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## Some Biological Characteristics of the Tub Gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) in the Sea of Marmara

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**Abstract:** The biology of the tub gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758), has been studied on data collected between November 1996 and November 1997 from the Sea of Marmara. Totally, 224 tub gurnards were sampled. The age, growth, length–weight relationship, condition factor, male to female ratio, first sexual maturity age, length and reproduction period were examined. The age composition of samples ranged between 1 and 6 years. Total length ranged between 12.3 and 41.5 cm, while weight varied from 15 to 617 g. The total length–weight relationship was estimated as  $W=0.0092L^{3.019}$ . The parameters of the von Bertalanffy growth equation were:  $L_{\infty} = 61.3$  cm,  $K = 0.17 \text{ year}^{-1}$ ,  $t_0 = -0.04$  year. The observed sex ratio was 1 female: 0.5 male in the samples. The lengths and ages at first maturity ( $L_{T50}$ ) for tub gurnard were 18.97 cm and 3 years for females, 18.50 cm and 3 years for males. Possibly, reproduction is achieved throughout the year.

**Key Words:** Tub gurnard, *Chelidonichthys lucernus*, Sea of Marmara, age, growth, reproduction

### Marmara Denizi'ndeki Kırlangıç Balığı, *Chelidonichthys lucernus* (Linnaeus, 1758)'un Bazı Biyolojik Özellikleri

**Özet:** Marmara Denizi'ndeki Kırlangıç balığı, *Chelidonichthys lucernus* (Linnaeus, 1758)'un Kasım 1996 ve Kasım 1997 tarihleri arasında toplanan 224 örneğine göre yaş, büyüme, boy-ağırlık ilişkisi, kondisyon faktörü, eşey oranları, ilk eşeyssel olgunluk yaşı ile boyu, üreme süresi incelenmiş ve yaş kompozisyonunun 1 – 6 arasında dağılım gösterdiği belirlenmiştir. Toplam boy 12,3 – 41,5 cm, ağırlık 15 – 617 gr arasında değişim göstermektedir. Boy-ağırlık ilişkisi  $W=0,0092L^{3,019}$  olarak saptanmıştır. Von Bertalanffy büyüme parametreleri  $L_{\infty} = 61,3$  cm,  $K= 0,17 \text{ yıl}^{-1}$ ,  $t_0 = -0,04$ 'dür. Dişi, erkek eşey oranı 1:0,5, ilk eşeyssel olgunluk yaşı ve boyu ( $L_{T50}$ ) dişilerde 3 yaş ve 18,97 cm, erkeklerde 3 yaş ve 18,50 cm olarak saptanmıştır. Üremenin yıl boyunca devam ettiği söylenebilir.

**Anahtar Sözcükler:** Kırlangıç Balığı, *Chelidonichthys lucernus*, Marmara Denizi, yaş, büyüme, üreme

### Introduction

The Sea of Marmara is a small basin (size: ~70 km x 250 km, surface area: 11,500 km<sup>2</sup>, maximum depth 1390 m) located between the continents of Europe and Asia, and forms the Turkish Straits System along with the Boğaziçi-İstanbul Boğazı (Bosphorus) and the Çanakkale Boğazı (Dardanelles) (1). It is connected to the Black Sea through the Boğaziçi-İstanbul Boğazı in the NE and to the Aegean Sea via Çanakkale Boğazı in the SW. The waters of the Black Sea (~17.6‰), flow to the Sea of Marmara through the Boğaziçi-İstanbul Boğazı (Bosphorus) by means of an upper layer flow (~38.5‰), and flow through the Çanakkale Boğazı (Dardanelles) by means of a lower layer flow (2). As a result of this, the Sea of

Marmara, with both brackish water and typical sea water, has a rich flora and fauna.

Tub gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) is a Mediterranean-Atlantic species, distributed from Norway to Senegal, Mediterranean Sea and the Black Sea (3).

There are few studies on the reproduction and growth biology of tub gurnard. Papaconstantinou (4) studied the age and growth with some comments on the tub gurnard in the Thermaikos Gulf (Greece), Baron (5) studied its biology from Douarnenez Bay (France), Altun et al. (6) from Yumurtalık Bay (Turkey) and İşmen et al. (7) from İskenderun Bay in the eastern Mediterranean.

