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RESEARCH ARTICLE

Seasonal Size Composition of Gelatinous Macrozooplankton in the Sinop Peninsula of Black Sea

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ABSTRACT

In this study, size compositions of *Aurelia aurita* (Linnaeus, 1758), *Pleurobrachia pileus* (O. F. Müller, 1776) and *Mnemiopsis leidyi* A. Agassiz, 1865 were presented seasonally between March 2015 and February 2016 at the Sinop Peninsula of Black Sea. Sampling was carried out monthly at the 6 stations by plankton net (50 cm diameter mouth opening, 500 µm mesh size for horizontal tows, 210 µm mesh size for vertical tows). Small sized individuals of *A. aurita*, *M. leidyi* and *P. pileus* were found dominant in summer. Bigger size individuals were observed for *A. aurita* in spring, *M. leidyi* in winter, and *P. pileus* in autumn. *A. aurita* <4 cm was determined as 57%, *M. leidyi* <2 cm was 58% and *P. pileus* < 0.6 was determined as 67%. Maximum and minimum lengths were measured 28 cm and 0.5 cm for *A. aurita*, 2 cm and 0.2 cm for *P. pileus*, 9 cm and 0.2 cm for *M. leidyi,* respectively. The size distribution of *A. aurita, M. leidyi* and *P. pileus* showed significantly different (ANOVA, $p<0.05$) between seasons.

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Introduction

Gelatinous macrozooplankton play a crucial role in the cycle of the food chain in fisheries-based ecosystems. These organisms have controlled whole ecosystem (Oguz et al., 2001, Purcell et al., 1999). Gelatinous populations are opportunistic and can quickly adapt to changes in physical and biological conditions in aquatic systems. When the gelatinous macrozooplankton present in an intensive amount, they saturate to nets during the fishing activity, decrease the fishing efficiency resulting in economic losses in commercial fishing (Özdemir et al., 2014). Increasing abundance of gelatinous due to global climate change, uncontrolled fishing, eutrophication of coastal areas caused negative changes in the Black Sea ecosystem in the last 20-30 years (Kideys, 2002; Bat et al., 2007; Bat et al., 2009). *Aurelia aurita* and invader *Mnemiopsis leidyi* reached high abundances in Black Sea

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ecosystem and negatively impacted on the zooplankton and pelagic fishing in the late 1980s (Kideys and Romanova, 2001; Gucu, 2002). Gelatinous macrozooplankton group mainly feeds on zooplankton, fish eggs and larvae in the Black Sea (Mutlu, 2001; Birinci Özdemir et al., 2018). Nutritional competition over zooplankton, which is the food of pelagic fish, is important in the food chain of the Black Sea. In the Black Sea ecosystem, which is open to changes and responds rapidly to these changes, it is important to monitor the distribution species diversity, population parameters and ecology of gelatinous organisms. *Aurelia aurita, Rhizostoma pulmo, Pleurobrachia pileus* and invasive species *Mnemiopsis leidyi* and *Beroe ovata* commonly found in the Black Sea (Kideys, 2002; Finenko et al., 2003; Birinci Özdemir and Özdemir, 2017; Birinci Özdemir et al., 2018; Dönmez and Bat, 2019). Although there are some studies on the gelatinous macrozooplankton organisms in the Black Sea coast of Turkey (Mutlu and Bingel, 1999; Mutlu, 2001; Mutlu, 2009; Kideys and Romanova, 2001, Bat et al., 2007; Bat et al., 2009; Birinci Özdemir et al., 2018; Ustun and Birinci Özdemir, 2019), these studies are mostly spatial distribution of these species are on the abundance and biomass. In order to contribute to these studies, seasonal size compositions of *A. aurita*, *P. pileus* and *M. leidyi* at Sinop Peninsula of the Black Sea were evaluated.

Material and Methods

In the study, seasonal size compositions of *A. aurita*, *M. leidyi* and *P. pileus* at Sinop Peninsula of the Black Sea were investigated between March 2015 and February 2016. Samplings were conducted by monthly in six stations during the daytime (Figure 1). The coordinates and depths of the stations were given in the Table 1.

