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An exploration of GOA northern and southern rock sole stock assessment models for 2015

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Introduction

This document represents an effort to respond to comments made by the GOA Plan Team and the SSC on the 2014 assessments of the northern and southern rock sole (*Lepidopsetta polyxystra* and *bilineata*) stocks in the Gulf of Alaska (A'mar et al., 2014). In order to allow for exploration of a wide variety of modeling assumptions, this preliminary overview focuses on model development rather than input data and the application of the same model(s) to multiple data sets. Specifically, the model configurations presented here are applied to data through 2014.

Comments from the Plan Teams and SSC

Plan Team Comments from the November 2014 Minutes

*PT1: "**The Team recommended that for 2015 the species composition sampling be weighted not just to the haul level, but also to reflect the total catch and sampling rates within sectors of the fishery**. This may help reduce or explain the high level of variability observed in the ratio of the catches. This should also help explain how comprehensive the observer sampling has been, how many vessels are being sampled from each sector of the fishery, and how the spatial and temporal distribution of the fishery may compare to that of the survey."*

Response: This recommendation will not be addressed in 2015.

*PT2: "The Team noted that the predicted variability of length-at-age, especially for smaller rock sole, appeared to be appreciably higher than in the observed data. **Therefore the Team recommended that adjustment of the Amin value downward should be explored to see if it might alleviate this problem.** Further, there was a pronounced lack of fit to strong modes in some of the survey length data, particularly the male distributions. The Team identified some descending limb selectivity parameters that appeared to be poorly estimated, and **recommended these values be re-estimated in 2015**."*

Response: The value of Amin was reduced from 3 to 2 for all model configurations; the lower Amin value worked well for northern rock sole model configurations only. The parameters for the descending curve for male fishery and survey selectivity were not estimated for all model configurations in this analysis.

*PT3: "The Team noted that for some flatfish species there is a probable relationship between trawl survey catchability and water temperature. **Therefore, the Team recommended that the authors evaluate similar species and investigate whether this relationship should be considered in the shallow water flatfish assessment and how it might be implemented.**"*

Response: This recommendation will not be addressed in 2015.

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*PT4: "**In 2013, the Team recommended that an evaluation of relative trends provided ADF&G survey data.**"*

Response: Many of the stations in the ADF&G nearshore survey were not surveyed every year, so other methods, including GLMs, may be used to make use of the data from consistently sampled stations. This recommendation will not be addressed in 2015.

SSC Comments from the December 2014 Minutes

*SSC: "Nonetheless, the description of the model lacked detail, making it difficult to understand. For instance, the growth equation was not specified and weight-at-age parameter values were not presented. The selectivity functional form used was not specified or justified, but appeared to be a double normal. It was unclear why survey catchability for the time period 1984-1993 was not estimated for the N and S models when it was for the U models. It was unclear what fishery or survey data were sex-specific, and how such information was used in the assessment. It was unclear how undifferentiated catch samples were allocated to species after 1996, as species identification was not complete. It was unclear whether there were any constraints forcing similarity or identity among time-varying selectivity parameters. Parameter definitions were not provided in Table 4.1.5, 4.1.6, or 4.1.12. Many of the figures has terse captions and text that ran off of the page. **The SSC recommends that the assessment document be edited to improve specificity and clarity.**"*

Response: Additional details and clarifications will be provided in this document and in the final stock assessment document.

Summary of the base model configurations

The software used to run the model configurations presented below was Stock Synthesis v3.24S as compiled with ADMB v.11.1 (used in the 2014 stock assessment).

Technical details of Stock Synthesis are described in Method and Wetzell (2013) and were presented in A'mar and Palsson (2014). All model configurations covered ages 0 through 30, were sex-specific, and estimated male natural mortality; female natural mortality was fixed at 0.2 (Turnock et al., 2011). Values for other biological parameters come from Turnock et al. (2011). All sets of time-varying parameters, e.g., for selectivity or growth, are unconstrained. All models used a σ_R value of 0.6.

Model evaluation

Model configurations for 2015

Northern and southern rock sole were differentiated by species in 1996. The data used in the model configurations were the fishery and survey data for 1977 through 2014 for undifferentiated, northern, and southern rock sole. The length and age composition and conditional age-at-length data are sex-specific. The survey biomass estimates, population length and age composition, and conditional age-at-length data from 1984-1993 are for undifferentiated rock sole; the data from 1996 on are species-specific. The fishery catch data for all years are for undifferentiated rock sole; the fishery observer length composition data from 1977-1996 are for undifferentiated rock sole, and the data from 1997 on are for undifferentiated, northern, and

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southern rock sole. The annual catch data used in the species-specific model configurations is half of the total annual rock sole catch.

Three independent sets of sex-specific model configurations were developed. One set was an undifferentiated rock sole model configuration which used aggregated fishery and survey data for undifferentiated, northern, and southern rock sole; the second set was a model configuration for northern rock sole; and the third set was a model configuration for southern rock sole. All of the model configuration sets are independent of each other.

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 2006-2014;
- 4 periods of sex-specific double normal survey selectivity-at-age, 1977-1989, 1990-1995, 1996-2004, and 2005-2014, with the latter 3 periods being asymptotic;
- 3 periods of sex-specific von Bertalanffy growth, 1977-1995, 1996-2004, and 2005-2014, which allows for the changing ratio of northern to southern rock sole;
- Fit to fishery length composition and survey age composition and conditional age-at-length data; and
- Estimated natural mortality for males.

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

The data used in the species-specific model configurations are from 1996 on, with the exception of the annual catch time series. The annual catch time series for the species-specific model configurations is 50% of the annual total rock sole catch; there is uncertainty about what fraction of the annual rock sole catch is northern and southern rock sole. Data for undifferentiated rock sole were not used in the species-specific model configurations.

RESULTS

Model evaluation

The main difference between the 2014 model configurations and the model configurations considered for 2015 is the use 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.

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 sand survey selectivity; and that the model estimated the variance-covariance matrix. Survey selectivity was age- or length-based and fitted to age composition data.

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The estimates of spawning biomass for Nrs had a similar pattern for the 2014 model configurations and the 2015 preliminary model configurations (Fig. 1), although the 2014 values were higher at the beginning of the historical period. There is less similarity between the 2014 and 2015 model configurations in the estimates of age-0 recruits (Fig. 2). The three model configurations had somewhat different fits to the survey biomass index (Fig. 3).

The estimates of spawning biomass for Srs also had a similar pattern for the three model configurations (Fig. 4), although the 2014 values were lower than the 2015 values for most of the historical period. The estimates of age-0 recruits were similar for the three model configurations (Fig. 5), although the magnitude of the 2014 values was lower in many years. The 2014 model configuration had a somewhat different fit to the survey biomass index compared to the 2015 model configurations (Fig. 6).

The patterns for Urs for spawning biomass (Fig. 7), age-0 recruits (Fig. 8), and fit to the survey biomass index (Fig. 9) were similar for the three model configurations.

Table 1 – Likelihood components for Nrs, Srs, and Urs model configurations with survey selectivity-at-age or –at-length and a lambda value of 1

	srv sel-at-age	srv sel-at-len
Nrs		
Total NLL	900.835	898.673
Parameters	88	88
Survey	-13.707	-14.827
Fsh len comp	192.831	197.855
Srv age comp	726.364	719.689
Recr	-10.477	-11.090
Srs		
Total NLL	944.967	940.726
Parameters	88	88
Survey	-12.064	-12. 428
Fsh len comp	155.250	153. 048
Srv age comp	801.165	799. 614
Recr	-5.602	-5. 617
Urs		
Total NLL	1063.940	1100.180
Parameters	130	130
Survey	-21. 027	-24.387
Fsh len comp	198.679	208.916
Srv len comp	1.863	1.426
Srv age comp	885.562	916.190
Recr	-6.432	-7.511

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The model configurations selected for further investigation have length-based survey selectivity fit to survey age composition data, as the Nrs and Srs model configurations had better fits to the survey indices and better fits to the survey age composition and conditional age-at-length data than the model configurations with age-based survey selectivity.

The lambda parameter is used to address the uncertainty in recent estimates of recruitment. The estimates of historical spawning biomass were virtually identical for lambda values 1, 2, 3, and 4 for the Nrs, Srs, and Urs model configurations; the main differences were the estimates of recent recruits and their associated uncertainty intervals. The model configuration with a lambda value of 3 will used for Nrs to address the large 2011 age-0 estimate (Figs. 10 and 11), a value of 2 for Srs to address the small 2012 age-0 estimate (Figs. 12 and 13), and a value of 3 for Urs to address the large 2011 age-0 estimate (Figs. 14 and 15).

Table 2 – Estimated growth parameters for Nrs, Srs, and Urs model configurations with a lambda value of 1

	L at A_{min}	L_∞	k			L at A_{min}	L_∞	k	M
Nrs females	10.12	45.48	0.212		Nrs males	9.90	39.29	0.257	0.249
Srs females	11.30	49.73	0.200		Srs males	12.49	40.26	0.241	0.245
Urs females #1	13.74	44.39	0.209		Urs males #1	14.81	37.51	0.233	0.244
Urs females #2	15.10	49.74	0.183		Urs males #2	14.27	40.96	0.240	-
Urs females #3	14.18	52.64	0.150		Urs males #3	13.71	43.22	0.203	-

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. M is fixed at 0.2 for females.

For the undifferentiated rock sole model configurations, the estimates of L_∞ increase over the historical period and the estimates of k decrease, for both males and females, indicating that both growth and the ratio of northern to southern rock sole has changed over time.

The estimates of spawning biomass for Urs and Srs have a similar pattern (Fig. 16), which is expected, given that a larger proportion of total rock sole survey biomass since species differentiation in 1996 is southern rock sole. There is also a similar pattern for age-0 recruits in most years for Urs and Srs (Fig. 17). The fits to the survey biomass indices is reasonable for Urs and Srs, and mediocre for Nrs (Fig. 18).

Literature

A'mar, T., Palsson, W. 2014. Assessment of the northern and southern rock sole (*Lepidopsetta polyxystra and bilineata*) stocks in the Gulf of Alaska for 2015. In: Stock Assessment and Fishery Evaluation Report for Groundfish Resources in the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK, USA.

