OMP-13 Development: Performance Statistics and Key Specifications for Projections

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Introduction

This documents provides a list of performance statistics which have been considered historically in the development of OMPs for the South African sardine and anchovy fishery as well as new performance statistics which are proposed to enable questions which are key in the development of a new OMP for this fishery to be addressed, e.g. the impact of a candidate MP on the sardine resource under one *vs* two sardine stock hypotheses, the effects of spatially explicit management etc. As the OMP under development will need to be tested against a wide range of underlying operating model assumptions, some of these key assumptions which are needed in specifying future projections are listed here to allow further discussion of their appropriateness. Discussion on how candidates for OMP-12 will best be tuned to facilitate a final choice would also be desirable, so some suggestions follow in that regard.

Constructive additions to this list are invited at the next Pelagic Scientific Working Group meeting in order that a consolidated document can be presented for further critique to the International Stock Assessment Workshop at the end of November.

Performance Statistics

This section summarises the performance statistics to be used. Details are provided in the appendix.

1) Risks to the resources
2) Average annual catch over projection period
3) Average annual variation in the catch over the projection period
4) 1+ biomass at the end of the projection period as a proportion of a) carrying capacity[1], b) risk threshold, and c) current biomass
5) Minimum 1+ biomass during the projection period as a proportion of a) carrying capacity, and b) risk threshold
6) When using the two sardine stock OM: 1+ biomass west of Cape Agulhas at the end of the projection period
7) When using the two sardine stock OM: Minimum 1+ biomass west of Cape Agulhas
8) Proportion of times Exceptional Circumstances are declared during the projection period
9) Average proportion of times Exceptional Circumstances are declared for two or more consecutive years
10) Average number of years for which Exceptional Circumstances, if declared, are declared consecutively

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[1]The term “carrying capacity” indicates the median biomass in the absence of harvesting.

11) Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year
12) Proportion of times Exceptional Circumstances are declared and the true biomass is below the corresponding threshold
13) Proportion of times Exceptional Circumstances are declared and the true biomass is above the corresponding threshold
14) Proportion of times Exceptional Circumstances are not declared and the true biomass is below the corresponding threshold
15) Proportion of times Exceptional Circumstances are not declared and the true biomass is above the corresponding threshold
16) Consideration will also be given to the trajectory of lower 2.5 or 5%ile of the projected biomass when considering alternative Exceptional Circumstances rules and/or thresholds
17) Utility function, which if desired would need to be defined.

Projection Specifications

Note that future simulated TACs are converted to catches-at-age as these are needed to progress the resource dynamics by assuming that the commercial selectivity-at-age as estimated for the OM concerned continues to apply deterministically.

- Future recruitment
    - Assumed to be lognormally distributed about the estimated stock recruitment relationship, standard deviation in this distribution is estimated from historic data.
    - For sardine single stock assessment, we will use the standard deviation estimated for non-peak years.
    - Autocorrelation is assumed, based on the autocorrelation estimated from historic data
    - Robustness test: increase this autocorrelation coefficient and begin with a negative residual in November 2011 (for recruitment first fished in the 2012 season). This is to simulate some consecutive years of poor recruitment as has been requested. This raises the question of how to define “poor” recruitment in terms of providing performance statistics which can count the number of times, and number of consecutive times that “poor” recruitment is simulated in the future – as a suggestion to initiate discussion, one possibility is a residual about the stock-recruitment curve that falls in the lowest quartile (i.e. only 25% of recruitments would normally be as poor or worse).
    - Robustness test: for sardine single stock assessment, assume the resource moves to a “peak” regime with a fixed probability (5/27 based on the period covered by the acoustic survey series) each year. If the resource is modelled to move to a “peak” regime, then “peak” standard deviation about the stock recruitment relationship will be used. After five years the resource will be modelled to return to a “non-peak” regime.

