Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 2, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

LENGTH-WEIGHT RELATIONSHIPS AND CONDITION FACTORS FOR THE MAIN COMMERCIAL FISH SPECIES FROM THE ROMANIAN BLACK SEA COAST

Cătălin PĂUN[1], Daniel GRIGORAȘ[1], George ȚIGANOV[1], Mădălina GALAȚCHI[1], Cristian-Sorin DANILOV[1], Carmen Georgeta NICOLAE[2]

[1]National Institute for Marine Research and Development "Grigore Antipa", 300 Mamaia Blvd, Constanta, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: dgrigoras@alpha.rmri.ro

Abstract

Fish length-weight relationships (LWR) are essential for estimating biomass and assessing fish population health. This study examined the LWR and condition factors (K) of seven commercial fish species caught along the Romanian Black Sea coast between March and November 2023. A total of 4,698 individuals were analyzed, with the most abundant species being Engraulis encrasicolus (2,248 individuals) and Atherina boyeri (810 individuals). The LWR parameters varied: the intercept "a" ranged from 0.0034 (Trachurus mediterraneus) to 0.0134 (A. boyeri), and the slope "b" ranged from 2.7 (A. boyeri) to 3.32 (T. mediterraneus). The coefficient of determination (r^2) ranged from 0.72 to 0.957. Growth was isometric for 4 species, negative allometric for 1 species, and positive allometric for 2 species. Condition factors (K) indicated suboptimal health (K < 1) for most species, except Neogobius melanostomus (K = 1.3) and Mullus barbatus (K = 1.09). These results are valuable for future fisheries management and conservation efforts.

Key words*: fish biometrics, Fulton index, growth, LWR, regression.*

INTRODUCTION

This study presents current data on the length-weight relationships for seven fish species caught at the Romanian Black Sea Coast and provides LWR, for the first time, for *Atherina boyeri* in the Romanian Black Sea Coast (GSA 29). Other studies have also been conducted on the length-weight relationship at Romanian Black Sea Coast (Radu et al., 2013; Păun et al., 2019a; Păun et al., 2019b; Păun et al., 2021; Păun et al., 2024), at the Turkey Black Sea Coast (Ak et al., 2009; Bengil & Aydın, 2020; Çalık and Erdoğan Sağlam, 2017; Demirhan & Can, 2007; Gözler & Baytaşoğlu, 2022; Kalaycı et al., 2007; Karadurmuş & Aydın, 2022; Kasapoğlu and Düzgüneş 2013; Onay & Dalgıç, 2021, Özdemir & Duyar, 2013;Türker & Bal, 2018a; Türker & Bal, 2018b; Van et al., 2019), at Bulgarian coast (Yankova et al., 2010; Yankova et al., 2011; Yankova, 2014; Yankova et al., 2020), in the Mediterranean Sea (Sangun et al. 2007;), Marmara Sea (Daban et al., 2020; Keskin & Gaygusuz, 2010), Aegean Sea (Kapiris & Klaoudatos, 2011) and other regions (Kale et al., 2023; İlhan and Sarı, 2015; İnnal & Engin, 2020), but in these studies the samples were obtained from stationary uncovered pound nets and pelagic trawl. The present study provides the LWRs and condition factors for seven commercial species: *Engraulis encrasicolus* (Linnaeus, 1758), *Sprattus sprattus* (Linnaeus, 1758), *Atherina boyeri* (Risso, 1810), *Trachurus mediterraneus* (Steindachner, 1868), *Mullus barbatus* (Linnaeus, 1758), *Neogobius melanostomus* (Pallas, 1814), *Mesogobius batrachocephalus* (Pallas, 1814), collected along the Romanian Black Sea Coast.

The LWR is an important tool in the assessment of fish stocks and populations. It is used to estimate the weight for a given length and reflects the welfare of individual fish (Froese, 2006).

Thus, this study presents updated data of length-weight relationships and body condition factors for seven commercial fish species collected along the Romanian Black Sea Coast.

MATERIALS AND METHODS

The samples were collected on the Romanian Black Sea Coast within fishing periods of March-November 2023. The samples were collected bimonthly from uncovered stationary pound nets along the Romanian coastline starting with the months of April-May when the nets are installed and until October-November when they are removed due to adverse weather. Samples were also collected during pelagic trawl expeditions carried out both in spring (March-April) and in autumn (September-October) with the research vessel Steaua de Mare I within the National Fisheries Data Collection Program (Figures 1 and 2).

Figure 1. Sample collected from uncovered stationary pound nets from Tabara Navodari (original photo)

Figure 2. Sample collected from pelagic trawl (original photo)

Fish specimens were moved to the laboratory and total length, total weight and sex was recorded (Figures 3 and 4). The fish species sampled were: *A. boyeri* (810 individuals), *M. barbatus* (230 individuals), *S. sprattus* (724 individuals), *E. encrasicolus* (2248 individuals), *T. mediterraneus* (540 individuals), *N. melanostomus* (100 individuals), *M. batrachocephalus* (46 individuals).

