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- RESEARCH ARTICLE –

Investigation Some Biological Properties of Atlantic Mackerel *Scomber scombrus* Linnaeus, 1758 in the Sea of Marmara

Habib Bal[1*] Dilek Türker[2]

[1]Livestock Research Institute, Department of Fisheries, Bandırma, Balıkesir, Turkey
[2]Balıkesir University, Faculty of Science and Arts, Department of Biology, Balıkesir, Turkey

Abstract

In this study, length-frequency, length-weight and length-length relationships and condition factors of Atlantic mackerel *Scomber scombrus* Linnaeus, 1758 were investigated. In 2016, a total of 163 individuals were examined by random sampling from commercial fishermen in the Sea of Marmara. It was determined that the total length distribution of the samples varied between 12.0-27.0 cm. The length-weight relationships were calculated as $W=0.0040L^{3.2975}$ ($r^2=0.978$) for females, $W=0.0045L^{3.2537}$ ($r^2=0.973$) for males and $W=0.0042L^{3.2782}$ ($r^2=0.976$) for all specimens. The *t-test* showed that the growth pattern was positive for all sex groups and for all samples ($b>3$, $P<0.05$). The relationship between length-length for all sex groups was also found to be quite strong (mean value: $r^2=0.94$; $P<0.05$). Fulton's condition factor (K) was calculated as 0.938±0.11 for females, 0.909±0.10 for males and 0.947±0.09 for all samples. The sex ratio (F:M) of the population was found to be 1:0.94.

Keywords:
Length-weight relationship, length-length relationship, growth, condition factor.

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Introduction

Atlantic mackerel *Scomber scombrus* Linnaeus, 1758 is a pelagic species that forms swarms with rapid swimming ability and extends over a wide area of the Atlantic Ocean (Whitehead et al., 1984; Sette, 1943; Anderson, 1976). It is one of the important target species of Portuguese fishermen with the Atlantic Ocean coast (Martins, 2007). It is reported that they reach 26 cm at the end of the

* *Corresponding Author: Habib Bal, e-mail: habipbal@hotmail.com*

second year and 33 cm at the end of the fifty year (Anderson, 1973; Isakov, 1973; Stobo & Hunt, 1974). In the researches, it was found that the first maturity length was between 25-30 cm. Spawning period reported that twice a year in spring and summer close to the continental shelf, mainly in the middle part of the Atlantic Ocean (O'Brien et al., 1993; MacKay, 1967). They feed on copepods, amphipods, shrimp and decapod (Bigelow & Schroeder, 1953). Mackerel has an important role in prey-predator relations in Atlantic Ocean. There are many predators feed on mackerel such as Sharks, Atlantic cod and Sea birds (Smith & Gaskin, 1974; Scott & Tibbo, 1968; Maurer & Bowman, 1975; Bowman & Michaels, 1984).

The conservation of the existing habitats of all fish species in the marine ecosystem depends on the development of sustainable fisheries management models with an ecosystem approach. Length-weight, length-length relationships, condition factors are important foundation stones for fisheries, ecology, physiology and fisheries management (Gonçalves et al., 1997). Thanks to the created growth equations comparison of environments where species are available, as well as helping to monitor vital cycles (Binohlan & Pauly, 1998; Radkhah & Eagderi, 2015).

In this study, length-weight, length-length, relationships, and condition factor and sex ratio of the mackerel *S. scombrus* Linnaeus, 1758 samples obtained from Sea of Marmara were determined. It is foreseen that the research results will contribute to the studies to be done in Sea of Marmara, where sampling is carried out and in the other seas of our country and to the sustainable management of stocks.

Materials and Methods

The samples were taken randomly from fishery boats catch by purse seine nets in the Sea of Marmara (North Kapıdağ Peninsula) in 2016 (Figure 1). The fish brought to the laboratory were measured in total length (*TL*), fork length (*FL*) and standard length (*SL*) in cm. Total weight (*TW*) was measured on a digital scale with a precision of 0.01 g. Estimation of length-weight relationships was calculated using $W=a.TL^b$ (Ricker, 1979). This can be expressed in linear form after logarithmic transformation by $log\ W=a+blogTL$ where *W* is the total weight (g) and *TL* is the total length (cm), *a* intercept, *b* is slope. The *t*-test was used to determine the growth type (Sokal & Rholf, 1987). The length-length relationship was calculated using liner regression analysis ($TL=a+bFL$, $FL=a+bSL$, $SL=a+bTL$). Condition factor (K)=(W/L^3)*100 formula using was calculated for female, male and all samples (Froese, 2006). In order to determine the sex ratio, gonads of all samples were examined by direct observation method. For all descriptive statistics and graphical drawings Excel was used (Microsoft Excel® 2010).

