Options for OMP-14

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Background

At the March 2014 Small Pelagics Working Group meeting it was agreed that the most appropriate way-forward in terms of management of the sardine and anchovy pelagic fishery would be to finalise an Operational Management Procedure (OMP) as soon as possible, based on an extension to Interim OMP-13 v3. The development of a new OMP would then be brought forward from the routine 4-5 year timeframe for updates, to begin likely early 2015 based on data up to the end of 2014.

Interim OMP-13 v3 (de Moor and Butterworth 2013a), used to set the directed sardine TAC and initial anchovy TAC and sardine TAB for 2014, differed from Interim OMP-13 v2 (de Moor and Butterworth 2013b) in only one respect: the provision for a conservative lower initial directed sardine TAC for the range of November hydroacoustic survey estimates of sardine biomass from 300 000t (below which Exceptional Circumstances would be declared) and 600 000t (Figure 1).

Rules for mid-year increase in directed sardine TAC

If Exceptional Circumstances are declared, the Harvest Control Rule is such that given the calculated directed >14cm sardine TAC ($TAC^{\#}$), only half of this is recommended as an initial TAC (TAC_{init}= $0.5TAC^{\#}$). The increase in TAC_{init} recommended after the recruit survey can range from 0-120% of TAC_{init}, dependent on the survey estimate of sardine recruitment, so that the final TAC can range from 50-110% of the $TAC^{\#}$ value calculated originally (Figure 2).

The new provision in Interim OMP-13 v3 moves linearly from this recommendation of 50% of the $TAC^{\#}$ as an initial TAC (TAC_{init}) at a survey estimate of 300 000t (with a potential increase during the year), to the recommendation of 100% $TAC^{\#}$ as an initial TAC (TAC_{init}) at a survey estimate of 600 000t (Figure 1). Thus for a November survey biomass estimate of 600 000t and above, $TAC^{\#}$ as recommended by Interim OMP-13 v3 at the start of the year is final and for the full calendar year, with no mid-season increase.

No rule upon which to base the potential mid-year increase in the directed sardine TAC, under the circumstances that the survey estimate of biomass is between 300 and 600 000t, was agreed for Interim OMP-13 v3. Instead, a new OMP was expected to be agreed before the May 2014 survey by which time

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such a rule might have been required. This document provides some alternative rules upon which to base the mid-year increase in the directed sardine TAC.

Alternative rules

i) Candidate MP-14.1: A similar rule as applied under Exceptional Circumstances is used. Thus the final TAC can range from that which was set initially (between 50-100% of $TAC^{\#}$, dependent on the survey estimate of November 1+ biomass) to 110% of $TAC^{\#}$, dependent on the survey estimate of recruitment, N_y^{obs}. The increase is dependent on TAC_{init}, consistent with the rule applied under Exceptional Circumstances (as shown in Figure 2). However, because TAC_{init} can be greater than 50%, this rule can result in a final TAC greater than 110% $TAC^{\#}$. Thus the final TAC is capped at 110% of $TAC^{\#}$.

$$TAC^{final} = \begin{cases} TAC_{init} + 1.2\dfrac{N_y^{obs}}{R_{crit}} \times TAC_{init} & if\ N_y^{obs} \le R_{crit} \\ 2.2 \times TAC_{init} & if\ N_y^{obs} > R_{crit} \end{cases} \le 1.1 \times TAC^{\#} \quad (1)$$

Here R_{crit} denotes the survey estimate of recruitment above which the maximum increase in the TAC is awarded, and is calculated such that the final TAC is the same as $TAC^{\#}$ when the observed recruitment from the May survey is average.

ii) Candidate MP-14.2: A similar rule as applied under Exceptional Circumstances is used. Thus the final TAC can range from that which was set initially (between 50-100% of $TAC^{\#}$, dependent on the survey estimate of November 1+ biomass) to 110% of $TAC^{\#}$, dependent on the survey estimate of recruitment (Figure 3). The increase is dependent on the portion of the original TAC not awarded (i.e. 1.1x$TAC^{\#}$ - TAC_{init}) and thus the maximum of 110% $TAC^{\#}$ is never exceeded.

$$TAC^{final} = \begin{cases} TAC_{init} + \dfrac{N_y^{obs}}{R_{crit}} \times \left(1.1 \times TAC^{\#} - TAC_{init}\right) & if\ N_y^{obs} \le R_{crit} \\ TAC_{init} + \left(1.1 \times TAC^{\#} - TAC_{init}\right) & if\ N_y^{obs} > R_{crit} \end{cases} \quad (2)$$

Results

Table 1 shows the key performance statistics for Interim OMP-13 v2 and the two Candidate MPs compared to a no catch scenario, assuming a single sardine stock hypothesis. The values of the key control parameters used in Interim OMP-13 v3 ($\beta = 0.090$ and $\alpha = 0.871$) were set to those used to tune Interim OMP-13 v2 to $risk_S < 0.21$ and $risk_A < 0.25$ (de Moor and Butterworth 2013a). This sardine risk level was chosen by trying to match the "leftward shift" of the final projected sardine 1+ distribution under OMP-13 : a no catch scenario to that of OMP-08 (de Moor and Butterworth 2012a,b). Given changes to key assumptions in the baseline operating model, the anchovy risk level was chosen via discussion through trade-off between different risk levels (de Moor and Butterworth 2013c).

