

Reproductive Biology of little tunny, *Euthynnus alletteratus* (Rafinesque 1810) in the Eastern Coast of Alexandria, Egypt

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ABSTRACT

Reproductive biology of *Euthynnus alletteratus* was described based on 628 fishes that were collected from Abu Qir landing site between October 2006 and September 2007. Only 146 specimens were sexually distinguished (102 females, 44 males) and the others were immature. The sex ratio was estimated as M: F 1:2.3. Size at first sexual maturity was estimated as 42cm. Spawning season was investigated based on monthly observation of gonadal maturity stages and gonad-somatic index (GSI). The spawning season extends from June to August with a highest GSI value in June. The fork length (FL)–guttled weight (GW) relationship was estimated as $GW=0.052 FL^{2.639}$ for combined sexes. Condition factor (K) was calculated using the gutted weight of all samples (regardless of sex) with an average of 1.3. Management plan is important to overcome the high percentage of immature fishes in the catch off Alexandria water. Extending closed season to July and increasing the length at capture to 44cm are important for enhancing the chance of spawning at least once during its life.

Keywords: *Euthynnus alletteratus*, reproduction, spawning season, condition factor, Alexandria, Egypt

INTRODUCTION

Little tunny or *Euthynnus alletteratus* is a pelagic species; one of the members of the Scombridae, has a wide distribution in the world and predominant in the Mediterranean Sea and black sea (Belloc, 1955; Valeiras and Abad, 2007). It is occurred in the Mediterranean catch all over the year but with more abundant during summer months (Sylva and Rathjen, 1961). Egyptian Mediterranean catch from *E. alletteratus* was fluctuated between 704 and 1442 tonnes in the period from 1998 to 2007 (GAFRD, 2008).

Some Biological studies on *E. alletteratus* have been conducted in different regions of Mediterranean Sea, e.g. in Turkey (Kahraman and Alicli, 2007), in Spain (Macias *et al.*, 2006), in Tunisia (Hajje *et al.*, 2010), in Eastern Atlantic Ocean (Gaykov and Bokhanov, 2008). They focused on length weight relationship, sex ratio, maturity stages, length at first sexual maturity, spawning season and gonad-somatic index. No reproductive study about *E. alletteratus* was conducted in Egypt. Results of such study could be used for stock assessment and fishery management of this important species (Hajje *et al.*, 2010).

So, the present study deals with the reproductive biology of *E. alletteratus* in the Eastern Coast of Mediterranean Sea, off Alexandria, Egypt.

MATERIALS AND METHODS

Samples of *E. alletteratus* were collected weekly during the period from October 2006 to September 2007 from Abu Qir landing site, off eastern coast of

Alexandria city (Fig. 1); closed season was applied from 1st May until 15th June. Total of 628 specimens were collected from commercial fishery using gill net. In laboratory fork length were measured to the nearest 1mm and gutted weight to the nearest 1g, while gonad weight to the nearest 0.01g. Sex was identified visually after dissecting. Sex ratio was calculated according to the number of males to females.

