Further Analyses Regarding the Exceptional Circumstances Provisions for OMP-08

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Introduction

OMP-08 was implemented for the South African sardine and anchovy resources in December 2007, with provisional rules governing the declaration of exceptional circumstances. It was agreed that the rules and thresholds for exceptional circumstances provisions would be finalised before June 2008 and some initial tests and alternatives to these exceptional circumstances provisions were given in Cunningham and Butterworth (2008b).

This document presents some further analyses relating to the rules and thresholds for exceptional circumstances provisions for OMP-08. During such analyses it has become evident that the anchovy risk threshold could be reconsidered in the light of new results; this is also addressed in this document. The following definitions of risk used for OMP-08 have been maintained from OMP-04:

$risk_S$ - the probability that adult sardine biomass falls below the average adult sardine biomass over November 1991 and November 1994 at least once during the projection period of 20 years.

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

Cunningham and Butterworth (2008a) recommended calculating the trade-off curve for OMP-08 by limiting $risk_S < 0.18$ and $risk_A < 0.28$.

Methods

Exceptional circumstances provisions

Two key changes have been made to the general form of the rule used to adjust the TAC once exceptional circumstances are declared from the "Current OMP-08" presented in Cunningham and Butterworth (2008a):

i) the TAC to which the exceptional circumstances rules are applied is now the basic control rule, which includes the constraints of the minimum and maximum TACs (previously the TAC was not constrained to the minimum and maximum prior to applying the exceptional circumstances rules); and

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ii) the rule has been modified to ensure continuity by allowing for a downward-adjustment to the TAC up to an amount of $\Delta = 100000$ t above the exceptional circumstances threshold.

Note that when exceptional circumstances are declared, rules concerning maximum decreases in TACs from one year to the next fall away. The 'continuity' provision ensures that this does not mean a large difference in the TAC between a situation where the biomass is slightly above and slightly below the exceptional circumstances threshold.

The OMP is run under a number of alternative exceptional circumstances options in order to examine the effect of such exceptional circumstances provisions on the resource. The 10% of simulations that resulted in the lowest simulated true biomass over the projection period under "Current OMP-08" were selected for clearer comparisons between the results of alternative options in the "lower tail", which provides better focus on cases where the status of a resource has become poor so that stronger measures may be needed to ensure recovery.

Anchovy risk

Previous risk evaluations have been based on two criteria. The first used a multiplicative adjustment of the probability threshold used to define the risk level, by comparing ratios of probabilities in the absence of fishing to the OMP-04 case. This multiplicative adjustment of the probability threshold defining the risk level was 27% for sardine and 37% for anchovy (Cunningham and Butterworth 2008a). The second criterion used was to compare the extent to which the biomass distribution curve is moved to the left under OMP-regulated fishing compared to the no-catch situation. Given the effect of the change in the exceptional circumstances provisions on the anchovy biomass distribution at the end of the projection period, this comparison was re-evaluated for the corner-point of the trade-off curve.

Results

The context to consider these results (as to the efficacy of exceptional circumstances rules) is that the MPs are designed to avoid the resource dropping below the thresholds in question, but if it does, remedial additional measures should be such as to see the resource recover rapidly to again be above such thresholds. Results under "Current OMP-08" as presented by Cunningham and Butterworth (2008b) are included in most of the tables and figures to enable comparison of the corrected continuous rule with that presented at the last Pelagic Working Group meeting.

Table 1 compares the key summary statistics for the sardine resource under "Current OMP-08" to a situation of no catch from 2008 to 2027 or the use of the OMP rules without any exceptional circumstances provisions and to the corrected continuous exceptional circumstances rule. Table 2 presents such statistics for the anchovy resource. As expected, in the case of no exceptional circumstances provisions, the risk to the sardine or anchovy resource increases substantially, the average projected catch decreases and the resource in

2027 is in a worse state than that projected under "Current OMP-08". The change in the rule has had little impact on the results for sardine for the same anchovy risk level, while increasing the anchovy risk threshold to 30% results in a decrease in the average directed sardine catch from 193 000t to 183 000t (Table 1). For an anchovy risk threshold of 28%, the average anchovy annual catch decreases from 263 000t to 220 000t, with an improvement in the anchovy resource at the end of the projection period (Table 2). Increasing the anchovy risk threshold to 30% results in an increase in the average anchovy catch to 252 000t, with the resource at the end of the projection period being between that under "Current OMP-08" and the corrected continuous rule with a risk threshold of 28%.

Although declared less frequently than "Current OMP-08", the frequency with which anchovy exceptional circumstances are declared remains high. For sardine, exceptional circumstances are declared unnecessarily or are not declared when necessary only in a small number of cases (Table 1). For anchovy exceptional circumstances are seldom declared unnecessarily, while are not declared when necessary 7-8% of the time. Note that when considering the proportion of times exceptional circumstances are declared unnecessarily, or are not declared when necessary, the true biomass is compared to the exceptional circumstances threshold adjusted by the bias in the November survey (i.e., true = threshold*bias).

Given the changes to the exceptional circumstances rules, the trade-off curves were re-calculated with $risk_S$<0.18 and $risk_A$<0.28 and alternative anchovy risk thresholds of $risk_A$<0.30 and $risk_A$<0.32 (Figure 1). Only the corner points of these curves are considered further, with control parameters listed in Table 5.

Figure 2 shows the sardine biomass distribution after 20 years of simulation under a no-catch scenario compared to OMP regulated fishing scenarios. As before, a sardine risk threshold that corresponded to a leftward shift in the distribution similar to that under OMP-04 is desired. Table 3 provides the ratios of the percentiles of these distributions for a more objective comparison. These percentiles indicate that under the corrected continuous rule for exceptional circumstances, retaining the current sardine risk threshold of 18% results in the biomass distribution under OMP-08 relative to that under a no-catch scenario after 20 years of simulation being very close to that under OMP-04, though the lower 10% of the distribution is somewhat lower.

