Updated GLM analyses of Area 8+

J.P. Glazer and D.S. Butterworth

Introduction

The existing standardized CPUE indices for trapboats and bakkies in Area 8 comprise data from Area 8 only and an *ad hoc* adjustment is made to accommodate the movement of lobster into the area East of Hangklip (Areas 12-14) by increasing the size of Area 8 over a period of time. Recently Glazer and Butterworth (2010) presented results from GLM analyses applied to data from Area 8+ (Areas 8, 10-14) for the two methods of fishing. Updated results are presented here and a method is applied whereby the indices of abundance derived from the Area 8 and Area 8+ analyses are combined to provide a composite index of abundance for trapboats and bakkies respectively.

The data and the models

Tables 1 and 2 present the trapboat and bakkie data sample sizes per year for Area 8+.

In summary the data available for trapboats and bakkies in Areas 8+ are as follows:

Area	Trapboats	Bakkies
8	1981[1]-2009	1986-2009
10	1992-2000	1997-2000
11	1992-2009	1996-2009
12	n/a	2000-2009
13	n/a	2003-2009
14	n/a	2003-2009

The following table summarises the various models considered and are applicable to both trapboats and bakkies:

Model Name	Model description	Area analyzed
Area 8	$ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+(\text{year}\times\text{month})+\varepsilon$	8
Revised Area 8	$ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+(\text{year}\times\text{month})+\varepsilon$	8
Area 8+	$ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+\kappa_{Area}+(\text{year}\times\text{month})+(\text{year}\times\text{Area})+\varepsilon$	8,10,11 (trapboats) 8,11,12,13 and 14 (bakkies)
Modified Area 8+	Scaling the Revised Area 8 indices to the Area 8+ indices and combining the two series	

[1] The year 1981, for example, refers to the 1981/1982 fishing season.

It should be noted that for each of the models considered an analysis of the studentized residuals in the form of qq-plots indicated that they were not normally distributed. Consequently each model was re-run, excluding records where the residuals exceeded ± 2SD. It is the resulting standardized indices from the respective re-runs that are reported in the Figures that follow.

Re-analysis of the Area 8 trapboat CPUE data

The model currently applied to standardize the Area 8 trapboat data is of the form $ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+(\text{year}\times\text{month})+\varepsilon$ and covers the period 1985 – 2009. The standardized CPUE indices are integrated over area, allowing for a linear increase in the size of area over the period 1987 – 1995 so that the area East of Hangklip can be incorporated into the area. At the time that this linear increase was implemented (in 1999) it was advised that the size of the area East of Hangklip was 1262km^2 (D. Schoeman, pers. commn). Brouwer (2006) provides updated calculations of area sizes and these are shown in Table 3. Given that these are likely more accurate than the estimate provided by D. Schoeman (pers. commn), it is suggested that the area sizes in Table 3 be used in updates of the Area 8 analysis which incorporates the *ad hoc* adjustment for movement into the East of Hangklip area. It has further been advised that area sizes only up to the 50m depth contour for the East of Hangklip Areas (12-14) should be used since no lobsters are found beyond 50m as indicated by a deepwater survey of that area (D. Van Zyl, pers. commn – paper in preparation for publication). The total area size for East of Hangklip (Areas 12-14) to the 50m contour is 161.96km^2. This differs markedly from the estimate of D. Schoeman, who likely calculated the area size to the 200m depth contour. Table 4 compares the Schoeman and Brouwer area sizes to be applied per annum to Area 8 to allow for the linear increase in area size over the period 1987-1995.

As a result of the revision of the area sizes for incorporating the area East of Hangklip into the Area 8 standard analysis, the indices of abundance have been re-calculated using the Brouwer (2006) area estimates for Areas 12-14 to the 50m depth contour (an increase in area size totalling 161.96km^2). The resulting trend (referred to henceforth as "Revised Area 8") is shown in Figure 1 together with the trend derived, as in the past, from the Schoeman (pers. commn) area size increase of 1262km^2.

Analysis of the Area 8+ trapboat CPUE data

Trapboat fishing does not extend into the area East of Hangklip. As a result, the data from Areas 8, 10 and 11 have been included in the analyses of Area 8+, and the size of Area 8 has been increased over the period 1987-1995 to accommodate for the movement of lobster into the East of Hangklip area.

