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Seasonal Distribution of Gelatinous Macrozooplankton in the Hamsilos Bay, Southern Black Sea, Turkey

Funda ÜSTÜN[1], Zekiye BİRİNCİ ÖZDEMİR[2]
University of Sinop, Faculty of Fisheries, Department of Hydrobiology, SİNOP
[1] https://orcid.org/0000-0002-7435-8414, [2] https://orcid.org/0000-0002-7443-1298
✉: fundaustun@gmail.com

ABSTRACT
The present study describes the abundance and biomass distribution of gelatinous macrozooplankton in relation to physical parameters in Hamsilos Bay. Gelatinous macrozooplankton samples were collected monthly from four stations between July 2015 and June 2016 using a plankton net with a 112 µm mesh size and a 50 cm diameter mouth opening by vertical hauls. Four gelatinous macrozooplankton species were identified: *Aurelia aurita* (Linnaeus, 1758); *Mnemiopsis leidyi* A. Agassiz, 1865; *Beroe ovata* Bruguière, 1789; and, *Pleurobrachia pileus* (O.F. Müller, 1776). The maximum mean abundance of gelatinous macrozooplankton was recorded in August 2015 (24.58 ind. m^{-2}), whereas the maximum mean biomass was recorded in April 2016 (147.79 g m^{-2}) from four sampling stations. The abundance and biomass of gelatinous macrozooplankton increased in the summer and spring. *M. leidyi* and *P. pileus* were primarily responsible for the increase in total gelatinous macrozooplankton abundance in the summer, whereas *A. aurita* and *B. ovata* were primarily responsible for the increase in total abundance in the spring and autumn. The abundance and biomass of *M. leidyi* were positively correlated with temperature and negatively correlated with dissolved oxygen.

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Güney Karadeniz'in Hamsilos Koyu'nda Jelimsi Makrozooplanktonun Mevsimsel Dağılımı

ÖZET
Bu çalışmada, jelimsi makrozooplankton türlerinin Hamsilos Koyu'ndaki mevsimsel bolluk-biomass dağılımları ve fiziksel parametreler ile ilişkisi belirlenmiştir. Jelimsi makrozooplankton örnekleri Temmuz 2015-Haziran 2016 tarihleri arasında belirlenen dört istasyondan aylık olarak 112 µm ağ göz ve 50 cm ağız açıklığına sahip plankton kepçesi ile dikey çekim yöntemi ile toplanmıştır. Çalışmada 4 jelimsi makrozooplankton türü tanımlanmıştır: *Aurelia aurita* (Linnaeus, 1758); *Mnemiopsis leidyi* A. Agassiz, 1865; *Beroe ovata* Bruguière, 1789; and, *Pleurobrachia pileus* (O.F. Müller, 1776). Dört örnekleme istasyonunun, maksimum ortalama jelimsi makrozooplankton bolluk değeri Ağustos 2015 (24.58 birey m^{-2}) tarihinde kaydedilmiştir. En yüksek ortalama jelimsi makrozooplankton biomass değeri Nisan 2016 tarihinde (147.79 g m^{-2}) belirlenmiştir. Jelimsi makrozooplankton bolluk ve biomass değerlerinin yaz ve ilkbaharda artış gösterdiği saptanmıştır. Toplam jelatinimsi makrozooplankton bolluğundaki artıştan *M. leidyi* ve *P. pileus* yaz aylarında sorumluyken, *A. aurita* ve *B. ovata* ilkbahar ve sonbaharda toplam bolluktaki artışta etkili olmuştur. *M. leidyi* bolluk ve biomass değerleri sıcaklık ile pozitif ilişki gösterirken çözünmüş oksijen değerleri ile negatif ilişki gösterdiği belirlenmiştir.

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INTRODUCTION

Gelatinous macrozooplankton are ecologically important in marine ecosystem because of their status as the most important consumer of zooplankton, wide distribution in the marine ecosystem, and complex lifestyle. Gelatinous organisms can readily adapt to an aquatic environment, reaching high population densities in coastal areas over a short period. However, they have negative effects on benthic and pelagic marine ecosystems. In the commercial fishing industry, these organisms clog and tear fishing nets which reduces catch efficiency resulting in economic losses in commercial fishing (Han et al., 2009; Özdemir et al., 2014).

