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# Mortalities and Exploitation Rate of Mediterranean Horse Mackerel, *Trachurus mediterraneus* (Steindachner, 1868) in the Central Black Sea

# Orta Karadeniz'deki İstavrit, *Trachurus mediterraneus* (Steindachner, 1868) Balığının Ölüm ve Sömürülme Oranları

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## ABSTRACT

This study provides some actual information about length, weight, age, and mortality rates of Mediterranean horse mackerel (*Trachurus mediterraneus*) population in the central Black Sea in order to detect whether fishing pressure or not. A total of 1467 specimens were monthly collected from commercial purse-seiners, which especially landed to Sinop fishing port between September 2016 and March 2017. A total of 109 otoliths were used for age reading. Total length and weight of *T. mediterraneus* specimens were ranged from 7.1 cm to 20.3 cm (average: 14.02 ±0.04 cm) and 3.2 g to 67.7 g (average: 23.8 ±0.19 g). The samples were grouped densely between 12 and 15 cm and about 84% of samples in this study were within the legal size. Length-weight relationship was calculated as $W = 0.0067 \times TL^{3.0848}$ ($r^2 = 0.94$). Age groups of horse mackerel in the central Black Sea were between I and III. Mean lengths according to age groups were 9.9 ±0.36 cm, 14.1 ±0.11 cm and 16.7 ±0.13 cm, respectively. Also, von Bertalanffy Growth Parameters were $L_\infty$ = 19.14 ±0.46 cm, K = 0.65 ±0.03, $t_0$ = -0.08 ±0.007 year. Mortalities (M, F and Z) and exploitation rate (E) of *T. mediterraneus* from the Central Black Sea were 0.84 $year^{-1}$, 0.87 $year^{-1}$, 1.712 $year^{-1}$ and 0.51 $year^{-1}$, respectively. The rates of exploitation and minimum landing size indicate that there is no overfishing on *T. mediterraneus* population in the area for the time being.

**Keywords:** Atlantic horse mackerel, *Trachurus mediterraneus*, length, weight, exploitation, Black Sea

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## ÖZET

Bu çalışma orta Karadeniz Bölgesindeki istavrit (*Trachurus mediterraneus)* popülasyonu üzerinde balıkçılık baskısı olup olmadığının tespiti amacıyla tür üzerindeki boy, ağırlık, yaş ve ölüm oranları gibi güncel bilgileri içermektedir. Toplamda 1467 adet birey Eylül 2016 ve Mart 2017 tarihleri arasında özelikle Sinop Limanı'ndaki ticari gırgır teknelerinden aylık olarak toplanmıştır. 109 adet bireyden yaş okumak amacıyla otolit çıkarılmıştır. *T. mediterraneus* bireylerinin boy dağılımları 7,1 cm ile 20,3 cm (ortalama: 14,02 ±0,04 cm) arasında değişmekte iken ağırlık dağılımlarının 3,2 g ile 67,7 g (ortalama: 23,8 ±0,19 g) arasında olduğu tespit edilmiştir. Örnekler 12-15 cm boy grupları arasında yoğunlaşmış ve elde edilen bireylerin %84'ünün yasal avlanma boy değerinin üzerinde olduğu tespit edilmiştir. Boy-ağırlık ilişkisi $W = 0{,}0067 \times TL^{3.0848}$ ($r^2 = 0{,}94$) olarak tespit edilmiştir. Örnekler I ile III yaş gurubu arasında dağılım göstermektedir. Yaşlara göre ortalama boylar I. yaş için 9,9 ±0,36 cm; II. yaş için 14,1 ±0,11 cm; III. yaş için 16,7 ±0,13 cm dir. von Bertalanffy Büyüme parametreleri ise $L_\infty$ = 19,14 ±0,46 cm, K = 0,65 ±0,03, $t_0$ = -0,08 ±0,007 yıl olarak hesaplanmıştır. Orta Karadeniz'den elde edilen *T. mediterraneus* bireylerinin doğal ölüm oranı (M) 0,84 $yıl^{-1}$, Balıkçılık kaynaklı ölüm oranı 0,87 $yıl^{-1}$ ve toplam ölüm oranı 1,712 $yıl^{-1}$ olarak hesaplanmıştır. Sömürülme oranı (E) ise 0,51 $yıl^{-1}$ olarak tespit edilmiştir. Sömürülme oranı ve karaya çıkarılan ürünlerin boy gruplarına bakıldığında şu an için bu bölgede *T. mediterraneus* popülasyonu üzerinde bir av baskısının olmadığı söylenebilir.


