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Population Parameters and Stock Assessment of the Lizardfish *Trachinocephalus trachinus* (Temminck & Schlegel, 1846) from the Southern Red Sea Coasts, Egypt

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ABSTRACT

Lizardfish are the most abundant demersal fish inhabiting the Egyptian coasts of the Red Sea. They instituted about 36.4% of the total trawl catch in the Egyptian Red Sea and 33.9% of the total trawl catch in the Foul Bay. A total of 1048 *Trachinocephalus trachinus* were sorted from the lizardfish collected from the Foul Bay. Stock assessment was done for the pseudocohort of the species using random samples collected between 2023 and 2025. Otoliths were used for age determination, and the maximum life span was two years for males and four years for females. The precision was measured by two age estimations from two replicate counts and indicated a good agreement between them (PA = 91.7%, CV = 2.5% and IAPE = 3.9%). The von Bertalanffy growth parameters were TL_∞ = 24.98 cm, W_∞ = 155.7 g, K = 0.67 $year^{-1}$, t_0 = -0.40 year for males and TL_∞ = 34.84 cm, K = 0.50 $year^{-1}$, t_0 = -0.08 year, W_∞ = 443.4 g for females. The instantaneous annual rates of total and fishing mortality and subsequently the exploitation rates were estimated, and the yield per recruit was analyzed. Stock assessment revealed an over exploitation situation for lizardfish fisheries in the Foul Bay. The total mortality coefficient Z and the fishing mortality F were high as indicated by the exploitation ratio E (> 0.5), and a large number of by-caught juvenile and young fishes showing that the stock of lizardfish in this area was overexploited and the fishing gear was irrational.

INTRODUCTION

Foul Bay (Fig. 1) lies in the west side of the Red Sea near the Egyptian boundaries with Sudan and enclosed between Ras Banas (23° 54' 10" N, 35° 47' 12" E) in the North and Abu Dara in the South (220° 41' 00" N, 360° 05' 00" E). Its length is about 150km and its width varied between 20 and 65km with a depth of about 200m **(El-Sharkawy, 1984)**. Three key fishing techniques are used in Foul Bay: trawling, purse seining, and artisanal fishing, particularly using longlines, hand lines, gill nets, and trammel nets. There are five landing sites along the bay: Ras Banas, Berenice, Mersa Hemaira, Shalatein, and Abo Ramad.