Figure 3 shows the anchovy biomass distribution after 20 years of simulation under a no-catch scenario compared to OMP regulated fishing scenarios. Table 4 provides the ratios of the percentiles of these distributions. Under the corrected continuous rule, the distribution is better than for OMP-04 for all percentiles for a risk threshold of 28%. A selection of 30% for this threshold results in a slightly improved situation from that previously selected (a 28% risk threshold under the "Current OMP-08").

Table 6 compares the key summary statistics for the lower 10% of biomass trajectories for sardine for alternative exceptional circumstances rules and thresholds for $risk_S$<0.18 and $risk_A$<0.30, while Table 7

compares similar key summary statistics for anchovy. As expected, a lower exceptional circumstances threshold results in a higher risk to the resource, with the resource at the end of the projection period being in a poorer state than that for the current threshold. In contrast a higher exceptional circumstances threshold results in a lower risk to the resource with the resource at the end of the projection period being in an improved state than that for the current threshold. The cubic rule, which results in a faster decrease in the TAC once the exceptional circumstances threshold in crossed, results in a small decrease to the sardine risk, but a substantial decrease to the anchovy risk.

In order to evaluate the "efficacy" with which the exceptional circumstances rules allow the resources to recover, Figures 4, 5 and 6 plot the biomass trajectories around the lower 2½ percentile of the distribution of minimum projected 2008 to 2022 biomass for sardine and 5 percentile for anchovy respectively for "Current OMP-08". Comparison is made to the same trajectories under the corrected continuous rule and the alternative exceptional circumstances thresholds and rules considered. The recovery for both resources is not immediate, frequently requiring a number of years of consecutive declaration of exceptional circumstances, although a more rapid increase out of the region of exceptional circumstances is seen for anchovy.

In Summary

This document has presented some further analyses of the exceptional circumstances provisions for the directed sardine and anchovy TACs. Without changing the threshold below which exceptional circumstances are declared, nor the rate at which the TAC is decreased once exceptional circumstances are declared, the new rule allows for an increase in the anchovy risk threshold to 0.30 from 0.28.

Further analyses still to be considered include:

i) to ascertain if more anchovy can be taken during the additional season (currently $\alpha_{ads} = 2\alpha_{ns}$) without increasing risk; and

ii) to test a rule that would allow only a portion of the directed sardine TAC at the beginning of the year if exceptional circumstances are declared, with the proportion of the remaining TAC allocated mid-year dependent on the observed May recruitment.

References

Cunningham, C.L., and Butterworth, D.S. 2008a. Re-evaluation of Risk Thresholds for Sardine and Anchovy. MCM Document MCM/2008/SWG-PEL/01. 7pp.

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

Table 1. 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	No EC rules	New Continuous Rule	
				$risk_A$<0.28	$risk_A$<0.30
β	N/A	0.096	0.096	0.099	0.089
α_{ns}	N/A	0.37	0.37	0.23	0.325
$risk_S$	0.027	0.178	0.451	0.178	0.178
$\overline{C}^S$ (2008-2027)	0	190	165	193	183
AAV^S (2008-2027)	0	0.24	0.24	0.24	0.23
$\overline{B^S_{2027}/K^S_{non-peak}}$	0.93	0.70	0.44	0.69	0.70
$\overline{B^S_{2027}/Risk^S}$	17.34	10.77	7.01	10.71	10.84
$\overline{B^S_{2027}/B^S_{2007}}$	9.65	5.84	3.85	5.82	5.89
$\overline{B^S_{\min}/K^S_{non-peak}}$	0.33	0.26	0.17	0.26	0.26
$\overline{B^S_{\min}/Risk^S}$	2.24	1.78	1.20	1.77	1.78
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.003[1]	0.035	N/A	0.039	0.039
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	0.136	0.133
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	0.172	0.171
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	2.375	3.924	N/A	4.221	4.248
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	0.024
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 the current exceptional circumstance threshold of 250 000t.

[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 2. 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	
				$risk_A$<0.28	$risk_A$<0.30
β	N/A	0.096	0.096	0.099	0.089
α_{ns}	N/A	0.37	0.37	0.23	0.325
$Risk_A$	0.037	0.278	0.49	0.279	0.297
$\overline{C}^A$ (2008-2027)	0	263	240	220	252
AAV^A (2008-2027)	0	0.40	0.38	0.43	0.41
$\overline{B^A_{2027}/K^A}$	0.96	0.61	0.42	0.68	0.63
$\overline{B^A_{2027}/Risk^A}$	2.57	1.71	1.26	1.88	1.75
$\overline{B^A_{2027}/B^A_{2007}}$	1.61	1.04	0.76	1.15	1.07
$\overline{B^A_{\min}/K^A}$	0.26	0.11	0.09	0.14	0.12
$\overline{B^A_{\min}/Risk^A}$	0.57	0.26	0.22	0.31	0.28
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.038[4]	0.201	N/A	0.160	0.179
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	0.625	0.687
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	0.195	0.192
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	3.500	4.706	N/A	4.538	4.632
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.033	0.191	N/A	0.153	0.172
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.005	0.010	N/A	0.007	0.007
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.038	0.084	N/A	0.065	0.077

[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 3. 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) and under the corrected continuous rule. The anchovy risk threshold is the same for both cases ($risk_A$ <0.28). 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"	Corrected Continuous Rule
10%ile	0.59	0.50	0.47
20%ile	0.68	0.70	0.69
30%ile	0.69	0.74	0.73
40%ile	0.71	0.75	0.75
Median	0.72	0.74	0.73

