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RESEARCH ARTICLE

Bioecological parameters and exploitation status of the short-beaked garfish (*Belone svetovidovi* Collette & Parin, 1970) in the Aegean Sea

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Abstract

The age, growth and exploitation parameters were investigated for the short-beaked garfish *Belone svetovidovi* collected from İzmir Bay, the Aegean Sea. A total of 505 individuals, 298 female (59.01%) and 207 male (40.99%), were obtained by commercial trawlers and trammel nets. The total length varied between 19.9 and 33.9 cm for females, 19.4 and 32.7 cm for males. The length-weight relationships were calculated for females, males, and all individuals as $W = 0.0246 \times L^{2.0717}$, $W = 0.0255 \times L^{2.0612}$, and $W = 0.0251 \times L^{2.0663}$, respectively. The growth type was detected as negative allometric. The maximum age class was III for both females and males. The von Bertalanffy growth parameters were L_∞ = 52.41 cm, k = 0.178 year^{-1}, t_0 = -1.912 years for females; L_∞ = 44.55 cm, k = 0.182 year^{-1}, t_0 = -1.388 years for males; L_∞ = 42.41 cm, k = 0.238 year^{-1}, t_0 = -0.754 years for all individuals. The total (Z), natural (M), and fishing (F) mortality rates were computed for all individuals as 0.53, 0.22, and 0.31 year^{-1}, respectively. The exploitation rate (E) was 0.58 year^{-1}. The fishing mortality and exploitation rates were higher than the biological reference points (F_{opt} = 0.11 year^{-1} and F_{limit} = 0.15 year^{-1}) and optimum exploitation rate (E_{opt} = 0.33 year^{-1}), respectively. The study concluded that *B. svetovidovi* populations in İzmir Bay are experiencing fisheries pressure; however, this can be managed through regular monitoring and periodic assessments to ensure the sustainability of the fishery.

Keywords: Short-beaked garfish, *Belone svetovidovi*, growth, exploitation, Aegean Sea

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Introduction

The family Belonidae, represented by 10 genera and 47 needlefish species worldwide (Fricke and Eschmeyer 2025), includes three species in Turkish marine waters: *Belone belone*, *Belone svetovidovi* and *Tylosurus acus* (Turan *et al.* 2007; Karatas *et al.* 2021). Among these belonids, the short-beaked garfish (*Belone svetovidovi* Collette & Parin, 1970) is a rare species of needlefishes distributed in the Eastern Atlantic Ocean along the coasts of Ireland, the United Kingdom, Spain and Portugal, and throughout the Mediterranean, inhabiting depths from 1 to 20 m (Froese and Pauly 2025). The distribution of *B. svetovidovi* in Turkish marine waters was previously confined to the Aegean and Mediterranean Seas. However, Turan *et al.* (2023a) have documented the species' expansion into the Marmara and Black Seas. The short-beaked garfish is an oviparous species, and its eggs can be found attached to objects in the water by tendrils on the surface of the egg (Breder and Rosen 1966). This epipelagic species' diet consists of crab larvae and young clupeids (Dorman 1987). Besides, the highest recorded length is 41.8 cm for a male individual (Bilge *et al.* 2014), while the maximum reported age is 7 years (Dorman 1987).

Similar to all needlefishes, *B. svetovidovi* is also characterized by a long, silvery body, jaws resembling a beak filled with razor-sharp teeth, and a typical black stripe along its lateral line (Collette and Parin 1986). This species has been, without doubt, confused with a more widespread species, *B. belone*, due to their shared habitat and morphological similarities (Collette and Parin 1970). The differentiation of *B. svetovidovi* from *B. belone* is remarked by the presence of smaller, closely spaced teeth in the jaws, the absence of vomerine teeth, and a large number of gill rakers as well as a lower jaw that is longer than the upper jaw (Bauchot 1987; Turan *et al.* 2007).

Despite the economic significance of *B. svetovidovi*, its fisheries trends in the Mediterranean have not stabilized. The species is primarily captured using beach and boat seines, pelagic trawls, encircling nets, and gillnets, while it is occasionally targeted in sport and recreational fisheries. Nevertheless, global catch data for the belonids are not included in the fisheries statistics of Food and Agriculture Organization (FAO), whereas the Turkish Statistical Institute (TURKSTAT) reports the total amount of catch data for garfishes found in Turkish seas. In this respect, TURKSTAT fisheries statistics indicate that the lowest catch of garfishes over the past 24 years amounted to 149.2 tons in 2023, with the largest being 661 tons recorded in 2010 (TURKSTAT 2024).

Variations in the dynamic structures of fish populations within a certain geographic area over time can yield critical insights into the bioecological traits of the species in question, as well as elucidate reasons for their potential stock declines (Pauly 1983; Sparre and Venema 1998). Elucidating the stock status of Belonidae spp., considering the effects of fishing and natural mortality, is key to developing ecosystem-based sustainable fisheries strategies and determination of catch limits for their vulnerable stocks (Turan *et al.* 2024, 2025).

Studies on the population dynamics of Belonidae spp. distributed in Turkish seas have focused on *B. belone*, whereas *B. svetovidovi* has not received the deserved attention both globally and in Türkiye. Therefore, this study aims to contribute to the optimum assessment of *B. svetovidovi* stocks in İzmir Bay by providing first combined information on growth and exploitation parameters and developing rational implications for sustainable fisheries management.

Materials and Methods

Belone svetovidovi specimens caught by commercial trawl and trammel nets in İzmir Bay were collected from Güzelbahçe fishery shelter between January and May 2025 (Figure 1).

