OMP-13: Initial Results Assuming a Two Sardine Stock Hypothesis

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Further work in the development of OMP-13 has continued with modifications to the documentation and code, mostly to allow for a generalisation towards one or two sardine stocks and one or two directed sardine TACs (de Moor and Butterworth 2013a). This document provides updated results for no catch scenarios and candidate MPs assuming a single sardine stock hypothesis, with different levels of variability about the stock recruitment relationship. Initial results are also presented for a no catch scenario and candidate MPs assuming a two sardine stock hypothesis; risk under this two stock hypothesis is discussed.

Results are presented for candidate MPs which set a single sardine TAC only. The split of the sardine catch between the "west" and "south" stocks, in the case of the two sardine stock hypothesis, is based on a relationship with the ratio of the directed sardine TAC to the "west" stock 1+ biomass in the previous November (de Moor and Butterworth 2013a).

Single sardine stock hypothesis

Figure 1a shows the projected sardine 1+ biomass for the updated operating model after 20 years of no catch for different levels of variability about the stock recruitment relationship ($\sigma^S_{j=1,r} = 0.4$, $\sigma^S_{j=1,r} = 0.45$ and $\sigma^S_{j=1,r} = 0.5$). The 20th percentile of these distributions in the absence of catch decreases as the recruitment variability increases because the resource is naturally more variable and thus the distribution becomes wider.

Given the update, for the control parameters of Interim OMP-13 v2 (de Moor and Butterworth 2013b), i.e. $\beta = 0.09$ and $\alpha_{ns} = 0.871$, the risk to the anchovy resource has decreased from 0.247 (tuned to be less than 0.25) to 0.232, and the risk to the sardine single stock has decreased from 0.209 (tuned to be less than 0.21) to 0.187, with an increase in average projected anchovy catch.

Retuning the MP such that the ratio of the projected biomass distribution under the catch : no catch scenario is similar to that of OMP-08 (de Moor and Butterworth, 2008) gives an average projected directed sardine catch ranging from 148 000t with $\beta = 0.083$ (for $\sigma^S_{j=1,r} = 0.5$) to 162 000t with $\beta = 0.097$ (for $\sigma^S_{j=1,r} = 0.4$). The projected distributions of sardine 1+ biomass under these retuned MPs are shown against those for assuming no future catch in Figures 1b-d.

The re-tuned trade-off curves for the updated MP under the single stock operating model are shown in Figure 2.

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Two sardine stock hypothesis

Figures 3a,b shows the projected sardine "west" and "south" stocks 1+ biomass after 20 years of no catch (assuming $\sigma^S_{j=1,r} = \sigma^S_{j=1,r} = 0.5$). To obtain these results, annual movement of "west" stock recruits to the "south" stock is assumed dependent on the ratio of the "south" stock to "west" stock 1+ biomass in the previous November (de Moor and Butterworth 2013a,c). The impact of this movement on the stocks can be seen by assuming no future movement. If no future movement is assumed then the "west" stock is simulated to be much larger and the "south" stock much smaller than under the movement hypothesis assumed here. Figure 3c shows that the projected total 1+ biomass is lower than that for the single stock hypothesis (median of 1184 000t compared to 2439 000t and average of 1812 000t compared to 2857 000t). However if no future movement is assumed then the projected total 1+ biomass is higher than that for the single stock hypothesis (median of 3647 000t and average of 4343 000t).

The sardine risk threshold used for the single stock hypothesis is the average 1991-4 November 1+ biomass. This threshold was chosen because the population was able to grow to reach peak abundance from this level and thus it is a level which we would aim to limit the possibility of the population decreasing below. This chosen average does not necessarily translate directly to the two stock hypothesis, particularly as the "west" stock 1+ biomass was below the 1991-4 average in the last 8 years of the assessment (Figure 4).

