Update regarding Potential Directed Sardine TAC for 2006

C.L. Cunningham* and D.S. Butterworth*

Introduction

Last year Cunningham and Butterworth (2004b) presented some potential future directed sardine and anchovy TACs and sardine TABs under OMP-04, given data available up to December 2003, and Cunningham and Butterworth (2004c) updated these predictions for sardine using data observed prior to and during the May 2004 recruit survey. Given a second successive year of low recruitment for both sardine and anchovy, the Marine and Coastal Management Pelagic Working Group has again requested an update to the potential future directed sardine TAC, given data collected prior to and during the May 2005 recruit survey.

A further update in the form of Cunningham and Butterworth (2004c) would not prove useful since the 2004 survey results would not be factored into the computations. Taking these into account requires updating the assessment itself. The most recent sardine assessment, upon which OMP-04 was based, made use of data available to October 2003 (Cunningham and Butterworth 2004a). This document provides a rough update of this assessment, taking into account the most recent spawner biomass and recruitment surveys.

Methods

The population dynamics model used for the South African sardine resource is unchanged from that detailed in Appendix A of Cunningham and Butterworth (2004a). The data and biological parameters used in the sardine assessment model are listed in Appendix B of Cunningham and Butterworth (2004a), with the updated data described below. AD Model Builder (Otter Research Ltd. 2000) was used to fit the model and find the posterior mode. No posterior probability distributions could be estimated in the time available for this work.

Due to the influence of the hockey-stick stock-recruitment function on the model predicted recruitment in November 2003 (observed in May 2004) and 2004 (observed in May 2005), a sensitivity test was also run

* MARAM (Marine Resource Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa. Email: c.l.cunningham@telkomsa.net, dll@maths.uct.ac.za.

assuming a much wider prior distribution on the recruitment residuals in 2003 and 2004, i.e.

$$\varepsilon_y^S \sim \begin{cases} N\left(0, 0.4^2 + \left(\lambda_0^S\right)^2\right) & y = 1979,...,2002 \\ N\left(0, 1^2 + \left(\lambda_0^S\right)^2\right) & y = 2003, 2004 \end{cases}.$$

This has the effect of placing much greater weight (in relative terms) on the results from the recruitment surveys of the last two years.

The following data were used in this updated assessment.

1) Sardine spawner biomass observed during the November 2004 survey: $B^S_{2004,Nov} = 2\ 617\ 125$ tonnes, with a CV of 0.334. Note that this is an update from the biomass recorded in Coetzee et al. (2004) and used in OMP-04 for the setting of 2005 TACs.
2) Sardine recruitment observed during the May 2004 recruit survey: $N^S_{2004,rec} = 8.786$ billion, with a CV of 0.27.
3) Sardine recruitment observed during the May 2005 recruit survey: $N^S_{2005,rec} = 3.569$ billion, with a CV of 0.28.
4) Time between 1 May and the start of the 2004 recruit survey: $t^S_{2004} = 0.226$ months (7 days).
5) Time between 1 May and the start of the 2005 recruit survey: $t^S_{2005} = 0.387$ months (12 days).
6) Sardine recruit catch from 1 November 2003 to day before commencement of the 2004 recruit survey: $C^S_{2004,0bs} = 1.098$ billion, with an associated mean weight of $w^S_{2004,0cbs} = 35.68$ g. This catch is estimated assuming all sardine < 15.5cm are recruits and the mean weight is calculated by weighting data disaggregated by area and month.
7) Sardine recruit catch from 1 November 2004 to day before commencement of the 2005 recruit survey: $C^S_{2005,0bs} = 0.528841$ billion, with an associated mean weight of $w^S_{2005,0cbs} = 30.46$ g.
8) Sardine catch-at-ages and catch weights-at-ages 0 to 4 from November 2003 to October 2004 (listed in Table 1) are based on the same average ALK calculated from the 1997 to 1999 ALKs used to calculate the 2000 to 2003 catch-at-age in Cunningham and Butterworth (2004a). Although there has been an update in the RLF for 2003, only the RLFs from November and December 2003 were included in this work and the same catch-at-age data as used in Cunningham and Butterworth (2004a) (i.e. those prior to November 2003) were input for this update.
9) Sardine catch-at-ages and catch weights-at-ages 0 to 4 from November 2004 to July 2005 were calculated based on the same average ALK calculated from the 1997 to 1999 ALKs. The catch-at-age for these 9 months corresponded to a catch biomass of 160 325 tonnes. An estimate for the catch-at-age and catch weight-at-age over the period November 2004 to October 2005 (listed in Table 1) was calculated by increasing these values proportionally, assuming the 2005 TAC of 397 000 tonnes will be caught before the end of October 2005.

