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POPULATION DYNAMICS OF THE CUTTLEFISH *SEPIA DOLLFUSI* (ADAM, 1941) IN THE GULF OF SUEZ, EGYPT

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ABSTRACT

Basic population parameters of the cuttlefish *Sepia dollfusi*, in the Gulf of Suez were described from samples of commercial landing made between September 2002 and May 2003. A total of 600 *S. dollfusi* with mantle lengths ranged from 45 to 147 mm were studied. Age and growth were estimated using progression analysis model by applying Bhattacharya method. There were no significant differences in population parameters between sexes. The theoretical maximum length $L\infty$ = 169 mm and the growth coefficient K = 0.91/ year. Total, natural and fishing mortalities were 3.57, 1.07 and 2.5 per year respectively. The exploitation ratio (E =0.7) suggests that the fishing pressure on *S. dollfusi* in the Gulf of Suez is high. Relative yield per recruit and relative biomass per recruit analysis showed that *S. dollfusi* stock in the Gulf of Suez in a situation of over-fishing. For the management purposes, the current exploitation rate should be reduced by about 51% to maintain a sufficient spawning biomass and the present length at first capture should be raised to about 86 mm ML.

INTRODUCTION

Cephalopod fishery in the Gulf of Suez is economically very important for Egypt, due to the high commercial values on national and international markets. Cephalopods constitute about 7.5% of the total catch by trawlers in the Gulf of Suez of which 5% was cuttlefish and 2.5% was squids (reports of General Authority for Development of Fisheries Resources during 1995-2003). The major species of cuttlefish in the Gulf of Suez are *S. savignyi* , *S. dollfusi*, *S.pharaonsis* and *S.prashadi* (Emam . 1983 & 1994).

Despite the great importance of cuttlefish in the Gulf of Suez. only very limited studies on these species are available. Emam (1983) on the morphometry of three species of the cuttlefish from the Mediterranean and Red Sea. Emam (1990) on the reproductive biology and nervous system of *S. savignyi*. Abdalla *et al.* (1993) estimated the age and growth of *S. savignyi*. Emam (1994) assessed the stock of *S. prashadi*. Emam and Saad (1997) studied the morphometry and population dynamics of *S. dollfusi*.

For cuttlefish stock assessment. it becomes necessary to elucidate the key aspects of their biology and dynamics. The present study is aimed to estimate the basic parameters required for the management of *S. dollfusi* in the Gulf of Suez during the present time and to compare them with the previous studies.

MATERIALS AND METHODS

Samples of *S. dollfusi* were collected monthly from the commercial trawl fishery off the Gulf of Suez. A total of 600 specimens were analysed from September 2002 to May 2003. Specimens were separated by sex and their mantle length (ML) was measured to the nearest mm and their total body weight (BW) was recorded to the nearest 0.1 g. The collected samples were grouped into 1 cm ML classes for modal progression analysis (MPA).

The length frequency data was treated by computer based analysis for estimation of the population parameters. FISAT software of Gayanilo *et al.* (1997) was used for all computations. The following methods were applied in this study:

- The Bhattacharya method (1967) to distinguish different components from the length frequency data.
- Wetherall method (1986) to estimate the ML_∞ and Z/K.
- Gulland and Holt method (1959) to estimate the growth parameters of the von Bertalanffy growth model (ML_∞, K and t_0).
- ELEFAN I method (Pauly. 1987) to estimate the growth parameters (ML_∞ and K).
- Length converted catch curve method of Pauly (1983 a&b) to estimate total mortality coefficient.
- Taylor's formula (1960) and Rikhter and Efanov method (1976) to estimate natural mortality coefficient.
- Catch curve analysis (Pauly. 1984 a&b) to estimate the length at first capture.

- The logistic curve to describe the gear selection ogive as $S_L = 1/[1 + e^{(S1-S2*L)}]$ where S_L = number of cuttlefish of length L in the codend divided by number of cuttlefishfish of length L in the codend and in the cover. L is the length interval midpoint and S_1 and S_2 are constants.

The relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)' were estimated by using the Beverton and Holt model (1966) as modified by Pauly and Soriano (1986).

The length - weight relationship was estimated using the power equation $W= aL^b$ where W is the total weight, L is the mantle length.

The fishing mortality coefficient (F) was computed as F = Z – M, while the exploitation rate was computed from the ratio F/Z (Gulland, 1971).

RESULTS AND DISCUSSION

Mantle length - body weight relationship

A total of 600 specimens of the cuttlefish *S. dollfusi* ranging in ML from 45 to 147 mm and in BW from 12.3 to 400 g were used to describe the ML-BW relationship (Fig. 1). The regression equation obtained from plotting BW against ML is:

$W = 0.12687\ L^{3.0091}$

Emam and Saad (1997) estimated the ML-BW relationship for the same species with average ML from 5.6 to 12.4 cm and mean BW from 35 and 238 g as $W = 0.4993\ L^{2.456}$ The difference between b-values may be due to the wider range of both ML and BW used in the present study.