A model of the form $ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+\kappa_{Area}+(\text{year}\times\text{month})+(\text{year}\times\text{Area})+\varepsilon$ was applied to data for the period 1992-2009 which is when trapboat fishing took place in all three areas. Given the year×area interaction the indices are integrated over area, where the area sizes for Area 8 are the Brouwer estimates in Table 4 and the 200m contour estimates for Areas 10 and 11 shown in Table 3. The resulting standardized index together with the Revised Area 8 index is shown in Figure 2.

Combining the Revised Area 8 and Area 8+ trapboat standardized indices of abundance

The Area 8+ analysis covers the period 1992-2009 (the period of overlap of data in each of the relevant areas), whereas the Revised Area 8 data extend back to 1985. A method of combining the two series is therefore desirable in order to extend the series back in time as far as possible. This is achieved by multiplying the pre-1992 Revised Area 8 values by the ratio $\frac{\overline{Std\ CPUE}_{A8+,1992-1996}}{\overline{Std\ CPUE}_{A8,1992-1996}}$ in order to scale them to the Area 8+ index and then combine them the Area 8+ index. The resulting combined index is shown in Figure 3.

Re-analysis of the Area 8 bakkie CPUE data

The model currently applied to standardize the Area 8 bakkie data is of the form $ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+(\text{year}\times\text{month})+\varepsilon$ and covers the period 1986 – 2009. As was the case for the trapboat cpue analysis, the bakkie standardized CPUE indices are integrated over area, allowing for a linear increase in the size of area over the period 1987 – 1995 so that the area East of Hangklip can be incorporated into the area.

As a result of the revision of the area sizes for incorporating the East of Hangklip area into the Area 8 standard analysis, the indices of abundance were re-calculated using the Brouwer (2006) estimates for Areas 12-14 to the 50m depth contour (an increase in area size totalling 161.96km^2). The resulting trend is shown in Figure 4 together with the trend derived from the Schoeman (pers. commn) area size increase of 1262km^2.

Analysis of the Area 8+ bakkie CPUE data

Data from Areas 8, 11, 12, 13 and 14 have been included in the analyses of Area 8+ (Area 10 is not included in the analyses due to very little bakkie activity in that area – see Table 2). A model of the form $ln\text{CPUE}=\alpha+\beta_{year}+\gamma_{month}+\kappa_{Area}+(\text{year}\times\text{month})+(\text{year}\times\text{Area})+\varepsilon$ was applied to data for the period 2003-2009 which is when bakkie fishing took place in all five areas. Given the year×area interaction the indices are integrated over area, where the area size for Area 8 is the size associated with the 200m depth contour in Table 3, and for Areas 11-14 the sizes associated with the 50m depth contour in Table 3. The resulting standardized index together with the Revised Area 8 index is shown in Figure 5.

Combining the Area 8 and Area 8+ bakkie standardized indices of abundance

The Area 8+ data are only available for the period 2003-2009 (the overlap period of data in all five areas), whereas the Revised Area 8 data extend back to 1986. The method applied to combine the two series as for the case of the trapboat analyses is also applied for the bakkie standardized indices i.e. multiply the pre-2003 Revised Area 8 standardized values by the ratio $\frac{\overline{Std\ CPUE}_{A8+,2003-2007}}{\overline{Std\ CPUE}_{A8,2003-2007}}$ in order to scale them to the Area 8+ index. The resulting combined index is shown in Figure 6.

Reference

Brouwer, Stephen. 2006. Area calculations for the South African West Coast Rock Lobster Resource. Unpublished Working Group Document: WG/03/06/WCRL18. 4pp.

Table 1: Trapboat sample size per year, month and Area. No trapboat fishing takes place in areas 12-14.

