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# FISHERIES MANAGEMENT OF THE SLIMY MACKEREL *SCOMBER JAPONICUS* IN THE GULF OF SUEZ BASED ON RELATIVE YIELD PER RECRUIT ANALYSIS.

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**Keywords**: *Scomber japonicus*; age; growth; mortality exploitation rate; length at first capture; relative yield relative biomass per recruit.

## ABSTRACT

A total of 928 slimy mackerel *Scomber japonicus* was collected from the Gulf of Suez during the fishing season 2000/2001. Age, growth, mortality, relative yield per recruit and biomass per recruit were studied. Age was determined by otolith-reading technique and was found to be four years. The values of the von Bertalanffy growth parameters were K = 0.48 year$^{-1}$ and $L_\infty$ = 33.06 cm. The mean total mortality coefficient "Z" was found to be 1.24 year$^{-1}$. The natural mortality coefficient "M" was estimated as 0.22 year$^{-1}$. Exploitation rate E was estimated as 0.82. The relative yield per recruit and biomass per recruit analysis showed that the stock of *Scomber japonicus* in the Gulf of Suez is overexploited and the fishing mortality should be decreased while length and age at first capture should be increased.

## INTRODUCTION

Scombrid fishes (Family Scombridae) are considered one of the important fishery resources in the Gulf of Suez. They are caught by the purse-seine fishery. Their average landings have been estimated to be around 2203.5 tons, contributing about 13.3% of the total purse-seine catch (Fig. 1). Scombrid fishes in the Gulf of Suez are represented mainly by two species, the slimy mackerel, *Scomber japonicus* and the indian mackerel *Rastrelliger kanagurta*.

Inspite of the great importance of the slimy mackerel to the economy of the Egyptian fisheries, it was only studied by Rafail (1972) who investigated age, growth and mortality rates of *S. japonicus* from Red Sea near Al-Ghardaqa.

On the other hand, many studies were done dealing with the biology and dynamics of *S. japonicus* in other world localities. Parrish and MacCall (1978) estimated growth parameters in California, USA; Cisneros *et al.* (1990) studied the growth, mortality and recruitment in the Gulf of California, Mexico; Edwards and Shaher (1991) estimated its growth parameters in the Gulf of Aden; Perrotta (1992) studied its growth Argentine Sea; Cucaln- Zenck (1999) estimated its growth parameters in its Gulf of Guayaquil, Ecuador.

The present study is the first trial so far undertaken to estimate growth parameters, mortality and exploitation rates, relative yield per recruit and biomass per recruit of *S. japonicus* in the Gulf of Suez.

## MATERIAL AND METHODS

A total of 928 specimens of *S. japonicus* was sampled from the landing site at Ataka during the fishing season 2000/2001. Total length in centimeter, total weight in gram and otoliths were taken for each specimen.

Annual rings on otoliths were counted using optical system consisting of Nikon Zoom- Stereomicroscope and Heidenhain's electronic bidirectional read out system V R X 182, under transmitted light. The total radius of the otolith "S" and the distance between the focus of the otolith and the successive annuli were measured to the nearest 0.001 mm. Lengths at age were back-calculated using Lee's (1920) equation as follows: $L_n = (L - a)\, S_n/S + a$

Where a is the intercept of the regression line with the Y-axis

The relation between length and weight was computed using the formula $W=a\,L^b$ where W is the total weight in gram, L is the total length in centimeter and, a & b are constants whose values were estimated by the least square method.

The growth parameters ($L_\infty$ and K), total mortality rate (Z), length at first capture ($L_c$), relative yield per recruit and relative biomass per recruit were estimated by applying the FAO-ICLARM Fish Stock Assessment Tools (FiSAT) software of Gayanilo *et al.*, 1997. The used methods are:

-Gulland and Holt (1959) plot incorporated in FiSAT software package to estimate the parameters of von Bertalanffy growth equation.

-Total mortality coefficient "Z" was estimated by the analysis of catch curve based on length frequency data using the method of Pauly (1983a) as provided in the FiSAT software. Also, "Z" was estimated by using the method of Ricker (1975) which is based on age composition data.

-Natural mortality coefficient "M" was estimated by using Ursin (1967) formula as $M = W^{-1/3}$, where W is the total weight of fish.

-Exploitation rate "E" was computed using the formula of Gulland (1971) as E = F/Z.

