OMP-13: Alternative Anchovy Control Rules

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Introduction

A number of alternative constraints and harvest control rules have been tabled for consideration during OMP-13 development (de Moor and Butterworth 2013a). This document provides summary statistics for a number of alternatives for the anchovy control rules for a given set of control parameters ($\alpha_{ns} = 0.501$ and $\beta = 0.094$). These control parameters were chosen from the corner point of the trade-off curve which was calculated constraining $risk^A < 0.35$ and $risk^S < 0.21$ (Figure 1). Further work on the choice of an appropriate risk level will be considered separately.

The "Base MP1" (Management Procedure) considered in this document differs from that considered by de Moor and Butterworth (2013b) in that the maximum anchovy TAC is constrained to 400 000t in the normal season (for Candidate MPs that allow for an additional season) and 450 000t for the total year, and the model predicted sardine bycatch before the survey is now only based on anchovy 0-year-old catch (see Appendix 1). A number of alternatives are also compared to a "Base MP2" which differs from "Base MP1" with a higher anchovy Exceptional Circumstances threshold of $B^A_{ec} = 600$ instead of $B^A_{ec} = 400$.

Below, the baseline constraints/rules are listed first, with alternatives to be tested (all biomasses are given in thousands of tons):

i) Additional season: October – December[1] or None[2].

ii) Scale-down factor applied to initial anchovy TAC: $\delta = 0.85$ or $\delta = 0.90$ or $\delta = 0.95$ or $\delta = 0.80$ or $\delta = 0.75$.

iii) Minimum normal season anchovy TAC: $c^A_{mntac} = 120$ or $c^A_{mntac} = 100$

iv) Maximum normal season/total season anchovy TAC: $c^A_{mxtac} = 450$ with $c^A_{mxtac,ns} = 400$ or $c^A_{mxtac} = 350$ with $c^A_{mxtac,ns} = 300$

v) Maximum additional season anchovy TAC: $c^{ads,A}_{mxinc} = 120$ or $c^{ads,A}_{mxinc} = 80$ [3]

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[1] The simulation testing procedure estimates sardine bycatch from July to September by multiplying the anchovy catch in each of these months by the predicted monthly bycatch ratios. For this calculation, the difference between the initial and revised normal season anchovy TAC is assumed to be caught in July, August and September in the ratio 0.45:0.30:0.25. Sardine bycatch from October-December is assumed to range from 0-1500t dependent on the anchovy additional season TAC.

[2] The simulation testing procedure estimates sardine bycatch from July to October-December by multiplying the anchovy catch in each of these sets of months by the predicted monthly bycatch ratios. For this calculation, the difference between the intial and revised normal season anchovy TAC is caught in July, August, September and October-December in the ratios 0.42:0.26:0.22:0.10.

[3] Not applicable if there is no additional season.

vi) Exceptional Circumstances threshold: $B_{ec}^{A} = 400$ or $B_{ec}^{A} = 600$ or $B_{ec}^{A} = 800$

vii) Two-tier threshold for normal season anchovy TAC: $c_{tier}^{A} = 330$ or $c_{tier}^{A} = 275$ or no two-tier system (i.e. $c_{tier}^{A} = c_{mxtac,ns}^{A} = 400$[4])

viii) Maximum increase in normal season anchovy TAC[5]: $c_{mxinc}^{ns,A} = 150$ or $c_{mxinc}^{ns,A} = 120$ or $c_{mxinc}^{ns,A} = 100$

ix) Initial sardine TAB with anchovy ($\gamma_y TAC_y^{1,A}$) : $\gamma_y = 0.1 + \frac{0.1}{1 + \exp\left(-\frac{1}{0.1} 0.00025\left(B_{y-1}^{obs,S} - 2000\right)\right)}$ or

$$\gamma_y = 0.1 + \frac{0.2}{1 + \exp\left(-\frac{1}{0.1} 0.00025\left(B_{y-1}^{obs,S} - 2000\right)\right)} \text{ or } \gamma_y = 0.1 + \frac{0.05}{1 + \exp\left(-\frac{1}{0.1} 0.00025\left(B_{y-1}^{obs,S} - 2000\right)\right)}$$

The sardine base case operating model is that for a single stock used to develop Interim OMP-13 (de Moor and Butterworth 2012). The anchovy base case operating model assumes a Beverton Holt stock recruitment relationship with juvenile and adult natural mortality rates of 1.2year^{-1}.

Alternative operating models test the possibility of extended periods of future good or poor recruitment:
OMs1: 5 years of poor sardine recruitment, taken to be 20% of the median predicted recruitment
OMs2: 5 years of poor sardine recruitment, taken to be 40% of the median predicted recruitment
OMs3: 5 years of good sardine recruitment, taken to be 1.4 times the median predicted recruitment
OMa1: 5 years of poor anchovy recruitment, taken to be 20% of the median predicted recruitment
OMa2: 5 years of poor anchovy recruitment, taken to be 40% of the median predicted recruitment
OMa3: 5 years of good anchovy recruitment, taken to be 1.4 times the median predicted recruitment
Combinations of these models are also considered. Unless other stated, the 5 years of good/poor recruitment are applied to November 2014-2018.

Results and Discussion.

Results are presented here for the alternatives i) - vi). The alternatives vii) and ix) will be considered at a later stage.

Tables 1a,b show that having a single anchovy season, in contrast to a normal and additional season lowers risk to the anchovy resource with little change in the average projected catch. The number of times the sardine bycatch limit is reached is also decreased, as a greater sardine bycatch limit would be given based on the larger revised normal season anchovy TAC if there were no additional season. There is little change in the average predicted sardine directed catch, bycatch and risk level for a given operating model. Figure 2 shows the trade-off curves for BaseMP1, tuned to $risk^{A} < 0.35$ and for BaseMP2, tuned to $risk^{A} < 0.20$. The removal of the additional season results in an increase of

[4] Or 450 if there is no additional season.
[5] This only applies to the revised normal season TAC, for which permits are normally made available July/August, and will apply until the end of September.

about 7000-8000t in average anchovy catch, with a decrease of about 4000-5000t in average directed sardine catch at the corner points of the trade-off curves.

Tables 2a,b show that there is little difference in the performance stats for values of δ ranging between 0.75 and 0.95.

A lower minimum anchovy TAC results in a lower risk to the resource for little other change in performance statistics (Table 3). Retuning the OMP to the same risk level has little difference in trade-off curves at the corner points of the trade-off curves (Figure 3).

A lower maximum anchovy TAC results in a decrease of about 30 000t of anchovy catch and a decrease in both the anchovy and sardine risk levels (Table 3). Retuning the OMP to the same risk level results in a decrease in average projected anchovy catch of about 30 000t at the corner points of the trade-off curves (Figure 3).

A lower maximum additional season anchovy TAC results in a decrease of between three and nine thousand tons of average additional season anchovy catch (dependent on the maximum anchovy TAC level) and a decrease of between one and four thousand tons of average total anchovy catch (dependent on the maximum anchovy TAC level) (Table 3). Thus, on average, more anchovy is simulated to be caught during the normal season. A lower anchovy risk results.

As the anchovy Exceptional Circumstances threshold increases from 400 000t to 600 000t and 800 000t, the risk to both the anchovy and sardine resources, both in terms of the risk statistic and the "leftward shift" decreases (Table 4). Under the base case operating models, the anchovy risk level decreases from 35% to 20% to 11%. The simulated average total anchovy catch increases between 4 and 5% (depending on the underlying operating model), and the average juvenile sardine bycatch decreases between 12 and 20% (depending on the underlying operating model) as the threshold increases from 400 to 600 thousand tons (Table 4). Under the base case operating models the percentage of times anchovy Exceptional Circumstances are simulated to be declared over the next 20 years increases from 25% to 29% to 33% as the threshold increases from 400 to 600 and 800 thousand tons, though the average period for which Exceptional Circumstances remains in effect decreases slightly (Table 4).

