Preliminary Results from the Base Case Assessment of the South African Sardine Resource

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This document provides some preliminary results for the fit of the base case sardine assessment model at the posterior mode. The model is detailed in Cunningham and Butterworth (2007), with the following changes:

i) the model is not tuned to the observed proportions-at-age in the November survey nor the observed proportions-at-length in the November survey (i.e. lnL^{prop} is excluded from the likelihood);

ii) the age at 50% selectivity, a^S, is fixed to age 1;

iii) selectivity at age 0 is estimated separately (i.e. not part of the logistic curve);

iv) adult natural mortality, M_a^S, $a = 1,\ldots,5+$, is estimated within the model.

In this model fit, the multiplicative bias associated with the November survey is fixed at 1 (Cunningham and Butterworth 2007), compared to 0.72 during the last assessment (Cunningham and Butterworth 2004). For the last base case assessment k_N^S was set equal to the median of the pdf for the overall bias in the November survey, including target strength as a source of error. The revised series of biomass estimates now takes the new target strength calculations into account.

The inclusion of the 5+ group in the model, as opposed to assuming sardine of age 5 spawn and then die, has prompted the move to estimate adult natural mortality rather than fix it at 0.4 as previously assumed.

Results

The model fit to the data at the posterior mode is shown in Figure 1 for acoustic spawner biomass, Figure 2 for recruitment and Figure 3 for the proportion-at-age in the November survey. The residuals from the model fit to the observed proportions-at-length in the November survey are shown in Figure 4 and for the proportions-at-length in the commercial catch in Figure 5. The model predicted November spawner biomass and recruitment at the posterior mode is shown in Figure 6, together with the model estimated hockey-stick stock-recruitment curve. The selectivity-at-age is shown in Figure 7.

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Table 1 lists the values of some key model parameters and outputs at the joint posterior mode for this current model fit. Samples from the posterior distributions of the finalised model of these parameters will be used to develop the new OMP. For initial comparative purposes, the corresponding values at the posterior mode from the last assessment used to develop OMP-04 are given. The average 1991 to 1994 biomass, previously used to define risk, is shown in comparison to the historic predicted biomass and the carrying capacity in Figure 8.

Discussion

The model fit to the November biomass and May recruitment is good. The latter is a little surprising, but it is important to know that the bias estimated for the May recruitment is just 0.4, i.e. the model predicts that the survey only estimates 40% of the recruitment numbers actually available. The proportion-at-age in the November survey has been excluded from the current fit due to the apparent mis-match between the proportion-at-age 1 during the 2000s compared to the 1990s. The reasons for this need to be further explored. In addition, further refinements to the commercial selectivity is required. In particular, the selectivity at age 0 relates mainly to the bycatch fishery and may require separate modelling by quarter.

References

Cunningham, C.L., and Butterworth, D.S. 2004. Base Case Bayesian Assessment of the South African Sardine Resource. MCM Document WG/PEL/APR04/02. 22pp.

Cunningham, C.L., and Butterworth, D.S. 2007. Base Case Assessment of the South African Sardine Resource. ASWS/JUL07/PEL/ASS/4a. 14pp.

Table 1. Key parameters and outputs at the joint posterior mode for the sardine assessment for use in developing the OMP. Biomasses are given in thousands of tonnes and numbers in billions.