-The length at first capture "$L_c$" was estimated by the analysis of catch curve using the method of Pauly (1984a&b).

-The relative yield per recruit (Y/R)' and biomass per recruit (B/R)' were estimated by using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in FiSAT software package. This model is defined by:

$$(Y/R)' = E\, U^{M/K}\ [1 - (3U/1+m) + (3U^2/1+2m) - (U^3/1+3m)]$$

$$(B/R)' = (Y/R)'/F$$

where (Y/R)' is the relative yield per recruit

(B/R)' is the relative biomass per recruit

M is the natural mortality coefficient

F is the fishing mortality coefficient

K is the growth parameter

E is the exploitation rate or the fraction of deaths caused by fishing

$m = (1-E)/(M/K) = (K/Z)$

$U = 1 - (L_c/L_\infty)$

$L_\infty$ is the asymptotic length

(Y/R)' can be calculated for a given input value of M/K and $L_c/L_\infty$ for values of E ranging from 0 to 1, corresponding to F-values ranging from 0 to ∞

## RESULTS AND DISCUSSION

### Age Determination

Atotal of 928 otoliths was used for age determination of *S. japonicus* from the Gulf of Suez. The use of otolith annual rings to age *S. japonicus* has been well documented by many authors (Knaggs & Parrish, 1973; Baird, 1977; Martins & Serrano-Gordo, 1984 and Dawson, 1986).

The obtained results indicate that the maximum life span of *S. japonicus* was four years. The age composition showed that, age group I was the dominant age group, contributing about 50.3%. This means that *S. japonicus* in the Gulf of Suez becomes fully recruited to the purse-seine fishery at an age of one year.

**Growth in Length**

**Body Length - Otolith Radius Relationship**

The otolith's measurements of 928 *S. japonicus* were used to describe the relationship between the total length and the otolith radius (Fig. 2). This relationship was found to be linear and can be represented by the following equation:

$$L = 2.79807 + 8.79272\ S \qquad (r = 0.9884)$$

where L is the total length in centimeter,
S is the otolith radius in millimeter
and r is the correlation coefficient.

**Back - Calculations**

The total lengths at the end of each year of life were back-calculated using Lee's equation (1920) as follows:

$$L_n = (L - 2.79807)\ S_n / S + 2.79807$$

where $L_n$ is the length at the end of $n^{th}$ year ,
$S_n$ is the radius of otolith to $n^{th}$ annulus,
S is the total radius of otolith
and L is the total length at capture

The back-calculated lengths at the end of each year of life are given in table (1). It's obvious that, *S. japonicus* attains its highest growth rate in length during the first year of life, after which a gradual decrease in growth increment was noticed with further increase in age.

**Length - Weight Relationship**

The relationship between total length and total weight of *S. japonicus* from the Gulf of Suez was calculated using the measurements of 928 specimens (Fig. 3). Their total lengths ranged between 16 and 30.9 cm, while their total weights varied between 38 and 300 g. The calculated length- weight equation was found to be:

$$W = 0.00806\ L^{3.07018} \qquad (r = 0.9964)$$

**Growth in Weight**

The calculated weights at the end of each year of life of *S. japonicus* were estimated by applying the corresponding length-weight equation to the back-calculated lengths. The results are given in table (2).

The obtained results indicated that the growth rate in weight was much slower during the first year of life. The maximum value of annual increment in weight was observed at the end of the second year of life, after which, a decrease in the growth increment was noticed.

**Theoretical Growth**

The back-calculated lengths were applied to Gulland and Holt (1959) plot to estimate the growth parameters ($L_\infty$, K and $t_0$) of the von Bertalanffy (1938) growth model. The obtained equations were as follows:

For growth in length $L_t = 33.06\ (1 - e^{-0.48\ (t + 0.82)})$

For growth in weight $W_t = 372.28\ (1 - e^{-0.48\ (t + 0.82)})^{3.07018}$

The growth parameters of *S. japonicus* from the Gulf of Suez are shown in table (3) with those reported by other authors.

**Instantaneous total Mortality Coefficient "Z"**

Z was estimated using two methods; Ricker, 1975 method which is based on age composition data and Pauly, 1983 method which is based on the analysis of length frequency data (Fig. 4). The results were as follows:

$Z = 1.21$ year$^{-1}$ (Ricker, 1975)

$Z = 1.27$ year$^{-1}$ (Pauly, 1983a)

It is evident that the estimated values of "Z" obtained from the two different methods are very close to each other.

