Density dependent movement of South African sardine

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Background

One baseline hypothesis for simulating the permanent future movement of west coast sardine to the south coast has been based on drawing random samples from the most recent 10 years of model estimated movement, called "MoveR" (e.g. de Moor *et al*. 2016, de Moor 2017a). It is common practice in making fisheries management decisions, to assume the future will be closely represented by the most recent 10 years, and this assumption is already used in many places in the projection framework used to simulation test the next Operational Management Procedure for sardine and anchovy (de Moor 2017a). In addition, parasite prevalence-by-length data were available only for the end of the time period over which the Operating Models were conditioned, resulting in the proportions moving being more precisely estimated in these latter years following the direct use of these data in the likelihood.

An alternative "0.5MoveR" was previously suggested as another comparative baseline hypothesis under the assumption that future movement may be less than that seen in the recent past. However, this hypothesis was rejected following comments by the Panel during the December 2017 International Stock Assessment Workshop that it was not backed by supporting data (Cox *et al*. 2017).

The OMP Task Team has subsequently revisited the hypothesis that future west to south movement is dependent on west coast biomass – a density dependent hypothesis.

Density dependent movement

The density dependent hypothesis ("MoveD", formally known as "MoveD1", de Moor *et al*. 2016), assumes *a priori* that more sardine would move away from the west coast during years of high west coast biomass. The proportion of 1-year-olds that are modelled to move in November of year *y* is assumed to be related to the model estimated biomass on the west coast in November of year *y*-1. The model fit here is linear in logit space:

$$p^{*}_{1,y} = aB^{S}_{w,y-1} + b$$

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and the parameters are estimated by minimising the sum of squares $\sum\left(p_{1,y}^{*}-ln\left(\frac{p_{1,y}^{mod}}{1-p_{1,y}^{mod}}\right)\right)^{2}$. Figures 1 and 2 show the fits of this linear relationship to historical model estimates.

Under the MoveD hypothesis, future movement is drawn from a normal distribution about this linear logit relationship, i.e.

$$p_{1,y}^{j,*}=a^{j}B_{w,y-1}^{S,j}+b^{j}+\varepsilon_{y}^{j}$$

where, $\varepsilon_{y}^{j}\sim N\left(0,\sigma_{j}^{2}\right)$ and the parameters a^{j}, b^{j}, and σ_{j}^{2} are taken from the fit to the time series for draw *j* from the posterior distribution. The proportion of 1-year-olds moving from the west coast to the south coast in November *y* of simulation *j* is thus given by:

$$p_{1,y}^{j}=\frac{e^{p_{1,y}^{j,*}}}{1+e^{p_{1,y}^{j,*}}}.$$

Projections under alternative movement hypotheses

Figure 3 shows the range of estimated historical and simulated future proportions of 1-year-olds modelled to move from the west to the south coast under MoveR[1] and MoveD. The median proportion moving is lower under MoveD than under MoveR, but the range of future proportions moving is a littler wider under Move D than MoveR.

The OMP Task Team members suggest both MoveR and MoveD be used as baseline hypotheses of future movement for South African sardine. However, there are currently varying opinions of what the relative weightings of these two hypotheses should be.

References

Cox S, Howell, D and Punt AE. 2017. International review panel report for the 2017 international fisheries stock assessment workshop. MARAM International Stock Assessment Workshop, 27 November – 1 December 2017, Cape Town. Document MARAM/IWS/2017/General/5.

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

[1] Under MoveR, future proportions of 1-year-olds moving, $p_{1,y}^{j}$, are drawn randomly from the proportions estimated between 2006 and 2015 for simulation *j* (de Moor 2017a).

de Moor CL. 2017b. A summary of the operating models being used to simulation test OMP-18 for South African sardine and anchovy. MARAM International Stock Assessment Workshop, 27 November – 1 December 2017, Cape Town. Document MARAM/IWS/2017/Sardine/P6.

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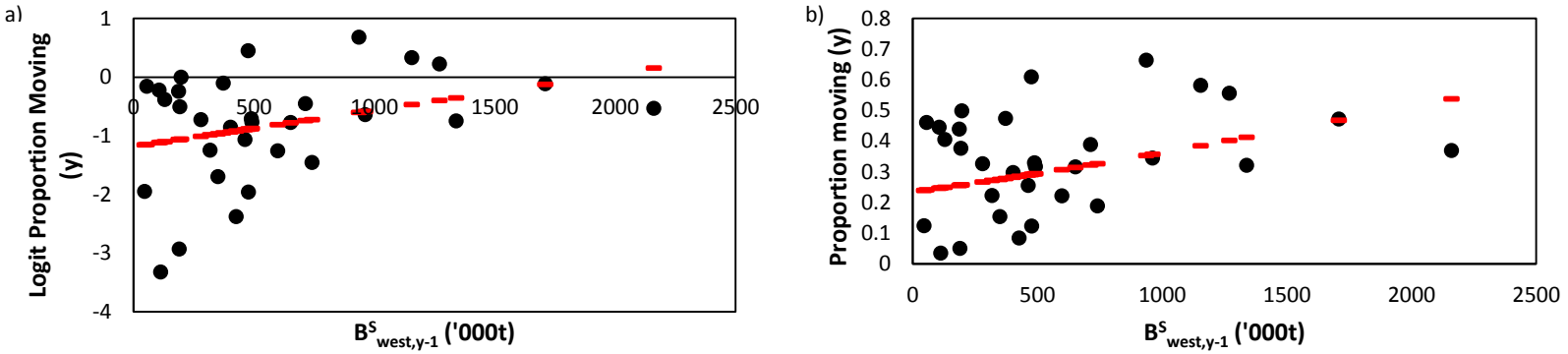

Figure 1. The posterior median proportion of 1-year old sardine modelled to permanently move from the west to the south coast in November each year, plotted against the median west component biomass in November of the previous year. These posterior medians are from the sardine model for which no stock recruitment curve is estimated during conditioning. This is shown in a) logit-transformed space and b) in normal space, with estimated linear relationships in logit space ($p^*_{1,y} = 0.00062B^S_{w,y-1} - 1.18166$, with SD = 0.911).