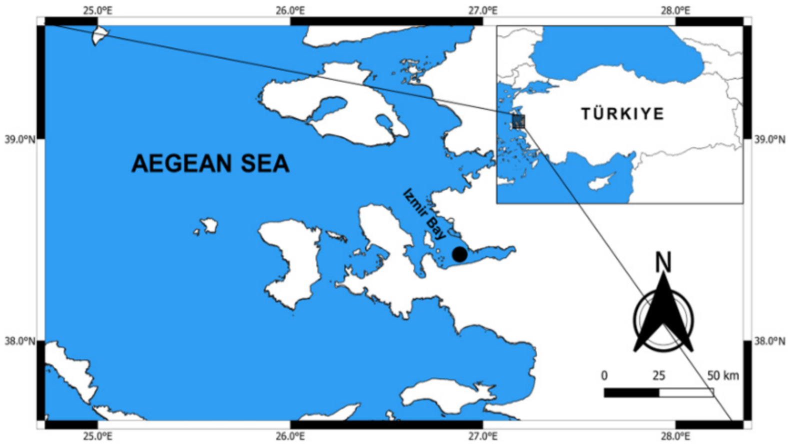

Figure 1. The sampling location of *Belone svetovidovi* specimens

Total length of the specimens was measured to the nearest 0.1 cm and their weight to the nearest 0.01 g. Following macroscopic observation of the gonads, the sex of the specimen was determined, then the sex ratio was tested using the chi-square test (χ^2) to assess for any significant departures from the expected 1:1 ratio (Nikolsky 1963). Age estimations were made by counting the growth rings on each extracted sagittal otolith, following the method suggested by Holden and Raitt (1974). The otoliths were subjected to ethanol clearing followed by immersion in glycerine for examination. Age estimations were conducted using a binocular microscope with reflected light.

Bioecological parameters

Length-weight relationships (LWRs) were calculated separately for female, male, and all individuals with the formula $W = a \times L^b$ (Ricker 1975). Here, W is the total body weight (g), L is the total length (cm), a is a coefficient for body form, and the exponent b is the allometry coefficient of the linear regression equation describing isometric (= 3), positive allometric (> 3), and negative allometric (< 3) length growth. The equation can be expressed logarithmically as $\log W = \log a + b \log L$. ANOVA was used to assess the significance of regressions (Zar 1999). The significance of the deviation of b values from linear regressions of the null hypothesis of isometric growth (H_0: $b = 3$) was assessed using a Student's t-test at a 95% confidence level, following the method recommended by Sokal and Rohlf (1987), with the formula $t_s = (b - 3) / sb$, where t_s represents the t-test value, b is the slope, and sb is the standard error of the slope (b).

Hypothetical growth parameters for females, males, and all individuals were determined using the von Bertalanffy growth function (VBGF), demonstrated as $L_t = L_\infty\left[1 - e^{-k(t-t_0)}\right]$ (Beverton and Holt 1957). Here, L_t represents the total length (cm) at age t (years), L_∞ refers to the average asymptotic length (cm), k is the growth coefficient (year^{-1}), and t_0 is the hypothetical age at which length is zero (years). The growth performance index (Φ') was determined using the equation $\Phi' = \log k + 2 \log L_\infty$ (Munro and Pauly 1983).

Exploitation parameters

Total mortality (Z) was estimated based on mean length (cm) with the formula $Z = k \times (L_\infty - \overline{L}) / (\overline{L} - L')$ suggested by Beverton and Holt (1957). Here, L represents the mean length (cm) of all individuals, while L' is the length (cm) of the smallest fish in the dataset. Natural mortality rate (M) was calculated using the equation $M = \overline{W}^{-(\frac{1}{b})}$ based on mean weight (g) according to Ursin (1967), where $\overline{W}$ mean weight of all individuals, and b is the constant of LWRs. Fishing mortality (F) was computed using the equation $F = Z - M$ (Pauly 1980). Exploitation rate (E) was determined by calculation $E = F / Z$ (Sparre and Venema 1998). Status of fisheries resource was determined through the comparison of current fishing mortality (F) with the optimum (F_{opt}) and limit (F_{limit}) biological reference points defined in the formula $F_{opt} = 0.5\,M$ and $F_{limit} = 2/3\,M$, respectively (Patterson 1992). Optimum exploitation rate (E_{opt}) was calculated with the equation $E_{opt} = F_{opt}(M + F_{opt})^{-1}$ (Gulland 1971).

Statistical analyses were performed using Microsoft Excel 2016 (Microsoft, Redmond, WA, USA) and SPSS Statistics 19.0 (SPSS Inc., Chicago, IL, USA).

Results

General population statistics of Belone svetovidovi

During the study, a total of 505 *B. svetovidovi* specimens were collected from İzmir Bay, comprised of 298 females (59.01%) and 207 males (40.99%). The sex ratio (M:F) was established at 1:1.43. The chi-square test (χ^2) indicated a significant deviation from the expected 1:1 sex ratio (χ^2,$P < 0.05$). Females ranged from 19.9 to 33.9 cm in total length and 12.10 to 36.49 g in weight, while males were 19.4 to 32.7 cm in total length and 11.50 to 33.71 g in weight. The mean length and weight for females were 26.82 ± 2.70 cm and 22.70 ± 4.72 g, and for males, 26.07 ± 2.93 cm and 21.47 ± 4.90 g, respectively. A significant difference in mean total length and weight was observed between females and males (t_{test}, $P < 0.05$). A substantial proportion of individuals, 28.91%, measured between 25.0 and 26.9 cm in total length (Figure 2).

