Interim OMP-13 v2

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Introduction

The management procedure used to recommend total allowable catches (TACs) and bycatches (TABs) for sardine and anchovy in South African waters is currently being revised. Given the extensive testing desired for this new management procedure, which among other factors includes taking account of the possibility of multiple sardine stocks and of the impact of the recommended catches on penguins, a final version of OMP-13 is not yet available. However, the Small Pelagic Scientific Working Group has agreed a revised version of "Interim OMP-13", called "Interim OMP-13v2" for use in June 2013 for calculating recommended final TAC/Bs for 2013. The revised management procedure, OMP-13, is expected to be finalised and agreed during 2013. This document details "Interim OMP-13v2".

Important Changes from OMP-08

Some of the key differences between OMP-08 (de Moor and Butterworth 2008) and Interim OMP-13v2 include the following:

i) The maximum total anchovy TAC has been decreased from 600 000t to 450 000t, to more accurately reflect the maximum catch possible by the industry.

ii) The normal season has been extended from the end of August to the end of the year, thereby removing the additional season altogether[1].

iii) The Exceptional Circumstances threshold below which the anchovy TAC is decreased rapidly has increased from 400 000t to 600 000t.

iv) A number of new (relatively small) TABs (e.g. a bycatch for anchovy landed by sardine only right holders and a bycatch for small sardine landed with directed (large) sardine) have been introduced so that all landings can be accurately accounted. These bycatch limits have been intentionally set quite generously so that the chance of them being reached is small. Technically, if these limits are reached, particularly as they are pools which all rights holders have access to, the season would be closed[2].

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[1] The results upon which this decision was based used data from September – December from years in which the additional season sardine bycatch restrictions were imposed. Thus the small sardine bycatch with anchovy in the last 4 months of the year under Interim OMP-13v2, and later OMP-13, will need to be monitored to ensure that these simulations accurately reflect future bycatches, after the removal of the additional season.

[2] In practice, the SPWG has suggested ad hoc decisions may need to be taken to deal with such unforeseen eventualities until such time as more reliable estimates of the required size of these pools can be made.

v) The key control parameters have been re-tuned based on updated perceptions of the sardine and anchovy resource productivity and dynamics (i.e. updated assessments), and changes to the operating model to account for the removal of the additional season.

Trade-Off Curve

The definitions of risk have remained unchanged from OMP-08:

$risk_S$ - 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.

$risk_A$ - the probability that adult anchovy biomass falls below 10% of the average adult anchovy biomass between November 1984 and November 1999 at least once during the projection period of 20 years.

The acceptable level of risk changes from one MP to the next given changes in the perceived level of productivity of a resource resulting from the inclusion of revised and new data in the underlying operating models. de Moor and Butterworth (2010) developed an objective method of determining an acceptable level of risk for a new MP. This method was applied to obtain a new maximum risk level of 0.21 for sardine. However, given changes to key assumptions in the base case operating model for anchovy, particularly relating to natural mortality and stock-recruit relationships, the method of de Moor and Butterworth (2010) could not be applied straight-forwardly to obtain a new risk level for anchovy. Work has been progressing to help determine an objective method of determining an acceptable level of risk for anchovy, but is still underway. In the meantime, the SPWG has agreed to temporarily use a maximum risk level of 0.25 for anchovy. The trade-off curve with $risk_S < 0.21$ and $risk_A < 0.25$ for Interim OMP-13v2 is shown in Figure 1. The 'corner point' of the trade-off curve, where the directed average sardine catch is maximised while maintaining a near-maximum average anchovy catch, was used to choose the directed sardine-anchovy trade-off (Figure 2).

In Summary

The details of all the rules governing Interim OMP-13v2 are fully described in the Appendix, while Table 1 lists the control parameters of Interim OMP-13v2, with comparisons to those for previous OMPs. Table 2 lists the data required for input to this OMP. Table 3 lists some key summary statistics for the sardine and anchovy resources under Interim OMP-13v2. Figure 3 shows the simulated distributions of sardine and anchovy at the end of the projection period under Interim OMP-13v2 compared to a no-catch scenario

References

de Moor, C.L., and Butterworth, D.S. 2008. OMP-08. Marine and Coastal Management document: MCM/2008/SWG-PEL/23.15pp.

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de Moor, C.L., Coetzee, J., Durholtz, D., Merkle, D., van der Westhuizen, J.J. and Butterworth, D.S. 2012. A record of the generation of data used in the 2012 sardine and anchovy assessments. DAFF Branch Fisheries document: FISHERIES/2012/AUG/SWG-PEL/41. 29pp.

Table 1. Definitions of control parameters and constraints used in OMP-02, OMP-04, OMP-08, Interim OMP-13 and Interim OMP-13v2 together with their values. All mass-related quantities are given in thousands of tons. Values for Interim OMP-13v2 which differ from OMP-08 are given in bold face.

