Biological diversity and seasonal variation of mesozooplankton in the southeastern Black Sea coastal ecosystem

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1. Introduction
One of the most important environmental factors that control commercial fish stocks showing great fluctuations throughout the year is food supply. Fish larvae start life as ichthyoplankton and feed on zooplankton during their initial feeding periods. The food of zooplankton is constituted of phytoplankton (Gislason and Silva, 2009). Zooplankton has a key role in the pelagic food chain for energy transfer to the upper energy level (Mauchline et al., 1998; Harris et al., 2000; Hays et al., 2005).

Many organisms of commercial importance in many parts of the world depend mostly on copepods as a food source at the planktonic larvae stage (Murdoch, 1990). Anchovy (Engraulis encrasicolorus), which is the most important fish species in the Black Sea ecosystem, feed in winter (when they form a shoal) on Calanus helgolandicus and Acartia clausi, which abound. These 2 calanoid copepod species are of great importance in the energy cycle of the Black Sea ecosystem (Kideys et al., 2000).

Studies concerning planktonic organisms, which are greatly important in the food chain in the Black Sea, are usually based on discrete sampling in the western and northern territories during certain periods (Besiktepe et al., 1998; Kideys et al., 2000; Besiktepe, 2001; Gubanova et al., 2001). In particular, this provides an opportunity to explain the long-term seasonal dynamics of zooplankton populations. The regime shifts occurring in the Black Sea in the last 20 years have had important effects on zooplankton and fishery. At the beginning of the 1990s, a decrease was observed in the production of second and third trophic levels in the marine ecosystems of the world. The Black Sea was negatively affected by global warming after the mid-1990s. This effect caused decreases in phytoplankton and zooplankton abundance (Oguz et al., 2006a). The changes observed throughout the Black Sea continued after the 2000s. The coastal ecosystem belonging to the southeastern Black Sea, in particular, is still under the influence of these changes. No data belonging to coastal ecosystems about time series for mesozooplankton abundance were available until the end of the 1990s. There are still no data on the annual zooplankton abundance, diversity, and species composition so far. This has caused a significant insufficiency in the interpretation of the ecosystem.

The aim of this study was to reveal the changes in the seasonal structure of mesozooplankton throughout the
years in the southeastern Black Sea coastal ecosystem, and
to provide data about the annual zooplankton abundance,
diversity, and species composition in the region. Moreover,
eliminating the shortage of data on the time series between
1999 and 2006 was also an aim. Data belonging to former
periods were also used. In this context, it is intended to
present the changes in planktonic structure due to regime
shifts and climate change on a global level, which has
been frequently discussed in recent years. In addition, the
study presents the differences between the southeastern
Black Sea and southwestern Black Sea in terms of species
composition and the point at which the eastern Black Sea
coastal ecosystem comes under the Mediterranean
process.

2. Materials and methods

2.1. Study area

The Black Sea is the largest anoxic marine environment in
the world. The maximum depth of the Black Sea is 2200
m; its surface area and volume are $4.2 \times 10^5$ km$^2$ and $5.3 \times$
$10^5$ km$^3$, respectively. The Black Sea is almost completely
isolated from the oceans of the world. It has a limited
connection to the Mediterranean Sea via the Turkish
Straits system and the Sea of Marmara. Strong density
stratification prevents vertical mixing. The oxygenated
upper layer reaches up to 150 m; the water mass at the
lower layers (only 13% of the sea volume) is anoxic and
contains hydrogen sulfide. A temporary halocline separates
oxic and anoxic waters (Özsoy and Ünlüata, 1997). There
is a well-determined oxygen-minimum zone between
these waters. General cyclonic circulation of the Black Sea
appears as wind effect (Oguz et al., 1991). Along with this,
the Batumi anticyclone is located in the southeastern part
of the Black Sea. This anticyclone provides the continuity
of coastal currents (Korotaev et al., 2011).

In order to collect mesozooplankton samples in the
southeastern Black Sea, 40 cruises were done between
1999 and 2006 to a station 15 nautical miles from the coast
and located at the coordinates of 41°11′15″N, 40°14′15″E
(Figure 1). The depth near the permanent station is about
780 m. The advantage of the sampling station is that it is
close to the Faculty of Marine Sciences and less affected
by anthropogenic pollution. Moreover, the oceanographic
conditions represent the eastern Black Sea ecosystem.

