Results from sensitivity tests related to the models used to standardize the offshore commercial trawl CPUE data of *M. capensis* and *M. paradoxus* respectively.

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Introduction

General Linear Models (GLMs) are applied to the catch per unit effort (CPUE) data from each of the two hake stocks, *Merluccius capensis* and *M. paradoxus*, in order to derive standardized indices of abundance which are then input into the stock assessment models and the Operational Management Procedure (OMP). Since it is difficult to distinguish between the two hake species at the landing site catches are reported for both species combined. An algorithm that makes use of size and depth information is thus used to split the catches into the two species (Gaylard and Bergh, 2004). In recent years, for various reasons, a large proportion of the drag records do not have the catches reported by size rendering them unusable; hence an extensive exercise was undertaken to allow for the inclusion of these data in the analyses (Fairweather *et al*, 2009).

The results reported here are for various sensitivities related to GLM3 of Fairweather *et al* (2009). This is the version of the data that corrects for the errors encountered in the historic extracts used previously, and also includes those data that were previously excluded given that size information was not reported. A procedure was applied to interpolate the size information from data for which there is size information within a given cell which, for each year, is defined by a depth range, latitude range (for the West Coast) or longitude range (for the South Coast), and quarter (Jan-Mar, Apr-Jun, July-Sept and Oct-Dec).

The Base Case GLMs

It should be noted that the GLMs are applied to the daily catch and effort data reported for the vessels in the offshore fleet. Although provision is made for recording of catch and effort information at a drag level by the skippers, it is common practice for freezer vessels (due to the nature of the operations of those vessels) to record the effort applied per drag, but not the catch. Generally the total catch of the day is recorded against the last drag of the day. This has necessitated the accumulation of the data over a day per vessel and the application of the GLMs to these daily data (a more detailed description of the process adopted in readying the data for analyses purposes is given in Rademeyer and Glazer, 2006).

The following two models are applied to the *M. capensis* and *M. paradoxus* CPUE data respectively:

$$\begin{aligned}\ell n(\text{CPUE}_{capensis}+\delta) = {} & \alpha+\beta_{year}+\gamma_{depth}+\eta_{area}+\kappa_{seas}+\lambda_{vessel}+\nu(\text{snoek CPUE}) \\ & +\nu'(\text{snoek CPUE})^2+\varpi(\text{hmack CPUE})+\varpi'(\text{hmack CPUE})^2 \\ & +interactions+\varepsilon\end{aligned} \qquad (1)$$

$$\ell n(\text{CPUE}_{paradoxus} + \delta) = \alpha + \beta_{year} + \gamma_{depth} + \eta_{area} + \kappa_{seas} + \lambda_{vessel} + \nu(\text{snoek CPUE}) + \nu'(\text{snoek CPUE})^2 + \varpi(\text{hmack CPUE}) + \varpi'(\text{hmack CPUE})^2 + interactions + \varepsilon \quad (2)$$

(Note: to avoid clutter, the subscripts "*capensis*" and "*paradoxus*" for the parameters of equations 1 and 2 have been omitted)

where: $\text{CPUE}_{capensis}$ is the catch of *M. capensis* per unit of (hake-directed) effort,

$\text{CPUE}_{paradoxus}$ is the catch of *M. paradoxus* per unit of (hake-directed) effort,

α is the intercept,

year is a factor with 31 levels (1978-2008) associated with the year effect,

depth is a factor with 8 levels in both the *M. capensis* and *M. paradoxus* models:

$d1_{wc}$: 0 - 100m
$d2_{wc}$: 101 - 200m
$d3_{wc}$: 201 – 300m
$d4_{wc}$: 301 – 400m
$d5_{wc}$: > 400m
$d6_{sc}$: 0 - 100m
$d7_{sc}$:101 - 200m
$d8_{sc}$: > 200m

area is a factor with 6 levels in both the *M. capensis* and *M. paradoxus* models*:*

$a1_{wc}$: ≤ 31º00S
$a2_{wc}$: 31º00S - 33º00S
$a3_{wc}$: 33º00S - 34º20S
$a4_{wc}$: > 34º20S
$a5_{sc}$: < 22º00E
$a6_{sc}$: ≥ 22º00E,

seas is a factor with 4 levels in both the *M. capensis* and *M. paradoxus* models:

Summer: December - February
Autumn: March - May
Winter: June - August
Spring: September - November,

vessel is a factor associated with each individual vessel in the dataset being analyzed (note that for the same vessel, different values of this factor may be estimated for *M. capensis* and *M. paradoxus*),

snoek CPUE and hmack CPUE refer to the CPUE of the bycatch species snoek and horse-mackerel respectively,

interactions refer to *year*×*depth*, *year*×*area* and *depth*×*area* interactions which allow for spatial density patterns which have changed over time, and

ε is the error term, assumed to follow a normal distribution.

δ is a (usually small) constant added to the CPUE of the species being modelled to allow for the occurrence of zero CPUE values - here δ is taken to be 10% of the average CPUE of the species being modelled in the respective datasets.

