Length-weight Relationship, Fulton's Condition Factor and Meat Yield of Atlantic Bonito, *Sarda sarda* (Bloch, 1793) in the Central Black Sea

Orta Karadeniz'de (Türkiye) Palamut Balığının, *Sarda sarda* (Bloch, 1793) Boy-Ağırlık İlişkisi, Fulton'un Kondisyon Faktörü ve Et Verimi

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ABSTRACT

A total of 271 Atlantic bonitos from the Black Sea were collected from commercial gillnet and purse-seine fisheries, which have especially landed at Sinop fishing ports between September 2016 and December 2016. Length and weight of Atlantic bonito specimens were ranged from 15.4 cm to 47.6 cm (average: 34.6 ± 0.38 cm), and 72 g to 1288.8 g (average: 506.7 ±19 g). The LWR equation calculated was $W = 0.0028 \times TL^{3.3763}$ ($R^2 = 0.9744$). Meat yield ratio was ranged from 42.2% to 79.7% (average: 69%). Fulton's condition factors were ranged from 0.816 to 1.972 (average: 1.066 ±0.008). The results seem that the populations of Atlantic bonitos in the Black Sea and the Sea of Marmara have quite large size and good conditions in terms of L_{max}, W_{max} and *a* and *b* values. Additionally, K value increased in bigger fish than >36 cm in this study. However, MLS with 25 cm is also unreasonable due to the reported of 42.5 cm for females and 37 cm for males in a previous study. In this study, only 1.5% under legal size is due to MLS with 25 cm. Whereas, MLS should be increased owing to first maturity length, and should be implemented new MLS with at least 40 cm for sustainable bonito fishery.

Keywords: Atlantic bonito, *Sarda sarda*, length, weight, condition factor, Black Sea.

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ÖZET

Karadeniz'den Eylül 2016 ve Aralık 2016 arasında özellikle Sinop balıkçı limanına ticari uzatma ağları ve gırgır balıkçılığından getirilen toplam 271 palamut balığı toplanmıştır. Palamut bireylerinin boy ve ağırlığı 15,4 cm'den 47,6 cm'e (ortalama: 34,6 ±0,38 cm) ve 72 g'dan 1288,8 g'a (ortalama: 506,7 ±19 g) değişmiştir. Boy-ağırlık ilişkisi $W = 0,0028 \times TL^{3,3763}$ ($R^2= 0,9744$) olarak hesaplanmıştır. Et verimi oranı %42,2'den %79,7'ye (ortalama: %69) değişmiştir. Fulton'un kondisyon faktörü (K) ise 0,816'dan 1,972'ye (ortalama: 1,066 ±0,008) değişmiştir. Sonuçlar Karadeniz ve Marmara Denizi'nde palamut populasyonlarının L_{maks}, W_{maks} ve *a* ve *b* değerleri bakımından oldukça büyük boyut ve iyi kondisyona sahip olduğunu göstermektedir. Buna ilave olarak, bu çalışmada K değeri >36 cm balıklardan daha büyük boylu olanlarda artmaktadır. Ancak, 25 cm olan minimum karaya çıkarma boyu önceki bir çalışmada erkekler için 37 cm, dişiler için 42,5 cm olduğundan mantıklı değildir. Bu çalışmada, minimum karaya çıkarma boyu olan 25 cm nedeniyle illegal karaya çıkarılanlar sadece %1,5'tur. Halbuki, ilk üreme boyu baz alındığında, sürdürülebilir palamut balıkçılığı için minimum karaya çıkarma boyu en az 40 cm olarak uygulanmalıdır.

Anahtar sözcükler: Palamut, *Sarda sarda*, boy, ağırlık, kondisyon faktörü, Karadeniz.

1. INTRODUCTION

Atlantic bonito, *Sarda sarda* (Bloch, 1793) is a pelagic schooling species that migrates along the shores and occasionally enters estuaries. They feed on mainly schooling fishes and large squids and shrimps, and known to be cannibalistic. Spawning season is between May and July. Sexually mature at 40 cm. It is very popular gamefish and caught in various fishing methods (Golani et al., 2006). It is marketed mostly fresh, dried, salted, smoked, canned and frozen. Maximum length: 91.4 cm FL; common length: 50 cm FL; maximum published weight: 11 kg; and maximum reported age: 5 years (Froese and Pauly, 2017).

Atlantic bonitos distribute in Eastern Atlantic: Oslo, Norway to Port Elizabeth, South Africa and also known from the Mediterranean and Black Sea. Western Atlantic: Nova Scotia, Canada to Florida, USA and northern Gulf of Mexico; then from Colombia, Venezuela, and south of the Amazon River to northern Argentina; (Froese and Pauly, 2017).