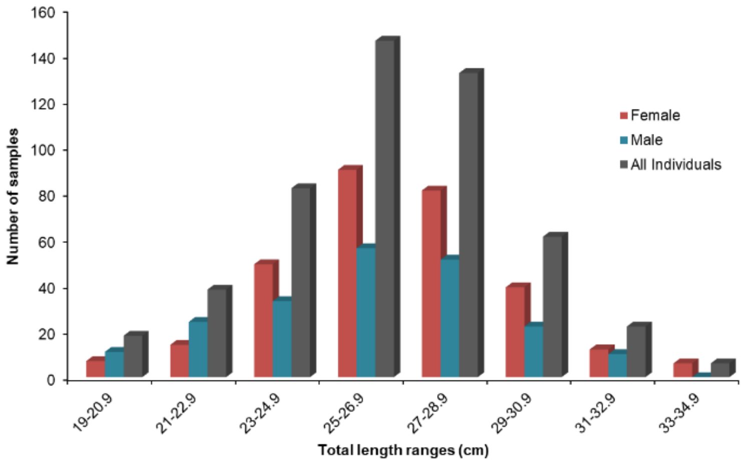

Figure 2. Frequency distribution of total length for female, male, and all individuals of *Belone svetovidovi* in İzmir Bay

Length-weight relationships

LWRs were separately determined in logarithmic form: *log W* = -1.6086 + 2.0717 *log L* for females; *log W* = -1.5932 + 2.0612 *log L* for males; *log W* = -1.6006 + 2.0663 *log L* for all individuals collected from İzmir Bay (Table 1). The exponent *b* parameter for females, males, and all individuals indicated negative allometry, which was statistically significant ($P < 0.05$). A robust correlation was obtained between length and weight in females, males, and all individuals ($P < 0.05$; $r^2 >$ 0.97). The length-weight relationships in this study were compared with those found in previous related investigations on Belonidae spp. in Table 2.

Estimating age patterns and parameters of the von Bertalanffy growth function (VBGF)

Age patterns ranging from I to III years were obtained for females and males from sagittal otolith examinations. Table 3 indicates the total length frequencies for each age group of *B. svetovidovi* in İzmir Bay. Age group II was dominant for females (43.96%), while ages II (16.04%) and III (15.45%) were dominant for males.

Table 1. Sampling characteristics and LWR parameters between total length (TL) and weight (W) for female, male and all individuals, and the possibility of isometry analysed by Student's *t*-test

Sex	N	Range of TL (cm) (L_{mean} ± SD)	Range of W (g) (W_{mean} ± SD)	LWR parameters					
				a	*b*	SE of *b*	95% CI of *b*	r^2	*t*-test
♀	298	19.9 – 33.9 (26.82±2.70)	12.10 – 36.49 (22.70±4.72)	0.0246	2.0717	0.0086	2.0547 – 2.0887	0.9936	107.52*
♂	207	19.4 – 32.7 (26.07±2.93)	11.50 – 33.71 (21.47±4.90)	0.0255	2.0612	0.0082	2.0449 – 2.0773	0.9955	114.21*
∑	505	19.4 – 33.9 (26.52±2.82)	11.50 – 36.49 (22.19±4.83)	0.0251	2.0663	0.0103	2.0545 – 2.0779	0.9945	156.37*

♀, female; ♂, male; ∑, all individuals; N, sample number; SD, standard deviation; *a*, intercept; *b*, slope; SE, standard error; CI, confidence interval; r^2, coefficient of correlation; * $t > t_{0.05,N>200} = 1.65$.

Table 2. The comparison of LWR parameters and growth types of Belonidae spp. in related studies in various geographical regions

Locality	Species	N	Sex	*a*	*b*	GT	References
SW coasts of Portugal	*B. belone*	14	∑	2.65E-06	2.87	A-	Goncalves *et al.* (1997)
Northern Aegean Sea (Greece)	*B. belone*	48	∑	0.0009	3.04	A+	Koutrakis and Tsikliras (2003)
Eastern Adriatic (Croatia)	*B. belone*	138	∑	0.0010	3.01	I	Sinovcic *et al.* (2004)
İzmir Bay (Türkiye)	*B. belone*	240 107	♀ ♂	0.0002 0.0009	3.46 3.07	A+ A+	Uçkun *et al.* (2004)*
Eastern Adriatic (Croatia)	*B. belone*	52	∑	0.0009	3.05	A+	Dulcic and Glamuzina (2006)
İzmir Bay (Türkiye)	*B. belone*	416	∑	0.0003	3.365	A+	Özaydın and Taşkavak (2006)