Standardizing the CPUE

The introduction of interactions with year requires that the standardized CPUE (assumed to provide an index of local density) be integrated over area to determine an index of abundance. The area sizes for depth/latitude (West Coast) and depth/longitude (South Coast) combinations are shown in Tables 1 and 2.

The formula applied to standardize the CPUE for *M. capensis* and *M. paradoxus* respectively is therefore:

$$CPUE_y = \sum_{strata}[e^{\{\alpha+\beta_{year}+\gamma_{depth}+\eta_{area}+\text{autumn}+\text{median vessel estimate}+\nu(\text{snoek }\overline{CPUE})+\nu'(\text{snoek }CPUE^2)+\varpi(\text{hmack }\overline{CPUE})+\varpi'(\text{hmack }CPUE^2)+\text{interactions}\}} - \delta] * \frac{A_{stratum}}{A_{total}} \quad (3)$$

where $A_{stratum}$ is the size of the area of the stratum in nm^2 (e.g. depth 200-300m and latitude 31 - 33º), and
A_{total} is the total size of the area considered (it is not strictly necessary to divide by A_{total}, but this keeps the units and size of the standardised CPUE index comparable with those of the basic CPUE data).

Empty cells exist because no fishing took place in the 0 - 100m depth zone in certain years on the West Coast. Consequently, the standardised CPUE is calculated for depths >200m. The rationale behind this is that although the area from 0 - 200m makes up a substantial portion (54%) of that below 500m, very little fishing (some 2% of the hauls) takes place at depths below 200m. The majority of hauls within the 0 - 200m depth range occur very close to the 200m depth contour, and accordingly are of questionable representativeness of densities within the whole depth-latitude stratum to which the above equation would take them to refer. Similarly empty cells exist on the South Coast

because no fishing took place in the 0 - 100m depth zone in certain years. Consequently the standardized CPUE for the South Coast is calculated for depths > 100m only.

Sensitivity tests

The following sensitivity tests were conducted for the Base Case models described in equations 1 and 2 above:

- Exclude the most northern area of the West Coast (<31ºS) from the standardization calculation given that in recent years very little fishing has taken place in that particular area, and this trend is expected to continue in the future.

- Omit days where *M. paradoxus* nominal CPUE is zero in the *M. paradoxus* model, and similarly omit days where *M. capensis* nominal CPUE is zero in the *M. capensis* model. This means that the addition of a small constant δ to the CPUE to allow for zero CPUE (in the context of a log-normal model) is no longer required.

- Assume δ to be 20% of the average CPUE for each species respectively, and not 10% of the average CPUE as assumed for the Base Case.

- Include all offshore companies in the GLMs, and not only the select set operating since 1994 that has been included to date.

- Include the effort associated with a drag as a covariate in the model.

Species and coast specific standardized CPUE indices

The assessment model for the hake resource requires that the data be split by species and coast. The models described in equations (1) and (2) of this paper are for species-specific, coast-combined indices. The indices were thus split by coast by simply adding up the West Coast component of the standardized CPUE values (defined by depth and lat) and the SC components of the standardized CPUE values (defined by depth and long) for each year. This implies that for each species the sum of the West and South Coast components will equal the coast-combined index. The resulting standardized indices are shown in Table 3.

Sensitivity test results

Table 4 indicates the sample sizes per year, depth and area for the Base Case. It is clear that very little fishing has taken place in the most northerly area (<31ºS) on the West Coast in most depth strata in recent years. The data from this particular area will still be included in the GLMs, but not in the calculation to derive the standardized index (equation 3 above). The exclusion of this area from the standardization calculation implies that the area size integrated over is reduced by 5055.59 nm^2. Table 5 shows the proportion contribution that each depth/lat(or long) cell makes to the final index both including and excluding the most northerly area on the West Coast.

Figures 1 and 2 plot the standardized CPUE indices for *M. capensis* and *M. paradoxus* respectively where the <31ºS area has been excluded from the standardization calculation. The indices derived from the Base Case (i.e. including the <31ºS area) are shown for comparative purposes and indicate very little difference in trends.

Figures 3 and 4 plot the standardized CPUE indices for the models that exclude records with zero CPUE (and hence the need for adding a small constant, δ, to allow for zero CPUE values). The indices derived from the Base Case are shown for comparative purposes. Figures 5 and 6 plot the standardized CPUE indices for the models that assume δ equal to 20% of the average CPUE for the respective species. The indices derived from the Base Case, which assumes delta to be equal to 10% of the average CPUE, are shown for comparative purposes and indicate very little difference in trends.

Figures 7 and 8 plot the standardized CPUE indices derived from including all offshore companies in the analyses. It was only possible to include the additional offshore companies for the years 2000-2008, but it is only since long term rights allocations that there has been a marked increase in the number of companies in the fishery in any case, so that this should not have much of an impact on the pre-2000 data. The inclusion of the additional companies increases the number of vessels included in the GLM from 171 to 188.

