Mar. Sci. Tech. Bull. (2019) 8(2): 85–91
e–ISSN: 2147–9666
info@masteb.com

http://dergipark.org.tr/en/pub/masteb
http://www.masteb.com/
DOI: 10.33714/masteb.641702

Marine Science and Technology Bulletin

RESEARCH ARTICLE

A New Maximum Length with Length–Weight Relationship of Tub Gurnard (*Chelidonichthys lucerna* Linnaeus, 1758) from Central Black Sea Coasts of Turkey

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ARTICLE INFO

Article History:

Received: 01.11.2019
Received in revised form: 04.12.2019
Accepted: 06.12.2019
Available online: 19.12.2019

Keywords:
Tub gurnard
Length–weight relationship
Coastal fisheries
Black Sea

ABSTRACT

The study was carried out in the 2012-2016 fishing seasons in the Central Black Sea coasts of Turkey. Tub gurnard (*Chelidonichthys lucerna* L., 1758) were examined in the commercial fishery (trawls, trammel nets and gillnets). A total of 56.104 kg tub gurnard was caught during the study period. Total length and weight of 117 tub gurnard individuals were measured. Minimum, maximum and average total lengths were calculated as 12.8 cm, 74.2 cm and 33.28±1.28 cm, respectively. The maximum length is the second maximum length for the Black Sea coasts however first maximum length for the Central Black Sea coasts of Turkey. Length-weight relationship (LWR) of tub gurnard were determined as $W=0.0103L^{2.9876}$ in the study. The value of the parameter 'b' was found to be 2.9876 and the growth was isometric (b = 3) for tub gurnard ($P > 0.05$).

Please cite this paper as follows:

Özdemir, S., Özsandıkçı, U., Büyükdeveci, F. (2019). A New Maximum Length with Length–Weight Relationship of Tub Gurnard (*Chelidonichthys lucerna* Linnaeus, 1758) from Central Black Sea Coasts of Turkey. *Marine Science and Technology Bulletin*, 8(2): 85-91.

Introduction

The Black Sea, an almost closed basin between Europe and the Anatolian peninsula, is one of the youngest seas in the world and connected to the Aegean Sea via the narrow Bosphorus and Dardanelles. The Black Sea is a prototypic anoxic sea due to the lack of oxygen in the water, which has existed in the deep for a long time. Eukaryotic life occurs in only 10% of the total depth of the Black Sea (Balkas et al., 1990; Bat et al., 2007; Talley et al., 2011; Bat, 2017).

Tub gurnard (*Chelidonichthys lucerna*) is one of the three species belong Triglidae family living in the Black Sea (Bat et al., 2008; Bilecenoğlu et al., 2014; Yankova et al., 2014). It is a nectobenthic fish distributed in the eastern Atlantic from Norway to Senegal, Mediterranean and Black Sea (Serena et al., 1998) and mainly habits sand or gravel bottoms up to 320 m depth (Mytilineou et al., 2005).

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They feed mainly on fish, crustacean and molluscs (Bat et al., 2008). It has been reported that tub gurnard spawn between May and September with 100 000-300 000 pelagic eggs in Georgian coasts of the Black Sea (Komakhidze et al., 2003). This species was classified as least concern in IUCN Red List (Nunoo et al., 2015).

Tub gurnard is mainly caught as by-catch by gill nets and trawls in mixed demersal fisheries for flatfish and round fish (ICES, 2010; Kasapoğlu and Düzgüneş, 2017) and have high commercial value (Bat et al., 2008). Set nets have been used in the Black Sea coastal fishery (Özdemir et al., 2017; Erdem et al., 2018). Target species of these fishing gears are red mullet, whiting, bluefish, horse mackerel and pontic shad (Kalaycı and Yeşilçiçek, 2014; Aydın and Hacıoğlu, 2017). However, some species can be caught by set nets and demersal trawl as economical by-catch for example, tub gurnard, sea bass, sea bream, shi drum, brown meagre and European flounder (Erdem, 2000; Erdem et al., 2007).