Age and growth

Age was determined based on length–frequency studies using the Bhattacharya's (1967) method (Fig. 2). It was possible to identify two components which were considered as distinct age groups or cohorts for *S. dollfusi*. The Bhattacharya method was used to analyse the monthly length frequency data to obtain the mean length and number of individuals in each cohort (Table 1). The instantaneous relative monthly growth in ML ranged from 4.2% to 26.6% while growth in body weight varied from 1.8% to 18.4%. The maximum growth rate was recorded during the first three months of life for ML and at age of 18 months for BW. These results are in close agreement with the findings of Emam and Saad (1997). They found that the longevity of *S. dollfusi* in the Gulf of Suez was extended to two years and rate of growth in length is much higher in young individuals than the old ones.

Growth parameters

First estimates of the asymptotic length ($L\infty$) and the ratio between the coefficients of total mortality and growth (Z/K) obtained from Wetherall plot (Fig. 3) were 166 mm and 3.78. Subsequently the estimates of $L\infty$ was used in ELEFAN I and the parameters obtained by this method are $L\infty$ = 165 mm and K = 0.89 per year. Although the growth parameter $L\infty$ could be estimated using ELEFAN I program directly, the Wetherall method was used to facilitate the identification of K-value compatible with the value of $L\infty$ which is more reliable than when this parameter is estimated together with $L\infty$ (Pauly, 1986a). The mean lengths obtained from Bhattacharya method (Table 1) were applied to the Gulland and Holt plot (Fig. 4) to estimate $L\infty$, K and t_0. The values obtained were $L\infty$ = 169 mm, K = 0.228 per quarter year (K= 0.91 per year) and t_0 = -0.08 year. Results of the ELEFAN I program compare well with those of the Bhattacharya analysis and also with the results of Emam and Saad (1997). They gave an estimate of L_∞ = 16.8 cm, K = 1.145 year^{-1} and t_0 = -0.024 year.

Mortality estimates

The Wetherall method gave an estimate of Z/K = 3.78 and subsequently the total mortality coefficient Z = 3.44 using K= 0.91. This value is closed to the value of Z obtained using length – converted catch curve analysis (Z= 3.7) (Fig. 5). The natural mortality coefficient calculated from Taylor's approximation (Caddy, 1983) was 0.96 per year. Rikhter and Efanov method gave an estimate of M = 1.18 per year. The mean values of Z and M gave a value of fishing mortality F = 2.5 and exploitation rate E = 0.7. Relatively high values of fishing mortality and exploitation rate reflect the high level of exploitation. Emam and Saad (1997) estimated Z, M, F and E as 5.025, 2.066, 2.959 and 0.59 respectively. The higher level of exploitation in the present study is due to the increasing of fishing effort exerted into the trawl fishery during the last fishing seasons.

Length at first capture

The resultant curve derived from the catch curve provided an estimate of L_{25}, L_{50} (L_c) and L_{75}. The obtained values were 63, 73 and 82 mm for L_{25}, L_{50} and L_{75} respectively (Fig. 6). These values are corresponding to an ages of 0.51, 0.62 and 0.73 year respectively. Emam and Saad (1997) gave an estimate of L_c = 8.2 cm. The lower value of L_c estimated in the present study is may be due to the increasing of small individual's numbers in the fishery as a result of the growth over-fishing.

Recruitment pattern

The recruitment pattern of *S. dollfusi* is obtained by projecting a set of length frequencies backward onto a one year time axis. The recruitment pattern suggests one recruitment pulse per year (Fig. 7).

Trawl net selectivity

Assuming a mean code-end mesh size of 1.9 cm for the trawl net and L_c = 7.3 cm, the estimate of selection factor (SF) was 3.79 (L_c = SF × mesh size), this factor making the calculations of L_c possible for other mesh sizes. The selection ogive analysis of *S. dollfusi* (Fig. 8) led to estimates of L_c = 7.7 cm and of the guessed L' (length at full retention) = 13 cm.

Relative yield per recruit (Y'/R)

The plot of Y'/R against E (Fig. 9A) gives an optimum level of exploitation rate at E = 0.61. Both of $E_{0.1}$ (the level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E) and $E_{0.5}$ (the exploitation level which will result in a reduction of the unexploited biomass by 50%) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.56 and 0.34, respectively. The present level of E (0.7) was higher than that which gives the maximum Y'/R. Also the current exploitation rate is higher than the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass. For management purpose, the exploitation rate of *S. dollfusi* should be reduced from 0.7 to 0.34 (51%) to maintain a sufficient spawning biomass since the maximum Y'/R is not the target point but the maximum constant yield (the maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass) is the target reference point for fisheries management (Caddy and Mahon, 1995). Besides, it is always safe to be on the left of the maximum Y'/R than to use its current value. Emam and Saad (1997) estimated the yield per recruit of *S. dollfusi* in the Gulf of Suez and concluded that this stock was slightly overexploited (they gave a value of E = 0.59).

To determine the effect of the length at first capture on yield, the relative yield per recruit was estimated using a different value of L_c (86 mm instead of 73 mm). The results (Fig. 9B) indicated that with increasing L_c a higher Y'/R can be obtained. It was obvious also that, when we use L_c = 86 mm, the maximum Y'/R was obtained at E= 0.69 (current E = 0.7). This means that. the present level of L_c is not the optimum L_c for this species and it must be about 86 mm (about 9 months old). The values obtained for $E_{0.1}$ and $E_{0.5}$ were 0.66 and 0.37 respectively.