The sample sizes of the year/depth/lat (or long) strata when including all offshore companies are shown in Table 6, and indicate that the sample sizes of the data available from the most northern West Coast area increases when the additional offshore companies are included.

The inclusion of effort as a covariate in the model was achieved by defining discrete intervals of effort in units of 180 minutes, and including those as explanatory variables in the respective models. The median parameter estimate of those covariates was then used in the standardization calculation (equation (3)). The resulting indices are shown in Figures 9 and 10 and indicate no difference in trend when compared to the Base Case models.

References

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Table 1: The sizes of the areas (nm^2) covered by each of the latitude/depth combination strata on the West Coast that are included in the standardization calculation. Also shown in brackets is the percentage contribution of each stratum to the total area (i.e. West +South Coast).

	Depth (m)		
Latitude (S)	201-300	301-400	401-500
≤ 31^O00	3598 (10.3)	801 (2.3)	657 (1.9)
31^O00-33^O00	2842 (8.1)	2383 (6.8)	1427 (4.1)
33^O00-34^O20	882 (2.5)	458 (1.3)	501 (1.4)
>34^O20	1357 (3.9)	726 (2.1)	586 (1.7)

Table 2: The sizes of the areas (nm^2) covered by each of the longitude/depth combinations on the South Coast that are included in the standardization calculation. Also shown in brackets is the percentage contribution of each stratum to the total area (i.e. West +South Coast).

	Depth (m)	
Longitude (E)	101 - 200	201 - 500
< 22º	6911 (19.8)	839 (2.4)
≥ 22º	8470 (24.2)	2535 (7.2)

Table 3: Species- and coast-specific standardized CPUE (kg/min). The coast-combined indices are also reported for each species.

	M. capensis		
Year	Coast combined	WC	SC
1978	2.983	0.758	2.225
1979	3.391	1.224	2.167
1980	3.777	1.063	2.714
1981	3.398	1.057	2.341
1982	3.355	0.938	2.416
1983	4.017	1.248	2.770
1984	4.617	1.338	3.278
1985	5.673	1.597	4.077
1986	4.537	1.196	3.341
1987	4.053	1.007	3.045
1988	4.051	0.841	3.210
1989	4.486	0.996	3.490
1990	5.098	1.100	3.998
1991	4.949	1.077	3.871
1992	4.890	1.394	3.497
1993	3.941	1.291	2.650
1994	4.593	1.409	3.185
1995	4.880	1.783	3.096
1996	4.607	1.524	3.083
1997	3.982	1.506	2.476
1998	4.250	1.727	2.523
1999	4.331	1.537	2.794
2000	4.377	1.501	2.876
2001	3.235	1.111	2.124
2002	3.639	1.118	2.522
2003	3.809	0.806	3.003
2004	3.407	0.795	2.612
2005	2.149	0.558	1.590
2006	1.873	0.513	1.360
2007	1.544	0.535	1.008
2008	2.216	0.703	1.513

	M. paradoxus		
Year	Coast combined	WC	SC
1978	5.057	4.181	0.876
1979	4.941	4.113	0.828
1980	5.130	3.849	1.281
1981	4.660	3.852	0.808
1982	4.916	3.785	1.131
1983	5.295	4.050	1.245
1984	5.459	4.139	1.319
1985	6.533	4.696	1.837
1986	6.086	4.255	1.831
1987	5.258	3.561	1.697
1988	4.940	3.604	1.336
1989	5.147	3.786	1.361
1990	5.821	3.753	2.068
1991	6.372	4.402	1.971
1992	6.095	3.708	2.387
1993	5.726	3.855	1.872
1994	5.929	4.302	1.627
1995	4.532	3.408	1.124
1996	6.019	4.311	1.708
1997	5.571	3.569	2.002
1998	5.873	4.072	1.801
1999	5.390	3.320	2.070
2000	4.310	2.906	1.404
2001	3.868	2.344	1.524
2002	3.546	2.241	1.305
2003	4.487	2.924	1.563
2004	3.668	2.339	1.329
2005	3.295	2.178	1.117
2006	3.535	2.412	1.123
2007	4.206	2.743	1.464
2008	5.406	3.160	2.246

Table 4: Sample sizes per year, depth and Area cells on the West Coast derived from the data included in the Base Case. The shaded cells represent cells where the sample size was ≤ 5, hence resulting in those data being excluded from the GLM.

