Final 2010 Operating Models for South Coast Rock Lobster Assessment update

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This document reports assessment results for the five final 2010 operating models (OMs) used to update the South Coast rock lobster resource assessments. These OMs contain the following modifications from the versions reported in Fisheries/2010/JUL/SWG-SCRL/08:

- Somatic growth parameters estimated during fitting procedure to be used for all length-at-weight relationships.
- Mean of recruit residuals over 1974-2000 period forced to zero.

The five OMs are:

1. Model 3 (MARAM time-varying selectivity)
2. Model 4 (OLRAC time-varying selectivity)
3. Effort Saturation (Model 3 but with effort saturation included – see Appendix for methodology)
4. CAL-down-weight (Model 3 but catch-at-length data down-weighted by a multiplicative factor of 0.1)
5. Fix h=0.8 (Model 3 but with stock recruitment steepness parameter h fixed at 0.8).

Tables 1a-d report the detailed model parameter values and outputs. Table 2 reports spawning biomass projection results for a future constant catch of 345 MT. Figures 1a-b show the fits to CPUE data and Figure 2 shows the B_{sp}/K trajectories.

Table 1a: Updated 2010 Model 3 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	3323			
h	S/R steepness parameter	0.99			
λ^{A}	proportion R to Area A		0.32	0.54	0.13
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)		69.75	65.88	86.68
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		78.63	73.20	108.52
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.42	63.48	81.91
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.86	70.07	97.65
β^{*}	growth function parameter	0.110			
$L_{\infty}^{m,A}$	L_{∞} for male lobsters in Area A (mm)		110.11	101.32	128.82
$L_{\infty}^{f,A}$	L_{∞} for female lobsters in Area A (mm)		105.84	96.58	124.18
κ	growth curve parameter (yr^{-1})	0.106			
t_0	growth curve parameter (yr^{-1})	-1.93			
l_m^{*}		65.91			
l_f^{*}		64.55			
ϖ		4.65			
λ		0.39			
-ln L (CPUE)		-132.56	-56.56	-34.59	-41.41
CPUE σ			0.104	0.206	0.167
-ln L (CAL)		-101.40	-9.05	0.201	-92.55
CAL σ			0.079	0.104	0.062
SR residual penalty		5.97			
Time varying selectivity penalty		12.54			
Growth parameters penalty		13.66			
Time varying recruitment penalty		14.62			
Total –ln$L$ value		-187.840			
B_{06}^{sp} / K^{sp}		0.28			
B_{09}^{sp} / K^{sp}		0.28			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.29	0.23	0.33	0.18
$B_{06}^{\exp,A}$		2331	436	1434	460
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.31	0.28	0.36	0.16
$B_{09}^{\exp,A}$		2503	529	1565	409

Table 1b: Updated 2010 Model 4 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	3276			
h	S/R steepness parameter	0.99			
λ^{A}	proportion R to Area A		0.35	0.40	0.26
μ^{A}	rel. female scaling parameter for Area A		0.93	0.86	0.94
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		63.13	6.34	63.35
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		121.27	9.21	83.64
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		64.11	59.44	62.35
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		71.17	65.63	64.44
β^{*}	growth function parameter	0.094			
$L_{\infty}^{m,A}$	L_{∞} for male lobsters in Area A (mm)		110.99	115.31	109.91
$L_{\infty}^{f,A}$	L_{∞} for female lobsters in Area A (mm)		108.19	102.69	106.16
κ	growth curve parameter (yr^{-1})	0.111			
t_0	growth curve parameter (yr^{-1})	-2.00			
l_m^{*}		64.84			
l_f^{*}		62.30			
ϖ		6.04			
λ		0.79			
-ln L (CPUE)		-134.18	-64.24	-47.32	-22.62
CPUE σ			0.081	0.138	0.300
-ln L (CAL)		-220.37	-33.52	-25.20	-161.65
CAL σ			0.073	0.095	0.051
SR residual penalty		6.16			
Time varying selectivity penalty		39.72			
Growth parameters penalty		12.12			
Time varying recruitment penalty		12.84			
Total –ln$L$ value		-284.37			
B_{06}^{sp} / K^{sp}		0.23			
B_{09}^{sp} / K^{sp}		0.22			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.29	0.22	0.27	0.27
$B_{06}^{\exp,A}$		1531	388	792	350
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.35	0.26	0.36	0.25
$B_{09}^{\exp,A}$		1844	475	1056	313