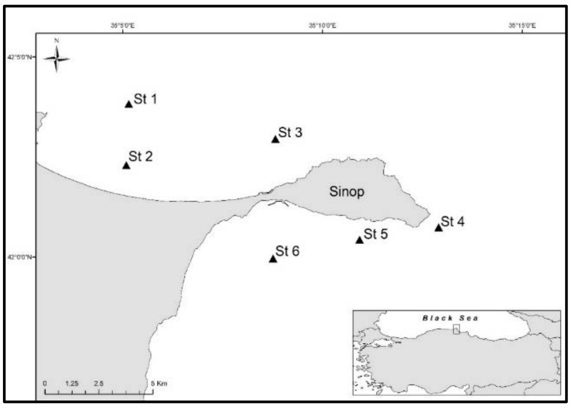

Figure 1. Sampling stations at Sinop Peninsula of the Black Sea

Table 1. Geographic coordinates and depth of sampling station stations

Sampling Stations	Geographic Coordinates	Sampling Depth (m)
St 1	42° 03.826'N- 035° 05.143'E	60
St 2	42° 02.294'N- 035° 05.081'E	20
St 3	42° 02.948'N- 035° 08.813'E	50
St 4	42° 00.739'N- 035° 12.899'E	40
St 5	42° 00.431'N- 035° 10.923'E	50
St 6	41° 59.961'N- 035° 08.757'E	60

Vertical tows were carried out from the bottom to the surface with two replications for each stations. Samples were collected by using plankton nets (50 cm diameter mouth opening, 500 µm mesh size for horizontal tows, and 210 µm mesh size for vertical tows). At the end of each tows, nets were exteriorly washed. Samples in cod-end contents were passed through a 1 mm sieve and the gelatinous macrozooplankton were separated. Disc diameter and length of specimens were measured to the nearest millimeter. Weights were determined respectively according to Birinci Özdemir (2011):

M. leidyi $W=0.7905L^{1.6406}$, $R=0.9267$

A. aurita $W=0.2895L^{2.1653}$, $R= 0.9298$

P. pileus $W=0.0757L^{0.7642}$, $R=0.7144$

One-way ANOVA and post hoc Tukey tests (MINITAB v17.0 statistical package) were used to determine differences in the disc diameters or lengths of gelatinous species between seasons (Zar, 1999).

Results and Discussion

Totally 953 *A. aurita*, 149 *M. leidyi*, and 472 *P. pileus* were evaluated. The mean, minimum and maximum length or disc diameter of species were given as seasonal in Table 2. Also, boxplot of length of gelatinous macrozooplankton according to seasonal changes were given in Figure 2.

Table 2. The mean, minimum and maximum length or disc diameter of gelatinous species collected from different seasons

	Seasons	Mean ±SE	Body length (cm)		
			Min	Max	Number (N)
A. aurita	Spring	8.61 ± 0.27	0.50	28.00	297
	Summer	4.69 ± 0.045	0.80	13.00	43
	Autumn	6.70 ± 0.22	1.00	26.00	381
	Winter	8.02 ± 0.38	0.50	21.00	232
M. leidyi	Spring	4.40 ± 0.67	3.00	7.00	5
	Summer	2.12 ± 0.15	0.20	9.00	100
	Autumn	3.29 ± 0.40	1.00	8.00	28
	Winter	4.02 ± 0.65	0.50	9.00	16
P. pileus	Spring	0.81 ± 0.27	0.40	1.40	79
	Summer	0.57 ± 0.03	0.20	1.50	101
	Autumn	0.70 ± 0.03	0.20	2.00	113
	Winter	0.72 ± 0.03	0.40	1.40	179

Maximum and minimum disc diameters were measured 28 cm and 0.5 cm for *A. aurita*, respectively. The seasonal mean diameters of *A. aurita* were shown in Table 2. In terms of size frequency for *A. aurita* were examined, large individuals were determined in spring season (Figures 2 and 3). In summer, percentage share of small *A. aurita* (< 4 cm) was found higher as 57% (Figure 3). In the Sinop region, mean length and weight of *A. aurita* were 8.3±0.10 cm and 43.2±1.58 g, respectively (Birinci Özdemir et al., 2019). In 2008, it was reported that 4-6 cm *A. aurita* was dominant in spring and summer in the southern coasts of central Black Sea (Birinci Özdemir, 2011). A maximum diameter of 42 cm has been found in the Western Baltic Sea and the Black Sea (Ishii and Bamstedt, 1998) whereas the maximum diameter was measured 17 cm in the northwestern Black Sea (Weisse and Gomoiu, 2000). Maximum diameter was 28 cm and individuals with a diameter <10 cm were determined to make up 25% of the population in March 1995 in the Black Sea (Mutlu, 2001). Disc diameter of *A. aurita* in open waters ranges from 20 to 30 cm, whereas it reaches from 4 to 10 cm in semi-enclosed/enclosed areas (Ishii and Bamstedt, 1998). In this study, it was found that the dominant diameter varies seasonally, however the diameters between 4 and 10 cm were the dominant size group in general. It was observed that larger individuals were more abundant in open stations.

