Further Considerations for OMP-08

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Summary

OMP-08 has been updated following the recommendations of the Pelagic Working Group. The implications of such changes to the OMP are shown in this document, together with the implications for some further alternatives to the sardine and anchovy exceptional circumstances rules and the additional season anchovy TAC rule.

We recommend that the 'updated OMP-08 rule' presented in this document, together with the modification to the additional season anchovy TAC such that $\alpha_{ads} = 1.5 \times \alpha_{ns}$ be adopted. This choice corresponds to OMP control parameter values of $\beta = 0.092$, $\alpha_{ns} = 0.445$ and $\alpha_{ads} = 0.6675$ and a projected average directed sardine catch of 186 000t together with a projected average total anchovy catch of 269 000t.

Updated OMP-08

At the March Pelagic Working Group (PWG) meeting, the following changes to OMP-08 were agreed:

i) minimum anchovy TAC has been decreased from 150 000t to 120 000t

ii) maximum anchovy additional season TAC has been decreased from 150 000t to 120 000t

iii) sardine exceptional circumstances threshold has been increased from 250 000t to 300 000t

In addition note that:

iv) no smoothing is required for the sardine TAC (previously between 250 000 and 350 000t) as the TAC function is already smooth due to the adjustment made below 800 000t

Also note that (as in previous versions of OMP-08) the exceptional circumstances rules decrease the directed sardine TAC to zero by the time observed sardine biomass is 62 500t (25% of the exceptional circumstances threshold) and decrease the anchovy TAC to zero by the time the observed or projected anchovy biomass is 100 000t (25% of the exceptional circumstances threshold). However, in the case of a zero directed sardine TAC, allowance is still made for sardine bycatch associated with both the anchovy and red-eye fisheries.

Updated Results

Figure 1 shows the 'Current OMP-08' trade-off curve tuned to $risk_A$<0.28 and $risk_S$<0.18 (Feb) from Cunningham and Butterworth (2008a), the 'new continuous rule' trade-off curve tuned to $risk_A$<0.30 and

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$risk_S$ <0.18 (Mar) given by Cunningham and Butterworth (2008b) and the 'updated rule' trade-off curve resulting from the above four changes to the OMP formulae.

Following the same method to determine an acceptable risk threshold as before (Cunningham and Butterworth 2008a), Tables 1 and 2 indicate that retaining the anchovy risk threshold at 30% from Cunningham and Butterworth (2008b) would result in a more pessimistic projection for anchovy biomass after 20 years compared to a no-catch scenario than what was agreed by the PWG in February. Decreasing the anchovy risk threshold to 28% results in an improved projection in terms of both sardine and anchovy biomass compared to that previously accepted by the PWG.

Table 3 indicates the trade-off between the average directed sardine catch and the anchovy catch for the corner points of the updated OMP trade-off curve in comparison to that given in Cunningham and Butterworth (2008b). The associated OMP control parameter values are also given. Note that the projected average catches may be less than the projected average TACs. This is because the simulation testing framework takes into account a number of factors such as bycatch drop-off and the closing of the anchovy fishery should the sardine bycatch limit be reached before the anchovy TAC is fully taken. For example, for the updated rule with an anchovy risk threshold of 28%, the average directed sardine TAC from 2008 to 2027 is 189 000t, similar to the average directed sardine catch, while the average total anchovy TAC from 2008 to 2027 is 284 000t, higher than the average total anchovy catch of 259 000t (Table 3).

Tables 4 and 5 list key summary statistics for the sardine and anchovy resources, respectively, under the updated rule compared to a no-catch scenario, 'Current OMP-08' (Cunningham and Butterworth 2008a) with and without exceptional circumstances rules and the new continuous rule (Cunningham and Butterworth 2008b).

Alternative Considerations for Sardine

Two further alternatives to the sardine TAC rules were considered:

1) Exceptional circumstances rule is cubic instead of quadratic

2) In the case of exceptional circumstances being declared, only 50% of directed sardine TAC is given initially with the 'top-up' ranging between 0% and 60% of the TAC, dependent on the May recruitment

Comparative Results

Cubic rule

Table 1 indicates that the biomass projected under OMP-08 using a cubic exceptional circumstances rule with a sardine risk threshold of 18% and an anchovy risk threshold of 28%, rather than a quadratic rule, as a ratio of that projected under a no-catch scenario is very similar to that accepted by the PWG in February.

Table 6 indicates that the sardine biomass at the end of the projection period is in a slightly more favourable state than that under the updated (quadratic) rule, while Figure 3 demonstrates that the cubic rule out-performs the updated rule in the speed of biomass recovery for situations where exceptional circumstances are declared.

Mid-year adjustment to directed sardine TAC

Table 1 indicates that the biomass projected under OMP-08 using a mid-year adjustment to the directed sardine TAC if exceptional circumstances are declared with a sardine risk threshold of 18% and an anchovy risk threshold of 28%, rather than the updated rule, as a ratio of that projected under a no-catch scenario is very similar to that accepted by the PWG in February.

Table 6 indicates that the sardine biomass at the end of the projection period is in a slightly more favourable state than that under the updated rule, while Figure 3 demonstrates that the mid-year adjustment to the directed sardine TAC out-performs the updated rule in the speed of biomass recovery for situations where exceptional circumstances are declared. Higher values for R_{crit} generally result in a faster recovery in the sardine biomass once exceptional circumstances are declared.

The directed sardine TAC in 2009, dependent on the observed November 2008 sardine biomass, under the updated rule and this mid-year adjustment rule are given in Table 7. The final directed sardine TAC under the mid-year adjustment if exceptional circumstances are declared would depend on the value for R_{crit} and the observed May 2009 sardine recruitment.

