

Length-Frequency Distribution of European Hake, *Merluccius merluccius* from 1995 to 2016 in The Sea of Marmara

Güzin Gül*, Ahsen Yüksek, Elif Murat-Dalkara, Nazlı Demirel

¹Istanbul University, Institute of Marine Sciences and Management, 34134, Fatih/Istanbul, Turkey

Correspondent: guzngul@gmail.com

(Received: 18.10.2019; Accepted: 17.12.2019)

Güzin Gül: Orcid 0000-0001-5888-3211, Ahsen Yüksek: Orcid 0000-0003-3004-7443, Elif Murat-Dalkara: Orcid 0000-0002-8757-2532, Nazlı Demirel: Orcid 0000-0003-4542-9276

Abstract: In this study, European hake (*Merluccius merluccius*) is one of the most important demersal species of the Sea of Marmara, has been subjected to estimate variation in length and size distribution based on obtained data from Sea of Marmara. A total of 174 bottom trawl hauls were performed in 19 stations representing the entire Sea of Marmara from 1995 to 2016 (July and November 1995, March and October 1996, December 2009, December 2010, February 2011 and August 2016). The estimation of length-weight relationships (LWRs) and distribution of length frequency was estimated according to years and sexes. A total of 5453 specimens were evaluated. Sex ratio was calculated as 1:1.2 males to females. Overall length-weight relations were estimated $W=0.006L^{3.077}$ ($r^2=0.97$) for females, $W=0.008L^{2.97}$ ($r^2=0.95$) for males. According to the length frequency results, observed changes were not significant in size distribution of the samples between 1995 to 1996 and from 2009 to 2011. However, the median value of the total lengths of the individuals obtained in the 90s is greater than the values obtained at the end of the 2000s. The size distributions of the samples obtained in the 1990s are in a wider range than the size range of samples in 2000s. Especially in 2009 and 2016, it was observed that the size distribution was very narrow, also very few large-sized individuals were obtained.

Keywords: Length-Weight Relationships, Demersal Fish, European Hake

1995-2016 Yılları Arasında Marmara Denizi'nde Berlam Balığının (*Merluccius merluccius*) Boy Frekans Dağılımı

Özet: Bu çalışma Marmara Denizi'nin en önemli demersal türlerinden biri olan Berlam balığının, (*Merluccius merluccius*) boy dağılımları ve değişimlerini, boy-ağırlık ilişkilerini belirlemek amacıyla yapılmıştır. Örneklem; tüm Marmara Denizi'ni temsil eden 19 istasyonda, 1995-2016 seneleri arasında farklı zaman dilimlerinde (Temmuz ve Kasım 1995, Mart ve Ekim 1996, Aralık 2009, Aralık 2010, Şubat 2011 ve Ağustos 2016) gerçekleştirilen 174 adet dip trol örnekleme ile yapılmıştır. Toplamda 5453 birey incelenerek boy-ağırlık ilişkisi (LWRs) ve boy dağılımı yıllara ve cinsiyete göre değerlendirilmiştir. Cinsiyet oranı 1:1.2 (erkek-dişi) şeklinde belirlenmiştir. Boy-ağırlık ilişkisi dişi bireyler için $W=0.006L^{3.077}$ ($r^2=0.97$), erkek bireyler için ise $W=0.008L^{2.97}$ ($r^2=0.95$) olarak hesaplanmıştır. Senelere göre boy dağılımlarındaki değişimlere göre 1995-1996 ve 2009-2011 yılları arasında değişimin anlamlı olmadığı, ancak 90'larda elde edilen bireylerin median değerlerinin 2000'li yılların sonlarına doğru olan bireylerden daha yüksek olduğu görülmüştür. 1990'larda elde edilen bireylerin toplam boy aralıkları 2000'lerdeki bireylerin toplam boy aralıklarından daha geniş bir aralıkta olduğu belirlenmiştir. Özellikle 2009 ve 2016 yıllarında büyüklük dağılımının çok dar olduğu, aynı zamanda çok az sayıda büyük boylu bireyin elde edildiği görülmüştür. LWRs balık biyolojisi araştırmalarının ve balıkçılık yönetimi için gerekli hesaplamaların önemli bir parçasıdır. LWR'ler vücut ağırlığının toplam boydan tahmin edilmesini sağlayabilir ve toplam balık ağırlığı biyokütlenin tahmin edilmesi için gereklidir, bu nedenle avcılığın düzenlenmesine yardımcı olur.

