Autocorrelated sardine movement

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

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

The sardine two-mixing stock hypothesis requires a model to inform on the future annual proportion of "west" stock recruits that move to the "south" stock. Previous projections have assumed three different models (de Moor and Butterworth 2013a):

NoMove - no future movement

MoveB - future movement is based on a relationship with the ratio of "south" to "west" stock 1+ biomass

MoveE - future movement "switches" between increasing or decreasing towards an equilibrium proportion, based on whether a favourable or unfavourable environment exists on the south coast.

NoMove was included purely as an extreme scenario, while it was recently agreed that *MoveB* would be removed from further simulations (Anon, 2013, SPSWG, 2014). A further model has been proposed, and is detailed in the Appendix:

MoveAutoC - future autocorrelated movement

Figure 1 shows the future simulated annual proportions of "west" stock recruits moving to the "south" stock. The proportions moving for *NoMove*, *MoveE* and *MoveAutoC* are all independent of the simulated biomass and are thus the same for both catch and no catch scenarios. One may *a priori* expect the median proportion moving to decrease slower than that plotted in Figure 1 under *MoveAutoC*. However, the rapid movement of the median towards around 0.5 is due to the low autocorrelation in logit space (Figure 2) – logit transformation of the proportion moving is necessary to maintain the 0 – 1 range.

Figures 3 and 4 show the future simulated 1+ biomass trajectories for *NoMove*, *MoveE* and *MoveAutoC*.

References

Anon. 2013. International Review Panel Report for the 2013 International Fisheries Stock Assessment Workshop. University of Cape Town, Cape Town, 2-6 December 2013. 22pp

de Moor, C.L. and Butterworth, D.S. 2013a. Comparisons of alternative single-area sardine TAC Management Procedures. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2013/NOV/SWG-PEL/33. 23pp.

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

de Moor, C.L. and Butterworth, D.S. 2013b. Interim OMP-13 v2. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2013/JUL/SWG-PEL/15. 18pp.

SPSWG, 2014. Aide memoire of the small pelagic scientific working group meeting on 4th February 2014. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2014/FEB/SWG-PEL/Aide memoire 04 February. 3pp.

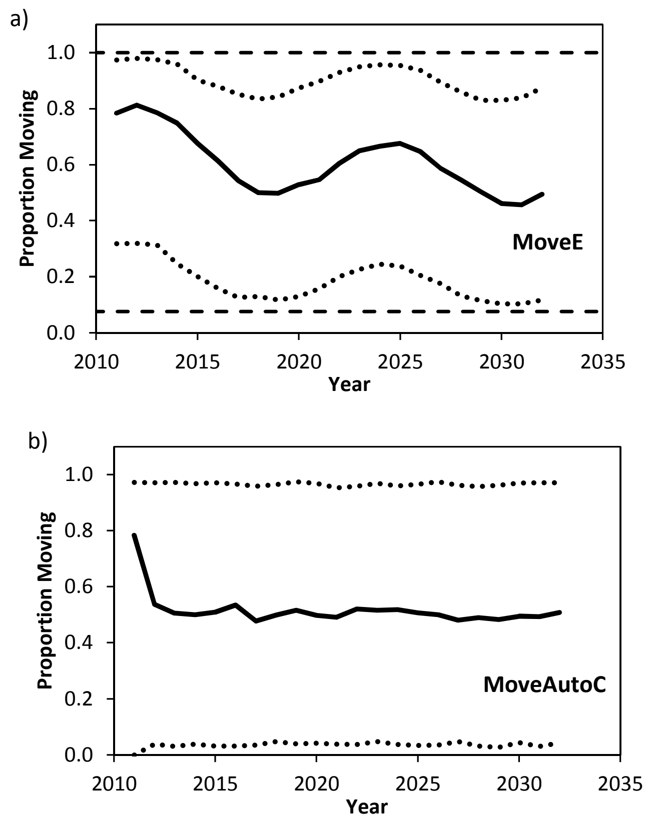

Figure 1. The median and 90% probability interval of future projected proportions of "west" stock recruits moving to the "south" stock, assuming different movement relationships: a) *MoveE* and b) *MoveAutoC*.