AREA 8

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1981	594	368	435	148	11							1556
1982	332	394	372	205	117	18						1438
1983	350	278	349	49	70							1096
1984	331	203	1		26							561
1985	249	190	73	98	39	67	32	53				801
1986	157	227	327	296	168	57	27	32	5			1296
1987	50	51	174	207	103	83	87	87	14			856
1988	17	46	150	154	194	134	80	91	85			951
1989	24	12	103	107	145	85	54	6				536
1990		19	68	104	40	75	163	155	37			661
1991	68	209	338	287	313	199	208	132	21			1775
1992	4		45	204	208	224	283	159	62	61		1250
1993	4	21	10	119	176	213	247	127	290	145		1352
1994	4	27	226	247	190	301	207	138	72	55	13	1480
1995	5	22	49	81	269	184	236	160	125	54		1185
1996		5	110	136	207	215	158	207	427	109	7	1581
1997			43	61	94	179	412	337	253	149	54	1582
1998		18	28	36	164	175	171	258	359	241	248	1698
1999		8	22	63	106	374	316	239	172	144	90	1534
2000		1	9	24	136	165	275	283	202	110	125	1330
2001		2	10	28	78	221	172	235	342	571	621	2280
2002	4	24	33	53	75	152	151	221	356	364	608	2041
2003	7	12	48	77	309	301	344	277	382	391	306	2454
2004	19	25	19	81	214	245	319	411	424	500	670	2927
2005					90	177	168	762	390	270	342	2199
2006	17	42	46	55	327	347	691	285	421	769	818	3818
2007	1	18	164	160	160	237	156	577	330	511	453	2767
2008		18	140	78	118	212	332	298	531	259	301	2287
2009		26	149	170	248	317	263	190				1363
Total	2237	2266	3541	3328	4395	4957	5552	5720	5300	4703	4656	46655

AREA 10

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1992	47	68	8							123
1993	73	12	3							88
1994	24	53				1				78
1995			90	19						109
1996		28	87	18						133
1997				121	10					131
1998							64	50		114
1999			57	67		28			2	154
2000						118		3		121
2001				95	9	1				105
2002						77				77
2003			77	9						86
2004		1			60	15				76
2005					124					124
2006			2	140	22					164
2007				66	130					196
2008				120	102					222
2009			40	252	5					297
Total	144	162	364	907	462	240	64	53	2	2398

AREA 11

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Total
1992				25	14	22			61
1993					52	13			65
1994		2		12	29				43
1995						26	23		49
1996					40	37	5		82
1997				1	1				2
1998						11	4	6	21
1999		1	1	12	16	3			33
2000			7			2	2		11
2001		1	2	4	8	1			16
2002			3	7	4	21	3		38
2003				8	5	34	1		48
2004		3		5	10	55	2		75
2005				10	35	31			76
2006	10	18	9	11	17	9			74
2007		2	18	14	27	69			130
2008	7	12	19	9	20	51			118
2009	4	21	21	10	4	9			69
Total	21	60	80	128	282	394	40	6	1011

Table 2: Bakkie sample size per year, month and Area.

AREA 8

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1986	14	12	22	20	21	18	3	3				113
1987	5	9	20	14	16	8	6	3				81
1988	5	13	12	20	22	11						83
1989	7	10		7	11		5	9				49
1990	1	5	13	13	14	17	11					74
1991	6	10	14	9	11	4	1					55
1992	53	111	38	141	172	73	77	86				751
1993	46	95	106	158	160	163	115	65	8			916
1994	64	136	199	129	115	12	114	119	5			893
1995	85	56	66	120	125	96	14	13		18		593
1996	66	69	130	36	87	102	15		91	29		625
1997		48	37	69	85	41	77	55	61	35	25	533
1998		33	27	20	102	38	83	56	74	71	51	555
1999		59	54	66	58	122	104					463
2000		44	101	44	53	63	82	52	3	5		447
2001			26	29	87	124	262	407				935
2002	1	7	63	76	162	329	403	558	42		1	1642
2003	5	17	92	56	123	324	448	644				1709
2004	1	1	42	86	219	292	310	539	1		2	1493
2005				10	133	119	220	224				706
2006	8	44	45	96	188	138	332	291	1			1143
2007		13	133	161	161	227	32	143				870
2008	19	23	112	181	114	85	66	130				730
2009	2	36	46	132	198	85	107	49				655
Total	388	851	1398	1693	2437	2491	2887	3446	286	158	79	16114

AREA 10

	Mar	Apr	May	Jun	Jul	Total
1997		5				5
1998				3	7	10
1999	11		4			15
2000	1		11			12
Total	12	5	15	3	7	42

AREA 11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
1987						9	8		17
1988									
1989									
1990									
1991									
1992									
1993									
1994									
1995									
1996				1				5	6
1997				1	4	15	7		27
1998									
1999					4	12			16
2000							2		2
2001		7	29	1	81	95	31		244
2002				7	111	65	109	1	293
2003	1	1			31	101	80		214
2004				1	22	93	116		232
2005				3	20	40	83		146
2006	6	14	16	25	35	77	72	1	246
2007	5	25	35	15	49	12	32		173
2008	4	23	22	16	15	30	36		146
2009	11	12	25	21	18	18	9		114
Total	27	82	127	91	390	567	585	7	1876

← Error??