It could be concluded that the *S. dollfusi* stock in the Gulf of Suez is overexploited. To maintain this valuable resource the present level of exploitation rate should be reduced by decreasing the fishing effort or reducing the duration of the fishing period. Also. it is recommended to increase the length and age at first capture by increasing the mesh sizes to about 2.3 cm.

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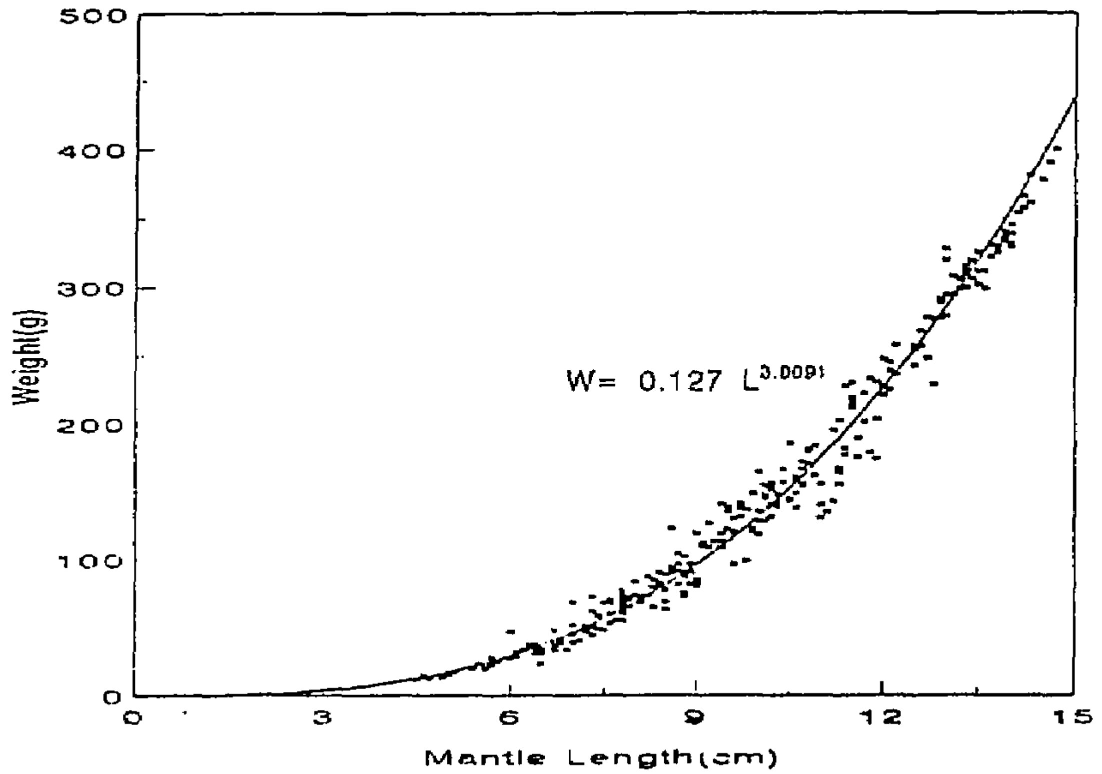

Fig.(1). Mantle length-body weight relationship of *Sepia dollfusi* from the Gulf of Suez.

