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Fishery and Population Characteristics of *Euthynnus alletteratus* (Rafinesque 1810) in the Eastern Coast of Alexandria, Egypt

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Abstract

Fishery and Population characteristics of *Euthynnus alletteratus* (Rafinesque 1810) were studied using 695 fishes collected from landing site in Eastern Coast of Mediterranean Sea off Alexandria, Egypt. Eight age groups were recorded using vertebrae. Von Bertalanffy growth parameters were estimated as $L_\infty = 123.4$ cm, $K = 0.16$ year^{-1} and $t_0 = -0.59$ year. The rate of total mortality (Z), natural mortality (M) and fishing mortality (F) were 1.996, 0.396 and 1.6 respectively. Length at first capture was estimated as 34cm (1.4 year). The results indicate that population is overexploited (E = 0.802) and suffering from high fishing pressure. Cohort analysis and yield per recruit analysis realized that *E. alletteratus* stock of the Eastern Coast of Alexandria needs a new management strategy for sustainable yield.

Keywords: *Euthynnus alletteratus*, little tunny, Eastern coast of Alexandria, catch, age, mortality, Yield per recruit, management.

Introduction

Little tunny (*Euthynnus alletteratus*) is a member of family Scombridae that has wide distribution in temperate and tropical areas of Atlantic Ocean, Mediterranean and Black Sea (Belloc, 1955; Valeiras and Abad, 2007). It occurs in most of these areas throughout the year and caught in large amount in the coastal region during summer months (Sylva and Rathjen, 1961). Usually found in coastal waters with swift currents, near shore and around the warmer waters of thermal fronts and upwelling along the tropical Atlantic where the water temperature ranged from 24º to 30º (Chur, 1973). This schooling species is an opportunistic predator which feeds on virtually everything within its range, e.g. crustaceans, fishes (mainly clupeoid), squids, heteropods and tunicates (Collette, 1986).

E. alletteratus is among the most common small tuna species that caught from Alexandria city coast accounted 1.3% of the total Egyptian Mediterranean Sea catch in 2007. Egyptian Mediterranean catch from *E. alletteratus* was fluctuated during the last decade with annual average equal 1019 MT (GAFRD, 2008). This area is characterized by seasonal water temperate varied from 17º to 30º with annual average 23.9º (Ramadan *et al.*. 2006).

Some biological studies on *E. alletteratus* have been conducted in different regions of Mediterranean Sea specially Tunisia (Hattour, 1984 and Hajjej *et al.* 2010 and 2011), Turkey (Kahraman, 1999 and 2005 and Kahraman and Oray, 2001) and Spain (Valeiras and Abad, 2007) mainly focused on length-weight and growth estimate. No related fisheries study was conducted in Egypt and little is currently known about its fishery biology.

General Fisheries Commission for the Mediterranean (GFCM) and International Commission for the Conservation of Atlantic Tunas (ICCAT) recommended that priority should be given to the improvement of knowledge on the sustainable exploitation of small tuna fisheries, including their biology. The present study deals with some biological and fisheries aspects of *E. alletteratus* focusing on stock status and presenting the essential information for proper management of this species in Eastern Coast of Alexandria, Egypt.

Materials and Methods

Fishery

The fishing ground of *E. alletteratus* at Eastern Coast of Alexandria-Mediterranean Sea, is concentrated in three main fishing sites as shown in Figure 1; the first area is Hars Alhory off Abu Qir

Bay with the depth range 25-35m. The second area is in front of Almontazah region where its depth ranging between 60 to 100m and the third area located in front Sidi Jaber with depth between 80 to 160m (where irregularly some longline used with gill net).

Sampling and Analysis

A total of 695 *E. alletteratus* were randomly collected from gill net catch twice a month for 15 months from September 2006 to November 2007. Closed season from 1st of May until 15th of June was applied during sampling period. Samples strategy was designed to reflect the real landing size and covering fishing ground that exploited by Abu Qir fleet (from AbuQir bay to Sidi Gaber). Samples were collected from fishing vessels regularly used gill net targeting the investigated species; moreover by-catch of other net types was considered. In laboratory fork length and total weight were recorded for each sample and vertebrae were removed and storage.

For age determination vertebrae were collected by cutting through the flesh between vertebrae number 15 to 19 (which were larger with clear rigs), then kept in small envelops until cleaned. Binocular stereomicroscope was used to count the annulus of 531 vertebrae.

Relationship between fork length FL in cm and vertebra radius R measured in micrometre division was expressed by linear regression as: $FL = a + b R$

Where: a and b are constants.

The intercept (a) of the previous relation was used for correction of back calculated fish length (L_n) at year (n) of life using the measured total vertebra radius(R) at annulus radius (r_n) by Lee's formula (Lee, 1920): $L_n = (r_n (L – a) / R) + a$

Lengths were used to estimate growth parameters of Von Bertalanffy equation (Pauly, 1983): $FL_t = L_\infty (1- e^{-k(t-to)})$

Where, FL_t is the length (cm) at age t (year), L_∞ is asymptotic length (cm), K is the growth coefficient ($year^{-1}$), t_0 is theoretical time when length was 0.

