Updated South Coast rock lobster stock assessments for 2010 and comparisons to the 2008 and 2009 assessments

S.J. Johnston and D.S. Butterworth

MARAM
Department of Mathematics and Applied Mathematics
University of Cape Town
Rondebosch, 7701

Introduction

This document is submitted in response to the requirement that "simple routine updated assessments (likely no more than core reference set models used in the OMP testing refitted taking a further year's data into account)" be tabled every year an OMP is in operation for a fishery (MCM, 2007)

This document reports such updated stock assessments for the South Coast rock lobster fishery. Essentially three further years' CPUE and catch-at-length data are available since the assessments upon which OMP testing was based were carried out in 2008 (see Johnston and Butterworth 2008a). Assessment updates produced in 2009 are now able to be further updated with one years' data. Although Johnston and Butterworth (2008a) initially presented stock assessment results for a wide range of models, only Models 3 and 4 were used as a final Reference Set in final OMP deliberations. Updates of Models 3 and 4 are thus presented here. To recap:

Model 3 – assumes time-varying selectivity using the MARAM method
Model 4 – assumes time-varying selectivity using the OLRAC method.

Besides data updates, a further update to the original 2008 assessment models is that the period for which recruitment residuals are estimated is extended from 1974-1997 by three further seasons to 1974-2000.

Corrections/Correction of programming glitch

A programming glitch was recently discovered in the underlying ASPM model program which has been used since 2008. The glitch was that population numbers at age were updated using catches by weight not numbers. Correction of this error leads to little difference in the Model 3 results particularly with respect to current biomass levels relative to pristine (see Figure 7b). Corrected absolute biomass values are however larger. Corrected Model 4 results are however less optimistic (compare Tables 6b and 7b and Figure 8b). Tables 5 and 6 report corrected 2008 and 2009 assessment results.

Data

The following input data are used in the updated assessment results presented here:

1. Commercial catch data for each Area as reported in Glazer (2010a) – see Table 1.
2. CPUE series for each Area from GLM analyses reported in Glazer (2010b) – see Table 2.

3. Catch-at-length data for each Area and both sexes as reported in Glazer (2010c) – see Table 3.

Results

Updated 2010 assessment results for Models 3 and 4 are reported in Tables 4a and b respectively. Tables 5 and 6 report the 2009 and 2008 assessment results respectively for comparison. Table 7 reports the original 2008 assessments. Table 8 provides some summarized comparisons between theses assessments.

Figure 1 shows the 2010 updated Model 3 and Model 4 fits to the observed CPUE data for all three areas. Figure 2a compares Model 3 and Model 4 fits to the averaged catch-at-length data for Area 1-3 males and females separately. Figure 3 compares Model 3 and 4 estimated stock-recruit residuals. Figure 4 shows the time-varying selectivity $\delta_y^{m/f}$ parameter values for Model 3. Figure 5 shows the time-varying $x_y^{m/f}$ parameter values estimated for Model 4. Finally, Figure 7a shows the comparison between the 2008, 2009 and 2010 Model 3 (MARAM TVS) assessments (all corrected versions) of spawning biomass relative to pristine (B_{sp}/K_{sp}). Figure 7b is similar but for Model 4 results.

Discussion

Updated assessment results (Tables 4a and 4b) for Models 3 and 4 report similar goodness of fit to the CPUE data. The best fit continues to be to the Area 1 CPUE data. Figure 2 shows that on average the models fit well to the catch-at-length data.

It is interesting to note that the stock-recruit residuals for the last three years in the series (1998 - 2000) are negative (Figure 3) for Model 3, and negative for the last 2 years (1999-2000) for Model 4.

Tables 8aq and 8b, together with the respectively corresponding Figures 7 and 8, show that the estimates from Model 3 are reasonably stable as new data are added, with the recent spawning biomass trend also now appearing stable. In contrast there is a strong retrospective pattern in the results for Model 4, with the resource status improving markedly given extra data. This effect arises because estimates of K_{sp} increase as new data are added.

References

Glazer, J.P. 2010a. The separation of catch by area in the South Coast rock lobster fishery. MCM document, MCM/2010/APR/SWG-SCRL/??.

Glazer, J.P. 2010b. A generalized linear model applied to the South Coast rock lobster CPUE data to obtain area-specific indices of abundance MCM document, MCM/2010/APR/SWG-SCRL/??.

Glazer, J.P. 2010c. Size composition of male and female South Coast rock lobsters per season and area. MCM document, MCM/2010/APR/SWG-SCRL/??.

Johnston, S.J. and D.S. Butterworth. 2008a. Near final specifications for the sex- and area-specific Operating models for testing OMPs for the South Coast rock lobster resource. MCM document, WG/08/08/SCRL17.

Johnston, S.J. and D.S. Butterworth. 2008b. Results for the final OMP 2008 for the South Coast rock lobster resource. MCM document, MCM/2008/AUG/SWG-SCRL/28.

Johnston, S.J. and D.S. Butterworth. 2009. Updated South Coast rock lobster assessment for 2010. MCM document, MCM/2009/AUG/SWG-SCRL/06.

MCM. 2007. Procedures for deviating from OMP output for the recommendation for a TAC, for initiating an OMP review. MCM document, reproduced as Appendix 2 of Rademeyer *et al.*, AFr. J. Mar. Sci. 2008 30(2):291-310.

Table 1: Annual catches (tons tail mass) per area in the South Coast rock lobster fishery (Glazer 2010a).

Year	Area 1	Area 2	Area 3
1973			
1974	No data available in the catch and effort database for these years.		
1975			
1976			
1977	245.68	254.76	166.56
1978	102.03	107.32	251.64
1979	31.89	29.92	60.19
1980	111.46	59.62	4.92
1981	138.26	169.32	40.42
1982	146.29	183.15	77.56
1983	125.16	280.90	117.94
1984	201.01	150.33	98.66
1985	85.52	200.30	164.17
1986	110.66	183.95	155.39
1987	106.23	146.37	199.40
1988	99.81	229.01	123.17
1989	112.36	241.00	98.64
1990	230.13	168.56	78.31
1991	183.06	204.02	137.46
1992	146.67	178.98	204.31
1993	191.22	242.92	90.13
1994	219.20	184.55	104.14
1995	122.68	249.99	132.23
1996	132.19	180.27	130.24
1997	105.57	156.72	154.10
1998	193.20	200.34	122.49
1999	248.62	157.99	105.55
2000	210.22	84.83	128.34
2001	108.53	111.05	68.41
2002	210.57	67.63	61.80
2003	207.18	123.88	18.94
2004	167.01	175.54	39.44
2005	173.67	134.14	74.19
2006	198.02	105.19	77.79
2007	173.43	101.76	111.81
2008	132.08	118.29	114.63

Table 2: Standardized South Coast rock lobster CPUE (kg/trap) per area (Glazer 2010b).

Year	Area 1	Area 2	Area 3
1977	1.873	1.703	2.710
1978	1.402	1.614	2.013
1979	1.483	1.630	1.601
1980	2.184	1.822	1.301
1981	1.751	1.751	1.585
1982	1.515	1.433	1.488
1983	1.694	1.671	1.687
1984	1.657	1.622	1.550
1985	1.360	1.463	1.606
1986	1.541	1.539	2.534
1987	2.060	1.738	1.516
1988	1.980	1.895	1.801
1989	1.947	1.978	1.571
1990	1.716	1.482	1.328
1991	1.292	1.091	1.581
1992	1.128	1.262	1.439
1993	1.015	1.233	0.981
1994	1.044	0.998	1.092
1995	0.904	0.863	1.659
1996	0.827	0.771	0.965
1997	0.811	0.611	0.892
1998	1.224	0.573	0.663
1999	0.997	0.575	0.642
2000	1.222	0.581	0.723
2001	1.265	0.755	0.830
2002	1.432	0.717	0.660
2003	1.343	0.975	0.527
2004	1.298	1.192	1.239
2005	1.186	0.921	1.026
2006	0.912	0.743	0.792
2007	0.958	0.962	1.124
2008	1.178	1.069	1.066

Table 3a: Proportional size distributions of male and female lobsters per year in Area 1 (Glazer 2010c).

