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POPULATION DYNAMICS OF *LUTJANUS LINEOLATUS* (FAMILY: LUTJANIDAE) FROM THE BITTER LAKES, SUEZ CANAL, EGYPT

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ABSTRACT

A total of 837 *Lutjanus lineolatus* was collected monthly from Bitter Lakes during October 2002 through October 2003 to study age and growth, mortality, relative yield per recruit and relative biomass per recruit. Age was determined from otolith's reading and the results showed that the maximum life span of *L. lineolatus* is 3 years. The growth parameters were estimated as K = 0.60 year-1, $L\infty$ = 22.92 cm TL and to = -0.27 yr. The annual rates of total, natural, fishing mortality and exploitation rate were calculated as 2.5, 0.6, 1.9 and 0.76 year-1 respectively. The high level of both fishing mortality and exploitation rate indicated the high level of exploitation of this species. The length at first capture Lc was 11.1 cm TL.The relative yield per recruit analysis showed that the stock of *L. lineolatus* is over-fished. To maintain this valuable fish resource, the present fishing effort should be decreased and the length at first capture should be increased.

INTRODUCTION

Before the construction of the Suez Canal in the 19th century, the Bitter Lakes were relatively small hyper-saline inland lakes surrounded by salt-encrusted sabkha. After the lakes were connected with both the Mediterranean and the Red Sea by the Suez Canal, they became a single marine body; their size increased, and their salinity decreased (Pietro *et al.*, 2004). The northern wider end of the water body is known as the Great Bitter Lake, while the southern narrower part is know as the Little Bitter Lake.

Family Lutjanidae which commonly known as snappers has a great economic importance in Bitter Lakes fisheries. These fish have been popular as excellent seafood with a reasonable market price. Despite the great importance of this species, no studies undertaken about its biology and dynamics at Bitter Lakes and the only two studies done in the Gulf of Suez were those of Sanders *et al*.,(1984) and Mehanna(2003).

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; Fischer *et al*., 2004; Garber *et al*., 2004; Pruett *et al*., 2005; Saillant and Gold, 2006).

The present study is the first to estimate age and growth, mortality and exploitation rates, relative yield per recruit and relative biomass per recruit of *L. lineolatus* at Bitter Lakes and to evaluate the status of this valuable fish resource.

MATERIAL AND METHODS

Monthly random samples of 837 fish ranging from 7 to 20.6 cm TL were collected from the landing site of Bitter Lakes (Shandoura and Fanara) during the period from October 2002 to October 2003.. 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*.

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 back-calculated lengths were used to estimate the growth parameters of the von Bertalanffy growth model $L_t = L_\infty (1-e^{-K(t - t_o)})$ by fitting the Ford (1933)-Walford (1946) plot while "to" was estimated by the equation $t_o = t + 1/K \, Ln \, (L_\infty - L_t / L_\infty)$. 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 Ricker (1975) which based on age composition of the stock. The natural mortality coefficient M was estimated using the formula of Taylor (1960) as M = 3/ tmax where tmax is the maximum age , 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 "Lc" 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) which is defined as:

$$(Y/R)' = E\,U\,M/K\ [1 - (3U/1+m) + (3U2/1+2m) - (U3/1+3m)]$$

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

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

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

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

$U = 1 - (Lc/L\infty)$

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* at Bitter Lakes. The use of otolith annual rings to age fish species belonging to family Lutjanidae 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; Mehanna, 2003). Mehanna (2003) gave back calculated lengths of 12.20, 16.30, 18.90 and 20.8 cm at the end of the 1^{st}, 2^{nd}, 3^{rd} and 4^{th} year of life respectively for *L. lineolatus* in the Gulf of suez (maximum length was 21.4 cm).The obtained results showed that, the maximum life span of *L. lineolatus* was three years. The age composition (Fig. 1) showed that age group I is the dominant age group, contributing about 89.5%. This means that *L. lineolatus* at Bitter Lakes become fully recruited to the fishery at an age of one year.