Alternative Considerations for Anchovy

Two further alternatives to the anchovy TAC rules were considered:

1) Exceptional circumstances rule is cubic instead of quadratic

2) Greater anchovy TAC during the additional season

For the updated rule presented above, the control parameter for anchovy total (normal + additional season) TAC, α_{ads}, was fixed at twice that for the anchovy normal season TAC, α_{ns}. In option 2) above, two further biomass thresholds are introduced (see Figure 4):

i) B_1 – above which the anchovy additional season TAC can begin to increase linearly above that calculated using the current OMP rule

ii) B_2 – above which the anchovy additional season TAC is a maximum of 120 000t

The November spawner biomass projected using the recent observed May recruitment is used to compare with B_1 and B_2, in the same manner as this projected biomass is used to determine whether exceptional circumstances are to be declared. Note that choices of B_1 are limited to $\geq B_{ec}^{A} + \Delta = 500\,000t$ to avoid problems from a lack of continuity. Given this possible increase in the anchovy additional season TAC, α_{ads} was tested at smaller multiples of α_{ns}.

<u>Comparative Results</u>

Cubic rule

Table 2 indicates that the biomass projected under OMP-08 using a cubic exceptional circumstances rule, rather than a quadratic rule as a ratio of that projected under a no-catch scenario is more conservative at lower percentiles,

but slightly more pessimistic at higher percentiles than that accepted by the PWG in February. As we are more concerned with being conservative at the lower percentiles, a lower risk threshold was not tested.

There is a slight gain in the average anchovy catch for the cubic rule, compared to the updated rule, together with an improvement in the biomass at the end of the projected period (Table 8). Figure 5 indicates that the cubic rule slightly out-performs the updated rule in the speed of biomass recovery for situations where exceptional circumstances are declared.

Greater anchovy additional season TAC

Table 9 indicates that allowing the additional season TAC to increase once projected biomass is above 1.4 million tons results in a 3 000t increase in the average projected anchovy TAC from the updated rule. A number of alternative values for B_1 and B_2 were tested with α_{ads} being either 1.2 or 1.5 times α_{ns}, using the values for β and α_{ns} from the corner point of the trade-off curve for the updated rule. These results seem to indicate that B_1 has a greater effect on the anchovy risk than B_2. Decreasing B_1 below 1 million tons resulted in the anchovy risk increasing above 28% (for the control parameters of the updated rule). Two cases were chosen for further analysis: $B_1 = 1$ million tons and $B_2 = 1.5$ million tons, with $\alpha_{ads} = 1.5 \times \alpha_{ns}$ and $\alpha_{ads} = 1.2 \times \alpha_{ns}$.

New trade-off curves were calculated using the current risk thresholds of 18% for sardine and 28% for anchovy as well as 30% for anchovy. Table 2 indicates that the biomass projected under OMP-08 using this greater additional season anchovy TAC rule as a ratio of that projected under a no-catch scenario is more conservative than that accepted by the PWG in February at almost all percentiles for an anchovy risk threshold of 28%, but more pessimistic at higher percentiles for an anchovy risk threshold of 30%.

The average anchovy catch increases from 259 000t for the updated rule to 269 000t for the greater additional season anchovy TAC rule with $\alpha_{ads} = 1.5 \times \alpha_{ns}$ and $\alpha_{ns} = 0.445$ to 271 000t for the greater additional season anchovy TAC rule with $\alpha_{ads} = 1.2 \times \alpha_{ns}$ and $\alpha_{ns} = 0.47$. The directed sardine catch, in contrast, decreases from 189 000t to 186 000t for $\alpha_{ads} = 1.5 \times \alpha_{ns}$ and 183 000t for $\alpha_{ads} = 1.2 \times \alpha_{ns}$ (Table 10). In addition, Table 8 shows that, for the same risk threshold, using this rule to allow greater additional season anchovy TAC results in the lowest 10% of the projected biomass distribution at the end of the simulation period being slightly improved over that for the updated rule.

Figure 6 demonstrates that the proportion of times the additional season anchovy TAC is set at a maximum increases from 49% for the updated rule to 60% for $\alpha_{ads} = 1.5 \times \alpha_{ns}$ and 61% for $\alpha_{ads} = 1.2 \times \alpha_{ns}$.

References

Cunningham, C.L., and Butterworth, D.S. 2008a. Exceptional Circumstances Provisions for OMP-08: Initial Evaluations. MCM Document MCM/2008/SWG-PEL/02. 21pp.

Cunningham, C.L., and Butterworth, D.S. 2008b. Further Analyses Regarding the Exceptional Circumstances Provisions for OMP-08. MCM Document MCM/2008/SWG-PEL/07. 19pp.

Table 1. *The ratio of the percentiles of the distribution of sardine biomass in 2027 under OMP-08 for a sardine risk threshold of* $risk_S$ *<0.18 to a no-catch scenario at the corner point of the trade-off curve under the "Current OMP-08" presented in Cunningham and Butterworth (2008a), under the new continuous rule presented in Cunningham and Butterworth (2008b) and for the updated rule discussed in this document. A comparison is made to the ratio of the percentiles of the distribution of sardine biomass in 2023 under OMP-04 to a no-catch scenario using the previous assessment. Shaded cells represent cases for which the predicted ratio (depletion) is more pessimistic than that used for OMP-04.*

	OMP-04/No-catch	OMP-08/No-catch (Corner Point)							
		"Current OMP-08" (Feb)	New Continuous Rule (March)	Updated Rule					
						Cubic	R_{crit}=14.48	R_{crit}=25	R_{crit}=40
		$risk_A$ <0.28	$risk_A$ <0.30	$risk_A$ <0.30	$risk_A$ <0.28	$risk_A$ <0.28	$risk_A$ <0.28	$risk_A$ <0.28	$risk_A$ <0.28
10%ile	0.59	**0.50**	0.47	0.51	0.50	0.51	0.51	0.51	0.51
20%ile	0.68	**0.70**	0.69	0.70	0.69	0.69	0.69	0.70	0.70
30%ile	0.69	**0.74**	0.73	0.74	0.74	0.74	0.74	0.74	0.74
40%ile	0.71	**0.75**	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Median	0.72	**0.74**	0.73	0.74	0.74	0.74	0.74	0.74	0.74