Five species of gelatinous macrozooplankton are common in the Black Sea. These are the Cnidaria *Aurelia aurita* (Linnaeus, 1758) and *Rhizostoma pulmo* (Macri, 1778) and the Ctenophora *Pleurobrachia pileus* (O.F. Müller, 1776); *Mnemiopsis leidyi* A. Agassiz, 1865; and, *Beroe ovata* Bruguière, 1789. Gelatinous macrozooplankton group mainly feeds on zooplankton, fish eggs, and larvae in the Black Sea (Mutlu, 1999, 2001; Birinci Özdemir et al., 2018). Notably, the pressure of *M. leidyi* on the anchovy stocks resulted in a remarkable decline of stocks in the late 1980s (Kideys and Romanova, 2001; Gucu, 2002). Due to their bloom in the summer months, gelatinous organisms in the Black Sea have a negative impact on tourism for an average of two months. Located in the Black Sea of the Sinop Peninsula region, the Hamsilos Bay is a prominent tourist area. The Bay is sheltered from storms and wave surges and is considered to be an important location for fish egg spawning. Studies in and around this region have reported the presence of larvae and eggs of many fish species that are on the Red Data Book Black Sea (Oral et al., 2013; Kaya, 2015; Uygun, 2015).

In the study area, no research has been conducted to date on the distribution and ecology of gelatinous macrozooplankton. Objective of this study is to determine key qualitative and quantitative indices (e.g., abundance) of gelatinous macrozooplankton species in the Hamsilos Bay and to analyse the relationships of these indices with important environmental parameters (temperature, salinity, dissolved oxygen).

MATERIAL and METHODS

Study Area

The city of Sinop is located on a large peninsula that extends north to south along the Southern Black Sea. Sinop and its environs have a low population density (TUIK, 2018) and are far from pollutant sources. Being within the Hamsilos Natural Park (first-degree protected natural area; Anonymous, 2018), Hamsilos Bay is located bordering the middle of the peninsula. It is an important region for marine flora and fauna because of its status.

Sampling Macrozooplankton and Environmental Conditions

The gelatinous macrozooplankton samples were collected from four stations monthly between July 2015 and June 2016 at the mouth of the Hamsilos Bay (Table 1 and Figure 1). Samples were collected by a vertical column collecting method using a plankton net with a 50 cm mouth opening and 112 µm mesh size. The work conducted by the fishing boat "Zıpkın." The temperature (°C), salinity (‰), and dissolved oxygen (mg L^{-1}) of the surface seawater were measured with an YSI 6600 MDS model multiparameter.

Table 1. Basic information about the stations used in sampling gelatinous macrozooplankton in the Hamsilos Bay of the Black Sea

Station Name	Geographic Coordinates	Sampling Depth (m)
St 1	42°3′45″N - 35°2′40″E	13
St 2	42°3′52″N - 35°3′14″E	30
St 3	42°4′5″N - 35°2′59″E	30
St 4	42°4′12″N - 35°2′45″E	30

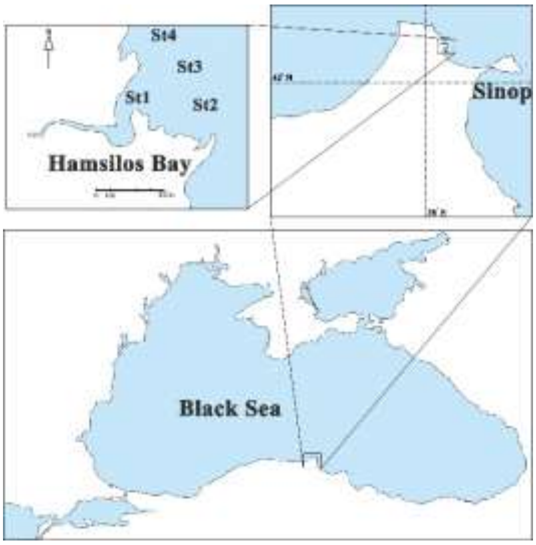

Figure 1. The location of the stations used in sampling gelatinous macrozooplankton of Hamsilos Bay of the Black Sea

Following the macrozooplankton sample collection, the net was washed from the outside, which acted to aggregate the plankton in the net collector. The gelatinous macrozooplankton in the collector were then passed through a 2 mm sieve and separated from the mesozooplankton samples (e.g., Copepoda, meroplankton). The species of gelatinous macrozooplankton aggregated on the sieve were then identified and measured for size. The disc diameter of *A. aurita* and the body length of *B. ovata*, *M. leidyi*, and

P. pileus were measured with a 1 mm section ruler. The length of the lobes of *M. leidyi* was also measured. Wet weights (WW) were determined for each individual by displacement volume using a finely divided cylinder.