AREA 12

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2000							85	1				86
2001							77					77
2002												
2003			5	82	81	48	39	20		40	36	351
2004				12	110	134	89	42				387
2005				7	56	31	24	123	154	19	29	443
2006		3	35	93	117	79	130	109	3			569
2007	2	29	99	125	93	164	84	64				660
2008	25	57	108	85	39	50	67	55				486
2009	16	91	101	87	107	47	82	53				584
Total	43	180	348	491	603	553	677	467	157	59	65	3643

AREA 13

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2003			27	73	130	80	93	75		9	21	508
2004			1	11	49	154	96	132				443
2005			1	139	191	70	34	106	139	28	45	753
2006	1	13	44	96	173	119	112	30		1		589
2007	20	71	188	312	163	231	22	10				1017
2008	83	244	267	183	109	60	87	28				1061
2009	63	313	197	95	180	34	35	14				931
Total	167	641	725	909	995	748	479	395	139	38	66	5302

AREA 14

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2003			9	16	52	41	77	20		20	58	293
2004			2	4	22	49	47	85				209
2005					4	13	58	53	9	1	1	139
2006		1	11	7	56	54	14					143
2007			34	83	44	131	1					293
2008		1	40	63	76	18	9		1			208
2009	1	17	46	23	88	50	15					240
Total	1	19	142	196	342	356	221	158	10	21	59	1525

Table 3: Area sizes (km^2) (Brouwer, 2006)

Area	Depth contour	Size (km^2)
8	200m	2621.00
10	200m	226.29
11	200m	1080.02
12	50m	16.66
	100m	71.96
	200m	273.11
13	50m	30.17
	100m	338.61
	200m	908.51
14	50m	115.13
	100m	216.79
	200m	725.92

Table 4: Area sizes (km^2) per annum over the period for which the size of Area 8 was increased to accommodate movement of lobster into the area East of Hangklip as indicated by Schoeman (pers. commn) and Brouwer (2006).

	Area size (km^2)	
Season	**Schoeman**	**Brouwer**
$\leq$ 1986	2621	2621
1987	2761	2639
1988	2901	2657
1989	3042	2675
1990	3182	2693
1991	3322	2711
1992	3462	2729
1993	3603	2747
1994	3743	2765
$\geq$ 1995	3883	2783

Figure 1: Area 8 trapboat standardized CPUE assuming i) an increase in area size of 161.96km^2 (Revised Area 8) and ii) 1262km^2 (Area 8), as in the past, over the period 1987-1995 in order to adjust for movement of lobster into the area East of Hangklip. Each index has been normalized to its mean.

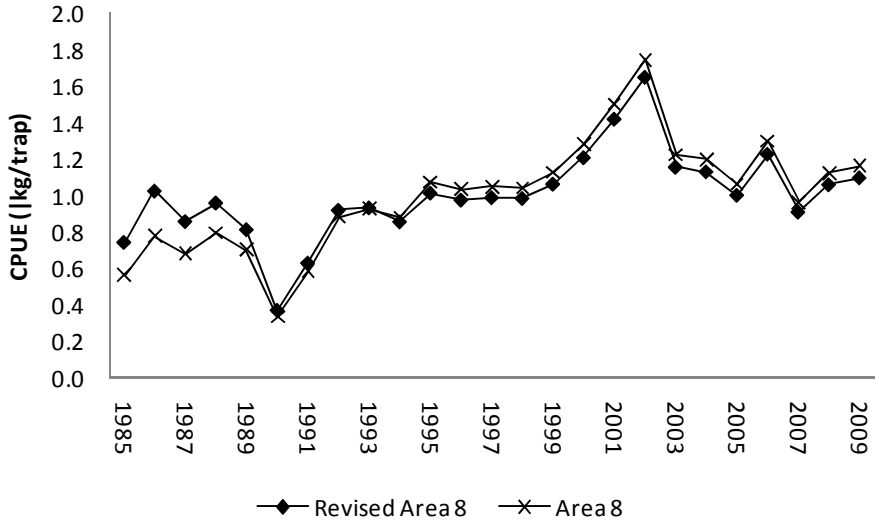

Figure 2: Revised Area 8 *vs* Area 8+ trapboat standardized CPUE. Each index has been normalized to its mean over the common period (1992-2009).