Growth parameter (L_∞ and K) were estimated using the a and b constants of the linear relationship between L_t and L_{t+1} after Ford (1933)-Walford (1946) formula,

$L_{t+1} = L_\infty (1- e^{-K}) + e^{-K} L_t$

Where, $L_\infty = a/1\text{-}b$ and $K = L_n$ (b)

While t_0 was estimated by equation of (Beverton and Holt, 1966): $t_0 = (-Log (L_\infty) + a)/K$

Catch curve method of Pauly (1984) was used to estimate length at first capture L_c (The length of 50% of fish at that size are vulnerable to capture).

Length weight relationship was computed according to Le Cren (1951): $W = a FL^b$

Where W is a total weight (g), FL is fork length

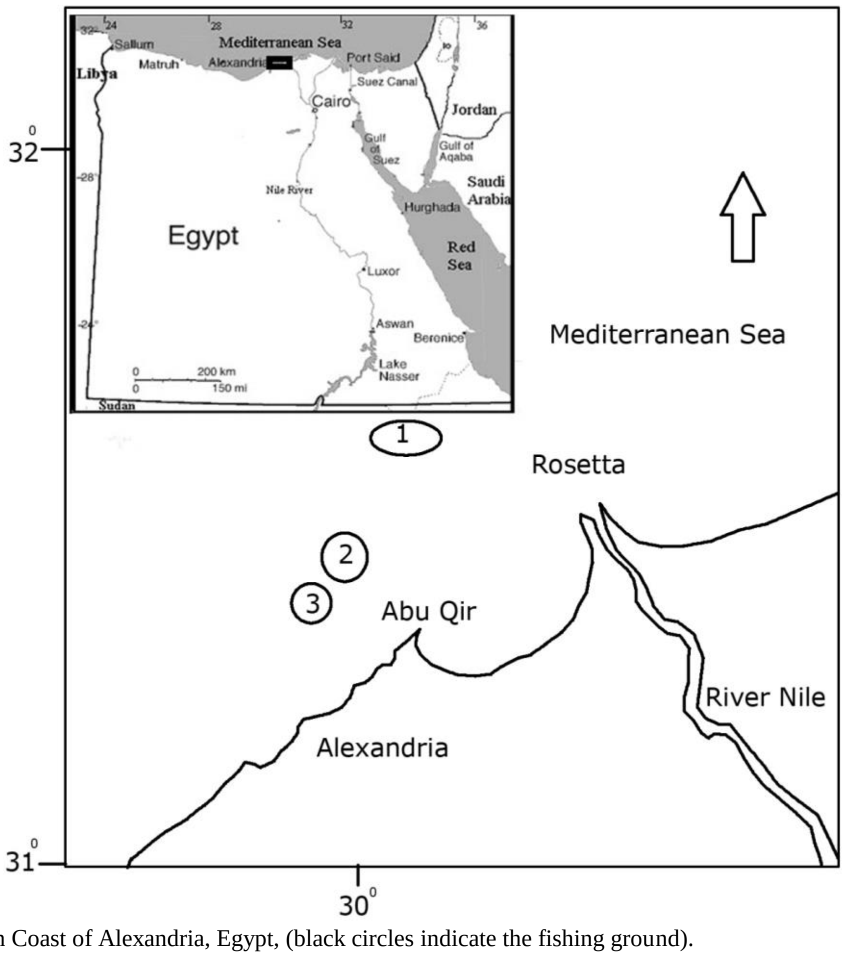

Figure 1. Eastern Coast of Alexandria, Egypt, (black circles indicate the fishing ground).

(cm), **a** and b are the relation factors.

Age at first capture (t_c) was computed by the equation of Beverton and Holt (1957) as:

$t_c = (-1/K) \ln (L_\infty - L_c)/ L_\infty) + t_0$

Instantaneous total mortality Z was estimated by (Beverton and Holt, 1957) equation:

$Z = K (L_\infty - \bar{L})/(\bar{L} - L_c)$

Where, $\bar{L}$ is the mean length of all fish sample.

Natural mortality was calculated using two methods, first by Djabali *et al.* (1994):

$\text{Log } M = -0.0278 - 0.1172 \text{Log } (L_\infty) + 0.5072 \text{ Log } (K)$

While the second method according to Taylor (1960):

$M = - (\ln (1-0.95)/(2.9957/K) + t_0$

Instantaneous fishing mortality F was calculated by subtracting the Natural mortality M from the total mortality Z according to Sparre and Venema (1998).

Survival S and exploitation E rates were calculated according to Gullund (1971) equations:

$S = \exp (-Z)$ and $E = F/Z$

Length and age at recruit (L_r and t_r) were computed by Beverton and Holt equation (1957) equations: $L_r = \bar{L} - (K (L_\infty - L_{min})/Z)$ Where L_{min} is the minimum length in the catch.

