Estimating the *Andromeda* catchability compared to the *Africana* for South African hake in an update of the Reference Case assessment

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August 2015

Summary

The 2013 RS1 Reference Case assessment used for OMP testing is updated to include abundance indices which have become available for the following two years. Trends are hardly altered, though for *M. paradoxus* a decline in spawning biomass over the most recent years is now evident. If instead of assuming that the catchability for the Andromeda and Africana are the same, their ratio is estimated in the assessment process, Andromeda is estimated to have a catchability 0.75 that of Africana with a 95% CI of (0.55; 1.03).

Introduction

Due to ongoing problems with DAFF's survey vessel (the *FRS Africana*) a commercial hake trawler (the *MV Andromeda*) was adapted for scientific deployment and has been used for the demersal surveys since 2013, i.e. the west coast summer surveys in 2013, 2014 and 2015 (AND001, AND002 and AND004) and the south coast autumn surveys in 2014 and 2015 (AND003 and AND005). Although the gear used on the *Andromeda* is the same as on the *Africana*, the *Andromeda* survey results have not yet been used in the stock **assessments** due to the need for further gear calibration to standardise the results with the historical *Africana* data. (Results of and projections for future *Andromeda* surveys were however used in OMP tests under certain assumptions concerning the *Andromeda* catchability relative to *Africana*.)

In this paper, the 2013 Reference Case assessment (RS1, Rademeyer and Butterworth, 2014) is updated to include the *Andromeda* survey data (as well as updated catch and CPUE series) and estimate a ratio for the *Andromeda*/*Africana* catchability coefficients (ρ). The update has been carried out as a two-steps process, first taking data to 2014 into account, then to 2015.

Data and Methods

The updated data (compared to those used in RS1, Rademeyer and Butterworth, 2014) are given in Appendix A.

The Andromeda survey biomass estimates are used as input to the model assuming that the *Andromeda* catchability coefficient $q^{Andromeda}$ is proportional to that of the *Africana*:

$$q^{Andromeda} = \rho q^{AfricanaNew} \tag{1}$$

ρ is either fixed or estimated in the model fitting procedure. A single ρ is estimated (across species, coasts and seasons).

The survey selectivities are taken to be the same for the *Africana* and the *Andromeda*.

Results and Discussion

Five runs are compared:

a. "RS1" (Rademeyer and Butterworth, 2014) with data to 2013 and not using the 2013 *Andromeda* biomass estimates.

b. "ratio=1 - data to 2014": As RS1 but with data extended to 2014 (new GLM-standardised CPUE (to 2013), surveys by *Andromeda* to 2014 and catches (with 2014 catches taken as the TAC for that year split by species and fleet using the 2013 proportions), with $\rho = 1$.

c. "ratio=est - data to 2014": As "ratio=1 - data to 2014" but with the ρ estimated in the model fitting.

d. "ratio=1 -data to 2015": As "ratio=1 - data to 2014" but with data extended to 2015 (with actual catches made for 2014 and the 2015 TAC assumed taken and split by species and fleet using the 2014 proportions) .

e. "ratio=est - data to 2015": As "ratio=1 - data to 2015" but with the ρ estimated in the model fitting.

Results are given in Table 1. The $q^{Andromeda}\big/q^{AfricanaNew}$ ratio is estimated to be 0.68 in the "ratio=est - data to 2014" case, with a 95% probability interval (0.44; 1.02) as estimated using a likelihood profile – this wide interval is a consequence of the *Andromeda* having carried out only three surveys. With data included to 2015, ρ is estimated to be 0.75 with a narrower 95% probability interval (0.55; 1.03).

The data update and estimating ρ have rather little effect on the overall estimated trends in abundance, though there is a downward indicated for *M. paradoxus* for the most recent years (see Figure 1).

Reference

Rademeyer RA and Butterworth DS. 2014. Specifications of the South African Hake 2014 Reference Case Assessment. MARAM/IWS/DEC14/Hake/P2.

