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RESEARCH ARTICLE

Otolith Shape Analysis and Otolith Morphometry of Bogue *Boops boops* (Linnaeus, 1758) in the Aegean Sea and the Marmara Sea

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Abstract: In the present study, otolith shape indices and some otolith morphometric characteristics in the left and right sagittal otoliths were identified and compared for *Boops boops* in the Aegean Sea and the Marmara Sea. Otoliths of *Boops boops* from 244 individuals in the North of Aegean Sea and 188 individuals from the Southwest of Marmara Sea were analyzed during the 2024 fishing season. The total length-otolith dimensions relationships were evaluated, the best fit was obtained between total length and otolith perimeter in the Marmara Sea and Aegean Sea, while the least fit was obtained among total length and otolith area of right otoliths, total length and otolith length of left otoliths in the Aegean Sea and Marmara Sea. Some similarities of *Boops boops* stocks were found with shape indices and otolith morphometry between the Aegean Sea and Marmara Sea. The otolith area and circularity of the left otolith, roundness and rectangularity of the right otolith, form factor of left and right otolith were significantly different ($p<0.05$). Principle Component Analysis may explain these differences as arising from variations in the roundness, otolith area and otolith width. Also, Canonical Discriminant Analysis demonstrated significant discrimination of otoliths between the Aegean Sea and the Marmara Sea ($p<0.05$), and 56.6% of the originally grouped cases were correctly classified. Based on the results of this study, two stocks of *Boops boops* in the North of Aegean Sea and the Southwest of Marmara Sea might be different. However, more detailed studies are required the determine whether this species constitues the same stock in these areas.

Anahtar kelimeler:

Sagittal otolith
Otolit şekil indeksi
Stok ayrımı
Çanakkale Boğazı
Otolit boyutları

Ege Denizi ve Marmara Denizi'ndeki Kupez'in *Boops boops* (Linnaeus, 1758) Otolit Şekil Analizi ve Otolit Morfometrisi

Öz: Bu çalışmada, Ege Denizi ve Marmara Denizi'nde *Boops boops*'un otolit şekil indeksleri ile bazı otolit morfometrisi özellikleri sağ ve sol sagittal otolitlerinde tanımlanmış ve karşılaştırılmıştır. 2024 balıkçılık sezonunda Ege Denizi'nin kuzeyinden 244 birey ile Marmara Denizi'nin güneybatısından 188 bireyin otolitleri analiz edilmiştir. Toplam boy-otolit boyutları ilişkileri değerlendirildiğinde, Marmara Denizi ve Ege Denizi'nde toplam boy ile otolit çevresi arasında en iyi uyum sağlanırken, Marmara Denizi ve Ege Denizi'nde toplam boy ile sağ otolitlerin otolit alanı ile toplam boy ile sol otolitlerin otolit boyu arasında en düşük uyum sağlanmıştır. *Boops boops* stokları arasında Ege Denizi ve Marmara Denizi'nde otolit şekil indeksleri ve otolit morfometrisi açısından bazı benzerlikler bulunmuştur. Sol otolitin alanı ve daireselliği, sağ otolitin yuvarlaklığı ve dikdörtgenselliği, sol ve sağ otolitin form faktörü açısından anlamlı farklılıklar göstermiştir ($p<0,05$). Temel Bileşen Analizi, bu denizlerdeki farklılıkların yuvarlaklık, otolit alanı ve otolit genişliğinden kaynaklandığını açıklayabilir. Ayrıca, Kanonik Ayırım Analizi, Ege Denizi ile Marmara Denizi arasında otolitlerin anlamlı şekilde ayırt edilebildiğini ($p<0,05$) ve gruplandırılan örneklerin %56,6'sının doğru şekilde sınıflandırıldığını ortaya koymuştur. Bu çalışmanın sonuçlarına göre, Ege Denizi'nin kuzeyindeki ve Marmara Denizi'nin güneybatısındaki iki *Boops boops* stoğunun farklı olabileceği düşünülmektedir. Fakat bu türün, bu denizlerde aynı stok olup olmadığının incelenmesini içeren daha ayrıntılı çalışmalar gerekmektedir.

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Introduction

Otoliths are calcareous structures located in the inner ear cavity of teleost fish. They are a function of balance, movement, and sound detection (Popper and Lu, 2000). Teleost fishes have three pairs of otoliths: lapillus, sagitta and asteriscus (Schultz-Mirbach and Reichenbacher, 2006). Among these, sagittal otoliths are used widely in biological studies because of their large size, relative ease of access and their variation in otolith shape and size in different groups of fishes (Tuset et al., 2003a). The otolith shape is often linked to the ecological, taxonomical phylogenetic and functional characteristics of fish species (Vignon and Morat, 2010; Tuset et al., 2016; Van Damme et al., 2024). Also, the morphometry and shape of otoliths can vary in different populations of the same species. Consequently, otoliths can be used in stock discrimination (Popper et al., 2005). The otolith shape analysis accounts for stock-specific differences in the morphometric outline of otoliths, and is a common otolith-based stock discrimination and identification method in fisheries science (Campana and Casselman, 1993; Schade et al., 2019).