Although some biological parameters of tub gurnard have been well-studied in coasts of Sea of Marmara, Aegean Sea, Mediterranean and contiguous Atlantic area (Papaconstantinou, 1984; Colloca et al., 1994; Abdallah, 2002; Santos et al., 2002; Borges et al., 2003; Mendes et al., 2004; İşmen et al., 2004; Eryılmaz and Meriç, 2005; İlhan and Toğulga, 2007; Deval et al., 2007; Boudaya et al., 2008; Çiçek et al., 2008; Vallisneri et al., 2011; Stagioni et al., 2012; Demirel and Dalkara, 2012; Akyol, 2013) the studies in the Black Sea coasts of Turkey are very limited (Ceylan et al., 2014; Haşimoğlu et al., 2016).

Scientific studies are most important for approaching ecosystems sustainable fisheries and success of the fisheries management. It is very essential research on biology, population parameters and length-weight relationships (LWRs) of all fishes (target, discard and bycatch) in the seas and oceans of the world. Maximum length and weight are important parameters used in life history studies and fishery science. These measurements are applied directly or indirectly in most stock assessment models (Borges 2001; Cengiz et al., 2019a). Therefore, it is important to regularly update the maximum size of commercially important species (Navarro et al., 2012; Cengiz et al., 2019b). LWRs are useful for life history and morphological comparisons of population from different location (Gonçalves et al., 1997; Moutopoulos and Stergiou, 2002).

The aim of the present study is to supply new data on maximum length, length weight relationship (LWR) and fishery of tub gurnard caught in the Central Black Sea coastal fisheries of Turkey.

Material and Methods

The study was carried out in the Central Black Sea coasts of Turkey at monthly basis by using a commercial demersal trawl (September 2014 - April 2015), trammel nets and gill nets (September 2012 - August 2016). The sampling area is Central Black Sea coasts (Sinop inner harbour, Sinop Peninsula and İnceburun off shore) this area is an important migration route of pelagic and demersal school fishes in the Black Sea coasts of Turkey. Samples were collected with demersal trawl at depths ranging from 70 m to 120 m. Sampling area is shown in Figure 1.

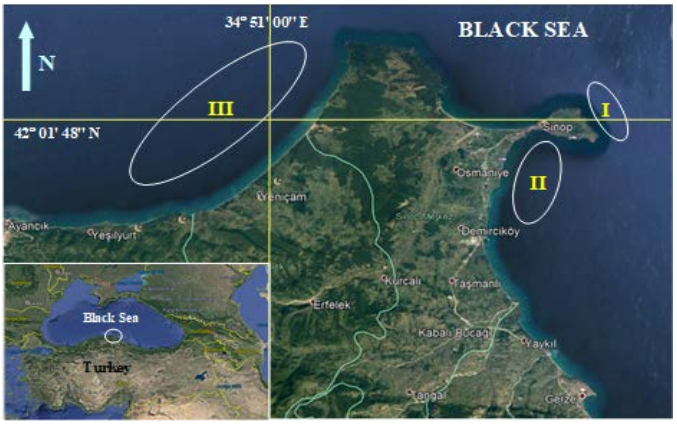

Figure 1. The study areas (I-II: surveys with trammel nets and gill nets, III: surveys with demersal trawls)

Fishes were caught by using a typical otter bottom trawl with 40 mm codend mesh size; tow duration was restricted to 60-120 min. Also, a total of 18 trammel nets were used with 32 mm, 36 mm, 40 mm, 44 mm, 48 mm and 52 mm mesh sizes. Gill nets had 36 mm, 44 mm, 48 mm, and 320 mm mesh size. The fishing gears were used between 15 m and 60 m depth.

A total of 22 hauls for trawl and 36 fishing operations for trammel and gill nets were conducted during the study period. Fish were measured to the nearest 0.1 cm (total length) and weighted to the nearest 0.01 g (wet weight) (Figure 2).

Figure 2. Tub gurnard (*Chelidonichthys lucerna* L., 1758) captured by demersal trawl net (Maximum length: 74.2 cm)

Length-weight relationships were estimated by fitting an exponential curve ($W = aL^b$) to the data (Ricker, 1975; Pauly, 1984).

Parameters a and b of the exponential curve were estimated by linear regression analysis over log-transformed data:

$$\log W = \log a + b \log L$$

where W is the total weight (g), L is the total length (cm), a is the intercept and b is the slope, using the least-squares method. The association-degree between variables of W and L was calculated by the determination coefficient (R). Additionally, 95% confidence limits of the parameter b were estimated. The Student's *t test* was used for comparison of the slopes (Zar, 1996).

$$t = \frac{Sd_{\log TL}}{Sd_{\log W}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2}$$

In this formula, $Sd_{\log TL}$ is the standard deviation of the $\log TL$ values, $Sd_{\log W}$ is the standard deviation of the $\log W$ values, n is the number of specimens used in the computation. The value of b is different from $b = 3$ if calculated t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984).