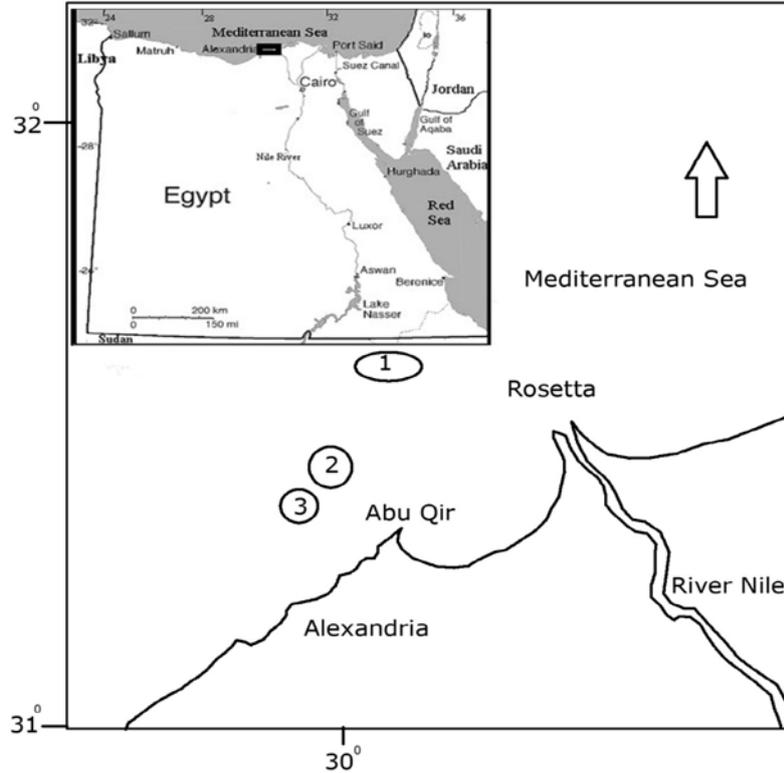


Fig.1: Eastern Coast of Alexandria city, Egypt, (black circles indicate the fishing ground and Abu Qir is the landing site)

Maturity stages of *E. alletteratus* gonads were identified based on morphological changes that take place during its development to reach spawning. Maturity stages were observed by gonad coloring and its volume percentage to the body cavity. Six stages were identified; I is immature, II is mature, III is maturing, IV is ripe, V is spawning and VI is spent (Nickolsky, 1963). Length at first maturity which 50% of fish were sexually mature (Pitt, 1970) was estimated for reproductively active fish (Stages III–VI).

Gonad-Somatic Index (**GSI**) was calculated to determine spawning season according to Shelly & Southgate (1988) formula as following:

$$\mathbf{GSI} = (\mathbf{G}/\mathbf{GW}) * 100$$

Where: **G** is Gonads weight (g) and **GW** is gutted weight (g).

The relationship between Gutted weight (GW) and Fork length (FL) was expressed by Le Cren, (1951) equation:

$$\mathbf{GW} = a \mathbf{FL}^b$$

Where: a = intercept and b = slop

The Fulton condition factor (**K**) was calculated using gutted weight and fork length by the following formula:

$$\mathbf{K} = (\mathbf{GW}/\mathbf{FL}^3) \times 100 \text{ (Le Cren, (1951))}$$

Where: **GW** is the gutted weight (g) and **FL** is the fork length (cm).

RESULTS

Sex ratio:

Only 146 fish of the entire sample could be identified by sex. Out of 628 sampled specimens, 483 fish were recorded as immature representing 77%. The calculated sex ratio of collected mature samples was M: F = 1.0: 2.3. Females dominated of the smallest sizes from 32 to 73cm FL and also largest lengths (90-95 cm), while males dominated the lengths of 80cm and lengths larger than 100cm (Fig. 2). No mature fish were found in November and December. Females dominated the catch throughout the year. The highest percentage for females was found in June (60%) and July (54%) as shown in Fig. 3.

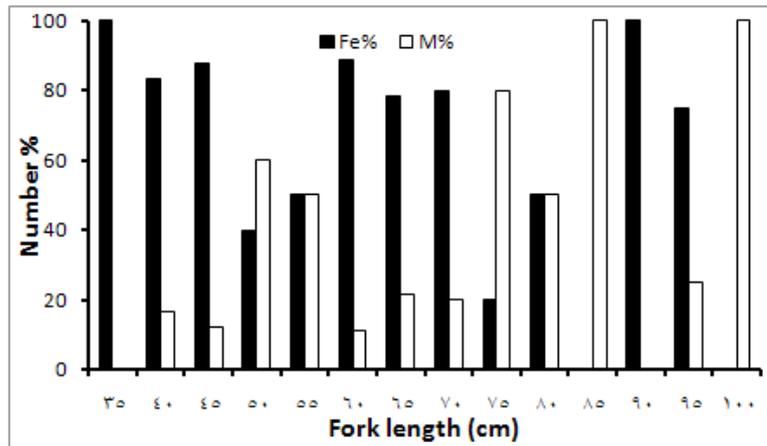


Fig. 2: Sex ratio by fork length for female and male of *E. alletteratus* in the Eastern Coast of Alexandria, Egypt.