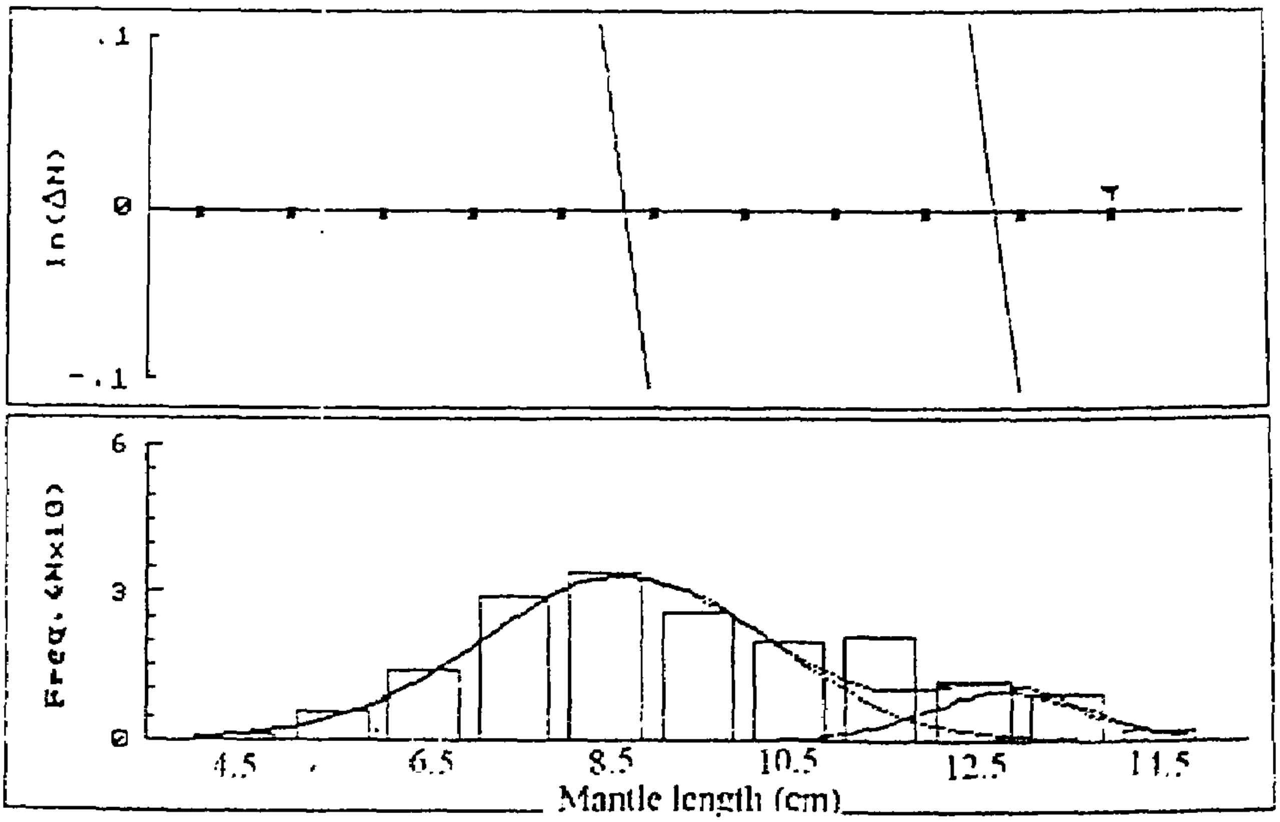

Fig. (2). Bhattacharya method for age determination of *Sepia dollfusi* from the Gulf of Suez.

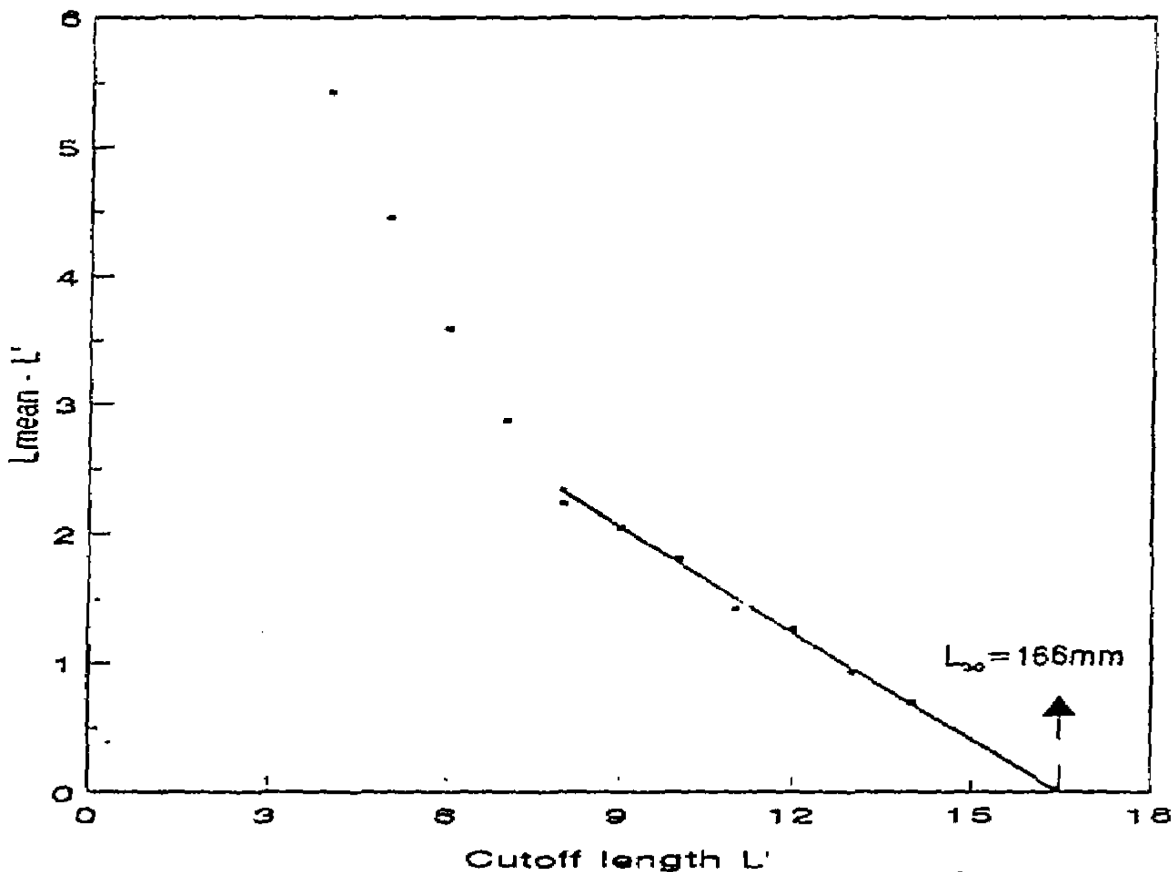

Fig. (3). Wetherall plot for *Sepia dollfusi* from the Gulf of Suez.

