

Update to the hake Reference Case model incorporating the 2020 commercial and 2021 survey data

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Summary

The Reference Case Ricker hake assessment model is updated with 2020 commercial and 2021 survey data. The updated assessment results are compatible with the previous (2020) Reference Case results and suggest a continued steady increase in spawning biomass for *M. capensis* but a recent decrease for *M. paradoxus*, with these estimates for both species lying well above B_{MSY} .

Key words: hake, assessment, 2021 update, South Africa

Introduction

The current (2020) Reference Case assessment model (the Ricker-like model with a central catch year of 1958), as reported in Ross-Gillespie and Butterworth (2021), is updated with the latest available commercial and survey data. Survey abundance indices from the 2021 south coast autumn survey have been included² (T. Fairweather, *pers. comm.*). Commercial catches are included to 2020, and the commercial CPUE has been re-standardised using data from 1978-2020 and applying the Model A6b species splitting algorithm (J. Glazer *pers. comm.*). Offshore commercial catch-at-length data have been updated to 2019, and the survey proportion-at-length data have been updated to include the 2020 west coast summer survey and 2021 south coast autumn survey data (T. Fairweather, *pers. comm.*). The updated data used for this assessment are given in Appendix A.

Results and Discussion

Table 1 lists the key outputs for these three assessment models. Table 2 gives a break-down of the negative log-likelihood components for the models.

Figure 1 shows the spawning biomass trajectories for both species in absolute and relative terms. Figure 2 plots the estimated stock-recruitment relationships, recruitment time series and standardized recruitment residuals. Figure 3 shows the fits to the commercial CPUE data, while Figure 4 shows the fits to the survey relative abundance estimates.

The 2021 Hake RC results are very similar to the 2020 Hake RC results. The 2021 assessment results indicate a continued steady increase in spawning biomass for *M. capensis* (increasing from 0.70 relative to K^{SP} in 2020 to 0.74 in 2021). *M. paradoxus* has however decreased from 0.29 relative to K^{SP} in 2020 to 0.27 in 2021. This downward reduction is consistent with the decline in the *M. paradoxus* west coast offshore commercial catch rates observed over the 2016-2019 period (see Figure 3). Both species are, however, estimated to lie well above B_{MSY} (B_{2021}^{SP}/B_{MSY} is estimated at 1.67 for *M. paradoxus* and 2.67 for *M. capensis*).

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² No west coast summer survey was conducted during 2021.

Acknowledgements

Computations were performed using facilities provided by the University of Cape Town's ICTS High Performance Computing team: hpc.uct.ac.za.

References

Ross-Gillespie, A. and Butterworth, D.S. 2021. Update to the hake Reference Case model incorporating the 2019 commercial and 2020 survey data. DEFF Fisheries document: FISHERIES/2021/JUN/SWG-DEM/07: 15pp.

Table 1: Key assessment outputs for the models reported upon in this document. The first column (1) lists the results for the RC assessment model in 2020 as they were reported on in FISHERIES/2021/JUN/SWG-DEM/07. The second column (2) shows results for the 2021 Reference Case model, with the 2020-2021 data updates included.

		(1) 2020 RC	(2) 2021 RC
	lnLtotal	-3257.96	-3382.75
<i>M. paradoxus</i>	K^{SP}	337	338
	B^{SP}_{MSY}	55	55
	B^{SP}_{2020}	101	98
	B^{SP}_{2020}/K^{SP}	0.30	0.29
	$B^{SP}_{2020}/B^{SP}_{MSY}$	1.84	1.80
	B^{SP}_{2021}	-	91
	B^{SP}_{2021}/K^{SP}	-	0.27
	$B^{SP}_{2021}/B^{SP}_{MSY}$	-	1.67
	<i>MSY</i>	139	139
<i>M. capensis</i>	K^{SP}	341	346
	B^{SP}_{MSY}	95	96
	B^{SP}_{2020}	244	243
	B^{SP}_{2020}/K^{SP}	0.72	0.70
	$B^{SP}_{2020}/B^{SP}_{MSY}$	2.57	2.54
	B^{SP}_{2021}	-	255
	B^{SP}_{2021}/K^{SP}	-	0.74
	$B^{SP}_{2021}/B^{SP}_{MSY}$	-	2.67
	<i>MSY</i>	81	79

Table 2: Negative log-likelihood components for the two assessment model runs reported in this document. Cells in grey indicate that those components are not comparable for the 2021 update in relation to the 2020 model, because of the additional data included in this update.

