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Seasonality of Mesozooplankton in the Southern Black Sea (off Sinop) Between 2002 and 2004

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Abstract – The monthly abundance, biomass and taxonomic composition of zooplankton of cape Sinop (the southern Black Sea) were determined from 2002 to 2004. Samplings of zooplankton were carried out vertically at monthly intervals using standard type plankton net (210 µm mesh size and 50 cm diameter mouth opening). In the present study, a total of 25 zooplankton taxa were identified. The highest abundance values of mesozooplankton were recorded in February 2003 (193,500 ind. m⁻²), particularly due to *Pseudocalanus elongatus* (83,300 ind. m⁻²). The mesozooplankton biomass, on the other hand, was the highest in August 2004 (4350 mg. m⁻²), due to *Acartia* (*Acartiura*) *clausi* (1820 mg. m⁻²). The heterotrophic dinoflagellate *Noctiluca scintillans*, was a major component of in Sinop region, presenting its highest values in May 2004. Annual mean mesozooplankton abundance and biomass showed no significant differences ($P > 0.05$) among the three years. Detailed results which have particular importance for long-term assessment of the ecosystem situation and for modeling studies show that during 2002-2004 mesozooplankton levels off Sinop were rather low compared data from other coastal areas.

Keywords -
Zooplankton,
Noctiluca, Black Sea,
Turkey, biomass,
abundance.

1. Introduction

The coastal regions is very special ecosystems which intense biochemical interactions occurred and they have important in terms of ecological, economic and social interest [1, 2]. In addition, coastal regions are under the impact of natural and anthropogenic activities [3], high in productivity, and highly susceptible to external influences [1]. Any change in a factor influencing the coastal region can lead to a chain reaction that can cause the

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disruption of environmental conditions. The most important component of this aquatic ecosystem that contributes directly to the high productivity is the zooplankton community, which is primarily responsible for the energy and carbon transfer between primary producers and high nutrient levels [4]. For this reason, it is most likely that the zooplankton makes up the living group that is influenced the most by the changes occurring in the pelagic ecosystem. Living organisms in an aquatic environment maintain their existence in a balanced nature. It is of up most importance that the pelagic ecosystem, which has a dynamic structure in the evaluation of ecosystems and making predictions about the future, be monitored via monitoring programs. To this end, in the current study the changes (yearly interval scales) in the distribution of the zooplankton composition were presented for the period of 2002-2004.

The first zooplankton studies on the Turkish coasts of Black Sea started with the identification of plankton species on the shores of Trabzon between 1952 and 1953 [5]. Subsequently, the number of these studies rapidly increased in southern Black Sea [6-24]. It is observed that studies carried out on plankton are predominantly based on discrete samples belonging to certain time periods. For this reason, monitoring studies need to be increased to protect and gain insight into the biological variety of the zooplankton and pursue the changes that can take place within the Black Sea ecosystem, which has a sensitive structure.

The aim of the studies was characterizing the monthly changes in the abundance, biomass, and species compositions of mesozooplankton between the years 2002 and 2004 on the coast of Sinop (the southern Black Sea).

2. Materials and Methods

The study took place in the coastal zone off Sinop, Turkey (the southern Black Sea, Figure 1.). Samples were obtained monthly from the sampling station (35° 09' 32" E-42° 00' 21" N) situated one mile off-shore at a depth of 50 m from January 2002 to December 2004 (excluding March, April, June 2002 and August 2003).

Temperature values of the sea water column were measured by using U-10 Horiba model equipment during 2002 and YSI 6600 profiler between 2003 and 2004.

Zooplankton sampling was carried out from surface to 50 m via vertical tows on the aboard of "Araştırma I" research vessel. All zooplankton samples were obtained during daytime with a single vertical haul by using a standard plankton net of 50 cm diameter mouth opening (210 µm mesh size). Following the vertical tow, contents of the cod ends were filtered using a 2 mm sieve to retain gelatinous organisms. The samples were preserved in borax buffered formalin solution (final concentration 4%). Sub-samples of 2.5 ml taken with a Stempel pipette were used for identification and counts. For species, which did not appear during subsampling and for rare groups (like Chaetognatha, Decapod larvae), all samples were analyzed.

Samples were analyzed under a stereomicroscope with the zooplankton counting apparatus. Results were averaged and extrapolated to the whole sample. Biomass transformations were based on wet individual weights according to Petipa [25]. Taxa of Cladocera, Copepoda, Appendicularia, Chaetognatha were identified to species level. All other taxa were identified to phylum, class or order levels.

The main references used for the identification of major zooplanktonic groups were Zhong [26], Bradford-Grieve et al. [27] and Conway et al. [28]. Systematic classification and nomenclature of zooplankton species were made according to Appeltans et al. [29]. The abundance and biomass results are given in ind.m^{-2} and mg.m^{-2} .

For the statistical analysis, SPSS 17.0 program was used. The statistical significance of differences in abundance and biomass among years was determined by using ANOVA at significance 0.05 level. Results are presented as mean \pm standard error of the mean (SEM).



Figure 1. Study area and location of the sampling station.

3. Results

3.1. Temperature

During the sampling period, monthly variations in sea water temperature at 10 m depth are given in Figure 2. Because of probable rapid changes in these parameters due to wind, solar heating or rain, depth of 10 meters was chosen. Sea water temperature varied from 7.92 °C (February) to 24.8 °C (August) in 2002; 6.25 °C (March) to 23.53 °C (July) in 2003 and 6.98 °C (February) to 24.25 °C (August) in 2004. The annual average of sea water temperature was 16.2 °C in 2002, 12.93°C in 2003 and 14.68 °C in 2004.