The Çanakkale Strait, with a length of 62 km, connects the Marmara Sea and the Aegean Sea. These adjacent seas are in constant interaction through the Çanakkale Strait, as surface currents carry water from the Marmara Sea to the Aegean Sea, and bottom currents carry water from the Aegean Sea to the Marmara Sea (Ozturk, 2021).Many species of fish living in this region are known to migrate in and out of the Aegean Sea and the Marmara Sea. However, only limited studies have been conducted on the otoliths of species until today. In previous studies, otolith shape analysis of *Pomatomus saltatrix* (Bal et al., 2021), *Engraulis encrasicolus* (Durrani et al., 2022), *Pagellus acarne* (Yedier et al., 2023a) were investigated in the Marmara Sea and the Aegean Sea. Therefore, there is a need to investigate the differences in stock structures of fish species living in different areas of constant interaction.

Bogue *Boops boops* (Linneaus, 1758) from the Sparidae family, is widely found in the Mediterranean Sea and adjacent seas. This species lives in the bottom and middle waters of coastal areas with muddy, rocky, sandy bottom structures or seagrass areas (Bauchot and Hureau, 1986). Yields from capture fishing reached a mean of 2317 tonnes in Türkiye seas between 2019- 2023, with 2244 tonnes coming from the Aegean Sea and 73 tonnes from the Marmara Sea (TUIK, 2024). The otolith shape analysis and morphometry of bogue have never been analyzed in the Turkish Seas. Only two studies were conducted of *B.boops* stock discrimination by elliptical Fourier analysis in Algerian and Tunisian coasts (Ider et al., 2017; Ben Labidi et al., 2020). The aims of the present study were to analyse the otolith shape and identify some otolith morphometric characteristics of *B.boops* sampled in the North of Aegean Sea and Southwest of Marmara Sea, Turkiye.

Material and Methods

B.boops samples were obtained using purse seine from January to April 2024 and September to December 2024, and using gillnets from May to August 2024. A minimum of five individuals were sampled from each month. The total length of these individuals were measured (nearest 0.01 mm) and the total weight was recorded using a precision scale (nearest 0.01 g). Sagittal otolith extractions of 244 *B.boops* individuals from the North of Aegean Sea and from 188 *B.boops* individuals from the Southwest of Marmara Sea were performed (Figure 1). These sagittal otolith pairs were cleaned, dried and stored in eppendorf tubes.