Males size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0.00065	0.00086	0	0.00057	0.00035	0	0	0	0	0	0	0	0.00032	0.00023
50	0.00004	0.00723	0	0.00184	0	0.00033	0.00011	0.00008	0.00002	0	0.0002	0	0.00086	0.00084
55	0.0011	0.01842	0.00176	0.0028	0.00105	0.00043	0.00041	0.00022	0.00026	0.00078	0.00761	0	0.00218	0.00759
60	0.01046	0.02364	0.02567	0.02068	0.03155	0.00624	0.00401	0.00313	0.00612	0.00852	0.01742	0.00206	0.01943	0.0708
65	0.06359	0.02964	0.05313	0.05872	0.12373	0.07068	0.03964	0.02766	0.03483	0.02857	0.02524	0.13866	0.0712	0.11914
70	0.13023	0.07881	0.10201	0.09538	0.13074	0.14685	0.15205	0.11843	0.10852	0.09455	0.04388	0.2567	0.11546	0.14981
75	0.08858	0.09376	0.13674	0.08918	0.07536	0.11952	0.16524	0.15936	0.1541	0.11452	0.07515	0.17938	0.10095	0.10511
80	0.04532	0.07135	0.08485	0.06314	0.03715	0.06964	0.09662	0.11878	0.14115	0.10084	0.11382	0.22938	0.09136	0.06991
85	0.02671	0.04958	0.0425	0.04063	0.01717	0.03908	0.04354	0.07858	0.08978	0.07319	0.09079	0.07113	0.05436	0.04625
90	0.0184	0.02997	0.02267	0.02638	0.00841	0.02716	0.0212	0.04305	0.05088	0.05013	0.07417	0.01856	0.02142	0.02294
95	0.01343	0.01819	0.01485	0.01756	0.00456	0.01299	0.00995	0.02329	0.02234	0.02693	0.02706	0.00361	0.00532	0.01122
100	0.00594	0.0104	0.00986	0.01589	0.0014	0.00776	0.00624	0.00847	0.00869	0.01838	0.01203	0.00258	0.00309	0.0014
105	0.00549	0.00239	0.00398	0.00777	0.0014	0.0038	0.00327	0.00459	0.00291	0.00998	0.002	0.00103	0.00069	0
110	0.00156	0.00123	0.00183	0.00246	0.00035	0.00161	0.00081	0.00158	0.00191	0.00427	0.0004	0	0.00023	0.00061
115	0.00115	0.00007	0.00026	0.00096	0	0.00057	0.00043	0.00075	0.00038	0.00198	0.0006	0	0.00012	0.00006
120	0.00005	0.00004	0.00044	0.00138	0	0.00028	0	0.0002	0.0002	0.0002	0.0004	0	0	0.00003
125	0	0	0	0.00024	0	0	0	0.00014	0	0.00021	0	0	0.00005	0
Total	0.4127	0.43558	0.50055	0.44558	0.43322	0.50694	0.54352	0.58831	0.62209	0.53305	0.49077	0.90309	0.48704	0.60594

Females size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0	0.00168	0	0.00115	0	0	0	0	0	0	0	0	0.0006	0.00012
50	0.00012	0.00939	0.00017	0.00241	0	0.00017	0	0.00008	0.00007	0	0.0008	0	0.00082	0.00044
55	0.00094	0.02233	0.00604	0.00676	0.0028	0	0.0001	0	0.0004	0.00029	0.00741	0	0.00379	0.01267
60	0.01801	0.02416	0.03646	0.02788	0.08587	0.02412	0.00902	0.00561	0.00542	0.0069	0.01482	0	0.03464	0.05612
65	0.13857	0.06792	0.0701	0.09742	0.18647	0.13904	0.07412	0.04551	0.03244	0.03835	0.03707	0.000515	0.10727	0.09464
70	0.19091	0.15445	0.13873	0.12882	0.16474	0.15633	0.16727	0.10005	0.085	0.09962	0.07436	0.001546	0.15164	0.08683
75	0.119	0.12724	0.12677	0.10861	0.07781	0.08874	0.12588	0.10952	0.1095	0.10516	0.11984	0	0.11751	0.0651
80	0.05444	0.07918	0.06858	0.0806	0.034	0.04492	0.04542	0.07095	0.08183	0.088	0.11404	0.005155	0.05843	0.03925
85	0.03471	0.04399	0.02978	0.052	0.01122	0.02295	0.0213	0.04272	0.03756	0.05618	0.07656	0.001546	0.02374	0.02497
90	0.0156	0.02196	0.01394	0.02135	0.0014	0.01073	0.00826	0.02318	0.01735	0.0374	0.03928	0.010825	0.01119	0.00941
95	0.00869	0.00802	0.00492	0.01638	0.00105	0.0033	0.00367	0.00959	0.00566	0.01989	0.01462	0.052577	0.00232	0.00366
100	0.00328	0.00295	0.00263	0.00382	0.00105	0.0018	0.00101	0.00285	0.00152	0.00929	0.00681	0.016495	0.00071	0.00064
105	0.00274	0.00071	0.00113	0.0031	0.00035	0.00066	0.0002	0.00131	0.00039	0.00395	0.002	0.008247	0.0002	0
110	0.00023	0.00026	0.00009	0.00057	0	0.00019	0.0001	0.00029	0.00034	0.00133	0.0006	0	0.00008	0.00017
115	0.00005	0.00011	0.00009	0.00184	0	0	0.0001	0.00007	0.00039	0.00055	0.0008	0	0	0.00003
120	0	0.00007	0	0.00057	0	0.00009	0	0	0.00006	0.00004	0.0002	0	0.00004	0
125	0	0	0	0.00115	0	0	0	0	0	0	0	0	0	0
Total	0.58729	0.56442	0.49943	0.55443	0.56676	0.49304	0.45645	0.41173	0.37793	0.46695	0.50921	0.096906	0.51298	0.39405

Table 3b: Proportional size distributions of male and female lobsters per year in Area 2 (Glazer 2010c).

Males size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0	0.00005	0	0.00215		0	0	0	0	0.00021	0	0	0	0
50	0	0.00069	0.00032	0.00117		0	0.00012	0.00046	0.0001	0.00056	0.00004	0	0	0.00106
55	0	0.01948	0.00452	0.00804		0	0.00168	0.00577	0.0002	0.00234	0.00046	0	0.00388	0.00143
60	0.01377	0.08335	0.0455	0.04236		0.00643	0.01899	0.0206	0.0057	0.01831	0.00999	0.00299	0.04827	0.04167
65	0.07153	0.11903	0.14714	0.08048		0.04033	0.05584	0.05781	0.04677	0.039	0.05388	0.09641	0.08977	0.11401
70	0.09871	0.07983	0.17264	0.0799		0.14199	0.09462	0.09389	0.08398	0.07688	0.12666	0.21999	0.18374	0.11759
75	0.08718	0.04667	0.09551	0.0401		0.09181	0.0946	0.09336	0.15241	0.08791	0.11724	0.20614	0.1247	0.06073
80	0.07615	0.04316	0.0597	0.04941		0.07867	0.08828	0.07076	0.14525	0.0875	0.08696	0.19772	0.11418	0.0298
85	0.05994	0.03307	0.02227	0.06053		0.05672	0.06045	0.04669	0.07431	0.05635	0.06053	0.03884	0.06841	0.02778
90	0.03033	0.02536	0.00936	0.05555		0.07166	0.03887	0.03359	0.09616	0.039	0.03172	0.01086	0.02377	0.03842
95	0.01702	0.01384	0.00323	0.04481		0.11123	0.02334	0.02087	0.03883	0.01864	0.01666	0.00326	0.01215	0.02152
100	0.00432	0.01188	0.00097	0.02217		0.01347	0.01155	0.01494	0.01723	0.00922	0.00817	0.00081	0.00439	0.02373
105	0.0036	0.00506	0.00097	0.01249		0.0067	0.00749	0.00916	0.00422	0.00354	0.0038	0.00081	0.00179	0.00728
110	0.00024	0.00262	0	0.0036		0.00292	0.00365	0.00347	0.00287	0.00182	0.00229	0	0.00164	0.00117
115	0.00141	0.00445	0	0.0037		0.00133	0.00217	0.00189	0.00126	0.00048	0.00095	0	0.00049	0.00205
120	0.00129	0.00055	0	0.00005		0.00066	0.00068	0.00078	0.00021	0.0002	0.00047	0	0.00034	0.00103
125	0.00135	0.00028	0	0.00042		0.0002	0.00035	0.00063	0.0001	0.00008	0.00006	0	0.00003	0
Total	0.46684	0.48937	0.56213	0.50693	0	0.62412	0.50268	0.47467	0.6696	0.44204	0.51988	0.77783	0.67755	0.48927