	Key Control Parameters	OMP-02	OMP-04	OMP-08	Interim OMP-13	Interim OMP13v2
β	Directed sardine catch control parameter	0.1865	0.14657	0.097	**0.090**	**0.090**
α_{ns}	Directed anchovy catch control parameter for normal season	0.16655	0.73752	0.78	**0.321**	**0.871**
α_{ads}	Directed anchovy catch control parameter for additional season	0.99956	1.47504	1.17	**0.4815**	**N/A**
	Fixed TABs	**OMP-02**	**OMP-04**	**OMP-08**	**Interim OMP-13**	**Interim OMP13v2**
TAB_{big}^{S}	Fixed >14cm sardine bycatch	10[3]	10[1]	3.5[1]	**7**	**7**
TAB^{A}	Fixed anchovy bycatch for sardine only right holders	N/A	N/A	N/A	**0.5**	**0.5**
$TAB_{y,small,rh}^{S}$	Fixed ≤14cm sardine bycatch with round herring	N/A	N/A	N/A	**1.0**	**1.0**
	Fixed Control Parameters	**OMP-02**	**OMP-04**	**OMP-08**	**Interim OMP-13**	**Interim OMP13v2**
δ	Scale-down factor applied to initial anchovy TAC	0.85[4]	0.85	0.85	0.85	0.85
p	Weighting given to recruitment survey in anchovy TAC	0.7[5]	0.7	0.7	0.7	0.7
q	Relates to average TAC under OMP-99 if $\alpha_{ns}=1$	300[6]	300	300	300	300
$\overline{B}_{Nov}^{A}$	Historic average 1984 to 1999 index of anchovy abundance from the November spawner biomass surveys		2 149	1 380	1 380	1380
$\overline{N}_{rec0}^{A}$	Average 1985 to 1999 observed anchovy recruitment in May, back-calculated to November of the previous year	N/A	N/A	198 billion	**180 billion**	**217 billion**
ϖ	Estimate of the percentage of ≤14cm sardine bycatch in the >14cm sardine catch	N/A	N/A	N/A	**0.07**	**0.07**
γ_y	Range within which initial estimate of juvenile sardine : anchovy ratio is set, dependent upon observed sardine biomass	0.1	0.1-0.2	0.1-0.2	0.1-0.2	0.1-0.2
$\gamma_{\max}$	Maximum of the logistic curve for γ_y	N/A	0.1	0.1	0.1	0.1
B_{50}	Biomass of sardine where the logistic curve for γ_y reaches 50%	N/A	2 000	2 000	2 000	2000

[3] TAB (assumed adult) with round herring only, initially set at 10 000t calculated as 12.5% of the predicted average round herring catch of 80 000t; subsequently decreased to 3 500t when considering historic bycatch had not been greater than 3 500t.
[4] A value of $\delta = 0.85$, used since OMP-02, reflects the industry's desire for greater 'up-front' TAC allocation for planning purposes, even if this means some sacrifice in expected average TAC to meet the same risk criterion.
[5] A value of $p = 0.7$ reflects the greater importance of the incoming recruits in the year's catch relative to the previous year's biomass survey.
[6] Leaving $q = 300$ unchanged facilitated easy comparison between the outputs from OMP-02 and subsequent revised OMP candidates

Table 1 (continued).

	Constraints	OMP-02	OMP-04	OMP-08	Interim OMP-13	Interim OMP13v2
B_{95}	Biomass of sardine where the logistic curve for γ_y reaches 95%	N/A	3 178	3 178	3 178	3178
c^S_{mntac}	Minimum directed sardine TAC	90	90	90	90	90
c^A_{mntac}	Minimum normal season anchovy TAC	150	150	120	120	120
c^S_{mxtac}	Maximum directed sardine TAC	250	500	500	500	500
c^A_{mxtac}	Maximum total anchovy TAC	600	600	600	**450**	**450**
c^S_{tier}	Two-tier threshold for directed sardine TAC	N/A	240	255	255	255
c^A_{tier}	Two-tier threshold for normal season anchovy TAC	N/A	330	330	330	330
c^S_{mxdn}	Maximum proportion by which directed sardine TAC can be reduced annually	0.20	0.15	0.20	0.20	0.20
c^A_{mxdn}	Maximum proportion by which normal season anchovy TAC can be reduced annually	0.30	0.25	0.25	0.25	0.25
$c^{ns,A}_{mxinc}$	Maximum increase in normal season anchovy TAC	150	200	150	150	**N/A**
$c^{ads,A}_{mxinc}$	Maximum additional season anchovy TAC	100	150	120	120	**N/A**
TAB^S_{ads}	Maximum sardine bycatch during the additional season	2	2	2	**1.5**[7]	**N/A**
B^S_{ec}	Threshold at which Exceptional Circumstances are invoked for sardine	150	250	300	300	300
B^A_{ec}	Threshold at which Exceptional Circumstances are invoked for anchovy	400	400	400	400	**600**
Δ^S	threshold above B^S_{ec} at which linear smoothing is introduced before sardine exceptional circumstances are declared (to ensure continuity)	N/A	500	500	**400**	**400**
Δ^A	threshold above B^A_{ec} at which linear smoothing is introduced before anchovy exceptional circumstances are declared (to ensure continuity)	N/A	N/A	100	100	100
B_1	threshold above which the anchovy additional sub-season TAC can increase more rapidly	N/A	N/A	1 000	1 000	**N/A**
B_2	threshold above which the anchovy additional sub-season TAC reaches a maximum	N/A	N/A	1 500	1 500	**N/A**
x^S	the proportion of B^S_{ec} below which sardine TAC is zero.	0	0	0.25	0.25	0.25
x^A	the proportion of B^A_{ec} below which anchovy TAC is zero.	0	0.25	0.25	0.25	0.25
R_{crit}	sardine recruitment threshold above which the maximum possible mid-year increase in sardine TAC under exceptional circumstances is achieved	N/A	N/A	17.38	**16.48**	**16.48**

[7] Interim OMP-13 assumed the additional season runs from October to December, rather than September to December as assumed for earlier OMPs.

Table 2. The data required as input to the Interim OMP-13v2 formulae to provide the directed sardine TAC and initial anchovy TAC and sardine TAB recommendations for year y in December of year $y-1$, and to set the revised and final anchovy TAC and sardine TAB recommendations in June of year y.