Table 4. 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) and under the corrected continuous rule. 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"					Corrected Continuous Rule		
		$risk_A$ <0.24	$risk_A$ <0.26	$risk_A$ <0.28	$risk_A$ <0.30	$risk_A$ <0.37	$risk_A$ <0.28	$risk_A$ <0.30	$risk_A$ <0.32
10%ile	0.25	0.30	0.30	0.26	0.27	0.22	0.28	0.28	0.25
20%ile	0.37	0.38	0.34	0.31	0.28	0.23	0.37	0.33	0.28
30%ile	0.45	0.52	0.43	0.39	0.35	0.28	0.51	0.44	0.36
40%ile	0.56	0.62	0.50	0.44	0.40	0.33	0.59	0.49	0.42
Median	0.58	0.65	0.53	0.48	0.44	0.37	0.61	0.53	0.46

Table 5. The average 2008-2027 directed sardine and anchovy catches (in thousands of tons) for different anchovy risk thresholds (with $risk_S$ <0.18) at the corner point. The control parameters for the OMP are also shown.

$risk_A$ <	β	α_{ns}	α_{ads}	Directed sardine	Anchovy
0.28	0.099	0.230	0.46	194	220
0.30	0.089	0.325	0.65	183	252
0.32	0.085	0.400	0.80	178	270

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 (lower 5%ile given in brackets), 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. Results for the corrected continuous rule are calculated with $risk_S<0.18$ and $risk_A<0.30$.

		Corrected Continuous Rule			
	Current OMP-08	Current EC Threshold	Lower EC Threshold	Higher EC Threshold	Cubic Rule
Exceptional Circumstances Threshold	250 000t	250 000t	200 000t	300 000t	250 000t
$\overline{C}^S$ (2008-2027)	79	78	78	78	78
AAV^S (2008-2027)	0.40	0.33	0.30	0.36	0.35
$\overline{B^S_{2027}/K^S_{non-peak}}$	0.18	0.16	0.14	0.18	0.17
$\overline{B^S_{2027}/Risk^S}$	1.88 (0.05)	1.62	1.43	1.83	1.71
$\overline{B^S_{2027}/B^S_{2007}}$	1.29	1.10	0.98	1.24	1.16
$\overline{B^S_{\min}/K^S_{non-peak}}$	0.06	0.05	0.05	0.06	0.06
$\overline{B^S_{\min}/Risk^S}$	0.39	0.34	0.29	0.39	0.36
$risk_S$	0.178	0.178	0.182	0.174	0.177
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.035	0.039	0.034	0.046	0.038
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.119	0.133	0.119	0.148	0.129
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.172	0.171	0.176	0.161	0.172
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	3.924	4.248	4.420	4.291	4.178
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.010	0.015	0.016	0.014	0.014
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.024	0.024	0.018	0.032	0.024
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.001	0.001	0.002	0.001	0.001

Table 7. 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 (lower 5%ile given in brackets), 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. Results for the corrected continuous rule are calculated with $risk_S<0.18$ and $risk_A<0.30$.

		Corrected Continuous Rule			
	Current OMP-08	Current EC Threshold	Lower EC Threshold	Higher EC Threshold	Cubic Rule
Exceptional Circumstances Threshold	400 000t	400 000t	350 000t	450 000t	400 000t
$\overline{C}^A$ (2008-2027)	161	159	158	160	160
AAV^A (2008-2027)	0.52	0.52	0.51	0.52	0.52
$\overline{B^A_{2027}/K^A}$	0.31	0.32	0.30	0.34	0.35
$\overline{B^A_{2027}/Risk^A}$	1.00 (0.01)	1.01	0.93	1.09	1.15
$\overline{B^A_{2027}/B^A_{2007}}$	0.61	0.61	0.57	0.66	0.70
$\overline{B^A_{\min}/K^A}$	0.01	0.01	0.01	0.02	0.02
$\overline{B^A_{\min}/Risk^A}$	0.03	0.03	0.03	0.04	0.04
$Risk_A$	0.278	0.297	0.354	0.258	0.264
Proportion of times Exceptional Circumstances are declared (2008-2027)	0.201	0.179	0.166	0.194	0.174
Mean number of times Exceptional Circumstances are declared for 2 or more consecutive years in a 20 year projection period	0.762	0.687	0.647	0.741	0.702
Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year	0.190	0.192	0.195	0.191	0.202
Average number of years for which Exceptional Circumstances, if declared, are declared consecutively	4.706	4.632	4.654	4.605	4.350
Proportion of times Exceptional Circumstances are declared and true biomass is below the corresponding threshold	0.191	0.172	0.160	0.185	0.166
Proportion of times Exceptional Circumstances are declared and true biomass is above the corresponding threshold	0.010	0.007	0.006	0.009	0.008
Proportion of times Exceptional Circumstances are not declared when true biomass is below the corresponding threshold	0.084	0.077	0.066	0.091	0.080

