TÜBİTAK

Research Article

Turk J Zool
33 (2009) 157-167
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doi:10.3906/zoo-0805-26

Age, Growth, and Gonadosomatic Index (GSI) of Mediterranean Horse Mackerel (*Trachurus mediterraneus* Steindachner, 1868) in the Eastern Black Sea

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Received: 28.05.2008

Abstract: The aim of this study was to calculate the basic population parameters of *Trachurus mediterraneus* off the coast of the Eastern Black Sea. Average total length was estimated as 13.52 ± 1.884 cm for the entire population, 13.08 ± 1.594 cm for males, and 13.62 ± 1.804 for females. Average weight was 20.27 ± 8.819 g for the entire population, 18.65 ± 7.626 g for males, and 21.31 ± 9.184 g for females. Age of the fish ranged between 0 and 5 years. Length-weight, age-length, and age-weight relationships were estimated for the population, where $W = 0.0089 \times L^{2.9552}$; $L_t = 26.09\ (1 - e^{-0.125(t + 4.002)})$; and $W_t = 136.56\ (1 - e^{-0.125(t + 4.002)})$. Total mortality rates were $Z = 3.73\ year^{-1}$ and $M = 0.29\ year^{-1}$ for natural deaths, and $F = 3.44\ year^{-1}$ for fishing mortality.

Key Words: Mediterranean horse mackerel, *T. mediterraneus*, Eastern Black Sea, age, growth, gonadosomatic index (GSI)

Doğu Karadeniz'deki İstavrit (*Trachurus mediterraneus* Steindacner, 1868)'in, Yaş, Büyüme ve Gonadosomatik İndeks (GSİ)

Özet: Bu araştırma ile Doğu Karadeniz kıyılarındaki istavrit (*T. mediterraneus*) balığı populasyonuna ilişkin bazı temel parametrelerin tahmin edilmesi amaçlanmıştır. Elde edilen tüm örneklerin ortalama boyu 13,52 ± 1,884 cm, erkek ve dişilerde sırasıyla 13,08 ± 1,594 cm, 13,62 ± 1,804 cm olarak hesaplanmıştır. Ortalama ağırlıklar örneklerin tümü için 20,27 ± 8,819 g, erkeklerde 18,65 ± 7,626 g, dişilerde 21,31 ± 9,184 g olarak tespit edilmiştir. İncelenen örneklerdeki balıklar, 0-V yaş arasında dağılım göstermiştir. Dişiler ve erkekler için de maksimum yaş V bulunmuştur. Boy-ağırlık ilişkisi, yaş-boy ve yaş-ağırlık ilişkileri cinsiyetlerine göre belirlenmiş olup, genel olarak sırasıyla $W = 0{,}0089 \times L^{2{,}9552}$, $L_t = 26{,}09(1 - e^{-0{,}125(t + 4{,}002)})$ ve $W_t = 136{,}56\ (1 - e^{-0{,}125(t + 4{,}002)})$ şeklindedir. GSİ değerlerinin ağustos ayında pik yaptığı belirlenmiştir. Anlık Toplam Ölüm Oranı (Z) 3,73 $yıl^{-1}$, Anlık Doğal Ölüm Oranı (M) 0,29 $yıl^{-1}$, Avcılık Ölüm Oranı (F) 3,44 $yıl^{-1}$ olarak tespit edilmiştir.

Anahtar Sözcükler: İstavrit, *T. mediterraneus*, Doğu Karadeniz, yaş, büyüme, gonadosomatik indeks (GSİ)

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Introduction

Mediterranean horse mackerel (*Trachurus mediterraneus*) was the second most important species in the Black Sea in 1984, with an average of 23% (115,000 t) of the total catch (T.Ü.İ.K., 1986), which decreased to 6% (27,000 t) in 2004 (T.Ü.İ.K., 2004).

Early studies on Mediterranean horse mackerel related to their biological characteristics, morphology, and geographical distribution were conducted by Slastenenko (1956). There are a few references to their morphological and geographical distribution in which the small and large types are, in fact, different age groups within the same stock (Nümann, 1956; Ivanov and Beverton, 1985; Atay, 1985; Kosswig, 1995). Later, genetic and serological studies showed that there were 2 groups with different subgroups (Altukhov and Apeken, 1963). Otolith morphology, along with age and growth parameters, were studied by Karlou-Riga (2000), and reproduction biology was studied by Viette et al. (1996). Feeding habits of *T. mediterraneus* in the Adriatic Sea were studied by Santic et al. (2003), seasonal size distribution and condition status in the North Aegean Sea were studied by Tzıkas et al. (2007), and age distribution was studied by Waldron et al. (2001).