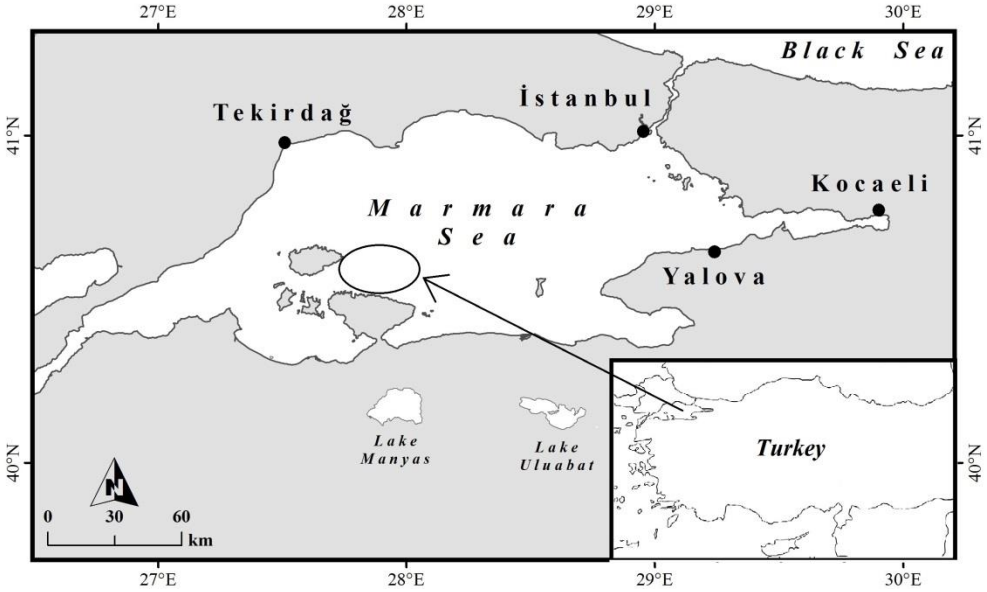

Figure 1. Sampling area.

Results

Length-frequency

The total length of the specimens varied between12.0-27.0 cm. However, the individuals included in the 18 cm length class were densely (26.99%) represented in the population (Figure 2).

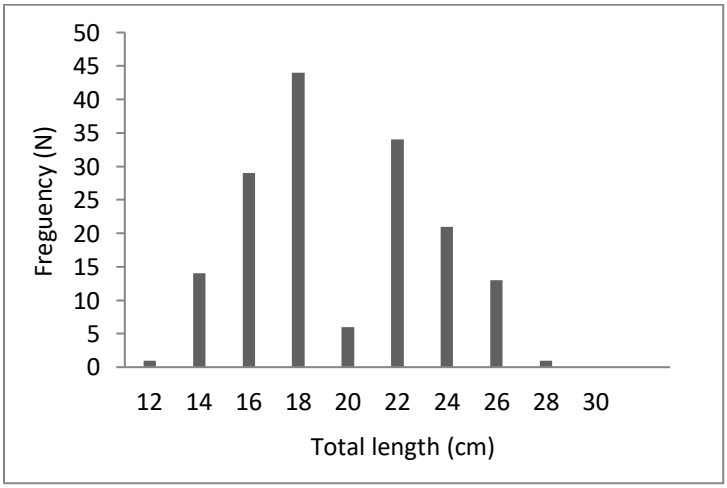

Figure 2. Total length frequency distribution of all *S. scombrus* specimens from Sea of Marmara.

Length-weight relationship

For all samples of *S. scombrus* (n=163), the length-weight relationship was calculated for male and female (Figure 3). It was determined that growth was positive allometric with *t test* ($b>3$; $P<0.05$).

