Further analyses of the GLM trends for *M. paradoxus* and *M. capensis*

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Introduction

This paper takes a closer look at CPUE analyses, particularly with a view towards determining the reason for the sharp decline in the standardized CPUE index from 2006 to 2007 for *M. capensis*. Results from including and excluding night-time trawls are also presented from an analysis of data covering the period 2000-2007.

Indices of abundance

The annual nominal CPUE indices for hake (species combined) are shown in Figure 1, while species-specific nominal indices are shown in Figure 2. Note that the indices are shown for two units of effort, namely kg/minute (the basis used for deriving indices for assessment purposes) and kg/day (the production measure to which Industry will be sensitive). The Figure shows that there is very little difference in trend for these two units of effort.

Of concern is the sharp drop in the standardized CPUE for *M. capensis* from 2006 to 2007, given that the nominal index actually indicates an increase in CPUE between those two years (Figure 2a). An inspection of the area-weighted CPUE per strata for 2007 (Figure 3) indicates that it is the 101-200m stratum on the South Coast that contributes the most to the index for that year (and this is in fact the case for all years). This is not surprising given that this particular stratum comprises just over 45% of the area covered in this analysis (Table 1). The nominal CPUE indices were thus separated into two strata, namely (i) SC 101-200m and (ii) all other strata excluding SC 101-200m, with results shown in Figure 4. Of note in this Figure is that fact that the overall nominal CPUE started declining from 2000 and has subsequently leveled off, whereas the CPUE in the SC 101-200m stratum only started declining later (from 2004), with a steady downward trend since then. This Figure also illustrates the fact that the nominal CPUE in the SC 101-200m stratum is much larger than the overall nominal CPUE for *M capensis*.

The amount of effort exerted in SC 101-200m relative to total effort is shown in Figure 5 and indicates that very little effort is exerted in this particular stratum. However, given the high contribution of this stratum to the overall standardized index of abundance, the SC 101-200m stratum dominates the standardized CPUE index, but has little impact on the nominal index. Note that the standardized index is area weighted, as appropriate when integrating an index of local density; in contrast the nominal index is effectively effort weighted, being in this case dominated by contributions from strata which are trawled frequently, but in which the *M. capensis* density is low.

The exclusion of night-time trawls

A preliminary investigation was conducted into the exclusion of night-time trawls from the analyses given that concern was raised that night-time trawls generally produce a lower CPUE than do day-time trawls in circumstances where in recent years there has been an increase in night-time trawling. Data that cover the period 2000-2007 were included in this analysis. The raw data for the period analyzed were revisited and a trawl was assigned as day or night depending on the time at which the trawl commenced. Those trawls that started between 5am and 5pm (inclusive) were considered day-time trawls, while those that started after 5pm and before 5am were considered night-time trawls. Once the assignment of day or night was made to the trawls, the usual process of accumulating the data over a day was followed. Two accumulated datasets were thus generated, one which contained days comprising both day and night trawls, and another which contained only day-time trawls. The standard GLMs were then applied to each dataset. The resulting standardized indices of abundance are shown in Figure 6, with statistics of interest shown in Table 2. It is clear that *M. paradoxus* are impacted more by the time of day during which trawls take place than are *M. capensis*, but differences are not large.

The exclusion of data in cells with small sample sizes

It is common practice in GLM analyses to exclude data from cells that have few samples in them ($n \leq 5$) given that the inclusion of these data may lead to anomalous results if the few samples available are atypical. The samples sizes per year, depth and area included in the hake GLM analyses are shown in Table 3. There are two instances where $n \leq 5$ and it is suggested that in future analyses the data from these two cells be excluded. Sensitivity to the exclusion of these data has already been tested, and there is no difference in the resulting standardized trends when compared to the base case indices for either species (Figure 7).

Errata

Table 3 of MCM/2008/AUG/SWG-DEM/44 has a typographical error in the area size for latitude stratum 33º00-34º20 and depth zone 101-200m. The correct figure should be 993.57, and not 93.57 nm^2 (see Table 4).

