Items to be considered in the development of an updated management procedure for the South African pelagic fishery (OMP-12)

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A new management procedure (MP) for the South African pelagic fishery is to be developed next year in time to be implemented by December 2011 to set the initial anchovy and directed sardine TACs (Total Allowable Catches) and sardine TAB[1] (Total Allowable Bycatch) for 2012. This document lists some of the issues which are proposed to be taken into consideration during the development and simulation testing of the new OMP. The authors invite comment on current best practice regarding the implementation of these considerations.

- Assign relative plausibility to one and two ('west' and 'east') stock hypotheses for sardine

Two separate hypotheses of stock structure will be modelled (Appendix A). Resource and catch projections under candidate MPs could differ under the alternative hypotheses. How do we best determine relative plausibility between hypotheses. Should higher weight always be given to the more pessimistic resource projections, and if so, how much?

- Modelling future recruitment in the operating models

There is a possibility that stock-recruitment dynamics have changed over time, perhaps in 1999/2000, or possibly due to density dependence (Appendix B). Should a different model be used for sardine "peak" periods? How should seemingly enhanced anchovy recruitment throughout the 2000's be interpreted? How do we best model recruitment and its variability in the future?

One suggestion for sardine would be to estimate a stock recruitment relationship using years excluding those of peak biomass (or peak recruitment?). Future recruitment would be based on this stock recruitment relationship. Alternatively, a separate stock recruitment relationship could be estimated using years of peak biomass (or peak recruitment?) and future recruitment could switch from one 'regime' to another with a probability of eg 5/27 (based on the period covered by the acoustic survey series) of switching to the 'peak regime' which then continues for 5 years.

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[1] As juvenile anchovy shoal together with juvenile sardine for a large part of the time for which they are available to the fishery, most anchovy landings are therefore associated with a juvenile sardine bycatch. As a result, landings of sardine and anchovy cannot be separately maximized and therefore a joint management procedure is employed for both species. In addition, redeye round herring incur a bycatch of adult sardine. A fixed tonnage of adult sardine bycatch is incorporated into the management procedure to allow for bycatch with redeye. (Redeye is managed using a precautionary upper catch limit.)

For anchovy, we could base future recruitment on a stock recruitment relationship estimated from all years for the base case hypothesis and a stock recruitment relationship estimated from 2000 onwards for the alternative hypothesis which assumes a change in stock recruitment relationship in 2000.

- Implementation uncertainty

The anchovy TAC has been undercaught for a number of years due to a variety of reasons (weather, processing capacity, environmental limitations on processing plants etc.). In addition, the final TAC is frequently announced only at the end of July, giving just one official month to catch the remaining normal season TAC/B[2]. How best do we account for implementation uncertainty in the OMP, taking into account that the maximum allowable anchovy TAC could be decreased in the next OMP because current industry processing capacity cannot handle as much as 600 thousand tons of fishmeal and is unlikely to be increased, and thus the extent of undercatch, if any, may reduce.

- No surveys

Rules should be included to determine the TAC if no survey result is available (see Appendix C for a proposal on this).

- Risk evaluation

The trade-off curve for OMP-08 is shown in Figure 1 of Appendix D. This curve is constructed by limiting $risk_S < 0.18$ and $risk_A < 0.10$, where the definitions of risk 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.

Objective methods of defining risk and the associated thresholds are desirable. The criterion used during the development of OMP-08 are given in Appendix D. How might these need (generalisable) adaptation?

[2] The joint sardine-anchovy management procedure allocates a annual directed sardine TAC and an initial anchovy TAC and sardine TAB at the beginning of the year. As the anchovy fishery is primarily a recruit fishery, once an estimate of the year's recruitment is obtained from the May hydroacoustic survey, the anchovy TAC and sardine TAB are finalized for the "normal season" (1 January to 31 August). The year is then split into an "additional season" from 1 September to 31 December when juvenile sardine tend to no longer shoal together with juvenile anchovy. Thus a separate anchovy TAC is allocated for the additional season with a small sardine TAB to allow for the targeting of "clean" anchovy.