The initial and final directed sardine TACs resulting from a range of November survey estimates of abundance between 300 and 600 000t and a range of May survey estimates of recruitment are given in Table 2.

As discussed by de Moor and Butterworth (2013e), updates to the operating models resulted in changes to the calculated risks to the resources for the same control parameter values. Interim OMP-13 v2 and Candidate MP-14.2 have therefore been retuned to maintain a similar level of depletion ("leftward shift") in the sardine single stock resource as implied when agreeing OMP-08. In order to achieve this, a sardine risk level of 0.21 is again used (Table 3). Results are shown for a range of anchovy risk levels (Tables 3 and 4).

Table 5 shows the key performance statistics for Interim OMP-13 v2 and the two Candidate MPs compared to the no catch scenario, assuming a two mixing stock hypothesis. Key performance statistics are also given in Tables 5 and 6 for alternative control parameters for Interim OMP-13 v2 and Candidate MP14.2 corresponding to those in Table 4.

References

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Table 1. Key summary statistics for the sardine and anchovy resources under a no catch scenario, Interim OMP-13 v2 (single area sardine TAC), and candidate (single area sardine TAC) MPs including a rule for the mid-year increase in the directed sardine TAC when the survey estimate of biomass is between 300 and 600 000t, assuming a **single sardine stock operating model**:

- 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, $risk^{A}$;
- the probability of breaching the sardine/anchovy risk threshold **in any one year, averaged over 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 directed catch (in thousands of tons), $\overline{C}^{S} / \overline{C}^{A}$, and average anchovy catch during the additional season, $\overline{C}_{ad}^{A}$;
- 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} .

	Sardine	No Catch	Interim OMP-13 v2	CMP-14.1	CMP-14.2	Anchovy	No Catch	Interim OMP-13 v2	CMP-14.1	CMP-14.2
Key Control Params	β		0.090	0.090	0.090	α_{ns}		0.871	0.871	0.871
Risk Statistics	$risk^S$	0.047	0.224	0.223	0.215	$risk^A$	0.008	0.226	0.226	0.226
	$risk^{*S}$	0.008	0.073	0.071	0.068	$risk^{*A}$	0.002	0.039	0.039	0.039
Biomass Statistics	$\overline{B^S_{\min}/K^S}$	0.50	0.39	0.39	0.39	$\overline{B^A_{\min}/K^A}$	0.26	0.10	0.10	0.10
	$\overline{B^S_{\min}/Risk^S}$	1.94	1.49	1.49	1.50	$\overline{B^A_{\min}/Risk^A}$	9.21	3.67	3.67	3.67
	$\overline{B^S_{2032}/K^S}$	0.99	0.76	0.76	0.76	$\overline{B^A_{2032}/K^A}$	1.20	0.56	0.56	0.56
	$\overline{B^S_{2032}/Risk^S}$	4.13	3.11	3.11	3.13	$\overline{B^A_{2032}/Risk^A}$	49.27	22.92	22.92	22.92
	$\overline{B^S_{2032}/B^S_{2011}}$	2.08	1.54	1.54	1.55	$\overline{B^A_{2032}/B^A_{2011}}$	4.55	1.82	1.82	1.82
Catch Statistics	$\overline{C}^S$ ('13-'32)	0	156	157	156	$\overline{C}^A$ ('13-'32)	0	290	290	290
	$\overline{C}^S_{by}$	0	33	33	33					
	$\overline{C}^S$ ('13-'15)	0	125	126	124	$\overline{C}^A$ ('13-'15)	0	339	339	339
	AAV^S ('13-'32)	0.00	0.31	0.37	0.39	AAV^A ('13-'32)	0.00	0.21	0.21	0.21
	AAV^S ('13-'15)	0.00	0.61	0.62	0.62	AAV^A ('13-'15)	0.00	0.13	0.13	0.13

Table 2. The Original, Initial and Final directed sardine TACs (rounded to nearest thousand) for 2014 (i.e. constraints take into account the 2013 directed sardine TAC) under candidate MPs 14.1 and 14.2 with the control parameter $\beta = 0.090$, for a range of November survey estimates of abundance between 300 and 600 000t and for a range of May estimates of recruitment (in billions).

