



Development of a new Baseline Assessment for the South African Hake resource, Incorporating catch-at-length information

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INTRODUCTION

Results are presented for a proposed new baseline assessment for the South African hake resource, incorporating catch-at-length (CAL) information in the fit of the model. In years for which age-length keys are not available, CAL information is used instead of catches-at-age (CAA) which had been previously based on averages of age-length keys for other years (a problematic and potentially biased approach). Further changes to the model and the data that have been made are described below.

DATA and METHODOLOGY

The data used in the new proposed baseline, but not in the 2008 baseline (as described in Rademeyer and Butterworth, 2008) are listed in Appendix A.

Updates to the model from the 2008 baseline assessment:

I. Using Pope's approximation

To speed model fitting, Pope's approximation for the catch equations was used rather than Baranov's equation.

II. Incorporating catch-at-length information

Appendix B sets out how CAL information is taken into account in the model fitting.

III. Estimating west coast winter survey selectivity for *M. paradoxus*

In previous assessments, the selectivity-at-age for this survey and species was assumed to be the same as that for the west coast summer survey because no west coast winter survey CAA data for *M. paradoxus* were available. Some age and length data are now available for these west coast surveys so that a different selectivity is estimated for the two seasons for *M. paradoxus* (as is done for *M. capensis*).

IV. Fitting to commercial coast-specific information

Previously, the model fit was coast-specific only for the survey data, while GLM-standardized CPUE, commercial catches and CAA information were combined across the two coasts and a single selectivity-at-age vector (for each fleet) was assumed to apply. The model is now fit to coast-specific commercial information. This was carried out by treating the offshore trawl fleet on the south and west coasts as two different fleets, with potentially different selectivities-at-age, and similarly for the longline fleet. The model therefore now includes six fleets:

- 1) west coast offshore fleet (catching *M. paradoxus* and *M. capensis*);
- 2) south coast offshore fleet (catching *M. paradoxus* and *M. capensis*);
- 3) south coast inshore fleet (catching *M. capensis* only);

- 4) west coast longline fleet (catching *M. paradoxus* and *M. capensis*);
- 5) south coast longline fleet (catching *M. capensis* only); and
- 6) south coast handline fleet (catching *M. capensis* only).

The annual catches of each species assumed for each of these six fleets are shown in Table App.A.1, while the commercial age and length information is shown in Tables App.A.11-15. As age/length information is not available disaggregated by species and therefore not available for each species/fleet combination, fishing selectivity-at-age cannot be estimated directly for all fleets and some assumptions have to be made. Details of the fishing selectivities used in the assessment are shown in Table 1.

V. Different selectivity for the *Africana* surveys with new gear

A different selectivity is estimated for the *Africana* with new gear, for the west coast summer and south coast (spring and autumn) surveys. As for the other survey selectivities, the *Africana* new gear selectivity is estimated separately for each age, from age 0 to 5+/7+ for *M. paradoxus* and *M. capensis* respectively. However, because the information available is length-based and only 3 or 4 years of data are available, a smoothing penalty was added to the negative log-likelihood in the fitting process to prevent unrealistically large variations in selectivity from one age to the next:

$$S_penalty = \sum_{a=1}^{z-1} 3(S_{a-1} - 2S_a + S_{a+1})^2 \quad (1)$$

The initial 3 multiplicative factor is a somewhat arbitrary weighting to ensure reasonable smoothness of the selectivity. For consistency, this smoothing penalty was also used for the old gear selectivity.

VI. Further three years of offshore commercial catch-at-length

Offshore trawl (species combined) CAL information has become available for 2005 to 2007 and has been taken into account in fitting the model. This is however only available combined across coasts, and is therefore compared to the predicted coast combined CAL, weighted by the actual catch on each coast.

RESULTS AND DISCUSSION

Table 2 compares estimates of management quantities for the 2008 baseline and the proposed new baseline assessment, while Fig. 1 plots the spawning biomass trajectories. For both *M. paradoxus* and *M. capensis*, the spawning biomass in absolute terms is estimated to be larger in the proposed new baseline assessment than in the 2008 baseline assessment. Relative to pre-exploitation levels however, spawning biomass is not much affected by the changes made.

Fig. 2 plots the estimated selectivities-at-age for the commercial fleets and the surveys. The new gear on the *Africana* is estimated to catch slightly smaller fish than the old gear, particularly for *M. capensis*.

Figs 3 and 4 show the fits the CPUE and survey abundance series. The fits to these data are generally good.

The fits to the commercial CAA and CAL data are show in Fig. 5. The fits are poor for certain CAL (West Coast Offshore, Both Coasts Offshore particularly, and the inshore *M. capensis* CAA). The likely reason for this is a conflict between the CAA and CAL information. For example, for the offshore trawl fleet (west coast and both coasts) the observed length distribution of the catch is very narrow compared to a relatively wide range of ages observed in the CAA.

As described in Appendix B, a selectivity-at-length effect had to be incorporated to allow for a reasonable fit of the survey CAL data. The effects on the estimated CAL distributions by age are shown in Fig. 6 for each species and survey. For both species, the effect is negligible for the south coast spring survey and greatest on the west coast surveys. The actual fits to the survey CAA and CAL are shown in Fig. 7. The fits are particularly poor for the *M. capensis* west coast summer CAL and south coast *M. paradoxus*, again likely due to a conflict between the CAA and CAL information. Note that the selectivity on the south coast is assumed to be the same for the spring and autumn surveys.

Fig. 8 plots the standardised stock-recruitment residuals and the estimated stock-recruitment relationships for *M. paradoxus* and *M. capensis*. Note that the “SR2” option is still used, with σ_R linearly decreasing from 0.25 to 0.1 over the 2004 to 2008 period.

The spawning biomass trajectories for two retrospective assessments are compared to those estimated in the proposed new baseline assessment (Fig. 9). For the retrospective analysis, the assessments are still run to 2008 but are fitted to data up to 2007 (“data to 2007”) and 2006 (“data to 2006”). A small retrospective pattern is apparent for *M. capensis* but not for *M. paradoxus*. There is a slight upturn in spawning biomass for both species from 2006 to 2007, which is likely a reflection of better recruitment indicated for recent years compared to the low values from the mid-1990s to 2003 (see Fig. 8).

An interesting feature of the new baseline assessment is that the estimates of natural mortality at age (see Table 2) are lower, which seems more realistic biologically.

The proposed new baseline assessment will be used for the sensitivities analyses to be conducted in the light of discussions during the WG meetings. While this new baseline is not entirely satisfactory given the misfits to some of the catch-at-length data, this does seem to be arising primarily from data conflicts which alternative models will not resolve at this stage. Further resolution attempts seem better to wait for analyses that treat the age readings in a better statistical manner, perhaps also distinguishing the sexes with their different growth curves.

REFERENCES

Rademeyer RA and Butterworth DS. 2008. 2008 routine update of the South African hake baseline assessment. Unpublished report, Marine and Coastal Management, South Africa. MCM/2008/SEPT/SWG-DEM/48. (13pp)

Table 1: Details for the commercial selectivity-at-age for each fleet and species combination, as well as indications of what data are available, for the proposed new baseline assessment.

	<i>M. paradoxus</i>	<i>M. capensis</i>	data available
1. West coast offshore			
1917-1976	set equal to 1989	set equal to 1989	
1977-1984	logistic, two parameters estimated slope estimated	same shift as paradoxus zero slope	species combined
1985-1992	linear change between 1984 and 1993 selectivity		species combined
1993-2008	logistic, two parameters estimated slope estimated	same as SC inshore but shifted to the right by 1 year, zero slope	species combined
2. South coast offshore			
1917-1976	set equal to 1989	set equal to 1989	
1977-1984	same shift as west coast slope as 1993-2008	same shift as paradoxus zero slope	species combined
1985-1992	linear change between 1984 and 1993 selectivity		species combined
1993-2008	logistic, two parameters estimated slope estimated	same as SC inshore but shifted to the right by 1 year, zero slope	species combined
3. South coast inshore		logistic, two parameters estimated slope estimated	capensis
4. West coast longline	logistic, two parameters estimated zero slope	same as South coast longline	species combined
5. South coast longline		logistic, two parameters estimated zero slope	capensis
6. South coast handline		average of South coast longline and inshore	

Table 2: Comparison of management quantities for the 2008 baseline assessment (D) and the proposed new baseline assessment. Note that the negative log likelihoods shown are not comparable as they are based on different data sets. Note that the fitting criteria used includes a penalty to encourage $M_2 > M_5$.

		2008 baseline (D)	new baseline
-lnL total		-192.1	-40.9
<i>M. paradoxus</i>	K^{sp}	1407	1821
	h	0.95	0.95
	MSY	116	114
	B^{sp}_{2008}/K^{sp}	216	265
	B^{sp}_{2008}/K^{sp}	0.15	0.15
	$B^{sp}_{2008}/MSYL^{sp}$	0.64	0.82
	$MSYL^{sp}$	0.24	0.18
	M	0	0.52
		1	0.52
		2	0.52
		3	0.44
	4	0.38	
	5+	0.35	
<i>M. capensis</i>	K^{sp}	692	871
	h	0.95	0.95
	MSY	81	86
	B^{sp}_{2008}	434	501
	B^{sp}_{2008}/K^{sp}	0.63	0.57
	$B^{sp}_{2008}/MSYL^{sp}$	2.01	2.31
	$MSYL^{sp}$	0.31	0.25
	M	0	1.00
		1	1.00
		2	1.00
		3	0.73
		4	0.57
		5	0.46
		6	0.46
	7+	0.46	
SC survey q		0.59	0.49
2008 species ratio	B^{sp}	2.07	1.89
(<i>paradoxus/capensis</i>)	B^{2+}	1.84	1.66