$t_r = (t_0 -(1/K) * \ln (1-t_c/ L_\infty))$

The maximum age (t_{max}) was estimated by the equation of Pauly (1983): $t_{max} = 3/K + t_0$

The age based cohort analysis (Pope's cohort analysis 1972) was used to estimate the fishing mortality and the population number at age using the catch-at-age data and input terminal fishing mortality samples to the total landed catch of eastern coast of Alexandria. Microsoft Excel sheet was used for calculation. Terminal 'F' used in that routine was assumed to be equal to 'F' of the oldest age group. The number of survivors in the oldest age group was estimated by the equation: $N_t = C_t / [(F_t / Z_t)(1- e^{-zt})]$

Where: N_t = number of survivors in the oldest age group.

C_t = number of fish caught in the oldest age group.

F_t = The terminal fishing mortality (F of the oldest age group).

Z_t = The total mortality.

The numbers of survivors in the previous years were estimated by the following equation:

$N_{t-1} = [((N_t) (e^{M/2})) + C_{t-1}] [e^{M/2}]$

Where: N_{t-1} = number of survivors in the previous age group.

C_{t-1} = number of fish caught in the previous age group.

M = the natural mortality.

Estimation of the different values of fishing mortality which corresponded to the previous age groups (F_{t-1}) were calculated from the following equation: $F_{t-1} = \ln (N_t / N_{t+1}) - M$

Yield per recruit (unsexed sample) was estimated using the model of Beverton and Holt (1957) as follows: $Y/R = F e^{-M} (t_c - t_r) W_\infty [1/Z - 3S/ Z+K + 3S^2 / Z+ 2K - S^3/ Z + 3K]$

Where $S = e^{-K} (T_c - t_0)$ and the other letters as defined above.

While biomass per recruits was estimated according the equation: $B/R = (Y/R) / F$

The extreme values of the fishing level such as "F_{max}" and "$F_{0.1}$", were defined as biological reference points "BRP" and were estimated according to Cadima (2003).

Results

Fishery

Four types of gill net with different local names and yarn materials were recorded in the Eastern Coast of Alexandria using for catching *E. alletteratus*. Nets are ranging from 750 to 1000 m in lengths and from 9 to 18 m in heights. Mesh size is varies between 10 and 20 cm according to the target fish size. The trip duration is usually takes one night.

Longline was another method used in catching of *E. alletteratus* as by catch, each vessel contain 1-3 long line sets (Meshana), each set has 500 hooks (size 6-7) using fresh sardine bait. Some fishing vessels are using both methods to maximize their catch.

According to the official annual statistical year book, *E. alletteratus* catch was about 1061 MT during 2007 from all Egyptian Mediterranean Waters and 329 from off Alexandria region. Monthly catch from off Alexandria showed a pike at October-November with 62-51MT while the lowest catch was in June due to closed season from 1st May to 15th June (Table 1).

Age and Growth

Age was determined from the opaque rings on the vertebrae. Alternative pairs of a translucent zone and an opaque zone were considered to be a year annuli (Figure 2).

Catch of *E. alletteratus* from Eastern Coast of Alexandria was composed of eight age groups in addition to age group zero which dominated the catch (79.5%) during 2006 – 2007 at average fork length 33.5 cm, followed by age group I which contribute

Table 1. Monthly catch (MT) of *E. alletteratus* from Off Alexandria and from All Egyptian Mediterranean Waters during 2007 (May is closed season for all fishing types)

Month Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Off Alex.	17	19	22	17	0	14	42	29	30	62	51	26	329
All Med.	121	143	81	65	0	39	123	69	81	121	106	112	1061

with 8.7% of total catch, then age groups II, III, IV, V, VI, VII and VIII which represent 2.64%, 1.9%, 0.94%, 2.07%, 2.07%, 1.7% and 0.56% respectively.

Fork length (FL) and total vertebra radius (R) relationship could be represented by straight line as follow: FL= 0.7679 R – 2.2892 (r^2 = 0.945)

Back-calculation method has been used to estimate fork lengths at earlier age. Eight age groups were recorded as shown in Table 2. The average lengths were calculated as 39.6 cm at the end of first year while for age group eight was 96.4 cm. The growth in the first year was higher than that of the following years, gradually the growth rate decrease with age.

Asymptotic length (L_∞) of *E. alletteratus* from Eastern Coast of Alexandria was estimated by Ford Walford plot from back calculated length-at age data as 123.4 cm, where K is calculated as 0.162 $year^{-1}$ and t_0 = -0.59 year while maximum age (t_{max}) was 17.9 years.