	Previous Assessment (used to develop OMP-04)		Updated Assessment	
Starting numbers at age	$N^S_{2003,1}$	29.543	$N^S_{2006,1}$	10.428
	$N^S_{2003,2}$	22.462	$N^S_{2006,2}$	0.866
	$N^S_{2003,3}$	15.701	$N^S_{2006,3}$	0.681
	$N^S_{2003,4}$	7.468	$N^S_{2006,4}$	1.959
			$N^S_{2006,5+}$	1.824
Starting spawner biomass	$B^S_{2003,N}$	3176	$B^S_{2006,N}$	713
Selectivity curve parameters			a'	1 (fixed)
			δ	0.000001
Directed fishery selectivity	$S^{S\ 1}_1$	0.662	$S_{q,1}{}^2$	0.500
	S^S_2	1.000	$S_{q,2}$	1.000
	S^S_3	0.857	$S_{q,3}$	1.000
	S^S_4	0.331	$S_{q,4}$	1.000
			$S_{q,5+}$	1.000
Juvenile natural mortality	M^S_{ja}	1.0 (fixed)	M^S_0	1.0 (fixed)
Adult natural mortality	M^S_{ad}	0.4 (fixed)	$M^S_a\ a=1,\dots,5+$	0.65
Biases for November and recruitment surveys	k^S_N	0.720	k^S_N	1 (fixed)
	k^S_r	1.039	k^S_r	0.464
Stock-recruitment parameters	a^S	86.3	a^S	26.4
	b^S	2319	b^S	583
	K^S	5926	K^S_{normal}	1532
			K^S_{peak}	1244
Last estimated recruitment residual	ε^S_{2002}	0.009	ε^S_{2005}	0.083
Recruitment residual standard deviation	$\sqrt{0.4^2+\left(\lambda^S_0\right)^2}$	0.416	$\sqrt{0.4^2+\left(\lambda^S_0\right)^2}$	1.077
Recruitment serial correlation	s^S_{cor}	0.257	s^S_{cor}	0.214
Average 91-94 Biomass[3]	$\overline{B}^S_{Nov}$	907	$\overline{B}^S_{Nov}$	441

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[1] Selectivity was estimated as $S^S_a = \overline{F}^S_a / \overline{F}^S_{max}$, using $\overline{F}^S_a = \tfrac{1}{5}\sum_{y=1999}^{2003} \dfrac{C^S_{y,a}}{N^S_{y,a}e^{-M^S_a/2}}$, where

$\overline{F}^S_{max} = \max\{\overline{F}^S_1;\overline{F}^S_2;\overline{F}^S_3;\overline{F}^S_4\}$.

[2] Selectivity calculated using the logistic curve (A.7).