Run	GLM CPUE	ICSEAF CPUE	Survey abun.	Comm. CAL	Survey CAL	Recruit. resid.	ALKs	Penalties	Total (w/o pen.)
<u>(1) 2020 RC</u>	-221.14	-37.21	-37.50	-1510.88	-1591.19	9.35	130.61	0.10	<u>-3257.96</u>
<u>(2) 2021 RC</u>	-226.73	-37.36	-38.65	-1570.34	-1649.08	9.05	130.26	0.09	<u>-3382.84</u>

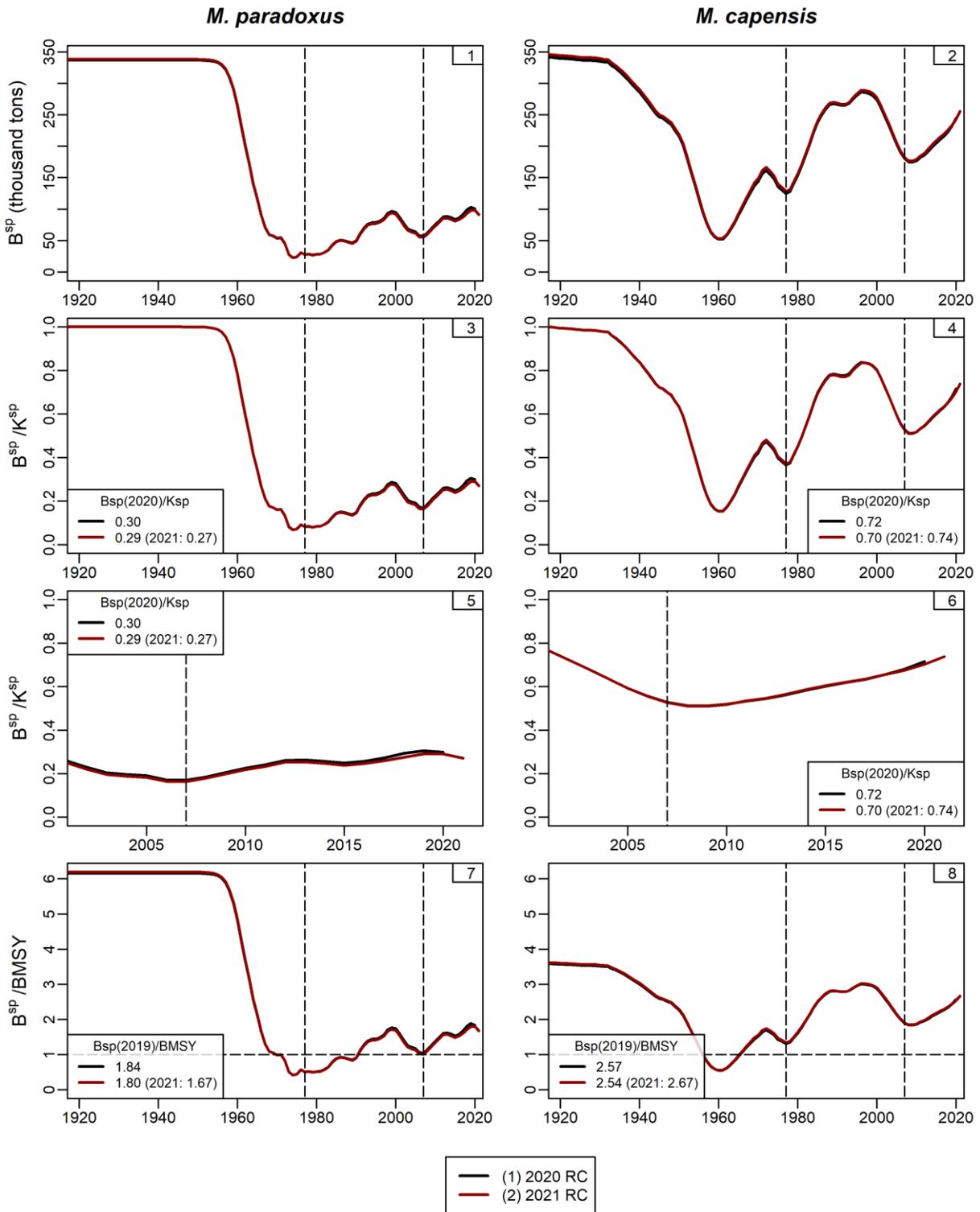


Figure 1: Female spawning biomass is shown for each species in absolute terms (top row), relative to pristine spawning biomass (second row), relative to pristine spawning biomass but for the 2000-2021 time period (third row) and relative to B_{MSY} (fourth row).