The objectives of the present study were to determine the age, sex distribution, growth in length and weight, length-weight relationship, condition factor, attainment of first maturity age and reproduction of the tub gurnard in the Sea of Marmara, which is of economic importance among the species of Triglidae.

**Materials and methods**

Fish samples (n = 224) were caught monthly by jointly working with the fishermen in the Sea of Marmara between November 1996 and November 1997 (Figure 1). Due to adverse weather conditions, in May 1997 specimens could not be collected. In the study 28 x 28 mm wide meshed nylon nets were used for the sampling. Additionally obtained fish samples (n = 50) by the research Vessel “Arar” from the trawling stations in the Sea of Marmara in February and July 1995 were taken into consideration for maximum length and maximum age. Identification and nomenclature of the species have been based on Hureau (8), Fischer et al. (9) and Richards and Saksena (10). English common name suggested by Wheeler (11) was used.

After being caught, fish samples were brought to the laboratory and the total lengths (L<sub>T</sub>) and weights were measured to the nearest 1.0 mm and 0.1 g, respectively.

The sex and maturity stages of the samples were determined by visual and microscopic examination of the gonads. The stages of maturation were classified according to Laevastu (12). The gonads were removed and weighed to the nearest 0.0001 g. The monthly gonadosomatic index (GSI) values of females were calculated with the following formula:

$$GSI = \frac{\text{Gonad Weight (g)}}{\text{Body Weight (g)}} - \frac{\text{Gonad Weight (g)}}{\text{Body Weight (g)}} \times 100 \quad (13)$$

For the estimation of the mean lengths at 50% maturity, a logistic function was fitted to the proportion of the mature individuals by size class using a nonlinear regression. The function used was (14):

$$P = \frac{1}{1 + \exp[-r(L - L_m)]}$$

where P is the proportion mature in each size class, r is the slope of the curve and L<sub>m</sub> is the mean length at sexual maturity (50%). L<sub>m</sub> = a/r, where a is intercept.

Sagittal otolith pairs were removed, cleaned and stored dry in small nylon bags for later age determination. Age was read from the whole otoliths immersed first in alcohol (70%) and then in glycerin and xylol and viewed with a binocular microscope under reflected light against a black background (15). Opaque and transparent rings were counted and one opaque zone

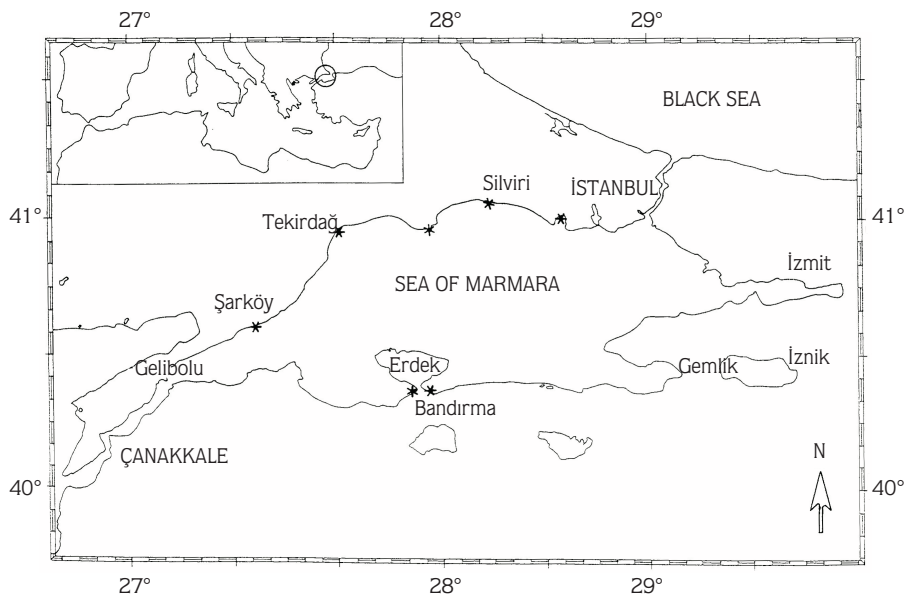


Figure 1. Map of sampling areas in the Sea of Marmara.

together with one transparent zone have been considered as annual growth. Otoliths were read at least twice. After determination of ages, fishes were categorized in age groups and classified by their lengths with 2 cm intervals.

