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 Triglididae 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).
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; Kasapoglu and Düzgünç, 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; Eryilmaz and Merić, 2005; Ilhan and Toğula, 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.

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

**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).

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

$Sd_{\log LR}$ is the standard deviation of the log-transformed length (LR), $Sd_{\log W}$ is the standard deviation of the log-transformed weight (W), $n$ is the number of observations, $r$ is the correlation coefficient.
In this formula, $S_{\text{log}T_t}$ is the standard deviation of the\nlog $T_t$ values, $S_{\text{log}W}$ is the standard deviation of the log $W$\nvalues, $n$ is the number of specimens used in the computation. The value of $b$ is\ndifferent from $b = 3$ if calculated $t$ value is greater than the tabled $t$\nvalues for $n-2$ degrees of freedom (Pauly, 1984).

When the parameter ‘$b$’ is statistically equal to 3, the growth is\ncalled isometric, but the growth is positive allometric when the ‘$b$’\nvalue is more than 3 and negative allometric when the ‘$b$’ value is less\nthan 3 (Dutta et al., 2012).

**Results**

A total of 56.104 kg tub gurnard was caught during the study\nperiod. Total length and weight of 117 tub gurnard individuals were\nmeasured in the study. A total 39 fishes captured by the trawl nets and\n78 fishes caught by the trammel nets (55 specimens) and gillnets (23\nspecimens).

Minimum, maximum and average total length was calculated as\n12.8 cm, 74.2 cm and 33.28±1.28 cm, respectively. Minimum,\nmaximum and average weight of the fish was recorded as 24.4 g, 3983.5\ng and 532.12±63.85 g, respectively (Table 1). The largest size fish (74.2\ncm) captured by the trawl nets in İinceburun off shores (region III) and\nthe smallest fish (12.8 cm) caught by the trammel nets in Sinop inner\nharbor region (region II).

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

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

| Parameters | $N$ | $a$ (SE) | $95\%$ Confident of $a$ | $b$ (SE) | $95\%$ Confident of $b$ | $R$ | Growth | $t$ test |
|------------|-----|----------|------------------------|---------|------------------------|-----|--------|----------|
| $N$        | 117 | 0.0103   | 0.0089 – 0.0142        | 2.9876  | 2.8910 – 3.0721        | 0.9884 | Isometric ($b=3$) | $>0.05$ |

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

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

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

![Figure 3. Length-weight frequency distribution and LWR of tub gurnard](image)

**Discussion**

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

The present study determined that the mean length and weight are\n33.28±1.28 cm and 532.12±63.85 g, respectively. The maximum,\ninimum total length and weight measured for fishes were 74.2 cm,\n12.8 cm, and 24.4 g, 3983.5 g, respectively. Minimum and maximum\ntotal lengths were reported as 2.2 cm (Eastern Mediterranean Sea) and\n88.2 cm (Eastern Black Sea) in Turkish seas (Çiçek et al., 2006;\nHaşimoğlu et al., 2016).

As well known, the individuals in populations exposed to high\nlevels fishing pressure will respond by reproducing at smaller average\nsizes and ages and so reached maximum lengths may getting and\ngetting smaller. However, the one individual that subjected to no\noverfishing pressure could be reached that kind of length (Filiz, 2011).\nOn the other hand, any factor that might possibly influence growth has\nbeen shown to have an effect, including nutrient availability, feeding,\nlight regime, oxygen, salinity, temperature, pollutants, current speed,\nnutrient concentration, predator density, intra-specific social\ninteractions 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\text{Max}-L\text{Min}  | a  | b       | R     | Growth |
|-------------------------------|----|-----|--------------------------|----|---------|-------|--------|
| "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     |
| "Papacostantinou et al. 1994" | 563| M+F | 6.0-35.0                 | 0.009846 | 3.011 | 0.93  | -A     |
| "Serena et al. 1998"          | 538| M+F | 11.7-45.5                | 0.013900 | 2.859 | 0.99  | -A     |
| "Abdallah, 2002"              | 196| M+F | 4.7-24.9                 | 0.029000 | 2.630 | 0.97  | -A     |
| "Santos et al. 2002"          | 75 | M+F | 14.0-34.4                | 0.018000 | 2.978 | 0.98  | -A     |
| "Borges et al. 2003"          | 10 | M+F | 13.6-29.2                | 0.001296 | 2.956 | 0.99  | I      |
|                               | 143| M   | 8.3-21.2                 | 0.089000 | 3.010 | 0.99  | I      |
| "İşmen et al. 2004"           | 199| F   | 8.0-30.3                 | 0.095000 | 3.010 | 0.98  | I      |
|                               | 342| M+F | 8.0-30.3                 | 0.093000 | 2.990 | 0.98  | I      |
| "Eryılmaz and Meriç, 2005"    | 224| M+F | 12.3-41.5                | 0.009200 | 3.019 | 0.98  | I      |
| "Çiçek et al. 2006"           | 137| M+F | 2.2-30.3                 | 0.013500 | 2.851 | 0.99  | -A     |
| "Ölim and Borges, 2006"       | 21 | M+F | 7.5-27.7                 | 0.011000 | 2.720 | 0.99  | -A     |
| "İşmen et al. 2007"           | 829| M+F | 12.5-76.0                | 0.009600 | 2.928 | 0.99  | -A     |
| "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     |
| "Sangun et al. 2007"          | 474| M+F | 6.7-24.5                 | 0.016600 | 2.743 | 0.97  | -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     |
| "İlkyaz et al. 2008"          | 121| M+F | 12.1-42.3                | 0.004300 | 3.240 | 0.97  | +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     |
| "Keskin and Gaygusuz, 2010"   | 17 | M+F | 6.3-15.1                 | 0.011300 | 2.902 | 0.98  | I      |
| "Bök et al. 2011"             | 90 | M+F | 8.0-64.0                 | 0.010000 | 2.982 | 0.98  | I      |
| "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      |
| "Demirel and Dalkıran, 2012"  | 352| M+F | 10.5-56.0                | 0.009000 | 3.000 | 0.98  | I      |
| "Bilge et al. 2014"           | 81 | M+F | 16.6-40.7                | 0.005200 | 3.222 | 0.98  | +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     |
| "İşmen et al. 2018"           | 204| M+F | 9.2-37.0                 | 0.027000 | 2.676 | 0.98  | -A     |
| "McCarty and Marriot, 2018"   | 804| M+F | 10.4-57.5                | 0.067000 | 3.103 | 0.98  | +A     |
| "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; McCarty and Marriott, 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; Ciçek et al., 2006; Olim and Borges, 2006; İşmen et al., 2007; Sangun et al., 2007; Ciçek et al., 2007; Ciçek et al., 2008; Boudaya et al., 2008; İşmen et al., 2018) and positive allometric growth (Papacostantinou, 1984; İlhan and Toğulga, 2007; İlkay et al., 2008; Bülge 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 fishing 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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