[3] OMP-04 was developed using Risk defined as "the probability that adult sardine biomass falls below the average adult sardine biomass over November 1991 and November 1994 at least once during the projection period of 20 years".
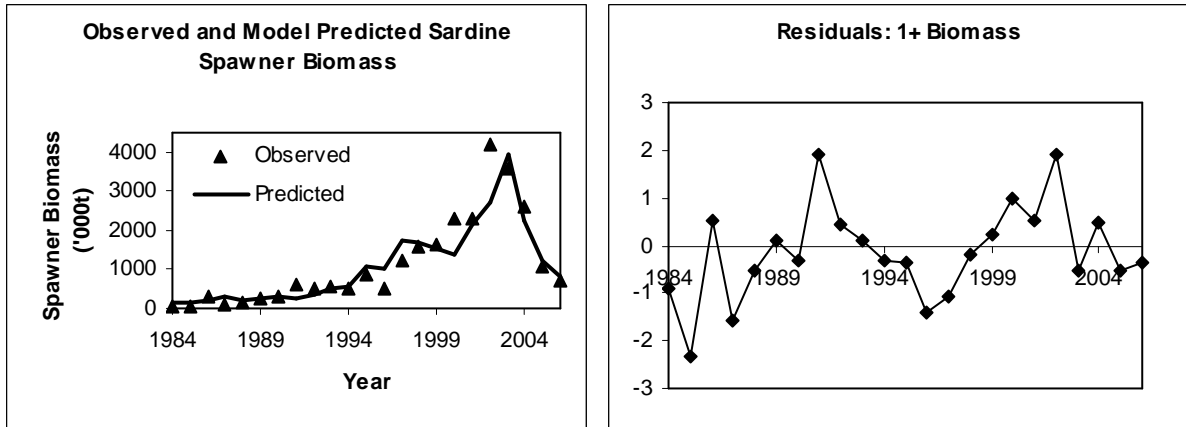
Figure 1. Observed and model predicted November sardine spawner