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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Length-Weight Relationship For 14 Fish Species From The South-Western Black Sea, Turkey

Ahmet Mutlu GÖZLER* **Hazel BAYTAŞOĞLU**
Recep Tayyip Erdogan University, Faculty of Fisheries and Aquatic Sciences, 53100 Rize, Turkey

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: https://orcid.org/0000-0002-0991-6395
: https://orcid.org/0000-0002-9959-1829

***Corresponding author:**
Ahmet Mutlu GÖZLER
Recep Tayyip Erdogan University, Faculty of Fisheries and Aquatic Sciences, 53100 Rize, Turkey
✉: ahmet.gozler@erdogan.edu.tr

Abstract: In this study, the length-weight relationship (LWR) of 14 fish species including *Merlangius merlangus* (Linnaeus, 1758),*Trachurus trachurus* (Linnaeus, 1758), *Mullus barbatus* Linnaeus, 1758, *Gobius niger* Linnaeus, 1758, *Scorpaena porcus* (Linnaeus, 1758), *Arnoglossus kessleri* Schmidt, 1915, *Uranoscopus scaber* Linnaeus, 1758, *Serranus hepatus* (Linnaeus, 1758), *Sygnathus thyphle* Linnaeus, 1758, *Aphia minuta (Risso, 1810), Trachinus draco* Linnaeus, 1758, *Parablennius tentacularis (Brünnich, 1768), Callionymus risso* Lesueur 1814, *Pomatoschistus marmoratus* (Risso, 1810) caught from the western Black Sea coasts of Turkey was investigated. Sampling was carried out between 2017-2018 with a beam troll net with a span of 2 m. The sampling depth was between 10 m and 30 m. The minimum and maximum lengths and weights, length-weight relationships, a and b parameters and growth type (isometric or allometric) of the samples were determined. The b parameter of the length-weight relationship was determined between 2.58 and 3.586. A total of 3615 individuals belonging to 14 species were examined in the study. The most caugth species were *M. barbatus* (1118 individuals) and *G. niger* (1077 individuals). The coefficient of determination r^2 value ranged from 0.79 (*T. trachurus*) to 0.99 (*S. hepatus*). It was determined that three species showed isometric growth, 4 species showed negative allometric growth and 7 species showed positive allometric growth.

Keywords: Fish, length-weight, western black sea.

Türkiye'nin Batı Karadeniz Kıyılarından 14 Balık Türü Için Boy-Ağırlık İlişkisi

***Sorumlu yazar:**
Ahmet Mutlu GÖZLER
Recep Tayyip Erdoğan Üniversitesi, Su Ürünleri ve Su Bilimleri Fakültesi, 53100 Rize, Türkiye
✉: ahmet.gozler@erdogan.edu.tr

Öz: Bu çalışmada Batı Karadeniz kıyılarından yakalanan 14 balık türünün *Merlangius merlangus* (Linnaeus, 1758), *Trachurus trachurus* (Linnaeus, 1758), *Mullus barbatus* Linnaeus, 1758, *Gobius niger* Linnaeus, 1758, *Scorpaena porcus* (Linnaeus, 1758), *Arnoglossus kessleri* Schmidt, 1915, *Uranoscopus scaber* Linnaeus, 1758, *Serranus hepatus* (Linnaeus, 1758), *Sygnathus thyphle* Linnaeus, 1758, *Aphia minuta* (Risso, 1810), *Trachinus draco* Linnaeus, 1758, *Parablennius tentacularis (Brünnich, 1768), Callionymus risso* Lesueur 1814, *Pomatoschistus marmoratus* (Risso, 1810) boy-ağırlık ilişkisi belirlenmiştir. Örnekleme 2017-2018 yılları arasında 2 m açıklığa sahip beam troll ağıyla yapılmıştır. Örnekleme derinliği 10 m ile 30 m arasındadır. Örneklerin minimum ve maksimum boy ve ağırlıkları, boy-ağırlık ilişkileri, a ve b parametreleri ve büyüme tipi (izometrik veya allometrik) belirlenmiştir. Boy-ağırlık ilişkisinin b parametresi 2.58 ile 3.586 arasındadır. Çalışmada 14 türe ait toplam 3615 birey incelenmiştir. En çok yakalanan türler *M. barbatus* (1118 birey) ve *G. niger* (1077 birey) olmuştur. Belirleme katsayısı r^2 değeri 0.79 (*T. trachurus*) ile 0.99 (S. hepatus) arasında değişmektedir. Üç türün izometrik, 4 türün negatif allometrik ve 7 türün pozitif allometrik büyüme gösterdiği tespit edilmiştir.