10) The weight-at-age in the November 2004 survey, used to calculate the model predicted sardine SSB, was based on an average ALK from the November 1997 to 1999 surveys. The model predicted sardine SSB in November 2005 was calculated using the average November weight-at-age, which has been updated from the last assessment to include the data from 2004. These weights-at-age are listed in Table 2.

The observed proportions-at-age in the November 2000 to 2003 surveys were not used to fit the model in Cunningham and Butterworth (2004a) and therefore the observed proportions-at-age in the November 2004 survey were similarly not included in this update. This is because, in the absence of recent annual ageing information, these proportions-at-age are based on an average ALK from the November 1997 to 1999 surveys. Models should be fit to more reliable "observed" data, to be obtained in due course from ALKs for the years concerned.

Results

The model fits to the November spawner biomass data at the posterior mode are shown in Figure 1 with the model fits to the May recruitment data at the posterior mode shown in Figure 2. The predicted spawner biomass trajectories from 1984 to 2003 are very similar to that in Cunningham and Butterworth (2004a), with the sensitivity test predicting a lower spawner biomass in November 2005 compared to the base case updated assessment.

This updated sardine assessment results in a lower predicted trajectory of sardine recruitment from 2000 onwards, compared to that in Cunningham and Butterworth (2004a), due to the model trying to fit the two most recent survey estimates which have been low (Figure 2). In the sensitivity test, the greater standard deviation for the prior distributions for the recruitment residuals in 2003 and 2004 allows the recruitment in these years to deviate to a greater degree from the stock recruitment function. As a result the sensitivity test is able to fit the latter two observations of poor recruitment better without jeopardising the fit of the model to the years of good recruitment.

Potential Sardine TAC for 2006

The model prediction for the result from the November 2005 spawner biomass survey (the "updated assessment") is 2.265 million tonnes. If this value were observed in November 2005, OMP-04 would calculate the 2006 sardine TAC to be about 343 000 tonnes. For the sensitivity test the predicted survey result is 1.764 million tonnes. If this value were observed in November 2005, OMP-04 would calculate the directed sardine TAC for 2006 to be about 267 0000 tonnes.

Discussion

This document has presented a rough update to the sardine assessment, taking into account data available to July 2005 and, in particular, the two most recent recruitment survey indices which have been low. This assessment is not to be considered as comprehensive due to some assumptions regarding data listed in the

text above (and particularly those relating to the lack of recent ageing information). Rather these results are intended only to provide a ball-park figure for the 2006 sardine TAC for the purposes of industry planning.

The range of 267 000 to 343 000 tonnes obtained reflects uncertainty as to the extent to which low results from the last two recruitment surveys are considered as reliable or instead indicative of negative errors arising from the substantial sampling and other variability associated with these surveys (as reflected by the variability of data points about estimated trends in Figure 2). Note further that this range does not incorporate the variance that will result from the survey sampling error associated with the result from the November 2005 survey.

Acknowledgements

Jan van der Westhuizen and Janet Coetzee are thanked for providing data for this analysis.

References

Coetzee, J., Merkle, D., Rademan, J., and van der Lingen, C. 2004. Results of the 2004 Spawner Biomass Survey. MCM document WG/DEC04/PEL/04.

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

Cunningham, C.L., and Butterworth, D.S. 2004b. Potential Future TACs and TABs Under OMP-04. MCM document WG/PEL/JUN04/06.

Cunningham, C.L., and Butterworth, D.S. 2004c. Update of Potential Future Sardine TACs Under OMP-04. MCM document WG/AUG2004/PEL/06.

Otter Research Ltd. 2000. An Introduction to AD Model Builder Version 4: For Use in Nonlinear Modeling and Statistics. Otter Research Ltd. (http://www.otter-rsch.com/)

Table 1. Sardine catch-at-age data by number (in millions), where $C^S_{y,a}$ is the catch-at-age a from 1 November in year y-1 to 31 October in year y, and where $w^S_{y,ac}$ is the weight-at-age a (in grams) in the catch from 1 November in year y-1 to 31 October in year y. Data for 1980 to 2003 are recorded in Cunningham and Butterworth (2004a).

