POPULATION DYNAMICS OF THE BIGEYE SNAPPER *LUTJANUS LINEOLATUS*, RUPPELL, 1829 (FAMILY: LUTJANIDAE) FROM THE GULF OF SUEZ, EGYPT.

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Key Words: *Lutjanus lineolatus*, age and growth, mortality and exploitation rates, relative yield per recruit, relative biomass per recruit.

ABSTRACT

Age, growth, mortality, relative yield per recruit and relative biomass per recruit of *Lutjanus lineolatus* collected from the Gulf of Suez during the period from October 2001 until May 2002 have been estimated. Age was determined from otolith's reading and the results showed that the maximum life span of *L. lineolatus* is 4 years. The growth parameters were estimated as $K = 0.40$ year^{-1} and $L_\infty = 24.45$ cm. The annual rates of total, natural and fishing mortality were calculated as 1.37, 0.31 and 1.06 year^{-1} respectively. Exploitation rate E was estimated as 0.77. The relative yield per recruit analysis showed that the stock of *L. lineolatus* is overexploited. To maintain this living marine resource, precautionary management measures including decrease of the present fishing pressure and increase of the length at first capture to be about 13.5 cm should be applied.

INTRODUCTION

Snappers of family Lutjanidae assume a very important place in trawl fishery in the Gulf of Suez. They constitute about 13.5% of the total trawl catch according to the fishery statistics obtained from the fisheries office of the Ministry of Agriculture at Suez Governorate (Fig. 1). Among the various species of snappers in the Gulf of Suez, *Lutjanus lineolatus* is the most widely distributed and heavily exploited one. This fish has been popular as excellent seafood with a reasonable market price. Despite the great importance of these species to the economy of the Egyptian fisheries, only one study is available. Sanders *et al.* (1984) estimated the growth parameter and mortality rates of *L. lineolatus* from the Gulf of Suez.

On the other hand, the biology and dynamics of snappers have been studied in different localities (Pauly, 1978; Brouard and Grandperrin, 1984; Edwards, 1985; Manooch, 1987; Cappo *et al.*, 2000; Wilson and Nieland, 2001; Burton, 2001).

The present study deals with estimating the growth, mortality and exploitation rates, relative yield per recruit and relative biomass per recruit of *L. lineolatus* from the Gulf of Suez. It also aims at finding out a proper management plan to reserve this valuable fish resource.

MATERIAL AND METHODS

Monthly random samples (913 fish ranging from 8.1 - 21.4 cm TL) were collected from the local market in Suez city during the period from October 2001 until May 2002. The total length to the nearest millimeter, total weight to the nearest 0.1g, sex and otoliths were taken for each individual of *L. lineolatus*.

Otoliths were removed, rinsed of any adhering tissues, and sorted dry in labelled vials until processing. Annual rings on otoliths were counted using optical system consisting of Nikon Zoom - Stereomicroscope focusing block, 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 by age were back - calculated using Lee's (1920) equation.

The relation between the total length (L) and total weight (W) was computed using the formula $W = a L^b$ where a and b are constants whose values were estimated by the least square method.

The FAO-ICLARM Stock Assessment Tools (FiSAT; Gayanilo *et al.* 1997) was used to store the length frequencies and, eventually, for the estimation of the population parameters. The back-calculated lengths were used to estimate the growth parameters of the von Bertalanffy growth model $L_t = L_\infty (1-e^{-K(t-t_0)})$ by fitting the Gulland and Holt (1959) plot while "t_0" was estimated by the equation $t_0 = t + 1/K \; Ln (L_\infty - L_t / L_\infty)$. The growth performance index (ø) was computed according to the formula of Pauly and Munro (1984) as $ø = Log K + 2 Log L_\infty$.

