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RESEARCH ARTICLE

Length-weight relationship of the most landed pelagic fish species European pilchard (*Sardina pilchardus* Walbaum, 1792) and European anchovy (*Engraulis encrasicolus* Linnaeus, 1758) in the Izmir Bay (Aegean Sea, Turkey) purse seine fishery

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ABSTRACT

Length-weight relationships (LWR) of the most landed pelagic fish species *Sardina pilchardus* Walbaum, 1792 and *Engraulis encrasicolus* Linnaeus, 1758 in the Izmir Bay purse seine fishery were determined to reveal latest situation. Purse seine is a non-selective fishing gear compare to the other fishing gear such as gillnet or trammel net. For this reason, sampling all size individuals is very important to calculate mean length and other LWR parameters. In this study, seasonal LWR coefficient and minimum-maximum lengths were established as monthly basis. LWR of *S. pilchardus* and *E. encrasicolus* were $W = 0.0059L^{2.7930}$ ($r^2 = 0.94$) and $W = 0.0019L^{3.4207}$, ($r^2 = 0.87$), respectively. Growth type of the *S. pilchardus* was found negative allometric whereas *E. encrasicolus* was positive allometric. A decrease of the mean total length of *S. pilchardus* has been considerable variable from 1994 to 2014 in Izmir Bay but with this study, it is observed that mean length of the sardine found near of 2006 value related to seasonal fishing pressure.

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Introduction

The length-weight relationship (LWR) is an important tool in fish biology, physiology, ecology and fisheries assessment (Oscoz et al., 2005) and also, provide invaluable information on stock assessment studies (Moutopoulos and Stergiou, 2002; Gonzalez Acosta et al., 2004) for conversion of length observations into weight estimates to provide some measurements of biomass (Froese, 1998; Gonzalez Acosta et al., 2004).

Purse seine fishery is especially important for the Turkish fishery since it is the most important gear that targets small pelagic species especially anchovy and sardines as well as big pelagic species such as tunas. Once a fish school has been detected and surrounded by the purse seine net, there is no selectivity for individual size, species or catch quantity (Handegard et al., 2017). The catch quantity of a purse seiner is too much to compare with other fishing gears (e.g. trawls, seines). However, scientific studies on this fishing gear and method are quite limited in Turkey (Özbilgin et al., 2015).

Landing coming from purse seine accounts for about 30% of the world's total catch (Watson et al., 2006). Vast majority marine fish landing (approximately 60-70%) achieved by purse seine in 2018 fishing season (TurkStat, 2019). According to the official catch records, anchovy is the most landed fish species in Turkey with 96452 tons (43%). Although sardine landing is only 8.5% in Turkey, this value is substantially higher for the Aegean Sea (67%). Anchovy (12969 tons) and sardine (12654 tons) are the most landed pelagic fish species in the Aegean Sea (TurkStat, 2019). However, anchovy landing was the first time recorded higher than the sardine's in 2018 in the Aegean Sea.

So far, a few studies conducted to determine the LWR of *S. pilchardus* and *E. encrasicolus* with 10-year intervals (Hoşsucu et al., 1994; Özaydin and Taskavak, 2006; Acarli et al., 2014). For this reason, the purpose of the study is to reveal the current LWR parameters and compare it with the previous studies.

Material and Methods

During the study, a total of 567 of *S. pilchardus* and 212 of *E. encrasicolus* individual sampled in seven months. All the materials obtained from the monthly purse seine operations between September 28, 2017 and March 21, 2018 from Izmir Bay (Fig. 1) in depths between 26 and 60 m. The purse seine net used by the commercial purse seiner Afala 24 m LOA is overall 750 m in length, 164 m net in height and 14 mm mesh size. Purse seine is a non-selective fishing gear compare to the other fishing gear such as gillnet or trammel net. For this reason, sampling all size individuals is very important to calculate mean length and other LWR parameters.

In this study sampling was made only for seven months (three seasons) due to the 4/1 notification regulates commercial fishery by the Ministry of Agriculture and Forestry of Turkey. According to the regulation, there was a closed season for purse seine fisheries between 15th April and 31st August in Turkish waters. In the analysis of LWR, monthly data was converted to seasons and seasons converted to the total value. Final estimations made on the total values.