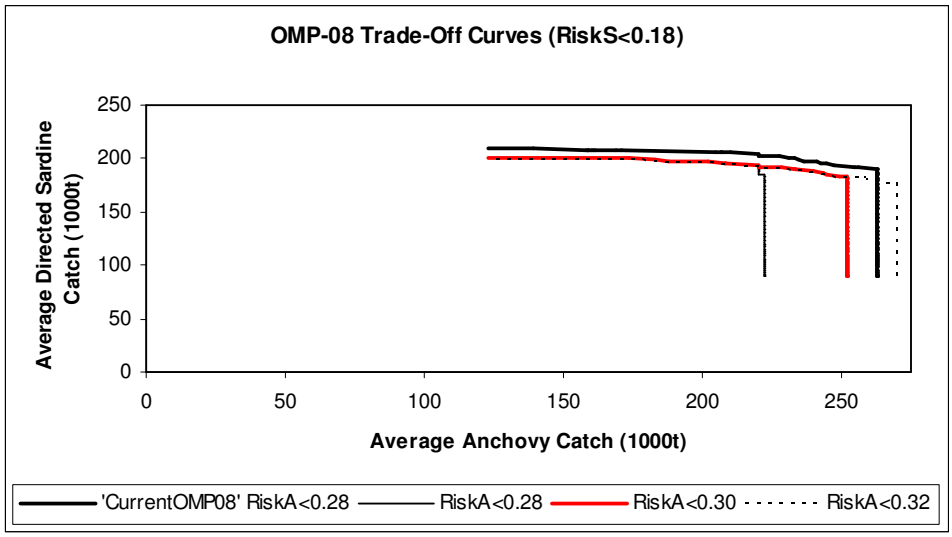


Figure 1. *Trade-off curves for OMP-08 under the "Current OMP-08" from Cunningham and Butterworth (2008a) and the corrected continuous rule. The trade-off curve for is determined by points satisfying* $risk_S$ *<0.18 and* $risk_A$ *<0.28, 0.30 or 0.32.*

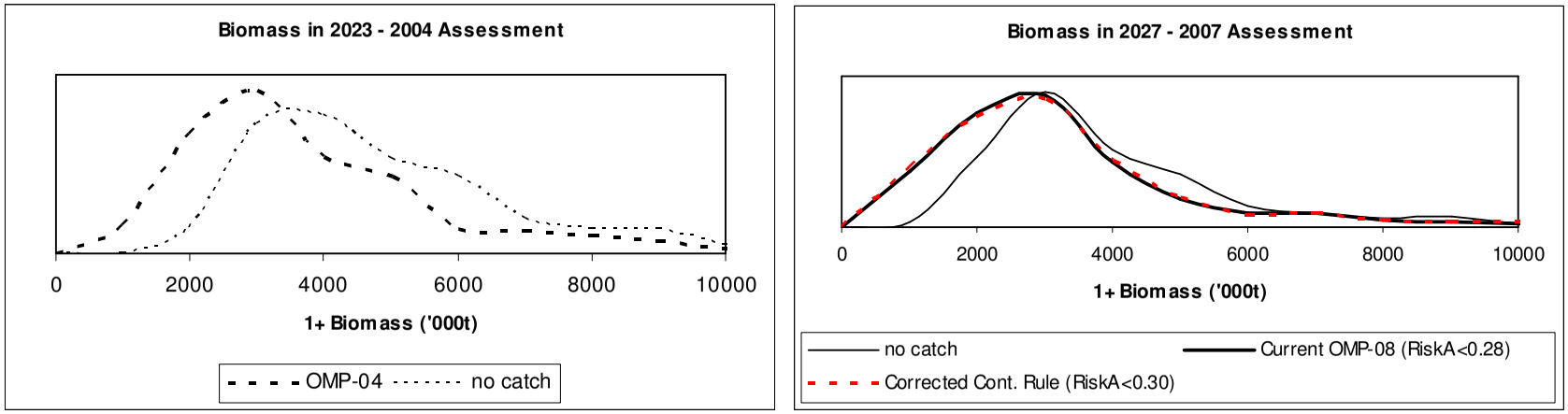


Figure 2. *Comparison of sardine biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (left panel) and the 2007 assessment (right panel). In the right panel the distribution under "Current OMP-08" ($risk_S$ <0.18 and $risk_A$ <0.28) from Cunningham and Butterworth (2008a) is shown together with the distribution under the corrected continuous rule ($risk_S$ <0.18 and $risk_A$ <0.30). The right panel is based on OMPs corresponding to the corner point.*