biomass from 1984 to 2006. The standardised residuals from the fit are given in the right hand plot.
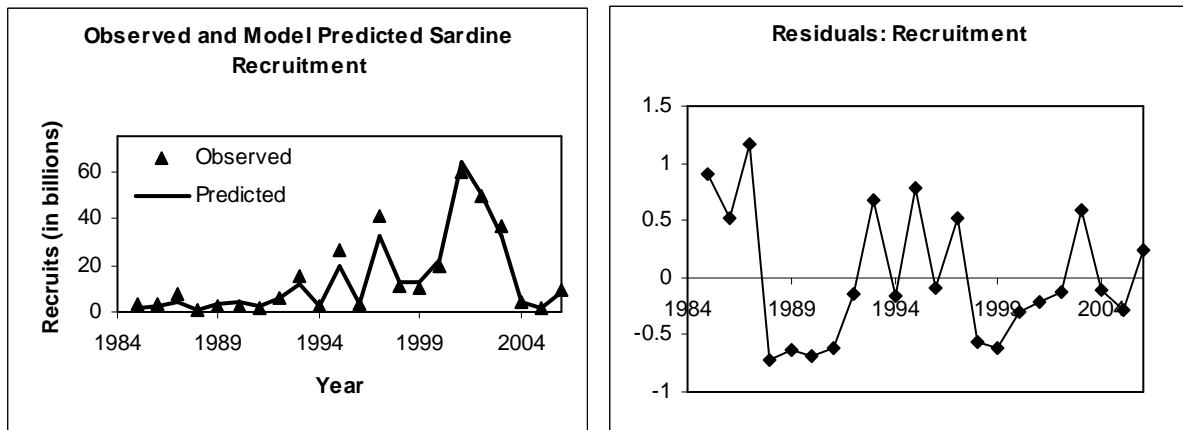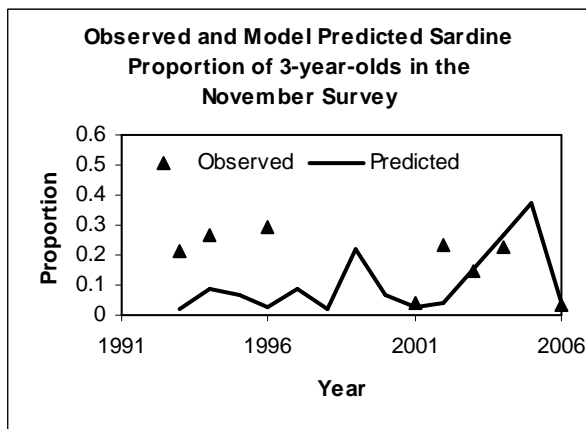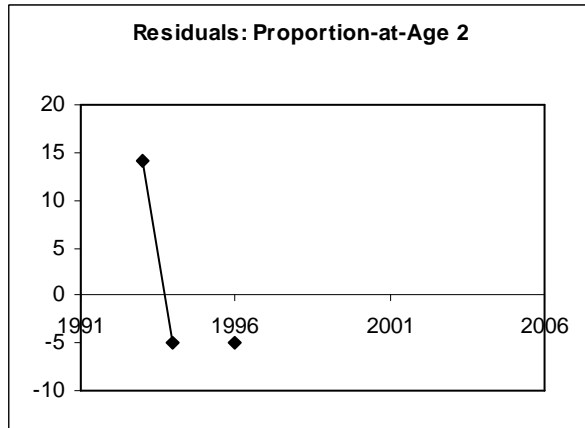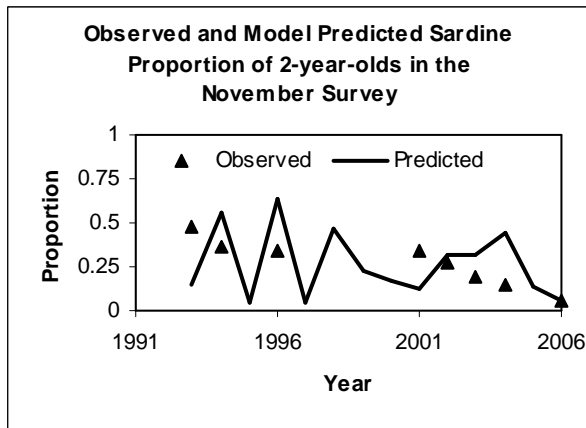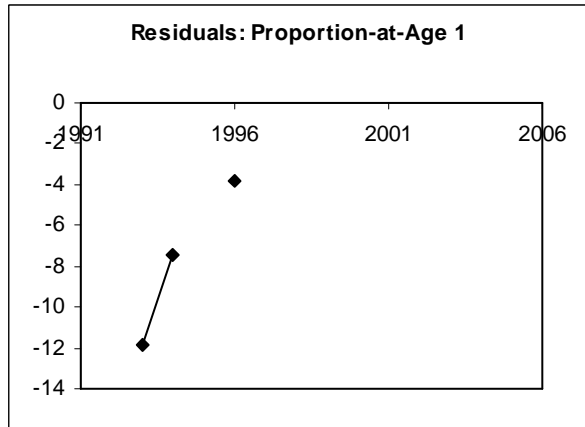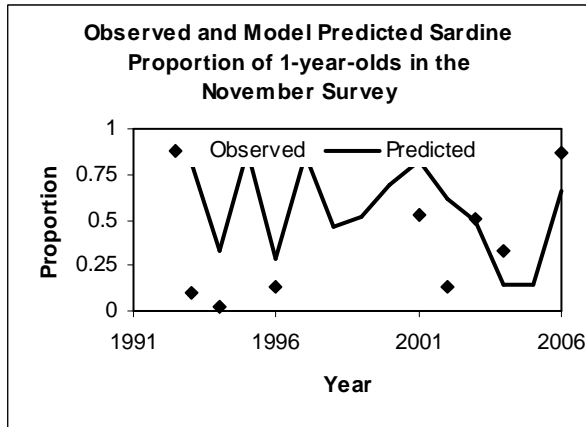

