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Some biological properties of different populations of the Atlantic horse mackerel *Trachurus trachurus* (L.) in Turkish Seas

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Age, growth, sex, and condition of different populations of the Atlantic horse mackerel, Trachurus trachurus *(L.) in the Turkish seas were determined from 300 specimens between November 2010 and March 2011. Fork length and total weight of the specimens ranged from 10.0 to 18.9 cm and from 12.81 to 81.71 g, respectively. Maximum age group was determined as IV, and sex ratio in samples did not differ significantly from a 1:1 ratio for all locations except for Bandirma, where it was skewed towards males (χ^2 test, $p>0.005$). Weight increased allometrically for [Zonguldak (BS), Bandirma (MS1), Edremit (AS1), Izmir (AS2), Marmaris (AS3)] populations together with b=2.881, b=2.973, b=3.210, b=3.120, b= 2.820 respectively except for b=3.004 for Sarköy (MS2) as isometry.*

Key words: Carangidae, *Trachurus trachurus,* Turkish Seas, Age, Growth

INTRODUCTION

The Atlantic horse mackerel, *Trachurus trachurus*, is distributed throughout the eastern Atlantic, the Mediterranean and Black Sea (WHITEHEAD *et al.* 1986; FISCHER *et al.* 1987). In the Turkish Seas, the genus *Trachurus* is represented by three species: Atlantic horse mackerel, *T. trachurus*, Mediterranean horse mackerel, *T. mediterraneus* and blue jack mackerel, *T. picturatus* (BILECENOGLU *et al.* 2002). In the Turkish Seas, the first two species are commercially valuable and very abundant, while the third is very scarce (AKSIRAY, 1987; TURAN, 2004). Atlantic horse mackerel is the third most important resource (after anchovy and sardine) for the Turkish fishing industry with the mean annual catch value of 18.072 tons (ANONYMUS, 2011) because of improvements in fishery technology (ERKOYUNCU, 1995).

The biology of this species has been well documented by numerous studies in the Atlantic (EATON, 1989; BORGES & GORDOA, 1991) in the Mediterranean Sea (ARRUDA, 1984; PETRAKIS & STERGIO, 1995; KARLOU-RIGA & SINIS, 1997; VILLAMOR *et al.* 1997; MURTA, 2000; KOUTRAKIS & TSIKLIRAS, 2003; ABAUNZA *et al.* 2003; CABRAL & MURTA, 2002; MOUTOPOULOS & STERGIOU, 2002; MACKENZIE *et al.* 2008) and in the Adriatic Sea (ALEGRIA- HERNANDEZ, 1984; DULČIĆ & KRALJEVIĆ, 1996) in the Black Sea (DEMIR, 1961; YANKOVA, 2010). There are some studies of the

biology of the Atlantic horse mackerel population in the Black Sea and the Sea of Marmara (SAHINOGLU, 1996; YUCEL & ERKOYUNCU, 2000; KURTOGLU *et al.* 2010; AYDIN & KARADURMUŞ, 2012). The present work investigates some aspects of the growth of Atlantic horse mackerel at different localities off Turkey.

MATERIAL AND METHODS

Fifty Atlantic horse mackerel specimens per sampling were obtained directly from fishermen at six different stations between November 2010 and March 2011. Fishermen provided the information on fishing methods (Table 1).

Specimens were measured to the nearest 1 cm below (Fork length) and weighted to the nearest 0.01 g and their sagittal otoliths were removed immediately and stored dry in properly labeled envelopes. All 300 specimens were used for the age and growth analysis. The ages were determined using the methods by CHUGUNOVA (1963). Sagittal otoliths were viewed under a binocular microscope at 20 times magnification using reflected light and a dark background. The number of opaque zones (summer rings, appearing dark under reflected light) was checked by two readers. To avoid subjectivity effect on age estimation, as much as possible, there was an interval of 1 month between readings. Translucent bands that continued around the entire circumference of the otolith were considered to be annuli and the total number of these bands was recorded as the age. Age-classes were assigned based on the number of annuli and the month fish was collected. Length-at-age data were used to estimate the parameters of the VON BERTALANFFY (1938) growth function *VBGF:* $L_t = L_\infty[1-e^{-k(t-t_0)}]$ (SPARRE & VENEMA, 1992). where L_t is the total length of the fish at time t, $L\infty$ is the ultimate length an average fish could achieve, k is the growth constant which determines how fast the fish approach $L\infty$ and t_0 is the hypothetical time at which the length of the fish is zero.

