Acta Biologica Turcica, 37(4), S2:1-7, 2024 Received 10 Feb. 2024; Accepted 29 Mar. 2024; Published Online 01 Apr. 2024

ACTA BIOLOGICA TURCICA

E-ISSN: 2458-7893, http://www.actabiologicaturcica.com

Research article

Length-weight relationships of teleost fish species caught in gillnets as non-target in the Southwest Marmara Sea

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Abstract: The mixed species can be caught together in the specific fishing gear at the same time. In the present study, 18 mm mesh size gillnets were used for catching Mediterranean horse mackerel *Trachurus mediterraneus* (Steindachner, 1868) in the Southwest Marmara Sea. Although, *Trachurus mediterraneus* was targeted with these nets, 29 non-target species of teleost fish were caught and evaluated. The length-weight relationships of targeted *Trachurus mediterraneus* and 11 non-target species were calculated because of the number of individuals. A specific species is targeted with fishing gear, but non-target species are caught and population characteristics such as the length-weight relationships of these species are important for fisheries management. The length-weight relationships from non-target species *Alosa immaculata* Bennett, 1835, *Boops boops* (Linnaeus, 1758), *Chromis chromis* (Linnaeus, 1758), *Serranus scriba* (Linnaeus, 1758) and *Pagellus erythrinus* (Linnaeus, 1758) were determined for the first time in the Marmara Sea in the present study. As a result, various fishing pressures, environmental disasters and hydrobiological effects necessitate the continuous investigation and monitoring of population characteristics, such as the length-weight relationships of species living in the Sea of Marmara.

Keywords: Gillnets, Marmara Sea, Fisheries management, Length-weight relationships, Teleost fish

Citing: Şen, Y., Özekinci, U., & Kalemli, C. (2024). Length-weight relationships of teleost fish species caught in gillnets as non-target in the Southwest Marmara Sea. *Acta Biologica Turcica*, 37(4), S2:1-7.

Introduction

Various species have used the Marmara Sea of ecological significance as a living area and migration route (Ozsoy et al., 2016). This sea is affected by various hydrobiological influences from the Aegean Sea and Black Sea (Yümün and Kam, 2021). Therefore, the biodiversity of this sea may change over time. Some previous studies with different fishing gears reported that 34 species were caught with beach seine net (Daban et al., 2023), 39 species with bottom trawl (Demirel & Dalkara, 2012), 73 species with bottom trawl surveys (Daban et al., 2021) in the Marmara Sea. The mixed species can be caught together in the fishing gear and fishing operations (Dolder et al., 2018). The target species are aimed at being generally caught by the fishing gear. But the non-target species are not wanted by fishers, either because they are too small, inedible, have little or no market value, or cannot be retained due to management or quota restrictions (Zeller et al., 2018).

The Mediterranean horse mackerel (*Trachurus mediterraneus*, Steindachner, 1868), belonging to the Carangidae family, is a pelagic and migratory species that is distributed in the Marmara Sea, Black Sea, Mediterranean, and Eastern Central and Atlantic Ocean (Whitehead et al., 1986). *T. mediterraneus* species are generally found near the bottom and sometimes near the surface (Froese and Pauly, 2023). This commercially important species was caught with different gillnet, trawl and purse seine. While this target species is caught, various non-target species and sizes are caught with these fishing gears.

The length-weight relationship (LWR) of species is a frequently used analytical tool in fisheries management (Sinovcic et al., 2004). These relations give us information on species life history and morphological comparison of populations from different and the same regions (Petrakis & Stergiou, 1995). The total length and weight of species may be affected by some effects such as nutrition and competition or environmental conditions and fishing pressure (Tesch, 1971; Weatherley & Gill, 1987; Moutopoulos & Stergiou, 2002). So, there is a need to investigate the length-weight relationships of the living species in the Marmara Sea. Although there have been some studies investigating the length-weight relationships of species living in the Sea of Marmara (Bök et al., 2011; Işmen et al., 2018; Daban et al., 2020; Karadurmuş, 2022), some species haven't been investigated yet. In the present study, the length-weight relationships of non-target species in the gillnets used for mainly caught *T. mediterraneus* in the Marmara Sea were determined and compared with previous studies.

Materials and Methods

A total of 30 fishing operations with the passive fixed method were made to catch *T. mediterraneus* by commercial fishermen using multifilament gillnets with an 18 mm mesh size (bar length) in coastal area at a maximum 10 meters depth. Fish samples were obtained from May 8, 2023 to June 30, 2023 in the Kemer Region, Çanakkale in the Southwest Marmara Sea, Turkiye (Figure 1). The caught species were separated and identified using the identification guides of Whitehead et al. (1986) and Froese & Pauly (2023).