Females size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0	0.00002	0	0.00014		0	0.00006	0	0.00002	0.00018	0	0	0	0
50	0	0.00035	0.00032	0.0033		0	0.00021	0.00112	0.00003	0.00062	0.00003	0	0.00034	0.00105
55	0.00054	0.03566	0.01065	0.00642		0.00013	0.00306	0.00579	0.00061	0.00332	0.00104	0	0.00154	0.0079
60	0.02778	0.08641	0.08035	0.04306		0.00988	0.02573	0.02996	0.00809	0.01988	0.0179	0	0.02385	0.05416
65	0.12164	0.13125	0.13875	0.07508		0.04391	0.06889	0.0711	0.03867	0.05352	0.079	0.002444	0.03722	0.15258
70	0.11982	0.07579	0.11681	0.06868		0.0727	0.10037	0.10878	0.08374	0.10212	0.13615	0.005703	0.07449	0.10082
75	0.09416	0.05969	0.05776	0.08274		0.079	0.10296	0.10421	0.08535	0.12662	0.12383	0.009777	0.06355	0.05772
80	0.05404	0.04416	0.02097	0.07817		0.06156	0.08261	0.07894	0.05523	0.11367	0.06718	0.039109	0.05786	0.0333
85	0.06611	0.03443	0.00678	0.05947		0.03642	0.05098	0.05212	0.02802	0.06853	0.02967	0.035035	0.03428	0.02843
90	0.03033	0.02088	0.00323	0.04091		0.02381	0.02976	0.03365	0.01559	0.03966	0.01566	0.061651	0.01735	0.02044
95	0.01267	0.01166	0.00129	0.02035		0.04128	0.01616	0.01994	0.0086	0.01892	0.00628	0.058121	0.00811	0.0383
100	0.00459	0.00692	0.00097	0.00812		0.00537	0.00844	0.01141	0.00402	0.00706	0.00198	0.007876	0.00257	0.00672
105	0.00135	0.00211	0	0.00302		0.00133	0.0046	0.00524	0.00161	0.00253	0.00088	0.002444	0.00076	0.00618
110	0.00012	0.00067	0	0.00143		0.00027	0.00215	0.00198	0.00063	0.00109	0.00033	0	0.00036	0.00106
115	0	0.00042	0	0.00165		0.0002	0.00094	0.00089	0.00013	0.0002	0.00013	0	0.00015	0.00205
120	0	0.00012	0	0.00044		0	0.00032	0.00005	0.00007	0.00005	0.00003	0	0	0
125	0	0.00009	0	0.00008		0	0.00007	0.00017	0.00001	0.00001	0.00002	0	0	0.00002
Total	0.53315	0.51063	0.43788	0.49306	0	0.37586	0.49731	0.52535	0.33042	0.55798	0.48011	0.22216	0.32243	0.51073

Table 3c: Proportional size distributions of male and female lobsters per year in Area 3 (Glazer 2010c).

Males size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0	0	0.00011	0.00415	0.00017	0.00018		0	0.0004	0	0	0	0	0
50	0.00118	0.00081	0.00043	0.02122	0.00169	0.00223		0.00319	0.00934	0.00036	0.001701	0.00013	0.00022	0.00061
55	0.01747	0.00936	0.00524	0.04265	0.03317	0.01439		0.04238	0.0801	0.02762	0.009513	0.00063	0.00923	0.00944
60	0.11158	0.06618	0.06636	0.09812	0.18514	0.08506		0.12721	0.16907	0.16853	0.050047	0.01675	0.10615	0.06989
65	0.14543	0.09119	0.12844	0.11081	0.1865	0.13045		0.10734	0.11549	0.15071	0.071031	0.05625	0.1593	0.11808
70	0.06933	0.06079	0.0679	0.07008	0.04908	0.08068		0.05877	0.04771	0.03931	0.046747	0.06538	0.07084	0.07793
75	0.03372	0.05582	0.03959	0.03188	0.01523	0.03878		0.03928	0.02058	0.01404	0.038857	0.06163	0.02772	0.03439
80	0.03573	0.06651	0.03804	0.02954	0.01472	0.03091		0.02513	0.0175	0.013	0.044327	0.08213	0.02566	0.03047
85	0.02952	0.0568	0.0353	0.02639	0.0154	0.03065		0.03267	0.01669	0.01924	0.046793	0.09	0.02649	0.03334
90	0.02462	0.04208	0.02965	0.02557	0.0088	0.02573		0.02779	0.01956	0.021218	0.049241	0.08325	0.02999	0.03876
95	0.01962	0.03039	0.02447	0.01569	0.00406	0.01805		0.02473	0.01804	0.021224	0.042469	0.0525	0.02525	0.03831
100	0.01294	0.01804	0.02138	0.01003	0.00152	0.01376		0.01053	0.00967	0.014928	0.0334	0.03125	0.02348	0.03295
105	0.0067	0.00556	0.01118	0.00597	0.00068	0.00911		0.00559	0.00509	0.007017	0.020396	0.01063	0.01263	0.0188
110	0.00254	0.00323	0.0067	0.00379	0.00068	0.00491		0.00339	0.00389	0.002795	0.00958	0.0075	0.00626	0.00828
115	0.0022	0.00254	0.00423	0.0017	0.00017	0.0025		0.00126	0.0025	0.001118	0.003256	0.00163	0.00198	0.00217
120	0.00313	0.0016	0.0026	0.00159	0	0.00089		0.00126	0.00105	0.000671	0.002402	0.00138	0.00084	0.00103
125	0.00176	0.00218	0.00269	0.00143	0	0.00286		0.00257	0.00135	0.000363	0.002055	0.00025	0.00048	0.00107
Total	0.51747	0.51308	0.48431	0.50061	0.51701	0.49114	0	0.51309	0.53803	0.502144	0.471815	0.56129	0.52652	0.51552