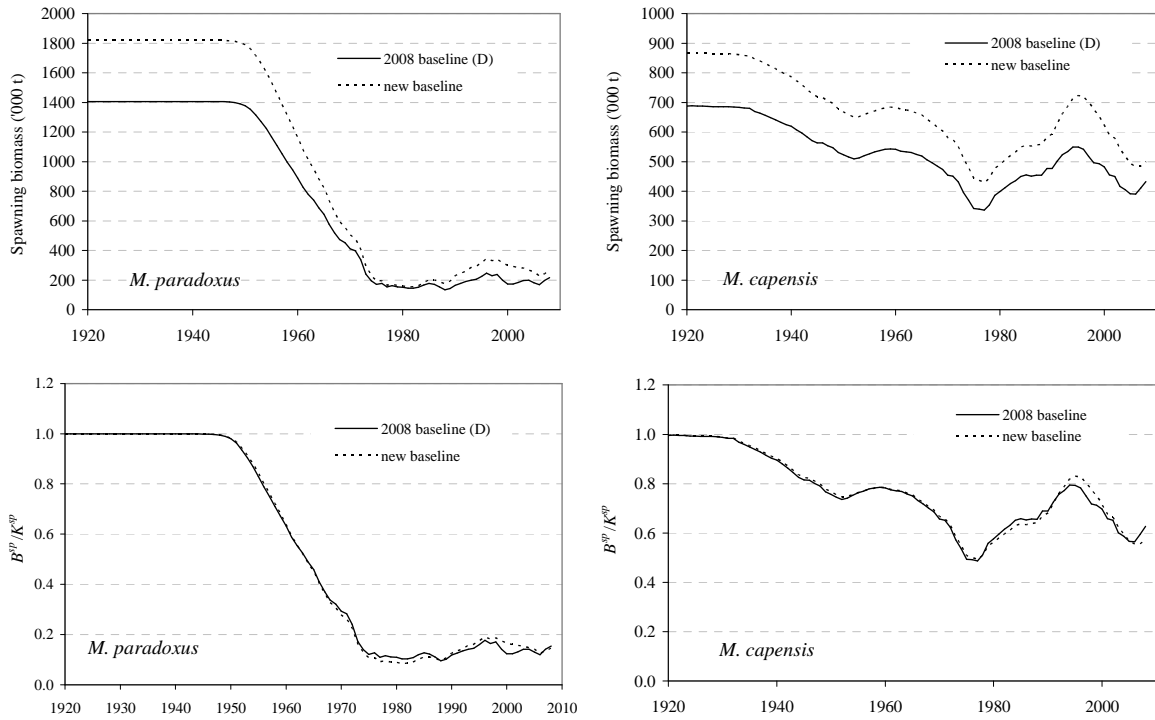


Fig. 1: *M. paradoxus* and *M. capensis* spawning biomass trajectories for the 2008 baseline and proposed new baseline assessments.

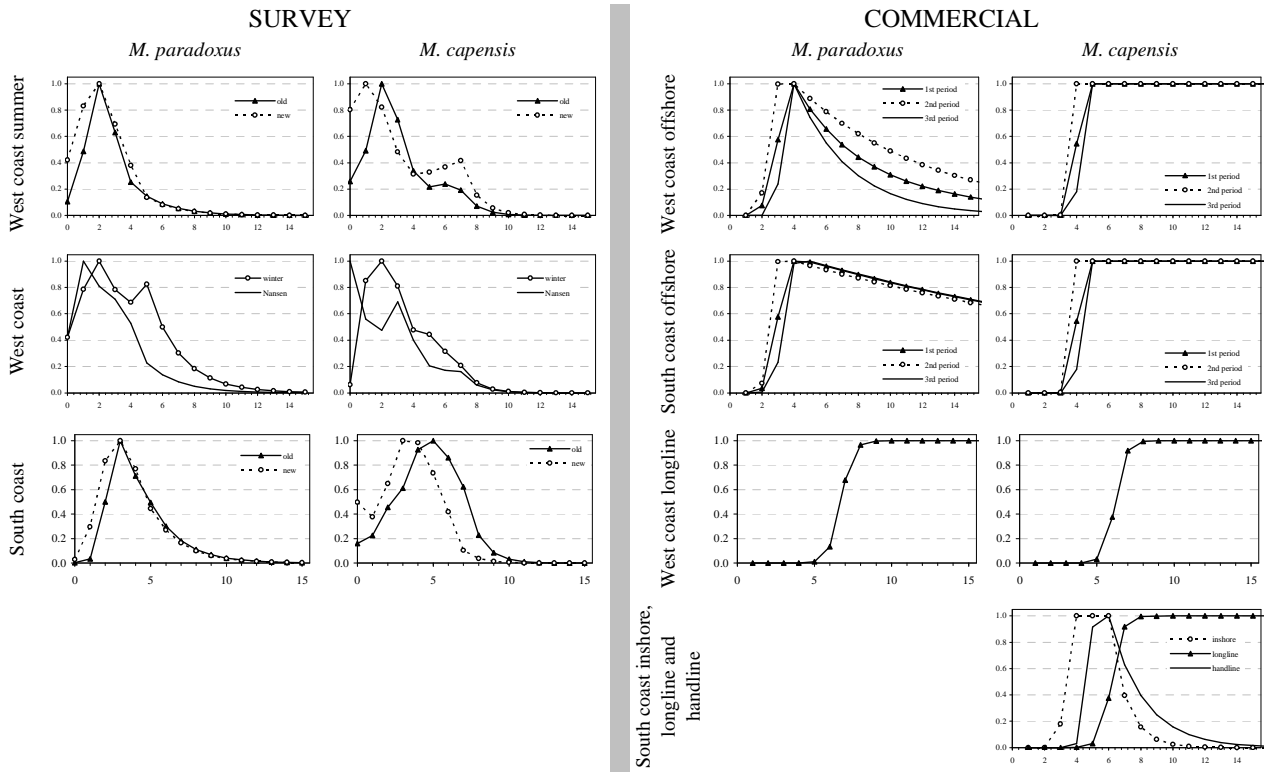


Fig. 2: Estimated survey and commercial fishing selectivities-at-age for the proposed new baseline assessment.

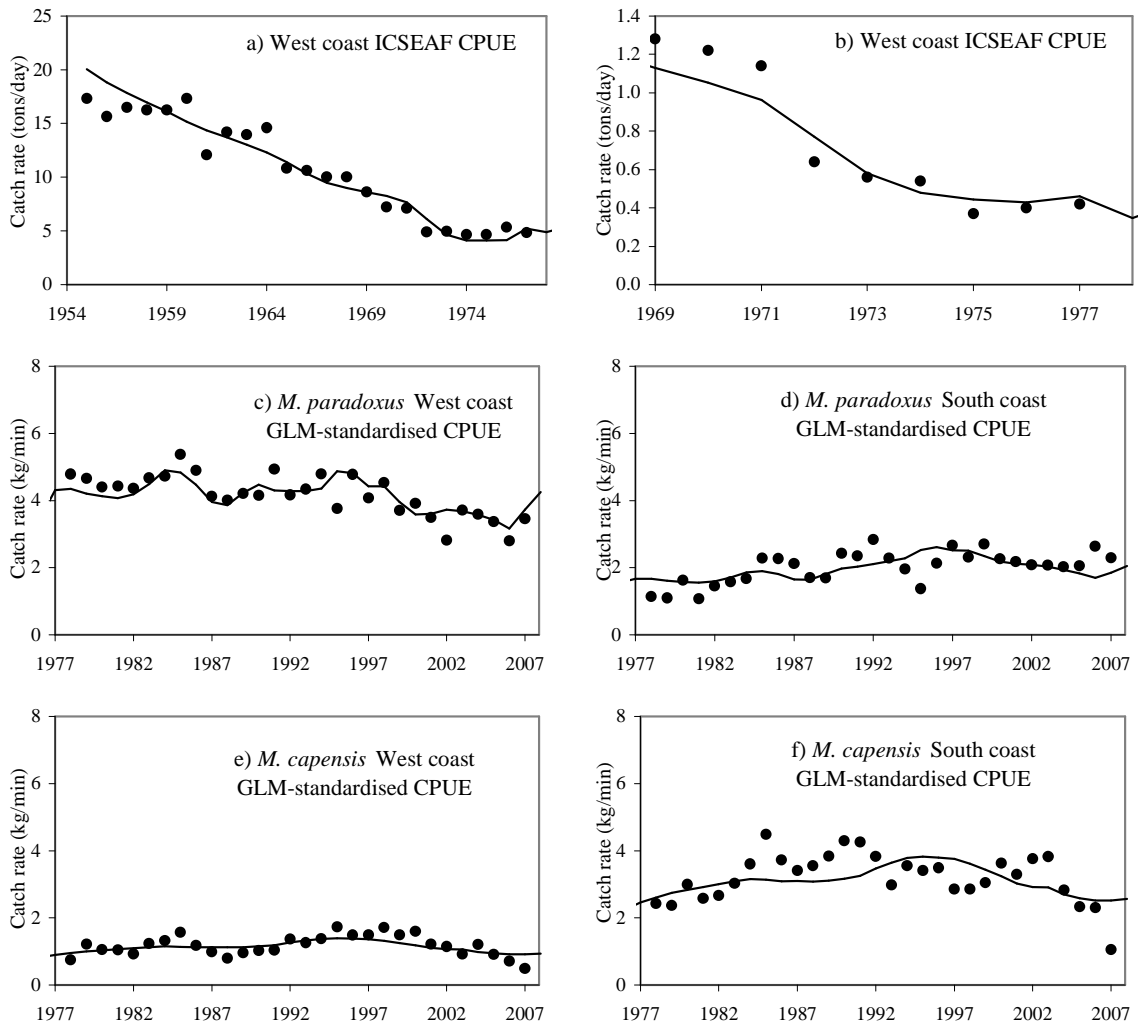


Fig. 3: Fits to the CPUE abundance indices for the proposed new baseline assessment. The historic (pre-1978) CPUE data are for both *M. capensis* and *M. paradoxus* combined.