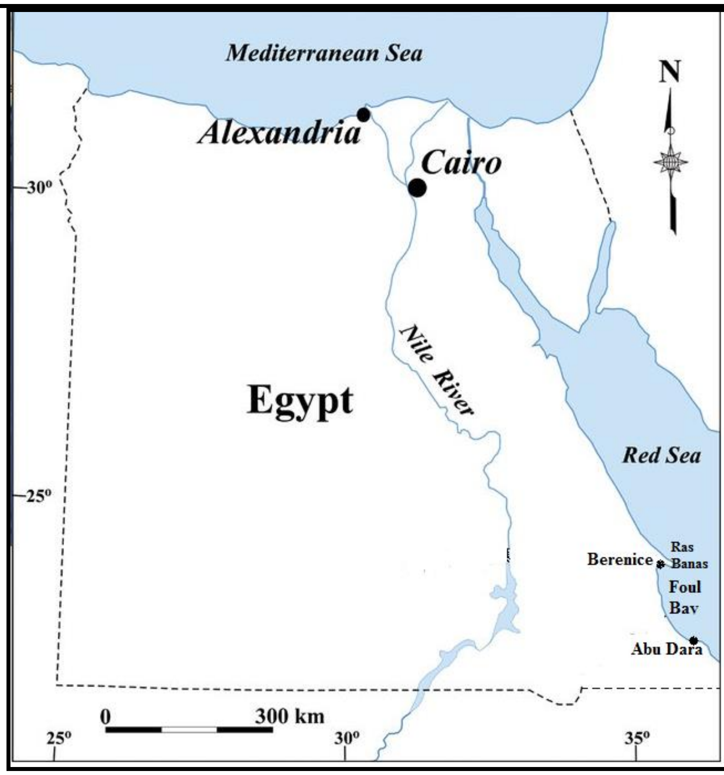

Fig. 1. Egypt map showing the Foul Bay and Berenice fishing area, Red Sea

Family Synodontidae which are commonly referred to as lizard fishes, comprises of 83 species in four genera, including the genera *Saurida*, *Trachinocephalus*, *Harpadon*, and *Synodus*. Members of this family are the most common fish among trawling landings; they constituted about 36.4% of the total trawl fishery in the Egyptian Red Sea, and a percentage of about 33.9% in the Foul Bay (General Authority for Fish Resources Development GAFRD 2010-2022). The brush-tooth lizardfish *Saurida undosquamis* is the most common and the most studied species in the Egyptian Red Sea followed by *S. tumbil*, while the *Trachinocephalus trachinus* has never been studied in the area.

Trachinocephalus (Gill, 1861) is a genus of lizardfishes, a group of small predatory fishes that inhabit inshore and offshore bottom areas at depths down to about 365 meters, but more commonly found in mid-shelf areas at depths between 25 and 90 meters **(Russell, 2002)**.

The lizardfish, *T. trachinus* is frequently found near shore above 40m over sandy bottoms of deep outer reef slopes bottoms in tropical and temperate areas **(Yamada *et al.*, 1995)**. They are distributed in the Red Sea, Indo-West Pacific: East Africa to Hawaiian Islands, north to southern Japan **(Polanco *et al.*, 2016)**. Although this species previously named *T. myops* (Forster, 1801), **Polanco *et al.* (2016)** confirmed that the two species are genetically separated. This fish resource attained more attention in the southern Red Sea, where the lizardfish family is very abundant. They are principally exploited by trawlers in the fishing grounds along the Foul Bay. Very few studies have been conducted on this species, focusing primarily on its classification, morphology, and distribution **(Yamada *et al.*, 1995; Mundy, 2005; Polanco *et al.*, 2016; Eagderi *et al.*, 2019)**. However, no studies have addressed its population dynamics or stock assessment. The present study aimed to estimate the population parameters and assess the stock of the lizardfish *Trachinocephalus trachinus* in the Foul Bay fishing area for the first time in the Egyptian waters, as well as recommending target reference points for its sustainable exploitation.

MATERIALS AND METHODS

The lizardfish catch represents a miscellaneous category that includes all synodontid species found in the Egyptian Red Sea. Therefore, sampling was conducted on lizardfish landed in the commercial trawl fishery at the Berenice landing site. In the laboratory, the samples were sorted and identified to the species level. A total of 1,048 specimens of *Trachinocephalus trachinus* were identified from Foul Bay during the period 2023 to 2025. Each fish was measured to the nearest millimeter (mm) for total length using a measuring board, and weighed to the nearest 0.1 gram (g) using an electronic balance.

Otoliths were extracted from each specimen, cleaned, and stored dry for subsequent age determination. Cleaning was performed using a 1% HCl solution, followed by rinsing with water. The otoliths were then dipped in clove oil as a clearing agent and examined. Annual rings were identified and counted using a Zeiss research microscope (magnifications 4× and 10×) equipped with an AxioCam HRC and a Zeiss KL 1500 LCD system using transmitted light. The total radius of each otolith and the radius of each annulus were measured to the nearest 0.001mm. A relationship between total fish length and otolith radius was established by plotting the two variables. Back-calculation of previous lengths was conducted using **Lee's** equation **(1920)**:

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

Where:
L_n = back-calculated length at the end of the nth year (cm)

L = length at capture (cm)

S_n = radius of the nth annulus (mm)

S = total otolith radius (mm)

a = intercept of the length-radius regression

Ages were assigned based on counts of alternating opaque and translucent bands (annual growth increments) observed on whole otoliths. Two independent readings were performed, and the precision of age estimates was assessed using the Average Percent Error (APE) **(Beamish & Fournier, 1981)**, the coefficient of variation (CV), and the index of precision (D) **(Chang, 1982)**. Bias and precision between the two readings were evaluated using paired t-tests.