The age-length distribution, sex ratio, and muscle yield of *T. mediterraneus* in the Eastern Black Sea of Turkey was studied by Düzgüneş and Karaçam (1991), reproduction biology was studied by Şahin et al. (1997), feeding ecology and prey variety were studied by Kayalı (1998), and the distribution and abundance of eggs were studied by Mater and Cihangir (1997). In addition, stock structure identification using morphometric characteristics of Mediterranean horse mackerel in 3 adjacent seas was studied by Turan (2004). In order to better manage the stocks of economically important species, monitoring these stocks is essential. For this purpose, determining the bio-ecological characteristics of the stocks may be useful for stock sustainability. The purpose of the present study was to determine the stock structure and growth parameters of horse mackerel in the Eastern Black Sea, which have not been observed for approximately 10 years, and to recommend measures necessary to sustain stock levels by comparing them with previous studies.

Materials and Method

Samples were randomly collected from purse seine vessels off the coasts of Trabzon and Rize (Figure 1). Monthly samples were taken from July 2004 to July 2005 at these ports with a total of 1312 collected samples. The samples were put into containers and brought to the laboratory the same day they were collected. Using biometric measurements, each sample was measured with a ruler accurate to 0.01 mm and weighed to the nearest 0.01 g. The gonads were removed and weighed using a Mark model scale accurate to 0.01 mg.

Otoliths were kept in 70%, 80%, and 96% alcohol for 15 min to determine age. Afterwards, the organic tissue from the otoliths was removed and rinsed with distilled water, and then the samples were placed inside an oven and heated at 100-103 °C for 20 min to dry. The

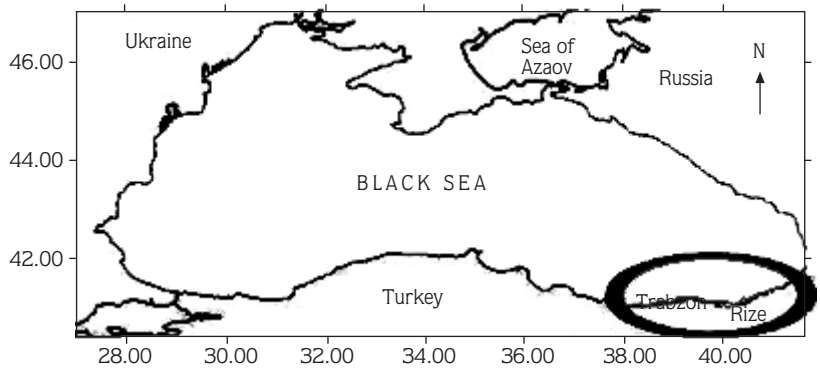

Figure 1. Research area.

samples were sanded down with 1200-grade sandpaper and then polished with an aluminum powder (0.05 mm). Age was determined using a stereomicroscope (Erkoyuncu, 1995; Avşar, 1998). The length-weight relationship was calculated using the following Ricker's formula (1975): $W = a.L^b$, where a and b are regressive constants, W is the total weight (g), and L is the total length (cm). The von Bertalanffy growth parameters were derived to determine growth (Pauly, 1983; Avşar, 1998) using the equation, $L_t = L_\infty(1 - e^{-k\,(t - t_0)})$, where L_∞ is asymptotic fish length (cm), L_t is length at age t (cm), k is the Brody growth coefficient, and t_0 is the theoretical age when the length equals zero. The growth constants were calculated using the Ford-Walford plot method with the following equations: $L_\infty = a/(1 - b)$; $k = -Ln(b)$; $t_0 = t + (1/k) \times Ln\,(1-(L_t/L_\infty))$. Weight increase of the fish over a period of time was determined using the equation $W_t = W_\infty(1 - e^{-k\,(t - t_0)})^b$, where W_t is the weight at age t (g) and W_∞ is asymptotic weight (g) (Pauly and Munro, 1984; Erkoyuncu, 1995; King, 1995; Avşar, 1998).

