Opercular girth, maximum girth and total length relationships for eight fish species from the Saros Bay (northern Aegean Sea, Turkey)

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ABSTRACT

This study was carried out to uncover the relationship between opercular girth (G_{ope}), maximum girth (G_{max}) and total length (TL) for eight fish species [(*Sardina pilchardus* (Walbaum, 1792), *Sardinella aurita* (Valenciennes, 1847), *Serranus cabrilla* (Linnaeus, 1758), *Serranus scriba* (Linnaeus, 1758), *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus tinca* (Linnaeus, 1758), *Trachurus mediterraneus* (Steindachner, 1868), and *Trachurus trachurus* (Linnaeus, 1758)] from four families (Carangidae, Clupeidae, Labridae, and Serranidae) sampled between August 2016 and December 2017 in Saros Bay (Northern Aegean Sea, Turkey). G_{ope} and G_{max} were found to increase linearly with the total length for all the species. All r^2 values were statistically significant ($r^2 > 0.83$, $P < 0.001$). The values about length-girth relationships (LGRs) of *S. mediterraneus* were estimated for the first time worldwide. This information will contribute to the development of ecosystem-based fisheries management.

Keywords: biometric relationship, fisheries management, fish morphlogy

INTRODUCTION

Fisheries management often requires the use of biometric parameters in order to transform data collected in the field into appropriate indices (Ecoutin and Albaret 2003). Biometric parameters are of utmost importance not only to fill up the gap of our present-day academic knowledge but also to increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious pisciculture management (Swain and Foote 1999). Fish morphology is inseparably related to the study of the mode of life. The analysis of size and shape variations becomes fundamental to highlights variability in living organisms (Turan et al. 2004). In this connection, the morphometric measurements have been used to identify fish stocks and remain the simplest and most direct way among methods of species identification (Turan et al.

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2004). In addition, the studies on differences and variability in morphometric relationships of fish stocks are significant in phylogenetics as they provide information for subsequent studies onthe genetic improvement of stocks (Umaru et al. 2015). The morphometric relationships between length and girth could be quite useful (Mendes et al. 2006). Length-girth relationships (LGRs) are an important component for (a) biological (e.g. condition and swimming capability) (Wootton 1998); (b) ecological (e.g. predator-prey relationships, trophic level estimation) (Stergiou and Karpouzi 2003); and (c) fisheries assessments (e.g. quantifying the catching efficiency of fishing gear) (Kyritsi et al. 2018). Moreover, the species-specific LGRs allow the computation of girth from length measurements, the latter of which is easier and less expensive to be obtained (Moutopoulos et al. 2017).

The published data on LGRs for fish species are scarce (Mendes et al. 2006) and studies on LGRs of fish species in the Aegean Sea have only been carried out in southern (Stergiou and Karpouzi 2003; Aydın and Düzgüneş 2007) and central (Beğburs et al. 2020) regions, up to the present. In this context, the present study provided preliminary information on LGRs of eight fish species for the Northern Aegean Sea. The following species were studied: *Sardina pilchardus* (Walbaum, 1792), *Sardinella aurita* (Valenciennes, 1847), *Serranus cabrilla* (Linnaeus, 1758), *Serranus scriba* (Linnaeus, 1758), *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus tinca* (Linnaeus, 1758), *Trachurus mediterraneus* (Steindachner, 1868), and *Trachurus trachurus* (Linnaeus, 1758). At present, there are no available data on LGRs estimates for *S. mediterraneus* worldwide. Hence, the reported results will be useful for developing ecosystem-based fisheries management.

METHODS

The northern Aegean areas are characterized by an extended continental shelf, smooth muddy/sandy bottoms and higher nutrient concentrations (Maravelias and Papaconstantinou 2006). The area is known for having higher phytoplankton and zooplankton abundance compared with the southern Aegean Sea (Theocharis et al. 1999). The northern Aegean coasts of Turkey are divided into sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökçeada and Bozcaada Islands and the Edremit Bay (Cengiz and Paruğ 2020) (Figure 1). The length of Saros Bay is about 61 km and the width at the opening to the Aegean Sea is about 36 km (Eronat and Sayın 2014). As the bay had been closed to bottom trawl fishing since 2000 (Cengiz et al. 2014) and no industrial activity was prevalent in the area (Sarı and Çağatay 2001), it can be considered as a pristine environment (Cengiz et al. 2015). Therefore, Saros Bay and its coastal area were declared as Special Environmental Protection Area (SEPA) due to its landscape, geomorphological, ecological, floristic biogenetic and touristic properties (Güçlüsoy 2015).