- Future natural mortality

- For the case where natural mortality varies with time, future values could be assumed generated randomly from a continuation of the AR(1) process assumed when fitting the operating model. Alternatively, or in addition, plausible relationships with biomass (e.g. lagged to reflect response of predator numbers to biomass variations) might be sought from the historic estimates to be used in the generation of future values.

- Initial year assumptions
  - Work before June 2012: Recruitment in November 2011 is simulated from the lognormal distribution about the stock recruitment relationship
  - Work after June 2012, by which time the results from the 2012 recruitment survey will be available: Recruitment in November 2011 is simulated from a lognormal distribution about the observed recruitment in May 2012 divided by the estimated bias factor, and then back-projected to November 2011 taking observed catch into account.
  - A recruitment residual is required for November 2011, to be used to inform the future recruitment residuals through autocorrelation. Within the assessment, the recruitment residuals are influenced by both the survey observation and the stock recruitment relationship. Thus an inverse-variance weighting of these two effects is used in the following manner:

    a) $\tilde{\varepsilon}^{i}_{2011,1} = \ln\left(\frac{N^{i}_{2011,0}}{N'^{i}_{2011,0}}\right) \Big/ \sigma^{i}_{rec}$, where $N^{i}_{2011,0}$ is back-calculated from the May 2011 survey observation, taking observed catch into account and $N'^{i}_{2011,0} = f(SSB^{i}_{2011,N})$, giving a distribution $\tilde{\varepsilon}^{i}_{2011,1} \sim N\left(\tilde{\mu}^{i}, \left(\tilde{\sigma}^{i}\right)^{2}\right)$,

    b) recruitment is assumed to be lognormally distributed around the stock recruit curve, so that $\tilde{\varepsilon}^{i}_{2011,2} \sim N(0,1)$,

    c) using inverse-variance weighting, a combined normal distribution for the recruitment residuals for November 2011 is $\varepsilon^{i}_{2011} \sim N\left(\frac{\frac{\tilde{\mu}^{i}}{\left(\tilde{\sigma}^{i}\right)^{2}} + \frac{0}{1}}{\frac{1}{\left(\tilde{\sigma}^{i}\right)^{2}} + \frac{1}{1}}, \frac{1}{\left(\tilde{\sigma}^{i}\right)^{2}} + \frac{1}{1}\right)$

- Future survey observations
  - Assumed to be lognormally distributed about the model predicted 1+ biomass/recruitment multiplied by the bias factor estimated for the corresponding OM.
  - Residuals used for generating the anchovy observation are correlated to those used to generate the sardine observation, with the correlation coefficient estimated from historic observations.
  - The standard deviation is dependent on the model predicted biomass, in a manner obtained from a regression of the historic observed CV against base case OM predicted biomass.

- For the sardine two-stock OM: how do we split the TAB by stock when simulating the implementation of the TAB into catches-at-age?
- For the sardine two-stock OM: how do we split the directed sardine TAC (when a single TAC is allocated) into future simulated catches-at-age by stock.
- Spatially disproportionate fishing with a single sardine stock but different selectivities-at-age west and east of Cape Agulhas – same two questions as above.

Tuning Procedures

- For anchovy we have two base case OMs (one with constant adult natural mortality and one with varying adult natural mortality)
- For sardine we have three base case OMs (single stock with constant natural mortality, single stock with varying natural mortality, two stock without varying natural mortality)
- Historically we tuned the OMP to the base case OMs (one for each resource) to satisfy resource risk criteria for both sardine and anchovy, and then checked this OMP against all the robustness tests.
- With multiple OMs, should we require risk criteria to be satisfied for each separately (conservative option), or for some plausibility-weighted combination, or use some other approach?

Table 1. The ratio of the percentiles of the distribution of sardine and anchovy biomass in 2027 under OMP-08 to a no-catch scenario. Shaded cells represent cases for which the predicted ratio (depletion) is more pessimistic than that used for OMP-04.