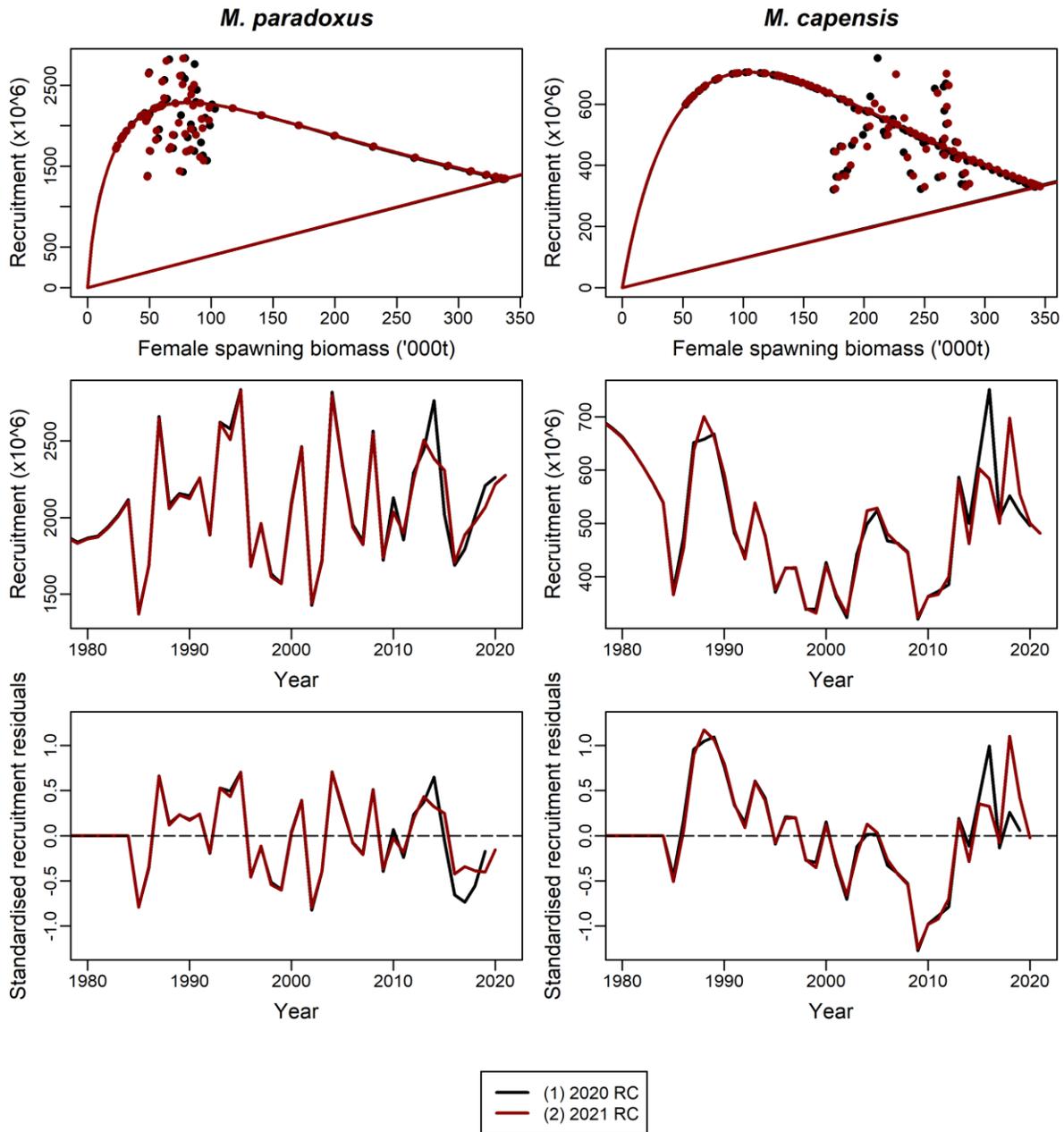
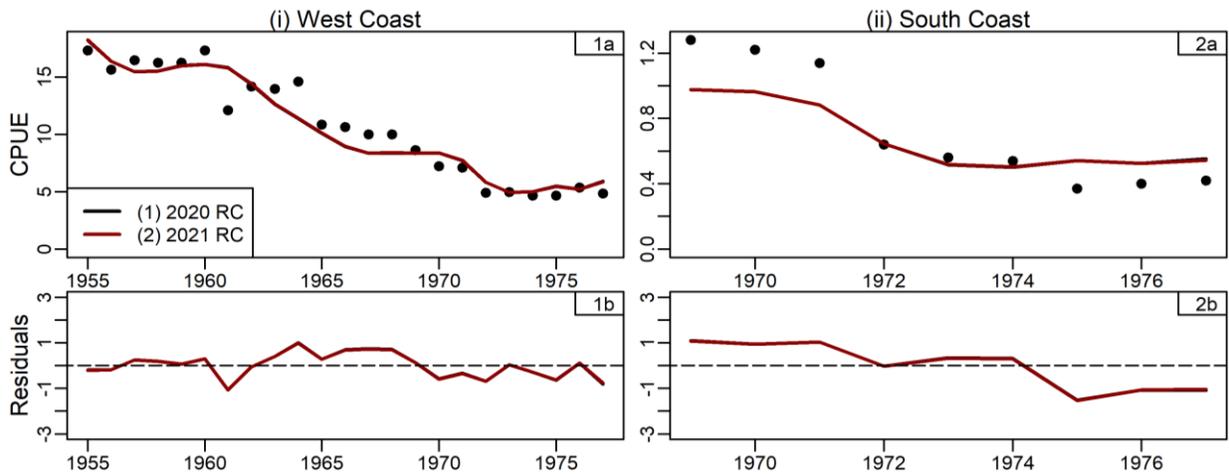


Figure 2: The top row shows the estimated recruitment-spawning biomass relationship for the two assessment models. The middle row plots the recruitment time series, while the bottom row shows the standardized estimated recruitment residuals.