Bobs	Robs	Original TAC	Initial TAC	Final TAC	
				CMP-14.1	CMP-14.2
300 000t	5	90 000t	45 000t	61 000t	61 000t
	10	90 000t	45 000t	78 000t	78 000t
	13.74	90 000t	45 000t	90 000t	90 000t
	$\geq R_{crit} = 16.48$	90 000t	45 000t	99 000t	99 000t
400 000t	5	90 000t	60 000t	82 000t	72 000t
	10	90 000t	60 000t	99 000t	84 000t
	13.74	90 000t	60 000t	99 000t	93 000t
	$\geq R_{crit} = 16.48$	90 000t	60 000t	99 000t	99 000t
500 000t	5	90 000t	75 000t	99 000t	82 000t
	10	90 000t	75 000t	99 000t	90 000t
	13.74	90 000t	75 000t	99 000t	95 000t
	$\geq R_{crit} = 16.48$	90 000t	75 000t	99 000t	99 000t
600 000t	5	90 000t	90 000t	99 000t	93 000t
	10	90 000t	90 000t	99 000t	95 000t
	13.74	90 000t	90 000t	99 000t	98 000t
	$\geq R_{crit} = 16.48$	90 000t	90 000t	99 000t	99 000t

Table 3. The ratio of the percentiles of the distribution of sardine and anchovy biomass in 2032 under Interim OMP-13 v2 and Candidate MP-14.2 compared to a no catch scenario, assuming a **single sardine stock operating model**. Shaded cells represent cases for which the predicted MP : no catch ratio is more pessimistic for sardine than that which applied for OMP-08. A direct comparison of these ratios between OMP-08 and Interim OMP-13 3v3 / Candidate MP-14.2 cannot be made for anchovy due to changes in the key operating model assumptions (e.g. de Moor and Butterworth 2013f). The ratios corresponding to OMP-04 are given for interest. The key MP control parameters, β and α_{ns}, are also given.

	OMP-04/No-catch	OMP-08/No-catch	Interim OMP-13 v2/No-catch (June13)	Interim OMP-13 v2/No-catch (new OM)				Candidate MP-14.2/No-catch				
					$risk_A < 0.20$	$risk_A < 0.25$	$risk_A < 0.30$		$risk_A < 0.15$	$risk_A < 0.20$	$risk_A < 0.25$	$risk_A < 0.30$
β	0.147	0.097	0.090	0.090	0.086	0.082	0.078	0.090	0.093	0.087	0.085	0.082
α_{ns}	0.738	0.780	0.871	0.871	0.797	0.915	1.029	0.871	0.666	0.797	0.911	1.027
$risk_S$		0.178	0.208	0.215	0.209	0.208	0.208	0.215	0.209	0.208	0.208	0.209
$risk_A$		0.097	0.244	0.226	0.190	0.245	0.297	0.226	0.148	0.190	0.244	0.296
Sardine												
10%ile	0.59	0.50	0.53	0.54	0.56	0.58	0.59	0.57	0.57	0.59	0.59	0.60
20%ile	0.68	0.68	0.63	0.67	0.69	0.69	0.69	0.67	0.67	0.69	0.69	0.69
30%ile	0.69	0.72	0.71	0.71	0.72	0.72	0.72	0.71	0.72	0.73	0.73	0.73
40%ile	0.71	0.73	0.75	0.75	0.76	0.76	0.77	0.75	0.75	0.76	0.76	0.76
median	0.72	0.72	0.76	0.77	0.78	0.79	0.79	0.77	0.78	0.78	0.78	0.79
Anchovy												
10%ile	0.25	0.30	0.15	0.14	0.16	0.14	0.12	0.14	0.19	0.16	0.14	0.12
20%ile	0.37	0.36	0.18	0.17	0.20	0.16	0.15	0.17	0.24	0.20	0.17	0.15
30%ile	0.45	0.40	0.22	0.21	0.24	0.19	0.16	0.21	0.29	0.24	0.20	0.16
40%ile	0.56	0.43	0.26	0.26	0.29	0.24	0.20	0.26	0.35	0.29	0.24	0.20
median	0.58	0.47	0.29	0.29	0.32	0.27	0.24	0.29	0.38	0.32	0.27	0.24

Table 4. Key summary statistics for the sardine and anchovy resources under a no catch scenario, Interim OMP-13 v2 and Candidate MP-14.2, assuming a **single sardine stock operating model**, but with different control parameters to Interim OMP-13 v2 and v3. Statistics are compared for the corner points from trade-off curves tuned to different anchovy risk levels and $risk^S < 0.21$. Additional statistics to those given in Table 1 are:

- proportion of times the directed TAC decreases below the minimum TAC (i.e., Exceptional Circumstances are declared), $p\left(TAC_y^{A/S} < c_{mntac}^{A/S}\right)$;
- average number of years for which Exceptional Circumstances, if declared, are declared consecutively, $EC_{consec}^{A/S}$;
- proportion of times the anchovy normal season fishery is closed due to the sardine TAB limit[1], $p(Close)$;
- average normal season anchovy catch lost in each of those years in which the fishery was closed, $\overline{C}_{lost}^{A}$; and
- average normal season anchovy TAC in years in which the fishery was closed $\overline{TAC}_{close}^{A}$.