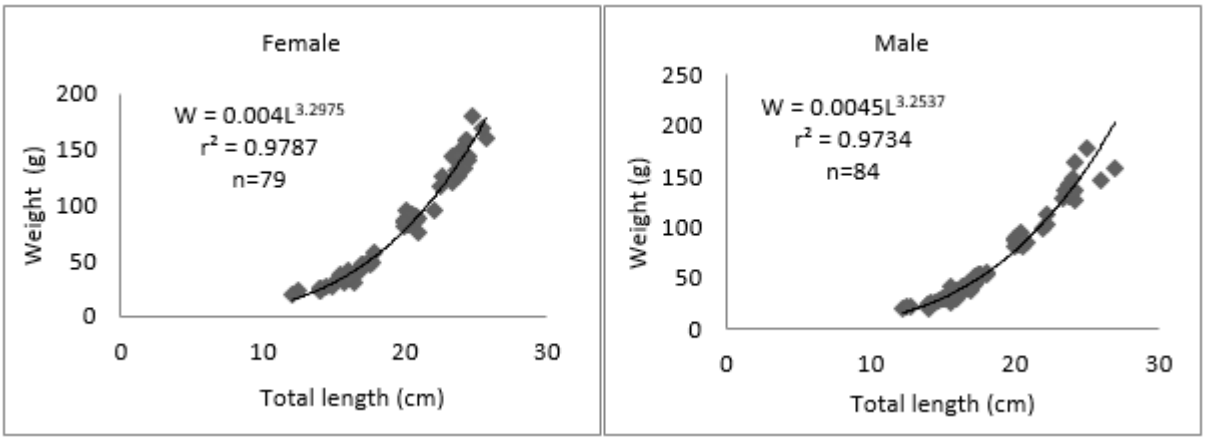

Figure 3. Length-weight relationship of *S. scombrus* specimen.

The relationship parameters for all samples were given in Table 1.

Table1. Length-weight relationship parameters of mackerel fish.

		Length (cm)		Weight (g)						
Sex		Min-max.	Mean±SD	Min-max.	Mean±SD	a	95%CI of b		SE(b)	r^2
F	79	12.0-25.7	19.3±0.79	20.0-179.9	78.3±4.78	0.0040	3.29	3.09-3.31	0.051	0.978
M	84	12.2-27.0	18.1±0.76	19.6-177.1	64.2±4.39	0.0045	3.25	3.17-3.30	0.041	0.973
F+M	163	12.0-27.0	18.7±0.79	19.6-179.9	71.0±4.58	0.0042	3.27	3.14-3.29	0.047	0.976

n: Number of individuals; F: female; M: male; SD: standard deviation; a: intercept b: slope; r^2: regression coefficient: CI: confidence intervals.

Length-length relationships

As the length-weight relationship, length-length relations were also found to be quite high ($P<0.05$). The lowest regression coefficient was found to be $r^2=0.89$ between fork length and standard length in the female samples. While the highest relationship was found to be $r^2=0.99$ in the male samples between fork length and standard length. Other calculated length-length relationships parameters were given in Table 2.

Table 2. Length-length relationships parameters of mackerel fish

	Length-length relationships parameters				
Sex	n	equations	a	b	r^2
		TL=a+bFL	0.89	0.68	0.96
Female	79	FL=a+bSL	1.21	0.89	0.89
		SL=a+bTL	0.25	0.86	0.91
		TL=a+bFL	1.51	0.83	0.97
Male	84	FL=a+bSL	0.03	1.06	0.99
		SL=a+bTL	1.43	0.78	0.98
		TL=a+bFL	1.02	0.87	0.97
Total	163	FL=a+bSL	0.98	1.00	0.93
		SL=a+bTL	0.76	0.83	0.94

n: Number of individuals; TL: total length (cm); FL: fork length (cm); SL: standard length (cm); a: intercept b: slope; r^2: regression coefficient.

Sex ratio

A total of 163 individuals, 84 (51.5%) male and 79 (48.4%) female, were sampled. The female male ratio (F:M) of the population was found to be 1:0.94. Differences between sexes were statistically insignificant (P>0.05).

Condition factor

The average of Fulton's condition factor for all sample individuals was calculated as 0.947±0.09. This rate was found to be 0.938±0.11 in females and 0.909±0.10 in males. The difference between male and female was statistically significant (P<0.05).