(A) ICSEAF CPUE



(B) GLM CPUE

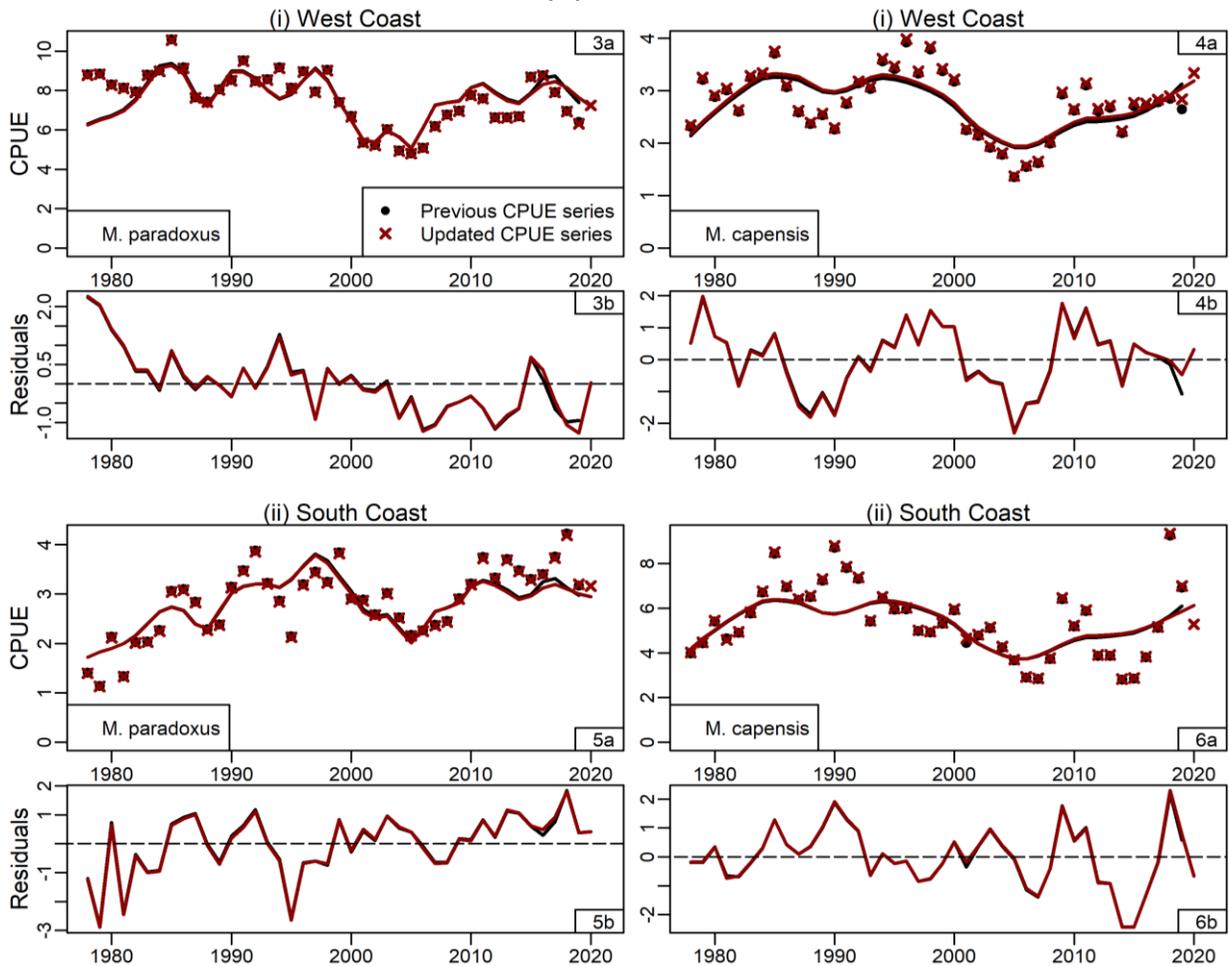
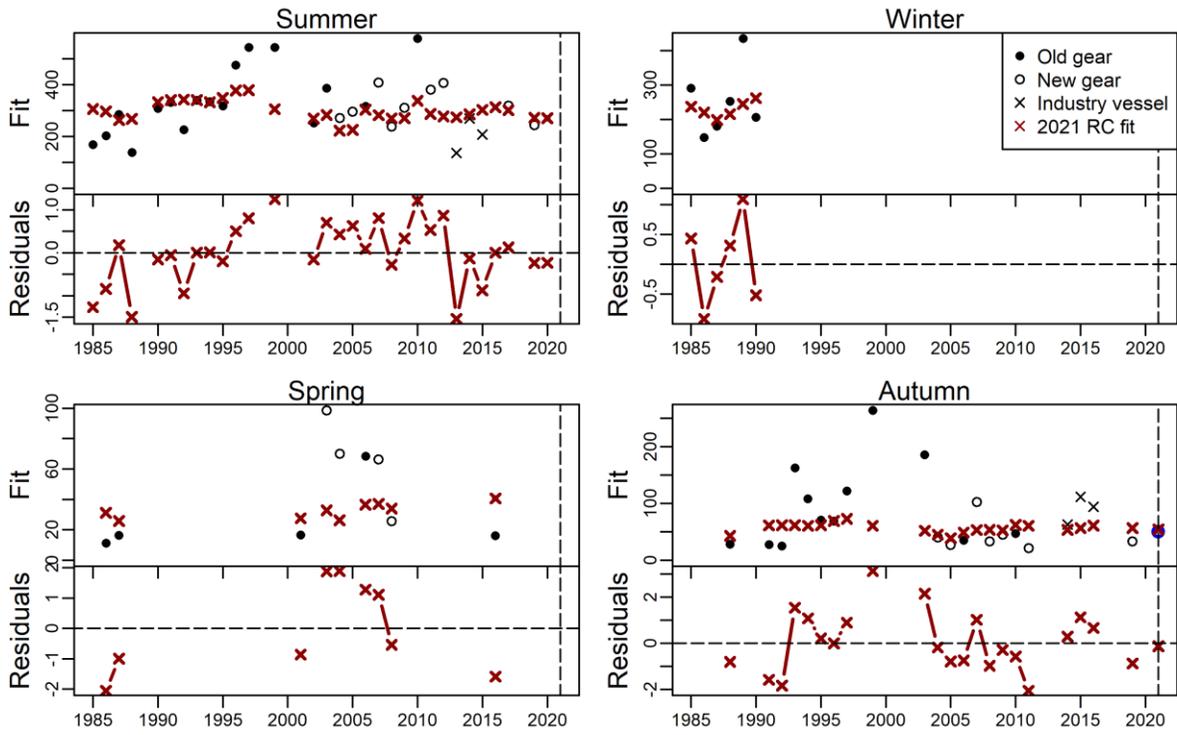