APPENDIX A: Proposed Sardine Stock Structure Hypotheses (extracted from MCM/2010/SWG-PEL/37)

1) A single sardine stock will be considered. The single area modelled will correspond to the area west of Port Alfred. Given this assumption, changes in distribution within this area over the period under consideration will not impact the population model to be used. To the extent that estimates or projections may be required (for example for models linking penguin dynamics to fish abundance in a smaller region), this can be achieved through proportional allocation by area by use of historical estimates for these proportions from past survey results.
2) Two discrete sardine stocks will be considered. A "western" stock will be modelled to be distributed throughout the "western area", defined as the area west of Cape Agulhas. An "eastern" stock will be modelled to be distributed throughout the "eastern area", defined as the area east of Cape Agulhas. The two stocks will be assumed to be independent and the model will assume no mixing between the stocks. Previous work suggested that the existing data could be reasonably explained by this hypothesis (de Moor and Butterworth 2009a), with the observed "peak" in abundance in the early 2000's explained by a larger increase in the "eastern" stock than the "western" stock.
3) Two partially overlapping sardine populations will be considered. The two discrete stock hypothesis will be amended to allow for mixing in the following manner (de Moor and Butterworth 2009b):

   a) Movement of recruits from the "western" stock to the "eastern" stock in the November in which they become 1-year-olds[3]. This movement is proposed to be biomass-dependent, i.e. the greater the "western" stock biomass, the greater the migration of recruits to the "eastern" stock. Alternatively this could be dependent on the recruit biomass, i.e. a greater migration of recruits would occur during years of good recruitment to the "western" stock.

   b) Movement of adults from the "eastern" stock to the "western" stock in the November in which they become 2+-year-olds. This movement is proposed to be independent of the stock biomass in a random effects type model framework (the process of fitting the model to the data will indicate to what extent this movement occurred each year).

   c) Recruitment to the "western" stock depends on the spawning biomass of the "western" and "eastern" stocks.

   Previous attempts at fitting a model of two partially overlapping sardine populations to the available data were not successful (de Moor and Butterworth 2009b); however this will be attempted again with the updated data set, which will now include ageing data that have recently become available.

[3] If such movement does occur, it is likely to be continuous throughout the year. This assumption is made in the interests of keeping the model simple.

References

de Moor CL and Butterworth DS 2009a. A Two Discrete Stock Hypothesis for South African Sardine Resource. Unpublished MCM Document MCM/2009/SWG-PEL/47. 14pp

de Moor CL and Butterworth DS 2009b. Some Initial Attempts at Fitting a Two Mixing Stock Hypothesis for the South African Sardine Resource. Document presented to the MARAM International Stock Assessment Workshop, Cape Town, 30 November-4 December 2009. MARAM IWS/DEC09/SP/2 3pp

APPENDIX B: Stock Recruitment Relationships

The anchovy November spawner (1+) biomass time series is shown in Figure 1 and the May recruitment time series is shown in Figure 2 for the base case (single stock recruitment curve) hypothesis, A_0. The (November) anchovy stock-recruitment relationship is plotted in Figure 3 for A_0 and an alternative assuming two stock recruitment relationships over the duration of the assessment.

The sardine November 1+ biomass time series is shown in Figure 4 and the May recruitment time series is shown in Figure 5. The (November) sardine stock-recruitment relationship is plotted in Figure 6, using a hockey stick curve for all years except 2000-2004 for which constant mean recruitment was assumed.

