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

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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.

<u>Corrections/Correction of programming glitch</u>

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 of Johnston and Butterworth 2010).

Johnston and Butterworth (2010) reported results of updated 2010 assessments. After discussions of the SWG it as decided that these results needed to be checked primarily to ensure that convergence of the model fit had been obtained. It was unclear whether this was the case for all the results presented in Johnston and Butterworth (2010). Comments were also made at that time that the model fits to CPUE trends differed somewhat to previous 2008 and 2009 results.
To this end, considerable time and effort was spent by both Johnston (MARAM) and Gaylard (OLRAC) in both checking code and ensuring that convergence had reached. MARAM and OLRAC have produced almost identical Model 3 fits independently

(see Appendix 1 for detailed comparisons). As an aside, it is interesting to note that more than 95 emails between Johnston and Gaylard took place during this intensive code checking exercise! Achieving such convergence is a positive outcome from this process.

Although the primary objective of this 2010 assessment update exercise was to see if model estimates (particularly of current relative to pristine biomass) are relatively close to those estimated by the models implemented in 2008 (upon which the current OMP was tested), during the code checking process a number of issues came to light which should be taken into account in further model assessment development. The three main issues are:

1. Growth parameters: Johnston and Butterworth (2008) provide full model specifications for the underlying SCRL assessment model. Observed L_{inf} values (as well as κ and t_0 values) provided by OLRAC (obtained from GLM analyses of tagging data) were used to produce weight-at-age vectors which were treated as data inputs. Another part of the program requires length-at-age values in order to calculate entries of the matrix which allocates numbers-at-age to number-at-age-at-length. The L_{inf} , κ and t_0 parameters of this function are estimated in the model fit, as it was found slight changes in these values could result in much improved fits to the catch-at-length data. A more defensible model would use the estimated growth parameter values for both the age-length conversion matrix as well as for calculating the weigths-at-age.

2. h : This is the steepness parameter of the stock-recruit function. The 2010 implementations of the assessment models estimate this h parameter to be effectively 1.0. What this means is that at even low levels of spawning biomass, there is no reduction in recruitment i.e. recruitment overfishing is not allowed. The 2008 and 2009 assessments estimated this parameter to be between 0.6 and 0.8. The model attempts to constrain this parameter to be near 0.95 by means of a prior for h ~ N(0.95, 0.2^2) where the normal distribution is truncated at 1. Clearly the current data are such as override this penalty. As a sensitivity therefore, a case is explored where h is fixed at 0.95.

3. Stock recruit residuals: The average of the estimated residuals are forced to equal zero. A further penalty term to the likelihood is thus added as follows:

   $-\ln L = \ln L + W[\sum_{1974}^{2000} \frac{\varepsilon_y}{\sigma_R}]^2$ where the weighting factor W is set high to ensure that the sum above end as zero. This is to ensure that when projecting, the stock-recruitment curve used more closely reflects the past patterns of recruitment and its variability.

Updated 2010 assessment results are reported here for the following models:

- Model 3
- Model 3 catch-at-length data downweighted (**cdw**) - CAL data down-weighted by 0.1
- Model 3 ***h* pen** - set $h = 0.95$
- Model 4

Projections

The updated 2010 assessment models are used to project the resource forwards under a constant catch harvesting strategy. Model assumptions for projecting forwards are as follows:

Future selectivity:

Model 3: the 2009+ values of the δ parameter are set equal to zero
Model 4: the 2009+ parameter values are set equal to the 1973-2008 average

Recruitment split between areas:

Future (2002+): use the average of the estimated proportional split values for 1973-2001

Future recruitment: The model estimates residuals for 1974-2000. For 2001+ recruitment is set equal to its expected values given the fitted stock-recruit relationship. The relationship itself is $R_y = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{\varepsilon_y}$ where $\varepsilon_y \sim N(0, \sigma_R^2)$ and $\sigma_R = 0.4$. This means that the expected recruitment $E[R_y] = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{\frac{\sigma_R^2}{2}} = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{0.08}$

Constant catch split between areas: The catch is split between the areas using the average *F* value calculated for each area over the 2004-2008 period $\overline{F}_A$, i.e.

$$C_A = C_{total} \frac{\overline{F}_A B_A^{exp}}{\sum_A' \overline{F}_A' B_A'^{\exp}}$$

The $\overline{F}_A$ values are 0.288, 0.079 and 0.178 for Area 1, 2 and 3 respectively for Model 3.

Results for three agreed levels of Constant Catch are reported: 345 MT, 330 MT and 315 MT.

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.

Tables 9a-d reports the projections results for the four assessment models presented here.

Figures 1a-b show the 2010 updated assessment model fits to the observed CPUE data for all three areas.

Figure 2 compares Model 3 and Model 4 fits to the averaged catch-at-length data for Area 1-3 males and females separately. Figures 3a-b reported the estimated stock-recruit residuals for each of the four models.

Figure 4 shows the spawning biomass trends for each of the four models.

Finally, Figure 5a shows the comparison between the 2008, 2009 and 2010 Model 3 assessments (all corrected versions) of spawning biomass relative to pristine (B_{sp}/K_{sp}). Figure 5b is similar but for Model 4 results.

Appendix 2 reports plots of CPUE fits to data comparing the 2010 updated assessments with those for the original 2008 model (upon which the OMP was tested and developed) as well as the 2009 updated assessment.

Discussion

The primary objective of this 2010 assessment updating exercise is to see if model estimates (particularly of current versus pristine biomass) are reasonably to those estimated by the 2008 models (upon which the current OMP was tested).

Although biomass estimates in absolute terms differ appreciably from those originally computed in 2008 (due to the glitch referenced above), in relative terms the results for model 3 do not show retrospective patterns/variability that are very large (Table 8a and Fig 5a). However the same does not hold for Model 4 (Table 8b and Fig. 5b) where results vary more substantially as new data are added with the passage of time.

This seems to be a consequence of possible over-parametrization of Model 4 (which has over 100 more estimable parameters than Model 3. It is evident from Table 4d (note the CPUE σ values and Figure 1a that for 2010, Model 4 has used this flexibility to fit the CPUE data near exactly, with residual variation that is consequently unrealistically large.

The projection results in Table 9 indicate that in terms of reaching the existing target of a 20% increase in the 2006 spawning biomass by 2025, this would be achieved under a constant annual catch of 345 tons for Model 3 even if steepness *h* is reduced to 0.95, but that a drop of over 10% in that quantity would be needed to reach this target under Model 3 with down-weighting of the catch-at-length data or Model 4/

Overall these results (specifically the retrospective variation in current spawning biomass relative to its pre-exploitation level) suggest that the large number of estimable parameters is leading to poor precision of this estimate, particularly in the case of Model 4.

