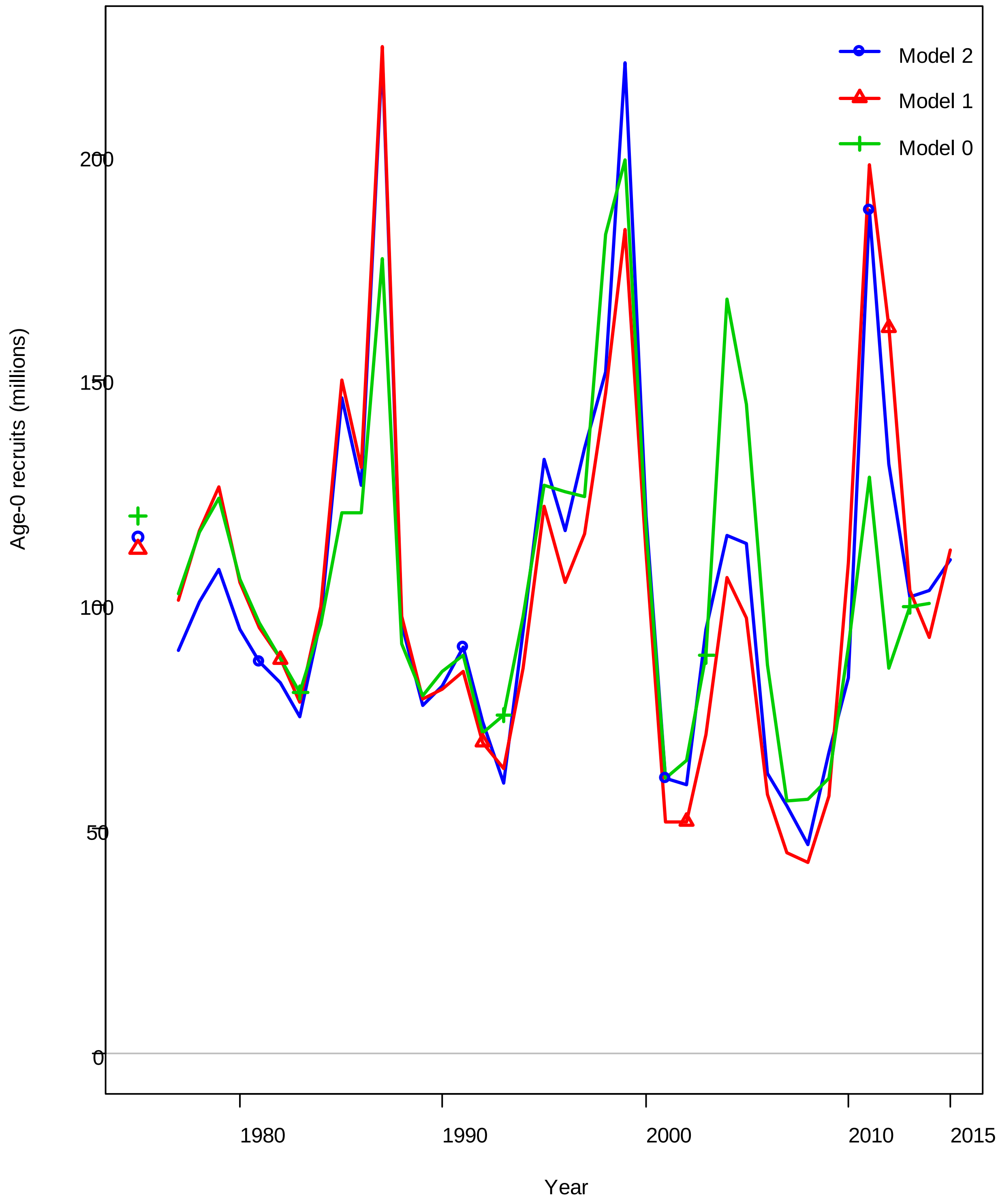


Figure 4.1.13 – Estimates of survey biomass for NRS for Models 0, 1, and 2

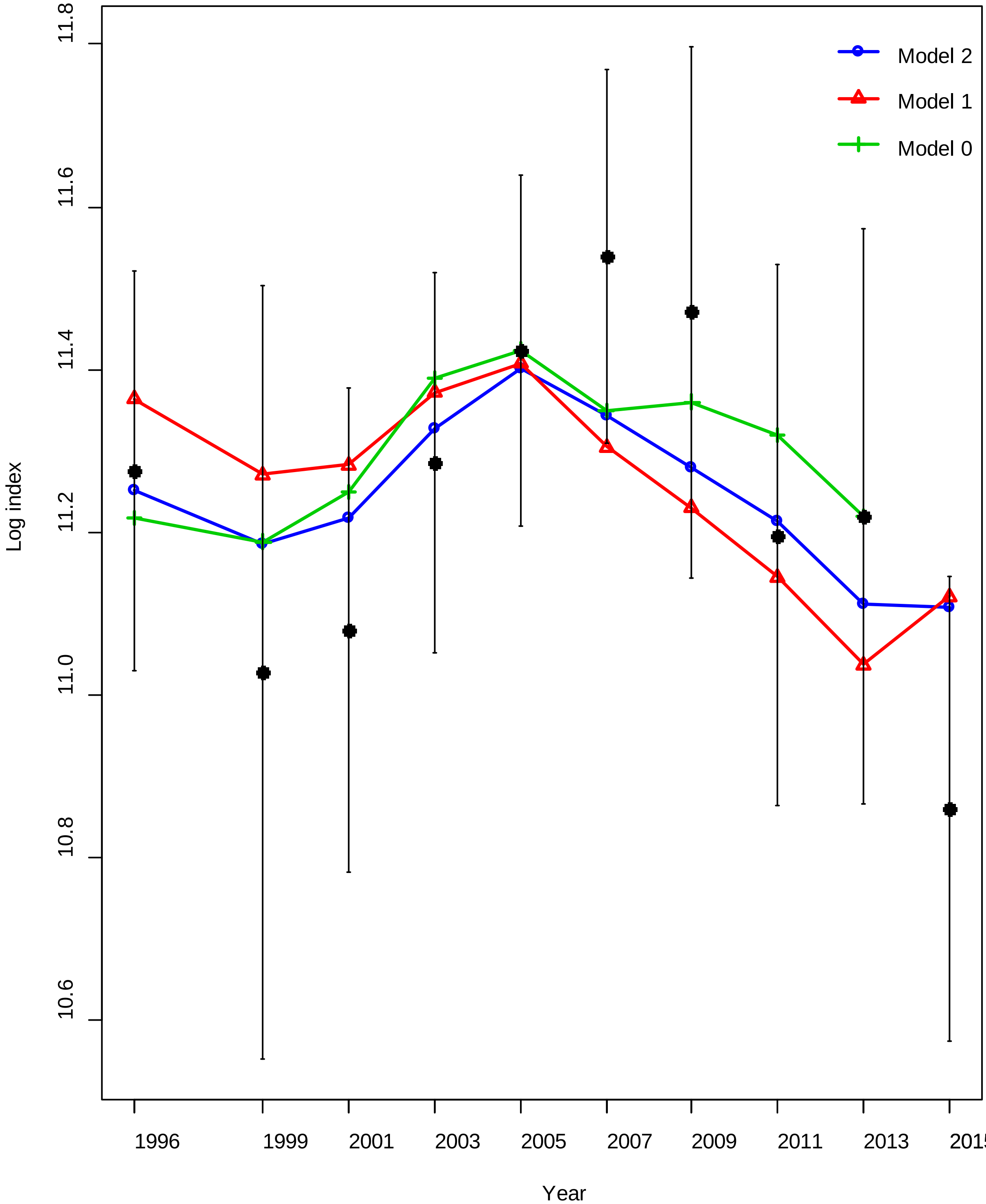


Figure 4.1.14 – Estimates of spawning biomass for SRS for Models 0, 1, and 2

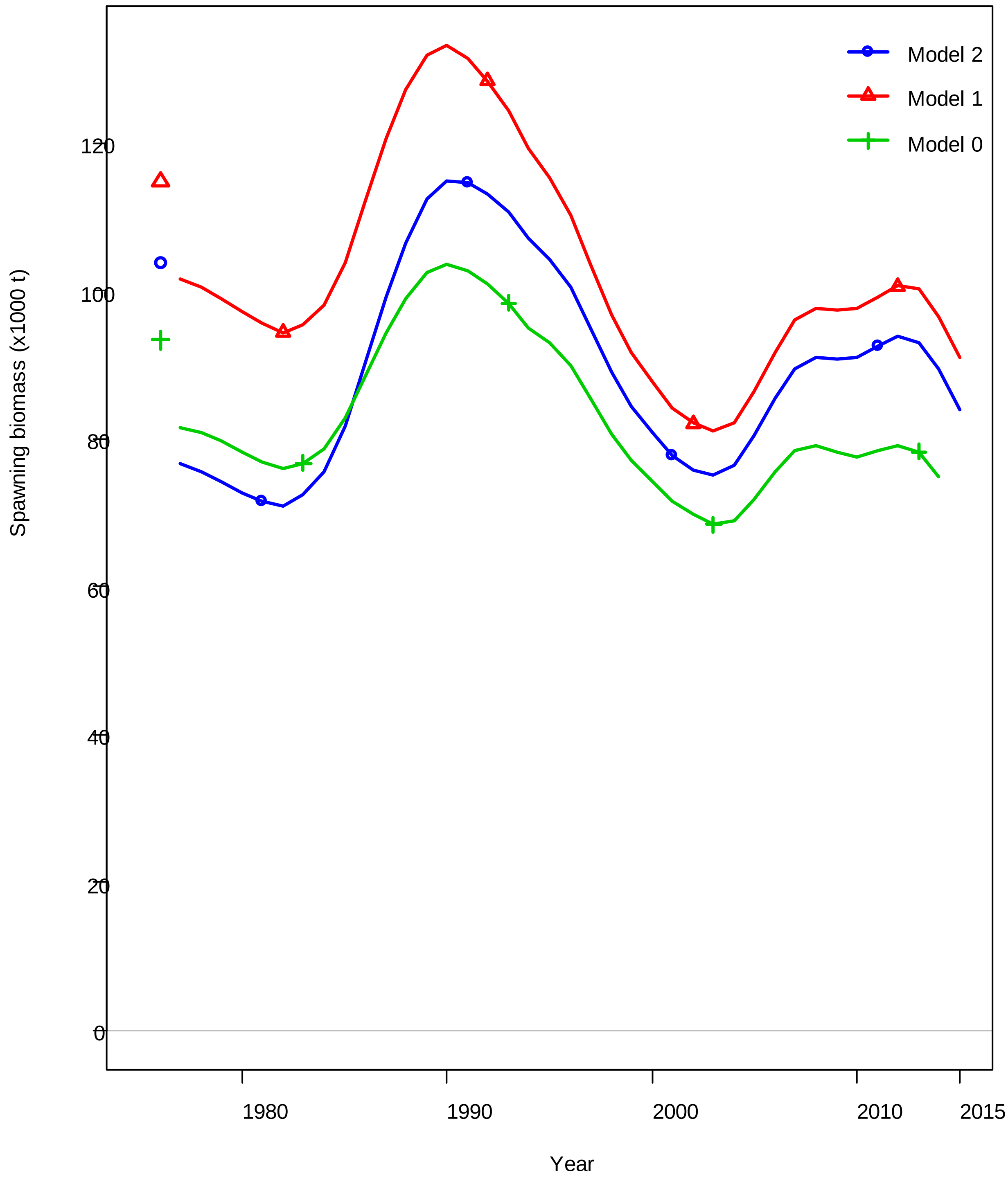


Figure 4.1.15 – Estimates of age-0 recruits for SRS for Models 0, 1, and 2

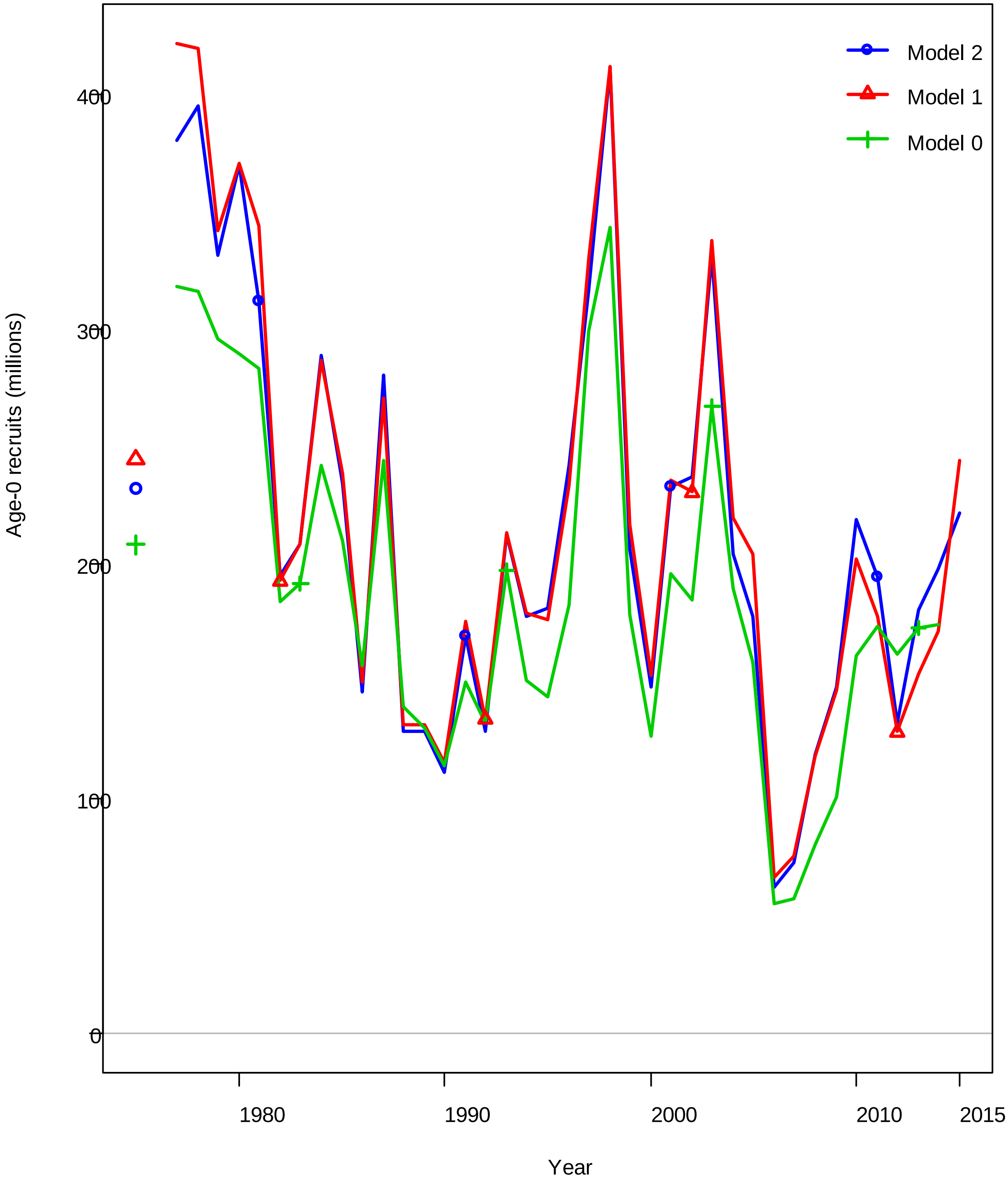


Figure 4.1.16 – Estimates of survey biomass for SRS for Models 0, 1, and 2

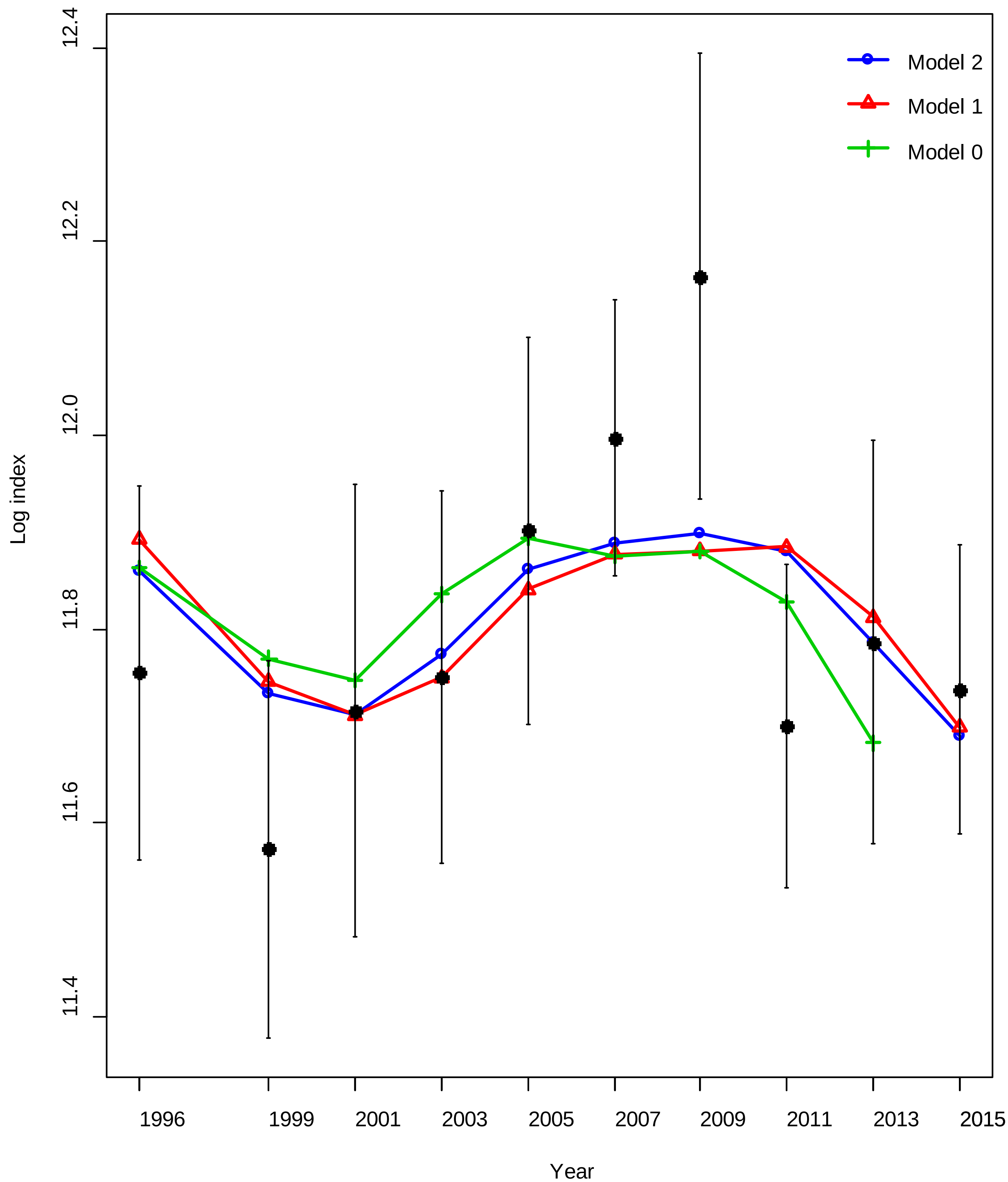


Figure 4.1.17 – Estimates of spawning biomass for URS for Models 0, 1, and 2

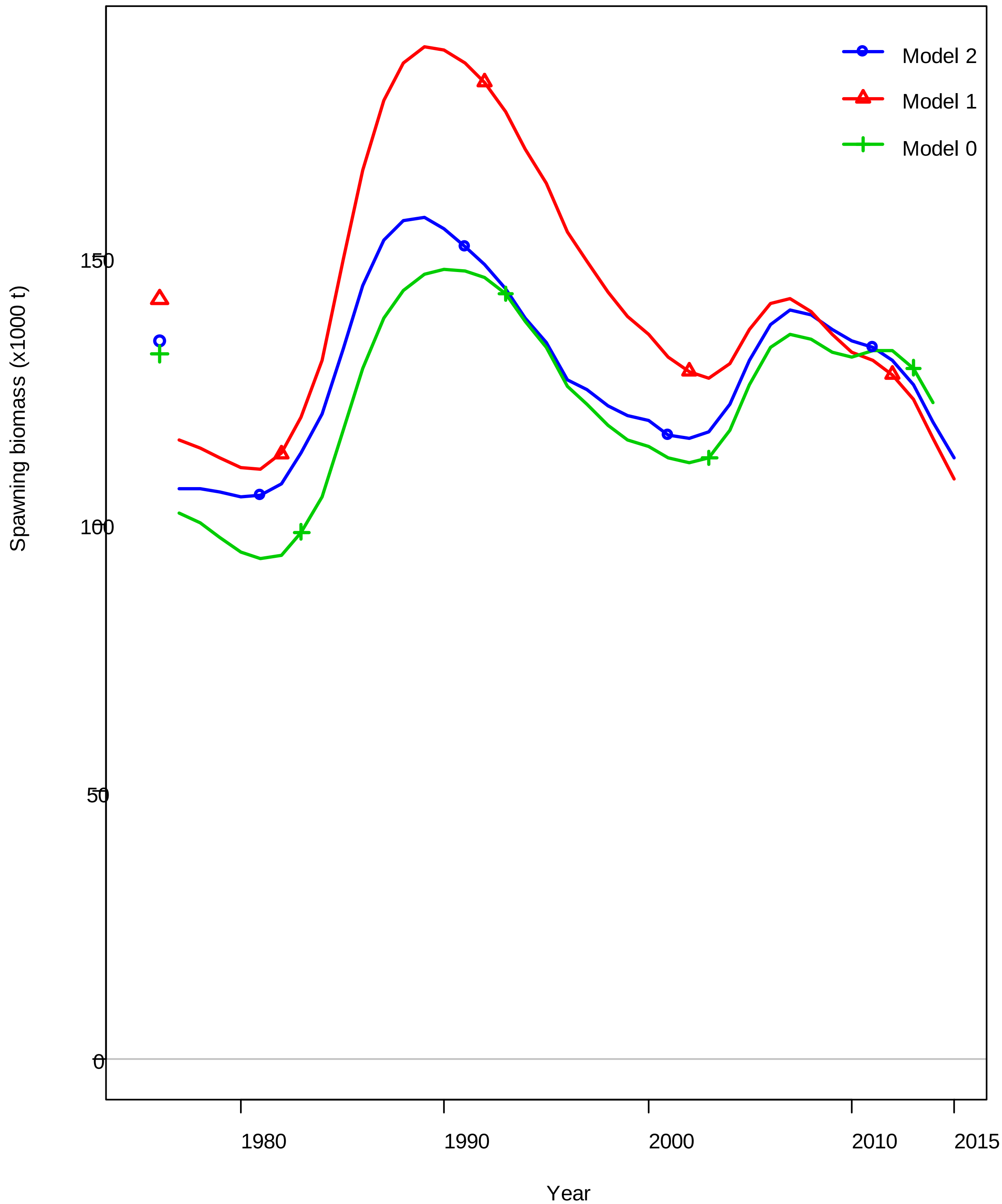


Figure 4.1.18 – Estimates of age-0 recruits for URS for Models 0, 1, and 2

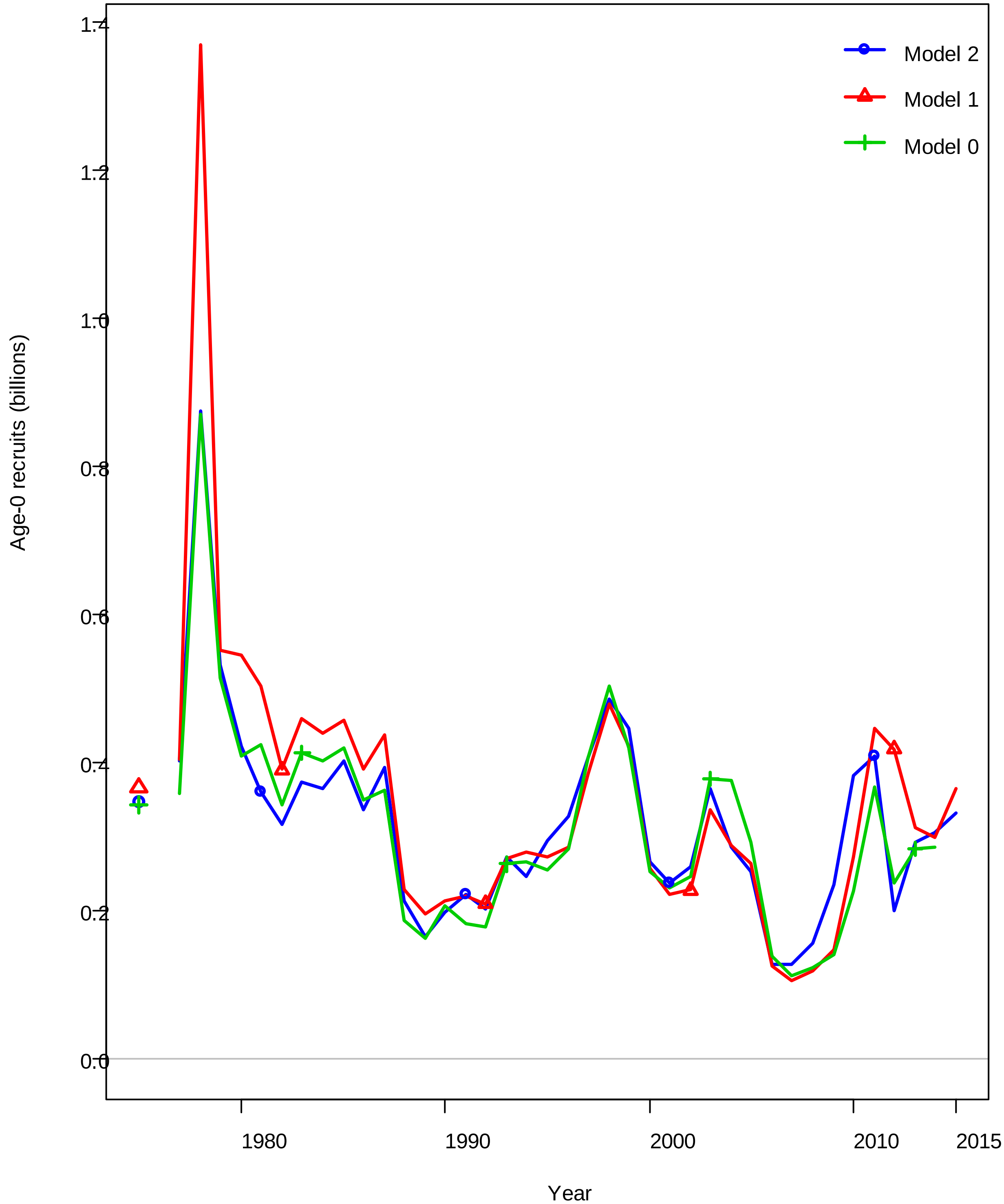


Figure 4.1.19 – Estimates of survey biomass for URS for Models 0, 1, and 2

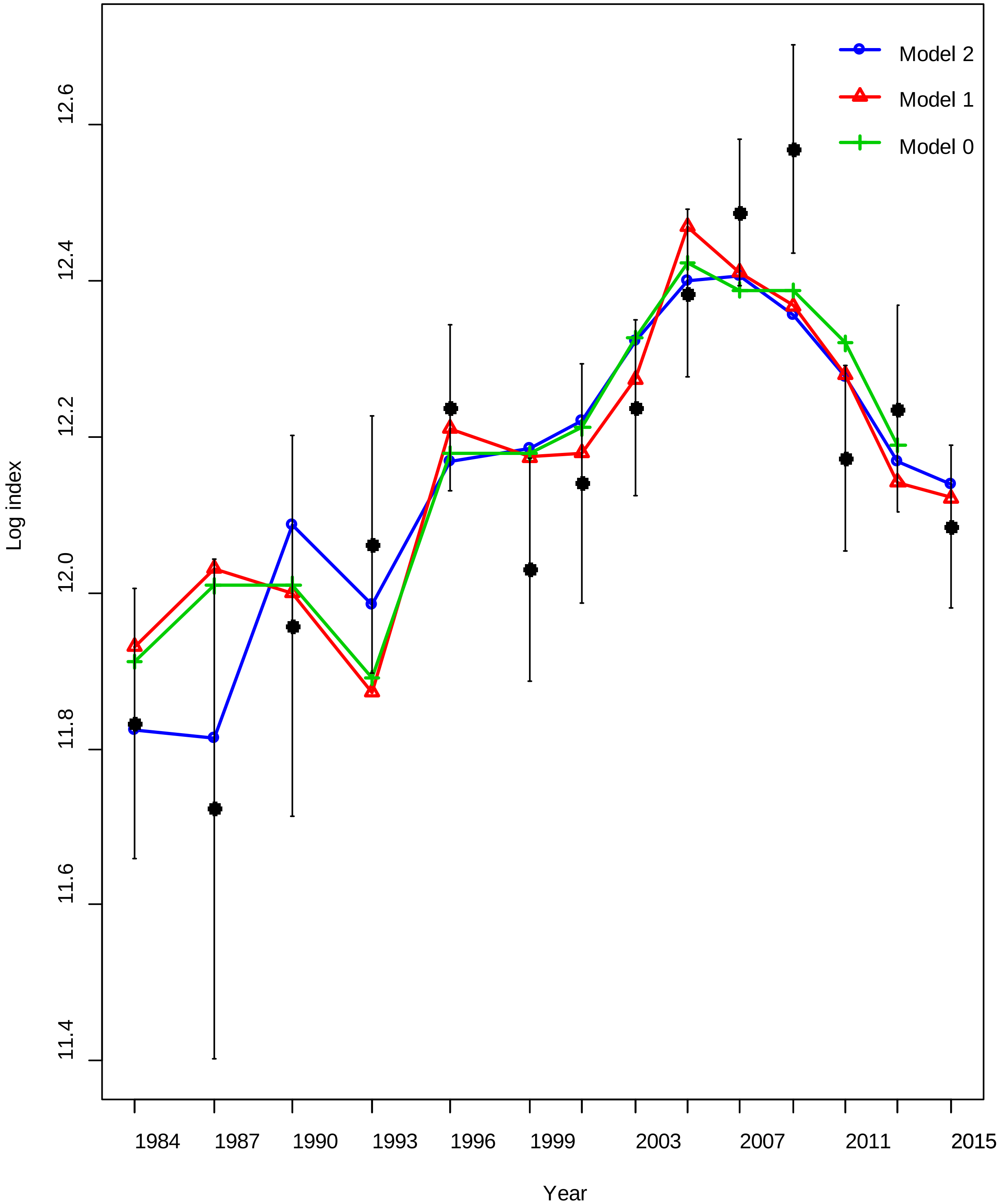


Figure 4.1.20 – Estimates of spawning biomass for URS, NRS, and SRS (Model 2)