	Input	Definition
December *y*-1	$B^S_{y-1,N}$	November survey estimate of sardine 1+ biomass in year $y-1$ (in thousands of tons)
	$B^A_{y-1,N}$	November survey estimate of anchovy 1+ biomass in year $y-1$ (in thousands of tons)
June *y*	$N^A_{y,r}$	May survey estimate of anchovy recruitment in year y (in billions)
	$N^S_{y,r}$ [8]	May survey estimate of sardine recruitment in year y (in billions)
	t^A_y	Day of commencement of recruitment survey (time in months after 1 May)
	$C^A_{y,1}$	Anchovy catch at age 1[9] from 1 November of year $y-1$ to the day before the commencement of the recruitment survey (in billions)
	$C^A_{y,0bs}$	Anchovy catch at age 0[9] from 1 November of year $y-1$ to the day before the commencement of the recruitment survey (in billions)
	$r_{y,sur}$	Ratio of juvenile sardine to anchovy (by mass) indicated by the recruitment survey
	$r_{y,com}$	Ratio of juvenile sardine to anchovy (by mass) in the commercial catches during May, using only the commercial catches comprising at least 50% anchovy
	$\overline{w}^A_1 = 10.689$	Average historic anchovy weight-at-age 1 in November
	$\overline{w}^A_2 = 13.671$	Average historic anchovy weight-at-age 2 in November
	$\overline{w}^A_{0c} = 4.847$	Average historic catch weight-at-age 0
	$\overline{w}^A_{1c} = 10.983$	Average historic catch weight-at-age 1

[8] Only needed if sardine Exceptional Circumstances are declared in December $y-1$.

[9] Monthly cut-off lengths are used to split the anchovy catch into juveniles and adults. The monthly cut-off lengths for November to March are given in de Moor *et al.* (2012), while the monthly cut-off lengths for April, May and June (if necessary) are dependent on the recruit cut-off length used for the recruit survey in year y.

Table 3. Key summary statistics for the sardine and anchovy resources under a no-catch scenario and Interim OMP-13:

- the probability that adult sardine biomass falls below the average adult sardine biomass over November 1991 to November 1994 (the "risk threshold", $Risk^S$) at least once during the projection period of 20 years, $risk_S$;
- the probability that adult anchovy biomass falls below 10% of the average adult anchovy biomass between November 1984 and November 1999 at least once during the projection period of 20 years, $risk_A$;
- average minimum biomass over the projection period as a proportion of carrying capacity ($K^{S/A}$) and as a proportion of the risk threshold;
- average biomass at the end of the projection period as a proportion of carrying capacity, as a proportion of the risk threshold, and as a proportion of biomass at the beginning of the projection period;
- average directed catch (in thousands of tons), $\overline{C}^S / \overline{C}^A$, and average anchovy catch during the additional season, $\overline{C}^A_{ad}$;
- average sardine bycatch comprising juvenile sardine bycatch with anchovy, round herring and large sardine (in thousands of tons), $\overline{C}^S_{by}$;
- average proportional annual change in directed catch, AAV^S / AAV^A .
- proportion of times Exceptional Circumstances are/not declared ($EC^{declared} / EC^{NOTdeclared}$) when true biomass is/not below the corresponding threshold ($B^{A/S}_y < \text{or} \geq Threshold$);
- proportion of times the directed TAC decreases below the minimum TAC (i.e., Exceptional Circumstances are declared), $TAC^{A/S}_y < c^{A/S}_{mntac}$; and
- average number of years for which Exceptional Circumstances, if declared, are declared consecutively, $EC^{A/S}_{consec}$.

	Sardine	No Catch	Interim OMP-13v2	Anchovy	No Catch	Interim OMP-13v2
Key Control Parameters	β		0.090	α_{ns}		0.871
Risk Statistics	$risk^S$	0.031	0.208	$risk^A$	0.02	0.244
Biomass Statistics	$\overline{B^S_{\min}/K^S}$	0.54	0.41	$\overline{B^A_{\min}/K^A}$	0.22	0.09
	$\overline{B^S_{\min}/Risk^S}$	2.03	1.56	$\overline{B^A_{\min}/Risk^A}$	7.57	3.20
	$\overline{B^S_{2032}/K^S}$	0.99	0.75	$\overline{B^A_{2032}/K^A}$	1.17	0.55
	$\overline{B^S_{2032}/Risk^S}$	4.04	3.00	$\overline{B^A_{2032}/Risk^A}$	48.19	22.25
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	1.45	$\overline{B^A_{2032}/B^A_{2011}}$	7.59	2.92
Catch Statistics	$\overline{C}^S$ ('13-'32)	0	154	$\overline{C}^A$ ('13-'32)	0	275
	$\overline{C}^S_{by}$	0	39			
	$\overline{C}^S$ ('13-'15)	0	125	$\overline{C}^A$ ('13-'15)	0	295
	AAV^S ('13-'32)	0.00	0.19	AAV^A ('13-'32)	0.00	0.19
	AAV^S ('13-'15)	0.00	0.04	AAV^A ('13-'15)	0.00	0.13
Exceptional Circumstances	$p\left(EC^{declared}, B^S_y < Threshold\right)$	0.00	0.01	$p\left(EC^{declared}, B^A_y < Threshold\right)$	0.02	0.28
	$p\left(EC^{declared}, B^S_y \geq Threshold\right)$	0.01	0.05	$p\left(EC^{declared}, B^A_y \geq Threshold\right)$	0.01	0.02
	$p\left(EC^{NOTdeclared}, B^S_y < Threshold\right)$	0.00	0.00	$p\left(EC^{NOTdeclared}, B^A_y < Threshold\right)$	0.01	0.05
	$p\left(EC^{NOTdeclared}, B^S_y \geq Threshold\right)$	0.99	0.95	$p\left(EC^{NOTdeclared}, B^A_y \geq Threshold\right)$	0.96	0.65
	$p\left(TAC^S_y < c^S_{mntac}\right)$	0	0.05	$p\left(TAC^A_y < c^A_{mntac}\right)$	0	0.30
	EC^S_{consec}	0	1.3 years	EC^A_{consec}	0	3.4 years