References

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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	No data available in the catch and effort database for these years.		
1974			
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	226			
K^{sp} total female spawning biomass	3172			
h S/R steepness parameter	0.99			
λ^A proportion R to Area A		0.38	0.43	0.19
μ^A rel. female scaling parameter for Area A		1.05	0.76	1.0
$l_{50}^{m,A}$ length at 50% selectivity for male lobsters in Area A (mm)		69.38	65.85	86.25
$l_{95}^{m,A}$ length at 95% selectivity for male lobsters in Area A (mm)		78.54	73.17	107.92
$l_{50}^{f,A}$ length at 50% selectivity for female lobsters in Area A (mm)		67.85	63.48	81.59
$l_{95}^{f,A}$ length at 95% selectivity for male lobsters in Area A (mm)		73.17	70.08	97.08
β^* growth function parameter	0.109			
$L_\infty^{m,A}$ L_∞ for male lobsters in Area A (mm)		109.86	101.53	130.17
$L_\infty^{f,A}$ L_∞ for female lobsters in Area A (mm)		105.16	96.87	125.41
κ growth curve parameter (yr^{-1})	0.111			
t_0 growth curve parameter (yr^{-1})	-1.92			
l_m^*	65.90			
l_f^*	64.54			
ϖ	4.66			
λ	0.40			
-ln L (CPUE)	-131.81	-55.83	-34.94	-41.05
CPUE σ		0.106	0.203	0.168
-ln L (CAL)	-99.79	-7.19	0.63	-93.23
CAL σ		0.080	0.104	0.062
SR residual penalty	7.52			
Time varying selectivity penalty	12.55			
Growth parameters penalty	13.91			
Time varying recruitment penalty	14.62			
Total –ln$L$ value	-183.67			
B_{06}^{sp} / K^{sp}	0.28			
B_{09}^{sp} / K^{sp}	0.29			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.27	0.24	0.33	0.18
$B_{06}^{\exp,A}$	2421	465	1520	435
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$	0.28	0.27	0.36	0.15
$B_{09}^{\exp,A}$	2548	534	1659	355

Table 4b: 2010 Model 3 **cdw** 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		226			
K^{sp}	total female spawning biomass	2708			
h	S/R steepness parameter	0.99			
λ^A	proportion R to Area A		0.41	0.39	0.20
μ^A	rel. female scaling parameter for Area A		0.96	0.80	1.03
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		69.80	66.86	92.44
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		78.64	74.87	116.93
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		66.97	64.11	86.20
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.15	71.07	105.12
β^*	growth function parameter	0.117			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		104.79	107.6	117.87
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		100.18	101.19	112.02
κ	growth curve parameter (yr^{-1})	0.096			
t_0	growth curve parameter (yr^{-1})	-1.98			
l_m^*		65.86			
l_f^*		64.45			
ϖ		4.48			
λ		0.27			
-ln L (CPUE)		-147.37	-53.65	-52.74	-40.98
CPUE σ			0.113	0.117	0.169
-ln L (CAL)		36.25	34.32	40.29	-38.36
CAL σ			0.092	0.122	0.072
SR residual penalty		10.63			
Time varying selectivity penalty		0.26			
Growth parameters penalty		1.02			
Time varying recruitment penalty		5.37			
Total –ln$L$ value		-127.13			
B_{06}^{sp} / K^{sp}		0.35			
B_{09}^{sp} / K^{sp}		0.35			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.31	0.35	0.20
$B_{06}^{\exp,A}$		2346	648	1084	614
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.31	0.30	0.37	0.17
$B_{09}^{\exp,A}$		2295	639	1135	521

Table 4c: 2010 Model 3 ***h* penalty** 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	226			
K^{sp} total female spawning biomass	3233			
h S/R steepness parameter	0.95			
λ^{A} proportion R to Area A		0.38	0.43	0.19
μ^{A} rel. female scaling parameter for Area A		1.05	0.76	1.00
$l_{50}^{m,A}$ length at 50% selectivity for male lobsters in Area A (mm)		69.70	65.80	86.30
$l_{95}^{m,A}$ length at 95% selectivity for male lobsters in Area A (mm)		78.56	73.07	107.98
$l_{50}^{f,A}$ length at 50% selectivity for female lobsters in Area A (mm)		67.39	63.43	81.62
$l_{95}^{f,A}$ length at 95% selectivity for male lobsters in Area A (mm)		74.82	70.00	97.14
β^{*} growth function parameter	0.110			
$L_{\infty}^{m,A}$ L_{∞} for male lobsters in Area A (mm)		109.06	101.20	130.13
$L_{\infty}^{f,A}$ L_{∞} for female lobsters in Area A (mm)		105.03	96.65	125.36
κ growth curve parameter (yr^{-1})	0.106			
t_0 growth curve parameter (yr^{-1})	-1.92			
l_m^{*}	65.90			
l_f^{*}	64.54			
ϖ	4.66			
λ	0.39			
-ln L (CPUE)	-131.60	-55.81	-34.75	-41.04
CPUE σ		0.106	0.205	0.168
-ln L (CAL)	-99.54	-7.22	0.76	-93.09
CAL σ		0.080	0.105	0.062
SR residual penalty	7.51			
Time varying selectivity penalty	12.55			
Growth parameters penalty	13.83			
Time varying recruitment penalty	14.74			
Total –ln$L$ value	-873.01			
B_{06}^{sp} / K^{sp}	0.29			
B_{09}^{sp} / K^{sp}	0.29			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.27	0.24	0.33	0.18
$B_{06}^{\exp,A}$	2466	464	1569	433
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$	0.28	0.27	0.36	0.14
$B_{09}^{\exp,A}$	2586	532	1703	351

Table 4d: (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		362			
K^{sp}	total female spawning biomass	2875			
h	S/R steepness parameter	0.933			
λ^A	proportion R to Area A		0.37	0.45	0.18
μ^A	rel. female scaling parameter for Area A		0.96	0.87	0.93
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		60.85	64.55	69.69
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		80.32	71.80	78.97
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		68.31	64.69	78.97
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		76.47	72.02	92.20
β^*	growth function parameter	0.118			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		110.70	106.11	119.03
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		105.30	97.48	113.32
κ	growth curve parameter (yr^{-1})	0.098			
t_0	growth curve parameter (yr^{-1})	-2.02			
l_m^*		65.81			
l_f^*		64.54			
ϖ		4.44			
λ		0.48			
-ln L (CPUE)		-800.24	-713.86	-44.80	-41.58
CPUE σ			0.000	0.003	0.001
-ln L (CAL)		-200.48	-22.97	-66.56	-110.94
CAL σ			0.076	0.081	0.058
SR residual penalty		13.22			
Time varying selectivity penalty		0			
Growth parameters penalty		4.12			
Time varying recruitment penalty		14.79			
Total –ln$L$ value		-969.07			
B_{06}^{sp} / K^{sp}		0.27			
B_{09}^{sp} / K^{sp}		0.32			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.22	0.11	0.29	0.25
$B_{06}^{\exp,A}$		2024	330	1090	605
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.26	0.14	0.35	0.25
$B_{09}^{\exp,A}$		2334	429	1291	611

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}	0.28	0.35	0.31	0.34
$B_{06}^{\exp} / K_{1973}^{\exp}$	0.27	0.32	0.32	0.29
$B_{06}^{\exp}$	2421	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}	0.27	0.34	0.26	0.47
$B_{06}^{\exp} / K_{1973}^{\exp}$	0.22	0.31	0.32	0.37
$B_{06}^{\exp}$	2024	1851	1662	584

Table 9a: Projection results for 2010 updated Model 3.

CC (MT)	**345**	**330**	**315**
B_{06}^{sp}/K^{sp}	0.28	0.28	0.28
B_{09}^{sp}/K^{sp}	0.29	0.29	0.29
B_{15}^{sp}/K^{sp}	0.33	0.34	0.34
B_{25}^{sp}/K^{sp}	0.34	0.37	0.39
B_{25}^{sp}/B_{06}^{sp}	1.21	1.30	1.37
$B_{06}^{\exp}/K^{\exp}$	0.28	0.28	0.28
$B_{09}^{\exp}/K^{\exp}$	0.29	0.29	0.29
$B_{15}^{\exp}/K^{\exp}$	0.31	0.32	0.33
$B_{25}^{\exp}/K^{\exp}$	0.33	0.36	0.38
$B_{25}^{\exp}/B_{06}^{\exp}$	1.23	1.32	1.42

Table 9b: Projection results for 2010 updated Model 3 **cdw**.