Total length (TL) of all individuals were measured to the nearest centimeter (cm), and wet weight (W) was recorded to the nearest gram (g). The functional relationship between the size and weight of the samples were fitted to the equation: $W = aL^b$, where W is the wet weight in grams, L the size in centimeters, a and b are the parameters to be estimated, with b being the coefficient of allometry (Ricker, 1975). The basic statistical data of the measured values were calculated and the relationships between them were determined (Sokal and Rohlf, 1973). Additionally, t-test was used for carried out to determine if the b coefficient was different from "3" (Sokal and Rohlf, 1969).

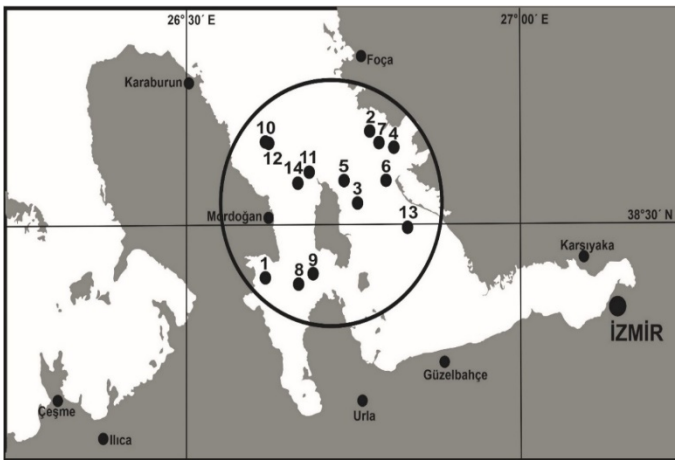

Figure 1. Sampling areas

Results

The overall mean length of the *S. pilchardus* was found 12.1 cm. However, vast majority of the sardine individuals (91%) accumulated between 11.0 and 14.0 cm (Fig. 2). It was found that there was no significant allometry coefficients of LWR among seasons (Table 1) and also, the LWR curve of the *S. pilchardus* has shown in Fig. 3. The estimated total value of b coefficient indicating negative allometric growth (b=2.79; t-test, $t<t_{0.05,\ n>500}=1.65$) (Table 1). Furthermore, the r^2 values of *S. pilchardus* indicated a strong relationship between length and weight as 0.94.