Based on the sampling locations, a map of the study area was created from which samples were taken, both from uncovered nets and from pelagic trawl (Figure 5).

Figure 3. Measuring total length of individuals from Gobidae family (original photo)

Figure 4. Laboratory analyses from individuals of Gobidae family (original photo)

The length-weight relationship (LWR) was calculated using the formula (Pauly, 1984):

$$W = a\ TL^b \qquad (1)$$

where:
W - the total weight of the fish (g);
TL - the total length of the fish (cm);
a - a constant;
b - the allometric coefficient (Froese, 2006).

The parameters *a* and *b* were calculated by functional regression. The *b* value for each species was tested by t-test at the 0.05 significance level to verify that it was significantly different from isometric growth (Beverton & Holt, 1957; Froese, 2006). It is well known that values of *b* provide information on fish growth; when $b = 3$, the growth is isometric, when the value of *b* is

higher and less than 3, weight is allometric, (positive allometric if $b>3$, negative allometric if $b<3$) (Ricker, 1975). The coefficient of determination (r^2) and the confidence limits (95% CL) were used as indicators of quality for parameters a and b (Froese, 2006; Froese et al., 2011).

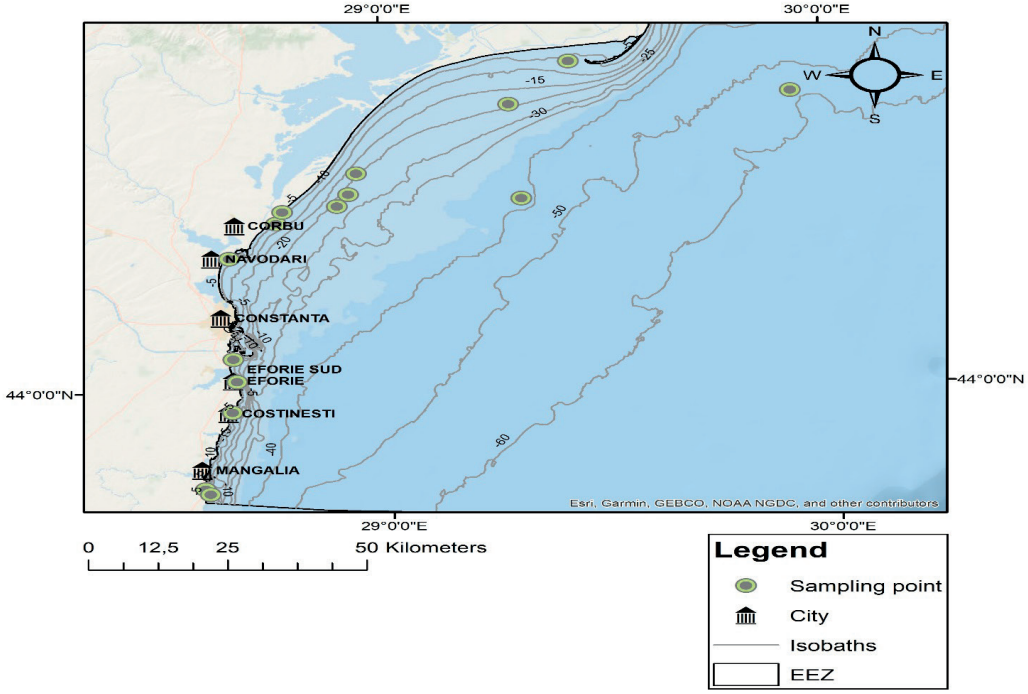

Figure 5. Sampling map (Made by Dragoș Niculescu, NIMRD "Grigore Antipa")

Fulton's condition factor was calculated with the formula:

$$K = (W/L^3) * 100 \quad (2)$$

where: W is the fish body weight, in g, and L is the fish total length, in cm (Froese, 2006).
The statistics were made in R Studio.

RESULTS AND DISCUSSIONS

In the present study, a total of 4,698 individuals belonging to seven different fish species were analysed to estimate the LWR's parameters. Length-weight relationships were presented in Figure 6. The sample size (N), length range, mean length, weight range and mean weight were presented in Table 1. The most specimens sampled were from *E. encrasicolus* species (2248), and the fewest from *M. batrachocephalus* species (46). Total length ranged from 6 cm in *S. sprattus* to 29.3 cm in *M. batrachocephalus*. The total weight ranged from 1.17 g in *E. encrasicolus* to 262 g in *M. batrachocephalus*.