		No Catch	Interim OMP-13 v2			CMP-14.2			
Anchovy tuning risk level			0.20	0.25	0.30	0.15	0.20	0.25	0.30
Key Control Parameters	β		0.086	0.082	0.078	0.093	0.087	0.085	0.082
	α_{ns}		0.797	0.915	1.029	0.666	0.797	0.911	1.027
Risk statistics	$risk^S < 0.21$	0.047	0.209	0.208	0.208	0.209	0.208	0.208	0.209
	$risk^A$	0.008	0.19	0.245	0.297	0.148	0.190	0.244	0.296
Anchovy biomass statistics	$\overline{B_{\min}^A / K^A}$	0.26	0.11	0.10	0.09	0.12	0.11	0.10	0.09
	$\overline{B_{\min}^A / Risk^A}$	9.21	3.90	3.55	3.28	4.35	3.90	3.56	3.29
	$\overline{B_{2032}^A / K^A}$	1.20	0.59	0.55	0.52	0.63	0.59	0.55	0.52
	$\overline{B_{2032}^A / Risk^A}$	49.27	23.87	22.39	21.32	25.70	23.87	22.44	21.34
	$\overline{B_{2032}^A / B_{2011}^A}$	4.55	1.90	1.78	1.69	2.04	1.90	1.78	1.69

[1] This is the proportion of times the revised normal season sardine TAB with anchovy is reached and excludes any times the initial normal season sardine TAB with anchovy may be reached.

Table 4 (continued).

		No Catch	Interim OMP-13 v2			CMP-14.2			
Anchovy tuning risk level			0.20	0.25	0.30	0.15	0.20	0.25	0.30
Anchovy catch statistics	$\overline{C}^A$ ('13-'32)	0	288	290	291	283	288	290	291
	$\overline{C}^A$ ('13-'15)	0	330	344	355	312	330	343	355
	AAV^A ('13-'32)		0.22	0.21	0.20	0.24	0.22	0.21	0.20
	AAV^A ('13-'15)		0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.50	0.39	0.39	0.39	0.39	0.39	0.39	0.39
	$\overline{B^S_{\min}/Risk^S}$	1.94	1.51	1.51	1.52	1.50	1.51	1.51	1.51
	$\overline{B^S_{2032}/K^S}$	0.99	0.76	0.77	0.77	0.76	0.77	0.77	0.77
	$\overline{B^S_{2032}/Risk^S}$	4.13	3.15	3.17	3.19	3.13	3.16	3.16	3.17
	$\overline{B^S_{2032}/B^S_{2011}}$	2.08	1.57	1.57	1.58	1.55	1.57	1.57	1.58
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0	153	148	144	160	153	151	148
	$\overline{C}^S_{by}$	0	32	33	35	30	32	33	35
	$\overline{C}^S$ ('13-'15)	0	121	118	114	27	121	120	117
	AAV^S ('13-'32)		0.31	0.29	0.30	0.41	0.38	0.37	0.36
	AAV^S ('13-'15)		0.61	0.61	0.61	0.62	0.62	0.62	0.62
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		0.24	0.27	0.30	0.20	0.24	0.27	0.30
	$EC^A_{con\,sec}$		3.28	3.48	3.63	3.13	3.28	3.46	3.62
Anchovy Fishery Closure	$p(Close)$		0.22	0.23	0.24	0.20	0.22	0.23	0.24
	$\overline{C}^A_{lost}$		37	36	35	36	36	36	35
	$\overline{TAC}^A_{close}$		173	168	164	175	173	168	164
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		0.06	0.06	0.06	0.05	0.05	0.05	0.05
	$EC^S_{con\,sec}$		1.37	1.37	1.37	1.32	1.32	1.32	1.32

Table 5. The risk to the resources and average annual directed catch for projections assuming a **two sardine stock operating model** assuming a fixed value of $k^{S}_{covE}=1$ for the multiplicative bias associated with the coverage of the "south" stock recruits by the recruit survey in comparison to the "west" stock recruits during the same survey. Results presented in the latter half of 2013 (e.g. de Moor and Butterworth 2013d) were from an MCMC chain that had not fully converged, but are included here for comparison. Statistics are shown for a no catch scenario, Interim OMP-13 v2 (single area sardine TAC), and Candidate (single area sardine TAC) MPs including a rule for the mid-year increase in the directed sardine TAC when the survey estimate of biomass is between 300 and 600 000t. Results are shown for alternative hypotheses of future movement of "west" recruits to the "south" stock: no future movement (*NoMove*), future movement is determined by switching between favourable and unfavourable environmental south coast states every 5-7 years (*MoveE*), and autocorrelated future movement (*MoveAutoC*).