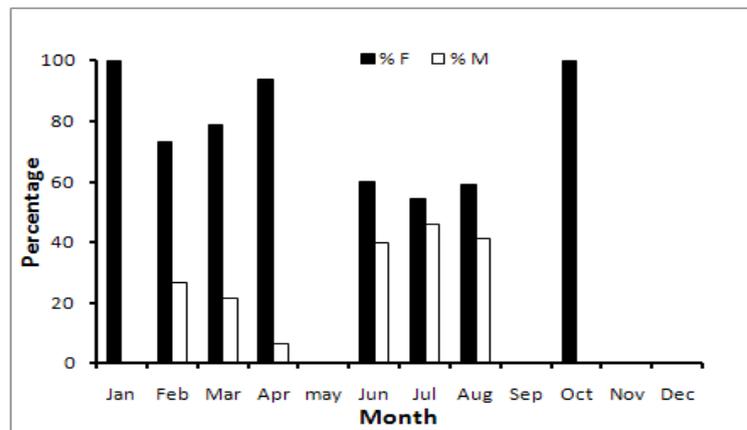


Fig. 3: Monthly variation in sex ratio of *E. alletteratus* in the Eastern Coast of Alexandria, Egypt.

Maturity Stages

Specimens of *E. alletteratus* from Eastern Coast of Alexandria were classified to immature and mature fishes. Immature fishes were absent in the catch during the period from June to August in which all samples were mature. Monthly pattern of gonadal activity showed occurrence of five maturity stages for females and males; from stage II up to stage VI (Fig. 4). For females, maturity stage II was dominated the catch from January to April and absent during spawning season, then appeared again in October. Maturity stage III was found from April to July and maturity stage IV from June, while maturity stages V and VI were occurred from June to August. For

Males, maturity stage II was dominated the catch from January to April, while maturity stage III and IV were available in June and July. Stages V and VI occurred from June to August.

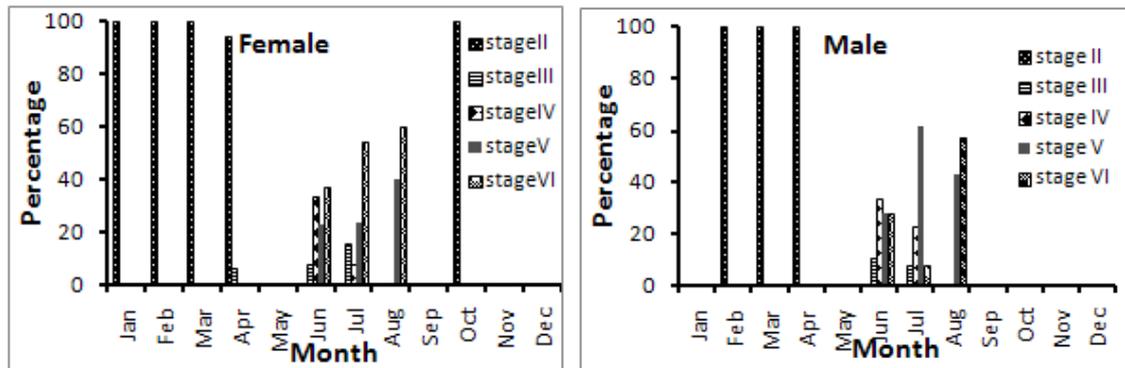


Fig. 4: Monthly changes of different maturity stages for female and male of *E. alletteratus* from Eastern Coast of Alexandria, Egypt.

Length at first sexual maturity

The length at first sexual maturity of *E. alletteratus* (50% maturity) was estimated as 42cm (Fig. 5). The smallest mature female and male was 33 and 38cm respectively.

Gonad-Somatic Index

Gonad-Somatic Index (GSI) was calculated for females and males of *E. alletteratus*. In general, gonads were in dormant condition from September to December, so the GSI had no value. When the gonads started to be developed in January, the GSI value of females increased from 0.2 in January to 5 in June, reaching its peak then decreased gradually from July, while for males gonads started to develop in February and reach its peak in June (5.6), then afterward start to decrease. The results revealed that spawning season is restricted from June to August as shown in Fig. 6.