To estimate the relation between total length (L) and total weight (W), the power function of Le Cren (1951) $W = a L^b$ was fitted to the data. Where "a" is the intercept and "b" is the slope. The degree of association between the variables was computed by the determination of the regression coefficient r^2 and 95% confidence limits of parameters a and b were estimated. To test for possible significant differences between sexes ($P<0.05$), the Student's t-test was used **(Sokal & Rohlf, 1981)**.

The von Bertalanffy growth model was applied to describe the theoretical growth of *T. trachinus*. The constants of the von Bertalanffy model ($L\infty$ & K) were estimated by fitting the **Gulland and Holt (1959)** plot for females, while those of males were estimated using von Bertalanffy plot. The growth performance index (Ø') for length was computed according to the formula of **Pauly and Munro (1984)** as $ø' = \text{Log } K + 2\text{Log } L\infty$.

The total mortality coefficient (Z) was estimated as the geometric mean of two methods; converted catch curve of **Pauly (1983)** and the catch curve method as described in **Ricker (1975)**. The natural mortality coefficient (M) was computed as the geometric mean of three different methods **(Taylor, 1960; Ursin, 1967; Hoenig, 1984)**. The fishing mortality coefficient (F) was computed as $F= Z – M$ while the exploitation ratio (E) was calculated from the ratio F/Z **(Gulland, 1971)** and the exploitation rate (U) was estimated as $U = (F/Z) * (1-e^{-Z})$. The length at first capture L_c (the length at which 50% of the fish are vulnerable to capture) was estimated by applying the method of **Caddy (1982)**. The length at first sexual maturity L_m (the length at which 50% of *T. trachinus* reach their sexual maturity) was estimated by fitting the percentage maturity against mid lengths. L_m was estimated as the point on X-axis corresponding to 50% point on Y-axis.

Total stock (P) and biomass (B) were estimated from the ratios Y/U and Y/F, respectively, where Y is the annual average yield in ton. Maximum sustainable yield was calculated by the equation for exploited fish stocks given by **Gulland (1983)** as $MSY = Z \times 0.5 \times B$.

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

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

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

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

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

These calculations were done for sexes combined as any management measures were planned for sexes combined.

RESULTS and DISCUSSION

1. Lizardfish fishery in Red Sea

T. trachinus is the third most dominant among the seven species of the lizardfish reported from the Egyptian Red Sea. Its distribution was restricted to the southern Red Sea, but in the recent years it appeared in very few quantities in the lizardfish catch from the Gulf of Suez (northern Red Sea). The lizardfish contribute about 7.3% to the Berenice total catch, 36.7% to the demersal fish catch (trawl fishery) in Berenice, 7.3% to the total fish catch of the Egyptian Red Sea, and 36.4% to the total trawl catch from Red Sea. The annual average catch of lizardfish from the Egyptian Red Sea during the period 2010-2022 was 3700 tons, with catch varying from a minimum of 2267 tons (2022) to maximum of 4504 tons (2016). In the last years, the lizardfish catch displayed a declined trend.

2. Age and growth

Sagittal otoliths were used for age determination of the lizardfish *T. trachinus* collected from Foul Bay. Otoliths as a consistent and valid technique for aging have been confirmed. Body length – otolith radius relationship showed a strong correlation (r^2 = 0.90 to 0.95), the increase of fish size is accompanied by an increase in the number of annuli on the otoliths, back-calculated lengths consensus with the observed lengths for the diverse age groups. The precision of the age estimates delivered independently from the two replicate readings was high (91.7%) and the Average Percent Error (APE) was 3.9%. Hence, otoliths of *T. trachinus* are readily interpretable, with a high level of agreement between the two replicate counts of annual growth increments. The percentage of error is rather low, which reveals the consistency of otolith reading.

The results showed that, the maximum life span of *T. trachinus* is two years for males and four years for females.

The length-otolith radius relationships were estimated for males, females and pooled data (Fig. 2). There is no significant difference between males and females for the studied species (P>0.05).