Anahtar Kelimeler: Boy-Ağırlık İlişkisi, Demersal Balık, Berlam

Introduction

European hake is one of the most heavily exploited demersal fish species in the Mediterranean (Casey and Pereiro, 1995). Global catch production is about 114,000 t and 15% of its total production comes from the Mediterranean Sea in 2013 (FAO, 2014). It was one of the main target demersal species in the Sea of Marmara and comprised around 50% percent of demersal fishery in the mid-90s which dramatically declined over the years (Gül and Demirel, 2016). According to national catch statistics, in 2018, only 90.8 tons' European hake caught in the Marmara Sea (TUIK, 2019). The status of the European hake which have economic value and have suffered intense fisheries pressure in the Sea of Marmara. According to Turkish fisheries law, trawl operation (mid and bottom) is forbidden in The Turkish Strait System (Sea of Marmara and both Dardanelles and Istanbul Straits). However, coast-guard records show illegal trawling activity while data obtained from TUIK (2018) indicates the three times increase of fleet size in the past 20 years. In addition to shrimp fisheries with beam trawl is not forbidden in some part of this area. Yazıcı et al., (2006) reported that the non-target species ratio was 75% in the study of the beam trawl survey during the period of 2011-2014 in the Sea of Marmara and they stated that European hake with the

highest rate in the non-target bony fish catch composition.

Length-weight relations (LWRs) are an important part of fish biology research and useful tools for fisheries management. LWRs can allow to predict body weight from body length and fish body weight is necessary to estimate biomass thus it helps to regulate the catches (Froese, 2006).

There are few studies about LWRs of *Merluccius merluccius* in the Sea of Marmara (Bok et al., 2011; Demirel and Dalkara-Murat 2012; Kahraman et al., 2017).

In this study, *Merluccius merluccius* has been subjected to estimation variation in length and size distribution over 20 years based on obtained data from different times at 19 stations in the Sea of Marmara.

Materials and Methods

A total of 174 bottom trawl hauls were performed in 19 stations representing the entire Sea of Marmara in different time periods from 1995 to 2016 (July and November 1995, March and October 1996, December 2009, December 2010, February 2011 and August 2016) (Fig. 1). Bottom trawl was used for sampling with 30 minutes hauling duration.

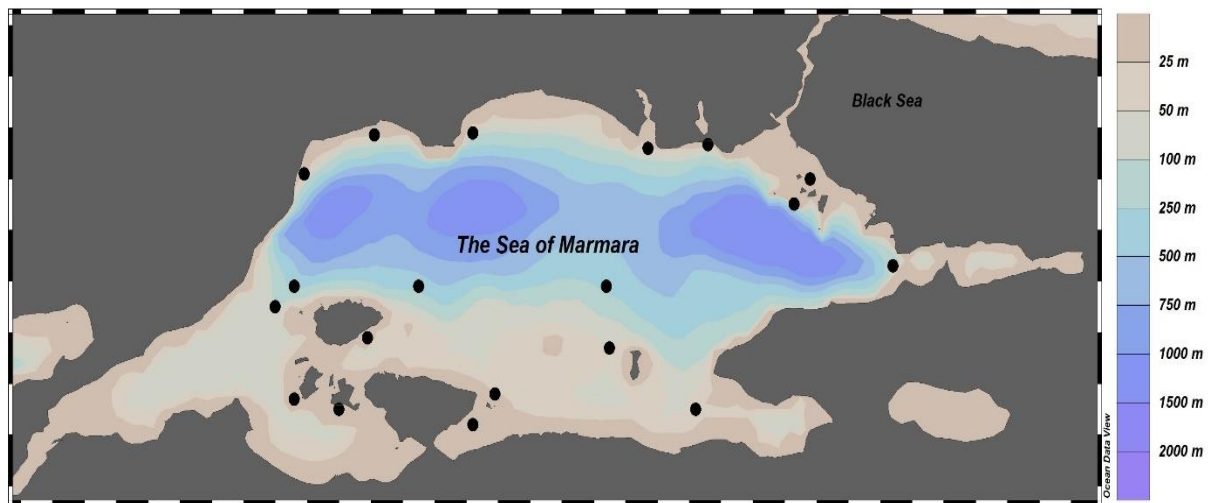


Figure 1. Study area and sampling stations in the Sea of Marmara.

Total length (TL) and total body weight (TW) were measured to the nearest 1 cm and 1 g, respectively. The estimation LWRs was calculated $W=a *L^b$. According the Ricker (1975) equation. This formula can be expressed in linearized form: $\log W=\log a+b\log L$ where W is the total body weight in grams, L is the total body length in cm, b is the slope and a is the intercept. LWRs estimations between sexes were analyzed statistically.