Two stock Operating Model	Management Procedure	Two stock movement model	β	α_{ns}	$risk_A$	$risk_S$	$risk_S^{west}$	$risk_S^{south}$	$risk_S^{west2}$	$\overline{C}^{A}$	$\overline{C}^{S}$	$\overline{C}^{S}_{west}$	$\overline{C}^{S}_{south}$
Not fully converged	No Catch	NoMove	N/A	N/A	0.008	0.183	0.328	0.997	0.068	0	0	0	0
		MoveE	N/A	N/A	0.008	0.748	0.948	0.416	0.908	0	0	0	0
	Interim OMP-13 v2	NoMove	0.090	0.871	0.238	0.368	0.507	0.998	0.225	288	180	161	20
		MoveE	0.090	0.871	0.241	0.962	0.992	0.938	0.976	292	26	14	12
Converged	No Catch	No Move	N/A	N/A	0.008	0.198	0.332	0.996	0.070	0	0	0	0
		MoveAutoC*	N/A	N/A	0.008	0.504	0.923	0.150	0.820	0	0	0	0
		MoveE	N/A	N/A	0.008	0.754	0.963	0.409	0.925	0	0	0	0
	Interim OMP-13 v2	No Move	0.090	0.871	0.234	0.387	0.496	1.000	0.201	288	181	161	20
		MoveAutoC*	0.090	0.871	0.247	0.964	0.996	0.902	0.987	292	40	22	17
		MoveE	0.090	0.871	0.246	0.968	0.991	0.943	0.984	292	28	12	15
	CMP-14.1	No Move	0.090	0.871	0.234	0.385	0.495	1.000	0.201	288	181	162	18
		MoveAutoC*	0.090	0.871	0.247	0.967	0.996	0.904	0.987	292	37	22	15
		MoveR	0.090	0.871	0.246	0.970	0.991	0.939	0.985	292	25	12	13
	CMP-14.2	No Move	0.090	0.871	0.234	0.385	0.497	1.000	0.199	288	180	162	18
		MoveAutoC*	0.090	0.871	0.247	0.967	0.996	0.907	0.987	292	37	22	15
		MoveE	0.090	0.871	0.246	0.970	0.991	0.939	0.985	292	25	12	13

Table 5 (continued).

Converged	Interim OMP-13 v2 retuned for single stock hypothesis	No Move	0.086	0.797	0.204	0.383	0.492	1.000	0.198	287	177	158	19
		MoveAutoC*	0.086	0.797	0.214	0.961	0.995	0.894	0.987	290	40	22	17
		MoveE	0.086	0.797	0.214	0.968	0.991	0.943	0.982	291	27	13	15
		No Move	0.082	0.915	0.258	0.383	0.491	1.000	0.203	289	172	153	18
		MoveAutoC*	0.082	0.915	0.264	0.959	0.995	0.888	0.986	292	39	22	17
		MoveE	0.082	0.915	0.268	0.968	0.991	0.944	0.981	293	27	12	15
		No Move	0.078	1.029	0.298	0.385	0.494	1.000	0.208	289	166	149	18
		MoveAutoC*	0.078	1.029	0.300	0.957	0.995	0.888	0.986	293	38	22	16
		MoveE	0.078	1.029	0.297	0.968	0.991	0.945	0.981	293	26	12	14
	CMP-14.2 retuned for single stock hypothesis	No Move	0.093	0.666	0.143	0.378	0.498	1.000	0.193	281	185	166	19
		MoveAutoC*	0.093	0.666	0.160	0.969	0.995	0.905	0.987	286	37	22	15
		MoveE	0.093	0.666	0.161	0.967	0.992	0.939	0.985	286	26	13	13
		No Move	0.087	0.797	0.205	0.379	0.494	1.000	0.195	287	178	160	18
		MoveAutoC*	0.087	0.797	0.214	0.966	0.995	0.904	0.987	290	37	22	15
		MoveE	0.087	0.797	0.214	0.968	0.991	0.939	0.984	291	25	12	13
		No Move	0.085	0.911	0.257	0.381	0.493	1.000	0.200	289	175	157	18
		MoveAutoC*	0.085	0.911	0.265	0.964	0.995	0.902	0.987	292	36	22	14
		MoveE	0.085	0.911	0.265	0.964	0.995	0.902	0.987	292	36	22	14
		No Move	0.082	1.027	0.297	0.382	0.497	1.000	0.205	290	171	154	17
		MoveAutoC*	0.082	1.027	0.298	0.962	0.995	0.900	0.986	293	36	22	14
		MoveE	0.082	1.027	0.298	0.962	0.995	0.900	0.986	293	36	22	14

* Further summary statistics for these options are given in Table 5.

