A sensitivity test to the assessment of the South African sardine resource based on an alternative estimate of November 2020 biomass

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A sensitivity test to the quantitative assessment of the South African sardine resource has been carried out, in which the survey estimate of sardine abundance west of Cape Agulhas was replaced with a 'combined' estimate taking into account a regression between the ratio of sardine bycatch with round herring fishing and round herring catches with the ratio of November survey estimated sardine to round herring. The model is not very sensitive to this alternative data point.

Keywords: assessment, sardine, sensitivity test

Introduction

This document presents a sensitivity test to the sardine assessment model (i) of de Moor (2021a). The sensitivity test assumes a November 2020 survey estimate of biomass that is informed by not only the survey, but additionally by a regression between the ratio of sardine to round herring in bycatches and in the November survey (OLSPS 2021a).

Data and Population Dynamics Model

The population dynamics model is identical to that used by de Moor (2021a)[1] to provide an updated assessment of the South African sardine resource using data listed in de Moor *et al*. (2021), extended for an additional year. The model corresponds to model (i) of de Moor (2021a) in which parasite prevalence-at-length data were excluded. This was the model selected by the Small Pelagic Scientific Working Group (SWG-PEL) for 2021 sardine TAC/B recommendations while further options of whether and how parasite data are included in the assessment are undertaken (de Moor 2021b).

The model is conditioned on (among other data) a time series of estimates of total sardine biomass in November from 1984 to 2020. The November 2020 survey estimate of abundance west of Cape Agulhas was 51 678t (CV of 0.729) (Coetzee *et al*. 2020). OLSPS (2021a,b) have fit a regression between the ratio of sardine to round herring west of Cape Agulhas estimated by the November hydroacoustic survey to the ratio of >14cm sardine bycatch with round herring fishing to round herring catches the subsequent year. Using ratios of >14cm sardine bycatch with round herring fishing to round herring catches during 2021, together with the November 2020 hydroacoustic survey estimate of round herring abundance west of Cape Agulhas, OLSPS (2021a,b) make predictions of the November 2020 sardine abundance west of Cape Agulhas. They suggest that their 'combined' estimate of sardine biomass west of Cape Agulhas, based on a combination of both the survey estimated biomass and the regression-based estimate of biomass could be more reliable than the survey estimate alone.

The Technical Task Team of the SWG-PEL has requested that a sensitivity test to the latest sardine assessment be run, replacing the survey estimate of abundance in November 2020 with that arising from the method of OLSPS (2021a,b) and selected the estimate of 65 395t (CV of 0.63) from the alternatives presented. While this results in a timeseries with "data" that are not

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[1] Detailed in Appendix A of de Moor (2020a), with adjustment to the growth curve for ages < 6 months for both south and west components, and extended for an additional year.

technically comparable (rather a full time series of 'combined estimates' should be compared to a full time series of survey estimates), this sensitivity test provides a useful check to see what impact the alternative value may have.

In addition, short-term projections of this model were undertaken using the methods of de Moor (2021b) and the alternative catch scenarios of de Moor (2021c).

Results and Discussion

There is little difference in the fit to all the available data between this sensitivity test and model (i) of de Moor (2021a) (Table 1, Figures 1 and 2). The only observed difference is a small increase in the (spawner) biomass of the west component in November 2020 (Table 1, Figures 1 and 2). This is associated with an increase in the west component November recruitment from 24.58 and 42.98 billion fish in Novembers 2018 and 2019, respectively, to 24.73 and 42.74 billion fish under the sensitivity test. There is also a small decrease in the (spawner) biomass of the south component in November 2020 (Table 1, Figures 1 and 2).

There is little difference in the summary statistics comparing catch to a no catch scenario, resulting from a one-year projection of the resource assuming this sensitivity test compared to the baseline model (i) of de Moor (2021a).

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Table 1. The contributions to the objective function from likelihood and prior components, together with the associated estimated survey bias parameters, $k^S_{j,N}$ and $k^S_{j,r}$, model predicted biomass in 2018-2020, $B^S_{j,y}$, and model predicted spawner biomass in 2018-2020, $B^{sp,S}_{j,y}$. The Hessian-based CV is included in parentheses for $B^S_{w,2020}$.