Instantaneous mortality rates were estimated based on $Z = k\,(L_\infty - L_m)/(L_m - L_c)$, where k is the growth constant, L_m is the average length of the fish already caught, and L_c is the length when first caught. Natural mortality rates were estimated using the equation $M = 0.8 \times \exp\,(-0.0152 - 0.279\ Ln\ L_\infty + 0.6543\ Ln\ K + 0.463\ LnT)$, where T is the average water temperature in the fishing area (°C) (Ricker, 1975; Nikolsky, 1980; King, 1995; Avşar, 1998; Bingel, 2002).

Fulton's condition factor equation, $K = (W/L^b) \times 100$, was used to calculate the condition factor (Htun-Han, 1978; King, 1995). In order to analyze gonad weight variation the gonadosomatic index (GSI) was calculated with the following relation:

$$GSI = (GW/W\text{-}GW) \times 100$$

where W is fish weight, and GW is gonad weight (King, 1995; Avşar, 1998)

Results

Length Composition

Length frequency distribution among the 1312 fish was determined for the entire research period (Figure 2); the shortest fish was 9.2 cm, while the longest was 19 cm. Distribution was very extensive between 12 cm and 12.9 cm which comprised 34% of the samples.

Generally, according to the length-frequency distribution, the majority (54%) of the Mediterranean horse mackerel caught were less than 13 cm long.

Sex Composition

Overall, the sex ratio was as follows: 1% immature, 68% female, and 31% male. Females were observed more frequently than males within all length groups and the difference was significant according to the χ^2 test ($P < 0.05$). Sex distribution in various length groups is given in Figure 3.

Growth

Length-weight relationships were determined for each sex (Figure 4). As a result of the statistical comparisons between length and weight according to sex, there were no differences ($P > 0.05$) observed.

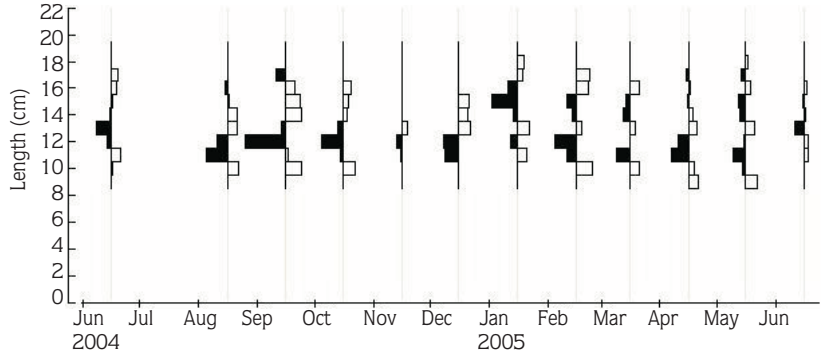

Figure 2. Monthly length-frequency distribution.

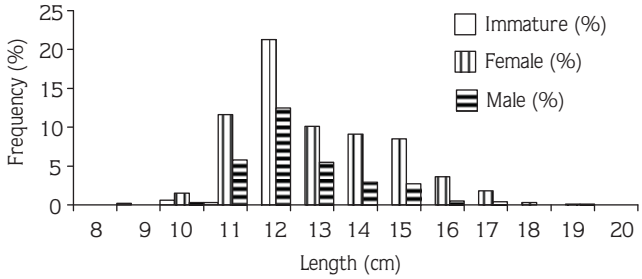

Figure 3. Sex distribution of length groups.