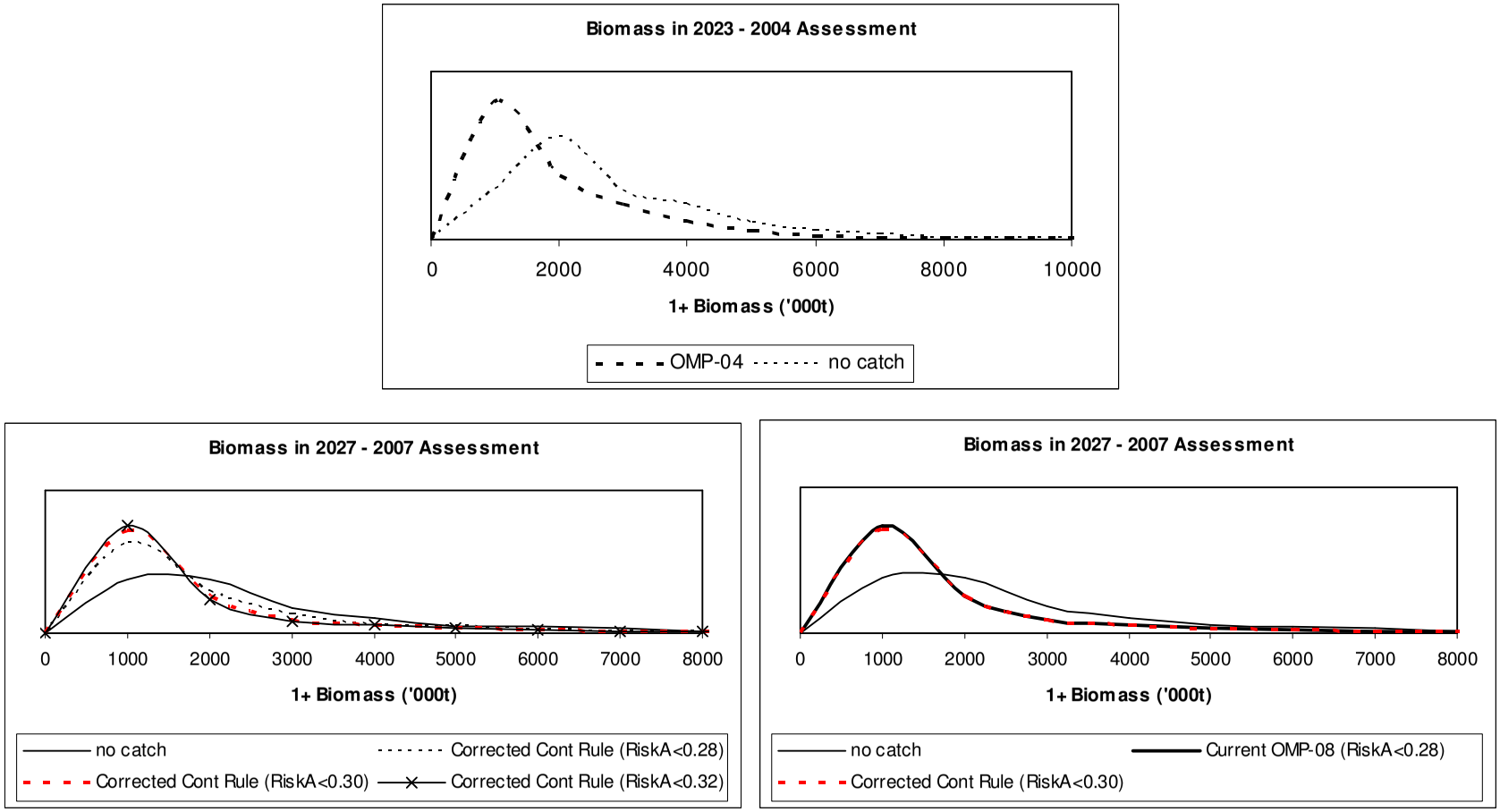
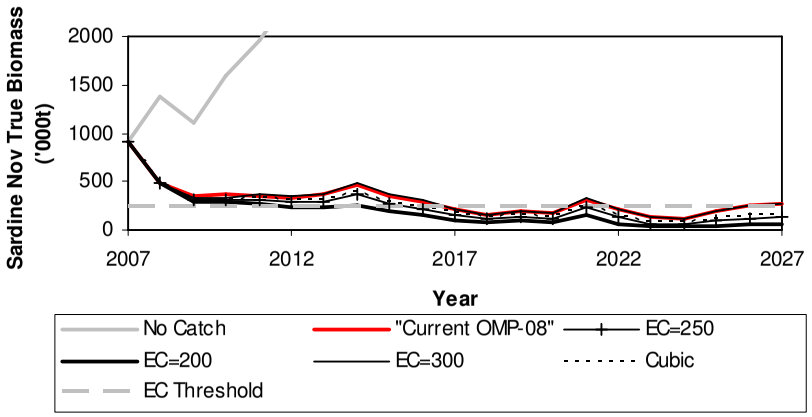
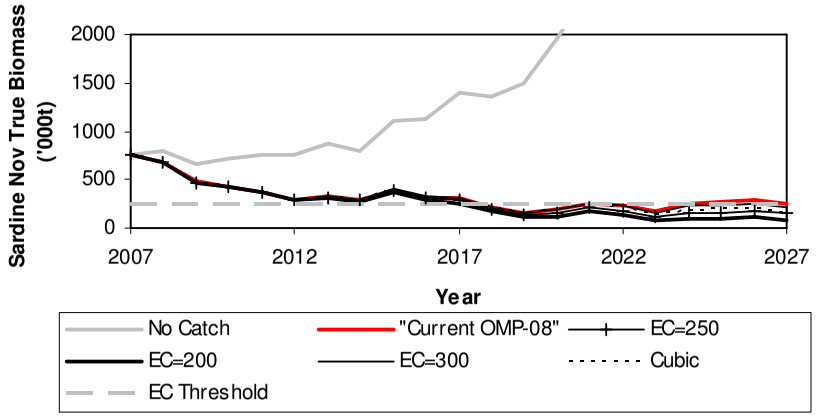


Figure 3. *Comparison of anchovy biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (upper panel) and the 2007 assessment (lower panels). In the lower panels the distribution under "Current OMP-08" ($risk_S$ <0.18 and $risk_A$ <0.28) from Cunningham and Butterworth (2008a) is shown together with the distribution under the corrected continuous rule ($risk_S$ <0.18) for alternative risk thresholds for anchovy, and the associated OMPs correspond to the respective corner points of the trade-off curves.*

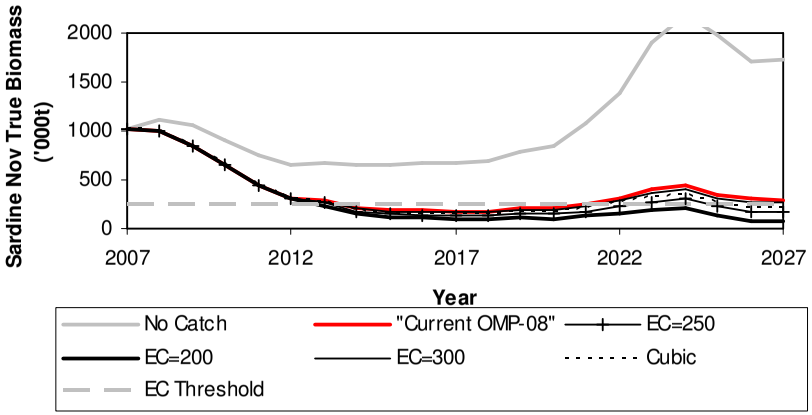
a)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
2000
1500
1000
500
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