The equation  $W = a L^n$  (16) was used in calculation of the length-weight relationship and condition factors ( $L_T$  is measured in cm) were determined by using the formula  $K = W 100/L^3$  (17).

Length at age was described by the three-parameter specialized von Bertalanffy growth model of the form  $L_t = L_\infty (1 - e^{-K(t-t_0)})$ , where  $L_t$  is the length at age  $t$ ;  $L_\infty$  is the predicted asymptotic length;  $K$  is the growth coefficient; and  $t_0$  is the age at 'zero' length (18). Growth parameters were estimated by using the FISAT II v.1.1.0 package program (19).

The widely used growth performance index ( $\phi'$ , phi-prime) for comparing fish growth was used:  $\phi' = \log_{10} K + 2 \log_{10} L_\infty$  (20).

All statistical analyses and graphics were prepared with the Microsoft Excel program.

## Results

### Age composition

The samples available for age and growth studies consisted of otoliths of 224 fish, covering all size classes sampled. The ages of the fish ranged from 1 to 6 years. According to the results of otolith readings, the age of *C. lucernus* varied between I and VI. The age group III (76.79%) was dominant in both sexes, followed by I (3.13%), II (8.04%), IV (10.27%), V (1.34%), VI (0.45%) age groups.

The samples taken by means of bottom trawl in 27-94 m depths in February and July 1995 showed a distribution between age groups 0 and IX.

### Length frequencies

The total length-frequency distribution of tub gurnard is shown in Figure 2. The total length of all individuals ( $n = 224$ ) ranged from 12.3 cm to 41.5 cm and weight varied from 15 g to 617 g. The age-length key for tub gurnard is presented in Table 1, which shows a considerable range in length for each age group.

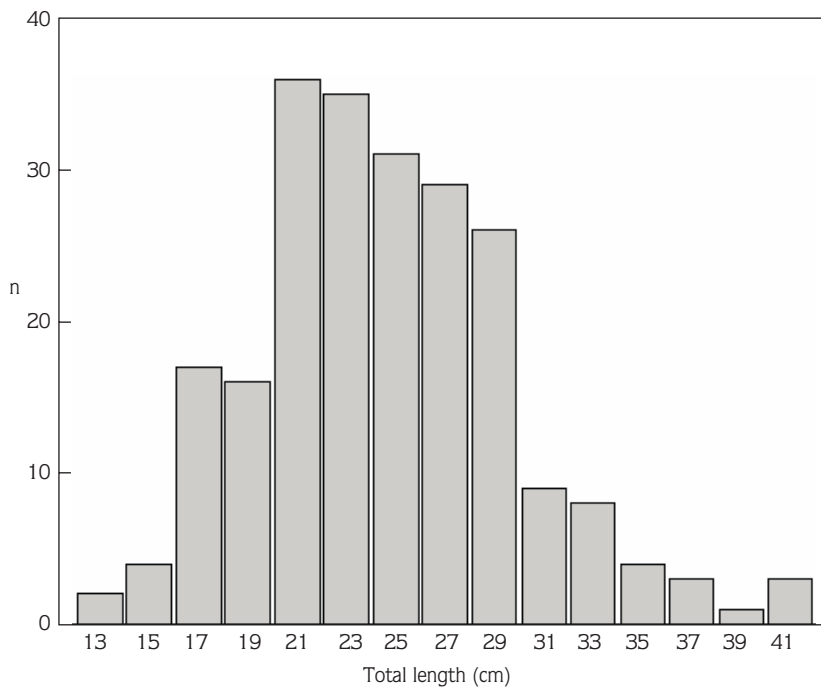


Figure 2. Total length - frequency distribution of *C. lucernus*, in the Sea of Marmara.