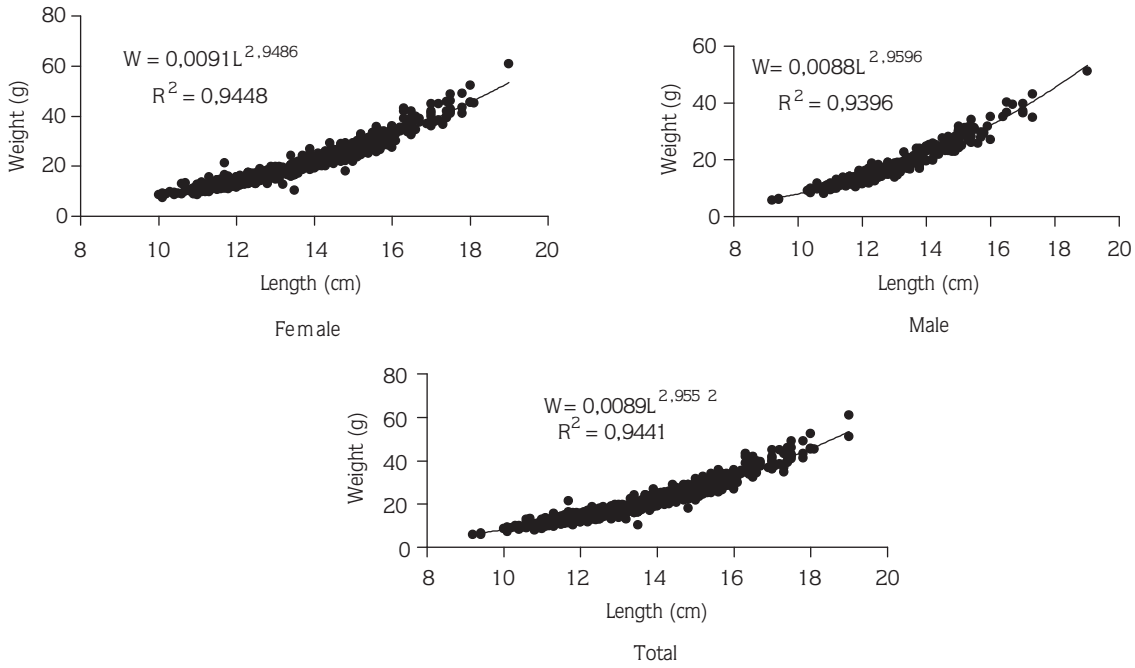

Figure 4. Length-weight relationships.

Age Composition and Growth Parameters

The otoliths of 632 fish were observed under a stereoscopic microscope and 0-5-year-old age groups were determined as summarized in Table 1.

The shortest length at maturity was 10.6 cm, corresponding to 1-year-old fish. Generally, average length and weight of the samples were 13.52 ± 1.884 cm and 20.27 ± 8.819 g, respectively (Table 1). When the average lengths and weights of all the samples whose ages had been determined were taken into consideration, the males were smaller than the females. As a result of the t-tests conducted to compare the lengths and weights of each age group, there were no statistically significant differences observed ($P > 0.05$).

Growth constants and equations giving the length and weight of the fish at each age were determined using ages according to sex and average lengths (Table 2).

Relationships between the average lengths and weights of the total samples are provided in Figure 5 below.

Condition Index

In order to determine the time and period of sexual maturity of the population and seasonal changes in nutrition, condition indices of the samples were taken monthly and tested. Monthly condition factors were calculated separately for both males and females (Tables 3 and 4, and Figure 6).

Table 1. Sex, average length, average weight, and standard deviation (SD) of the samples (f: female; m: male; i: immature).

Age	Sex	Frequency		Average Length (cm) ± SD	Average Weight (g) ± SD
		n	%		
0	I	8	0.80	10.45 ± 0.721	8.96 ± 2.251
	F	22	3.48	10.70 ± 0.342	9.74 ± 1.547
	M	3	0.47	10.58 ± 0.613	9.66 ± 1.990
	F+M+I	33	5.22	10.61 ± 0.477	9.67 ± 1.763
1	F	138	28.34	12.67 ± 0.409	13.72 ± 1.863
	M	63	14.73	12.64 ± 0.479	13.87 ± 1.721
	F+M	201	43.07	12.66 ± 0.451	13.76 ± 1.842
2	F	138	23.12	13.98 ± 0.821	19.74 ± 4.564
	M	64	9.66	13.65 ± 0.930	18.90 ± 4.176
	F+M	202	32.78	13.77 ± 0.896	19.21 ± 4.347
3	F	134	14.49	15.09 ± 0.750	29.77 ± 5.575
	M	29	4.04	15.49 ± 0.752	27.95 ± 4.843
	F+M	163	18.53	15.36 ± 0.753	28.97 ± 5.723
4	F	26	2.13	16.75 ± 0.861	38.36 ± 6.183
	M	5	0.32	16.67 ± 0.836	38.50 ± 3.849
	F+M	31	2.45	16.74 ± 0.821	38.31 ± 4.917
5	F	1	0.08	19.00	60.812
	M	1	0.08	18.80	52.785
	F+M	2	0.16	18.90	56.79 ± 6.788
Total/Average	F	459	72.62	13.62 ± 1.804	21.31 ± 9.184
	M	165	27.38	13.08 ± 1.594	18.65 ± 7.626
	F+M+I	632	100.00	13 52 ± 1.884	20.27 ± 8.819

Table 2. Growth parameters of *Trachurus mediterraneus*.

