

## At what biomass threshold should the directed sardine fishery be closed?

D.S. Butterworth\*, C.L. de Moor\* and J.C. Coetzee#

Correspondence email: [carryn.demoor@uct.ac.za](mailto:carryn.demoor@uct.ac.za)

This document considers alternative survey biomass thresholds below which closure might be recommended for the directed sardine fishery. The document is written to provide background information to the key question to the panel “How might one best specify the November survey estimate of abundance below which the sardine fishery should be closed”?

### Background

The Harvest Control Rule (HCR) in the current joint Operational Management Procedure (OMP-14, de Moor and Butterworth 2014) for South African sardine and anchovy includes a rapid (quadratic) decrease in the TAC for a November survey estimate of total biomass as it drops below a pre-defined “Exceptional Circumstances” threshold to reach zero at a quarter of that threshold. For sardine under OMP-14 the Exceptional Circumstances threshold is 300 000t, and thus under this HCR the TAC would be zero if a survey estimate of sardine biomass under 75 000t was observed (Figure 1).

As part of the development of a new OMP, and also for consideration in developing *ad hoc* rules to be used to set the directed sardine TAC in the interim period, alternative thresholds below which the directed sardine fishery would be closed are being considered

### Discussion Points

- The threshold being considered would only apply to the directed sardine fishery and not to the directed anchovy or round herring fisheries (with associated sardine bycatches – mainly juvenile and adult respectively).
- Ideally such a threshold would be part of the Harvest Control Rule (as 75 000t was for OMP-14).
- Initial informal indications from some industry members suggests that there is no TAC level that would be considered too low such that it is not economically viable to conduct directed sardine fishing. The Harvest Control Rule could thus still involve a rule which takes the TAC down continuously to reach zero as the survey biomass decreases, rather than have a step function drop to zero below some threshold for a directed TAC.
- The only quantitative relationship currently available to inform an ‘escapement’ threshold is that from Robinson et al. (2015) who showed a decrease in penguin adult survival when the survey estimate of sardine biomass west of Cape Agulhas dropped below 336 000t (see Figure 2). Crawford et al. (2006) suggested that the breeding success (number of chicks fledged per pair) of penguins at Robben Island decreased from an average of 0.73 chicks per pair to 0.46 chicks per pair when the combined biomass of anchovy and sardine dropped below 2 million tons (Figure 3).

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\* MARAM (Marine Resource Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa.

# Fisheries Management Branch, Department of Agriculture, Forestry and Fisheries, Cape Town.

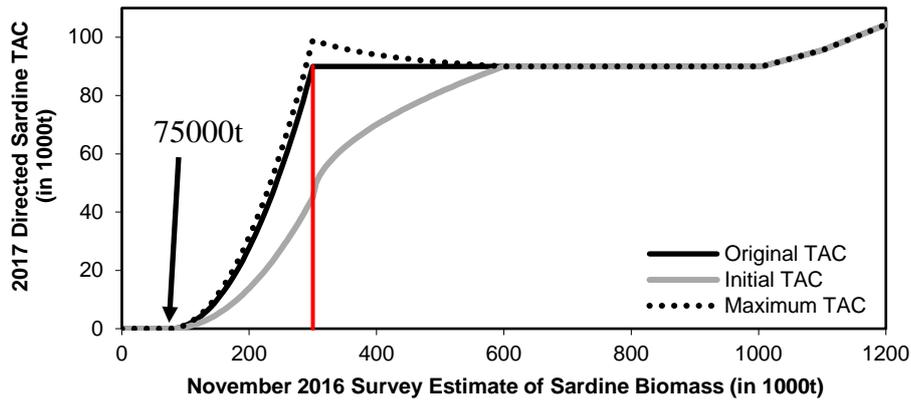
- The total biomass and spawner biomass risk thresholds discussed in de Moor (2017) do not directly translate to survey estimates of biomass, but may help guide the choice of an appropriate threshold.
- Cury et al. 2011 suggested a limit threshold of one third of the maximum historical biomass should be retained for forage fish, though de Moor (2015) provided some indication of why this threshold wouldn't work for South African sardine and anchovy.
- Ideally information from other populations of small pelagics (if available and reliable!) regarding abundances below which recruitment success is “impaired”, and below which depensation (or critical depensation) might occur, would assist the debate.

Discussion (including drawing from examples in fisheries where the panel have worked) on and recommendations in relation to the following question is sought:

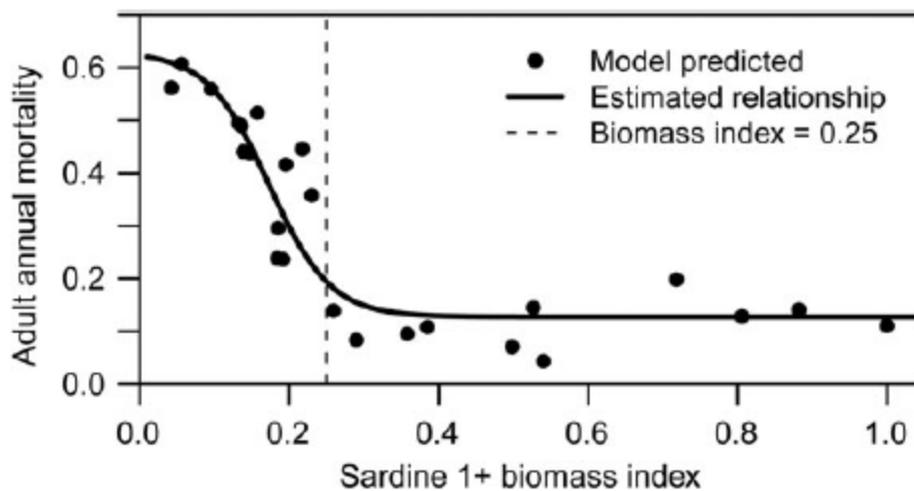
- i) How should we best define a risk threshold in terms of survey estimate of sardine biomass, below which the directed sardine fishery should be closed?

## References

- Crawford RJM, Barham PJ, Underhill LG, Shannon LJ, Coetzee JC, Dyer BM, Leshoro TM and Upfold L. 2006. The influence of food availability on breeding success of African Penguins *Spheniscus demersus* at Robben Island, South Africa. *Biological conservation*. 132: 119-125.
- Cury PM, Boyd IL, Bonhommeau S, Anker-Nilssen T, Crawford RJM, Furness RW, Mills JA, Murphy JE, Österblom H, Paleczny M, Piatt JF, Roux J-P, Shannon L, Sydeman WJ. 2011. Global Seabird Response to Forage Fish Depletion—One-Third for the Birds. *Science*, 23: 1703-1706
- de Moor CL. 2015. “Third for the Birds” for South African Sardine and Anchovy? DAFF: Branch Fisheries Document FISHERIES/2015/JUL/SWG-PEL/21.
- de Moor CL. 2017. Alternative risk thresholds for South African sardine and anchovy resources. MARAM International Stock Assessment Workshop, 27 Nov – 1 Dec 2017, Cape Town, Document **MARAM/IWS/DEC17/Sardine/P2**.
- de Moor CL and Butterworth DS. 2014. OMP-14. DAFF: Branch Fisheries Document FISHERIES/2014/DEC/SWG-PEL/60.
- Robinson WML, Butterworth DS and Plagányi ÉE. 2015. Quantifying the projected impact of the South African sardine fishery on the Robben Island penguin colony. *ICES Journal of Marine Science*. *ICES Journal of Marine Science*, 72(6): 1822-1833.

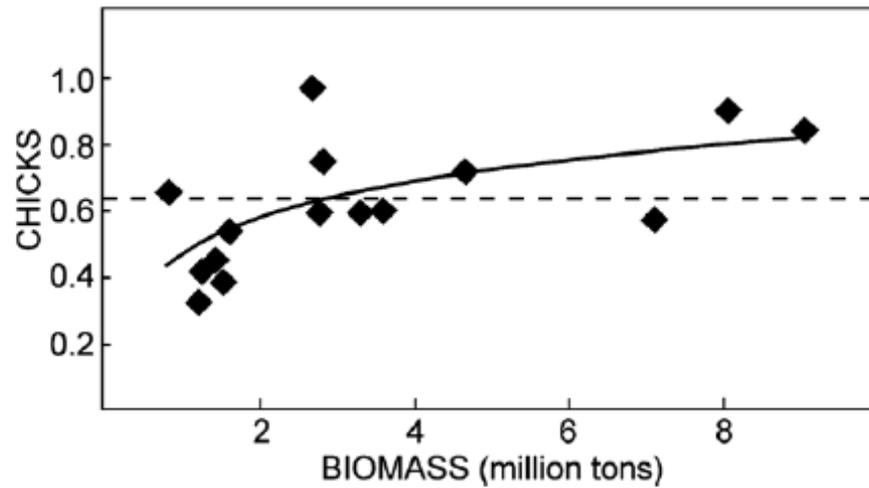


**Figure 1.** The directed sardine Harvest Control Rule for OMP-14 (de Moor and Butterworth 2014). The rule differs by year, dependent on the previous year's TAC and is thus shown here for a November 2016 survey estimate of biomass used to inform the 2017 directed sardine TAC. However, the rule below the "Exceptional Circumstances" threshold of 300 000t (indicated by the vertical red line) is independent of the previous year's TAC.



**Figure 4.** The estimated relationship (posterior mode) between the sardine 1+ biomass index (scaled to the maximum November survey estimate of 1 343 000 t in 2003) and penguin adult mortality. The vertical dashed line is at 25% of the maximum observed biomass.

**Figure 2.** Extract from Robinson et al. (2015). Note that the survey estimate referenced refers to the area west of Cape Agulhas.



**Fig. 3 – The relationship between the breeding success of African penguins (chicks/pair) and the combined spawner biomass of anchovy and sardine, 1989–2004, excluding 2000, when breeding was curtailed by the *Treasure* oil spill. The dashed line indicates the mean breeding success. The best-fitting regression curve is shown.**

**Figure 3** Extract from Crawford et al. (2006). Biomass referred to here is the combined anchovy and sardine biomass from November surveys.