Table 2. *The ratio of the percentiles of the distribution of anchovy biomass in 2027 under OMP-08 for alternative anchovy risk thresholds to a no-catch scenario under the "Current OMP-08" presented in Cunningham and Butterworth (2008a), under the new continuous rule presented in Cunningham and Butterworth (2008b) and for the updated rule discussed in this document. The sardine risk threshold is the same for all cases ($risk_S$ <0.18). A comparison is made to the ratio of the percentiles of the distribution of anchovy biomass in 2023 under OMP-04 to a no-catch scenario using the previous assessment. Shaded cells represent cases for which the predicted ratio (depletion) is more pessimistic than that used for OMP-04.*

	OMP-04/No-Catch	OMP-08/No-catch (Corner Point)								
		"Current OMP-08" (Feb)	New Continuous Rule (March)	Updated Rule						
						Cubic	$\alpha_{ads} = 1.5 \times \alpha_{ns}$		$\alpha_{ads} = 1.2 \times \alpha_{ns}$	
		$risk_A$ <0.28	$risk_A$ <0.30	$risk_A$ <0.30	$risk_A$ <0.28	$risk_A$ <0.28	$risk_A$ <0.28	$risk_A$ <0.30	$risk_A$ <0.28	$risk_A$ <0.30
10%ile	0.25	**0.26**	0.28	0.27	0.28	0.30	0.28	0.26	0.29	0.27
20%ile	0.37	**0.31**	0.33	0.29	0.32	0.32	0.33	0.30	0.34	0.31
30%ile	0.45	**0.39**	0.44	0.35	0.40	0.36	0.42	0.36	0.43	0.39
40%ile	0.56	**0.44**	0.49	0.40	0.44	0.41	0.44	0.39	0.46	0.41
Median	0.58	**0.48**	0.53	0.44	0.48	0.44	0.47	0.42	0.47	0.44

Table 3. *The OMP control parameters and average catches for the corner points of the 'new continuous rule' (Cunningham and Butterworth 2008b) and the updated rule.*

$risk_A$ <	Rule	β	α_{ns}	α_{ads}	Average directed sardine catch	Average anchovy catch
0.30	New Continuous (March)	0.089	0.325	0.65	183 000t	252 000t
0.30	Updated	0.093	0.450	0.90	187 000t	266 000t
0.28	Updated	0.095	0.405	0.81	189 000t	259 000t

Table 4. *Key summary statistics for the sardine resource: 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, $risk_S$; average directed catch (in thousands of tons), $\overline{C}^S$; average proportional annual change in directed catch, AAV^S; 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; and average minimum biomass over the projection period as a proportion of carrying capacity and as a proportion of the risk threshold. Statistics are calculated from all simulations.*

	No Catch	Current OMP-08 (Feb)	No EC rules	New Continuous Rule (March)	Updated Rule
		$risk_A$<0.28		$risk_A$<0.30	$risk_A$<0.28
β	N/A	0.096	0.096	0.089	0.095
α_{ns}	N/A	0.37	0.37	0.325	0.405
$risk_S$	0.027	0.178	0.451	0.178	0.178
$\overline{C}^S$ (2008-2027)	0	190	165	183	189
AAV^S (2008-2027)	0	0.24	0.24	0.23	0.24
$\overline{B^S_{2027} / K^S_{non-peak}}$	0.93	0.70	0.44	0.70	0.70
$\overline{B^S_{2027} / Risk^S}$	17.34	10.77	7.01	10.84	10.81
$\overline{B^S_{2027} / B^S_{2007}}$	9.65	5.84	3.85	5.89	5.87
$\overline{B^S_{\min} / K^S_{non-peak}}$	0.33	0.26	0.17	0.26	0.26
$\overline{B^S_{\min} / Risk^S}$	2.24	1.78	1.20	1.78	1.78
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.003[1]	0.035	N/A	0.039	0.047
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.008	0.119	N/A	0.133	0.153
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.121	0.172	N/A	0.171	0.162
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	2.375	3.924	N/A	4.248	4.275
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.000	0.010	N/A	0.015	0.015
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold[2]	0.003	0.024	N/A	0.024	0.033
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold[3]	0.000	0.001	N/A	0.001	0.001

[1] References to the declaration of exceptional circumstances under the no catch option refer to the number of times the simulated observed biomass drops below an exceptional circumstance threshold of 250 000t (the threshold used for "Current OMP-08").

[2] This reports the proportion of times exceptional circumstances are declared unnecessarily.

[3] This reports the proportion of times exceptional circumstances are not declared when they should have been.

Table 5. *Key summary statistics for the anchovy resource: 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 directed catch (in thousands of tons), $\overline{C}^A$, average proportional annual change in directed catch, AAV^A, average biomass at the end of the projection period as a proportion of carrying capacity, as a proportion of the risk threshold, as a proportion of biomass at the beginning of the projection period, and average minimum biomass over the projection period as a proportion of carrying capacity and as a proportion of the risk threshold. Statistics are calculated from all simulations.*

	No Catch	Current OMP-08	No EC rules	New Continuous Rule	Updated Rule
		$risk_A$<0.28		$risk_A$<0.30	$risk_A$<0.28
β	N/A	0.096	0.096	0.089	0.095
α_{ns}	N/A	0.37	0.37	0.325	0.405
$Risk_A$	0.037	0.278	0.49	0.297	0.279
$\overline{C}^A$ (2008-2027)	0	263	240	252	259
AAV^A (2008-2027)	0	0.40	0.38	0.41	0.38
$\overline{B^A_{2027}/K^A}$	0.96	0.61	0.42	0.63	0.62
$\overline{B^A_{2027}/Risk^A}$	2.57	1.71	1.26	1.75	1.71
$\overline{B^A_{2027}/B^A_{2007}}$	1.61	1.04	0.76	1.07	1.04
$\overline{B^A_{\min}/K^A}$	0.26	0.11	0.09	0.12	0.11
$\overline{B^A_{\min}/Risk^A}$	0.57	0.26	0.22	0.28	0.26
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.038[4]	0.201	N/A	0.179	0.196
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.166	0.762	N/A	0.687	0.751
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.219	0.190	N/A	0.192	0.192
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	3.500	4.706	N/A	4.632	4.579
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.033	0.191	N/A	0.172	0.186
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.005	0.010	N/A	0.007	0.010
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.038	0.084	N/A	0.077	0.091

[4] References to the declaration of exceptional circumstances under the no catch option refer to the number of times the simulated observed biomass drops below the current exceptional circumstance threshold of 400 000t.