	WC 0-100m				WC 101-200m				WC 201-300m				WC 301-400m				WC >400m			
year	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S
1978				10		64	71	363	51	347	738	2275	240	1364	1465	651	83	1364	696	75
1979				16	6	20	85	816	90	450	782	3574	272	876	1536	545	122	1224	760	54
1980					6	137	176	839	61	729	885	3359	311	1673	1631	1037	145	1495	984	172
1981				35	54	118	101	712	119	731	1106	2905	360	1892	1971	858	74	887	711	136
1982				16	49	50	74	555	129	583	1195	3010	255	1163	1261	1162	54	963	1001	268
1983				10	65	32	23	485	178	518	672	2214	155	1087	1143	829	66	1087	711	260
1984	11			8	14	102	62	506	190	566	653	2463	152	795	1226	1106	73	1019	1198	282
1985					28	8	13	341	169	224	351	2279	220	763	1442	1184	75	591	835	182
1986					12	20	43	307	239	198	789	1991	113	643	1669	1587	78	1155	740	413
1987				8			23	256	324	479	1156	1902	227	1000	1486	892	136	1453	1475	186
1988					10		47	268	282	267	1398	2322	372	527	1807	1266	70	706	554	345
1989					8	6	40	467	560	322	906	2097	256	487	1486	1076	92	762	1065	157
1990					8		38	350	445	103	468	2219	158	244	1458	1019	36	818	1255	171
1991							6	184	92	59	389	1956	141	468	1384	1389	167	1471	1341	283
1992							8	103	209	25	313	1881	165	279	1427	1458	212	1616	1006	326
1993							14	96	369	51	328	1270	161	385	1297	860	413	1805	2032	559
1994							19	84	133	94	368	1509	76	238	1383	973	224	861	2182	585
1995							10	35	76	22	455	1678	58	231	1355	1937	40	960	2007	922
1996							6	69	55	39	241	1537	35	368	1036	2021	59	1261	1582	1055
1997							44	26	75	28	403	1029	74	238	1254	1880	130	1171	1755	1505
1998							55	82	88	100	628	843	65	233	1128	1151	81	1335	1949	1330
1999							64	42	29	81	446	770	33	337	977	1168	80	984	1407	1205
2000							63	37	31	75	531	1009	26	134	872	1158	108	997	1206	1308
2001							75	20	17	31	290	951	25	99	654	1214	92	1044	1529	1798
2002							85	20	8	30	271	875	44	154	721	1293	71	951	1646	1832
2003							68	24	29	63	191	754	88	75	851	1219	51	913	1339	1674
2004							48	43	37	37	148	818	44	129	678	1149	68	623	1488	1444
2005			12	11			34	28	48	21	131	525	98	212	552	865	85	853	1282	1599
2006			14	10			25	141	28	20	116	789	91	146	609	1084	59	661	1086	1623
2007			13	19			29	130	15	10	249	1046	59	161	738	1200	46	708	593	1003
2008							33	78	83	11	224	532	112	54	524	1050	62	344	783	989

Table 4 continued: Sample sizes per year, depth and Area cells on the South Coast derived from the data included in the Base Case. The shaded cells represent cells where the sample size was ≤ 5, hence resulting in those data being excluded from the GLM.

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year	SC 0-100m <22°E	SC 0-100m GE 22°E	SC 101-200m <22°E	SC 101-200m GE 22°E	SC >200m <22°E	SC >200m GE 22°E
1978	22		330	75	75	395
1979	14	24	335	162	58	405
1980	13		423	26	46	259
1981	59	34	552	119	35	210
1982	41	45	713	197	45	415
1983	13	35	630	314	37	610
1984	44	20	540	259	53	538
1985	13	25	613	465	51	922
1986	26	17	417	363	19	790
1987	13	8	433	312	57	654
1988			559	362	90	570
1989			864	414	119	488
1990			544	501	44	605
1991			514	298	42	914
1992			162	207	54	1039
1993			81	222	45	747
1994			143	156	90	574
1995			88	112	113	386
1996			149	119	62	786
1997			46	282	90	1234
1998			161	322	71	807
1999			58	316	65	953
2000			99	437	80	976
2001			243	426	100	1158
2002			100	214	159	1213
2003			255	126	167	1150
2004			103	86	162	1328
2005			74	127	115	1014
2006			78	146	245	745
2007			25	165	95	522
2008			15	59	53	325

Table 5: The proportional contribution that each depth/lat and depth/long cell makes to the standardized CPUE index, where the most northerly area on the West Coast is either included or excluded from the standardization calculation.

Depth	lat/long	incl <31°S	excl <31°S
WC: 201-300m	<31°S	0.103	
	31-33°S	0.081	0.095
	33-34°20S	0.025	0.029
	>34°20S	0.039	0.045
WC: 301-400m	<31°S	0.023	
	31-33°S	0.068	0.080
	33-34°20S	0.013	0.015
	>34°20S	0.021	0.024
WC: >400m	<31°S	0.019	
	31-33°S	0.041	0.048
	33-34°20S	0.014	0.017
	>34°20S	0.017	0.020
SC: 101-200m	<22°E	0.198	0.231
	GE 22°E	0.242	0.283
SC: >200m	<22°E	0.024	0.028
	GE 22°E	0.072	0.085

Table 6: Sample sizes per year, depth and Area cells on the West Coast derived from the data incorporating all offshore companies. The shaded cells represent cells where the sample size was ≤ 5, hence resulting in those data being excluded from the GLM.

