The 2017 Horse Mackerel Updated Assessment

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FISHERIES/2016/SEP/SWG-DM/51 provided a full description of the current stock assessment model for the South African Horse Mackerel. FISHERIES/2016/SEP/SWG-DM/52 reported updated 2016 assessments for a number of model variants where the assessments were extended to allow for better fits to the low CPUE values (2014-2015). This document here provides updated 2017 assessment results for a number of model variants which follow on from the variants that were explored in 2016 and take the data from 2016 now available into account.

The assessment models, as used in assessments and MP testing since 2014, assume q_{aut} = 0.75 and *h* = 0.75. These values were selected as they fall in the middle of the bounds defined by the original Reference Set for the MP testing. Better fits are possible to the midwater CPUE data for 2014 (which is particularly low), 2015 and 2016 by either assuming these low CPUE values are due to reduced fishing catchability, or that extra mortality of fish occurred at the start of 2014. Assessment variants reported here for the 2017 updated assessment report are as follows:

Model 1: Fit to all the DD (*Desert Diamond*) CPUE data without any further extension to allow for a better fit to the low recent CPUE values.

Model 2: Model 1 above, but omit the DD CPUE for 2014, 2015 and 2016.

Model 3: $q = q_1$ for years up to and including 2013

$q = q_2$ for years 2014, 2015 and 2016.

This model thus assumes the recent low CPUE values could be a result of reduced fishing catchability.

Model 4: Model 1 but add the Dual rights CPUE to the likelihood fitting procedure.

Model 5: Model 1 but extra mortality occurs at the start of 2014 (numbers-at-age in 2014 reduced by an estimated additional proportion M^{extra}). This extra mortality is a one-off event.

Updated data are reported in Tables 1 to 3 with Figure 1 comparing the DD and Dual rights CPUE indices.

RESULTS

Table 4 reports the results of the updated 2017 assessment for Models 1-5.

Figure 2 compares the model fits to the observed abundance indices. Figure 3 plots the stock-recruit residuals estimated for each model. Figure 4 plots the estimated spawning biomass trajectories in absolute terms (top) and as proportions of their unexploited equilibrium levels (bottom).

DISCUSSION

Model 2 (for which the recent low CPUE data are excluded in the fit) produces a poor fit to the most recent (2014-2016) CPUE data – see Figure 1. Model 1 which includes these low CPUE data but makes no further allowance in the model for the low observations, results in a poor fit to the DD CPUE as well. Similarly adding the Dual rights CPUE does not improve the model fit very much (see Figure 3 for fit to the Dual rights CPUE for Model 4). Both Models 3 and 5, however, produce reasonable fits to these recent CPUE values and result in similar total –lnL values (Table 4). The implications for current spawning stock size are very different for these two models, with Model 3 estimating current (2017) spawning biomass to be 62% of the carrying capacity, whereas Model 5 estimates this value to be only some 24%. The differences between these two alternate models when projecting into the future will be substantial.

Table 1: Horse Mackerel catch data for the three different fleets (values in kilo tonnes KT).

Year	Pelagic catch	Demersal catch	Midwater catch
1949	3360	0.00001	0.00001
1950	49900	445	0.00001
1951	98900	1105	0.00001
1952	102600	1226	0.00001
1953	85200	1456	0.00001
1954	118100	2550	0.00001
1955	78800	1926	0.00001
1956	45800	1334	0.00001
1957	84600	959	0.00001
1958	56400	2073	0.00001
1959	17700	2075	0.00001
1960	62900	3712	0.00001
1961	38900	3627	0.00001
1962	66700	3079	0.00001
1963	23300	1401	0.00001
1964	24400	9522	0.00001
1965	55000	7017	0.00001
1966	26300	7596	0.00001
1967	8800	6189	0.00001
1968	1400	9116	0.00001
1969	26800	12252	0.00001
1970	7900	17872	0.00001
1971	2200	33329	0.00001
1972	1300	20560	0.00001
1973	1600	33900	0.00001
1974	2500	38391	0.00001
1975	1600	55459	0.00001
1976	400	50981	0.00001
1977	1900	116400	0.00001
1978	3600	37290	0.00001
1979	4300	53584.5	0.00001
1980	400	39187.5	0.00001
1981	6100	41215	0.00001
1982	1100	32176	0.00001
1983	2100	38332	0.00001
1984	2800	37969	0.00001
1985	700	27278	0.00001
1986	500	31378	0.00001
1987	2834	38571	0.00001
1988	6403	41482	0.00001
1989	25872	58205.5	0.00001