	Obj fn	$-lnL$	$-lnL^{Nov}$	$-lnL^{rec}$	$-lnL^{com\ propl}$	$-lnL^{sur\ propl}$	$-lnL^{prev}$	$ln(k^S_{ac})$	$move_{y,1}$	η^t_y	$\bar{l}_{1,y}$	$k^S_{j,N}$	$k^S_{w,r}$
de Moor (2021a) model i)	-705.30	-771.83	56.32	38.56	-458.39	-408.32	-	-1.40	-32.74	-20.47	121.04	0.75	0.48
Sensitivity test of this document	-705.44	-771.97	56.19	38.56	-458.41	-408.31	-	-1.40	-32.74	-20.47	121.04	0.75	0.48
Alternative sensitivity test	-705.47	-771.99	56.17	38.56	-458.42	-408.30	-	-1.40	-32.75	-20.47	121.04	0.75	0.48
	$B^S_{w,2018}$	$B^S_{w,2019}$	$B^S_{w,2020}$	$B^{sp,S}_{w,2018}$	$B^{sp,S}_{w,2019}$	$B^{sp,S}_{w,2020}$	$B^S_{s,2018}$	$B^S_{s,2019}$	$B^S_{s,2020}$	$B^{sp,S}_{s,2018}$	$B^{sp,S}_{s,2019}$	$B^{sp,S}_{s,2020}$	
de Moor (2021a) model i)	35.6	45.3	79.1 (0.92)	8.5	6.8	9.4	308.8	450.2	723.8	132.9	135.9	213.6	
Sensitivity test of this document	35.5	45.4	99.4	8.5	6.9	11.8	308.8	449.3	711.2	132.9	135.9	211.5	
Alternative sensitivity test	35.5	45.5	107.9	8.5	6.9	12.8	308.8	448.9	706.2	132.9	135.8	210.6	

*Non positive definite Hessian

Table 2. The 5%ile, 20%ile and 50%ile of the multiplicative and additive change in **west component effective spawning biomass** and additive change in **west component total biomass** from November 2020 to 2021 under alternative catch options and the baseline model i) of de Moor (2021a) compared to the sensitivity test in this document. The 5%ile, 20%ile and 50%ile of the multiplicative change under the catch options relative to the no catch option are also given. Grey cells indicate cases for which the selectivity function needed modification to enable the catch to be taken; the percentage of times this occurred for ages 2 and below (S2) and ages 1 and below (S1) are given. The percentage of times the full bycatch could not be realised (By) or the full catch could still not be realised after selectivity was modified (C) are also given. These statistics (S2, S1, By and C) are given for 2021 only, although such problems in realising the catch are also projected to occur in subsequent years. The top two rows give the comparative statistics under the zero catch and 2019 TAC/B alternatives as estimated by de Moor (2019). The next three rows give the comparative statistics under the zero catch and April 2020 TAC/B as estimated by de Moor (2020b) and August 2020 TAC/B under a more optimistic recruitment model (de Moor 2020c).