When the parameter 'b' is statistically equal to 3, the growth is called isometric, but the growth is positive allometric when the 'b' value is more than 3 and negative allometric when the 'b' value is less than 3 (Dutta et al., 2012).

Results

A total of 56.104 kg tub gurnard was caught during the study period. Total length and weight of 117 tub gurnard individuals were measured in the study. A total 39 fishes captured by the trawl nets and 78 fishes caught by the trammel nets (55 specimens) and gillnets (23 specimens).

Minimum, maximum and average total length was calculated as 12.8 cm, 74.2 cm and 33.28±1.28 cm, respectively. Minimum, maximum and average weight of the fish was recorded as 24.4 g, 3983.5 g and 532.12±63.85 g, respectively (Table 1). The largest size fish (74.2 cm) captured by the trawl nets in İnceburun off shores (region III) and the smallest fish (12.8 cm) caught by the trammel nets in Sinop inner harbor region (region II).

Table 1. Length parameters of tub gurnard for the fishing gears (cm)

Parameters	Trammel nets	Gill nets	Trawl nets	All
Specimens	55	23	39	117
Minimum	12.8	44.2	23.5	12.8
Maximum	55.2	68.5	74.2	74.2
Average	30.1±1.37	49.6±1.44	38.4±1.32	33.3±1.28

Table 2. Length-weight relationship (LWR) parameters for tub gurnard

Parameters	
N	117
a	0.0103
a (SE)	0.0647
95 % Confident of a	0.0089 – 0.0142
b	2.9876
b (SE)	0.0431
95 % Confident of b	2.89102 – 3.0721
R	0.9884
Growth	Isometric (b=3)
t test	p>0.05

Note: N is number of specimens; *a* is intercept of the relationship; *b* is slope of the relationship; *R is* coefficient of determination; *b (SE)* is the standard error of *b*; *a (SE)* is the standard error of *a*.

The fish between the 25 cm and 35 cm length group represented the majority of all fish with 59.83%. When the most of fishes were captured in the 35 cm (31.62 %) length group, the least fish were caught in the 75 cm (3.42 %) length group. Length-weight relationship (LWR) of tub gurnard was determined as $W=0.0103L^{2.9876}$. Length-weight frequency distributions and graphic of LWR are shown in Figure 3.

Descriptive statistics on the length and sample size (n), regression parameters a and b of the length-weight relationship (LWR), 95% confidence intervals of a and b, the coefficient of determination (R) of analyzed species are shown in Table 2.

These results displayed that there was significant relationship between length and weight for tub gurnard. The value of the parameter b was 2.9876 for tub gurnard in the study. The a value of tub gurnard was 0.0143 and coefficient of determination (R) was 0.9884. The growth was isometric ($b = 3$) for tub gurnard.

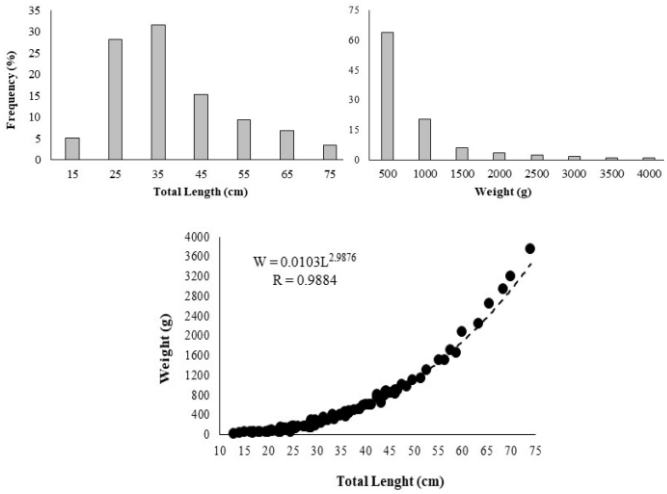

Figure 3. Length-weight frequency distribution and LWR of tub gurnard

Discussion

The tub gurnard has an important economic value and is important by-catch species in Turkish seas. Many scientists expressed that tub gurnard was captured by trammel nets, gill nets and demersal trawl nets (Özdemir et al., 2003; Çiçek et al., 2006; Ceylan et al., 2014; Kasapoğlu and Düzgüneş, 2017; McCartey and Marriott, 2018).