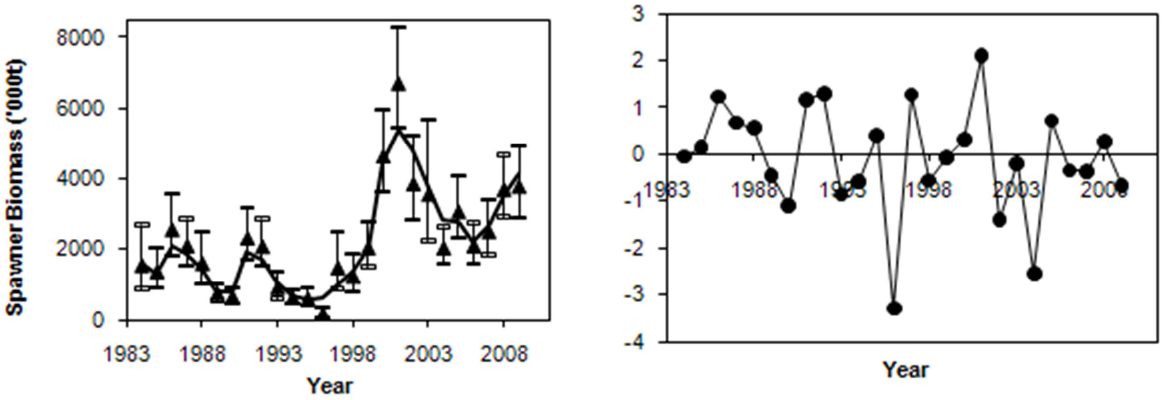

Figure 1. Acoustic survey results and A_0 model estimates for November anchovy spawner biomass from 1984 to 2009. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fit are given in the right hand plot. Figure taken from de Moor and Butterworth (2010a).

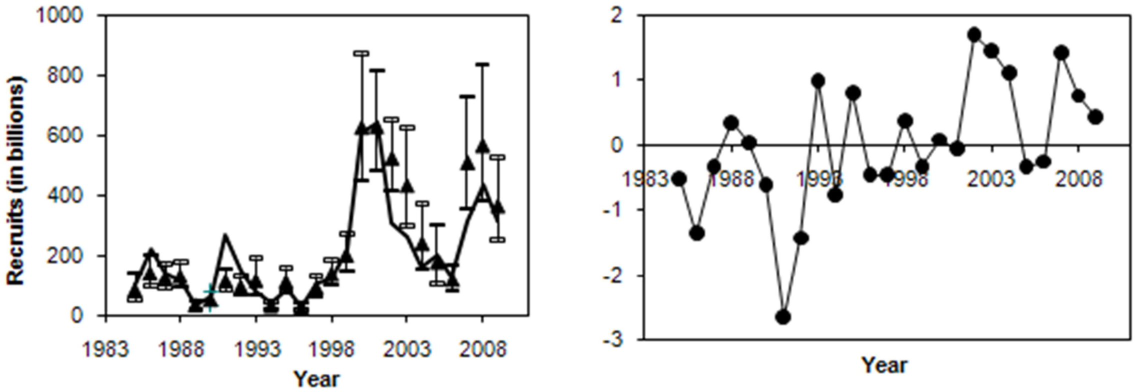

Figure 2. Acoustic survey results and A_0 model estimates for anchovy recruitment numbers from May 1985 to May 2009. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fit are given in the right hand plot. Figure taken from de Moor and Butterworth (2010a).