Anahtar kelimeler: Balık, batı karadeniz, boy-ağırlık.

INTRODUCTION

The Black Sea is located between latitudes 40° 55'N to 46° 32'N and longitudes 27° 27'E to 41°42'E in the east-west, the Pontic Mountains to the south and the Caucasus Mountains to the northeast. Black sea with an average depth of 1240 m, is the world's largest anoxic basin (Degens & Ross 1974). It is reported among the most polluted seas in the world due to the fact that 23 countries directly or indirectly carry the pollution load, so does the discharge of wastes transported by ships (Göktepe, 2002). Uncontrolled industrial and domestic wastewater, climate change, and overfishing are important factors affecting Black Sea biodiversity (Borysova et al., 2005). The western Black Sea is the most important trawling shelf in Turkey (Kara, 1980). In the western part of the Black sea, fishing operations takes second place in the Turkish seas. Trawl fishing is prohibited in the Black Sea within 3 miles from the coast to the sea.

Length-weight relationship (LWR) is of great importance in fishery assessments (Goncalves et al., 1997). Length-weight relationships are also originally used to provide information on the condition of fish and may help determine whether somatic growth is isometric (b=3) or allometric (negative allometric: b<3 or positive allometric: b>3) (Ricker, 1973; Spiegel, 1991). These measurements can give information on the stock composition, life span, mortality, growth and production (Bolger & Connoly, 1989; Moutopoulos & Stergiou, 2002).

This study aims to provide data on the length-weight relationship for the 14 fish species captured by beam trawl from the coastal waters of the Western Black Sea. Examining the length-weight relationships is important for the conservation and management of fish in the Black Sea. It will contribute to the decisions to be taken for the Black Sea fisheries in the future.

MATERIAL AND METHOD

Study Area and Fish Sampling: Samples were collected from the Western Black Sea using beam trawl seasonally between 2017-2018 with 2 m aperture. Although beam trawling is prohibited in the sampling area, sampling was carried out with a special permission from the Ministry of Agriculture and Forestry. Study area and sampling points are given in Figure 1.

For sampling, the research vessel named R/V KARADENİZ RESEARCH was used. The depths of the surveys were ranged from 10 m up to 30 m. Samples were obtained by operating an experimental beam trawlnet (15 mm mesh size) at a constant speed of 1,7 knots. The samples were placed in large plastic containers and transported to the laboratory. Species at each station were examined separately and species identifications were made based on morphological characteristics according to Whitehead, (1985). Coordinate and location information of the sampling points are given in Table 1.

