An updated Reference Case for the South African hake resource

Rebecca Rademeyer
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The development of and results for an updated Reference Case for the South African hake resource are presented here. This update takes account of the recommendations made by the December 2013 International Fisheries Stock Assessment Review Workshop (Smith *et al*., 2013) as well as new species- and gender-disaggregated longline data.

The changes from RS1-2013e (Rademeyer and Butterworth, 2013) to the proposed RC have been carried out in a series of steps described below, each run building on the previous one. The results for each of these steps are given in Table 1.

1) "RS1-2013e".
2) "Calibration factors": as recommended by the Review Panel (recommendation A.3), the penalty function on the change in survey catchability associated with the use of a new gear by Africana is set to the best estimate obtained in the most recent calibration analysis based on "Model 1": 0.652 (SE 0.073) for *M. capensis* and 0.883 (SE 0.082) for *M. paradoxus* (see Table 1, "Model 1" of Smith *et al*., 2013).
3) "With gender-disaggregated longline CAL": Taking account of the gender-disaggregated length-frequency data for longline, as recommended by the Review Panel (recommendation A.4) (Tables 4, 5 and 7 of Rademeyer, 2014). In this run the selectivity for males and females is taken to be the same. Furthermore, three years of offshore, species- and -coast-aggregated length frequency data (2005, 2006 and 2007) that were used previously are omitted in this run since the model is already fitted to south coast only offshore catch-at-length data for these same years.
4) "Gender-specific selectivity for longline": (Review Panel recommendation A.5) a scaling factor is estimated for the female longline selectivity separately for each of *M. paradoxus* on the West Coast, *M. capensis* on the West Coast and *M. capensis* on the South Coast, so that the female longline selectivities don't necessarily have a maximum of 1. The shape of the male and female selectivities stay the same.
5) " Double normal selectivity - longline only": In the previous RC, the longline fleet selectivities were taken as logistic up to a fixed length, with a decreasing selectivity at larger lengths estimated in the model. In this run, these are replaced by double logistic selectivities, as described in OLRAC (2014). The number of parameters estimated does not change.
6) " Double normal all fleets": as for 5) above, all the commercial selectivities are replaced by the double logistic function. Again, the number of parameters does not change.

7) " Longline selectivity female shift": Three extra parameters are estimated for each of *M. paradoxus* on the West Coast, *M. capensis* on the West Coast and *M. capensis* on the South Coast to "shift" the female longline selectivities (to the right or the left).
8) "Gender-disagg. ll catches + paradoxus ll catches on SC": This run takes into account the data as described in Rademeyer (2014), i.e. gender-disaggregated catches and updated species split (including catches of *M. paradoxus* on the south coast). Some changes to the selectivity functions are also made in order to improve the fit to the CAL data. Details of the fishing selectivities that are used in this run are shown in Table 2.

Results for the proposed RC (run 8) are shown in Figures 1-8. Spawning biomass trajectories are compared to those for RS1-2013e in Figure 1. The estimated stock-recruitment curves and trajectories of recruitment are shown in Figure 2. The estimated survey and commercial selectivities-at-length are plotted in Figures 3 and 4 respectively. The fits to the surveys and CPUE series are shown in Figures 5 and 6 respectively, while the fits to the commercial gender-aggregated and gender-disaggregated length frequencies are shown in Figures 7 and 8 respectively.

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Rademeyer RA. 2014. Taking account of the new longline data in the updated Reference Case for the South African hake resource.

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Smith ADM, Cox S, Parma A and AE Punt. 2013. International Review Panel report for the 2013 International Fisheries Stock Assessment Workshop. 2-6 December 2013, University of Cape Town, South Africa. MARAM IWS(DEC13/General/4.

Table 1: Estimates of management quantities for a series of runs.