For reasons that are no longer clear, the indices of abundance from past analyses have been integrated over the area between 28º30S and 35º20S on the West Coast, although area sizes per latitude/depth strata exist for the area up to 36º20S for this coast i.e. an area covering a one degree block of latitude has been excluded from the area size attributed to the West Coast. Table 4 provides updated stratum sizes for the West Coast if the area is extended to 36º20S. The impact of integrating the CPUE over area utilizing the revised sizes for the West Coast is shown in Figure 8, illustrating that there is no difference in the resulting standardized trends when compared to the base case indices for either species. Future analyses will be based on the full area for which sizes are available for the West Coast, i.e. 28º30S - 36º20S.

Table 1: The proportion that of each of the 16 strata make up of the total area considered in the coast-combined, species specific analysis of the hake CPUE data.

	Depth				
lat/long	**201-300m, WC**	**301-400m, WC**	**401-500m, WC**	**101-200m, SC**	**201-500m, SC**
<31°S	0.106	0.024	0.019		
31-33°S	0.084	0.070	0.042		
33-34°20S	0.026	0.013	0.015		
34°20-35°20S	0.022	0.015	0.013		
20-22°E				0.203	0.025
22-27°E				0.249	0.075
Total					1

Table 2: The amount of variation (r^2) and slope statistics (average annual percentage change in abundance) associated with each of the models related to the inclusion and exclusion of night-time trawls from the analyses.

Model	r^2 **(%)**	**Slope (%)**
M. capensis (day+night)	68.5	-14.6
M. capensis (day)	68.1	-14.6
M. paradoxus (day+night)	47.8	1.51
M. paradoxus (day)	48.1	0.18

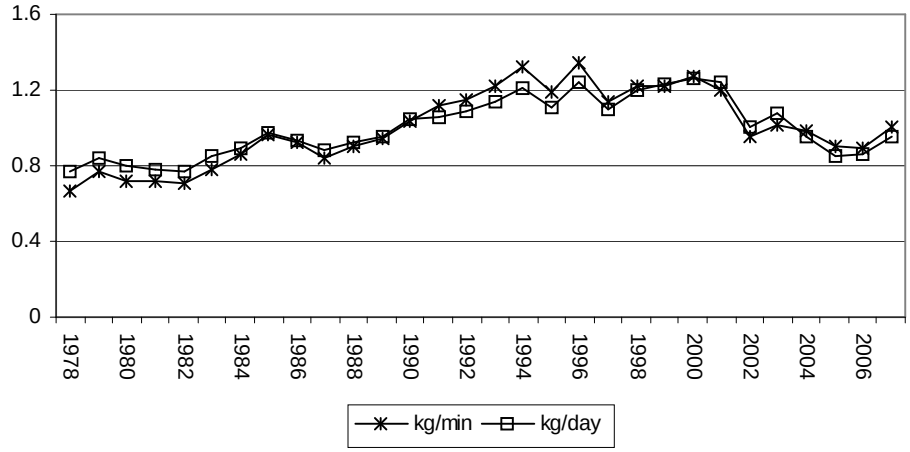
Table 3: Sample sizes per year, depth and area stratum for those strata included in the GLM analyses.