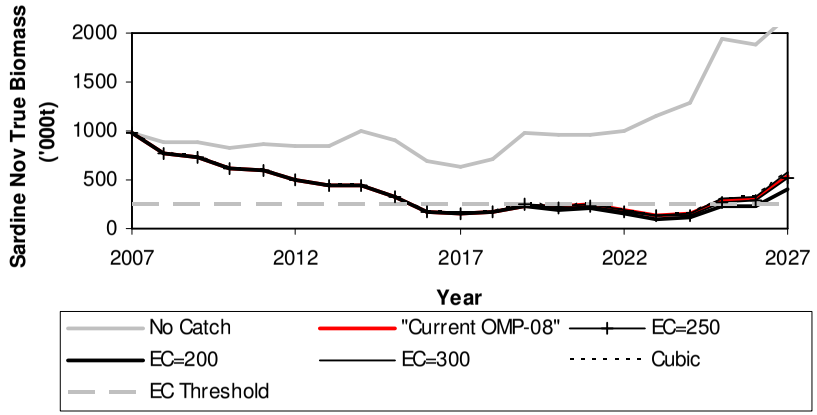
b)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
2000
1500
1000
500
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

c)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
2000
1500
1000
500
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

d)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
2000
1500
1000
500
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

e)

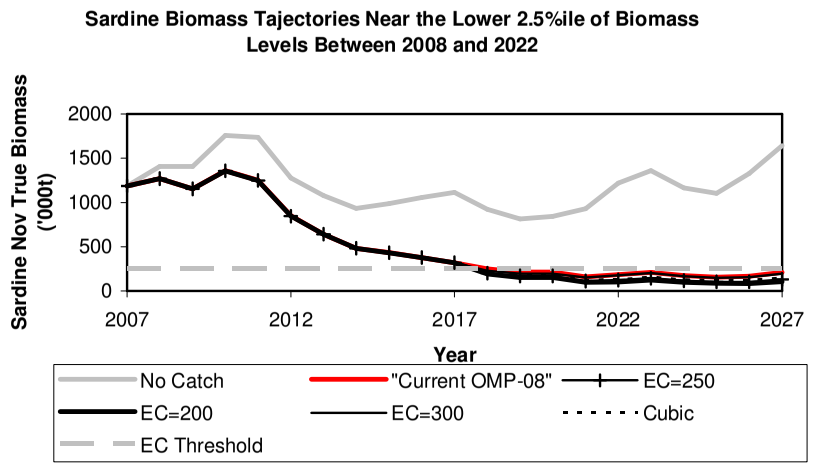
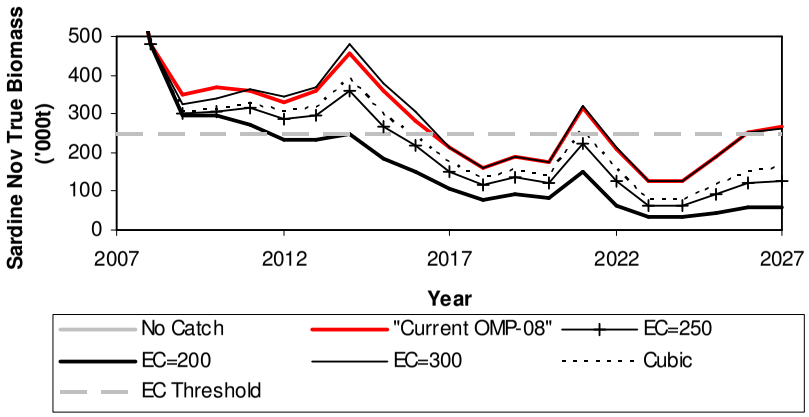
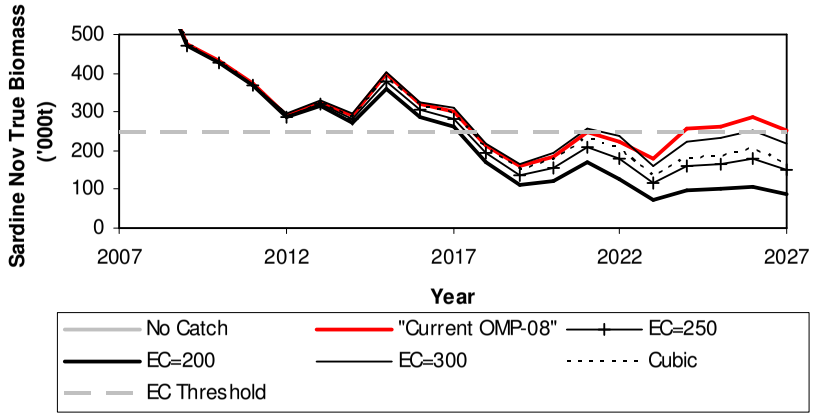


Figure 4. *Sardine biomass trajectories under "Current OMP-08" from Cunningham and Butterworth (2008a) and from the corrected continuous rule corresponding to the a) 21st , b) 22nd , c) 23rd , d) 24th and e) 25th lowest (of 1000) biomass levels between 2008 and 2022. The trajectories in this figure correspond to results obtained when* $\beta = 0.099$ *and* $\alpha_{ns} = 0.23$, *i.e. when* $risk_S$ *<0.18 and* $risk_A$ *<0.28. The grey dashed line indicates the reference case exceptional circumstances threshold of 250 000t.*

