Update to the hake Reference Case model incorporating the 2018 commerical and 2019 survey data

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Summary

The Reference Case Ricker model is updated with commercial and survey data from 2018 and 2019. The updated data points lie within the bounds predicted by OMP2018 projections, except for the 2018 proportion of *M. capensis* in the South Coast offshore trawl fishery catch, which is markedly higher than predicted. The updated assessment results are compatible with the previous Reference Case results and suggest an increase in spawning biomass since 2017 for both species.

Introduction

The current Reference Case assessment model (the Ricker model with a central catch year of 1958), is updated with the latest available commercial and survey data. Survey abundance indices and catch-at-length proportions from the 2019 summer survey have been included[2] (T. Fairweather*, pers. comm*.). Additionally, survey abundance estimates from the 2016 spring survey, which have previously been unavailable, have also been included. Commercial catches are included up to 2018 and the commercial CPUE has been re-standardised using data from 1978-2018 and applying the Model A6b species splitting algorithm (J. Glazer *pers. comm.*). Commercial catches-at-age from 2018 have not been included in the update presented in this paper as they are not yet available. The data used for this updated assessment are presented in Appendix A.

Several modifications have been made to the RC model methodology in 2019: (a) fairly substantial updates to take into account recommendations made at the 2018 International Stock Assessment Workshop led to the results presented to the DWG in March (details of these updates can be found in FISHERIES/2019/MARCH/SWG-DEM/03), and (b) a correction of a coding glitch that resulted in the juvenile age-length-key (ALK) data being inadvertently excluded (results for the corrected model were presented to the DWG in August, FISHERIES/2019/AUG/SWG-DEM/10rev). Since August one further modification has been made to the RC methodology, namely that the maximum length considered in the model has been increased from 105cm to 201cm, as the length of 105cm used previously inadvertently truncated the lengths of the hake in the plus age group.

Results

Results have been presented for three models:

(1) the RC last presented to the DWG in August (August RC),

(2) an update to the August RC that increases the maximum length to 201cm (Pre-update RC), and

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[2] No surveys were conducted during 2018.

(3) the 2019 updated RC, which uses the same methodology as model (2), but incorporates the 2018-2019 data update.

Table 1 lists the key assessment outputs for these three models, as well as the RC presented to the DWG in March for reference purposes. Table 2 gives a break-down of the negative log-likelihood components for the three primary models.

Figure 1 shows the spawning biomass trajectories for both species in absolute and relative terms. Figure 2 shows the fits to the commercial CPUE data, while Figure 3 shows the fits to the survey relative abundance estimates.

Discussion

A few key points are discussed in bullet form below.

Data updates

- Appendix B superimposes the updated commercial and survey data points onto the OMP2018 projections to ascertain whether these points lie within the range projected by the OMP, or whether Exceptional Circumstances should perhaps be triggered. The commercial CPUE and survey abundance estimates all lie within the error bounds projected by the OMP; however, the proportion of *M. capensis* catch in the South Coast offshore catch is markedly higher than expected. This warrants some further discussion.

- The *M. capensis* South Coast GLM CPUE estimate for 2018 is markedly higher than the values in the preceding years. Preliminary investigations indicate that this is not as a possible consequence of small sample sizes, and may warrant some further investigation.

Assessment update

- For this aspect, the Pre-update RC (Model 2) and the 2019 Updated RC (Model 3) should be compared as they employ the same methodology – the only difference is the addition of recently available data. The results for these two models are very similar, indicating that the new data are not suggesting contradictory information to previous data series.

- The assessment results suggest a steady increase in spawning biomass for both species, with *M. paradoxus* increasing from 0.28 relative to K^{sp} in 2017 to 0.31 in 2019, and *M. capensis* increasing from 0.64 to 0.69.

- It should be noted that the *M. capensis* estimate of B^{sp}/B_{MSY} appears not to be very well determined. During the jittering exercise (where the estimation process is restarted from different starting positions several times to ensure as best as possible that a global minimum has been found), an alternative solution was found where B^{sp}/B_{MSY} for 2019 was estimated to be 2.28 (instead of the 2.44 reported here) with an only marginally worse negative log-likelihood (0.06 points worse).