Table 6. *Key summary statistics for the sardine resource: 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, $risk_S$; average directed catch (in thousands of tons), $\overline{C}^S$; average proportional annual change in directed catch, AAV^S; 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; and average minimum biomass over the projection period as a proportion of carrying capacity and as a proportion of the risk threshold.* ***Statistics in the top half of the table are calculated from the 10% of simulations corresponding to the lowest projected biomass under "Current OMP-08",*** *while those in the lower half of the table are calculated from all simulations.*

	Current OMP-08 (Feb)	New Continuous Rule (March)	Updated Rule	Cubic Rule	Mid-Year Adjustment		
					R_{crit}=14.5	R_{crit}=25	R_{crit}=40
Exceptional Circumstances Threshold	250 000t	250 000t	300 000t	300 000t	300 000t	300 000t	300 000t
$risk_S <$	0.18	0.18	0.18	0.18	0.18	0.18	0.18
$risk_A <$	0.28	0.30	0.28	0.28	0.28	0.28	0.28
β	0.096	0.089	0.095	0.097	0.096	0.096	0.097
α_{ns}	0.37	0.325	0.405	0.405	0.405	0.405	0.405
α_{ads}	0.740	0.650	0.810	0.810	0.810	0.810	0.810
$\overline{C}^S$ (2008-2027)	79	78	79	79	79	79	79
AAV^S (2008-2027)	0.40	0.33	0.37	0.39	0.39	0.37	0.38
$\overline{B^S_{2027} / K^S_{non-peak}}$	0.18	0.16	0.17	0.18	0.18	0.18	0.18
$\overline{B^S_{2027} / Risk^S}$	1.88	1.62	1.79	1.88	1.88	1.84	1.89
$\overline{B^S_{2027} / B^S_{2007}}$	1.29	1.10	1.21	1.27	1.27	1.25	1.28
$\overline{B^S_{\min} / K^S_{non-peak}}$	0.06	0.05	0.06	0.06	0.06	0.06	0.06
$\overline{B^S_{\min} / Risk^S}$	0.39	0.34	0.38	0.40	0.40	0.40	0.41
$risk_S$	0.178	0.178	0.178	0.179	0.179	0.177	0.179
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.035	0.039	0.047	0.046	0.047	0.045	0.045
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.119	0.133	0.153	0.152	0.156	0.154	0.153
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.172	0.171	0.162	0.167	0.167	0.170	0.170
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	3.924	4.248	4.275	4.079	4.128	3.994	3.974
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.010	0.015	0.015	0.013	0.013	0.012	0.012
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.024	0.024	0.033	0.033	0.034	0.033	0.033
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.001	0.001	0.001	0.001	0.001	0.001	0.001

***Table 7**. Directed sardine TAC in 2009 (rounded to the nearest '000t) under the updated rule ($\beta = 0.095$) and under the rule allowing for a mid-year adjustment to the TAC if exceptional circumstances are declared.*

Observed November 2008 Sardine Biomass	Updated Rule	Mid-year Adjustment	
		Initial TAC	Final TAC
0t	0	0	0
60 000t	0	0	0
80 000t	0.04	0.02	0.02-0.05
100 000t	1.1	0.6	0.6-1.2
120 000t	3.6	1.8	1.8-4.0
140 000t	7.5	3.8	3.8-8.3
160 000t	12.8	6.4	6.4-14.1
180 000t	19.6	9.8	21.6
200 000t	27.8	13.9	13.9-30.6
220 000t	37.4	18.7	18.7-41.1
240 000t	48.4	24.2	24.2-53.2
260 000t	60.8	30.4	30.4-66.9
280 000t	74.7	37.4	37.4-82.2
300 000t	90	90	90
350 000t	90	90	90
400 000t	90	90	90
450 000t	90	90	90
500 000t	90	90	90

Table 8. *Key summary statistics for the anchovy resource: 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 directed catch (in thousands of tons),* $\overline{C}^A$, *average proportional annual change in directed catch,* AAV^A, *average biomass at the end of the projection period as a proportion of carrying capacity, as a proportion of the risk threshold, as a proportion of biomass at the beginning of the projection period, and average minimum biomass over the projection period as a proportion of carrying capacity and as a proportion of the risk threshold.* ***Statistics in the top half of the table are calculated from the 10% of simulations corresponding to the lowest projected biomass under "Current" OMP-08****, while those in the lower half of the table are calculated from all simulations.*