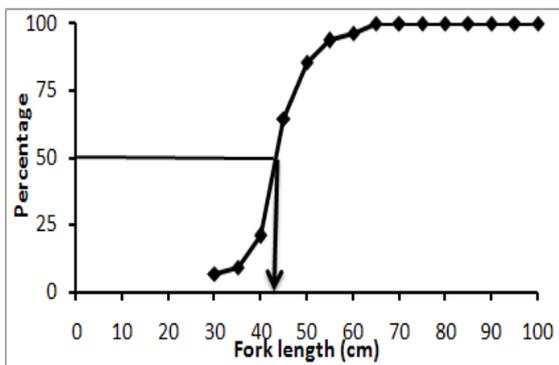


Fig. 5: Length at first Sexual maturity of *E. alletteratus* in the Eastern Coast of Mediterranean Sea off Alexandria, Egypt.

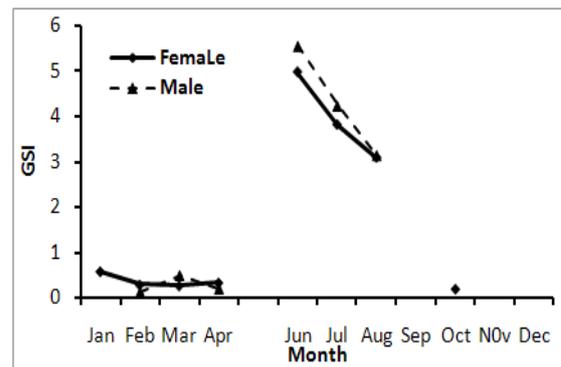


Fig. 6: Monthly variation of Gonad-somatic Index (GSI) of *E. alletteratus* from Eastern Coast of Alexandria, Egypt.

Length weight relationship

Length weight relationship of *E. alletteratus* was calculated for all mature samples (females and males). Fork length of females were ranged between 33 and 96cm and their gutted weights ranged from 554 to 9000g., while males length varied

between 38 and 102cm and their weights varied between 782 and 11500g. Moreover, immature fork lengths ranged between 13 and 53cm and their weights ranged between 16 and 1800g (Fig. 7). Length weight relationship equations were estimated as:

$GW=0.052FL^{2.639}$ ($r^2 = 0.981$, $n = 146$) for combined sex
 $GW=0.060FL^{2.600}$ ($r^2 = 0.980$, $n = 102$) for females
 $GW=0.037FL^{2.722}$ ($r^2 = 0.984$, $n = 44$) for males
 $GW=0.008FL^{3.125}$ ($r^2 = 0.988$, $n = 483$) for immature samples