Table 1: Results for RS1 and the update assessments with $\rho = 1$ and ρ estimated.

		data to 2013	data to 2014		data to 2015	
		RS1	ratio=1	ratio=est	ratio=1	ratio=est
	-lnL total	-181.3	-245.9	-249.0	-250.7	-252.3
	Survey	-32.1	-31.4	-32.9	-33.3	-34.5
	ρ	-	1.00	0.68	1.00	0.75
				(0.44; 1.02)		(0.55; 1.03)
M. paradoxus	B^{sp}_{MSY}	153	164	172	181	180
	B^{sp}_{2013}	150	191	189	200	192
	B^{sp}_{2013}/K^{sp}	0.18	0.19	0.19	0.20	0.19
	$B^{sp}_{2013}/B^{sp}_{MSY}$	0.98	1.17	1.10	1.11	1.07
	B^{sp}_{2014}	-	180	180	191	184
	B^{sp}_{2014}/K^{sp}	-	0.18	0.18	0.19	0.18
	$B^{sp}_{2014}/B^{sp}_{MSY}$	-	1.10	1.04	1.06	1.02
	B^{sp}_{2015}	-	-	-	177	172
	B^{sp}_{2015}/K^{sp}	-	-	-	0.17	0.17
	$B^{sp}_{2015}/B^{sp}_{MSY}$	-	-	-	0.98	0.96
