Updated Anchovy Assessment

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The previous full assessment of the SA anchovy resource, used to develop OMP-08, was tuned to data up to and including November 2006 (Cunningham and Butterworth 2007, with further undocumented updates). Since then 3 further years of estimates of May recruitment and 2 further years of estimates of November 1+ biomass have been forthcoming from surveys. This document presents an update of the anchovy assessment (posterior modes only), now taking data up to August 2009 into account. This is to obtain a better understanding of the current status of the population, and as a routine check to confirm that the situation remains within the range tested when developing OMP-08.

Methods

The new data used in this assessment, other than those used in the previous assessment and documented in Cunningham *et al*. 2007, are detailed in the Appendix. An assumption was made for the base case that the monthly average anchovy catch between April and August 2009 (chosen because this broadly corresponds to the period when recruits of the year have entered the fishery) is also caught in September and in October 2009. A sensitivity test assuming double this catch in September and October 2009 was also run (see Appendix for the actual values used).

The base case assessment model is identical to that implemented to produce the Bayesian posterior distributions used to develop OMP-08 (Cunningham and Butterworth 2007, with further undocumented updates). Due to time constraints, model runs have been taken as far only as to provide posterior modes.

Results and Discussion

The model fits to the November 1+ biomass, May recruitment and proportion-at-age 1 in the November survey are shown in Figures 1, 2 and 3 respectively. The residuals from the model fit to the November 1+ biomass and May recruitment data are shown in Figures 4 and 5 respectively. It is evident from these Figures that there is little difference in the predictions from 1984 to 2006 from the updated model compared to those of the previous assessment. There was no difference between the model fit to the DEPM estimates of spawner biomass between the updated and previous assessments (results therefore not shown). The inclusion of three further years of data has only slightly altered the predicted hockey stick stock recruitment curve from that estimated by the previous assessment (Table 1, Figure 6), with the three most recent recruitments being estimated with positive residuals (Figure 7).

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There is little difference between the base case assessment and the sensitivity test assuming a higher anchovy catch during September and October 2009 (and thus results are not shown on the Figures). The November 2009 1+ biomass is predicted to be only 9 000t smaller under the sensitivity test (Table 1).

There seems to be a weak increasing trend over time in the stock-recruitment residuals (Figure 7), which corresponds with the systematic under-estimation of recruitment since 2000 (Figures 2,5). Assuming alternative (higher and lower) fixed values of juvenile and/or adult natural mortality from 2000 – 2009 offered only a minor improvement in the fit to May recruitment for some cases; however, the general increasing trend remained.

The loss to natural mortality estimated by the base case assessment is given in Table 2.

Summary

In summary, the results from this updated assessment are broadly similar to what was obtained from the previous assessment using data up to November 2006. There is nothing sufficiently "unusual" to suggest other than the continued application of OMP-08.

The base case assessment predicts a November 2009 1+ biomass of 4 693 000t (taking bias into account). If this biomass was observed in November 2009, the 2010 initial anchovy TAC would be 342 000t (calculated by applying the initial anchovy TAC rule with the values:

$$0.78 * 0.85 * 300 * (0.7 + 0.3 * 4693/1380)$$

with no constraints applied).

Acknowledgements

Janet Coetzee and Jan van der Westhuisen are thanked for providing the data to update the anchovy assessment.

References

Cunningham, C.L., and Butterworth, D.S. 2007. Assessment of the South African Anchovy Resource. MCM/2007/SEP/SWG-PEL/05. 29pp.

Cunningham, C.L., van der Westhuizen, J.J., Durholtz D. and Coetzee, J. 2007b. A Record of the Generation of Data Used in the Sardine and Anchovy Assessments. MCM Document MCM/2007/SEPT/SWG-PEL/03. 28pp.

Table 1. *Key model parameter values and model outputs estimated at the joint posterior mode (see Glossary for definitions). Fixed values are given in bold. Numbers are reported in billions and biomass in thousands of tonnes.*

