Preliminary results from a GLM standardised CPUE series for the South Coast midwater horse mackerel fishery

L.B. Furman and D.S. Butterworth

MARAM,
Department of Mathematics and Applied Mathematics,
University of Cape Town
Rondebosch, 7701

Introduction

This paper provides results for a preliminary GLM standardisation analysis of the CPUE data for the South African horse mackerel (*Trachurus trachurus capensis*) midwater fishery from commercial trawl data. The series is to be used as part of an updated horse mackerel assessment.

The data, provided by Jan van der Westhuizen (pers. commn), cover a variety of vessels and fisheries. However, the *Desert Diamond* accounted for the vast majority (81 percent) of the horse mackerel caught. Therefore, this GLM uses only data recorded by the *Desert Diamond*, a midwater trawl vessel, which covers the years 2003-2010.

Method

To provide insight into the relationship between CPUE and each effect considered, the mean marginal CPUE is calculated at different levels of each effect and plotted (Fig. 1 a-h). The plots suggest that there is a linear relationship between CPUE and depth (Fig. 1 f), wind speed (Fig. 1 g) and the percentage of the moon visible (Fig. 1 h); therefore, these effects are treated as continuous explanatory variables. The other effects are not simply related to CPUE, so their ranges are split into intervals where necessary to reflect changes and they are treated as categorical variables.

The GLM assumes that:

$$\log(\mathrm{CPUE}+\delta) = b_1 \times \mathrm{depth} + b_2 \times \mathrm{wind\_speed} + b_3 \times \mathrm{lunar\_phase} + \mathrm{year} + \mathrm{month} + \mathrm{time} + \mathrm{longitude} + \mathrm{wind\_dir} + \mathrm{constant}$$

where:

CPUE is the catch per unit effort for the trawl:

$$\mathrm{CPUE} = \mathrm{catch}/(\mathrm{trawl\_time} \times \mathrm{trawl\_speed} \times \mathrm{vertical\_opening}),$$

where catch is the mass of the horse mackerel caught, trawl_time is the duration of the trawl, trawl_speed is the speed of the vessel during the

	trawl and $\mathrm{vertical\_opening}$ refers to the size of the opening of the trawl net;
δ	is equal to $0.05 \times \overline{\mathrm{CPUE}}$ and is added to CPUE to avoid the problem of taking the logarithm of zero when no horse mackerel catch is reported;
b_1	is the regression coefficient associated with depth;
b_2	is the regression coefficient associated with $\mathrm{wind\_speed}$;
b_3	is the regression coefficient associated with $\mathrm{lunar\_phase}$;
depth	is the depth of the trawl;
$\mathrm{wind\_speed}$	is the wind speed during the trawl in Beaufort, as estimated by an onboard observer;
$\mathrm{lunar\_phase}$	is the percentage of the moon that is lighted during the trawl;
year	is the year in which the trawl took place;
month	is the month in which the trawl took place;
time	is the time of day midway through the trawl;
$\mathrm{longitude}$	is the average of the starting longitude and ending longitude of the trawl;
$\mathrm{wind\_dir}$	is the wind direction during the trawl; and
$\mathrm{constant}$	is the regression constant.

Table 1 summarises the treatment of each effect.

Results

The model used in the GLM was able to account for 21.6 percent of the variation of CPUE about its mean. Table 1 gives the estimated slope parameters (b_1, b_2 and b_3) for the continuous variables and the estimated effect size for the categorical variables, as well their associated standard errors. Figure 1 (a-h) show comparisons between mean marginal CPUE and mean GLM standardised CPUE for each effect. A standardised CPUE series is produced by setting all effects in the GLM, apart from effect of interest, to a constant reference level. Thus, as the effect of interest is varied, all changes to the CPUE are attributable to that effect. Note that marginal and standardised results can differ because of the impacts of other effects. Figure 2 shows diagnostic plots of the standardised residuals.

Discussion

Upward trends in both the marginal CPUE and GLM standardised CPUE (Fig. 1 a) are encouraging and consistent with abundance estimates from demersal surveys, which indicate a recent increase in exploitable biomass. Furthermore, the absence of a systematic pattern in the residuals and the close match to a normal distribution provides support for the model used (Fig. 3).