In Table 2, the parameters of the length-weight relationship (a and b), the confidence intervals 95% CI, the coefficient of determination (r^2), the P value for t-test comparing differences for isometric growth, growth type and the Fulton body condition index (K) were estimated. The exponent b values ranged from 2.7006 (in *A. boyeri*) to 3.3256 (in *T. mediterraneus*). The coefficient of determination r^2 varied between 0.72 (in *A. boyeri)* and 0.957 (in *N. melanostomus).* Also r^2 values were >0.90 in four species. Regarding the growth type four species showed isometric (*E. encrasicolus, S. sprattus, M. barbatus*, *M. batrachocephalus*) ($b = 3$, $P > 0.05$), two species showed positive allometric patterns (*T. mediterraneus*, *N. melanostomus*) ($b > 3$, $P < 0.05$) and only one species, *A. boyeri* showed negative allometric pattern ($b < 3$, $P < 0.05$). The lowest value of K

was recorded in *S. sprattus* (0.63), and the higher value 1.3 in *N. melanostomus. M. barbatus and N. melanostomus* showed a good relative condition body (K>1). The b values in the seven species sampled fell within the anticipated range of 2.5 to 3.5 (Carlander, 1977).

In Table 3 comparatives studies in different regions regarding the length-weight relationship for the seven fish species were presented.

In *T. mediterraneus*, *b* value is similar to that one found on the Bulgarian Black Sea coast by Yankova et al. (2010) and Yankova (2014). Also, the value of r^2 is higher than 0.9 on the Bulgarian Black Sea coast and the sizes and weights of the individuals are similar. The growth in *T. mediterraneus* is of positive allometric type in the present work. In contrast, Şahin et al. (2009) found a lower value of *b* (2.9552) on the Turkish Black Sea coast.

The value of the parameter *b* in *M. barbatus* is <3 and is similar to those found by Kalaycı et al. (2007) on the Turkish Black Sea coast and Daban et al. (2020) in the Sea of Marmara, but different from those found by Türker & Bal (2018a), Onay & Dalgıç (2021), Demirhan & Can (2007) and Gözler & Baytaşoğlu (2022), also on the Turkish Black Sea coast (b>3). The value of the coefficient of determination r^2 in *M. barbatus* is >0.9 as in all other studies, except in the study carried out by Daban et al. (2020) in the Sea of Marmara, where r^2<0.9. We observed that the maximum length and weight of red mullet differ in the other studies, being smaller on the Romanian Black Sea coast compared to the Turkish Black Sea coast or the Sea of Marmara.

In *S. sprattus*, the value of the parameter *b* is <3 and is similar to those found by Kasapoğlu and Düzgüneş (2013) and Kalaycı et al. (2007) on the Turkish Black Sea coast but different from those found by Türker & Bal (2018b) on the Turkish Black Sea coast and Daban et al. (2020) in the Sea of Marmara (b>3). The value of the coefficient of determination r^2 in *S. sprattus* is >0.9 as in the studies carried out by Kasapoğlu & Düzgüneş (2013), Türker & Bal (2018b) on the Turkish Black Sea coast but differs from those reported by Keskin & Gaygusuz (2010) in the Sea of Marmara, where r^2<0.8. Also the lengths of individuals in the Sea of Marmara are much smaller than in the other studies carried out in the Black Sea.

The value of the parameter *b* in *E. encrasicolus* is <3 as in the other studies carried out on the Turkish Black Sea coast and in the Mediterranean Sea but differs from the study carried out by Kapiris & Klaoudatos (2011) in the Aegean Sea where the value of *b*>3. The value of the coefficient of determination r^2 in *S. sprattus* is <0.9 as in the study carried out by Kalaycı et al. (2007), but differs from the other studies where r^2>0.9 on the Turkish Black Sea coast, the Aegean Sea and in the Mediterranean Sea. Sangun et al. (2007), in the study carried out in the Northern Mediterranean Sea found higher values of total length and total weight in anchovies than in the other studies.

In the research conducted, we did not find studies regarding the length-weight relationship for *A. boyeri* in the Black Sea, therefore we compared the data with the studies found in other regions.

The value of the parameter *b*<3 and the growth type is negative allometric as in the studies conducted by Kale et al. (2023) in Atikhisar Reservoir, İlhan & Sarı (2015) in Marmara Lake and Innal & Engin (2020) in Demirköprü Dam Lake, but it differs from the study conducted by Keskin & Gaygusuz (2010) in Marmara Sea, where *b*>3 and showed a positive allometric growth. The values of minimum length and minimum weight in the present study are higher than in the other studies conducted.

The value of *b* in *M. batrachocephalus* is <3 as in the studies carried out by Demirhan & Can (2007), Ak et al. (2009) and Çalık & Sağlam (2017) on the Turkish Black Sea coast, but differs from the study by Bengil & Aydın (2020), where *b*>3. The value of the coefficient of determination r^2 in this study is <0.9 and differs from the other studies on the Turkish Black Sea coast where r^2>0.9. The values of the length and total weight of the specimens measured in the present study were higher than in the other studies carried out.

