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Zooplankton of the Black Sea and the Eastern Mediterranean: Similarities and dissimilarities

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Abstract

A synthesis of data on abundance and biomass of zooplankton in the Eastern Mediterranean (EMED) and the Black Sea shows major differences in the composition and structure of pelagic communities in the two basins. Few Mediterranean planktonic animals have invaded in the Black Sea. The great bulk of Black Sea species is represented by coastal inhabitants that spread throughout the whole basin. This process has been called "neritization" of the Black Sea fauna. Peculiarities in zooplankton assemblages of the Black Sea have been further strengthened over the last few decades due to increasing eutrophication and the massive invasion of the ctenophore Mnemiopsis leidyi. The relative contribution of copepods, cladocerans, chaetognaths, and appendicularians to total zooplankton biomass has notably decreased , whereas gelatinous groups (mainly represented by Mnemiopsis and Aurelia aurita) contributed up to 99% of total wet weight in 1995 in the Black Sea.

The basic features of planktonic fauna in the Black Sea are mainly due do the geo-morphological characters of the basin and the limited exchanges with the EMED, that are confined to the surface-subsurface layers in the Dardanelles and Bosphorus Straits. However, the dramatic changes that have recently occurred in the structure of zooplankton assemblages seem to have been caused by heavy anthropogenic impact on the pelagic system.

Keywords: Zooplankton, Eastern Mediterranean, Black Sea, Abundance, Biomass.

Introduction

The pelagic environments of the Eastern Mediterranean (EMED) and the Black Sea share some basic common features due to their connection through the Dardanelles and Bosphorus Straits, dating back 5000-6000 years. Some similarity is evident in the composition of flora and fauna (ZENKEVICH, 1963), and the zooplanktonic communities in both regions consist mainly of species of Atlantic origin. However, geographical and geo-morphological characteristics are responsible for noticeable differences in hydrology, environmental parameters such as temperature and salinity (Table 1) and in biological production. The straits are narrow and shallow and allow limited water exchange which occurs only in the surface layer (OVCHINNIKOV *et al.,* 1976), preventing the entrance of deep-water species from the EMED to the Black Sea. The relatively larger volume of freshwater flowing from rivers into the Black Sea is responsible for a higher organic matter production in comparison with the EMED (KOVALEV, 1991). This nutrient enrichment has further increased in recent years because of heavy anthropogenic impact (ALTMAN *et al.,* 1990; ZAITSEV & ALEXANDROV, 1997). Moreover, anoxic conditions below 200 m in the Black Sea, with high levels of hydrogen sulphide, result in an azoic environment below the epipelagic zone (SOROKIN, 1982). The combination of these peculiar conditions have finally established a characteristic zooplankton community in the Black Sea.

We provide here data on the major differences between the mesozooplankton assemblages of the EMED and the Black Sea, both in terms of species composition, abundance and biomass. We also discuss some considerable changes which have recently occurred in the pelagic system of the Black Sea.

Materials and Methods

The present contribution is mainly based on data collected during cruises of the Institute of Biology of the Southern Seas (IBSS), in the EMED and Black Sea from 1957 to 1982 (for the sampling data see, KOVALEV *et al.,* 1999a for the EMED and PETIPA *et al.,* 1963, SAZHINA, 1964, FEDORINA, 1978, KOVALEV *et al.,* 1996 for the Black Sea) and on data from the literature. In order to explain the important changes occurring in the last two decades, recent data obtained during the 1990's were also utilized (KOVALEV *et al.,* 1996; 1999b; KOVALEV & PIONTKOVSKI, 1998).

Studies carried out by other institutes had in general employed different methods for sample collection and processing and are hardly comparable. For this reason, the present study has mainly focused on data from the IBSS since data was obtained from

Table 1
Surface temperature and salinity values in the EMED regions and Black Sea.

Region	Summer		Winter		Reference
	T⁰C	S ‰	T⁰C	S ‰	
North Adriatic	22-23	33-37	8-12	36-38.5	OVCHINNIKOV *et al.,* 1976
South Adriatic	24-25	38-38.25	13.5	38.5	OVCHINNIKOV *et al.,* 1976
North Aegean	24-27	33-37	12-14	37-38.5	OVCHINNIKOV *et al.,* 1976
South Aegean	24	38-39	16-17	38.75-39	OVCHINNIKOV *et al.,* 1976
Ionian Sea	25	38.25-38.75	14-15	38.25-38.75	OVCHINNIKOV *et al.,* 1976
Levantine Sea	25-27	39-39.25	16-17.5	38.5-39	OVCHINNIKOV *et al.,* 1976
Black Sea	21-27	18.24	0-9	17.44	ZENKEVICH, 1963

the two basins by utilizing similar methods. Samples were collected by vertical hauls from standard depth layers (0-10, 10-25, 25-50, 50-100, 100-150/200 m) or through integrated water columns (0-100, 0-200 m or 0-bottom) using Juday nets with a mesh size of 125 μm. Data of abundance (ind. m^{-3}) and biomass (as g m^{-3} wet weight) are provided for zooplankton collected in open water regions.