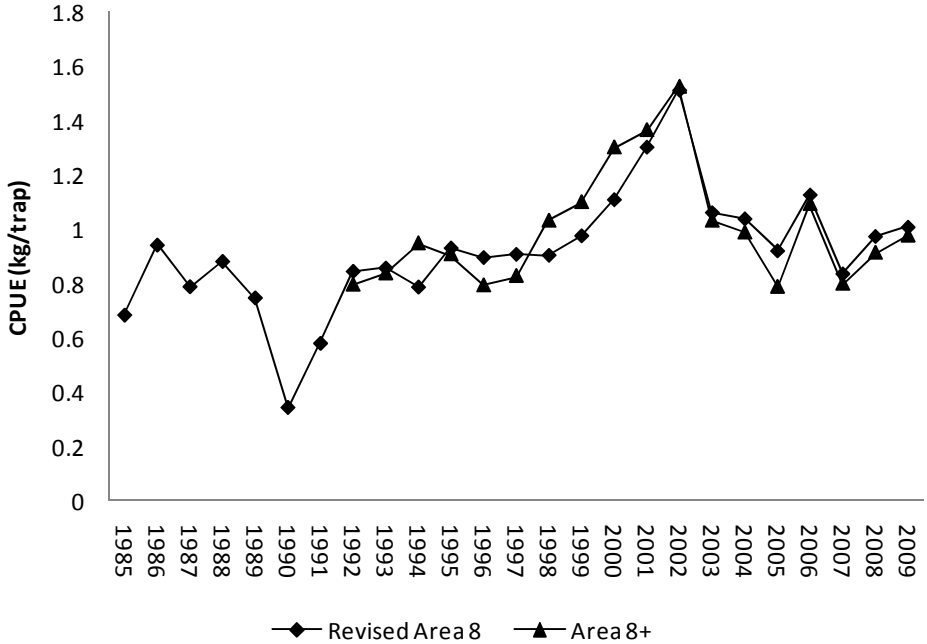

Figure 3: Modified Area 8+ trapboat standardized CPUE index, incorporating the pre-1992 Revised Area 8 standardized values by scaling them to the Area 8+ index. The Revised Area 8 standardized index is shown for comparative purposes. Each index has been normalized to its mean.

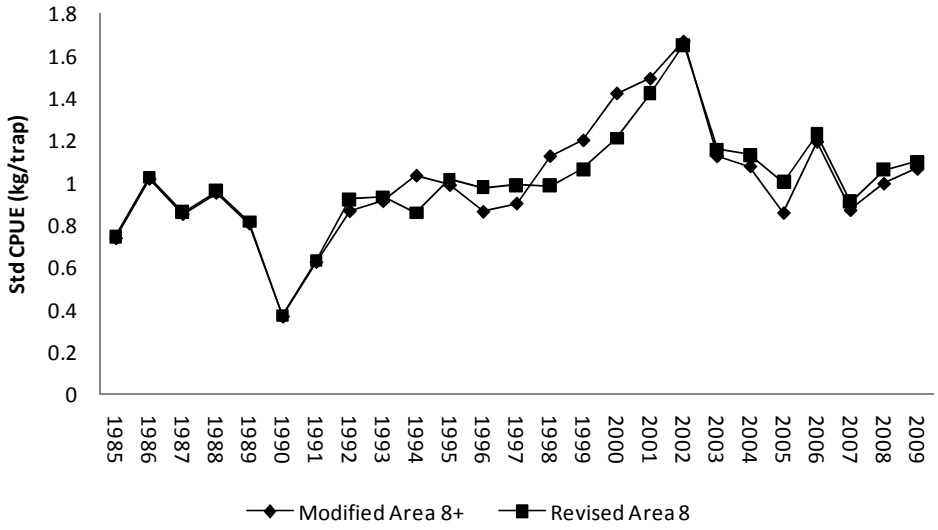

Figure 4: Area 8 bakkie standardized CPUE assuming i) an increase in area size of 161.96km^2 (Revised Area 8) and ii) 1262km^2 (Area 8), as in the past, over the period 1987-1995 in order to adjust for movement of lobster into the area East of Hangklip. Each index has been normalized to its mean.