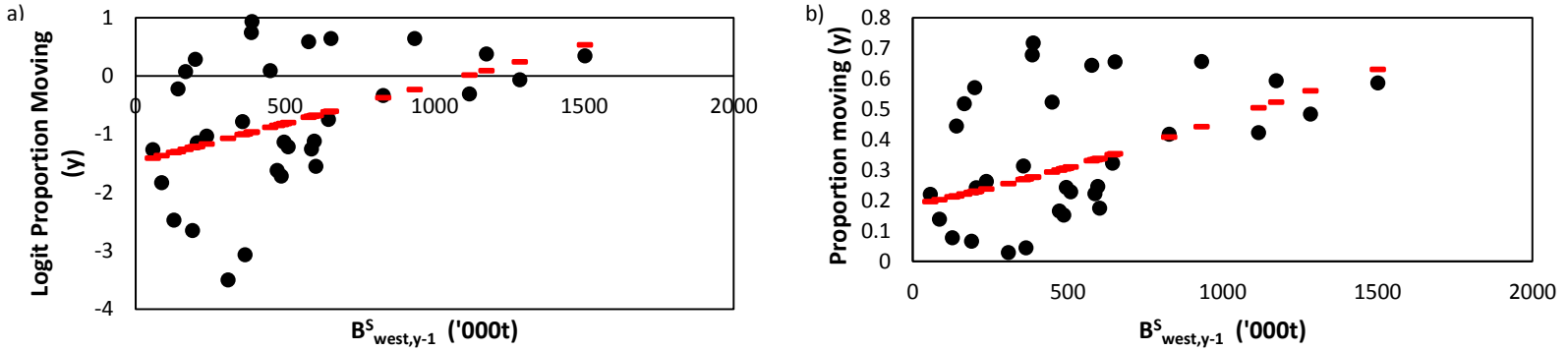

Figure 2. The posterior median proportion of 1-year old sardine modelled to permanently move from the west to the south coast in November each year, plotted against the median west component biomass in November of the previous year. These posterior medians are from the sardine model for which a Hockey Stick stock recruitment curve is estimated during conditioning. This is shown in a) logit-transformed space and b) in normal space, with estimated linear relationships in logit space ($p^*_{1,y} = 0.00134B^S_{w,y-1} - 1.48439$, with SD = 1.080).

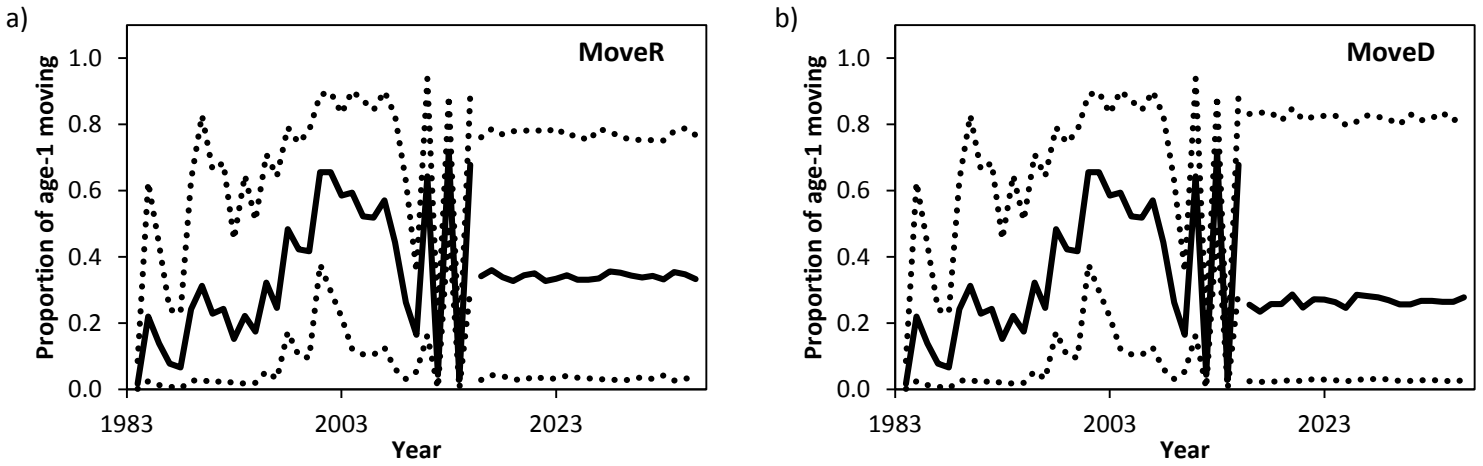

Figure 3. Median (solid line) and 90% probability intervals (dotted lines) of the proportion of west component 1-year-olds which are simulated to move to the south component each November, for the model where the stock recruitment relationship is estimated after conditioning, for a) MoveR and b) MoveD (the 1984-2015 values are the same in both plots). Future movement is plotted under a no catch scenario. The simulated movement under MoveD assuming a constant harvest proportion strategy of 11% of observed biomass results in a similar distribution for MoveD.