The two mixing stock hypothesis for South African sardine without an assumed stock-recruit relationship

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Background

The two mixing stock hypotheses for South African sardine presented in de Moor and Butterworth (2016) and de Moor (2016) assumed a Hockey-Stick stock-recruit relationship, with the stock-recruit parameters estimated to differ by "effective spawning stock". In addition, recruitment to the west stock during the "peak" 2000-2004 years was estimated to vary about a different median level. In this document the two-mixing stock hypothesis is re-run without any assumed stock-recruit relationship.

Methods

The model detailed in the Appendices of de Moor and Butterworth (2016) was used with the following modifications.

i) The parameters a_j^S, c_j^S, b_j^S, $\varepsilon_{j,y}^S$, $\sigma_{j,r}^S$ and $\sigma_{r,peak}^S$, with corresponding prior distributions were removed from the model, and

ii) The priors for numbers at age 0 were assumed to be uniform distributions, i.e. $N_{j,p=1,y,a=0}^S \sim U(0,30)$ billion, for $1983 \leq y \leq 2014$.

Two methods were used to estimate alternative stock-recruitment relationships based on model outputs. The relationships considered assumed different curves for the west and south stock, with the following functional forms: i) Hockey Stick, ii) Hockey Stick with recruitment during 2000-2004 about a different median, iii) Beverton Holt, and iv) Ricker. Except for the difference in 2000-2004 in ii), the same functional form was assumed for both stocks in all options tested. The two minimisations used for this initial comparison, where R_y^{SR} denotes the recruitment resulting from the assumed stock-recruit relationship and R_y^{Mod} denotes the recruitment output from the assessment model, are:

i) A simple sum of squares : $-lnL = \sum_{y=1983}^{2014}\left(R_y^{SR} - R_y^{Mod}\right)^2$, and

ii) A lognormal likelihood excluding 1983-1985 due to zero $-lnL = \sum_{y=1983}^{2014}\left[-ln\sigma - \frac{\left(R_y^{SR} - R_y^{Mod}\right)^2}{2\sigma^2}\right]$.

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This initial comparison was carried out using Solver in MSExcel, and thus note there are a number of alternatives which produce similar fits particularly to the south stock data.

Results

As a result of the lack of "constraint" towards an assumed stock-recruit relationship, this model is able to produce an improved fit at the joint posterior mode to the hydroacoustic survey data (Table 1, Figures 1 and 2), and to a lesser extent to the length frequency data (Table 1).

The November recruitment corresponding to each model estimated November spawner biomass are shown in Figures 3 and 4. In a number of years, the model predicts zero recruitment for the south stock. There is little information to inform recruitment to the south stock prior to 1994, given the absence of hydroacoustic estimates of recruitment for the south coast. Using a simple sum of squares, the hockey-stick model with west stock recruitment during 2000-2004 being assumed to originate from a different median recruitment is the preferred functional form (Table 2, Figure 3). Excluding 1983-1985 and using a lognormal likelihood, Beverton Holt is the preferred functional form, but all AIC values are within 2 points of the Beverton Holt (Table 2, Figure 4).

Summary

This document has considered an alternative two mixing stock model for South African sardine, which excludes an assumed stock-recruitment relationship during conditioning. The many very low estimates of recruitment to the south stock in the absence of an assumed stock-recruitment curve will be influential in subsequently fitted stock-recruitment relationships, with a higher weighting being afforded to these low recruitments when working in log-space. There is, however, no prior information that south stock recruitment should not be very low in some years, and thus it would not be suitable to use an informative prior on recruitment in the assessment.

References

de Moor, C.L. 2016. An alternative two mixing stock hypothesis for South African sardine. DAFF: Branch Fisheries Document FISHERIES/2016/OCT/SWG-PEL/45.

de Moor, C.L., and Butterworth, D.S. 2016. Assessment of the South African sardine resource using data from 1984-2015: Results at the joint posterior mode for the two mixing-stock hypothesis. DAFF: Branch Fisheries Document FISHERIES/2016/JUL/SWG-PEL/22REV2.

Table 1. The individual contributions to the posterior distribution at the joint posterior mode for this model, compared to the results presented by de Moor and Butterworth (2016) and de Moor (2016).