		1. RS1-2013e	2. Calibration factors	3. With gender-disaggregated longline CAL	4. Gender-specific selectivity for longline	5. Double normal selectivity - longline only	6. Double normal all fleets	7. Longline selectivity female shift	8. Gender-disagg. ll catches + paradoxus ll catches on SC
	-lnL total	-172.3	-170.0	-100.3	-125.9	-128.5	-131.6	-136.0	-180.2
	CPUE historic	-39.9	-39.9	-40.4	-40.2	-40.3	-40.2	-40.1	-40.5
	CPUE GLM	-168.6	-168.3	-169.7	-168.8	-169.7	-173.6	-173.5	-178.4
	Survey	-32.1	-31.5	-31.5	-30.1	-32.2	-31.9	-32.1	-31.6
	Sex-aggr. CAL - trawl	-45.1	-45.5	-39.8	-41.8	-41.4	-40.4	-41.1	-43.6
	Sex-aggr. CAL - longline	-68.9	-68.2	-16.3	-16.4	-17.3	-17.3	-17.3	-17.1
	Sex-disaggr. CAL - longline	-	-	8.6	-11.5	-11.4	-11.5	-13.9	-52.0
	Survey CAL (sex-aggr.)	-3.0	-2.2	-3.4	-3.0	-2.2	-2.1	-2.4	-1.6
	Survey CAL (sex-disaggr.)	42.9	43.5	43.4	43.9	43.8	44.3	43.1	42.4
	ALK	117.4	117.5	125.1	118.2	118.3	118.0	117.8	117.6
	Recruitment penalty	8.6	8.6	8.4	8.1	8.0	7.6	7.6	8.5
	Selectivity smoothing penalty	15.5	15.8	15.0	15.5	15.6	15.2	15.4	15.9
M. paradoxus	K^{sp}	754	759	838	821	854	883	892	842
	h	0.96	0.96	0.93	0.93	0.93	0.89	0.89	0.91
	B^{sp}_{2012}	114	121	130	132	143	135	142	147
	B^{sp}_{2012}/K^{sp}	0.15	0.16	0.16	0.16	0.17	0.15	0.16	0.18
	B^{sp}_{2013}	108	116	123	127	138	134	141	144
	B^{sp}_{2013}/K^{sp}	0.14	0.15	0.15	0.16	0.16	0.15	0.16	0.17
	B^{sp}_{MSY}	158	158	167	162	169	175	178	154
	B^{sp}_{MSY}/K^{sp}	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.18
	$B^{sp}_{2012}/B^{sp}_{MSY}$	0.72	0.76	0.78	0.82	0.84	0.77	0.80	0.95
	$B^{sp}_{2013}/B^{sp}_{MSY}$	0.68	0.73	0.74	0.79	0.81	0.76	0.79	0.93
	MSY	113	112	112	114	116	113	113	111
M. capensis	K^{sp}	239	239	255	247	248	262	261	231
	h	1.03	1.03	1.14	0.99	0.97	0.98	0.98	1.15
	B^{sp}_{2012}	152	154	164	159	157	163	161	142
	B^{sp}_{2012}/K^{sp}	0.64	0.65	0.64	0.64	0.63	0.62	0.62	0.61
	B^{sp}_{2013}	170	172	183	177	175	182	180	159
	B^{sp}_{2013}/K^{sp}	0.71	0.72	0.72	0.72	0.71	0.69	0.69	0.69
	B^{sp}_{MSY}	96	96	93	100	102	106	105	81
	B^{sp}_{MSY}/K^{sp}	0.40	0.40	0.36	0.41	0.41	0.41	0.40	0.35
	$B^{sp}_{2012}/B^{sp}_{MSY}$	1.58	1.60	1.77	1.58	1.54	1.54	1.54	1.75
	$B^{sp}_{2013}/B^{sp}_{MSY}$	1.76	1.78	1.98	1.76	1.72	1.72	1.72	1.96
	MSY	63	63	65	62	63	65	65	62

Table 2: Details for the commercial selectivity-at-length for each fleet and species combination, as well as indications of what data are available.

