2003 Updated Assessment for the *Merluccius paradoxus* Hake resource off the South and West Coasts

R. A. Rademeyer and D.S. Butterworth
MARAM, Department of Mathematics and Applied Mathematics,
University of Cape Town, Rondebosch 7701, South Africa

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Introduction

This document presents an updated assessment of the *M. paradoxus* hake resource off the south and west coasts of South Africa. The previous assessment of this resource is described in Rademeyer and Butterworth (2002).

Data

The total annual catches of *M. paradoxus* assumed for this analysis are shown in Table 1 for the south and west coasts separately. Rademeyer and Butterworth (2002) provide details of the assumptions made to disaggregate the total annual catch by species. Historic and GLM-standardised CPUE data are given in Table 2. The GLM-standardised CPUE series are from Glazer (2003).

Survey biomass estimates and catch-at-age data are shown in Tables 3 to 6. No new data of this type since those used in Rademeyer and Butterworth (2002) are as yet available.

Methods

The updated assessments (“Case 3”) of the *M. paradoxus* stock as a whole (west and south coasts combined) and of the west coast only are compared to the previous assessments (Rademeyer and Butterworth, 2002 – “Case 1”). In Case 1, residuals about the stock-recruit curve have been directly estimated from year 1985 to 1996 for the west coast only assessments, and from year 1986 to 1993 for the coasts combined assessments, while in the updated assessment stock-recruit residuals have been estimated in both cases from 1985 to 2003. An intermediate assessment (“Case 2”) is also presented for comparison where data up to 2003 are used in fitting the model, but the stock-recruit residuals estimated are as in Case 1. Except for the range over which the stock-recruit residuals are estimated, the age-structured production model used is exactly the same in all assessments, only the data input change and the period considered has been extended. This model is described in Rademeyer and Butterworth (2002).

Results and Discussion

In Rademeyer and Butterworth (2002), three variants of the model (varying in term of the shape of the selectivity function at older ages) are compared. Here, only the intermediate variant (with a selectivity slope of 0.2 – the best fit in both the west coast and two coast cases) is presented.

Table 7 summarises the results of the model for each of the three Cases described above, for both the ‘West Coast only’ and the ‘Both Coasts’ cases. Fig. 1 compares the population trajectories for Cases 1 and 3. The decrease in the CPUE in recent years results in a less optimistic view of the current status and trends of the resource. The MSY and related estimates on the other hand are not affected appreciably.

Fig. 2 shows the fit of the CPUE and survey indices to Case 3. The model shows broadly reasonable fits to the CPUE indices, however, it does not fit the positive trend shown by the survey biomass estimates. Fig. 3 shows the fit of Case 3 to the survey catch-at-age data as averaged over all the years with data. Fig. 4 is the ‘bubble’ plot of the standardised catch-at-age residuals. In both the “West coast only” and “Both coasts combined” assessments there is a consistentpattern of too many large (4+) fish predicted in the catches-at-age.

Fig. 5 plots the stock-recruitment curve, and Fig. 6 shows the standardised residuals about the stock-recruitment curve, for Case 3. Because there are no catch-at-age data for the last few years of the assessment, deviations about the stock-recruitment curve can not be estimated satisfactorily, and are set to zero by the stock-recruitment penalty function term in the penalised likelihood. Over the later half of the 1990s, recruitment is now estimated to have been consistently below average, which in term leads to the recent decreasing trend in spawning biomass shown for Case 3 in Fig. 1.

Fig. 7 shows the spawning biomass projected to 2020 under a selection of constant catch strategies. For each case, the catches were selected (to the nearest thousand tons) as a) the one keeping the spawning biomass roughly constant over the last 10 years of the projection period, b) 5 thousand tons above this value and, c) 5 thousand tons below this value. These longer term replacement yield values are some 28 thousand tons larger for the ‘Both Coasts’ than for the ‘West Coast only’ for the 1999 assessment; this difference increases to 31 thousand tons for the 2003 assessment.

References

Glazer, J. 2003. The standardized *Merluccius paradoxus* CPUE series. Unpublished report, MCM, South Africa. WG/10/03/D:H:7.

Rademeyer R.A. and Butterworth D.S. 2002. An Age-Structured Production Model applied to the *Merluccius paradoxus* Hake resource off the South and West Coasts. Unpublished report, MCM, South Africa. WG/10/02/D:H:16.

Table 1: Assumed total annual catches by coast for *M. paradoxus* for the period 1917 to 2003. Catches are given in thousand tons. Here, and in subsequent Tables, data that are newly added to or changed from those used in Rademeyer and Butterworth (2002) are shown in bold.

