Generating the future proportion of directed sardine catch taken west of Cape Agulhas in the absence of explicit spatial management

C.L. de Moor* and D.S. Butterworth*

Correspondance email: *carryn.demoor@uct.ac.za*

Introduction

When simulating testing alternative candidate Management Procedures for South African sardine and anchovy assuming the sardine resource consists of two components, a proportion of the catch must be simulated to be taken from each component. In the absence of explicit spatial management rules, the proportion of the catch taken west of Cape Agulhas is based on a relationship with the ratio of the model predicted biomass of sardine west of Cape Agulhas in the previous November to the directed sardine Total Allowable Catch (TAC) (de Moor *et al*. 2016, de Moor 2017, de Moor and Coetzee 2017). This relationship quantifies how the proportion of the catch taken west of Cape Agulhas increases as this biomass : TAC ratio increases (Figure 1); for example, once this western component of the biomass exceeds about five times the TAC, the proportion of the TAC taken west of Agulhas starts to exceed about 80% on average.

In simulations to date, the proportion of catch simulated to be taken west of Cape Agulhas was based on a single relationship fitted to the posterior median west component biomass, with random deviations generated about this relationship in logit space (de Moor 2017, de Moor and Coetzee 2017). This is now updated to allow for a different relationship for each simulation (Cox *et al*. 2017) and a different error structure.

Method

For each simulation, i=1,…,1000, a relationship was estimated as follows:

$$p_y^{pred} = f\left(TAC_y^S / B_{1,y-1}^{S,i}\right) = g_1^i\left(1 - exp\left\{-g_2^i \, B_{1,y-1}^{S,i} / TAC_y^S\right\}\right) \qquad (1)$$

by minimising a binomial likelihood:

$$-lnL = \sum_{y=1987}^{2015}\left\{-Np_y^{obs} ln\left(p_y^{pred}\right) - N\left(1 - p_y^{obs}\right) ln\left(1 - p_y^{pred}\right)\right\},$$

where p_y^{obs} is the historically observed proportion of directed sardine catch taken west of Cape Agulhas in year y. The value of the variance-determining parameter N was estimated by $N = \frac{\sum_{y=1987}^{2015} p_y^{pred}\left(1-p_y^{pred}\right)}{\sum_{y=1987}^{2015}\left(p_y^{obs}-p_y^{pred}\right)}$ (McAllister and Ianelli 1997), which yielded 13 for the time series of posterior median biomass; it was assumed that this value could reasonably be applied to all simulations.

For each simulation, i=1,…,1000, the future proportion of catch west of Cape Agulhas, p_y^i, was generated from the relationship in equation (1) with normally distributed error. The standard deviation of that normal distribution was assumed to be that given by the binomial distribution form used in the estimation, i.e.:

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

$$p_y^i = p_y^{pred} + \varepsilon_y^i \sqrt{\frac{p_y^{pred}\left(1-p_y^{pred}\right)}{N}}, \text{ where } \varepsilon_y^i \sim N(0,1) \tag{2}$$

with the restriction that $0 \le p_y^i \le 1$.

Results and discussion

This data generation method was checked using the historical posterior median biomass west of Cape Agulhas. The standard deviation in normal space of the fitted relationship was calculated as:

$$SD_{fit}^{median} = \sqrt{\frac{1}{29}\sum_{y=1987}^{2015}\left(p_y^{obs} - p_y^{pred}\right)^2} = 0.10 \tag{3}$$

The standard deviation in normal space of the generated values about the relationship was calculated as:

$$SD_{gen}^{median} = \sqrt{\frac{1}{29}\sum_{y=1987}^{2015}\left(p_y^{generated} - p_y^{pred}\right)^2}. \tag{4}$$

This standard deviation ranged from ~0.08 to 0.11, depending on the replicate projection, i.e. the ε_y^i (blue circles in Figure 1), suggesting that N=13 is not unreasonable even though the estimator for *N* is not very robust.

Fitting the relationship to the 1000 draws from the posterior distribution did not result in substantial changes in the relationship from that estimated using the time series of west component biomass as the posterior median (Figure 1). The median of g_1^i was 0.905, with a 90% probability interval of [0.903, 0.907], and the median of g_2^i was 0.417, with a 90% probability interval of [0.407,0.427].

Figure 2 shows the generated proportions of catch west of Cape Agulhas using equation (2) for N=13 and N=20. A problem with the N=13 choice is that 6% of the values generated had to be culled because they exceeded 1, suggesting also that the simulated distribution is somewhat wider than appropriate; pending examination of other methods to avoid generating these *p* values above 1, we opted to use N=20 for the time being as this reduced this proportion to 4%.

References

Cox S, Howell D and Punt AE. 2017. International Review Panel Report for the 2017 International Fisheries Stock Assessment Workshop. Document MARAM/IWS/2017/General/5.

de Moor CL. 2017. Updated simulation testing framework to be used during the development of OMP-18. MARAM International Stock Assessment Workshop, Cape Town, 27 November – 1 December 2017. Document MARAM/IWS/2017/Sardine/BG7.

de Moor CL, Butterworth DS and Coetzee JC. 2016. Discussion of OMP-17 simulation projection framework in respect of sardine. DAFF: Branch Fisheries Document FISHERIES/2016/SEP/SWG-PEL/43.

de Moor CL and Coetzee JC. 2017. Simulating single area management on two sardine components. MARAM International Stock Assessment Workshop, Cape Town, 27 November – 1 December 2017. Document MARAM/IWS/2017/Sardine/P4.