Table 2. Continued

Locality	Species	N	Sex	*a*	*b*	GT	References
Sinop coasts (Türkiye)	*B. belone*	609 322	♀ ♂	0.00061 0.00280	3.153 2.998	A+ A-	Samsun *et al.* (2006)
Northern Aegean Sea (Greece)	*B. belone*	69	∑	0.0011	2.972	A-	Karachle and Stergiou (2008)
Samsun coasts (Türkiye)	*B. belone*	278	∑	0.0005	3.245	A+	Polat *et al.* (2009)*
Gulf of Gabes (Tunisia)	*B. belone*	115	∑	0.0102	3.132	A+	Ghailen *et al.* (2010)
NE Aegean Sea (Türkiye)	*B. belone*	5	∑	0.0058	1.933	A-	Gürkan *et al.* (2010)
Erdek Bay (Türkiye)	*B. belone*	10	∑	0.0034	2.282	A-	Keskin and Gaygusuz (2010)
Rize coasts (Türkiye)	*B. belone*	469 523	♀ ♂	0.0003 0.0005	3.327 3.174	A+ A+	Kalaycı and Yeşilçiçek (2012)
Eastern Adriatic (Croatia)	*B. belone*	3393	∑	0.0002	3.482	A+	Zorica and Kec (2013)
İzmir Bay (Türkiye)	*B. belone*	105	∑	0.0008	3.114	A+	Acarlı *et al.* (2014)
Southern Aegean Sea (Türkiye)	*B. belone* *B. svetovidovi*	44 36	∑	0.0003 0.0007	3.395 3.117	A+ A+	Bilge *et al.* (2014)
Rize coasts (Türkiye)	*B. belone*	618 593	♀ ♂	0.0005 0.0007	3.18 3.09	A+ A+	Bilgin *et al.* (2014)
Tunisian waters	*T. acus*	54 72	♀ ♂	0.0027 0.0026	2.832 2.827	A- A-	Chaari *et al.* (2014)
Gökçeada Island (Türkiye)	*B. belone*	49	∑	0.000	3.280	A+	Altın *et al.* (2015)
Veracruz coasts (Mexico)	*T. acus*	45	∑	0.0024	2.827	A-	Galindo-Cortes *et al.* (2015)
Northern Aegean Sea (Greece)	*T. acus*	112	∑	0.0003	3.307	A+	Karachle *et al.* (2015)

Table 2. Continued

Locality	Species	N	Sex	*a*	*b*	GT	References
Central Black Sea (Türkiye)	*B. belone*	647	∑	0.008	3.09	I	Samsun *et al.* (2017)
Suez Canal (Egypt)	*T. acus*	210	∑	0.0005	3.26	A+	Sabrah *et al. (*2018)
Sinop coasts (Türkiye)	*B. belone*	986	∑	0.0009	3.04	A+	Ceyhan *et al.* (2019)
Candarli Bay (Türkiye)	*B. belone*	93	∑	0.0008	3.115	A+	Babaoğlu *et al.* (2021)
Saros Bay (Türkiye)	*B. belone*	58	∑	0.0004	3.263	A+	Çolakoğlu (2021)
Ordu coasts (Türkiye)	*B. belone*	110	∑	0.0031	2.705	A-	Samsun and Sağlam (2021)
İzmir Bay (Türkiye)	*B. svetovidovi*	30	∑	0.0003	3.356	A+	Bayhan and Uncumusaoğlu (2022)
Kandira coasts (Türkiye)	*B. belone*	79	∑	0.0006	3.171	A+	Çayır and Bostancı (2022)
Darica coasts (Türkiye)		29		0.0007	3.115	A+	
Tunisian waters	*B. belone*	284	♀	0.0003	3.419	A+	Chaari *et al.* (2022)
		120	♂	0.0002	3.530	A+	
SE Black Sea (Türkiye)	*B. belone*	591	♀	0.0005	3.196	A+	Samsun and Sağlam (2024)
		326	♂	0.0009	3.040	I	
Sea of Marmara (Türkiye)	*B. belone*	10	∑	0.0002	3.483	A+	Şen *et al.* (2024)
Akçakoca coasts (Türkiye)	*B. svetovidovi*	189	♀	0.0002	3.4750	A+	Yağlıoğlu *et al.* (2025)
		163	♂	0.0002	3.4569	A+	
		352	∑	0.0002	3.4606	A+	
İzmir Bay (Türkiye)	*B. svetovidovi*	298	♀	0.0246	2.0717	A-	This study
		207	♂	0.0255	2.0612	A-	
		505	∑	0.0251	2.0663	A-	

N, sample number; ♀, female; ♂, male; ∑, all individuals; *a*, intercept; *b*, slope; GT, growth type; A+, positive allometric; A-, negative allometric; I, isometric; *, using fork length.

Table 3. Length key based on age groups for females, males, and all individuals of *Belone svetovidovi* from İzmir Bay

Intervals of TL (cm)	Age groups						Total (% coverage)
	♀			♂			
	I	II	III	I	II	III	
19.0 – 20.9	7			11			18 (3.56%)
21.0 – 22.9	11	3		24			38 (7.75%)
23.0 – 24.9		49		13	20		82 (16.24%)
25.0 – 26.9		90			56		146 (28.91%)
27.0 – 28.9		79	2		5	46	132 (26.14%)
29.0 – 30.9		1	38			22	61 (12.08%)
31.0 – 32.9			12			10	22 (4.36%)
33.0 – 34.9			6				6 (1.19%)
Total (% coverage)	18 (3.56%)	222 (43.96%)	58 (11.49%)	48 (9.50%)	81 (16.04%)	78 (15.45%)	505 (100.00%)
Mean TL ± SD	21.21±0.86	26.30±1.61	30.56±1.56	21.99±1.29	25.76±0.87	28.90±1.60	26.52±2.82
Mean W ± SD	13.90±1.17	21.61±2.75	29.59±3.02	14.98±1.85	20.65±1.38	26.31±3.09	22.19±4.83

TL, total length; W, weight; SD, standard deviation; ♀, female; ♂, male.