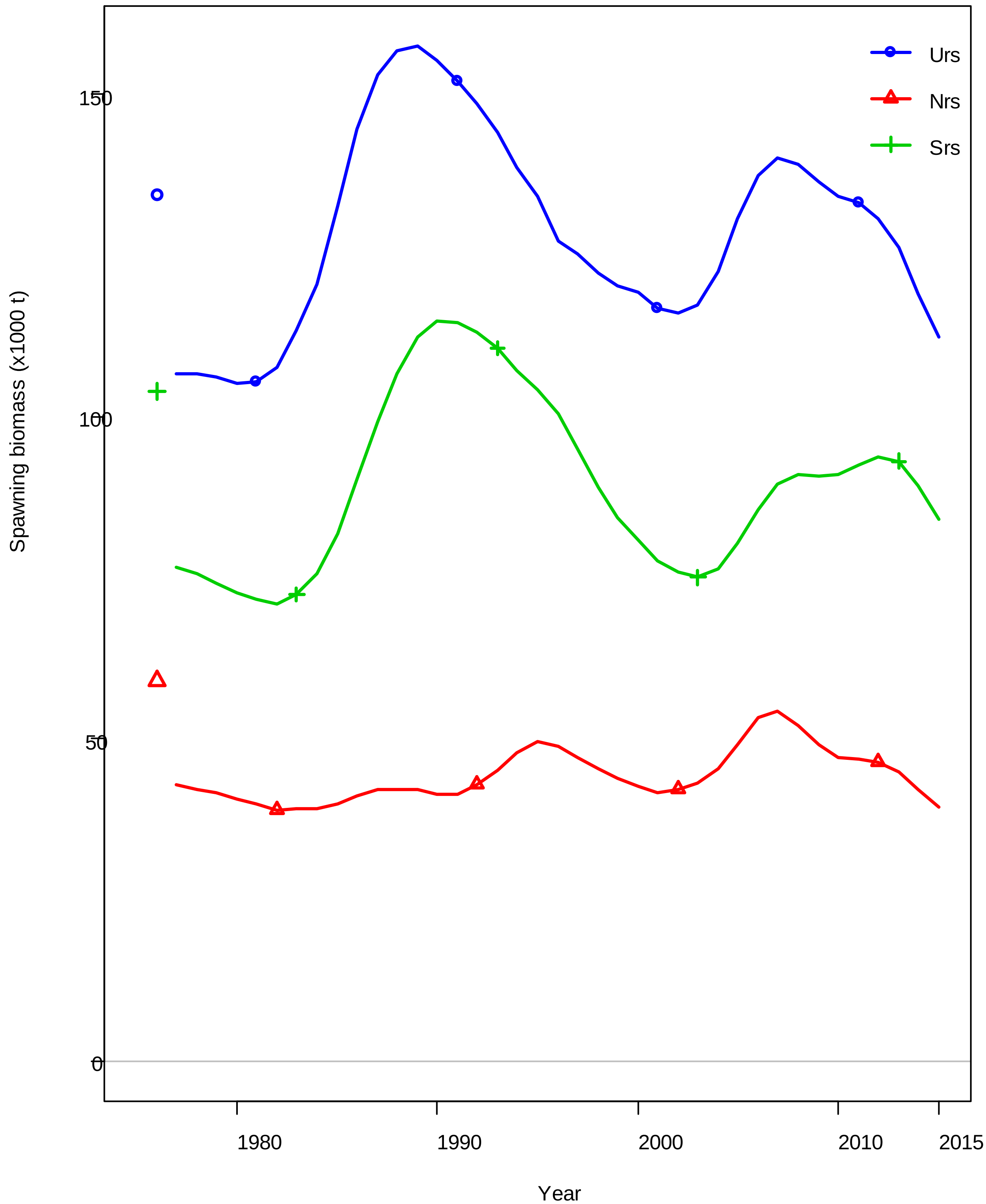


Figure 4.1.21 – Estimates of age-0 recruits for URS, NRS, and SRS (Model 2)

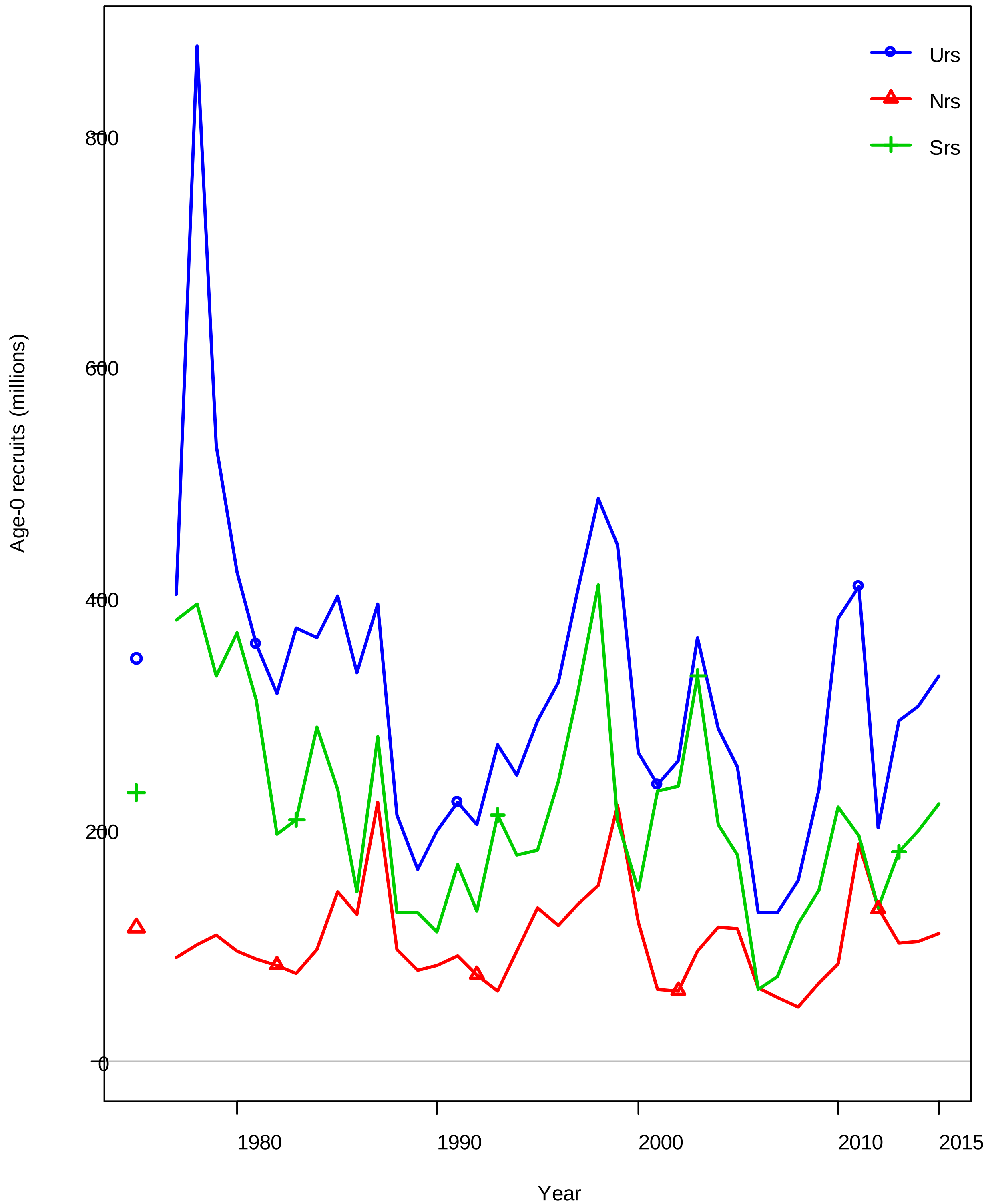


Figure 4.1.22 – Estimates of survey biomass for URS, NRS, and SRS (Model 2)

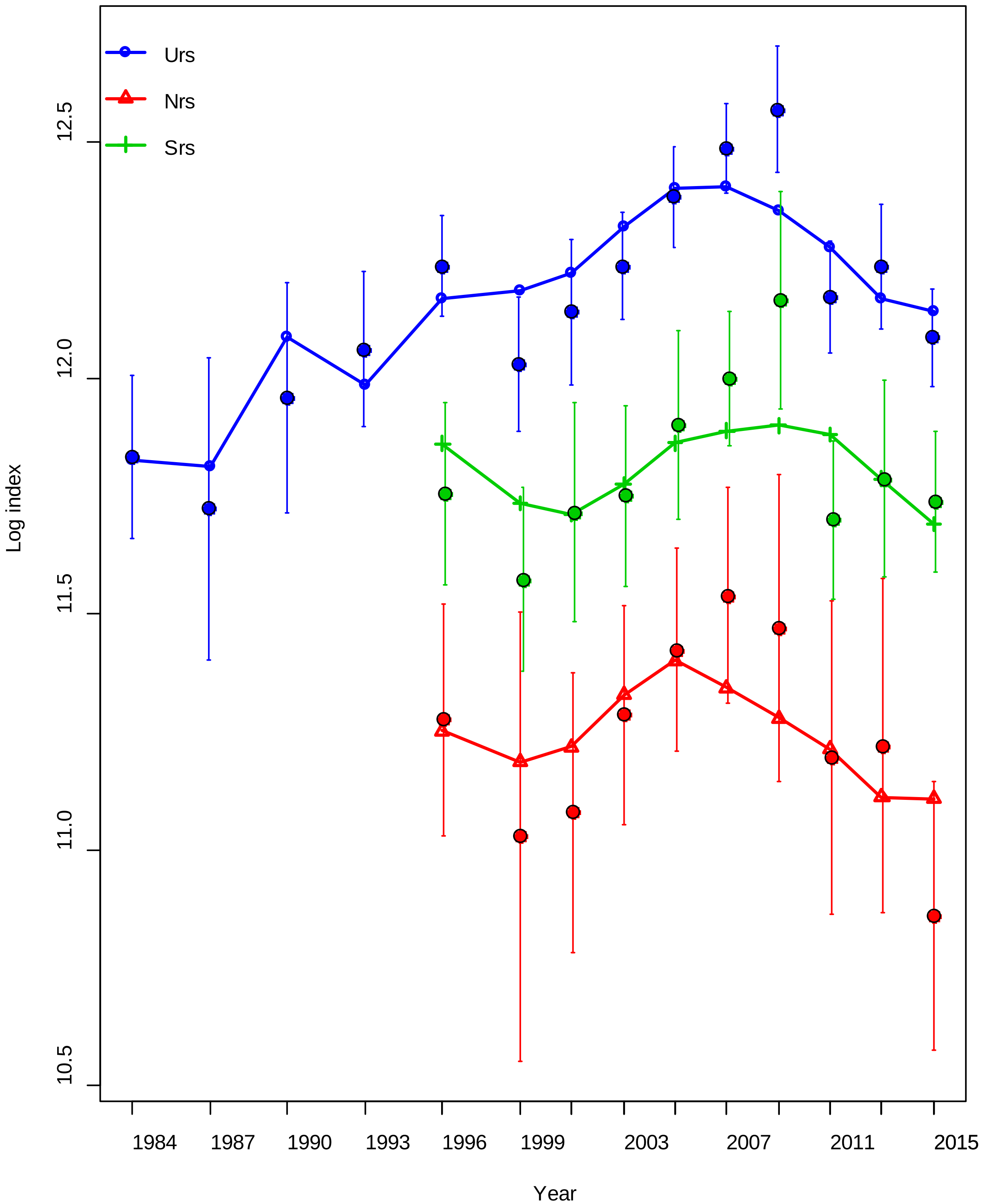


Figure 4.1.23 – Estimates of total biomass for NRS

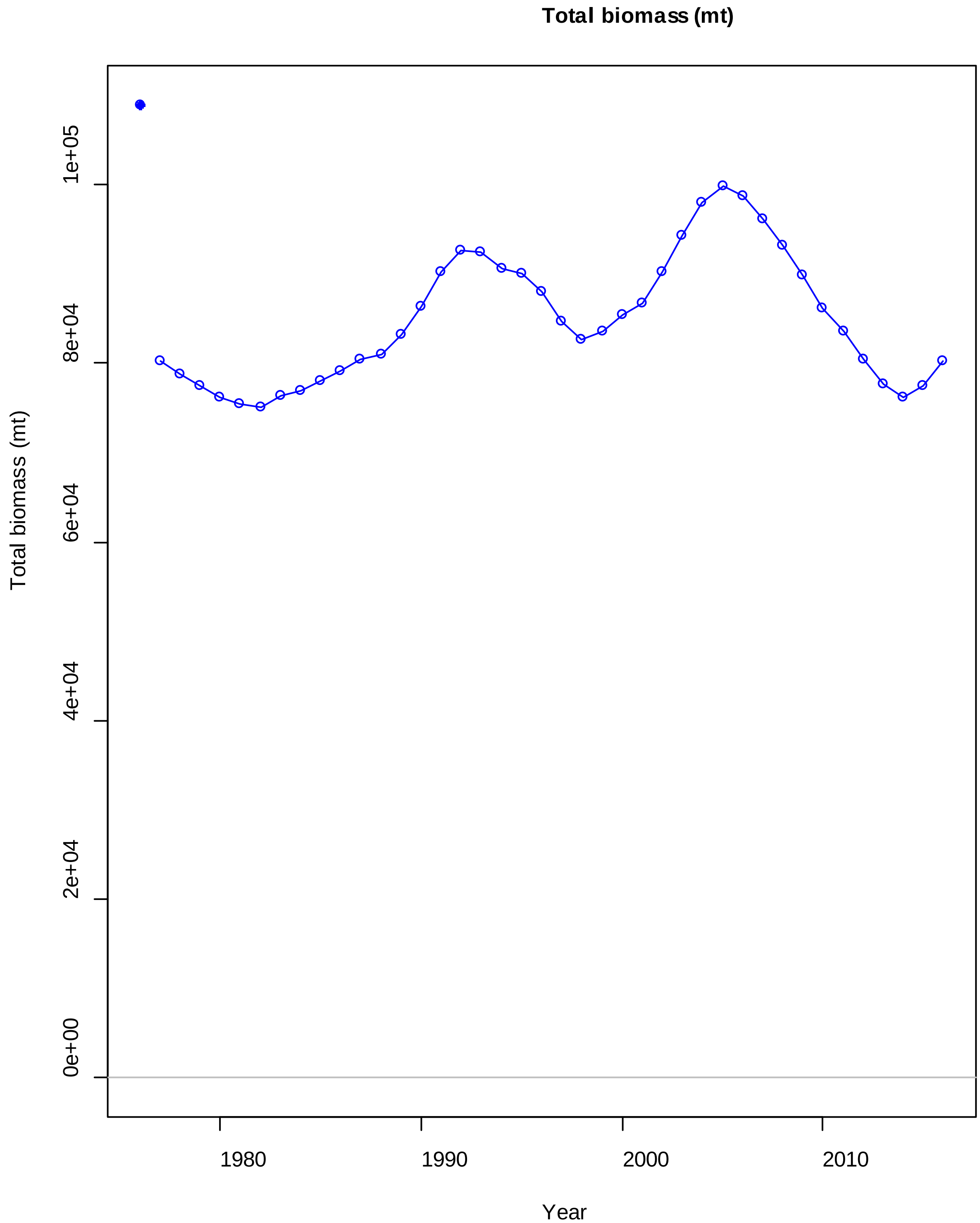


Figure 4.1.24 – Estimates of spawning biomass for NRS

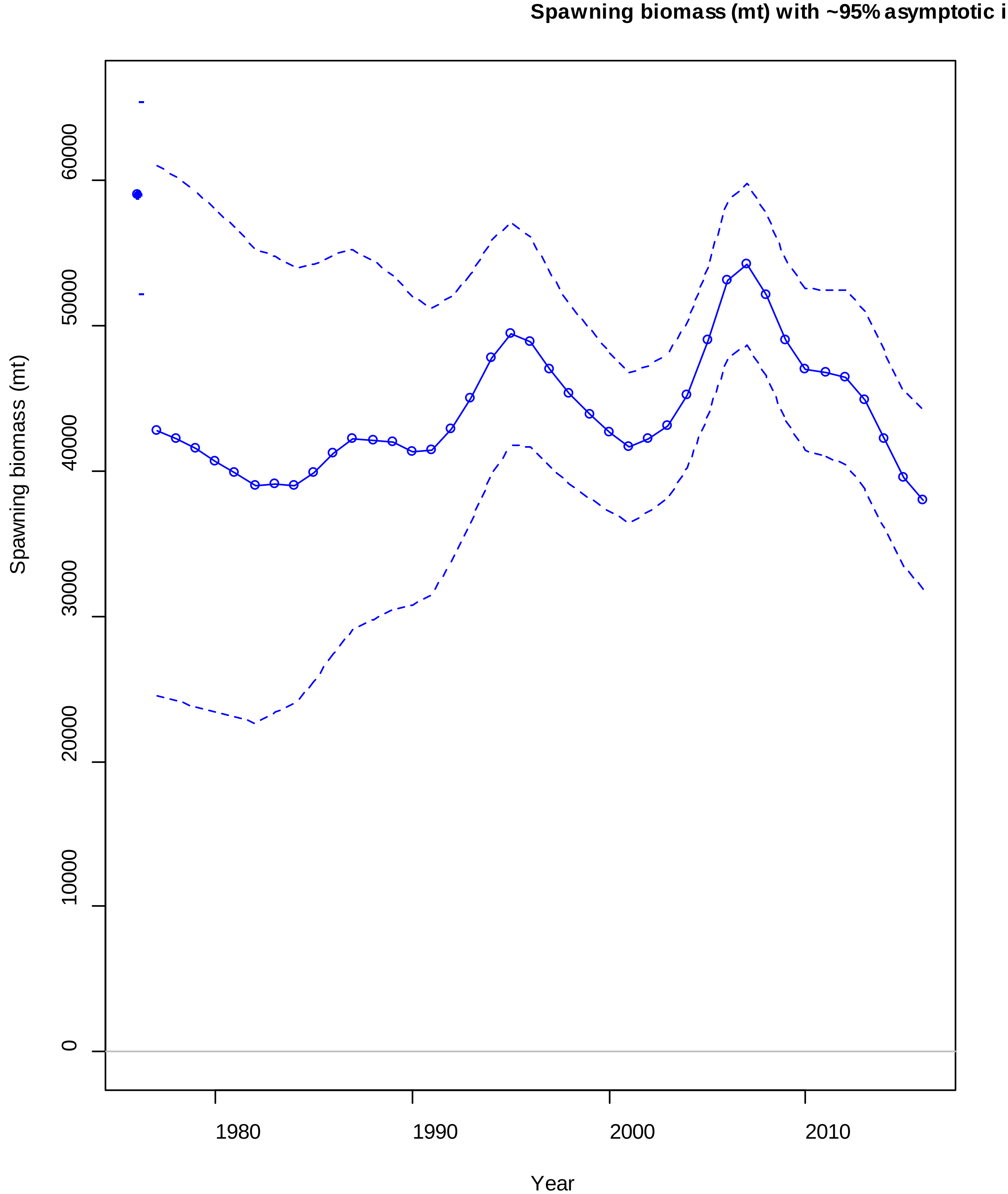


Figure 4.1.25 – Estimates of age-0 recruits for NRS

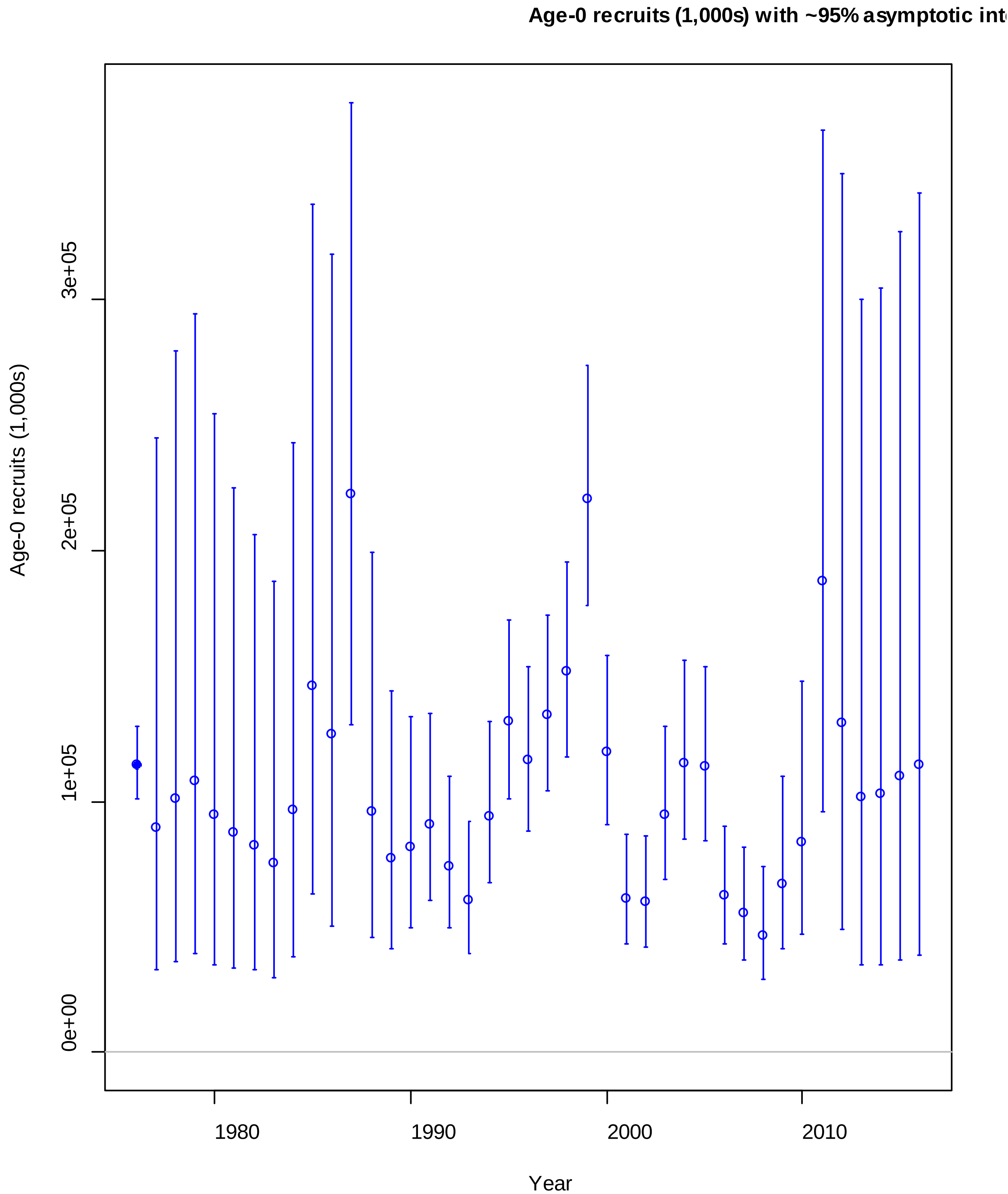


Figure 4.1.26 – Estimates of survey biomass for NRS

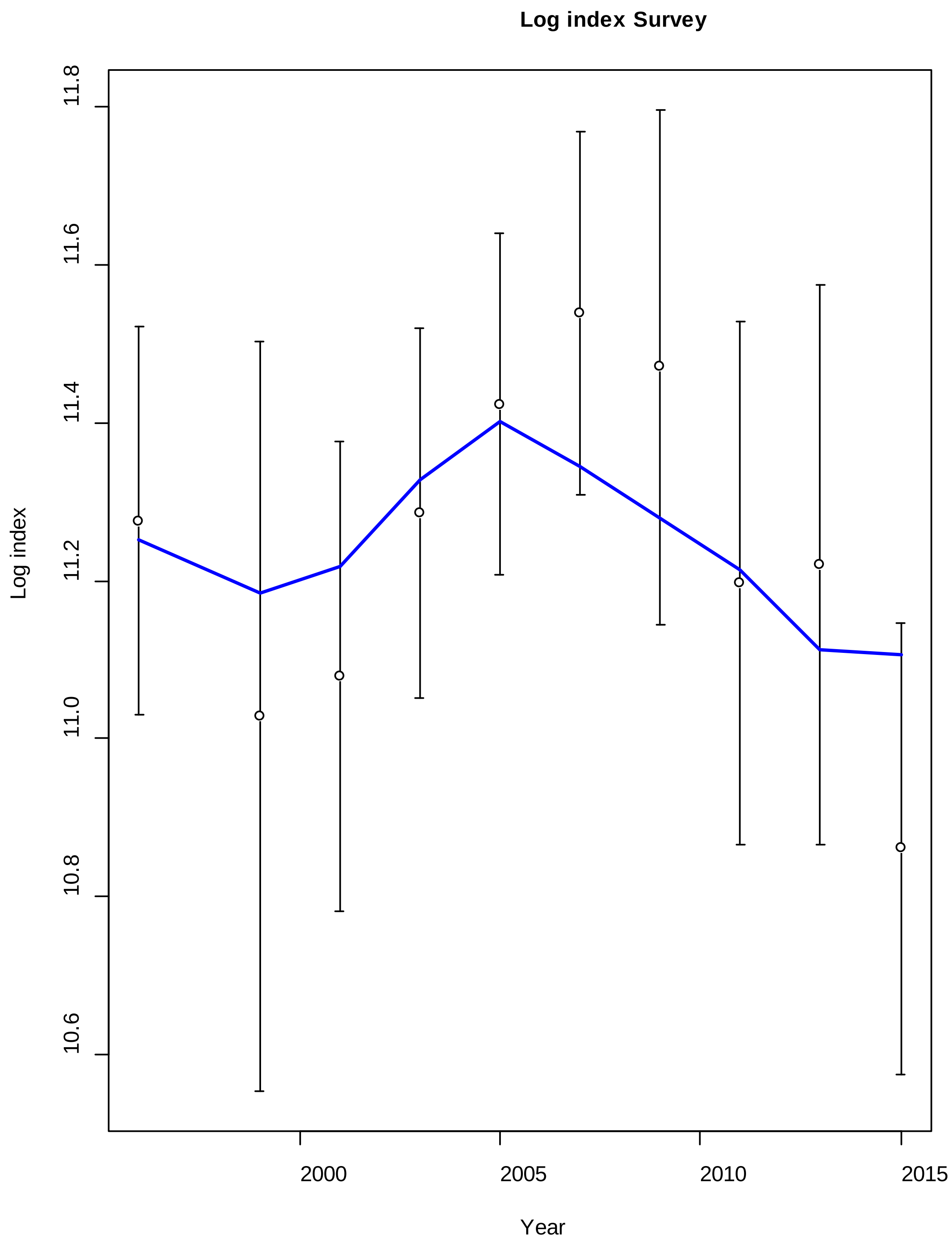


Figure 4.1.27 – Fishery and survey selectivity-at-length for NRS

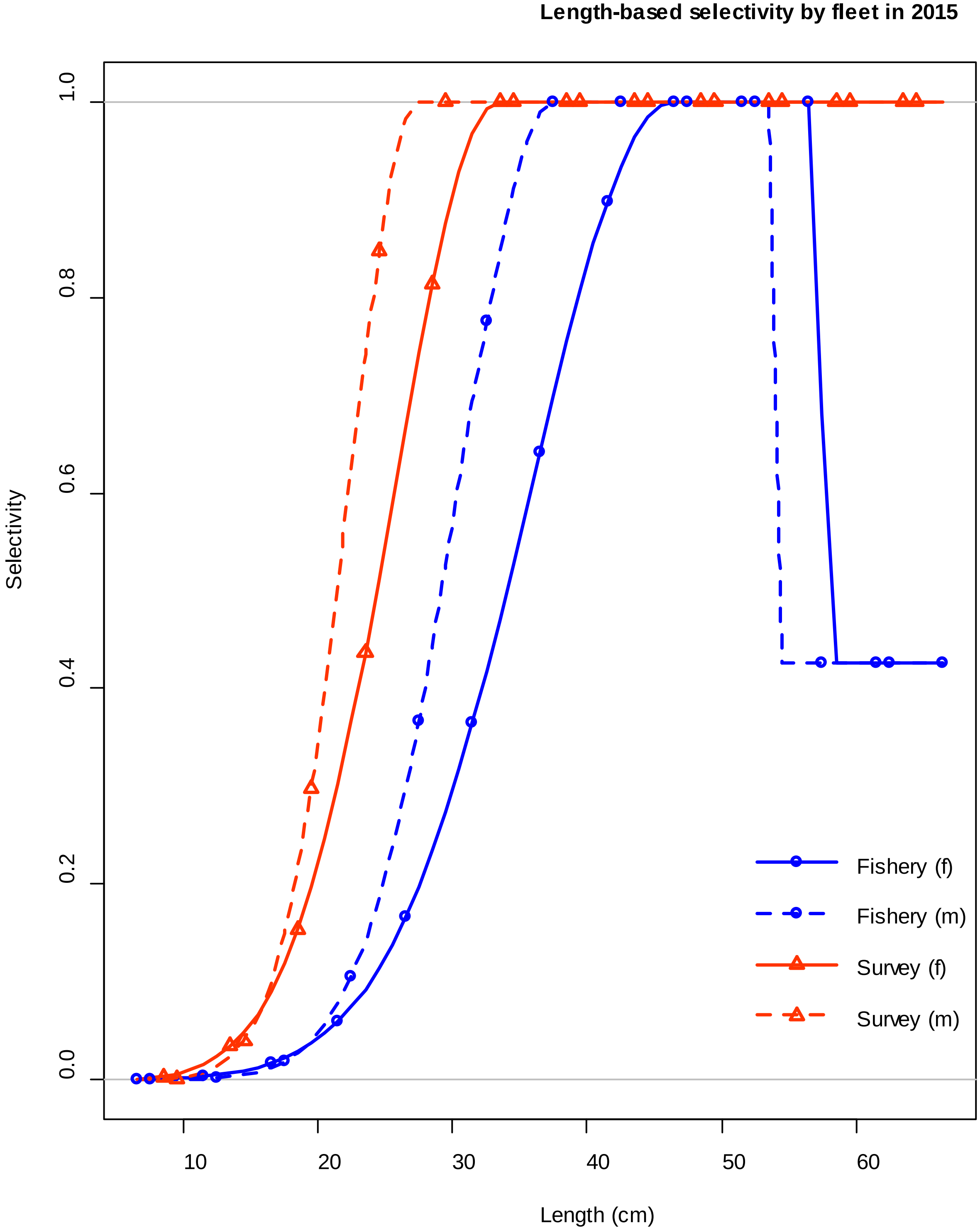


Figure 4.1.28 – Summary of fits to the fishery and survey length composition data for NRS. The information in the bottom panel is the fit to the 2015 survey length composition data.