Table 6. As for Table 3, but assuming a **two sardine stock operating model**, with movement hypothesis *MoveAutoC*. The upper table gives results for the full sardine and anchovy populations while the lower table gives results for the “west” and “south” sardine stocks and catch west/south of Cape Agulhas.

		No Catch	Interim OMP-13 v2				CMP-14.1	CMP-14.2				
Anchovy tuning risk level				0.20	0.25	0.30			0.15	0.20	0.25	0.30
Key Control Parameters	β		0.090	0.086	0.082	0.078	0.090	0.090	0.093	0.087	0.085	0.082
	α_{ns}		0.871	0.797	0.915	1.029	0.871	0.871	0.666	0.797	0.911	1.027
Risk statistics	$risk^S$	0.504	0.964	0.961	0.959	0.957	0.967	0.967	0.969	0.966	0.964	0.962
	$risk^A$	0.008	0.247	0.214	0.264	0.300	0.247	0.247	0.160	0.214	0.265	0.298
Anchovy biomass statistics	$\overline{B^A_{\min}/K^A}$	0.26	0.09	0.10	0.09	0.08	0.09	0.09	0.11	0.10	0.09	0.08
	$\overline{B^A_{\min}/Risk^A}$	9.21	3.50	3.71	3.38	3.13	3.49	3.49	4.16	3.71	3.39	3.13
	$\overline{B^A_{2032}/K^A}$	1.20	0.54	0.57	0.53	0.50	0.55	0.55	0.62	0.57	0.54	0.51
	$\overline{B^A_{2032}/Risk^A}$	49.27	22.12	23.02	21.66	20.46	22.17	22.17	25.09	23.08	21.76	20.54
	$\overline{B^A_{2032}/B^A_{2011}}$	4.55	1.75	1.83	1.72	1.62	1.76	1.76	1.99	1.83	1.73	1.62
Anchovy catch statistics	$\overline{C}^A$ (‘13-‘32)	0	292	290	292	293	292	292	286	290	292	293
	$\overline{C}^A$ (’13-‘15)	0	343	334	348	360	343	343	316	334	348	359
	AAV^A (’13-‘32)		0.23	0.24	0.22	0.21	0.24	0.23	0.27	0.25	0.23	0.22
	AAV^A (‘13-‘15)		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.50	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	$\overline{B^S_{\min}/Risk^S}$	1.94	0.20	0.21	0.21	0.21	0.20	0.20	0.20	0.21	0.21	0.21
	$\overline{B^S_{2032}/K^S}$	0.99	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06
	$\overline{B^S_{2032}/Risk^S}$	4.13	0.35	0.37	0.37	0.38	0.34	0.34	0.34	0.35	0.35	0.35
	$\overline{B^S_{2032}/B^S_{2011}}$	2.08	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.20

Table 6 (continued).

		No Catch	Interim OMP-13 v2				CMP-14.1	CMP-14.2				
Anchovy tuning risk level				0.20	0.25	0.30			0.15	0.20	0.25	0.30
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0	40	40	39	38	37	37	37	37	36	36
	$\overline{C}^S_{by}$	0	8	8	8	8	7	7	7	7	8	8
	$\overline{C}^S$ ('13-'15)	0	93	91	90	88	90	90	92	89	88	87
	AAV^S ('13-'32)	0	0.64	0.63	0.61	0.59	0.66	0.65	0.66	0.64	0.63	0.62
	AAV^S ('13-'15)	0	0.81	0.79	0.77	0.75	0.81	0.81	0.82	0.79	0.78	0.77
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$	0	0.27	0.25	0.29	0.32	0.27	0.27	0.21	0.25	0.29	0.31
	EC^A_{consec}		3.40	3.28	3.50	3.67	3.41	3.41	3.11	3.29	3.50	3.66
Anchovy Fishery Closure	$p(Close)$	0										
	$\overline{C}^A_{lost}$											
	$\overline{TAC}^A_{close}$											
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$	0	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
	EC^S_{consec}		4.61	4.58	4.60	4.58	4.56	4.57	4.55	4.56	4.56	4.58
"West" Sardine Stock Risk Statistics	$risk^S$	0.923	0.996	0.995	0.995	0.995	0.996	0.996	0.995	0.995	0.995	0.995
	$risk^{*S}$	0.511	0.924	0.921	0.920	0.919	0.930	0.930	0.930	0.927	0.927	0.926
"West" Sardine Stock Biomass Statistics	$\overline{B^S_{min}/K^S}$	0.006	0.006	0.01	0.01	0.01	0.006	0.005	0.01	0.01	0.01	0.01
	$\overline{B^S_{min}/Risk^S}$	0.45	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04
	$\overline{B^S_{2032}/K^S}$	0.27	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	$\overline{B^S_{2032}/Risk^S}$	2.20	0.10	0.11	0.11	0.12	0.10	0.09	0.10	0.10	0.10	0.10
	$\overline{B^S_{2032}/B^S_{2011}}$	3.44	0.12	0.12	0.13	0.13	0.10	0.11	0.11	0.11	0.11	0.11

Table 6 (continued).