Table 1. Age-length key for females (F) and males (M) based on scale readings of *C. lucernus* from the Sea of Marmara

Total Length Range (cm)	Age Group												n		
	I		II		III		IV		V		VI			Total	
	F	M	F	M	F	M	F	M	F	M	F	M		F	M
12.0-13.9	1	1											1	1	2
14.0-15.9	2	2											2	2	4
16.0-17.9	1		6	9		1							7	10	17
18.0-19.9			1	1	7	7							8	8	16
20.0-21.9				1	22	13							22	14	36
22.0-23.9					15	20							15	20	35
24.0-25.9					22	9							22	9	31
26.0-27.9					23	4	2						25	4	29
28.0-29.9					22	2	2						24	2	26
30.0-31.9					4		4	1					8	1	9
32.0-33.9					1		5	2					6	2	8
34.0-35.9							3	1					3	1	4
36.0-37.9							2	1	1				3	1	4
38.0-39.9									2				2		2
40.0-41.9											1		1		1
Total	4	3	7	11	116	56	18	5	3		1		149	75	224
Observed Mean For Each Age	15.20	14.27	17.31	17.48	24.97	22.80	31.93	33.50	39.93	-	41.50	-			

The samples caught in February and July 1995 showed a distribution between 7.9 cm and 56.2 cm, and 10 g and 1443 g.

The von Bertalanffy growth constants for *C. lucernus* were computed using FISAT II v.1.1.0 (19) as follows:  $L_{\infty} = 61.3$  cm,  $K = 0.17$  (year<sup>-1</sup>) and  $t_0 = -0.04$  (year). The growth curve fitted by length at age data is given in Figure 3.

#### Length-Weight relationship

The length-weight relationships calculated by using the total lengths (cm) and weights (g) were found as  $W = 0.0092 L_T^{3.019}$  ( $R = 0.989$ ) for all fish. The length-weight curve of the samples is plotted in Figure 4. The exponent  $n$  demonstrated an isometric growth ( $n < 3.5$ ).

#### Condition factor

The condition factors were calculated monthly for overall combined samples and the obtained results are given in Figure 5.

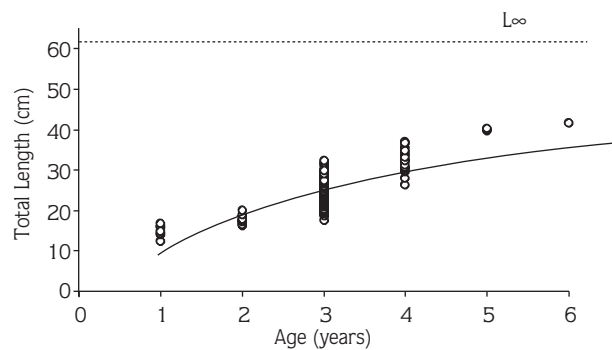


Figure 3. The von Bertalanffy growth curve fitted by length at age data for *C. lucernus* ( $n = 224$ ).

#### Maturity stages and sex ratio

Eight maturity stages were distinguished for the females and males. The monthly distribution of the maturity stages of both sexes in the period from November 1996 to November 1997 is shown in Figure 6. Spawning begins in V and VI gonad maturity stages.

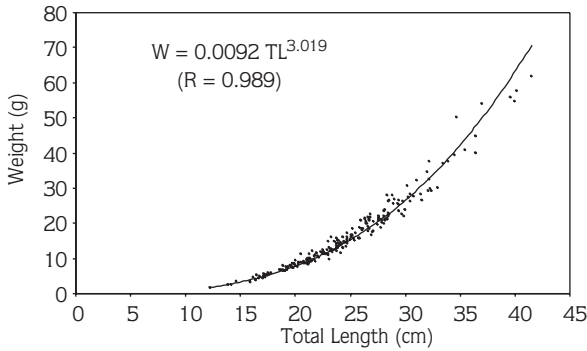


Figure 4. The length-weight relationships of *C. lucernus* samples from the Sea of Marmara.