Table 1c: Updated 2010 effort saturation model 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		232			
K^{sp}	total female spawning biomass	3440			
h	S/R steepness parameter	0.99			
λ^A	proportion R to Area A		0.31	0.57	0.12
μ^A	rel. female scaling parameter for Area A		1.05	0.76	1.00
$l_{50}^{m,A}$			69.76	65.47	86.83
$l_{95}^{m,A}$			78.62	72.44	108.72
$l_{50}^{f,A}$			67.45	63.13	82.02
$l_{95}^{f,A}$			74.88	69.53	97.86
β^*	growth function parameter	0.113			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		109.74	99.86	128.49
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		105.46	95.56	123.86
κ	growth curve parameter (yr^{-1})	0.106			
t_0	growth curve parameter (yr^{-1})	-1.93			
l_m^*		65.92			
l_f^*		64.55			
ϖ		4.65			
λ		0.38			
$\bar{E}$			228	204	174
q'			0.0022	0.0005	0.0024
-ln L (CPUE)		-137.59	-56.86	-39.07	-41.65
CPUE σ			0.103	0.179	0.165
-ln L (CAL)		-100.67	-9.39	0.66	-91.94
CAL σ			0.079	0.105	0.062
SR residual penalty		5.57			
Time varying selectivity penalty		12.64			
Growth parameters penalty		13.47			
Time varying recruitment penalty		15.11			
Total –ln$L$ value		-192.12			
B_{06}^{sp} / K^{sp}		0.30			
B_{09}^{sp} / K^{sp}		0.31			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.31	0.23	0.36	0.18
$B_{06}^{\exp,A}$		2490	433	1601	456
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.33	0.28	0.38	0.16
$B_{09}^{\exp,A}$		2634	532	1701	401

Table 1d: Updated 2010 CAL-down-weight model 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	3609			
h	S/R steepness parameter	0.99			
λ^A	proportion R to Area A		0.32	0.51	0.17
μ^A	rel. female scaling parameter for Area A		1.01	0.77	1.03
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		70.18	65.70	91.72
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		79.25	73.15	115.91
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.61	63.21	85.69
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		75.24	69.82	104.18
β^*	growth function parameter	0.121			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		108.93	102.28	118.33
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		102.90	97.11	112.32
κ	growth curve parameter (yr^{-1})	0.100			
t_0	growth curve parameter (yr^{-1})	-2.00			
l_m^*		65.91			
l_f^*		64.51			
ϖ		4.51			
λ		0.28			
-ln L (CPUE)		-140.52	-56.45	-42.59	-41.48
CPUE σ			0.104	0.160	0.166
-ln L (CAL)		11.73	21.18	31.97	-41.43
CAL σ			0.088	0.118	0.071
SR residual penalty		5.07			
Time varying selectivity penalty		0.28			
Growth parameters penalty		3.57			
Time varying recruitment penalty		5.98			
Total –ln$L$ value		-126.12			
B_{06}^{sp} / K^{sp}		0.35			
B_{09}^{sp} / K^{sp}		0.36			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.32	0.38	0.19	0.18
$B_{06}^{\exp,A}$		2839	455	1819	565
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.34	0.29	0.40	0.18
$B_{09}^{\exp,A}$		2974	535	1915	525

Table 1e: Updated 2010 fixed h=0.8 model 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		225			
K^{sp}	total female spawning biomass	3600			
h	S/R steepness parameter	0.80 fixed			
λ^A	proportion R to Area A		0.31	0.56	0.13
μ^A	rel. female scaling parameter for Area A		1.05	0.75	1.00
$l_{50}^{m,A}$	length at 50% selectivity for male lobsters in Area A (mm)		69.81	65.63	86.79
$l_{95}^{m,A}$	length at 95% selectivity for male lobsters in Area A (mm)		78.70	72.78	108.64
$l_{50}^{f,A}$	length at 50% selectivity for female lobsters in Area A (mm)		67.46	63.24	81.99
$l_{95}^{f,A}$	length at 95% selectivity for male lobsters in Area A (mm)		74.91	69.70	97.80
β^*	growth function parameter	0.110			
$L_\infty^{m,A}$	L_∞ for male lobsters in Area A (mm)		109.64	99.88	128.76
$L_\infty^{f,A}$	L_∞ for female lobsters in Area A (mm)		105.36	95.63	124.08
κ	growth curve parameter (yr^{-1})	0.106			
t_0	growth curve parameter (yr^{-1})	-1.93			
l_m^*		65.92			
l_f^*		64.55			
ϖ		4.65			
λ		0.38			
-ln L (CPUE)		-131/70	-56.44	-33.83	-41.43
CPUE σ			0.104	0.211	0.166
-ln L (CAL)		-100.28	-9.03	1.06	-92.31
CAL σ			0.079	0.105	0.062
SR residual penalty		5.97			
Time varying selectivity penalty		12.53			
Growth parameters penalty		13.57			
Time varying recruitment penalty		14.89			
Total –ln$L$ value		-185.03			
B_{06}^{sp} / K^{sp}		0.29			
B_{09}^{sp} / K^{sp}		0.30			
$B_{06}^{\exp,A} / K_{1973}^{\exp,A}$		0.30	0.23	0.34	0.18
$B_{06}^{\exp,A}$		2490	430	1612	448
$B_{09}^{\exp,A} / K_{1973}^{\exp,A}$		0.31	0.28	0.35	0.15
$B_{09}^{\exp,A}$		2609	521	1704	382

