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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Age, growth, reproduction and mortality of Red Mullet (*Mullus barbatus ponticus* Essipov, 1927) from the Turkish coasts of the Black Sea

Türkiye'nin Karadeniz kıyılarından avlanan barbunya (*Mullus barbatus ponticus* Essipov, 1927) balığında yaş, büyüme, üreme ve ölüm oranları

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Öz: Bu çalışmada, özellikle Sinop balıkçı limanına gelen uzatma ağı ve trol avcılığı yapan ticari teknelerden Kasım 2015 ve Kasım 2016 tarihleri arasında 989 adet barbunya (*Mullus barbatus ponticus*) bireyi toplanmıştır. Elde edilen örneklerin boyları 9,2 ile 19,2 cm (ortalama: 13,3 ±1,3 cm) arasında; ağırlıkları ise 8,2 ile 68,6 g (ortalama: 25,7 ±8,0 g) arasında değişim göstermiştir. Örnekler ağırlıklı olarak 13–15 cm boy grubunda yer almaktadır. 4/1 Numaralı Ticari Amaçlı Su Ürünleri Avcılığının düzenlenmesi hakkındaki tebliğde *Mullus barbatus* türü için asgari avlanma boyu 13 cm olarak bildirilmektedir. Bu çalışmada elde edilen örneklerin %39'unun söz konusu yasal boyun altında kaldığı tespit edilmiştir. Barbunya bireylerinin boy–ağırlık ilişkisi log(W) = –1,864 + 2,902 log(TL) (r^2= 0,92) olarak hesaplanmıştır. Bireylerin yaş grupları ise I ile IV arasında değişim göstermektedir. Yaşlara göre ortalama boylar; I yaş grubu için 11,43 ±0,04 cm, II yaş grubu için 13,22 ±0,04 cm, III yaş grubu için 15,24 ±0,06 cm ve IV yaş grubu için 18,44 ±0,29 cm olarak hesaplanmıştır. GSI değerleri dikkate alındığında, türün üreme faaliyetini Mayıs ile Temmuz ayları arasında gerçekleştirdiği ve bu aktivitenin en yüksek düzeye Haziran ve Temmuz aylarında ulaştığı anlaşılmaktadır. *M. barbatus ponticus* bireyleri için hesaplanan von Bertalanffy büyüme parametreleri; L_∞ = 17,64 ±1,43 cm, k = 0,43 ±0,13 ve t_0 = –11,33 ±0,37 olarak bulunmuştur. Ayrıca, bireylerde doğal ölüm oranı (M) 0,91 yıl^{-1}, balıkçılık kaynaklı ölüm oranı (F) 0,52 yıl^{-1}, toplam ölüm oranı (Z) 1,43 yıl^{-1} ve sömürülme oranı (E) ise 0,36 olarak hesaplanmıştır.

Anahtar Kelimeler: *Barbunya, yaş, büyüme, üreme, ölüm oranları, Sinop, Karadeniz*

Abstract: A total of 989 red mullets, *Mullus barbatus ponticus*, from the Black Sea were monthly collected from commercial gill/trammel net and bottom trawl fisheries, especially landed at Sinop Fishing Port, between December 2015 and December 2016. Total lengths and weights of red mullet specimens were ranged from 9.2 cm to 19.2 cm (average: 13.3 ±1.3 cm) and from 8.2 g to 68.6 g (average: 25.7 ±8.0 g), respectively. The samples were grouped densely between 13 and 15 cm. Minimum landing size (MLS) is 13 cm for *Mullus barbatus* according to Turkish Fisheries Regulation Circular. Thus, 39% of all samples in this study are under legal size. The LWR equation calculated was $W = 0.0137 \times TL^{2.902}$ (r^2= 0.92). Age groups of red mullets in the Black Sea were ranged from I to IV. The mean lengths according to age groups (I, II, III, and IV) were 11.43 ±0.04 cm, 13.22 ±0.04 cm, 15.24 ±0.06 cm, and 18.44 ±0.29 cm, respectively. According to GSI values, reproduction of red mullets is between May and July with the peaks of June–July. The estimated von Bertalanffy growth parameters with standard errors were L_∞ = 17.64 ±1.43 cm, k = 0.43 ±0.13, and t_0 = –1.33 ±0.37. The mortality rates (M, F, and Z), and exploitation rate (E) of *M. barbatus ponticus* were 0.91 year^{-1}, 0.52 year^{-1}, 1.43 year^{-1}, and 0.36, respectively.