Figure 3: Fits to (A) the historical ICSEAF CPUE data and (B) the commercial GLM-standardized CPUE data are shown. For the GLM CPUE, the series used in the 2020 RC model (which include data from 1978-2019) are indicated by black filled circles, while the updated series used in the 2020 RC model (data from 1978-2020) are indicated by red crosses.

M. paradoxus



M. capensis

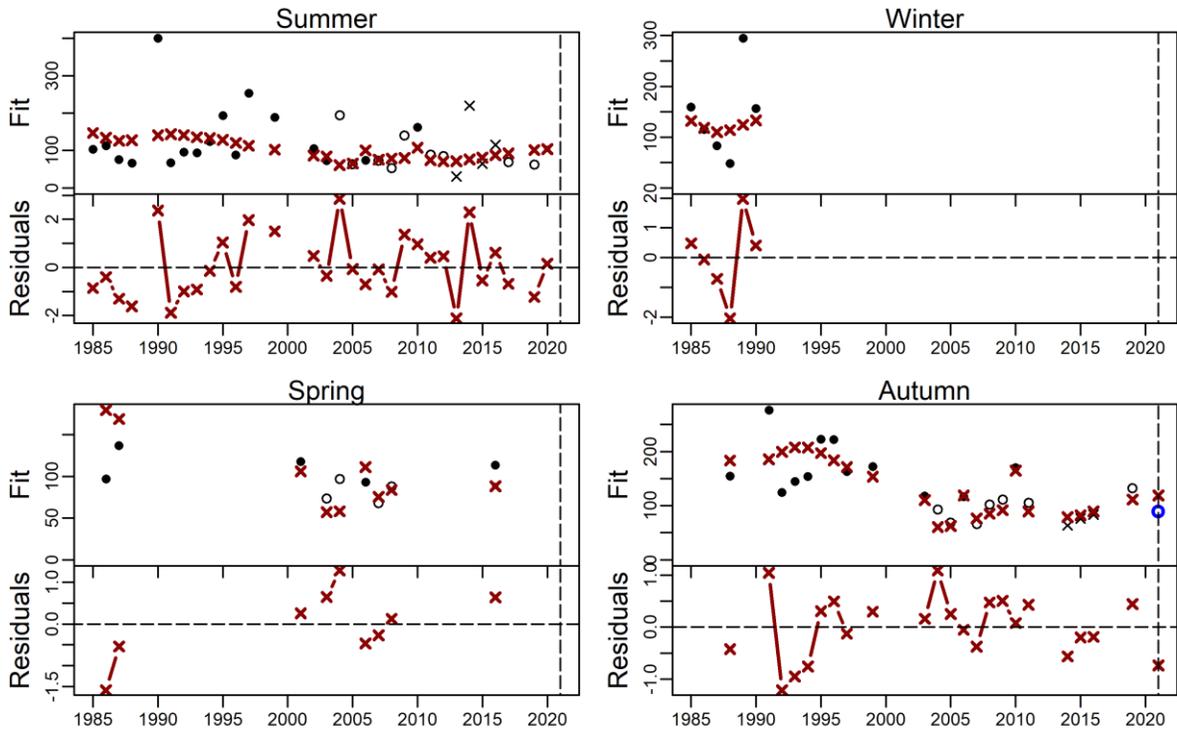


Figure 4: Fits to the survey relative abundance series are shown for the 2021 RC assessment model. The 2021 autumn survey abundance estimates are indicated by the last open circle in each respective plot (blue in colour). Standardised residuals are shown underneath each plot.