Females size	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
45	0.00012	0	0.00016	0.0104	0.00034	0.00009		0.0004	0	0.00003	0	0	0	0
50	0.00219	0.00169	0.00074	0.01596	0.00372	0.00366		0.00628	0.0111	0.00322	0.001231	0.000125	0.00029	0.0013
55	0.02393	0.02097	0.01319	0.0525	0.06312	0.02475		0.05711	0.07954	0.05415	0.014842	0.000625	0.01458	0.01819
60	0.13226	0.07818	0.08694	0.09977	0.19513	0.10373		0.12153	0.13371	0.16444	0.058556	0.014625	0.09887	0.0604
65	0.12581	0.07964	0.10499	0.09488	0.11965	0.11624		0.08543	0.07435	0.09488	0.060458	0.034375	0.11744	0.09147
70	0.04767	0.06126	0.06244	0.04997	0.03419	0.05799		0.03928	0.02622	0.05331	0.041858	0.0505	0.04765	0.05383
75	0.02898	0.0601	0.05024	0.03887	0.01862	0.03833		0.0344	0.0173	0.0179	0.048994	0.051	0.03109	0.033
80	0.0284	0.05814	0.05465	0.0412	0.01794	0.04771		0.03107	0.0228	0.0196	0.060589	0.07575	0.02893	0.04042
85	0.03247	0.04965	0.04896	0.03286	0.01422	0.03824		0.0381	0.02826	0.02982	0.074144	0.0765	0.03492	0.04651
90	0.02876	0.03604	0.04286	0.02762	0.00914	0.03172		0.03695	0.02758	0.027038	0.07784	0.066625	0.04015	0.05696
95	0.01443	0.01798	0.02489	0.01639	0.00355	0.02109		0.0177	0.01932	0.020223	0.048708	0.036875	0.03146	0.04499
100	0.00748	0.00991	0.01265	0.00851	0.00169	0.01287		0.01096	0.01419	0.008079	0.02564	0.021125	0.01847	0.02429
105	0.0035	0.00575	0.00531	0.00486	0.00102	0.00617		0.00271	0.0048	0.003299	0.009598	0.006	0.00667	0.00774
110	0.00257	0.00391	0.00384	0.00348	0.00034	0.00241		0.00242	0.00189	0.00109	0.00259	0.002375	0.00212	0.00416
115	0.00213	0.00293	0.00206	0.0014	0.00034	0.00152		0.00173	0.00045	0.000447	0.001859	0.001625	0.00055	0.00061
120	0.00062	0.00059	0.00142	0.00043	0	0.00152		0.00029	0.00045	0.000252	0.000735	0.0005	0.00018	0.0005
125	0.00122	0.00016	0.00038	0.00027	0	0.0008		0.00058	0	0.000084	0.000543	0.000125	0.00011	0.00011
Total	0.48254	0.4869	0.51572	0.49937	0.48301	0.50884	0	0.48694	0.46196	0.497862	0.528185	0.43875	0.47348	0.48448

Table 4a: (Corrected) 2010 Model 3 (time varying selectivity MARAM method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		230			
K^{sp}	total female spawning biomass	3903			
h	S/R steepness parameter	0.918			
λ^{A}	proportion R to Area A		0.36	0.45	0.19
μ^{A}	rel. female scaling parameter for Area A		0.99	0.78	0.94
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		70.97	62.00	60.02
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		79.89	62.00	60.02
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		68.05	63.59	77.59
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		75.30	70.69	88.66
β^{*}	growth function parameter	0.109			
$L_{\infty}^{m,A}$	L_{∞} for male lobsters in Area A (mm)		106.20	105.20	114.06
$L_{\infty}^{f,A}$	L_{∞} for female lobsters in Area A (mm)		103.22	98.92	108.91
κ	growth curve parameter (yr^{-1})	0.093			
t_0	growth curve parameter (yr^{-1})	-1.87			
l_m^{*}		63.63			
l_f^{*}		64.15			
ϖ		7.04			
λ		0.55			
-ln L (CPUE)		-114.93	-53.75	-32.58	-28.60
CPUE σ			0.113	0.219	0.248
-ln L (CAL)		-10.71	4.26	26.73	-41.70
CAL σ			0.079	0.111	0.079
SR residual penalty		4.81			
Time varying selectivity penalty		5.38			
Growth parameters penalty		3.27			
Time varying recruitment penalty		15.28			
Total –ln$L$ value		-97.58			
B_{06}^{sp} / K^{sp}		0.36			
B_{09}^{sp} / K^{sp}		0.37			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.34	0.32	0.37	0.32
$B_{06}^{\exp,A}$		3010	696	1518	796
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.34	0.37	0.37	0.26
$B_{09}^{\exp,A}$		2962	809	1488	665

Table 4b: (Corrected) 2010 Model 4 (time varying selectivity OLRAC method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		356			
K^{sp}	total female spawning biomass	4813			
h	S/R steepness parameter	0.677			
λ^A	proportion R to Area A		0.32	0.46	0.22
μ^A	rel. female scaling parameter for Area A		0.90	0.54	1.05
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		69.86	17.88	62.75
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		78.47	18.89	78.76
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		66.97	31.22	66.73
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		73.89	31.26	86.32
β^*	growth function parameter	0.114			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		107.04	105.37	110.04
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		102.40	97.97	106.90
κ	growth curve parameter (yr^{-1})	0.089			
t_0	growth curve parameter (yr^{-1})	-1.899			
l_m^*		64.62			
l_f^*		63.41			
ϖ		5.60			
λ		0.72			
-ln L (CPUE)		-121.02	-58.60	-35.94	-26.48
CPUE σ			0.097	0.197	0.265
-ln L (CAL)		-87.76	-3.72	48.87	-132.91
CAL σ			0.077	0.121	0.052
SR residual penalty		3.68			
Time varying selectivity penalty		7.22			
Growth parameters penalty		3.96			
Time varying recruitment penalty		14.04			
Total –ln$L$ value		-150.76			
B_{06}^{sp} / K^{sp}		0.45			
B_{09}^{sp} / K^{sp}		0.45			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.35	0.28	0.37	0.37
$B_{06}^{\exp,A}$		2863	493	1766	604
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.36	0.40	0.37	0.32
$B_{09}^{\exp,A}$		2946	698	1726	521

Table 5a: Corrected 2009 Model 3 (time varying selectivity MARAM method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		220			
K^{sp}	total female spawning biomass	3933			
h	S/R steepness parameter	0.77			
λ^{A}	proportion R to Area A		0.36	0.43	0.20
μ^{A}	rel. female scaling parameter for Area A		0.96	0.80	0.97
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		70.81	62.00	61.94
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		79.87	62.00	64.65
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.62	64.32	76.36
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.57	71.52	87.75
β^{*}	growth function parameter	0.108			
$L_{\infty}^{m,A}$	L_{∞} for male lobsters in Area A (mm)		104.08	106.69	113.10
$L_{\infty}^{f,A}$	L_{∞} for female lobsters in Area A (mm)		101.05	100.48	110.09
κ	growth curve parameter (yr^{-1})	0.092			
t_0	growth curve parameter (yr^{-1})	-1.780			
l_m^{*}		63.42			
l_f^{*}		64.09			
ϖ		690			
λ		0.58			
-ln L (CPUE)		-113.95	-50.04	-35.08	-28.84
CPUE σ			0.121	0.196	0.239
-ln L (CAL)		-1.25	10.65	29.47	-41.36
CAL σ			0.081	0.112	0.071
SR residual penalty		6.83			
Time varying selectivity penalty		5.22			
Growth parameters penalty		4.00			
Time varying recruitment penalty		14.23			
Total –ln$L$ value		-85.17			
B_{06}^{sp} / K^{sp}		0.35			
B_{08}^{sp} / K^{sp}		0.36			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.33	0.34	0.32
$B_{06}^{\exp,A}$		2884	773	1251	859
$B_{08}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.34	0.33	0.29
$B_{08}^{\exp,A}$		2809	784	1240	785

Table 5b: Corrected 2009 Model 4 (time varying selectivity OLRAC method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		346			
K^{sp}	total female spawning biomass	4025			
h	S/R steepness parameter	0.685			
λ^A	proportion R to Area A		0.38	0.41	0.21
μ^A	rel. female scaling parameter for Area A		0.92	0.89	0.99
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		69.33	67.30	66.50
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		77.81	77.07	89.22
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		66.78	63.71	56.92
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		73.64	80.74	85.01
β^*	growth function parameter	0.111			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		105.06	106.88	109.38
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		100.42	100.15	106.78
κ	growth curve parameter (yr^{-1})	0.093			
t_0	growth curve parameter (yr^{-1})	-1.95			
l_m^*		64.76			
l_f^*		62.59			
ϖ		5.87			
λ		0.78			
-ln L (CPUE)		-120.98	-53.23	-44.34	-23.41
CPUE σ			0.109	0.145	0.285
-ln L (CAL)		-100.25	3.99	9.74	-113.98
CAL σ			0.080	0.103	0.056
SR residual penalty		8.41			
Time varying selectivity penalty		6.15			
Growth parameters penalty		2.18			
Time varying recruitment penalty		18.07			
Total –ln$L$ value		-161.63			
B_{06}^{sp} / K^{sp}		0.34			
B_{08}^{sp} / K^{sp}		0.37			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.31	0.31	0.30	0.33
$B_{06}^{\exp,A}$		1851	616	763	472
$B_{08}^{\exp,A} / K_{1973}^{\exp,A}$		0.34	0.35	0.36	0.30
$B_{08}^{\exp,A}$		2032	696	900	436