Year	South coast	West coast	Total	Year	South coast	West coast	Total
1917		0.920	0.920	1961		136.733	136.733
1918		1.011	1.011	1962		135.722	135.722
1919		1.747	1.747	1963		155.859	155.859
1920		0.000	0.000	1964		149.239	149.239
1921		1.195	1.195	1965		186.663	186.663
1922		0.920	0.920	1966		179.307	179.307
1923		2.299	2.299	1967	2.657	162.480	165.137
1924		1.379	1.379	1968	7.735	132.044	139.779
1925		1.747	1.747	1969	11.475	151.813	163.289
1926		1.287	1.287	1970	6.444	131.032	137.476
1927		0.736	0.736	1971	8.869	185.744	194.613
1928		2.391	2.391	1972	19.825	224.302	244.127
1929		3.494	3.494	1973	24.382	145.084	169.466
1930		4.046	4.046	1974	32.888	113.101	145.989
1931		2.575	2.575	1975	24.421	82.405	106.826
1932		13.149	13.149	1976	18.798	132.314	151.112
1933		10.207	10.207	1977	13.383	94.093	107.477
1934		12.689	12.689	1978	13.947	95.335	109.281
1935		13.793	13.793	1979	15.475	84.400	99.874
1936		16.276	16.276	1980	15.328	93.762	109.091
1937		18.574	18.574	1981	7.880	91.704	99.584
1938		19.402	19.402	1982	14.051	78.260	92.312
1939		18.390	18.390	1983	12.447	68.938	81.385
1940		26.298	26.298	1984	13.960	81.354	95.314
1941		28.137	28.137	1985	18.651	95.089	113.740
1942		31.724	31.724	1986	21.071	104.435	125.506
1943		34.850	34.850	1987	13.801	100.118	113.919
1944		31.356	31.356	1988	14.767	86.409	101.176
1945		26.850	26.850	1989	14.112	81.341	95.453
1946		37.149	37.149	1990	17.335	76.573	93.908
1947		38.068	38.068	1991	20.999	84.260	105.258
1948		54.068	54.068	1992	24.446	84.660	109.106
1949		52.781	52.781	1993	19.451	96.745	116.196
1950		66.206	66.206	1994	16.622	101.836	118.458
1951		82.297	82.297	1995	19.536	93.874	113.409
1952		81.654	81.654	1996	34.451	90.201	124.652
1953		85.975	85.975	1997	29.290	91.480	120.770
1954		96.918	96.918	1998	21.450	107.388	128.837
1955		106.113	106.113	1999	**29.772**	**84.596**	**114.368**
1956		108.688	108.688	2000	**28.231**	**89.525**	**117.756**
1957		116.228	116.228	2001	**30.417**	**91.344**	**121.761**
1958		120.182	120.182	2002	**33.336**	**81.970**	**115.306**
1959		134.251	134.251	2003	**34.745**	**90.056**	**124.801**
1960		147.032	147.032				

Table 2: Historic (1969 to 1977) and GLM standardised (1978 to 2002) CPUE data for *M. paradoxus*. The historic CPUE series is for *M. capensis* and *M. paradoxus* combined.

Year	South coast ICSEAF CPUE tons/hr	South coast GLM CPUE kg/min	West coast ICSEAF CPUE tons/day	West coast GLM CPUE kg/min	Combined GLM CPUE kg/min
1955			17.31		
1956			15.64		
1957			16.47		
1958			16.26		
1959			16.26		
1960			17.31		
1961			12.09		
1962			14.18		
1963			13.97		
1964			14.60		
1965			10.84		
1966			10.63		
1967			10.01		
1968			10.01		
1969	1.28		8.62		
1970	1.22		7.23		
1971	1.14		7.09		
1972	0.64		4.90		
1973	0.56		4.97		
1974	0.54		4.65		
1975	0.37		4.66		
1976	0.40		5.35		
1977	0.42		4.84		
1978		**2.237**		**10.275**	**12.512**
1979		**1.943**		**10.842**	**12.785**
1980		**2.701**		**10.267**	**12.968**
1981		**1.732**		**10.111**	**11.843**
1982		**2.569**		**9.548**	**12.135**
1983		**2.806**		**10.905**	**13.710**
1984		**3.239**		**11.414**	**14.653**
1985		**4.265**		**13.183**	**17.430**
1986		**4.805**		**11.527**	**16.332**
1987		**3.889**		**9.642**	**13.531**
1988		**3.333**		**9.066**	**12.399**
1989		**3.029**		**9.794**	**12.823**
1990		**3.561**		**9.640**	**13.202**
1991		**4.806**		**11.618**	**16.424**
1992		**5.120**		**11.043**	**16.162**
1993		**5.036**		**10.259**	**15.295**
1994		**4.426**		**10.945**	**15.372**
1995		**4.321**		**10.306**	**14.626**
1996		**6.592**		**10.939**	**17.531**
1997		**6.101**		**10.473**	**16.573**
1998		**5.645**		**12.222**	**17.866**
1999		**6.687**		**9.687**	**16.374**
2000		**6.371**		**10.265**	**16.635**
2001		**6.616**		**9.420**	**16.036**
2002		**5.008**		**8.617**	**13.625**

Table 3: Survey abundance estimates and associated standard errors in thousand tons for *M. paradoxus* for depth range 0-500m for the south coast and west coast. The combined estimates are obtained by adding the South Coast autumn estimates to the West Coast summer estimates.

