Further OMP-14 Performance Statistics

C.L. de Moor*

Correspondence email: *carryn.demoor@uct.ac.za*

Background

de Moor and Butterworth (2014) detailed OMP-14, and provided many of the performance statistics relating to the objectives that were agreed for use during OMP-14 development (de Moor and Coetzee 2012). This document provides the remaining performance statistics that were not given in de Moor and Butterworth (2014). These relate to the "secondary trade-off" objectives P4, E2 and E3. Some further performance statistics relating to suggestions from Hagen and Jarre (2015) are also calculated.

Performance Statistics Relating to Agreed Objectives

For completeness, Table 1 lists all the performance statistics relating to the agreed objectives for OMP-14 development. A "lower percentile" was agreed for use for Performance Statistic E3. Results for the 5%ile, 10%ile and 20%ile are given in Table 1. Figure 1 shows the individual worm plots of the 1st, 2nd, 3rd, 4th and 5th %iles once projections are sorted according to the lowest projected future biomasses.

The 0.46 probability of future combined sardine and anchovy biomass falling below one third of the maximum historical (1984-2011) value seems high at first consideration. However, this should be viewed in the light of the proportions of years during 1984-2011 for which the combined biomass was below this same threshold[1]. The median maximum historical value is 9.5 million tons, with a 90% PI of 7.6 – 12.1 million tons. The median one third of this maximum is 3.2 million tons, with a 90% PI of 2.5-4.0 million tons. The median proportion of times historical combined biomass fell below this same "one third of maximum" threshold is 0.61, with a 90% PI of 0.46-0.71 (Figure 2). Although the projected probability of future combined sardine and anchovy biomass is much lower than that observed between 1984 and 2011, implying the performance statistic satisfactorily meets the objective under OMP-14, one may question the usefulness of this performance statistic given Figure 2 and the natural highly variable fluctuations of these short-lived species.

Further Performance Statistics

The Small Pelagic Scientific Working Group meeting on 1st April 2015 considered whether any further performance statistics could be easily output from the OMP-14 simulation testing framework to relate to the

* MARAM (Marine Resource Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa.

[1] The threshold used differs by simulation, but the same threshold is used WITHIN a simulation to test future years and compare here against historical years.

suggestions of Hagen and Jarre (2015). Their suggestions for "additional ecosystem considerations" are repeated in italics below, followed by comments.

1. *Whether the combined sardine and anchovy spawner biomass falls below one third of the historical maximum, either east and west of Cape Agulhas.* The performance statistic $p\left(B_y^{S+A} < B_{\max}^{S+A}/3\right)$ in Table 1 considers the full distributional area, although note the discussion above regarding the suitability of this performance statistic. Despite that reservation, additional performance statistics considering only sardine and anchovy west or south of Cape Agulhas would need to assume a future proportion of true model sardine + anchovy biomass west or south of Cape Agulhas. Performance statistics ROI_y, $\overline{P_y/P_{2011}}$ and $Thresh^S_{con\,\sec}$ (Table 1) assume future **sardine** survey **observations** are distributed west of Cape Agulhas either similar to those observed from 1984-99 or 2000-11. The same assumption (i.e. set of "high" and "low" proportions of biomass) is now extended to true model sardine biomass. Figure 3 shows the proportions of anchovy biomass observed west of Cape Agulhas during the November surveys. These proportions are also split into a "high" and "low" set, being 1984-1995 and 1996-2011, and assumed to apply to true model anchovy biomass. The additional performance statistic $p\left(B_y^{WEST\,S+A} < B_{\max}^{WEST\,S+A}/3\right)$ indicates the proportion of times the combined sardine and anchovy biomass assumed to be distributed west of Cape Agulhas, falls below one third of the historical maximum west of Cape Agulhas[2] (Table 2). As per the performance statistics already agreed for OMP-14 (de Moor and Coetzee 2012), adequate performance for the west coast is assumed to secure adequate performance for the south coast.