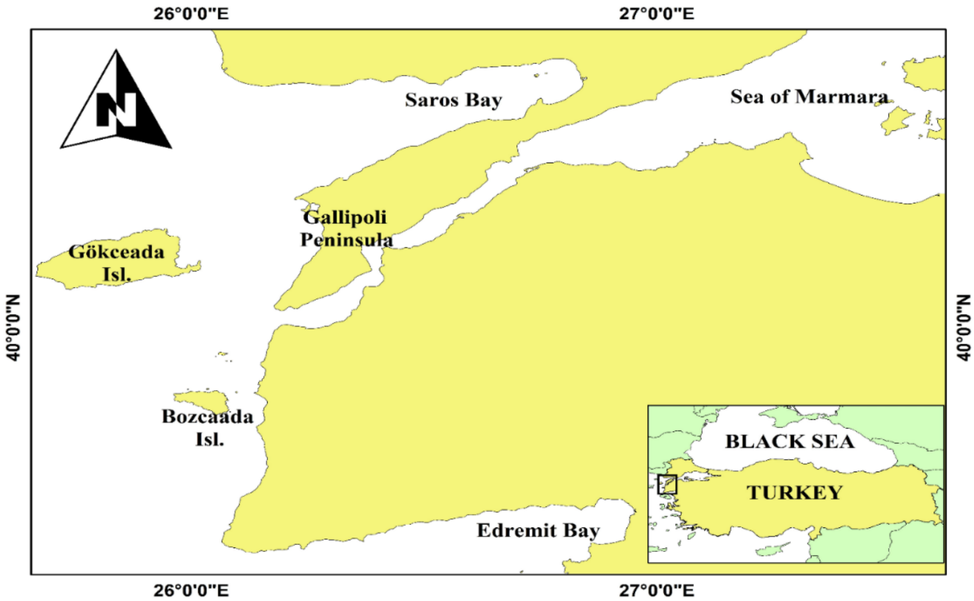

Figure 1. Saros Bay and the northern Aegean coasts of Turkey.

Samples were obtained, monthly, between August 2016 and December 2017 in stratified random sampling, from catches of commercial fisheries around Saros Bay. Most of these were stationary set and drive in fishing methods with gillnets which have 20, 22, 23, 25 mm mesh sizes, net height of 105 meshes and 210d/3 twine thickness. The total length and the body girth measurements were taken to the nearest centimeter using a tape measure: (1) behind the gill-cover (G_{ope}) and (2) in front of the first dorsal fin (G_{max}). Relationships between fish total length (TL) and opercular or maximum girth (y) were estimated by linear regression analysis: y = a+bTL, where the intersect (a) and slope (b) were found by least-squares estimation (Neter et al. 1988). The correlation coefficient (r^2) was used to evaluate the strength of this linear relationship.

RESULTS

Overall, 786 individuals were sampled, belonging to the eight fish species (*Sardina pilchardus, Sardinella aurita, Serranus cabrilla, Serranus scriba, Symphodus mediterraneus, Symphodus tinca, Trachurus mediterraneus,* and *Trachurus trachurus*) from four families (Carangidae, Clupeidae, Labridae, and Serranidae). The relationships of G_{ope} and G_{max} with

TL for the eight fish species are summarised in Table 1 and Table 2, respectively. For all species, both opercular and maximum girth were generally linearly related to body length. For the relationship between opercular girth and the total length, the slope (*b*) is lowest for *Trachurus mediterraneus* and highest for *Symphodus tinca* representing a greater increase in girth with the length for the latter species. The correlation coefficient (r^2) shows a range of 0.85-0.95, with the lowest value obtained for *Sardina pilchardus* and the highest for *Sardinella aurita* and *Serranus cabrilla*. For the relationship between maximum girth and total length, the slope (*b*), is lowest for *Trachurus trachurus* and highest for *Serranus scriba*, representing a greater increase in girth with the length for the latter species. The correlation coefficient (r^2) indicates a range of 0.83-0.95 with the lowest value obtained for *Sardina pilchardus* and the highest value for *Serranus cabrilla*. All linear regressions were statistically significant ($P < 0.001$). These relationships pointed out that opercular and maximum girth increased faster with the length for all species.