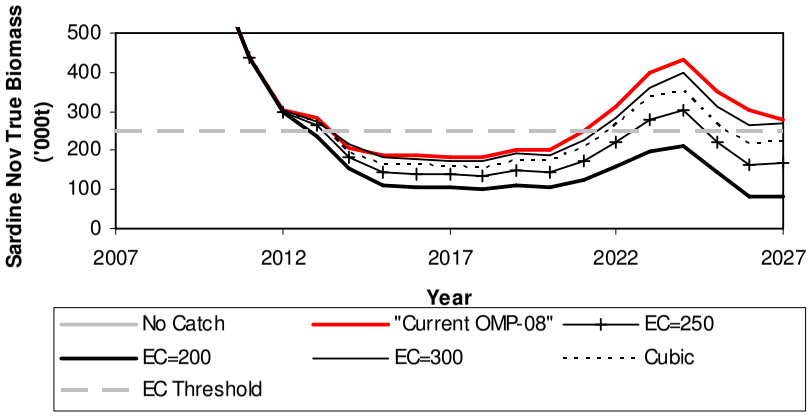
a)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

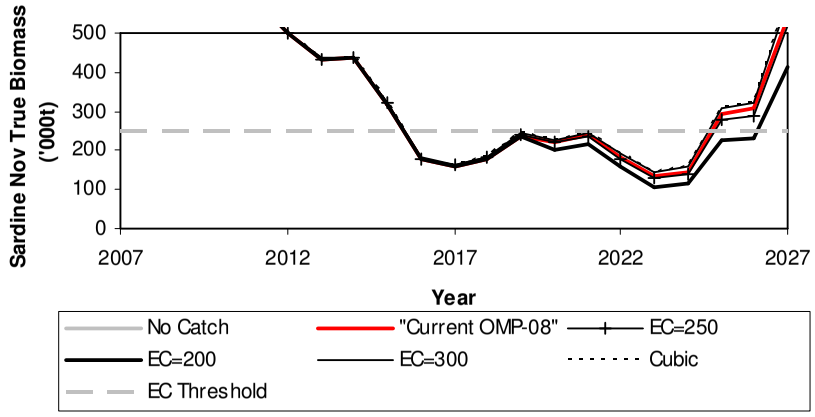
b)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

c)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

d)


Sardine Biomass Tajectories Near the Lower 2.5%ile of Biomass Levels Between 2008 and 2022
Sardine Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
"Current OMP-08"
EC=250
EC=200
EC=300
Cubic
EC Threshold

e)

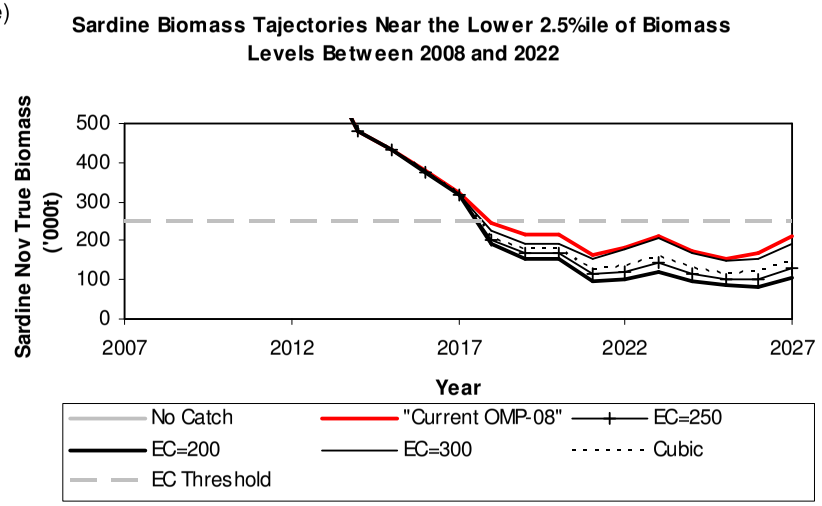
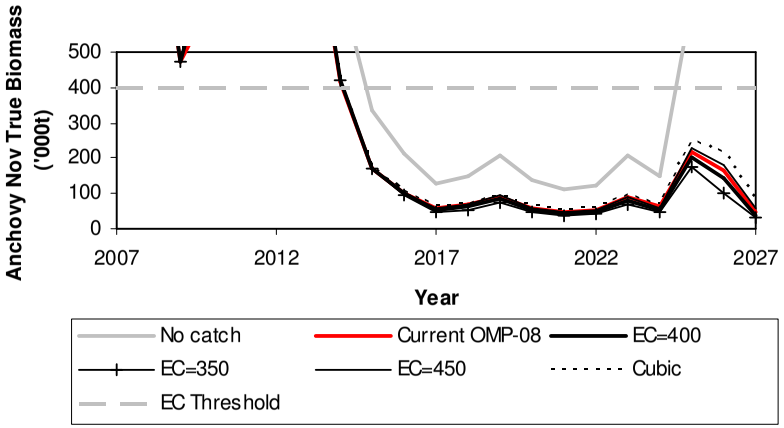
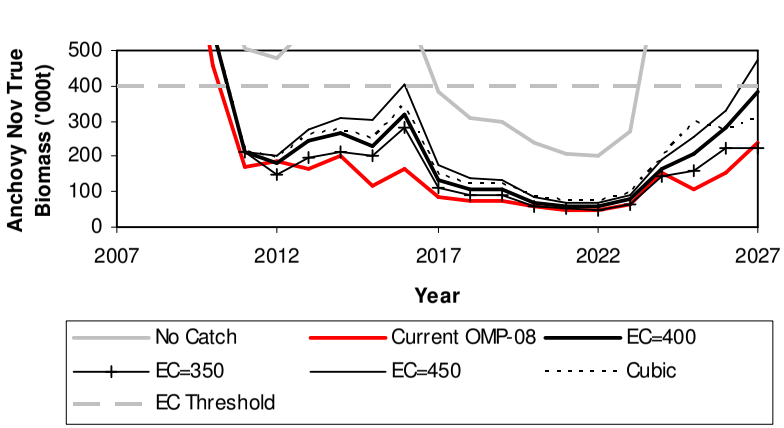