Table 1: Key assessment outputs for the models reported upon in this document. The first column lists the results for the RC assessment model as they were reported on in FISHERIES/2019/MAR/SWG-DEM/03, where the juvenile ALK data had accidentally been excluded and the maximum length considered in the model was 105cm. The second column shows results for the RC model reported on in FISHERIES/2019/AUG/SWG-DEM/10rev where the juvenile ALK data have been included in the likelihood calculations, but the maximum length considered in the model remains 105cm as for the March RC. The third column shows the results for model (2) with the ALK data included and the maximum length considered increased to 201cm. The final column shows the results for the update of model (3) which uses the same methodology as (2), but with the 2018-2019 data updates included. Note that the difference in the negative log-likelihood between (0) and (1) is due to the inclusion of the juvenile ALK data, and between (1) and (2) results from an improved fit to the GLM CPUE data and to the commercial catch-at-length data. The Figures in this document show results for runs (1), (2) and (3).

		(0) March RC	(1) August RC	(2) Pre-update RC	(3) 2019 Update
	Juvenile ALK data	Excluded	Included	Included	Included
	Maximum length	105cm	105cm	201cm	201cm
	lnLtotal	-3154.46	-3144.82	-3154.75	-3253.87
M. paradoxus	K^{sp}	294	280	314	329
	B^{sp}_{MSY}	51	54	56	55
	B^{sp}_{2017}	78	83	89	91
	B^{sp}_{2017}/K^{sp}	0.27	0.30	0.28	0.28
	$B^{sp}_{2017}/B^{sp}_{MSY}$	1.55	1.54	1.60	1.63
	B^{sp}_{2019}	-	-	-	104
	B^{sp}_{2019}/K^{sp}	-	-	-	0.31
	$B^{sp}_{2019}/B^{sp}_{MSY}$	-	-	-	1.87
	MSY	144	145	145	142
M. capensis	K^{sp}	272	273	343	342
	B^{sp}_{MSY}	81	81	98	96
	B^{sp}_{2017}	186	186	220	218
	B^{sp}_{2017}/K^{sp}	0.68	0.68	0.64	0.64
	$B^{sp}_{2017}/B^{sp}_{MSY}$	2.30	2.29	2.25	2.26
	B^{sp}_{2019}	-	-	-	235
	B^{sp}_{2019}/K^{sp}	-	-	-	0.69
	$B^{sp}_{2019}/B^{sp}_{MSY}$	-	-	-	2.44
	MSY	84	84	81	82

Table 2: Negative log-likelihood components for the three main runs reported upon in this document. Cells in grey indicate that those components are not comparable for the 2019 update in relation to the earlier models, because of the additional data included in the update. The likelihood components for Model (1) and (2) are all comparable; the better fits to the CLM CPUE and commercial CAL data for Model (2) are as a result of the increased maximum length considered in the model to 201 cm.

Run	GLM CPUE	ICSEAF CPUE	Survey abun.	Comm. CAL	Survey CAL	Recruit. resid.	ALKs	Penalties	Total (w/o pen.)
(1) August RC	-202.62	-36.58	-34.56	-1508.39	-1502.21	9.50	129.93	0.12	-3144.94
(2) Pre-update RC	-205.54	-36.50	-34.21	-1515.82	-1501.37	8.50	130.07	0.13	-3154.88
(3) 2019 Update	-215.33	-36.86	-35.28	-1514.93	-1591.28	8.93	130.78	0.12	-3253.99