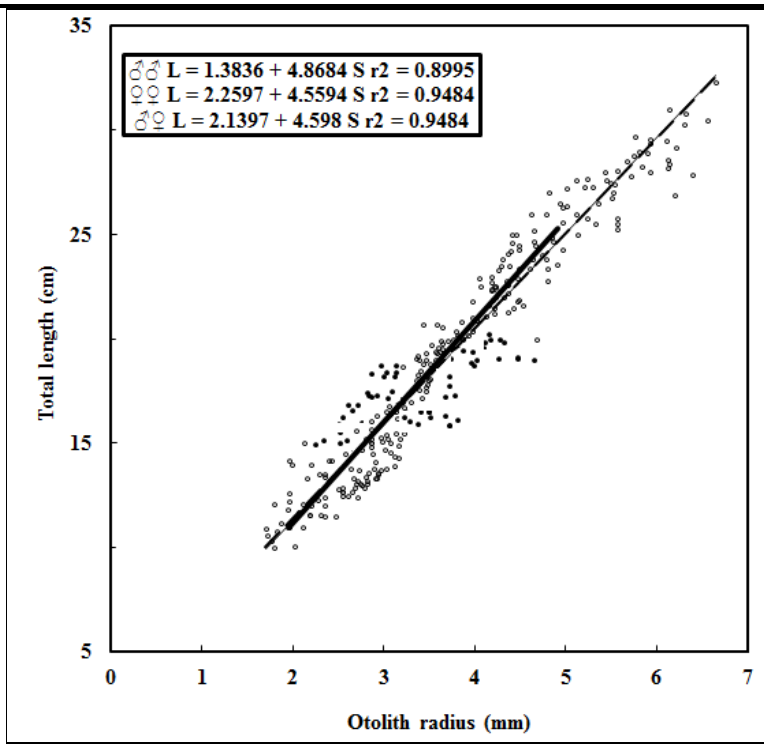

Fig. 2. Length-otolith radius relationship of the *Trachinocephalus trachinus* in the Foul Bay

Males *T. trachinus* attained lengths of 15.24 and 20.11cm for the two years of life, while females attained lengths of 14.53, 22.53, 27.26 and 30.29cm for the 1st, 2nd, 3rd and 4th year of life, respectively. The highest growth rate in length for the species was detected during the first year of life then declined with further increase in age (Fig. 3). This species is relatively short lived synodontid species and females attained higher maximum length and age than males.

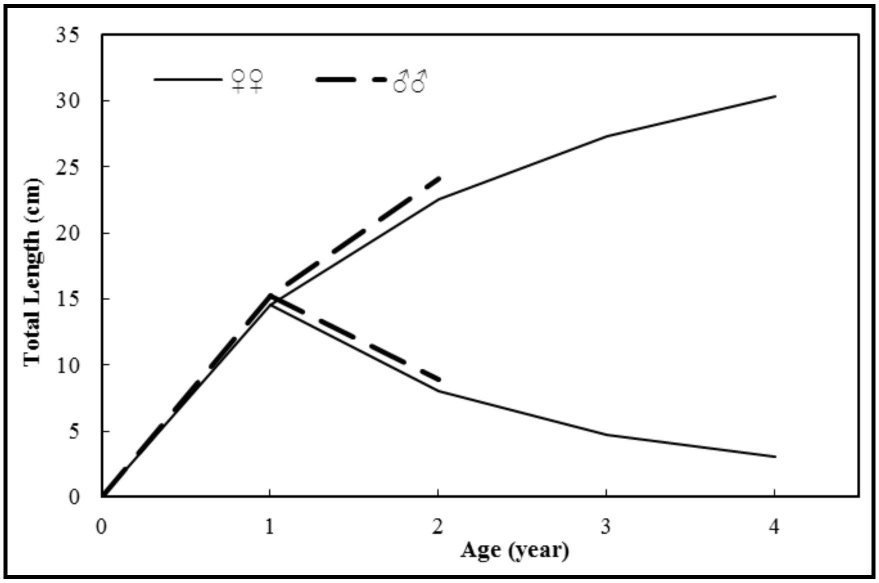

Fig. 3. Growth in length and growth increment of *Trachinocephalus trachinus* in the Foul Bay