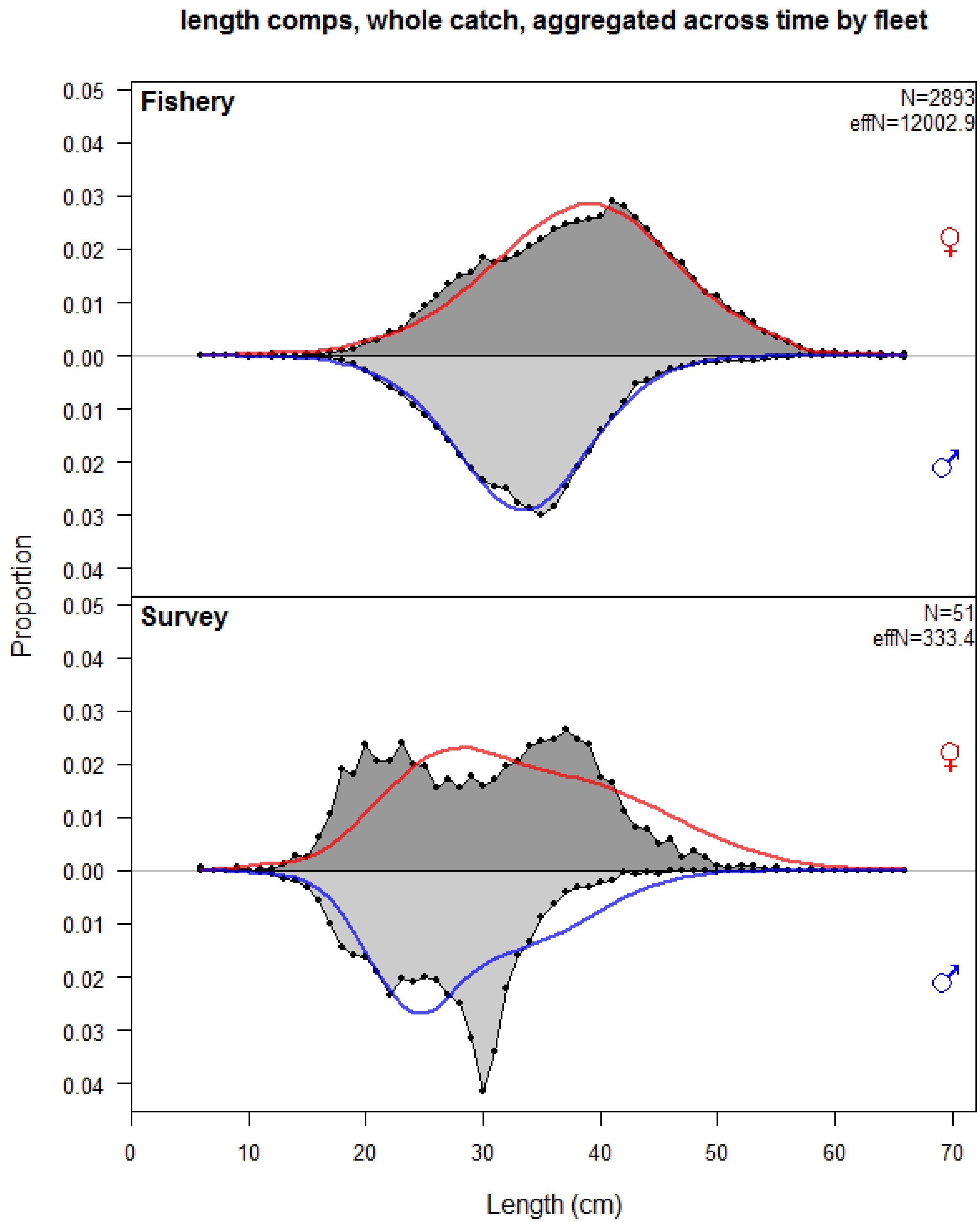
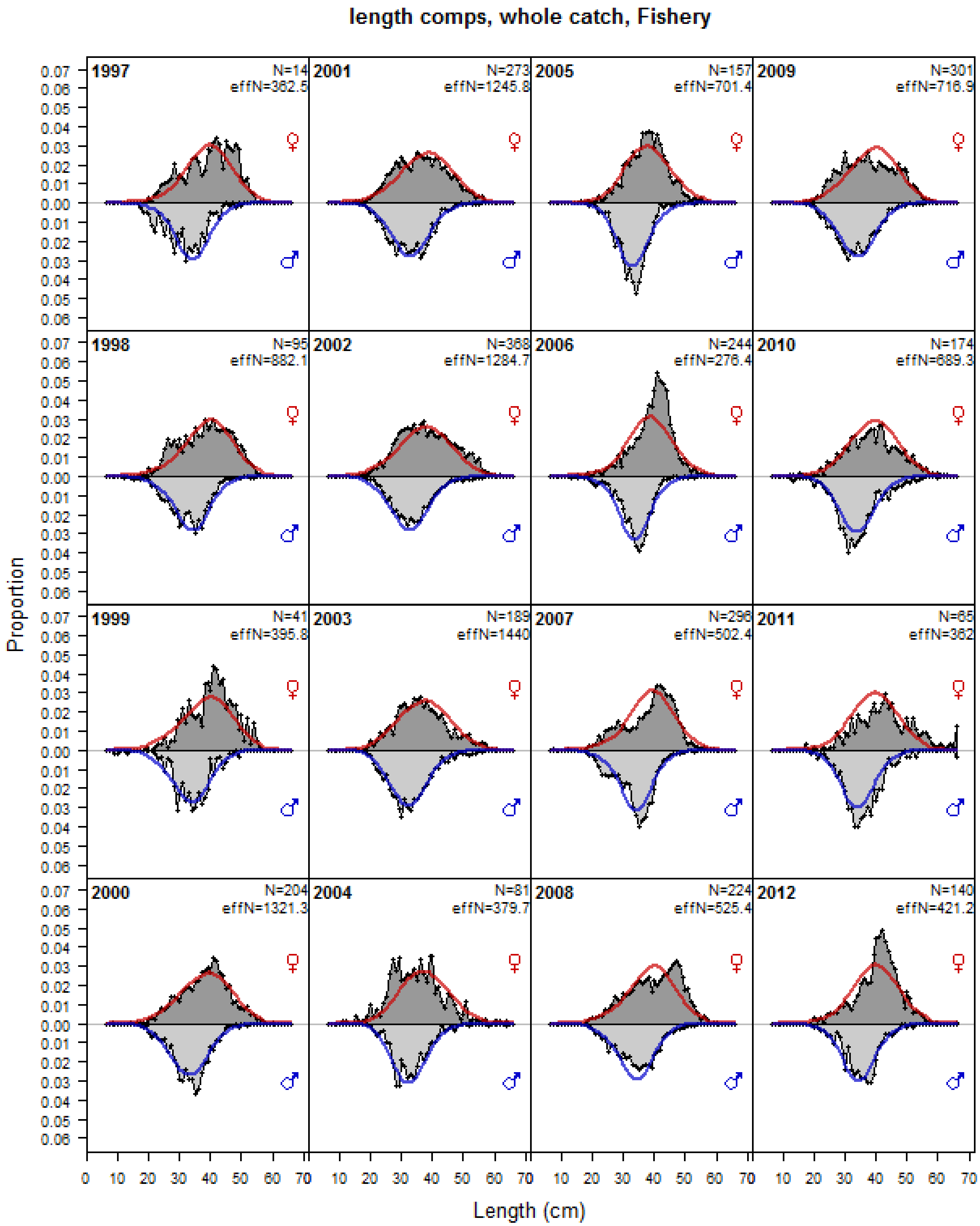


Figure 4.1.29 – Fits to fishery length composition data for NRS



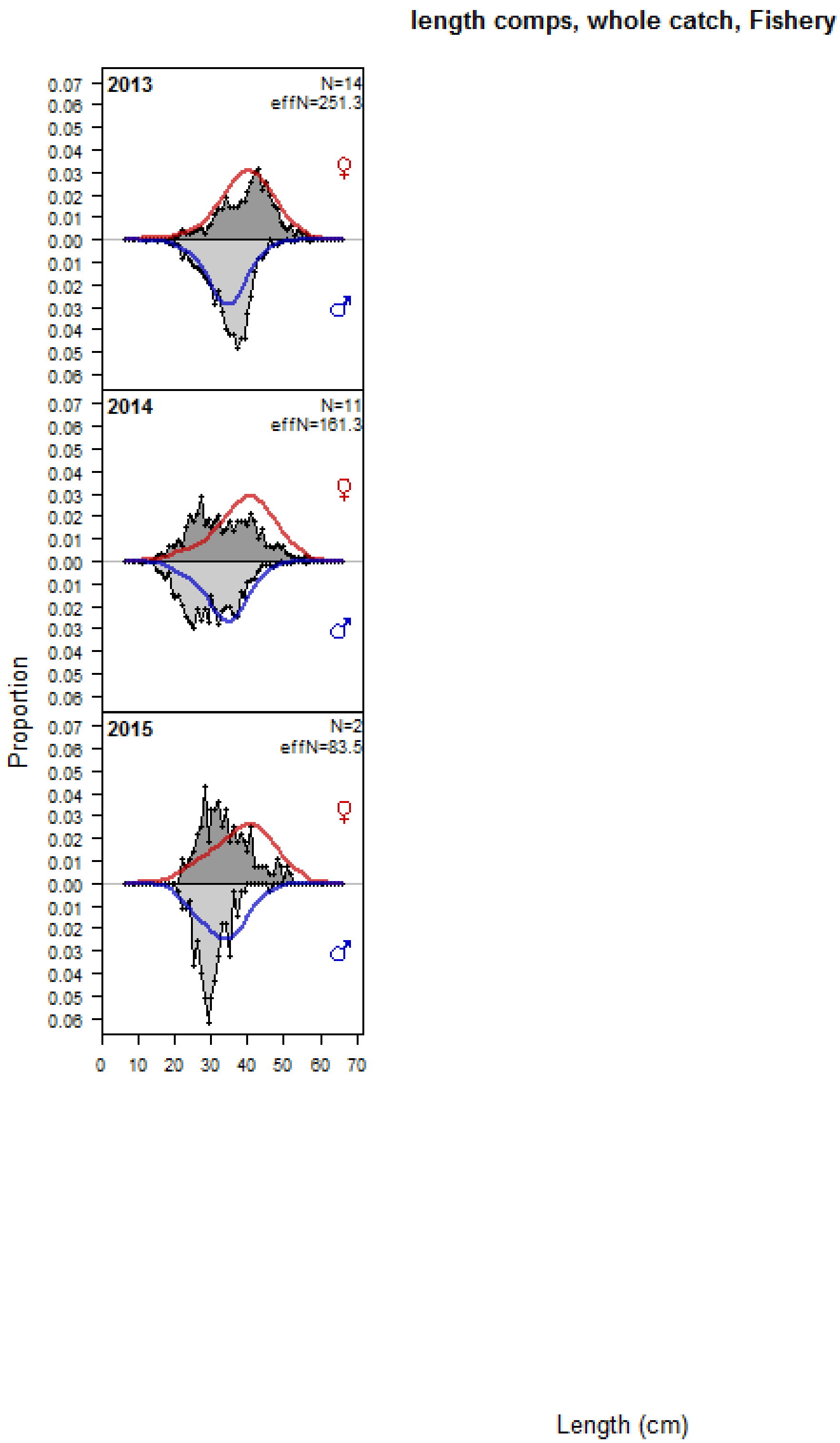

length comps, whole catch, Fishery
2013
N=14
effN=251.3
2014
N=11
effN=161.3
2015
N=2
effN=83.5
Proportion
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0 10 20 30 40 50 60 70
Length (cm)

Figure 4.1.30 – Estimates of survey population length composition data (not used in model fitting) for NRS

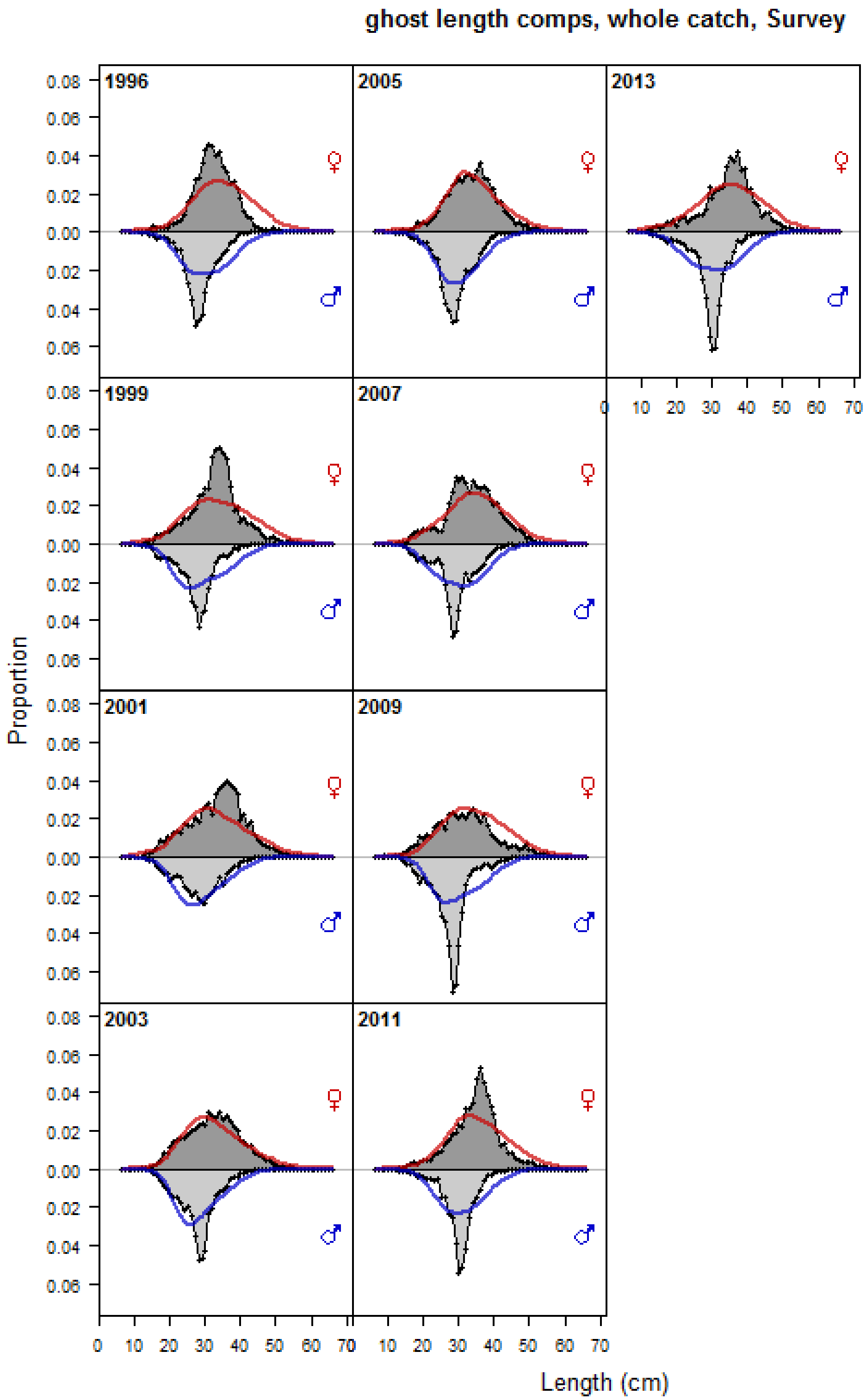


Figure 4.1.31 – Fits to survey population age composition data for NRS

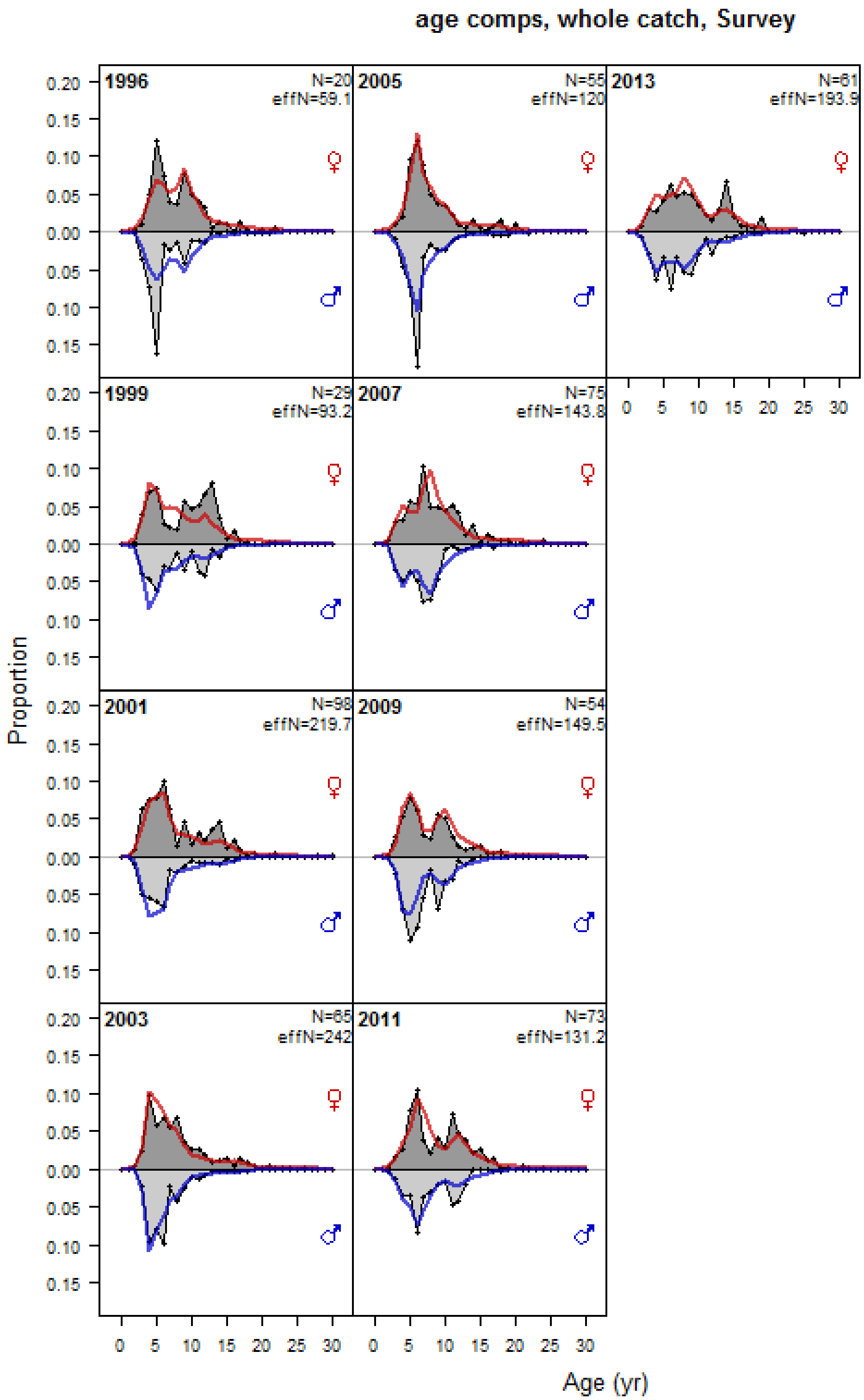
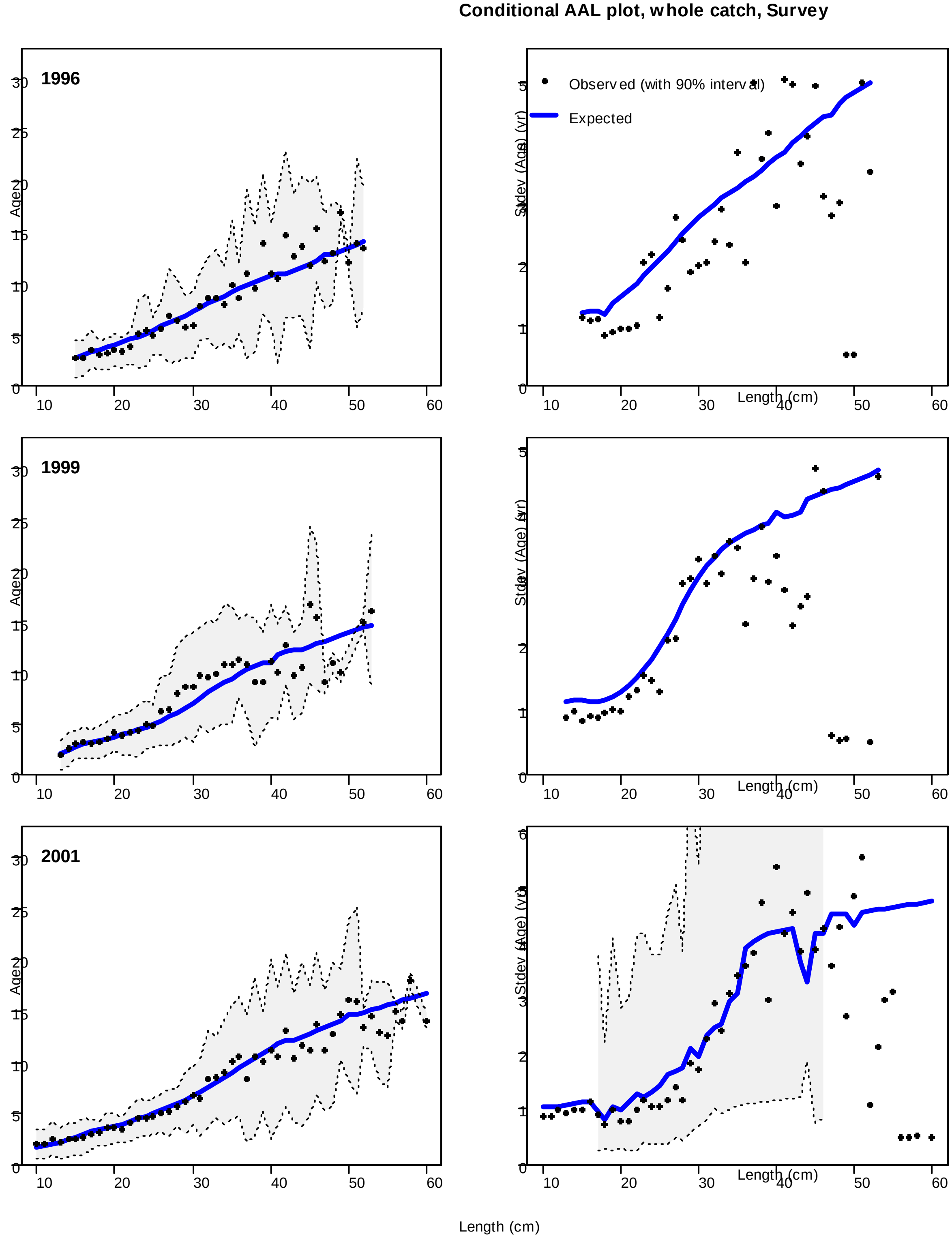
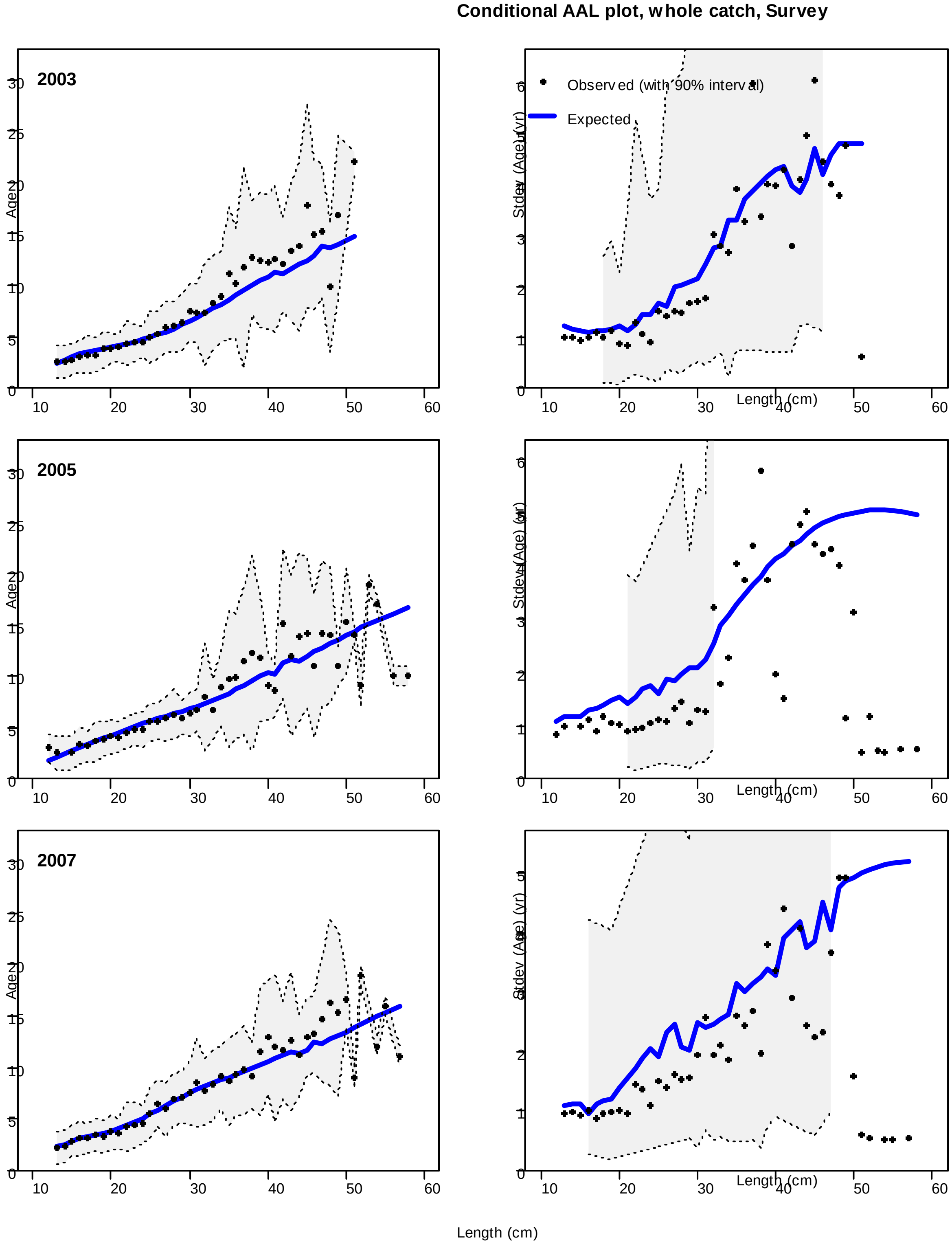


Figure 4.1.32 – Fits to survey conditional age-at-length data for NRS





Conditional AAL plot, whole catch, Survey
2003
2005
2007
Age (yr)
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

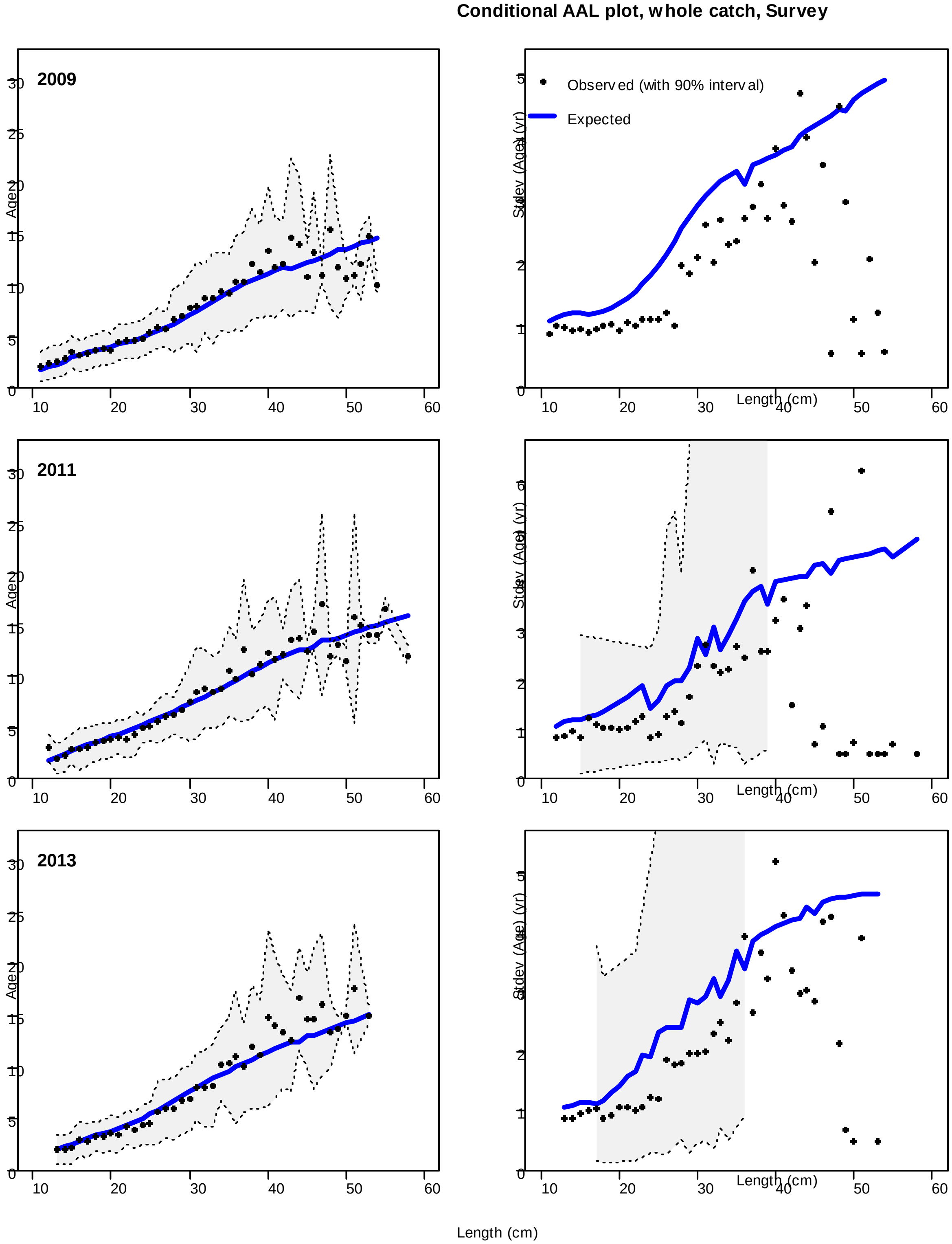

Conditional AAL plot, whole catch, Survey
2009
2011
2013
Age (yr)
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Figure 4.1.33 – Estimated size-at-age for NRS