Table 6a: Corrected 2008 Model 3 (time varying selectivity MARAM method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		206			
K^{sp}	total female spawning biomass	3931			
h	S/R steepness parameter	0.604			
λ^A	proportion R to Area A		0.336	0.467	0.197
μ^A	rel. female scaling parameter for Area A		1.165	1.033	1.015
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		70.30	62.00	60.00
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		79.53	62.00	60.00
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.36	63.70	77.08
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.32	71.02	86.41
β^*	growth function parameter	0.107			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		10.5.13	107.04	112/85
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		101.50	100.28	110.04
κ	growth curve parameter (yr^{-1})	0.092			
t_0	growth curve parameter (yr^{-1})	-1.83			
l_m^*		63.71			
l_f^*		64.21			
ϖ		7.25			
λ		0.58			
-ln L (CPUE)		-102.09	-44.98	-29.63	-27.49
CPUE σ			0.129	0.218	0.235
-ln L (CAL)		-208.93	-103.97	-25.89	-79.06
CAL σ			0.054	0.093	0.061
SR residual penalty		7.61			
Time varying selectivity penalty		4.84			
Growth parameters penalty		3.15			
Time varying recruitment penalty		19.05			
Total –ln$L$ value		-275.58			
B_{06}^{sp} / K^{sp}		0.31			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.33	0.32	0.29
$B_{06}^{\exp,A}$		2995	839	1393	763
$B_{2015}^{sp} / B_{2006}^{sp}$ *		0.88			

* The basis for this projection is a total future annual catch of 381 tons.

Table 6b: Corrected Model 4 (time varying selectivity OLRAC method) estimated parameters and quantities of management interest. Biomass quantities are in MT.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		332			
K^{sp}	total female spawning biomass	3414			
h	S/R steepness parameter	0.791			
λ^{A}	proportion R to Area A		0.38	0.43	0.19
μ^{A}	rel. female scaling parameter for Area A		1.04	1.05	0.95
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		70.00	66.82	76.19
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		79.14	75.93	102.46
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.41	65.57	73.85
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.89	74.47	93.36
β^{*}	growth function parameter	0.114			
$L_{\infty}^{m,A}$	L_{∞} for male lobsters in Area A (mm)		104.71	106.20	110.05
$L_{\infty}^{f,A}$	L_{∞} for female lobsters in Area A (mm)		99.21	100.63	107.58
κ	growth curve parameter (yr^{-1})	0.095			
t_0	growth curve parameter (yr^{-1})	-1.91			
l_m^{*}		64.99			
l_f^{*}		63.36			
ϖ		6.30			
λ		0.65			
-ln L (CPUE)		-112.11	-50.53	-37.27	-24.30
CPUE σ			0.106	0.168	0.262
-ln L (CAL)		-337.58	-108.09	-53.51	-175.98
CAL σ			0.053	0.081	0.041
SR residual penalty		5.43			
Time varying selectivity penalty		8.83			
Growth parameters penalty		1.94			
Time varying recruitment penalty		22.49			
Total –ln$L$ value		-376.04			
B_{06}^{sp} / K^{sp}		0.26			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.39	0.34	0.29
$B_{06}^{\exp,A}$		1662	667	778	217
$B_{2015}^{sp} / B_{2006}^{sp}$*		0.88			

* The basis for this projection is a total future annual catch of 381 tons.

Table 7a: Original 2008 Model 3 assessment results.

Parameter/quantity	**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters	206			
K^{sp} total female spawning biomass	781			
h S/R steepness parameter	0.713			
λ^A proportion R to Area A		0.37	0.44	0.19
μ^A rel. female scaling parameter for Area A		1.25	1.23	1.19
$l_{50}^{m,A}$ length at 50% selectivity for male lobsters in Area A (mm)		67.84	61.98	60.03
$l_{95}^{m,A}$ length at 95% selectivity for male lobsters in Area A (mm)		77.19	61.98	60.03
$l_{50}^{f,A}$ length at 50% selectivity for female lobsters in Area A (mm)		65.81	62.31	74.42
$l_{95}^{f,A}$ length at 95% selectivity for male lobsters in Area A (mm)		72.38	62.31	81.12
β^* growth function parameter	0.104			
$L_\infty^{m,A}$ L_∞ for male lobsters in Area A (mm)		104.94	107.05	112.59
$L_\infty^{f,A}$ L_∞ for female lobsters in Area A (mm)		101.05	100.40	110.22
κ growth curve parameter (yr^{-1})	0.090			
t_0 growth curve parameter (yr^{-1})	-1.93			
l_m^*	63.21			
l_f^*	63.28			
ϖ	7.25			
λ	0.76			
-ln L (CPUE)	-83.55	-33.91	-28.60	-21.02
CPUE σ		0.188	0.226	0.294
-ln L (CAL)	-180.20	-77.49	-24.92	-77.78
CAL σ		0.061	0.094	0.061
SR residual penalty	7.20			
Time varying selectivity penalty	3.25			
Growth parameters penalty	2.31			
Time varying recruitment penalty	17.54			
Total –ln$L$ value	-231.23			
B_{06}^{sp} / K^{sp}	0.34			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.29	0.33	0.29	0.26
$B_{06}^{\exp,A}$	503	177	211	115
$B_{2015}^{sp} / B_{2006}^{sp}$ *	0.89			

Table 7b: Original 2008 Model 4 assessment results.

Parameter/quantity		**Global**	**Area 1**	**Area 2**	**Area 3**
Total number of estimable parameters		332			
K^{sp}	total female spawning biomass	1110			
h	S/R steepness parameter	0.724			
λ^A	proportion R to Area A		0.30	0.32	0.38
μ^A	rel. female scaling parameter for Area A		1.26	1.55	1.33
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		66.03	62.70	52.97
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.87	68.82	74.64
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		65.41	62.34	55.90
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		71.79	70.01	74.05
β^*	growth function parameter	0.119			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		104.73	106.21	110.04
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		99.16	100.63	107.58
κ	growth curve parameter (yr^{-1})	0.084			
t_0	growth curve parameter (yr^{-1})	-1.98			
l_m^*		64.11			
l_f^*		62.27			
ϖ		6.24			
λ		0.87			
-ln L (CPUE)		-89.40	-39.24	-36.40	-13.76
CPUE σ			0.157	0.173	0.377
-ln L (CAL)		-269.06	-61.51	-45.97	-153.57
CAL σ			0.063	0.084	0.045
SR residual penalty		4.23			
Time varying selectivity penalty		7.38			
Growth parameters penalty		4.29			
Time varying recruitment penalty		14.78			
Total –ln$L$ value		-296.70			
B_{06}^{sp} / K^{sp}		0.47			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.37	0.36	0.34	0.43
$B_{06}^{\exp,A}$		584	201	222	161
$B_{2015}^{sp} / B_{2006}^{sp}$ *		0.98			

Table 8a: Comparison of **Model 3** 2008 and 2009 (corrected) assessments, along with the 2010 assessment and the 2008 original assessment.

	2010 (corrected)	**2009 corrected**	**2008 corrected**	**2008 original**
B_{06}^{sp} / K^{sp}	0.36	0.35	0.31	0.34
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.34	0.32	0.32	0.29
$B_{06}^{\exp,A}$	3010	2884	2995	503

Table 8b: Comparison of **Model 4** 2008 and 2009 (corrected) assessments, along with the 2010 assessment and the 2008 original assessment.

	2010 (corrected)	**2009 corrected**	**2008 corrected**	**2008 original**
B_{06}^{sp} / K^{sp}	0.45	0.34	0.26	0.47
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.35	0.31	0.32	0.37
$B_{06}^{\exp,A}$	2863	1851	1662	584

Figure 1: Comparison of model fits to observed CPUE trends for Models 3 and 4 for the 2010 assessment.