Year	South coast				West coast				Combined	
	Spring		Autumn		Summer		Winter		Autumn/Summer	
	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)	Biomass	(s.e.)
1985					168.139	(36.607)	264.916	(52.968)		
1986	23.049	(5.946)			196.151	(36.366)	172.522	(24.129)		
1987	21.545	(4.601)			284.859	(53.108)	195.530	(44.425)		
1988			30.236	(11.084)	158.796	(27.390)	233.103	(64.016)	189.032	(29.547)
1989							468.928	(124.878)		
1990					282.225	(78.956)	226.910	(46.016)		
1991			26.604	(10.431)	327.105	(82.209)			353.709	(82.868)
1992			24.305	(15.197)	234.699	(33.963)			259.004	(37.208)
1993			198.403	(98.423)	321.782	(48.799)			520.185	(109.856)
1994			111.354	(34.622)	329.927	(58.332)			441.281	(67.833)
1995			44.618	(19.823)	324.626	(80.370)			369.244	(82.778)
1996			85.530	(25.485)	430.971	(80.614)			516.501	(84.547)
1997			134.656	(50.922)	570.091	(108.230)			704.747	(119.611)
1998										
1999					562.988	(116.322)				

Table 4: Autumn survey catches-at-age (proportions) of *M. paradoxus* on the south coast for the 0-500m depth range.

	Proportions caught at age: *Merluccius paradoxus*					
	0	1	2	3	4	5+
1991	0.0038	0.0099	0.5219	0.2920	0.1162	0.0563
1992	0.0000	0.0006	0.3698	0.5407	0.0653	0.0236
1993	0.0000	0.0047	0.4157	0.5439	0.0260	0.0097
1994	0.0054	0.0898	0.6558	0.1857	0.0170	0.0463
1995	0.0002	0.0002	0.1241	0.7729	0.0886	0.0139
1996	0.0000	0.0000	0.0968	0.7494	0.0999	0.0539
1997	0.0002	0.0012	0.1108	0.5806	0.1055	0.2016

Table 5: Summer survey catches-at-age (proportions) of *M. paradoxus* on the west coast for the 0-500m depth range.

	Proportions caught at age: *Merluccius paradoxus*					
	0	1	2	3	4	5+
1990	0.0285	0.3098	0.4918	0.1583	0.0088	0.0017
1991	0.0182	0.2777	0.5608	0.1069	0.024	0.0079
1992	0.0098	0.3834	0.4847	0.0824	0.0231	0.0118
1993	0.0089	0.1995	0.5469	0.1866	0.0439	0.0097
1994	0.0107	0.2441	0.5508	0.1656	0.0174	0.0078
1995	0.0651	0.1905	0.4435	0.2583	0.0282	0.0096
1996	0.0572	0.3939	0.3018	0.2096	0.0298	0.005
1997	0.0055	0.1708	0.5459	0.2564	0.0164	0.0032
1998						
1999	0.1613	0.4099	0.3358	0.0808	0.0084	0.0026

Table 6: Autumn/summer survey catches-at-age (proportions) of *M. paradoxus* for the two coasts combined for the 0-500m depth range.

	Proportions caught at age: *Merluccius paradoxus*					
	0	1	2	3	4	5+
1991	0.0177	0.2679	0.5594	0.1137	0.0274	0.0140
1992	0.0093	0.3653	0.4793	0.1039	0.0251	0.0170
1993	0.0064	0.1442	0.5097	0.2881	0.0388	0.0129
1994	0.0098	0.2174	0.5690	0.1691	0.0173	0.0175
1995	0.0605	0.1769	0.4206	0.2951	0.0325	0.0145
1996	0.0529	0.3642	0.2863	0.2503	0.0351	0.0112
1997	0.0052	0.1611	0.5212	0.2748	0.0215	0.0162

Table 7: Estimates of management quantities for the west coast component of the resource only and for both coasts combined. Results are shown for Cases 1 to 3 (see text for details).