Parameters	Female	Male	General
L_∞	28.19	24.00	26.09
k	0.105	0.150	0.125
t_0	–4.524	–3.607	–4.002
W_∞	171.70	106.99	136.56
L_t=	$28.19 \times (1 - e^{-0.105(t + 4.524)})$	$24.00 \times (1 - e^{-0.150(t + 3.607)})$	$26.09 \times (1 - e^{-0.125(t + 4.002)})$
$W_{t=}$	$171.70 \times (1 - e^{-0.105(t + 4.524)})^b$	$106.99 \times (1\text{-}e^{-0.150(t + 3.607)})^b$	$136.56 \times (1 - e^{-0.125(t + 4.002)})^b$

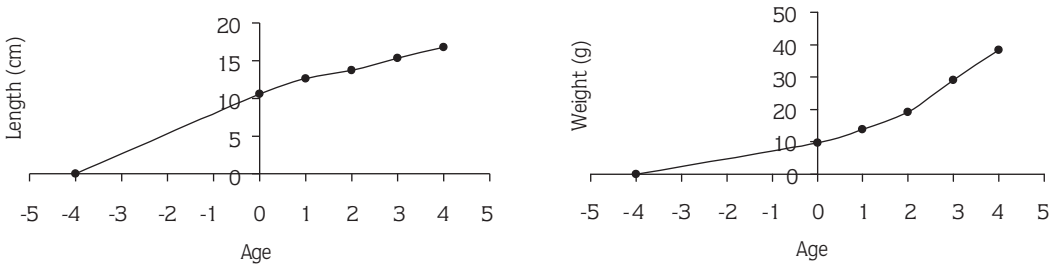

Figure 5. General age-length and age-weight relationships.

Table 3. Monthly condition factors and standard deviations (SD) for females.

Month	n	Average Weight (g) ± SD	Average Length (cm) ± SD	Condition Factor ± SD
June	25	20.733 ± 7.392	13.692 ± 1.542	0.895 ± 0.112
August	24	16.902 ± 5.126	12.352 ± 1.362	1.007 ± 0.095
September	180	16.391 ± 3.478	12.600 ± 0.786	0.923 ± 0.056
October	52	18.259 ± 5.076	12.984 ± 1.187	0.931 ± 0.055
November	58	18.561 ± 5.875	13.181 ± 1.264	0.898 ± 0.064
December	50	14.881 ± 3.816	12.364 ± 0.927	0.883 ± 0.103
January	102	30.392 ± 8.784	15.440 ± 1.355	0.923 ± 0.074
February	127	18.454 ± 6.660	13.183 ± 1.490	0.886 ± 0.081
March	114	20.257 ± 6.758	13.663 ± 1.583	0.877 ± 0.106
April	64	17.756 ± 9.469	12.893 ± 1.893	0.876 ± 0.069
May	61	22.266 ± 11.732	13.640 ± 2.349	0.916 ± 0.066
June	36	24.272 ± 6.318	14.150 ± 1.429	0.964 ± 0.083
Total/Average	893	19.927 ± 6.457	13.345 ± 1.430	0.914 ± 0.080

Table 4. Monthly condition factors and standard deviations (SD) for males.