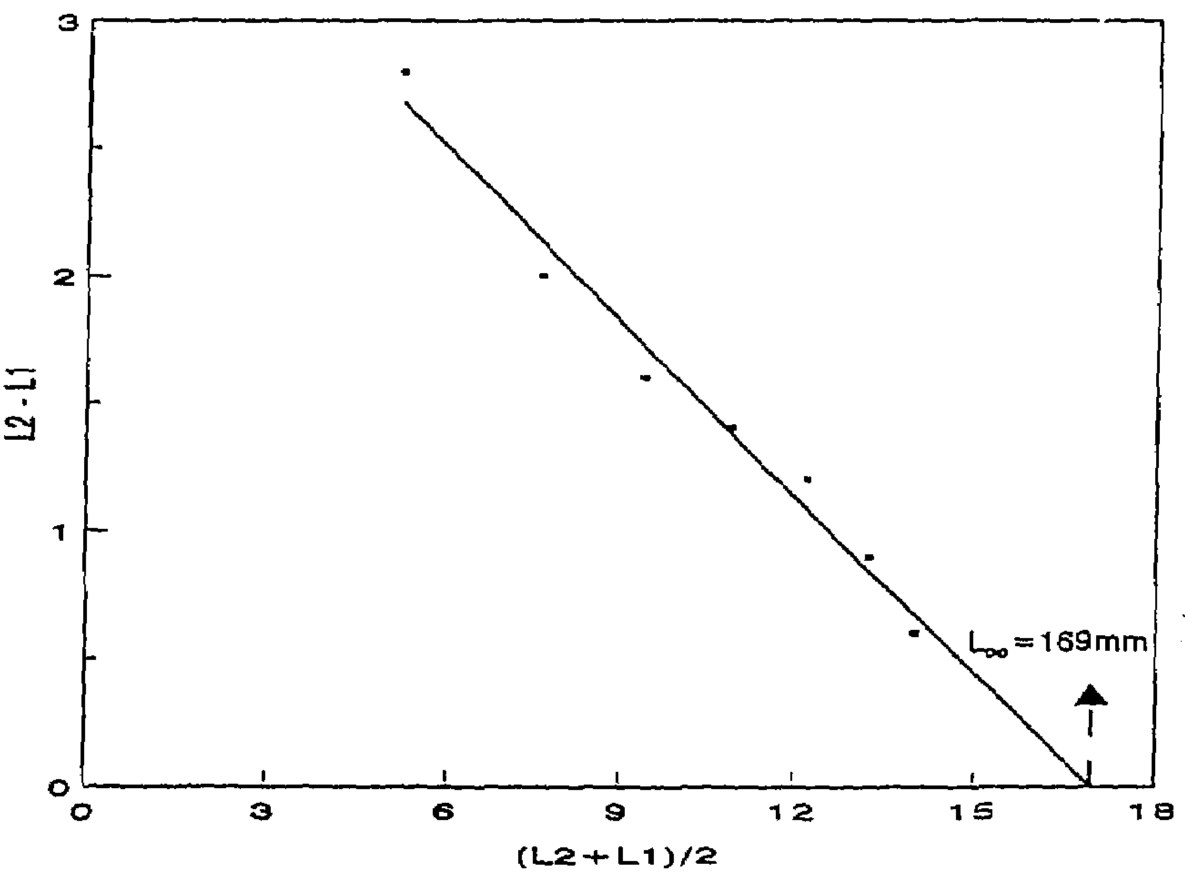

Fig.(4). Gulland and Holt plot for *Sepia dollfusi* from the Gulf of Suez.