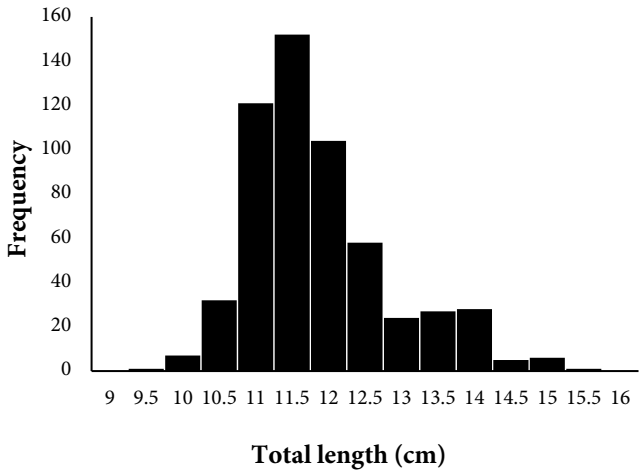

Figure 2. Length-frequency distribution of *S. pilchardus*

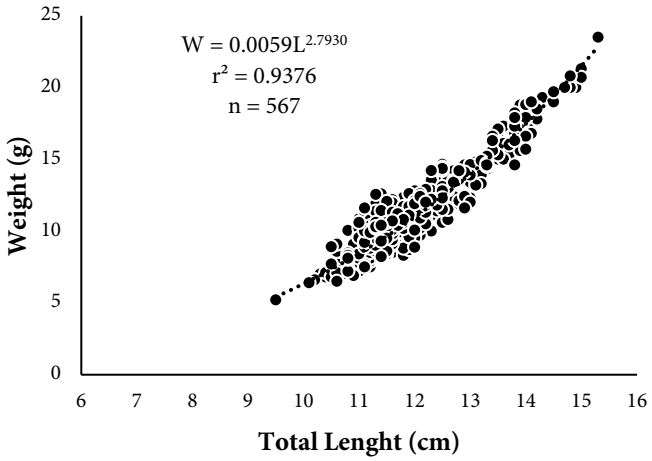

Figure 3. Length – weight relationship of *S. pilchardus*

Table 1. Overall estimated LWR values of *S. pilchardus*

		Length (cm)			Weight (g)							
Seasons	**N**	L_{min}	L_{max}	L_{mean}	W_{min}	W_{max}	W_{mean}	**a**	**b**	**SE(b)**	r^2	***t*-test**
Spring	56	11.5	15.0	12.7	9.1	21.3	13.4	0.0077	2.7981	0.009745	0.9405	-20.7
Autumn	303	9.5	15.3	11.6	5.2	23.5	9.8	0.0049	2.9256	0.005431	0.9289	-13.6
Winter	209	10.5	14.8	11.9	8.3	20.8	11.7	0.0227	2.5182	0.008901	0.8460	-54.1
Total	567	9.5	15.3	12.1	5.2	20.8	3.0	0.0059	2.7930	0.005862	0.9376	-35.3

Note: SE is the standard error.

Table 2. Overall estimated LWR values of *E. encrasicoulus*.

		Length (cm)			Weight (g)							
Seasons	**N**	L_{min}	L_{max}	L_{mean}	W_{min}	W_{max}	W_{mean}	**a**	**b**	**SE(b)**	r^2	***t*-test**
Spring	33	11.4	13.9	12.7	8.6	16.5	12.0	0.0040	3.1460	0.014423	0.9485	10.1
Autumn	31	9.2	11.4	10.2	3.6	8.0	4.7	0.0024	3.2584	0.055790	0.7196	4.6
Winter	148	9.7	13.8	11.3	4.1	15.5	8.1	0.0019	3.4370	0.008759	0.9142	49.8
Total	212	9.2	13.9	11.4	3.6	16.5	8.3	0.0019	3.4207	0.005935	0.8687	70.8

Note: SE is the standard error.

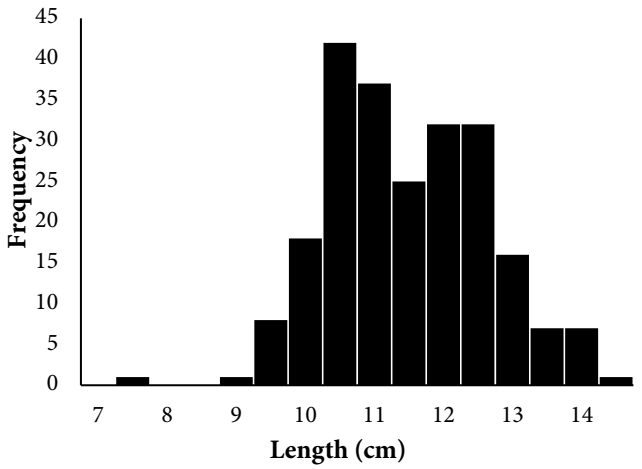

Figure 4. Length-frequency distribution of *E. encrasicolus*

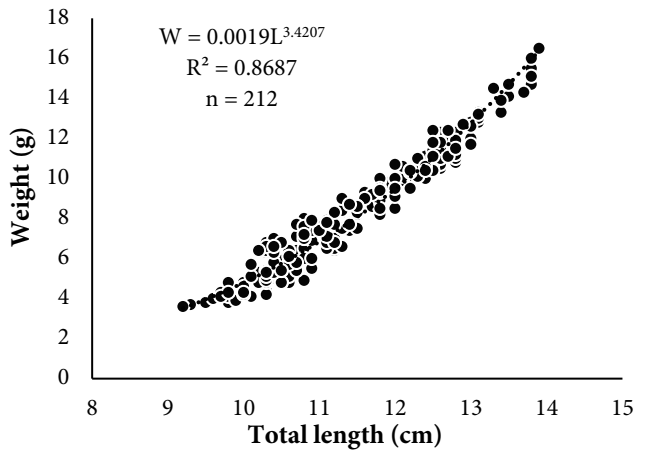

Figure 5. Length – weight relationship of *E. encrasicolus*

According to length-frequency distribution, mean length of the *E. encrasicoulus* was found as 11.4 cm and vast majority (87%) accumulated between 10.5 and 14.0 cm (Fig. 4). Allometry coefficient of the seasonal LWR parameters estimated and have been found for every season (Table 2). In detail, *b* value of the *E. encrasicoulus* was found for months as 3.1460, 3.2584, 3.4370 and total as 3.4207, respectively (Table 2) and these values are indicating positive allometric growth (b=3.42; *t*-test, $t>t_{0.05,\ n>200}=1.65$) (Fig. 5). Also, r^2 values of *E. encrasicoulus* shown a strong relationship between length and weight as 0.87.

