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

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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} (r²=0.978) for females, W=0.0045L^{3.2537} (r²=0.973) for males and W=0.0042L^{3.2782} (r²=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: r²=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
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 & Egaderi, 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.TLb (Ricker, 1979). This can be expressed in linear form after logarithmic transformation by log W=a+blog TL 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 & Rolf, 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).
Results

Length-frequency

The total length of the specimens varied between 12.0-27.0 cm. However, the individuals included in the 18 cm length class were densely (26.99%) represented in the population (Figure 2).

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.

Table 1. Length-weight relationship parameters of mackerel fish.

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>Min-max. (cm)</th>
<th>Mean±SD</th>
<th>Min-max. (g)</th>
<th>Mean±SD</th>
<th>a</th>
<th>95%CI of b</th>
<th>SE(b)</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>79</td>
<td>12.0-25.7</td>
<td>19.3±0.79</td>
<td>20.0-179.9</td>
<td>78.3±4.78</td>
<td>0.0040</td>
<td>3.29-3.31</td>
<td>0.051</td>
<td>0.978</td>
</tr>
<tr>
<td>M</td>
<td>84</td>
<td>12.2-27.0</td>
<td>18.1±0.76</td>
<td>19.6-177.1</td>
<td>64.2±4.39</td>
<td>0.0045</td>
<td>3.25-3.30</td>
<td>0.041</td>
<td>0.973</td>
</tr>
<tr>
<td>F+M</td>
<td>163</td>
<td>12.0-27.0</td>
<td>18.7±0.79</td>
<td>19.6-179.9</td>
<td>71.0±4.58</td>
<td>0.0042</td>
<td>3.27-3.29</td>
<td>0.047</td>
<td>0.976</td>
</tr>
</tbody>
</table>

n: Number of individuals; F: female; M: male; SD: standard deviation; a: intercept; b: slope; r²: 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 r²=0.89 between fork length and standard length in the female samples. While the highest relationship was found to be r²=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

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>equations</th>
<th>a</th>
<th>b</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>79</td>
<td>TL=a+bFL</td>
<td>0.89</td>
<td>0.68</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL=a+bSL</td>
<td>1.21</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL=a+bTL</td>
<td>0.25</td>
<td>0.86</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TL=a+bFL</td>
<td>1.51</td>
<td>0.83</td>
<td>0.97</td>
</tr>
<tr>
<td>Male</td>
<td>84</td>
<td>FL=a+bSL</td>
<td>0.03</td>
<td>1.06</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL=a+bTL</td>
<td>1.43</td>
<td>0.78</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TL=a+bFL</td>
<td>1.02</td>
<td>0.87</td>
<td>0.97</td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>FL=a+bSL</td>
<td>0.98</td>
<td>1.00</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL=a+bTL</td>
<td>0.76</td>
<td>0.83</td>
<td>0.94</td>
</tr>
</tbody>
</table>
n: Number of individuals; TL: total length (cm); FL: fork length (cm); SL: standard length (cm); a: intercept b: slope; r²: 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.**

<table>
<thead>
<tr>
<th>References</th>
<th>Length (cm)</th>
<th>Weight (g)</th>
<th>Length-weight relationship parameters</th>
<th>T</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min-max.</td>
<td>Min-max.</td>
<td>a</td>
<td>r²</td>
<td></td>
</tr>
<tr>
<td>Santos et al. (2002)</td>
<td>245</td>
<td>19.6-45.6</td>
<td>51.0-886.0</td>
<td>0.0064</td>
<td>3.07 0.91 I</td>
</tr>
<tr>
<td>Sinovčić et al. (2004)</td>
<td>630</td>
<td>17.3-41.4</td>
<td>46.5-533.7</td>
<td>0.0141</td>
<td>2.88 0.91 -</td>
</tr>
<tr>
<td>Mendes et al. (2004)</td>
<td>181</td>
<td>-</td>
<td>-</td>
<td>0.0043</td>
<td>3.17 -</td>
</tr>
<tr>
<td>Karakulak et al. (2006)</td>
<td>54</td>
<td>22.0-31.1</td>
<td>-</td>
<td>0.025</td>
<td>3.38 0.85 ^A+</td>
</tr>
<tr>
<td>Özaydın &amp; Taskavak (2006)</td>
<td>50</td>
<td>19.0-28.5</td>
<td>64.0-271.0</td>
<td>0.001</td>
<td>3.72 0.91 ^A+</td>
</tr>
</tbody>
</table>
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 (r²) for all the length-length parameters of male, female and combine were r² > 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 Fulton’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.

References


