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A re-analysis of the squid jig CPUE data

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Introduction

The catch per unit effort (CPUE) indices from the squid jig fishery have to date been expressed in terms of catch per man-hour (Roel, 1998). Industry has for many years questioned the use of man-hours as the unit of effort since it is alleged that the information contained in the database regarding the number of hours fished is unreliable. A re-analysis of the jig catch and effort data has therefore been undertaken, with the unit of effort revised to one of man-days, under the assumption (though see further discussion below) that the proportion of a day spent fishing has remained roughly unchanged over time.

The choice of unit of effort

Roel (1998) defined effort in the jig fishery in terms of man-hours. Annual effort was calculated to be $E_y = \dfrac{C_y}{CPUE_{y,partial}}$, where C_y is the total catch for the year, and $CPUE_{y,partial} = \dfrac{\Sigma(Catch_{y,3-20\,men})}{\Sigma((crew \times hours)_{y,3-20\,men})}$, i.e. the CPUE computation was constrained to vessels that carry between 3 and 20 men. The reason for this is that Roel (1998) found a linear relationship to exist between crew size and catch per hour within the range of 3-20 men, whereas outside of this range factors other than crew size appear to impact CPUE.

Information contained in the database relating to effort in this fishery, and their degree of reliability, may be summarized as follows:

- Number of hours fished (not always accurately recorded)
- Days fished (accurately record for those books that are submitted to MCM)
- Number of crew fishing (this figure generally refers to the crew complement on the trip)

Given that the number of hours fished is considered unreliable, a move to defining effort in terms of man-days is proposed (note that each record in the database corresponds to a day for a particular vessel so that catch/man-day is equivalent to catch/man). It was advised (W. Sauer, pers commn) that large vessels (> 16 crew) have changed their fishing patterns over time because unlike the smaller vessels they can continue fishing by moving offshore during periods of bad weather closer to the coast. Thus allowance needs to be made for possible changes in efficiency over time for these vessels. Generalized Linear Modelling (GLM) was applied to obtain a standardized index of abundance.

The GLMs

Two models with different error structures (Poisson and log-normal) were considered. These were as follows:

(i) Poisson error structure: $ln(\text{catch})=ln(\text{crew})+\alpha+\beta_{year}+\gamma_{area}+\kappa_{month}+\eta_{vess}+\varepsilon$

(ii) Log-normal error structure: $ln(\text{catch/crew})=\alpha+\beta_{year}+\gamma_{area}+\kappa_{month}+\eta_{vess}+\varepsilon$

For both models *year* is a factor with 21 levels (1985-2005), *month* is a factor with 12 levels, *area* is a factor with 274 levels and *vess* is a factor with 22 levels (Small, Large_{1985}, Large_{1986}…Large_{2005}) to account for the fact that larger vessels (> 16 crew) have fished further offshore over time.

The exponent of the *vess* factors relative to small vessels for each model is plotted in Figure 1. The trends from the two models are quite similar and indicate that the CPUE of large vessels is lower relative to small vessels and that since 1998 the efficiency for large vessels has been increasing.

In order to select between the two models, the variance structure of the residuals was investigated. Figures 2 and 3 plot the standard deviation of the appropriately standardized residuals from each of the two models against the model predicted values which have been binned accordingly. An increasing trend is evident for the model that assumes a Poisson error structure (Figure 2), while for the model that assumes a log-normal error structure no trend is evident (Figure 3). This indicates that the data show a variance structure more in line with the assumptions underlying a log-normal distribution and on this basis this model is preferred.

Sensitivity tests

The sensitivity tests reported here all pertain to the model that assumes a log-normal error structure. The first sensitivity test restricts the analyses to records that have between 3 and 20 crew reported. This is to allow for a comparison with the CPUE index derived by Roel (1998), who applied this restriction in her CPUE calculations. The exponent of the year factor from the GLM and the CPUE index of Roel (1998) are shown in Figure 4. It is clear that both indices have similar trends. The GLM index indicates a decrease in abundance of 2.8±0.9% (1 standard error) per annum while the Roel (1998) index indicates a decrease in abundance of 3.3±1.1% per annum.

In the assessment of the squid resource, a year is split into two periods: January-March and April-December to better model the dynamics of the resource and the fisheries that exploit it. Roel (1998) omitted the January-March index from the model fit, but included the April-December index. The second sensitivity test therefore restricts the GLM to records where crew size is between 3 and 20 men and the April-December period. The exponent of the year factor compared to the index of Roel (1998) is shown in Figure 5.

Once again the trends are very similar. The GLM index indicates a decrease in abundance of 2.9±0.9% (1 standard error) per annum while the Roel (1998) index indicates a decrease in abundance of 3.4±1.1% per annum.

Conclusion

Figure 5 indicates similar trends for the GLM index where effort is defined in terms of catch/man-day compared to the index in terms of man-hours as derived by Roel (1998). This indicates that there is no reason to suggest that the previous results computed for the appropriate effort level in this fishery would be appreciably different from what would be obtained if the newer (and more reliable) standardized jig series based on catch per day were input instead.

Reference

Roel. B.A. 1998. Stock assessment of the chokka squid *Loligo vulgaris reynaudii*. PhD. University of Cape Town. 217pp.

Figure 1: The exponent of the *vess* factor for the two models (each assuming a different error structure).