	WC 0-100m				WC 101-200m				WC 201-300m				WC 301-400m				WC >400m			
year	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S	<=31°S	31-33°S	33-34°20S	>34°20S
1978				10		64	71	363	51	347	738	2275	240	1364	1465	651	83	1364	696	75
1979				16	6	20	85	816	90	450	782	3574	272	876	1536	545	122	1224	760	54
1980					6	137	176	839	61	729	885	3359	311	1673	1631	1037	145	1495	984	172
1981				35	54	118	101	712	119	731	1106	2905	360	1892	1971	858	74	887	711	136
1982				16	49	50	74	555	129	583	1195	3010	255	1163	1261	1162	54	963	1001	268
1983				10	65	32	23	485	178	518	672	2214	155	1087	1143	829	66	1087	711	260
1984	11			8	14	102	62	506	190	566	653	2463	152	795	1226	1106	73	1019	1198	282
1985					28	8	13	341	169	224	351	2279	220	763	1442	1184	75	591	835	182
1986					12	20	43	307	239	198	789	1991	113	643	1669	1587	78	1155	740	413
1987				8			23	256	324	479	1156	1902	227	1000	1486	892	136	1453	1475	186
1988					10		47	268	282	267	1398	2322	372	527	1807	1266	70	706	554	345
1989					8	6	40	467	560	322	906	2097	256	487	1486	1076	92	762	1065	157
1990					8		38	350	445	103	468	2219	158	244	1458	1019	36	818	1255	171
1991							6	184	92	59	389	1956	141	468	1384	1389	167	1471	1341	283
1992							8	103	209	25	313	1881	165	279	1427	1458	212	1616	1006	326
1993							14	96	369	51	328	1270	161	385	1297	860	413	1805	2032	559
1994							19	84	133	94	368	1509	76	238	1383	973	224	861	2182	585
1995							10	35	76	22	455	1678	58	231	1355	1937	40	960	2007	922
1996							6	69	55	39	241	1537	35	368	1036	2021	59	1261	1582	1055
1997							44	26	75	28	403	1029	74	238	1254	1880	130	1171	1755	1505
1998							55	82	88	100	628	843	65	233	1128	1151	81	1335	1949	1330
1999							64	42	29	81	446	770	33	337	977	1168	80	984	1407	1205
2000							65	39	39	80	568	1070	33	141	954	1200	144	1108	1266	1335
2001						11	77	20	26	34	384	1073	109	133	697	1309	172	1291	1576	1835
2002							88	21	14	34	342	1060	69	224	817	1381	130	1398	1840	1869
2003		7					71	31	29	83	279	1085	130	155	989	1460	110	1561	1654	1868
2004				10	7		54	84	65	52	216	1335	97	204	855	1441	304	1291	2061	1731
2005			14	15	10		38	52	199	60	253	1036	287	278	766	1312	356	1480	1936	2125
2006			16	10			30	274	61	35	142	1401	194	214	741	1554	169	1380	1666	2156
2007			14	19			30	245	41	15	412	1889	101	238	1018	1673	116	1364	1160	1409
2008							37	185	110	14	411	1031	193	119	812	1463	141	737	1140	1220

Table 6 continued: Sample sizes per year, depth and Area cells on the South Coast derived from the data incorporating all offshore companies. The shaded cells represent cells where the sample size was ≤ 5, hence resulting in those data being excluded from the GLM.

	SC 0-100m		SC 101-200m		SC >200m	
year	<22°E	GE 22°E	<22°E	GE 22°E	<22°E	GE 22°E
1978	22		330	75	75	395
1979	14	24	335	162	58	405
1980	13		423	26	46	259
1981	59	34	552	119	35	210
1982	41	45	713	197	45	415
1983	13	35	630	314	37	610
1984	44	20	540	259	53	538
1985	13	25	613	465	51	922
1986	26	17	417	363	19	790
1987	13	8	433	312	57	654
1988			559	362	90	570
1989			864	414	119	488
1990			544	501	44	605
1991			514	298	42	914
1992			162	207	54	1039
1993			81	222	45	747
1994			143	156	90	574
1995			88	112	113	386
1996			149	119	62	786
1997			46	282	90	1234
1998			161	322	71	807
1999			58	316	65	953
2000			99	437	83	995
2001			255	458	103	1293
2002			129	291	173	1360
2003			371	290	240	1736
2004		9	170	348	230	2300
2005	10	19	366	345	155	2043
2006	13	14	222	372	397	1586
2007		10	127	231	193	1045
2008		34	151	244	75	752

Figure 1: Standardized *M. capensis* CPUE including and excluding the Area <31ºS on the West Coast from the standardization calculation. Also shown is the Base Case index that includes this Area for comparative purposes. Each index has been normalized to its mean.