As a result of the regression analyses (Figure 3 a,b) between fork length (FL) and total weight (W) for 695 fish ranged in length from 13 to 102cm and in weight from 18 to 13150g. Only 145 fish were separated by sex while the majority were immature or could not be identified. The growth was founded to be allometric expressed by power equation for sexed samples (female and male) and all samples collected (sexed and undetermined sex samples) as follow:

Female: W=0.0614 $FL^{2.6232}$ (r^2 =0.9806) n=101

Male: W=0.0370 $FL^{2.7519}$ (r^2 =0.9754) n=44

All sample: W=0.0201 $FL^{2.9078}$ (r^2 = 0.9899) n= 695

Population Structure

Length Frequency Distribution

There were two large modes of abundance for size frequency distribution of the *E. alletteratus* population during the study period, the first was at 13 to 28 cm and the second was larger with a size range

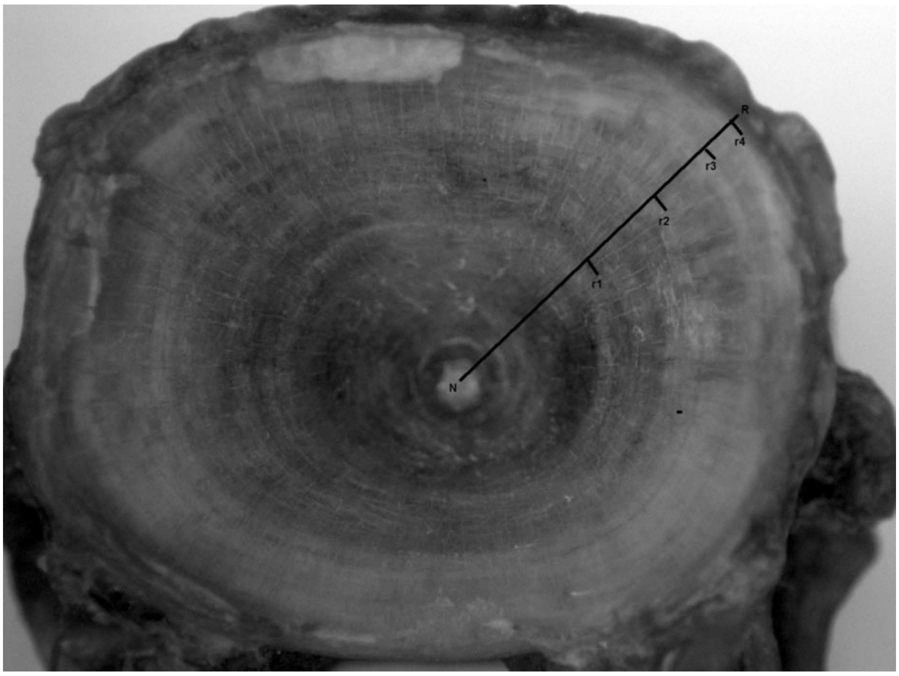

Figure 2. Four year vertebrae of *E. alletteratus* from Eastern Coast of Alexandria during June 2007.

Table 2. Back calculated length (cm) at age (year) for *E. alletteratus* from Eastern Coast of Alexandria during 2006-2007

Age	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
1	46.5							
2	46.4	58.9						
3	45.2	57.1	67.2					
4	39.3	52.7	65.9	76.8				
5	38.6	52.4	64.8	75.7	84.8			
6	35.7	48.8	59.9	70.1	79.5	87.8		
7	35.3	48	59.3	70.7	79.4	87	92.9	
8	29.7	44.1	56.3	67.6	78.2	85.4	91.8	96.4
Average	39.6	51.7	62.2	72.1	80.5	86.7	92.4	96.4

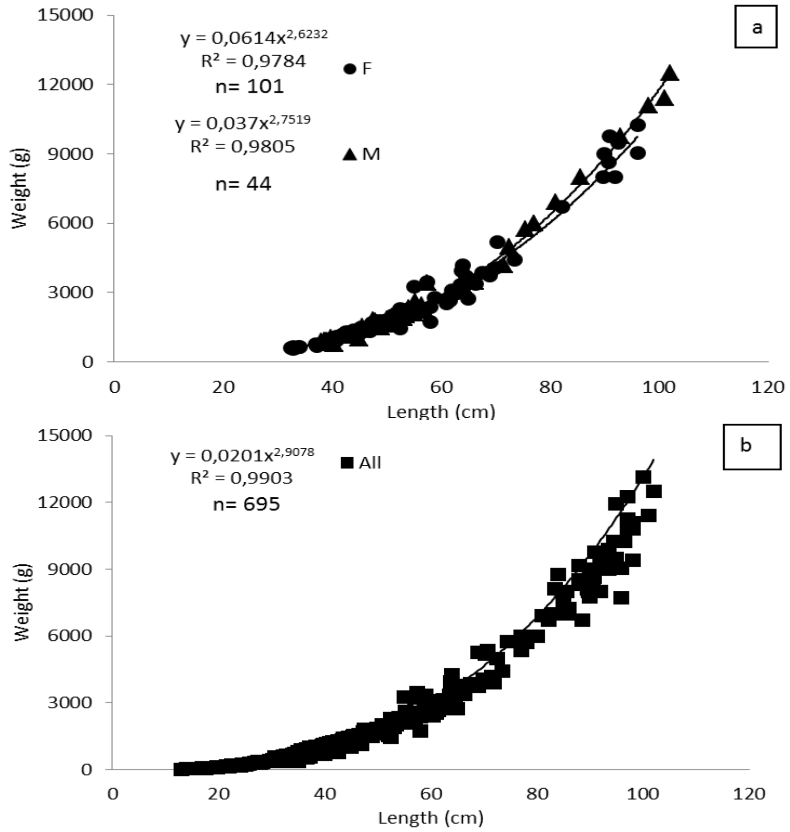

Figure 3. Length-weight relationship of E. alletteratus from Eastern Coast of Alexandria during 2006 – 2007 (a is sexed sample where F is female and M is male and b is all samples).

from 30 to 50 cm while the others following size range showed little modes at 62.5 and 92.5 cm. The catch was dominated by smaller fish < 45 cm and the mean length of all samples ($\bar{L}$) was 40.7 cm FL. Length frequency was varies seasonally as shown in Figure 4. Length range was 13-102 cm in summer and autumn (with mean length 37.8 cm), while in winter and spring larger fish were more (length rage 34-100cm and mean length 45 cm).

