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- RESEARCH ARTICLE -

Relationships between total length and otolith size of bluefish *Pomatomus saltatrix* (Linnaeus, 1766) in the Marmara Sea of Turkey

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Abstract

In the present study, bluefish, *Pomatomus saltatrix*, was monthly collected from commercial fishing boats operating in the Marmara Sea between January and December 2014. The relationship between total length and otolith size of 346 bluefish samples were examined. Total lengths of females, males and unidentified samples were ranged from between 13.2-37.0, 12.3-34.8 and 13.0-31.6 cm, respectively. Otolith lengths were between 3.82-12.60 mm and otolith width were between 1.59-4.34 mm for all samples. It was found that there is a strong correlations between otolith length-total length (r^2 =0.88) and otolith width-total length (r^2 0.81).

Keywords:

Pomatomus saltatrix, otolith length, otolith width, total length.

Article history:

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Introduction

The bluefish *Pomatomus saltatrix* (Linnaeus, 1766) is a migratory species, occur in temperate and warm temperate zones throughout the world and are generally found in continental shelf waters (Briggs, 1960). Its distribution in the Indian Ocean includes the east coast of southern Africa,

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Madagascar, and Malay Peninsula, Tasmania, the southern and western coast of Australia. In the eastern Atlantic Ocean, distribution ranges from Portugal to Senegal, including the Azores, the Mediterranean and Black Seas and Angola to South Africa (Briggs, 1960). Bluefish economically is one of the important species in coasts of Turkey. It is migrating via the Aegean Sea northwards from the Mediterranean in spring and returning south in early autumn (Ceyhan et al*.,* 2007). Scientific researchers has been concerned with various aspect of bluefish biology (Sabates & Martin, 1993), variation between stock and stock structure (Turan et al., 2006; Graves et al., 1992), age, growth, maturity and mortality (Salerno et al., 2001; Cengiz et al., 2013), reproduction and fisheries (Dhieb et al., 2006; Ceyhan et al., 2007), heavy metal contamination (Türkmen et al., 2009). But the study of the relation between fish size and otolith morphology is limited (Ceyhan & Akyol 2006, Cengiz et al. 2012, Zengin et al. 2017).

Bluefish is one of the most important economic species and its stocks needs to be protected. The biology of the species must be well known in order to ensure the sustainability of stocks. The life history properties of otoliths allow accurate estimates of age and growth on both the daily and yearly scale (Campana & Thorrold 2001). For this reason, otoliths are the basic building blocks that make a significant contribution to the management of fish stocks (Zengin et al. 2017).

In this study, relationships total length and otolith size of bluefish was examined. This research is an important new contribution for sustainable fisheries management in the area.

Materials and methods

A total of 346 bluefish samples were monthly collected from commercial fishing boats operating in the Marmara Sea between January and December 2014 (Figure 1). All captured individuals were measured to the nearest 0.1 cm for total length (TL). Examination of the gonads was macroscopically determined (144♀, 143♂, 64 unidentified). Sagittal otoliths were removed, wiped clean, and stored dry in U-plates, then placed in glycerol for examination under reflected light using a triocular microscope Because of there was no statistical difference between right and left otolith the right otolith was used for otolith width and otolith length. Otolith length (OL) and otolith width (OW) (± 0.001 mm) were determined by Leica M125. Otolith length was defined as the greatest distance between anterior and posterior edge and otolith width was described as the greatest distance from dorsal to ventral edge (Figure 2). The total length-otolith length and total length-otolith width relationships were examined by using the linear regression model and following equation: $y = a + bx$, where: x - fish length, y - otolith length-otolith width, a - intercept value, b - coefficient value. Descriptive statistics were derived using Excel (Microsoft Excel® 2010).