	Current OMP-08 (Feb)	New Continuous Rule (March)	Updated Rule	Cubic Rule	$\alpha_{ads}=1.5\times\alpha_{ns}$	$\alpha_{ads}=1.2\times\alpha_{ns}$
Exceptional Circumstances Threshold	400 000t	400 000t	400 000t	400 000t	400 000t	400 000t
$risk_S <$	0.18	0.18	0.18	0.18	0.18	0.18
$risk_A <$	0.28	0.30	0.28	0.28	0.28	0.28
β	0.096	0.089	0.095	0.096	0.092	0.090
α_{ns}	0.37	0.325	0.405	0.445	0.445	0.470
α_{ads}	0.740	0.650	0.810	0.890	0.6675	0.564
$\overline{C}^A$ (2008-2027)	161	159	160	163	165	166
AAV^A (2008-2027)	0.52	0.52	0.50	0.51	0.49	0.50
$\overline{B^A_{2027}/K^A}$	0.31	0.32	0.29	0.31	0.31	0.32
$\overline{B^A_{2027}/Risk^A}$	1.00	1.01	0.92	0.99	0.97	1.02
$\overline{B^A_{2027}/B^A_{2007}}$	0.61	0.61	0.56	0.60	0.59	0.62
$\overline{B^A_{\min}/K^A}$	0.01	0.01	0.01	0.02	0.01	0.01
$\overline{B^A_{\min}/Risk^A}$	0.03	0.03	0.03	0.03	0.03	0.03
$Risk_A$	0.278	0.297	0.279	0.274	0.279	0.279
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.201	0.179	0.196	0.210	0.189	0.186
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.762	0.687	0.751	0.834	0.725	0.718
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.190	0.192	0.192	0.199	0.192	0.193
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	4.706	4.632	4.579	4.421	4.532	4.471
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.191	0.172	0.186	0.199	0.179	0.176
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.010	0.007	0.010	0.011	0.010	0.010
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.084	0.077	0.091	0.095	0.096	0.096

Table 9. *Risk and average projected catch associated alternative values for the thresholds B_1 and B_2, determining the points at which additional season anchovy TAC may increase. Results are given corresponding to the control parameters for the corner point of the updated rule ($\beta = 0.095$, $\alpha_{ns} = 0.405$). The grey cells correspond to cases where the anchovy risk increases above 0.28.*

Multiple used	α_{ns}	α_{ads}	B_1	B_2	$risk_S$	$risk_A$	Average directed sardine catch	Average anchovy catch
2x (Updated Rule)	0.405	0.81	NA	NA	0.178	0.279	189 000t	259 000t
2x	0.405	0.81	1 400 000t	2 000 000t	0.178	0.28	189 000t	262 000t
1.5x	0.405	0.6075	1 400 000t	2 000 000t	0.178	0.263	189 000t	257 000t
1.5x	0.405	0.6075	1 000 000t	2 000 000t	0.178	0.275	189 000t	262 000t
1.5x	**0.405**	**0.6065**	**1 000 000t**	**1 500 000t**	**0.178**	**0.275**	**189 000t**	**262 000t**
1.5x	0.405	0.6075	800 000t	1 200 000t	0.179	0.288	189 000t	264 000t
1.2x	0.405	0.486	1 400 000t	2 000 000t	0.178	0.26	189 000t	254 000t
1.2x	0.405	0.486	1 000 000t	2 000 000t	0.178	0.277	189 000t	262 000t
1.2x	**0.405**	**0.486**	**1 000 000t**	**1 500 000t**	**0.178**	**0.277**	**189 000t**	**262 000t**
1.2x	0.405	0.486	1 000 000t	1 100 000t	0.178	0.277	189 000t	262 000t
1.2x	0.405	0.486	900 000t	2 000 000t	0.178	0.285	189 000t	263 000t
1.2x	0.405	0.486	900 000t	1 300 000t	0.178	0.285	189 000t	263 000t
1.2x	0.405	0.486	800 000t	1 200 000t	0.179	0.289	189 000t	265 000t

Table 10. *Risk and average projected TAC and catch associated alternative values for the thresholds B_1 and B_2, determining the points at which additional season anchovy TAC may increase. Results are given corresponding to the control parameters for the corner point of each alternative. The first row reflects the "Updated rule".*

β	α_{ns}	α_{ads}	Multiple used	B_1	B_2	$risk_S$	$risk_A$	Average directed sardine TAC	Average total anchovy TAC	Average directed sardine catch	Average anchovy catch
0.095	0.405	0.81	2x	NA	NA	0.178	0.279	189 000t	284 000t	189 000t	259 000t
0.092	0.445	0.6675	1.5x	1 000 000t	1 500 000t	0.178	0.279	186 000t	299 000t	186 000t	269 000t
0.090	0.470	0.564	1.2x	1 000 000t	1 500 000t	0.179	0.279	183 000t	302 000t	183 000t	271 000t

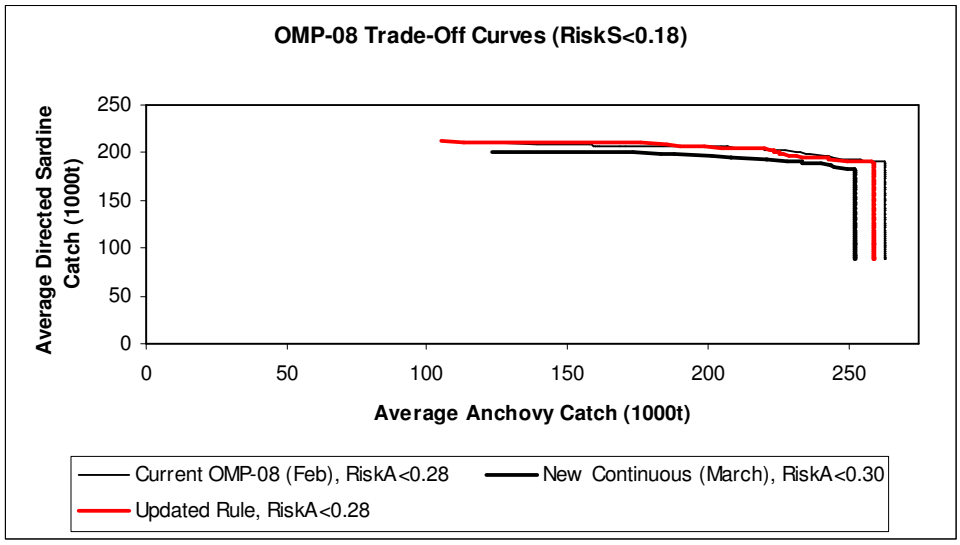

Figure 1. *Trade-off curves for OMP-08 under the "Current OMP-08" (Feb) from Cunningham and Butterworth (2008a), the new continuous rule (Mar) from Cunningham and Butterworth (2008b) and the updated rule presented in this document. The trade-off curve for is determined by points satisfying* $risk_S$ *<0.18 and either* $risk_A$ *<0.28 or 0.30 (as denoted in the legend).*

