State of the Deep-sea Shrimp Stock of Angola

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ABSTRACT

A non-equilibrium biomass dynamic model has been used to assess the state of exploitation of the deep-sea shrimp stock of *Parapeneopsis longirostris* off Angola. Results show that the fishery is being overexploited. The proposed Maximum Sustainable Yield and the related f_{MSY} values are approximately 3,000 tonnes and 8,000 days-fishing respectively. These results are statistically different from those obtained using biomass equilibrium model, underlying *ipso facto* the importance of the model assumptions in stock assessment. Adopting a policy aiming at the biological conservation of the resource (fishing at MSY and f_{MSY} levels), the catches of the fishery will increase and stabilise after 3 years at least twice their present level. This increase of shrimp landings will certainly improve the revenue of the country (foreign exchange) as well as fishermen social welfare.

RÉSUMÉ

Un modèle de production de biomasse non-équilibré a été utilisé pour évaluer le niveau d'exploitation du stock de la crevette profonde parapeneopsis longirostris d'angola. Les résultats de cette étude montrent que cete pêcherie est en voie de surexploitation. Les valeurs de la Prise Maximale Equilibrée et de son effort relative fpme proposes sont approxiamtivement de 3000 tonnes et 8000 jours de pêche respectivement. Ces resultants sont statistiquement différents de ceux obtenus en utilisant le modèle standard de production de biomasse, relevant ipso facto l'importance des hypotheses de depart dans le choix du modèle d'évaluation. En adoptant la conservation biologique de la resource comme politique d'aménagement (ne pas aller au-delà de PME et fpme), la production de la pêcherie va doubler et se stabilizer à ce niveau après trios années. Cette augmentation de la production de crevettes va certainement amèliorer le revenue du pays en termes d'apport de devises extérieurs ainsi que le bien-être social des pêcheurs

Key words:

1. Introduction

The shrimp fishery off Angola catches the rose shrimp, *Parapenaeus longirostris* and striped shrimp *Ariteus varidens*, both constituting 70 and 25% respectively of the total landings of the crustacean fisheries (de Sousa *et al.*, 1999). *Parapenaeus longirostris* is found between 50-400 metres depth (Lopez Abellán and Cárdenas, 1990). The deep-sea rose shrimp fishery for *Parapenaeus longirostris* is one of the most important fisheries in Angola, with regards to its contribution to foreign income earning and employment generation for the country. For instance, *Parapenaeus longirostris* export value in 1995 represented 48% of the total value from the fishery sector (Ana *et al.*, 1999).

The deep-sea rose shrimp fishery for *Parapenaeus longirostris* off Angola began in 1967 with 40 Spanish trawlers. The Spanish fleet ceased to exploit the stock in 1977 and was replaced by a Cuban fleet, which continued to operate until 1979. In 1999, there were 44 vessels of which 22 fishing under an agreement with the European Community (EU) and the others being Angolan vessels which in fact were older EU vessels sold to Angolan nationals.

Surveys of the fishery are carried out either by the Instituto de Investigação Pesqueira of Angola, or in collaboration with the Instituto Español de Oceanografia and/or the Norwegian Research vessel "Dr Fridtjof Nansen". The main objectives of these surveys are to study the distribution, biology and standing biomasses of the deep-sea rose shrimp stocks.

Assessment of *Parapenaeus longirostris* is done each year, using classic equilibrium biomass production models (Caramelo *et al.*, 1996; de Sousa *et al.*, 1999). However, equilibrium situations are seldom found in nature. This paper therefore, intends to correct for this, by using a non-equilibrium dynamic surplus production model (Walters and Hilborn, 1992), in order to put more insight into the assessment of this important stock, as a prerequisite for its rational exploitation.

2. Materials and methods

Catch and effort data were collected from logbooks of the fishing companies operating in Angola. This data collection started in 1987 for foreign fleets and in 1993 for national fleets. Data used in this work cover the

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Table 1. Catches (wet weight in tonnes) and fishing effort (days-fishing) of *Parapenaeus longirostris* from the Angolan and Eu fleets. The two asterixes in 1994 indicate values used in the model whereas parentheses are original values and were not used in the model (outliers).

Year	Total catches (tonnes)	Total fishing effort (days-fishing)
1990	3,700	6,720
1991	3,359	7,548
1992	2,821	7,133
1993	3,223	9,847
1994	2,970** (3,625)	9,510** (8,289)
1995	2,717	9,174
1996	3,499	11,332
1997	4,246	11,029

Source: de Sousa *et al.*, 1999

period 1990-1997. Catches are expressed in terms of wet weight of the species and the fishing effort represents the number of days-fishing (Table 1).

The model

A non-equilibrium biomass dynamic model seems more appropriate for this work especially as there is at present no appropriate data on length frequency composition of the catch, to enable the application of age-structured models.