3. Length – weight relationship LWR

Length–weight relationship (LWR) has essential implications in fisheries science and population dynamics **(Erzini, 1994)**. It is useful in fishery assessments for predicting weights from the more easily measured lengths, because direct weight measurements can take more time in the field yield assessment and biomass calculation **(Ricker, 1973; Petrakis & Stergiou, 1995; Martin-Smith, 1996; Garcia *et al.*, 1998; Sinovcic *et al.*, 2004; Froese, 2006; Mehanna & Farouk, 2021)**. This relationship was basically used to obtain information on the growth condition of fish and to demonstrate whether the somatic growth was isometric or allometric **(Le Cren, 1951; Ricker, 1975)**. The establishment of length-weight relationships are also essential for the calculation of production and biomass of a fish population **(Anderson & Gutreuter, 1983; Mehanna & Farouk, 2021)**.

The total length of *T. trachinus* ranged from 13 to 23.9cm and their weights varied between 16 and 125g for males. Female samples comprised larger individuals where their lengths varied from 10 to 32.5cm, and the weight ranged between 8 and 375g and for pooled data the length varied from 8 to 32.5cm TL and the weight from 4 to 375g TW. The obtained length-weight relationships (Fig. 4) were:

Males $W= 0.0027\ L^{3.4065}$ (95% confidence limits of “b” 3.212 – 3.6015)

Females $W= 0.0043\ L^{3.251}$ (95% confidence limits of “b” 3.061 – 3.439)

Pooled data $W= 0.0041\ L^{3.2659}$ (95% confidence limits of “b” 3.076 – 3.456)

The confidence limits estimates of the exponent b statistically differ from three (b > 3) for *T. trachinus*, indicating a positive allometric growth. Additionally, the covariance analysis evidenced that there is no significant difference between males and females for the species.

Shoba Joe and Gomathy (2007) reported more or less similar b value (3.047) for *Trachinocephalus myops* at Chennai. **Jayaprapha *et al.* (2015)** stated b value at 3.17 in southeast coast of India. These differences could be due to difference in environmental and biological parameters and also to the type of the sampling, like size ranges, number of individuals collected and period of collection. In addition, the LWR are not stable for fishes from various regions, it may vary in relation to their environmental factors like temperature, salinity, food (quality, quantity and size), habitat and gonad maturity, spawning period, season, sex, absence of juveniles, health, fishing time and fishing gears **(Ricker, 1973; Safran, 1992; Froese, 2006)**.