References

de Moor, C.L. and Butterworth, D.S. 2012. Interim OMP-13. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2012/DEC/SWG-PEL/64. 17pp.

de Moor, C.L. and Butterworth, D.S. 2013a. Timeline for remaining OMP-13 development. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2013/MAY/SWG-PEL/08. 6pp.

de Moor, C.L. and Butterworth, D.S. 2013b. Re-considering the appropriate risk level for anchovy in OMP-13 development. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2013/APR/SWG-PEL/04. 18pp.

Table 1a. Key summary statistics for the sardine and anchovy resources under a no-catch scenario and alternative constraints on the Harvest Control Rules for Candidate OMP-13:

- $risk^S$ - 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;
- $risk^A$ - 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;
- average minimum biomass, $B_{\min}^{S/A}$, 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, $B_{2032}^{S/A}$, 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;
- 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;
- proportion of times the directed TAC decreases 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 times the anchovy normal season fishery is closed due to the sardine TAB limit, $p(Close)$;
- 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 $\overline{TAC}_{close}^A$.

Statistics are compared between **"BaseMP1" with** $B_{ec}^A = 400$ and a corresponding alternative with no additional season, for five different underlying operating models.

Operating Models		Base OM			OMs1			OMs2			OMa3 OMs1			OMa3 OMs2		
HCR Alternatives		No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season
Key control parameters	β	N/A	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
	α	N/A	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501
Risk statistics	$risk^A$	0.020	0.344	0.261	0.020	0.385	0.284	0.020	0.359	0.275	0.005	0.284	0.183	0.005	0.27	0.174
	$risk^S$	0.031	0.209	0.212	0.982	1.00	1.00	0.363	0.941	0.94	0.982	1.00	1.00	0.363	0.938	0.937
Anchovy depletion ratios	10%ile	1.00	0.11	0.13	1.00	0.10	0.12	1.00	0.10	0.12	1.00	0.10	0.13	1.00	0.10	0.14
	20%ile	1.00	0.14	0.22	1.00	0.13	0.19	1.00	0.13	0.20	1.00	0.13	0.21	1.00	0.13	0.22
	30%ile	1.00	0.18	0.31	1.00	0.16	0.26	1.00	0.17	0.28	1.00	0.17	0.30	1.00	0.18	0.31
	40%ile	1.00	0.24	0.36	1.00	0.20	0.32	1.00	0.21	0.34	1.00	0.21	0.35	1.00	0.23	0.36
	50%ile	1.00	0.27	0.40	1.00	0.24	0.38	1.00	0.26	0.39	1.00	0.25	0.39	1.00	0.27	0.40
Anchovy biomass statistics	$\overline{B^A_{\min}/K^A}$	0.22	0.08	0.14	0.22	0.07	0.10	0.22	0.08	0.10	0.25	0.10	0.13	0.25	0.10	0.13
	$\overline{B^A_{\min}/Risk^A}$	7.57	2.84	3.79	7.57	2.68	3.61	7.57	2.74	3.67	8.70	3.58	4.76	8.70	3.64	4.83
	$\overline{B^A_{2032}/K^A}$	1.17	0.52	0.63	1.17	0.50	0.61	1.17	0.50	0.62	1.23	0.53	0.65	1.23	0.54	0.65
	$\overline{B^A_{2032}/Risk^A}$	48.19	20.68	25.51	48.19	19.70	24.58	48.19	20.07	24.91	50.79	21.78	26.79	50.79	22.16	27.04
	$\overline{B^A_{2032}/B^A_{2011}}$	7.59	3.20	3.32	7.59	3.03	3.20	7.59	3.09	3.24	8.05	3.30	3.46	8.05	3.36	3.49
Anchovy catch statistics	$\overline{C}^A$ ('13-'32)	0.0	258.6	258.3	0.0	258.0	259.6	0.0	258.3	259.3	0.0	293.0	293.8	0.0	293.1	293.3
	$\overline{C}^A_{ad}$ ('13-'32)	0.0	50.3	N/A	0.0	49.0	N/A	0.0	49.4	N/A	0.0	55.9	N/A	0.0	56.4	N/A
	$\overline{C}^A$ ('13-'15)	0.0	274.8	263.2	0.0	277.0	265.5	0.0	276.3	264.8	0.0	285.4	272.3	0.0	285.0	271.9
	$\overline{C}^A_{ad}$ ('13-'15)	0.0	48.1	N/A	0.0	48.1	N/A	0.0	48.1	N/A	0.0	51.2	N/A	0.0	51.2	N/A
	AAV^A ('13-'32)	0.00	0.18	0.23	0.00	0.16	0.22	0.00	0.16	0.22	0.00	0.18	0.27	0.00	0.17	0.27
	AAV^A ('13-'15)	0.00	0.05	0.14	0.00	0.05	0.14	0.00	0.05	0.14	0.00	0.07	0.22	0.00	0.07	0.22

Operating Models		Base OM			OMs1			OMs2			OMa3 OMs1			OMa3 OMs2		
HCR Alternatives		No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season	No Catch	Base MP1	No ad season
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.54	0.41	0.41	0.13	0.04	0.04	0.31	0.12	0.12	0.13	0.04	0.04	0.31	0.12	0.13
	$\overline{B^S_{\min}/Risk^S}$	2.03	1.56	1.56	0.50	0.14	0.14	1.18	0.46	0.47	0.50	0.14	0.14	1.18	0.47	0.48
	$\overline{B^S_{2032}/K^S}$	0.99	0.75	0.74	0.89	0.20	0.20	0.97	0.43	0.43	0.89	0.20	0.20	0.97	0.43	0.44
	$\overline{B^S_{2032}/Risk^S}$	4.04	3.00	3.00	3.51	0.74	0.75	3.89	1.66	1.67	3.51	0.74	0.76	3.89	1.67	1.69
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	1.45	1.45	1.71	0.34	0.35	1.91	0.77	0.78	1.71	0.34	0.35	1.91	0.78	0.79
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0.0	159.2	159.2	0.0	51.9	52.4	0.0	87.0	87.5	0.0	52.1	52.9	0.0	87.6	88.4
	$\overline{C}^S_{by}$	0.0	33.5	34.1	0.0	11.2	10.9	0.0	18.6	18.5	0.0	11.1	10.7	0.0	18.5	18.1
	$\overline{C}^S$ ('13-'15)	0.00	128.9	129.1	0.0	128.6	128.9	0.0	128.7	129.0	0.0	128.6	128.9	0.0	128.8	129.0
	AAV^S ('13-'32)	0.0	0.2	0.21	0.0	0.5	0.6	0.0	0.6	0.6	0.0	0.5	0.6	0.0	0.6	0.6
	AAV^S ('13-'15)	0.0	0.04	0.04	0.0	0.04	0.04	0.0	0.04	0.04	0.0	0.04	0.04	0.00	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		0.25	0.18		0.27	0.19		0.26	0.19		0.19	0.12		0.19	0.12
	$EC^A_{con\,sec}$		3.46	3.37		3.53	3.42		3.50	3.41		3.01	2.81		2.97	2.73
Anchovy Fishery Closure	$p(Close)$		0.28	0.23		0.19	0.14		0.22	0.18		0.13	0.10		0.17	0.13
	$\overline{C}^A_{lost}$		26	31		15	18		19	23		18	24		23	29
	$\overline{TAC}^A_{close}$		113	139		60	75		81	101		77	102		103	134
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		0.05	0.05		0.59	0.58		0.34	0.34		0.58	0.58		0.34	0.33
	$EC^S_{con\,sec}$		1.34	1.34		3.93	3.89		2.22	2.19		3.91	3.83		2.22	2.19

Table 1b. A repeat of Table 1a, but statistics are compared between **"BaseMP2" with** $B_{ec}^{A} = 600$ and a corresponding alternative with no additional season, for five different underlying operating models.