	Sardine		Anchovy	
	OMP-04/No-catch	OMP-08/No-catch	OMP-04/No-catch	OMP-08/No-catch
10%ile	0.59	0.49	0.25	0.31
20%ile	0.68	0.68	0.37	0.38
30%ile	0.69	0.72	0.45	0.42
40%ile	0.71	0.73	0.56	0.44
Median	0.72	0.72	0.58	0.51

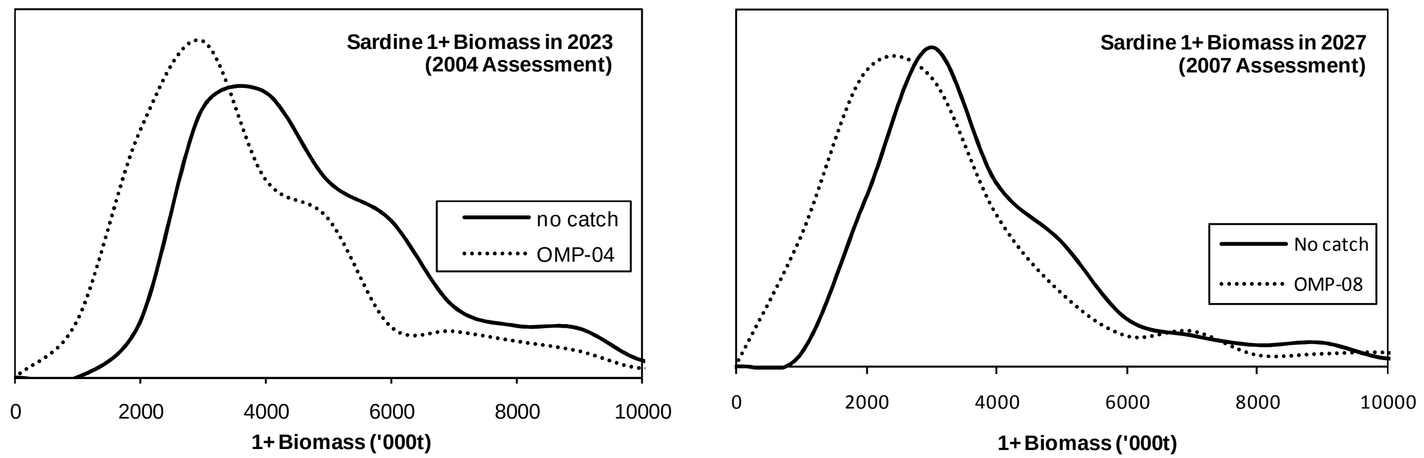

Figure 1. Comparison of sardine biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (left panel) and the 2007 assessment (right panel). The right panel is based on OMP-08 with $risk_S$ <0.18 and $risk_A$ <0.10.