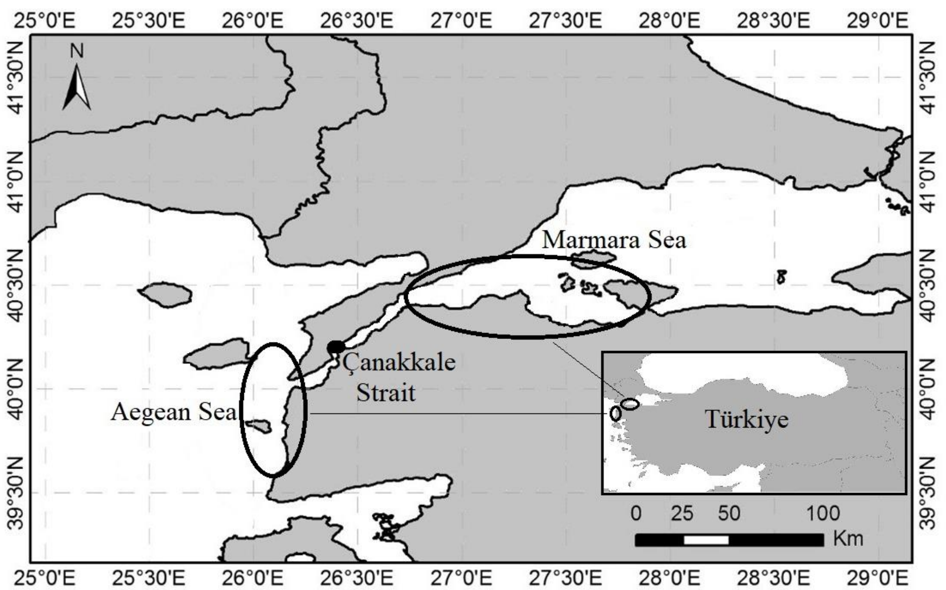

Figure 1. Sampling areas of *Boops boops* in the Marmara Sea and Aegean Sea

Otolith measurements were then performed to determine otolith morphometries of *B.boops*. The length (OL), width (OW), radius (OR), perimeter (OP), area (OA) and weight (W) of the right and left otoliths of each individual were measured to the nearest ±0.0001 mm from the undamaged otolith using a stereomicroscope and Q-Capture digital imaging program (Figure 2). Otolith pairs were weighted with an accuracy of ±0.0001 g sensitiveness. The Independent Samples T-test was used to compare right and left otoliths measurements between Aegean Sea and Marmara Sea.

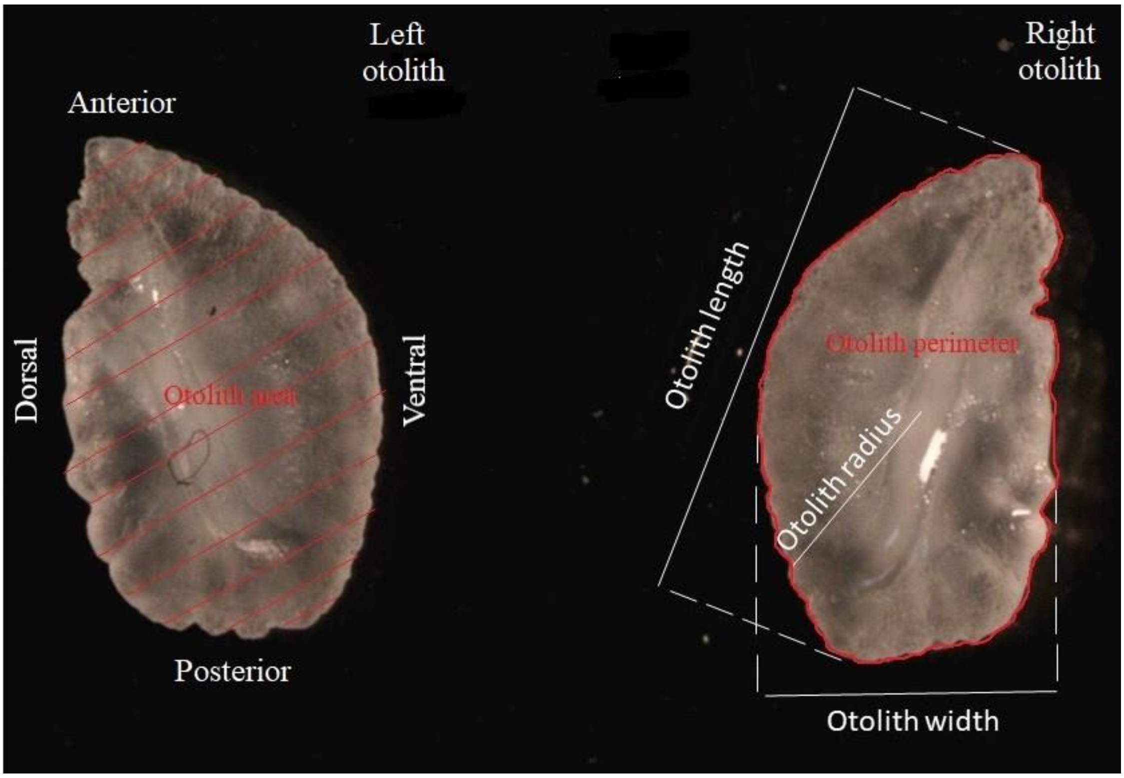

Figure 2. The left and right sagittal otolith measurements of proximal surface for *B.boops*

The relationships between different otolith dimensions were determined using linear regression analysis (Scherrer, 1984). Also, total length-otolith dimensions relationships and coefficient (R^2) were determined with this analysis. Linear regression analysis estimated by using the equation:

$y = bx + a$ (where a is the intercept and b is the slope of the linear regression)

The otolith shape indices were analyzed for *B.boops* individuals using the data obtained from the measured otolith dimensions. The otolith shape indices were calculated separately for both left and right otoliths in the Aegean Sea and Marmara Sea. The otolith shape indices used include (Tuset et al., 2003b; Ponton, 2006):

Aspect ratio (AR) = OL/OW

Elipticity (E) = $(OL–OW)/(OL+OW)$

Form factor (FF) = $(4\pi \times O \times A)/OP^2$

Roundness (RD) = $(4 \times OA)/(\pi OL^2)$

Circularity (C) = OP^2/OA

Rectangularity (R) = $OA/(OL \times OW)$

Independent sample T-test was used to compare the right and left otolith shape indices between Aegean Sea and Marmara Sea. Principal component analysis (PCA) was applied to show similarities/differences in otolith shapes and morphometry between Marmara Sea and Aegean Sea. Canonical Discriminant Analysis (CDA) was also used to determine the differences between the two stocks. The performance of the discriminant analyses was assessed using Wilk's lambda (λ) test. All analyzes were performed using the PAST (Ver. 4.04) (Hammer et al., 2001) and SPSS 25 (IBM Corp 2017) software.