Demersal surveys do not reflect the pattern in trawling locations that is clear from the trawling data (Fig. 3). The *Desert Diamond* is heavily targeting two regions, both around 200m depth, one offshore of Mossel Bay and the other offshore of Port Elizabeth, but it is not trawling the region in between, offshore of Tsitsikamma. However, demersal surveys do not indicate higher horse mackerel CPUEs in the heavily fished regions or lower CPUEs off Tsitsikamma, as might be expected from the commercial data. In fact, the demersal surveys are unable to trawl in the region at about 200m offshore of Mossel Bay. Therefore, it is unclear at this stage why the disparity between commercial and survey data exists, and also why there is a strong preference for fishing in the areas offshore of Port Elizabeth and Mossel Bay.

Type	Effect	Level	Estimate	Standard error	Significant
continuous	depth	-	-0.00046	0.000233	*
	wind speed		0.0257	0.0124	*
	% moon visible		-0.1481	0.0488	*
categorical	year	2003	0	-	-
		2004	-0.1743	0.0929	
		2005	0.1349	0.0936	
		2006	0.2419	0.0964	*
		2007	0.549	0.0948	*
		2008	0.2342	0.0957	*
		2009	0.362	0.0967	*
		2010	0.4942	0.0975	*
	month	Jan	0	-	-
		Feb	0.1739	0.0877	*
		Mar	0.0878	0.0838	
		Apr	-0.0067	0.0849	
		May-Sep	-0.2705	0.0692	*
		Oct	-0.0487	0.0866	
		Nov	0.1417	0.0837	
		Dec	0.2399	0.0826	*
	time of day	00:00-01:00	0	-	-
		01:00-02:00	-0.19	0.101	
		02:00-03:00	-0.3772	0.0949	*
		03:00-12:00	-0.686	0.0755	*
		12:00-13:00	-0.553	0.188	*
		13:00-14:00	-0.598	0.196	*
		14:00-15:00	-0.384	0.194	*
		15:00-16:00	-0.272	0.222	
		16:00-17:00	-0.14	0.197	
		17:00-18:00	-0.022	0.222	
		18:00-19:00	0.783	0.16	*
		19:00-20:00	0.5332	0.0939	*
		20:00-21:00	0.3172	0.0849	*
		21:00-22:00	0.022	0.0879	
		22:00-23:00	-0.117	0.0975	
		23:00-24:00	0.026	0.101	
	longitude	west of 23.4°E	0	-	-
		east of 23.4°E	-0.1379	0.0435	*
	wind direction	45°-225°	0	-	-
		225°-45°	-0.0876	0.0355	*

Table 1: Summary of effects included in the model and results. Effects significant at the 5% level are shown by *.