Appendix A

This Appendix lists data series which have been updated with new 2020 and 2021 data, namely the commercial catches and GLM-standardized CPUE series, and the survey relative abundance series. The commercial catch-at-length data have been updated for the west coast offshore trawl fishery (to 2018) and south coast offshore and inshore trawl fisheries (to 2019)³. The survey proportion-at-length data have been updated to include the 2020 west coast summer survey and 2021 south coast autumn survey data. These proportions data were provided by T. Fairweather (*pers. comm.*) but have not been listed in this Appendix.

Table A.1: Species-disaggregated catches (in thousand tons) by fleet of South African hake from the south and west coasts for the period 1978-2020 (J. Glazer, *pers. comm.*). The catch data which are newly introduced for this 2021 assessment have been highlighted grey, as well as corrections made to the 2019 west coast offshore catches previously reported.

	<i>M. paradoxus</i>				<i>M. capensis</i>					
	Offshore		Longline		Offshore		Inshore	Longline		Handline
	WC	SC	WC	SC	WC	SC	SC	WC	SC	SC
1978	101.042	3.220	-	-	26.470	4.365	4.931	-	-	-
1979	94.331	1.924	-	-	39.192	4.995	6.093	-	-	-
1980	99.654	2.206	-	-	33.873	4.254	9.121	-	-	-
1981	88.883	0.910	-	-	32.048	4.575	9.400	-	-	-
1982	83.618	3.353	-	-	29.732	8.005	8.089	-	-	-
1983	71.238	4.723	0.126	-	23.195	7.792	7.672	0.104	-	-
1984	82.358	3.796	0.200	0.005	28.897	7.139	9.035	0.166	0.011	-
1985	94.428	8.059	0.638	0.091	30.642	11.957	9.203	0.529	0.201	0.065
1986	103.756	8.580	0.753	0.094	30.049	7.385	8.724	0.625	0.208	0.084
1987	93.517	7.459	1.952	0.110	24.008	8.225	8.607	1.619	0.243	0.096
1988	79.913	5.876	2.833	0.103	26.669	8.640	8.417	2.350	0.228	0.071
1989	82.230	6.182	0.158	0.010	25.029	12.730	10.038	0.132	0.022	0.137
1990	81.996	9.341	0.211	-	21.640	13.451	10.012	0.175	-	0.348
1991	87.093	12.448	-	0.932	19.357	9.626	8.206	-	2.068	1.270
1992	84.768	17.297	-	0.466	18.519	9.165	9.252	-	1.034	1.099
1993	102.125	9.880	-	-	15.940	4.380	8.870	-	-	0.278
1994	103.541	6.726	0.882	0.194	20.327	4.326	9.569	0.732	0.432	0.449
1995	100.268	4.004	0.523	0.202	20.629	3.146	10.630	0.434	0.448	0.756
1996	107.381	8.966	1.308	0.568	21.794	4.323	11.062	1.086	1.260	1.515
1997	100.654	10.509	1.410	0.582	16.500	5.327	8.834	1.170	1.290	1.404
1998	111.154	9.742	0.505	0.457	16.499	4.411	8.283	0.419	1.014	1.738
1999	88.581	11.420	1.532	1.288	15.179	3.926	8.595	1.272	2.856	2.749
2000	96.587	7.700	2.706	3.105	21.114	5.830	10.906	2.000	1.977	5.500
2001	101.247	7.850	1.417	0.084	16.349	8.306	11.836	2.394	1.527	7.300
2002	91.207	12.443	4.469	1.585	13.724	6.141	9.581	2.391	2.546	3.500
2003	93.711	17.397	3.305	1.252	11.665	7.636	9.883	2.526	3.078	3.000
2004	85.722	26.065	2.855	1.196	12.510	8.704	10.004	2.297	2.731	1.600
2005	85.869	21.778	3.091	0.472	9.398	7.468	7.881	2.773	3.270	0.700
2006	81.513	18.050	3.241	0.485	11.984	6.578	5.524	2.520	3.227	0.400
2007	92.724	13.488	2.512	3.021	16.145	3.757	6.350	2.522	2.522	0.400
2008	85.538	13.191	2.255	0.809	13.838	4.316	5.496	1.937	1.893	0.231
2009	68.202	10.895	2.410	1.069	12.296	4.806	5.639	2.828	2.520	0.265
2010	69.709	15.457	2.394	1.527	10.186	4.055	5.472	3.086	3.024	0.275
2011	76.576	17.904	2.522	0.140	15.673	4.086	6.013	3.521	3.047	0.186
2012	81.411	16.542	4.358	0.306	12.928	4.584	3.223	2.570	1.737	0.008
2013	74.341	28.859	6.056	0.060	8.761	4.475	2.920	2.606	1.308	0.000
2014	73.252	41.156	6.879	0.008	9.671	6.286	2.965	2.123	0.315	0.001
2015	77.521	31.745	4.001	0.018	12.727	4.035	3.077	2.325	0.053	0.001
2016	93.173	18.968	2.806	0.001	14.744	2.810	3.973	4.360	0.002	0.001
2017	72.326	30.961	5.288	0.025	15.273	4.466	2.812	2.807	0.126	0.004
2018	64.252	29.218	5.156	0.089	12.689	12.863	3.983	2.615	0.481	0.024
2019	70.608	22.201	3.177	0.02	14.193	9.454	4.149	2.16	0.179	0.009
2020	97.093	10.061	3.220	0.003	18.115	3.500	4.536	1.293	0.177	0.004