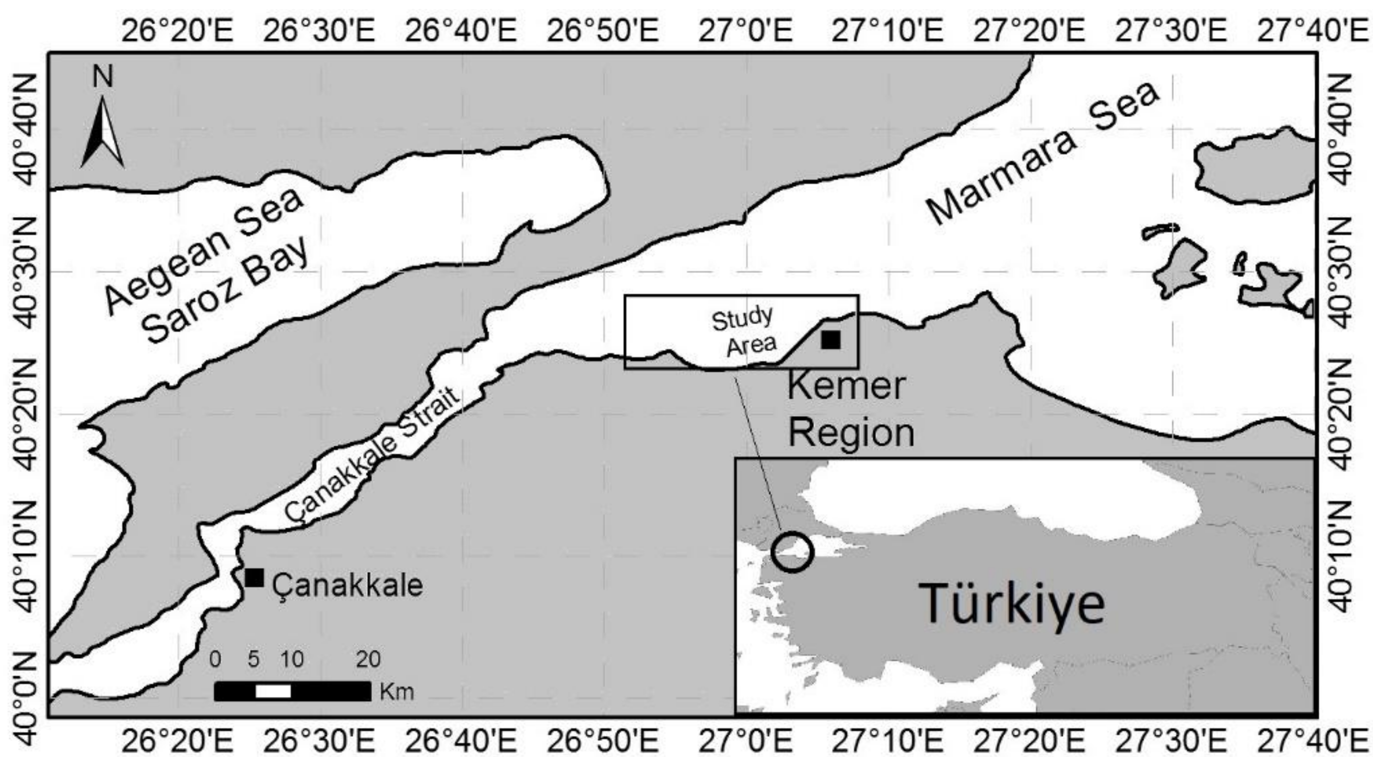

Figure 1. Study area.

The total length of these species was performed to the nearest 0.01 centimeters (cm) using a measuring board. The total weight was recorded to the nearest 0.01 gram (g) using a digital scale. The total length-weight relationships of species were estimated by using the equation: $TW = a * TL^b$ was converted into its logarithmic expression: $\ln TW = \ln a + b \ln TL$, where TW: Total weight (g); TL: Total length (cm); a: Intercept and b: Regression coefficient. The parameters a and b were calculated by least-squares regression, as was the coefficient of determination (R^2) (Ricker, 1975). The 95% confidence interval (CI) was determined for parameters a and b (Froese, 2006). Subsamples of higher individuals were taken for LWR calculations. Also, these species with a small sample size (<14) were not taken into account to LWR calculation.