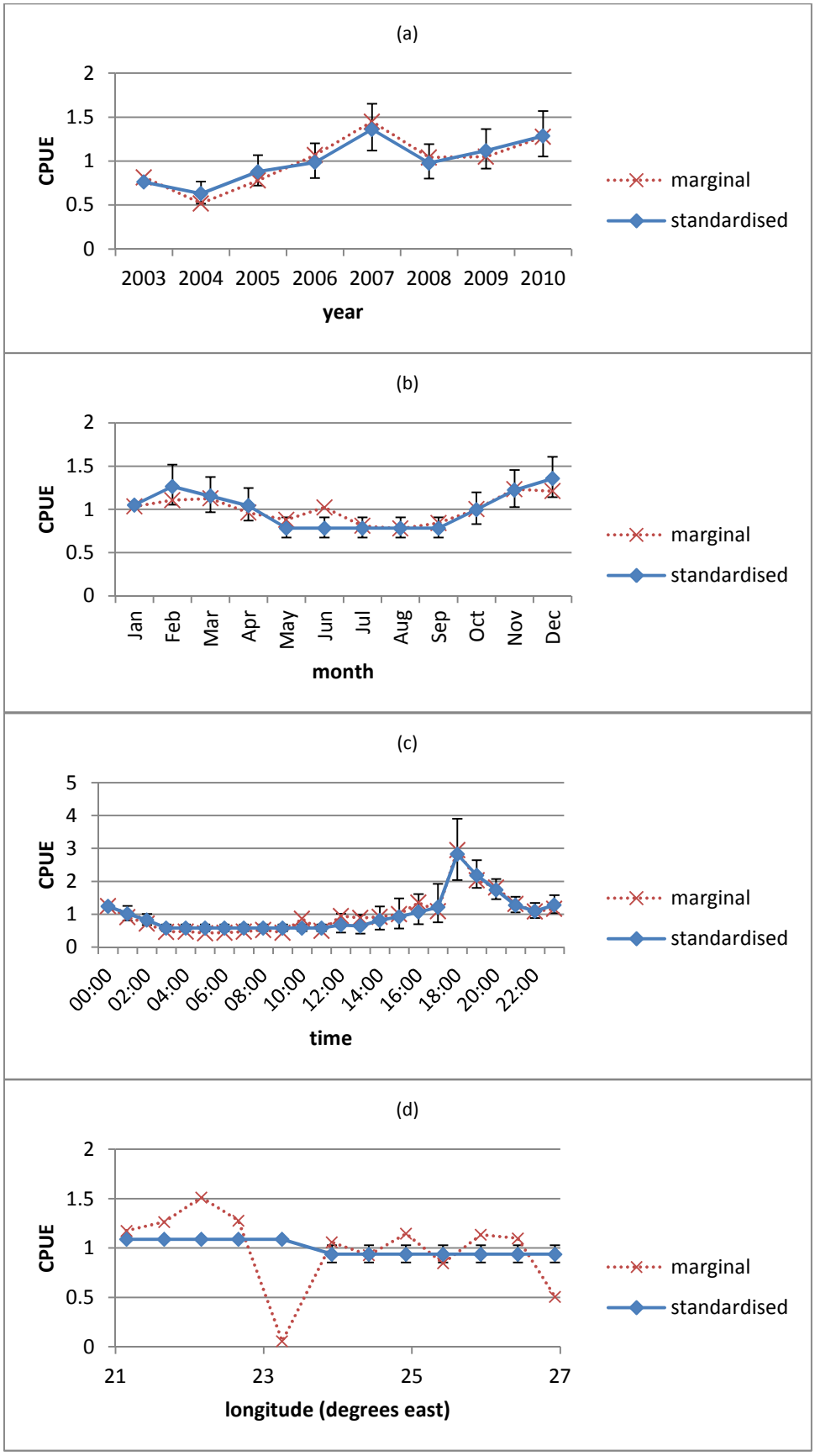

Fig 1 (a-d): Comparison between mean marginal CPUE and standardised CPUE at different effect levels. Error bars for standardised CPUE trends indicate 95% confidence intervals; (a) shows the effect of year, (b) the effect of month, (c) the effect of time of day and (d) the effect of longitude.

