Simulating single area management on two sardine components

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This document considers alternative methods to simulate the spread of directed sardine catches between the west and south components of sardine in cases where a candidate Management Procedure allocates a single area TAC, but the Operating Model assumes two sardine components. The document is written to provide background information to the key question to the panel "What would be the best way to simulation test the impact of a single area directed sardine TAC in a situation of two spatially distinct sardine population components"?

Background

In developing a new Operational Management Procedure (OMP) for South African sardine, the baseline Operating Model (OM) assumes that the sardine resource consists of two mixing components, a west and south component, separated at Cape Agulhas (Butterworth et al. 2016). For continuity, and comparison with past MPs, a robustness test assuming a single homogeneously distributed stock is also considered. Candidate MPs currently being considered for future management of this resource could either allocate separate directed sardine Total Allowable Catches (TACs) for the west and south coast or a single area directed sardine TAC. The implementation of the allocated quotas on catches modelled to be taken from each stock/component are as follows:

i) Single area TAC and single sardine stock
   - The single area TAC is modelled to be taken from the single sardine stock.

ii) Two area TAC and single sardine stock
   - The two TACs are added and modelled to be taken from the single sardine stock.

iii) Single area TAC and two sardine components
   - A proportion of the TAC is modelled to be taken from the west/south component, where the proportion is according to an assumed relationship.

iv) Two area TAC and two sardine components
   - The TAC west of Cape Agulhas is modelled to be taken from the west component and the TAC south of Cape Agulhas is modelled to be taken from the south component[1].

This document refers to option iii) above. It is important that the implications of a single area TAC on two sardine components is robustly modelled since performance statistics to be considered in comparing the merits of single-area v two-area MPs are dependent on the assumptions made.

Relationships based on past catch

Figure 1 shows the historical directed sardine TACs, catches, and proportion of catch west of Cape Agulhas.

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[1] Some variability in this assumption may later be considered to allow for some flexibility in catch about the boundary line.

Figure 2 shows the relationship of the proportion of catch west of Cape Agulhas against the ratio of west coast biomass to the TAC. This relationship was derived based on the hypothesis that if the TAC is small relative to the biomass available on the west coast, most of the TAC would be caught on the west coast. This is due to the historical distribution of small pelagic fishing ports and sardine canneries primarily along the west coast, and the assumption that targeting of sardine off the south coast would only occur should industry find it difficult to catch the required quota from the west coast. When simulating this relationship, the proportion of catch modelled to be taken from the west component in the future is given by:

$$\tau = \frac{exp\left\{ln\left(\frac{\tau^*}{1-\tau^*}\right)+\xi_y\right\}}{1+exp\left\{ln\left(\frac{\tau^*}{1-\tau^*}\right)+\xi_y\right\}}, \quad (1)$$

$$\tau^* = 0.9376\left(1 - exp\left\{-0.4647\, TAC_y^S / B_{1,y-1}^S\right\}\right), \quad (2)$$

$$\xi_y \sim N(0, 0.976^2). \quad (3)$$

One example of future simulated catch proportions west of Cape Agulhas assuming this relationship is shown in Figure 3. While the majority of simulations model more than 90% of the future catch taken from the west component, when considering the risk to the resource (and in particular the risk to the west component) it is perhaps the proportion of this catch particularly in years of low west component biomass that is of greater importance (e.g. the red shaded panels of Figure 4).

One simple alternative to the relationship in Figure 2 could be to sample randomly from the proportion of catch observed west of Cape Agulhas between 2002 and 2015/6, excluding the first part of the time series given that the directed fishery for sardine on the south coast only began during the late 1990s. The assumption made here is that the sardine fishery will continue on the south coast which is expected given the development of a sardine cannery in Mossel Bay in 2007.

Considering the percentage of the sardine TAC held by Rights Holders on the South Coast, and an estimate that the Mossel Bay cannery could process up to 20 000t a year (were sufficient directed sardine catches supplied to the cannery), it may be realistic to assume in the absence of explicit spatial restrictions that 15% of the directed sardine TAC would be routinely caught on the South Coast subject to a maximum of 30 000t[2].