**Natural Mortality Coefficient "M"**

In the present study, the formula of Ursin (1967) was applied to estimate the natural mortality coefficient "M". The obtained value of "M" was 0.22 year$^{-1}$

**Fishing Mortality Coefficient "F"**

Fishing mortality coefficient "F" was estimated as 1.02 year$^{-1}$.

**Exploitation Rate "E"**

The obtained exploitation rate was 0.82. Gulland suggested that the optimum exploitation rate is about 0.5, so the high value of the present exploitation rate indicates that the stock of *S. japonicus* in the Gulf of Suez is overexploited.

**Length at first capture "$L_c$"**

The length at first capture (the length at which 50% of the fish at that size are vulnerable to capture) was estimated as a component of the length converted catch curve analysis (FiSAT). The value obtained was $L_{50\%}$ = 19.14 cm which corresponds to an age of 0.97 year (Fig. 5).

**Relative Yield per Recruit (Y/R)' and Biomass per Recruit (B/R)'**

The model of Beverton and Holt (1966) was applied to estimate the relative yield per recruit and biomass per recruit of *S. japonicus* from the Gulf of Suez. This model allows a relative prediction of the long term catch weights and stock biomass under different exploitation rates.

The plot of (Y/R)' and (B/R)' against E was shown in Fig 6. As shown from the figure the maximum (Y/R)' was obtained at an exploitation rate 0.7, which is higher than the present level of exploitation rate (0.82). Both of $E_{0.1}$ (the level of exploitation at which the marginal increase in relative yield per recruit is $1/10^{th}$ its value at E=0) and $E_{0.5}$ (the exploitation level under which the stock has been reduced to 50% of its unexploited biomass) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.65 and 0.41 respectively. The results indicated that the present levels of E and F were higher than those which give the maximum (Y/R)'. Also the present level of exploitation rate (E = 0.82) is higher than the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass. For management purpose, the exploitation rate of *S. japonicus* must be reduced from 0.82 to 0.41 (50%) to maintain a sufficient spawning biomass.

Therefore, it could be concluded that the *S. japonicus* stock in the Gulf of Suez is in a situation of overexploitation. To maintain this valuable fish resource, the present level of fishing mortality should be reduced. At the same time, the length at first capture should be increased and the exploitation rate should be reduced below the optimum value.

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**Table (1).** Average back-calculated lengths (cm) of *Scomber japonicus* from the Gulf of Suez.

| Age group | No. of fish | Empirical length | Back-calculated lengths at the end of each year of life | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| I | 467 | 19.11 | 19.58 | | | |
| II | 372 | 24.39 | 19.43 | 24.77 | | |
| III | 75 | 27.95 | 19.35 | 24.58 | 28.12 | |
| IV | 14 | 29.55 | 19.28 | 24.49 | 28.05 | 29.96 |

**Table (2).** Calculated weights (g) of *Scomber japonicus* from the Gulf of Suez.

| Age group | No. of fish | Calculated weights at the end of each year of life | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| I | 467 | 74.51 | | | |
| II | 372 | 72.77 | 153.36 | | |
| III | 75 | 71.85 | 149.78 | 226.38 | |
| IV | 14 | 71.06 | 148.10 | 224.66 | 275.01 |

Table (3). the growth parameters of *Scomber japonicus* from different localities.

| Locality | $L_\infty$ (TL) | K | $t_0$ | Author |
|---|---|---|---|---|
| Red Sea, Egypt | 27.9 | 0.48 | -0.03 | Rafail, 1972 |
| Sea of Marmara | 33.0 | 0.47 | --- | Pauly, 1978 |
| Central Japan Sea | 44.0 | 0.44 | -0.42 | Pauly, 1978 |
| USA(California) | 40.5 | 0.40 | --- | Parrish&MacCall, 1978 |
| Gulf of California | 29.3 SL | 0.50 | --- | Cisneros *et al.*, 1990 |
| Yemen | 53 FL | 0.28 | 0.04 | Edwards&Shaher, 1991 |
| Argentina | 46.0 | 0.28 | -1.54 | Perrotta, 1992 |
| Gulf of Guayaquil | 39.6 | 0.39 | --- | Cucaln-Zenck, 1999 |
| Gulf of Suez, Egypt | 33.06 | 0.48 | -0.82 | The present study |