					Multiplicative Δ in effSSB			Additive Δ in effSSB			Additive Δ in B			Relative Multiplicative Δ						
	Total	West	South	ByC	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile	S2	S1	C	By
2019	0	0	0	0	2.20	2.67	3.40	25	35	50										
	23	6.5	7	9.5	1.88	2.36	3.09	19	28	43				0.86	0.88	0.90				
2020	0	0	0	0	1.25	1.55	2.14	9	15	21	-35	-8	17				0	0	0	0
	34.05	13.65	13	7.4	1.15	1.43	1.93	5	12	17	-46	-20	6	0.88	0.90	0.91	0.14	0.02	0	0
	45.05	16.65	18	10.4	1.27	1.59	2.14	10	16	21	-44	-19	5	0.88	0.89	0.9	0.20	0.01		
Model (i)	0	0	0	0	1.81	2.29	3.61	27	36	48	22	41	104				0	0	0	0
	27.00	12.25	8.5	6.25	1.72	2.15	3.34	22	31	43	10	29	92	0.88	0.90	0.93	7.6	6.2	0.6	0
	40.65	12.25	18.0	10.4	1.71	2.13	3.29	22	30	43	7	26	88	0.85	0.89	0.92	7.6	6.4	0.6	0
	42.05	13.65	18.0	10.4	1.70	2.11	3.26	21	30	42	6	25	87	0.84	0.88	0.91	10.6	7.4	1.2	0
	45.05	16.65	18.0	10.4	1.68	2.09	3.21	20	29	41	4	23	86	0.82	0.86	0.90	16.4	12.0	1.6	0
Sensitivity Test	0	0	0	0	1.99	2.44	3.65	30	40	54	16	40	100				0	0	0	0
	27.00	12.25	8.5	6.25	1.92	2.30	3.40	26	35	49	4	27	87	0.88	0.91	0.93	5.8	3.4	0.2	0
	40.65	12.25	18.0	10.4	1.90	2.29	3.36	25	34	48	0	24	84	0.86	0.89	0.92	6.2	3.4	0.2	0
	42.05	13.65	18.0	10.4	1.89	2.28	3.33	25	34	48	-1	23	83	0.85	0.88	0.92	7.6	5.8	0.2	0
	45.05	16.65	18.0	10.4	1.88	2.26	3.29	24	33	47	-2	22	81	0.83	0.87	0.91	11.4	7.8	1.4	0

Table 3. The 5%ile, 20%ile and 50%ile of the multiplicative and additive change in **south component effective spawning biomass** and additive change in **south component total biomass** from November 2020 to 2021 under alternative catch options and the baseline model i) of de Moor (2021a) compared to the sensitivity test in this document. The 5%ile, 20%ile and 50%ile of the multiplicative change under the catch options relative to the no catch option are also given. There were no problems in the scenarios tested being able to realise the catch from the south component. The top two rows give the comparative statistics under the zero catch and 2019 TAC/B alternatives as estimated by de Moor (2019b). The next three rows give the comparative statistics under the zero catch and April 2020 TAC/B as estimated by de Moor (2020b) and August 2020 TAC/B under a more optimistic recruitment model (de Moor 2020c).

					Multiplicative Δ in effSSB			Additive Δ in effSSB			Additive Δ in B			Relative Multiplicative Δ		
	Total	West	South	ByC	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile	5%ile	20%ile	50%ile
2019	0	0	0	0	0.45	1.05	1.55	-70	6	70						
	23	6.5	7	9.5	0.44	1.01	1.51	-72	1	65				0.96	0.97	0.97
2020	0	0	0	0	1.27	1.31	1.39	43	53	65	10	42	79			
	34.05	13.65	13	7.4	1.23	1.27	1.33	34	43	56	-10	22	59	0.93	0.95	0.96
	45.05	16.65	18	10.4	1.23	1.27	1.33	34	44	56	17	42	75	0.91	0.93	0.94
Model (i)	0	0	0	0	1.45	1.48	1.52	55	74	98	-280	-143	-52			
	27.00	12.25	8.5	6.25	1.42	1.45	1.49	49	69	92	-293	-156	-65	0.96	0.97	0.98
	40.65	12.25	18.0	10.4	1.40	1.43	1.47	45	64	88	-302	-165	-74	0.93	0.95	0.97
	42.05	13.65	18.0	10.4	1.40	1.42	1.47	45	64	88	-303	-165	-75	0.93	0.95	0.96
	45.05	16.65	18.0	10.4	1.40	1.42	1.47	45	64	87	-304	-166	-76	0.93	0.95	0.96
Sensitivity Test	0	0	0	0	1.44	1.47	1.53	55	74	98	-270	-134	-45			
	27.00	12.25	8.5	6.25	1.42	1.45	1.49	50	69	92	-283	-147	-58	0.96	0.97	0.98
	40.65	12.25	18.0	10.4	1.40	1.42	1.47	45	64	88	-292	-157	-67	0.93	0.95	0.96
	42.05	13.65	18.0	10.4	1.40	1.42	1.47	45	64	88	-292	-157	-68	0.93	0.95	0.96
	45.05	16.65	18.0	10.4	1.39	1.42	1.47	45	64	87	-293	-158	-69	0.93	0.95	0.96