Discussion

Overall results of *S. pilchardus* and *E. encrasicolus* showed dissimilarities in total length (TL) and mean length based on sampling sites (Table 3 and Table 4). So far, TL of *S. pilchardus* has been shown a great variety in the Aegean Sea. However, maximum total length value of *S. pilchardus* reported from Izmir Bay by Hoşsucu et al. (1994) as 17.0 cm and it is still maintaining validity. In Izmir Bay, prior records indicating that the mean length of European pilchard has been reported as 14.2 cm by Hoşsucu et al. (1994), 11.82 cm by Özaydin and Taskavak (2006) and 9.39 cm by Acarli et al. (2014). In the results of this study, total length distribution of *S. pilchardus* between 9.5-15.3 cm. For the estimation of the mean length values of *E. encrasicolus* distribution range has been reported as 9.95 cm by Acarli et al. (2014) and 12.09 cm by Özaydin and Taskavak (2006). In this study, the mean length found as 11.4 cm and it has been shown similarity and also, it has been found as a medium value of these results.

Furthermore, the reported results of the *b* coefficient, which show different types of growth, such as isometric and allometric growth depending on different sampling areas are notable. As a short note, the *b* value is useful in explaining the body shape (growth type) according to the conditions in which the fish is present. If this value is equal to "3" it is called isometric but if it is a different value than "3", then it is called allometric growth (Ricker, 1975; Sparre et al., 1989; Sparre and Venema, 1992; Avsar, 2016).

Table 3. Comparative results of LWR parameters of *S. pilchardus*

Author	Location	Sex	n	*a*	*b*	r^2	Growth
Present study	Aegean Sea- Izmir Bay	♂♀	567	0.0059	2.793	0.94	- allometric
Petrakis and Stergiou, 1995	South Euboikos Gulf	♂♀	82	0.00003	2.754	0.82	-allometric
Sinovčić et al., 2004	Adriatic Sea	♂♀	4441	0.0038	3.230	0.98	+allometric
Mendes et al., 2004	Portuguese west coast	♂♀	113	0.0017	2.772	0.77	- allometric
Tarkan et al., 2006	Marmara Region -Turkey	♂♀	11	0.0021	3.540	0.98	+allometric
Pešić et al., 2006	Boka Kotorska Bay	♂♀	2489	-0.0047	3.167	0.99	+allometric
Özaydin and Taskavak, 2006	Aegean Sea- Izmir Bay	♂♀	388	0.0076	3.190	0.89	+allometric
Karachle et al., 2008	North Aegean Sea	♂♀	752	0.0053	3.144	0.90	+allometric
Veiga et al., 2009	Southern Portugal	♂♀	676	0.0051	3.140	0.95	+allometric
Mustac et al., 2010	Middle Adriatic Sea	♂	668	0.0425	2.371	0.58	- allometric
		♀	541	0.0342	2.465	0.73	- allometric
Torres et al., 2012	Gulf of Cadiz	♂♀	1656	0.0082	3.016	0.87	isometric
Acarli et al., 2014	Izmir Bay – Homa Lagoon	♂♀	77	0.0070	3.053	0.99	+allometric

Table 4. Comparative results of LWR parameters of *E. encrasicolus*

Author	Location	Sex	n	*a*	*b*	r^2	Growth
Present study	Aegean Sea- Izmir Bay	♂♀	212	0.0019	3.421	0.87	+allometric
Sinovčić et al., 2004	Adriatic Sea	♂♀	4234	0.0039	3.160	0.99	+allometric
Özaydin and Taskavak, 2006	Aegean Sea- Izmir Bay	♂♀	513	0.0116	2.840	0.94	-allometric
Ismen et al., 2007	Saros Bay	♂♀	212	0.0050	2.970	0.87	-allometric
Karachle et al., 2008	North Aegean Sea	♂♀	759	0.0008	3.822	0.95	+allometric
Veiga et al., 2009	Southern Portugal	♂♀	278	0.0039	3.190	0.98	+allometric
Torres et al., 2012	Gulf of Cadiz	♂♀	2293	0.0049	3.125	0.97	+allometric
Acarli et al., 2014	Izmir Bay – Homa Lagoon	♂♀	68	0.0070	2.917	0.99	-allometric