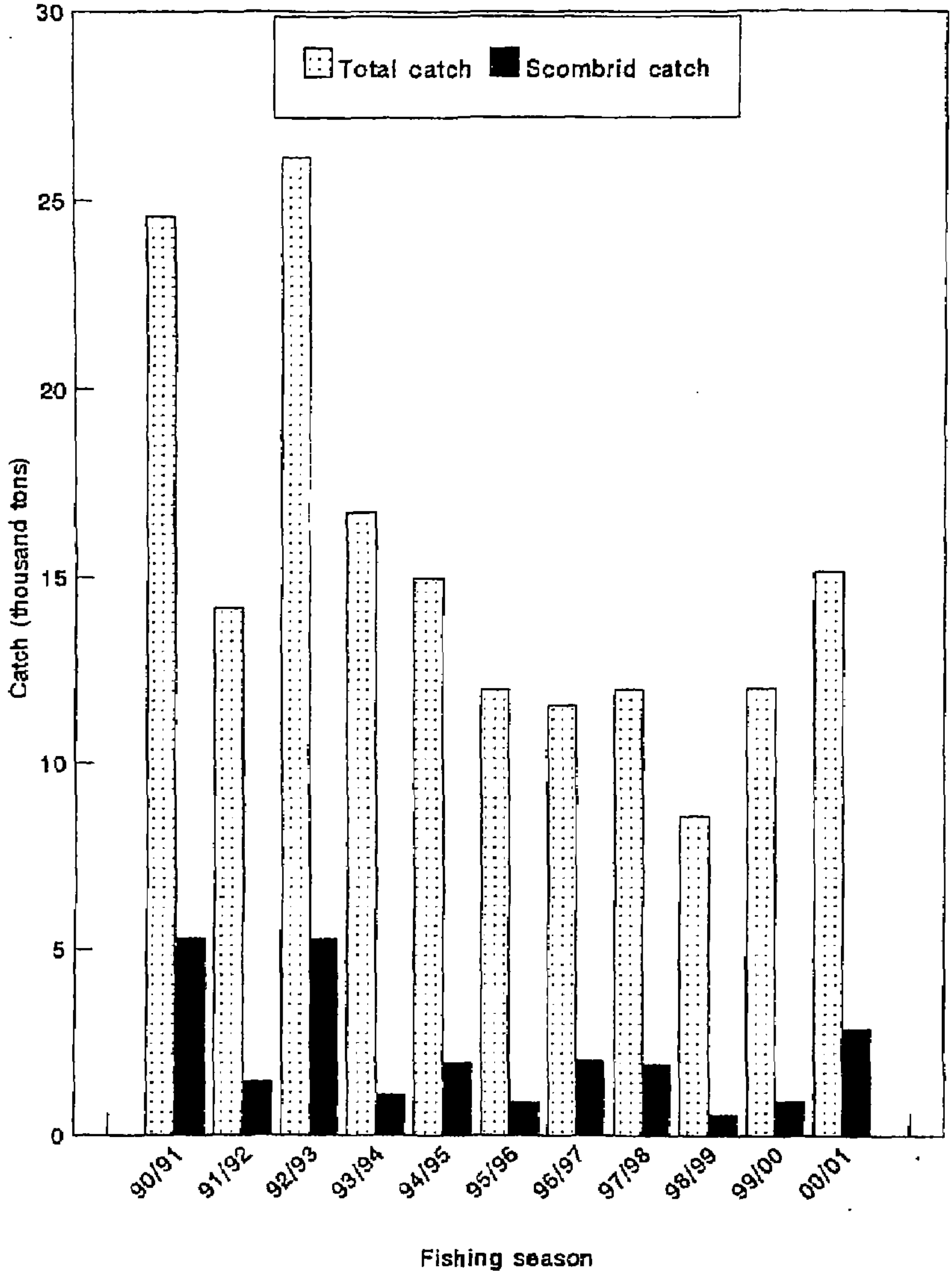



Fig.(1). Total purse-seine catch (ton) and scombrid catch from the Gulf of Suez during the fishing seasons from 1990/1991 to 2000/2001 according to General Authority for Development of Fish Resources.