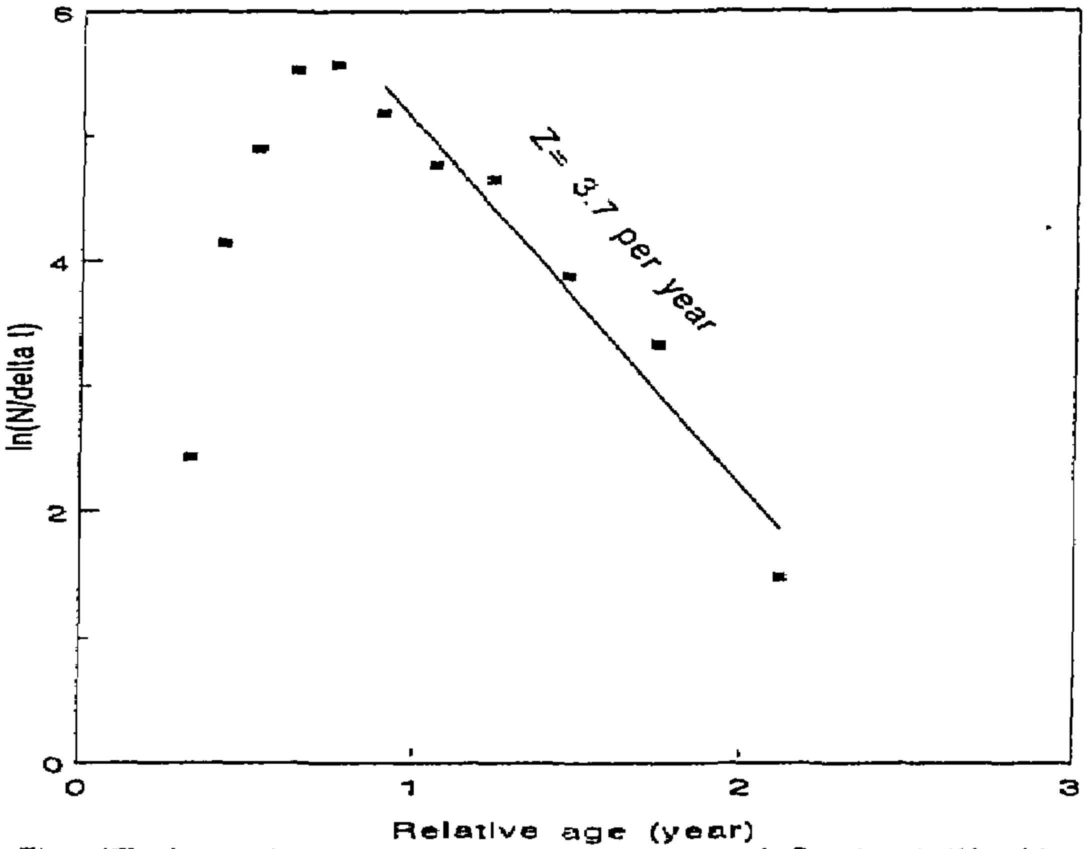

Fig. (5). Length - converted catch curve of *Sepia dollfusi* from the Gulf of Suez.

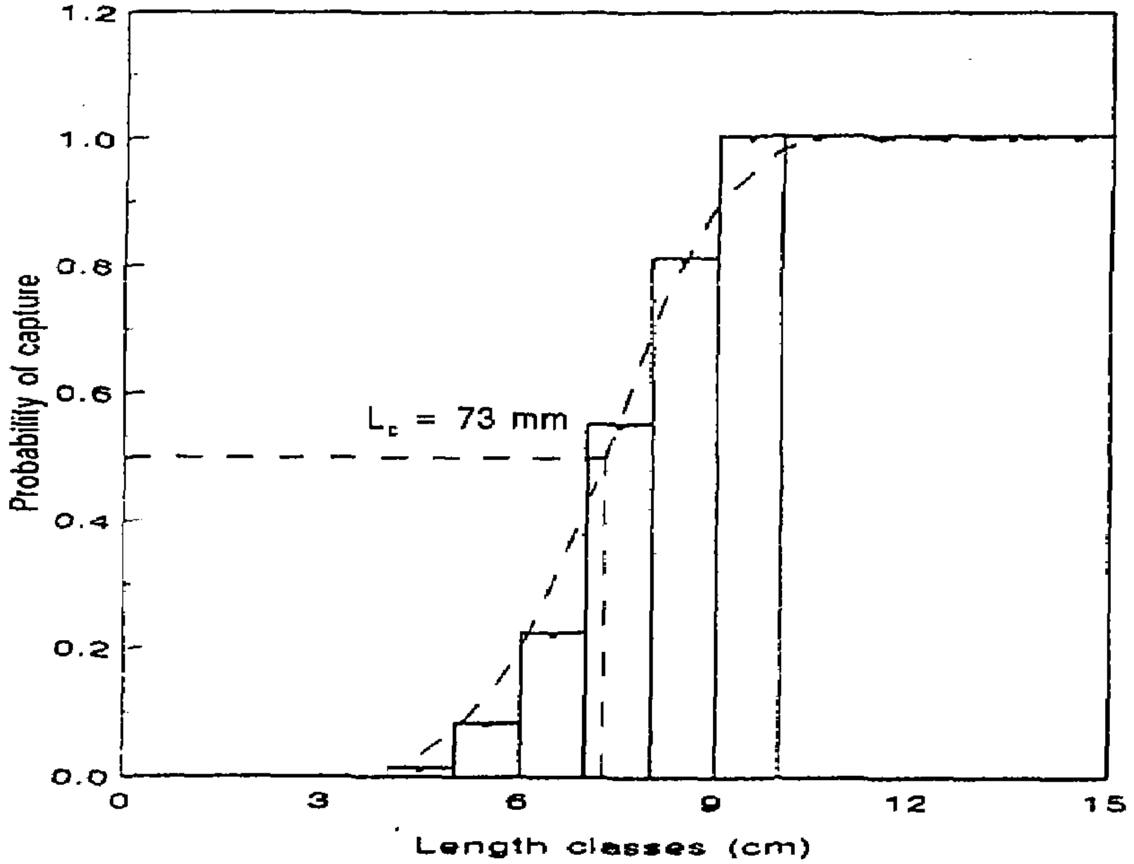

Fig. (6). Probabilities of capture of *Sepia dollfusi* from the Gulf of Suez.