2. *Whether the sardine biomass falls below 20% of the maximum observed biomass in stratum C (Cape Point to Cape Agulhas), approximately 330 000 t.* The performance statistic $Thresh^S_{con\,\sec}$ corresponds to 25% of the maximum historical observed sardine biomass west of Cape Agulhas, which has been shown to be a threshold below which Robben Island penguin natural mortality rates start to increase (Robinson and Butterworth 2012). An additional performance statistic $p\left(B_y^{obs,S} < Thresh^S\right)$ indicating

[2] Due to time constraints, this was simply taken to be the average of the proportions drawn for sardine and anchovy distributed west of Cape Agulhas.

the proportion of times future simulated observed biomass is below this threshold has also been calculated and is given in Table 2.

3. *Whether the sardine stock 1+biomass west of Cape Agulhas is below the threshold advised in the most updated spatial assessment documents.* No further work has been done relating to this suggestion as no "threshold" was proposed by de Moor and Butterworth (2015).

4. *Whether numbers of large sardine are found west of Cape Agulhas are sufficient to support rebuilding of the spawner stock at the west coast.* The number of 2+ sardine available has already been considered within the simulation testing framework through the feedback modelled with the stock-recruitment relationships considered.

References

de Moor CL, Butterworth DS. 2014. OMP-14. DAFF Branch Fisheries document: FISHERIES/2014/DEC/SWG-PEL/60. 27pp.

de Moor CL and Butterworth DS. 2015. Assessing the South African sardine resource: two stocks rather than one? *African Journal of Marine Science* 37: 41-51.

de Moor CL, Coetzee JC 2012. Objectives for the management of the South African pelagic fishery for anchovy and sardine, using OMP-13. DAFF Branch Fisheries document: FISHERIES/2012/FEB/SWG-PEL/03rev2. 5pp.

Hagen C, Jarre A. 2015. Additional ecosystem considerations for exceptional circumstances. DAFF Branch Fisheries document: FISHERIES/2015/APR/SWG-PEL/12. 1pp.

Robinson W, Butterworth D. 2012. Some updates to the penguin-fish interaction model. DAFF: Branch Fisheries document FISHERIES/2012/SWG-PEL/01. 9pp

Table 1. Performance statistics for the sardine and anchovy resources under a no-catch scenario and OMP-14:

- the probability that sardine 1+ biomass falls below the average sardine 1+ 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 anchovy 1+ biomass falls below 10% of the average anchovy 1+ biomass between November 1984 and November 1999 **at least once during the projection period of 20 years**, $risk_A$;
- the probability of breaching the sardine/anchovy risk threshold **in any one year, averaged over the years** during the projection period ($risk_{*S/A}$);
- average minimum biomass over the projection period ($B_{\min}^{S/A}$) as a proportion of carrying capacity ($K^{S/A}$) and as a proportion of the risk threshold ($Risk^{S/A}$);
- average biomass at the end of the projection period ($B_{2032}^{S/A}$) 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 ($B_{2011}^{S/A}$);
- average (median in brackets) directed catch (in thousands of tons), $\overline{C}^S / \overline{C}^A$;
- average sardine bycatch comprising juvenile sardine bycatch with anchovy, round herring and large sardine (in thousands of tons), $\overline{C}_{by}^S$;
- average proportional annual change in directed catch, AAV^S / AAV^A;
- proportion of occasions Exceptional Circumstances are/are not declared ($EC^{declared} / EC^{NOTdeclared}$) when true biomass is/is not below the corresponding threshold ($B_y^{A/S} < \text{or} \geq Threshold$);
- proportion of occasions the directed TAC drops below the minimum TAC (i.e., Exceptional Circumstances are declared), $TAC_y^{A/S} < c_{mntac}^{A/S}$;
- average number of years for which Exceptional Circumstances, if declared, are declared consecutively, $EC_{con\sec}^{A/S}$;
- proportion of occasions the anchovy fishery is closed due to the sardine TAB limit[3], $p(Close)$;
- average normal season anchovy catch lost in each of those years in which the fishery was closed, $\overline{C}_{lost}^A$;

[3] This is the proportion of occasions the revised sardine TAB with anchovy is reached and excludes any occasions when the initial sardine TAB with anchovy may be reached.