	West coast only												West and south coasts combined only											
	Case 1 (data up to 1999)				**Case 2** (as Case 1 but with data up to 2003)				**Case 3** (as Case 2 but with SR residuals up to 2003)				**Case 1** (data up to 1999)				**Case 2** (as Case 1 but with data up to 2003)				**Case 3** (as Case 2 but with SR residuals up to 2003)			
Total -lnL	-113.14				-108.55				-118.34				-111.25				-109.89				-125.72			
-lnL : CPUE	-93.73				-87.26				-101.77				-96.98				-94.15				-111.64			
-lnL: Survey	-12.15				-11.50				-11.44				-6.11				-5.62				-6.05			
-lnL: CAA com.	-				-				-				-				-				-			
-lnL: CAA surv	-9.82				-12.09				-9.34				-9.18				-10.67				-11.20			
-lnL: SR Residuals	2.56				2.30				4.20				1.02				0.55				3.18			
K^{sp}	674				668				668				813				835				787			
K^{ex}	870				889				871				926				953				898			
B^{sp}_{2003}	160				108				87				191				144				102			
B^{ex}_{2003}	237				170				153				276				218				173			
h	0.641				0.603				0.634				0.763				0.731				0.795			
$MSYL^{sp}$	202				209				202				211				228				194			
$MSYL^{ex}$	304				314				304				306				324				287			
MSY	123				119				122				142				140				143			
B^{sp}_{2003}/K^{sp}	0.238				0.161				0.130				0.235				0.172				0.129			
B^{ex}_{2003}/K^{ex}	0.273				0.191				0.176				0.298				0.229				0.193			
$B^{sp}_{2003}/MSYL^{sp}$	0.793				0.514				0.432				0.904				0.630				0.526			
$B^{ex}_{2003}/MSYL^{ex}$	0.782				0.539				0.503				0.903				0.673				0.604			
$MSYL^{sp}/K^{sp}$	0.300				0.313				0.302				0.260				0.273				0.246			
$MSYL^{ex}/K^{ex}$	0.349				0.354				0.349				0.330				0.339				0.320			
Age	M_a	S^{surv}	S_1^{com}	S_2^{com}	M_a	S^{surv}	S_1^{com}	S_2^{com}	M_a	S^{surv}	S_1^{com}	S_2^{com}	M_a	S^{surv}	S_1^{com}	S_2^{com}	M_a	S^{surv}	S_1^{com}	S_2^{com}	M_a	S^{surv}	S_1^{com}	S_2^{com}
0	0.99	0.01	0.00	0.00	1.04	0.01	0.00	0.00	1.01	0.01	0.00	0.00	0.80	0.01	0.00	0.00	0.80	0.01	0.00	0.00	0.80	0.01	0.00	0.00
1	0.99	0.24	0.00	0.00	1.04	0.22	0.00	0.00	1.01	0.24	0.00	0.00	0.80	0.22	0.00	0.00	0.80	0.22	0.00	0.00	0.80	0.23	0.00	0.00
2	0.99	1.00	0.70	0.12	1.04	1.00	0.70	0.12	1.01	1.00	0.70	0.12	0.80	1.00	0.70	0.12	0.80	1.00	0.70	0.12	0.80	1.00	0.70	0.12
3	0.75	1.00	1.00	0.98	0.78	1.00	1.00	0.98	0.76	1.00	1.00	0.98	0.60	1.00	1.00	0.98	0.60	1.00	1.00	0.98	0.60	1.00	1.00	0.98
4	0.60	0.82	0.82	1.00	0.63	0.82	0.82	1.00	0.61	0.82	0.82	1.00	0.48	0.82	0.82	1.00	0.49	0.82	0.82	1.00	0.48	0.82	0.82	1.00
5+	0.50	0.67	0.67	0.82	0.52	0.67	0.67	0.82	0.51	0.67	0.67	0.82	0.40	0.67	0.67	0.82	0.41	0.67	0.67	0.82	0.41	0.67	0.67	0.82
Commercial q's:																								
SC ICSEAF CPUE													0.003				0.003				0.003			
WC ICSEAF CPUE	0.028				0.027				0.028				0.027				0.026				0.028			
GLM CPUE	0.061				0.064				0.061				0.080				0.081				0.083			
Commercial sigma's:																								
SC ICSEAF CPUE													0.207				0.213				0.202			
WC ICSEAF CPUE	0.112				0.114				0.113				0.116				0.115				0.119			
GLM CPUE	0.050				0.086				0.049				0.065				0.094				0.047			
Survey q's:																								
Summer/Autumn	0.856				0.868				0.855				1.103				1.103				1.119			
Winter	0.901				0.922				0.897															
Catches-at-age sigma's:	0.142				0.138				0.143				0.142				0.137				0.144			
Addnl sigma (survey)	0.248				0.263				0.264				0.256				0.256				0.258			