	M. paradoxus			*M. capensis*			data available
		No of est. parameters	Comments		No of est. parameters	Comments	
1. West coast offshore							
1917-1976		0	average between 77-84 and 93-2013 period		0	average between 77-84 and 93-2013 period	species combined
1977-1984		3	double logistic (σ_{Left}, σ_{Right} and l_{max})		0	as 93-13 but σ_{Left} same difference as for paradoxus btw 77-84 and 93-13 periods	
1985-1992		0	linear change between 1984 and 1993 selectivity		0	linear change between 1984 and 1993 selectivity	
1993-2013		3	double logistic (σ_{Left}, σ_{Right} and l_{max})		0	Based on inshore selectivity: l_{max}=l_{max}(inshore)+5, σ_{Left}=σ_{Left}(inshore) and σ_{Right}=3*σ_{Right}(inshore)	
2. South coast offshore							
1917-1976		0	double logistic (σ_{Left}, σ_{Right} and l_{max})		0	average between 77-84 and 93-2013 period	species combined
1977-1984		0	double logistic (σ_{Left}, σ_{Right} and l_{max})		0	as 93-13 but σ_{Left} same difference as for paradoxus btw 77-84 and 93-13 periods	
1985-1992		0	linear change between 1984 and 1993 selectivity		0	linear change between 1984 and 1993 selectivity	
1993-2013		3	double logistic (σ_{Left}, σ_{Right} and l_{max})		0	Based on inshore selectivity: l_{max}=l_{max}(inshore)+5, σ_{Left}=σ_{Left}(inshore)	
		0	female downscaling factor (av. of SC spring and autumn surveys's factors)				
3. South coast inshore		-	-		3	double logistic (σ_{Left}, σ_{Right} and l_{max})	*M. capensis*
4. West coast longline							
1984-1999	Males	3	$l_{max}^{84\text{-}99}$=$l_{max}^{00\text{-}05}$-δ_1^{WCpara} (δ_1^{WCpara}	Males	3	$l_{max}^{84\text{-}99}$=$l_{max}^{00\text{-}05}$-δ_1^{WCcap} (δ_1^{WCcap}	species and gender combined
	Females	3	estimated, same for males and females)	Females	3	estimated, same for males and females)	
2000-2005	Males	1	double logistic (σ_{Left}, σ_{Right} and l_{max})	Males	1	double logistic (σ_{Left}, σ_{Right} and l_{max})	species and gender disaggregated
	Females	0	double logistic (σ_{Left}, σ_{Right} and l_{max})	Females	0	double logistic (σ_{Left}, σ_{Right} and l_{max})	
2006-2013	Males	1	$l_{max}^{06\text{-}13}$=$l_{max}^{00\text{-}05}$-δ_2^{WCpara} (δ_2^{WCpara}	Males	1	$l_{max}^{06\text{-}13}$=$l_{max}^{00\text{-}05}$-δ_2^{WCcap} (δ_2^{WCcap}	
	Females	0	estimated, same for males and females)	Females	0	estimated, same for males and females)	
5. South coast longline							
1984-1999	Males	1	double logistic (σ_{Left}, σ_{Right} and l_{max})	Males	1	double logistic (σ_{Left}, σ_{Right} and l_{max})	species and gender combined
	Females	0	double logistic (σ_{Left}, σ_{Right} and l_{max})	Females	0	double logistic (σ_{Left}, σ_{Right} and l_{max})	
2000-2005	Males	3	$l_{max}^{00\text{-}05}$=$l_{max}^{84\text{-}99}$-δ_1^{SCpara} (δ_1^{SCpara}	Males	3	$l_{max}^{00\text{-}05}$=$l_{max}^{84\text{-}99}$-δ_1^{SCcap} (δ_1^{SCcap} estimated,	species and gender disaggregated
	Females	3	estimated, same for males and females)	Females	3	same for males and females)	
2006-2013	Males	1	$l_{max}^{06\text{-}13}$=$l_{max}^{84\text{-}99}$-δ_2^{SCpara} (δ_2^{SCpara}	Males	1	$l_{max}^{06\text{-}13}$=$l_{max}^{84\text{-}99}$-δ_2^{SCcap} (δ_2^{SCcap} estimated,	
	Females	0	estimated, same for males and females)	Females	0	same for males and females)	
6. South coast handline		-	-		0	parameters taken as average of SC longline (female, 00-05) and inshore parameters	-
Total		25			19		

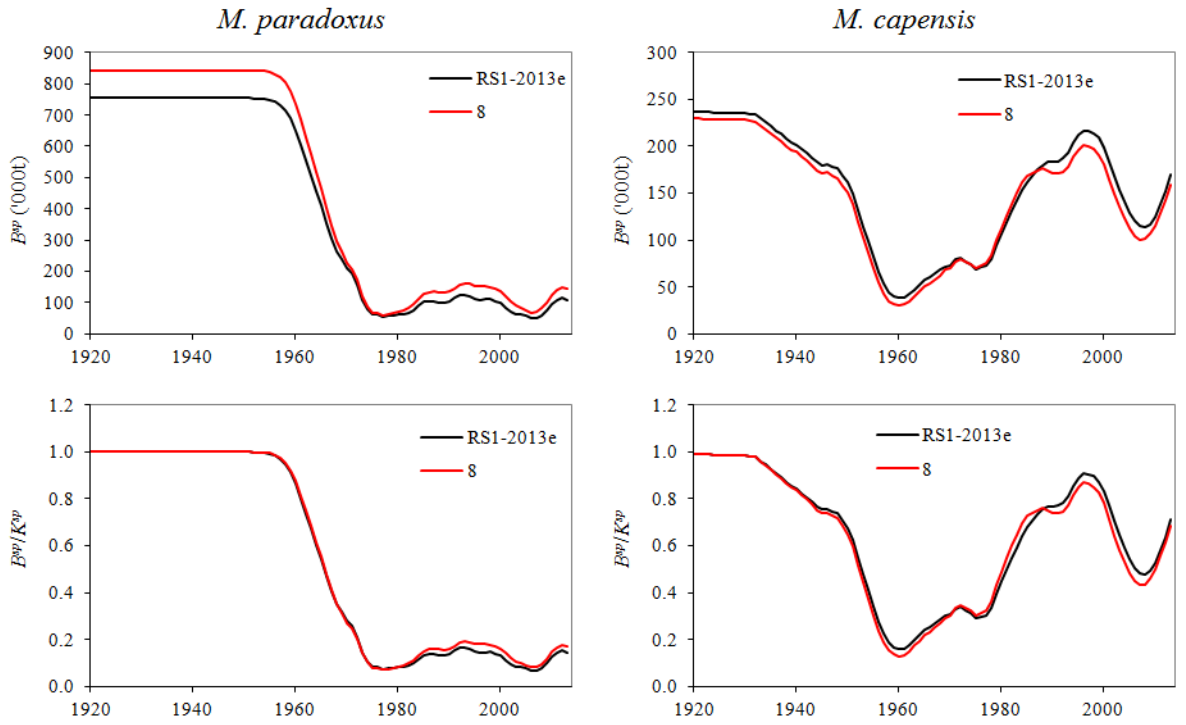

Figure 1: Spawning biomass trajectories (in absolute terms and relative to pre-exploitation level) for RS1-2013e and run 8 (the proposed RC).