Operating Models		Base OM			OMs1			OMs2			OMa3 OMs1			OMa3 OMs2		
HCR Alternatives		No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season
Key control parameters	β	N/A	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
	α	N/A	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501
Risk statistics	$risk^{A}$	0.020	0.196	0.143	0.020	0.212	0.158	0.363	0.207	0.154	0.005	0.143	0.094	0.005	0.141	0.085
	$risk^{S}$	0.031	0.203	0.201	0.982	1.00	1.00	0.02	0.939	0.939	0.982	1.00	1.00	0.363	0.935	0.936
Anchovy depletion ratios	10%ile	1.00	0.19	0.22	1.00	0.17	0.21	1.00	0.18	0.22	1.00	0.17	0.24	1.00	0.19	0.24
	20%ile	1.00	0.22	0.29	1.00	0.20	0.26	1.00	0.21	0.28	1.00	0.20	0.28	1.00	0.21	0.29
	30%ile	1.00	0.25	0.35	1.00	0.23	0.32	1.00	0.24	0.33	1.00	0.23	0.33	1.00	0.24	0.35
	40%ile	1.00	0.29	0.40	1.00	0.27	0.37	1.00	0.28	0.38	1.00	0.26	0.38	1.00	0.27	0.38
	50%ile	1.00	0.31	0.42	1.00	0.29	0.40	1.00	0.30	0.41	1.00	0.30	0.41	1.00	0.30	0.42
Anchovy biomass statistics	$\overline{B_{\min}^{A} / K^{A}}$	0.22	0.09	0.11	0.22	0.09	0.11	0.22	0.09	0.11	0.25	0.11	0.14	0.25	0.11	0.14
	$\overline{B_{\min}^{A} / Risk^{A}}$	7.57	3.17	4.04	7.57	3.03	3.87	7.57	3.08	3.93	8.70	3.89	4.97	8.70	3.95	5.04
	$\overline{B_{2032}^{A} / K^{A}}$	1.17	0.57	0.66	1.17	0.55	0.64	1.17	0.56	0.65	1.23	0.58	0.67	1.23	0.58	0.68
	$\overline{B_{2032}^{A} / Risk^{A}}$	48.19	22.76	26.76	48.19	22.02	25.97	48.19	22.25	26.21	50.79	23.70	27.82	50.79	23.96	28.06
	$\overline{B_{2032}^{A} / B_{2011}^{A}}$	7.59	3.57	3.51	7.59	3.45	3.41	7.59	3.49	3.44	8.05	3.66	3.63	8.05	3.71	3.66
Anchovy catch statistics	$\overline{C}^{A}$ ('13-'32)	0.0	264.4	262.1	0.0	264.8	263.8	0.0	264.8	263.3	0.0	298.8	297.3	0.0	298.6	296.6
	$\overline{C}_{ad}^{A}$ ('13-'32)	0.0	52.1	N/A	0.0	51.2	N/A	0.0	51.6	N/A	0.0	57.6	N/A	0.0	58.0	N/A
	$\overline{C}^{A}$ ('13-'15)	0.0	266.8	258.2	0.0	268.7	260.2	0.0	268.1	259.6	0.0	278.4	267.3	0.0	278.1	267.0
	$\overline{C}_{ad}^{A}$ ('13-'15)	0.0	49.1	N/A	0.0	49.1	N/A	0.0	49.1	N/A	0.0	52.6	N/A	0.0	52.6	N/A
	AAV^{A} ('13-'32)	0.00	0.18	0.23	0.00	0.17	0.22	0.00	0.17	0.22	0.00	0.19	0.27	0.00	0.19	0.27
	AAV^{A} ('13-'15)	0.00	0.05	0.14	0.00	0.05	0.14	0.00	0.05	0.14	0.00	0.07	0.22	0.00	0.07	0.22

Operating Models		Base OM			OMs1			OMs2			OMa3 OMs1			OMa3 OMs2		
HCR Alternatives		No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season	No Catch	Base MP2	No ad season
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.54	0.41	0.41	0.13	0.04	0.04	0.31	0.12	0.12	0.13	0.04	0.04	0.31	0.13	0.13
	$\overline{B^S_{\min}/Risk^S}$	2.03	1.57	1.57	0.50	0.14	0.14	1.18	0.47	0.47	0.50	0.14	0.14	1.18	0.48	0.48
	$\overline{B^S_{2032}/K^S}$	0.99	0.75	0.75	0.89	0.21	0.21	0.97	0.44	0.44	0.89	0.20	0.21	0.97	0.44	0.44
	$\overline{B^S_{2032}/Risk^S}$	4.04	3.02	3.01	3.51	0.76	0.77	3.89	1.69	1.69	3.51	0.76	0.78	3.89	1.70	1.71
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	1.46	1.46	1.71	0.36	0.36	1.91	0.79	0.79	1.71	0.35	0.36	1.91	0.79	0.80
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0.0	160.1	159.9	0.0	52.7	53.0	0.0	88.2	88.4	0.0	52.8	53.3	0.0	88.6	89.0
	$\overline{C}^S_{by}$	0.0	31.4	32.6	0.0	10.3	10.3	0.0	17.2	17.5	0.0	10.3	10.1	0.0	17.3	17.4
	$\overline{C}^S$ ('13-'15)	0.0	129.3	129.3	0.0	129.0	129.1	0.0	129.1	129.2	0.0	129.0	129.1	0.0	129.1	129.2
	AAV^S ('13-'32)	0.00	0.20	0.21	0.00	0.54	0.56	0.00	0.60	0.58	0.00	0.55	0.57	0.00	0.58	0.56
	AAV^S ('13-'15)	0.00	0.04	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		0.29	0.22		0.31	0.23		0.31	0.23		0.23	0.15		0.23	0.15
	$EC^A_{con\,sec}$		3.18	3.01		3.29	3.08		3.26	3.07		2.85	2.57		2.83	2.57
Anchovy Fishery Closure	$p(Close)$		0.27	0.23		0.18	0.14		0.22	0.18		0.13	0.10		0.17	0.12
	$\overline{C}^A_{lost}$		26	32		16	20		19	23		19	25		23	29
	$\overline{TAC}^A_{close}$		113	140		61	77		81	102		76	103		101	134
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		0.05	0.05		0.58	0.58		0.33	0.33		0.58	0.57		0.33	0.33
	$EC^S_{con\,sec}$		1.32	1.32		3.88	3.84		2.20	2.17		3.87	3.81		2.20	2.17

Table 2a. A repeat of Table 1a, for **"BaseMP1" with** $B_{ec}^{A} = 400$**,** but statistics are shown for alternative values used to downweight the initial anchovy TAC, for three different underlying operating models.

