

The South African anchovy assessment with an informative prior distribution on the bias in hydro-acoustic survey estimates of abundance

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The assessment of South African anchovy has been updated to consider an informative prior distribution on the bias in hydro-acoustic survey estimates of abundance. By removing the assumption that the Daily Egg Production Method indices of abundance provide an absolute time-series of estimates of anchovy spawner biomass, the model estimated biomasses from two alternative time-invariant maturity ogives converge. These results will be further updated once an ongoing analysis of annual maturity ogives is completed.

Introduction

The current short-term management advice for South African anchovy has been based on short-term projections from recent assessments of the resource using data from 1984 to 2019 (de Moor 2020a,b,c). One of the key uncertainties raised at the time was the difference in model estimates and predictions using the time-invariant maturity ogive derived from Melo (1992) (model A₀) and an alternative based on initial investigations of maturity data sampled from recent November surveys (Geja and Coetzee pers comm.) (model A₁).

The assessment of South African anchovy has traditionally assumed that the time-series of Daily Egg Production Method (DEPM) indices of abundance provide an absolute time-series of estimates of anchovy spawner biomass. Robustness to this assumption (assuming either over- or under-estimation by the DEPM indices of abundance) is typically tested during OMP development (e.g. de Moor 2019). By fixing the assumed bias of this DEPM time-series, the assessment is able to estimate the bias associated with the hydro-acoustic survey estimates of abundance from the November survey (k_{ac}^A) with an uninformative prior distribution. This bias was estimated to centre on 0.68 for model A₀ and 0.98 for model A₁, resulting in different levels of historical (and predicted future) anchovy biomass.

de Moor et al. (2020) have recently estimated an informative prior distribution for the hydro-acoustic survey bias. Further analyses towards selecting an appropriate maturity ogive for South African anchovy are also expected soon (Coetzee pers. comm.). In the meantime, this document provides updates to the anchovy assessments taking this informative prior into account. Further updates can be provided once revised maturity ogives are available.

Methods

The assessment model is detailed in Appendix A of de Moor (2020a). The analyses now assume an informative prior of $\ln(k_{ac}^A) \sim N(-0.158, 0.112^2)$ instead of $\ln(k_N^A) \sim U(-100, 0.7)$ used by de Moor (2020a,b). The negative log-likelihood functions are updated to include the additional acoustic survey variance, $(\phi_{ac}^A)^2 = 0.197^2$, as follows:

$$-\ln L^{Nov} = \frac{1}{2} \sum_{y=y_1}^{y_n} \left\{ \frac{(\ln \bar{B}_y^A - \ln(k_N^A \bar{B}_y^A))^2}{(\sigma_{y,N}^A)^2 + (\phi_{ac}^A)^2 + (\lambda_N^A)^2} + \ln \left(2\pi \left((\sigma_{y,N}^A)^2 + (\phi_{ac}^A)^2 + (\lambda_N^A)^2 \right) \right) \right\} \quad (1)$$

$$-\ln L^{rec} = \frac{1}{2} \sum_{y=y_1+1}^{2017,2019} \left\{ \frac{(\ln \bar{N}_{y,r}^A - \ln(k_{r,N}^A \bar{N}_{y,r}^A))^2}{(\sigma_{y,r}^A)^2 + (\phi_{ac}^A)^2 + (\lambda_r^A)^2} + \ln \left(2\pi \left((\sigma_{y,r}^A)^2 + (\phi_{ac}^A)^2 + (\lambda_r^A)^2 \right) \right) \right\} \quad (2)$$

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Results are presented firstly simply updating this prior distribution and then secondly by removing the constraint that DEPM estimates of abundance are assumed to be absolute and instead using an uninformative prior $\ln(k_g^A) \sim U(-100, 0.7)$.