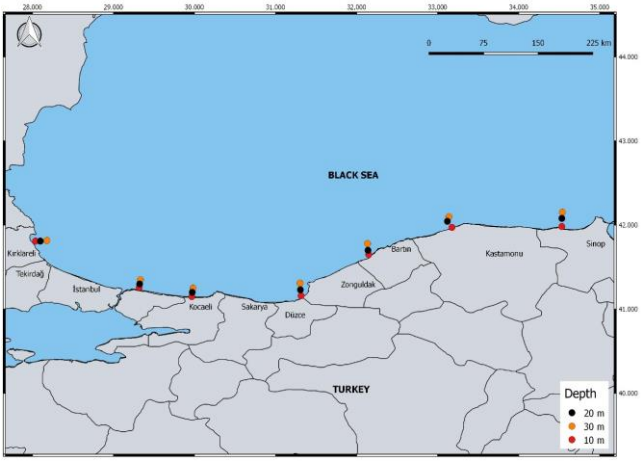

Figure 1. The map of sampling points

Table 1. GPS coordinates of stations the sampling point

Stations Code	Stations Name	Coordinates	Meters
B	Çaylıoğlu	41°58'223' N 34°31'601" E	10 m
		41°58'85" N 34°32'294" E	20 m
		41°58"718" N 34°31'286" E	30 m
D	Doğanyurt	41°57'816" N 33°10'72" E	10 m
		41°58'342" N 33°10'720" E	20 m
		42°1'358" N 33°19'860" E	30 m
F	Bartın İncekum	41°39'256" N 32°9'22" E	10 m
		41°38'70" N 32°8'131" E	20 m
		41°37'235" N 32°7'191" E	30 m
H	Alaplı	41°8'269" N 31°18'540" E	10 m
		41°9'341" N 31°19'523" E	20 m
		41°10'543" N 31°19'990" E	30 m
L	Barganlı	41°8'747" N 29°57'730" E	10 m
		41°9'62" N 29°59'297" E	20 m
		41°9'974" N 29°59'657" E	30 m
N	Riva	41°13'811" N 29°16'611" E	10 m
		40°14'263" N 29°17'349" E	20 m
		40°15'663" N 29°19' 297" E	30 m
P	İğneada	41°53'29" N 28°0'949" E	10 m
		41°52'834" N 27°59'954" E	20 m
		41°50'682" N 28°0'929" E	30 m

Length- Weight Relationship (LWR): Fish were measured to the nearest cm (total length) and weight to the nearest g. The length and weight relationship of fish were calculated using the exponential relationship (Ricker, 1973) (Equation 1) using the least-squares method:

$$W=a\times TL^{b}$$

where W is the total weight, L is the total length, "a" is the intercept, and "b" is the slope. Comparison of the difference of slope value from b = 3 (isometric growth) for all species, Pauly's t-test was applied (Pauly, 1984). Pauly's t-test was calculated as:

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

,

where Sd logTL is the standard deviation of the log TL values, Sd logW is the standard deviation of the log W values, and n is the number of fish species used in the computation. The value of b is different from 3 if the t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984; Mazlum & Turan, 2018).

RESULTS AND DISCUSSION

In the present study, the length-weight relationships for 14 species including *Merlangius merlangus* (Linnaeus, 1758),, *Trachurus trachurus* (Linnaeus, 1758), *Mullus barbatus* Linnaeus, 1758, *Gobius niger* Linnaeus, 1758, *Scorpaena porcus* (Linnaeus, 1758), *Arnoglossus kessleri* Schmidt, 1915, *Uranoscopus scaber* Linnaeus, 1758, *Serranus hepatus* (Linnaeus, 1758), *Sygnathus thyphle* Linnaeus, 1758, *Aphia minuta (Risso, 1810), Trachinus draco* Linnaeus, 1758, *Parablennius tentacularis (Brünnich, 1768), Callionymus risso* Lesueur 1814, *Pomatoschistus marmoratus* (Risso, 1810) were examined.

For each species, the sample size, length and weight ranges (minimum-maximum and average), parameters of length-weight relationships (*a* and *b*), 95% confidence intervals of *b* and the coefficient of determination (r^2) and growth type are given in Table 2. According to the results of this study, the "*a*" value ranged from 0.0006 to 0.049 while the "*b*" values varied between 2.58 and 3.586. The coefficients (r^2) ranged from 0.79 (*T. trachurus*) to 0.99 (*S. hepatus*). A total of 3615 individuals belonging to 14 species were used in the analysis. The most abundant species were *M. barbatus* (1118 ind.) and *G. niger* (1077 ind.). Concerning the type of growth, isometric growth in 3 species, negative allometry in 4 species, and positive allometry in 7 species were obtained.