1990	7645	56721.3	0.00001
1991	582	39759.14	0.00001
1992	2057	37207.53	0.00001
1993	11651	35998	0.00001
1994	8207	20029.5	0.00001
1995	1986	10790	0.00001
1996	18920	31846	0.00001
1997	12654	34670.5	0.00001
1998	26680	36278.8	15769.8
1999	2057	21579.73	2160.77
2000	4503	9259.243	15375.74
2001	915	8823.672	19220.38
2002	8148	4862.927	11098.47
2003	1012	3577.588	25290.98
2004	2048	4932.08	27154.31
2005	5627	5272.47	29005.21
2006	4824	4121.529	18068.35
2007	1903	4798.871	24251.18
2008	2280	4745.469	23774.56
2009	2087	4446.889	29021.42
2010	4385	4125.916	23479.62
2011	10990	5592.836	29048.46
2012	2199	5228.117	22616.49
2013	596	4903.783	28480.64
2014	2760	2631.106	10053.03
2015	2040	3086.954	7993.067
2016	1588	4729.633	11710.58

Table 2: GLM standardised CPUE (for the *Desert Diamond*), the Dual rights CPUE and survey abundance data for South African horse mackerel for the period 1986-2016. Data were provided by Coetzee, Fairweather and Singh (DAFF, *pers. commn*).

Year	Desert Diamond CPUE	Dual rights CPUE	Autumn demersal survey		Spring demersal survey	
			Biomass (KT)	CV	Biomass (KT)	CV
1986					97.36	0.13
1987					332.97	0.14
1988			159.07	0.29		
1989						
1990						
1991			352.19	0.23		
1992			422.21	0.23		
1993			435.28	0.20		
1994			340.72	0.26		
1995			195.13	0.24		
1996			261.77	0.23		
1997			241.02	0.23		
1998						
1999			330.63	0.24		
2000						
2001					316.72	0.18
2002						
2003	0.791		146.72	0.24	231.36*	0.20*
2004	0.648		195.73*	0.32*	366.50*	0.19*
2005	0.932		175.04*	0.21*		
2006	1.023		386.57	0.20	350.28	0.19
2007	1.559	0.994	243.58*	0.40*	473.22*	0.19*
2008	1.080	2.202	279.86*	0.27*	300.00*	0.17*
2009	1.103	4.820	337.16*	0.24*		
2010	1.309	4.254	271.79	0.37		
2011	1.528	6.098	213.09*	0.22*		
2012	0.883	3.854				
2013	1.298	4.432	522.69	0.28		
2014	0.244	2.311	180.08	0.17		
2015	0.570	3.381				
2016	0.600	2.960				

*These values correspond to surveys that used the new trawl net, which was introduced in September 2003.

Table 3a: Spring demersal survey catch-at-length for South African horse mackerel (shown as proportions of numbers each year) as used in the assessment model. Provided by Fairweather (DAFF, *pers. commn*).

Year	Total length (cm)								
	0–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45+
1986	0.000	0.000	0.002	0.090	0.238	0.164	0.169	0.231	0.105
1987	0.000	0.000	0.116	0.223	0.160	0.206	0.124	0.129	0.043
2001	0.002	0.015	0.375	0.255	0.124	0.136	0.075	0.015	0.004
2003	0.000	0.050	0.068	0.376	0.367	0.091	0.040	0.008	0.001
2004	0.001	0.238	0.256	0.161	0.226	0.074	0.035	0.008	0.001
2006	0.008	0.267	0.243	0.288	0.144	0.041	0.008	0.001	0.000
2007	0.000	0.223	0.634	0.095	0.044	0.003	0.001	0.000	0.000
2008	0.001	0.027	0.458	0.429	0.068	0.010	0.005	0.002	0.000

Table 3b: Autumn demersal survey catch-at-length for South African horse mackerel (shown as proportions of numbers each year) as used in the assessment model. Provided by Fairweather (DAFF, *pers. commn*).