CC (MT)	**345**	**330**	**315**
B_{06}^{sp}/K^{sp}	0.35	0.35	0.35
B_{09}^{sp}/K^{sp}	0.35	0.35	0.35
B_{15}^{sp}/K^{sp}	0.34	0.35	0.36
B_{25}^{sp}/K^{sp}	0.32	0.35	0.38
B_{25}^{sp}/B_{06}^{sp}	0.92	1.01	1.08
$B_{06}^{\exp}/K^{\exp}$	0.29	0.29	0.29
$B_{09}^{\exp}/K^{\exp}$	0.28	0.28	0.28
$B_{15}^{\exp}/K^{\exp}$	0.28	0.29	0.31
$B_{25}^{\exp}/K^{\exp}$	0.27	0.30	0.33
$B_{25}^{\exp}/B_{06}^{\exp}$	0.95	1.04	1.14

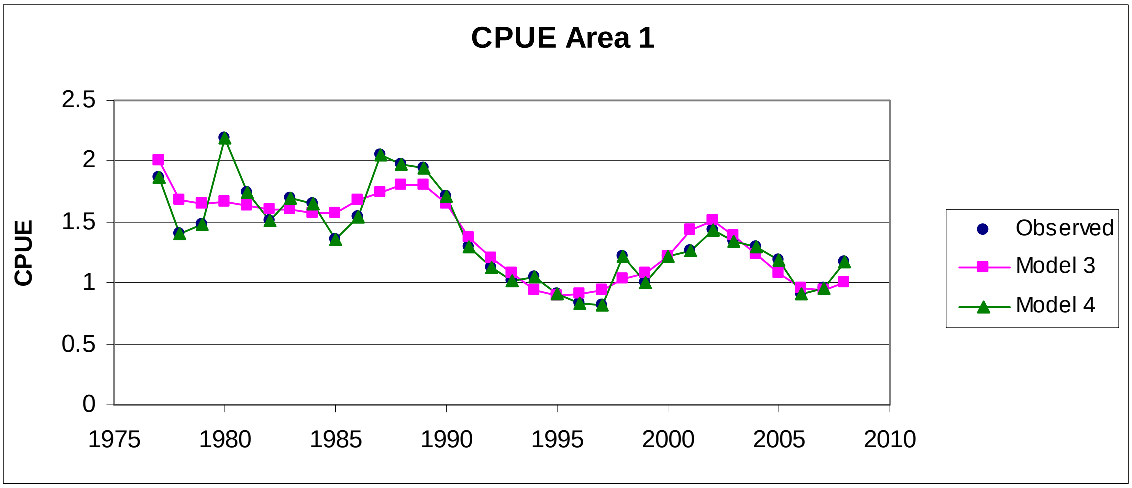
Table 9c: Projection results for 2010 updated Model 3 ***h* pen**.

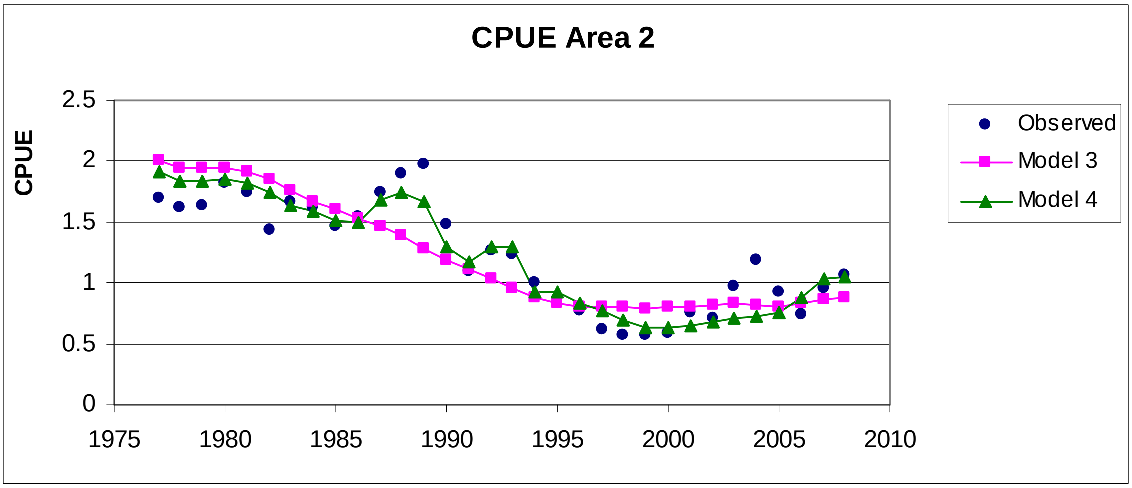
CC (MT)	**345**	**330**	**315**
B_{06}^{sp} / K^{sp}	0.29	0.29	0.30
B_{09}^{sp} / K^{sp}	0.29	0.29	0.29
B_{15}^{sp} / K^{sp}	0.33	0.34	0.34
B_{25}^{sp} / K^{sp}	0.34	0.36	0.38
$B_{25}^{sp} / B_{06}^{sp}$	1.17	1.25	1.33
B_{06}^{exp} / K^{exp}	0.27	0.27	0.27
B_{09}^{exp} / K^{exp}	0.29	0.29	0.29
B_{15}^{exp} / K^{exp}	0.31	0.32	0.33
B_{25}^{exp} / K^{exp}	0.32	0.35	0.38
$B_{25}^{exp} / B_{06}^{exp}$	1.19	1.29	1.38

Table 9d: Projection results for 2010 updated Model **4**.

CC (MT)	**345**	**330**	**315**
B_{06}^{sp} / K^{sp}	0.27	0.27	0.27
B_{09}^{sp} / K^{sp}	0.32	0.32	0.32
B_{15}^{sp} / K^{sp}	0.29	0.30	0.31
B_{25}^{sp} / K^{sp}	0.25	0.28	0.30
$B_{25}^{sp} / B_{06}^{sp}$	0.94	1.02	1.12
B_{06}^{exp} / K^{exp}	0.22	0.22	0.22
B_{09}^{exp} / K^{exp}	0.24	0.24	0.24
B_{15}^{exp} / K^{exp}	0.22	0.23	0.24
B_{25}^{exp} / K^{exp}	0.19	0.21	0.23
$B_{25}^{exp} / B_{06}^{exp}$	0.84	0.93	1.04

Figure 1a: Comparison of model fits to observed CPUE trends for Models 3 and 4 for the 2010 assessment. For Area 1 the agreement between the observed values and Model 4 is exact.





