Standardised commercial abalone CPUE for Zones A-D over the period 1980-2010

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August 2011

Abstract

This paper presents an update of the standardisation of the abalone CPUE using the conventional GLM approach and adding new data for the 2009/2010 fishing in Zones A and B.

Introduction

The catch-per-unit-effort (CPUE) General Linear Model (GLM) standardisation procedure described in Plagányi and Edwards (2007) and Brandão and Butterworth (2009) has been applied to the commercial abalone data for Zones A-D to incorporate further available data for Zones A and B for the 2010 Model-year, where a Model-year *y* runs from October of year *y*-1 to September of year *y*. The principle objective of the GLM analysis is to obtain a series of relative abundance indices that have been standardised by incorporating important covariates in the explanation of abalone CPUE variation.

The data

Commercial catch data (as kg whole mass), and effort data (as total duration of dives in minutes for each day dived) are available for the period 1980 to 2010. The covariates included in the GLM analysis include the date (in terms of Model-year and season (3-monthly periods)), the divers, and the Zones that were dived. Zone C is split into subareas CNP (nonpoached) and CP (poached). Records with a dive time less than 10 minutes were excluded as well as outliers based upon observations with large residuals (> 6 standard deviations) in an initial GLM fit. Years which had too few records (less than eight) in a Zone/subarea were also excluded. A total of 41 414 data points remained for the analysis. Table 1a gives the number of records used in the final GLM

analysis per Model-year and per Zone/subarea. Table 1b shows the legal abalone catch per Zone/subarea (in MT).

The General Linear Model (GLM) to standardise the CPUE

The following GLM model, which allows for possible annual differences in abalone spatial and temporal distribution, is used to standardise the commercial abalone CPUE data:

$$\ln(CPUE) = \mu + \alpha_{year} + \beta_{season} + \gamma_{zone} + \varphi_{diver} + \eta_{year\times season} + \delta_{year\times zone} + \varepsilon \qquad (1)$$

where:

CPUE	is the catch-per-unit-effort defined as catch (kg) divided by dive time (minutes),
μ	is the intercept,
year	is a factor with 30 levels associated with the Model-years 1980–2010 (excluding 2009 in which the fishery was closed),
season	is a factor with 4 levels associated with the season effect (1 = Jan-Mar; 2 = Apr-Jun; 3 = Jul-Sep; 4 = Oct-Dec),
zone	is a factor with 5 levels associated with the different Zones/subareas (A, B, CNP, CP and D),
diver	is a factor with 352 levels associated with the diver code, which includes both the entitlement holders coded in the database as well as "divers". Some recent divers not yet allocated a code were given a temporary code of 555 for the purposes of this analysis,
year×*season*	is the interaction between year and season,
year×*zone*	is the interaction between year and zones/subareas, and
ε	is the error term assumed to be normally distributed.

For this model, because of interactions with year (which imply changing spatio-temporal distribution patterns), the standardised CPUE series for each zone/subarea is obtained from:

$$CPUE_{year,zone} = \left[\sum_{season}\left(\exp\left(\mu + \alpha_{year} + \beta_{season} + \gamma_{zone} + \varphi_{fisher} + \eta_{year\times season} + \delta_{year\times zone}\right)\right)\right] / 4 \qquad (2)$$

where the standardisation is with respect to a diver code = 8, which contained the most observations as well as the longest period in operation in the fishery.

The reason for standardising in this way when year interactions are present is that the standardised CPUE is to be used as an index of relative abundance when input to assessment models. CPUE itself is assumed to be proportional to local density, so that averaging over season is necessary to provide a quantity proportional to overall abundance. This averaging is

unnecessary in the absence of such interactions, because then the exp(α_{year}) term alone will then be proportional to abundance.

GLM Results and Discussion

The examination of the residuals of an initial fit showed evidence of heteroscedasticity, in particular, larger residuals were associated with larger effort (Figure 1). To account for this heteroscedasticity, the iterative, inverse-weighting procedure applied by Plagányi and Edwards (2007) has been applied in which reduced weight is given to the data points with the largest variance in the model.