Table 2: Projection results for 2010 updated models under a constant catch of 345 MT.

	Model 3	**Model 4**	**Effort saturation**	**Catch-down-weight**	***h*=0.8**
B_{06}^{sp} / K^{sp}	0.28	0.23	0.30	0.35	0.29
B_{09}^{sp} / K^{sp}	0.28	0.22	0.31	0.36	0.30
B_{15}^{sp} / K^{sp}	0.34	0.28	0.36	0.40	0.32
B_{25}^{sp} / K^{sp}	0.40	0.34	0.42	0.47	0.35
$B_{25}^{sp} / B_{06}^{sp}$	1.44	1.45	1.40	1.34	1.21

Figure 1a: Model 3 and Model 4 fits to CPUE data.

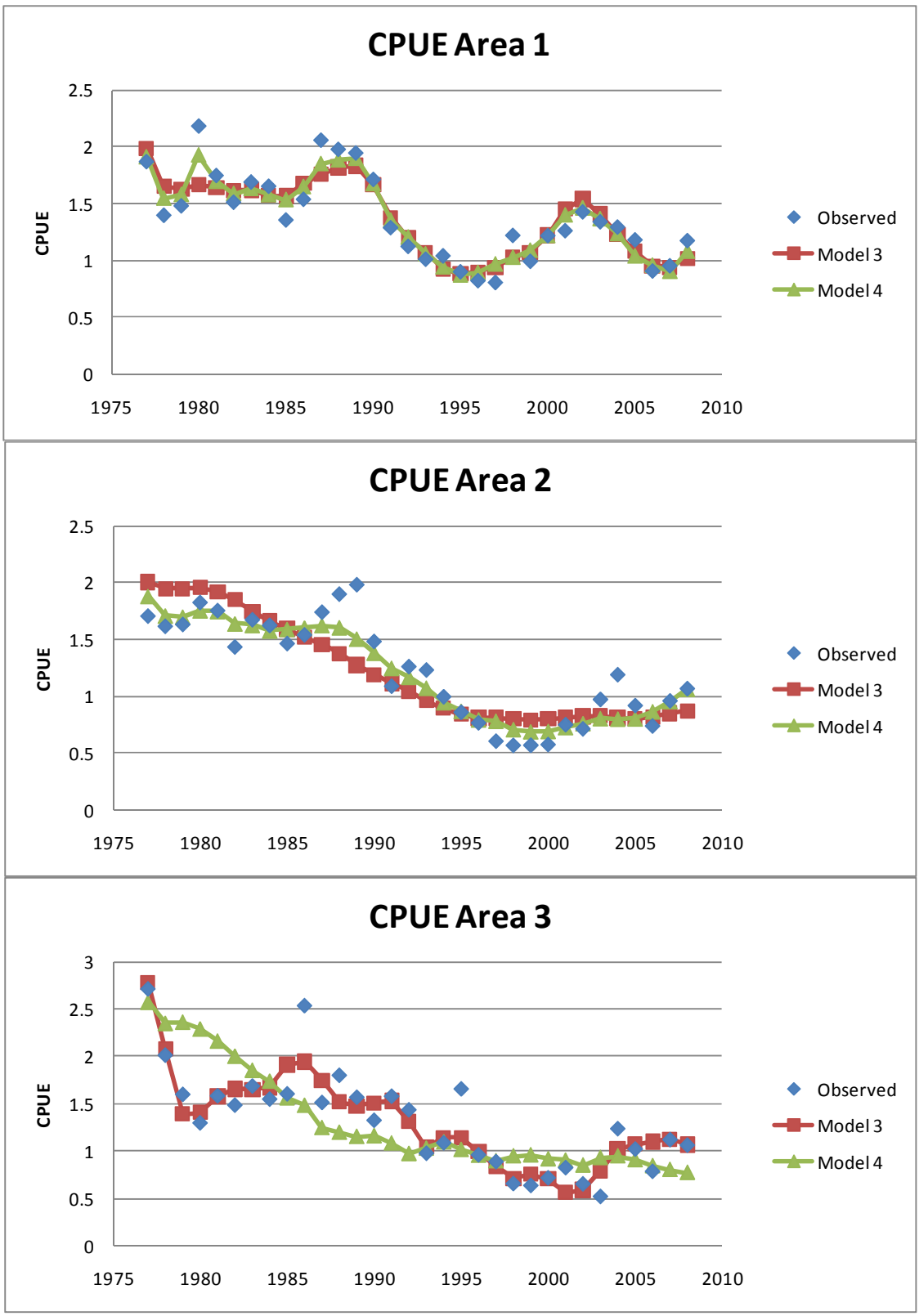


Figure 1b: Effort saturation, CAL-down-weight and fix *h*=0.8 model fits to CPUE data.

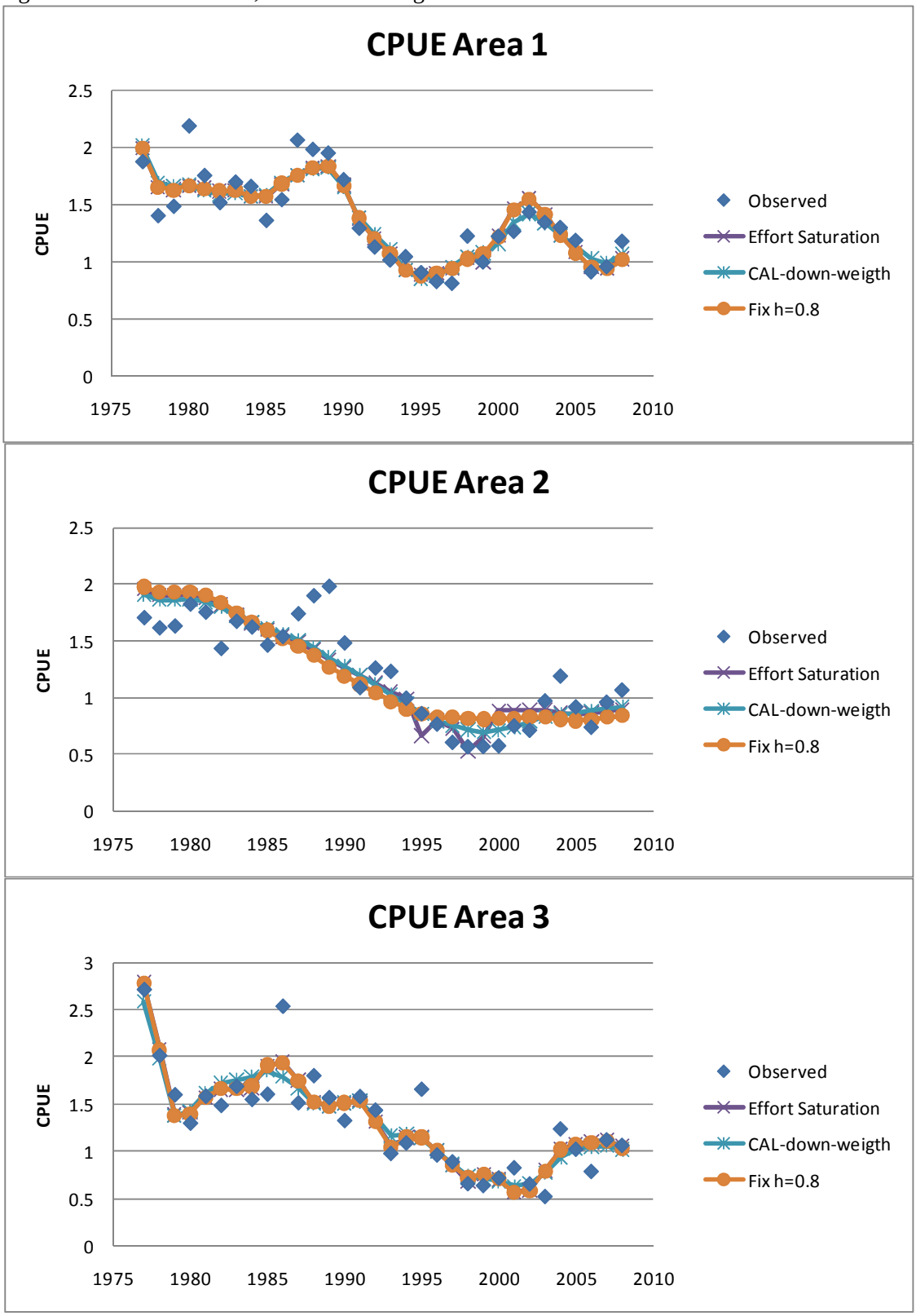
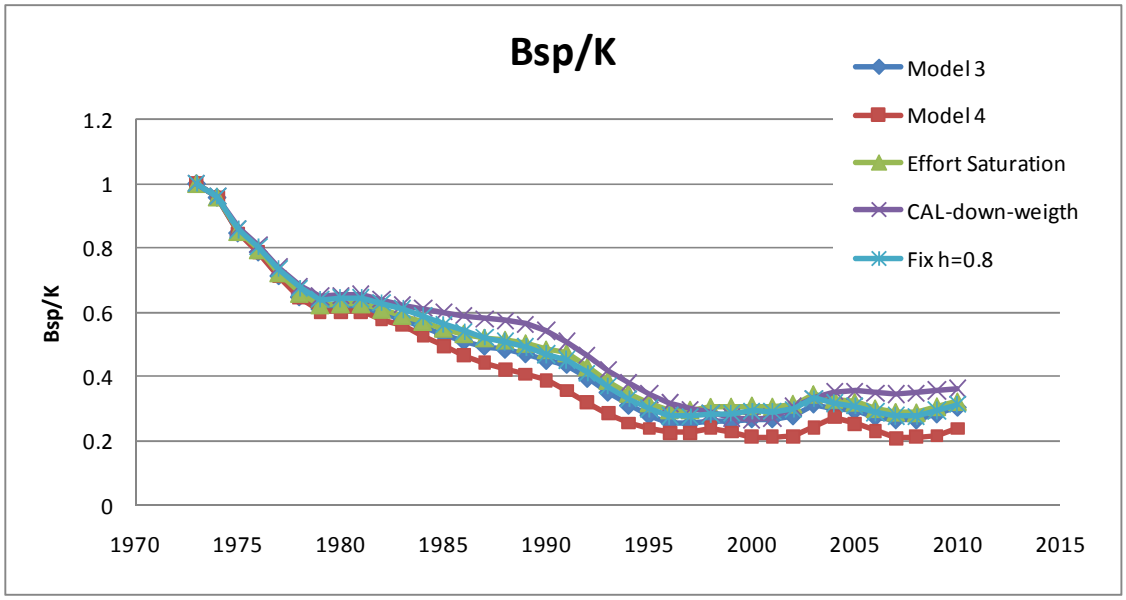