It is important for comparison purposes, that the material was collected during the same period in both seas (e.g. 1957-1982), when the anthropogenic influence on pelagic ecosystems was still relatively weak. Cruises took place in different seasons of the year, therefore the results obtained demonstrate both average annual and seasonal values of biomass and abundance in different regions of the EMED (KOVALEV *et al.,* 1999a) and of the Black Sea (FEDORINA, 1978; PETIPA *et al.,* 1963; SAZHINA, 1964).

Results and Discussion

About 150 zooplanktonic species are reported for the Black Sea, including numerous brackish-water and freshwater organisms, which are restricted to the north-western and other coastal areas (KOVAL, 1984). This number differs by one order of magnitude from that reported for the whole Mediterranean (KOVALEV, 1991). Only about 50% of the Black Sea species occur in the Mediterranean. Therefore, the taxonomic composition of zooplankton in the EMED and Black Sea shows some remarkable differences. All taxonomic groups of planktonic animals are presented in the EMED, but only a few of them have penetrated into and acclimatized in the Black Sea. This feature seems to be mainly due to differences in salinity between the two basins. Typical stenohaline marine organisms such as radiolarians, siphonophores, pteropods, and salps, which are common in the Mediterranean, do not occur in the Black Sea. Abundantly occurring groups such as copepods, chaetognaths, medusae are present in much reduced numbers in the EMED (Table 2).

Zooplankton in the Black Sea is characterized by the absence of mesopelagic and deep sea species because the water exchanges with the EMED are confined to the surface and sub-surface layers. Due to the extended continental shelf, the neighbouring North Aegean Sea is characterized by mixed neritic-pelagic assemblages but only strictly neritic species penetrate into the Black Sea. For instance, five out of six EMED cladoceran species (*Evadne nordmanni, E. spinifera, E. tergestina, Podon polyphemoides, Penilia avirostris*), and three out of fifteen species of Pontellidae copepods (*Pontella mediterranea, Anomalocera patersoni, Labidocera brunescens*) are reported from the Black Sea (KOVAL, 1984; LAKKIS *et al.,* 1999).

The intruding zooplankters are euryhaline and eurythermic animals, able to survive and reproduce even in a marine envi-

Table 2
Number of Atlantic species of some zooplankton groups in the EMED and Black Sea.

Group of Zooplankton	EMED	Black Sea	Reference
Copepoda	313	12	KOVALEV, SHMELEVA, 1982; KOVAL, 1984
Cladocera	6	5	LAKKIS *et al.*, 1999, KOVAL, 1984
Siphonophora	25	0	LAKKIS *et al.*, 1999, KOVAL, 1984
Appendicularia	15	1	LAKKIS *et al.*, 1999, KOVAL, 1984
Chaetognatha	10	1	LAKKIS *et al.*, 1999, KOVAL, 1984
Hydrozoa	70	7	LAKKIS *et al.*, 1999, KOVAL, 1984

ronment characterized by very low salinity values (18 ‰) and high seasonal variations in water temperature (0-27°C). Most of the species invading the Black Sea occur only in coastal areas of the EMED, whereas in the Black Sea they are distributed throughout the entire basin. The notable success of their populations in open waters is probably supported by the high levels of eutrophication over the whole Black Sea basin. This phenomenon of intrusion and mass development of these species has been called “neritization” of the Black Sea fauna (KOVALEV, 1991). This process is similar to that reported for the Adriatic Sea by HURE *et al.* (1980). Factors that play major roles in these dynamics are probably: 1) the small size of these seas, with high surface/volume ratio, 2) nutrient enrichment affecting the entire basins through river inflow, 3) intensive water-exchange between coastal and deep-water regions providing diffusion of neritic species into the whole of the water column.