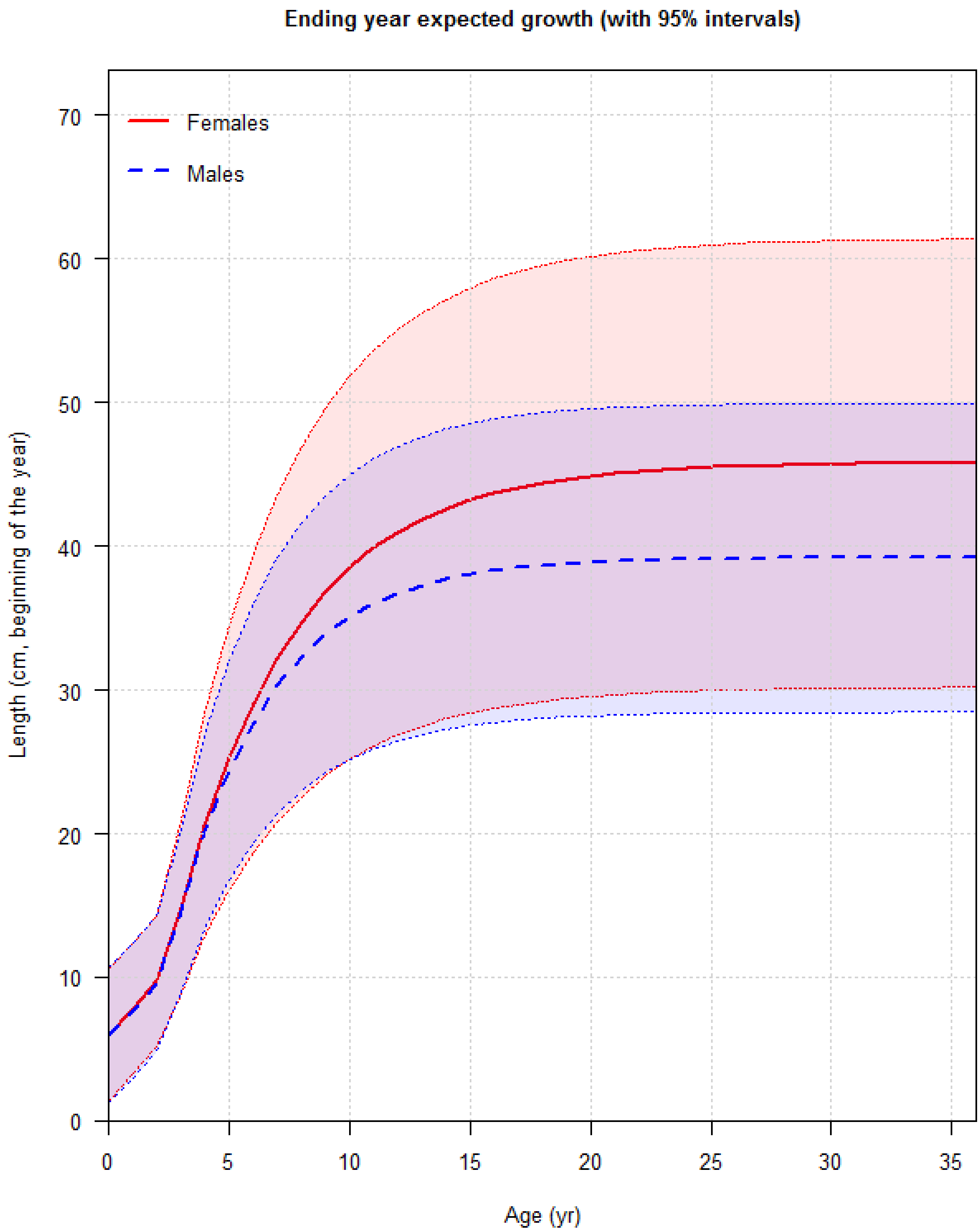


Figure 4.1.34 – Estimates of total biomass for SRS

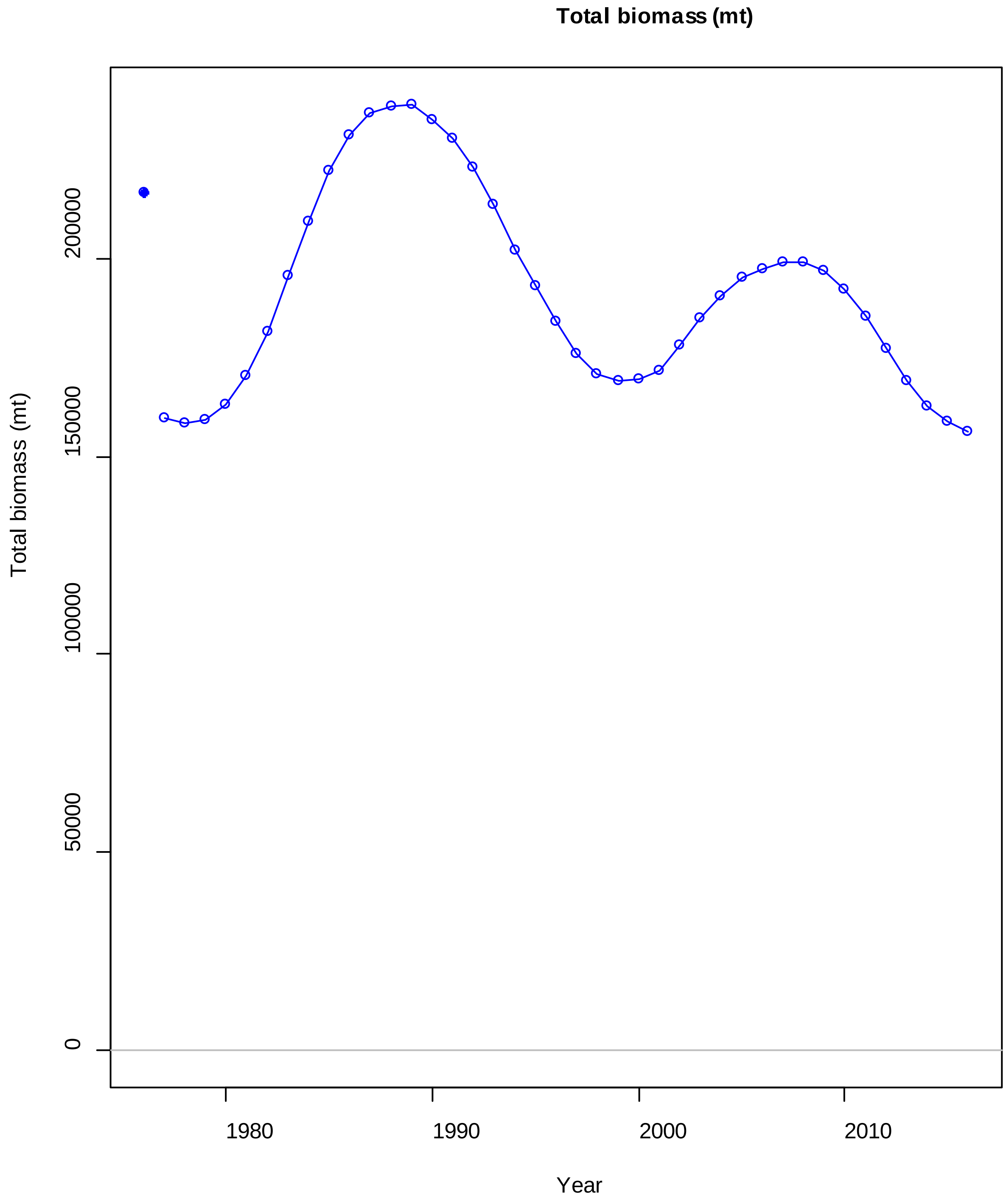


Figure 4.1.35 – Estimates of spawning biomass for SRS

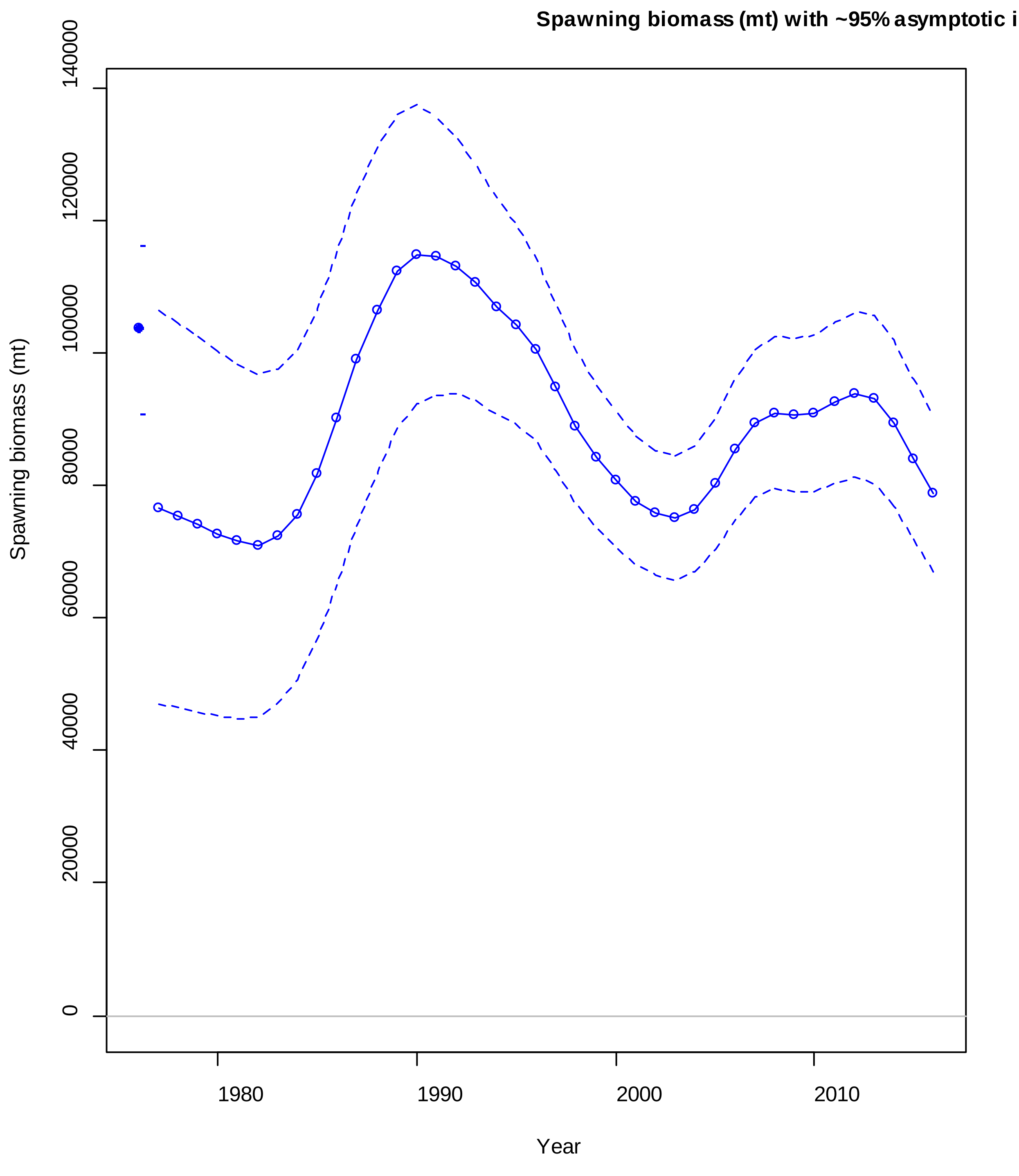


Figure 4.1.36 – Estimates of age-0 recruits for SRS

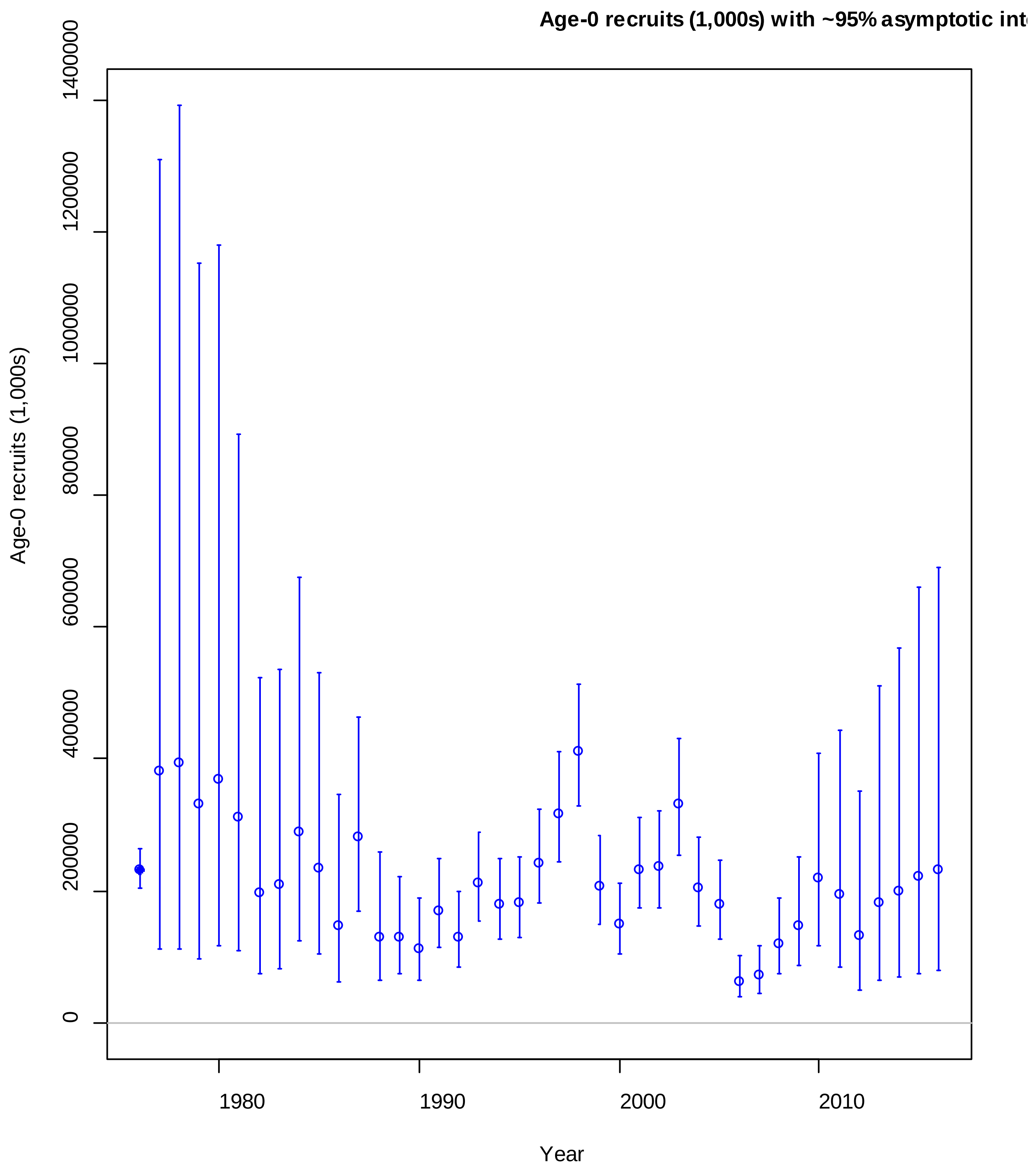


Figure 4.1.37 – Estimates of survey biomass for SRS

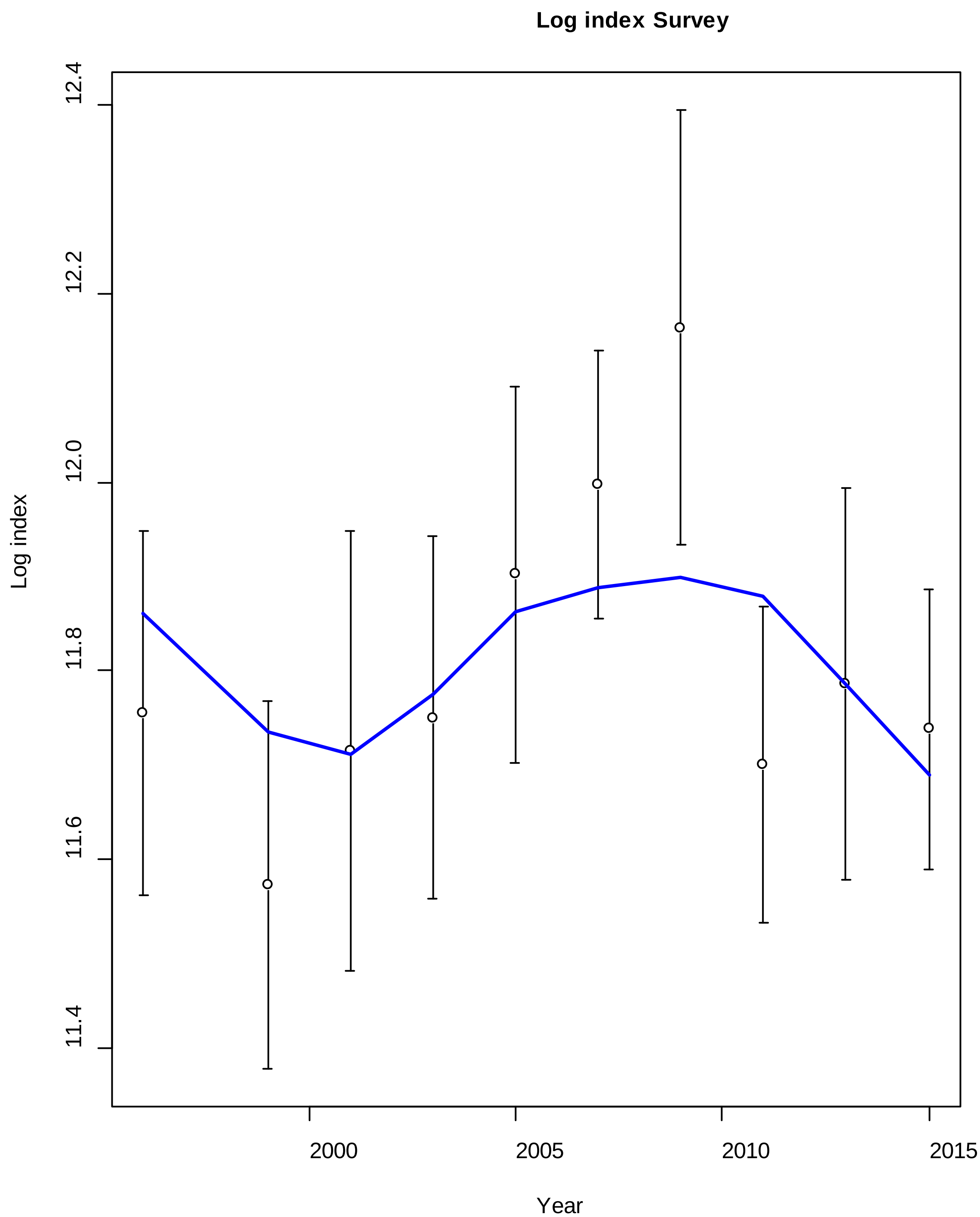


Figure 4.1.38 – Fishery and survey selectivity-at-length for SRS

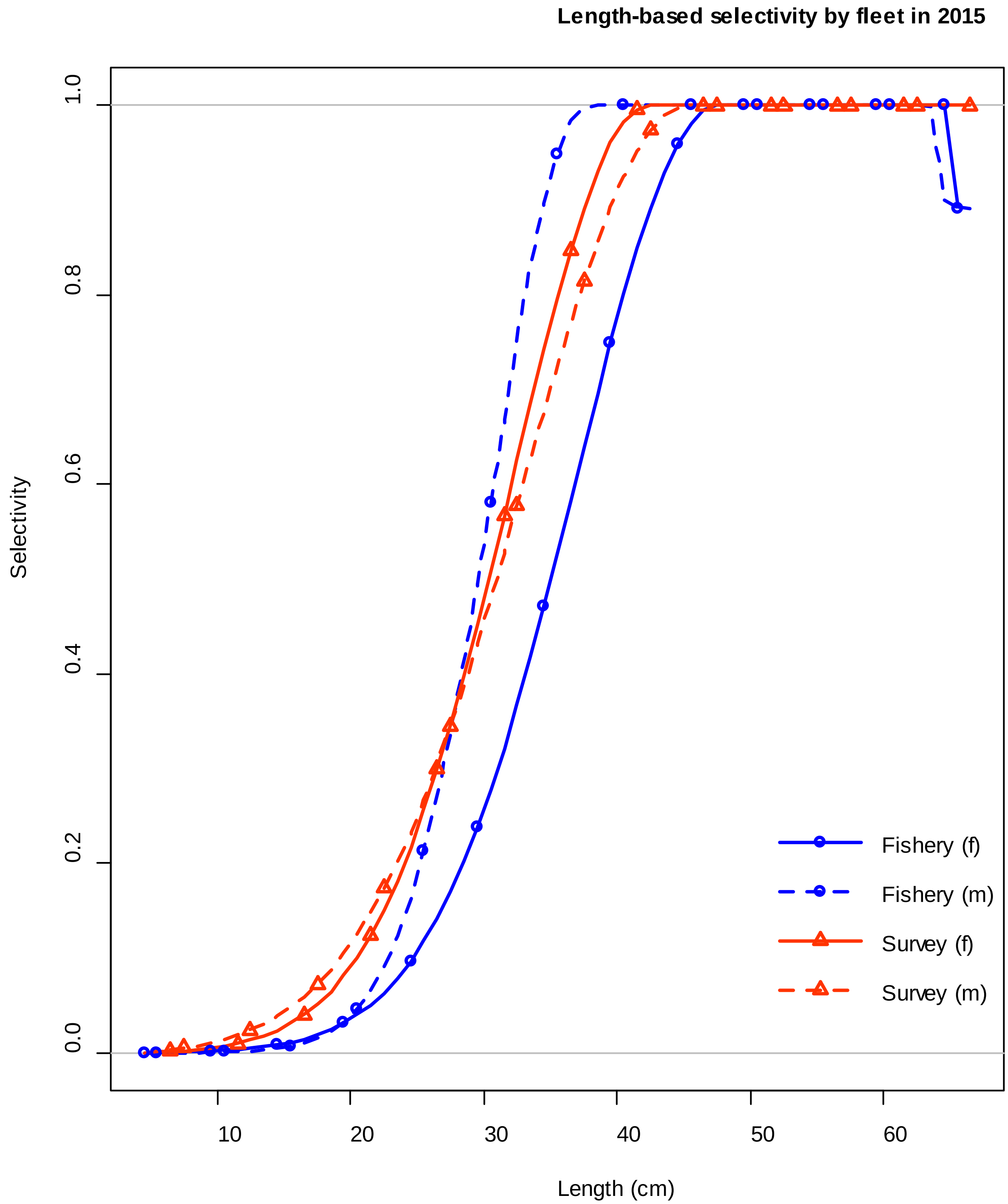


Figure 4.1.39 – Summary of fits to the fishery and survey length composition data for SRS. The information in the bottom panel is the fit to the 2015 survey length composition data.

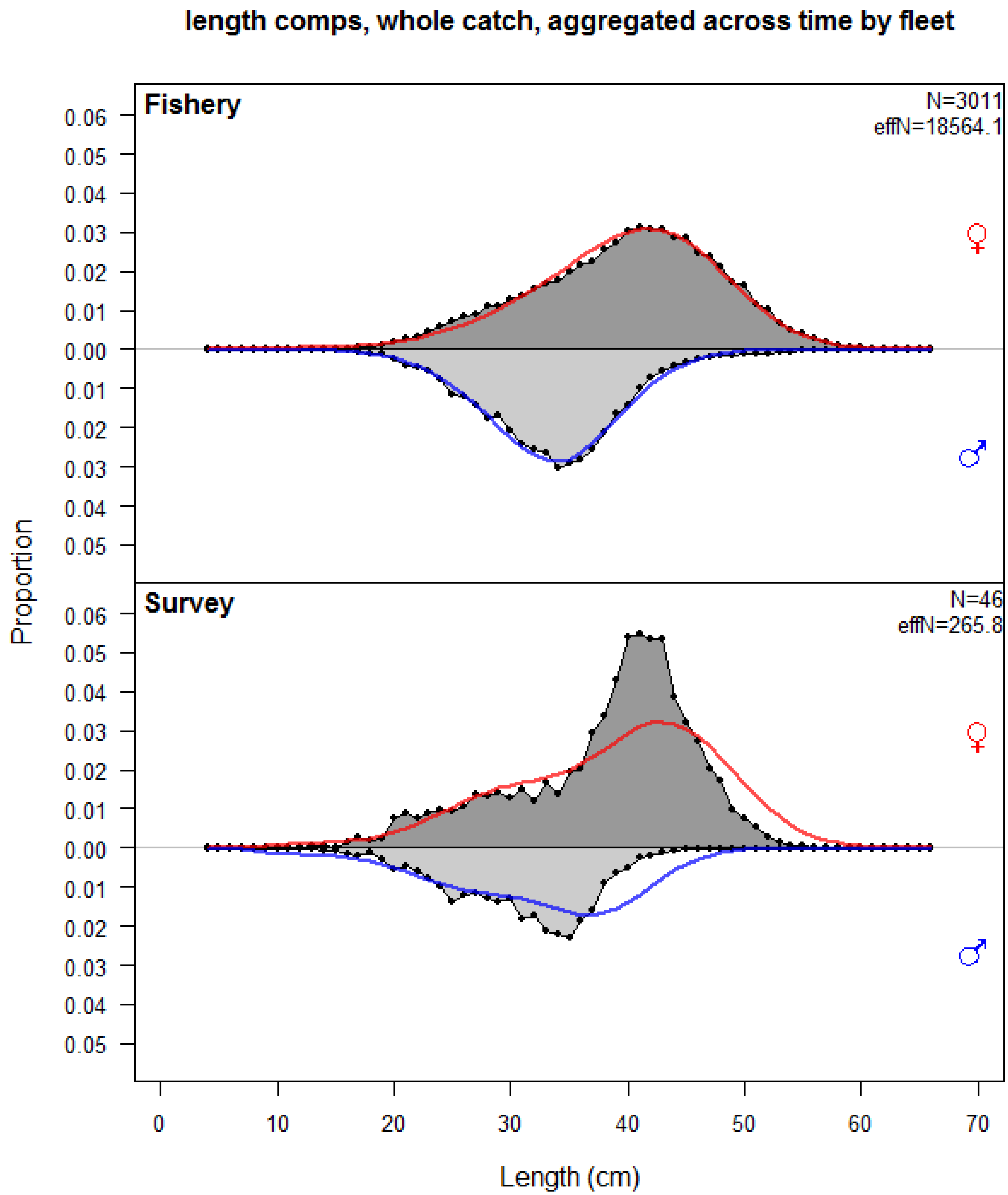
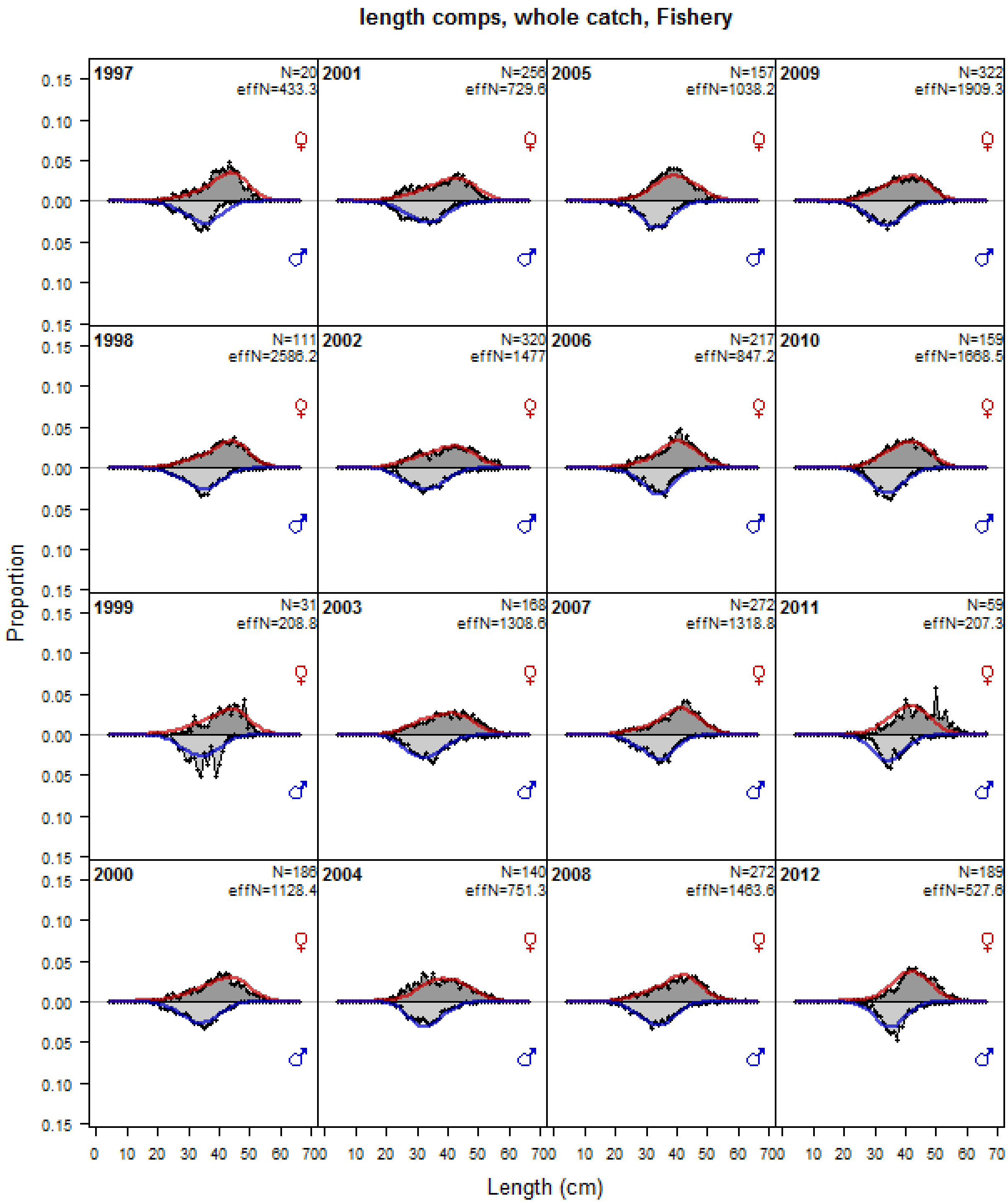


Figure 4.1.40 – Fits to fishery length composition data for SRS



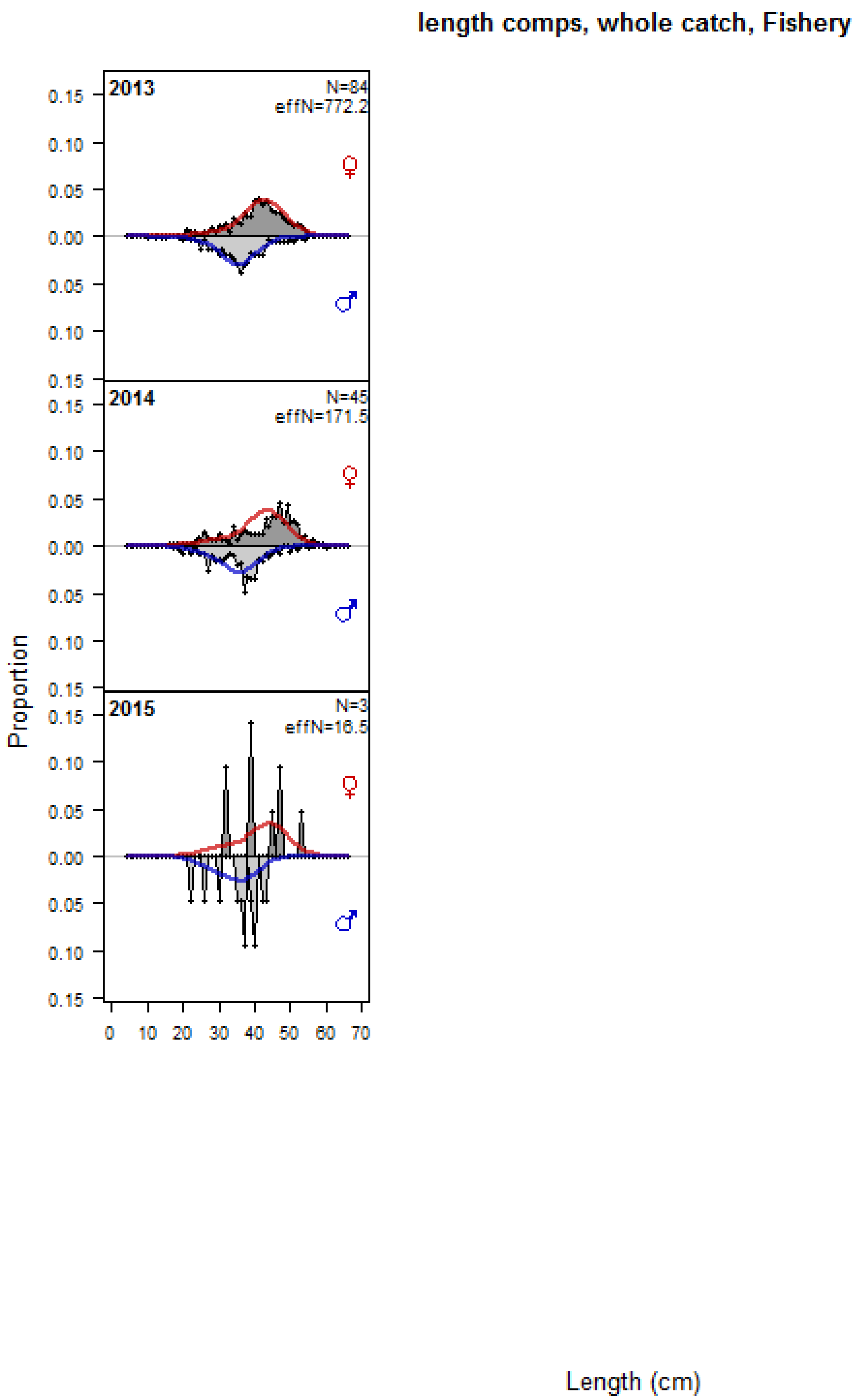

length comps, whole catch, Fishery
2013
N=84
effN=772.2
2014
N=45
effN=171.5
2015
N=3
effN=16.5
Proportion
0.15
0.10
0.05
0.00
0 10 20 30 40 50 60 70
Length (cm)

Figure 4.1.41 – Estimates of survey population length composition data (not used in model fitting) for SRS