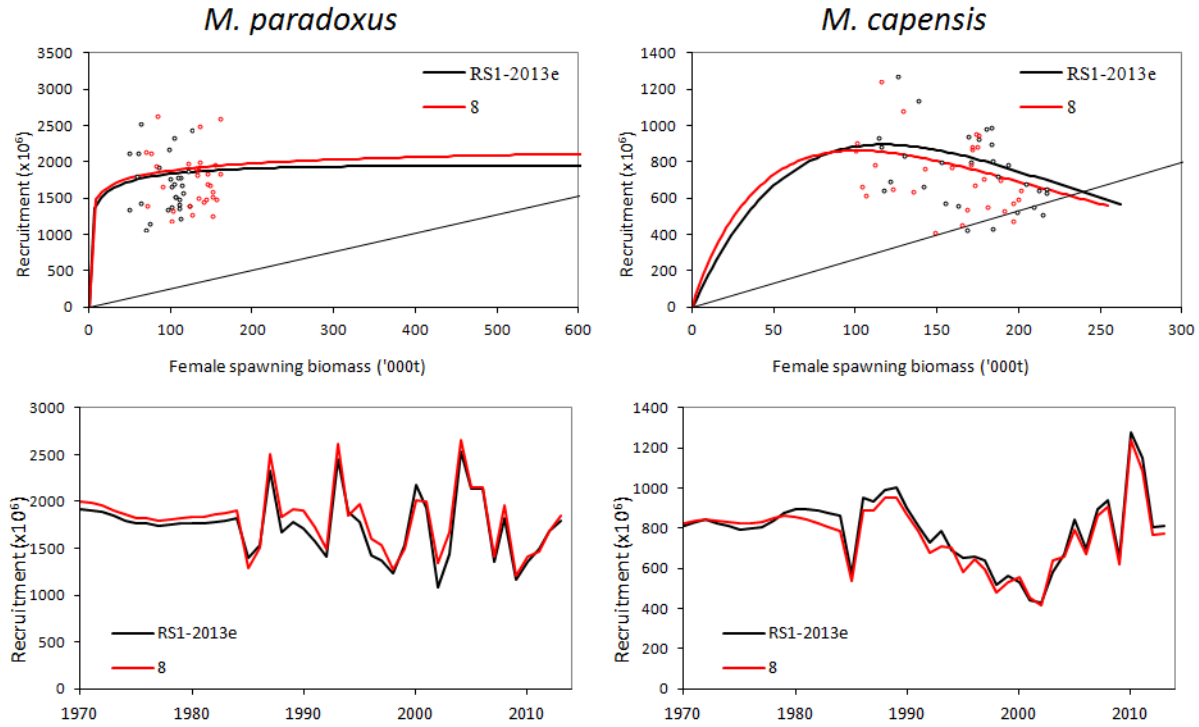

Figure 2: Stock-recruitment curves and recruitment trajectories for RS1-2013e and run 8 (the proposed RC).