Month	n	Average Weight (g) ± SD	Average Length (cm) ± SD	Condition Factor ± SD
June	17	20.571 ± 6.500	13.538 ± 1.472	0.815 ± 0.067
August	5	14.623 ± 0.946	11.861 ± 0.357	0.969 ± 0.060
September	153	16.246 ± 4.656	12.652 ± 1.013	0.875 ± 0.056
October	49	18.488 ± 5.363	13.093 ± 1.100	0.893 ± 0.072
November	37	19.801 ± 7.236	13.307 ± 1.244	0.892 ± 0.083
December	21	13.824 ± 3.068	12.190 ± 0.707	0.832 ± 0.051
January	26	26.773 ± 5.321	15.051 ± 0.968	0.868 ± 0.070
February	25	17.435 ± 6.256	12.962 ± 1.491	0.855 ± 0.060
March	21	16.615 ± 5.162	12.828 ± 1.373	0.853 ± 0.078
April	18	18.330 ± 7.882	13.111 ± 1.651	0.854 ± 0.077
May	17	23.992 ± 9.298	14.329 ± 1.973	0.831 ± 0.050
June	15	22.891 ± 6.605	13.793 ± 1.284	0.947 ± 0.091
Total/Average	404	19.132 ± 5.691	13.226 ± 1.219	0.876 ± 0.067

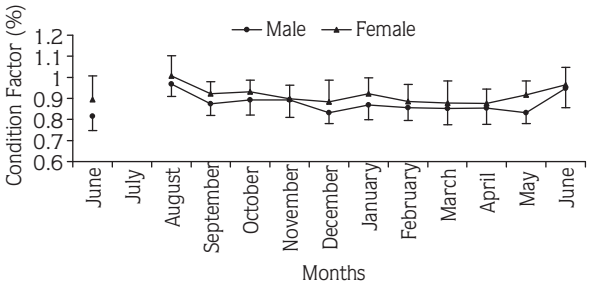

Figure 6. Monthly condition distribution.

Excluding July, in which sampling was not performed, the monthly condition factor was the highest (1.007 ± 0.095) during August 2004. Compared to other months of the year, higher condition factors were observed during the period from June to September 2004, a period that included August 2004. Condition factors did not vary significantly during the remainder of the year.

The same tendency was observed for males; the maximum value was 0.969 ± 0.060 in August and the minimum of 0.831 ± 0.050 was in May.

GSI

GSI of the samples was calculated monthly, and a peak was observed between June and September (Tables 5 and 6).

During monthly observations the maximum value for females, calculated in August, was 2.368 ± 0.890 and the minimum value was 0.680 ± 0.451, in April (Table 5). For males the maximum value was 1.756 ± 0.049, in August, and the minimum value was 0.300 ± 0.188, in February (Table 6 and Figure 7).

Mortality Rates

The natural mortality rate (M) was calculated for the sampling area using von Bertalanaffy growth parameters and average water temperature (16.15 ± 6.713 °C), according to Pauly (1983). Monthly water temperature was provided from the State Meteorological Service: $M = 0.8 \times \exp(-0.0152 - 0.279\, L_n 29.06 + 0.6543\, L_n 0.125 + 0.463\, L_n 16.15) = 0.29\ year^{-1}$. Total instantaneous

Table 5. Monthly GSI and standard deviations (SD) for females.

Months	n	Live Weight ± SD	Gonad Weight ± SD	GSI ± SD
June	25	20.733 ± 7.392	0.183 ± 0.140	0.895 ± 0.480
August	24	16.969 ± 5.225	0.392 ± 0.160	2.368 ± 0.890
September	180	16.304 ± 3.392	0.159 ± 0.056	0.987 ± 0.326
October	52	18.259 ± 5.076	0.140 ± 0.306	0,775 ± 1.344
November	58	18.561 ± 5.875	0.156 ± 0.083	0.853 ± 0.497
December	50	14.663 ± 3.525	0.119 ± 0.155	0.822 ± 1.345
January	102	30.392 ± 8.784	0.209 ± 0.182	0.694 ± 0.498
February	127	18.454 ± 6.660	0.142 ± 0.117	0.779 ± 0.497
March	114	20.257 ± 6.758	0.185 ± 0.123	0.924 ± 0.531
April	64	17.756 ± 9.469	0.119 ± 0.093	0.680 ± 0.451
May	61	22.266 ± 11.732	0.214 ± 0.239	0.971 ± 0.605
June	36	24.272 ± 6.318	0.276 ± 0.091	1.153 ± 0.439
Total/Average	893	19.907 ± 6.683	0.191 ± 0.145	0.991 ± 0.658

Table 6. Monthly GSI and standard deviations (SD) for males.