2.2. Hydrography

Vertical profiles of temperature and salinity were measured
continuously from the surface down to 1 m above the
bottom using the General Oceanic Idronaut 316 CTD.

2.3. Zooplankton sampling procedure

All tows were made by vertical hauls from the different
depth layers from the beginning of the anoxic layer to
the surface in the southeastern part of the Black Sea.
The beginning of the anoxic water layer was determined
according to sigma-$t$ values. If sigma-$t$ values are greater
than 16.2, water bodies are considered to be anoxic
(Baştürk et al., 1994). All samples were collected during
the day by vertical hauls using a Hydro-Bios net (39 cm
mouth diameter and 200 µm mesh size). A Hydro-Bios
digital 5-digit flowmeter was used for the calculation
of seawater filtration (UNESCO, 1968). To eliminate
differences attributable to vertical migration, samples were
taken between 1100 and 1400 hours.

After each haul, the nets were carefully rinsed. The
contents of the cod-ends after collection were fixed
immediately and preserved in a 4% formaldehyde seawater
solution buffered with sodium borate. The samples were
concentrated in jars for quantitative analyses, depending
on the density. Counting was done under an Olympus
BH2 stereomicroscope and Nikon E 600 using 4× and
10× objectives and a Bogorov–Rass counting chamber.
Quantitative analyses of species were performed by using
9-mL subsamples. Counts were repeated on 8 subsamples
(Harris et al., 2000). Zooplankton data were classified
at the phylum, class, or order level. Adult copepods
(females and males), copepodites, copepod nauplii, and
the cladocerans were identified to species or genus level.

Figure 1. Sampling station.
following the inventory of Mauchline et al. (1998) and Johnson and Allen (2005).

Marine ecologists use the Bray–Curtis index to explain the similarities and differences between samples (Yoshiyoka, 2008). Biological and environmental data were analyzed by using PRIMER v. 5 and Stat 200 statistical software packages. In order to examine the mesozooplankton population in the eastern Black Sea coastal ecosystem, copepods, the most common group, were used as the base. The Bray–Curtis index was utilized to reveal the differences and similarities of this group throughout the year. In order to determine the similarity of sampling periods throughout the year, the Bray–Curtis similarity index was calculated by the equation below:

\[ BC_{IJ} = 100 \left\{ \frac{\sum_{k=1}^{s} |n_{ik} - n_{jk}|}{\sum_{k=1}^{s} (n_{ik} + n_{jk})} \right\} , \]

where \( s \) is the number of core taxa present in sampling periods \( i \) and \( j \), \( n_{ik} \) is the number of individuals in taxon \( k \) in sampling period \( i \), and \( n_{jk} \) is the number of individuals in taxon \( k \) in sampling period \( j \).

3. Results
3.1. Environmental parameters
In order to determine the environment in which mesozooplankton organisms live, the variation in temperature and salinity with respect to depth is given in graphs (Figure 2).

Figure 2. Monthly average temperature (°C), salinity (%), and density (sigma-t kg/m³) profiles in the Black Sea.
It was determined in CTD profiles obtained during the study that the variation in water temperature with respect to depth was statistically significant for all seasons except winter (P < 0.05). The surface water temperature ranged from 8.5 °C to 28.3 °C in the region of concern. The thermocline layer was observed at depths of 15–25 m in spring, whereas in summer and autumn it was observed at depths of 25–45 m. This shows that the mixing layer moved to higher depths in summer and autumn. It was observed in the temperature profile that the temperature did not change after a depth of 100 m. Moreover, the cold intermediate layer was encountered at a depth of 35–75 m. According to our sigma-t profile, the beginning of the anoxic zone water body was at 155 and 162 m during the summer and winter sampling periods, respectively.

The salinity profiles measured within the study area are given in Figure 2. It was determined that the salinity of 17‰ measured at the surface showed a gradual change, reaching 21.2‰ at a depth of 200 m. The measurements showed that the average salinity of 17.6‰ at the surface rose to 19‰ at 100 m and to 21.2‰ at 200 m.

Monthly sigma-t profiles used in expressing seawater density are given in Figure 2. The sigma-t value in the surface waters was lower in the summer months than in the winter months. The average sigma-t value was 9.6 kg/m³, while it increased to 14.3 kg/m³ in winter months. The sigma-t profile, which varied greatly by season up to 50 m, did not reveal a statistically significant change after 50 m. It reached 16.6 kg/m³ after 200 m. The anoxic zone started at the sigma-t value of 16.2 kg/m³ and varied between 120 and 130 m throughout the year, depending on the season.