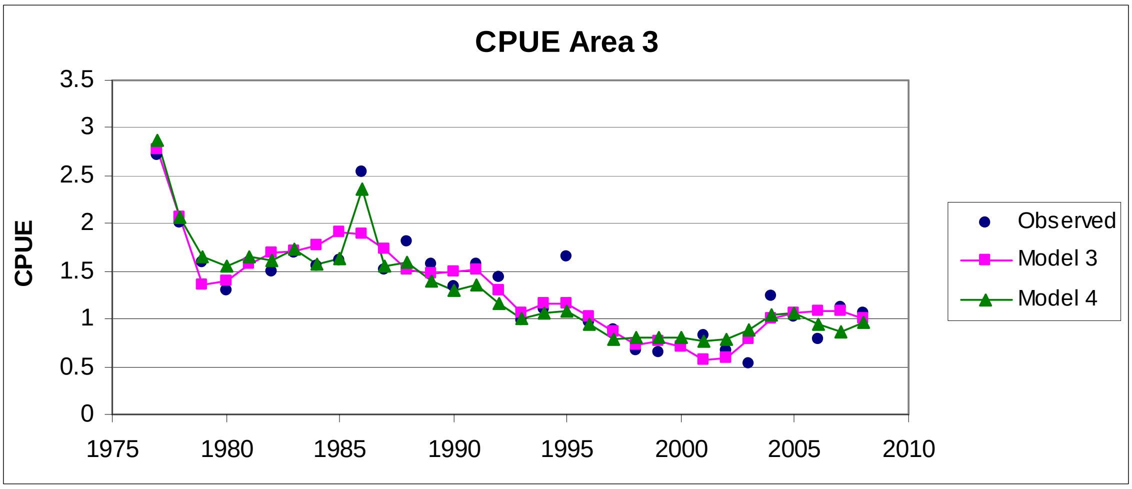
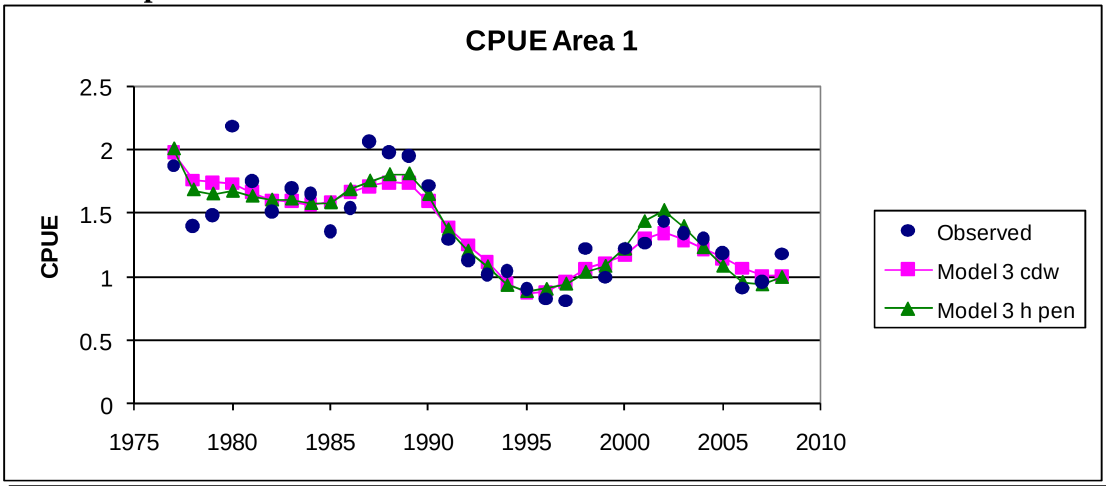
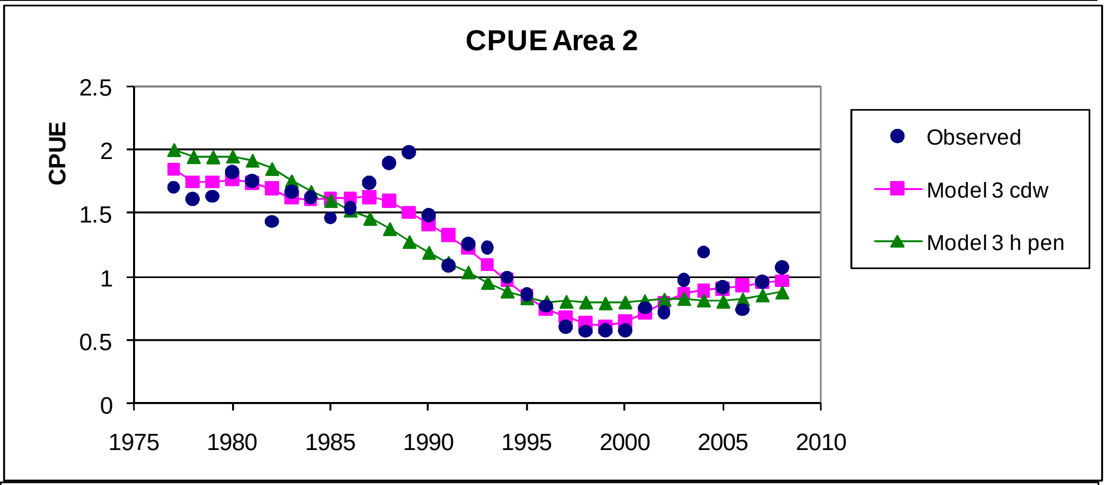


Figure 1b: Comparison of model fits to observed CPUE trends for Models 3 **cdw** and Model 3 ***h* pen** for the 2010 assessment.





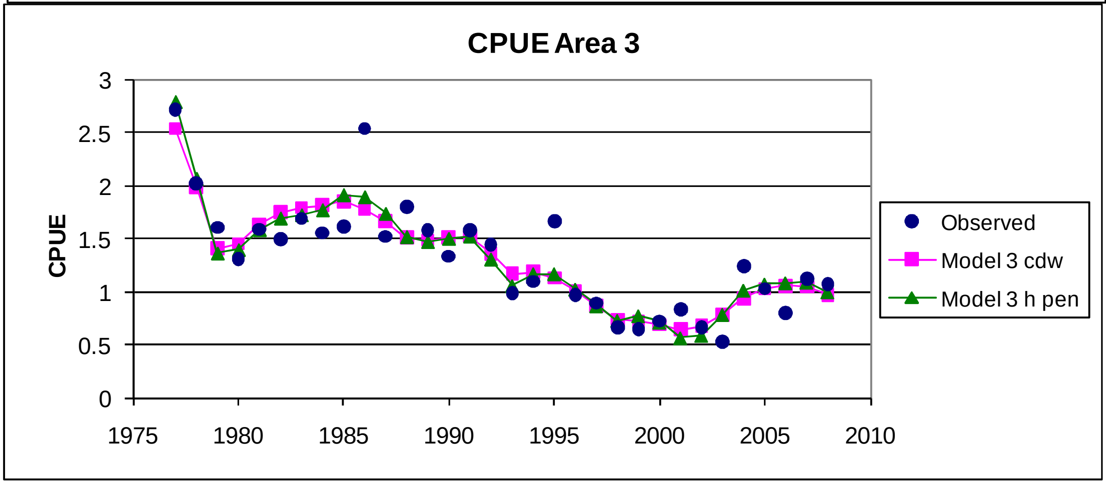


Figure 2: Comparison of model fits to observed catch-at-length (CAL) trends for Models 3 and 4 for the 2010 assessment averaged over all years. Note that proportions sum to 1 for males and females combined.