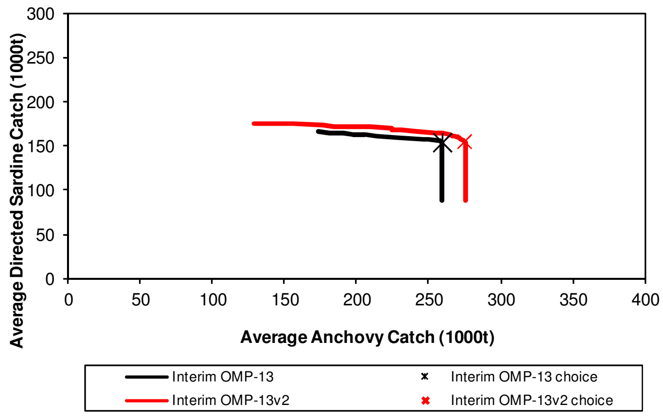

Figure 1. Trade-off curves and chosen points on the curve for Interim OMP-13 and Interim OMP-13v2. The trade-off curve for Interim OMP-13v2 is determined by points satisfying $risk_S$ <0.21 and $risk_A$ <0.25.

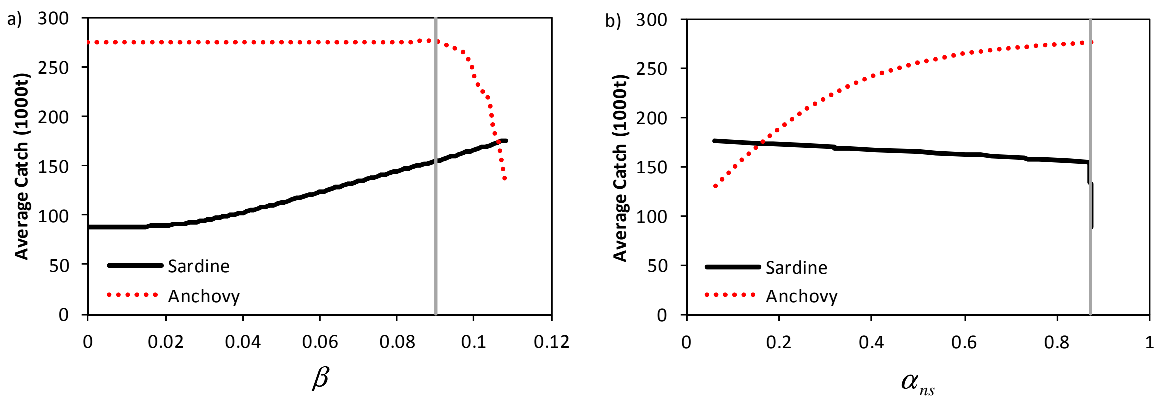

Figure 2. The average directed sardine and anchovy catches (as shown on the Trade-off curve in Figure 1) plotted against a) the sardine control parameter, β and b) the anchovy control parameter, α_{ns}. The grey vertical lines indicate a value of a) $\beta = 0.090$ and b) $\alpha_{ns} = 0.871$ corresponding to the corner point of Interim OMP-13v2.

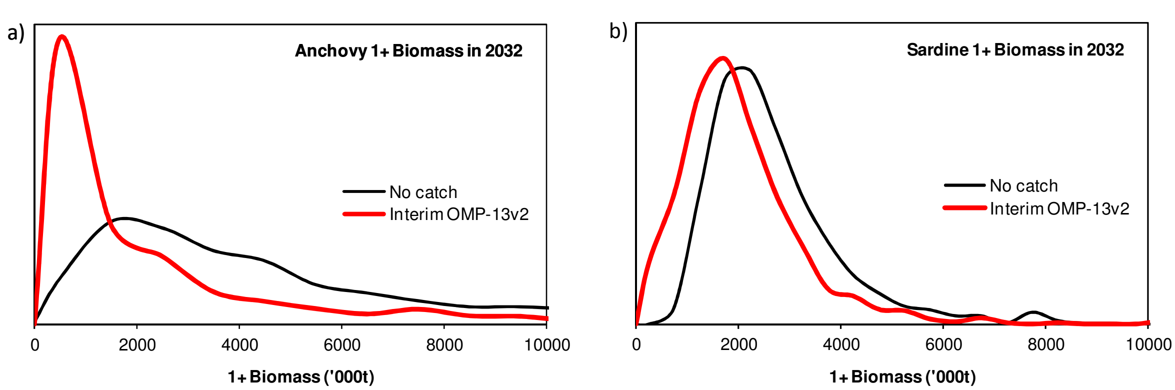

Figure 3. Comparison of a) anchovy and b) sardine 1+ biomass distributions in the final projection year under a no catch scenario and Interim OMP-13v2.

Appendix: Interim OMP-13v2 Harvest Control Rules

In this Appendix, catches-at-age are given in numbers of fish (in billions), whereas the TACs and TABs are given in thousands of tons. Sardine and anchovy total allowable catches (TACs) and sardine total allowable bycatches (TABs) are set at the start of the year and the latter two are revised during the year (or all three if Exceptional Circumstances apply for sardine).

Initial TACs / TAB (January)

The directed sardine TAC and initial directed anchovy TAC and TAB for sardine bycatch are based on the results of the November biomass survey. These limits are announced prior to the start of the pelagic fishery at the beginning of each year.

The directed sardine TAC is set at a proportion of the previous year's November 1+ biomass index of abundance, but subject to the constraints of a minimum and a maximum value. If the previous year's TAC is below the 'two-tier' threshold, then the TAC is subject to a maximum percentage drop from the previous year's TAC. If it is above this threshold, any reduction in TAC is limited only by a lower bound of the corresponding threshold less the maximum percentage drop.

The directed anchovy initial TAC is based on how the most recent November biomass survey estimate of abundance relates to the historic (non-peak) average between 1984 and 1999. In the absence of further information, which will become available after the May recruitment survey, this initial TAC assumes the forthcoming recruitment (which will form the bulk of the catch) will be average. A 'scale-down' factor, δ, is therefore introduced to provide a buffer against possible poor recruitment. The anchovy TAC is subject to similar constraints as apply for sardine.