The total mortality coefficient "Z" was estimated using the method of Pauly (1983a). The natural mortality coefficient "M" was estimated using the formula of Ursin (1967) which was expressed as $M = W^{-1/3}$ where W is the total weight of fish while the fishing mortality coefficient "F" was estimated as F = Z – M. The exploitation rate "E" was calculated 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). Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)' were estimated using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in the FiSAT software. 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
$m = (1-E)/(M/K) = (K/Z)$
$U = 1 - (L_c/L_\infty)$
M = the natural mortality coefficient
F = the fishing mortality coefficient
K = the growth parameter
E = the exploitation rate

RESULTS AND DISCUSSION

Age Determination

Otoliths were used to age *L. lineolatus* in the Gulf of Suez. The use of otolith annual rings to age several tropical and subtropical lutjanids has been well documented by many authors (Beamish and Mc Farlane, 1983 & 1987; Manooch, 1987; Fowler, 1995; Cappo *et al.*, 2000; Wilson and Nieland, 2001). The obtained results indicated that, the maximum life span of *L. lineolatus* was four years. The age composition showed that ,age group I is the dominant age group, contributing about 65.7%. This means that *L. lineolatus* in the Gulf of Suez become fully recruited to the trawl fishery at an age of one year.

Growth in Length

Body Length - Otolith Radius Relationship

The otolith's measurements of 913 *L. lineolatus* were used to describe the relationship between the total length and the otolith radius. This relationship was found to be linear and can be represented by the following equation:

$$L = 0.6762 + 3.7812\,S \qquad (r = 0.98)$$

where L = the total length in centimeter,
S = the otolith radius in millimeter
and r = 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:

$$L_n = (L - 0.6762)\, S_n / S + 0.6762$$

where L_n = the length at the end of n^{th} year ,
S_n = the radius of otolith to n^{th} annulus,
S = the total radius of otolith
and L = 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, *L. lineolatus* 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. This result is in a good agreement with the findings of Sanders *et al.*, 1984. They stated that the young stages of *L. lineolatus* characterized by a higher growth rate than the old ones.

Length - Weight Relationship

Length and weight measurements of 913 specimens were used to describe the length-weight relationship of *L. lineolatus* in the Gulf of Suez (Fig. 2). Their total lengths varied between 8.1 and 21.4 cm while the total weights ranged between 8 and 130.5 g. The obtained equation was as follows:

$$W = 0.0133\ L^{3.0253}$$

or $\quad \text{Log } W = -1.8762 + 3.0253 \text{ Log } L$

Growth in Weight

The calculated weights at the end of each year of life of *L. lineolatus* were estimated by applying the corresponding length-weight equation to the back-calculated lengths and the resulting values are given in Table 2. The results indicated that, the growth rate in weight was much slower during the first year of life and reaches its maximum value at the end of the second year of life after which, a decrease in the growth increment was observed.

Growth Parameters

The back-calculated lengths were applied according to Gulland and Holt (1959) plot incorporated in FiSAT software package to estimate the von Bertalanffy growth parameters (L_∞ and K). The obtained equations were as follows:

For growth in length $L_t = 24.45\ (1 - e^{-0.4\ (t+0.6)})$

For growth in weight $W_t = 210.77\ (1 - e^{-0.4\ (t+0.6)})^{3.025}$

The only previous work estimating the growth parameters of *L. lineolatus* in the Gulf of Suez is that of Sanders *et al.*, 1984. They found that K= 0.14, L_∞ = 22 cm and t_0= -3.4yr. Table (3) demonstrated the values of growth parameters obtained from the present study compared with those reported by other authors for some related species.

Growth Performance Index (ø)

The growth performance index (ø) of *L. lineolatus* was computed as 2.38. This value is consistent with other estimates.

Mortality Rates

The total mortality coefficient "Z" was estimated using the method of Pauly (1983a) which is based on the analysis of length-frequency data (Fig. 3). The results show that the total mortality coefficient of *L. lineolatus* was 1.37 year^{-1}. The natural mortality coefficient "M" was estimated using the formula suggested by Ursin (1967) and the obtained value of M was 0.31 year^{-1} while the fishing mortality coefficient "F" was estimated as F = Z - M and found to be 1.06 year^{-1}

The high value of "Z" is due to the high value of fishing mortality. This indicates that this fish is very vulnerable to the gear used. Sanders *et al.*, 1984 estimated the total mortality coefficient and natural mortality coefficient as 1.5 year^{-1} and 0.5 year^{-1} respectively.