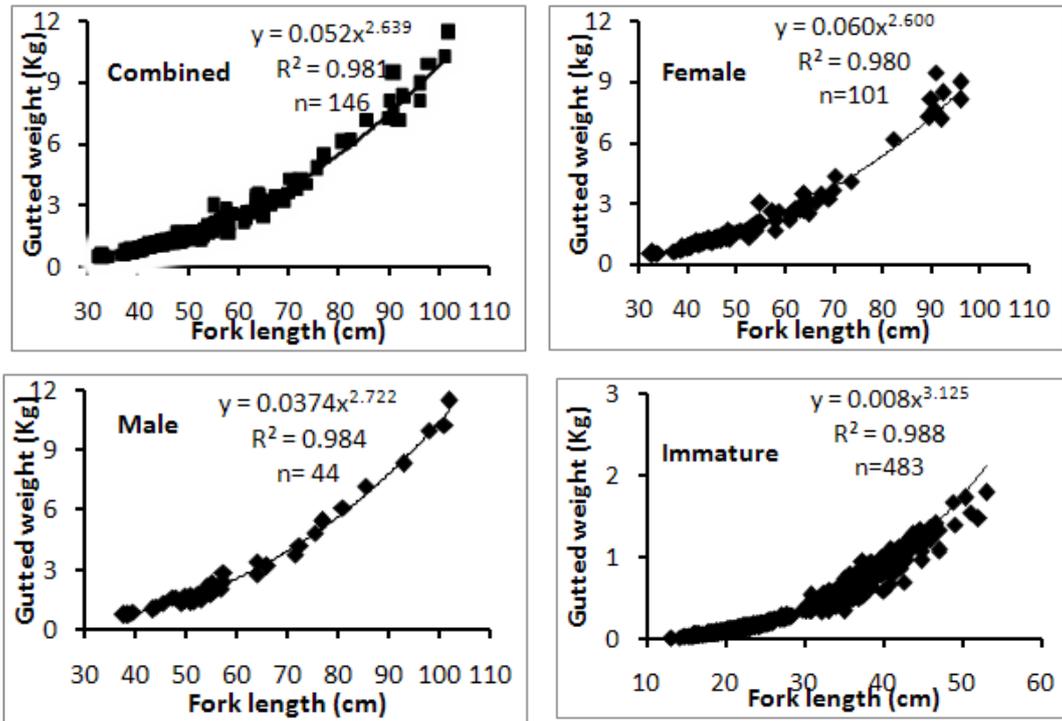


Fig. 7: Length weight relationship for combined sexes, females, males and immature of *E. alletteratus* in the Eastern Coast of Alexandria, Egypt.

Condition factors

The average condition factor (K) of *E. alletteratus* was calculated using the gutted weight of all samples (regardless of sex) with value of 1.3 (Fig. 8).

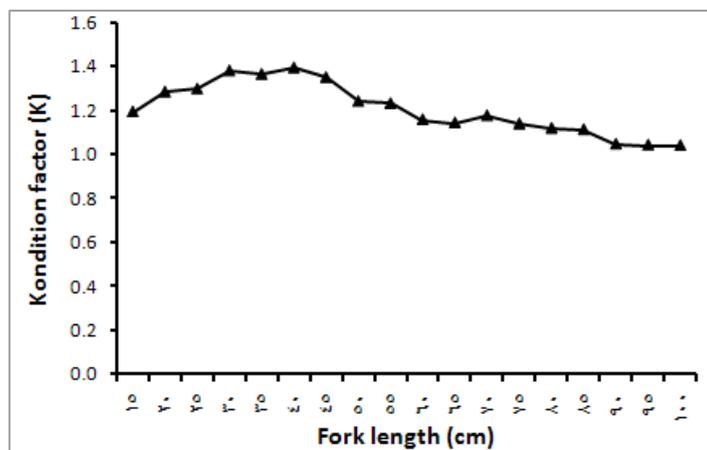


Fig. 8: Changes of condition factor (K) by length of *E. alletteratus* from Eastern Coast of Alexandria, Egypt.

The condition factor was increasing with the increasing of fish length before 42cm and then K value decreased with increasing the length. Monthly variation of condition factor showed lowest values in June and July (Table1).

Table 1: Months changes of condition factor (K) of *E. alletteratus* from Eastern Coast of Alexandria.

Month	K
Oct.	1.324
Nov.	1.361
Dec.	1.384
Jan.	1.344
Feb.	1.365
Mar.	1.343
Apr.	1.388
June	1.174
Jul.	1.102
Aug.	1.261
Sep.	1.283
Average	1.3

DISCUSSION

Euthynnus alletteratus is a common pelagic species in Egyptian Mediterranean fisheries; the catch of *E. alletteratus* fluctuated between 704 to 1442 tonnes (GAFRD, 2008). The present study investigates the biological parameters of *E. alletteratus* for this important species in the Egyptian Mediterranean waters.

Reproduction is the process by which species are propagated. The success of any fish species is ultimately determined by the ability of its members to reproduce successfully in a fluctuating environment (Moyle and Czech, 2000). Sex ratio indicates the proportion of male and female in the population and is expected to be 1:1 in nature. Any deviation from this ratio may indicate the dominance of one sex over the other. This happens because of differential behavior of sexes, environmental conditions, fishing activities, etc. (Bal and Rao, 1984). Sex ratio in the present study for male to female was found to be 1.0:2.3 (i.e. females dominated males through the year). This means that there is a difference in availability of both sexes for fishery; this may be due to a spatial segregation of sexes or because of different behavior in relation to the gear (Mendonça *et al.*, 2006). This result is closer to what reported by Kahraman *et al.* (2008) in Eastern Mediterranean, Valeiras *et al.* (2008) in Western Mediterranean and Hajje *et al.* (2009) in Tunisia. This phenomenon was observed for other tuna species like *Thunnus obesus* (Nikaido *et al.* 1991), *Thunnus thynnus* (Clay 1991), *Thunnus alalunga* (Wu and Kuo 1993; Ramon and Bailey 1996), and *Thunnus albacares* (Sun *et al.*, 2005). Circumstantial evidence suggests that the observed difference in sex ratio at size, is probably due to the possibility of different natural mortality rates, as suggested for swordfish in the North Atlantic Ocean by Restrepo *et al.* (1991).