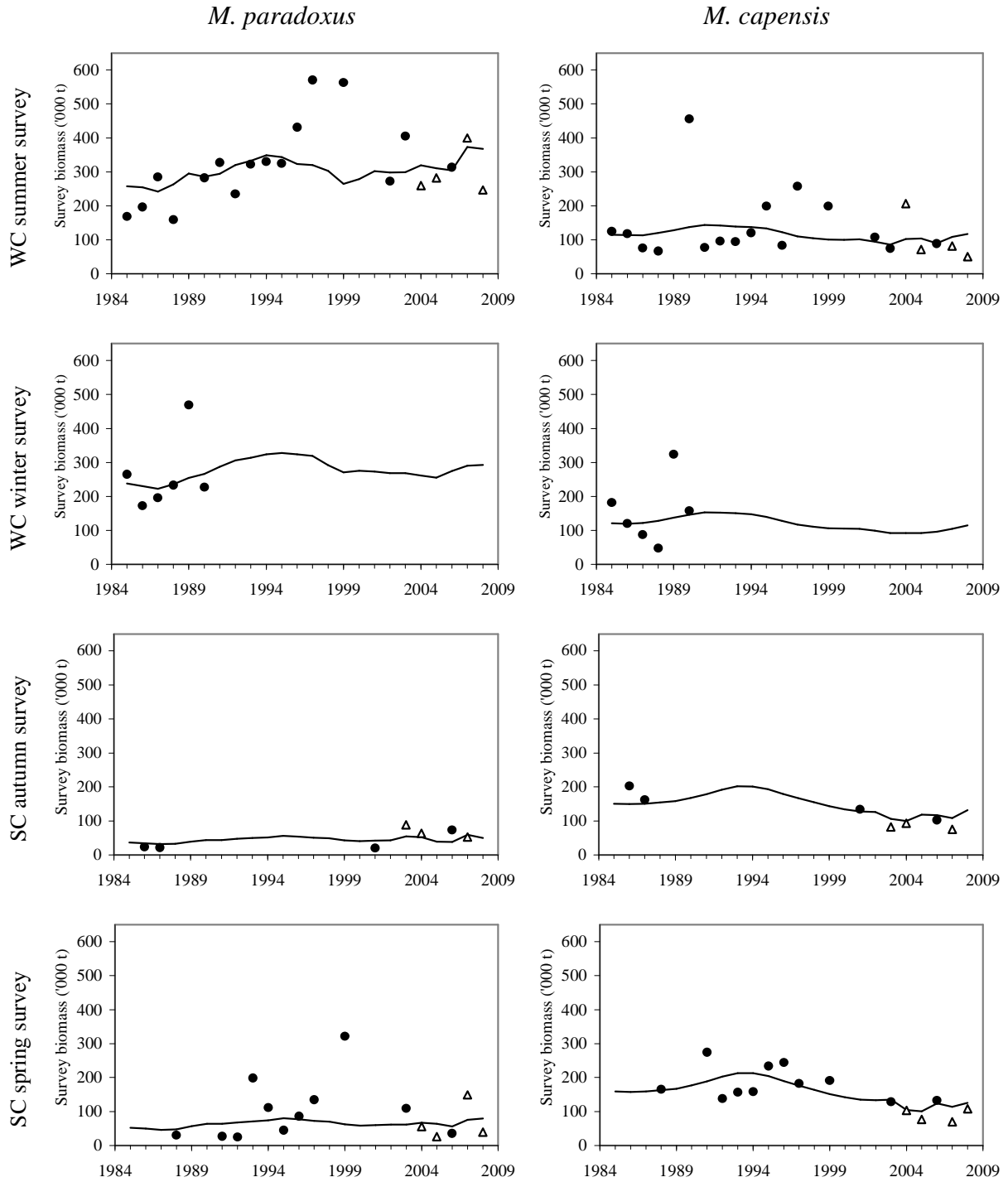


Fig. 4: Fits to the west coast summer and south coast autumn abundance series from surveys by *Africana* (the two longest series) for the proposed new baseline assessment. The observed values shown as Δ were conducted by the *Africana* with the new gear and have been rescaled by the agreed calibration factor for the species concerned (0.95 and 0.8 for *M. paradoxus* and *M. capensis* respectively). Note: the estimated survey biomass trends incorporate the change in selectivity between the old and new *Africana* gear.

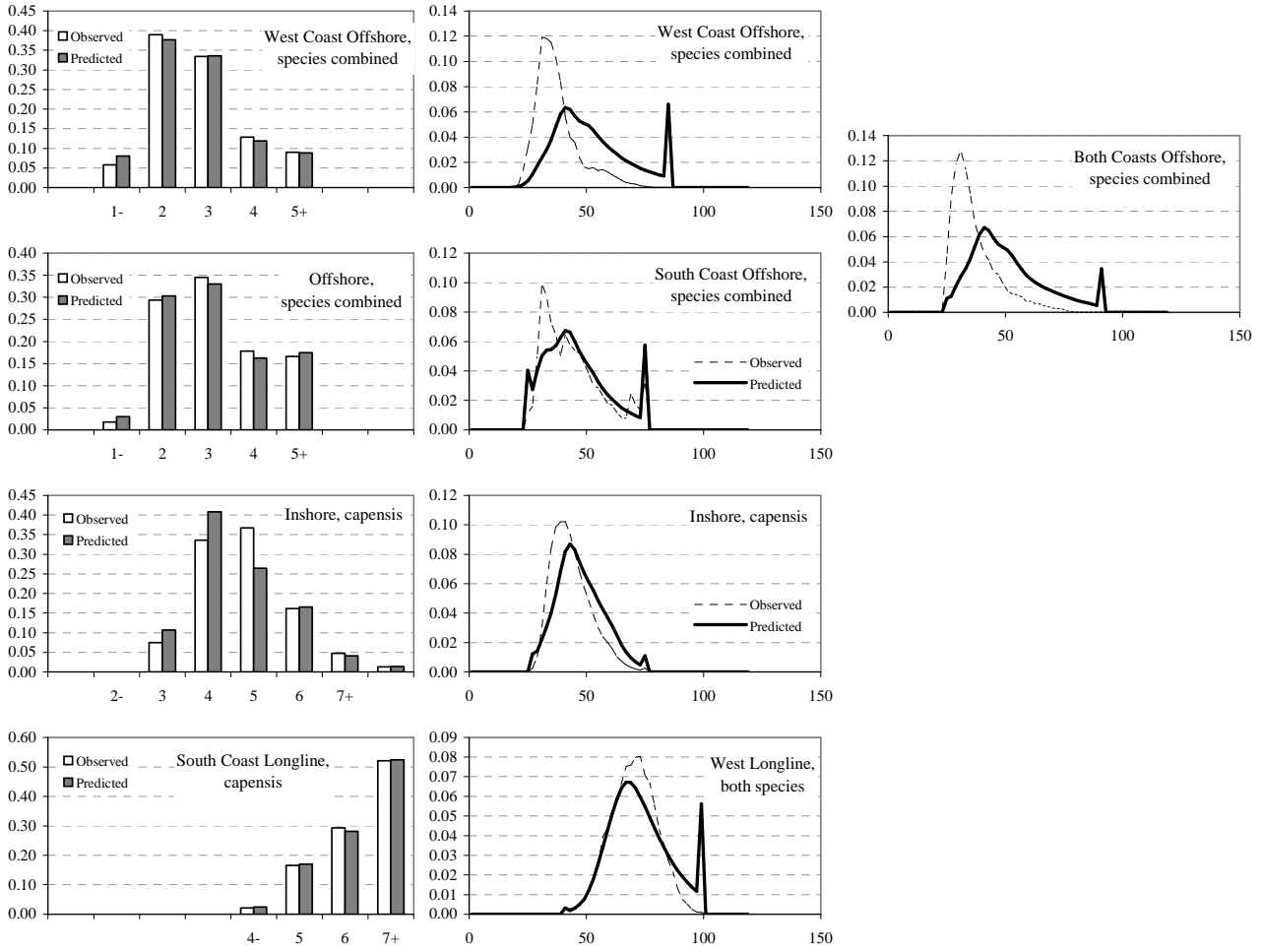


Fig. 5: Fit to the commercial CAA and CAL data for the proposed new baseline assessment.

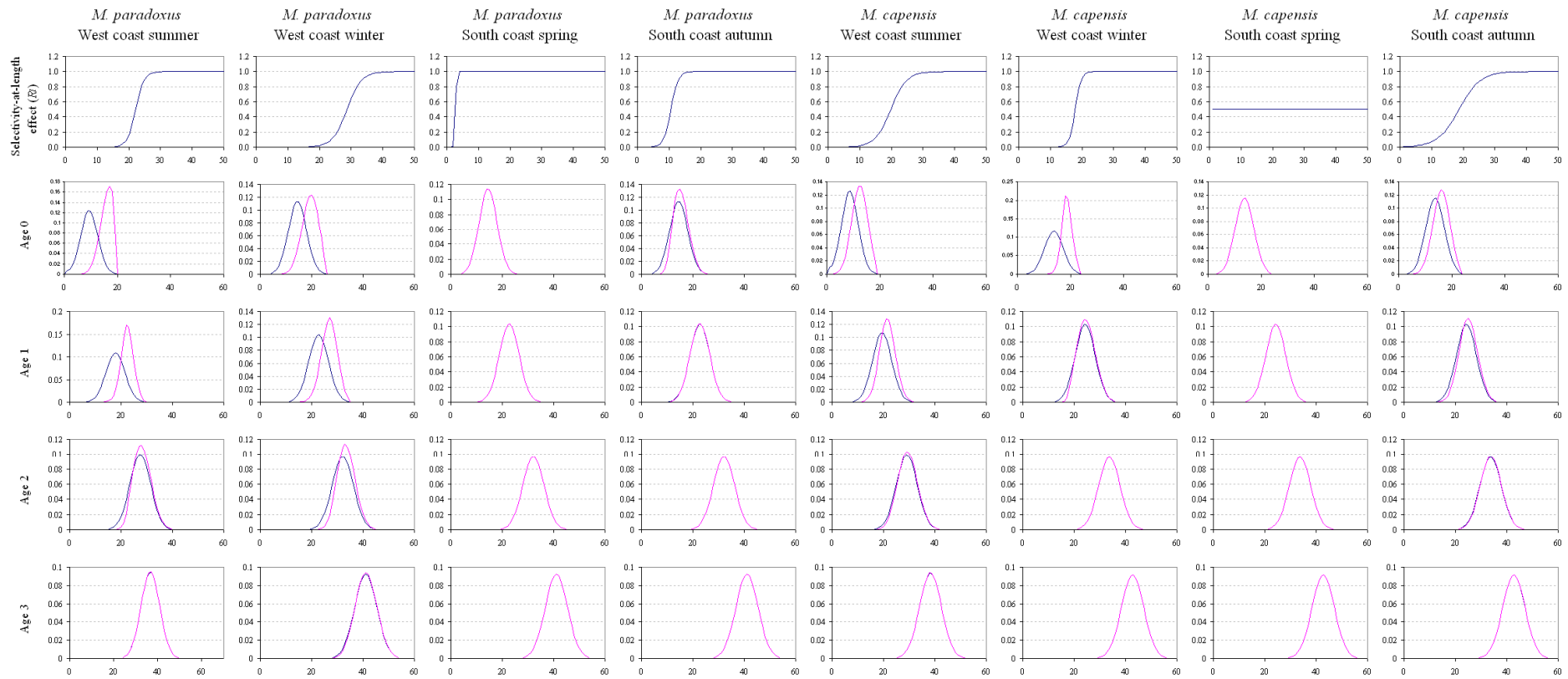


Fig 6: Survey selectivity-at-length effect in the proposed new baseline assessment (see Appendix B for details). The first row shows the R_l factor (see equation B.7), and the remaining rows show the consequent shifts in the catch-at-length distributions by age. The length units are cm.