Figure 2. Observed and model predicted sardine recruitment numbers from May 1985 to May 2006. The standardised residuals from the fit are given in the right hand plot.
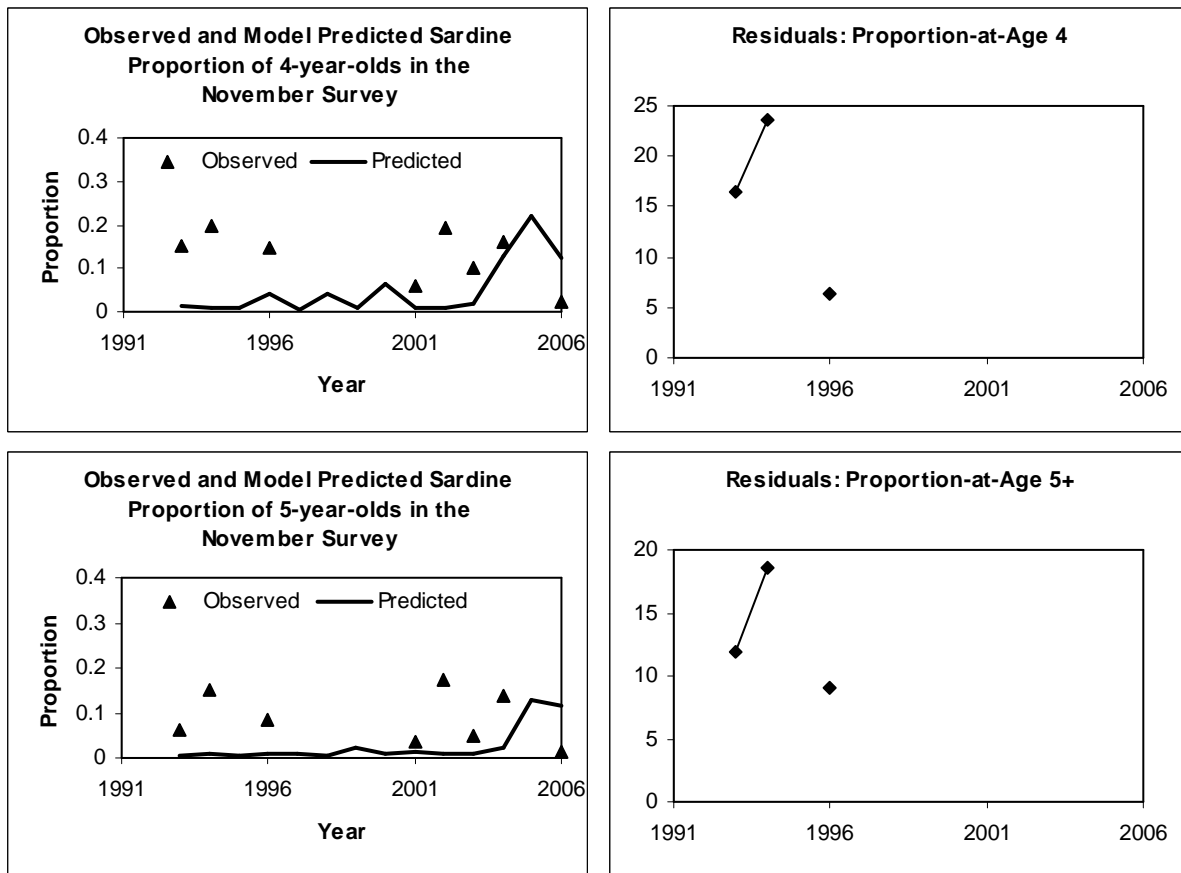
Observed and Model Predicted Sardine Proportion of 1-year-olds in the November Survey