Year	Total length (cm)								
	0–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45+
1988	0.000	0.015	0.051	0.014	0.156	0.166	0.180	0.291	0.127
1992	0.000	0.072	0.046	0.105	0.374	0.273	0.056	0.043	0.030
1993	0.000	0.092	0.353	0.075	0.198	0.118	0.076	0.065	0.023
1994	0.000	0.027	0.157	0.220	0.298	0.254	0.029	0.010	0.004
1995	0.000	0.000	0.023	0.109	0.460	0.271	0.092	0.033	0.011
1996	0.000	0.000	0.001	0.023	0.542	0.308	0.111	0.013	0.002
1997	0.000	0.003	0.024	0.005	0.468	0.401	0.079	0.016	0.005
1999	0.000	0.010	0.169	0.063	0.082	0.522	0.114	0.033	0.006
2003	0.000	0.001	0.393	0.329	0.120	0.060	0.082	0.015	0.001
2004	0.022	0.142	0.432	0.055	0.186	0.100	0.053	0.008	0.001
2005	0.000	0.354	0.198	0.148	0.186	0.057	0.050	0.007	0.000
2006	0.001	0.033	0.239	0.345	0.282	0.063	0.030	0.006	0.000
2007	0.108	0.463	0.319	0.088	0.016	0.004	0.002	0.001	0.000
2008	0.001	0.071	0.382	0.384	0.150	0.009	0.001	0.002	0.000
2009	0.000	0.068	0.155	0.525	0.220	0.028	0.002	0.001	0.000
2010	0.000	0.056	0.068	0.527	0.294	0.044	0.003	0.006	0.001
2011	0.141	0.770	0.032	0.033	0.022	0.001	0.000	0.000	0.000

Table 3c: Commercial midwater catch-at-length for South African horse mackerel (shown as proportions of numbers each year) as used in the assessment model. Provided by Singh (DAFF, *pers. commn*).

Year	Total length (cm)								
	0–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45+
2003	0.000	0.000	0.000	0.001	0.135	0.256	0.505	0.102	0.001
2004	0.000	0.000	0.000	0.012	0.241	0.382	0.328	0.036	0.001
2005	0.000	0.000	0.004	0.079	0.288	0.388	0.190	0.035	0.016
2006	0.000	0.000	0.006	0.113	0.339	0.403	0.126	0.010	0.003
2007	0.000	0.000	0.003	0.090	0.293	0.359	0.187	0.054	0.014
2008	0.000	0.001	0.043	0.256	0.328	0.246	0.111	0.014	0.001
2009	0.000	0.000	0.001	0.088	0.386	0.318	0.170	0.034	0.002
2010	0.000	0.000	0.018	0.220	0.378	0.255	0.100	0.026	0.003
2011	0.000	0.000	0.001	0.146	0.490	0.236	0.104	0.022	0.001
2012	0.000	0.000	0.076	0.147	0.266	0.342	0.120	0.045	0.004
2013	0.000	0.000	0.220	0.474	0.076	0.164	0.058	0.007	0.002
2014	0.000	0.000	0.000	0.019	0.071	0.492	0.383	0.032	0.003

Table 4: Summary of results for the 2017 updated assessment – results are reported for Models 1-5. For all variants q_{aut} = 0.75 and h = 0.75. The first numbers shown are the best estimates, while the figures in parentheses are the Hessian-based CVs. "SR" and "CAL" refer to stock-recruitment and catch-at-length respectively. Biomass units are kilo tonnes. Note that log likelihood values are comparable only for Models 1, 3 and 5 which input identical data.

	Model 1 No adjustments to take account of low recent CPUE	Model 2 Model 1 but omit low DD CPUE for 2014-2016.	Model 3 $q = q_2$ for 2014, 2015 and 2016	Model 4 Model 1 but add Dual rights CPUE to fit	Model 5 Extra proportion M^{extra} die at start of 2014
-ln L :Total	-228.06	-238.13	-233.39	-232.59	-234.90
-ln L :Spr survey	0.582	0.635	0.785	1.043	0.879
-ln L :Aut survey	-9.28	-11.05	-9.95	-8.95	-9.69
-ln L :CPUE	-3.83	-13.80	-8.00	-2.05	-11.89
-ln L :CAL Spr survey	-46.04	-44.80	-45.93	-47.34	-44.84
-ln L :CAL Aut survey	-88.06	-87.81	-87.65	-88.43	-86.39
-ln L :CAL commercial	-65.43	-65.60	-65.73	-65.60	-65.81
-ln L :SR residuals	-16.01	-15.71	-16.82	-15.80	-17.15
K^{sp} (KT)	780	780	799	783	869
B^{sp}_{2017} (KT)	**437**	**523**	**496**	**481**	**206**
$MSYL^{sp}$ (KT)	193	198	198	194	216
MSY (KT)	58	60	60	59	65
B^{sp}_{2017}/K^{sp}	**0.560**	**0.654**	**0.621**	**0.613**	**0.237**
$B^{sp}_{2017}/MSYL^{sp}$	2.264	2.641	2.505	2.479	0.954
$MSYL^{sp}/K^{sp}$	0.247	0.254	0.248	0.248	0.249
q: Spr survey	0.764	0.790	0.780	0.794	0.734
q: CPUE (x10^{-6})	1.675	2.065	1.611	1.654	1.837
q_2 (applies to 2014-2016)	-	-	0.426*q_{CPUE}	-	-
M^{extra} (once-off extra proportion die in 2014)	-	-	-	-	0.324