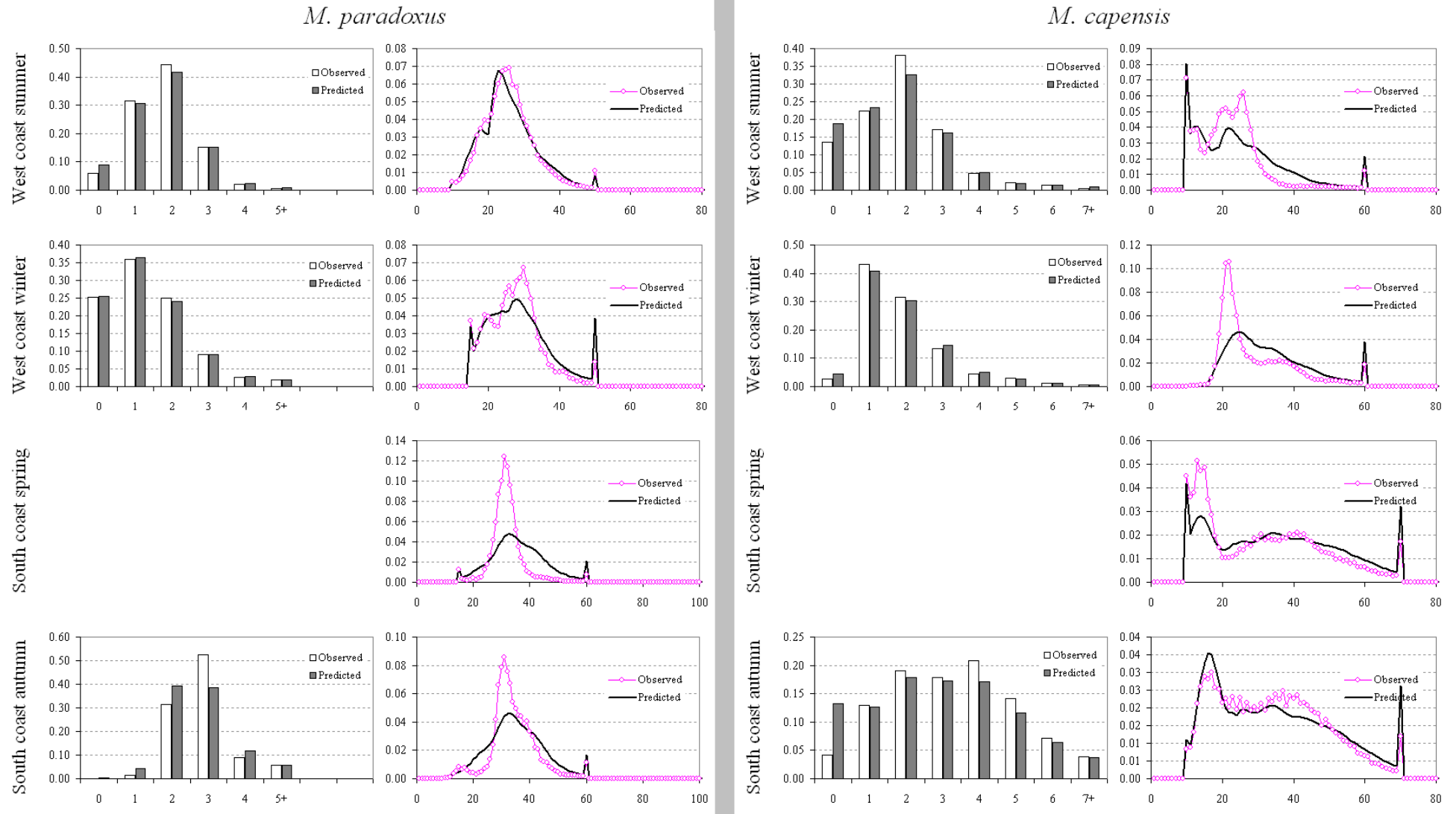


Fig. 7: Fit to survey CAA and CAL for *M. paradoxus* for the proposed new baseline assessment.

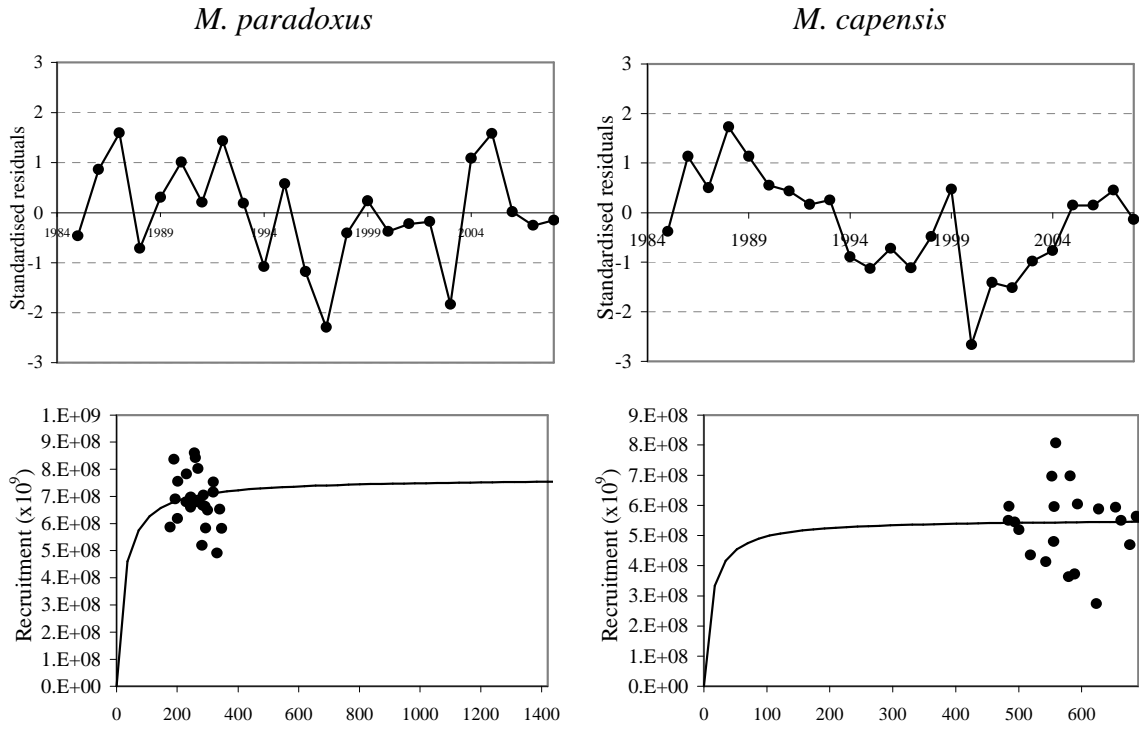


Fig. 8: Time series of standardised stock-recruitment residuals and estimated stock-recruitment relationships for the proposed new baseline assessment.

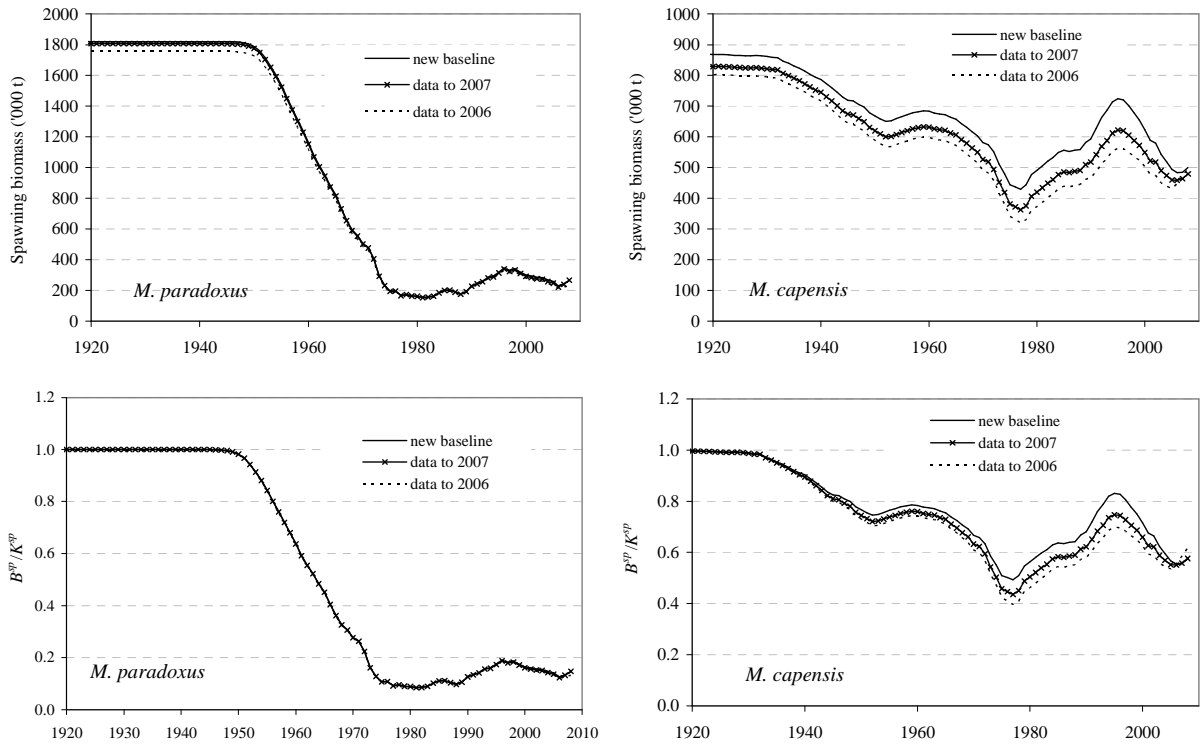


Fig. 9: *M. paradoxus* and *M. capensis* spawning biomass trajectories for the proposed new baseline and two retrospective assessments.

Appendix B – Age data used

Table App.A.1: Assumed annual catches disaggregated by species, fleet and coast in thousand tons.