The values of total mesozooplankton abundance differ by one order of magnitude between the EMED and the Black Sea. In epipelagic waters (0 - 200 m) of the EMED, the values range between 100 - 1000 ind.m^{-3} (GREZE, 1989). Only in more eutrophic neritic regions (such as the North and Central Adriatic and the North Aegean Sea), does total abundance show higher values (KOVALEV *et al.,* 1999a). In the open Black Sea, zooplankton assemblages are generally more abundant (mean value for the year about 10,000 ind. m^{-3}). The values may reach up to 40,000 and even 70,000 ind.m^{-3} in spring and summer, respectively (Table 3), in the north-western area which is under the influence of large river inflow.

In terms of group composition, mesozooplankton communities differ between the two basins. According to historical data (1957-1982), copepods accounted for 70 to 96% of total zooplankton numbers in the EMED, whereas in the Black Sea their relative abundances ranged from 60 to 80%. Among other major groups, cladocerans, appendicularians, and gelatinous organisms occurred with higher relative abundance in the Black Sea (Table 4).

Remarkable differences between the EMED and the Black Sea have also been recorded for total zooplankton biomass. Reports from Soviet surveys held during 1957-1982 throughout the basins (DELALO, 1966; GREZE, 1989) show that wet weight values in the EMED ranged from 18.0 mg m^{-3} to 56.0 mg m^{-3} in the warm period of the year for the layer 0-200 m. Winter - spring values were within this range. In the Black Sea, the same parameter was in the order of 500 - 1000 mg m^{-3} in summer (Table 5). The contribution of different groups to total zooplankton biomass also differed between the EMED and Black Sea. In the 0-200 m layer, copepods constituted 42-75% of the

Table 3
Abundance of zooplankton (ind. m^{-3}) in the EMED and Black Sea.

Region	Season	Abundance (ind. m^{-3})	Reference
South and Middle Adriatic	summer	1724	GREZE *et al.*, 1982
Ionian Sea	summer	1041	GREZE *et al.*, 1982
Aegean Sea	summer	1032	GREZE *et al.*, 1982
Levantine Sea	summer-autumn	1397	DELALO, 1966
Black Sea, different regions	all seasons	10000	PETIPA *et al.,* 1963
Black Sea, north western part	spring	37320	SAZHINA, 1964
Black Sea, north western part	summer	70960	SAZHINA, 1964

Table 4
Percentage of total zooplankton abundances (ind. m^{-3}).

Region	Season Year	Copepods	Chaetognaths	Gelatinous Macrozooplankton	Appendicularians	Cladocerans	Ostracods	Reference
Sicily Channel	autumn 1991	81.83	2.43	0.79	5.49	0.42	5.43	MAZZOCCHI *et al.*, 1997*
Ionian Sea	autumn 1991	79.11	8.09	1.33	2.04	0.53	6.55	MAZZOCCHI *et al.*, 1997*
Cretan Sea	autumn 1991	88.57	3.22	0.23	1.9	0.09	4.27	MAZZOCCHI *et al.*,1997*
Cretan Passage	autumn 1991	77.21	5.86	1.19	0.78	0.13	9.61	MAZZOCCHI *et al.*, 1997*
Rhodos area	autumn 1991	74.68	3.53	0.65	9.44	0.46	6.61	MAZZOCCHI *et al.*,1997*
Levantine Sea	autumn 1991	82.91	1.52	2.79	4.17	0.02	5.57	MAZZOCCHI *et al.*, 1997*
Adriatic Sea	summer 1960	96	0.59	0.24	1.2	0.21	0.66	GREZE *et al.*, 1982**
Ionian Sea	summer 1959	94.6	0.54	0.34	1.2	0.37	0.85	GREZE *et al.*, 1982**
Levantine Sea	summer 1959	87.4	0.28	0.38	1.26	0.14	0.6	GREZE *et al.*, 1982**
Gulf of Sirte	summer 1959	88.9	0.5	0.28	1.15	0.1	0.5	GREZE *et al.*, 1982**
Aegean Sea	summer 1958, 1960	86	0.68	0.38	1.8	0.55	0.39	GREZE *et al.*, 1982**
Black Sea	May 1957	71	0.08	19	4.5			SAZHINA, 1964**
Black Sea	August 1957	57.8	1.5	10	3.6	20		SAZHINA 1964**
Black Sea	spring-autumn	61.3	0.3	25.3	2.3			FEDORINA, 1978***

* - Layer 0-300 m, Wp3 Net , Mesh Size 200 μm
** - Layer 0-200 m, Juday Net , Mesh Size 125 μm
*** - Layer 0-100 m, Juday Net, Mesh Size 200 μm

Table 5
Long-term changes in the abundance (ind. m^{-3}) of mass organisms of zooplankton in the Black Sea (Crimea Region).