Figure 1: Comparison between the Desert Diamond (DD) and Dual rights CPUE values. The series have each been normalised to the 2009-2013 period for each of comparison.

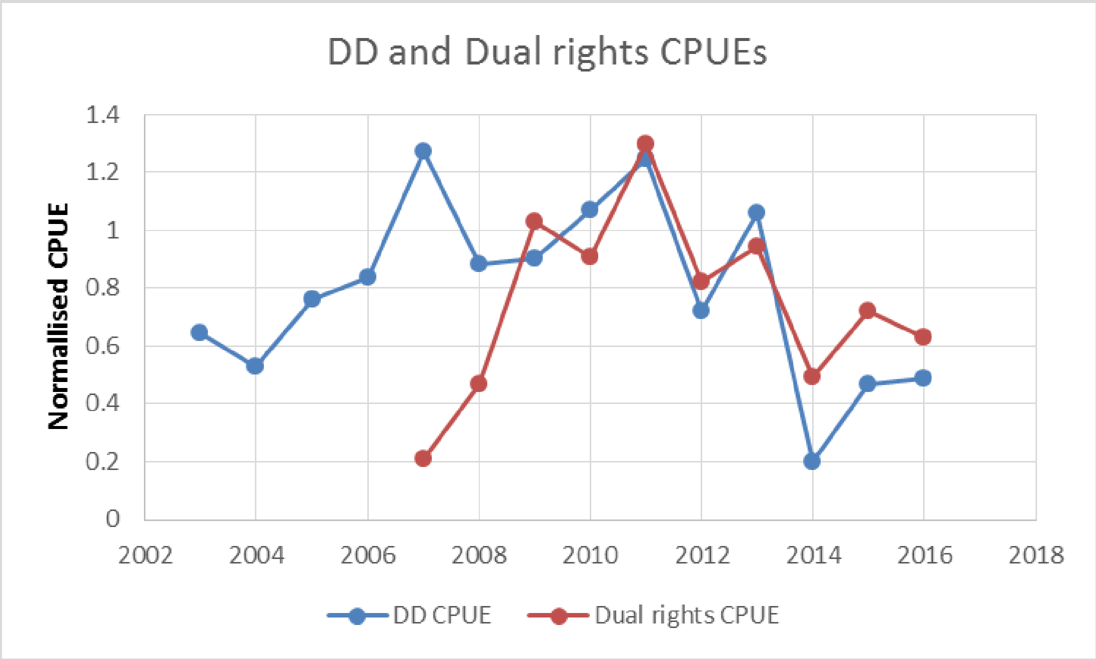

Figure 1: Assessment model fits to the abundance indices.