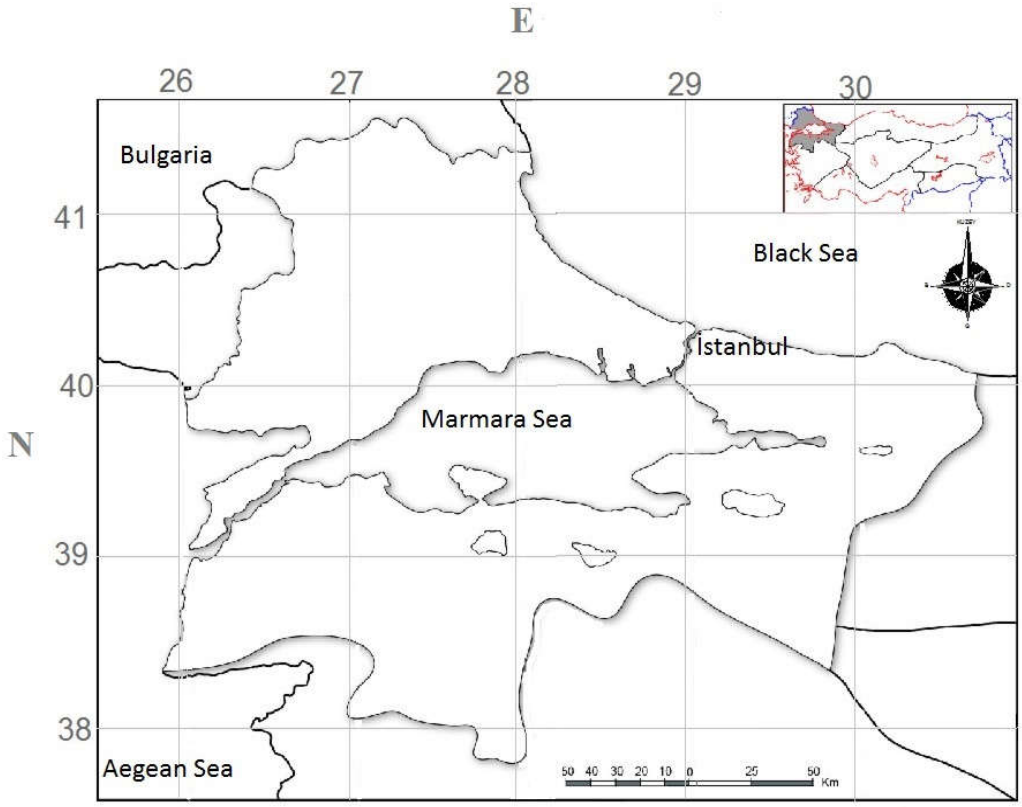

Figure 1. Map of study area (Marmara Sea, Turkey)