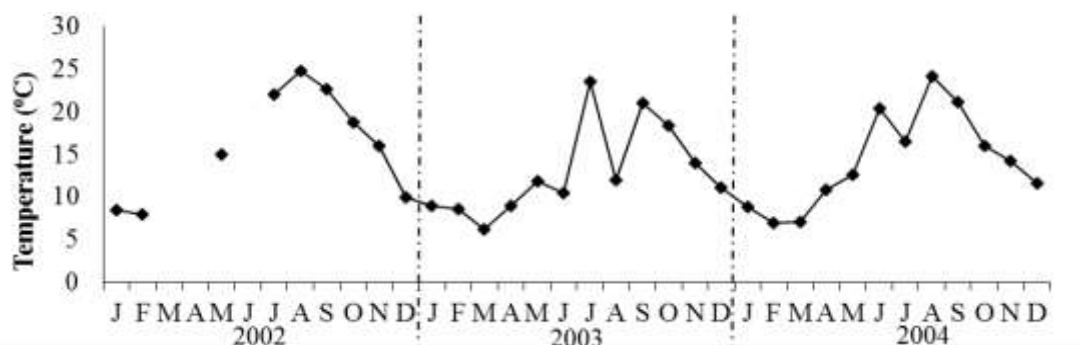


Figure 2. The monthly change of sea water temperature (°C) at 10 m depth off Sinop 2002, 2003 and 2004.

3.2. Abundance and biomass of total mesozooplankton

There was a good agreement between the abundance and biomass of mesozooplankton (Figure 3.). However, both of them were highly variable within the study period; the total annual abundance of mesozooplankton ranged between 13,900-61,300 ind. m^{-2} in 2002; 4,100-193,500 ind. m^{-2} in 2003 and 2,900-147,700 ind. m^{-2} in 2004. The annual total

biomass of mesozooplankton ranged between 140-1430 mg m⁻² in 2002; 150-4160 mg m⁻² in 2003 and 50-4350 mg m⁻² in 2004.

The annual abundance and biomass cycles of mesozooplankton (excluding the dinoflagellate *Noctiluca scintillans*) in the Sinop region between 2002 and 2004 showed a clear seasonal pattern and was characterized by two peaks (spring) in 2002, four peaks (spring, winter and autumn) in 2003 and two peaks (winter and summer) in 2004 (Figure 3.).

In terms of both abundance and biomass, the highest values were recorded in February, September and November 2002; February, September, November and April 2003 and August and January 2004. The highest mesozooplankton abundance was encountered in February 2003 (193,500 ind. m⁻²), particularly due to high levels of *Pseudocalanus elongatus* (83,300 ind. m⁻²). However, in August 2004, the mesozooplankton biomass, was the highest (4350 mg m⁻²), due to the concentration *Acartia* (*Acartiura*) *clausi* (1820 mg m⁻²) (Figure 3-6).

Although mesozooplankton abundance and biomass values showed no statistically significant differences ($P > 0.05$) amongst the three years studied, the total mean mesozooplankton abundance and biomass values were the highest for 2003 (79,900±20,700 ind. m⁻² and 1560±420 mg m⁻²), followed by 2004 (37,400±10,400 ind. m⁻²-1100±320 mg m⁻²) and 2002 (36,500±6100 ind. m⁻²-590±140 mg m⁻²). Abundance and biomass values of all mesozooplankton groups and their identified species are presented in Table 1.

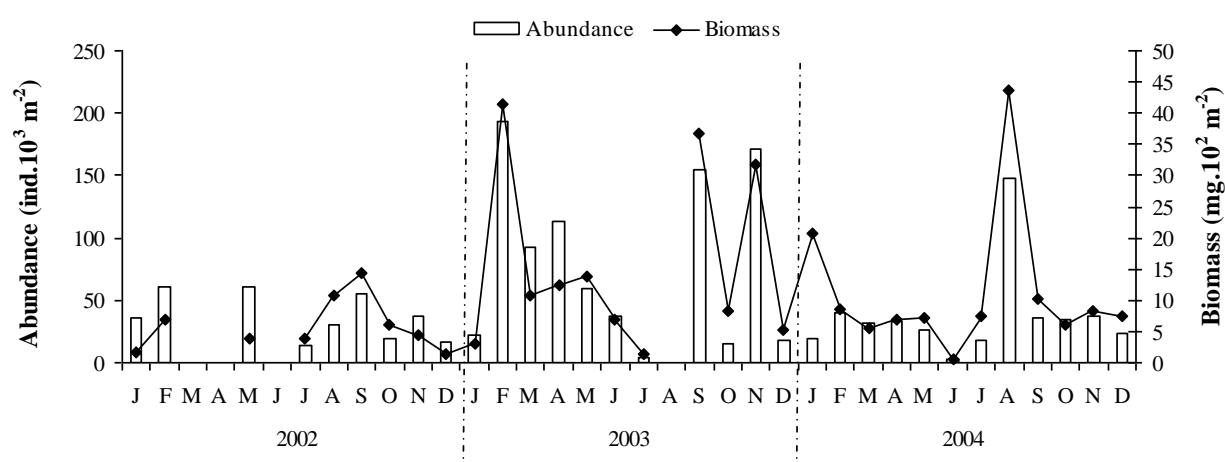


Figure 3. Annual pattern of mesozooplankton abundance (ind.10³m⁻²) and biomass (mg.10²m⁻²) (excluding *Noctiluca scintillans*) off Sinop in 2002, 2003 and 2004.

Table 1. Annual mean abundances and biomasses of mesozooplankton groups during this study (standard error values given after \pm).