Results and Discussion

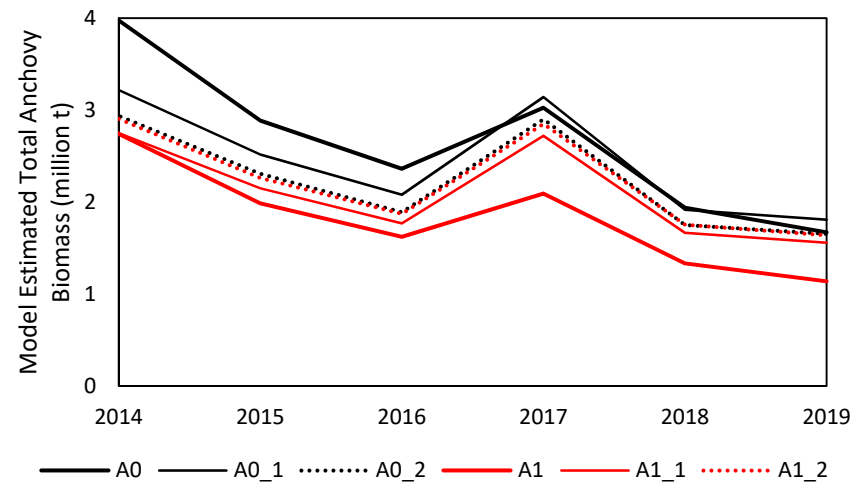
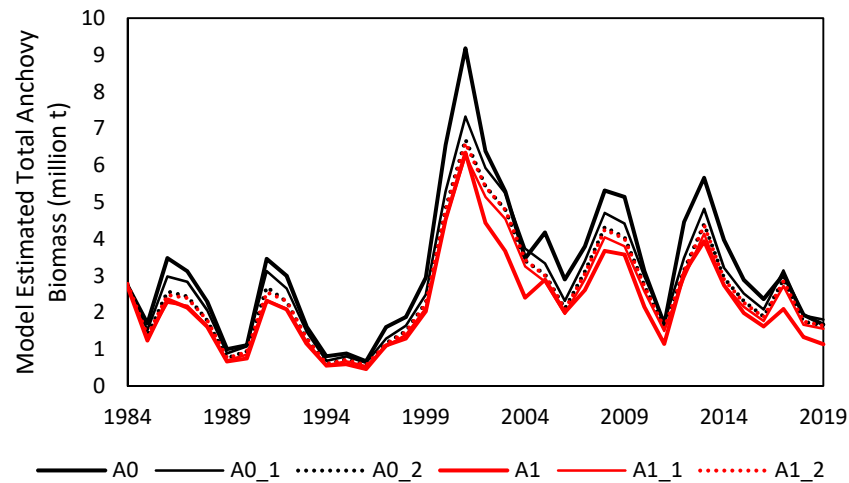
Table 1 lists the contributions to the objective function from the different models as well as the changes in the estimated acoustic and egg survey bias parameters. Updating the previous A_0 and A_1 models with the informative prior distribution on $\ln(k_{ac}^A)$ increases the estimates of k_{ac}^A under A_0 and decreases the estimate under A_1 . However, when the DEPM estimates of abundance are no longer assumed to be absolute the estimates of k_{ac}^A and subsequently of model predicted biomass (Figure 1) converge under the two alternative time-invariant maturity ogive assumptions. The estimates of spawner biomass remain higher under the new maturity ogive compared to the one estimated from Melo (1992) (Figure 2). The estimates of both biomass and spawner biomass have a Hessian-based CV of 20-24% in the most recent two years. The ± 1 SE final year total biomass therefore ranges from 895 000t to 2 223 000t.

References

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Table 1. Contributions to the objective function at the joint posterior mode for the alternative models, and the estimated k_{ac}^A .