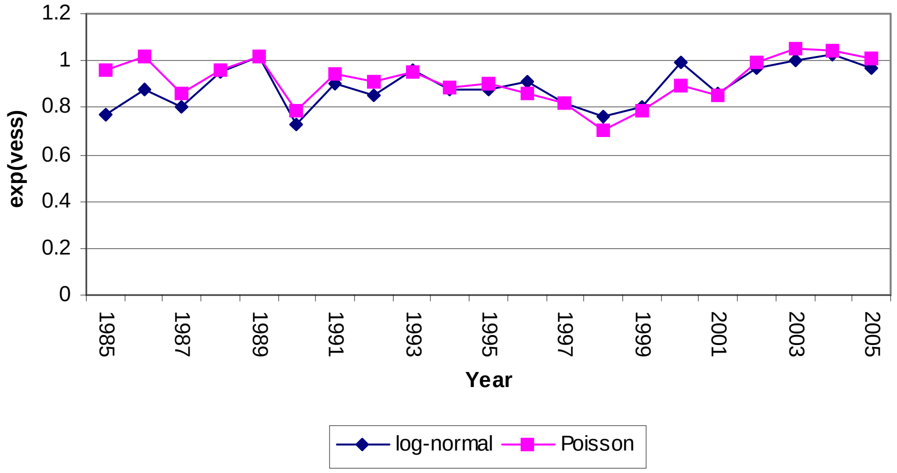

Figure 2: Standard deviation of the raw residuals (standardized by dividing by the square root of the predicted catch as appropriate given the mean-variance relationship for a Poisson error structure) plotted against predicted catch for the model that assumes a Poisson error structure.

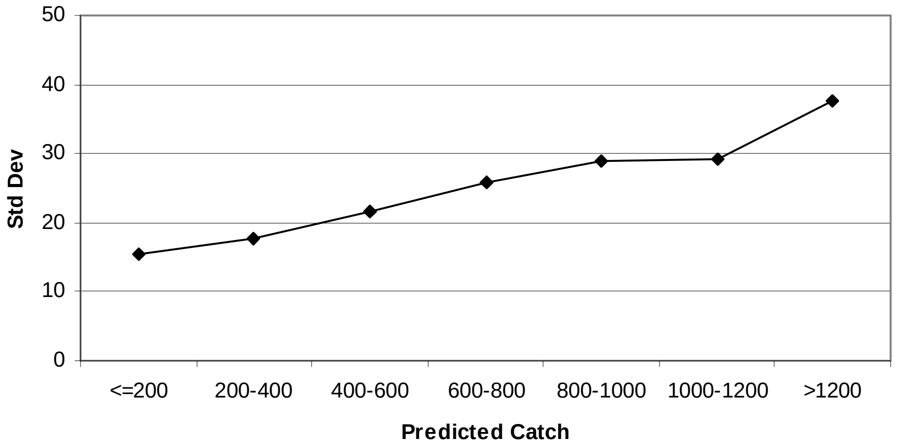

Figure 3: Standard deviation of the studentized residuals plotted against predicted CPUE for the model that assumes a log-normal error structure.

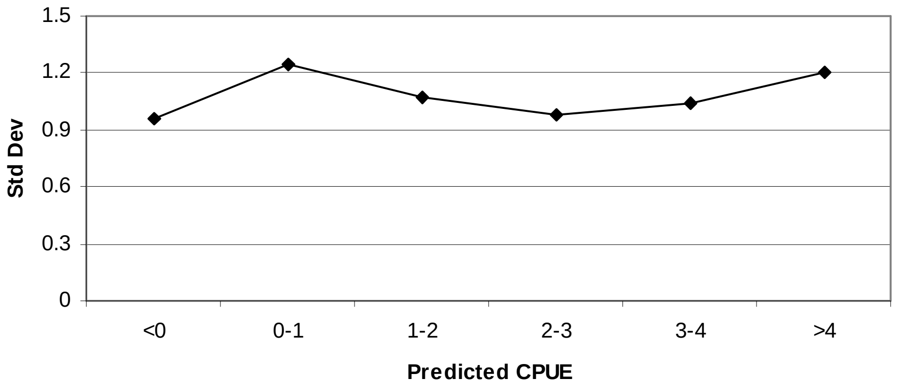

Figure 4: The exponent of the *year* factor from the GLM constrained to crew between 3 and 20 men compared to the CPUE index of Roel (1998). Each series has been normalized to its mean.

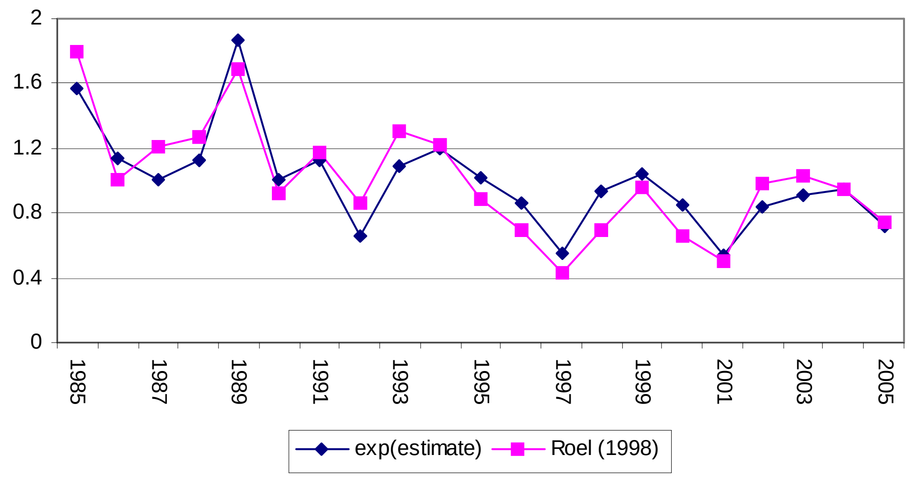

Figure 5: The exponent of the *year* factor from the GLM constrained to April-December and crew between 3 and 20 men compared to the CPUE index of Roel (1998). Each series has been normalized to its mean.