Species	Abundance (ind.10 ³ m ⁻²)			Biomass(mg 10 ² m ⁻²)		
	2002	2003	2004	2002	2003	2004
APPENDICULARIA						
<i>Oikopleura (Vexillaria) dioica</i> Fol, 1872	2.04 \pm 0.84	8.35 \pm 2.04	3.02 \pm 1.01	0.35 \pm 0.18	1.14 \pm 0.32	0.51 \pm 0.16
CLADOERA						
<i>Evadne spinifera</i> P.E.Müller, 1867	0.01 \pm 0.01	0.5 \pm 0.55	0.08 \pm 0.06	0.001 \pm 0.0004	0.02 \pm 0.02	0.003 \pm 0.002
<i>Penilia avirostris</i> Dana, 1849	3.70 \pm 2.31	7.17 \pm 6.96	4.21 \pm 3.47	1.13 \pm 0.71	2.15 \pm 2.08	1.39 \pm 1.15
<i>Pleopis polyphaemoides</i> (Leuckart, 1859)	0.26 \pm 0.07	0.60 \pm 0.51	0.08 \pm 0.06	0.02 \pm 0.01	0.05 \pm 0.05	0.01 \pm 0.01
<i>Pseudevadne tergestina</i> (Claus, 1877)	0.29 \pm 0.26	0.79 \pm 0.79	0.17 \pm 0.10	0.01 \pm 0.01	0.03 \pm 0.03	0.01 \pm 0.04
Total	4.26\pm2.52	9.06\pm8.77	4.53\pm3.6	1.17\pm0.72	2.26\pm2.18	1.41\pm1.15
CHAETOGNATHA						
<i>Parasagitta setosa</i> (Müller, 1847)	0.68 \pm 0.29	0.45 \pm 0.15	0.74 \pm 0.33	1.10 \pm 0.51	1.50 \pm 0.49	3.19 \pm 1.43
COPEPODA						
<i>Acartia (Acartiura) clausi</i> Giesbrecht, 1889	7.79 \pm 2.01	22.04 \pm 8.31	17.10 \pm 7.17	1.25 \pm 0.33	3.76 \pm 1.52	3.19 \pm 1.39
<i>Acartia (Acanthacartia) tonsa</i> Dana, 1849	0.05 \pm 0.05	0	0	0.01 \pm 0.01	0	0
<i>Calanus euxinus</i> Hulsemann, 1991	0.46 \pm 0.15	1.38 \pm 0.43	0.68 \pm 0.28	0.66 \pm 0.35	1.67 \pm 0.45	0.88 \pm 0.28
<i>Centropages ponticus</i> Karavaev, 1895	0.06 \pm 0.03	0.36 \pm 0.25	0.27 \pm 0.19	0.02 \pm 0.01	0.11 \pm 0.08	0.13 \pm 0.09
<i>Oithona similis</i> Claus, 1866	1.09 \pm 0.40	0.84 \pm 0.21	0.64 \pm 0.20	0.05 \pm 0.02	0.04 \pm 0.01	0.03 \pm 0.01
<i>Paracalanus parvus</i> (Claus, 1863)	4.15 \pm 1.03	10.15 \pm 4.93	2.91 \pm 1.06	0.35 \pm 0.1	0.92 \pm 0.45	0.28 \pm 0.1
<i>Pseudocalanus elongatus</i> (Boeck, 1865)	3.30 \pm 1.07	15.93 \pm 8.30	4.73 \pm 1.93	0.59 \pm 0.19	3.69 \pm 2.20	1.26 \pm 0.52
Copepoda naupli	7.28 \pm 2.99	5.13 \pm 1.66	1.93 \pm 0.96	0.07 \pm 0.03	0.05 \pm 0.02	0.02 \pm 0.01
Harpacticoida	0.02 \pm 0.02	0.05 \pm 0.05	0.02 \pm 0.01	0.004 \pm 0.004	0.01 \pm 0.01	0.004 \pm 0.003
Total	24.20\pm4.69	55.87\pm17.04	28.28\pm6.89	3.00\pm0.57	10.26\pm3.43	5.79\pm1.38
MEROPLANKTON						
Bivalvia larvae	4.79 \pm 2.41	2.99 \pm 1.34	0.59 \pm 0.16	0.24 \pm 0.12	0.15 \pm 0.07	0.03 \pm 0.01
Byrzoa larvae	0.06 \pm 0.03	0.01 \pm 0.01	0	0.0007 \pm 0.0004	0.001 \pm 0.0001	0
Cirripedia larvae	0.14 \pm 0.05	0.21 \pm 0.09	0.06 \pm 0.04	0.03 \pm 0.01	0.02 \pm 0.01	0.01 \pm 0.01
Coelenterata larvae	0.14 \pm 0.13	2.47 \pm 2.44	0.07 \pm 0.07	0.01 \pm 0.01	0.15 \pm 0.16	0.004 \pm 0.005
Decapoda larvae	0.003 \pm 0.003	0.08 \pm 0.07	0.08 \pm 0.08	0.002 \pm 0.002	0.06 \pm 0.05	0.05 \pm 0.05
Gastropoda larvae	0.19 \pm 0.06	0.34 \pm 0.19	0.05 \pm 0.03	0.02 \pm 0.01	0.04 \pm 0.02	0.01 \pm 0.0003
Isopoda	0.01 \pm 0.01	0.05 \pm 0.03	0.02 \pm 0.02	0.004 \pm 0.003	.02 \pm 0.02	0.1 \pm 0.01
Nematoda	0	0	0.02 \pm 0.01	0	0	0.0003 \pm 0.0001
Polychaeta larvae	0.05 \pm 0.03	0.05 \pm 0.03	0.04 \pm 0.02	0.01 \pm 0.001	0.01 \pm 0.002	0.004 \pm 0.001
Total	5.38\pm2.38	6.20\pm3.10	0.93\pm0.19	0.32\pm0.12	0.45\pm0.17	0.11\pm0.06
Total Average m⁻²	36.56\pm6.19	79.95\pm20.76	37.43\pm10.46	5.93\pm1.41	15.6\pm4.27	11\pm3.25
Total Average m⁻³	0.75\pm0.13	1.63\pm0.42	0.76\pm0.21	0.12\pm0.03	0.32\pm0.09	0.22\pm0.07
DINOFLAGELLATA						
<i>Noctiluca scintillans</i> (Macartney) Kofoid & Swezy, 1921	9.22 \pm 5.67	11.70 \pm 3.399	36.87 \pm 14.50	8.45 \pm 5.44	11.80 \pm 3.63	42.48 \pm 16.46

