Banana prawns and the Southern Oscillation Index

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The prawn season in the Gulf of Carpentaria extends (approximately) from March to June. Data are presented which show that the total catch of banana prawns is highly correlated with Troup's Southern Oscillation Index (SOI) computed for the preceding November. Following the work of Vance et al. (1985) which indicates that the banana prawn life cycle is significantly affected by the timing of peak river discharge, suitably stratified rainfall data are used to show the differences between good, average and bad prawn seasons.

Introduction

The development of models to predict likely seasonal catches of naturally occurring fish, such as prawns, assumes great significance when the earnings from their export is considered. In the best years (e.g. 1974) the volume of the catch has overwhelmed the fishermen, in the worst years (e.g. 1983) export markets have been inadequately serviced. With good predictive models it is possible to plan the industry to minimise the disruption caused by the variability of seasons.

Work by Vance et al. (1985) has shown that juvenile prawns are quite tolerant to water of low salinity, however, as they grow to maturity they require a more saline environment. With the advent of heavy wet-season rainfall, salinity in the rivers where the banana prawns breed is lowered and they are forced to migrate offshore. Once offshore the banana prawns may be harvested by prawn trawlers.

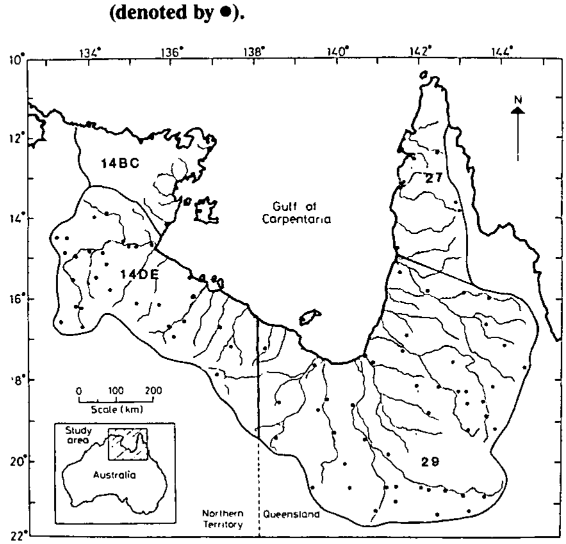
Having noted that prawn numbers in the Gulf of Carpentaria should be related to rainfall, Vance et al. derived a number of regression equations for catches in sub-sections of the Gulf of Carpentaria fed by distinct river systems. For each river system they located a 'representative' rainfall station and stratified the rain data by season (spring, summer, autumn, winter). The resulting regressions at times had a negative correlation with summer rainfall, though most had a positive correlation between total seasonal rainfall and prawn catch. Staples (1983) also reported a correlation between the mean summer SOI, rainfall and prawn catch.

Noting that in an area-integrated sense it is the strength of the Walker circulation (Bjerknes 1969) which correlates positively with the wet-season average, daily north Australian rainfall rate (Holland 1986), it was felt that in a gross sense a more stable forecast scheme could be obtained from use of Troup's Southern Oscillation Index (SOI) (Troup 1965) computed immediately prior to the onset of the wet season, and the banana prawn catch for the entire Gulf of Carpentaria. This approach is consistent with that of Nicholls (1985, 1986) where it is shown that the SOI provides a good basis for the forecasting of economically important crops whose growth is dependent on average rainfall totals over a wide area.

The data

Statistics of prawn-catch numbers for the years 1968 to 1979 were obtained from Somers and Taylor (1981). Prawn statistics for the years 1980 to 1984 were obtained from B. Taylor (personal communication). District average rainfall statistics for districts 14BC and 14DE (see Fig. 1 for locations) were obtained from copies of the *Monthly Weather Review* published by the Darwin Regional Office of the Bureau of Meteorology.

Fig. 1 Location map showing rainfall districts 14BC, 14DE, 27 and 29 and the location of rainfall stations used to compute district averages (denoted by ●).



District average rainfall data for districts 27 and 29 were obtained from copies of the *Monthly Weather Review* published by the Brisbane Regional Office of the Bureau of Meteorology. The time series of SOI data was obtained from the *Darwin Tropical Diagnostic Statement*.*

Discussion

Figure 2 shows graphically the relationship between November SOI, total landings (TL) of banana prawns and the prawn catch expressed in terms of tonnes per boat day (the so-called catch per unit effort (CPUE)). The high correlation between the three time-series' is visually evident, the correlation coefficient between CPUE and November SOI is 0.80 and between total landings and the SOI is 0.83. Each correlation is significant at the 0.001 level. Another interesting feature of the three curves is their downward trend with time. Without being aware of the correlation between catch and the SOI the downward trend of CPUE and TL may have been explained simply in terms of overfishing. It would appear that a significant percentage of the prawn catch decrease in recent years is related to a long-term variation in the rainfall regime.