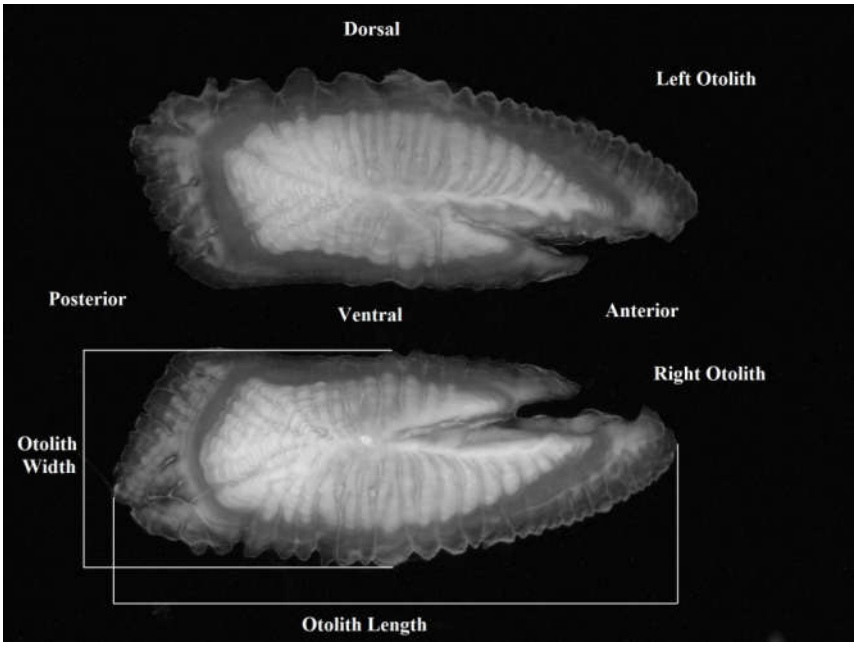

Figure 2. Measurement axes of the sagittal otolith of bluefish

Results

In this study, the relationship between total length and otolith length of 346 bluefish samples were examined. Total lengths of females, males and unidentified samples were ranged from between 13.2-37.0, 12.3-34.8 and 13.0-31.6 cm, respectively. Otolith lengths were between 3.82-12.60 mm, and otolith width were between 1.59-4.34 mm for all samples. It has been determined that there is high correlation between otolith and total length. Positive linear relationship between total fish length-otolith length and total fish length-otolith width were found in all fish (Figure 3).

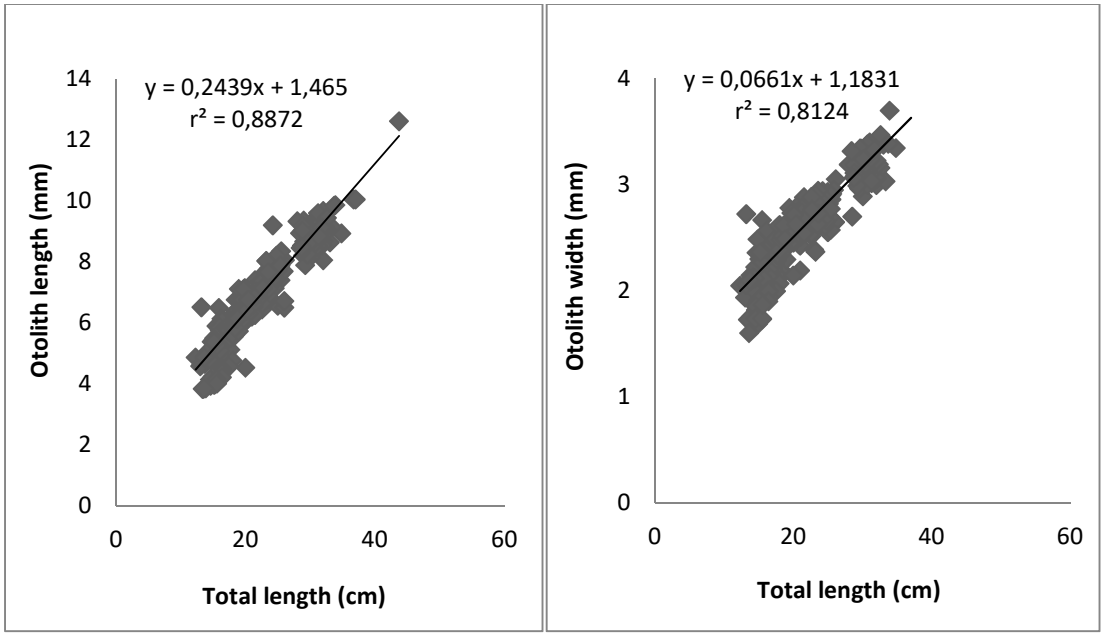

Figure 3. Relationships of total length-otolith length and total length-otolith width of bluefish.

The otolith measurements for each sex are given in Table 1 and Table 2

Table 1. Relationship total length (TL)-otolith length (OL) of bluefish *P. saltatrix*

		TL (cm)		OL (mm)		Relationship TL-OL		
sex	**n**	**min-max.**	**mean±SD**	**min-max.**	**mean±SD**	**a**	**b**	**r^2**
Female	142	13.2-37.0	22.4±1.27	3.84-10.04	6.92±0.60	1.23	0.06	0.81
Male	141	12.3-34.8	21.2±1.10	3.98-12.60	6.77±0.51	1.86	0.22	0.87
Unidentified	63	13.0-31.6	19.4±0.80	3.82-8.72	6.09±0.45	1.42	0.24	0.85
Total	346	12.3-37.0	19.1±0.89	3.82-12.60	6.71±0.55	1.46	0.24	0.88

n: sample size, TL: total length (cm), OL: otolith length (mm), min: minimum, max: maximum, a: intercept, b: slope.