Atlantic bonito is common in all Turkish seas, especially in the Black Sea and the Sea of Marmara and they are mainly caught by artisanal fishery such as handlines, encircling nets, gillnets, and purse seines in Turkey. Total annual yield of Atlantic bonito in Turkey was 39.460 metric tons in 2016 (TUIK, 2017). A total of 36.274 tons (92%) come from the Black Sea. This figure indicated that the Turkish Atlantic bonito fishery mainly belongs to the Black Sea. Thus, we can think that there is an intensive fishing on Atlantic bonito stocks in the Black Sea.

This fish is very commercial in Turkish waters, especially Bosphorus and Sea of Marmara and the Black Sea. However, there are only a few studies on *Sarda sarda* in Turkish seas. This study provides some actual information such as length, weight, condition factors depending on length

groups and meat yield of Atlantic bonito population in the Central Black Sea.

2. MATERIAL AND METHOD

A total of 271 Atlantic bonitos from the Black Sea were collected from commercial gillnet and purse-seine fisheries, which have especially landed at Sinop fishing ports in the Central Black Sea, between September 2016 and December 2016.

Total length (TL) of each fish has been measured to nearest $\pm$ 0.1 cm and $\pm$ 0.1 g. Length-weight relationship (LWR) was computed from the following formula: $W = a \times TL^b$. Where W is weight, *a* and *b* are constants.

Fulton's condition factor (K) was calculated for each total length class for both sexes according to the equation $K = (W/TL^3) \times 100$.

Meat yield (MY) ratio from 128 specimens was determined from the formula: MY = (gutted weight / total body weight) x 100. The gutted weight is flesh after removed internal organs, visceral fat, fins and head (except fishbone). For the relationship between fish weight and meat yield, logarithmic transformation was implemented. All of the means were given with standard error ($\pm$ SE).

3. RESULTS

Length and weight of Atlantic bonito specimens were ranged from 15.4 cm to 47.6 cm (average: 34.6 $\pm$0.38 cm), and 72 g to 1288.8 g (average: 506.7 $\pm$19 g). The samples were grouped densely between 27 and 33 cm (Figure 1).

Minimum landing size (MLS) is 25 cm for *Sarda sarda* according to Turkish Fisheries Regulation Circular (TFRC). Thus, 1.5% of all samples in this study are under legal size (Figure 2).

The LWR equation calculated was $W = 0.0028 \times TL^{3.3763}$ ($R^2 = 0.9744$) (Figure 3). It seems that there is a positive allometry in terms of *b* value.

Meat yield ratio of Atlantic bonito in the Central Black Sea was ranged from 42.2% to 79.7% (average: 69%). The relationship between fish weight and meat yield was found as y = 1.0312x -0.2445 ($R^2 = 0.9574$) (Figure 4).

Fulton's condition factors were ranged from 0.816 to 1.972 (average: 1.066 $\pm$0.008) (Figure 5).

4. DISCUSSIONS AND CONCLUSIONS

Sarda sarda exhibited positive allometric growth (*b* = 3.3763). The previous data about LWRs in the Black Sea are presented in Table 1. During the present study, the *b* values were generally in agreement with all former results, however, disagreement with Kasapoğlu and Düzgüneş (2014) due to the unique negative allometric finding.