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

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

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Figures

Figure 1 – Estimates of spawning biomass for northern rock sole

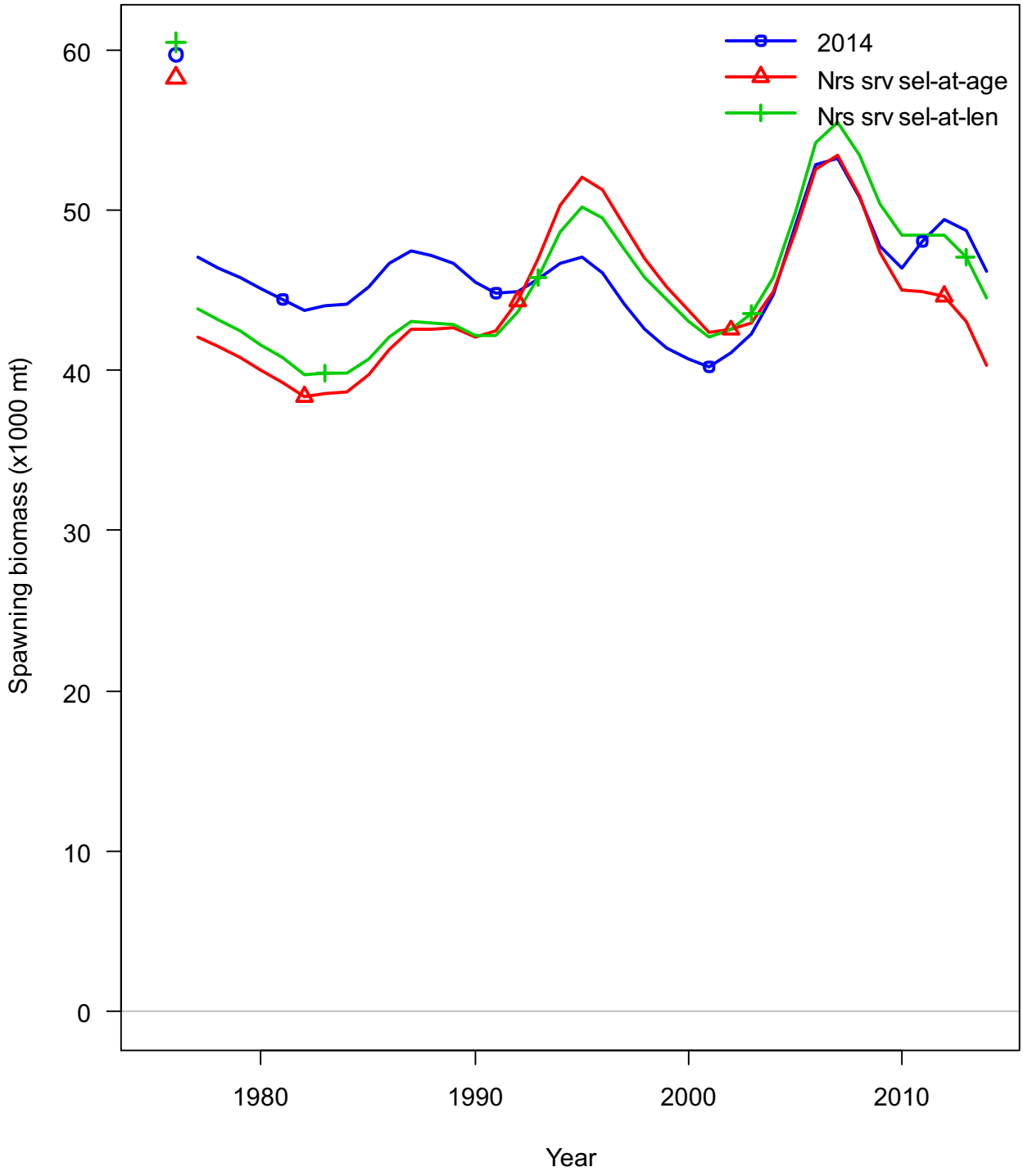

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Figure 2 – Estimated of age-0 recruits for northern rock sole

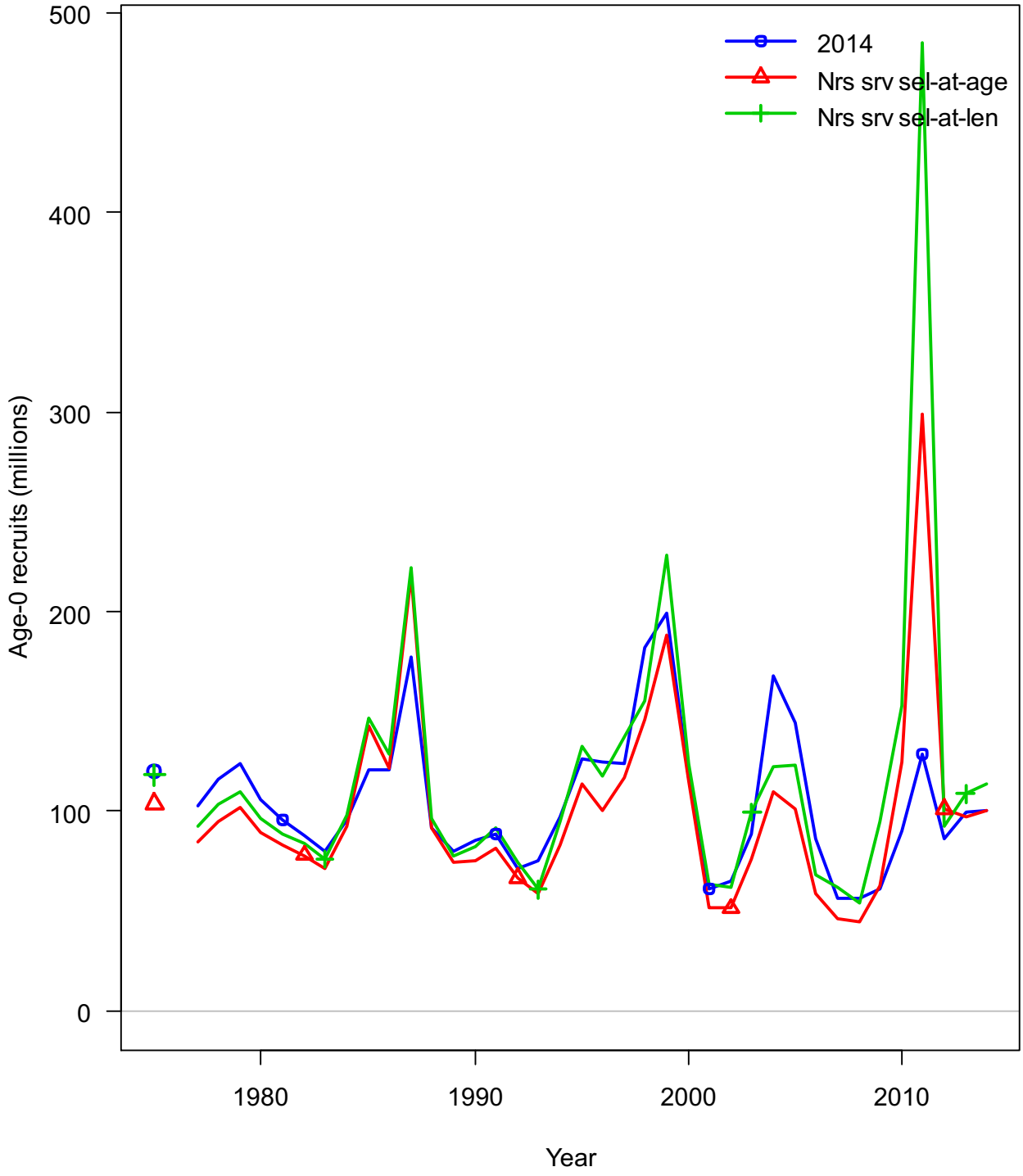

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Figure 3 – Estimates of survey biomass for northern rock sole

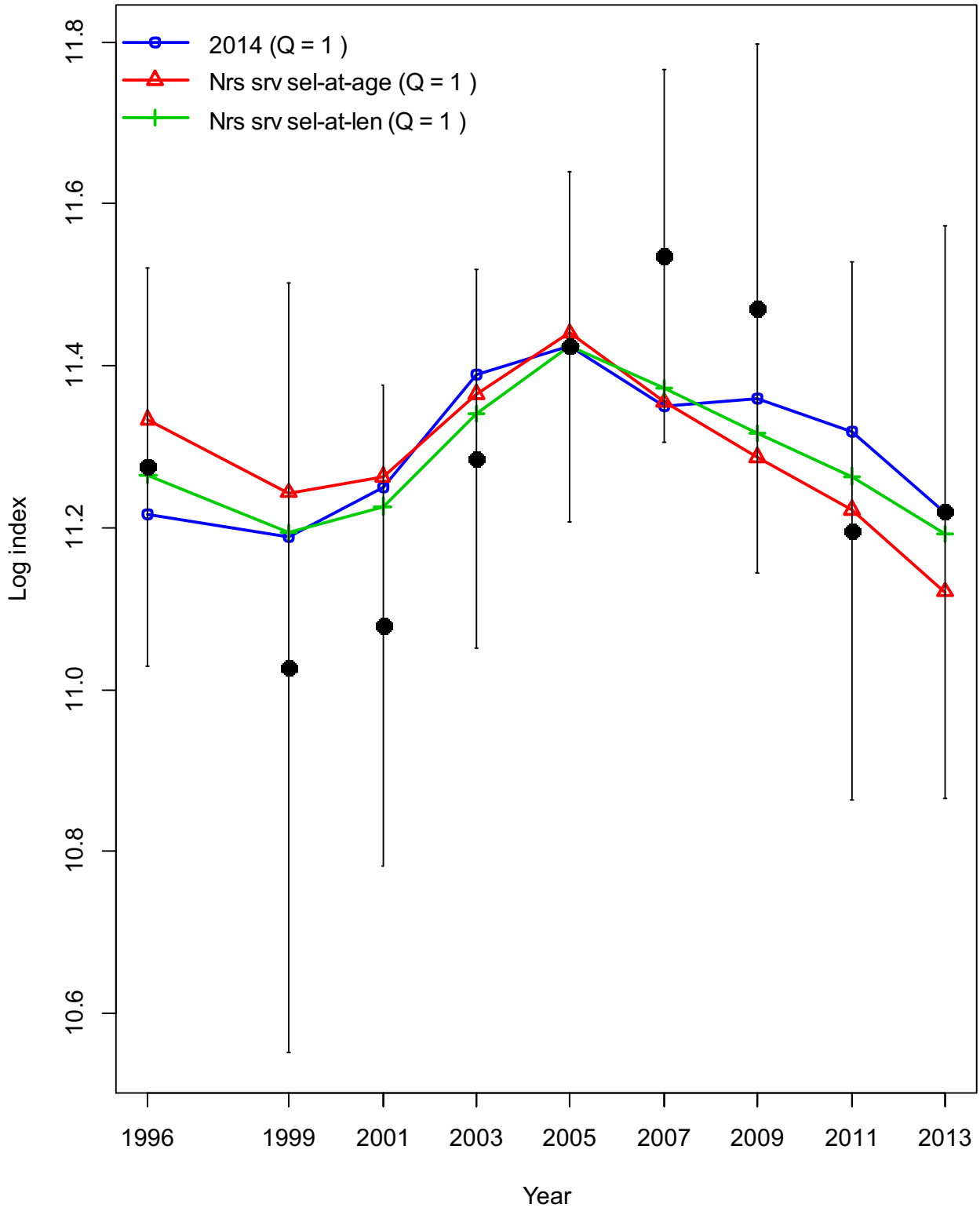

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Figure 4 – Estimates of spawning biomass for southern rock sole