	<i>M. paradoxus</i>			<i>M. capensis</i>					
	Offshore		Longline	Offshore		Inshore	Longline		Handline
	West Coast	South Coast	West Coast	West Coast	South Coast	South Coast	West Coast	South Coast	South Coast
1917	-	-	-	1.000	-	-	-	-	-
1918	-	-	-	1.100	-	-	-	-	-
1919	-	-	-	1.900	-	-	-	-	-
1920	-	-	-	0.000	-	-	-	-	-
1921	-	-	-	1.300	-	-	-	-	-
1922	-	-	-	1.000	-	-	-	-	-
1923	-	-	-	2.500	-	-	-	-	-
1924	-	-	-	1.500	-	-	-	-	-
1925	-	-	-	1.900	-	-	-	-	-
1926	-	-	-	1.400	-	-	-	-	-
1927	-	-	-	0.800	-	-	-	-	-
1928	-	-	-	2.600	-	-	-	-	-
1929	-	-	-	3.800	-	-	-	-	-
1930	-	-	-	4.400	-	-	-	-	-
1931	-	-	-	2.800	-	-	-	-	-
1932	-	-	-	14.300	-	-	-	-	-
1933	-	-	-	11.100	-	-	-	-	-
1934	-	-	-	13.800	-	-	-	-	-
1935	0.001	-	-	14.999	-	-	-	-	-
1936	0.001	-	-	17.699	-	-	-	-	-
1937	0.003	-	-	20.197	-	-	-	-	-
1938	0.005	-	-	21.095	-	-	-	-	-
1939	0.010	-	-	19.990	-	-	-	-	-
1940	0.028	-	-	28.572	-	-	-	-	-
1941	0.057	-	-	30.543	-	-	-	-	-
1942	0.126	-	-	34.374	-	-	-	-	-
1943	0.268	-	-	37.632	-	-	-	-	-
1944	0.465	-	-	33.635	-	-	-	-	-
1945	0.763	-	-	28.437	-	-	-	-	-
1946	1.991	-	-	38.409	-	-	-	-	-
1947	3.743	-	-	37.657	-	-	-	-	-
1948	9.304	-	-	49.496	-	-	-	-	-
1949	14.770	-	-	42.630	-	-	-	-	-
1950	27.306	-	-	44.694	-	-	-	-	-
1951	44.856	-	-	44.644	-	-	-	-	-
1952	53.304	-	-	35.496	-	-	-	-	-
1953	62.466	-	-	31.034	-	-	-	-	-
1954	74.752	-	-	30.648	-	-	-	-	-
1955	84.517	-	-	30.883	-	-	-	-	-
1956	88.043	-	-	30.157	-	-	-	-	-
1957	94.982	-	-	31.418	-	-	-	-	-
1958	98.660	-	-	32.040	-	-	-	-	-
1959	110.468	-	-	35.532	-	-	-	-	-
1960	121.131	-	-	38.769	-	1.000	-	-	-
1961	112.716	-	-	35.984	-	1.308	-	-	-
1962	111.918	-	-	35.682	-	1.615	-	-	-
1963	128.545	-	-	40.955	-	1.923	-	-	-
1964	123.095	-	-	39.205	-	2.231	-	-	-
1965	153.970	-	-	49.030	-	2.538	-	-	-
1966	147.905	-	-	47.095	-	2.846	-	-	-
1967	134.026	5.661	-	42.674	8.525	3.154	-	-	-
1968	108.921	11.136	-	34.679	16.772	3.462	-	-	-
1969	125.229	15.136	-	39.871	22.795	3.769	-	-	-
1970	108.087	9.466	-	34.413	14.257	4.077	-	-	-
1971	153.218	12.017	-	48.782	18.098	4.385	-	-	-
1972	185.025	18.633	-	58.908	28.062	4.692	-	-	-
1973	119.679	28.873	-	38.103	43.483	5.000	-	-	-
1974	93.296	36.254	-	29.704	54.599	10.056	-	-	-
1975	67.975	26.920	-	21.642	40.543	6.372	-	-	-
1976	109.144	20.722	-	34.750	31.208	5.740	-	-	-
1977	77.616	14.753	-	24.712	22.219	3.500	-	-	-
1978	104.093	4.017	-	23.414	3.574	4.931	-	-	-
1979	95.374	2.759	-	38.149	4.161	6.093	-	-	-
1980	100.766	2.948	-	32.766	3.508	9.121	-	-	-
1981	91.599	1.301	-	29.333	4.182	9.400	-	-	-
1982	84.990	4.240	-	28.359	7.118	8.089	-	-	-
1983	71.202	6.124	0.161	23.231	6.392	7.672	0.069	-	-
1984	81.804	4.843	0.256	29.451	6.092	9.035	0.110	0.016	-
1985	91.090	10.442	0.817	33.980	9.574	9.203	0.350	0.292	0.065
1986	103.405	10.214	0.965	30.401	5.751	8.724	0.413	0.302	0.084
1987	94.724	9.269	2.500	22.801	6.415	8.607	1.071	0.353	0.096
1988	82.964	7.424	3.628	23.601	7.108	8.417	1.555	0.331	0.071
1989	82.543	7.619	0.203	24.653	11.355	10.038	0.087	0.032	0.137
1990	76.684	11.995	0.270	26.884	10.865	10.012	0.116	-	0.348
1991	86.151	13.997	-	20.288	8.087	8.206	-	3.000	1.270
1992	81.782	20.020	-	21.503	6.444	9.252	-	1.500	1.099
1993	101.964	11.086	-	16.100	3.175	8.870	-	-	0.278
1994	104.326	7.601	1.130	19.541	3.451	9.569	0.484	0.626	0.449
1995	93.332	4.552	0.670	27.564	2.598	10.630	0.287	0.650	0.756
1996	109.817	9.759	1.676	19.358	3.530	11.062	0.718	1.828	1.515
1997	99.873	11.904	1.806	17.281	3.932	8.834	0.774	1.872	1.404
1998	110.854	10.796	0.647	16.799	3.357	8.283	0.277	1.471	1.738
1999	87.507	12.435	1.963	16.254	2.911	8.595	0.841	4.144	2.749
2000	96.180	7.800	3.456	23.058	4.193	10.906	1.481	2.077	5.500
2001	108.121	6.107	2.793	16.693	2.832	11.836	1.197	1.688	7.300
2002	89.560	12.637	4.772	19.223	2.095	9.581	2.045	3.945	3.500
2003	98.976	16.342	4.668	11.837	3.255	9.883	2.000	4.878	3.000
2004	91.749	23.254	3.758	14.067	3.931	10.004	1.611	4.429	1.600
2005	89.185	21.896	4.172	9.712	3.720	7.881	1.788	4.559	0.700
2006	90.074	14.524	3.592	9.192	3.142	5.524	1.539	4.032	0.400
2007	97.210	15.675	3.151	9.920	3.391	6.350	1.350	3.834	0.400
2008	89.792	14.479	2.910	9.163	3.132	5.865	1.247	3.541	0.369

Table App.A.2: South and west coast historic and GLM standardized CPUE data (Glazer, 2008) for *M. paradoxus* and *M. capensis*. The historic CPUE series are for *M. capensis* and *M. paradoxus* combined.

Year	ICSEAF CPUE (tons/hr)		Year	GLM CPUE (kg/min)		GLM CPUE (kg/min)	
	Species-aggregated			<i>M. capensis</i>	<i>M. paradoxus</i>	<i>M. capensis</i>	<i>M. paradoxus</i>
	South Coast	West Coast		West coast		South coast	
1955		17.31	1978	0.75	4.79	2.42	1.14
1956		15.64	1979	1.22	4.66	2.37	1.10
1957		16.47	1980	1.06	4.40	3.00	1.63
1958		16.26	1981	1.05	4.43	2.58	1.07
1959		16.26	1982	0.93	4.36	2.67	1.45
1960		17.31	1983	1.24	4.67	3.03	1.58
1961		12.09	1984	1.32	4.72	3.61	1.68
1962		14.18	1985	1.57	5.37	4.49	2.29
1963		13.97	1986	1.18	4.90	3.73	2.27
1964		14.60	1987	0.99	4.13	3.41	2.13
1965		10.84	1988	0.80	4.01	3.56	1.70
1966		10.63	1989	0.96	4.21	3.85	1.70
1967		10.01	1990	1.03	4.15	4.30	2.42
1968		10.01	1991	1.04	4.93	4.25	2.36
1969	1.28	8.62	1992	1.37	4.16	3.83	2.84
1970	1.22	7.23	1993	1.26	4.34	2.98	2.29
1971	1.14	7.09	1994	1.38	4.80	3.56	1.96
1972	0.64	4.90	1995	1.73	3.76	3.41	1.38
1973	0.56	4.97	1996	1.49	4.78	3.49	2.14
1974	0.54	4.65	1997	1.50	4.08	2.86	2.67
1975	0.37	4.66	1998	1.72	4.54	2.85	2.31
1976	0.40	5.35	1999	1.50	3.70	3.06	2.70
1977	0.42	4.84	2000	1.60	3.91	3.63	2.27
			2001	1.22	3.50	3.30	2.18
			2002	1.15	2.82	3.76	2.08
			2003	0.92	3.72	3.82	2.08
			2004	1.21	3.59	2.83	2.02
			2005	0.91	3.37	2.33	2.06
			2006	0.71	2.80	2.31	2.64
			2007	0.50	3.46	1.06	2.29

Table App.A.3: Summer survey catches-at-age (proportions) of *M. capensis* and *M. paradoxus* on the west coast for the 0-500m depth range. Here and in the following tables, the data to which the proposed new baseline assessment (with CAL) is NOT fitted to are shown in light grey. Data that were not included in the 2008 baseline assessment (D) (Rademeyer and Butterworth, 2008) are shaded.

Age	<i>M. capensis</i>								<i>M. paradoxus</i>					
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5+
1986	0.034	0.230	0.603	0.085	0.023	0.014	0.008	0.003	-	-	-	-	-	-
1987	0.024	0.113	0.465	0.223	0.139	0.022	0.010	0.004	-	-	-	-	-	-
1988	0.280	0.483	0.135	0.059	0.018	0.015	0.009	0.002	0.234	0.568	0.171	0.014	0.004	0.009
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	0.004	0.325	0.635	0.023	0.009	0.003	0.001	0.000	0.029	0.310	0.492	0.158	0.009	0.002
1991	0.072	0.122	0.644	0.097	0.038	0.017	0.009	0.002	0.018	0.278	0.561	0.107	0.024	0.008
1992	0.131	0.260	0.313	0.162	0.078	0.025	0.019	0.010	0.010	0.383	0.485	0.082	0.023	0.012
1993	0.038	0.176	0.207	0.399	0.088	0.057	0.024	0.011	0.009	0.200	0.547	0.187	0.044	0.010
1994	0.081	0.253	0.208	0.262	0.075	0.054	0.048	0.020	0.011	0.244	0.551	0.166	0.017	0.008
1995	0.001	0.147	0.739	0.066	0.021	0.018	0.005	0.003	0.065	0.191	0.444	0.258	0.028	0.010
1996	0.065	0.368	0.205	0.237	0.066	0.023	0.025	0.011	0.057	0.394	0.302	0.210	0.030	0.005
1997	0.036	0.141	0.384	0.407	0.014	0.010	0.004	0.003	0.006	0.171	0.546	0.256	0.016	0.003
1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	0.867	0.059	0.024	0.026	0.011	0.008	0.005	0.001	0.161	0.410	0.336	0.081	0.008	0.003
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	0.198	0.441	0.230	0.070	0.032	0.019	0.007	0.002	0.076	0.373	0.380	0.132	0.028	0.012
2003	0.247	0.209	0.254	0.156	0.046	0.047	0.032	0.009	0.063	0.322	0.400	0.181	0.023	0.012
2004	0.110	0.457	0.359	0.064	0.007	0.002	0.001	0.001	0.175	0.307	0.321	0.152	0.035	0.011
2005	0.679	0.092	0.133	0.076	0.012	0.005	0.002	0.001	0.218	0.493	0.208	0.069	0.009	0.003
2006	0.446	0.325	0.169	0.042	0.008	0.005	0.003	0.001	0.073	0.321	0.440	0.144	0.017	0.005
2007	0.057	0.144	0.533	0.236	0.018	0.006	0.003	0.003	0.074	0.341	0.372	0.175	0.031	0.008

Table App.A.4: Winter survey catches-at-age (proportions) of *M. capensis* and *M. paradoxus* on the west coast for the 0-500m depth range.