Operating Models		Base OM						OMa1						OMa3					
HCR Alternatives, δ values		No Catch	0.75	0.80	Base MP1	0.90	0.95	No Catch	0.75	0.80	Base MP1	0.90	0.95	No Catch	0.75	0.80	Base MP1	0.90	0.95
Key control parameters	β	N/A	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
	α	N/A	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501
Risk statistics	$risk^{A}$	0.020	0.346	0.346	0.344	0.344	0.344	0.56	0.938	0.938	0.938	0.938	0.939	0.005	0.25	0.25	0.25	0.249	0.25
	$risk^{S}$	0.031	0.209	0.209	0.209	0.209	0.209	0.031	0.199	0.199	0.199	0.199	0.200	0.031	0.208	0.208	0.208	0.209	0.209
Anchovy depletion ratios	10%ile	1.00	0.11	0.11	0.11	0.11	0.11	1.00	0.05	0.05	0.05	0.05	0.05	1.00	0.11	0.11	0.11	0.11	0.11
	20%ile	1.00	0.14	0.14	0.14	0.14	0.14	1.00	0.12	0.12	0.12	0.12	0.12	1.00	0.15	0.15	0.15	0.15	0.15
	30%ile	1.00	0.18	0.18	0.18	0.18	0.18	1.00	0.14	0.14	0.14	0.14	0.14	1.00	0.20	0.20	0.20	0.20	0.21
	40%ile	1.00	0.24	0.24	0.24	0.24	0.24	1.00	0.18	0.18	0.18	0.18	0.18	1.00	0.24	0.24	0.24	0.24	0.24
	50%ile	1.00	0.27	0.27	0.27	0.27	0.27	1.00	0.22	0.22	0.22	0.22	0.22	1.00	0.28	0.28	0.28	0.28	0.28
Anchovy biomass statistics	$\overline{B_{\min}^{A} / K^{A}}$	0.22	0.08	0.08	0.08	0.08	0.08	0.04	0.01	0.01	0.01	0.01	0.01	0.25	0.10	0.10	0.10	0.10	0.10
	$\overline{B_{\min}^{A} / Risk^{A}}$	7.57	2.84	2.84	2.84	2.84	2.84	1.11	0.33	0.33	0.33	0.33	0.33	8.70	3.74	3.74	3.74	3.74	3.74
	$\overline{B_{2032}^{A} / K^{A}}$	1.17	0.52	0.52	0.52	0.52	0.52	0.87	0.37	0.37	0.37	0.37	0.37	1.23	0.55	0.55	0.55	0.55	0.55
	$\overline{B_{2032}^{A} / Risk^{A}}$	48.19	20.65	20.67	20.68	20.69	20.69	33.02	13.00	13.00	13.00	12.99	12.97	50.79	22.69	22.70	22.71	22.72	22.72
	$\overline{B_{2032}^{A} / B_{2011}^{A}}$	7.59	3.19	3.19	3.19	3.20	3.20	5.12	2.06	2.06	2.06	2.06	2.05	8.05	3.46	3.46	3.46	3.46	3.47
Anchovy catch statistics	$\overline{C}^{A}$('13-'32)	0.0	258.5	258.5	258.6	258.7	258.9	0.0	125.2	125.3	125.3	125.4	125.5	0.0	293.0	293.0	293.1	293.2	293.4
	$\overline{C}_{ad}^{A}$ ('13-'32)	0.0	50.5	50.4	50.3	50.1	49.8	0.0	24.6	24.6	24.5	24.4	24.3	0.0	57.4	57.3	57.2	57.0	56.7
	$\overline{C}^{A}$('13-'15)	0.0	274.8	274.8	274.8	274.9	274.9	0.0	238.4	238.4	238.5	238.5	238.7	0.0	283.6	283.6	283.6	283.6	283.6
	$\overline{C}_{ad}^{A}$ ('13-'15)	0.0	48.2	48.2	48.1	48.1	48.0	0.0	36.2	36.2	36.2	36.1	36.0	0.0	51.3	51.2	51.2	51.2	51.1
	AAV^{A} ('13-'32)	0.00	0.18	0.18	0.18	0.18	0.18	0.00	0.49	0.49	0.49	0.49	0.49	0.00	0.19	0.19	0.19	0.19	0.19
	AAV^{A} ('13-'15)	0.00	0.05	0.05	0.05	0.05	0.05	0.00	0.24	0.24	0.24	0.24	0.24	0.00	0.07	0.07	0.07	0.07	0.07

Operating Models		Base OM						OMa1						OMa3					
HCR Alternatives, δ values		No Catch	0.75	0.80	Base MP1	0.90	0.95	No Catch	0.75	0.80	Base MP1	0.90	0.95	No Catch	0.75	0.80	Base MP1	0.90	0.95
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.54	0.41	0.41	0.41	0.41	0.41	0.54	0.41	0.41	0.41	0.41	0.41	0.54	0.41	0.41	0.41	0.41	0.41
	$\overline{B^S_{\min}/Risk^S}$	2.03	1.56	1.56	1.56	1.56	1.56	2.03	1.57	1.57	1.57	1.57	1.57	2.03	1.57	1.57	1.57	1.57	1.56
	$\overline{B^S_{2032}/K^S}$	0.99	0.75	0.75	0.75	0.75	0.75	0.99	0.76	0.76	0.76	0.76	0.76	0.99	0.75	0.75	0.75	0.75	0.75
	$\overline{B^S_{2032}/Risk^S}$	4.04	3.00	3.00	3.00	3.00	3.00	4.04	3.06	3.06	3.06	3.06	3.06	4.04	3.00	3.00	3.00	3.00	3.00
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	1.45	1.45	1.45	1.45	1.45	1.99	1.48	1.48	1.48	1.48	1.48	1.99	1.45	1.45	1.45	1.45	1.45
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0.0	159.2	159.2	159.2	159.2	159.1	0.0	160.9	160.9	160.9	160.9	160.8	0.0	159.6	159.5	159.5	159.5	159.5
	$\overline{C}^S_{by}$	0.0	33.4	33.4	33.5	33.5	33.7	0.0	24.7	24.8	24.8	24.9	25.0	0.0	33.3	33.4	33.4	33.5	33.7
	$\overline{C}^S$ ('13-'15)	0.0	128.9	128.9	128.9	128.9	128.9	0.0	128.9	128.9	128.9	128.9	128.9	0.0	128.9	128.9	128.9	128.9	128.9
	AAV^S ('13-'32)	0.00	0.20	0.20	0.20	0.20	0.20	0.00	0.22	0.22	0.22	0.22	0.22	0.00	0.21	0.21	0.21	0.21	0.21
	AAV^S ('13-'15)	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.04	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		0.25	0.25	0.25	0.25	0.25		0.60	0.60	0.60	0.60	0.60		0.17	0.17	0.17	0.17	0.17
	$EC^A_{con\,sec}$		3.45	3.46	3.46	3.46	3.47		7.52	7.52	7.52	7.53	7.53		2.90	2.90	2.90	2.90	2.90
Anchovy Fishery Closure	$p(Close)$		0.28	0.28	0.28	0.28	0.28		0.57	0.57	0.57	0.57	0.57		0.22	0.22	0.22	0.22	0.22
	$\overline{C}^A_{lost}$		26	26	26	26	26		10	10	10	10	10		31	31	31	31	31
	$\overline{TAC}^A_{close}$		112	112	113	113	114		39	39	39	39	39		139	139	139	140	140
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05
	$EC^S_{con\,sec}$		1.34	1.34	1.34	1.35	1.35		1.34	1.34	1.34	1.34	1.34		1.33	1.33	1.33	1.33	1.33

Table 2b. A repeat of Table 1b, for **"BaseMP2" with** $B_{ec}^{A} = 600$ **,** but statistics are shown for alternative values used to downweight the initial anchovy TAC, for three different underlying operating models.