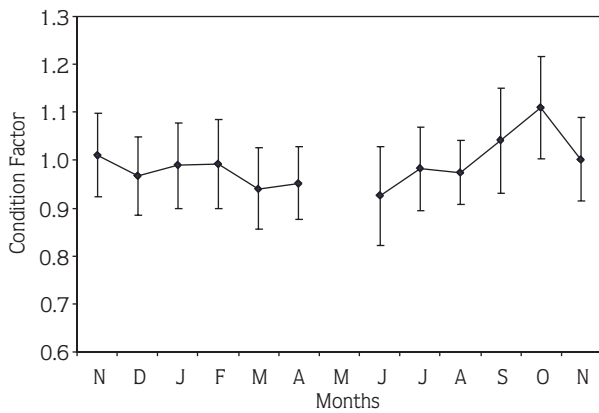


Figure 5. Monthly fluctuation in the condition factors of the combined sexes *C. lucernus* samples from the Sea of Marmara.

A total of 224 tub gurnards, consisting of 149 female (66.52 %) and 75 males (33.48 %) were used in the reproductive biology study. The female to male sex ratio was 1:0.5 in mature years.

#### Gonadosomatic index

Monthly average gonadosomatic index values of total 149 female gurnards were higher in April, July, August and November than those in other months (Figure 7). Based on the gonadosomatic index values, it can be said that spawning is more frequent in the periods of March to April, July to August, and October to the first week of November. It can be suggested that the reproduction of *C. lucernus* continues throughout the year.

#### Age and length at first sexual maturity

Male matured at a shorter length than female. Fifty percent maturity occurred at approximately 18.97 and 18.50 cm  $L_T$  for females and males, respectively (Figure 8).

$$P_{\text{female}} = 1 / \{1 + \exp[0.024(L-18.97)]\} \quad r = 0.748 \quad n = 98$$

$$P_{\text{male}} = 1 / \{1 + \exp[0.044(L-18.50)]\} \quad r = 0.908 \quad n = 45$$

Observed smallest and youngest mature female was 19.3 cm  $L_T$  (3 years) and male 17.3 cm  $L_T$  (2 years). The sexual maturity age was found in their 3<sup>rd</sup> year in both sexes.

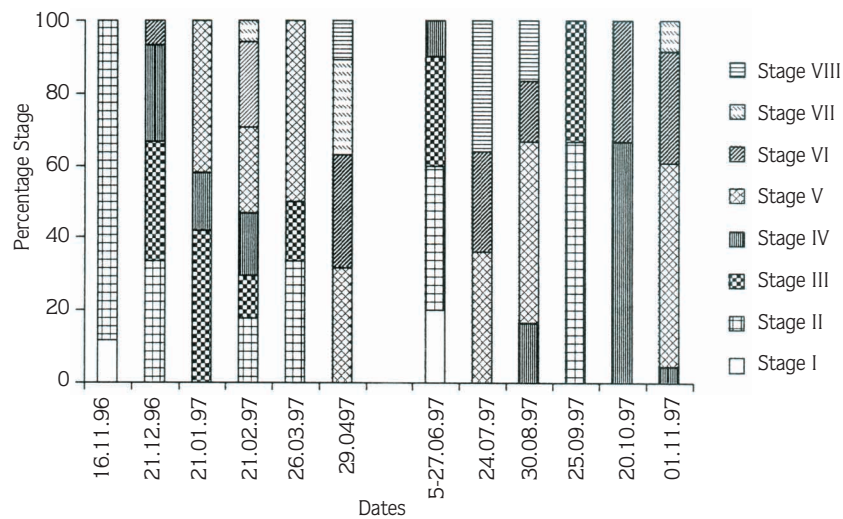


Figure 6. Monthly percentages in the maturity stages of *C. lucernus* (both sexes combined).

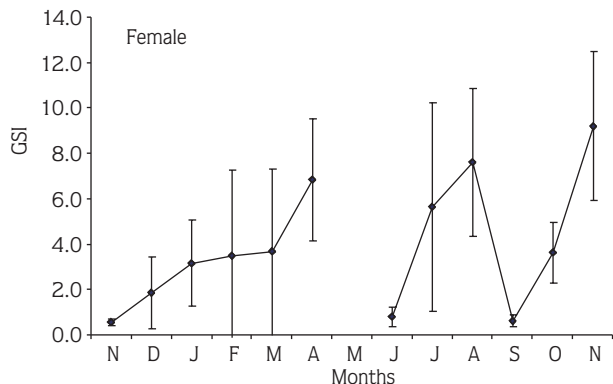


Figure 7. Gonadosomatic index (GSI) values of females by month for *C. lucernus*. The error bars represent  $\pm$ SD.