Parameter	Previous Assessment (Data up to Nov 2006)	Updated Assessment (Data up to Aug 2008)	
	Base Case	Base Case	Sensitivity Test
M_j^A	**0.9**	**0.9**	**0.9**
M_{ad}^A	**0.9**	**0.9**	**0.9**
-ln(posterior)	55.74	59.51	59.51
k_N^A	1.45	1.44	1.44
k_r^A	1.13	1.17	1.17
k_r^A / k_N^A	0.78	0.82	0.82
k_q^A		0.94	0.94
$\left(\lambda_N^A\right)^2$	**0**	**0**	**0**
$\left(\lambda_r^A\right)^2$	**0**	**0**	**0**
$\overline{B}_{Nov}^A$	928.4	930.8	930.8
$k_N^A \times \hat{B}_{2008,N}^A$	N/A	3775	3775
$k_N^A \times \hat{B}_{2009,N}^A$	N/A	4693	4684
K^A	2455	2703	2703
a^A	231.8	255.5	255.5
b^A	491.1	540.7	540.6
σ_r^A	0.732	0.730	0.730
η_{2005}^A or η_{2008}^A	-0.421	0.776	0.776
s_{cor}^A	0.508	0.514	0.514

***Table 2**. The annual estimated loss to natural mortality shown as a proportion of the corresponding mid-season biomass.*[1]

Year	Loss to Natural Mortality	Year	Loss to Natural Mortality	Year	Loss to Natural Mortality
1984	0.20	1993	0.21	2002	0.05
1985	0.22	1994	0.23	2003	0.08
1986	0.18	1995	0.33	2004	0.09
1987	0.28	1996	0.11	2005	0.14
1988	0.31	1997	0.08	2006	0.09
1989	0.31	1998	0.11	2007	0.12
1990	0.22	1999	0.11	2008	0.08
1991	0.09	2000	0.07	2009	0.05
1992	0.20	2001	0.06		

[1] Note this is approximated as half way through the modelled year (i.e. 1st May), though in the assessment juvenile and 1-year-old catch are modelled to be taken in a pulse at different times of the year (Cunningham and Butterworth 2007).

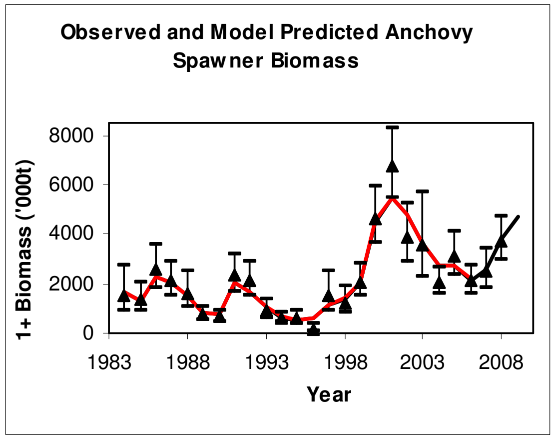


Figure 1. *Observed and model predicted anchovy 1+ biomass from the previous assessment (red line) and the base case updated assessment (black line). The predicted 1+ biomasses from the sensitivity test are not distinguishable from the base case and are thus not included in this figure.*

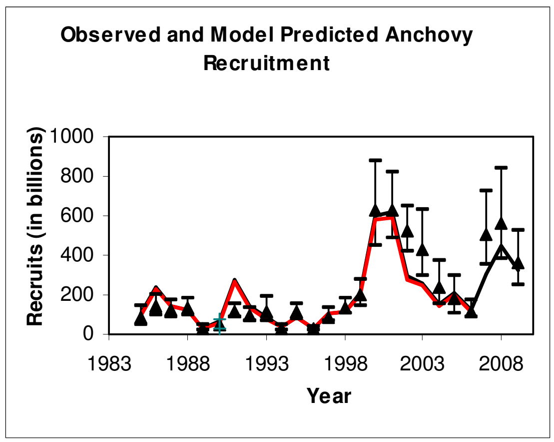


Figure 2. *Observed and model predicted anchovy May recruitment from the previous assessment (red line) and the base case updated assessment (black line).*

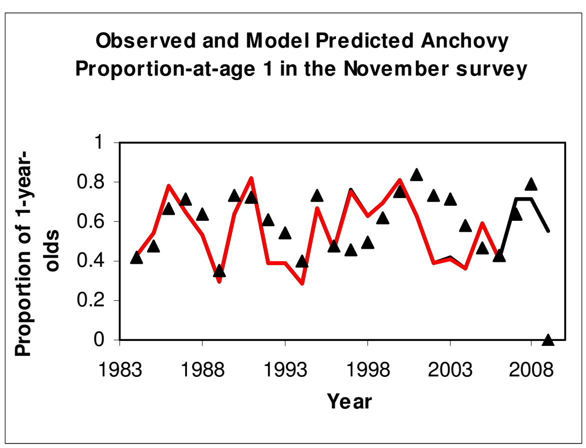


Figure 3. *Observed and model predicted anchovy proportion-at-age 1 in the November survey from the previous assessment (red line) and the base case updated assessment (black line).*