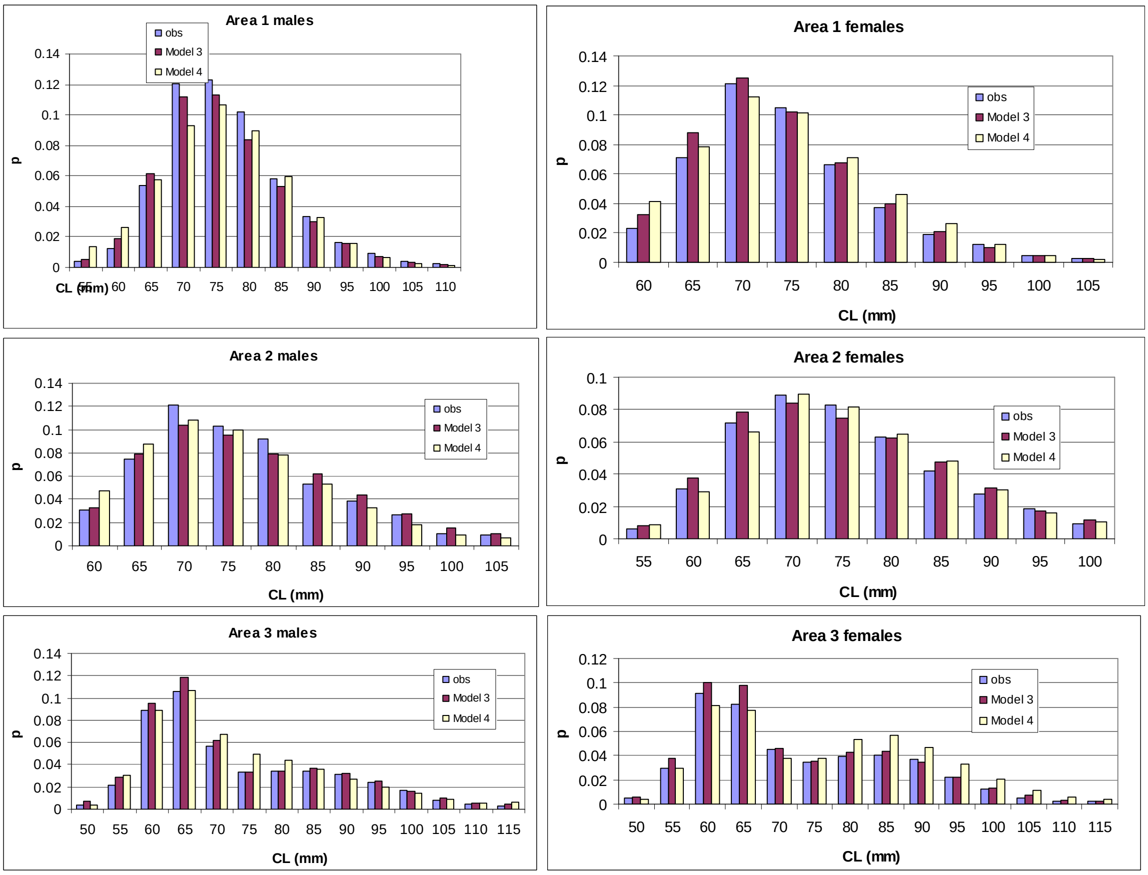


Figure 3a: Plots of the stock recruit residuals for Models 3 and 4 for the 2010 assessment.

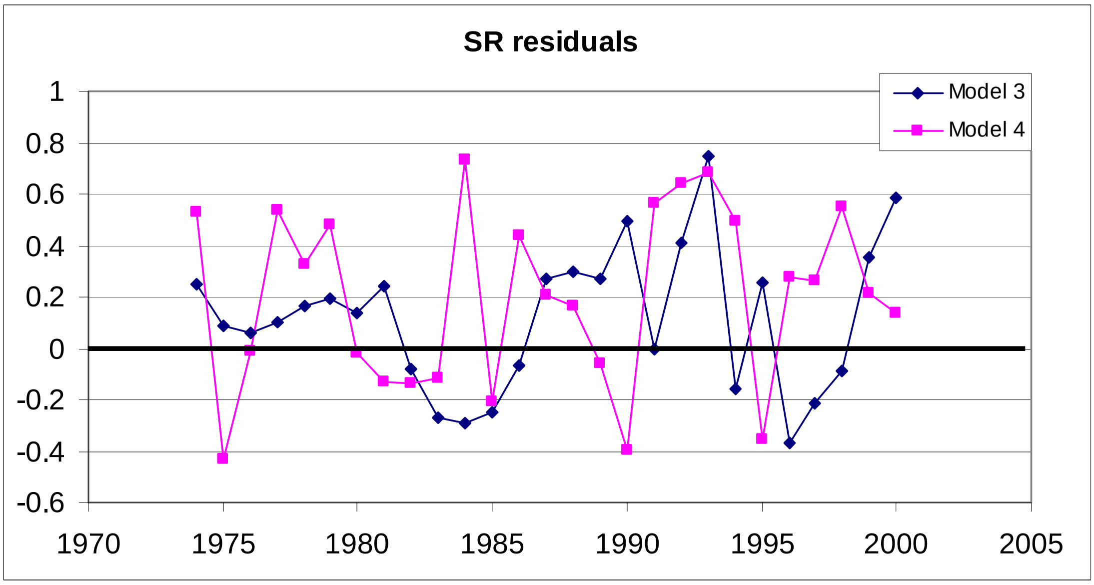


Figure 3b: Plots of the stock recruit residuals for Models 3 **cdw** and Model 3 ***h* pen** for the 2010 assessment.

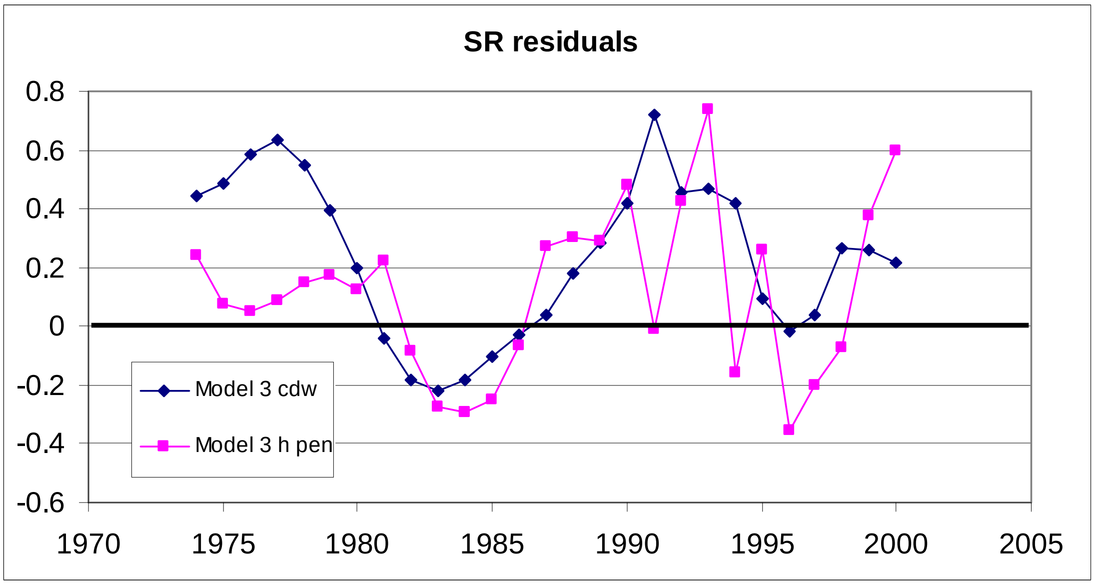
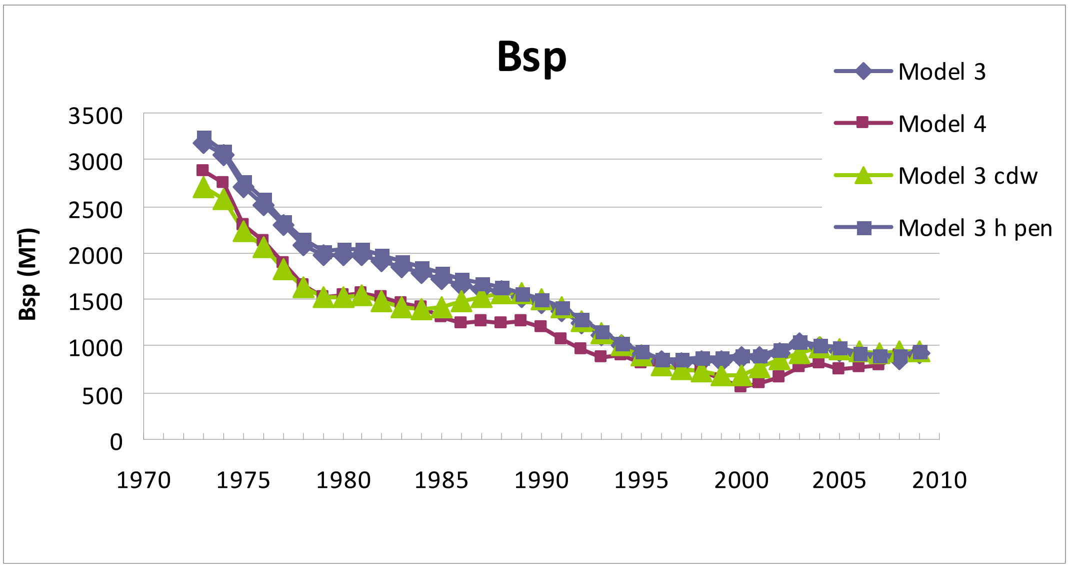


Figure 4: B_{sp} estimated trends for Model 3, Model 3 **cdw**, Model 3 ***h* pen** and Model 4.