The growth pattern in mean lengths for each age group was estimated using the VBGF for females, males, and all individuals of *B. svetovidovi* from İzmir Bay. The total lengths for females, males, and all individuals corresponding to each age group are displayed in Figure 3. The von Bertalanffy growth parameters were L_∞ = 52.41 cm, k = 0.178 year^{-1}, t_0 = -1.912 years for females; L_∞ = 44.55 cm, k = 0.182 year^{-1}, t_0 = -1.388 years for males; L_∞ = 42.41 cm, k = 0.238 year^{-1}, t_0 = -0.754 years for all individuals. The growth performance index (Φ') was computed for females, males, and all individuals as 2.689, 2.559, and 2.632, respectively. Table 4 presents the comparison of von Bertalanffy growth parameters with former related studies for Belonidae spp. distributed in different geographical areas.

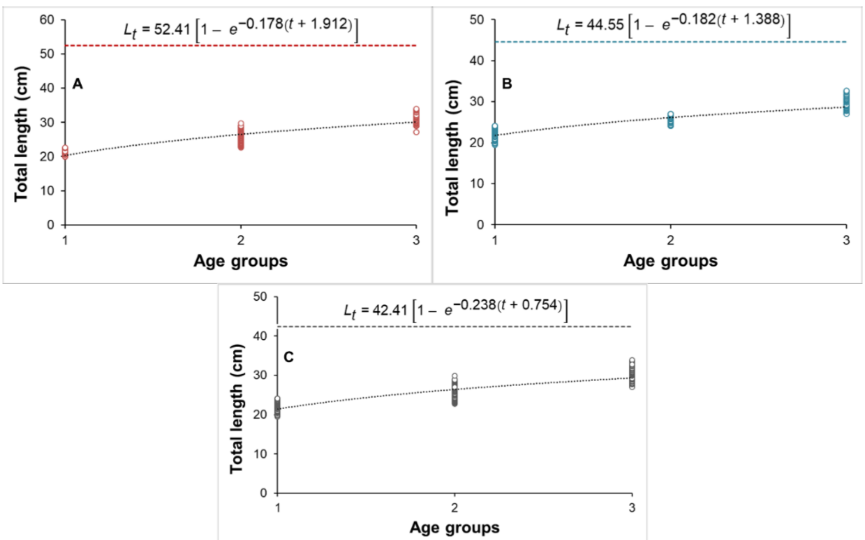

Figure 3. von Bertalanffy growth curves applied to total length-at-age data for females (A), males (B), and all individuals (C) of *B. svetovidovi* from İzmir Bay

Determination of exploitation parameters

The total, natural, and fishing mortality rates for *B. svetovidovi* were calculated. Concordantly, the total mortality (Z) was 0.66, 0.51, and 0.53 year^{-1}, the natural mortality (M) rate was 0.22, 0.23, and 0.22 year^{-1}, and the fishing mortality (F) was 0.44, 0.28, and 0.31 year^{-1}, for females, males, and all individuals, respectively. The exploitation rate (E) was found to be 0.58 year^{-1} for all individuals. Biological reference points were determined as follows: the optimum fishing mortality, F_{opt} = 0.11 year^{-1}, the fishing mortality limit, F_{limit} = 0.15 year^{-1} and the optimum exploitation rate, E_{opt} = 0.33 year^{-1}. The exploitation parameters for *B. svetovidovi* were then compared with previous studies related to Belonidae spp. as shown in Table 5.

Table 4. The VBGF comparisons of Belonidae spp. for related studies in different areas.

Locality	Species	Sex	L_∞	k	t_o	Φ'	References
İzmir Bay (Türkiye)	*B. belone*	♀ ♂	62.24 54.32	0.249 0.336	-1.422 -1.252	2.990 2.996	Uçkun *et al.* (2004)*
Sinop coasts (Türkiye)	*B. belone*	∑	74.64	0.13	-3.67	2.86	Samsun *et al.* (2006)
Samsun coasts (Türkiye)	*B. belone*	∑	79.05	0.198	-1.42	3.09	Polat *et al.* (2009)*
Rize coasts (Türkiye)	*B. belone*	♀ ♂	41.16 37.48	0.728 0.752	-0.51 -0.61	3.09 3.02	Kalaycı and Yeşilçiçek (2012)
Eastern Adriatic (Croatia)	*B. belone*	♀ ♂	89.5 85.2	0.166 0.159	-0.063 -0.322	3.124 3.062	Zorica and Kec (2013)
Rize coasts (Türkiye)	*B. belone*	♀ ♂	81.6 71.9	0.1248 0.1507	-2.245 -2.127	2.92 2.89	Bilgin *et al.* (2014)
Tunisian waters	*T. acus*	♀ ♂	123.78 92.28	0.20 0.50	-2.28 -1.16	3.49 3.63	Chaari *et al.* (2014)
Suez Canal (Egypt)	*T. acus*	∑	79.85	0.44	-0.58		Sabrah *et al.* (2018)
Sinop coasts (Türkiye)	*B. belone*	∑	55.74	0.28	-1.68	2.939	Ceyhan *et al.* (2019)
Tunisian waters	*B. belone*	♀ ♂	48.48 44.70	0.57 0.67	-1.00 -1.00	3.12 3.12	Chaari *et al.* (2022)
SE Black Sea (Türkiye)	*B. belone*	♀ ♂	78.20 69.82	0.119 0.120	-2.742 -3.521	2.86 2.77	Samsun and Sağlam (2024)
Akçakoca coasts (Türkiye)	*B. svetovidovi*	♀ ♂ ∑	65.50 66.75 66.59	0.109 0.108 0.108	-2.586 -2.621 -2.666	2.669 2.682 2.680	Yağlıoğlu *et al.* (2025)
İzmir Bay (Türkiye)	*B. svetovidovi*	♀ ♂ ∑	52.41 44.55 42.41	0.178 0.182 0.238	-1.912 -1.388 -0.754	2.689 2.559 2.632	This study

♀, female; ♂, male; ∑, all individuals; L_∞, asymptotic length; k, growth coefficient (year^{-1}); t_0, theoretical age at length equal to zero; Φ', growth performance index; *, using fork length.