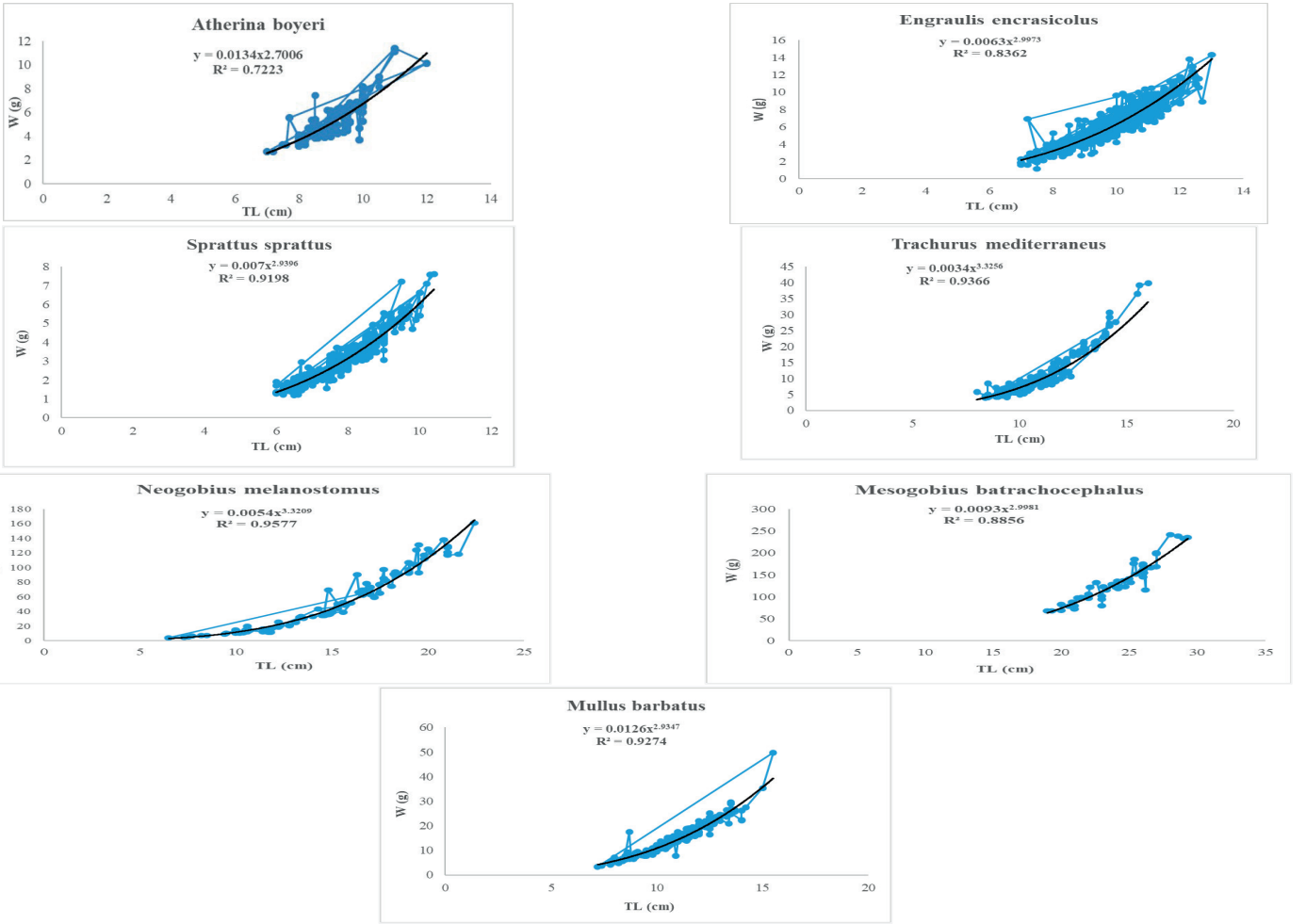

Figure 6. Length-weight relationship's for seven fish species on the Romanian Black Sea Coast (original)

Table 1. Statistical description for the main commercial species on the Romanian Black Sea Coast