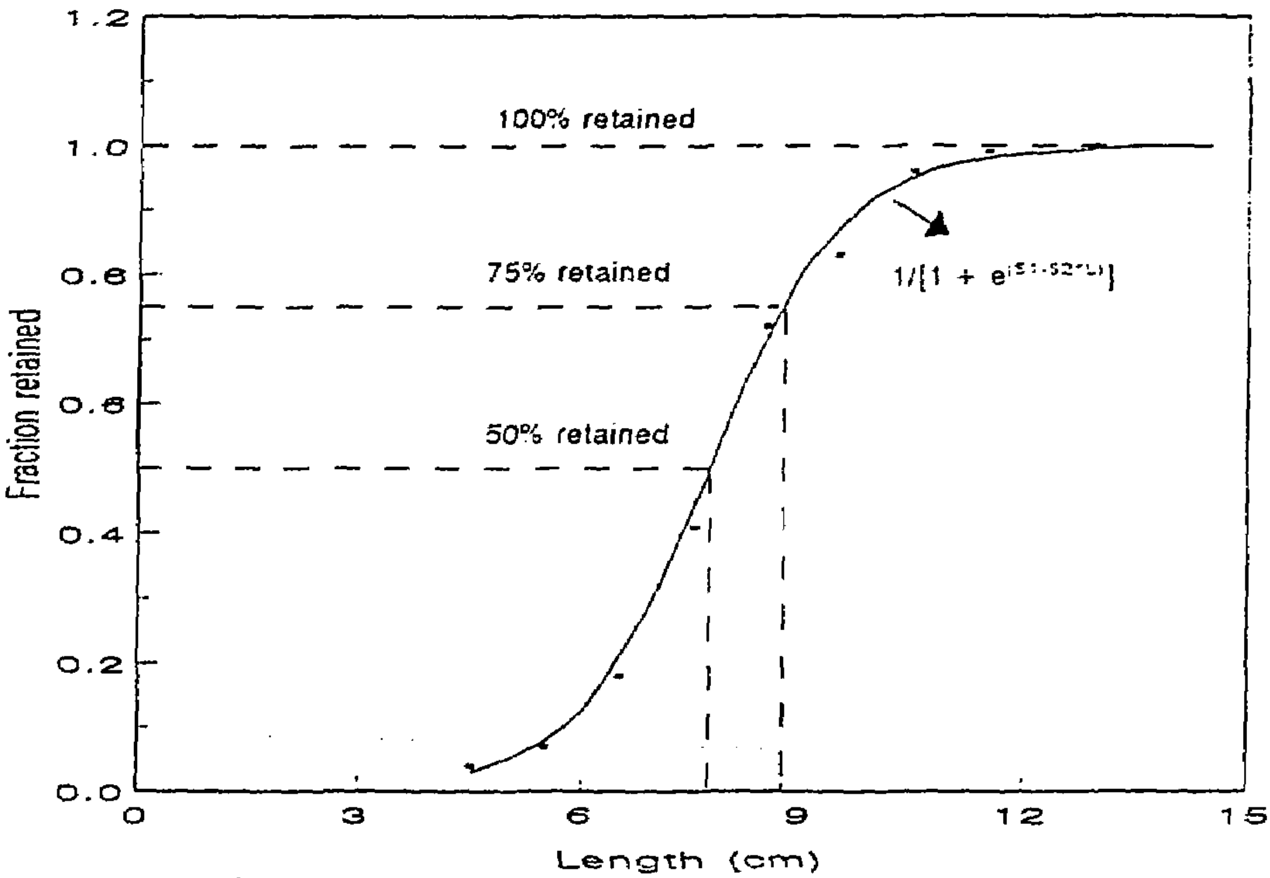

Fig. (7). Gear selection ogive for *Sepia dollfusi* from the Gulf of Suez.