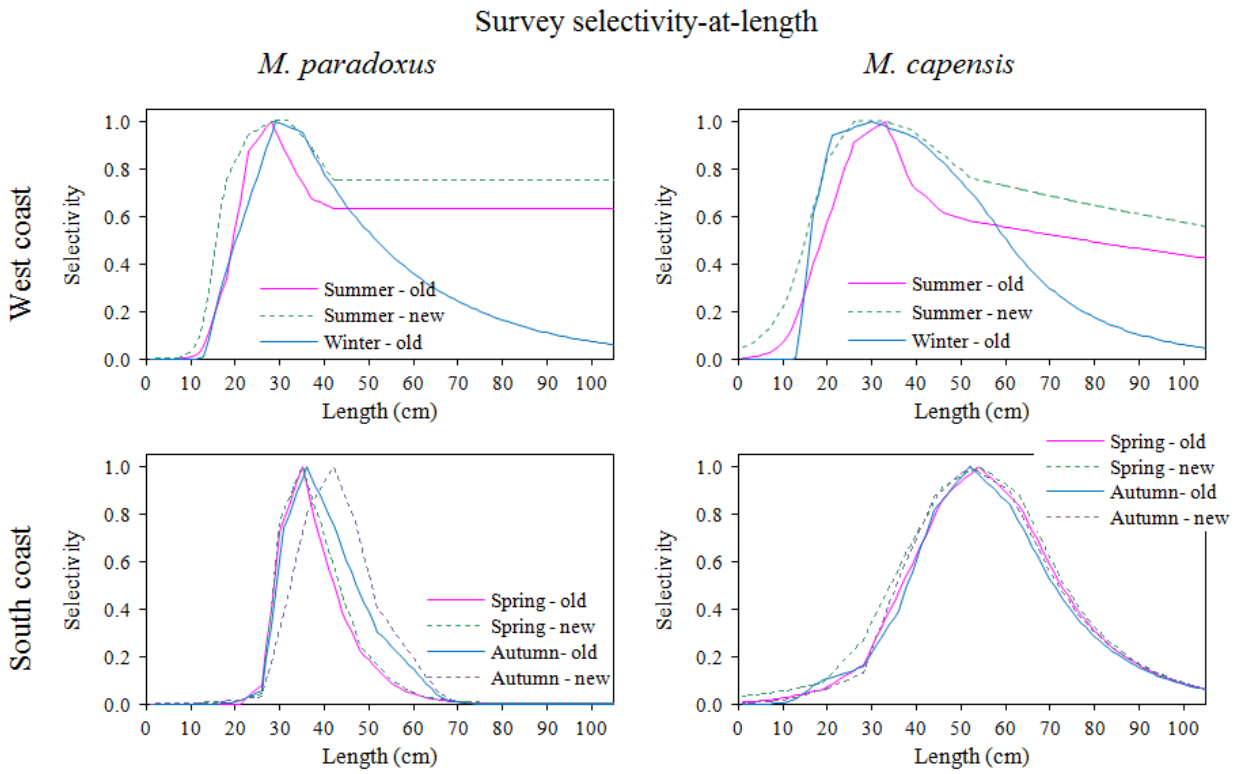

Figure 3: Survey selectivities-at-length for run 8 (the proposed RC).

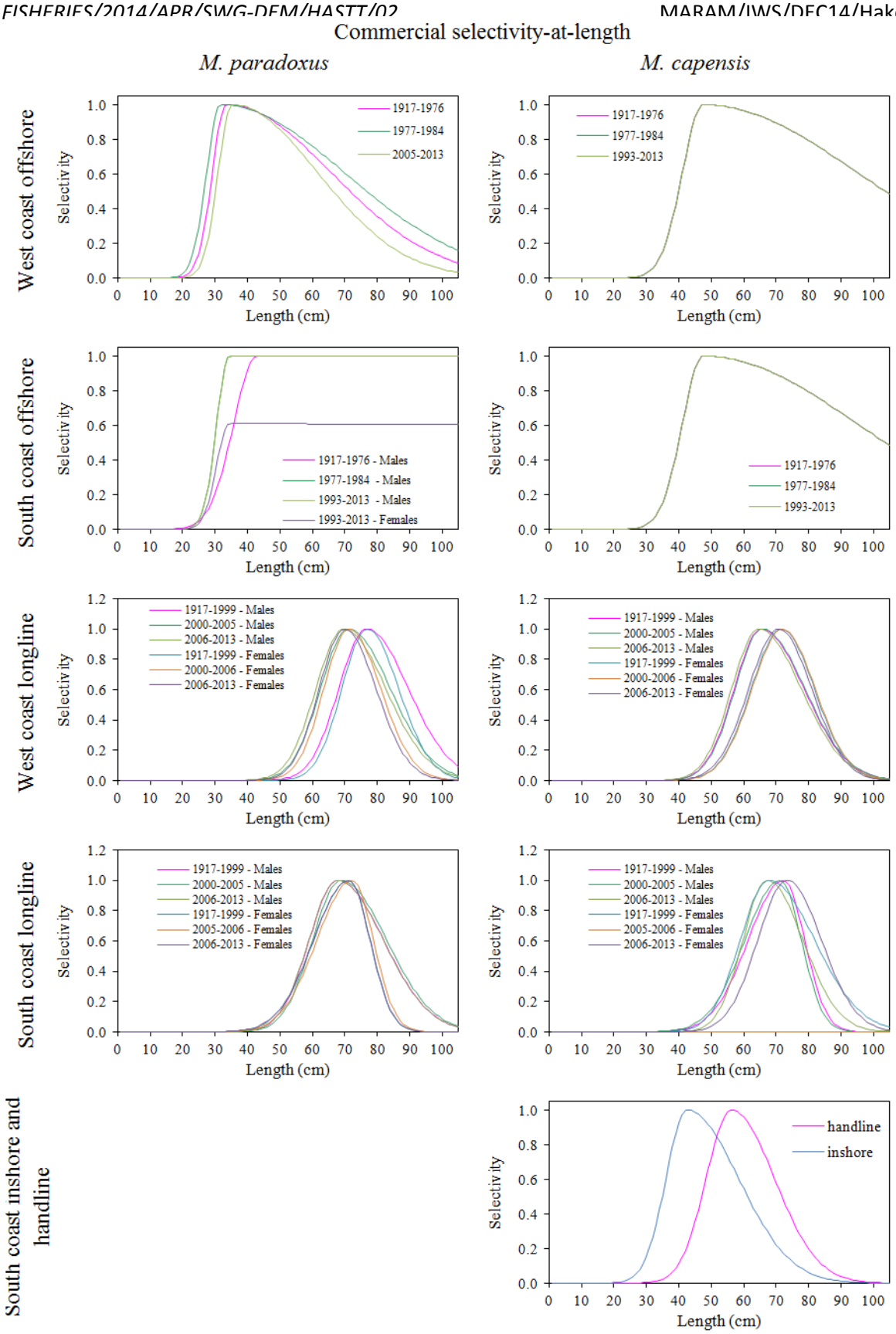

Figure 4: Commercial selectivity-at- length for run 8 (the proposed RC).