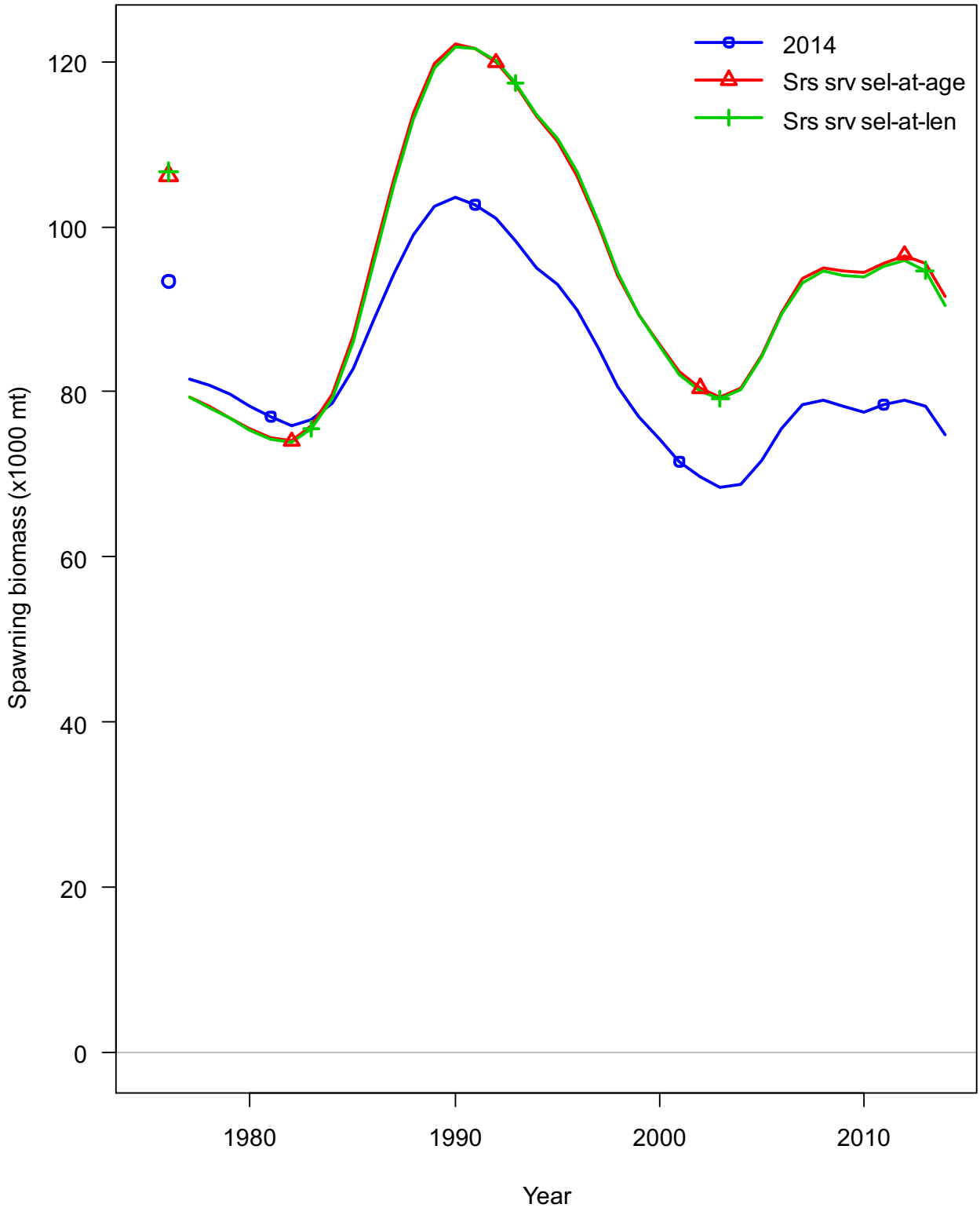

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Figure 5 – Estimates of age-0 recruits for southern rock sole

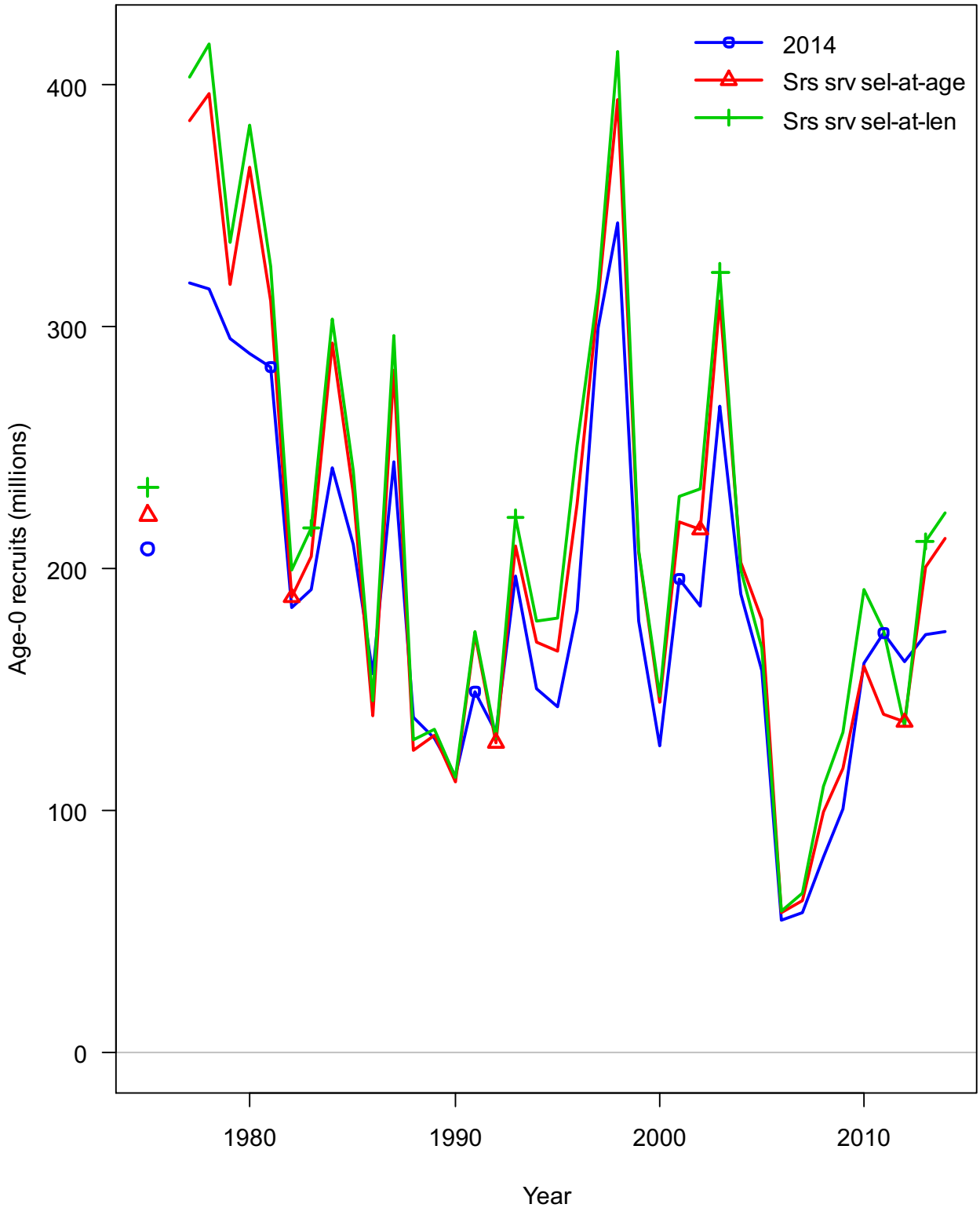

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Figure 6 – Estimates of survey biomass for southern rock sole