The results seem that the populations of Atlantic bonitos in the Black Sea and the Sea of Marmara have quite large size and good conditions in terms of L_{max}, W_{max} and *a* and *b* values [except Kasapoğlu and Düzgüneş (2014)'s study that it had quite narrow size range with only 36 samples]. Additionally, K value increases in bigger fish than >36 cm in this study. In other words, the bigger fish has higher condition. Kahraman et al. (2014) reported that K values were the highest in December and March; also, reproduction was occurring between June and July. The closed season between 1 April and 31 August for Atlantic bonito in Turkish seas seem reasonable (TFRC, notification no: 2016/35). However, MLS with 25 cm is also unreasonable due to the reported of 42.5 cm for females and 37 cm for males in Kahraman et al. (2014)'s study. In this study, only 1.5% under legal size is due to MLS with 25 cm. Whereas, MLS should be increased owing to first maturity length, and should be implemented new MLS with at least 40 cm for sustainable bonito fishery.
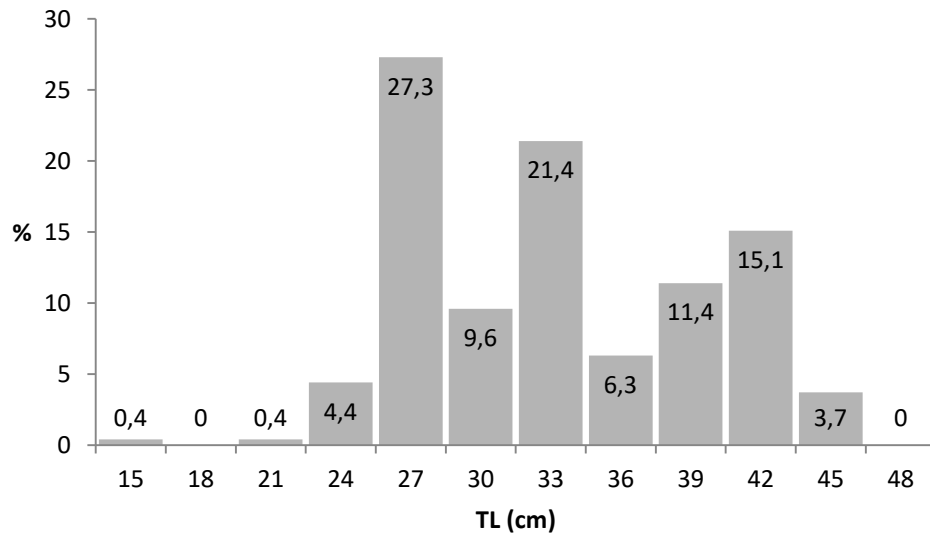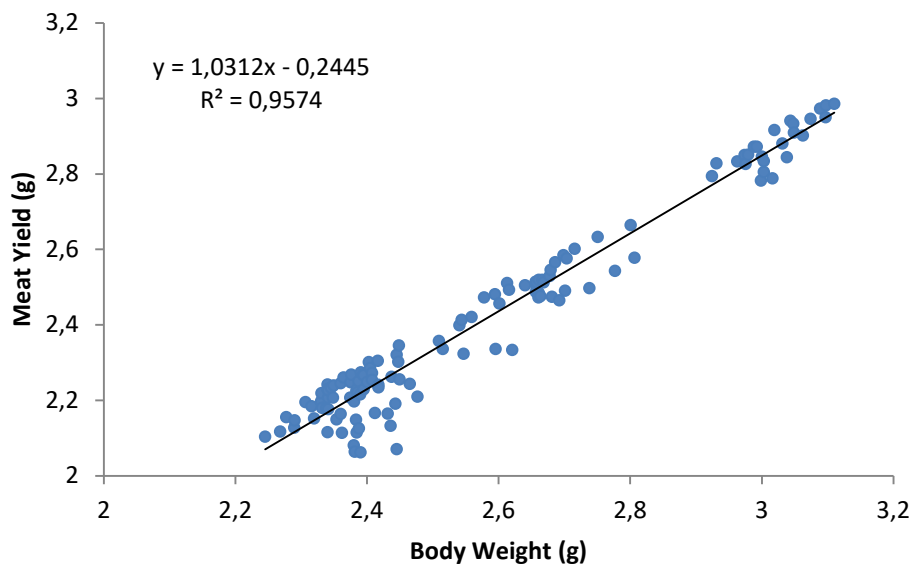
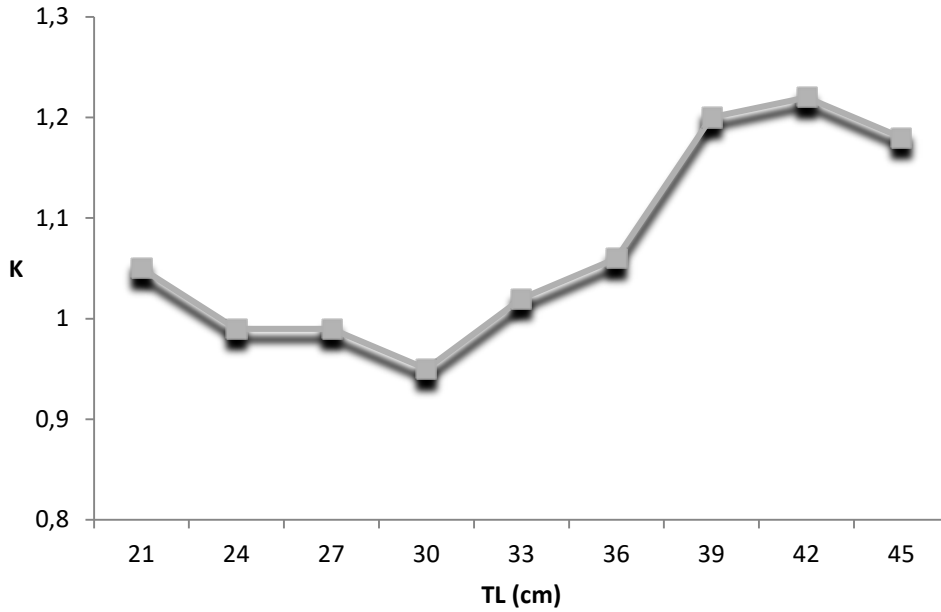**Figure 1.** Length frequency of *Sarda sarda* in the Central Black Sea.
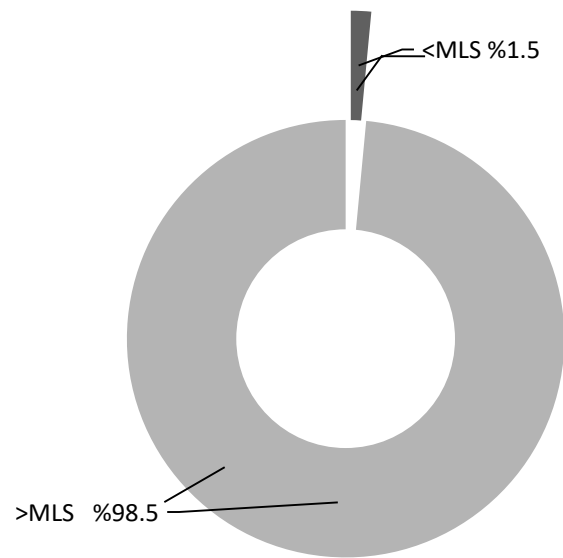
Figure 2. MLS percentages for *Sarda sarda* in the Central Black Sea.