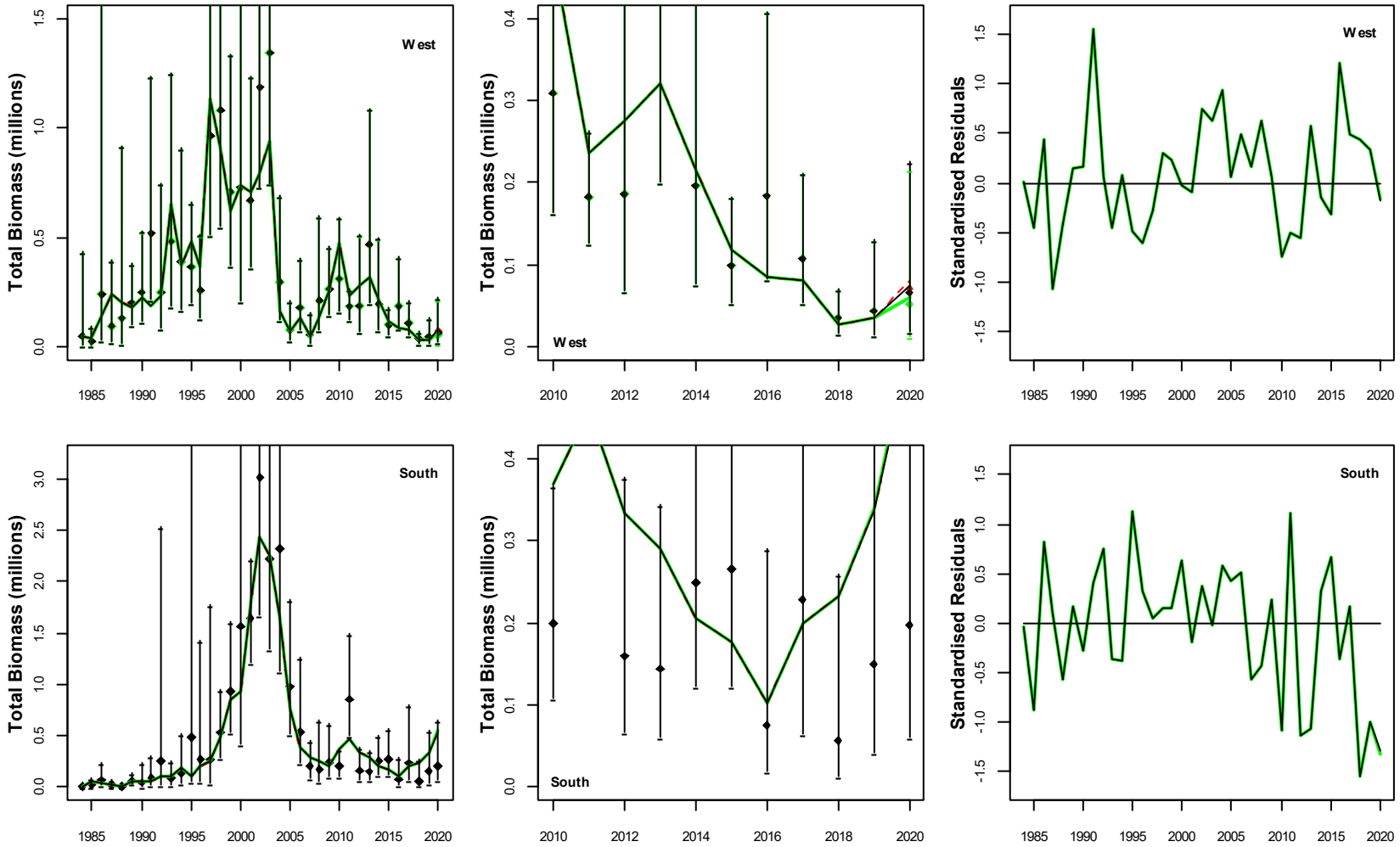

Figure 1. Acoustic survey estimated and model predicted November sardine total biomass from 1984 to 2020 for model option i) from de Moor (2021a) (green) compared to the sensitivity test in this document (black). The red dashed line indicates the sensitivity test if the November 2020 survey estimate of biomass were replaced with an alternative value of 70 634 (CV of 0.62). The observed indices are shown with 95% confidence intervals. The centre plot shows only the most recent 11 years of the left hand plot. 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.