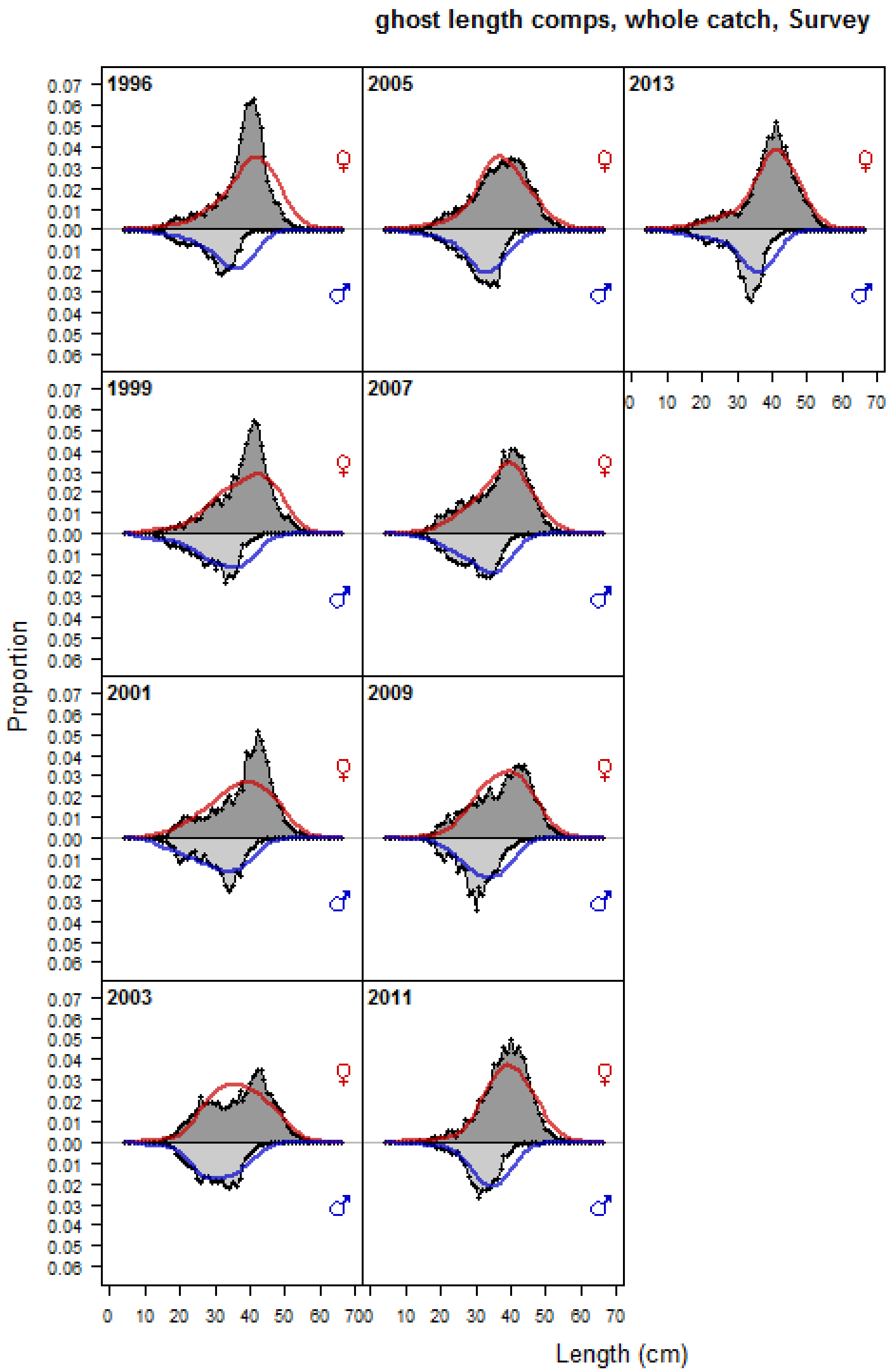


Figure 4.1.42 – Fits to survey population age composition data for SRS

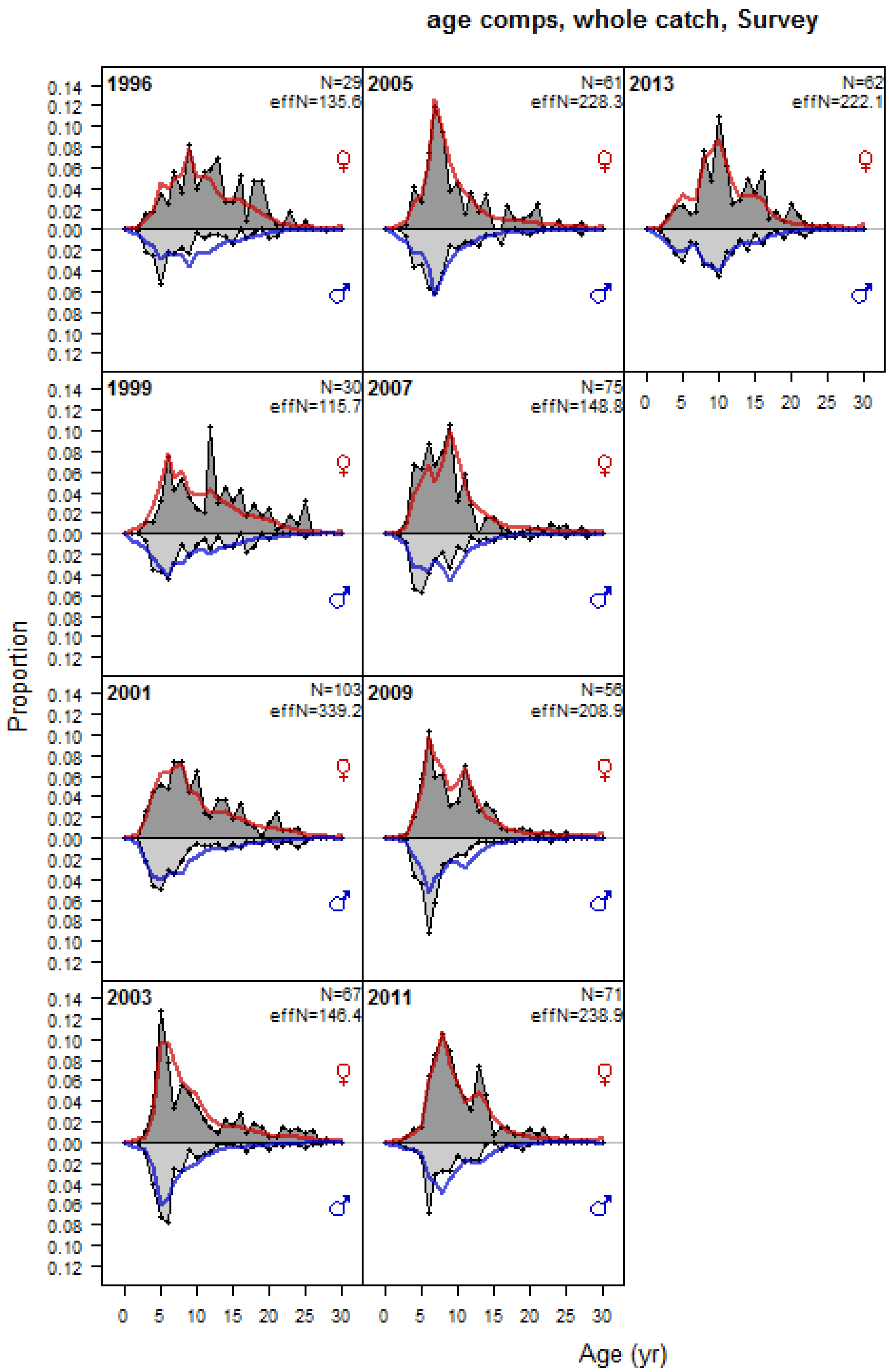
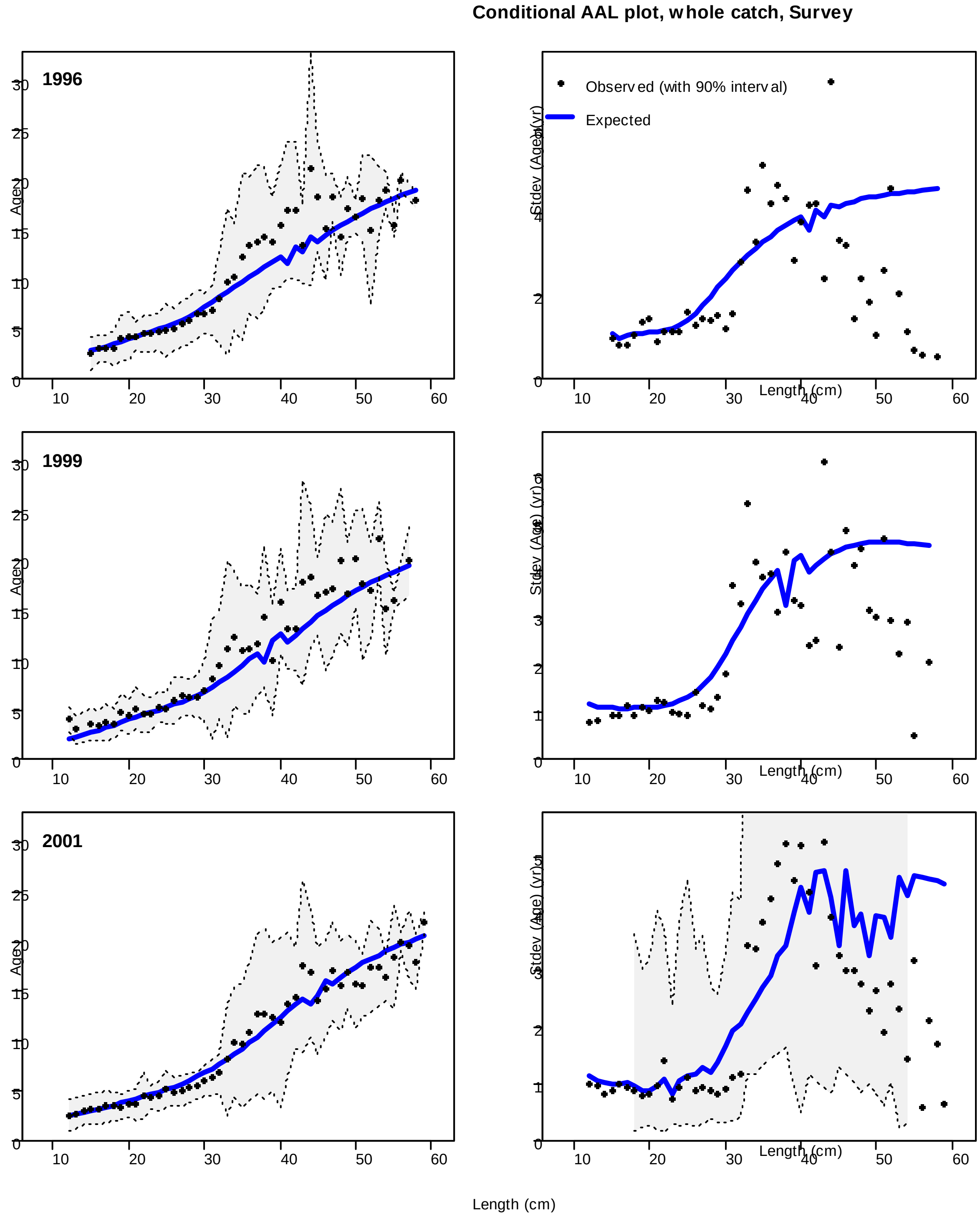
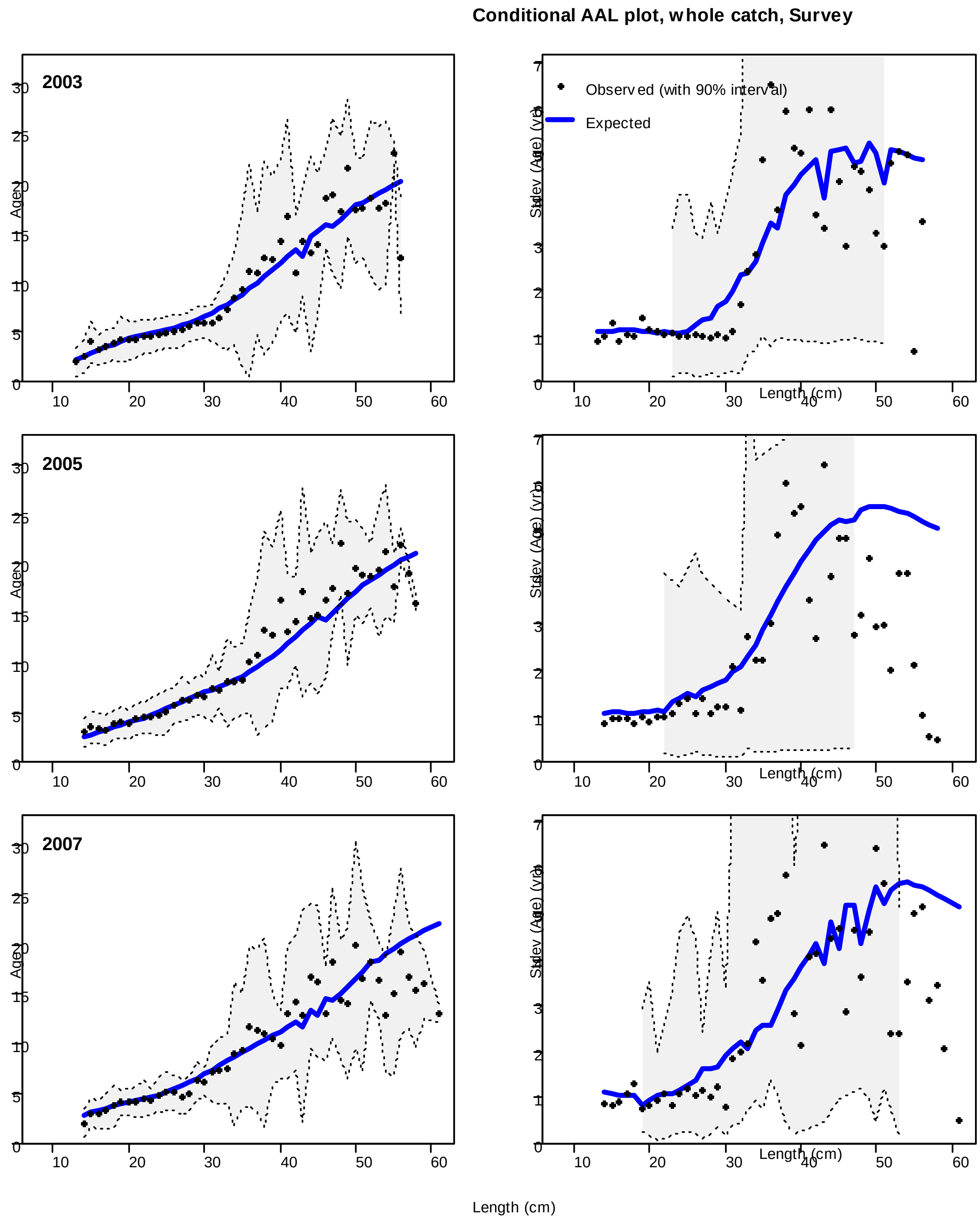


Figure 4.1.43 – Fits to survey conditional age-at-length data for SRS




Conditional AAL plot, whole catch, Survey
2003
2005
2007
Age (yr)
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
10
20
30
40
50
60

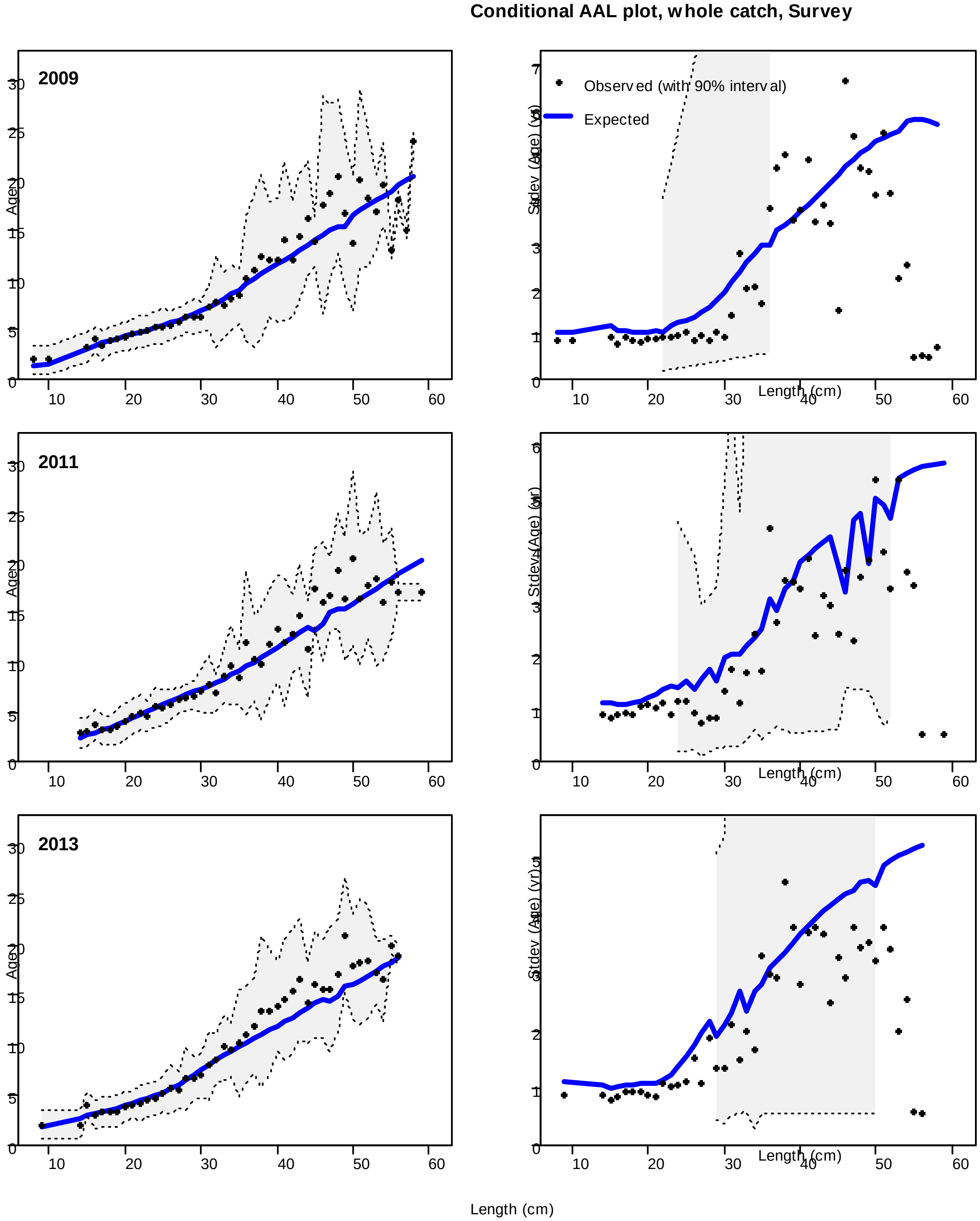

Conditional AAL plot, whole catch, Survey
2009
2011
2013
Age (yr)
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Figure 4.1.44 – Estimated size-at-age for SRS

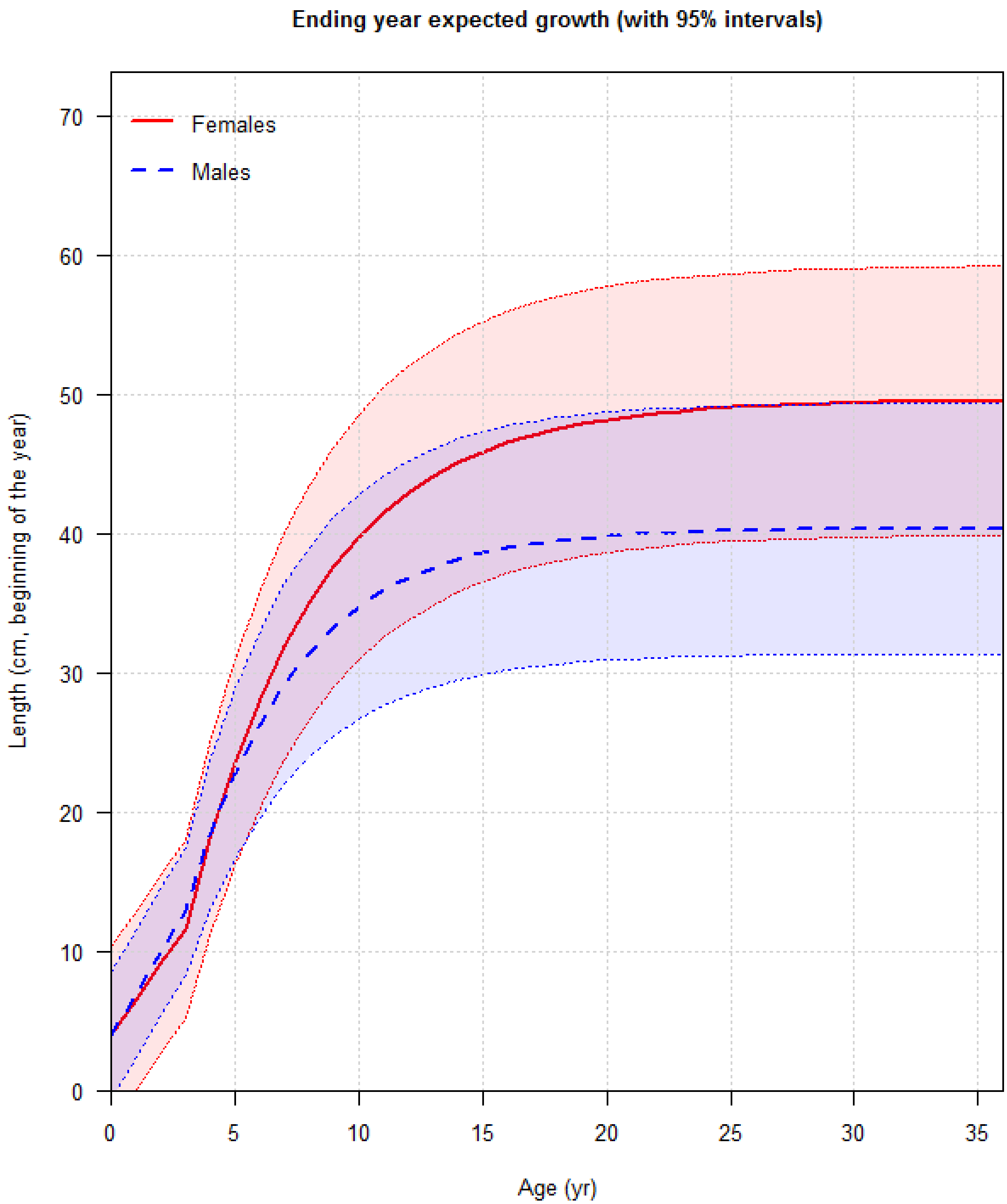


Figure 4.1.45 – Estimates of spawning biomass for NRS from retrospective model runs

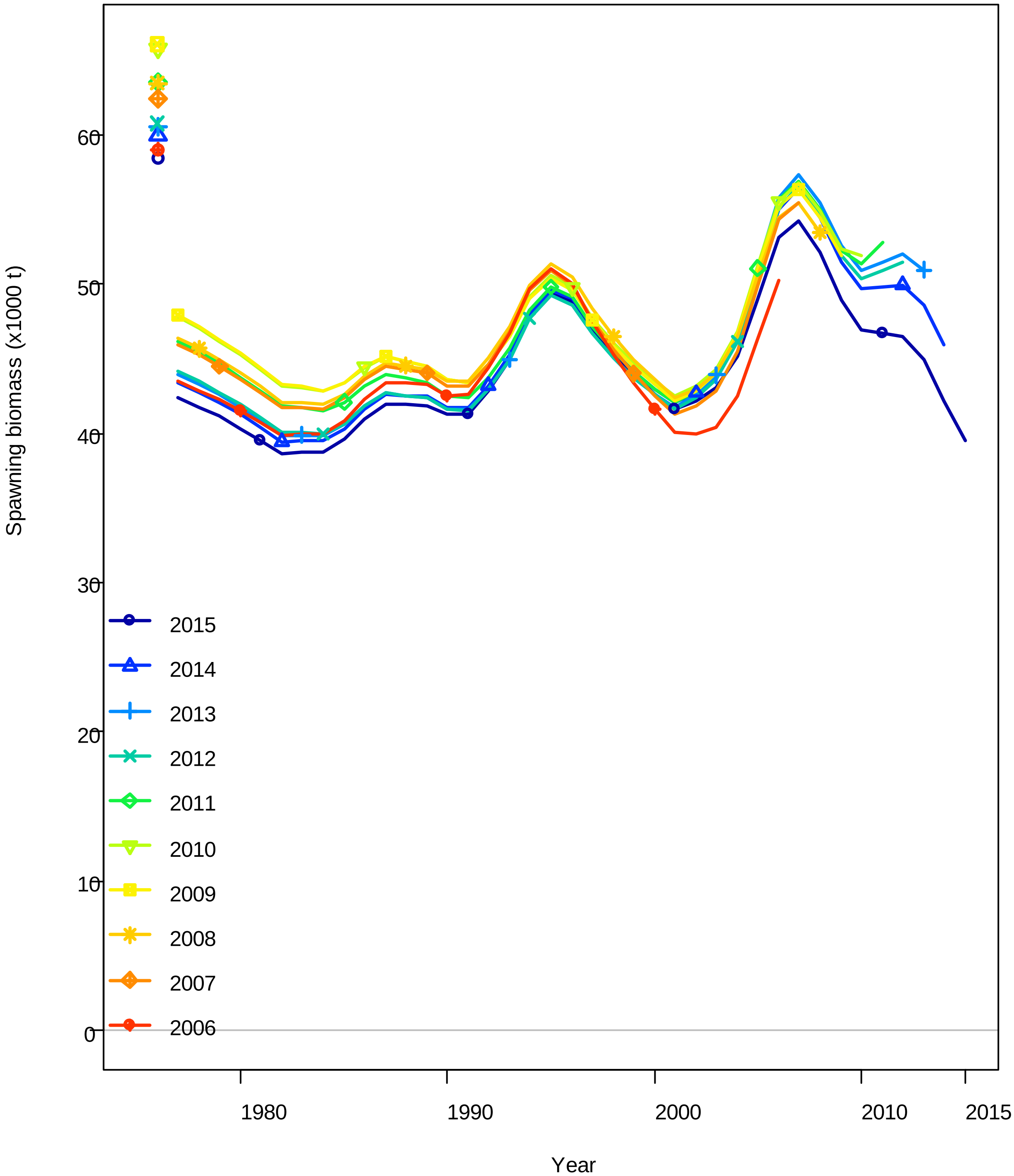


Figure 4.1.46 – Estimates of survey biomass for NRS from retrospective model runs

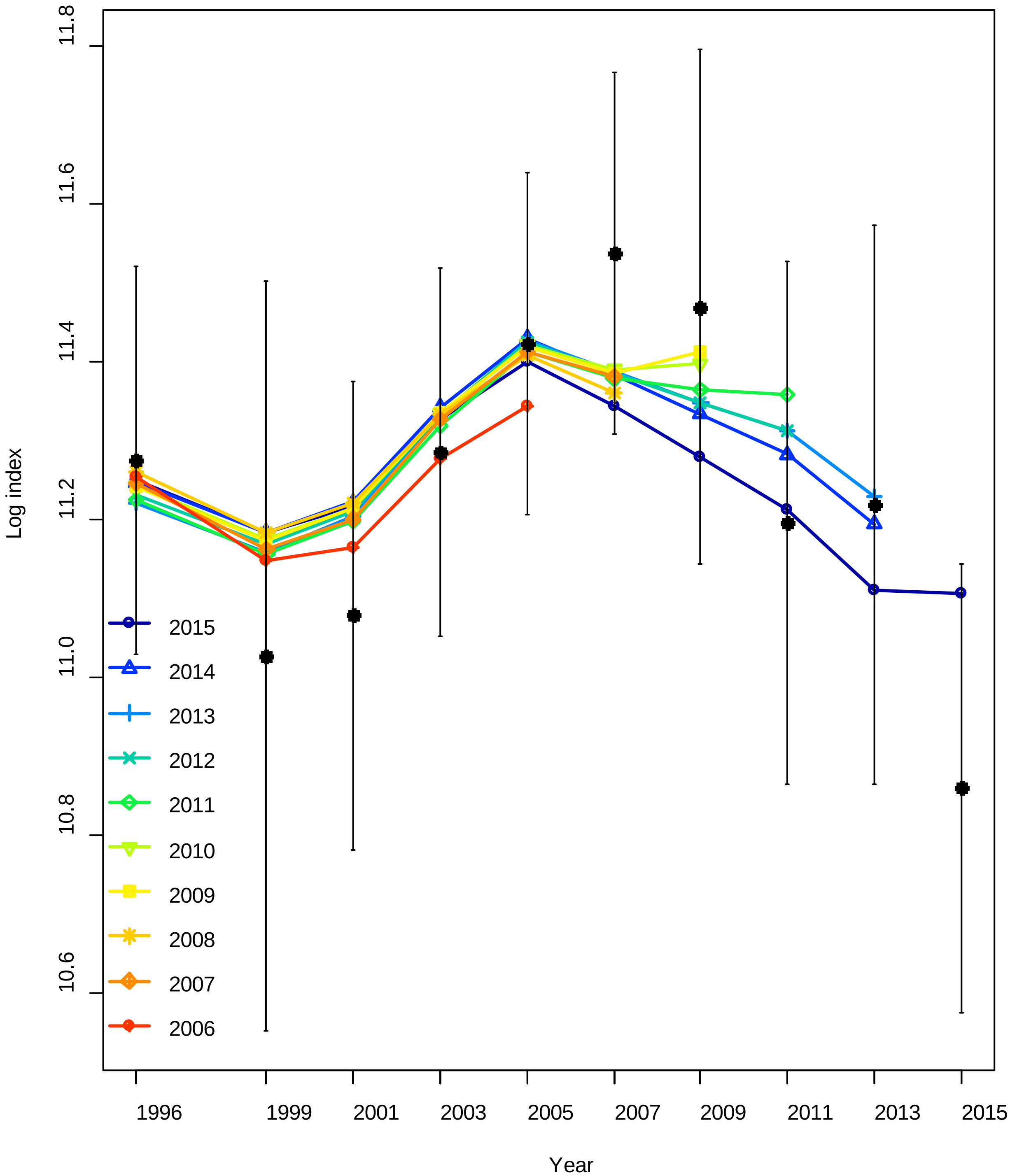


Figure 4.1.47 – Estimates of spawning biomass for SRS from the retrospective model runs

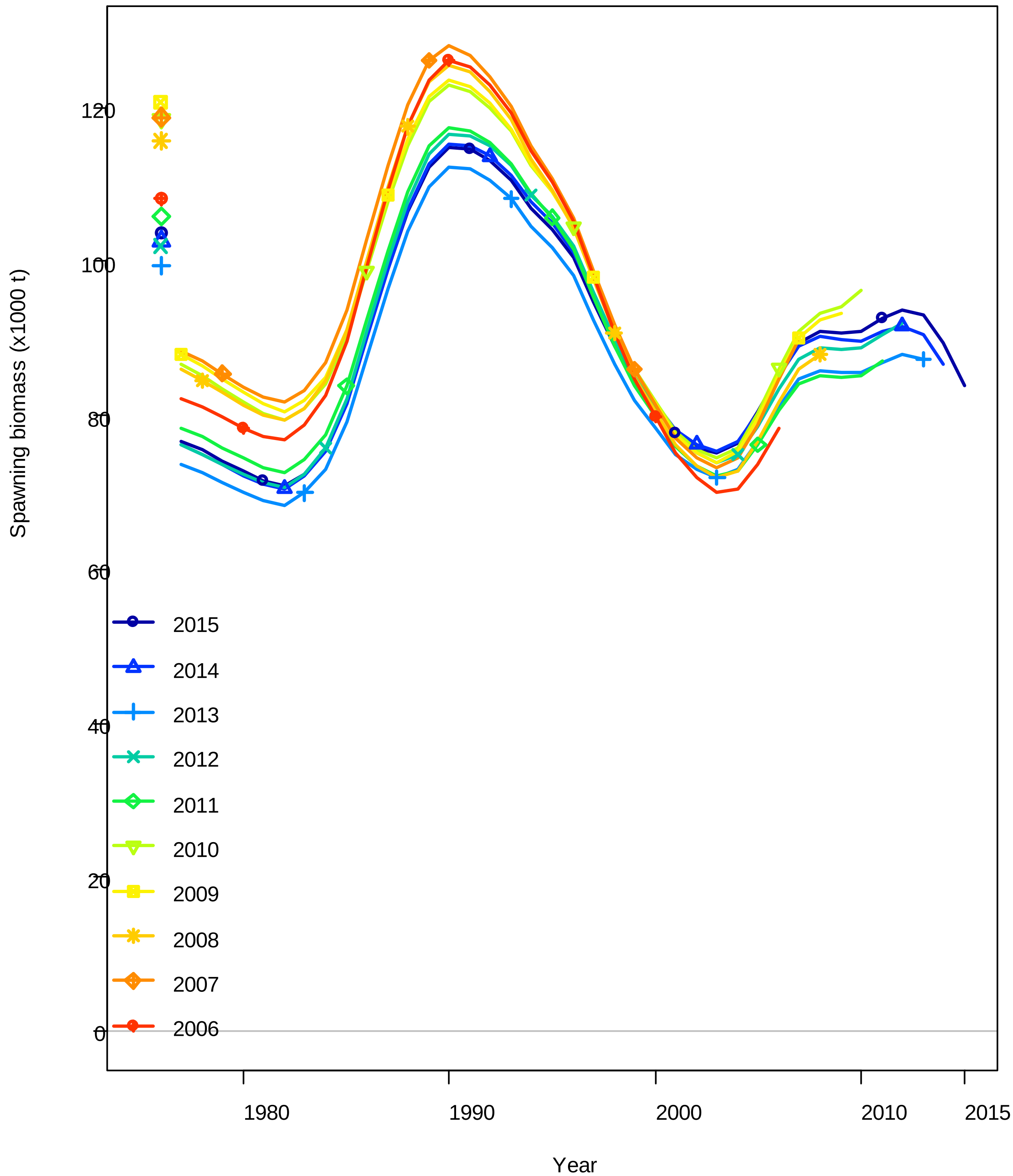


Figure 4.1.48 – Estimates of survey biomass for SRS from the retrospective model runs