Contribution to Posterior	No assumed stock-recruit relationship (This document)	Separate west and south Hockey-Stick relationships (dM and B, 2016)	Hockey-Stick relationships with some South stock contribution to West effective SSB (dM, 2016)
-lnposterior	616.35*	689.22*	696.77*
$-\ln L^{Nov}$	53.70	60.51	58.10
$-\ln L^{rec}$	36.66	64.52	64.27
$-\ln L^{compropl}$	-388.08	-387.32	-385.17
$-\ln L^{surpropl}$	-371.35	-356.39	-360.29
$-\ln L^{prev}$	1273.87	1280.64	1283.43
$-\ln prior(k_{ac})$	-1.39	-1.42	-1.44
-lnprior(recres)	-	25.51	25.63
-lnprior(movres)	-27.76	-27.69	-27.72
-lnprior(t0res)	40.65	40.64	40.76
-lnprior(b/K)	-	-0.84	-0.84

* These are not directly comparable due to the exclusion of some prior distributions in the model presented in this document.

Table 2. The estimated stock recruitment parameters and minimised log likelihoods for the alternative stock recruitment relationships fit to estimates of spawner biomass and recruitment from this model.

		Contribution to Posterior	Hockey Stick	Hockey Stick with alternative 2000-2004 for West Stock	Beverton Holt	Ricker
Simple sum of squares	West stock	a^1 / α	53.0	28.3	63.7	0.57
		b^2 / β	180.3	57.7	78.9	0.004
		a^3(2000-2004)		88.7		
	South stock	a / α	5.3	5.2	9.9	0.07
		b / β	9.4	21.7	78.7	0.003
		σ				
		-lnL	43272	**31468**	44669	43696
		AIC	86553	**62946**	89346	87399
Lognormal likelihood, excluding 83-85	West stock	a / α	22.8	19.1	31.2	0.40
		b / β	16.7	14.5	33.2	0.005
		a(2000-2004)		88.7		
		σ	0.90	0.85	0.88	0.90
	South stock	a / α	3.2	1.5	3.4	0.02
		b / β	144.3	1.0	81.8	0.002
		σ	3.0	3.1	3.0	3.0
		-lnL	61	60	**60**	61
		AIC	130	129	**129**	131

[1] Maximum recruitment in the hockey stick model.
[2] Spawner biomass below which the expectation for recruitment is reduced below the maximum in the hockey stick model.
[3] Median recruitment in the hockey stock model during peak years.