The GLM model accounts for 44.6% of the total variation of abalone CPUE. Table 2 lists the nominal and standardised CPUE indices provided by the model and Figures 2a–e show graphical comparisons of the same. Table 3 shows the parameter estimates, together with standard errors, obtained for the single factors included in the GLM model except for the diver factor as there are 352 levels for this factor.

The reasons for slight differences in the standardised CPUE abundance indices obtained in the present analysis to those obtained by Plagányi and Edwards (2007) and in the nominal CPUE series, especially in the later years of Zones A and D, have not been resolved. A thorough investigation of the database has been conducted and the methodology of Plagányi and Edwards (2007) to eliminate data from the GLM analysis has been replicated as far as possible. Thus, the standardised CPUE series presented in this paper will be used as input in the current 2011 abalone assessment.

Acknowledgements

Thanks to Angus Mackenzie and Genevieve Maharaj of DAFF for assistance with queries about the data upon which this paper is based.

Reference

Brandão, A. and Butterworth, D.S. 2009. A summary of the General Linear Model analyses applied to the commercial abalone CPUE data for Zones A-D over the period 1980-2008. Marine and Coastal Management document: MCM/2009/OCT/SWG-AB/06.

Plagányi, É. and Edwards, C. 2007. Summary of the GLM used to standardise abalone catch-per-unit-effort data for Zones A-D over the period 1980-2006. Marine and Coastal Management document: WG/AB/07/Aug/19.

Table 1. The number of data entries per Zone available for the final GLM analysis to standardise the commercial abalone CPUE series are shown in part a). Subarea CNP was closed during the 2001 fishing season and subarea CP during both the 2001, 2002 and 2003 fishing seasons. The abalone fishery was closed in February 2008 and reopened 2010. Some sample sizes were considered too small and were not included in the analysis (see text). Model-years are defined as the period October to September. Part b) of the table shows the legal abalone catch per zone (in MT).

a) Number of records

Model year	Zone/subarea				
	A	**B**	**CNP**	**CP**	**D**
1980	257	555	73	754	535
1981	192	578	147	622	383
1982	311	610	109	594	608
1983	327	690	144	466	301
1984	334	699	303	366	373
1985	359	620	158	366	583
1986	340	763	222	445	205
1987	443	586	106	494	144
1988	457	434	96	498	147
1989	448	414	91	504	184
1990	525	410	138	458	140
1991	446	404	161	539	167
1992	348	302	98	396	142
1993	299	238	110	334	75
1994	345	290	155	287	162
1995	441	238	137	333	171
1996	509	324	403	428	206
1997	720	248	249	117	194
1998	600	472	207	71	291
1999	696	427	57	8	304
2000	451	333	24		313
2001	399	291			135
2002	290	229	103		96
2003	415	128	54		26
2004	100	576	158		69
2005	63	597	170		54
2006	42	673	164		48
2007		483			
2008		290			
2009					
2010	157	225			

b) Legal catch (in MT)

Model year	Zone/subarea				
	A	B	CNP	CP	D
1980	144.2	173.6	17.1	162.3	183.8
1981	111.0	173.8	38.5	140.7	127.3
1982	144.8	186.6	26.7	131.1	191.1
1983	158.5	200.5	37.0	105.4	78.4
1984	165.2	205.1	82.6	95.4	101.0
1985	136.8	176.4	41.6	98.7	153.8
1986	132.0	229.4	57.3	120.6	50.3
1987	171.8	166.1	29.7	126.4	45.2
1988	194.9	138.7	26.2	139.5	49.2
1989	190.9	137.3	28.6	134.8	51.0
1990	199.2	142.4	40.3	116.6	46.3
1991	182.9	138.0	41.0	119.0	49.6
1992	184.1	147.5	30.3	113.9	56.3
1993	179.2	152.1	31.9	105.2	53.7
1994	174.0	150.0	44.1	91.2	92.5
1995	210.8	152.3	39.1	84.7	90.2
1996	204.1	146.8	64.6	61.3	89.9
1997	196.8	145.9	36.7	16.1	92.6
1998	162.4	148.4	24.3	7.6	108.5
1999	191.5	155.5	11.3	1.0	103.8
2000	179.6	139.7	3.6	0.2	100.1
2001	156.5	113.4	0.2	0.0	34.1
2002	112.6	84.6	30.0	0.5	19.0
2003	119.5	36.5	5.1	0.0	1.4
2004	31.9	149.8	8.6	0.3	10.9
2005	10.1	140.3	8.6	0.2	8.5
2006	7.6	138.2	7.5	0.3	7.4
2007	0.0	72.1	0.0	0.0	0.0
2008	0.0	24.2	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	36.5	49.5	0.0	0.0	0.0