A further simple alternative could be to sample proportions randomly from 0.6 to 0.75, based roughly on the observations since 2002 (Figure 1), noting that the catch patterns during 2005-2007 corresponded with pulse years of TAC and biomass and are unlikely to occur in the near future. Simulation under this assumption, however, effectively places a spatial restriction on future catches such that the proportion of catch west of Cape Agulhas ranges randomly between 0.6 and 0.75.

Discussion Points

Discussion and recommendations towards the following questions are sought:

[2] Given an additional allowance of 10 000t of directed sardine supplied to various smaller sardine processing establishments.

i) What would be the best way to simulation test the impact of a single area directed sardine TAC on two sardine components?

ii) If a single area directed sardine TAC is selected as a 'short-listed' candidate Management Procedure for OMP-18, how does one best mitigate the risk (both too conservative and too aggressive) of incorrectly predicting the impact of single area management on two sardine components.

References

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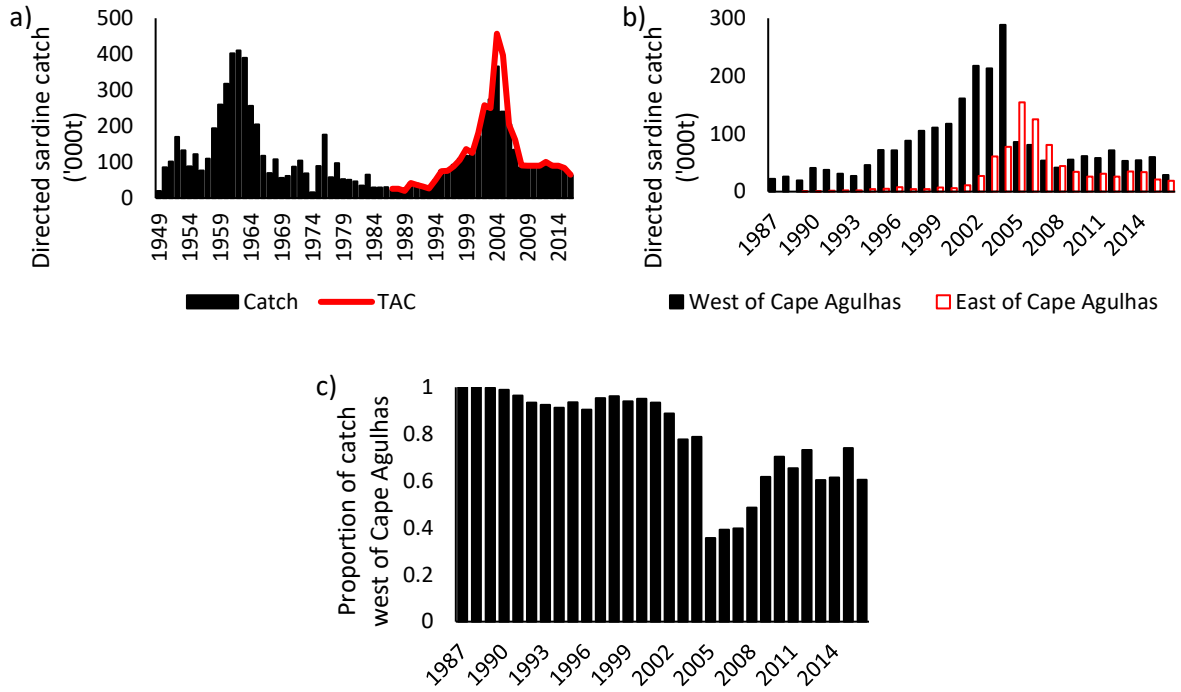

Figure 1. The a) historical catches[3] and TACs for directed sardine, b) the split of these catches between the west and south coasts, and c) the historical proportion of these catches west of Cape Agulhas.

[3] Catches prior to 1987 include sardine bycatch.