3.2. Mesozooplankton abundance and distribution
Ten mesozooplanktonic species belonging to 10 orders were identified during the study. Four of these orders belong to the phylum Arthropoda (Copepoda, Cirripedia, Cladocera, and Decapoda) and 2 to the phylum Mollusca (Bivalvia and Gastropoda). The phyla Cnidaria, Chordata, Chaetognatha, and Annelida were each represented by 1 order. Seven species in the Copepoda group and 2 species in the Cladocera group of Arthropoda were determined. The Appendicularia and Chaetognatha groups were represented by 1 species each. The Bivalvia, Cirripedia, Decapoda, Gastropoda, Polychaeta, and Hydrozoa groups were evaluated as meroplankton. The systematic groups to which these species belong and their abundances are presented in Table 1.

Differences were observed in terms of mesozooplankton abundance (P < 0.05). The lowest abundance was determined in 1999 (Figure 3). Three peaks were observed in summer (June), autumn (September), and winter (December). The maximum mesozooplankton abundance was reached in September, with 162,042 ind./m². Copepods were observed in all sampling periods. In addition, it was seen that the copepod group had its maximum value in terms of abundance in December. The copepods were determined as 73,638 ind./m² (Figure 4). The Cladocera species were the second dominant group in September. The number of organisms belonging to this group reached up to 90,409 ind./m².

The highest mesozooplankton abundance was determined in August 2000 (Figure 3). In this period, the number of organisms in the water column reached 479,369 ind./m². The Copepoda species were continuously observed in the year 2000 (Figure 4). The highest value of copepods was determined in May as 136,382 ind./m². In samplings done in 2000, the Cladocera species were encountered only at the end of summer.

During 2001, the highest mesozooplankton abundance was determined in August (491,856 ind./m²) (Figure 3). The Copepoda group was the dominant group during the sampling period (Figure 4). This group had its maximum value in terms of abundance in December, with 185,662 ind./m². The number of organisms of the Cladocera species, however, reached its maximum in August. The Cladocera abundance reached 261,091 ind./m² in this period.

The samplings done in 2002 covered the winter, spring, and summer seasons. The highest abundance was determined in February (417,073 ind./m²) (Figure 3). Copepoda species were regularly observed in the samples taken (Figure 4). The Copepoda became dominant in 2002 and reached 269,046 ind./m² in February. While the Cladocera species were not observed in the winter or spring months, the highest value was determined in August as 7280 ind./m².

In 2005, sampling was done in February, April, May, and June. The highest mesozooplankton number was determined in April, with 251,821 ind./m² (Figure 3). In this sampling period, the Copepoda group had its maximum value in April, with 170,184 ind./m² (Figure 4).

For the sampling done in 2006, mesozooplankton abundance was the highest in June (319,258 ind./m²) (Figure 3). *Oikopleura dioica* was the species with the highest abundance in the water column, with 178,493 ind./m² organisms in June (Figure 4). The Copepoda species were again observed in all samples and became the second dominant group of 2006. It was seen that the Copepoda group reached 85,325 ind./m² in 2006. The Cladocera species reached 24,623 ind./m² in June.

The results of similarity index applications for copepods are presented in Figure 5. Population structure showed similarities between the other periods and July 1999 (23%), August–September 2000 (53%), July 2001 (57%), May–June 2002 (63%), June 2005 (78%), and September 2006 (52%). Those sampling months showed differences due to a low similarity rate in these periods. Thus, the copepod group had a significantly different population structure in July.