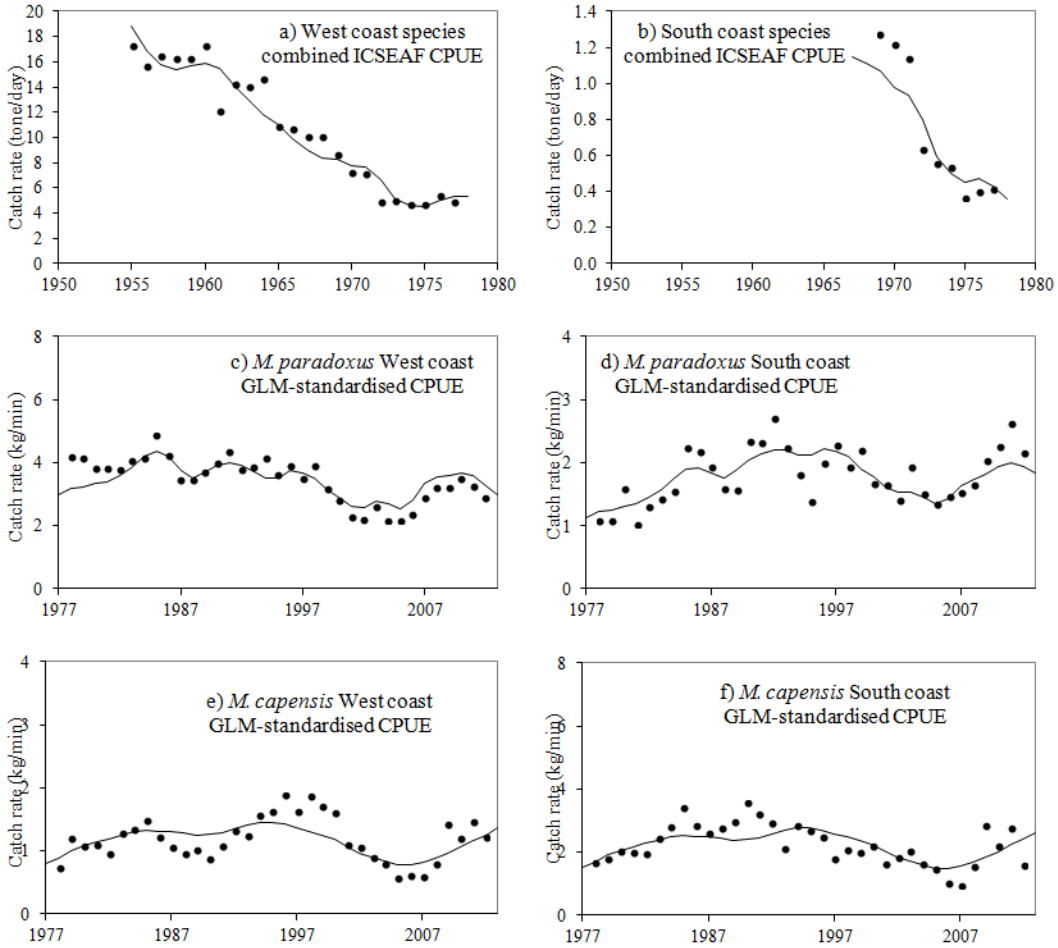

Figure 5: Fit to the CPUE series for run 8 (the proposed RC).