Length-weight relationships for 14 species presented here were discussed deeply within previous studies (Table 3). The parameter b calculated in the present study found to be different compared to the previous studies (*M. merlangius, T. trachurus, A. kessleri, C. risso, P. tentacularis, T. draco, S. typhla*) (Table 2). In the remaining 7 fish species, b values were found to be in accordance with previous studies. These differences may be the result of sampling methods, selectivity of fishing gear or sample size.

M. merlangius, T. trachurus, A. kessleri, M. barbatus, Uranoscopus scaber, Sygnathus thyphle, Aphia minuta, Trachinus draco, Callionymus risso, Pomatoschistus marmoratus, species obtained in this study are compatible with the data of previous studies in different regions. It is seen that the lenght data of the *Gobius niger* species are higher than those stated in the literature, and the lenght and weight measurements of the *Scorpaena porcus* species are less. It is seen that while the weight measurements of the *Serranus hepatus* species are higher, the weight measurements of the *Parablennius tentacularis* species are less. It has been stated that the length-weight relationship may vary based on several parameters including the sampling sites, sampling method, salinity, sex, temperature, time of year as well as the stage of maturity (Karakulak et al. 2006; Ricker, 1973). In addition, excessive fishing pressure that exists on the coast of the Black Sea (Knudsen et al., 2010) may lead to pressure alteration in the length-weight relationship. The high fishing mortality brings some changes to the biology of the species, such as a decrease in total length and first sexual maturity length (Jennings et al., 1999).

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Table 2. Descriptive statistics of length-weight relationship of 14 fish species in the Western Black Sea, Turkey.

Species	*n*	Total Length (cm)		Total Weight (gr)		*a*	*b*	*95%Confidence Interval b(±SE)*	r^2	*Pauly's t-test*	*P*	
		Min-Max	Mean±SE	Min-Max	Mean±SE							
Arnoglossus kessleri	365	3.2-12.8	5.80±0.031	0.28-20.85	2.01±0.04	0.0091	3.0502	2.977-3.0122 (±0.037)	0.9101	1.36	> 0.05	Isometric
Mullus barbatus	1118	4.3-15.3	7.5±0.38	0.71-37.73	4.31±0.09	0.049	3.2945	3.2389-3.3499 (±0.0282)	0.924	10.41	<0.01	+ Allometric
Gobius niger	1077	2.9-286	7.4±0.050	0.18-31.63	3.28±0.1	0.0091	3.057	3.009-3.1054 (±0.0245)	0.9355	2.09	<0.05	+ Allometric
Callionymus risso	48	2.8-6.6	4.60±0.128	0.18-3.35	0.98±0.09	0.0048	3.4216	3.1325-3.7106 (±0.1436)	0.925	2.93	<0.05	- Allometric
Parablennius tentacularis	13	4.8-9.8	6.76±0.362	1.1-6	3.21±0.41	0.0218	2.58	2.093-3.066 (±0.2183)	0.987	2.02	<0.05	- Allometric
Pomatoschistus marmoratus	44	3.0-7.8	4.50±0.1560	0.15-7.5	0.93±0.22	0.0079	2.8789	2.5579-3.1999 (±1.590)	0.8863	0.75	> 0.05	Isometric
Trachinus draco	53	5.6-21.5	10.69±0.4597	1.52-101.73	4.31±2.48	0.0174	2.6572	2.4523-2.8619 (±0.1020)	0.93	3.33	<0.001	- Allometric
Uranoscopus scaber	120	5.7-22.8	12.00±0.2267	1.63-178.45	31.4±2.40	0.0108	3.1501	2.990-3.309 (±0.0805)	0.9284	1.86	<0.05	+ Allometric
Merlangius merlangus	332	3.9-12.2	7.70±0.089	0.52-14.26	3.72±0.13	0.0082	2.9241	2.8530-2.9952 (±0.0179)	0.952	2.1	<0.05	+ Allometric
Scorpaena porcus	18	3.6-16.1	7.80±0.8202	0.83-82.50	16.74±4.64	0.0182	3.0783	2.7477-3.409 (±0.156)	0.9605	4.95	<0.001	+ Allometric
Serranus hepatus	9	4.5-25.2	7.00±2.59	1.44-220.05	118.75±29.36	0.0136	3.0496	2.8467-3.2525 (±0.085)	0.9944	0.47	>0.05	Isometric
Syngnathus typhle	9	13.0-30.5	25.4±4.81	0.53-13.75	7.83±1.23	0.0006	3.5845	2.9683-4.2005 (±0.2605)	0.9643	29.96	<0.001	+ Allometric
Aphia minuta	14	3.3-4.9	4.3±0.1187	0.15-0.69	0.40±0.03	0.0021	3.586	2.9768-4.1951 (±0.279)	0.932	28.92	<0.001	+ Allometric
Trachurus trachurus	395	4.9-12.5	8.4087±0.03757	0.81-16.7	4.68±0.07	0.0143	2.7068	2.57204-2.8415 (±0.0068)	0.7987	39.24	<0.001	- Allometric