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Order</th>
<th>Species</th>
<th>Years (Sampling depth: 0–150 m)</th>
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<td></td>
<td></td>
<td></td>
<td>0–150 m</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>Copepoda</td>
<td>Acartia clausi</td>
<td>6254</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calanus euxinus</td>
<td>5253</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centropages ponticus</td>
<td>759</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oithona similis</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paracalanus parvus</td>
<td>756</td>
</tr>
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<td></td>
<td></td>
<td>Pseudocalanus elongatus</td>
<td>8068</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harpacticoid copepod</td>
<td>15</td>
</tr>
<tr>
<td>Cirripedia</td>
<td>Cirripedia nauplii</td>
<td></td>
<td>935</td>
</tr>
<tr>
<td>Cladocera</td>
<td>Penilia avirostris</td>
<td></td>
<td>16,054</td>
</tr>
<tr>
<td></td>
<td>Pseudoevadne tergestina</td>
<td></td>
<td>5589</td>
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<tr>
<td>Decapoda</td>
<td>Decapoda larvae</td>
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<td>38</td>
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<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Bivalvia larvae</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Gastropoda</td>
<td>Gastropoda larvae</td>
<td>9</td>
</tr>
<tr>
<td>Chordata</td>
<td>Appendicularia</td>
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<td>1462</td>
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<tr>
<td>Chaetognatha</td>
<td>Aphragmorphora</td>
<td>Sagitta setosa</td>
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</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td></td>
<td>102</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>Coelenterata</td>
<td>Medusae planula</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 3. The variation in total mesozooplankton abundance and temperature with respect to years (SST: sea surface temperature).
compared to the other months of 1999. This difference was observed because the *Paracalanus parvus* species and copepodite stages of the species had been encountered in July. However, the reason for the difference observed at the end of summer in similar applications in 2000 was because *Oithona similis*, harpacticoid copepods, and the copepodite stages of other copepod species had reached higher numbers than in other months. Since *Calanus euxinus* was
highly abundant even though the numbers of other species decreased in July 2001, the copepod group displayed a different population structure. Because of the decrease in the numbers of copepod species in May and August 2002, this period showed characteristic differences. A similar situation is valid for June 2005. The difference in September 2006 can be explained by the increase in the abundance of *Acartia clausi* and *Centropages ponticus* species.

4. Discussion

4.1. Environmental parameters

The surface temperature in the Black Sea shows seasonal and spatial variations. Sea surface temperature in the winter period (February–March) decreases down to an average of 6–7 °C (Figure 2). The temperature gradient, showing spatial differences, is given as 8–9 °C in southern parts and 2–3 °C in northern parts. Sea surface temperature, having an average of 20–22 °C in summer months, increases up to 24–25 °C along the eastern and southern coasts. No anomalies were observed during the sampling done between 1999 and 2006. Yearly temperature variations in the sea surface remained within the seasonal temperature limits found in previous studies (Oguz et al., 2006b). The seasonal thermocline layer changed between 15 and 25 m, starting from spring to midsummer. The change from midsummer to the end of autumn was between the depths
of 25 and 45 m. The surface mixed layer in the winter season reached a depth of 75 m, whereas yearly water temperatures showed no change after a depth of 100 m (Figure 2).

The difference in salinity observed between the surface waters and deep waters is one of the most characteristic properties of the Black Sea. Low salinity and density in surface waters and high salinity and density of deeper waters cause stagnation. This situation leads to the existence of hydrogen sulfide in circular cyclonic stream edges (periphery) at depths of 160–200 m in regions close to the coast and at depths of 80–120 m in the central parts of the Black Sea (Vinogradov et al., 1985).

The salinity of surface water ranges between 17‰ and 18‰ in the Black Sea (Figure 2). Even though changes with respect to months were observed in salinity, these were not statistically significant (P < 0.05).

4.2. The composition and seasonal distribution of mesozooplankton species

Zooplankton is the most important component of the food chain in seas and oceans. Copepods are the most important mesozooplanktonic group constituting the primary food supply of fish larvae and some fishes having high economic value. The other important groups are Cladocera, Cirripedia, Polychaeta, Chaetognatha, Appendicularia, and meroplankton. In our study, a total of 15 zooplankton, 7 of which belonged to the copepod group, were identified (Tables 1 and 2). The Acartia tonsa and Pontella mediterranea species found in previous studies in the Sinop region were not encountered in this study (Ünal, 2002; Üstün, 2005). In our study, unlike in Üstün’s (2005) study performed to determine the composition and distribution of zooplankton in the central Black Sea, harpacticoid copepod abundance was also identified.

It is seen that species diversity in the southeastern Black Sea region is lower than in the Marmara Sea and western Black Sea. In the samples obtained during the study, 7 copepods and 2 Cladocera species were identified. The species Evadne nordmani, Evadne spinifera, and Pleopis polyphemoides (Cladocera), which are present in the western Black Sea, were not observed in this study. Furthermore, Aetideus sp., Ctenocalanus vanus, Metridia lucens, Microcalanus pusillus, Oncaea media, Oncaea minuta, Oncaea subtilis, and Scolichthricella sp., which are among the Mediterranean species, were not encountered in the southeastern Black Sea ecosystem, either. It has been reported that Mediterranean-origin mature zooplanktonic organisms died within 24 h if the salinity decreased to below 18‰ (Isinibilir et al., 2011). This situation explains why Mediterranean-origin species of plankton cannot be found away from the straits in the Black Sea.