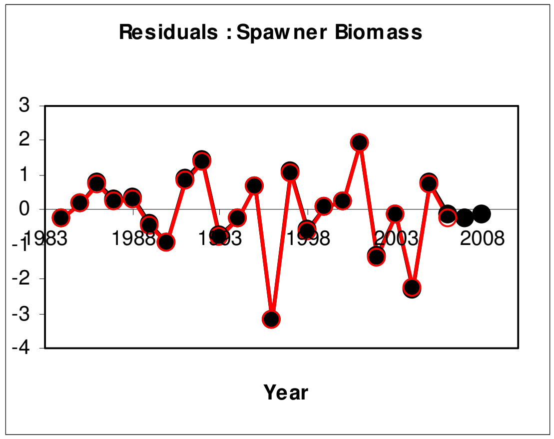


Figure 4. *Standardised residuals of the model fit to the November 1+ biomass data from the previous assessment (red line) and the base case updated assessment (black line).*

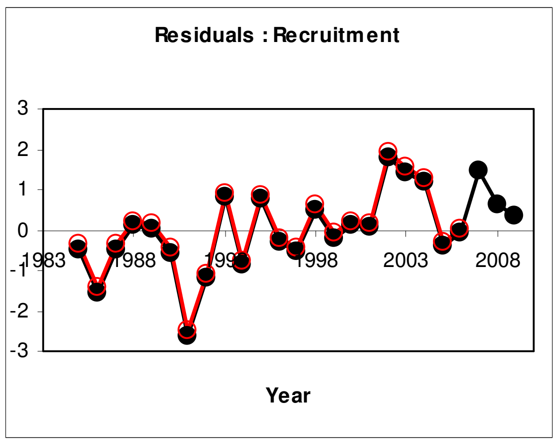


Figure 5. *Standardised residuals of the model fit to the May recruitment data from the previous assessment (red line) and the base case updated assessment (black line).*

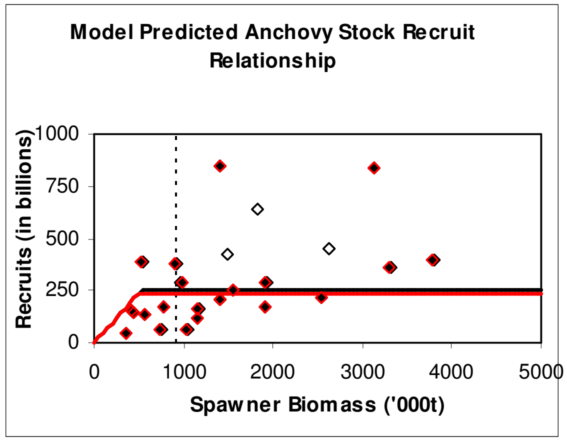
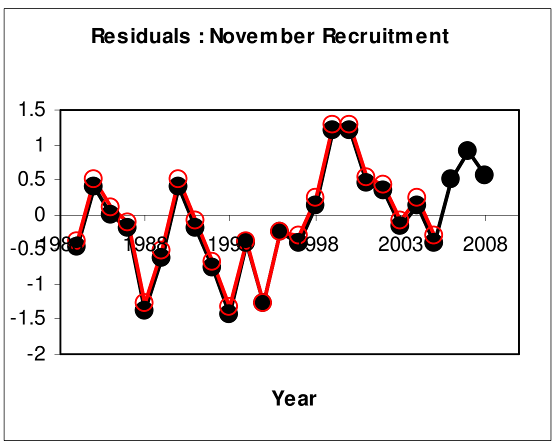


Figure 6. *Model predicted anchovy recruitment (in November) plotted against spawner biomass from November 1984 to November 2008 (previous assessment, red points; updated assessment, black points), with the 'hockey-stick' stock-recruit curve. The open diamonds denote the 2006 to 2008 November spawner biomass and recruitment. The dashed line indicates the average 1991 to 1994 1+ biomass (used in the definition of risk in OMP-08).*