Family	Scientific name	N	L range (cm)	L mean ± SD	W range (g)	W mean ± SD
Atherinidae	*Atherina boyeri*	810	7.0-12.0	9.05±0.65	2.68-11.37	5.22±1.27
Carangidae	*Trachurus mediterraneus*	540	8.0-16.0	10.29±1.13	3.89-39.71	8.31±4.40
Engraulidae	*Engraulis encrasicolus*	2248	7.0-13.0	9.91±0.87	1.17-14.31	6.3±1.71
Gobiidae	*Mesogobius batrachocephalus*	46	19.0-29.3	24.11±2.61	68.0-242.0	135.46±47.27
Gobiidae	*Neogobius melanostomus*	100	6.5-22.4	14.97±3.94	3.77-161.0	55.56±40.56
Clupeidae	*Sprattus sprattus*	724	6.0-10.4	7.73±0.86	1.21-7.61	2.96±1.05
Mullidae	*Mullus barbatus*	230	7.2-15.5	10.68±1.65	3.31-49.8	14.16±6.5

Table 2. Length-weight relationships (LWRs) parameters for 7 fish species on the Romania Black Sea Coast

Family	Scientific name	*a*	95% CI of a ± SE	*b*	95% CI of b± SE	r^2	P	GT	K± SD
Atherinidae	*Atherina boyeri*	0.01345	(0.0103 - 0.0174) ± 0.1335	2.7006	(2.5815 - 2.8195) ± 0.0606	0.7223	< 0.05	A–	0.7±0.09
Carangidae	*Trachurus mediterraneus*	0.0034	(0.0027 - 0.0042) ± 0.1176	3.3256	(3.2263 - 3.4248) ± 0.0505	0.9366	< 0.05	A+	0.72±0.09
Engraulidae	*Engraulis encrasicolus*	0.0063	(0.0056 - 0.0071) ± 0.0615	2.9973	(2.9447 - 3.0499) ± 0.0268	0.8362	> 0.05	I	0.63±0.08
Gobiidae	*Mesogobius batrachocephalus*	0.0093	(0.0032 - 0.0268) ± 0.5246	2.9981	(2.6655 - 3.3307) ± 0.165	0.8856	> 0.05	I	0.93±0.11
Gobiidae	*Neogobius melanostomus*	0.0054	(0.004 - 0.0073) ± 0.153	3.3209	(3.2076 - 3.4341) ± 0.057	0.9577	< 0.05	A+	1.3±0.24
Clupeidae	*Sprattus sprattus*	0.007	(0.0061 - 0.0079) ± 0.0672	2.9396	(2.8744 - 3.0047) ± 0.0332	0.9198	> 0.05	I	0.62±0.06
Mullidae	*Mullus barbatus*	0.0126	(0.0100 - 0.0159) ± 0.1178	2.9347	(2.8365 - 3.0329) ± 0.0499	0.9274	> 0.05	I	1.09±0.15

Note: N - sample size; a - value, regression intercept; b - value, regression slope; 95% CI, 95% confidence intervals; r^2, coefficient of determination; P- P value for t-test comparing differences for isometric growth (b = 3); GT - growth type; A+, positive allometry; I, isometric; A–, negative allometry, K - Fulton body condition index.

Table 3. Comparative studies regarding the length-weight relationship for fish species in different zones

Species	L (min.-max.)	W (min.-max.)	n	*a*	*b*	r^2	Zone	References
Trachurus mediterraneus	9.5-18.0	6.47-53.6	2900	0.00678	3.2773	0.9883	Bulgarian Black Sea	Yankova (2014)
	10.5-17.0		1995	0.0035	3.3046	0.9084	Bulgarian Black Sea	Yankova et al. (2010)
	9.2-19.0	7.26-60.81	1312	0.0089	2.9552	0.9441	Turkey Black Sea	Şahin et al. (2009)
	3.0-19.0	0.6-61.2	1200	0.0094	2.9485	0.9492	Romanian Black Sea	Păun et al. (2024)
	11.5 ± 2.1	14.3 ± 8.3	817	0.0063	3.1129	0.8726	Romanian Black Sea	Păun et al. (2021)
	8.0-15.5	9.62-39.45	NA	NA	NA	0.952	Romanian Black Sea	Păun et al. (2019a)
	8.0-16.0	3.89-39.71	540	0.0034	3.3256	0.9366	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 (2018a)
	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	Eastern Black Sea	Demirhan & Can (2007)
	4.3-15.3	0.71-37.73	1118	0.049	3.2945	0.924	Western Black Sea	Gözler & Baytaşoğlu (2022)
	7.2-15.5	3.31-49.8	230(C)	0.0126	2.9347	0.9274	Black Sea	Present study
Sprattus sprattus	5.6-12.6	0.95-12.39	5087(C)	0.0079	2.867	0.88	Middle Black Sea	Kalaycı et al. (2007)
	5.1-11.8	0.95-9.96	655(C)	0.007	3.11	0.98	Western Black Sea	Türker & Bal (2018b)
	5.6-10.7	1.08-8.14	423(C)	0.0064	2.92	0.916	Black Sea	Kasapoğlu & Düzgüneş (2013)
	3.8-5.5		52 (C)	0.023	3.52	0.795	Marmara Sea	Keskin & Gaygusuz (2010)
	6-10.4	1.21-7.61	724(C)	0.007	2.9396	0.9198	Black Sea	Present study
Engraulis encrasicolus	8.0-14.7	2.85-19.14	575(C)	0.0174	2.6014	0.85	Middle Black Sea	Kalaycı et al. (2007)
	7.0-17.0	2.0-34.99	392(C)	0.0156	2.66	0.96	North Mediterranean Sea	Sangun et al. (2007)
	10.5-13.5	7.0-17.0	46(C)	0.000005	3.02	0.93	Aegean Sea	Kapiris & Klaoudatos (2011)
	5.9-14.6	1.06-18.10	1588(C)	0.0124	2.711	0.944	Black Sea	Kasapoğlu & Düzgüneş (2013)
	7.0-13.0	1.17-14.31	2248(C)	0.0063	2.9973	0.8362	Black Sea	Present study