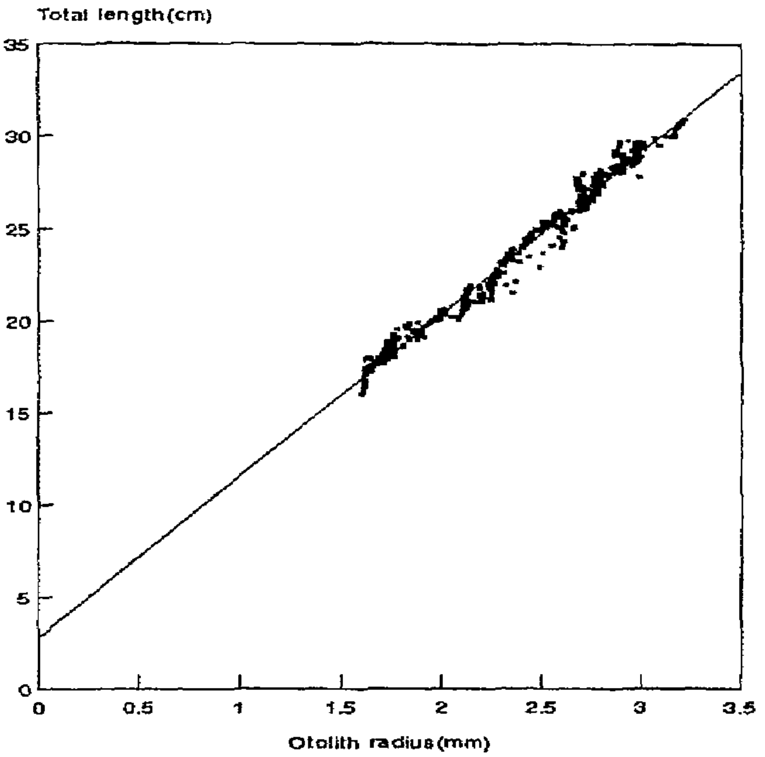



Fig. (2). Length-otolith radius relationship of *Scomber japonicus* from the Gulf of Suez.

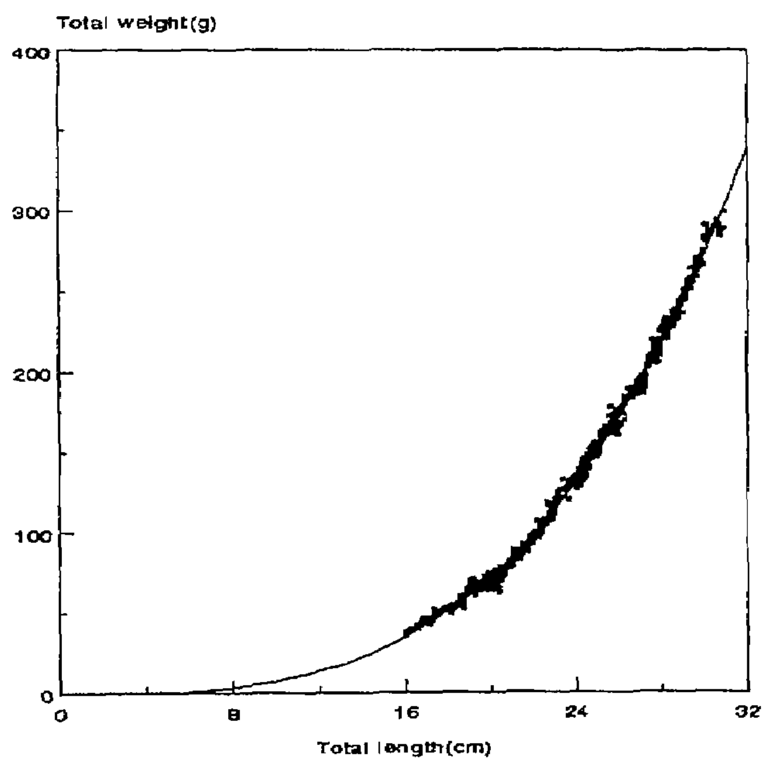



Fig. (3). Length-weight relationship of *Scomber japonicus* from the Gulf of Suez.