Exploitation Rate "E"

Exploitation rate "E" was computed using the formula of Gulland (1971) and the obtained E was 0.77. 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 *L. lineolatus* 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 $L_{50\%}$ = 10.80 cm (Fig. 4).

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

The model of Beverton and Holt (1966) modified by Pauly and Soriano (1986) and incorporated in FiSAT software package was applied to estimate the relative yield per recruit of *L. lineolatus* in 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)' against E was shown in Fig 5. As shown from the figure the maximum (Y/R)' was obtained at $E_{MSY} = 0.61$ as the exploitation rate increases beyond this value, relative yield per recruit decreases. 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 0.36 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 = 0.77) is higher than the exploitation rate ($E_{0.5}$) which maintains 50% of the stock biomass (Fig. 6). For management purposes, the exploitation rate of *L. lineolatus* must be reduced from 0.77 to 0.36 (53.25%) to maintain a sufficient spawning biomass.

It could be concluded that the *L. lineolatus* stock in the Gulf of Suez is in a situation of overexploitation and to maintain this valuable fish resource, the exploitation rate should be reduced below the optimum value as well as increase the length at first capture to be about 15 cm.

Sanders *et al.* (1984) came to the same conclusion. They stated that the stock of *L. lineolatus* in the Gulf of Suez is fully exploited and any addition in the fishing effort will be associated with a decrease in the catch.

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

Age group	No. of fish	Empirical length	Back-calculated lengths at the end of each year of life (cm)			
			1	2	3	4
I	600	13.05	**12.20**			
II	228	16.96	12.15	**16.30**		
III	71	19.41	12.12	16.29	**18.90**	
IV	14	21.18	12.06	16.21	18.82	**20.8**
Total	913					

Table (2). Calculated weights (g) of *Lutjanus lineolatus* from the Gulf of Suez.

Age group	No. of fish	Calculated weights at the end of each year of life (g)			
		1	2	3	4
I	600	**25.73**			
II	228	25.41	**61.81**		
III	71	25.22	61.70	**96.72**	
IV	14	24.85	60.79	95.49	**129.24**
Total	913				

Table (3). Comparison of growth parameters of *Lutjanus lineolatus* and some related species in different localities.

Species	K	L_∞	Ø	Locality	Author
Lutjanus apodus	0.18	63.0	2.85	Jamaica	Pauly, 1978
L. malabaricus	0.31	60.0	3.05	South Pacific	Brouard&Grandperrin, 1984
L. malabaricus	0.17	83.0	3.06	Australia	Edwards, 1985
L. sanguineus	0.24	89.0	3.27	Gulf of Aden	Edwards, 1985
L. griseus	0.17	71.7	2.94	North Florida	Burton, 2001
L. griseus	0.13	62.5	2.71	South Florida	Burton, 2001
L. lineolatus	0.14	22.0	1.83*	Gulf of Suez	Sanders *et al.*, 1984
L. lineolatus	0.40	24.45	2.38	Gulf of Suez	The present study

* ø was estimated with the present author.