Length-weight relationships were calculated by applying an exponential regression $W=aL^b$, Where, W=weight, L=Fork length, a and b are constants (RICKER, 1975; SPARRE &VENEMA, 1992). The gonads were examined on fresh specimens to determine sex macroscopically. Sex ratio was analyzed in each population (AVSAR, 2005).

Deviations from 1:1 sex ratio null hypothesis was statistically tested by x^2 analysis. All statistical analyses and graphics were prepared using Quattro Pro Windows and Microsoft Excel.

Table 1. Sampling details of Trachurus trachurus *used in this study. The age structure, parameters of length–weight relationship (a and b), growth (L∞, K, t_0) fork length (FL).*

Stations	Abbrev.	Coordinates	Date of capture	Sampling gear	Mesh size (mm)	FL (cm)	W (g)	L∞	K	t_0	a	b	R^2
Black Sea (Zonguldak)	BS	41°27’23’’ N, 31°47’55’’ E	10 November 2010	Purse seiners	7	11.0-11.9	20.00-24.99	23.47	0.26	-1.61	0.016	2.881	0.983
Marmara Sea (Bandırma)	MS1	40°21’34’’ N, 27°58’45’’ E	25 March 2011	Gill nets	16	16.0-16.9	50.00-69.99	21.63	0.31	-1.62	0.012	2.973	0.967
Marmara Sea (Şarköy)	MS2	40°36’48’’ N, 27°6’48’’ E	15 November 2010	Purse seiners	7	11.0-11.9	15.00-19.99	14.73	0.27	-4.48	0.012	3.004	0.888
Aegean Sea (Edremit)	AS1	39°35’56’’ N, 27°1’19’’ E	1 January 2011	Purse seiners	7	12.0-12.9	20.00-29.99	15.49	0.29	-3.77	0.007	3.210	0.862
Aegean Sea (İzmir)	AS2	38° 32’ 09’’ N, 26° 45’18’’ E	20 January 2011	Purse seiners	7	12.0-12.9	15.00-19.99	17.19	0.21	-4.17	0.009	3.121	0.856
Aegean Sea (Marmaris)	AS3	36°51’48’’ N, 28°16’30’’ E	1 February 2011	Gill nets	16	13.0-13.9	10.00-19.99	15.07	0.40	-4.09	0.017	2.820	0.832

RESULTS

Length-weight frequency distribution

Fork length of Atlantic horse mackerels ranged from 10.0-18.9 cm. The most abundantly captured specimen ranged from 11.0-11.9 cm (36%) in BS; 16.0-16.9 cm (36%) in MS1; 11.0-11.9 (66%) in MS2; 12.0-12.9 cm (40%) in AS1; 12-12.9 cm (40%) in AS2; 13.0-13.9 cm (54%) in AS3 in length groups respectively (Fig. 1).

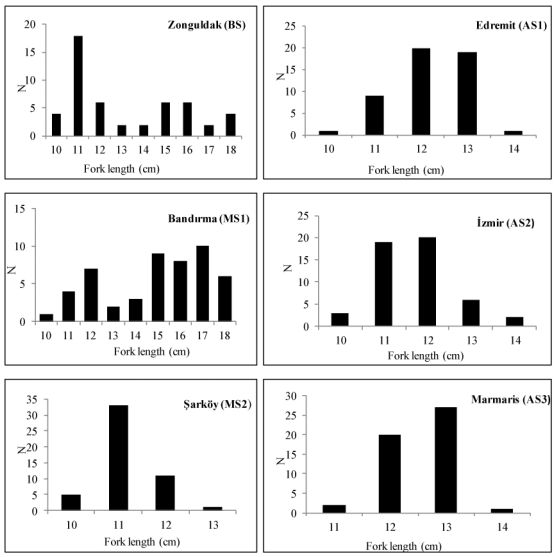

Fig1. Length frequency distribution of Trachurus trachurus *in different populations of Turkish Seas.*