3.3. Abundance and biomass of mesozooplankton group

The minimum and maximum abundance values of copepods ranged between 9100-46,650 ind. m^{-2} (December-May) in 2002; 300-172,200 ind. m^{-2} (July-February) in 2003 and 2700-98,000 ind. m^{-2} (June-August) in 2004 (Figure 4a). Minimum and maximum biomass values of copepods ranged between 76-594 mg m^{-2} (December-February) in 2002, 55-3920 mg m^{-2} (July-February) in 2003 and 45-1961 mg m^{-2} (June-August) in 2004. Copepods dominated the mesozooplankton composition over the three years (Figure 5). The highest percentages of copepod abundance were observed in January 2002 (86.4%), February 2003 (89%) and March 2004 (98.1%). The highest copepod biomasses were observed in July 2002 (92.5%), February 2003 (94.3%) and March 2004 (99%).

In terms of both abundance and biomass, maximum values of cladocerans were recorded in August 2002, August 2004 and September 2003 (Figure 4b). Whilst minimum values of cladocerans were recorded in May 2002, and in January and July of 2003 (Figure 4b).

The contribution of chaetognaths was virtually negligible throughout the three-year study period. Chaetognaths only accounted for a significant part of plankton community biomass, in January 2004 with a share of 79.4% (Figure 4c and Figure 5.).

The highest peaks in abundance and biomass of appendicularians were observed in September 2002, November 2003 and September 2004 with the lowest occurring in May 2002, July 2003 and June 2004 (Figure 4d).

During both spring and winter periods, meroplanktonic forms also contributed notably to the mesozooplankton abundance and biomass (Figure 5). The maximum abundance and biomass values of meroplankton were seen in February 2002, April 2003 and August 2004 (Figure 4e).

Most of the zooplankton groups exhibited evident seasonality in Sinop region. This was especially apparent for cladocerans and chaetognaths; which occurred in summer-autumn, and for meroplankton, which were more important during the spring and winter months (Figure 4).

The heterotrophic dinoflagellate *Noctiluca scintillans* was a major component of plankton samples in the region off Sinop, attaining highest values in May 2004 (172,000 ind. m^{-2} and 19,395 mg m^{-2}). This species was not present in samples in January and February 2002 (Figure 4f).

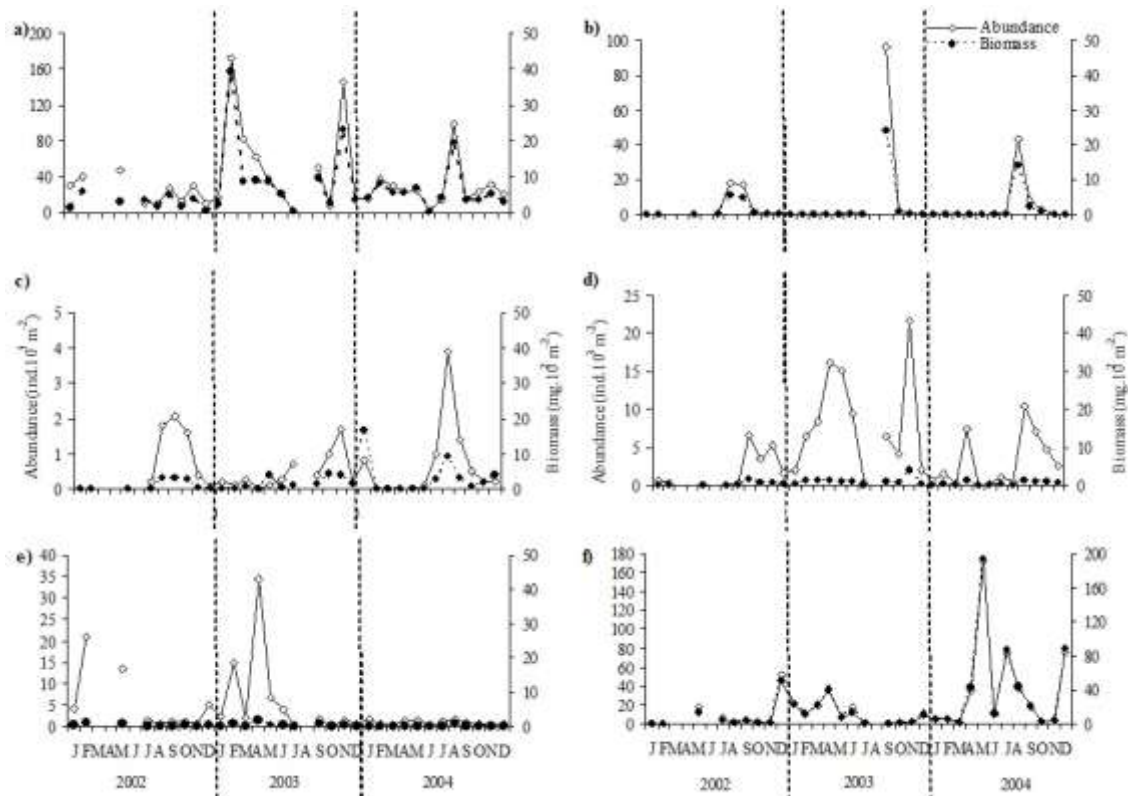


Figure 4. Annual cycle in abundance and biomass of zooplankton groups off Sinop in 2002, 2003 and 2004. (a: Copepoda; b: Cladocera c: Chaetognatha; d: Appendicularia; e: Meroplankton; f: *Noctiluca scintillans*).