So far, many studies of *S. pilchardus* indicating allometric growth and only one study reported as isometric growth such as Torres et al. (2012). As it seems in Table 3, there were differences between allometric growth. So that, Mendes et al. (2004), Petrakis and Stergiou (1995) and this present study results has been shown negative allometric growth. Otherwise, the rest of them has been indicated positive allometric growth. Comparison of the reported values of *E. encrasicolus* shown that all researchers have been agreed on the allometric growth of this species. However, growth type of depending on *b* value have a variety among conducted studies. Such that, Sinovčić et al. (2004), Karachle et al. (2008), Veiga et al. (2009), Torres et al. (2012) and this present studies *b* value indicating positive allometric growth. On the contrary, other studies has been shown negative allometric growth (Table 4). Length-frequency distributions and *b* value is directly associated to the fishing gear and method. While gillnets/trammel nets are shown higher selectivity for sardine related to mesh size and mesh shape, selectivity of the purse seine bunt is so poor that even very small sizes of juveniles are not selected. For instance, Torres et al. (2012) reported an unusually isometric growth of *S. pilchardus* with bottom trawl and this shows us the importance of sampling method. Also, except for the method, there are so many contributing variables (feeding, reproduction and temperature of the habitat that fish population live, etc.) to the effect of change of *b* value. Izmir Bay is also known as an important spawning and nursery ground for several fish species, mainly because of lagoons which serve as sheltered habitats and the input of nutrients from the Gediz River (Özaydın and Taskavak, 2006). So that, sampling sites that fish caught is also an important variable to establish the *b* value, even in the Izmir Bay.

Conclusion

S. pilchardus and *E. encrasicolus* are highly demanding and invaluable fish species for human consumption as well as fish meal and oil industry in worldwide and also in Turkey. We believe that this study will contribute to understanding the changing of the populations of *S. pilchardus* and *E. encrasicolus* in Izmir Bay. A decrease of the mean total length of *S. pilchardus* has been considerable variable from 1994 to 2014 in Izmir Bay but with this study, it is observed that mean length of the sardine found near of 2006 value related to seasonal fishing pressure.

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Conflict of Interest

The authors declare that there is no conflict of interest.

References

Acarli, D., Kara, A. & Bayhan, B. (2014). Length-weight relations for 29 fish species from Homa Lagoon, Aegean Sea, Turkey. *Acta Ichthyologica et Piscatoria*, ***44***(3): 249-257. https://doi.org/10.3750/AIP2014.44.3.09

Avsar, D. (2016). Fisheries Biology and Population Dynamics (*in Turkish*). Ankara, Turkey: Akademisyen Publishing. 148 p.

Froese, R. & Pauly, D. (1998). FishBase 98: Concepts, Design and Data sources. 293 p

González Acosta, A. F., De La Cruz Agüero, G. & De La Cruz Agüero, J. (2004). Length-weight relationships of fish species caught in a mangrove swamp in the Gulf of California (Mexico). *Journal of Applied Ichthyology*, ***20***(2): 154-155. https://doi.org/10.1046/j.1439-0426.2003.00518.x

Handegard, N. O., Tenningen, M., Howarth, K., Anders, N., Rieucau, G. & Breen, M. (2017). Effects on schooling function in mackerel of sub-lethal capture related stressors: crowding and hypoxia. *PLoS ONE,* ***12***(12): e0190259. https://doi.org/10.1371/journal.pone.0190259

Hoşsucu, H., Kara, A., Metin, C., Tosunoğlu, Z. & Ulaş, A. (1994). Purse seine fisheries in Aegean Region and catch effort of the purse seine vessels (*in Turkish with English abstract*). *Ege Journal of Fisheries and Aquatic Sciences*, ***11***: 17-32.

Ismen, A., Ozen, O., Altinagac, U., Ozekinci, U. & Ayaz, A. (2007). Weight-length relationships of 63 fish species in Saros Bay, Turkey. *Journal of Applied Ichthyology*, ***23***(6): 707-708. https://doi.org/10.1111/j.1439-0426.2007.00872.x

Karachle, P. K. & Stergiou, K. I. (2008). Length–length and length–weight relationships of several fish species from the North Aegean Sea (Greece). *Journal of Biological Research-Thessaloniki*, ***10***: 149-157.