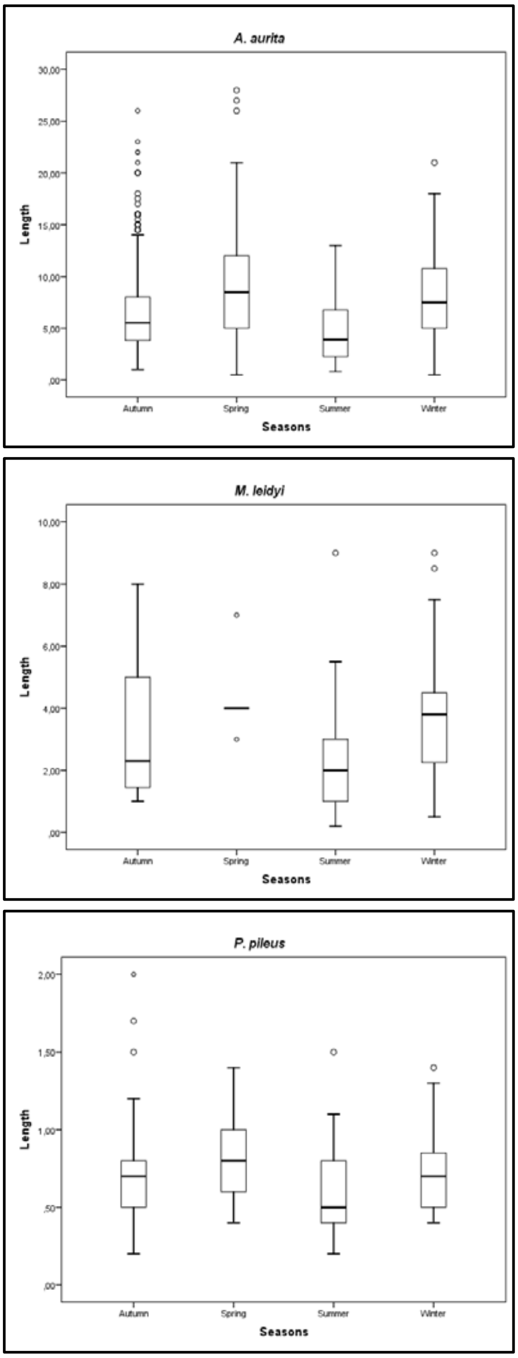

Figure 2. Seasonal length distribution of gelatinous species in Sinop Peninsula during March 2015 and February 2016

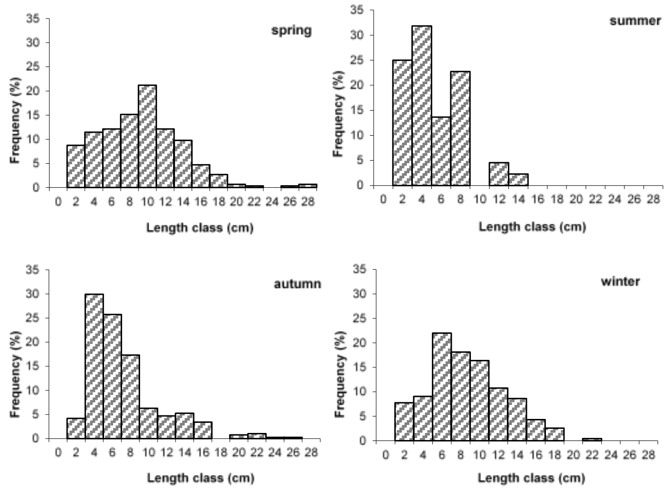

Figure 3. *Aurelia aurita* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

In this study, *M. leidyi* (<2 cm) were determined dominant and percentage share as 58% (Figure 4). It was determined that large individuals were more in spring and autumn (Figures 2 and 4). Maximum and minimum length was measured 9 cm and 0.2 cm, respectively (Table 2). In the northern Black Sea, small *M. leidyi* individuals (1-1.5 cm) predominated in August 1995 (Weisse and Gomoiu, 2000). In 2008, small (<2 cm) *M. leidyi* individuals were determined in summer and maximum individual was 10.8 cm (Birinci Özdemir, 2011). Unal (2002) reported parallel results to the present study. However, researcher found maximum length of *M. leidyi* as 17.3 cm. The largest *M. leidyi* in the Black Sea was determined as 18 cm (Shiganova et al., 2001). Maximum length was measured for *M. leidyi* as 15 cm in the Gulf of Izmit (Isinibilir, 2012). In the present study, the maximum length was found to be lower compared to other studies. It is thought that the dissimilarities between maximum lengths could be resulted from different temperature, sampling area and feeding conditions.