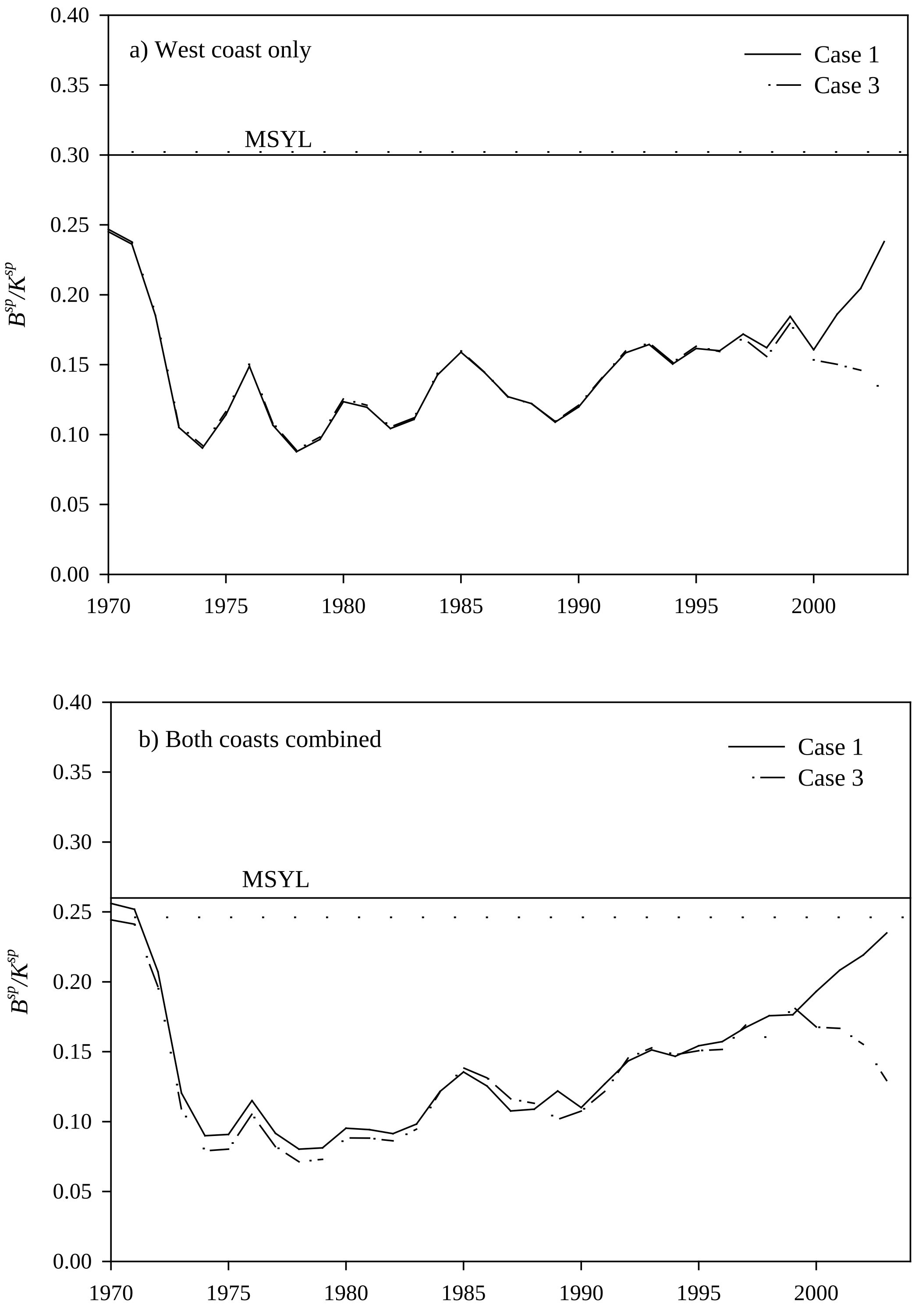


Fig. 1: Estimated spawning biomass (as a proportion of the pre-exploitation level) for a) the west coast component of and b) the whole (both coasts) of the *M. paradoxus* resource, for Cases 1 and 3. MSYL is also shown.

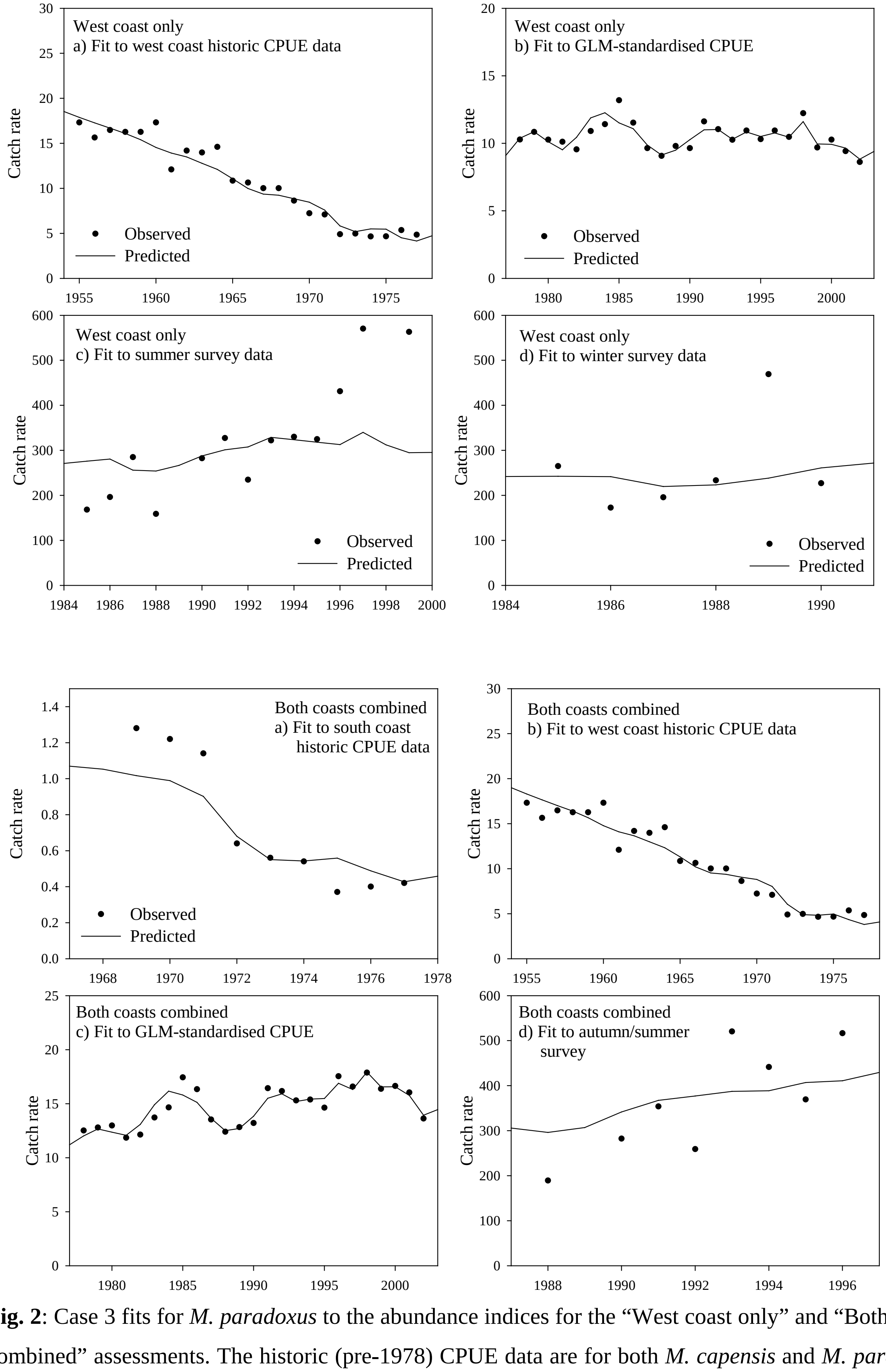
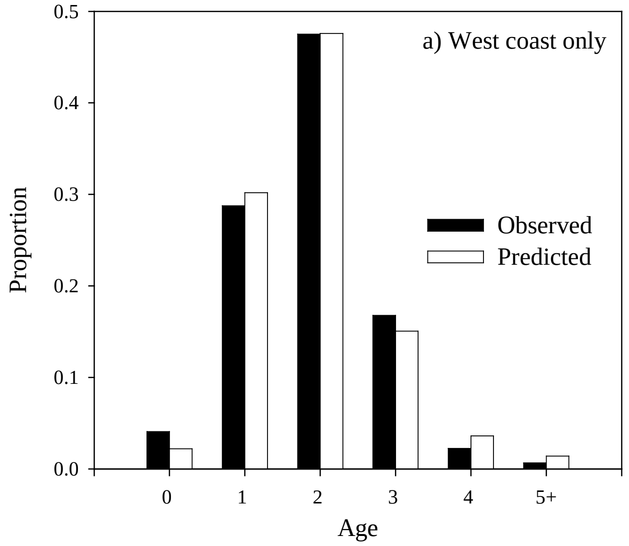