**Anahtar sözcükler**: İstavrit, *Trachurus mediterraneus*, boy, ağırlık, sömürülme, Karadeniz.

## 1. INTRODUCTION

Mediterranean horse mackerel (Family Carangidae) are pelagic-oceanic active migratory fish and swims in large schools in mid-water but feeds also near the bottom. They feed on crustaceans (mainly shrimps and mysids) and schooling fish such as sardines and anchovies. Common length is 30 cm and maximum length is 60 cm FL (Golani et al., 2006; Froese and Pauly, 2017). Distribution is in Eastern Atlantic: Bay of Biscay to Mauritania including the Mediterranean Sea (Froese and Pauly, 2017).

*Trachurus mediterraneus* (Steindachner, 1868) is common in all Turkish seas; it also inhabits in the Black Sea and the Sea of Azov. *T. mediterraneus* is a very commercial fish species along the coasts of Black Sea. Its fishing is conducted with different fishing gears including pelagic trawl, set nets, purse seine, and hand line (Aydın and Karadurmuş, 2013).

Total catch amount of Mediterranean horse mackerel (including Atlantic horse mackerel, *Trachurus trachurus*) in the Black Sea in 2016 was about 7349 tons. Catch amount of both horse mackerels in the Black Sea is 2/3 in all horse mackerel (as *T. mediterraneus* and *T. trachurus*) production of Turkey (TUIK, 2017). It is seen that there is an intensive fishing on horse mackerel stocks in the Black Sea. Thus, this study provides some actual information such as length, weight, age and mortality rates of Mediterranean horse mackerel population in the southern Black Sea in order to detect whether fishing pressure or not.

## 2. MATERIAL AND METHOD

A total of 1467 specimens of *T. mediterraneus* from the Black Sea were monthly collected from commercial purse-

seiners, which especially landed to Sinop fishing port between September 2016 and March 2017.

Total length (TL) of fish has been measured to nearest ± 0.1 cm and ± 0.1 g. Length-weight relationship (LWR) was computed from the following formula: $W = a \times TL^b$. The logarithmic transformation was performed as $\log W = \log a + b \log L$ where W is weight (g), L is length (cm), *a* is the intercept and *b* is the slope of the linear regressions.

A total of 109 otoliths were used for ageing. Sagittal otoliths were removed, wiped clean, and stored dry, and then otoliths were placed in glycerol and were examined (10X magnification) under reflected light using a binocular microscope (SOIF XSZ-7GX).

Non-seasonal growth parameters ($L_\infty$, K, and $t_0$) were estimated with the von Bertalanffy growth formula (VBGF) in the FAO–ICLARM Stock Assessment Tools (FISAT II) computer program (FAO, 2006-2008) using individual lengths-at-age. The von Bertalanffy growth equation for length, $L_t = L_\infty\left[1 - e^{-K(t-t_0)}\right]$, where $L_\infty$ is the asymptotic length, K the growth curve parameter, and $t_0$ the theoretical age when fish length would have been zero, was applied.

Natural mortality of Mediterranean horse mackerel was computed from Pauly (1980)'s following multiple regression formula: $\ln M = -0.0152 - 0.279 * \ln L_\infty + 0.6543 * \ln K + 0.463 * \ln T$. But Pauly (1983) proposed that the formula can be calculated lower percent 20 for schooling fishes. The converted formula: $M = 0.8 * \exp(-0.0152 - 0.279 * \ln L\infty + 0.6543 * \ln K + 0.463 * \ln T)$. Where M is natural mortality in a given stock, $L_\infty$ is asymptotic length, K is growth coefficient and the value of T is the annual mean temperature (in ºC) of the sea water. The mean annual habitat temperature (according to World Sea Temperatures, 2018) is assumed as 13ºC.

Total mortality (Z) was estimated from the mean size in the catch, developed by Beverton and Holt (1957). Z can be estimated from mean length in the catch from a given population by means of $Z = K (L_\infty - L_{mean}) / (L_{mean} - L_c)$. Where $L_\infty$ and K are parameters of the von Bertalanffy growth equations; Erkoyuncu (1995) stated that if $L_c$ is not available, L' can use in the formula instead of the $L_c$, i.e. $L_c = L'$. $L_{mean}$ is the mean length computed from L' upward, the latter being a length not smaller than the smallest length of fish fully represented in catch samples (Pauly and Soriano, 1986). Note that L' is the lower limit of the corresponding length interval (Sparre and Venema, 1992).

Fishing mortality (F) can be estimated from F=Z-M. Once values of F and M are available, an exploitation ratio (E) can be computed from E = F / Z (Sparre and Venema, 1992). Which allows one to assess if a stock is overfished or not, on the assumption that the optimal value of E ($E_{opt}$) is about equal to 0.5 (Pauly, 1980).