During 10-year sampling in the Mediterranean, important interannual variability emerged when the total zooplankton abundance was considered (Berline et al., 2012). The copepods were the most abundant group, as in the Black Sea. Three higher peaks were determined in mesozooplankton during the annual cycle in both marine environments (Black Sea and Mediterranean). Monthly zooplankton abundance data indicated that the highest peaks were found during the first part of cool years, and the lowest values during the second part (Berline et al., 2012). According to the literature, annual peaks of similar taxonomic groups take place during almost the same periods in the Mediterranean and Black Seas.

Mesozooplankton peaks were determined in every season in studies performed on the middle part of the Black Sea’s Anatolian coast (Sinop). It was reported that the most important of these peaks were observed in the autumn and winter months (Ünal, 2002; Üstün, 2005). Zooplankton seasonal peaks were affected by phytoplankton seasonality and population structure (Kovalev et al., 2003). Phytoplankton populations of the eastern and western parts of the Black Sea show differences in community structure in the same periods (Uysal and Sur, 1995; Feyzioglu and Guneroglu, 2011). When the present data were compared with the literature (Üstün, 2005), it was observed that the western and eastern Black Sea showed differences in zooplankton peak seasons during the same period.

In this study performed between 1999 and 2006, the mesozooplankton abundances changed with respect to the years. Depending on the temperature and phytoplankton intensity, peaks were identified in the summer season of 2000–2001, at the beginning of the spring of 2005, and in the summer season of 2006 (Figure 3). Seasonal variations in biomass of different zooplankton groups occur together with seasonal variations in phytoplankton, bacterioplankton, and water temperature (Kovalev et al., 2003).

The contribution of Cladocera to the autumn peak in 1999 was very high (90,409 ind./m²). When the seasons are compared, as seen in Table 1 and Figure 4, the group showed differences for 1999 (P < 0.05). Penilia avirostris, in particular, reached a high abundance. P. avirostris plays an important role in the food chain in the transportation of organic matter to higher levels (Paffenhöfer and Orcutt, 1986; Turner et al., 1988; Atienza et al., 2006a, 2006b).

The highest mesozooplankton abundance was observed in August 2000 and 2001, due to the high contribution of P. avirostris (Table 1; Figure 4). It was reported in research that Cladocera species were intermittently present in the marine environment year-round, and after a rapid decrease following a very high abundance, they disappeared from the plankton (Onbé and Ikeda, 1995; Tang et al., 1995; Marazzo and Valentin, 2003; Valentin and Marazzo, 2004). The factors controlling the abundance of this group are not
Table 2. Seasonal distributions abundance of Copepoda species with respect to years during the sampling period (ind./m²).

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Calanus euxinus</th>
<th>Acartia clausi</th>
<th>Centropages ponticus</th>
<th>Paracalanus parvus</th>
<th>Pseudocalanus elongatus</th>
<th>Oithona similis</th>
<th>Harpacticoid copepod</th>
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<td>46</td>
<td>727</td>
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<td>137</td>
<td>1546</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
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<td>0</td>
<td>732</td>
<td>6534</td>
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<td></td>
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<td>1673</td>
<td>8800</td>
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<td>73</td>
</tr>
<tr>
<td></td>
<td>Jul</td>
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<td>91</td>
<td>0</td>
<td>0</td>
<td>46</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td></td>
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<td>682</td>
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<td>256</td>
<td>1705</td>
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<td></td>
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<td>3580</td>
<td>2307</td>
<td>158</td>
<td>2069</td>
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clear despite the studies performed up to now. According to some researchers, temperature variation throughout the year plays an important role in the population dynamics of *P. arirostris* (Onbé and Ikeda, 1995).

The peak in autumn 1999 occurred through the high abundance of *Sagitta setosa* (82,618 ind./m²) and Copepoda (36,976 ind./m²) (Figure 4). Copepods are the primary food source of *Sagitta setosa* (Feigenbaum, 1991). In this period, high copepod abundance was followed by the breeding and growth of *Sagitta setosa*. It is known that the most important factors affecting the growth of *S. setosa* in the Black Sea are temperature and food supply (Besiktepe and Unsal, 2000). Therefore, the high abundance of *Sagitta setosa* was affected by the existence of appropriate food intensity during the previous month.