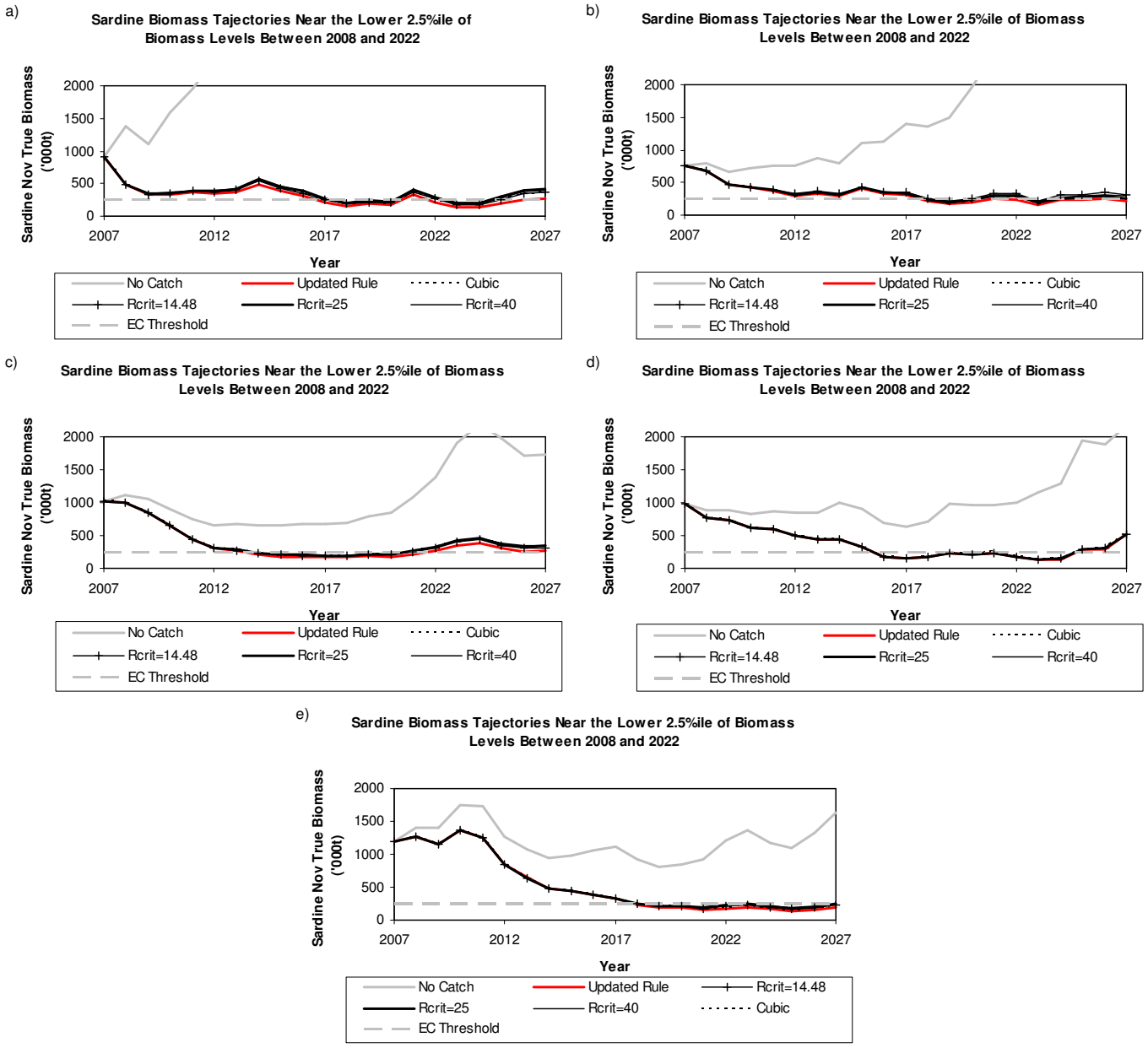

Figure 2. *Sardine biomass trajectories under the updated rule corresponding to the a) 21st , b) 22nd , c) 23rd , d) 24th and e) 25th lowest (of 1000) biomass levels between 2008 and 2022. The grey dashed line indicates the reference case exceptional circumstances threshold of 250 000t.*