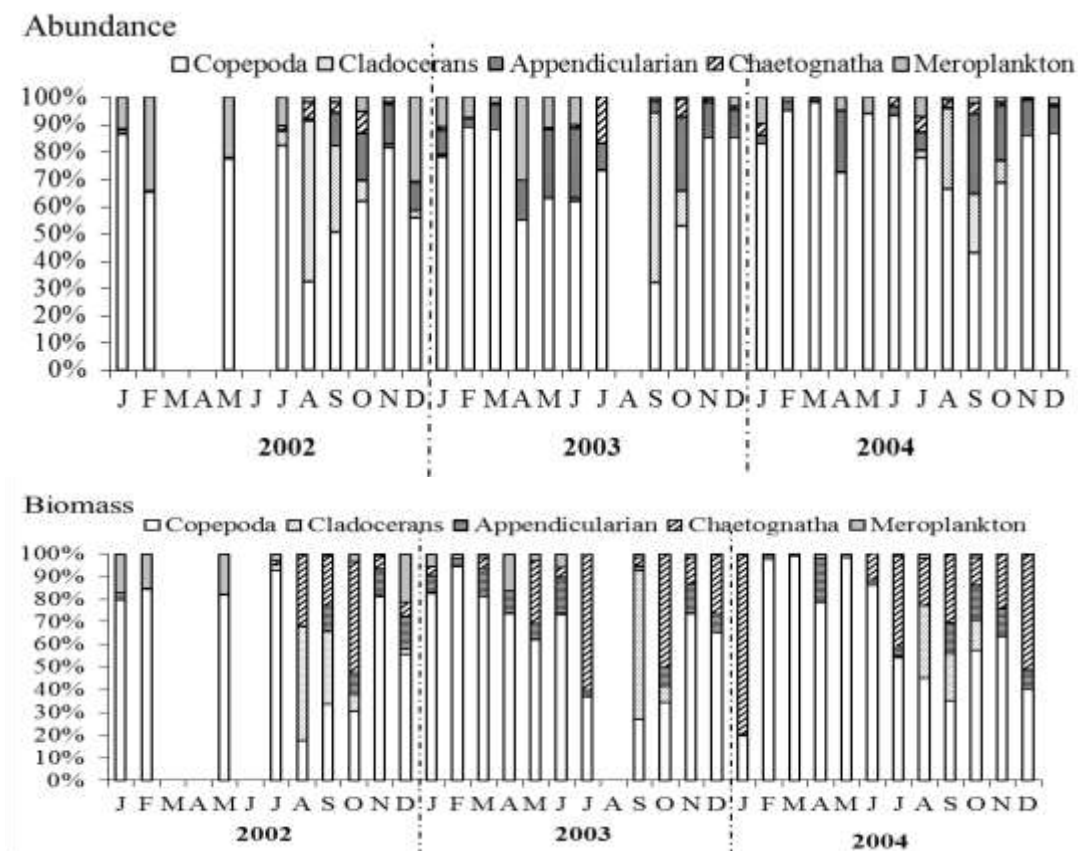


Figure 5. Percentage composition of the main mesozooplankton groups in terms of abundance and biomass off Sinop in 2002, 2003 and 2004.

3.3. Abundance and biomass of species

In this study, seven copepod species were identified (*Acartia (Acartiura) clausi*, *Acartia (Acanthacartia) tonsa*, *Calanus euxinus*, *Pseudocalanus elongatus*, *Paracalanus parvus*, *Centropages ponticus*, *Oithona similis*). We observed *A. tonsa* only in one sub-sample in September 2002. *A. clausi* was present all years, reaching higher abundance and biomass values in summer and autumn, while *Calanus euxinus*, *P. elongatus*, *O. similis* and *P. parvus* were more pronounced in colder months (Figure 6). *Centropages ponticus* was the most important contributor to the copepod community in late summer and early autumn.