Discussion

This research represents the first contribution to reveal both growth and exploitation parameters of *Belone svetovidovi* from İzmir Bay. Although the sampling period was relatively short (January-May 2025), the growth and mortality parameters obtained provide a reliable baseline for the sustainability of *B. svetovidovi* populations. Up to now, the bioecological knowledge on *B. svetovidovi* has been rather limited, as only two studies have been conducted that determined the length-weight relationship using a small sample number from trawl surveys involving multiple species (Bilge *et al.* 2014; Bayhan and Uncumusaoğlu 2022), and one study analysing the length-weight relationship and growth parameters with a larger sample size (Yağlıoğlu *et al.* 2025). However, the relevant species, *B. belone* and *T. acus*, with an emphasis on *B. belone*, have been examined for their growth and exploitation parameters in various studies conducted across different geographical areas and Turkish marine waters (Tables 2, 4 and 5). Therefore, the findings obtained from this study were discussed with respect to bioecological and exploitation parameters mostly those of *B. belone*.

Table 5. Comparison of exploitation parameters for Belonidae spp. in related studies across various locations

Locality	Species	Sex	*Z*	*M*	*F*	*E*	References
Sinop coasts (Türkiye)	*B. belone*	∑	1.24	0.23	1.01	0.81	Samsun *et al.* (2006)
Eastern Adriatic (Croatia)	*B. belone*	∑	0.88	0.43	0.45	0.51	Zorica and Kec (2013)
Rize coasts (Türkiye)	*B. belone*	♀ ♂	1.04 1.24				Bilgin *et al.* (2014)
Suez Canal (Egypt)	*T. acus*	∑	1.70	0.72	0.98	0.58	Sabrah *et al.* (2018)
Sinop coasts (Türkiye)	*B. belone*	∑	1.16	0.47	0.69	0.59	Ceyhan *et al.* (2019)
SE Black Sea (Türkiye)	*B. belone*	∑	1.02	0.16	0.86	0.84	Samsun and Sağlam (2024)
İzmir Bay (Türkiye)	*B. svetovidovi*	∑	0.53	0.22	0.31	0.58	This study

♀, female; ♂, male; ∑, all individuals.

Bioecological characteristics

The LWR constant *b* obtained from present study pointed to negative allometry for females (2.0717), males (2.0612) and all individuals (2.0663), which is consistent with a small number of previous studies presented in Table 2. Conflictingly, a positive allometric *b* was obtained for *B. svetovidovi* from the Turkish coasts of southern Aegean Sea (Bilge *et al.* 2014), İzmir Bay (Bayhan and Uncumusaoğlu 2022), and Akcakoca coasts (Yağlıoğlu *et al.* 2025). However, the negative allometric *b* values reported from the southwestern coasts of Portugal (Goncalves *et al.* 1997), Sinop coasts (Samsun *et al.* 2006), the Greek (Karachle and Stergiou 2008) and Turkish (Gürkan *et al.* 2010) coasts of the northern Aegean Sea, Erdek Bay (Keskin and Gaygusuz 2010), and Ordu coasts (Samsun and Sağlam 2021) for *B. belone*, and Tunisian waters (Chaari *et al.* 2014) and Veracruz coasts (Galindo-Cortes *et al.* 2015) for *T. acus* align with the present study. The constant *b*, indicative of fish natural growth, ranges from 2 to 4 (Tesch 1971). Factors including species, sampling location, habitat, season, maturity, sex, age, dietary habits, and variations in the length of fish samples can cause discrepancies in the LWRs noted across different geographical regions (Ricker 1975; Bagenal and Tesch 1978). The low *b* found in this study is assumed to have resulted from the narrow size range (19.4 – 33.9 cm) of samples collected during the study period. Despite the high regression fit (r^2 = 0.99), the limited size distribution might have reduced the pattern's sensitivity to increasing weight.

Age determinations obtained from otolith readings of *B. svetovidovi* individuals sampled from İzmir Bay revealed that all individuals were in age groups I to III. The most common age group for females was II (222 individuals), while those for males were II (81 individuals) and III (78 individuals), which is consistent with the findings of Uçkun *et al.* (2004), Samsun *et al.* (2006), Polat *et al.* (2009), Sabrah *et al.* (2018), and Chaari *et al.* (2022). Uçkun *et al.* (2004) determined the most dominant age group of *B. belone* in İzmir Bay, ranging from I to V, for both females and males as II. Samsun *et al.* (2006) found the common age group of *B. belone* up to VI years old in the Sinop coasts to be II. Polat *et al.* (2009) reported that the most common age group of *B. belone* in the Samsun coasts, ranging from I to V, was II. Sabrah *et al.* (2018) found II to be the most common age group of *T. acus* up to age V on the Egyptian coast of the Suez Canal. Chaari *et al.* (2022) determined II as the most dominant age group of *B. belone* between ages 0-V in Tunisian waters. Bilgin *et al.* (2014) found the frequent age group of *B. belone* in the Rize coasts as III for females and II for males, which partially coincides with this study. On the other hand, the predominant age group of all individuals of *B. svetovidovi* in Akcakoca coasts (Yağlıoğlu *et al.* 2025), *B. belone* in the Adriatic Sea (Zorica and Kec 2013) and southeastern Black Sea coasts (Samsun and Sağlam 2024), and *T. acus* in Tunisian waters (Chaari *et al.* 2014) was found to be III.