Keywords: *Red mullet, age, growth, reproduction, mortality rates, Sinop, Black Sea*

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INTRODUCTION

Red mullets (or Goatfishes, Family Mullidae) are small to moderate size demersal fish found mainly in shallow waters to the depth range 100-300 m and the most characteristic feature of the family is a pair of barbels on the chin which are used locate the prey by stirring and probing the substrate. They feed on small benthic invertebrates such as crustaceans, worms and molluscs (Golani et al., 2006; Froese and Pauly, 2017). The family consists of six genera and about 62 species are present in the Atlantic, Indian, and Pacific oceans. Five species of goatfishes are present in the Mediterranean Sea: the indigenous species, *Mullus barbatus* Linnaeus, 1758 and *Mullus surmuletus* Linnaeus, 1758; the exotic species, *Upeneus moluccensis* (Bleeker, 1855) and *Upeneus pori* Ben-Tuvia and Golani, 1989 of Indo-Pacific origin; and *Pseudupeneus prayensis* (Cuvier, 1829) from the Atlantic Ocean (Bariche et al., 2013). A new species of mullids, *Parupeneus forsskali* (Fourmanoir and Guézé, 1976) was also captured the north of Beirut (Bariche et al., 2013).

Although *Mullus barbatus* Linnaeus, 1758 is common in all Turkish waters (i.e. the Sea of Marmara, the Aegean Sea, and the southern coasts of Turkey), subspecies *Mullus barbatus ponticus* Essipov, 1927 inhabits in the Black Sea and the Sea of Azov. It is distinguished from *M. barbatus barbatus* by the number of suborbital scales, the length of maxillae and also by its general silver colour and darker colour between the dorsal fins and the lateral line (Hureau, 1986).

Mullus barbatus ponticus is a very commercial fish species along the coasts of Black Sea and it is mainly caught by trawls and gillnets along the Turkish coasts of the Black Sea. Dinçer and Bahar (2008) stated that the gillnets were predominant gear owing to prohibition of area within the three miles range for bottom trawls and also the existence of unfavourable bottom structure.

Total catch amount of red mullet in the Black Sea in 2015 was about 328 tons, of which 254 tons in eastern and 74 tons in western parts of the Black Sea. Catch amount of *M. barbatus ponticus* in the Black Sea is 1/3 in all red mullet's production of Turkey (TUIK, 2015). Between 2000 and 2016, 14% of the total production of red mullet throughout the Mediterranean comes from Turkey, while 91% of catch of red mullet from Black Sea countries (Bulgaria, Ukraine and Turkey) belongs to Turkey (FAO, 2018). Therefore, Turkey is the third main red mullet producer in the Mediterranean. However, total production tends to declining in the last six years (average: 1916 tons). For instance, red mullet production fluctuated from 2790 tons in 2011 to 1281 tons in 2015 (average for 2000-2016: 2205 tons). It is obvious that there is an intensive fishing on red mullet stocks in the Black Sea. The stock status and level of fishing of the red mullet in the Black Sea should be monitored in order to realize the fisheries management aimed to sustainable economic and social benefits from harvesting and conserving productivity of the fish stock. Thus, this study provides some actual information such as length, weight, age, reproduction period, and mortality rates of red mullet population in the southern Black Sea in order to detect whether the fishing pressure exists or not.

MATERIAL AND METHODS

A total of 989 red mullets from the Black Sea were monthly obtained from the commercial coastal gillnetters and bottom trawlers which landed their catches in Sinop, Türkeli, Ayancık, Akliman and Gerze fishing ports between December 2015 and December 2016.