Table 2. Relationship total length (TL)-otolith width (OW) of bluefish *P. saltatrix*

		TL (cm)		OW (mm)		Relationship TL-OW		
Sex	**n**	**min-max.**	**mean±SD**	**min-max.**	**mean±SD**	**a**	**b**	**r^2**
Female	142	13.2-37.0	22.4±1.27	1.59-4.34	2.66±0.26	1.11	0.06	0.81
Male	141	12.3-34.8	21.2±1.10	1.73-3.69	2.61±0.20	1.35	0.05	0.82
Unidentified	63	13.0-31.6	19.4±0.80	1.68-3.34	2.42±0.21	1.00	0.07	0.80
Total	346	12.3-37.0	19.1±0.89	1.59-4.34	2.60±0.24	1.18	0.06	0.81

n: sample size, TL: total length (cm), OW: otolith width (mm), min: minimum, max: maximum, a: intercept, b: slope.

Discussion

Otoliths are commonly used to determine the taxon and age of fish~~es~~. This information is useful for population management, predator-prey studies, and archaeological research (Harvey et al., 2000). Particularly, fish-otolith size studies and predators size distributions of fish are important information to be used in fisheries biology. Firstly, Härkönen, (1986) showed that from North Atlantic fish *Gadus morhua* can detect true fish length using otolith length. However, the relationship between the length of a fish and its otoliths biometry unknown for many species of marine fishes. Although studies have been done for some marine fish (Yasutake et al., 1981; Cihangir &Kaya 1988; Aydin et al., 2004). There are limited studies about the relationships between otolith morphology values and total length of bluefish (Ceyhan & Akyol 2006; Cengiz et al. 2012; Zengin et al. 2017).

In study, the smallest otolith size was determined 3.82 mm and the largest otolith size as 12.60 mm. Mean of otolith size 6.71±0.55. Minimum total length, 12.3 cm, maximum fish length, 37.0 cm, average and standard error was determined as 19.1±0.89 cm. According to the results of the regression analysis, it was found that the relationship between the fish length-otolith length and the fish length-otolith width was strong each sex group. But the highest correlation was found in males (total length-otolith length: r^2 0.87; total length-otolith width: r^2 0.82). In a survey conducted in the Sea of Marmara (Ceyhan & Akyol 2006), the smallest otolith size was determined as 4.51 mm and the largest otolith size 10.1 mm. In total, the average otolith size corresponding to the fish size of 193.9±1.1 mm was 6.6±0.03 mm. also It was reported that a strong correlation (r^2 0.94) between otolith length and total length in all sex groups. The correlation equation and the regression coefficient in a study by Cengiz et al. 2012 were reported as y = 3.7113x-2.7951, r^2 = 0.89, respectively. Results are similar to our study. But the regression coefficient was found to be higher than result of study in the black sea (Zengin et al., 2017). The comparative parameters are given in table 3.There were no other studies in this subject; therefore no any comprehensive comparison was made. This research is new contribution in the studies of total length and otolith size for fish species. The results of this research could be used as a reference for fisheries and stock management in the area.

Table 3. Comparison of total length-otolith length with other study results

		TL/FL (cm/mm)	OL (mm)	Relationships TL-OL			
Researchers		**min-max**	**min-max**	**a**	**b**	**r^2**	**Location**
Ceyhan & Akyol (2006)	688	FL (mm) 131-342	4.51-10.1	1.91	0.02	0.93	Marmara Sea
Cengiz et al. (2012)	492	13.8-61.2	4.01-14.8	2.79	3.71	0.89	Çanakkale Peninsula
Zengin et al. (2017)	125	13.5-23.6	4.31-7.16			0.61	Black Sea
Present study	346	12.3-37.0	3.82-12.60	1.46	0.24	0.88	Marmara Sea

n: sample size, TL: total length (cm), FL: fork length (mm), min: minimum, max: maximum, a: intercept, b: slope.

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