Length at first capture (L_c) was estimated by analysis of accumulated percentage catch curve as 34 cm which represents 50% of accumulative lengths frequency distribution as shown in Figure 5, where age at first capture (t_c) was calculated as 1.4 years. Moreover, Length and age at first capture (L_c and t_c) were found to be 34 cm and 1.4 year, while length and age at recruit (L_r and t_r) were estimated as 31.7 cm and 1.24 year respectively.

Instantaneous Mortality Coefficients, Survival and Exploitation Rates

Instantaneous total mortality coefficient (Z) of *E. alletteratus* was found to be 1.996. Two methods for natural mortality (M) were estimated, their values were different (0.396 and 0.167), the first value was used in the forward calculation, fishing mortality (F) was found to be 1.6.

Where survival (S) value was calculated as 0.136 and exploitation rate as 0.8. Figure 6 represents the estimated values of catch numbers, survivors, natural and fishing mortalities for each age group of *E. alletteratus* using VPA. The population number decreased sharply after the first year due to higher fishing rate (which decreases with age) and natural mortalities. Fishing mortality was found to be 0.5 for age zero and drop for age 1 and the following 3 years, then gradually increase for age groups 5 up to age 8 reaching 1.6.

Yield and Biomass per Recruit and Biological Reference Points (F_{max} and $F_{0.1}$)

Yield per recruit of *E. alletteratus* in the Eastern Coast of Alexandria was found to be 702.7 g, where biomass per recruit was found to be 439.2 g at actual fishing mortality 1.6.

The value of yield per recruit (Y/R) of *E. alletteratus* as a function of fishing mortality is shown in Figure 7. The maximum yield per recruit F_{max} was 0.44 far less than the current fishing mortality (1.6) while $F_{0.1}$ was 0.22.

Yield (Y/R) and biomass (B/R) per recruit were increased with increasing length at first capture (L_c) as shown in Table 3. The increase of L_c to 44 cm will increase the Y/R from 880.54 g at the present L_c (34 cm) to 980.72 g and also the B/R from 2001.23 to 2228.91 g.

Discussion

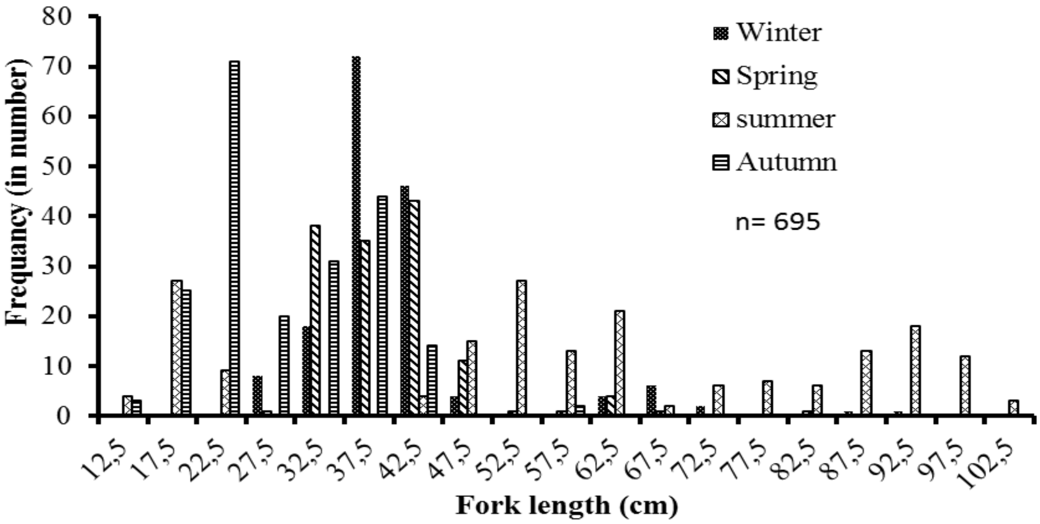

Figure 4. Seasonal Lengths frequency distribution (Population structure) of *E. alletteratus* in the Eastern Coast of Alexandria during 2006-2007.