DISCUSSION

The length-girth relationships for the eight fish species have been estimated for the first time in the Northern Aegean Sea. In addition, no LGRs estimates existed for *S. mediterraneus* worldwide with the exception of the present study. Both the opercular girth-total length and maximum girth-total length relationships reported herein were found to be linear. Due to the size-selective characteristics of the fishing gear used (e.g. Mendes et al. 2006; Santos et al. 2006; Jawad et al. 2009), the samples were based on a restrictive range of lengths. Small-sized individuals and immature stages of these species were absent from the samples. Thus, the use of these relationships should be strictly limited to the size ranges used in the estimation of the linear regression parameters. Table 3 and Table 4 reveal the findings of the opercular girth-total length and maximum girth-total length relationships of these fish species between the present study and other studies, respectively. The differences in LGRs may be attributed to biological (e.g. sex, food availability) and/or abiotic (e.g. water temperature) factors (Wootton 1998) together with different variations in the size range. Concordantly, the spawning/reproduction frequency and gonad activity/development could give rise to cause seasonal variations in the LGRs (Santos et al. 2006; Kyritsi et al. 2018). The possible reasons for differences in the results involved between other studies and the present study may be related to one or more factors given above. Fish body girth could be estimated by way of three procedures: (1) body perimeter around the eye (G_{eye}), (2) behind the gill-cover (G_{ope}) and (3) in front of the

Table 1. Relationship between opercular girth and total length for eight fish species from Northern Aegean Sea (Turkey). *N*: sample size, min: minimum, max: maximum, *TL*: total length (cm), G_{ope}: opercular girth (cm), r^2 = the coefficient of determination, *SE* = standard error, *a* = intersect, *b* = slope.

Family/Species	N	Mean TL ± SE (min-max)	Mean G_{ope} ± SE (min-max)	Lenght - Opercular Girth equation	r^2	SE of *a*	SE of *b*
Carangidae							
Trachurus mediterraneus	296	15.1 ± 0.14 (13.0 – 27.1)	6.6 ± 0.07 (5.4 – 12.6)	G_{ope} = -0.3053 + 0.462TL	0.93	0.2040	0.0302
Trachurus trachurus	64	14.5 ± 0.17 (13.0 – 19.0)	6.8 ± 0.09 (5.8 – 8.6)	G_{ope} = -0.0372 + 0.4674TL	0.88	0.6041	0.0890
Clupeidae							
Sardina pilchardus	146	13.0 ± 0.08 (11.0 - 16,1)	4.8 ± 0.05 (3.5 – 6.5)	G_{ope} = -2.2056 + 0.539TL	0.85	0.2676	0.0556
Sardinella aurita	126	20.2 ± 0.52 (16.4 – 24.6)	7.9 + 0.29 (6.1 – 10.4)	G_{ope} = -3.1133 + 0.5455TL	0.95	0.6610	0.0824
Labridae							
Symphodus mediterraneus	31	12.1 ± 0.26 (9.9 – 13.8)	7.0 ± 0.16 (5.8 – 8.3)	G_{ope} = 0.0928 + 0.5696TL	0.85	1.0191	0.1454
Symphodus tinca	32	13.3 ± 0.58 (10.9 – 17.1)	8.1 ± 0.48 (5.8 – 10.6)	G_{ope} = -2.4288 + 0.787TL	0.94	0.8113	0.0988
Serranidae							
Serranus cabrilla	49	14.6 ± 0.51 (11.9 – 23.5)	7.8 ± 0.32 (6.2 – 13.5)	G_{ope} = -1.245 + 0.6177TL	0.95	0.5296	0.0665
Serranus scriba	42	15.7 ± 0.42 (12.1 – 22.6)	9.2 ± 0.27 (7.1 – 14.1)	G_{ope} = -0.6448 + 0.625TL	0.92	0.7305	0.0784

Table 2. Relationship between maximum girth and total length for eight fish species from Northern Aegean Sea (Turkey). *N*: sample size, min: minimum, max: maximum, *TL*: total length (cm), G_{max}: maximum girth (cm), r^2 = the coefficient of determination, *SE* = standard error, *a* = intersect, *b* = slope.