Red mullets were measured to the nearest millimetre [total length (TL)], weighed to the nearest gram (total wet weight). The gonadosomatic index (GSI) was calculated monthly by the equation: GSI = (gonad weight / fish weight) *100.

Totally 989 otoliths were used for ageing. Sagittal otoliths were removed, wiped clean, and stored dry, and then otoliths were placed in glycerol and were examined (10X magnification) under reflected light using a binocular microscope (NIKON SMZ 745T).

Total lengths (TL) of fish were measured to nearest ± 0.1 cm and ± 0.1 g. Length–weight relationship (LWR) was computed from the following formula: $W = a * TL^b$. The logarithmic transformation was performed as $\log W = \log a + b \log L$, where W is weight (g), L is length (cm), *a* is the intercept and *b* is the slope of the linear regressions.

Natural mortality of red mullet was computed from Pauly (1980)'s following multiple regression formula: $\ln M = -0.0152 - 0.279 * \ln L_\infty + 0.6543 * \ln k + 0.463 * \ln T$, where M is natural mortality in a given stock, L_∞ is asymptotic length, *k* is growth coefficient and the value of T is the annual mean temperature (in °C) of the sea water. Non–seasonal growth parameters, L_∞ and *k*, were estimated with von Bertalanffy growth formula in the FAO–ICLARM Stock Assessment Tools (FISAT II) computer program (FAO, 2006–2008). The mean annual temperature (T) for the Black Sea was obtained from World Sea Temperatures (2018). Overall growth performance was estimated by the index Φ′ (phi-prime test) (Pauly and Munro, 1983), $\Phi' = \log K + 2\log L_\infty$.

Total mortality (Z) was estimated from the mean size in the catch, developed by Beverton and Holt (1957). It can be estimated from the mean length in the catch from a given population by means of $Z = k (L_\infty - L_{mean})$

/ (L_{mean} – L_c), where L_∞ and k are parameters of the von Bertalanffy growth equations. Erkoyuncu (1995) stated that if L_c is not available, L' can be used in the formula instead of the L_c, *i.e.* L_c = L'. Pauly and Soriano (1986) indicated that L_{mean} is the mean length computed from L' upward, the latter being a length not smaller than the smallest length of fish fully represented in the catch samples. Note that L' is the lower limit of the corresponding length interval (Sparre and Venema, 1998).

Fishing mortality (F) can be estimated from F = Z–M. Once values of F and M are available, an exploitation ratio (E) can be computed from E = F / Z, which allows one to assess if a stock is overfished or not, on the assumption that the optimal value of E (E_{opt}) is about equal to 0.5 (Pauly, 1980).

The null hypothesis of isometric growth (H_0: b = 3) was tested by *t*-test, using the statistic: ts= (b-3) / Sb, where Sb is the standard error of the slope for α = 0.05 (Sokal and Rohlf, 1987). The difference between the observed mean lengths and calculated mean lengths in all age groups was tested by Paired Sample *t*-test (Zar, 1999). The comparisons of growth performance indices were also performed by unpaired two–tailed *t*-tests. The significance level α for a given hypothesis in all statistical tests performed in this text is at 0.05. All of the mean values were given with standard error (± SE). All calculations were performed using the IBM SPSS Statistics Ver. 20 software package.

RESULTS

The length and weight values were ranged from 9.2 cm to 19.2 cm (average: 13.3 ±0.04 cm) and from 8.2 g to 68.6 g (average: 25.7 ±0.25 g), respectively. According to sex, the length and weight distribution of *M. barbatus ponticus* were shown in Table 1.

Table 1. Length–weight distribution of *M. barbatus ponticus* in Sinop, Black Sea (♀: female, ♂: male, ?: undefined, Σ: Total)

	♀		♂		?		Σ	
	TL (cm)	W (g)	TL (cm)	W (g)	TL (cm)	W (g)	TL (cm)	W (g)
Minimum	10.1	11.8	9.2	8.2	10.1	11.7	9.2	8.2
Maximum	19.2	68.6	17.2	53.9	14.1	30.0	19.2	68.6
Mean	13.5	26.7	13.1	24.2	11.5	16.6	13.3	25.7
SE (±)	0.05	0.33	0.06	0.38	0.28	1.36	0,04	0.25
n	632		344		13		989	

The length distributions of all fish are shown in Figure 1. It is clear that the 14 cm length group had the highest percentage (approximately 32%). The female/male ratio was calculated as 1:0.5 and the females dominated in all age groups. There is a significant difference between female/male ratios in all age groups (p<0.05).