Spawning in fish can be affected by several different environmental factors; temperature and photoperiod influence fish reproduction by stimulating sensory organs that induce the production of gonad hormones, which can induce physiological or behavioral responses (Junk, 1999). In the present study the monthly changes in the maturity stages for males and females indicated that the spawning period occurred between June and August. Monthly variation in mean Gonad-Somatic Index (GSI) of females and males confirmed the spawning season finding i.e. occurred between June and August. This agrees with what reported by Valeiras *et al.* (2008) and Kahraman *et al.*

al. (2008) for western and eastern Mediterranean population respectively. Rodriguez-Roda, (1979) in southern Spain and off the coast of Senegal by Cayre and Diouf, (1983), Andaloro *et al.* (1998) in South Tyrrhenian and Sicily Strait, Hattour, (2000) and Hajje *et al.* (2010) off Tunisia reported closer results. Oray and Karakulak, (2005) reported that spawning occurs only during June in East Mediterranean near Cyprus and Santamaria *et al.* (2005) reported that spawning occurs in July and August in South Italian seas. Landau (1965) showed that the spawning period starts early May to September and Collette & Nauen (1983), while Gaykov & Bakhanov (2008) reported that spawning of *E. alletteratus* occurs from April to November in eastern and western Atlantic. In the present study no samples were collected during May (closed season) and maturing females were present in April which indicates that spawning may occurred in May. Different spawning periods from January till May were observed in Tropical African Coast (Chur, 1973 ; Rudomiotkina, 1986). Gaykov and Bokhanov (2008) concluded that the spawning duration may vary from 4 to 8 months depending on the area latitude. Spawning time occurs in the areas with pronounced season alternation of the northern and southern hemispheres in the opposite calendar time corresponding to the warm period of the year.

Size at sexual maturity of *E. alletteratus* is an important life history parameter that has been estimated in previous studies. Knowing the size at first maturity of fish helps to predicts catchable size of the fish. The size at first maturity depends on the nature of the environment in which the population of concern lives (Moyle & Czech, 2000). The present study revealed that *E. alletteratus* reached its first sexual maturity at 42 cm fork length, which was exactly similar to that found in the Gulf of Guinea (Chur, 1973) and close to that reported for Gulf of Gabes (Hajje *et al.*, 2010), while in southern Spain sexual maturity is reached at 57 cm fork length (Rodriguez-Roda, 1966). This difference in maturity size may relate to the environmental condition which induced phenotypic flexibility in fishes which may change size at maturity (Ishida *et al.*, 1993; Cox and Hinch, 1997; Pyper *et al.*, 1999; Wertheimer *et al.*, 2004). Immature fishes were abundant in the catch during the present study and the length at first capture was estimated as 32cm (Elhaweet *et al.*, 2013) i.e. less than the length at first maturity suggesting many fishes could not get chance to spawn even once. The smallest mature size of *E. alletteratus* female and male was 33 cm and 38 cm respectively which is shorter than what were reported in Tunisian water by Hajje *et al.* (2010) for female and male as 38.7 and 39.4 cm respectively and Hattour (2000) as 40 cm and 41 cm respectively, while Diouf, (1980) determined that samples at 60 cm of length were fully mature in Senegal. These different between current study and other previous studies may be due to the negative effect of exploitation and mechanism of compensation which affect changes in size of maturation (Walker & Ellis, 1998).

The Length weight relationship is used to describe mathematic model between weight and length (Wootton, 1990). It is an important biological factor which helps in the study gonad development. In the present study; length weight relationship of *E. alletteratus* was calculated by allometric growth equation, the value of b for combined sex was found to be 2.64 and for females samples 2.6 while for males samples 2.72, which show negative allometric growth equation ($b < 3$), while it was expressed as 3.125 for immature samples (positive allometric growth) which reflects better growth in weight by length for immature fishes. Length weight relationship was the subject of many studies in Mediterranean Sea; the b value of the present study is similar to that obtained in Aegen Sea and from Eastern Mediterranean Sea by Kahraman and Oray (2001) and in Levantin basin by Kahraman and Alicli (2007).