The abundance (i.e., number of individuals) of the gelatinous mesozooplankton species were estimated as individuals m^{-2} (ind. m^{-2}). The abundance for each species was calculated based on the area of the net ($A = \pi r^2$; r: the radius of the mouth portion of the net).

Data Analyses

One-way ANOVA and post hoc Tukey tests were used to determine differences in the abundance and biomass of gelatinous macrozooplankton between stations. In addition, the Spearman's Rank Correlation was used to the relationships between the abundance and biomass of the gelatinous macrozooplankton species and the physical data (SPSS 21 IBM Crop., Armonk, NY, USA).

All data were log10(x+1) transformed for normalizing. Detrended Correspondance Analysis (DCA) was applied first to determine behaviour of the data. The length of the first axis of DCA was found to be lower than 3 and Redundancy Analysis (linear method) was chosen (Leps and Similaur, 2003). Monte Carlo permutation test (n = 999) was used for the statistical differences. Analysis steps followed by Gürbüzer et al., 2017 and CANOCO 4.5 software package (Ter Braak, 1986) was used for the multivariate analysis.

RESULTS and DISCUSSION

During the sampling, the highest average temperature of surface seawater was recorded as 25.8 °C in August 2015, and the lowest as 8.5 °C in February 2016. The surface seawater average salinity was the highest in May 2016 (19 ‰) and the lowest in September 2015 (17.8 ‰). The highest average dissolved oxygen in the surface seawater was 9.9 mg L^{-1} in February 2016, and the lowest was 7.06 mg L^{-1} in September 2015 (Figure 2).

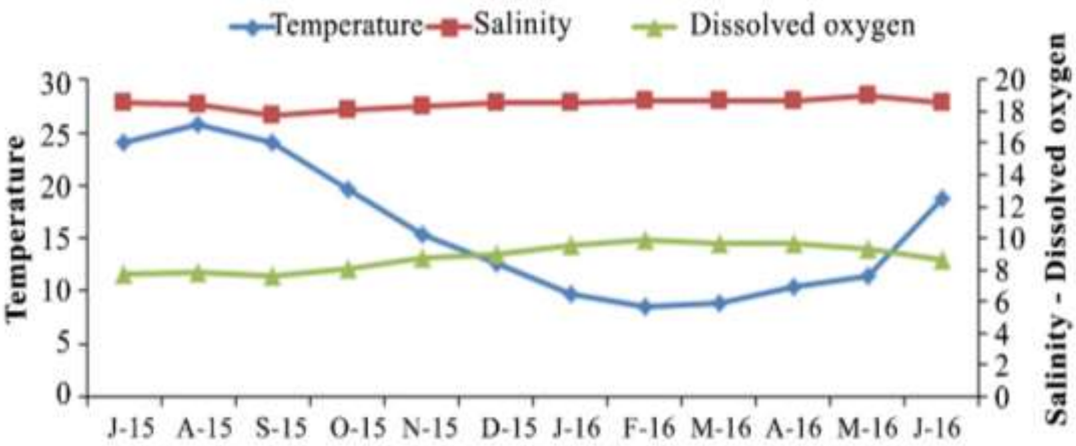

Figure 2. The monthly variation in the average temperature (°C), salinity (‰) and dissolved oxygen (mg L^{-1}) of surface seawater in Hamsilos Bay

Temperature, oxygen, and salinity are determinant in the distribution and mass increment of gelatinous organisms (Niermann et al., 1994; Oguz, 2005; Bat et al., 2009; Mutlu, 2009; Mazlum and Seyhan, 2011). Previous studies conducted on the Sinop Peninsula reported peak abundance of gelatinous macrozooplankton at high temperatures (Ünal, 2002; Birinci Özdemir 2005, 2011).

In the present study, one species belonging to the phylum Cnidaria (*Aurelia aurita* [Linnaeus, 1758]) and three species belonging to the phylum Ctenophora (*Pleurobrachia pileus* [O.F. Müller, 1776], *Mnemiopsis leidyi* [A. Agassiz, 1865], and *Beroe ovata* [Bruguière, 1789]) were identified. Results indicated that there were no statistically significant differences abundance and biomass among the stations for each species ($P > 0.05$). The average abundance of the gelatinous organisms ranged between 0.83 (November 2015) and 24.58 ind. m^{-2} (August 2015) and the average biomass ranged between 1.04 (November 2015) and 147.79 g m^2 (April 2016) (Table 2 and Figure 3).

Gelatinous macrozooplankton increased in abundance and biomass in the summer and spring months. In February 2016, gelatinous macrozooplankton were not observed in the sampling area, probably due to the excessive rainfall and huge wave observed there (Figure 3).