	<31°S	<31°S	<31°S	31-33°S	31-33°S	31-33°S	33-34°20S	33-34°20S	33-34°20S	>34°20S	>34°20S	>34°20S	<22°E	<22°E	?22°E	?22°E
year	201-300m	301-400m	>400m	201-300m	301-400m	>400m	201-300m	301-400m	>400m	201-300m	301-400m	>400m	101-200m	>200m	101-200m	>200m
1978	51	240	83	347	1364	1364	738	1465	696	2275	651	75	330	75	75	395
1979	90	272	122	450	876	1224	782	1536	760	3574	545	54	335	58	162	405
1980	61	311	145	729	1673	1495	885	1631	984	3359	1037	172	423	46	26	259
1981	119	360	74	731	1892	887	1106	1971	711	2905	858	136	552	35	119	210
1982	129	255	54	583	1163	963	1195	1261	1001	3010	1162	268	713	45	197	415
1983	178	155	66	518	1087	1087	672	1143	711	2214	829	260	630	37	314	610
1984	190	152	73	566	795	1019	653	1226	1198	2463	1106	282	540	53	259	538
1985	169	220	75	224	763	591	351	1442	835	2279	1184	182	613	51	465	922
1986	239	113	78	198	643	1155	789	1669	740	1991	1587	413	417	19	363	790
1987	324	227	136	479	1000	1453	1156	1486	1475	1902	892	186	433	57	312	654
1988	282	372	70	267	527	706	1398	1807	554	2322	1266	345	559	90	362	570
1989	560	256	92	322	487	762	906	1486	1065	2097	1076	157	864	119	414	488
1990	445	158	36	103	244	818	468	1458	1255	2219	1019	171	544	44	501	605
1991	92	141	167	59	468	1471	389	1384	1341	1956	1389	283	514	42	298	914
1992	209	165	212	25	279	1616	313	1427	1006	1881	1458	326	162	54	207	1039
1993	369	161	413	51	385	1805	328	1297	2032	1270	860	559	81	45	222	747
1994	133	76	224	94	238	861	368	1383	2182	1509	973	585	143	90	156	574
1995	76	58	40	22	231	960	455	1355	2007	1678	1937	922	88	113	112	386
1996	55	35	59	39	368	1261	241	1036	1582	1537	2021	1055	149	62	119	786
1997	75	74	130	28	238	1171	403	1254	1755	1029	1880	1505	46	90	282	1234
1998	88	65	81	100	233	1335	628	1128	1949	843	1151	1330	161	71	322	807
1999	29	33	80	81	337	984	446	977	1407	770	1168	1205	58	65	316	953
2000	28	28	102	65	123	868	368	786	783	891	1058	942	46	72	305	557
2001	16	25	57	30	95	930	218	583	1071	676	1050	1337	96	78	105	250
2002	8	44	50	28	132	704	219	622	1019	658	1178	1258	48	120	26	449
2003	27	50	35	62	64	721	157	733	833	602	1012	1183	65	165	30	581
2004	26	23	45	28	115	510	121	575	1233	628	932	1224	58	125	43	746
2005	31	44	92	20	178	571	113	508	1105	464	796	1437	68	95	123	794
2006	2	10	38	11	75	363	83	461	900	491	864	1472	56	212	85	452
2007	8	21	21	5	104	370	144	563	433	634	1037	745	12	79	86	318

Table 4: Revised sizes of the areas (nm^2) covered by each of the latitude/depth combination strata on the West Coast. Where differences exist, the sizes used in previous analyses are shown in brackets for comparative purposes. Note that it is only the strata between 200 and 500m that contributes towards the standardized index of abundance.

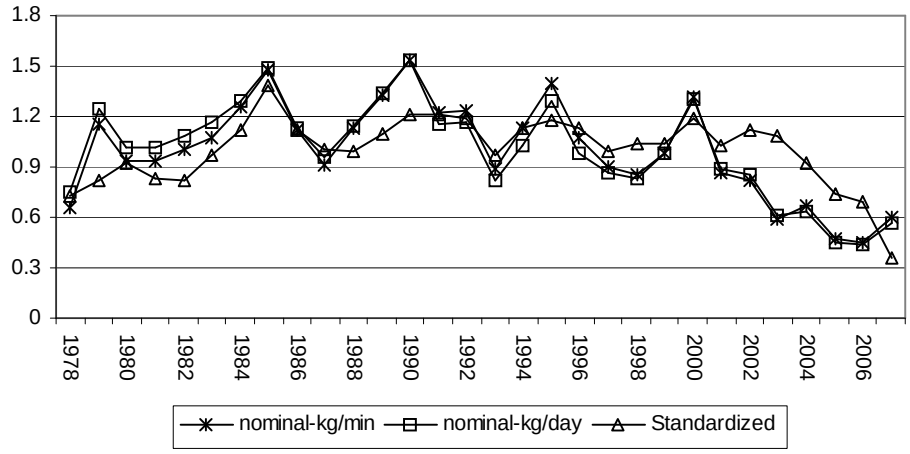
Latitude (S)	Depth (m) 0-100	101-200	201-300	301-400	401-500
≤ 31°00	906.84	6712.13	3597.79	800.68	657.12
31°00-33°00	1179.97	3383.32	2842.35	2382.84	1426.62
33°00-34°20	1052.23	993.57	882.33	458.3	500.59
>34°20	933.14	3699.07 (2869.8)	1357.2 (751.5)	726.47 (507.76)	586.17 (438.24)

Figure 1: Nominal hake CPUE for two different units of effort (kg/minute and kg/day). Each index has been normalized to its mean.