	MSY	111	116	117	119	119
M. capensis	B^{sp}_{MSY}	81	60	63	63	63
	B^{sp}_{2013}	158	142	143	142	141
	B^{sp}_{2013}/K^{sp}	0.69	0.63	0.64	0.63	0.63
	$B^{sp}_{2013}/B^{sp}_{MSY}$	1.95	2.36	2.28	2.25	2.25
	B^{sp}_{2014}	-	155	157	150	150
	B^{sp}_{2014}/K^{sp}	-	0.69	0.70	0.67	0.67
	$B^{sp}_{2014}/B^{sp}_{MSY}$	-	2.57	2.50	2.38	2.40
	B^{sp}_{2015}	-	-	-	156	158
	B^{sp}_{2015}/K^{sp}	-	-	-	0.70	0.70
	$B^{sp}_{2015}/B^{sp}_{MSY}$	-	-	-	2.47	2.52
	MSY	62	62	62	63	63
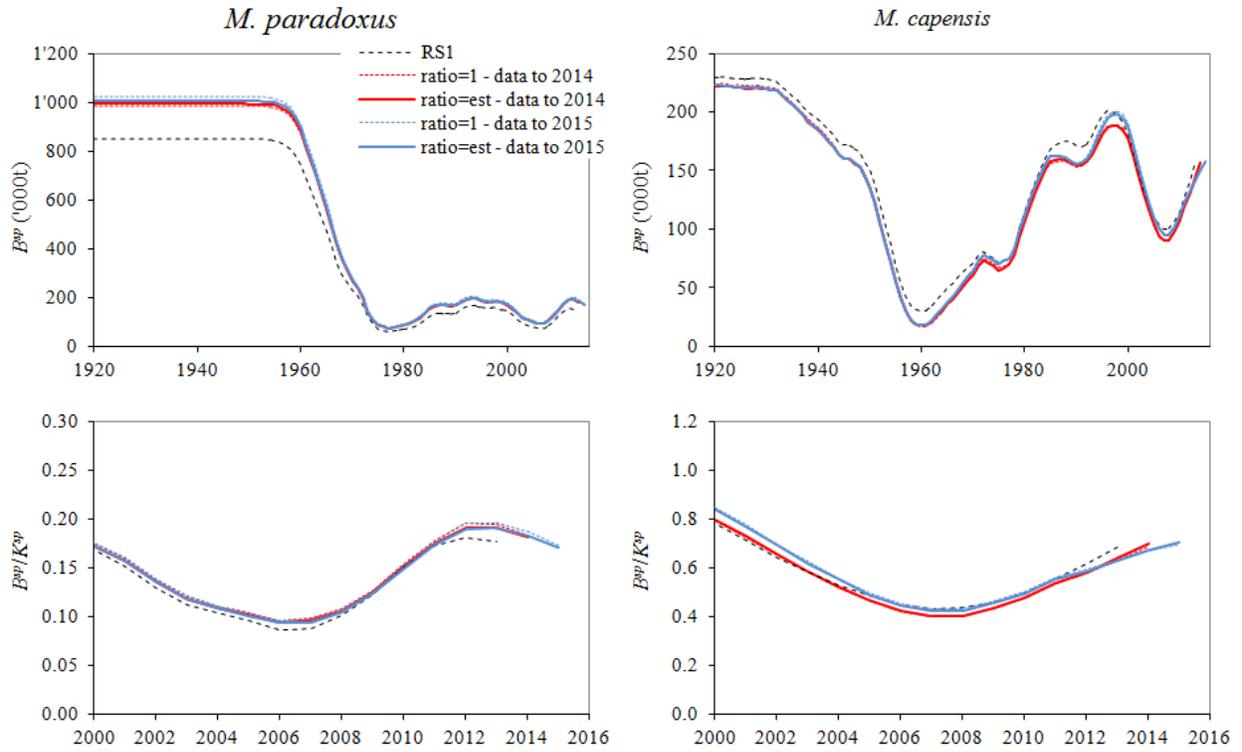
Figure 1: Spawning biomass trajectories (in absolute terms, top row, and relative to pre-exploitation level, bottom row) for the five cases for *M. paradoxus* (LHS) and *M. capensis* (RHS).