³ There were insufficient data to compile catch-at-length proportions for the west coast offshore trawl fishery in 2019.

Table A.2: GLM standardized CPUE data for *M. paradoxus* and *M. capensis*, corresponding to the Model A6b species splitting algorithm applied to data from 1978-2020 (J. Glazer, *pers. comm.*).

Year	GLM CPUE (kg min ⁻¹)			
	<i>M. paradoxus</i>		<i>M. capensis</i>	
	West Coast	South Coast	West Coast	South Coast
1978	8.78	1.40	2.35	4.02
1979	8.82	1.13	3.25	4.47
1980	8.26	2.12	2.92	5.44
1981	8.10	1.33	3.04	4.58
1982	7.91	2.01	2.63	4.94
1983	8.77	2.03	3.29	5.81
1984	8.97	2.25	3.34	6.75
1985	10.55	3.04	3.75	8.51
1986	9.12	3.08	3.11	6.99
1987	7.62	2.83	2.62	6.42
1988	7.40	2.27	2.40	6.54
1989	8.02	2.37	2.57	7.30
1990	8.49	3.13	2.29	8.78
1991	9.49	3.46	2.79	7.86
1992	8.45	3.86	3.18	7.37
1993	8.53	3.21	3.08	5.44
1994	9.12	2.84	3.61	6.51
1995	8.11	2.12	3.47	5.99
1996	8.94	3.18	3.98	6.01
1997	7.91	3.43	3.37	5.01
1998	9.00	3.23	3.84	4.95
1999	7.39	3.82	3.42	5.35
2000	6.67	2.90	3.22	5.95
2001	5.34	2.87	2.28	4.64
2002	5.21	2.57	2.17	4.81
2003	6.01	3.01	1.95	5.15
2004	4.92	2.51	1.81	4.28
2005	4.79	2.15	1.38	3.70
2006	5.07	2.25	1.58	2.92
2007	6.17	2.36	1.65	2.86
2008	6.74	2.43	2.03	3.77
2009	6.95	2.90	2.97	6.46
2010	7.75	3.19	2.65	5.22
2011	7.58	3.72	3.14	5.92
2012	6.61	3.31	2.66	3.91
2013	6.61	3.69	2.72	3.91
2014	6.67	3.46	2.23	2.83
2015	8.68	3.28	2.77	2.88
2016	8.75	3.39	2.76	3.82
2017	7.90	3.73	2.83	5.15
2018	6.93	4.19	2.90	9.34
2019	6.31	3.20	2.84	6.98
2020	7.24	3.16	3.34	5.28

Table A.3a: Survey abundance estimates and associated standard errors in thousand tons for *M. paradoxus* for the depth range 0-500m for the South Coast and for the West Coast (T. Fairweather, *pers. comm.*). Values in bold are for the surveys conducted by the *Africana* with the new gear, while underlined values are for the surveys conducted by the *Andromeda* and in 2016 by the *Compass Challenger*. The 2016 spring survey was conducted by the *Africana* - the abundance estimates for this survey were previously unavailable, but have now been included. Grey highlighting has been used to indicate the data point new to this 2021 assessment that has been added.