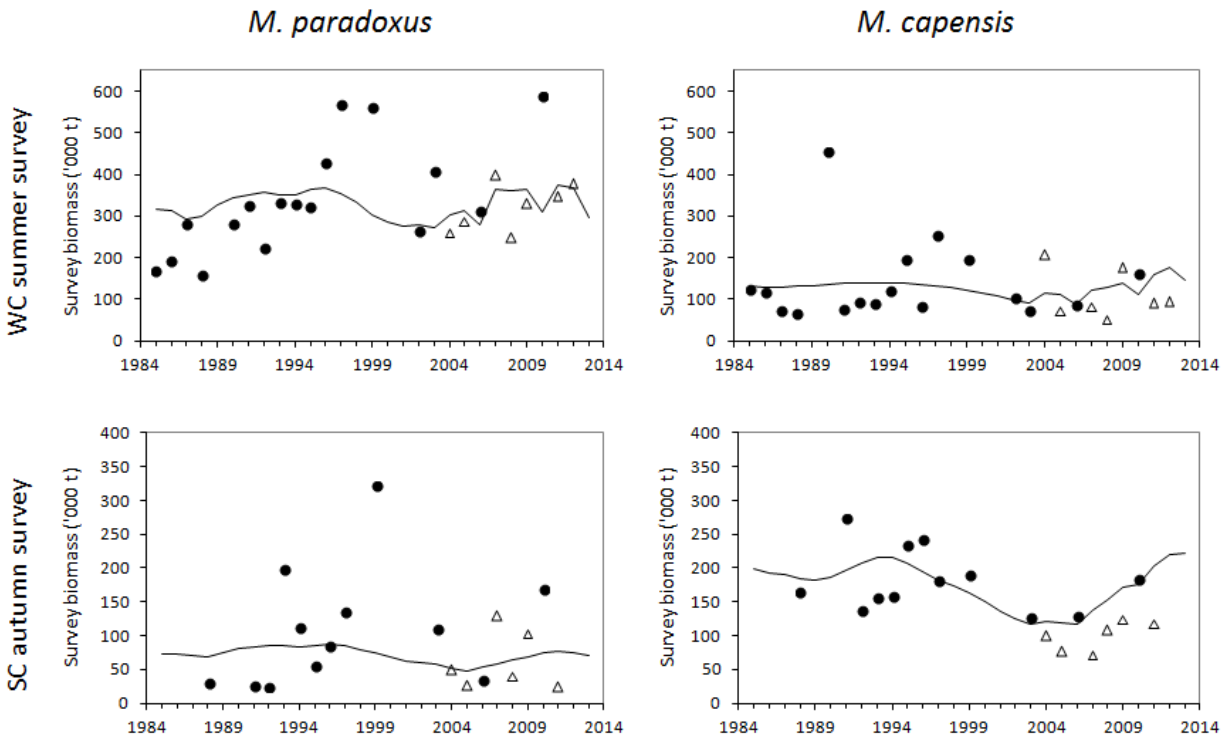

Figure 6: Fit to the survey series for run 8 (the proposed RC).