Appendix A: Updated data

Table App.A.1: Species-disaggregated catches (in thousand tons) by fleet of South African hake from the south and west coasts for the period 1978-present. The recent offshore trawl catches are from Glazer (pers. comm.), the recent inshore and handline catches are from Rob Cooper (pers. comm.) and the new longline catches from Sobahle Somhlaba (pers. comm.). For 2015, the catches are taken as the 2014 TAC with the same proportion by species and fleet as in 2013. Shaded cells are either new or updated data compared to those used for RS1.

| | M. paradoxus | | | | M. capensis | | | | | |
| | Offshore | | Longline | | Offshore | | Inshore | Longline | | Handline |
	WC	SC	WC	SC	WC	SC	SC	WC	SC	SC
1978	107.701	4.937	-	-	19.812	2.648	4.931	-	-	-
1979	101.890	3.575	-	-	31.633	3.345	6.093	-	-	-
1980	105.483	3.676	-	-	28.045	2.784	9.121	-	-	-
1981	95.330	1.767	-	-	25.601	3.719	9.400	-	-	-
1982	88.933	5.057	-	-	24.417	6.300	8.089	-	-	-
1983	74.173	7.034	0.126	-	20.260	5.482	7.672	0.104	-	-
1984	86.045	5.718	0.200	0.005	25.210	5.217	9.035	0.166	0.011	-
1985	98.283	12.694	0.638	0.091	26.788	7.322	9.203	0.529	0.201	0.065
1986	107.907	11.539	0.753	0.094	25.898	4.427	8.724	0.625	0.208	0.084
1987	96.162	10.536	1.952	0.110	21.363	5.148	8.607	1.619	0.243	0.096
1988	83.606	8.664	2.833	0.103	22.976	5.852	8.417	2.350	0.228	0.071
1989	85.298	9.039	0.158	0.010	21.961	9.873	10.038	0.132	0.022	0.137
1990	84.969	13.622	0.211	-	18.668	9.169	10.012	0.175	-	0.348
1991	89.371	15.955	-	0.932	17.079	6.119	8.206	-	2.068	1.270
1992	86.777	22.368	-	0.466	16.510	4.094	9.252	-	1.034	1.099
1993	105.114	12.472	-	-	12.951	1.789	8.870	-	-	0.278
1994	106.287	8.588	0.882	0.194	17.580	2.464	9.569	0.732	0.432	0.449
1995	102.877	5.395	0.523	0.202	18.020	1.755	10.630	0.434	0.448	0.756
1996	110.460	11.080	1.308	0.568	18.715	2.209	11.062	1.086	1.260	1.515
1997	103.035	13.651	1.410	0.582	14.119	2.185	8.834	1.170	1.290	1.404
1998	113.083	11.703	0.505	0.457	14.570	2.450	8.283	0.419	1.014	1.738
1999	89.147	13.435	1.532	1.288	14.614	1.912	8.595	1.272	2.856	2.749
2000	97.417	9.920	2.706	3.105	20.285	3.610	10.906	2.000	1.977	5.500
2001	101.990	11.016	2.045	0.370	15.606	5.141	11.836	1.750	1.347	7.300
2002	91.720	15.445	4.469	1.585	13.211	3.140	9.581	2.391	2.546	3.500
2003	95.143	21.107	3.305	1.252	10.233	3.926	9.883	2.526	3.078	3.000
2004	86.916	30.746	2.855	1.196	11.315	4.024	10.004	2.297	2.731	1.600
2005	87.540	25.051	3.091	0.472	7.727	4.195	7.881	2.773	3.270	0.700
2006	83.840	22.133	3.241	0.485	9.657	2.494	5.524	2.520	3.227	0.400
2007	96.332	15.825	2.512	3.021	12.537	1.420	6.350	2.522	2.522	0.400
2008	88.290	14.940	2.255	0.809	11.085	2.567	5.496	1.937	1.893	0.231
2009	69.716	13.269	2.410	1.069	10.783	2.431	5.639	2.828	2.520	0.265
2010	70.156	17.863	2.045	0.370	9.738	1.649	5.472	1.750	1.347	0.275
2011	76.744	20.447	3.261	0.905	15.505	1.543	6.013	2.705	2.009	0.185
2012	82.362	19.356	3.572	2.963	11.970	1.776	3.223	0.829	1.840	0.001
data to 2014										
2013	74.340	31.845	4.085	3.389	7.638	0.622	2.920	0.996	0.428	0.0002
2014	91.425	39.164	5.023	4.168	9.393	0.765	3.591	1.225	0.526	0.0003
data to 2015										
2013	75.616	32.398	6.302	1.312	7.787	0.636	2.920	1.537	0.1656	0.222
2014	76.240	46.146	6.938	0.512	7.381	0.597	2.965	1.6919	0.0647	1.39
2015	78.1329	47.2918	7.1098	0.5252	7.5645	0.6122	3.0389	1.7339	0.0663	1.4245

Table App.A.2: GLM standardized CPUE data for *M. paradoxus* and *M. capensis* (Glazer, pers. comm.). Shaded cells are either new or updated data.