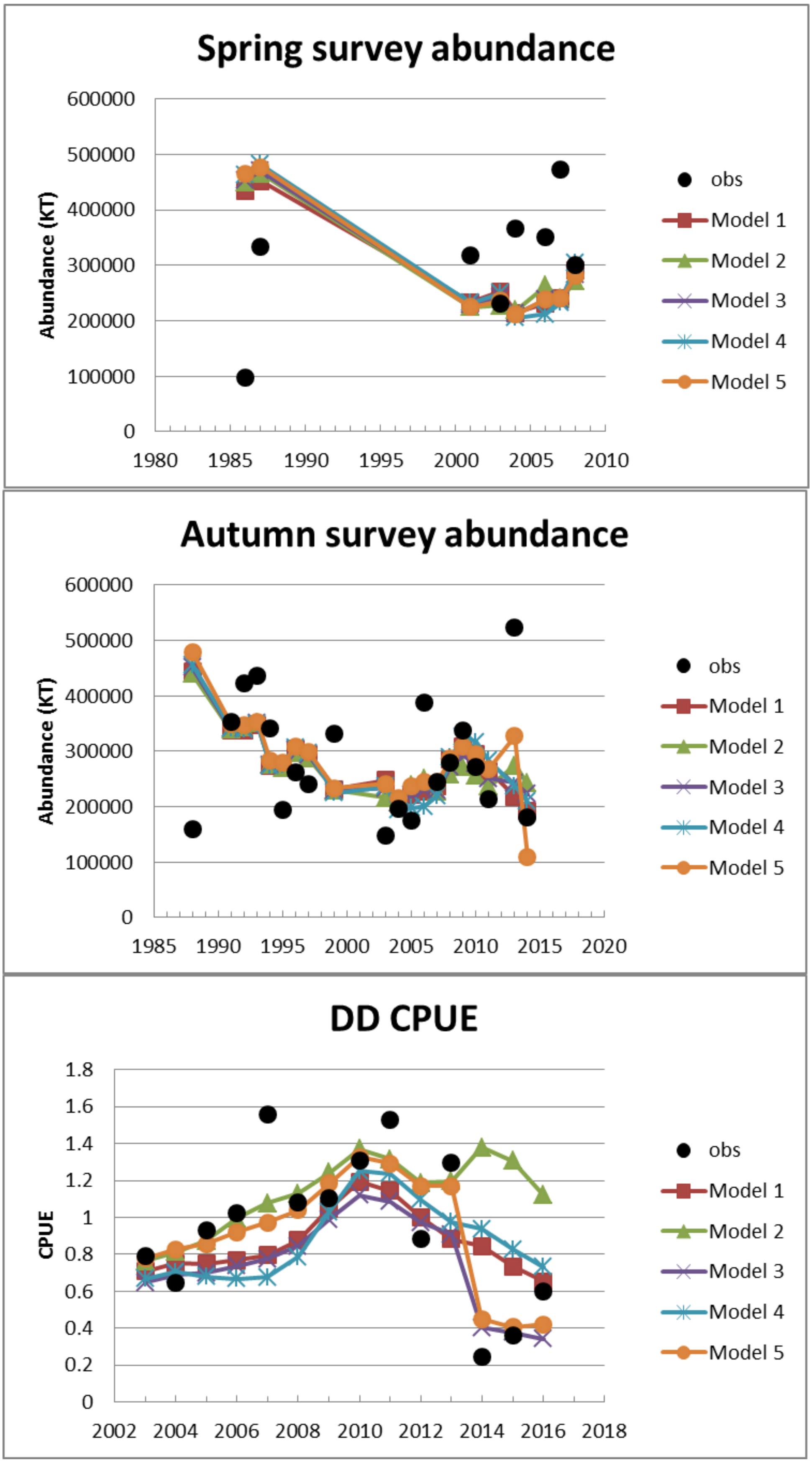

Figure 2: Estimated Stock-recruit residuals.