		No Catch	Interim OMP-13 v2				CMP-14.1	CMP-14.2				
Anchovy tuning risk level				0.20	0.25	0.30			0.15	0.20	0.25	0.30
"West" Sardine Catch Statistics	$\overline{C}^S$ ('13-'32)	0	22	22	22	22	22	22	22	22	22	22
	$\overline{C}^S_{by}$	0	7	7	8	8	7	7	6	7	7	8
	$\overline{C}^S$ ('13-'15)	0	59	58	57	57	60	60	61	60	59	59
	AAV^S ('13-'32)	0	0.39	0.39	0.37	0.36	0.40	0.39	0.40	0.39	0.38	0.37
	AAV^S ('13-'15)	0	0.44	0.42	0.41	0.40	0.44	0.44	0.45	0.43	0.42	0.41
"South" Sardine Stock Risk Statistic	$risk^S$	0.150	0.902	0.894	0.888	0.888	0.904	0.907	0.905	0.904	0.902	0.900
	$risk^{*S}$	0.031	0.461	0.456	0.457	0.458	0.455	0.456	0.454	0.453	0.454	0.454
"South" Sardine Sock Biomass Statistics	$\overline{B^S_{min}/K^S}$	2.78	0.81	0.82	0.82	0.82	0.82	0.82	0.82	0.83	0.83	0.83
	$\overline{B^S_{min}/Risk^S}$	2.12	0.61	0.62	0.62	0.63	0.63	0.62	0.62	0.63	0.63	0.63
	$\overline{B^S_{2032}/K^S}$	10.71	1.48	1.52	1.53	1.55	1.43	1.43	1.43	1.46	1.46	1.48
	$\overline{B^S_{2032}/Risk^S}$	8.09	1.11	1.14	1.15	1.16	1.07	1.07	1.08	1.10	1.10	1.11
	$\overline{B^S_{2032}/B^S_{2011}}$	1.98	0.28	0.29	0.29	0.29	0.27	0.27	0.27	0.28	0.28	0.28
"South" Sardine Catch Statistics	$\overline{C}^S$ ('13-'32)	0	17	17	17	16	15	15	15	15	14	14
	$\overline{C}^S_{by}$	0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	$\overline{C}^S$ ('13-'15)	0	34	33	32	32	30	30	31	30	29	29
	AAV^S ('13-'32)		1.28	1.28	1.28	1.28	1.33	1.33	1.33	1.33	1.33	1.33
	AAV^S ('13-'15)		1.57	1.58	1.58	1.58	1.57	1.57	1.57	1.58	1.58	1.58

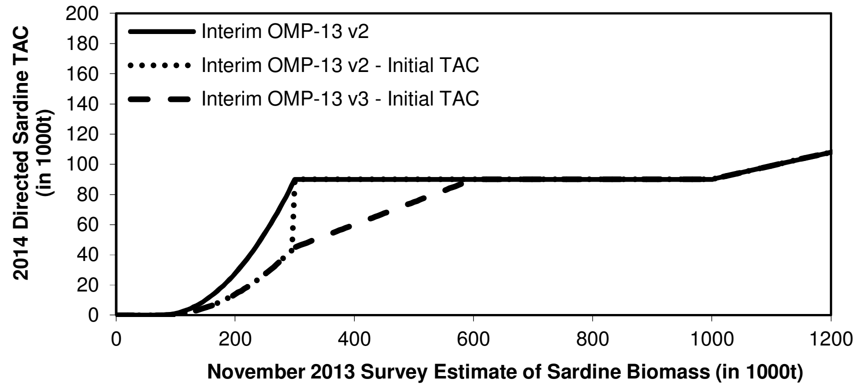

Figure 1. The Harvest Control Rule for directed ≥14cm sardine TAC in 2014 under Interim OMP-13 v2 and Interim OMP-13 v3. The initial sardine TAC awarded at the beginning of the year under Interim OMP-13 v2 and Interim OMP-13 v3 are also plotted.

Figure 2. The proportion of the initial directed sardine TAC (TAC_{init}) that is awarded as a final directed sardine TAC in the mid-year revision when sardine Exceptional Circumstances are declared. As TAC_{init}=0.5$TAC^{\#}$, the final TAC can be a maximum of 110% of $TAC^{\#}$ if recruitment is above average. The historic (May 1984 – 2011) average observed May sardine recruitment is 13.74 billion recruits. For Interim OMP-13 v3, $R_{crit} = 16.48$ billion, such that the mid-year revision is the same as the initial TAC when observed recruitment from the May survey is average.