In Sinop Peninsula, the maximum gelatinous macrozooplankton abundance was determined as 643 ind. m^{-2} in July 1999, 42.5 ind. m^{-2} in September 2002, 120 ind. m^{-2} in July 2003, 67.5 ind. m^{-2} in July 2004, and 56 ind. m^{-2} in August 2008. The maximum biomass of gelatinous macrozooplankton in that area was determined as 1298 g m^{-2} in July 1999, 224.4 g m^{-2} in July 2002, 2141.5 g m^{-2} in March 2003, 327.75 g m^{-2} in August 2004, and 360 g m^{-2} in April 2008 (Ünal, 2002; Birinci Özdemir, 2005; Birinci Ozdemir et al., 2007; Birinci Özdemir, 2011).

Table 2. The abundance (individuals [ind.] m^{-2}) and biomass ($g\ m^{-2}$) of gelatinous macrozooplankton species determined for the Hamsilos Bay

	Abundance (ind. m^{-2})			Biomass ($g\ m^{-2}$)		
	Minimum	**Maximum**	**Mean**	**Minimum**	**Maximum**	**Mean**
Aurelia aurita	1.67 (September 15, December 15, March 16)	18.33 (April 16)	4.41	6.67 (December 15)	147.79 (April 16)	39.63
Pleurobrachia pileus	0.83 (September 15)	15.42 (May 16)	4.2	0.46 (March 16)	8.87 (August 15)	2.72
Mnemiopsis leidyi	0.42 (November 15)	5 (July 15)	0.9	0.63 (November 15)	30.79 (July 15)	4.11
Beroe ovata	0.42 (November 15)	0.83 (October 15-January 16)	0.17	0.42 (November 15)	2.08 (October 15)	0.35
Total gelatinous macrozooplankton	0.83 (November 15)	24.58 (August 15)	9.69	1.04 (November 15)	147.79 (April 15)	46.80

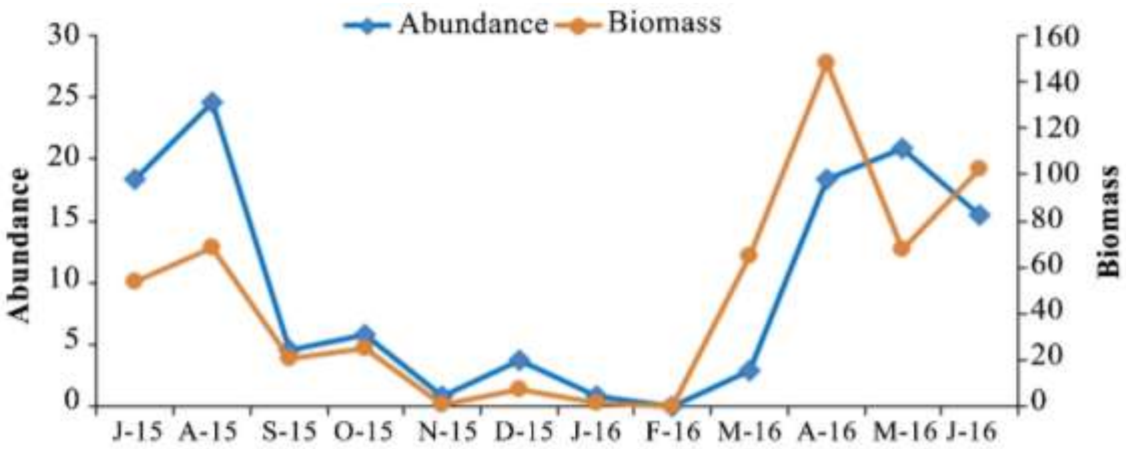

Figure 3. The monthly variation of the average abundance (individuals [ind.] m^{-2}) and biomass ($g\ m^{-2}$) of gelatinous macrozooplankton in the Hamsilos Bay

Throughout the entire sampling period, the average gelatinous macrozooplankton abundance was calculated as 9.7 ind. m^{-2}, and the average biomass was 46.8 $g\ m^{-2}$ (Table 2).

A. aurita was determined to be the dominant species in terms of abundance (46 %) and biomass (84 %). *P. pileus* was determined to be the second dominant species in terms of abundance (43 %) and *M. leidyi* in terms of biomass (9 %). *B. ovata* was found to be the least dominant species in terms of both abundance and biomass (Figure 4).