Fig. 2: Case 3 fits for *M. paradoxus* to the abundance indices for the "West coast only" and "Both coasts combined" assessments. The historic (pre-1978) CPUE data are for both *M. capensis* and *M. paradoxus* combined.



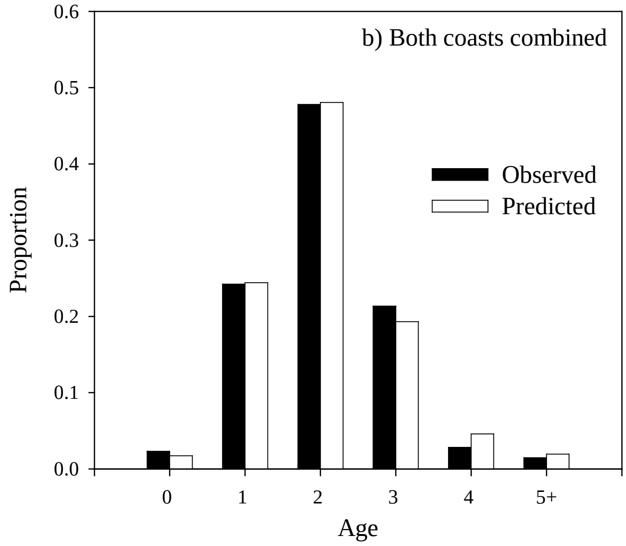
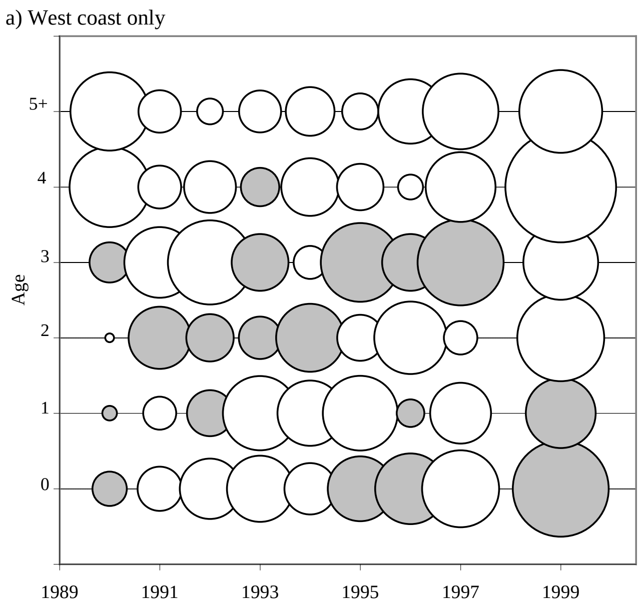


Fig. 3: Case 3 fit to catches-at-age, as averaged over all the years with data, for the "West coast only" and "Both coasts combined" assessments.