The present study determined that the mean length and weight are 33.28±1.28 cm and 532.12±63.85 g, respectively. The maximum, minimum total length and weight measured for fishes were 74.2 cm, 12.8 cm, and 24.4 g, 3983.5 g, respectively. Minimum and maximum total lengths were reported as 2.2 cm (Eastern Mediterranean Sea) and 88.2 cm (Eastern Black Sea) in Turkish seas (Çiçek et al., 2006; Haşimoğlu et al., 2016).

As well known, the individuals in populations exposed to high levels fishing pressure will respond by reproducing at smaller average sizes and ages and so reached maximum lengths may getting and getting smaller. However, the one individual that subjected to no overfishing pressure could be reached that kind of length (Filiz, 2011). On the other hand, any factor that might possibly influence growth has been shown to have an effect, including nutrient availability, feeding, light regime, oxygen, salinity, temperature, pollutants, current speed, nutrient concentration, predator density, intra-specific social interactions and genetics (Helfman et al., 2009; Acarlı et al., 2018).

Table 3. Studies on parameters of length-weight relationship (LWR) of tub gurnard

Authors	N	Sex	L_{Max}-L_{Min}	a	b	R	Growth
[a]Papacostantinou, 1984*	153	M	13.5-76.7	0.007014	3.146	0.99	+A
	122	F	13.2-32.7	0.007729	3.110	0.99	+A
[a]Papacostantinou et al. 1994	563	M+F	6.0-35.0	0.009846	3.011	0.93	-A
[a]Serena et al. 1998	538	M+F	11.7-45.5	0.013900	2.859	0.99	-A
[a]Abdallah, 2002	196	M+F	4.7-24.9	0.029000	2.630	0.97	-A
[a]Santos et al. 2002	75	M+F	14.0-34.4	0.018000	2.978	0.98	-A
[a]Borges et al. 2003	10	M+F	13.6-29.2	0.001296	2.956	0.99	I
[a]İşmen et al. 2004	143	M	8.3-21.2	0.089000	3.010	0.99	I
	199	F	8.0-30.3	0.095000	3.010	0.98	I
	342	M+F	8.0-30.3	0.009300	2.990	0.98	I
[c]Eryılmaz and Meriç, 2005	224	M+F	12.3-41.5	0.009200	3.019	0.98	I
[a]Çiçek et al. 2006	137	M+F	2.2-30.3	0.013500	2.851	0.99	-A
[a]Olim and Borges, 2006	21	M+F	7.5-27.7	0.011000	2.720	0.99	-A
[b]İşmen et al. 2007	829	M+F	12.5-76.0	0.009600	2.928	0.99	-A
[b]İlhan and Toğulga, 2007*	186	M	14.1-29.9	0.005300	3.237	0.98	+A
	360	F	12.7-34.4	0.005100	3.245	0.98	+A
	546	M+F	12.7-34.4	0.005200	3.240	0.98	+A
[a]Sangun et al. 2007	474	M+F	6.7-24.5	0.016600	2.743	0.97	-A
[a]Boudaya et al. 2008	126	M	17.0-26.0	0.007300	3.037	0.93	I
	160	F	16.0-36.0	0.015500	2.826	0.95	-A
[b]İlkyaz et al. 2008	121	M+F	12.1-42.3	0.004300	3.240	0.97	+A
[a]Çiçek et al. 2008	106	M	6.5-29.3	0.009400	2.988	0.99	I
	113	F	6.1-30.3	0.011400	2.918	0.99	-A
	228	M+F	2.2-30.3	0.012900	2.874	0.99	-A
[c]Keskin and Gaygusuz, 2010	17	M+F	6.3-15.1	0.011300	2.902	0.98	I
[c]Bök et al. 2011	90	M+F	8.0-64.0	0.010000	2.982	0.98	I
[a]Vallisneri et al. 2011	396	M	12.8-34.2	0.000001	2.952	0.97	I
	484	F	11.3-41.5	0.000001	3.038	0.98	I
[c]Demirel and Dalkıran, 2012	352	M+F	10.5-56.0	0.009000	3.000	0.98	I
[b]Bilge et al. 2014	81	M+F	16.6-40.7	0.005200	3.222	0.98	+A
[a]El-Serafy et al. 2015	315	M	12.6-23.3	0.004300	3.264	0.97	+A
	511	F	11.8-28.2	0.004200	3.265	0.98	+A
[c]İşmen et al. 2018	204	M+F	9.2-37.0	0.027000	2.676	0.98	-A
[d]McCarty and Marriot, 2018	804	M+F	10.4-57.5	0.067000	3.103	0.98	+A
[e]Present study	117	M+F	12.8-74.2	0.010300	2.988	0.98	I