The samples were grouped densely between 13 and 15 cm. Minimum landing size (MLS) is 13 cm for *Mullus barbatus* according to Regulation for Commercial Fisheries in Turkish Waters by General Directorate of Fisheries and Aquaculture (BSGM, 2016). Thus, 39% of all samples in this study are under legal size (Figure 2).

The reproduction period of red mullet is between May and July with the peaks of June and July (Figure 3).

The length–weight relationship is shown in Figure 4. The LWR parameters (a, b, r^2) were computed as 0.0137 ± 0.031, 2.902 ± 0.027, and 0.92 ±0.036, respectively. The b value indicates an allometric growth (p<0.05).

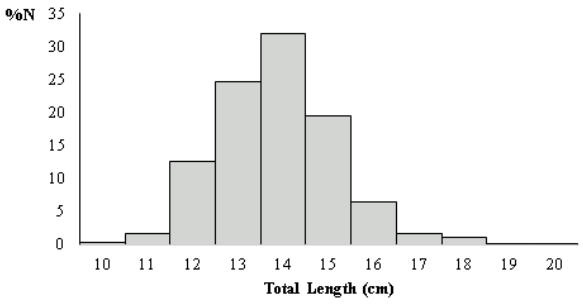

Figure 1. Length frequency of *M. barbatus ponticus* in Sinop region (the Black Sea)

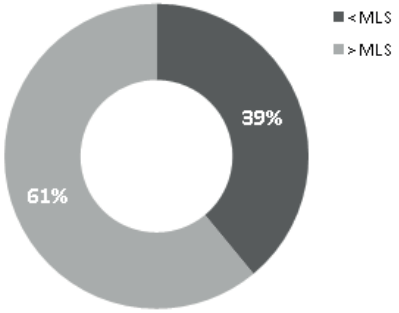

Figure 2. MLS percentages for *M. barbatus ponticus* in the Black Sea.

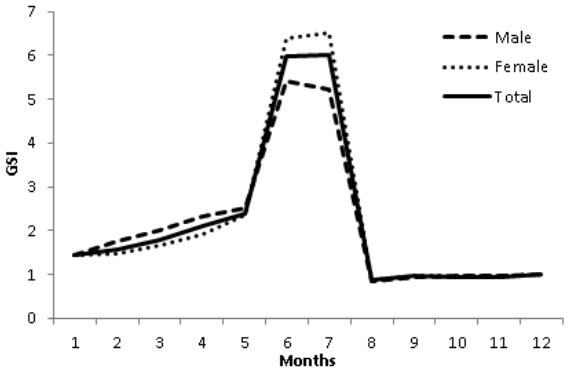

Figure 3. Reproduction period of *M. barbatus ponticus* in the Black Sea

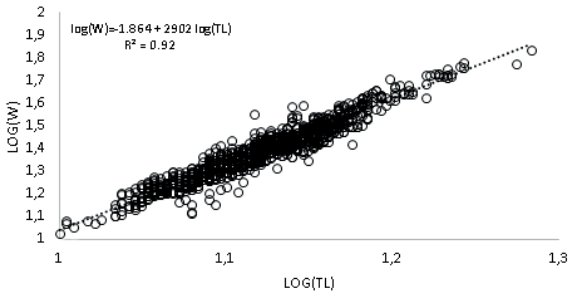

Figure 4. Length–weight relationship of *M. barbatus ponticus* in Sinop (Black Sea)

