



## Revised Anchovy TAC and Sardine TAB for 2006, using Re-Revised OMP-04

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The 2006 directed sardine TAC, initial 2006 anchovy TAC and sardine TAB were calculated using the re-revised OMP-04 to be as follows (Johnston and Butterworth 2005):

Directed sardine TAC: 204 000 tonnes

Initial normal season anchovy TAC: 212 251 tonnes

Initial normal season sardine TAB: 32 711 tonnes

Following the recent 2006 recruit survey, the TAC for anchovy and the sardine TAB are to be revised in terms of standard practice. The following data have been used for input to the OMP-04 formulae:

- 1) November 2005 survey sardine spawner biomass: 962 229 tonnes<sup>1</sup>.  
(November 2004 = 2 607 064 tonnes)
- 2) November 2005 survey anchovy spawner biomass: 3 062 712 tonnes<sup>2</sup>.  
(November 2004 = 2 035 827 tonnes)
- 3) Directed sardine TAC for 2005: 382 119 tonnes.
- 4) Directed anchovy normal season TAC for 2005: 215 000 tonnes.
- 5) Anchovy recruitment from May 2006 survey: 118.599 billion (May 2005 = 109.665 billion<sup>3</sup>).
- 6) Anchovy recruit catch from 1 April to day prior to commencement of survey: 0.978 billion (8.749 billion in 2005).
- 7) Time after 1 May that the survey commenced: 0.613 months (19<sup>th</sup> May).
- 8) Anchovy 1-year-old catch from 1 November to 31 March: 0.303 billion (0.275 billion in 2004/5).
- 9) Mean weight of anchovy 1-year-old in catch from 1 November to 31 March: 12.43 grams (14.33 grams in 2004/5).
- 10) Juvenile sardine : anchovy ratio (by mass) during the May survey: 0.326 (0.0387 in 2005).

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<sup>1</sup> This value has been updated from 962 289 tonnes provided to Johnston and Butterworth (2005) for the 2006 directed sardine TAC recommendation using OMP-04.

<sup>2</sup> This value has been updated from 3 137 333 tonnes provided to Johnston and Butterworth (2005) for the initial 2006 anchovy TAC and sardine TAB recommendations using OMP-04.

<sup>3</sup> This value has been updated from 109.607 billion provided to Cunningham and Butterworth (2005a) for calculating the revised 2005 TAC/B recommendation using OMP-04.

11) Juvenile sardine : anchovy ratio (by mass) during the May commercial catch: 0.139 (0.1443 in 2005).

Using the above data, the final South African pelagic TACs and TAB for 2006 are calculated by OMP-04 to be (Cunningham and Butterworth 2005b):

Directed sardine TAC:	204 000 tonnes	(eqn (A.1))
Normal season anchovy TAC:	212 051 tonnes	(eqn (A.3))
Additional season anchovy TAC:	150 000 tonnes	
Total anchovy TAC:	362 051 tonnes	(eqn (A.5))
Normal season sardine TAB:	59 302 tonnes	(eqn (A.9))
Additional season sardine TAB:	2 000 tonnes	
Total sardine TAB:	61 302 tonnes	(eqn (A.10))

Three constraints have been applied when calculating the above sardine and anchovy TACs. As mentioned in Johnston and Butterworth (2005), the sardine TAC in 2005 was above the two-tier threshold and thus at the start of the year, the decrease in the sardine TAC from 2005 to 2006 was limited to the maximum proportional amount by which the directed sardine TAC can be reduced from one year to the next given this threshold.

Two further constraints have now come into play at mid-season. The final anchovy normal season TAC is bounded below by the initial anchovy TAC calculated by OMP-04 (see constraints (A.4)), while the additional season anchovy TAC is limited to the maximum. Further details of these calculations are shown in the Appendix.

However, if this course of action was followed, the normal season anchovy TAC recommended for 2006 (212 051 tonnes) would be lower than that of 212 251 tonnes set as the initial 2006 anchovy TAC. The reason for this difference is recently acquired updated survey data for May and November 2005. The final normal season anchovy TAC for 2006 cannot be lower than that for which initial allocations have already been made. Thus the final pelagic TACs and TAB for 2006 are recommended to be:

Directed sardine TAC:	204 000 tonnes
Normal season anchovy TAC:	212 251 tonnes
Additional season anchovy TAC:	150 000 tonnes
Total anchovy TAC:	362 251 tonnes
Normal season sardine TAB:	59 302 tonnes
Additional season sardine TAB:	2 000 tonnes
Total sardine TAB:	61 302 tonnes

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**References**

- Cunningham, C.L., and Butterworth, D.S. 2005a. Revised Anchovy TAC and Sardine TAB for 2005, using OMP-04. MCM document SWG/JUN05/PEL/04.
- Cunningham, C.L., and Butterworth, D.S. 2005b. Re-Revised OMP-04. MCM document SWG/DEC2005/PEL/05
- Johnston, S.J., and Butterworth, D.S. 2005. Initial Sardine and Anchovy TACs and Sardine TAB for 2006, using Re-Revised OMP-04. MCM document SWG/DEC05/PEL/04.