- average normal season anchovy TAC in years in which the fishery was closed $\overline{TAC}^{A}_{close}$;
- average rate of increase of number of moulters of adult penguins on Robben island from November 2012 to November 2017 and to November 2022, ROI_y ; the average number of moulters of penguins on Robben Island compared to the initial year, $\overline{P_y / P_{2011}}$;
- average number of years for which simulated observed sardine biomass west of Cape Agulhas remains below a threshold of 336 000t, once it drops below this threshold, $Thresh^{S}_{con\,sec}$;
- proportion of times the future combined sardine-anchovy biomass drops below the 5, 10 and 20 percentile of historical (1984-2011) combined biomass, $p\left(B_y^{S+A} < B_{5\%ile}^{S+A}\right)$, $p\left(B_y^{S+A} < B_{10\%ile}^{S+A}\right)$ and $p\left(B_y^{S+A} < B_{20\%ile}^{S+A}\right)$; and
- proportion of times the future combined sardine-anchovy biomass drops below one third of the historical (1984-2011) maximum combined biomass, $p\left(B_y^{S+A} < B_{\max}^{S+A}/3\right)$.

The performance statistics that were not included in de Moor and Butterworth (2014) are highlighted for ease of reference.

	Sardine	No Catch	OMP-14	Anchovy	No Catch	OMP-14
Key Control Parameters	β		0.0869	α_{ns}		0.8890
Risk Statistics	$risk_S$	0.047	0.209	$risk_A$	0.008	0.234
	$risk_{*S}$	0.008	0.066	$risk_{*A}$	0.002	0.041
Biomass Statistics	$\overline{B^S_{\min}/K^S}$	0.50	0.39	$\overline{B^A_{\min}/K^A}$	0.26	0.10
	$\overline{B^S_{\min}/Risk^S}$	1.94	1.51	$\overline{B^A_{\min}/Risk^A}$	9.21	3.62
	$\overline{B^S_{2032}/K^S}$	0.99	0.77	$\overline{B^A_{2032}/K^A}$	1.20	0.56
	$\overline{B^S_{2032}/Risk^S}$	4.13	3.15	$\overline{B^A_{2032}/Risk^A}$	49.27	22.71
	$\overline{B^S_{2032}/B^S_{2011}}$	2.08	1.57	$\overline{B^A_{2032}/B^A_{2011}}$	4.55	1.80

	Sardine		No Catch	OMP-14	Anchovy		No Catch	OMP-14
Catch Statistics	$\overline{C}^{S}$ ('13-'32)		0	153 (129)	$\overline{C}^{A}$ ('13-'32)		0	290 (321)
	$\overline{C}^{S}_{by}$		0	33				
	$\overline{C}^{S}$ ('13-'15)		0	121 (96)	$\overline{C}^{A}$ ('13-'15)		0	341 (375)
	AAV^{S} ('13-'32)			0.38	AAV^{A} ('13-'32)			0.21
	AAV^{S} ('13-'15)			0.62	AAV^{A} ('13-'15)			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	0.25
	$p\left(EC^{declared}, B^{S}_{y} \geq Threshold\right)$		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	0.04
	$p\left(EC^{NOTdeclared}, B^{S}_{y} \geq Threshold\right)$		0.99	0.94	$p\left(EC^{NOTdeclared}, B^{A}_{y} \geq Threshold\right)$		0.96	0.69
	$p\left(TAC^{S}_{y} < c^{S}_{mntac}\right)$		-	0.05	$p\left(TAC^{A}_{y} < c^{A}_{mntac}\right)$		-	0.27
	$EC^{S}_{con\sec}$		-	1.3 years	$EC^{A}_{con\sec}$		-	3.5 years
Anchovy Fishery Closure					$p\left(Close\right)$		-	0.23
					$\overline{C}^{A}_{lost}$		-	36
					$\overline{TAC}^{A}_{close}$		-	169
Penguins	Assuming sardine biomass distributed west of Cape Agulhas similar to 1980-90s	ROI_{2017}	0.018	0.006	Assuming sardine biomass distributed west of Cape Agulhas similar to 2000s	ROI_{2017}	-0.065	-0.080
		ROI_{2022}	0.011	-0.003		ROI_{2022}	-0.050	-0.065
		$\overline{P_{2017}/P_{2011}}$	1.091	1.032		$\overline{P_{2017}/P_{2011}}$	0.676	0.601
		$\overline{P_{2022}/P_{2011}}$	1.108	0.970		$\overline{P_{2022}/P_{2011}}$	0.497	0.353
		$Thresh^{S}_{con\sec}$	1.2	1.6		$Thresh^{S}_{con\sec}$	1.9	2.5
Combined Biomass	$p\left(B^{S+A}_{y} < B^{S+A}_{5\%ile}\right)$		0.001	0.05				
	$p\left(B^{S+A}_{y} < B^{S+A}_{10\%ile}\right)$		0.003	0.08				
	$p\left(B^{S+A}_{y} < B^{S+A}_{20\%ile}\right)$		0.01	0.14				
	$p\left(B^{S+A}_{y} < B^{S+A}_{\max}/3\right)$		0.12	0.46				