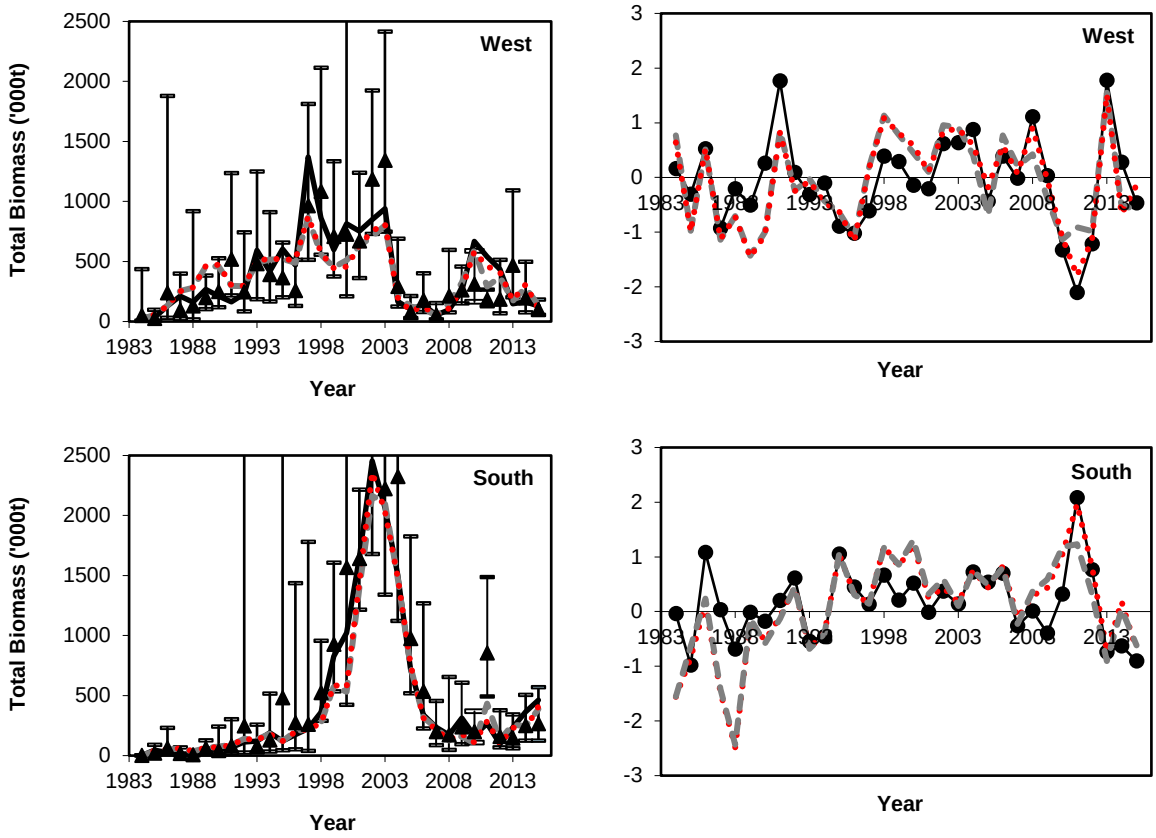

Figure 1. Acoustic survey estimated and model predicted November sardine 1+ biomass from 1984 to 2015 for the two mixing stock hypothesis with an assumed Hockey-Stick stock-recruit relationship, with no south coast contribution to west coast effective spawning (red dotted lines; de Moor and Butterworth (2016)), with an assumed Hockey-Stick stock-recruit relationship with variable partial south coast contribution to west coast effective spawning (grey dashed lines; de Moor (2016)), and without any assumed stock-recruit relationship (black solid lines). The observed indices are shown with 95% confidence intervals. The standardised residuals (i.e. the residual divided by the corresponding standard deviation, including additional variance where appropriate) from the fits are given in the right hand plots.