Operating Models		Base OM						OMa1						OMa3					
HCR Alternatives, δ values		No Catch	0.75	0.80	Base MP2	0.90	0.95	No Catch	0.75	0.80	Base MP2	0.90	0.95	No Catch	0.75	0.80	Base MP2	0.90	0.95
Key control parameters	β	N/A	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.005	0.094	0.094	0.094	0.094	0.094
	α	N/A	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.031	0.501	0.501	0.501	0.501	0.501
Risk statistics	$risk^{A}$	0.020	0.196	0.196	0.196	0.196	0.196	0.56	0.876	0.876	0.867	0.877	0.877	1.00	0.131	0.131	0.131	0.131	0.131
	$risk^{S}$	0.031	0.203	0.203	0.203	0.203	0.203	0.031	0.187	0.187	0.188	0.188	0.189	1.00	0.205	0.205	0.206	0.206	0.206
Anchovy depletion ratios	10%ile	1.00	0.19	0.19	0.19	0.19	0.19	1.00	0.17	0.17	0.17	0.17	0.17	1.00	0.19	0.19	0.19	0.19	0.19
	20%ile	1.00	0.22	0.22	0.22	0.22	0.22	1.00	0.21	0.21	0.21	0.21	0.21	1.00	0.22	0.22	0.22	0.22	0.22
	30%ile	1.00	0.25	0.25	0.25	0.25	0.25	1.00	0.24	0.24	0.24	0.24	0.23	1.00	0.25	0.25	0.25	0.25	0.25
	40%ile	1.00	0.29	0.29	0.29	0.29	0.29	1.00	0.28	0.28	0.28	0.28	0.27	0.25	0.28	0.28	0.28	0.28	0.28
	50%ile	1.00	0.31	0.31	0.31	0.31	0.31	1.00	0.29	0.29	0.29	0.29	0.29	8.70	0.31	0.31	0.31	0.31	0.31
Anchovy biomass statistics	$\overline{B_{\min}^{A} / K^{A}}$	0.22	0.09	0.09	0.09	0.09	0.09	0.04	0.02	0.02	0.02	0.02	0.02	1.23	0.11	0.11	0.11	0.11	0.11
	$\overline{B_{\min}^{A} / Risk^{A}}$	7.57	3.17	3.17	3.17	3.17	3.17	1.11	0.46	0.46	0.46	0.46	0.46	50.79	4.04	4.04	4.04	4.04	4.04
	$\overline{B_{2032}^{A} / K^{A}}$	1.17	0.57	0.57	0.57	0.57	0.57	0.87	0.42	0.42	0.42	0.42	0.42	8.05	0.59	0.59	0.59	0.59	0.59
	$\overline{B_{2032}^{A} / Risk^{A}}$	48.19	22.73	22.75	22.76	22.77	22.77	33.02	15.27	15.27	15.27	15.27	15.25	0.0	24.44	24.45	24.47	24.47	24.48
	$\overline{B_{2032}^{A} / B_{2011}^{A}}$	7.59	3.57	3.57	3.57	3.58	3.57	5.12	2.42	2.42	2.42	2.42	2.42	0.0	3.79	3.80	3.80	3.80	3.80
Anchovy catch statistics	$\overline{C}^{A}$ ('13-'32)	0.0	264.2	264.3	264.4	264.6	264.8	0.0	129.3	129.3	129.4	129.5	129.7	0.0	297.9	297.9	298.0	298.2	298.4
	$\overline{C}_{ad}^{A}$ ('13-'32)	0.0	52.4	52.2	52.1	51.9	51.6	0.0	26.5	26.4	26.3	26.2	26.0	0.0	58.8	58.7	58.5	58.3	58.0
	$\overline{C}^{A}$ ('13-'15)	0.0	266.7	266.7	266.8	266.8	267.0	0.0	229.3	229.4	229.5	229.6	229.8	0.00	276.8	276.8	276.8	276.9	277.0
	$\overline{C}_{ad}^{A}$ ('13-'15)	0.0	49.2	49.2	49.1	49.1	49.0	0.0	36.1	36.0	36.0	35.9	35.8	0.00	52.7	52.7	52.6	52.6	52.5
	AAV^{A} ('13-'32)	0.00	0.18	0.18	0.18	0.18	0.19	0.00	0.47	0.47	0.47	0.47	0.47	0.005	0.20	0.20	0.20	0.20	0.20
	AAV^{A} ('13-'15)	0.00	0.05	0.05	0.05	0.05	0.05	0.00	0.24	0.24	0.24	0.24	0.24	0.031	0.07	0.07	0.07	0.07	0.07

Operating Models		Base OM						OMa1						OMa3					
HCR Alternatives, δ values		No Catch	0.75	0.80	Base MP2	0.90	0.95	No Catch	0.75	0.80	Base MP2	0.90	0.95	No Catch	0.75	0.80	Base MP2	0.90	0.95
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.54	0.41	0.41	0.41	0.41	0.41	0.54	0.42	0.42	0.42	0.42	0.42	0.54	0.41	0.41	0.41	0.41	0.41
	$\overline{B^S_{\min}/Risk^S}$	2.03	1.57	1.57	1.57	1.57	1.57	2.03	1.60	1.60	1.60	1.59	1.59	2.03	1.58	1.58	1.58	1.58	1.58
	$\overline{B^S_{2032}/K^S}$	0.99	0.75	0.75	0.75	0.75	0.75	0.99	0.77	0.77	0.77	0.77	0.77	0.99	0.75	0.75	0.75	0.75	0.75
	$\overline{B^S_{2032}/Risk^S}$	4.04	3.02	3.02	3.02	3.02	3.02	4.04	3.09	3.09	3.09	3.09	3.09	4.04	3.02	3.02	3.02	3.02	3.02
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	1.46	1.46	1.46	1.46	1.46	1.99	1.50	1.50	1.50	1.50	1.50	1.99	1.46	1.46	1.46	1.46	1.46
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0.0	160.1	160.1	160.1	160.1	160.0	0.0	162.2	162.2	162.2	162.2	162.1	0.0	160.3	160.2	160.2	160.2	160.2
	$\overline{C}^S_{by}$	0.0	31.3	31.4	31.4	31.6	31.7	0.0	21.8	21.8	21.9	22.0	22.1	0.0	31.6	31.6	31.7	31.8	32.0
	$\overline{C}^S$ ('13-'15)	0.0	129.3	129.3	129.3	129.3	129.3	0.0	129.3	129.3	129.3	129.3	129.3	0.0	129.3	129.3	129.3	129.3	129.3
	AAV^S ('13-'32)	0.00	0.20	0.20	0.20	0.20	0.20	0.00	0.22	0.22	0.22	0.22	0.22	0.00	0.21	0.21	0.21	0.21	0.21
	AAV^S ('13-'15)	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.04	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		0.29	0.29	0.29	0.29	0.29		0.64	0.64	0.64	0.64	0.64		0.22	0.22	0.22	0.22	0.22
	$EC^A_{con\sec}$		3.18	3.18	3.18	3.18	3.18		7.31	7.31	7.31	7.32	7.31		2.76	2.76	2.76	2.76	2.76
Anchovy Fishery Closure	$p(Close)$		0.27	0.27	0.27	0.27	0.27		0.57	0.57	0.57	0.57	0.57		0.22	0.22	0.22	0.22	0.22
	$\overline{C}^A_{lost}$		26	26	26	26	26		9	9	9	9	9		31	31	31	31	31
	$\overline{TAC}^A_{close}$		112	112	112	113	113		36	36	36	36	36		138	138	139	139	140
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05
	$EC^S_{con\sec}$		1.32	1.32	1.32	1.32	1.32		1.32	1.32	1.32	1.32	1.32		1.31	1.31	1.31	1.31	1.31

Table 3. A repeat of Table 1, for **"BaseMP1" with** $B_{ec}^{A}=400$ **and "BaseMP2" with** $B_{ec}^{A}=600$**,** with $\beta=0.094$ and $\alpha=0.501$ but statistics are shown for alternative maximum and minimum constraints on the anchovy TAC, for base case operating models only. The **bold column** indicates the BaseMP1 and BaseMP2 results. The remaining **bold values** in the first few rows show the changes in the constraints from BaseMP1 or BaseMP2.