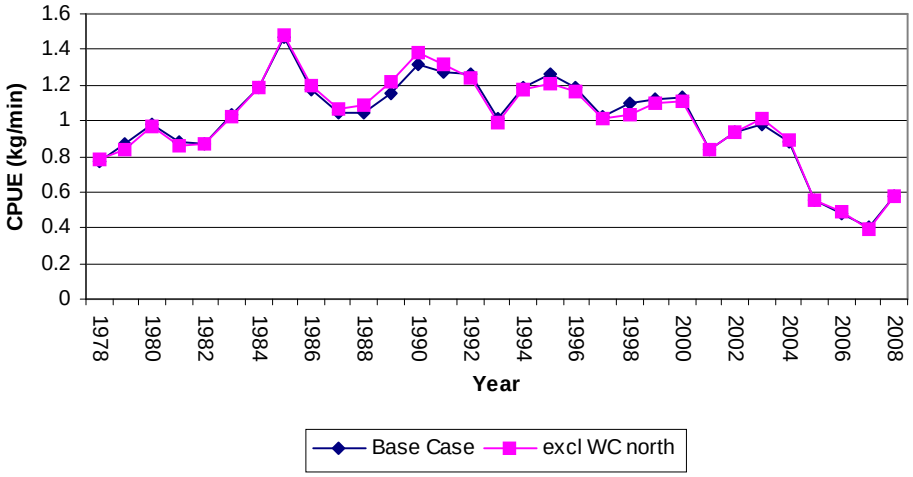

Figure 2: Standardized *M. paradoxus* CPUE including and excluding the Area <31ºS on the West Coast from the standardization calculation. Also shown is the Base Case index that includes this Area for comparative purposes. Each index has been normalized to its mean.

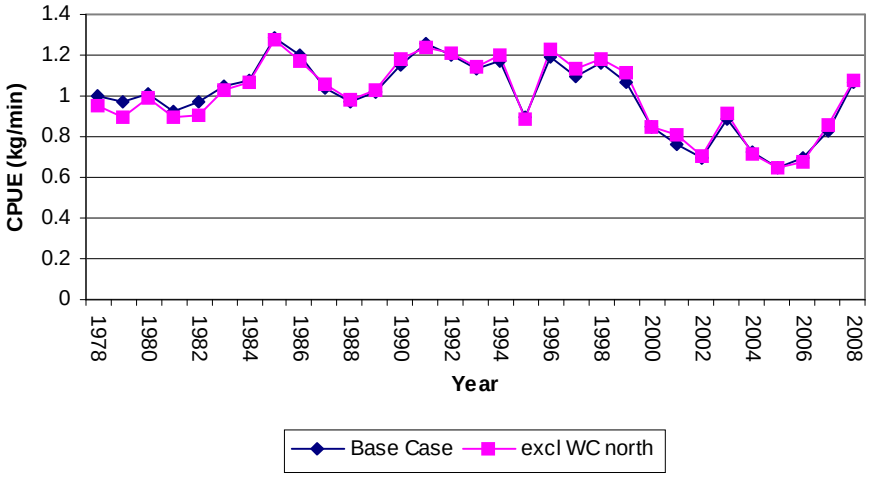

Figure 3: Standardized *M. capensis* CPUE where records with zero CPUE have been excluded from the analyses. The need to add a small constant to the CPUE to allow for zeros is therefore no longer necessary. Also shown is the Base Case index for comparative purposes. Each index has been normalized to its mean.

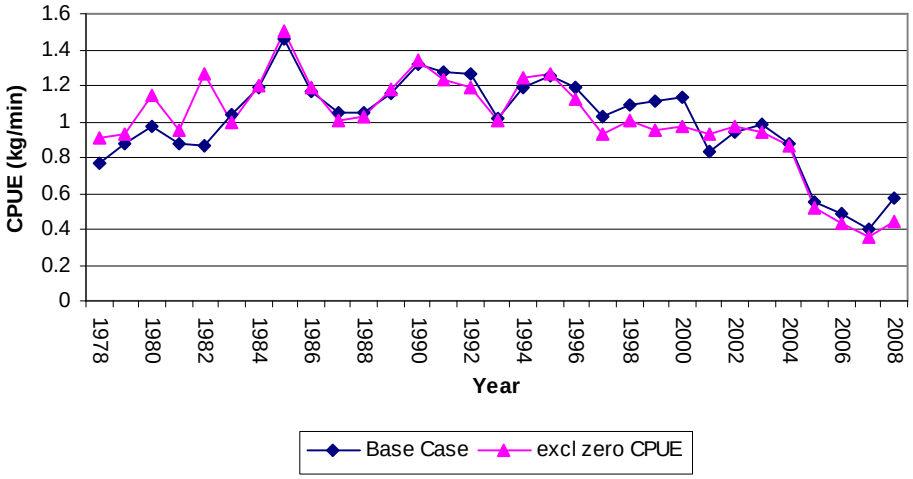

Figure 4: Standardized *M. paradoxus* CPUE where records with zero CPUE have been excluded from the analyses. The need to add a small constant to the CPUE to allow for zeros is therefore no longer necessary. Also shown is the Base Case index for comparative purposes. Each index has been normalized to its mean.