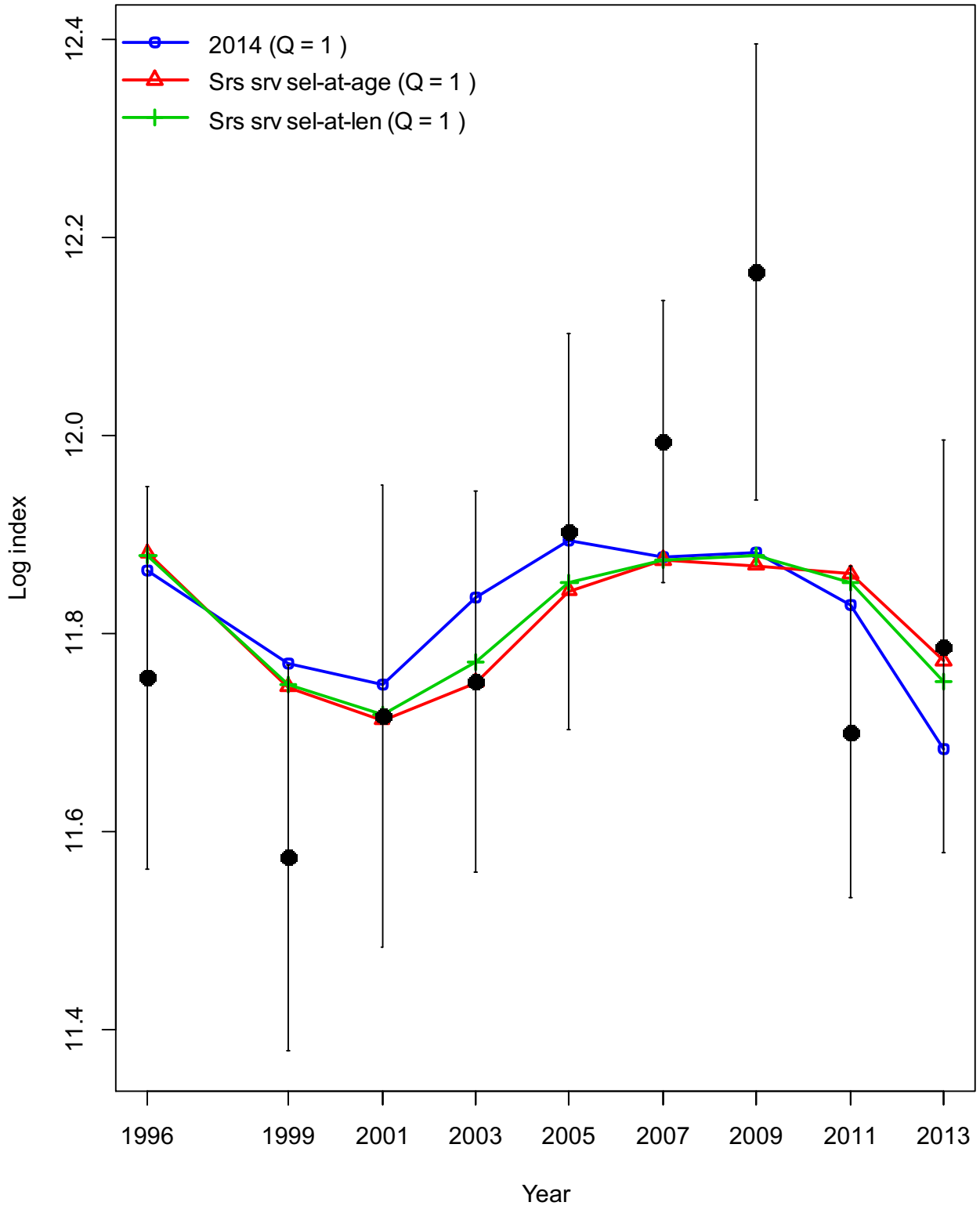

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Figure 7 – Estimates of spawning biomass for undifferentiated rock sole

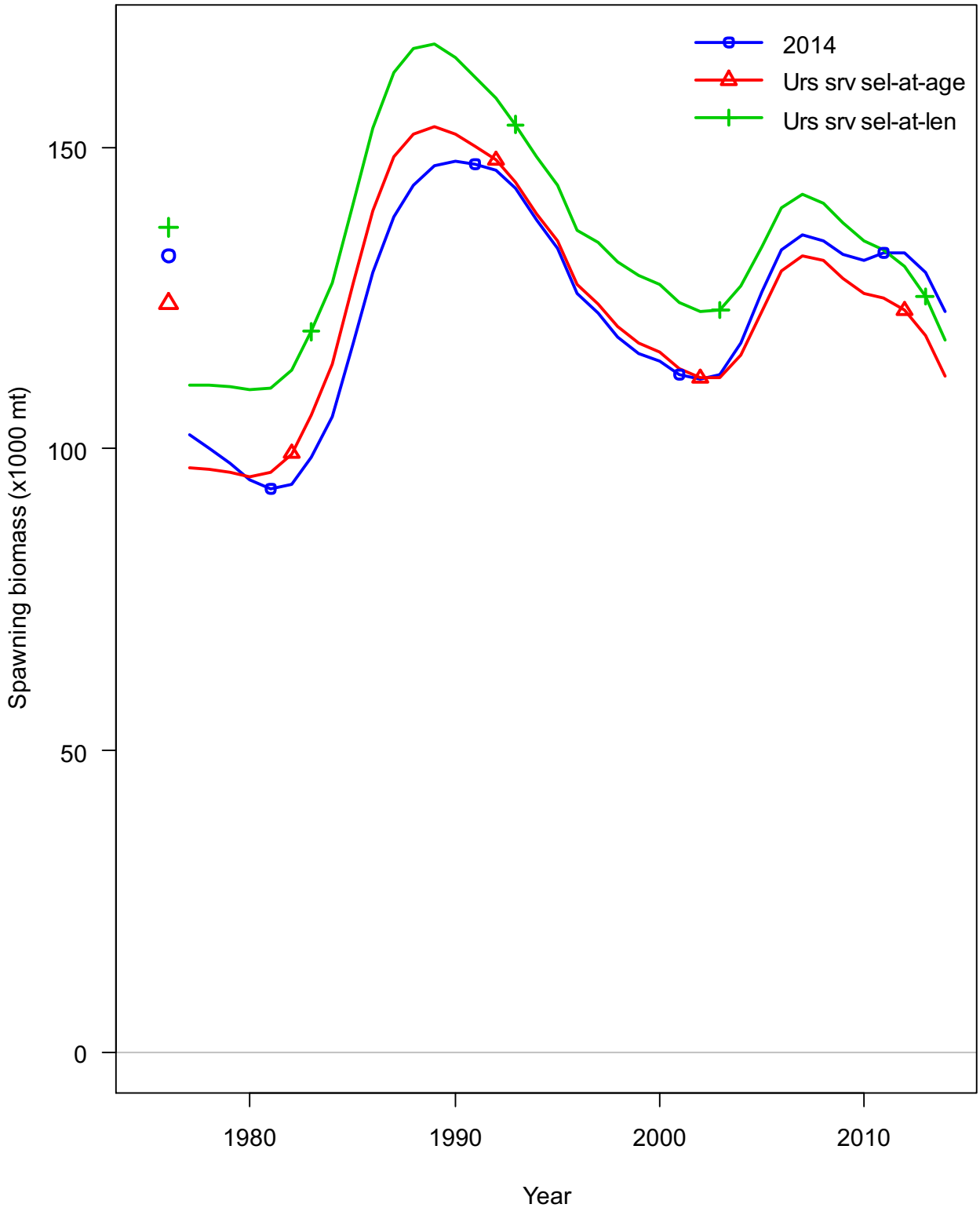

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Figure 8 – Estimates of age-0 recruits for undifferentiated rock sole

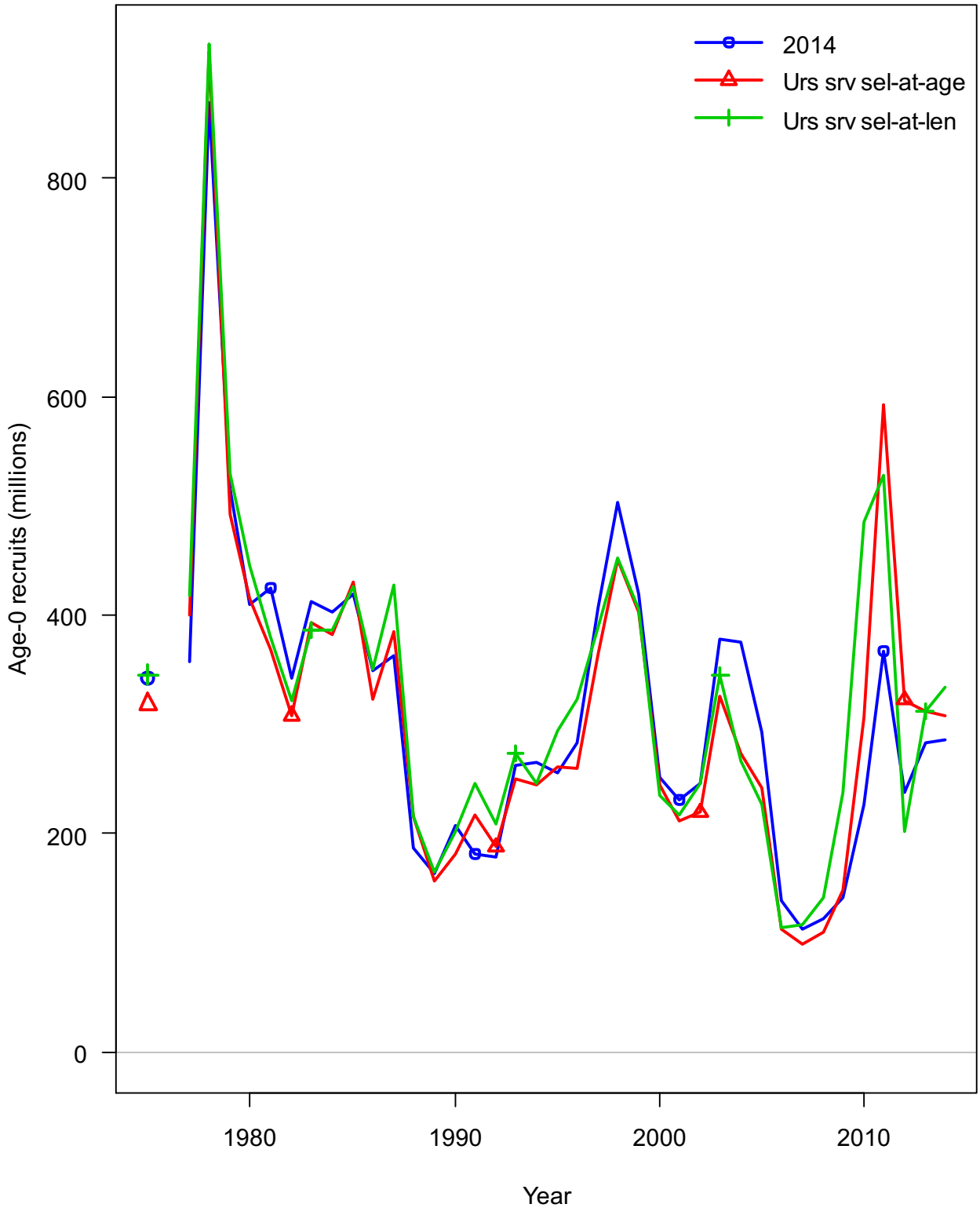

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Figure 9 – Estimates of survey biomass for undifferentiated rock sole