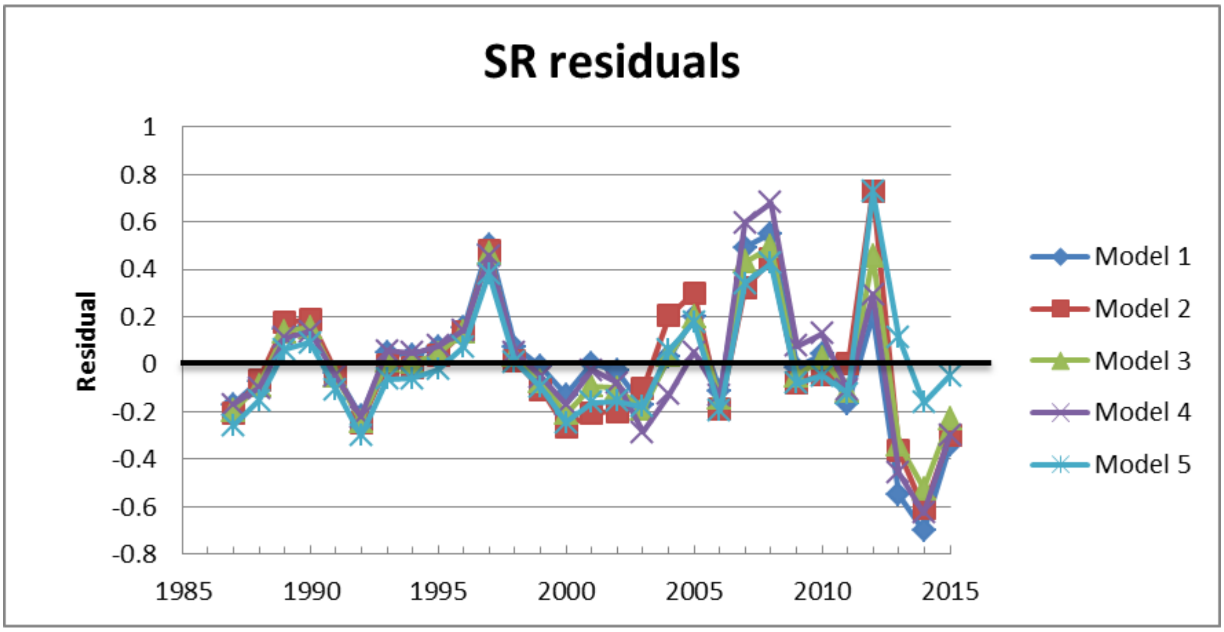

Figure 3: Model 4 fit to Dual rights CPUE.

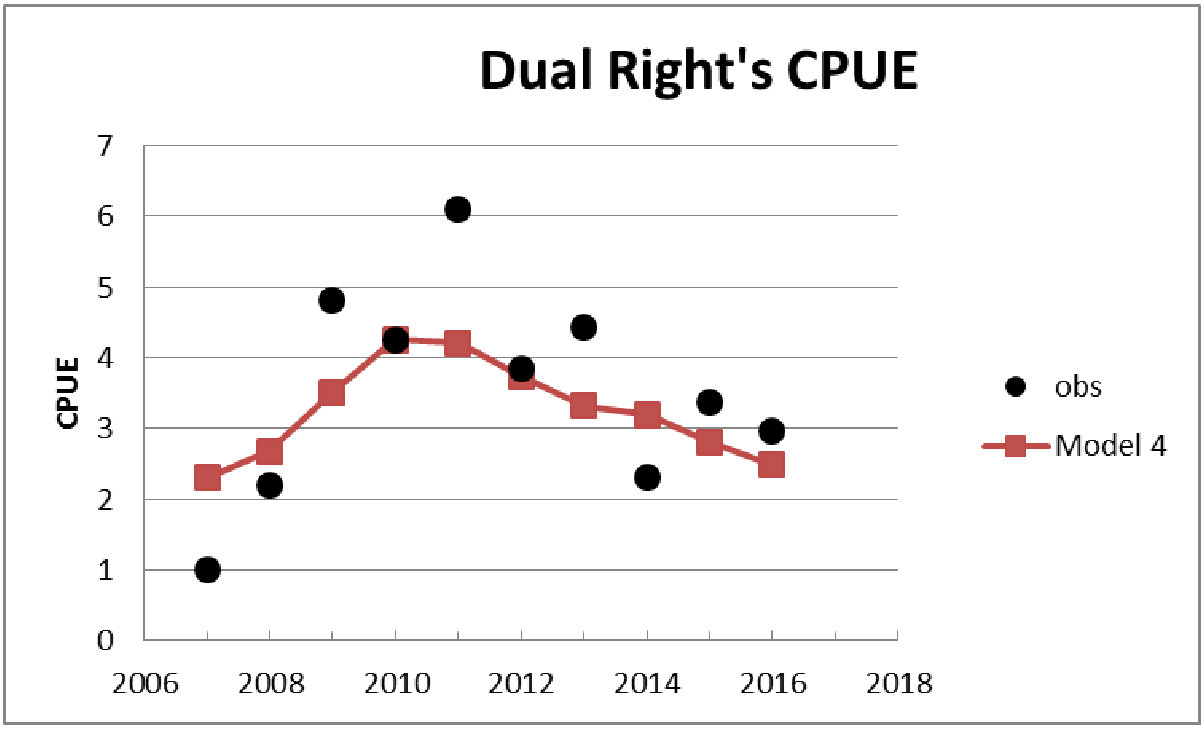

Figure 4: Estimated spawning biomass trajectories in absolute terms (top) and as proportions of their unexploited equilibrium levels (bottom).