But it is slightly less than that obtained in North Tunisia and from South Tunisia, Zarzis by Hajjej *et al.* (2011). These differences could be due to the sampling procedure, namely size and length range or related to seasonal reproduction or feeding activities or using data not derived from all seasons in equal proportions (Wootton, 1990).

In fisheries science, the condition factor is used in order to compare the condition fitness or well being of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal, 1978), also influences the reproductive cycle in fish (Welcome, 1979) and could use as an indicator of physiological state of the fish in relation to its welfare (Le Cren, 1951). It also provides information when comparing two populations living in certain feeding density, climate and other conditions (Weatherley, 1972; Ricker, 1975; Weatherly and Gills 1987). The condition factor of *E. alletteratus* showed steady increase from January to April then suddenly dropped in June and July (spawning season); it probably related to energy available used for reproduction. The condition factor was increasing with the increasing of fish length less than 42cm (i.e. immature fishes) and then decreased with increasing the length. Bakare (1970) and Fagade (1979) stated that condition factor decreases with increase in length.

Reproductive parameters such as sex ratio and size at first maturity are of great value in fishery prediction and formulation of management measures (Bal and Rao, 1984). The results revealed that management plan is necessary for this important species in the Egyptian Mediterranean water to catch more mature fishes than immature one. To ensure sustainability of this species, applying management measures is recommended. Minimum size at capture fishes should be more than 42cm and the present closed season should extend from May to July for increasing the possibilities of spawning. Elhaweet *et al.* (2013) during the population dynamics study of *E. alletteratus* in the present study area have recommended to increase the length at first capture to reach 44cm.

CONCLUSION

The biological parameter of *E. alletteratus* in Eastern Coast of Alexandria, Egypt, has been studied and revealed that immature fishes are more abundant in the catch than mature ones. First sexual maturity estimation indicates that 50% of the samples reached their first sexual maturity at length 46cm, while the mean length at capture was 32cm which realize the important of management plan to overcome the overfishing situation in the off Alexandria population. Extending the closed season to July and increasing the length at capture to 44cm, is recommended for enhancing the chance of spawning at least once during its life.

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ARABIC SUMMARY

بيولوجية تكاثر سمكة البلاميطة (*Euthynnus alletteratus* (Rafinesque 1810) في الساحل الشرقي للاسكندرية - مصر

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تعد سمكة البلاميطة من الاسماك الهامة تجاريا في الساحل الشرقي للبحر الابيض المتوسط وبدراسة بيولوجية التكاثر لـ ٦٢٨ عينة من اسماك البلاميطة من منطقة ابو قير خلال الفترة من أكتوبر ٢٠٠٦ وحتى سبتمبر ٢٠٠٧. وجد ان عدد الاسماك الناضجة جنسيا هو فقط ١٤٦ سمكة (١٠٢ اناث و ٤٤ ذكور) حيث تم في هذا البحث دراسة النضج الجنسي والطول عند اول بلوغ وموسم التكاثر. وتمثل الاناث حوالي ٧٠% من اجمالي العينات الناضجة جنسيا ويتراوح الطول عند مفرق الذيل ما بين ٣٢-١٠٢ سنتيمتر وتتراوح اوزانها ما بين ٥٦٩ - ١١٥٠٠ جرام ، كما تم احتساب العلاقة بين اطوال الاسماك واوزانها واحتساب معامل الحالة لجميع العينات المجمعة. كما اظهرت الدراسة تفوق اعداد الاناث على الذكور وكانت بداية النضج الجنسي عند طول ٤٢سم، و يمتد موسم التكاثر من يونيو وحتى اغسطس.

توضح نتائج هذه الدراسة اهمية اتخاذ اجراءات لمعالجة الوضع الحرج لمصايد اسماك البلاميطه بالاسكندرية بزيادة فترة موسم وقف الصيد ليتمد الي شهر يوليو وتحسين مواصفات شباك الصيد لزيادة متوسط طول المصيد الي ٤4سم حتي تستطيع الاسماك ان تبيض ولو مره واحده في حياتها.