Family/Species	N	Mean TL ± SE (min-max)	Mean G_{max} ± SE (min-max)	Lenght - Maximum Girth equation	r^2	SE of *a*	SE of *b*
Carangidae							
Trachurus mediterraneus	296	15.1 ± 0.14 (13.0 – 27.1)	7.3 ± 0.08 (5.7 – 13.5)	G_{max} = -0.701 + 0.5312TL	0.92	0.2110	0.0284
Trachurus trachurus	64	14.5 ± 0.17 (13.0 – 19.0)	7.3 ± 0.09 (6.4 – 9.2)	G_{max} = 0.0008 + 0.5025TL	0.90	0.5537	0.0755
Clupeidae							
Sardina pilchardus	146	13.0 ± 0.08 (11.0 – 16.1)	5.9 ± 0.05 (4.7 – 7.6)	G_{max} = -1.2212 + 0.5492TL	0.83	0.3722	0.0628
Sardinella aurita	126	20.2 ± 0.52 (16.4 – 24.6)	9.3 ± 0.38 (7.1 – 12.9)	G_{max} = -4.8748 + 0.7036TL	0.90	0.8118	0.0853
Labridae							
Symphodus mediterraneus	31	12.1 ± 0.26 (9.9 – 13.8)	8.4 ± 0.16 (7.6 – 9.6)	G_{max} = 1.3316 + 0.5849TL	0.86	1.1558	0.1371
Symphodus tinca	32	13.3 ± 0.58 (10.9 – 17.1)	9.6 ± 0.38 (7.7 – 11.9)	G_{max} = 1.3559 + 0.6185TL	0.89	1.5457	0.1596
Serranidae							
Serranus cabrilla	49	14.6 ± 0.51 (11.9 – 23.5)	8.7 ± 0.38 (7.0 – 16.3)	G_{max} = -1.8132 + 0.7222TL	0.95	0.5460	0.0609
Serranus scriba	42	15.7 ± 0.42 (12.1 – 22.6)	10.4 ± 0.33 (8.0 – 16.8)	G_{max} = -1.6634 + 0.764TL	0.92	0.6740	0.0640

first dorsal fin (G_{max}). In this study, there was a linear relationship between the increasing opercular girth (G_{ope}), maximum girth (G_{max}) and total length (TL), which is in agreement with the results of Stergiou and Karpouzi (2003), Mendes et al. (2006), Jawad et al. (2009, 2015), Daliri et al. (2012), and Moutopoulos et al. (2017).

In general, fish retention by fishing gear is primarily related to girth rather than to length (Jawad et al. 2009). The different girth types calculate the probability of different ways of capture by fishing gear, assessed by G_{eye} when fish are tangled (i.e. held in the gear by teeth, maxillaries, or other projections), by G_{ope} when fish are gilled (i.e. being prevented from backing out of the gear by a mesh caught behind the gill-cover), and by G_{max} when fish are wedged (i.e. being held tightly by a mesh around the body) (Reis and Pawson 1999). Concerning this, the maximum girth is generally used to describe cod-end mesh retention, whereas in gillnets, opercular and maximum girths are the two parameters related to the methods of the capture of gilled and wedged fish, respectively (McCombie and Berst 1969). Baranov (1948) has made the first study that the fish morphology strongly influences the retention by fishing gear. The probability of a fish being retained by a given mesh is primarily determined by the relationship between the body shape and the mesh opening. Thereby, the girth has been considered as a significant parameter in understanding the gear selection process (Reis and Pawson 1999). In addition to this information, the data on girth have been used to define selection patterns during indirect selectivity experiments with gillnets (Kurkilahti et al. 2002). Similarly, length-girth relationships have been one of the critical parameters in cod-end selectivity studies to understand the selection pattern of species that differ in behavioural and morphological characteristics (Tokai and Omoto 1994). As stated above, the gillnet selectivity could be calculated by using the girth than length. This approach has been uncovered so as to predict selectivity curves of gillnet by Sechin (1969) and Kawamura (1972). Both selectivity models estimates the probabilities of fish retention as a function of morphometric features of the body between the operculum (G_{ope}) and the maximum girth of the fish (G_{max}).