The peaks in December 2001, January–February 2002, and winter and spring 2005 were caused by the high abundance of the copepod group (Figures 4 and 6). *Oithona similis* of the cyclopoid copepods contributed most to the mesozooplankton abundance in May 2001 (49,959 ind./m², Table 2). Although *Oithona similis* is a cold-water species and represents the cold-water copepods in the Black Sea (Gubanova and Altukhov, 2007), it was also observed in the hot seasons through the years during the sampling period.

This is because the species is also a bathypelagic organism and, therefore, it is possible to find it in deep water during the summer. As a result, it was observed in the vertical tow samples in each sampling period. In 2002, however, *Acartia clausi*, which is a euryhaline and eurythermal species, was an important species of the winter peak due to high abundance in February. Moreover, *A. clausi* was continuously identified in samplings in our study. *A. clausi* is abundant in hot and warm seas and is observed within plankton all year. It is known as a species that can survive in negative environmental conditions (Gubanova, 2000; Gubanova et al., 2001). Thus, it is a species continuously observed in the regions that are under the influence of the continental climate.

Regarding the distribution of *Calanus euxinus* and *Pseudocalanus elongatus* in the Black Sea, it has been reported that they are cold-water species and start to reproduce in late autumn (Arashkevich et al., 1998). In our study, the high abundance of *Calanus euxinus* and *Pseudocalanus elongatus* was determined in winter and at the beginning of spring. It was reported that these species, called cold-water species, were dominant in the upper part of the mixed layer of the Black Sea ecosystem, and their abundance increased in the winter (Vinogradov et al., 1992). The species observed in the late summer and autumn peaks in the eastern Black Sea are Cladocera species, *Acartia clausi* and *Oikopleura dioica*. These species are called eurythermal mesozooplankton species. These species observed in the study area were also reported by Shiganova (2005) in offshore waters of the Black Sea. Additionally, peaks of *Penilia arirostris* from Cladocera, *Centropages ponticus* from Copepoda, and *Sagitta setosa* from Chaetognatha were observed in midsummer and at the beginning of autumn. Since *Oithona similis* is a eurythermal species, high abundance was identified in all seasons. *Paracalanus parvus*, which is another eurythermal species, was identified in the sampling periods and in all seasons except summer in the southeastern Black Sea ecosystem.

In our study, while mesozooplankton abundance belonging to 1999–2000 was lower, it was observed that average mesozooplankton abundance increased by a few times. This is parallel to the findings of Finenko et al. (2003). The pressure of *Mnemiopsis leidyi* on zooplankton was very high before 2000. After the 2000s, *M. leidyi*, which fed on zooplankton, was brought under control by the introduction of *Beroe ovata*, which is a predator of *M. leidyi*, into the Black Sea ecosystem. This situation brought about an increase in mesozooplankton numbers (Shiganova et al., 2001; Shiganova, 2005). The increase after 2000 in general mesozooplankton abundance, particularly in copepod nauplii, observed in our study can be explained by *B. ovata*, which brought *M. leidyi* under control. The physical parameters revealing a dynamic structure during the year do not show big differences between years. It seems that the reason species composition and abundance differ with respect to years is food supply and prey–predator relationships. When the density of *Mnemiopsis* declined in 1992–1993, zooplankton abundance began to rise. In 1996, the abundance of zooplankton, and particularly Copepoda, which is the basic food for anchovy, increased significantly (Shiganova and Bulgaikova, 2000).

According to the data presented here, it is clearly seen that the increase in zooplankton abundance continued from 1996 to 2002, and copepod abundance reached its peak level in 2002, reflecting an increase in the anchovy catch for the Turkish Black Sea fishery (Figure 6). This period coincides with the highest anchovy catch from the Turkish Black Sea fishery. The anchovy catch was 385,000 t during this period (TSI, 2009). It can thus be said that the anchovy catch is partly dependent on copepod abundance.

According to our results, despite the species diversity changes, the most important mesozooplankton group in the region is Copepoda. The Cladocera group is seen only during the summer period. *Calanus euxinus* and *Pseudocalanus elongatus* have been specified as cold-water species. The eurythermal species of *Acartia clausi* was observed throughout the year. In light of the obtained
data, the Mediterranization process was not observed in the southeastern Black Sea coastal ecosystem until 2006. It has been determined that the southeastern Black Sea region is affected in a similar way by changes on a global scale. Monitoring studies should be given importance in order to put forth the dynamic structure of the ecosystem.

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