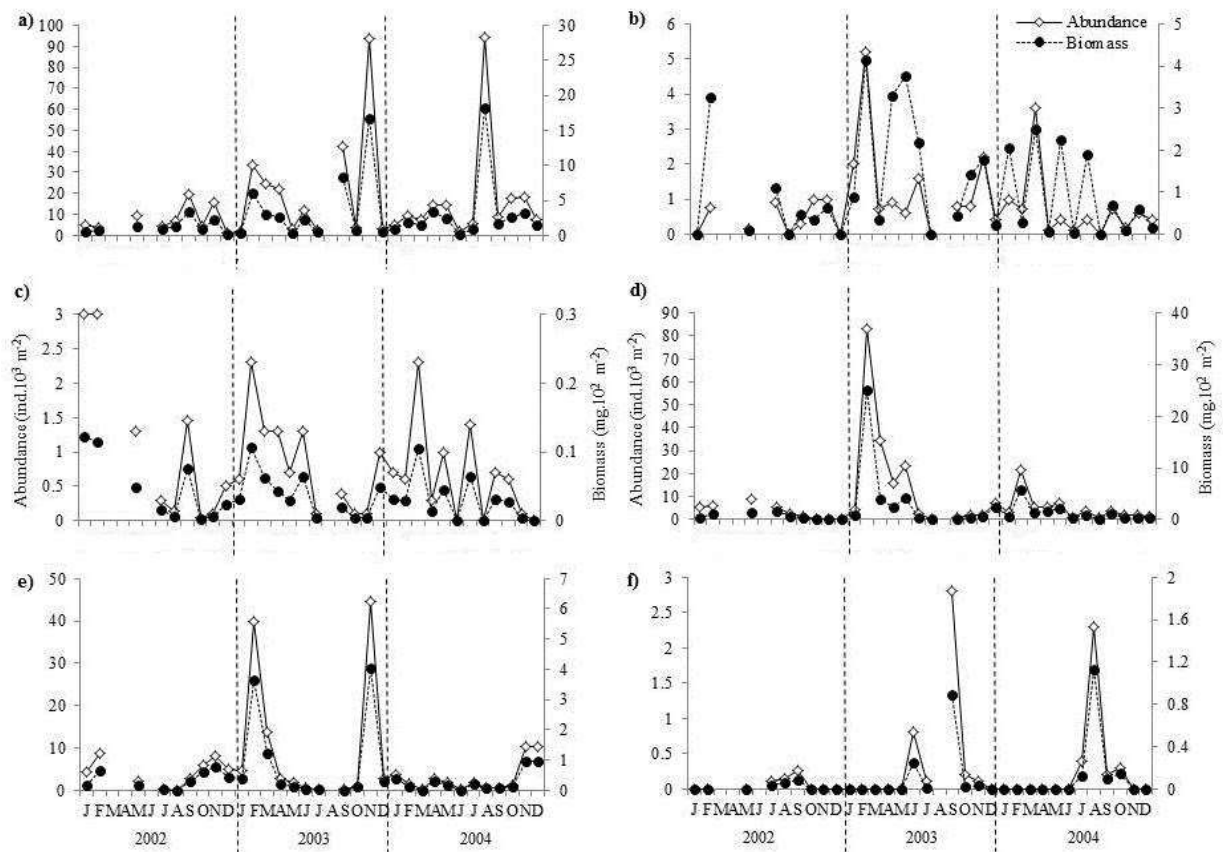


Figure 6. Annual cycle in abundance (ind. 10^3 m^{-2}) and biomass (mg 10^2 m^{-2}) of each copepod species off Sinop in 2002, 2003 and 2004 (a: *Acartia (Acartiura) clausi*; b: *Calanus euxinus*; c: *Oithona similis*; d: *Pseudocalanus elongatus*; e: *Paracalanus parvus*; f: *Centropages ponticus*).

In the present study, four cladoceran species were identified (*Penilia avirostris*, *Evadne spinifera*, *Pleopis polyphaemoides* and *Pseudevadne tergestina*). Amongst the cladocerans, *P. avirostris* was dominant during summer and early autumn with values up to 60,000 ind. m^{-2} and 2,000 mg m^{-2} . The other groups only appeared in the plankton between August and September (Figure 7.).

Bivalve larvae dominated the meroplankton. Highest peaks in both the abundance and biomass values of bivalve larvae occurred in February 2002 (21,000 ind. m^{-2} and 100 mg m^{-2} , respectively) followed by February 2003 and January 2004. The next most abundant of the meroplankton groups were identified to be larvae belonging to cirripeds, polychaetes and gastropods (Figure 8.).

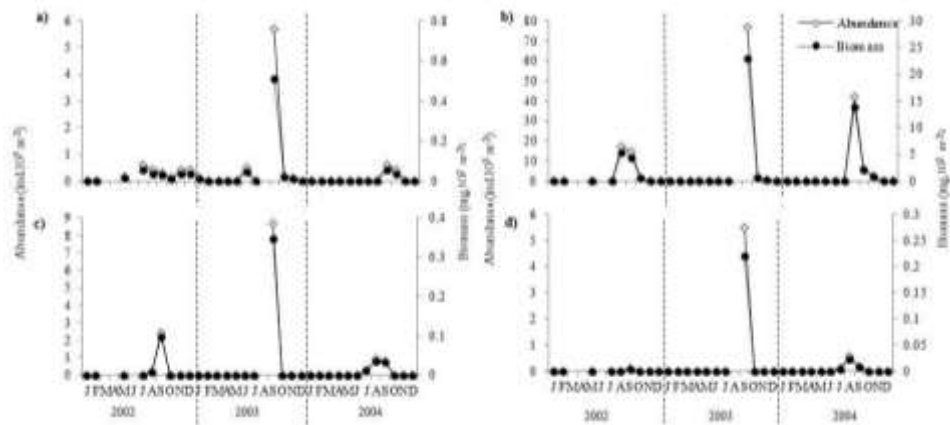


Figure 7. Annual cycle in abundance and biomass of cladoceran species off Sinop in 2002, 2003 and 2004 (a: *Pleopis polyphemoides*; b: *Penilia avirostris*; c: *Pleopis tergestina*; d: *Evadne spinifera*).