Figure 2: B_{sp}/K trajectories for all five operating models.



Appendix: Effort Saturation Model (taken from WG/04/08/SCRL12)

Effort saturation

This scenario examines the possibility that the proportional relationship between CPUE and biomass does not hold true at high levels of effort due to competition between units of effort – i.e. effort saturation occurs. This effort saturation effect is taken into account here by allowing the constant of proportionality between the GLM derived CPUE index and exploitable biomass, *q*, to become a declining function of fishing effort once effort exceeds a certain level.

For this application, three further parameters $E^{'A}$ are estimated for each Area, as well as $q^{'A}$ for each Area.

When the possibility of "effort saturation" is taken into account, the CPUE abundance relationship is modified as follows:

$$CPUE_y^A = q_y^A B_y^A e^{\varepsilon_y^A} \text{ or } \varepsilon_y^A = \ln(CPUE_y^A) - \ln(q_y^A B_y^A) \quad (1)$$

where

$$q_y^A = q^{'A} \frac{E^{'A}}{E_y^A} \quad \text{if } E_y^A > X\ E^{'A} \quad (2)$$

$$q_y^A = q^{'A}\left[(1-\alpha) + \frac{\alpha E^{'A}}{E_y^A}\right] \quad \text{if } E^{'A} \le E_y^A \le X\,E^{'A} \quad (3)$$

$$q_y^A = q^{'A} \quad \text{if } E_y^A < E^{'A} \quad (4)$$

where

$$\alpha = (\frac{E_y^A}{E^{'A}} - 1)/(X-1)\,; \quad (5)$$

$CPUE_y^A$ is the "observed" GLM standardised CPUE data given in Glazer (2010),

E_y^A is the estimated effort given by $\frac{C_y^A}{CPUE_y^A}$,

$E^{'A}$ is the threshold effort above which "effort saturation" sets in for Area *A*.

The effort saturation model has $X = 1.05$, and estimates $E^{'A}$ and $q^{'A}$ for each Area.

Reference

Glazer, J.P. 2010. 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/1.