$$y = 0{,}0028x^{3{,}3763}$$
$$R^2 = 0{,}9744$$
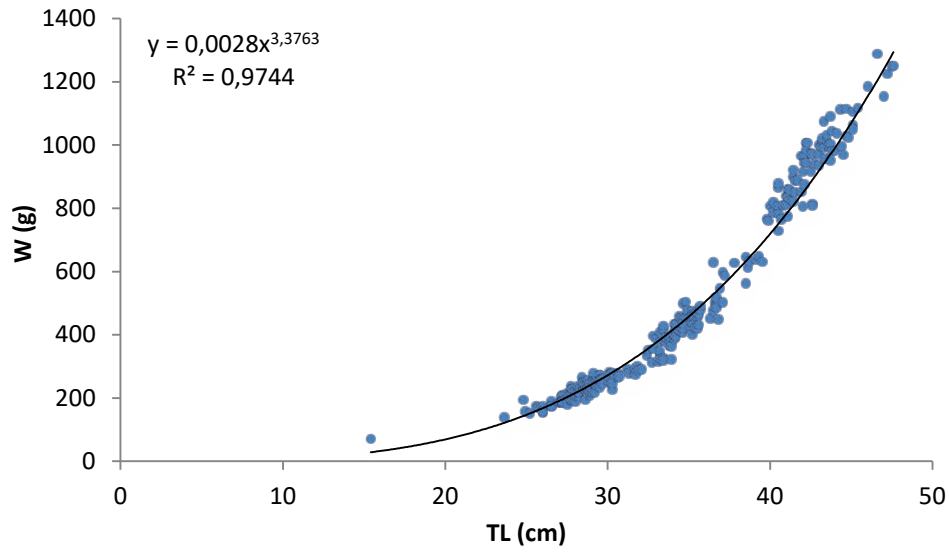
Figure 3. Length-weight relationship of *Sarda sarda* in the Central Black Sea.

$$y = 1{,}0312x - 0{,}2445$$
$$R^2 = 0{,}9574$$

Figure 4. Body weight – Meat yield relationship of *Sarda sarda* in the Central Black Sea.

Figure 5. Condition factors of *Sarda sarda* depending on the length groups in the Central Black Sea.

Table 1. Substantial LWR records of Atlantic bonito in the Black Sea.

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	*a*	*b*	R^2
Oray et al. (1997)*	332	31.0-66.0	380-4848	0.0065	3.228	0.94
Oray et al. (2004)*	415	21.8-70.5	110-5000	0.0039	3.326	-
Ateş et al. (2008)*	694	23.5-71.0	122-4724	0.0054	3.215	0.98
Yankova et al. (2011)**	411	29.0-37.6	300-880	0.001	3.839	0.89
Kahraman et al. (2014)*	212	17.7-63.0	69-3860	0.010	3.085	0.99
Kasapoğlu and Düzgüneş (2014)	36	28.1-37.5	234-518	0.050	2.562	0.89
This study	271	15.4-47.6	72-1289	0.0028	3.376	0.97

*Fishes from both Black Sea and the Sea of Marmara
** Bulgarian Black Sea waters

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