Results

In the present study, the length-weight relationships of the target species *T. mediterraneus* and higher individuals of 11 non-target species were calculated. These species of LWRs in the Sea of Marmara and comparative results with previous studies in this sea are presented in Table 1. While R^2 values were generally detected to be higher for *B. boops* (0.96), *A. immaculata* (0.76), *C. chromis* (0.80), *D. annularis* (0.82), *P. erythrinus* (0.76), *S. scriba* (0.88), *S. porcus* (0.91), *S. maena* and *T. mediterraneus* (0.75), *S. roissali* (0.89) and *S. tinca* (0.79), the smallest R^2 value (0.50) was determined for *O. barbatum*. While the value of "a" from LWR parameters varied between 0.014 for *A. immaculata* and 0.8058 for *C. chromis,* the exponent "b" from LWR parameters ranged between 1.3392 for *C. chromis* and 3.0662 for *B. boops* (Table 1).

The total length and total weight of the other 18 non-target species were measured. The LWRs of these species were not calculated, because the number of individuals was less than 14 individuals. The total length and total weight of these species are given in Table 2. The largest total length among the total species was determined to be *T. draco*, while the smallest total length was identified as *C. chromis*. In terms of total weight, the largest species was *T. draco,* the smallest species belongs to *M. hispidus.* The largest and lowest mean total length among the total species were determined to be *P. saltatrix* and *M. hispidus* respectively, while the target species of *T. mediterraneus* mean total length was detected at 17.39±0.21 cm. In terms of mean total weight, the largest and lowest species belong to *T. draco* and *E. encrasicolus,* while the target species of *T. mediterraneus* mean total length was detected at 49.81±1.70 gr (Table 1; Table 2).

Discussion

Fishing gear is capable of catching specific species and sizes of fish from a mixed population (Fridman, 1986). Also, the number of species and their length and weight caught in the fishing nets were associated with body shape and length distribution (Millner, 1985; Hovgård & Lassen, 2000). In the present study, only gillnets with mesh size of 18 mm were used with the passive fixed method to catch the target species *T. mediterraneus* in the fishing operations. Although, *T. mediterraneus* was targeted, 29 non-target species were evaluated with these nets. So, it has been determined that these caught species have specific total length and weight. The fact that the target species *T. mediterraneus* caught at larger total length and weight compared to previous studies can be explained by the technical characteristics of these gillnets. Also, it is considered that these length and weight variations were affected by the body shape of these species.

Since the number of individuals was low, the LWRs of only 11 species were estimated. In natural fish populations, the expected "a" value ranged between 0.001 and 0.050 (Froese, 2006). The "a" value was determined to be > 0.05 for *C. chromis, D. annularis, O. barbatum, S. tinca, T. mediterraneus* in the present study. This can show the relatively high body height of these species. Froese (2006) reported that the estimates of the "b" value ranged from 2.5 to 3.5, which are within the limits for most fish species. But, the b value was determined to be < 2.0 for *C. chromis* and *O. barbatum*, while confidence intervals of b value were expected range.

Table 1. Parameters of total length, total weight and length-weight relationship of species present and previous studies in Sea of Marmara (N: Number of individuals, SE: Standard error, Min: Minimum, Max: Maximum, CL: Confidence interval).