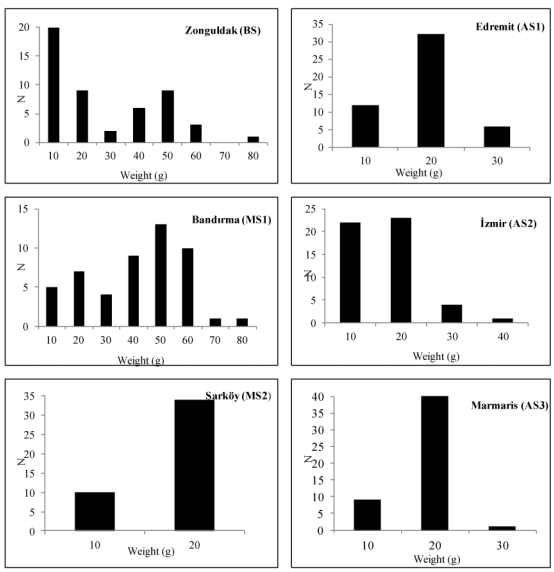

Fig. 2. Weight frequency distribution of Trachurus trachurus *in different populations of Turkish Seas.*

Weight of mackerels ranged from 12.81-81.71 g. The most abundantly captured specimen ranged from 20.00-24.99 g.(38%) in BS; 50.00-69.99g (46%) in MS1; 15.00-19.99 g (62%) in MS2; 20.00-29.99 g (80%) in AS1; 15.00-19.99 g.(40%) in AS2; 10.00-19.99g (40%) in AS3 in weight groups (Fig. 2), respectively.

Age and sex ratio

According to the age determinations, the specimens ranged from age group I to age group IV. Age groups I and II were the most abundant age groups in the samples taken at all localities except for Bandirma where age groups III and IV were the most abundant (Fig. 3).

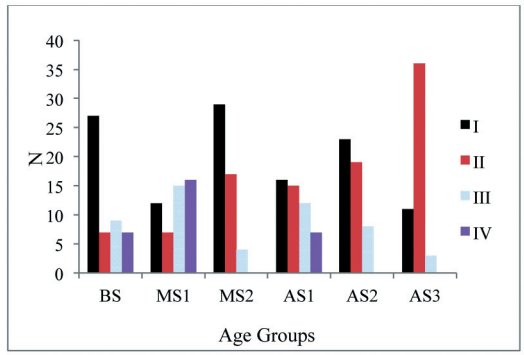

Fig.3. Age groups of Trachurus trachurus *in different populations of Turkish Seas.*

The sex ratios in samples from BS (Zonguldak), MS2 (Sarköy), AS1 (Edremit), AS2 (Izmir), and AS3 (Marmaris) did not differ significantly from a 1:1 ratio (c^2 test, $p>0.005$). The sex ratio in the sample from MS1 (Bandirma) was skewed in favor of males and was significantly different from 1:1 ratio (c^2 test $p<0.005$) (Fig. 4).

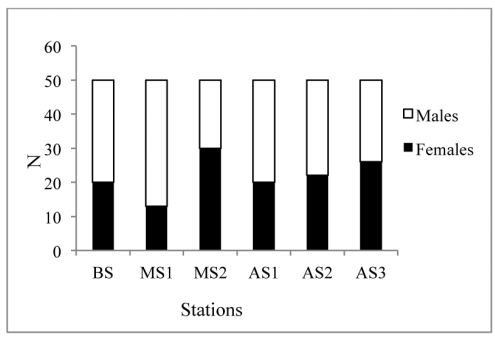

Fig. 4.- Sexes of Trachurus trachurus *in different populations of Turkish Seas.*

Growth

The von Bertalanffy growth equations (age-length relationships) calculated with mean lengths at different ages in AS1, MS1, MS2, AS3, AS2, and BS, respectively were found as follows:

L_t=15.49 [1−e$^{-0,29(t+3,77)}$], L_t=21.63 [1−e$^{-0,31(t+1,62)}$], L_t=14.73 [1−e$^{-0,27(t+4,48)}$],
L_t=15.07 [1−e$^{-0,40(t+4,09)}$], L_t=17.19 [1−e$^{-0,21(t+4,17)}$], L_t=23.47 [1−e$^{-0,26(t+1,61)}$]

Length-weight relationships

The values of length-weight relationships are:
W=0.0016L$^{2.881}$ R^2=0.983 in BS (Zonguldak),
W=0.012L$^{2.973}$ R^2=0.967 in MS1 (Bandırma),
W=0.00067L$^{3.2109}$ R^2=0.9621 in AS1 (Edremit),
W=0.009L$^{3.1207}$ R^2=0.9341 in AS2 (Izmir),
W=0.017L$^{2.819}$ R^2=0.832 in AS3 (Marmaris),
Weight increased allometrically (b>3 or b>3) above, showing isometry as
W=0.0121L$^{3.0042}$ R^2=0.8905 in MS2 (Sarköy).