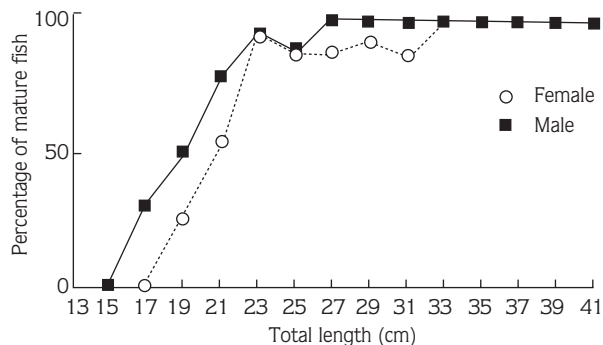


Figure 8. Percentage of mature male and female increasing total length of fish ( $L_T$ ) in *C. lucernus* in the Sea of Marmara.

### Discussion

The present study of 224 *C. lucernus* from the Sea of Marmara shows that 66.52% are females and 33.48% males, ranging between I and VI age groups. Looking at the other studies in other seas, distribution of age groups of females and males in total 241 tub gurnard samples in the territorial waters of Greece in Aegean Sea (Thermaikos Gulf) reported by Papaconstantinou (4) were respectively 0-X and 0-IV, and total 456 samples in Douarnenez Bay (France) stated by Baron (5) were I-XIV and I-XIII, and total 348 samples in Yumurtalık Bay in Adana reported by Altun et al. (6) showed an age group distribution between I and V; on the other hand, in 342 samples in İskenderun Bay reported by İşmen et al. (7) the maximum age was IV for females and III for males.

In this study, the maximum length ( $L_T$ ) measured for females and males was 41.5 cm and 36.5 cm, respectively. Female tub gurnards appeared to have a slower growth rate and a larger maximum length and age than males. This difference is the most common pattern found in other triglid species, particularly those with significant sexual morphometric differences (4,5). Average values  $L_T$  for age groups of I-VI have been calculated as respectively 14.80, 17.42, 24.26, 32.27, 39.93, and 41.50 cm. Maximum length ( $L_F$ ) reported by Papaconstantinou (4) for total 111 females was 76.7 cm and for total 130 males was 34 cm (because of the tail morphology, there is not a significant difference between fork length values and total length values). Baron (5) reported the maximum length ( $L_T$ ) of this species as 70 cm, Altun et al. (6) as 26.9 cm, and İşmen et al. (7) as 30.3 cm. According to Akşiray (21), gurnard reaches a length of 18-20 cm within the first year of age.

The theoretical maximal length value was close to the size of the largest fish, and growth coefficient value indicated relatively low attainment of maximal size. The values of our study are similar to a study carried out in Morocco (Table 2). The values of Morocco (Data Ref: 22) and Thermaikos Gulf (Data Ref: 23) are according to Fish Base (24). The differences in growth between regions can be attributed to the difference in size of the largest individual sampled in each area, and methodological differences in the age and growth studies, fishing mortality, variation in temperature, salinity, and, possibly, differences in feeding habits.

The growth performances shown by the tub gurnard in this study are in accordance with those observed in other areas, as indicated by the values of the  $\phi'$  parameter after Pauly and Munro (20) (Table 2). The  $\phi'$  values were tested according to Avşar (25). Munro's phi prime test showed that there is no significant difference ( $P > 0.05$ ) between the overall growth performances of the tub gurnard sampled from the other areas.

Length-weight relationship was found as  $W = 0.0092L^{3.019}$  ( $R = 0.989$ ) for all fish. Papaconstantinou (4) defined length-weight relation with 122 females and 153 males, and gave the equation of relation as  $W = 0.000006 \cdot L^{3.11}$  ( $R = 0.997$ ) for females and as  $W = 0.000005 \cdot L^{3.147}$  ( $R = 0.992$ ) for males. İşmen et al. (7) reported the equation for the relationship  $W = 0.0095 \cdot L^{2.99}$  ( $R = 0.98$ ) for females, and  $W = 0.0089 \cdot L^{3.01}$  ( $R = 0.99$ ) for males. According to Stergiou and Moutopoulos (26), Papaconstantinou et al. (23) found  $W = 0.0000096L^{3.011}$  ( $R = 0.93$ ) for combined sex. These values are in concordance with our study.