Results

The mean total length and weight of *B.boops* individuals were 177.6±0.29 mm and 75.97±5.22 g from the Marmara Sea, while they were 179.8±0.72 mm and 63.5 g from the Aegean Sea, respectively. While no significant difference was found for total length ($p>0.05$), a significant difference was found for weight between the Aegean Sea and Marmara Sea ($p<0.05$). The sampling details are given in Table 1.

Table 1. Total length and weight distribution of *B.boops* (N:Number of individual; SE:Standard error; Min:Minimum; Max:Maximum; p:Significant differences)

Measurements	N	Area	Mean	SE	Min	Max	p
Total length (mm)	188	Marmara Sea	177.6	0.29	108	291	0.525
	244	Aegean Sea	179.8	0.72	106	286	
Total weight (g)	188	Marmara Sea	75.97	5.22	13.08	399.88	**0.03**
	244	Aegean Sea	63.5	5.31	8.1	236.86	

Table 2. The otolith morphometric charateristics of *B.boops* from left and right otoliths (Se:Standard error; Min:Minimum; Max:Maximum; p:Significant differences)

Otolith morphometrics	Side	Area	Mean	Se	Min	Max	p
Otolith length (mm)	Right	Marmara Sea	5.8533	0.0647	4.2530	8.2630	
		Aegean Sea	6.0711	0.0501	3.6910	7.7130	0.322
	Left	Marmara Sea	5.8589	0.0648	4.2410	8.3800	
		Aegean Sea	6.0709	0.0501	3.6690	7.9450	0.274
Otolith width (mm)	Right	Marmara Sea	3.4149	0.0246	2.6780	4.9410	
		Aegean Sea	3.5107	0.0227	2.1850	4.4220	0.600
	Left	Marmara Sea	3.4423	0.0280	2.7210	5.0430	
		Aegean Sea	3.5548	0.0245	2.2960	4.4710	0.606
Otolith radius (mm)	Right	Marmara Sea	2.3140	0.0284	1.6250	3.6020	
		Aegean Sea	2.4336	0.0214	1.3940	3.4600	0.067
	Left	Marmara Sea	2.3713	0.0257	1.6440	3.3780	
		Aegean Sea	2.4993	0.0213	1.4020	3.4700	0.449
Otolith perimeter (mm)	Right	Marmara Sea	15.6499	0.1834	10.0780	22.8260	
		Aegean Sea	16.2786	0.1317	9.7780	21.2880	0.172
	Left	Marmara Sea	15.5934	0.1821	11.3420	23.4850	
		Aegean Sea	16.2309	0.1315	9.7670	22.5520	0.166
Otolith area (mm^2)	Right	Marmara Sea	13.6265	0.2637	8.0340	27.5860	
		Aegean Sea	14.3378	0.1950	5.6660	22.9200	0.051
	Left	Marmara Sea	13.5679	0.2709	7.9500	28.3590	
		Aegean Sea	14.4117	0.2020	5.9100	22.6140	**0.039**
Otolith weight (g)	Right	Marmara Sea	0.0194	0.0006	0.0098	0.0552	
		Aegean Sea	0.0217	0.0004	0.0064	0.0436	0.392
	Left	Marmara Sea	0.0192	0.0006	0.0099	0.0551	
		Aegean Sea	0.0217	0.0004	0.0062	0.0442	0.447

Otolith morphometric measurements of *B.boops* in the Marmara Sea and Aegean Sea were presented separately for right and left otoliths in Table 2. The otolith morphometry for right and left otoliths were not significantly ($p>0.05$) different among Marmara Sea and Aegean Sea stocks of *B.boops*, except for the left otolith area ($p<0.05$).

Plots of relationships between total length and right and left otolith dimensions of *B.boops* were presented in Aegean Sea and Marmara Sea in Figure 3. R^2 values were generally higher in the right otoliths than in the left otoliths in the both seas. When the total length-otolith dimensions relationships were evaluated, the best fit was obtained between TL-OP in the Marmara Sea (R^2:0.90) and TL-OP in the Aegean Sea (R^2:0.87), whereas the least fit was obtained among TL-OA of right otoliths (R^2:0.54) and TL-OL of left otoliths (R^2:0.70) in the Aegean Sea, TL-OA of right otoliths (R^2:0.67) and TL-OL of left otoliths (R^2:0.70) in the Marmara Sea.