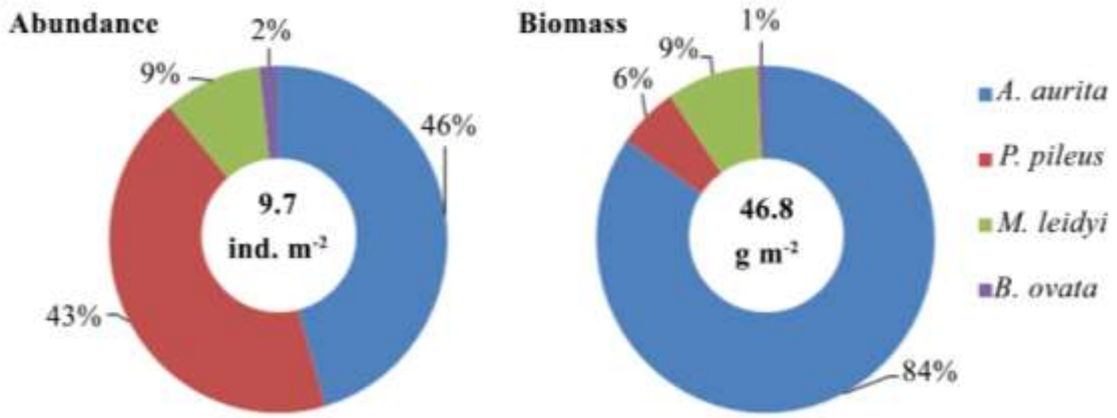

Figure 4. The percent composition of gelatinous macrozooplankton species in terms of abundance and biomass values in the Hamsilos Bay

In similar studies conducted in the coastal area of the Sinop Peninsula, the averages of abundance and biomass of gelatinous macrozooplankton species were found to be 1387 ind. m^{-2} and 613.3 g m^{-2} in 1999 and 16.30 ind. m^{-2} and 79.90 g m^{-2} in 2008, respectively. In both years, *M. leidyi* (60 % in 1999 and 52 % in 2008) and *P. pileus* (31 % in 1999 and 27 % in 2008) were the most dominant species in terms of abundance, and *A. aurita* (54% in 1999 and 53% in 2008) and *M. leidyi* (42 % in 1999 and 41 % in 2008) were the most dominant in terms of biomass (Ünal, 2002; Birinci Özdemir, 2011).

Several previous studies indicated that the abundance and biomass of *A. aurita* in the Black Sea increased in the spring due to new individuals from reproduction and reached the highest values during the summer months (Mutlu, 2001; Birinci Özdemir 2005; Bat et al., 2009). Similarly, we found that the abundance and biomass of *A. aurita* increased during the spring and summer months. In fact, *A. aurita* was found in all sampling months except November 2015, January 2016, and February 2016. The highest averages of abundance of *A. aurita* were recorded in August 2015 (11.25 ind. m^{-2}) and April 2016 (18.33 ind. m^{-2}). The maximum averages of biomass of *A. aurita* were recorded in April 2016 (147.79 g m^{-2}) and June 2016 (96.29 g m^{-2}). The lowest averages of abundance were recorded as 1.67 ind. m^{-2} in September 2015, December 2015, and March 2015, while the lowest average biomass was recorded as 6.67 g m^{-2} in December 2015 (Table 2 and Figure 5). In previous some studies conducted in the coastal area of the Sinop Peninsula, the highest averages of biomass of *A. aurita* were recorded as 225 g m^{-2} in July 2002, 2130 g m^{-2} in March 2003, 268 g m^{-2} in August 2004, and 124.17 g m^{-2} in April 2008 (Birinci Özdemir, 2005; Birinci Özdemir et al., 2018).