Table 3. Previous literature indicating the result of length-weight relationship for fish species in different area.

Species	L (min-max)	W (min-max)	n	a	b	r^2	Area	References
Merlangius merlangus	7.5-23.4	3.7-113.8	1891(C)	0.010	2.90	0.93	Central Black Sea	Samsun et al., (2017)
	8.8-22.7	4.18-79.69	480(F)	0.007	3.01	0.96	Middle Black Sea	Kalaycı et al., (2007)
	8.1-22.4(E)	3.53-65.43	400(M)	0.084	2.93	0.94		
	7.8-22.7	2.67-76.28	318(C)	0.006	3.01	0.96	Western black sea	Türker & Bal., (2018)
	6.40-24.02	1.75-106.07	1287(C)	0.0058	3.07	0.96	Marmara denizi	Daban et al., (2020)
	5.7-24.9	1.13-111.49	1444(C)	0.0063	3.04	0.97	Eastern Black Sea	Onay & Dalgıç (2021)
	3.9-12.2	0.52-14.26	332	0.0082	2.9241	0.9284	Western Black Sea	Present study
Trachurus trachurus	6–15.7	1.75–44.32	267(C)	0.004	3.24	0.94	Eastern Black Sea	Ak et al., (2009)
	11.5-18.3	12.19-47.38	358(F)	0.0095	2.9467	0.94	Middle Black Sea	Kalaycı et al., (2007)
	10.3-17.8	9.47-45.48	383(M)	0.0079	3.0128	0.96		
	8.0-16.6	3.03-38.3	489(C)	0.0056	3.12	0.98	Western Black Sea	Türker & Bal (2018)
	7.80-18.10	3.79-50.01	286(C)	0.0102	2.90	0.91	Marmara Sea	Daban et al., (2020)
	4.9-12.5	0.81-16.7	395	0.0143	2.7068	0.7987	Western Black Sea	Present study
Mullus barbatus	8.7-18.4	6.32-60.16	86 (F)	0.009	3.02	0.98	Middle Black Sea	Kalaycı et al., (2007)
	9.1-16.1	7.32-41.85	75(M)	0.013	2.89	0.98		
	9.0-18.4	7.97-71.29	663(C)	0.004	3.36	0.92	Western Black Sea	Türker & Bal. (2018)
	7.90-20.20	5.54-83.77	44(C)	0.0149	2.87	0.89	Marmara Sea	Daban et al., (2020)
	5.2-23.6	1.15-129.21	2930(C)	0.005	3.23	0.98	Eastern Black Sea	Onay & Dalgıç, (2021)
	6.8	14.6	432(C)	0.0051	3.24	0.97		Demirhan & Can, (2007)
	4.3-15.3	0.71-37.73	1118	0.049	3.2945	0.924	Western Black Sea	Present Study
Gobius niger	5.6–15.7	1.69-45.0	208(C)	0.009	3.04	0.88	Eastern Black Sea	Ak et al., (2009)
	8.0-24.8	5.37-165.7	122 (F)	0.015	2.89	0.96	Middle Black Sea	Kalaycı et al., (2007)
	9.0-25.3	8.18-168.7	105(M)	0.017	2.84	0.96		
	6.20-14.20	2.85-36.25	331(C)	0.0095	3.08	0.90	Marmara Sea	Daban et al., (2020)
	5.7-13.5	1.91-24.78	427(C)	0.0112	2.97	0.93	Eastern Black Sea	Onay & Dalgıç, (2021)
	2.9-286	0.18-31.63	1077	0.0091	3.057	0.9355	Western Black Sea	Present Study
Scorpaena porcus	9.3-29.2	14.4-508	71(F)	0.017	3.02	0.98	Middle Black Sea	Kalaycı et al., (2007)
	8.5-20.8	13.00-172	65(M)	0.016	3.05	0.98		
	5.0–34.2	2.1–406.1	351(C)	0.009	3.27	0.88	Eastern Black Sea	Ak et al., (2009)
	5.4-25.5	3.4-305.56	32(C)	0.032	2.84	0.96	Western Black Sea	Türker & Bal, (2018)
	5.5-25.9	3.03-49.58	219(C)	0.014	3.11	0.99	Eastern Black Sea	Onay & Dalgıç, (2021)
		4.6	17.5(C)	0.012	3.19	0.94		Demirhan & Can, (2007)
	3.8-23.8	1.01-335.12	316(C)	0.015	3.10	0.97	Middle Black Sea	Samsun & Erdoğan Sağlam, (2018)
				0.019	2.98	0.93		
	3.6-16.1	0.83-82.50	18	0.0182	3.0783	0.9605	Western Black Sea	Present Study