Months	n	Live Weight ± SD	Gonad Weight ± SD	GSI ± SD
June	17	20.571 ± 6.500	0.166 ± 0.067	0.817 ± 0.194
August	5	14.623 ± 0.946	0.252 ± 0.008	1.756 ± 0.049
September	153	16.246 ± 4.656	0.093 ± 0.044	0.578 ± 0.299
October	49	18.488 ± 5.363	0.112 ± 0.249	0.614 ± 0.595
November	37	19.801 ± 7.236	0.168 ± 0.128	0.791 ± 0.387
December	22	13.824 ± 3.068	0.078 ± 0.063	0.534 ± 0.282
January	26	26.773 ± 5.321	0.104 ± 0.059	0.404 ± 0.240
February	25	17.435 ± 6.256	0.055 ± 0.051	0.300 ± 0.188
March	21	16.615 ± 5.162	0.105 ± 0.087	0.608 ± 0.387
April	18	18.330 ± 7.882	0.092 ± 0.078	0.473 ± 0.262
May	17	23.992 ± 9.298	0.240 ± 0.213	0.878 ± 0.586
June	15	22.891 ± 6.605	0.203 ± 0.156	0.896 ± 0.488
Total/Average	404	19.132 ± 5.691	0.139 ± 0.100	0.720 ± 0.371

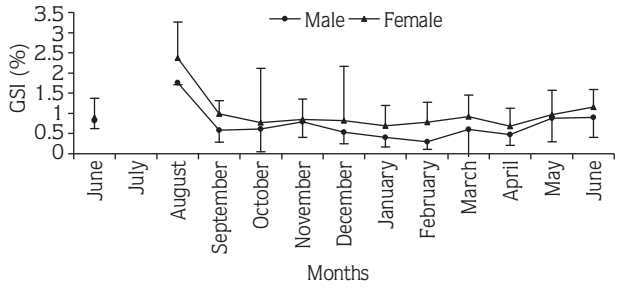

Figure 7. Monthly GSI distribution.

mortality rates (Z) were determined using the lengths of the first catch (L_c = 13 cm) that were announced in fishery circulars as the minimum catch length allowed by the General Directorate of Protection and Control of the Ministry of Agriculture and Rural Affairs (MARA). The total instantaneous mortality rate was calculated using the Beverton and Holt (1957) method: Z = 0.125 (29.06 – 13.52)/(13.52 – 13) = 3.73 year^{-1}. The instantaneous fishing mortality rate (F) was calculated using the components of the total instantaneous mortality rate: (Z = F + M), where F = 3.44.

Discussion

Based on production, the Mediterranean horse mackerel is the second most important species for Turkish fisheries (TUIK, 2004). The catch was 115,000 t in 1989, but dropped sharply to 30,000 t after 1991 due to comb jellyfish, pollution, and overfishing (TUIK, 1989, 1991). In order to provide updated information on the exploited stock, the present study was conducted between June 2004 and June 2005. Fish length during this study ranged between 9.2 cm and 19 cm, while weight varied between 7.263 g and 60.812 g. According to length groups, the majority of fish were shorter than 13 cm (54%), at which size the fish are considered undersized and cannot be caught. In a previous study carried out in the same region this range was 64% and 49% during the 1991-1992 and 1996-1997 fishing seasons, respectively (Genç et al., 1998; Kayalı, 1998). Later it was reported that 60% of the catch was below the legal size limit (Kalaycı, 2006). Seemingly, over time the recruitment rate has decreased due to overfishing when compared to other stocks. Changes in average length in successive years indicate overfishing. During the 1991-92 fishing season the average length and weight were 11.80 cm and 14.76 g, increasing to 12.47 cm and 22.39 g during 1996-97. Increases in the total length and weight in this study (13.52 ± 1.884 cm and 19.10 ± 8.819 g) demonstrate ongoing improvement during the last 15 years, though this is not reflected in total production (Genç et al., 1998; Kayalı, 1998; Samsun et al., 2006).

Age analysis of fish is paramount in defining the population structure. In the present study age was determined using the otoliths of fish aged 0-5 years, as

defined by the samples observed. Average length and weight of fish of different ages were compared with the ages provided by the Ministry of Agriculture Project and by the FİSAT method during the 1991-1992 and 1996-1997 seasons, respectively (Genç et al., 1998; Kayalı, 1998) (Table 7).