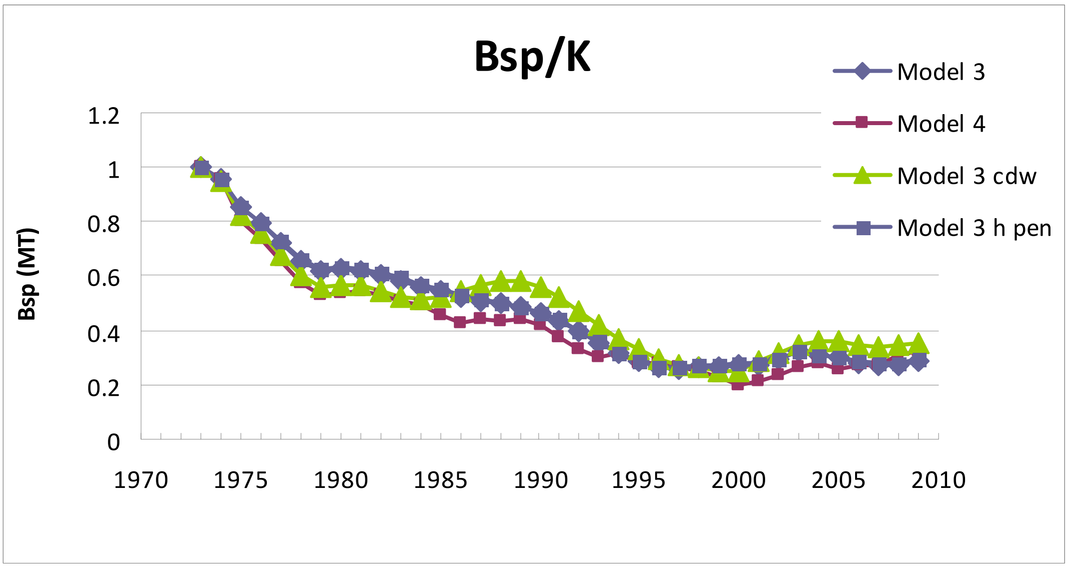


Figure 5a: Comparison between the 2008, 2009 and 2010 Model 3 (MARAM TVS) assessments (all corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).

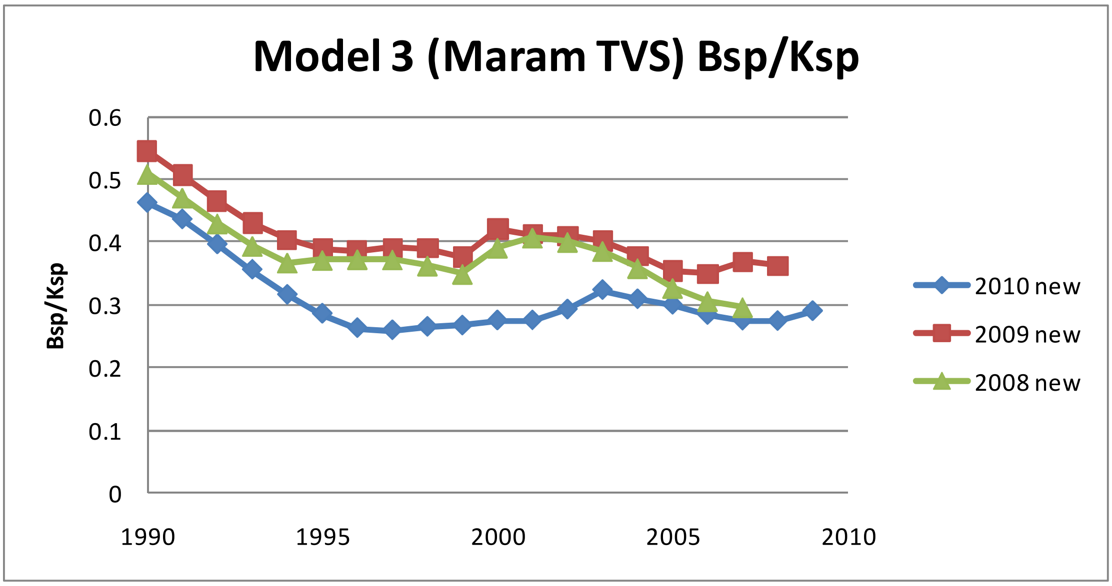
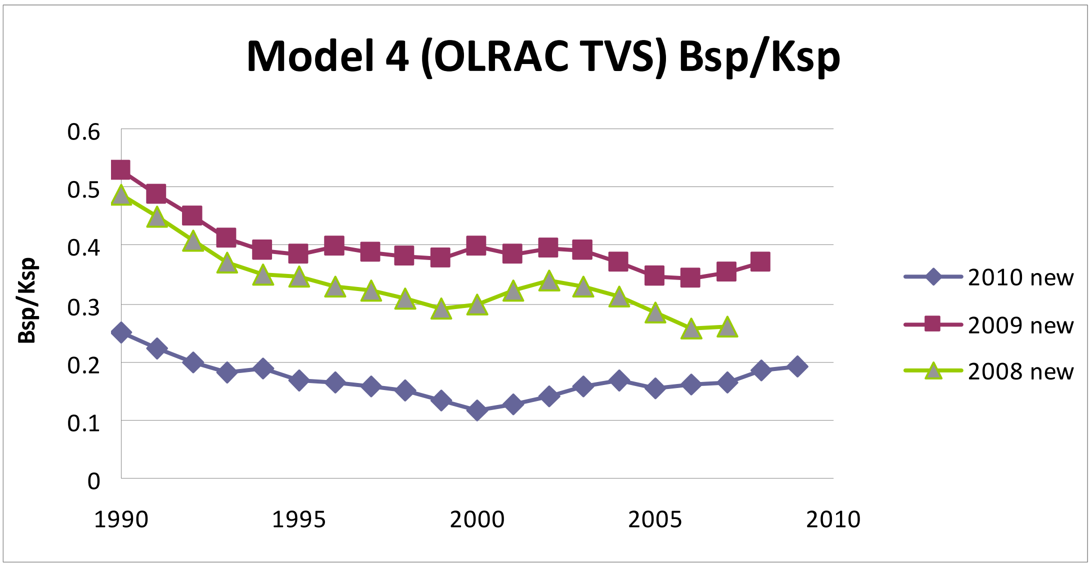


Figure 5b: Comparison between the 2008, 2009 and 2010 Model 4 (OLRAC TVS) assessments (all corrected versions) of spawning biomass relative to pristine (*B*sp/*K*sp).



Appendix 1
Comparison between MARAM and OLRAC 2010 Model 3 assessments.