In fact, biomass dynamic models in general are more or less equilibrium models, with the assumptions that the stock remain constant from one year to the next due to constant parameters of recruitment, growth and mortality. These models also assume a linear relationship between catch per unit effort (CPUE) and effort (Schaefer, 1954; Fox, 1970 and Pella-Tomlinson, 1969). However, equilibrium are rarely found in nature and especially for the Angolan fishery which is characterised by the existence of an upwelling system with variations in time of the productivity of its ecosystem.

Another reason for the choice of the model is that, biomass dynamic models provide better estimates of management parameters than age-structured approaches even when important parameters such as growth and mortality are known (Ludwig and Walters, 1985; 1989).

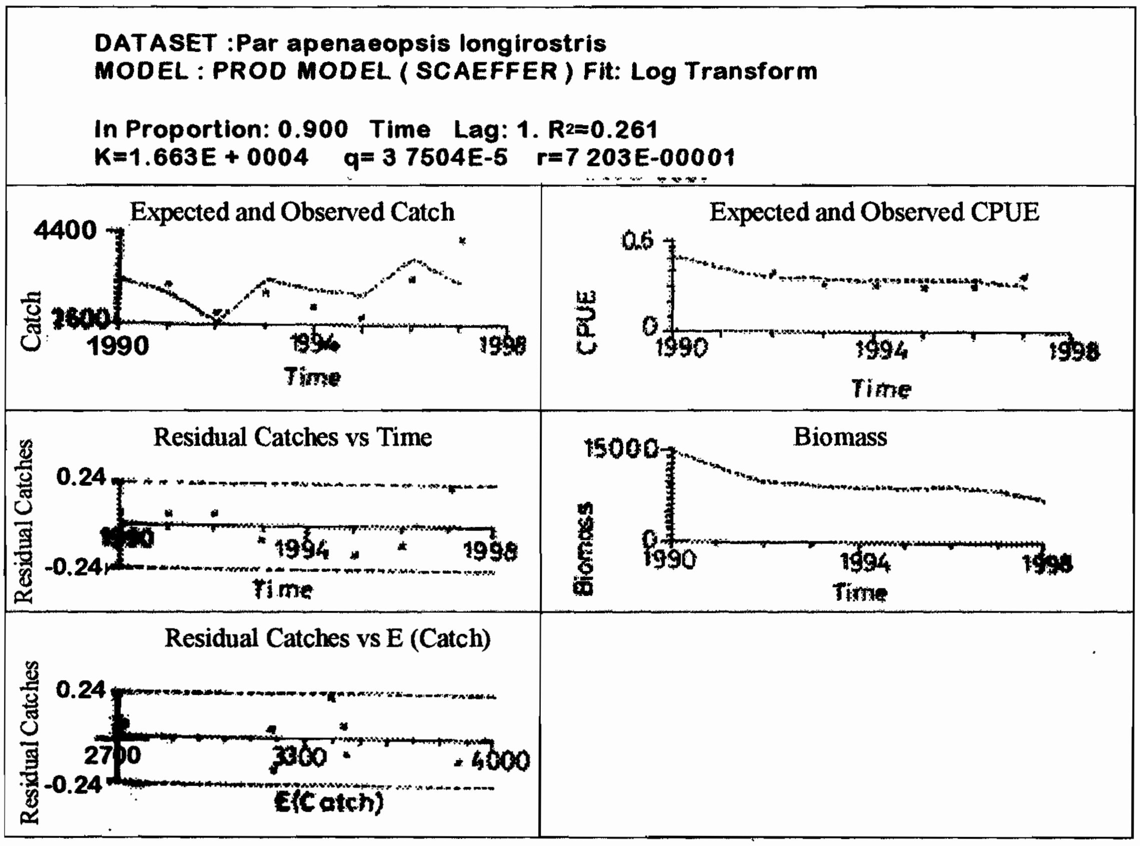


Table 2. Summary table for the comparison of MSY and f_{MSY} values from de Sousa (1999) and this work.

Authors	**MSY (tonnes)**	**f_{MSY} (days-fishing)**
Present work	2,421? MSY ? 3,291	7,808? f_{MSY} ? 8,320
De Sousa *et al.*, 1999	3,750	9,000

Walters and Hilborn (1976) used a simple difference equation of the Schaefer model (Schaefer, 1954) to express a non-equilibrium production function as:

$$B_{t+1} = B_t + rB_t(1-B_{t-L}/K)-C_t \qquad (1)$$

where B_t represents the biomass at time t, and r, K the intrinsic rate of growth and the carrying capacity respectively. L is the time lag, and C_t the catch during time t, and defined as:

$$C_t = qB_tf_t$$

where q, is the catchability coefficient and f_t, fishing effort during year t. This model is essentially identical to the differential equation, but estimation of its parameters can be very difficult.