Table 2. Nominal and GLM-standardised commercial CPUE series for abalone for Model-years (October to September) 1980 to 2010 and Zones/subareas A, B, CNP, CP and D. Both the nominal and the standardised values have been divided by the mean value of the respective series.

a) Nominal CPUE series

Model year	Zone/subarea				
	A	**B**	**CNP**	**CP**	**D**
1980	1.041	0.773	0.876	0.841	0.908
1981	1.016	0.776	0.900	0.834	0.834
1982	0.892	0.785	0.885	0.834	0.804
1983	0.880	0.766	0.942	0.875	0.724
1984	0.955	0.817	0.961	0.891	0.797
1985	0.896	0.827	0.922	0.965	0.810
1986	0.993	0.902	1.027	1.104	0.771
1987	1.020	0.884	1.138	1.057	0.869
1988	1.095	0.971	1.189	1.149	1.034
1989	1.000	0.987	1.158	1.116	0.895
1990	1.149	1.203	1.422	1.215	1.247
1991	1.148	1.244	1.226	1.103	1.233
1992	1.265	1.309	1.268	1.234	1.165
1993	1.373	1.548	1.093	1.292	1.911
1994	1.303	1.345	1.223	1.324	1.711
1995	1.212	1.450	1.257	1.131	1.469
1996	1.199	1.370	0.979	0.902	1.441
1997	1.114	1.457	0.895	0.722	1.497
1998	1.176	1.308	0.978	0.737	1.544
1999	0.978	1.146	0.985	0.673	1.024
2000	1.024	1.150	1.112		0.949
2001	1.011	1.070			0.842
2002	1.022	1.097	1.226		0.761
2003	0.829	1.045	0.805		0.484
2004	0.780	0.765	0.560		0.444
2005	0.503	0.689	0.512		0.401
2006	0.531	0.581	0.462		0.434
2007		0.501			
2008		0.495			
2009					
2010	0.596	0.740			

b) Standardised CPUE series

Model year	Zone/subarea				
	A	**B**	**CNP**	**CP**	**D**
1980	1.092	0.876	0.988	0.967	0.980
1981	1.038	0.839	1.027	0.926	0.878
1982	0.907	0.862	1.020	0.913	0.853
1983	0.880	0.811	0.991	0.930	0.753
1984	0.949	0.842	0.983	0.941	0.817
1985	0.895	0.847	0.948	0.966	0.831
1986	0.925	0.930	1.062	1.136	0.898
1987	0.962	0.860	1.098	1.007	0.945
1988	0.998	0.942	1.119	1.069	1.061
1989	1.009	1.002	1.162	1.119	0.991
1990	1.050	1.101	1.275	1.127	1.207
1991	1.066	1.041	1.167	1.061	1.042
1992	1.209	1.266	1.280	1.219	1.198
1993	1.132	1.356	1.085	1.289	1.658
1994	1.092	1.049	1.198	1.205	1.292
1995	1.124	1.198	1.194	1.120	1.171
1996	1.161	1.298	1.039	0.978	1.305
1997	1.129	1.451	0.849	0.708	1.409
1998	1.113	1.315	0.945	0.700	1.439
1999	1.025	1.276	1.082	0.620	1.082
2000	1.025	1.152	1.071		0.960
2001	1.086	1.139			0.884
2002	1.144	1.122	1.087		0.811
2003	0.908	1.059	0.759		0.563
2004	0.924	0.896	0.560		0.710
2005	0.713	0.777	0.526		0.575
2006	0.793	0.724	0.483		0.689
2007		0.654			
2008		0.509			
2009					
2010	0.649	0.805			