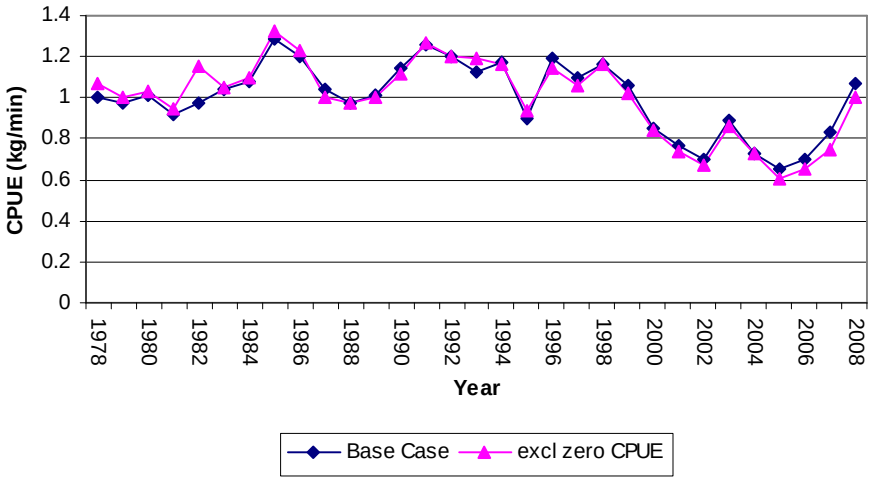

Figure 5: Standardized *M. capensis* CPUE, where δ is assumed to be 20% of the average *M. capensis* CPUE. Also shown is the Base Case index (which assumes δ to be 10% of the average *M. capensis* CPUE) for comparative purposes. Each index has been normalized to its mean.

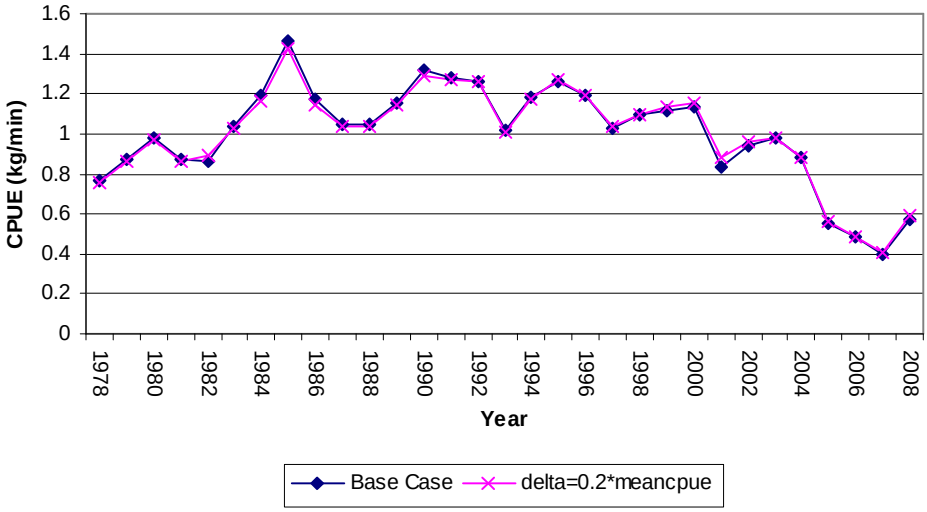

Figure 6: Standardized *M. paradoxus* CPUE, where δ is assumed to be 20% of the average *M. capensis* CPUE. Also shown is the Base Case index (which assumes δ to be 10% of the average *M. capensis* CPUE) for comparative purposes. Each index has been normalized to its mean.

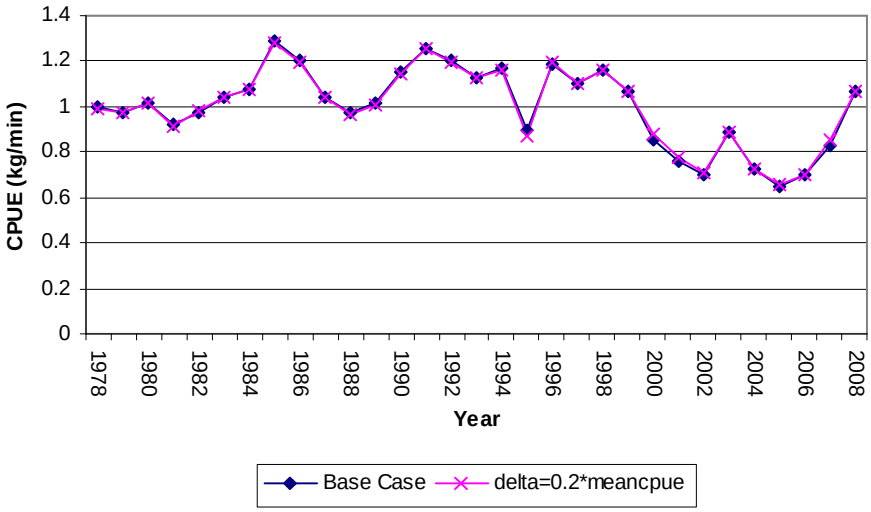

Figure 7: Standardized *M. capensis* CPUE, where data from all offshore companies are included in the GLM. Also shown is the Base Case index (which includes only a select set of offshore companies) for comparative purposes. Each index has been normalized to its mean.