The correlation coefficients computed for the length-weight relationships suggested that the growths in the populations were harmonious and balanced (Fig. 5).

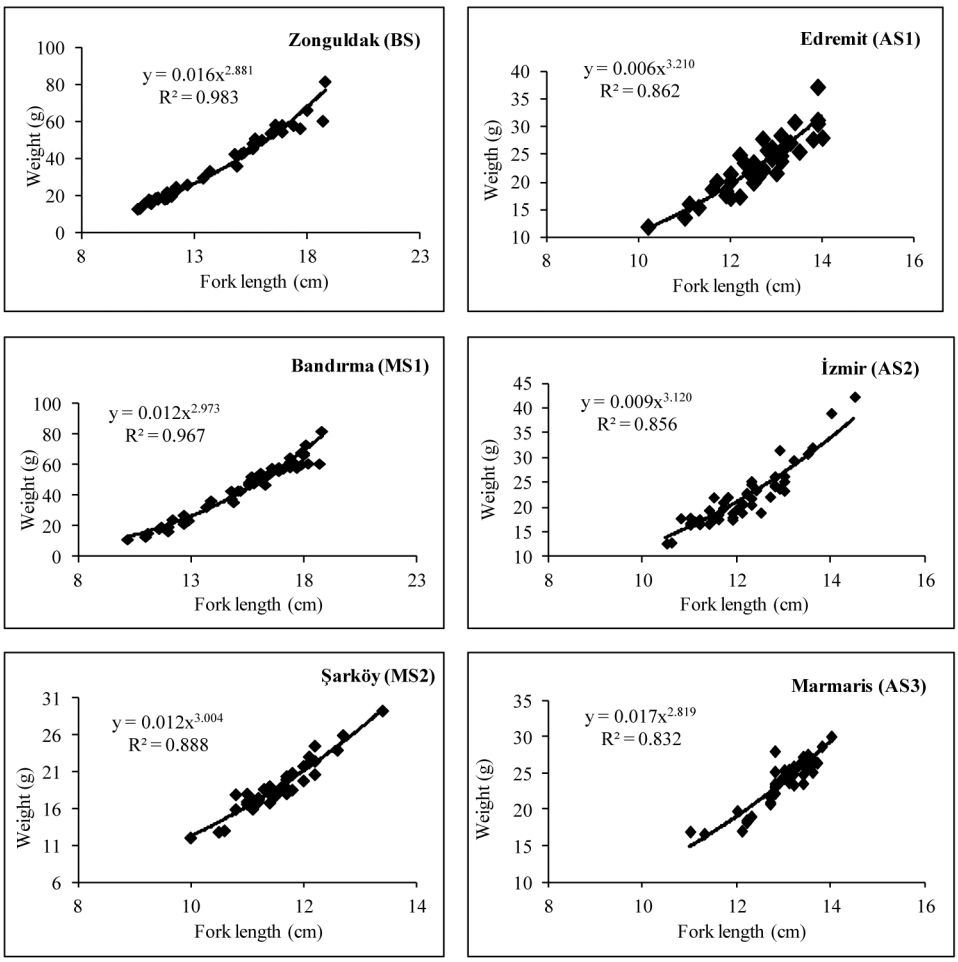

Fig. 5.- Length-weight relationship of Trachurus trachurus *in different populations of Turkish Seas.*

DISCUSSION

The fork length of Atlantic horse mackerel in the coastal waters of Turkey ranged from 10.0 to 18.9 cm. This range was compared with the given results as 6.0-16.0 cm, 10.1-34.0, 13.0-39.0 cm, 10.1-39.0, and 25.0-35.0 cm, for the Atlantic horse mackerel populations of coastal waters of Adriatic and British waters by KARLOVAC & KARLOVAC (1971), JUKIĆ & PICCINETTI (1981), ALEGRIA-HERNANDEZ (1984), respectively. The range values in our samples are different from the relevant literature probably due to differences in ontogenetic development, condition, sex, maturity as well as variations in geographic location, seasonality and small sample size. The fork length of Atlantic horse mackerel specimens ranged between 10.0-18.9 cm, the dominant ones between 11.0-13.0 cm, except for MS1 (Fig. 1). Regarding the Turkish Seas, total length values in the Black Sea (6.9-19.2 and 9.4-16.8 cm) by AYDIN & KARADURMUS (2012), and the Sea of Marmara (10.0-17.8 cm) by KURTOGLU *et al.* (2010) are different to those calculated by us in the Turkish Seas (Table 2).