Note: a: Mediterranean Sea, *b*: Aegean Sea, *c*: Marmara Sea, *d*: North Sea, *e*: Black Sea, * indicates fork length, *M*: male, *F*: female, *M+F*: male and female, *Max*: maximum, *Min*: minimum, *I*: isometric, *+A*: positive allometric; *-A*: negative allometric,

The second maximum size for tub gurnard was measured as 74.2 cm for Black Sea coasts of Turkey. Moreover, this length was the maximum size for this species in the Central Black Sea coasts of Turkey. Maximum lengths were determined as 76 cm in Aegean Sea,

30.3 cm in Eastern Mediterranean Sea and 64 cm in Marmara Sea in other studies for Turkish seas (İşmen et al., 2007; Çiçek et al., 2008; Bök et al., 2011). The minimum and maximum lengths were measured in the different countries 6.0 cm and 57.5 cm, respectively (Papacostantinou et al. 1994; McCartey and Marriot, 2018).

Length-weight relationship was found as $W=0.0103L^{2.9876}$ (R=0.989) for tub gurnard (Isometric growth, *b=3* (p>0.05)). In the present study, the *b* value was estimated to be 2.987 for tub gurnard. It was identified that *b* values of tub gurnard varied from 2.630 to 3.265 by other authors (Table 1). The variations in *b*-values may be ascribed to one or more factors: the seasons and effects of different areas, differences in salinity, temperature and pollution of aquatic environment, gender, nutrient quality and availability, differences in the quantity of fish analyzed, as well as in the observed size ranges of the sampled species (Gonçalves et al., 1997; Froese et al., 2011).

Seventeen of twenty-four studies had significantly different *b*-values, which reported negative allometric growth (Papacostantinou et al., 1994; Serena et al., 1998; Abdallah, 2002; Santos et al., 2002; Çiçek et al., 2006; Olim and Borges, 2006; İşmen et al., 2007; Sangun et al. 2007; Çiçek et al., 2008; Boudaya et al., 2008; İşmen et al., 2018) and positive allometric growth (Papacostantinou, 1984; İlhan and Toğulga, 2007; İlkyaz et al., 2008; Bilge et al., 2014; El-Serafy et al., 2015; McCarty and Marriott, 2018) for tub gurnard. Also, the present study showed that the *b*-values have generally been in agreement with similar results (isometric growth) in seven studies (Table 1).

On the other hand, tub gurnard were generally captured in small sizes. First maturity size of female and male are 19-20 cm and 17-18 cm for Turkish seas, respectively (İşmen et al., 2004; Eryılmaz and Meriç, 2005; İlhan and Toğulga, 2007). The sizes ranged between 25 cm and 40 cm in some studies carried out in other Mediterranean countries (Papacostantinou, 1984; Baron, 1985; McCarty and Marriott, 2018). The minimum landing size (MLS) is 18 cm for tub gurnard in Turkish seas (Anonymous, 2016). However, it is not enough once for reproductive of fish. The MLS has to be raise for the sustainability of tub gurnard fish stocks in Turkish seas.

Conclusion

These important data and results are usually used by authorities of fisheries management, scientific institutions and academic studies. Therefore, the relevant studies on fishery, biology, populations and stocks of fish species captured in the Black Sea should be improved and appraised in the future.

Consequently, the tub gurnard is an economic fish for the coastal fishermen, although the fish is captured as by-catch in small scale fisheries in Turkey. Tub gurnard fishery has been decreasing in the Turkish seas for last decade (TurkStat, 2019). For this reason, tub gurnard should not be caught by the fishermen before they reach the first reproduction length (19 cm). Captured small fishes must be released to the sea once for reproduction. Also, minimum fishing size measure for tub gurnard should be reviewed and the MLS must be raised to more than 18 cm.

Conflict of Interest

The authors declare that there is no conflict of interest.

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