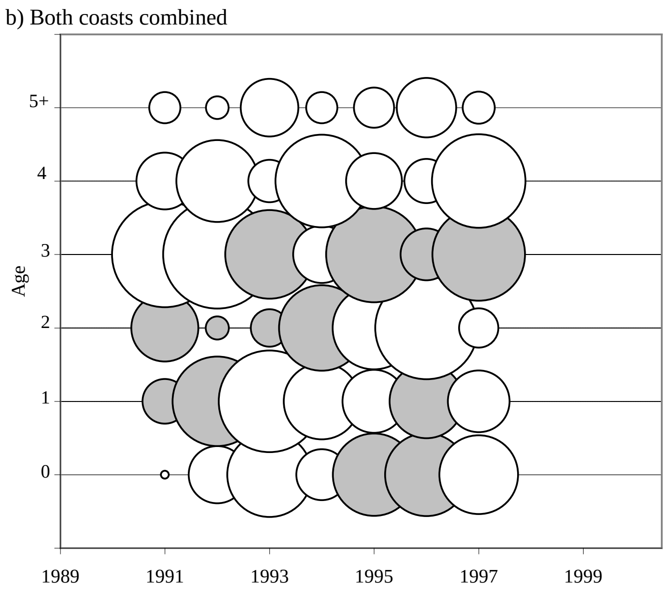


Fig. 4: "Bubble plots" of the survey catch-at-age residuals for the "West coast only" and "Both coasts combined" assessments, Case 3. The size (radius) of the bubbles is proportional to the standardized residuals. For positive residuals, the bubbles are gray and for negative residuals, the bubbles are white.

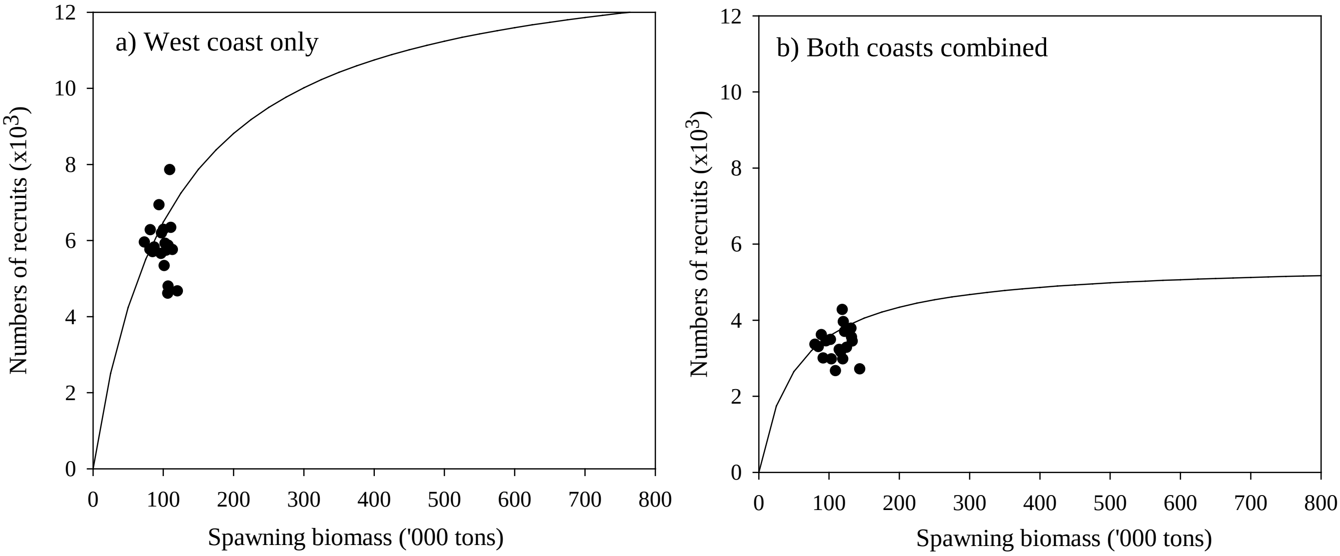


Fig. 5: Estimated stock-recruitment relationship for the "West coast only" and "Both coasts combined" assessments, Case 3. Note that the differences in recruitment levels in absolute terms reflect the different values of *M* estimated for the two cases.