		BaseMP1								BaseMP2						
Additional season		No Catch	**Yes**	**No**					**No**	**Yes**	**No**					**No**
c_{mntac}^{A}			**120**	120	**100**	120	120	120	120	**120**	120	**100**	120	120	120	120
$c_{mxtac,ns}^{A}$			**400**	**450**	400	**300**	400	**300**	**350**	**400**	**450**	400	**300**	400	**300**	**350**
c_{mxtac}^{A}			**450**	450	450	**350**	450	**350**	**350**	**450**	450	450	**350**	450	**350**	**350**
$c_{mxinc}^{ads,A}$			**120**	120	120	120	**80**	**80**	120	**120**	120	120	120	**80**	**80**	120
Risk statistics	$risk^{A}$	0.020	**0.344**	0.261	0.330	0.329	0.330	0.318	0.251	**0.196**	0.143	0.186	0.186	0.187	0.179	0.137
	$risk^{S}$	0.031	**0.209**	0.212	0.209	0.199	0.208	0.200	0.208	**0.203**	0.201	0.203	0.195	0.204	0.195	0.198
Anchovy depletion ratios	10%ile	1.00	**0.11**	0.13	0.11	0.11	0.11	0.11	0.14	**0.19**	0.22	0.20	0.20	0.20	0.20	0.24
	20%ile	1.00	**0.14**	0.22	0.15	0.16	0.16	0.17	0.24	**0.22**	0.29	0.22	0.24	0.23	0.25	0.32
	30%ile	1.00	**0.18**	0.31	0.19	0.22	0.20	0.23	0.32	**0.25**	0.35	0.25	0.28	0.27	0.29	0.37
	40%ile	1.00	**0.24**	0.36	0.24	0.27	0.26	0.28	0.39	**0.29**	0.40	0.29	0.32	0.32	0.35	0.44
	50%ile	1.00	**0.27**	0.40	0.28	0.33	0.30	0.35	0.43	**0.31**	0.42	0.32	0.37	0.34	0.38	0.46
Anchovy biomass statistics	$\overline{B_{\min}^{A}/K^{A}}$	0.22	**0.08**	0.14	0.08	0.09	0.08	0.09	0.11	**0.09**	0.11	0.09	0.10	0.09	0.10	0.12
	$\overline{B_{\min}^{A}/Risk^{A}}$	7.57	**2.84**	3.79	2.87	3.19	3.00	3.26	4.05	**3.17**	4.04	3.19	3.49	3.31	3.56	4.28
	$\overline{B_{2032}^{A}/K^{A}}$	1.17	**0.52**	0.63	0.52	0.59	0.55	0.60	0.69	**0.57**	0.66	0.57	0.63	0.60	0.65	0.71
	$\overline{B_{2032}^{A}/Risk^{A}}$	48.19	**20.68**	25.51	20.86	23.46	21.84	24.00	27.91	**22.76**	26.76	22.91	25.56	23.85	26.06	29.10
	$\overline{B_{2032}^{A}/B_{2011}^{A}}$	7.59	**3.20**	3.32	3.23	3.61	3.38	3.69	3.61	**3.57**	3.51	3.60	3.99	3.74	4.07	3.80
Anchovy catch statistics	$\overline{C}^{A}$('13-'32)	0.0	**258.6**	258.3	258.9	229.4	254.7	228.2	229.4	**264.4**	262.1	264.5	233.5	260.3	232.4	232.3
	$\overline{C}_{ad}^{A}$ ('13-'32)	0.0	**50.3**	N/A	51.1	40.8	41.6	37.9	N/A	**52.1**	N/A	52.5	42.3	43.0	39.2	N/A
	$\overline{C}^{A}$('13-'15)	0.0	**274.8**	263.2	274.5	244.0	266.1	241.1	238.7	**266.8**	258.2	266.3	236.7	258.2	234.0	233.5
	$\overline{C}_{ad}^{A}$ ('13-'15)	0.0	**48.1**	N/A	48	38	39	34	N/A	**49.1**	N/A	49.1	38.6	39.5	35.5	N/A
	AAV^{A} ('13-'32)	0.00	**0.18**	0.23	0.18	0.14	0.18	0.15	0.17	**0.18**	0.23	0.18	0.14	0.18	0.15	0.17
	AAV^{A} ('13-'15)	0.00	**0.05**	0.14	0.05	0.04	0.05	0.04	0.08	**0.05**	0.14	0.05	0.05	0.05	0.04	0.08

		BaseMP1								BaseMP2						
Additional season		No Catch	**Yes**	**No**					**No**	**Yes**	**No**					**No**
c^{A}_{mntac}			**120**	120	**100**	120	120	120	120	**120**	120	**100**	120	120	120	120
$c^{A}_{mxtac,ns}$			**400**	**450**	400	**300**	400	**300**	**350**	**400**	**450**	400	**300**	400	**300**	**350**
c^{A}_{mxtac}			**450**	450	450	**350**	450	**350**	**350**	**450**	450	450	**350**	450	**350**	**350**
$c^{ads,A}_{mxinc}$			**120**	120	120	120	**80**	**80**	120	**120**	120	120	120	**80**	**80**	120
Sardine biomass statistics	$\overline{B^{S}_{\min}/K^{S}}$	0.54	**0.41**	0.41	0.41	0.41	0.41	0.41	0.41	**0.41**	0.41	0.41	0.41	0.41	0.41	0.41
	$\overline{B^{S}_{\min}/Risk^{S}}$	2.03	**1.56**	1.56	1.56	1.57	1.56	1.57	1.57	**1.57**	1.57	1.58	1.58	1.57	1.58	1.58
	$\overline{B^{S}_{2032}/K^{S}}$	0.99	**0.75**	0.74	0.75	0.75	0.75	0.75	0.75	**0.75**	0.75	0.75	0.75	0.75	0.75	0.75
	$\overline{B^{S}_{2032}/Risk^{S}}$	4.04	**3.00**	3.00	3.01	3.02	3.00	3.02	3.01	**3.02**	3.01	3.03	3.04	3.02	3.04	3.03
	$\overline{B^{S}_{2032}/B^{S}_{2011}}$	1.99	**1.45**	1.45	1.45	1.46	1.45	1.46	1.45	**1.46**	1.46	1.46	1.47	1.46	1.47	1.46
Sardine catch statistics	$\overline{C}^{S}$ ('13-'32)	0.0	**159.2**	159.2	159.3	159.7	159.2	159.7	159.5	**160.1**	159.9	160.2	160.5	160.0	160.5	160.2
	$\overline{C}^{S}_{by}$	0.0	**33.5**	34.1	33.0	31.9	33.6	31.9	32.9	**31.4**	32.6	31.1	30.0	31.7	30.1	31.5
	$\overline{C}^{S}$ ('13-'15)	0.00	**128.9**	129.1	128.9	129.0	128.9	129.0	129.2	**129.3**	129.3	129.3	129.3	129.3	129.3	129.4
	AAV^{S} ('13-'32)	0.0	**0.2**	0.21	0.20	0.21	0.20	0.21	0.21	**0.20**	0.21	0.20	0.21	0.20	0.21	0.21
	AAV^{S} ('13-'15)	0.0	**0.04**	0.04	0.04	0.04	0.04	0.04	0.04	**0.04**	0.04	0.04	0.04	0.04	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^{A}_{y} < c^{A}_{mntac}\right)$		**0.25**	0.18	0.24	0.23	0.24	0.23	0.17	**0.29**	0.22	0.29	0.28	0.28	0.27	0.21
	$EC^{A}_{con\sec}$		**3.46**	3.37	3.39	3.51	3.46	3.52	3.41	**3.18**	3.01	3.15	3.20	3.12	3.14	3.03
Anchovy Fishery Closure	$p(Close)$		**0.28**	0.23	0.27	0.27	0.27	0.26	0.23	**0.27**	0.23	0.27	0.26	0.26	0.26	0.22
	$\overline{C}^{A}_{lost}$		**26**	31	26	25	26	25	30	**26**	32	26	25	27	26	30
	$\overline{TAC}^{A}_{close}$		**113**	139	113	111	116	113	135	**113**	140	112	111	116	113	135
Sardine Exceptional Circumstances	$p\left(TAC^{S}_{y} < c^{S}_{mntac}\right)$		**0.05**	0.05	0.05	0.05	0.05	0.05	0.05	**0.05**	0.05	0.05	0.05	0.05	0.05	0.05
	$EC^{S}_{con\sec}$		**1.34**	1.34	1.34	1.34	1.34	1.34	1.34	**1.32**	1.32	1.32	1.32	1.32	1.32	1.32

Table 4. A repeat of Table 1, for **"BaseMP1" with** $B_{ec}^{A} = 400$ **and "BaseMP2" with** $B_{ec}^{A} = 600$**,** compared to an alternative with $B_{ec}^{A} = 800$ **(**$\beta = 0.094$ and $\alpha = 0.501$**),** and statistics are shown for two alternative anchovy operating models. The **bold column** indicates the BaseMP1 and BaseMP2 results.