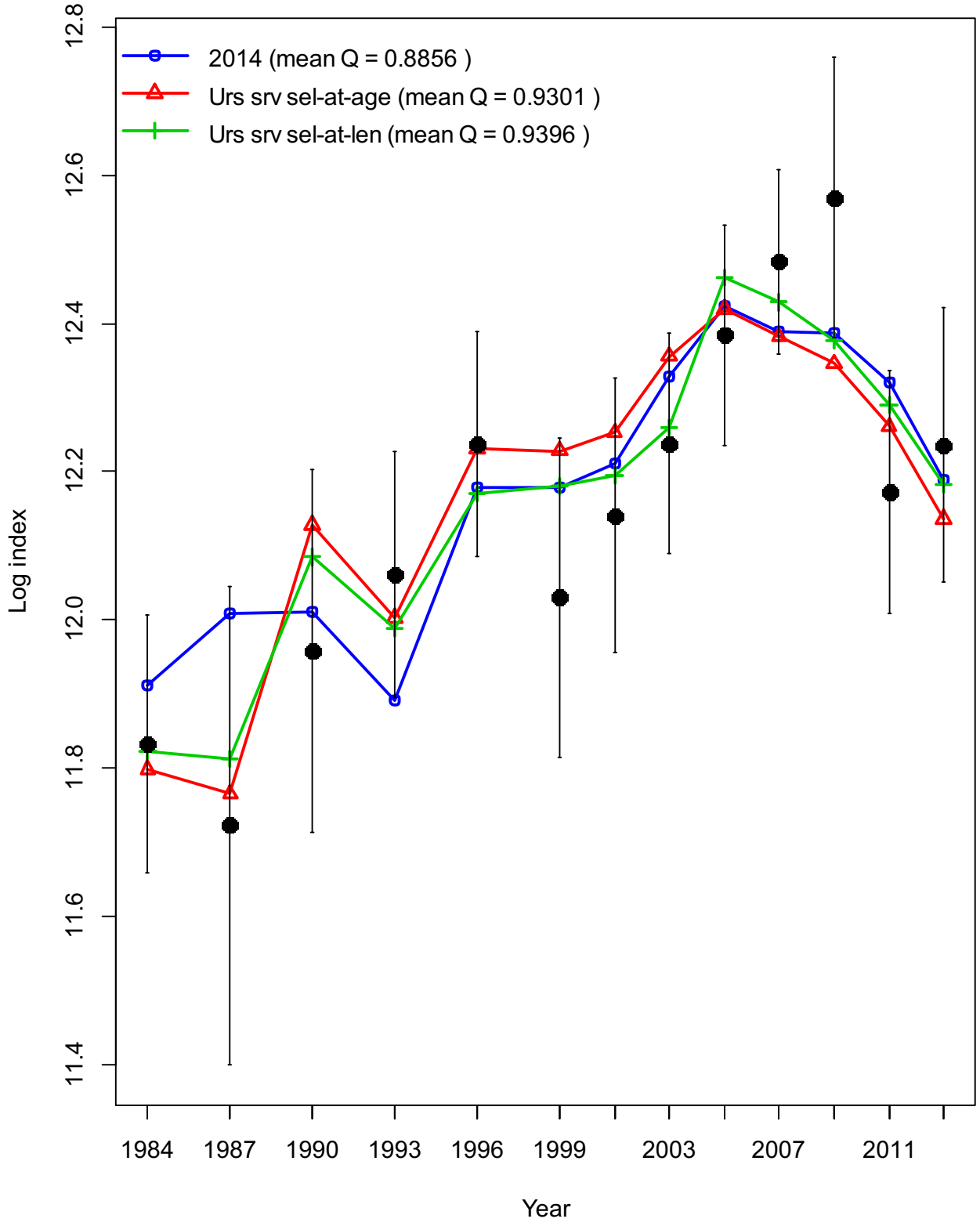

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Figure 10 – Estimates of recent spawning biomass for northern rock sole

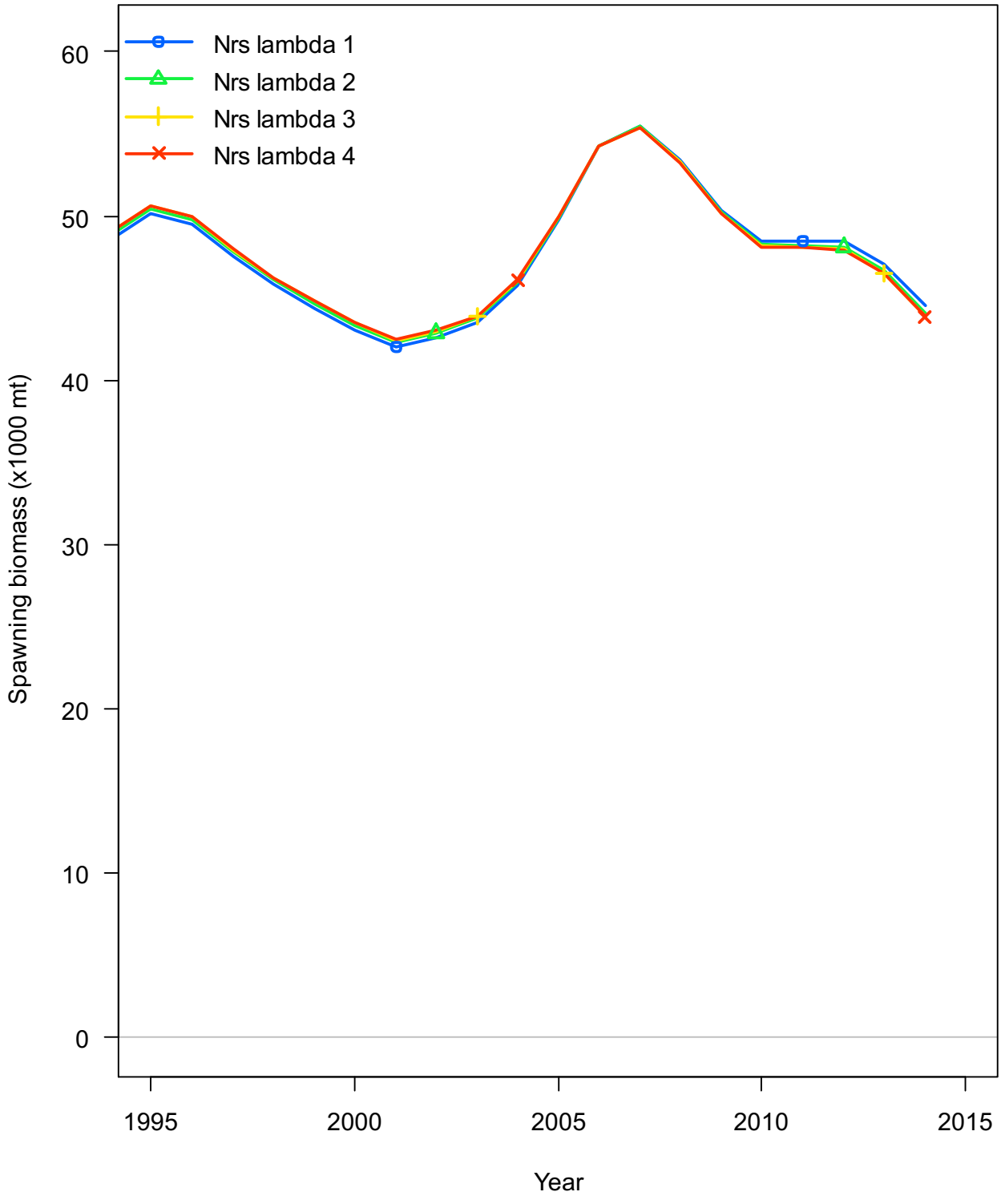

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Figure 11 – Estimates of recent age-0 recruits for northern rock sole

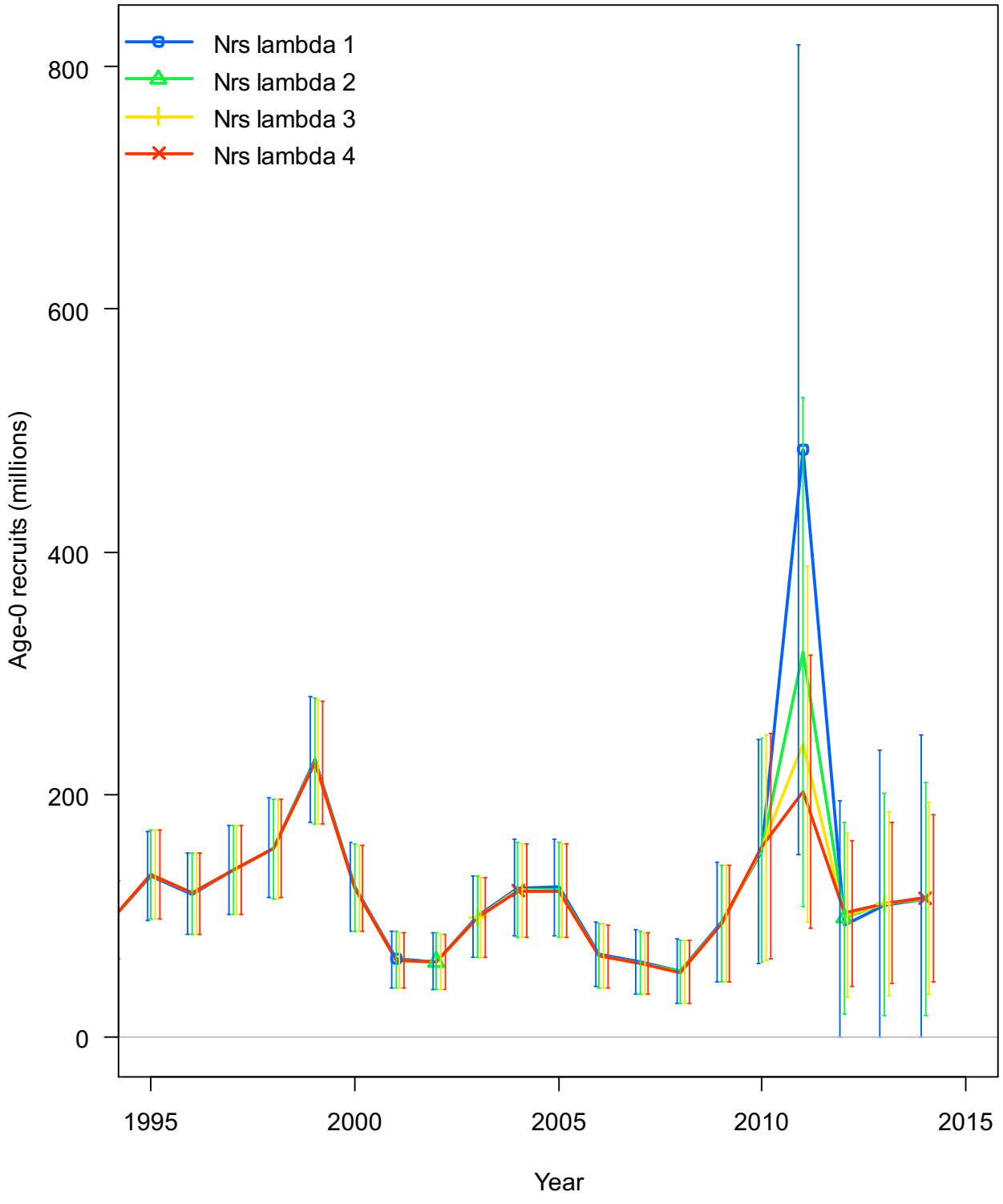

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Figure 12 – Estimates of recent spawning biomass for southern rock sole