Under this no catch scenario, assuming a two stock operating model, the risk to the total sardine population, where the threshold is taken to be the 1991-4 November 1+ biomass, is 0.593 (baseline), decreasing to 0.183 if no future movement of "west" stock recruits to the "south" stock is assumed. The impact of movement is further seen in that the risk to the "west" stock is higher when movement is assumed compared to when no future movement is assumed (Table 2). (As for the single stock hypothesis, risk to the anchovy resource is simulated to be 0.008.)

Given these risks under a no catch scenario, using the control parameters of Interim OMP-13 v2 ($\beta = 0.09$ and $\alpha_{ns} = 0.871$) in the updated MP, it is unsurprising that extremely high probabilities of the risk thresholds being exceeded result (Table 2). Again, the impact of future movement is demonstrated in the result that if no future movement is assumed, them the risk to the "west" stock and total population decreases substantially, while the risk to the "south" stock increases slightly.

In the results discussed above, the multiplicative bias associated with the coverage of the "south" stock recruits by the recruit survey in comparison to the "west" stock recruits during the same survey is assumed to be 1. Results are also shown for an alternative extreme where this bias is assumed to be 0.4. The qualitative comments made above do not differ for this alternative.

Discussion

This document has shown updated results for a Candidate MP based on the same equations as Interim OMP-13 v2, but assuming an updated operating model for the single stock hypothesis, with alternative values for time-invariant variability about the stock recruitment relationship. Initial results have also been presented assuming a two stock hypothesis. These results show that assuming movement of “west” stock recruits to the “south” stock are dependent on the ratio of “south” to “west” 1+ biomass, even if there were no future catch, there is a 60% probability that total sardine 1+ biomass and a 95% probability that the “west” stock 1+ biomass will decrease below the corresponding average 1991-4 biomass at least once during the projection period. .

An extensive list of alternative operating models has been suggested for the two stock hypothesis. The results have been shown to not be qualitatively sensitivity to one potentially key alternative (the chosen value for the multiplicative bias associated with the coverage of the “south” stock recruits compared to the “west” stock recruits).

References

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de Moor, C.L., and D.S. Butterworth. 2013c. Assessment of the South African sardine resource using data from 1984-2011: results for a two stock hypothesis at the posterior mode. DAFF Branch Fisheries document: FISHERIES/2013/AUG/SWG-PEL/20. 46pp

Table 1. The risk to the resources and average projected annual directed catch for projections assuming a single sardine stock hypothesis with an updated underlying operating model. Statistics are shown for Interim OMP-13v2 (with the previous operating model), no catch scenarios and the updated candidate MP for three alternative choices for variability about the stock recruitment relationship ($\sigma^{S}_{j=1,r}$).

	$\sigma^{S}_{j=1,r}$	β	α_{ns}	$risk_A$	$risk_S$	$\overline{C}^{A}$	$\overline{C}^{S}$
Interim OMP-13 v2	0.4	0.090	0.871	0.247	0.209	275	154
No catch	0.4	N/A	N/A	0.008	0.031	0	0
	0.45	N/A	N/A	0.008	0.047	0	0
	0.5	N/A	N/A	0.008	0.072	0	0
Candidate MP	0.4	0.090	0.871	0.232	0.187	290	156
	0.45	0.090	0.871	0.227	0.223	290	156
	0.5	0.090	0.871	0.237	0.294	290	154
Retuned Candidate MP	0.4	0.097	0.867	0.231 (<0.25)	0.199 (<0.20)	290	162
	0.45	0.088	0.889	0.237 (<0.25)	0.219 (<0.22)	290	154
	0.5	0.083	0.870	0.237 (<0.25)	0.279 (<0.28)	290	148

Table 2. The risk to the resources and average projected annual directed catch for projections assuming a two sardine stock hypothesis. Statistics are shown for no catch scenarios and the candidate MP, and assuming two alternative fixed choices for the multiplicative bias associated with the coverage of the "south" stock recruits by the recruit survey in comparison to the "west" stock recruits during the same survey, $k^S_{\mathrm{cov}\,E}$, and assuming two alternative movement hypotheses: a baseline and a no movement hypothesis. The risk thresholds considered for sardine are

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

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

$risk_S^{west}$ - the probability that adult "west" stock sardine biomass falls below the average adult "west" stock sardine biomass over November 2004 and November 2011 at least once during the projection period of 20 years.