Table 2.The age structure, parameters of length–weight relationship (a and b), growth (L∞, K, t 0) and CF of Trachurus trachurus *in this and previous studies(– indicates absence of data)*

References	L∞	Age	N	a	b	R^2	K	t_O	CF	Weight range (g)	Length range (cm)	Area
Farina Perez 1983	-	-	1238	0.0129	2,854	-	-	-	-	-	7.4-51.0	NW Spain
Hernandez-Allegria. 1984	37.55	9	-	-	-	-	0.218	-1.28	-	-	10.1-34.0	Adriactic Sea
Arruda 1984	-	-	1519	0.0199	2.885	-	-	-	-	-	17.2-25.5	Portugese
Kerstan 1985	-	-	-	0.0043	3.125	-	-	-	-	-	-	Irland -UK
Coull et al. 1989			283	0.0034	3.294						16.0-41.0	North Sea
Akyol 1995	19.28											İzmir Bay
Sahinoglu 1996	24.82											Black Sea
Karlou and Sinis 1997	30.27											Saronikos
Prodonov et al., 1997	24.52						0.172					Black Sea
Kayalı 1998	38.85						0.100					Eastern Black Sea
Genç et al. 1999	19.88						0.396					Eastern Black Sea
Olaso et al. 1999											25-30	Northern Spain
Yücel and Erkoyuncu, 2000	16.92	7	720	0.0075	3.05		0.353	-2.79	0.843	9.4-16.8	5.27-43.95	Black Sea
Santic et al. 2002	37.68		2304	0.0080	3.019		0.23	-0.30		6.04-437.5	10.3-37.3	Adriatic
Jardas et al 2004			1200								10.5-37.6	Adriatic
Santic et al. 2005			1200								12.9-17.6	Adriatic Sea
Kalaycı 2006	24.12						0.170					Black Sea
Samsun et al. 2006	26.74						0.138					Black Sea
Kasapoglu 2006	26.09						0.125					Black Sea
Güroy et al 2006	30.34	3	459	0.006	3.1234		0.255	-2.48		8.50-171.7	8.80-25.90	Dardanelles
Garrido et al. 2008		15	1626								12-42	Portugal

Özdemir et al 2009	22.54		946				0.16				5.0-17.5	Black Sea
Kurtoglu et al. 2010	23.64	5	256	0.002	3,45		0.13	-4.59	0,873	8.94-58.64	10.40-17.80	Marmara Sea
Santic et al. 2011			1384	0.0081	3,001		0.064		0.060-0.09	7.0-430.3	9.1-37.8	Adriatic Sea
Aydın and Karadurmuş 2012	20.5	7	1307	0.0049	3,17	0.96	0.231	-2.96		2.32-59.98	6.9-19.02	Black Sea
This study (2010-2011)	14.73-23.47	I-IV	300	0.007-0.017	2.82-3.21	0.89-0.98	0.21-0.40	-1.61-4.48		12.81-81.71	10.0-18.9	Turkish Seas

The weight of Atlantic horse mackerel in the coastal waters of Turkey ranged from 12.81 to 81.71 g. (Fig. 2). Regarding Turkish Seas, weight values in Black Sea (9.4-16.8 and 2.32-59.98 g.) by YUCEL & ERKOYUNCU (2000) and AYDIN & KARADURMUS (2012), and Adriatic Sea (7.0-430.3 g) by ŠANTIĆ *et al.* (2011) are different to those calculated for all Turkish Seas (Table 2).