Residuals: Proportion-at-Age 1

Observed and Model Predicted Sardine Proportion of 2-year-olds in the November Survey

Residuals: Proportion-at-Age 2

Observed and Model Predicted Sardine Proportion of 3-year-olds in the November Survey

Residuals: Proportion-at-Age 3

Figure 3. Observed and model predicted sardine proportions-at-age in the November survey from November 1993 to November 2006. (Excluded from the likelihood for these results). The standardised residuals are given in the right hand plot.
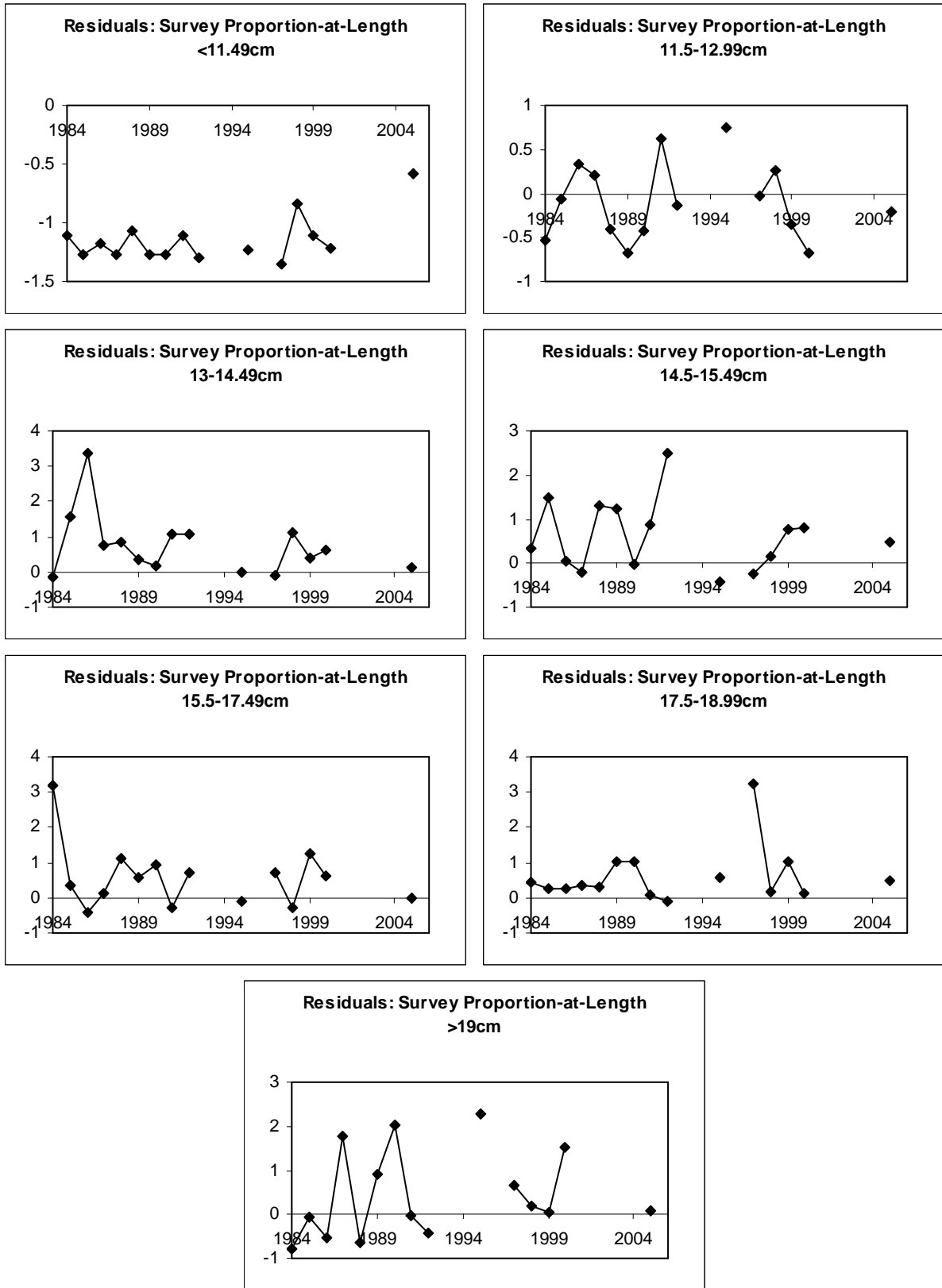