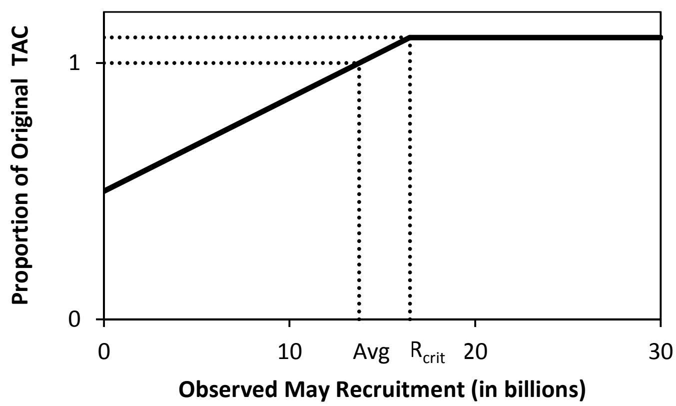

Figure 3. The proportion of the original directed sardine TAC ($TAC^{\#}$) that is awarded as a final directed sardine TAC in the mid-year revision under Candidate MP-14.2 when the survey estimate of sardine biomass is between 300 and 600 000t. The final TAC can be a maximum of 110% of $TAC^{\#}$. The historic (May 1984 – 2011) average observed May sardine recruitment is 13.74 billion recruits. For Interim OMP-13 v3, $R_{crit} = 16.48$ billion, such that the mid-year revision is the same as the initial TAC when observed recruitment from the May survey is average.

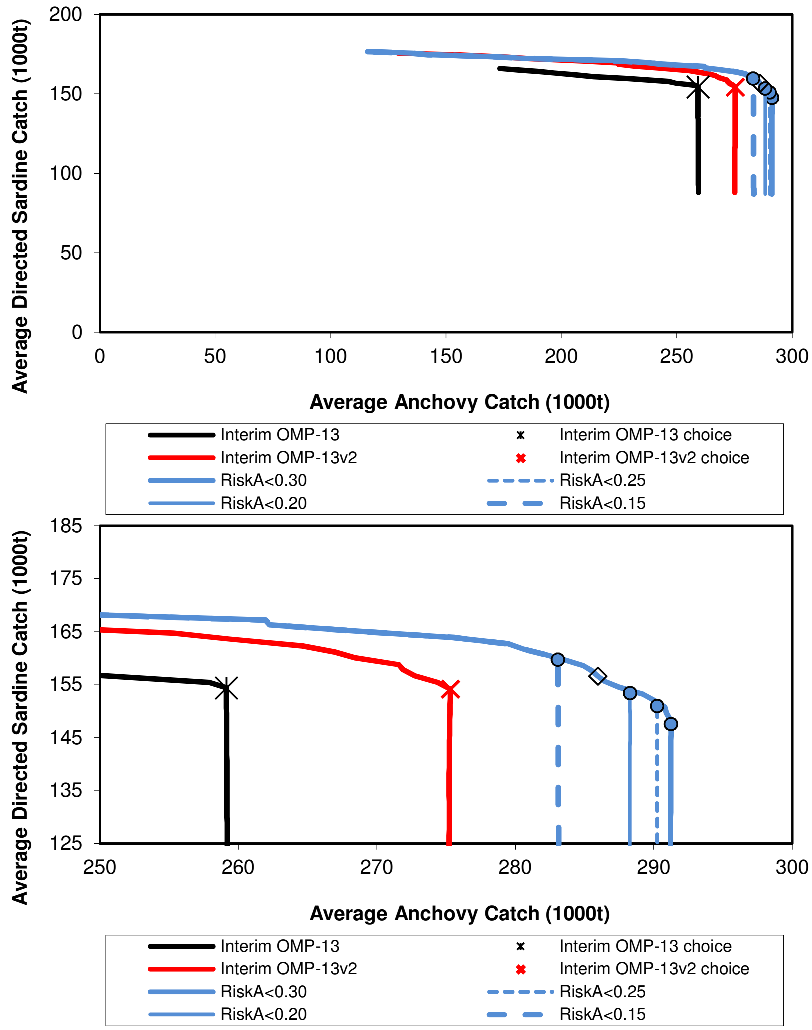

Figure 4. Trade-off curves for Interim OMP-13 ($risk_S < 0.21, risk_A < 0.20$), Interim OMP-13v2 ($risk_s < 0.21, risk_A < 0.25$) and CMP-14.2 ($risk_s < 0.21$) with different anchovy risk levels. The lower figure covers a smaller range on both axes to allow easier comparison of the corner points. The corner points of the CMP-14.2 curves chosen for Table 3 are shown by the dots, while the open diamond corresponds to $\beta = 0.090$ and $\alpha = 0.726$ for $risk_A < 0.30$, $risk_A < 0.25$ and $risk_A < 0.20$.