Operating Models		Base OM				OMa1				OMa2			
Exceptional Circumstances Threshold		No Catch	400	600	800	No Catch	400	600	800	No Catch	400	600	800
Risk statistics	$risk^{A}$	0.020	**0.344**	**0.196**	0.110	0.56	0.938	0.867	0.842	0.156	0.702	0.520	0.395
	$risk^{S}$	0.031	**0.209**	**0.203**	0.194	0.031	0.199	0.188	0.172	0.031	0.197	0.188	0.180
Anchovy depletion ratios	10%ile	1.00	**0.11**	**0.19**	0.27	1.00	0.05	0.17	0.28	1.00	0.13	0.23	0.31
	20%ile	1.00	**0.14**	**0.22**	0.30	1.00	0.12	0.21	0.32	1.00	0.13	0.23	0.32
	30%ile	1.00	**0.18**	**0.25**	0.30	1.00	0.14	0.24	0.31	1.00	0.14	0.24	0.32
	40%ile	1.00	**0.24**	**0.29**	0.34	1.00	0.18	0.28	0.35	1.00	0.18	0.26	0.33
	50%ile	1.00	**0.27**	**0.31**	0.36	1.00	0.22	0.29	0.35	1.00	0.21	0.28	0.35
Anchovy biomass statistics	$\overline{B_{\min}^{A} / K^{A}}$	0.22	**0.08**	**0.09**	0.10	0.04	0.01	0.02	0.02	0.10	0.03	0.04	0.05
	$\overline{B_{\min}^{A} / Risk^{A}}$	7.57	**2.84**	**3.17**	3.53	1.11	0.33	0.46	0.56	3.32	0.86	1.18	1.49
	$\overline{B_{2032}^{A} / K^{A}}$	1.17	**0.52**	**0.57**	0.61	0.87	0.37	0.42	0.46	0.98	0.41	0.47	0.51
	$\overline{B_{2032}^{A} / Risk^{A}}$	48.19	**20.68**	**22.76**	24.64	33.02	13.00	15.27	17.1	38.34	15.10	17.58	19.54
	$\overline{B_{2032}^{A} / B_{2011}^{A}}$	7.59	**3.20**	**3.57**	3.90	5.12	2.06	2.42	2.7	5.97	2.41	2.80	3.11
Anchovy catch statistics	$\overline{C}^{A}$ ('13-'32)	0.0	**258.6**	**264.4**	267.2	0.0	125.3	129.4	129.7	0.0	155.6	162.0	163.5
	$\overline{C}_{ad}^{A}$ ('13-'32)	0.0	**50.3**	**52.1**	52.6	0.0	24.5	26.3	26.7	0.0	30.5	33.2	33.8
	$\overline{C}^{A}$ ('13-'15)	0.0	**274.8**	**266.8**	254.9	0.0	238.5	229.5	217.2	0.0	249.7	240.1	227.4
	$\overline{C}_{ad}^{A}$ ('13-'15)	0.0	**48.1**	**49.1**	49.1	0.0	36.2	36.0	35.6	0.0	39.4	39.7	39.5
	AAV^{A} ('13-'32)	0.0	**0.18**	**0.18**	0.18	0.0	0.49	0.47	0.45	0.0	0.50	0.49	0.50
	AAV^{A} ('13-'15)	0.0	**0.05**	**0.05**	0.05	0.0	0.24	0.24	0.24	0.0	0.16	0.21	0.23

Operating Models		Base OM				OMa1				OMa2			
Exceptional Circumstances Threshold		No Catch	400	600	800	No Catch	400	600	800	No Catch	400	600	800
Sardine biomass statistics	$\overline{B^S_{\min}/K^S}$	0.54	**0.41**	**0.41**	0.41	0.54	0.41	0.42	0.42	0.54	0.41	0.42	0.42
	$\overline{B^S_{\min}/Risk^S}$	2.03	**1.56**	**1.57**	1.59	2.03	1.57	1.60	1.61	2.03	1.57	1.59	1.61
	$\overline{B^S_{2032}/K^S}$	0.99	**0.75**	**0.75**	0.75	0.99	0.76	0.77	0.77	0.99	0.76	0.76	0.76
	$\overline{B^S_{2032}/Risk^S}$	4.04	**3.00**	**3.02**	3.04	4.04	3.06	3.09	3.11	4.04	3.04	3.06	3.08
	$\overline{B^S_{2032}/B^S_{2011}}$	1.99	**1.45**	**1.46**	1.7	1.99	1.48	1.50	1.51	1.99	1.47	1.48	1.49
Sardine catch statistics	$\overline{C}^S$ ('13-'32)	0.0	**159.2**	**160.1**	160.9	0.0	160.9	162.2	163.2	0.0	160.6	161.8	162.7
	$\overline{C}^S_{by}$	0.0	**33.5**	**31.4**	29.6	0.0	24.8	21.9	19.7	0.0	27.7	25.0	22.7
	$\overline{C}^S$ ('13-'15)	0.0	**128.9**	**129.3**	129.6	0.0	128.9	129.3	169.6	0.0	128.9	129.3	129.6
	AAV^S ('13-'32)	0.0	**0.2**	**0.20**	0.21	0.0	0.22	0.22	0.23	0.0	0.21	0.21	0.22
	AAV^S ('13-'15)	0.0	**0.04**	**0.04**	0.04	0.0	0.04	0.04	0.04	0.0	0.04	0.04	0.04
Anchovy Exceptional Circumstances	$p\left(TAC^A_y < c^A_{mntac}\right)$		**0.25**	**0.29**	0.33		0.60	0.64	0.67		0.51	0.55	0.59
	$EC^A_{con\sec}$		**3.46**	**3.18**	3.12		7.52	7.31	7.22		5.67	5.58	5.61
Anchovy Fishery Closure	$p(Close)$		**0.28**	**0.27**	0.27		0.57	0.57	0.58		0.47	0.47	0.47
	$\overline{C}^A_{lost}$		**26**	**26**	26		10	9	9		14	13	13
	$\overline{TAC}^A_{close}$		**113**	**113**	110		39	36	34		56	54	52
Sardine Exceptional Circumstances	$p\left(TAC^S_y < c^S_{mntac}\right)$		**0.05**	**0.05**	0.05		0.05	0.05	0.04		0.05	0.05	0.05
	$EC^S_{con\sec}$		**1.34**	**1.32**	1.31		1.34	1.32	1.31		1.33	**1.31**	**1.30**

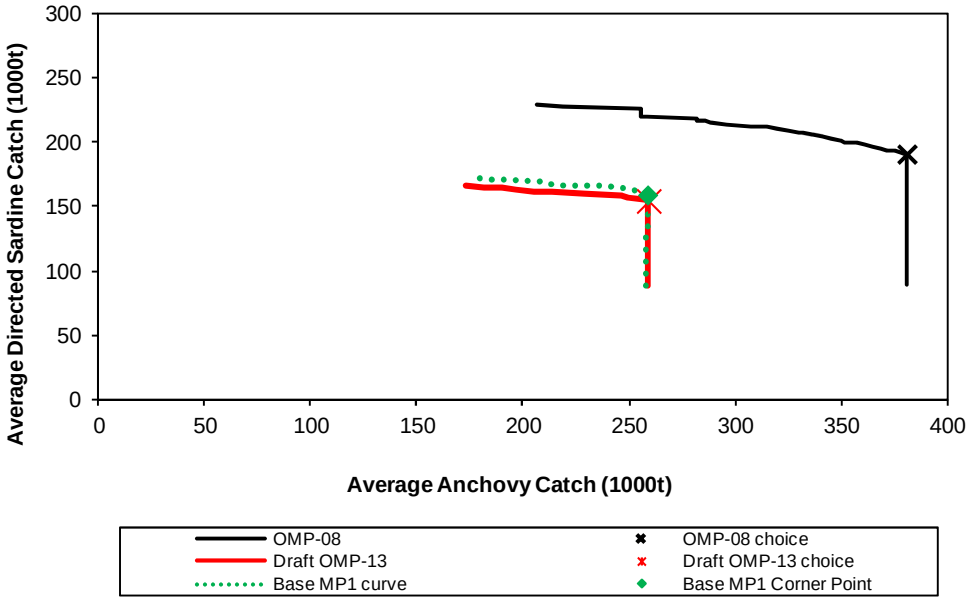

Figure 1. Trade-off curves for OMP-08, Interim OMP-13 and BaseMP1 with $B_{ec}^{A} = 400$.