Growth in Length

Body length - otolith radius relationship

The relationship between the total length and the otolith radius of *L. lineolatus* (Fig. 2) was estimated by using otolith's measurements of 837 fish and the obtained e`3e`quation was as follows:

$$L = 4.5481 + 8.2558\ S \qquad (R^2 = 0.975)$$

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

Back - calculations

The total lengths corresponding to different age groups were back-calculated using Lee's equation (1920) as follows:

$$L_n = (L - 4.5481)\ S_n / S + 4.5481$$

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 (Table 1) indicated that, *L. lineolatus* attains its highest growth rate in length during the first year of life. This result is in agreement with the findings of Sanders *et al.* (1984) and Mehanna (2003). They stated that the young stages of *L. lineolatus are* characterized by a higher growth rate than the old ones and the first year of life had the maximum growth rate in length.

Length - Weight Relationship

The length-weight relationship of *L. lineolatus* at Bitter Lakes (Fig. 3) was described using length and weight measurements of 837 specimens. The total lengths ranged between 7 and 20.6 cm, while the total weights varied from 5 and 125 g. The obtained equation was as follows:

$$W = 0.0191\ L^{2.8663} \qquad (r^2 = 0.976)$$

Or Log W = -1.7190 + 2.8663 Log L

Growth in Weight

The estimated parameters of length-weight equation was used to convert the back-calculated lengths to the corresponding weights (Table 2). It was obvious that, the minimum growth rate in weight was at the first year of life and the maximum value was at the end of the second year of life.

Growth Parameters

Ford (1933) – Walford (1946) plot was applied to estimate the von Bertalanffy growth parameters (L_∞ and K). The obtained values were K = 0.6 per year, L_∞ = 22.92 cm TL, t_0 = -0.27 year and W_∞ = 151.29 g.

Table (3) summarizes the values of growth parameters obtained from the present study compared with those reported by other authors for the same and some related species.

Growth Performance Index (ø)

The growth performance index (ø) of at Bitter Lakes was estimated as 2.5, this means that the growth rate of *L. lineolatus* at Bitter Lakes is greater than that of the same species in the Gulf of Suez (Table 3).

Mortality and Exploitation Rates

The obtained values of the total mortality (Z), natural mortality (M) and fishing mortality (F) coefficients of *L. lineolatus* were 2.5, 0.6 and 1.9 year^{-1} respectively. The exploitation rate (E) was computed as 0.76. Gulland(1971) 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* at Bitter Lakes is overexploited.

For the same species in the Gulf of Suez, Sanders *et al.* (1984) estimated Z and M as 1.5 and 0.5 year^{-1} respectively, while Mehanna (2003) gave Z= 1.37 year^{-1} M = 0.31 year^{-1}and E = 0.77 year^{-1}. This difference may be due to the difference in the length range between the two fishing areas.

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 11.1cm which corresponding to an age of 0.83 year.

Yield of biomass Per Recruit Analysis

The model of Beverton and Holt (1966) modified by Pauly and Soriano (1986) was applied to estimate the relative yield per recruit and biomass per recruit for *L. lineolatus* at Bitter Lakes (Fig. 4).

The maximum (Y/R)' was obtained at E_{MSY} = 0.65 as the exploitation rate increases beyond this value,the relative yield per recruit decreases and 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 0.57 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 = 0.76) was higher than the exploitation rate ($E_{0.5}$) which maintains 50% of the stock biomass (Fig. 4). For management purposes, the exploitation rate of *L. lineolatus* must be reduced from 0.76 to 0.36 (52.63%) to maintain a sufficient spawning biomass.

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Table (1). Average back-calculated lengths of *Lutjanus lineolatus* at Bitter Lakes.