Organisms	March-August 1959-1974, (0-100 m) (FEDORINA, 1978)		January, April, August 1995, (0-150m) (KOVALEV *et al.*, 1996)	
	Abundance (ind. m^{-3})	%	Abundance (ind. m^{-3})	%
Copepoda	5125	65.1	983	52.7
Cladocera	-	-	100	5.5
Oikopleura dioica	220	2.7	3	0.15
Bivalve larvae	257	3.3	58	3.3
Sagitta setosa	22	0.3	4	0.2
Noctiluca scintillans	1905	24.1	715	38.0
Pleurobrachica rhodopis	74	0.9	1,2	0.05
Mnemiopsis leidyi	0	0	2,3	0.1
Other	236	3.6	-	-
Total	7639	100.0	1868	100.0

EMED fauna, followed by chaetognaths (9-13%) and appendicularians (3.8-15.6%). The contribution of other groups was not significant (GREZE, 1989). The three mentioned groups also dominated in the Black Sea, but with much lower percentages, because a considerable fraction of the biomass was represented by *Noctiluca scintillans* (up to 62% in 1960-1969) and gelatinous organisms such as *Pleurobrachia rhodopis* (35% in 1959-1974) (FEDORINA, 1978; MASHTAKOVA, 1985).

In recent decades, a remarkable increase in the anthropogenic impact on the ecosystem of the Black Sea has noticeably affected the species, composition of zooplankton assemblages (KIDEYS *et al.,* 2000). In the 1970 - 80s, the abundance of common species especially those inhabiting the surface layer, greatly decreased (POLISCHUK *et al.,* 1984; ZAITSEV, 1992). This change was further pronounced after the invasion of the ctenophore *Mnemiopsis leidyi*. The transport of this species in ballast waters from the northwestern Atlantic caused major changes in the structure and dynamics of pelagic communities in the Black Sea after 1988. The previously dominant cyclopoid *Oithona nana* and the calanoid *Labidocera brunescens* no longer occur in zooplankton samples (KOVALEV *et al.,* 1993; ZAGORODNYAYA & SKRYABIN, 1995). In the north-western Black Sea, the abundance of hyponeustonic copepods (i.e. *Pontellidae*) decreased by 35 fold between 1960 and 1980. In the same region, *Paracalanus parvus, Centropages ponticus, Pseudocalanus elongatus, Calanus euxinus (helgolandicus), Sagitta setosa, Penilia avirostris* and *Evadne spinifera* decreased by some 4 to 50 fold for the same period (POLISCHUK *et al.,* 1984). All these dramatic changes recently observed in the pelagic system of the Black Sea seem to be due to the toxic impact of pollution and heavy predation by *Mnemiopsis leidyi* on zooplanktonic animals (POLISHUK *et al.,* 1984; ZAITSEV, 1992; KIDEYS, 1994; KOVALEV & GUBANOVA, 1995; KOVALEV *et al.,* 1998; KIDEYS *et al.* 1999).

Significant long-term changes in zooplankton assemblages occurred in the Black Sea between the period 1950-70 and 1995 (Table 5). The number of some groups and

Table 6
Total biomass of zooplankton (mg m^{-3}) in the EMED and Black Sea in 0-200 m layer (Juday Net, mesh size 125 μm).

Region	Season, Year	Biomass (mg m^{-3})	Reference
South and Middle Adriatic	Summer, 1960,1982	56.0	GREZE *et al.,* 1982
Ionian Sea	Summer, 1959, 1960	33.0	GREZE *et al.,* 1982
Aegean Sea	Summer, 1958, 1960, 1968	23.0	GREZE *et al.,* 1982
Levantine and Sirte Seas	Summer, Autumn, 1959, 1960	18.0	DELALO, 1966
Black Sea	all year 1960-1974	400*	GREZE *et al.,* 1979
Black Sea	different seasons, 1957	257	PETIPA *et al.,*1963
Black Sea	Summer, 1980	597	KOVALEV & PIONTKOVSKI, 1998
Black Sea	Summer, 1990	1005 (6495) **	KOVALEV & PIONTKOVSKI, 1998
Black Sea	Summer, 1995	517 (12535) **	KOVALEV & PIONTKOVSKI, 1998