Table 2. Further new performance statistics for the sardine and anchovy resources under a no-catch scenario and OMP-14:

- proportion of times the future combined sardine-anchovy biomass west of Cape Agulhas drops below one third of the historical (1984-2011) maximum combined biomass $p\left(B_y^{WEST\,S+A} < B_{\max}^{WEST\,S+A}/3\right)$; and
- proportion of times the future simulated observed sardine biomass west of Cape Agulhas is below a threshold of 336 000t, $p\left(B_y^{obs,S} < Thresh^S\right)$.

	Sardine+Anchovy		No Catch	OMP-14	Sardine+Anchovy		No Catch	OMP-14
Combined Biomass	Assuming sardine and anchovy biomass distributed west of Cape Agulhas similar to 1980-90s	$p\left(B_y^{WEST\,S+A} < B_{\max}^{WEST\,S+A}/3\right)$	0.12	0.45	Assuming sardine and anchovy biomass distributed west of Cape Agulhas similar to 2000s	$p\left(B_y^{WEST\,S+A} < B_{\max}^{WEST\,S+A}/3\right)$	0.56	0.80
		$p\left(B_y^{obs,S} < Thresh^S\right)$	0.07	0.15		$p\left(B_y^{obs,S} < Thresh^S\right)$	0.39	0.51