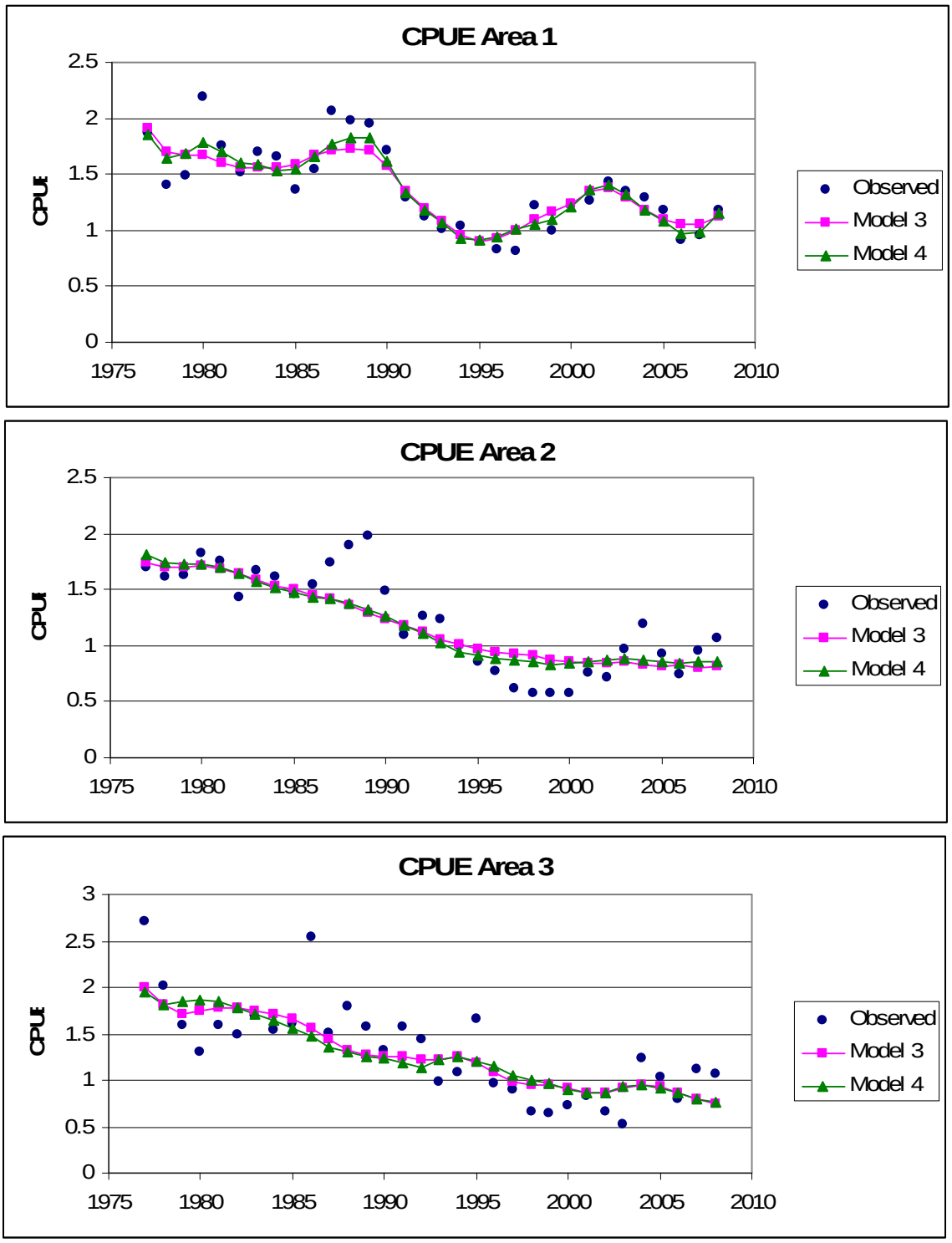

Figure 2: Comparison of model fits to observed catch-at-length (CAL) trends for Models 3 and 4 for the 2010 assessment averaged over all years. Note that proportions sum to 1 for males and females combined.

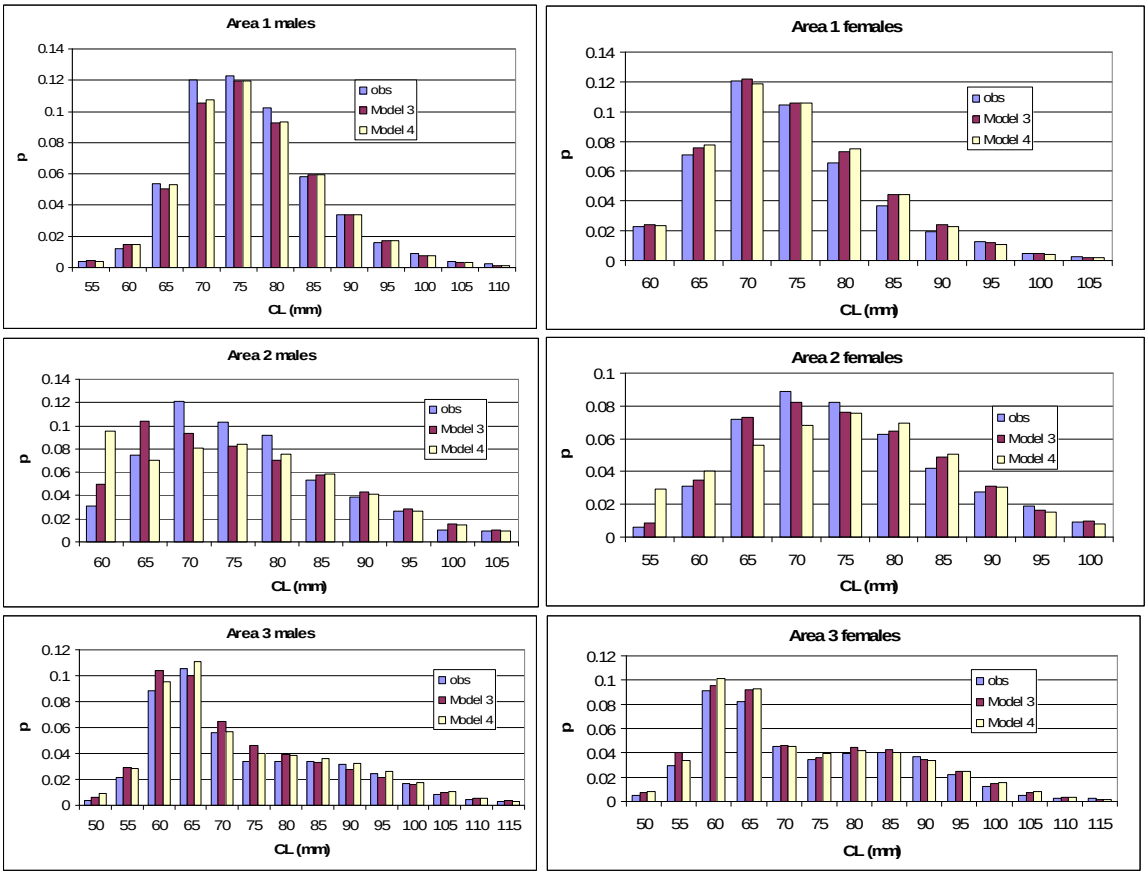

Figure 3: Plots of the stock recruit residuals for Models 3 and 4 for the 2010 assessment .