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

Parameter/quantity	**MARAM**	**OLRAC**
K^{sp} total female spawning biomass	3172	3249
h S/R steepness parameter	1.00	1.00
-ln L (CPUE)	-131.81	-132.47
-ln L (CAL)	-99.79	-95.52
SR residual penalty	7.52	7.52
Time varying selectivity penalty	12.55	12.95
Growth parameters penalty	13.91	11.27
Time varying recruitment penalty	14.62	15.12
Total –ln$L$ value	-183.67	-181.10
B_{06}^{sp} / K^{sp}	0.28	0.28
B_{09}^{sp} / K^{sp}	0.29	0.27
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$	0.27	0.28
$B_{06}^{\exp,A}$	2421	2641
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$	0.28	0.29
$B_{09}^{\exp,A}$	2548	2742

Figure A1.1: Comparison of CPUE fits to data between MARAM and OLRAC best fits.

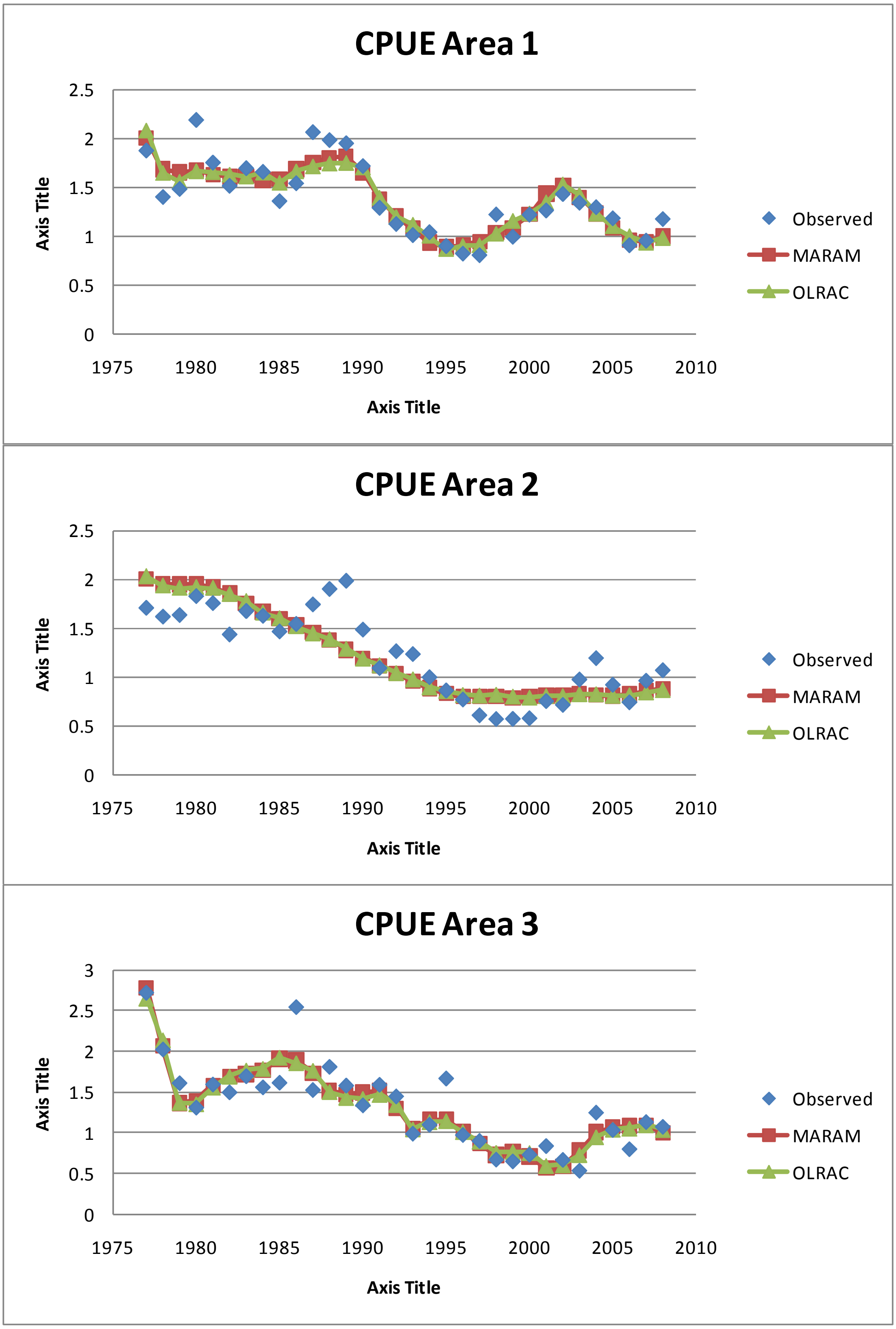
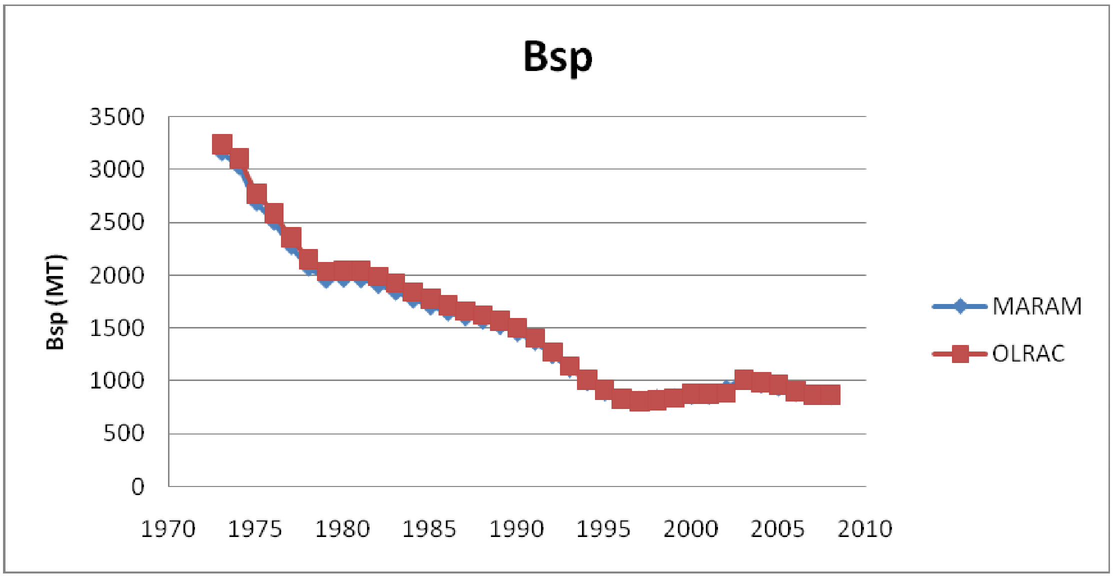


Figure A1.2: Comparison of B_{sp} estimated trend between MARAM and OLRAC best fits.



Appendix 2
Comparison between the 2008 and 2010 updated assessments

Figure A2.1: Comparisons of Model 3 CPUE fits to data between the original and corrected 2008 assessments. The values in parentheses are the standard errors of the fits.