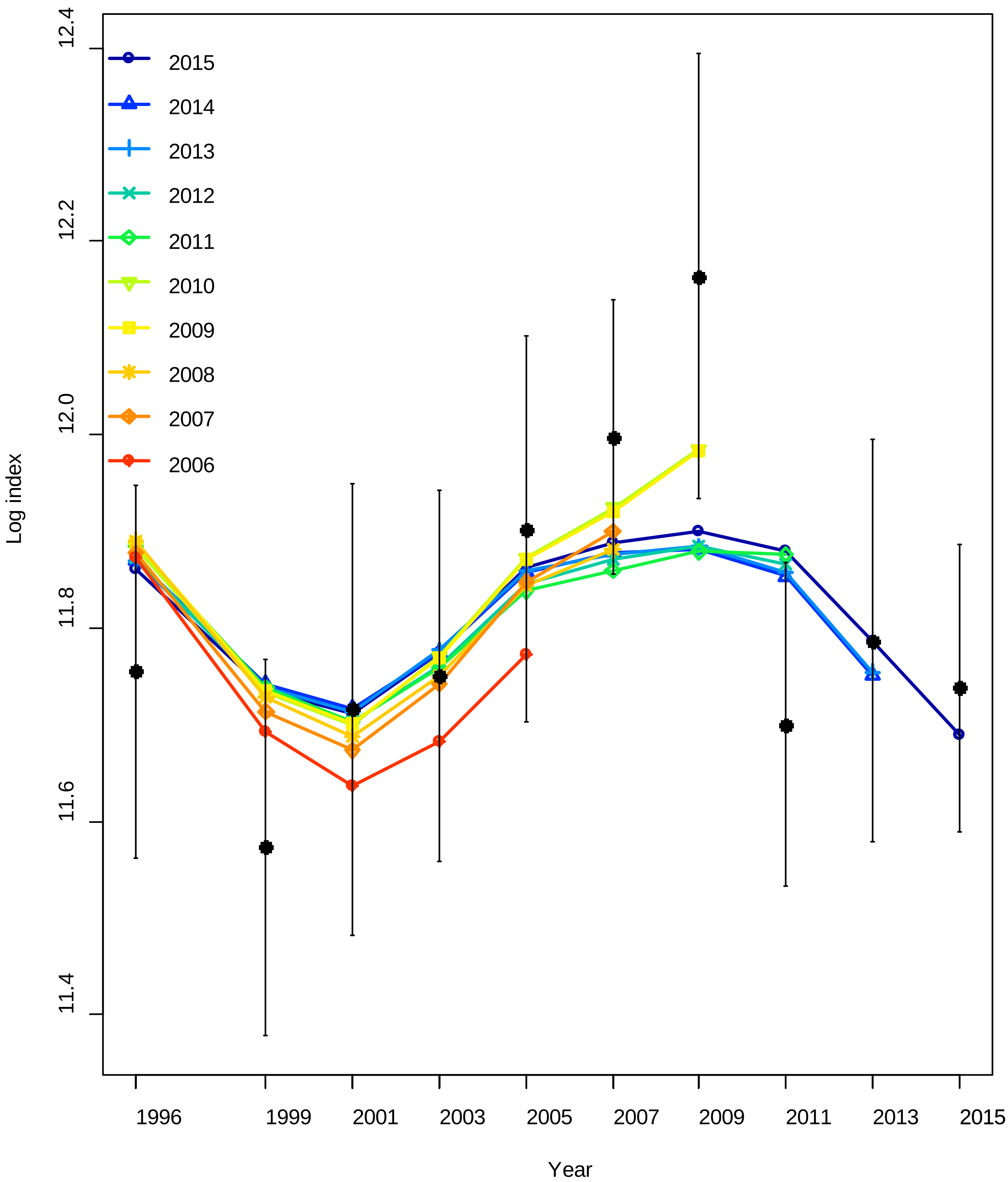


Figure 4.1.49 – Estimates of total biomass for URS

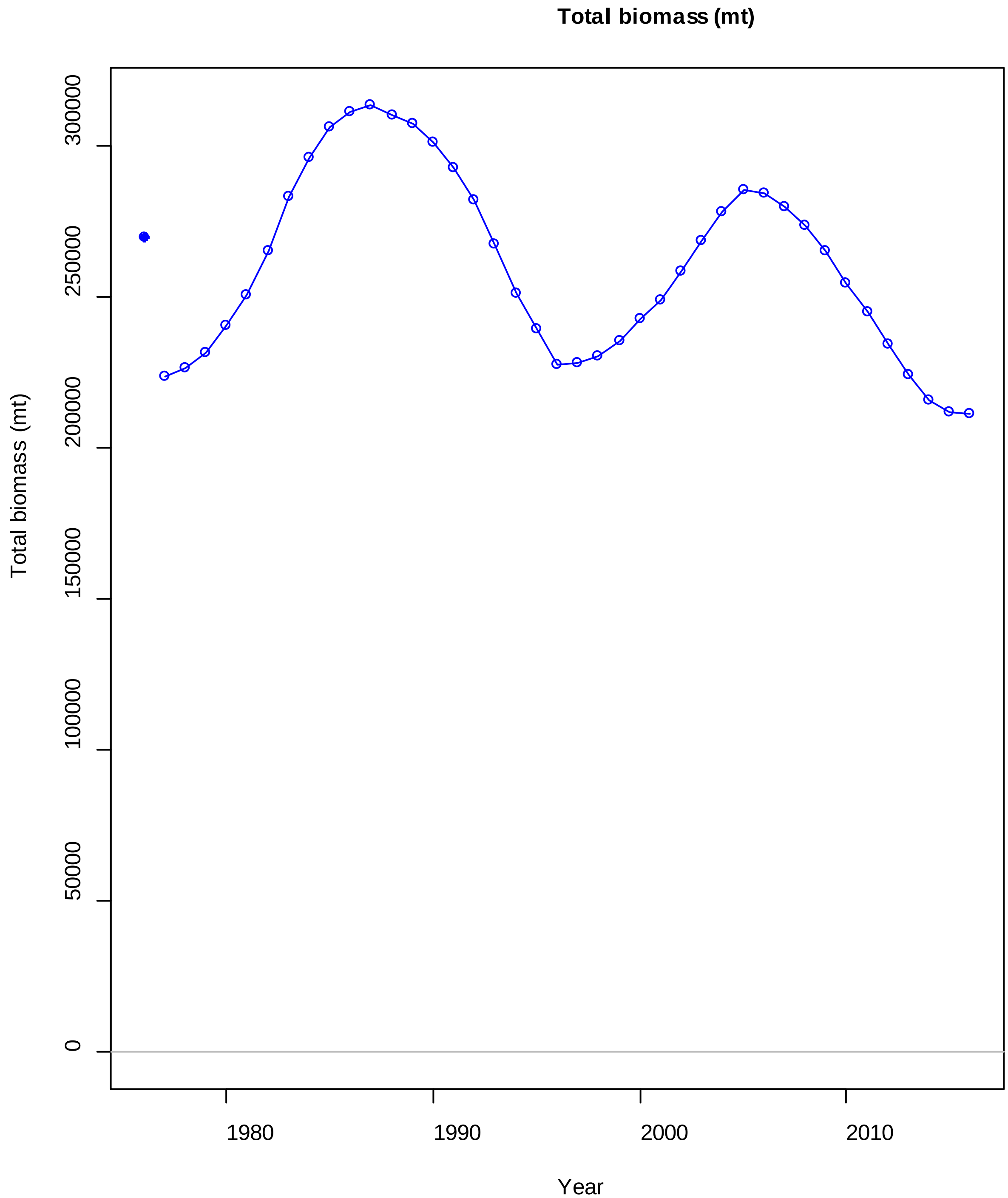


Figure 4.1.50 – Estimates of spawning biomass for URS

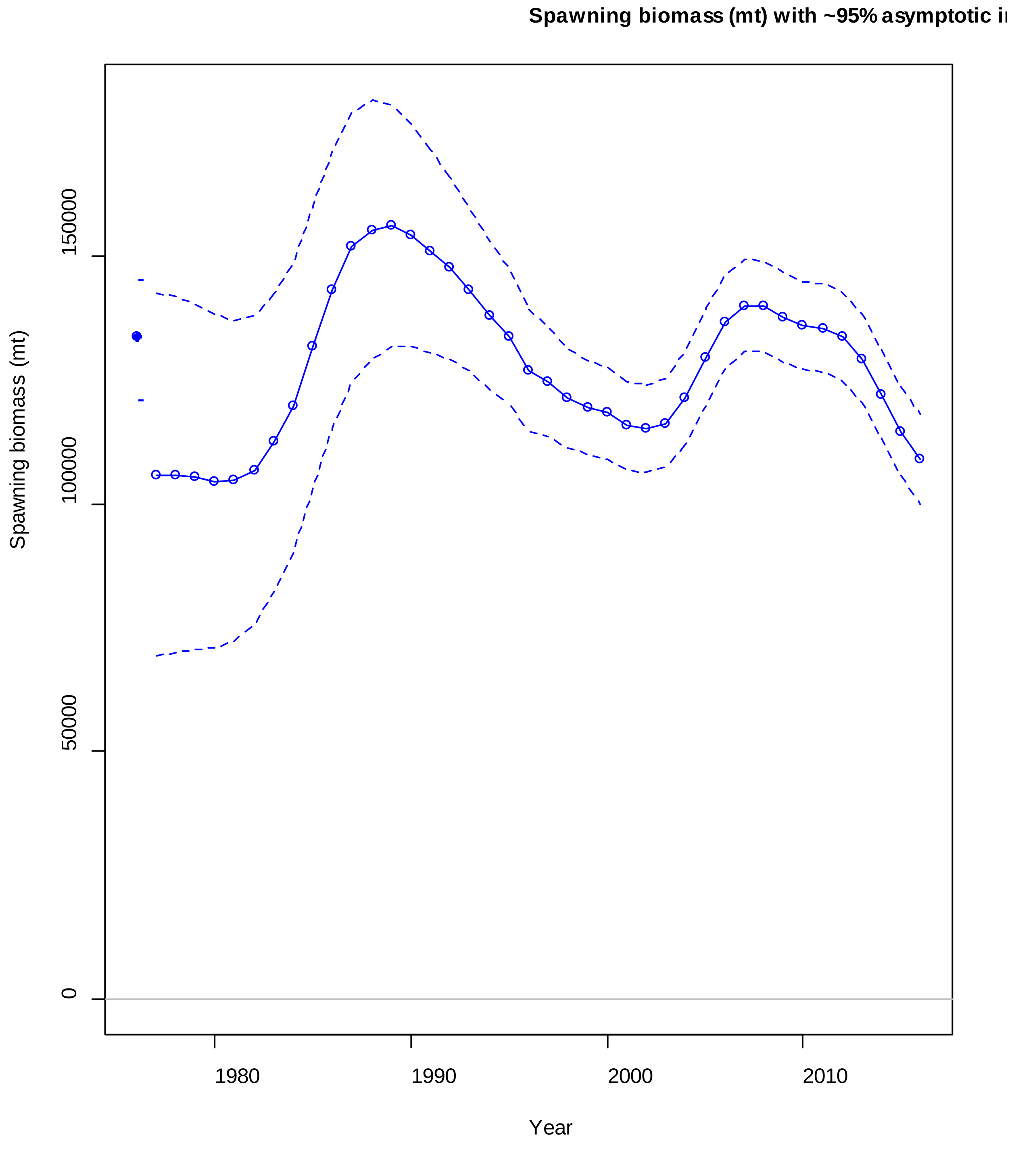


Figure 4.1.51 – Estimates of age-0 recruits for URS

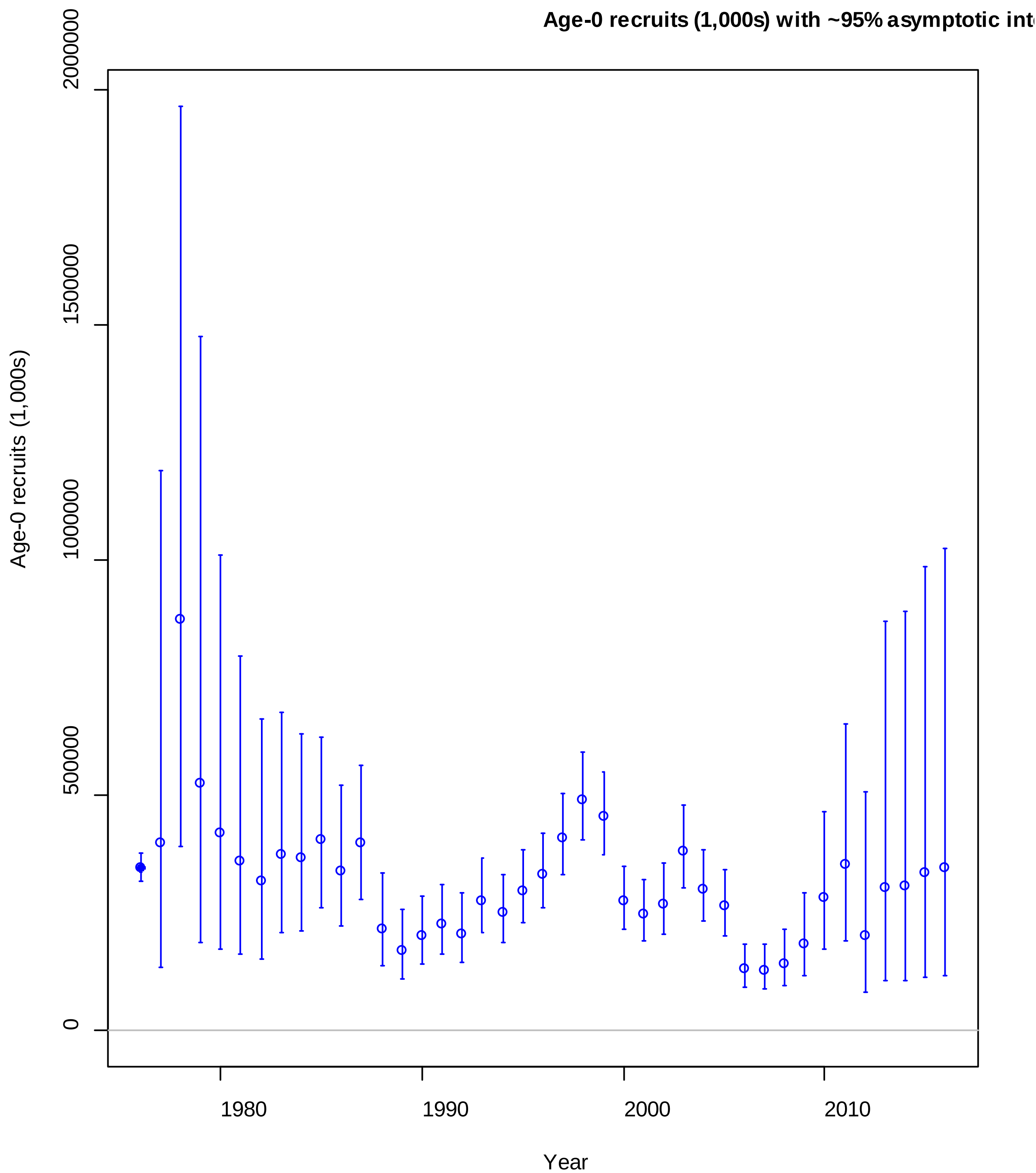


Figure 4.1.52 – Estimates of survey biomass for URS

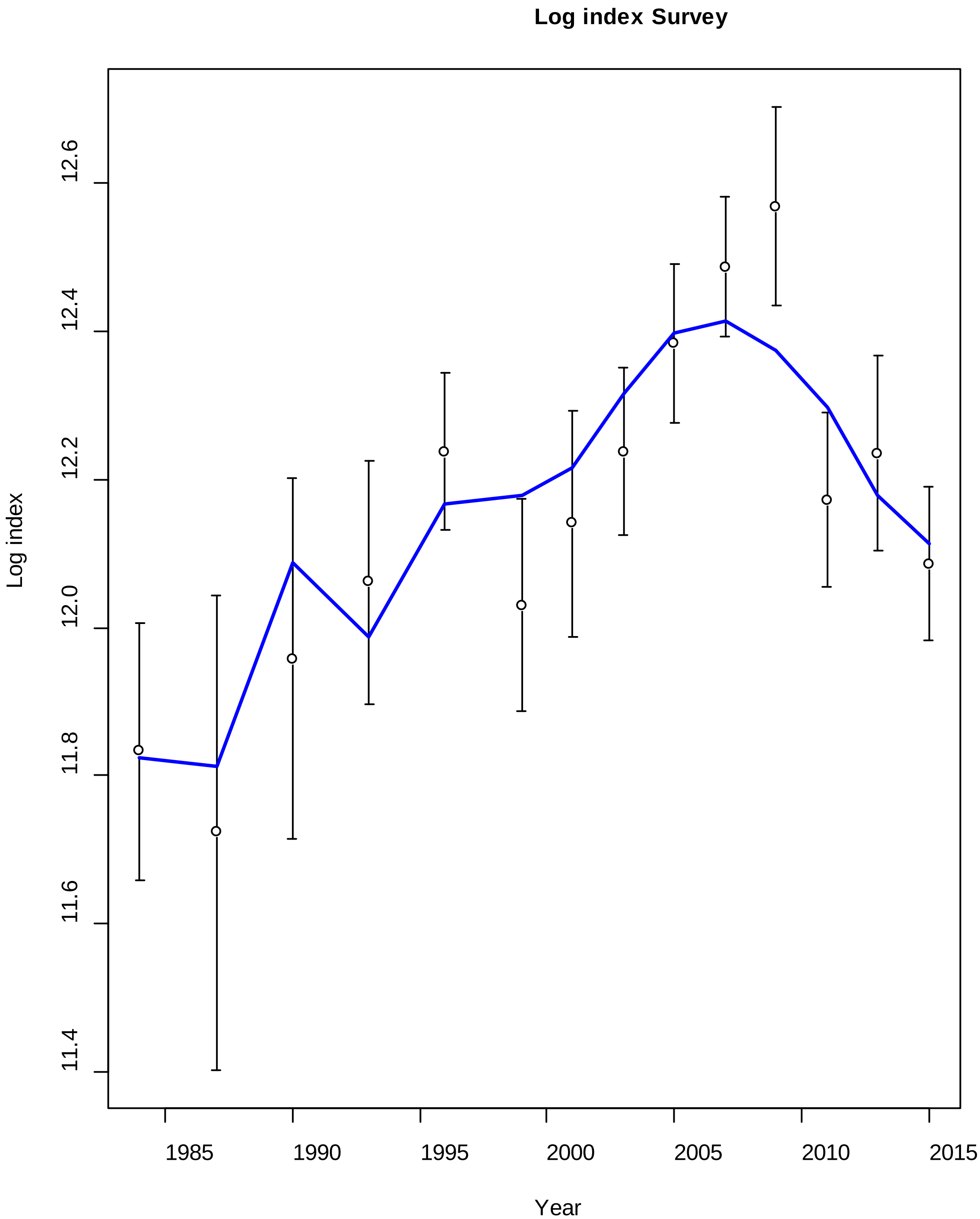


Figure 4.1.53 – Female fishery selectivity-at-length for URS

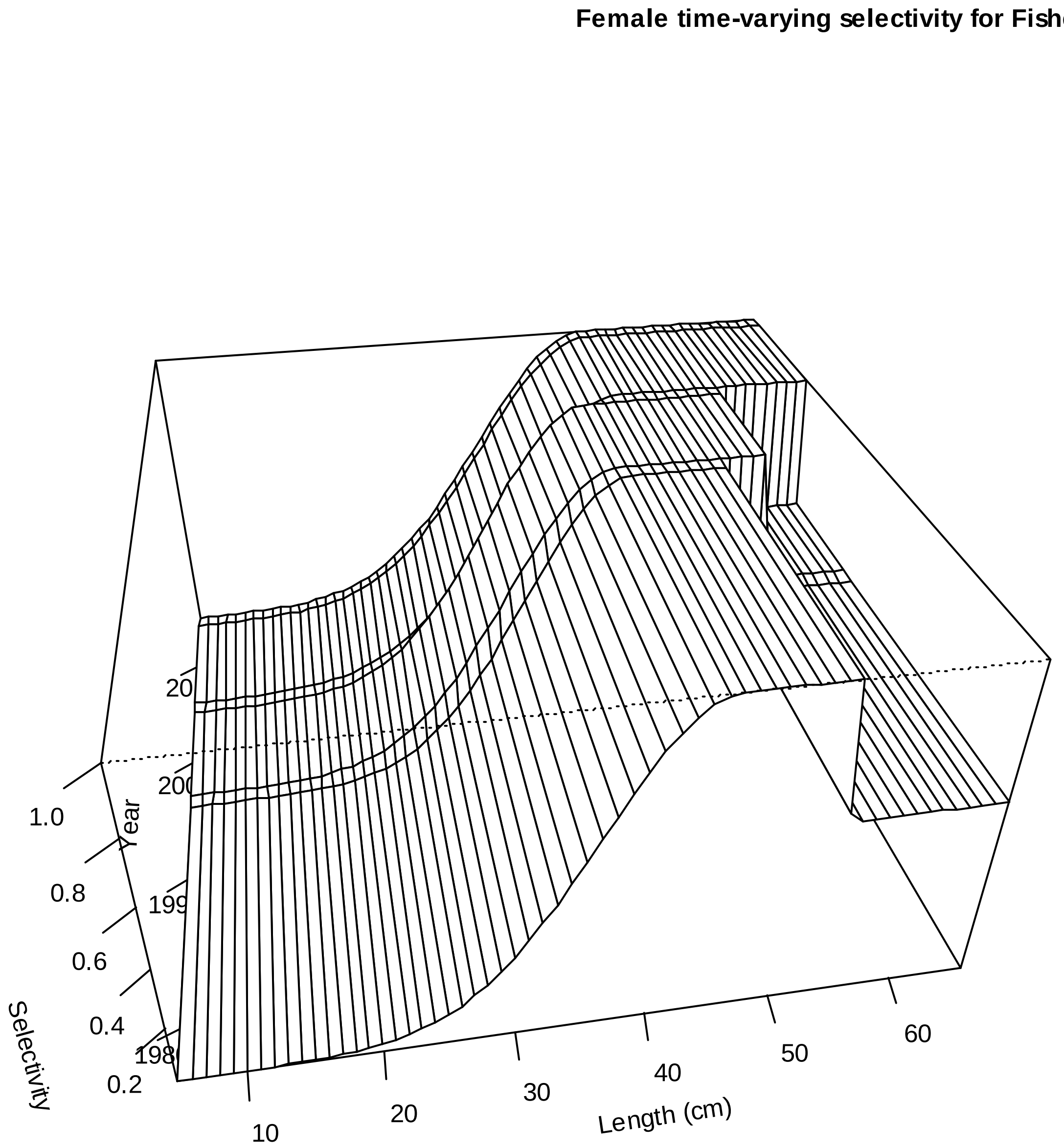


Figure 4.1.54 – Male fishery selectivity-at-length for URS

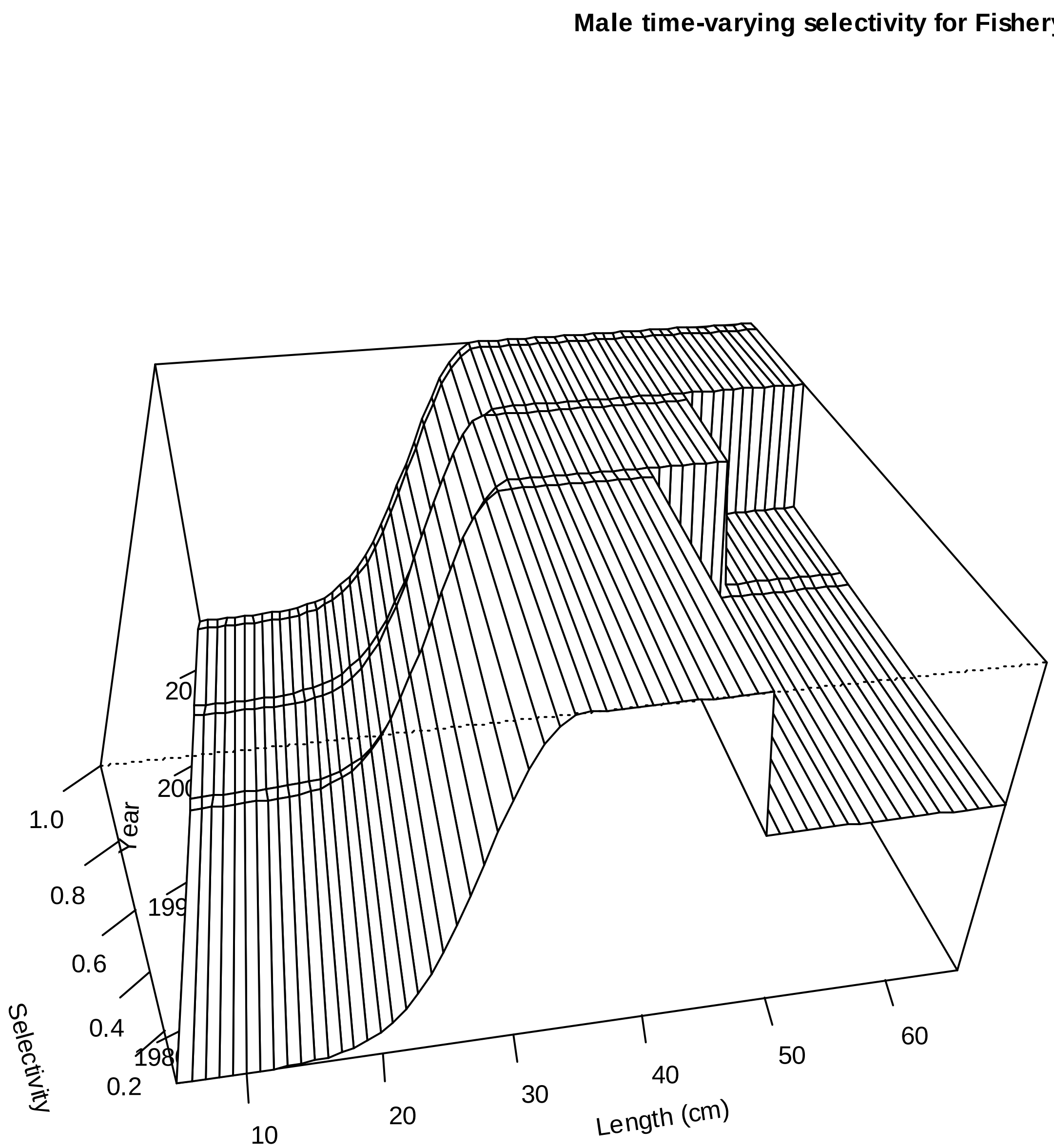


Figure 4.1.55 – Female survey selectivity-at-length for URS

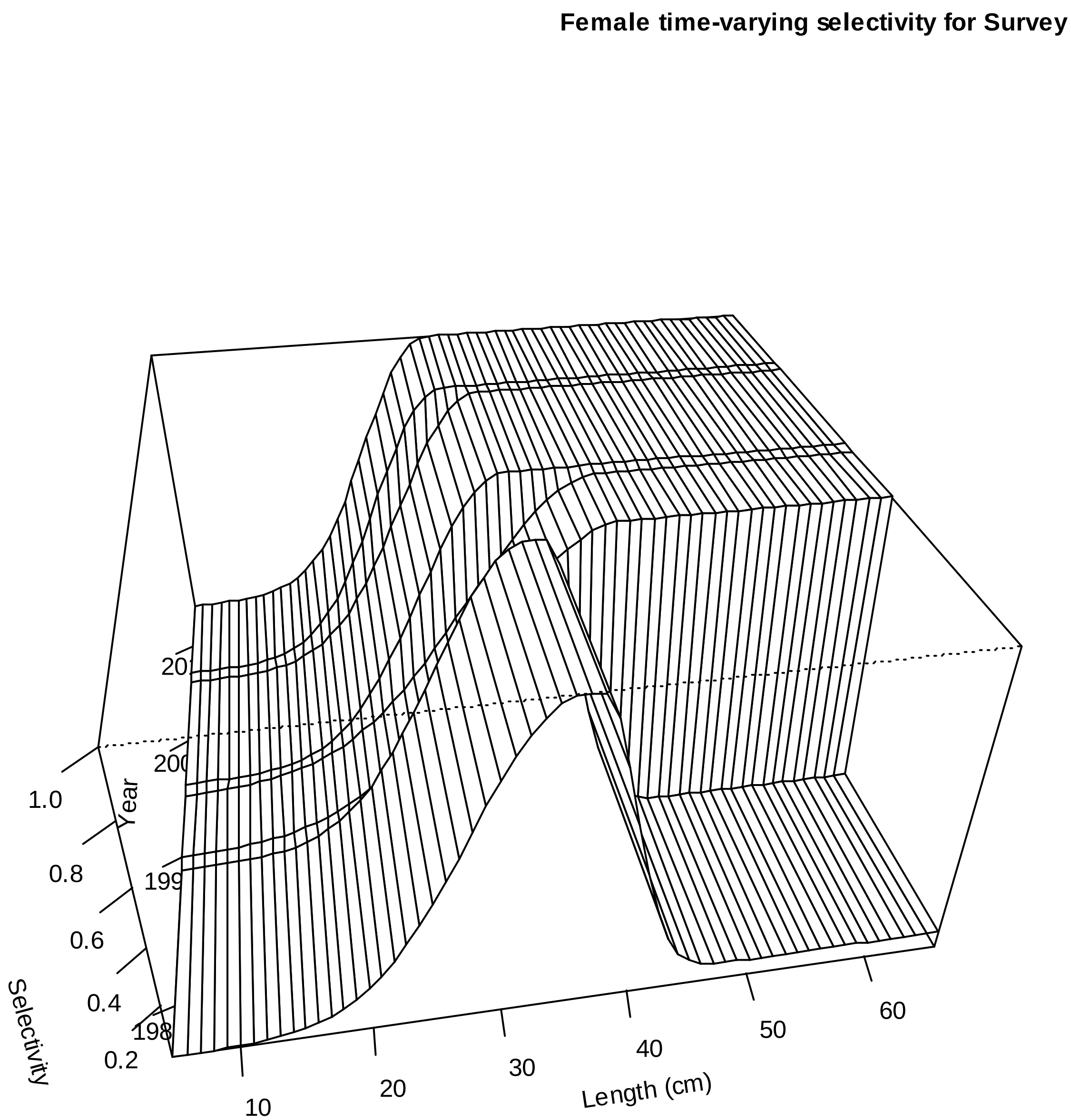


Figure 4.1.56 – Male survey selectivity-at-length for URS

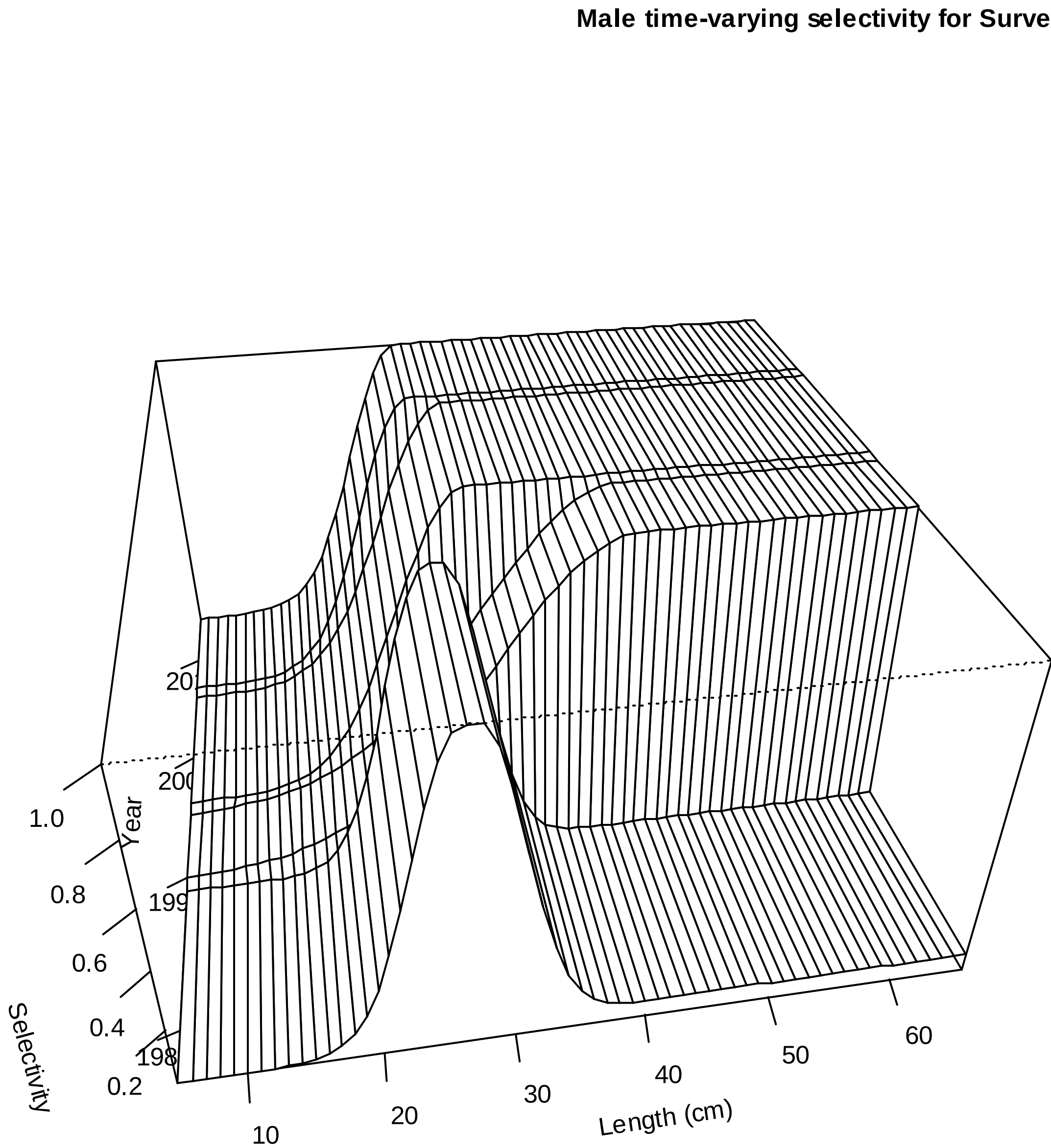


Figure 4.1.57 – Summary of fits to fishery and survey length composition data for URS