Results

A total of 5453 European hake specimens were evaluated. Sex determination were performed for 4492 individuals and 2106 of them (%47) were females while 1782 individuals were (40%) males and 604 (13%) were immature. Sex ratio was expressed 1:1.2 males to females.

Total lengths were found between 5 and 57 cm while total weights were varied from 1 to 1387 g (Table 1). According to length-frequency analysis, the size distributions of the samples obtained in the

1990s are in a wider range than the size range of samples in 2000s (Fig. 2). Especially in 2009 and 2016 it was observed that the size distribution was very narrow, also very few large-sized individuals were obtained. In 2010, two different cohorts were clearly observed (Fig. 2). In generally, female-male length-frequency distribution shows that total length

of females was larger than males. LWRs were estimated as $W=0.006L^{3.077}$ ($r^2=0.97$) (95 %CI b= 3.056-3.096, 95 %CI a= 0.0056-0.0063) for females and $W=0.008L^{2.97}$ ($r^2=0.95$) (95 %CI b=2.938-3.001, 95 %CI a=0.0073-0.0088) for males (Table 2; Fig. 3). There is a statistically significant difference between LWRs of females and males ($p<0.05$).

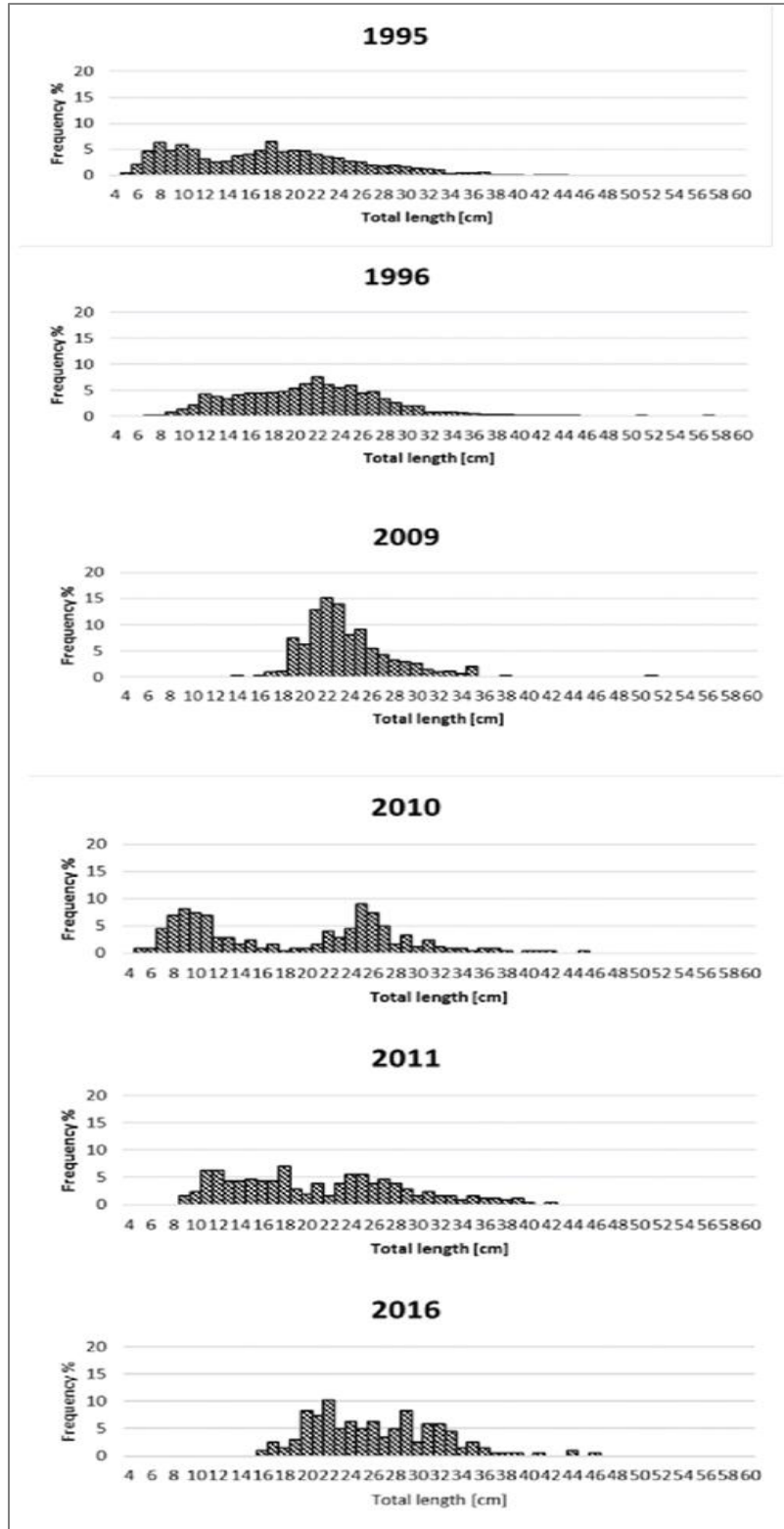


Figure 2. Length-frequency of European hake according to years in the Sea of Marmara

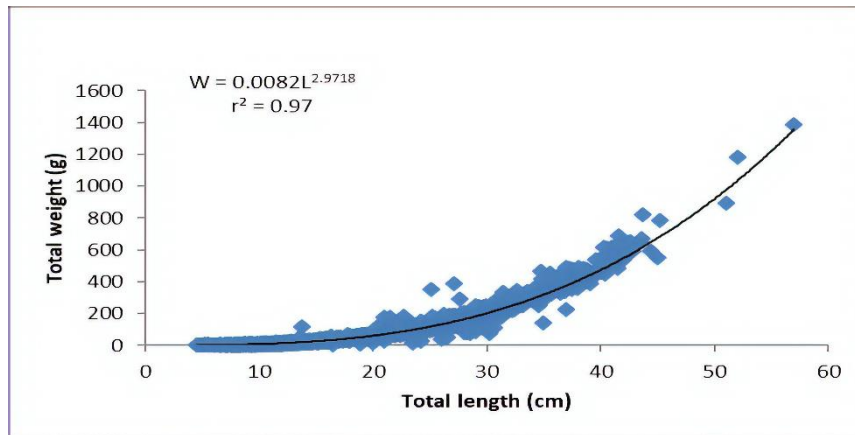


Figure 3. Total length-weight relationship of European hake from Sea of Marmara

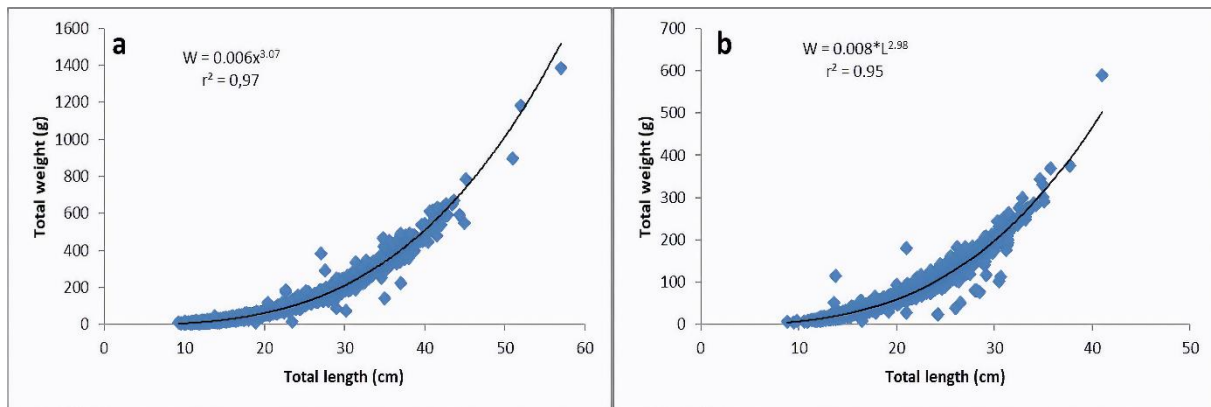


Figure 4. Total length-weight relationship of European hake by sexes in the Sea of Marmara (a=females, b=males)

Table 1. Descriptive statistics for length and weight by years of European hake from Sea of Marmara

Years	N	Total length (cm)		Total weight (g)	
		Min-Max	Mean+(SE)]	Min-Max	Mean+(SE)
1995	2049	4.5-43.7	17.45±1.69	1-820	68.23±1.92
1996	2348	7-57	21.33±0.13	2-1387	95.90±1.95
2009	351	13.6-52	23.73±0.22	27-1180	108.27± 4.41
2010	244	5-45	18.76±0.58	2-632	88.22±6.75
2011	256	8.7-41.5	21.04±0.48	5-481	93.47± 6.47
2016	205	16.2-46	26.11±0.39	26-686	145.8±7.26