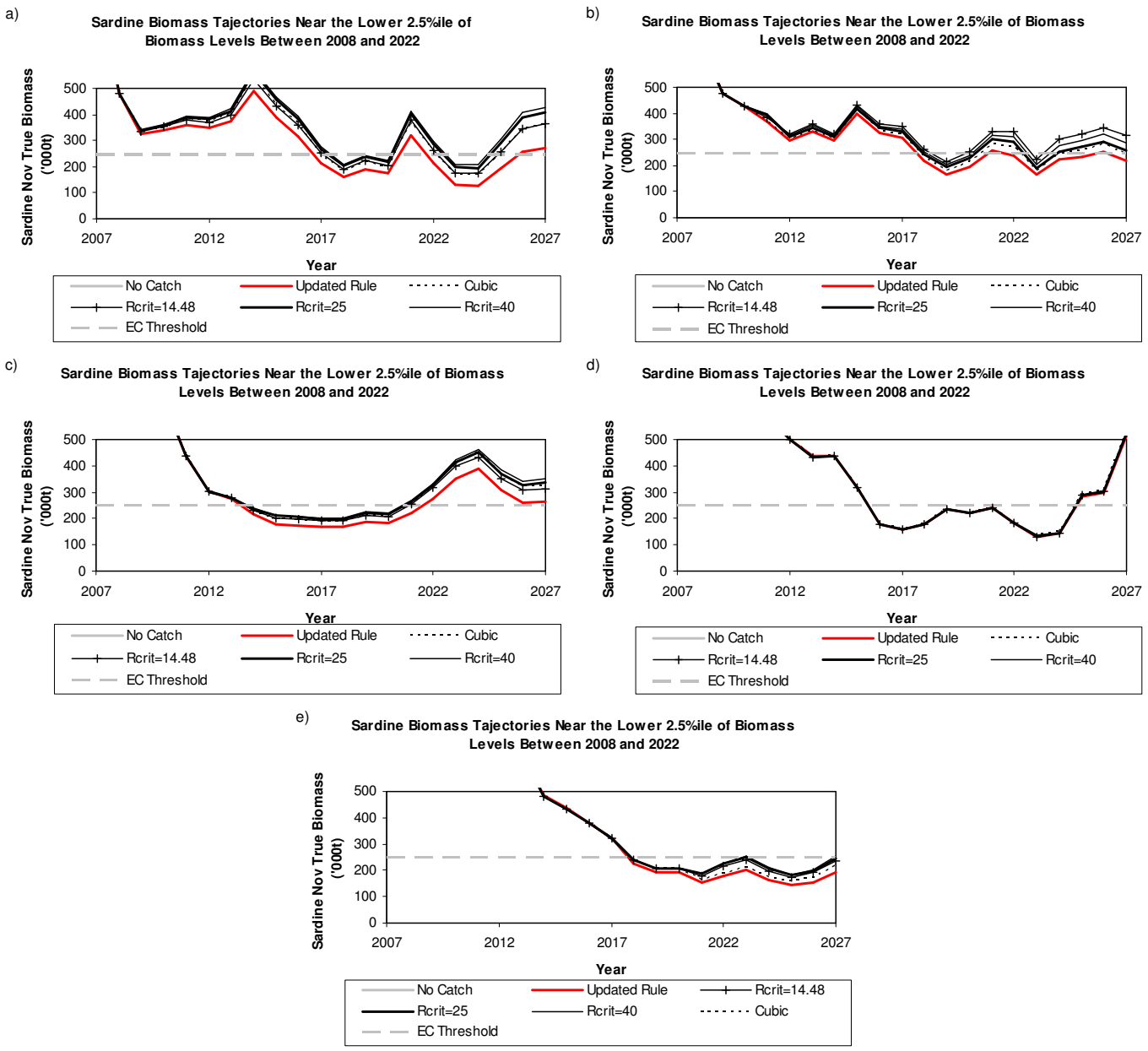

Figure 3. *As for Figure 2, but for a smaller vertical axis scale.*

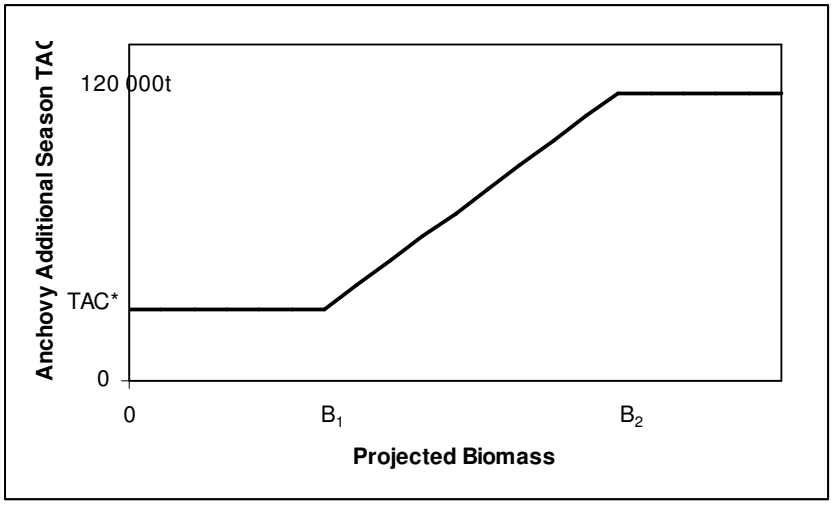

Figure 4. *The alternative rule considered for anchovy additional season TAC, which increases linearly from TAC*, that calculated using the current OMP rules, at* $B_{proj} = B_1$ *to the maximum of 120 000t for* $B_{proj} \geq B_2$.