Figure 4. The standardised residuals between the model predicted sardine proportions-at-length and those observed in the November survey from November 1984 to November 2006. (Excluded from the likelihood for these results).
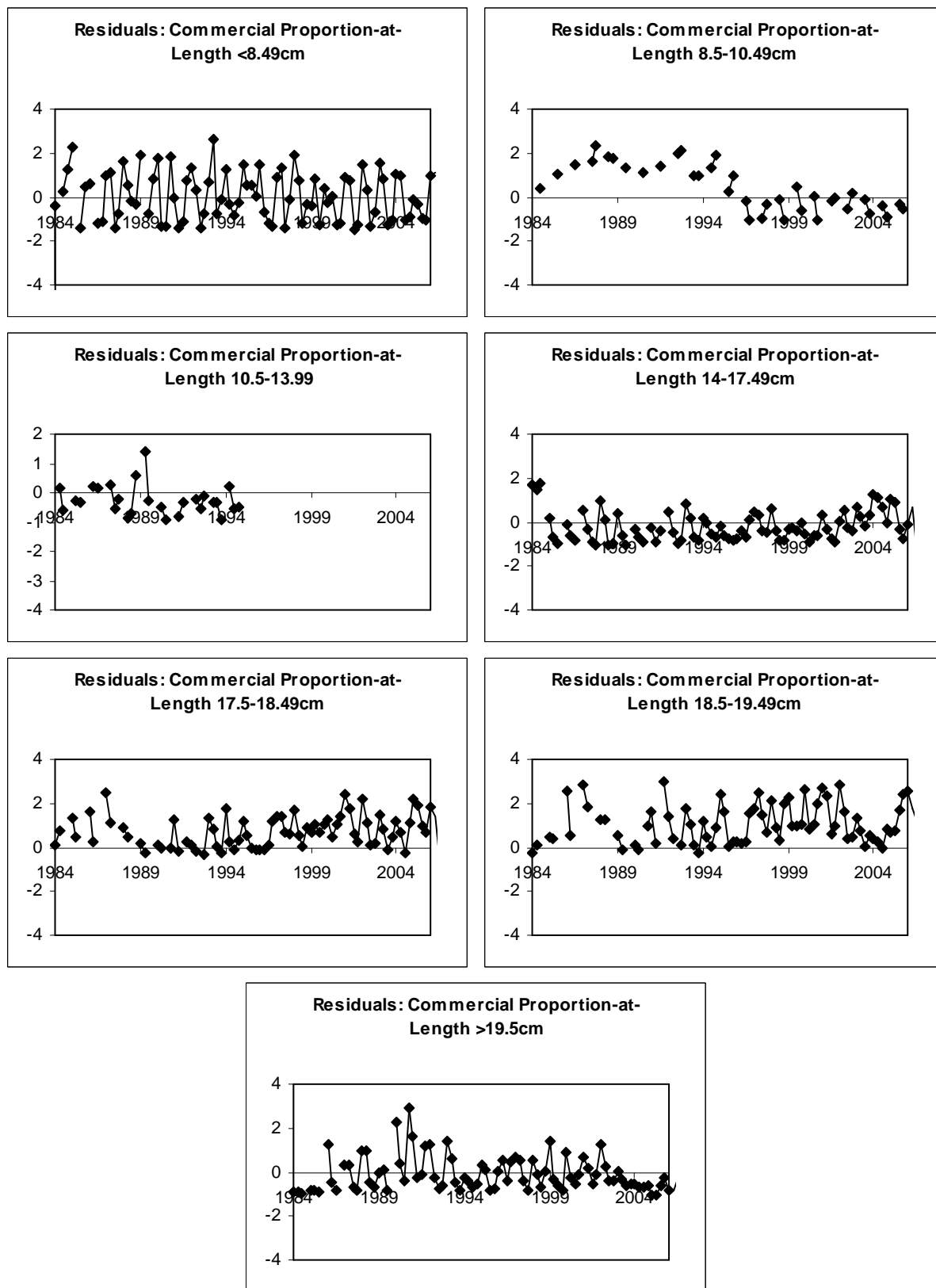
Figure 5. *The standardised residuals from the fit of model predicted sardine catch proportions-at-length to those observed in quarterly commercial catch from November 1984 to October 2006.*
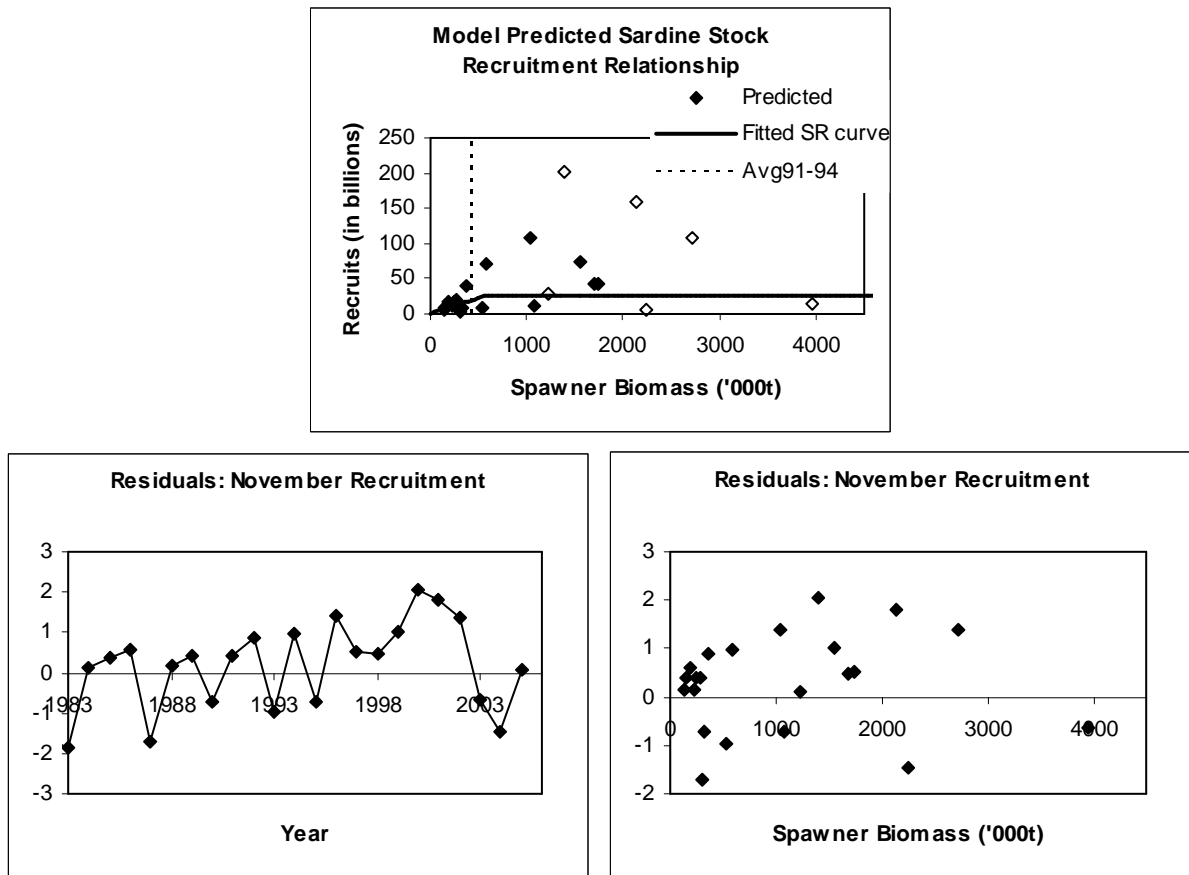
Figure 6. Model predicted sardine recruitment (in November) plotted against spawner biomass from November 1984 to November 2005, with the 'hockey-stick' stock-recruitment curve. The open diamonds represent November 2000 to 2005. The average 