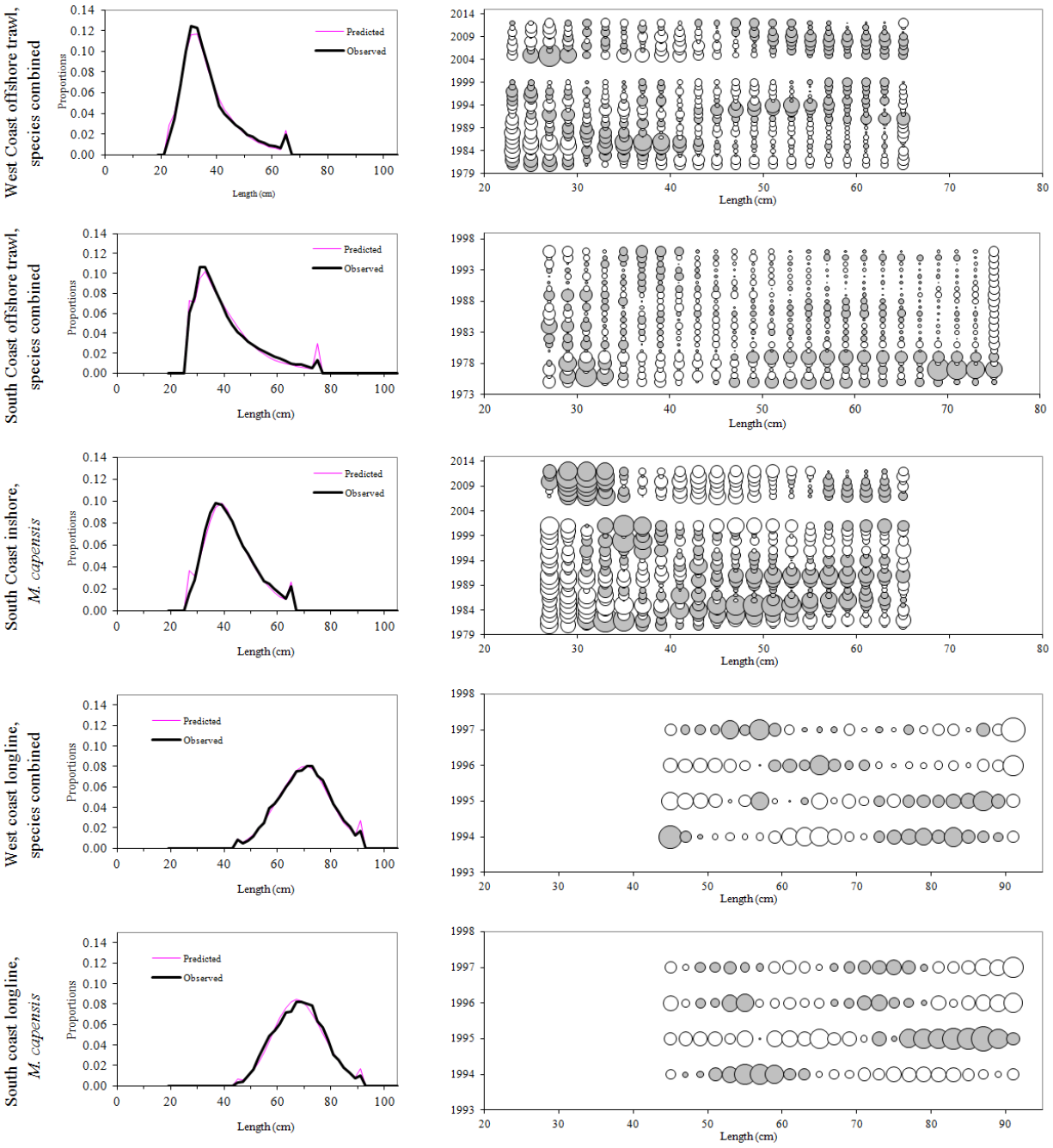

Figure 7: Fit to the commercial sex-aggregated catch-at-lengths for run 8 (the proposed RC).

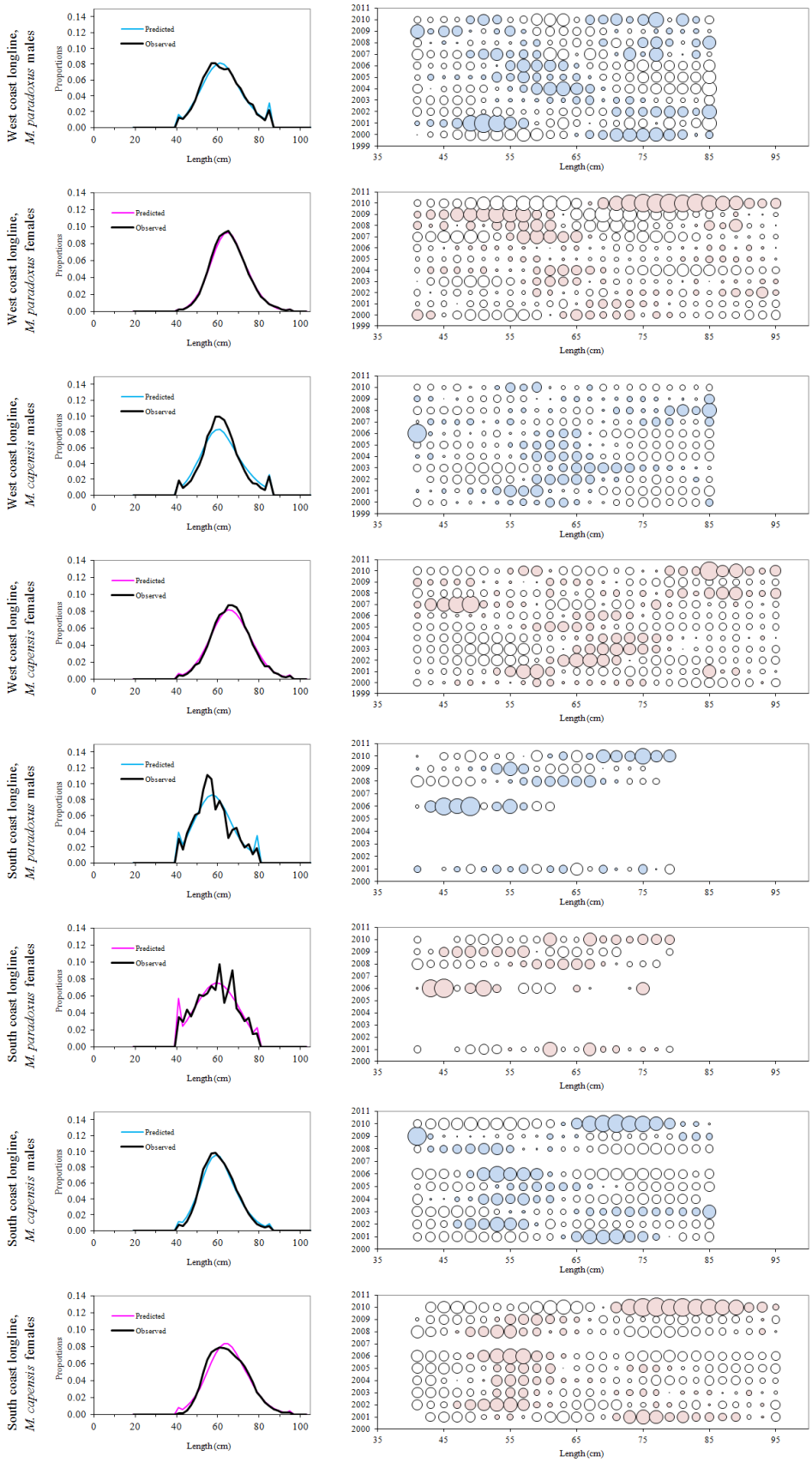

Figure 8: Fit to the commercial sex-disaggregated catch-at-lengths for run 8 (the proposed RC).