A computer programme CEDA (Catch and Effort Data Analysis) version 2.01 developed and programmed by Holden, Kirkwood and Bravinton (1995) under the Fish Management Science Programme of the Overseas Development Administration, is a useful method of solving this problem of parameters estimations. However, as the method gives the value of the unexploited population size and carries out projection of future catches, two other parameters are included in the model; the stock size at the start of the catch data series (initial proportion) and time lags.

Actually, in order to obtain basic estimates with the Schaefer (1954) model, catch data should be extended as far back in time as possible, to times of very low catches. However, the collection of catch data begins only after a significant fishery has existed for some time. This implies that catch data series are seldom complete. Some good assumption can all the same be made of the stock size at the start of catch data in relation to an unexploited stock size. This ratio is known as initial proportions, and its value is constrained between 0 and 1. The time lag is a condition necessary to relate biomass this year to the biomass in previous years. Information on the size at recruitment is therefore necessary.

One of the most important feature of CEDA is its ability to allow one to assess the goodness of fit of the model with the actual data; its also generates confidence intervals of the estimated parameters using bootstrapping methods.

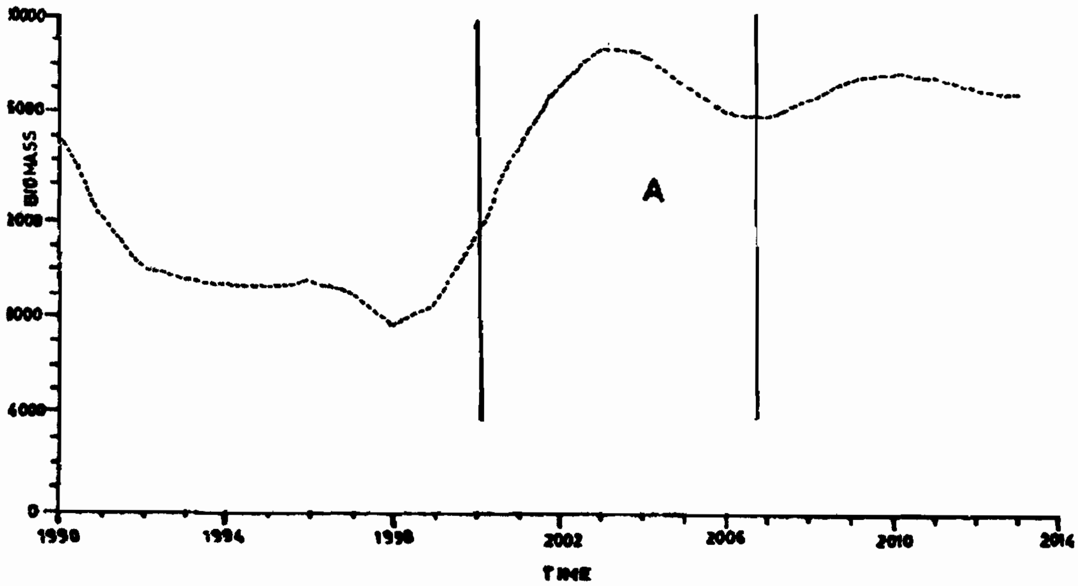
1. Results and discussions

With the assumption that the biomass this year will affect the biomass next year (time lag is 1 relative year) and the initial proportions is 0.9 (log transform), the parameter estimates found with the dynamic non-equilibrium Schaefer (1954) model at 95% confidence limits, are as follow:

2,421=MSY =3,291 tonnes and

7,808= fMSY =8,320 days fishing

To assess the validity of these hypotheses, we looked into the plots of observed and expected catch, observed and expected catch per unit effort, residual catches against time, residual catches against effort. All these plots show good fits (Fig.1). This actually suggests that there is no



major violation of the model assumptions with the actual data (although goodness of fit is not always a sign of appropriate results).

Actually, the catch and fishing effort recorded in the deep-sea rose shrimp fishery for the last five years are on average 3,331 tonnes and 10,178 days-fishing respectively. These values are statistically higher than our findings, suggesting that the fishery is being overexploited.

Assessment using the classic Schaefer (1954) model (de Sousa *et al.*, 1999) with the assumption of equilibrium conditions (growth and recruitment constant), estimated MSY and related f_{MSY} values at 3,750 tonnes and 9,000 days-fishing respectively. These results have been found statistically higher (95%) than the estimates of this work which takes into account non equilibrium situation of the ecosystem (Table 2).

The disagreement between these two results can be justified by the fact that the equilibrium assumption is not met in the Angolan case. To that end, biomass production models are still to be utilised as stock assessment tools, but one should be very careful about which model to apply in her or his fishery, as the consequences resulting from inappropriate model application can be detrimental to resource management.

Adopting the policy aiming at the biological conservation of the resource that is fishing at MSY and f_{MSY} values (appropriate economic data not available), the catches of the fisheries will increase and stabilise after three years at least twice their present values (Fig. 2, A). This increase of shrimp catches will certainly improve the revenue of the country (foreign exchange) as well as fishermen social welfare.

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