Species	L (min.-max.)	W (min.-max.)	n	*a*	*b*	r^2	Zone	References
Atherina boyeri	2.7-9.5	0.11-5.31	1103(C)	0.0002	2.9212	0.8	Atikhisar Reservoir (Çanakkale)	Kale et al. (2023)
	3.7-8.7	0.4-5.4	101(C)	0.0084	2.908	0.971	Marmara Lake (Manisa)	İlhan & Sarı (2015)
	3.9-13.6	0.4-16.5	41(C)	0.008	2.949	0.99	Demirköprü Dam Lake (Manisa)	Innal & Engin (2020)
	2.5-11.2		606(C)	0.0045	3.215	0.974	Marmara Sea	Keskin & Gaygusuz (2010)
	7.0-12.0	2.68-11.37	810(C)	0.01345	2.7006	0.7223	Black Sea	Present study
Mesogobius batrachocephalus	7.2-13.3		37(C)	0.0203	2.75	0.93	South-eastern Black Sea	Demirhan & Can (2007)
	12.6-31.8	12.62-377.54	470(C)	0.0062	3.13	0.9606	Southern Black Sea	Bengil & Aydın (2020)
	5.5-18.0	1.71-77.0	184(C)	0.024	2.736	0.913	Eastern Black Sea	Ak et al. (2009)
	12.2-23.5	14.0-120.0	35(C)	0.0149	2.7768	0.92	South-Central Black Sea	Çalık & Sağlam (2017)
	19.0-29.3	68.0-242.0	46(C)	0.0093	2.9981	0.8856	Black Sea	Present study
Neogobius melanostomus	8.6-19.1		99(C)	0.0047	3.39	0.95	South-eastern Black Sea	Demirhan & Can (2007)
	9.1-35.0	8.58-381.42	73(C)	0.01	3.033	0.886	Eastern Black Sea	Ak et al. (2009)
	9.0-26.0	8.0-265.0	58(C)	0.0059	3.3062	0.99	South-Central Black Sea	Çalık & Sağlam (2017)
	6.5-22.4	3.77-161.0	100(C)	0.0054	3.3209	0.9577	Black Sea	Present study

Note: n - sample size; F - female; M - male; C - combine(F+M); L (min.-max.) - total length; W (min.-max.) - total weight; n - sample size; *a* - value, regression intercept; *b* - value; r^2 - coefficient of determination.

In *N. melanostomus* both the value of *b*>3 and the coefficient of determination r^2>0.9 are similar to those found in other studies on the Turkish Black Sea Coast, only in the study conducted by Ak et al. (2009), the value of r^2>0.9. The specimens measured in the present study are somewhat smaller than those from the Turkish Black Sea Coast.

LWR parameters (*a* and *b*) can differ due to various factors such as the method of sampling, duration of sampling, preservation techniques, salinity, sex, temperature, seasonal timing, maturity stage, diet, stomach content, sample size, and environmental or seasonal influences (Bagenal & Tesch, 1978; Wootton, 1990; Ricker, 1975). None of these factors have been considered in the present study.

In fisheries, understanding the length-weight relationship is important for setting fishing quotas and ensuring sustainable practices.

CONCLUSIONS

Sprat, anchovy and horse mackerel are highly demanding and invaluable fish species for human consumption in Romanian area.

The biological parameters presented in this study help researchers compare them with those from other similar studies and establish the length-weight relationship for *A. boyeri* for the first time on the Romanian Black Sea Coast.

More studies conducted over a longer period, as well as a larger number of specimens are required to help improve the species length-weight relation.

By comparing LWRs across different species, we can monitor changes in growth patterns, which may reflect environmental factors like food availability, water temperature, and habitat quality.

Deviations from typical LWRs can by signal problems such as overfishing or pollution.