Age group	No. of fish	Empirical length(cm)	Back-calculated lengths (cm)at the end of each year of life		
			1	2	3
I	749	13.10	12.28		
II	83	17.92	11.97	17.11	
III	5	20.05	11.66	16.98	19.75
Total	837				

Table (2). Calculated weights of *Lutjanus lineolatus* from Bitter Lakes.

Age group	No. of fish	Calculated weights (g)at the end of each year of life		
		1	2	3
I	749	25.29		
II	83	23.51	65.45	
III	5	21.80	64.03	98.75

Table (3). Growth parameters of *Lutjanus lineolatus* and some related species.

Species	K	L_∞	Θ	Locality	Author
Lutjanus	0.18	63.0	2.85	Jamaica	Pauly(1978)
apodus	0.31	60.0	3.05	South Pacific	Brouard&Grandperrin (1984)
L.malabaricus	0.17	83.0	3.06	Australia	Edwards(1985)
L.malabaricus	0.24	89.0	3.27	Gulf of Aden	Edwards(1985)
L. sanguineus	0.17	71.7	2.94	North	Burton(2001)
L. griseus	0.13	62.5	2.71	Florida	Burton(2001)
L. griseus	0.14	22.0	1.83	South	Sanders *et al.*(1984)
L. lineolatus		24.4	2.38	Florida	Mehanna(2003)
L. lineolatus	0.40	5	2.5	Gulf of Suez	The present study
L. lineolatus	0.6	22.9		Gulf of Suez	
		2		Bitter Lakes	

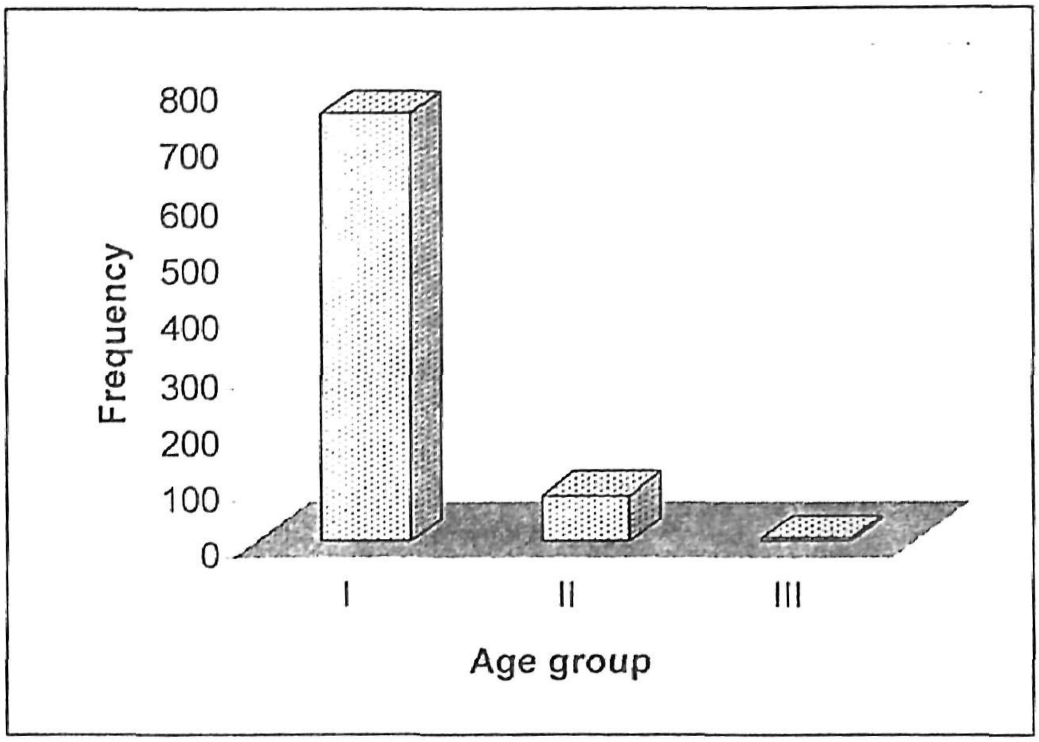

Fig. (1). Age composition of *Lutjanus lineolatus* from the Bitter Lakes.