Year	$C^S_{y,0}$	$C^S_{y,1}$	$C^S_{y,2}$	$C^S_{y,3}$	$C^S_{y,4}$	$w^S_{y,0c}$	$w^S_{y,1c}$	$w^S_{y,2c}$	$w^S_{y,3c}$	$w^S_{y,4c}$
2004	3651.998	2448.166	977.583	436.332	69.482	31.91	58.77	74.49	75.60	87.25
2005	4156.484	3784.601	2079.601	931.080	132.814	30.32	63.35	76.69	75.79	85.41

Table 2. Sardine mean masses-at-age, $w^S_{y,a}$, observed during the November spawner biomass survey. For years in which the mass-at-age is not available (i.e. 1984 to 1987 and 2005), the average mass-at-age, $\overline{w}^S_a$, is used. Data for 1980 to 2003 are recorded in Cunningham and Butterworth (2004a).

Year	$w^S_{y,1}$	$w^S_{y,2}$	$w^S_{y,3}$	$w^S_{y,4}$	$w^S_{y,5}$
2004	32.64	79.25	85.71	92.61	103.02
Average	34.44	70.57	85.88	96.61	108.77

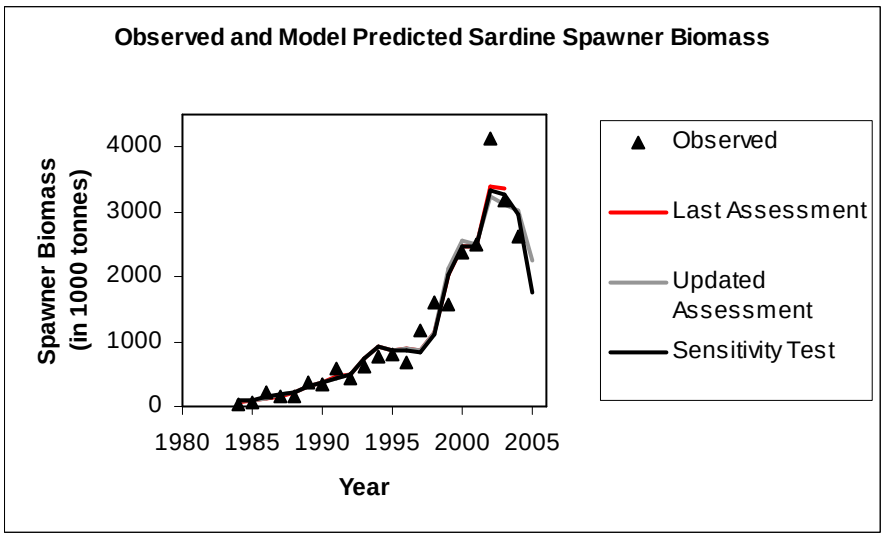

Figure 1. Observed and model predicted uncapped November sardine spawner biomass from November 1984 to November 2005 from the updated assessment and sensitivity test described in this document. The predicted spawner biomass from November 1984 to November 2003 from Cunningham and Butterworth (2004a) is included for comparison.

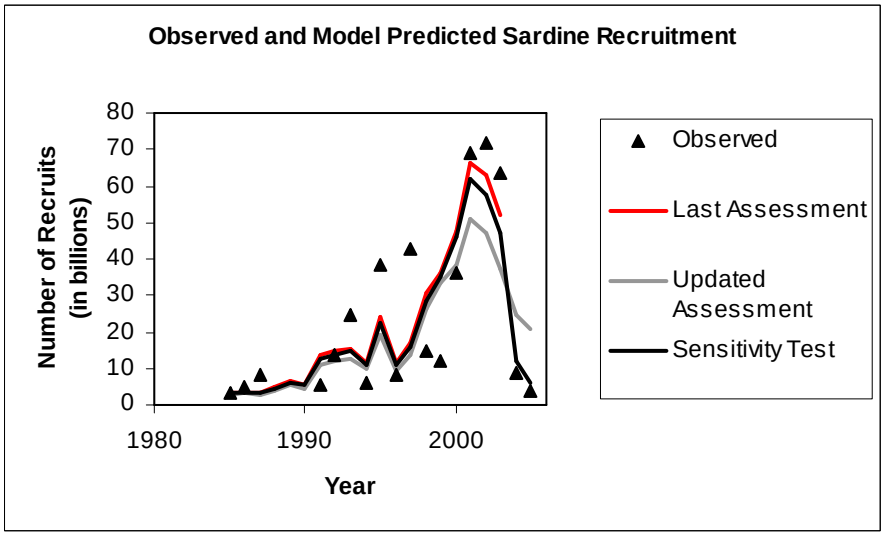

Figure 2. Observed and model predicted uncapped sardine recruitment numbers from May 1985 to May 2005 from the updated assessment and sensitivity test described in this document. The predicted recruitment from May 1985 to May 2003 from Cunningham and Butterworth (2004a) is included for comparison.