A fixed anchovy TAB, TAB^A, for sardine only right holders has been introduced in OMP-13 (see Table 1).

A fixed >14cm sardine TAB, TAB^S_{big}, consisting of mainly adult sardine bycatch with round herring and to a lesser extent with anchovy has been introduced in OMP-13 (replacing the "adult sardine bycatch with round herring" TAB in OMP-08) (see Table 1).

A new ≤14cm sardine TAB has been introduced in OMP-13. This consists of a fixed allocation for bycatch with round herring, $TAB^S_{y,small,rh}$, and an allocation for small sardine bycatch in the >14cm directed sardine landings, set proportional to the directed sardine TAC.

The final TAB is a ≤14cm sardine TAB with anchovy, and is set proportional to the anchovy TAC.

Directed sardine TAC: $TAC_y^S = \beta\, B_{y-1,Nov}^{obs,S}$ (OMP.1)

Subject to:

$$\begin{array}{ll} \max\left\{\left(1-c_{mxdn}^S\right)TAC_{y-1}^S\,;\,c_{mntac}^S\right\} \le TAC_y^S \le c_{mxtac}^S & \text{if } TAC_{y-1}^S \le c_{tier}^S \\ \max\left\{\left(1-c_{mxdn}^S\right)c_{tier}^S\,;\,c_{mntac}^S\right\} \le TAC_y^S \le c_{mxtac}^S & \text{if } TAC_{y-1}^S > c_{tier}^S \end{array} \quad \text{(OMP.2)}$$

Initial directed anchovy TAC: $TAC_y^{1,A} = \alpha_{ns}\,\delta\, q\left(p + (1-p)\dfrac{B_{y-1}^{obs,A}}{\bar{B}_{Nov}^A}\right)$ (OMP.3)

Subject to:

$$\begin{array}{ll} \max\left\{\left(1-c_{mxdn}^A\right)TAC_{y-1}^{2,A}\,;\,c_{mntac}^A\right\} \le TAC_y^{1,A} \le c_{mxtac}^A & \text{if } TAC_{y-1}^{2,A} \le c_{tier}^A \\ \max\left\{\left(1-c_{mxdn}^A\right)c_{tier}^A\,;\,c_{mntac}^A\right\} \le TAC_y^{1,A} \le c_{mxtac}^A & \text{if } TAC_{y-1}^{2,A} > c_{tier}^A \end{array} \quad \text{(OMP.4)}$$

<14cm sardine TAB with directed >14cm sardine:

$$TAB_{y,small}^S = \omega TAC_y^S \quad \text{(OMP.5)}$$

Initial <14cm sardine TAB with anchovy: $TAB_{y,anch}^{1,S} = \gamma_y TAC_y^{1,A}$ (OMP.6)

where:

$$\gamma_y = 0.1 + \frac{\gamma_{\max}}{1+\exp\left(-\ln(19)\dfrac{\left(B_{y-1,N}^{S,obs} - B_{50}\right)}{\left(B_{95}-B_{50}\right)}\right)}. \quad \text{(OMP.7)}$$

Here γ_y increases according to a logistic curve from 10% in years in which the survey estimated sardine November 1+ biomass, $B_{y-1,N}^{S,obs}$, is poor to average, towards a maximum when sardine biomass is higher (Figure A.1).

To maintain continuity in the directed sardine and initial anchovy TACs as the Exceptional Circumstances thresholds (see below), B_{ec}^S and B_{ec}^A, are approached from above and below, the following linear smoothing is applied.

If $B_{ec}^S \le B_{y-1,N}^{obs,S} \le B_{ec}^S + \Delta^S$ we have:

$$TAC_y^S = \left(1 - \frac{B_{y-1,N}^{obs,S} - B_{ec}^S}{\Delta^S}\right)\times TAC_y^{S-EC} + \left(\frac{B_{y-1,N}^{obs,S} - B_{ec}^S}{\Delta^S}\right)\times TAC_y^S \quad \text{(OMP.8)}$$

where TAC_y^{S-EC} is the value output from equation (OMP.16) when $B_{y-1,N}^{obs,S} = B_{ec}^S$, while TAC_y^S is the value output from equation (OMP.2) when $B_{y-1,N}^{obs,S} = B_{ec}^S + \Delta^S$.

If $B_{ec}^A \le B_{y-1,N}^{obs,A} \le B_{ec}^A + \Delta^A$ we have:

$$TAC_y^{1,A} = \left(1 - \frac{B_{y-1,N}^{obs,A} - B_{ec}^{A}}{\Delta^A}\right) \times TAC_y^{1,A\_EC} + \left(\frac{B_{y-1,N}^{obs,A} - B_{ec}^{A}}{\Delta^A}\right) \times TAC_y^{1,A} \qquad \text{(OMP.9)}$$

where TAC_y^{1,A_EC} is the value output from equation (OMP.17) when $B_{y-1,N}^{obs,A} = B_{ec}^{A}$, while $TAC_y^{1,A}$ is the value output from equation (OMP.4) when $B_{y-1,N}^{obs,A} = B_{ec}^{A} + \Delta^A$.

In the above equations the symbols used are as follows. See Table 1 for fixed values:

$B_{y,N}^{obs,S}$ - the observed estimate of sardine abundance from the hydroacoustic biomass survey in November of year y.

β - a control parameter reflecting the proportion of the previous year's November 1+ biomass index of abundance that is used to set the directed sardine TAC, scaled to meet target risk levels for sardine and anchovy.

$B_{y,N}^{obs,A}$ - the observed estimate of anchovy abundance from the hydroacoustic biomass survey in November of year y.

$\overline{B}_{Nov}^{A}$ - the historic average index of anchovy 1+ biomass from the November surveys from 1984 to 1999.