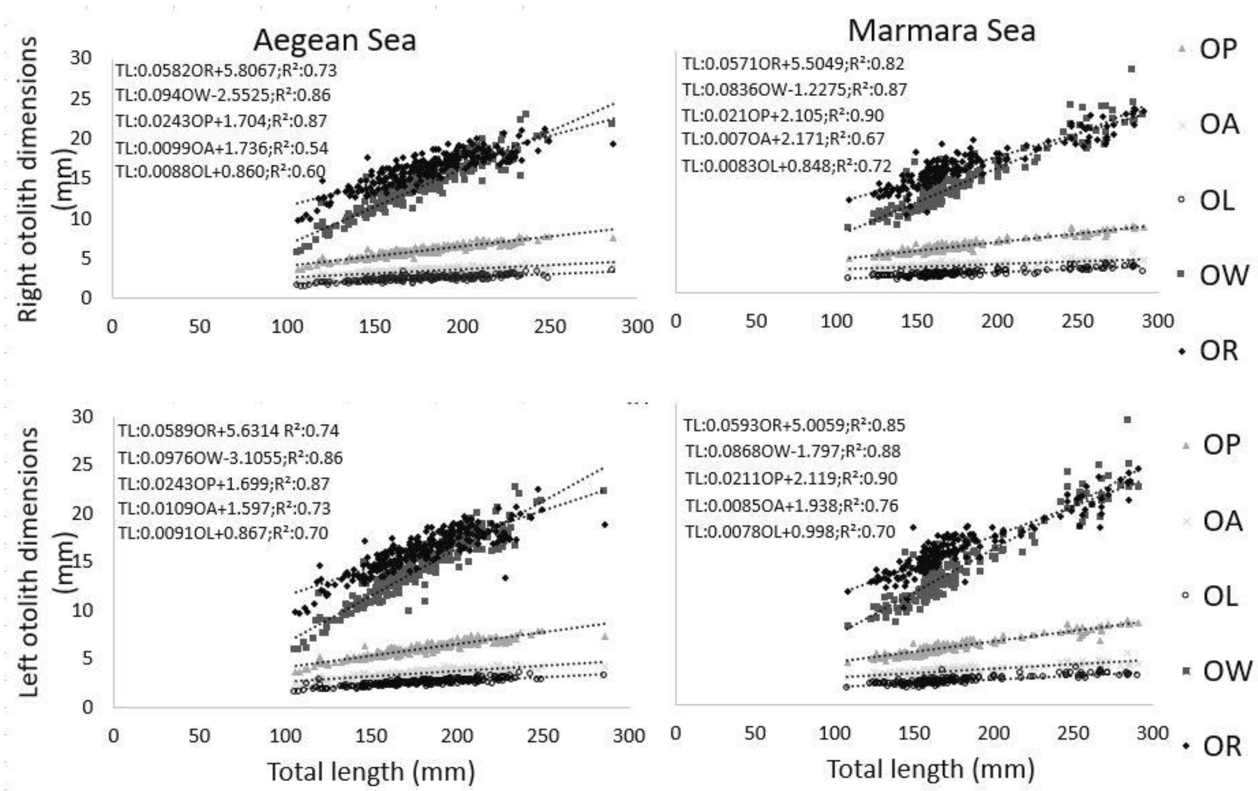

Figure 3. Total length-otolith dimensions relationships for left and right otoliths in *B.boops* in Aegean Sea and Marmara Sea

The otolith dimension relationships of *B.boops* in the Marmara Sea and Aegean Sea were presented separately for right and left otoliths in Table 3. R^2 values were generally higher in the left otoliths than in the right otoliths in the both seas. R^2 values of otolith dimensions with otolith radios relation were generally lower in both sides of otoliths and seas. When the otoliths dimension relations were evaluated, the best fit was obtained among OA-W of right otoliths (R^2:0.92) and OL-OA of left otoliths (R^2:0.93) in the Marmara Sea, and OL-OA of right otoliths (R^2:0.94) and left otoliths (R^2:0.92) in the Aegean Sea. The least fit was obtained among OR-OP and OW-OR of right otoliths (R^2:0.67), OR-OP of left otoliths (R^2:0.65) in the Marmara Sea, OR-OP of right (R^2:0.50) and left (R^2:0.57) otoliths in the Aegean Sea.