In conclusion, the given length-girth values in the present study and previous ones could be used in the experimental design for selectivity surveys, particularly for gillnets where decisions on the suitable mesh size ranges need to be taken. In addition, these values are of great significance, owing to the fact that they determine fish growth patterns, which in turn are necessary for the development of ecosystem-based fisheries management. Because, the ecosystem-based fisheries management is a holistic method of managing fisheries and entire marine resources by keeping in view all ecosystem of the species being managed. Herewith, these data will help fisheries management authorities worldwide.

Table 3. Comparison of opercular girth-total length relationships of eight fish species between the present study and other studies. *N*: sample size, min: minimum, max: maximum, *TL*: total length (cm), *FL*: fork length (cm), G_{ope}: opercular girth (cm), r^2 = the coefficient of determination, *SE* = standard error, *a* = intersect, *b* =slope, * *FL*: fork length. [1] first *TL*-G_{ope} relationship reference for Northern Aegean Sea. [2] first *TL*-G_{ope} relationship reference for the species worldwide.

Fish species	References	Location	N	TL_{min} - TL_{max}	Length - Opercular Girth equation	r^2	SE of *a*	SE of *b*
Serranus cabrilla[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	49	16.3 – 25.5	G_{ope} = -2.126 + 0.653TL	0.89	-	0.0320
	Santos et al. (2006)	Algarve coast (southern Portugal)	68	18.4 – 24.8	G_{ope} = -1.3469 + 0.5664TL	0.95	0.3411	0.0164
	Aydın & Düzgüneş (2007)	Bodrum Peninsula (southern Aegean Sea, Turkey)	263	13.4 – 19.8	G_{ope} = 1.2393 + 0.3982TL	0.83	-	-
	This study	Saros Bay (northern Agean Sea, Turkey)	49	11.9 – 23.5	G_{ope} = -1.245 + 0.6177TL	0.95	0.5296	0.0665
Serranus scriba[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	105	13.0 – 24.1	G_{ope} = -0.945 + 0.608TL	0.71	-	0.0380
	This study	Saros Bay (northern Agean Sea, Turkey)	42	12.1 – 22.6	G_{ope} = -0.6448 + 0.625TL	0.92	0.7305	0.0784
Symphodus mediterraneus[2]	This study	Saros Bay (northern Agean Sea, Turkey)	31	9.9 – 13.8	G_{ope} = 0.0928 + 0.5696TL	0.85	1.0191	0.1454
Symphodus tinca[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	231	13.2 – 25.0	G_{ope} = -2.557 + 0.708TL	0.83	-	0.0210
	This study	Saros Bay (northern Agean Sea, Turkey)	32	10.9 – 17.1	G_{ope} = -2.4288 + 0.787TL	0.94	0.8113	0.0988
Sardina pilchardus[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	60	17.2 – 23.7	G_{ope} = -2.351 + 0.505TL	0.82	-	0.0310
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	81	10.5 – 17.0	G_{ope} = -0.495 + 0.411TL	0.83	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	146	11.0 – 16.1	G_{ope} = -2.2056 + 0.539TL	0.85	0.2676	0.0556
Sardinella aurita[1]	Aydın & Düzgüneş (2007)*	Bodrum Peninsula (southern Aegean Sea, Turkey)	253	15.4 – 24.0	G_{ope} = -1.5595 + 0.508FL	0.90	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	126	16.4 – 24.6	G_{ope} = -3.1133 + 0.5455TL	0.95	0.6610	0.0824
Trachurus mediterraneus[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	234	18.3 – 33.7	G_{ope} = -1.743 + 0.487TL	0.73	-	0.0190
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	75	27.0 – 33.5	G_{ope} = -4.462 + 0.622TL	0.97	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	296	13.0 – 27.1	G_{ope} = -0.3053 + 0.462TL	0.93	0.2040	0.0302
Trachurus trachurus[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	233	15.8 – 39.8	G_{ope} = 1.321 + 0.400TL	0.93	-	0.0070
	Santos et al. (2006)	Algarve coast (southern Portugal)	596	12.9 – 44.2	G_{ope} = 0.1611 + 0.4322TL	0.97	0.0727	0.0029
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	134	13.5 – 30.8	G_{ope} = -0.784 + 0.475TL	0.97	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	64	13.0 – 19.0	G_{ope} = -0,0372 + 0,4674TL	0.88	0.6041	0.0890