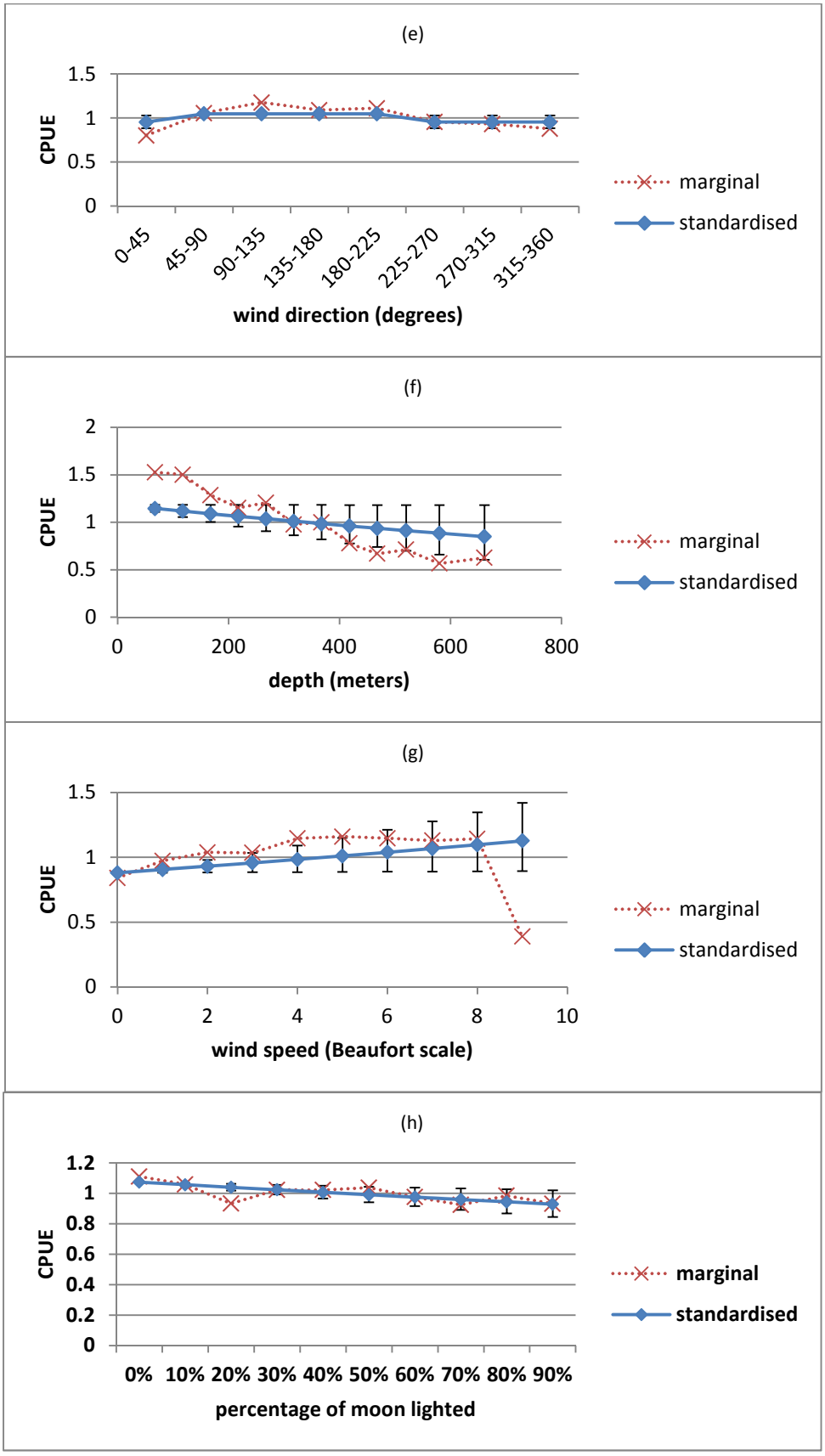

Fig 1 (e-h): Comparison between mean marginal CPUE and mean adjusted CPUE at different effect levels. Error bars for standardised CPUE trends indicate 95% confidence intervals; (e) shows the effect of wind direction, (f) the effect of trawl depth, (g) the effect of wind speed and (h) the effect of lunar phase.