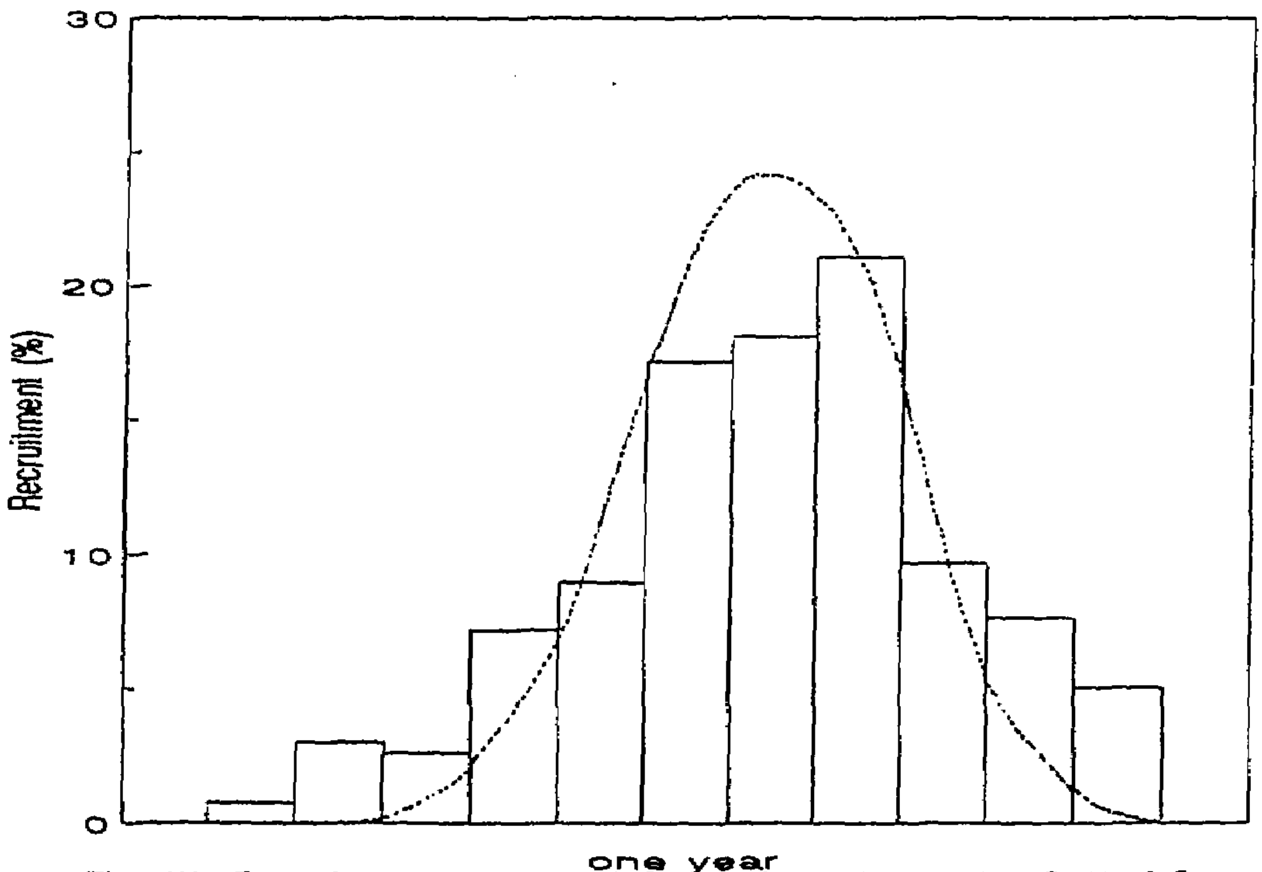

Fig. (8). Recruitment pattern of *Sepia dollfusi* from the Gulf of Suez.

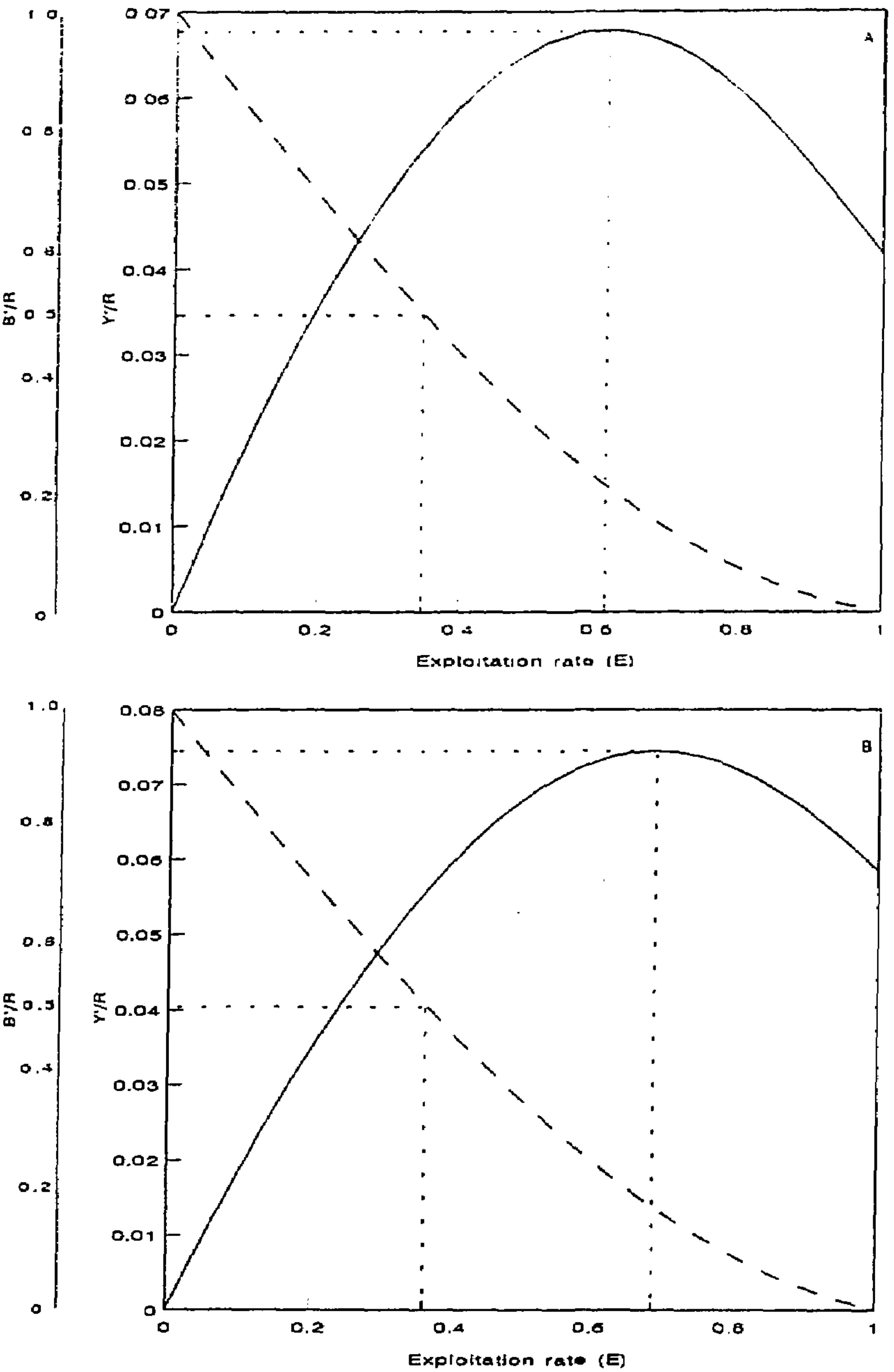

Fig. (9). Relative yield and relative biomass per recruit of *Sepia dollfusi* with different values of L_c(A:L_c=72mm - B:L_c= 86mm).