The null hypothesis of isometric growth ($H_0$: b = 3) was tested by t-test, using the statistic: ts= (b-3)/Sb, where Sb is the standard error of the slope for $\alpha = 0.05$ (Sokal and Rohlf, 1987). The difference between the observed mean lengths and calculated mean lengths in all age groups was tested by Paired Sample t-test (Zar, 1999). The comparisons of growth performance indices were also performed by unpaired two-tailed t- tests. The significance level α for a given hypothesis in all statistical tests performed in this text is at 0.05. All of the means were given with standard error (± SE). All calculations were performed using the IBM SPSS Statistics Ver. 20 software package.

## 3. RESULTS

Length and weight of Mediterranean horse mackerel specimens were ranged from 7.1 cm to 20.3 cm (average: 14.02 ±0.04 cm)

and 3.2 g to 67.7 g (average: 23.8 ±0.19 g). The samples were grouped densely between 12 and 15 cm in this study were within the legal size (Figure 1).
Minimum landing size (MLS) is 13 cm for *T. mediterraneus* according to Turkish Fisheries Regulation Circular (TFRC). Thus, 84% of all samples in this study are over legal size (Figure 2).

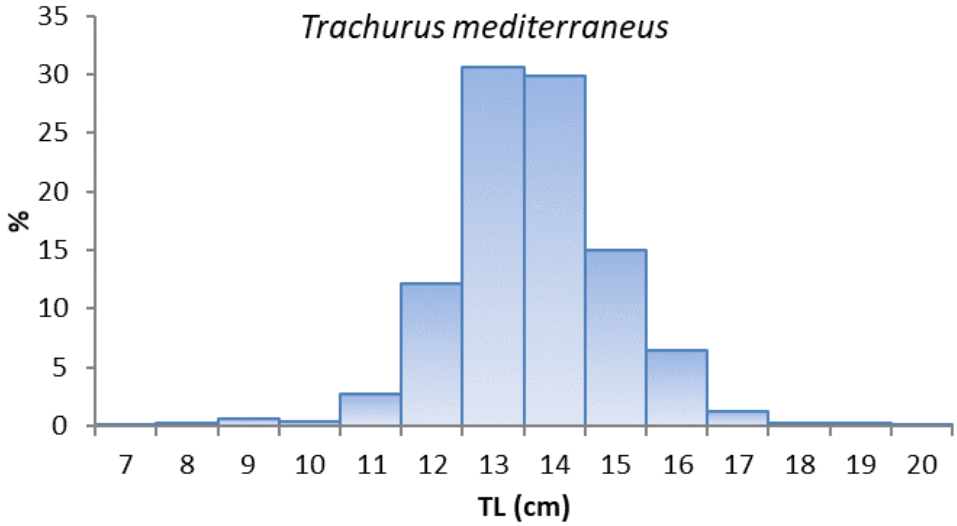


**Figure 1.** Length frequency of *Trachurus mediterraneus* in the Black Sea.

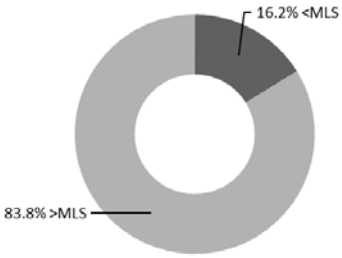


**Figure 2.** MLS percentages for *Trachurus mediterraneus* in the Black Sea.

The LWR equation was calculated as log (W) = - 2.1758 + 3.0848 log (TL) (and $W = 0.0067 \times TL^{3.0848}$) ($R^2$= 0.94) (Figure 3). It seems that there is a positive allometry in terms of *b* value.

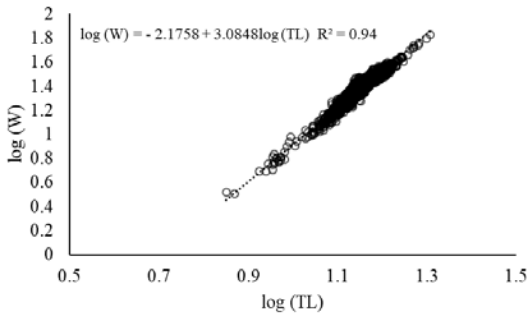


**Figure 3.** Length-weight relationship of *Trachurus mediterraneus* in the Black Sea.

Age groups of Mediterranean horse mackerel in the Black Sea were ranged from I to III. Mean lengths according to age groups were 9.9 ±0.36 cm, 14.1 ±0.11cm and 16.7 ±0.13 cm, respectively. Also, von Bertalanffy growth parameters were $L_\infty$ = 19.14 ±0.46 cm, K = 0.65 ±0.03, $t_0$ = -0.08 ±0.007 year (Figure 4).