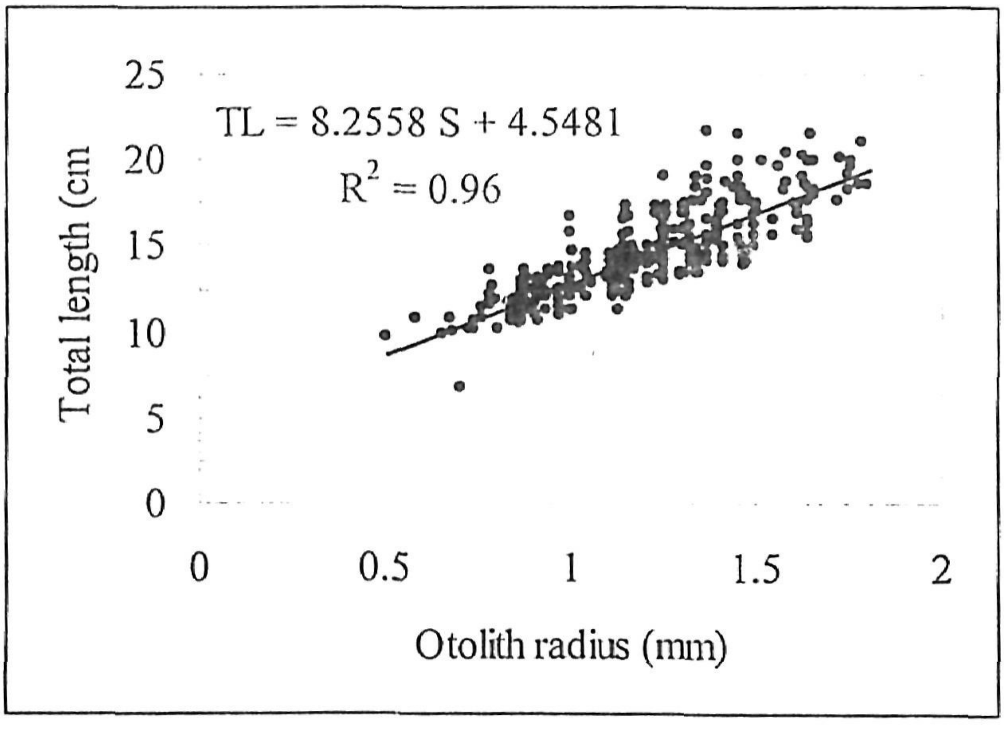

Fig. (2). Length-otolith radius relationship of *Lutjanus lineolatus* at the Bitter Lakes.