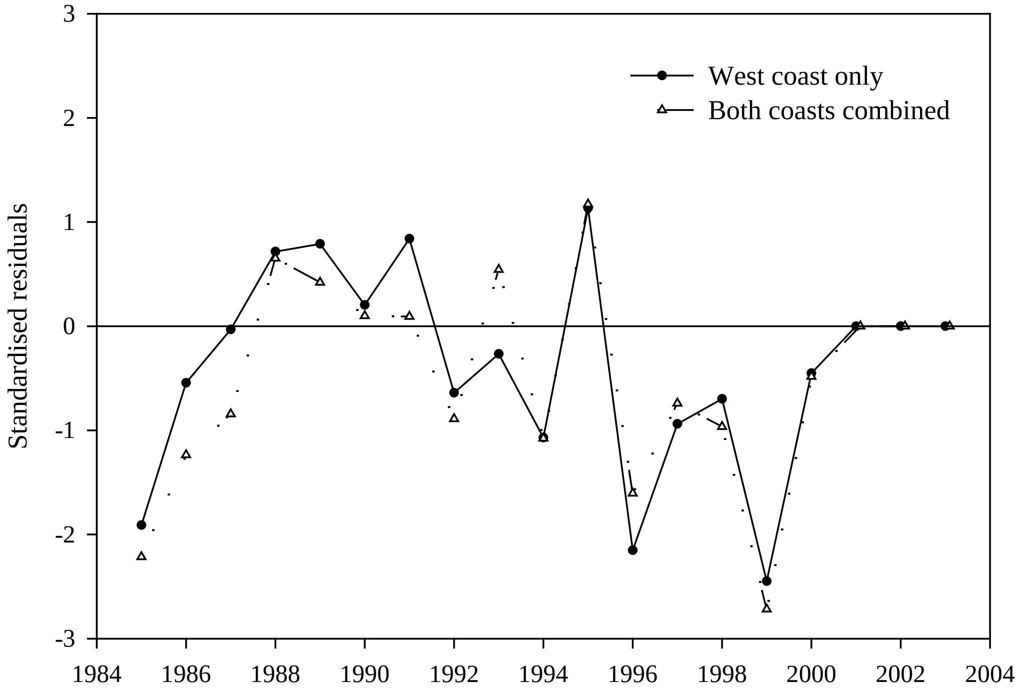


Fig. 6: Standardised residuals about the stock-recruitment curve for Case 3, for the "West coast only" and "Both coasts combined" assessments.

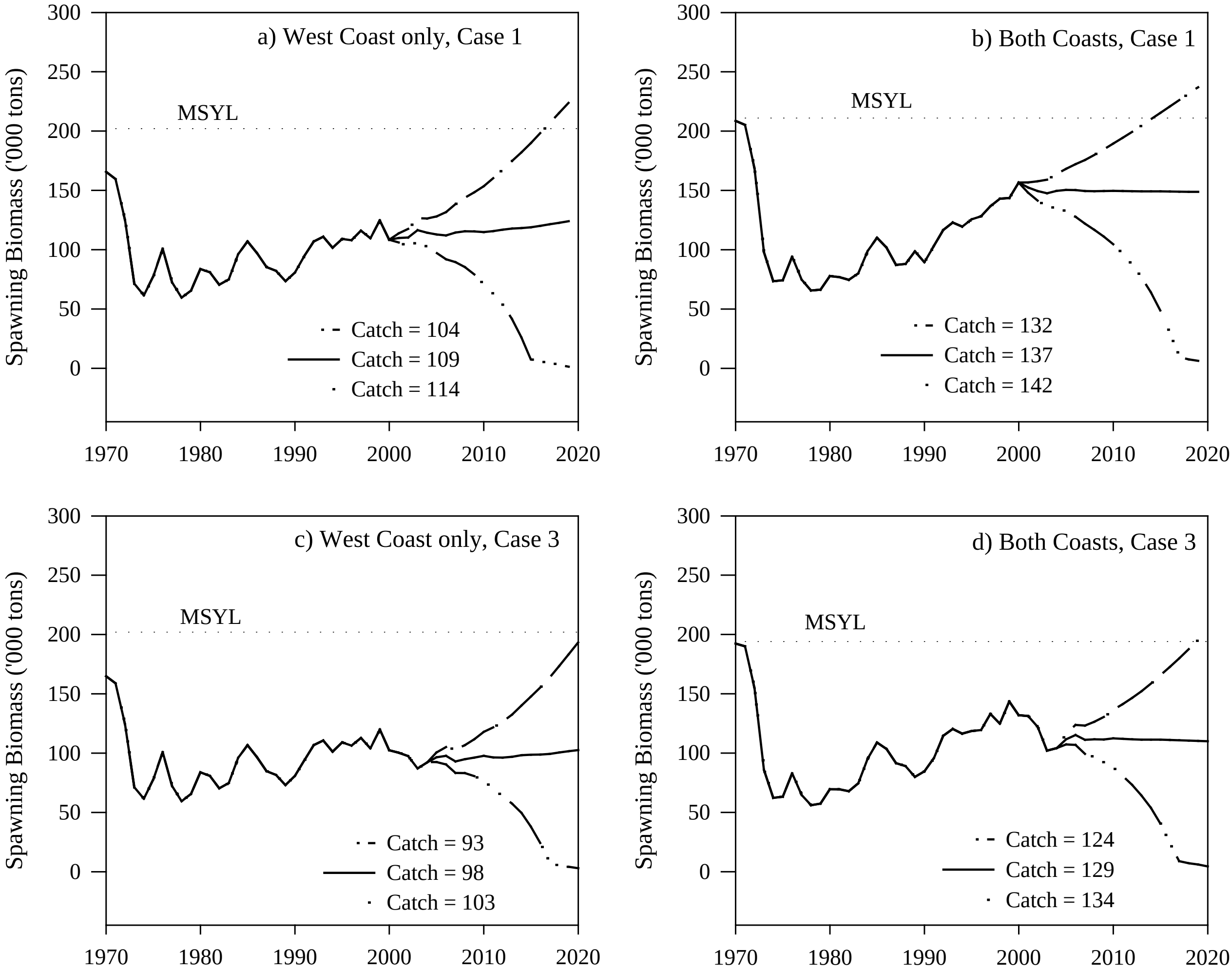


Fig. 7: Projected spawning biomass under selected constant catch strategies, for the 'West Coast only' component of the *M. paradoxus* and 'Both Coasts', for Cases 1 and 3. The catches are in thousands of tons. MSYL is also shown.