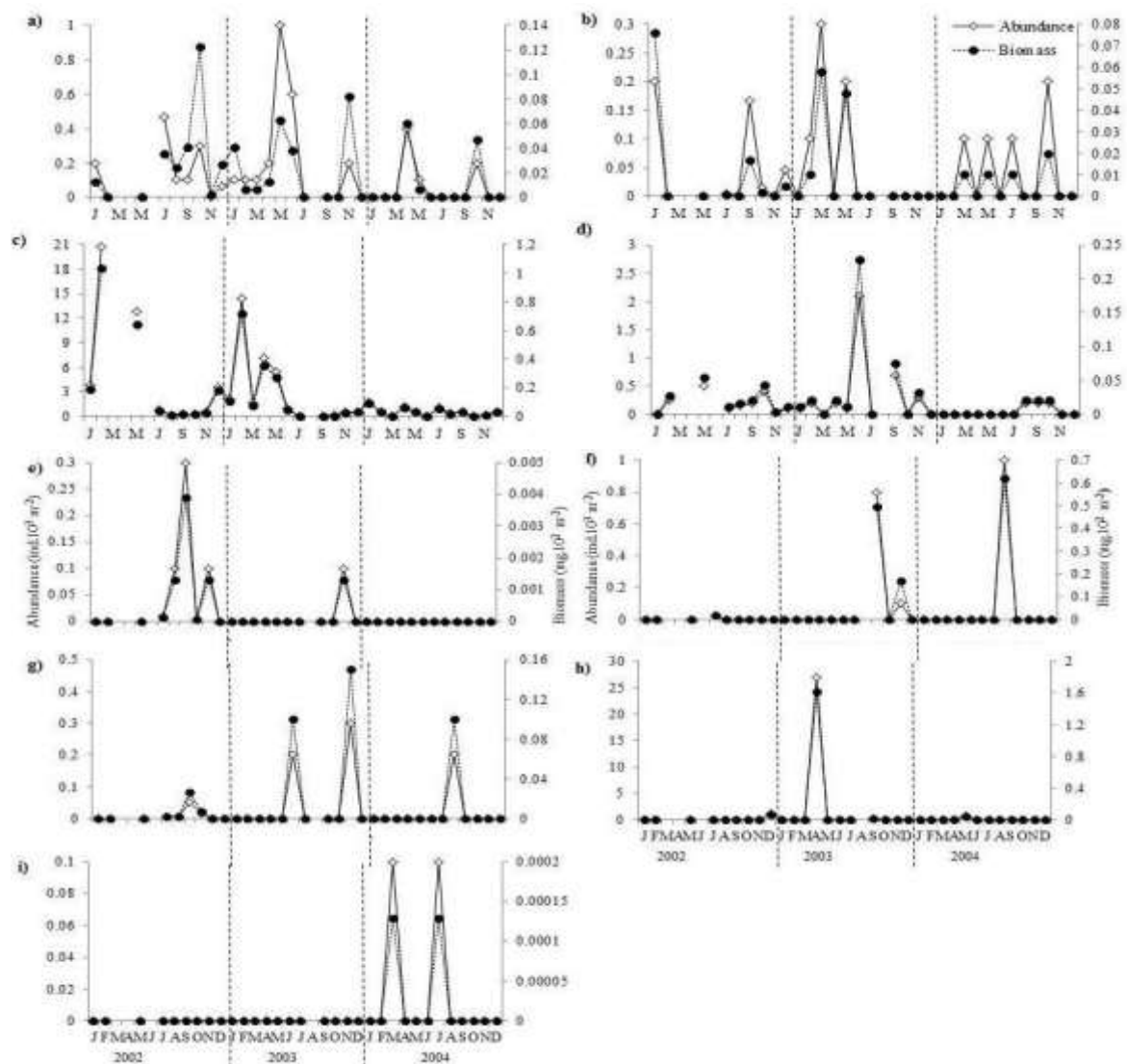


Figure 8. Annual cycle in abundance and biomass of meroplankton groups off Sinop in 2002, 2003 and 2004 (a: Cirripedia; b: Polychaeta; c: Bivalvia; d: Gastropoda; e: Byrozoa; f: Decapoda; g: Isopoda; h: Coelenterata; i: Nematoda).

4. Discussion

Our results from the middle southern Black Sea could be compared with limited number of studies carried out in the Black Sea (mainly from the having similar methodology for mesozooplankton analyses).

Present study found temperature of sea water ranging from 6.25°C (March)-24.8°C (August). The temperature of sea water in other studies in region varied between in 6.6 (March)-29.1 (July) in Sinop 1999; 8.11 (February)-27.7 (August) in Trabzon and 10.2 (January)-28.5 (June) in Samsun [14, 21, 22]. However, surface of temperature of the other studies was higher than our finding. Sea water temperature is affected by daily temperature changes, wind, rain, wave and current. These factors may have caused the temperature difference between zones.

Similar to most studies presented in Table 2, a total of 25 mesozooplankton species (including 8 copepod and 4 cladoceran species) were identified in our study.

Traditionally mesozooplankton is mentioned to display three distinctive peaks in the Black Sea occurring in February, end of April and August [30]. In this study, we also observed three peaks occurring February-May-September in 2002, three distinct peaks occurring in February-September-November in 2003 but only one distinct peak occurring in August in 2004 in terms of abundance (Figure 3 and Table 1). In terms of biomass one peak occurring in September was recorded in 2002, 3 peaks occurring in February, September and November in 2003 and 2 distinct peak occurring in January and August in 2004 off Sinop (Figure 3.). Seasonality and population structure of phytoplankton influenced seasonal peaks of zooplankton abundance [31]. In the same period studies, species diversity and abundance values of phytoplankton were found to be different in the eastern and western parts of Black Sea [32, 33].

It was recorded that the most important peaks were observed in winter and autumn months off Sinop in the years 1999-2000 [14, 19]. Yıldız ve Feyzioğlu [24] observed for Trabzon coasts in the eastern southern Black Sea that mesozooplankton shows differences in peak periods among different years: summer in 2000-2001 and in 2006, beginning of spring in 2005 and one peak in August in 2008.