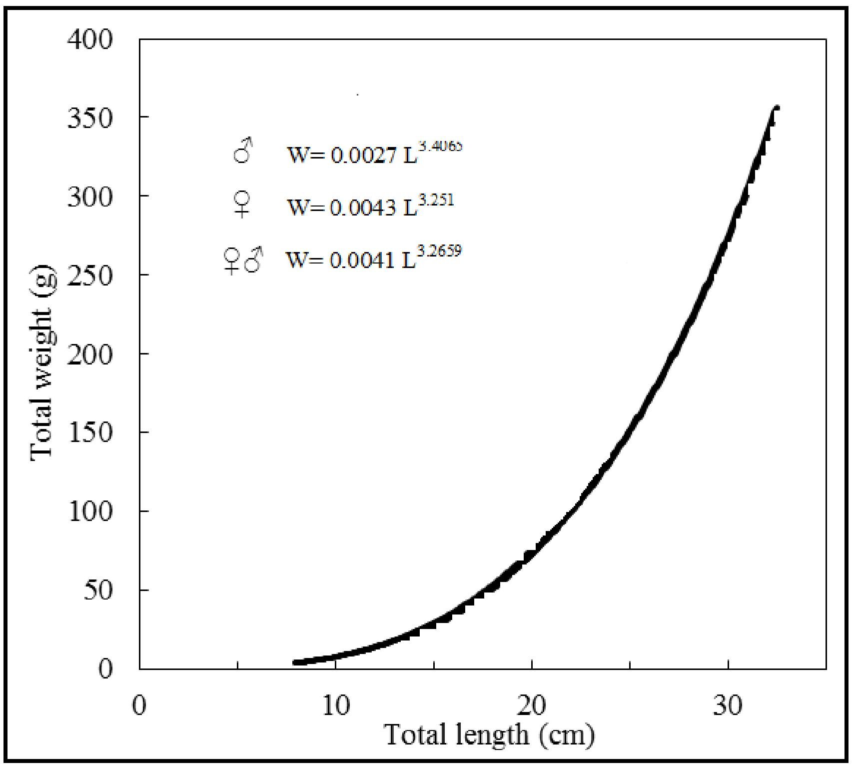

Fig. 4. Length weight relationship of *Trachinocephalus trachinus* from Foul Bay

4. Population parameters

The constants of von Bertalanffy's growth model, the growth performance index, mortality and the exploitation rates were estimated for the lizardfish species from Foul Bay, and the results are given in Table (1). **Walters (2000)** reported that any fishery assessment that results in levels of F_{opt} above 0.5M needs to be very carefully justified, either by a clear demonstration that higher fishing mortality rates have been sustained for several fish generations or that the age-selectivity schedule permits virtually full replacement of recruits (by the fish that survive to spawn) prior to the age at first capture. Furthermore, **Patterson (1992)** reported that fishing mortality rates above 2/3 M are often associated with stock declines, whereas fishing mortality rates below this level have resulted in stock recovery. Calculations of F_{opt} (F_{opt} = 0.5M) for *T. trachinus* were 0.155, 0.17 and 0.225 for male, female and pooled data, respectively. While the F_{limit} (F_{limit} = 2/3M) was 0.21, 0.23 and 0.30 for male, female and pooled data, respectively. Considering these values, the current fishing mortality rates are greatly above 2/3M representing an undesirable state for the resource, hence a management action should be taken.

Table 1. Population parameters for *Trachinocephalus trachinus* in the Foul Bay

Parameter	*T. trachinus*		
	Male	Female	Pooled
L∞ cm	24.98	34.84	36.14
K year^{-1}	0.67	0.50	0.43
t_0 year	-0.40	-0.08	-0.21
W∞ g	155.7	443.4	502.3
Ø’	2.62	2.78	2.75
Z	1.49	1.24	1.54
M	0.31	0.34	0.45
F	1.18	0.90	1.09
E	0.79	0.73	0.71
U	0.61	0.52	0.56

5. Length at first capture L_c and length at first maturity L_m

The length at first capture (L_c) was estimated for pooled data using the method of **Caddy (1982)**. The obtained values was L_c = 15.5cm TL for the studied species (Fig. 5). The length at first sexual maturity Lm was estimated at 17.1cm TL which is smaller than the estimated L_c. Based on the estimated L_c and L_m, the most caught *T. trachinus* were at sizes not reaching their sexual maturation. Therefore, there is an urgent need to increase the mesh size of trawl net along the Foul Bay at the present level of effort. This suggested the necessity of formulation and implementation of measures to rise the size at first capture and to diminish fishing pressure for sustaining stock of *T. trachinus* and increasing harvest.