Our values of b (2.881, 2.973, 3.004, 3.210, 3.120, 2.820) (Fig. 5) are similar to the ones estimated in Izmir Bay, Çanakkale Boğazı, Mid and Eastern Black Sea, (b=3.21, b=3.22, b=3.017, b=3.05, b=3.12, b=3.09, b=2.98, b=3.15, b=3.17,) by AKYOL (1995), GENC *et al.* (1999), YUCEL & ERKOYUNCU (2000), GUROY *et al.* (2006), SAMSUN *et al.* (2006), KALAYCI (2006), AYDIN & KARADURMUS (2012), except in the result from the Sea of Marmara (b=3.45) by KURTOGLU *et al.* (2010). It is thought that this difference can be the result of the assessment methodologies in sampling. KARLOU-RIGA & SINIS (1997), ŠANTIĆ *et al.* (2002), and CHERIF *et al.* (2006), SANTOS *et al.* (2002), estimated b=3.07, b=3.01, b=2.98, b=3.02 for the Saronikos Bay, Middle Adriatic, Tunisian coasts, Portuguese Waters, respectively which are close to the values we calculated while MENDES *et al.* (2004) found *b* value as a highly contradict to the findings in this study. These differences between the values of *b* may be the result of several ecological factors, such as the characteristics of the biotope, temperature, spawning conditions, feeding, length, age, and gonad maturity as reported by RICKER (1975) and SAMSUN *et al.* (2006). SINOVČIĆ reported that the coefficient of the length-weight relationship changed according to the time of year, the physiological state of the fish, and length range analyzed (SINOVČIĆ, 2003).

The age of the mackerel caught in Turkish Seas between ages I and IV (Fig. 3). While the I and II age groups of the mackerel were dominant in total samples, the age groups III and IV were the most abundant in MS1 (Marmaris). As seen in Table 2, age distribution was reported to be I-IV in Dardanelles (GUROY *et al.* 2006), while some populations showed the age groups until XXXV in Britain, Atlantic, Adriatic Sea, Middle Black Sea, Portugal, the Sea of Marmara (MACER, 1977; KAMPOWSKI, 1981; ALEGRIA-HERNANDEZ, 1984; YUCEL & ERKOYUNCU, 2000; GARRIDO *et al.* 2008; KURTOGLU *et al.* 2010). These differences in the age distribution of the populations may be due to gill net selectivity, fishing activity, feeding habits and the ecological characteristics of the lakes and reservoirs (NIKOLSKY, 1963; WOOTON, 1998). As to the theoretical maximum lengths, the values of Atlantic horse mackerel populations in Turkish Seas were found to be close to estimates by AKYOL (1995), GENC *et al.* (1999), YUCEL & ERKOYUNCU (2000), KALAYCI (2006), OZDEMIR *et al.* (2009), KURTOGLU *et al.* (2010), AYDIN & KARADURMUS (2012) (Table 2).

The sex ratio for Atlantic horse mackerel is 1:1 in general in the Black Sea (DUZGUNES & KARACAM, 1991; GENC *et al.* 1999) and Adriatic (ALEGRIA- HERNANDEZ, 1984). Sex ratio value of specimens in MS_1 (Bandırma) population was skewed in favor of males with 26% females and 74% males ($p>0.005$) that may be due, in part, to the greater catchability of males with random sampling. ABAUNZA *et al.* (2003) found that the sex ratio of the Atlantic horse mackerel was close to 1:1 for the whole area, similar to our samples, except for those in MS1 (Bandirma) for Turkish Seas (Fig. 4).

Atlantic horse mackerel is the most important species after anchovy and sardine. The

present study contributes to the body of information regarding growth, age, and length-weight composition of Atlantic horse mackerel at different localities off Turkey.

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Neka biološka svojstva različitih populacija atlantskog šaruna *Trachurus trachurus* (L.) u turskim morima

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SAŽETAK

Starost, rast, spol i stanje različitih populacija atlantskog šaruna *Trachurus trachurus* (L) u turskim morima procijenjene su kod 300 jedinki u razdoblju od studenog 2010. do ožujka 2011. Dužina do repne peraje i ukupna masa jedinki u rasponu je od 10.0 do 18.9 cm, odnosno od 12.81 do 81.71 g. Najstarija dobna skupina označena je oznakom IV, dok se omjer zastupljenosti spolova nije značajno razlikovao od odnosa 1:1 koji je ustanovljen na svim postajama, osim u Bandirmi gdje je bio u korist mužjaka (c^2 test, $p>0.005$). Masa se na sljedećim postajama [Zonguldak (BS) Bandirma (MSI), Edremit (AS1), Izmir (AS2), Marmaris (AS3)], povećavala uz koeficijente alometrije b=2.881, b=2.973, b=3.210, b=3.120, b= 2.820 respektivno, osim za b=3.004 u Sarköyu (MS2) koji ukazuje na izometriju.

Ključne riječi: Carangidae (bitnice), *Trachurus trachurus,* turske vode, starost, rast