McAllister MK and Ianelli JN. 1997. Bayesian stock assessment using catch-age data and the sampling-importance resampling algorithm. *Canadian Journal of Fisheries and Aquatic Sciences* 54:284-300.

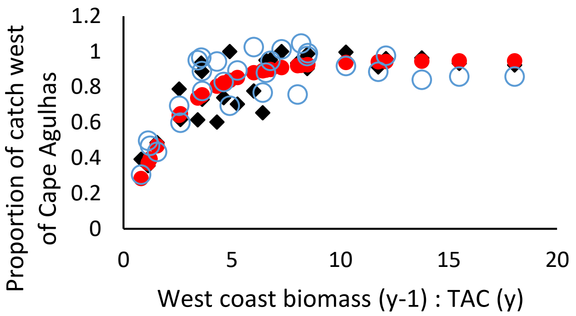

Figure 1. The proportion of catch west of Cape Agulhas in year y plotted against the ratio of the west coast biomass in November (y-1) : TAC in year y (black diamonds). This relationship (red circles) was estimated using the **posterior median** of the two component hypothesis with the stock recruitment relationship estimated after conditioning. The blue open circles are proportions generated about the relationship using equation (2) with one set of random residuals for a single replicate trajectory.

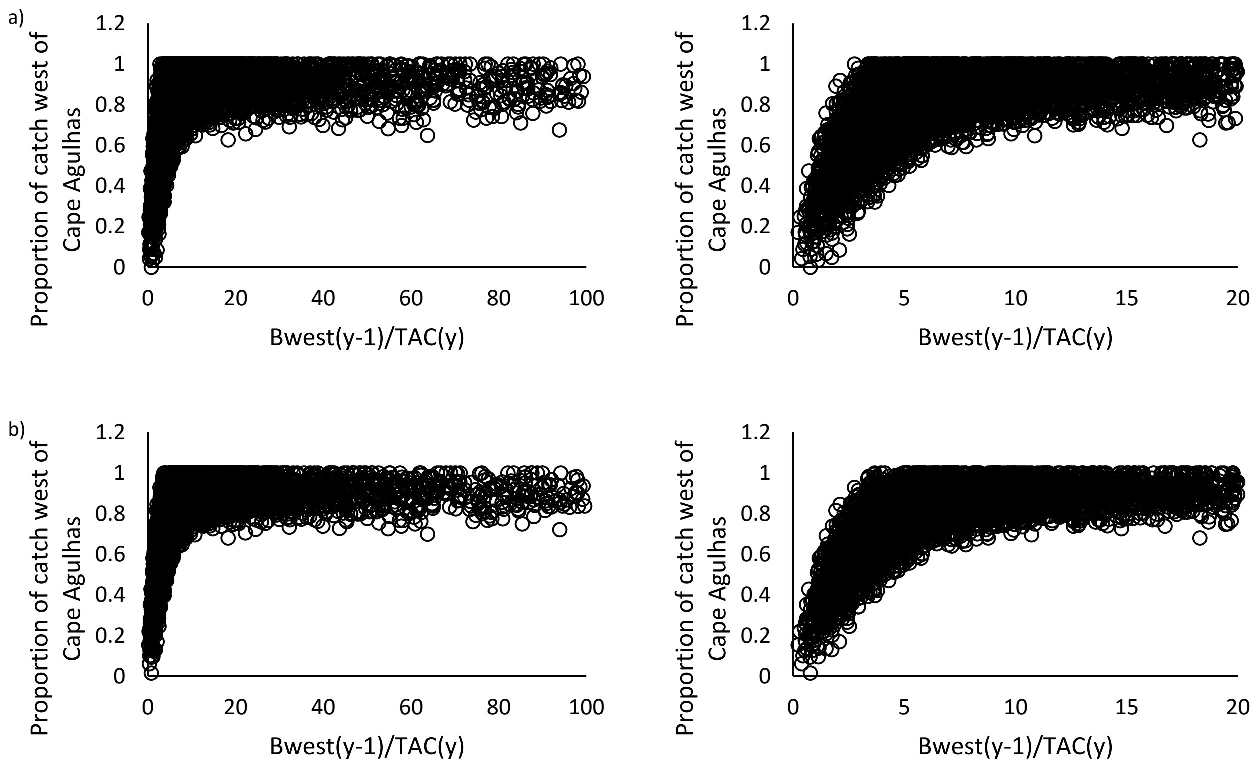

Figure 2. The **future** generated proportion of catch west of Cape Agulhas in year y plotted against the ratio of the west coast biomass in November (y-1) : TAC(y) for the **1000 simulations** assuming a) N=13 and b) N=20. The plots on the right hand side are a repeat of those on the left, but with a different horizontal axis scale.