**Appendix: Summary of Final TAC and TAB Equations of Re-Revised OMP-04**

The directed sardine TAC was set in proportion to the 2005 November spawner biomass index of abundance:

$$TAC_y^S = \beta B_{y-1,Nov}^S \quad (A.1)$$

where here, and below where appropriate,  $y = 2006$ . This results in  $TAC_{2006}^S = 141\,034$  t. This TAC was subject to the constraints of a minimum and a maximum value and a maximum drop to the ‘two-tier’ threshold:

$$\max\left\{\left(1 - c_{mxdn}^S\right)TAC_{y-1}^S ; c_{mntac}^S\right\} \leq TAC_y^S \leq c_{mxtac}^S \quad TAC_{y-1}^S \leq c_{tier}^S$$

$$\left(1 - c_{mxdn}^S\right)c_{tier}^S \leq TAC_y^S \leq c_{mxtac}^S \quad TAC_{y-1}^S > c_{tier}^S \quad (A.2)$$

Since  $TAC_{2005}^S = 382\,119t > c_{tier}^S$ , the sardine TAC for 2006 was restricted to  $\left(1 - c_{mxdn}^S\right)c_{tier}^S = (1 - 0.15) \times 240\,000 = 204\,000$  t. In the above equations we have:

$\beta = 0.14657$  - a control parameter reflecting the proportion of the previous year’s November spawner biomass index of abundance that is used to set the directed sardine TAC.

$B_{y,Nov}^S$  - the observed estimate of sardine abundance (in thousands of tonnes) from the hydroacoustic spawner biomass survey in November of year  $y$ .

$c_{tier}^S = 240\,000$  t - 2-tier threshold for directed sardine TAC.

$c_{mxdn}^S = 0.15$  - the maximum proportional amount by which the directed sardine TAC can be reduced from one year to the next.

$c_{mntac}^S = 90\,000$  t - the minimum directed TAC that may be set for sardine.

$c_{mxtac}^S = 500\,000$  t - the maximum directed TAC that may be set for sardine.

The directed anchovy normal season TAC was based on how the 2005 November spawner biomass survey estimate of abundance and the 2006 recruitment survey estimate related to the historic average.

Revised anchovy TAC: 
$$TAC_y^{2,A} = \alpha_{ns} q \left( p \frac{N_{y-1,rec0}^A}{\bar{N}_{y-1,rec0}^A} + (1 - p) \frac{B_{y-1,Nov}^A}{\bar{B}_{Nov}^A} \right) \quad (A.3)$$

This results in  $TAC_{2006}^{2,A} = 194\,313$ t. The anchovy normal season TAC is subject to similar constraints as apply for sardine:

$$\max\left\{\left(1 - c_{mxdn}^A\right)TAC_{y-1}^{2,A} ; TAC_y^{1,A} ; c_{mntac}^A\right\} \leq TAC_y^{2,A} \leq \min\left\{c_{mxtac}^A ; TAC_y^{1,A} + c_{mxinc}^{ns,A}\right\} \quad TAC_{y-1}^{2,A} \leq c_{tier}^A$$

$$\max\left\{TAC_y^{1,A} ; \left(1 - c_{mxdn}^A\right)c_{tier}^A\right\} \leq TAC_y^{2,A} \leq \min\left\{c_{mxtac}^A ; TAC_y^{1,A} + c_{mxinc}^{ns,A}\right\} \quad TAC_{y-1}^{2,A} > c_{tier}^A \quad (A.4)$$

Since  $TAC_{2006}^{2,A} = 212\ 051t$ , the anchovy normal season TAC was restricted to 212 051t. Because the anchovy additional sub-season is treated as completely separate from the anchovy normal season, the anchovy TAC actually applied during the sub-season is  $TAC_y^{3,A} - TAC_y^{2,A}$ , where:

$$\text{Final anchovy TAC: } TAC_y^{3,A} = \alpha_{ads} q \left( p \frac{N_{y-1,rec0}^A}{\bar{N}_{y-2,rec0}^A} + (1-p) \frac{B_{y-1,Nov}^A}{\bar{B}_{Nov}^A} \right) \quad (A.5)$$

This results in  $TAC_{2006}^{3,A} = 388\ 625t$ , subject to the constraints:

$$\max\{TAC_y^{2,A}; c_{mntac}^A\} \leq TAC_y^{3,A} \leq \min\{c_{mxtac}^A; TAC_y^{2,A} + c_{mxinc}^{ads,A}\} \quad (A.6)$$

Thus  $TAC_{2006}^{3,A}$  is limited to  $TAC_y^{2,A} + c_{mxinc}^{ads,A} = 362\ 051t$ .

In the above equations we have:

$B_{y,Nov}^A$  - the observed estimate of anchovy abundance (in thousands of tonnes) from the hydroacoustic spawner biomass survey in November of year  $y$ .