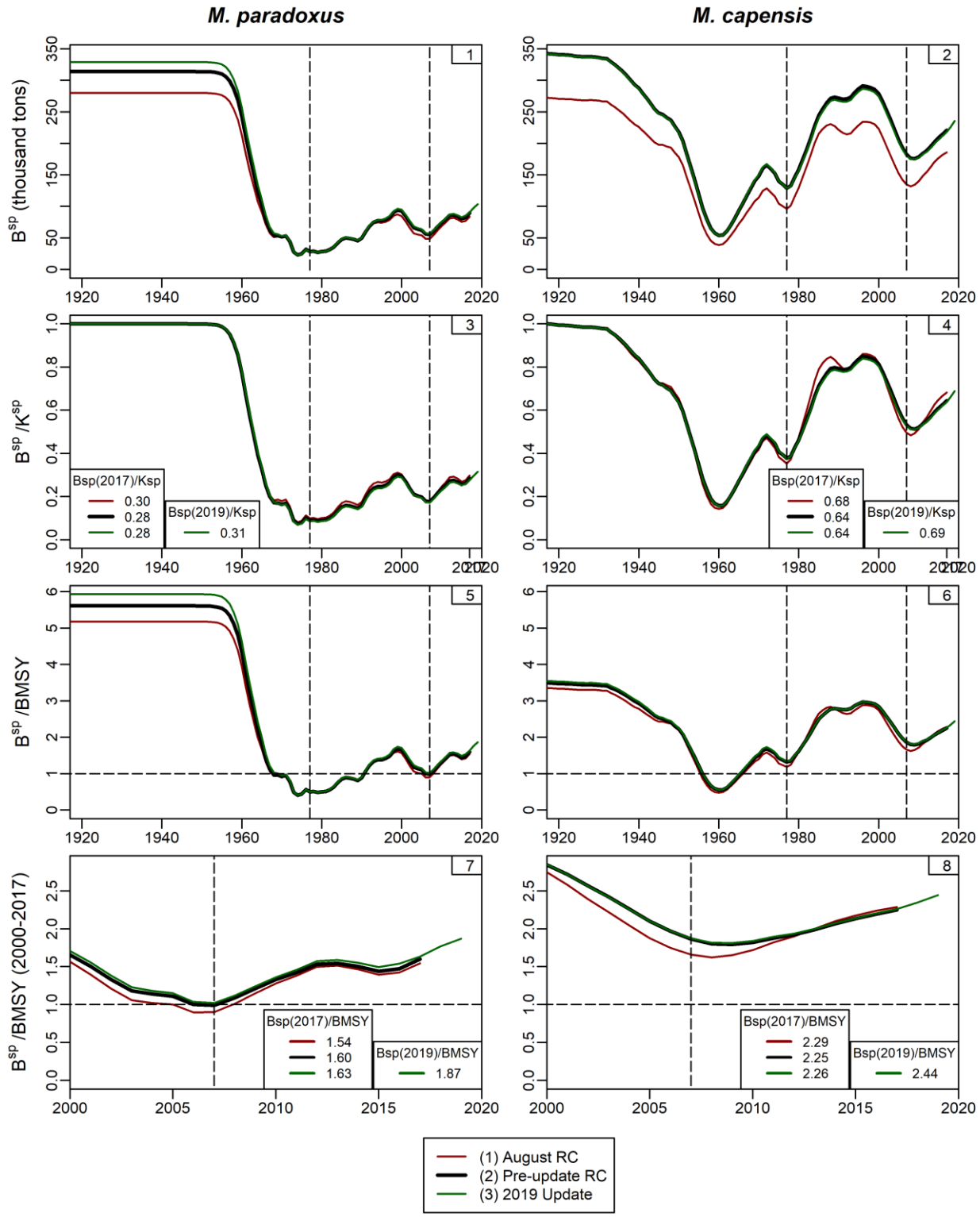

Figure 1: Female spawning biomass is shown for each species in absolute terms (top row), relative to pristine spawning biomass (second row), relative to B_{MSY} (third row), and again relative to B_{MSY} but for the 2000-2019 time period in the last row.