The condition factors did not vary significantly during the rest of months of the year. There were no significant differences between the ages shown in Table 7 and the corresponding lengths and weights of the fish ($P > 0.05$) ($Ft (2\text{-}13; 0.05) = 3.81$; $Fh = 1.8117$).

Sex growth parameters of *Trachurus mediterraneus* were compared with the results of other research studies (Table 8).

When the growth parameters are compared with those of other studies (Genç et al., 1998), we can see that they have similarly reliable limits ($P > 0.05$). As observed, the difference in a and b values was not statistically significant. According to our statistical analysis, the b coefficient (2.87-3.025) varied within confidence limits (95%).

In all, 1% of the fish were immature, 68% were female, and 31% were male. A significant difference was observed between males and females according to the χ^2 test ($P < 0.05$) ($\chi^2_{h\ (9;0.05)} = 10{,}660$; $\chi_t^2 = 16.92$). The shortest mature Mediterranean horse mackerel was 10.4 cm. In the present study the sex ratio (male to female) of *T. mediterraneus* was 1:2; in another study conducted in this region it was 1:1 (Genç et al., 1998), and in yet

Table 7. Age of *Trachurus mediterraneus* in earlier studies.

	Current Study (± SD)		Kayalı (1998)		Genç et al. (1998)	
Age	Average Length (cm)	Average Weight (g)	Average Length (cm)	Average Weight (g)	Average Length (cm)	Average Weight (g)
0	10.61 ± 0.477	9.67 ± 1.763	8.31	5.51	-	-
1	12.66 ± 0.451	13.76 ± 1.842	10.39	12.30	11.73	11.32
2	13.77 ± 0.896	19.21 ± 4.347	13.77	26.96	13.83	20.80
3	15.36 ± 0.753	28.97 ± 5.723	16.14	39.59	15.57	29.52
4	16.74 ± 0.821	38.31 ± 4.917	-	-	16.89	38.88
5	18.90	56.79 ± 6.788	-	-	18.35	52.61
6	-	-	-	-	19.20	65.19

Table 8. Growth parameters of *Trachurus mediterraneus*.

	Growth Parameters								
	L_∞			k			t_0		
Regions Researched	F	M	F+M	F	M	F+M	F	M	F+M
Kayalı (1998) E. Black Sea	39.54	38.96	38.85	0.099	0.087	0.100	–2.294	–2.713	–2.302
Karlou-Riga (2000) Aegean	-	-	37.24	-	-	0.326	-	-	–0.842
Genç et al. (1998) E. Black Sea	20.62	19.88	24.52	0.356	0.396	0.177	–1.110	–1.024	–2.678
Current Study E. Black Sea	28.19	24.00	26.09	0.105	0.150	0.125	–4.524	–3.607	–4.002

another study the percentages were 60.5% female and 39.5% male (Kayalı, 1998).

According to the GSI and the condition index values, the spawning period started in the beginning of July and continued until early September. In other studies carried out in the same region the spawning period was from 15 May to 15 August (Slastenenko, 1956; Ivanov and Beverton, 1985) and from June to September (Genç et al., 1998). The maximum female GSI values were 4.90 in July, 3.29 in August, and 1.04 in September (Genç et al., 1998). In the present study the female GSI was 2.368 ± 0.890 in August and 0.987 ± 0.326 in September; the spawning periods were very close to each other.

The instantaneous fishing mortality coefficient (F) was 3.44 year^{-1}, conclusively indicative of overfishing. According to Beverton and Holt (1957), excessive fishing was determined by observing samples with an average length of 13.52 cm, while the fishing length was 13.00 cm.

Conclusion

Data obtained from the present and previous studies show that continuous fishing is putting pressure on the stocks of Mediterranean horse mackerel, as seen in the length and age composition, and fishing mortality rates. The production of 115,000 t in 1989 fell sharply to 30,000 t through 2004 because of harvesting immature fish. In order to increase production levels, efficacious monitoring, control, and surveillance systems are necessary. To sustain the stocks, alternative fishing methods, such as gill netting rather than indiscriminate purse seines, should be encouraged. Furthermore, fishing efforts and fishing gear must be optimized.

Acknowledgements

This study was financially supported by the Scientific Research Fund of Karadenız Technical University. We would also like to thank Prof. Dr. Ertuğ Düzgüneş for his invaluable comments about this study.

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