	$k^S_{\mathrm{cov}\,E}$	Movement	β	α_{ns}	$risk_A$	$risk_S$	$risk_S^{west}$	$risk_S^{south}$	$risk_S^{west\,2}$	$\overline{C}^A$	$\overline{C}^S$	$\overline{C}^S_{west}$	$\overline{C}^S_{south}$
No catch	1.0	None	N/A	N/A	0.008	0.183	0.328	0.997	0.068	0	0	0	0
	1.0	Baseline	N/A	N/A	0.008	0.593	0.952	0.134	0.904	0	0	0	0
	0.4	None	N/A	N/A	0.008	0.196	0.335	0.991	0.064	0	0	0	0
	0.4	Baseline	N/A	N/A	0.008	0.597	0.949	0.217	0.898	0	0	0	0
Candidate MP	1.0	None	0.090	0.871	0.238	0.369	0.507	0.998	0.227	288	165	163	2
	1.0	Baseline	0.090	0.871	0.238	0.993	0.999	0.979	0.999	292	27	14	13
	0.4	None	0.090	0.871	0.234	0.452	0.542	0.994	0.264	288	161	158	3
	0.4	Baseline	0.090	0.871	0.240	0.994	1.000	0.982	0.999	292	32	12	20
Candidate MP Retuned for	1.0	None	0.088	0.889	0.245	0.367	0.507	0.998	0.227	288	163	161	2
	1.0	Baseline	0.088	0.889	0.247	0.993	0.999	0.978	0.999	292	27	14	13
	0.4	None	0.088	0.889	0.246	0.449	0.541	0.994	0.262	288	159	156	3
	0.4	Baseline	0.088	0.889	0.250	0.994	1.000	0.982	0.999	293	32	12	20