The age of red mullet was between I and IV. The mean lengths according to age groups (I, II, III and IV) were 11.43 ±0.04, 13.22 ±0.04, 15.24 ±0.06 and 18.44 ±0.29, respectively. The estimated von Bertalanffy growth parameters with standard errors were L_∞ = 17.64 ±1.43 cm, k = 0.43 ±0.13, and t_0 = −1.33 ±0.37. The von Bertalanffy growth equation for length was $L_t = 17.64\left[1 - e^{-0.43(t+1.33)}\right]$. We also estimated growth parameters for males, females separately (Table 2), and found significant differences between the growth curves for each sex (p<0.05).The observed lengths of red mullet assigned to each age group were used to fit the VBGF (Figure 5). There were statistical differences between the observed (obs.) and calculated (calc.) mean lengths in all age groups (p<0.05) except age I males, age IV females and all age IV (p>0.05; Table 3).

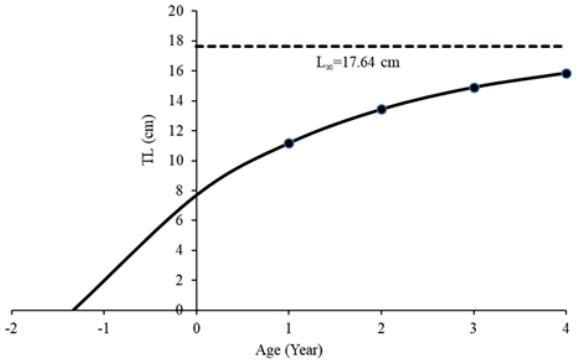

Figure 5. Age–length curve of *M. barbatus ponticus* in Sinop (Black Sea)

Table 2. Von Bertalanffy growth parameters for males, females and all samples combined. (L_∞ is the asymptotic length, K the growth coefficient, and t_0 is the theoretical age at zero length)

Sex	L_∞(cm)	K	t_0
Male	16.72	0.47	−1.35
Female	17.67	0.46	−1.11
All fish	17.64	0.43	−1.33

Table 3. Observed and calculated mean lengths (FL, cm) of red mullet of each age group for females, males and sexes combined.

Sex and length parameter	Value per age group (years)			
	1	2	3	4
Female				
L_{obs}	11.52	13.27	15.27	18.50*
L_{calc}	10.85	13.43	14.90	15.86
Male				
L_{obs}	11.44*	13.12	15.13	
L_{calc}	11.2	13.27	14.56	
All fish				
L_{obs}	11.43	13.22	15.24	18.50*

*Significant differences (p<0.05)

Mortalities (M, F, and Z) and exploitation rate (E) of red mullet from the Black Sea were 0.91 year^{-1}, 0.52 year^{-1}, 1.43 year^{-1} and 0.36 year^{-1}, respectively. The mean annual habitat temperature (T), L_{mean} and L' are assumed as 15.6 ºC, 13.3 cm, and 12 cm, respectively.

DISCUSSION

Red mullet is very commercial species in Sinop region as well as whole Black Sea coasts. The fish is usually caught by trawl nets in western part of Sinop, while caught by gillnets (in this study, the mesh size: 32 mm) eastern coasts of Sinop. However, the highest length with 14 cm (*i.e.* over MLS) seems good selection of these gears. Dinçer and Bahar (2008) calculated the gillnet selectivity that optimum length was 14.24 cm for 32 mm mesh size. Thus, the gillnet with 32 mm mesh size is a selective fishing gear for the red mullet.

LWR of red mullet seems that there is a negative allometric growth (*b* = 2.90). Other LWR parameters and minimum and maximum lengths and weights of red mullet in the Black Sea were shown in Table 4. Froese (2006) stated that seasonal, geographic, climatic or other patterns in the variation of the condition factor should be used to explain within-species variation in weight–length relationships.

The Ø' values were ranged from 1.87 to 2.64 in the Black Sea. In this study, Ø' was calculated as 2.12, 2.16 and 2.13 for males, females and all, respectively (Table 5). Our results are between ranges of the other studies. Burton et al. (2014) stated that population parameters can vary interannually for variable recruitment and environmental conditions and other reasons Moreover, the temperature, density of food and diseases, etc. may affect the growth indice (Pauly, 1994; Wootton, 1998).