Table 3. Parameters estimates and standard errors for the single factors *Year*, *Season* and *Zone* included in the GLM to obtain standardised indices of abundance for abalone.

	Parameter estimate	Standard error
Year		
1980	0.000	—
1981	0.030	0.025
1982	0.041	0.025
1983	0.053	0.025
1984	0.062	0.025
1985	0.098	0.026
1986	0.079	0.025
1987	0.065	0.028
1988	0.160	0.030
1989	0.166	0.029
1990	0.398	0.030
1991	0.312	0.033
1992	0.494	0.039
1993	0.516	0.049
1994	0.381	0.041
1995	0.307	0.042
1996	0.537	0.030
1997	0.533	0.045
1998	0.585	0.026
1999	0.487	0.029
2000	0.456	0.032
2001	0.424	0.033
2002	0.390	0.034
2003	0.326	0.046
2004	0.328	0.044
2005	0.133	0.029
2006	-0.046	0.029
2007	-0.169	0.047
2008	-0.454	0.035
2009	0.004	0.037
2010	0.030	0.025
Season		
Jan-Mar	0.000	—
Apr-Jun	-0.020	0.020
Jul-Sep	0.119	0.020
Oct-Nov	0.235	0.063
Zone		
A	0.383	0.028
B	0.000	—
CNP	-0.059	0.048
CP	-0.063	0.022
D	0.141	0.023

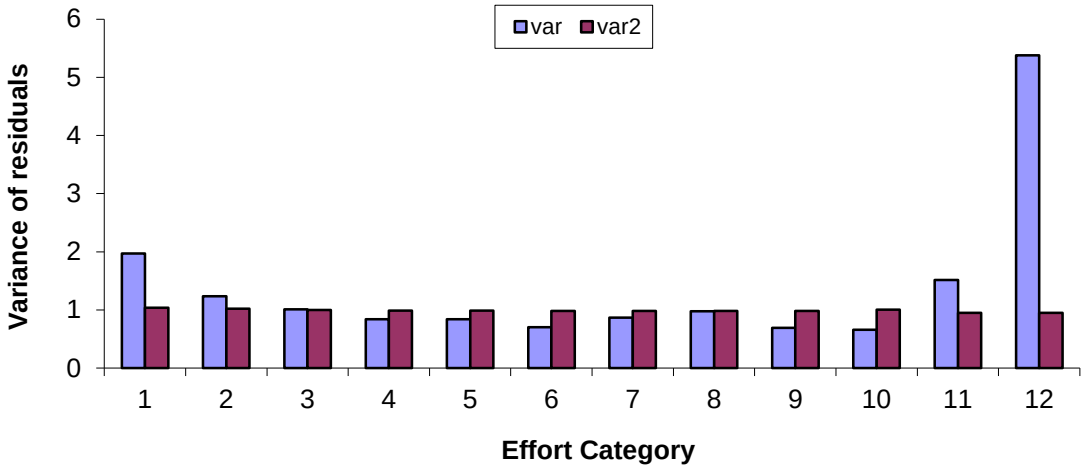

Figure 1. Plot of the average variance of the residuals versus effort category (50 minutes interval) for an initial GLM fit of the data (var, showing evidence of heteroscedasticity) and for the final weighted GLM (var2, showing homoscedastic residuals).