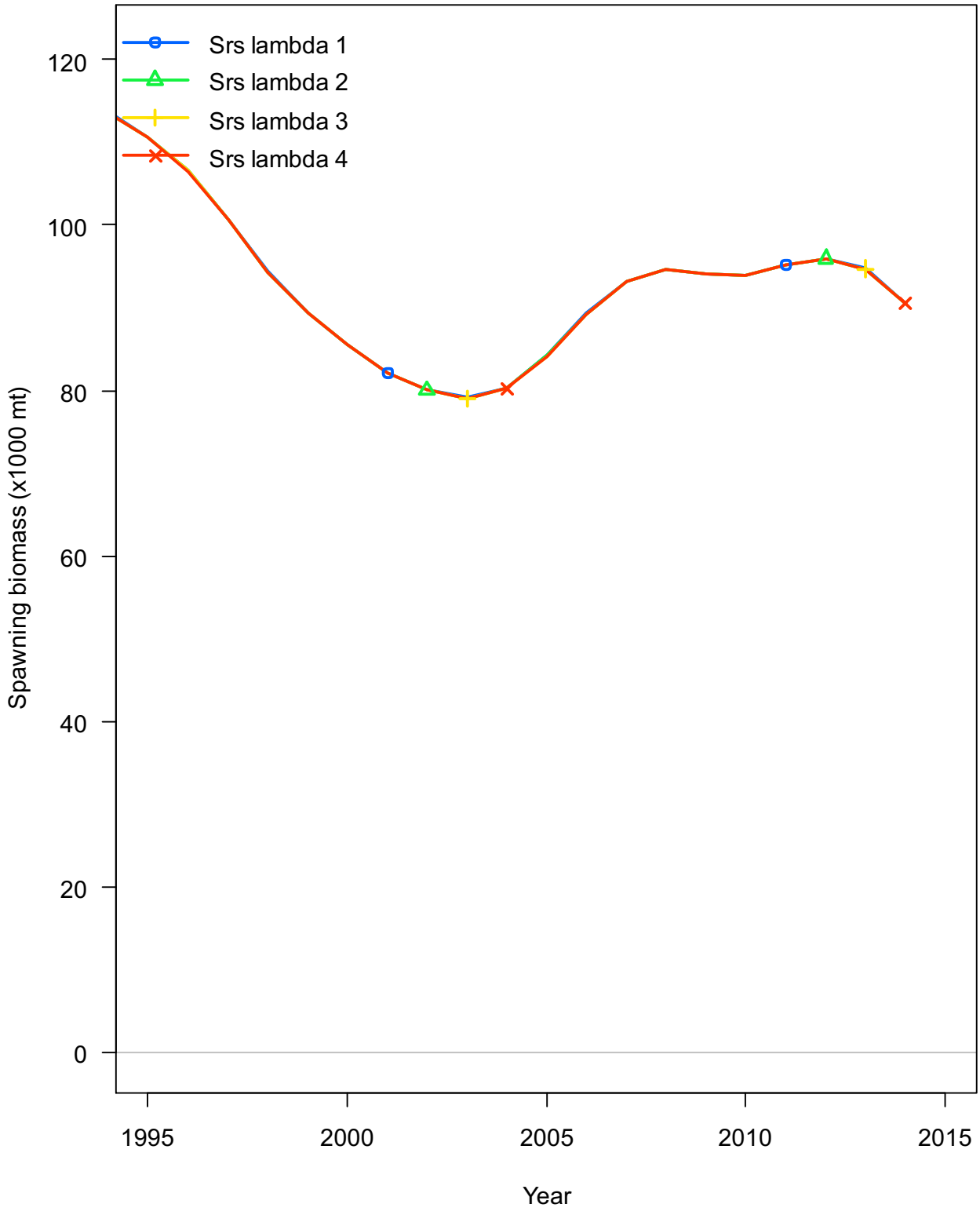

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Figure 13 – Estimates of recent age-0 recruits for southern rock sole

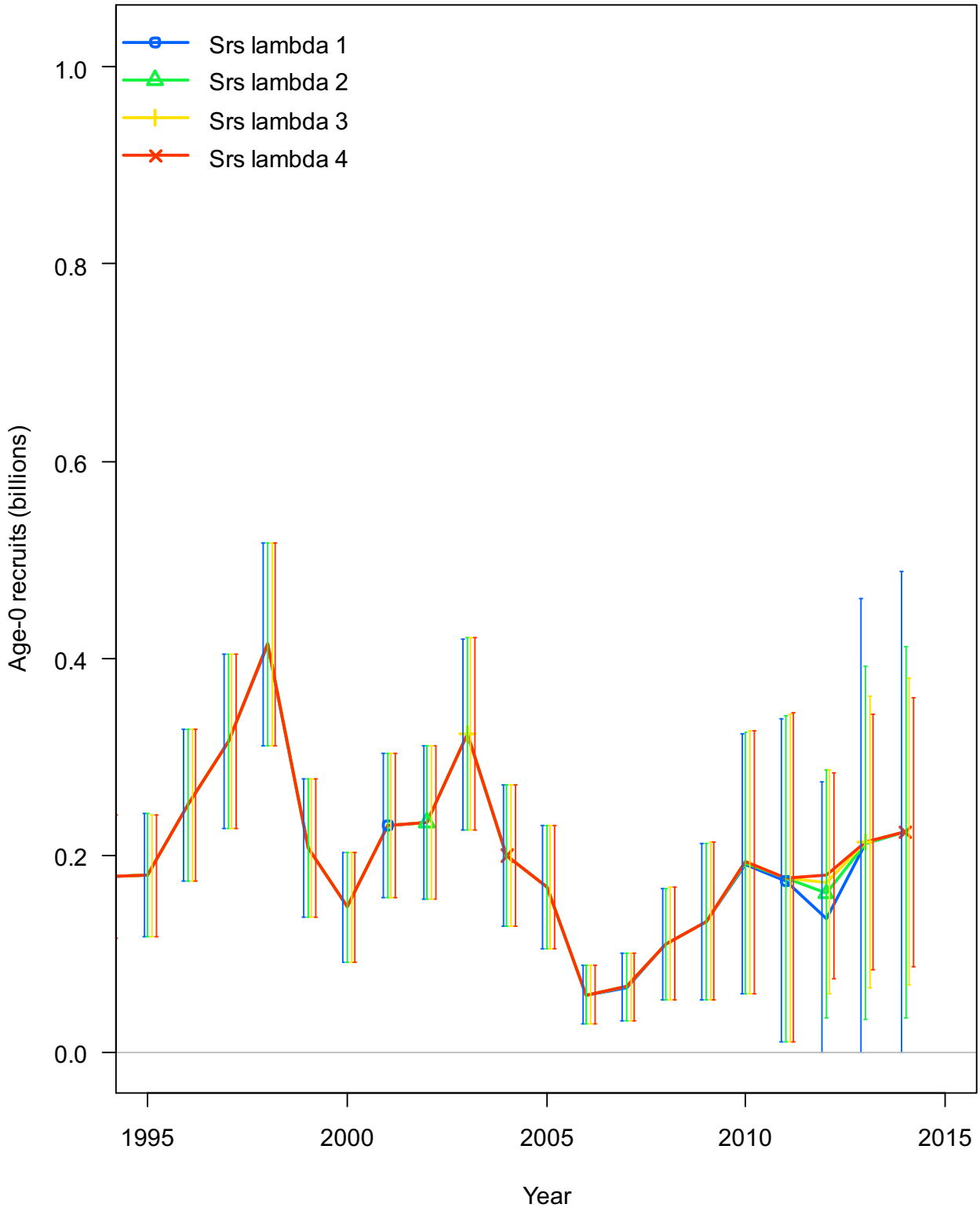

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Figure 14 – Estimates of recent spawning biomass for undifferentiated rock sole

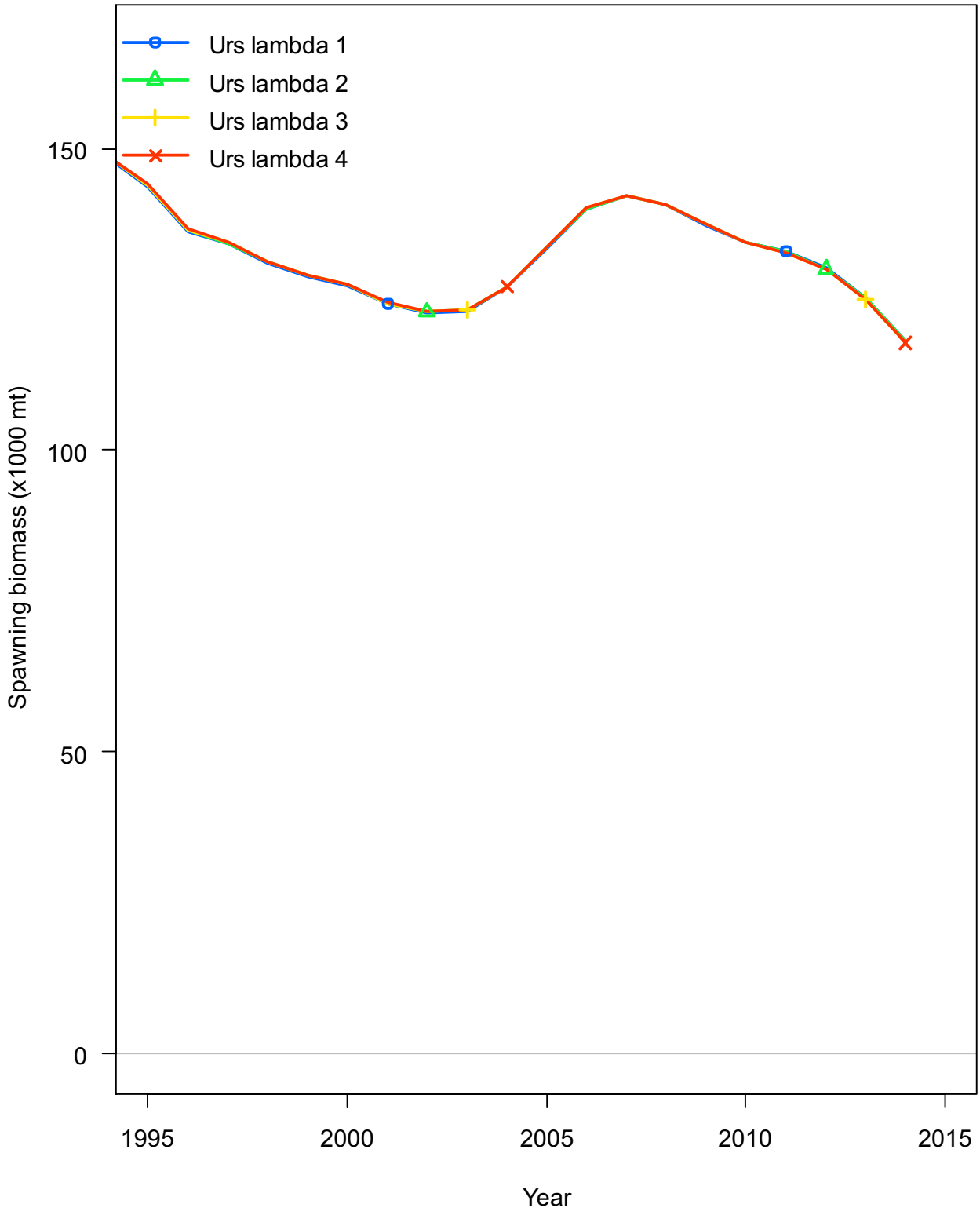

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Figure 15 – Estimates of recent age-0 recruits for undifferentiated rock sole