	5.2-8.9		32(C)	0.0017	2.68	0.86		Türker Çakır et al., (2008)
	6.0-8.9		76(C)	0.0179	2.60	0.87		Bayhan et al., (2008)
Arnoglossus kessleri	4.3-9.8	1.2–8.94	60(C)	0.021	2.98	0.72	Eastern Black Sea	Ak et. al., (2009)
	2.0-7.6		682(C)	0.008	3.00	0.916		Bilgin & Onay, (2019)
	4.90-13.00	0.79-20.43	917(C)	0.0081	2.92	0.85	Marmara Sea	Daban et al., (2020)
	3.2-12.8	0.28-20.85	365	0.0091	3.0502	0.9101	Western Black Sea	Present Study
	1.8-56.4	1.01-551.51	620(C)	0.008	3.22	0.81	Eastern Black Sea	Ak et al., (2009)
	9.1-20.8	10.81-147.85	244(M)	0.014	3.05	0.96	Eeastern Black Sea	Yeşilçiçek et. al., (2015)
	7.3-25.5	6.03-326.66	271(F)	0.009	3.20			
	9.20-21.00	13.30-176.83	22(C)	0.0133	3.12	0.98	Marmara Sea	Daban et al., (2020)
Uranoscopus scaber	4.8-24.2	2.31-263.45	264(C)	0.017	2.96	0.97	Eastern Black Sea	Onay & Dalgıç, (2021)
	6.6-25.5	4.28-312.65	189 (C)	0.009	3.21	0.98	Western Black Sea	Türker & Bal, (2018)
	5.3-21.8	-	45 (F)	0.014	3.07	0.98	Southeastern Black Sea	Demirhan & Can, (2007)
	5.7-15.2		22(M)	0.014	3.09	0.97		
	5.7-22.8	1.63-178.45	120	0.0108	3.1501	0.9284	Western Black Sea	Present study
	3.9–12.3	-	2410(C)	0.013	3.11	0.96	İzmir Bay	Soykan et al., (2013)
	5.2–11.7	1.89-24.97	603(C)	0.015	2.99	0.97	İzmir Bay	Bilecenoğlu, (2009)
Serranus hepatus	2.4–10.5	0.25-22.05	584(C)	0.016	3.02	0.97	Northeastern mediterranean	Çiçek et al., (2006)
	6.0–11.1		204(C)	0.009	3.22	0.95	İzmir Bay	Gürkan & Bayhan, (2010)
	4.5-25.2	1.44-220.05	9	0.0136	3.0496	0.9944	Western Black Sea	Present Study
	40-258	0.01-8.2	125(C)	3E-07	2.42	0.96	İzmir bay	Gürkan & Taşkavak, (2007)
	1.61-22.7	0.08-3.48	61(C)	0.0004	2.98	0.86	Aegean Sea	Gürkan et al., (2020)
Sygnathus thyphle	5.4-28.6	0.05-8.95	70(C)	0	2985	0.97	Gökçeada Island	Altın et al.., (2015)