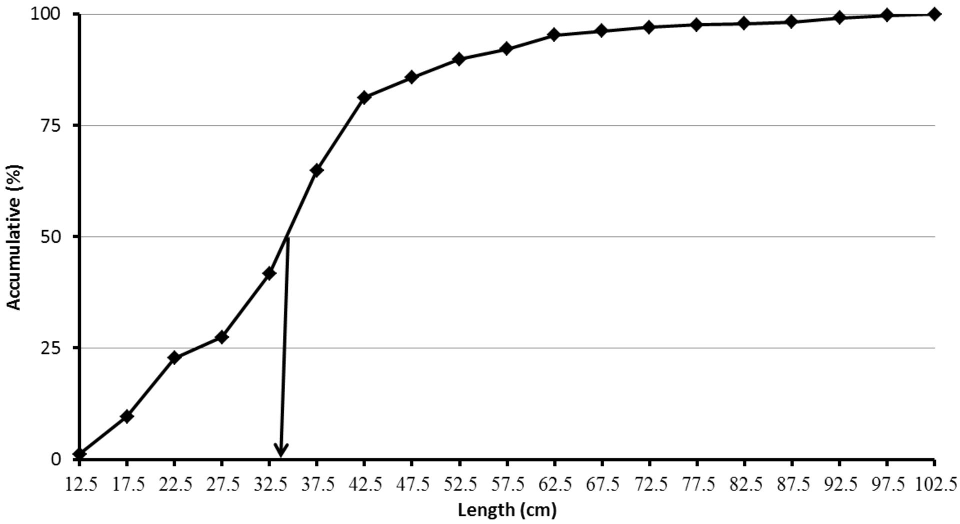

Figure 5. Length at first capture from accumulated percentage catch curve of *E. alletteratus* from Eastern Coast of Alexandria during 2006-2007

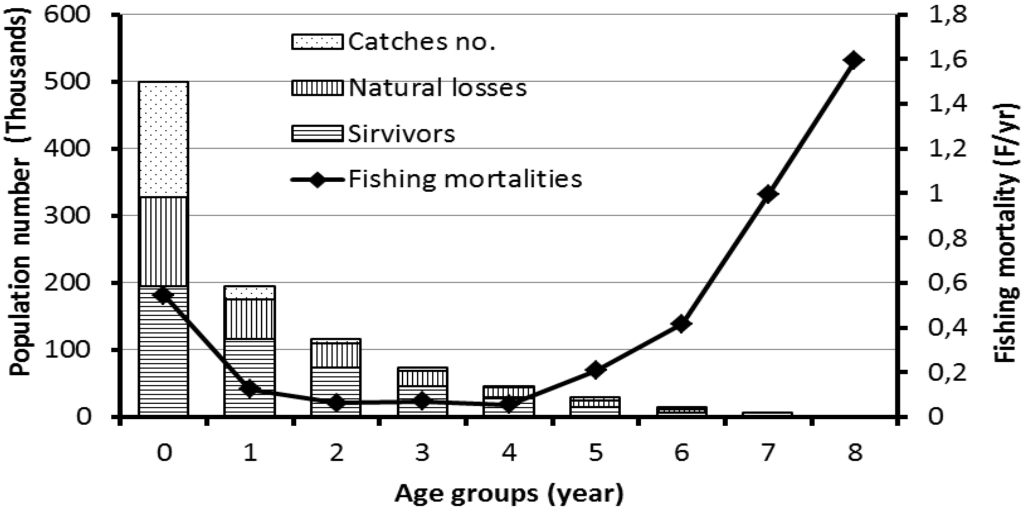

Figure 6. Catch numbers, survivors, natural and fishing mortalities of *E. alletteratus* from Eastern Cost of Alexandria during 2006-2007.

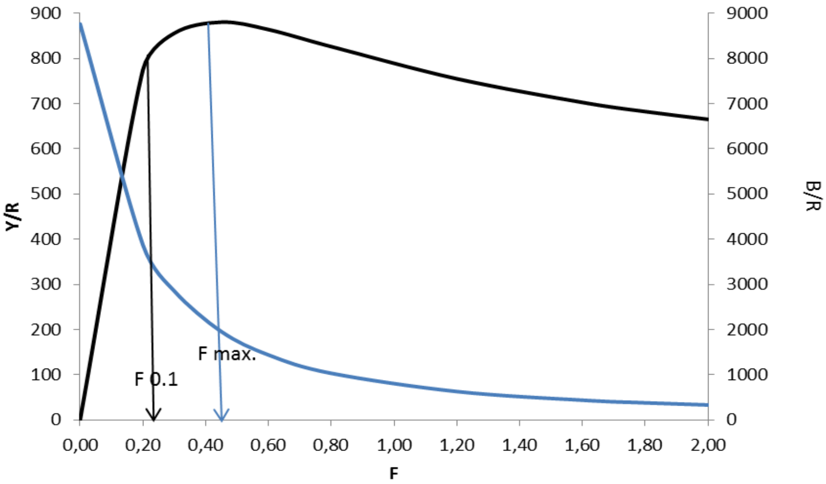

Figure 7. Effect of fishing mortalities F on Yield (Y/R) and biomass (B/R) per recruit for *E. alletteratus* from Eastern Cost of Alexandria during 2006-2007.