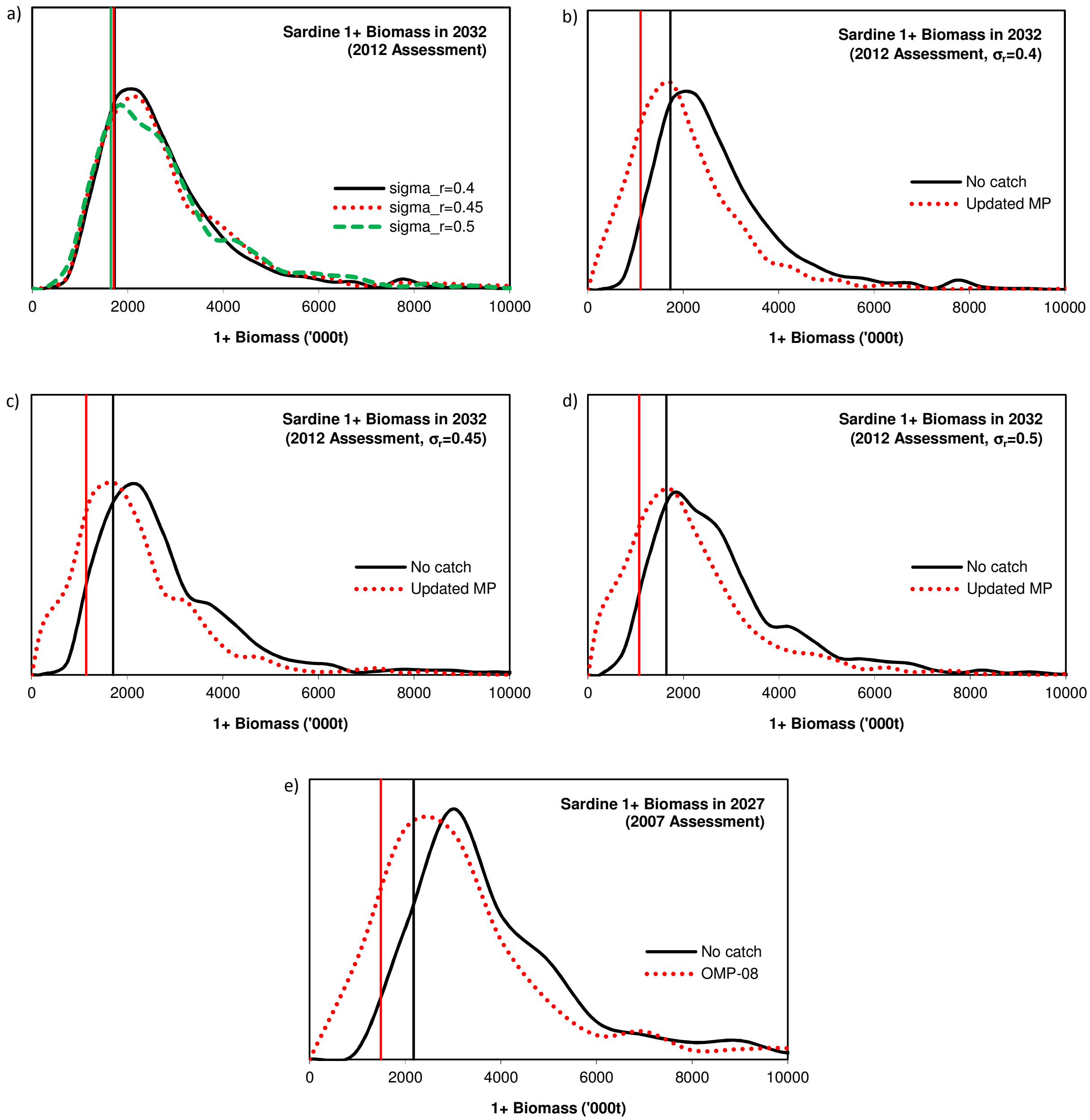

Figure 1. The projected sardine single stock 1+ biomass distribution after 20 years under a) a no catch scenario and three different underlying operating models assuming different time-invariant levels of recruitment variability, b) a no catch and MP scenario assuming $\sigma^S_{j=1,r}=0.4$, c) a no catch and MP scenario assuming $\sigma^S_{j=1,r}=0.45$, and d) a no catch and MP scenario assuming $\sigma^S_{j=1,r}=0.5$. The 20%iles of the distributions are shown by the dashed vertical lines. The projected distributions simulated under OMP-08 and a no catch scenario using the 2007 assessment (using samples from distributions assuming $\sigma^S_{j=1,r}=0.4$, $\sigma^S_{j=1,r}=0.5$, $\sigma^S_{j=1,r}=0.6$ and $\sigma^S_{j=1,r}=0.7$) is shown in e) for comparison.