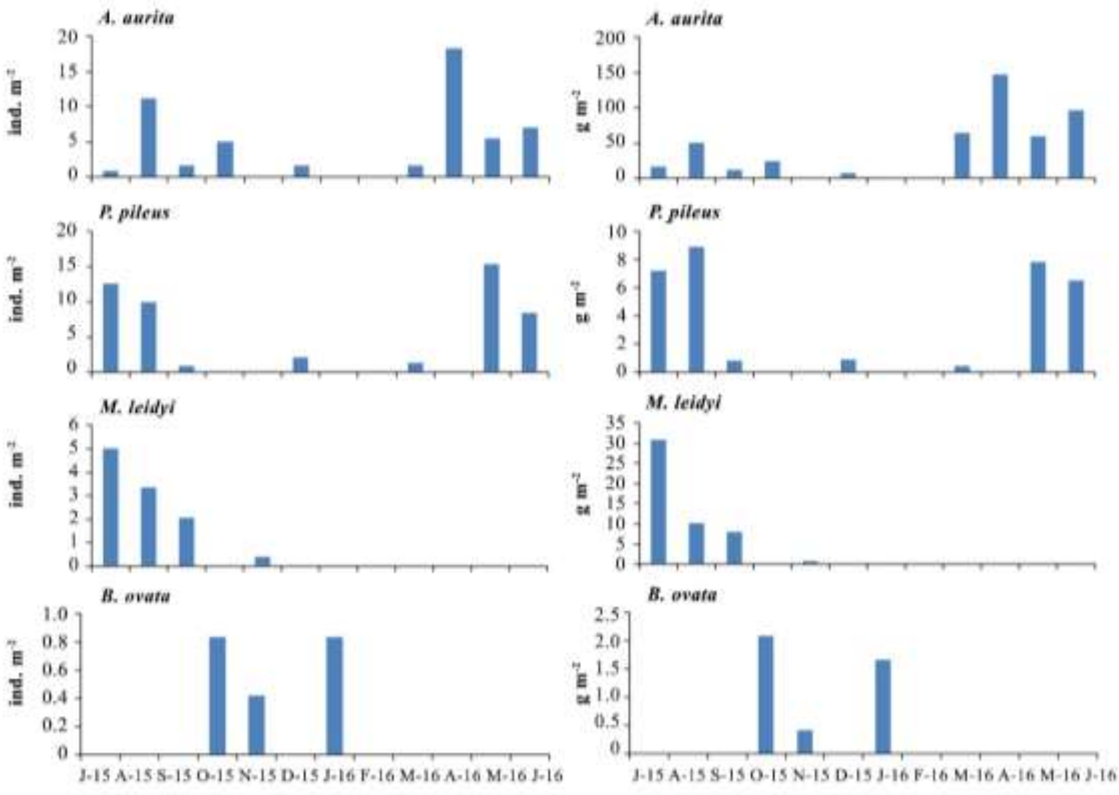

Figure 5. The monthly variation in the average abundance (individuals [ind]. m^{-2}) and biomass (g m^{-2}) of gelatinous macrozooplankton species in the Hamsilos Bay

P. pileus individuals exhibited a vertical distribution in the Black Sea (Mutlu and Bingel, 1999) and a more intense distribution in deep waters than in shallow, coastal waters (Kideys and Romanova, 2001; Ünal, 2002; Mazlum, 2004; Birinci Özdemir, 2011). Mutlu and Bingel (1999) reported that the abundance and biomass of *P. pileus* began to increase in the spring, which is the breeding period of this species in the Black Sea and reached maximum values in the summer months. Petranu (1997) reported that *P. pileus* usually increased during the autumn and winter and migrated to deeper and more open waters when the temperature increased. In the present study, *P. pileus* was recorded at high levels in the spring and summer months. *P. pileus* individuals were not encountered in October 2015, November 2015, January 2016, February 2016, and April 2016 in Hamsilos Bay. The maximum abundance of *P. pileus* was 15.42 ind. m^{-2} in May 2016, and the maximum biomass was 8.87 g m^{-2} in August 2015 (Table 2 and Figure 5). Two studies performed in the Sinop Peninsula region concluded that *P. pileus* abundance and biomass started to increase in the spring and reached its maximum during the summer months (Ünal, 2002; Birinci Özdemir, 2005). In another study in the Sinop Peninsula region in 2008, unlike other studies in this region, Birinci Özdemir (2011) observed high *P. pileus* abundance and biomass in the autumn and winter. Furthermore, high estimates of abundance were recorded in June 2003 (74.16 ind. m^{-2}), July 2004 (104.16 ind. m^{-2}), and September 2008 (11.67 ind. m^{-2}). On the other hand, high biomass was recorded in June 2003 (83.5 g m^{-2}), July 2004 (76.4 g m^{-2}), and January 2008 (7.14 g m^{-2}; Birinci Özdemir, 2005, 2011). Similarly, in studies conducted along the southeastern Black Sea coast, high estimates of abundance were determined in the spring (127 ind. m^{-2} in Trabzon and 184.41 ind. m^{-2} in Rize; Mazlum, 2004, 2016). In the present study, the abundance and biomass of *P. pileus* were found lower in the Sinop Peninsula compared to the previous data (Ünal, 2002; Birinci Özdemir, 2005). However Birinci Özdemir (2011) determined parallel results with the study.