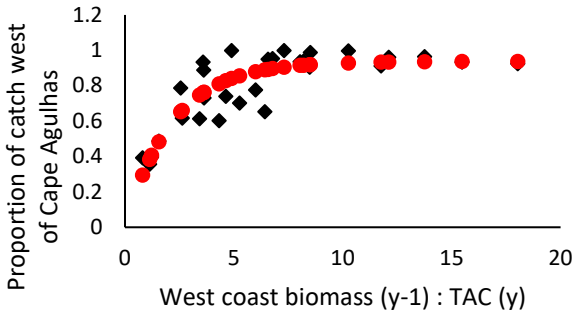

Figure 2. The proportion of catch west of Cape Agulhas in year y plotted against the ratio of the west coast biomass in November (y-1) : TAC in year y for the posterior median) of the two component hypothesis with no south coast contribution to west coast recruitment (de Moor and Butterworth 2016).

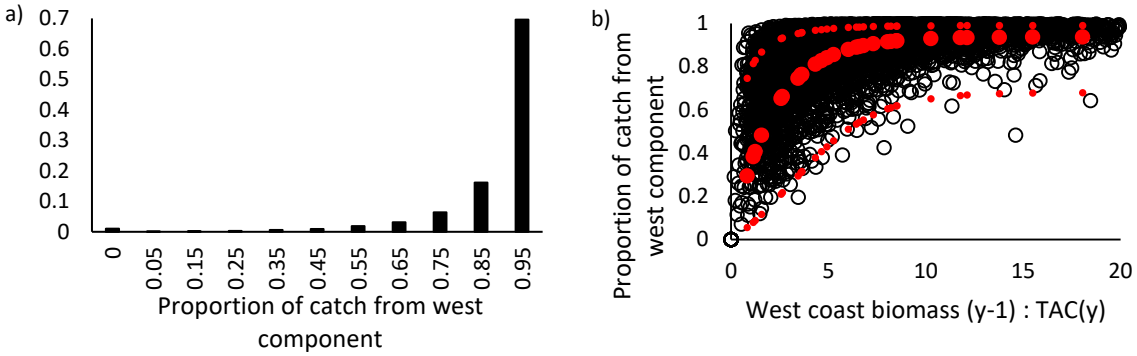

Figure 3. The a) histogram and b) relationship against modelled biomass: TAC of simulated future proportion of catch modelled to be taken from the west component for cases where a single area directed sardine TAC is allocated (using OMP-14), but the underlying OM consists of two sardine components (de Moor 2017). The red dotted lines indicate the relationship assumed with +-1 and +-2 standard deviations in logit space.

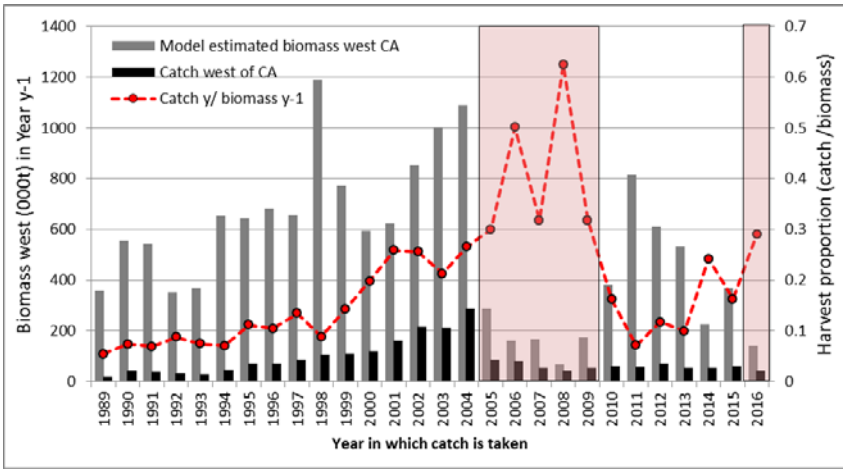

Figure 4. Time-series of directed sardine catches taken in the current year (black bars) and model estimated total biomass in the previous year (grey bars) for the area to the west of Cape Agulhas as well as the harvest proportion (catch in the current year/model estimated total biomass in the previous year) in the area to the west of Cape Agulhas (red dashed line). Red panels show periods in which the catch is relatively large in comparison to the biomass with harvest proportions at or above 0.3.