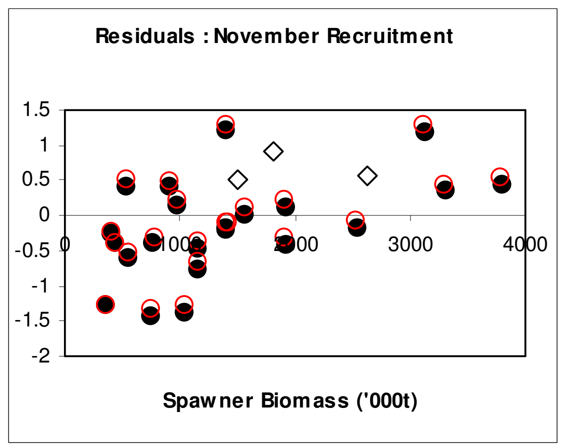


Figure 7. *Standardised November recruitment residuals from the previous assessment (red open circles) and the base case updated assessment (black circles), plotted against time (left panel) and against spawner biomass (right panel). The three most recent residuals (November 2006 to November 2008) are shown as open diamonds in the right panel.*

Glossary of Model Parameters

M_j^A is the natural mortality of juvenile anchovy (i.e. fish of age 0); and

M_{ad}^A is the natural mortality of adult anchovy (i.e. fish of age 1+).

k_N^A is the multiplicative bias associated with the November survey

k_r^A is the multiplicative bias associated with the recruit survey

k_q^A is the multiplicative bias associated with the proportion of 1-year-olds in the November survey

$(\lambda_{N/r}^A)^2$ is the additional variance (over and above the survey sampling CV that reflects survey inter-transect variance) associated with the November/recruit surveys;

$\overline{B}_{Nov}^A$

$\hat{B}_{y,N}^A$ is the biomass of adult anchovy at the beginning of November in year y, which are taken to be associated with the November survey

K^A is the carrying capacity

a^A is the maximum recruitment;

b^A is the spawner biomass below which the expectation for recruitment is reduced below the maximum

σ_r^A is the standard deviation of the recruitment residuals

η_y^A is the standardised recruitment residual value for year y

s_{cor}^A is the recruitment serial correlation

Appendix : Updated Data

Acoustic Survey Data

The new data included in this assessment are listed in the Table A.

Table A. *The hydroacoustic survey data from 2007.*

November Acoustic Survey			May Recruitment Survey			
Year	1+ Biomass ('000t)	CV	Year	Commencement Date	Recruitment (billions)	CV
2007	2507.501	0.157	2007	18th May	506.7	0.183
2008	3705.893	0.12	2008	21st May	563.2	0.202
			2009	15th May	363.4	0.188

As for earlier years, the 92-95 average Prosch ALK was used to calculate the weights-at-age and proportions-at-age 1 in the November 2007 and 2008 surveys. The average weights-at-age are used for estimating the November 2009 1+ biomass. These data, together with the average recruit weights from the May surveys are listed in Table B.

Table B. *November survey weights-at-age (in grams) and proportions-at-age 1.*

Year	Age 1	Age 2	Age 3	Age 4	Proportion-at-age 1	Average recruit weight (g)
Average	9.72	13.94	16.01	16.73		2.959
2007	7.96	15.72	18.71	19.14	0.64	2.544
2008	7.17	13.89	17.19	18.69	0.79	3.598

Commercial Catch Data

The data available for these calculations include the number of fish in length class l in month m, $N^{c}_{l,m}$, and the observed tonnage in month m, $ObsT_m$ from Nov 2006 to Aug 2009[2]. The September and October 2009 observed tonnage was taken to be either a) the average April-August 2009 landings or b) double this average. The RLF for September and October 2009 was taken to be proportional (by tonnage) to that in August 2009. The commercial catches-at-age are calculated in the same manner as described in Cunningham *et al*. 2007[3].

[2] August 2009 tonnage was raised by 2200t, the amount estimated to be outstanding when the data were collated.
[3] Recall, though, that the anchovy catch numbers in Cunningham *et al.* 2007 were given in thousands, not in numbers as mentioned therein.

Table C. *New anchovy catch data used in the updated assessment. The two alternatives for anchovy catch in September and October 2009 are listed as a) the average April-August 2009 catch (base case) and b) double the average (sensitivity test).*

Year	Catch-at-age 0 (billions)	Catch weight-at-age 0 (grams)	Catch-at-age 1 (billions)	Catch weight-at-age 1 (grams)	Recruit catch from 1 Nov to the day before the survey (billions)
2007	48.871	4.852	1.222	11.391	5.784
2008	50.416	4.132	4.376	11.682	3.720
2009a)	25.442	5.173	4.671	7.872	
2009b)	26.302	6.462	4.675	7.963	6.745