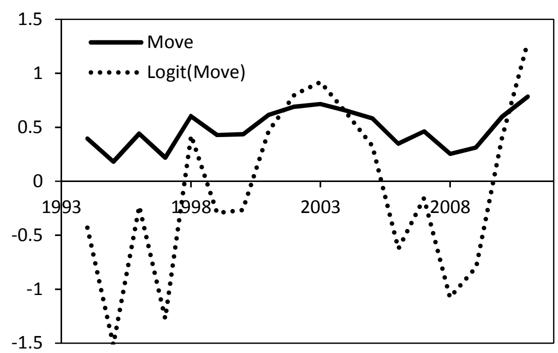

Figure 2. The median estimated annual proportions of "west" stock recruits that move to the "south" stock and the logit transformation of these proportions.

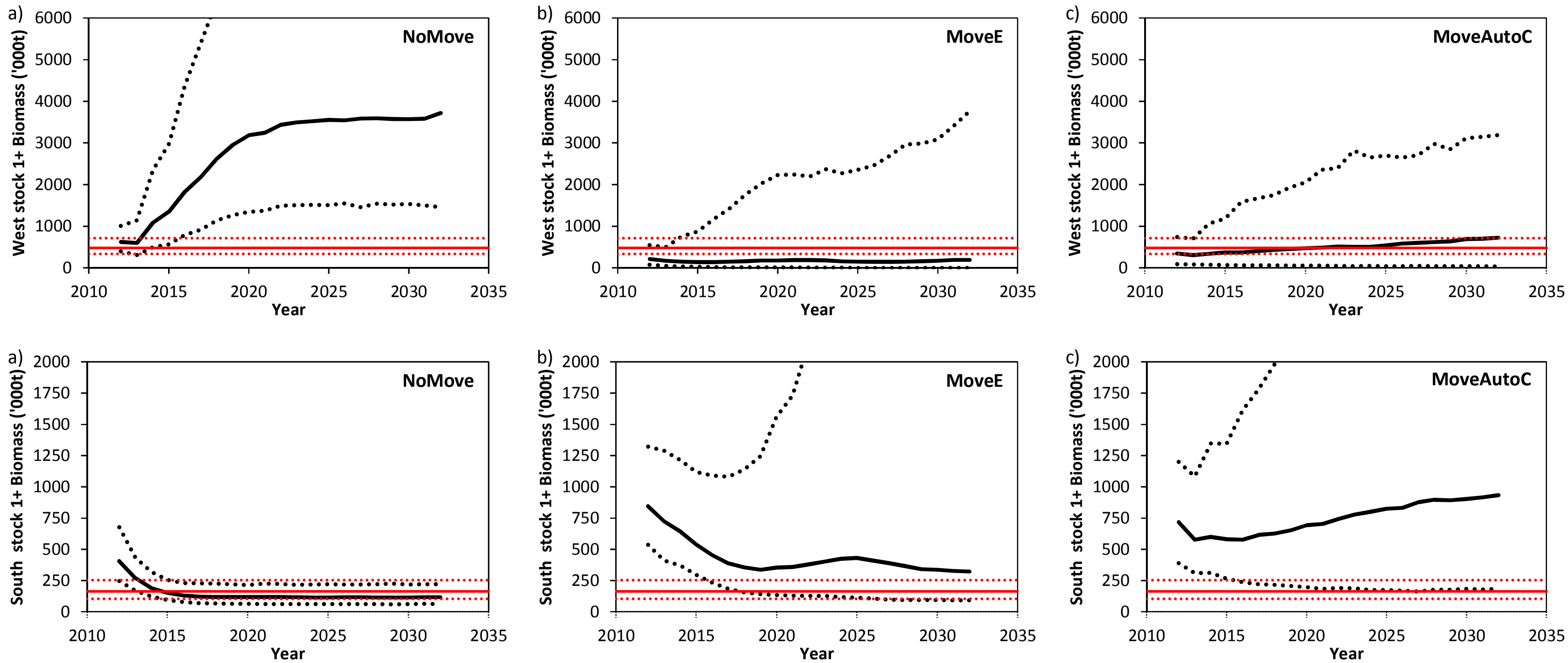

Figure 3. The median and 90% probability interval of future projected sardine 1+ biomass for the "west" stock (upper row) and "south" stock (lower row) under a no catch scenario and different movement relationships: a) *NoMove*, b) *MoveE* and c) *MoveAutoC*.