Figure 5. *As for Figure 4, but for a smaller vertical axis scale.*

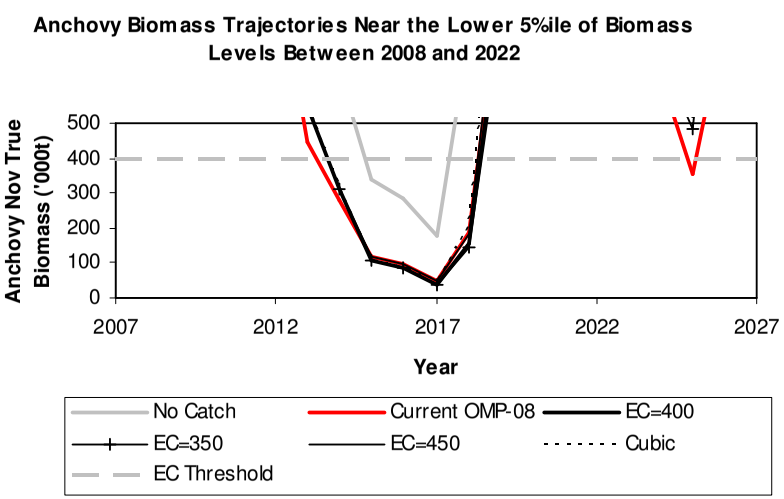
a)


Anchovy Biomass Trajectories Near the Lower 5%ile of Biomass Levels Between 2008 and 2022
Anchovy Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No catch
Current OMP-08
EC=400
EC=350
EC=450
Cubic
EC Threshold

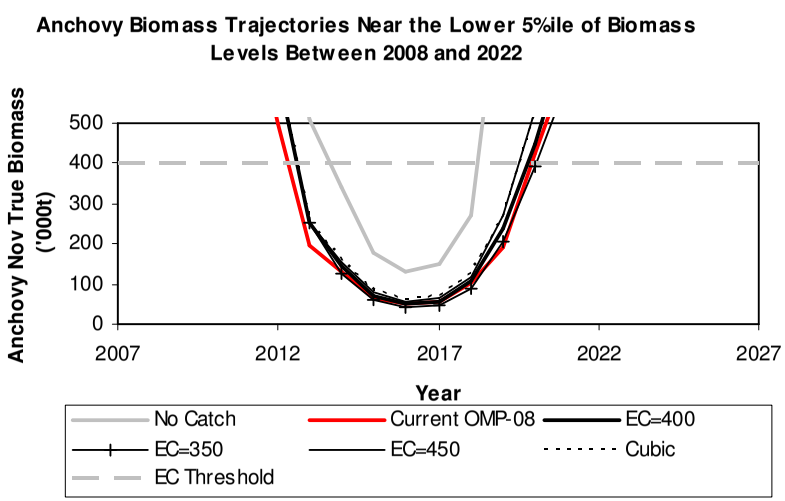
b)


Anchovy Biomass Trajectories Near the Lower 5%ile of Biomass Levels Between 2008 and 2022
Anchovy Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
Current OMP-08
EC=400
EC=350
EC=450
Cubic
EC Threshold

c)


Anchovy Biomass Trajectories Near the Lower 5%ile of Biomass Levels Between 2008 and 2022
Anchovy Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
Current OMP-08
EC=400
EC=350
EC=450
Cubic
EC Threshold

d)


Anchovy Biomass Trajectories Near the Lower 5%ile of Biomass Levels Between 2008 and 2022
Anchovy Nov True Biomass ('000t)
500
400
300
200
100
0
2007
2012
2017
2022
2027
Year
No Catch
Current OMP-08
EC=400
EC=350
EC=450
Cubic
EC Threshold

e)

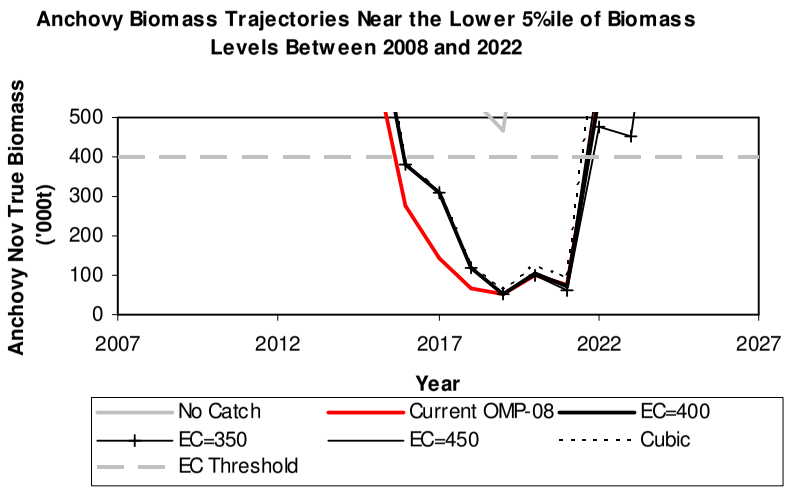


Figure 6. *Anchovy biomass trajectories under "Current OMP-08" from Cunningham and Butterworth (2008a) and from the corrected continuous rule corresponding to the a) 51st, b) 52nd , c) 53rd , d) 54th and e) 55th lowest (of 1000) biomass levels between 2008 and 2022. The trajectories in this figure correspond to results obtained when* $\beta = 0.099$ *and* $\alpha_{ns} = 0.23$, *i.e. when* $risk_S < 0.18$ *and* $risk_A < 0.28$. *The grey dashed line indicates the reference case exceptional circumstances threshold of 400 000t.*