Table 2. Length-weight relationship parameters of European hake over years from Sea of Marmara

Years	n	a	95 % CI a	b	95 % CI b	r ₂
1995	2049	0.078	0.007-0.008	2.99	2.97-3.01	0.97
1996	2348	0.005	0.0053-0.0059	3.09	3.07-3.11	0.98
2009	251	0.007	0.006-0.010	2.97	2.89-3.05	0.93
2010	244	0.025	0.021-0.030	2.61	2.55-2.67	0.97
2011	256	0.010	0.007-0.0131	2.87	2.78-2.95	0.94
2016	206	0.011	0.007-0.0163	2.86	2.74-2.98	0.91

n= number of spicemens, a= intercept, b= slope of the regression, r²= coefficient of determination

Table 3. LWRs of European hake from previous studies in Mediterranean

Author	a	b	Sex	TL (cm)	r ²	n	Region
Stergiou and Moutopoulos 2001	0.0038	3.28	C	4.0-46.0	0.94	284	Greece
Santos et al., 2002	0.0032	3.25	-	17.7-55.3	0.96	104	Portugal
Çicek et al., 2006	0.0046	3.15	J	3.1-29.9	0.98	567	NE Mediterranean
Karakulak et al. 2006	0.0049	3.10	J	19.7-41.1	0.98	22	North Aegean Sea
İşmen et al., 2007	0.0044	3.15		7.9-66.0	0.97	-	North Aegean Sea
	0.0031	3.28	J	9.3-44.2	0.98	-	
İlkyaz et al., 2008	0.0042	3.18	M	10.4-45.5	0.97	-	
	0.0038	3.21	F	9.0-44.2	0.98	-	Central Aegean Sea
Ceyhan et al., 2009	0.0061	3.04	J	21.5-40.5	0.94	-	Aegean Sea
Bok et al., 2011	0.0026	3.37		8.9-44.8	0.99	319	Sea of Marmara
Moutopoulos et al., 2013	0.0043	3.14		14.8-60.6	0.98	1408	Korinthiakos Gulf

C= combined, F= female, M= male, J= Juvenile

Discussion

Maximum total length of European hake was found 57 cm (1387 g), that was compatible with previous records which were 52.1 cm (Gözenç et al., 1997), 44.8 cm (Torcu-Koç et al., 2012) and 52 cm (Demirel and Dalkara-Murat 2012). Length-frequency results show observed changes were not significant in size distribution of the samples between 1995 to 1996 and from 2009 to 2011.

The median value of the total lengths of the individuals obtained in the 90s is greater than the values obtained at the end of the 2000s. It was reported that in the period between 1991 and 1994, the average length of specimens was 20-24 cm in the Sea of Marmara (Gözenç et al., 1997). Parameter estimates from other studies show some discrepancy, those differences can be derived physical condition of sampling area where is effective in the fish growth and condition factor and may be sampling methods. According to Bayesian approach estimates of LWRs (Froese and Pauly, 2018) parameters for European hake was calculated $a=0.00479$ (0.00423-0.00541), $b=3.10$ (3.06-3.14).

In conclusion, it is important to monitor fish populations and to evaluate the basic parameters of fish biology in an up-to-date manner. It is crucial that monitoring work is fundamentally addressed in the formulation of fisheries policies for the efficient use of the country's resources and sustainable economy. The basic data obtained from this study will constitute additional data for the future fisheries studies.

Acknowledgment

This study is dedicated to Prof. Erdoğan Okuş, who always will be remembered with his great contribution to Turkish marine sciences. Authors are grateful to Dr. Ayhan Uysal, crew of R/V ARAR and R/V ALEMDAR II for their help in samplings. This study was supported from The Scientific and Technological Research Council of Turkey (TUBITAK) Project 115Y107, and The Integrated Pollution Monitoring Project in Turkish Seas (ÇŞB/ÇEDİDGM-TUBİTAK/MAM; 2014-2016).

References

- Anonymus, (2014). Food and Agriculture Organization (FAO) Fisheries and Aquaculture Department. [Accessed on 14 September 2018] <http://www.fao.org/fishery/species/2238/en>
- Anonymus, (2018). Turkish Statistical Institute (TUIK) Fishery statistics 2018. Ankara. [Accessed on 14 September 2018] <http://www.tuik.gov.tr>
- Anonymus, (2019). Turkish Statistical Institute (TUIK) Fishery statistics 2018. Ankara. [Accessed on 5 December 2019] <http://www.tuik.gov.tr>
- Bok T.D., Goktürk S.D., Kahraman A.E., Alicli T.Z., Acun T, Ates C. (2011). Length-weight relationships of 34 fish species from the Sea of Marmara, Turkey. *Journal of Animal and Veterinary Advances*. B (23): 3037-3042.