Table 3. Yield per recruit as a function of L_c for *E. alletteratus* from Cost of Alexandria

L_c	Y/R	B/R
24	744.31	1691.62
34	880.54	2001.23
44	980.72	2228.91

Fishery of *E. alletteratus* in Egypt is relatively important. This small-scale fishery is artisanal and fairly typical of the fisheries found in many Mediterranean countries. In fact tuna like species appear among bycatch of gill nets, long line and purse-seines, hence similar studies should be done to such gears. Based on available data, this species is economic importance and monitoring of fishing effort is essential.

In the Atlantic and Mediterranean Sea, several authors have estimated the *E. alletteratus* age by counting rings in both Vertebrae and first dorsal fin spine. Vertebrae were used in the present study and eight age groups were determined. Prince and Pulos (1983) found an agreement between vertebra and spine of *E. alletteratus* and the back calculation body size at various ages were similar. Mean length-at-age values estimated in different regions are represented in Table 4. The length-at-age for 1 to 5 years that obtained in the present study is similar to that obtained in east and west Mediterranean Sea by Landau (1965) and Valeiras *et al.* (2008) respectively. Nevertheless some differences on mean length at age have been found regarding other studies in Atlantic (Cayre and Diouf, 1983) and eastern Mediterranean Sea estimates (Kahraman and Oray, 2001). Various estimates of length at age were recorded at different geographical regions. This could be due to the differences in used techniques, the environmental parameters, availability and competition for food or fishing methods and gear selectivity (Johnson, 1983).

The present study revealed that earlier age groups of *E. alletteratus* are most abundance than latter age groups. Lower number of medium age groups than latter one is perhaps a result of the year class strength. Fromentin and Restrepo (2001) proposed that such results may be due to year-class strength which probably due to the availability of plankton food in such year or fish starvation by which larvae and eggs might be drifted away out of nursery ground by current with no ability to return.

Von-Bertalanffy growth model is one of the most commonly used methods in studying theoretical growth in fishery's biology. Among the previous growth studies of little tunny, the growth coefficient (K) was ranging from 0.11 to 0.39 per year and the asymptotic length (L_∞) ranged from 91.5 to 123cm FL (Table 5). It can be concluded that the growth pattern of *E. alletteratus* from the Egyptian Mediterranean coast off Alexandria appears to have middle growth rate between other population inhabiting eastern and western Mediterranean Sea basins but with higher longevity. The longevity of fish species might be affected by the environmental conditions under which a fish lives (Wootton, 1990).

In the present study, length weight relationship of *E. alletteratus* was calculated by the allometric growth equation for all samples regardless sex; with b value at 2.9078 i.e. the fish becomes lighter for its corresponding length. Difference equations were recognized for female and male separately but small number of sexed samples was suggested to compare the equation of the all samples collected (including unsexed samples) to the previous data reported about the species in other regions of the Mediterranean See.

Length weight relationship of *E. alletteratus* was the subject of many studies in the Mediterranean Sea (Table 6). The b value of the present study relation is closer to that obtained in Spanish Mediterranean Sea water (Macias, 2009), Tunisian water (Hajjej *et al.*, 2010 and 2011) and in Turkish water (Kahraman, 2005), but little higher than that calculated for Turkish water (Kahraman and Oray, 2001). Early at 1984 in Tunisian water Hattour found b value higher than that obtained in the present study. Observed differences could be due to the sampling procedure, namely size and length range or related to seasonal reproduction or feeding activities (Wootton, 1990). Such difference perhaps due to use data for the estimation of the length–weight relationships not derived from all seasons in equal proportions.

Gaykov1 and Bokhanov (2008) recorded the length range of little tunny in eastern Atlantic from 21 to 75 cm with mean length of 46.5 cm. In the north-eastern Mediterranean coast of Turkey, the mean length distribution was calculated as 39.8 cm (33.2-58.5) for the autumn and 46.7 cm (32.0-84.5) for the

Table 4. Length at age of *E. alletteratus* from different areas and ageing methods

Area	Author	Method	Age							
			1	2	3	4	5	6	7	8
East Med.	Landau 1965	Vertebrae	35.8	53.9	63.7	70.1	75.5	80.1	81	
Spain	Rodriguez-Roda,1979	Vertebrae	46.2	58.1	67.9	76	82.7			
Senegal	Cayre and Diouf, 1983	1^{St} dorsal fin spine	32.9	41.1	49.2	57.4	65.6	73.6	77	
Aegean Sea	Kahraman and Oray, 2001	1^{St} dorsal fin spine	56	58.3	65.6	71. 6	80.8	84.8		
Turkey	Kahraman and Oray, 2001	1^{St} dorsal fin spine	55.8	61.6	71.5	77.2	79.3	84	93.1	
West Med.	Valeiras *et al.*, 2008	1^{St} dorsal fin spine	38.6	58.2	65.4	74.6	81.6			
Tunisia	Hattour 2008	Vertebrae	33.2	46.6	59.6	64	72	79	82	
Tunisia	Hattour 2008	1^{St} dorsal fin spine	32.8	41	50.1	56.7	63.5	69.9	73.6	
Egypt	Present study	Vertebrae	39.6	51.7	62.2	72.1	80.5	86.7	92.4	96.4