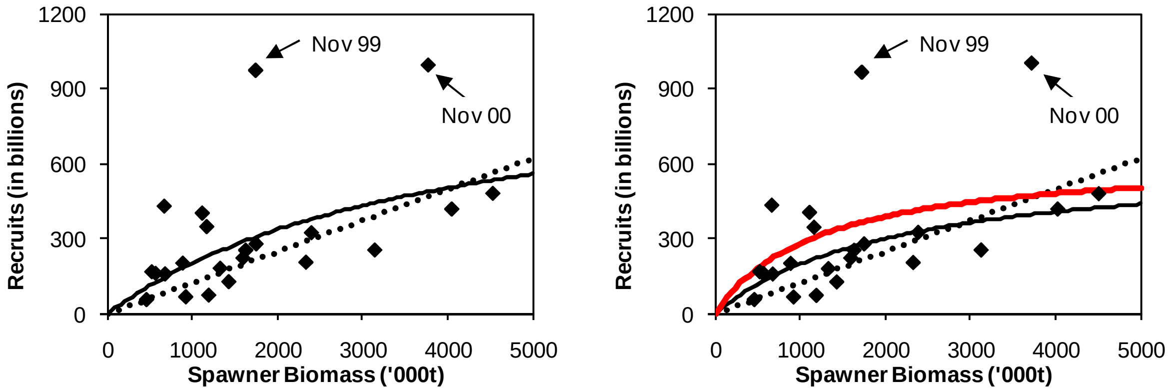

Figure 3. Model predicted anchovy recruitment (in November) plotted against spawner biomass from November 1984 to November 2008, showing the model estimated Beverton Holt stock-recruit relationship for a) the proposed base case scenario of a single stock-recruit relationship in all years and b) an alternative scenario where one stock-recruit relationship is estimated from 1984 to 1999 and another from 2000 to 2008. The dotted line indicates the replacement line. Plots taken from de Moor and Butterworth (2010b).

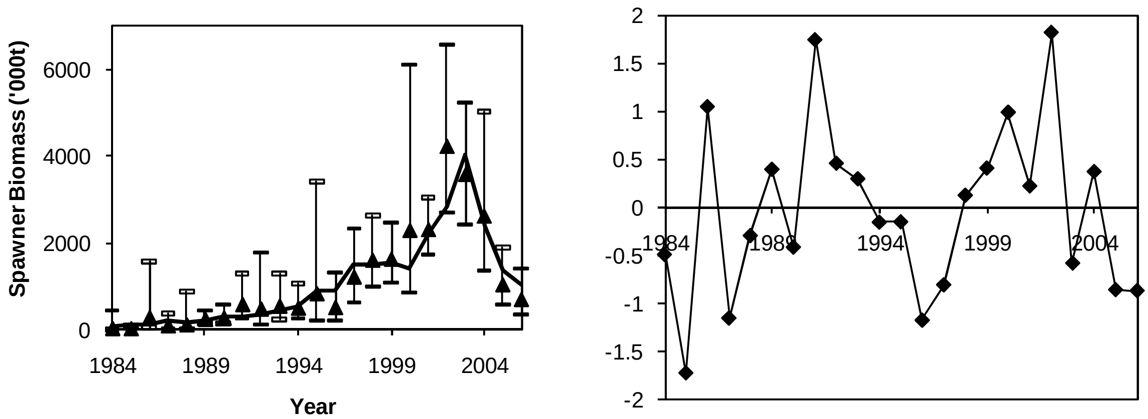

Figure 4. Acoustic survey estimates and model predicted November sardine 1+ biomass from 1984 to 2006. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fit are given in the right hand plot. Figure taken from Cunningham and Butterworth (2007).