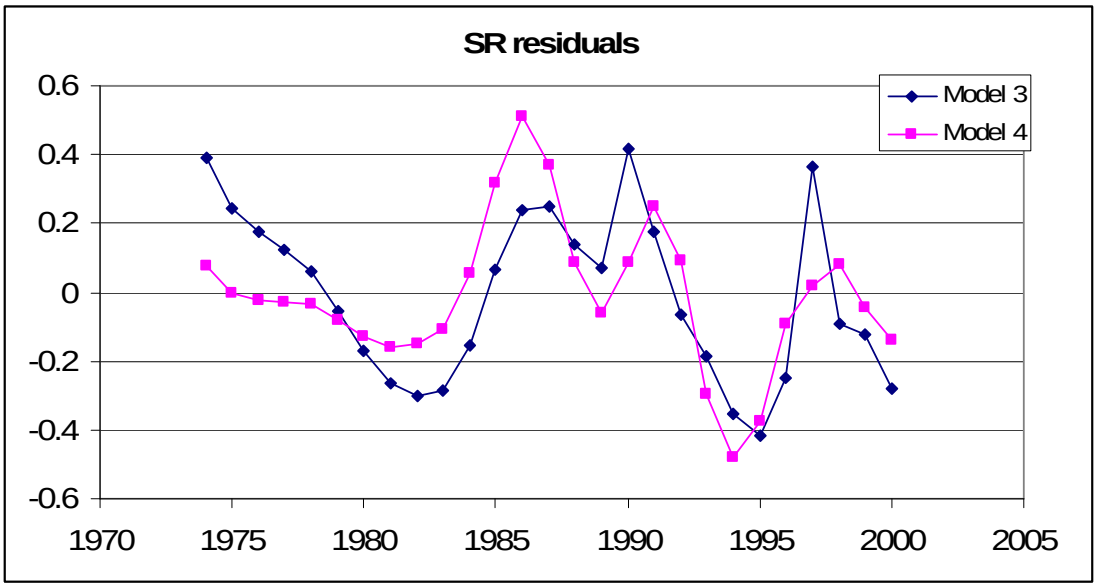

Figure 4: The MARAM method time-varying selectivity parameter $\delta_y^{m/f}$ values for each Area (and male and female) for Model 3 for the 2010 assessment.

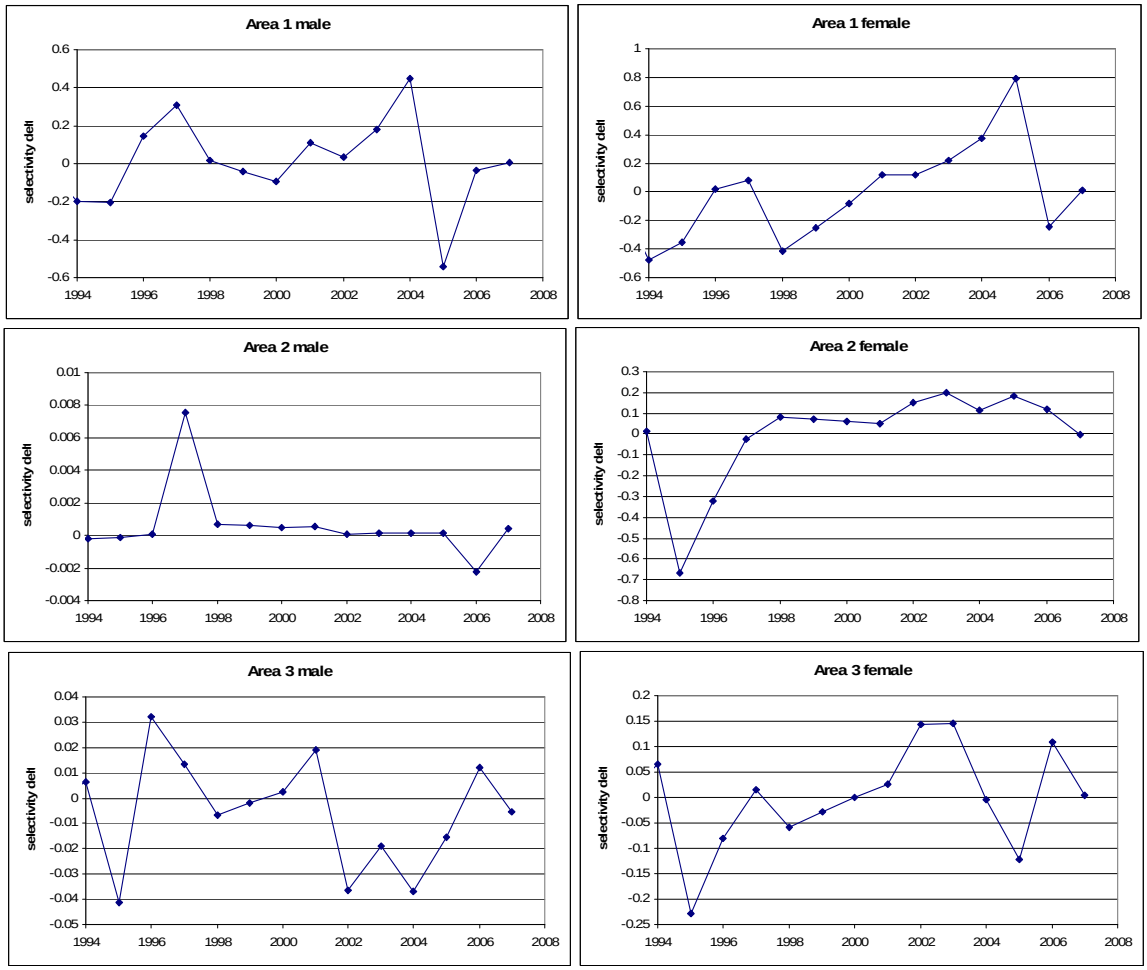

Figure 5: The OLRAC method time-varying selectivity parameter $x_y^{m/f}$ values for each Area (and male and female) for Model 4 for the 2010 assessment.