Figures 2a and b: *M. capensis* and *M. paradoxus* nominal CPUE for two different units of effort (kg/minute and kg/day). Also shown is the standardized index of abundance. Each index had been normalized to its mean.

a) *M. capensis*



b) *M. paradoxus*

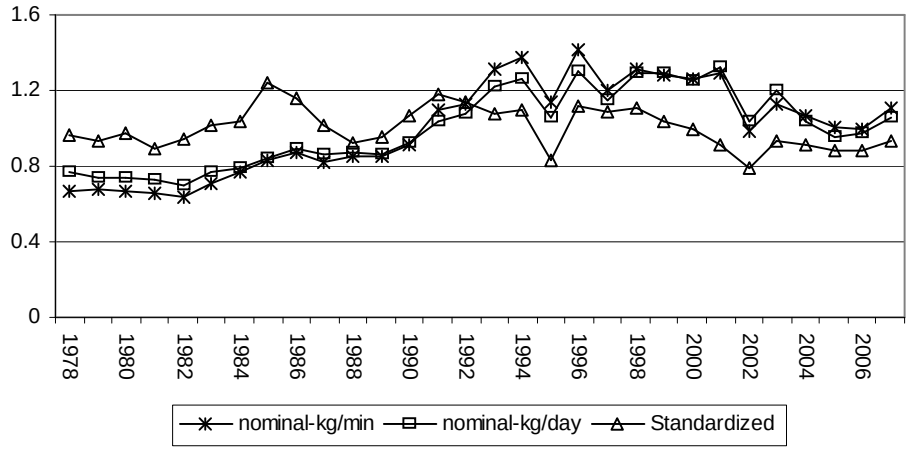


Figure 3: Area-weighted CPUE (kg/min) per stratum in 2007.

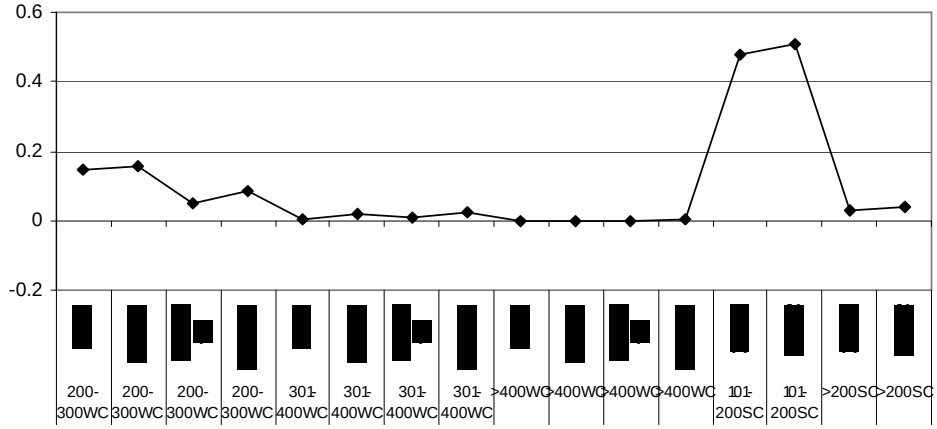


Figure 4: Nominal CPUE for (i) all strata, (ii) SC 101-200m only, and (iii) all strata, but excluding SC 101-200m.