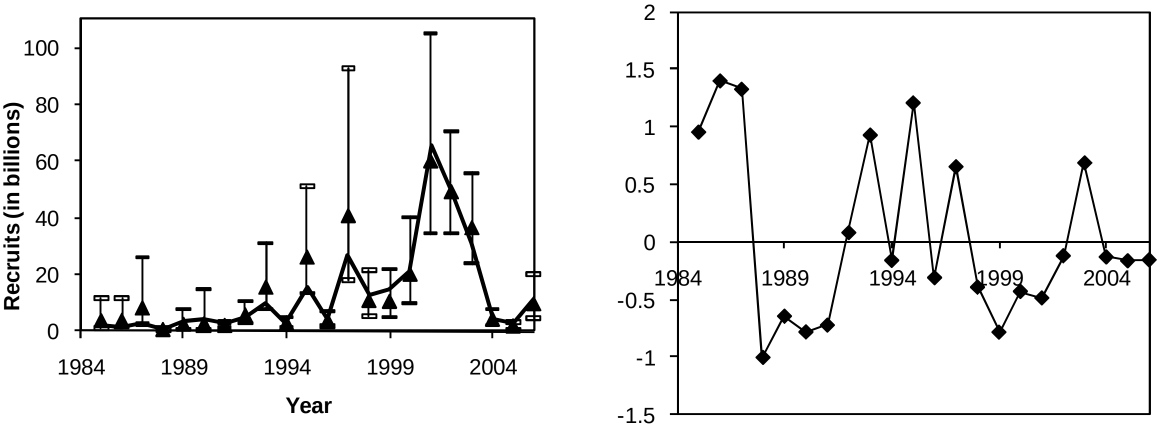

Figure 5. Acoustic survey estimates and model predicted sardine recruitment numbers from May 1985 to May 2006. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fits are given in the right hand plots. Figure taken from Cunningham and Butterworth (2007).

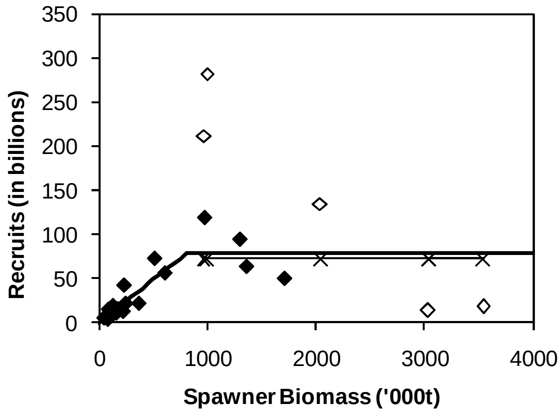

Figure 6. Model predicted sardine recruitment (in November) plotted against spawner biomass from November 1984 to November 2005, with the 'hockey-stick' stock-recruit curve and the constant recruitment between 2000 and 2004 also shown (straight line with crosses). The open circles denote the 2000 to 2004 November spawner biomass and recruitment. Figure taken from Cunningham and Butterworth (2007).

References

Cunningham CL and Butterworth DS 2007. Base Case Assessment of the South African Sardine Resource. MCM Document MCM/2007/SEP/SWG-PEL/06. 30pp

de Moor CL and Butterworth DS 2010a. Assessment of the South African anchovy resource using data from 1984-2009. Marine and Coastal Management Document MCM/2010/SWG-PEL/38. 25pp.

de Moor CL and Butterworth DS 2010b. Assessment of the South African anchovy resource using data from 1984-2009: attempts to resolve residual trends. MCM Document MCM/2010/SWG-PEL/43. 10pp

APPENDIX C: Document MCM/2010/SWG-PEL/42 presented to the PWG

Proposed rules to determine inputs to the OMP should there be no hydro-acoustic survey result in November 2010 or May 2011

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Estimates of sardine and anchovy resource abundance from hydro-acoustic surveys carried out in November and May each year form the key inputs into the OMP-08 formulae (de Moor and Butterworth 2008). OMP-08 is used to calculate the recommended annual directed sardine and anchovy TACs and sardine TAB. The Pelagic Scientific Working Group has recognised the need to agree on a "back-up plan" to implement in the unfortunate event that either the survey does not take place, or the survey does not achieve sufficient coverage to allow for a reliable estimate to be computed (DEAT 2009). Following discussions at the Pelagic Scientific Working Group on 11th August 2010, the following rules are proposed for adoption by the Pelagic Scientific Working Group to be implemented in the event of no hydro-acoustic survey result being available for November 2010 or May 2011.