Table 4. Comparison of maximum girth-total length relationships of eight fish species between the present study and other studies. *N*: sample size, min: minimum, max: maximum, *TL*: total length (cm), *FL*: fork length (cm), G_{max}: maximum girth (cm), r^2 = the coefficient of determination, *SE* = standard error, *a* = intersect, *b* = slope, * *FL*: fork length. [1] first TL-G_{max} relationship reference for Northern Aegean Sea. [2] first TL-G_{max} relationship reference for the species worldwide.

Fish species	References	Location	N	TL_{min} - TL_{max}	Length – Maximum Girth equation	r^2	SE of *a*	SE of *b*
Serranus cabrilla[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	46	16.3 – 25.6	G_{max} = -0.902 + 0,627TL	0.89	-	0.0320
	Santos et al. (2006)	Algarve coast (southern Portugal)	68	18.4 – 24.8	G_{max} = -3.0089 + 0.7467TL	0.94	0.4688	0.0225
	Aydın & Düzgüneş (2007)	Bodrum Peninsula (southern Aegean Sea, Turkey)	263	13.4 – 19.8	G_{max} = 0.2834 + 0.5473TL	0.84	-	-
	This study	Saros Bay (northern Agean Sea, Turkey)	49	11.9 – 23.5	G_{max} = -1.8132 + 0.7222TL	0.95	0.5460	0.0609
Serranus scriba[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	74	14.3 – 23.9	log(G_{max}) = −0.298 + 1.075 log(TL)	0,78	-	0,0680
	This study	Saros Bay (northern Agean Sea, Turkey)	42	12.1 – 22.6	G_{max} = -1.6634 + 0.764TL	0.92	0.6740	0.0640
Symphodus mediterraneus[2]	This study	Saros Bay (northern Agean Sea, Turkey)	31	9.9 – 13.8	G_{max} = 1.3316 + 0.5849TL	0.86	1.1558	0.1371
Symphodus tinca[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	169	13.2 – 25.0	G_{max} = -2.486 + 0.744TL	0.83	-	0.0270
	This study	Saros Bay (northern Agean Sea, Turkey)	32	10.9 – 17.1	G_{max} = 1.3559 + 0.6185TL	0,89	1,5457	0,1596
Sardina pilchardus[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	60	17.2 – 23.7	G_{max} = -1.508 + 0.531TL	0.81	-	0.0330
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	81	10.5 – 17.0	G_{max} = -1.688 + 0.557TL	0.72	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	146	11.0 – 16.1	G_{max} = -1.2212 + 0.5492TL	0.83	0.3722	0.0628
Sardinella aurita[1]	Aydın & Düzgüneş (2007)*	Bodrum Peninsula (southern Aegean Sea, Turkey)	253	15.4 – 24.0	G_{max} = -5.973 + 0.822FL	0.94	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	126	16.4 – 24.6	G_{max} = -4.8748 + 0.7036TL	0.90	0.8118	0.0853
Trachurus mediterraneus[1]	Stergiou & Karpouzi (2003)	Cyclades (southern Aegean Sea, Greece)	192	18.3 – 33.7	G_{max} = -3.265 + 0.580TL	0.69	-	0.0280
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	75	27.0 – 33.5	G_{max} = -7.793 + 0.763TL	0.96	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	296	13.0 – 27.1	G_{max} = -0.701 + 0.5312TL	0.92	0.2110	0.0284
Trachurus trachurus[1]	Mendes et al. (2006)	from Póvoa do Varzim to Santo Andre (western Portugues coast)	230	15.8 – 39.8	G_{max} = 1.916 + 0.402TL	0.92	-	0.0070
	Santos et al. (2006)	Algarve coast (southern Portugal)	598	12.9 – 44.2	G_{max} = 0.0441 + 0.4972TL	0.97	0.0889	0.0036
	Beğburs et al. (2020)	Izmir Bay (central Agean Sea, Turkey)	134	13.5 – 30.8	Gmax = -0.797 + 0.497TL	0.97	-	-
	This study	Saros Bay (northern Aegean Sea, Turkey)	64	13.0 – 19.0	G_{max} = 0.0008 + 0.5025TL	0.90	0.5537	0.0755