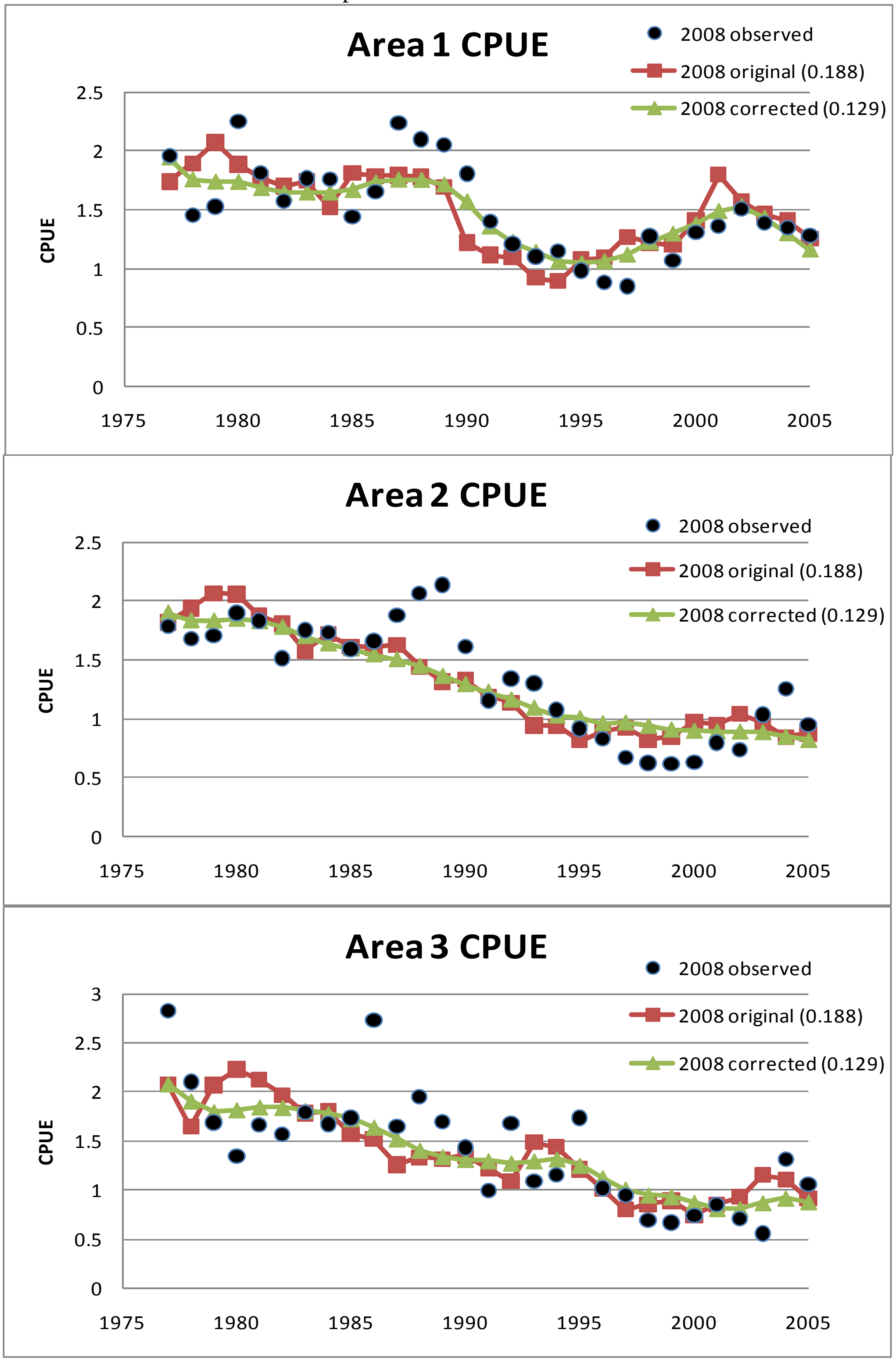


Figure A2.2: Comparisons of Model 3 CPUE fits to data for the corrected 2008 and 2010 assessments. The values in parentheses are the standard errors of the fits.

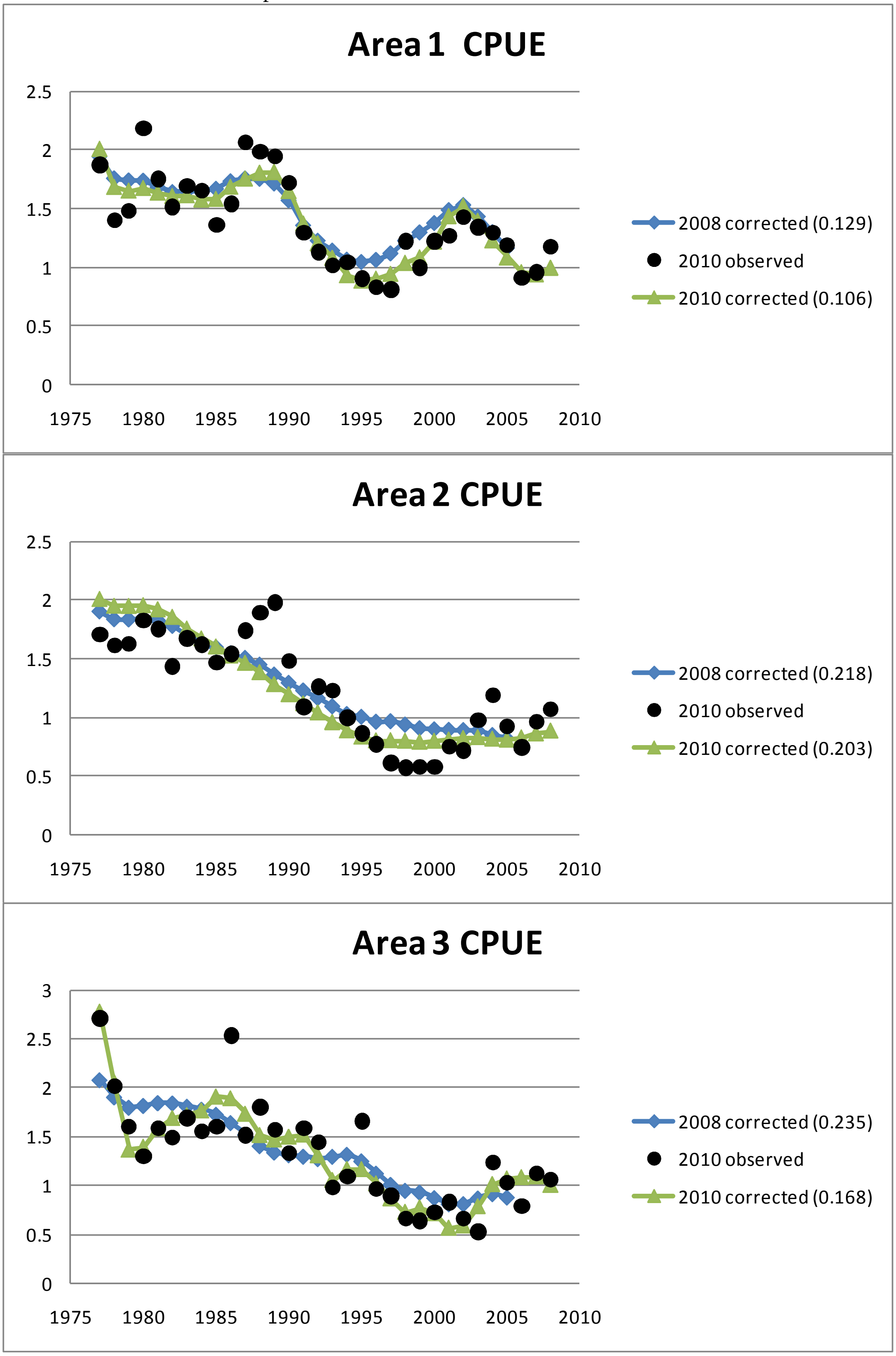


Figure A2.3: Comparisons of Model 3 B_{sp}/K trends for the corrected 2008, 2009 and 2010 assessments.