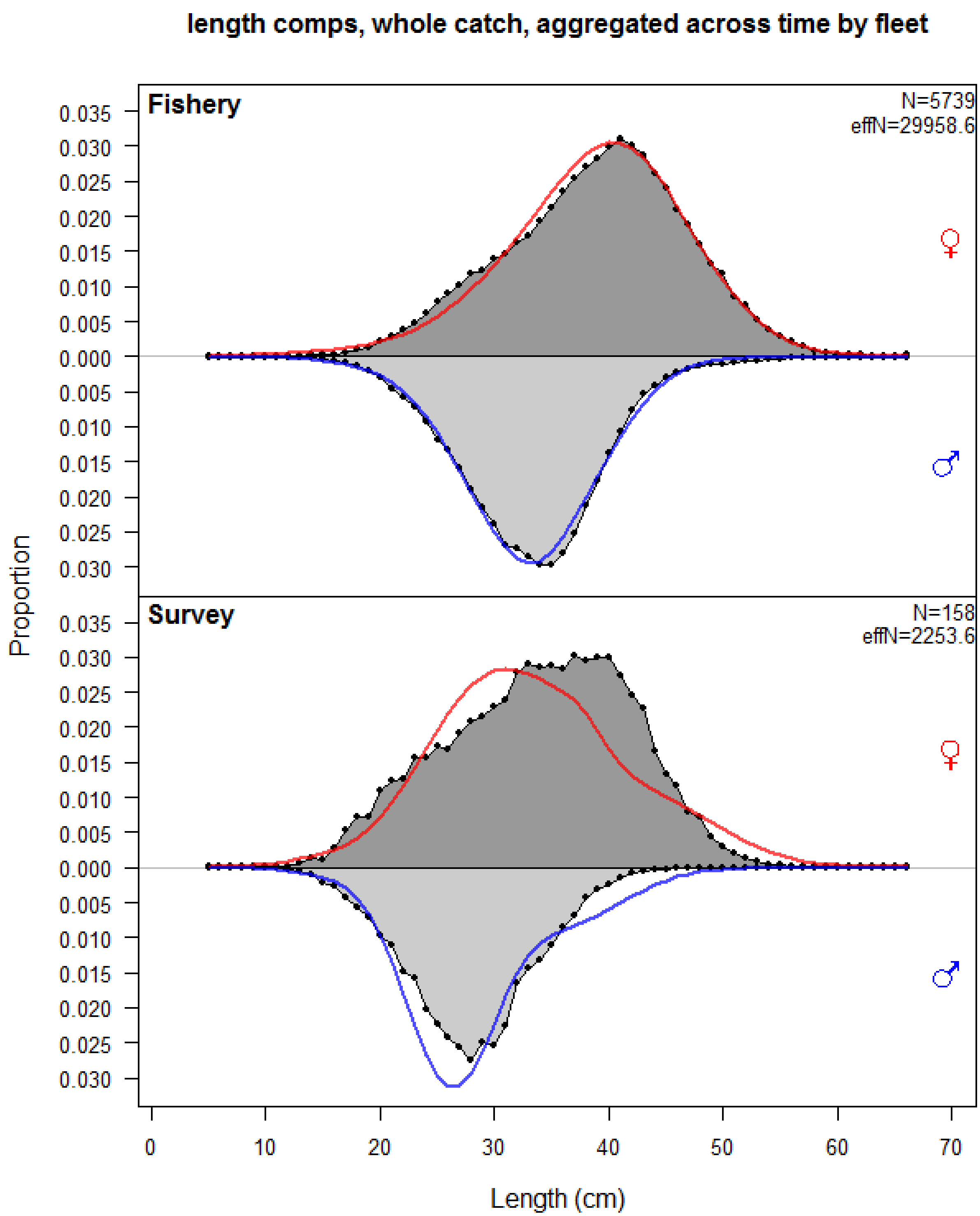
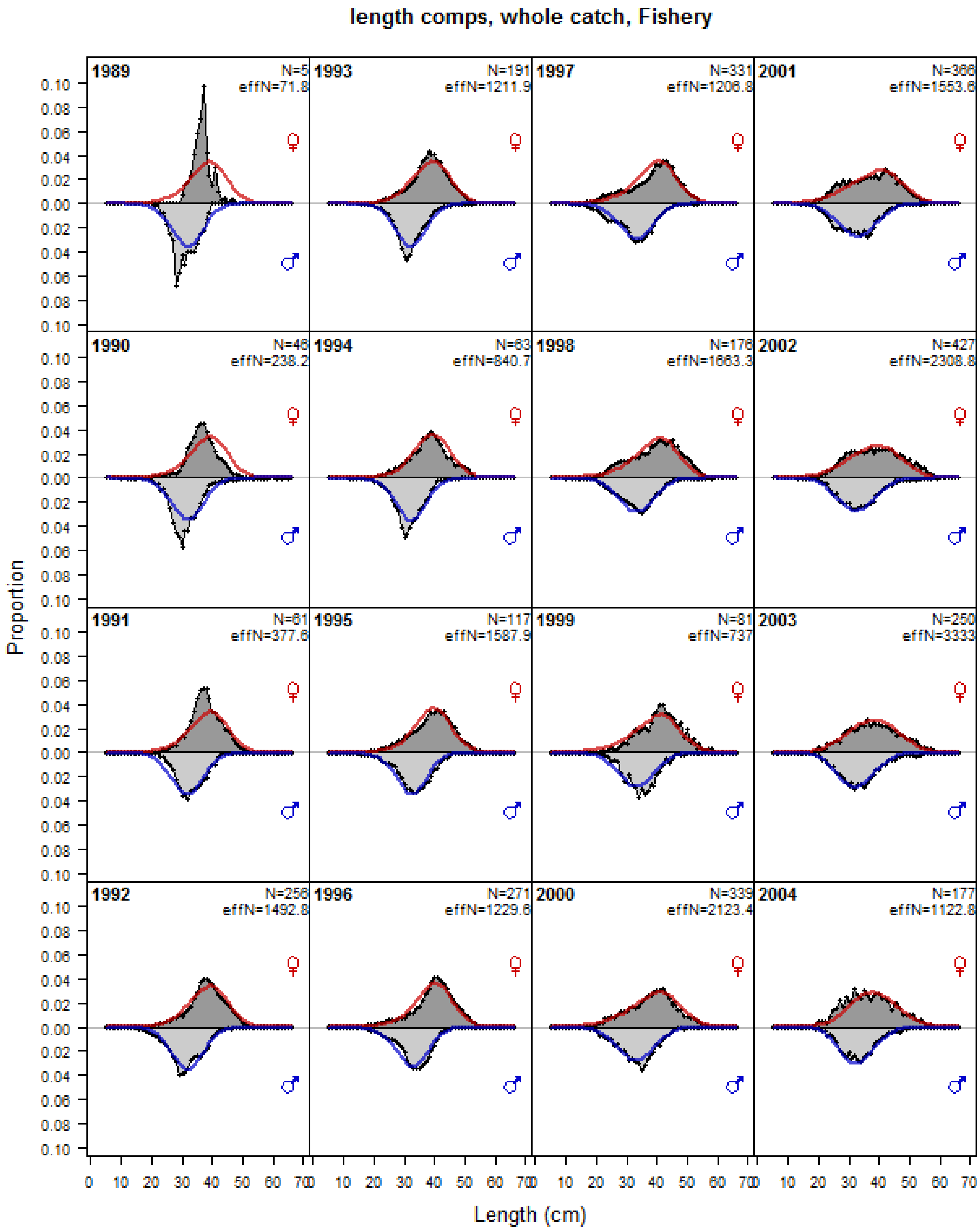


Figure 4.1.58 – Fits to fishery length composition data for URS



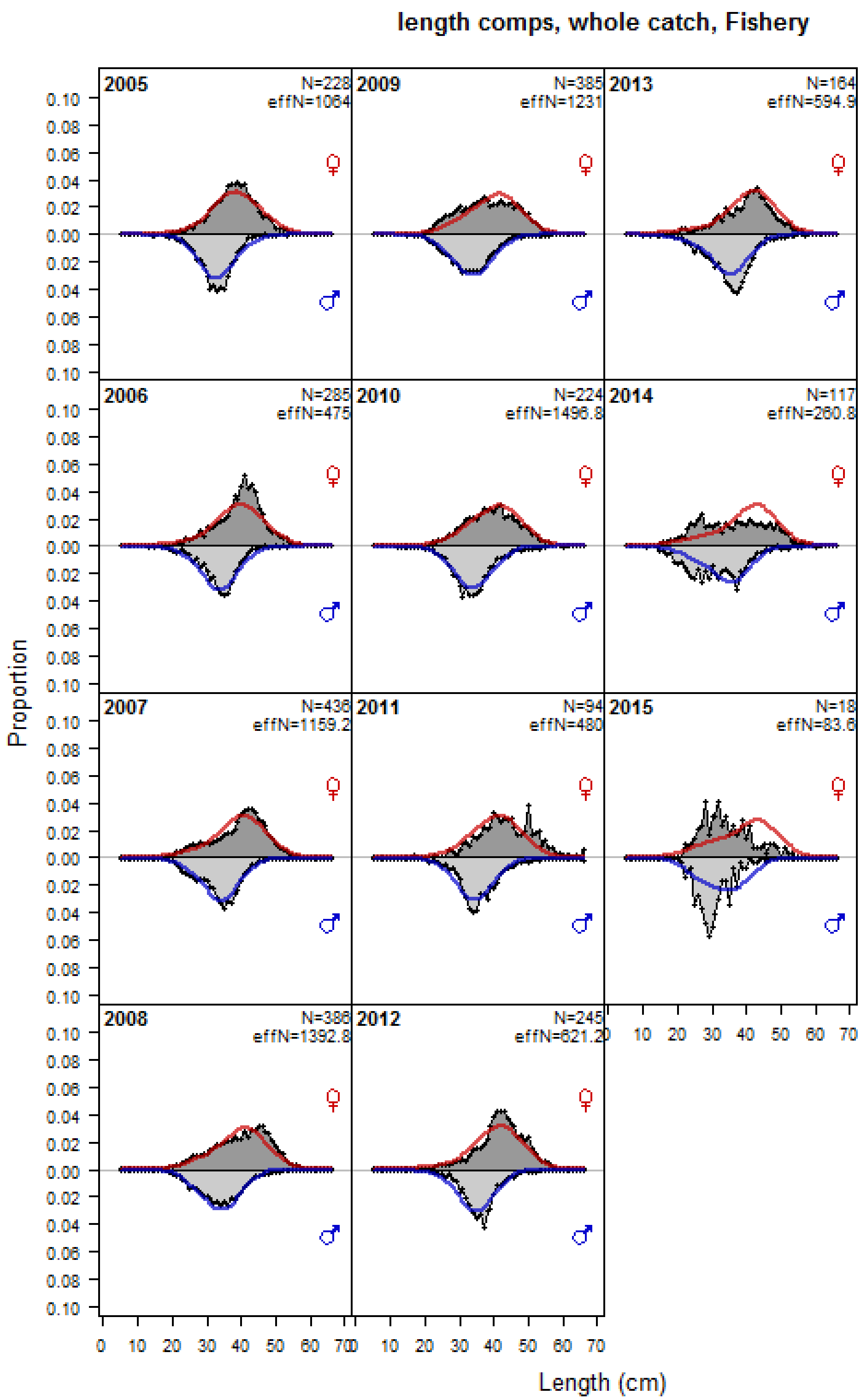

length comps, whole catch, Fishery
2005
N=228
effN=1064
2009
N=385
effN=1231
2013
N=164
effN=594.9
2006
N=285
effN=475
2010
N=224
effN=1496.8
2014
N=117
effN=260.8
2007
N=436
effN=1159.2
2011
N=94
effN=480
2015
N=18
effN=83.6
2008
N=386
effN=1392.8
2012
N=245
effN=621.2
Proportion
Length (cm)

Figure 4.1.59 – Fits to survey length composition data for URS

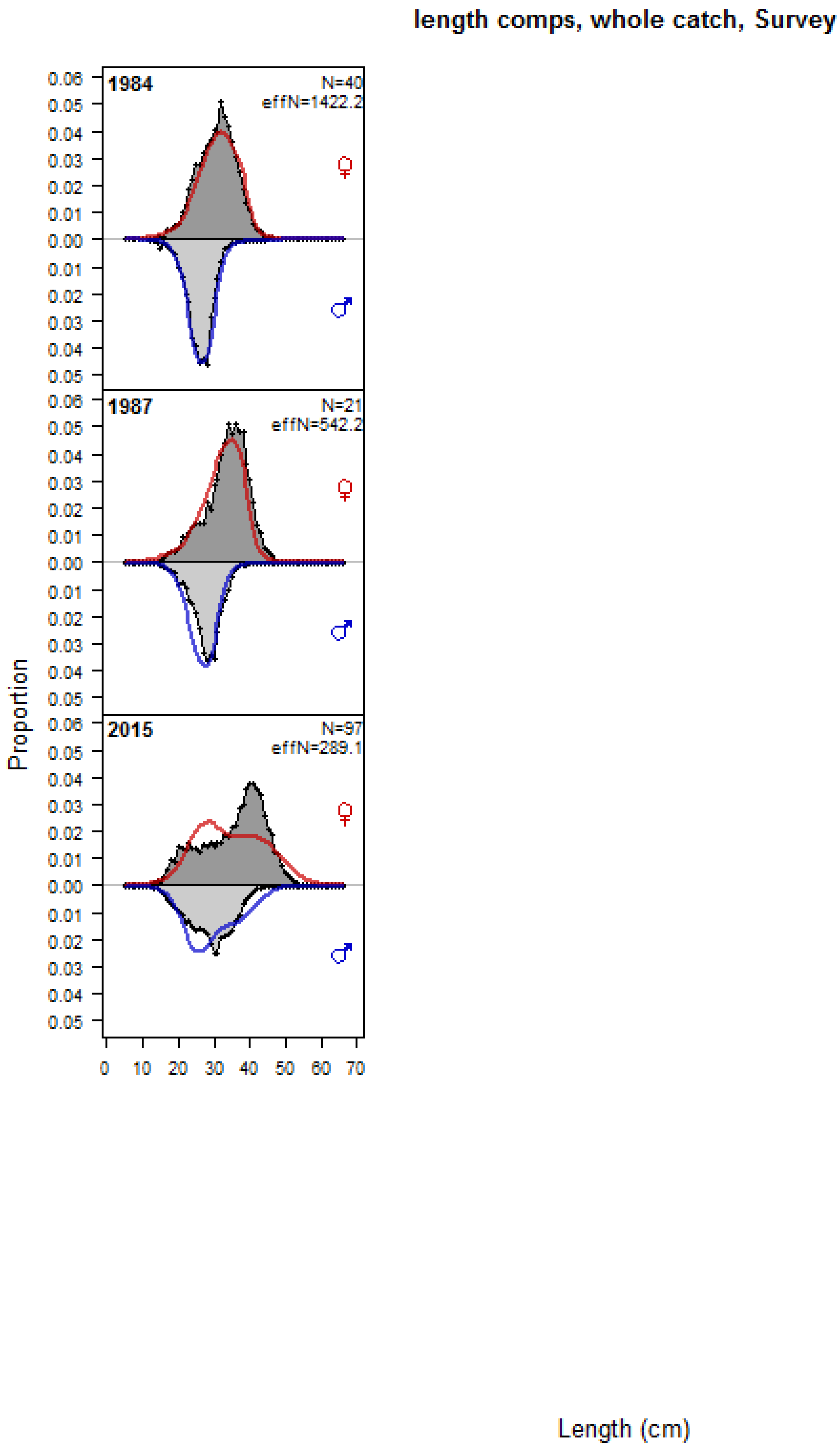


Figure 4.1.60 – Estimates of survey length composition (not used in model fitting) for URS

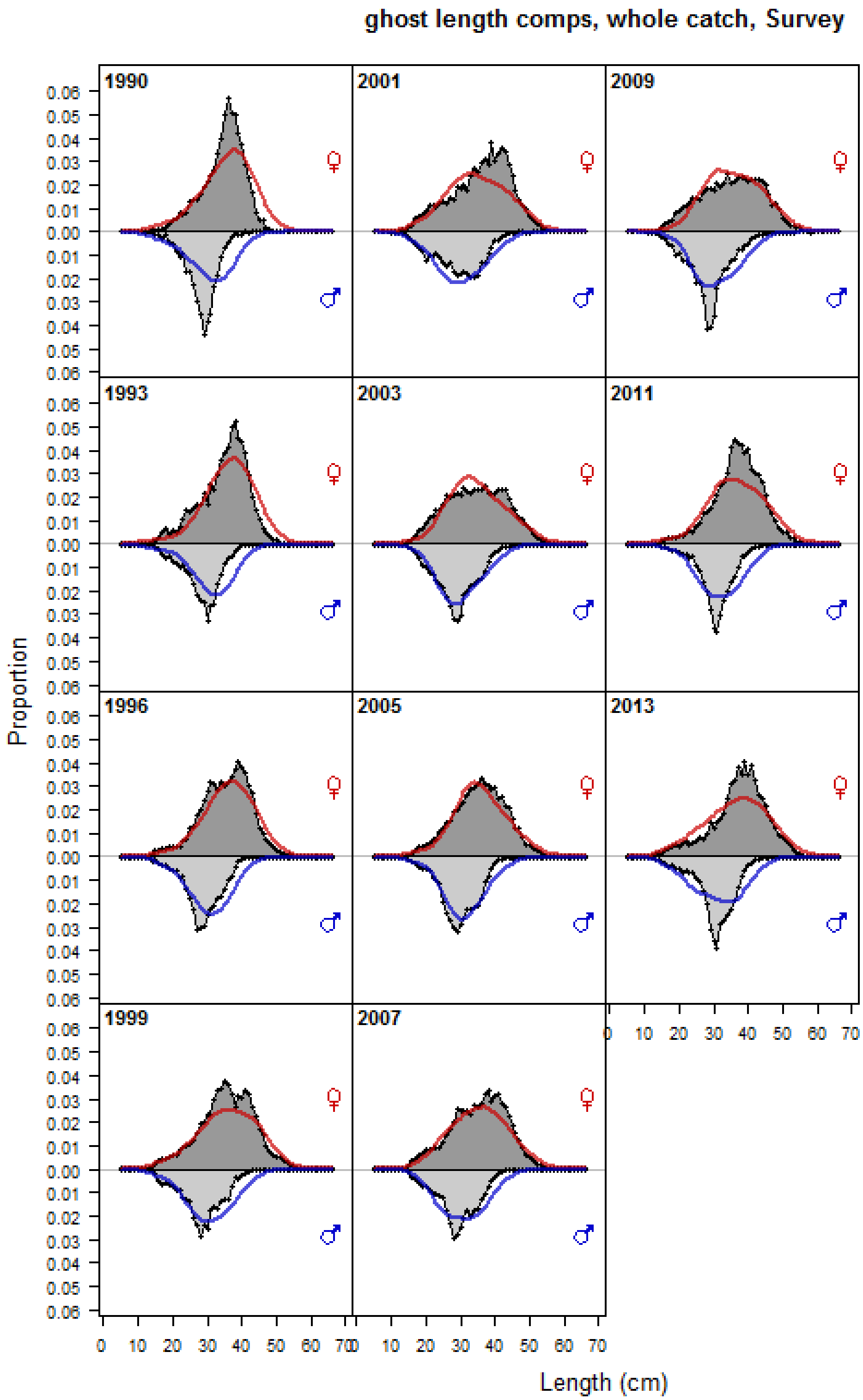


Figure 4.1.61 – Fits to survey age composition data for URS

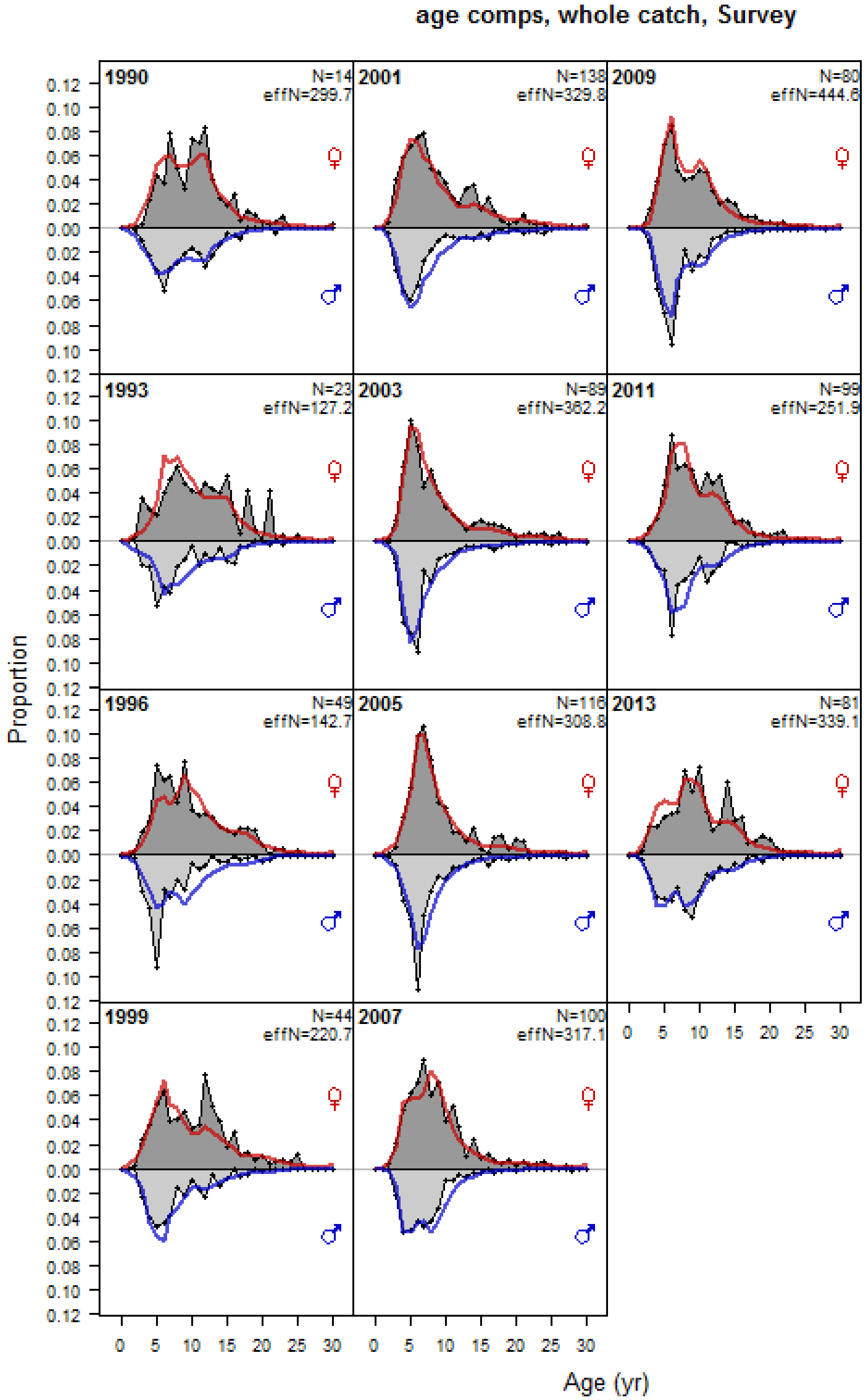


Figure 4.1.62 – Estimates of survey length composition data (not used in model fitting) for URS

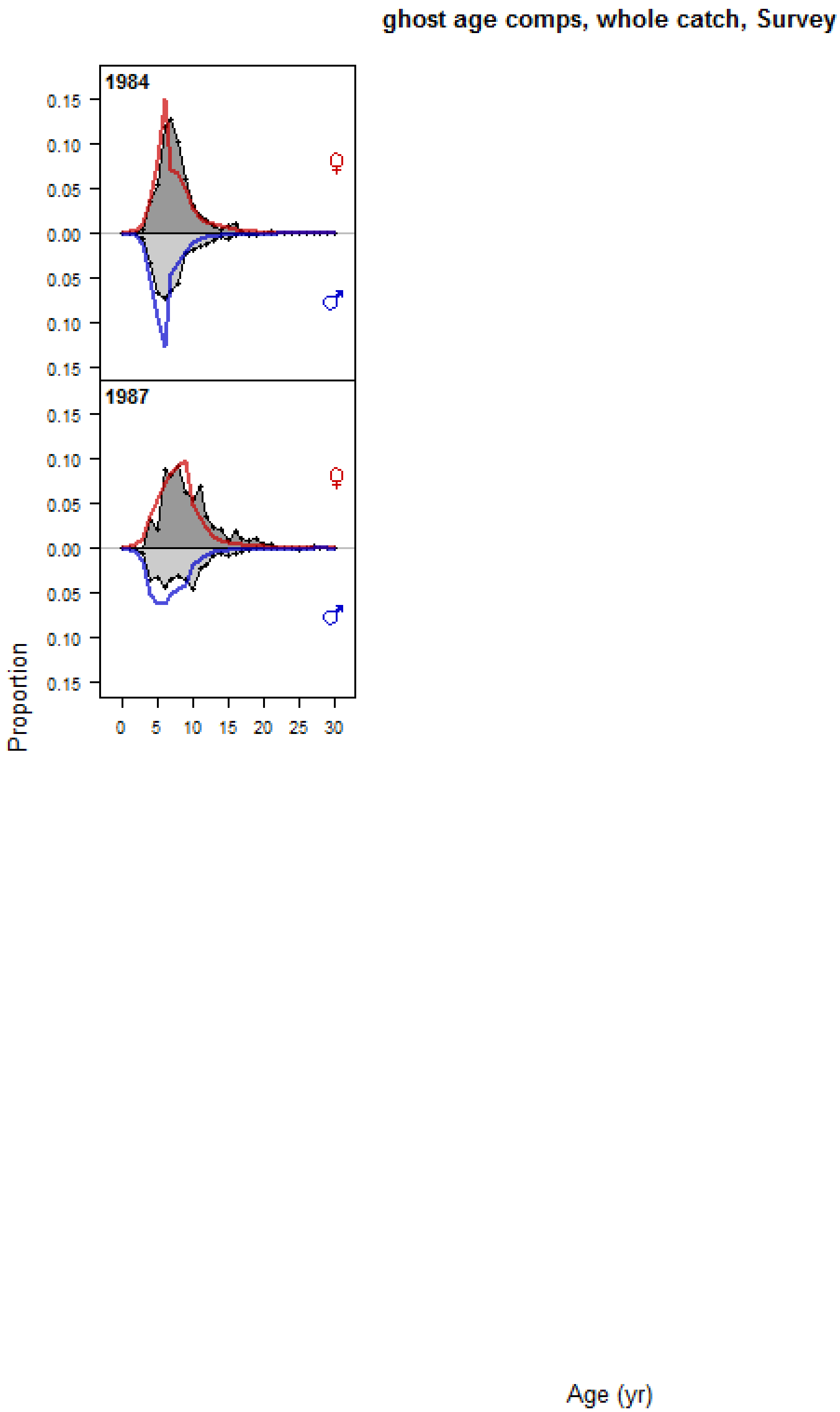
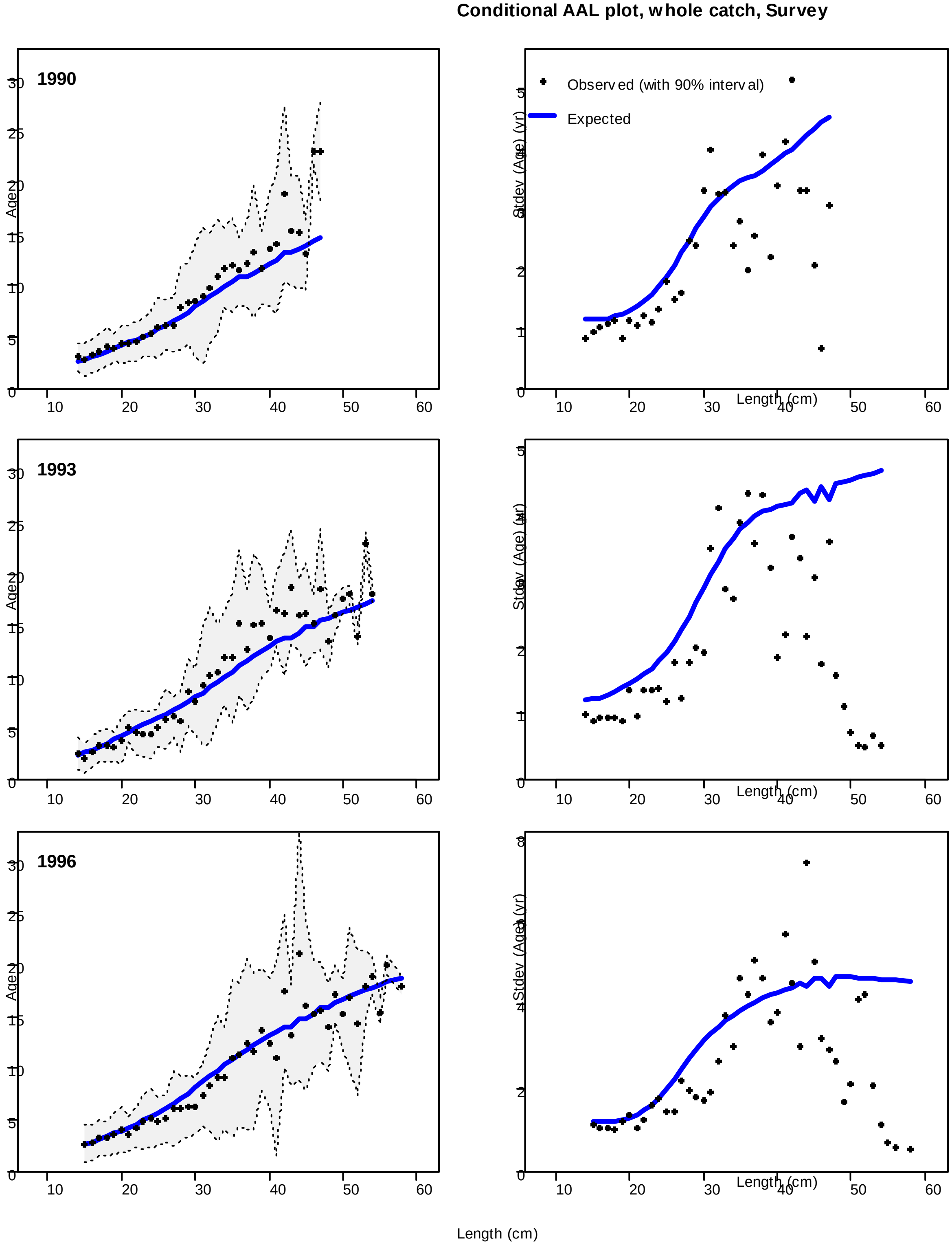
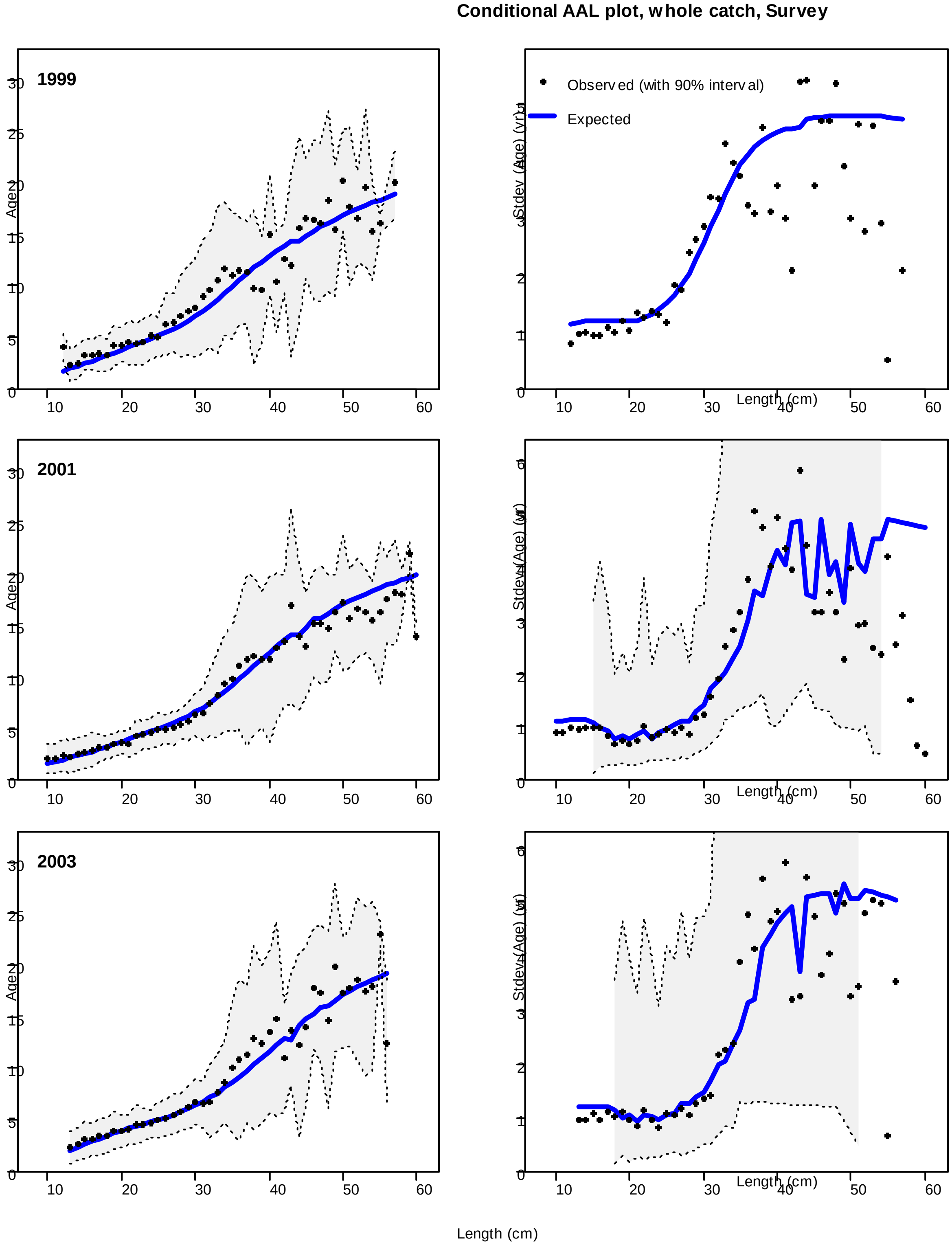
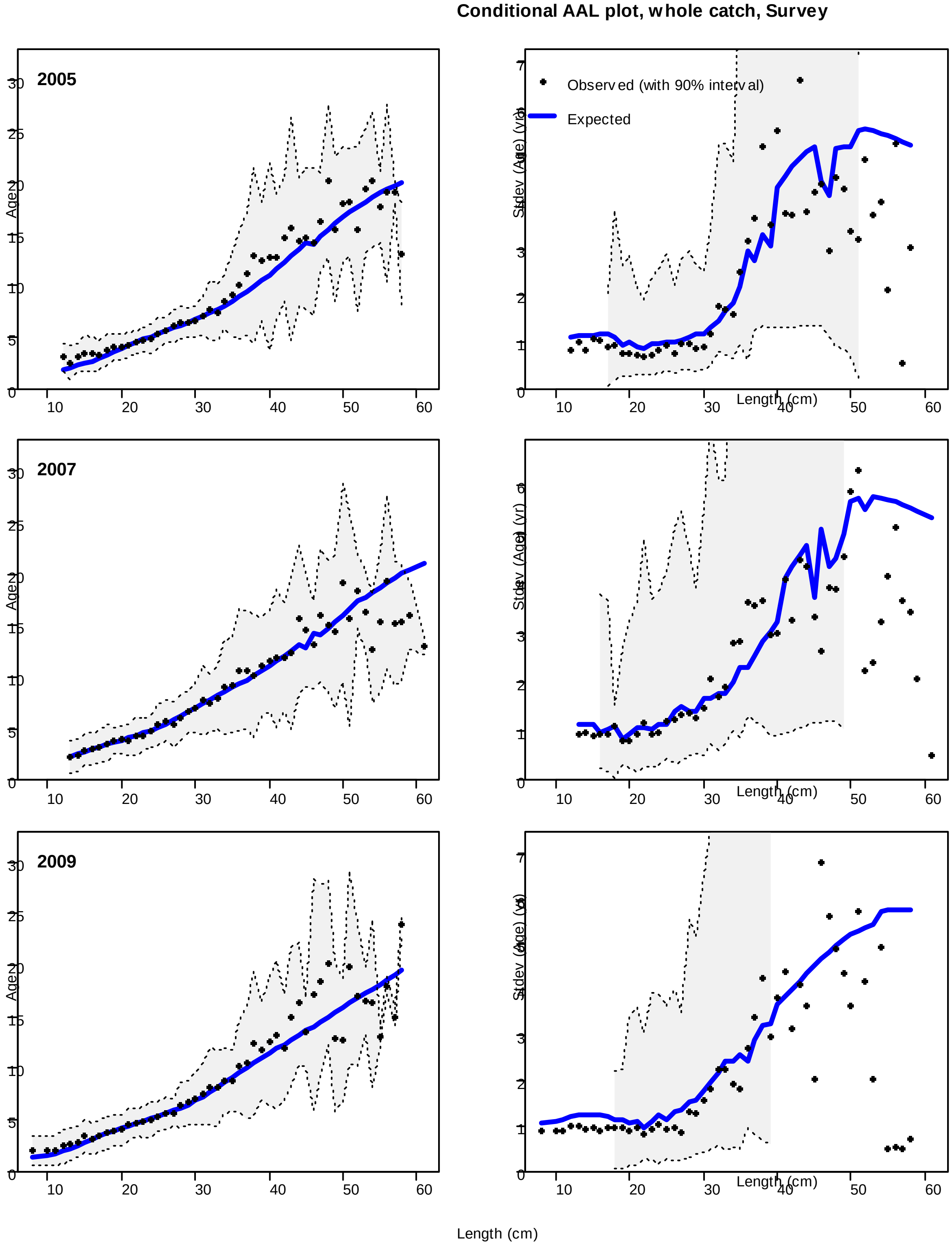