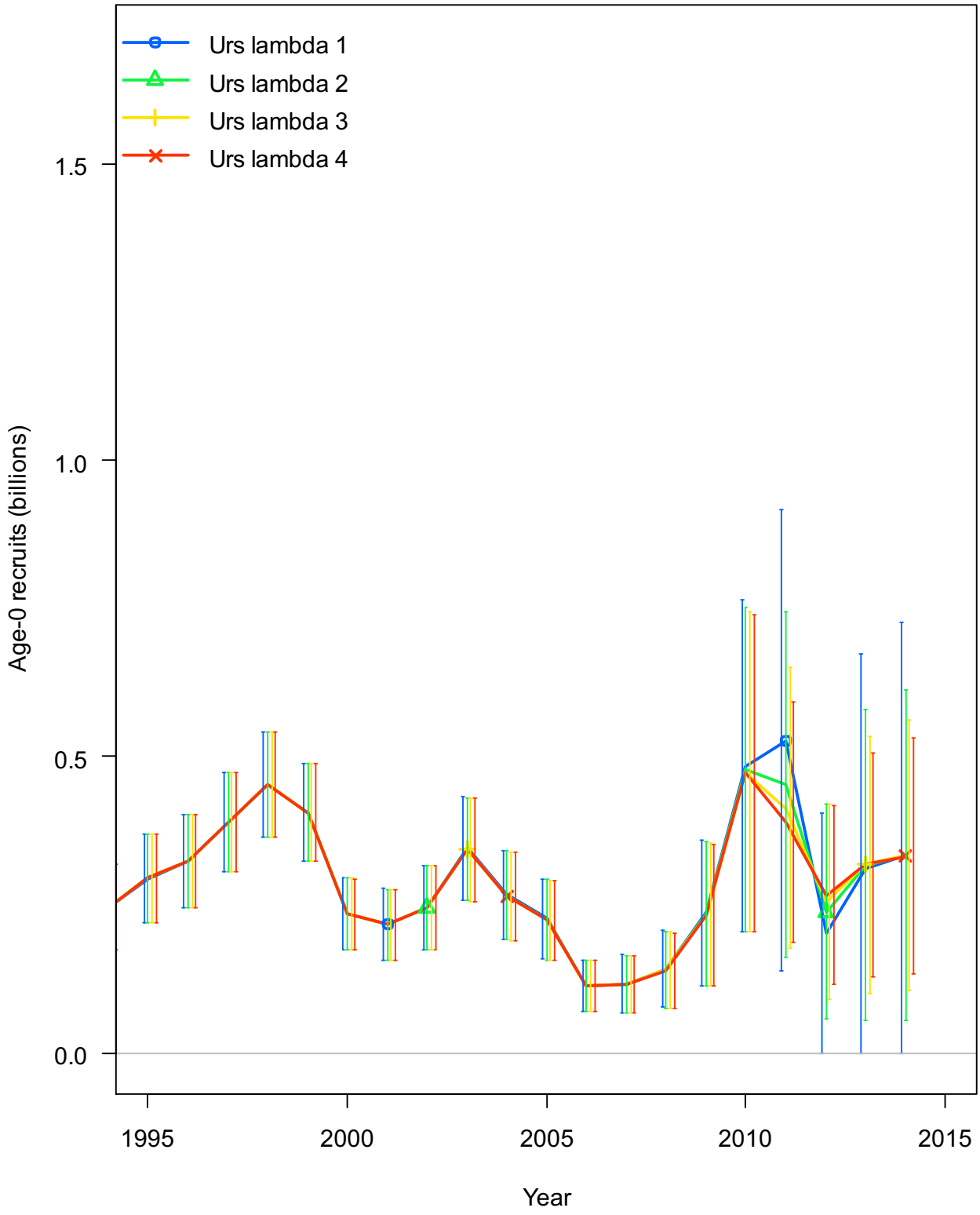

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Figure 16 – Estimates of spawning biomass for undifferentiated, northern, and southern rock sole

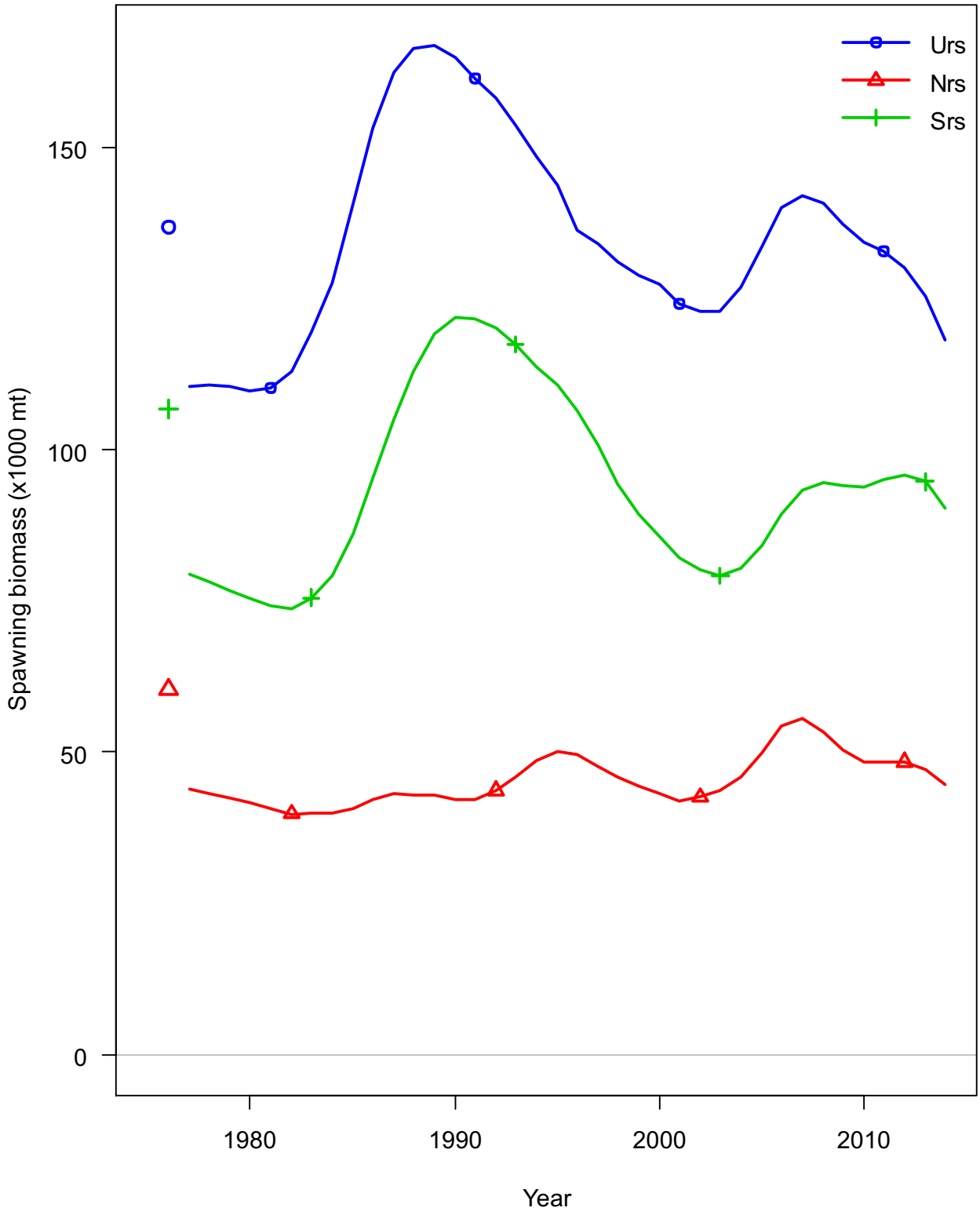

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Figure 17 – Estimates of age-0 recruits for undifferentiated, northern, and southern rock sole