* - Layer 0-100 m, mesh size 200 μm
** - Including *Aurelia aurita* and *Mnemiopsis leidyi*

species such as total copepods, *Oikopleura*, and *Pleurobrachia* decreased considerably as well as their relative contribution to total abundances. The opposite trend was observed for *Noctiluca*. Over the past few decades, gelatinous zooplankters have overwhelmed the remaining groups in terms of numerical abundance and biomass. A significant part of the planktonic biomass consisted of *Noctiluca scintillans* (up to 62% during 1960-1969) and *Pleurobrachia rhodopis* (35% during 1959-1974). *Mnemiopsis* accounted for only 0.1% of total numbers in 1995 but its contribution to zooplankton biomass was much higher because of its relatively large size. In 1995, the gelatinous component (mainly *Mnemiopsis leydi* and *Aurelia aurita*) accounted for 99.5% of total zooplankton biomass as wet weight (KOVALEV & PIONTKOVSKI, 1998) (Table 6).

Conclusion

The basic features in the planktonic fauna of the Black Sea greatly differ from that of the EMED. This difference in zooplankton composition has been aggravated in recent years due to sensitivity of the Black Sea ecosystem because of anthropogenic impact.

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References

ALTMAN, E.N., BEZBORODOV, A.A. & BOGATOVA, YU.J., 1990. Applied ecology of sea regions: The Black Sea (eds. Keondjan V.P., Kudin A. M., Terechin Yu.V.). Kiev: Naukova dumka: 252p. (in Russian).

DELALO, E.P., 1966. Zooplankton in the eastern part of the Mediterranean Sea (Levantine and Syrtis Seas). Investigation of Plankton in the Southern seas. Moscow, 7: 62-81 (in Russian).

FEDORINA, A.J., 1978. Dynamics of the Black Sea zooplankton development and reasons causing it // VNIRO. - Moscow - 49p. - Dep. In CNI TACRH 11.05.78. No.149 (in Russian).

GREZE, V.N., BOGUSLAVSKIY, S.G. & BELYAKOV, YU.M., 1979. Principles of biological productivity of the Black Sea (eds. Greze V.N.).- Kiev: Naukova dumka: 391p. (in Russian).

GREZE, V.N., PAVLOVA, E.V., SHMELEVA, A.A. & DELALO, E.P., 1982. Zooplankton of the eastern Mediterranean and its quantitative distribution. Ecologya morya 8: 37-46 (in Russian).

GREZE, V.N., 1989. Pelagial of the Mediterranean Sea as ecological system. Kiev: Naukova dumka, 198p. (in Russian).

HURE, J., JANORA, A. & DI CARLO, B.S., 1980. Spatial and temporal distribution of copepod communities in the Adriatic Sea. J. of Plankton Research.2: 295-316.

KIDEYS, A.E., 1994. Recent dramatic changes in the Black Sea ecosystem: The reason for the sharp decline in Turkish anchovy fisheries. J Mar Sys 5: 171-181.

KIDEYS, A.E., GORDINA, A.D., BINGEL, F. & NIERMANN, U., 1999. The effect of environmental conditions on the distribution of eggs and larvae of anchovy (*Engraulis encrasicolus L.*) in the Black Sea. ICES J mar Sci 56: 58-64.

KIDEYS, A.E., KOVALEV, A.V., SHULMAN, G., GORDINA, A.D. & BINGEL, F., 2000. A review of zooplankton investigations of the Black Sea over the last decade. J Mar Sys 24:355-371.

KOVAL, L.G., 1984. Zoo- and macrozooplankton of the Black Sea. - Kiev: Naukova dumka, 141 (in Russian).

KOVALEV, A.V., 1991. Structure of zooplankton communities of the Atlantic and the Mediterranean basins. - Kiev: Naukova dumka, 141p. (in Russian)

KOVALEV, A.V. & SHMELEVA, A.A., 1982. Fauna of Copepoda in the Mediterranean Sea. Ecologia morya 8: 82-87 (in Russian).

KOVALEV, A.V., MELNIKOV, V.V., OSTROVSKAYA, N.A. & PRUSOVA, I.YU., 1993. Macrozooplankton: Plankton of the Black Sea (eds. Kovalev A.V., Finenko Z.Z.) - Kiev: Naukova dumka: 183-193 (in Russian).

KOVALEV, A.V. & GUBANOVA, A.D., 1995. Historical dynamics of plankton in the Sevastopol Bay. Investigations of shelf zone of Azov-Black seas basin. NAS Ukraine. MHI, Sevastopol: 96-99. (in Russian).