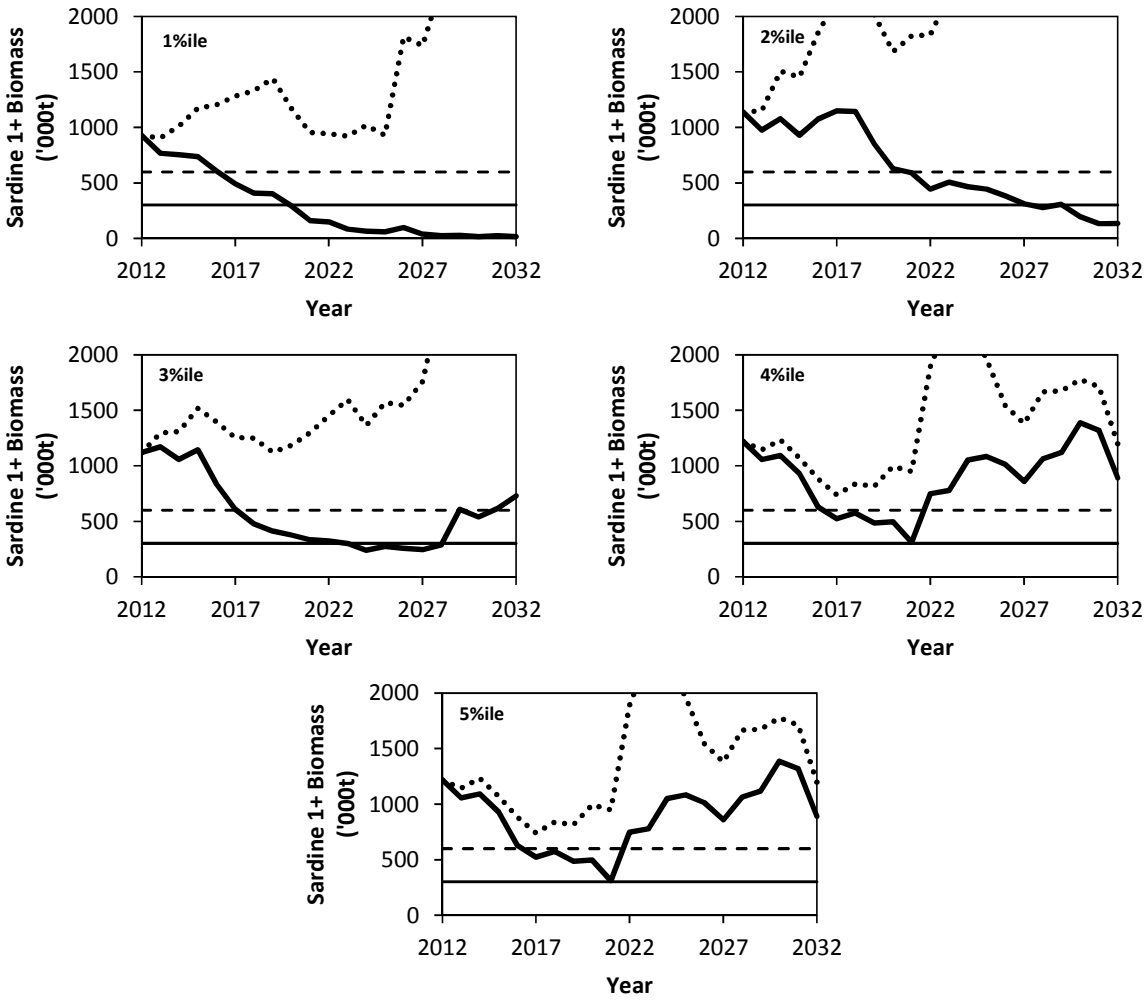

Figure 1. The lowest 1st, 2nd, 3rd, 4th and 5th percentiles of future projections under OMP-14 (solid line) and no catch (dotted line), once projections are sorted according to lowest future biomasses. The horizontal lines indicate the 300 000t Exceptional Circumstances threshold and 600 000t "Buffer" threshold.

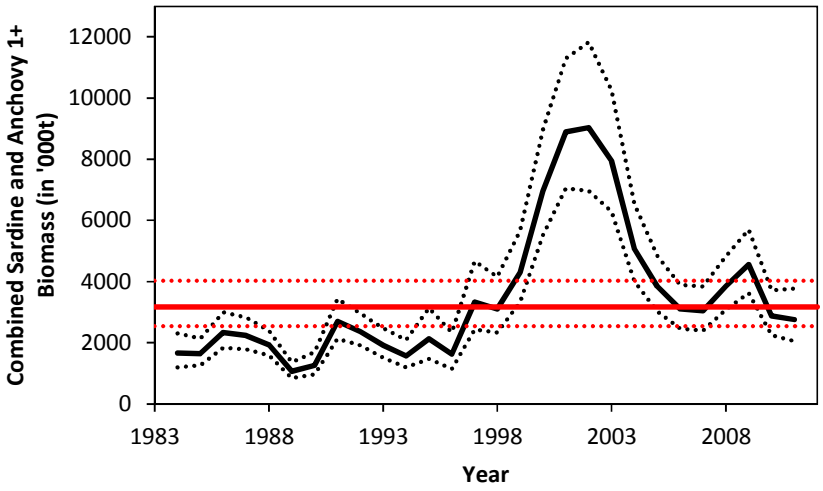

Figure 2. The median (solid line) and 90% probability interval (dotted lines) of the historical combined sardine and anchovy biomass, with one third of the historical maximum combined biomass shown in red.

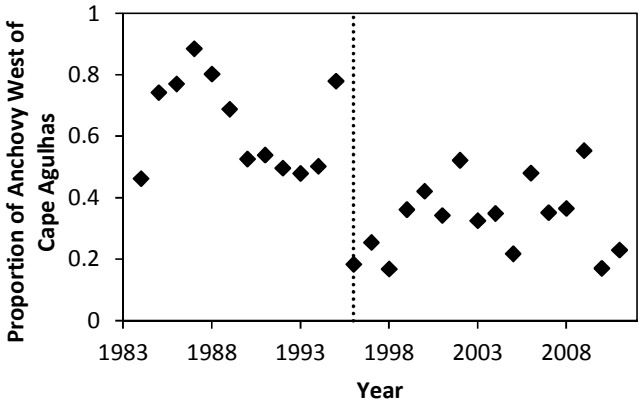

Figure 3. The proportions of anchovy biomass observed west of Cape Agulhas during the November surveys from 1984-2011. The vertical line indicates 1996.