Age	<i>M. capensis</i>								<i>M. paradoxus</i>					
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5+
1986	0.005	0.305	0.267	0.318	0.051	0.027	0.017	0.010	-	-	-	-	-	-
1987	0.010	0.477	0.202	0.171	0.072	0.048	0.011	0.009	-	-	-	-	-	-
1988	0.031	0.432	0.388	0.063	0.042	0.029	0.012	0.004	0.176	0.431	0.298	0.077	0.013	0.006
1989	0.079	0.676	0.213	0.022	0.008	0.001	0.001	0.000	-	-	-	-	-	-
1990	0.006	0.267	0.514	0.098	0.052	0.042	0.013	0.008	0.329	0.290	0.202	0.105	0.041	0.032

Table App.A.5: Nansen summer survey catches-at-age (proportions) of *M. capensis* and *M. paradoxus* on the west coast for the 0-500m depth range.

Age	<i>M. capensis</i>								<i>M. paradoxus</i>					
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5+
2000	0.393	0.336	0.147	0.111	0.007	0.004	0.002	0.001	0.261	0.460	0.204	0.056	0.015	0.004
2001	0.493	0.109	0.157	0.157	0.050	0.018	0.009	0.007	0.199	0.378	0.237	0.143	0.031	0.011

Table App.A.6: Spring survey catches-at-age (proportions) of *M. capensis* and *M. paradoxus* on the south coast for the 0-500m depth range.

Age	<i>M. capensis</i>								<i>M. paradoxus</i>					
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5+
2001	0.158	0.106	0.091	0.171	0.264	0.139	0.039	0.033	0.007	0.085	0.518	0.369	0.015	0.006
2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	0.192	0.139	0.151	0.163	0.170	0.117	0.039	0.029	0.000	0.026	0.448	0.463	0.035	0.029
2004	0.457	0.103	0.109	0.122	0.104	0.067	0.021	0.016	0.034	0.034	0.358	0.499	0.042	0.033

Table App.B.7: Autumn survey catches-at-age (proportions) of *M. capensis* and *M. paradoxus* on the south coast for the 0-500m depth range.

Age	<i>M. capensis</i>								<i>M. paradoxus</i>					
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5+
1991	0.011	0.111	0.126	0.173	0.215	0.181	0.112	0.073	0.004	0.010	0.522	0.292	0.116	0.056
1992	0.015	0.203	0.358	0.145	0.118	0.110	0.038	0.014	0.000	0.001	0.370	0.541	0.065	0.024
1993	0.001	0.083	0.120	0.171	0.373	0.143	0.068	0.042	0.000	0.005	0.416	0.544	0.026	0.010
1994	0.061	0.140	0.123	0.219	0.137	0.159	0.116	0.045	0.005	0.090	0.656	0.186	0.017	0.046
1995	0.019	0.121	0.225	0.189	0.202	0.149	0.066	0.029	0.000	0.000	0.124	0.773	0.089	0.014
1996	0.005	0.104	0.188	0.192	0.288	0.131	0.061	0.031	0.000	0.000	0.097	0.749	0.100	0.054
1997	0.064	0.134	0.105	0.187	0.216	0.175	0.067	0.052	0.000	0.001	0.111	0.581	0.105	0.202
1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	0.159	0.140	0.281	0.145	0.117	0.087	0.040	0.030	0.000	0.014	0.216	0.527	0.190	0.054
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	0.149	0.112	0.085	0.175	0.279	0.137	0.036	0.027	0.006	0.053	0.444	0.462	0.027	0.007
2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	0.109	0.214	0.195	0.142	0.161	0.116	0.035	0.028	0.008	0.023	0.385	0.530	0.034	0.020
2004	0.130	0.103	0.132	0.187	0.228	0.141	0.045	0.034	0.029	0.115	0.350	0.438	0.060	0.008
2005	0.110	0.159	0.169	0.161	0.216	0.126	0.035	0.023	0.065	0.142	0.240	0.370	0.130	0.053
2006	0.030	0.072	0.194	0.264	0.232	0.123	0.047	0.037	0.001	0.012	0.314	0.582	0.073	0.018
2007	0.250	0.250	0.169	0.157	0.112	0.044	0.011	0.008	0.050	0.039	0.191	0.501	0.197	0.022

Table App.A.8: Offshore trawl fleet catches-at-age (*M. capensis* and *M. paradoxus* combined) for west and south coasts.

Age	West coast, species combined								South coast, species combined							
	0	1	2	3	4	5	6	7+	0	1	2	3	4	5	6	7+
1978	0.000	0.072	0.716	0.152	0.039	0.016	0.005	0.001	0.000	0.058	0.570	0.249	0.073	0.028	0.013	0.009
1979	0.000	0.114	0.545	0.215	0.064	0.046	0.013	0.004	0.000	0.000	0.077	0.235	0.256	0.240	0.111	0.082
1980	0.000	0.056	0.472	0.289	0.112	0.048	0.017	0.008	0.000	0.027	0.419	0.272	0.144	0.067	0.039	0.032
1981	0.004	0.235	0.492	0.158	0.068	0.026	0.011	0.006	0.000	0.024	0.270	0.331	0.227	0.085	0.040	0.024
1982	0.037	0.290	0.484	0.114	0.040	0.023	0.009	0.003	0.000	0.056	0.399	0.205	0.128	0.106	0.070	0.035
1983	0.001	0.121	0.488	0.238	0.085	0.044	0.016	0.007	0.000	0.031	0.376	0.302	0.136	0.088	0.049	0.017
1984	0.000	0.063	0.483	0.275	0.097	0.046	0.024	0.012	0.009	0.085	0.387	0.232	0.154	0.071	0.040	0.022
1985	0.000	0.008	0.350	0.395	0.133	0.069	0.030	0.016	0.000	0.005	0.339	0.343	0.139	0.099	0.049	0.027
1986	0.000	0.014	0.339	0.467	0.104	0.040	0.022	0.015	0.000	0.003	0.226	0.366	0.177	0.115	0.077	0.035
1987	0.000	0.023	0.524	0.276	0.103	0.048	0.016	0.009	0.000	0.002	0.398	0.258	0.135	0.111	0.065	0.032
1988	0.000	0.021	0.589	0.266	0.059	0.036	0.021	0.009	0.000	0.009	0.414	0.264	0.136	0.103	0.053	0.021
1989	0.000	0.014	0.434	0.402	0.090	0.036	0.018	0.006	0.000	0.002	0.352	0.392	0.114	0.082	0.045	0.013
1990	0.000	0.002	0.313	0.496	0.137	0.034	0.013	0.005	0.000	0.002	0.216	0.416	0.233	0.084	0.035	0.015
1991	0.000	0.003	0.253	0.357	0.233	0.087	0.049	0.019	0.000	0.003	0.281	0.414	0.181	0.066	0.040	0.015
1992	0.000	0.012	0.405	0.303	0.145	0.088	0.035	0.013	0.000	0.005	0.333	0.377	0.156	0.077	0.035	0.017
1993	0.000	0.003	0.146	0.378	0.307	0.128	0.029	0.009	0.000	0.000	0.166	0.485	0.229	0.070	0.035	0.016
1994	0.000	0.001	0.140	0.464	0.200	0.157	0.030	0.008	0.000	0.001	0.209	0.477	0.165	0.091	0.039	0.019
1995	0.000	0.001	0.109	0.552	0.207	0.075	0.044	0.012	0.000	0.002	0.100	0.473	0.252	0.070	0.067	0.037
1996	0.000	0.002	0.120	0.554	0.221	0.063	0.029	0.011	0.000	0.000	0.054	0.477	0.342	0.073	0.037	0.018

Table App.A.9: Longline fleet catches-at-age (assumed to consist of *M. capensis* only) on the south coast.

Age	<i>M. capensis</i>							
	0	1	2	3	4	5	6	7+
1994	0.000	0.000	0.000	0.001	0.030	0.248	0.404	0.318
1995	0.000	0.000	0.000	0.000	0.006	0.093	0.262	0.638
1996	0.000	0.000	0.000	0.000	0.007	0.134	0.297	0.561
1997	0.000	0.000	0.000	0.002	0.036	0.201	0.298	0.464
1998	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	0.000	0.000	0.001	0.003	0.020	0.148	0.203	0.626

Table App.A.10: Inshore fleet catches-at-age (assumed to consist of *M. capensis* only) on the south coast.

Age	<i>M. capensis</i>							
	0	1	2	3	4	5	6	7+
1989	0.000	0.000	0.081	0.478	0.285	0.109	0.039	0.008
1990	0.000	0.000	0.055	0.279	0.439	0.171	0.045	0.011
1991	0.000	0.000	0.053	0.281	0.367	0.219	0.067	0.014
1992	0.000	0.001	0.151	0.371	0.237	0.184	0.048	0.009
1993	0.000	0.000	0.026	0.332	0.457	0.139	0.039	0.006
1994	0.000	0.000	0.060	0.380	0.304	0.183	0.067	0.007
1995	0.000	0.000	0.015	0.232	0.455	0.209	0.072	0.018
1996	0.000	0.000	0.024	0.327	0.457	0.140	0.043	0.008
1997	0.000	0.000	0.034	0.369	0.394	0.159	0.034	0.011
1998	0.000	0.008	0.166	0.377	0.284	0.116	0.034	0.015
1999	0.000	0.012	0.190	0.365	0.248	0.116	0.044	0.024
2000	0.000	0.000	0.022	0.244	0.476	0.196	0.034	0.028

Table App.A.12: Winter survey catches-at-length of *M. capensis* and *M. paradoxus* on the west coast for the 0-500m depth range.