Table 2. A summary *C. lucernus* growth estimates using otoliths in different geographical areas. Growth performance is calculated using  $\phi' = \log_{10} K + 2 \log_{10} L_{\infty}$  (20)

Country	Locality	Sex	$L_{\infty}$	K	$t_0$	$\phi'$	Source
France	Douarnenez Bay	Female	66.8	0.32	-0.46	2.89	Baron (1985)
France	Douarnenez Bay	Male	48.4	0.46	-0.41	3.03	Baron (1985)
Morocco	(50-120 m depth)	All	65	0.15	-1.11	2.8	Collignon (1968)
Greece	Thermaikos Gulf	All	71.3	1.57	-0.1	3.9	Papaconstantinou et al.(1994)
Turkey	Yumurtalık Bay	All	40.9	0.14	-2.27	2.37	Altun et al.(1997)
Turkey	Sea of Marmara	All	61.3	0.17	-0.04	2.81	This study

In this study, the annual mean of condition factors calculated for all individuals is 0.990. The mean of condition factors of the samples were found to be high from December to March and from July to November, and low in June. This probably suggests that in this species the fluctuation in condition factor may be largely be attributed to the filling gonads and spent condition of the fish, and to the changes in food. Altun et al. (6) reported the condition factors of tub gurnard in of Yumurtalık Bay as  $0.8634 \pm 0.0142$ .

The sex ratio was found to be 1 female to 0.5 males in the studied samples (excluded immature specimens). As seen in Table 1, number of females is more than the number of males in all age groups except II, no males is seen in age group V and VI, and a decrease is seen in the number of older fishes. This is considered to have resulted from the migration of the older fishes to deeper regions. There are supportive findings of this opinion. This migration is more evident in females, because they show larger length and longer lifetime. Existence of young fishes living closer to river mouths and shallow coasts is related with the feeding, spawning and growth periods of the species (4).

Reproduction period of *C. lucernus* was reported by Slastenenko (27) to be from June and July in the Black Sea; by Tortonese (3) to be between December and May along the Italian coast; by Fischer et al. (9) to be from December to April and July in the Black Sea; by Papaconstantinou (4) to be from January to May and sometimes October to July in Thermaikos Gulf; by Hureau (8) to be from May to July in the Black Sea; and by İşmen et al. (7) to be between December and May in İskenderun Bay. In addition, Papaconstantinou (28) studied the ecology of gurnards in Greek Seas and stated that tub gurnard (*T. lucerna*) in Greek Seas reproduce all

year around, especially from autumn to spring. When reviewed the annual cycle of gonad phases determined by macroscopic definition of gonads of 224 male and female gurnards examined (Figure 6), it is seen that reproduction continues throughout the year. In addition, average gonadosomatic index values of total 149 female are higher in April, July, August and November (Figure 7). So, it can be said that reproduction is more frequent in the periods of March to April, July to August, and October to the first week of November.

Our results indicate that *C. lucernus* matured at their 3<sup>rd</sup> year of life in the Sea of Marmara. The lengths at first maturity of males and females were 18.50 cm and 18.97 cm ( $L_T$ ), respectively. Papaconstantinou (4) reported that the maturity of males begins after the completion of 3<sup>rd</sup> year and the maturity of females after 4<sup>th</sup> year. Altun et al. (6) stated that gurnards in Yumurtalık Bay achieve sexual maturity beginning from the first year. Banarescu (29) expressed that males and females achieve reproductive maturity when they are respectively 3 and 4 years old. İşmen et al. (7) indicated that males of *C. lucernus* matured at about 18 cm ( $L_T$ ) (2 years old) and females at about 20 cm ( $L_T$ ) (2 years old). The differences in growth rates might be attributed to different biological conditions.

In conclusion, for the continuity and improved yield of the *C. lucernus* population in the Sea of Marmara, *C. lucernus* smaller than 19 cm must not be caught and fishing should be restricted between November and April.

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