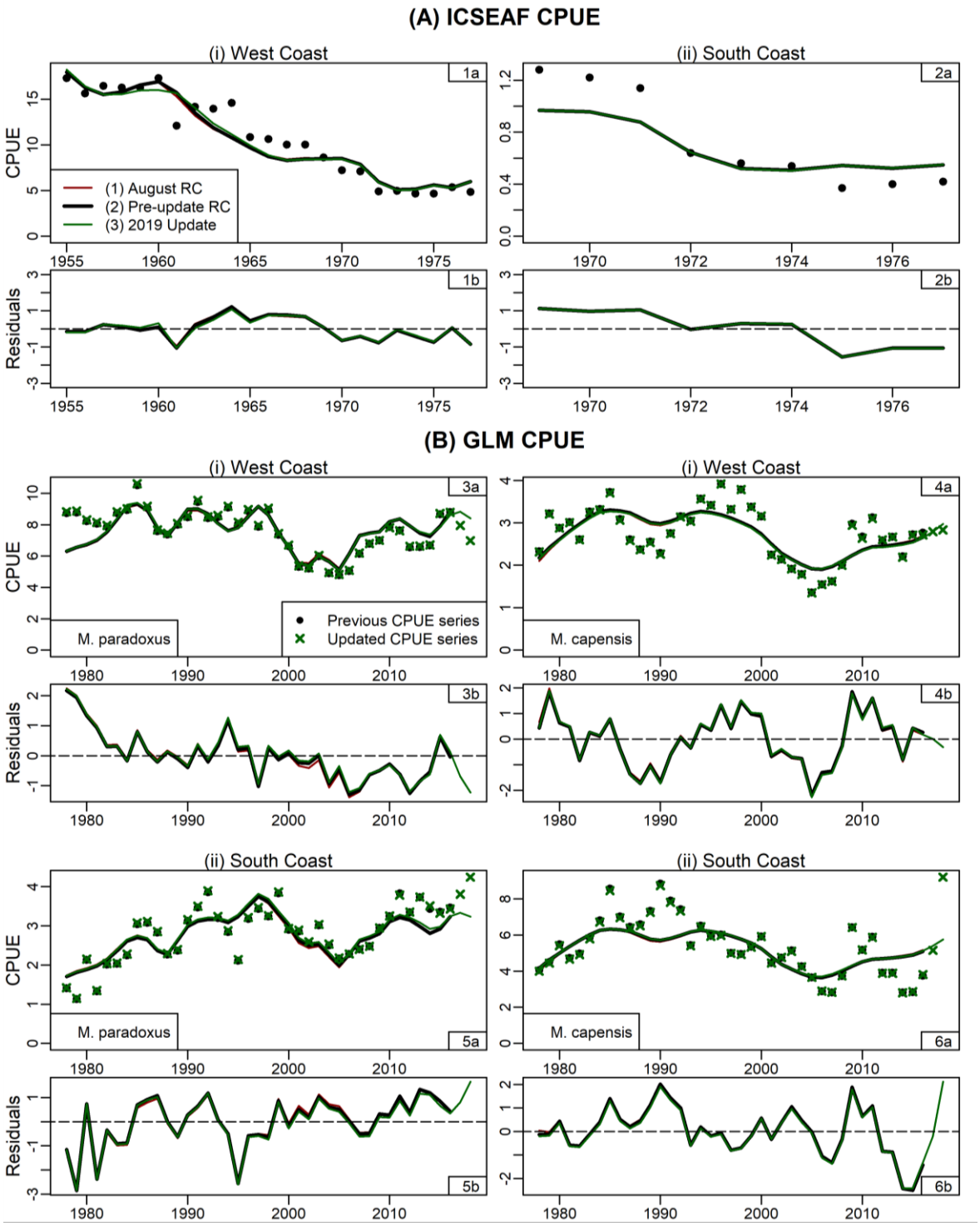

Figure 2: Fits to (A) the historical ICSEAF CPUE data and (B) the commercial GLM-standardized CPUE data are shown here. For the GLM CPUE, the series used to date (which include data from 1978-2017) are indicated by black filled circles, while the updated 2019 series (data from 1978-2018) are indicated by green crosses.