Size	<i>Merluccius capensis</i>			<i>Merluccius paradoxus</i>			
	1985	1986	1987	1985	1986	1987	1989
5	0	0	0	0	0	0	0
6	0	0	0	14	0	0	0
7	0	0	0	28	16	0	58
8	42	0	0	196	112	0	87
9	0	32	0	211	272	37	192
10	42	96	0	98	784	223	1203
11	156	352	295	190	1536	1443	2510
12	28	384	463	364	1453	4512	7771
13	113	288	166	1067	2579	7926	27694
14	453	160	626	3036	3733	12290	58366
15	1076	162	886	4643	7828	20410	99068
16	2633	129	795	4754	15670	23759	107783
17	10716	146	2459	6828	28611	32773	83410
18	21541	480	7725	9365	45754	53277	61986
19	75443	1370	13706	14197	68036	59200	59923
20	109270	7704	24043	21577	59250	58377	55435
21	152455	12362	32234	32146	45989	54724	57052
22	132880	22549	30631	34215	41562	43618	59486
23	98769	25638	15389	37210	42842	35457	61196
24	76139	23449	8757	44965	53271	54048	96122
25	44864	17376	5934	54962	52078	63029	127838
26	31247	13985	5336	57436	48345	63657	167468
27	17301	11061	7082	55353	40357	56770	158154
28	22426	9362	6128	62718	44408	75713	167888
29	15838	9344	5544	83998	42374	71586	157416
30	12597	10093	4438	96043	43062	85780	156045
31	10718	10808	4044	99807	42731	55477	126820
32	11336	11435	3680	83911	35546	42091	121659
33	11287	12443	3876	80392	27926	24361	81775
34	9455	13405	3137	57443	18722	18881	59161
35	8321	13932	3435	41560	10836	15575	53662
36	8332	13654	4646	31001	11419	13753	55573
37	6549	13295	4298	25788	8763	7190	28920
38	7453	12145	5146	22051	9084	6764	25202
39	7522	10249	5352	11000	5891	9196	23189
40	6963	8412	4952	12556	6926	8346	16221
41	6370	6986	4943	14604	5455	7448	21931
42	6142	5045	4769	13469	5355	7224	13944
43	5293	3701	4599	8864	4111	4400	9128
44	4268	2953	3519	6337	4751	4139	8927
45	3454	2451	2682	3762	2841	2661	6153
46	3386	1541	2615	3003	2587	5578	8658
47	2482	1532	2689	2542	1777	2189	5835
48	2720	1315	3072	1828	1896	2454	5000
49	2175	1019	2257	1764	1585	1959	4553
50	2397	1248	2578	1138	1261	1726	4784
51	1954	931	2901	778	962	1301	3009
52	2021	1227	2253	842	906	1715	3959
53	1505	1273	2186	898	1053	1009	1469
54	1845	1305	2185	673	872	1138	1553
55	1674	1289	1300	715	970	1056	1743
56	1538	1297	1112	575	635	782	1143
57	1743	1024	1386	358	1036	540	1362
58	1729	1189	904	481	848	743	1373
59	1192	1139	891	323	807	675	1154
60	1484	885	481	393	610	531	2009
61	862	1015	570	516	602	361	773
62	847	849	308	386	651	388	1764
63	587	693	435	291	651	259	1589
64	479	708	388	235	614	302	582
65	367	558	346	186	463	345	1317
66	503	396	386	249	696	263	850
67	302	483	211	309	344	217	990
68	461	510	195	253	356	68	1680
69	323	253	236	270	344	187	602
70	285	444	253	130	246	133	1612
71	158	292	194	67	270	254	622
72	449	287	230	60	258	189	296
73	320	187	223	161	184	144	58
74	242	261	70	49	111	146	0
75	169	130	116	42	110	131	25
76	227	144	17	84	98	41	38
77	188	103	97	42	98	98	0
78	146	33	17	53	49	168	0
79	263	66	48	35	86	123	0
80	193	119	49	18	61	59	0
81	135	90	132	18	86	41	0
82	33	91	48	18	0	0	0
83	67	58	17	0	131	29	0
84	14	33	50	0	37	14	0
85	25	25	17	25	49	14	0
86	14	29	52	0	49	14	0
87	0	82	17	0	0	0	0
88	0	17	0	0	0	0	0
89	0	17	17	0	0	0	0
90	19	0	17	18	0	0	0
91	14	12	32	0	0	0	0
92	83	0	19	0	25	14	246
93	0	0	31	0	0	0	0
94	0	0	0	0	0	0	0
95	0	0	17	0	0	16	0
96	0	0	17	0	0	0	0
97	0	0	0	0	0	0	0
98	0	29	0	0	0	0	0
99	0	0	0	0	17	0	0
100	14	0	0	0	0	0	0
101	0	0	50	0	0	0	0

Table App.A.13: Spring survey catches-at-length of *M. capensis* and *M. paradoxus* on the south coast for the 0-500m depth range.

Size	<i>Merluccius capensis</i>							<i>Merluccius paradoxus</i>						
	1986	1987	2001	2003	2004	2006	2007	1986	1987	2001	2003	2004	2006	2007
5	0	0	0	248	562	64	0	0	0	0	10	0	0	0
6	0	10	35	41	328	633	96	0	0	0	0	21	0	0
7	212	27	189	249	1283	1815	721	0	0	0	27	42	0	0
8	0	68	215	570	4257	3494	989	0	0	0	0	106	0	0
9	121	301	1114	1472	12946	5977	3459	0	0	0	54	125	0	0
10	298	618	2226	3003	30434	6248	4940	0	0	0	53	102	0	0
11	925	2004	4543	5469	39084	8158	9783	0	0	67	299	337	0	13
12	2591	5156	6514	6768	28934	9486	10682	133	0	67	292	392	0	26
13	10704	8576	9127	6111	22470	14704	26015	213	0	245	439	2078	0	13
14	18941	9346	6964	5163	14178	14548	22072	1010	0	67	699	3293	55	0
15	28348	7012	7406	5277	7065	15565	25247	2154	0	83	487	2219	0	0
16	32129	4866	5173	4122	4138	10445	11588	1915	0	16	284	933	0	0
17	29698	3446	4431	3735	2793	7026	8316	1250	45	0	176	122	0	26
18	20937	2527	3176	3325	1511	4268	4677	1117	0	0	27	202	22	13
19	9114	2946	2698	3307	1569	3644	3887	1250	134	0	149	0	556	497
20	4860	2628	2316	2425	1648	3061	2126	2043	0	0	41	42	584	549
21	3490	2481	1771	2246	1692	4464	2604	948	67	0	150	0	266	666
22	2566	2946	1837	2146	1750	4667	2584	1808	45	0	111	200	441	1032
23	1467	2195	1225	2627	2195	6663	2795	2454	0	289	146	484	811	327
24	2462	2378	1060	2977	2323	7406	2382	6312	89	588	314	1319	697	627
25	2030	1829	1007	3004	3835	9027	4702	7103	89	1682	1977	1262	3598	693
26	2633	2316	1580	3154	3942	7969	3429	8251	911	3730	2915	3354	3377	209
27	3009	1915	1573	3030	4680	8638	6876	4275	2636	6254	11697	7334	12268	2509
28	5259	2666	1939	2604	4794	6654	5494	3028	5450	7538	16166	15002	20587	3444
29	5327	2962	2223	2560	5759	7576	8769	2325	8316	8244	29715	19470	36512	7947
30	6706	3867	2196	2261	6522	5471	7520	2741	10351	7971	31326	25330	34253	14401
31	6960	4095	2669	3048	6523	6214	9244	4218	10454	8417	51083	30996	43203	19000
32	7621	4059	2789	2411	5892	4388	7179	4700	9026	9435	47244	26635	26485	23332
33	6169	3958	2942	3517	5114	5649	7565	5634	6292	7171	42205	20634	27196	17630
34	7477	4108	3616	2623	5044	4837	5765	5416	3894	6278	26324	17851	17153	22075
35	6548	3839	3793	3428	3649	6431	5468	3994	2308	4197	17522	16330	11729	10630
36	7878	3865	4310	2797	3129	5885	4939	4575	1256	2569	9386	8419	5202	10262
37	6892	3916	5301	3351	3044	7460	4797	3467	1211	1033	4705	6065	3740	7988
38	8380	4818	6103	2155	3078	5570	4305	3305	974	1256	2409	3013	2363	4625
39	7041	5323	6875	3035	3249	7020	4416	1752	569	312	1355	2547	1527	3789
40	7074	6611	7343	2388	3203	5556	3943	2739	387	277	1181	1250	1128	1829
41	6439	5845	8180	3547	3068	6287	3779	1442	636	178	776	545	840	1863
42	5604	5967	8506	2888	3516	4910	2970	1096	622	223	379	1165	629	810
43	4887	5111	9203	3741	3777	4930	3703	861	857	111	486	1436	618	395
44	4691	4656	8093	3007	4182	3999	2583	924	776	178	459	668	284	836
45	3489	3920	7518	3369	3701	4032	3195	588	1059	45	565	824	270	287
46	3705	3930	6892	2548	3923	2908	1930	675	1013	134	534	229	247	157
47	3297	3294	6340	2948	3406	3363	2238	380	901	0	551	261	205	157
48	4093	4216	4921	2206	3467	1987	1651	380	598	178	354	386	191	157
49	3131	3545	4499	2707	3277	2526	2011	283	617	0	770	469	124	235
50	4265	4097	3745	2617	3164	1783	1388	349	490	111	534	146	90	105
51	3509	3698	3819	2807	2761	2066	1460	131	294	0	551	219	157	118
52	4277	3541	2877	2025	2191	1219	1000	109	283	22	508	188	126	39
53	4226	3352	2911	2255	2177	1667	1258	22	194	22	503	198	104	131
54	4551	3422	2387	1563	1960	1217	843	65	237	0	647	219	135	91
55	4789	3068	2536	1947	1880	1606	1012	109	178	22	384	219	124	78
56	4043	3006	2478	1481	1448	1017	700	109	122	0	551	323	124	91
57	4346	2737	2148	1862	1495	1437	916	44	83	22	408	449	194	91
58	3913	2639	1579	1161	1161	1050	602	0	99	0	312	490	146	118
59	3827	2380	1660	1205	1283	966	461	44	128	22	360	449	79	78
60	3919	2360	1135	1024	2279	667	508	0	99	0	360	480	11	39
61	3176	2288	940	827	862	962	782	0	150	0	264	501	112	157
62	3287	2209	887	730	742	780	428	65	39	45	288	417	112	26
63	2707	2089	961	736	969	778	586	22	22	0	324	407	34	105
64	2752	1742	690	410	597	592	323	0	61	22	252	449	90	91
65	1889	1383	873	656	578	691	260	44	0	0	204	522	79	52
66	1732	1414	697	558	479	683	242	65	0	22	108	323	101	13
67	1601	1817	629	575	619	618	365	22	16	0	144	469	292	13
68	1457	1151	398	384	330	511	330	0	0	22	120	271	56	39
69	1572	1266	636	368	438	415	221	0	45	0	84	198	0	26
70	1107	1086	512	354	322	397	200	44	22	45	36	94	45	13
71	1205	872	465	297	242	289	142	22	0	0	48	115	34	13
72	989	903	269	284	317	329	118	0	22	0	24	115	45	0
73	1093	843	267	394	176	369	185	22	0	111	12	219	22	13
74	1158	662	292	282	290	253	73	0	0	45	36	63	0	0
75	472	778	152	305	121	184	76	0	0	22	12	63	0	13
76	741	575	171	225	334	149	146	44	0	0	60	31	45	13
77	271	403	241	167	45	137	127	0	0	0	60	83	11	13
78	581	288	136	126	164	180	54	0	0	0	12	42	34	13
79	296	294	104	51	155	80	45	0	0	0	12	63	0	0
80	306	446	66	75	57	56	38	0	0	22	36	52	0	0
81	392	298	143	61	25	37	38	0	0	0	12	21	0	0
82	27	120	50	51	23	75	16	0	0	0	36	52	0	0
83	117	221	91	50	82	0	16	0	0	0	0	10	22	0
84	136	193	0	39	55	59	0	0	0	0	0	0	0	0
85	123	165	67	51	21	37	0	0	0	0	0	0	0	0
86	152	122	16	0	12	0	0	0	0	0	0	0	0	0
87	75	70	0	12	0	23	0	0	0	0	0	10	0	0
88	97	141	28	27	36	7	32	0	0	0	0	0	11	0
89	80	45	16	0	48	0	0	0	0	0	12	10	0	0
90	102	120	16	0	11	0	0	0	0	0	0	10	0	0
91	80	39	38	27	0	0	0	0	0	0	0	0	0	0
92	48	104	28	0	12	0	0	0	0	0	0	10	0	0
93	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	47	67	0	0	0	0	0	0	0	0	0	0	0	0
95	27	10	16	0	0	11	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	27	22	0	0	0	0	0	0	0	0	0	0	0	0
99	0	0	0	0	0	14	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	16	0	0	0	0	0	0	0

Table App.A.15: Commercial catches-at-length (species combined).