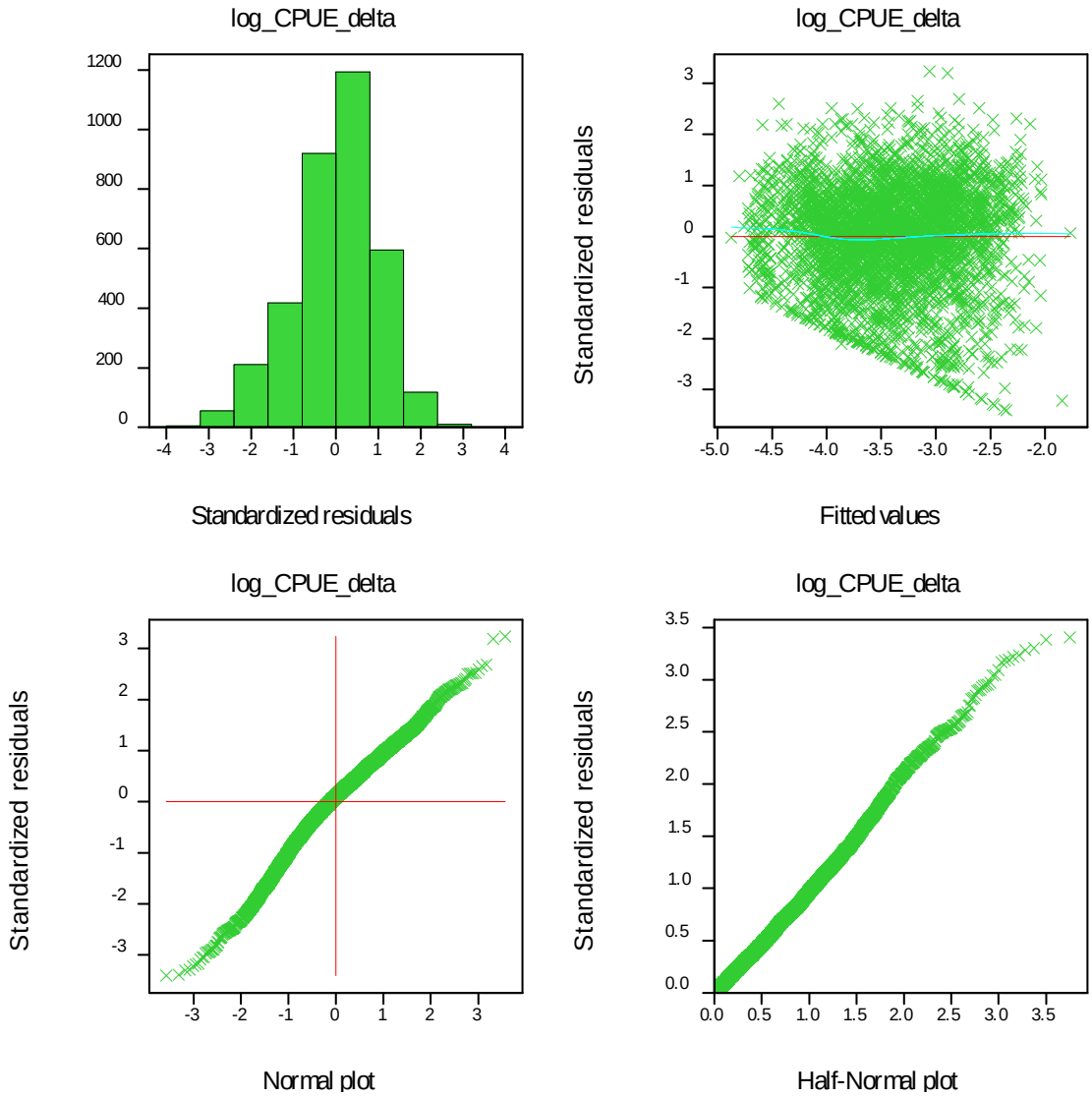

Figure 2: Diagnostic plots of standardized residuals.

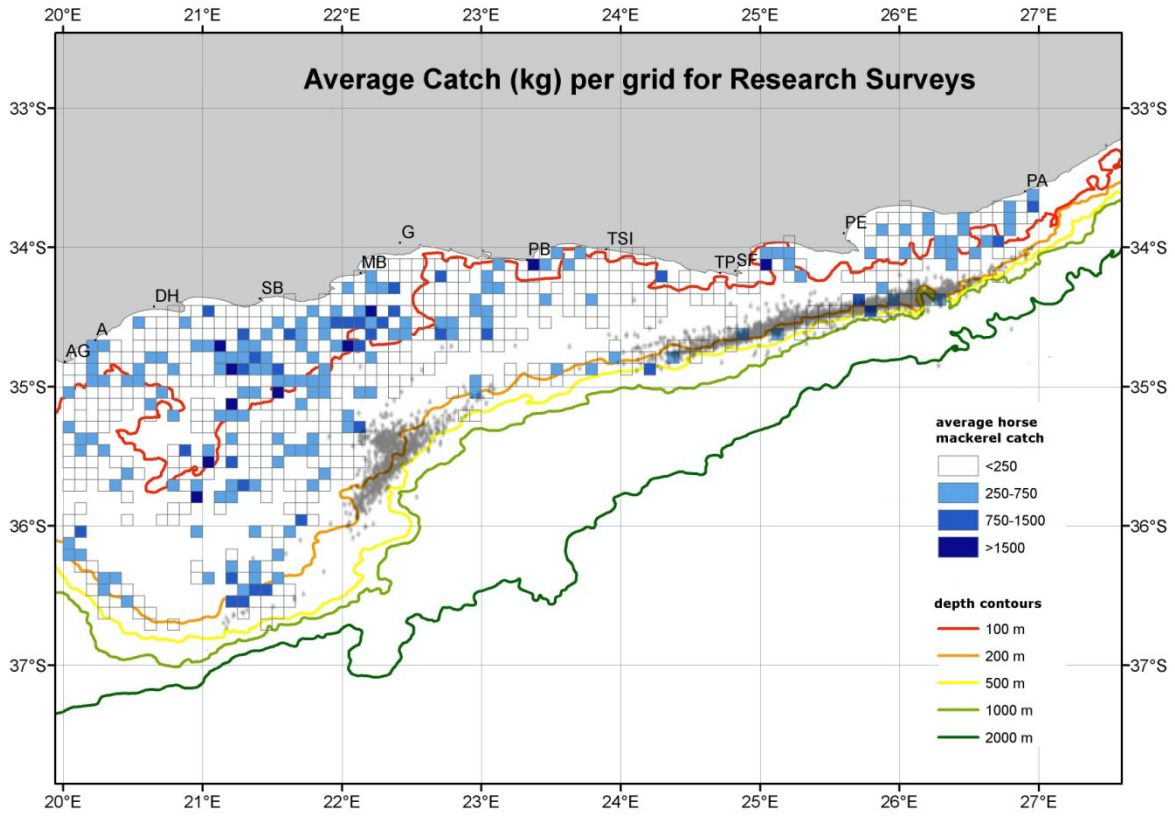

Figure 3: Correspondence between *Desert Diamond* trawl locations and demersal survey average horse mackerel catches (with standardised effort) in the last decade. *Desert Diamond* trawl locations are marked by semi-transparent grey dots.