Table 5. Growth parameter for *E. alletteratus* from the present and previous studies

Area	Country	Growth Parameter			Reference
		L_∞	K	t_0	
East Atlantic	Spain	115	0.19	-1.17	Rodriguez-Roda, 1979
East Atlantic	Senegal	99.5	0.32		Diouf, 1980
Off Senegalese coast	Senegal	112	0.13		Cayré and Diouf, 1983
Mediterranean Sea	Tunisia	111	0.22		Hattour, 1984
Mediterranean Sea	Tunisia	136	0.16		Hattour, 1984
Mediterranean Sea	Turkey	123	0.13	-3.84	Kahraman and Oray, 2001
Aegean sea	Turkey	128	0.11	-4.18	Kahraman and Oray, 2001
West Mediterranean	Spain	91.5	0.39	-0.4	Valeiras *et al.*, 2008
Coast of Alexandria	Egypt	123.4	0.16	-0.59	Present study

Table 6. b value of length weight relationship of *E. alletteratus* in different area

Area	b value	Author
Gibraltar strait	2.915	Rodriguez-Roda (1966)
Tunisia	3	Hattour (1984)
Sicily seas	2.903	Andaloro *et al.* (1998)
Eastern Mediterranean sea, Turkey	2.726	Kharahman and Oray (2001)
Aegean sea, Turkey	2.697	Kharahman and Oray (2001)
Eastern Mediterranean, Turkey	2.468	Kahraman (2005)
Eastern Mediterranean in North Cyprus	2.956	Kahraman (2005)
Levantin basin, Turkey	2.77	Kahraman and Alicli (2007)
Western Mediterranean, Spain	2.967	Macias (2009)
Gulf of Gabes, Tunisia (Sept.)	2.94	Hajjej *et al.* (2010)
Gulf of Gabes, Tunisia (Dec.)	2.86	Hajjej *et al.* (2010)
Teboulbah, North Tunisia	2.82	Hajjej *et al.* (2011)
Zarzis, South Tunisia	2.91	Hajjej *et al.* (2011)
Alexandria, Egypt	2.9	Present study

spring (Zengin and Karakulak, 2009). Similar seasonal variation between autumn and spring in the present study was recorded, however; the length range was from 13 to 102cm with mean length of 40.7cm, dominated by small size fishes. It is clear that the recorded minimum length (13cm FL) of the little tunny catch is not realistic and the majority of the catch is immature individuals when considering the length at first maturity (40cm FL) for *E. alletteratus* stock in the present study (unpublished data by present authors).

Two methods for natural mortality were estimated, the difference between two estimates are large. In the present study, estimate from Djabali *et al.* (1994) method which contains asymptotic length as a function of natural mortality was used in calculation. According to Gislason, *et al.* (2008) the asymptotic length is influence the estimate of natural mortality.

Virtual population analysis (VPA) has been widely used in fish stock assessment during the last 30 years (Sparre and Venema, 1998). It is commonly used for studying the dynamics of harvested fish populations. The results in the present study which were obtained from VPA analysis indicate that, the fish which died by natural mortality are higher than those which die by fishing mortality from age group one to five, except for age group 0 which revealed that little tunny in Egyptian Mediterranean Sea water is subjected to a high fishing effort directed to younger fishes negatively affecting its stock. Exploitation rate estimate (E_{cur} = 0.8) confirmed the previous conclusion. According to Gulland (1971) the optimum exploitation ratio E_{opt} = 0.5, this implies that the stock of *E. alletteratus* from Eastern Coast of Alexandria is heavily exploited and the fishing pressure exerted in the region is high.

The results indicate also that, at the present level of fishing mortality coefficient (F= 1.6), age at first capture (T_c= 1.4 year) and natural mortality coefficient (M= 0.396), the yield per recruit was found to be 702.72g. This means that, the present level of fishing mortality is higher than that which gives the maximum yield per recruit (880.54g). Fishing mortality should be reduced from 1.6 to 0.44 (72.5%) to achieve this yield per recruit. Moreover, the present level of L_c should be raised to at least 44cm for allowing fish to spawn at least one time during its life and increase its biomass. In Turkey, the law disallows catching *E. alletteratus* less than 45 cm (Zengin and Karakulak, 2009).

Conclusion

It can be concluded that the *E. alletteratus* stock off the Eastern Alexandria is in a situation of overexploitation and not at sustainable rate, indicating a tendency for catching immature and maturing fishes together. To ensure sustainability of this species, optimum size is required to maximize yield per recruit and allow the stock to recovery through applying management measures including reduction of the present level of fishing effort by about 72.5% and an increase in the length at first capture to reach 44cm. Where reducing of fishing effort seems difficult for socio-economic reasons (low income for artisanal fishery), it is recommended a closed season during late early autumn (September- November) with regulate the mesh sizes of the gill nets used or design an appropriate fishing gear targeted little tunny instead of fishing as bycatch with other target fishes. A new monitoring and control system based on annual data which implements realistic measures with further stock assessment study is urgently needed.

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