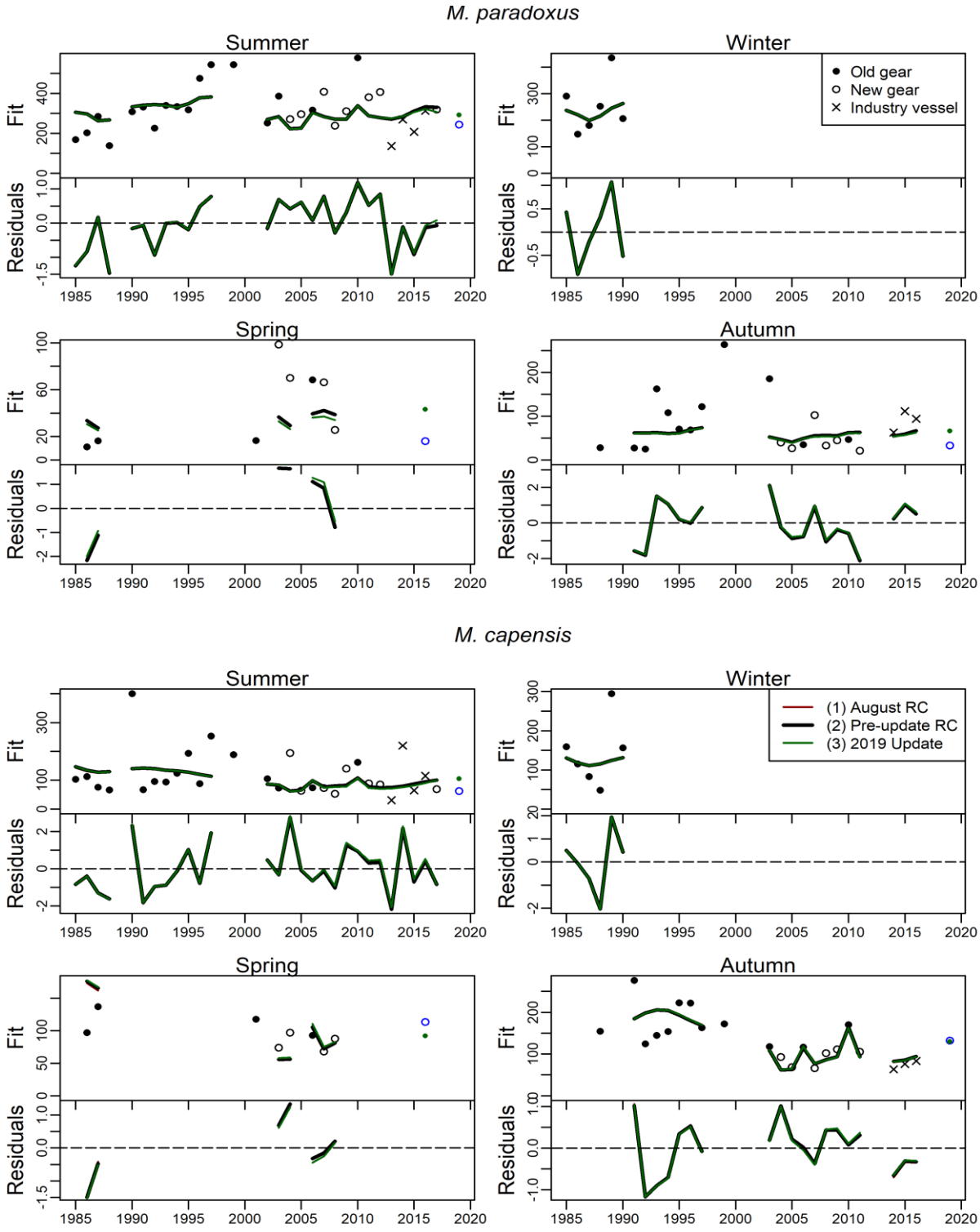

Figure 3: Fits to the survey relative abundance series are shown for the three main models reported on in this document. The 2019 summer and autumn survey abundance estimates are indicated by the last open circle in each respective plot (blue in colour), and the 2016 spring abundance estimate has similarly been indicated by a blue open circle. The model fits to the abundance estimates for Model (3) have been indicated by a green dot for both the 2016 Spring and the 2019 estimates.