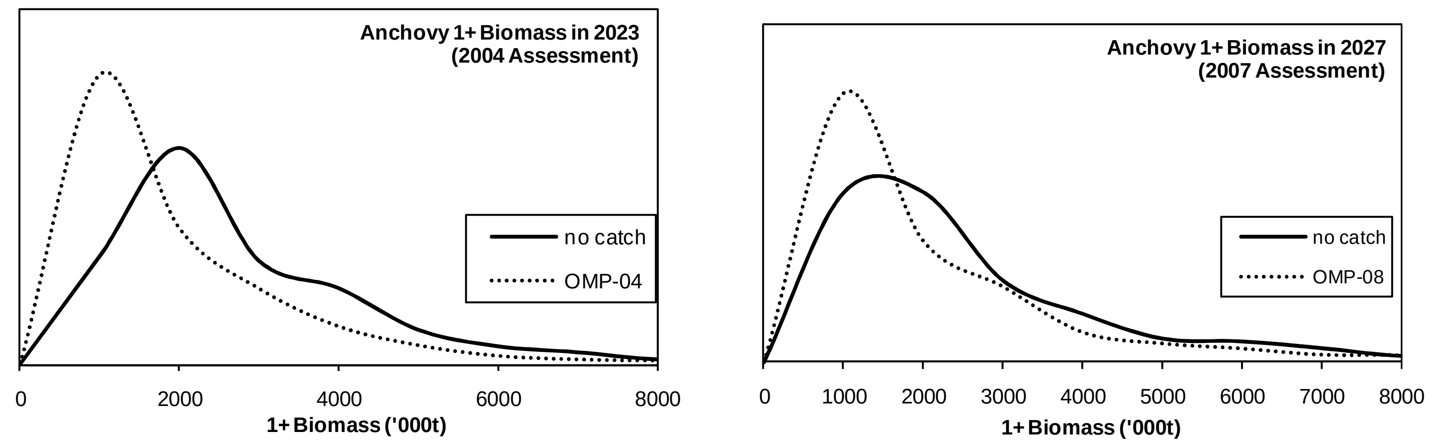

Figure 2. Comparison of anchovy biomass distributions in the final projection year under a no catch scenario and the pertinent OMP for the 2004 assessment (left panel) and the 2007 assessment (right panels). The right panel is based on OMP-08 with $risk_S$ <0.18 and $risk_A$ <0.10.

Appendix: Details of the performance statics to be used to inform between candidate MPs

1) Risk: For single stock OMs, the proportion of times the resource biomass falls below a threshold at least once during the projection period. The thresholds and acceptable level to which this will be tuned will be tested during initial OMP-12 development. For OMP-08 we had $risk_S < 0.18$ and $risk_A < 0.10$, where the definitions of risk had 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. Note that the 0.18 and 0.10 thresholds were chosen to maintain the leftward shifts of the resource abundance distribution under fishing compared to an absence of fishing at extents very similar to that for previous pelagic OMPs (see Figures 1 and 2; lower percentiles of these distributions were also compared in tabular form when informing a decision, see Table 1).

   For the sardine two-stock OM, new definitions of risk will be required for the individual sardine stocks. It is suggested that these be based upon the same extents of "leftward shift" as for the single stock situation.

2) Average annual catch[2] over the 20 year projection period, i.e. $\overline{C}^{A/S} = \frac{1}{nsim}\sum_{i=1}^{nsim}\left\{\frac{1}{20}\sum_{2012}^{2031}\sum_{a} w_{ac}^{A/S} C_{y,a}^{A/S,i}\right\}$, where for anchovy the sum is over ages 0 and 1, while for sardine the sum is over projected catch-at-ages 1 to 5+. Catch-at-age 0 is excluded from this sum as it is expected this would primarily be bycatch.

Note that the full range of average directed sardine and anchovy catches (i.e. 2) is also visible from the Trade-off Curve which is constructed to satisfy 1). Should results for shorter periods also be considered?

3) Average annual variation in the catch over the 20 year projection period, i.e.

$$AAV^{A/S} = \frac{\frac{1}{19\times nsim}\sum_{i=1}^{nsim}\sum_{2013}^{2031}\sum_{a}\left(w_{ac}^{A/S}C_{y,a}^{A/S,i} - w_{ac}^{A/S}C_{y-1,a}^{A/S,i}\right)}{\frac{1}{19\times nsim}\sum_{i=1}^{nsim}\sum_{2013}^{2031}\sum_{a} w_{ac}^{A/S}C_{y,a}^{A/S,i}}$$

4) 1+ biomass at the end of the projection period as a proportion of a) carrying capacity, i.e. $\overline{B_{2031}^{A/S}\big/K^{A/S}} = \frac{1}{nsim}\sum_{i=1}^{nsim} B_{2031}^{A/S,i}\big/K^{A/S,i}$, b) risk threshold, i.e. $\overline{B_{2031}^{A/S}\big/Risk^{A/S}} = \frac{1}{nsim}\sum_{i=1}^{nsim} B_{2031}^{A/S,i}\big/Risk^{A/S,i}$, and c) current biomass, i.e. $\overline{B_{2031}^{A/S}\big/B_{2011}^{A/S}} = \frac{1}{nsim}\sum_{i=1}^{nsim} B_{2031}^{A/S,i}\big/B_{2011}^{A/S,i}$, where $nsim$ is the number of simulations.