In the present study, *M. leidyi* was only sampled in July 2015, August 2015, September 2015, and November 2015. The highest abundance and biomass were recorded in July 2015 (5 ind. m^{-2} and 30.79 g m^{-2}, respectively); the lowest were recorded in November 2015 (0.42 ind. m^{-2} and 0.63 g m^{-2}, respectively). *M. leidyi* individuals were not encountered in the winter and spring (Table 2 and Figure 5). Studies conducted throughout the Black Sea reported that *M. leidyi* reached high volumes during the summer (Mutlu, 1999; Kideys, 2002; Ünal, 2002; Shiganova et al., 2004; Birinci Özdemir, 2005; Birinci Özdemir et al., 2018). In the Black Sea, *M. leidyi* shows high reproduction and growth at 20-24 °C (Finenko and Romanova, 2000; Kamburska and Stefanova, 2005). In the present study, this species reached high abundance and biomass in the temperature range of 20-26 °C. A study conducted in the Sinop Peninsula region in 2008, reported that the species reached its highest abundance (51 ind. m^{-2}) at 23.5 °C in August (Birinci Özdemir et al., 2018).

The annual development of *B. ovata* in the Black Sea occurs between August and November (Konsulov and Kamburska, 1998). We only observed individuals of *B. ovata* in October 2015, November 2015, and January 2016. The highest abundance (0.83 ind. m^{-2}) and biomass (2.08 g m^{-2}) were evidenced in October 2015. *B. ovata* was observed from October to January in the coastal area of the Sinop Peninsula (Birinci Özdemir 2005, 2011).

We found no relationships between the total abundance and biomass of gelatinous macrozooplankton organisms with the physical parameters according to Spearmen Corr. The abundance of *M. leidyi* was positively correlated with temperature (P < 0.01) however negatively correlated with dissolved oxygen (P < 0.01). The biomass of *M. leidyi* was positively correlated with temperature (P < 0.05) but negatively correlated with seawater dissolved oxygen (P < 0.05). There were no statistically significant relationships between the abundance and biomass of the other gelatinous macrozooplankton species and the environmental parameters (Table 3).

Table 3. The relationships between the abundance and biomass of gelatinous macrozooplankton species with different environmental parameters in Hamsilos Bay (Total: Total gelatinous macrozooplankton; *Aa*: *Aurelia aurita*; *Pp*: *Pleurobrachia pileus*; *Ml*: *Mnemiopsis leidyi*; *Bo*: *Beroe ovata*; T: Temperature; S: Salinity; Do: Dissolved oxygen)

		T	S	Do
ABUNDANCE	**Total**	.437	.302	-.317
	Aa	.09	.211	.012
	Pp	.382	.373	-.302
	Ml	**.774****	-.29	**-.721****
	Bo	-.085	-.272	-.006
BIOMASS	**Total**	.042	.376	.071
	Aa	-.127	.396	.227
	Pp	.523	.262	-.412
	Ml	**.652***	-.18	**-.620***
	Bo	-.044	-.277	-.054

**Correlation is significant at the 0.01 level (2 tailed).
*Correlation is significant at the 0.05 level (2-tailed).

RDA analysis displayed that the first two eigenvalues explained 40.2% of the cumulative variance of species data, covering 97.6% of relationship of with environmental data (Table 4). The RDA analysis show that *M. leidyi*, *A. aurita* and *P. pileus* positive correlation with temperature and salinity in between May and August (Figure 6). In the RDA triplot, the distribution of species by months formed two group except September. First group was October, November, December, January, February, March, and April, second group was May, June, July and August. It is thought that the distribution of species in September differs according to other months, due to the strong winds and wave at the time of sampling (Figure 6).

Birinci Özdemir et al. (2018) determined a positive relationship between *M. leidyi* abundance and seawater temperature but did not find any relationships between the abundance of other species and the environmental parameters under study. Isinibilir (2012) found no relationships between the abundance and biomass of *M. leidyi* with temperature in the Izmit Bay but showed positive relationships of the abundance and biomass of *B. ovata* with seawater temperature.

Table 4. Summary statistics for the four axes of redundancy analysis (RDA) analysis

Axes	1	2	3	4
Eigenvalues	0.370	0.032	0.010	0.309
Species–environment correlations	0.792	0.422	0.225	0.000
Cumulative percentage variance				
Of species data (%)	37.0	40.2	41.2	72.2
Of species–environment relation (%)	89.8	97.6	100.0	0.0