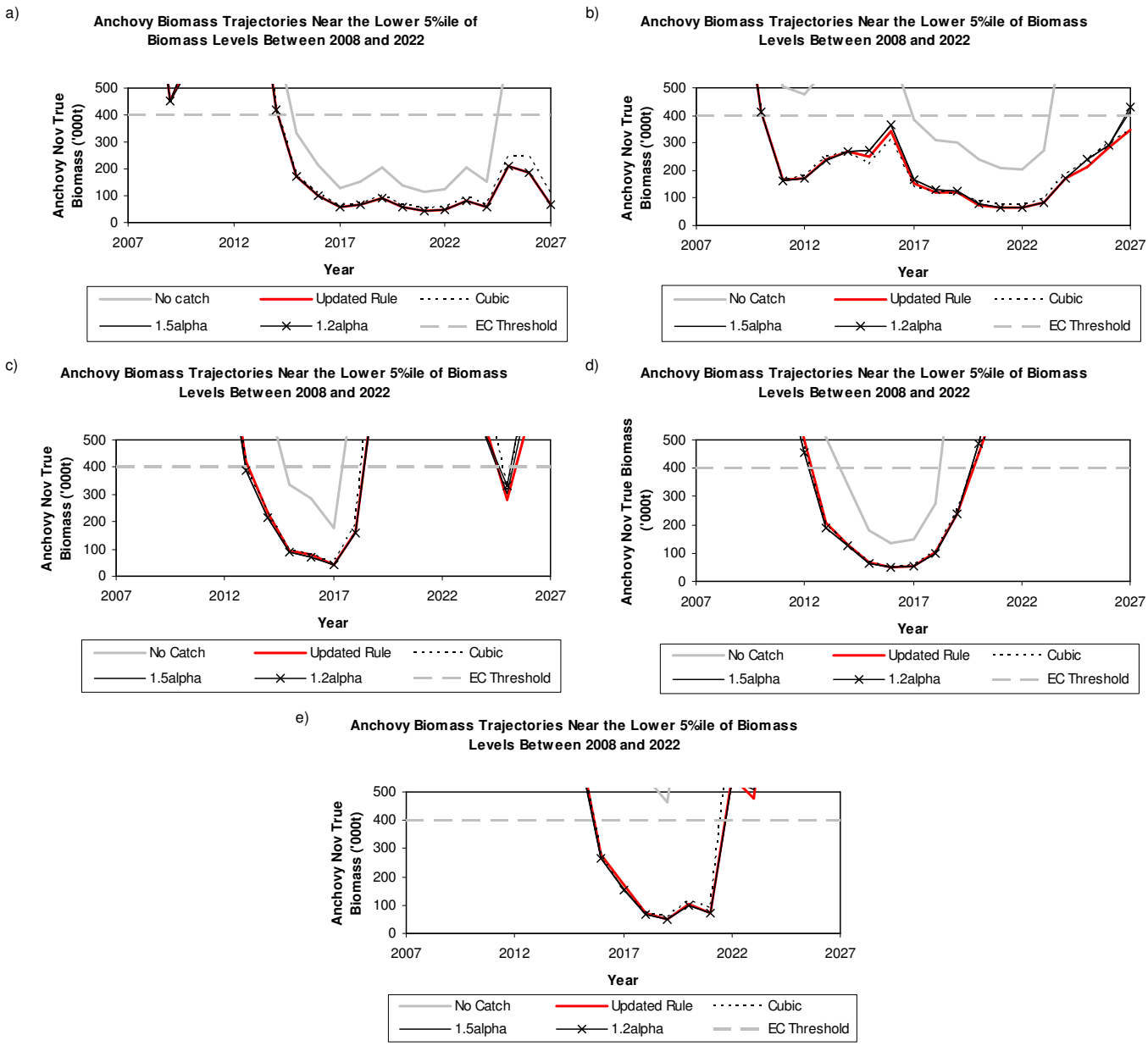

Figure 5. *Anchovy biomass trajectories under the updated rule corresponding to the a) 51st, b) 52nd , c) 53rd , d) 54th and e) 55th lowest (of 1000) biomass levels between 2008 and 2022. The grey dashed line indicates the exceptional circumstances threshold of 400 000t.*

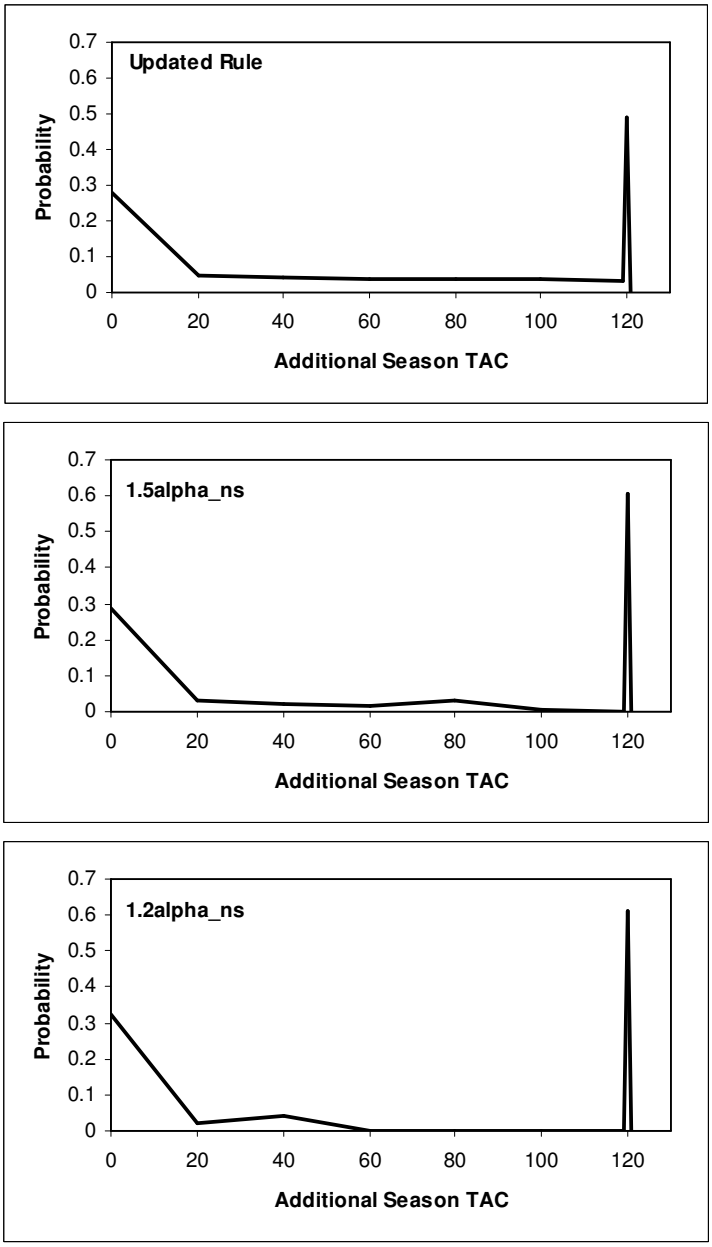

Figure 6*. Histogram of the additional season anchovy TAC for the updated rule and the two options allowing for a greater increase in the anchovy additional season TAC.*