<u>November 2010</u>

In the event of no survey taking place, sufficient time would be available before the TAC recommendations are required to enable updates of the latest sardine and anchovy assessments (results at the posterior mode only). Retrospective runs would be carried out for the past ±6-8 years to compare the difference between the model predicted November 1+ biomass (including estimated bias) and the survey observation in each final year. The model predicted November 2010 1+ biomass (with estimated bias) will then be reduced by either the maximum difference between these historic model predictions and survey estimates, or one standard error of the projection estimate, whichever is greater. This reduced estimate of 1+ biomass will be used to input into the OMP-08 formulae to calculate the directed sardine and initial anchovy TACs and initial sardine TAB for 2011.

<u>May 2011</u>

The normal season anchovy TAC and sardine TAB will remain unchanged from that recommended at the start of the year. By default there will be no additional season. However, if there is a survey in November 2010, updates to the assessment models, along the lines of those mentioned above, will be

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attempted. Projections under OMP-08 with the allowance for some additional season TAC/B will be simulated. [Note that preliminary projections under the assumption of half the maximum additional TAC is taken every year increased the risk to the sardine and anchovy resources substantially.]

OMP-12

Rules on how to determine the inputs to the OMP should there be no hydro-acoustic survey result will be incorporated into the development and testing of OMP-12. The rule for no November survey result will likely be similar to that proposed for November 2010. A separate rule will be developed for May surveys, likely also dependent on updated assessment model results with retrospective comparisons between model predicted and survey estimated May recruitment. A 'penalty' will be needed for either of these cases in the event of two or more consecutive survey results not being available. Further comments on possible rules to incorporate into OMP-12 are welcomed.

References

DEAT 2009. Research projects to support the sustainable management of small pelagic resources. Unpublished MCM Document MCM/2009/SWG-PEL/08. April 2009. 26pp.

de Moor CL and Butterworth DS 2008. OMP-08. Unpublished MCM Document MCM/2008/SWG-PEL/23. 15pp

APPENDIX D: Risk definitions and thresholds

With each new OMP we are faced with the need to consider redefinition of the risk criteria. This is because the more or less the abundance of an unexploited resource fluctuates naturally, the more or less resilient it is to reduction to a specified level through exploitation, and hence the greater or lesser the acceptable probability that fishing reduce the resource to below that level (the basis we use for a risk criterion).

Updated assessments often result in revised estimates of the extent of recruitment fluctuation and natural mortality, both of which impact the extent to which biomass fluctuates from year to year with or without fishing.

In an attempt to redefine the level of risk in an objective manner as possible, two criteria were used during the development of OMP-08. The primary criterion was a multiplicative adjustment of the probability threshold defining risk level for a biomass threshold defined as for OMP-04, by comparing ratios of probabilities in the absence of fishing to the OMP-04 case (Tables D.2 and D.4). The secondary criterion was to compare the extent to which the biomass distribution is moved to the left under OMP-regulated fishing compared to the no-fishing situation (Figures D.2 and D.3). The percentiles of the biomass distribution curve after 20 years future projection under OMP-08 compared to a no-catch scenario were compared to those under OMP-04 (Tables D.5 and D.6).

These percentiles informed the threshold of 18% for sardine to maintain a 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). The threshold of 10% for anchovy was primarily informed by the former criterion.

Table D.1. The probability that sardine biomass drops below B^*_{04} at least once during the projection period of 20 years, using the OMP-04 simulation framework with the associated 2004 assessment (this defines "Risk" for OMP-04). B^*_{04} is the average 1991 to 1994 sardine November biomass calculated using the 2004 sardine assessment.

	B^*_{04}	$1.25\times B^*_{04}$
C=0	0.01	0.030
C=OMP-04	0.098	0.188

Table D.2. The probability that sardine biomass drops below B^*_{07} at least once during the projection period of 20 years, using the OMP-08 simulation framework with the associated updated assessment. B^*_{07} is the average 1991 to 1994 sardine November biomass calculated using the 2007 sardine assessment.