ACKNOWLEDGEMENTS

This research work was funded by the Romanian Ministry of Research, Innovation and Digitization, in the frame of the NUCLEU SMART-BLUE Programme, Project PN23230301 and Project "Services for the realization and implementation of the National Program for Data Collection of the Romanian Fishing Sector", 2024.

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 & Aquatic Sciences*, *9*, 125-126.

Bagenal, T. B., & Tesch, F. W. (1978). Age and growth. In: T. Bagenal (Ed.) *Methods for assessment of fish production in fresh waters, Third Edition* (IBP Handbook No. 3). Oxford, UK: Blackwell Scientific Publication.

Bengil, E. G. T., & Aydın, M. (2020). The length and weight relationships and feeding ecology of knout goby, *Mesogobius batrachocephalus* (Pallas, 1814) from Southern Black Sea. *Ege Journal of Fisheries and Aquatic Sciences*, *37*(4), 409-414. https://doi.org/10.12714/egejfas.37.4.12.

Beverton, R. J. H., & Holt, S. J. (1957). *On the Dynamics of Exploited Fish Populations*. London, UK: Chapman and Hall Publishing House.

Çalık, S., & Sağlam, E.N. (2017). Length-weight relationships of demersal sh species caught by bottom trawl from Eastern Black Sea (Turkey). *Cahiers de Biologie Marine, 58*, 485-490. https://doi.org/10.21411/CBM.A.AA0D91E6

Carlander, K. D. (1977). *Handbook of Freshwater Fishery Biology*. Ames, USA: The Iowa State University Press Publishing House.

Daban, İ. B., İhsanoğlu, A.M., İşmen, A. & İnceoğlu, H. (2020). Length-Weight Relationships of 17 Teleost Fishes in the Marmara Sea. Turkey. *KSÜ Tarım & Doğa Dergisi*, *23*(5), 1245-1256.

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

Froese, R. (2006). Cube law, condition factor and weight–length relationships: History, metaanalysis and recommendations. *Journal of Applied Ichthyology 22*(4), 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

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. https://doi.org/10.3750/AIP2011.41.4.01

Gözler, A. M. & Baytaşoğlu, H. (2022). Length-Weight Relationship for 14 Fish Species from The Western Black Sea, Turkey. *Journal of Anatolian Environmental and Animal Sciences*, *7*(2), 138-144. https://doi.org/10.35229/jaes.1038903

İlhan, A., & Sarı, H.M. (2015). Length-weight relationships of fish species in Marmara Lake, West Anatolia, Turkey. *Croatian Journal of Fisheries*, *73*, 30-32. https://doi.org/10.14798/73.1.784

İnnal, D., & Engin, S. (2020). Length-weight relationships of *Atherina boyeri* Risso, 1810 and *A. hepsetus* Linnaeus, 1758 (Teleostei: Atherinidae) from some inland, brackish water and marine systems of Turkey. *Indian Journal of Geo Marine Sciences*, *49*(6), 1099-1104.

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 & Aquatic Sciences*, *7*, 33-36.

Kale, S., Berber, S., Acarlı, D., & Gürkan, Ş. (2023). First Knowledge on Data Poor Stock: LWR and Condition Factor of a Recently Established Population of *Atherina boyeri* in Atikhisar Reservoir, Türkiye. *Turkish Journal of Fisheries and Aquatic Sciences*, *23*(SI), TRJFAS22503. https://doi.org/10.4194/TRJFAS22503

Kapiris, K., & Klaoudatos, D. (2011). Length-weight relationships for 21 fish species caught in the Argolikos Gulf (central Aegean Sea, eastern Mediterranean). *Turkish Journal of Zoology, 35*(5), 717-723.

Karadurmuş, U. & Aydın, M. (2022). Length–weight relationships of 23 marine fish species from the southern coast of black sea associated with small-scale fisheries. *Thalassas: An International Journal of Marine Sciences, 39*, 111-114. https://doi.org/10.1007/s41208-023-00524-x

Kasapoğlu, N., & Düzgüneş, E. (2013). Length-weight relationships of marine species caught by five gears from the Black Sea. *Mediterranean Marine Science, 15*(1), 95-100.

Keskin, Ç., & Gaygusuz, Ö. (2010). Length-weight relationships of fishes in shallow waters of Erdek Bay (Sea of Marmara, Turkey). *IUFS Journal of Biology, 69*(2), 87-94.

Onay, H., & Dalgıç, G. (2021). Length–weight relationships for fourteen fish species collected by bottom trawl from the Eastern Black Sea coast.Turkey. *Marine Science & Technology Bulletin*, *10*(4), 326-332.

Özdemir, S., & Duyar, H. A. (2013). Length-weight relationships for ten fish species collected by trawl surveys from Black Sea coast, Turkey. *International Journal of Chemical, Environmental Biological Sciences, 1*(2), 405-407.