Length	Offshore trawl West Coast Both species			Offshore trawl South Coast Both species			Offshore trawl Both Coasts Both species			Inshore trawl South coast <i>M. capensis</i>						Longline West Coast Both species					
	1997	1998	1999	1975	1976	1977	2005	2006	2007	1981	1982	1983	1984	1985	1986	1987	1988	1994	1995	1996	1997
19	36	26	16	0	0	0	15320	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	575	418	265	0	753275	8256	146700	340993	0	0	0	0	0	0	0	0	0	0	0	0	0
23	3109	2281	1406	0	1027193	4128	1947301	2420009	329913	0	0	0	0	0	201	0	812	0	0	0	0
25	7080	5322	3394	149765	2602221	74306	13414502	10114184	3341151	14616	16062	1284	0	313	1602	0	7356	0	0	0	0
27	10636	8525	5780	688919	5409881	90818	33275953	19878889	12886979	43847	96373	4397	7510	1731	6750	3785	68805	0	0	0	0
29	16979	13788	9978	1597494	16914437	499501	36836651	25382280	21131296	204618	497928	43819	42362	17424	49482	34644	256192	0	0	0	0
31	22842	21168	15156	3504502	31158173	1515017	37150093	28909583	24166107	540775	1365287	191172	235286	63890	208646	113552	622506	0	0	0	0
33	20830	22423	15365	4193421	24858059	1671885	30298498	25782332	22961329	1023088	2136273	419654	681695	174492	520621	329855	1148827	7	0	0	0
35	19531	22565	15069	3584377	16982916	1948468	23060176	20993022	21195853	1476170	2312957	683207	1180629	381287	880580	688169	1190681	55	0	68	0
37	17087	20516	13485	4263312	9929528	2423201	14081990	15576440	18526775	1710019	2007775	873549	1564328	580814	1100662	1124012	1143296	145	0	68	0
39	14006	16694	10952	3424628	4999004	2472738	11226958	11396663	16293899	1739250	1798966	960018	1817904	725458	1039693	1247484	1043460	290	151	204	0
41	9239	11404	7376	5032106	7464266	2617222	8381432	9452470	13611807	1505401	1413474	1011188	1906240	878907	975200	1534650	1015551	642	227	511	668
43	6425	8039	5235	5181871	5478360	2299358	9589056	8144595	10702986	1373861	1076167	1064233	1666818	1068546	779643	1274141	995372	980	113	1498	3339
45	5769	7292	4825	5181871	4999004	2055799	7778592	7113076	7348419	1096166	835234	1088795	1138668	1233793	720842	969945	844254	1180	605	2519	2893
47	3693	4738	3289	5711041	5957717	1407686	8649677	6120703	6379690	876933	610364	995056	803947	1130354	642917	735431	761449	1477	794	2927	7345
49	2428	3219	2394	5101996	4725086	1205408	5482530	4830979	5267271	716162	465804	830025	592794	1030908	585256	623045	637884	1801	1852	4867	10906
51	2177	2906	2268	5181871	2739180	1003131	4637750	4108786	3334680	526160	369431	632843	479697	924507	596237	524386	580651	2423	3591	7897	15135
53	2254	3050	2374	4193421	1232631	891672	4123671	3555076	2520877	453082	256995	479038	382114	667560	563458	455587	438897	3299	6993	13105	26264
55	1927	2588	2064	4193421	684795	875160	4033206	3250875	2605755	306926	192746	330390	306103	483651	511108	355258	378324	4728	8278	20831	27822
57	2069	2780	2201	3354737	479357	747188	3821585	3002475	1908180	248464	160622	233878	242642	345335	453663	292439	301004	6074	16782	31315	45405
59	1804	2358	1958	2366288	273918	730676	2943441	1978579	1299511	219233	112435	160384	214044	270558	390459	282002	263996	6937	15837	44896	46296
61	1438	1844	1570	1827134	342398	800854	2808123	1804417	1470292	160771	96373	111543	158277	208466	269362	261303	238268	7716	20071	56299	45183
63	1169	1438	1288	1218089	205439	606832	1947249	1680277	1084712	116924	64249	87219	118168	153740	180754	153010	119120	8579	24455	63039	58760
65	847	976	965	988449	136959	367402	2089726	1394477	1105531	87693	48187	61463	79663	108274	114094	108928	91704	9525	21696	84959	67218
67	602	681	682	988449	205439	317865	1451537	1210351	859275	58462	32124	43058	49378	67904	74811	63570	63129	11816	28273	80228	74340
69	472	517	545	838684	136959	2064055	1138007	905966	815793	43847	32124	28891	33978	45175	47366	40858	38916	13514	26799	80704	70334
71	409	440	471	459279	136959	1490248	775412	757464	524991	29231	16062	19882	18260	28132	30239	30355	22497	13935	28689	83870	76121
73	206	219	230	459279	68480	1168255	614793	439740	919148	14616	16062	16144	12982	20409	20971	18270	18390	14660	31372	73216	77456
75	159	169	177	379405	68480	1498504	306312	293611	782060	14616	0	10668	8631	11917	13171	11837	10979	13983	23624	68757	68553
77	88	89	105	379405	0	722419	217081	154424	152939	14616	0	6510	5822	9037	11994	11188	8588	12424	26081	58988	65437
79	66	69	75	379405	0	24769	105159	83279	128618	14616	0	5112	4413	4880	7442	6010	4509	10588	22603	50342	49857
81	46	48	54	379405	0	33025	174162	72984	62199	0	0	2908	2150	4141	4872	4690	3368	7710	18370	39859	38283
83	25	27	29	229640	0	0	19449	44491	35991	0	0	1704	1512	3724	3107	3669	3477	7026	15535	30736	29603
85	12	11	14	229640	0	4128	27914	31774	29354	0	0	466	1553	2164	2250	1254	155	4410	12020	25222	25819
87	8	8	10	149765	0	0	7397	9825	25463	0	0	704	905	866	864	1233	1150	3037	10508	15726	24038
89	6	6	6	149765	0	12384	56178	9428	32283	0	0	648	658	358	477	328	283	2015	6312	11062	11574
91	5	6	5	79875	0	8256	15428	26237	5740	0	0	136	288	478	693	394	0	1256	3251	7761	6010
93	3	4	3	0	0	0	2497	1318	0	0	0	114	82	119	37	430	73	1001	2419	4119	3561
95	1	1	1	0	0	0	0	2277	10401	0	0	57	237	30	521	0	0	435	983	2757	2003
97	1	2	1	0	0	0	0	2936	0	0	0	80	0	97	0	0	0	242	643	1123	668
99	0	0	0	0	0	0	0	0	4661	0	0	0	134	97	0	0	0	97	189	579	668
101	0	0	0	0	0	0	0	563	0	0	0	0	0	0	0	0	0	69	113	374	0
103	1	1	1	0	0	0	0	0	0	0	0	0	0	119	0	0	0	7	0	204	0
105	1	1	1	0	0	0	0	2277	0	0	0	0	0	0	0	0	0	7	0	34	0

Appendix B – Incorporation of catch-at-length information in fitting an ASPM

To be able to incorporate the proportion at length information, the proportions at age predicted by the model ($\hat{p}_{y,a}$) (with is based upon age-specific selectivity) are converted to proportions at length ($\hat{p}_{y,l}$) using the von Bertalanffy growth equation, assuming that the length-at-age distribution remains constant over time:

$$\hat{p}_{y,l} = \sum_a \hat{p}_{y,a} A_{a,l} \quad (\text{B.1})$$

where $A_{a,l}$ is the proportion of fish of age a that fall in the length group l (i.e., $\sum_l A_{a,l} = 1$ for all ages a). The matrix A is calculated under the assumption that length-at-age is normally distributed about a mean given by the von Bertalanffy equation, i.e.:

$$L_a \sim N\left[L_\infty\left(1 - e^{-\kappa(a-t_0)}\right); \theta_a^2\right] \quad (\text{B.2})$$

where θ_a is the standard deviation of length-at-age a , which is modelled as a function of the expected length at age a , i.e.:

$$\theta_a = \beta\left[L_\infty\left(1 - e^{-\kappa(a-t_0)}\right)\right]^\gamma \quad (\text{B.3})$$

β and γ are estimated in the fitting process. The resultant term added to $-\ln L$ in the fitting process is:

$$-\ell n L^{\text{length}} = 0.1 \sum_y \sum_l \left[\ell n \left(\sigma_{len} / \sqrt{p_{y,l}} \right) + p_{y,l} \left(\ell n p_{y,l} - \ell n \hat{p}_{y,l} \right)^2 / 2 \left(\sigma_{len} \right)^2 \right] \quad (\text{B.4})$$

where σ_{len} is the standard deviation associated with the length-at-age data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{len} = \sqrt{\sum_y \sum_l p_{y,l} \left(\ln p_{y,l} - \ln \hat{p}_{y,l} \right)^2 / \sum_y \sum_l 1} \quad (\text{B.5})$$

The initial 0.1 multiplicative factor is a somewhat arbitrary downweighting to allow for correlation between proportions in adjacent length groups.

Age 0 correction:

To allow for the fact that zero-year old fish are not available to the trawl fishery throughout their first year of life the mean length at age 0 is computed as:

$$L_0 = L_\infty \left(1 - e^{-\kappa(A_0-t_0)} \right) \quad (\text{B.6})$$

where A_0 is estimated in the model fitting procedure (for each species separately).

Selectivity-at-length effect for the surveys

Although the model, and therefore the fishing selectivity, is age-based, many selectivity effects are in fact length-based. This applies particularly to the small fish that can escape through the mesh. A selectivity-at-length effect was therefore included when fitting to the survey catch-at-length information. This correction was applied only to the survey data, as the commercial fleets do not catch enough of the very young fish for this effect to be important.

The selectivity-at-length effect is included by estimating a logistic function to model the proportion of fish of length l actually retained by the gear:

$$R_l = \frac{1}{1 + e^{-(l-L_1)/\Delta}} \quad (\text{B.7})$$

where L_1 and L_2 are estimated in the model fitting procedure for each survey and species separately.

The proportion of fish of age a caught that fall in length group l is computed as:

$$A'_{a,l} = \frac{A_{a,l} R_l}{\sum_l A_{a,l} R_l} \quad (\text{B.8})$$