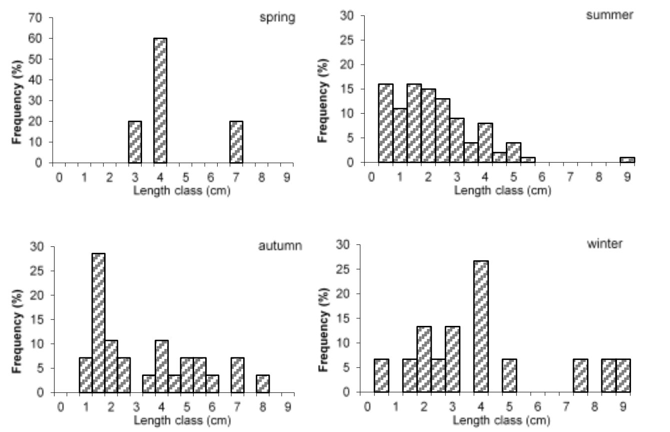

Figure 4. *Mnemiopsis leidyi* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

Small individuals (< 0.6 cm) of *P. pileus* were dense in the summer and it covers 67% (Figure 5). Larger individuals were found in summer (Figure 2). In the present study, the largest and smallest individuals were detected 2 cm and 0.2 cm, respectively. Mean lowest and highest length was determined in summer 0.57±0.03 cm and spring 0.81±0.27 cm (Table 2). Mazlum et al. (2018) informed that maximum and minimum length of *P. pileus* was 1.5 cm (in winter) and 0.1 cm (in summer) in Southern coasts of the Black Sea. Maximum *P. pileus* was reported as 1.6 cm and an increase were reported in small individuals in autumn and winter in 2008 (Birinci Özdemir, 2011). Mutlu (2009) pointed out that small individuals constitute a large part of the population in spring season in the Black Sea.

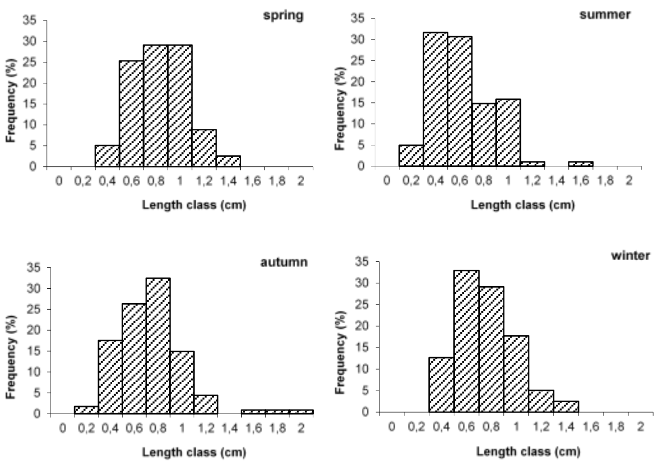

Figure 5. *Pleurobrachia pileus* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

Size distribution of *A. aurita*, *M. leidyi* and *P. pileus* showed significantly differences seasonally (for all species $p<0.05$; $F = 17.34$ for *A. aurita*, $F = 9.13$ for *M. leidyi* and $F = 12.34$ for *P. pileus*). In this study, small-sized individuals of *A. aurita*, *M. leidyi* and *P. pileus* were found dominant in summer. It demonstrated reproduction of gelatinous populations was in this period. Temperature and food availability are really controlling factors for growth of gelatinous in natural environments. Population increase and growth of gelatinous macrozooplankton are parallel to these factors (Finenko et al., 2003; Möller and Riisgard, 2007; Finenko et al., 2014). Consequently, predation pressure of gelatinous macrozooplankton on zooplankton and ichthyoplankton is more intense during this period in the Black Sea.

Conclusion

It is known that climate change, fisheries pressure and the invasions of opportunistic species into the ecosystem have changed the balance in the Black Sea (Gucu, 2002; Kideys, 2002; Oğuz and Gilbert, 2007). With this change in the Black Sea, the negative effects of the gelatinous organisms that exploit the void and become dominant in the pelagic ecosystem on fisheries cannot be doubted. It is necessary to determine the morphological and biological changes of these organisms to monitor the time-dependent species changes and distribution in the system. Considering the possible changes in the ecosystem with the increase in temperature in the future, it is important that these data are recorded regularly in order to observe the effects on the gelatinous, reveal the predictions and determine the differences. Thus, solutions to problems that may be encountered in ecosystem, fisheries, and fishery activities will be presented.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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