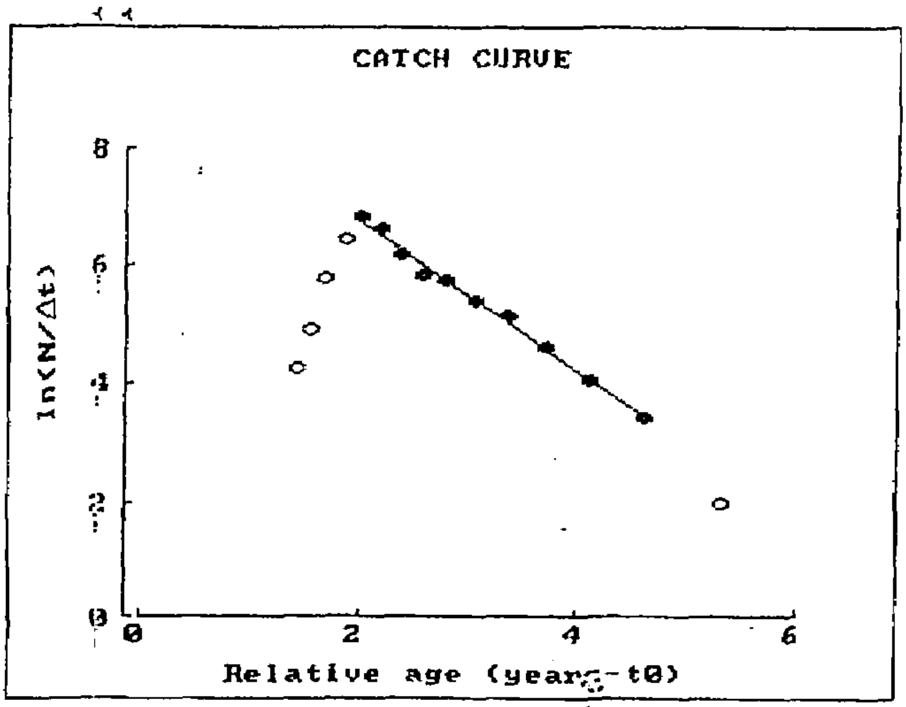



Fig. (4). Estimation of total mortality coefficient "Z" of *Scomber japonicus* from the Gulf of Suez using Pauly's (1983) method.

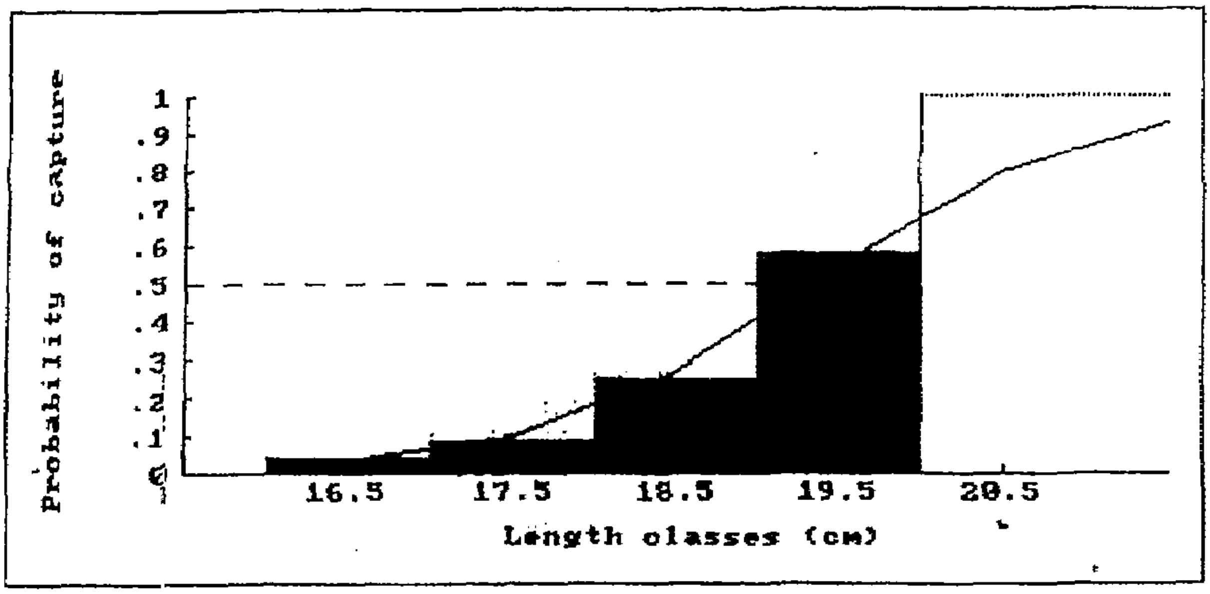
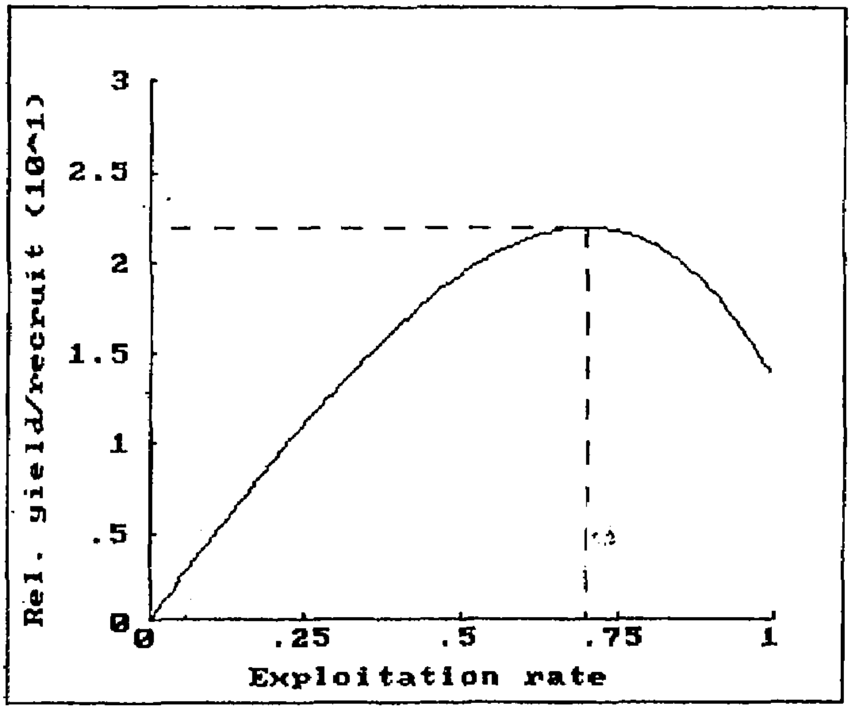