The estimate of fishing mortality (F = 0.52) is lower than natural mortality (M = 0.91), and according to exploitation rate (E = 0.36), there is no overfishing on red mullet stocks. In fact, the over fishing on red mullet stock seems in the Black Sea depends on the annual catch data. Yıldız and Karakulak (2016) also found as E =0.65 from the data obtained from the commercial trawlers. The lower E value in this study may be obtained from fishery dependent data, collected from mostly gillnetters. The mesh sizes in gillnets used in this study could select the fish that are bigger than MLS. Thus, the differences between the fishing gears and methodologies may affect the calculated value of E. In conclusion, the authors propose that the further studies related to the fishing effort of the fleets as well as the selectivity must be conducted repeatedly in terms of the sustainable red mullet fishery.

Table 4. Substantial LWR records of red mullet in the Black Sea

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	*a*	*b*	r^2
Kalaycı et al. (2007)	176	6.6–18.4	2.9–60.2	0.011	2.96	0.98
Demirhan and Can (2007)	432	6.8–14.6	–	0.005	3.24	0.97
Ak et al. (2009)	714	6.1–21.9	2.1–161.1	0.007	3.14	0.99
Aksu et al. (2011)	699	7.3–18.7	-	0.011	2.97	0.98
Özdemir and Duyar (2013)	225	9.3–20.1	8.6–87.9	0.011	2.98	0.97
Aydın and Karadurmuş (2013)	1435	6.4–21.5	2.1–105.4	0.009	3.03	0.97
Akyol and Samsun (2017)	1301	8.2–20.2	5.6–86.5	0.008	3.11	0.96
This study	989	9.2–19.2	8.2–68.6	0.014	2.90	0.92

Table 5. Growth parameters and growth performance index values of red mullet from the Black Sea

Sex	L_∞	K	t_0	Ø′	Source
Σ	29.49	0.10	-3.22	1.96	Samsun and Erkoyuncu (1992)
Σ	24.8	0.12	-0,33	1.87	Bingel et al (1995)
♂	21.03	0.20	-2.33	1.96	Şahin and Akbulut (1997)
♀	21.26	0.23	-1.94	2.02	
Σ	24.99	0.12	-3.28	1.87	Samsun and Özdamar (1995)
♂	22.16	0.21	-2.04	2.02	Genç (2000)
♀	25.55	0.24	-1.32	2.19	
Σ	23.83	0.23	-1.62	2.11	
Σ	30.8	0.14	-1.79	2.12	İşmen et al (2000)
Σ	24.22	0.22	-1.71	2.11	Genç et al.(2002)
♂	25.25	0.15	-1.59	1.99	Süer (2008)
♀	39.36	0.08	-1.92	2.10	
Σ	20.15	0.33	--	2.13	Aksu et al. (2011)
♂	19.30	0.35	-0.75	2.12	Aydın and Karadurmuş (2013)
♀	25.40	0.14	-2.70	1.97	
Σ	27.40	0.14	-2.35	2.02	
♂	23.10	0.81	-1.91	2.64	Yıldız and Karakulak (2016)
♀	24.80	0.15	-2.31	1.96	
Σ	24.10	0.17	-1.98	2.00	
Σ	19.21	0.68	-0.13	2.40	Samsun (2017)
♂	16.72	0.47	–1.35	2.12	This study
♀	17.67	0.46	–1.11	2.16	
Σ	17.64	0.43	–1.33	2.13	

REFERENCES

Ak, O., Kutlu, S. & Aydın, İ. (2009). Length–weight relationship for 16 fish species from the eastern Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Science*, 9, 125-126.

Aksu, H., Erdem, Y., Ozdemir, S. & Erdem, E. (2011). Estimation of some population parameters of red mullet (*Mullus barbatus ponticus*, Essipov, 1927) caught in the Black Sea. *Journal of FisheriesSciences.com* 5, 345-353.