1991-1994 biomass, previously used to define risk, is also shown. The unstandardised residuals, ε_y^S, over time and plotted against spawner biomass are given in the lower plots.
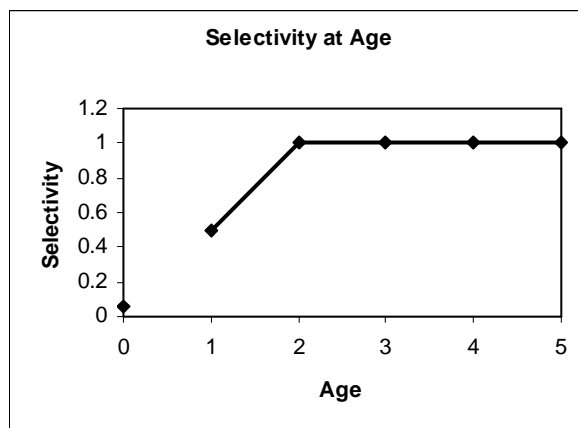

Figure 7. Commercial selectivity at age. Selectivity at age 0 was estimated separately, while a logistic curve was used for ages 1+, with the allowance for a decrease from age 3.
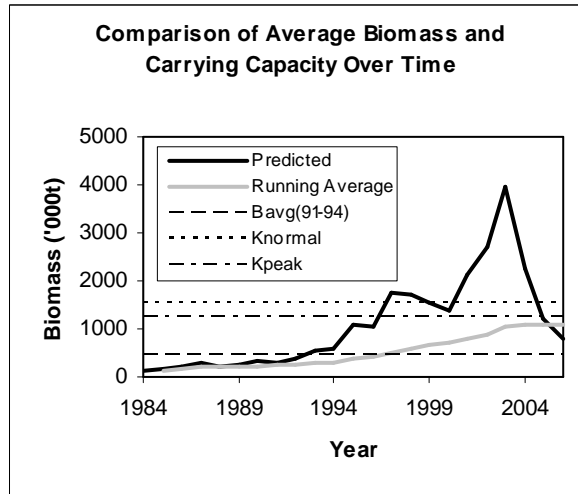
Figure 8. The model predicted November 1+ biomass compared to the average biomass over time, the average biomass between 1991 and 1994 (previously used as the risk threshold) and carrying capacity.