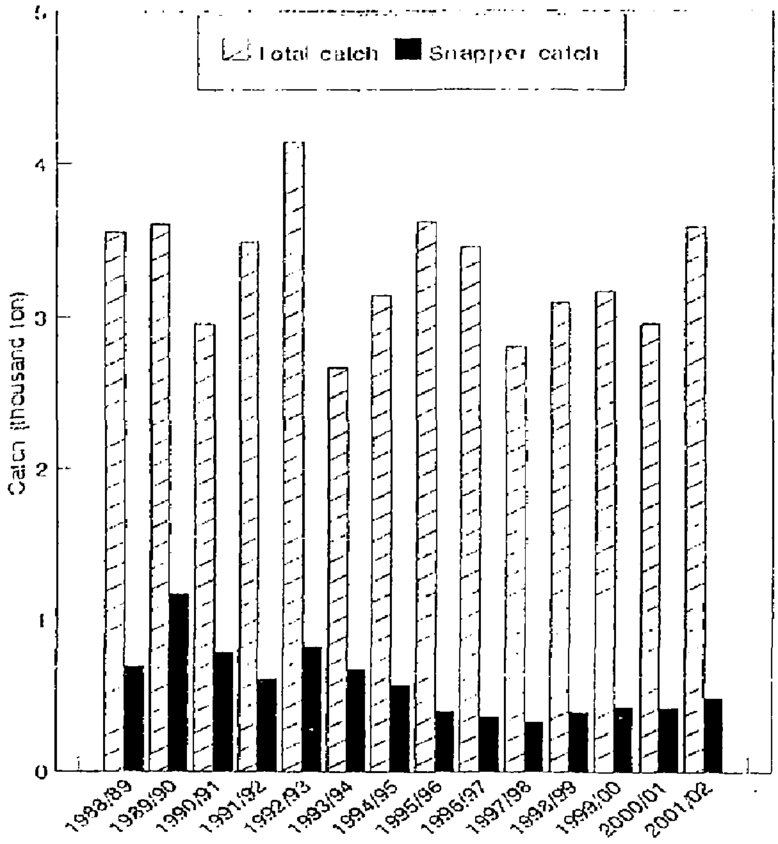

Fig. (1). Total trawl catch and snapper catch (ton) from the Gulf of Suez during the fishing seasons from 1988/89 to 2001/02

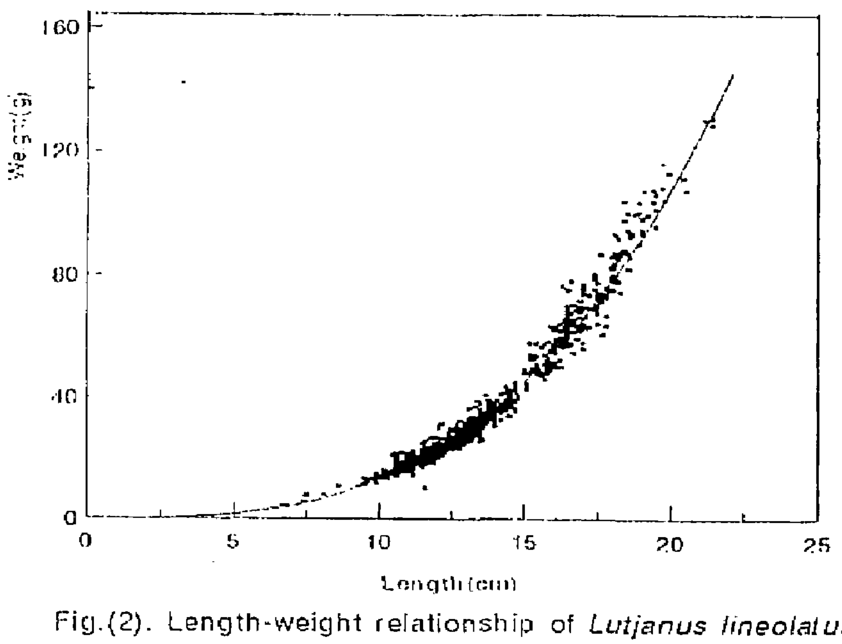

Fig.(2). Length-weight relationship of *Lutjanus lineolatus*.