	B^*_{07}	$1.25\times B^*_{07}$
C=0	0.028	0.088
$(C{=}OMP\text{-}04)^{04}/(C{=}0)^{04}x(C{=}0)^{08}$	**0.274**	0.551
$(C{=}OMP\text{-}04)^{04}\text{-}(C{=}0)^{04}+(C{=}0)^{08}$	0.116	0.246

Table D.3. The probability that anchovy biomass drops below $0.1\times B^*_{04}$ at least once during the projection period of 20 years, using the OMP-04 simulation framework with the associated 2004 assessment (this defines "Risk" for anchovy for OMP-04). B^*_{04} is the average 1984 to 1999 anchovy November biomass calculated using the 2004 anchovy assessment.

	$0.1\times B^*_{04}$	$0.15\times B^*_{04}$
C=0	0.028	0.042
C=OMP-04	0.28	0.376

Table D.4. The probability that anchovy biomass drops below $0.1\times B^*_{07}$ at least once during the projection period of 20 years, using the OMP-08 simulation framework with the associated updated assessment. B^*_{07} is the average 1984 to 1999 anchovy November biomass calculated using the 2007 anchovy assessment.

	$0.1\times B^*_{07}$	$0.15\times B^*_{07}$
C=0	0.001	0.007
$(C{=}OMP\text{-}04)^{04}/(C{=}0)^{04}x(C{=}0)^{08}$	**0.010**	0.063
$(C{=}OMP\text{-}04)^{04}\text{-}(C{=}0)^{04}+(C{=}0)^{08}$	0.253	0.341

Table D.5. The ratio of the percentiles of the distribution of sardine biomass in 2027 under OMP-08 for the chosen sardine risk threshold ($risk_S$ <0.18) to a no-catch scenario. The anchovy risk threshold is the same for both cases ($risk_A$ <0.10). 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
		$risk_S$ <0.18
10%ile	0.59	0.49
20%ile	0.68	0.68
30%ile	0.69	0.72
40%ile	0.71	0.73
Median	0.72	0.72

Table D.6. The ratio of the percentiles of the distribution of anchovy biomass in 2027 under OMP-08 for the chosen anchovy risk threshold ($risk_A$ <0.10) to a no-catch scenario. 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
		$risk_A$ <0.10
10%ile	0.25	0.31
20%ile	0.37	0.38
30%ile	0.45	0.42
40%ile	0.56	0.44
Median	0.58	0.51

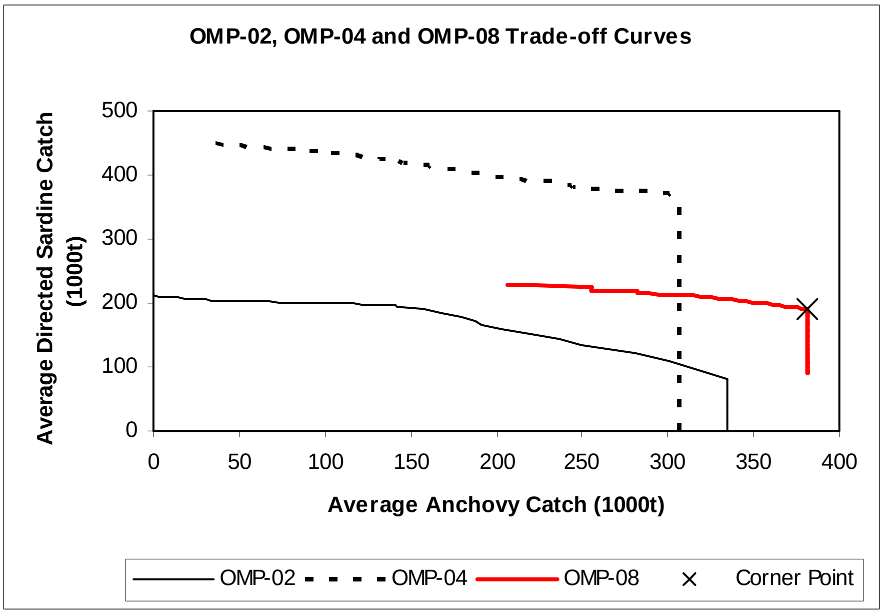

Figure D.1. Trade-off curves for OMP-02, OMP-04 and OMP-08. The trade-off curve for OMP-08 is determined by points satisfying $risk_S$ <0.18 and $risk_A$ <0.10.