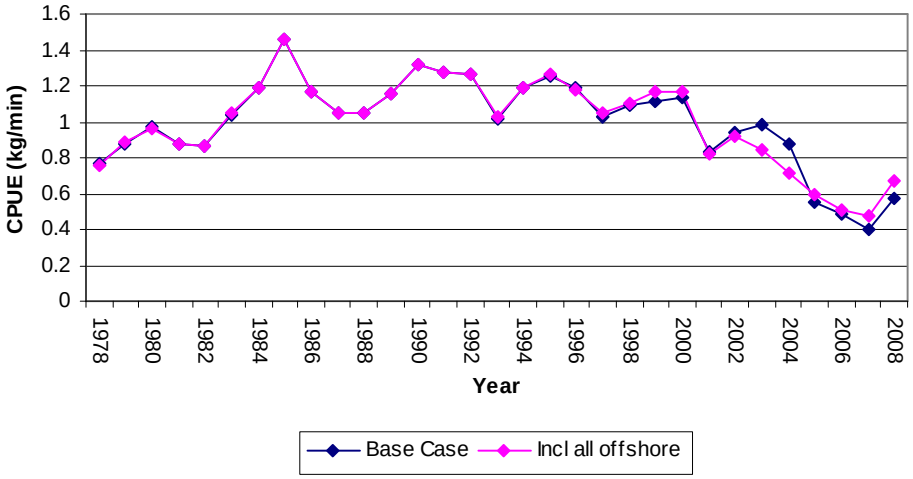

Figure 8: Standardized *M. paradoxus* CPUE, where data from all offshore companies are included in the GLM. Also shown is the Base Case index (which includes only a select set of offshore companies) for comparative purposes. Each index has been normalized to its mean.

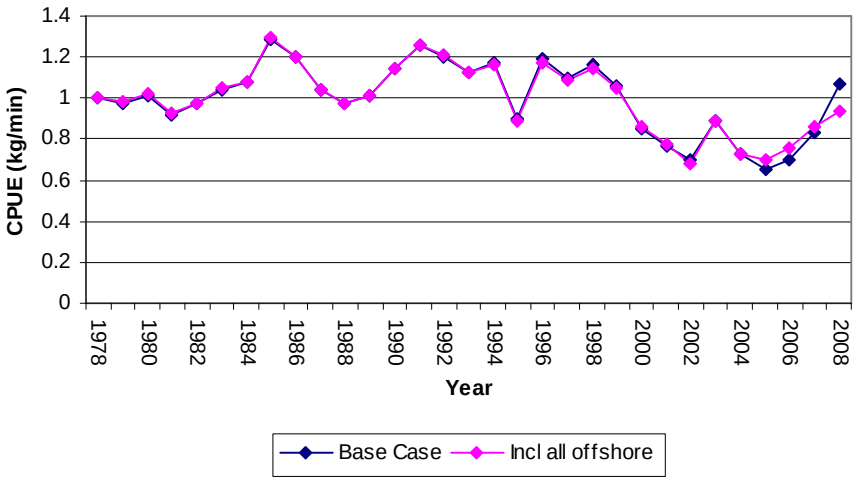

Figure 9: Standardized *M. capensis* CPUE, where effort is included as an explanatory variable in the model. Also shown is the Base Case index for comparative purposes. Each index has been normalized to its mean.

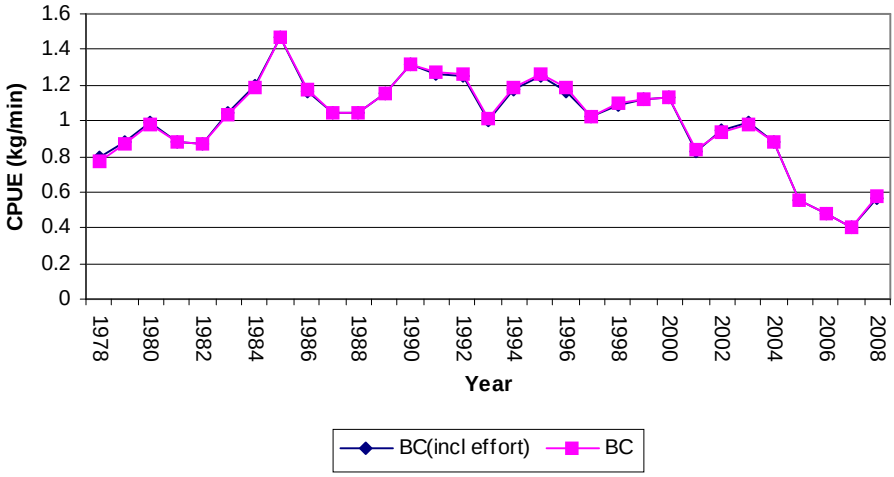

Figure 10: Standardized *M. paradoxus* CPUE, where effort is included as an explanatory variable in the model. Also shown is the Base Case index for comparative purposes. Each index has been normalized to its mean.