			Obj fn	-log likelihood						-lnprior				Survey bias		
	$\ln(k_N^A)$	DEPM survey bias		$-\ln L$	$-\ln L^{Nov}$	$-\ln L^{Egg}$	$-\ln L^{rec}$	$-\ln L^{sur}$	$-\ln L^{com}$	ε_y^A	All growth param eters	δ_1 and δ_3	$N_{1983,a}^A$	k_N^A	k_r^A	k_g^A
A_0	$U(-100,0.7)$	1	-725.7	-767.9	-17.9	6.1	25.9	-479.0	-303.1	35.5	-2.0	-2.0	10.8	0.68	0.58	1
	$N(-0.158,0.112^2)$	1	-718.6	-758.9	-1.1	7.4	20.9	-483.3	-302.8	34.1	-1.8	-2.0	10.8	0.76	0.64	1
	$N(-0.158,0.112^2)$	$U(-100,0.7)$	-720.0	-759.4	-0.6	7.5	20.0	-483.4	-302.9	33.7	-1.8	-2.0	10.8	0.84	0.69	1.31
A_1	$U(-100,0.7)$	1	-727.1	-769.0	-16.4	6.3	25.7	-481.8	-302.9	35.0	-1.9	-2.0	10.8	0.98	0.80	1
	$N(-0.158,0.112^2)$	1	-721.7	-761.1	0.5	6.8	19.3	-485.2	-302.5	33.3	-1.5	-2.0	10.8	0.89	0.73	1
	$N(-0.158,0.112^2)$	$U(-100,0.7)$	-722.2	-761.7	-0.2	6.0	20.0	-485.0	-302.5	33.5	-1.6	-2.0	10.8	0.84	0.70	0.85

**Figure 1.** The model estimated total anchovy biomass under the alternative models considered in this document. The right hand plot shows the final 5 years only on a smaller vertical scale.

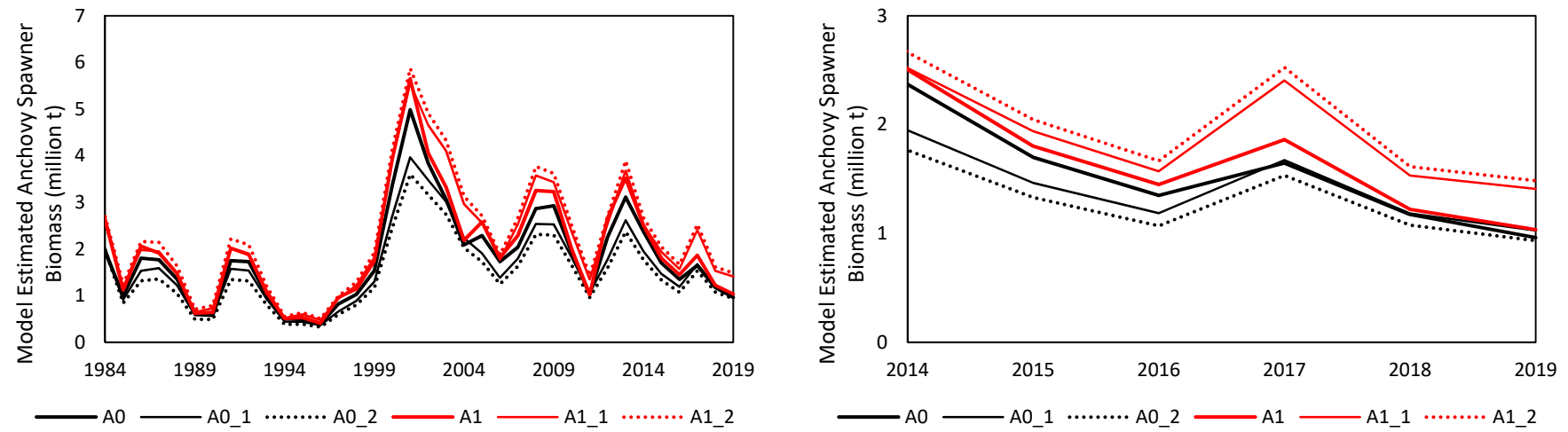


Figure 2. The model estimated total anchovy spawner biomass under the alternative models considered in this document. The right hand plot shows the final 5 years only on a smaller vertical scale.