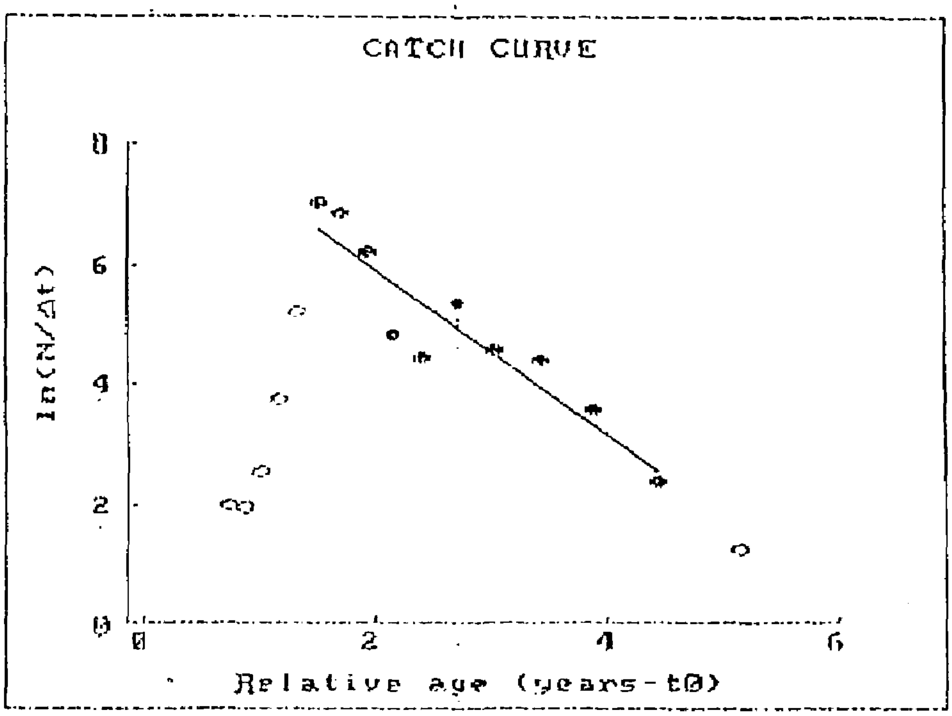

Fig. (3). Estimation of "Z" of *Lutjanus lineolatus* from the Gulf of Suez.

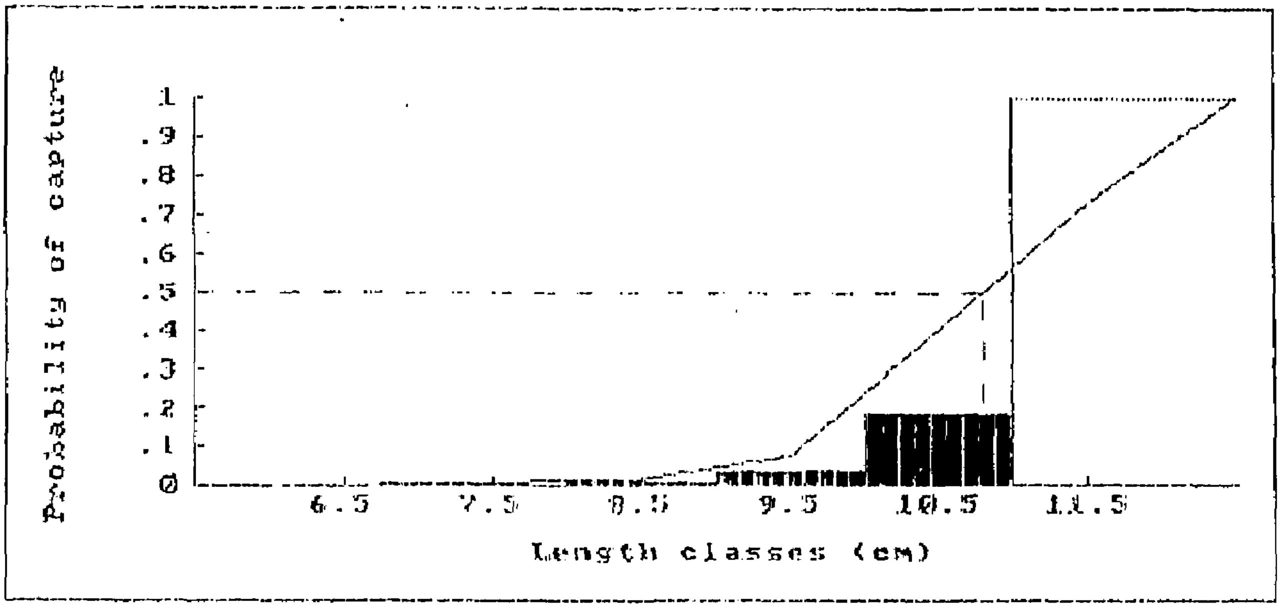

Fig. (4). Length at first capture "Lc" of *Lutjanus lineolatus* from the Gulf of Suez.