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REFERENCES

Aydın M and Düzgüneş E. 2007. Estimation of selectivity of gillnets used in the Bodrum Peninsula. Turkish Journal of Aquatic Life, 3: 456-466.

Baranov FI. 1948. Theory of Fishing with Gill Nets. In: Baranov FI (ed). Theory and Assessment of Fishing Gear. Pishchepromizdat, Moscow. pp45. (Translation from Russian by the Ontario Department of Land and Forests, Maples, Ontario).

Beğburs CR, Babaoğlu AÖ, Kara A and İlkyaz AT. 2020. Length-girth and length-weight relationships of 13 fish species from Izmir Bay (Turkey). Fresenius Environmental Bulletin, 29: 8104-8108.

Cengiz Ö, İşmen A and Özekinci U. 2014. Reproductive biology of the spotted flounder, *Citharus linguatula* (Actinopterygii: Pleuronectiformes: Citharidae), from Saros Bay (northern Aegean Sea, Turkey). Acta Ichthyologica et Piscatoria, 44: 123-129. https://10.3750/AIP2014.44.2.06

Cengiz Ö, İşmen A, Özekinci U and Öztekin A. 2015. Some reproductive characteristics of four-spotted megrim (*Lepidorhombus boscii* Risso, 1810) from Saros Bay (Northern Aegean Sea, Turkey). Journal of Agricultural Sciences, 21: 270-278. https://10.15832/tbd.10768

Cengiz Ö and Paruğ ŞŞ. 2020. A new record of the rarely reported grey triggerfish (*Balistes capriscus* Gmelin, 1789) from Northern Aegean Sea (Turkey). Marine and Life Sciences, 2: 1-4.

Daliri M, Paighambari SY, Shabani MJ, Pouladi M and Davoodi R. 2012. Length-weight and length-girth relationships, relative weight and relative condition factor of four commercial fish species of northern Persian Gulf. Annual Research & Review in Biology, 2: 15-26.

Ecoutin JM and Albaret JJ. 2003. Length-weight rela-tionship of 52 fish species from West African estuaries and lagoons. Cybium, 27: 3-9.

Eronat C and Sayın E. 2014. Temporal evolution of the water characteristics in the bays along the eastern coast of the Aegean Sea: Saros, İzmir, and Gökova bays. Turkish Journal of Earth Sciences, 23: 53-66. https://10.3906/yer-1307-4

Güçlüsoy H. 2015. Marine and Coastal Protected Areas of Turkish Aegean Coasts. In: Katağan T, Tokaç A, Beşiktepe Ş and Öztürk B (eds). The Aegean Sea Marine Biodiversity, Fisheries, Conservation and Governance. Turkish Marine Research Foundation (TUDAV), Publication No: 41, Istanbul, Turkey, pp. 669-684.

Jawad LA, McKenzie U and Al-Noor SS. 2009. Relationship between opercular girth, maximum girth and total length of fishes caught in gillnets in the estuarine and lower river sections of Shatt al-Arab River (Basrah Province, Iraq). Journal of Applied Ichthyology, 25: 470-473. https://10.1111/j.1439-0426.2009.01254.x

Jawad L, Bobori D, Al-Shwikh H and Al-Saleh F. 2015. Opercular girth, maximum girth and total length relationships for *Planiliza abu* (Heckel, 1843) and *Chondrostoma regium* (Heckel, 1843) (Actinoprerygii) from Euphrates River at Dier Ez-Zor Governorate, Syria. Acta Zoologica Bulgarica, 67: 591-594.