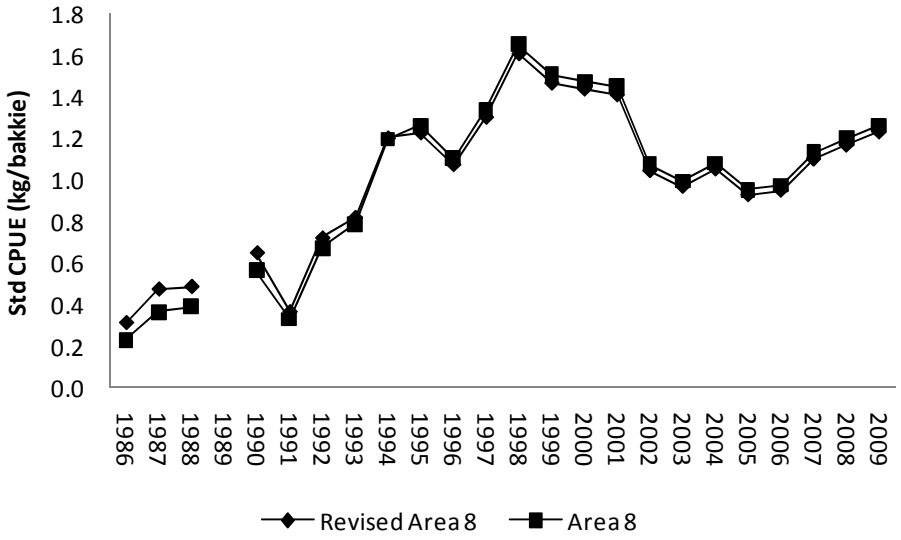

Figure 5: Revised Area 8 *vs* Area 8+ bakkie standardized CPUE. Each index has been normalized to its mean over the common period (1992-2009).

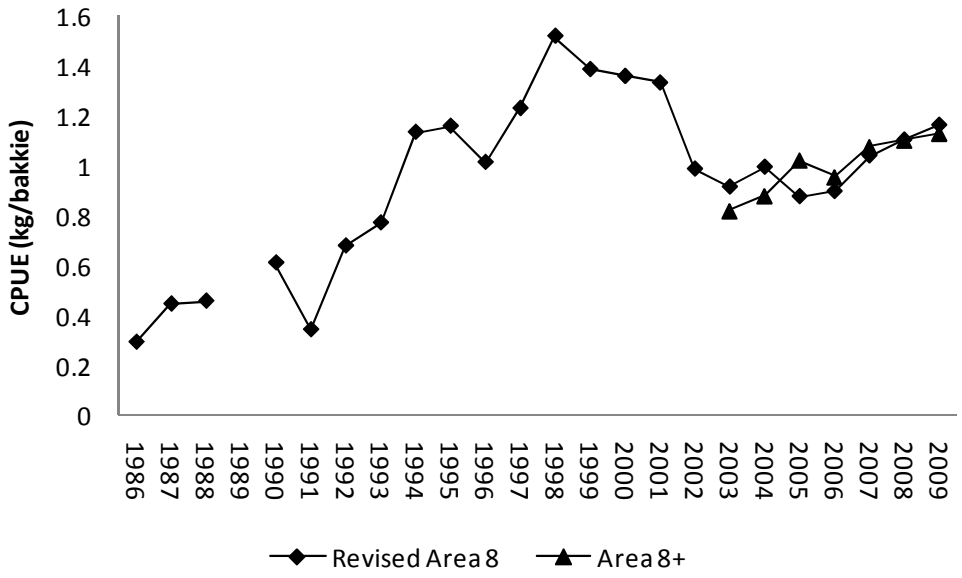

Figure 6: Modified Area 8+ bakkie standardized CPUE index, incorporating the pre-1992 Revised Area 8 standardized values by scaling them to the Area 8+ index. The Area 8 standardized index is shown for comparative purposes. Each index has been normalized to its mean.