α_{ns} - a control parameter which scales the anchovy TAC to meet target risk levels for sardine and anchovy.

δ - a 'scale-down' factor used to lower the initial anchovy TAC to provide a buffer against possible poor recruitment.

p - the weight given to the recruit survey component compared to the 1+ biomass survey component in setting the anchovy TAC.

q - a constant value reflecting the average annual TAC expected under OMP99 under average conditions if $\alpha_{ns} = 1$.

c_{mntac}^{S} - the minimum directed TAC to be set for sardine.

c_{mntac}^{A} - the minimum directed TAC to be set for anchovy.

c_{mxtac}^{S} - the maximum directed TAC to be set for sardine.

c_{mxtac}^{A} - the maximum directed TAC to be set for anchovy.

c_{tier}^{S} - the two-tier threshold for directed sardine TAC.

c_{tier}^{A} - the two-tier threshold for directed anchovy TAC.

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

c^A_{mxdn} - the maximum proportional amount by which the directed anchovy TAC can be reduced from one year to the next.

ϖ - an estimate of the maximum percentage of ≤14cm sardine bycatch in the >14cm sardine catch.

γ_y - a conservative estimate of the anticipated ratio of juvenile sardine to juvenile anchovy in subsequent catches.

$\gamma_{\max}$ - maximum of the logistic curve for γ_y.

B_{50} - biomass where the logistic curve for γ_y reaches 50%.

B_{95} - biomass where the logistic curve for γ_y reaches 95%.

B^S_{ec} - the biomass threshold below which Exceptional Circumstances apply for sardine.

B^A_{ec} - the biomass threshold below which Exceptional Circumstances apply for anchovy.

Δ^S - the threshold above the Exceptional Circumstances threshold, B^S_{ec}, below which the sardine TAC is smoothed until B^S_{ec} is reached.

Δ^A - the threshold above the Exceptional Circumstances threshold, B^A_{ec}, below which the anchovy TAC is smoothed until B^A_{ec} is reached.

Revised TACs / TAB (June)

The anchovy TAC and sardine TAB midyear revisions are based on the most recent November and now also recruit surveys. As the estimate of recruitment is now available, the 'scale-down' factor, δ, is no longer required to set the anchovy TAC. The additional constraints include ensuring that the revised anchovy TAC is not less than the initial anchovy TAC.

The revised ≤14cm sardine TAB with anchovy is calculated using an estimate of the ratio, r_y, of juvenile sardine to anchovy, provided this ratio is larger than γ_y, which was used to set the initial TAB.

Revised anchovy TAC:
$$TAC^{2,A}_y = \alpha_{ns}\, q\left(p\frac{N^A_{y-1,rec0}}{\overline{N}^A_{rec0}} + (1-p)\frac{B^{obs,A}_{y-1,N}}{\overline{B}^A_{Nov}}\right) \quad \text{(OMP.10)}$$

Subject to:
$$\begin{aligned}
&\max\left\{TAC^{1,A}_y ; \left(1-c^A_{mxdn}\right)TAC^{2,A}_{y-1}\right\} \le TAC^{2,A}_y \le c^A_{mxtac} && TAC^{2,A}_{y-1} \le c^A_{tier}\\
&\max\left\{TAC^{1,A}_y ; \left(1-c^A_{mxdn}\right)c^A_{tier}\right\} \le TAC^{2,A}_y \le c^A_{mxtac} && TAC^{2,A}_{y-1} > c^A_{tier}
\end{aligned} \quad \text{(OMP.11)}$$

Revised <14cm sardine TAB with anchovy:
$$TAB^{2,S}_{y,anch} = \lambda_y\, TAC^{1,A}_y + r_y\,(TAC^{2,A}_y - TAC^{1,A}_y) \quad \text{(OMP.12)}$$

Where: $\lambda_y = \max\{\gamma_y, r_y\}$

As for the initial TAC, continuity in the revised anchovy TAC as the Exceptional Circumstances thresholds are approached from above and below, is maintained by applying the following linear smoothing.
If $B^A_{ec} \le B^A_{y,proj} \le B^A_{ec} + \Delta^A$ we have:

$$TAC^{2,A}_y = \left(1 - \frac{B^A_{y,proj} - B^A_{ec}}{\Delta^A}\right) \times TAC^{2,A\_EC}_y + \left(\frac{B^A_{y,proj} - B^A_{ec}}{\Delta^A}\right) \times TAC^{2,A}_y \qquad \text{(OMP.13)}$$

where TAC^{2,A_EC}_y is the value output from equation (OMP.22) when $B^A_{y,proj} = B^A_{ec}$, while $TAC^{2,A}_y$ is the value output from equation (OMP.11) when $B^A_{y,proj} = B^A_{ec} + \Delta^A$, and $B^A_{y,proj}$ is determined by equation (OMP.19).

Note that by construction $TAB^{2,S}_y \ge TAB^{1,S}_y$ as $\lambda_y \ge \gamma_y$ and $TAC^{2,A}_y \ge TAC^{1,A}_y$. In addition to the previous definitions, we have:

$N^A_{y-1,rec0}$ - the simulated estimate of anchovy recruitment from the recruitment survey in year y, $N^{obs,A}_{y,r}$ [10], back-calculated to 1 November $y-1$ by taking natural and fishing mortality into account (equation (OMP.14) below).

$\overline{N}^A_{rec0}$ - the average 1985 to 1999 observed anchovy recruitment in May, back-calculated (using equation (A.14)) to November of the previous year.

$r_y = \frac{1}{2}(r_{y,sur} + r_{y,com})$

- the ratio of juvenile sardine to anchovy "in the sea" during May in year y, calculated from the recruit survey and the sardine bycatch to anchovy ratio in the commercial catches[11] during May.