Kawamura G. 1972. Gill-net mesh selectivity curve developed from length-girth relationship. Bulletin of the Japanese Society of Scientific Fisheries, 38: 1119-1127. https://10.2331/suisan.38.1119

Kurkilahti M, Appelberg M, Hesthagen T and Rask M. 2002. Effects of fish shape on gillnet selectivity: a study with Fulton's condition factor. Fisheries Research, 54: 153-170. https://10.1016/S0165-7836(00)00301-5

Kyritsi S, Mantzouni I and Moutopoulos DK. 2018. Length-girth relationships for freshwater fishes from Lake Volvi (Northern Greece). International Journal of Fisheries and Aquatic Studies, 6: 231-234.

Maravelias CD and Papaconstantinou C. 2006. Geographic, seasonal and bathymetric distribution of demersal fish species in the eastern Mediterranean. Journal of Applied Ichthyology, 22: 35-42. https://10.1111/j.1439-0426.2006.00695.x

McCombie AM and Berst HA. 1969. Some effects of shape and structure of fish on selectivity of gillnets. Journal of the Fisheries Research Board of Canada, 26: 2681-2689. https://10.1139/f69-260

Mendes B, Fonseca P and Campos A. 2006. Relationships between opercula girth, maximum girth and total length of fish species caught in gillnet and trammel net selectivity surveys off the Portuguese coast. Journal of Applied Ichthyology, 22: 209-213. https://10.1111/j.1439-0426.2006.00734.x

Moutopoulos DK, Dimitriou N, Nystas T and Koutsikopoulos C. 2017. Length-girth relations of fishes from a Mediterranean lagoon system. Acta Ichthyologica et Piscatoria, 47: 397-400. https://10.3750/AIEP/02248

Neter J, Wasserman W and Whitmore GA. 1988. Applied statistics, 3rd Ed. Allyn and Bacon Inc, New York, NY. 1006pp

Reis EG and Pawson MG. 1999. Fish morphology and estimating selectivity by gillnets. Fisheries Research, 39: 263-273. https://10.1016/S0165-7836(98)00199-4

Santos MNA, Canas PGL and Monterio CC. 2006. Length-girth relationships for 30 marine species. Fisheris Research, 78: 368-373. https://10.1016/j.fishres.2006.01.008

Sarı E and Çağatay MN. 2001. Distributions of heavy metals in the surface sediments of the Gulf of Saros, NE Aegean Sea. Environment International, 26: 169-173. https://10.1016/s0160-4120(00)00097-0
Sechin YT. 1969. A mathematical model for the selectivity curve of a gill net. Rybnoe Khozyajstvo, 45: 56-58 (in Russian).
Stergiou KI and Karpouzi VS. 2003. Length-girth relationships for several marine fishes. Fisheries Research, 60: 161-168. https://10.1016/S0165-7836(02)00077-2
Swain DP and Foote CJ. 1999. Stocks and chameleons the use of phenotypic variation in stock identification. Fisheries Research, 43: 113-128. https://10.1016/S0165-7836(99)00069-7
Theocharis A, Balopoulos E, Kioroglou S, Kontoyiannis H and Iona A. 1999. A synthesis of the circulation and hydrography of the South Aegean Sea and the Straits of the Cretan Arc (March 1994-January 1995). Progress In Oceanography, 44: 469-509. https://10.1016/S0079-6611(99)00041-5
Tokai T and Omoto TK. 1994. Mesh size selectivity of unmarketable trash fish by a small trawl fishery in the Seto inland sea. Nippon Suisan Gakkaishi, 60: 347-352 (In Japanese with English abstract).
Turan C, Erguden D, Turan F and Gurlek M. 2004. Genetic and morphologic structure of *Liza abu* (Heckel, 1843) populations from the Rivers Orontes, Euphrates and Tigris. Turkish Journal of Veterinary and Animal Science, 28: 729-734.
Umaru JA, Annune PA, Cheikyula JO and Okomoda VT. 2015. Some biometric parameters of four selected fish species in Doma Dam, Nasarawa State, Nigeria. International Journal of Aquaculture, 5(31): 1-7. https://10.5376/ija.2015.05.0031
Wootton RJ. 1998. Ecology of teleost fishes, 2nd Ed. Kluwer Academic Publishers, The Netherlands. 386pp.

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