The asymptotic length (L_∞) of *B. svetovidovi* from this study is 52.41 cm for females, 44.55 cm for males, and 42.41 cm for all individuals which is close to those in the former estimations of Belonidae spp. as summarized in Table 4, except for findings of L_∞ from Uçkun *et al.* (2004), Samsun *et al.* (2006), Polat *et al.* (2009), Zorica and Kec (2013), Bilgin *et al.* (2014), Chaari *et al.* (2014), Sabrah *et al.* (2018), Samsun and Sağlam (2024), and Yağlıoğlu *et al.* (2025). Uçkun *et al.* (2004) found L_∞ of *B. belone* based on the fork length to be 62.24 cm for females and 54.32 cm for males. Samsun *et al.* (2006) detected L_∞ as 74.64 cm for all individuals of *B. belone*. Polat *et al.* (2009) computed L_∞ as 79.05 cm for *B. belone* using fork length. Zorica and Kec (2013) found L_∞ of *B. belone* to be 89.5 cm for females and 85.2 cm for males. Bilgin *et al.* (2014) calculated L_∞ for female and male individuals of *B. belone* as 81.6 and 71.9 cm, respectively. Chaari *et al.* (2014) detected L_∞ of *T. acus* as 123.78 cm for females and 92.28 cm for males. Sabrah *et al.* (2018) estimated L_∞ as 79.85 cm for *T. acus*. Samsun and Sağlam (2024) determined L_∞ of *B. belone* for females and males 78.20 and 69.82 cm, respectively. Yağlıoğlu *et al.* (2025) found L_∞ of *B. svetovidovi* to be 65.50 cm for females and 66.75 cm for males. Wotton (1990) emphasized that there are remarkable differences in the growth characteristics of fish populations of the same or similar species in different marine ecosystems. Santic *et al.* (2002) suggested that the quality of a species' diet and fluctuations in water temperature of different geographical areas may affect these growth differences. In particular, as noted by Uyan *et al.* (2020, 2024), Doğdu *et al.* (2022), Turan *et al.* (2023b), and Uyan and Turan (2024) differences in predicted asymptotic length can be attributed to phylogeographic diversity, together with influences such as fishing pressure, global climate change, and pollution.

The growth performance index (Φ') of *B. svetovidovi* was found to be 2.689 for females, 2.559 for males, and 2.632 for all individuals in this study. These values are comparable to the growth performance indexes reported by Yağlıoğlu *et al.* (2025) for *B. svetovidovi*, and Uçkun *et al.* (2004), Samsun *et al.* (2006), Bilgin *et al.* (2014), Ceyhan *et al.* (2019) and Samsun and Sağlam (2024) for *B. belone*, whereas lower than those noticed by Polat *et al.* (2009), Kalaycı and Yeşilçiçek (2012), Zorica and Kec (2013), and Chaari *et al.* (2022) for *B. belone*, as well as Chaari *et al.* (2014) for *T. acus*. Besides biological factors, environmental conditions such as seawater temperature and salinity can alter metabolism and osmoregulation of short-beaked garfish, thereby affecting growth rates and consequently Φ', which links the estimated K and L_∞ (King 2007).

Exploitation parameters

The parameters of total (Z), natural (M), and fishing (F) mortality rates calculated for all *B. svetovidovi* individuals are summarized in Table 5 and compared with the findings of *B. belone* and *T. acus* from various locations. The estimated total mortality (Z) at 0.53 year^{-1} was significantly lower than all previously reported Z values for *B. belone* and *T. acus*. Natural mortality (M) detected as 0.22 year^{-1} was lower than the estimates for *B. belone* reported by Zorica and Kec (2013) (M = 0.43 year^{-1}), Sabrah *et al.* (2018) (M = 0.72 year^{-1}), and Ceyhan *et al.* (2019) (M=0.47 year^{-1}), while closer to those by Samsun *et al.* (2006) (M = 0.23 year^{-1}) and Samsun and Sağlam (2024) (M = 0.16 year^{-1}). Fishing mortality (F) was 0.31 year^{-1}, considerably lower than the estimations by Samsun *et al.* (2006), Zorica and Kec (2013), Ceyhan *et al.* (2019), and Samsun and Sağlam (2024) for *B. belone*, and Sabrah *et al.* (2018) for *T. acus*. Present study indicated that the total (Z) and fishing mortality rates (F) for *B. svetovidovi* are significantly lower than those observed in *B. belone* from the Adriatic and Black Seas, as well as in *T. acus* from the Suez Canal. Variations in total and fishing mortality rates may be ascribed to the level of fisheries efforts across different marine ecosystems and the intra- and interspecific bioecological features and behavioural patterns of fish species (Hewitt and Hoenig 2005). The notably low fishing mortality of observation in the present study could be attributed to the absence of older and larger specimens in the samples, likely due to factors affecting their catchability. Sparre and Venema (1998) have noted that natural mortality rates for the related species can differ regionally, influenced by the abundance of predators and competitors and the intensity of fisheries activities.