KOVALEV, A.V., ZAGORODNYAYA, YU.A. & OSTROVSKAYA, N.A., 1996. The Investigations of the Black Sea zooplankton. Diagnosis of the coastal and shelf zone condition of the Black Sea. NAS of the Ukraine, MHI, Sevastopol: 254-265 (in Russian).

KOVALEV, A., NIERMANN, U., MELNIKOV, V., BELOKOPITOV, V., UYSAL, Z., KIDEYS, A.E., UNSAL, M. & ALTUKHOV, D., 1998. Long-term changes in the Black Sea zooplankton: The role of natural and anthropogenic factors. Ecosystem Modelling as a Management Tool for the Black Sea (eds. L. Ivanov and T. Oguz). Kluwer Acad. Publ.., V.47, No.1: 221-235.

KOVALEV, A.V. & PIONTKOVSKI, S.A., 1998. Interannual changes in the biomass of the Black Sea gelatinous zooplankton. J. of Plankton Research 20: 1377-1385.

KOVALEV, A.V., KIDEYS, A.E., PAVLOVA, E.V., SHMELEVA, A.A., SKRYABIN, V.A., OSTROVSKAYA, N.A. & UYSAL, Z., 1999a. Composition and abundance of zooplankton of the Eastern Mediterranean Sea. The Eastern Mediterranean as a laboratory basin for the assessment of contrasting ecosystems (eds. P. Malanotte-Rizzoli and V.N.Eremeev). Kluwer Academic Publ.: 81-95.

KOVALEV, A.V., SKRYABIN, V.A., ZAGORODNYAYA, YU.A., BINGEL, F., KIDEYS, A.E., NIERMANN, U. & UYSAL, Z., 1999b. The Black Sea zooplankton: Composition, spatial/temporal distribution and history of investigations. Turkish Journal of Zoology 23:195-209.

LAKKIS, S., SIOKOU-FRANGOU, I, CHRISTOU, E., MAZZOCCHI, M.G. & ZEIDANE, R., 1999. Distinctive features of the mesozooplankton from the Levantine basin and adjacent seas (Eastern Mediterranean). Oceanography of the Eastern Mediterranean and Black Sea. Int. Conference, 23-26 February 1999. Athens, Greece. Abstracts: 246.

MASHTAKOVA, G.P., 1985. Long-term dynamics of plankton community in the eastern part of the Black Sea. Moskow: Nauka: 50-61 (in Russian).

MAZZOCCHI, M.G., CHRISTOU, E.D., FRAGOPOULOU, N., SIOKOU-FRANGOU, I., 1997. Mesozooplankton distribution from Sicily to Cyprus

(Eastern Mediterranean), I. General aspects. Oceanologica acta, 20: 521-535.

OVCHINNIKOV, I.M., PLAKHIN, E.A. & MOSKALENKO, L.V., 1976. Hydrology of the Mediterranean Sea. Moscow: Hydrometeoizdat: 375p. (in Russian).

PETIPA, T.S., SAZHINA, L.I. & DELALO, E.P., 1963. Distribution of zooplankton in the Black Sea in 1951-1956. Oceanology.3: 110-129 (in Russian).

POLISCHUK, L.N., NASTENKO, E.V. & GARKAVAYA, G.P., 1984. Some peculiarities of modern state of pelagic and neustonic zoocenosis of the Black Sea. Ecologiya morya 18: 25-34 (in Russian).

SAZHINA, L.I., 1964. Seasonal changes of zooplankton in the north-western part of the Black Sea in 1957. Proc. of Sevastop. Biol. st., 17:262-275 (in Russian).

SOROKIN, YU.I., 1982. The Black Sea: Nature resources. Moscow, Nauka, 216 p (in Russian).

ZAGORODNYAYA, YU.A., SKRYABIN, V.A., 1995. Current trends in the zooplankton evolution in the Black Sea coastal areas. Investigations of shelf zone of Azov-Black Seas basin. Nas Ukraine, MHI, Sevastopol: 87-95 (in Russian).

ZAITSEV, YU.P., 1992. Recent changes in the trophic structure of the Black Sea. Fisheries Oceanography, 1: 180-189.

ZAITSEV, YU.P. & ALEXANDROV, B.G., 1997. Recent man-made changes in the Black Sea. In: Ecosystem sensitivity to change: Black Sea, Baltic Sea and North Sea (eds. E. Ozsoy & A. Mikaelyan). Kluwer Acad. Publ., 25-31.

ZENKEVICH, L.A., 1963. Biology of the seas of the USSR. Moscow: Publ. Ac. Sci. USSR, 739 p. (in Russian).