Seasonal distribution of mesozooplankton (excluding *Noctiluca scintillans*) abundance and biomass values showed no statistical differences ($P > 0.05$) among years although higher mean values observed in 2003, followed by 2004 ($37,400 \pm 10,400$ ind. m^{-2} and $1,100 \pm 320$ mg m^{-2}) and 2002 ($36,500 \pm 6,100$ ind. m^{-2} and 590 ± 140 mg m^{-2}) (Table 2.).

The highest average abundance of mesozooplankton was determined in 2000 in coastal region between 1999 and 2004 in Sinop [14, 19]. The obtained data in 2000 (129.56 ind. $10^3 m^{-2}$) was 1.6 to 3.5 times higher than other studies conducted in Sinop [14, 19 and present data]. It was observed that mesozooplankton abundance value in the southeastern Black Sea was higher than that off Sinop region except for the year 2007-2008 (Table 2.) [14, 19, 21, 22, 24]. It was determined that abundance values of mesozooplankton groups were lower in Sinop region compared to the Black Sea region. This difference can be attributed to the temperature, phytoplankton community structure, jelly fish abundance values and geographical location of the other studies areas.

The highest mesozooplankton abundance was encountered in February 2003 ($193.5 \text{ ind.} \cdot 10^3 \text{ m}^{-2}$ - $41.57 \text{ mg } 10^2 \text{ m}^{-2}$), particularly due to high *Pseudocalanus elongatus* ($83.30 \text{ ind.} \cdot 10^3 \text{ m}^{-2}$ - $25.2 \text{ mg } 10^2 \text{ m}^{-2}$). The mesozooplankton biomass, on the other hand, was the highest in August 2004 ($43.5 \text{ mg } 10^2 \text{ m}^{-2}$ - $147.70 \text{ ind.} \cdot 10^3 \text{ m}^{-2}$), due to *Acartia clausi* ($18.2 \text{ mg } 10^2 \text{ m}^{-2}$ - $94.2 \text{ ind.} \cdot 10^3 \text{ m}^{-2}$) (Figure 5).

According to our results, the most dominant groups within the mesozooplankton community were Copepoda in three years, followed by Cladocera (Figure 5.). The same results were observed in other studies as well (Table 3) [14, 19, 21, 22, 24].

Due to rapid succession observed in zooplankton populations in coastal regions, planning these studies in longer period and in short intervals are quite important in the sense of collecting more detailed and meaningful data.

The aim of this study, description of composition zooplankton structure of the southern Black Sea (coastal sea): this will be particularly important in modeling studies. This study has an importance in order to make a base for future qualitative and quantitative studies and also to have information about regional species composition.

Table 2. Minimum, maximum and mean abundances ($\text{ind.} \cdot 10^3 \text{ m}^{-2}$) of mesozooplankton (excluding *Noctiluca scintillans*).

Years	Minimum- Month	Maximum- Month	Average Abundance	Region- Depth	References
1999	12.75 early June	186.84 early February	68.93	Sinop-70m	[14]
	17.49 early January	237.70 late September	77.70	Sinop-180m	[14]
	15.41 June	172.24 September	89.89	Trabzon-150m	[24]
2000	32.60 June	293.83 March	129.56	Sinop-50m	[19]
	36.775 May	162.99 March	79.21	Sinop-180m	[19]
	18.82 February	926.68 August	197.21	Trabzon-150m	[24]
2001		938.54 December	220.36	Trabzon-150m	[24]
2002	13.90 July	61.30 February	36.50	Sinop-50m	Present study
		1669.40 February	122.50	Trabzon-150m	[24]
2003	4.10 July	193.50 February	79.90	Sinop-50m	Present study
2004	2.90 June	147.70 August	37.40	Sinop-50m	Present study
2005		666.82 April	124.07	Trabzon-150m	[24]
2006		488.75 June	112.56	Trabzon-150m	[24]
2007-2008	3.65 May	49.25 August	26.62	Trabzon-50m	[21]
2012-2013	15.28 February	113.2 April	61.25	Samsun-40m	[22]
	10.2 February	149.3 April	52.7	Samsun-50m	[22]

Table 3. Mean abundance (ind. 10^3 m^{-2}) of main zooplankton groups

Years	Copepoda	Cladocera	Appendicularia	Chaetognatha	Meroplankton	Other groups	<i>N. scintillans</i>	Region-Depth	References
1999	44.12	9.22	3.26	1.75	10.44		59.42	Sinop-70m	[14]
	60.34	7.23	1.89	1.35	6.75		55.97	Sinop-180m	[14]
	21.13	21.64	1.46	44.35	1.29			Trabzon-150m	[24]
2000	106.48	0.96	0.12	0.15	21.85		0.66	Sinop-50m	[19]
	65.98	0.27	0.34	0.31	12.31		6.27	Sinop-180m	[19]
	54.43	68.04	8.28	33.36	5.51			Trabzon-150m	[24]
2001	74.55	35.37	22.46	50.05	34.96			Trabzon-150m	[24]
2002	24.20	4.26	2.04	0.68	5.38		9.22	Sinop-50m	Present study
	54.33	1.17	9.82	2.59	46.23			Trabzon-150m	[24]
2003	55.87	9.06	8.35	0.45	6.20		11.70	Sinop-50m	Present study
2004	28.28	4.53	3.02	0.68	0.93		36.87	Sinop-50m	Present study
2005	81.75	1	13.04	1.83	26.45			Trabzon-150m	[24]
2006	40.42	7.17	42.14	9.32	8.33			Trabzon-150m	[24]
2007-2008	11.92	7.40				7.10	29.37	Trabzon-50m	[21]
2012-2013	42.55	4.97	6.65	4.67	1.7	0.72	42.83	Samsun-40m	[22]
	39.47	3.5	4.98	3.33	1.17	0.25	56.81	Samsun-50m	[22]

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