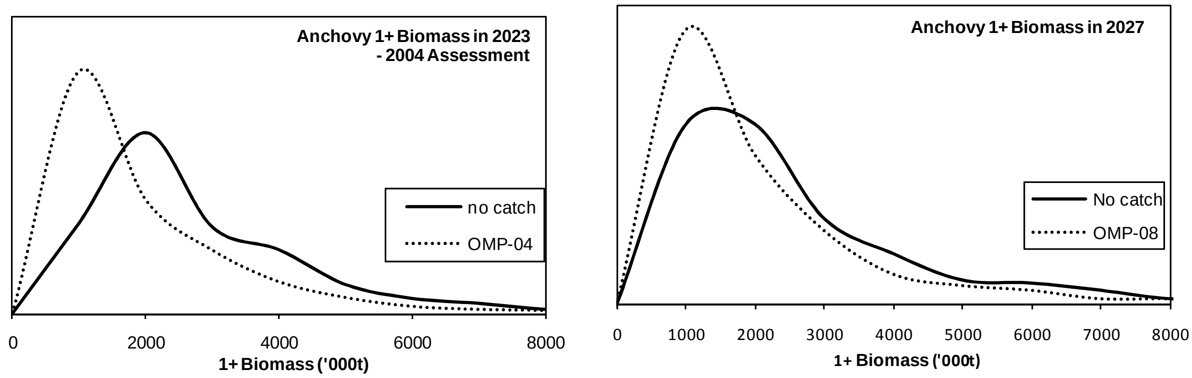

Figure D.2. Comparison of anchovy biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (left plot) and the 2007 assessment (right plot). In the right hand plot the risk threshold for anchovy is 0.10 and for sardine is 0.18.

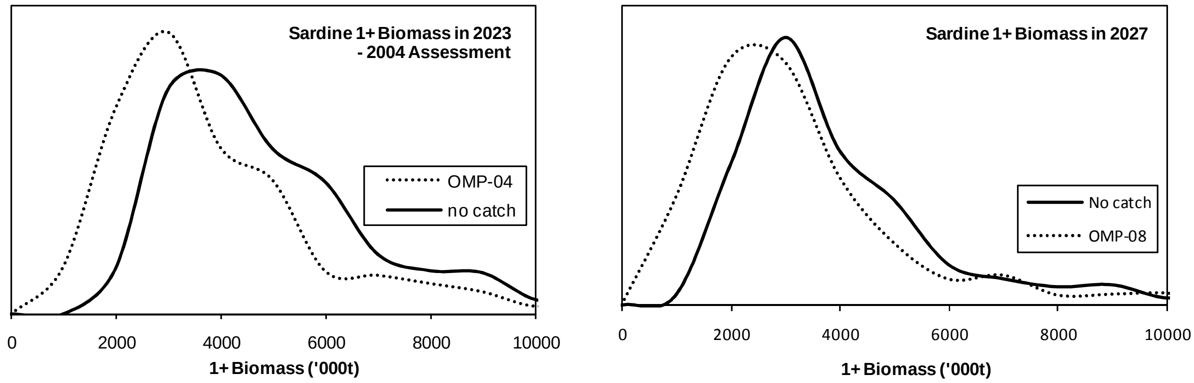

Figure D.3. Comparison of sardine biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (left plot) and the 2007 assessment (right plot). In the right hand plot the risk threshold for anchovy is 0.10 and for sardine is 0.18.