Appendix A

This Appendix lists data series which have been updated with new 2016, 2018 and 2019 data, namely the commercial catches and GLM-standardized CPUE series, and the survey relative abundance series. The survey catch-at-length proportions have also been updated, but in the interest of brevity those tables have not been reproduced here.

Table A.1: Species-disaggregated catches (in thousand tons) by fleet of South African hake from the south and west coasts for the period 1978-2018 (J. Glazer, *pers. comm.)*. Grey cells indicate that the data have been updated from what has been used previously in the assessment models: the 2018 values (dark grey) are from the routine 2019 update, while the 2014-2017 values (light grey) have been updated following various checks and corrections.

	M. paradoxus				*M. capensis*					
	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

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 1978-2018 (J. Glazer, *pers. comm*.).

	GLM CPUE (kg min^{-1})			
	M. paradoxus		*M. capensis*	
Year	West Coast	South Coast	West Coast	South Coast
1978	8.82	1.42	2.31	3.99
1979	8.87	1.15	3.21	4.44
1980	8.30	2.15	2.88	5.40
1981	8.14	1.35	3.00	4.66
1982	7.95	2.04	2.60	4.91
1983	8.82	2.05	3.25	5.78
1984	9.02	2.28	3.30	6.71
1985	10.61	3.07	3.70	8.45
1986	9.17	3.11	3.06	6.95
1987	7.66	2.86	2.59	6.38
1988	7.45	2.29	2.36	6.50
1989	8.07	2.40	2.53	7.25
1990	8.55	3.16	2.26	8.73
1991	9.54	3.50	2.74	7.81
1992	8.50	3.89	3.14	7.33
1993	8.58	3.24	3.04	5.40
1994	9.18	2.87	3.56	6.46
1995	8.15	2.14	3.41	5.92
1996	8.97	3.21	3.92	5.97
1997	7.95	3.46	3.32	4.98
1998	9.04	3.26	3.78	4.92
1999	7.43	3.86	3.37	5.32
2000	6.69	2.93	3.16	5.91
2001	5.37	2.89	2.24	4.45
2002	5.24	2.59	2.13	4.75
2003	6.04	3.04	1.91	5.10
2004	4.95	2.54	1.78	4.24
2005	4.82	2.18	1.35	3.65
2006	5.09	2.28	1.54	2.89
2007	6.19	2.40	1.62	2.83
2008	6.79	2.48	2.00	3.73
2009	7.00	2.95	2.94	6.41
2010	7.81	3.25	2.63	5.17
2011	7.61	3.78	3.10	5.86
2012	6.63	3.35	2.60	3.88
2013	6.63	3.73	2.67	3.88
2014	6.70	3.51	2.19	2.80
2015	8.71	3.32	2.71	2.86
2016	8.78	3.43	2.72	3.81
2017	7.95	3.81	2.79	5.15
2018	6.98	4.24	2.83	9.20

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 new data points that have been added.

	West coast				South coast			
Year	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	136.260	(25.116)	-	-	-	-	-	-
2014	269.482	(37.492)	-	-	-	-	62.925	(24.802)
2015	207.583	(24.057)	-	-	-	-	111.411	(51.852)
2016	312.876	(33.250)	-	-	**16.147**	(6.862)	94.177	(51.731)
2017	**319.024**	(58.766)	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	**243.560**	**(**51.558**)**	**-**	**-**	**-**	**-**	**33.176**	15.444

Table A.3b: Survey abundance estimates and associated standard errors in thousand tons for ***M. capensis***.

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	30.383	(4.575)	-	-	-	-	-	-
2014	219.756	(60.342)	-	-	-	-	63.389	(6.415)
2015	65.086	(9.178)	-	-	-	-	76.059	(6.873)
2016	115.058	(30.400)	-	-	**113.384**	(13.828)	83.197	(6.600)
2017	**69.289**	(14.486)	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	**62.560**	(7.697)	-	-	-	-	**132.099**	(14.486)

Appendix B

The 2018/2019 commercial and survey data updates have been superimposed into the OMP2018 projection plots to ascertain whether these points lie within the error range projected by the OMP.