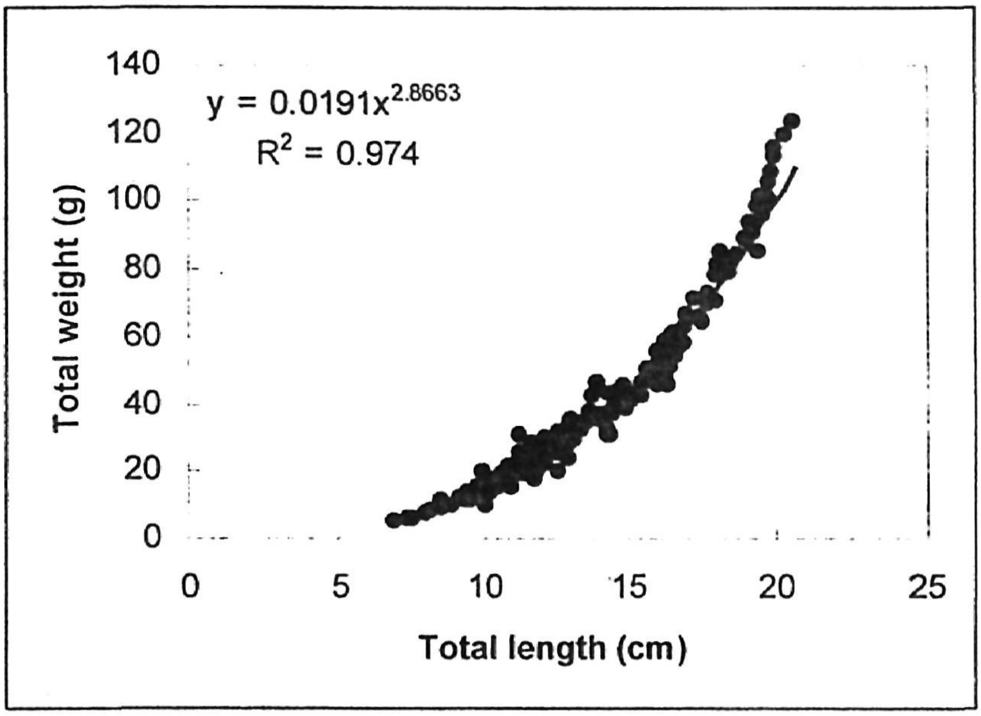

Fig. (3). Length-weight relationship of *Lutjanus lineolatus* at the Bitter Lakes.

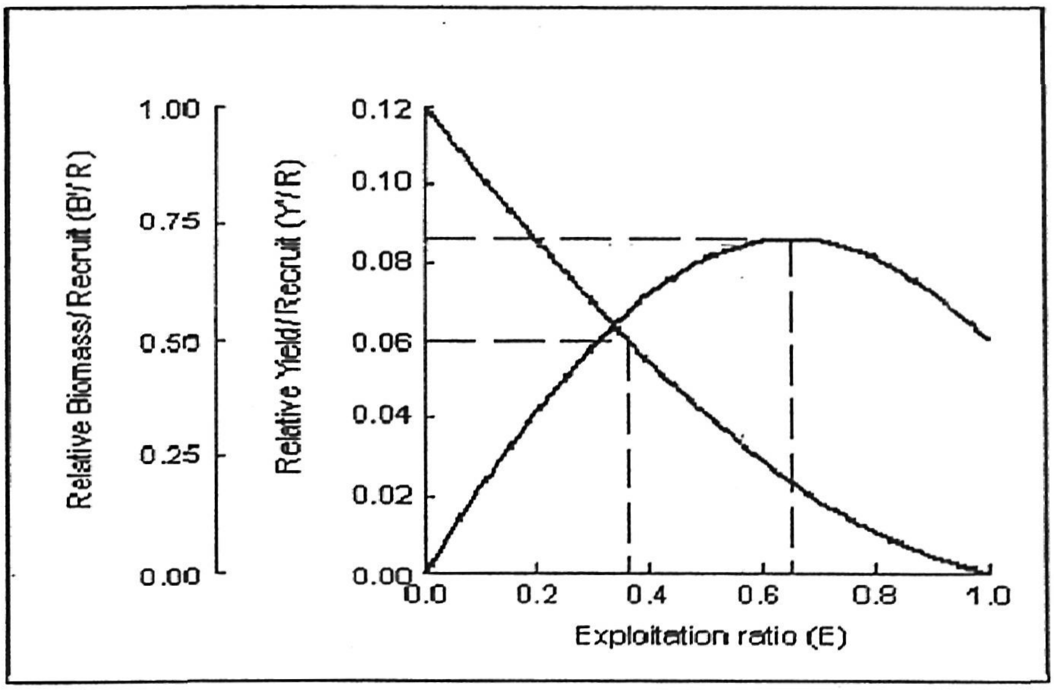

Fig. (4). Yield of biomass per recruit of *Lutjanus lineolatus* at the Bitter Lakes L_c=11.5 cm.