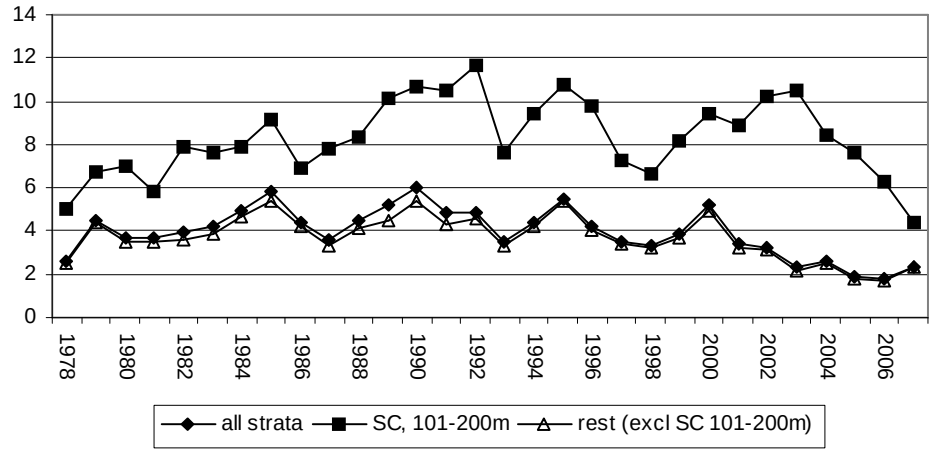
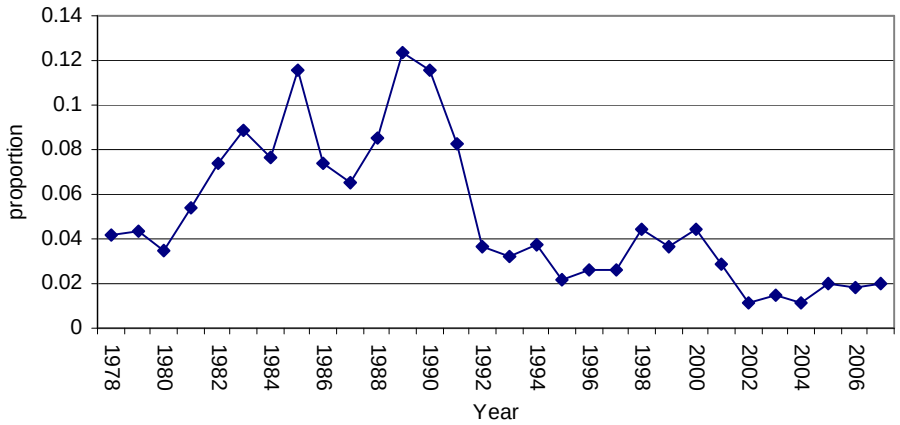
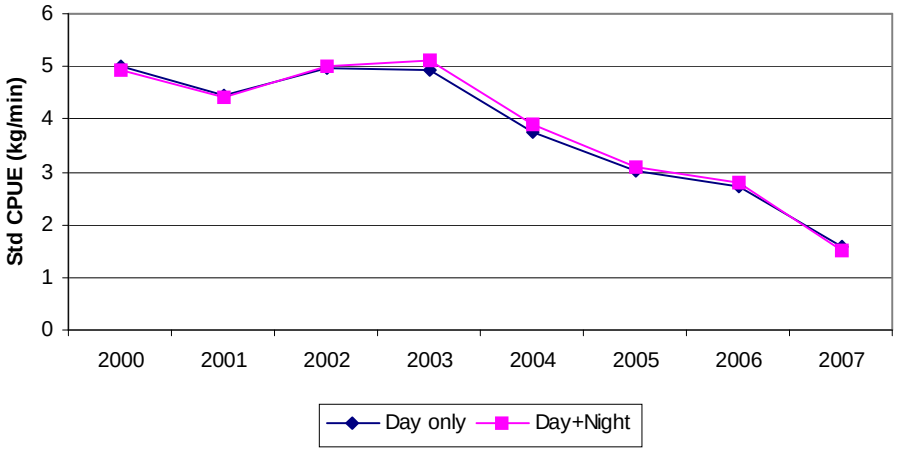


Figure 5: SC 101-200m nominal effort as a proportion of total effort.