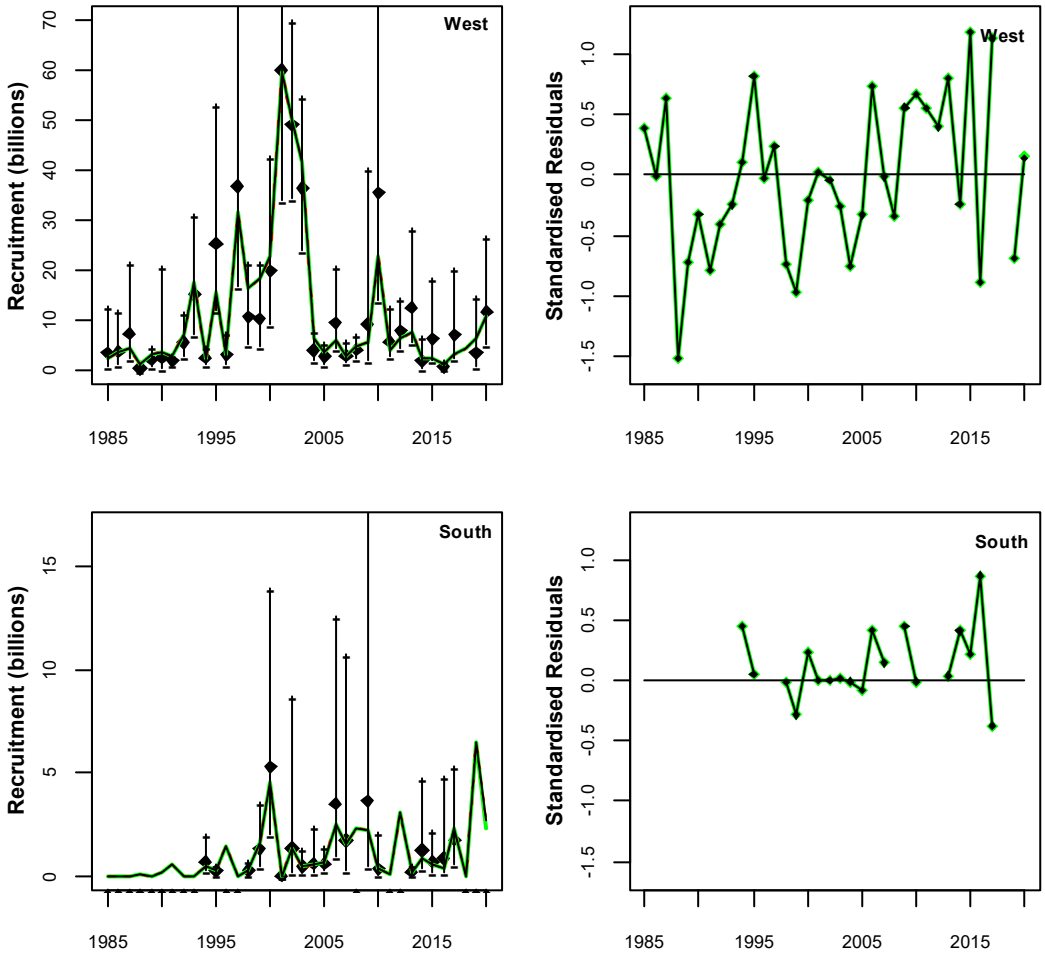

Figure 2. Acoustic survey estimated and model predicted sardine recruitment numbers from May/June 1985 to 2020 for model option i) of de Moor (2021a) (green) compared to the sensitivity test in this document (black). The red dashed line indicates the sensitivity test if the November 2020 survey estimate of biomass were replaced with an alternative value of 70 634t (CV of 0.62). There was no survey observation in 2018; the model predicted value corresponds to the recruitment predicted at 8th June 2018 which is the average start date of the survey from 2016, 2017 and 2019 surveys. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fit are given in the right hand plots.