The anchovy TAC equations require that $N^{obs,A}_{y,r}$, the recruitment numbers estimated in the survey, be back-calculated to November of the previous year, assuming a fixed value of 1.2 *year*$^{-1}$ for M^A_j. The back-calculated recruitment numbers are calculated as follows:

$$N^A_{y-1,rec0} = (N^{obs,A}_{y,r} e^{t^A_y \times 1.2/12} + C^A_{y,0bs})\, e^{0.5 \times 1.2} \qquad \text{(OMP.14)}$$

In the above equation we have

[10] This estimate of recruitment is calculated using a cut-off length determined from modal progression analysis. In the event of this modal progression analysis being unable to detect a clear mode, a recruit cut-off (caudal) length of 10.5cm for anchovy and 15.5cm for sardine will be used. These are the cut-off lengths used historically and from which there has not been substantial deviation over a 10 year period (Coetzee pers. comm.).
[11] Only commercial catches comprising at least 50% anchovy with sardine bycatch are considered.

$C^{A}_{y,0bs}$ - the observed juvenile anchovy landed by number (in billions) from the 1st of November year $y-1$ to the day before the recruit survey commences in year y

t^{A}_{y} - the timing of the anchovy recruit survey in year y (number of months) after the 1st of May year y.

Exceptional Circumstances

Sardine directed TAC

Exceptional Circumstances for the sardine directed TAC apply if:

$B^{obs,S}_{y-1,N} < B^{S}_{ec}$

in which case the TAC under Exceptional Circumstances is calculated as follows. Only a portion (half) of the directed sardine TAC is awarded with the initial TACs, with a revised TAC in June dependent on the observed May sardine recruitment (see Figure A.2):

Initial TAC: $$TAC^{S}_{y,init} = 0.5 \times \begin{cases} 0 & \text{if } \dfrac{B^{obs,S}_{y-1,N}}{B^{S}_{ec}} < x^{S} \\ TAC^{S\_before}_{y} \left(\dfrac{\dfrac{B^{obs,S}_{y-1,N}}{B^{S}_{ec}} - x^{S}}{1 - x^{S}} \right)^{2} & \text{if } x^{S} < \dfrac{B^{obs,S}_{y-1,N}}{B^{S}_{ec}} < 1 \end{cases} \quad \text{(OMP.15)}$$

Revised TAC: $$TAC^{S}_{y} = \begin{cases} TAC^{S}_{y,init} + 1.2 \times \dfrac{N^{obs,S}_{y,r}}{R_{crit}} TAC^{S}_{y,init} & \text{if } N^{obs,S}_{y,r} \le R_{crit} \\ TAC^{S}_{y,init} + 1.2 \times TAC^{S}_{y,init} & \text{if } N^{obs,S}_{y,r} > R_{crit} \end{cases} \quad \text{(OMP.16)}$$

where $TAC^{S\_before}_{y} = \beta\, B^{obs,S}_{y-1,N}$, subject to $c^{S}_{mntac} \le TAC^{S\_before}_{y} \le c^{S}_{mxtac}$. The rule allows for the TAC to be set to zero if the survey estimated sardine biomass falls below x^{S} of the threshold (see Table 1). Further we have:

R_{crit} - the level of sardine recruitment required in order to achieve the maximum possible mid-year increase in sardine TAC under Exceptional Circumstances (see Figure A.2 and Table 1).

Initial Anchovy TAC

Exceptional Circumstances for the initial anchovy TAC apply if

$B^{obs,A}_{y-1,N} < B^{A}_{ec}$

in which case the TAC under Exceptional Circumstances is calculated as follows:

$$TAC_y^{1,A} = \begin{cases} 0 & \text{if} \quad \dfrac{B_{y-1,N}^{obs,A}}{B_{ec}^{A}} < x^A \\ TAC_y^{1,A\_before}\left(\dfrac{\dfrac{B_{y-1,N}^{obs,A}}{B_{ec}^{A}} - x^A}{1-x^A}\right)^2 & \text{if} \quad x^A < \dfrac{B_{y-1,N}^{obs,A}}{B_{ec}^{A}} < 1 \end{cases} \qquad \text{(OMP.17)}$$

where $TAC_y^{1,A\_before} = \alpha_{ns}\,\delta\, q\left(p + (1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}\right)$, subject to $c_{mntac}^{A} \le TAC_y^{1,A\_before} \le c_{mxtac}^{A}$. The rule allows for the TAC to be set to zero if the survey estimated anchovy biomass falls below x^A of the threshold (see Table 1).

Revised Anchovy TAC

The results of the most recent November and recruit surveys are projected forward, taking natural and anticipated fishing mortality into account, in order to provide a proxy ($B_{y,proj}^{A}$) for the forthcoming November survey, and hence have a basis for invoking Exceptional Circumstances, if necessary. Define $TAC_y^{2,A\_before} = \alpha_{ns} q\left(p\dfrac{N_{y-1,rec0}^{A}}{\overline{N}_{rec0}^{A}} + (1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}\right)$, subject to $\max\{TAC_y^{1,A}; c_{mntac}^{A}\} \le TAC_y^{2,A\_before} \le c_{mxtac}^{A}$, a projected anchovy biomass, $B_{y,proj0}^{A}$, is calculated as follows:

$$B_{y,proj0}^{A} = \max \text{ of}\left\{0; \left(N_{y,r}^{obs,A} - \left[\frac{TAC_y^{2,A\_before} + TAB^A - \overline{w}_{1c}^{A} C_{y,1}^{A}}{\overline{w}_{0c}^{A}} - C_{y,0bs}^{A}\right]\right) e^{-(6-t_y)*1.2/12}\,\overline{w}_1^{A}\right\}. \qquad \text{(OMP.18)}$$