Figures 6a and b: *M. capensis* and *M. paradoxus* standardized CPUE i) including and ii) excluding night-time trawls.

a) *M. capensis*



a) *M. paradoxus*

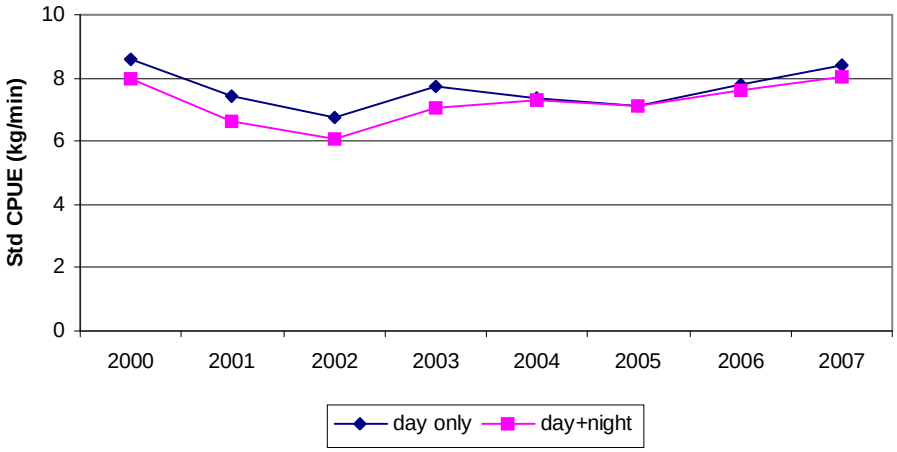
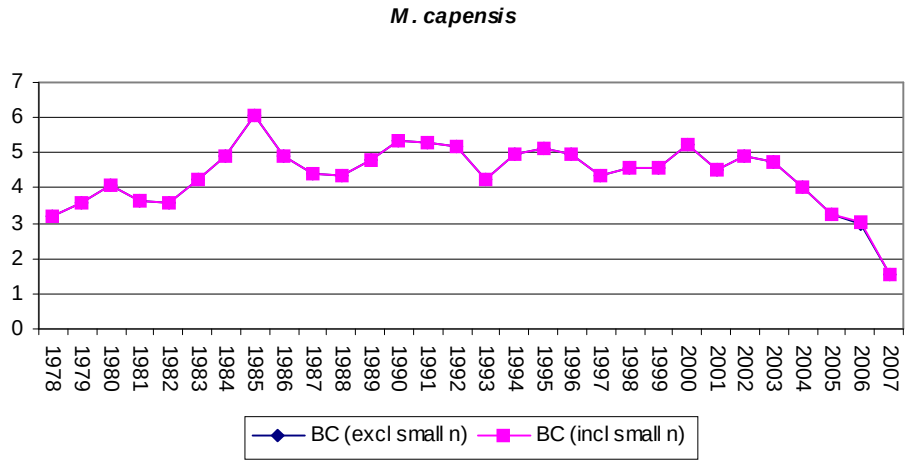


Figure 7: Standardized CPUE for *M. capensis* and *M. paradoxus* including and excluding data from year/depth/area cells where n ≤ 5.



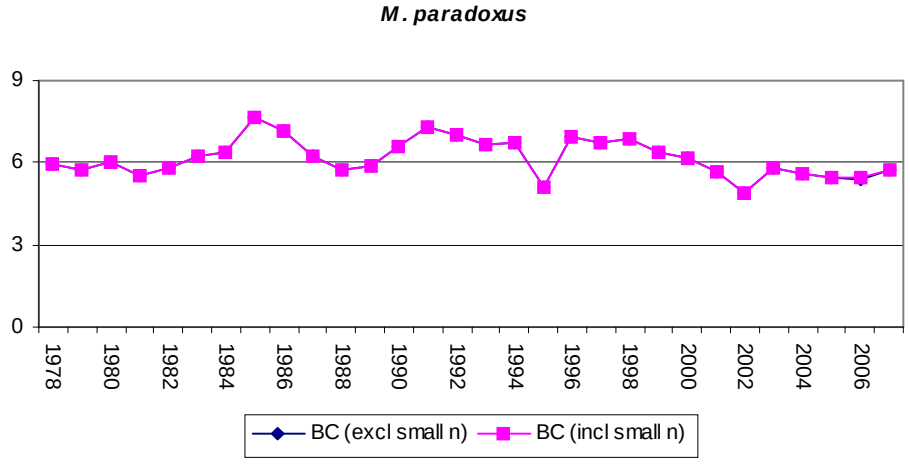


Figure 8: Standardized CPUE for *M. capensis* and *M. paradoxus* where the size of the area covered on the West Coast is between 28º30S-36º20S. The index derived from integrating over the area between 28º30S-35º20S (the base case) is shown for comparative purposes.