	data to 2014					data to 2015			
	GLM CPUE (kg min^{-1})					GLM CPUE (kg min^{-1})			
	M. paradoxus		*M. capensis*			*M. paradoxus*		*M. capensis*	
Year	West Coast	South Coast	West Coast	South Coast	Year	West Coast	South Coast	West Coast	South Coast
1978	9.09	2.04	1.61	3.14	1978	9.14	2.05	1.61	3.13
1979	9.00	2.01	2.63	3.43	1979	9.05	2.02	2.63	3.43
1980	8.35	2.98	2.35	3.88	1980	8.40	3.00	2.35	3.87
1981	8.32	1.92	2.40	3.76	1981	8.37	1.94	2.40	3.75
1982	8.19	2.46	2.07	3.73	1982	8.24	2.48	2.07	3.72
1983	8.82	2.68	2.77	4.60	1983	8.87	2.70	2.77	4.59
1984	9.01	2.90	2.91	5.32	1984	9.06	2.91	2.91	5.31
1985	10.55	4.19	3.23	6.45	1985	10.60	4.21	3.22	6.44
1986	9.18	4.08	2.64	5.37	1986	9.23	4.09	2.64	5.36
1987	7.56	3.63	2.32	4.92	1987	7.60	3.64	2.32	4.90
1988	7.48	2.98	2.08	5.22	1988	7.52	3.00	2.07	5.21
1989	8.07	2.94	2.22	5.61	1989	8.11	2.96	2.22	5.60
1990	8.68	4.37	1.89	6.70	1990	8.73	4.38	1.89	6.68
1991	9.43	4.32	2.34	6.07	1991	9.47	4.33	2.33	6.05
1992	8.24	5.06	2.86	5.54	1992	8.28	5.07	2.86	5.53
1993	8.40	4.18	2.68	3.98	1993	8.43	4.19	2.68	3.97
1994	8.99	3.38	3.41	5.38	1994	9.02	3.39	3.41	5.38
1995	7.85	2.60	3.54	5.07	1995	7.88	2.60	3.53	5.05
1996	8.51	3.70	4.09	4.67	1996	8.54	3.71	4.08	4.66
1997	7.61	4.24	3.54	3.41	1997	7.65	4.24	3.53	3.42
1998	8.49	3.58	4.05	3.92	1998	8.52	3.57	4.04	3.93
1999	6.88	4.09	3.72	3.79	1999	6.91	4.09	3.72	3.82
2000	6.13	3.10	3.49	4.18	2000	6.16	3.10	3.48	4.21
2001	4.96	3.06	2.39	3.08	2001	4.98	3.06	2.38	3.08
2002	4.79	2.63	2.29	3.46	2002	4.79	2.63	2.29	3.46
2003	5.69	3.58	1.95	3.88	2003	5.70	3.57	1.94	3.88
2004	4.74	2.82	1.75	3.10	2004	4.75	2.82	1.74	3.10
2005	4.71	2.49	1.24	2.78	2005	4.72	2.48	1.24	2.78
2006	5.11	2.71	1.34	1.93	2006	5.11	2.70	1.33	1.94
2007	6.33	2.84	1.30	1.86	2007	6.36	2.82	1.30	1.87
2008	6.96	3.04	1.74	2.92	2008	6.97	3.02	1.73	2.94
2009	6.93	3.79	3.06	5.43	2009	6.92	3.77	3.04	5.46
2010	7.62	4.18	2.61	4.17	2010	7.61	4.14	2.59	4.18
2011	7.16	4.93	3.17	5.12	2011	7.22	4.88	3.15	5.11
2012	6.16	4.19	2.61	2.85	2012	6.17	4.20	2.59	2.82
2013	6.33	4.27	2.51	3.21	2013	6.27	4.26	2.49	3.18
					2014	7.04	4.11	2.04	2.28

Table App.A.3: 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 (Fairweather, pers. comm.). Values in bold are for the surveys conducted by the *Africana* with the new gear. Shaded cells are for the surveys conducted by the *Andromeda*.