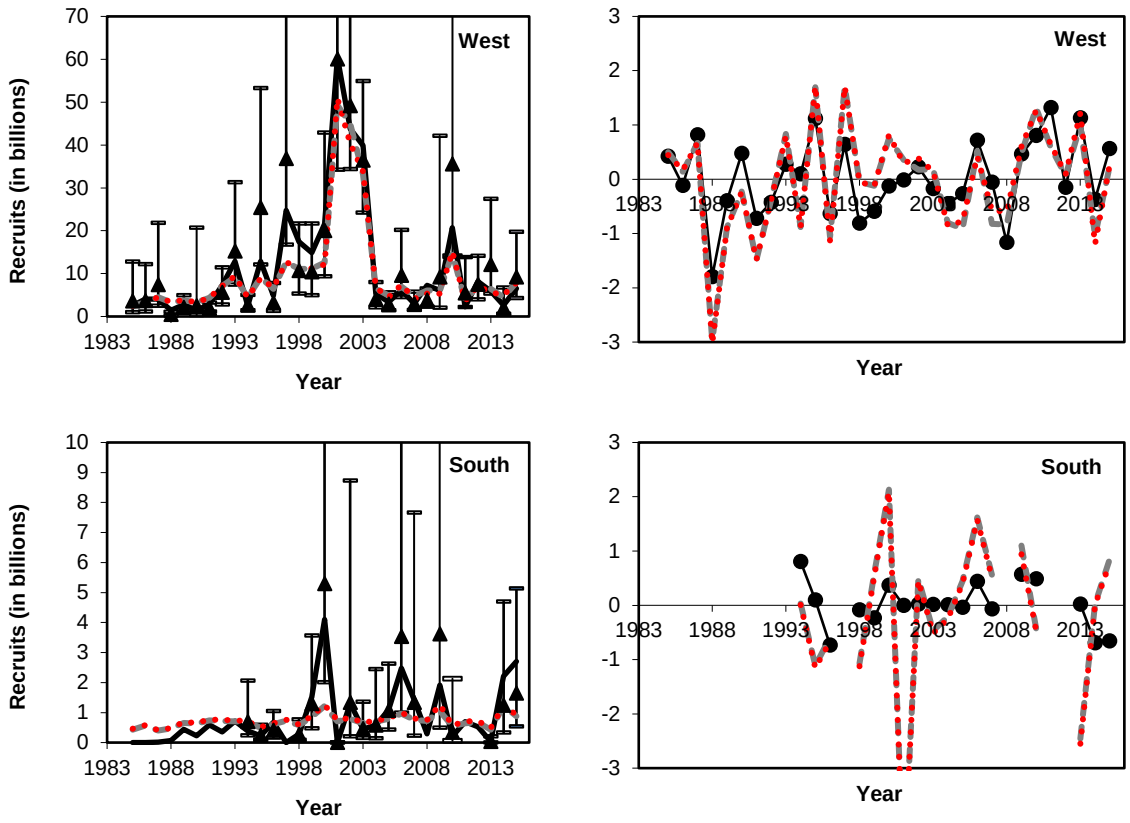

Figure 2. Acoustic survey estimated and model predicted May sardine recruitment from 1985 to 2015 for the two mixing stock hypothesis with an assumed Hockey-Stick stock-recruit relationship, with no south coast contribution to west coast effective spawning (red dotted lines; de Moor and Butterworth (2016)), with an assumed Hockey-Stick stock-recruit relationship with variable partial south coast contribution to west coast effective spawning (grey dashed lines; de Moor (2016)), and without any assumed stock-recruit relationship (black solid lines). The observed indices are shown with 95% confidence intervals. The standardised residuals from the fits are given in the right hand plots.

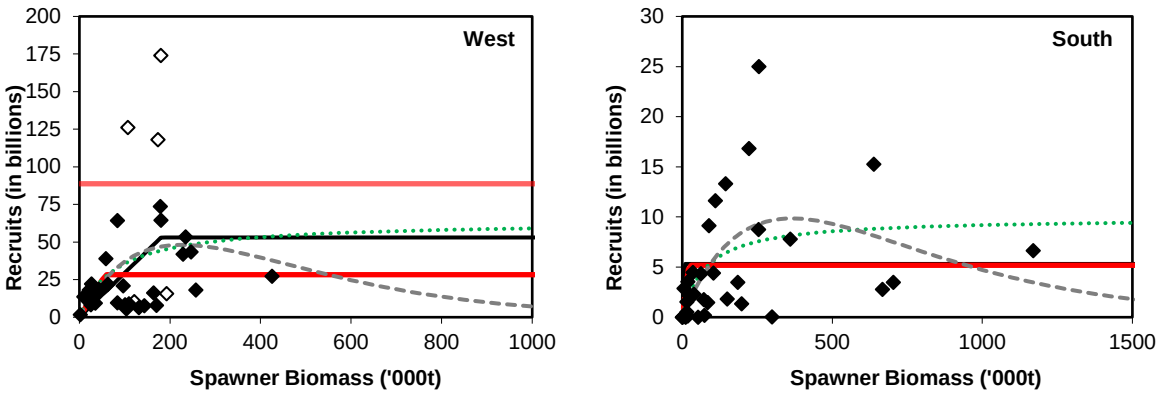

Figure 3. Assessment model estimated SSB-recruitment output, together with externally fitted stock recruit relationships using a simple sum of squares, i) Hockey Stick (black line), ii) Hockey Stick with a different median recruitment for the west stock for 2000-2004 (red line), iii) Beverton Holt (green dotted line) and iv) Ricker (grey dashed line).

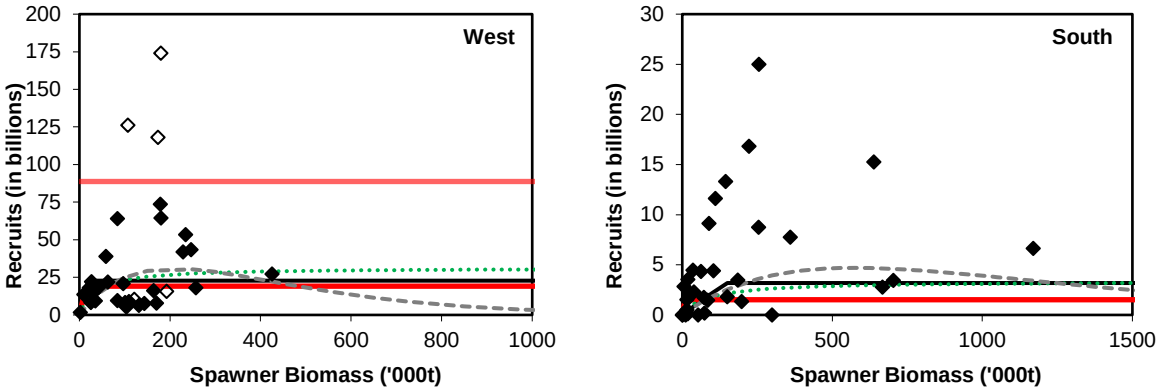

Figure 4. Assessment model estimated SSB-recruitment output, together with externally fitted stock recruit relationships using a lognormal likelihood, but excluding 1983-1985 “data”, i) Hockey Stick (black line), ii) Hockey Stick with a different median recruitment for the west stock for 2000-2004 (red line), iii) Beverton Holt (green dotted line) and iv) Ricker (grey dashed line).