Year	West coast				South coast			
	Summer		Winter		Spring (Sept)		Autumn (Apr/May)	
	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)
1985	168.989	(37.765)	290.281	(63.295)	-	-	-	-
1986	202.334	(37.745)	147.378	(21.667)	11.280	(3.111)	-	-
1987	284.434	(54.165)	180.158	(39.047)	16.381	(3.033)	-	-
1988	138.534	(20.303)	252.121	(71.246)	-	-	28.293	(8.673)
1989	-	-	434.092	(142.716)	-	-	-	-
1990	307.615	(87.841)	205.704	(43.607)	-	-	-	-
1991	331.177	(81.633)	-	-	-	-	27.570	(8.153)
1992	225.755	(33.711)	-	-	-	-	25.036	(6.650)
1993	340.079	(51.427)	-	-	-	-	162.375	(81.691)
1994	333.499	(56.259)	-	-	-	-	108.179	(38.369)
1995	317.104	(76.709)	-	-	-	-	70.890	(39.330)
1996	474.270	(92.744)	-	-	-	-	68.859	(19.929)
1997	543.615	(96.043)	-	-	-	-	121.707	(51.507)
1998	-	-	-	-	-	-	-	-
1999	542.830	(110.541)	-	-	-	-	263.256	(59.439)
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	16.668	(7.159)	-	-
2002	251.820	(32.690)	-	-	-	-	-	-
2003	386.321	(63.565)	-	-	98.434	(42.249)	185.345	(82.188)
2004	271.540	(55.710)	-	-	70.001	(22.156)	39.822	(22.153)
2005	296.065	(42.409)	-	-	-	-	26.691	(6.017)
2006	316.247	(57.332)	-	-	68.507	(18.283)	34.868	(5.843)
2007	407.377	(77.222)	-	-	66.267	(21.966)	102.195	(53.688)
2008	238.143	(37.018)	-	-	25.661	(8.324)	33.034	(9.340)
2009	310.760	(27.768)	-	-	-	-	45.030	(15.551)
2010	576.848	(88.202)	-	-	-	-	46.938	(12.160)
2011	380.185	(128.013)	-	-	-	-	21.054	(6.531)
2012	405.865	(59.099)	-	-	-	-	-	-
2013	<u>136.260</u>	(25.116)	-	-	-	-	-	-
2014	<u>269.482</u>	(37.492)	-	-	-	-	<u>62.925</u>	(24.802)
2015	<u>207.583</u>	(24.057)	-	-	-	-	<u>111.411</u>	(51.852)
2016	<u>312.876</u>	(33.250)	-	-	16.147	(6.862)	<u>94.177</u>	(51.731)
2017	319.024	(58.766)	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	243.560	(51.558)	-	-	-	-	33.176	15.444
2020	243.090	(43.989)	-	-	-	-	-	-
2021	-	-	-	-	-	-	50.060	(20.43)

Table A.3b: Survey abundance estimates and associated standard errors in thousand tons for *M. capensis*. Grey highlighting has been used to indicate the data point new to this 2021 assessment that has been added.

Year	West coast				South coast			
	Summer		Winter		Spring (Sept)		Autumn (Apr/May)	
	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)
1985	102.929	(18.888)	159.198	(18.982)	-	-	-	-
1986	113.154	(23.474)	115.218	(19.733)	96.768	(10.737)	-	-
1987	75.438	(9.709)	83.050	(10.306)	137.008	(13.057)	-	-
1988	66.365	(9.930)	48.046	(9.574)	-	-	154.548	(23.984)
1989	-	-	294.740	(67.495)	-	-	-	-
1990	400.142	(97.102)	156.337	(22.507)	-	-	-	-
1991	67.565	(9.656)	-	-	-	-	276.607	(25.274)
1992	95.401	(11.892)	-	-	-	-	124.495	(13.600)
1993	93.613	(14.390)	-	-	-	-	144.551	(12.379)
1994	124.497	(37.845)	-	-	-	-	153.790	(20.310)
1995	193.292	(24.270)	-	-	-	-	222.464	(31.245)
1996	87.969	(9.866)	-	-	-	-	222.176	(23.144)
1997	252.606	(42.721)	-	-	-	-	163.163	(17.274)
1998	-	-	-	-	-	-	-	-
1999	188.624	(31.362)	-	-	-	-	171.946	(13.330)
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	117.590	(20.093)	-	-
2002	105.093	(16.130)	-	-	-	-	-	-
2003	73.020	(12.518)	-	-	73.604	(9.142)	117.538	(17.192)
2004	194.294	(30.714)	-	-	96.933	(13.936)	92.796	(11.318)
2005	63.363	(11.498)	-	-	-	-	68.672	(5.302)
2006	73.655	(17.255)	-	-	92.831	(8.998)	116.298	(11.931)
2007	73.230	(9.306)	-	-	67.937	(6.553)	65.935	(5.303)
2008	52.577	(7.069)	-	-	87.836	(9.723)	102.169	(9.681)
2009	140.437	(26.486)	-	-	-	-	111.191	(10.832)
2010	162.402	(34.891)	-	-	-	-	170.261	(33.235)
2011	89.095	(23.574)	-	-	-	-	105.424	(10.688)
2012	84.746	(8.331)	-	-	-	-	-	-
2013	<u>30.383</u>	(4.575)	-	-	-	-	-	-
2014	<u>219.756</u>	(60.342)	-	-	-	-	<u>63.389</u>	(6.415)
2015	<u>65.086</u>	(9.178)	-	-	-	-	<u>76.059</u>	(6.873)
2016	<u>115.058</u>	(30.400)	-	-	113.384	(13.828)	<u>83.197</u>	(6.600)
2017	69.289	(14.486)	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	62.560	(7.697)	-	-	-	-	132.099	(14.486)
2020	109.983	(11.836)	-	-	-	-	-	-
2021	-	-	-	-	-	-	89.119	(10.798)