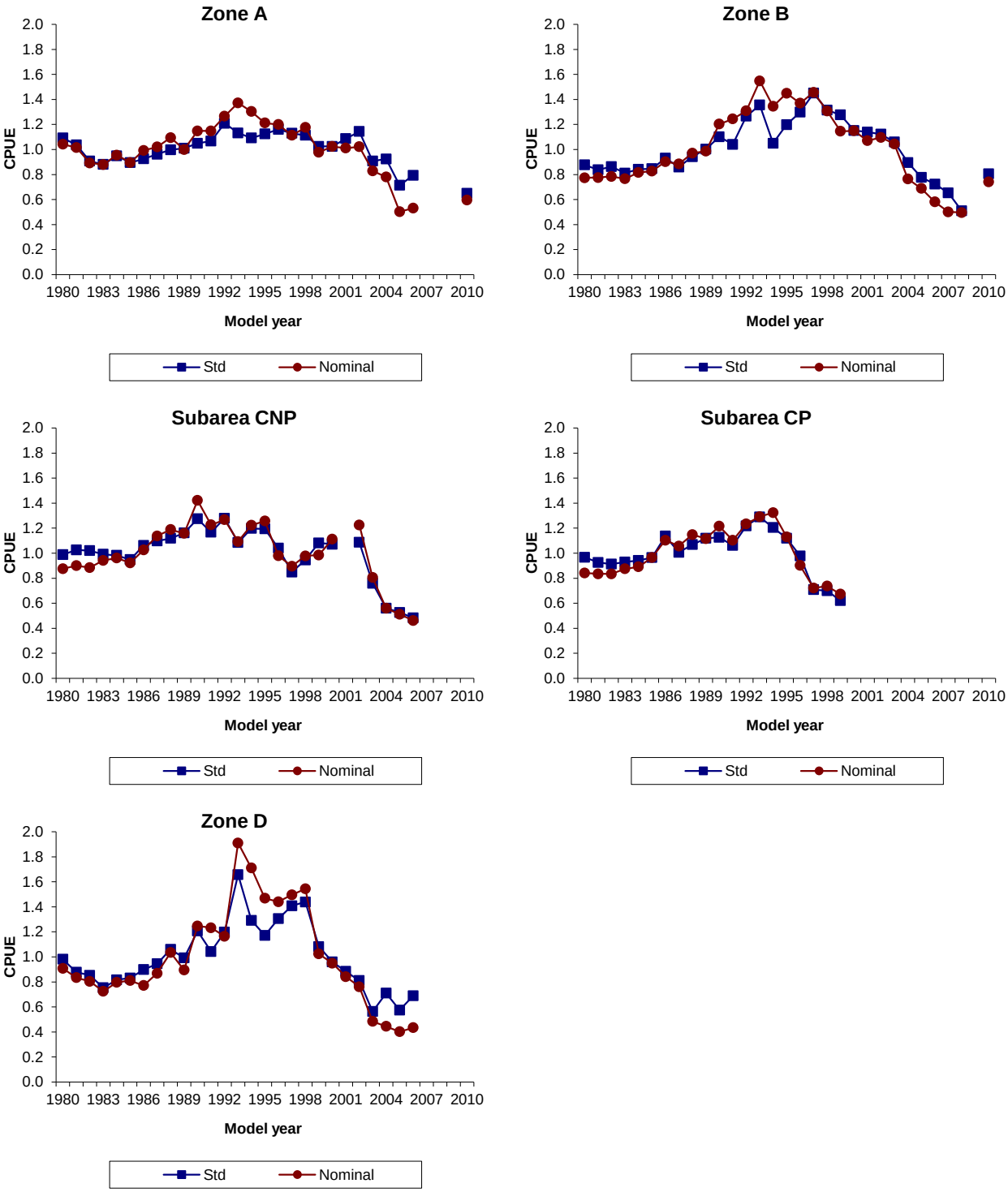

Figure 2. GLM-standardised CPUE trends (normalised to their means over the 30 year period) for Zones/subareas A, B, CNP, CP and D. For comparison, the nominal series (also normalised to their means over the 30 year period) are also shown.