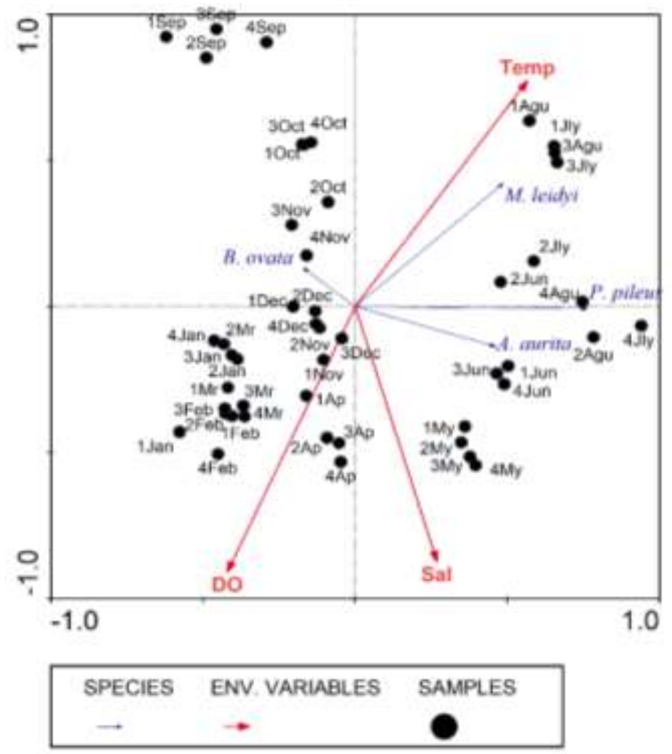

Figure 6. Distribution of sampling stations–months, abundance of gelatinous macrozooplankton species, and ecological factors in redundancy analysis (RDA) triplot. Temp, Temperature; Sal, Salinity; DO, Dissolved oxygen; 1, Station 1; 2, Station 2; 3, Station 3; 4, Station 4.

In the Black Sea, a significant negative (inverse) relationship was determined between the abundance of *M. leidyi* and *A. aurita* (Shiganova et al., 1998; Kideys and Romanova, 2001; Mutlu 2001; Birinci Özdemir, 2005), which was attributed to food competition (Mutlu, 1999; Mutlu 2001; Birinci Özdemir et al. 2018) since the species live in the same water column (Kideys and Romanova, 2001). However, Weisse and Gomoiu (2000) did not find a relationship between the abundance of these two species in their study in the Northern Black Sea. When an increase in the abundance was observed of *B. ovata*, which feeds on ctenophores (Harbison et al., 1978), a decrease was observed in the abundance of *M. leidyi* and *P. pileus* (Finenko et al., 2003; Mazlum, 2004; Mutlu, 2009; Finenko et al., 2018); a similar situation was observed in the Izmit Bay (Isinibilir, 2012). In the present study, no statistical relationship was observed between the abundance of the two species ($P > 0.05$); however, it was evidenced that the population (i.e., abundance) of *A. aurita* decreased as the population of *M. leidyi* increased, whereas the populations of *M. leidyi* and *P. pileus* decreased when the population of *B. ovata* increased. We believe that it is important to analyse the stomach content of gelatinous organisms and to make feeding experiments in the laboratory because of the different results of the nutrient content in the marine environment with regional differences.

We found that the distribution of gelatinous macrozooplankton species differed seasonally. Overall, *A. aurita* and *P. pileus* were found to be the dominant species. Moreover, it was determined that temperature affected *M. leidyi* populations significantly. Studies conducted in the Black Sea, Caspian Sea, and Bay of Sevastopol have reported a relationship between *M. leidyi* abundance and temperature, which is consistent with the present study (Sullivan et al., 2001; Finenko et al., 2003; Shiganova et al., 2004; Gambill et al., 2015; Birinci Özdemir et al., 2018).

We also determined that the abundance and biomass of gelatinous species were lower than those reported in previous studies conducted in the Black Sea (Shiganova et al., 2004; Kideys et al., 2005; Birinci Özdemir, 2005; Mutlu, 2009; Birinci Özdemir, 2011). Gelatinous organisms usually have higher populations in areas with adequate water circulation and currents (Mutlu and Bingel, 1999; Kideys and Romanova, 2001; Lynam et al., 2011). The reason for the observed lower detection of gelatinous macrozooplankton abundance and biomass in the present study may be because the study area is a coastal, sheltered bay area, unlike the other study areas. Gelatinous organisms have an important role in the pelagic ecosystem of the Black Sea, in terms of their ecology, and because of commercial fishing, tourism, and human health (Gucu, 2002; Kideys, 2002; Bat et al., 2007; Boero, 2013). Thus, gelatinous macrozooplankton taxa in the region should be analysed, and their life cycles should be monitored. Environmental factors such as climate change that may favour gelatinous species, should be continuously monitored. The ability to control the populations of these organisms should be analysed, and the problems encountered in that control should be discussed so that mechanisms designed for their sustainability can be developed.

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