Aydın, M. & Karadurmuş, U. (2013). An investigation on age, growth and biological characteristics of red mullet (*Mullus barbatus ponticus*, Essipov, 1927) in the eastern Black Sea. *Iranian Journal of Fisheries Science*, 12, 277-288.

Bariche, M., Bilecenoğlu, M. & Azurro, E. (2013). Confirmed presence of the Red Sea goatfish *Parupeneus forskali* (Fourmanoir and Guézé, 1976) in the Mediterranean Sea. *BioInvasions Records,* 2, 173-175. DOI:10.3391/bir.2013.2.2.15

Beverton, R.J.H. & Holt, S.J. (1957). On the dynamics of exploited fish populations. UK Ministry Agriculture and Fisheries, *Fish Invest,* 19, 533 p.

Bingel, F., Gücü, A.C., Stepnowski, A., Niermann, U., Doğan, M., Kayıkçı, Y., Mutlu, E., Avşar, D., Kideyş, A.E., Uysal, Z., İşmen, A., Bekiroğlu, Y., Genç, Y., Okur, H., Zengin, M., (1995). *Stock assessment studies for the Turkish Black Sea coast: Fisheries Investigations.* Final Report. Sponsored by NATO-SSP, DPT through TUBİTAK. Institute of Marine Sciences of Middle East Technical University, Turkey, 159 s.

BSGM (2016). Regulation for commercial fisheries in seas and inland waters for 2016–2020 fishing period, numbered 4/1 (No: 2016/35). General Directorate of Fisheries and Aquaculture (BSGM), Republic of Turkey Ministry of Food Agriculture and Livestock, Ankara, Turkey (in Turkish).

Burton, M.L., Potts, J.C. & Carr, D.R. (2014). Age, growth, and mortality of Yellowmouth grouper from the South-eastern United States. *Marine and Coastal Fisheries*, 6, 33-42. DOI: 10.1080/19425120.2013.866998

Demirhan, S.A. & Can, M.F. (2007). Length–weight relationships for seven fish species from the south eastern Black Sea. *Journal of Applied Ichthyology*, 23, 282-283. DOI: 10.1111/j.1439-0426.2007.00835.x

Dinçer, A.C. & Bahar, M. (2008). Multifilament gillnet selectivity for the red mullet (*Mullus barbatus*) in the eastern Black Sea coast of Turkey, Trabzon. *Turkish Journal of Fisheries and Aquatic Science,* 8, 355-359.

Erkoyuncu, İ. (1995). Fisheries biology and population dynamics (In Turkish). Sinop: On Dokuz Mayıs University, Faculty of Fisheries.

FAO. (2006-2008). Fisheries and aquaculture software. FISAT II - FAO-ICLARM Stock Assessment Tool. Rome: FAO.

FAO. 2018. Fishery and Aquaculture Statistics. Global capture production 1950-2016 (FishstatJ). In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 2017. Available at: https://www.fao.org/fishery/statistics/software/fishstatj/en (accessed 9 Novermber 2018).

Froese, R. (2006). Cube law, condition factor and weight-length relationships: meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241-253.
DOI: 10.1111/j.1439-0426.2006.00805.x

Froese, R. & Pauly, D. **(**2017). FishBase. World Wide Web electronic publication. Retrieved from www.fishbase.org. Version (10/2016) (22.02. 2017).

Genç, Y. (2000). *Bio-ecological and population parameters for red mullet (Mullus barbatus ponticus, Ess. 1927) in the Eastern Black Sea Coastal.* Black Sea Technical University, Department of Fisheries Technology Engineering, PhD Thesis, Trabzon. (In Turkish).

Genç, Y., Mutlu, C., Zengin, M., Aydin, I., Zengin, B. & Tabak, I. (2002). *Determination of the effect of catch effort on demersal fish stocks in the Eastern Black Sea*. Agricultural and Rural Affairs, TAGEM Final Report. (In Turkish).

Golani, D., Öztürk, B. & Başusta, N. (2006). The fishes of the eastern Mediterranean. Istanbul: Turkish Marine Research Foundation.