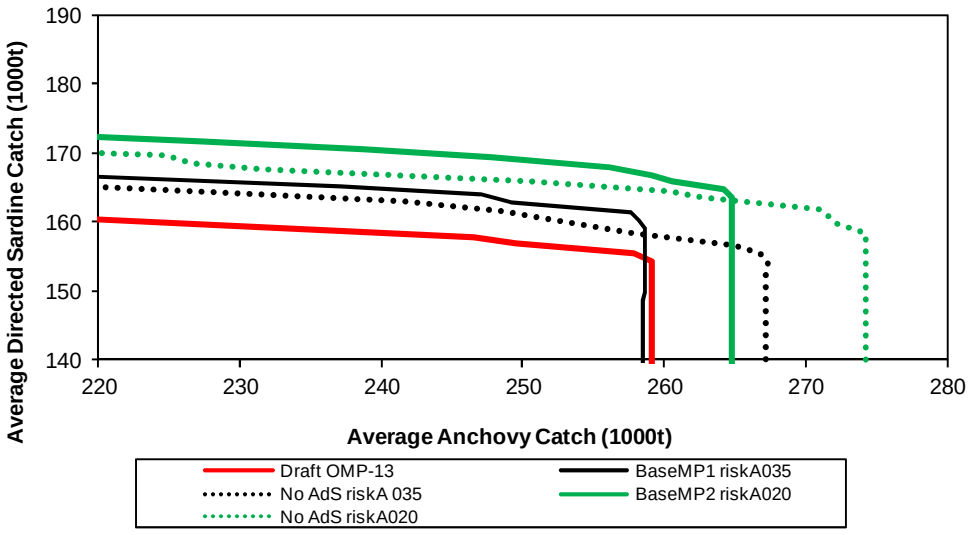

Figure 2. Trade-off curves for Interim OMP-13, BaseMP1 with $B_{ec}^{A} = 400$ and BaseMP2 with $B_{ec}^{A} = 600$. The latter two MPs are shown with and without an additional season from October-December.

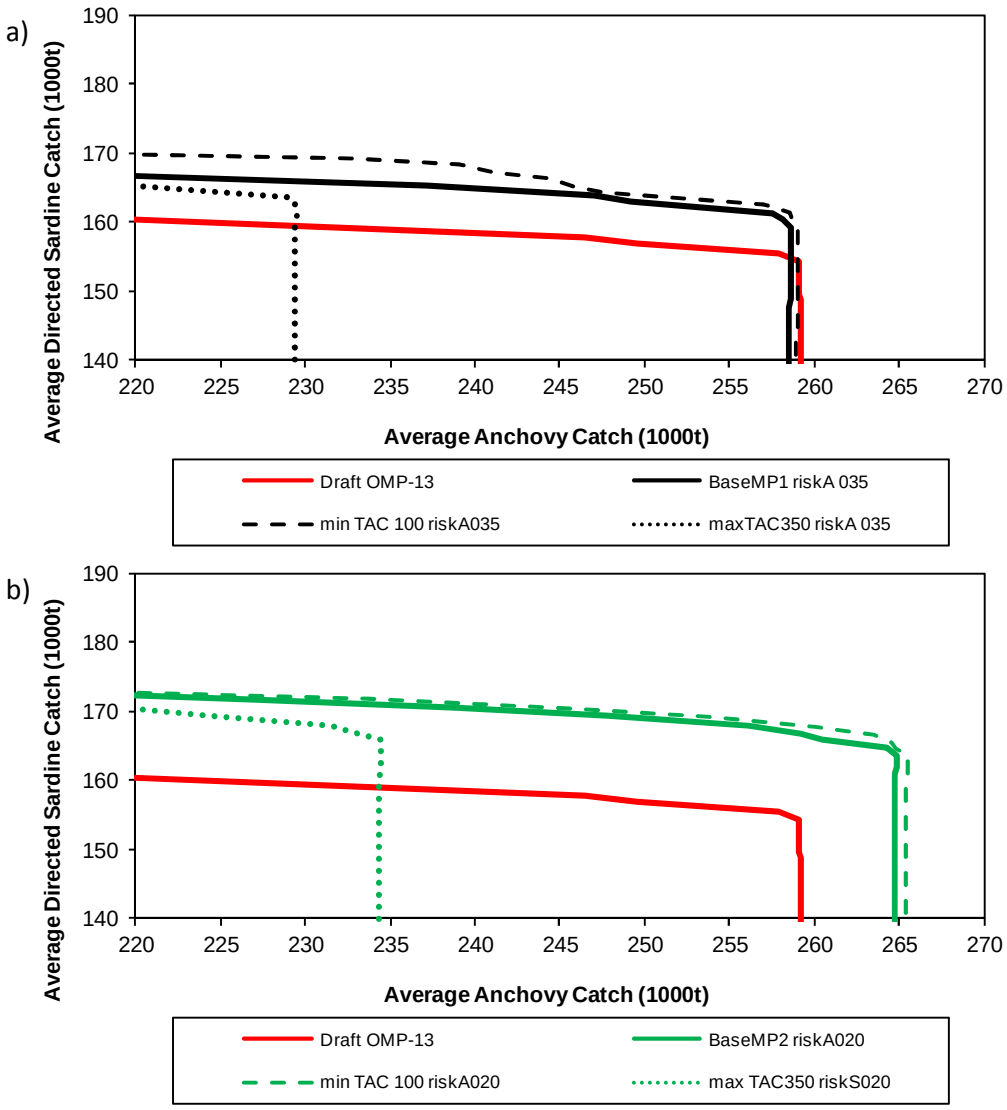

Figure 3. Trade-off curves for Interim OMP-13, a) BaseMP1 with $B_{ec}^{A} = 400$ and b) BaseMP2 with $B_{ec}^{A} = 600$. The latter two MPs are shown with alternative minimum and maximum anchovy TACs.

Appendix 1 : An update to equation A.10 of the Simulation Testing Framework used for OMP-13

Sardine 0-year-old catch prior to the recruit survey

The 0-year-old sardine catch prior to the recruit survey is based on the January to mid-May bycatch occurring with i) round herring, ii) adult sardine in the directed fishery, and iii) juvenile anchovy. It is assumed that all juvenile sardine bycatch with round herring occurs after the recruit survey. It is further assumed that half the juvenile sardine in the directed sardine catch is caught by the time of the survey. The 0-year-old sardine catch prior to the survey is thus:

$$C_{1,y,0bs}^{S,pred} = \frac{\frac{1}{2}\varpi_y^{draw}\tau_1 TAC_y^S}{\overline{w}_{1,0c}^S} + k_{janmay}\frac{N_{1,y-1,0}^{S,pred}}{N_{1,y-1,0}^{A,pred}} e^{\sigma_{janmay}\eta_{y,janmay}} \frac{C_{y,0bs}^{A,pred}\overline{w}_{0c}^A}{\overline{w}_{1,0c}^S},$$

$$C_{2,y,0bs}^{S,pred} = \frac{\frac{1}{2}\varpi_y^{draw}\tau_2 TAC_y^S}{\overline{w}_{2,0c}^S},$$

where $\eta_{y,jan:may} \sim N(0;1)$ (A.10)

and $k_{jan:may}$ and σ_{janmay} are given in equations (A.41) and (A.43) respectively. ϖ is the estimate of the maximum amount of ≤14cm sardine bycatch in the directed (>14cm) sardine catch used to set the sardine TAB. During simulation, this maximum amount is not always assumed taken. Instead, the proportion, ϖ_y^{draw}, of the directed catch assumed taken is drawn from a distribution based on the historic proportions (Figure A1).