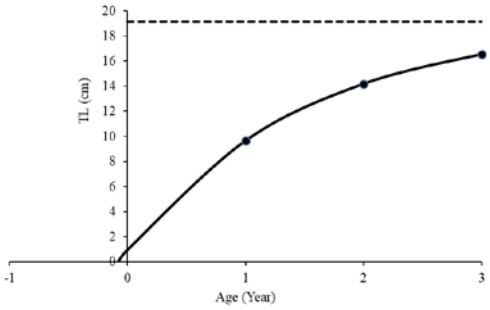


**Figure 4.** Age-length curve of *Trachurus mediterraneus* in the Black Sea.

Observed and calculated lengths according to age groups were shown in Table 1. There is a significantly differences between observed and calculated lengths ($P<0.05$).

**Table 1.** Observed and calculated lengths of *Trachurus mediterraneus* according to age groups in the Black Sea

| **Age** | **1** | **2** | **3** |
|---|---|---|---|
| $\mathbf{L_{obs.}}$ | 9.85 | 14.1 | 16.7 |
| $\mathbf{L_{cal.}}$ | 9.70 | 14.2 | 16.6 |

Mortalities (M, F and Z) and exploitation rate (E) of *T. mediterraneus* from the Central Black Sea were 0.84 $year^{-1}$, 0.87 $year^{-1}$, 1.712 $year^{-1}$ and 0.51 $year^{-1}$, respectively. The mean annual habitat temperature (T), $L_{mean}$ and L' are assumed as 13ºC, 14 cm and 12 cm, respectively.

## 4. DISCUSSION

There is gap on the population biology of *T. mediterraneus* in the Black Sea. Only a few studies were carried on merely length-weight relations. LWR of *T. mediterraneus* seems that there is a positive allometric growth (*b* = 3.085). Other LWR parameters and minimum and maximum lengths and weights of Mediterranean horse mackerel in the Black Sea were shown in Table 2. There was usually allometric growth (except Şahin et al. 2009) on *T. mediterraneus* in the Black Sea according to the previous studies. In this study, the maximal length has been also seen among the other studies.

Age groups of *T. mediterraneus* in the present study were ranged from I to III; the largest group was II. Şahin et al. (2009) reported similarly that age groups of I and II accounted for the majority of the *T. mediterraneus* population in the Eastern Black Sea. $L_\infty$ value (19.14 cm) is different with Şahin et al. (2009)'s study (26.1 cm). This variation may be due to the calculation methodology or age reading verifying. Şahin et al. (2009) reported that the 54% of fish caught was under MLS, while 16.2% of fish was under MLS in this study. This reduction of <MLS might be arisen by strict surveillance of net meshes or accurate resource management.

Thus, the existing of larger fish in our samples may suggest that there is no heavy fishing pressure on *T. mediterraneus* stocks in the Black Sea. Moreover, the estimate of fishing mortality (F = 0.87) is some lower than natural mortality (M = 1.07), and according to exploitation rate (E = 0.51), *T. mediterraneus* fishery goes with equilibrium.

*T. mediterraneus* is very commercial pelagic species for the Black Sea region. The current findings are in line with past studies indicating that most Mediterranean and Black Sea stocks are over-exploited (Vasilakopoulos et al., 2014; Cardinale and Scarcella, 2017).Thus, the fish stock should be monitored and further studies on the stock status are needed for sustainable fisheries management.

**Table 2.** Substantial LWR records of *Trachurus mediterraneus* in the Black Sea

| Authors | n | $L_{min}$-$L_{max}$ | $W_{min}$-$W_{max}$ | a | b | $R^2$ |
|---|---|---|---|---|---|---|
| Şahin et al. (2009) | 1312 | 9.2-19.0 | - | 0.009 | 2.955 | 0.94 |
| Özdemir et al. (2010) | 902 | 7.2-18.0 | 3.6-49.8 | 0.007 | 3.045 | 0.98 |
| Yankova et al. (2011)* | 1432 | 7.0-18.4 | 4.5-55.0 | 0.005 | 3.168 | 0.92 |
| Özdemir and Duyar (2013) | 526 | 9.4-15.1 | 4.6-25.2 | 0.003 | 3.302 | 0.90 |
| Kasapoğlu and Düzgüneş (2014) | 624 | 6.2-19.5 | 1.7-64.3 | 0.005 | 3.138 | 0.97 |
| This study | 1467 | 7.1-20.3 | 3.2-67.7 | 0.007 | 3.085 | 0.94 |

*Bulgarian waters

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