The otolith shape indices values are given in Table 4. Statistically significant differences were determined in the FF value of both side otoliths, RD and R values of right otoliths, C value of left otoliths ($p<0.05$) between the right and left otoliths of individuals among the Marmara Sea and Aegean Sea stocks.

Principal component analysis (PCA) explained 65.87 and 75.4% of the model of right and left otoliths, respectively. The left sagittal otoliths were preferred for analysis. The some otolith shape indices and dimensions explained as different between Aegean Sea and Marmara Sea. The PCA performed on RD of otolith shape indice and OA and OW of otolith dimensions were the most effective variables for stock discrimination of *B.boops* (Figure 4). The CDA analysis performed on the RD, OA, and OW demonstrated significant discrimination of otoliths between Aegean Sea and Marmara Sea (Wilks' lambda:0.979, df:1, p:0.003) and 56.6% of the originally grouped cases were correctly classified.

Table 3. Otolith dimension relations with coefficient determination (R^2) for *B.boops* in the Marmara Sea and Aegean Sea (OL:Otolith length; OW:Otolith width; OR:Otolith radius; OP:Otolith perimeter; OA:Otolith area; W:Otolith weight)

Relations	**Marmara Sea**		**Aegean Sea**	
	Right otolith	**Left otolith**	**Right otolith**	**Left otolith**
OL-OW;R^2	y:0.3397x+1.4266;0.72	y:0.3927x+1.1412;0.82	y:0.3908x+1.138;0.75	y:0.4315x+0.9353;0.77
OL-OR;R^2	y:0.3789x+0.096;0.74	y:0.3495x+0.3236;0.77	y:0.3341x+0.4052;0.62	y:0.3703x+0.2514;0.75
OL-OP;R^2	y:2.6876x-0.0816;0.90	y:2.698x-0.214;0.92	y:2.4728x+1.2663;0.89	y:2.5071x+1.0107;0.91
OL-OA;R^2	y:3.8963x-9.1796;0.91	y:4.0709x-10.283;0.95	y:3.7693x-8.5457;0.94	y:3.8702x-9.084;0.92
OL-W;R^2	y:0.0084x-0.0299;0.90	y:0.0082x-0.0289;0.89	y:0.0076x-0.0246;0.81	y:0.0076x-0.0241;0.80
OW-OR;R^2	y:0.8952x-07432;0.67	y:0.7981x-0.3761;0.76	y:0.7052x-0.0422;0.56	y:0.7162x-0.0466;0.68
OW-OP;R^2	y:5.9548x-4.685;0.71	y:5.6887x-3.9887;0.77	y:5.1019x-1.6327;0.78	y:4.7311x-0.5876;0.78
OW-OA;R^2	y:9.0545x-17294;0.80	y:9.1506x-17.931;0.90	y:7.9058x-13.417;0.84	y:7.5231x-12.332;0.84
OW-W;R^2	y:0.019x-0.0454;0.74	y:0.0184x-0.044;0.83	y:0.0158x-0.034;0.71	y:0.0147x-0.0306;0.73
OR-OP;R^2	y:5.2669x+3.4626;0.67	y:5.7244x+2.0192;0.65	y:4.3409x+5.7146;0.50	y:5.0364x+3.6435;0.57
OR-OA;R^2	y:7.8856x-4.6205;0.72	y:9.1418x-8.11;0.75	y:7.2251x-3.2451;0.62	y:7.9762x-5.5233;0.71
OR-W;R^2	y:0.0176x-0.0213;0.76	y:0.0186x-0.0248;0.72	y:0.016x-0.0172;0.64	y:0.0165x-0.0196;0.70
OP-OA;R^2	y:0.6361x+6.9821;0.84	y:0.6416x+6.8887;0.91	y:0.6342x+7.1855;0.89	y:0.6197x+7.2994;0.90
OP-W;R^2	y:0.0028x-0.0251;0.83	y:0.0029x-0.0252;0.84	y:0.0027x-0.0222;0.69	y:0.0027x-0.0227;0.73
OA-W;R^2	y:0.0021x-0.009;0.92	y:0.002x-0.0082;0.93	y:0.0076x-0.0246;0.81	y:0.0019x-0.0054;0.81

Table 4. Comparison of descriptive statistics and otolith shape indices for left and right otoliths of *B.boops* in the Marmara Sea and Aegean Sea (SE:Standard error; Min:Minimum; Max:Maximum; Sig:Significant differences)