From the time series given in Fig. 2 a forecast for total landings in the following season from the November SOI is given by:

$$TL = 3584.3 + 119.5 \times SOI \text{ (tonnes)} \quad \ldots 1$$

and the expression for the forecast CPUE from the November SOI is given by:

$$CPUE = 844.7 + 22.84 \times SOI \text{ (tonnes/boat day)} \quad \ldots 2$$

There are a number of advantages in using the November SOI (or alternatively an October/November/December average) as a predictor. The predictor can be computed prior to the commencement of the prawn season and furthermore it provides an estimate of average daily rainfall rates likely to be recorded over the broad Gulf region (Holland 1986) and thus from biological arguments can be expected to represent a good estimate of the likely Gulf of Carpentaria prawn catch.

The alternative to using the SOI as a predictor is to use spring rainfall statistics for single stations (as per Vance et al 1985) to derive forecasts. Unfortunately these can be biased by very small-scale, isolated events. Furthermore, using wet-season rainfall totals means that a forecast cannot be generated until the season is over and the catch is known. Because of these drawbacks inherent in using a regression based on rainfall statistics to forecast the banana prawn catch, it is strongly advocated that a regression based on the SOI be used.

It is possible to analyse the differences between the good, bad and average seasons, as observed over the past 15 seasons, and draw some useful inferences.

* Darwin and Tahiti pressure time series were appended to the *Darwin Tropical Diagnostic Statement*, April 1987. Published by the NT Regional Office, Bureau of Meteorology. PO Box 735, Darwin, Australia 5794.

Fig. 2 Time series of November Southern Oscillation Index, total landings of banana prawns (tonnes) and the catch per unit effort (tonnes/boat day).

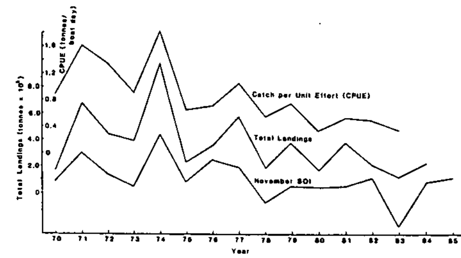
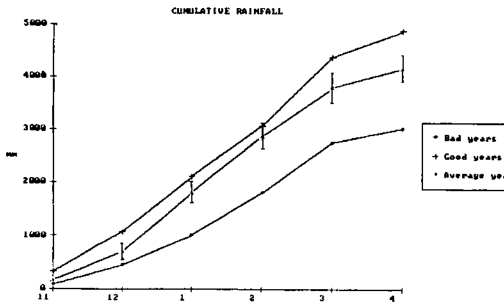


Figure 3 shows the average cumulative rainfall totals for the three 'best' (1971, 1974 and 1977) and the three 'worst' (1970, 1980 and 1983) banana prawn years (by total catch) and nine 'average' years. Also plotted on the 'average year curve' are error bars of one standard deviation in length. The bad years are clearly those for which the rainfall in all months is significantly below average. The good years appear to be those which have heavier than usual falls early and late, but through the wettest months (January and February) are similar to average years.

Given the need to flush the prawns out of the river systems with low salinity water it is probable that it is the late wet-season rains which contribute much to the good years catch. It has been noted that while SOI provides a good predictor of wet season onset it performs poorly as a predictor of the length of the wet season or likely total rainfall for a given district (Nicholls et al. 1982). Thus, it is most likely that the regressions suggested earlier (Eqns 1 and 2) will perform well at distinguishing bad years from the others but perhaps less well at discriminating between good and average years.

Fig. 3 Cumulative rainfall totals (in mm) for the three 'best', three 'worst' and ten 'average' years as determined by total catch. Rainfall totals are the sum of the averages of the four rainfall districts adjoining the Gulf of Carpentaria (see Fig. 1).



Summary

Following the work of Staples (1983), Nicholls (1985 and 1986) and Vance et al. (1985) it has been shown that the SOI for November can be used to provide a good estimate of the banana prawn harvest in the Gulf of Carpentaria the following year. Linear regression equations to provide such forecasts are presented.

It is also suggested that the differences between good and average years is the persistence of wet-season rains for a longer duration than usual whereas the poor years are characterised by below average rains in all wet-season months.

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