Mendes, B., Fonseca, P. & Campos, A. (2004). Weight-length relationships for 46 fish species of the Portuguese west coast. *Journal of Applied Ichthyology*, ***20***(5): 355-361. https://doi.org/10.1111/j.1439-0426.2004.00559.x

Moutopoulos, D. K. & Stergiou, K. I. (2002). Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology*, ***18***(3): 200-203. https://doi.org/10.1046/j.1439-0426.2002.00281.x

Mustač, B. & Sinovčić, G. (2010). Reproduction, length-weight relationship and condition of sardine, *Sardina pilchardus* (Walbaum, 1792), in the eastern Middle Adriatic Sea (Croatia). *Periodicum Biologorum*, ***112***(2): 133-138.

Oscoz, J., Campos, F. & Escala, M. C. (2005). Weight-length relationships of some fish species of the Iberian Peninsula. *Journal of Applied Ichthyology*, ***21***(1): 73-74. https://doi.org/10.1111/j.1439-0426.2004.00587.x

Özaydin, O. & Taskavak, E. (2006). Length-weight relationships for 47 fish species from Izmir Bay (eastern Aegean Sea, Turkey). *Acta Adriatica,* ***47***(2): 211-216.

Özbilgin, H., Eryaşar, A. R., Fakıoğlu, Y. E., Kalecik, E., Demir, O. & Saygu, İ. (2015). Reference list of the fisheries studies carried out in Turkish waters (*in Turkish*). *Proceedings of the 18th National Fisheries Symposium,* Izmir, Turkey. pp. 93.

Pešić, A., Đurović, M., Regner, S., Joksimović, A. & Simić, V. (2006). Length-weight relationship of juvenile sardine *Sardina pilchardus* (Walbaum, 1792) from Boka Kotorska Bay. *Kragujevac Journal of Science*, ***28***: 91-95.

Petrakis, G. & Stergiou, K. I. (1995). Weight-length relationships for 33 fish species in Greek waters. *Fisheries Research*, ***21***(3-4): 465-469. https://doi.org/10.1016/0165-7836(94)00294-7

Ricker, W. E. (1975). Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada*. Bulletin No. 191, Ottawa, Canada. 382p.

Sinovčić, G., Franičević, M., Zorica, B. & Čikeš-Keč, V. (2004). Length-weight and length-length relationships for 10 pelagic fish species from the Adriatic Sea (Croatia). *Journal of Applied Ichthyology*, ***20***(2): 156-158. https://doi.org/10.1046/j.1439-0426.2003.00519.x

Sokal, R. R. & Rohlf, F. J. (1969). Biometry: The principles and practice of statistics in biological research. 3rd ed. San Francisco, CA, USA: W. H. Freeman and Company. 776p.

Sokal, R. R. & Rohlf, F. J. (1973). Introduction to Biostatistics. San Francisco, CA, USA: W. H. Freeman & Company Ltd. 368 p.

Sparre, P., Ursin, E. & Venema, S. C. (1989). Introduction to tropical fish stock assessment: Part I. Manual FAO Fisheries Technical Paper. No. 306. 1. Rev. 1 Rome, Italy: FAO. 376 p.

Sparre, P. & Venema, S. C. (1992). Introduction to tropical fish stock assessment: Part I. Manual FAO Fisheries Technical Paper. No. 306. 1. Rome, Italy: FAO. 337 p.

Tarkan, A. S., Gaygusuz, Ö., Acıpınar, H., Gürsoy, Ç. & Özuluğ, M. (2006). Length-weight relationship of fishes from the Marmara region (NW-Turkey). *Journal of Applied Ichthyology*, ***22***(4): 271-273. https://doi.org/10.1111/j.1439-0426.2006.00711.x

Torres, M. A., Ramos, F. & Sobrino, I. (2012). Length–weight relationships of 76 fish species from the Gulf of Cadiz (SW Spain). *Fisheries Research*, ***127-128***: 171-175. https://doi.org/10.1016/j.fishres.2012.02.001

TurkStat. (2019). Fishery Statistics. Retrieved in December 28, 2019 from http://www.turkstat.gov.tr/

Veiga, P., Machado, D., Almeida, C., Bentes, L., Monteiro, P., Oliveira, F. & Gonçalves, J. M. S. (2009). Weight-length relationships for 54 species of the Arade estuary, southern Portugal. *Journal of Applied Ichthyology*, ***25***(4): 493-496. https://doi.org/10.1111/j.1439-0426.2009.01230.x

Watson, R., Revenga, C. & Kura, Y. (2006). Fishing gear associated with global marine catches: I. Database development. *Fisheries Research,* ***79***(1-2): 97-102. https://doi.org/10.1016/j.fishres.2006.01.010