	13.0-30.5	0.53-13.75	9	0.0006	3.5845	0.9643	Western Black Sea	Present Study
Aphia minuta	2.9-5.8	0.11-1.81	308(C)	0.0025	3.49	0.82	Southeastern Black Sea	Van et al., (2019)
	3.3-4.9	0.15-0.69	14	0.0021	3.586	0.932	Western Black Sea	Present study
	5.0–35.0	1.01–549.2	338(C)	0.004	3.43	0.884	Eastern Black Sea	Ak et al., (2009)
Trachinus draco	9.5-22.5	5.34-75.84	319 (M)	0.0079	2.95	0.93	Eastern Black Sea	Ak & Genç, (2013)
	10-25.8	6.96-131.76	306 (F)	0.0064	3.03	0.96		
	5.6-21.5	1.52-101.73	53	0.0174	2.6572	0.93	Western Black Sea	Present Study
	1.40-14.50	15.84-41.46	2	-	-	-	-	Kasapoğlu & Düzgüneş, (2014)
	7.1-11.6		72	0.01370	2.763	0,979	Southern Agean Sea	Bilge et al., (2014)
Parablennius tentacularis	3.5-10		64	0.0072	3.125	0.973	Erdek Bay,Sea of Marmara	Keskin & Gaygusuz, (2010)
	9.5-22.5	5.34-75.84						Ak & Genç, (2013)
	10-25.8	6.96-131.7						
	4.8-9.8	1.1-6	13	0.0218	2.58	0.987	Western Black Sea	Present Study
	11.6 - 18.2	10.13-38.60	15	0.00790	2.929	0.99	Northern Sea of Marmara	Bok et al., (2011)
Callionymus risso	3.5-7.4		43 M	0,00820	2.844	0.931	Southern Agean Sea,	Bilge et al., (2014)
	3,2-7.0		13	0.01370	2.705	0.938	Erdek Bay,Sea of Marmara	Keskin & Gaygusuz, (2010)
	2.8-6.6	0.18-3.35	48	0.0048	3.4216	0.925	Western Black Sea	Present Study
	3.7-9.0		71	0.0004	2.522	0.721	Erdek Bay,Sea of Marmara	Keskin & Gaygusuz, (2010)
Pomatoschistus marmoratus	2.5 -6.5	0.11 -1.81	553	0.00566	3.0931	0.93	Southeastern Black Sea	Van et al., (2019)
	4.9-7.1	1.05-7.1	13	0.00050	3.3286	0.917	Western Black Sea	Yildiz et al., (2018)
	3.0-7.8	0.15-7.5	44	0.0079	2.8789	0.8863	Western Black Se	Present Study

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