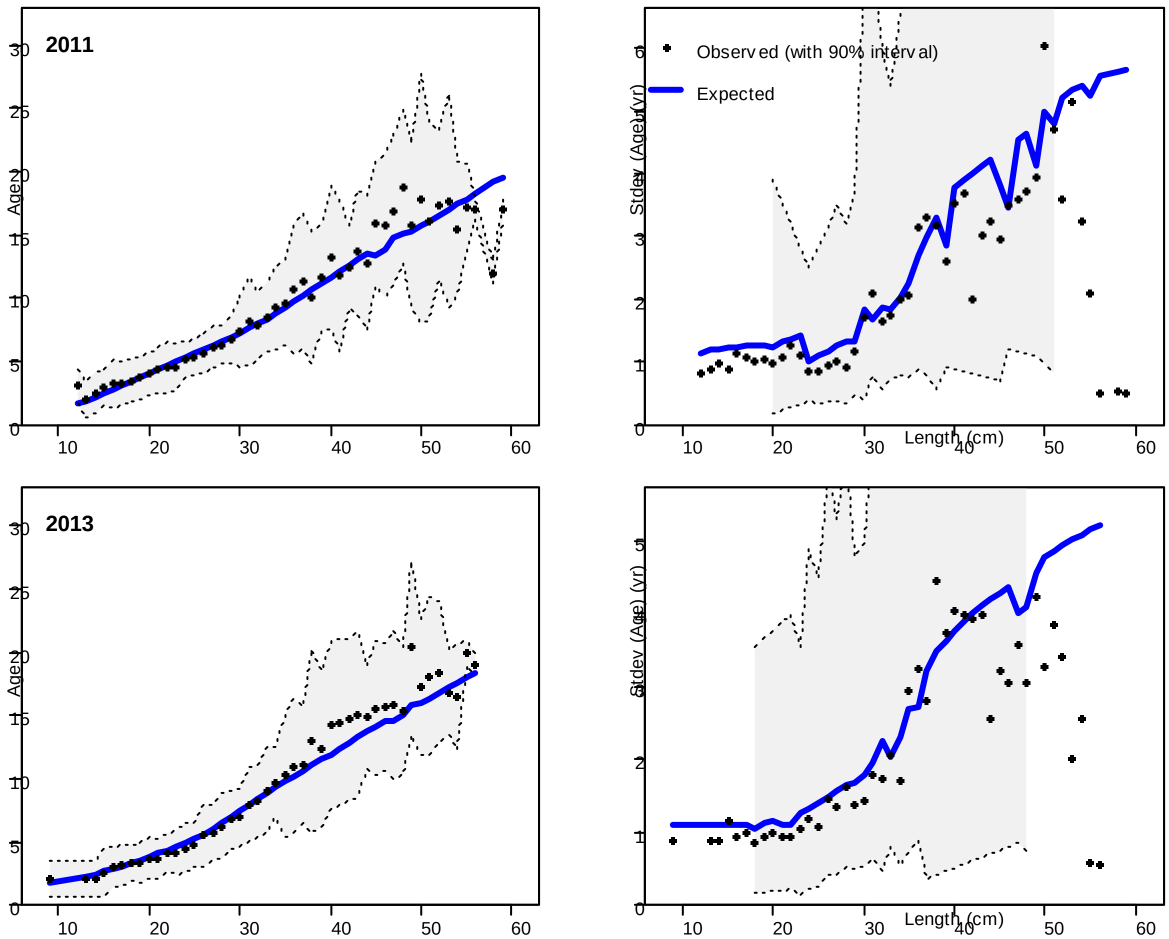
Figure 4.1.63 – Fits to survey conditional age-at-length data for URS




Conditional AAL plot, whole catch, Survey
1999
2001
2003
Age (yr)
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, whole catch, Survey
2005
2007
2009
Age
Stdev (Age) (yr)
Observed (with 90% interval)
Expected
Length (cm)

Conditional AAL plot, whole catch, Survey



Length (cm)

Figure 4.1.64 – Estimated size-at-age for URS in 2015

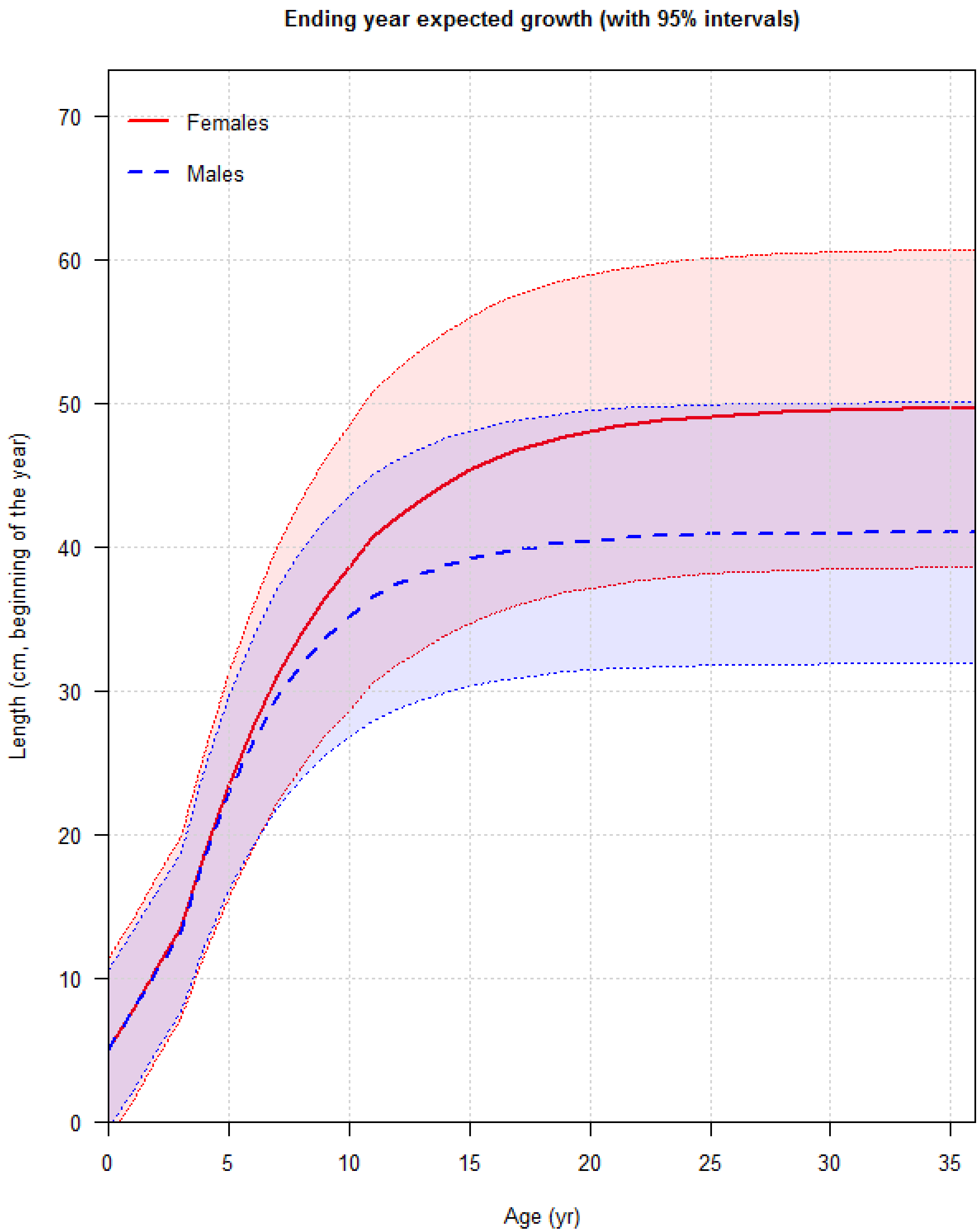


Figure 4.1.65 – Estimated time-varying size-at-age for females for URS

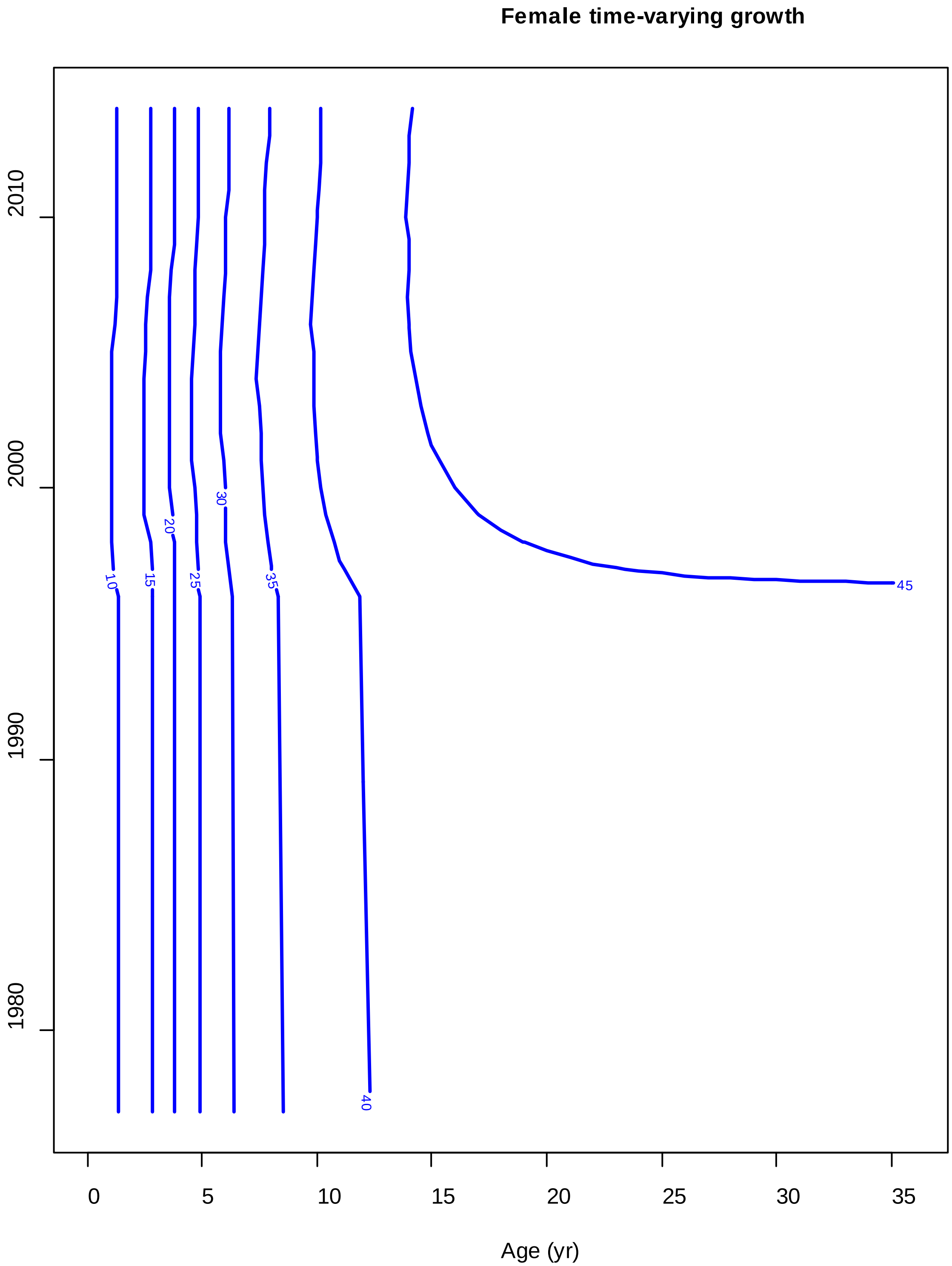


Figure 4.1.66 – Estimated time-varying size-at-age for males for URS

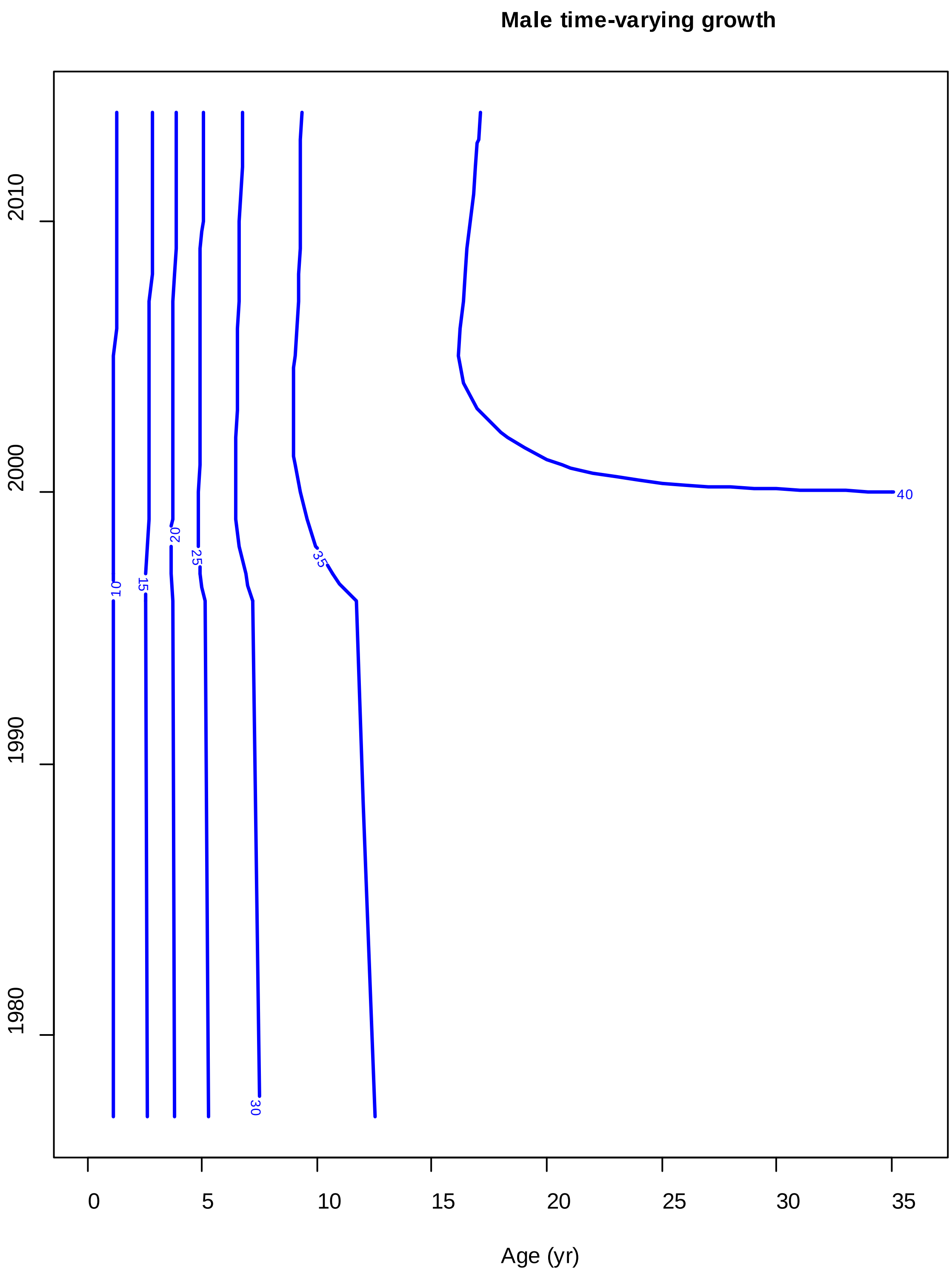


Figure 4.1.67 – Data summary of data used for model fitting for NRS

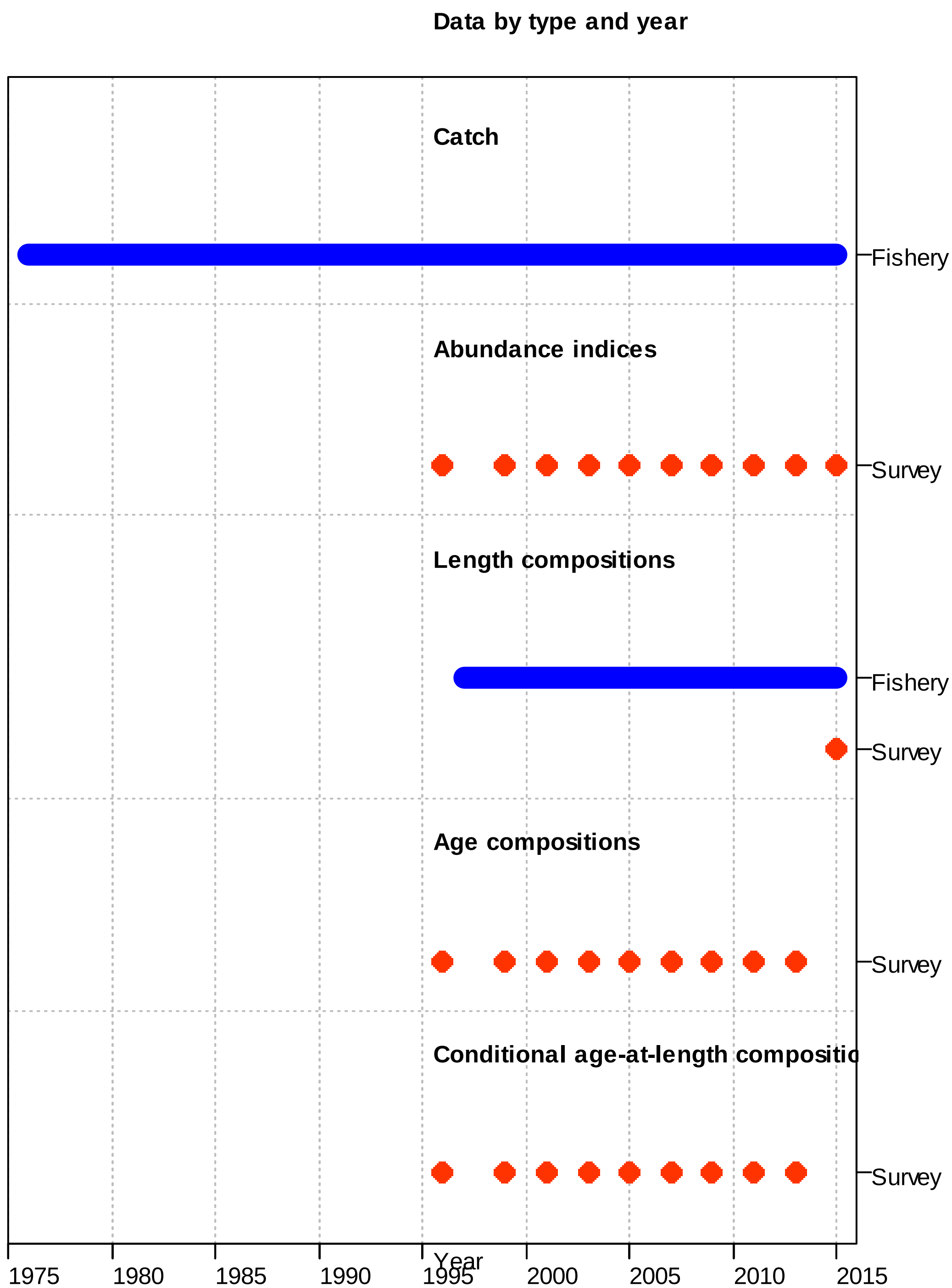


Figure 4.1.68 – Data summary of data used for model fitting for SRS

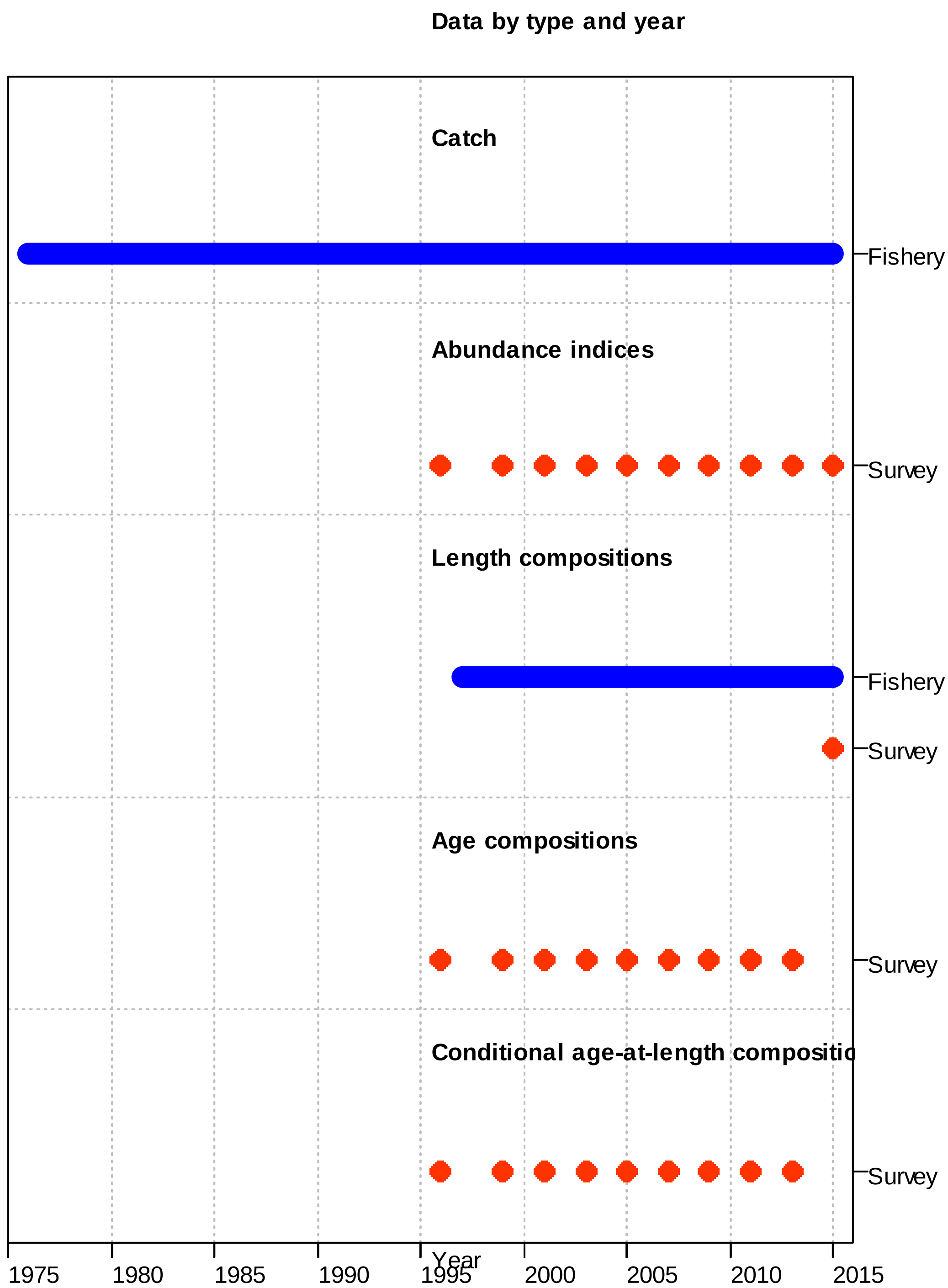
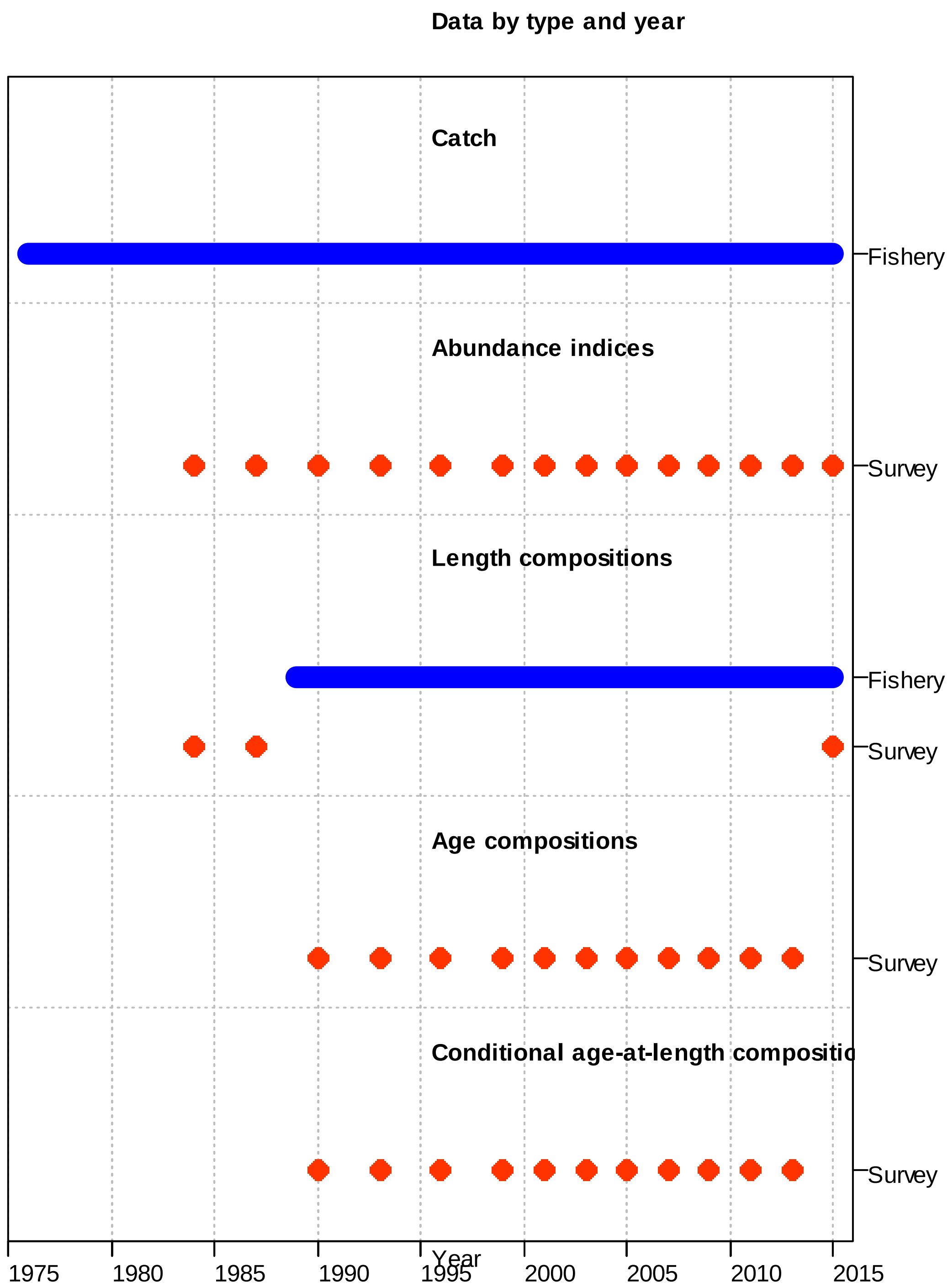


Figure 4.1.69 – Data summary of data used for model fitting for URS



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