Calculate $B_{y,proj}^{A}$ as follows:

$$B_{y,proj}^{A} = \left(\frac{B_{y-1,N}^{obs,A}}{\overline{w}_1^{A}} e^{-5*1.2/12} - C_{y,1}^{A}\right) e^{-7\times 1.2/12}\,\overline{w}_2^{A} + B_{y,proj0}^{A} \qquad \text{(OMP.19)}$$

If $B_{y,proj}^{A} < B_{ec}^{A}$, then Exceptional Circumstances apply. The recruit survey result in year y (in numbers) that would be sufficient to yield a $B_{y,proj}^{A}$ value of exactly B_{ec}^{A} is calculated as follows:

$$\theta = \frac{[B_{ec}^{A} - (B_{y,proj}^{A} - B_{y,proj0}^{A})]}{\overline{w}_1^{A}} e^{(6-t_y)*1.2/12} + \frac{TAC_y^{2,A\_before} + TAB^A - \overline{w}_{1c}^{A} C_{y,1}^{A}}{\overline{w}_{0c}^{A}} - C_{y,0bs}^{A} \qquad \text{(OMP.20)}$$

This is back-calculated to November of the previous year in the same way as equation (A.14) during OMP implementation:

$$N_{y-1,rec0}^{A*} = (\theta\, e^{t_y^A \times 1.2/12} + C_{y,0bs}^{A})\, e^{6\times 1.2/12} \qquad \text{(OMP.21)}$$

In the above equations we have:

$C_{y,1}^{A}$ - the observed anchovy catch at age 1 landed by number (in billions) from the 1st of November year $y-1$ to the day before the recruit survey commences in year y.

$\overline{w}_{a}^{A}$ - average historic anchovy weight-at-age a in November.

$\overline{w}_{ac}^{A}$ - average historic anchovy catch weight-at-age a.

The revised anchovy TAC is calculated by reducing TAC_{y}^{2,A_before} by the ratio (squared) of TAC_{y}^{2,A_before} calculated with the annual recruitment for year y to $TAC_{y}^{2,A}$ calculated with θ, thus providing a means to reduce the TAC fairly rapidly when the Exceptional Circumstances threshold is surpassed. The rule allows for the TAC to be set to zero (or to the initial anchovy TAC, if greater than zero) if the survey estimated anchovy recruitment and biomass falls below a quarter of the threshold:

$$TAC_{y}^{2,A} = \max \text{ of } \begin{cases} TAC_{y}^{1,A};\, TAC_{y}^{2,A\_before}\dfrac{\left(\dfrac{p\dfrac{N_{y-1,rec0}^{A}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}}{p\dfrac{N_{y-1,rec0}^{A*}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}}-x^{A}\right)^{2}}{\left(1-x^{A}\right)^{2}} & \text{if } x^{A} < \dfrac{p\dfrac{N_{y-1,rec0}^{A}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}}{p\dfrac{N_{y-1,rec0}^{A*}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}} < 1 \\ TAC_{y}^{1,A};0 & \text{if } \dfrac{p\dfrac{N_{y-1,rec0}^{A}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}}{p\dfrac{N_{y-1,rec0}^{A*}}{\overline{N}_{rec0}^{A}}+(1-p)\dfrac{B_{y-1,N}^{obs,A}}{\overline{B}_{Nov}^{A}}} < x^{A} \end{cases} \quad \text{(OMP.22)}$$

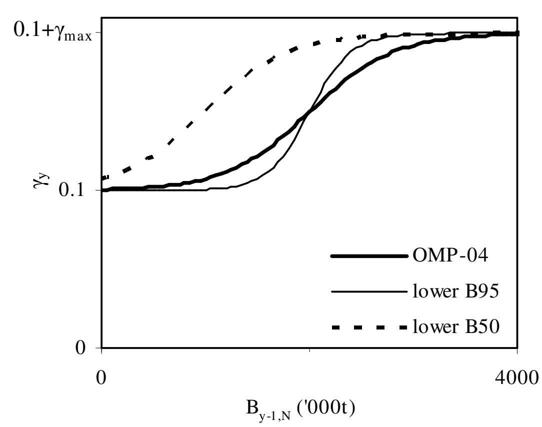

Figure A.1. The logistic curve used to calculate the proportion of initial anchovy TAC that provides the initial sardine TAB (γ_{y}, Equation OMP.7). Curves for a lower value of B_{95} and centred on a lower value of B_{50} are also shown.

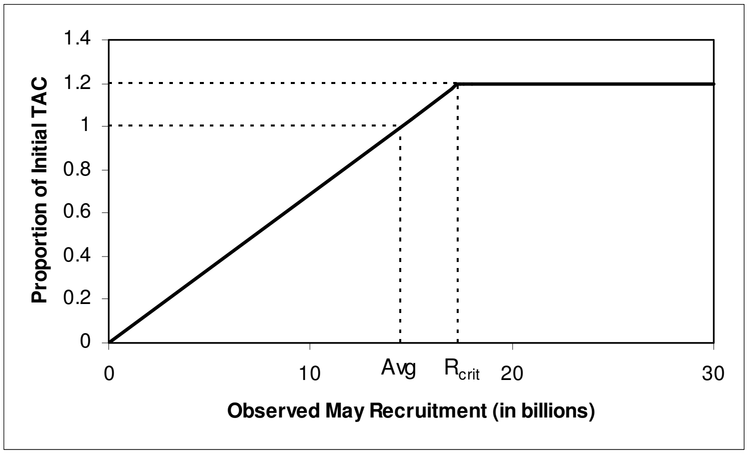

Figure A.2. The proportion of the initial directed sardine TAC that is awarded in the mid-year revision to the directed sardine TAC if Exceptional Circumstances are declared. The historic (May 1984 – 2011) average observed May sardine recruitment is 13.74 billion recruits. For Interim OMP-13v2, $R_{crit} = 16.48$ billion, such that the mid-year revision is the same as the initial TAC when observed recruitment from the May survey is average.