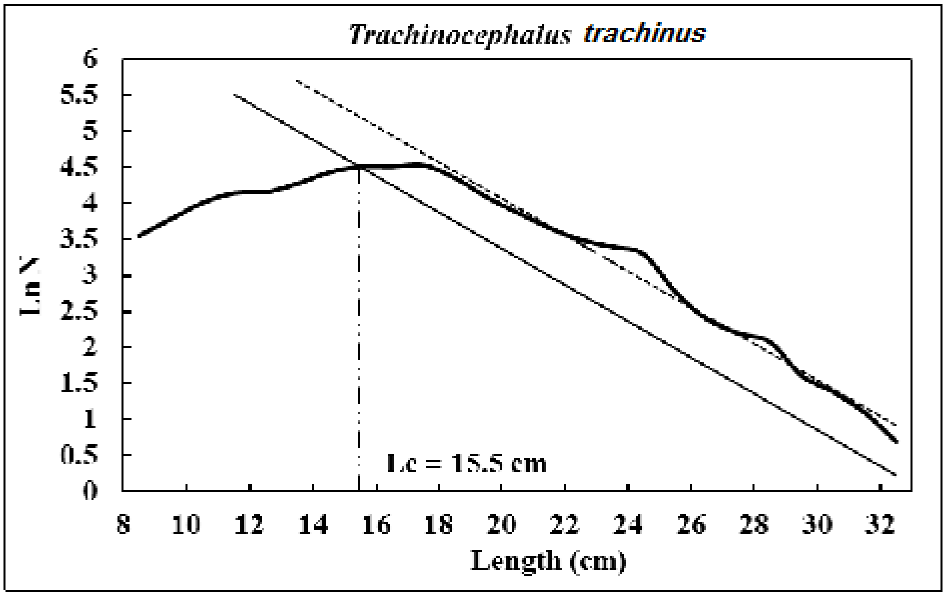

Fig. 5. Length at first capture (L_c) of *Trachinocephalus trachinus* from Foul Bay

6. Stock assessment (estimation of stock and MSY)

As there is no separated statistics for each lizardfish species, the mean values of F and U were used for stock assessment. The estimated annual total stock, biomass and MSY of the lizardfish in Foul Bay were 3813.6, 1875 and 1546.9 tons, respectively. The estimated MSY is greatly higher than the current annual catch (1086 ton) from Foul Bay, but it will achieve the sustainability of the fishery.

7. Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)'

Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' analysis (Fig. 6) displayed that the maximum (Y/R)' of *T. trachinus*, was attained at E_{MSY} = 0.60, while the achieved values of $E_{0.1}$ and $E_{0.5}$ were 0.52 and 0.35, respectively. In comparison, the results designated that the present level of E (0.71) was higher giving the maximum (Y/R)' and the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass.

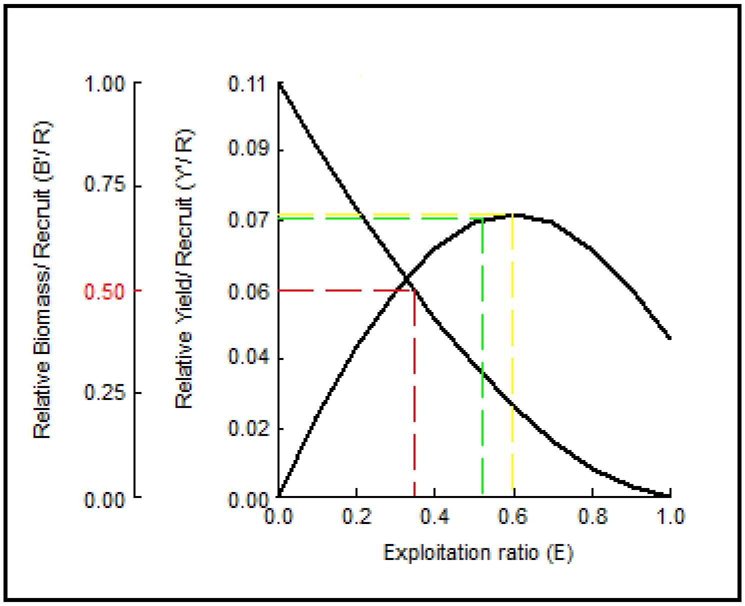

Fig. 6. Yield per recruit analysis of *Trachinocephalus trachinus* from Foul Bay

CONCLUSION

It could be concluded that the lizardfish in the Foul Bay are heavily exploited. For the management purpose, the existent level of exploitation rate should be diminished by about 50 - 60% in Foul Bay to conserve a sufficient spawning biomass for recruitment. This can be accomplished by reducing the fishing effort by at least 40% of its current level to protect the spawners, establishing the relation between the spawning stock and the recruitment.In addition, all commercial stocks exploited by trawling should be assessed to propose a truthful management strategy for this multispecies fishery and to improve the gear selectivity. Furthermore, the fisheries statistics recording system should be improved to provide an actual picture about the catch and effort statistics from the Egyptian Red Sea fisheries.

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