Species	N	Total Length (cm)	Total Weight (gr)	Relationship			95% CL (range)		References
		Mean±SE (Min-Max)	Mean±SE (Min-Max)	a	b	R^2	a	b	
Alosa immaculata Bennett, 1835	127	19.16±0.08 (17.4-23)	53.62±0.80 (38.59-95.26)	0.014	2.7902	0.76	0.006-0.032	2.509-3.071	This study
Boops boops (Linnaeus, 1758)	51	19.17±0.37 (15.4-25.8)	84.66±5.29 (37.12-186.61)	0.0093	3.0662	0.96	0.005-0.016	2.888-3.244	This study
Chromis chromis (Linnaeus, 1758)	14	10.46±0.28 (9.2-13.7)	18.75±0.69 (14.58-24.57)	0.8058	1.3392	0.80	0.092-0.224	1.906-2.772	This study
Diplodus annularis (Linnaeus, 1758)	29	12.31±0.33 (10.3-18.7)	32.29±2.10 (18.11-56.31)	0.0925	2.3172	0.82	0.031-0.277	1.881-2.753	This study
	7	(3.6-16.9)	-	0.0134	3.1104	0.99	-	-	Keskin & Gaygusuz (2010)
	15	(7-16.7)	(6.8-94.38)	0.022	2.957	0.99	-	2.868-3.066	Bök et al. (2011)
	81	13.4±1.5 (10.0-16.7)	-	0.004	3.432	0.74	-	-	Demirel & Dalkara (2012)
Ophidion barbatum Linnaeus, 1758	18	20.09±0.75 (18-21.5)	46.90±4.03 (42.31-58)	0.2979	1.685	0.50	0.020-0.42	1.786-2.584	This study
	15	(7.3-17.1)	-	0.0029	3.24	0.98	-	-	Ozen et al. (2009)
Pagellus erythrinus (Linnaeus, 1758)	32	14.71±0.14 (13.4-17.3)	43.08±1.44 (34.05-67.03)	0.0247	2.7718	0.76	0.005-0.119	2.187-3.357	This study
Serranus scriba (Linnaeus, 1758)	104	14.6±0.10 (12.7-19)	43.42±1.06 (29.67-96.7)	0.0167	2.9273	0.88	0.009-0.029	2.719-3.136	This study
Scorpaena porcus Linnaeus, 1758	93	11.02±0.16 (8.5-19.9)	27.49±1.86 (11.34-165.01)	0.0254	2.8807	0.91	0.016-0.040	2.692-3.07	This study
	45	(4.9-19.0)	-	0.0158	3.088	0.98	-	-	Keskin & Gaygusuz (2010)
	15	(17.3-21.4)	(84.02-186.02)	0.0067	3.3343	0.94	-	2.525-4.161	Bök et al. (2011)
	93	13.91 (3.55-26.4)	72.84 (6.12-374.58)	0.03	2.818	0.94	0.020-0.044	2.669-2.967	Karadurmuş (2022)
Spicara maena (Linnaeus, 1758)	571	13.93±0.72 (10.3-16.7)	28.24± 4.68 (10.41-53.59)	0.0249	2.7167	0.75	0.019-0.035	2.589-2.844	This study
	175	14.3±1.4 (10.4-18)	-	0.010	3.025	0.85	-	-	Demirel & Dalkara (2012)
	155	13.8±0.1 (8.4-18.1)	35.1±0.94 (5.4-82.3)	0.003	3.320	0.91	-	-	Saygılı et al. (2016)
	76	13.03±0.2 (8.4-18.1)	28.08±1.52 (5.39-82.35)	0.0042	28.383	0.97	-	-	Daban et al. (2020)
Symphodus roissali (Risso, 1810)	56	11.82±0.12 (10.3-15.4)	26.01±0.93 (15.68-56.54)	0.0264	2.783	0.89	0.014-0.050	2.522-3.044	This study
	22	(2.4-14.1)	-	0.0069	3.386	0.99	-	-	Keskin & Gaygusuz (2010)
Symphodus tinca (Linnaeus, 1758)	36	13.54±0.73 (10.3-16.15)	23.27±0.95 (10.7-33.56)	0.1081	2.2002	0.79	0.040-0.289	1.801-2.599	This study
	41	(2.1-15.5)	-	0.0111	3.098	0.99	-	-	Keskin & Gaygusuz (2010)
Trachurus mediterraneus (Steindachner, 1868)	58	17.39±0.21 (13.2-20.8)	49.81±1.70 (25.12-78.5)	0.0557	2.3712	0.75	0.009-0.041	2.477-3.005	This study
	30	14.01±1.6 (11.5-15.4)	25.8±1 (12.9-37.1)	0.006	3.337	0.88	-	-	Kara & Akyol (2003)
	30	13.44±0.7 (12.7-14.1)	23±0.3 (19.2-25.6)	0.0038	1.816	0.61	-	-	Kara & Akyol (2003)
	17	14.7±1.2 (13.9-15.5)	31.3±0.8 (26.1-36.5)	0.0001	2.505	0.82	-	-	Kara & Akyol (2003)
	30	12.12±1.5 (10.3-14.2)	15±0.5 (8.7-23.3)	9E-05	2.562	0.85	-	-	Kara & Akyol (2003)
	158	12.32±0.12 (7.9-16.5)	19.30±0.56 (4.10-45.93)	0.0115	2.9367	0.99	-	-	Bostancı (2009)
	496	13.4±1.9 (7.5-18.5)	-	0.018	2.727	0.84	-	-	Demirel & Dalkara (2012)
	1232	9.5-17.5	5.67-44.0	0.044	2.4706	0.94	-	-	Torcu & Erdoğan (2019)
	717	10.42±0.051 (6.2-16.6)	9.07±0.15 (2.91-25.9)	0.007	3.0515	0.91	-	-	Daban et al. (2020)

Table 2. The total length and total weight of other 18 non-target species in the present study (N: Number of individuals, SE: Standard error, Min: Minimum, Max: Maximum).