$\bar{B}_{Nov}^A$  - the historic average index of anchovy abundance from the spawner biomass surveys from November 1984 to November 2003, of 2149.15 thousand tonnes.

$N_{y-1,rec0}^A$  - the simulated estimate of anchovy recruitment from the recruitment survey in year  $y$ , back-calculated to 1 November  $y-1$  by taking natural and fishing mortality into account, calculated using equation (A.7).

$\bar{N}_{y-1,rec0}^A = 304.824$  - the average back-calculated (see below) estimate of anchovy recruitment at the beginning of November from 1984 to  $y-2$ .

$\alpha_{ns} = 0.73752$  - a control parameter which scales the anchovy TAC to meet target risk levels for sardine and anchovy.

$\alpha_{ads} = 1.47504$  - a control parameter which scales the anchovy TAC to meet target risk levels for sardine and anchovy.

$\delta = 0.85$  - a 'scale-down' factor used to lower the initial anchovy TAC to provide a buffer against possible poor recruitment.

$p = 0.7$  - the weight given to the recruit survey component compared to the spawner biomass survey component in setting the anchovy TAC.

$q = 300$  - reflects the average annual TAC expected under OMP99 under average conditions if  $\alpha_{ns} = 1$ .

$c_{mxdn}^A = 0.25$  - the maximum proportional amount by which the normal season directed anchovy TAC can be reduced from one year to the next (note that the additional season anchovy TAC is not taken into consideration in this constraint).

$c_{mntac}^A = 150\ 000t$  - the minimum directed TAC that may be set for anchovy.

$c_{mx\text{tac}}^A = 600\,000t$  - the maximum directed TAC that may be set for anchovy.

$c_{mx\text{inc}}^{ns,A} = 200\,000t$  - the maximum amount by which the anchovy TAC is allowed to be increased within the normal season.

$c_{mx\text{inc}}^{ads,A} = 150\,000t$  - the maximum amount by which the anchovy TAC is allowed to be increased within the additional sub-season.

$r_y$  - the average of the juvenile sardine to anchovy ratio in the commercial catches in May and in the recruit survey, in year  $y$ , calculated using equation (A.8).

The observed  $N_{y,\text{rec}}^A$  is back-calculated to November of the previous year, assuming a fixed value of 0.9  $\text{year}^{-1}$  for  $M_{ju}^A$ :

$$N_{y-1,\text{rec}0}^A = (N_{y,\text{rec}}^A e^{0.5(1+r_y^A)0.9/12} + C_{y,0\text{bs}}^A) e^{[5+0.5(1+r_y^A)]0.9/12}. \quad (\text{A.7})$$

In the above equations we have

$C_{y,0\text{bs}}^A$  - the observed anchovy landed by number (in billions) from the 1<sup>st</sup> of April to the day before the recruit survey commences in year  $y$ , all assumed to be 0-year-old fish.

$t_y^A$  - the timing of the anchovy recruit survey in year  $y$  (number of months) relative to the 1<sup>st</sup> of May that year.

In calculating the ratio of juvenile sardine to anchovy “in the sea” during May,  $r_y$ , only the commercial catches comprising at least 50% anchovy with sardine bycatch were considered. The ratio  $r_y$  is calculated as follows:

$$r_y = \frac{1}{2}(r_{y,\text{sur}} + r_{y,\text{com}}), \quad (\text{A.8})$$

where  $r_{y,\text{sur}}$  denotes the observed ratio in the May recruit survey and  $r_{y,\text{com}}$  denotes the observed ratio from the commercial catches in May.

The revised normal season sardine TAB was calculated using:

$$TAB_y^{2,S} = \lambda TAC_y^{1,A} + r_y (TAC_y^{2,A} - TAC_y^{1,A}) + TAB_{rh}^S \quad (\text{A.9})$$

where: 
$$\lambda = \max \left\{ 0.1 + \frac{0.1}{1 + \exp\left(-\frac{1}{0.1} 0.00025 (B_{y-1,\text{Nov}}^S - 2000)\right)} = 0.107, r_y = 0.233 \right\}$$

Because the anchovy additional sub-season is treated as completely separate from the anchovy normal season, the sardine TAB actually applied during the sub-season is  $TAB_y^{3,S} - TAB_y^{2,S}$ , where

Final sardine TAB: 
$$TAB_y^{3,S} = TAB_y^{2,S} + \min\{TAB_{ads}^S; \gamma_y (TAC_y^{3,A} - TAC_y^{2,A})\} \quad (\text{A.10})$$

In the above equations we have:

$TAB_{rh}^S = 10000t$  - the fixed tonnage of adult sardine bycatch set aside for the round herring fishery each year.

$TAB_{ads}^S = 2000t$  - the maximum fixed tonnage of juvenile sardine bycatch set aside for the anchovy additional sub-season each year.

Since observed November 2005 sardine spawner biomass was above 250 000t, no exceptional circumstances provisions for sardine were invoked. Similarly, since the observed November 2005 anchovy spawner biomass was above 400 000t, no exceptional circumstances for anchovy were invoked.