Hureau, J.C. (1986). Mullidae. In: PJP. Whitehead, ML. Bauchot, JC. Hureau, J. Nielsen, E. Tortonese (Ed), *Fishes of the North-Western Atlantic and the Mediterranean. Vol II* (pp.877-882).Paris: UNESCO.

İşmen, A., Yıldırım, Y., İşmen, P., (2000). Growth characteristics and reproductive biology of red mullet (*Mullus barbatus*, L. 1758) in the eastern Black Sea. *Fisheries Symposium* (pp. 342-356). Sinop, Turkey. (In Turkish)

Kalaycı, F., Samsun, N., Bilgin, S. & Samsun, O. (2007). Length–weight relationship of 10 fish species caught by bottom trawl and midwater trawl from the Middle Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Science,* 7, 33-36.

Özdemir, S. & Duyar, H.A. (2013). Length–weight relationships for ten fish species collected by trawl surveys from Black Sea coasts, Turkey. *International Journal of Chemical, Environmental and Biological Sciences*, 1, 405–407.

Pauly, D. (1980). A Selection of simple methods for the assessment of tropical fish stocks. FAO Fisheries Circular No.729, Rome: FAO.

Pauly, D. (1994). *On the sex of the fish and the gender of scientists: A collection of essays in fisheries science*. London : Chapman & Hall.

Pauly, D. & Munro, J.L. (1984). Once more on the comparison of growth fin fish and invertebrates. *ICLARM Fishbyte*, 1, 21-22.

Pauly, D. & Soriano, M.L. (1986). Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In JL Maclean, LB Dizon, LV Hosillo (ed.), *The First Asian Fisheries Forum* (pp. 491–496). Manila: Asian Fisheries Society.

Samsun, O. (2017). Length-Weight Relationship and Mortalities of *Mullus barbatus ponticus* Essipov, 1927 in the Central Black Sea, Turkey. *Turkish Journal of Maritime and Marine Sciences*, 3(2), 75-80.

Samsun, O. & Erkoyuncu, İ. (1992). Investigation on some properties in terms of fisheries biology of red mullet caught by trawlers in the middle Black Sea. *XI. National Biology Congress*. Elazığ, Turkey. (In Turkish).

Samsun, O., Özdamar, E., (1995). The assessment of the some population parameters of red mullet (*Mullus barbatus ponticus* Es., 1927) at 1994-1995 fishing season in Samsun Bay. *Ondokuz Mayıs Üniversitesi Fen/Edebiyat Fakültesi Fen Dergisi*, 5(1), 90–96. (In Turkish)

Sokal, R. & Rohlf, F. (1987). *Introduction to biostatistics, 2nd edn*. USA: Freeman Publication.

Sparre, P. & Venema, S.C. (1998). *Introduction to tropical fish stock assessments. Part 1: Manual*. FAO Fish Tech Pap 306/1 Rev. 2, Rome: FAO.

Süer, S. (2008). Determination of age and growth model of red mullet *Mullus barbatus ponticus* (Essipov, 1927) (Mullidae) by means of otolith reading and length-frequency analysis. *19 May University. Ph.D. Thesis*. (In Turkish).

Şahin, T. & Akbulut, B. (1997). Some biological characteristics of *Mullus barbatus ponticus* Essipov, 1927 in the Eastern Black Sea coast of Turkey. *Turkish Journal of Zoology*, 21, 179-185.

TUIK (2015). Fishery Statistics 2015. Retrieved from www.tuik.gov.tr (23.02.2017).

Yıldız, T. & Karakulak, F.S. (2016). An investigation of age, growth and mortality of the red mullet *Mullus barbatus* Linnaeus, 1758 in the western Black Sea, *Cahiers De Biologie Marine*, 57, 415-425.

World Sea Temperatures, (2018). Sinop Sea Temperature. Retrieved from https://www.seatemperature.org/ (23.02. 2017).

Wootton, R.J. (1998). *Ecology of Teleost Fishes*. Dordrecht: Kluwer Academic Publishers.

Zar, J. H. (1999). *Biostatistical Analysis*, 4th edn. USA: Prentice-Hall.