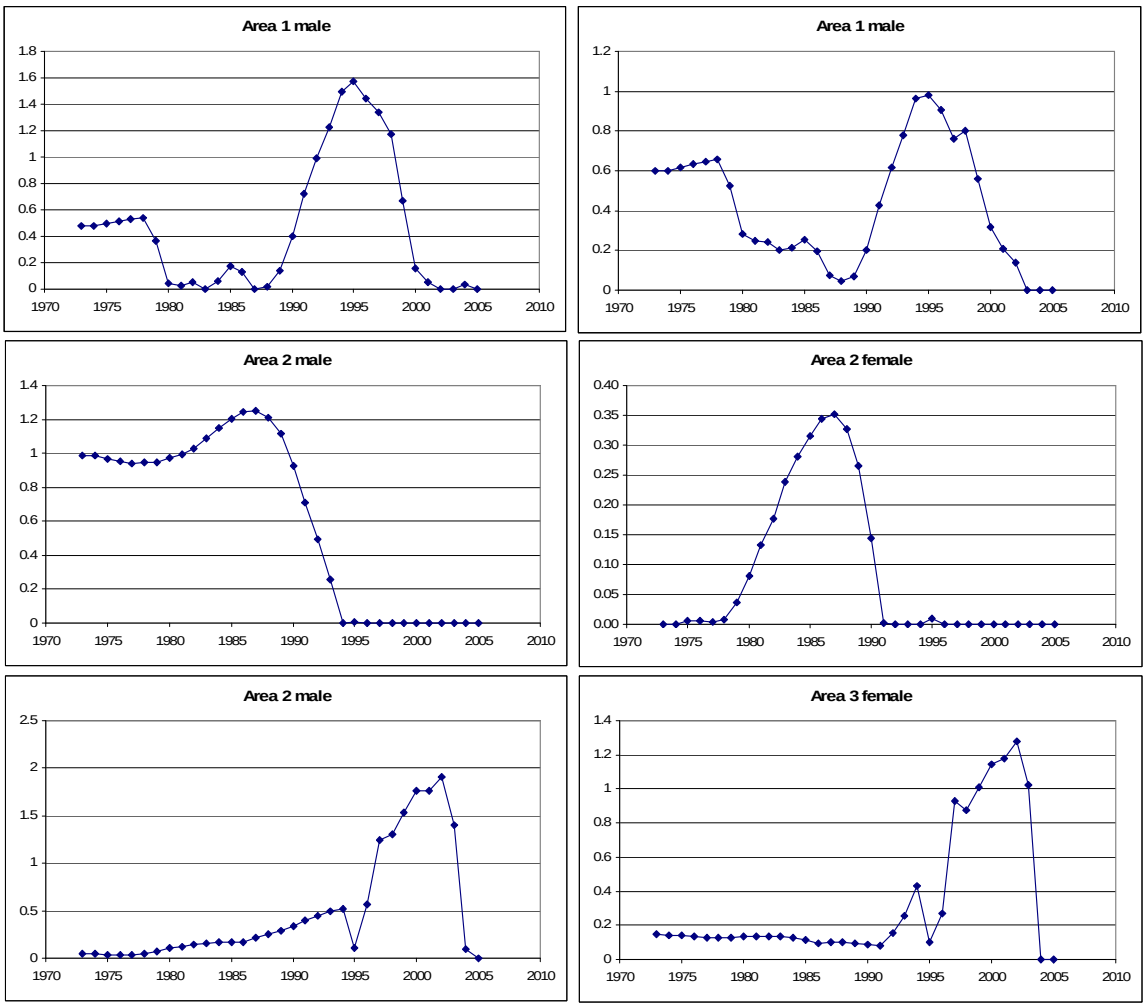

Figure 7a: Comparison between the 2008, 2009 and 2010 Model 3 (MARAM TVS) assessments (all corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).

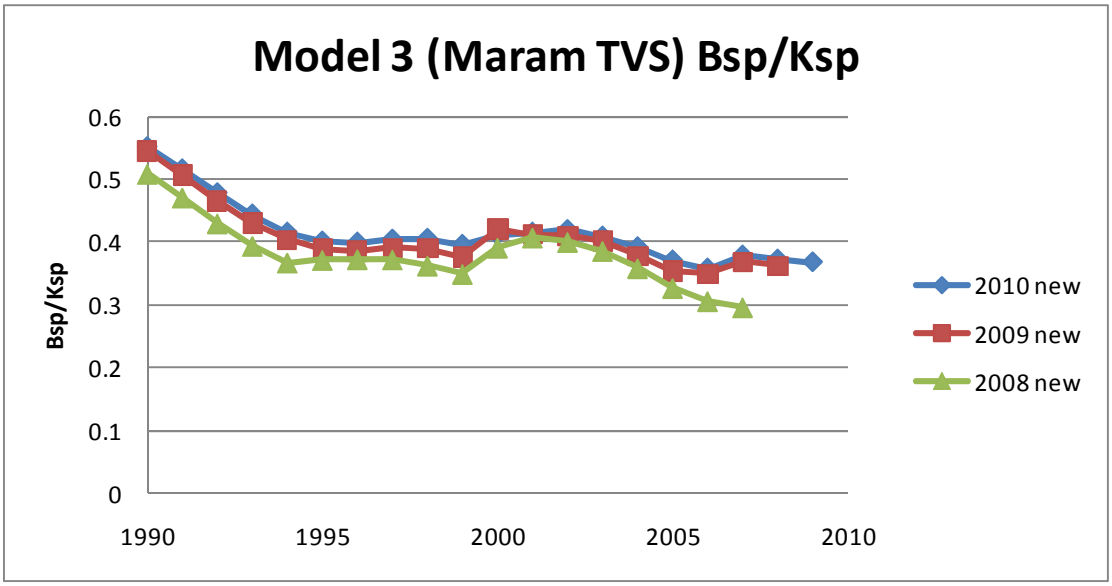

Figure 7b: Comparison between the Model 3 (Maram TVS) 2008 original and 2008 new assessments (i.e. incorrect vs corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).

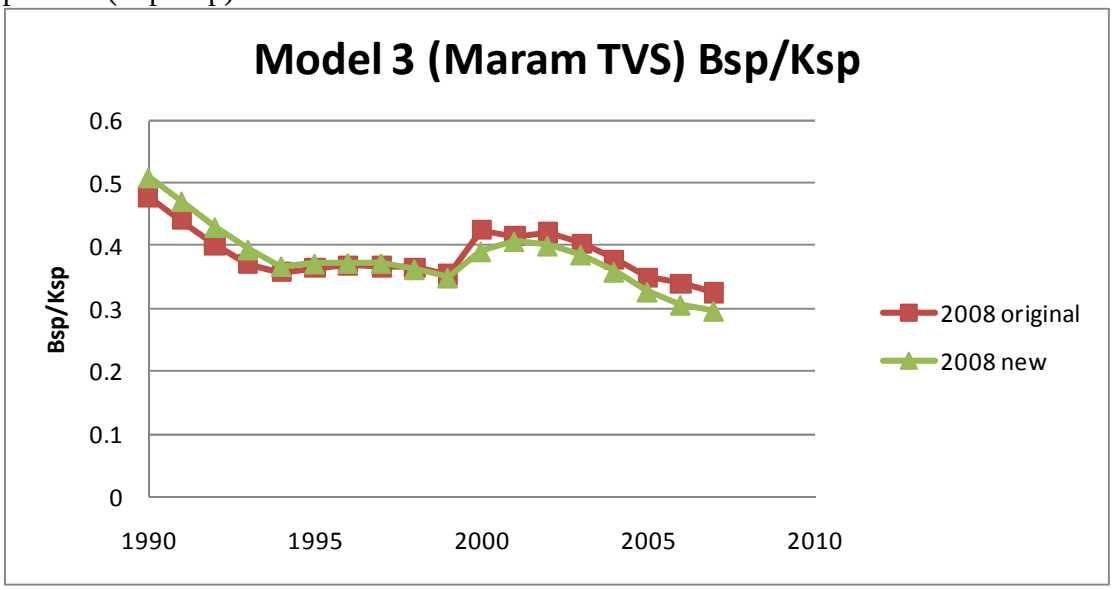

Figure 8a: Comparison between the 2008, 2009 and 2010 Model 4 (OLRAC TVS) assessments (all corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).

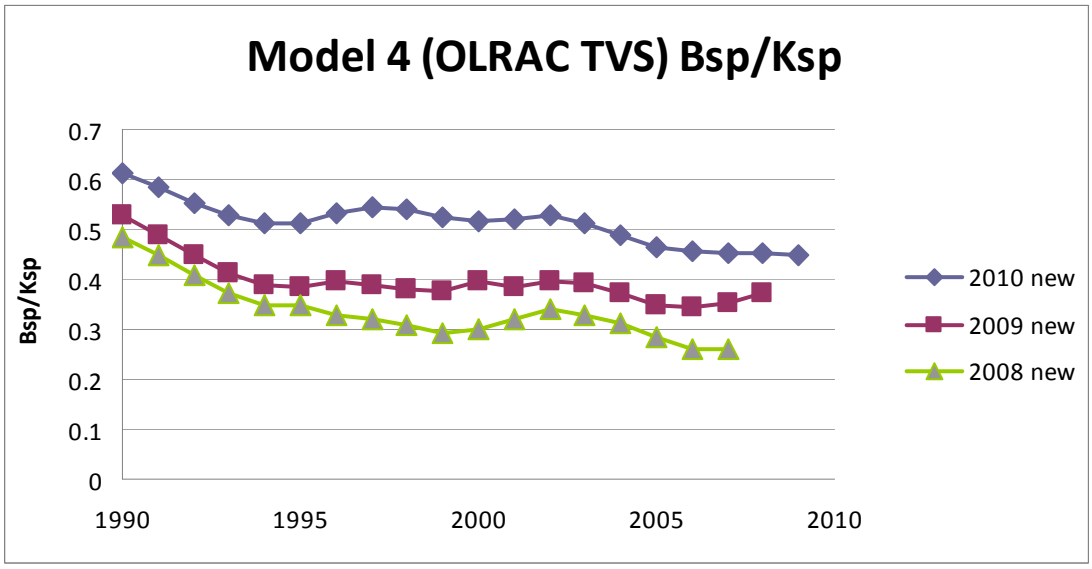

Figure 8b: Comparison between the Model 4 (OLRAC TVS) 2008 original and 2008 new assessments (i.e. incorrect vs corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).