[2] In the interest of simplicity here and below, considerations such as allowance for bycatch in the redeye fishery etc. are not detailed.

5) Minimum 1+ biomass during the projection period as a proportion of a) carrying capacity, i.e. $\overline{B_{\min}^{A/S} \big/ K^{A/S}} = \frac{1}{nsim}\sum_{i=1}^{nsim} B_{\min}^{A/S,i} \big/ K^{A/S,i}$, and b) risk threshold, i.e. $\overline{B_{\min}^{A/S} \big/ Risk^{A/S}} = \frac{1}{nsim}\sum_{i=1}^{nsim} B_{\min}^{A/S,i} \big/ Risk^{A/S,i}$, where $nsim$ is the number of simulations.

6) When using the two sardine stock OM: Average 1+ biomass west of Cape Agulhas during the projection period, i.e. $\frac{1}{nsim}\sum_{i=1}^{nsim}\left\{\frac{1}{20}\sum_{y=2012}^{2031} B_{west,y}^{S,i}\right\}$.

7) When using the two sardine stock OM: Minimum 1+ biomass west of Cape Agulhas during the projection period, i.e. $\frac{1}{nsim}\sum_{i=1}^{nsim}\min_{y\in(2011,2031)}\left\{B_{west,y}^{S,i}\right\}$.

8) Proportion of times Exceptional Circumstances are declared during the projection period, i.e. number of times Exceptional Circumstances are declared / ($20\times nsim$).

9) Average number of times Exceptional Circumstances are declared for 2 or more consecutive years, i.e. number of "runs" of Exceptional Circumstances / ($19\times nsim$).

10) Average number of years for which Exceptional Circumstances, if declared, are declared consecutively, i.e. sum over the number of years for which each "run" of Exceptional Circumstances is declared[3]/ (number of "runs" of Exceptional Circumstances[4]).

11) Probability that Exceptional Circumstances are declared in the following year, given the declaration of Exceptional Circumstances in any year, i.e. sum over the number of times Exceptional Circumstances are declared in two consecutive years / ($19\times nsim$).

12) Proportion of times Exceptional Circumstances are declared and the true biomass is below the corresponding threshold.

13) Proportion of times Exceptional Circumstances are declared and the true biomass is above the corresponding threshold. This reports the proportion of times Exceptional Circumstances are declared unnecessarily.

14) Proportion of times Exceptional Circumstances are not declared and the true biomass is below the corresponding threshold. This reports the proportion of times Exceptional Circumstances are not declared when they should have been.

15) Proportion of times Exceptional Circumstances are not declared and the true biomass is above the corresponding threshold. Note that 12)-15) will sum to 1.

16) Consideration will also be given to the trajectory of lower 2.5 or 5%ile of the projected biomass when considering alternative Exceptional Circumstances rules and/or thresholds.

17) Utility function, which if desired would need to be defined.

[3] Summed over all years and simulations
[4] Summed over all years and simulations

Note:

a) All pertinent statistics can be repeated by area or stock for candidate MPs which assign an area-specific directed sardine TAC and/or OMs which assume two sardine stocks.

b) If the OMP finally adopted involves spatial components which consider the resource status in different areas, there may be a need to define Exceptional Circumstances separately for each area, and hence to add related performance statistics.

c) For performance statistics such as 2) and 3) above, average projected catch by stock can be given. Average projected catch is not necessarily the same as average projected TAC as a result of, e.g. fisheries closed due to bycatch limits being reached. However, for the scenario of a candidate MP which recommends TAC by area, while the underlying OM involves a single sardine stock only, average projected TAC and average variation in the TAC can be given by area, even though average projected catch and average variation in the catch will be given only as corresponds to the one stock.