Species	N	Total Length (cm)	Total Weight (gr)
		Mean±SE (Min-Max)	Mean±SE (Min-Max)
Chelidonichthys lucerna (Linnaeus, 1758)	2	14.75±0.18 (14.5-15)	28.56±1.53 (26.39-30.73)
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	4	13.8±1.08 (11.7-17.4)	36.01±3.88 (27.02-48.42)
Engraulis encrasicolus (Linnaeus, 1758)	5	12.28±0.51 (11.3-14.4)	11.35±2.10 (7.18-20.43)
Gaidropsarus mediterraneus (Linnaeus, 1758)	5	20.5±0.33 (19.5-20.3)	61.41±2.16 (55.74-67.82)
Gaidropsarus vulgaris (Cloquet, 1824)	1	19.3	55.52
Gobius niger Linnaeus, 1758	3	14.83±0.07 (14.7-15)	41.46±1.22 (38.48-43.11)
Lithognathus mormyrus (Linnaeus, 1758)	3	13.03±0.31 (12.6-13.8)	27.26±0.54 (26.05-28.31)
Merlangius merlangus (Linnaeus, 1758)	5	14.42±0.74 (11.8-16.3)	29.07±3.35 (19.11-38.11)
Merluccius merluccius (Linnaeus, 1758)	1	16.9	30.12
Monochirus hispidus Rafinesque, 1814	2	9.55±0.03 (9.5-9.6)	14.57±0.01 (14.56-14.58)
Mullus surmuletus Linnaeus, 1758	7	15.9±0.34 (14.1-17)	43.90±2.92 (28.12-55.42)
Pagellus acerna (Risso, 1827)	3	14.1±0.19 (13.7-14.5)	36.9±1.37 (34.48-40.12)
Pomatomus saltatrix (Linnaeus, 1766)	9	23.43±0.27 (21.6-24.6)	109.22±2.06 (95-120)
Spicara smaris (Linnaeus, 1758)	5	13.46±0.47 (12.7-15.5)	28.07±3.03 (20.69-38.12)
Symphodus mediterraneus (Linnaeus, 1758)	6	11.85±0.35 (10.4-13.2)	29.29±2.79 (17.25-39.35)
Symphodus melops (Linnaeus, 1758)	1	10.6	21.04
Symphodus ocellatus (Linnaeus, 1758)	8	10.86±0.31 (9.3-12.4)	22.41±1.04 (18.76-28.29)
Trachinus draco Linnaeus, 1758	7	22.91±2.54 (15-34)	115.89±35.78 (26.68-292.07)

While R^2 values of species were generally found to be relatively low correlation in the current study from the previous studies. The smallest R^2 value (0.50) was determined for *O. barbatum*. The a, b and R^2 values differences from previous studies of these species may be effect of sampling methods, seasons, sizes and length ranges. In addition to these, it has been reported in the literature that areas, sex, food availability, environmental conditions and fish condition factor also affect length-weight relationships (Tesch, 1971; Weatherley & Gill, 1987; Moutopoulos & Stergiou, 2002).

Even though a specific species is targeted with fishing gear, non-target species are caught and population characteristics such as the length-weight relationships of these species are important for fisheries management. As a result, the length-weight relationships of *A. immaculata*, *B. boops*, *C. chromis*, *S. scriba* and *P. erythrinus* were determined for the first time in the Marmara Sea in the present study. This sea is an inland sea that experiences various biological events like mucilage formation, which can negatively impact populations of species, leading to mass mortality (Savun-Hekimoğlu & Gazioğlu, 2021; Karadurmuş & Sarı, 2022; Daban et al., 2023). Also, this sea is affected by various hydrobiological influences. These effects may have an impact on the length and weight values of species. Additionally, fish species have dense fishing pressure in the Marmara Sea (Daban et al., 2020; Karadurmuş, 2022). So, the population structures of species living in the Marmara Sea should be monitored. We hope that these findings will contribution to the investigations of researchers.

Acknowledgements

The authors grateful to captain Ahmet ŞEN of #Yusuf Kaptan 17# fishing boat for providing supports the fishing operations.

Ethical Approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Funding Statement

This study was supported by TUBITAK 2209-A University Students Research Projects with application number 1919B012300624.

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