Otolith shape indices	**Side**	**Area**	**Mean**	**SE**	**Min**	**Max**	**Sig**
Aspect ratio (AR)	Right	Marmara Sea	1.7100	0.01	1.3794	2.1787	0.066
		Aegean Sea	1.7271	0.0073	1.503	2.0957	
	Left	Marmara Sea	1.6976	0.0081	1.3864	2.0781	0.967
		Aegean Sea	1.7064	0.0067	1.4402	2.0454	
Ellipticity (E)	Right	Marmara Sea	0.6954	0.0069	0.1594	0.3708	0.113
		Aegean Sea	0.2654	0.0019	0.201	0.3539	
	Left	Marmara Sea	0.2574	0.0022	0.1619	0.3503	0.372
		Aegean Sea	0.2599	0.0018	0.1804	0.3433	
Form factor (FF)	Right	Marmara Sea	0.6954	0.0069	0.511	1.286	**0.019**
		Aegean Sea	0.6791	0.0038	0.4932	0.807	
	Left	Marmara Sea	0.698	0.0057	0.4952	1.1025	**0.001**
		Aegean Sea	0.6826	0.0033	0.5225	0.8223	
Roundness (RD)	Right	Marmara Sea	0.504	0.0035	0.4013	0.7558	**0.018**
		Aegean Sea	0.493	0.033	0.3973	0.5857	
	Left	Marmara Sea	0.4992	0.0026	0.4022	0.6024	0.807
		Aegean Sea	0.495	0.0022	0.3431	0.5969	
Circularity (C)	Right	Marmara Sea	18.2527	0.1621	7.8484	24.1044	0.059
		Aegean Sea	18.6941	0.0964	15.1949	22.6632	
	Left	Marmara Sea	18.1709	0.1333	11.3924	25.3642	**0.003**
		Aegean Sea	18.5056	0.0906	15.2744	24.0367	
Rectangularity (R)	Right	Marmara Sea	0.6731	0.0035	0.5703	0.9503	**0.000**
		Aegean Sea	0.6659	0.0016	0.5704	0.751	
	Left	Marmara Sea	0.6627	0.002	0.5591	0.7593	0.531
		Aegean Sea	0.661	0.0021	0.4442	0.7648	

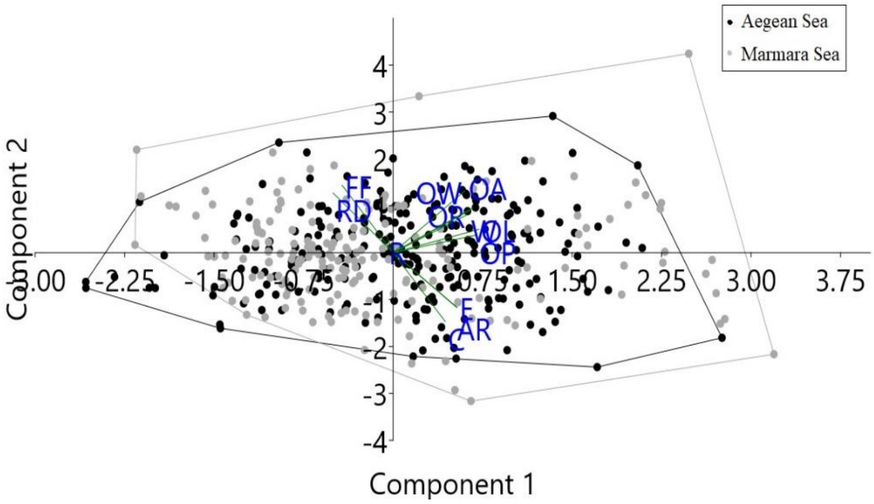

Figure 4. Principal component analysis (PCA) plot showing similarities/differences in otolith shapes and dimensions for the left otoliths for *B.boops* in the Aegean Sea and Marmara Sea.

Discussion

The present study is the first to identify and compare the shape indices of the otoliths and morphometry of *B.boops* between the Aegean Sea and Marmara Sea. This study found some similarities in *B.boops* stocks of the Aegean Sea and Marmara Sea . The otolith area and circularity of the left otolith, roundness and rectangularity of the right otolith, form factor of the left and right otolith in otolith shape indices and morphometry were significantly different ($p<0.05$) between *B.boops* stocks in the Aegean Sea and Marmara Sea . Also, the PCA analysis from the left otolith for otolith shape indices and morphometry varriables may explain differences in roundness, otolith area and otolith width of *B.boops* stocks. Also, CDA analysis performed on the RD, OA, and OW demonstrated significant discrimination. However, different methods such as genetic analysis, analysis of biological markers, stable isotope analysis and otolith microchemistry should be used in stock discrimination (Schade et al., 2019; Morales-Nin et al., 2022; Yedier et al., 2023b). Besides otolith shape indices, also elliptic fourier and wavelet analyses are used to compare otolith shape. So, these analyses are also needed to verify whether *B.boops* belong to the same stock in the Marmara Sea and the Aegean Sea.