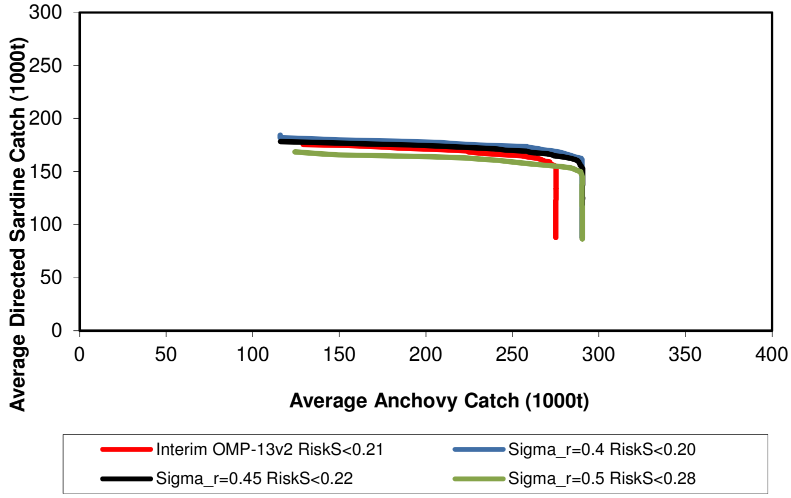

Figure 2. The trade-off curves between average projected directed sardine and anchovy catch over the next 20 years under Interim OMP-13 v2 (with the previous operating model) compared to the Candidate MPs re-tuned to different sardine risk levels for different levels assumed for time invariant recruitment variability assuming the updated underlying operating model. All trade-off curves are tuned to $risk_A < 0.25$.