Discussion

The growth rate in fish is estimated by the calculated coefficient of growth. According to Bagenal & Tesch (1978), growth coefficient can vary between 2 and 4. If this value is *b*=3, the growth pattern is isometric, *b*<3 is negative allometric and *b*>3 is considered as positive allometric growth (Bagenal & Tesch 1978). Growth coefficient (*b*) gender, diet, gonadal development, presence of natural predators and even different populations of the same species may be different (Bagenal & Tesch, 1978). MacKay (1967) reported in his study that growth is associated with population density, and that the intensive population tends to grow more slowly than in sparse populations.

The growth coefficient for this study was calculated as *b*=3.27 and the growth (*b* >3; P <0.05) was found to be positive allometric growth. In a study conducted on 47 fish species in the North Aegean Sea, growth for *S. scombrus* species was found to be positive allometric (Karakulak et al., 2006). Study in the Gulf of Edremit and Aegean Sea growth for this species was reported to be positive allometric (Çakır et al., 2008; Özaydın & Taskavak, 2006). In this respect, it was determined that the results of these studies were similar in our findings. However, due to the different factors mentioned above, the growth pattern may be different for different populations of the same species (Cengiz, 2013; Santos et al., 2002). The previous study result was given in Table 3.

Table 3. Previous study of length-weight relationships parameters.

References		Length (cm)	Weight (g)	Length-weight relationship parameters			T	Locations
		Min-max.	Min-max.	a		r^2		
Santos et al. (2002)	245	19.6-45.6	51.0-886.0	0.0064	3.07	0.91	I	Algarve
Sinovčić et al. (2004)	630	17.3-41.4	46.5-533.7	0.0141	2.88	0.91	-	Adriatic Sea
Mendes et al. (2004)	181	-	-	0.0043	3.17	-	-	Portuguese Coast
Karakulak et al. (2006)	54	22.0-31.1	-	0.025	3.38	0.85	A+	North Aegean Sea
Özaydın &Taskavak (2006)	50	19.0-28.5	64.0-271.0	0.001	3.72	0.91	A+	Aegean Sea

İşmen et al. (2007)	100	13.6-24.0	15.0-95.0	0.0028	3.29	0.95	-	Saros Bay
Çakır (2008)	52	15.8-21.7	33.0-101.7	1.10^{-7}	3.81	0.98	A^+	Edremit Bay
Torres et al. (2012)	456	12.3-38.2	24.2-501.2	0.0016	3.43	0.95	A^+	Cadiz Gulf
Crec'hriou et al. (2012)	124	19.0-46.0	70.0-960.0	0.069	3.04	0.92	-	Catalan Coast
Bolognini et al. (2013)	835	10.0-38.5	7.0-548.0	0.002	3.39	0.96	A^+	Adriatic Sea
Cengiz (2013)	58	16.4-29.0	31.7-191.3	0.0061	3.08	0.94	I	Gallipoli Peninsula
Present study (2016)	163	12.0-27.0	19.6-179.9	0.0042	3.27	0.97	A^+	Sea of Marmara

n: Number of individuals; min: minimum; max.: maximum; GT: growth type (A^+: positive allometrik, A^-: negative allometrik, I: isometric); a: intercept; b: slope; r^2: regression coefficient.

Length-length relationships are also important in fisheries management for comparative growth studies (Moutopoulos & Stergiou, 2002). Thus, in present study all the length-length (LLRs) values were determined. The values for coefficient of determination (r^2) for all the length-length parameters of male, female and combine were $r^2>0.89$ and significant ($P< 0.05$). However, it was not found any results of research about length-length relationships of *S. scombrus* for the region. Therefore, it was not make any comparison.

There are many reasons that affect the Fulton's condition factor such as age, sex, gonadal development, different environmental factors, food supply, predators and sampling method (Farran, 1936; Deason & Hile, 1947; Brown, 1946). Fulton's condition factor showed significant variation for male and female individuals of *S. scombrus* ($P<0.05$). The reason of the difference between the sex groups of Futon's condition factors may be one of the reasons above mentioned.

Although the sex ratio (F:M) in most of the fish population was 1:1, this may vary from species to species and different populations of the same species (Nikolsky, 1980). In this study sex ratio (F:M) was found 1:0.94 and our results support this information.

Results of the research may use to be a reference for fish biologists and may contribute to the monitoring stocks of species for the region.

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