Yedier et al. (2023a) reported that *Pagellus acarne* stocks were different according to otolith morphometrics, shape and ecomorphological indices from the Aegean Sea and the Marmara Sea. Durrani et al. (2022) revealed that the body and otolith shapes of *Engraulis encrasicolus* were separated between the Aegean Sea and the Marmara Sea. In these areas, the different populations of *Pomatomus saltatrix* were successfully demonstrated with the morphometrics, meristics, and otolith shape analyses (Bal et al., 2021). Saygılı et al. (2016) showed that *Spicara maena* stocks from the Northern Aegean Sea and the Marmara Sea might be different baed on the otolith shape. Also, *B.boops* stocks sampled from three Algerian locations, and also two Tunisian stations shown that stocks may be different based on the otolith shape analysis (Ider et al., 2017; Ben Labidi et al., 2020). Our findings suggested that, *B.boops* stocks from the Aegean Sea and the Marmara Sea might be different based on comparisons of shape indices and some morphometric characteristics of otoliths.

The Marmara Sea and the Aegean Sea, connected by the Çanakkale Strait, are in constant interaction with each other (Ozturk, 2021). The environmental and ecological factors are different in these areas. Vignon et al. (2008) and Vignon and Morat (2010) emphasized that environmental and ecological factors may have an effect on the otolith shape and morphology. Also, otolith morphology is affected by a complex combination of physiological (sexual maturity, growth, etc.) factors (Vignon and Morat, 2010; Mille et al., 2015). In the present study, in order to account for differences in fish size a large number and various sizes of *B.boops* individuals were sampled monthly to minimize errors. The effects of above mentioned factors should be investigated to discriminate stocks inhabiting the Marmara Sea and the Aegean Sea.

The otolith shape indices AR, E, FF, RD, C and R for *B.boops* were calculated as 0.682, 0.472, 1.812, 18.455, 0.672, 0.289, respectively, by Cicek et al. (2021) in the İskenderun Bay, Northeastern Mediterranean Sea. Although their study was in a different area, the calculated otolith shape indices were similar to those reported in this study.

The relationship between fish length and otolith length of 179 specimens of *B.boops* was estimated as OL=0.233TL+0.971 in the Algerian coast, Southwestern Mediterranean Sea (Ider et al. 2017). Ider et al. (2017) reported that a significant linear relationship (R^2:0.823) existed between fish length and otolith length. In this study, the parameters “a” and “b” in the equation with 244 and 188 individuals for this species were estimated as

0.0243, 1.704 and 0.021, 2.105 for the right otoliths in the Aegean Sea and the Marmara Sea,. The a and b values reported by Ider et al. (2017) were different than those in the present study. The R^2 value of left and right otoliths by their study were mostly lower than in the study. The best fit R^2 value was obtained among TL and OL (R^2:0.945). These differences may be related to changing environmental conditions, sampling sizes and sampling area. Although the sampling locations were different between the Aegean Sea and the Marmara Sea, the TL-OL relationship was found to be mostly similar in this study. When, the dimensions of the otoliths were compared, R^2 values were generally higher in the left otoliths than in the right otoliths in the both seas.

The current results of this study suggested that *B.boops* stocks in the North of Aegean Sea and the Southwest of Marmara Sea may be different based on the right and left otolith shape indices and otolith dimensions. . This is the first study evaluating differences of otolith shape indices and otolith dimensions to discriminate *B.boops* stocks in the Aegean Sea and Marmara Sea. The present study found significant differences in OA of otolith dimension and FF, RD, C and R of shape indices. So, these parameters can be used as alternative and effective parameters to discriminate *B.boops* stocks from the Aegean Sea and the Marmara Sea. However, more detailed studies involving environmental, physicochemical, ecological parameters and genetic traits will be required to better understand the origin of these variations between *B.boops* stocks. In conclusion, this study suggests that *B. boops* stocks in the Marmara Sea and the Aegean Sea should be strategically assessed and managed separately to their sustainable use in the future.

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Conflict of Interest

The authors declare that there are no conflicts of interest or competing interests.

Author Contributions

Yusuf ŞEN: Designing of the study, laboratory study, data analysis, writing original draft preparation. İsmail Burak DABAN: Data analysis, software, checking-original draft preparation. Mukadder ARSLAN İHSANOĞLU: Supported the laboratory study. Oğuzhan AYAZ: Sample collections. Uğur ÖZEKİNCİ: Checking-original draft preparation.

Ethics Approval

Ethics committee approval is not necessary for this study.

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