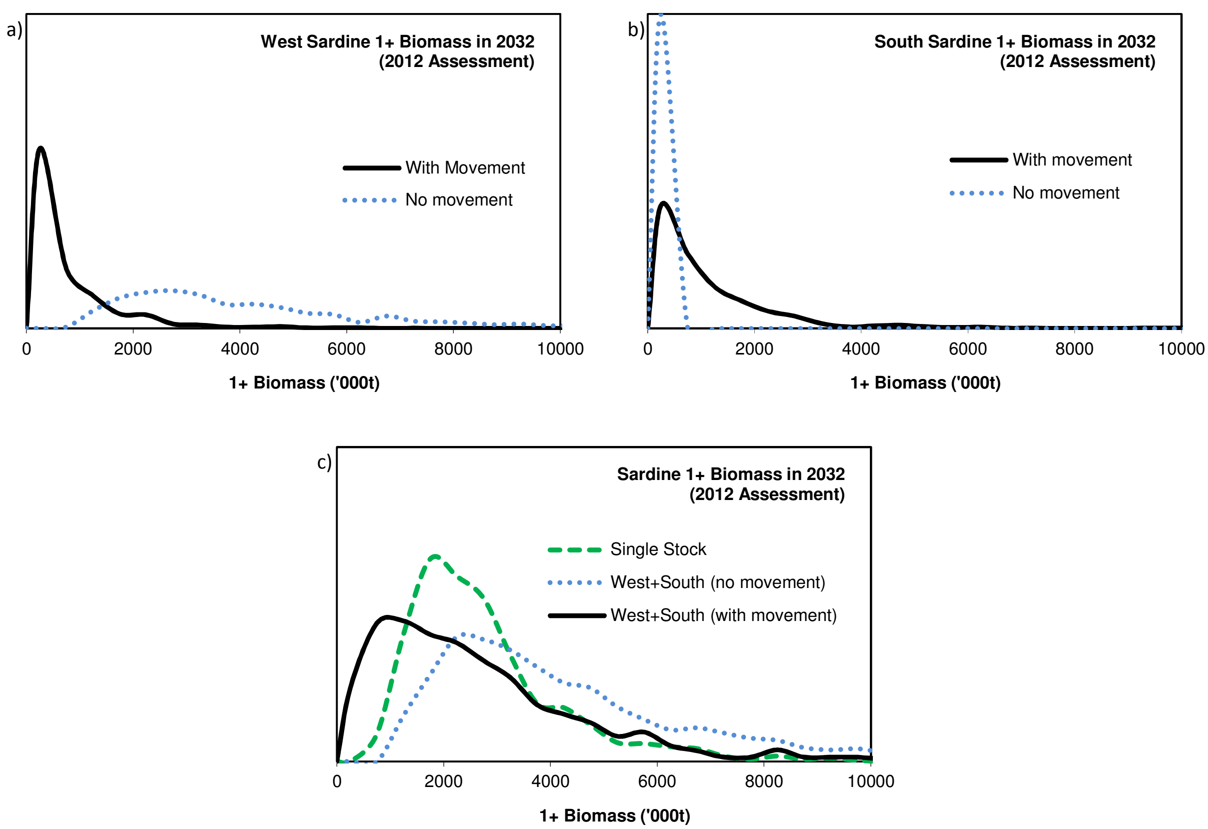

Figure 3. The projected sardine a) "west", b) "south" and c) total stock 1+ biomass distribution after 20 years under a no catch scenario. A comparison is made with an underlying operating model which assumes no future movement of "west" stock recruits to the "south" stock. Plot c) also includes the single stock distribution assuming $\sigma^S_{j=1,r} = 0.5$ as for the two stock hypothesis.

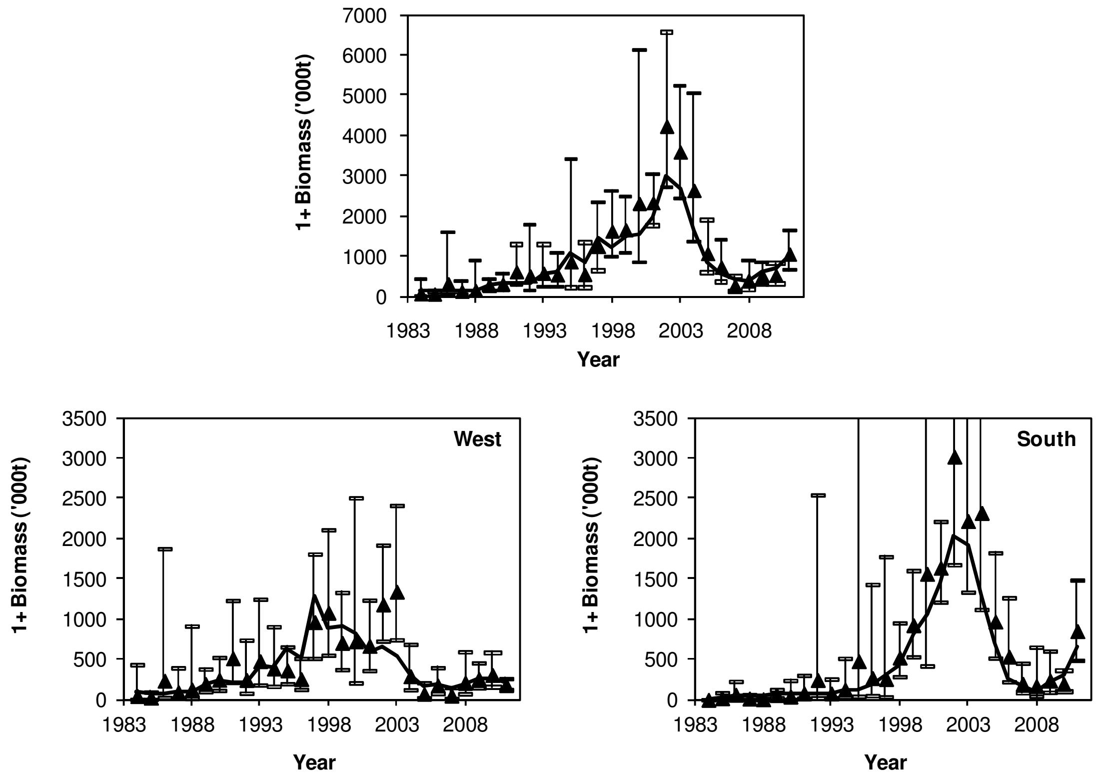

Figure 4. Acoustic survey estimated and model predicted November sardine 1+ biomass from 1984 to 2011 for a) the single stock hypothesis (de Moor and Butterworth 2012), b) the "west" stock and c) the "south" stock (de Moor and Butterworth 2013c). The survey estimates are shown with their 95% confidence intervals.