Păun, C., Galatchi, M., Popescu, A., Vidu, L., Pogurschi, E. & Nicolae, C. G. (2019a). Age at first sexual maturity of *Trachurus Mediterraneus* (Steindachner, 1868) from Romanian Black Sea waters, indicator of good status of the population. *Scientific Papers, Series D. Animal Science*, *LXII*(2), 371-377.

Păun, C., Galatchi, M., Tiganov, G., Danilov, C., Nicolaev, A., Maximov, V., Nita, V. & Nicolae, C.G. (2019b). Growth and age of *Trachurus mediterraneus* (Steindachner, 1868) on the Romanian Black Sea Coast. *Cercetari Marine – Recherches Marines*, *49*(1), 116-124.

Păun, C., Bănaru, D., Țiganov, G., Galațchi, M., Marin, M., Vidu, L., & Nicolae, C. G. (2021). Observation regarding the biology aspects of horse mackerel from romanian coast between 2018-2020, *Scientific Papers, Series D, Animal Science*, *LXIV*(2), 479-485.

Păun C., Țiganov, G., Galațchi, M., Grigoraș, D., Danilov, C.S., Bănaru, D., & Nicolae, C.G. (2024). Spatio-temporal variations of length, total weight and body condition index of the mediterranean horse mackerel from the Romanian Black Sea Area. *Scientific Papers. Series D. Animal Science, LXVII*(2), 614-622.

Pauly, D. (1984). *Fish Population Dynamics in Tropical Water: A Manual for Use with Programmable Calculators,* ICLARM Studies & Reviews, 8. Manila, PH: International Center for Living Aquatic Resources Management Publishing House.

Ricker, W. E. (1975). Computation and interpretation of biological statistics of fish population. *Bulletin of the Fisheries Research Board of Canada, 191*, 1-382.

Sangun, L., Akamca, E., & Akar, M. (2007). Weight-length relationships for 39 fish species from the north-eastern Mediterranean coast of Turkey. *Turkish Journal of Fisheries and Aquatic Sciences, 7*(1), 37-40.

Şahin, C., Kasapoğlu, N., Gözler, A. M., Kalayci, F., Hacimurtazaoğlu, N., & Mutlu, C. (2009). Age, growth, and Gonadosomatic Index (GSI) of Mediterranean Horse Mackerel (*Trachurus mediterraneus* Steindachner, 1868) in the Eastern Black Sea. *Turkish Journal of Zoology*, *33*(2), 157-167. https://doi.org/10.3906/zoo-0805-26.

Türker, D., & Bal, H. (2018a). Length–Weight Relationship and Condition Factor of Red Mullet (Mullus barbatus barbatus Linnaeus, 1758) from the Western Black Sea, Turkey. *Natural and Engineering Sciences*, *3*(2), 120-127. https://doi.org/10.28978/nesciences.424653

Türker, D., & Bal, H. (2018b). Length–weight relationships of 13 fish species from the western Black Sea (Zonguldak-Amasra), Turkey. *Journal of Black Sea/Mediterranean Environment, 24*(2), 115-127.

Van, A., Gümüş, A., & Süer, S. (2019). Length-Weight Relationships and Condition Factors of 15 Fish Species from Kizilirmak Yesilirmak Shelf Area, the Southeastern Black Sea. *Natural and Engineering Sciences*, *4*(1), 21-27. https://doi.org/10.28978/nesciences.522375

Wootton, R. J. (1990). *Ecology of Teleost Fish*. London, UK: Chapman and Hall Publishing House.

Yankova, M., Raykov, V., Gerdzhikov, D., & Bogomilova, P. (2010). Growth and length-weight relationships of the Horse Mackerel, Trachurus mediterraneus ponticus (Aleev, 1956), in the Bulgarian Black Sea Coast. *Turkish. Journal of. Zoology, 34*(1), 85-92.

Yankova, M., Pavlov, D., Raykov, V., Mihneva, V., & Radu, G. (2011). Length-weight relationships of ten fish species from the Bulgarian Black Sea waters. *Turkish Journal of Zoology*, *35*(2), 265-270. doi:10.3906/zoo-0912-44

Yankova, M. (2014). Length-weight relationship of horse mackerel Trachurus mediterraneus Aleev, 1956 from Bulgarian Black Sea coast. *Journal of Black Sea / Mediterranean Environment*, *20*(1), 18-24.

Yankova, M., Raykov, V., Ivanova, P., Djembekova, N., Valcheva, N., Dechev, D., Hristova, D., Trandafilov, P. & Bacheva, S. (2020). Biological monitoring of landings of commercially important species. *Scientific report covering the results over 2017-2019*, Institute of Oceanology, Fridtjov Nansen, Bulgarian Academy of Sciences.