- Ceyhan T., Akyol O., Erdem M. (2009). Length-weight relationships of fishes from Gökova Bay, Turkey (Aegean Sea). *Turkish Journal of Zoology* 33: 69-72.
- Çicek E., Avsar D., Yeldan H., Ozutok M. (2006). Length-weight relationships for 31 teleost fishes caught by bottom trawl net in the Babadil Limani Bight (Northeastern Mediterranean). *Journal of Applied Ichthyology* 22: 290-292.
- Demirel N., Murat-Dalkara E. (2012). Weight-length relationships of 28 fish species in the Sea of Marmara. *Turkish Journal of Zoology* 36: 785-791.
- Froese R., Tsikliras A.C., Stergiou K.I. (2011). Editorial note on weight-length relations of fishes. *Acta Ichthyologica et Piscatoria* 41 (4): 261-263.
- Froese R., Pauly D. (eds.) 2018. FishBase. [Version 06/2018] <http://www.fishbase.org>
- Froese R., Thorso, J.T., Reyes Jr., R.B. (2014). A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology* 30 (1): 78-85.
- Gül, G. and Demirel, N. (2016). Demersal Fishes and Fisheries in the Sea of Marmara *In: The Marmara Sea - Marine Biodiversity, Fisheries, Conservation and Governance*, Özsoy, E., Çağatay, M.N., Balkıs, N., Balkıs, N., & Öztürk, B. (eds.) Turkish Marine Research Foundation Press, İstanbul, pp.612-629, ISBN 978-975-8825-34-9, 2016.
- Gözenç S., Kurter A., Mater K.A, Bilecik N., Adatepe F.M., Uysal A., Orhon S., Kıratlı N., Gümüş E., Demirel S., Yüksek A., Orhon V., Çimen N., Yıldırım V., Dilek M., Kamil Y. and Harun K. (1997). Marmara Denizi'nde ekonomik demersal balıkların stok tayini, The Scientific and Technological Research Council of Turkey (TUBITAK-DEBAG). Final Report, Project No: 13/g.
- Ilkyaz, A.T., G. Metin, O. Soykan and H.T. Kinacıgil. (2008). Length-weight relationship of 62 fish species from the Central Aegean Sea, Turkey. *Journal of Applied Ichthyology* 24: 699-702.
- İşmen A., Ozen O., Altınagac U., Ozekinci U., Ayaz A. (2007). Weight-length relationships of 63 fish species in Saros Bay, Turkey. *Journal of Applied Ichthyology* 23:707-708.
- Kahraman A.E., Yıldız T., Uzer U., Karakulak F.S. (2017). Age composition, growth and mortality of European Hake *Merluccius merluccius* (Linnaeus, 1758) (Actinopterygii: Merlucciidae) from the Sea of Marmara, Turkey. *Acta Zoologica Bulgarica* 69 (3): 377-384.
- Karakulak F.S., Erk H., Bilgin B. (2006). Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *Journal of Applied Ichthyology* 22: 274-278.
- Moutopoulos D.K., Ramfos A., Mouka A., Katselis G. (2013). Length-weight relations of 34 fish species caught by small-scale fishery in Korinthiakos Gulf (Central Greece). *Acta Ichthyologica et Piscatoria* 43 (1): 57-64.
- Ricker W.E. (1975). Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada* 191. 382 pp.
- Santos M.N., Gaspar M.B., Vasconcelos P., Monteiro C.C. (2002). Weight-length relationships for 50 selected fish species of the Algarve coast (southern Portugal). *Fisheries Research* 59 (1-2): 289-295.
- Torcu-Koç H., Üstün F., Erdoğan Z., Artüz L. (2012). Species composition of benthic fish fauna in the Sea of Marmara, Turkey. *Journal of Applied Ichthyology* DOI: 10.1111/j.1439-0426.2012.02037x
- Yazıcı M.F., İşmen A., Altınagac U., Ayaz, A. (2006). A study on the catch composition and bycatch of shrimp beam trawl in the Sea of Marmara. *E.U. Journal of Fisheries & Aquatic Sciences* 23 (3-4): 269-275.