Fig. (5). Length at first capture "$L_c$" estimation of *Scomber japonicus* from the Gulf of Suez.



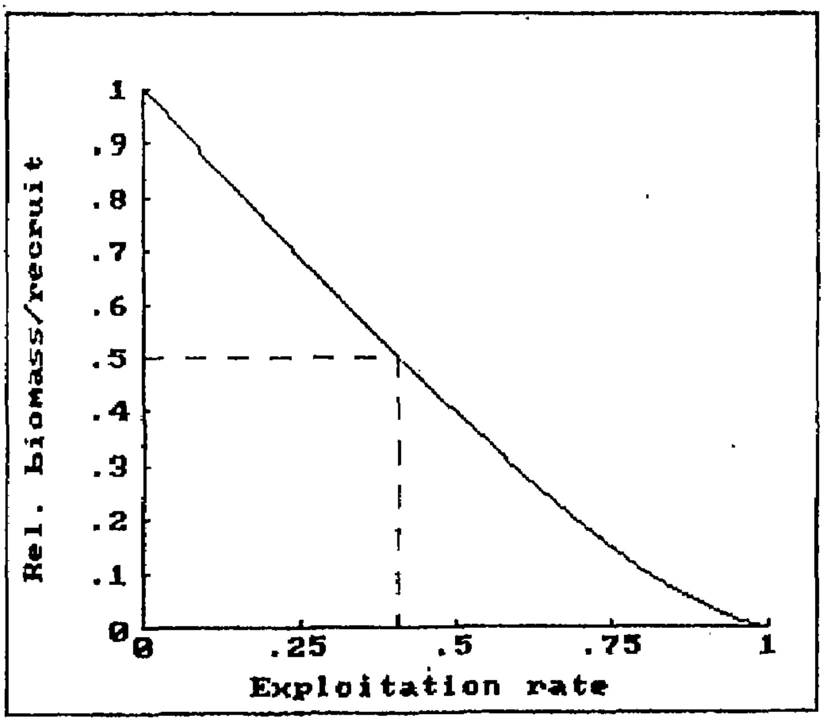




Fig. (6). Relative yield per recruit and relative biomass per recruit of *Scomber japonicus* from the Gulf of Suez.