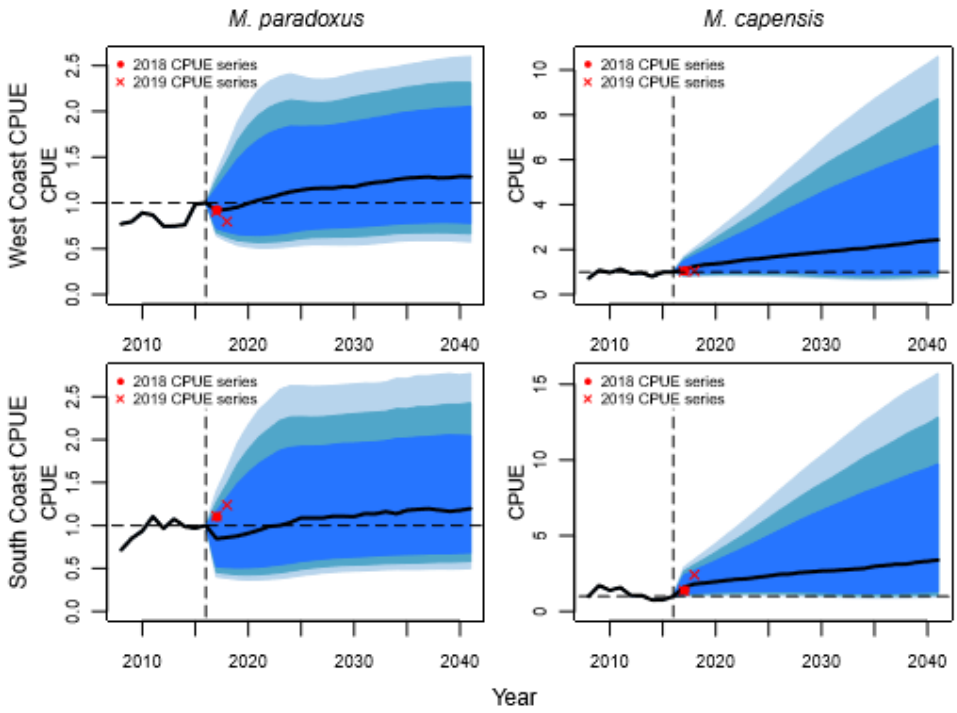

Fig. B1: 95, 90, 80% PE and median for the projected GLM-standardised CPUE for *M. paradoxus* and *M. capensis* for the updated RS under OMP-2018. The red dots show the 2017 CPUE indices, standardised relative to the 2016 value in the updated GLM series. Red crosses show the updated 2017 and 2018 CPUE indices (relative to 2016) as per the latest CPUE series (J. Glazer, *pers. comm*).