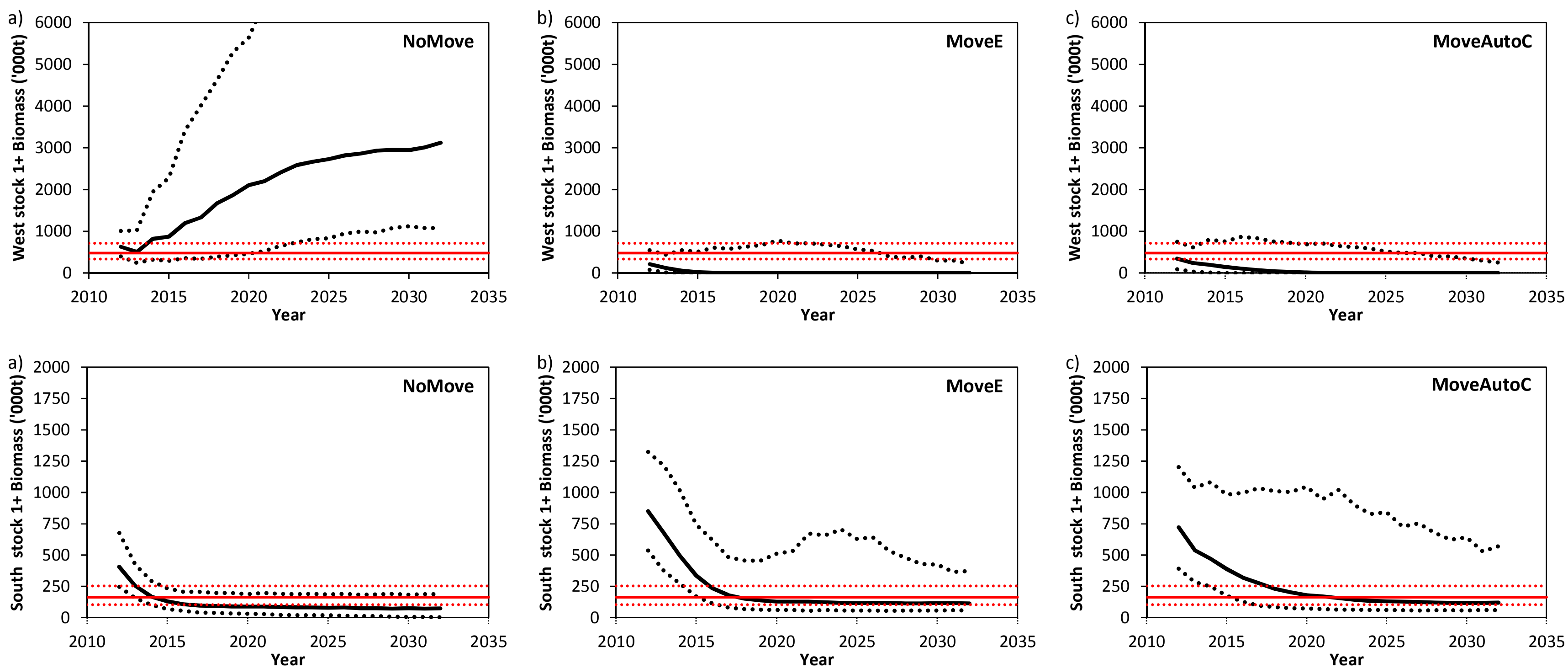

Figure 4. The median and 90% probability interval of future projected sardine 1+ biomass for the "west" stock (upper row) and "south" stock (lower row) under Interim OMP-13v2 (de Moor and Butterworth 2013b) and different movement relationships: a) *NoMove*, b) *MoveE* and c) *MoveAutoC*.

Appendix : Autocorrelated movement

In order to maintain $0 \le move_y \le 1$, the autocorrelated movement is calculated in logit-space. Thus setting

$$move^*_y = \ln\left(\frac{move_y}{1-move_y}\right), \text{ for } 1994 \le y \le 2011$$

$$\rho_{move} = \frac{\sum_{y=1994}^{2010} move^*_y move^*_{y+1}}{\sum_{y=1994}^{2010} \left(move^*_y\right)^2}$$

$$\sigma^2_{move} = \frac{\sum_{y=1994}^{2010} \left(move^*_{y+1} - \rho_{move} move^*_y\right)^2}{2010-1994+1}$$

Future proportions moving are thus calculated as follows:

$$move_y = \frac{\exp\left(move^*_y\right)}{1+\exp\left(move^*_y\right)}, \text{ where}$$

$$move^*_y = \rho_{move} \times move^*_{y-1} + \sqrt{1-\rho^2_{move}}\,\varepsilon_y, \text{ with } \varepsilon_y \sim N\left(0, \sigma^2_{move}\right)$$