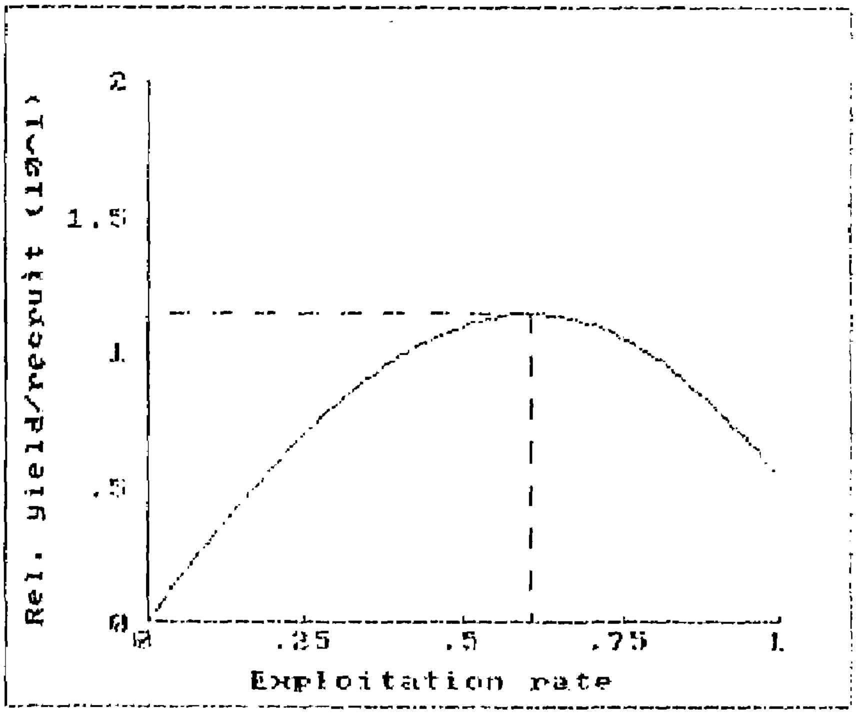

Fig. (5). Relative yield per recruit of *Lutjanus lineolatus* from the Gulf of Suez.

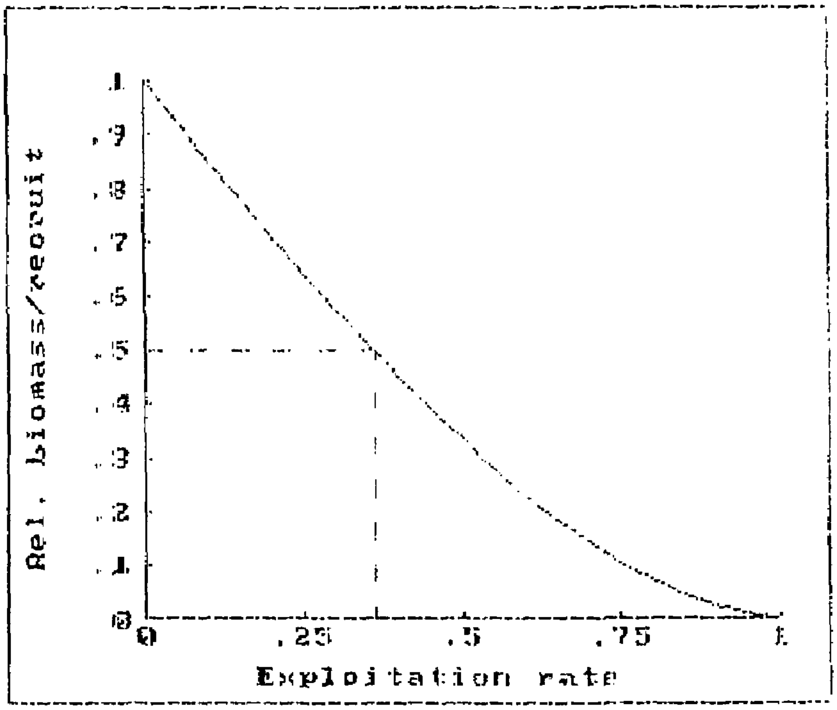

Fig. (6). Relative biomass per recruit of *Lutjanus lineolatus* from the Gulf of Sue