| 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	166.294	(35.299)	264.839	(52.949)	-	-	-	-
1986	196.111	(36.358)	172.477	(24.122)	13.758	(3.554)	-	-
1987	284.805	(53.101)	195.482	(44.415)	21.554	(4.605)	-	-
1988	158.758	(27.383)	233.041	(64.003)	-	-	30.316	(11.104)
1989	-	-	468.780	(124.830)	-	-	-	-
1990	282.174	(78.945)	226.862	(46.007)	-	-	-	-
1991	327.020	(82.180)	-	-	-	-	26.638	(10.460)
1992	226.687	(32.990)	-	-	-	-	24.304	(15.195)
1993	334.151	(50.234)	-	-	-	-	198.849	(98.452)
1994	330.270	(58.319)	-	-	-	-	111.469	(34.627)
1995	324.554	(80.357)	-	-	-	-	55.068	(22.380)
1996	430.908	(80.604)	-	-	-	-	85.546	(25.484)
1997	569.957	(108.200)	-	-	-	-	135.192	(51.031)
1998	-	-	-	-	-	-	-	-
1999	569.364	(114.536)	-	-	-	-	321.478	(113.557)
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	19.929	(9.956)	-	-
2002	267.487	(35.068)	-	-	-	-	-	-
2003	411.177	(69.431)	-	-	**88.442**	(36.051)	108.857	(37.528)
2004	**259.527**	(56.021)	-	-	**63.900**	(17.894)	**48.898**	(20.343)
2005	**286.416**	(39.849)	-	-	-	-	**26.605**	(7.952)
2006	315.310	(49.490)	-	-	72.415	(15.500)	34.799	(8.325)
2007	**397.049**	(71.564)	-	-	**52.287**	(19.231)	**129.646**	(60.661)
2008	**246.542**	(51.973)	-	-	**24.816**	(8.775)	**39.505**	(11.408)
2009	**330.235**	(28.526)	-	-	-	-	**102.834**	(28.670)
2010	589.533	(85.686)	-	-	-	-	169.560	(67.650)
2011	**347.082**	(92.540)	-	-	-	-	**24.105**	(7.089)
2012	**377.515**	(50.690)	-	-	-	-	-	-
2013	210.175	(69.911)	-	-	-	-	-	-
2014	260.245	(37.945)	-	-	-	-	72.811	(31.813)
2015	196.441	(22.788)	-	-	-	-	117.521	(50.701)

Table App.A.4: Survey abundance estimates and associated standard errors in thousand tons for *M. capensis* for the depth range 0-500m for the South Coast and for the West Coast (Fairweather, pers. commn). Values in bold are for the surveys conducted by the *Africana* with the new gear. Shaded cells are for the surveys conducted by the *Andromeda*.

| 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	125.028	(22.719)	181.487	(27.476)	-	-	-	-
1986	117.810	(23.636)	119.587	(18.489)	121.197	(16.625)	-	-
1987	75.693	(10.241)	87.391	(11.198)	159.088	(17.233)	-	-
1988	66.725	(10.765)	47.120	(9.568)	-	-	165.939	(21.871)
1989	-	-	323.833	(67.295)	-	-	-	-
1990	455.798	(135.237)	157.800	(23.561)	-	-	-	-
1991	77.357	(14.995)	-	-	-	-	274.298	(44.395)
1992	95.407	(11.744)	-	-	-	-	138.085	(15.357)
1993	92.598	(14.589)	-	-	-	-	158.340	(13.733)
1994	121.257	(35.951)	-	-	-	-	160.555	(23.701)
1995	199.142	(26.812)	-	-	-	-	236.025	(31.840)
1996	83.337	(9.285)	-	-	-	-	244.410	(25.107)
1997	257.293	(46.056)	-	-	-	-	183.087	(18.906)
1998	-	-	-	-	-	-	-	-
1999	196.992	(32.059)	-	-	-	-	191.203	(14.952)
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	133.793	(20.858)	-	-
2002	106.253	(15.813)	-	-	-	-	-	-
2003	75.960	(13.314)	-	-	**82.928**	(9.010)	128.450	(20.062)
2004	**205.939**	(33.216)	-	-	**106.119**	(15.596)	**99.902**	(12.027)
2005	**70.983**	(13.845)	-	-	-	-	**76.932**	(5.965)
2006	88.420	(22.851)	-	-	99.867	(9.803)	130.900	(14.816)
2007	**82.040**	(11.491)	-	-	**74.615**	(7.383)	**70.940**	(5.615)
2008	**50.877**	(5.355)	-	-	**94.232**	(11.456)	**108.195**	(9.978)
2009	**175.289**	(39.920)	-	-	-	-	**124.004**	(11.808)
2010	163.545	(34.444)	-	-	-	-	184.960	(37.720)
2011	**89.392**	(23.218)	-	-	-	-	**117.222**	(11.857)
2012	**92.588**	(11.926)	-	-	-	-	-	-
2013	30.241	(4.417)	-	-	-	-	-	-
2014	232.823	(64.477)	-	-	-	-	67.530	(6.853)
2015	65.939	(9.573)	-	-	-	-	86.322	(8.397)