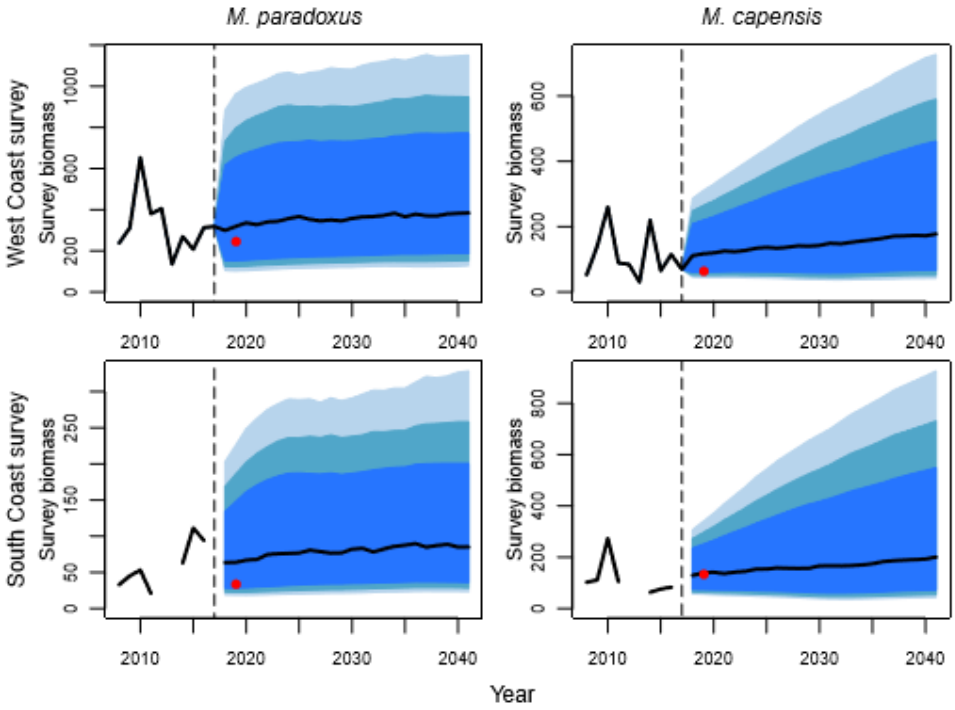

Fig. B2: 95, 90, 80% PE and median for the survey abundance indices for *M. paradoxus* and *M. capensis* for the updated RS under OMP-2018. Gaps in the median trajectory for the South Coast survey indicate surveys that did not take place. Estimates from the 2019 surveys are indicated by red dots. Note: future surveys are assumed to be carried out using the new gear on the *Africana*; if an industry vessel is used instead, the resultant estimates must be multiplied by 1.25 before comparison with the bounds in these plots.

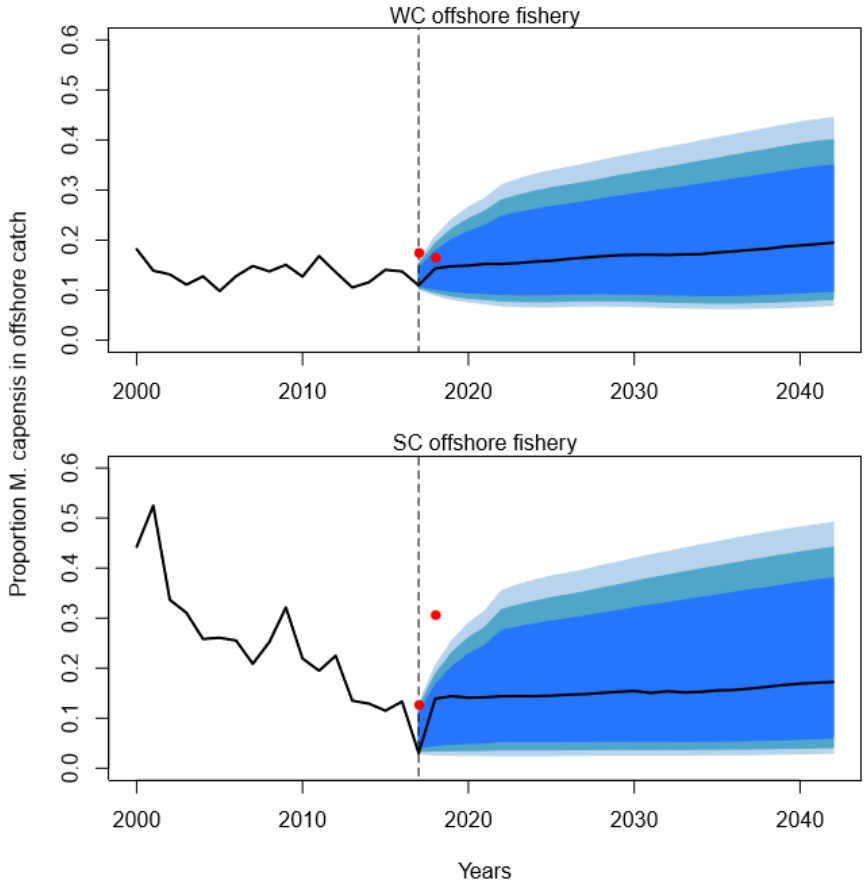

Fig. B3: 95, 90, 80% PE and median for the proportion *M. capensis* in the offshore trawl catch, with the 2017 and 2018 observed proportions indicated by the red dots.