Exploitation rate (E) for all individuals was estimated at 0.58 year^{-1}, which is lower than the estimations for *B. belone* as determined by Samsun *et al.* (2006) (E = 0.81 year^{-1}) and Samsun and Sağlam (2024) (E = 0.84 year^{-1}). Gulland (1971, 1983) suggested that the ideal exploitation rate for a fisheries should not exceed 0.50 and the fishing mortality rate (F) should be equal to the natural mortality rate

(M) for sustainable fisheries. Given that the present study includes findings of exploitation that contradict recognized assumption, discussing high fisheries pressure is possible for *B. svetovidovi* in İzmir Bay. On the other hand, this study, despite the limited age range of the sampling, provides another evidence of fisheries pressure on *B. svetovidovi* in İzmir Bay, with calculated fishing mortality rate (F = 0.31 year^{-1}) exceeding biological reference points based on the approach of fisheries resource status by Patterson (1992) (F_{opt} = 0.11 year^{-1} and F_{limit} = 0.15 year^{-1}), and the exploitation rate (E = 0.58 year^{-1}) being above 0.50 and the optimum exploitation rate (E_{opt} = 0.33 year^{-1}) defined by the criterion of Gulland (1971).

Mortality rates are crucial in the management of sustainable fisheries and in preserving the equilibrium of stocks and ecosystems. Total mortality demonstrates the risk of overexploitation of stocks, whereas natural mortality reveals the condition of the ecosystem. Fishing mortality, manageable through strategic interventions, aids reduce fisheries pressure and ensures the sustainability of fish stocks. Therefore, monitoring the exploitation rates of *B. svetovidovi*, which faces fishing pressure in İzmir Bay, is crucial for biodiversity conservation and ecosystem-based fisheries management (Turan 2021, 2022).

Conclusions

This study provides the first integrated contribution toward understanding the bioecological and exploitation parameters of *B. svetovidovi*. The relatively limited length and age range did not prevent evidence of fisheries pressure on *B. svetovidovi* distributed in İzmir Bay due to the adequacy of the sample size. The inconsistency of two important parameters, fishing mortality and exploitation rates, with biological reference points and accepted assumptions, respectively, highlights the importance of long-term monitoring of population dynamics for the sustainability of short-beaked garfish stocks in İzmir Bay. These initiatives are crucial for fisheries management as they assist in establishing catch limits and temporary and/or local fishing closures during spawning season, identifying fisheries methods that preserve susceptible age groups, and examining the impact of climate change on growth patterns. Hence, this study provides valuable insights for future research by fisheries scientists and managers focusing on other economically important species in the region.

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participated in data analysis, manuscript design and writing, interpretation of the results, and review of the final version of the manuscript.

Ege Denizi'nde dağılım gösteren zargana balığının (*Belone svetovidovi* Collette & Parin, 1970) biyoekolojik parametreleri ve sömürülme durumu

Öz

Bu çalışmada, İzmir Körfezi'nden toplanan zargana balığı *Belone svetovidovi*'nin yaş, büyüme ve sömürülme parametreleri araştırılmıştır. Ticari trol tekneleri ve fanyalı ağlarla 298 dişi (%59.01) ve 207 erkek (%40.99) olmak üzere toplam 505 birey elde edilmiştir. Dişilerde toplam uzunluk 19.9 ile 33.9 cm, erkeklerde ise 19.4 ile 32.7 cm arasında değişmiştir. Boy-ağırlık ilişkileri dişiler, erkekler ve tüm bireyler için sırasıyla $W = 0.0246 \times L^{2.0717}$, $W = 0.0255 \times L^{2.0612}$ ve $W = 0.0251 \times L^{2.0663}$ olarak hesaplanmış olup büyüme tipi negatif allometrik olarak gözlemlenmiştir. Hem dişiler hem de erkekler için en yüksek yaş sınıfı III bulunmuştur. Von Bertalanffy büyüme parametreleri dişiler için $L_\infty = 52.41$ cm, $k = 0.178$ yıl^{-1}, $t_0 = -1.912$ yıl; erkekler için $L_\infty = 44.55$ cm, $k = 0.182$ yıl^{-1}, $t_0 = -1.388$ yıl; tüm bireyler için $L_\infty = 42.41$ cm, $k = 0.238$ yıl^{-1}, $t_0 = -0.754$ yıl olarak hesaplanmıştır. Toplam (Z), doğal (M) ve balıkçılık (F) ölüm oranları tüm bireyler için sırasıyla 0.53, 0.22 ve 0.31 yıl^{-1} bulunmuştur. Sömürülme oranı (E) 0.58 yıl^{-1} olarak bulundu. Balıkçılık ölüm oranı ve avlanma oranları sırasıyla biyolojik referans noktalarından ($F_{opt} = 0.11$ yıl^{-1} ve $F_{limit} = 0.15$ yıl^{-1}) ve optimum avlanma oranından ($E_{opt} = 0.33$ yıl^{-1}) daha yüksek bulunmuştur. Bu araştırma, İzmir Körfezi'ndeki *B. svetovidovi* popülasyonlarının balıkçılık baskısı altında olduğu; ancak bunun, balıkçılığın sürdürülebilirliğini sağlamak için düzenli izleme ve periyodik değerlendirmelerle yönetilebileceği sonucuna varmıştır.

Anahtar kelimeler: Zargana, *Belone svetovidovi*, büyüme parametreleri, sömürülme durumu, Ege Denizi

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