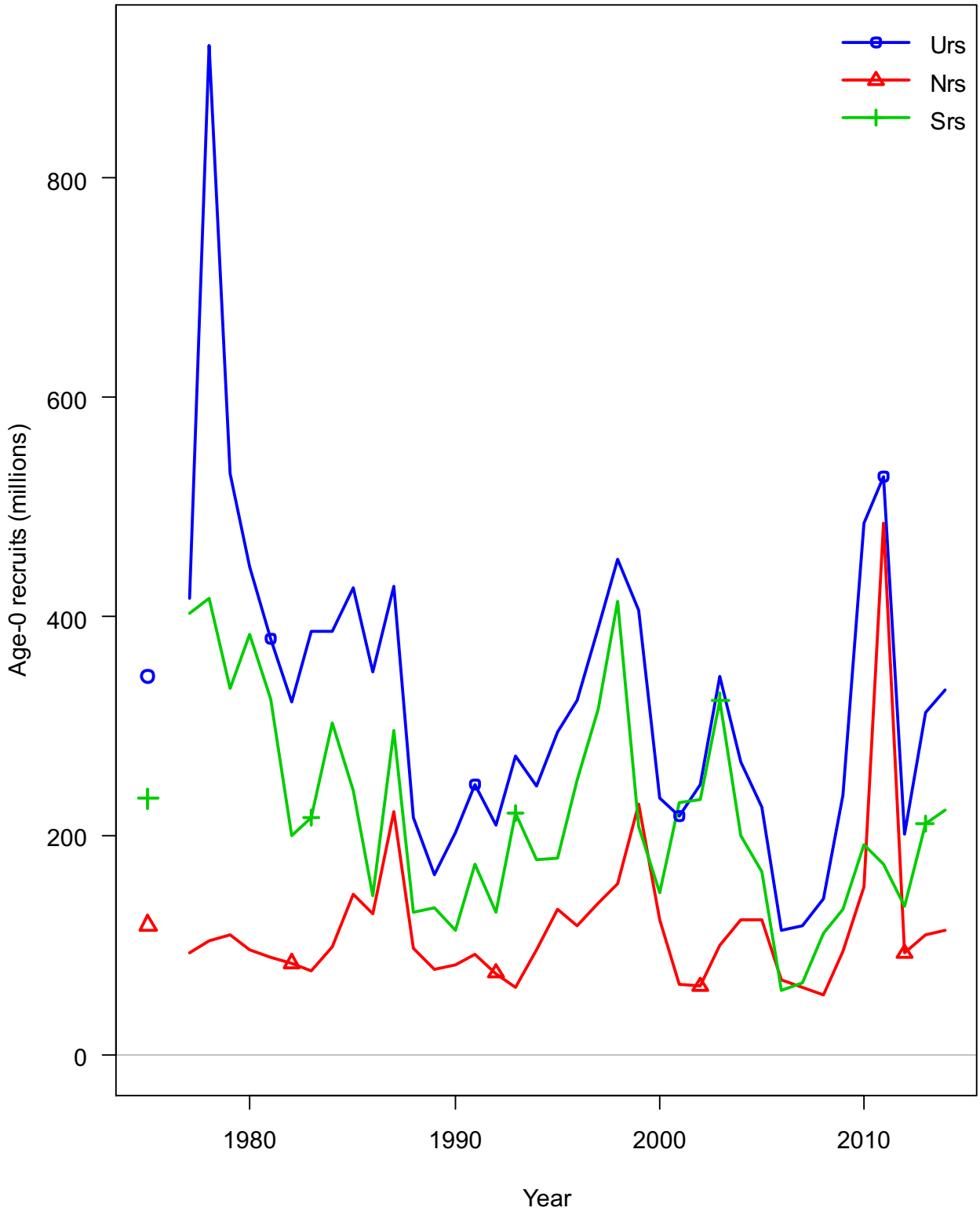

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Figure 18 – Estimates of survey biomass for undifferentiated, northern, and southern rock sole

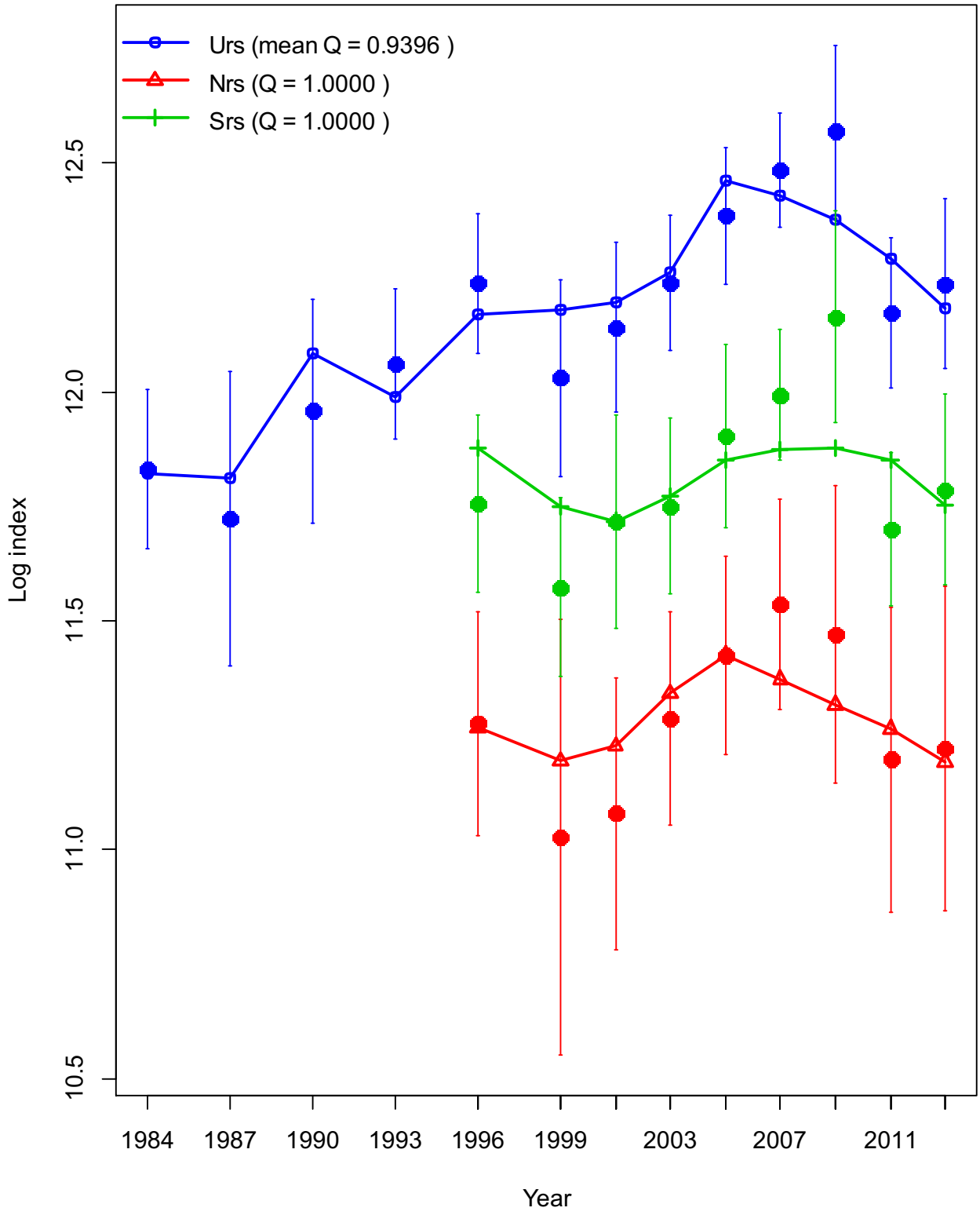

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Figure 19 – Fishery and survey selectivity-at-length curves for males and females for Nrs

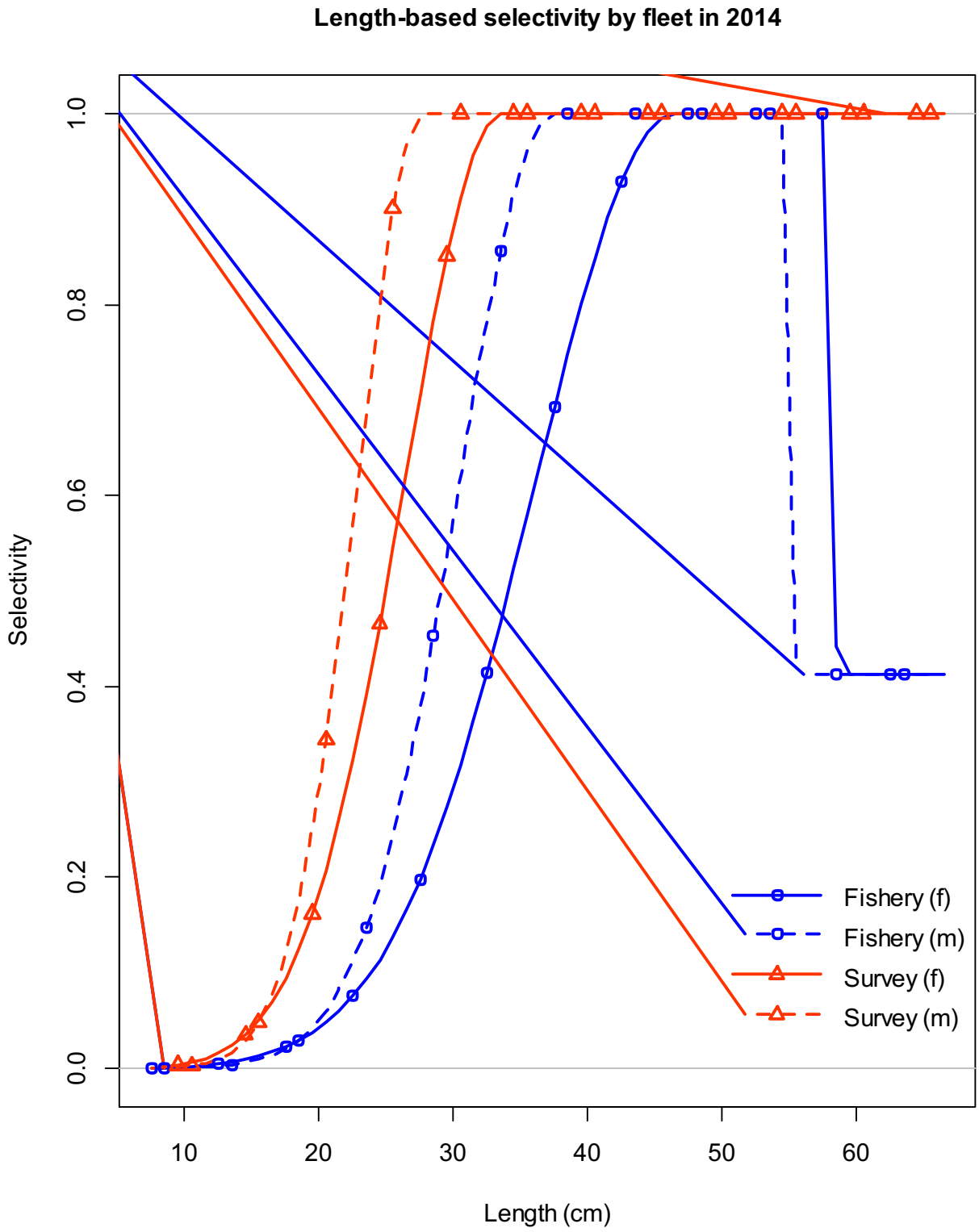

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Figure 20 - Fishery and survey selectivity-at-length curves for males and females for Srs